全天MeVガンマ線観測衛星計画 AMEGO-Xの状況と日本の関わり

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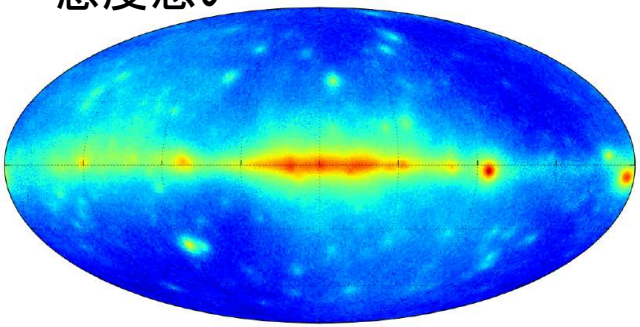
昨今のガンマ線天文学の発展

2000年代　　TeVガンマ線望遠鏡観測の本格化（天体数200に迫る）
2008年以降　フェルミ衛星によるGeVガンマ線観測の飛躍（天体数5000以上）
2020年代　　CTAによるTeVガンマ線観測の発展（天体数1000以上が期待）

一方、MeVガンマ線観測は.....
(数100 keV– 数10 MeV)

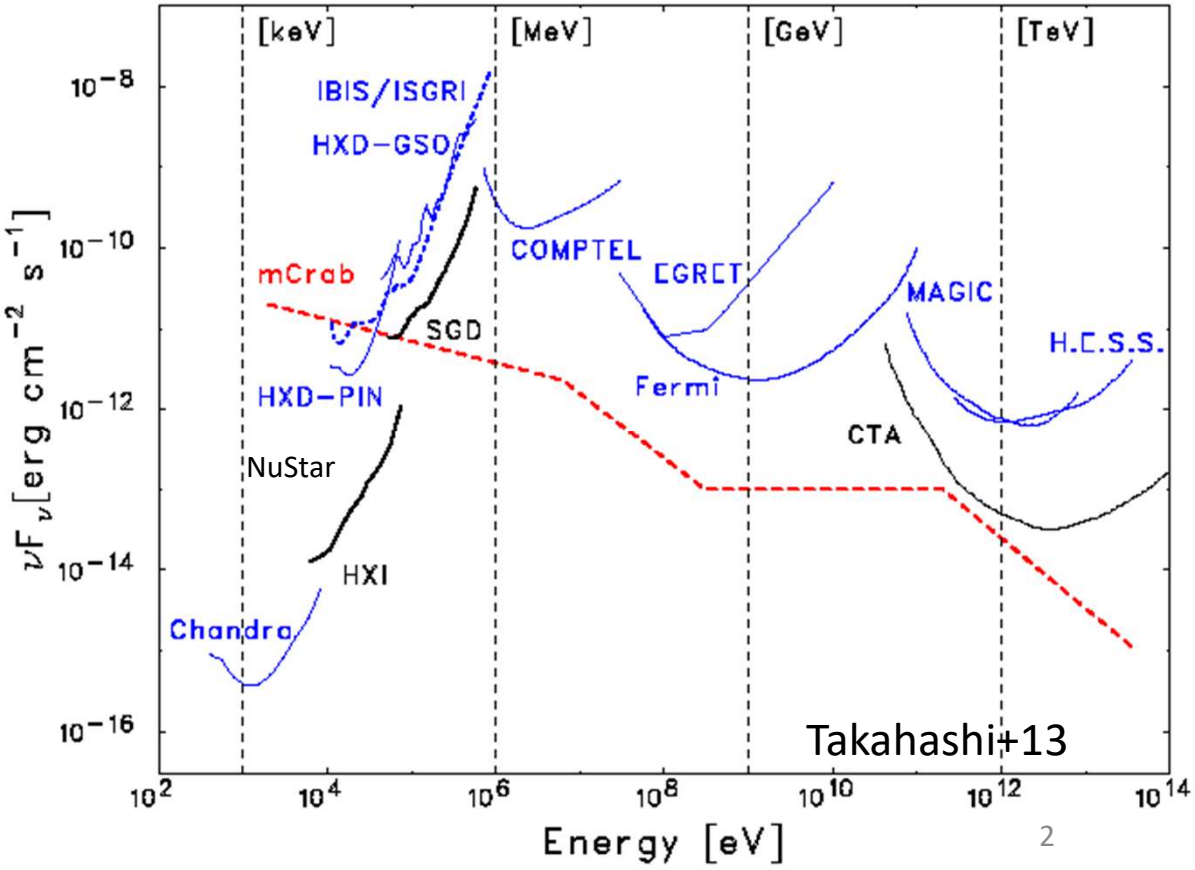
1990年代のCGRO衛星COMPTEL以降進展無し
（天体数 約30）

Fermiでも100MeV以下は
感度悪い



Fermi/LAT 30-100MeV

Principe+18



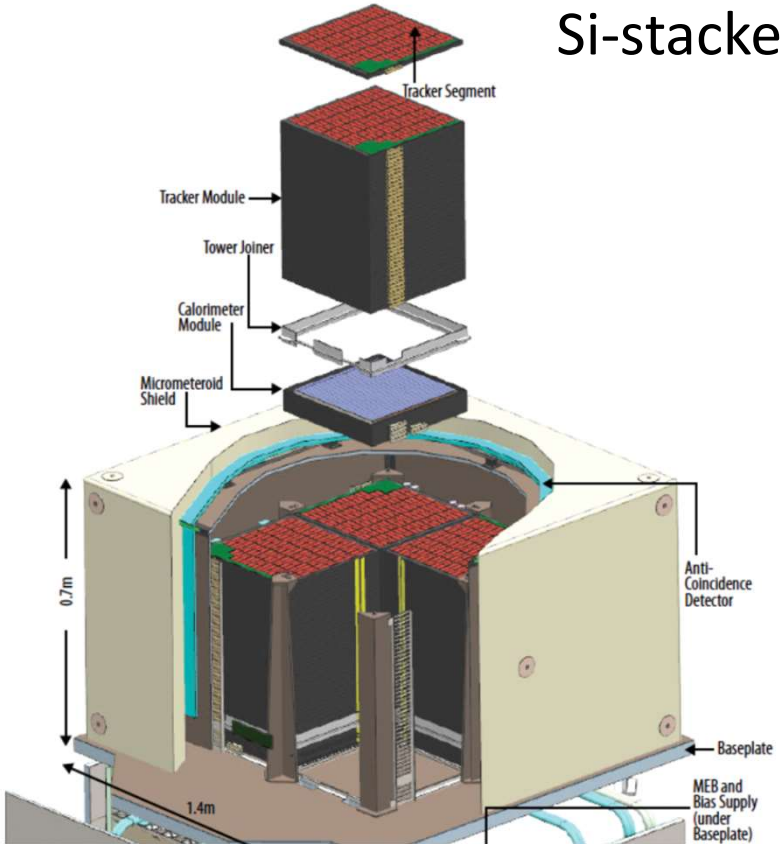
AMEGO-X

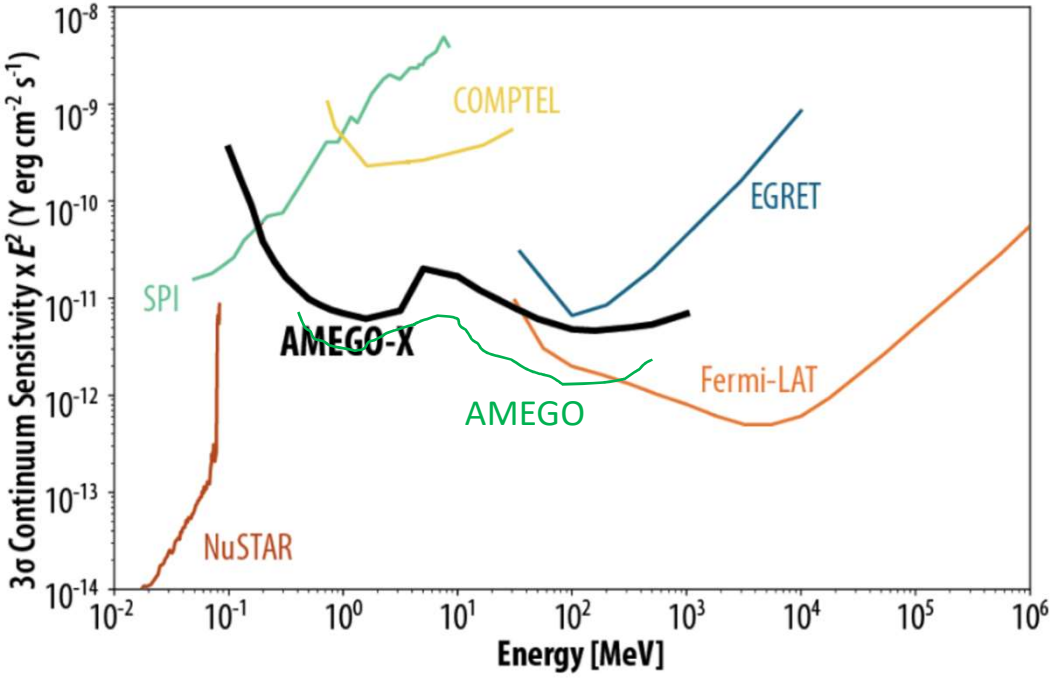
All-sky Medium Energy Gamma-ray Observatory Explorer

PI: Regina Caputo
(GSFC/NASA)

日本人メンバー
田島、深沢、須田

Si-stacked Compoton Telescope



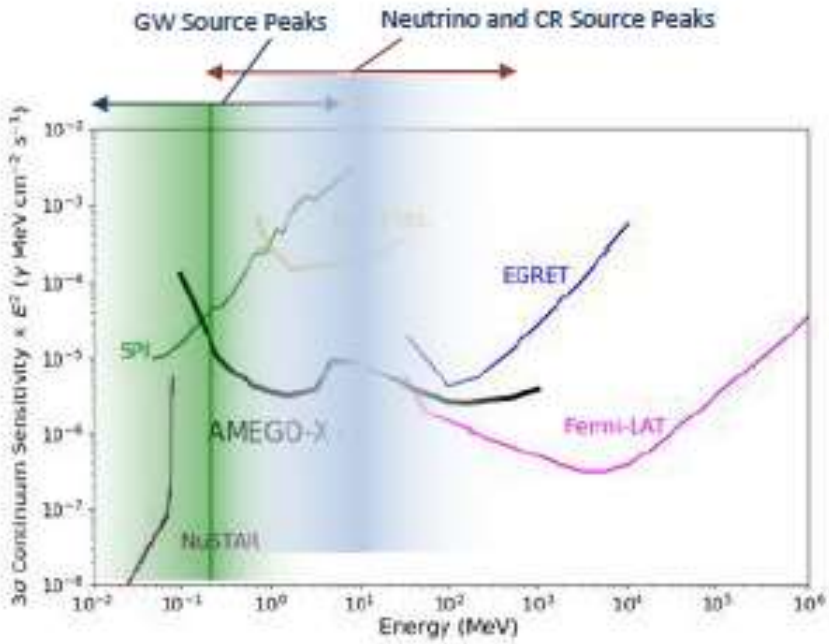


AMEGO-Xの基本要求性能

AMEGO-X will:

- Be at least 10x more sensitive than the previous MeV instrument COMPTEL
- Detect 1000x lower energies than *Fermi*-LAT
- Achieve >10x better localization than *Fermi*-GBM

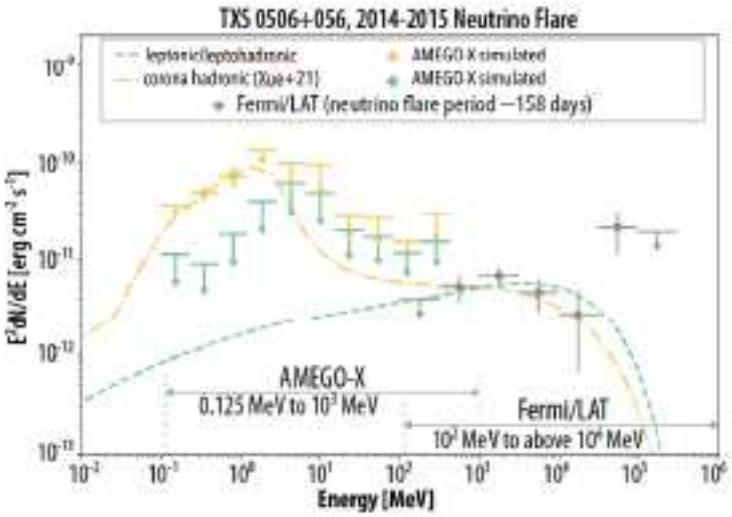
Energy Range	100 keV - 1 GeV
Angular Resolution	3° (1 MeV), 2° (100 MeV)
Field of View	2pi sr (50% of the sky)
Transient Sensitivity (ph cm^{-2})	0.5 (100 keV-1 MeV) 1s
Continuum Sensitivity (MeV cm^{-2} s^{-1})	2x10^{-6} (100 MeV) 3 yr

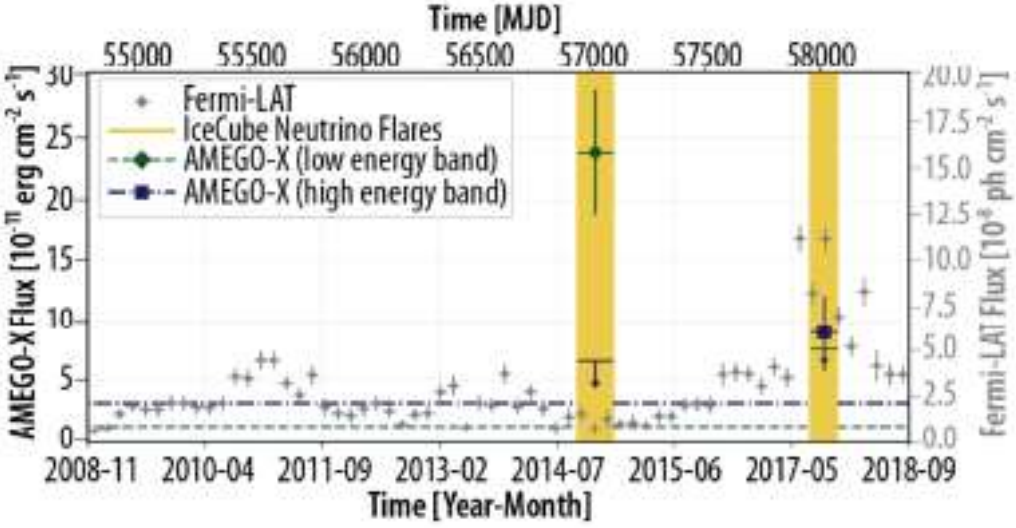


AMEGO-X will lead to major scientific discoveries and breakthroughs in the MeV gamma-ray band like Fermi-LAT in the GeV band

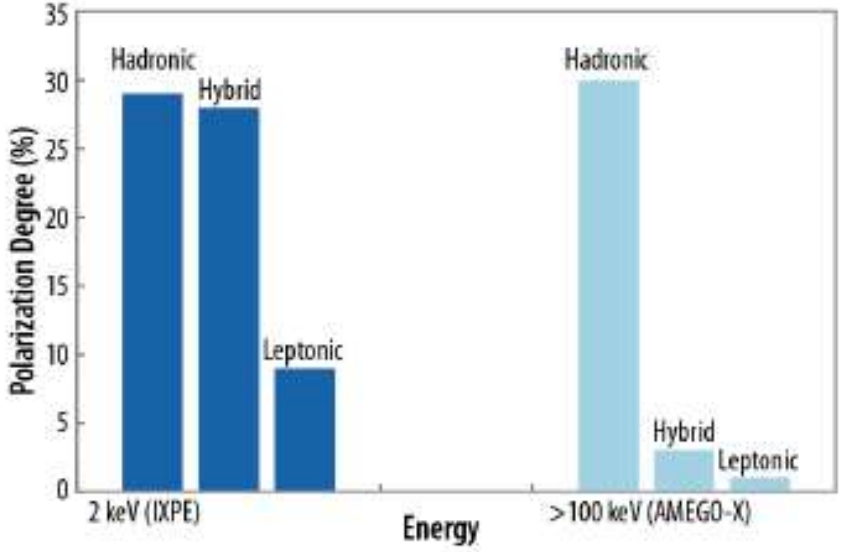
AGN関連サイエンス

HE-νに同期したガンマ線(GeV,TeVでは不透明)

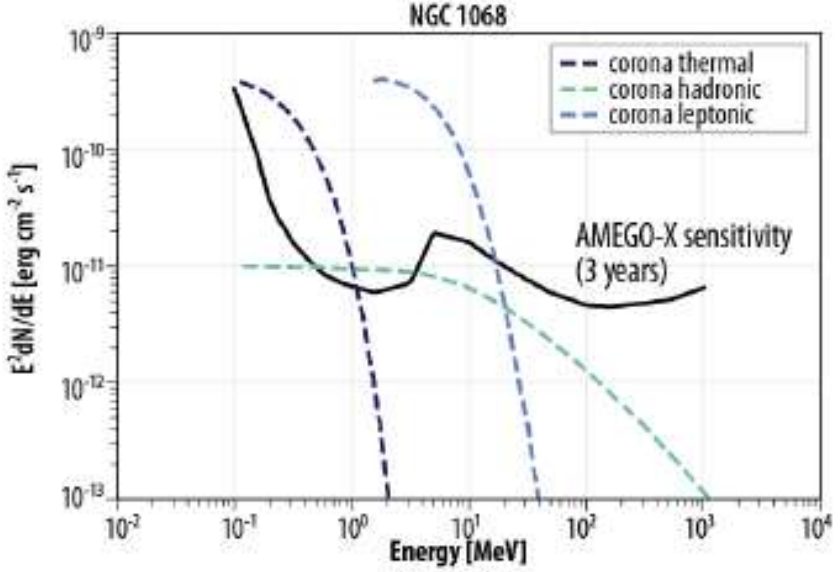




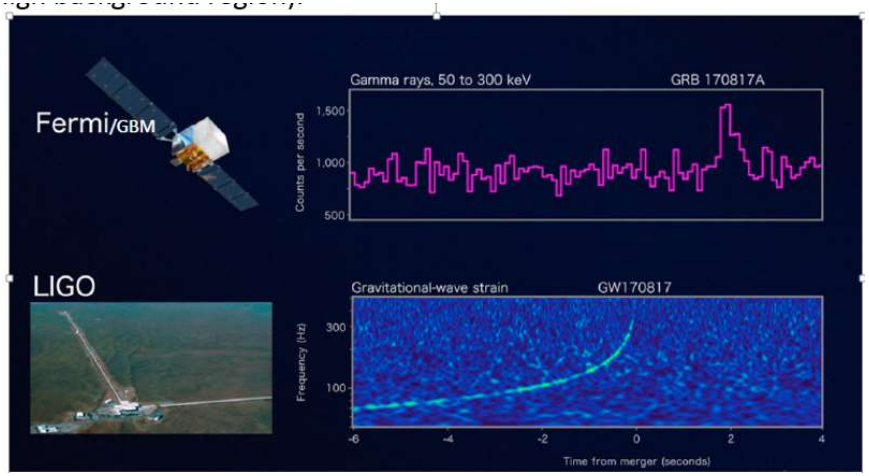
偏光によるレプトン、ハドロン放射の区別



Non-jetted AGN　のガンマ線, HE-ν放射

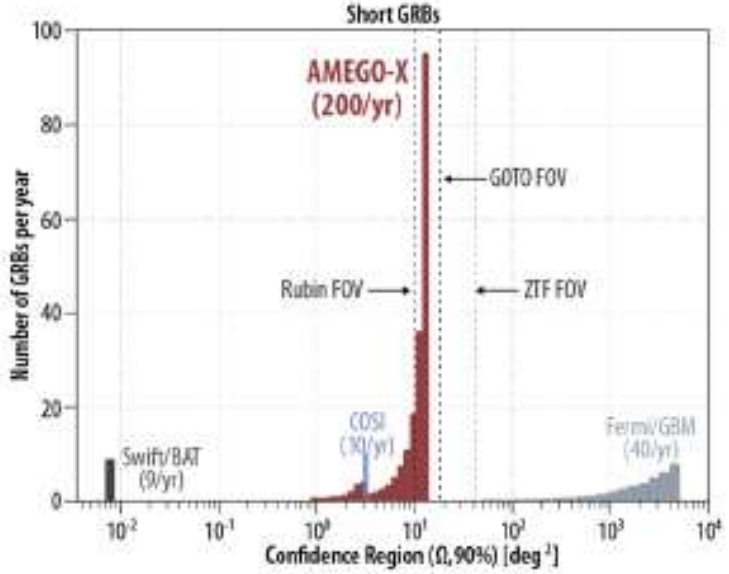


ガンマ線バースト関連サイエンス

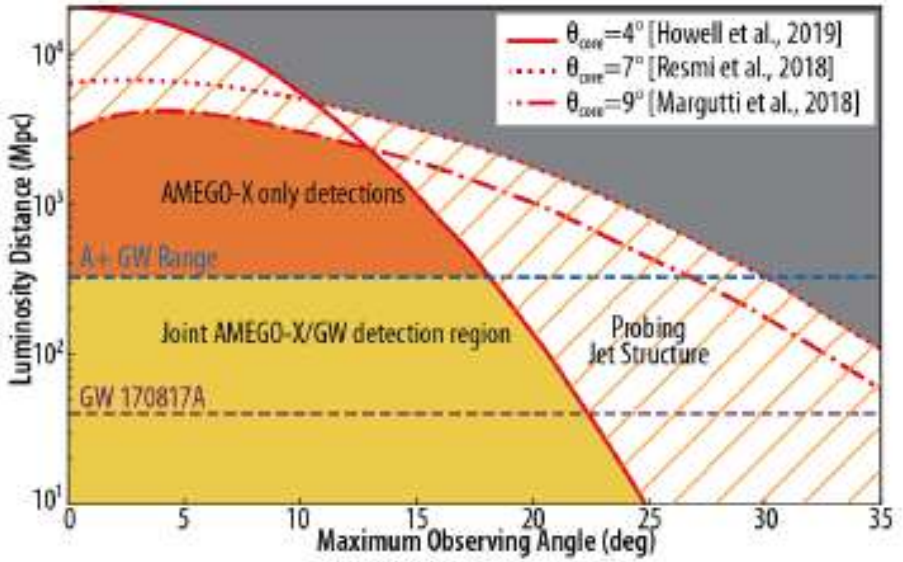


暗いガンマ線バーストも検出

GWとの同期イベントの高感度広視野サーチ

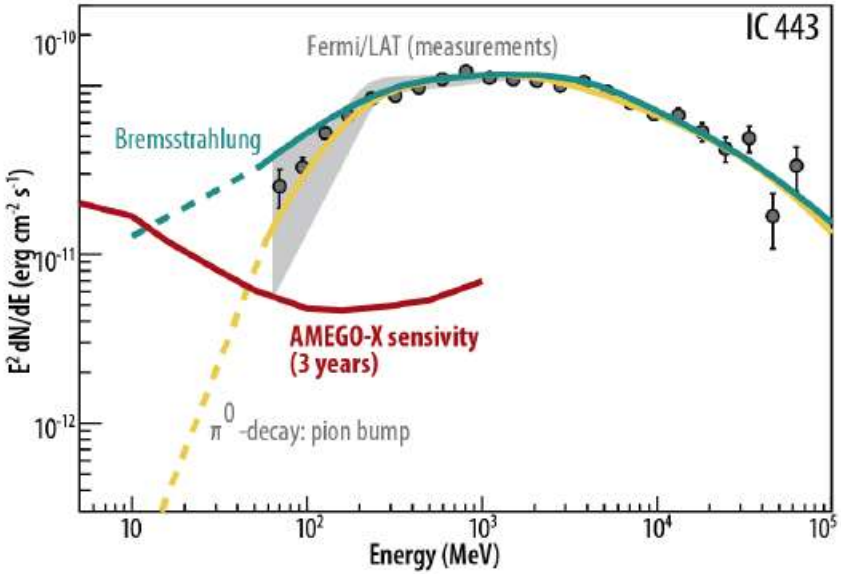


ジェット放射の見込み角分布

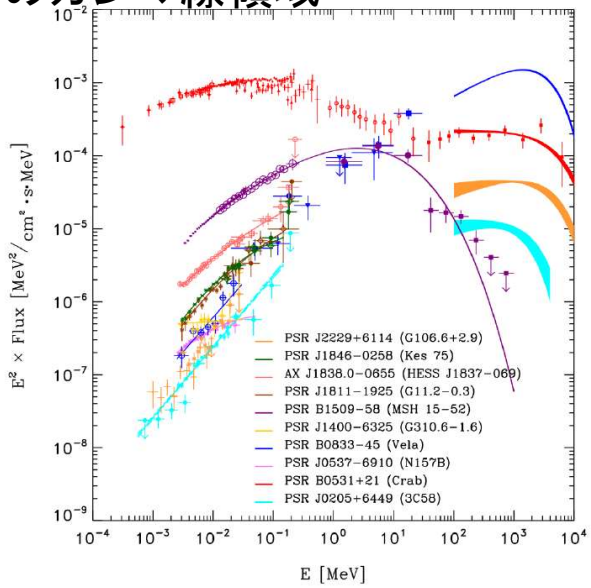


銀河宇宙線関連

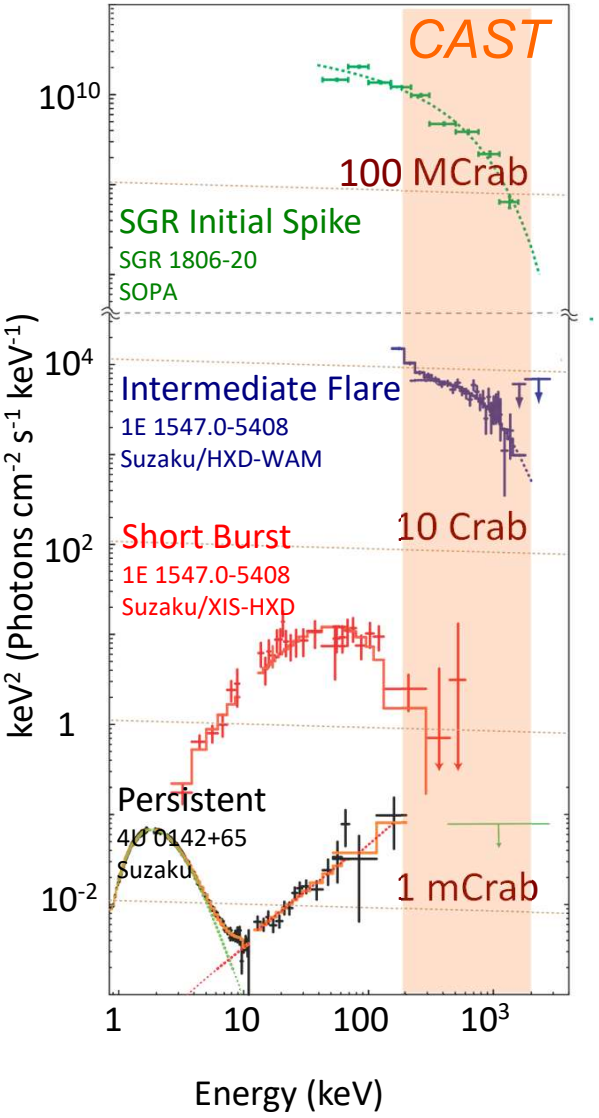
陽子由来パイオン成分の精密測定



パルサーのガンマ線領域

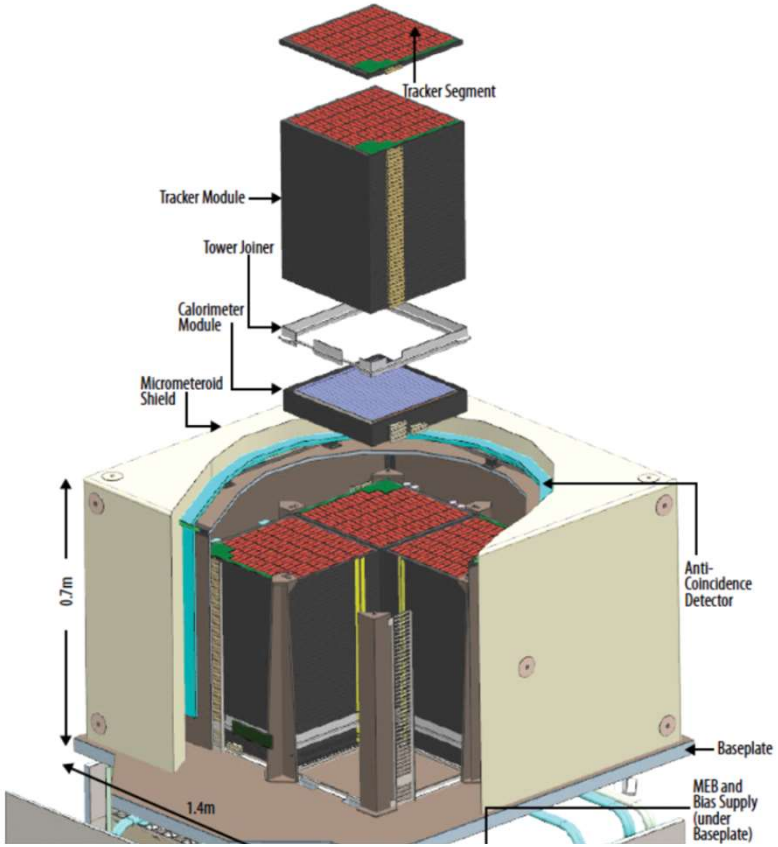


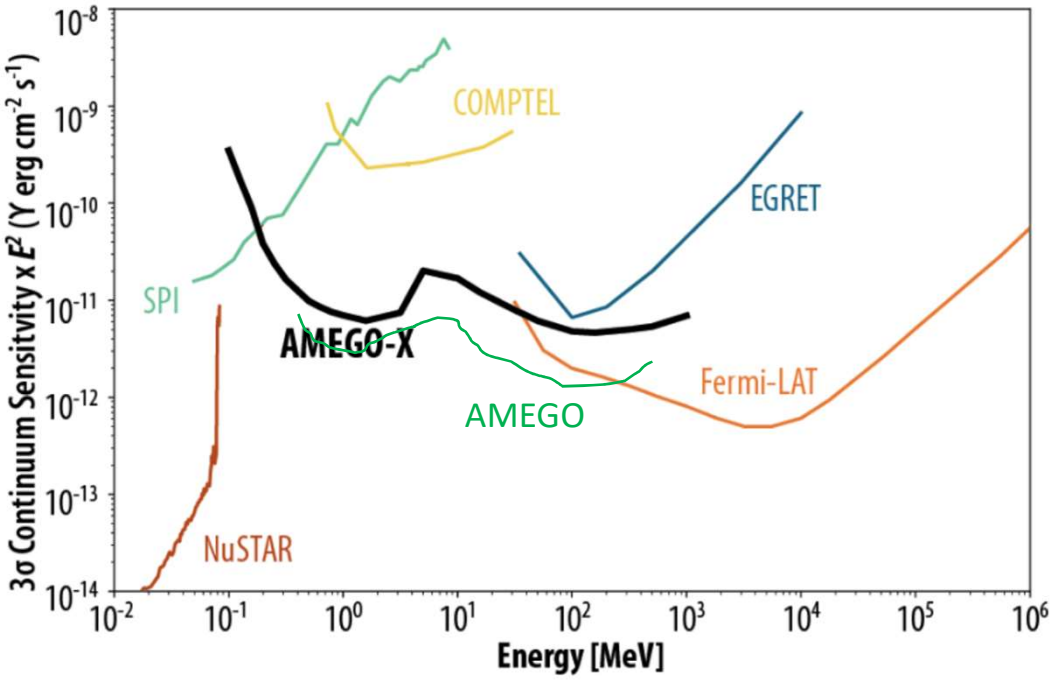
マグネターのフレア



AMEGO-X

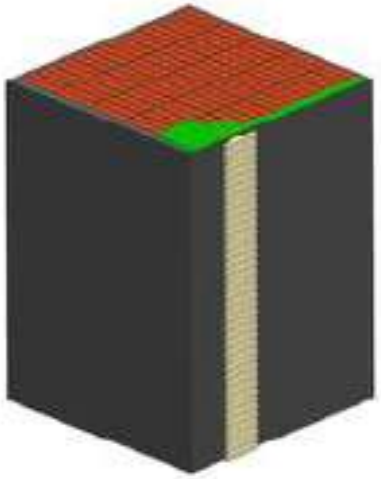
現状で最も技術習熟や実績のある技術で、
できるだけ早く実現
　半島隊コンプトンカメラ　＋フェルミ衛星の継承

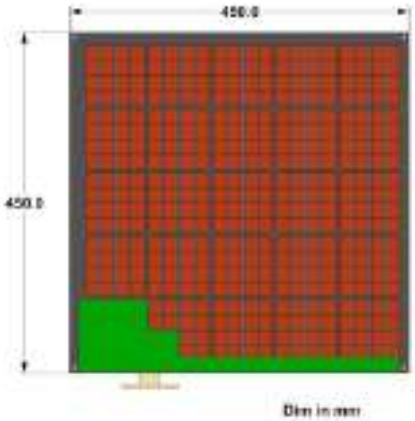


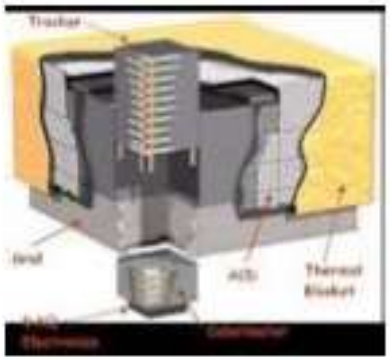


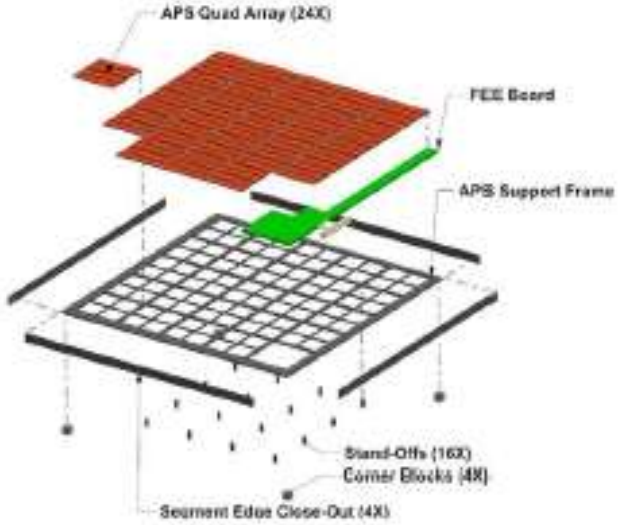
Tracker

- The Tracker Module is composed of 40 Tracker Segments
- The Tracker Segment is composed of 380 APS arrays, an FEE Board and a segment frame
- Draws on heritage from Fermi-LAT



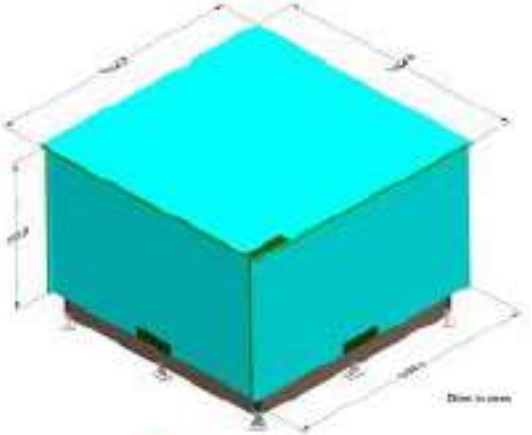


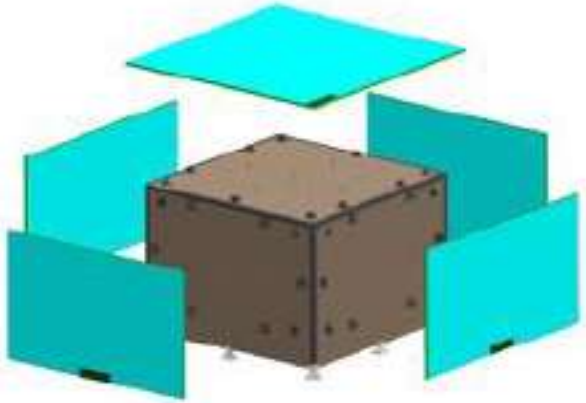




Anticoincidence Detector

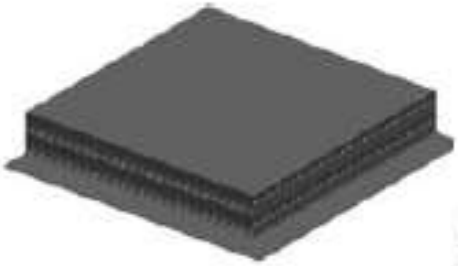
- The Anti-coincidence Detector is composed of 5 Panels
- Each Panel is composed of scintillator tiles with WLS bars and SiPMs on the edge
- FEE cards are on bottom of side panels and in corner of top panel
- Each panel is mounted to the ACD structure
- Draws on Fermi-LAT Heritage

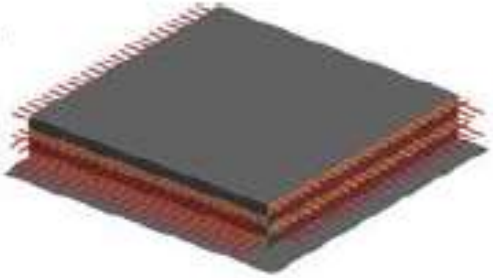


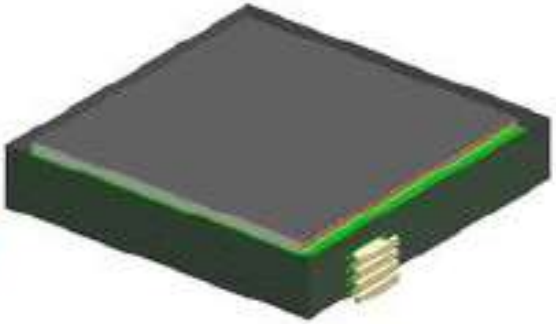


Calorimeter

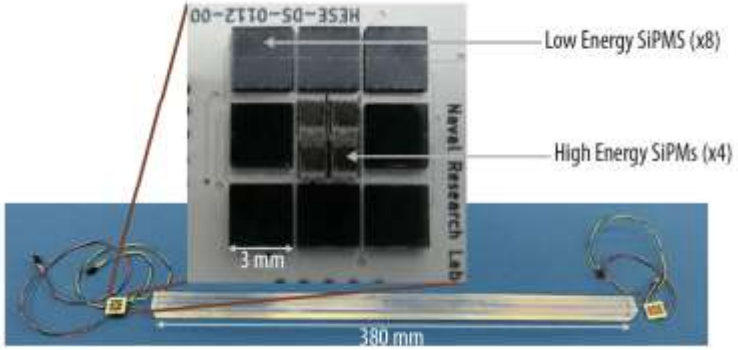
- The Calorimeter is a 4 layer module
- The 4 layers of CsI Crystals are installed in a unibody frame
- Each Crystal has high and low energy SiPMs on each end
- The SiPMs feed the FEE PCB
- Draws on heritage from Fermi-LAT

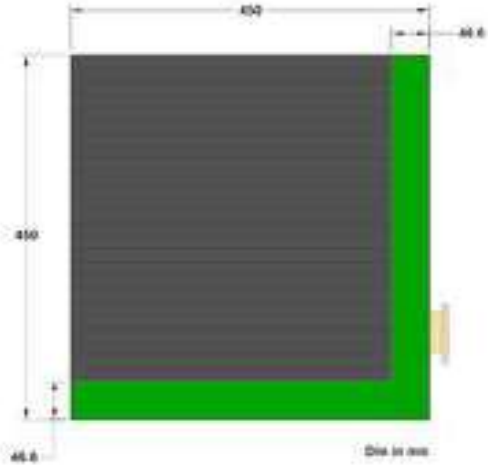






FERMI-LAT Calorimeter Structure Design





AstroPix

HV-CMOS from ATLASPix

pix size: 0.5mm or 1mm

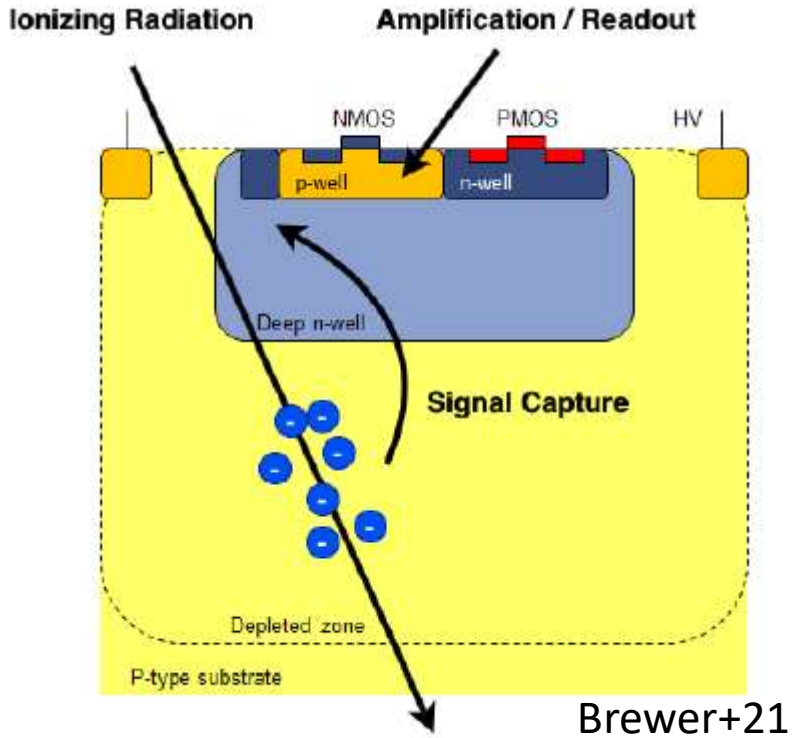
Give lower threshold than DSSD

60 keV → 25 keV

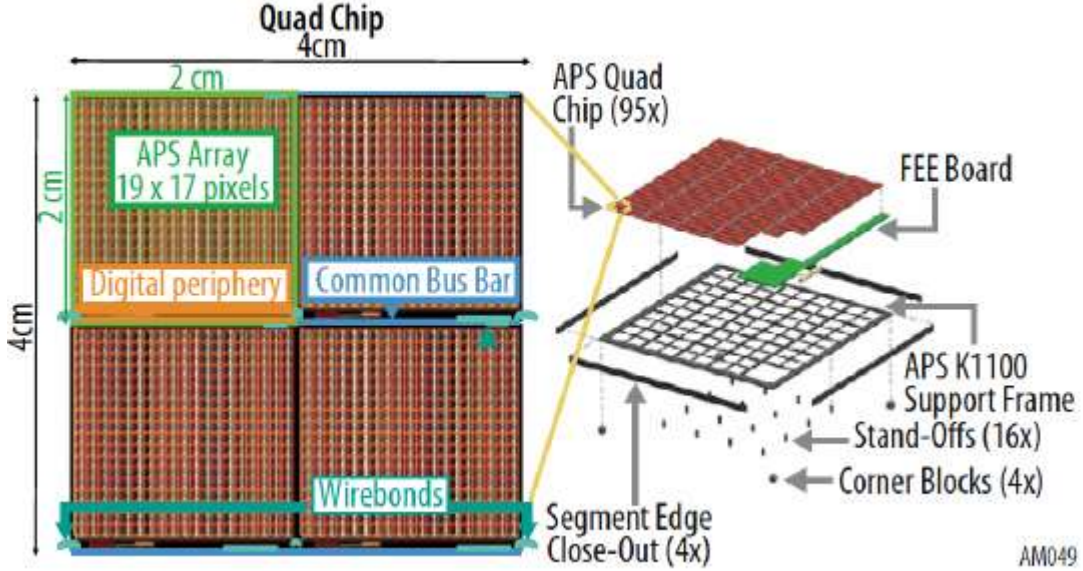
Improve low-E performance

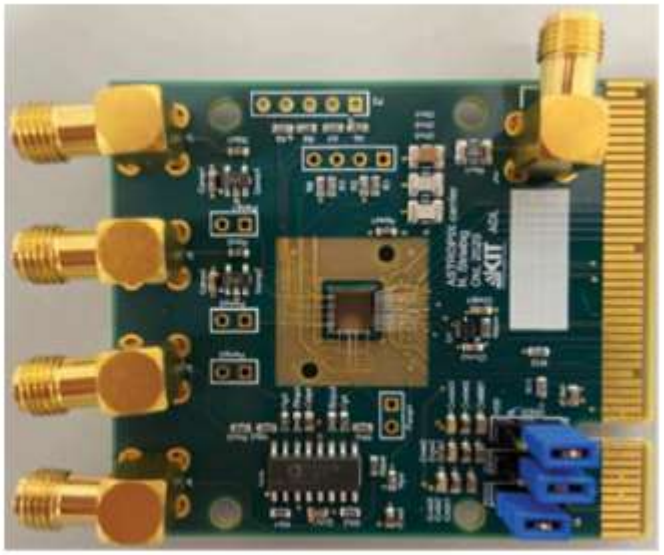
(below 1 MeV)

<1.5mW/cm2



Brewer+21





AstroPix Series

AstroPix1
2021

AstroPix2
2022

AstroPix3
2023

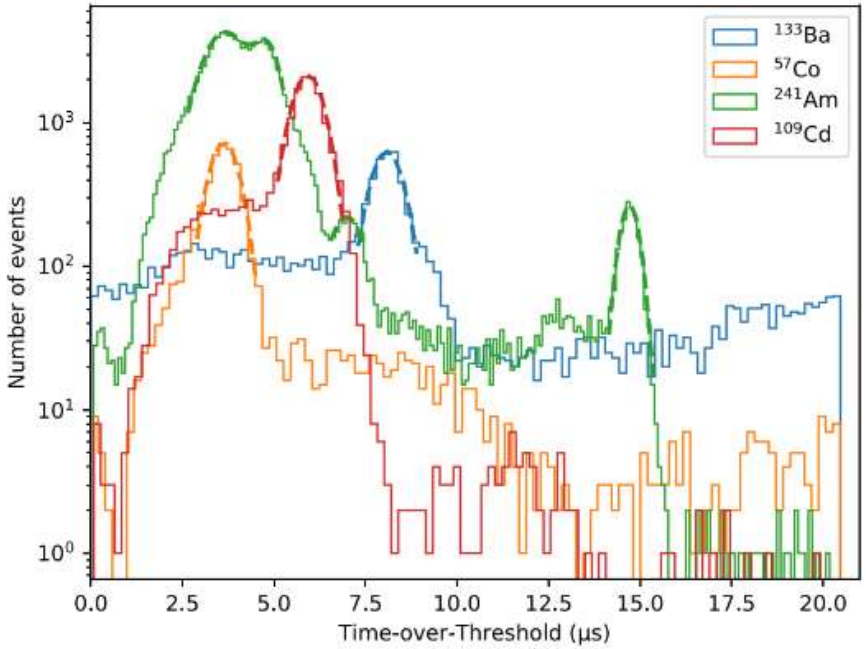
AstroPix4
2024

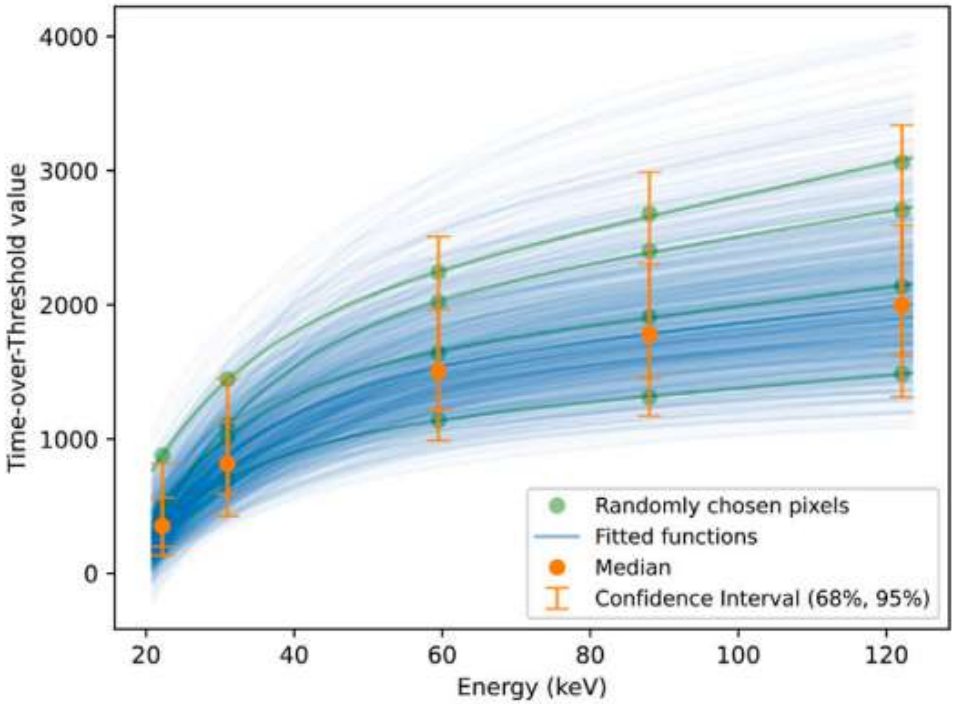
AstroPix3 Quad-chip
(Flight prototype)

AstroPix5 will be delivered.
2025

Evaluation of analog properties
Energy scale and linearity, dynamic range, gain, etc
Measurement of depletion depth
Measurement of sensitive area

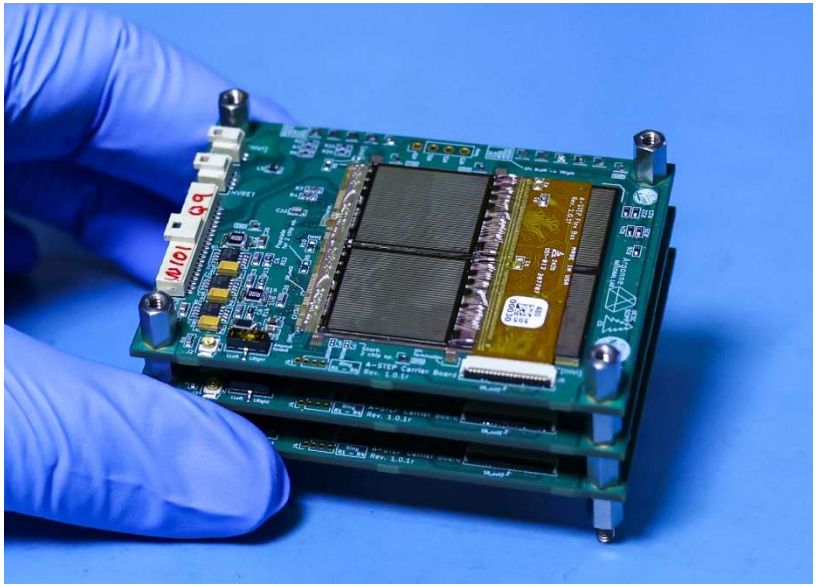
Suda＋24、NIM-A

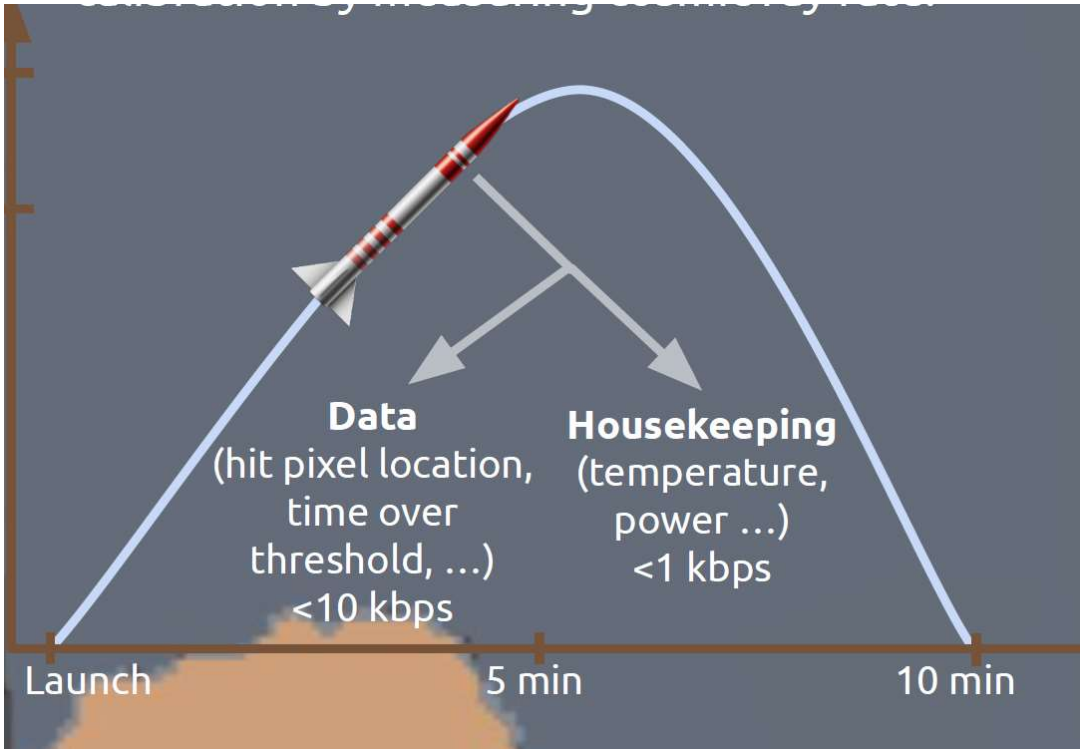


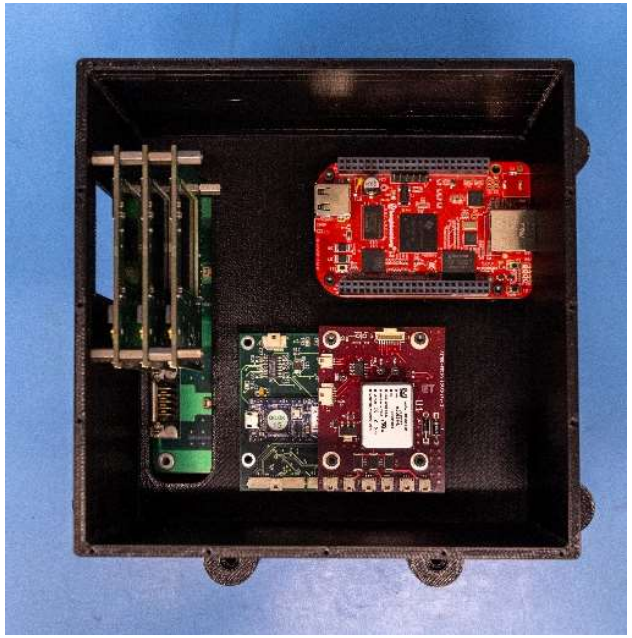


A-STEP

Sounding rocket 2026

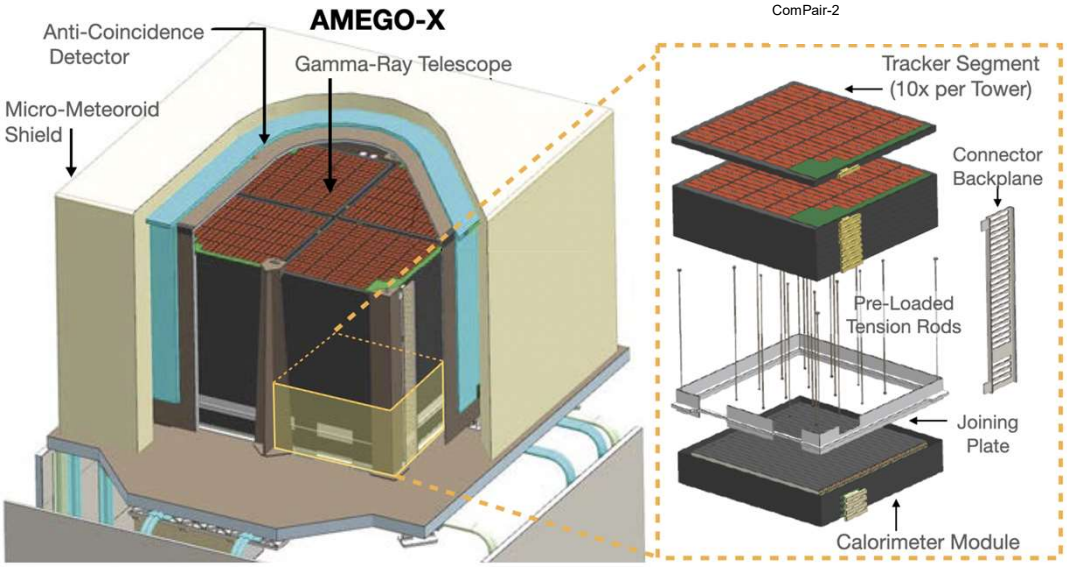


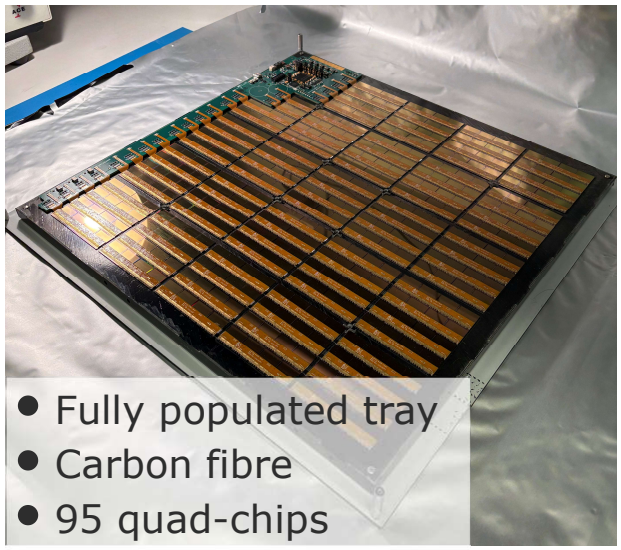




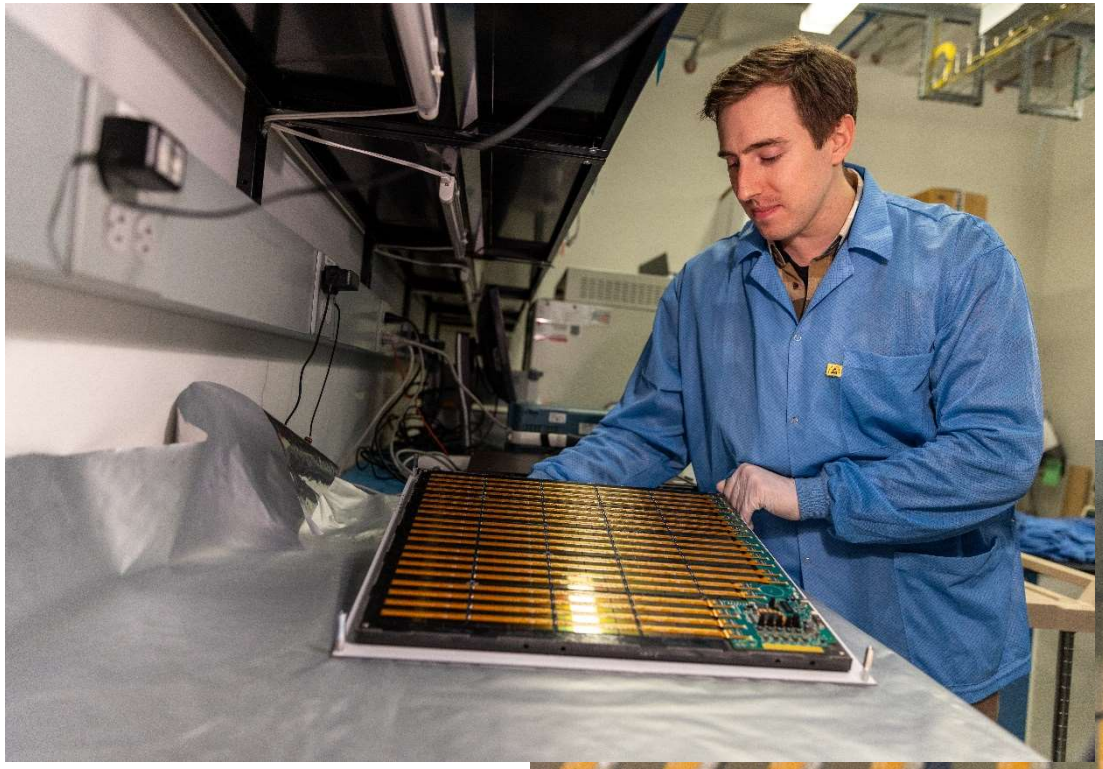
Prototype Telescope

ComPair-2 One tower with 10 layers





- ComPair-2 (PI: R. Caputo (GSFC/NASA)): AstroPix tracker + CsI calorimeter
  - Demonstration of Compton and Pair reconstructions
- Instrument integration, environmental testi test in **2026-2027**
  → Long duration balloon flight

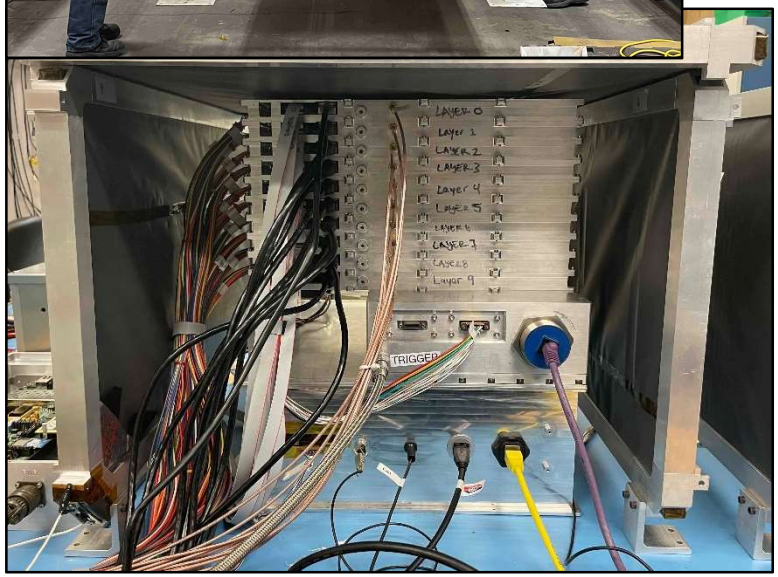


AstroPix tracker tower

one tower with 10 layers

IT and V,TV test in 2026

Balloon flight experiments of Compare-1 (DSSD ttacker)



Date/Time Launched: 27 August, 2023 / 08:57:20 MT

Launch Site: Ft Sumner, NM

Experience can be used for AstroPix tracker Tower.

2022 MIDEX proposal　not accepted

　the highest rank among the dropped ones

2024kick-off meeting for next MIDEX proposal

　7 core members (深沢も参加)

　hardware team強化 （イタリア参加）

2025-2027　toward MIDEX proposal

　discussion for science matrix and hardware

2027 MIDEX propisal