First Flight of the Gamma-Ray Imager/Polarimeter for Solar Flares Instrument (GRIPS)

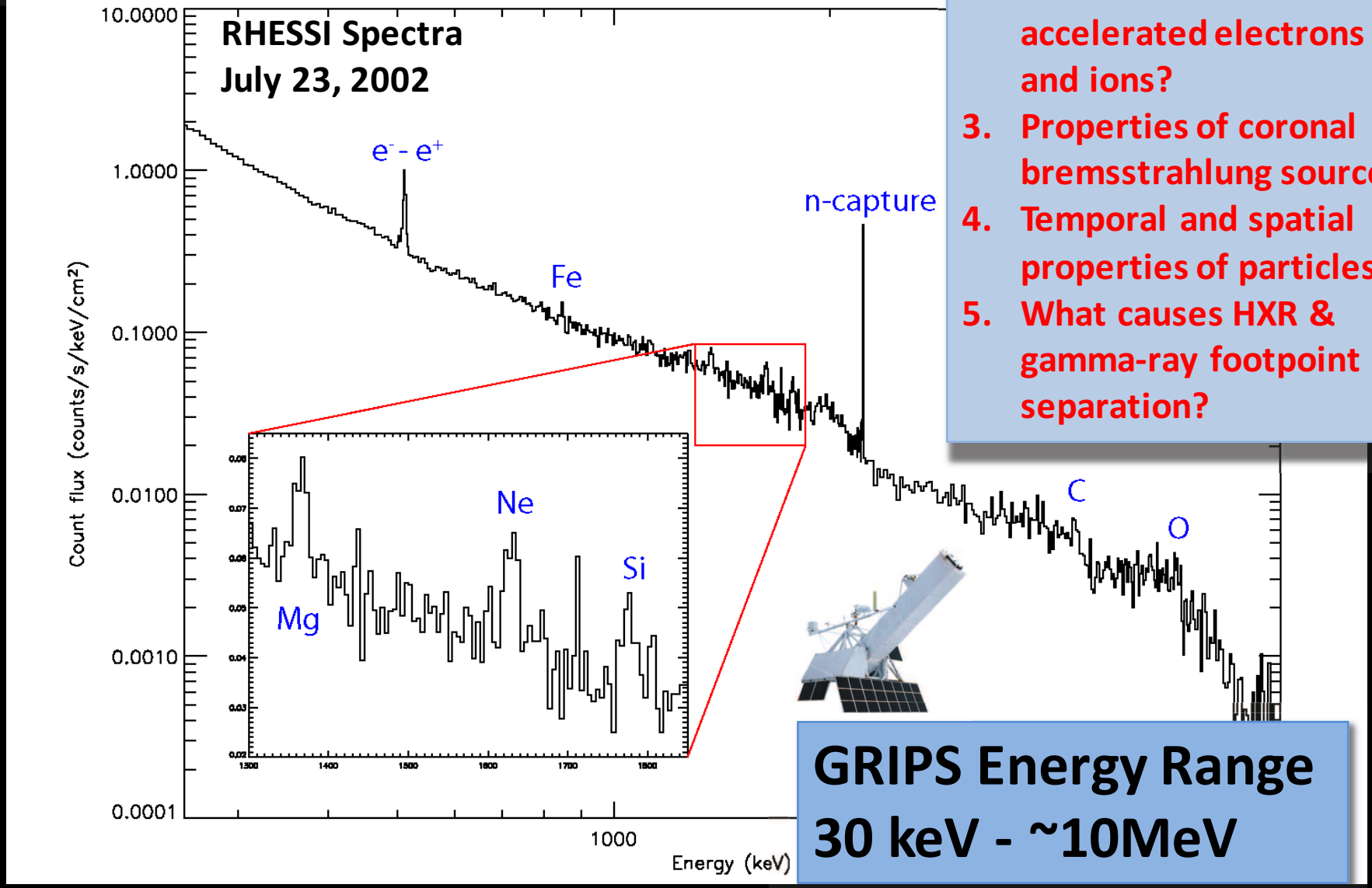
Author: Nicole Duncan

PI: Pascal Saint-Hilaire

SSL, UC Berkeley

H. Bain, N. Kelley, N. Godbole,
J. Hoberman, B.A. Maruca, B. Mochizuki,
J. Olson, J. Sample, A. Zoglauer,
S.E. Boggs, G.J. Hurford : SSL/UCB
A.Y. Shih: NASA/GSFC
M. Amman: LBNL
D.M. Smith: UC Santa Cruz
A. Caspi: SWRI
P. Kaufmann: Universidade Presbiteriana Mackenzie, Brazil

Solar HXR & Gamma-rays



GRIPS Science Goals

1. Do all flares accelerate ions?
2. What is the angular distribution of accelerated electrons and ions?
3. Properties of coronal bremsstrahlung sources
4. Temporal and spatial properties of particles
5. What causes HXR & gamma-ray footpoint separation?

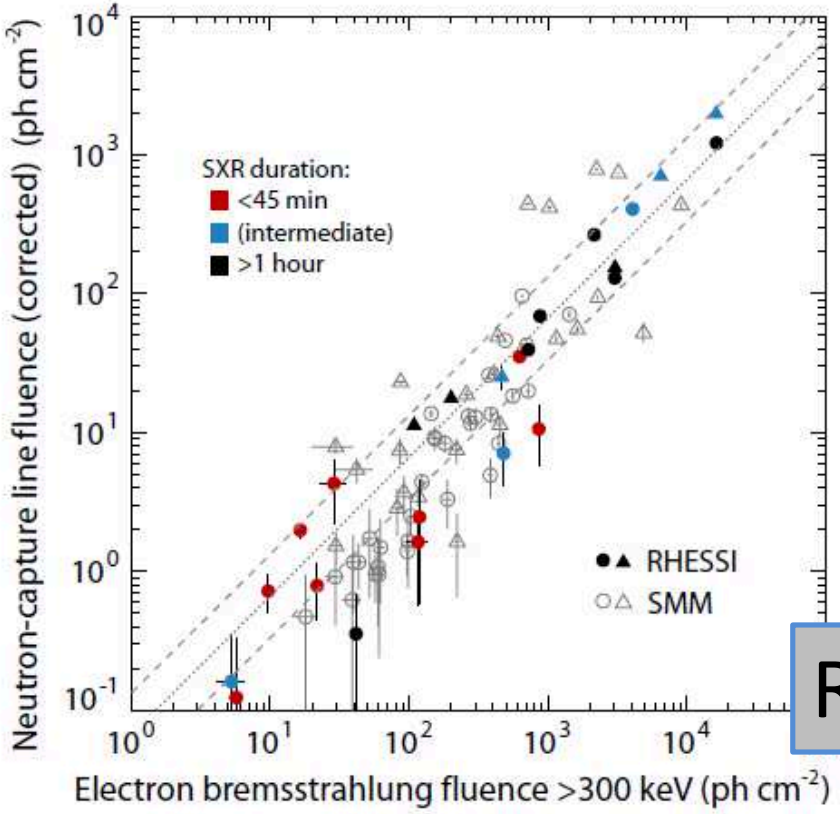
GRIPS Energy Range
30 keV - ~10MeV

Ion & Electron Transport

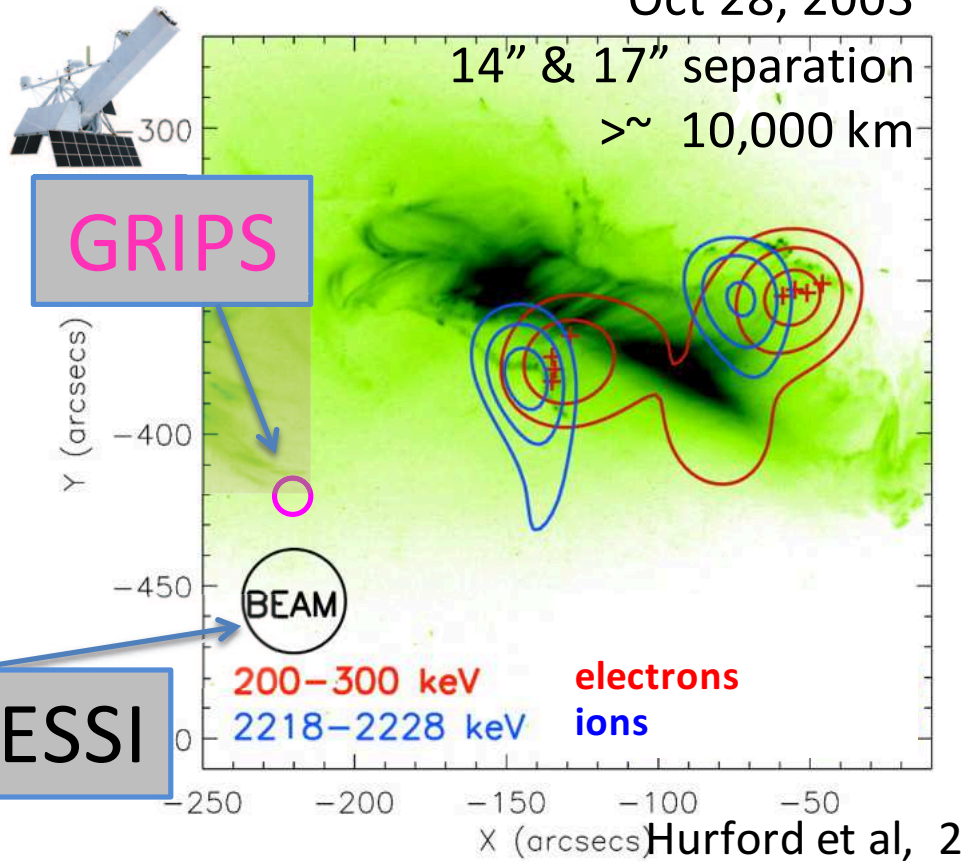
Spectroscopy:
Correlation between relativistic electron and ion emission

Imaging:
Spatially separated centroids for ion and electron emission

Shih et al, 2009



Oct 28, 2003

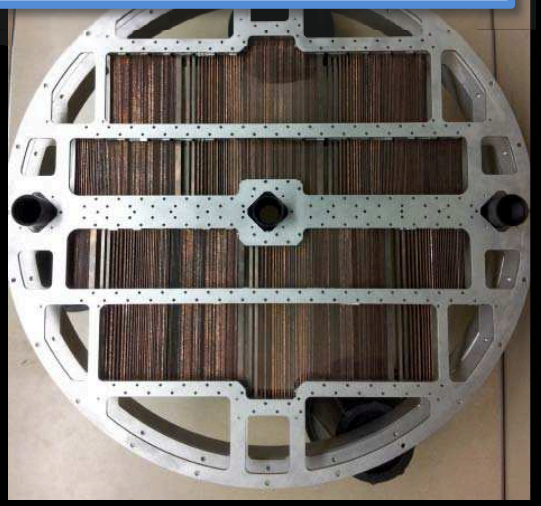


Hurford et al, 2006

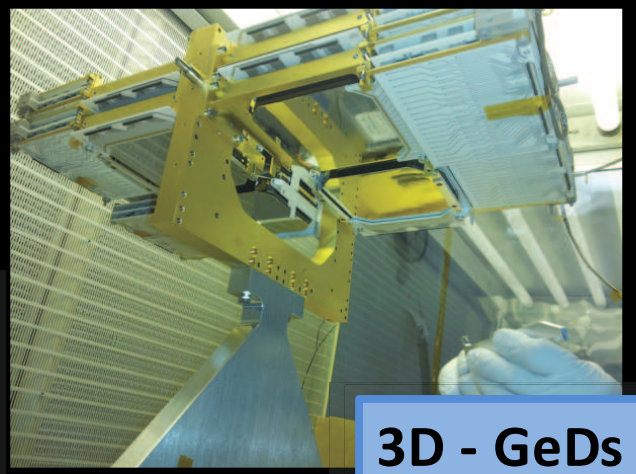
GRIPS

Gamma-Ray Imager/Polarimeter for Solar Flares

Multi-Pitch Rotating Modulator



2x throughput than similar bi-grid imaging designs

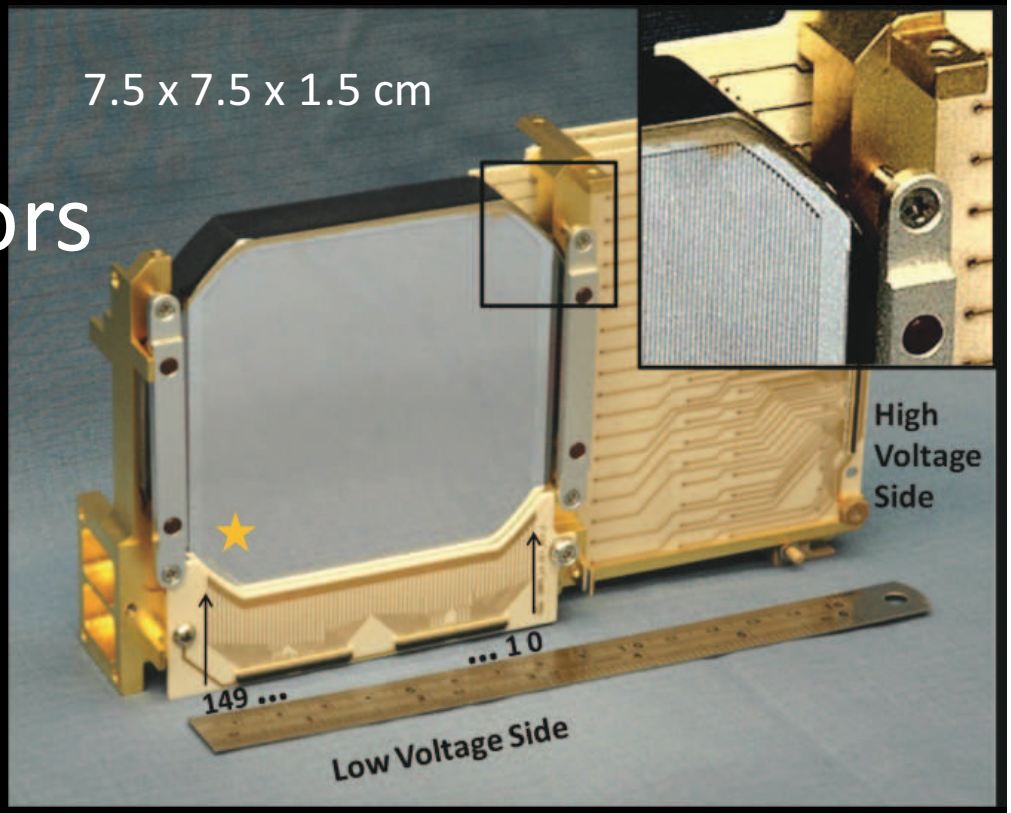


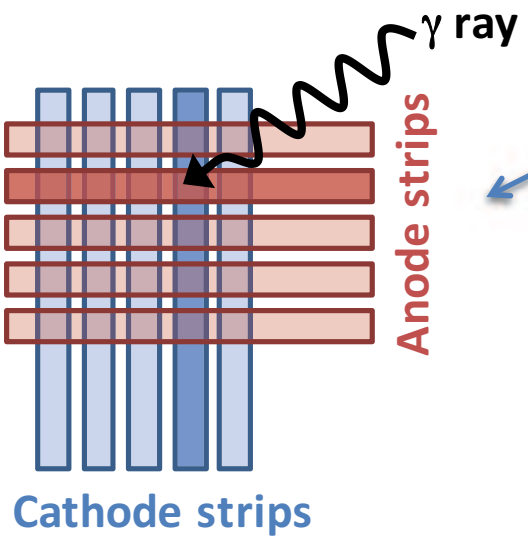
3D - GeDs

Locates photon energy deposition in 3D

3D-GeD
Ge Strip Detectors

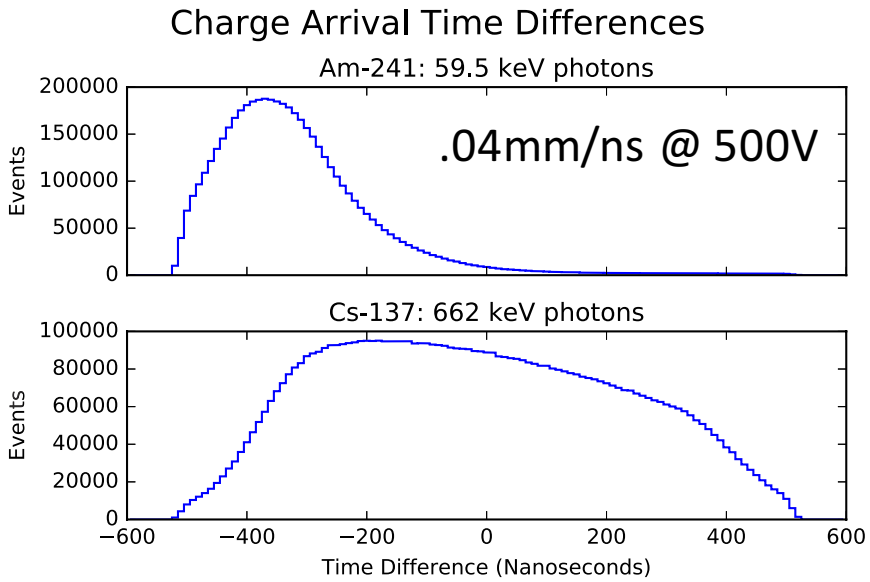
- 2 x 149 electrodes
- .5 mm pitch
- ~1800 instrumented strips
- “Virtually Pixelated”





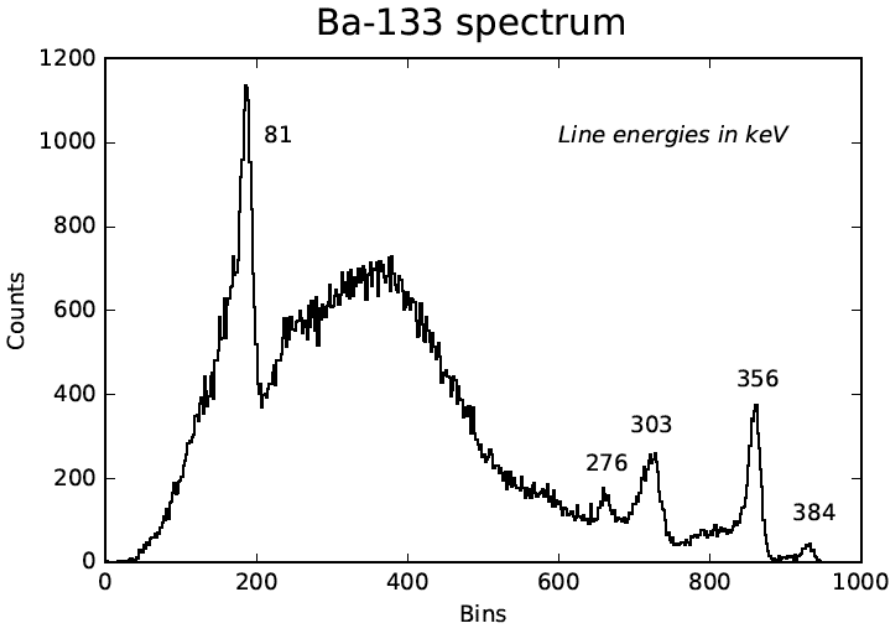
X, Y (strips)

Z (timing)

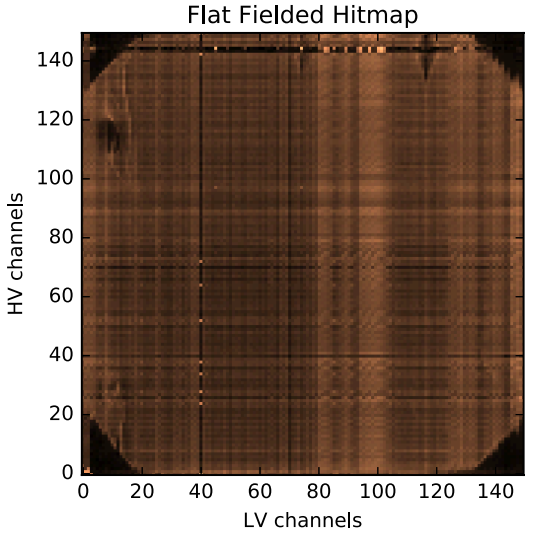


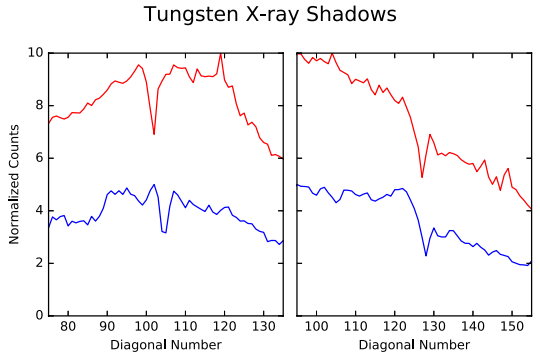
Preliminary Spectroscopy

- Threshold: ~ 30keV
- Deadtime: maintained < 5%
- Planar spatial calibration: ~.5 mm (1 strip)



Preliminary FWHMs ~ 5keV
Expected FWHM → ~ 3 keV





Solar Imaging: MPRM

Single-grid imager: RHESSI RMC heritage

~ 2x improved throughput

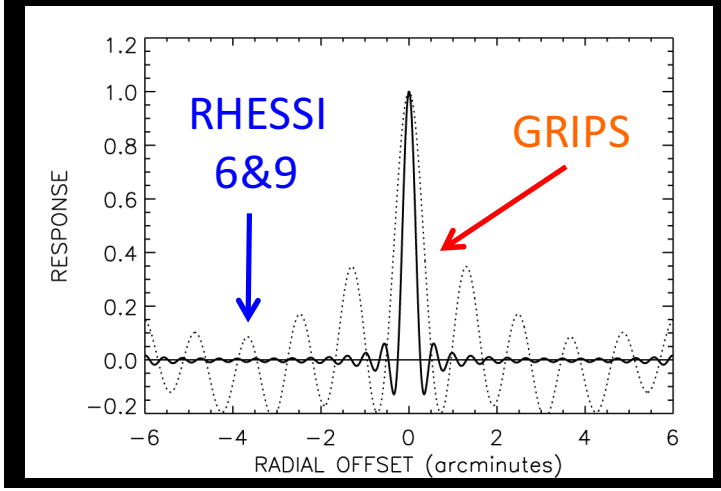
Improved point response

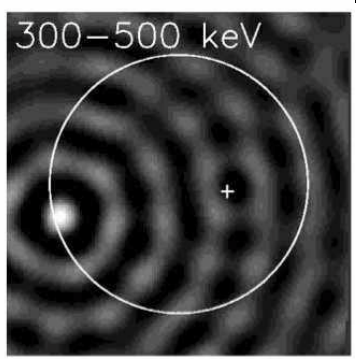
12.5 – 162 arcsec @ 2.2 MeV

Quasi-continuous: 13 spatial resolutions

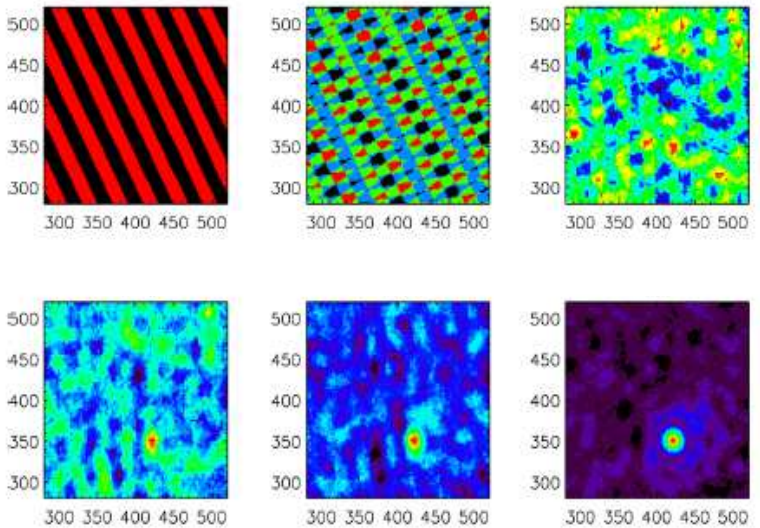
Focusing Optics → "long" focal lengths

Compton → ~ 1 deg





RHESSI 6&9



Simulated image 1 → 1000 photons

Flight Campaign

Jan 19 – Jan 30

Mission Success!!!!

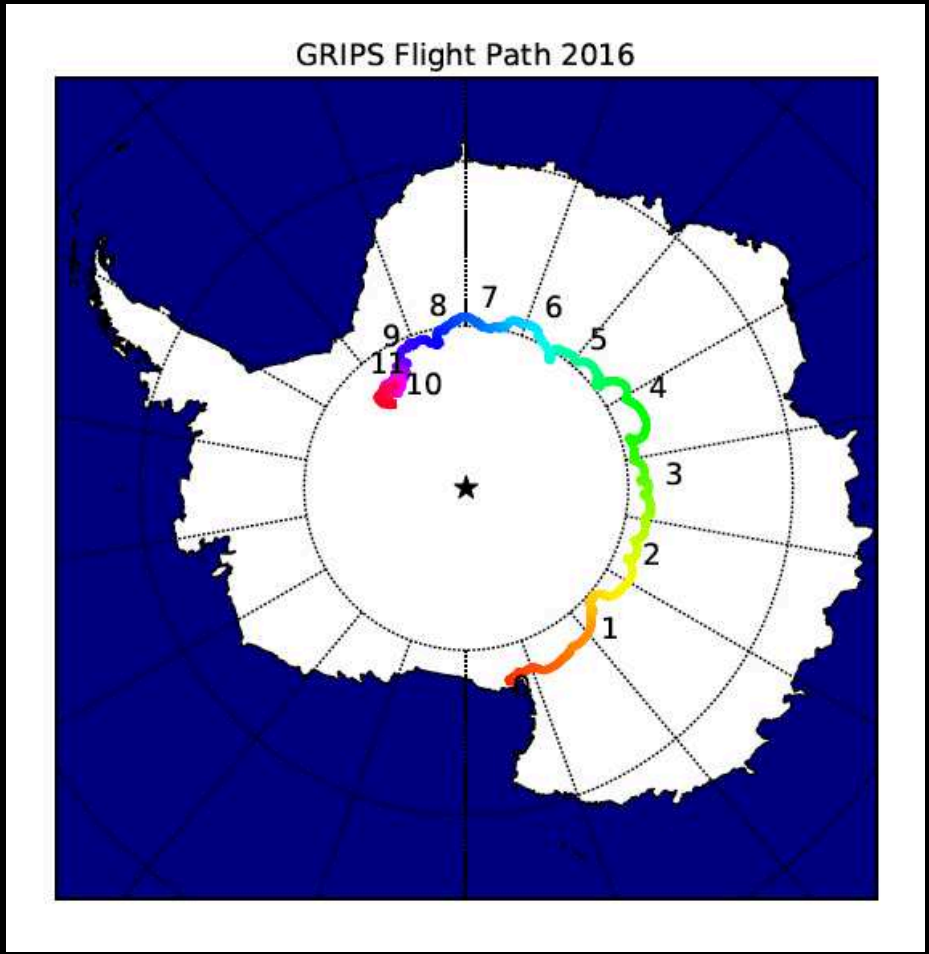
- All 5 data vaults recovered
- Flight time ~12 days

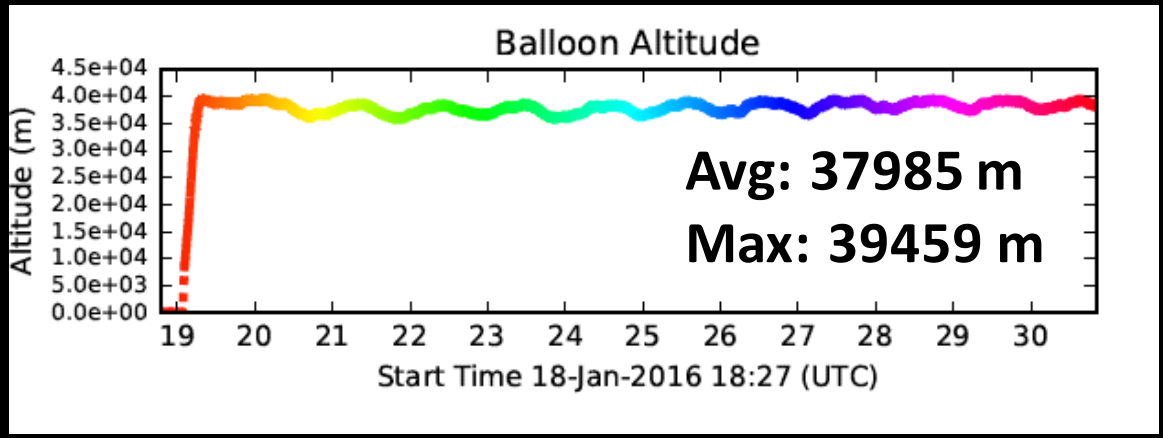
Systems

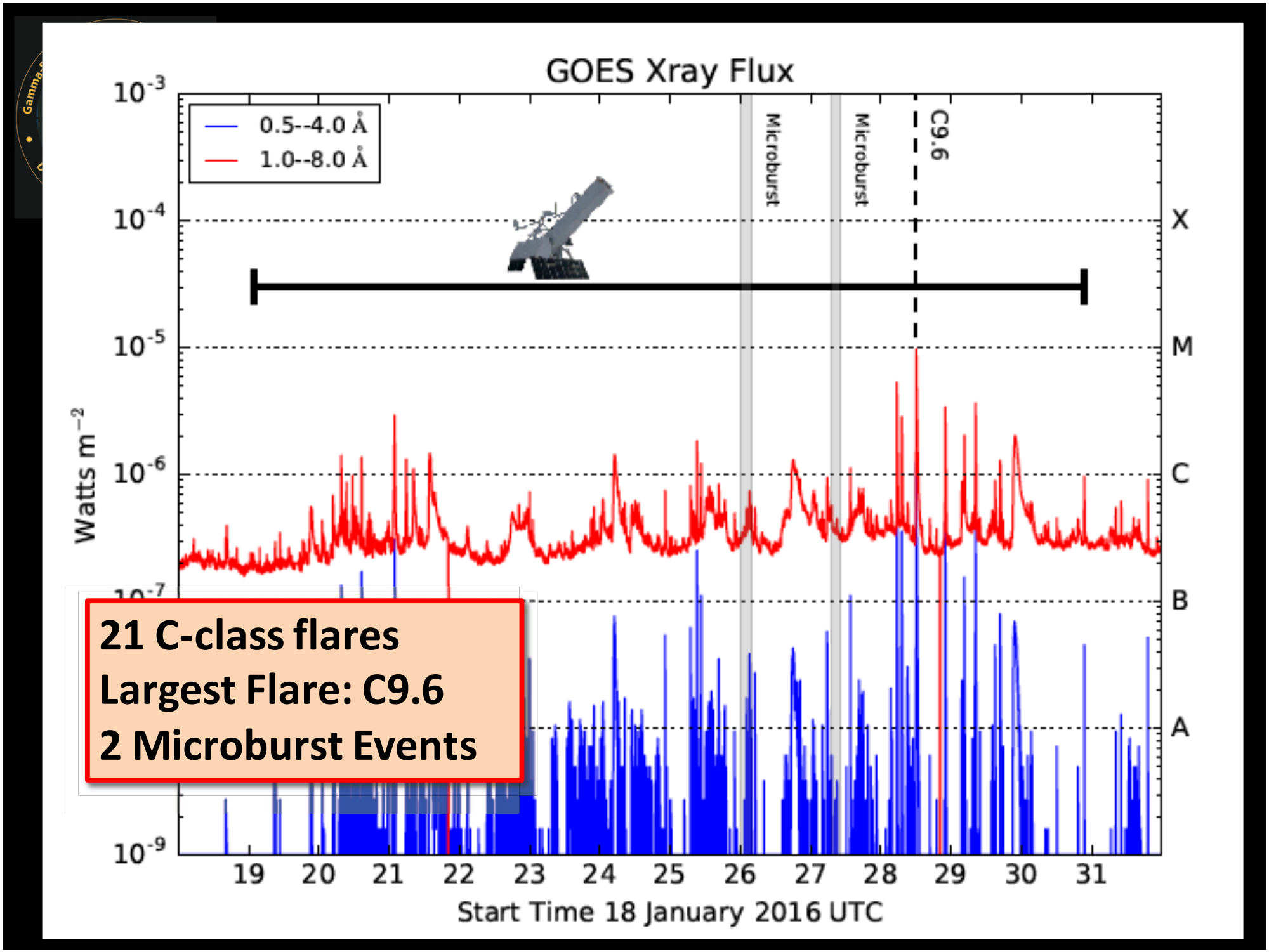
- Performed as designed
- Ethernet switch upset
- One SSD failure

8 launch attempts

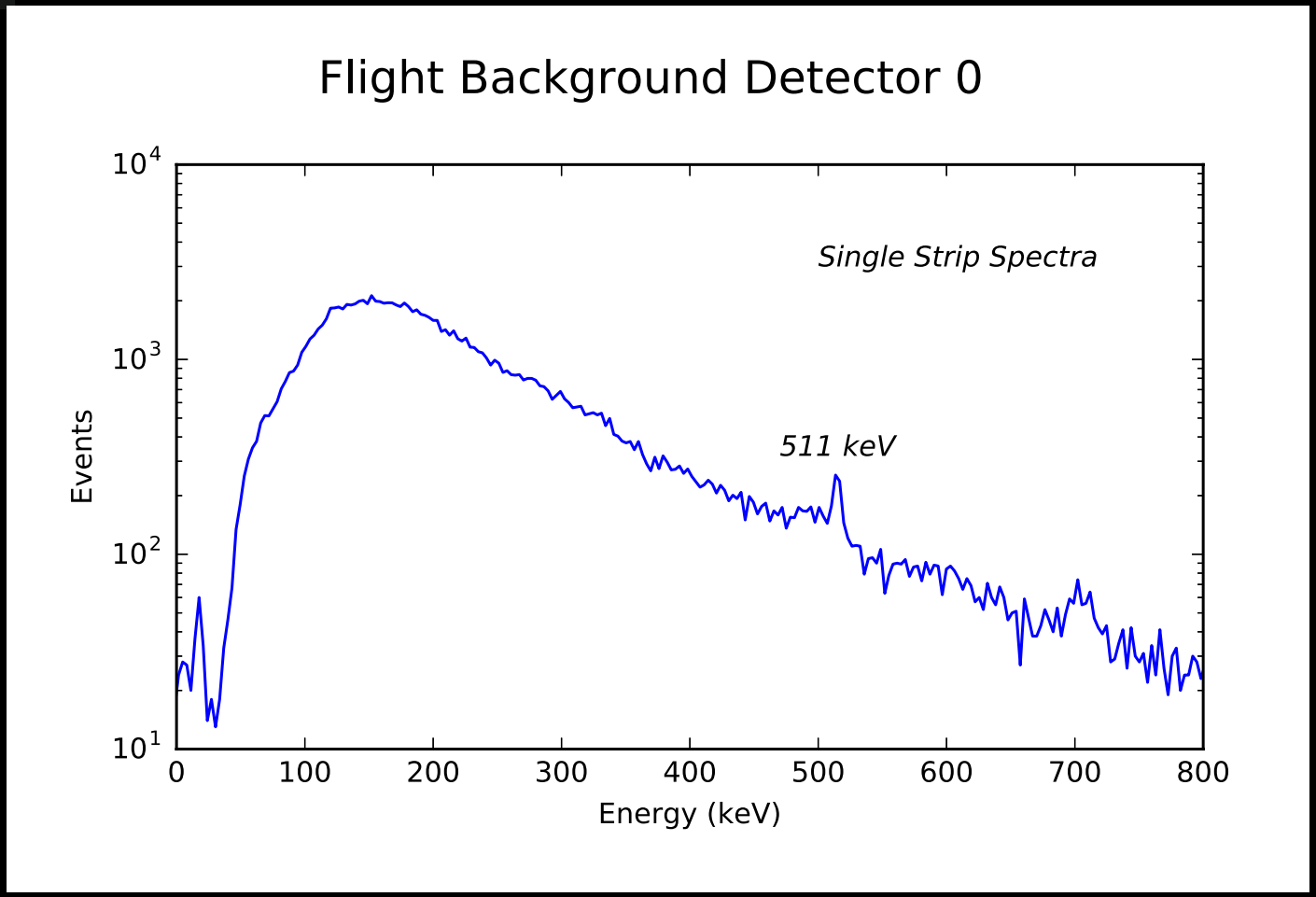
- Colder temperatures on ground than in flight
- Ground pointing tests complicated by wind and cloudy skies






GOES Xray Flux
0.5--4.0 Å
1.0--8.0 Å
Microburst
Microburst
C9.6
X
M
C
B
A
Watts m^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-9}
19 20 21 22 23 24 25 26 27 28 29 30 31
Start Time 18 January 2016 UTC
21 C-class flares
Largest Flare: C9.6
2 Microburst Events

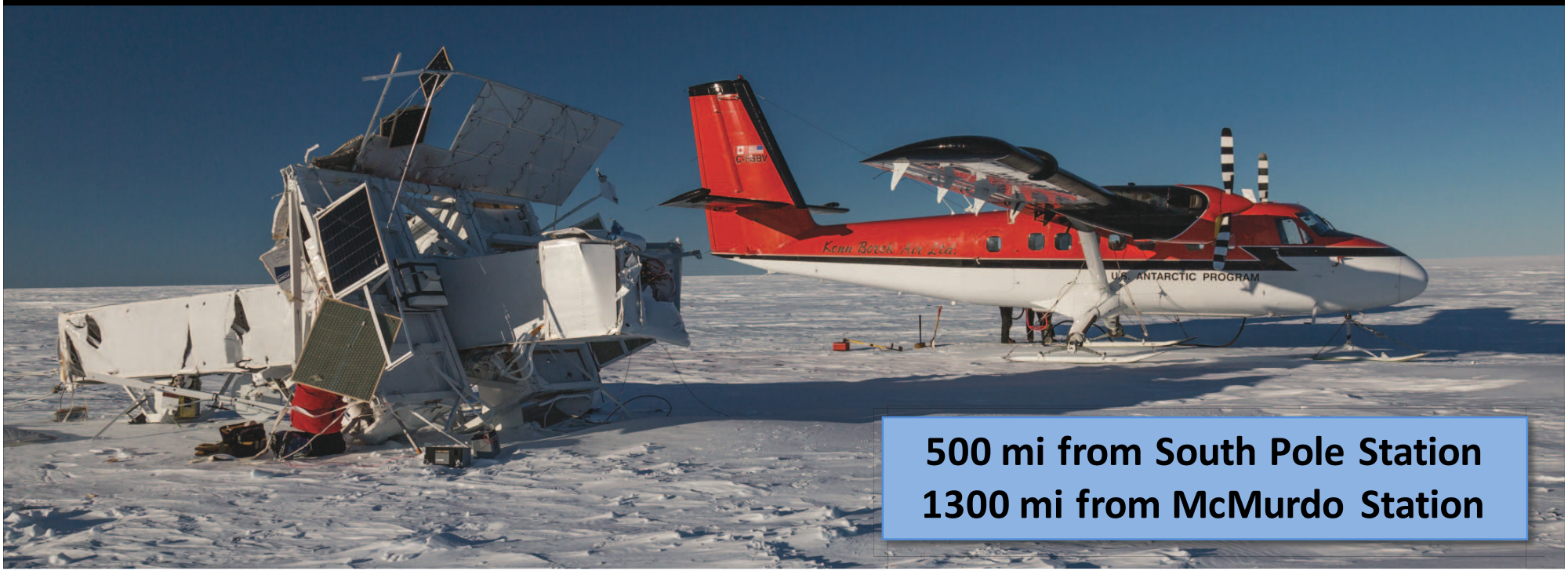
Antarctic Flight Background



20% of total flight time

Post-Flight Status

- All GRIPS & piggy-back data recovered
- No damage to imaging mask, cryostat and detectors are likely undamaged
- 2nd season equipment recovery



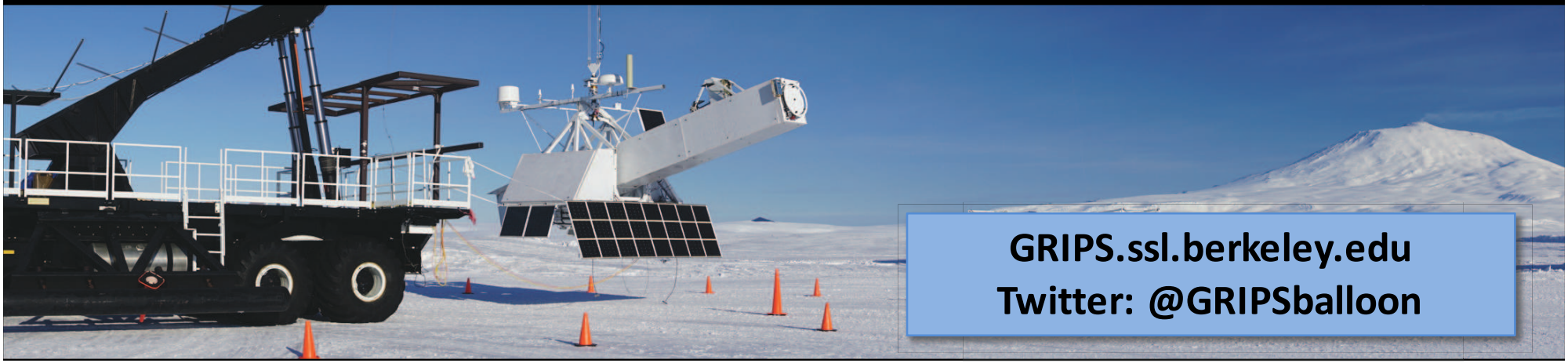
What's next for GRIPS?

Duncan et al., *"First Flight of the Gamma-Ray Imager and Polarimeter for Solar Flares (GRIPS) instrument"*, Proc. SPIE 9905-94

Analysis during flare times and fine calibrations

Look forward to the next GRIPS proposal!!!

- Fleet of GRIPS?
- Super-pressure?
- Missions of opportunity?



GRIPS.ssl.berkeley.edu
Twitter: @GRIPSballoon

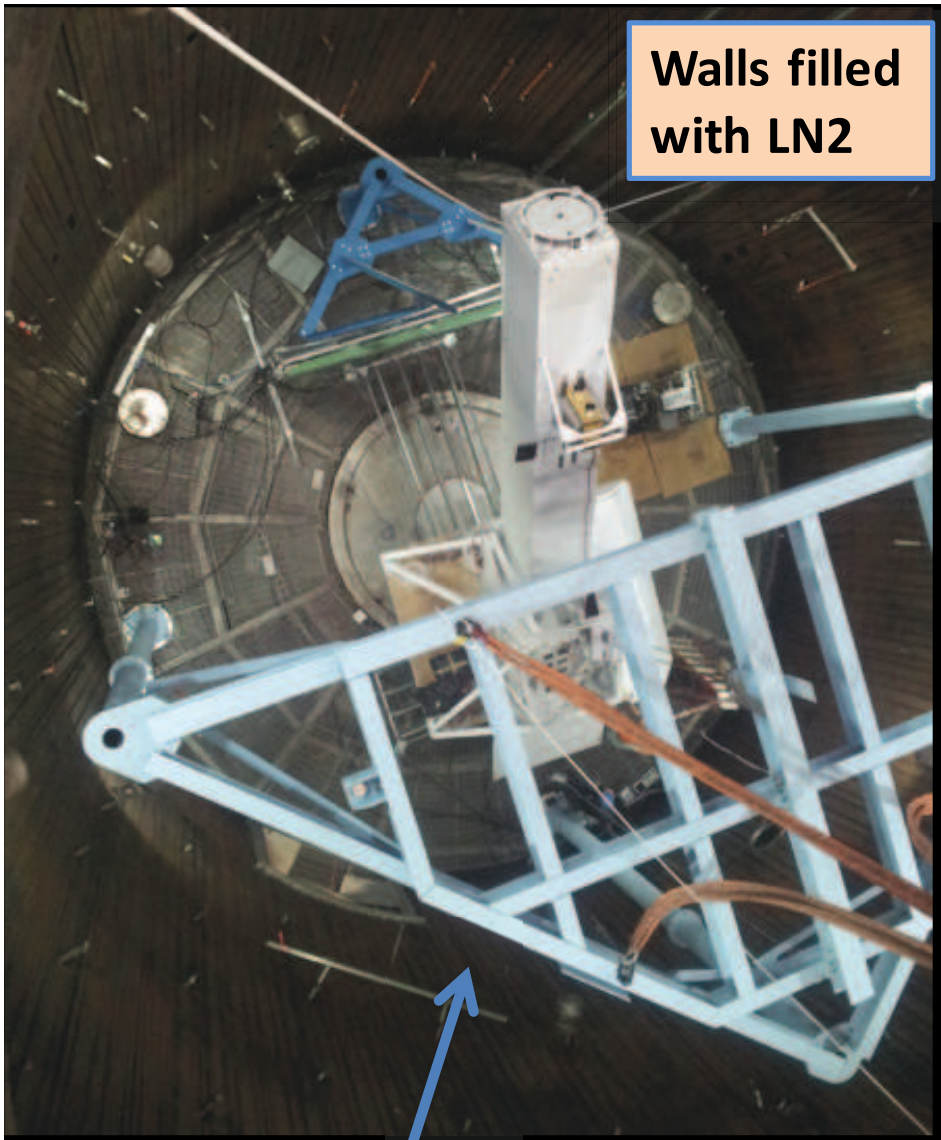

Gamma-Ray Imaging Polarimeter for Solar flares
GRIPS
NASA GSFC
UC Berkeley SSL

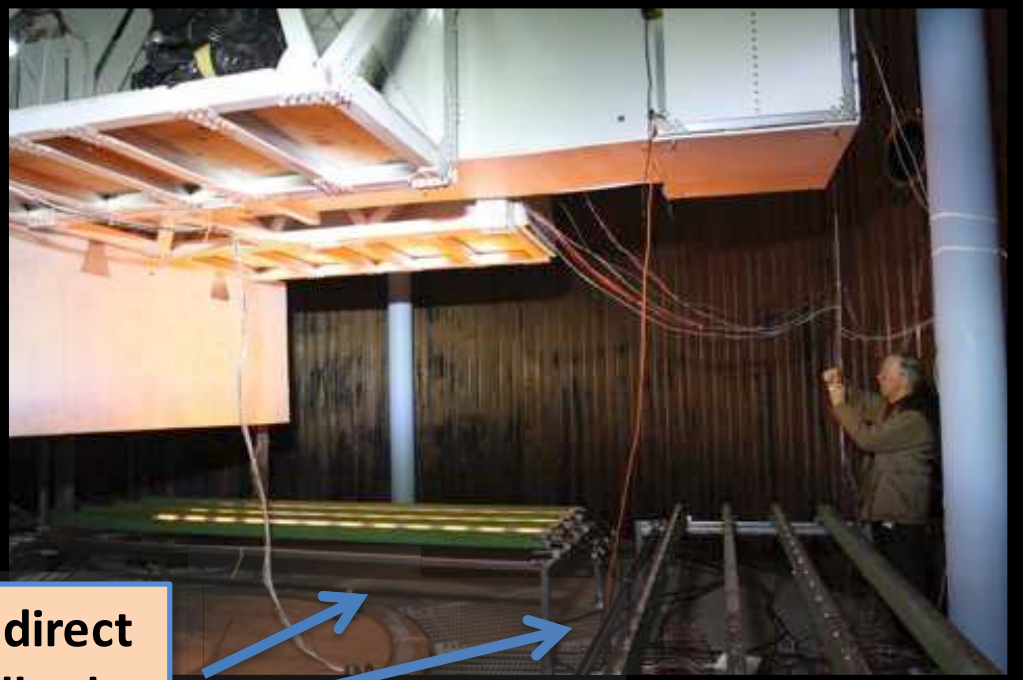
Thermal Vacuum Test

March 2015
NASA Glenn's Plum Brook B2 facility
Sandusky, Ohio

Simulated float conditions
30 h @ ~ 2 Torr and ~ 77K

Input for flight thermal model

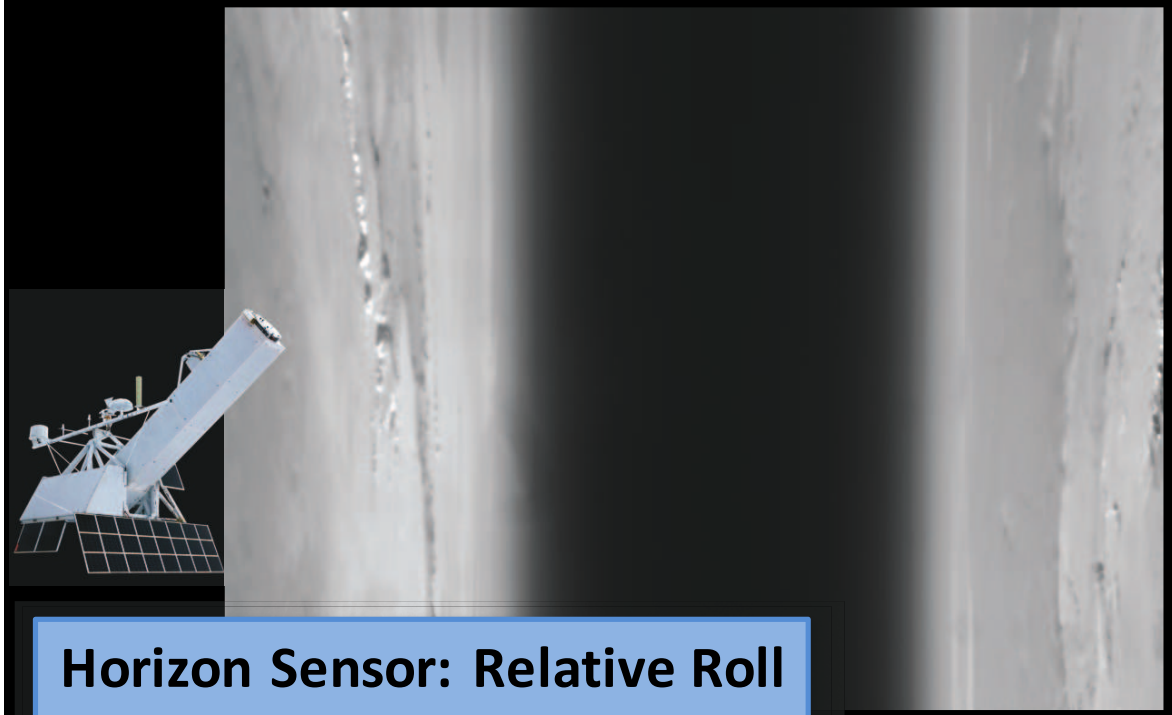




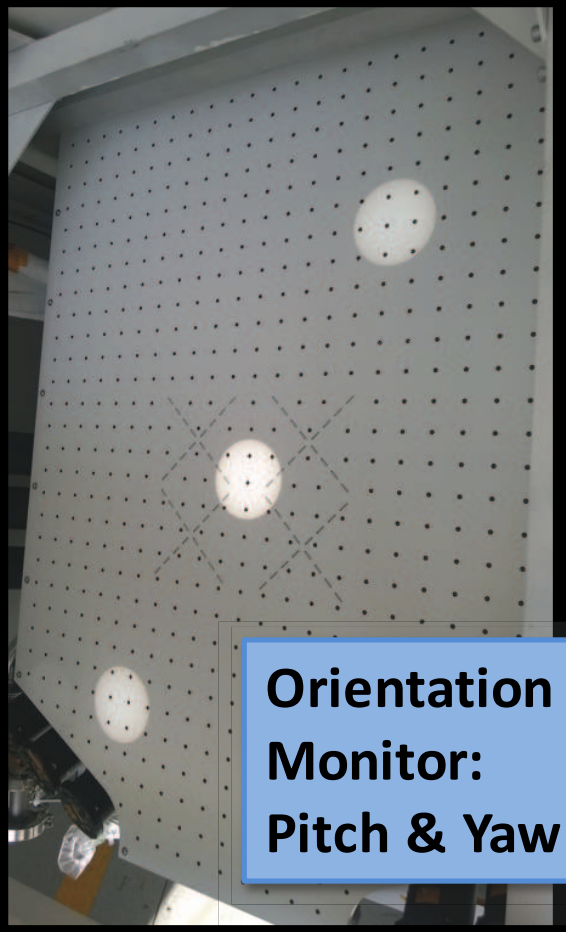
Aspect System

" Trading control for knowledge " – G. Hurford

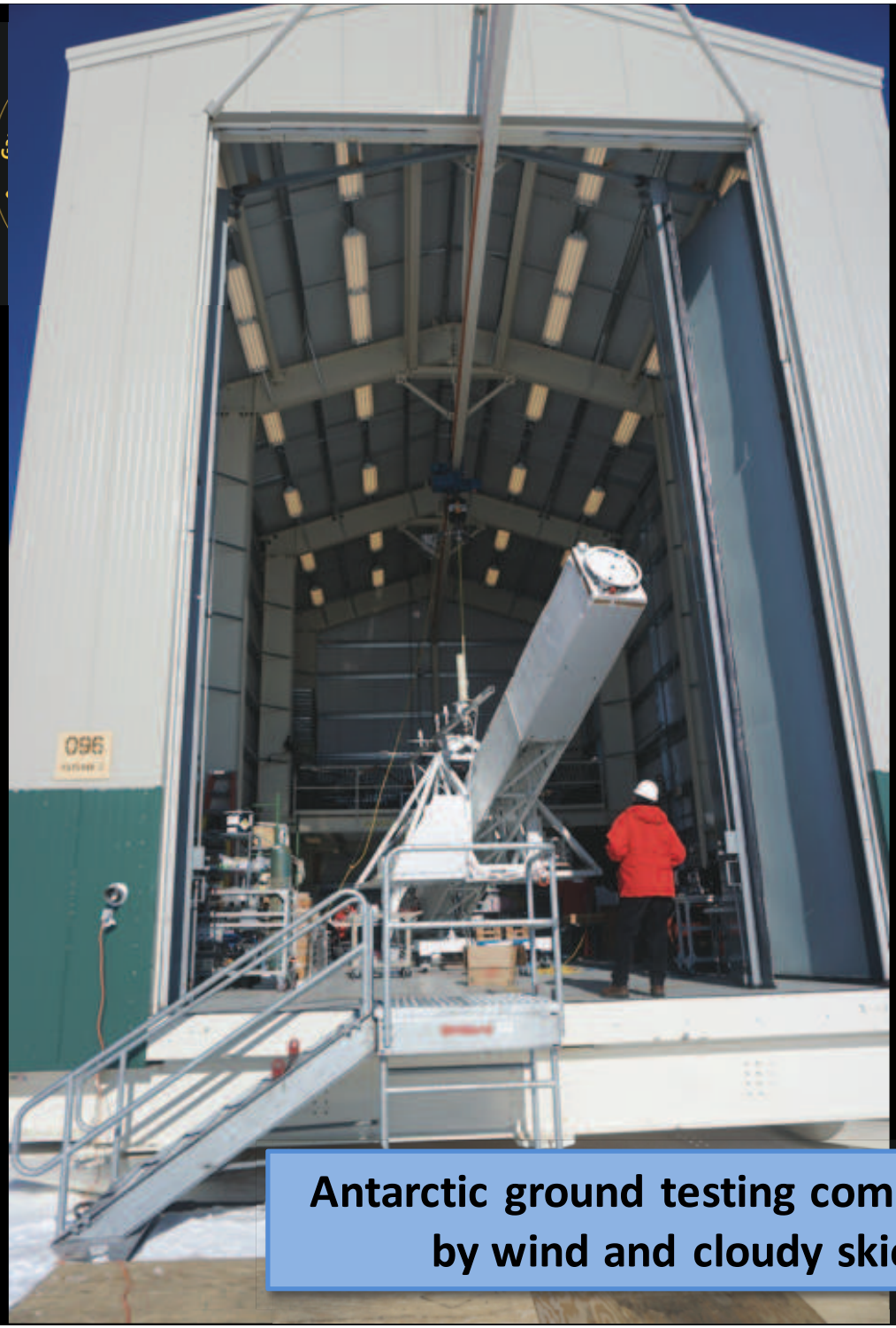
- Precise monitoring of Pitch, Yaw and Relative Roll
  - Arcsecond level *knowledge* of pointing
  - Allows for .5°–rms *controlled* pointing
- Corrects for twist/flexure of 8m boom



Horizon Sensor: Relative Roll
HEROES heritage equipment



Orientation Monitor: Pitch & Yaw



Antarctic ground testing complicated by wind and cloudy skies

Solar Pointing

Digital control loop

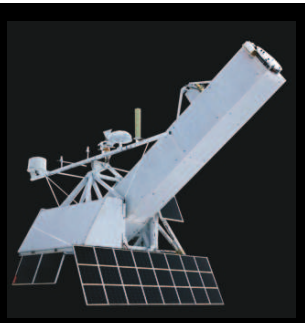
- Quad-cell photodiode
- Azimuth (PID) and Elevation (PD) motors maintain pointing

In flight performance:

- at 0.2° rms level (0.5° required for imaging)
- Sun lost for ~5 hrs, due to required flight computer reboot. No loss to science.
- Rotator redesign successful

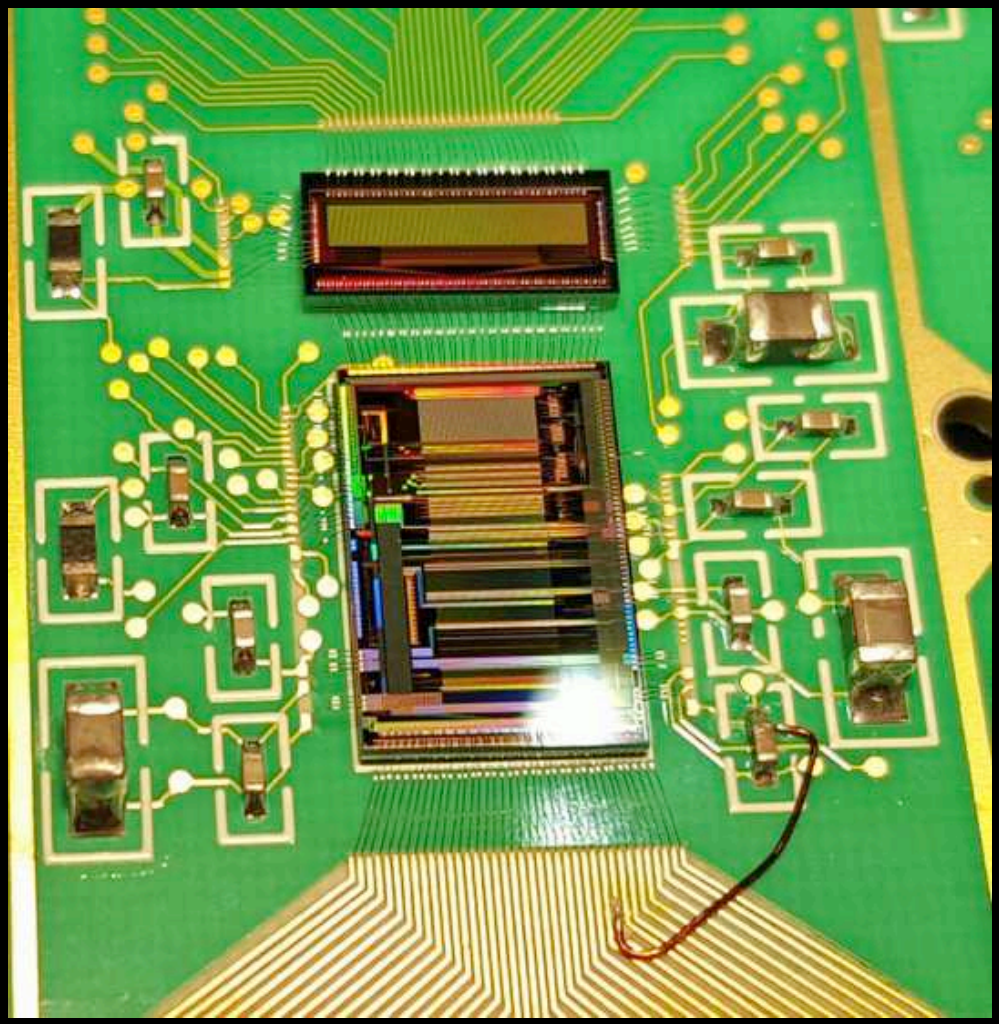
ASICs

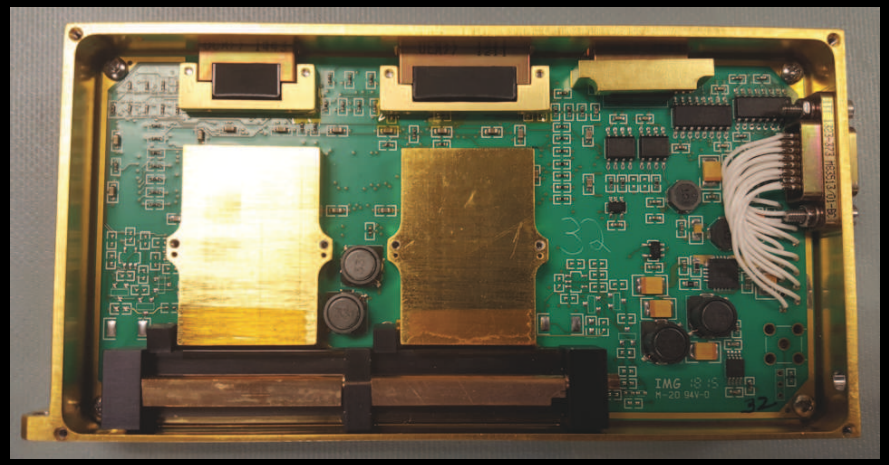
Mfg by Ideas: VATA453
AstroH/FOXSI heritage



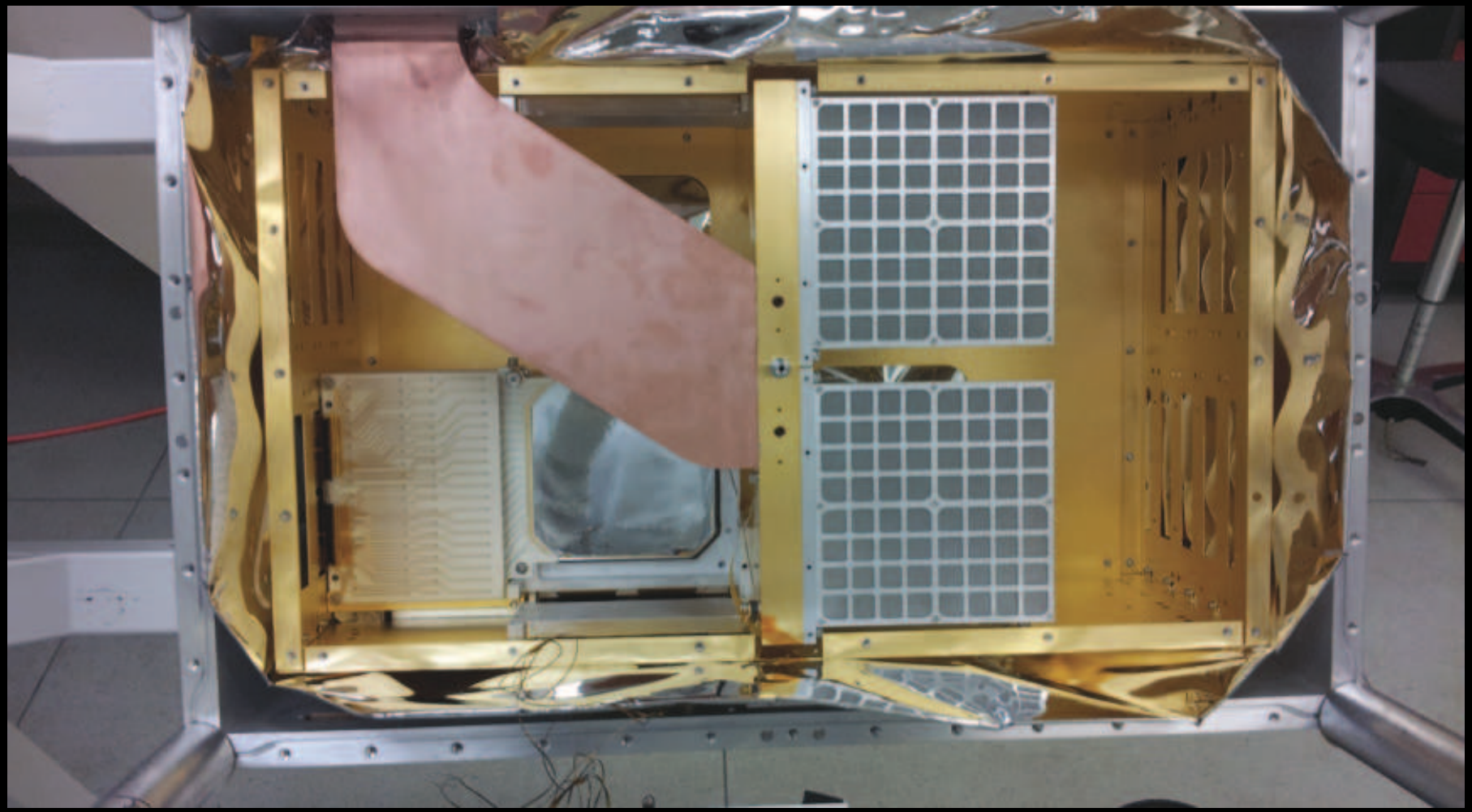
Chosen for signal density & power:
64 channels/chip
44 flight ASICs
25mW/ch

VA/TA architecture:
CSA, triggering, shaping,
Wilkinson ramp comparator





Inside the Cryostat



Effective Area

Table 1. Comparison of *GRIPS* and *RHESSI* capabilities

	RHESSI	*GRIPS* (balloon)	*GRIPS*-like spacecraft
Effective area at 2.2 MeV	~3 cm^2 *	~13 cm^2 **	~52 cm^2
Effective area at 300 keV	~50 cm^2	~55 cm^2 **	~210 cm^2
Effective area at 50 keV	~47 cm^2	~89 cm^2 **	~356 cm^2
Angular resolution at 2.2 MeV	35”	12.5”	5”
Minimum detectable polarization at 150–650 keV (for the 2002 July 23 flare), three-sigma level	~30% ***	~3%	~1%

* Including only the detectors capable of imaging at this energy

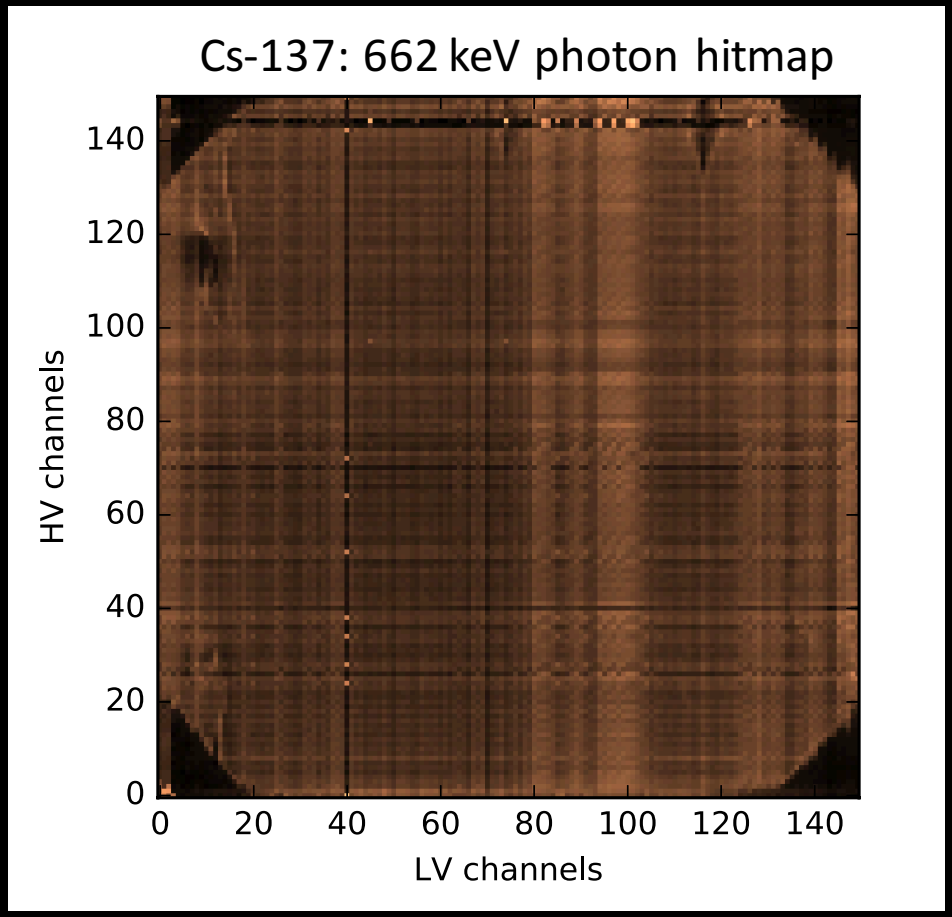
** The effective areas after accounting for atmospheric absorption at Antarctica are ~9 cm^2 at 2.2 MeV, ~20 cm^2 at 300 keV, and ~14 cm^2 at 50 keV

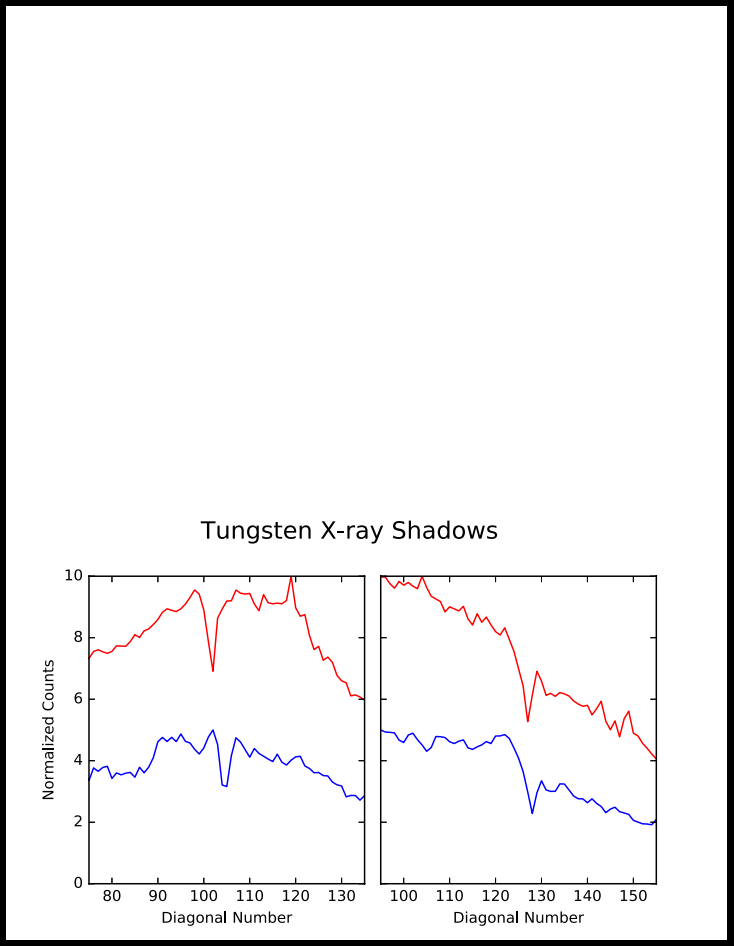
*** Based on the analysis of Boggs et al.[4] in the ranges 200–400 keV and 0.2–1.0 MeV

Theoretical values for GRIPS –
actual calibration and flight values are in progress

Preliminary Detectors

- FWHM @ 59.5 keV: ~8-9% (~5 keV)
- Threshold: ~30keV
- Deadtime: maintained < 5%
- Planar spatial calibration: ~.5 mm (1 strip)





GRIPS 2015/16 Milestones

- Feb 2015:
  - Full Instrument Thermal Vacuum Test
- May 2015:
  - Flight Detector Integration
- July 2015:
  - CSBF Systems Integration
- Nov – Jan 2016:
  - Antarctic Integration
- Jan 2016:
  - Antarctic Flight