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

深沢泰司（広島大学）、
田島宏康（名古屋大学）、
須田祐介（広島大学）、
Regina Caputo, Jeremy Perkins (GSFC/NASA)

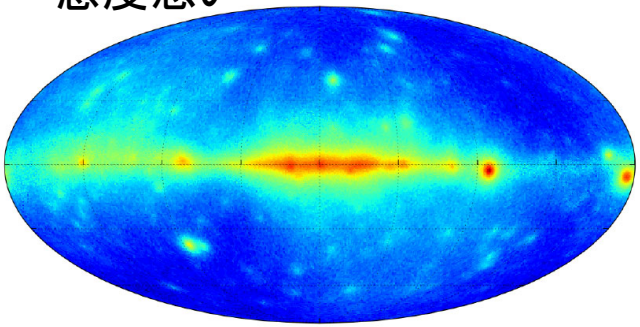
昨今のガンマ線天文学の発展

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)

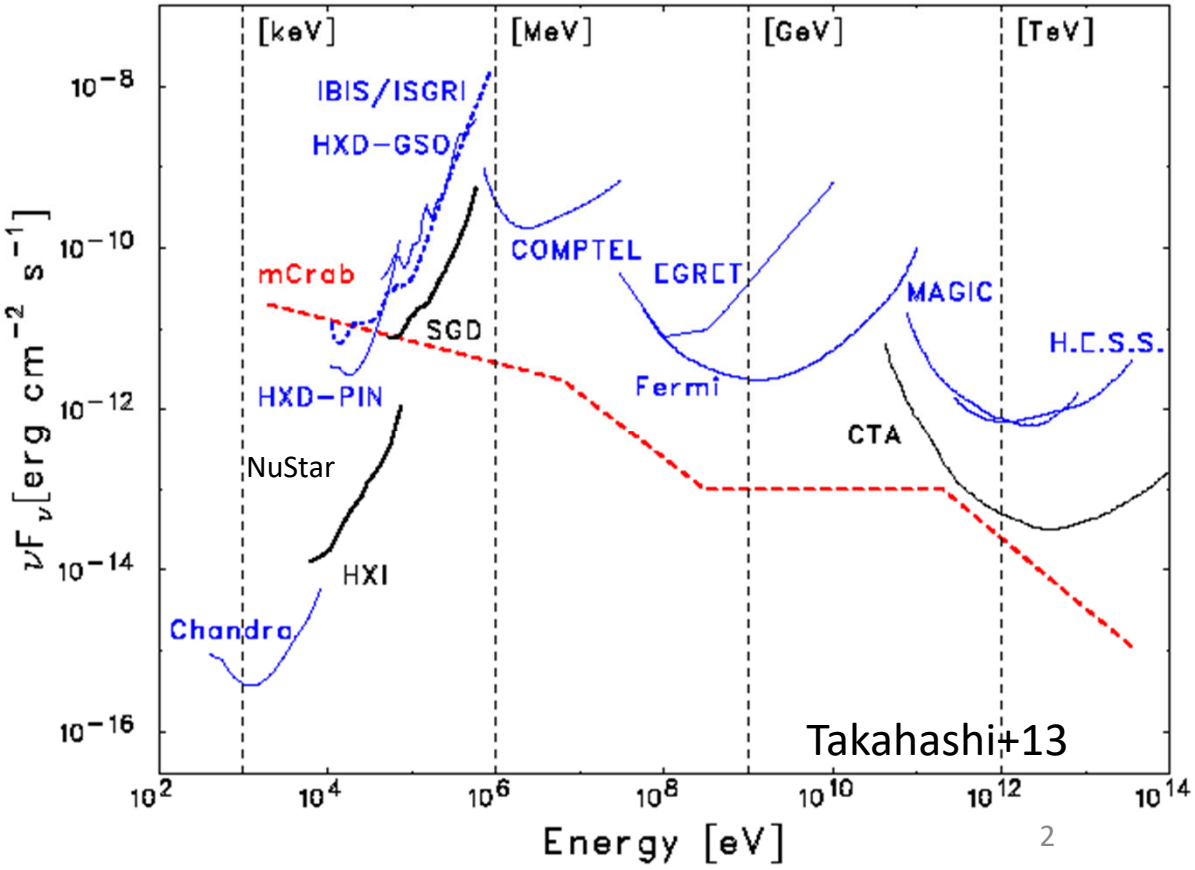
1990年代のCGRO衛星COMPTEL以降進展無し
（天体数 約30）

Fermiでも100MeV以下は
感度悪い



Fermi/LAT 30-100MeV

Principe+18



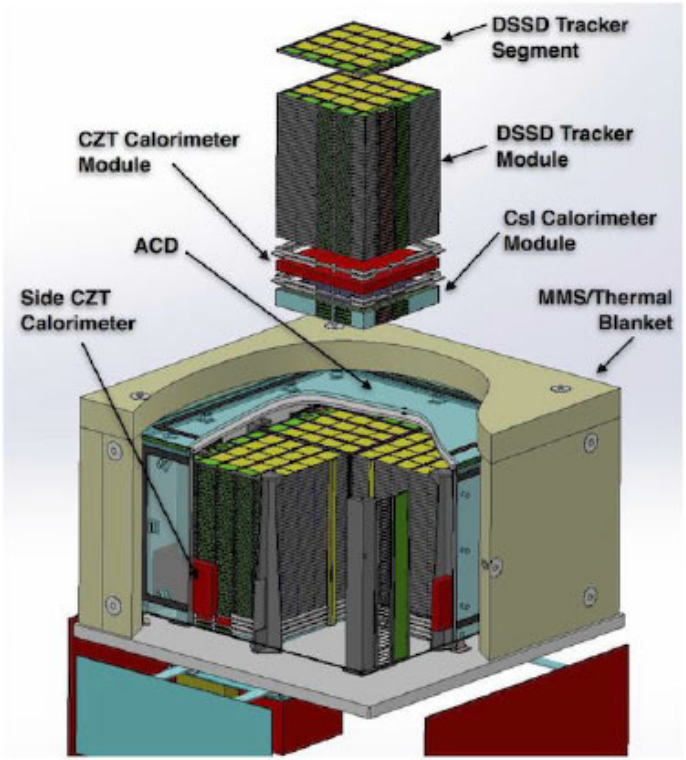
AMEGO : Probe

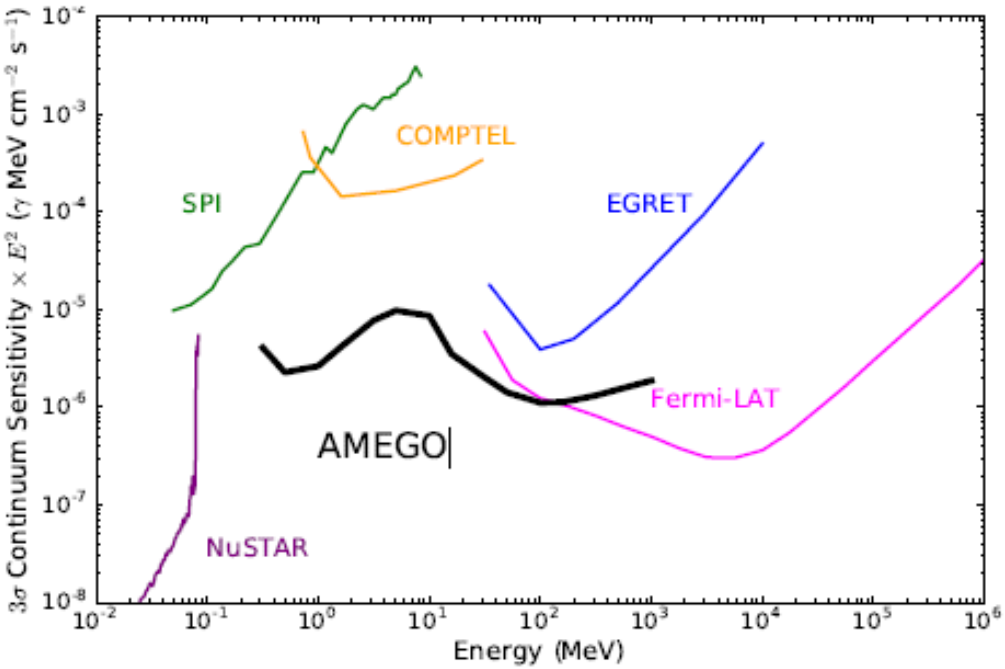
Submitted to Decadal suevey 2020 McEnery+19

Not recommended in the report of Decadal survey 2020,

But,

Highest priority sustaining activity is a space based time-domain and multimessenger program of small and medium-scale missions

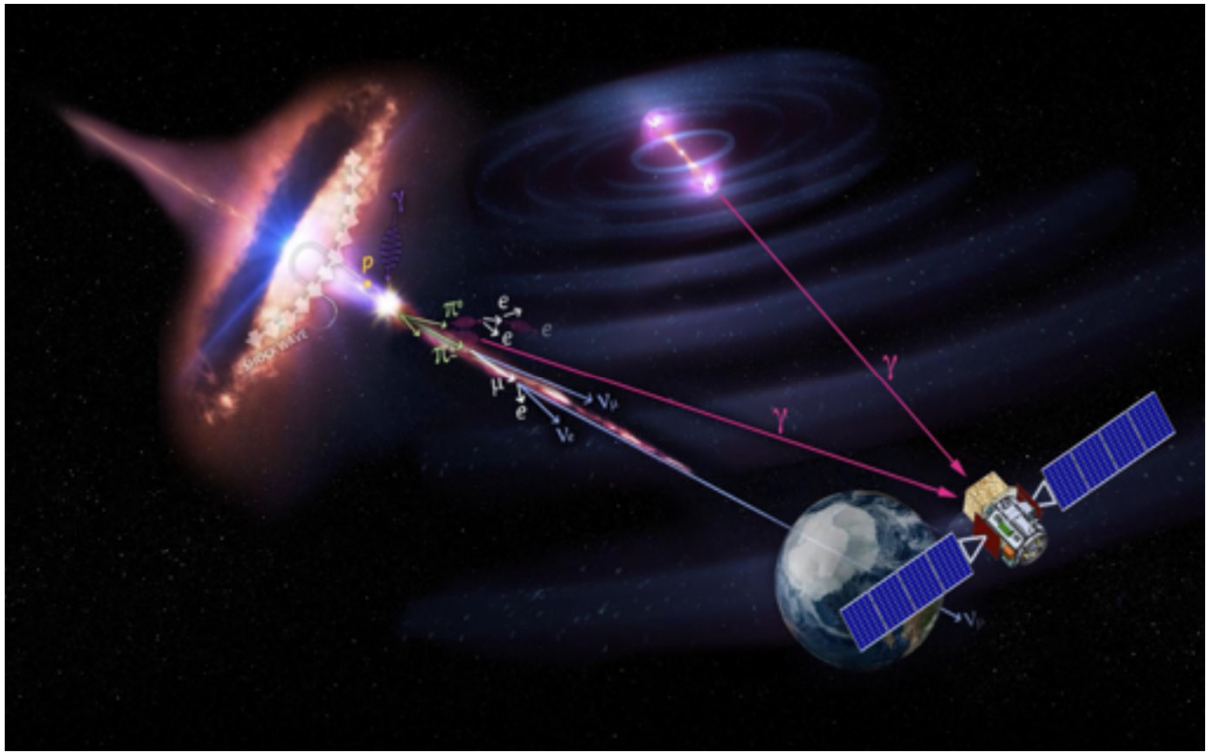


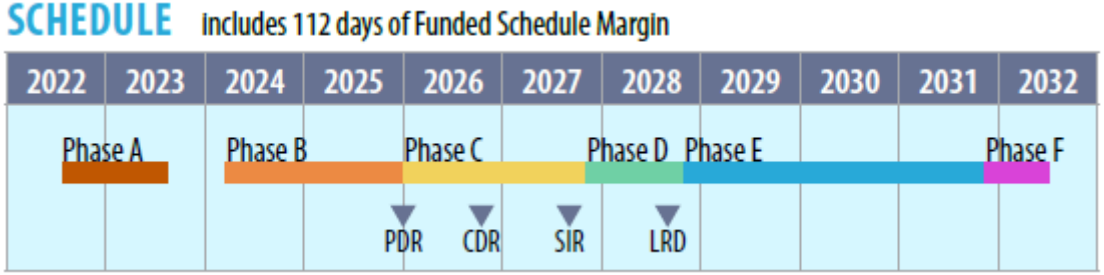


AMEGO-X: MIDEX

Explore multi-messenger and time-domain astronomy

- GRB and GW
- Hi-E ν and SMBH/Jet
- CR sources in the Galaxy





PI: Regina Caputo
(GSFC/NASA)

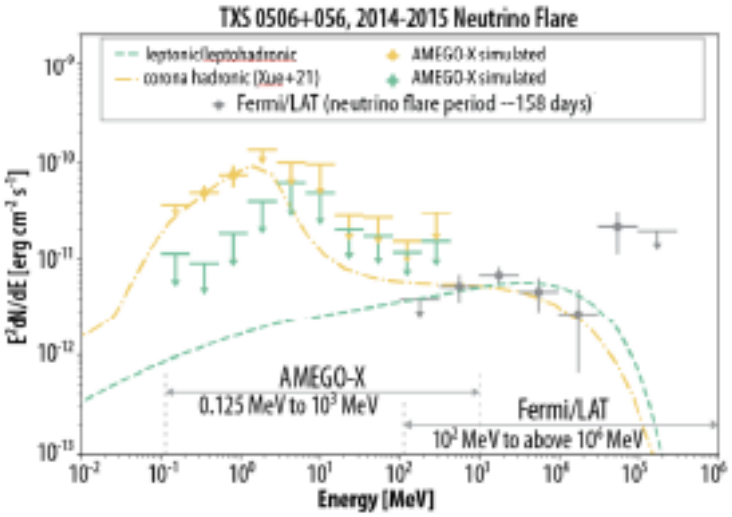
日本人メンバー
田島、深沢、須田、
村瀬

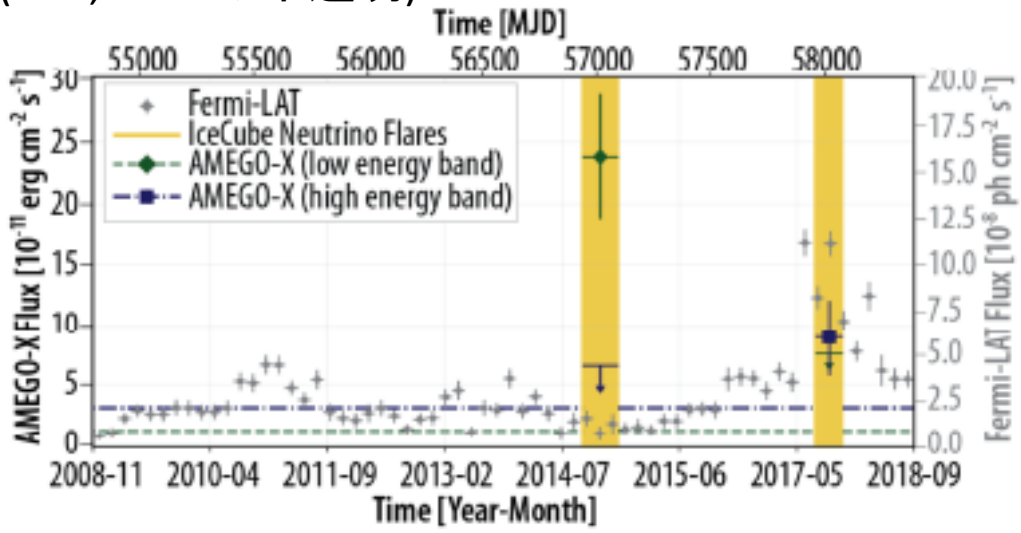
Submitted a MIDEX proposal
(Dec. 2021)

Cost cap $300M

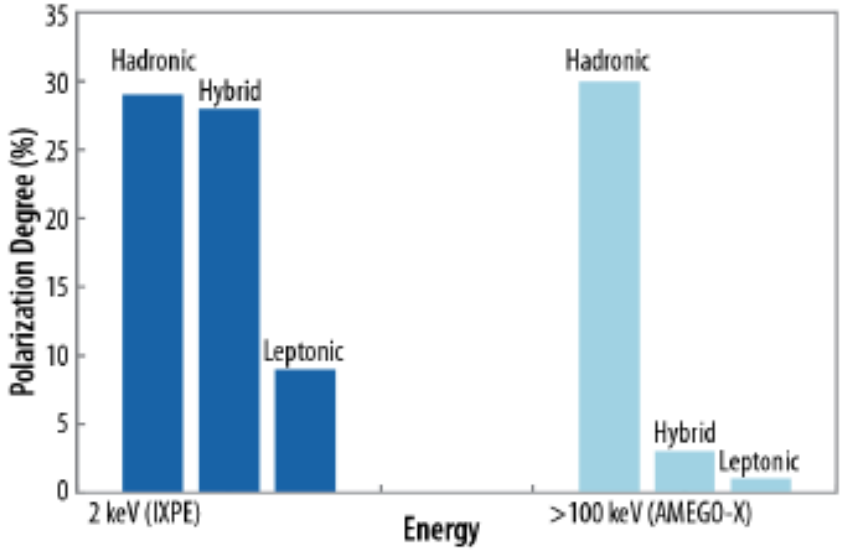
AGN関連サイエンス

He-νに同期したガンマ線(GeV,TeVでは不透明)

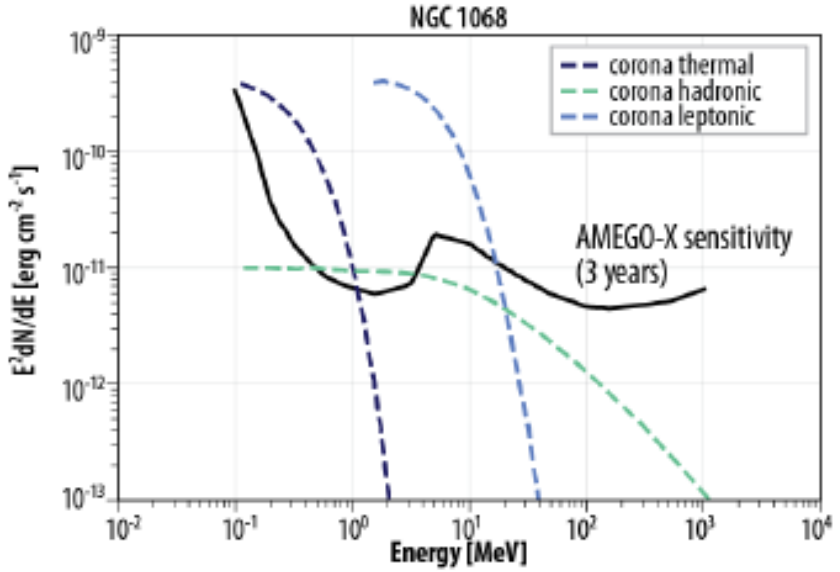




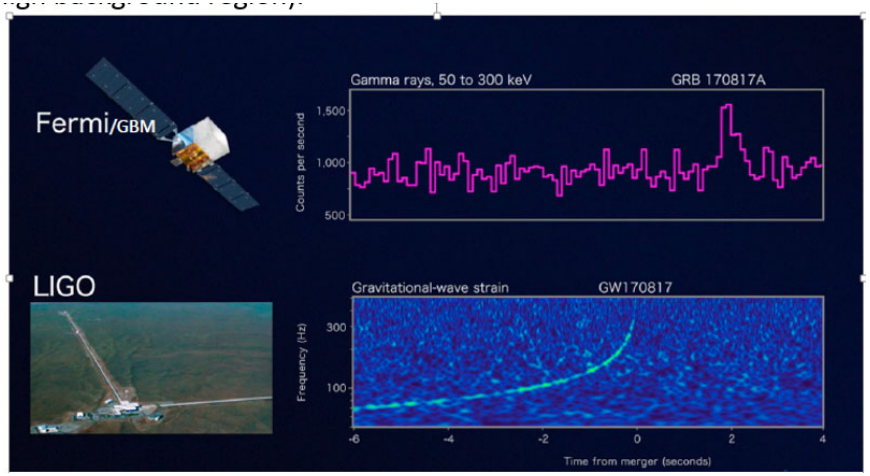
偏光によるレプトン、ハドロン放射の区別



Non-jetted AGN　のガンマ線放射

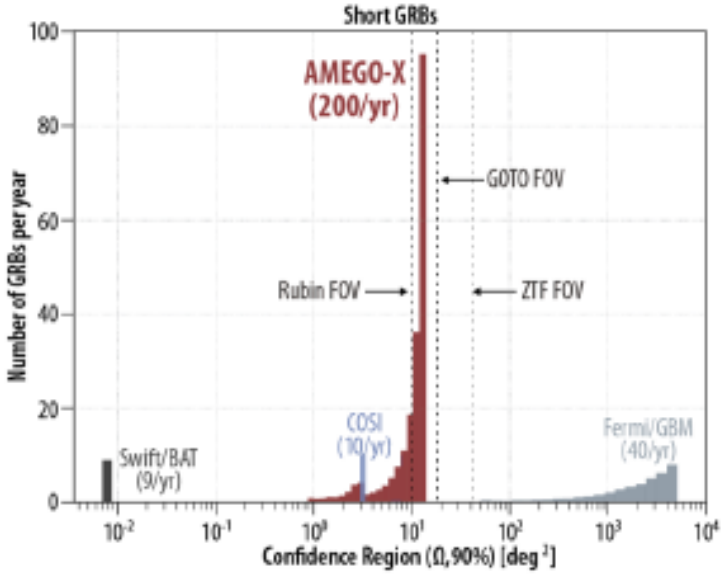


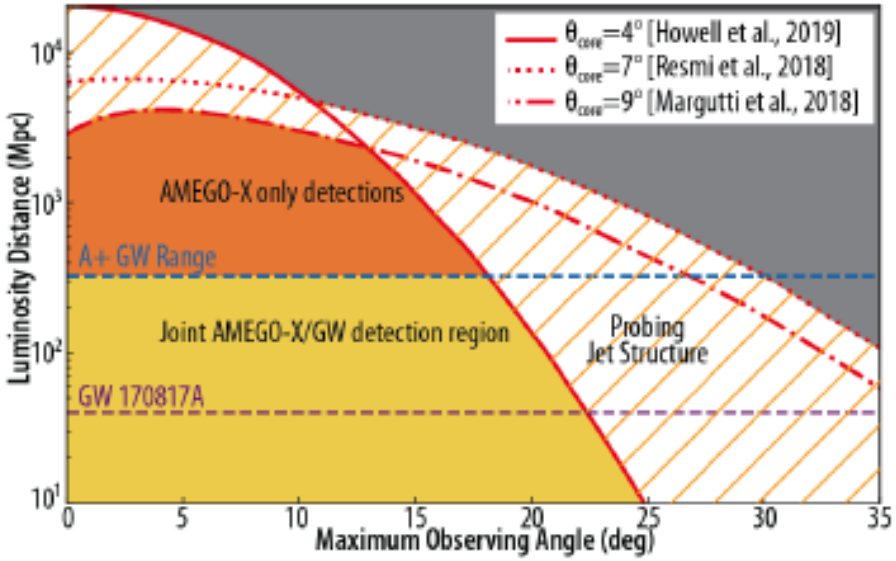
ガンマ線バースト関連サイエンス



GWとの同期イベントの高感度広視野サーチ

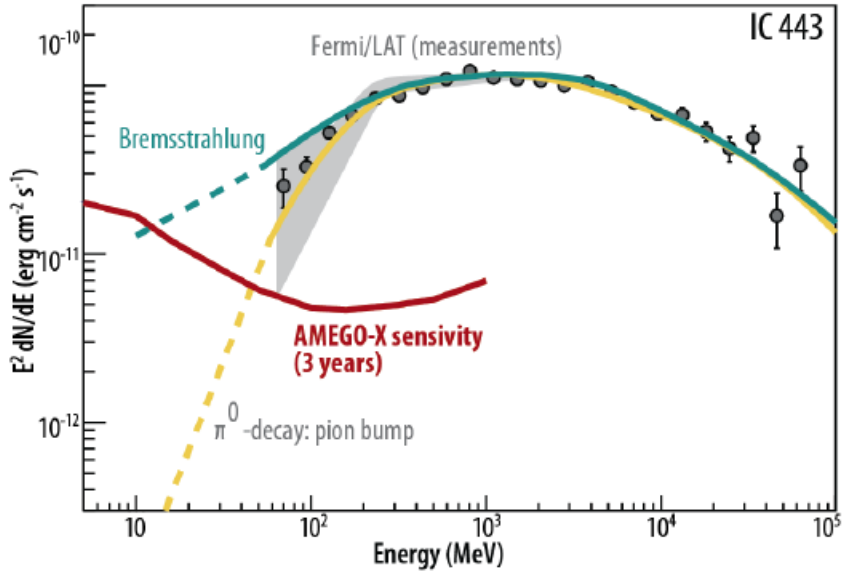
ジェット放射の見込み角分布



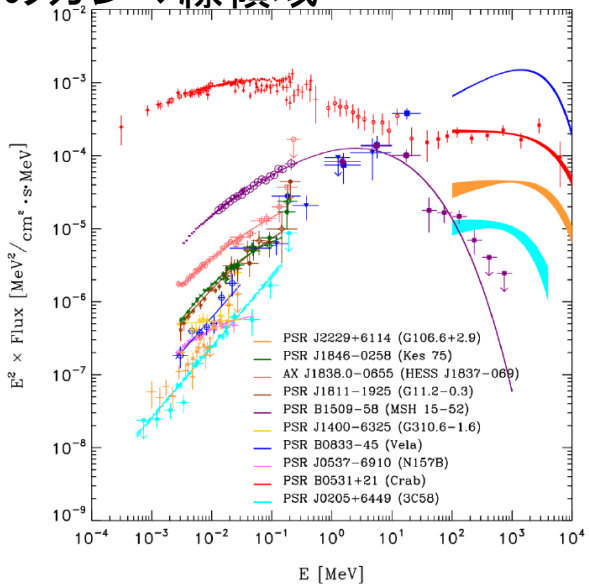


銀河宇宙線関連

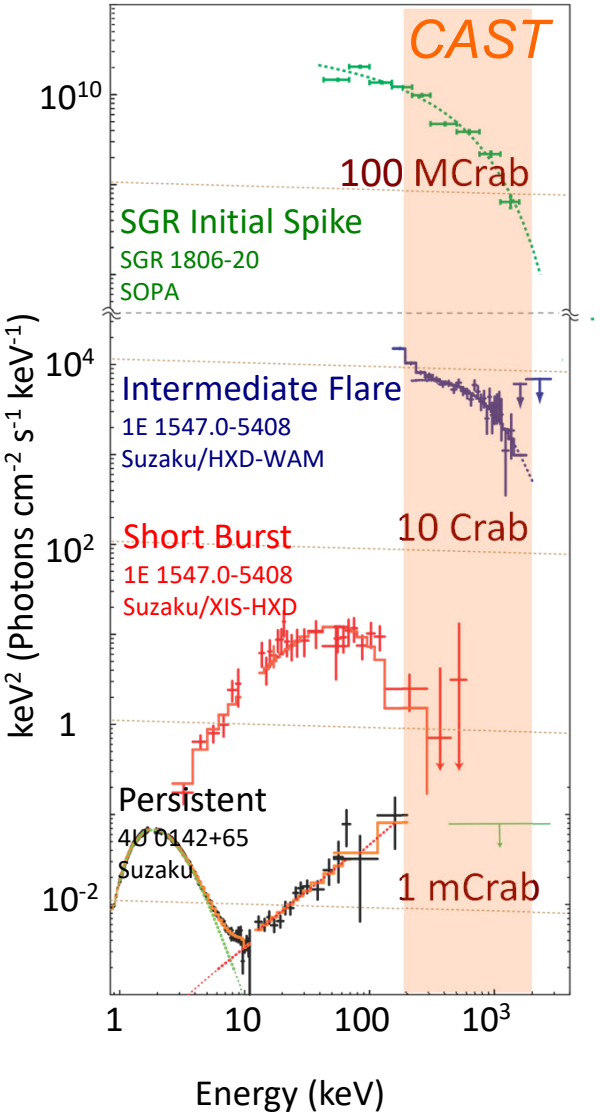
陽子由来パイオン成分の精密測定



パルサーのガンマ線領域



マグネターのフレア



AMEGO-Xのサイエンス要求

How do massive stars and neutron stars form, evolvbe and die ?

GW同期のshort GRBs, short GRBsの詳細時間変動, GRBのkeV to GeVのスペクトル, TeVガンマ線動機のGRB, マグネターのgiant flareの時間変動スペクトル

How do galactic accelerators , such as pulsars, magnetars and large0scale shocks, energize the local cosmic ray population ?

SNRや星生成領域のパイオンハンプスペクトル, パルサーやマグネターの広帯域スペクトル, パルサーやマグネターの位相ごとのスペクトルと偏光, PWNやそれを含む連星の広帯域スペクトル,. Short magnetar bursts

How does massive black hole activity give rise to particle acceleration tied to observable gamma-rays, cosmic-rays and neutrinos ?

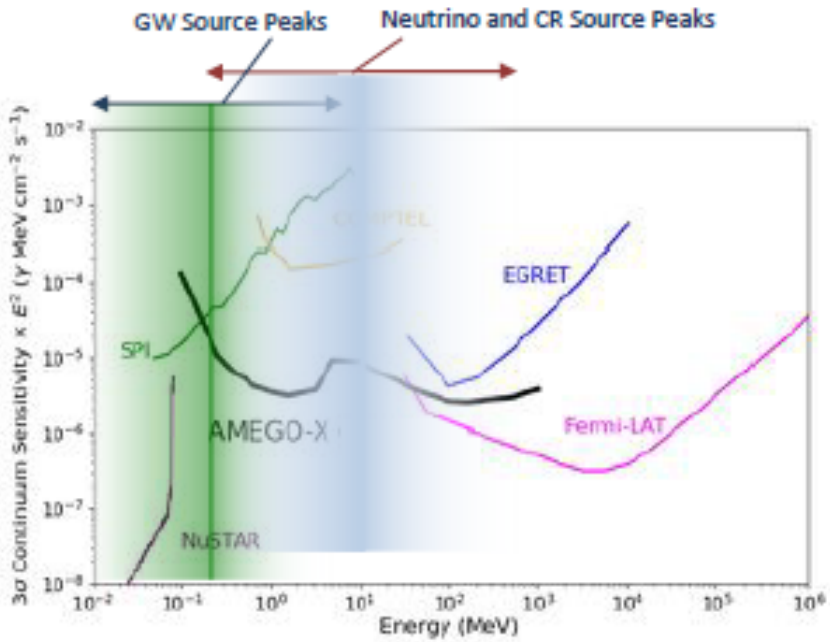
AGモニター（）マルチメッセンジャー、時間変動), MeV peaked blazars, 明るいAGNの偏光, non-jetted AGNからのガンマ線探査

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



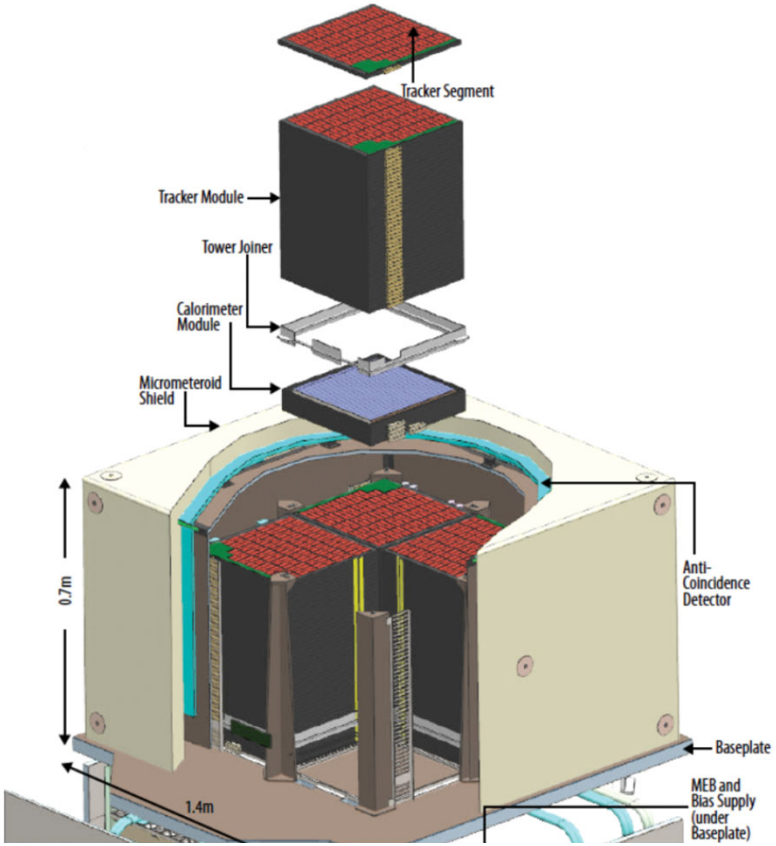
AMEGO-X will lead to major scientific discoveries and breakthroughs in the MeV gamma-ray band like Fermi-LAT in the GeV band

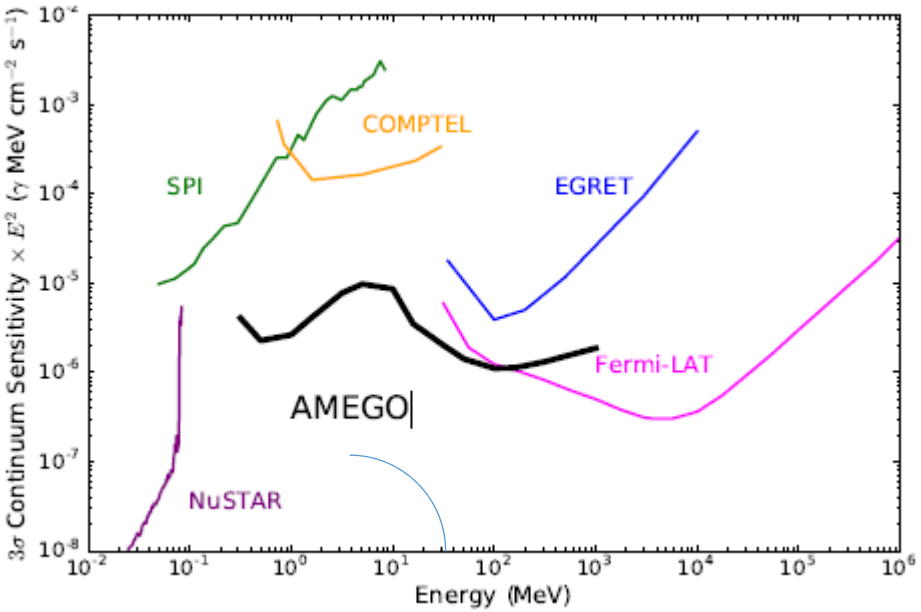
From AMEGO,

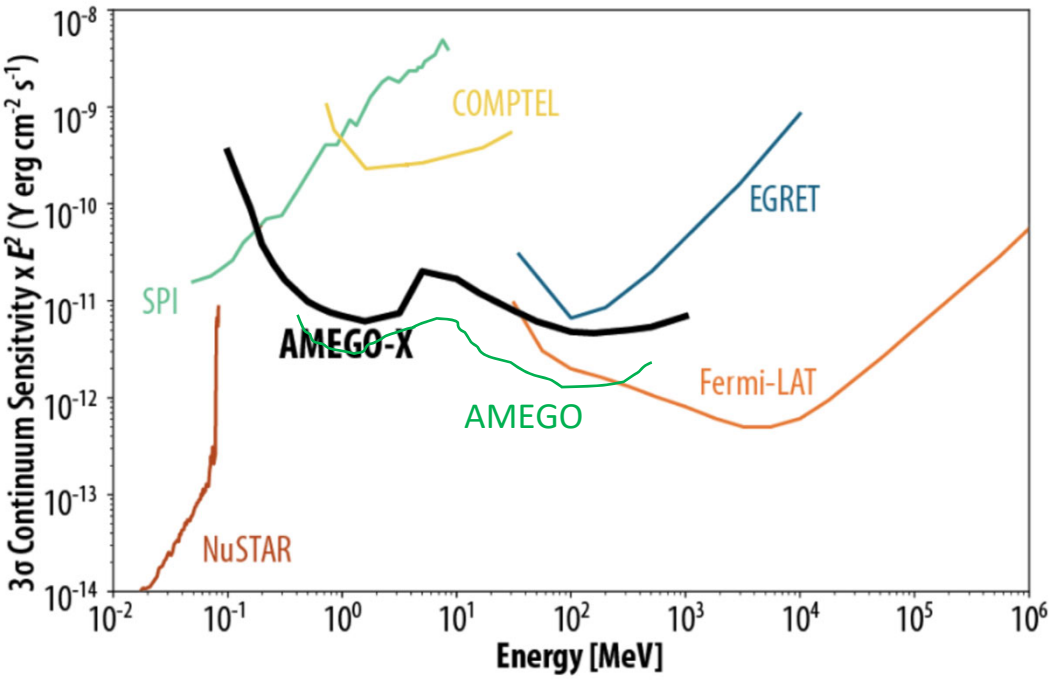
DSSD → AstroPix (Pixsel Detector)

Remove CZT

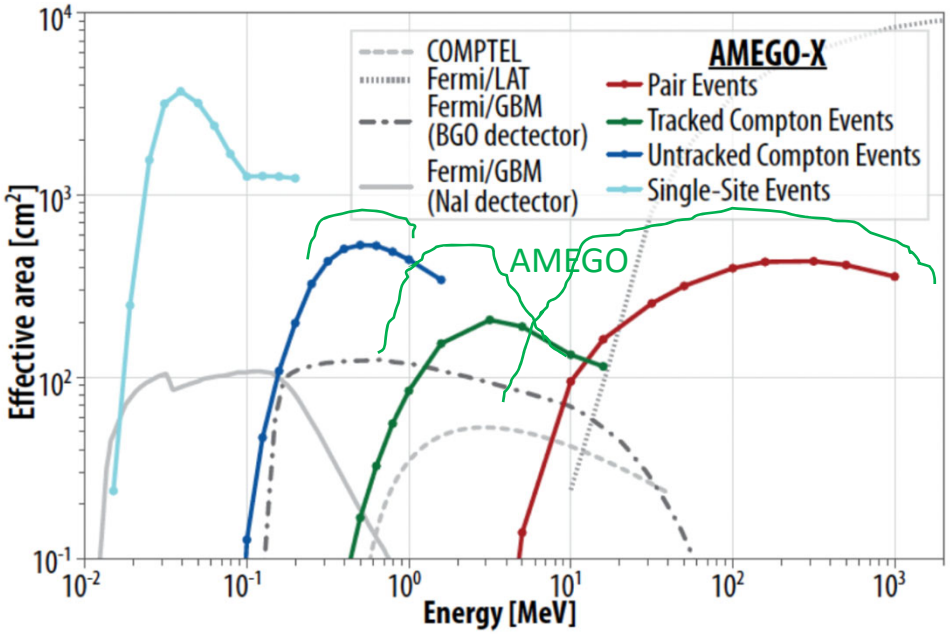
about haef of EA



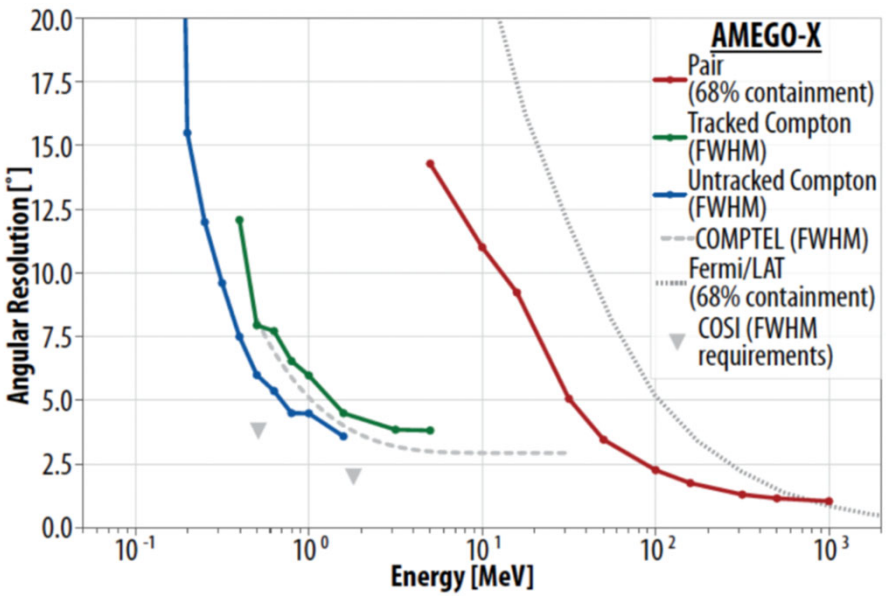




有効面積

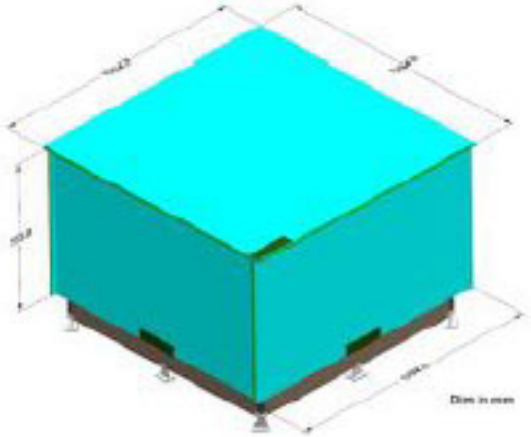

Effective area [cm²]
Energy [MeV]
COMPTEL
Fermi/LAT
Fermi/GBM
(BGO dectector)
Fermi/GBM
(NaI dectector)
AMEGO-X
Pair Events
Tracked Compton Events
Untracked Compton Events
Single-Site Events
AMEGO

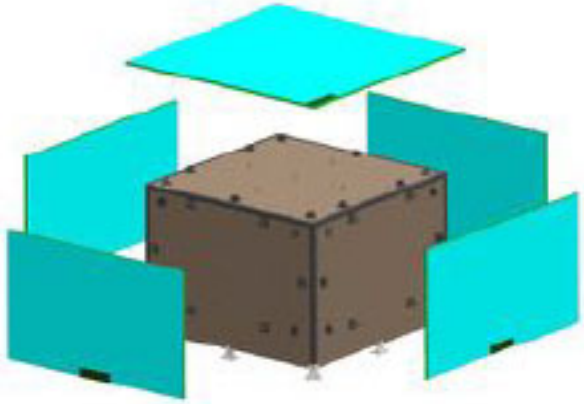
角度分解能


Angular Resolution [°]
Energy [MeV]
AMEGO-X
Pair
(68% containment)
Tracked Compton
(FWHM)
Untracked Compton
(FWHM)
COMPTEL (FWHM)
Fermi/LAT
(68% containment)
COSI (FWHM
requirements)

Anticoincidence Detector

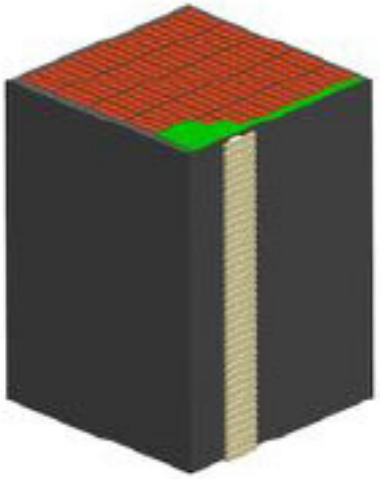
- The Anti-coincidence Detector is composed of 5 Panels
- Each Panel is composed of scintillator tiles with WLS bars and SiPMs on the edge
- FEE cards are on bottom of side panels and in corner of top panel
- Each panel is mounted to the ACD structure
- Draws on Fermi-LAT Heritage

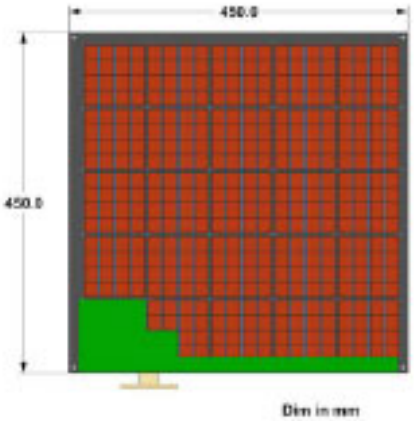


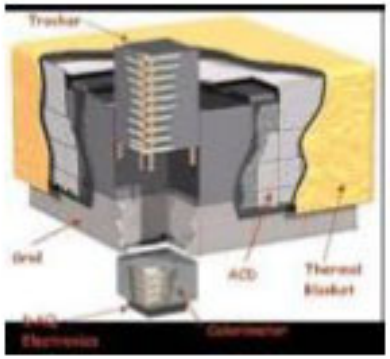


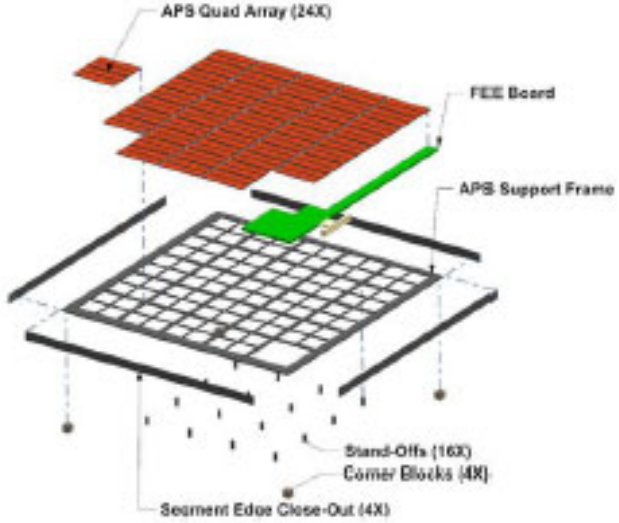
Tracker

- 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



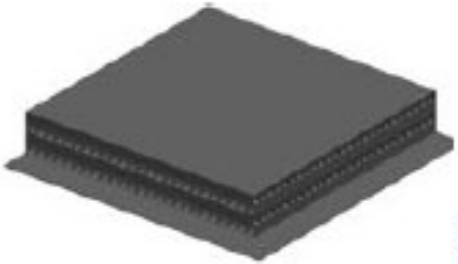


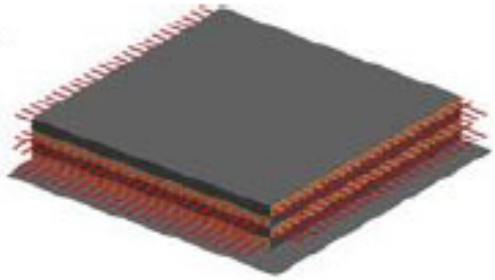


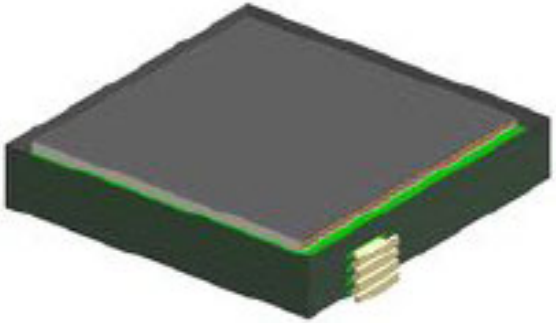


Calorimeter

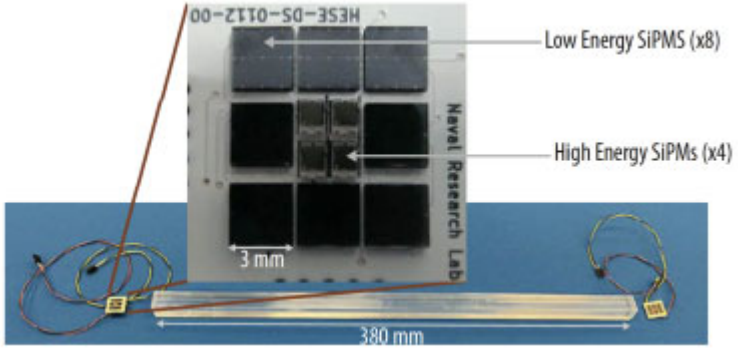
- The Calorimeter is a 4 layer module
- The 4 layers of CsI Crystals are installed in a unibody frame
- Each Crystal has high and low energy SiPMs on each end
- The SiPMs feed the FEE PCB
- Draws on heritage from Fermi-LAT

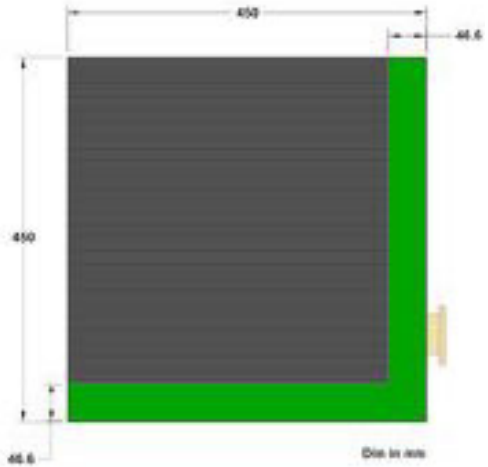






FERMI-LAT Calorimeter Structure Design





AstroPix

HV-CMOS from ATLASPix

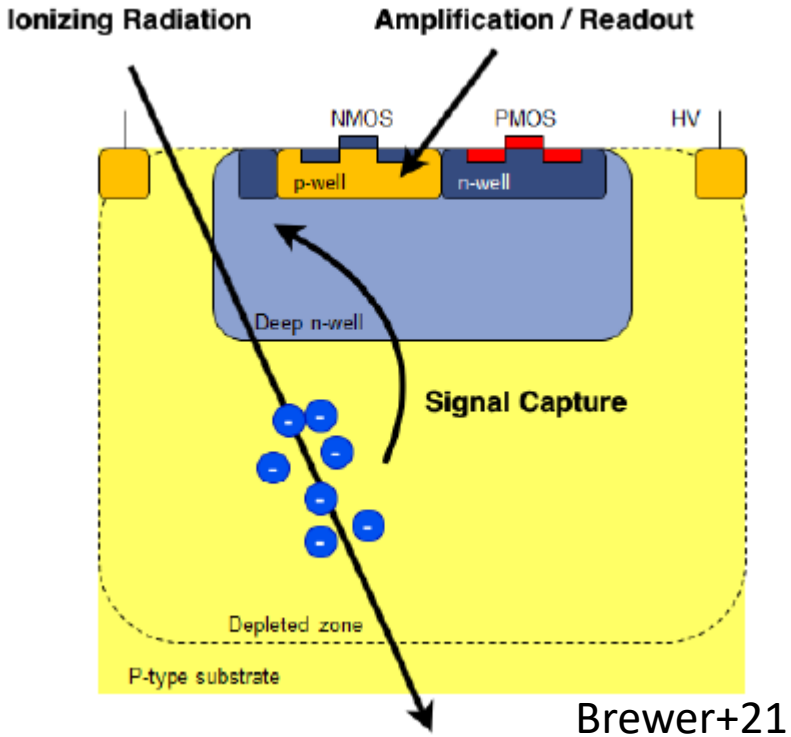
pix size: 0.5mm or 1mm

Give lower threshold than DSSD

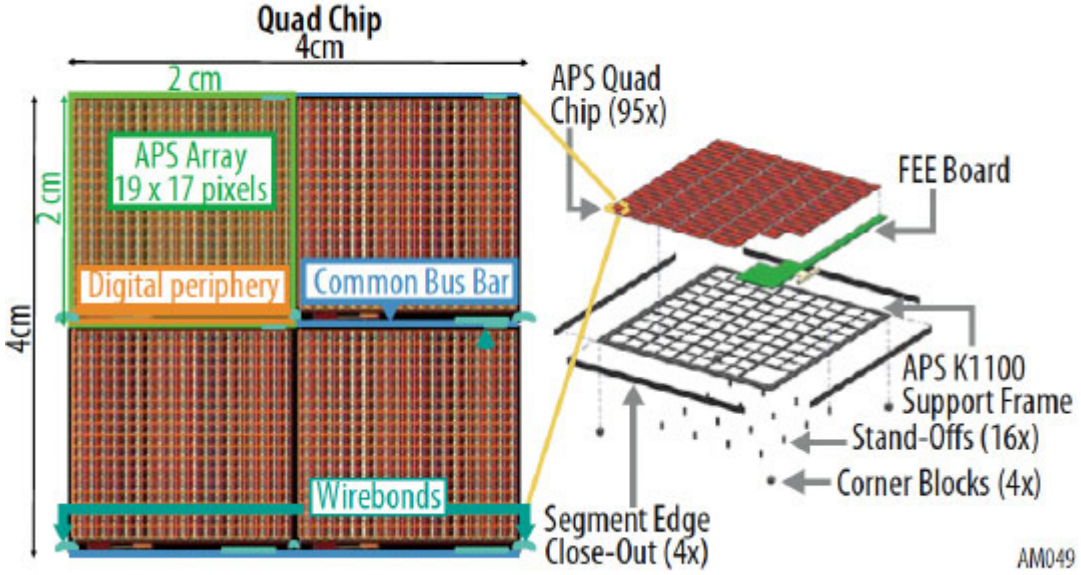
60 keV → 15 keV

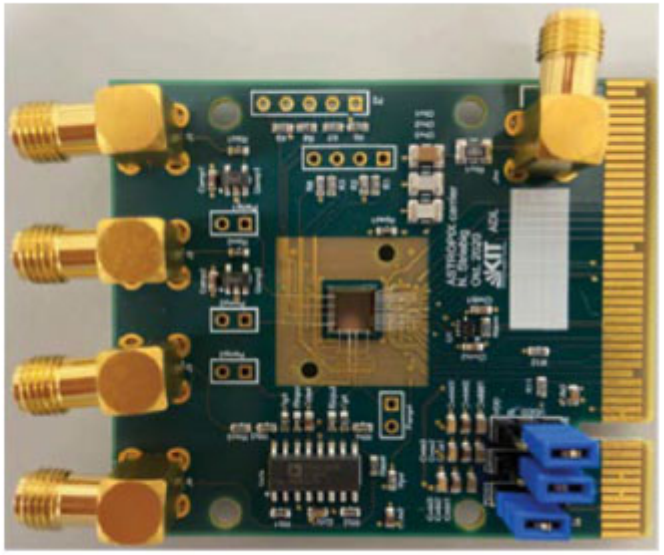
Improve low-E performance

(below 1 MeV)



Brewer+21





AMEGO-Xの状況と今後

MIDEXには選定されず、次にチャレンジ予定

2023-2025で、プロトタイプタワー検出器を製造、ビーム試験、気球実験予定（日本からも参加）

AstroPixの改良を進め、TRL向上（日本も参加）