“Results From a Test Beam Study of a Fully Assembled Sensor-Plane for BeamCal”

Olga Novgorodova - IKTP Dresden

On behalf of FCAL Collaboration

27-30 May 2013

DESY

Content:

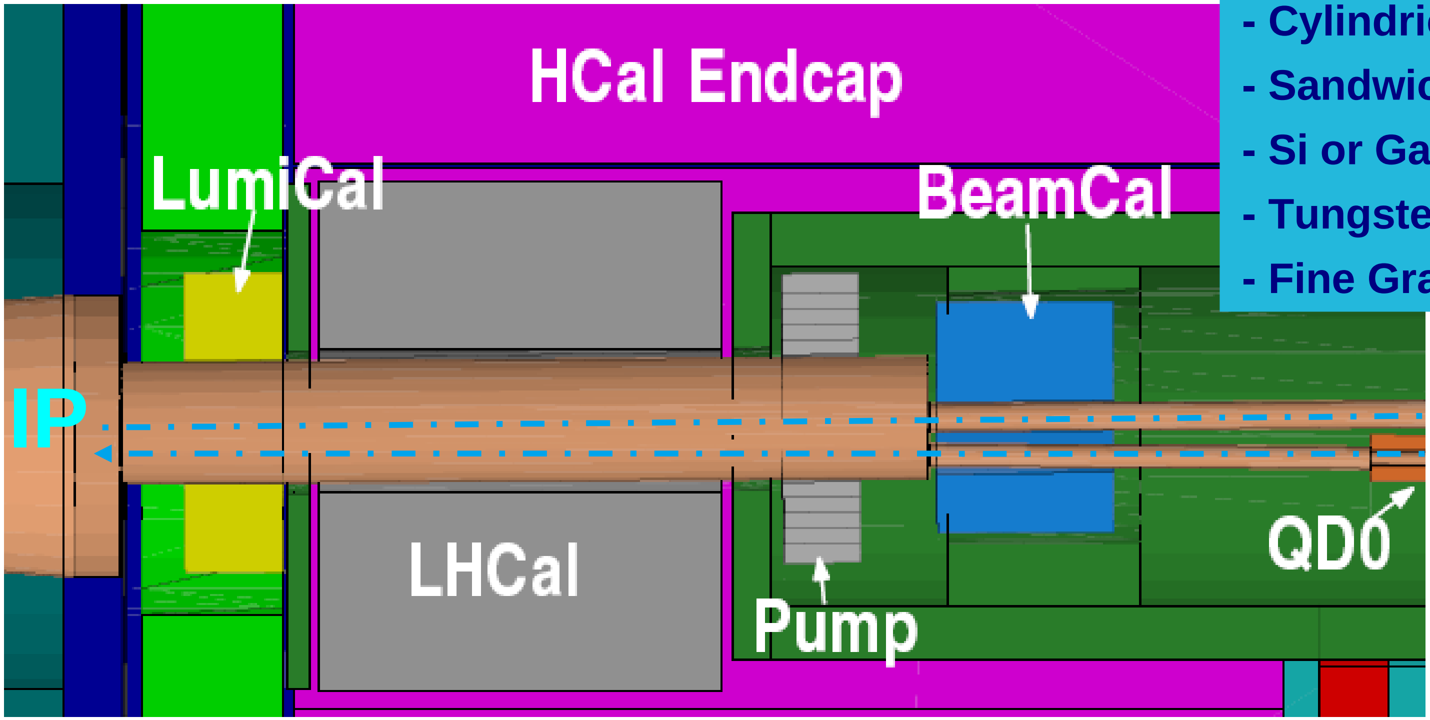
Forward Calorimeters

Future Prototype

Current Prototypes

Test Beams Results

Forward Region



LumiCal & BeamCal
- Cylindrical
- Sandwich (30 or 40 Layers)
- Si or GaAs
- Tungsten Absorbers
- Fine Granularity

Precise luminosity measurement,

Hermeticity (electron detection at low polar angles),

Assisting beam tuning (fast feedback of BeamCal data to machine)

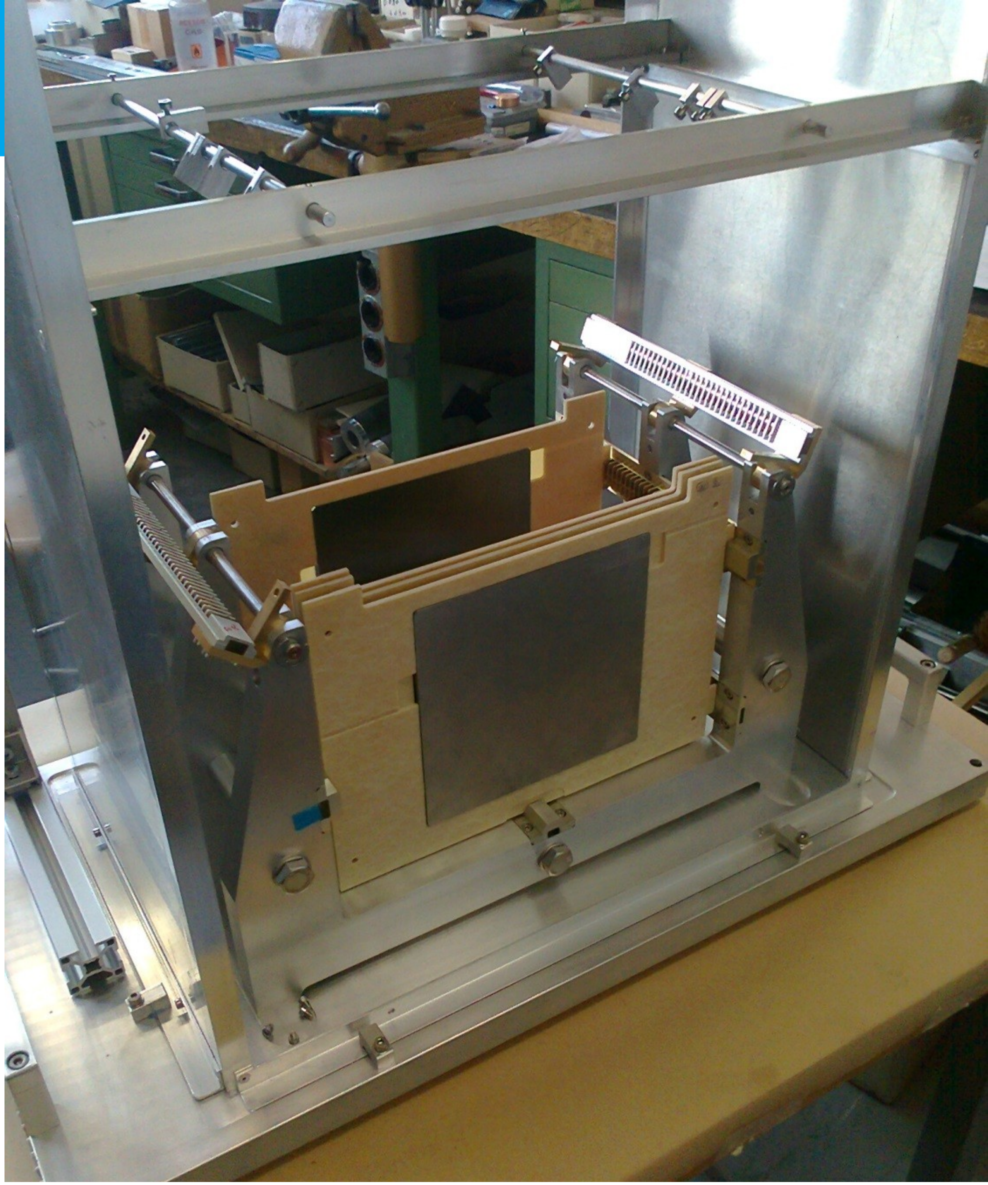
Challenges: radiation hardness (BeamCal), high precision (LumiCal) and fast readout (both)

Future Prototype:

- AIDA infrastructure for the future prototype
- Metal structure for the full calorimeter prototype is ready
- Next test beam with 5 planes inter-spread with tungsten plates
- 5 tungsten plates were assembled into the permaglass frames

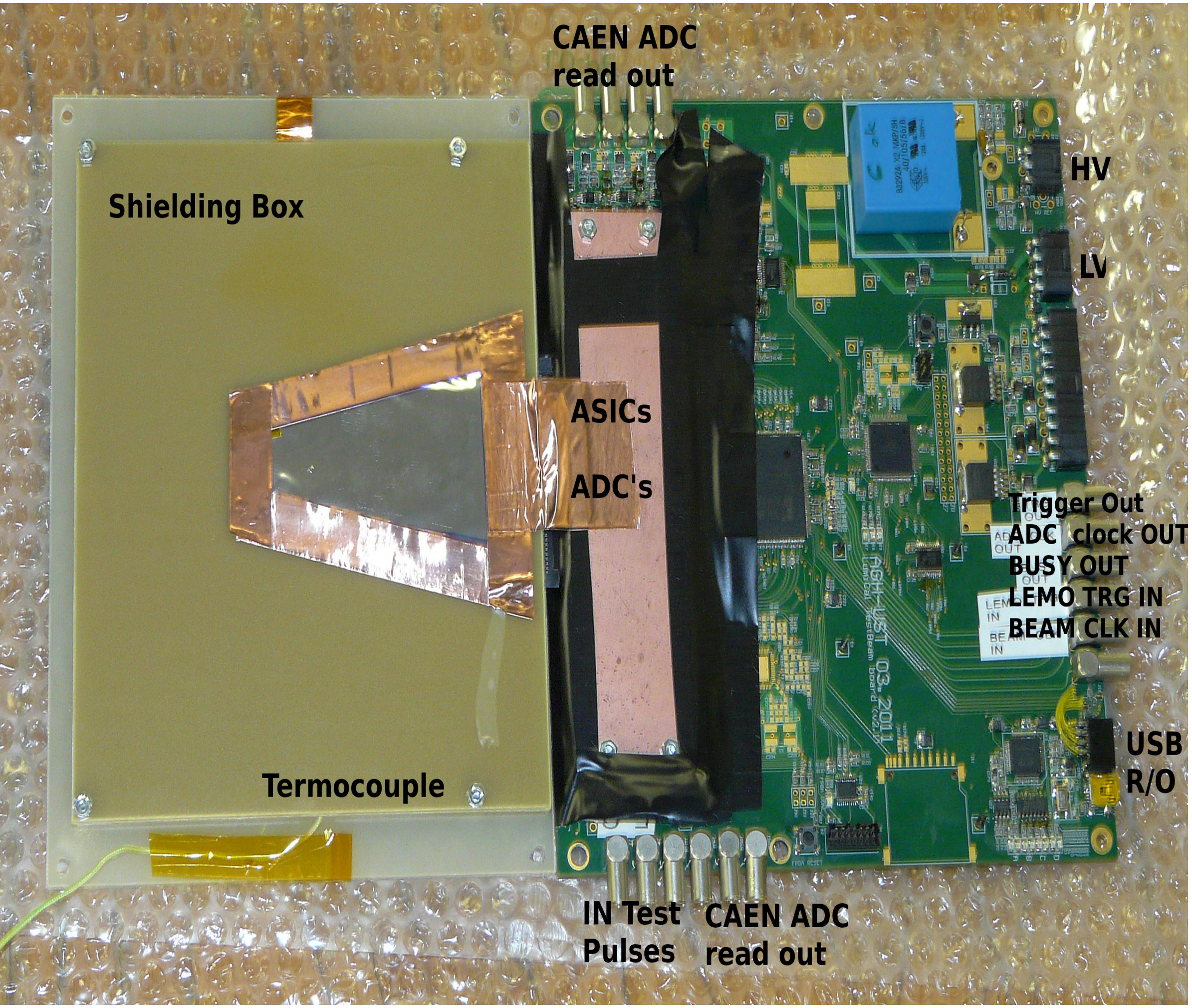
- 5 sensor planes will be assembled this year for two sensor types (Si and GaAs)

- Test beam is expected 2013-2014



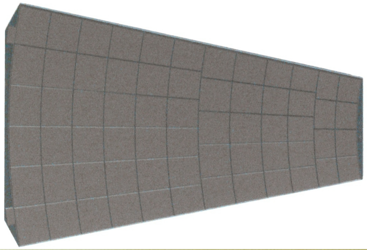
Prototype Structure

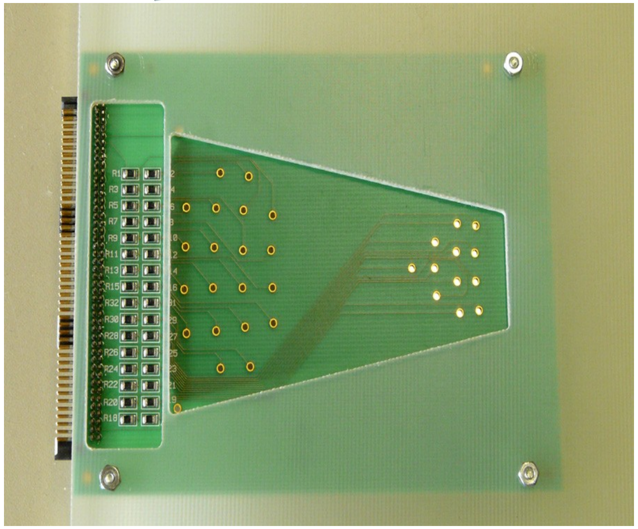
> GaAs sensor planes – 22 all together, Fanout PCB for 32 channels



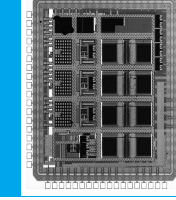
GaAs – semi-insulating material

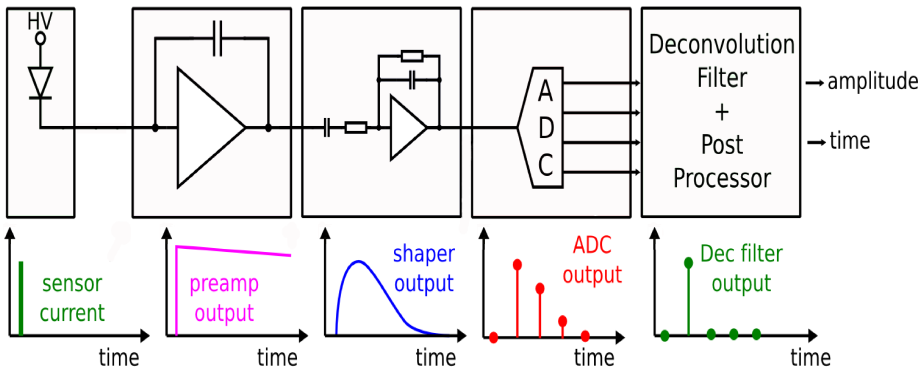
> Ionization chamber





Front End Electronics:



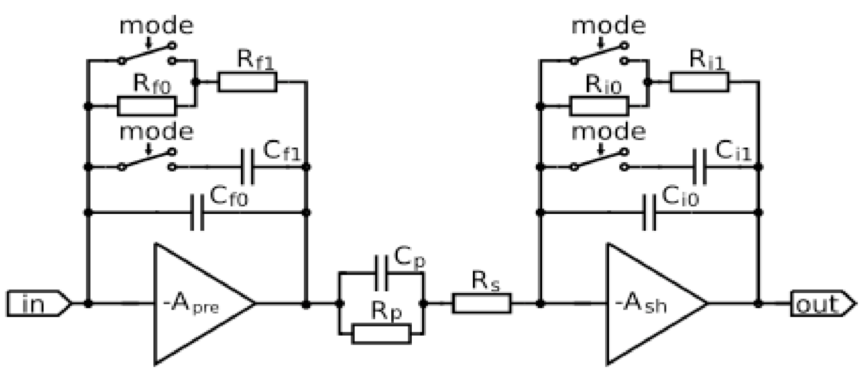


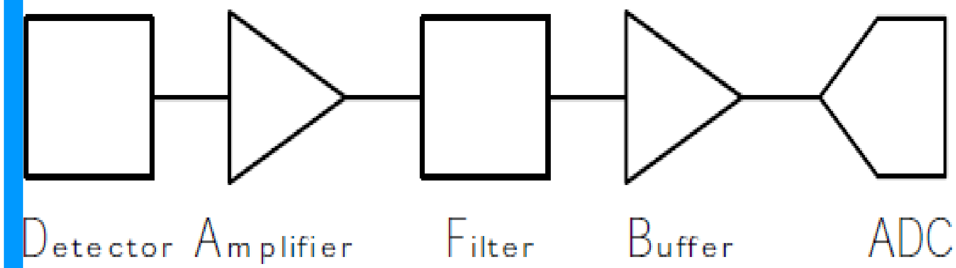
LumiCal FE and ADC ASICs (350 nm AMS Technology → new development in 180 nm)

Two Gains + Two feed back technologies (R_f and MOS) → 60 ns peaking time

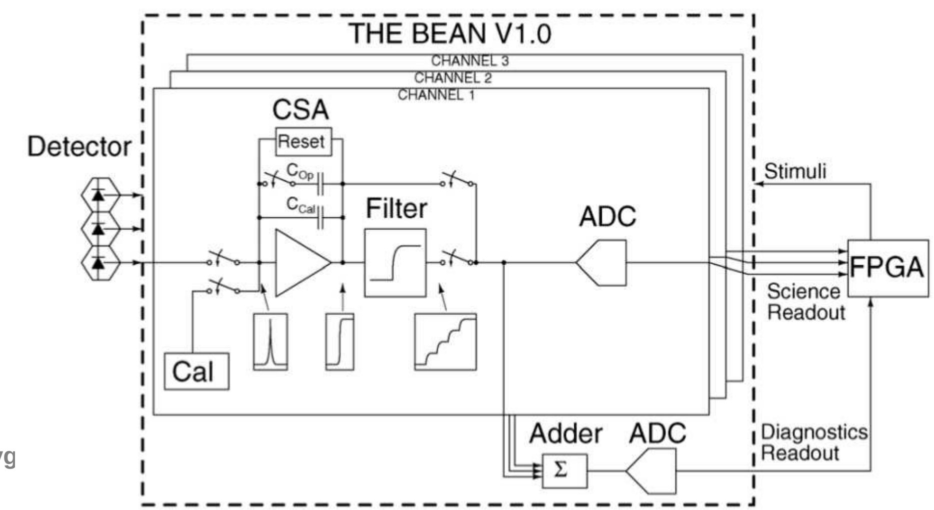
Compatible with both Si and GaAs

→ Used for all Test Beams (2010-2011)

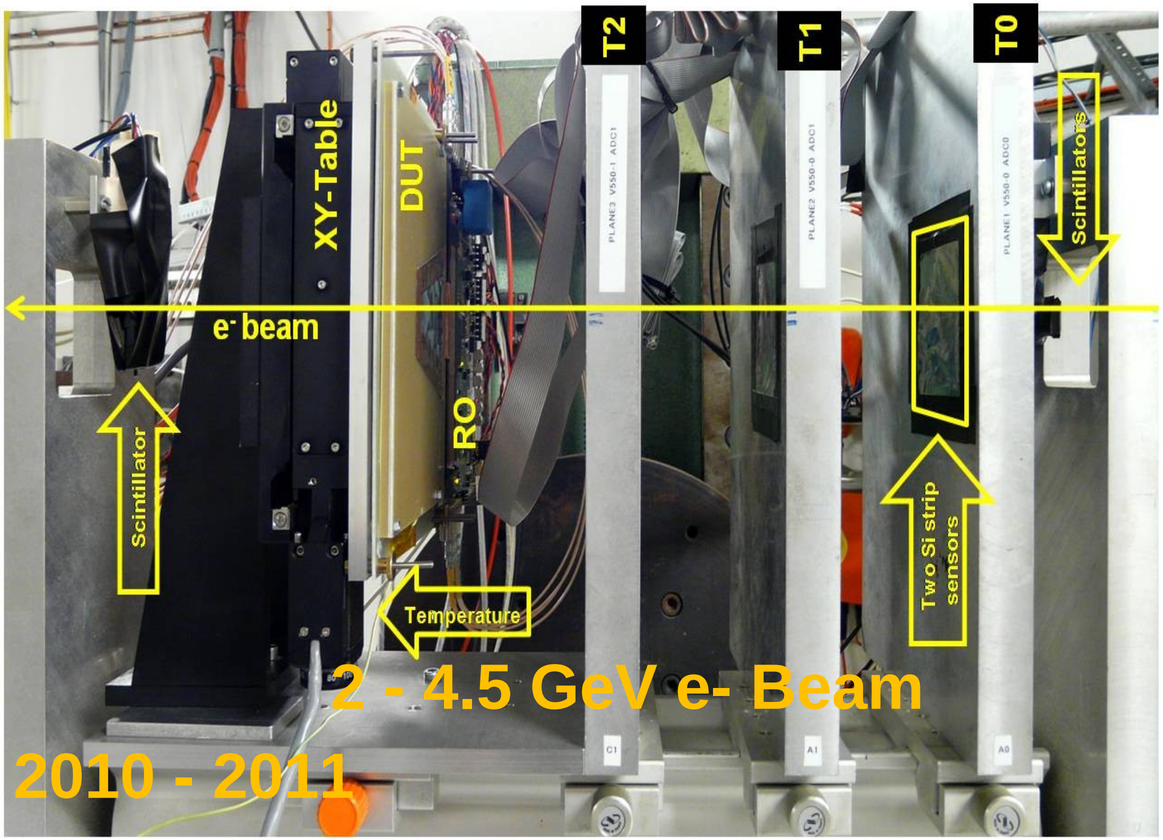




BeamCal prototype for a few channels is designed and is currently under test (180 nm mixed-signal technology)



Test beams – Hamburg (DESY II)



- 3 scintillators for trigger
- 3 pairs of single sided Si strip detectors ($3x3\ cm^2$)
- Strip pitch of 25µm, readout pitch of 50µm

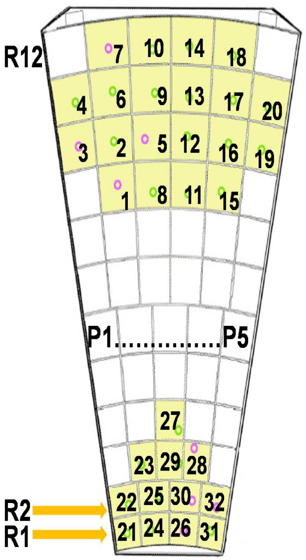
- Next Test Beam → EUDET Pixel Telescope

2010: GaAs+Fanout+FE ASIC (8 channel readout)

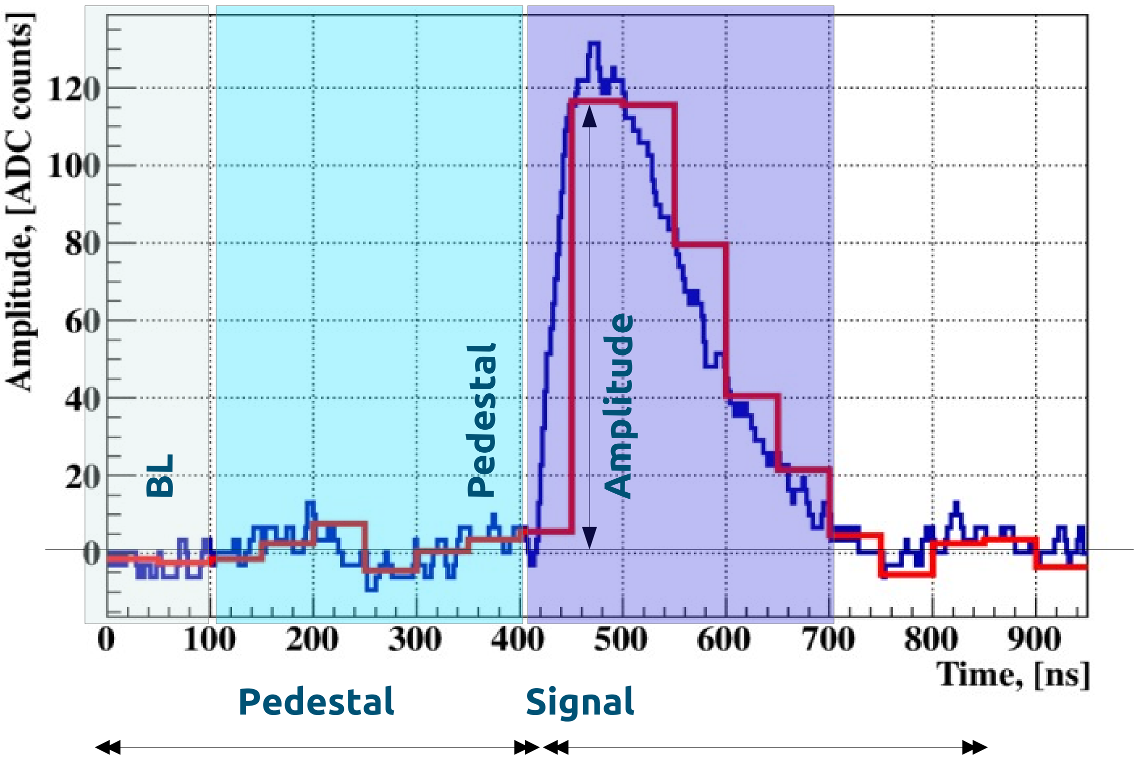
2011: GaAs+Fanout+FE ASIC+ADC ASIC (32 ch)

2012: Analysis

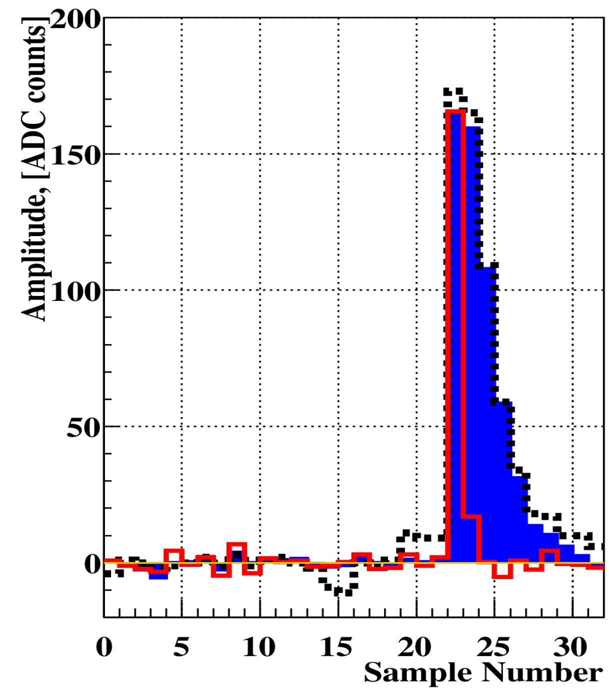
2013: Test Beam Preparation + Simulation



Read Out

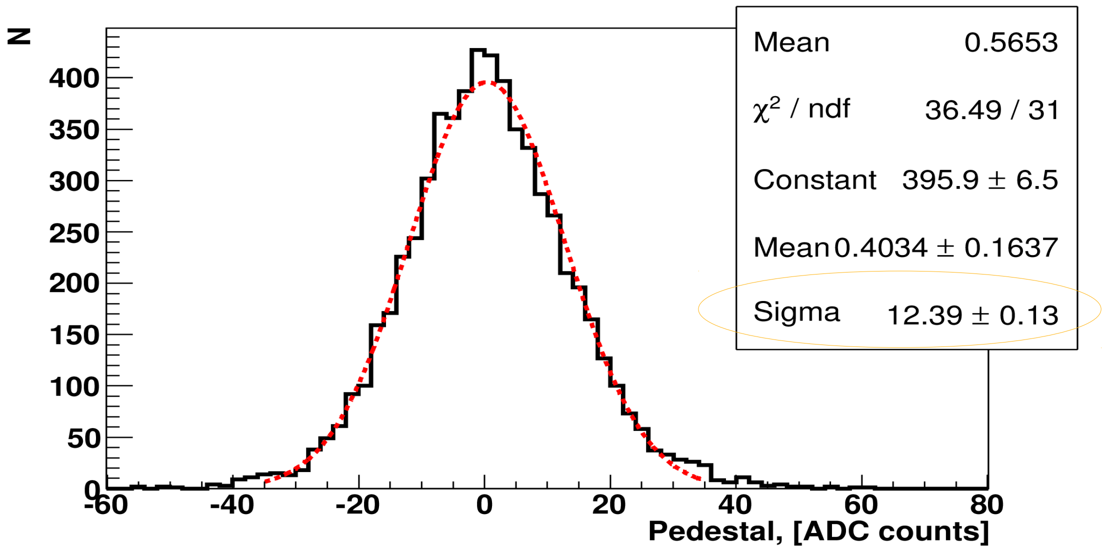


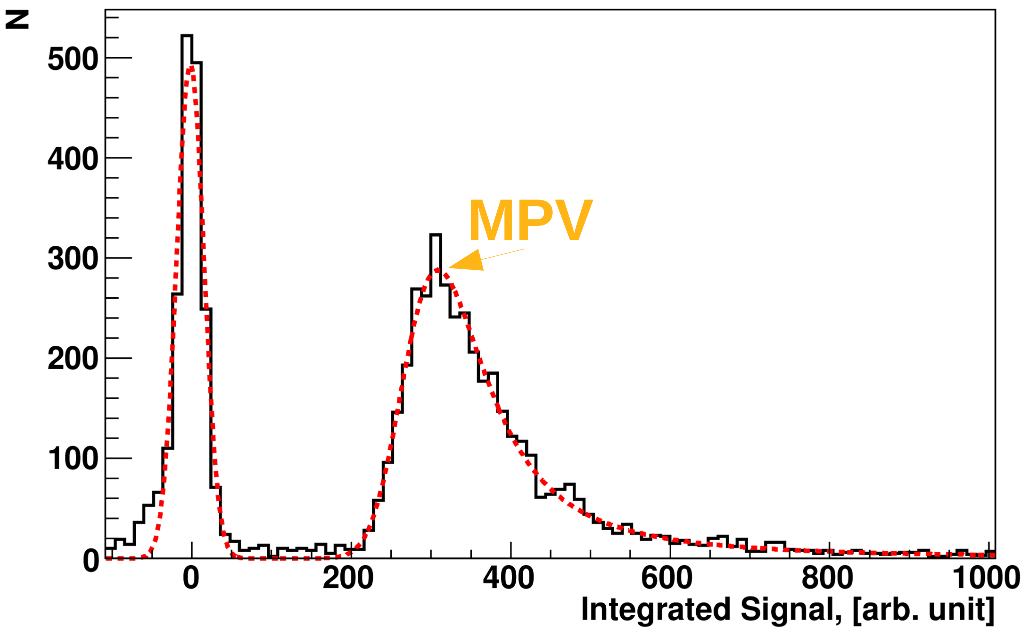
$$V_k = w_1 V_k + w_2 V_{k-1} + w_3 V_{k-2}$$



- Two ADC → Two sampling time (CAEN ADC → 2 ns, ASIC ADC → 50 ns)
- Two ADCs measurements were compared and correlated to each other
- Analysis → Amplitude, Integral, Deconvolution Amplitude (Was designed to be implemented on chip fast analysis → reducing the processed data)

Spectra





Pedestals, Amplitude, Integral and Deconvoluted amplitude spectra are collected

Fitted by Gaussian and Landau& Gauss convoluted functions

MPV of the spectrum represents the signal

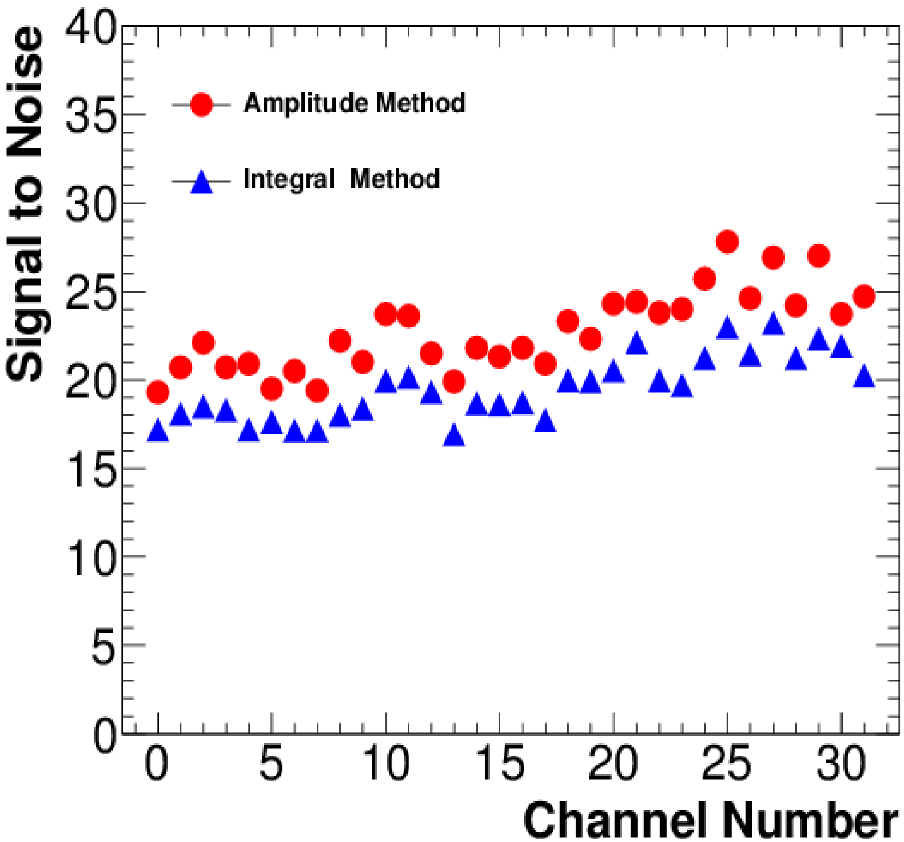
Sigma of the pedestal distribution – noise

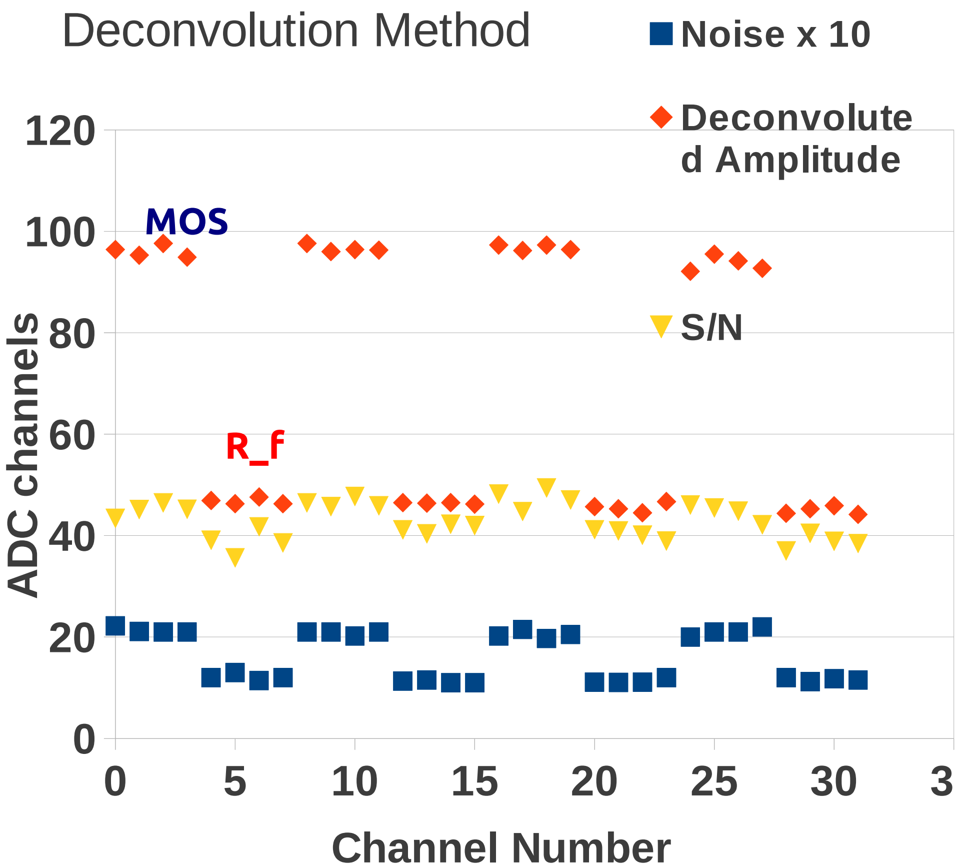
S/N = MPV/Pedestal Sigma

In addition:

CMN was detected and subtracted

S/N Stability





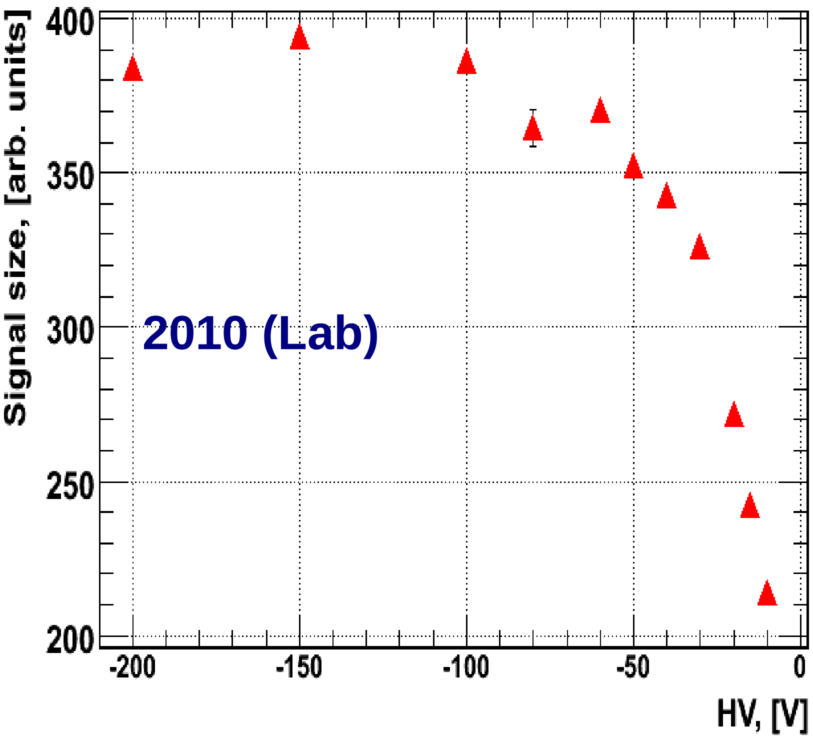
Uniform distribution for tree methods

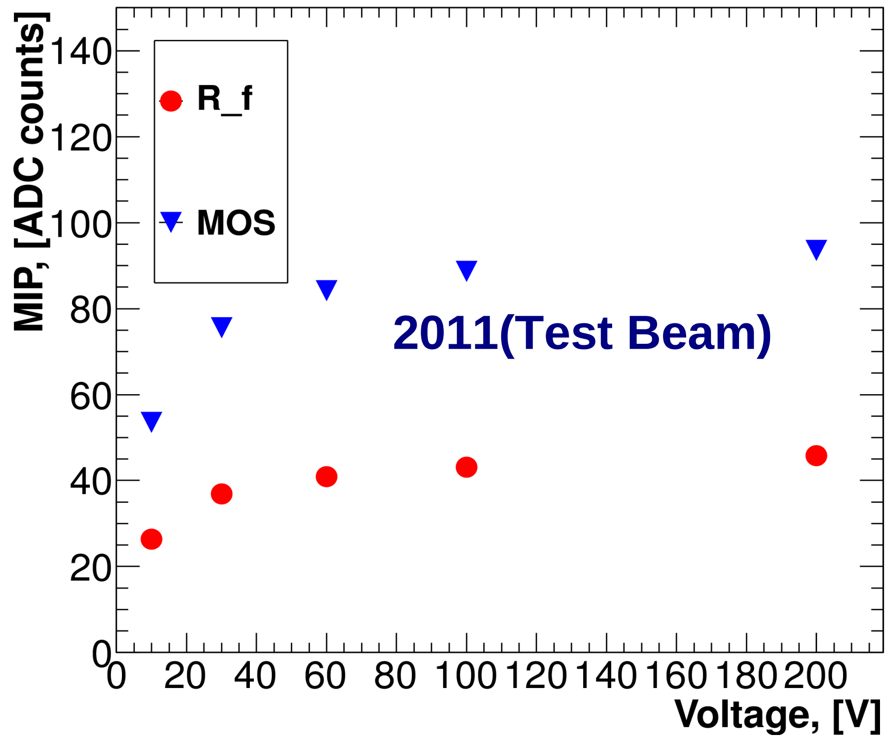
Amplitude and Integral methods showed slight increase

Deconvolution method is more feedback dependent

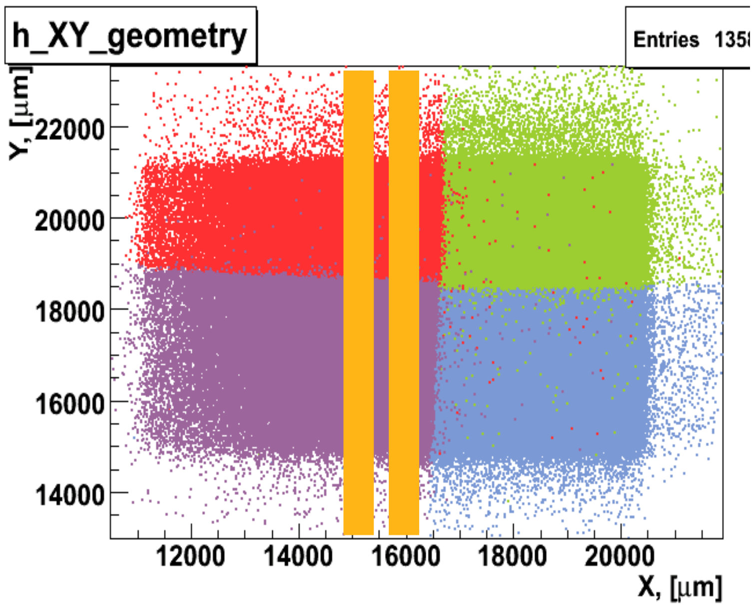
Signal Size vs HV

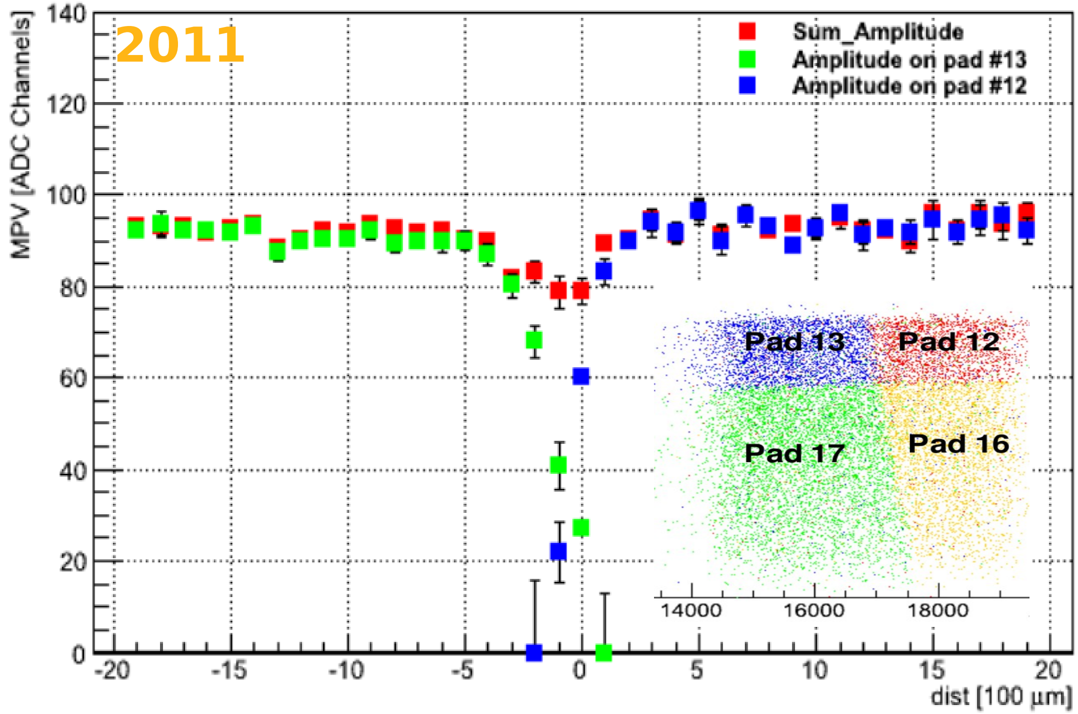
Charge Collection Efficiency as a function of voltage for a few pads in the lab and on the test beam.
CCE = ratio between collected and generated charge in the pad.
Generated charge is calculated from GEANT3 simulation.
In the saturation CCE = 42%





Pads Gap Investigation (TB2011)

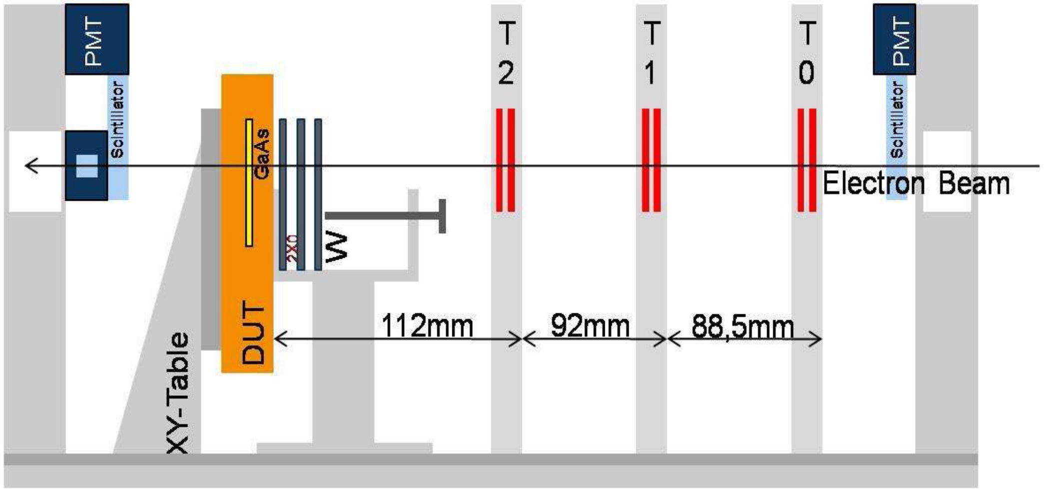




- > **Tracks are reconstructed from 3 telescope planes with linear fit**
- > **2010-2011 studies**

- > **Signal sum (MPV) in stripes between 2 pads is presented.**
- > **Signal sum (MPV) of two pads shows decrease on ~15% in 200um gap between pads**

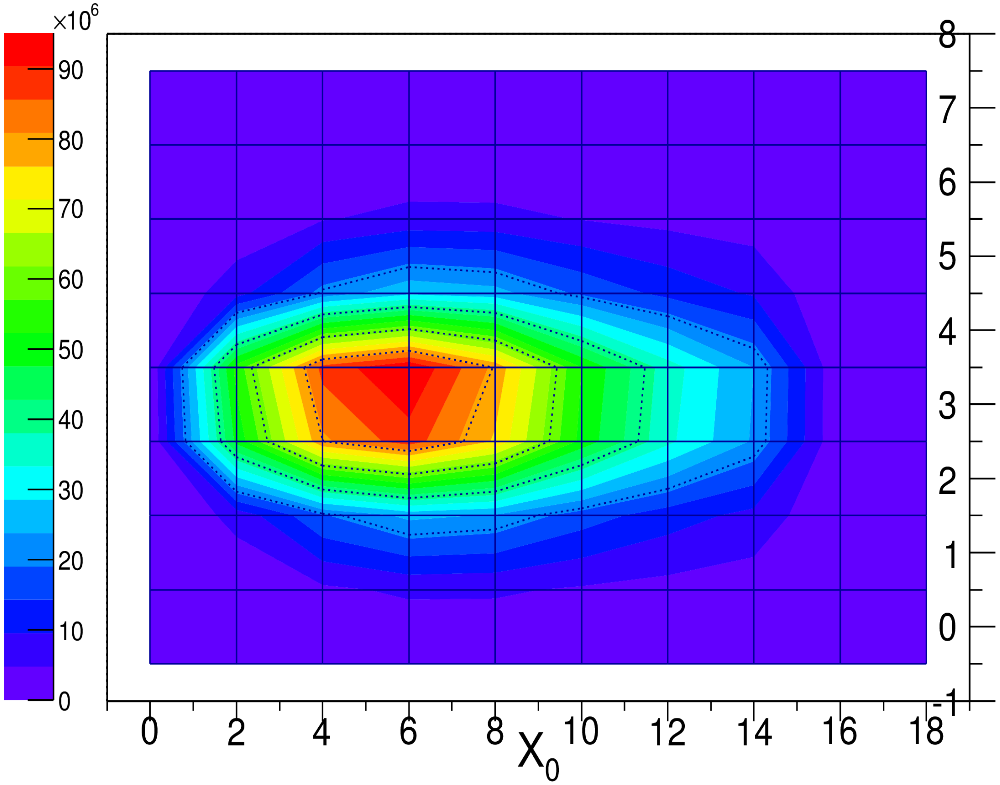
Multiple Particle Irradiation

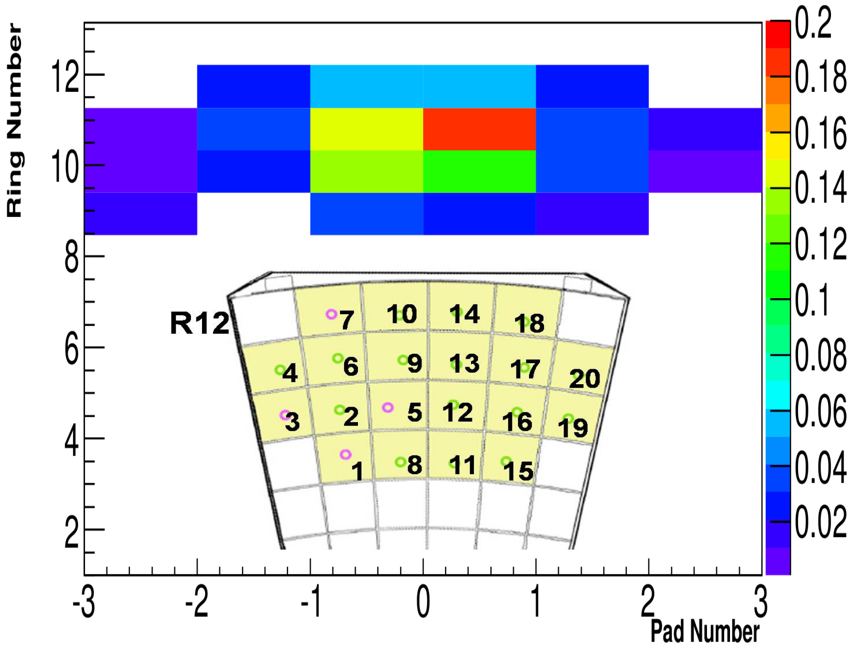


Two modes of operation → Calibration, Multiple Particles Operation.

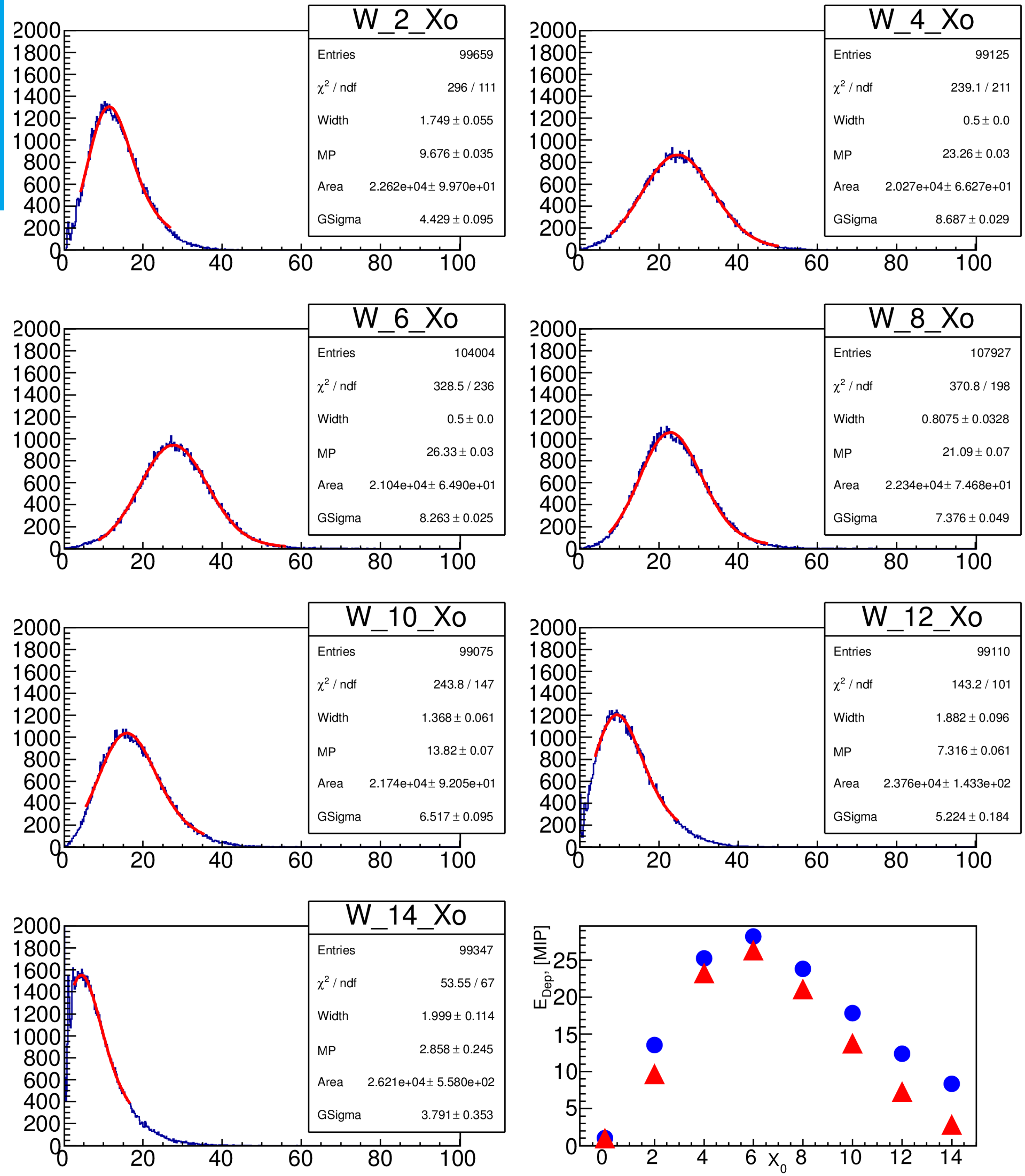
To see BeamCal prototype with multi particles hits (with W-plates).

Telescope helps to predict position of the shower.



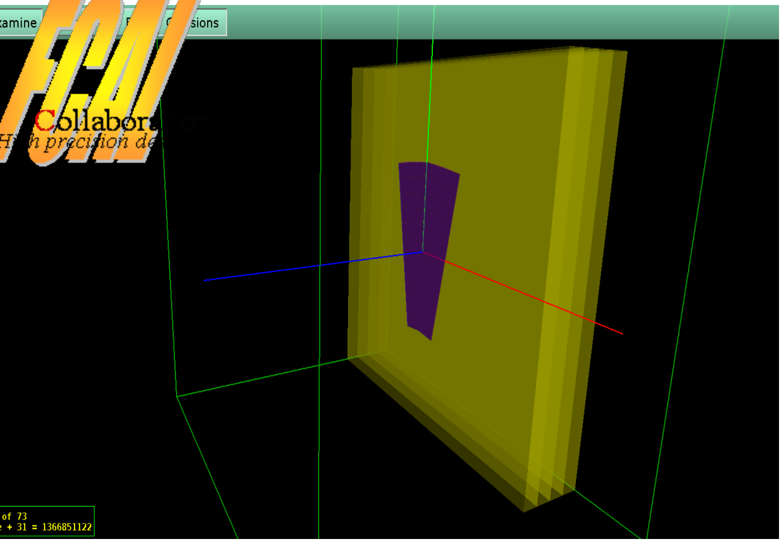


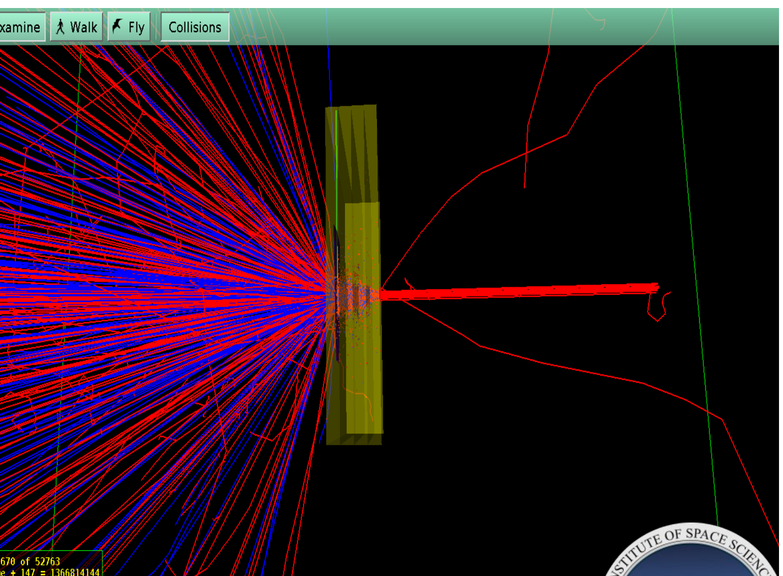
W → HH



- **Blue – MPV from the fit**
- **Red – Mean value of histogram**
- **Simulation is missing**

MC Simulation





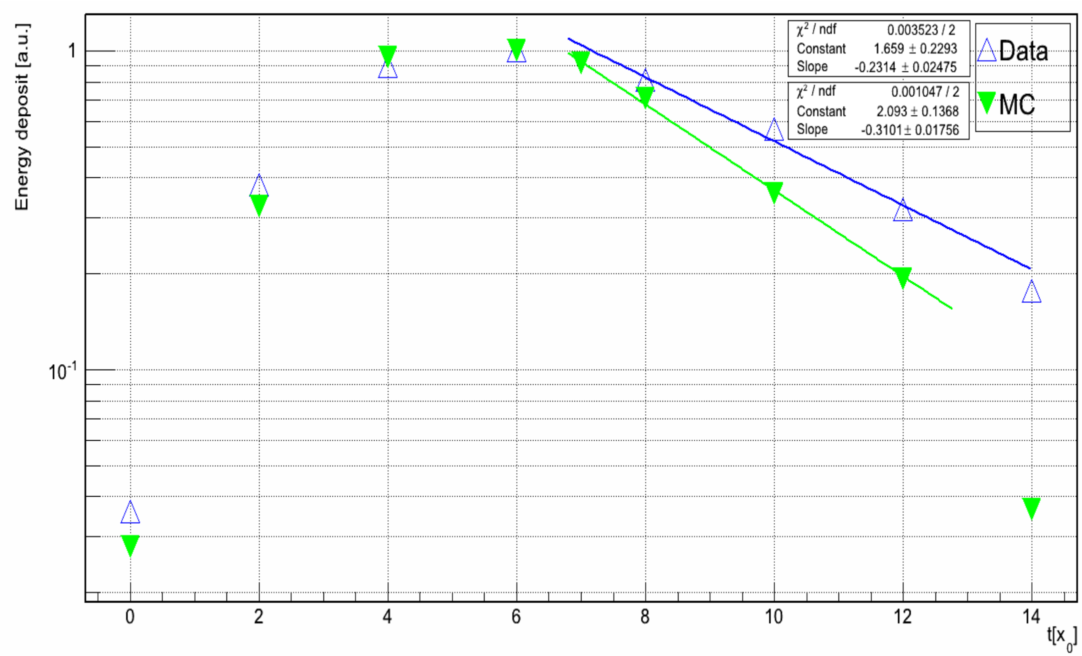
Tracking example for 8 X0 tungsten

T. Preda, V. Ghenescu

Particle Gun definition:

- Incident particles: e-
- Beam energy: 4GeV
- Gauss distribution of beam with σ = 3 *mm*

- Energy deposition per layer is compared with measured → Not consistent jet in the tail of the shower



Conclusions

- Two GaAs sensor planes were tested at the electron beam in 2010-2011.
- Functionality of the chain: FE ASIC + ADC ASIC + fan-out + sensors, positively verified on test beam

Result:

- Operation at room temperature & Low leakage current
- 3 methods (Amplitude, integral, Deconvolution) with stable S/N
- High S/N ratio
- Noise is capacitance dependent
- CCE up to 50% in the HV – saturation
- Radiation hardness up to 1.5MGy
- Spectra uniformity in central part of pads
- ~15% loss of signals in gaps between pad

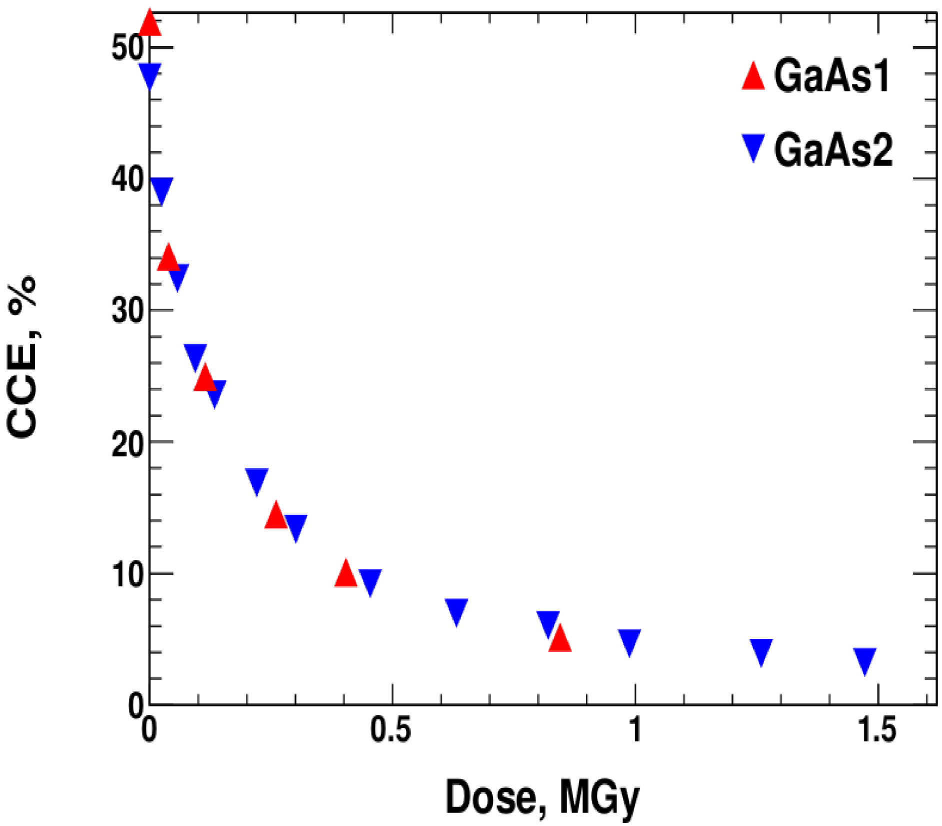
Future:

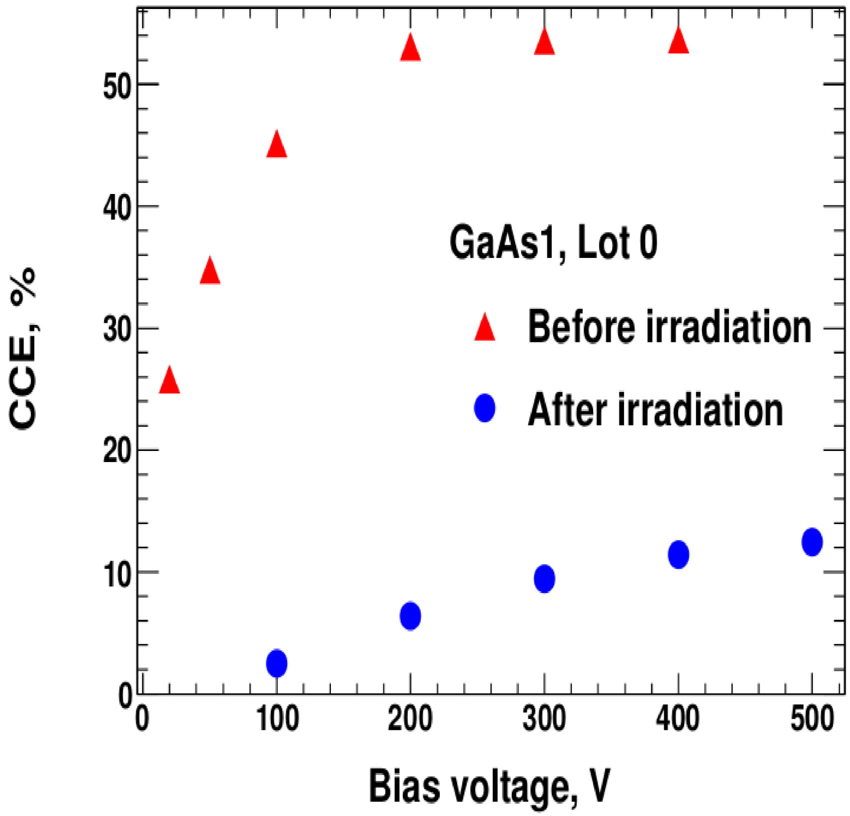
- AIDA infrastructure + 5 FE Boards + 5 Sensors → Shower profile measurements → Comparison with GEANT4

Thank you for your attention!

Back Up Slides

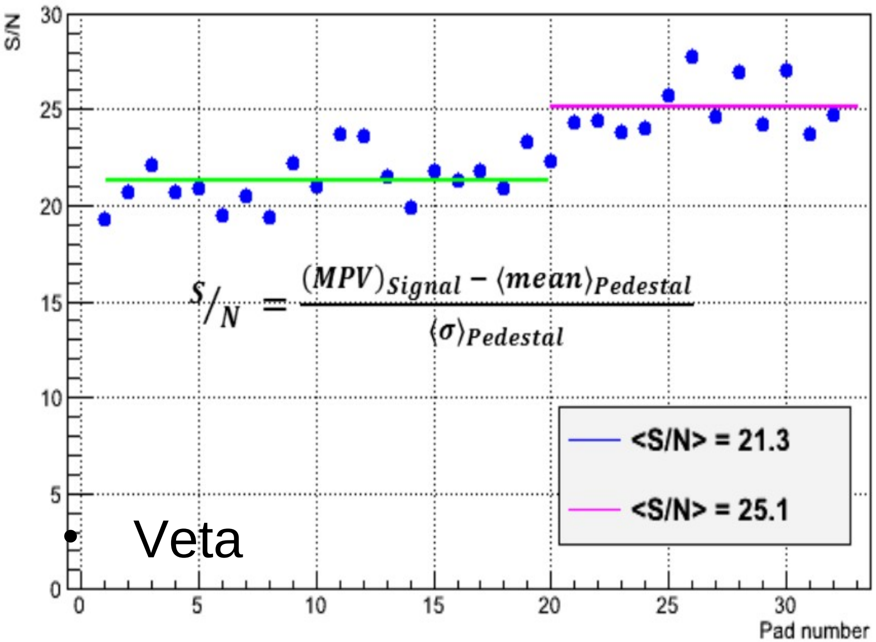
Radiation Degradation

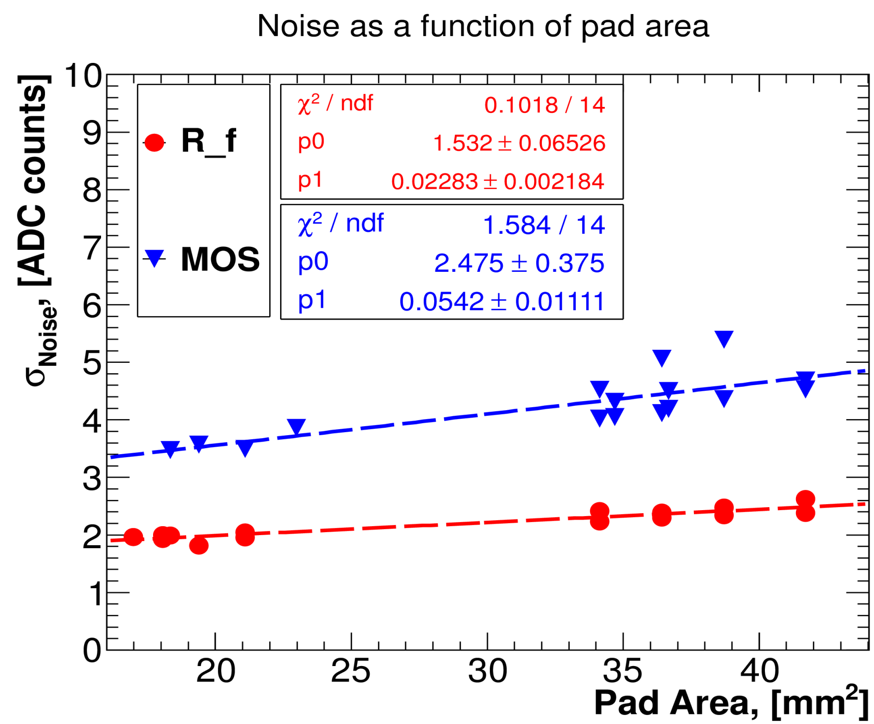




- **The CCE as a function of accumulated dose for two pads of GaAs sensor sector**
- **The CCE as a function of applied voltage for the same pad of GaAs sensor sector before and after irradiation**

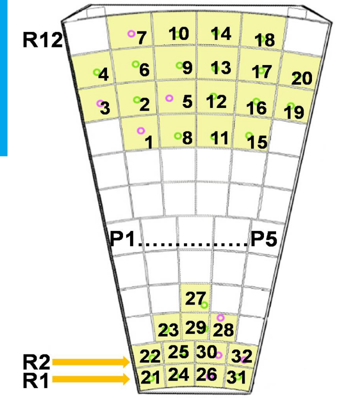
S/N (Amplitude Method)



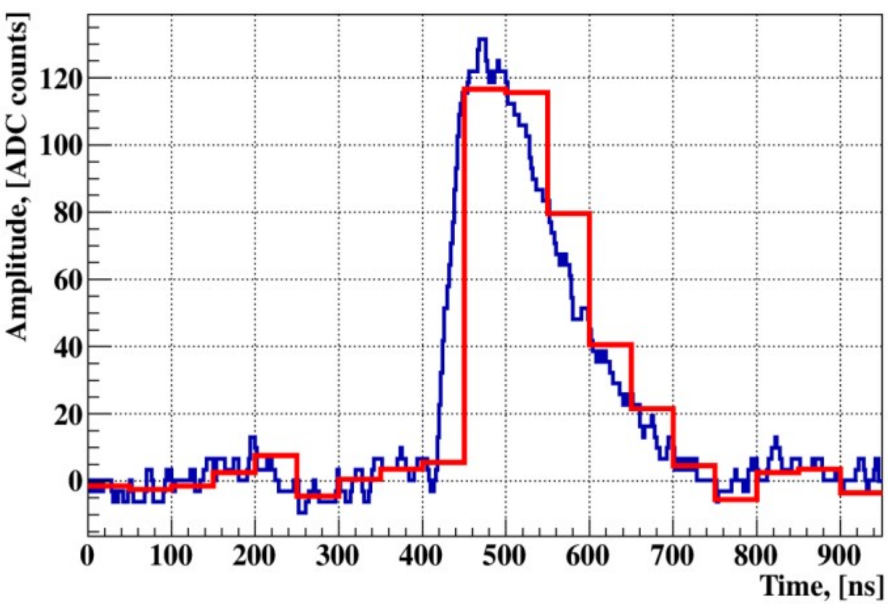


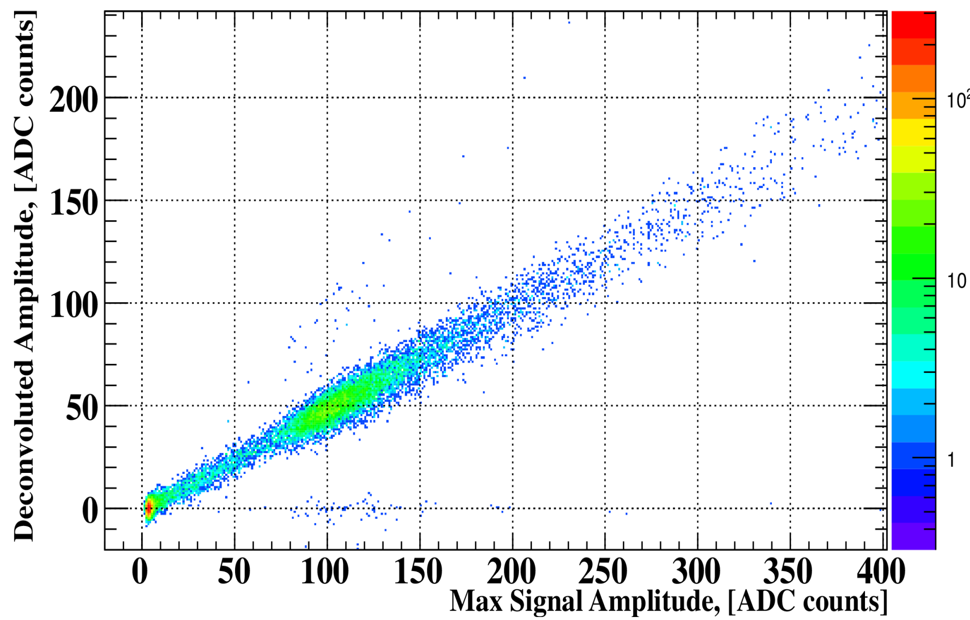
- **The amplitude method shows stable amplitudes for all channels, but S/N is different**
- **Noise shows the dependence on the pad capacitance**

Different DAQ and ADC



Purpose:
See difference in operation with different ADCs to be able to compare the signals.



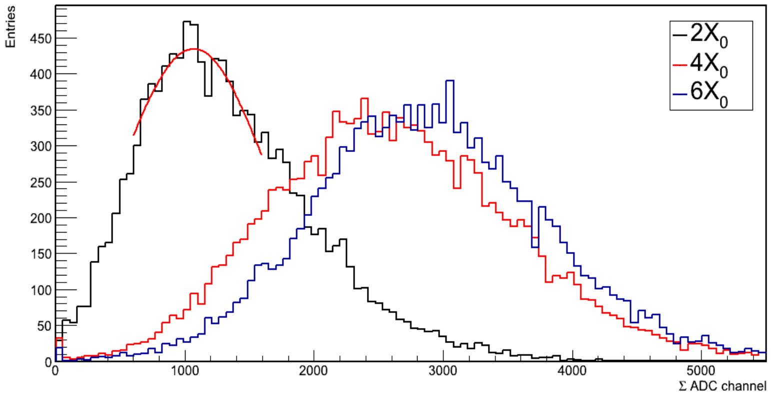


Allowed to see CMN (but not enough channels to subtract)

S/N 11-22

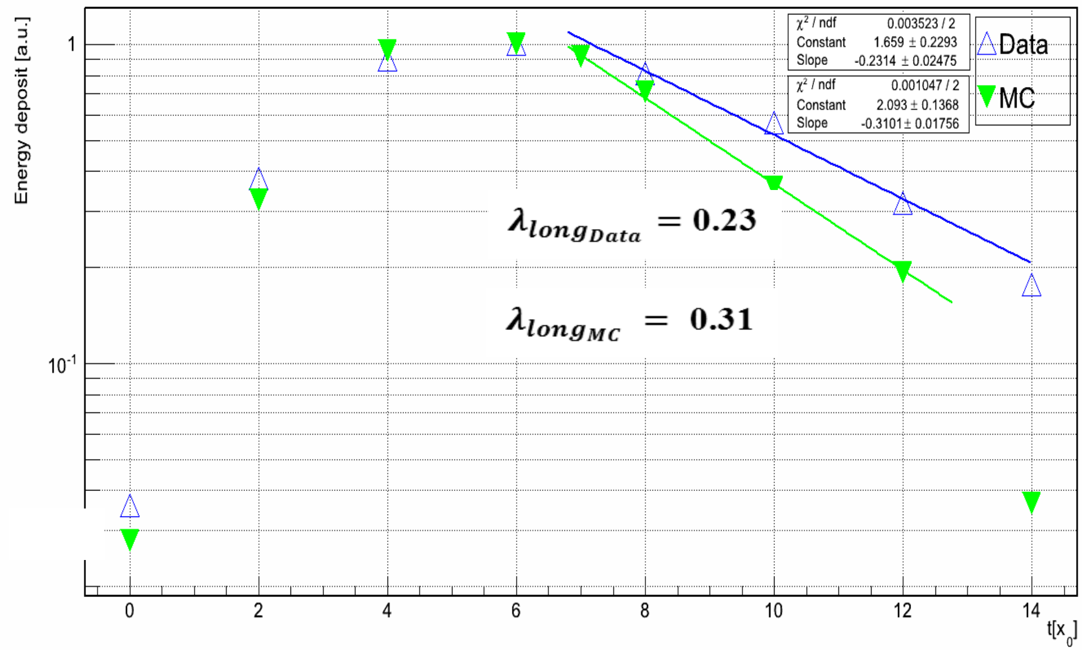
Compare two ADCs

Longitudinal shower distribution

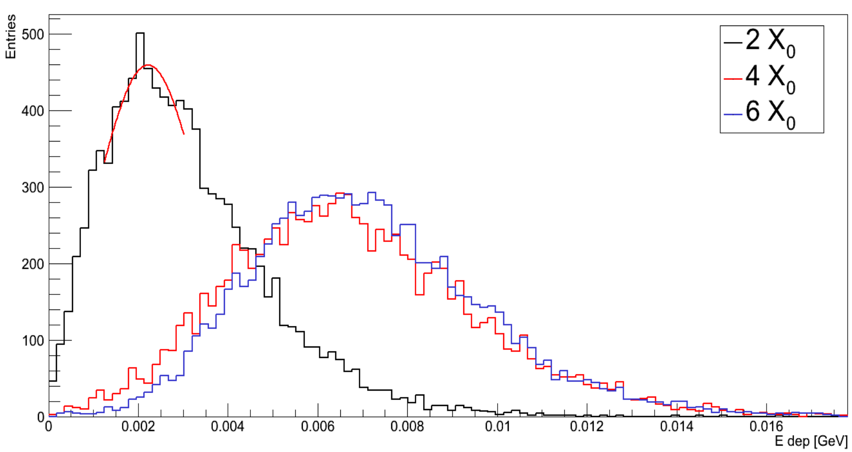


f(*Stotal*) = …

$S_{total} = \sum S_i$: where i – active pads



The energy deposited dependence by tungsten radiation lengths for experimental data and MC simulation, respectively



Olga Nov