Future Instruments

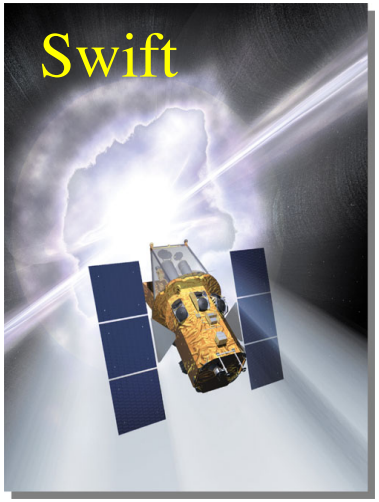
Neil Gehrels

NASA-GSFC

Skokloster Jet Workshop

August 31, 2013

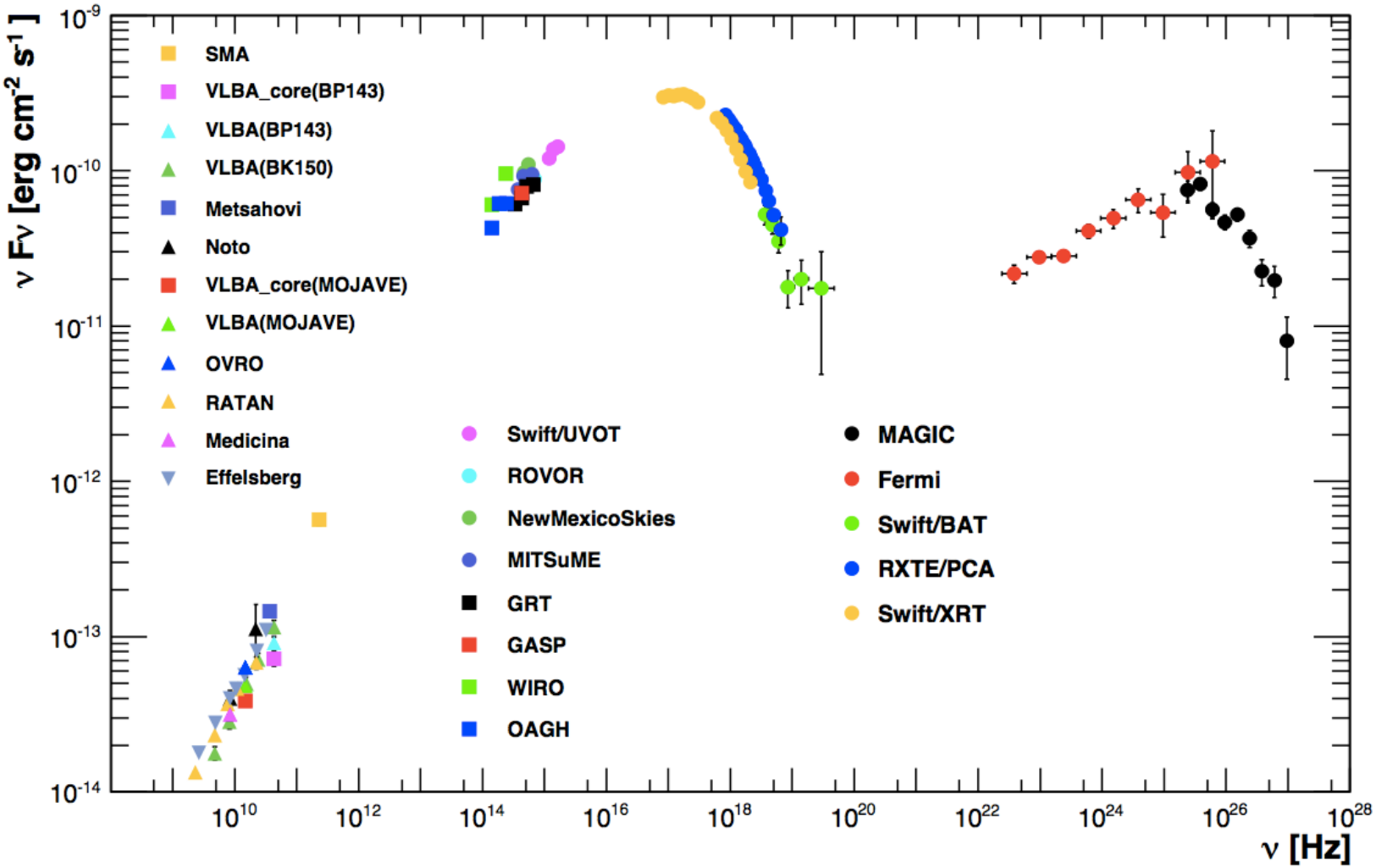
Space Gamma-Ray Observatories



Also: RHESSI,
Suzaku & AGILE

Ground Gamma-Ray Observatories

Mrk 421 Campaign



Abdo+ 11

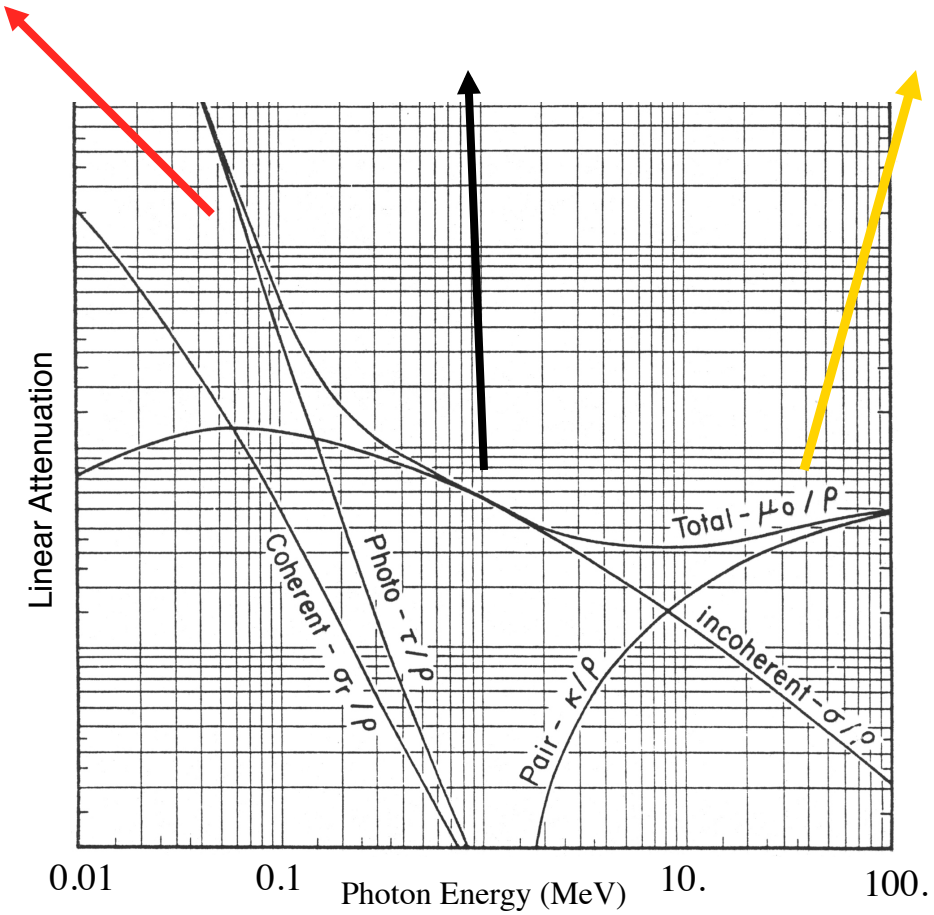
corr. authors: Paneque, Finke,, Georganopoulos,, Reimer, Tescaros

Photon Interactions

Photoelectric

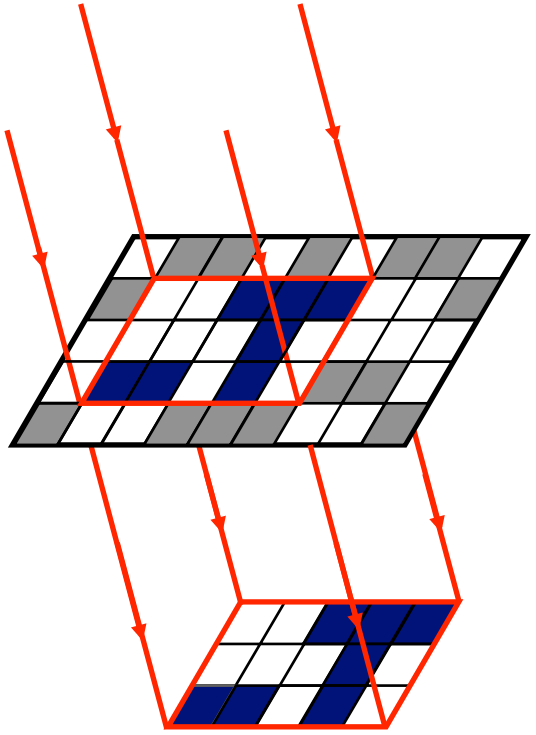
Compton Scattering

Pair Production



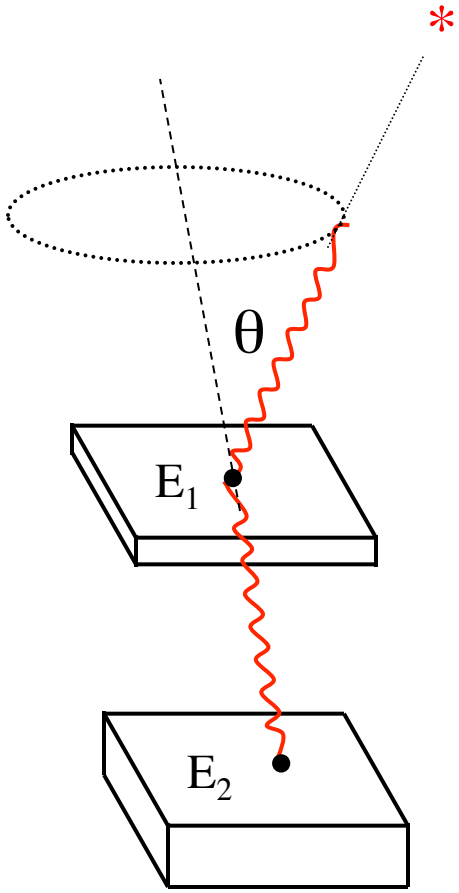
Telescope Types

Coded Aperature Telescope



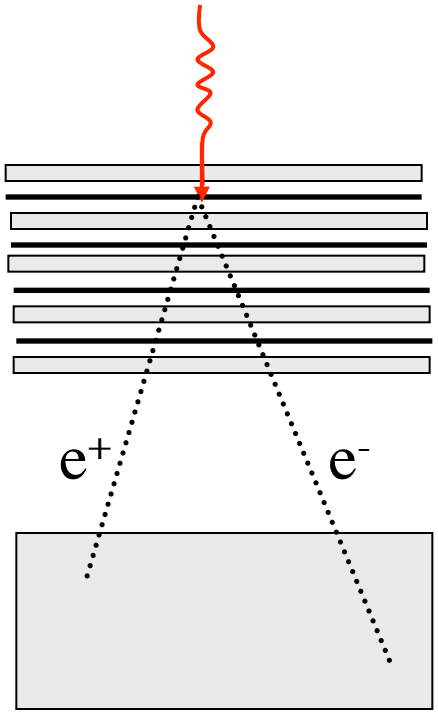
low energy

Compton Telescope



medium energy

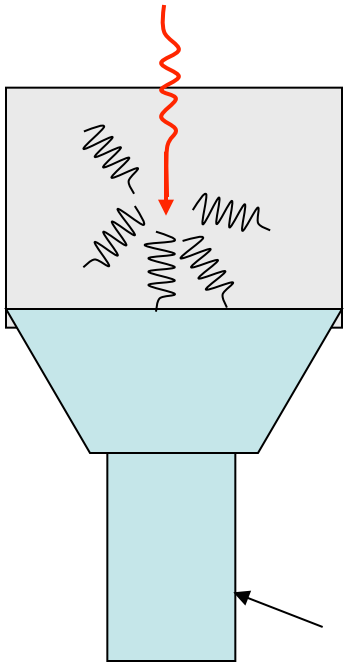
Pair Telescopes



high energy

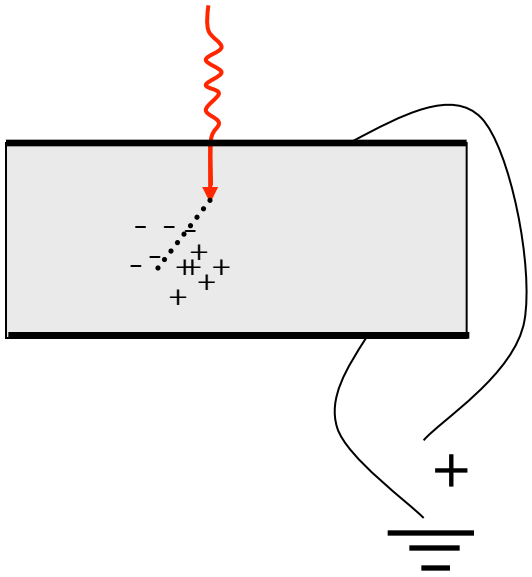
Detector Types

Scintillators

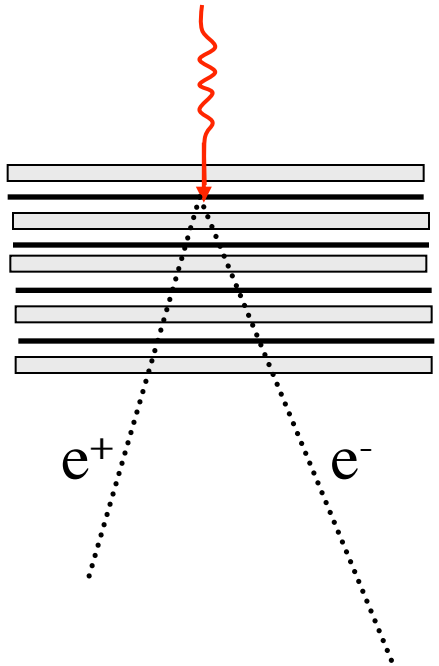


PMT
photomultiplier

Solid State Detectors



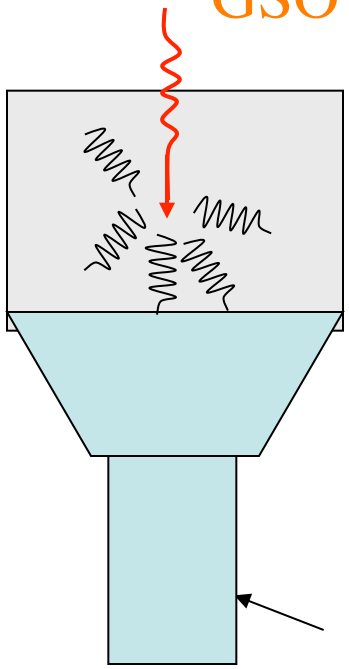
Pair Trackers



Detector Types

Scintillators

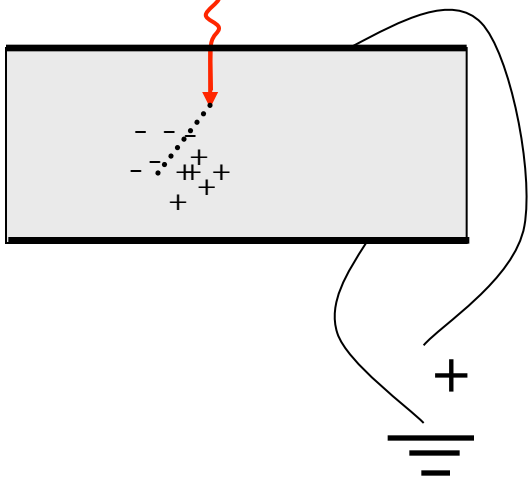
NaI CsI BGO $LaBr_3$ GSO



PMT
photomultiplier

Solid State Detectors

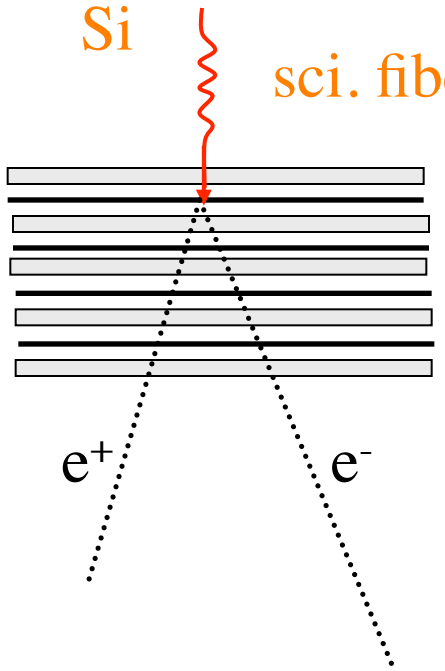
Si Ge CZT HgI_2



Pair Trackers

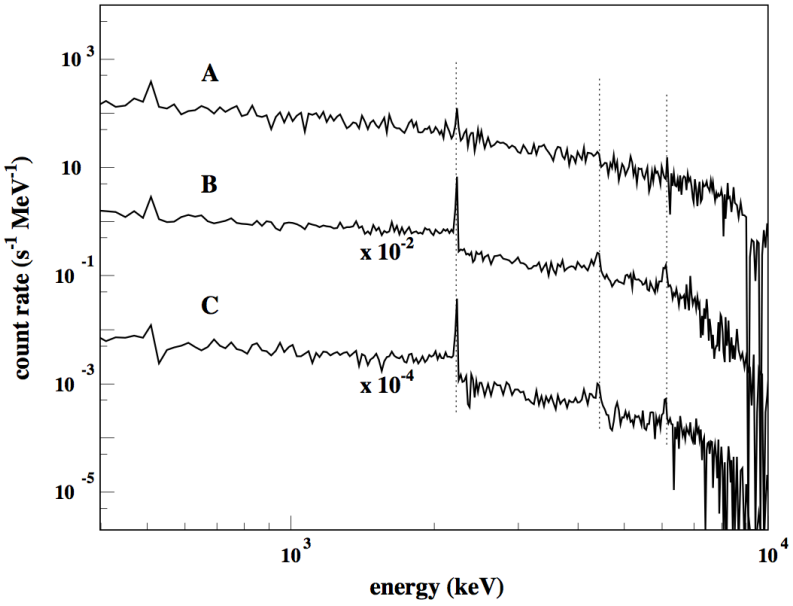
spark chamber

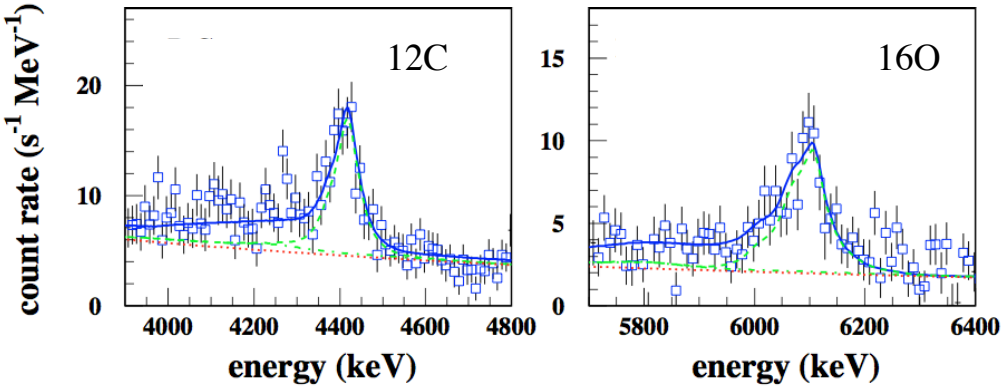
Si sci. fibers



October 28, 2003 Solar Flare

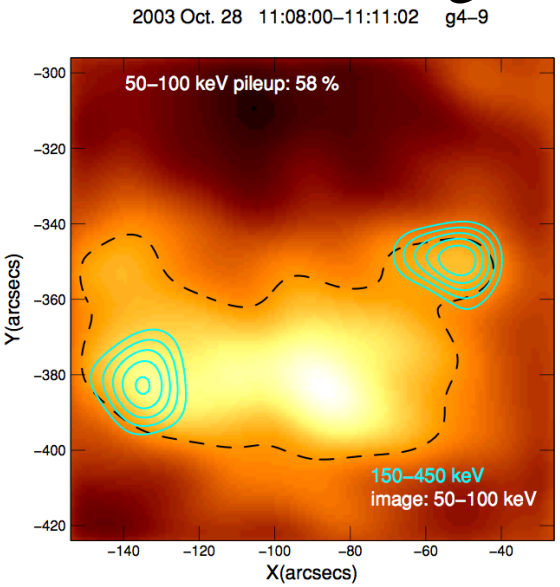
SPI Spectroscopy





Kiener+ 06

RHESSI Image

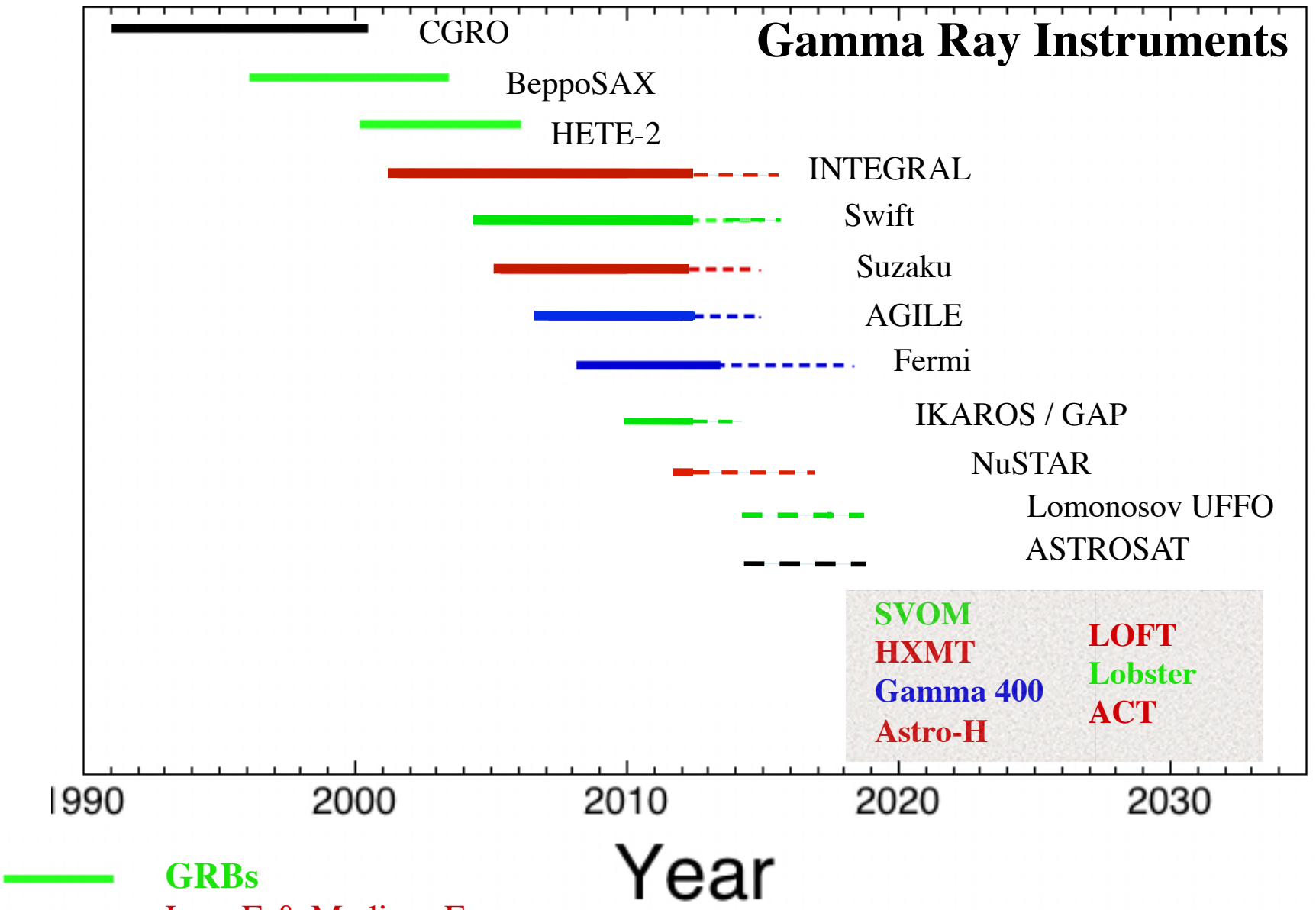


Ishikawa+ 10

9 Ge Detectors - Launch 2002

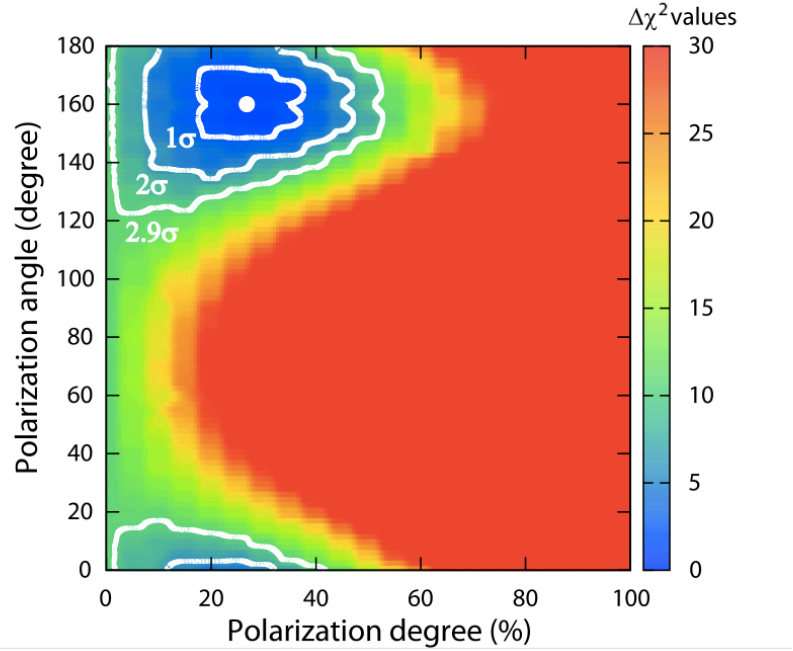
Motivations for Future Instruments

beaming in jetted sources	multiwavelength, long time
spectral components	broad spectral coverage
variability in jetted sources	broad spectral coverage
leptonic vs hadronic outflows	multiwavelength during prompt
internal vs external shock models	multiwavelength during prompt
polarization in magnetic outflows	polarimetry
origin of short GRBs	arcsec positions, hard γ-rays
GRB probes of high-z universe	soft γ-rays, IR spectroscopy
spectra in MeV desert	Compton telescope

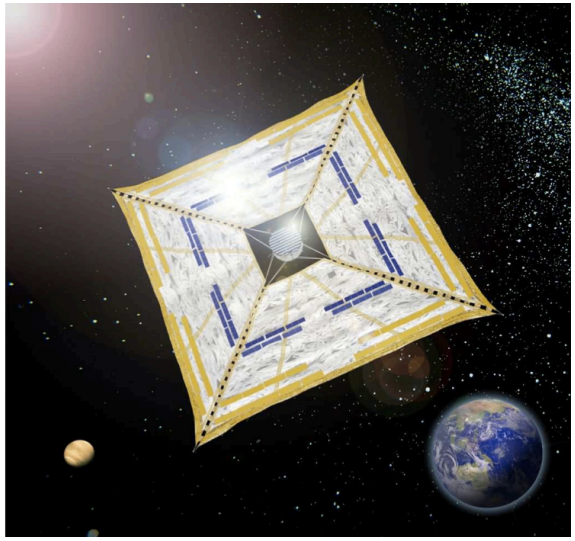


also RHESSI, MAXI, Spectrum X

IKAROS/GAP GRB Polarization



20 m
solar sail



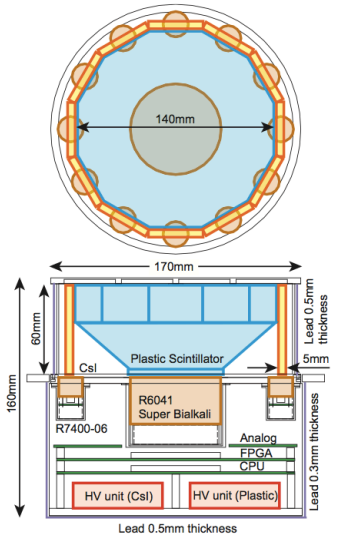
Japanese solar sail demo mission

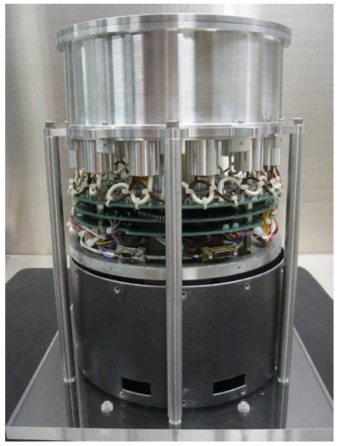
4kg GAP instrument

50 – 300 keV

Polarization measured for GRB 100826A

3.5σ detection





Yonetoku+ 11, 12

SVOM

2018

Chinese/French satellite

~300 kg

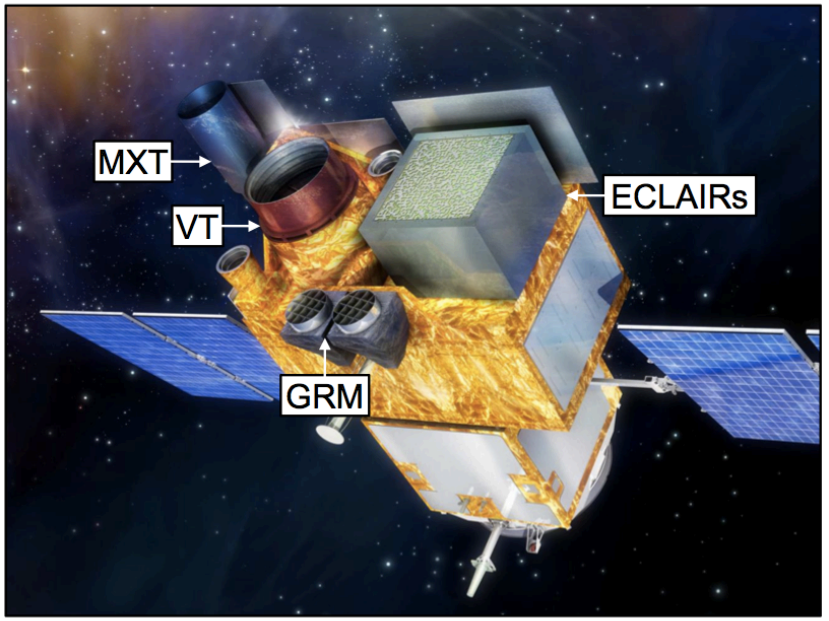
ECLAIRS coded aperture 4 – 250 keV

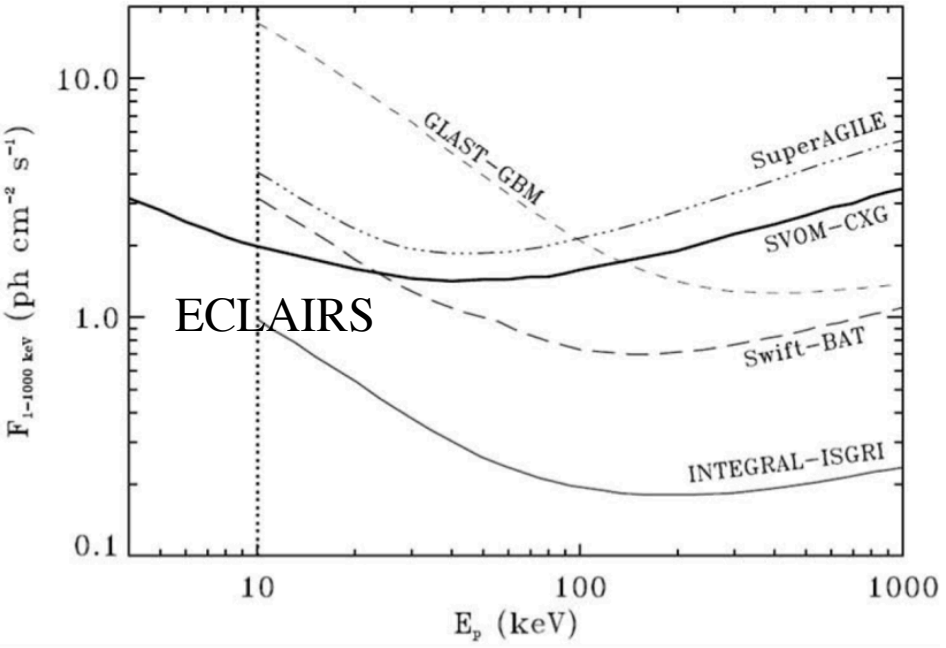
GRM 30 keV – 5 MeV

Narrow-field X-rays and optical

Wide-field optical camera

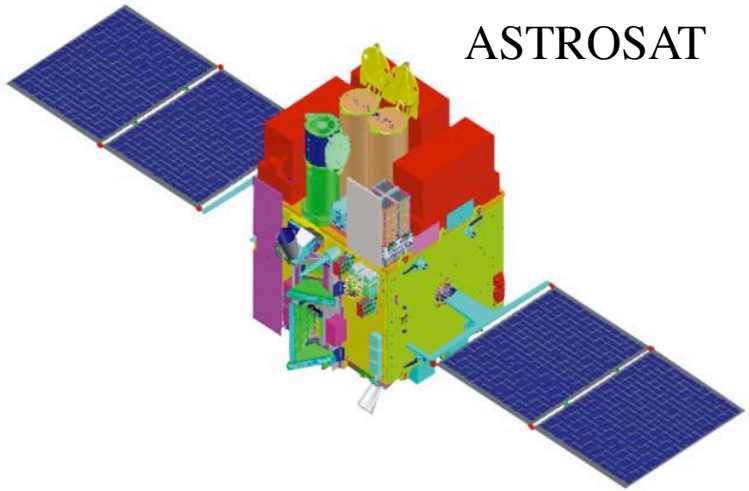
GRB & transient science





Missions in Development

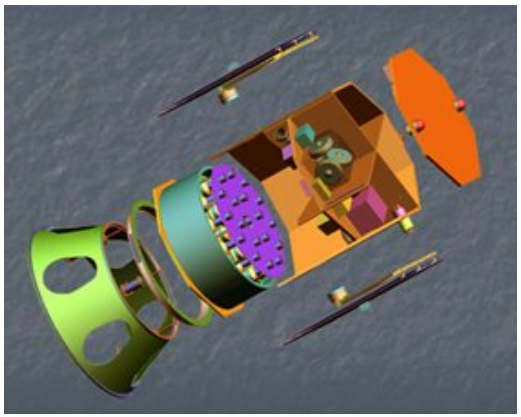
ASTROSAT



ASTROSAT (2014)

- Indian mission with 5 instruments
- CZT coded aperture 10-150 keV (1000 cm^2)
- Large area PC 2 – 80 keV (6000 cm^2)
- Scanning sky monitor 2 – 10 keV

HXMT



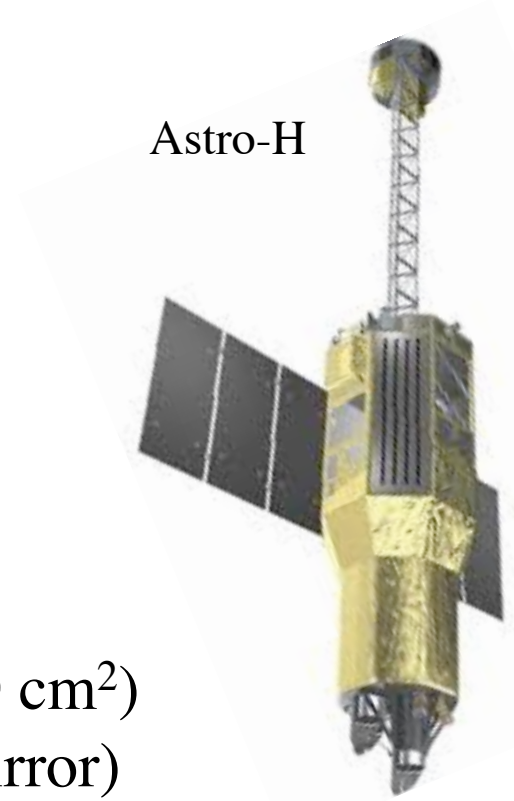
HXMT (2016)

- Chinese mission for 2-200 keV all-sky survey
- 18 phoswich detectors, 6° x 6° FoV (5000 cm^2)

Missions in Development

Astro-H (2015)

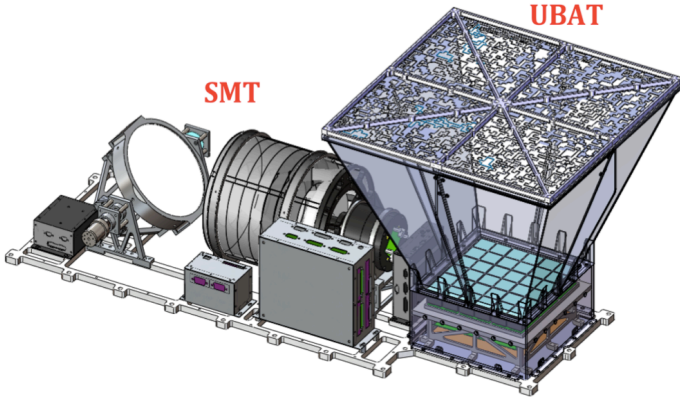
- JAXA / NASA / SRON mission, launch 2014
- Hard and soft X-ray focusing telescopes
- Calorimeter X-ray spectrometer
- Collimated γ-ray instrument 4-600 keV, Si/CdTe



Astro-H

Lomonosov / UFFO Pathfinder (2014)

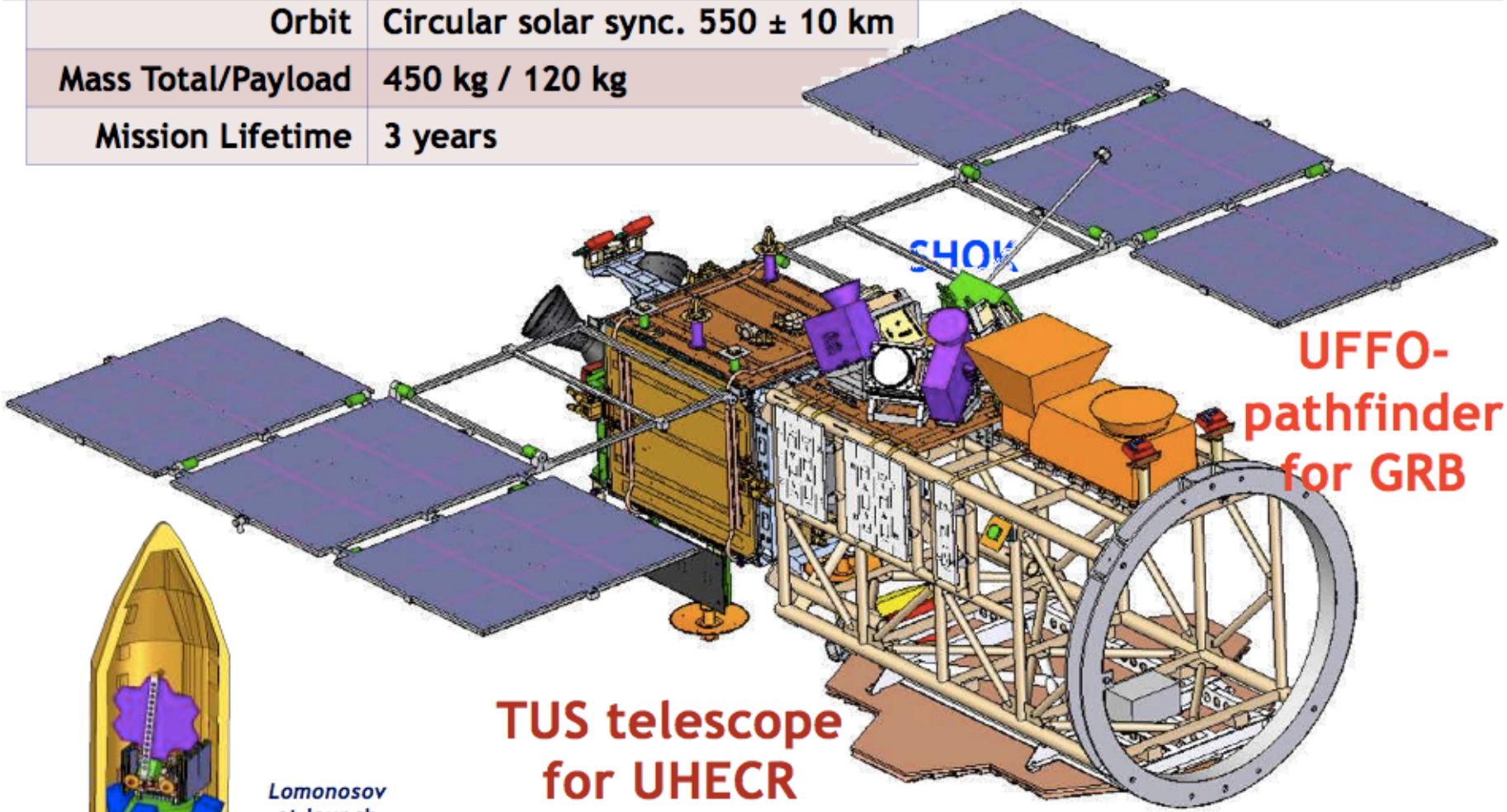
- Konus-like scintillators, 100 GRBs/yr 2π sr
- UFFO with coded aperture hard X-rays (200 cm^2) and rapid-pointing UV telescope (20 cm mirror)



UFFO
Korea / Russia

Lomonosov Spacecraft & Payloads

Spacecraft	*Lomonosov* & FGUM-VNIIEM
Launch Date	end of 2013 or early 2014
Orbit	Circular solar sync. 550 ± 10 km
Mass Total/Payload	450 kg / 120 kg
Mission Lifetime	3 years



Lomonosov
at launch

Proposed Missions

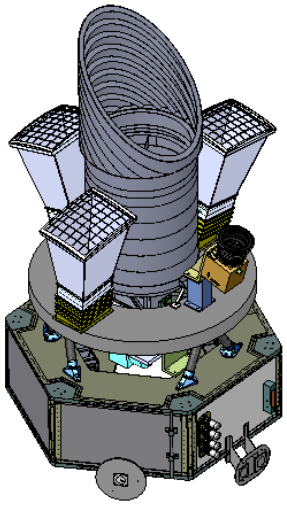
LOFT

- Wide-area X-ray timing instrument (~20 m^2)
- Wide-Field Monitor with ~3 sr & ~150 GRBs / yr

Lobster

- Lobster optic for wide-field X-ray focusing
- ~0.5 sr with 100x sensitivity of coded apertures
- Explorer with IR telescope, ISS and ESA small mission

Lobster



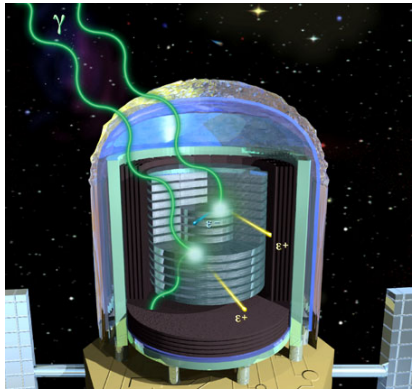
JANUS

- X-ray coded aperture
- Very large field of view (~4 sr) with arcmin imaging

ACT Compton Telescope

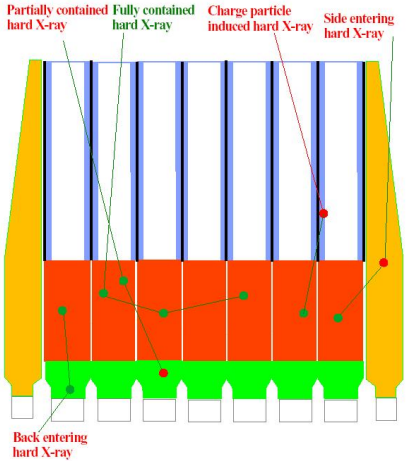
- Several concepts under study and balloon flights
- Larger FoV, large area Si, Ge, & CZT stacks

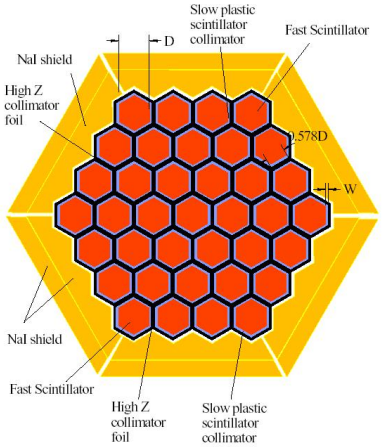
ACT



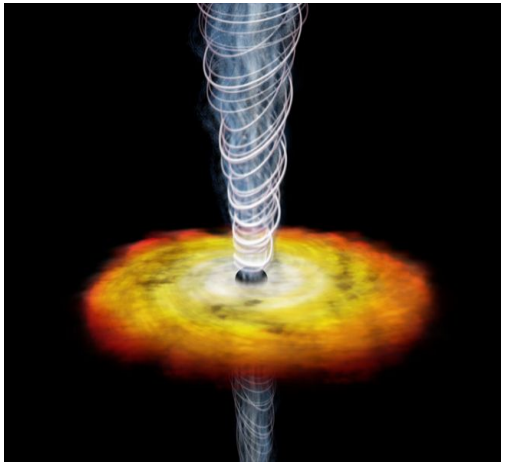
Future Hard X-ray Polarization Instrument

PoGO

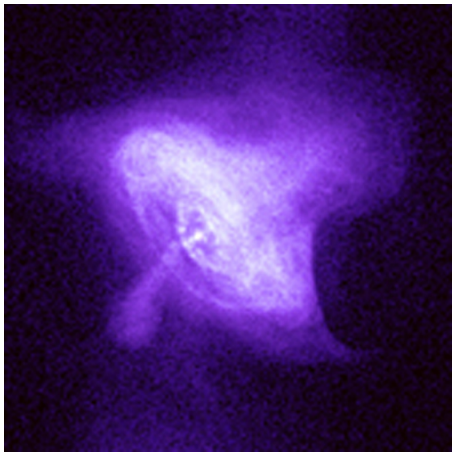




- Technology development phase
- Compton scattering polarization
- Jet outflows & SNRs
- Complementary to GEMS in X-rays



Crab Nebula - Chandra



Gamma 400 Mission

Russian, high-energy γ-rays

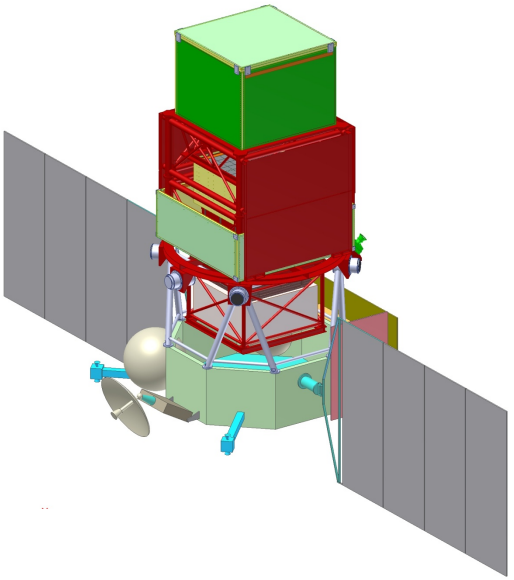
1 GeV – 3 TeV

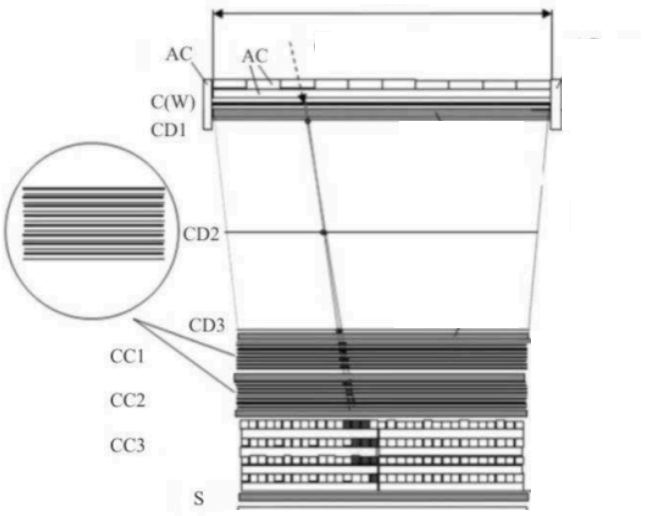
1m x 1m

1700 kg

Pair conversion telescope

Jet outflows & SNRs



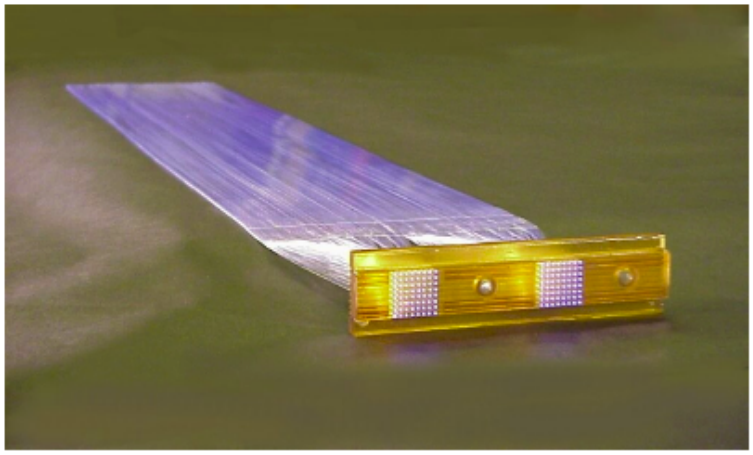


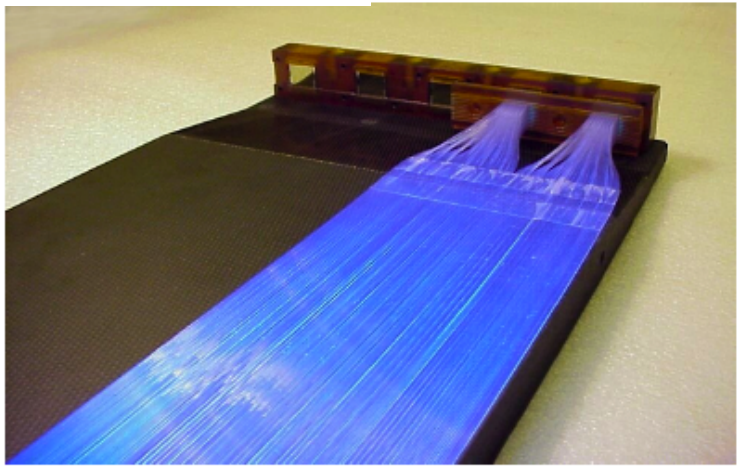
Higher Energies

30 r.l.

Future HE Gamma Ray Technologies

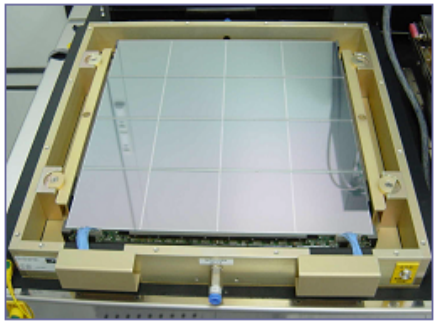
Scintillating Fibers





Binns, Buckley & Wash U. group

Si Strip Detectors

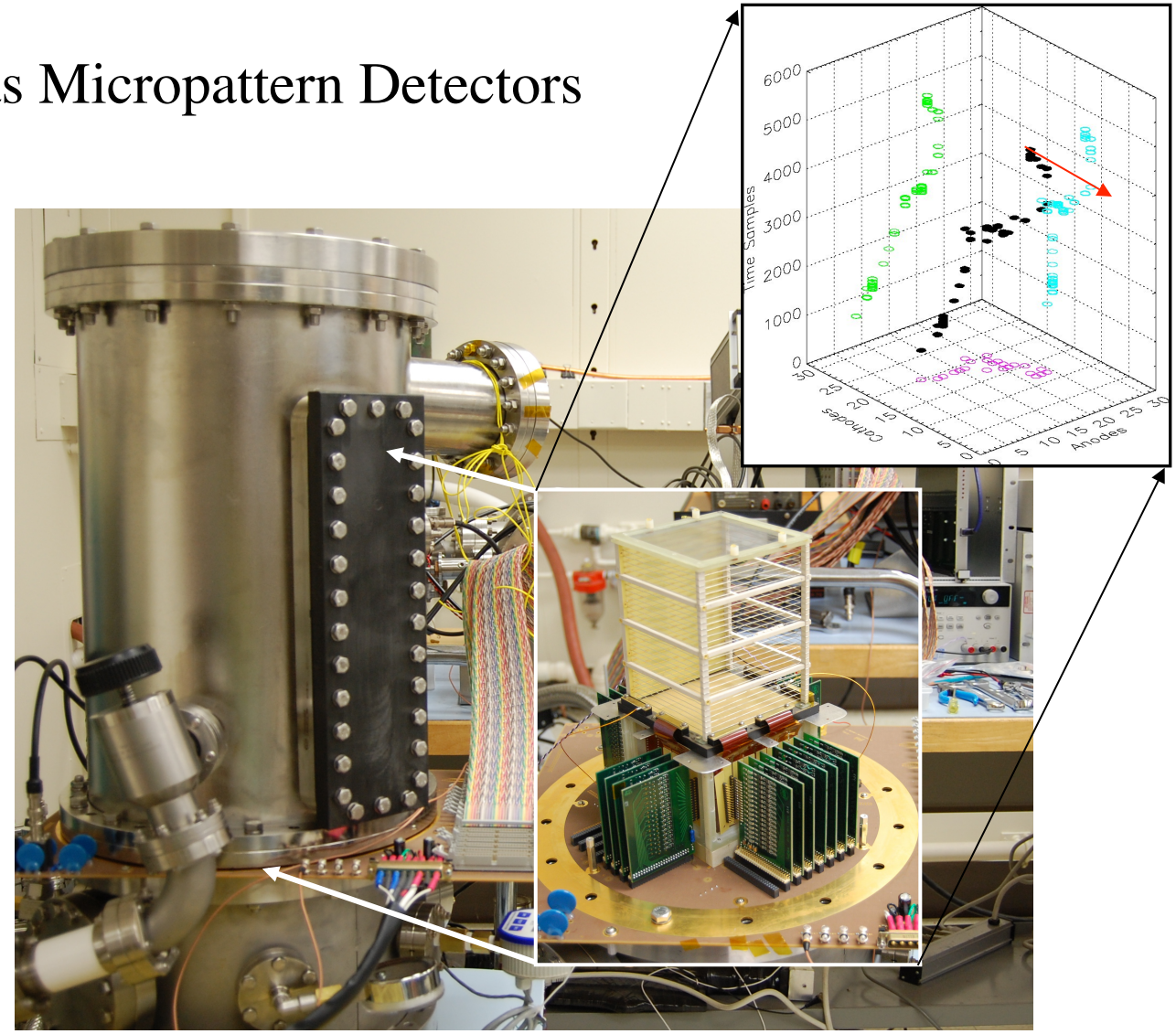


LAT tracker team
Japan, Italy, US

Future Technologies cont.

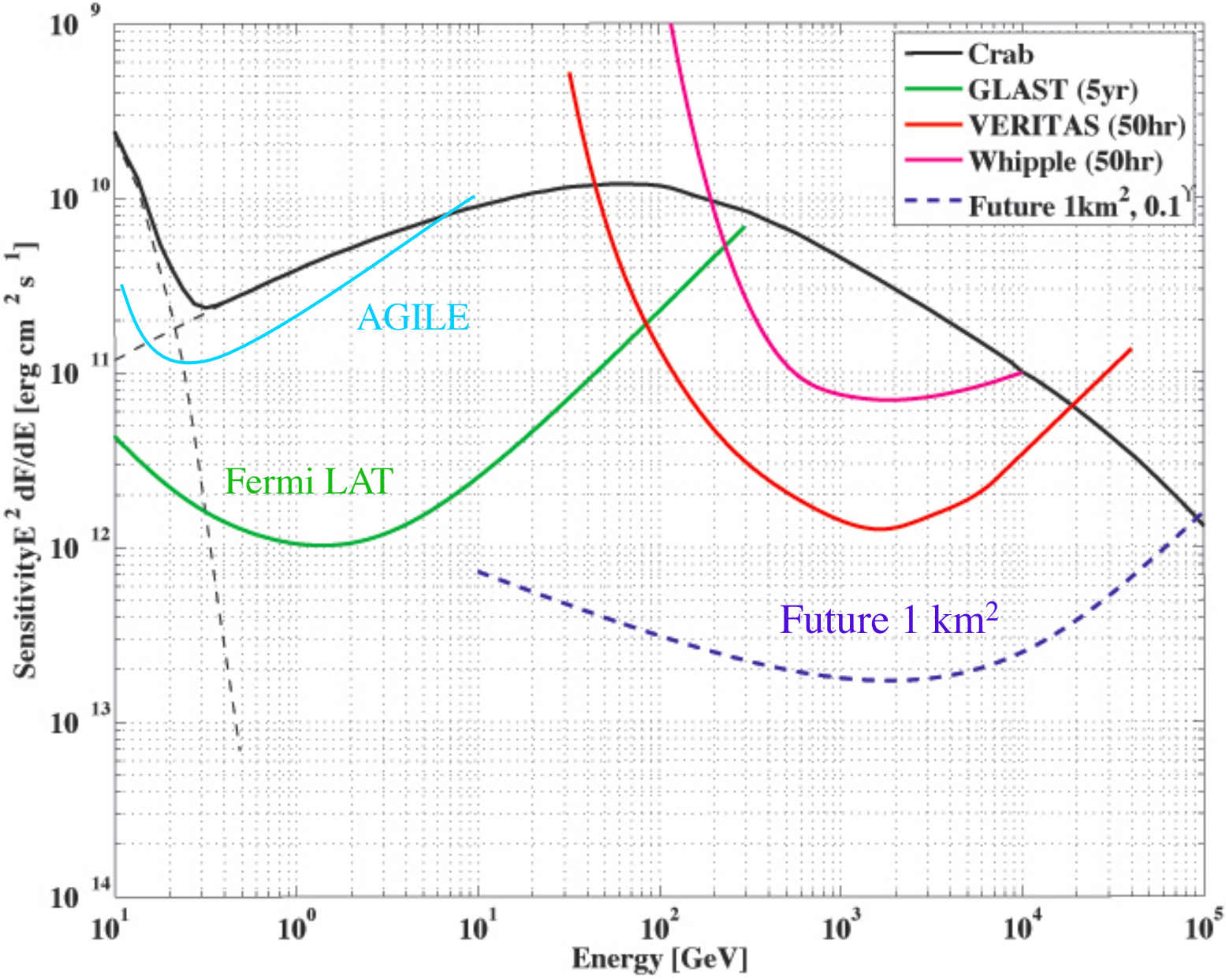
Image of 6 MeV gamma

3-D Gas Micropattern Detectors



Hunter & GSFC group

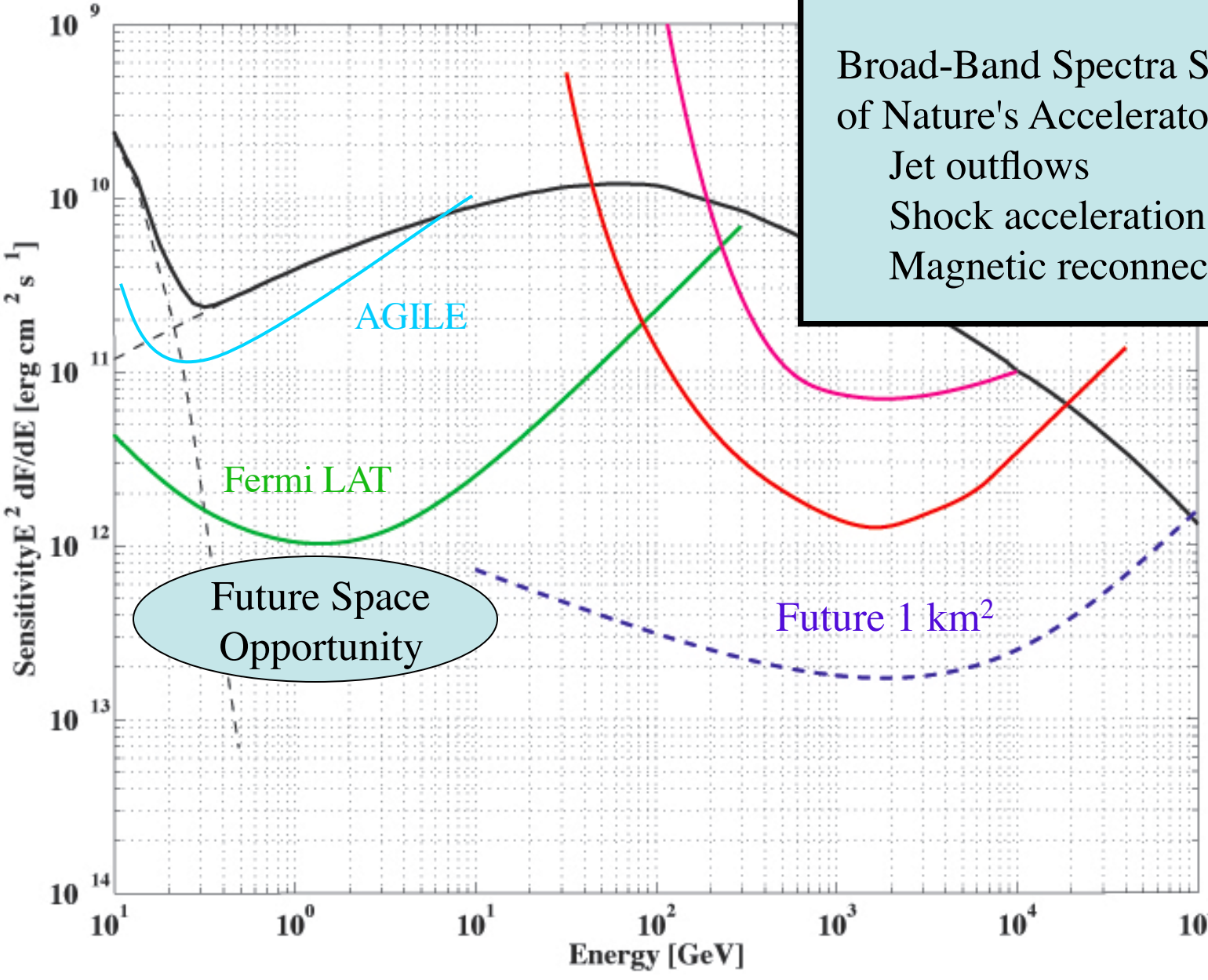
HE Gamma Ray Sensitivity



AGIS
CTA

Fegan

HE Gamma Ray Se



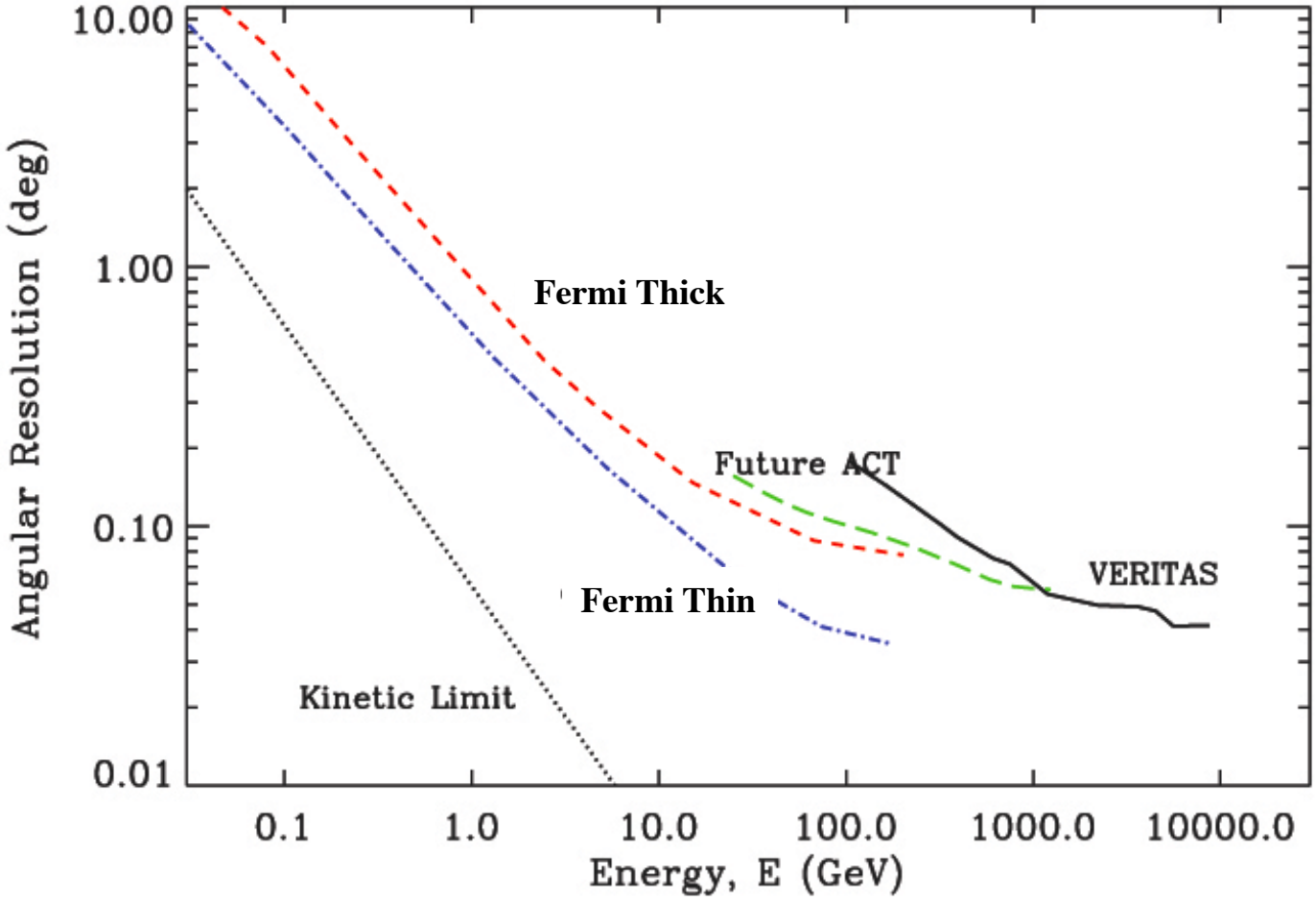
Future Science

Broad-Band Spectra Studies of Nature's Accelerators

- Jet outflows
- Shock acceleration
- Magnetic reconnection

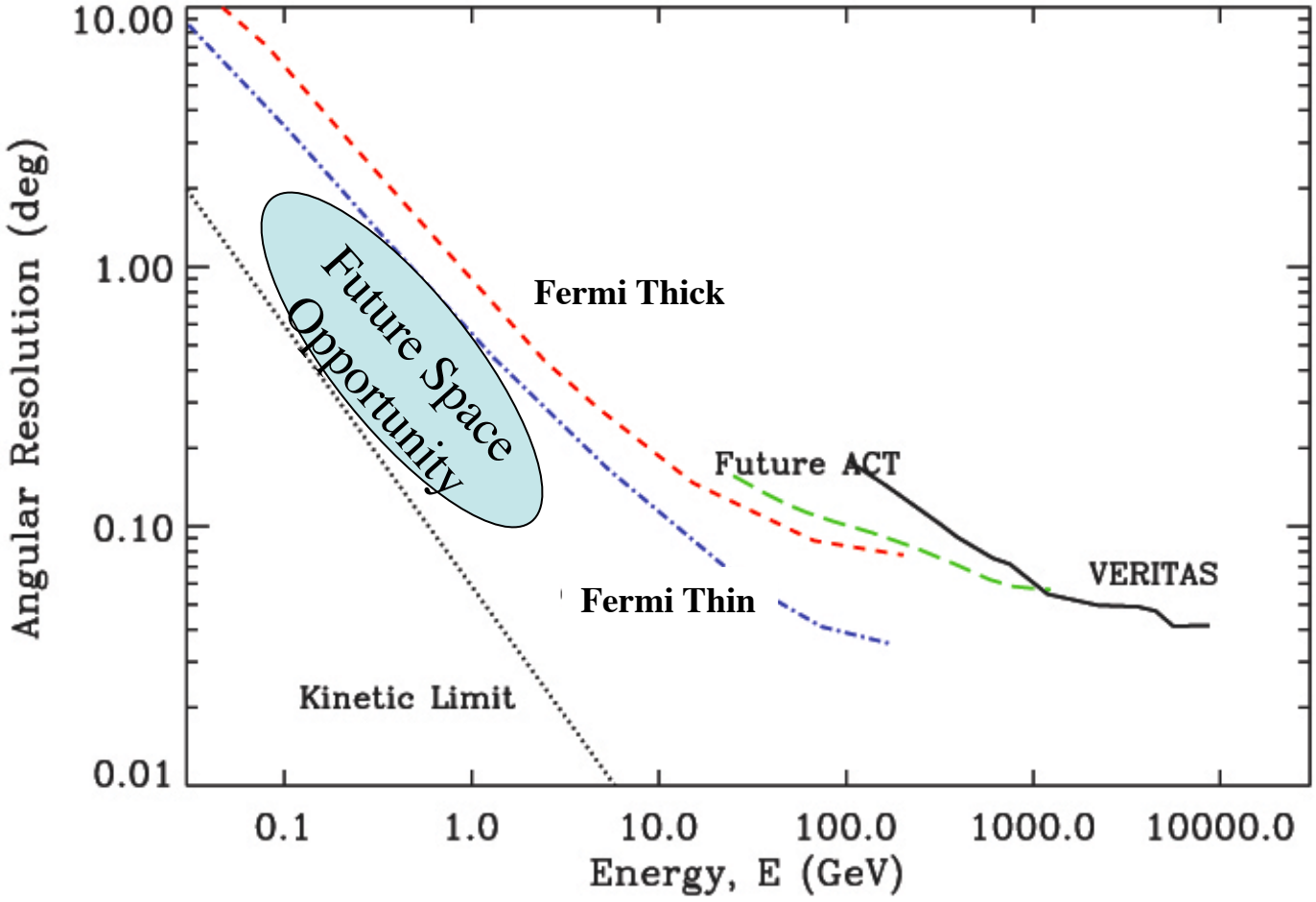
Fegan

HE Gamma Ray Angular Resolution



Buckley

HE Gamma Ray Angular Resolution



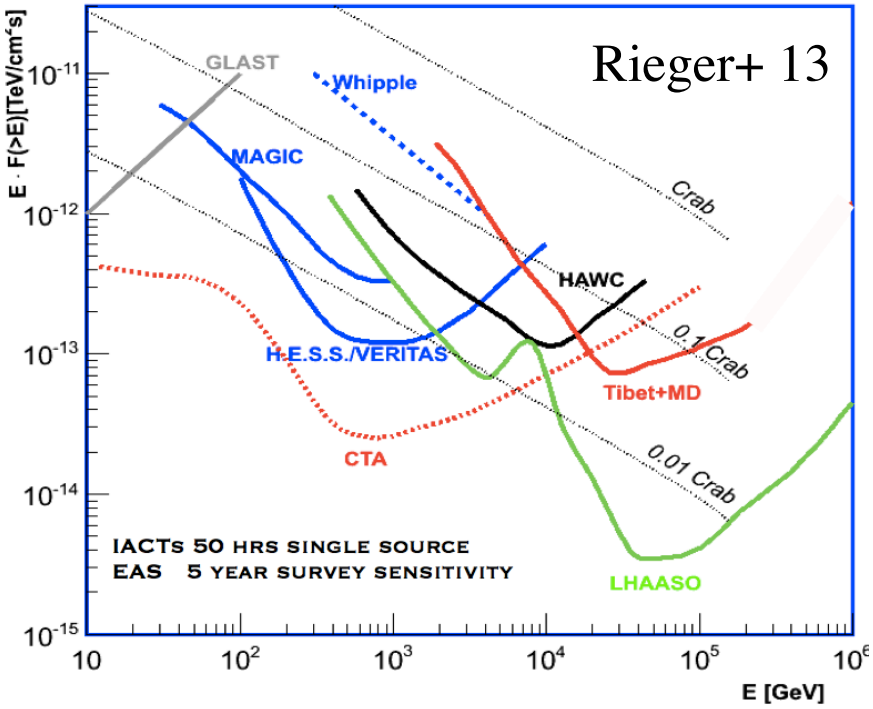
Buckley

Future Very High Energy Instruments

- *HESS, VERITAS, MAGIC* upgrades
  - more dishes, larger dishes
- *HAWC*
  - wide-field water instrument at high altitude
  - 15x better sensitivity than Milagro
- *CTA*
  - large arrays of small dishes

    $\Rightarrow$ high sensitivity
  - smaller arrays of large dishes

    $\Rightarrow$ lower threshold
- *MACE*
  - India, 21m dish, 4200 m altitude
- *LHAASO*
  - Yangbajing, China
  - huger air shower facility



Balloon Payloads

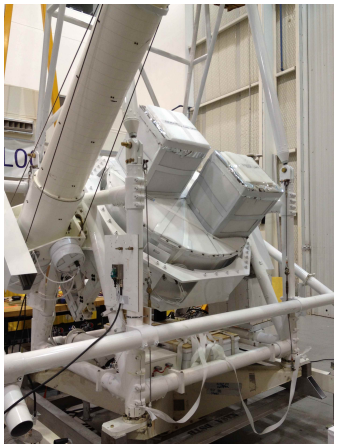
Many groups have been active in gamma-ray ballooning

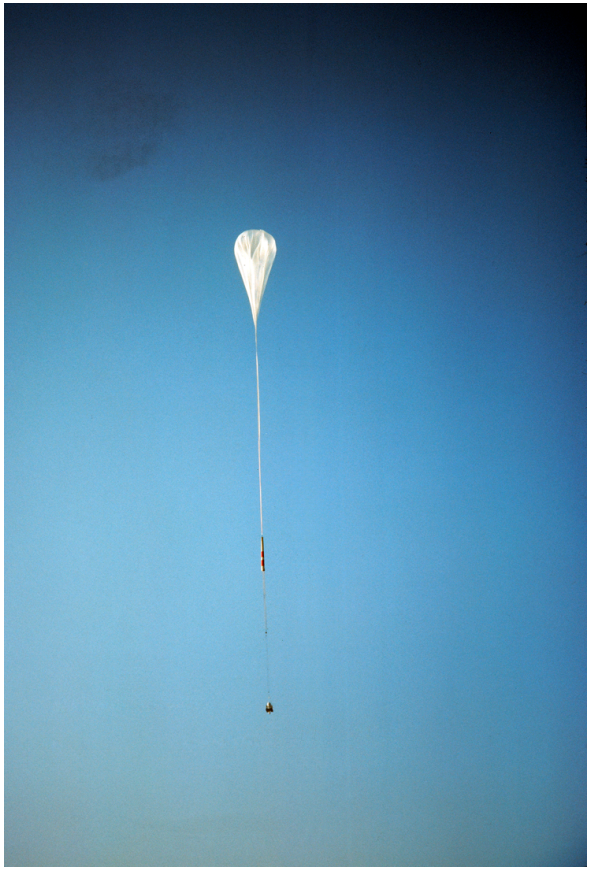
GSFC, MSFC, Berkeley, Harvard, San Diego, UNH, MPE, Tübingen, Rome, Bologna, Milan, Southampton, Toulouse, San Paolo, U. Tokyo, Tata, ...

New technologies and new science

Example: Harvard/GSFC/MSFC ProtoEXIST

- Hard X-ray imager, large CZT array






GRIS

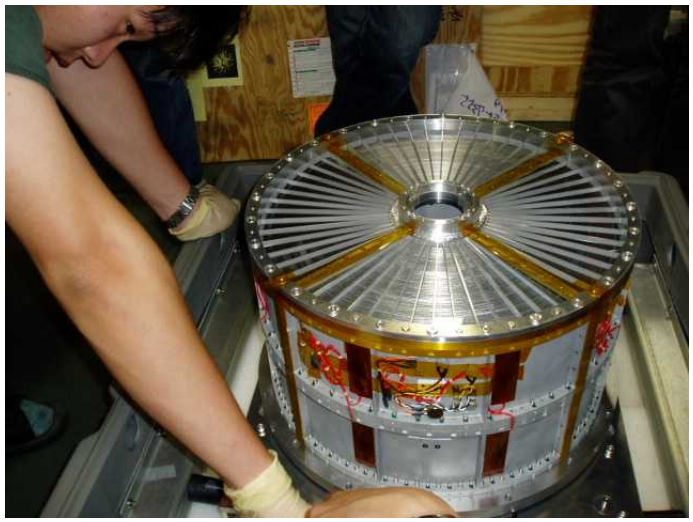
InFOCUS: Hard X-ray Polarimetry

Multilayer mirrors

Hard X-rays 5 - 80 keV

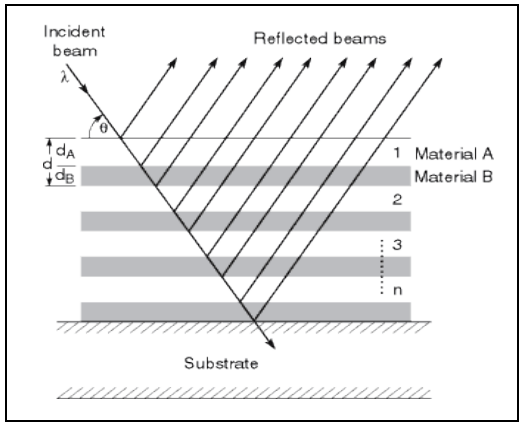
X-Calibur polarimeter

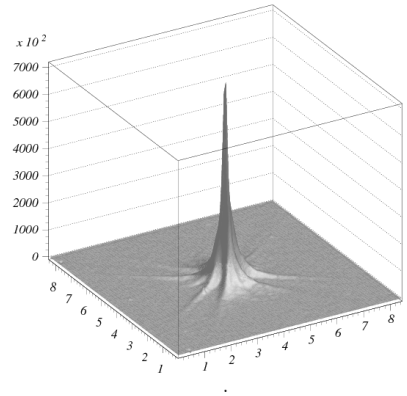
InFOCμS balloon instrument



Barthelmy, Krawczynski, Okajima, (Tueller)

4U 0115





2.6 arcmin HPD

Summary

- We living in a privileged time with INTEGRAL, Swift, Fermi, NuSTAR, HESS, MAGIC, VERITAS
- This era may continue for ~5 years
- Future space missions will be:
  - smaller and focused (NASA, ESA, JAXA)
  - becoming larger (Russia, India, China)
- New ground VHE instruments under development

Motivations for Future Instruments

beaming in jetted sources	multiwavelength, long time
spectral components	broad spectral coverage
variability in jetted sources	broad spectral coverage
leptonic vs hadronic outflows	multiwavelength during prompt
internal vs external shock models	multiwavelength during prompt
polarization in magnetic outflows	polarimetry
origin of short GRBs	arcsec positions, hard γ-rays
GRB probes of high-z universe	soft γ-rays, IR spectroscopy
spectra in MeV desert	Compton telescope