International Meteor Organization

2012 Meteor Shower Calendar

compiled by Alastair McBeath [1]

1 Introduction

Welcome to the twenty-second International Meteor Organization (IMO) Meteor Shower Calendar, for 2012. The three strongest annual showers—Quadrantids, Perseids and Geminids—all enjoy some moonless skies for their expected maxima this year, the Geminids particularly, peaking at new Moon, along with plenty of the less-active sources, notably later in the year. However, the three stronger southern hemisphere showers—α-Centaurids, η-Aquariids and δ-Aquariids—all peak very close to full Moon. There is though the chance that the virtually-unknown ϵ-Eridanids may produce activity in September, while Taurid swarm returns are predicted for both the June daytime and October-November night-time skies, including the possibility of an especially fireball-rich return during the northern autumn spell. Of course in an ideal world, meteor observing should be carried on throughout the year to check on all the established sources, and for any new ones. Such routine monitoring is possible now with automated video systems, but we appreciate not everyone is able to employ these, and that observing in other ways regularly is impractical for most people, so the Shower Calendar has been helping to highlight times when a particular effort might be most usefully employed since 1991.

The heart of the Calendar is the Working List of Visual Meteor Showers, Table 5, which has undergone a thorough revision in the last few years, including some further minor tweaks this time, helping it to remain the single most accurate listing available anywhere today for naked-eye meteor observing. Of course, for all its accuracy, it is a **Working** List, so is continually subject to further checks and corrections, based on the best data we had at the time the Calendar was written, thus it is always as well to check the information here fully, taking account of any later changes noted in the IMO's journal *WGN* or on the IMO website, before going out to observe (and please notify us if you find any anomalies!).

This is an especially dynamic time for minor shower studies, with video results detecting many showers too weak to be observed visually, as well as sometimes revealing fresh aspects of those already known, and even of the low-activity phases of some of the major showers well away from their maxima. Video has established itself as a valuable tool in meteor studies in recent years, and professional radar meteor examinations have been producing excellent new results as well, but we should not forget the other instrumental techniques available to amateur observers. Telescopic observations can also separate minor shower activity from the omnipresent background sporadics, and detect showers whose meteors are too faint even for current video systems. Still-imaging

[1] Based on information in the *Handbook for Meteor Observers*, edited by Jürgen Rendtel and Rainer Arlt, IMO, 2011 (referred to as 'HMO' in the Calendar), and "A Comprehensive List of Meteor Showers Obtained from 10 Years of Observations with the IMO Video Meteor Network" by Sirko Molau and Jürgen Rendtel (*WGN* **37:4**, 2009, pp. 98–121; referred to as 'VID' in the Calendar), as amended by subsequent discussions and additional material extracted from reliable data analyses produced since. Particular thanks are due to Rainer Arlt, David Asher and Jérémie Vaubaillon for new information and comments in respect of events in 2012.

enables a whole range of studies to be carried out on the brighter meteors particularly, and multi-station observing with still or video cameras can allow orbital data to be established, essential for meteoroid-stream examinations. Showers with radiants too near the Sun for observing by the various optical methods can be detected by forward-scatter radio or radar observations. Some of these showers are given in Table 7, the Working List of Daytime Radio Meteor Streams. Automated radio and radar work also allows 24-hour coverage of meteor activity.

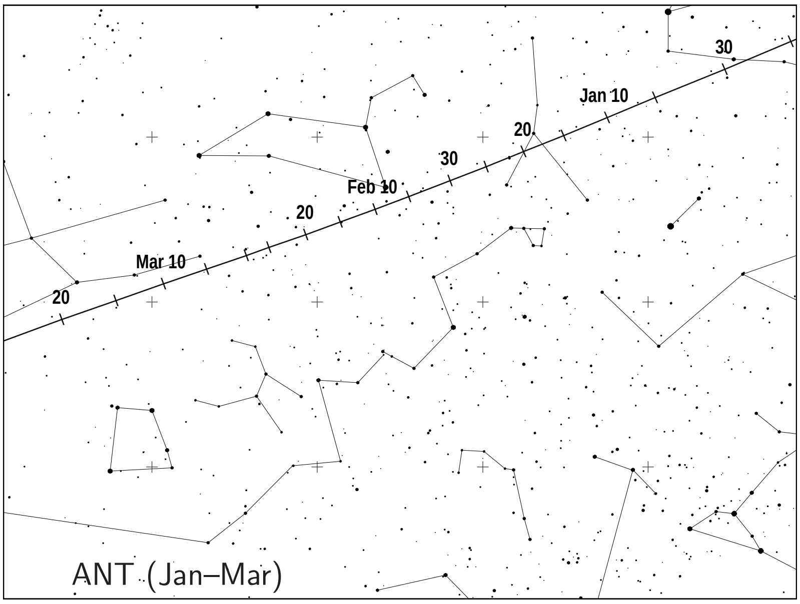
The IMO's aims are to encourage, collect, analyze, and publish combined meteor data obtained from sites all over the globe, to help better our understanding of the meteor activity detectable from the Earth's surface. Thus, we encourage these more specialist forms of observing alongside visual work. Consequently, for best effects, all meteor workers, wherever you are and whatever methods you use to record meteors, should follow the standard IMO observing guidelines when compiling your information, and submit those data promptly to the appropriate Commission for analysis (contact details are at the end of the Calendar). Thanks to the efforts of the many IMO observers worldwide since 1988 that have done this, we have been able to achieve as much as we have to date, including keeping the shower listings vibrant. This is not a matter for complacency however, since it is solely by the continued support of many people across the planet that our steps towards constructing a better and more complete picture of the near-Earth meteoroid flux can proceed.

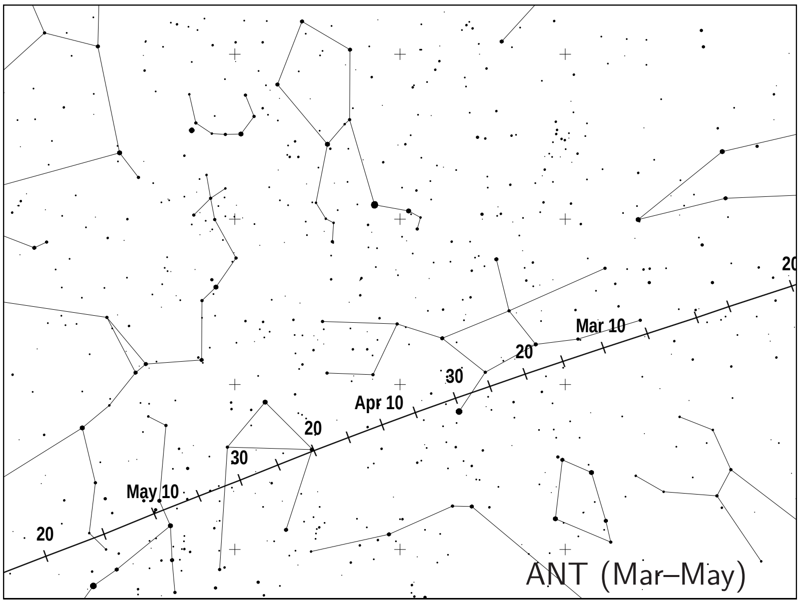
Although timing predictions are included below on all the more active night-time and daytime shower maxima, as reliably as possible, it is essential to understand that in many cases, such maxima are not known more precisely than to the nearest 1° of solar longitude (even less accurately for the daytime radio showers, which have received little regular attention until quite recently). In addition, variations in individual showers from year to year mean past returns are only a guide as to when even major shower peaks can be expected. As noted already, the information given here may be updated and added-to after the Calendar has been published. Some showers are known to show particle mass-sorting within their meteoroid streams, so the radar, radio, still-imaging, telescopic, video and visual meteor maxima may occur at different times from one another, and not necessarily just in those showers. The majority of data available are for visual shower maxima, so this must be borne in mind when employing other observing techniques. However and whenever you are able to observe, we wish you all a most successful year's work and very much look forward to receiving your data. Clear skies!

2 Antihelion Source

The Antihelion Source (ANT) is a large, roughly oval area around $\alpha = 30°$ by $\delta = 15°$ in size, centred about 12° east of the solar opposition point on the ecliptic, hence its name. It is not a true shower at all, but is rather a region of sky in which a number of variably, if weakly, active minor showers have their radiants. Until 2006, attempts were made to define specific showers within this complex, but this often proved very difficult for visual observers to achieve. IMO video results from the last decade have shown why, because even instrumentally, it was impossible to define distinct radiants for many of the showers here! Thus we believe currently it is best for observers simply to identify meteors from these streams as coming from the ANT alone. At present, we think the July-August α–Capricornids (CAP), and particularly the δ–Aquariids (SDA), should remain discretely-observable visually from the ANT, so they have been retained on the Working List.Later in the year, the strength of the Taurid showers (STA and NTA) means the ANT should be considered inactive while the Taurids are underway, from early September to early December. To assist observers, a set of charts showing the location for the ANT and any other nearby shower radiants is included here, to complement the numerical positions of

Table 6, while comments on the ANT's location and likely activity are given in the quarterly summary notes.



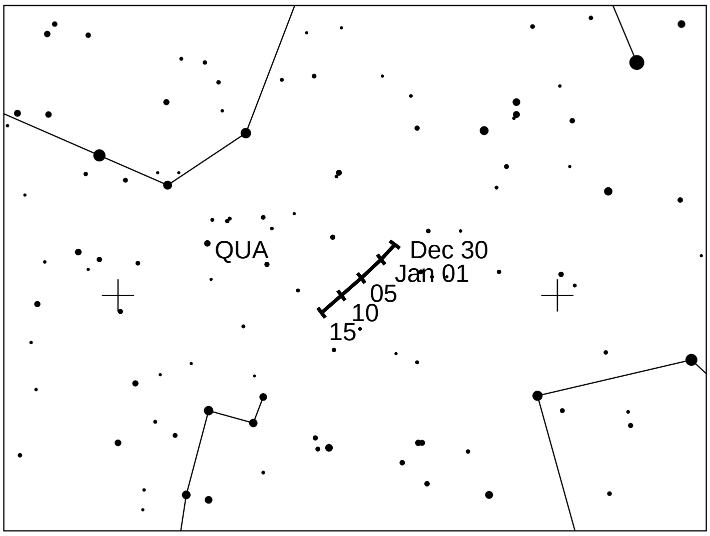


3 January to March

Much of the northern-hemisphere Quadrantid maximum survives the Moon, but the southern-hemisphere's ***α*–Centaurid** and minor ***γ*–Normid** returns are not so lucky. The former's peak has a full Moon on February 8, while the latter's might happen at some point between March 7 to 17 (perhaps most likely around the 14th), with an unhelpful full to waning Moon—last quarter is on March 15. The **ANT's** radiant centre starts January in south-east Gemini, and crosses Cancer during much of the month, before passing into southern Leo for most of February. It then glides through southern Virgo during March. Probable ANT ZHRs will be < 2, though IMO analyses have suggested there may be an ill-defined minor peak with ZHRs ~ 2 to 3 around $\lambda_{\odot} \sim 286° - 293°$ (January 7 to 13 in 2012; spoilt by full Moon, if so), and ZHRs could be ~ 3 for most of March. By contrast, the late January to early February spell, during which several, swift-meteor, **minor showers radiating from the Coma-Leo-Virgo area** have been proposed in some recent years, has an excellent new Moon for its potential core period, January 20–27. Theoretical timings (rounded to the nearest hour) for the **daytime radio shower maxima** this quarter are: Capricornids/Sagittarids – February 2, $03^{\rm h}$ UT and χ–Capricornids – February 14, $04^{\rm h}$ UT. Recent radio results have implied the Cap/Sgr maximum may fall variably sometime between February 1–4 however, while activity near the expected χ–Capricornid peak has tended to be slight and up to a day late. Both showers have radiants $< 10°–15°$ west of the Sun at maximum, so cannot be regarded as visual targets even from the southern hemisphere.

Quadrantids (QUA)

Active: December 28-January 12; Maximum: January 4, $07^{\rm h}20^{\rm m}$ UT ($\lambda_\odot = 283.^\circ16$);
ZHR = 120 (can vary $\sim$ 60–200);
Radiant: $\alpha = 230°$, $\delta = +49°$; Radiant drift: see Table 6;
$V_\infty = 41$ km/s; $r = 2.1$ at maximum, but variable;
TFC: $\alpha = 242°$, $\delta = +75°$ and $\alpha = 198°$, $\delta = +40°$ ($\beta > 40°$ N).
IFC: before $0^{\rm h}$ local time $\alpha = 150°$, $\delta = +70°$; after $0^{\rm h}$ local time $\alpha = 180°$, $\delta = +40°$ and $\alpha = 240°$, $\delta = +70°$ ($\beta > 40°$ N).



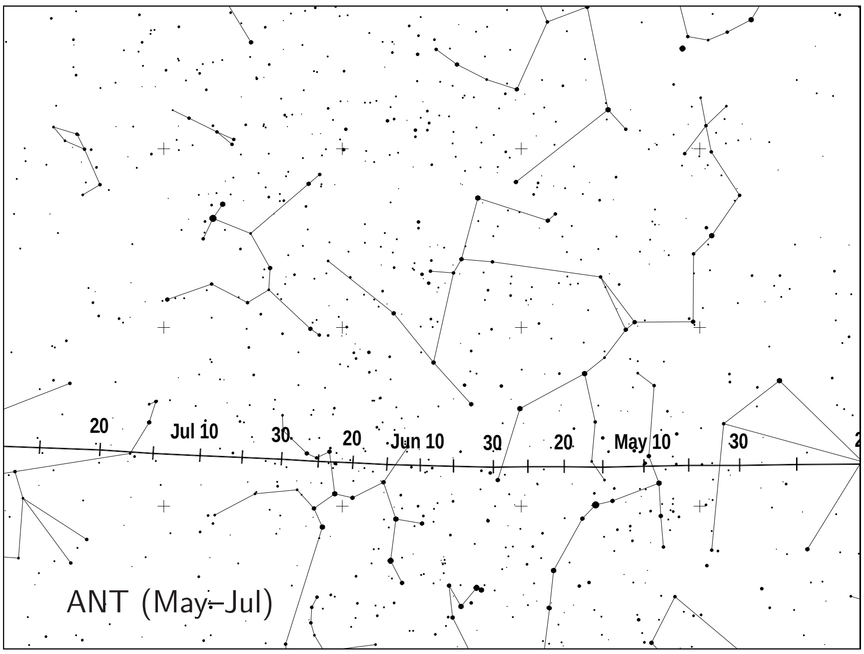
Waxing gibbous moonset for the predicted Quadrantid maximum leaves several dark-sky hours for visual observing before morning twilight begins from northern hemisphere sites this year. From many such places, the shower's radiant is circumpolar, in northern Boötes, first attaining a useful elevation after local midnight, improving steadily later, making this a reasonably favourable return. Observing sites from eastern North America east to the extreme west of Europe should be best-placed to record what happens, if the maximum time above is correct.

Modelling the stream is difficult. While the graph shown in HMO p. 129, based on computations by Jérémie Vaubaillon, seemed to suggest enhanced rates could happen between roughly $01^{\rm h}$ to $10^{\rm h}$ UT on January 4, his recent results do not support this. The $\lambda_\odot = 283.^\circ16$ maximum timing is based on the best-observed return of the shower ever analysed, from IMO data collected in 1992, as confirmed by radio results in most years since 1996. The peak itself is normally short-lived, and can be easily missed in just a few hours of poor northern-winter weather, which may be why the ZHR level apparently fluctuates from year to year. However, some genuine variability is probably present too. An added level of complexity comes from the fact mass-sorting of particles across the meteoroid stream may make fainter objects (radio and telescopic meteors) reach maximum up to 14 hours before the brighter (visual and photographic) ones, so observers should be alert throughout the shower. A few years since 2000 seem to have produced a, primarily radio, maximum following the main visual one by some 9–12 hours. Visual confirmation of any repeat of such behaviour would be welcomed. QUA activity tends to be very low more than a day or so from the peak, and past observations have suggested the radiant is diffuse away from the maximum too, contracting notably during the peak itself, perhaps because of this lower activity then. Imaging observations would be welcomed to help investigate this topic, along with telescopic results.

4 April to June

Meteor activity picks up towards the April-May boundary, with new Moon gracing both the late April shower maxima. Sadly, the ***η*–Aquariids** in early May are very poorly-placed, with full Moon on May 6, just a day after their predicted peak on the 5th. Stronger η–Aquariid activity can persist at near-maximum levels for several days, although the shower can be observed usefully only from equatorial and southern hemisphere sites for a few hours before dawn. Rates should be in the declining phase of the shower's theoretical 12-year cycle in 2012, with ZHRs of perhaps 60–70. The minor ***η*–Lyrids** fare little better, expected at maximum perhaps on May 8 or 10, with May's waning gibbous Moon.

Daytime showers: Later in May and throughout June, most of the meteor action switches to the daylight sky, with six shower peaks expected during this time. Although occasional meteors from the o–Cetids and Arietids have been claimed as seen from tropical and southern hemisphere sites visually in past years, ZHRs cannot be sensibly calculated from such observations. For radio observers, the theoretical UT peaks for these showers are as follows: April Piscids – April 20, 04^{h}; δ–Piscids – April 24, 04^{h}; ε–Arietids – May 9, 02^{h}; May Arietids – May 16, 03^{h}; o–Cetids – May 20, 02^{h}; Arietids – June 7, 05^{h}; ζ–Perseids – June 9, 05^{h}; β–Taurids – June 28, 04^{h}. Signs of most were found in radio data from 1994–2007, though some are difficult to define individually because of their proximity to other radiants. There seems to be a modest recurring peak around April 24, perhaps due to combined rates from the first three showers listed here, for instance, while the Arietid and ζ–Perseid maxima tend to blend into one another, producing a strong radio signature for several days in early to mid June. There are indications these two June shower maxima now each occur up to a day later than indicated above.

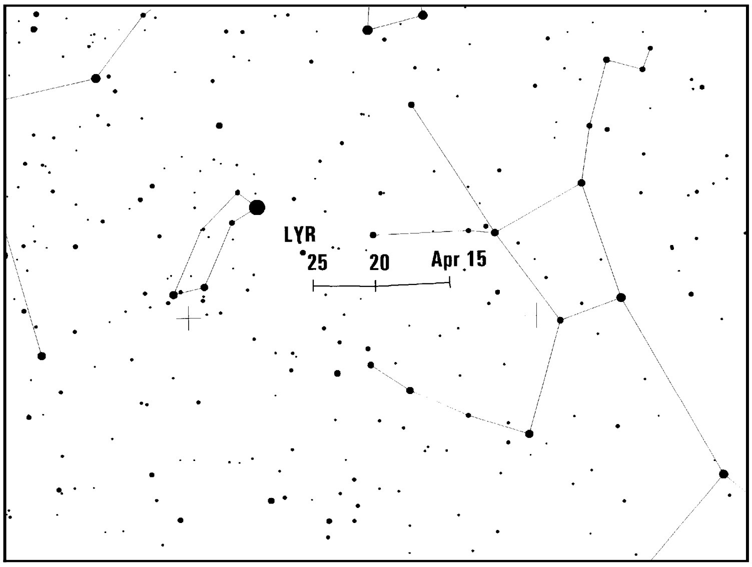


The **ANT** should be relatively strong, with ZHRs of 3 to 4 through till mid April, and again around late April to early May, late May to early June, and late June to early July. At other times, the ZHR seems to be below $\sim$ 2 to 3. The radiant area drifts from south-east Virgo through Libra in April, then across the northern part of Scorpius to southern Ophiuchus in May, and on into Sagittarius for much of June. For northern observers, circumstances for checking on any potential June Lyrids are favourable this year, as also for possible June Boötid hunting.

Taurid 'swarm' return: Work by David Asher has suggested the possibility of another return of the Taurid meteoroid 'swarm' during June 2012 (see HMO, p. 160). If so, it may be detectable as an increased radio meteor flux during the ζ–Perseids or β–Taurids, both of which are probably associated with the Taurid Complex of meteor showers, asteroids and comets. Each of the last four predicted night-time 'swarm' events from the October-November Taurids, in 1995, 1998, 2005 and 2008 produced noticeably different activity to normal. The most impressive of these was in 2005, which included increased Taurid ZHRs and numerous shower fireballs from late October to mid-November. Another night-time 'swarm' return is due later this year. However, previous theoretical daytime 'swarm' returns in 1995, 1999, 2002 and 2009 have proven elusive, with nothing very remarkable found in the June-July radio results for any of those years that might be definite signs of such a return. Consequently, it is unclear what, if anything, may be expected from the daytime-sky this time. The most likely period for anything to be detected is perhaps about 5–8 days before the β–Taurid peak, thus around June 20–23, but its potential timing and strength are unknown. There is also the chance that if an increased fireball flux takes place, there may be some daylight fireballs reported visually, though of course these cannot be deliberately watched for.

Lyrids (LYR)

Active: April 16–25; Maximum: April 22, $05^{\rm h}30^{\rm m}$ UT ($\lambda_\odot = 32.^\circ32$, but may vary - see text);
ZHR = 18 (can be variable, up to 90);
Radiant: $\alpha = 271^\circ$, $\delta = +34^\circ$; Radiant drift: see Table 6;
$V_\infty = 49$ km/s; $r = 2.1$;
TFC: $\alpha = 262^\circ$, $\delta = +16^\circ$ and $\alpha = 282^\circ$, $\delta = +19^\circ$ ($\beta > 10^\circ$ S).



The $\lambda_\odot = 32.^\circ32$ timing given above is the 'ideal' maximum found in *IMO* results from 1988–2000. However, the maximum time was variable from year to year between $\lambda_\odot = 32.^\circ0$–$32.^\circ45$ (equivalent to 2012 April 21, $21^{\rm h}30^{\rm m}$ to April 22, $08^{\rm h}30^{\rm m}$ UT). Activity was variable too. A peak at the ideal time produced the highest ZHRs, ~ 23, while the further the peak happened from this, the lower the ZHRs were, down to ~ 14. (The last very high maximum was in 1982, when a short-lived ZHR of 90 was recorded.) The mean peak ZHR was 18 over the thirteen years examined.

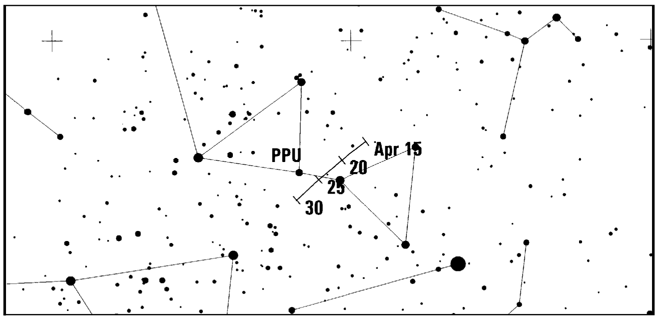
While generally thought of as having a short, quite sharp, maximum, this investigation showed the shower's peak length was inconstant. Using the Full-Width-Half-Maximum time (the period ZHRs were above half the peak level), a variation between 14.8 to 61.7 hours was detected (mean 32.1 hours). The best rates are normally achieved for just a few hours even so. The analysis also confirmed that occasionally, as their highest rates occurred, the Lyrids produced a brief increase in fainter meteors. Lyrids are best viewed from the northern hemisphere, but are visible from many sites north and south of the equator. As the radiant rises during the night, watches can be carried out usefully after about $22^{\rm h}30^{\rm m}$ local time from mid-northern sites, but only well after midnight from the mid-southern hemisphere. New Moon on April 21 makes this year perfect for Lyrid maximum observing, and if the ideal peak time recurs, it should be best-seen from sites across much of North America, particularly the eastern half. Remember, other maximum times are perfectly possible!

π–Puppids (PPU)

Active: April 15–28; Maximum: April 23, $10^{\rm h}30^{\rm m}$ UT ($\lambda_\odot = 33.^\circ5$);
ZHR = periodic, up to around 40;
Radiant: $\alpha = 110^\circ$, $\delta = -45^\circ$; Radiant drift: see Table 6; $V_\infty = 18$ km/s; $r = 2.0$;
TFC: $\alpha = 135^\circ$, $\delta = -55^\circ$ and $\alpha = 105^\circ$, $\delta = -25^\circ$ ($\beta < 20^\circ$ N).

Activity has only been detected from this source since 1972, with notable, short-lived, shower maxima of around 40 meteors per hour in 1977 and 1982, both years when its parent comet, 26P/Grigg-Skjellerup was at perihelion. Before 1982, little activity had been seen at other times, but in 1983, a ZHR of ~ 13 was reported, perhaps suggesting material has begun to spread further along the comet's orbit, as theory predicts. Comet Grigg-Skjellerup's most recent perihelion in 2008 March produced nothing meteorically significant that April, but lunar circumstances in 2008 were poor, and faint-meteor activity (which was predicted as likely in advance) could have been missed. There were no predictions for activity in 2012 when this Calendar was prepared. The π–Puppids are best-seen from the southern hemisphere, with useful observations mainly practical there before midnight, as the radiant is very low to setting after $01^{\rm h}$ local time. April's new Moon creates perfect viewing circumstances this year.

Covering whatever happens is important, even if that is to report no obvious activity, as past datasets on the shower have typically been very patchy. So far, visual and radio data have been collected on the shower, but the slow, sometimes bright nature of the meteors makes them ideal subjects for imaging too. No telescopic or video data have been reported in any detail as yet.



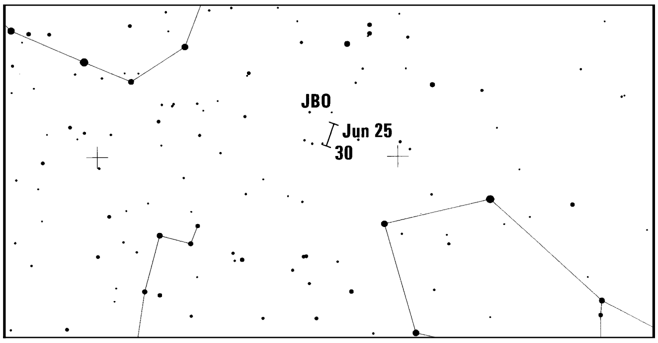
June Lyrids (JLY)

Active: June 11–21; Maximum: June 15 ($\lambda_\odot = 85^\circ$); ZHR = variable, 0–5;
Radiant and drift: June 10 $\alpha = 273^\circ$, $\delta = +35^\circ$,
June 15 $\alpha = 277^\circ$, $\delta = +35^\circ$,
June 20 $\alpha = 281^\circ$, $\delta = +35^\circ$;
$V_\infty = 31$ km/s; $r = 3.0$.

This possible source does not feature in the current IMO Working List, as apart from some activity seen from northern hemisphere sites in a few years during the 1960s (first seen 1966) and 1970s, evidence for its existence has been virtually zero since. In 1996, several observers independently reported some June Lyrids, though no definite activity has been found subsequently. The probable maximum date in 2012 has just a waning crescent Moon, yielding ideal viewing conditions for all observers who wish to check for it. The radiant may lie a few degrees south of the bright star Vega (α Lyrae), so would be well on-view throughout the short northern summer nights, but there are discrepancies in its position in the literature. All suspected visual June Lyrids should be carefully plotted, paying especial attention to the meteors' apparent velocities. Confirmation or denial of activity from this source by imaging techniques would be very useful too.

June Boötids (JBO)

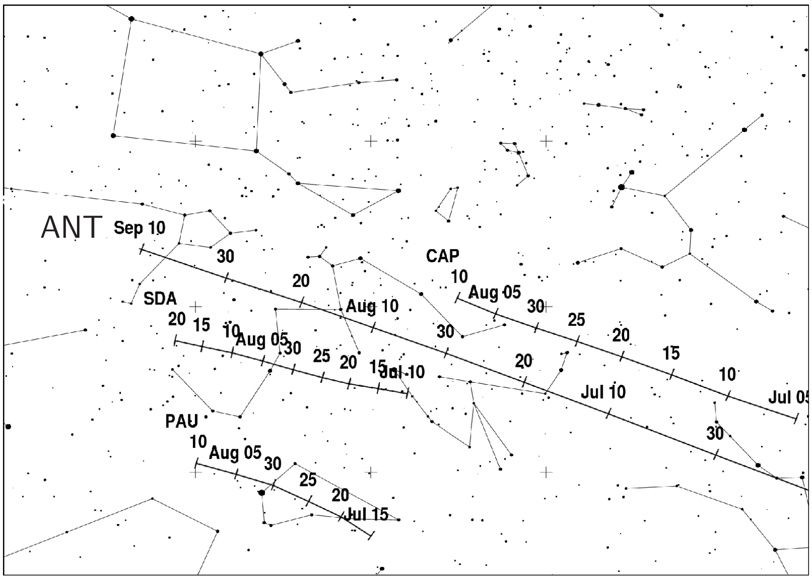
Active: June 22–July 2; Maximum: June 27, 03^h UT ($\lambda_\odot = 95.^\circ7$), but see text;
ZHR = variable, 0–100+;
Radiant: $\alpha = 224°$, $\delta = +48°$; Radiant drift: see Table 6;
$V_\infty = 18$ km/s; $r = 2.2$;
TFC: $\alpha = 156°$, $\delta = +64°$ and $\alpha = 289°$, $\delta = +67°$ ($\beta = 25°$–$60°$ N).



This source was reinstated on the Working List after its unexpected return of 1998, when ZHRs of 50–100+ were visible for more than half a day. Another outburst of similar length, but with ZHRs of $\sim$ 20–50 was observed on 2004 June 23, a date before definite activity had previously been recorded from this shower. Consequently, the shower's start date was altered to try to ensure future rates so early are caught, and we encourage all observers to routinely monitor throughout the proposed period, in case of fresh outbursts. However, the 2010 return was disappointing. ZHRs of $\sim$ 20–50 were anticipated for June 23–24, but detected ZHRs then were less than 10, and not all experienced observers confirmed even these. Prior to 1998, only three more probable returns had been detected, in 1916, 1921 and 1927, and with no significant reports between 1928 and 1997, it seemed likely these meteoroids no longer encountered Earth. The dynamics of the stream were poorly understood, although recent theoretical modelling has improved our comprehension. The shower's parent, Comet 7P/Pons-Winnecke, has an orbit that now lies around 0.24 astronomical units outside the Earth's at its closest approach. Its most recent perihelion passage was in 2008 September. Clearly, the 1998 and 2004 events resulted from material shed by the comet in the past which now lies on slightly different orbits to the comet itself. Although no predictions for activity are in-force for 2012, conditions for checking are favourable from the mid-northern latitudes where the radiant is best-seen (indeed it is usefully-observable almost all night from here), with only a waxing crescent Moon, at first quarter on June 27. The prolonged—in some places continuous—twilight will cause greater difficulties. VID suggested some June Boötids may be visible in most years around June 20–25, but with activity largely negligible except near $\lambda_\odot = 92°$ (2012 June 23), radiating from an area about ten degrees south of the radiant found in 1998 and 2004, close to $\alpha = 216°$, $\delta = +38°$.

5 July to September

The **ANT** is the chief focus for visual attention during most of July, as its radiant area moves steadily through eastern Sagittarius, then across northern Capricornus into southwest Aquarius. Results suggest the Source may not be especially recognisable after the first few days however, as ZHRs for most of the month seem < 2, and for a time in mid-month even < 1! Activity appears to improve somewhat, with ZHRs $\sim$ 2 to 3, by late July and through the first half of August. The large ANT radiant area now overlaps that of the minor α–Capricornids (CAP) in July-August, but the δ–Aquariids (SDA) are strong enough, and the Piscis Austrinids (PAU) have a radiant probably distant enough from the ANT area, that both should be separable from it still, particularly from the southern hemisphere. The peaks from the **SDA and CAP** (both expected around July 29–30) are too close to August's first full Moon for useful visual watching this year.



August's second full Moon on the 31st arrives in perfect time to ruin the **Aurigid** maximum, due around $19^{\rm h}$ UT on that date. Luckily, no repeat of the strong outburst in 2007 is expected from the shower this year. **ANT** ZHRs will likely have dropped back below 2 again by late August, rising once more to $\sim$ 2–3 by early September, as the radiant tracks on through Aquarius and into western Pisces. Remember, the Southern Taurids begin around September 10, effectively taking over the near-ecliptic activity from the ANT through to December.

ε–Eridanids: Scarcely nothing is known of this possible minor shower. It has been suggested as associated with Comet C/1854 L1 Klinkerfues, and as a theoretical encounter with the comet's 1600 AD dust trail was still to come in 2011 September when this text was written, more may be known about the shower by its 2012 return than is noted here. The IMO's Visual Meteor Database suggests any ϵ–Eridanid activity is most likely from about September 9–12, with a maximum around September 10 from a radiant at $\alpha = 57°$, $\delta = -12°$. No atmospheric velocity is known for the meteors. For 2012, Jérémie Vaubaillon has indicated the Earth may encounter a weak dust trail from Comet Klinkerfues, which could produce ZHRs of $\sim$ 10 around $13^{\rm h}09^{\rm m}$ UT on September 12. The activity level is uncertain, but observers need to be alert for whatever occurs. As this proposed encounter date is at the end of the previously-suggested activity period, it may be ϵ–Eridanid meteors could occur beyond September 12 this year. The radiant can be observed from both hemispheres, but is more favourable south of the equator. For mid-northern sites, it rises around local midnight, attaining a useful elevation by $\sim 02^{\rm h}$. From mid-southern latitudes, the radiant rises by $22^{\rm h}$ and can be viably observed from midnight onwards. This assumes the theoretical radiant location is correct, of course! With only a waning crescent Moon four days from new on September 12, well-placed observers should be able to confirm if anything takes place. Video observing is liable to be most successful, if the event is as weak as supposed, with telescopic plotting. Careful visual plotting should work as well, and would help confirm the ZHR level, though anything as low as $\sim$ 10 may be difficult to detect clearly using forward-scatter radio systems. Should the timing prove accurate, locations across the southern Pacific Ocean, including New Zealand, and perhaps the extreme east of Australia, would be better-placed to cover whatever happens.

For **daylight radio observers**, the interest of May-June has waned, but there remain the visually-impossible γ–Leonids (peak due near August 25, $04^{\rm h}$ UT, albeit not found in recent radio results), and a tricky visual shower, the Sextantids. Their maximum is expected on

September 27, around 04$^{\mathrm{h}}$ UT, but possibly it may occur a day earlier. In 1999 a strong return was detected at $\lambda_{\odot} \sim 186°$, equivalent to 2012 September 28, while in 2002, the September 27 peak was not found, but one around September 29–30 was! It seems plausible several minor maxima in early October may also be due to this radio shower. September's waxing gibbous Moon should set in time to cause little further hindrance for visual observers hoping to catch some Sextantids in the pre-dawn of late September, though radiant-rise is less than an hour before sunrise in either hemisphere.

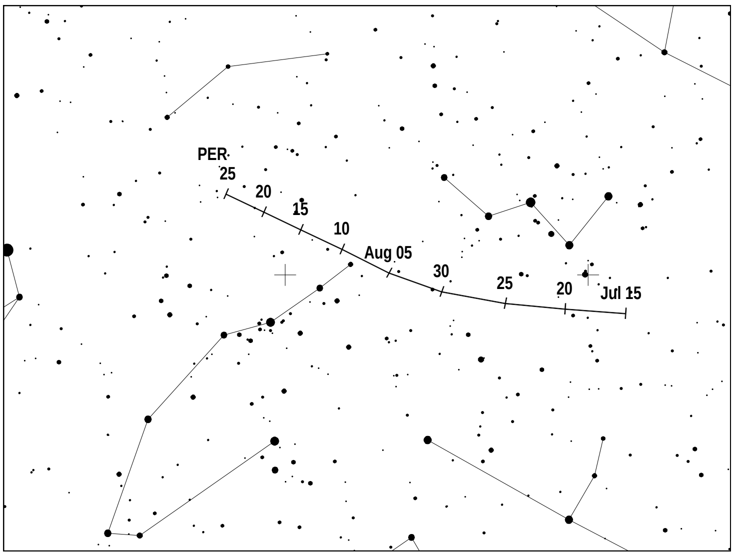
Piscis Austrinids (PAU)

Active: July 15–August 10; Maximum: July 27 ($\lambda_{\odot} = 125°$); ZHR = 5;
Radiant: $\alpha = 341°$, $\delta = -30°$; Radiant drift: see Table 6;
$V_{\infty} = 35$ km/s; $r = 3.2$;
TFC: $\alpha = 255°$ to 000°, $\delta = 00°$ to $+15°$, choose pairs separated by about 30° in α ($\beta < 30°$ N).

Very little information has been collected on the PAU in recent decades, so the details on the shower are not well-confirmed, and it seems possible the ZHR may be a little optimistic. However, that impression could be due simply to the large amount of northern hemisphere summer data, and the almost complete lack of southern hemisphere winter results, on it. The stream seems to be rich in faint meteors, rather like the nearby ANT and SDA, so telescopic and video work is advisable to try to establish more about it. Although there is a waxing gibbous Moon for the probable maximum, it will set between local midnight and 1 a.m., while the PAU radiant is available virtually all night, especially from mid-southern latitudes.

Perseids (PER)

Active: July 17–August 24; Maximum: August 12, 12$^{\mathrm{h}}$ to 14$^{\mathrm{h}}$30$^{\mathrm{m}}$ UT (node at $\lambda_{\odot} = 140.^{\circ}0$–$140.^{\circ}1$), but see text; ZHR = 100;
Radiant: $\alpha = 48°$, $\delta = +58°$; Radiant drift: see Table 6; $V_{\infty} = 59$ km/s; $r = 2.2$;
TFC: $\alpha = 019°$, $\delta = +38°$ and $\alpha = 348°$, $\delta = +74°$ before 2$^{\mathrm{h}}$ local time; $\alpha = 043°$, $\delta = +38°$ and $\alpha = 073°$, $\delta = +66°$ after 2$^{\mathrm{h}}$ local time ($\beta > 20°$ N);
IFC: $\alpha = 300°$, $\delta = +40°$, $\alpha = 000°$, $\delta = +20°$ or $\alpha = 240°$, $\delta = +70°$ ($\beta > 20°$ N).



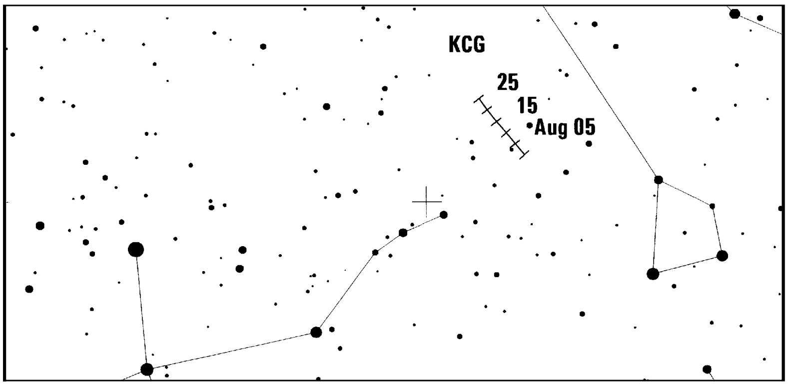
The Perseids produced strong activity from an unexpected primary maximum throughout the 1990s, associated with the perihelion passage of their parent comet, 109P/Swift-Tuttle, in 1992. The comet's orbital period is about 130 years. Further enhanced activity ahead of the usual maximum was last seen in 2004. Recent IMO observations (see HMO p. 145) found the timing of the mean or 'traditional' broad maximum varied between $\lambda_{\odot} \sim 139.^{\circ}8$ to $140.^{\circ}3$, equivalent to 2012 August 12, 07$^{\mathrm{h}}$ to 19$^{\mathrm{h}}$30$^{\mathrm{m}}$ UT. No additional peaks are anticipated this year, but this does not guarantee what **will** occur!

Although the Moon is a waning crescent, three days after last quarter on August 12, it will rise from mid-northern locations around local midnight to one a.m. Its brightness and relative proximity to the Perseid radiant should be considered more of a nuisance than a deterrent, even so. Such mid-northern latitudes are the more favoured for Perseid observing, as from here, the shower's radiant is usefully observable from $22^{\rm h}$–$23^{\rm h}$ local time onwards, gaining altitude throughout the night. The near-nodal part of the 'traditional' maximum interval would be best-viewed from eastern Asia east to far western North America (with increasing moonlight for places further east in this zone), assuming it happens as expected. All forms of observing can be carried out on the shower, though unfortunately, it cannot be usefully observed from most of the southern hemisphere.

κ-Cygnids (KCG)

Active: August 3–25; Maximum: August 17 ($\lambda_\odot = 145°$); ZHR = 3;
Radiant: $\alpha = 286°$, $\delta = +59°$; Radiant drift: see Table 6;
$V_\infty = 25$ km/s; $r = 3.0$;
IFC: $\alpha = 330°$, $\delta = +60°$ and $\alpha = 300°$, $\delta = +30°$($\beta > 20°$ N).

New Moon falls perfectly for the expected κ–Cygnid peak this year. The shower is best-observed from northern hemisphere sites, from where the radiant is easily available all night. VID suggested a number of discrepancies to the currently-accepted parameters listed above, including that the peak might happen closer to August 13, from a more southerly radiant (around $\alpha = 186°$, $\delta = +51°$), and that activity might be present only from August 6–19 overall.

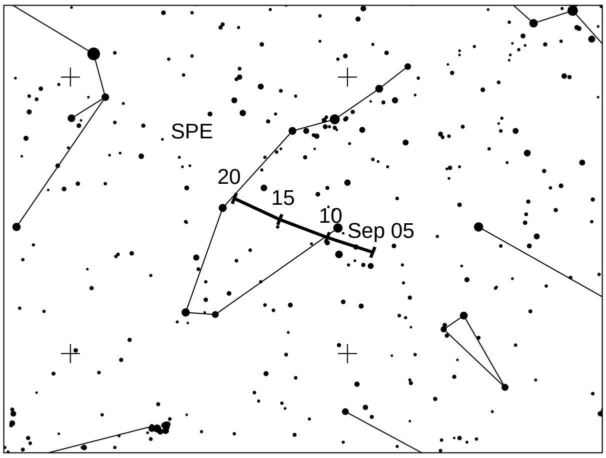


Previous video results had implied that rather than having an almost stationary radiant, as expected due to its proximity to the ecliptic north pole in Draco, the radiant showed a discernible daily drift. Consequently observers should be aware that the shower may not behave as it is "supposed to"! There have been past suggestions of variations in κ-Cygnid rates at times too, perhaps coupled with a periodicity in fireball sightings.

September ε–Perseids (SPE)

Active: September 5–21; Maximum: September 9, $04^{\rm h}$ UT ($\lambda_\odot = 166\overset{\circ}{.}7$), but see text;
ZHR = 5;
Radiant: $\alpha = 48°$, $\delta = +40°$; Radiant drift: see Table 6;
$V_\infty = 64$ km/s; $r = 3.0$;
TFC: $\alpha = 030°$, $\delta = +55°$; $\alpha = 28°$, $\delta = +35°$ and $\alpha = 25°$, $\delta = +40°$ ($\beta > 10°$ S).

A short observing window is available on September 9 before the waning crescent Moon rises (one day after last quarter) for this primarily northern-hemisphere shower's maximum. The radiant area is well on-view overnight from about $22^{\rm h}$–$23^{\rm h}$ local time for mid-northern locations, while moonrise then is between about $22^{\rm h}$–$00^{\rm h}$ for similar places. Though previously little-known, this radiant was apparently that responsible for producing an unexpected outburst of swift, bright meteors on 2008 September 9, between roughly $\lambda_\odot = 166\overset{\circ}{.}894$–$166\overset{\circ}{.}921$. The repeat time for that outburst interval converted to 2012 would be September 9, between 08^h40^m–09^h20^m UT, but nothing unusual is predicted to occur this time.



It is possible that along with the Aurigids (peak Aug 31/Sep 01) and later δ–Aurigids, this shower is simply one more easily-detected in a series of poorly-observed sources with radiants around Aries, Perseus, Cassiopeia and Auriga during the northern early autumn. The telescopic shower of the β–Cassiopeids is suspected of being active too during September, for example, and there may be others.

6 October to December

October 5/6 meteors: Short-lived video outbursts were recorded in 2005 and 2006 by European observers, with activity from a north-circumpolar radiant near the 'tail' of Draco, around $\alpha \sim 165°$, $\delta \sim +78°$, on October 5/6. The meteors showed an atmospheric velocity of $\sim$ 45–50 km/s. The 2005 event (only) was recorded very weakly by radio, but no visual results confirmed either occurrence, and no recurrence was reported in 2007 or 2008. Weak video rates were claimed detected near the 2009 and 2010 repeat times, but again, no other method confirmed these, and the shower was not found by the full ten-year VID analysis. The active interval suggested by video data lies between $\lambda_\odot \sim 192\overset{\circ}{.}5$–$192\overset{\circ}{.}8$, equivalent to 2012 October 5, 12^h40^m–20^h00^m UT, a date with a waning gibbous Moon that rises between the early to mid evening hours for most mid-northern sites (later rising times further south). If the active interval remains the same, it would be best-observed from dusk to moonrise, likely by video only, from European longitudes east to eastern Asian ones.

Taurid 'swarm' return: Model calculations by David Asher have indicated the possibility there may be a second return of the Taurid 'swarm' of larger particles this year, in October-November (see HMO, p. 160, and the notes for the possible June return under the "April to June" notes above). The last four northern autumn Taurid 'swarm' returns have each produced unusual, if variable, activity, so there seems a good prospect something may again happen this time. As for what may occur, David suggests two possibilities. One, based purely on model calculations for where the swarm should be, suggests we may catch only its end, so whatever is observed will help refine the nature and extent of the swarm. The other is more interesting, because the Taurid resonant swarm theory indicates the pattern of such returns should repeat every 61 years, and the 1951 Taurid return, as observed from the Netherlands, was so notably strong in bright to fireball-class meteors, it was one of the key pieces of evidence which Victor Clube and David used when originally formulating the theory! The 1951 events were observed between October 28 and November 11, remarkably close to the date-range found from the strongest recent Taurid swarm return, in 2005, that persisted from about October 29 to November 10. Although full Moon on October 29 will cause problems for standard observing, this will become less troublesome during early November, and all observers should be alert to cover whatever happens. Fireball analysts as well should be prepared for the potential of increased casual fireball sightings around this period. However, do please remember that nothing is ever guaranteed in meteor astronomy!

The **ANT** starts the quarter effectively inactive in favour of the Taurids, resuming only around December 10, as the Northern Taurids fade away, from a radiant centre that tracks across southern Gemini during later December, likely producing ZHRs < 2, although some of this apparent inactivity may be due to the strength of the Geminids close-by to the north during part of December, plus the minor Monocerotids a little way to its south simultaneously.

Draconids (DRA)

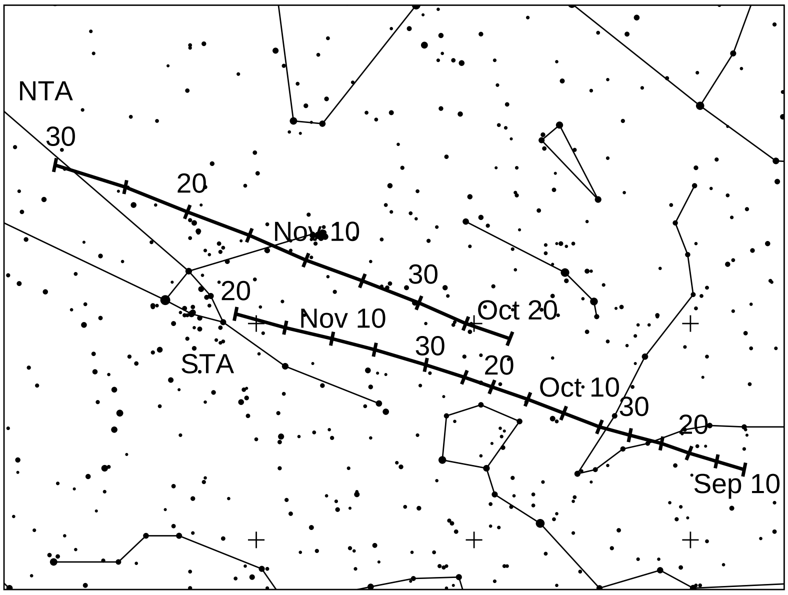
Active: October 6–10; Maximum: October 8, 11^h15^m UT ($\lambda_\odot = 195\overset{\circ}{.}4$), but see text;
ZHR = periodic, up to storm levels;
Radiant: $\alpha = 262°$, $\delta = +54°$; Radiant drift: negligible;
$V_\infty = 20$ km/s; $r = 2.6$;
TFC: $\alpha = 290°$, $\delta = +65°$ and $\alpha = 288°$, $\delta = +39°$ ($\beta > 30°$ N).

The Draconids are primarily a periodic shower which produced spectacular, brief, meteor storms twice last century, in 1933 and 1946, and lower rates in several other years (ZHRs $\sim$ 20–500+). Most detected showers were in years when the stream's parent comet, 21P/Giacobini-Zinner, returned to perihelion, as it should next in 2012 February. Its orbital period is currently about 6.6 years. The 2011 potentially strong return was still to come when this text was written, but in 2005 October, the comet's previous perihelion year, a largely unexpected outburst happened near the nodal crossing time, around $\lambda_\odot = 195\overset{\circ}{.}40$–$195\overset{\circ}{.}44$, probably due to material shed in 1946. Visual ZHRs were ~ 35, though radar detections suggested a much higher estimated rate, closer to ~ 150. Outlying maximum times from the recent past have spanned from $\lambda_\odot = 195\overset{\circ}{.}075$ (in 1998; EZHRs ~ 700), equivalent to 2012 October 8, 03^h20^m UT, through the nodal passage time above, to $\lambda_\odot 195\overset{\circ}{.}63$–$195\overset{\circ}{.}76$ (a minor outburst in 1999, not a perihelion-return year; ZHRs $\sim$ 10–20), equating to 2012 October 8, 16^h50^m to 20^h00^m UT. No predictions of unusual activity are in-force this October, but observers should be alert just in case. Last quarter Moon on October 8 makes this quite a favourable year, as the Moon rises in late evening for the many northern hemisphere locations from where the Draconid radiant is circumpolar. The radiant is at its highest during the first half of the night, and Draconid meteors are exceptionally slow-moving.

Southern Taurids (STA)

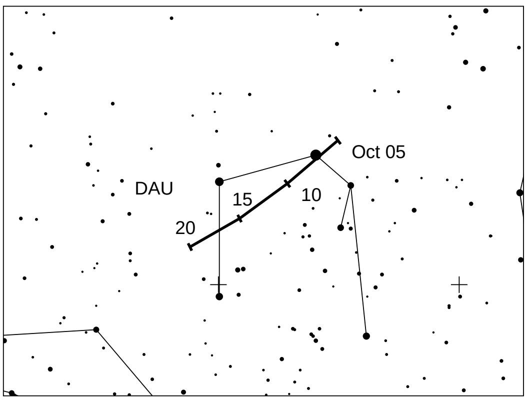
Active: September 10–November 20; Maximum: October 10 ($\lambda_\odot = 197°$); ZHR = 5;
Radiant: $\alpha = 32°$, $\delta = +09°$; Radiant drift: see Table 6;
$V_\infty = 27$ km/s; $r = 2.3$;
TFC: Choose fields on the ecliptic and $\sim 10°$ E or W of the radiant ($\beta > 40°$ S).

This stream, with its Northern counterpart, forms part of the complex associated with Comet 2P/Encke. Defining its radiant is best achieved by video, telescopic or careful visual plotting, since it is large and diffuse. For shower association, assume the radiant to be an oval area, $\sim 20° \times 10°$, $\alpha \times \delta$, centred on the radiant position for any given date. The Taurid activity overall dominates the Antihelion Source area's during the northern autumn, so much so that the ANT is considered inactive while either branch of the Taurids is present. The brightness and relative slowness of many Taurid meteors makes them ideal targets for still-imaging, while these factors coupled with low, steady, Taurid rates makes them excellent subjects for newcomers to practice their plotting techniques on. Although long thought to combine with the Northern Taurids to produce an apparently plateau-like maximum in the first decade of November, VID and recent visual plotting work have indicated the Southern branch probably reaches its peak about a month before the Northern one, this year with just a waning crescent Moon. Its near-ecliptic radiant means all meteoricists can observe the STA, albeit northern hemisphere observers are somewhat better-placed, as here suitable radiant zenith distances persist for much of the night. Even in the southern hemisphere however, 3–5 hours' watching around local midnight is possible with Taurus well above the horizon. See the "October to December" notes above for the possible Taurid 'swarm' return in late October to early November.



δ–Aurigids (DAU)

Active: October 10–18; Maximum: October 11 ($\lambda_\odot = 198°$); ZHR = 2;
Radiant: $\alpha = 84°$, $\delta = +44°$; Radiant drift: see Table 6;
$V_\infty = 64$ km/s; $r = 2.9$;
TFC: $\alpha = 080°$, $\delta = +55°$; $\alpha = 080g$, $\delta = +30°$ and $\alpha = 060°$, $\delta = +40°$ ($\beta > 10°$ S).



The weakest of the three known near-Auriga-Perseus showers of late August to October, visual observers seem to have struggled to properly identify this minor source previously, and its current parameters are based on a detailed review of IMO video data since the late 1990s. If correct, the peak will have little trouble with the waning Moon, four days from new. The radiant area, visible chiefly from the northern hemisphere, can be properly observed only after local midnight.

ε-Geminids (EGE)

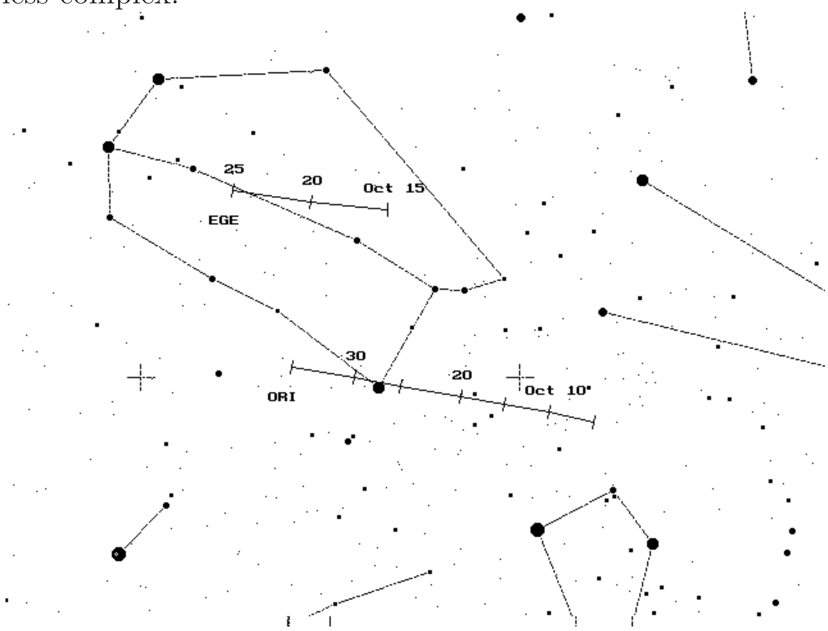
Active: October 14–27; Maximum: October 18($\lambda_\odot = 205°$); ZHR = 3;
Radiant: $\alpha = 102°$, $\delta = +27°$; Radiant drift: see Table 6;
$V_\infty = 70$ km/s; $r = 3.0$;
TFC: $\alpha = 090°$, $\delta = +20°$ and $\alpha = 125°$, $\delta = +20°$($\beta > 20°$ S).

A weak minor shower with characteristics and activity nearly coincident with the Orionids, so great care must be taken to separate the two sources, preferably by video or telescopic work, or perhaps visual plotting. The waxing crescent Moon gives no problems this year, as it will have set from either hemisphere before radiant-rise. Northern observers have a radiant elevation advantage, with observing practical from about midnight onwards. There is some uncertainty about the shower's parameters, with both visual and video data indicating the peak may be up to four or five days later than suggested above.

Orionids (ORI)

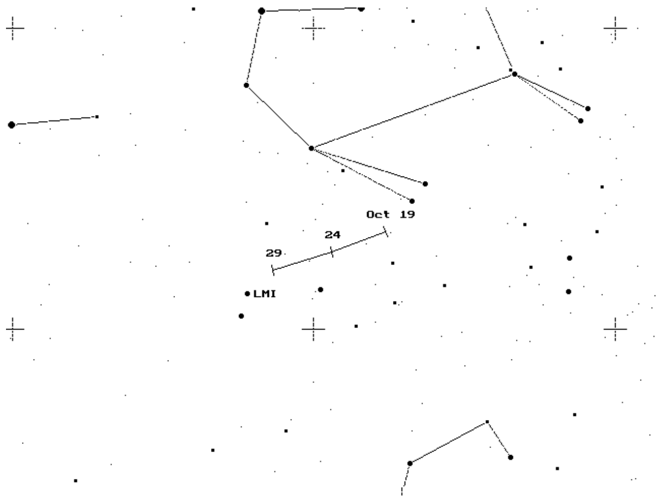
Active: October 2–November 7; Maximum: October 21 ($\lambda_\odot = 208°$); ZHR = 25;
Radiant: $\alpha = 95°$, $\delta = +16°$; Radiant drift: see Table 6;
$V_\infty = 66$ km/s; $r = 2.5$;
TFC: $\alpha = 100°$, $\delta = +39°$ and $\alpha = 075°$, $\delta = +24° (\beta > 40°$ N);
or $\alpha = 080°$, $\delta = +01°$ and $\alpha = 117°$, $\delta = +01° (\beta < 40°$ N).

October's waxing Moon favours the Orionid peak in 2012 too. The shower's radiant, near the celestial equator, is at a useful elevation by around local midnight in either hemisphere, somewhat before in the north, so most of the world can enjoy the shower. Each return from 2006 to 2009 produced unexpectedly strong ZHRs of around 40–70 on two or three consecutive dates. An earlier IMO analysis of the shower, using data from 1984–2001, found both the peak ZHR and r parameters varied somewhat from year to year, with the highest mean ZHR ranging from $\sim$ 14–31 during the examined interval. In addition, a suspected 12-year periodicity in stronger returns found earlier in the 20th century appeared to have been partly confirmed. That suggested better returns in the 2008–2010 interval, falling thereafter towards 2014–2016, so perhaps with ZHRs of about 25 this year. The recent strong returns seem to have had a separate resonant cause, though nothing further is anticipated for 2012. The Orionids often provide several lesser maxima, helping activity sometimes remain roughly constant for several consecutive nights centred on the main peak. In 1993 and 1998, a submaximum about as strong as the normal peak was detected on October 17/18 from Europe, for instance. All observers should be aware of these possibilities, as circumstances are equally favourable for covering October 17/18 under dark skies this time too. Several visual subradiants had been reported in the past, but recent video work found the radiant to be far less complex.



Leonis Minorids (LMI)

Active: October 19–27; Maximum: October 24 ($\lambda_\odot = 211°$); ZHR = 2;
Radiant: $\alpha = 162°$, $\delta = +37°$; Radiant drift: See Table 6;
$V_\infty = 62$ km/s; $r = 3.0$;
TFC: $\alpha = 190°$, $\delta = +58°$ and $\alpha = 135°$, $\delta = +30°$ ($\beta > 40°$ N).



This weak minor shower has a peak ZHR apparently on or below the visual threshold, found so far by video only. The radiant area can be seen solely from the northern hemisphere, where it rises around midnight. The probable maximum date has a waxing gibbous Moon, but this sets by about one a.m. on October 24, so will cause little distraction for visual work. Telescopic, imaging or very careful visual plotting observations are advised.

Northern Taurids (NTA)

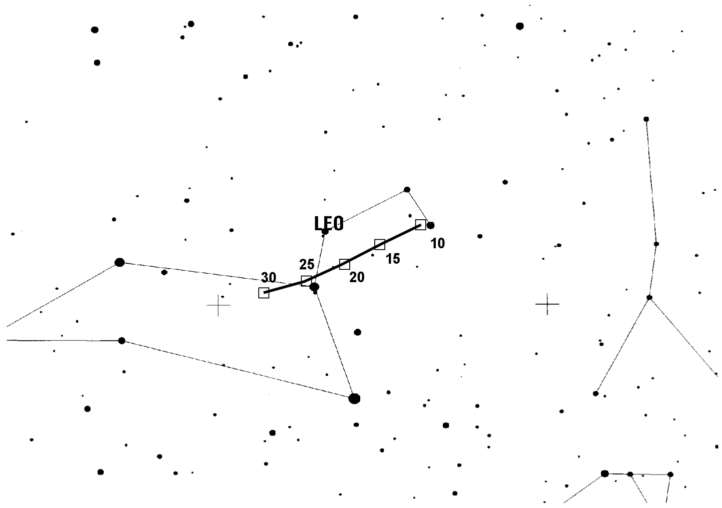
Active: October 20–December 10; Maximum: November 12 ($\lambda_\odot = 230°$); ZHR = 5;
Radiant: $\alpha = 58°$, $\delta = +22°$; Radiant drift: see Table 6;
$V_\infty = 29$ km/s; $r = 2.3$;
TFC: Choose fields on the ecliptic and $\sim 10°$ E or W of the radiant ($\beta > 40°$ S).

Some details on this branch of the Taurid streams were given with the Southern Taurids above. Other aspects are the same too, such as the large, oval radiant region to be used for shower association, the shower's excellent visibility overnight, its dominance over the ANT during September to December, and the potential for enhanced activity from the Taurids as a whole due to the predicted 'swarm' return in 2012. As previous results had suggested seemingly plateau-like maximum rates persisted for roughly ten days in early to mid November, the NTA peak may not be so sharp as its single maximum date might imply. Whatever the case, new Moon on November 13 should allow plenty of coverage.

Leonids (LEO)

Active: November 6–30; Maximum: November 17, 09^h30^m UT (nodal crossing at $\lambda_\odot = 235\overset{\circ}{.}27$), but see below; ZHR = 15?
Radiant: $\alpha = 152°$, $\delta = +22°$; Radiant drift: see Table 6;
$V_\infty = 71$ km/s; $r = 2.5$;
TFC: $\alpha = 140°$, $\delta = +35°$ and $\alpha = 129°$, $\delta = +06°$($\beta > 35°$ N);
or $\alpha = 156°$, $\delta = -03°$ and $\alpha = 129°$, $\delta = +06°$($\beta < 35°$ N).
IFC: $\alpha = 120°$, $\delta = +40°$ before 0^h local time ($\beta > 40°$ N);
$\alpha = 120°$, $\delta = +20°$ before 4^h local time and $\alpha = 160°$, $\delta = 00°$ after 4^h local time ($\beta > 00°$ N);
$\alpha = 120°$, $\delta = +10°$ before 0^h local time and $\alpha = 160°$, $\delta = -10°$($\beta < 00°$ N).

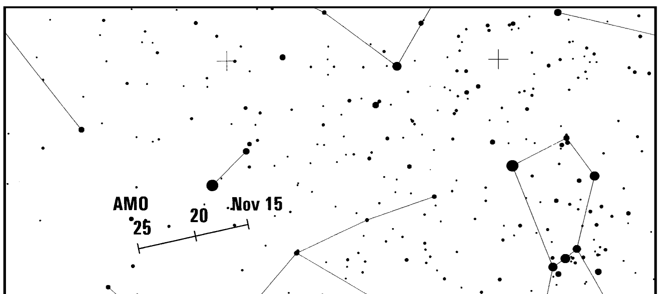
The most recent perihelion passage of the Leonids' parent comet, 55P/Tempel-Tuttle, in 1998 may be nearly 15 years ago now, but the shower's activity has continued to be fascinatingly variable from year to year recently. This year seems unlikely to produce enhanced rates, but there may be more than one peak. Apart from the nodal timing above, Mikhail Maslov has suggested that there could be a peak with ZHRs of $\sim$ 5–10 at 21^h UT on November 17, followed by another increase to ZHRs of $\sim$ 10–15, probably of below-average brightness meteors, on November 20, at $\sim 06^{\mathrm{h}}$ UT (the latter due to the 1400 AD dust-trail).



ZHRs for the nodal peak are liable to be 'normal', so probably about 15 ± 5. November's waxing Moon is excellent news for either date, as it will set before or soon after the time the Leonid radiant first becomes usefully-observable, by local midnight or so north of the equator, afterwards for places further south. All observing methods can be employed. While these potential maximum timings do not exclude all others, if they prove correct, the two November 17 ones would be best-detectable from North American, and Middle East to Asian longitudes respectively, while that on November 20 would be similarly available from places between eastern North America east to extreme western North African longitudes.

α–Monocerotids (AMO)

Active: November 15–25; Maximum: November 21, $09^{\mathrm{h}}55^{\mathrm{m}}$ UT ($\lambda_{\odot} = 239\overset{\circ}{.}32$);
ZHR = variable, usually ~ 5, but may produce outbursts to $\sim 400+$;
Radiant: $\alpha = 117°$, $\delta = +01°$; Radiant drift: see Table 6;
$V_{\infty} = 65$ km/s; $r = 2.4$;
TFC: $\alpha = 115°$, $\delta = +23°$ and $\alpha = 129°$, $\delta = +20°$ ($\beta > 20°$ N);
or $\alpha = 110°$, $\delta = -27°$ and $\alpha = 098°$, $\delta = +06°$ ($\beta < 20°$ N).

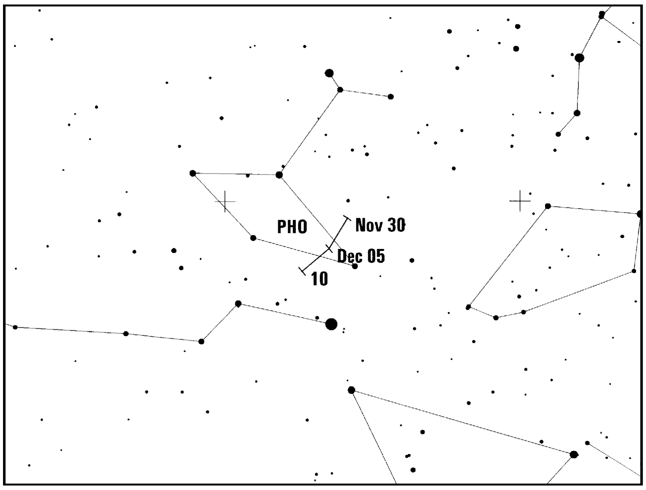


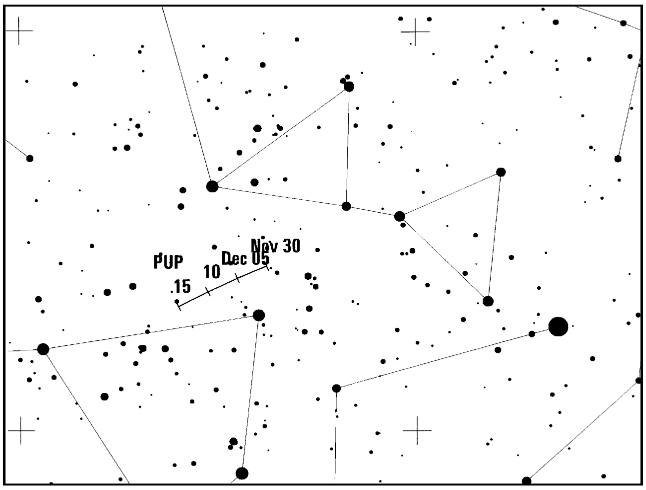
The α–Monocerotids gave their most recent brief outburst in 1995 for Europe (the top EZHR, $\sim$ 420, lasted five minutes, the entire outburst 30 minutes). Recent modelling by Esko Lyytinen has indicated the main AMO trail will not cross the Earth's orbit again until 2017 and 2020. However, the Earth will not be near those points in November, so nothing is likely to happen then. A weak return may occur in November 2019, ahead of the 2020 encounter, depending on how broad the trail may be. The next strong AMO outburst is unlikely before 2043. Despite this, observers should monitor the AMO closely in every year possible, in case of unanticipated events. The brevity of all past outbursts means breaks under clear skies should be kept to a minimum near the predicted peak. The waxing gibbous Moon causes few problems for the maximum date this year, as the shower's radiant is well on view from either hemisphere after about 23^{h} local time, with moonset around 00^{h}–01^{h} (later further north). If correct, the peak timing would fall well for sites across North America.

Phoenicids (PHO)

Active: November 28–December 9; Maximum: December 6, $03^{\mathrm{h}}45^{\mathrm{m}}$ UT ($\lambda_\odot = 254.^\circ25$);
ZHR = variable, usually none, but may reach 100;
Radiant: $\alpha = 18^\circ$, $\delta = -53^\circ$; Radiant drift: see Table 6;
$V_\infty = 18$ km/s; $r = 2.8$;
TFC: $\alpha = 040^\circ$, $\delta = -39^\circ$ and $\alpha = 065^\circ$, $\delta = -62^\circ$ ($\beta < 10^\circ$ N).

Only one impressive Phoenicid return has been reported so far, that of its discovery in 1956, when the EZHR was probably ~ 100, possibly with several peaks spread over a few hours. Three other potential, if uncertain, bursts of lower activity have been claimed. Reliable IMO data has shown recent activity to have been virtually nonexistent. This may be a periodic shower however, and more observations of it are needed by all methods. From the southern hemisphere (only), the Phoenicid radiant culminates at dusk, remaining well on view for most of the night. Last quarter Moon rises soon after midnight, leaving the first half of the night with dark skies for observers on December 6. As the predicted possible 2011 return was still to come when this was written, any activity then may help refine the shower's parameters given here. No predictions of activity are in-force for 2012. Phoenicids are extremely slow meteors.





Puppid-Velids (PUP)

Active: December 1–15; Maximum: December ~ 6 ($\lambda_\odot \sim 255^\circ$); ZHR ~ 10;
Radiant: $\alpha = 123^\circ$, $\delta = -45^\circ$; Radiant drift: see Table 6;
$V_\infty = 40$ km/s; $r = 2.9$;
TFC: $\alpha = 090^\circ$ to 150°, $\delta = -20^\circ$ to -60°;
choose pairs of fields separated by about 30° in α, moving eastwards as the shower progresses ($\beta < 10^\circ$ N).

This is a complex system of poorly-studied showers, visible chiefly to those south of the equator. Up to ten sub-streams have been proposed, with radiants so tightly clustered, visual observing cannot readily separate them. Imaging or telescopic work would thus be sensible, or very careful visual plotting. The activity is poorly-established, though the higher rates seem to occur in early to mid December, with a waning to new Moon this year. Some PUP activity may be visible from late October to late January, however.Most PUP meteors are quite faint, but occasional bright fireballs, notably around the suggested maximum, have been reported previously. The radiant area is on-view all night, but is highest towards dawn.

Monocerotids (MON)

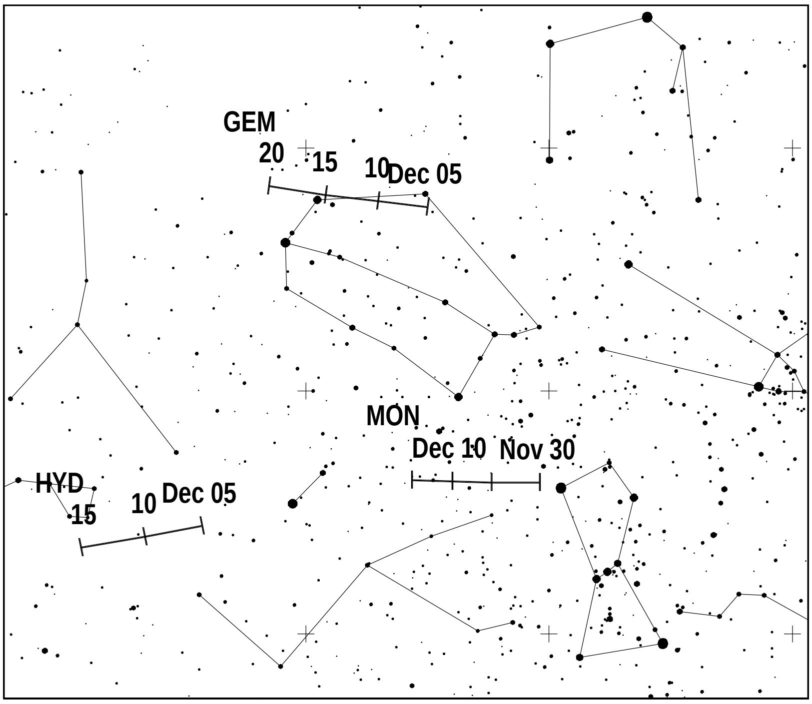
Active: November 27–December 17; Maximum: December 8 ($\lambda_\odot = 257°$); ZHR = 2; Radiant: $\alpha = 100°$, $\delta = +08°$; Radiant drift: see Table 6;
$V_\infty = 42$ km/s; $r = 3.0$;
TFC: $\alpha = 088°$, $\delta = +20°$ and $\alpha = 135°$, $\delta = +48°$ ($\beta > 40°$ N);
or $\alpha = 120°$, $\delta = -03°$ and $\alpha = 084°$, $\delta = +10°$ ($\beta < 40°$ N).

This very minor shower's details, including its radiant position, are rather uncertain. Telescopic results have suggested a later maximum, around $\lambda_\odot \sim 264°$ (December 15), from a radiant at $\alpha = 117°$, $\delta = +20°$, for instance. December's waning crescent Moon leaves plenty of dark-sky observing time for checking on the shower, as the radiant area is available virtually all night for much of the globe, culminating at about $1^{\rm h}30^{\rm m}$ local time.

σ-Hydrids (HYD)

Active: December 3–15; Maximum: December 11 ($\lambda_\odot = 260°$); ZHR = 3;
Radiant: $\alpha = 127°$, $\delta = +02°$; Radiant drift: see Table 6;
$V_\infty = 58$ km/s; $r = 3.0$;
TFC: $\alpha = 095°$, $\delta = 00°$ and $\alpha = 160°$, $\delta = 00°$ (all sites, after midnight only).

Although first detected in the 1960s by photography, σ-Hydrids are typically swift and faint, and rates are generally close to the visual-detection threshold. The radiant rises in the late evening hours, but is best viewed after local midnight from either hemisphere. This is a good year for them, with a nearly-new Moon on December 11. Recent IMO visual data (HMO p. 170) indicated the maximum might happen nearer $\lambda_\odot \sim 262°$ (December 13), while VID implied a peak closer to $\lambda_\odot \sim 254°$ (December 6), and that HYD activity might persist till December 24.



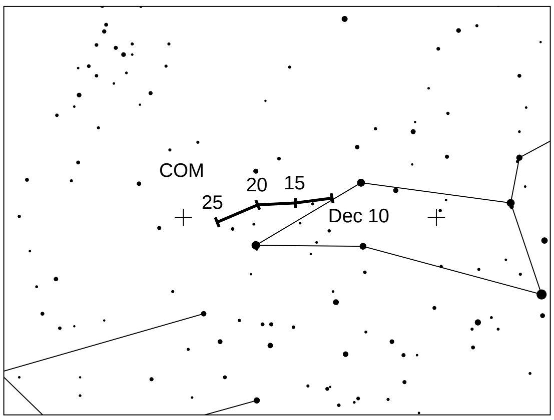
Geminids (GEM)

Active: December 4–17; Maximum: December 13, $23^{\rm h}30^{\rm m}$ UT ($\lambda_\odot = 262\overset{\circ}{.}2$); ZHR = 120;
Radiant: $\alpha = 112°$, $\delta = +33°$; Radiant drift: see Table 6;
$V_\infty = 35$ km/s; $r = 2.6$;
TFC: $\alpha = 087°$, $\delta = +20°$ and $\alpha = 135°$, $\delta = +49°$ before $23^{\rm h}$ local time,
$\alpha = 087°$, $\delta = +20°$ and $\alpha = 129°$, $\delta = +20°$ after $23^{\rm h}$ local time ($\beta > 40°$ N);
$\alpha = 120°$, $\delta = -03°$ and $\alpha = 084°$, $\delta = +10°$($\beta < 40°$ N).
IFC: $\alpha = 150°$, $\delta = +20°$ and $\alpha = 060°$, $\delta = +40°$($\beta > 20°$ N);
$\alpha = 135°$, $\delta = -05°$ and $\alpha = 080°$, $\delta = 00°$($\beta < 20°$ N).

One of the finest, and probably the most reliable, of the major annual showers presently observable, whose peak this year falls perfectly for new Moon. Well north of the equator, the radiant rises about sunset, reaching a usable elevation from the local evening hours onwards. In the southern hemisphere, the radiant appears only around local midnight or so. It culminates near $02^{\rm h}$. Even from more southerly sites, this is a splendid stream of often bright, medium-speed meteors, a rewarding event for all observers, whatever method they employ. The peak has shown slight signs of variability in its rates and timing in recent years, with the more reliably-reported maxima during the past two decades (HMO, p. 171) all having occurred within $\lambda_\odot = 261\overset{\circ}{.}5$ to $262\overset{\circ}{.}4$, 2012 December 13, $07^{\rm h}$ to December 14, $04^{\rm h}$ UT. Near-peak rates usually persist for almost a day, so much of the world has the chance to enjoy something of the Geminids' best. Some mass-sorting within the stream means fainter telescopic meteors should be most abundant almost a day ahead of the visual maximum, with telescopic results indicating such meteors radiate from an elongated region, perhaps with three sub-centres. Further results on this topic would be useful.

Comae Berenicids (COM)

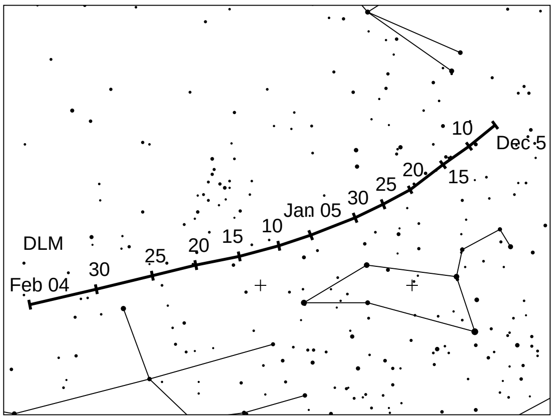
Active: December 12–23; Maximum: December 15 ($\lambda_\odot = 264°$); ZHR = 3;
Radiant: $\alpha = 175°$, $\delta = +18°$; Radiant drift: see Table 6;
$V_\infty = 65$ km/s; $r = 3.0$;
TFC: $\alpha = 180°$, $\delta = +50°$ and $\alpha = 165°$, $\delta = +20°$ before $3^{\rm h}$ local time,
$\alpha = 195°$, $\delta = +10°$ and $\alpha = 200°$, $\delta = +45°$ after $3^{\rm h}$ local time ($\beta > 20°$ N).



Years of work to resolve uncertainties have now shown this source to be weak, shorter in duration than was once thought, and with a maximum significantly earlier than previously believed. From the mid northern hemisphere, its radiant reaches a useful elevation by about one a.m. local time in mid December, culminating around $06^{\rm h}$, but it is almost unobservable from the mid southern hemisphere until near dawn. December's new Moon makes the probable peak very favourable for observing.

December Leonis Minorids (DLM)

Active: December 5–February 4; Maximum: December 19 ($\lambda_\odot = 268°$); ZHR = 5;
Radiant: $\alpha = 161°$, $\delta = +30°$; Radiant drift: see Table 6;
$V_\infty = 64$ km/s; $r = 3.0$;
TFC: $\alpha = 180°$, $\delta = +50°$ and $\alpha = 165°$, $\delta = +20°$ before 3^h local time,
$\alpha = 195°$, $\delta = +10°$ and $\alpha = 200°$, $\delta = +45°$ after 3^h local time ($\beta > 20°$ N).



Like the COM, the DLM have similarly been recently redefined. This shower too is quite weak, but is probably long-lasting, though more coverage after the Quadrantid epoch in January would be valuable. The shower is primarily a northern hemisphere target, from where its radiant can be properly observed from $\sim 23^h$ local time onwards. Almost first quarter Moon means dark skies will prevail for much of the second half of the northern midwinter maximum night.

Ursids (URS)

Active: December 17–26; Maximum: December 22, 08^h UT ($\lambda_\odot = 270.°7$), but see below;
ZHR = 10 (occasionally variable up to 50);
Radiant: $\alpha = 217°$, $\delta = +76°$; Radiant drift: see Table 6;
$V_\infty = 33$ km/s; $r = 3.0$;
TFC: $\alpha = 348°$, $\delta = +75°$ and $\alpha = 131°$, $\delta = +66°$ ($\beta > 40°$ N); $\alpha = 063°$,
$\delta = +84°$ and $\alpha = 156°$, $\delta = +64°$ (β 30° to 40° N).

A very poorly-observed northern hemisphere shower, but one which has produced at least two major outbursts in the past 70 years, in 1945 and 1986. Several lesser rate enhancements have been reported as well, most recently from 2006–2008 inclusive which were probably influenced by the relative proximity of the shower's parent comet, 8P/Tuttle, at perihelion in January 2008. Other events could have been easily missed. Jérémie Vaubaillon suggests there could be another peak this year, around 03^h01^m UT on December 22, with ZHRs of ~ 15. The Ursid radiant is circumpolar from most northern sites (thus fails to rise for most southern ones), though it culminates after daybreak, and is highest in the sky later in the night. The waxing gibbous Moon at the maximum will set by roughly two a.m. from mid northern sites, so this return is not unfavourable. The $\sim 03^h$ timing would be best-seen from European longitudes with no Moon, while the $\sim 08^h$ peak would be good for eastern North America similarly.

7 Radiant sizes and meteor plotting for visual observers

by Rainer Arlt

If you are not observing during a major-shower maximum, it is essential to associate meteors with their radiants correctly, since the total number of meteors will be small for each source. Meteor plotting allows shower association by more objective criteria after your observation than the simple imaginary back-prolongation of paths under the sky. With meteors plotted on gnomonic maps, you can trace them back to their radiants by extending their straight line paths. If a radiant lies on another chart, you should find common stars on an adjacent chart to extend this back-prolongation correctly.

How large a radiant should be assumed for shower association? The real physical radiant size is very small, but visual plotting errors cause many true shower meteors to miss this real radiant area. Thus we have to assume a larger effective radiant to allow for these errors. Unfortunately, as we enlarge the radiant, so more and more sporadic meteors will appear to line up accidentally with this region. Hence we have to apply an optimum radiant diameter to compensate for the plotting errors loss, but which will not then be swamped by sporadic meteor pollution. Table 1 gives this optimum diameter as a function of the distance of the meteor from the radiant.

Table 1. Optimum radiant diameters to be assumed for shower association of minor-shower meteors as a function of the radiant distance D of the meteor.

D	optimum diameter
15°	14°
30°	17°
50°	20°
70°	23°

Note that this radiant diameter criterion applies to all shower radiants *except* those of the Southern and Northern Taurids, and the Antihelion Source, all of which have notably larger radiant areas. The optimum $\alpha \times \delta$ size to be assumed for each radiant of the two Taurid showers is instead $20° \times 10°$, while that for the Antihelion Source is still larger, at $30° \times 15°$.

Path-direction is not the only criterion for shower association. The angular velocity of the meteor should match the expected speed of the given shower meteors according to their geocentric velocities. Angular velocity estimates should be made in degrees per second (°/s). To do this, make the meteors you see move for one second in your imagination at the speed you saw them. The path length of this imaginary meteor is the angular velocity in °/s. Note that typical speeds are in the range 3°/s to 25°/s. Typical errors for such estimates are given in Table 2.

Table 2. Error limits for the angular velocity.

angular velocity [°/s]	5	10	15	20	30
permitted error [°/s]	3	5	6	7	8

If you find a meteor in your plots which passes the radiant within the diameter given by Table 1, check its angular velocity. Table 3 gives the angular speeds for a few geocentric velocities, which can then be looked up in Table 5 for each shower.

Table 3. Angular velocities as a function of the radiant distance of the meteor (D) and the elevation of the meteor above the horizon (h) for three different geocentric velocities (V_∞). All velocities are in °/s.

$h \backslash D$	$V_\infty = 25$ km/s					$V_\infty = 40$ km/s					$V_\infty = 60$ km/ s				
	10°	20°	40°	60°	90°	10°	20°	40°	60°	90°	10°	20°	40°	60°	90°
10°	0.4	0.9	1.6	2.2	2.5	0.7	1.4	2.6	3.5	4.0	0.9	1.8	3.7	4.6	5.3
20°	0.9	1.7	3.2	4.3	4.9	1.4	2.7	5.0	6.8	7.9	1.8	3.5	6.7	9.0	10
40°	1.6	3.2	5.9	8.0	9.3	2.6	5.0	9.5	13	15	3.7	6.7	13	17	20
60°	2.2	4.3	8.0	11	13	3.5	6.8	13	17	20	4.6	9.0	17	23	26
90°	2.5	4.9	9.3	13	14	4.0	7.9	15	20	23	5.3	10	20	26	30

8 Abbreviations

- α, δ: Coordinates for a shower's radiant position, usually at maximum. α is right ascension, δ is declination. Radiants drift across the sky each day due to the Earth's own orbital motion around the Sun, and this must be allowed for using the details in Table 6 for nights away from the listed shower maxima.

- r: The population index, a term computed from each shower's meteor magnitude distribution. $r = 2.0$–2.5 is brighter than average, while r above 3.0 is fainter than average.

- $\lambda_\odot$: Solar longitude, a precise measure of the Earth's position on its orbit which is not dependent on the vagaries of the calendar. All $\lambda_\odot$ are given for the equinox 2000.0.

- V_∞: Atmospheric or apparent meteoric velocity, given in km/s. Velocities range from about 11 km/s (very slow) to 72 km/s (very fast). 40 km/s is roughly medium speed.

- ZHR: Zenithal Hourly Rate, a calculated maximum number of meteors an ideal observer would see in perfectly clear skies with the shower radiant overhead. This figure is given in terms of meteors per hour. Where meteor activity persisted at a high level for less than an hour, or where observing circumstances were very poor, an estimated ZHR (EZHR) is used, which is less accurate than the normal ZHR.

- TFC and IFC: Suggested telescopic and still-imaging (including photographic) field centres respectively. β is the observer's latitude ('$<$' means 'south of' and '$>$' means 'north of'). *Pairs* of telescopic fields must be observed, alternating about every half hour, so that the positions of radiants can be defined. The exact choice of TFC or IFC depends on the observer's location and the elevation of the radiant. Note that the TFCs are also useful centres to use for video camera fields as well.

Table 4. Lunar phases for 2012.

New Moon	First Quarter	Full Moon	Last Quarter
	January 1	January 9	January 16
January 23	January 31	February 7	February 14
Fabruary 21	March 1	March 8	March 15
March 22	March 30	April 6	April 13
April 21	April 29	May 6	May 12
May 21	May 28	June 4	June 11
June 19	June 27	July 3	July 11
July 19	July 26	August 2	August 9
August 17	August 24	August 31	September 8
September 16	September 22	September 30	October 8
October 15	October 22	October 29	November 7
November 13	November 20	November 28	December 6
December 13	December 20	December 28	

Table 5. Working List of Visual Meteor Showers. Details in this Table were correct according to the best information available in May 2011, with maximum dates accurate only for 2012. Except for the Antihelion Source, all other showers are listed in order of their maximum solar longitude. An asterisk ('*') in the 'Shower' column indicates that source may have additional peak times, as noted in the text above. The parenthesized maximum date for the Puppids-Velids indicates a reference date for the radiant only, not necessarily a true maximum. Some showers have ZHRs that vary from year to year. The most recent reliable figure is given here, except for possibly periodic showers. These are either are noted as 'Var' = variable, where there is considerable uncertainty over the likely maximum rates, or with an asterisk to indicate the value is that suggested from theoretical considerations for the current year. For more information, contact the IMO's Visual Commission.

Shower	Activity	Maximum Date	Maximum $\lambda_\odot$	Radiant α	Radiant δ	V_∞ km/s	r	ZHR
Antihelion Source (ANT)	Dec 10–Sep 10 –	March–April, late May, late June		see Table 6		30	3.0	4
Quadrantids (QUA)	Dec 28–Jan 12	Jan 04	283°.16	230°	+49°	41	2.1	120
α-Centaurids (ACE)	Jan 28–Feb 21	Feb 08	319°.2	210°	−59°	56	2.0	6
γ-Normids (GNO)	Feb 25–Mar 22	Mar 14	354°	239°	−50°	56	2.4	6
Lyrids (LYR)	Apr 16–Apr 25	Apr 22	32°.32	271°	+34°	49	2.1	18
π-Puppids (PPU)	Apr 15–Apr 28	Apr 23	33°.5	110°	−45°	18	2.0	Var
η-Aquariids (ETA)	Apr 19–May 28	May 05	45°.5	338°	−01°	66	2.4	65*
η-Lyrids (ELY)	May 03–May 14	May 08	48°.0	287°	+44°	43	3.0	3
June Bootids (JBO)	Jun 22–Jul 02	Jun 27	95°.7	224°	+48°	18	2.2	Var
Piscis Austrinids (PAU)	Jul 15–Aug 10	Jul 27	125°	341°	−30°	35	3.2	5
South. δ-Aquariids (SDA)	Jul 12–Aug 23	Jul 29	127°	340°	−16°	41	3.2	16
α-Capricornids (CAP)	Jul 03–Aug 15	Jul 29	127°	307°	−10°	23	2.5	5
Perseids (PER)	Jul 17–Aug 24	Aug 12	140°.0	48°	+58°	59	2.2	100
κ-Cygnids (KCG)	Aug 03–Aug 25	Aug 17	145°	286°	+59°	25	3.0	3
Aurigids (AUR)	Aug 28–Sep 05	Aug 31	158°.6	91°	+39°	66	2.5	6
Sept. ε-Perseids (SPE)	Sep 05–Sep 21	Sep 09	166°.7	48°	+40°	64	3.0	5
Draconids (DRA)	Oct 06–Oct 10	Oct 08	195°.4	262°	+54°	20	2.6	Var
Southern Taurids (STA)*	Sep 10–Nov 20	Oct 10	197°	32°	+09°	27	2.3	5
δ-Aurigids (DAU)	Oct 10–Oct 18	Oct 11	198°	84°	+44°	64	3.0	2
ε-Geminids (EGE)	Oct 14–Oct 27	Oct 18	205°	102°	+27°	70	3.0	3
Orionids (ORI)	Oct 02–Nov 07	Oct 21	208°	95°	+16°	66	2.5	25*
Leonis Minorids (LMI)	Oct 19–Oct 27	Oct 24	211°	162°	+37°	62	3.0	2
Northern Taurids (NTA)*	Oct 20–Dec 10	Nov 12	230°	58°	+22°	29	2.3	5
Leonids (LEO)*	Nov 06–Nov 30	Nov 17	235°.27	152°	+22°	71	2.5	15*
α-Monocerotids (AMO)	Nov 15–Nov 25	Nov 21	239°.32	117°	+01°	65	2.4	Var
Phoenicids (PHO)	Nov 28–Dec 09	Dec 06	254°.25	18°	−53°	18	2.8	Var
Puppid/Velids (PUP)	Dec 01–Dec 15	(Dec 06)	(255°)	123°	−45°	40	2.9	10
Monocerotids (MON)	Nov 27–Dec 17	Dec 08	257°	100°	+08°	42	3.0	2
σ-Hydrids (HYD)	Dec 03–Dec 15	Dec 11	260°	127°	+02°	58	3.0	3
Geminids (GEM)	Dec 04–Dec 17	Dec 13	262°.2	112°	+33°	35	2.6	120
Comae Berenicids (COM)	Dec 12–Dec 23	Dec 15	264°	175°	+18°	65	3.0	3
Dec. Leonis Minorids (DLM)	Dec 05–Feb 04	Dec 19	268°	161°	+30°	64	3.0	5
Ursids (URS)	Dec 17–Dec 26	Dec 22	270°.7	217°	+76°	33	3.0	10

Table 6 (next page). Radiant positions during the year in α and δ.

Date	ANT		QUA		DLM									
Jan 0	112°	+21°	228°	+50°	172°	+25°								
Jan 5	117°	+20°	231°	+49°	176°	+23°								
Jan 10	122°	+19°	234°	+48°	180°	+21°								
Jan 15	127°	+17°			185°	+19°								
Jan 20	132°	+16°			189°	+17°								
Jan 25	138°	+15°			193°	+15°	**ACE**							
Jan 30	143°	+13°			198°	+12°	200°	−57°						
Feb 5	149°	+11°			203°	+10°	208°	−59°						
Feb 10	154°	+9°					214°	−60°						
Feb 15	159°	+7°					220°	−62°						
Feb 20	164°	+5°	**GNO**				225°	−63°						
Feb 28	172°	+2°	225°	-51°										
Mar 5	177°	0°	230°	-50°										
Mar 10	182°	−2°	235°	-50°										
Mar 15	187°	−4°	240°	-50°										
Mar 20	192°	−6°	245°	-49°										
Mar 25	197°	−7°												
Mar 30	202°	−9°												
Apr 5	208°	−11°												
Apr 10	213°	−13°	**LYR**		**PPU**									
Apr 15	218°	−15°	263°	+34°	106°	−44°	**ETA**							
Apr 20	222°	−16°	269°	+34°	109°	−45°	323°	−7°						
Apr 25	227°	−18°	274°	+34°	111°	−45°	328°	−5°						
Apr 30	232°	−19°					332°	−3°	**ELY**					
May 05	237°	−20°					337°	−1°	283°	+44°				
May 10	242°	−21°					341°	+1°	288°	+44°				
May 15	247°	−22°					345°	+3°	293°	+45°				
May 20	252°	−22°					349°	+5°						
May 25	256°	−23°					353°	+7°						
May 30	262°	−23°												
Jun 5	267°	−23°												
Jun 10	272°	−23°												
Jun 15	276°	−23°												
Jun 20	281°	−23°	**JBO**											
Jun 25	286°	−22°	223°	+48°										
Jun 30	291°	−21°	225°	+47°	**CAP**									
Jul 5	296°	−20°			285°	−16°	**SDA**							
Jul 10	300°	−19°	**PER**		289°	−15°	325°	−19°	**PAU**					
Jul 15	305°	−18°	6°	+50°	294°	−14°	329°	−19°	330°	−34				
Jul 20	310°	−17°	11°	+52°	299°	−12°	333°	−18°	334°	−33				
Jul 25	315°	−15°	22°	+53°	303°	−11°	337°	−17°	338°	−31				
Jul 30	319°	−14°	29°	+54°	307°	−10°	340°	−16°	343°	−29	**KCG**			
Aug 5	325°	−12°	37°	+56°	313°	−8°	345°	−14°	348°	−27	283°	+58°		
Aug 10	330°	−10°	45°	+57°	318°	−6°	349°	−13°	352°	−26	284°	+58°		
Aug 15	335°	−8°	51°	+58°			352°	−12°			285°	+59°		
Aug 20	340°	−7°	57°	+58°	**AUR**		356°	−11°			286°	+59°		
Aug 25	344°	−5°	63°	+58°	85°	+40°					288°	+60°		
Aug 30	349°	−3°			90°	+39°	**SPE**				289°	+60°		
Sep 5	355°	−1°	**STA**		96°	+39°	43°	+40°						
Sep 10	0°	+1°	12°	+3°	102°	+39°	48°	+40°						
Sep 15			15°	+4°			53°	+40°						
Sep 20			18°	+5°			59°	+41°						
Sep 25			21°	+6°										
Sep 30			25°	+7°			**ORI**							
Oct 5			28°	+8°			85°	+14°	**DAU**				**DRA**	
Oct 10	**EGE**		32°	+9°			88°	+15°	82°	+45°			262°	+54°
Oct 15	99°	+27°	36°	+11°	**NTA**		91°	+15°	87°	+43°	**LMI**			
Oct 20	104°	+27°	40°	+12°	38°	+18°	94°	+16°	92°	+41°	158°	+39°		
Oct 25	109°	+27°	43°	+13°	43°	+19°	98°	+16°			163°	+37°		
Oct 30			47°	+14°	47°	+20°	101°	+16°			168°	+35°		
Nov 5			52°	+15°	52°	+21°	105°	+17°	**LEO**					
Nov 10			56°	+15°	56°	+22°			147°	+24°			**AMO**	
Nov 15			60°	+16°	61°	+23°			150°	+23°			112°	+2°
Nov 20			64°	+16°	65°	+24°			153°	+21°			116°	+1°
Nov 25					70°	+24°	**PHO**		156°	+20°	**PUP**		120°	0°
Nov 30	**ANT**		**GEM**		74°	+24°	14°	−52°	159°	+19°	120°	−45°	91°	+8°
Dec 5	85°	+23°	103°	+33°	149°	+37°	18°	−53°	122°	+3°	122°	−45°	96°	+8°
Dec 10	90°	+23°	108°	+33°	153°	+35°	22°	−53°	126°	+2°	125°	−45°	100°	+8°
Dec 15	96°	+23°	113°	+33°	157°	+33°	174°	+19°	130°	+1°	128°	−45°	104°	+8°
Dec 20	101°	+23°	118°	+32°	161°	+31°	177°	+18°	**HYD**		217°	+76°	**MON**	
Dec 25	106°	+22°	**QUA**		166°	+28°	180°	+16°			217°	+74°		
Dec 30	111°	+21°	226°	+50°	170°	+26°	**COM**				**URS**			
					DLM									

Table 7. Working List of Daytime Radio Meteor Showers. An asterisk ('*') in the 'Max date' column indicates that source may have additional peak times, as noted in the text above. The 'Best Observed' columns give the approximate local mean times between which a four-element antenna at an elevation of 45° receiving a signal from a 30 kW transmitter 1000 km away should record at least 85% of any suitably positioned radio-reflecting meteor trails for the appropriate latitudes. Note that this is often heavily dependent on the compass direction in which the antenna is pointing, however, and applies only to dates near the shower's maximum. An asterisk in the 'Rate' column shows the suggested rate may not recur in all years.

Shower	Activity	Max Date	$\lambda_\odot$ 2000	Radiant α	Radiant δ	Best observed 50° N	Best observed 35° S	Rate
Cap/Sagittariids	Jan 13–Feb 04	Feb 02*	312°.5	299°	−15°	11^h–14^h	09^h–14^h	Medium*
χ-Capricornids	Jan 29–Feb 28	Feb 14*	324°.7	315°	−24°	10^h–13^h	08^h–15^h	Low*
Piscids (Apr)	Apr 08–Apr 29	Apr 20	30°.3	7°	+07°	07^h–14^h	08^h–13^h	Low
δ-Piscids	Apr 24–Apr 24	Apr 24	34°.2	11°	+12°	07^h–14^h	08^h–13^h	Low
ε-Arietids	Apr 24–May 27	May 09	48°.7	44°	+21°	08^h–15^h	10^h–14^h	Low
Arietids (May)	May 04–Jun 06	May 16	55°.5	37°	+18°	08^h–15^h	09^h–13^h	Low
o-Cetids	May 05–Jun 02	May 20	59°.3	28°	−04°	07^h–13^h	07^h–13^h	Medium*
Arietids	May 22–Jul 02	Jun 07*	76°.7	44°	+24°	06^h–14^h	08^h–12^h	High
ζ-Perseids	May 20–Jul 05	Jun 09*	78°.6	62°	+23°	07^h–15^h	09^h–13^h	High
β-Taurids	Jun 05–Jul 17	Jun 28	96°.7	86°	+19°	08^h–15^h	09^h–13^h	Medium
γ-Leonids	Aug 14–Sep 12	Aug 25	152°.2	155°	+20°	08^h–16^h	10^h–14^h	Low*
Sextantids	Sep 09–Oct 09	Sep 27*	184°.3	152°	00°	06^h–12^h	06^h–13^h	Medium*

9 Useful addresses

For more information on observing techniques, and when submitting results, please contact the appropriate IMO Commission Director:

Fireball Data Center (FIDAC): André Knöfel, Am Observatorium 2, D-15848 Lindenberg, Germany; e-mail: `aknoefel@minorplanets.de`

Photographic Commission: Vacant. Questions can be sent to e-mail: `photo@imo.net`

Radio Commission: Jean-Louis Rault, Société Astronomique de France, 16 Rue de la Valleé, 91360 Epinay sur Orge, France; e-mail: `f6agr@orange.fr`

Telescopic Commission: Malcolm Currie, 25 Collett Way, Grove, Wantage, Oxfordshire, OX12 0NT, UK; e-mail: `mjc@star.rl.ac.uk`

Video Commission Sirko Molau, Abenstalstraße 13b, D-84072 Seysdorf, Germany; e-mail: `sirko@molau.de`

Visual Commission: Rainer Arlt, Bahnstraße 11, D-14974 Ludwigsfelde, Germany; e-mail: `rarlt@aip.de`

or contact IMO's Homepage on the World-Wide-Web at: `http://www.imo.net`

For further details on **IMO membership**, please write to: Robert Lunsford, IMO Secretary-General, 1828 Cobblecreek Street, Chula Vista, CA 91913-3917, USA; `lunro.imo.usa@cox.net`

Please try to enclose return postage when writing to any IMO officials, either in the form of stamps (same country *only*) or as an International Reply Coupon (I.R.C. – available from main postal outlets). Thank you!