

# 全天MeVガンマ線衛星計画AMEGO-Xの現状

## Status of AMEGO-X, the All-sky Medium Energy Gamma-ray Observatory eXplorer

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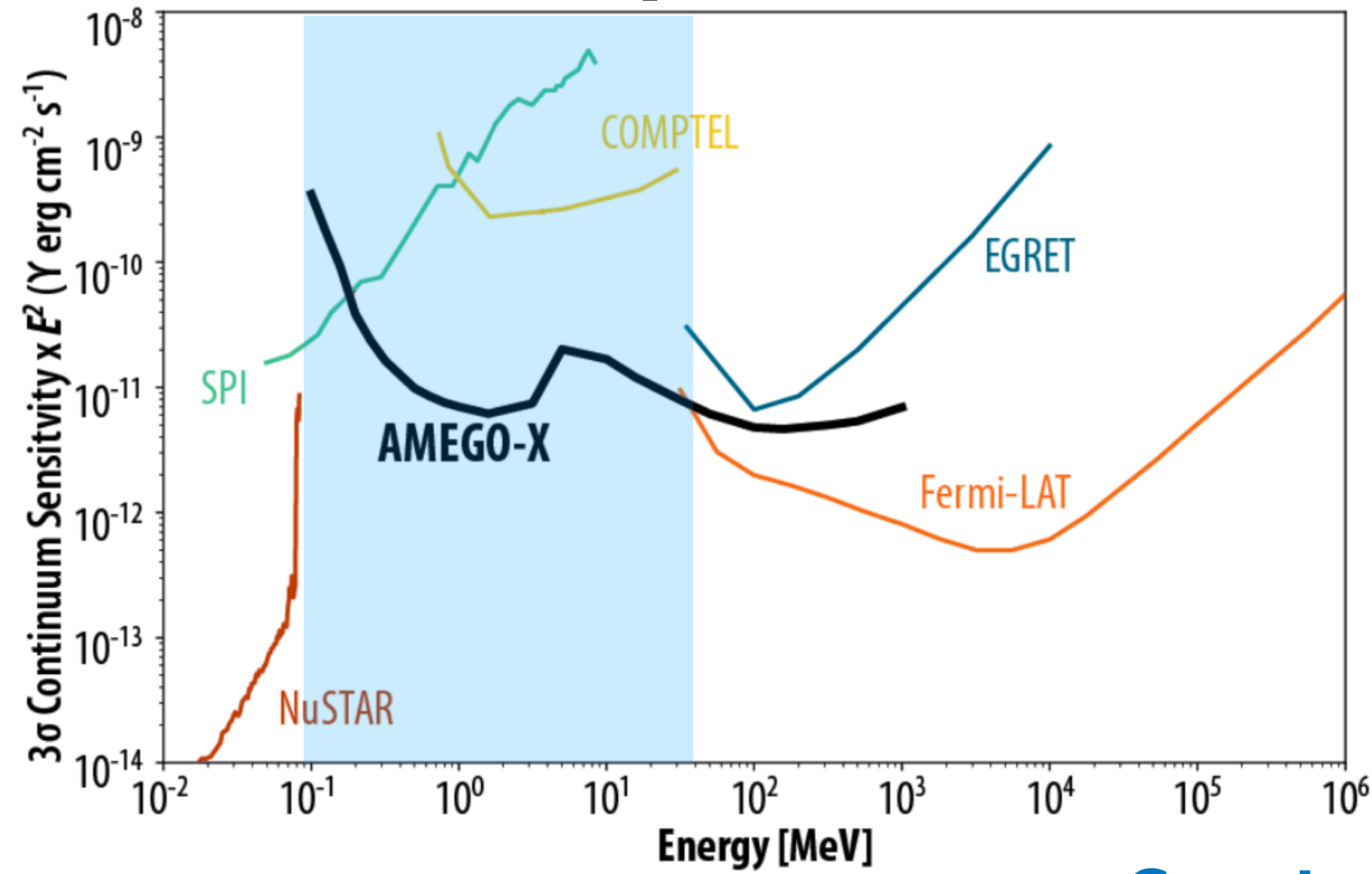
JPS 2025 Autumn Meeting

Hiroshima University

Sep 19, 2025

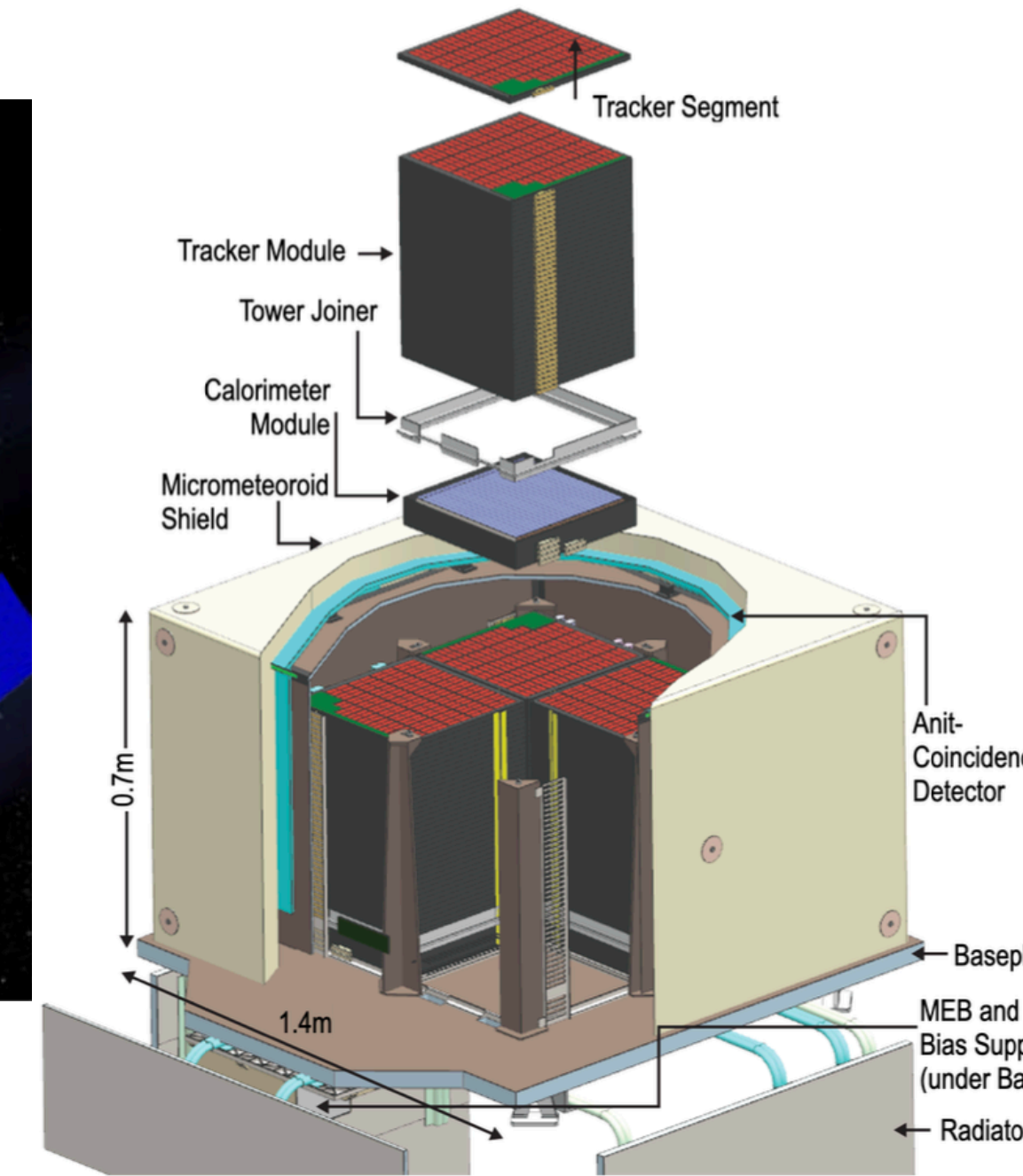
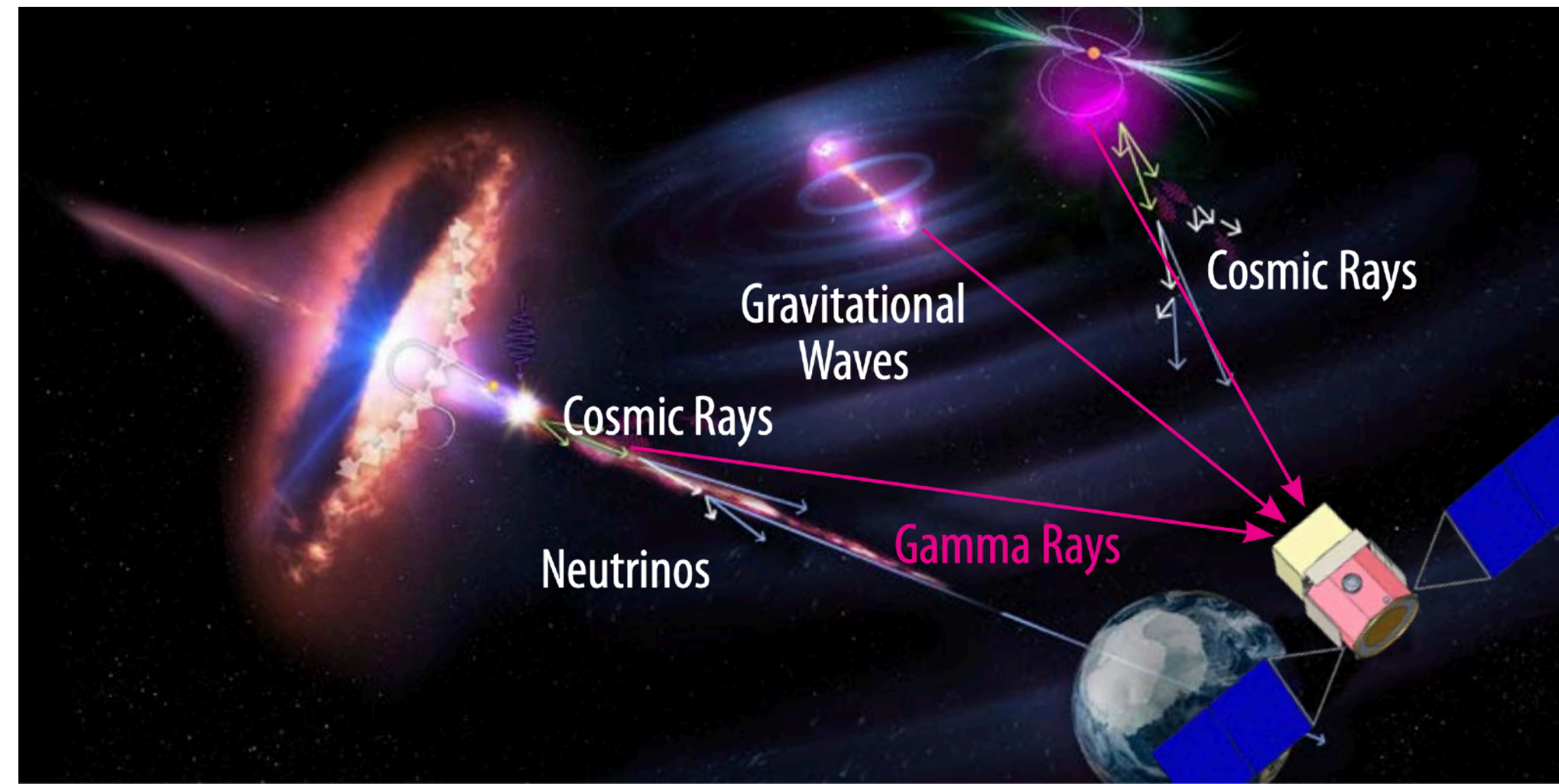
# AMEGO-X: All-Sky MeV Gamma Satellite

## "MeV Gap"



[Caputo+22 JATIS](#)

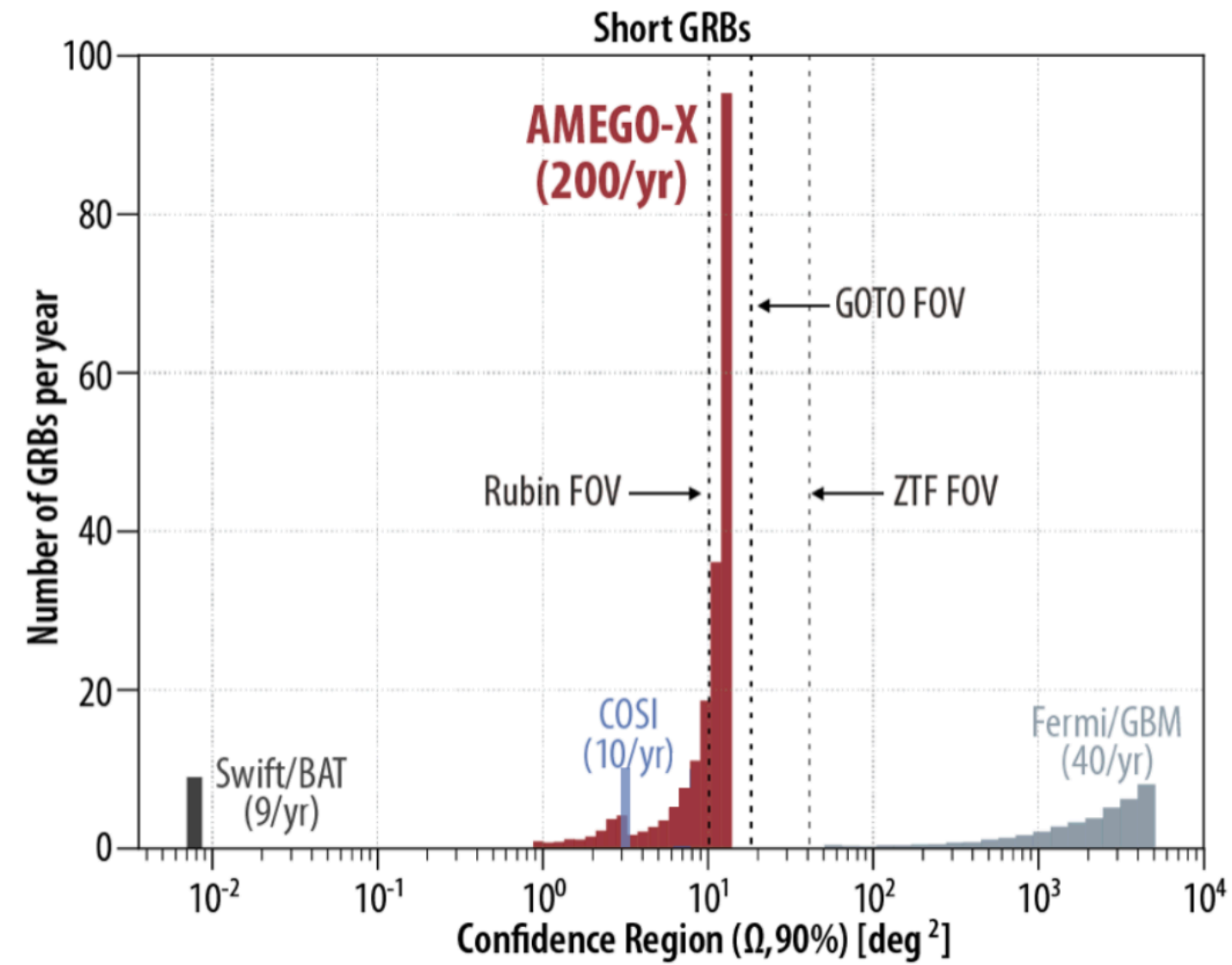
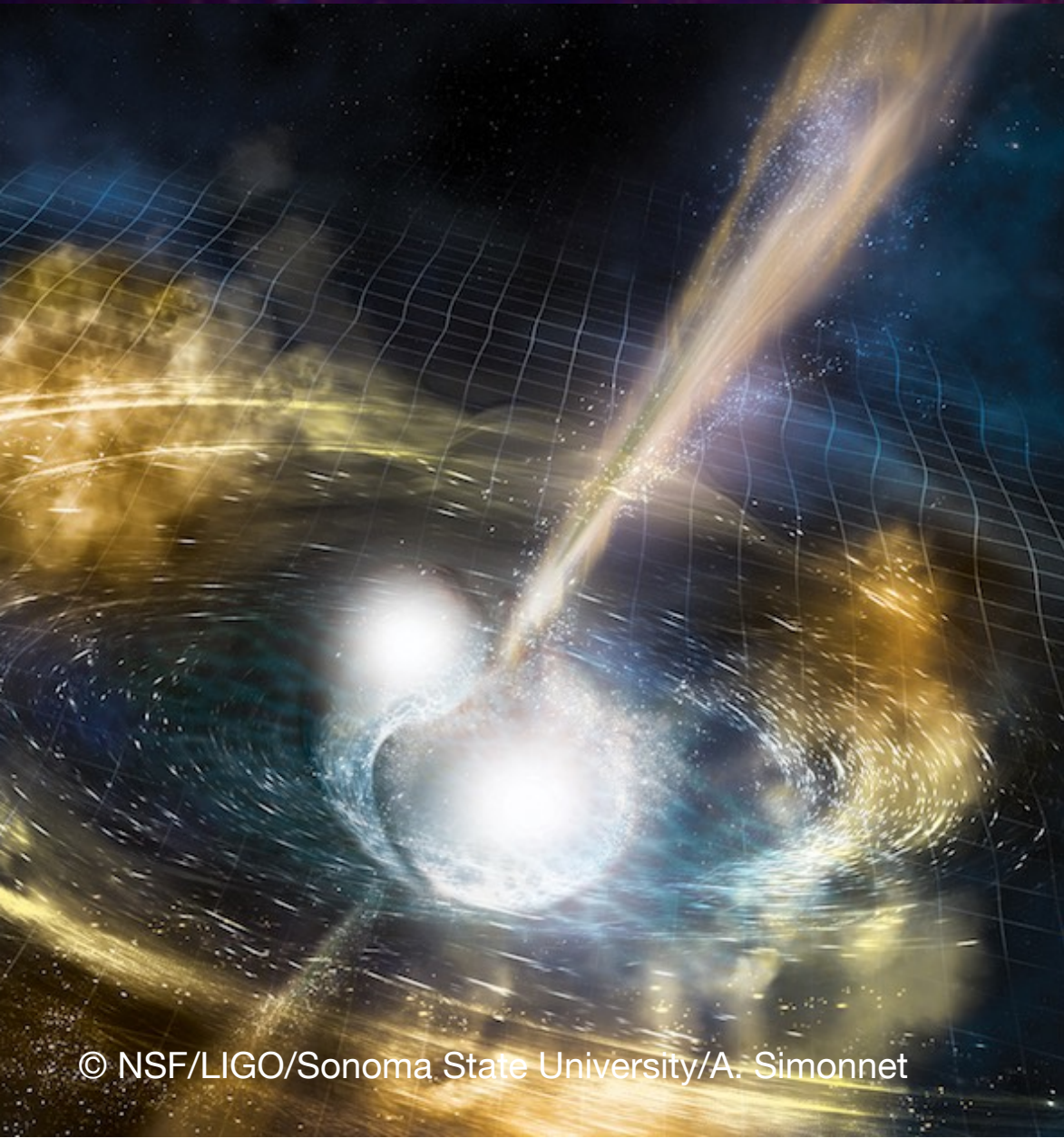
## AMEGO-X



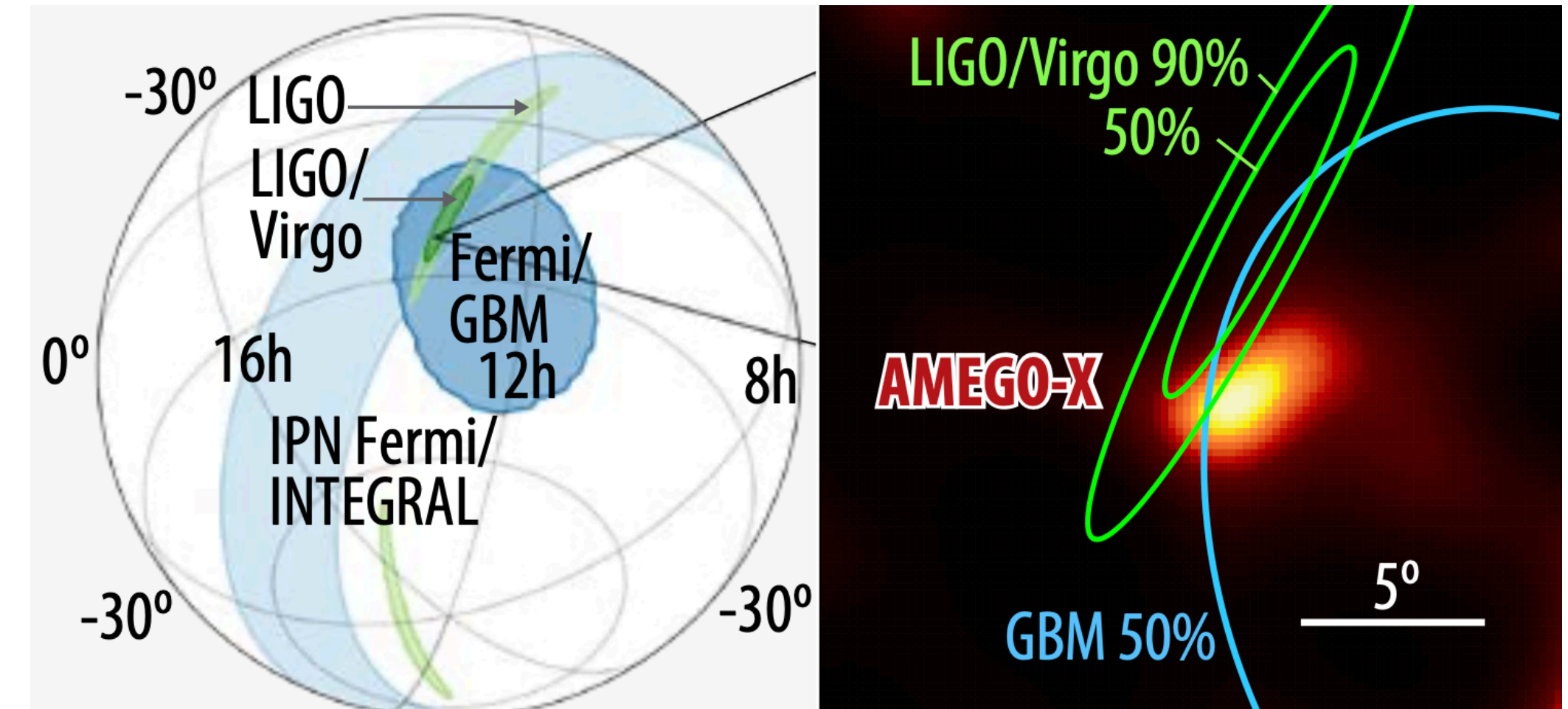
- AMEGO-X (PI: R. Caputo GSFC/NASA) is a proposed MeV mission to study the engines of extreme explosions and extreme accelerators
- Game-changer in high-energy/multi-messenger astronomy

Parameter	
Energy Range	25 keV – 1 GeV
Energy Resolution	5% FWHM at 1 MeV, 17% (68% containment half width) at 100 MeV
Point Spread Function	4° FWHM at 1 MeV, 3° (68% containment) at 100 MeV
Localization Accuracy	transient: 1° (90% CL radius), persistent: 0.6° (90% CL radius)
Effective Area	1200 cm <sup>2</sup> at 100 keV, 500 cm <sup>2</sup> at 1 MeV, 400 cm <sup>2</sup> at 100 MeV
Field of View	2π sr (<10 MeV), 2.5 sr (>10 MeV)

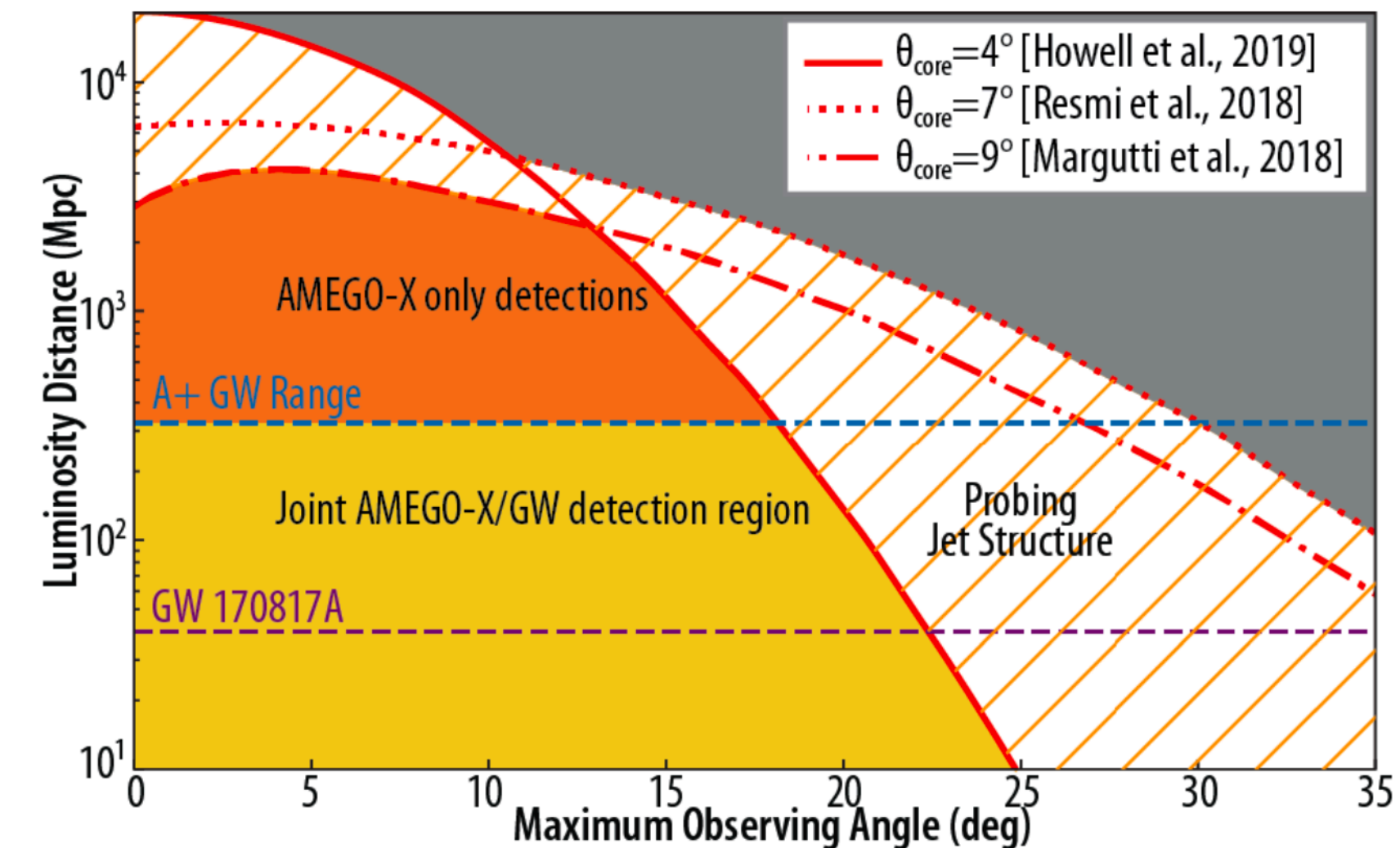
# Gamma-Ray Bursts



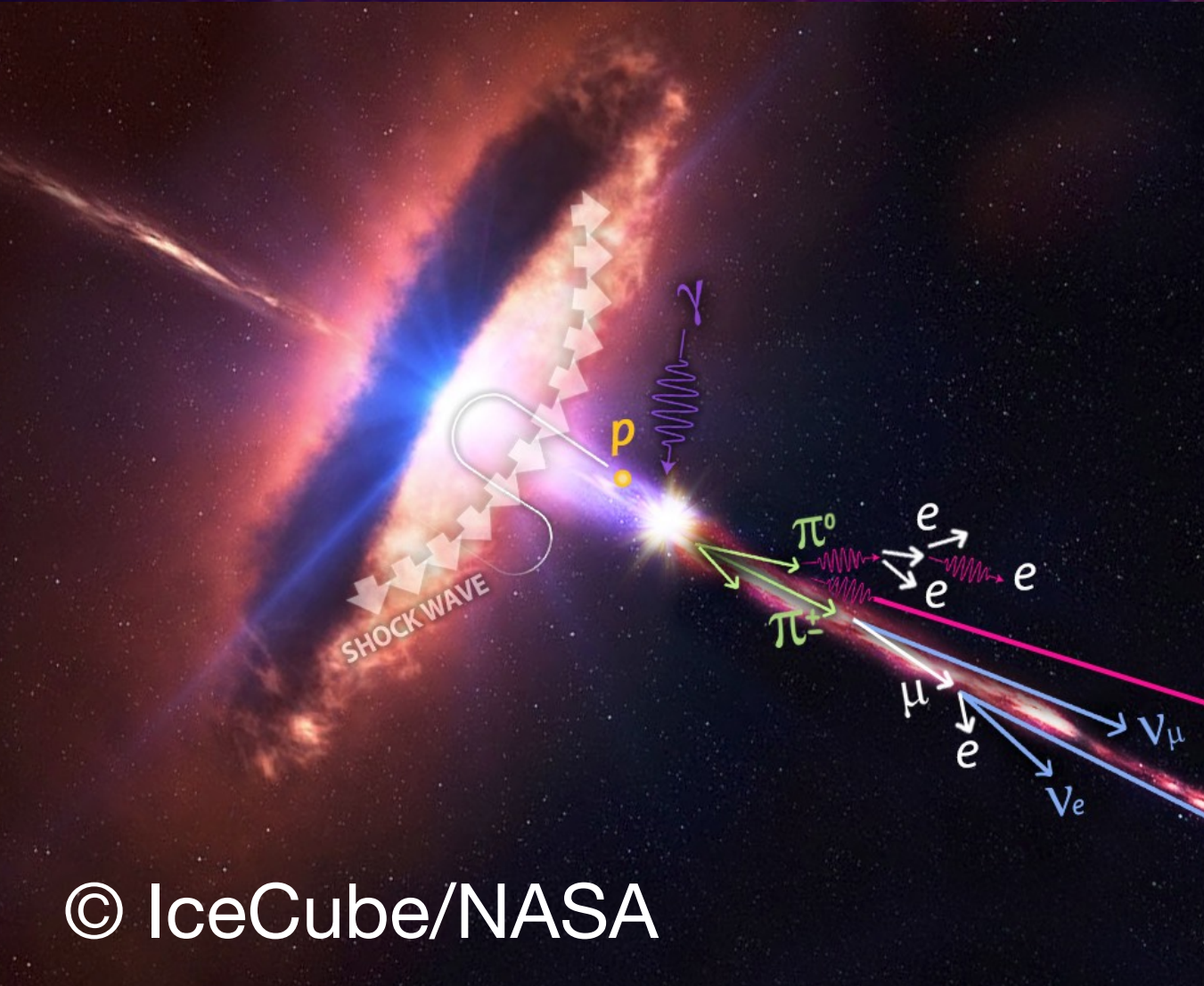
## Simulated GRB 170817A



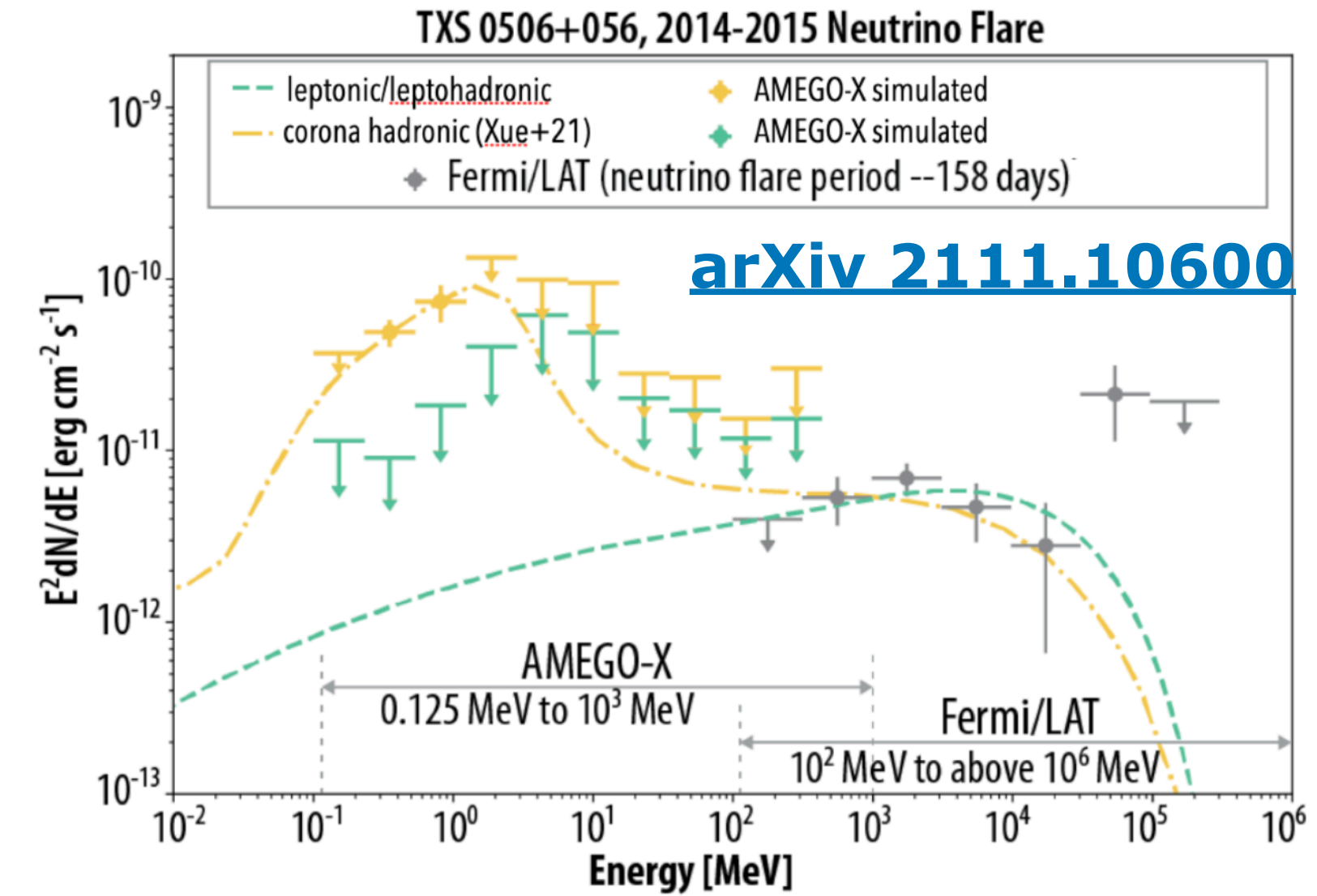
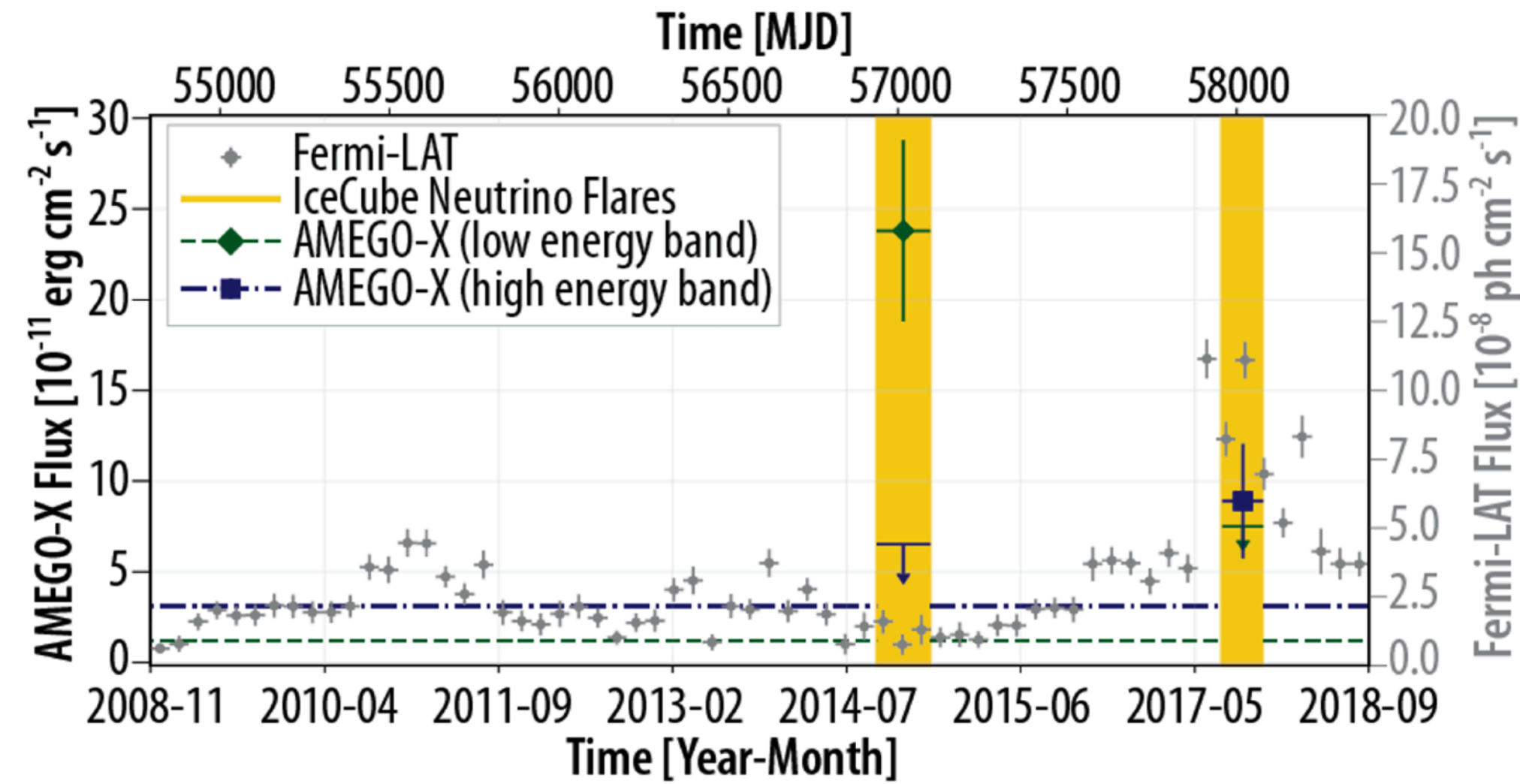
- AMEGO-X will detect >200 SGRBs/year, with a good localization accuracy  
→ Successful early follow-up observations
- AMEGO-X will constrain the jet parameters providing insights into the formation of relativistic outflows



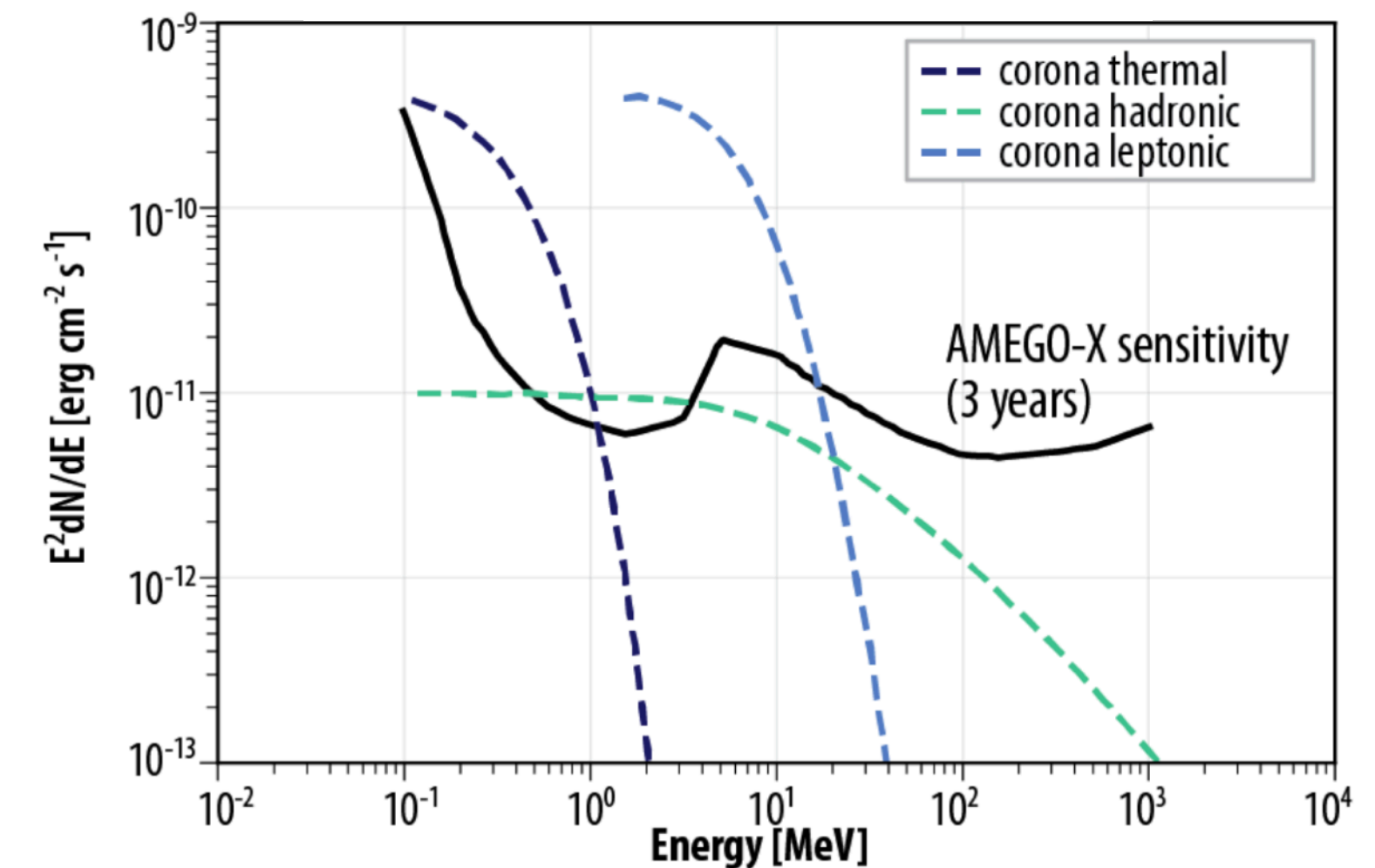
# Active Galactic Nuclei



## TXS 0506+056

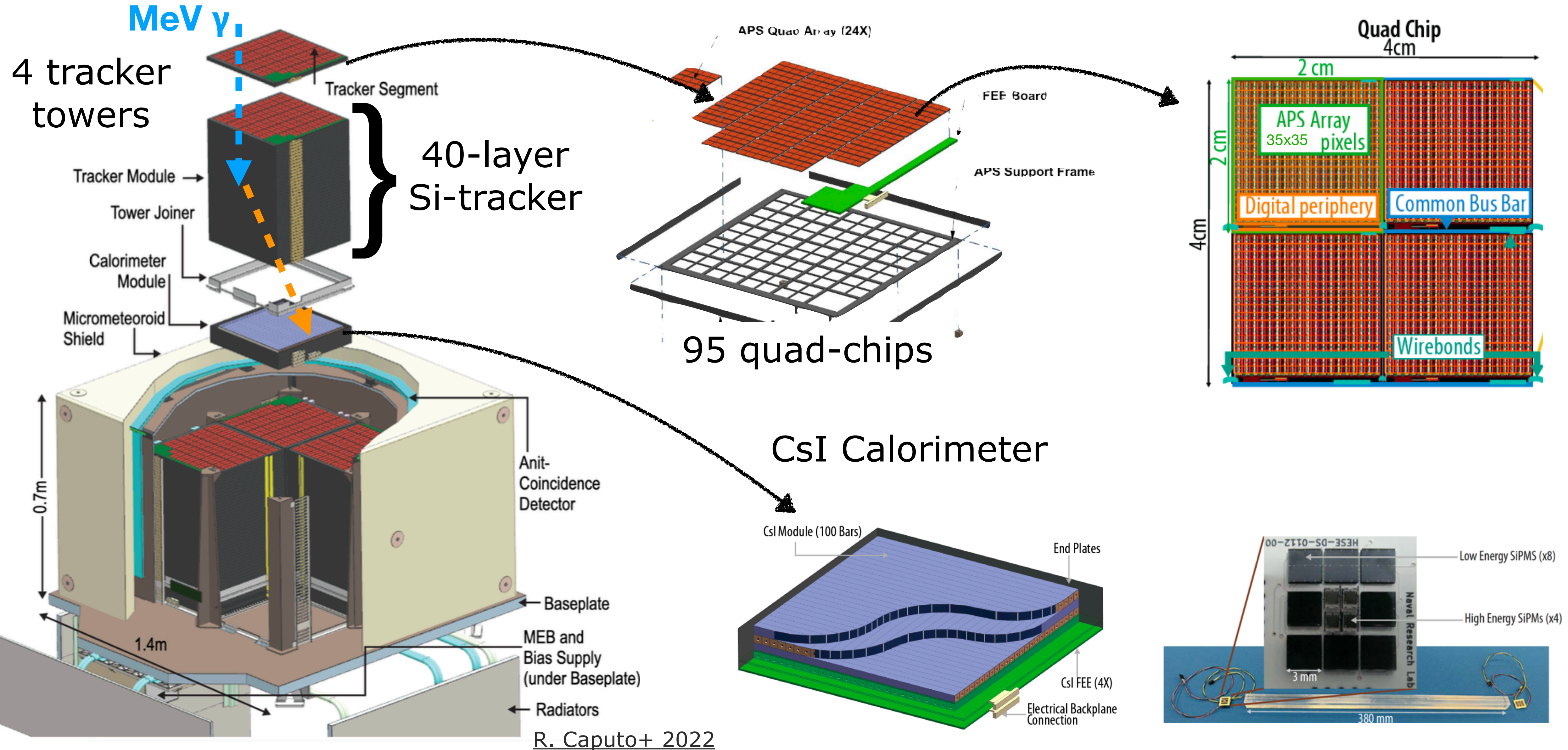


## NGC 1068



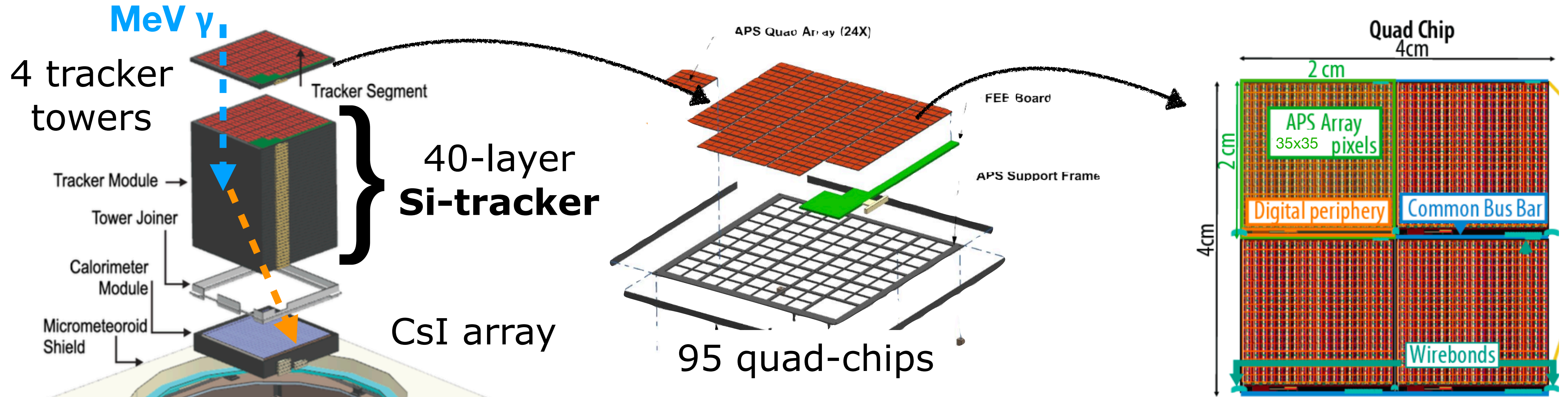
- By monitoring the entire MeV sky every 3 hours, AMEGO-X will detect  $\sim 150$  blazar flares/year
- AMEGO-X will be able to determine the particles accelerated in certain AGN corona

# AMEGO-X Gamma-Ray Telescope



# AMEGO-X Trackers

6 / 13

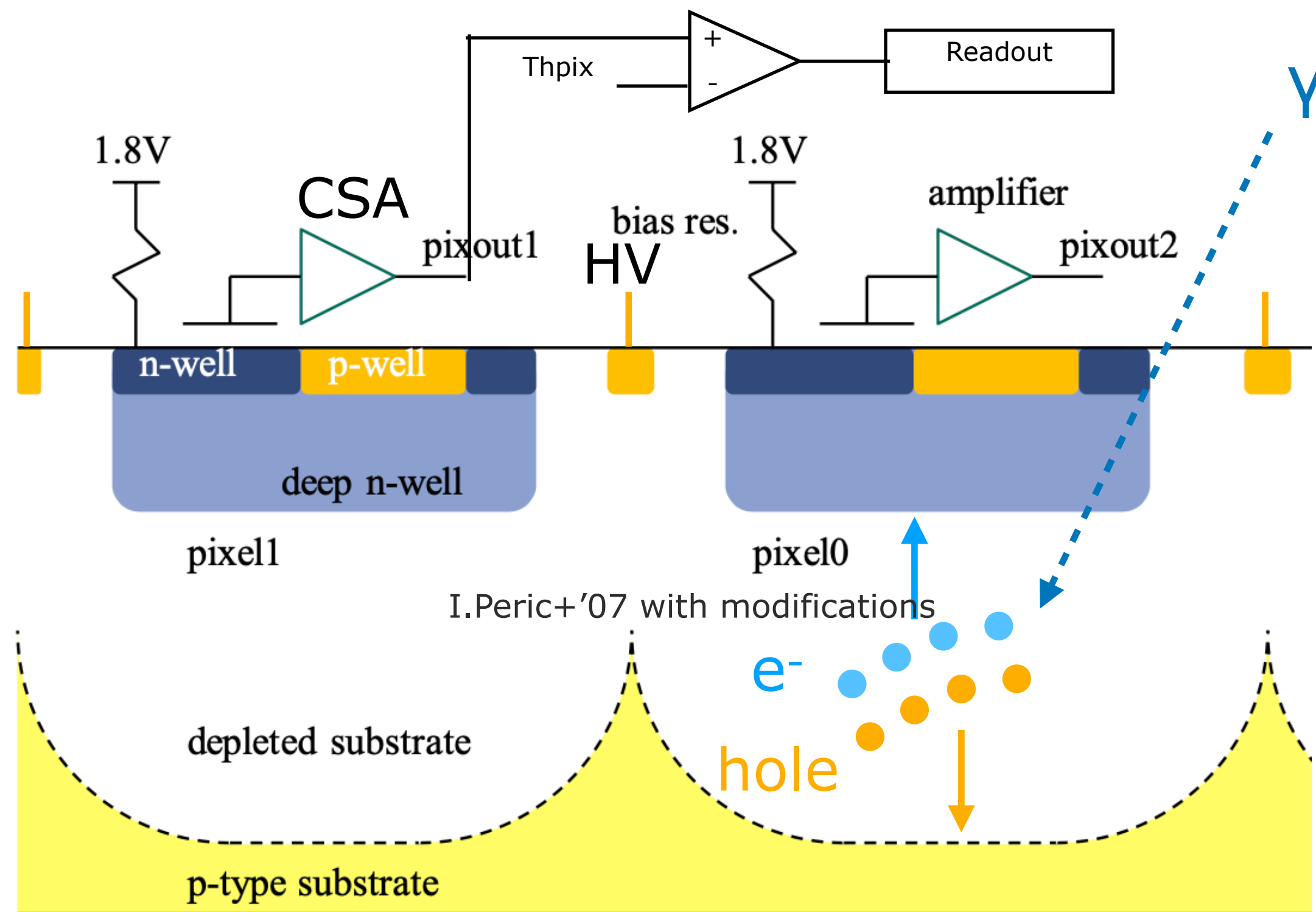


- Compton scattering  
→ **Fully depleted thick sensor**  
**Low noise**  
**Low passive material quantity**
- Huge silicon area in space (24 m<sup>2</sup>, 74M pixels)  
→ **Low power**  
**Low cost**

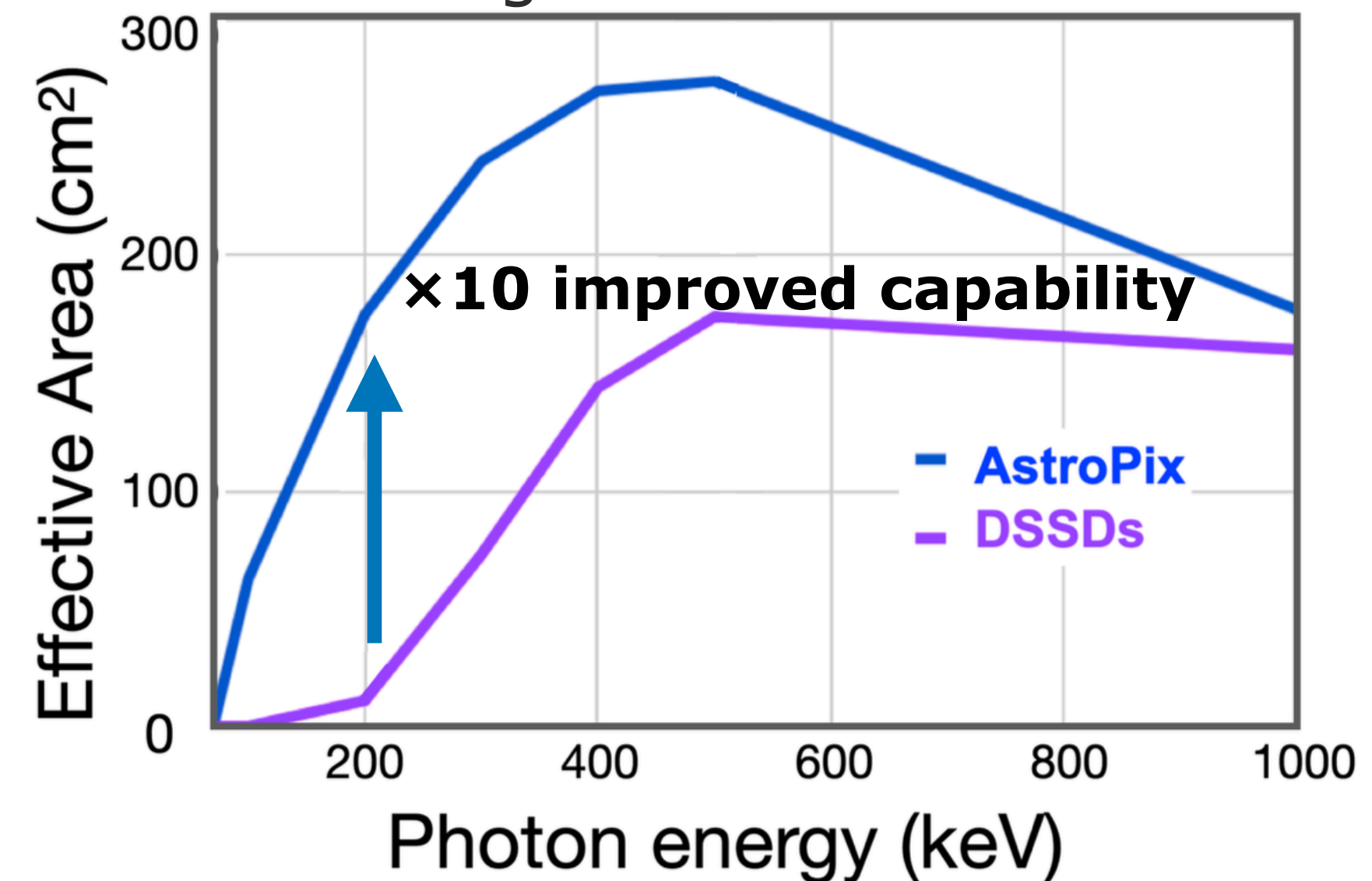
R. Caputo+ 2022

# AstroPix: Novel Pixel Sensor

## HV-CMOS pixel sensor



- PI: R. Caputo (GSFC). Designed by KIT
- Charge collection/amplification/readout co-integrated in substrate in pixel matrix
- No external analog readout needed



	Pixel pitch	Full depletion	Dynamic range	Energy resolution (FWHM at 122 keV)	Power
<b>Goal</b>	500 × 500 μm <sup>2</sup>	500 μm	25 - 700 keV	10%	< 1.5 mW/cm <sup>2</sup>

# AstroPix Evolution

2020

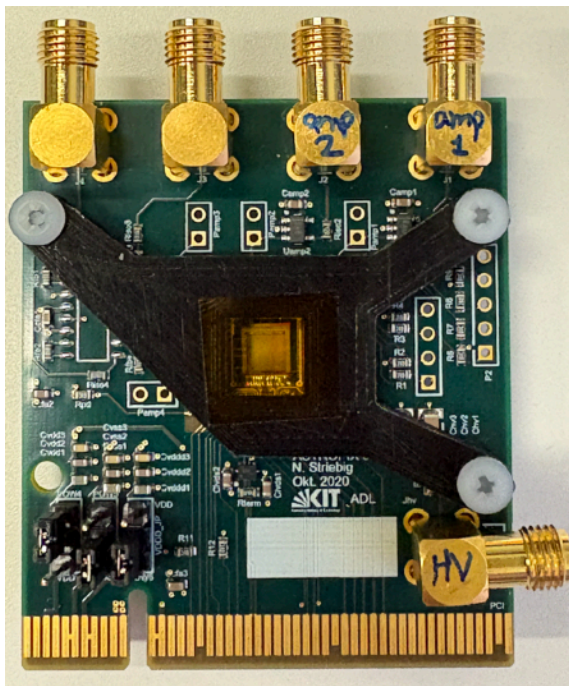
2021

2022

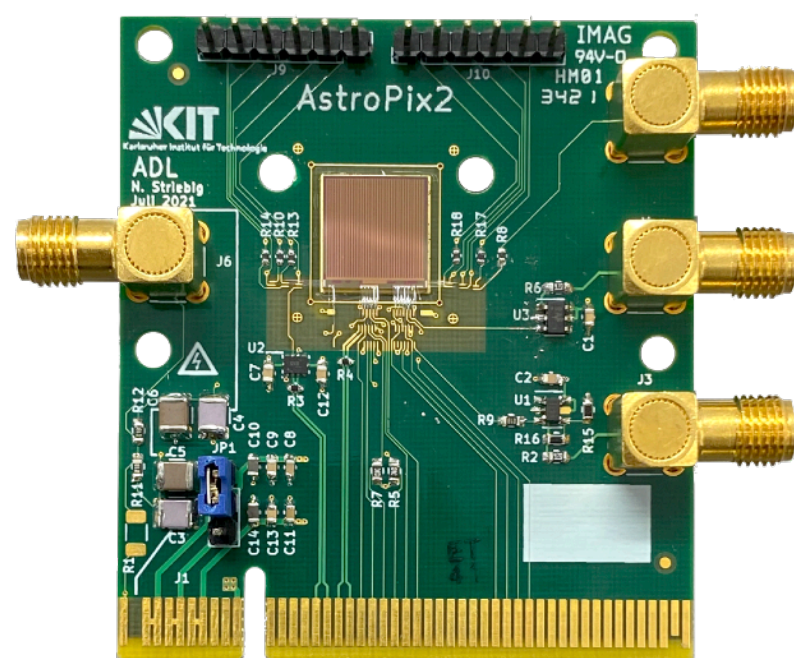
2023

2024

2026



**AstroPix1**



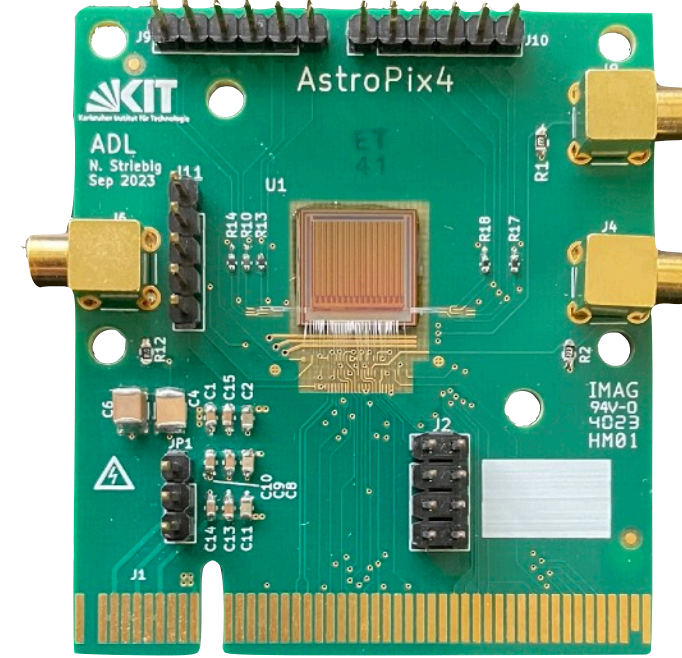
**AstroPix2**

[Steinhebel+25](#)



**AstroPix3**

[Suda+24](#)



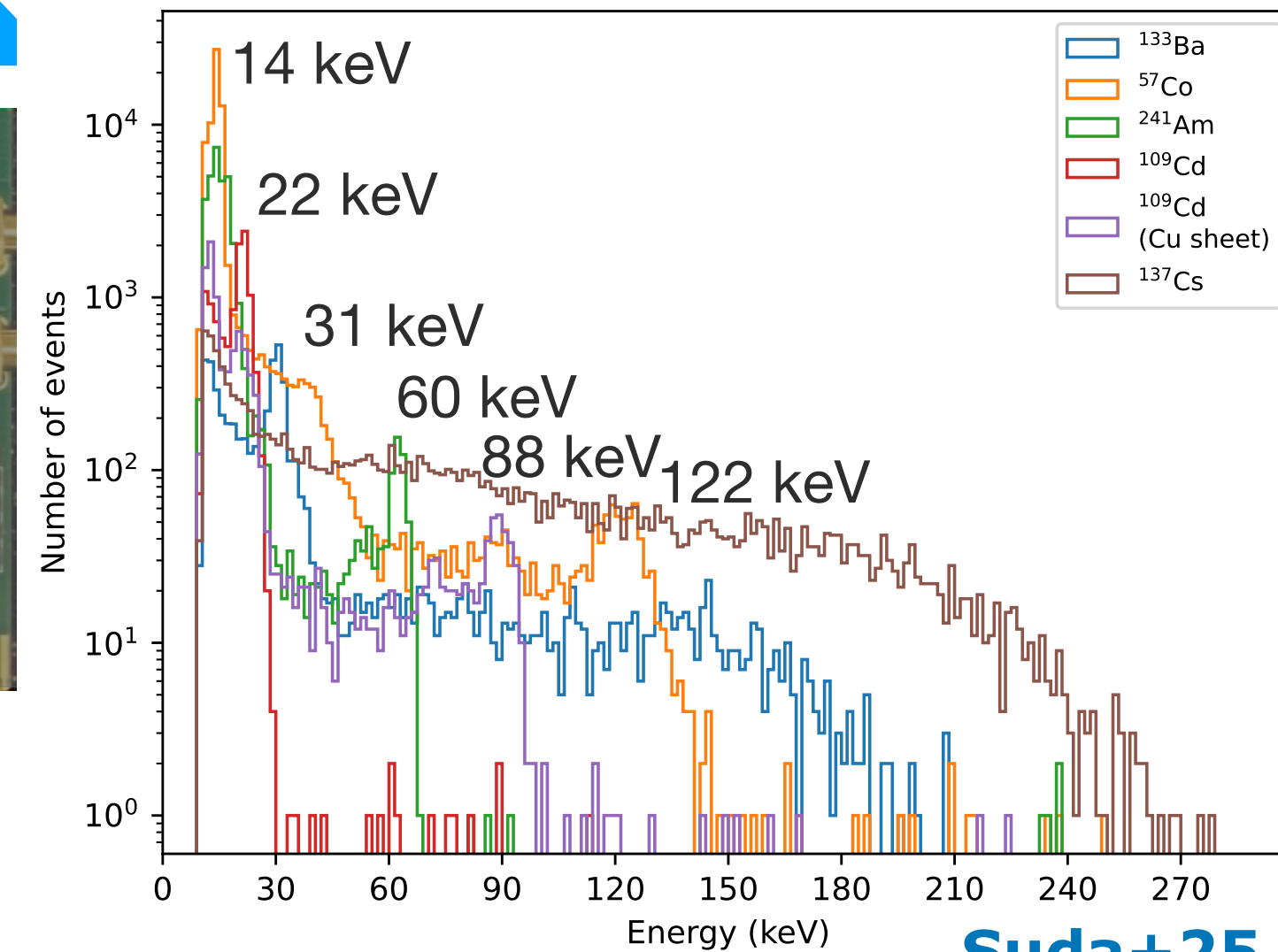
**AstroPix4**

[Striebig+24](#)



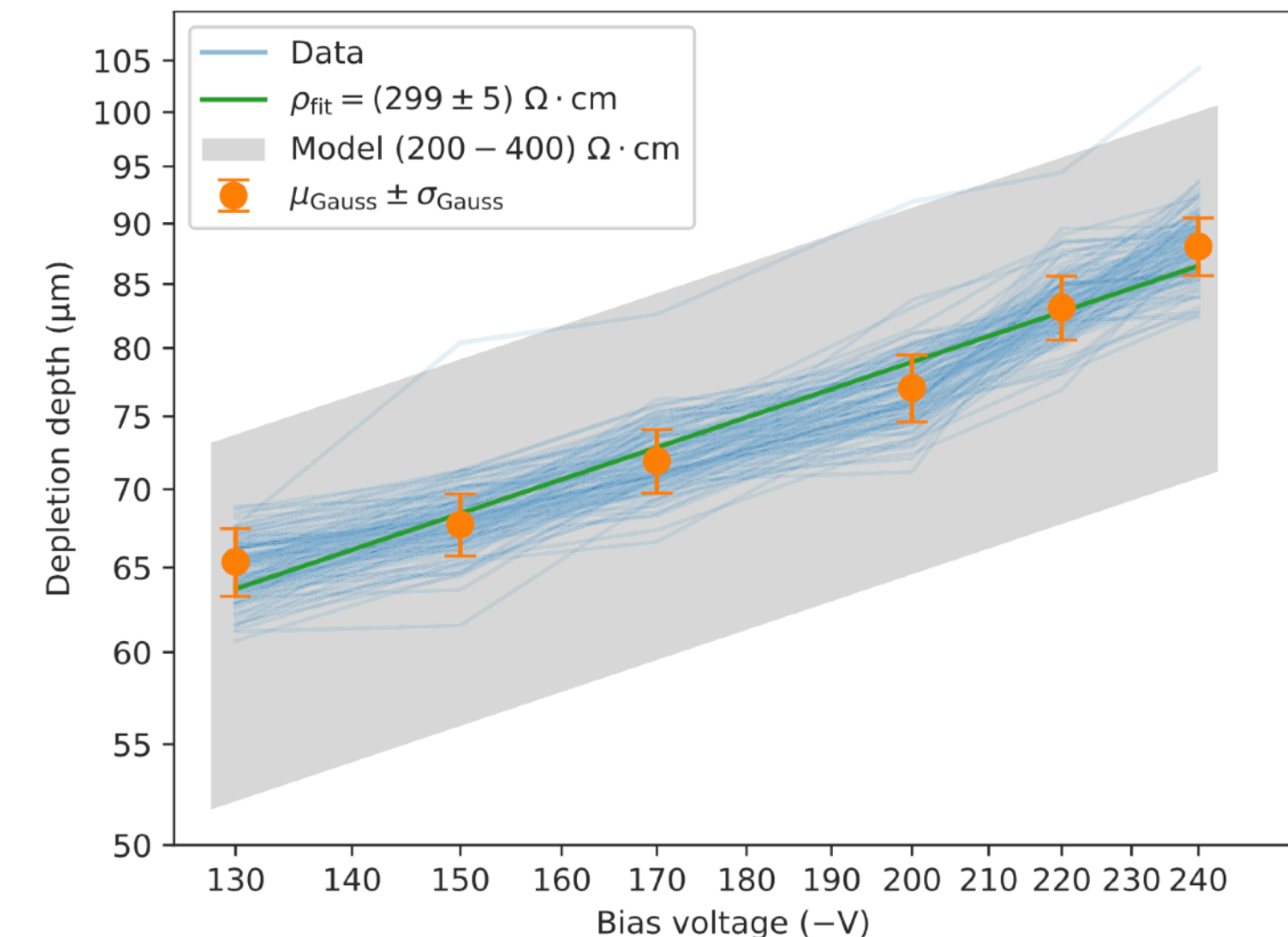
**AstroPix5**

## V4: Energy Spectra



[Suda+25](#)

## V4: Depletion depth



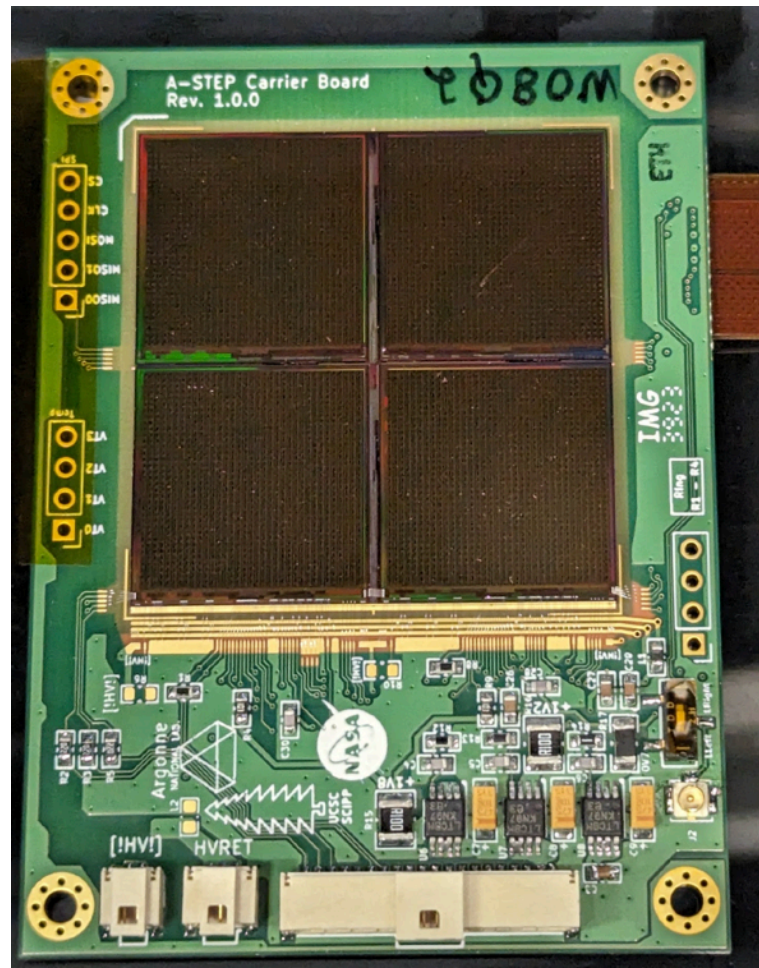
	Pixel pitch	Depletion depth	Dynamic range	Energy resolution	Power
<b>Goal</b>	500×500 μm <sup>2</sup>	500 μm	25 - 700 keV	10%	< 1.5 mW/cm <sup>2</sup>
<b>AstroPix4</b>	500×500 μm <sup>2</sup>	~90 μm	14 - ~250 keV	14%	~2 mW/cm <sup>2</sup>

- Latest AstroPix, V4, has a low enough noise floor with moderate energy resolutions. Depletion depth is far from the goal
- Future AstroPix will have a higher breakdown voltage allowing deeper depletion depth

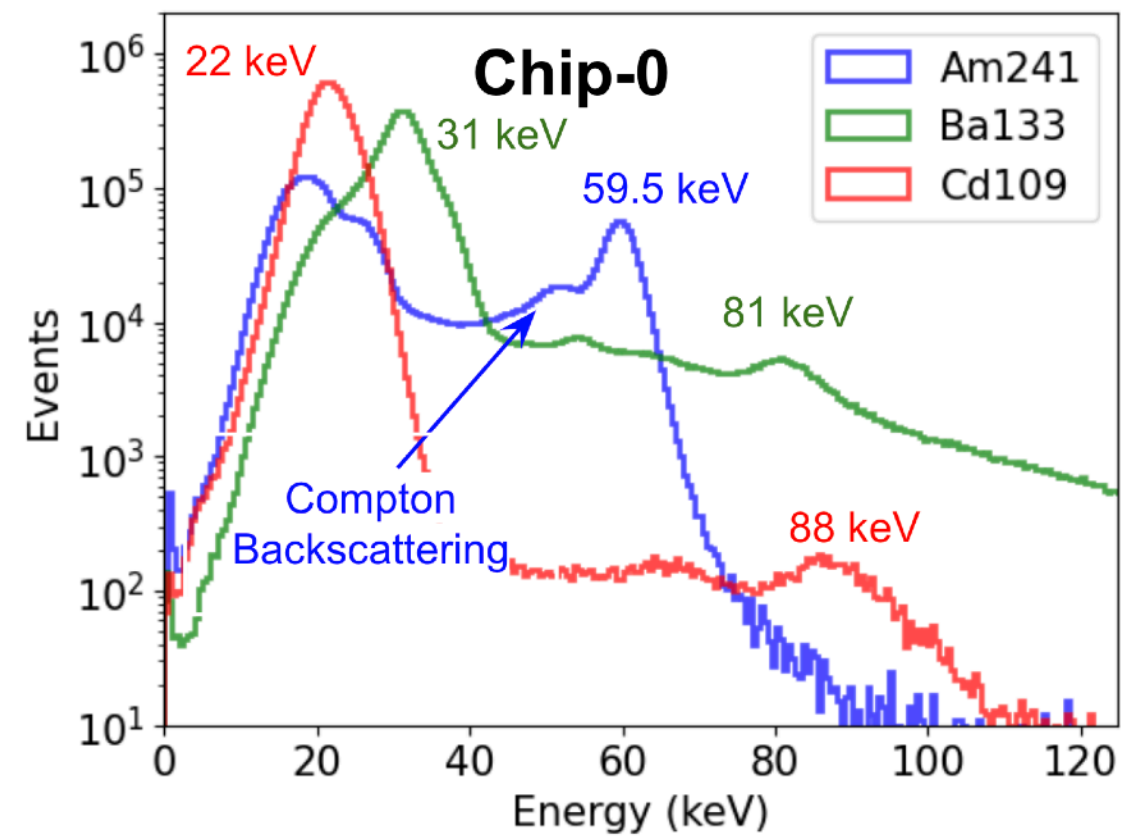
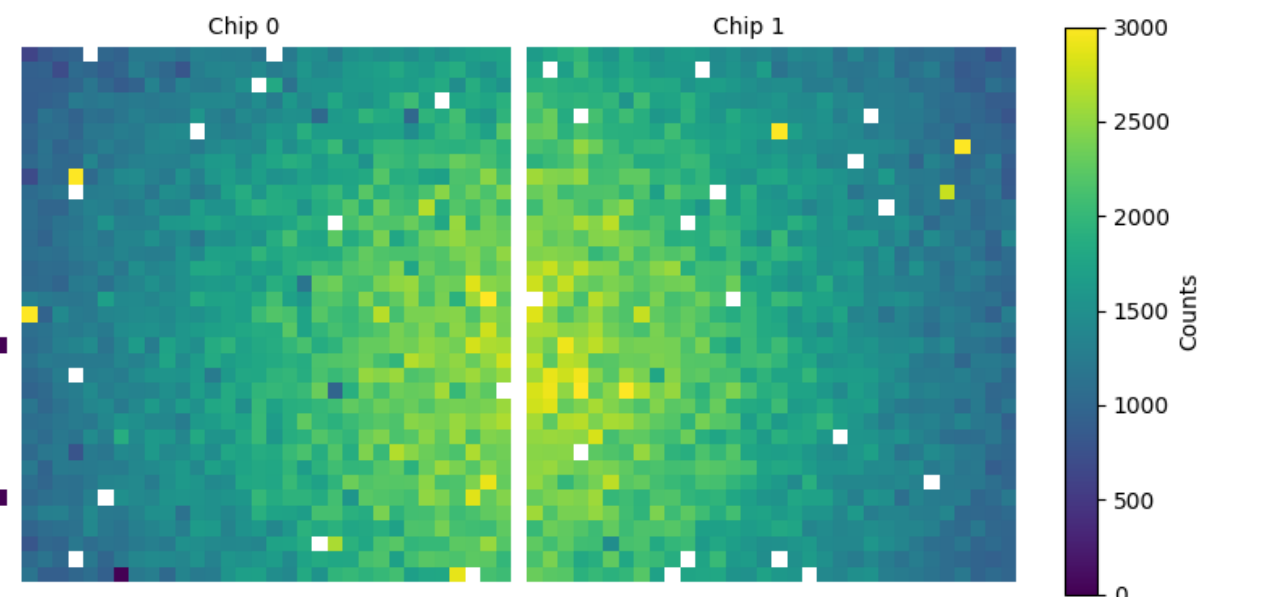
**N. Norito's talk about V3 sub-pixel response (16aEK215)**

# AstroPix in Space

## Quad-chip

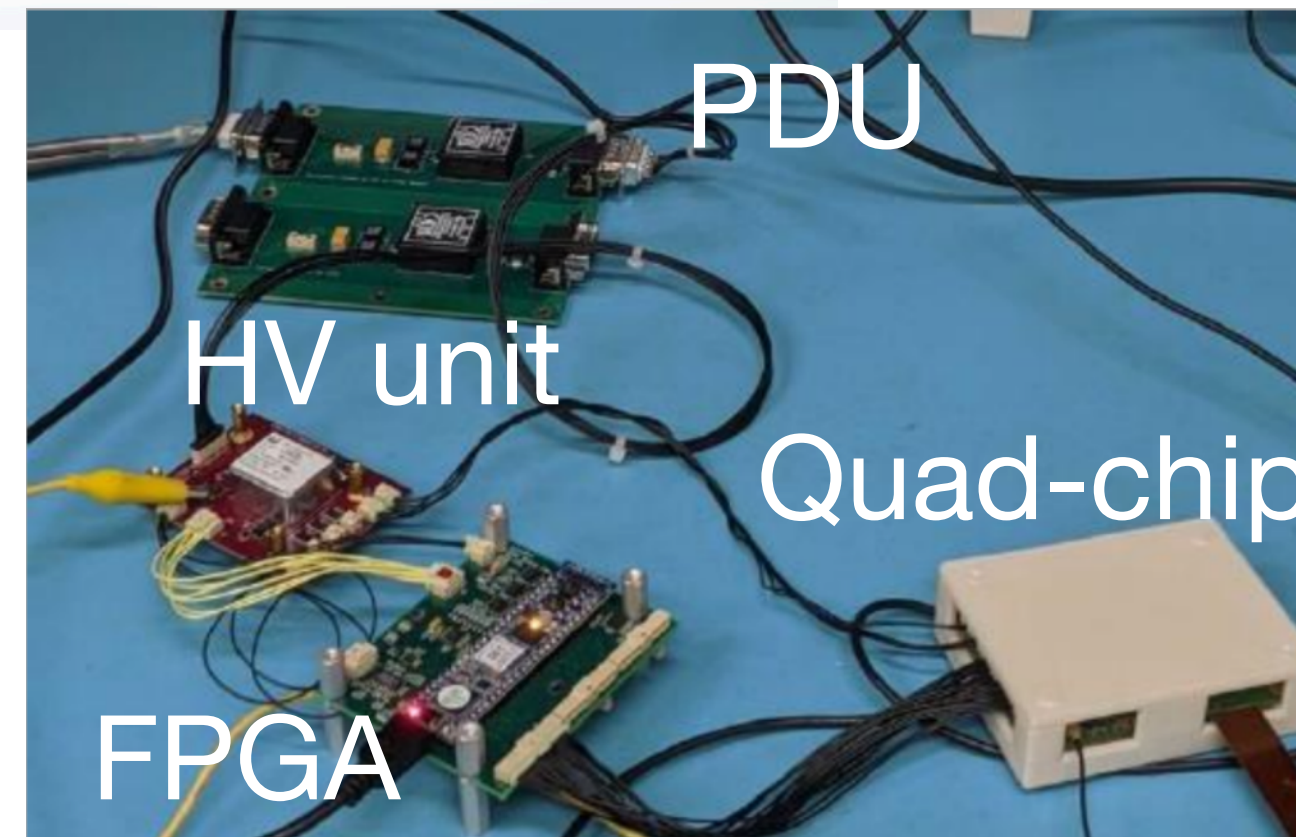
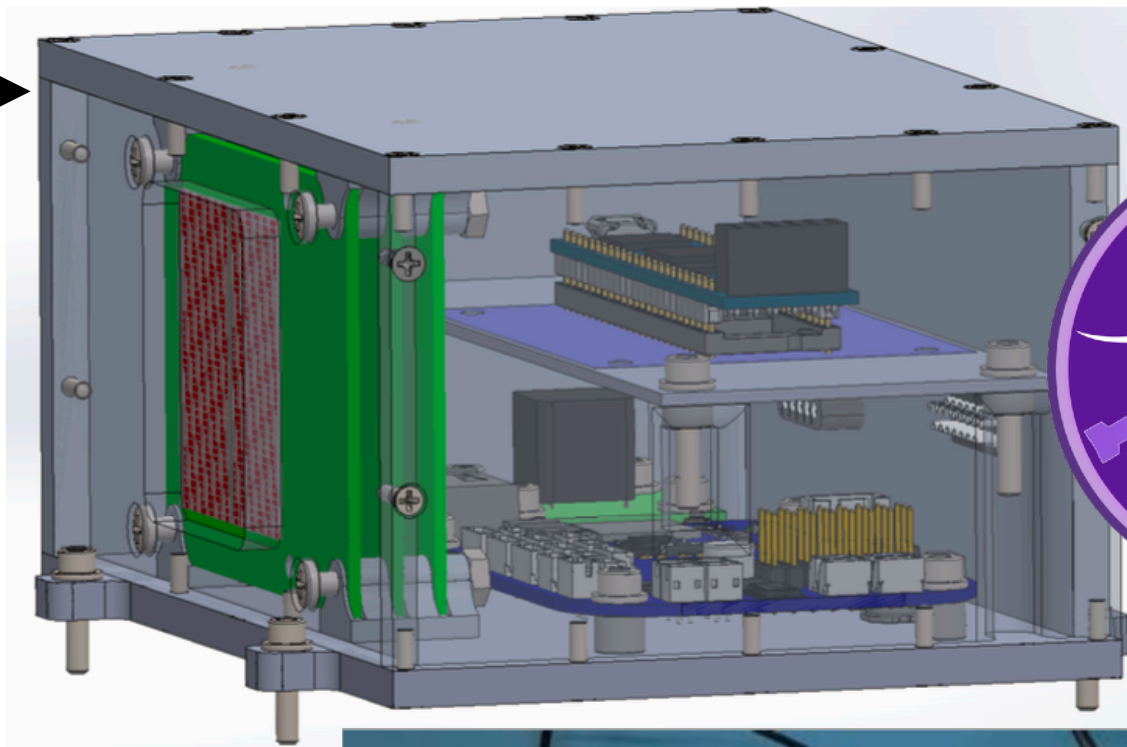


## 3 layers



Credit: A. Roy (Hiroshima U)

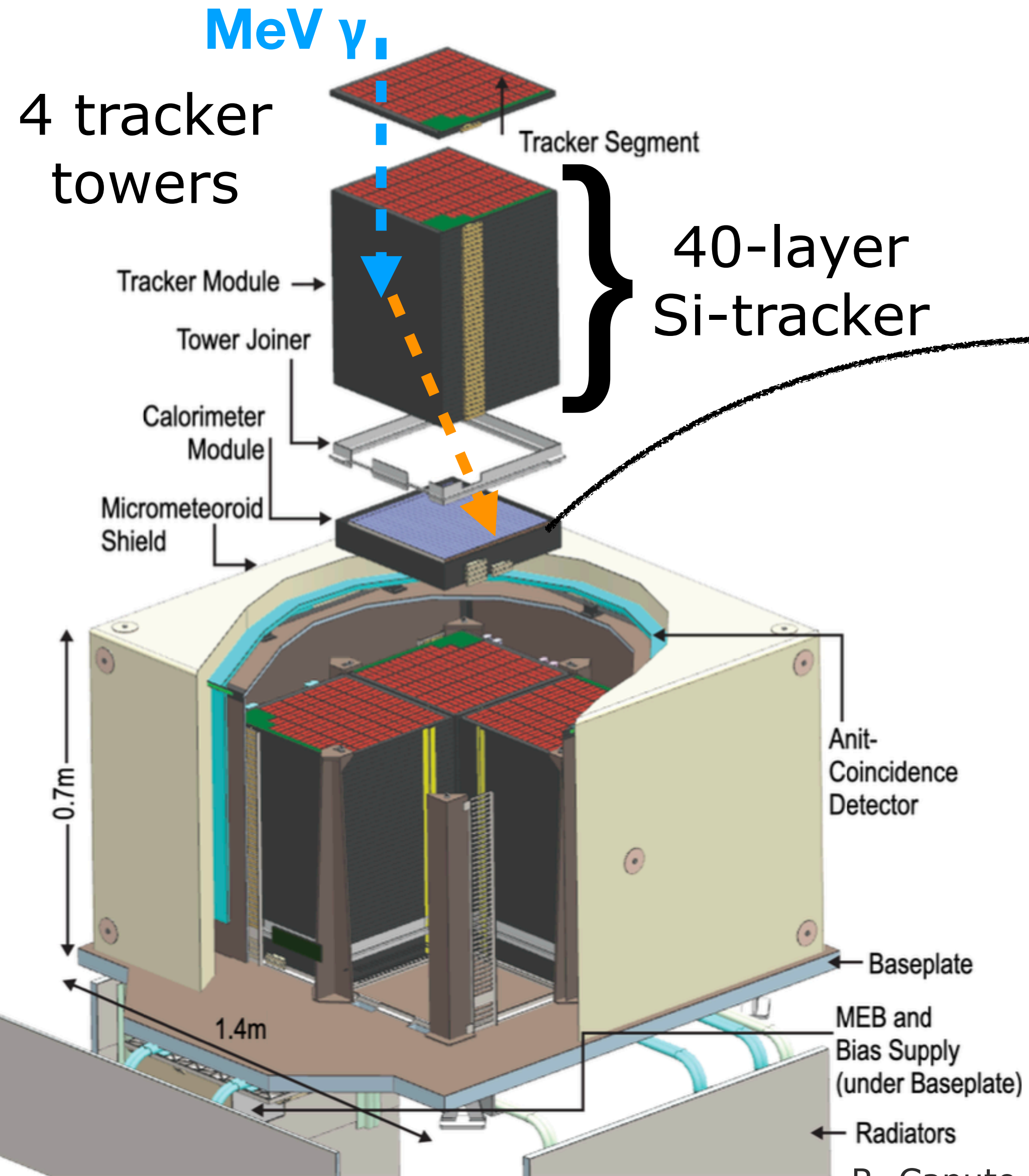
## A-STEP detector



- Sounding rocket hosted flight ("**A-STEP**") to increase the Technical Readiness Level of the AstroPix sensors
- Launch from Wallops Flight Facility in early 2026

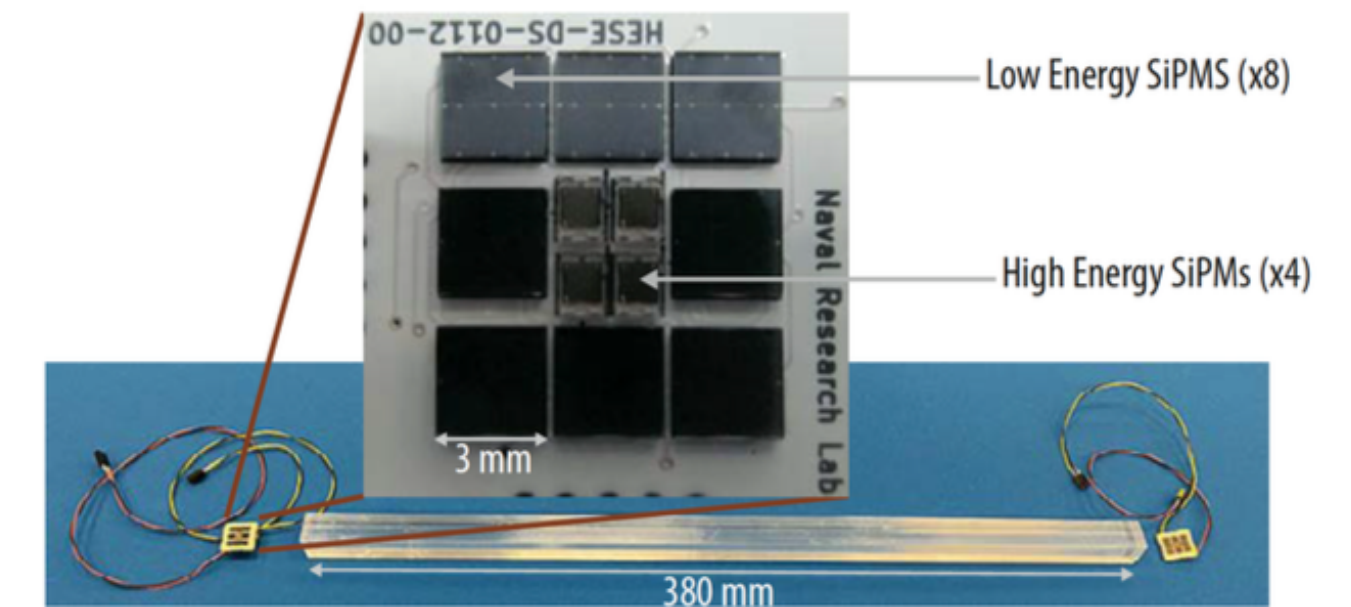
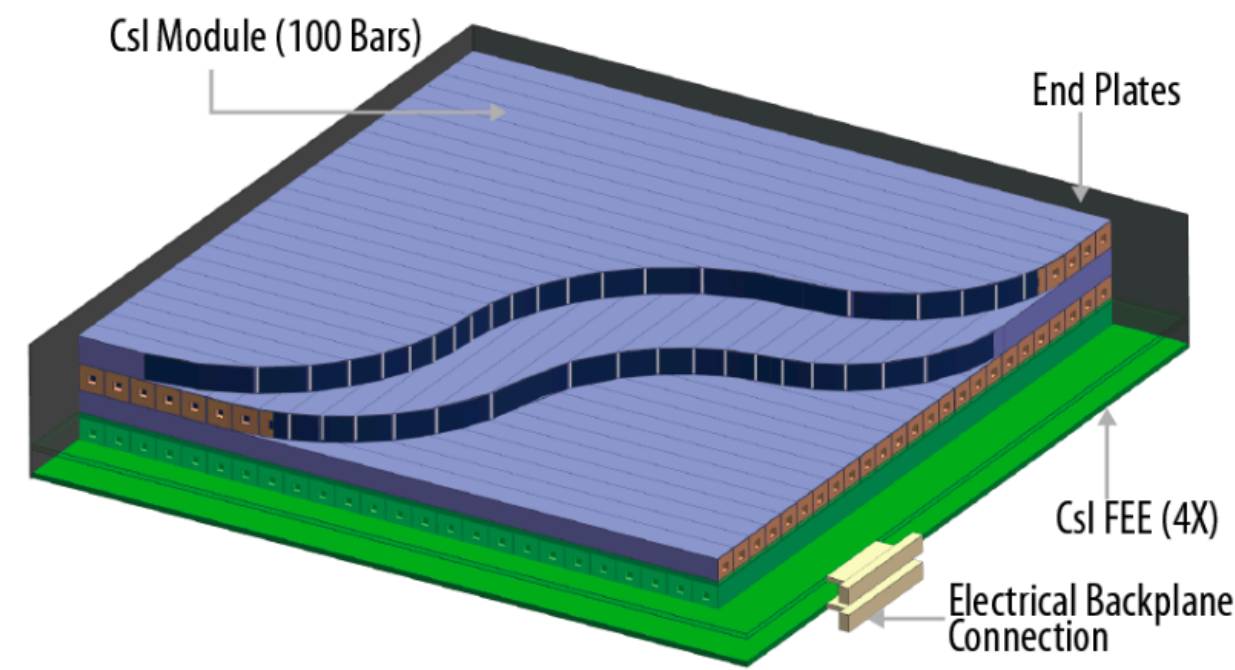
**Ref. A. Roy's talk  
in 16aEK215**

# AMEGO-X Calorimeters



## CsI Calorimeter:

4 layers. 25 bars/layer read out by SiPMs

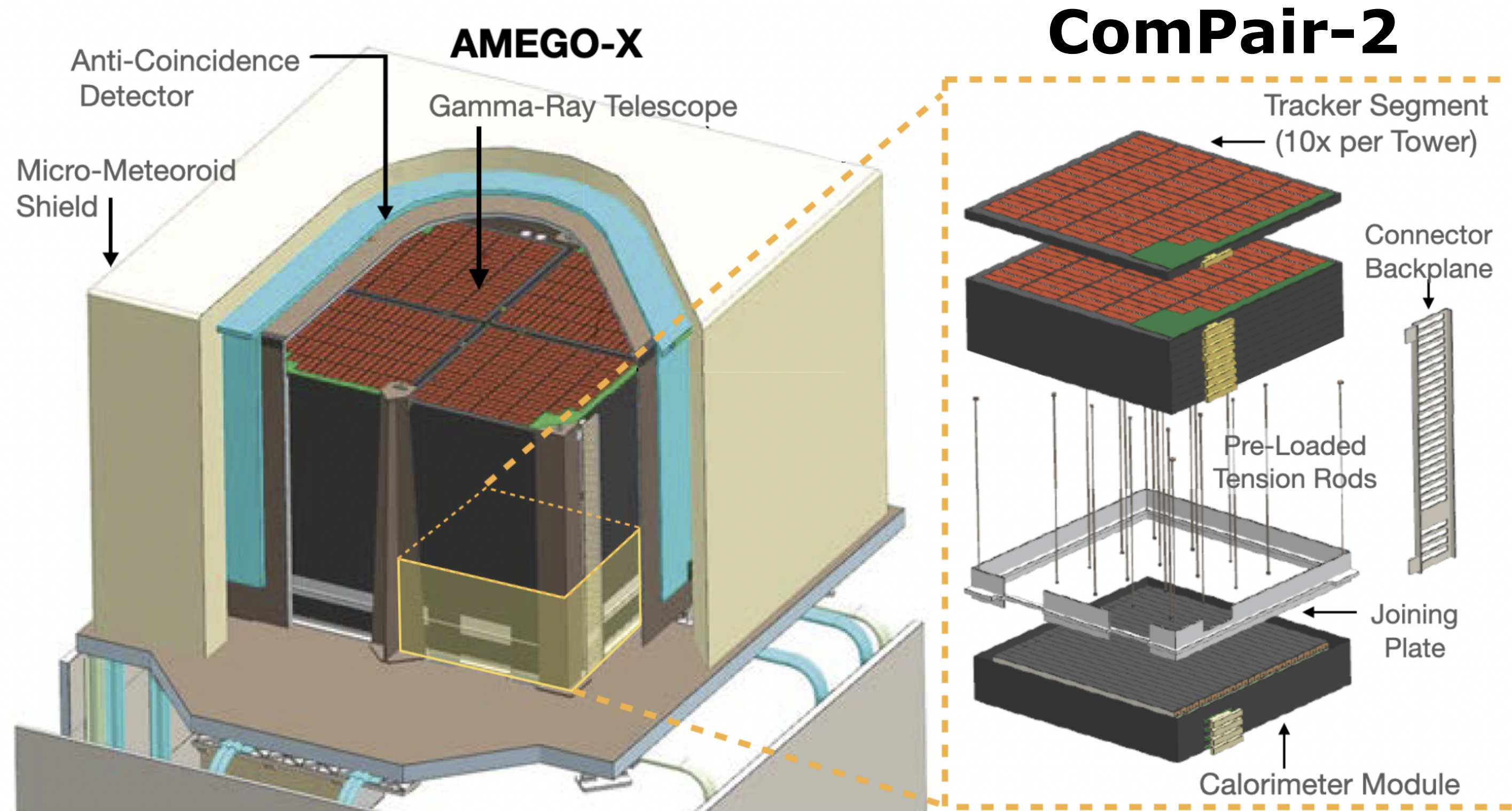


- Members from Fermi-LAT calorimeter team have been developing the CsI calorimeter array
- Two different types of SiPMs used to ensure large dynamic range: a few 100 keV - ~400 MeV
- Working on assembling a 2-layer prototype calorimeter

R. Caputo+ 2022

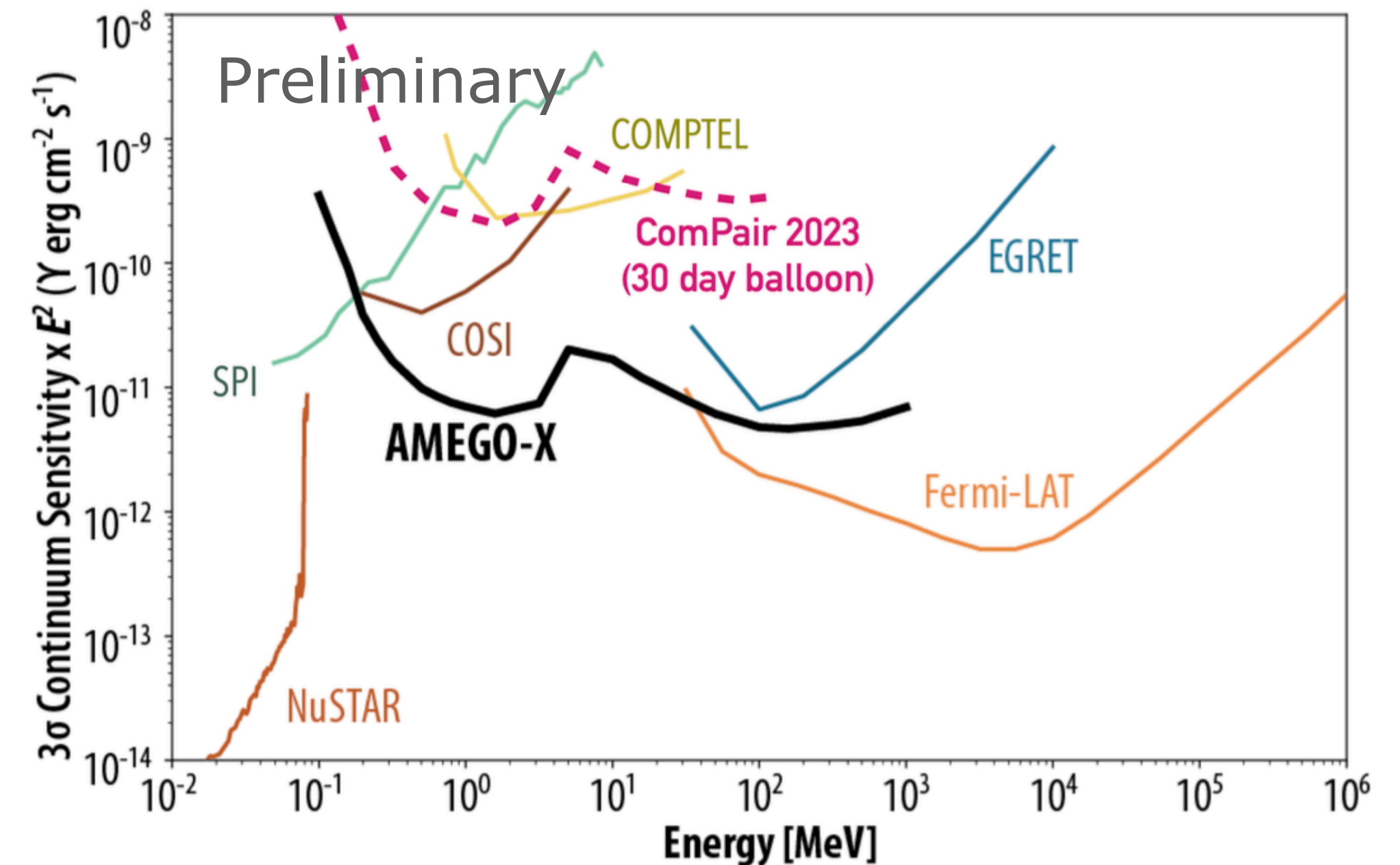
# Prototype Telescope

11/13



## 30 day balloon flight

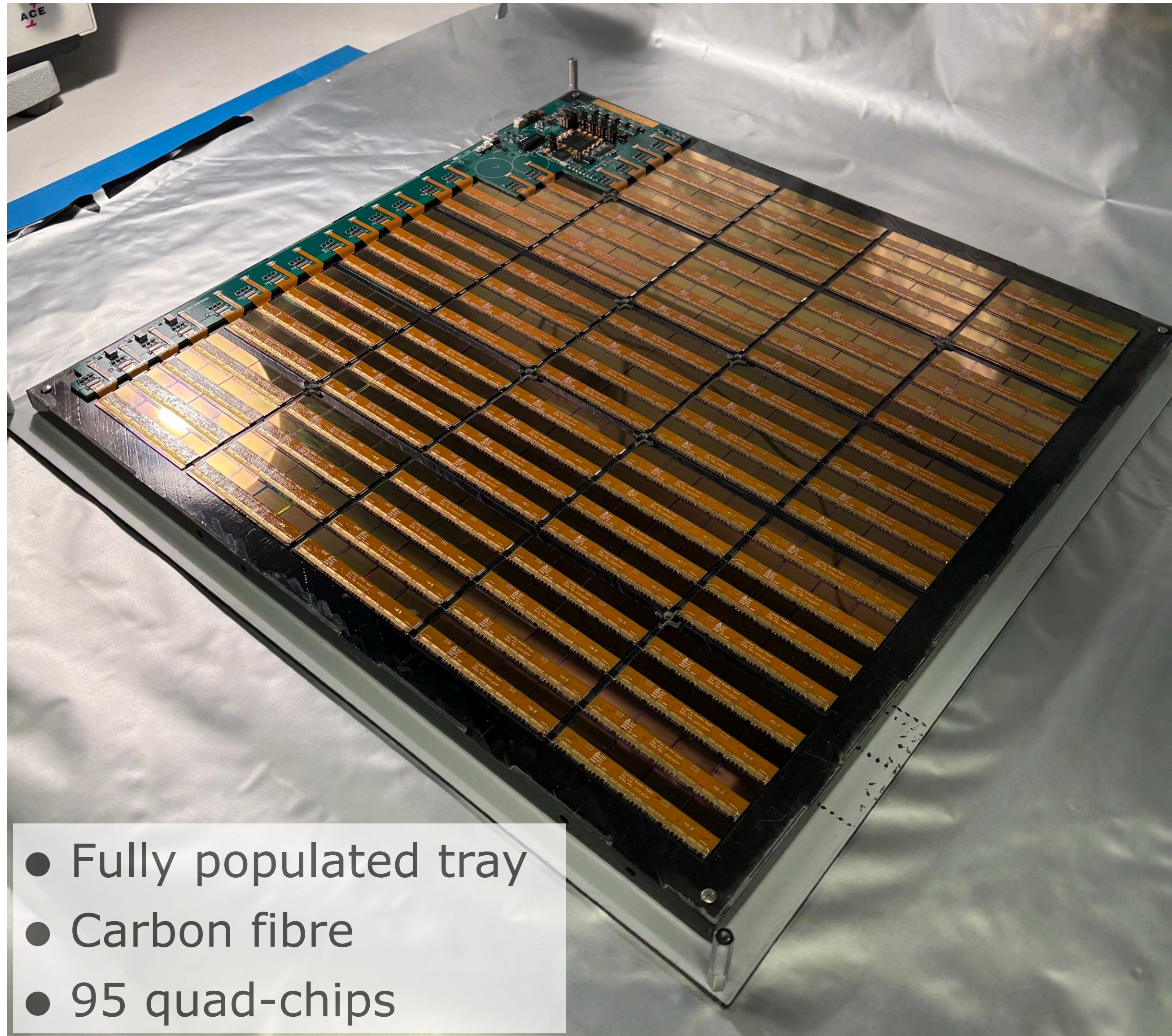
(Rough scaling based on AMEGO-X sensitivity)



- ComPair-2 (PI: R. Caputo (GSFC/NASA)): AstroPix tracker + CsI calorimeter
- Demonstration of Compton and Pair reconstructions
- Aim to conduct a long-duration balloon flight

# Prototype Telescope

12/13



- Fully populated tray
- Carbon fibre
- 95 quad-chips

- First prototype tray with 95 Quad-chips and FPGA
- Successful a TVAC test and vibe test of the single tray
- Will get the custom FEE working
- Instrument integration and testing in 2026
- Machine learning approach to improve event classification and reconstruction
- Follow-up funding for balloon flight

# Summary

- AMEGO-X will provide unique insight into the acceleration of protons and production of neutrinos near SMBHs, the nature of GRBs, and the acceleration of cosmic rays in the Galaxy
- Development of the key component, AstroPix, is going well. Sounding rocket test flight in early 2026
- We will built the prototype telescope in 2026 and demonstrate the AMEGO-X concept
- Aim to resubmit in next MDEX call

