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Astroparticle physics at KTH, Stockholm

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Strategy of group and science goals

The main task of the group is to study the high-energy universe through X- and gamma-radiation and cosmic rays.

The fundamental scientific questions addressed concern particle acceleration and radiation processes in cosmic plasmas.

Specific topics:

- Search for dark matter
- Physics of gamma-ray bursts
- The origin of cosmic rays
- High energy emission from compact objects

The focus is on design and development of strategic satellite- and balloon-borne instrumentation. In particular, X/gamma-ray polarimeters.

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Astrophysics @ KTH

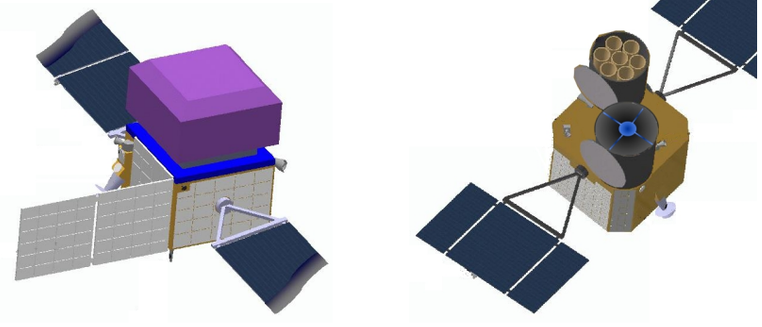
CAPRICE (1990's)
Cosmic antimatter

Fermi (2008 -)
Cosmic gamma-rays

PoGOLite (now!)
Polarised X-rays

PAMELA (2006 -)
Cosmic antimatter

PFD / ISS (2009, 2011)
Education



GRIPS
Proposal

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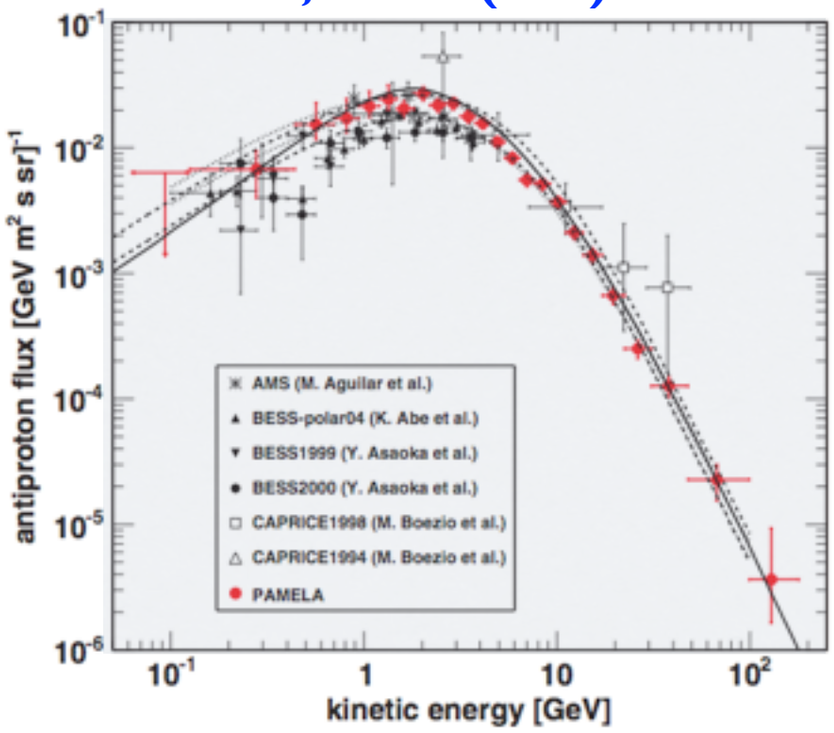
Main recent results achieved from platforms that we have been involved in

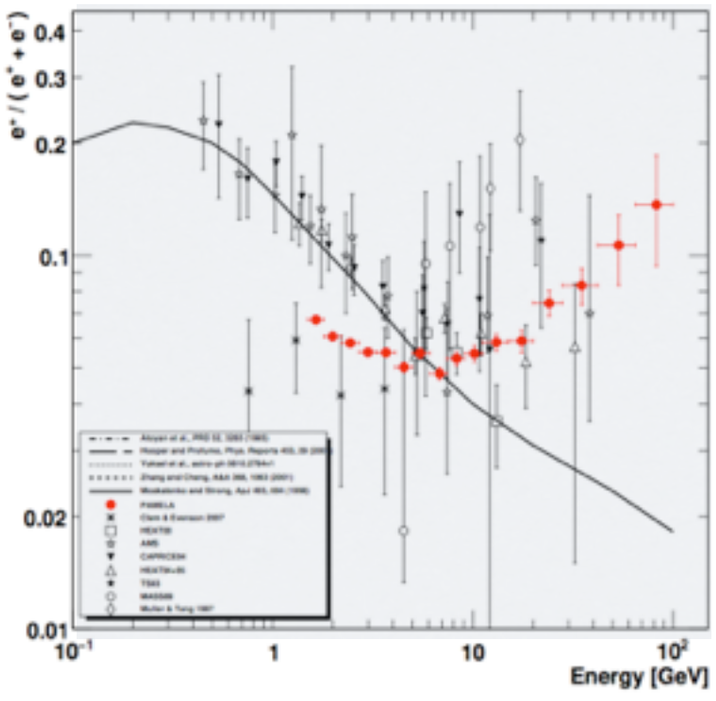
PRL 105, 121101 (2010)



Precision measurement of the cosmic-ray antiproton flux with the PAMELA satellite.

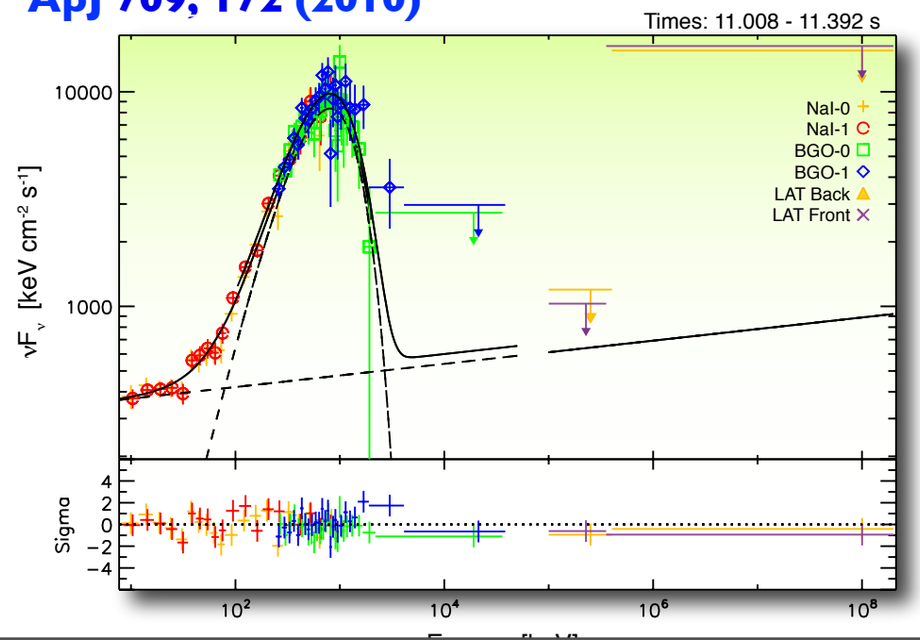
Discovery of an anomalous positron fraction with the PAMELA satellite.

Nature 458, 607 (2009)



Identification of the jet photosphere in GRBs using the *Fermi* satellite

ApJ 709, 172 (2010)



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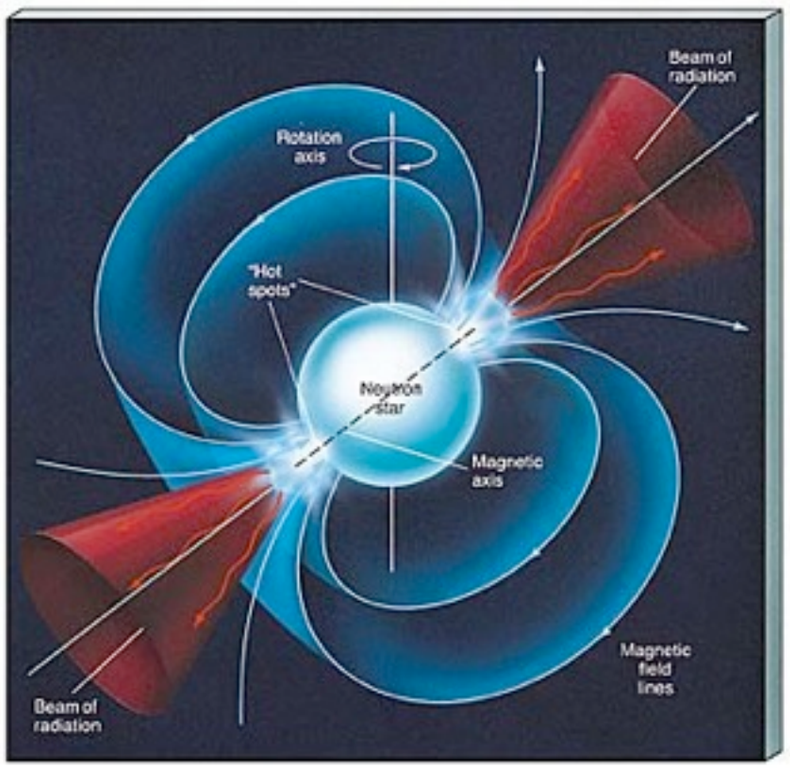
PoGOLite: Targets for a X/γ polarimeter

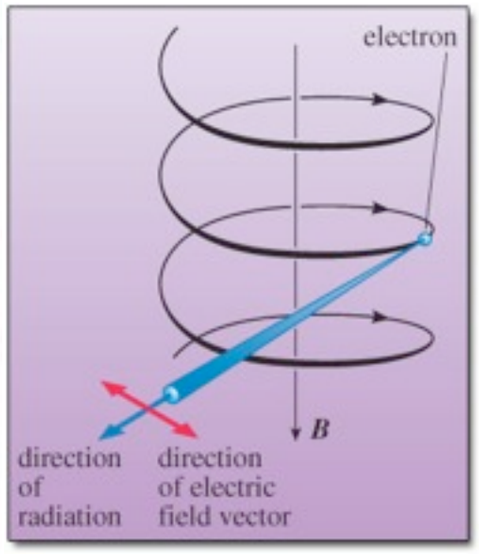
- **Synchrotron emission**:
  - **Rotation-powered neutron stars** (e.g. the Crab pulsar)
  - **Pulsar wind nebulae** (e.g. the Crab nebula)
  - **Jets in active galactic nuclei**

- **Compton scattering**:
  - **Accretion disk around black holes** (e.g. Cygnus X-1)

- **Propagation in strong magnetic field:**
  - **Highly magnetised neutron stars** (e.g. Hercules X-1)

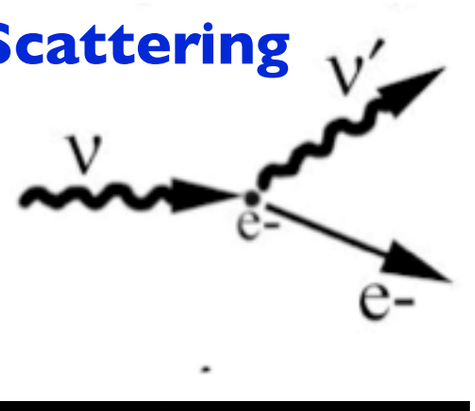
Crab





Synchrotron emission

Scattering



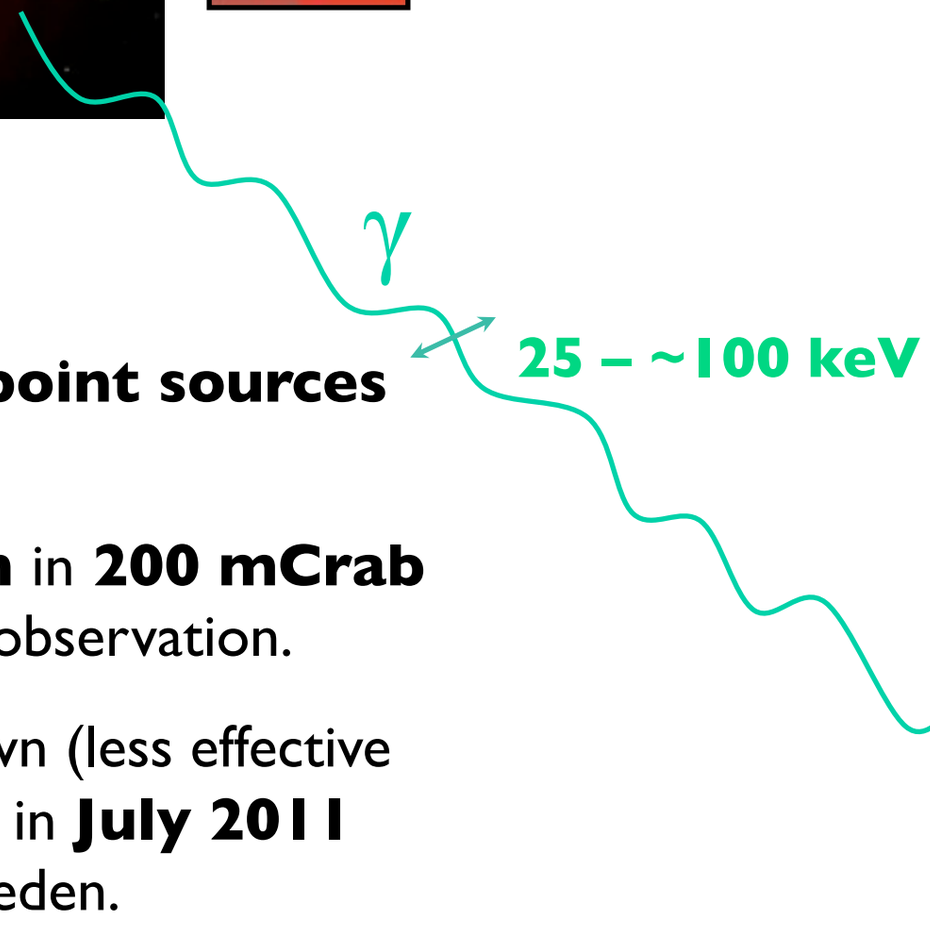
PoGOLite

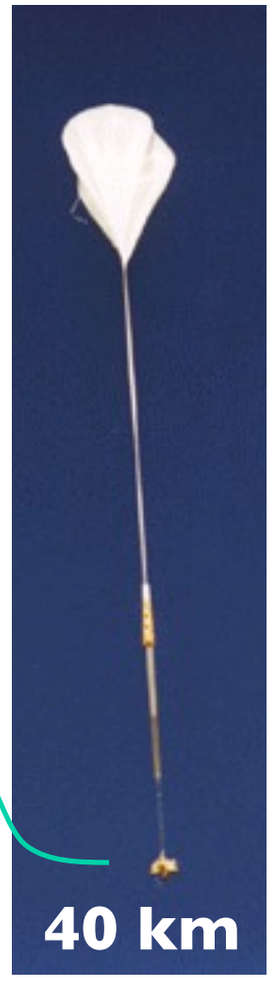
X-rays (Chandra),
optical (HST),
radio (VLA)

KTH
Stockholm University
DST Control
SSC Esrange

Hiroshima University,
Tokyo Inst. of Tech,
ISAS/JAXA, Waseda Uni.

SLAC - KIPAC
Uni. of Hawaii





- **PoGOLite** is optimised for **point sources** (e.g. Crab pulsar, Cygnus X-1).
- Measures **10% polarisation** in **200 mCrab sources** in a **6 hour** balloon observation.
- **Maiden flight** of scaled down (less effective area) **'pathfinder'** took place in **July 2011** from Esrange Space Centre, Sweden.
- **Flight terminated** due to a leaking balloon after a few hours. Payload safely recovered. Reflight in summer 2012.

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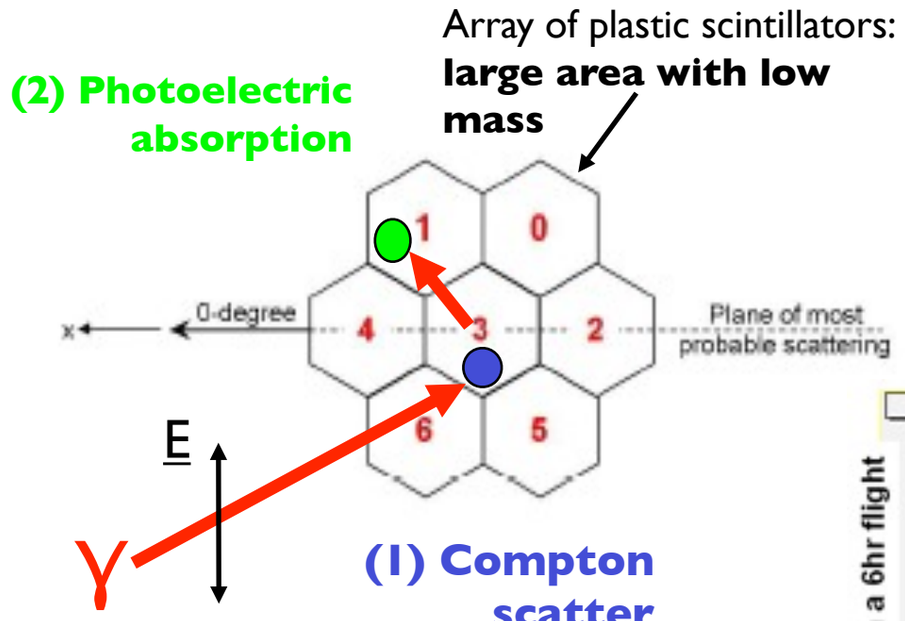
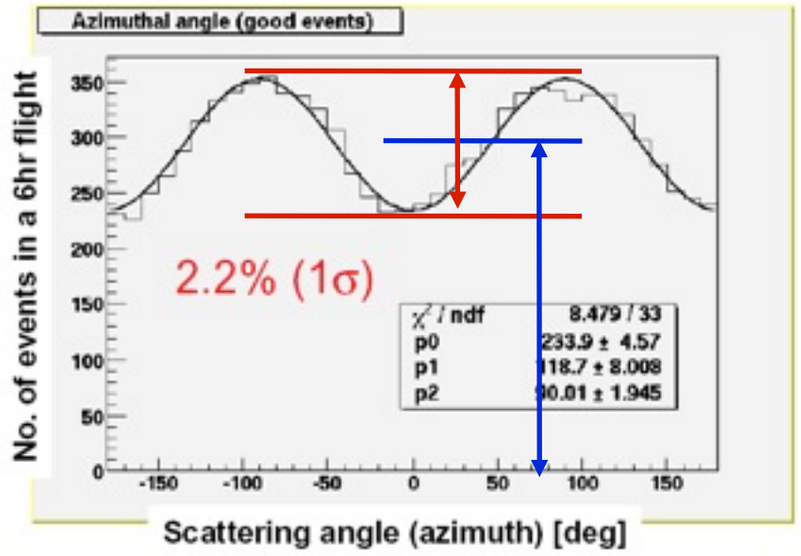
PoGOLite Principles

- γ from a **polarised** source undergo **Compton scattering** in segmented detector material
- Higher probability of being **scattered perpendicular** to the **electric field vector**
- Observed **azimuthal scattering angles** are **modulated by polarisation**





MF=difference/average

- Incident γ deposits little energy at Compton site
- Most deposited at photoelectric absorption site
- Large energy difference
- Can be distinguished by simple plastic scintillators (despite intrinsic poor energy resolution)

$$P_{source} = \frac{M_{obs}}{M_{100}}$$

$$MDP_{99\%} = \frac{4.29}{M_{100} R_S} \sqrt{\frac{R_S + R_B}{T}}$$

minimum detectable polarisation

signal rate

background rate

modulation for 100% polarised source

observation time

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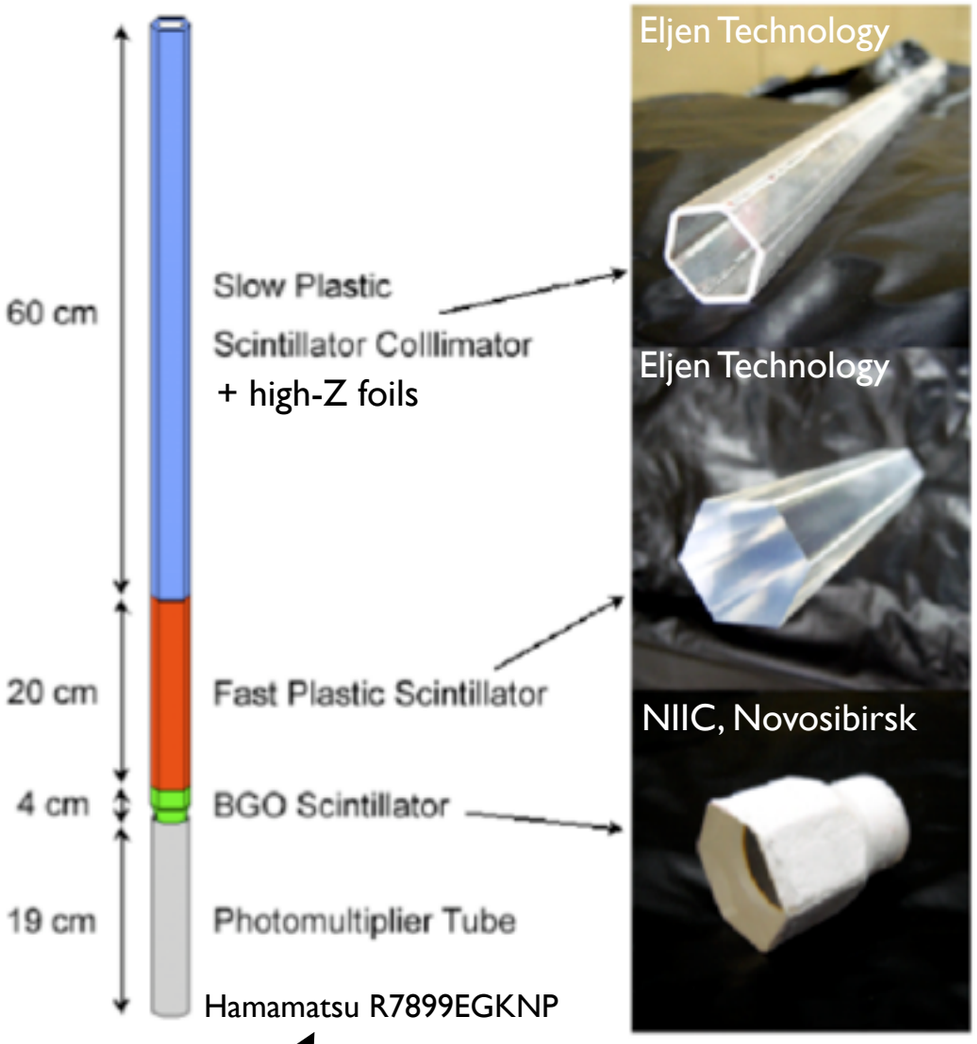
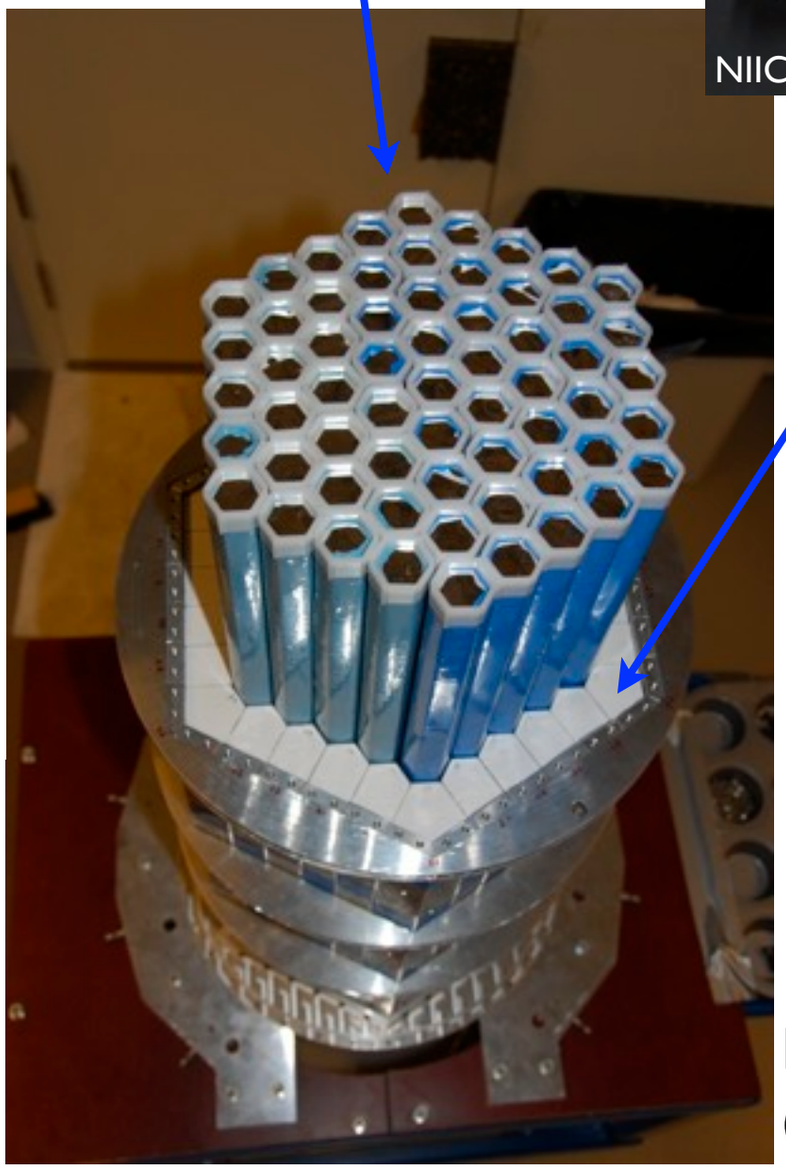
PoGOLite: Scintillator array

Reflective wrappings:
VM2000 (plastic) / $BaSO_4$ (BGO)



@ 25 keV only 1-3 keV Compton deposited - single p.e. detection
(PMT has 0.05 p.e. ripple @ 10^6 gain)

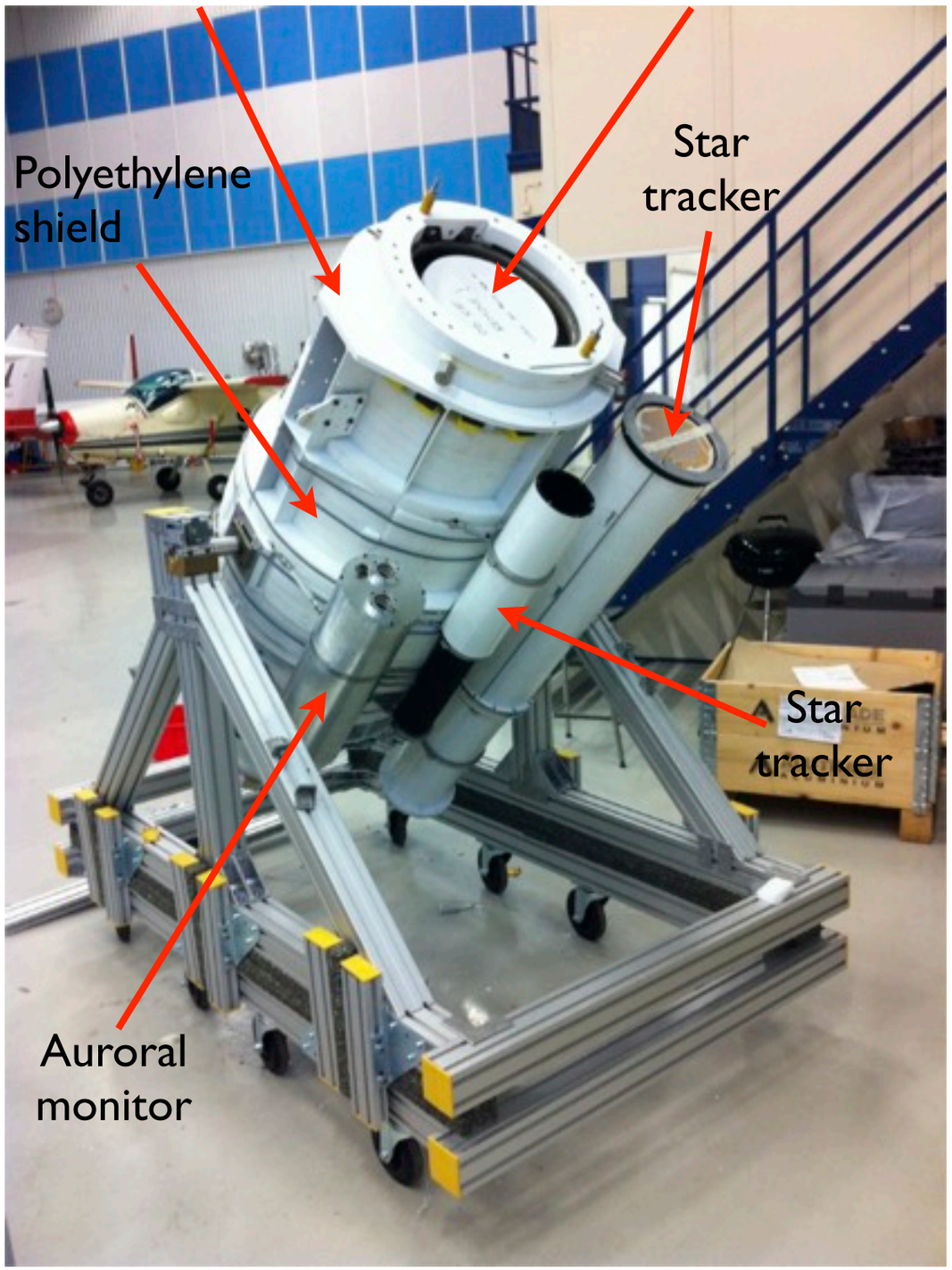
Phoswich Detector Cells (~30 kg)



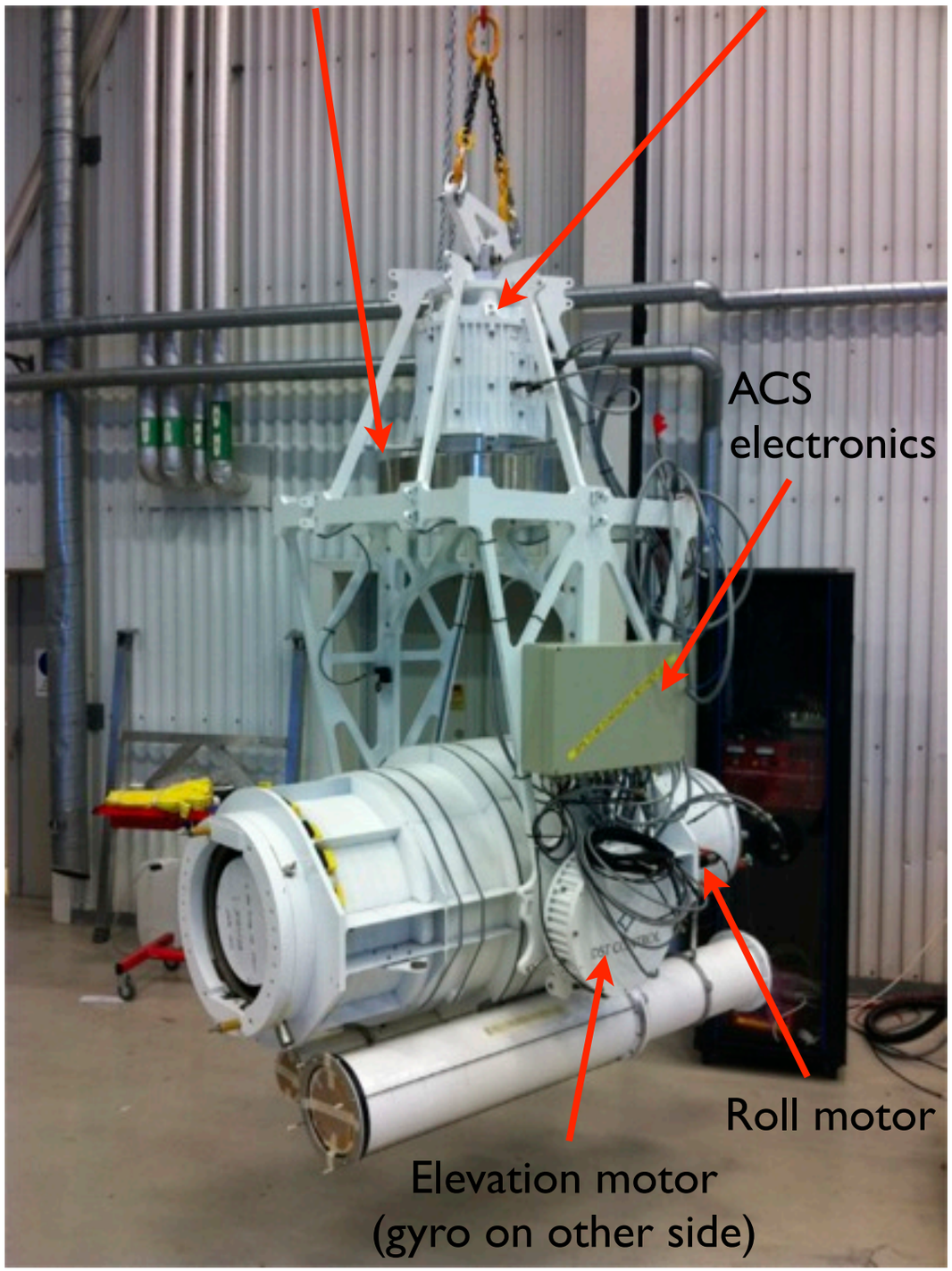
Side anticoincidence, BGO ~150 kg

Pathfinder instrument
(61 units)

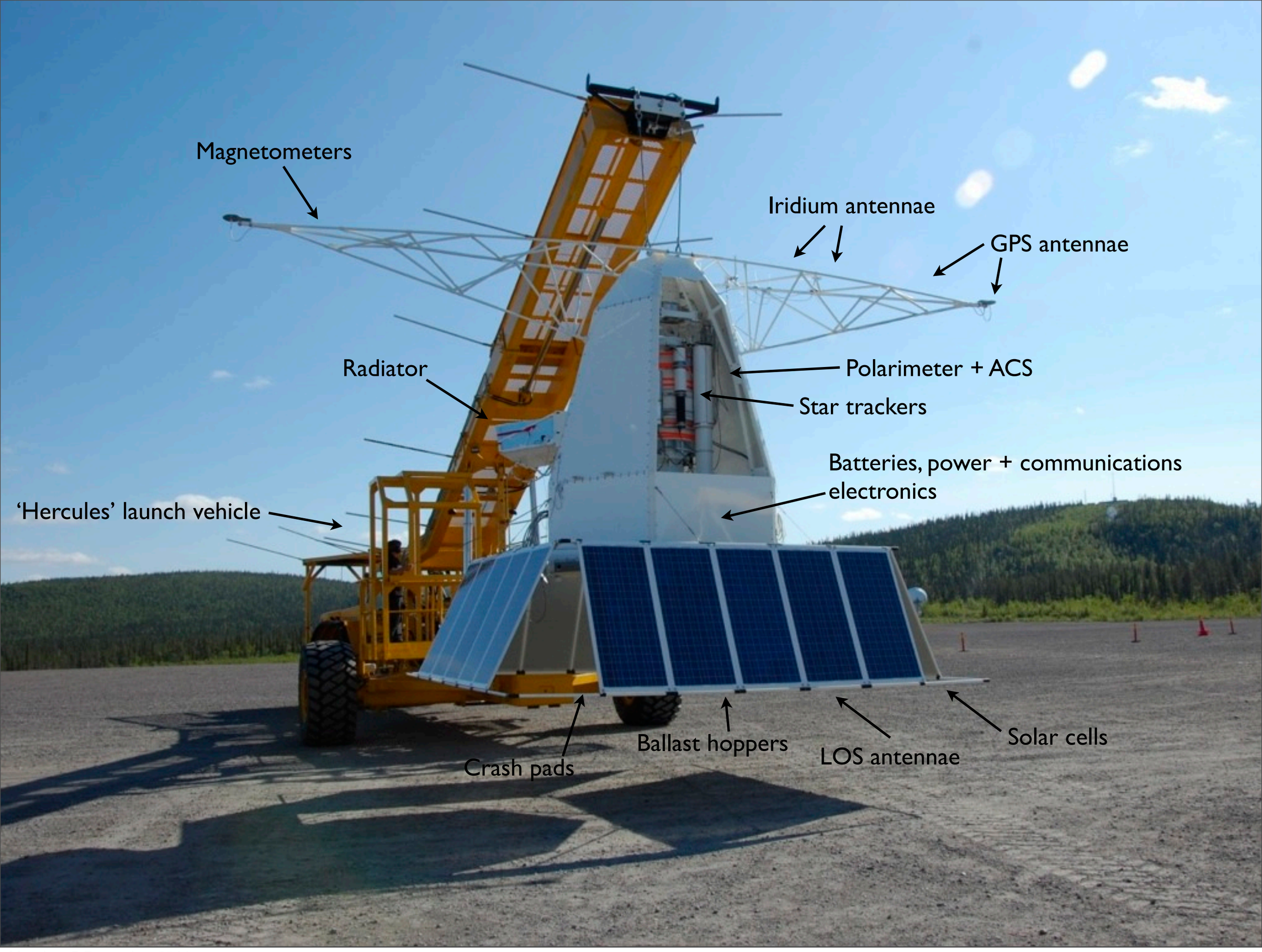
PoGOLite: Polarimeter + ACS



Aim: pointing to better than 5% of FOV (~0.1°)



DST CONTROL


Magnetometers
Iridium antennae
GPS antennae
Radiator
Polarimeter + ACS
Star trackers
Batteries, power + communications electronics
'Hercules' launch vehicle
Crash pads
Ballast hoppers
LOS antennae
Solar cells

Monday, 5 December 2011

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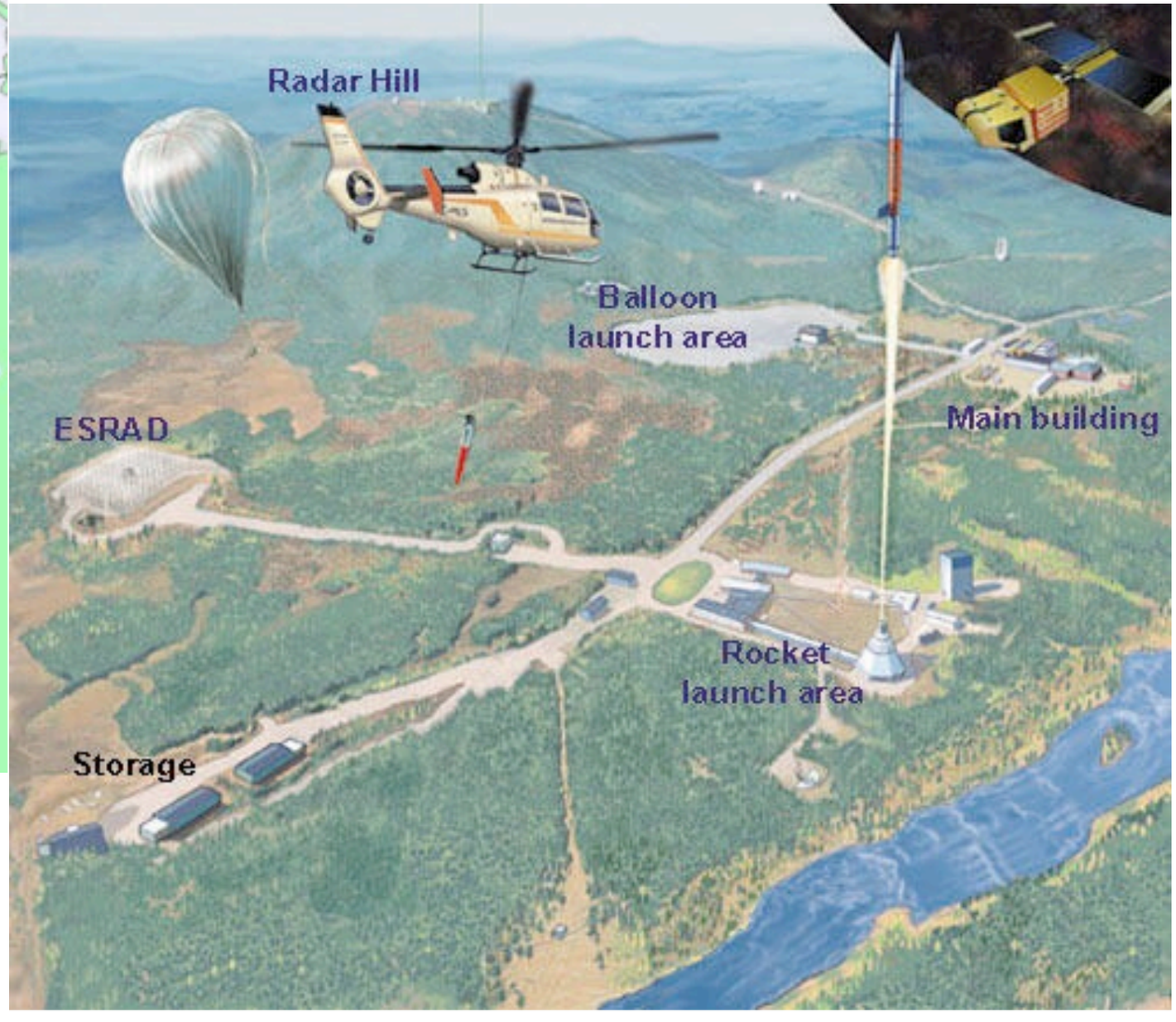
ESRANGE: European Space Range



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Future work and collaboration

We are interested in a collaborative effort for a future high energy mission, in particular involving a polarimeter

We have valuable experience from balloon missions, in particular from the recent PoGOLite mission campaigns

We have large experience in balloon launching from ESRANGE, such as planning, design, and logistics