INAF
ISTITUTO NAZIONALE DI ASTROFISICA
NATIONAL INSTITUTE FOR ASTROPHYSICS

POLITECNICO MILANO 1863

Agenzia Spaziale Italiana

HERMES

HERMES-Pathfinder

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The project has received funding from the Accordo Attuativi ASI-INAF and ASI-POLIMI

Outline

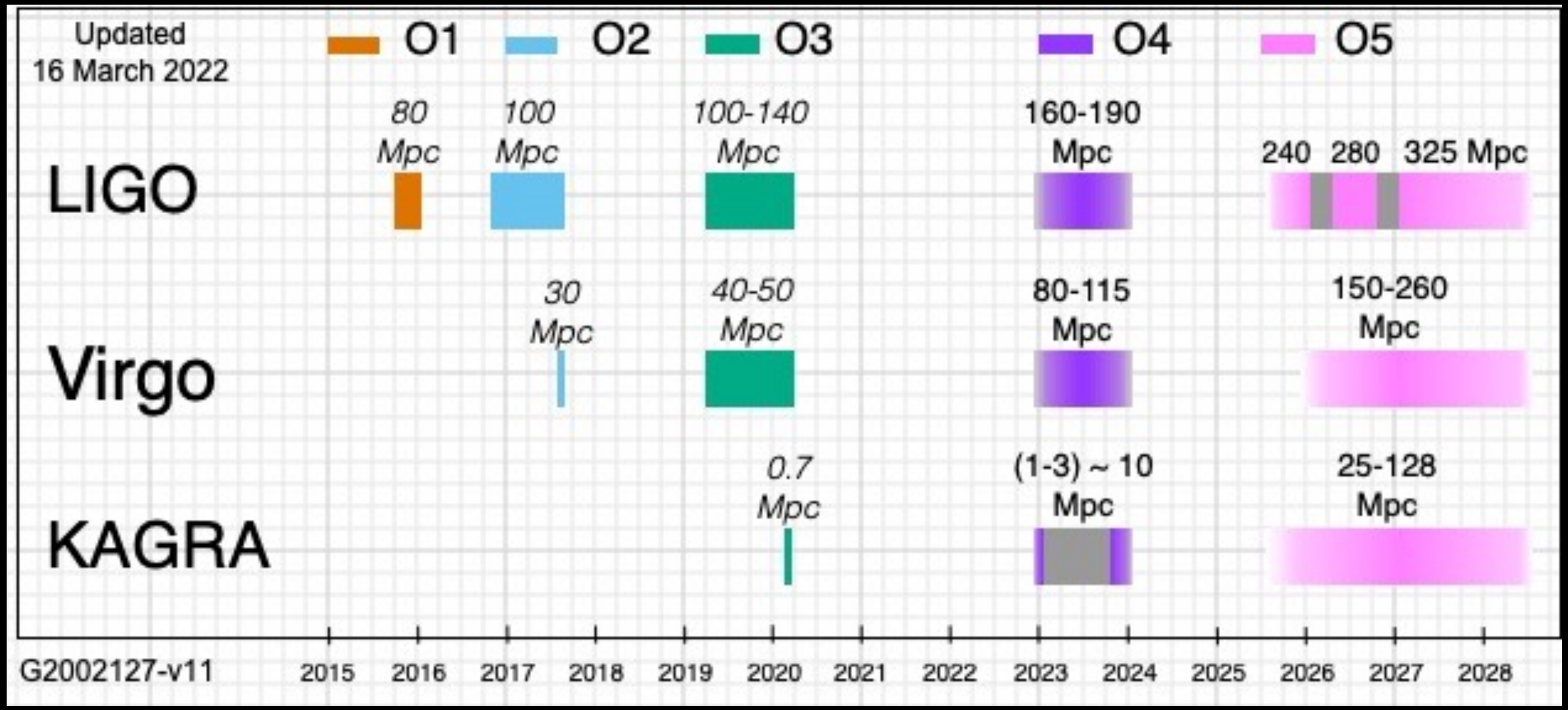
- Motivation
- Where we are
- Expected performances
- Next steps

Motivation

- Prove that ***breakthrough science*** can be done with nano-sats. ***“Smaller”*** enables the“***faster, better, cheaper***”[1] mantra, but also ***expand usership,*** increasing competition ***and*** collaborations
- ***Join the multimessenger revolution*** by providing a first mini-constellation for GRB localizations
- Develop miniaturized payload technology for breakthrough science and demonstrate COTS applicability to challenging missions, contribute to Space 4.0 goals
- Push and prepare for a high reliability, large constellation

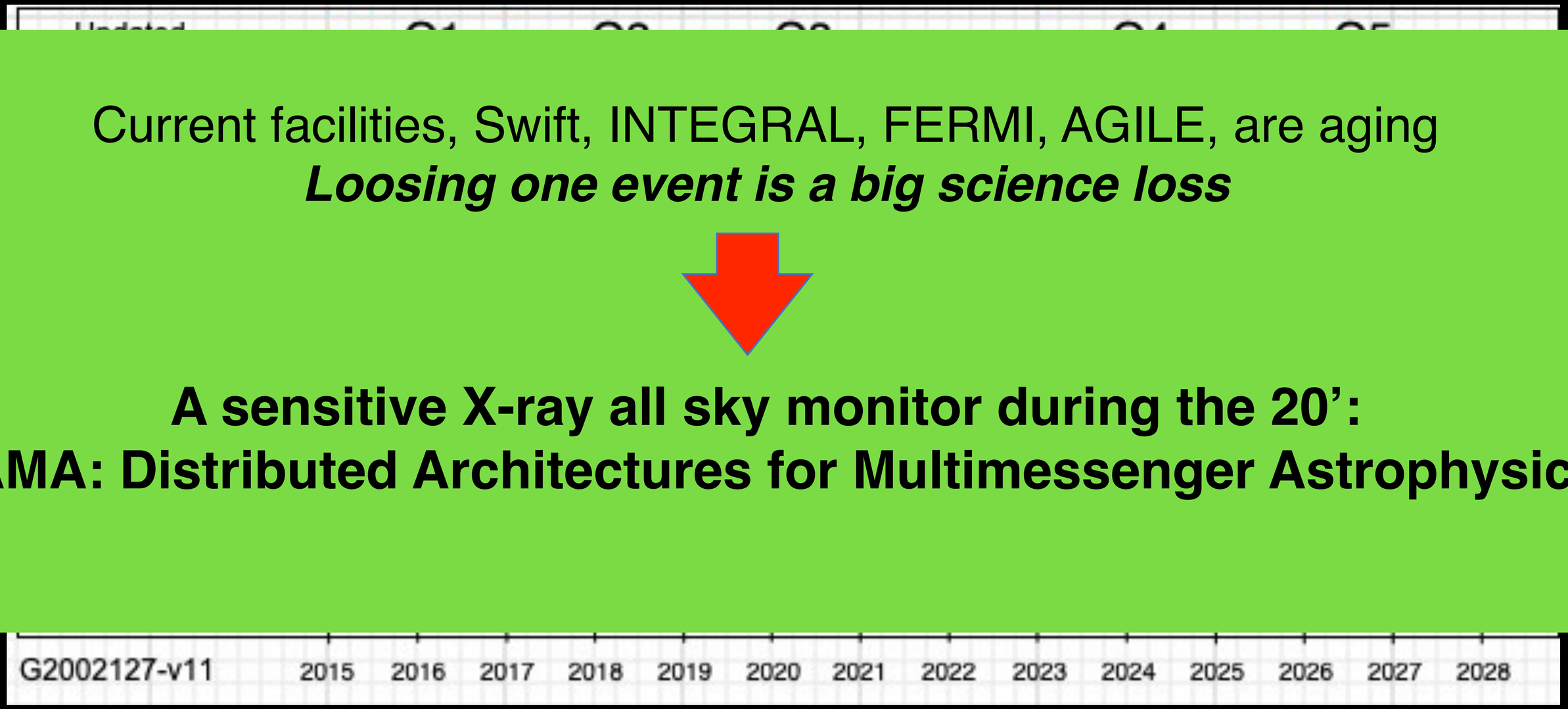
1 Dan Goldin 1992

Compact binary coalescence



HERMES PF DAMA

Compact binary coalescence



Current facilities, Swift, INTEGRAL, FERMI, AGILE, are aging

Loosing one event is a big science loss

A sensitive X-ray all sky monitor during the 20’:
DAMA: Distributed Architectures for Multimessenger Astrophysics

HERMES PF DAMA

Mission concept

Disruptive technologies: cheap, underperforming, but producing high impact.
Distributed instrument: tens/hundreds of simple units to form a sensitive ***all sky monitor***

HERMES constellation of cubesat

2016: ASI funds for detector R&D

2018: MIUR funds (Progetti premiali 2015), managed by ASI

2018 H2020 Space-SCI-20 project

2019-2022 ASI internal funds

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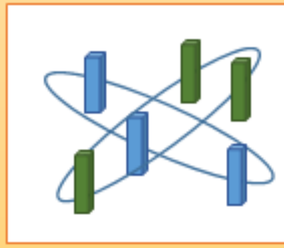
FULL CONSTELLATION

γ/X Transients

- Global Surveying
- Precise Localization
- Faint Detection
- Timely Transmission

Sci-20-2018

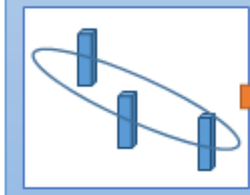


SCIENTIFIC PATHFINDER

γ/X Transients

- Precise Localization
- Faint Detection
- Timely Transmission

MIUR



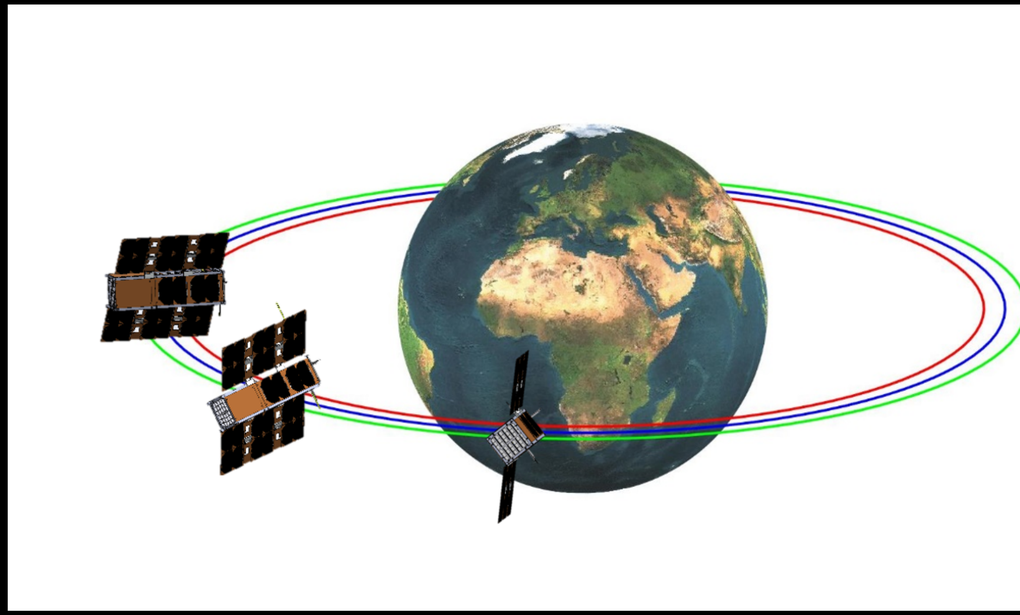
Technological Pathfinder

γ/X Transients

- Faint Detection
- Timely Transmission

HERMES-PF & SpIRIT in a nutshel

- HERMES Pathfinder: six 3U cubesat equipped with advanced X-ray/gamma/ray wide field detector. Nearly equatorial LEO.
- SpIRIT: 6U cubesat managed by University of Melbourne and funded by ASA. Host 1 HERMES-PF X-ray/gamma-ray payload + S-band system. SSO.

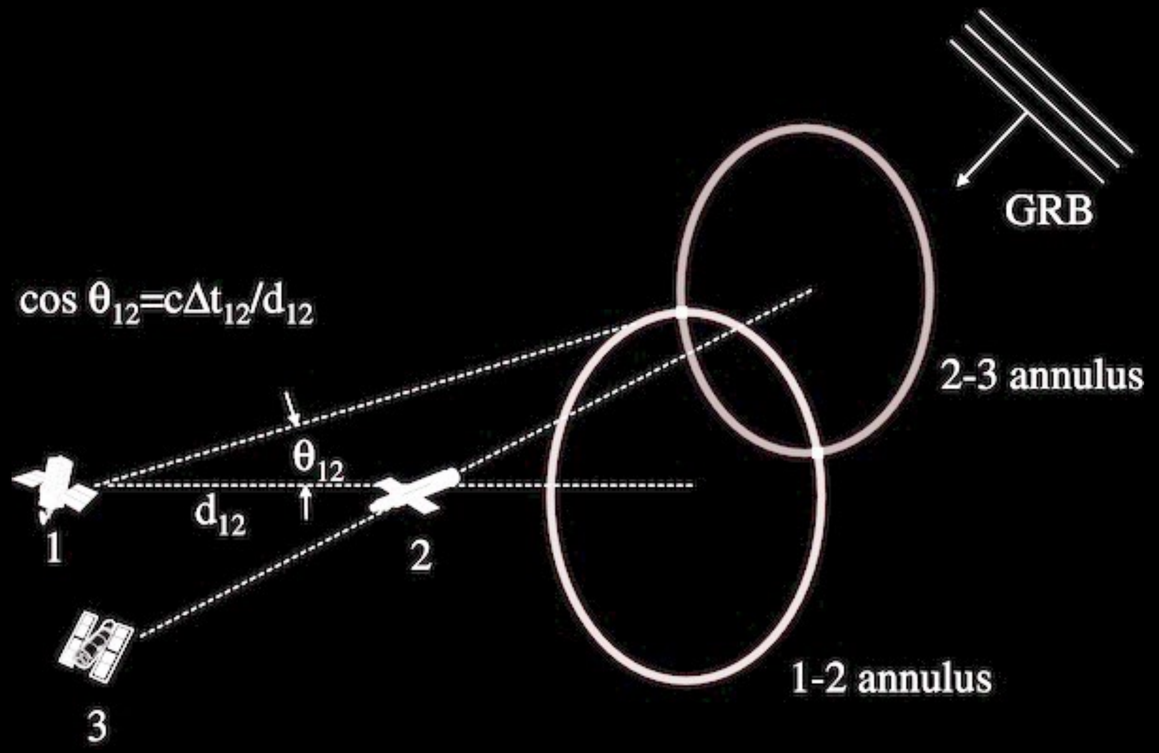


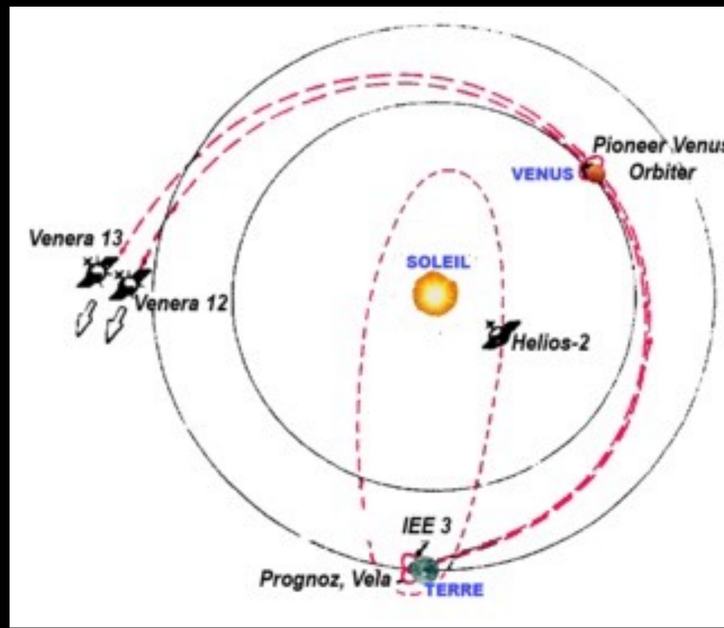
IPN legacy

First IPN 1976
4-6 spacecrafts.
Baseline ~ 1 AU

Second IPN ~1990
PVO, Ulysses, CGRO,
Wind

Third IPN 2000
~ 20 spacecrafts

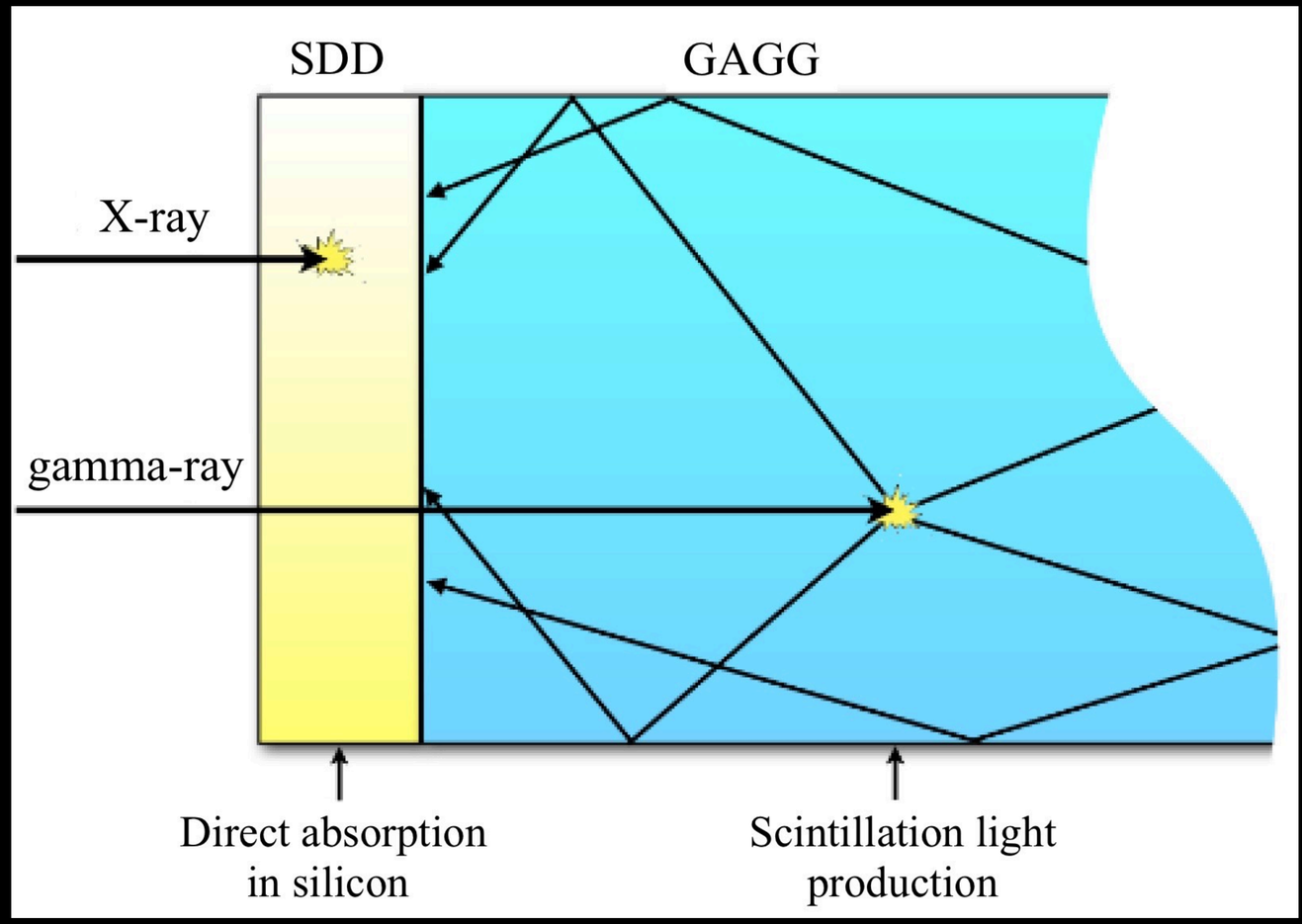




Localisations: arcmin-deg
Main disadvantages: long data acquisition ~days,
large systematic errors

Payload concept

- Photo detector, SDD
  Scintillator crystal GAGG
- 5-300 keV (3-1000 keV)
- ≥50 cm^2 coll. area
- a few st FOV
- Temporal res. ≤300 nsec
- ~1.6kg



Fuschino+2018, 2020, Evangelista+2020,2022, Campana+2020,2022

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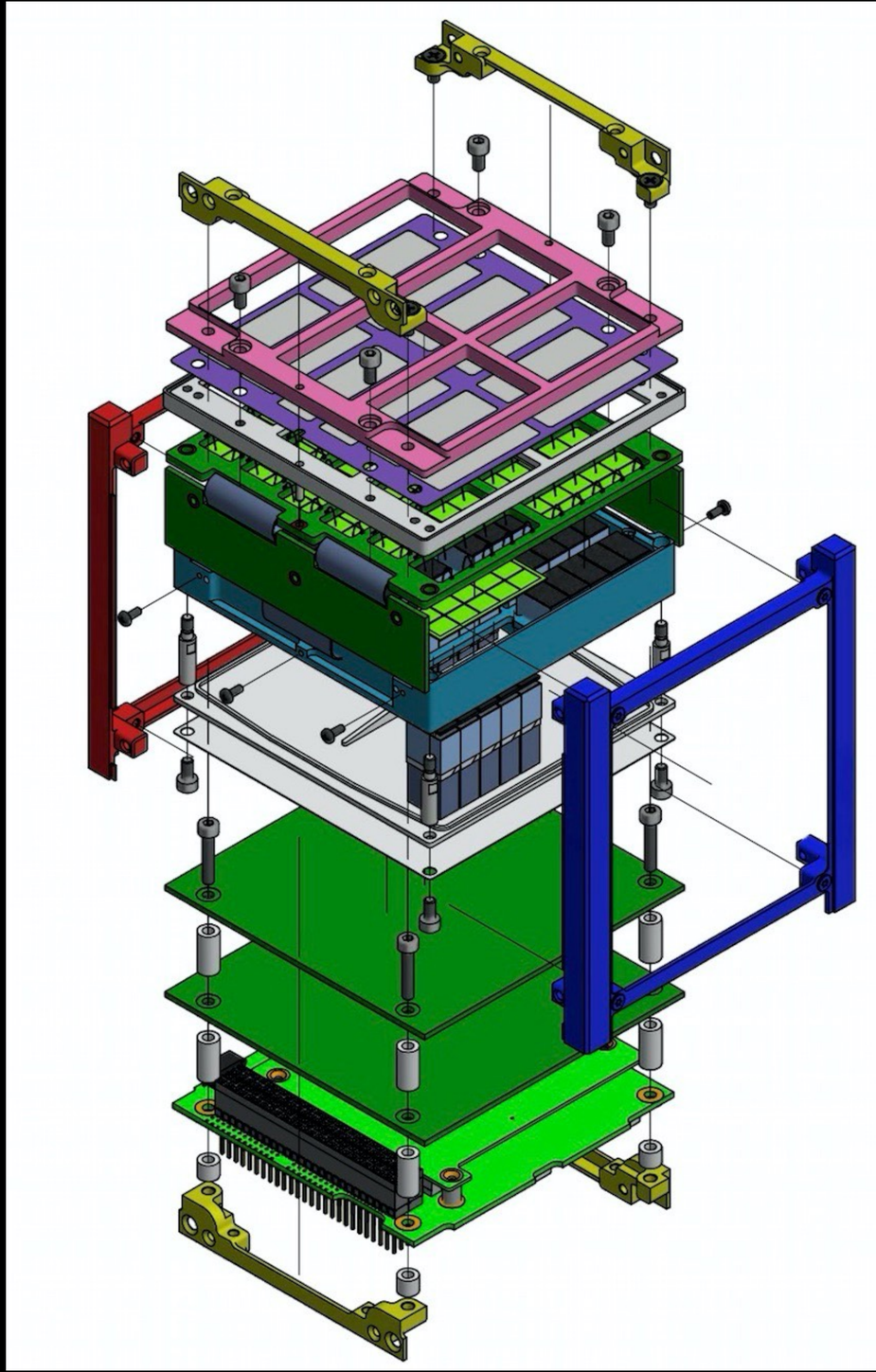

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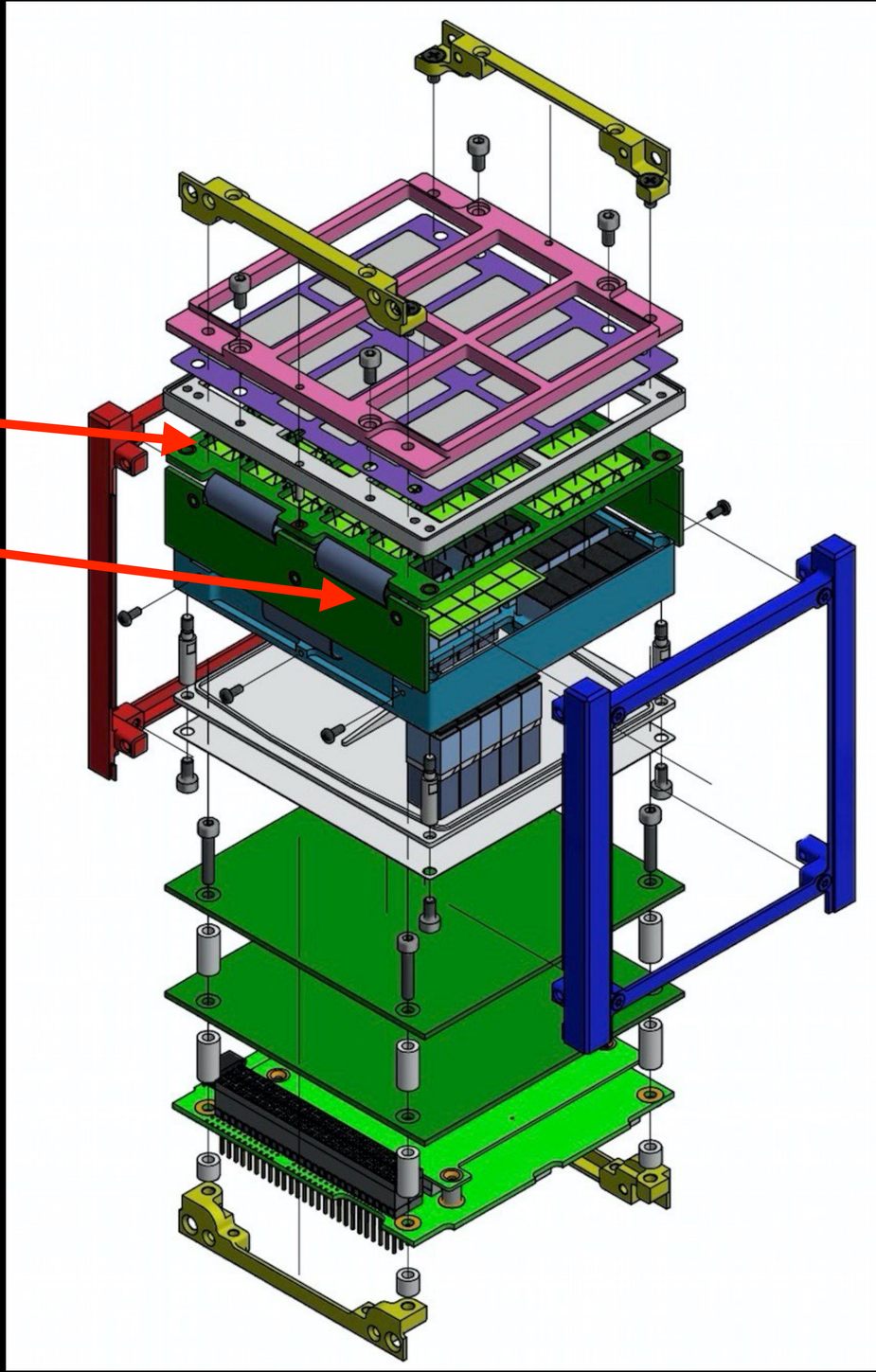
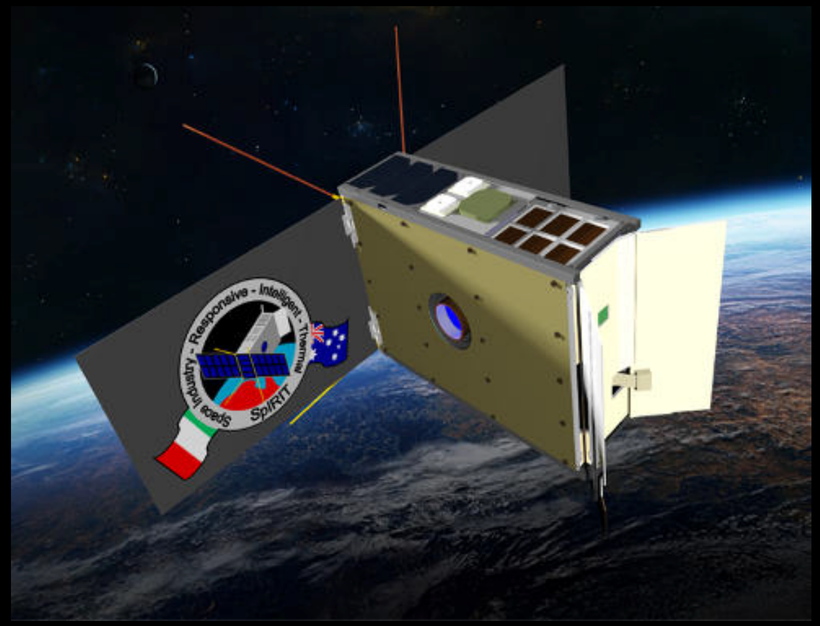
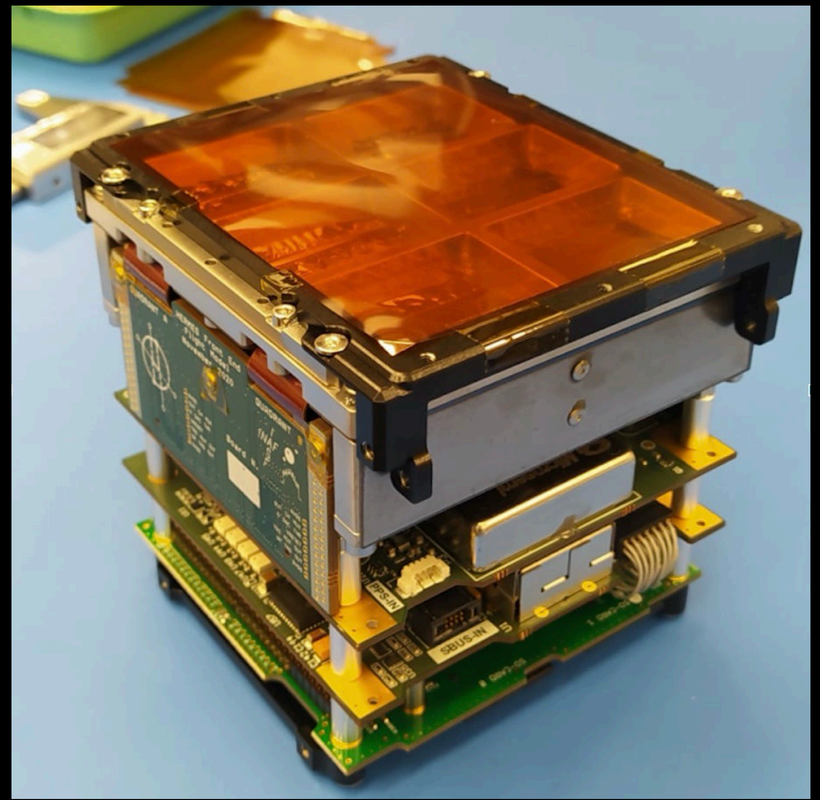


Fuschino+2018, 2020, Evangelista+2020,2022, Campana+2020,2022

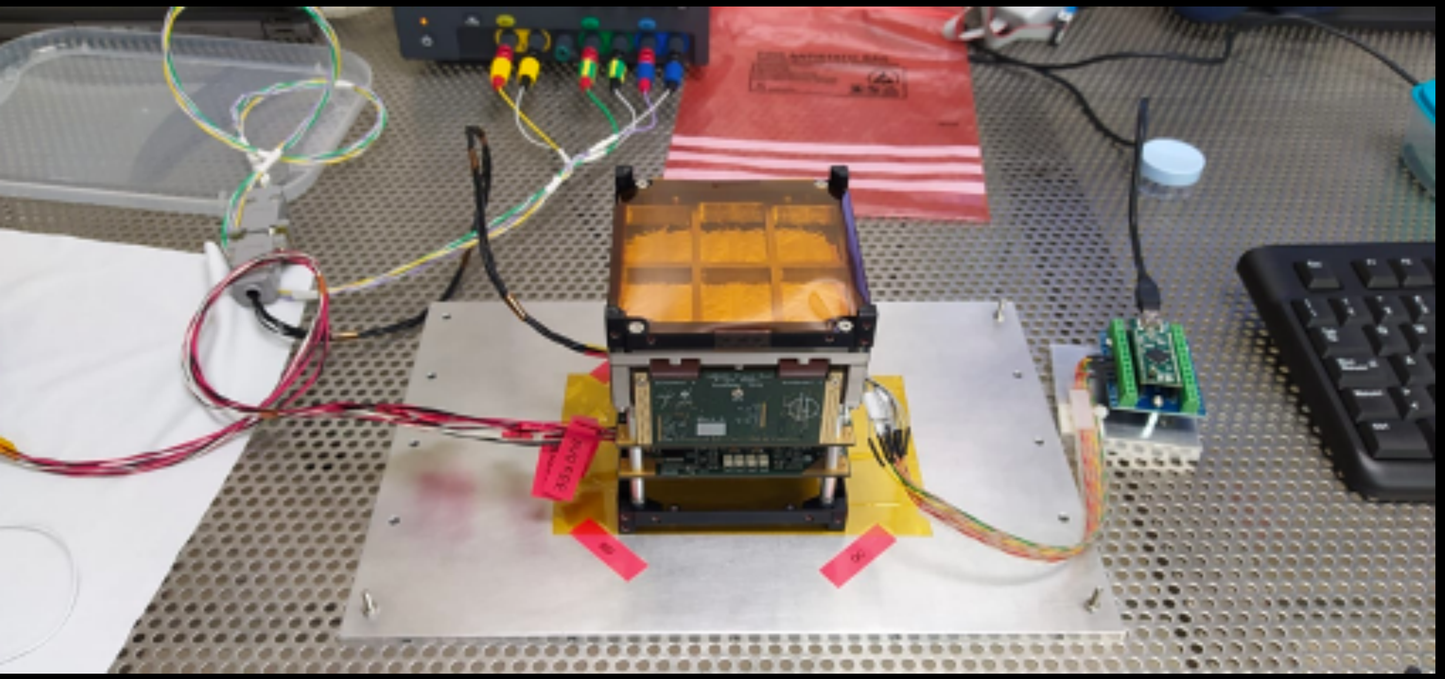
Where we are: SpIRIT

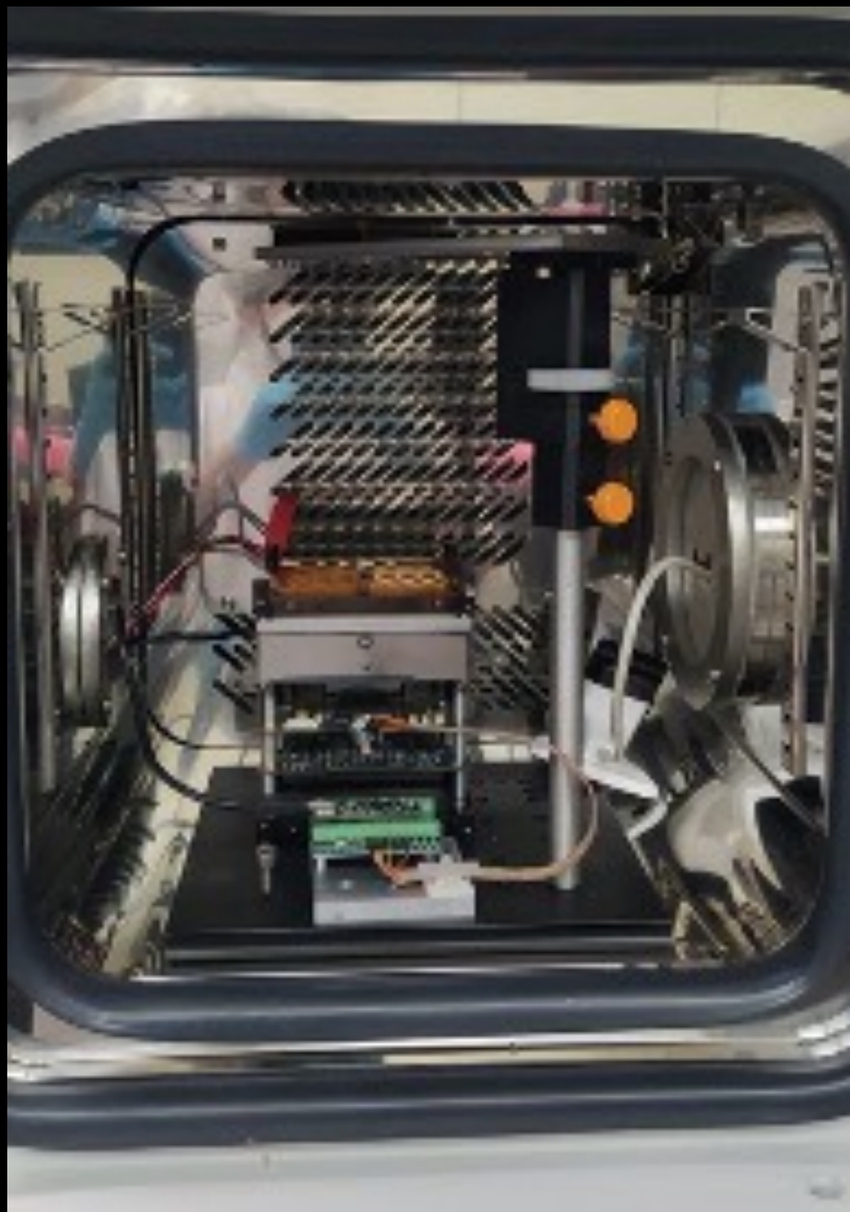
- SpIRIT paylod FM delivered to UoM on July 2022 after calibration and qualification (evironmental tests @ SERMS on June 2022).
- SpIRIT S-band system delivered to UoM Q2 2022
- Integration tests (mechanical, electrical, electronic) performed in July 2022
- S/M payload integration planned for October 2022, full system acceptance tests planned for November-December 2022, launch May 2023





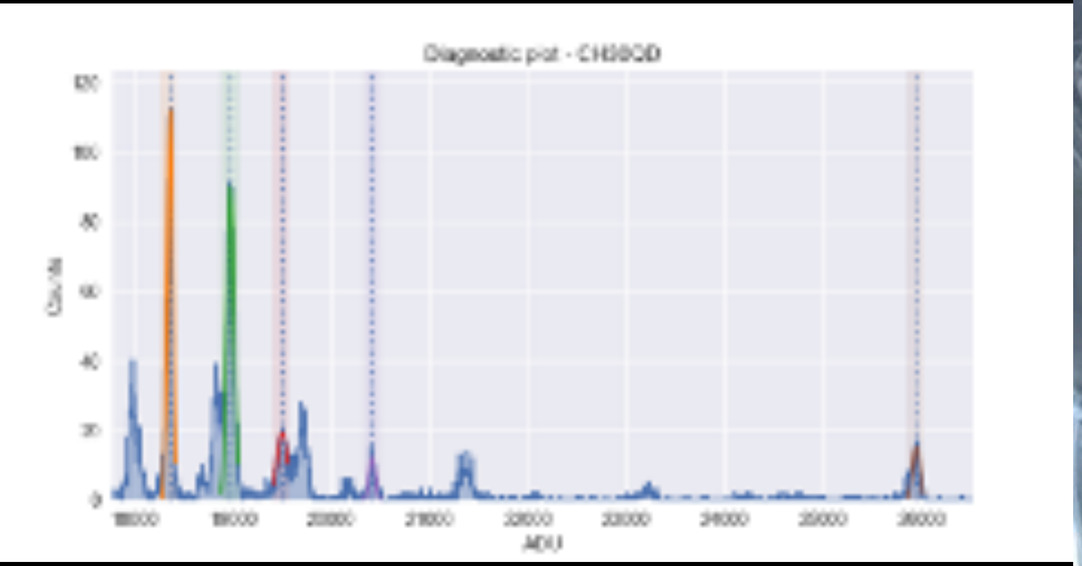
SpIRIT payload FM

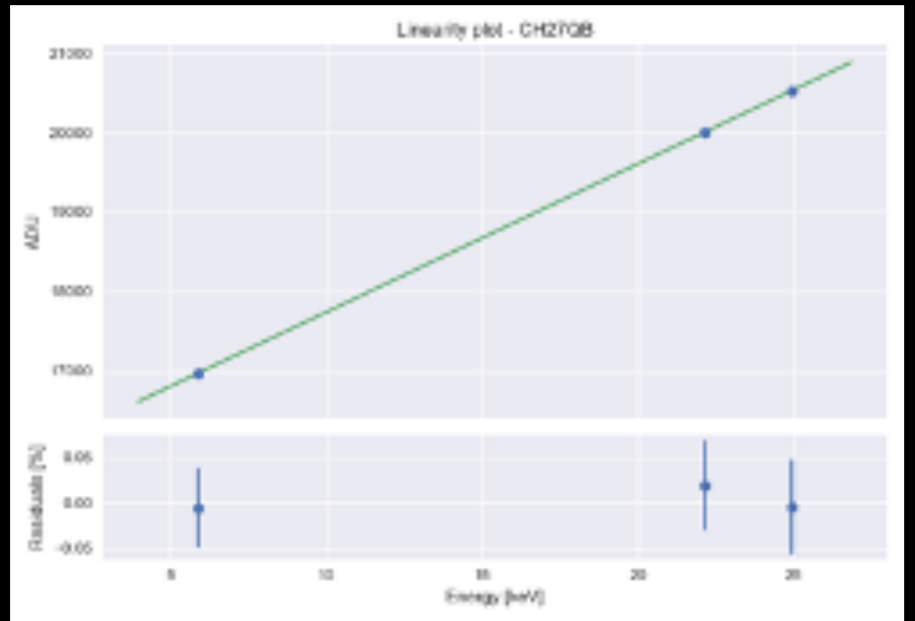


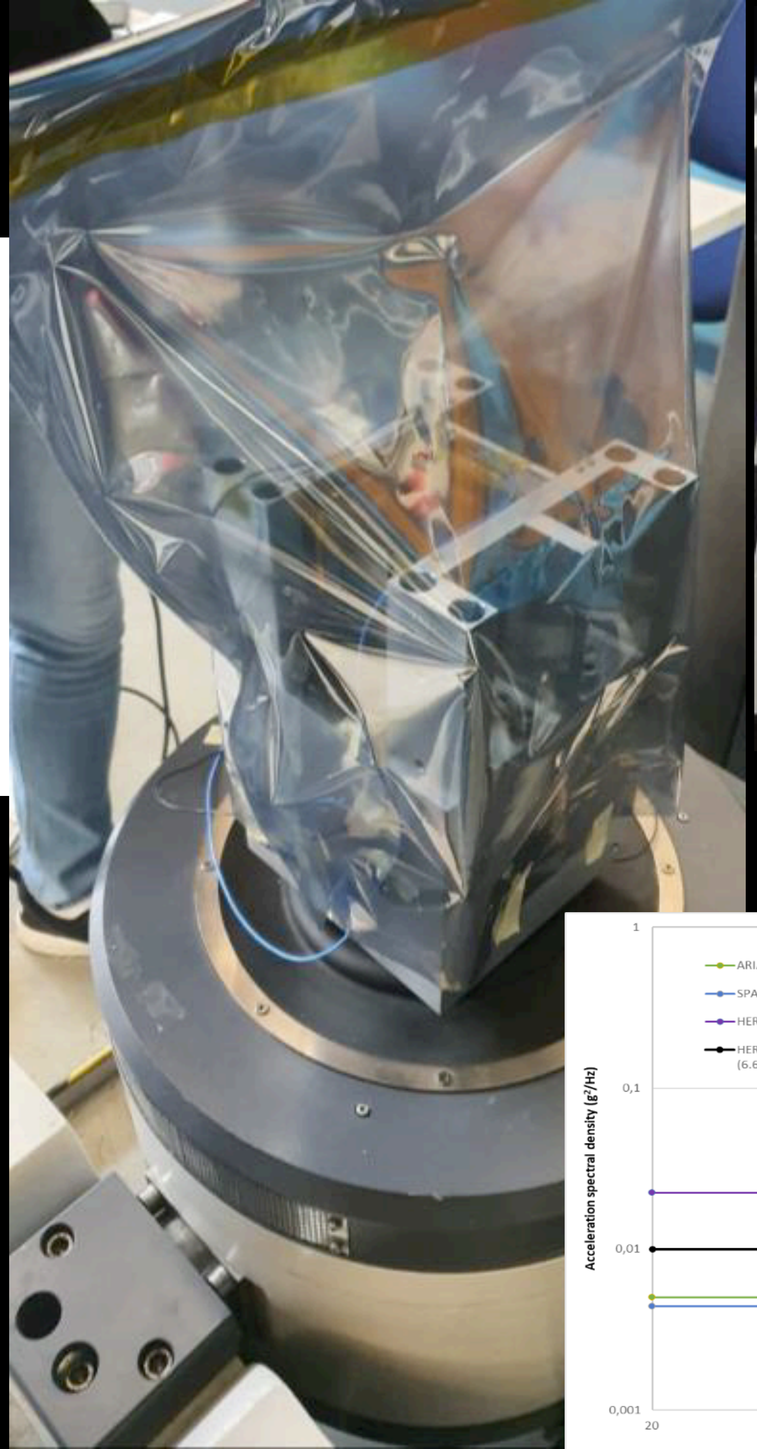


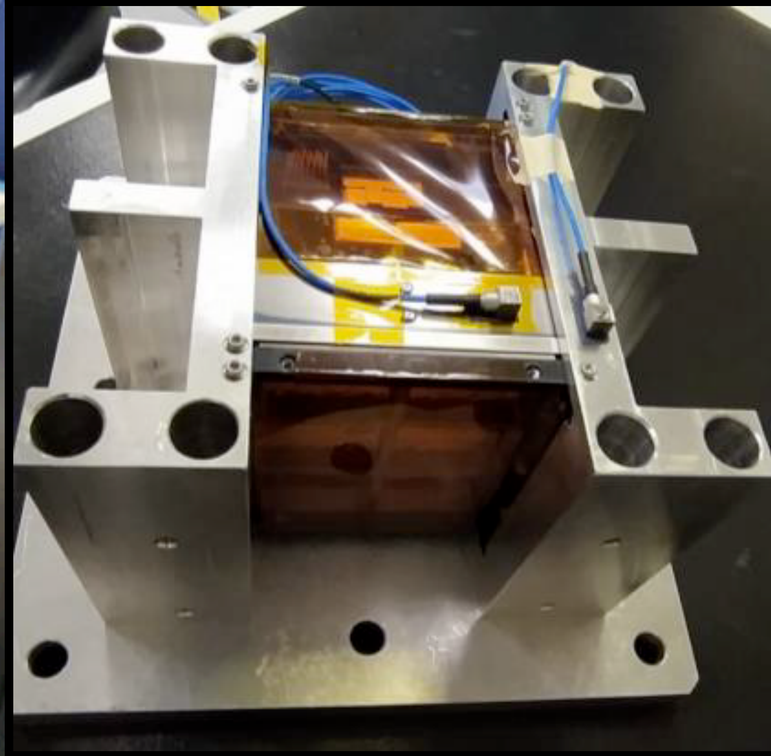
Step	Mode	Measurement	Temperature	Notes	Integration time [s]
1	X	^{109}Cd + ^{55}Fe	20 °C	≥ 10 kcts/channel	900 s
2	X	^{109}Cd + ^{55}Fe	0 °C	≥ 10 kcts/channel	900 s
3	X	^{109}Cd + ^{55}Fe	–10 °C	≥ 10 kcts/channel	900 s
4	X	^{109}Cd + ^{55}Fe	–20 °C	≥ 10 kcts/channel	900 s

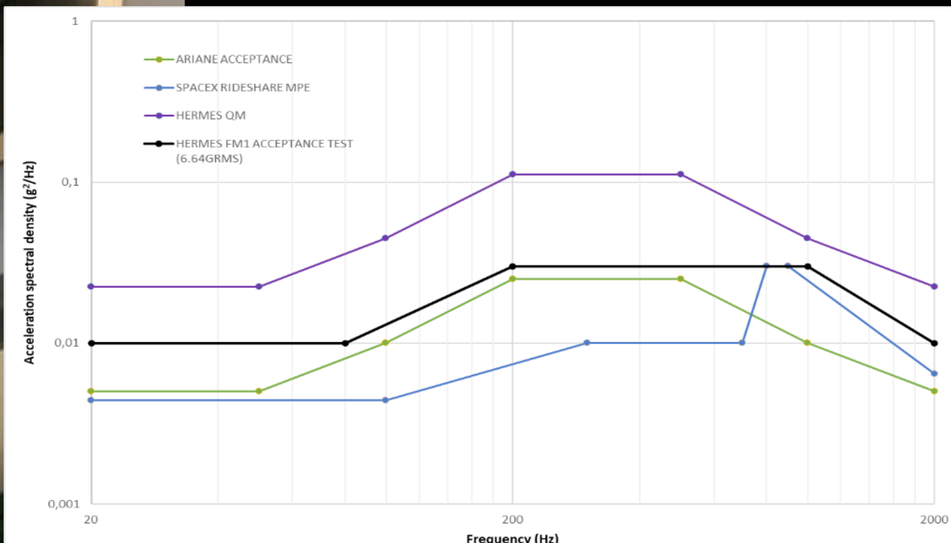
SpIRIT payload FM









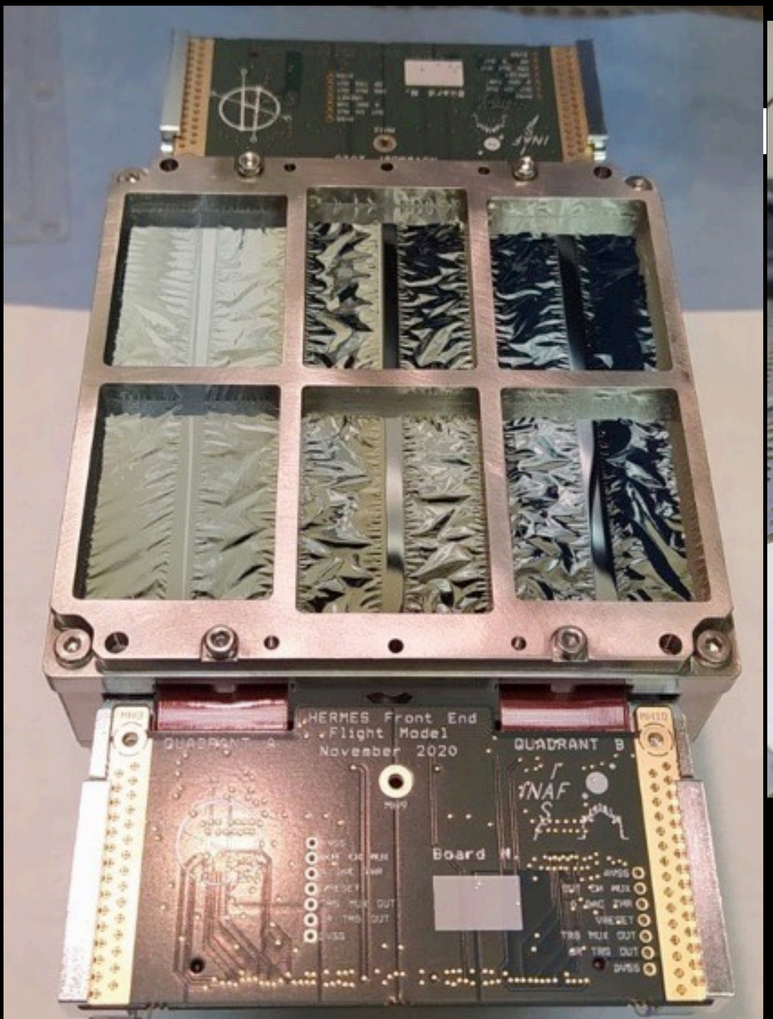


Where we are: HERMES pathfinder payload

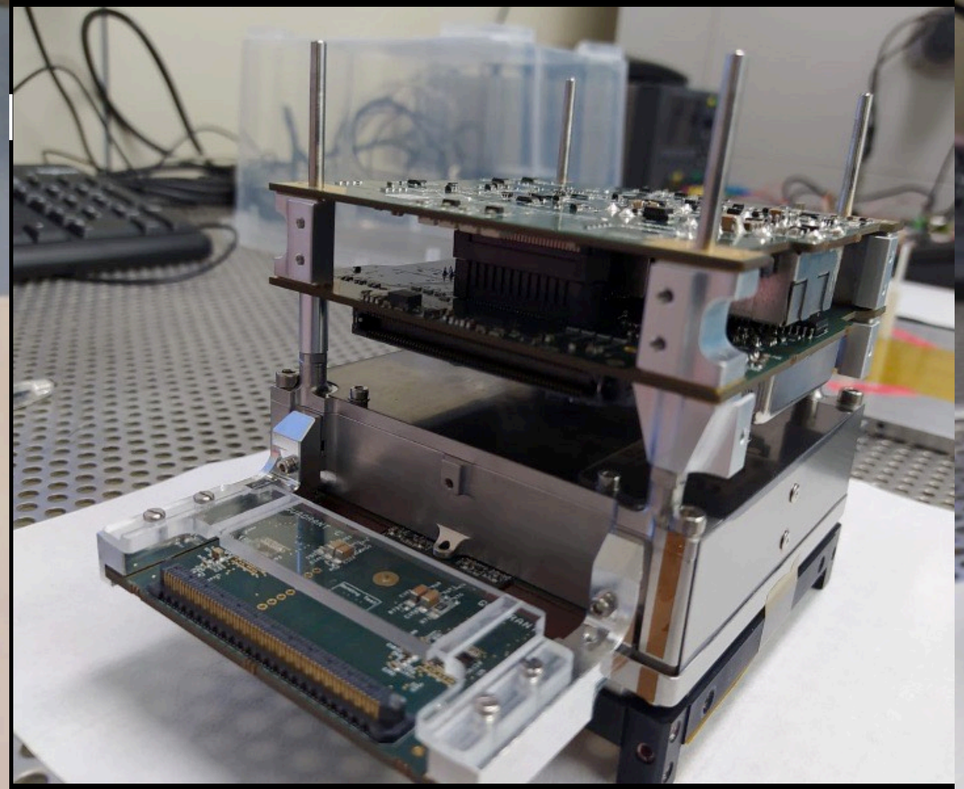
- PFM ready for integration in the S/M after calibration. Integration planned for September 2022, qualification test planned for October 2022
- FM2, FM3 detector system integrated and tested @FBK labs in Trento. Integration with electronic boards planned in September/October 2022 @INAF-IAPS
- FM4, FM5 and FM6 integration and test planned for October-December 2022

HERMES payload PFM

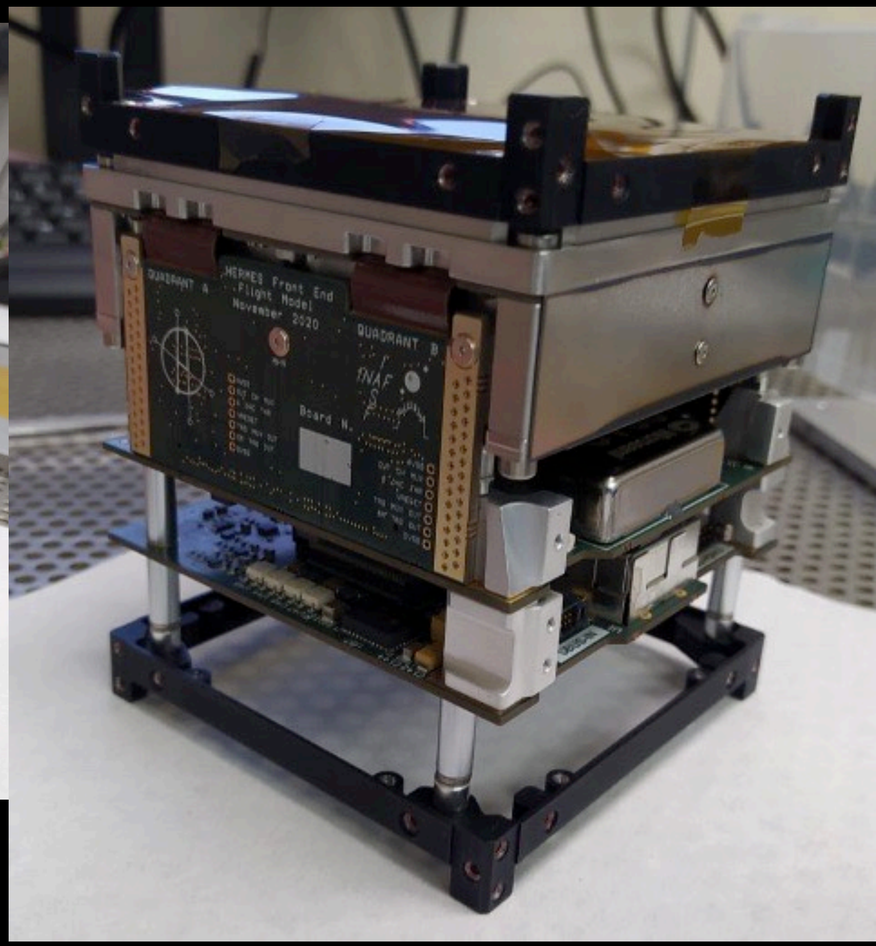
Detector system



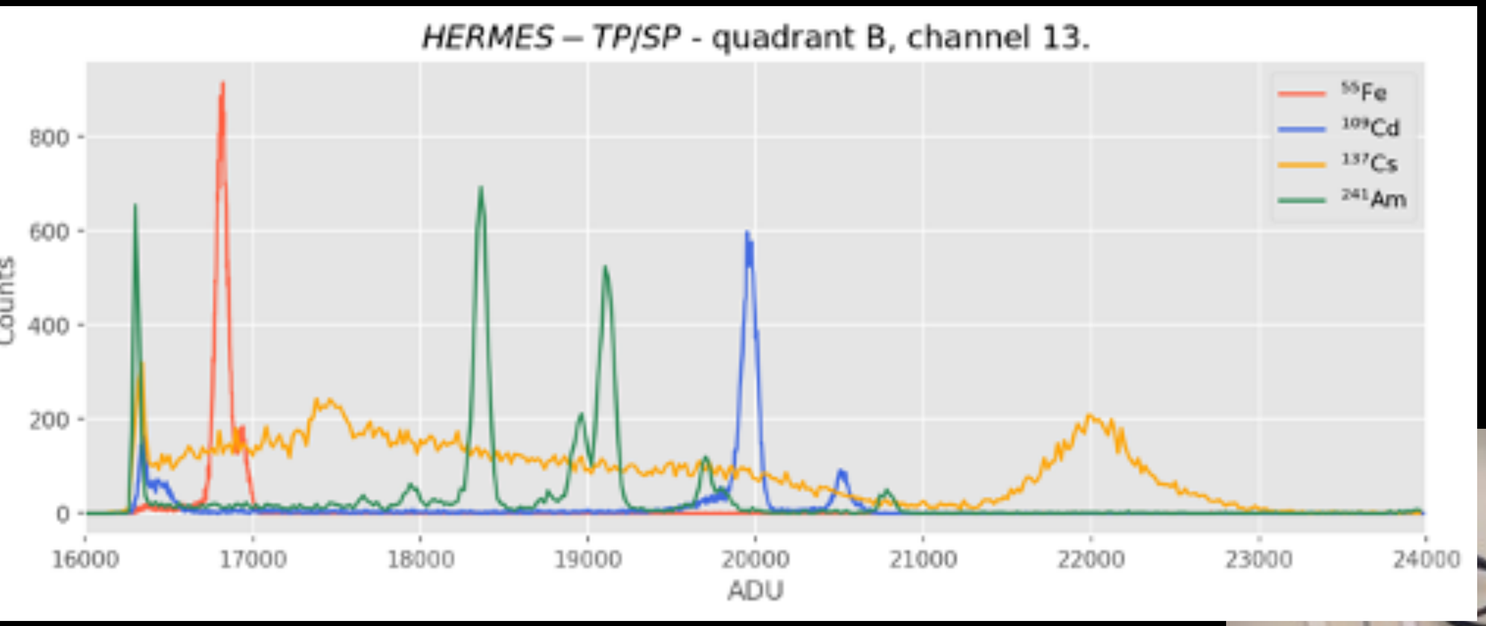
+BEE+PSU



Side wings connected



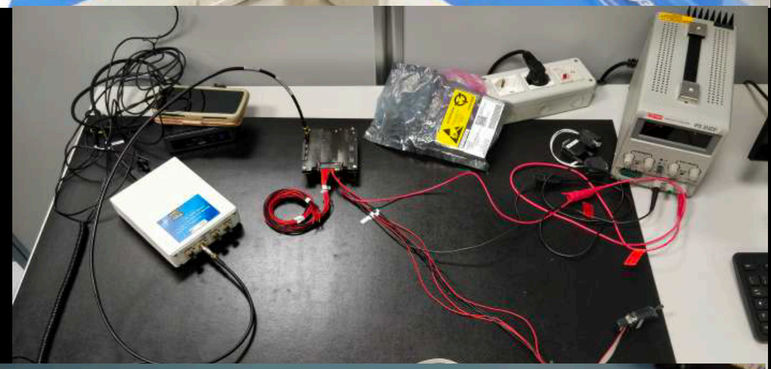
HSP payload PFM

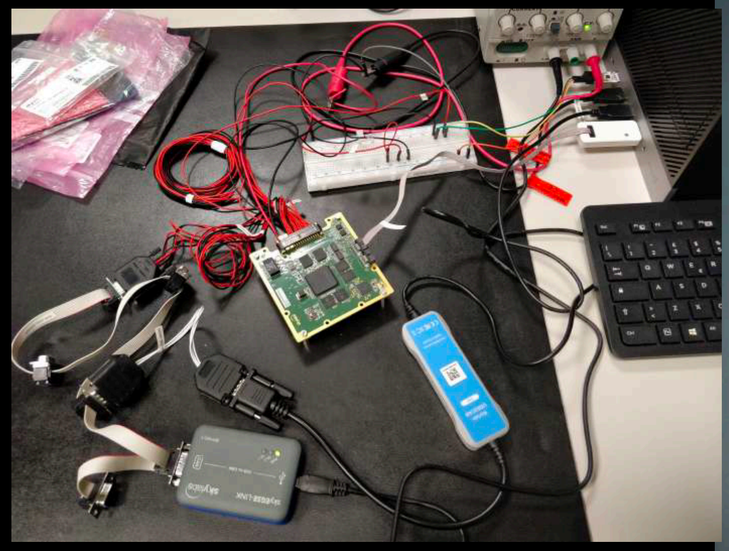


Example acquisition of four radioactive sources, showing different X and gamma-ray photon lines acquired with one representative channel.

Where we are: HERMES pathfinder S/M

- PFM integration planned @POLIMI in September/ October 2022, qualification test planned for October 2022
- FM2, FM3 integration and test planned for Q4 2022
- FM4, FM5 and FM6 integration and test planned for Q12023

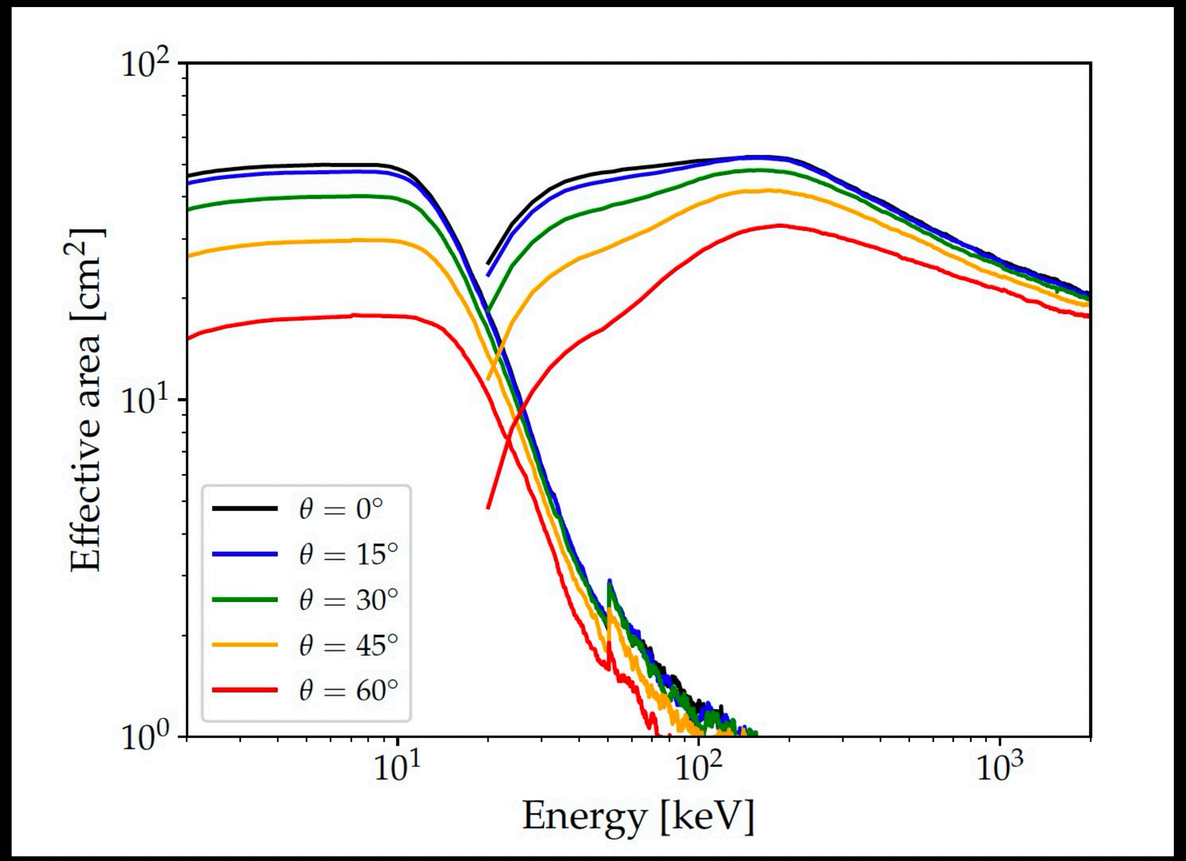


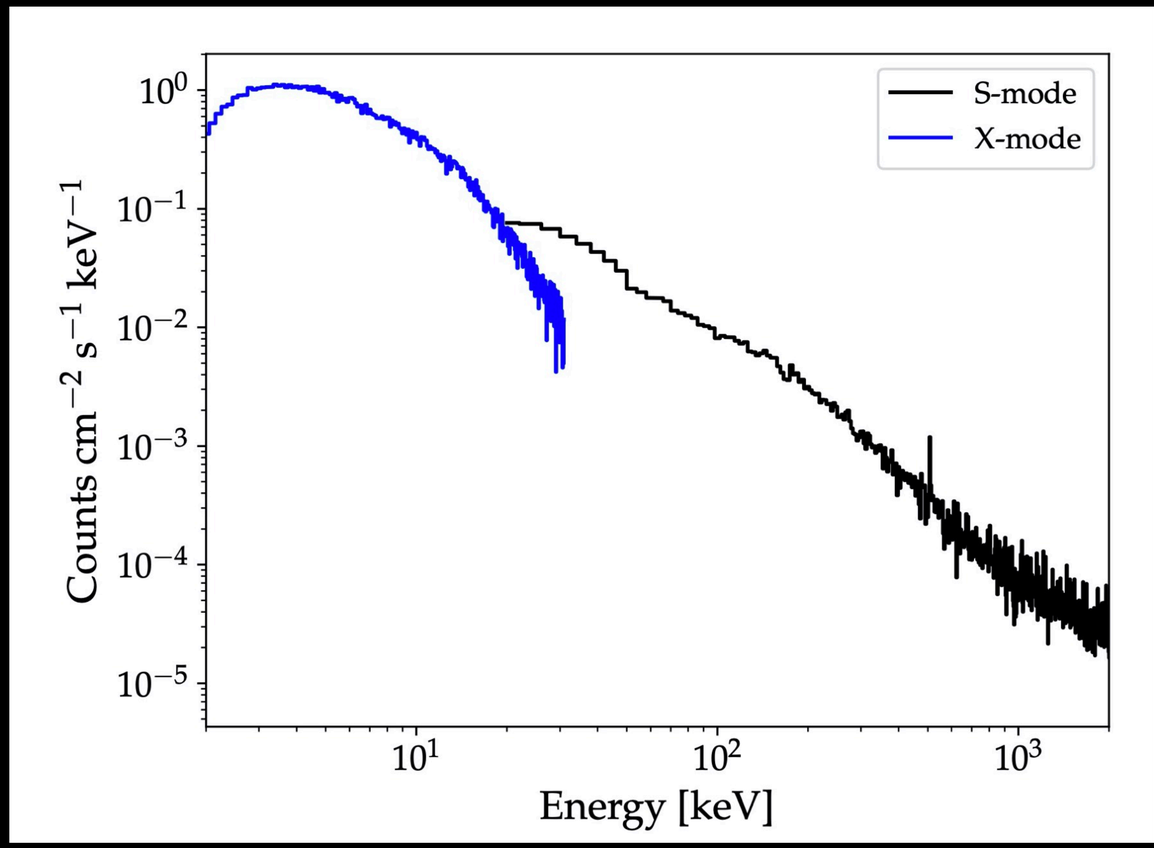


Where we are: HERMES Pathfinder program

- Launch contract negotiation on going, industrial operator identified, offer expected for end of September 2022. Contract signature Q42022
- MOC deployment contract under negotiation. Three industrial operators are partecipating to the bid. Contract signature predicted by the end of the year 2022. A contract for operations will be issued to the same industrial operator.
- Accordo Attuativo with INAF-POLIMI-UNICA for operations and scientific exploitation under negotiation. KO predicted for October 2022
- All funds to support above contracts already allocated in ASI budget

HERMES PF expected performances





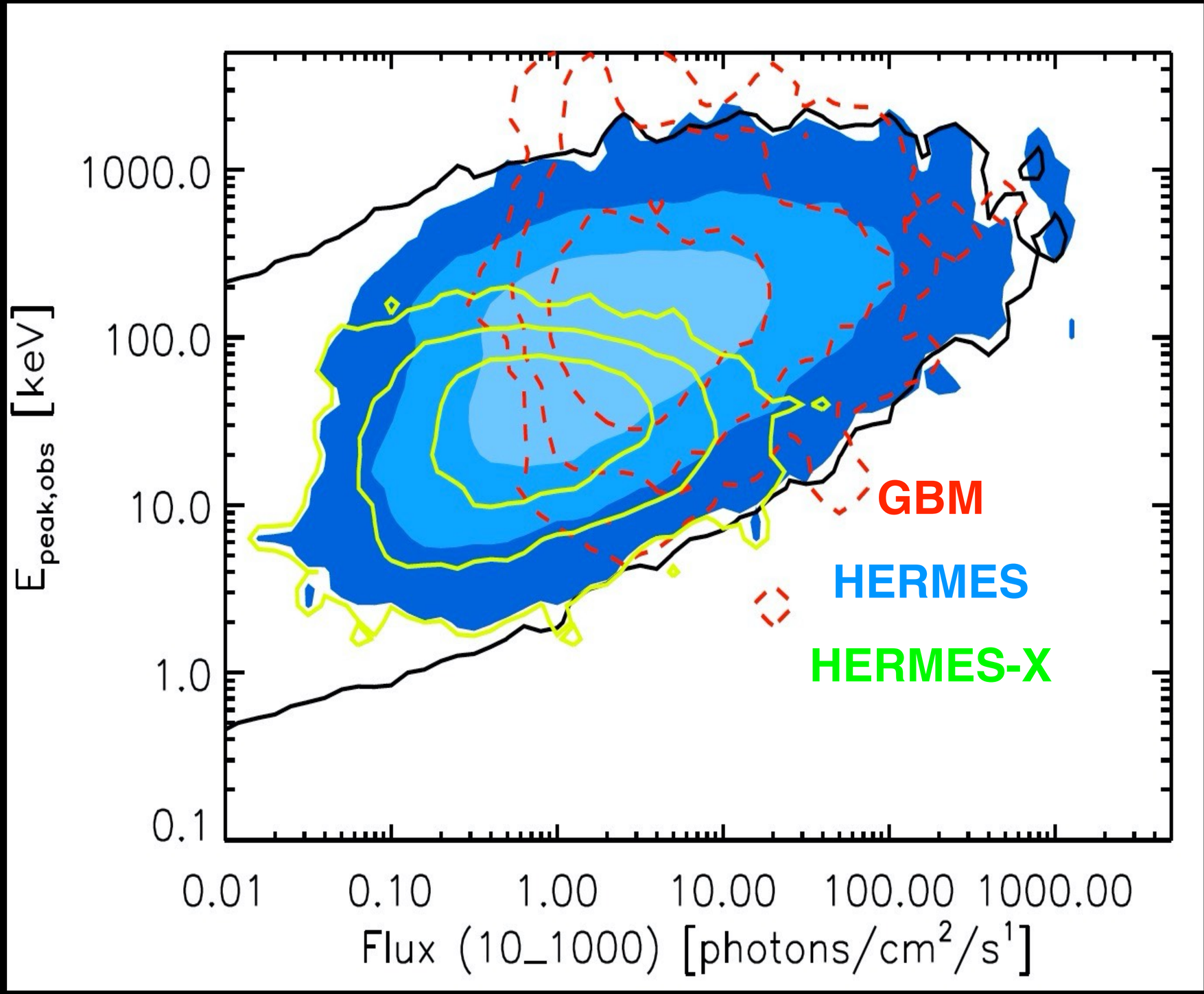
Background: 50-300 keV ~75cts/s; 100-500 keV~35cts/s; 3-20 keV 390counts/s

HERMES vs. GBM: half collecting area but ~1/3 lower background and soft energy band.

Campana et al. 2020

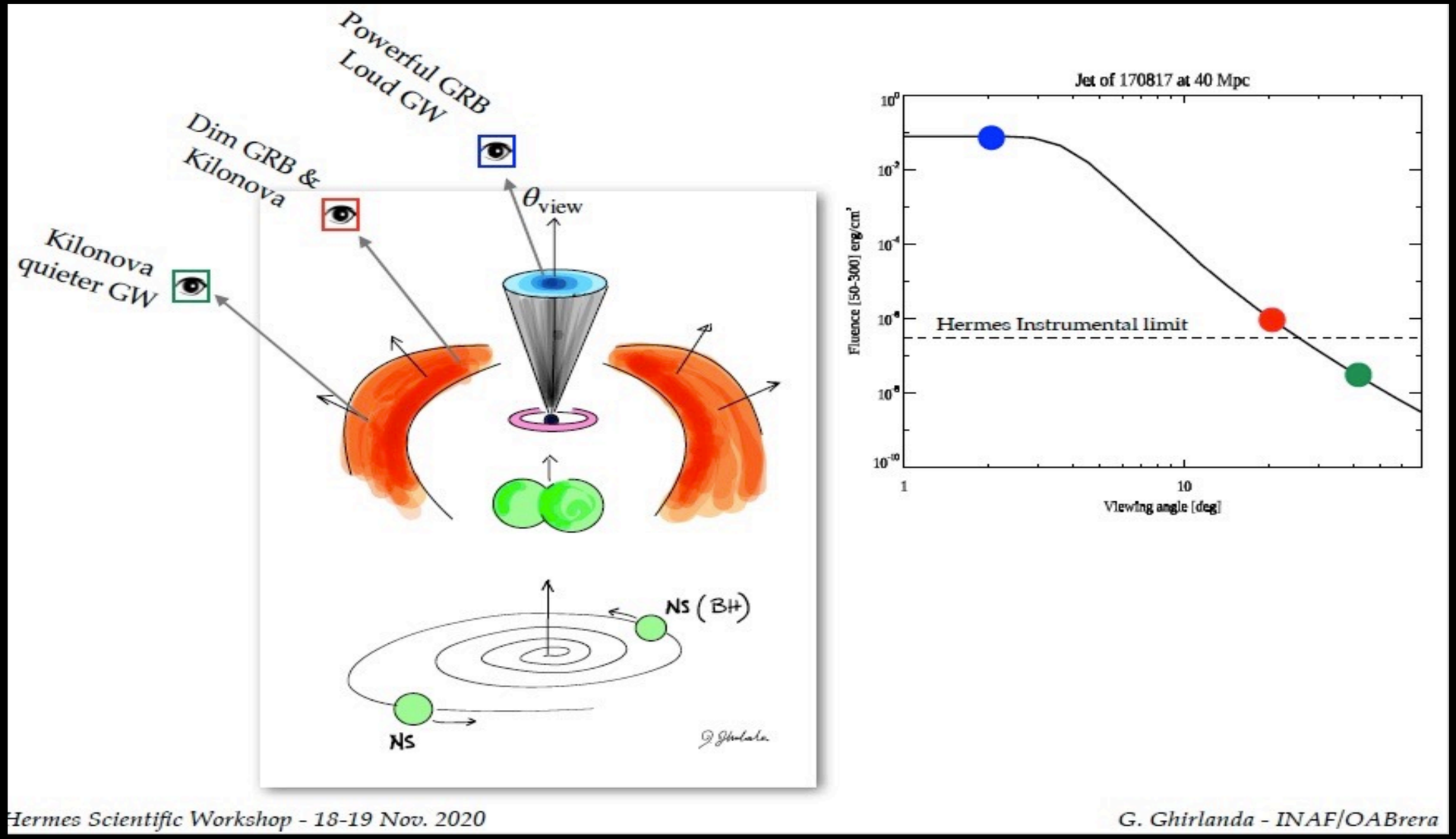
Performances

Ghirlanda & Nava



Performances for off-axies GRBs

Ghirlanda & Nava



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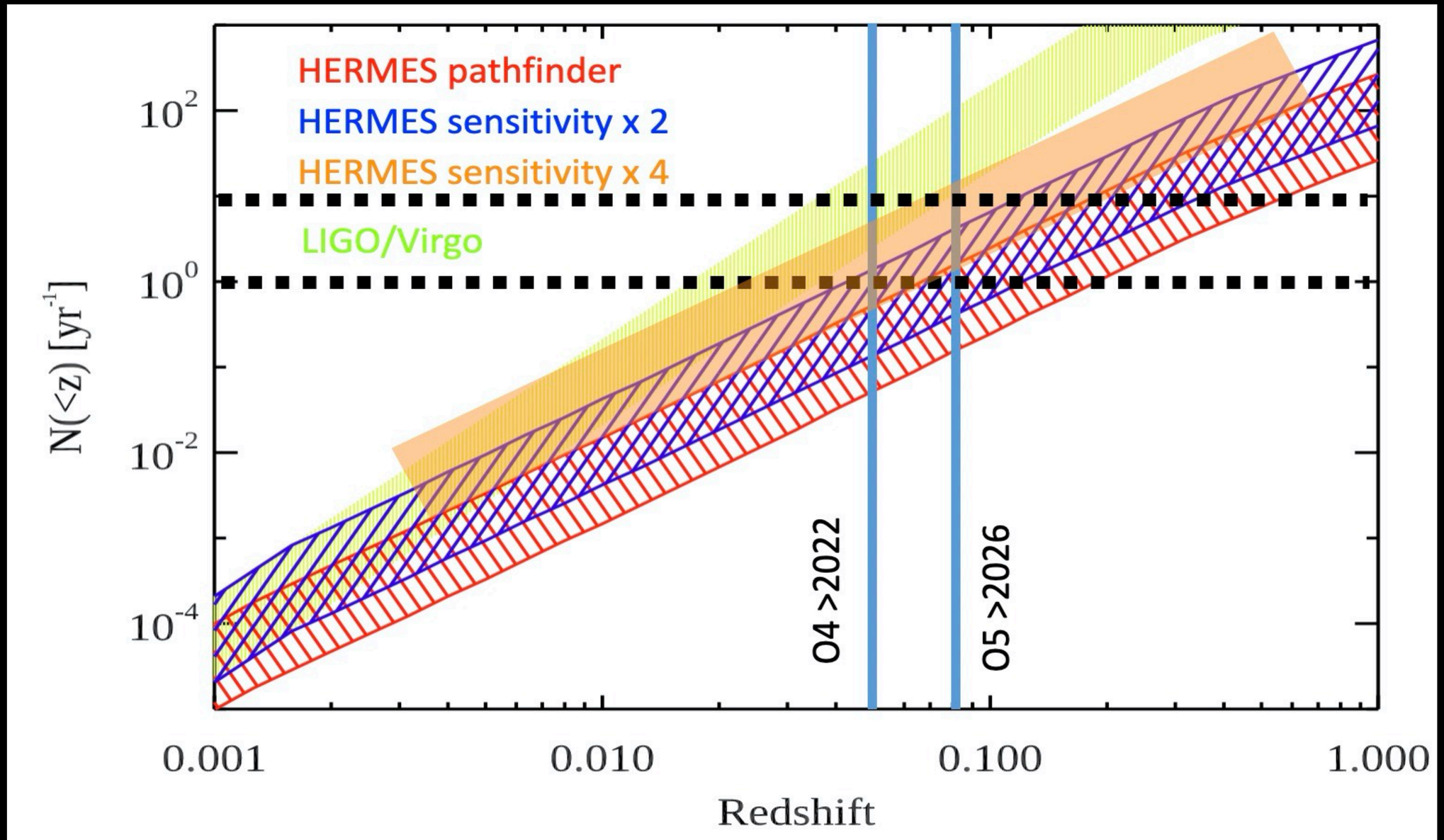


Localization performances

$\sigma_{Pos} = 2.4°[(\sigma_{CCF}^2 + \sigma_{sys}^2)/(N-3)]^{0.5}$

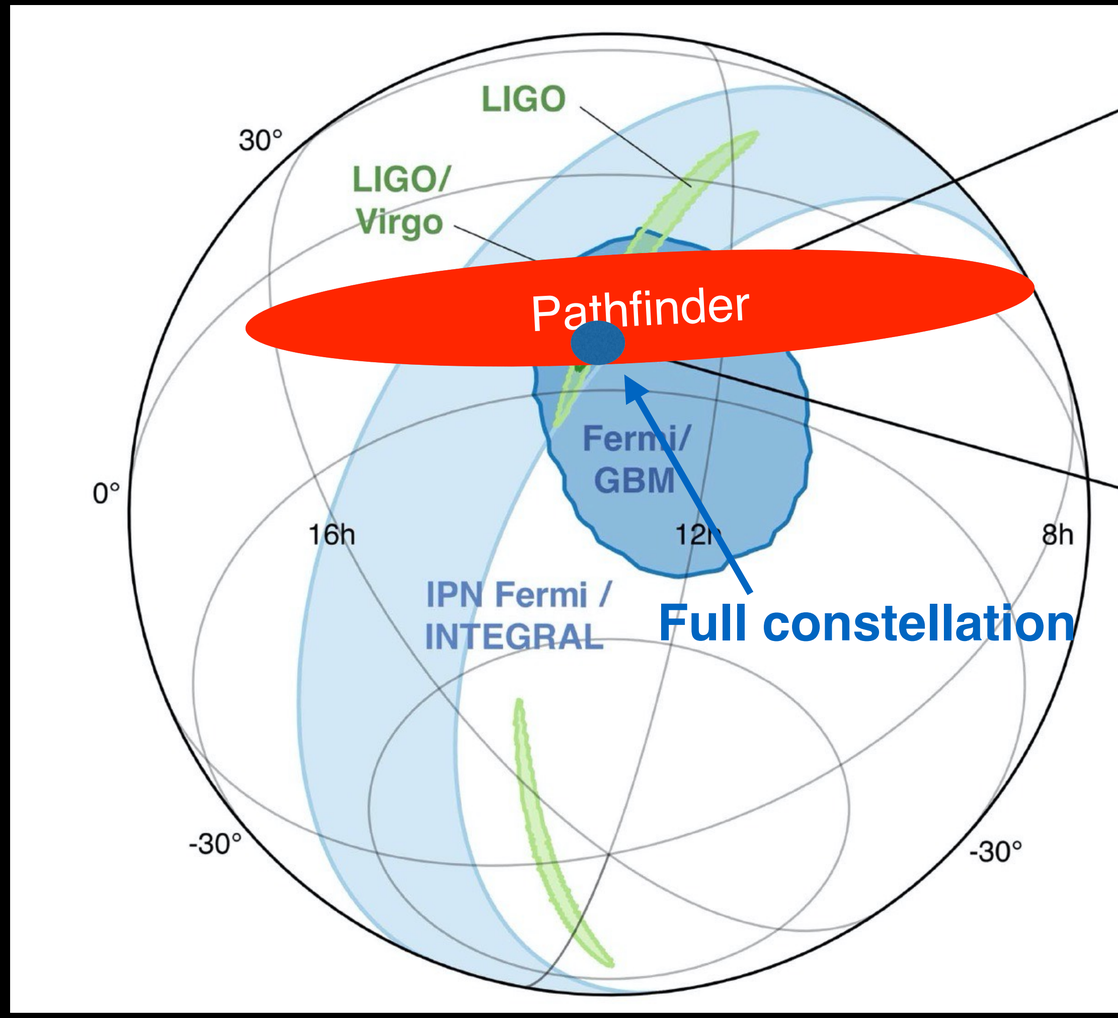
<B>~7000km

N(pathfinder)~6-8, active simultaneously 3-4

σ_{Pos}~ 2.4 deg if **$\sigma_{CCF},\sigma_{sys}$~1ms**

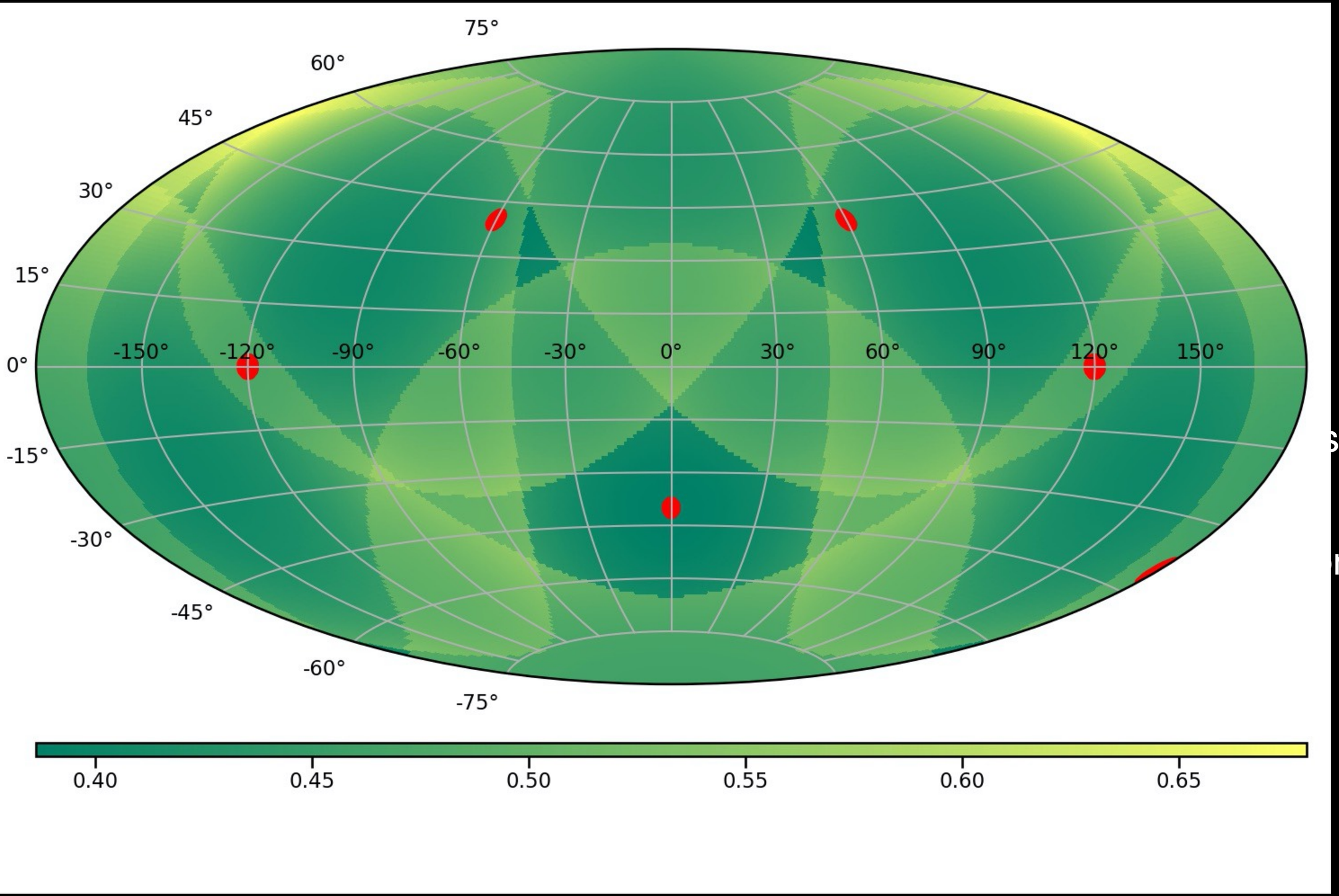
Goal for a real observatory (more units, longer baseline)

$\sigma_{Pos(FC)}$ ~ 15 arcmin **if $\sigma_{CCF},\sigma_{sys}$~1ms**



Next steps

- Toward a sensitive all sky monitor during the 20’:
- First phase: **crash program to deploy in LEO 6-8 units (6-12U) in three years** to provide a first all-sky monitor for Ligo/Virgo O5 events
- Second phase: deploy additional 6-10 units (6-12U) after ~2 years to boost monitoring and localization capabilities during Ligo/Virgo O5 - O6… ET!
- Third phase: deploy a few units in HEO or Moon orbits to boost localization capabilities


75°
60°
45°
30°
15°
0°
-15°
-30°
-45°
-60°
-75°
-150°
-120°
-90°
-60°
-30°
0°
30°
60°
90°
120°
150°
0.40
0.45
0.50
0.55
0.60
0.65

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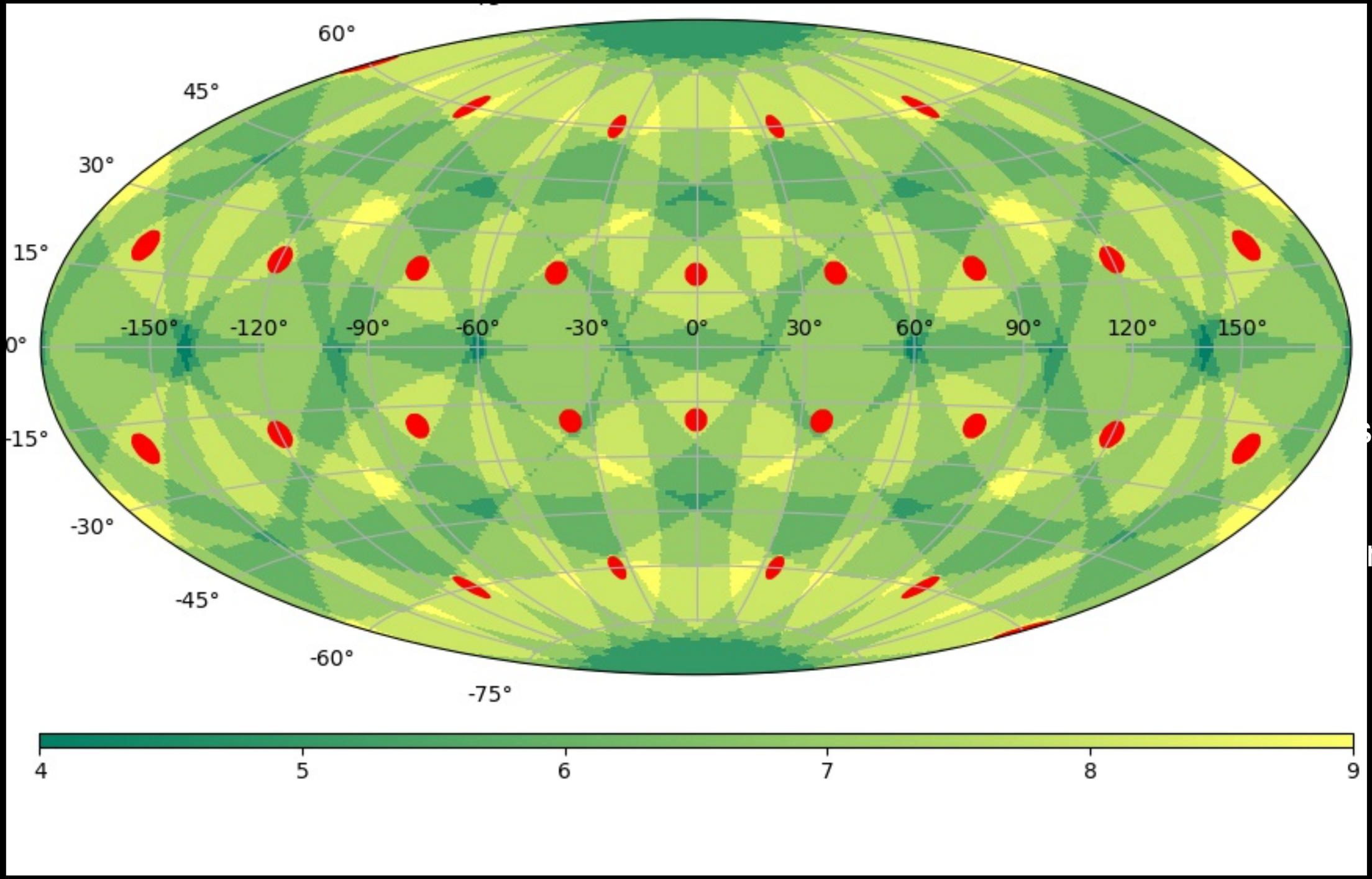
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-60°
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HERMES PF Institutes

- INAF, ASI, PoliMi, UniCagliari, UniPalermo, UniUdine, INFN, UniTrieste, UniPavia, UniFedericoII, UniFerrara, FBK, FPM
- University of Tubingen (Germany)
- University of Eotvos Budapest, C3S (Hungary), MUNI (CZ)
- University of Nova Gorica, Skylabs, AALTA (Slovenia)
- Deimos (Spain)
- Institute of High Energy Physics, Chinese Academy of Science