



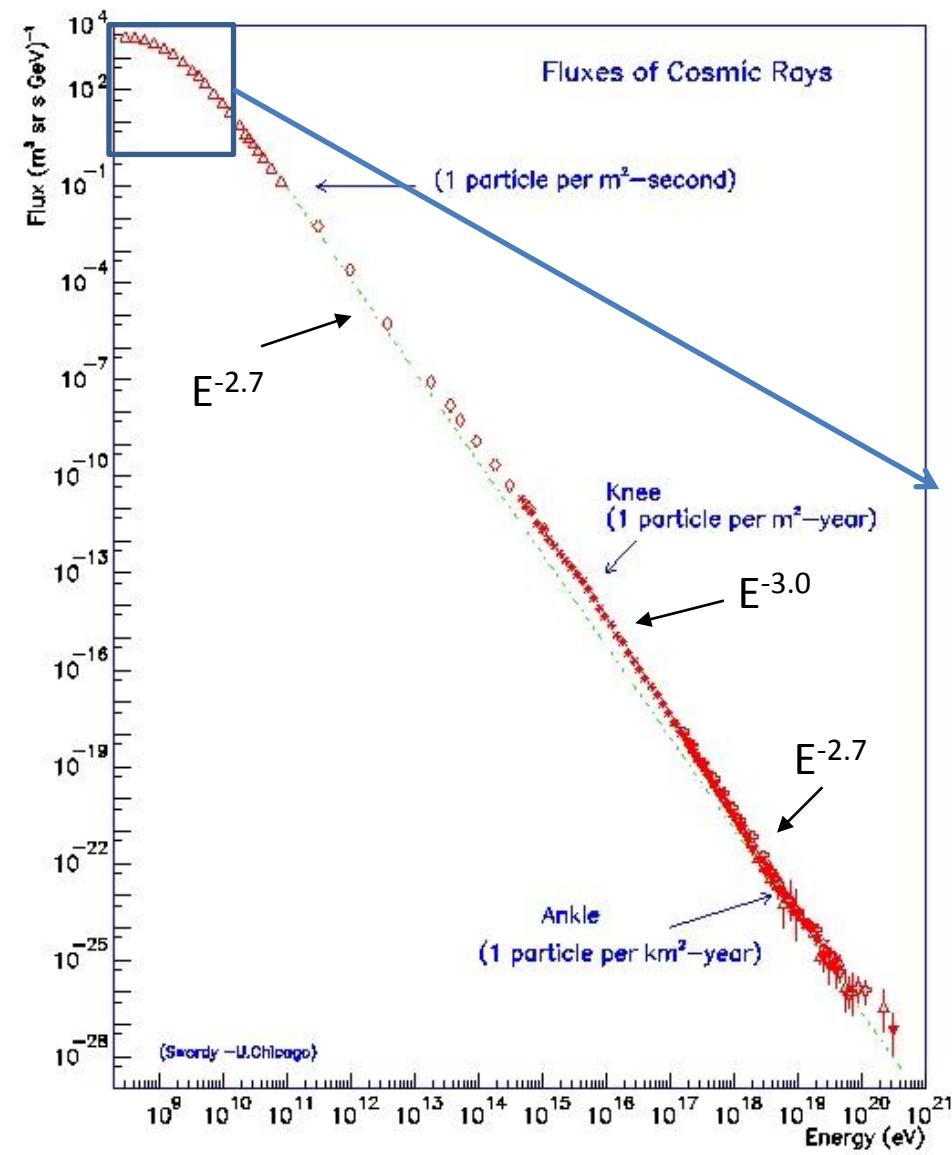
The PERDaix Detector

Thomas Kirn
I. Physikalisches Institut B

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UNIVERSITY**

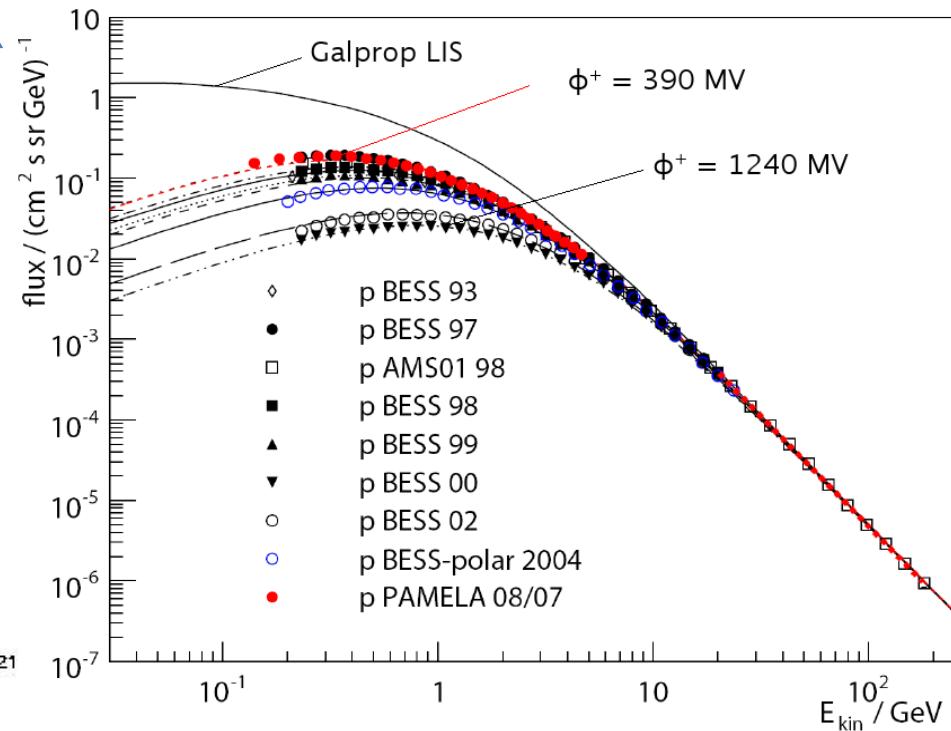


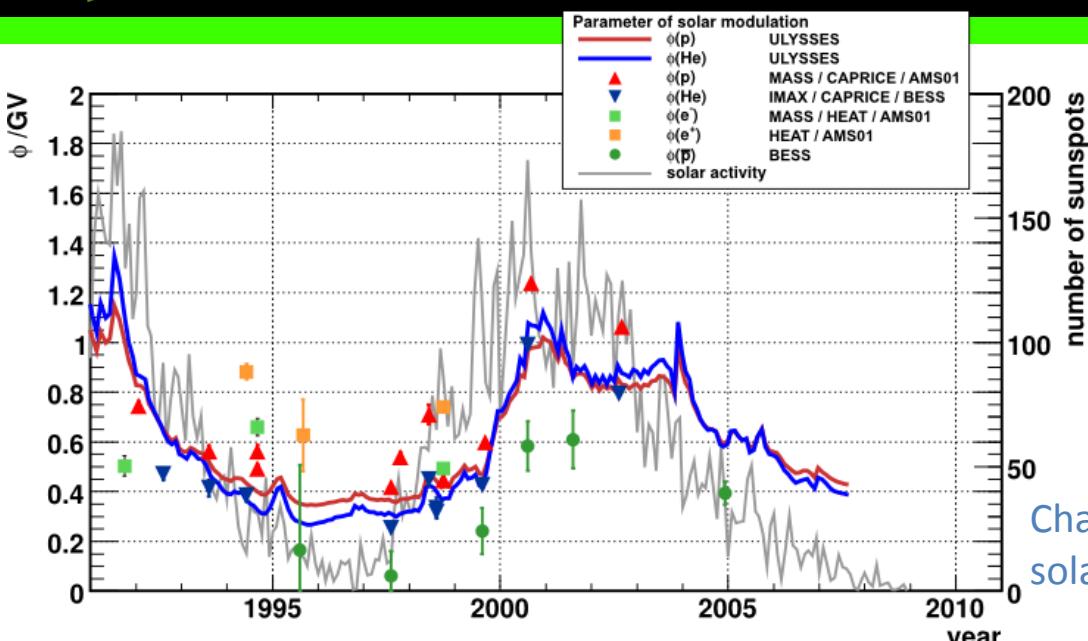
July 5th 2011, 6th International Conference on
New Developments In Photodetection



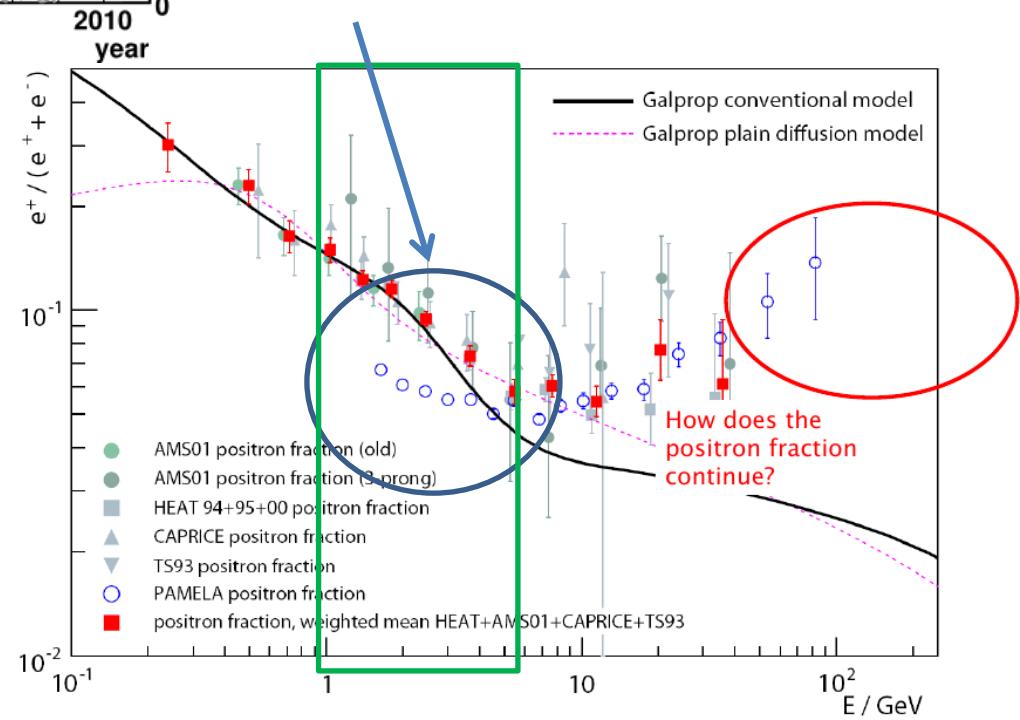
Cosmic Ray Composition:

Protons	88 %
Helium	10 %
e^-	1 %
e^+	0.1 %
Antiprotons	0.01 %





Charge sign dependent
solar modulation?





- Rocket and Balloon Experiments

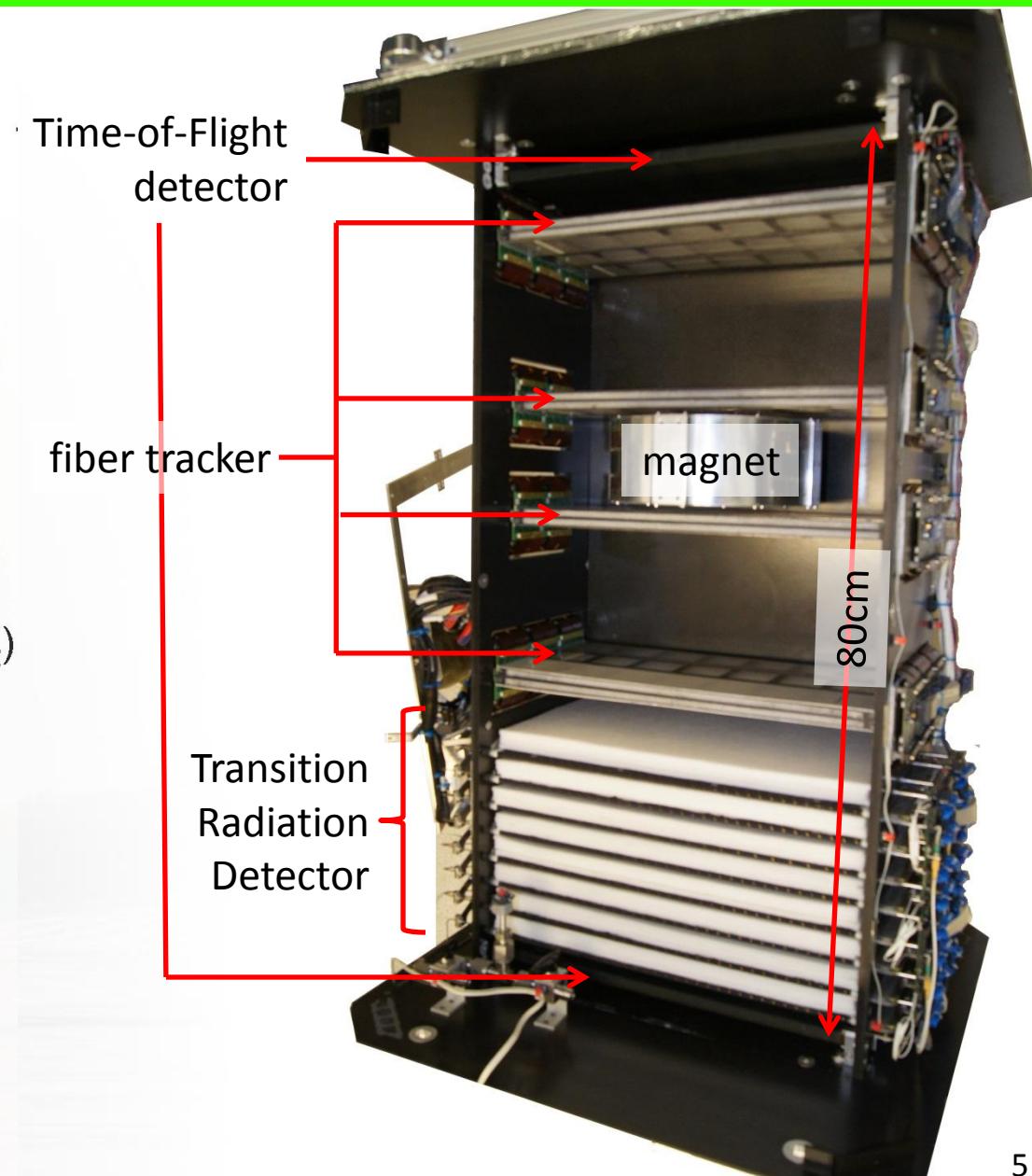


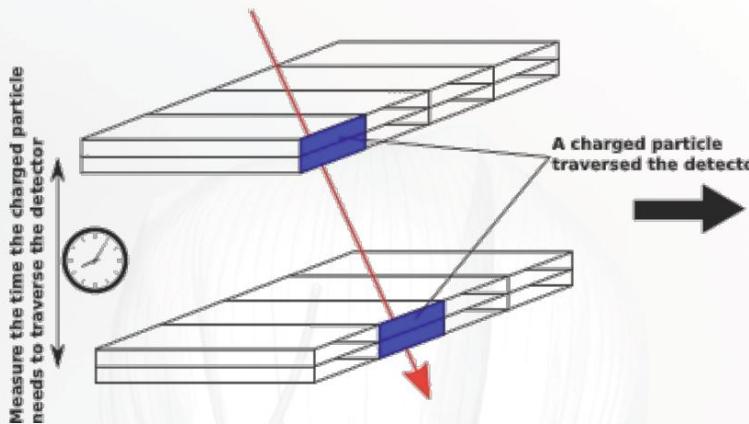
in
cies



- Temperature -50°C
- Low pressure ≈1mbar

- Spectrometer (Tracker)
 - Permanent magnet 0.2 T in Halbacharrangement
 - Scintillating fiber tracker
 - $\frac{\sigma_p}{p} = 0.08 \cdot \frac{p}{GeV} \oplus 0.25 \cdot \frac{1}{\beta}$
 - Charge-sign separation up to a rigidity of 5 GV
- Transition radiation detector (TRD)
 - Fleece radiator
 - Proportional counter tubes ($XeCo_2$)
- Time-of-Flight (TOF) detector
- Acceptance $32 \text{ cm}^2 \text{ sr}$
- Total weight 40 kg
- Total power consumption 60 W
- Flight in November 2010
northern Sweden (Kiruna)
- 2 h float at 33 km
- 177.000 trigger events





Time-of-Flight
detector

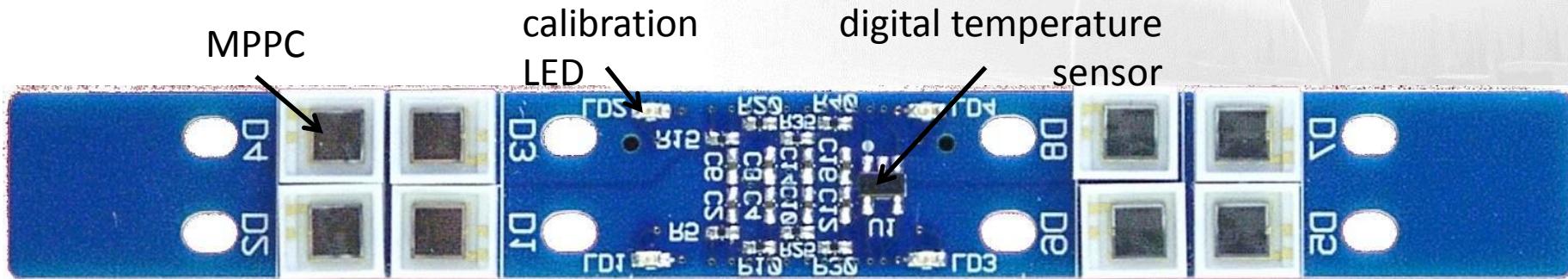
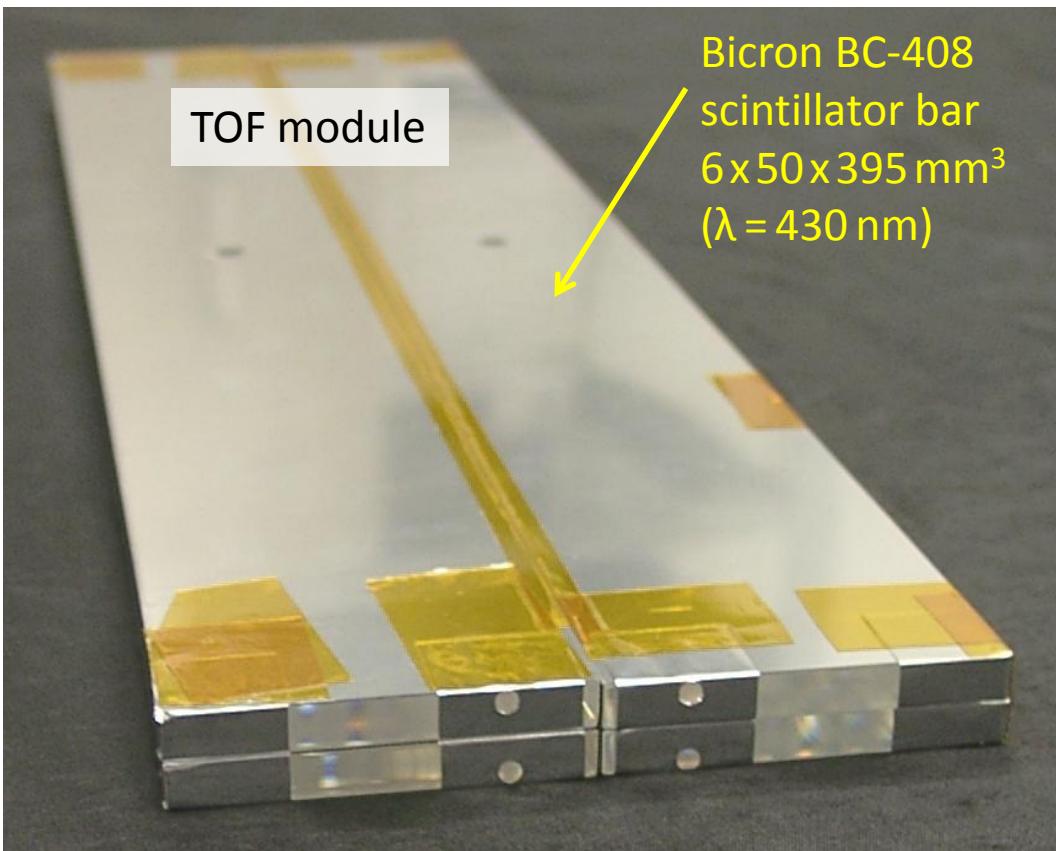
Trigger



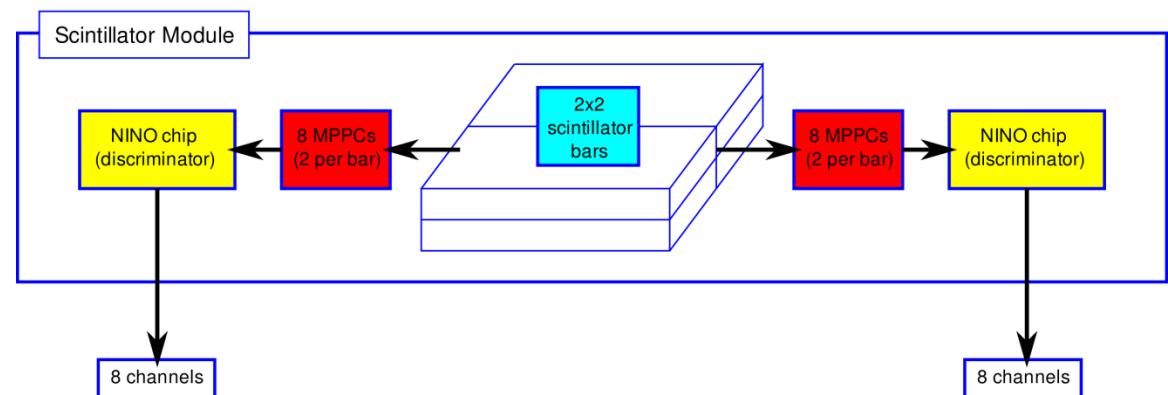
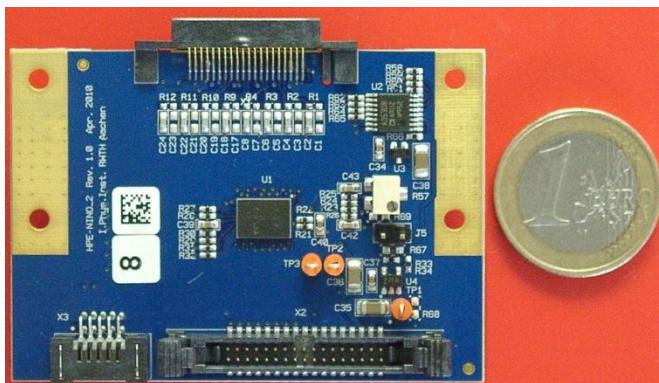
Mandatory tasks

- Main trigger
- Rejection of upward from downward flying particles (Albedo particles)
- Four layers of scintillator bars
- Two at top and two at bottom
- Distance 80 cm → 2.7 ns flight time
- Modular design

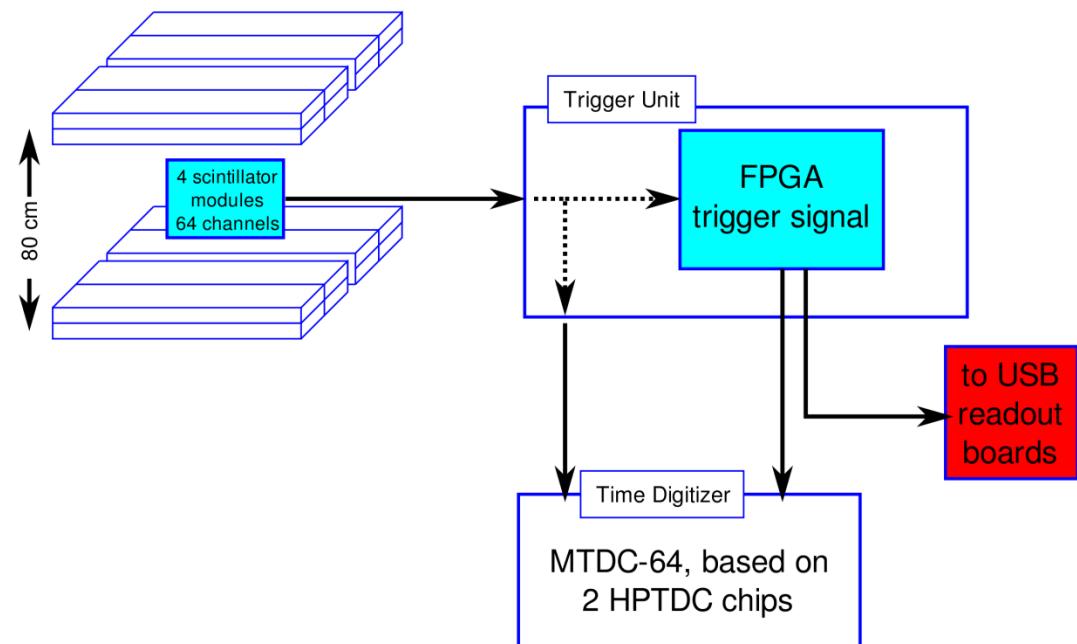
Time-of-Flight System



- two top and two bottom modules
- scintillator bars optically separated, wrapped in reflective aluminized Mylar foil
- 2 optical hybrids
 - 8 Hamamatsu S10362-33-100C on each side of module (440 nm peak sensitivity)
- Coupling with optical grease

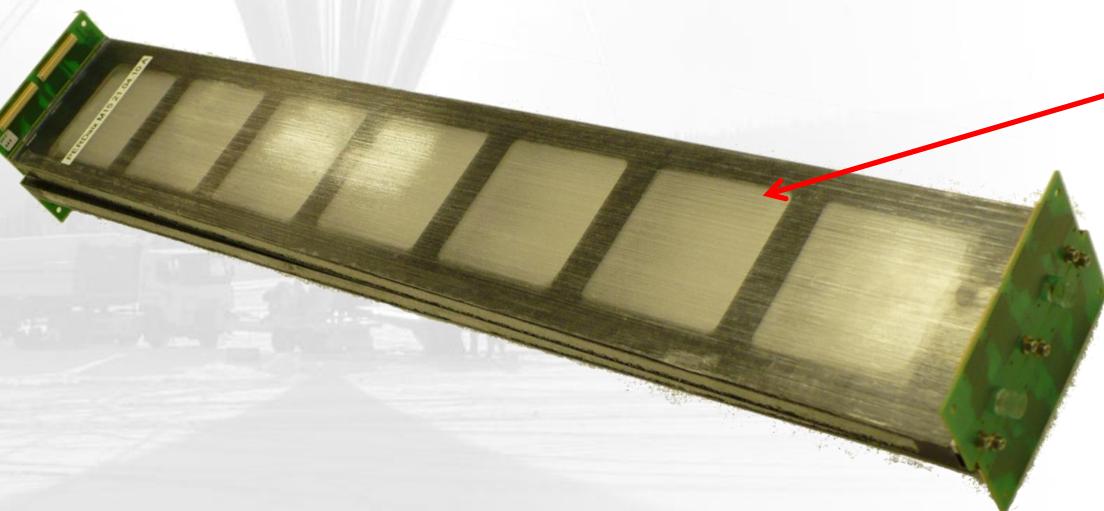


- NINO: 8 channel preamplifier discriminator ASIC
- power consumption 30 mW/channel
- fully differential readout chain
- 1 ns rise time
- DAC for individual MPPC voltages on PCB

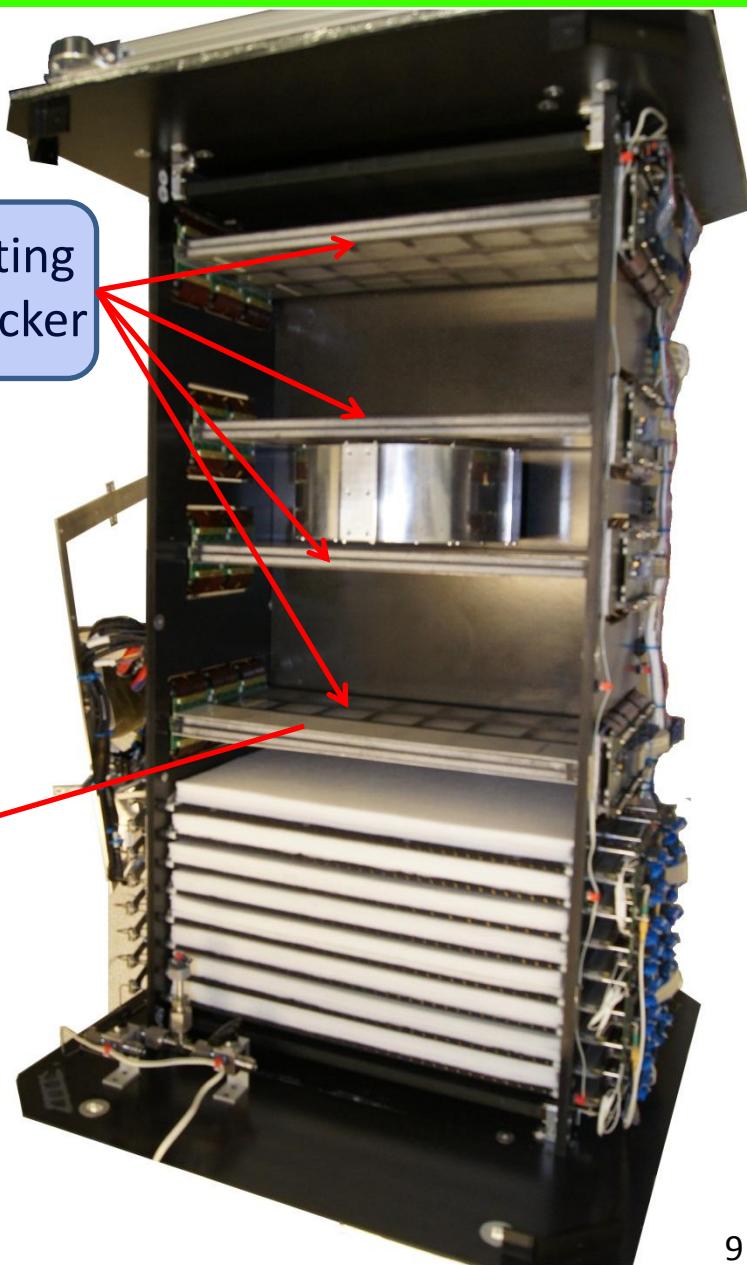


4 double layers of scintillating fiber tracker

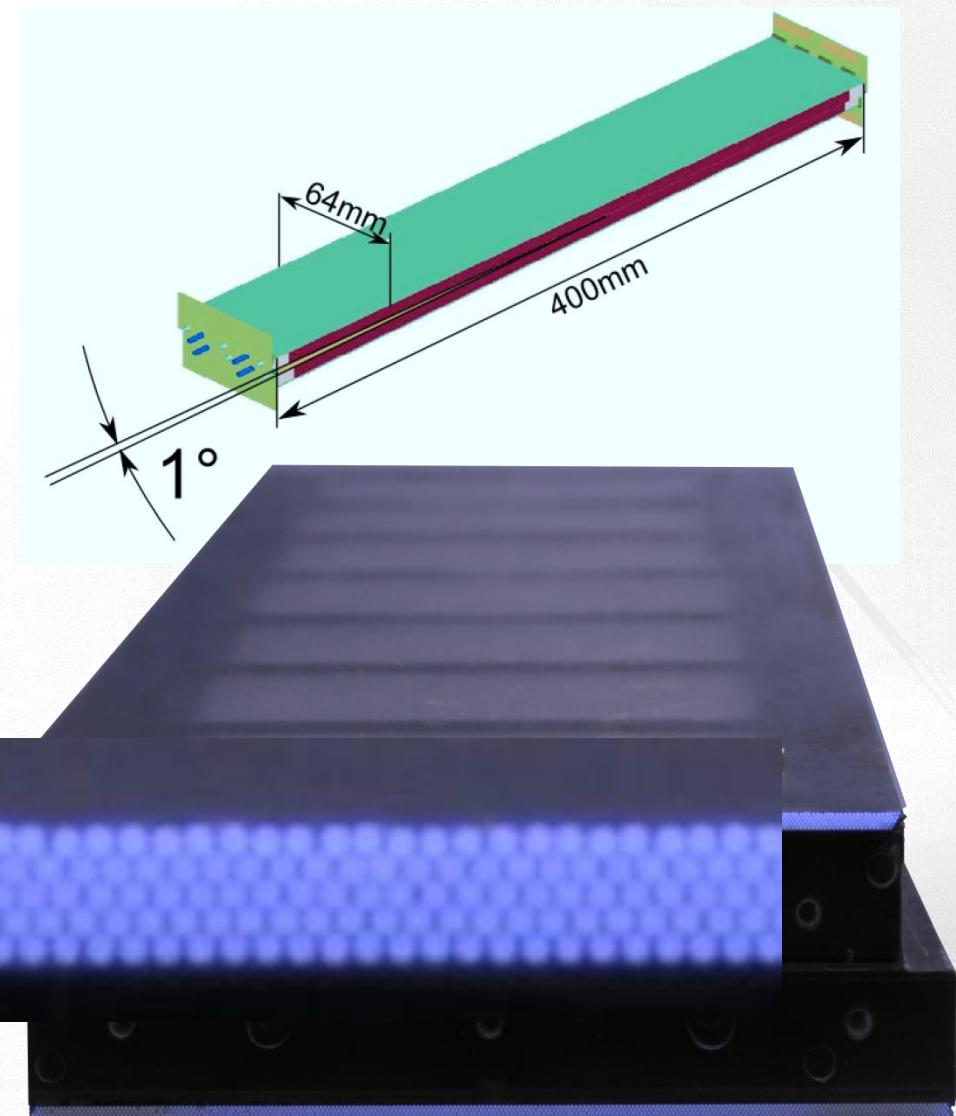
- 10 stereo modules
 - 20 fiber ribbons
 - 160 SiPM arrays
 - 5120 channels
- two ribbons made of 5x256 250 μ m thick scintillating fibers mounted on Rohacell foam/Carbon fiber support structure
(ladder structure for material saving)
 - 1,1 % X0 per module)



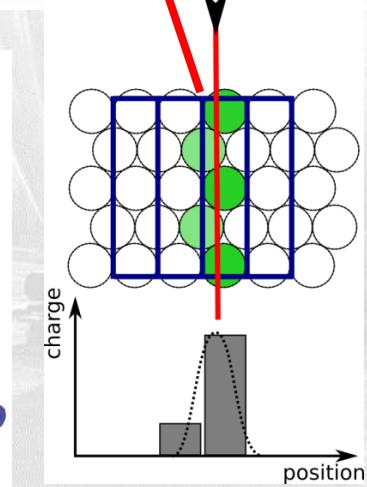
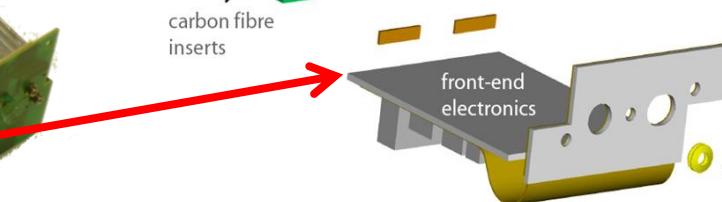
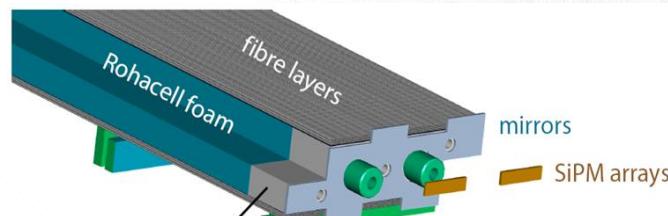
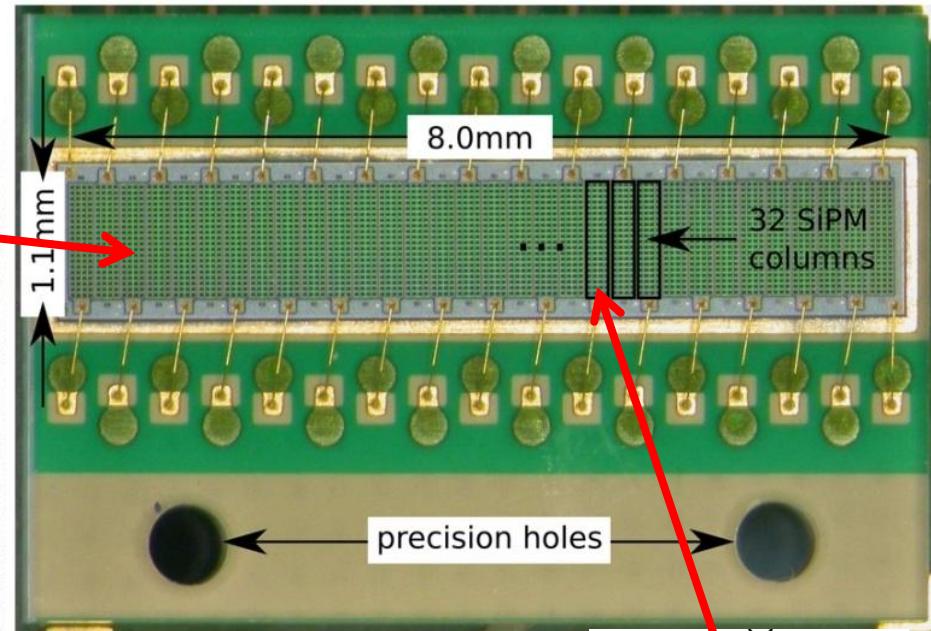
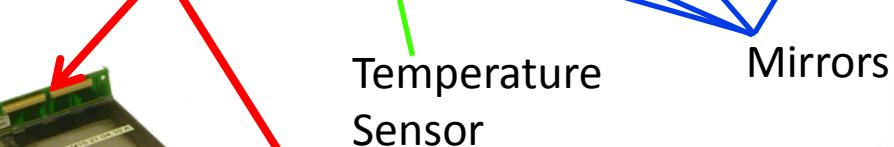
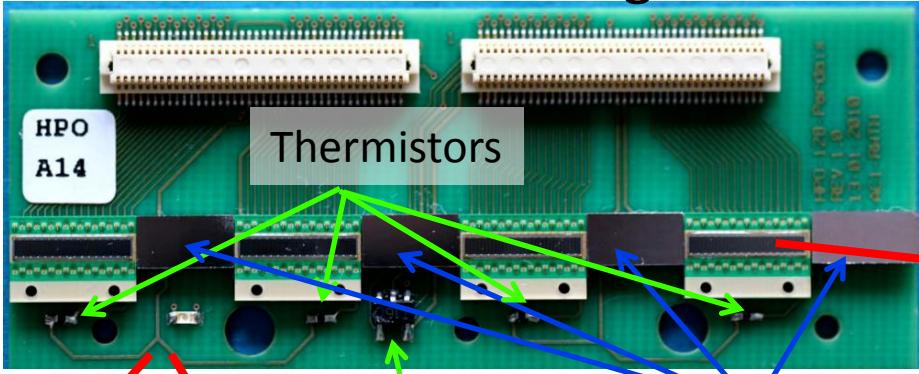
Scintillating
fiber tracker

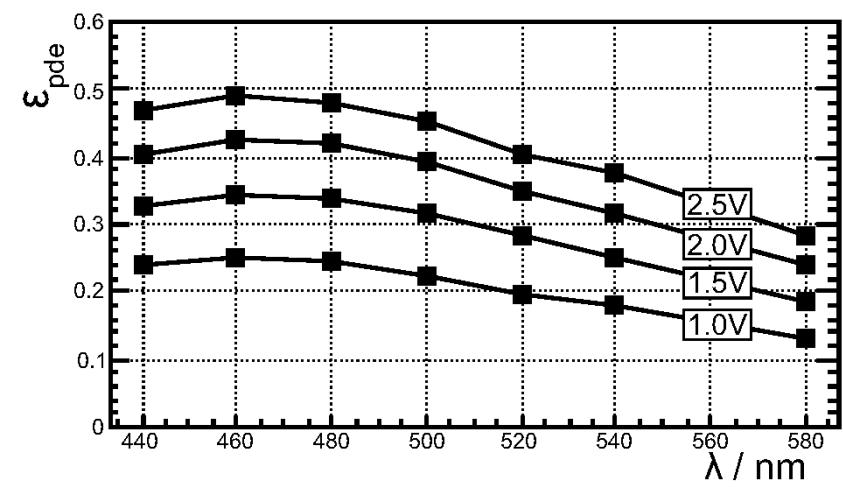
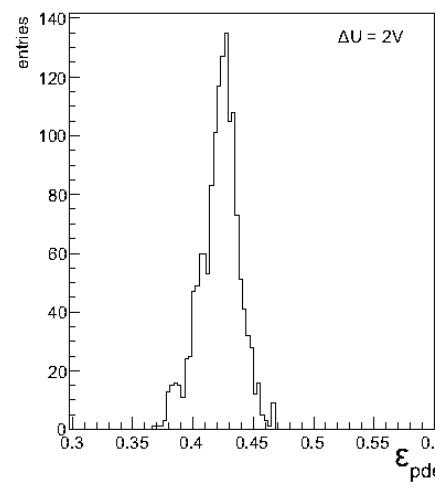
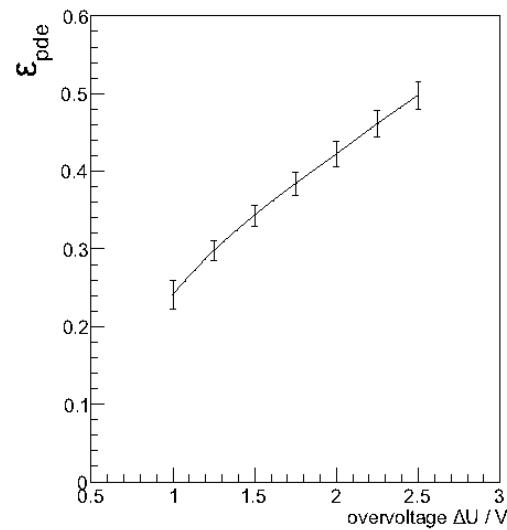
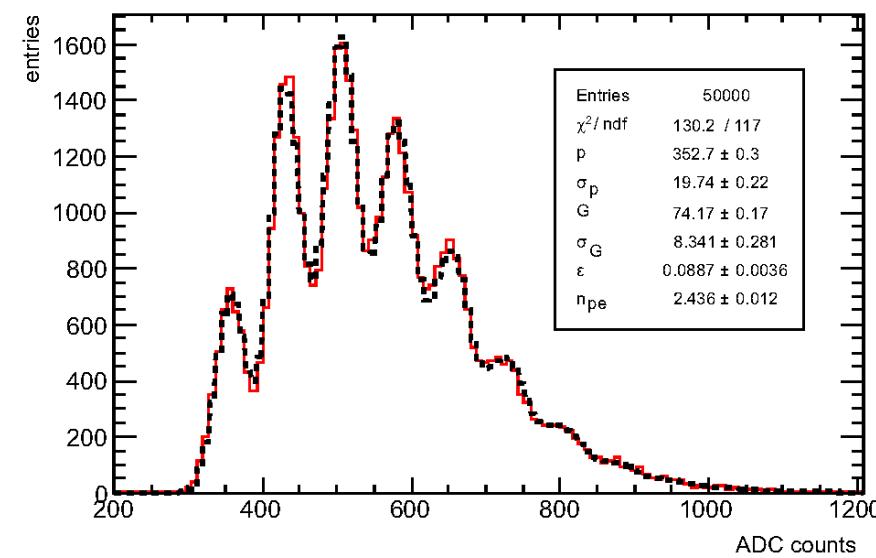
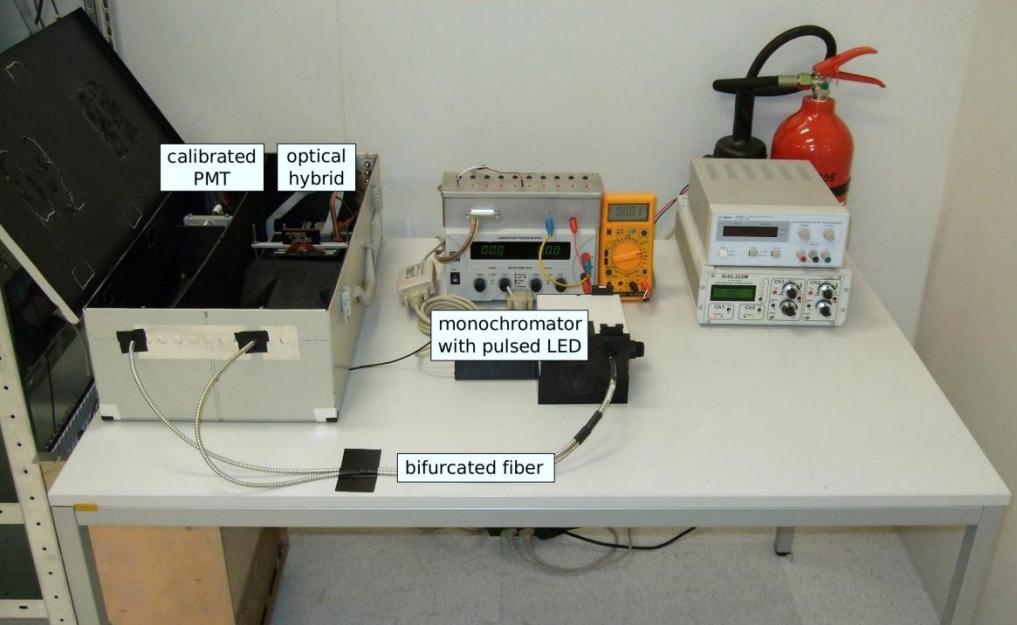


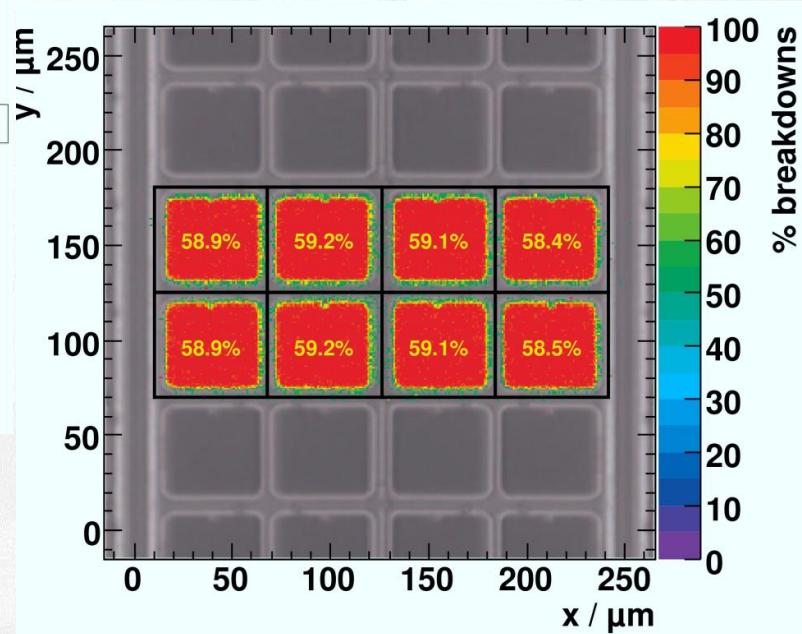
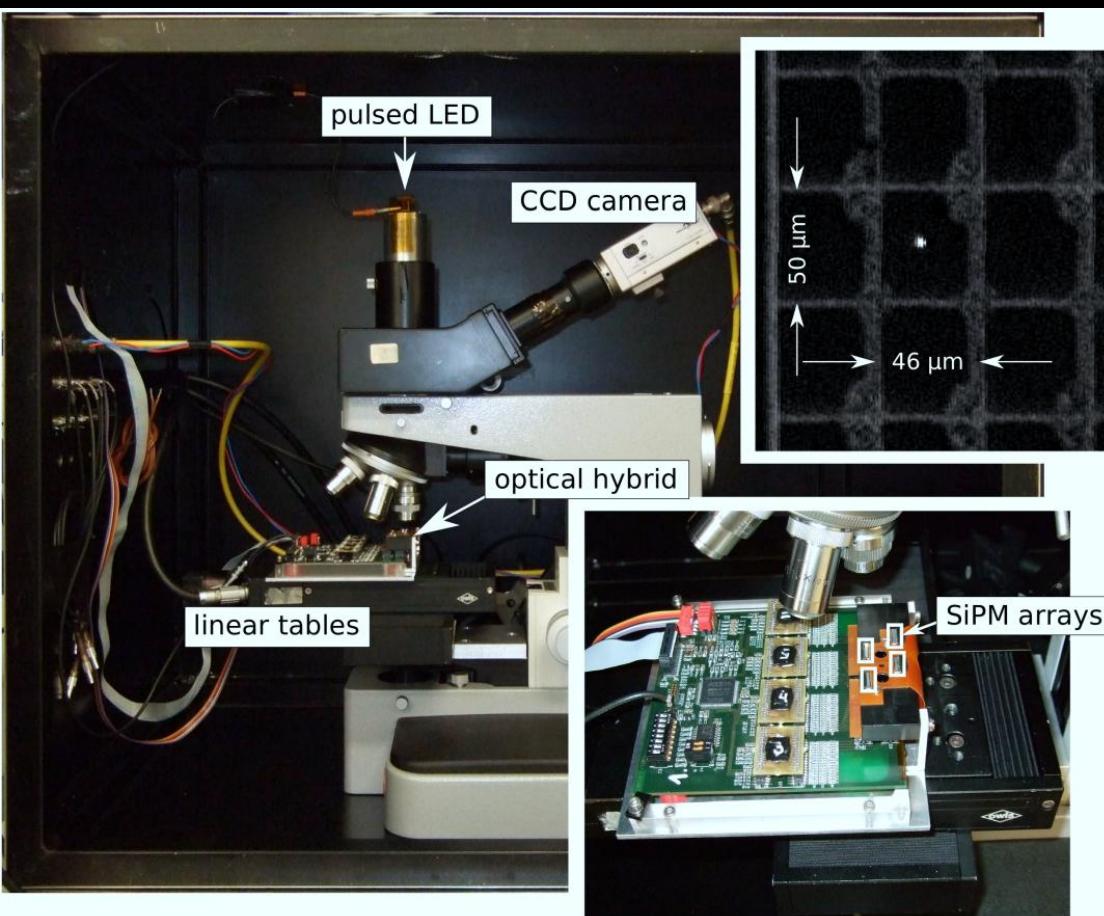
- CFC module carrier
 - fiber ribbons on top & bottom
 - 1 stereo angle
 - 1.1% X₀
- Kuraray SCSF-78MJ fibers
 - (250 6) μm fiber diameter
 - $\lambda_{\text{Emission}} = 450\text{nm}$
 - 5 fiber layers per ribbon
 - Each layer with 256 fibers

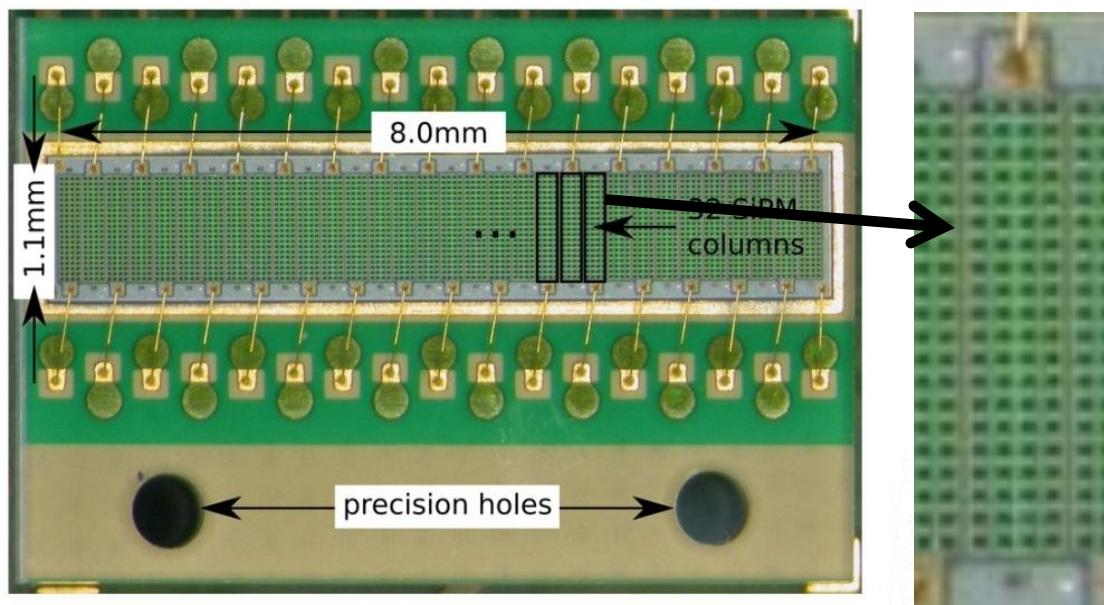


- Readout of scintillating fibers with 32 channel MPPC 5583 arrays

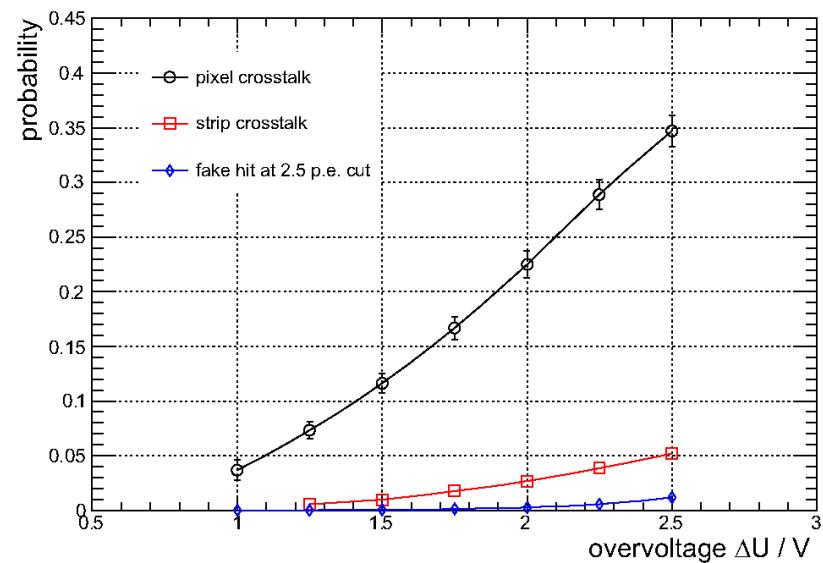
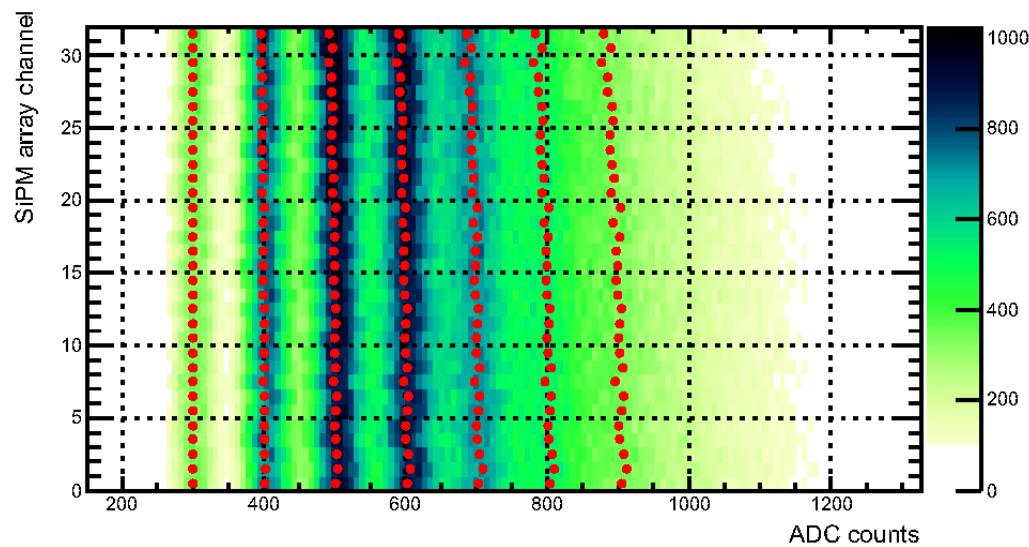


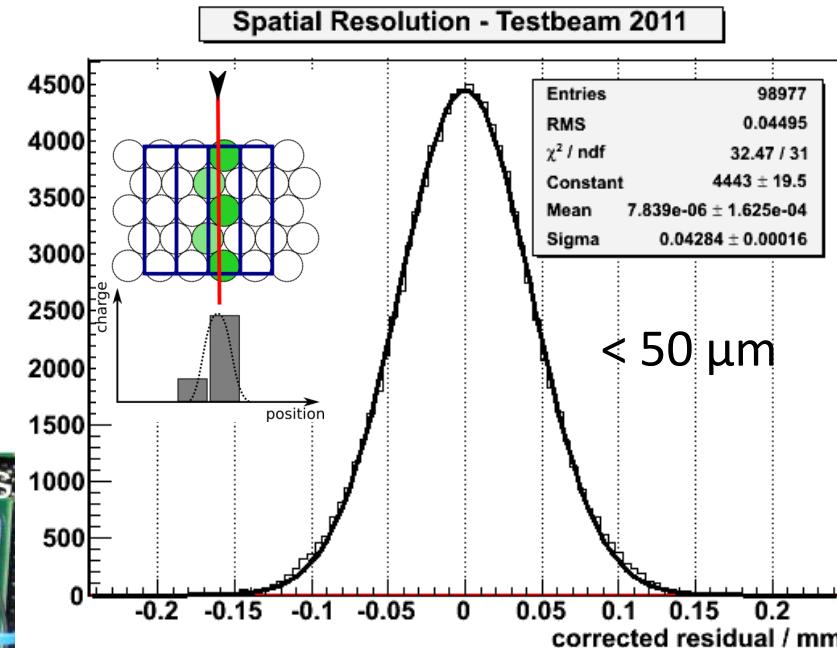
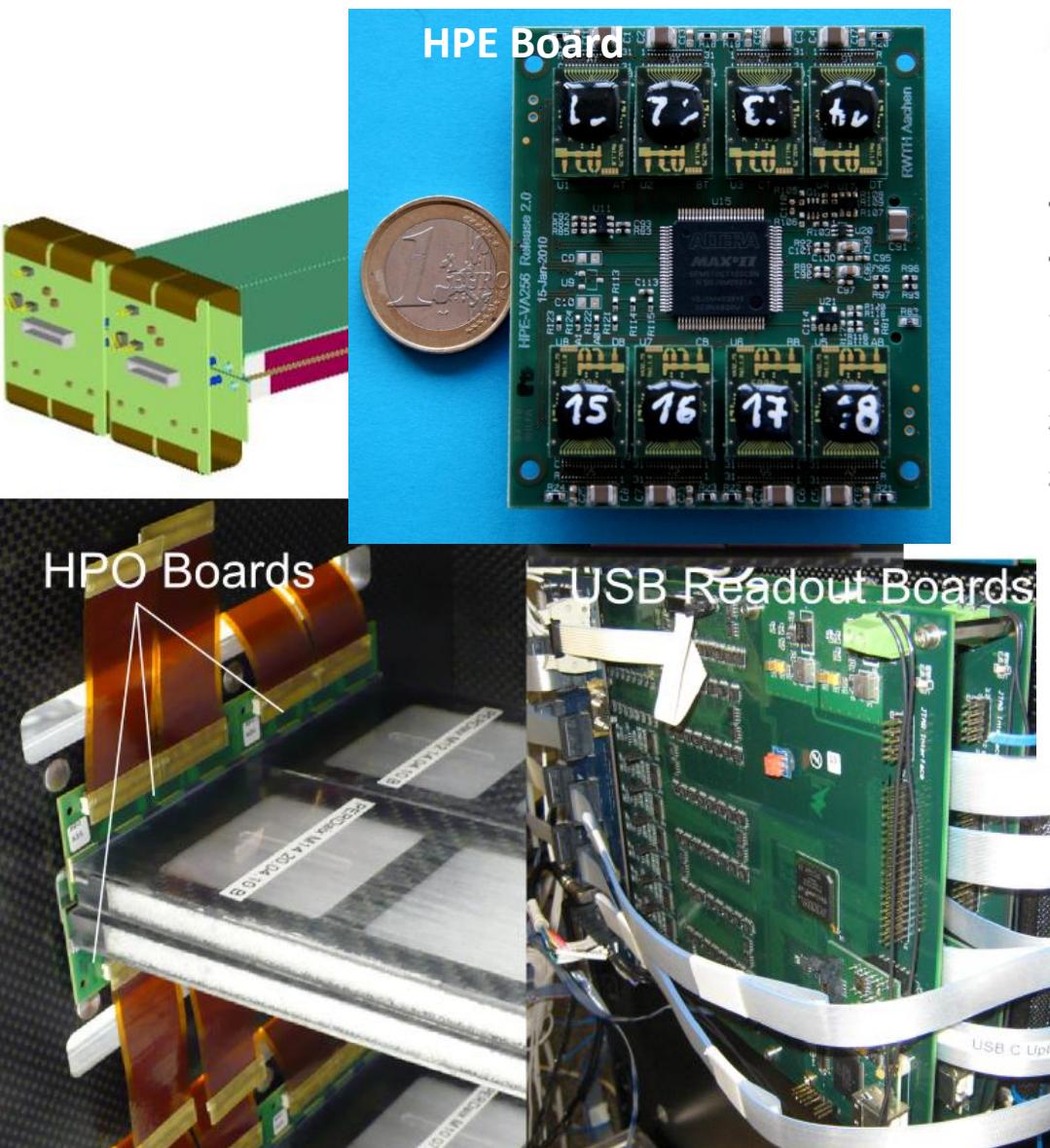




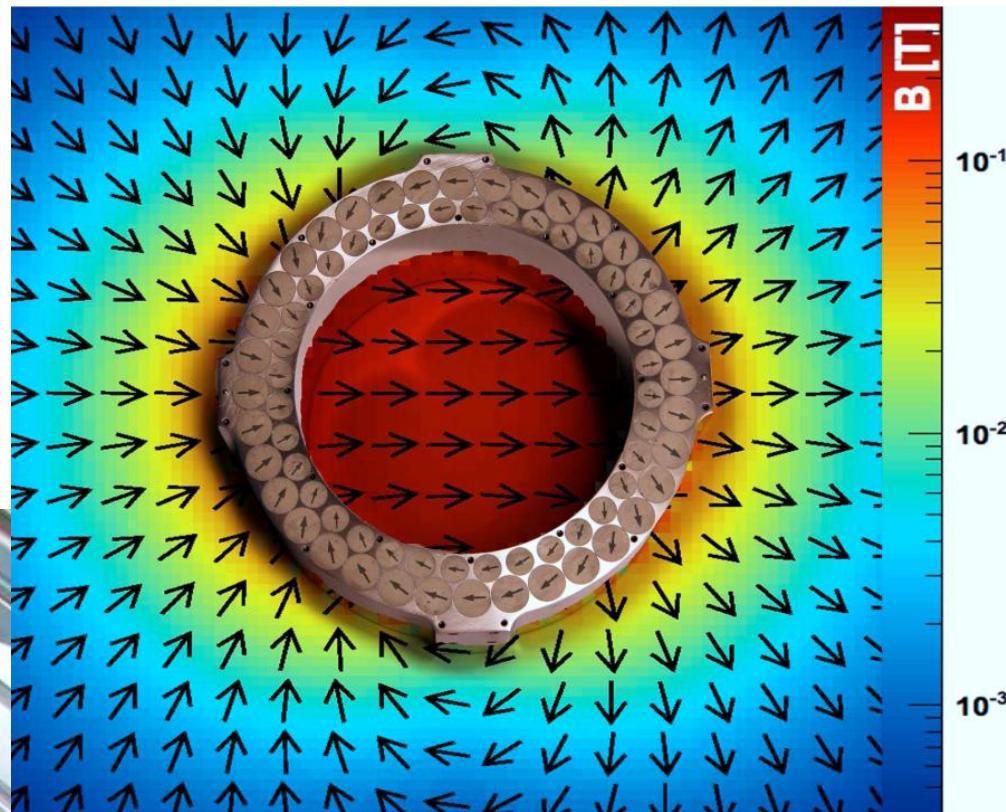


- Hamamatsu MPPC 5883
 - 32-channel SiPM arrays
 - 0.25mm channel pitch
 - 80 pixels (dynamic range)
 - $U_{bias} = 70V$
 - PDE 50%, Gain 10^6
 - Pixel Crosstalk 30%
 - Dark count $\sim 200\text{kHz}/\text{channel}$

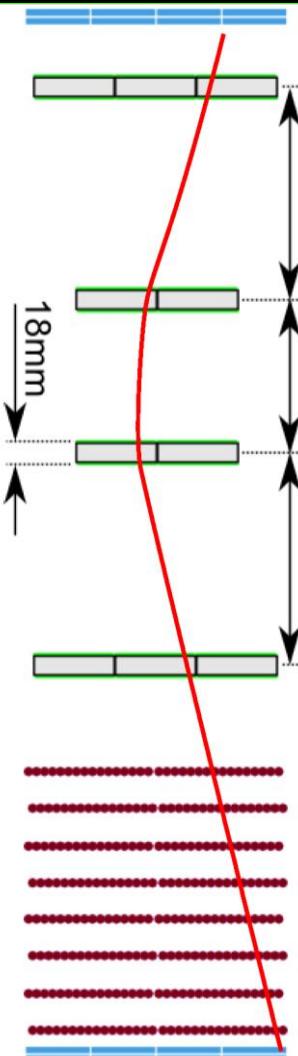




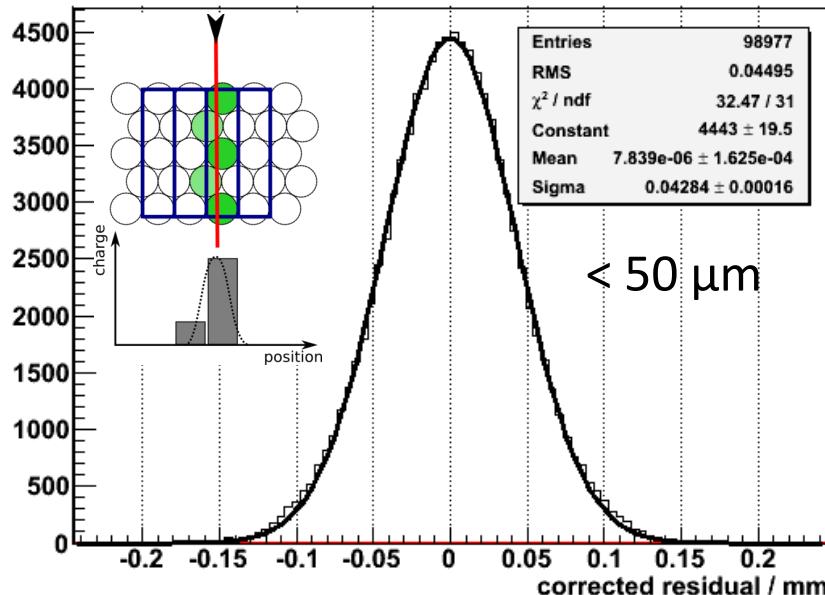
- small cylindrical magnets
- inner magnetic field: 0.2T
- weight: 7.4kg
- inner diameter: 15cm
- outer diameter: 21cm
- height: 8cm



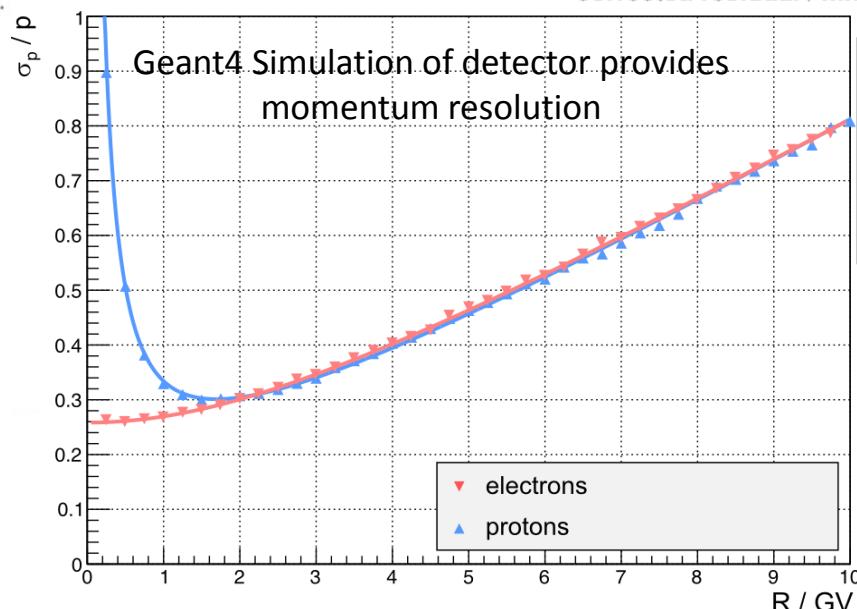
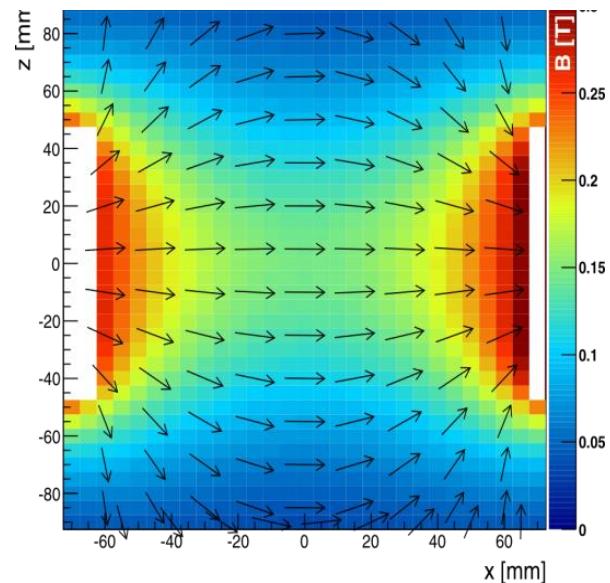
Momentum resolution



Spatial Resolution - Testbeam 2011



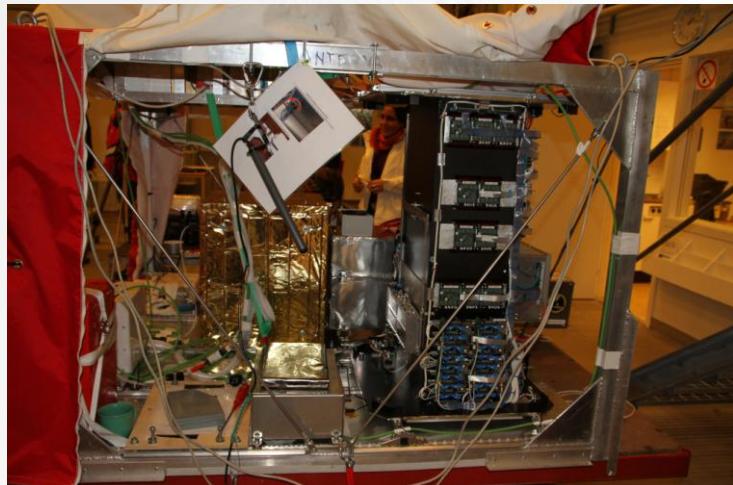
PERDaix magnetic field 0.2T



- 3d reconstruction algorithm:
- inhomogeneity of magnetic field
 - stereo angle in modules
 - multiple scattering

maximum detectable rigidity
~10GV

November 23rd, 2010 03:00 am
T-5:30 Start Countdown

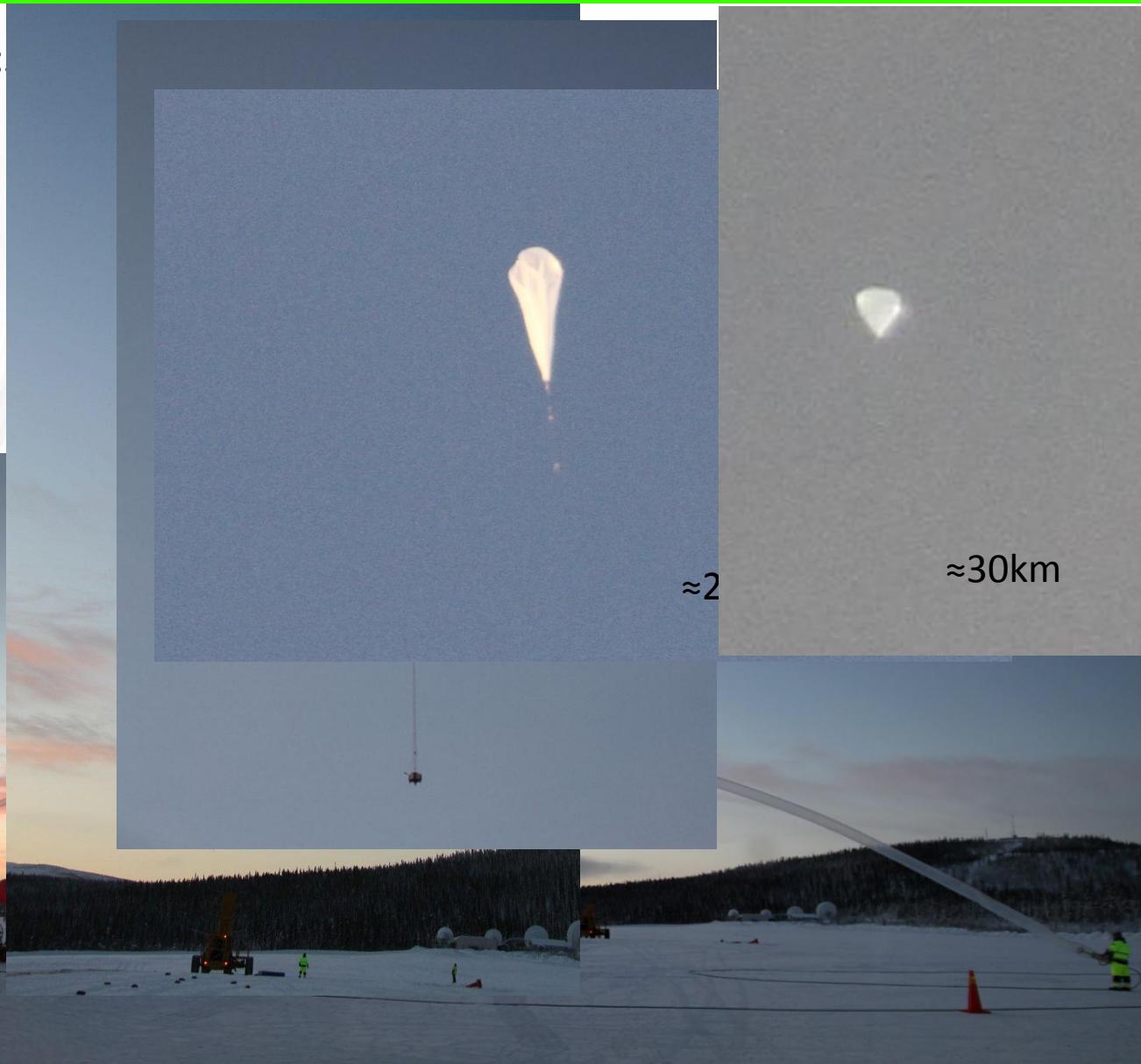
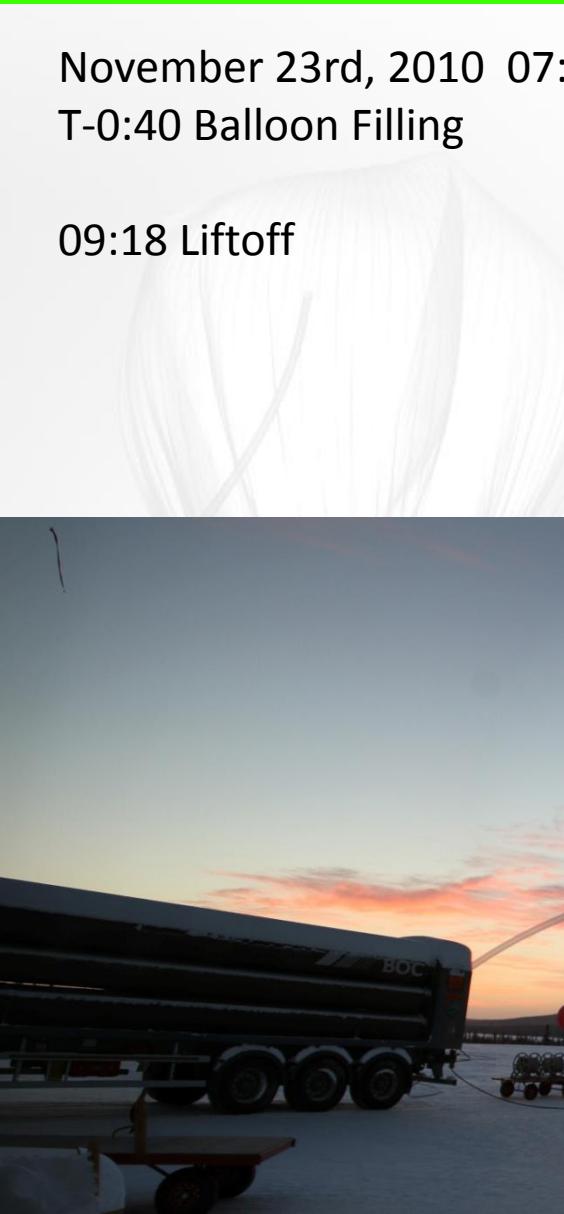


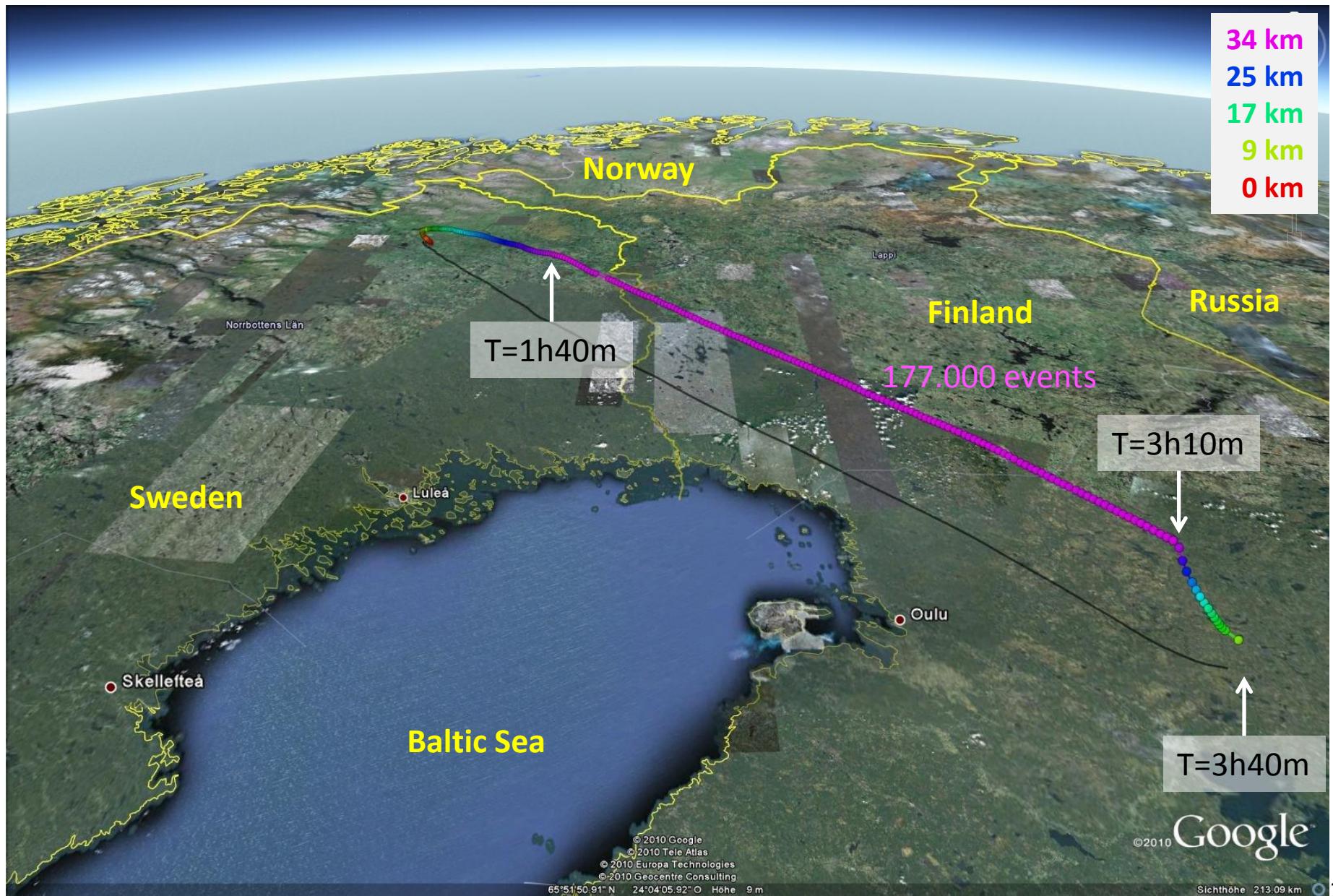
November 23rd, 2010 05:30 am
T-3:00 Gondola to Launchpad

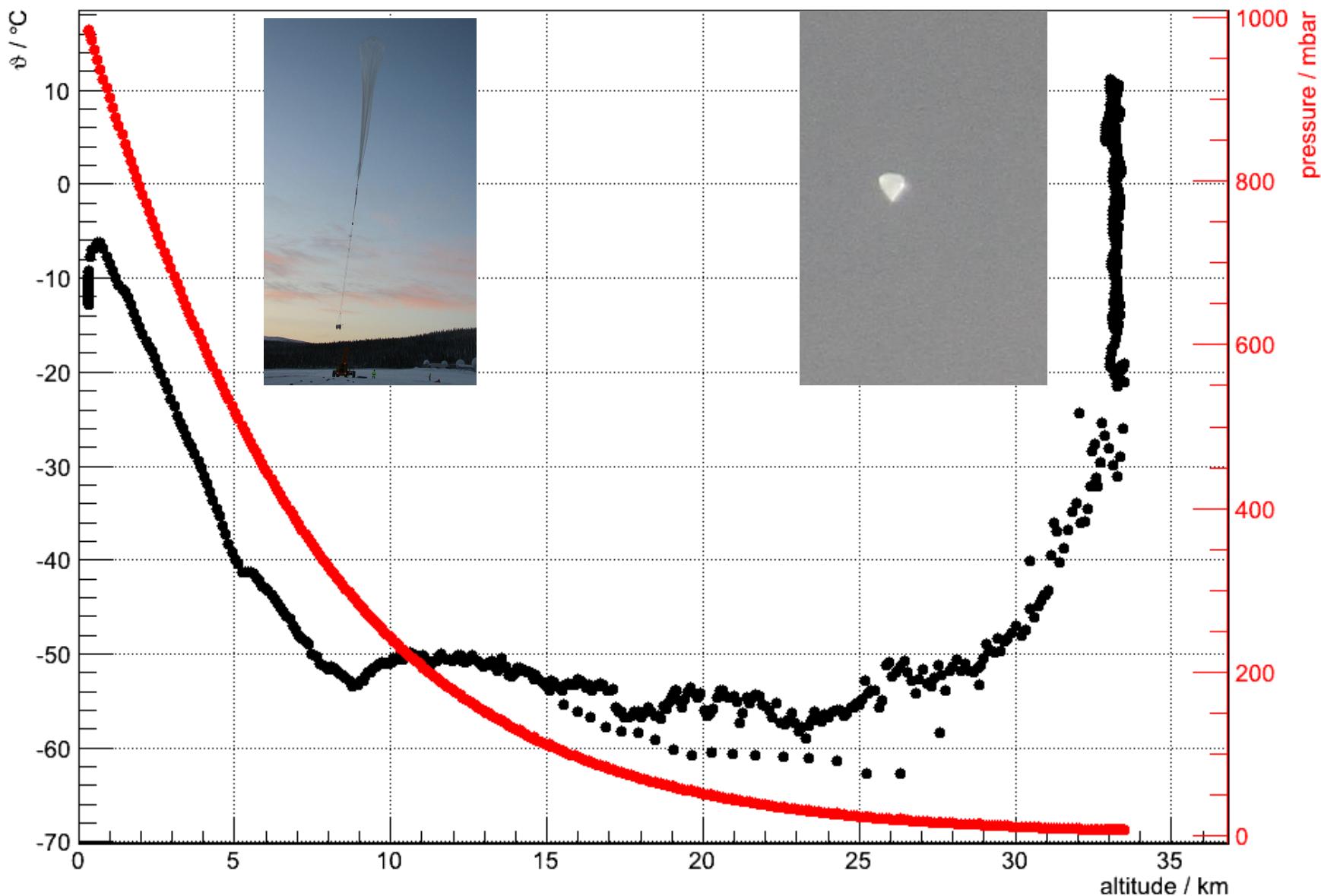


November 23rd, 2010 07:
T-0:40 Balloon Filling

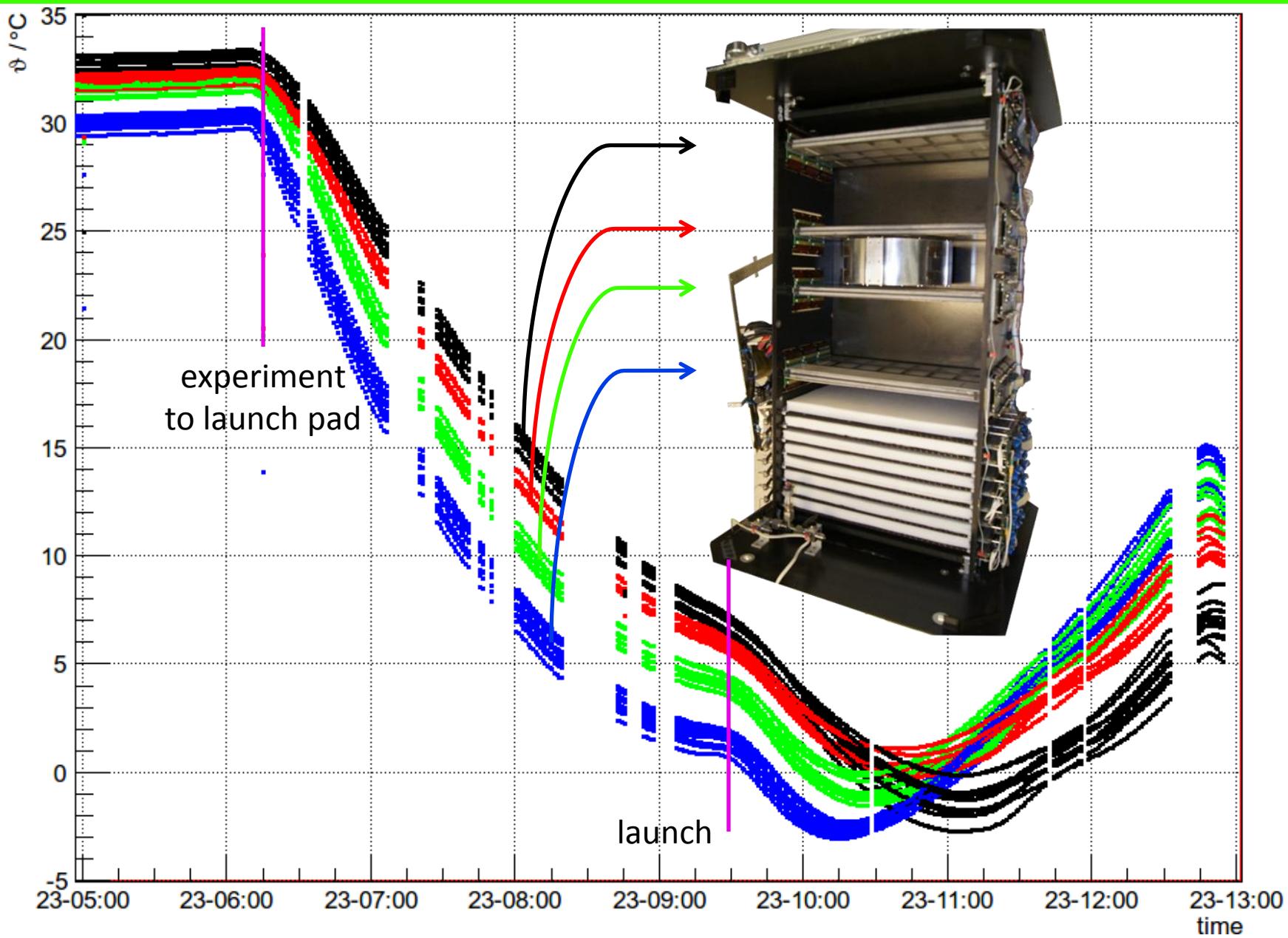
09:18 Liftoff

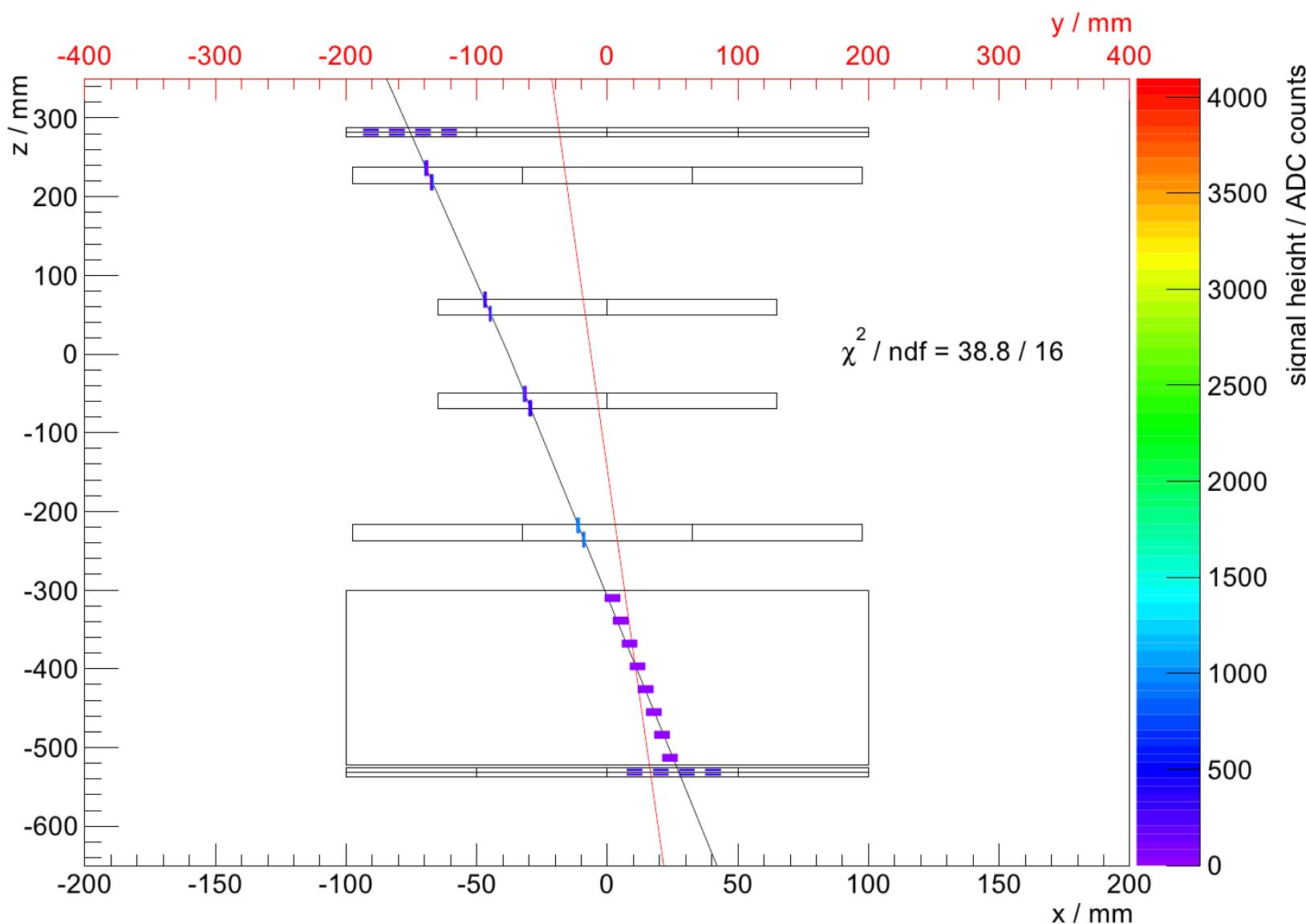


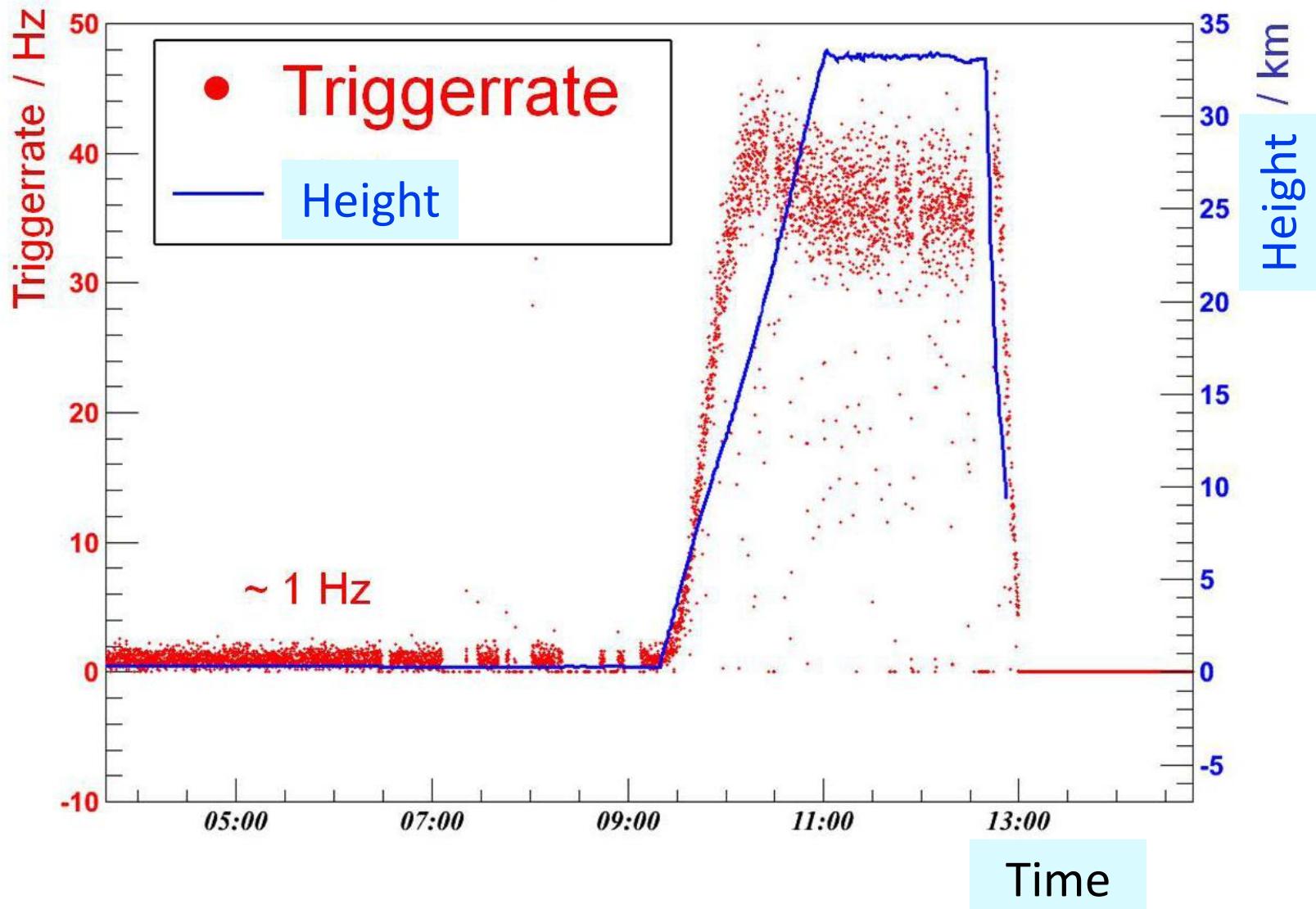




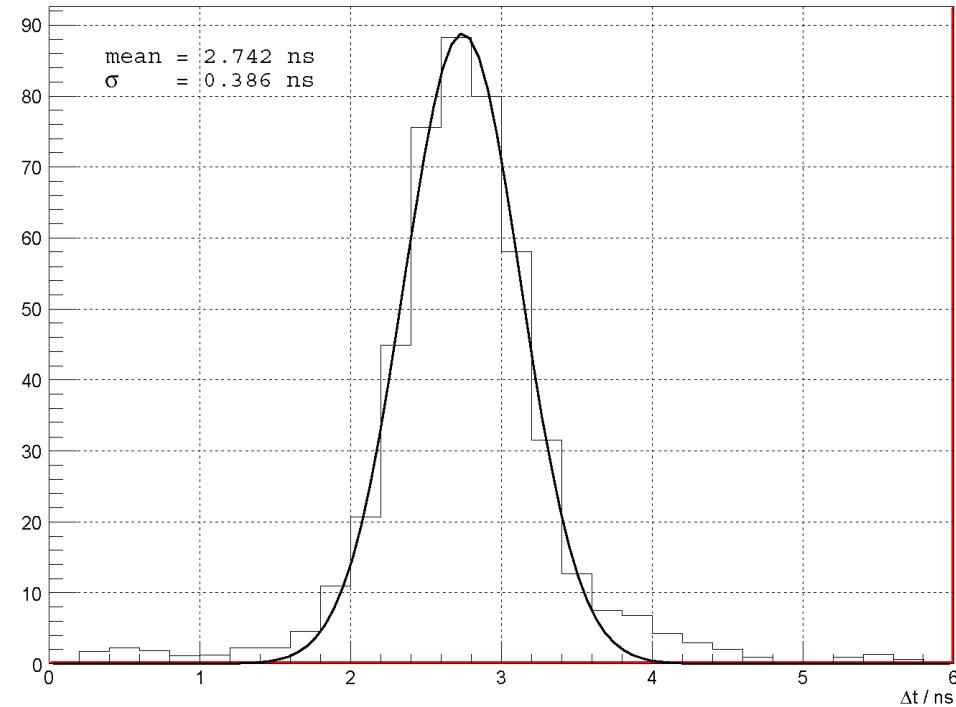
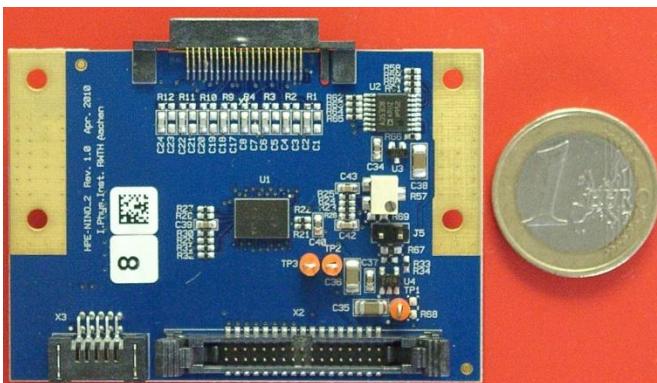
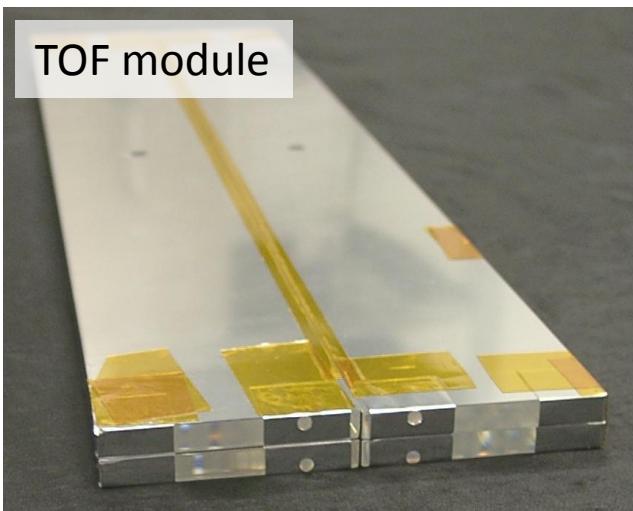
Tracker temperatures





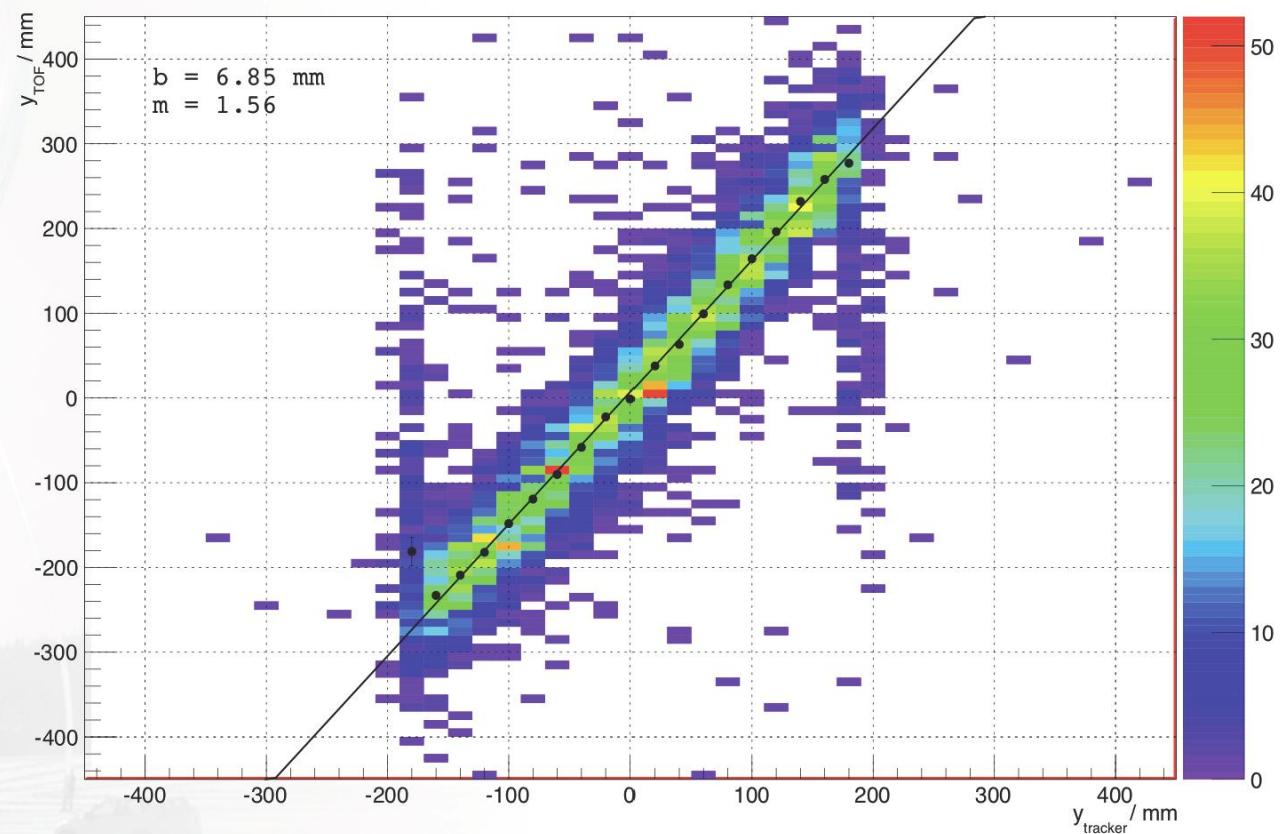
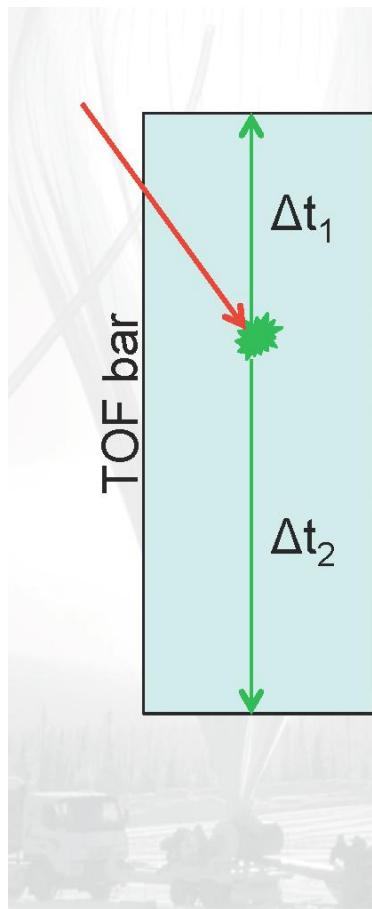


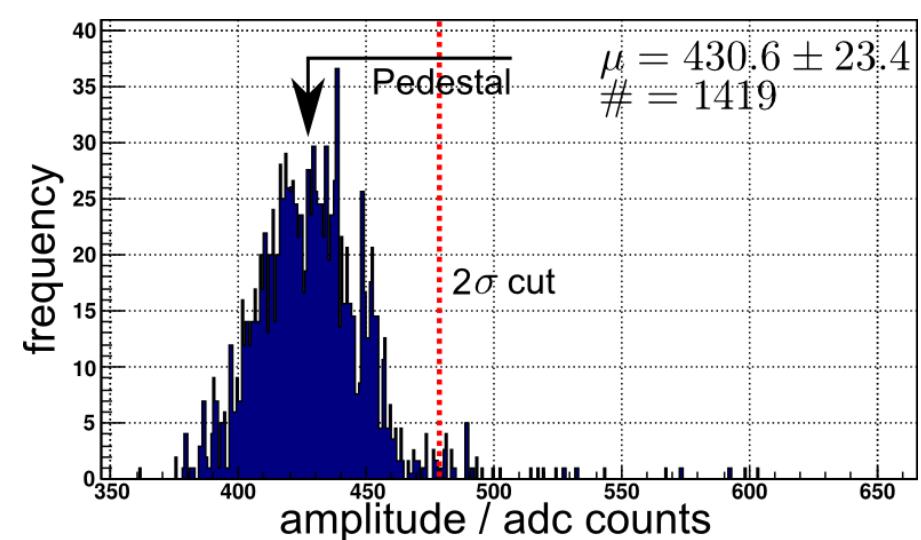
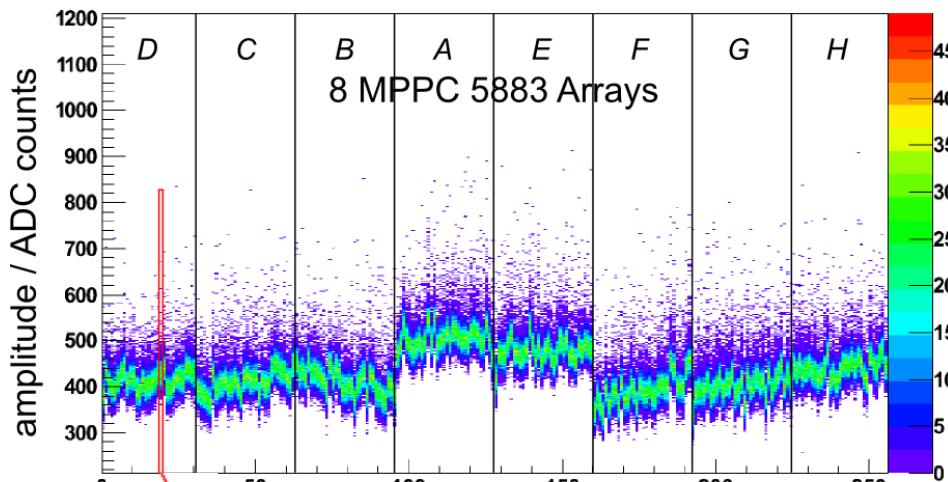
TOF module



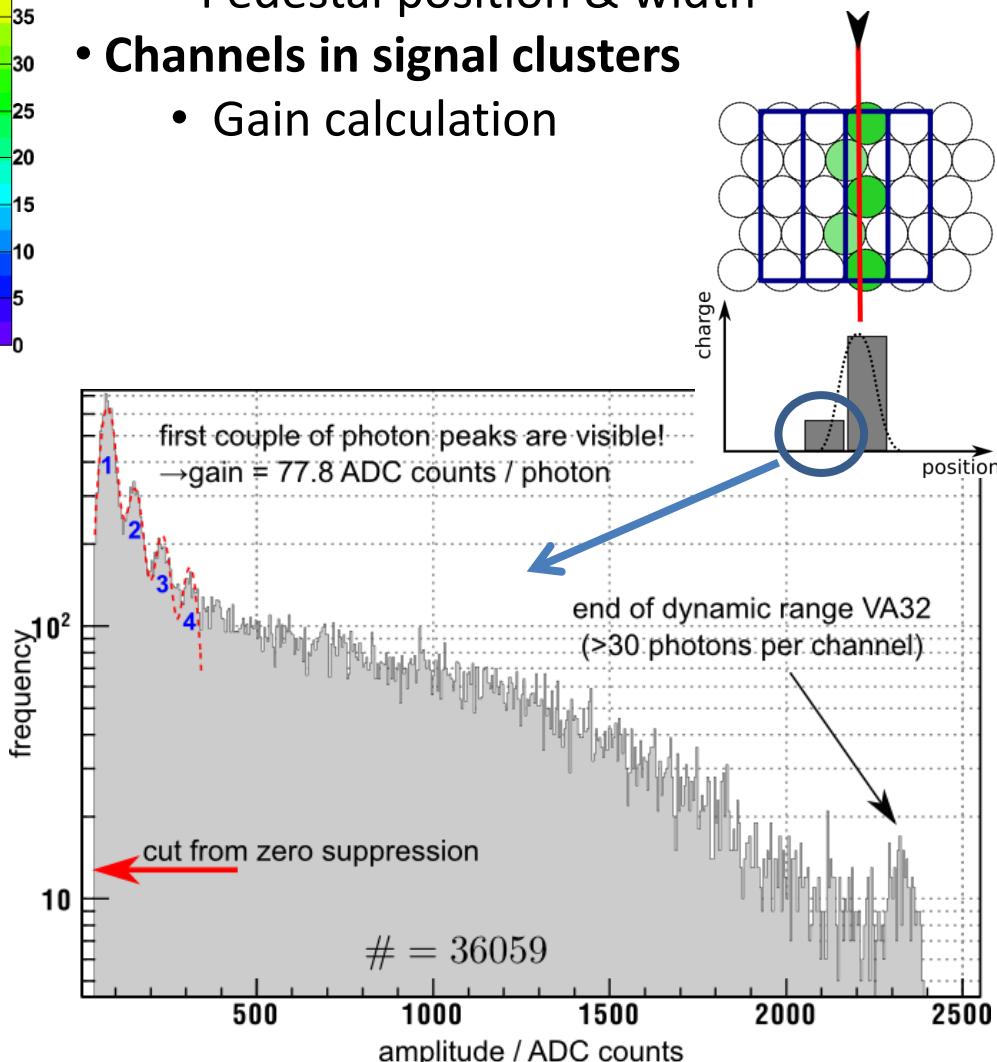
Correlation between y-coordinate measured by TOF and by Tracker

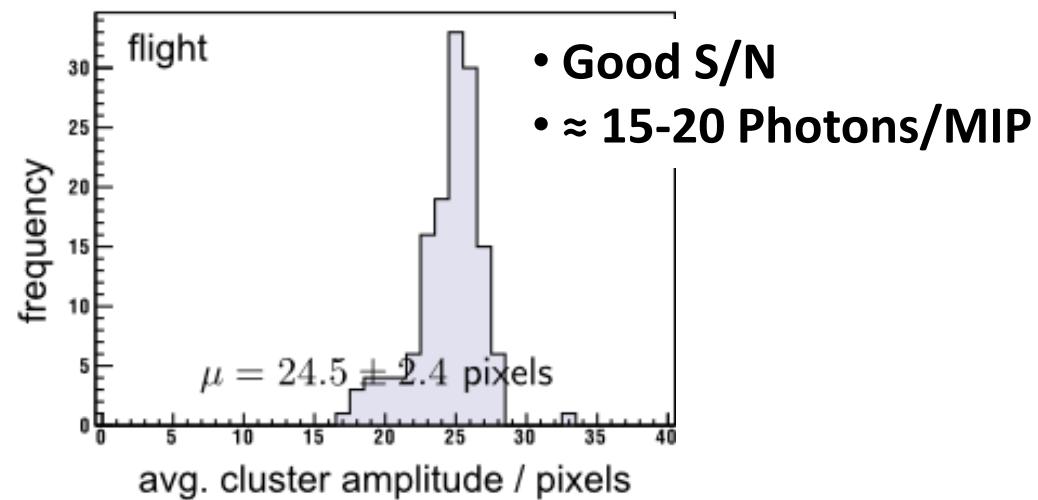
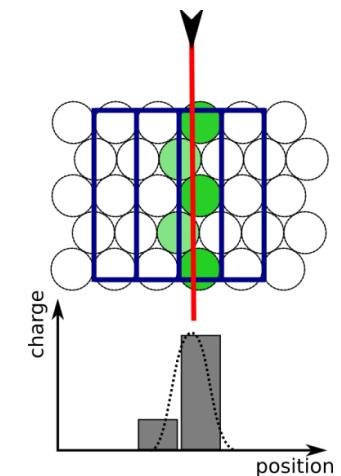
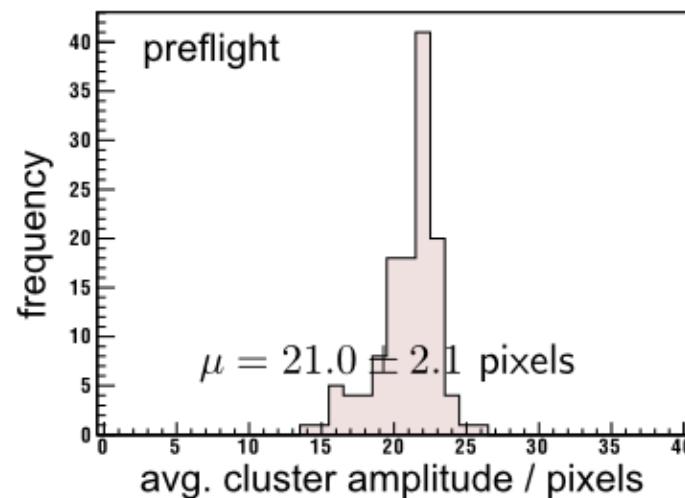
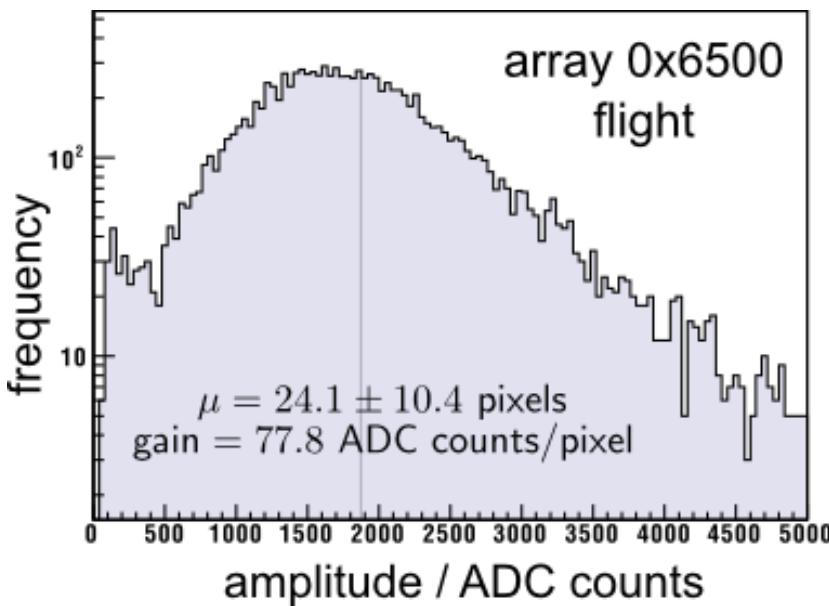
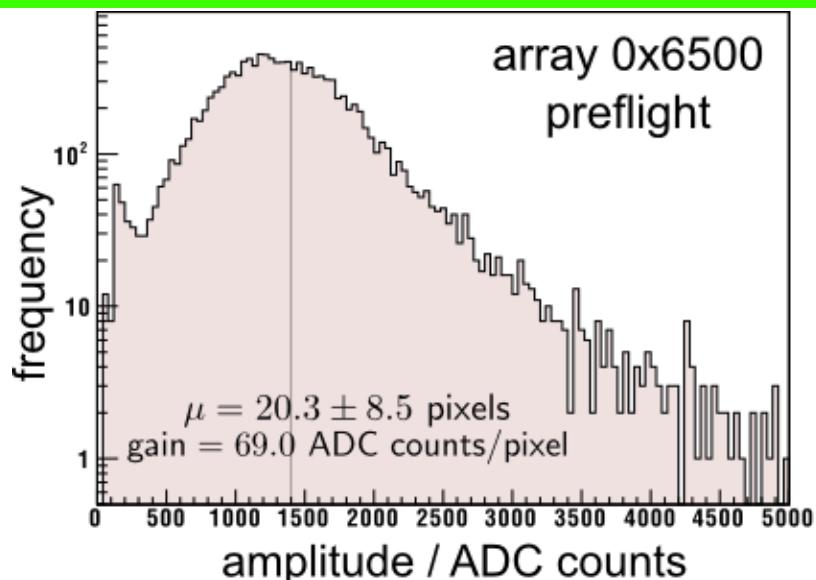
(Y-coordinate measured by difference in photon travel time to each side of the scintillator bar)

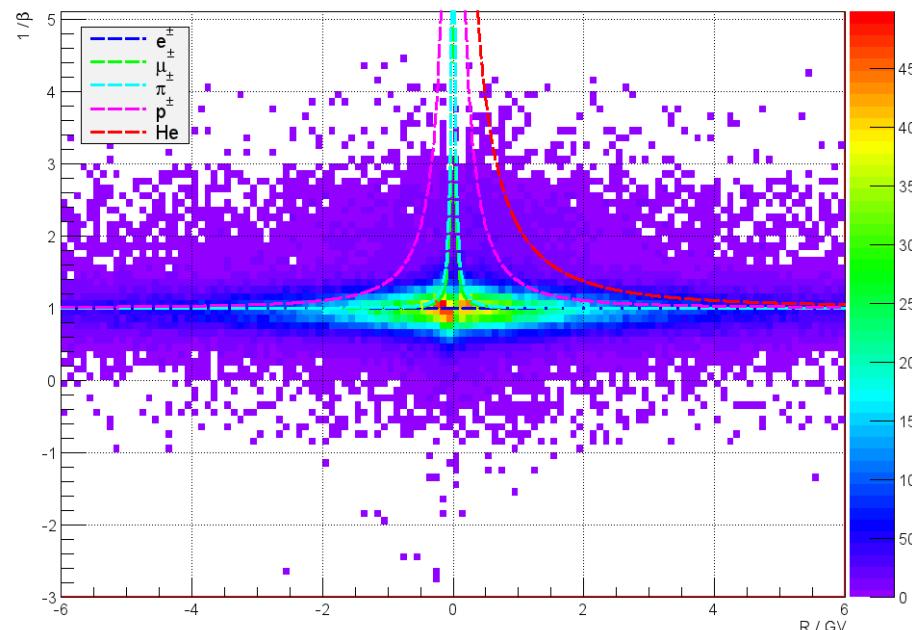




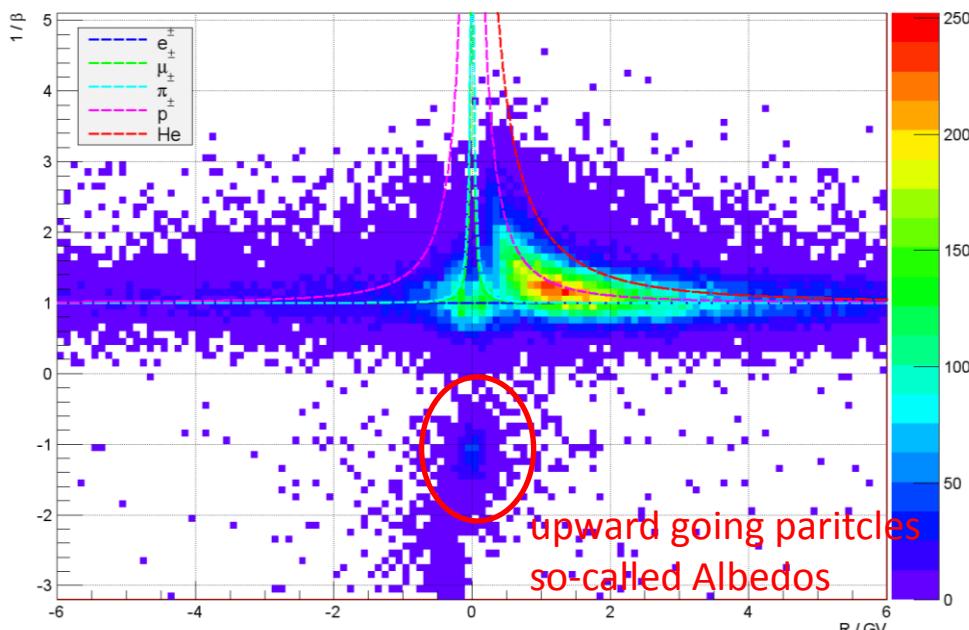
- Random Trigger → Dark Spectra
 - Pedestal position & width
- Channels in signal clusters
 - Gain calculation







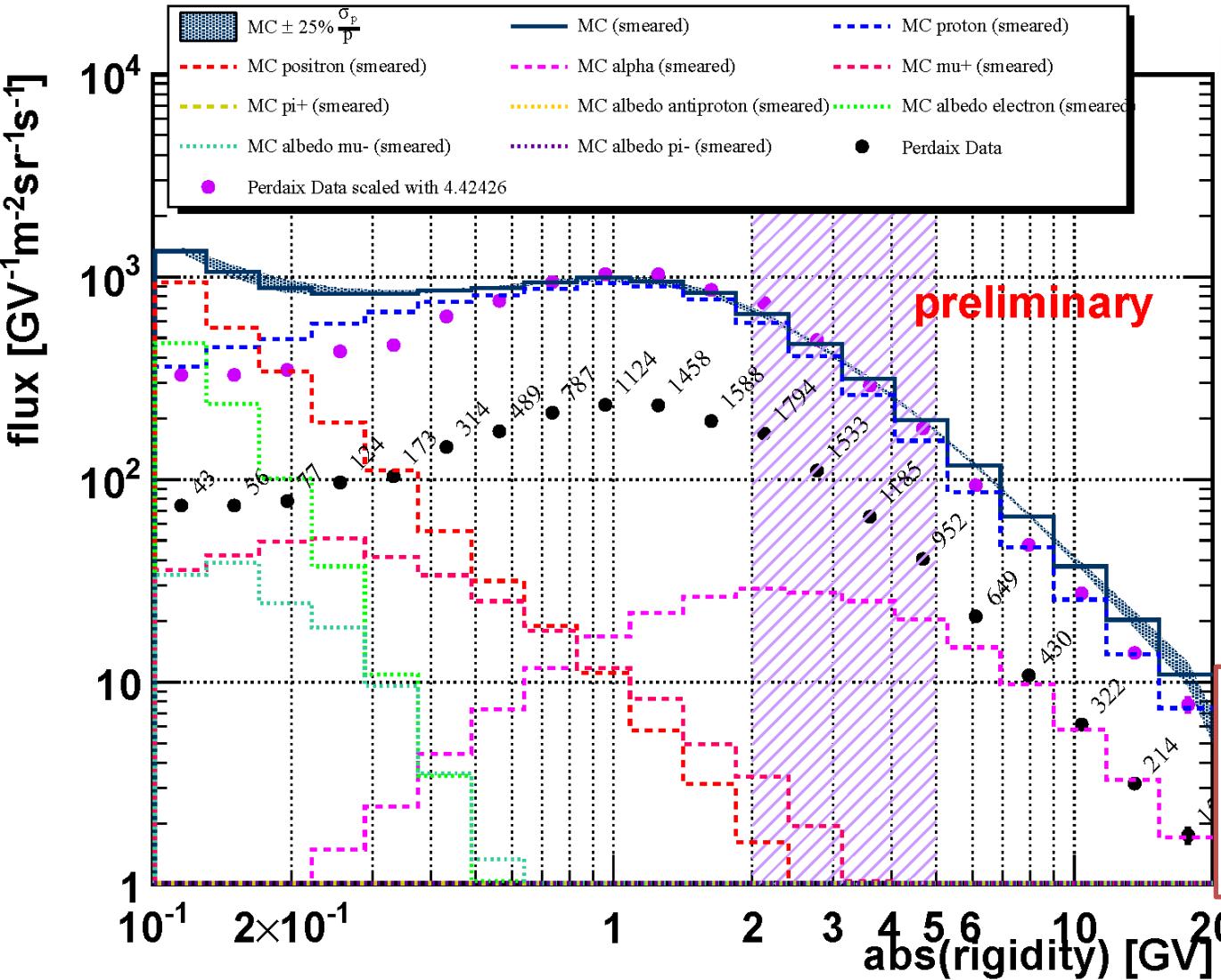
Cosmic data on ground before launch



Flight data taken on Nov 23rd 2010

Measured positive fluxes at 33 km, $\phi = 550\text{MV}$

PRELIMINARY, WORK IN PROGRESS!

efficiency: $\approx 25\%$

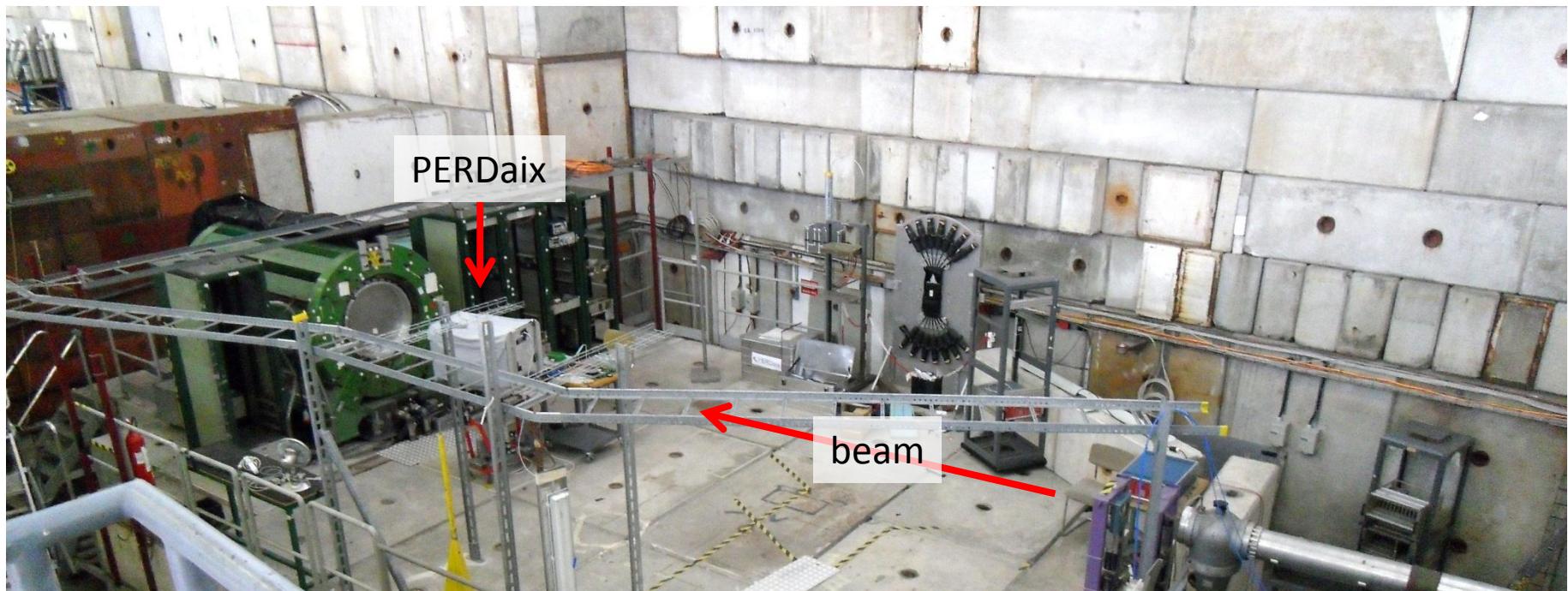
contribution:

- trigger
- track finding
- reconstruction algorithm
- detector dead times

→ Monte Carlo studies

discrepancy in spectral shape due to detector resolutions

unfolding



CERN, PS accelerator
T9 beamline

- particles: $p^\pm, \pi^\pm, \mu^\pm, e^\pm$
- 0.5-10.0 GeV
- calibration measurements as input for further analysis



Summary

- Very successful balloon flight in November 2010
- 177.00 particle tracks recorded
- Spatial resolution of 50 µm
- Lightyield 15-20 Photons/MIP
- First preliminary estimation of proton spectrum

Outlook:

- Determination of efficiencies
- Unfolding of spectrum to account for detector resolution
- e^- - spectrum, He - spectrum
- further corrections
(rest atmosphere, geomagnetic cutoff, etc.)

Next SiPM-generation (128 channels)

→ Next Ballon experiment

