CALET experiment and CALET GRB Monitor

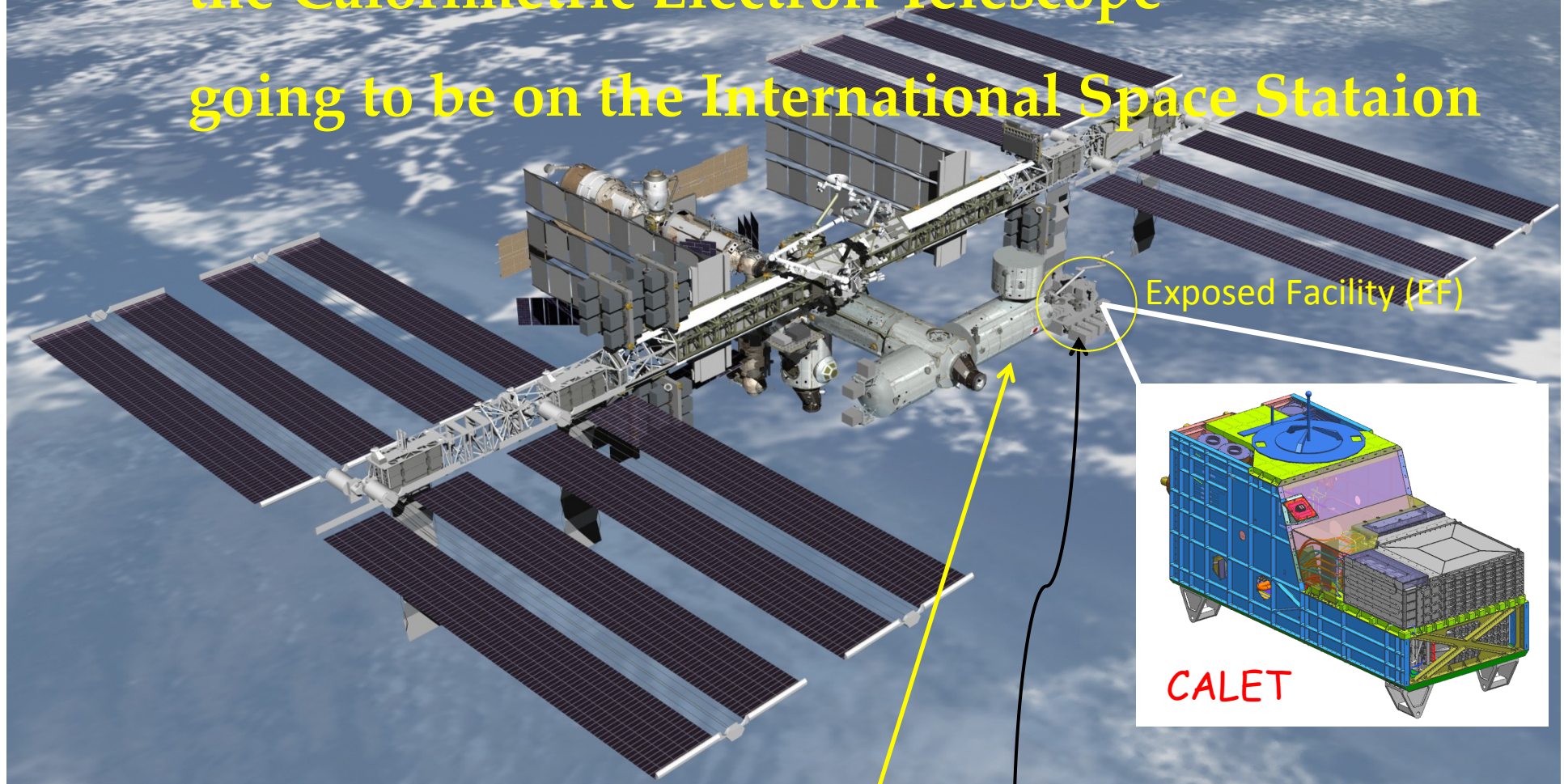
Atsu Yoshida (Aoyama Gakuin Univ.)

for the CALET team

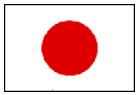
CALET

the Calorimetric Electron Telescope

going to be on the International Space Stataion



CALET International Collaboration Team



JAPAN — 22 institutions

Aoyama Gakuin University
Hirosaki University
Ibaraki University
Institute for Cosmic Ray Research, University of Tokyo
JAXA/Space Environment Utilization Center
JAXA/ Institute of Aerospace and Astronautical Sciences
St. Marianna University, School of Medicine
Kanagawa University
High Energy Accelerator Research Organization (KEK)
Nagoya University
National Institute of Radiological Sciences
National Institute of Polar Research
Nihon University
Ritsumeikan University
Saitama University
Shibaura Institute of Technology
Shinshu University
Tokiwa University
Tokyo Institute of Technology
University of Tokyo
Waseda University (PI Institute)
Yokohama National University

ITALY — 5 institutions

University of Siena and INFN
University of Florence & IFAC (CNR) and INFN
University of Pisa and INFN
University of Roma Tor Vergata and INFN
University of Padova and INFN

USA — 6 institutions

NASA/GSFC
CRESST/NASA/GSFC and University of Maryland
CRESST/NASA/GSFC and Universities Space Research Association
Louisiana State University
Washington University - St Louis
University of Denver

Support Agencies

JAXA 宇宙航空研究開発機構 Japan Aerospace Exploration Agency

JAXA/SEUC

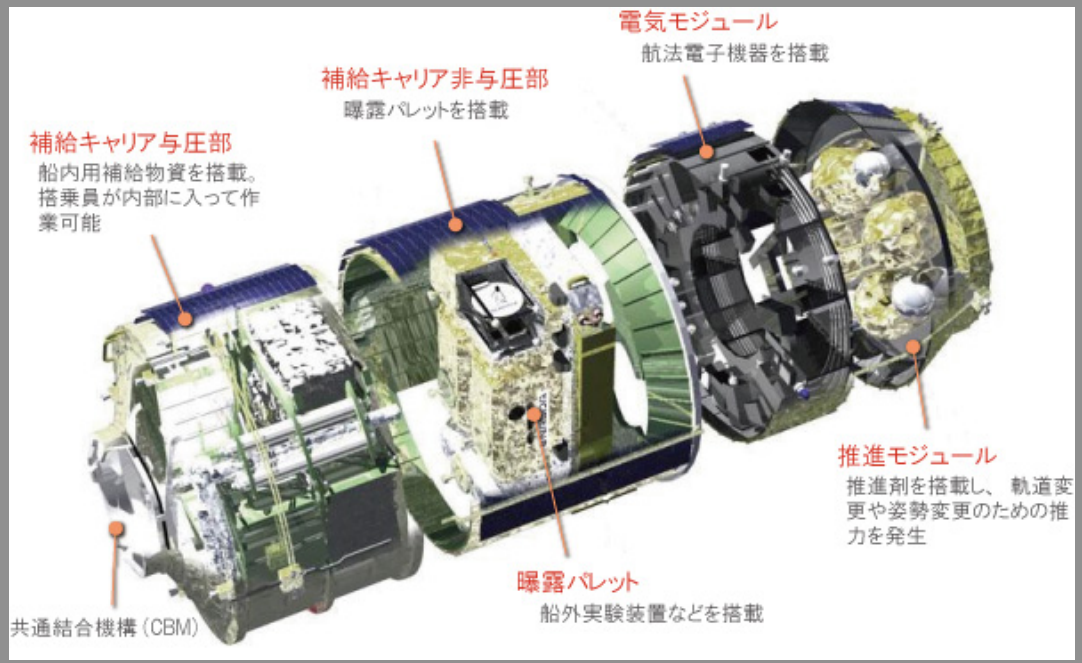
PI I: Waseda University

ASI

NASA

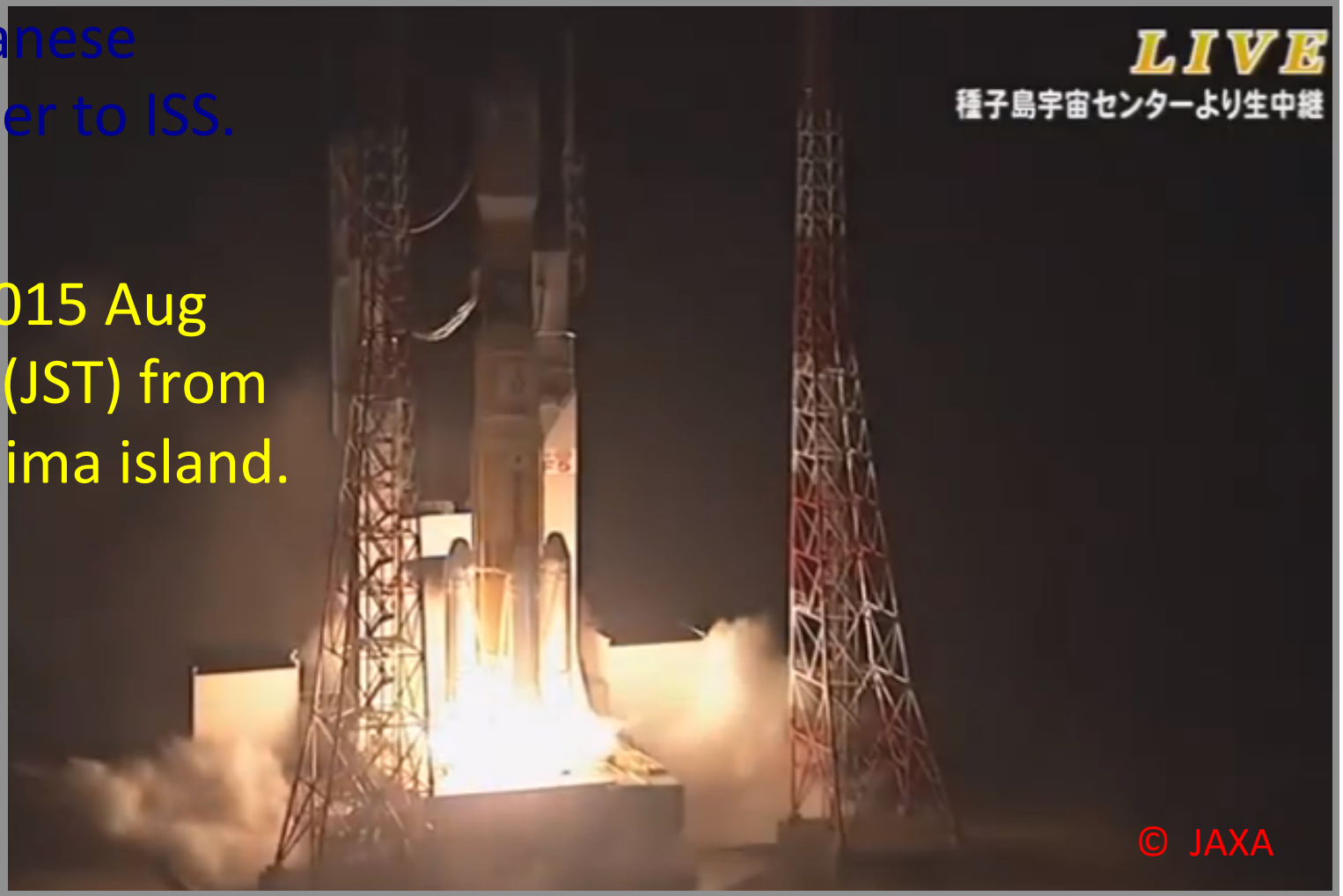
HTV5

- HTV: Japanese transporter to ISS.
- .



HTV5

- HTV: Japanese transporter to ISS.
- Launch 2015 Aug 20:50:49 (JST) from Tanegashima island.



HTV5

- Captured by ISS Aug 24 19:29.

CALET was moved to port#9 on Aug 26.

CALET in orbit

- MDC (Mission Data Processor) is ON.
- Instruments with high voltage will be on in a month.
- Commissioning period until this November.
- From December 2015, normal operations.

CALET Observations

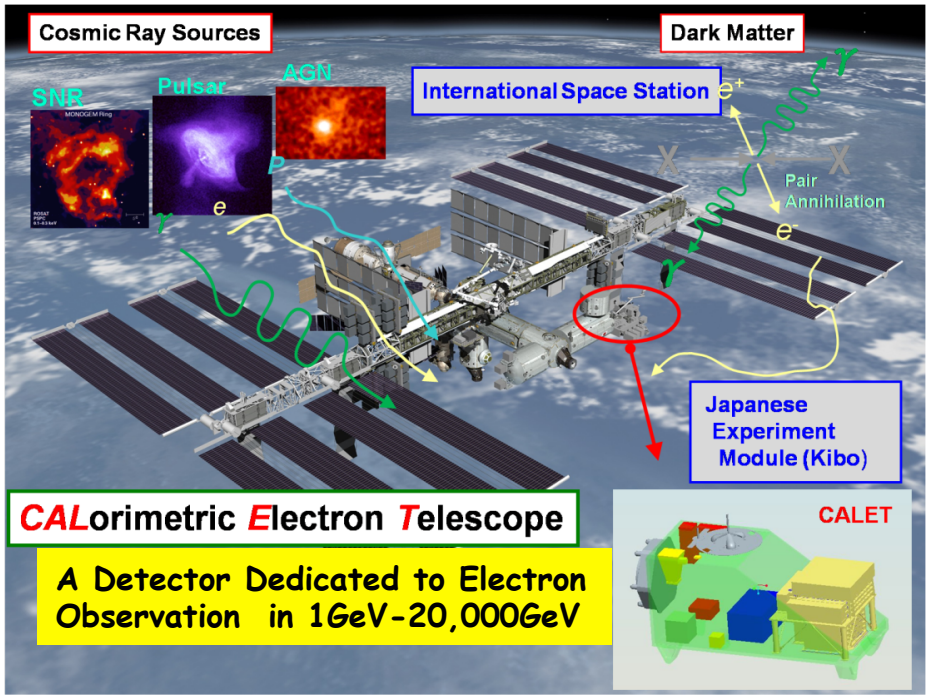
Calorimeter (CALET/CAL)

- Electrons: 1 GeV – 20 TeV
- Gamma-rays: 4 *GeV – 10 **TeV
  (Gamma-ray Bursts: > 1 GeV)
- Protons and Heavy Ions:
  10's of GeV – 1,000** TeV
- Ultra Heavy (Z>28) Nuclei:
  E> 600 MeV/nucleon

(* 50% efficiency, ** statistical dependent)

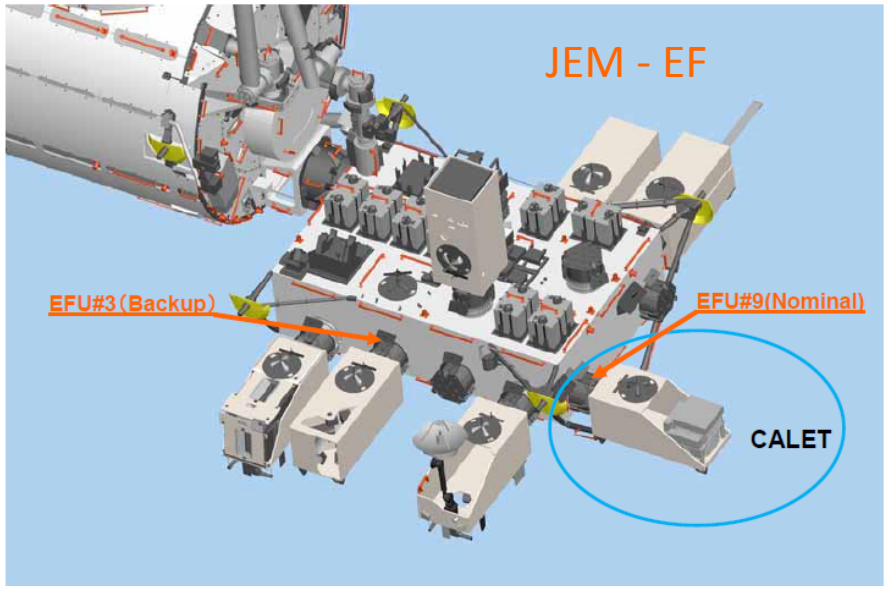
Gamma-ray Burst Monitor (CGBM)

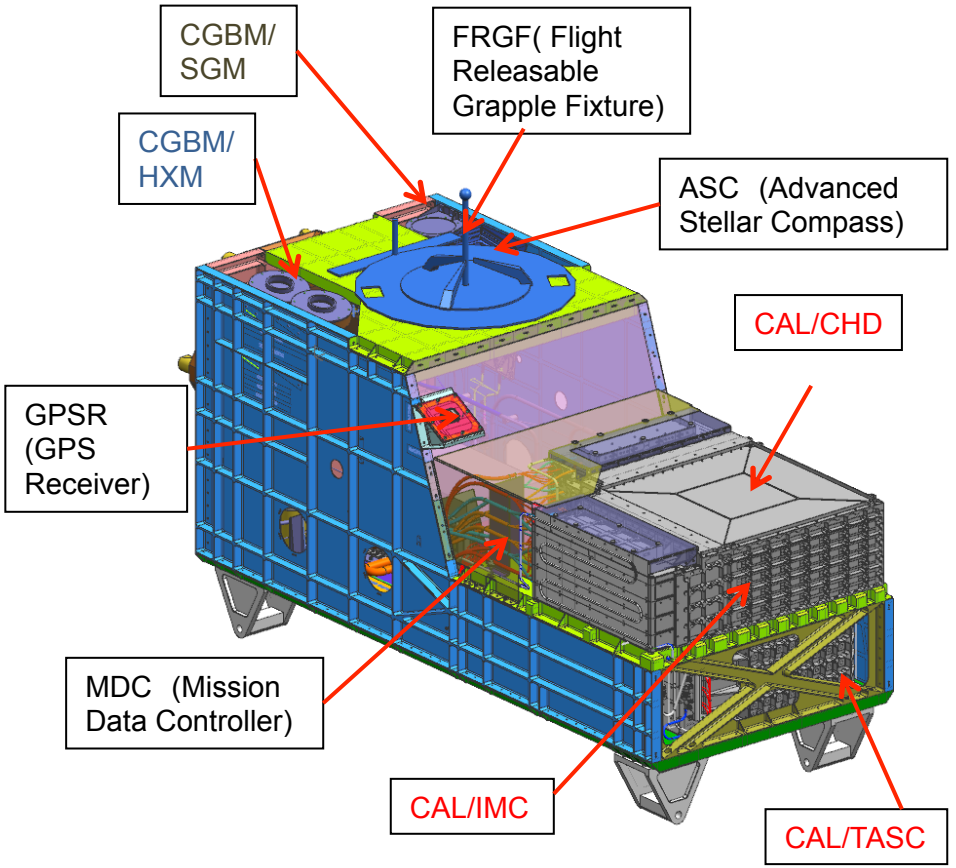
X-rays/Soft Gamma-rays:
7keV – 20MeV



Science Objectives	Observation Targets
Nearby Cosmic-ray Sources	Electron spectrum in trans-TeV region
Dark Matter	Signatures in electron/gamma energy spectra in 10 GeV – 10 TeV region
Origin and Acceleration of Cosmic Rays	p-Fe over several tens of GeV, Ultra Heavy Nuclei
Cosmic –ray Propagation in the Galaxy	B/C ratio up to several TeV /n
Solar Physics	Electron flux below 10 GeV
Gamma-ray Transients	Gamma-rays and X-rays in 7 keV – 20 MeV

CALET Payload Overview





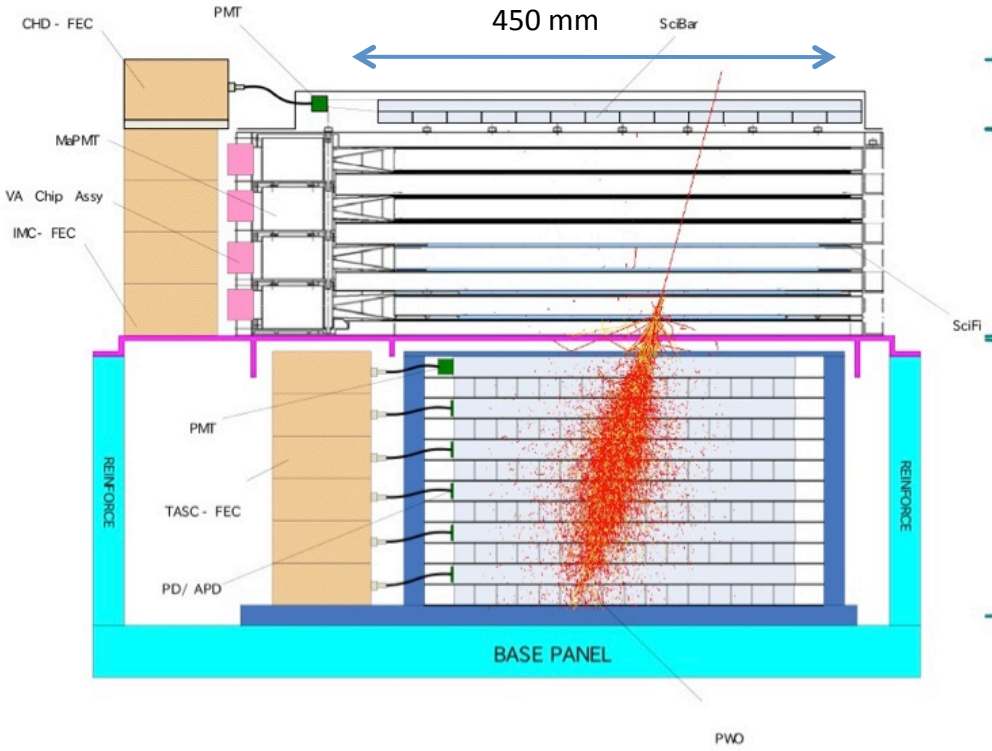
- Launch carrier: HTV-5
- Launch date: 2015/08/19
- Mission period: More than 2 years
  (5 years target)

- Data rate:
  - Medium data rate: 600 kbps
  - Low data rate: 35 kbps

- Mass: 650kg (Max)
- JEM/EF Standard Payload Size
- Power: 650W (Nominal)

Main High-Energy Particle Telescope

The unique feature of CALET is its thick, fully active calorimeter that allows measurements well into the TeV energy region with excellent energy resolution, coupled with a fine imaging upper calorimeter to accurately identify the starting point of electromagnetic showers. Combined, they powerfully separate electrons from the abundant protons: selection protons: selection power $>10^5$.



Plastic Scintillator : 14 × 1 layer (x,y)
Unit Size: 32mmx10mmx450mm

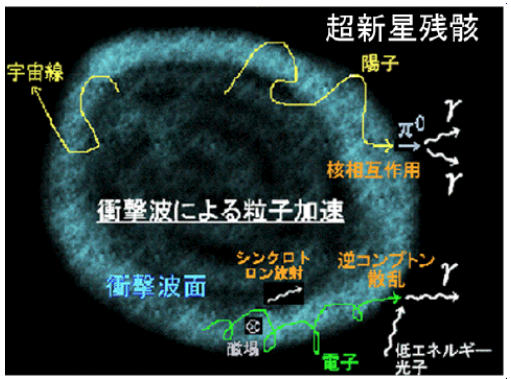
SciFi : 448 x 8 layers (x,y) = 7168
Unit size: 1mmsq x 448 mm
Total thickness of Tungsten:
3 radiation lengths.

PWO log: 16 x 6 layers (x,y)= 192
Unit size: 19mm x 20mm x 326mm
Total Thickness of PWO:
27 radiation lengths.

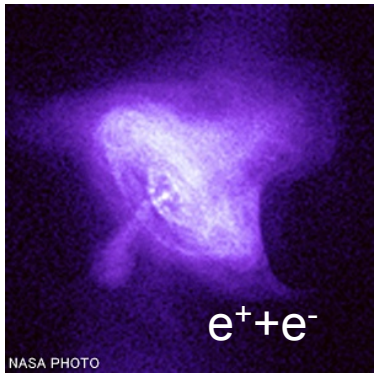
Primary: Sensitive Physics Probes by Electron Observations

Astrophysical Origin: Charged Particle Astronomy

Shock Wave Acceleration in SNR



Acceleration in PWN

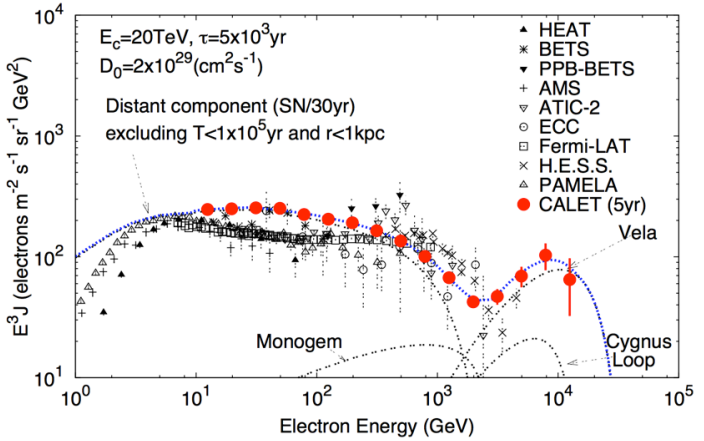


> 1 TeV Synchrotron and Inverse Compton losses

⇒ Age < ~10^5 years, Distance < 1 kpc

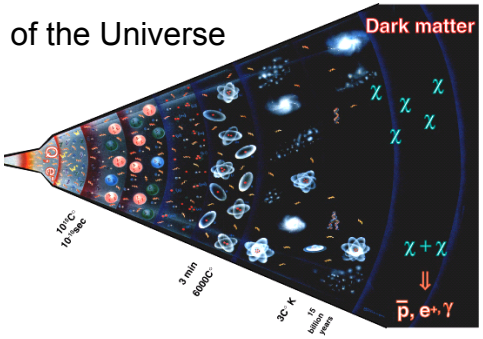
(A few sources: Vela, Monogem, Cygnus Loop)

⇒

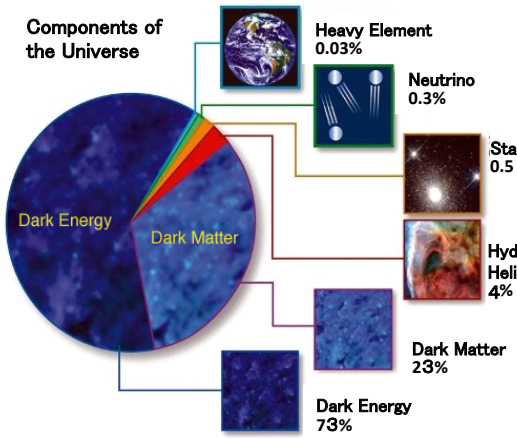


Dark Matter Origin: Annihilation or Decay Signatures

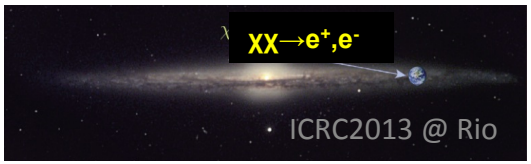
Evolution of the Universe



Components of the Universe



Annihilation of Dark Matter (WIMP)



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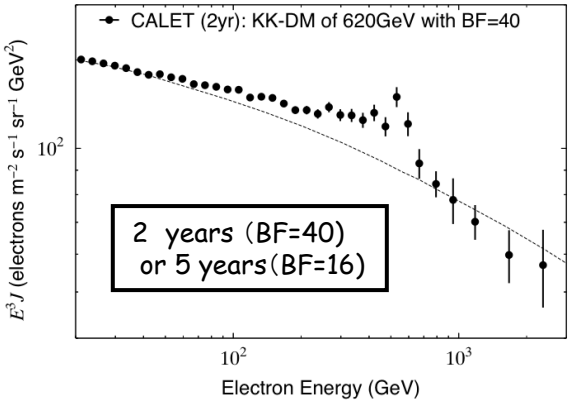
Measured Spectrum Tags DM Species

(i) Kaluza-Klein Particle Annihilation: Monoenergetic direct production of e+e- pair – Sharp high energy cut-off

(ii) Neutralino Particle Annihilation: Broad production spectrum via intermediate particles – Soft distribution over range of energy

(iii) Single WIMP Decay: Wide production spectrum below mass via Neutrino (Ibarra et al. 2010) - Soft cut-off and high intensity without requiring local DM "clump"

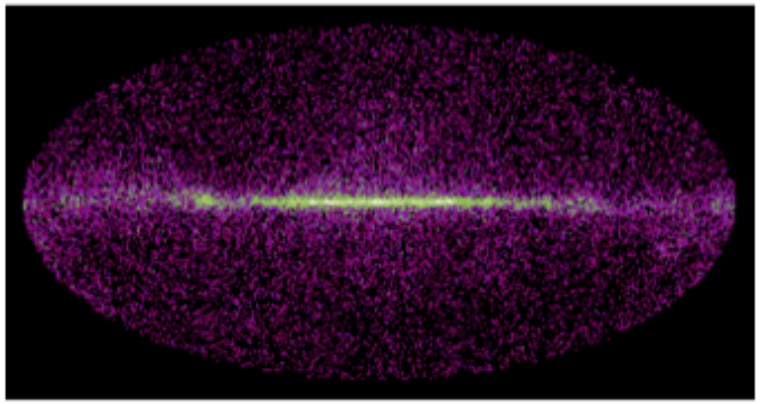


Detection of High Energy Gamma-rays

Performance for Gamma-ray Detection

Energy Range	4 GeV-10 TeV (normal)
Effective Area	600 cm^2 (10GeV)
Field-of-View	2 sr
Geometrical Factor	1100 $cm^2 sr$
Energy Resolution	3% (10 GeV)
Angular Resolution	0.35 ° (10GeV)
Pointing Accuracy	6′
Point Source Sensitivity	8×10^{-9} $cm^{-2} s^{-1}$
Observation Period (planned)	2014-2019 (5 years)

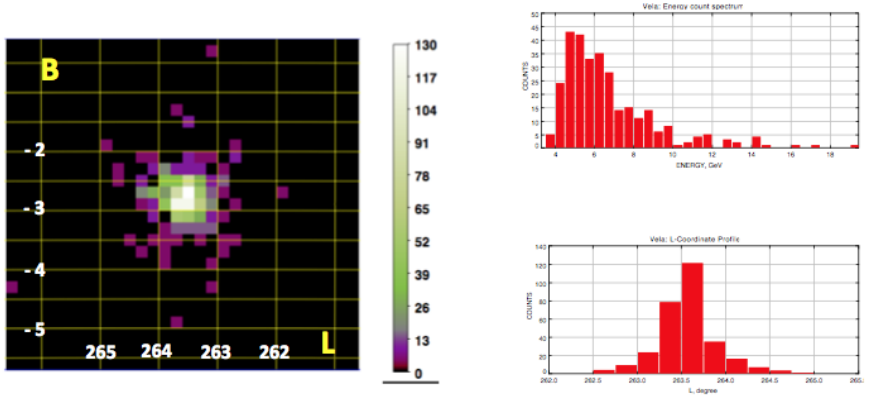
Simulation of Galactic Diffuse Radiation



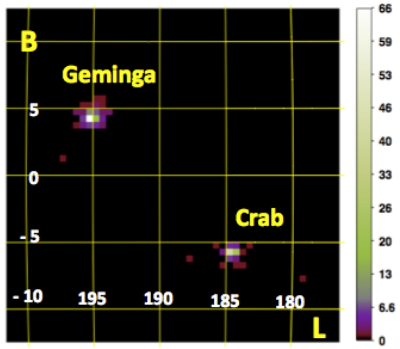
~25,000 photons are expected per one year

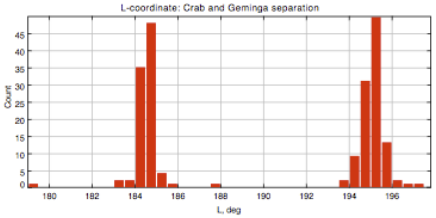
*) ~7,000 photons from extragalactic γ-background (EGB) per one year

Simulation of point sources per one year



Vela: ~ 300 photons above 5 GeV



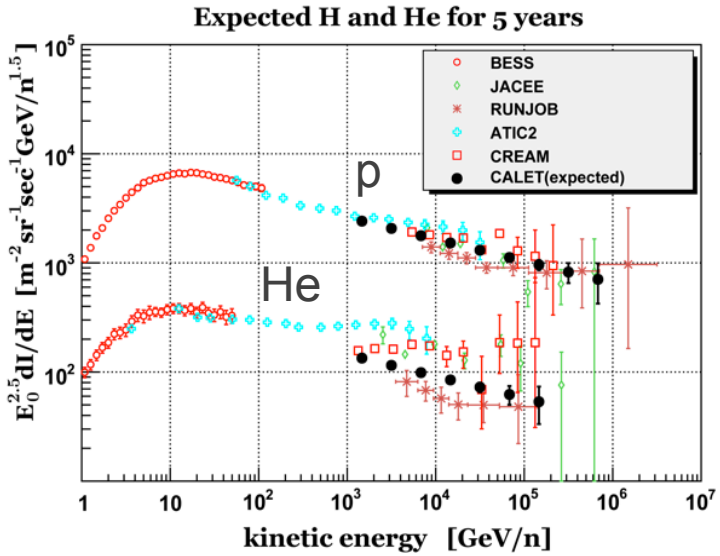


Geminga: ~150 photons above 5 GeV
Crab: ~ 100 photons above 5 GeV

High Energy Protons and Nuclei, and Ultra Heavy Nuclei

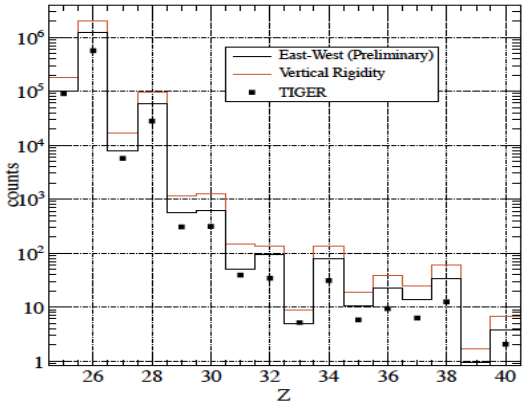
Nuclear Spectra to "Knee" Energies

-Spectral shape and composition probe supernova acceleration



UH Composition to Z=40

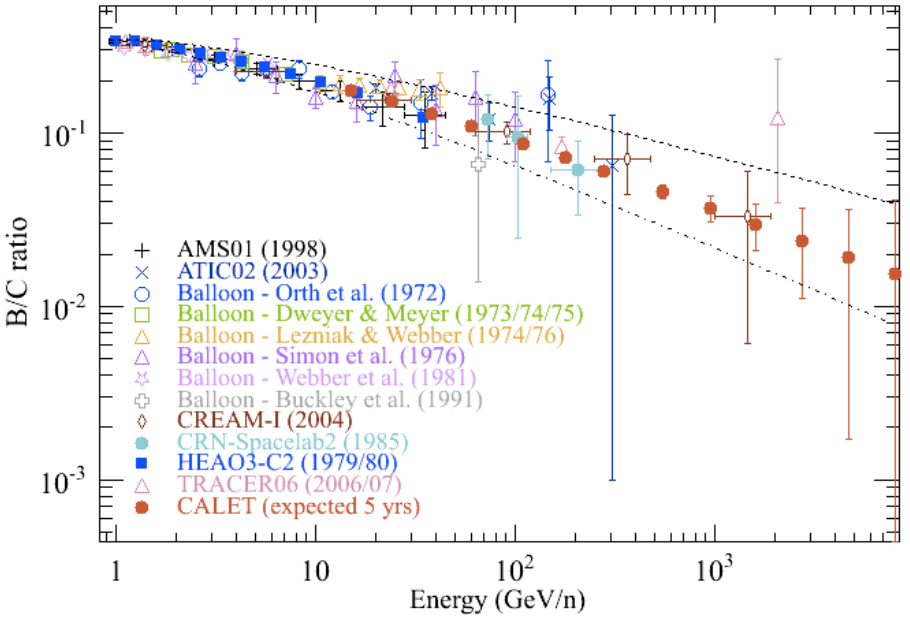
-Much cleaner UH composition than previous balloon experiments B.Rauch Oral ID: 819



Secondary to Primary ratio (B/C, sub-Fe/Fe)

- Energy dependence of diffusion constant: $D \sim E^{\delta}$
- Observation up to several TeV/n free from the atmospheric production of boron by heavier cosmic ray nuclei

P.S.Marrocchesi Oral ID:362



Direct measurement of heavy ion interactions

- Cross sections above accelerator energy ; Input for Monte Carlo codes
- Critical for Air Shower interpretation

CALET Gamma-ray Burst Monitor (CGBM)

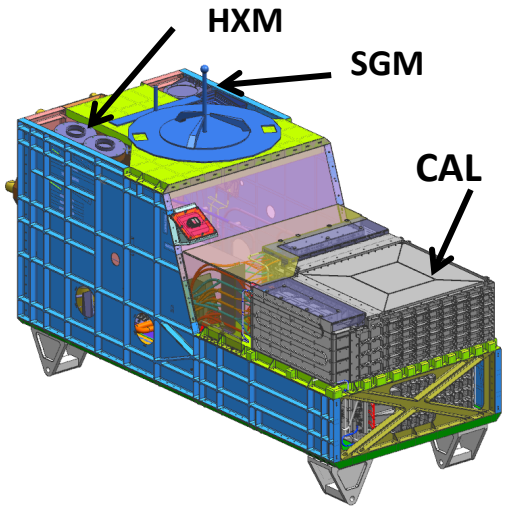
$LaBr_3$(Ce) (Hard X-ray Monitor: HXM)

& BGO (Soft Gamma-ray Monitor: SGM)

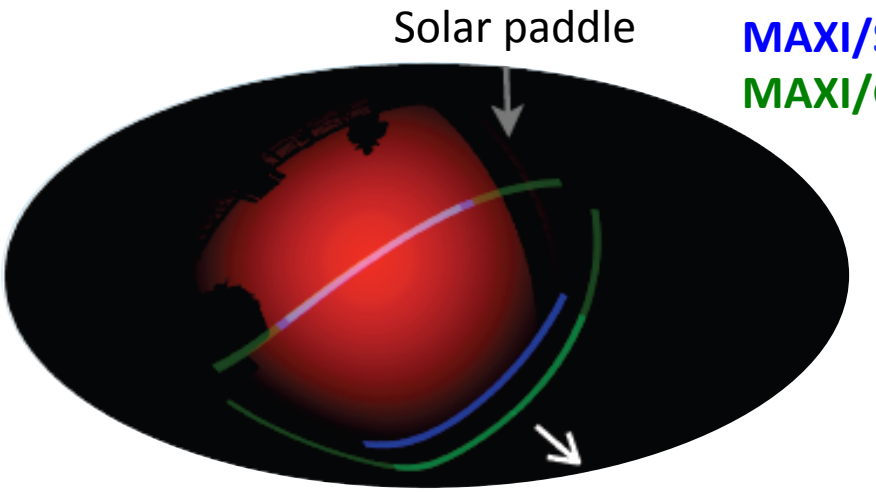
Sensitivity: $>\sim 10^{-8}$ erg cm^{-2} s^{-1} (1-1000 keV).

Covering a broad energy range (~7 keV – 20 MeV) , and up to ~1-10 TeV range together with the CAL.

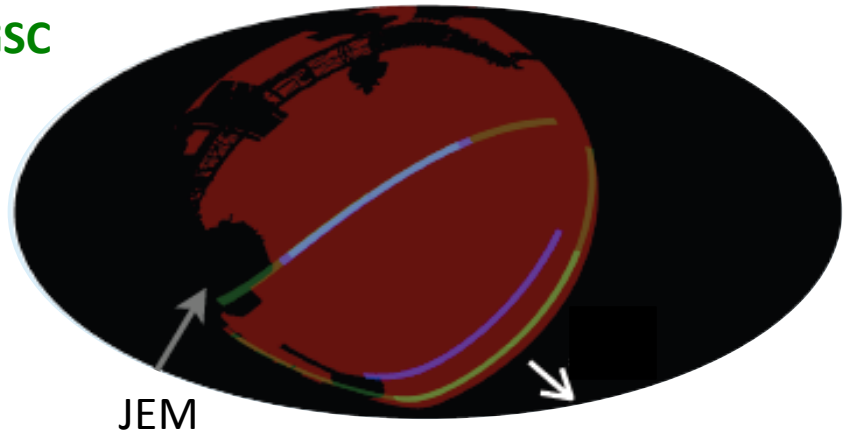
Also down to ~1 keV when simultaneous observations with the MAXI.



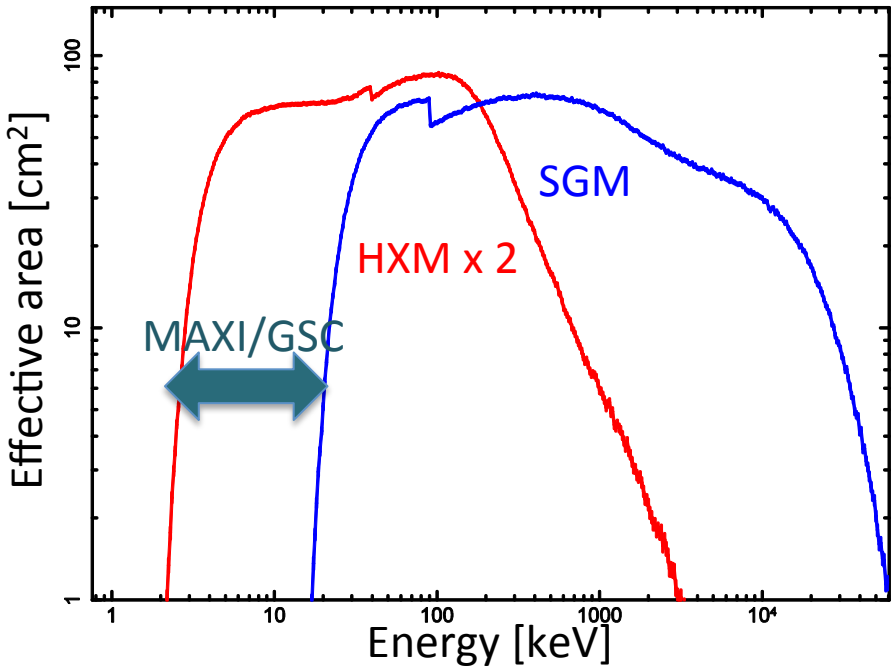
FoV of MAXI/GSC & CGBM



FoV of HXM@10 keV



FoV of SGM



Alert base collaboration is OK in the current framework. Further analyses can deliver more fruitage.

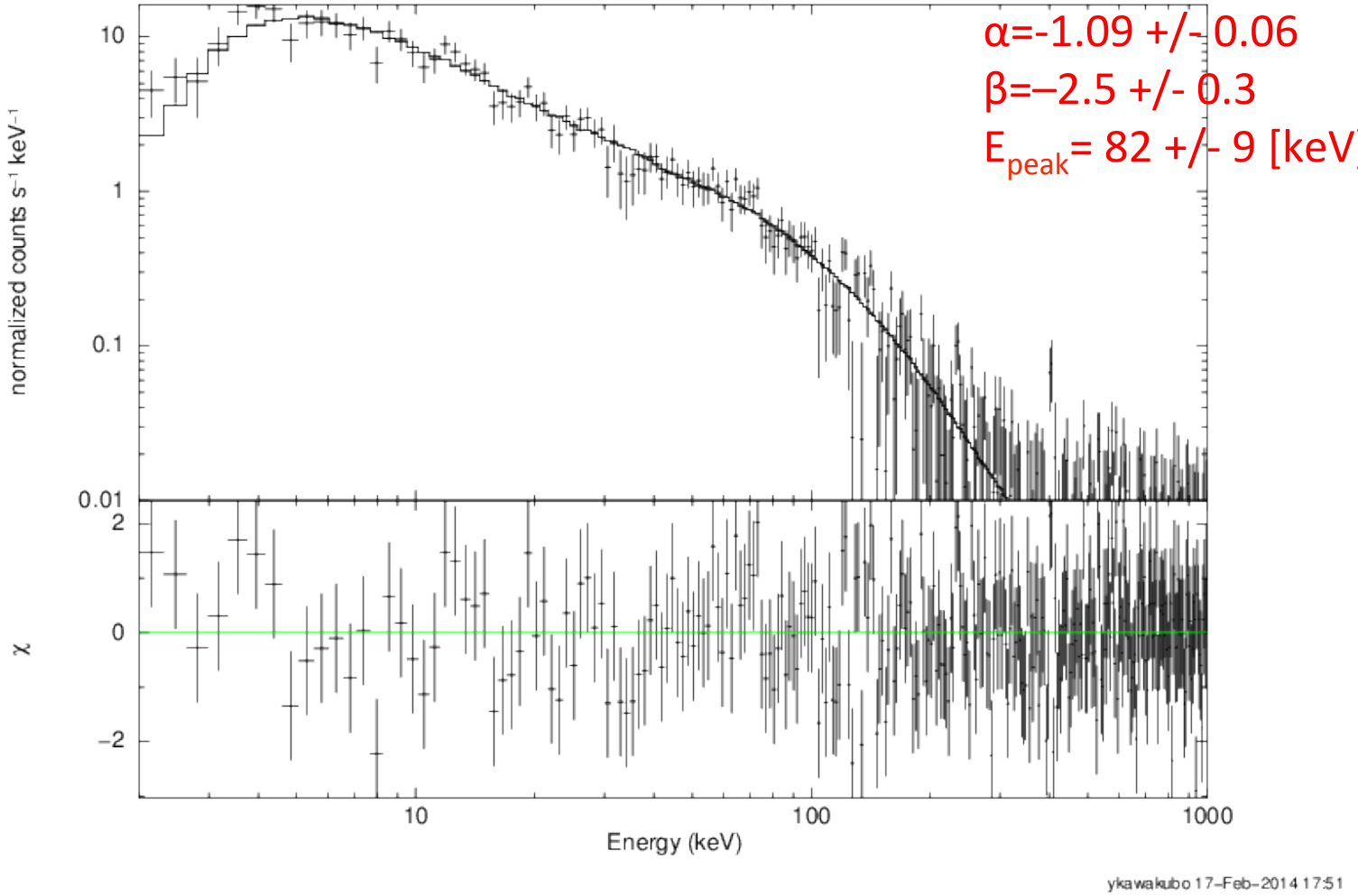
Simulation for MAXI event

– 30GRBs with MAXI (Serino et al 2014.)

Example simulated spectra (GRB091120)

Fluence (8-1000 keV) (3.02 +/- 0.04)E-5 erg/cm^2
(by Fermi GBM) (taking CXB into account)

SNR =60 (7—300 keV)
α=-1.09 +/- 0.06
β=–2.5 +/- 0.3
E_{peak}= 82 +/- 9 [keV]



CALET Gamma-ray Burst Monitor (CGBM)

Objectives

long/short-duration GRBs:

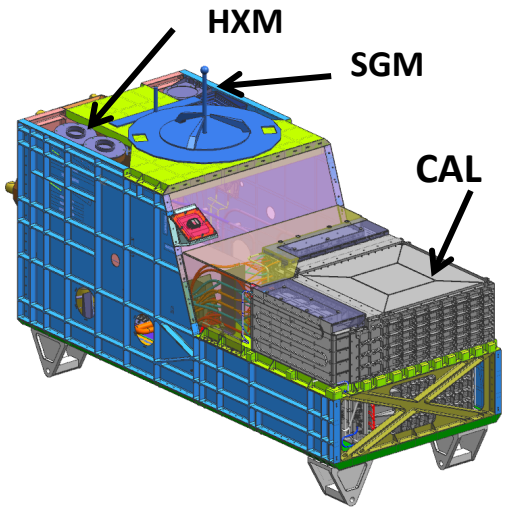
~25 GRBs/yr (HXM), ~50 GRBs/yr (SGM) ,

X-ray flashes,

GeV GRBs, and

other X-/gamma-ray transients.

Short GRBs would be the most possible counterparts of GW events. The team is planning to deliver specially processed data to GW instruments.



CALET Gamma-ray Burst Monitor (CGBM)

Pro

HXM/Be window without any heavily absorbing material (such as silicone etc) between the crystal and the window.

=> sensitive to soft X-rays as below ~10keV:

X-ray flashes, X-ray Rich GRBs …

Electronics/ separate high and low gain amplifiers are utilized for each detector to achieve a large observation energy ranges of two orders of magnitude.

=> ~7 to 1000keV (HXM) :

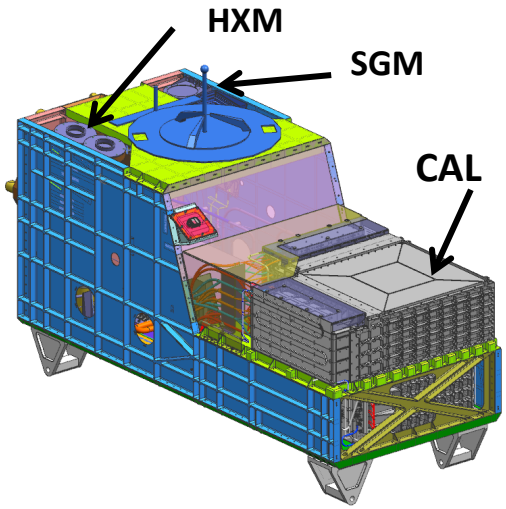
0.1 to 20 MeV (SGM)

(~1GeV – 10TeV (CAL))

Con

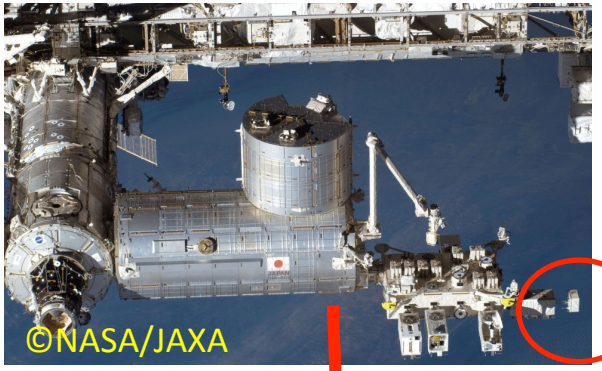
No localization capability.

Moving FOV > somewhat complex Detector Response Function. (similar to those for maneuvering period of Swift/BAT.



CALET on the port #9 for a wide FoV

The CALET instruments have large field FoVs that move in the sky along the rotation of ISS with the period of about 90 minutes.

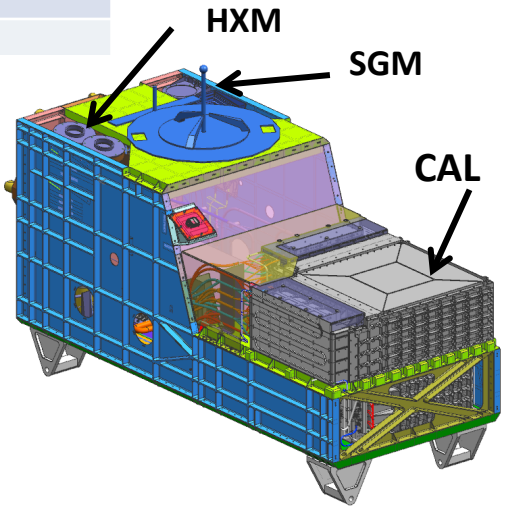


CALET onto Port #9

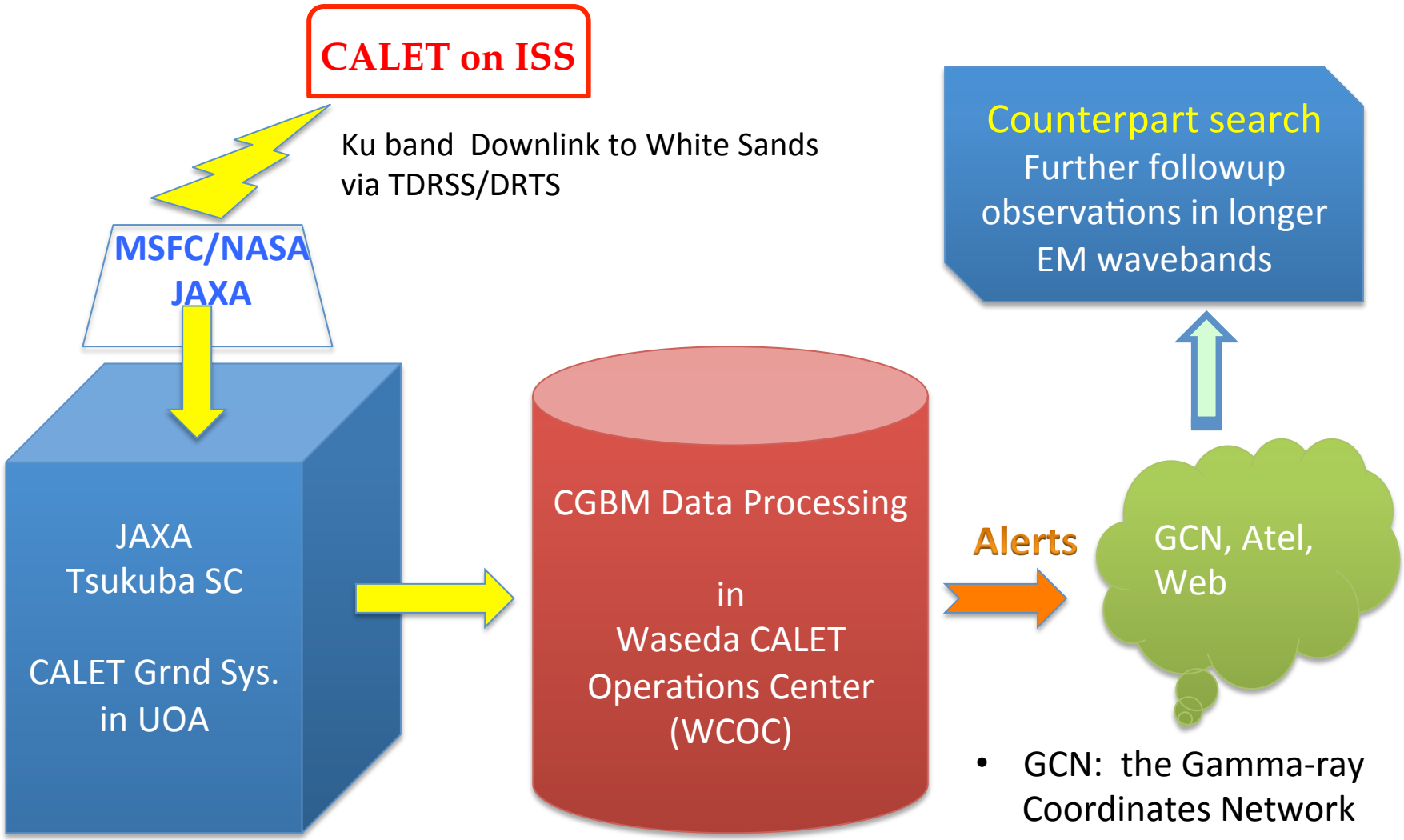
One rotation per every ~90 minutes

Moving direction

Parameters	CAL	CGBM
Energy range	1 GeV - 10 TeV (GRB trigger)	HXM: 7 keV - 1 MeV (goal 3 keV - 3 MeV) SGM: 100 keV - 20 MeV (goal 30 keV - 30 MeV)
Energy resolution	3% (10 GeV)	HXM: ~3% (662 keV) SGM: ~15% (662 keV)
Effective area	~600 cm^2 (10 GeV)	68 cm^2 (2 HXMs), 82 cm^2 (SGM)
Angular resolution	2.5° (1 GeV) 0.35° (10 GeV)	-
Field of view	~45° (~2 sr)	~3 sr (HXM), ~4π sr (SGM)
Dead time	2 ms	40 μs
Time resolution	62.5 μs	Triggered data: 62.5 μs (event-by-event data) Regular data: 125 ms with 8 ch, 4 s with 512 ch



General Alerts of transients



- GCN: the Gamma-ray Coordinates Network
- ATel: the Astronomer' Telegram

Possible further data delivery for GW events

The MOU is established with the LIGO-Virgo Collaboration for follow-ups by the CALET.

The Plan: If GW triggers

- Fine time resolution (<125 ms) light curve of GRB/EM transient from CGBM within a day.
- GRB spectra (CGBM) within a few days (if position available).
- Very preliminary result from CAL data within a few days if a bright gamma-ray transient.
- Possible separate/joint publications of further analyses.