POLAR: Construction and qualification

Univ. Geneva

PSI Zurich

ISDC Geneva

IHEP Beijing

Switzerland, Poland, China

POLAR construction and qualification

- POLAR is a all plastic Compton polarimeter. It will measure prompt polarization of GRB (several per year with a precision on linear polarization fraction better then 10%)
- We will do the easy stuff (Weisskopf Monday):
  - we expect possible large polarization in GRB.
  - We don't have to do imaging (point source).
  - We don't have to do long exposure...
  - We use very fast coincidence (50 nsec)
- But collect large background from diffuse sky (3 sr)
- POLAR will fly on the Tiangong 2 Chinese space station officially in 2015

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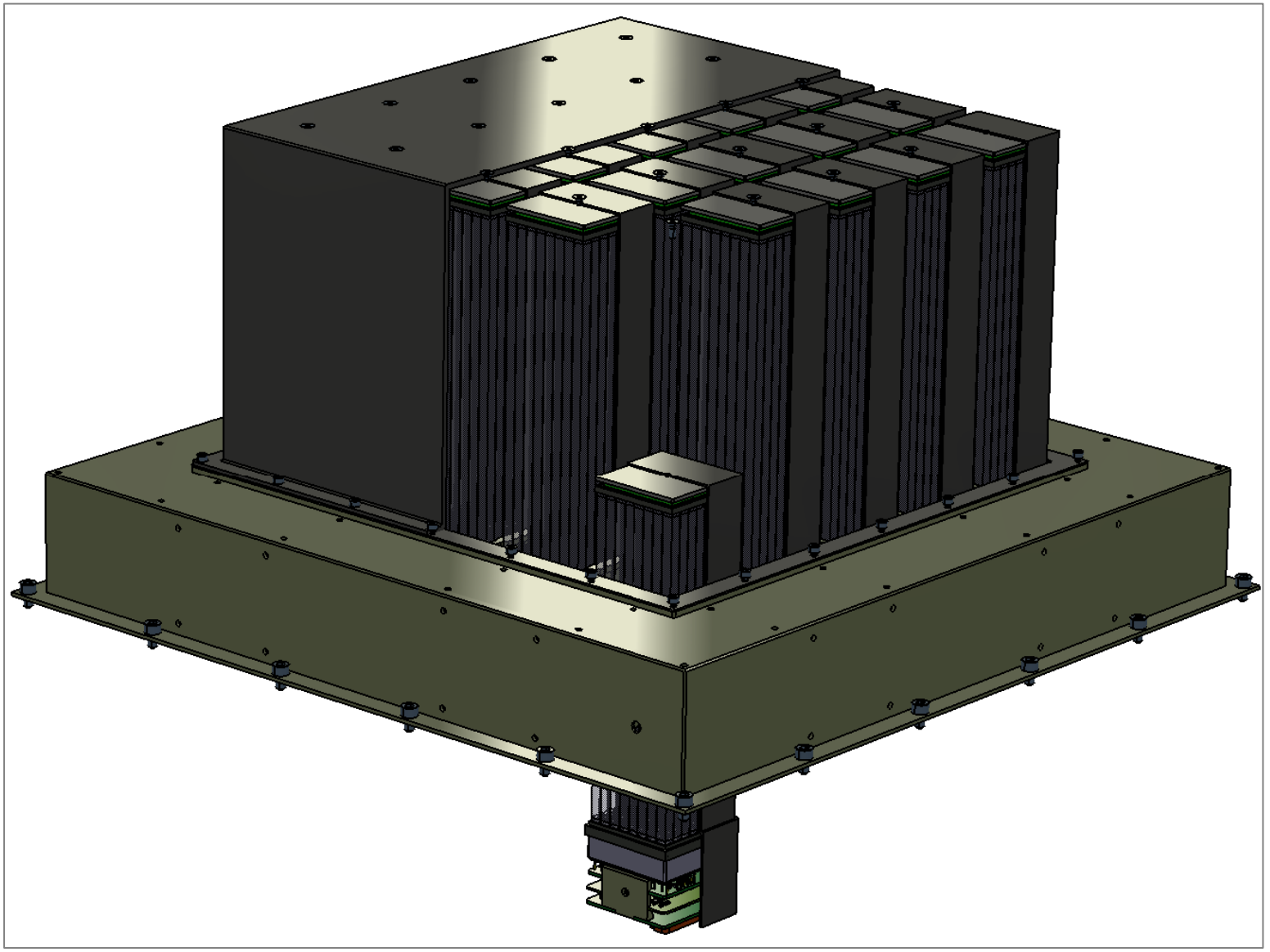
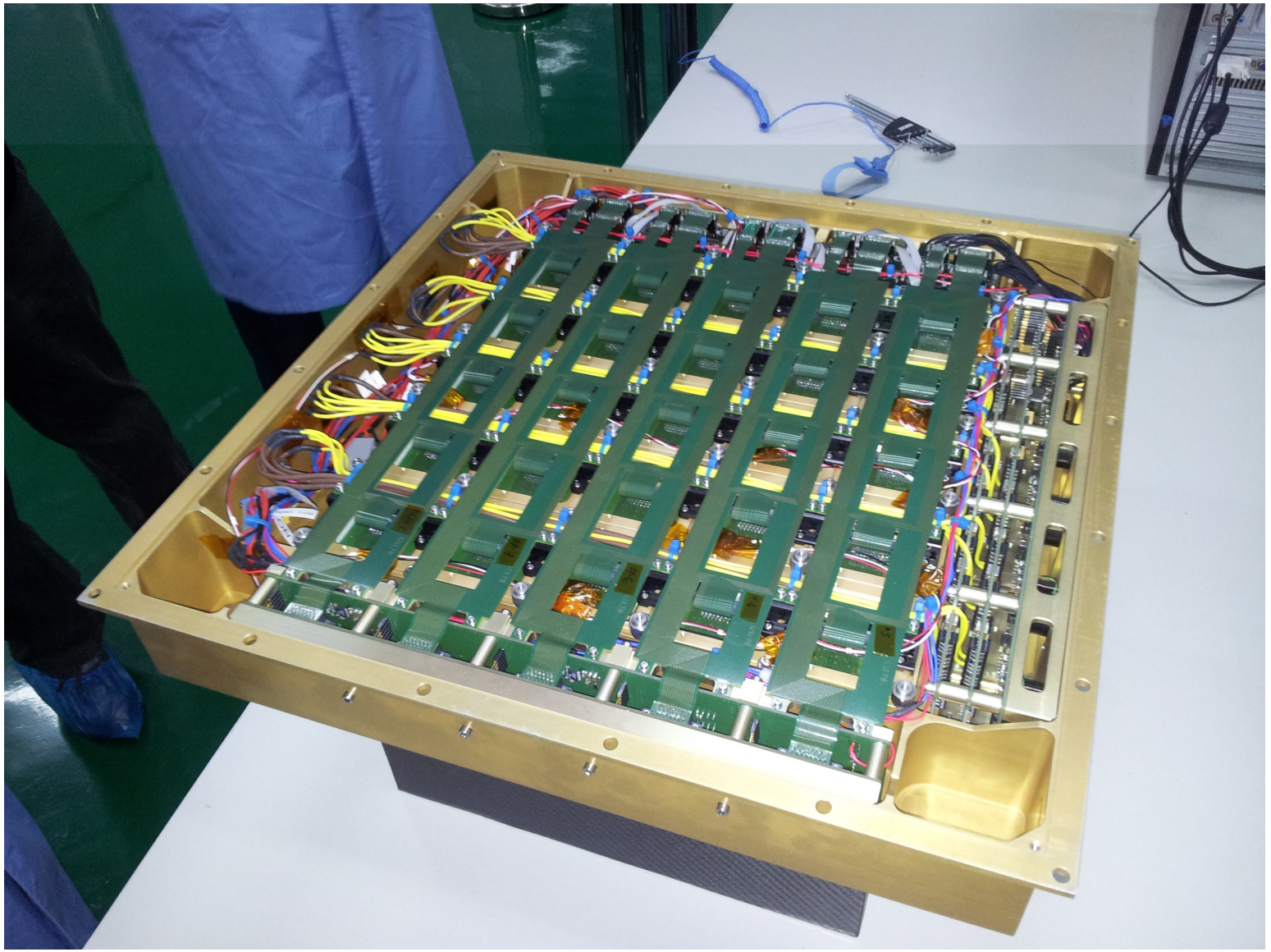
Overall detector





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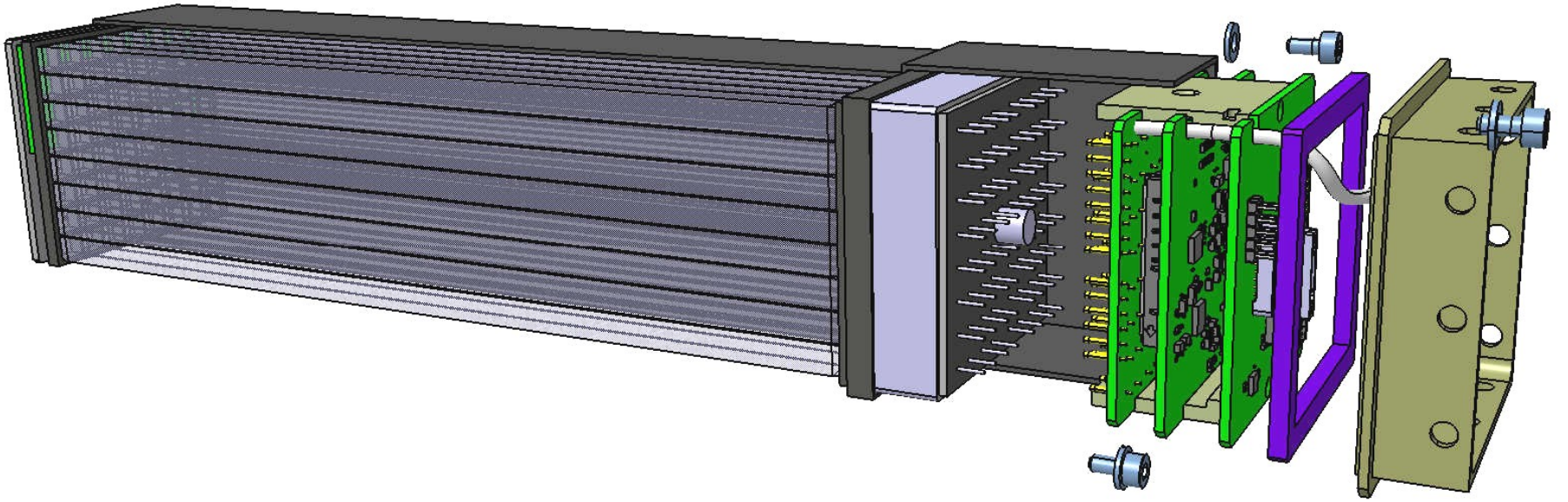
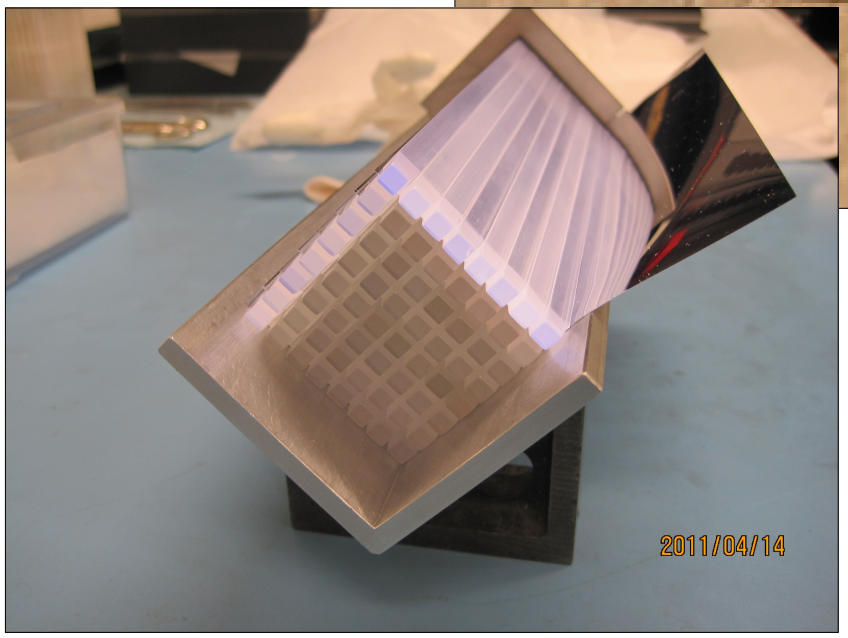
Module



Module



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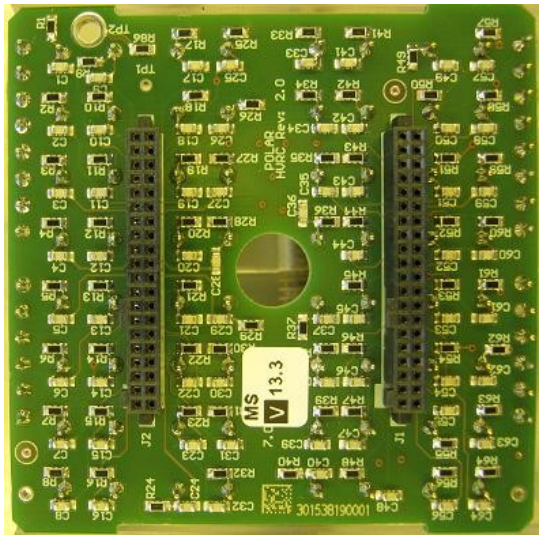
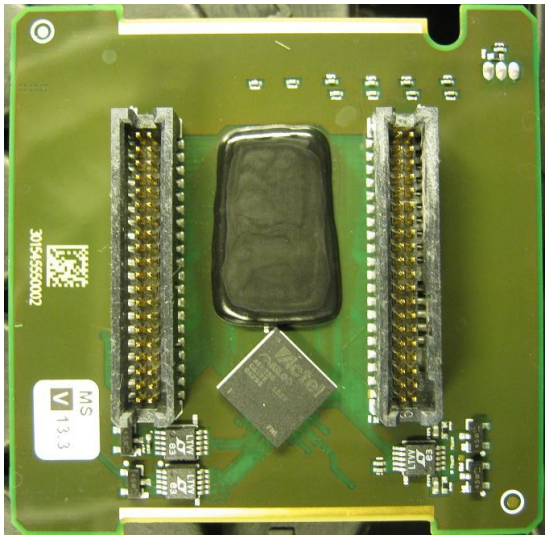
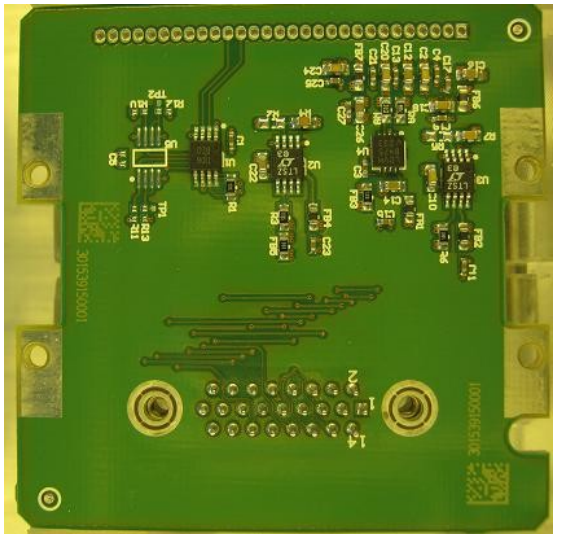
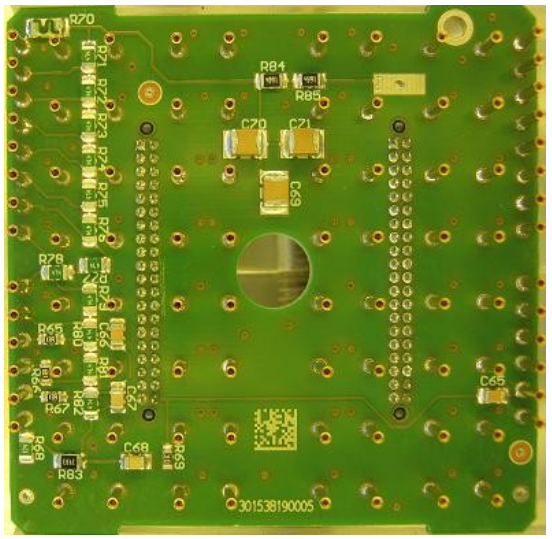
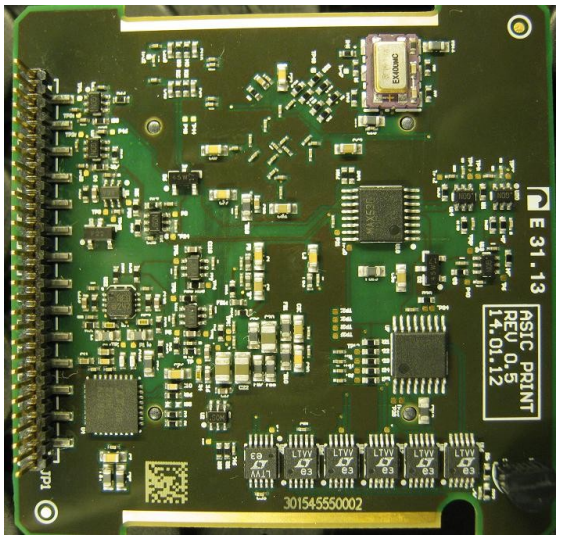
FEE: HV, ASCI and Interface PCBs

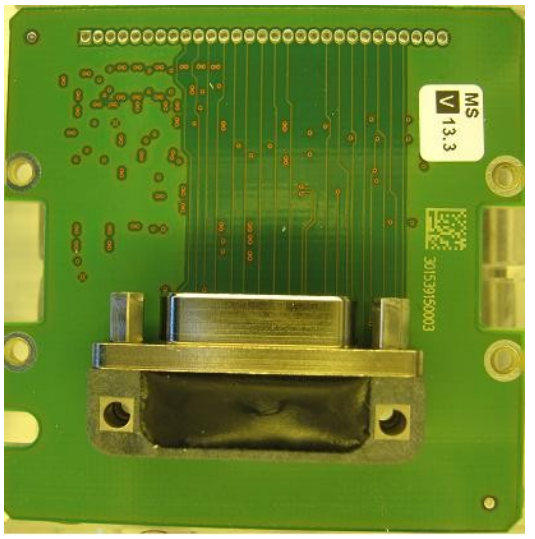












N. Produit August 2014

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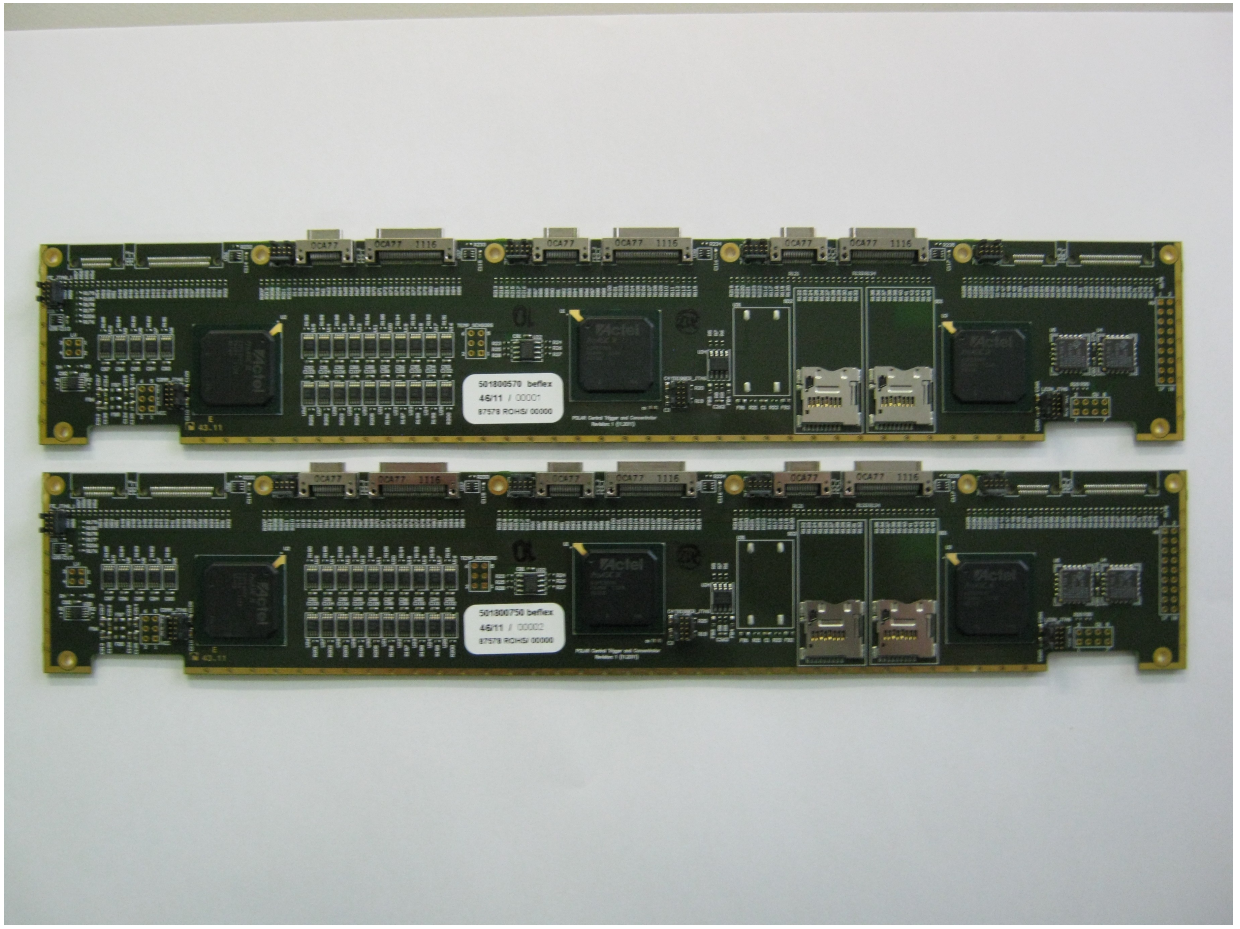
Central computer (cold redundant)



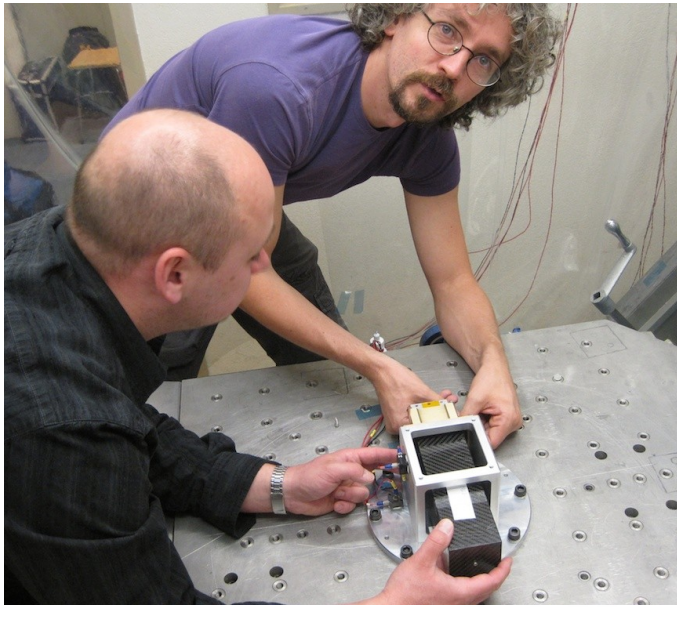
Qualification and acceptance

- China define two criteria for spatialization: qualification level and acceptance level (acceptance level is milder).
- Flight model and flight spare have to pass acceptance level test. One qualification model (identical to FM) has to pass qualification level
- Qualification level requirement and list of tests have been moving targets along the tests.

Qualification

- Vibration of PMT was the most feared test.
- Vibration was tested at component level (PMT, module) very early. No problems found.
- Specific thermal test and radiation test of front end electronic was performed.
- Then test where done at level

  of whole assembly

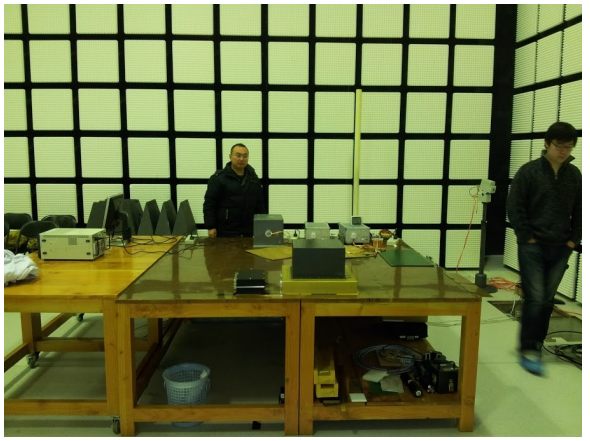


QM1

- QM1 was meant to be the qualification model
- We started qualification with it but had problem during vibration (on coil of HVPS detached)
- QM1 was repaired
- Then a model was needed in China for integration and EMC tests so QM1 was sent to China.

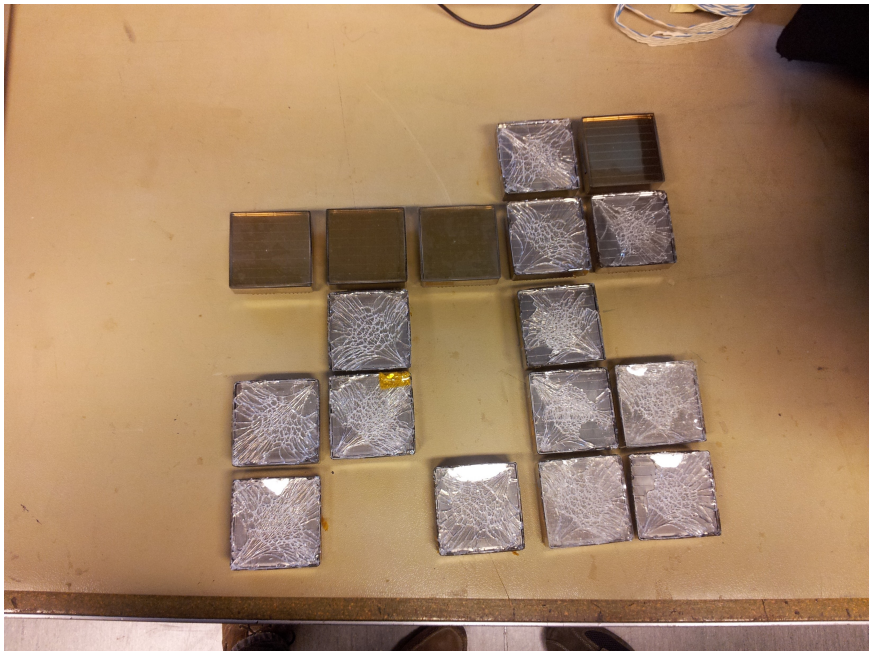
December

2012



QM2

- We constructed QM2 to resume qualification tests.
- All tests passed (acceleration, EMC, thermal, thermovacuum, vibration, lateral shocks)
- But QM2 was destroyed during longitudinal shock (900g) (very last test) (summer 2013)



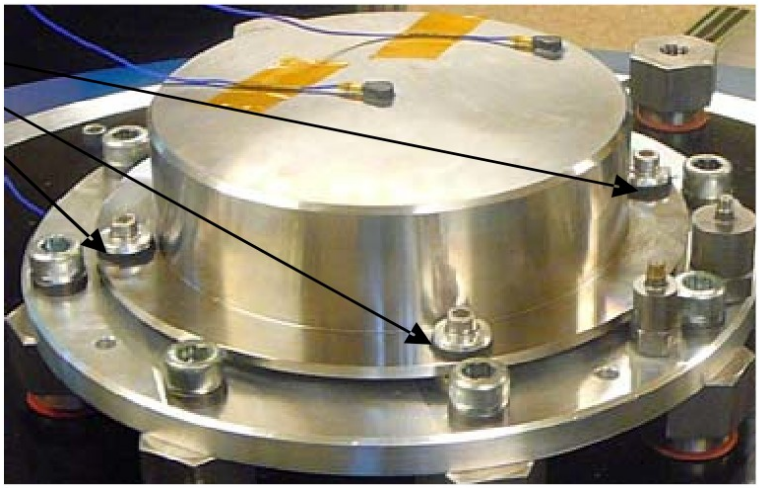
Analysis of problem

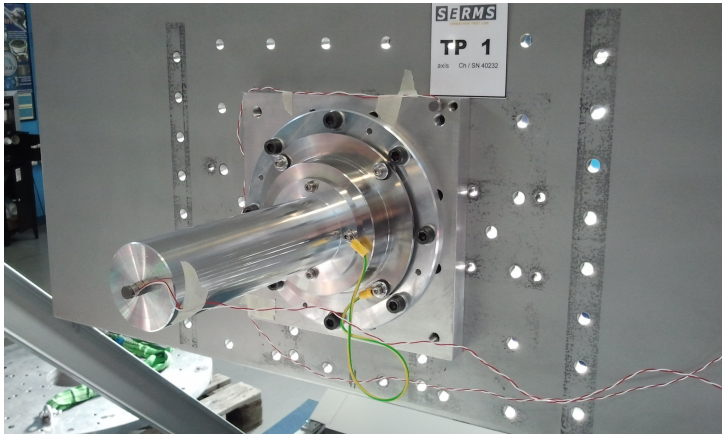
- Target on PMT act has a spring loaded load and come back violently on PMT.
- We had a rubber damper in the module
- Rubber is not compressible! (poisson ratio 0.5) (cannot change volume under pressure just change shape).
- The shape of rubber is more important then material. If it cannot change shaper it is more solid then concrete!

Shock campaign

- We decided to understand and retest shock at all level (PMT, module, assembly)
- Decided to cut shock at entrance: mount everything on springs (but enhance acceleration at resonance around 100 Hz)
- Make a stiffer structure (increase in weight)
- Segment the rubber damper!
- Better material: sorbothane, unfortunately too much outgassing.

Shock re-qualification





Incremental test

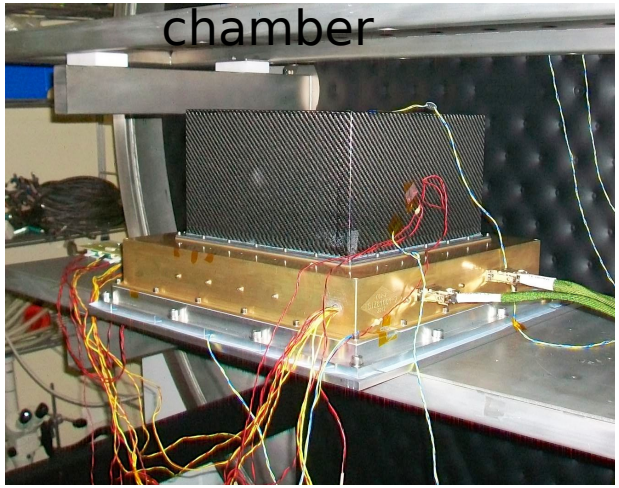
- Have shown that we do understand shock and shock propagation
- Eventually the shock level requested by China where reasonable (less then ESA Ariane)
- We lost one year but we have now a solid and proven solution

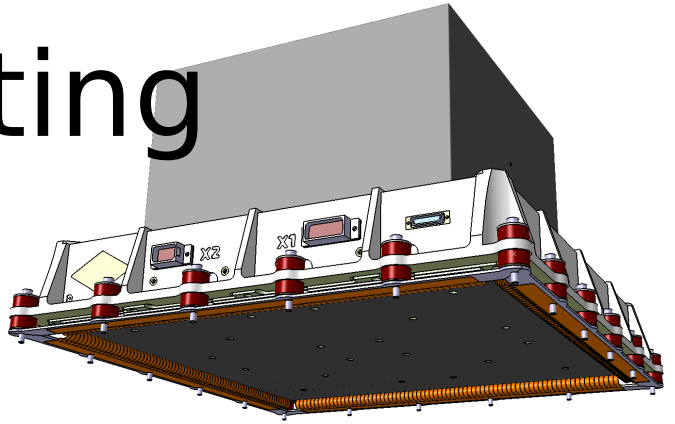
QM3

- Redesigned grid (more stiff)
- Mounted on shock absorbers
- Redesign thermal contact
- Resume all qualification campaign
- Finished successfully (including shocks) in May this year

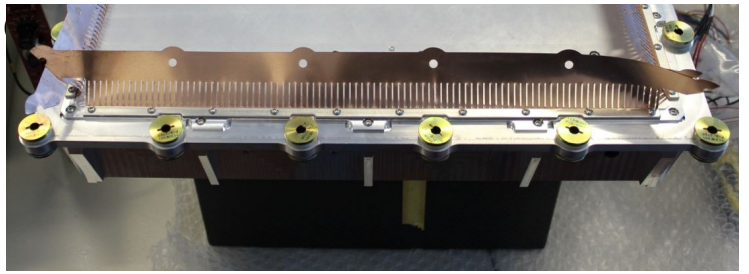
Thermal Testing

POLAR in the thermal vacuum chamber

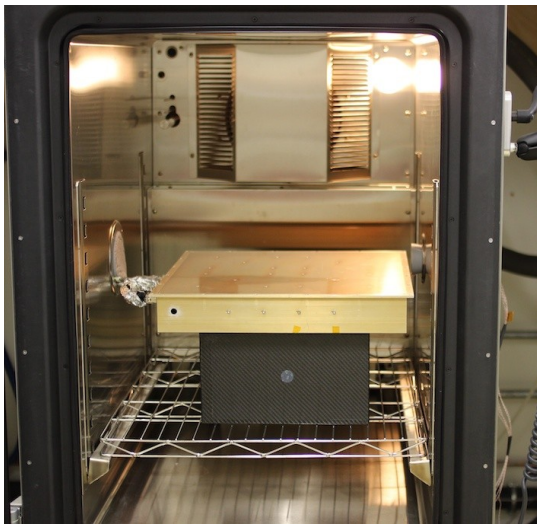




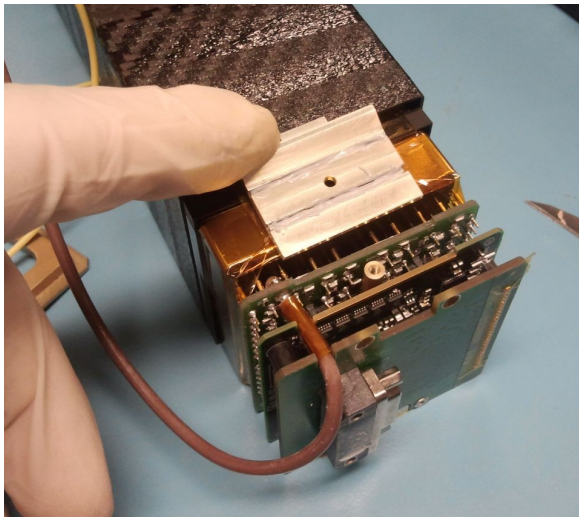
Heat POLAR/spacecraft is transferred through



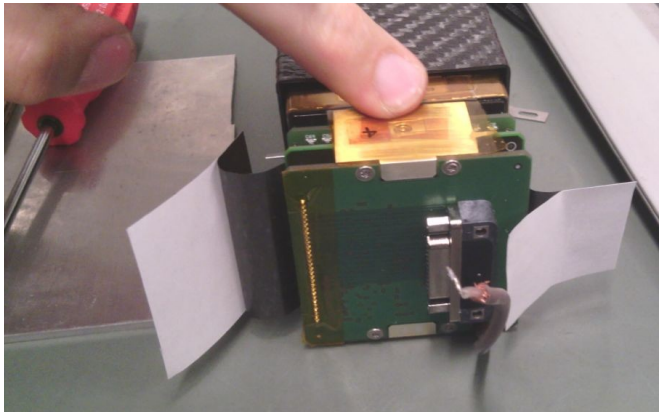
POLAR in climatic chamber: Thermal test



Thermal grease in FEE (detail)



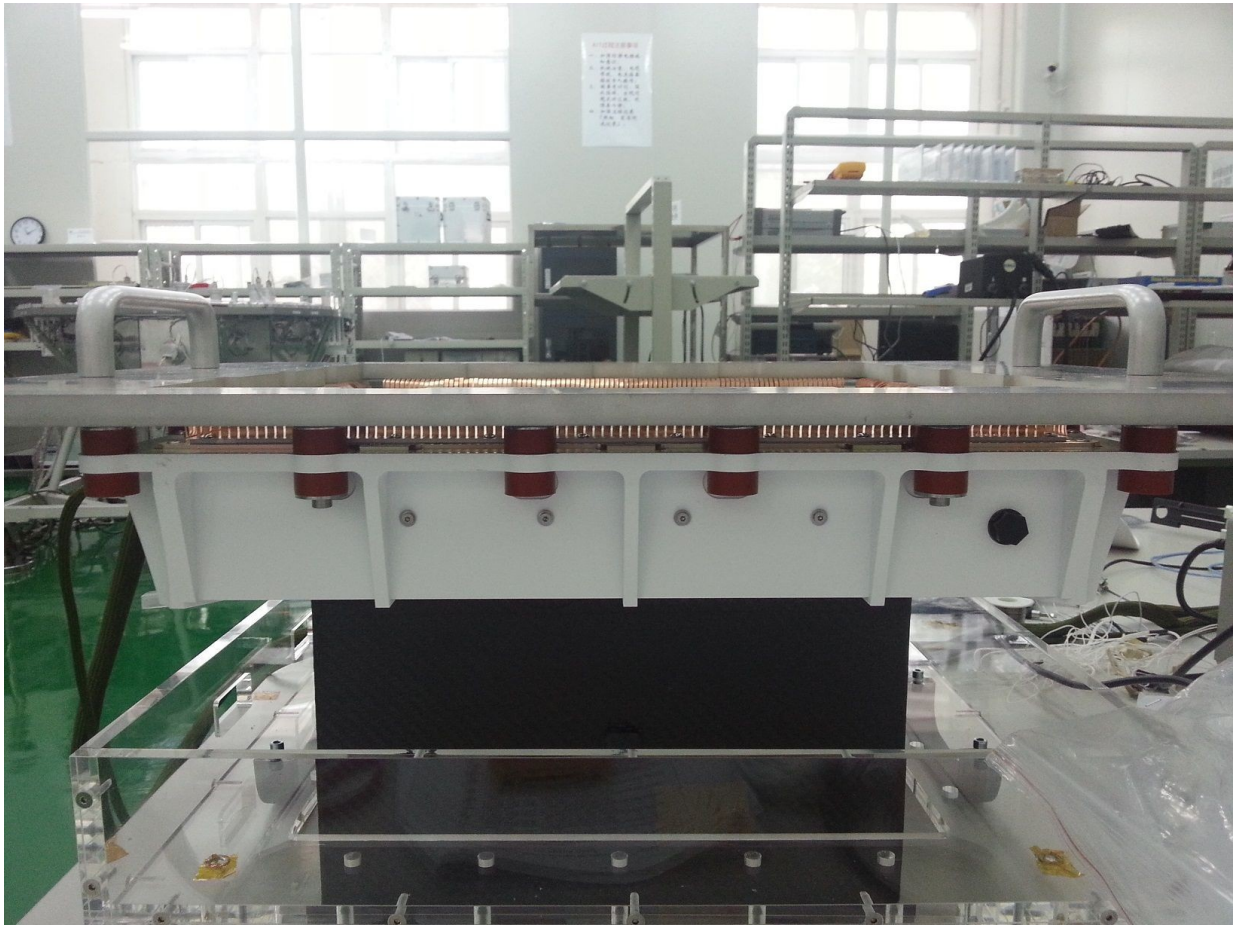
PGS sheets in FEE (pyrolytic graphite sheets)



FMS

- FMS cannot use module that underwent shock test at qualification level
- QM3 was unmounted
- Modules are used now in a lab test bench in PSI
- Final space paint (fragile)
- New flight grade modules installed
- Better cabling
- FMS delivered to China in August 2014
- Acceptance tests will be performed by China

Last week in Beijing



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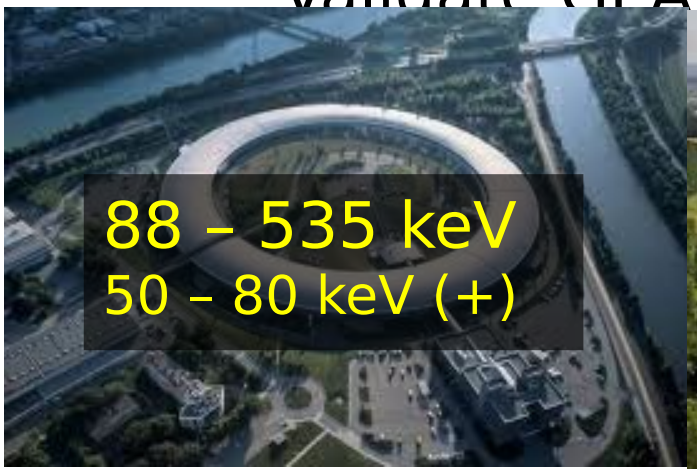
FM

- FM has started to be build in Geneva.
- We will perform acceptance test before end of the year
- We want to do a calibration with synchrotron radiation early 2015
- We need to perform a thermal balance test (with solar simulator)
- Delivery of FM early 2015
- Fly in 2015

Performance Tests

- Experiments with 100% pol. synchrotron radiation
- Objectives:
  - Assess the polarimetric capabilities of POLAR
  - Validate GEANT4 Monte Carlo simulations



ESRF, France
(2009, 2011, 2012, 2014)

Range: 30 – 700 keV

(+): presence of harmonics

SLS / PSI, Switzerland
(twice in 2011)

E range: 5 – 22.5 keV

(*): 3rd harmonics

SSRF, China
(2012, 2014)

E range: 8 – 72.5 keV

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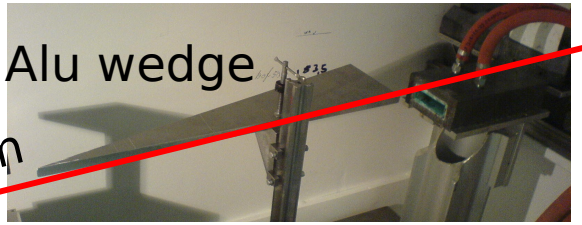
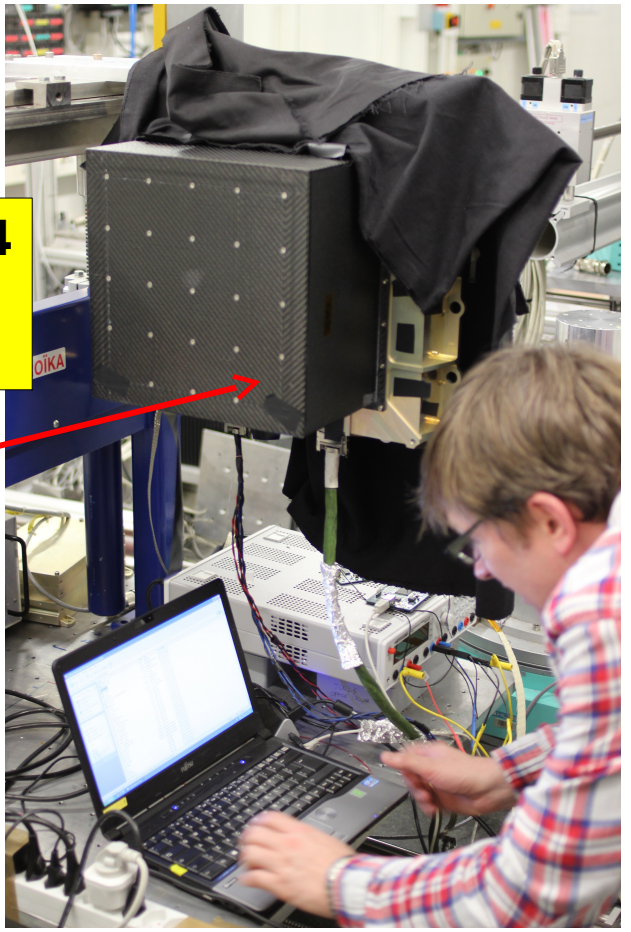
Experimental setup

- 100% polarized beams
- Uniform illumination of POLAR
- Beam at the zenith and off-axis
- Beam size: 0.1x0.1 – 0.5x0.5 mm^2 (ESRF)
  45 x 5 mm2 (SSRF)
- H/V polarization

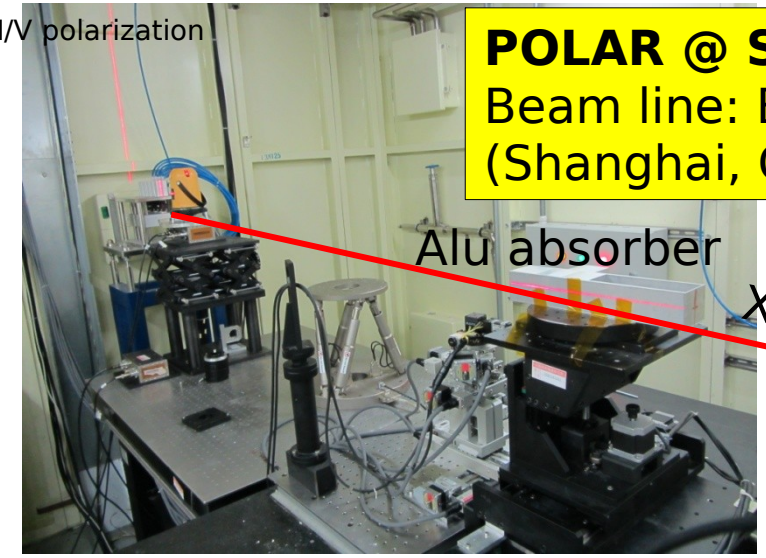
POLAR @ ESRF 2014
Beam line ID15A
(Grenoble, France)



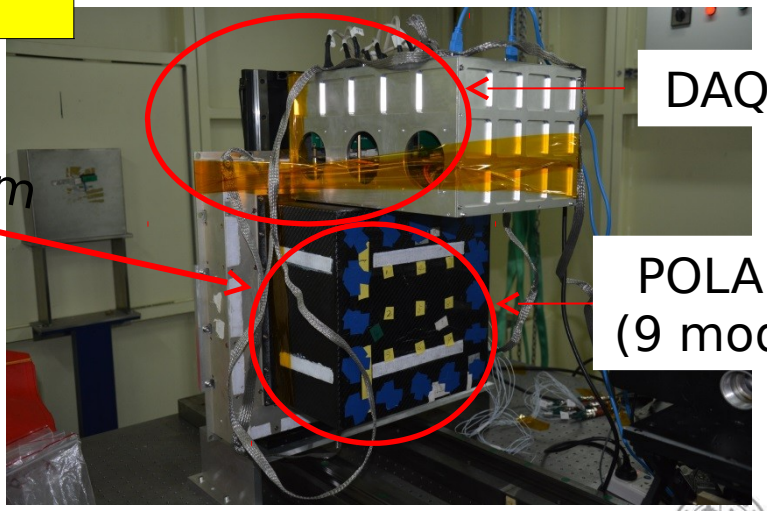
X-ray beam



POLAR @ SSRF 2014
Beam line: BL13W1
(Shanghai, China)



X-ray beam



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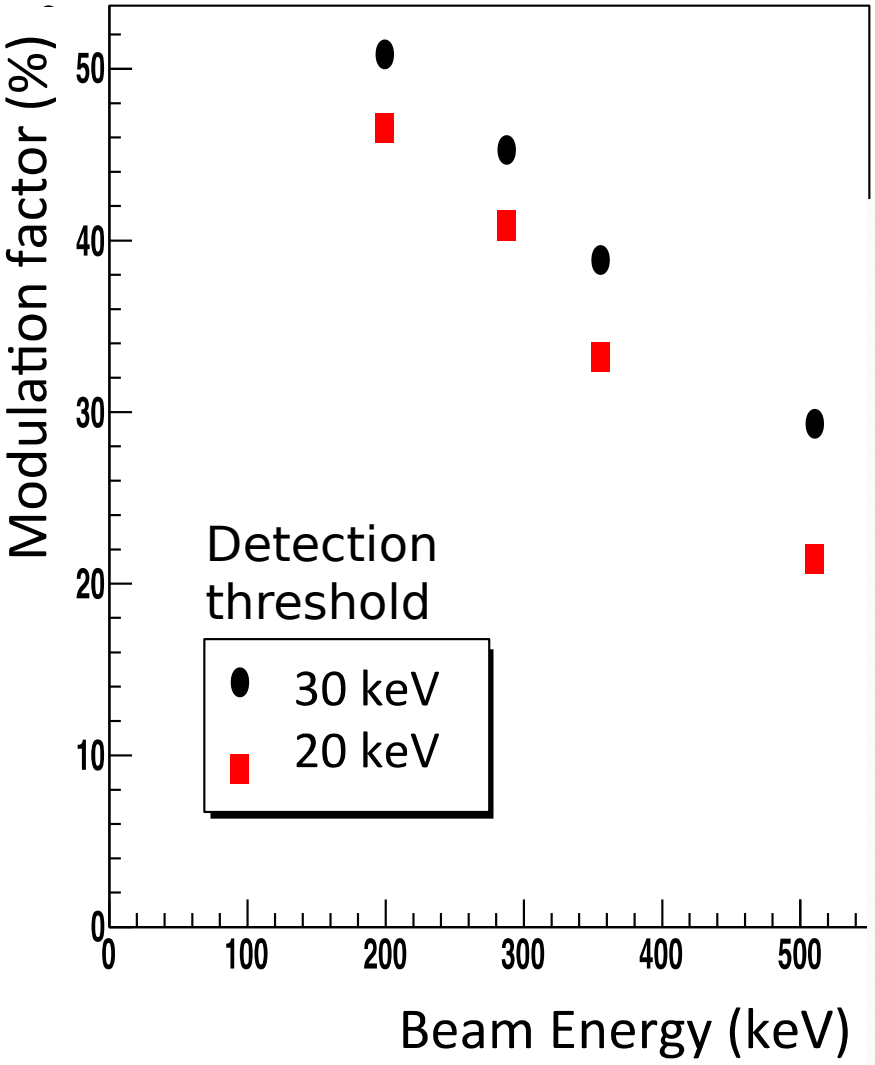
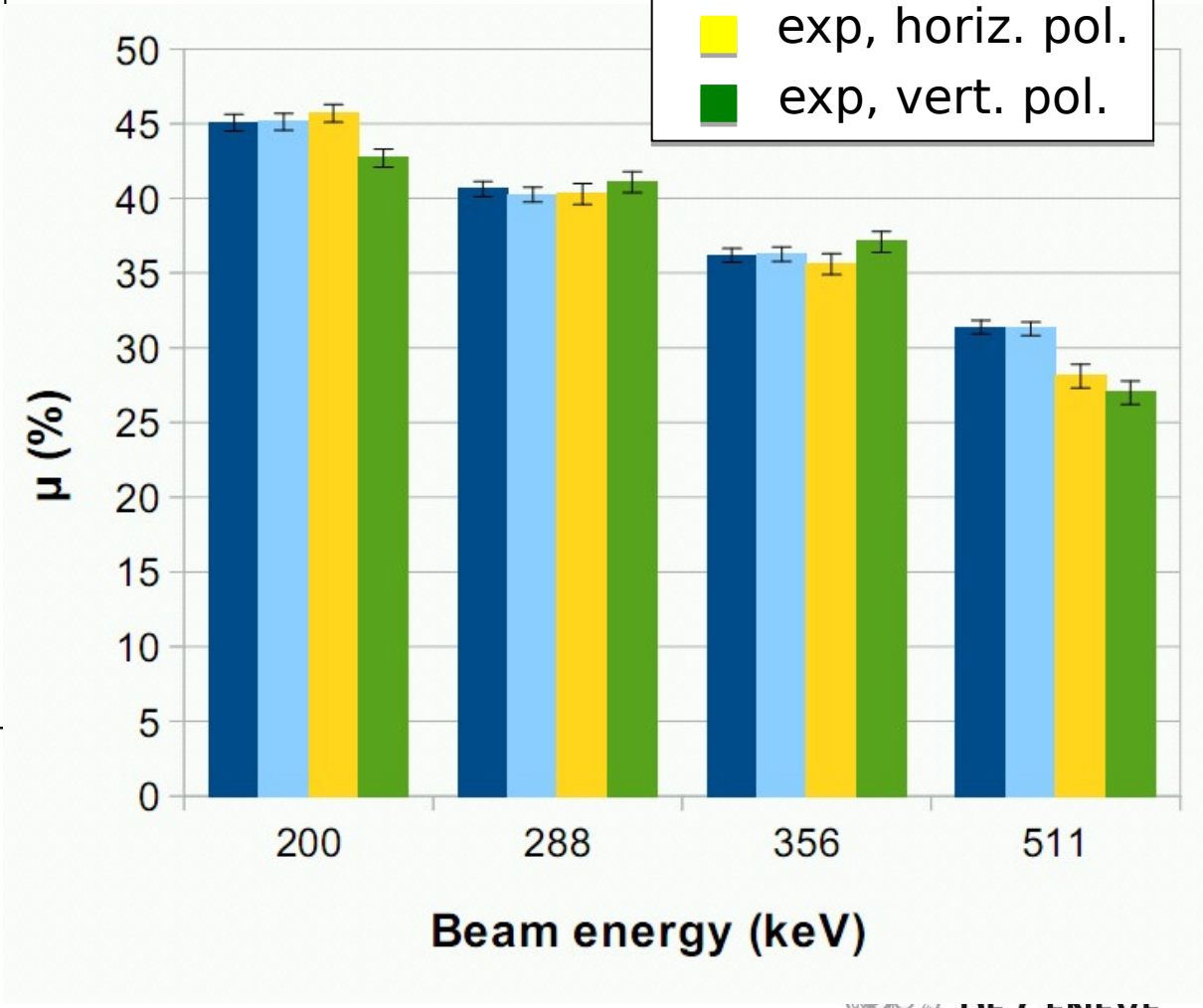
Modulation factors (high E)



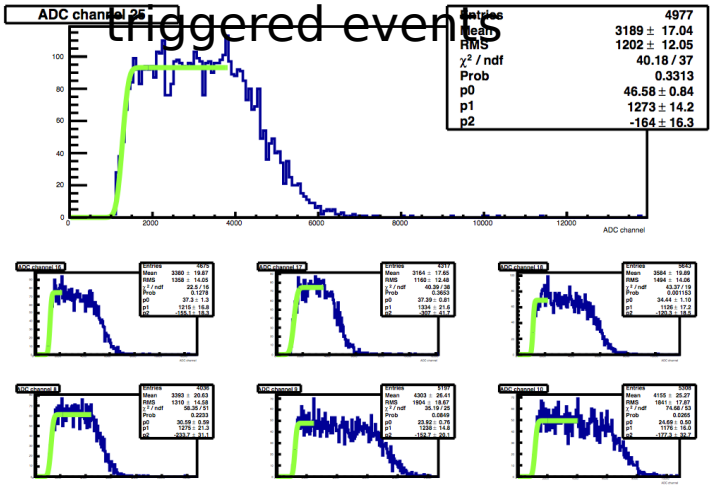


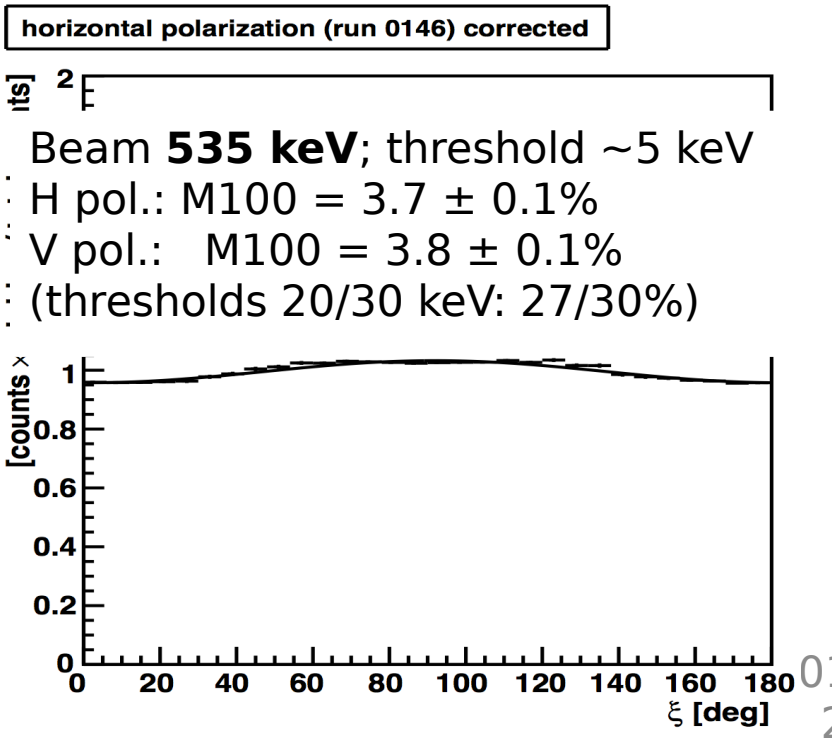
S.Orsi et al., NIM A 648 (2011) 139-154

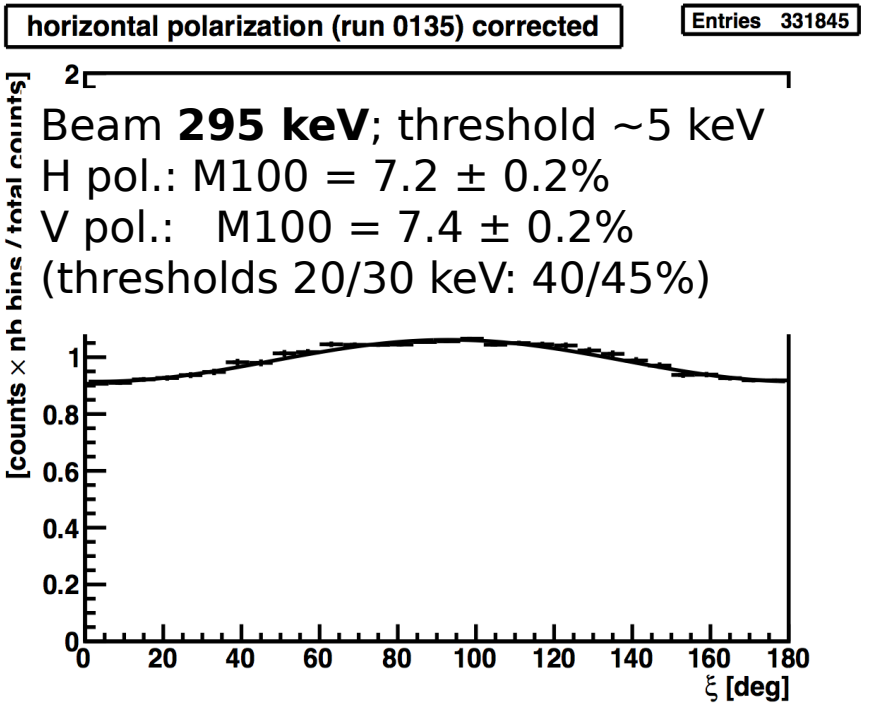
Detection threshold

- Thresholds optimized for 2 modules for beam test ESRF2014
- Thresholds: 4.6 ± 3.0 keV
- Data analysis ongoing
- Mod. factor depends on threshold

Fit of detection thresholds with triggered events







Conclusion

- Constructing a polarimeter is difficult
- It seems that we will be able to reach performance as described in our Monte Carlo papers.
- Qualification was a painful process (require long time, big human and financial resources)
- Even if your instrument is fully understood in lab there are a lot of small detail that require attention during qualification (cabling, paint, screws...)
- We look forward to a launch in 2015
- POLAR opened several collaboration opportunities with China (DAMPE, HERD, PANGU …)
- Future is in China or with commercial launcher