Observing Solar System Objects with Herschel

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Solar System Objects in HSpot

- **What can and cannot be observed?**
  - **Only the Superior Planets can be observed.**
    - **Mars, Jupiter, Saturn, Uranus and Neptune**
  - **The satellites of these planets can be observed, if resolved**
    - **For the brightest planets, scattered light and saturation from the primary are the major problems.**
    - **Some satellites are too close in to their primary to be resolved easily**
      - **At 90 microns the spatial resolution of Herschel is 6 arcseconds.**
      - **Phobos and Deimos, Triton and several of the satellites of Uranus will difficult or impossible to resolve. Io will be challenging except at greatest elongation.**

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Solar System Objects in HSpot

- Many asteroids and NEOs can be observed.
  - Some tens of Main Belt asteroids will be used as primary calibrators for Herschel.
  - But very close-approach NEOs may be impossible to track.
- Several hundred TNOs are theoretically observable.
  - Approximately 350 are ***potentially*** detectable in at least one PACS band.
- Many comets can be observed.
  - ☑ But usually only if they are outside the Earth's orbit.
  - ☒ Bright comets with perihelion inside the Earth's orbit will, unfortunately, almost never be observable close to perihelion.

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Entering Solar System Objects

- Solar system objects offer the problem that, unlike stars, galaxies and nebulae, they move.
  - The Observation Planning System must calculate their position at the moment of observation.
  - It has to calculate a tracking rate for the moment of observation and maintain the tracking during the observation.
  - The visibility windows are complicated.
    - Objects in the ecliptic may have close encounters with bright planets that interrupt their visibility.
    - But, HSpot *does not take into account* the times when a satellite is behind its primary when calculating visibility windows!
- HSpot uses the NAIF identifier code for Solar System Objects. It does not present a sample position.

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NAIF Identifiers (NAIF ID)

- **What is the NAIF identifier?**
  - **NAIF stands for “Navigation and Ancilliary Information Facility”.**
    - **NAIF offers the SPICE information system.**
    - **This is the system used by NASA for spacecraft navigation.**

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Observation Planning

- **The Observation Planning System takes the NAIF ID and makes a series of calculations:**
  - **It calculates the X, Y, Z coordinates of the object for the date of observation.**
  - **The visibility, position and tracking rate are calculated for the position of Herschel on that date.**
  - **It checks visibility constraints for the date of observation (proximity to the Earth, Moon, planets and bright asteroids)**

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NAIF Identifiers (NAIF ID)

- **What constitutes a NAIF ID?**
  - **It is a unique 1, 3 or 7-figure identifier for each Solar System Object.**
    - **Integers from 1-9 for the barycentre of planetary systems (Mars = 4, Jupiter = 5, Saturn = 6, etc.)**
    - **Physical centres of planets are 3-figure integers**
      - **Mars = 499, Jupiter = 599, Saturn = 699, etc.**
      - **In no case is the difference between the physical and barycentre significant for Herschel.**
    - **7-digit numbers beginning with "1" for comets**
    - **7-digit numbers beginning with "2" for numbered asteroids**
    - **7-digit numbers beginning with "3" for unnumbered minor bodies.**

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Observation Planning

- **What are the problems?**
  - **Objects with a NAIF ID starting with "3" may not have an orbit of high enough quality to be observable.**
    - **Positional errors that may be of arcminutes, or in extreme cases, even degrees for some comets, asteroids and TNOs.**
      - **For PACS the maximum acceptable position error for photometry is 25 arcseconds.**
      - **For HIFI observations in the smallest aperture, a position uncertainty of even 2 arcseconds may be unacceptable.**
    - **Uncertain ephemerides = uncertain tracking rate.**

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What Solar System Objects does HSpot Support?

- There are several hundred thousand objects with a NAIF ID.
  - Many of them are not observable by Herschel.
  - At present the ephemeris for each new Solar System Object (SSO) that is added has to be processed by hand, so we have had to be selective.

What Solar System Objects does HSpot Support?

- **About 600 SSOs are currently supported by HSpot**
  - **All observable planets and their principal satellites provided that the satellite reaches an elongation of at least 15 arcseconds from the centre of the disk.**
  - **Numbered comets brighter than magnitude 13 during the expected duration of the Herschel mission.**
  - **About 50 of the brightest Main Belt asteroids**
  - **All NEOs with a close pass to within 0.15AU during the expected duration of the Herschel mission.**
  - **About 350 TNOs observable with PACS.**
  - **Additional objects can be entered on request.**

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Galactic Latitude Matters

- **Even for bright objects, the Galactic Latitude really does matter.**
- **Avoid observing even the brightest objects at Latitude <5°.**
- **Check the Horizons ephemeris carefully and stay clear - with time constraints – of low Galactic latitudes.**
- **Always use the Herschel ephemeris, not the geocentric because the parallax makes a big difference in the Asteroid Belt [put in 500@-486 to get the ephemeris from Herschel].**
- **Overlay your SSO on the IRAS 60 or 100 micron image to see the background.**

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Beat that Confusion!

- **Remember that SSOs can beat the confusion limit for Herschel if you observe the SSO and then the background where the SSO was.**
- **This observing method also removes the cirrus background effectively.**
- **However, you need to bear in mind very carefully the rate of SSO motion.**
  - **Ideally for PACS you want your two observations separated in time by just enough time for the SSO to have moved by about 4 pixels between the "on" and the "off" exposure.**

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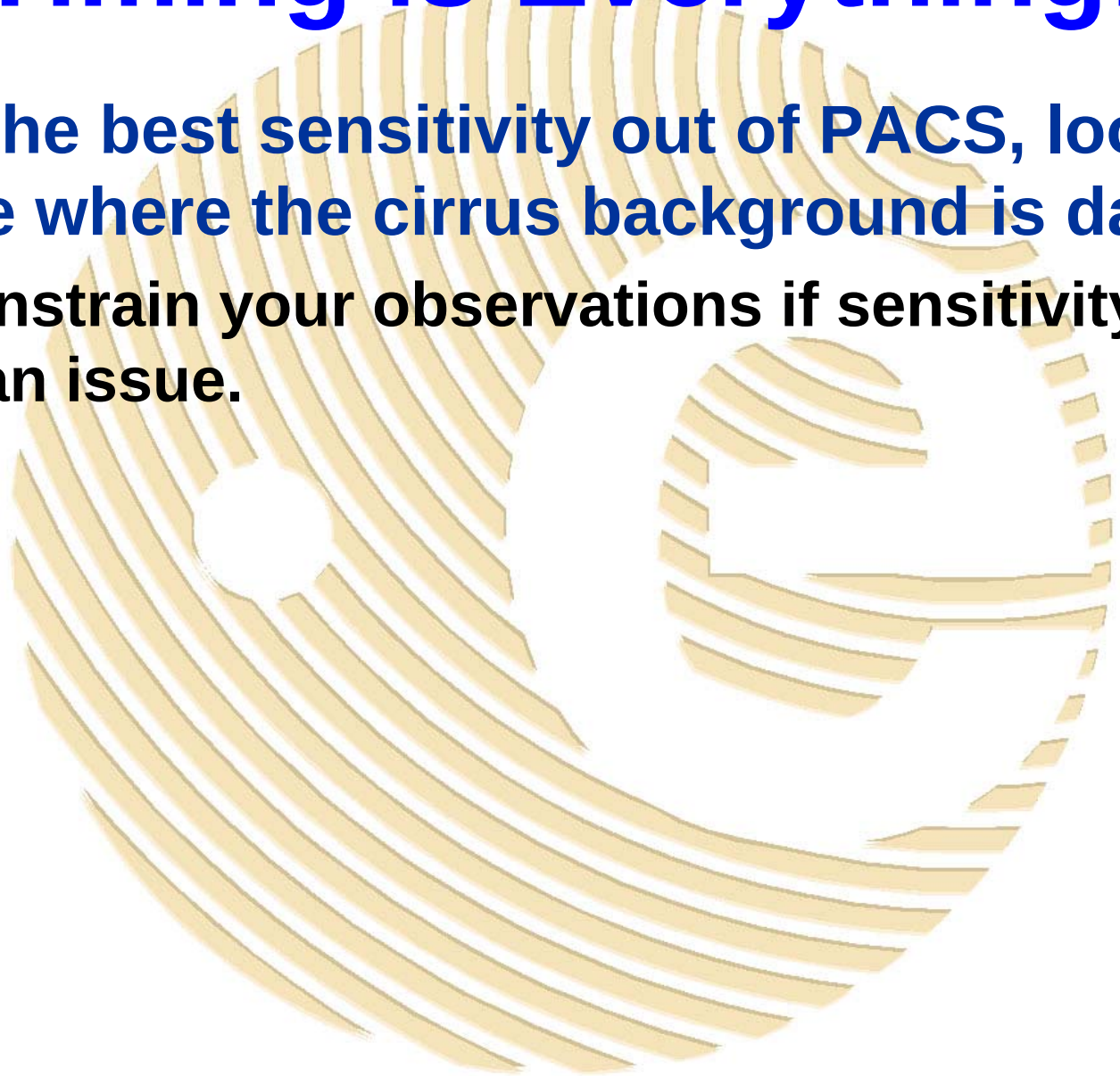
Timing is Everything!

- **To get the best sensitivity out of PACS, look to observe where the cirrus background is dark.**
- **Time constrain your observations if sensitivity and s/n are an issue.**



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