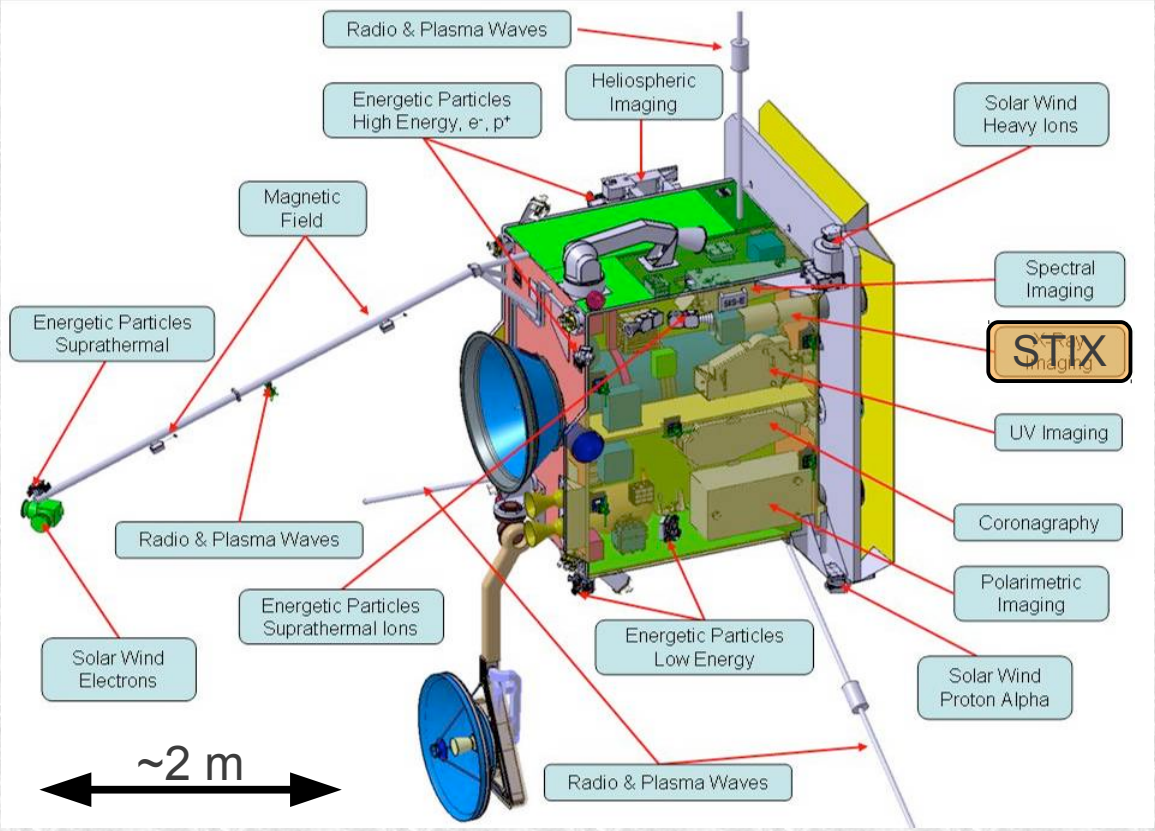
Space Users: Status, Requirements and Open Issues

- Despite asking a number of key people, I only received 1.5 responses of user requirements...
- Are space users too busy or just simply happy? :-)
- I will describe only a few space and balloon experiments and developments
  - STIX (Solar Orbiter)
  - PEBS and PoGOLite (Balloons)
  - JUICE (Jupiter)
  - INTA + G4SUW requirements
  - Reverse MC
- ESA/Space development strategy?

ESA Solar Orbiter

"How does the Sun create and control the heliosphere?"

- Sun-heliosphere interaction
- Energetic solar phenomena
- Solar transients, heliospheric variability
- Solar wind accelerating mechanisms
- Solar wind plasma, coronal magnetic fields
- Solar dynamo working principle



10 instruments
(remote-sensing and in-situ)

Mass **1.8 t** (payload 180 kg)
Power **180 W**
Telemetry **150 kbps** (@ 1 AU)

Launch January **2017**
Mission duration **4+3 years**

Resonance orbit with Venus

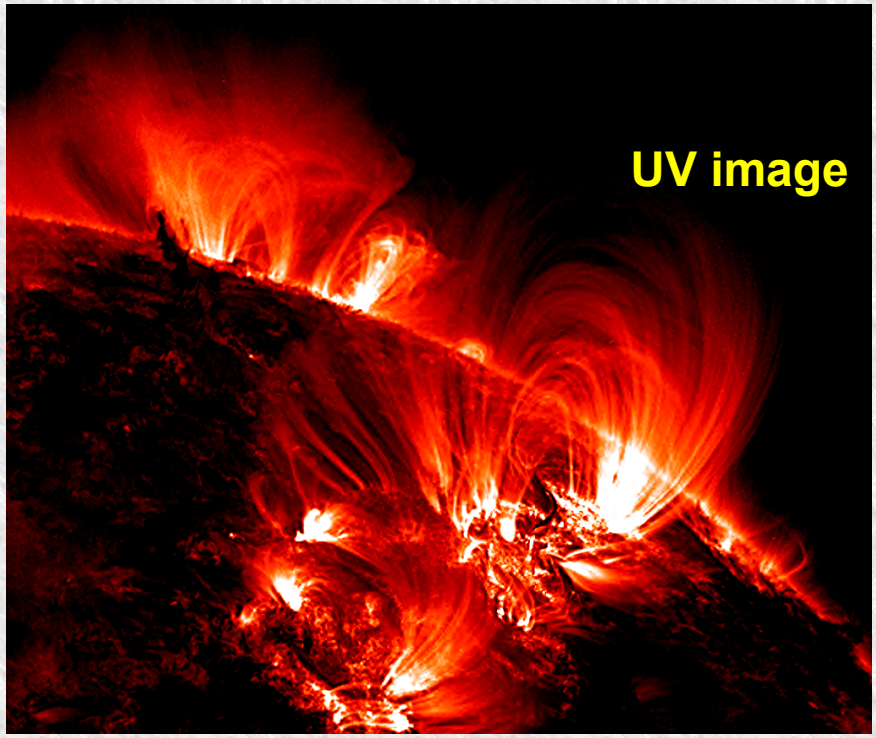
Currently in realization phase C

STIX – Spectrometer Telescope for Imaging X-rays

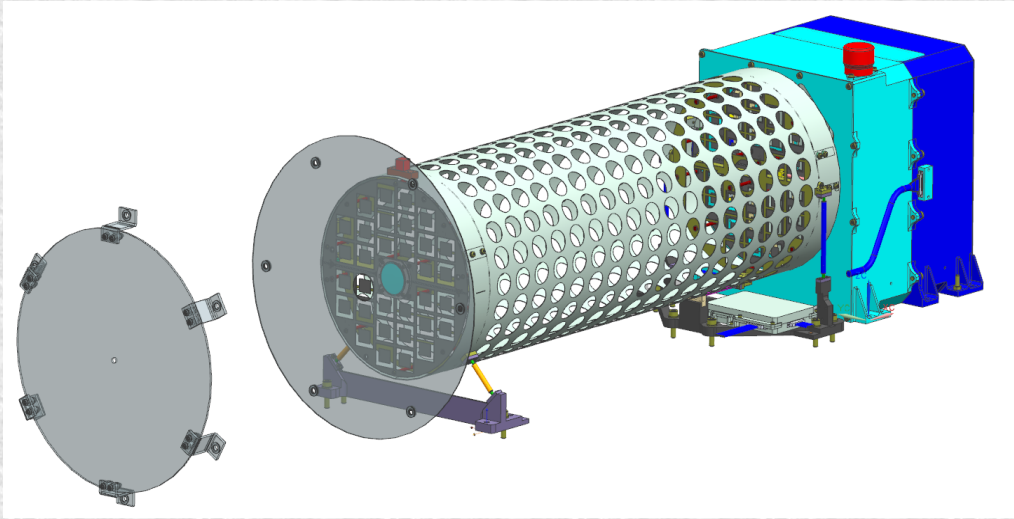
Imaging 4-150 keV x-rays

determines **intensity, spectrum, timing and location** of **accelerated electrons** near the Sun.

Study
- **acceleration mechanism of electrons** at the Sun
- electron transport into interplanetary space



SDO AIA image



CdTe x-ray detector
- Incomplete and transient signal response
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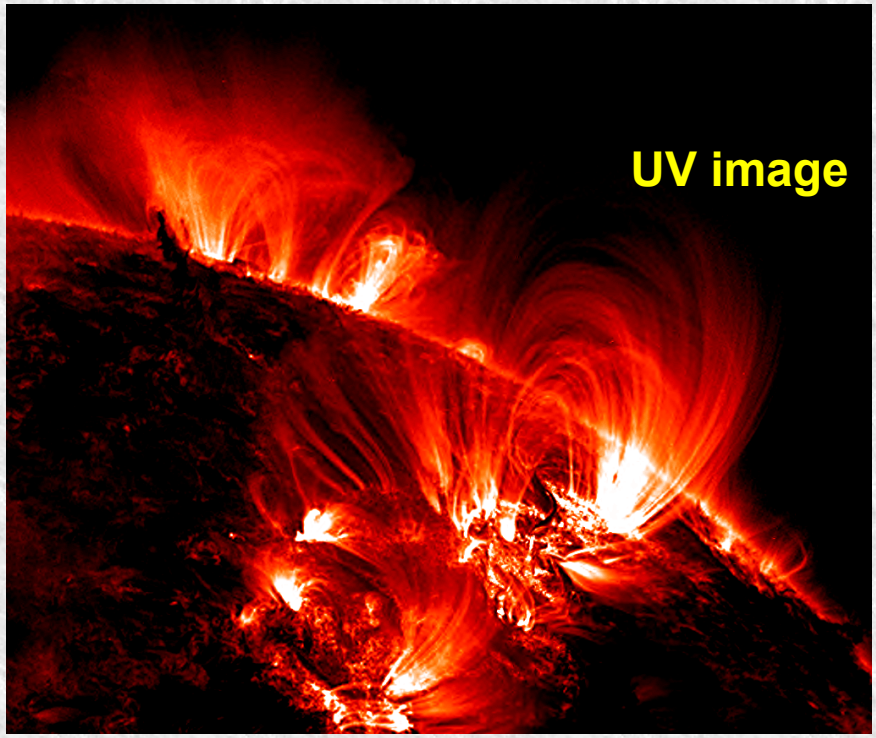

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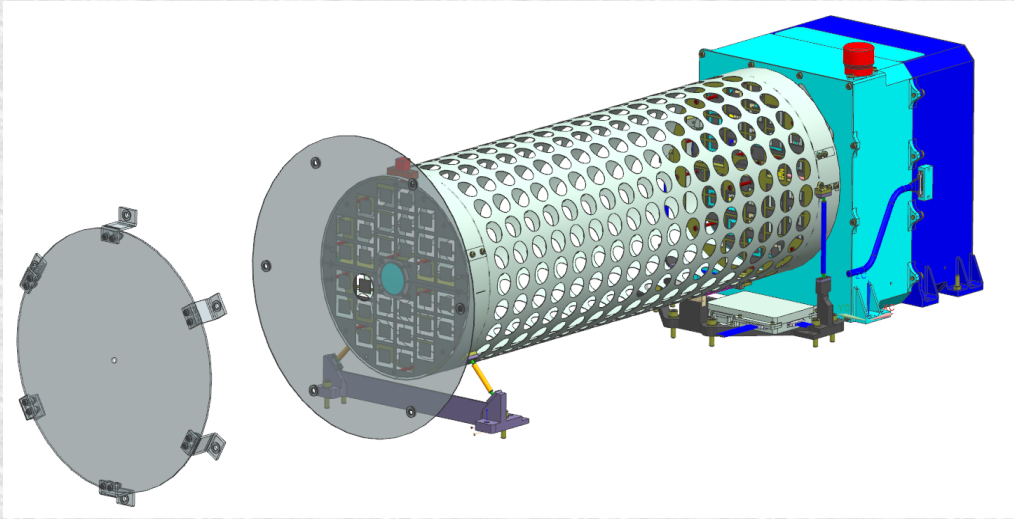

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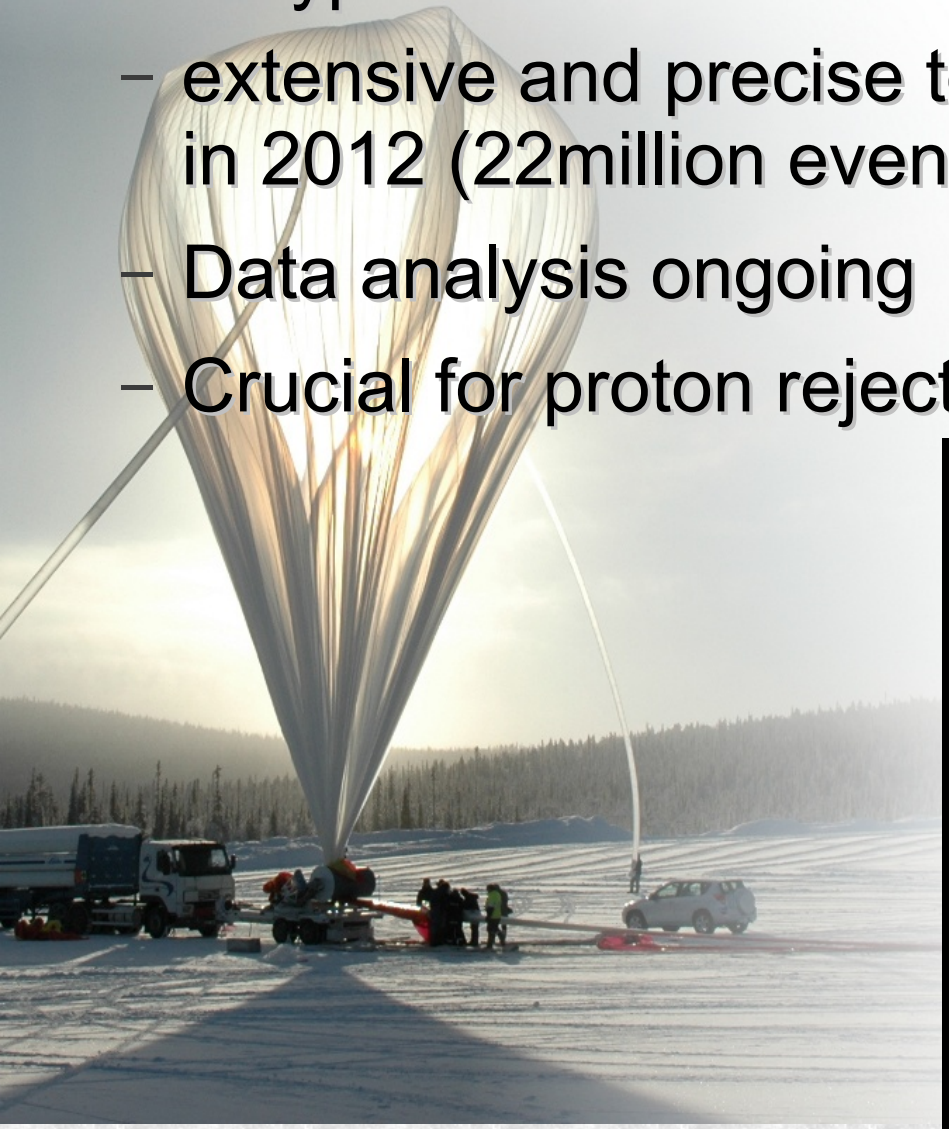
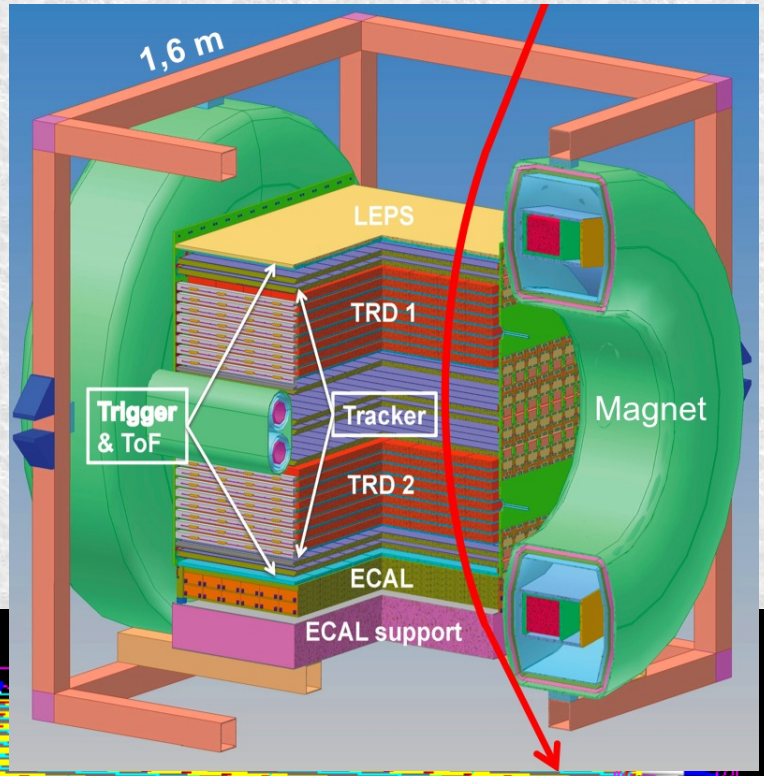
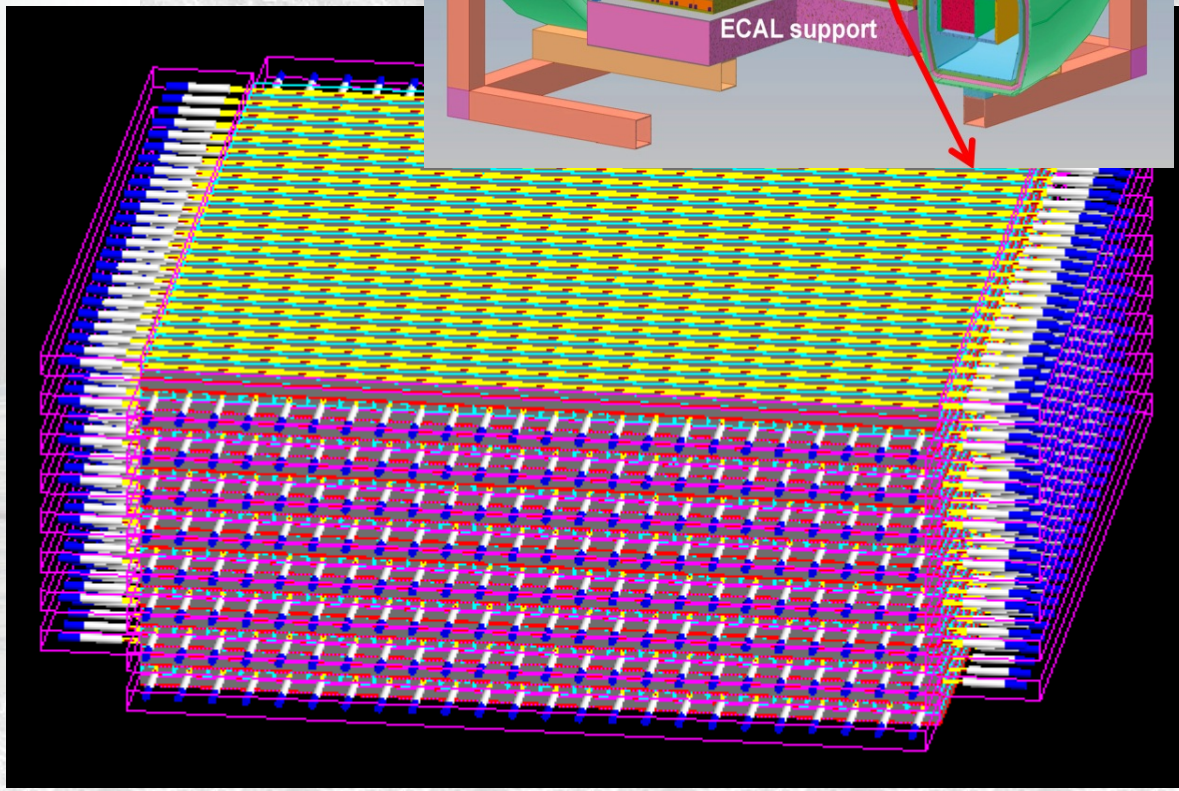
G4 Simulations required to calculate background rates, radiation levels, and ultimately full instrument response

PEBS – Positron Electron Balloon Spectrometer

- Proposed experiment
- Prototype ECAL
  - extensive and precise testbeam in 2012 (22million events)
  - Data analysis ongoing
  - Crucial for proton rejection







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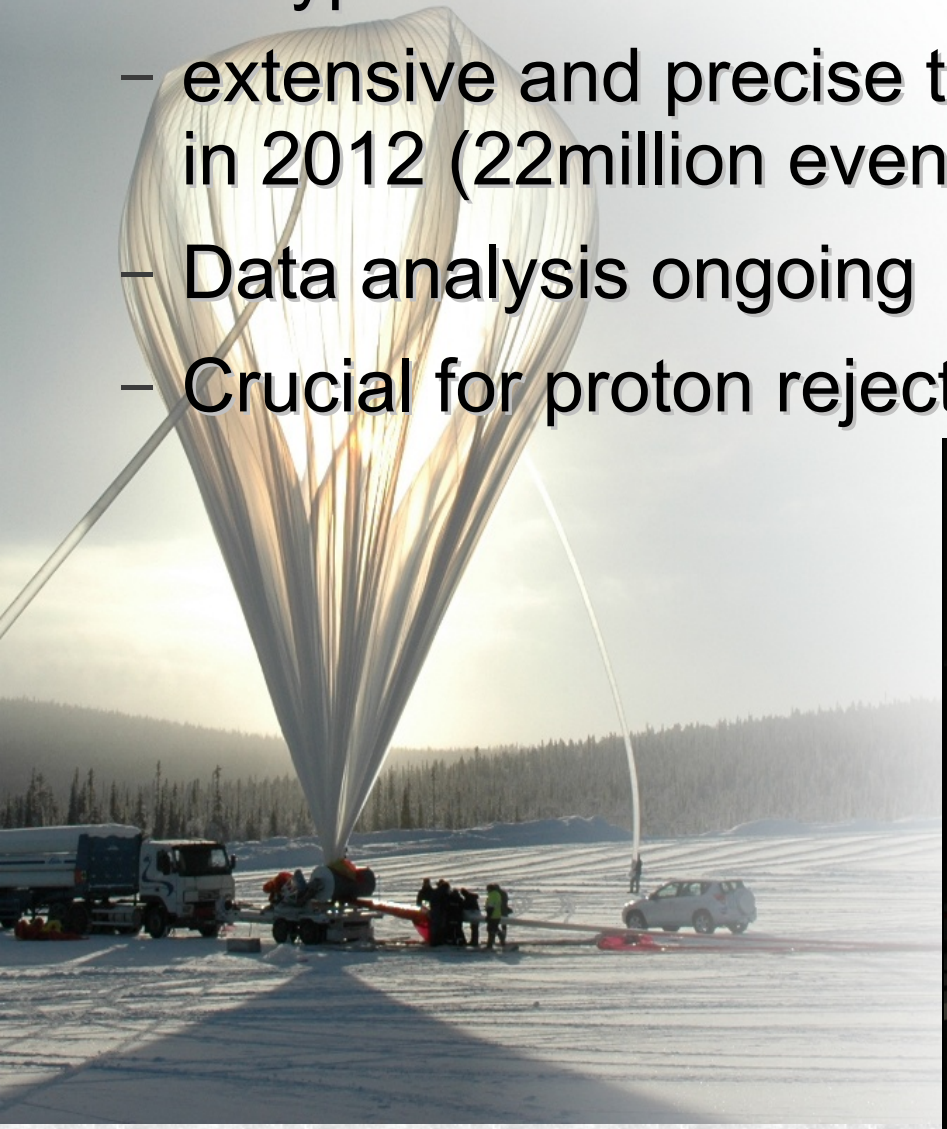
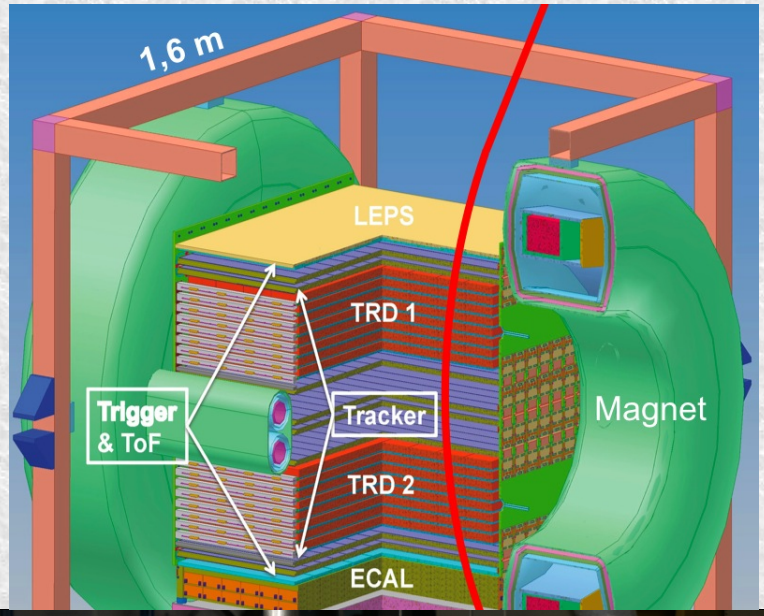
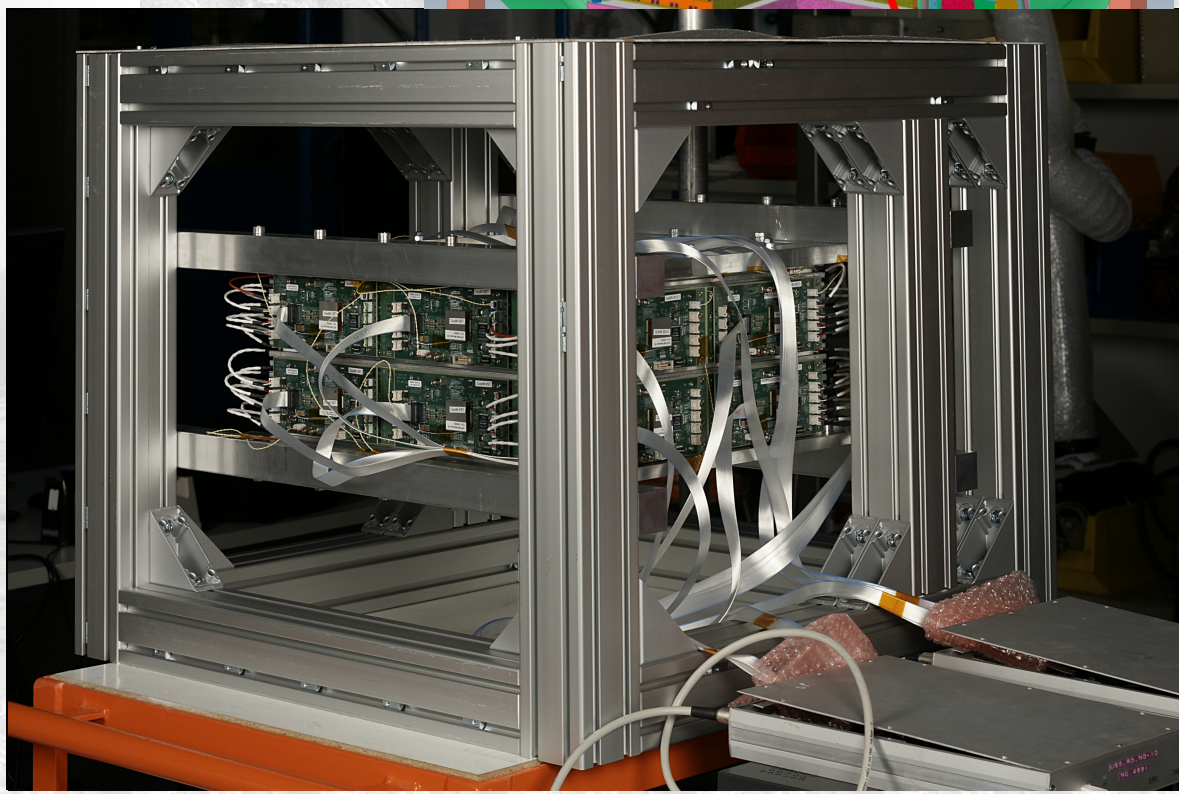
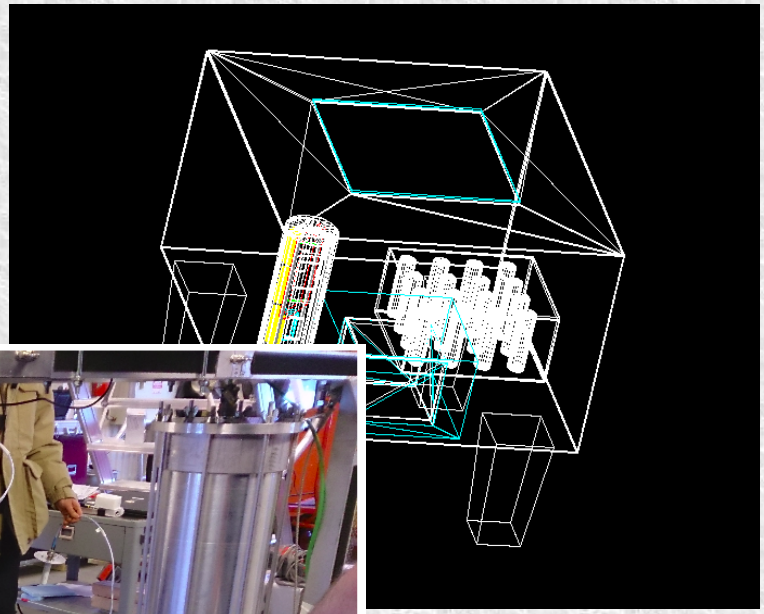


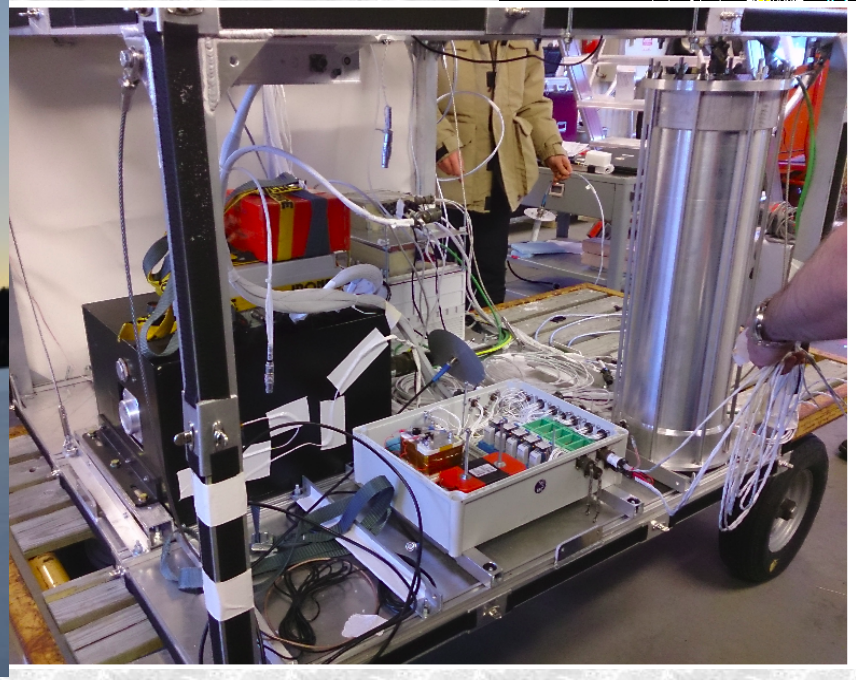




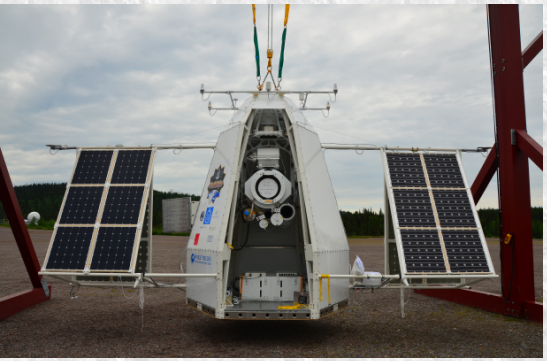
PoGOLino (KTH)

- Neutron Detection rates at high latitudes
- New detector design/material
- Planetocosmics
  - background cosmic spectra at their specific altitude and latitudes





PoGOLite (Balloon User – KTH, Japan, SLAC...)



A polarised x-ray telescope

- Generally happy with Geant4
- Have their own private polarised x-ray compton class – why?
- Testing: Neutrons, EM physics, Planetocosmics
  - background cosmic spectra at their specific altitude and latitudes
- Will publish at 2 - 3 papers quite soon (incl. PoGOLino):
  - First polarised x-ray measurements of Crab Nebula
  - Neutron rates at altitude/latitude
  - Planetocosmics + Geant4 compared to data (2 flights)

User Requirements (INTA) - 1

End User, Space Engineering viewpoint

- Reverse Monte Carlo very important for following the evolution of space craft design
  - Reduces CPU by orders of magnitudes
  - Concentrates on sensitive region of interest
  - Accurate development of shielding
  - Conventional biasing not helpful due to scale of total geometry
- Issues to be solved:
  - the set of reverse processes already implemented is limited, covering only some EM interactions and particle species
  - the stability of the results is still not clear. Latest releases of GRAS/RMC seem to solve stability problems, but it must be validated (against other codes, forward MC, ...)

User Requirements (INTA) - 2

- Parallel Computing
  - Current Multi-Threading solution seems to be an advantage, but not clear how easy it is to implement a MT application.
  - Want to take the advantage of big computation servers, they usually have multiple nodes with sometimes heterogenous processors.
  - MT can only run on a multi-core processor/s in a single machine but not in multiple-nodes, HPC clusters or a PC farm. However, such environments can be easily parallelized with MPI standard.
  - In the past there were a few Geant4 MPI implementation (ParGeant4, G4MPI,...) but none of them seem to have evolved...

Jupiter (JUICE)

- ESA JUICE mission selected
  - Largest ESA mission to date
- Harsh environment (Jovian moons)
- X-rays and electrons up to 1 GeV (high magnetic field)
- Multi-layered Shielding
- Modern electronics now more sensitive to electromagnets and SEU's
- Simulation driving design for shielding, performance, reliability
- Radiation environment not well measured/understood

Open Issues (Vladimir)

- From ELSHIELD the problem left that Geant4 predicts shorter electron length than Penelope
  - from other comparisons - also EGSnrc is longer
- Concerns about Ion fragmentation
  - Raised at last Space User Workshop (Barcelona 2013)
- Requirement to have good results for small steps in silicon devices with low cuts
  - Also from Space User Workshop.

Open Issues with RMC (Laurent)

Multi-threading of reverse MC:

- Migration to MT implies important changes in the Reverse MC
- Forward and backward trackings are now handled in the same event in order to be treated by the same worker
- Status of development:
  - Main code developed
  - ReverseMC compiled in non MT mode is working as before
  - Test of the ReverseMC in MT mode block at some barrier- >still need to figure out why

ESA Developments/Contracts

- ELSHIELD (finished)
- JUICE software – simulation and framework (for 2027)
  - Awarded March 2013
- JUICE – EM charging tool (1-D, S/C design driver)
  - Call for bids end October 2013
- JUICE – Radiation modelling in Jovian atmosphere
  - Instruments and above software projects
- Geant4 DNA
- Radiation Monitors (Earth, Moon, Mars)

Status of Space Developments (my view)

- A number of developments appear to be self-contained and with no clear strategy for integration or commonality
- Independent/dependent engineering tools (coherency?):
  - SPENVIS, GRAS, MULASSIS, Charging tools, CAD
- Somethings remain commercial – e.g. CAD interface
- By using an ESA orientated contract model, older developments have little or no maintenance:
  - e.g. General Particle Source, RDM
  - Documentation can also be updated
    - Complaints
    - Lack of use, despite powerful tools
- Solution?