HermeS

HERMES: a constellation of nano-satellites for high energy astrophysics and fundamental physics research

Fabrizio Fiore INAF-OATs fabrizio.fiore@inaf.it

Lessons learned

Vela satellites, IPN, BeppoSAX, Swift

Distributed instrument **—>** arcmin-deg positions

Modularity **—>** improved performances

Prompt arcmin-arcsec positions **—>** game changer

Mission concept

Disruptive technologies: cheap, underperforming, but producing high impact. Distributed instrument, tens/hundreds of simple units

HERMES constellation of cubesat

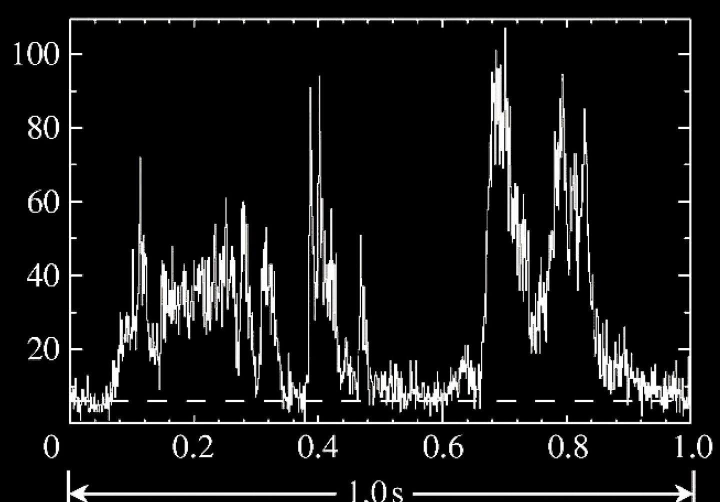
2016: ASI funds for detector R&D
2018: MIUR funds for pathfinder (Progetti premiali 2015)
2018 H2020 Space-SCI-20 project

2018 ASI internal proposal

Experiment concept

1. Measure GRB positions through delays between photons arrival times:

$\sigma_{Pos} = \sigma_{CCF} \times c / \langle B \rangle / (N\times(N - 1 - 2)^{1/2}$



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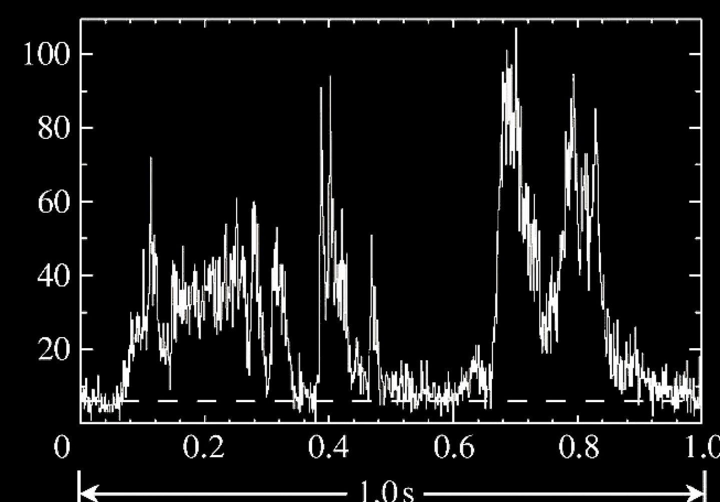

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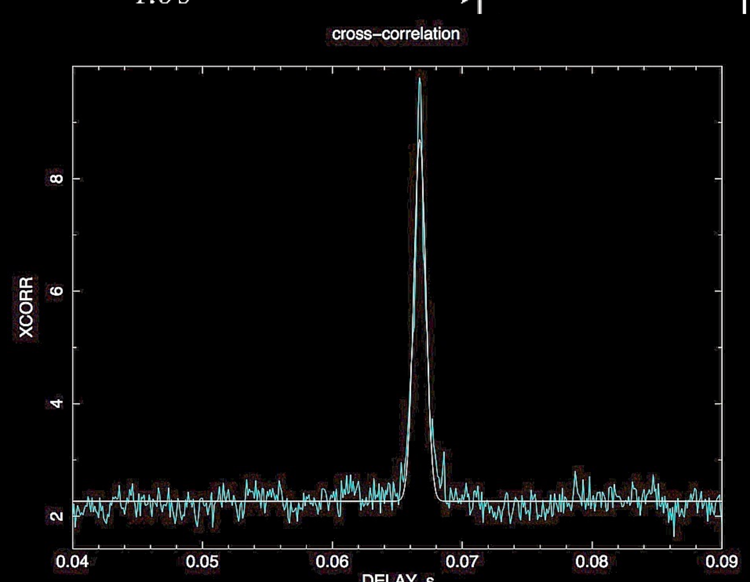


$\sigma_{CCF} \sim 10\mu s$

$\sigma_{Pos} \sim 10$arcsec

if $\langle B \rangle \sim 7000$km, $N \sim 100$

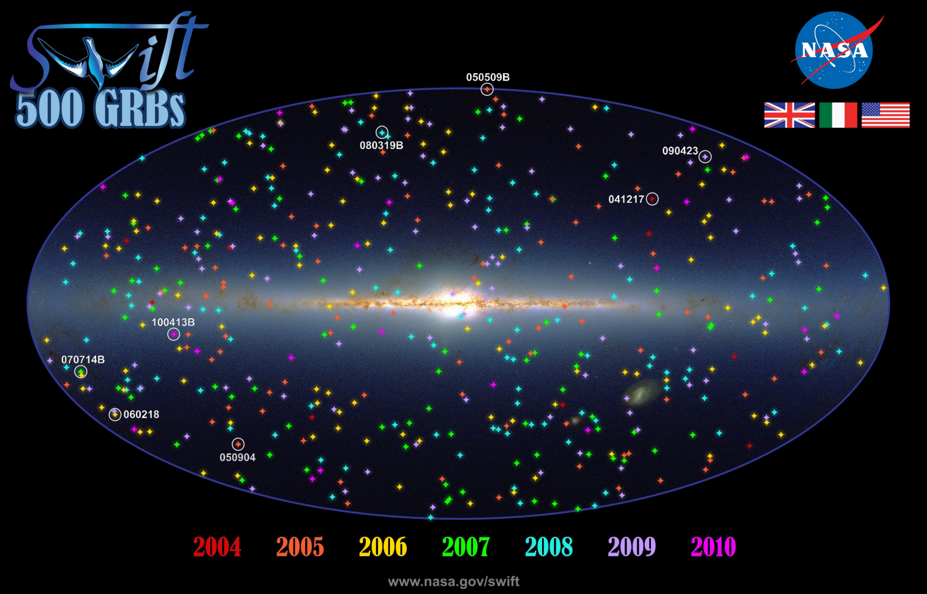
Experiment concept

2. Add the signal from different units

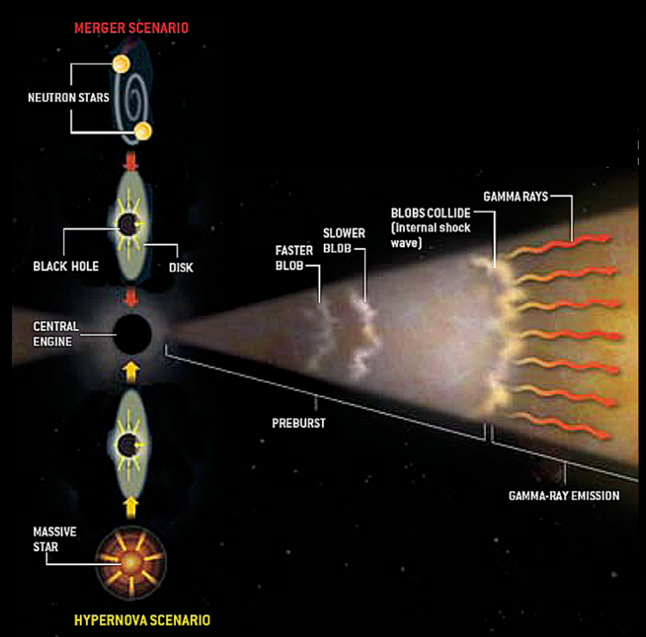
Total collecting area 50-100-cm^2 x 100-200 = 0.5-2 m^2

Transient fine (μs-ms) temporal structure

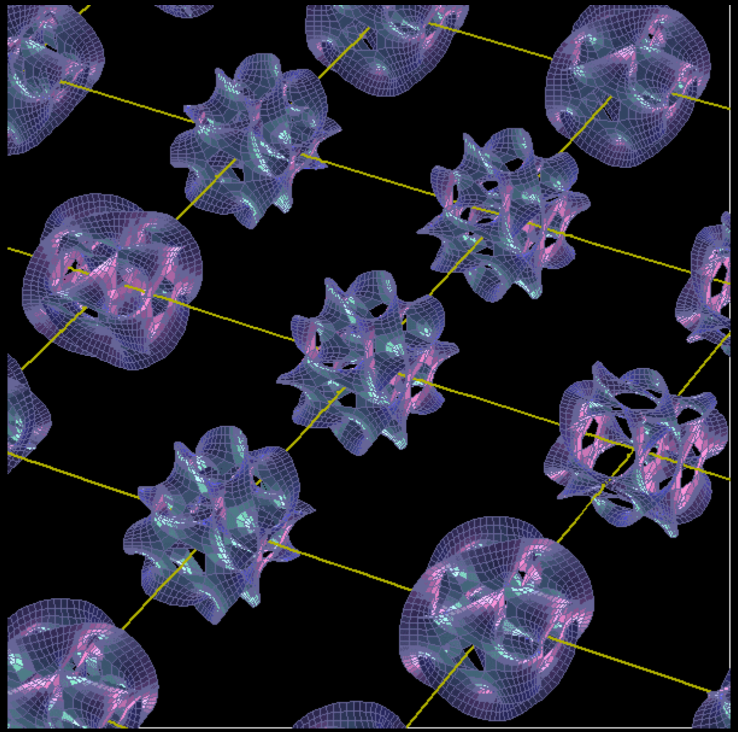
How to *promptly* localise a GRB *prompt* event?



How to construct a GRB engine?



Which is the ultimate granular structure of space-time?



Requirements

Scientific:

Arcmin-arcsec positions of ~a few dozen GRB/yr

Prompt(minute) localisation

μs timing

$\Delta t/\Delta E \sim 3\mu s/100keV$ $30\mu s/1MeV \longrightarrow M_{QG} \sim M_{Planck}$

Requirements

System:

≈hundreds detectors

single collecting area ≥50cm^2

total collecting area ≥1m^2

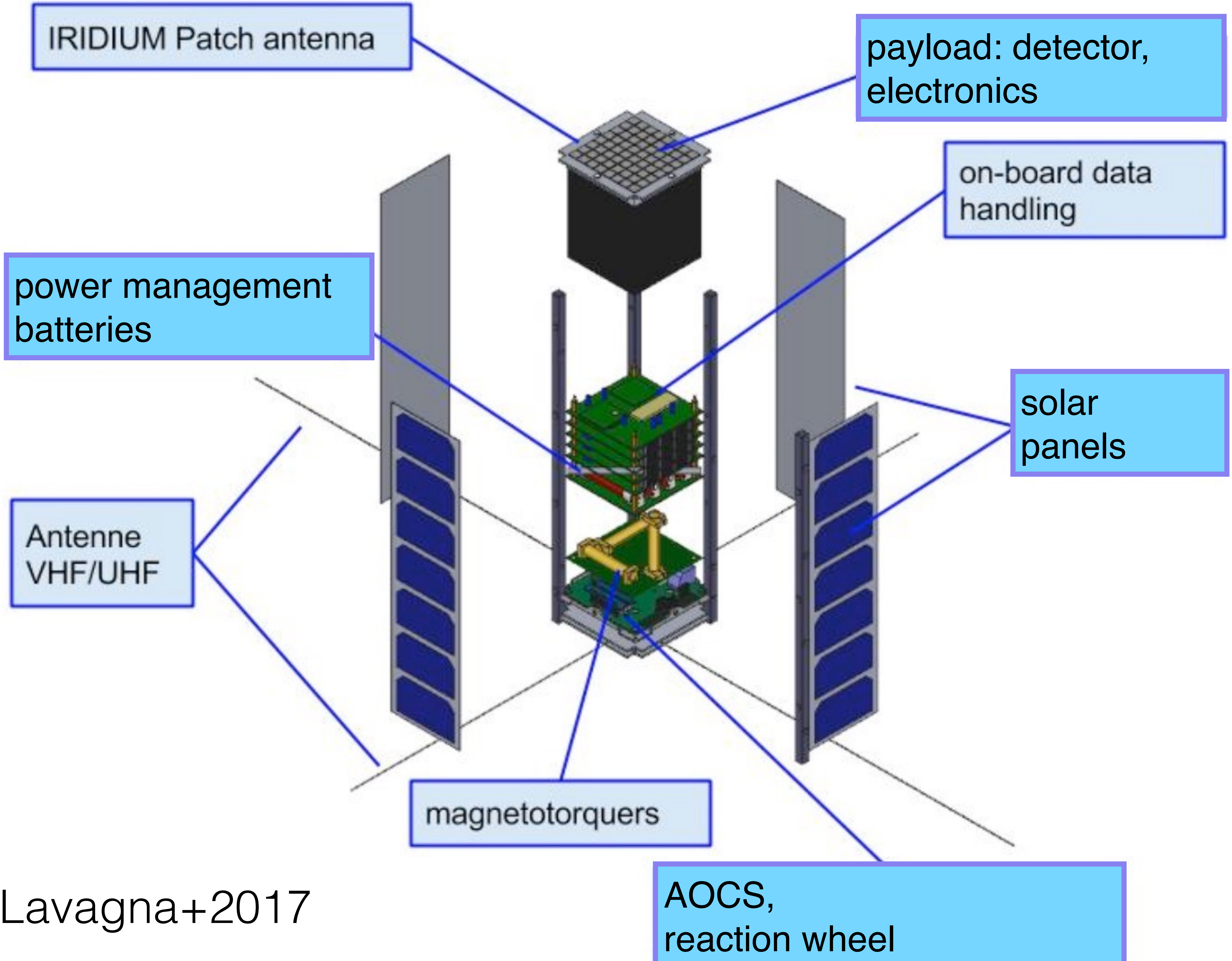
Energy range 3-10 — 300-1000 keV

Temporal resolution 10-100ns

Position reconstruction of each satellite < a few m

Absolute time reconstruction <10-100 ns

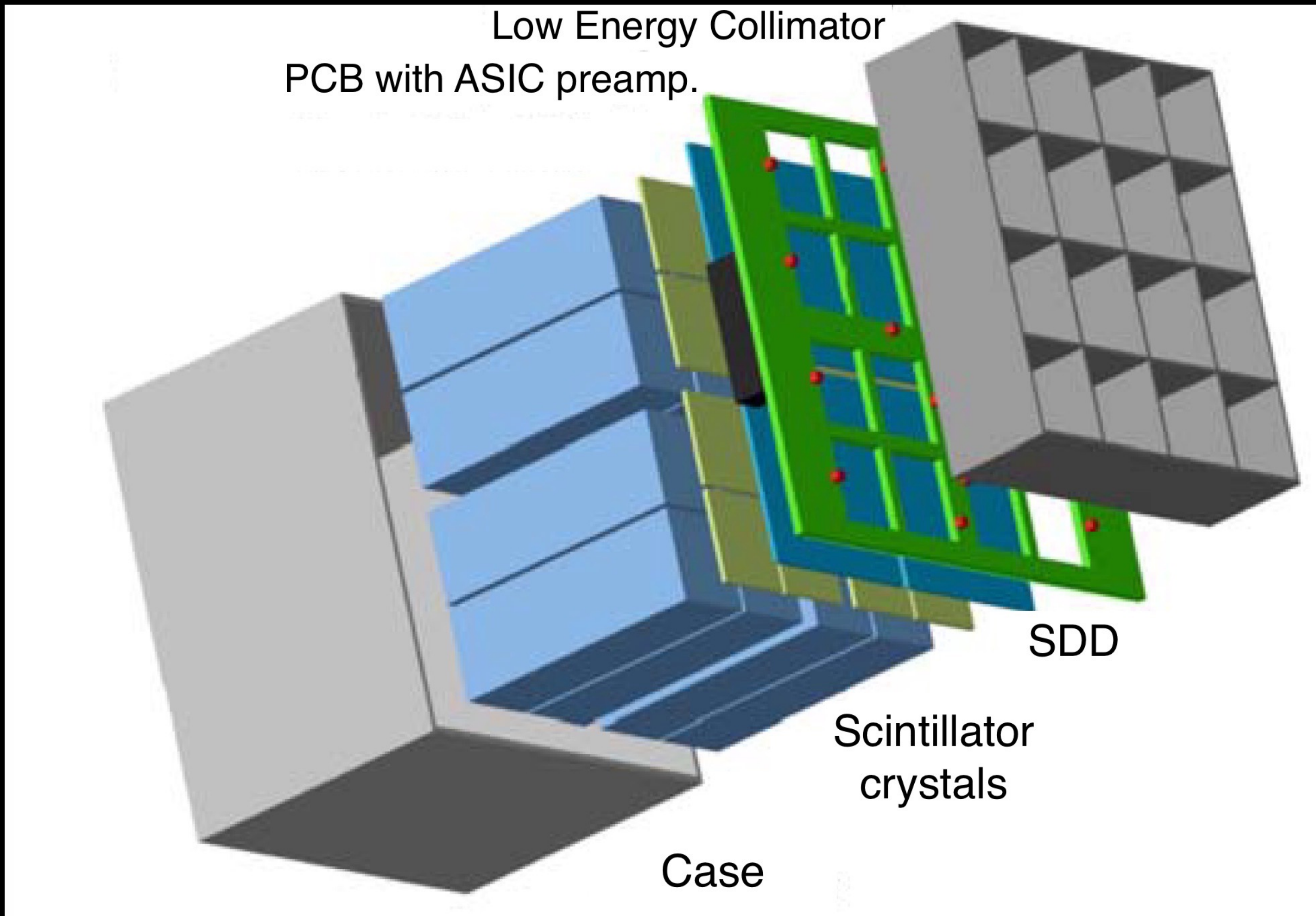
Download full burst info in minutes



Lavagna+2017

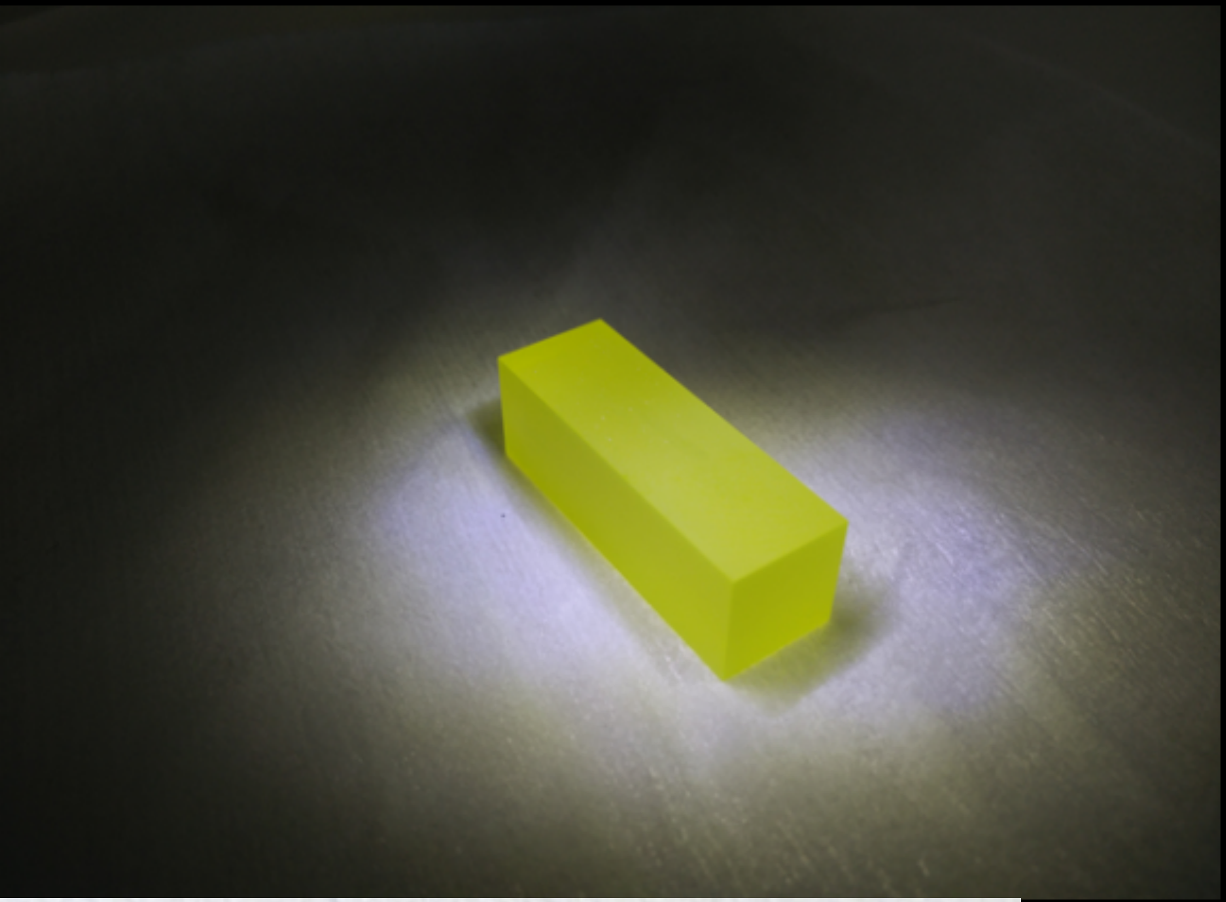
Payload

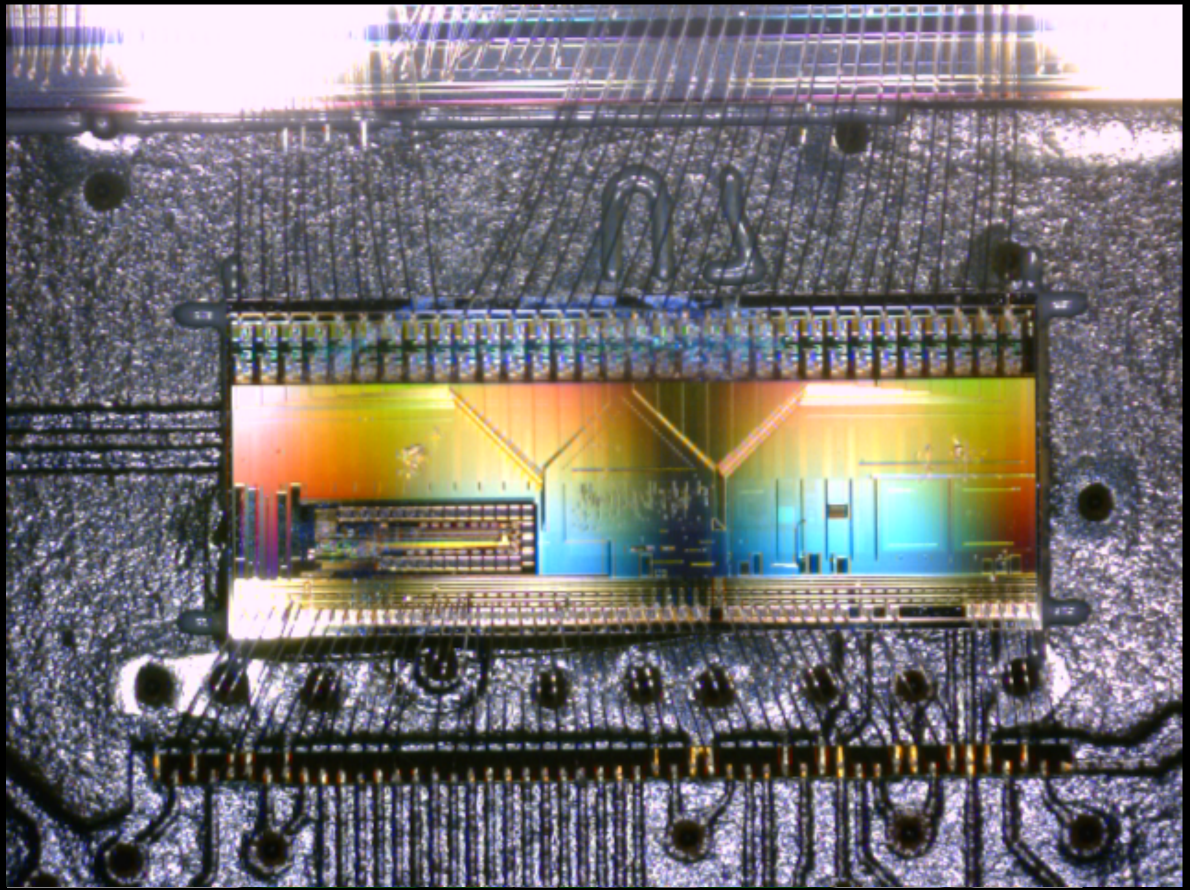
- Scintillator cristal GAGG Photo detector, SDD
- 5-300 keV (3-1000 keV)
- ~50 cm^2 coll. area
- a few st FOV
- Temporal res. 10-100 nsec
- ~1.8kg

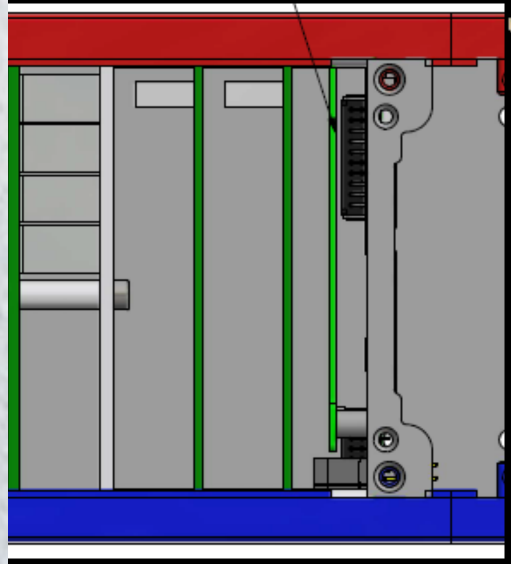


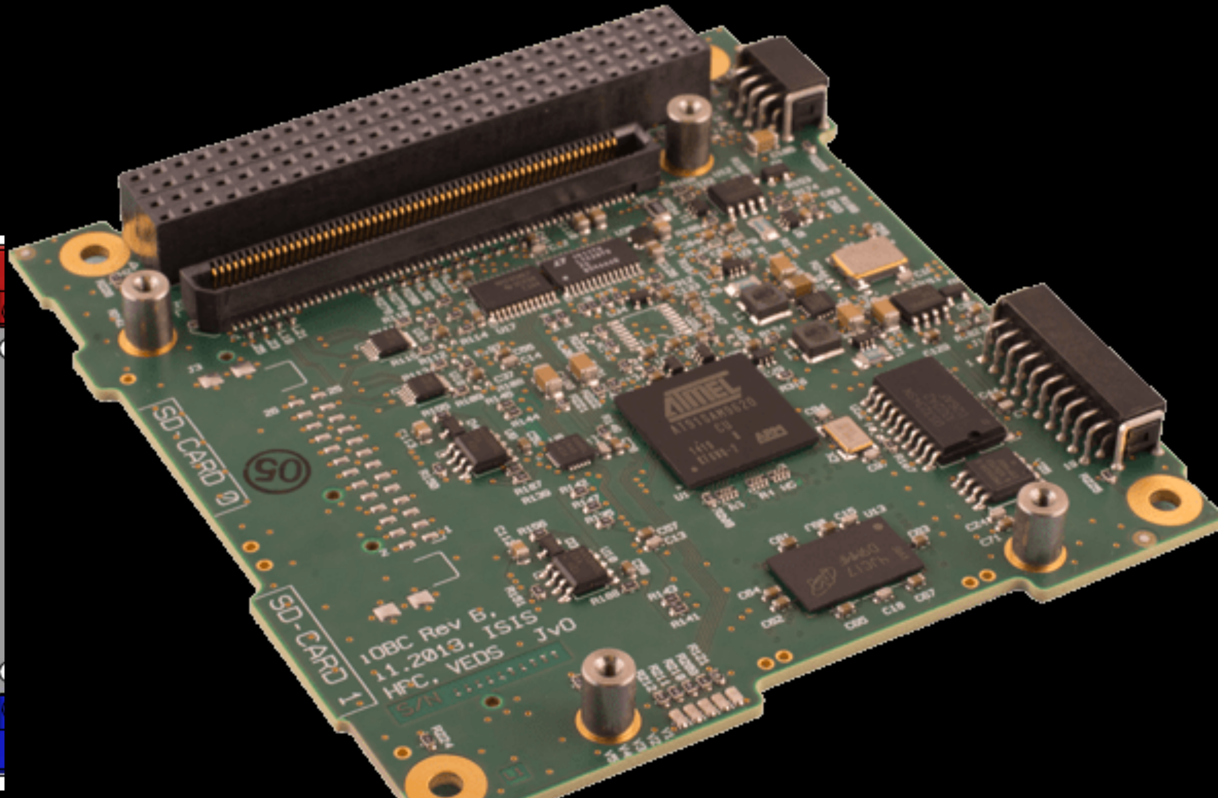
Fuschino+2018
Evangelista+2018
Campana+2018

From ppt to CAD to real stuff…









HERMES performances

Assumptions:

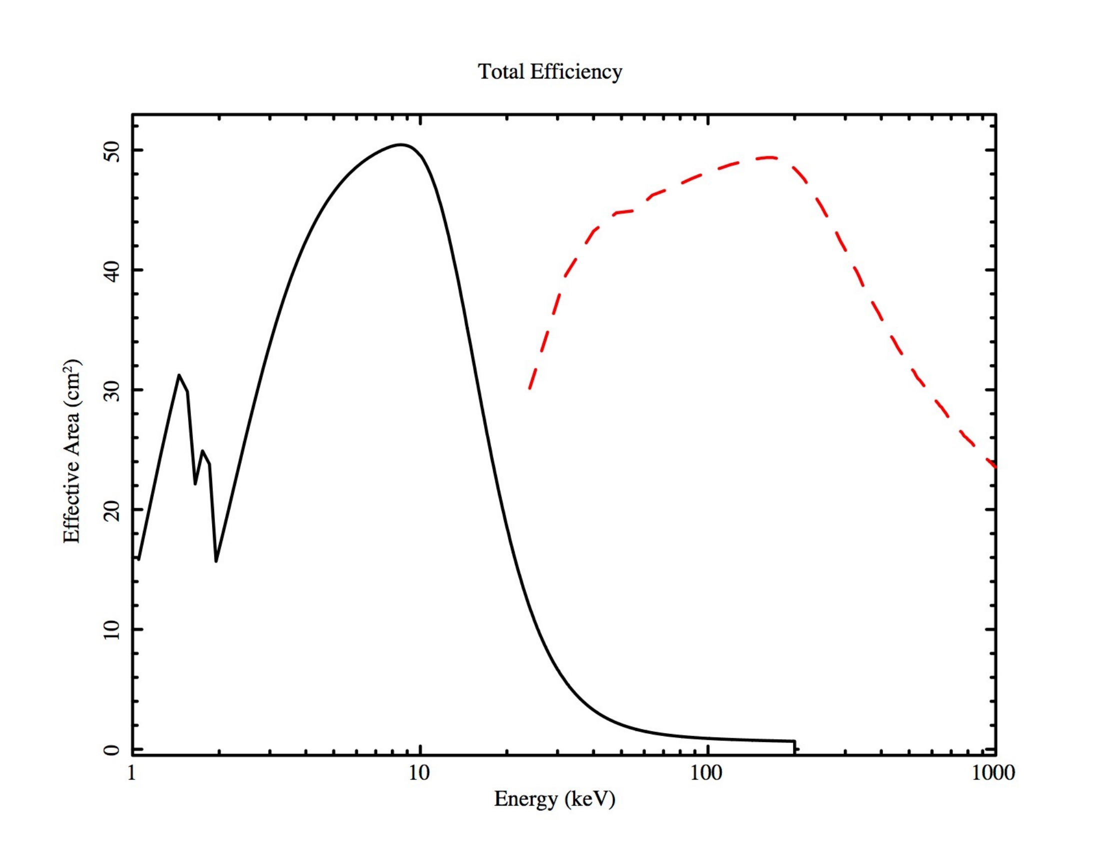
Instrument ~ 1 GBM module

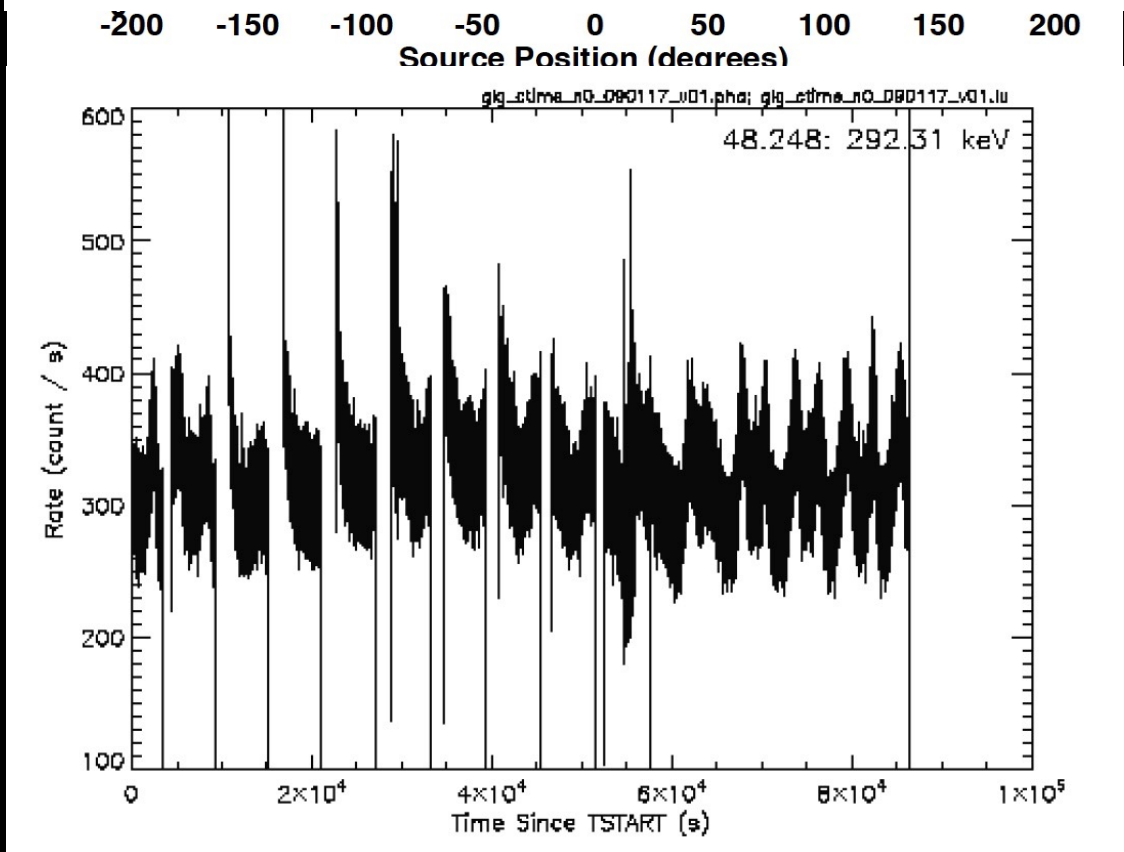
~100cm^2 collecting area

Offaxis response ~ a few sterad

Background ~ 300-500 cts/s 50-300 keV

Minimum detectable count rate ~ 1 ph/cm^2/s





HERMES performances

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

<B>~7000km

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

N(final constellation) ~100, active 50

$\sigma_{Pos(pathfinder)}$ ~ 1 arcmin if σ_{CCF}, σ_{sys}~10usec

$\sigma_{Pos(FC)}$ <1arcsec if σ_{CCF}, σ_{sys}~10usec

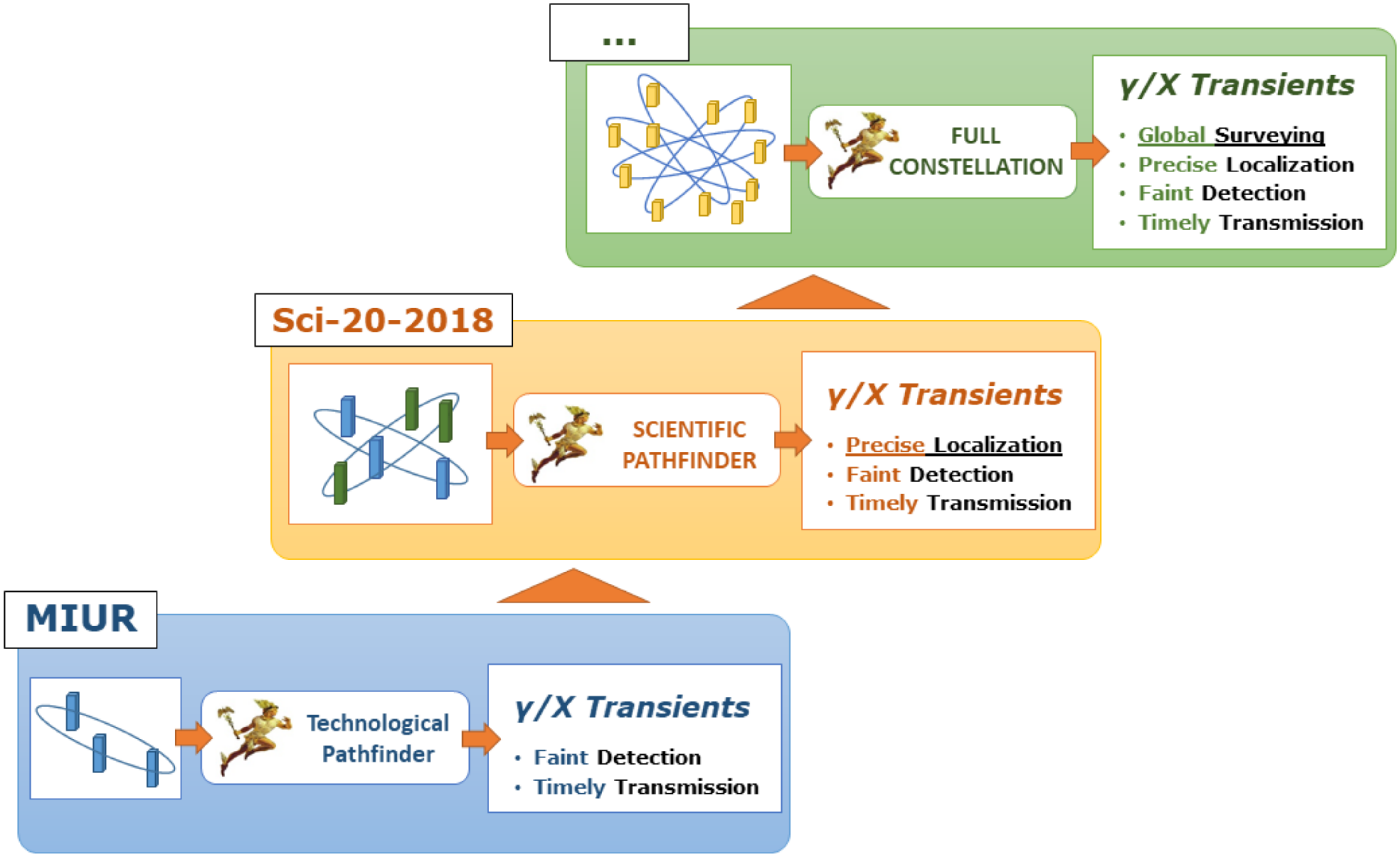
Bright GRBs with msec structure

$\sigma_{Pos(pathfinder)}$ ~ 2.4 deg if σ_{CCF},σ_{sys}~0.001s

$\sigma_{Pos(FC)}$ ~ 3 arcmin if σ_{CCF},σ_{sys}~0.001s

Short GRBs without substructure, risetime fraction of second.

Why HERMES now



- Trend in cost reduction of manufacturing and launching QS

Programmatics 1

Progetto Premiale 2015: **HERMES-Techonogic Pathfinder**

Main objectives:

1. Detect GRBs with simple payload hosted by a 3U CubeSat
2. Study statistical and systematic errors in the determination of the CCF

- KO May 2018
- CDR+QR T0+15 QM—> PFM1
- AR T0+24 —> PFM2+PFM3
- Launch mid-end 2020 ASI provided

(VegaC maiden flight or Vega, or other opportunities)

Programmatics 2

H2020 SPACE-SCI-20: **HERMES-Scientific Pathfinder**

- Main objectives:
    1. First GRB localization experiment with ≥4 CubeSat
    2. Study the systematics associated to the localization
- KO November 2018
- CDR+QR T0+15 QM—> PFM1
- AR T0+24 —> PFM2+PFM3
- Launch 2021 (ASI provided)

Programmatics 3

ASI 2019: **HERMES - Advanced Scientific Pathfinder**

- Main objectives:

  1. Nearly all sky coverage

  2. First accurate GRB localization experiment with ≥6 CubeSat

- Submitted to ASI September 2018

- Launch 2022? (ASI provided)

HERMES Institutes

- INAF, ASI, PoliMi, UniCagliari, UniPalermo, UniUdine, UniTrieste, UniPavia, UniFedericoII, UniFerrara, FBK, FPM

HERMES is open to ideas and collaboration

Want to be involved? Send an e-mail

fabrizio.fiore@inaf.it

burderi@dsf.unica.it