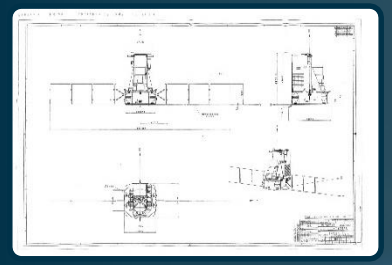
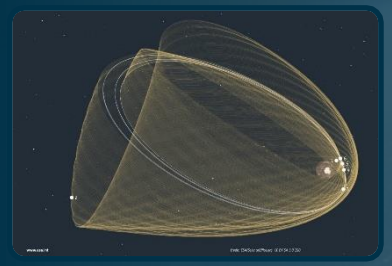




ESA-DRAMA

DEBRIS RISK ASSESSMENT AND MITIGATION ANALYSIS

MASTER

Manoeuvre **Threshold**

& Strategy

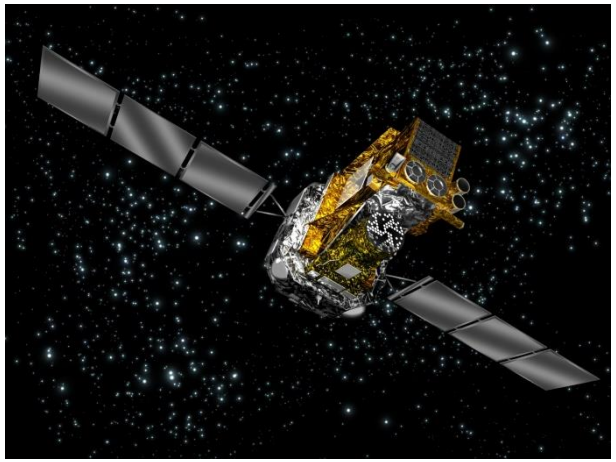
Use of MASTER and ARES for Operational Collision Avoidance Support Planning

Master Modelling Workshop 2021
March 3, 2021

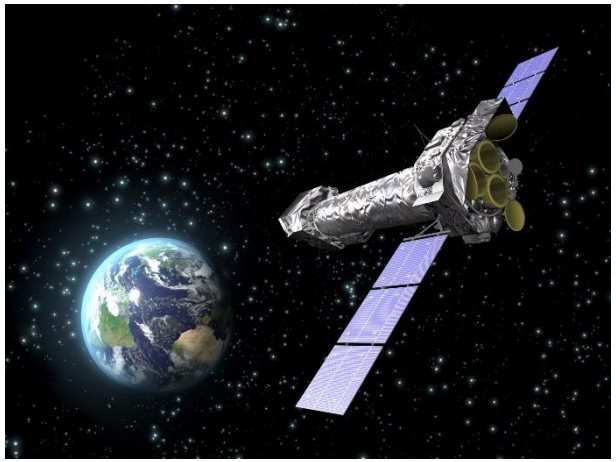
Francesca Letizia | Sven Flegel | Klaus Merz

ESA Space Debris Office

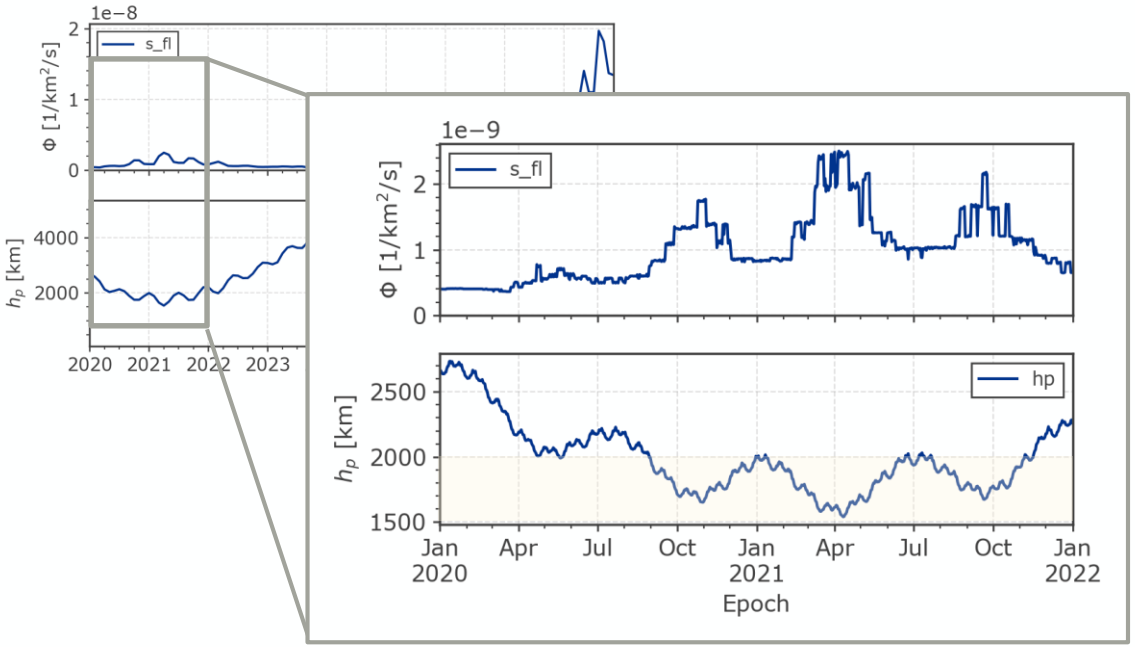
Collision Avoidance Analysis for HEO missions

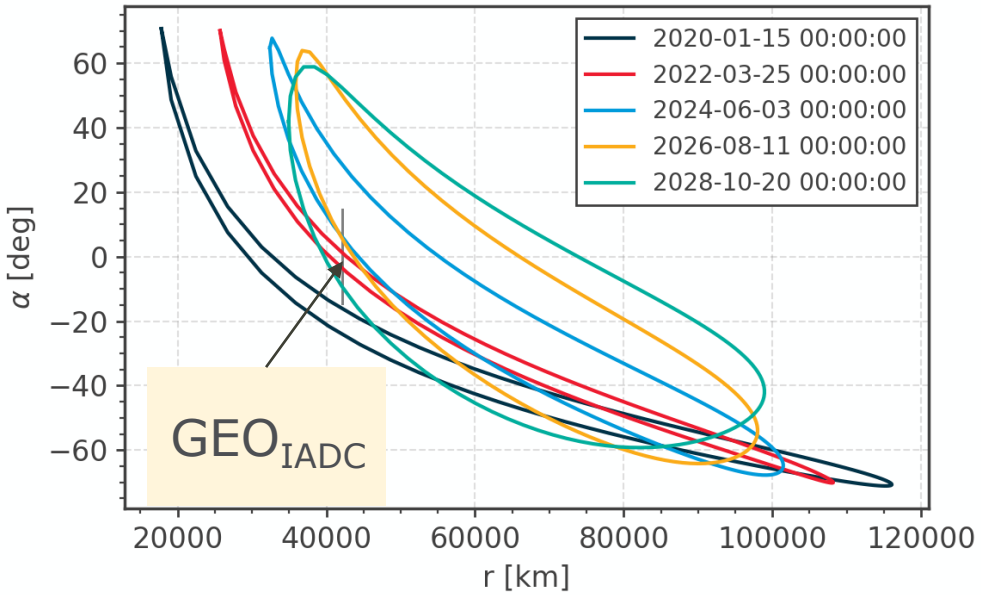


Integral
LEO crossing
Sept 2020-Nov 2021



XMM
GEO crossing
mid 2020-mid 2029

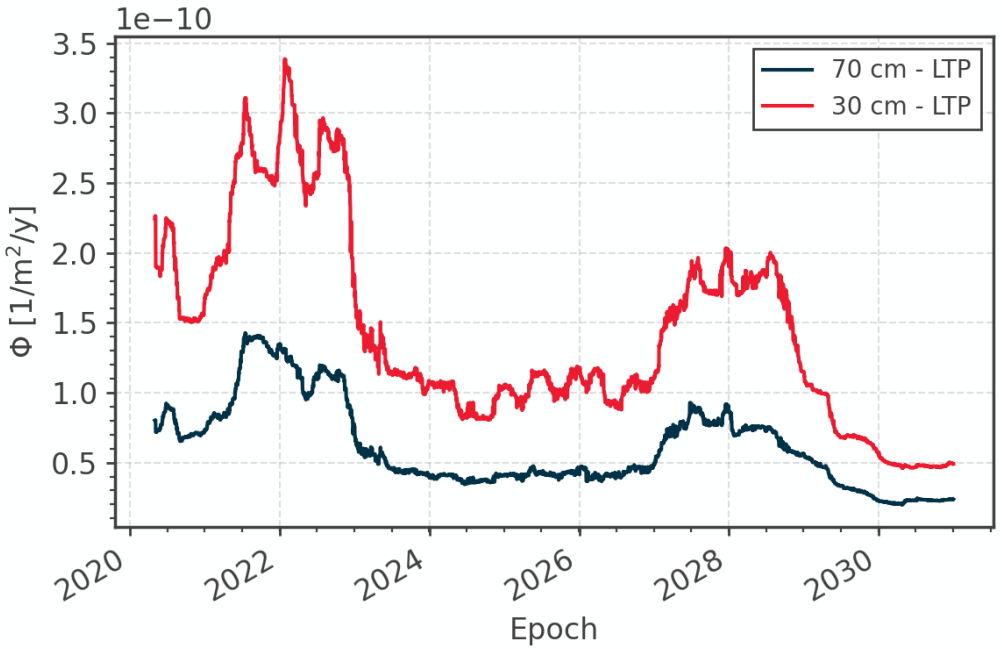


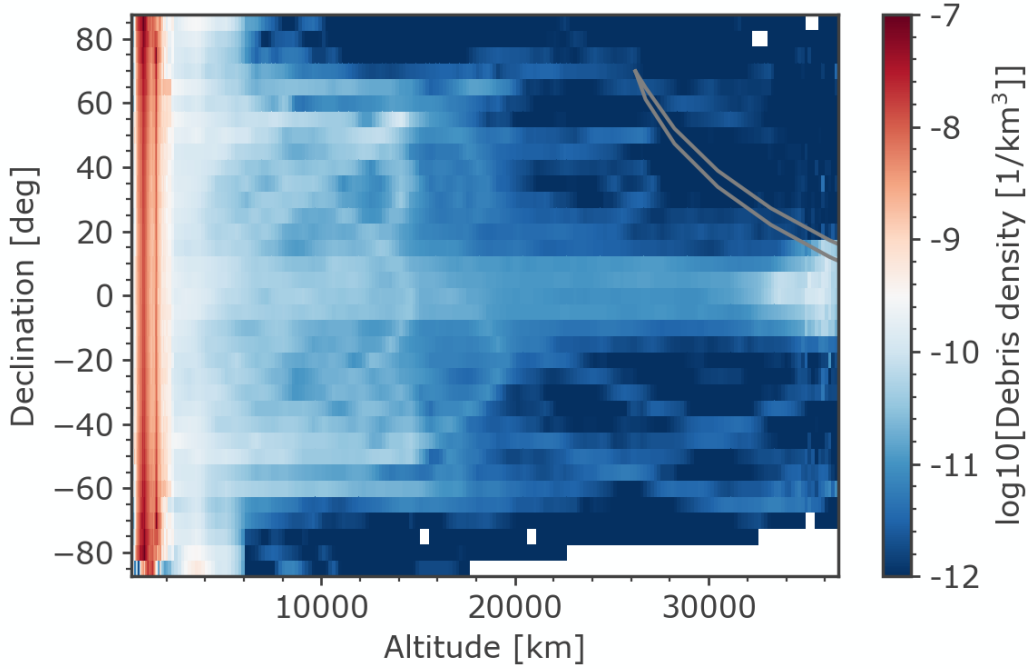


Flux analysis – Example: XMM

Python wrapper for **analysis** along given **trajectory** files
Interface to common **orbit file types** (e.g. OEM, NAPEOS files)
Output: plots + .csv file

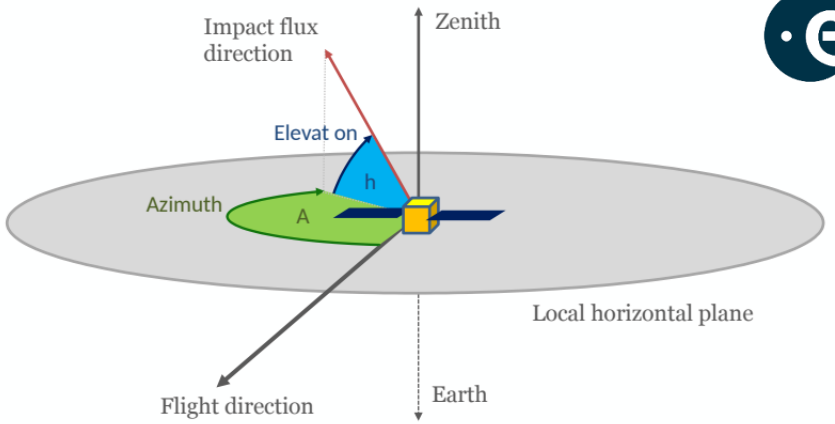
Debris flux



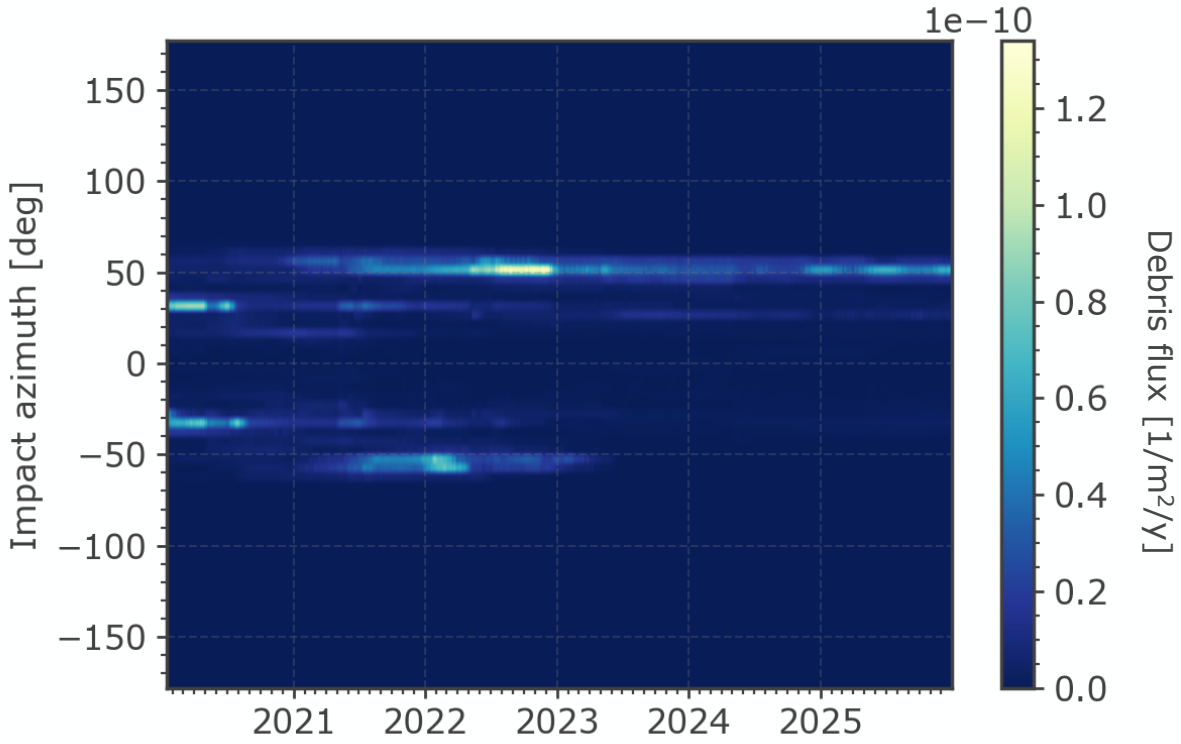


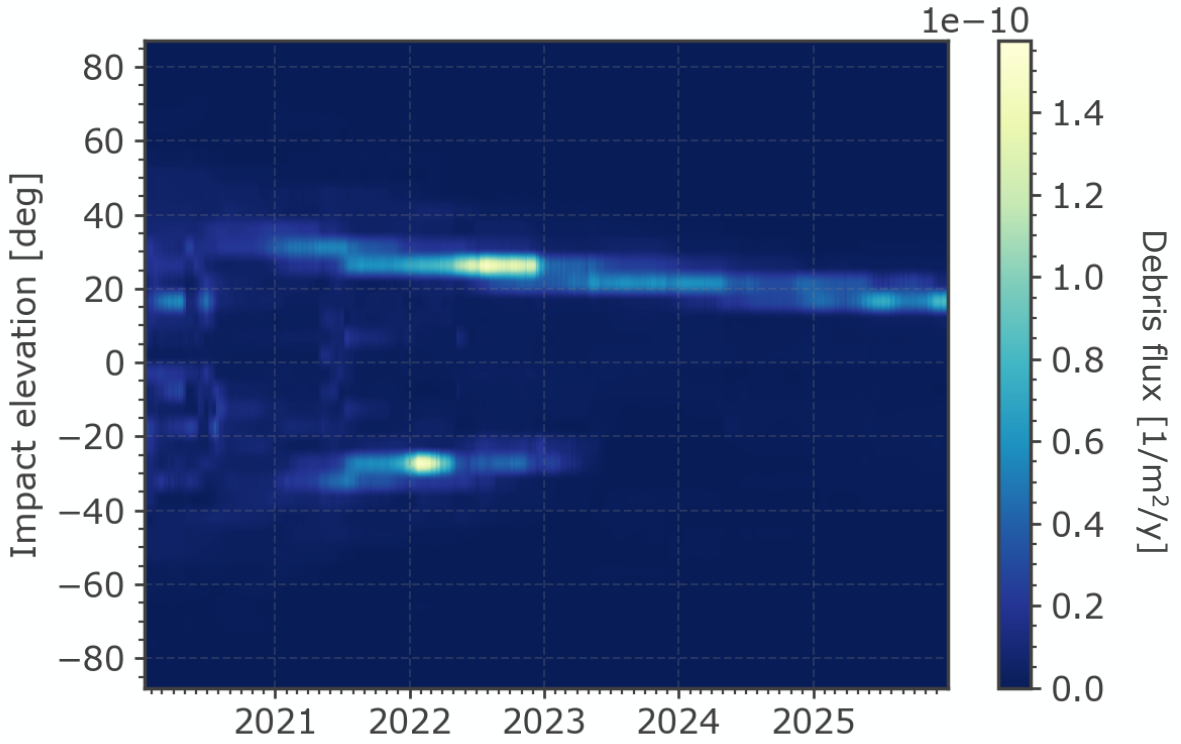
30-70 cm cut-off for detectability in GEO
LTP – Long-Term Propagation

Flux analysis – Example: XMM



Preliminary encounter **geometry** characterisation in **azimuth** and **elevation**

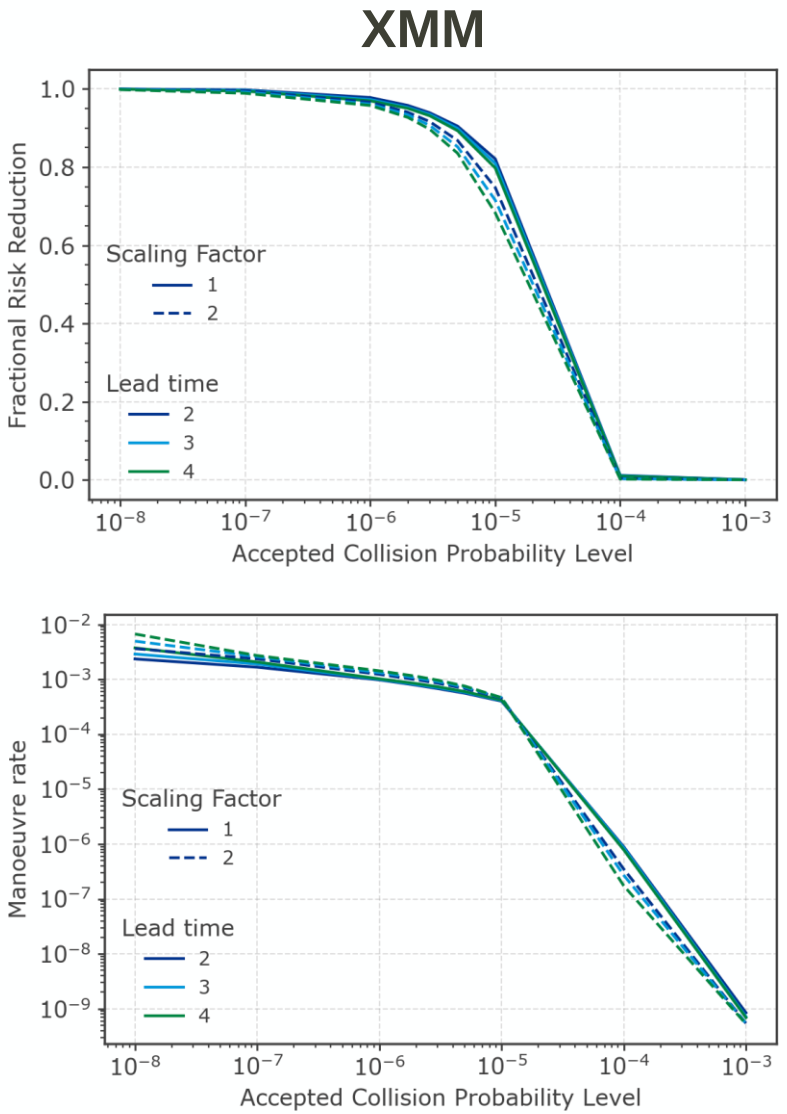




Collision probability & threshold definition

Next step: **DRAMA/ARES** analysis

- Check on the **mitigated risk** through collision avoidance at the epoch of **maximum flux**
- **Parametric** evaluation based on
  - Minimum debris size
  - Target covariance
  - Chaser covariance (i.e. scaling factor)
  - Lead time
- Definition of a suitable **reaction threshold** and determination of the corresponding **manoeuvre rate**



Realistic Close Encounters

?

If manoeuvre (CAM) necessary:

- How much $\Delta \boldsymbol{v}$?
- What kind of CAM? e.g. Hohmann
- CAM schedule (e.g. time to TCA)

!

Require:

Target & chaser
states + uncertainties
for likely close encounters

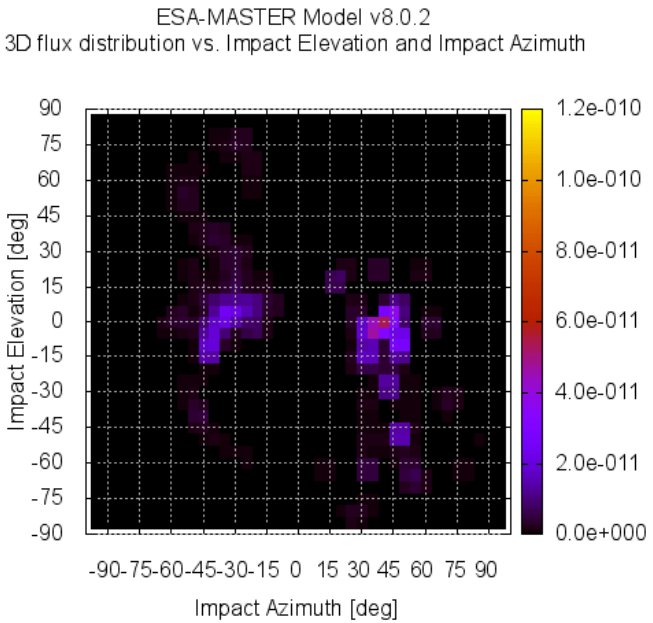
Realistic Close Encounters

- Target orbit prediction (ESA flight dynamics team)
- Chaser size threshold

→ MASTER →

heat maps

INTEGRAL



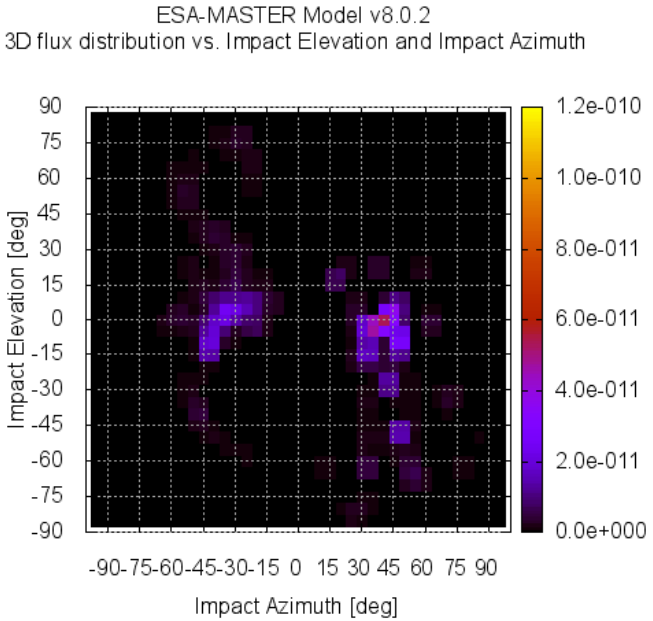
Realistic Close Encounters

- Target orbit prediction (ESA flight dynamics team)
- Chaser size threshold

→ MASTER →

heat maps

INTEGRAL



Insight from 2-d heat maps

- Likeliest impact properties

Caveat

- Need to combine multiple heat maps for full picture
- Likely target & chaser state not readily available
- Likeliest per chaser category (e.g. orbit, size) not directly accessible

Realistic Close Encounters

- Target orbit prediction (ESA flight dynamics team)
- Chaser size threshold

INTEGRAL

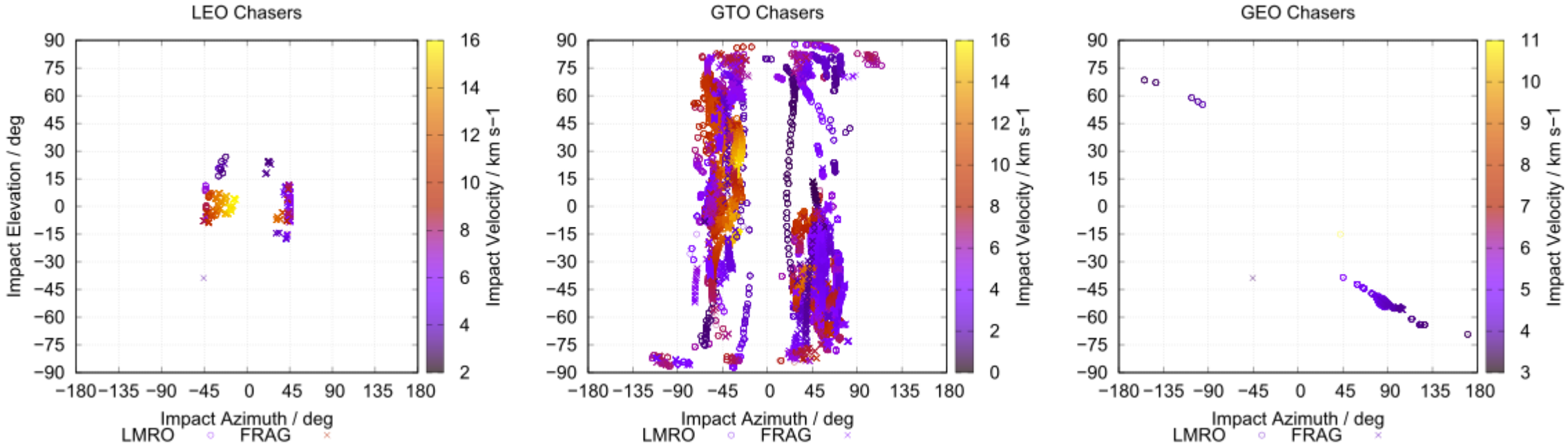
Realistic Close Encounters

- Target orbit prediction (ESA flight dynamics team)
- Chaser size threshold

→ MASTER →

cpe files → GEO chasers
cpe files → MEO chasers
cpe files → LEO chasers

INTEGRAL



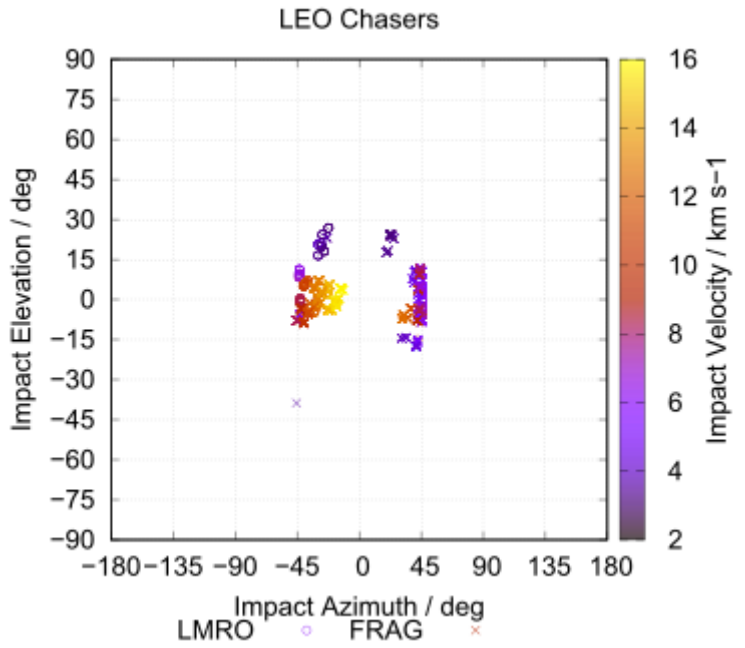
Realistic Close Encounters

- Target orbit prediction (ESA flight dynamics team)
- Chaser size threshold

→ MASTER →

cpe files → GEO chasers
cpe files → MEO chasers
cpe files → LEO chasers

INTEGRAL



Insight

- Chaser orbit (sma, inc, ecc)
- Impact angle + Δv combination
- Impact location (important for ecc > 0)

Postprocessing

➔ realistic & significant target & chaser states

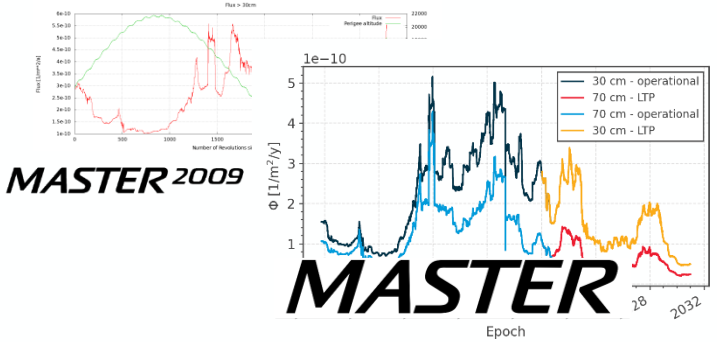
Outlook / Summary

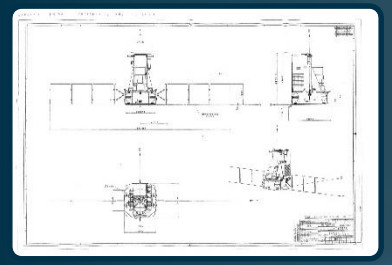
- Manual extract likeliest:
  - .. chaser per orbit (LEO/HEO/GEO)
  - .. impact location

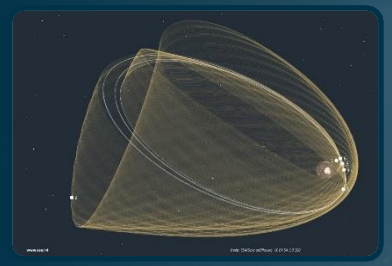
Rank	Target	Chaser

- Interfaces:
  - **Python** wrapper
  - Options to load a **pre-computed trajectory** (with standard orbit format)

- Re-assessment for long-running missions can span over multiple model versions: More visibility of the **changes** in the **reference populations**







ESA-DRAMA

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