Very Forward Calorimetry

Project : 6

ESR : Olga Novgorodova

Supervisor: Pr. Wolfgang Lohmann

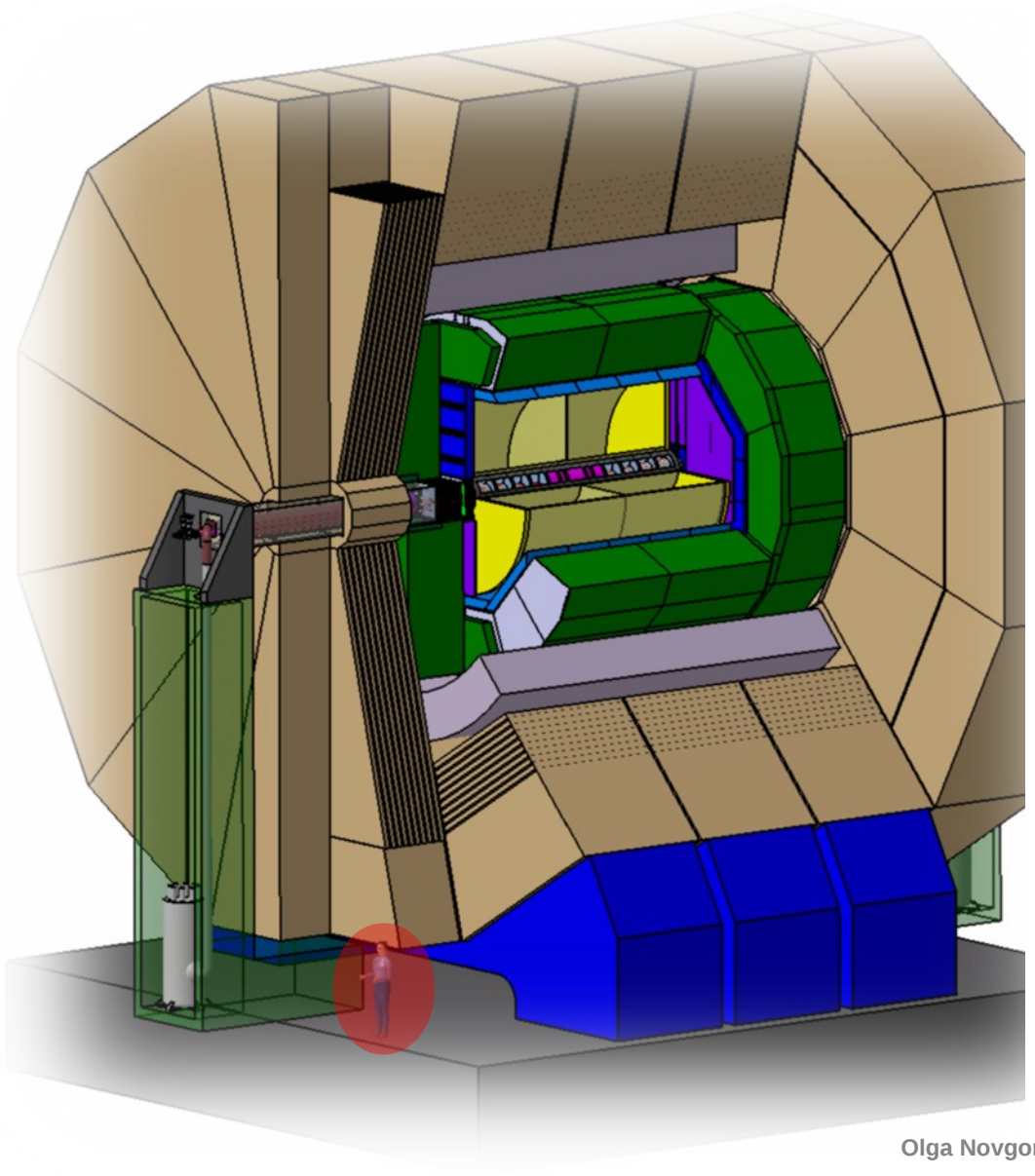
20-22 September 2012 at Frascati20/09/2012


Test-beam crew 2011

Outlook

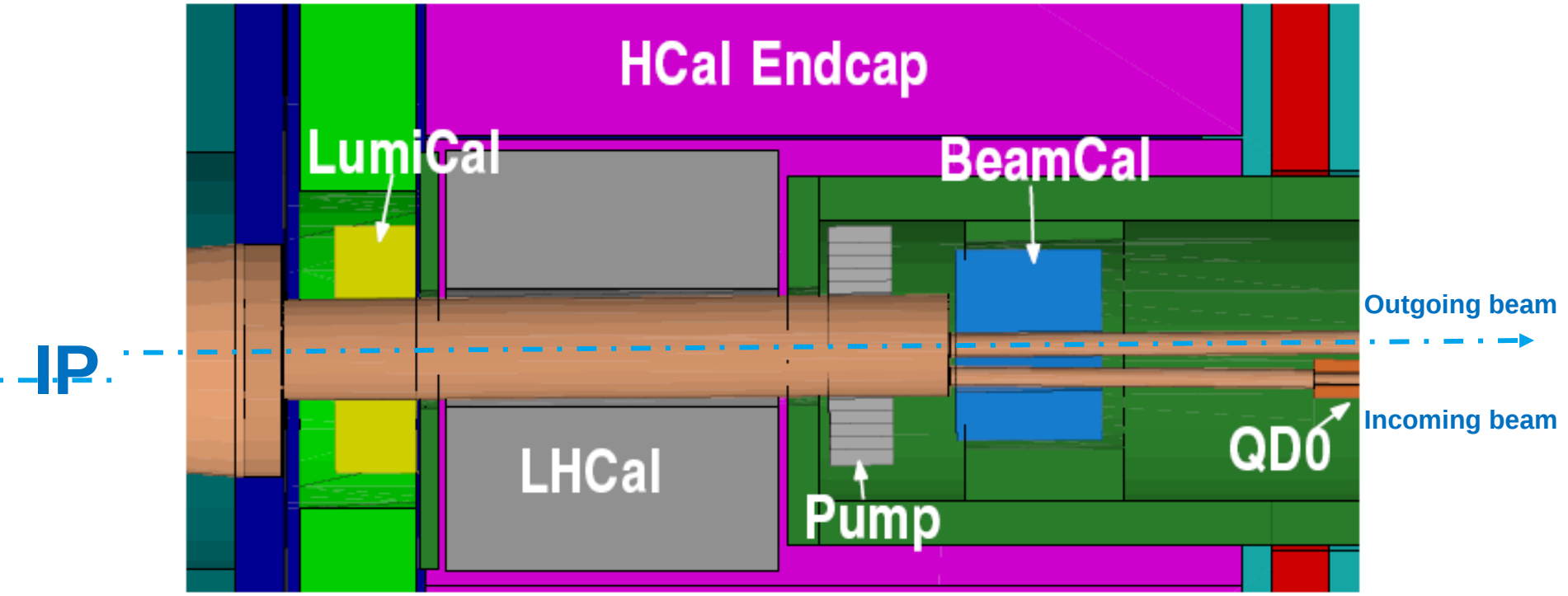
- Motivation
- ILD, Forward Calorimeters
- Monte Carlo
- Collaboration
- Radiation Hard Sensors
- Test Beams
- Data analysis
- Personal Evolution

International Large Detector



- Multi-layer **pixel-vertex detector (VTX)**
- **Time projection chamber (TPC)**
- **Electromagnetic CALorimeter (ECAL) -** highly segmented
- **Hadronic CALorimeter (HCAL)** highly segmented
- **Superconducting coil**
- **Iron yoke**
- **Forward region:**
  - **-Luminosity CALorimeter (LumiCAL)**
  - **-Beam Calorimeter (BeamCAL)**

Forward Region



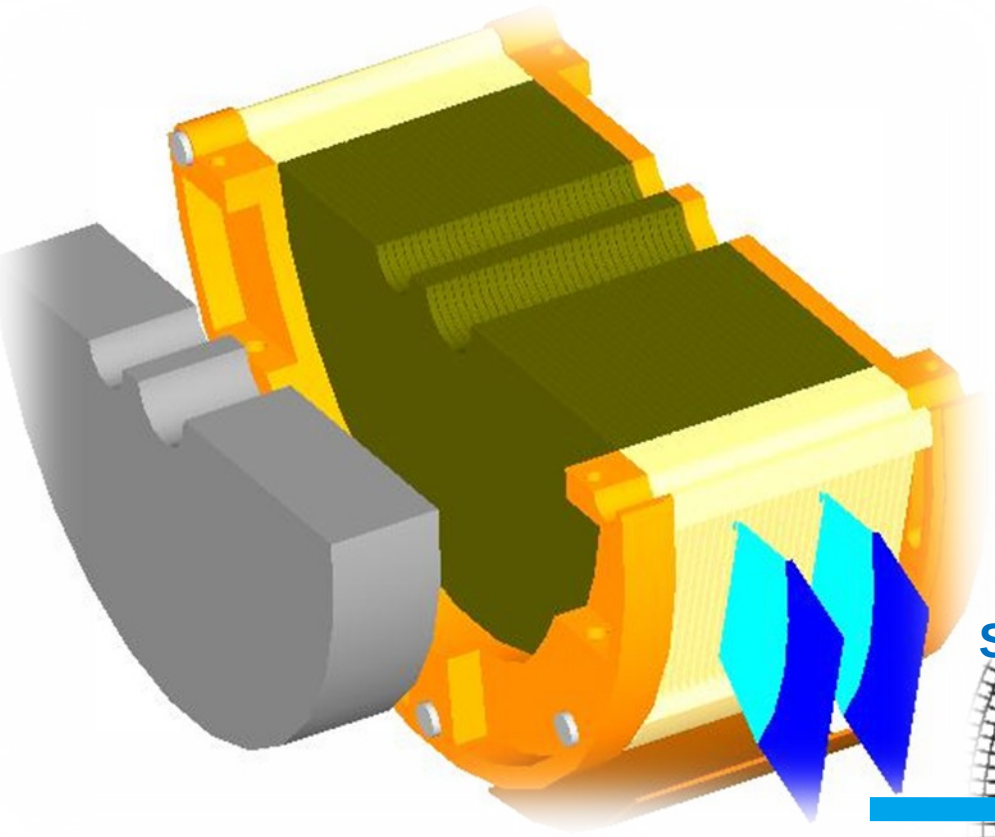
Precise luminosity measurement,

Hermeticity (electron detection at low polar angles),

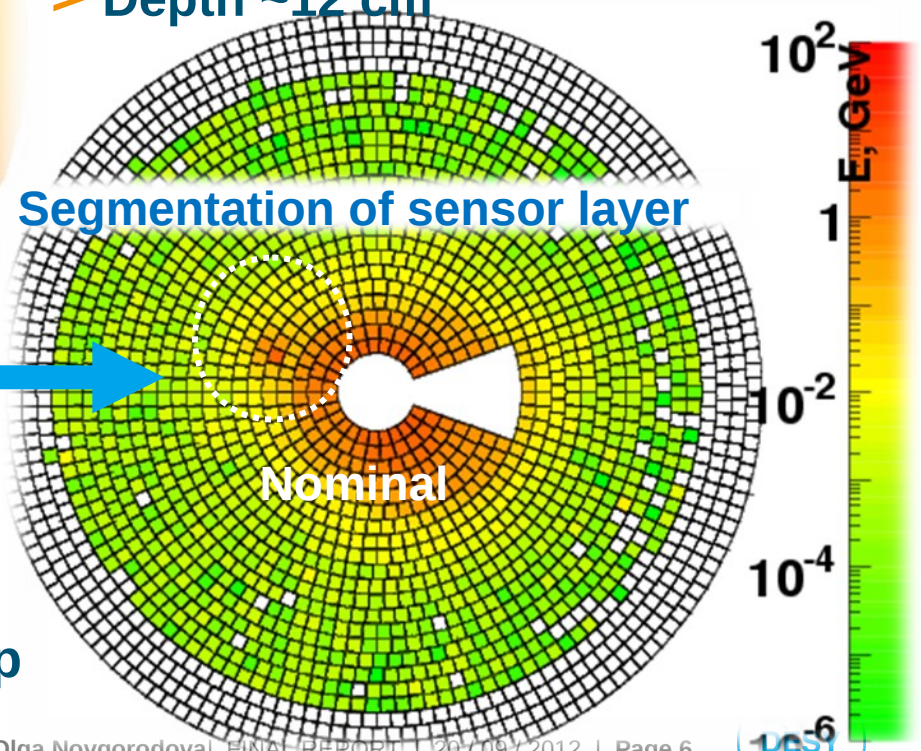
Assisting beam tuning (fast feedback of BeamCal data to machine)

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

Beam Calorimeter



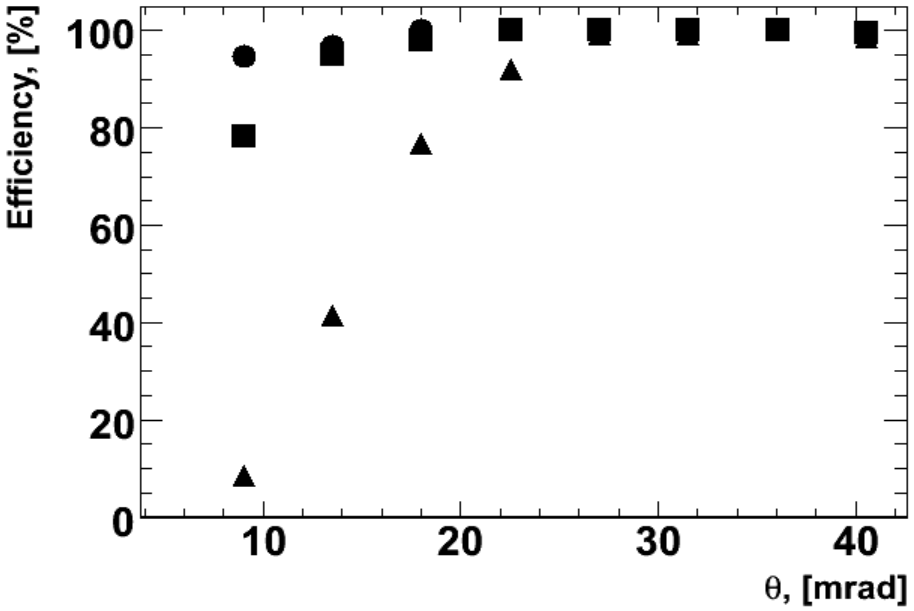
- Around Beam-pipe
- 30 Layers
  - Tungsten absorber:
  - Sensor layer
- Outer radius 15cm, inner radius 2cm
- Depth ~12 cm

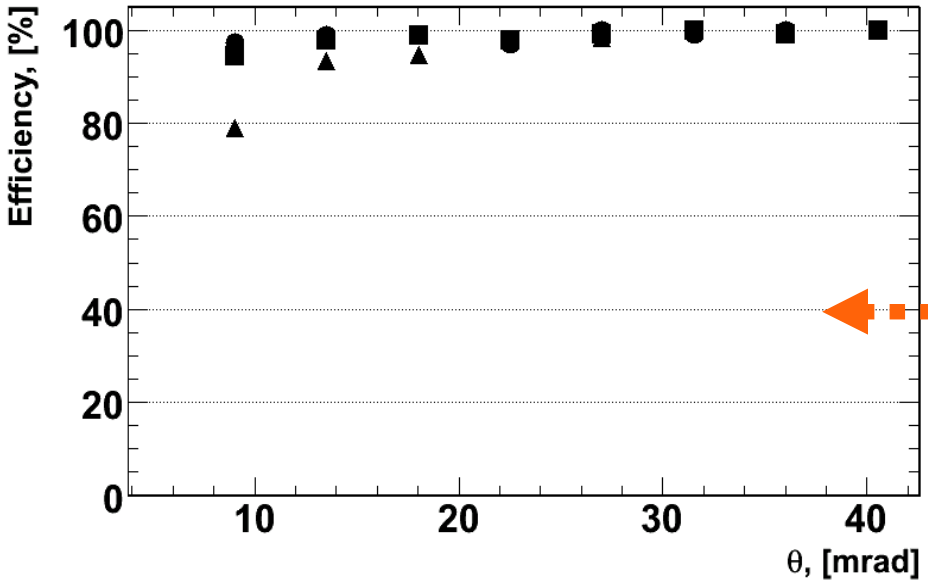


Sensor segmentation 8x8 mm²

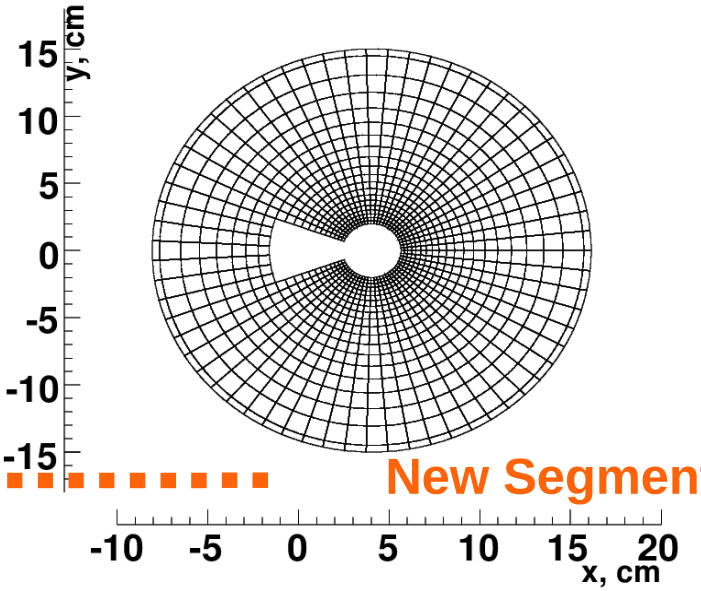
Expected dose in the inner rings up to 1 MGy per year

Cluster Search Algorithm





- Algorithm for cluster search
- New Segmentation proposed
- Two segmentations compared



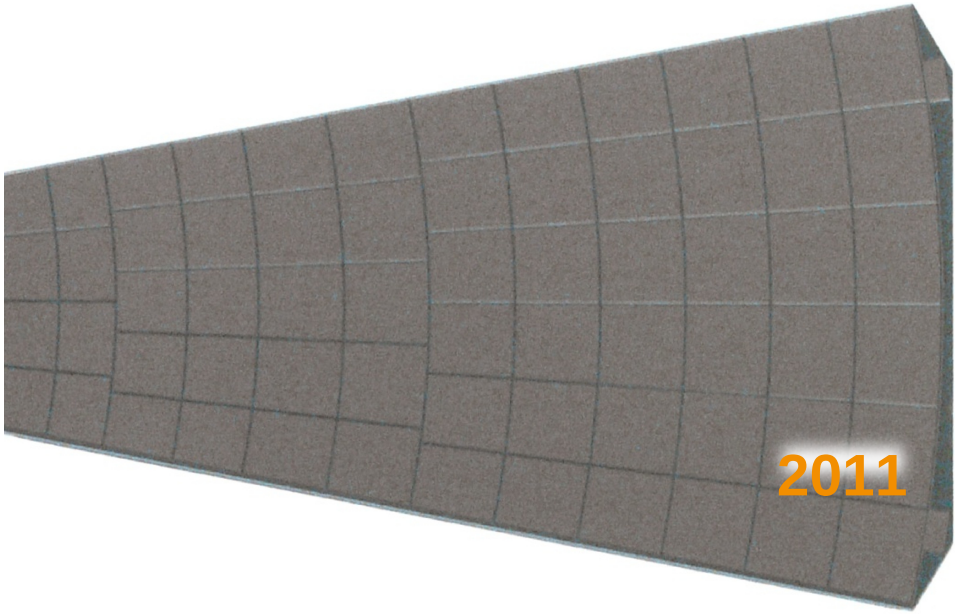
New Segmentation

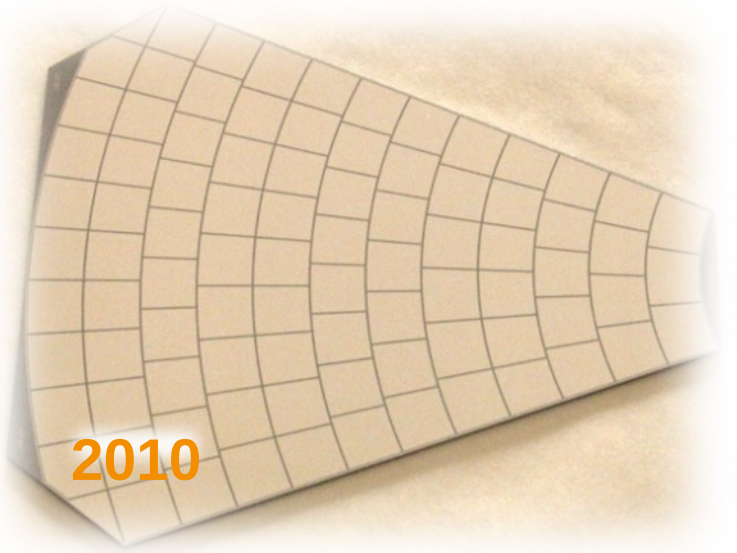
BeamCal Sensors

Sensor Candidates

->GaAs or Di (BeamCal), Si (LumiCal)

Operation principle as ionization chamber





- **GaAs plate with Al or Ni metalization, 500 μm thick**

5 Sensors: 45 deg tiles, segmented into 12 rings, ~5x5 mm² pads

11 Sensors: 22.5 deg tiles, segmented into 12 rings, varying pads area 16-40 mm²

Characteristics of SENSORS

- **I-V – Current-Voltage characteristic** is a dependence of current on applied voltage (Leakage Current)

- **C-V – Capacitance-Voltage characteristic with LCR-Meter**

Does not depend from Bias Voltage

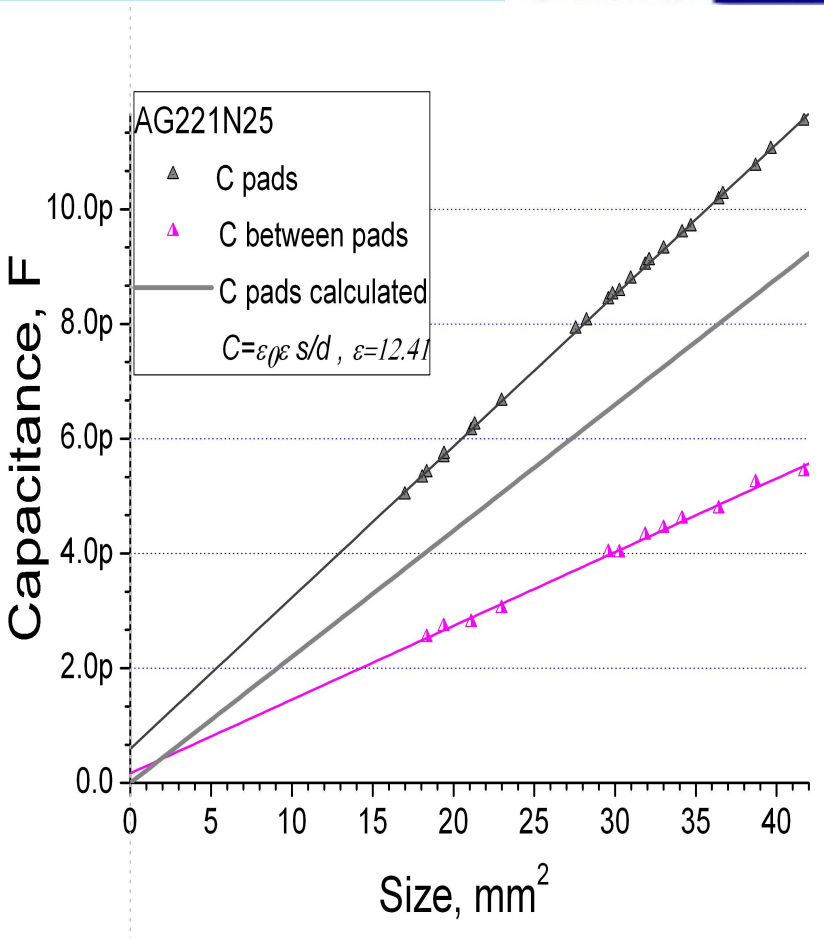
- **Charge Collection Efficiency**

$$\mathrm{CCE} = \frac{Q_{\mathrm{collected}}}{Q_{\mathrm{induced}}}$$

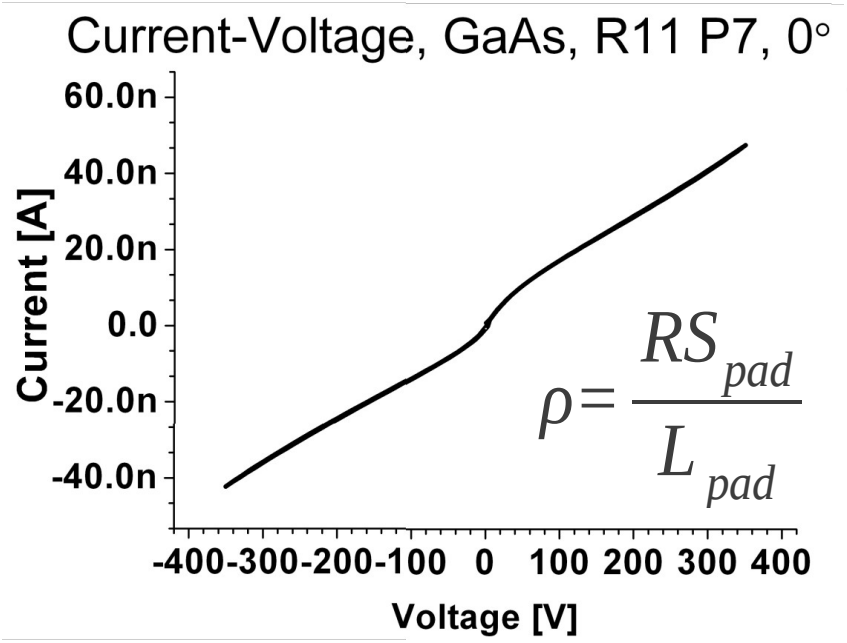
- **Geant Simulation of the setup for the induced charge calculation**

- **Signal to Noise ratio**

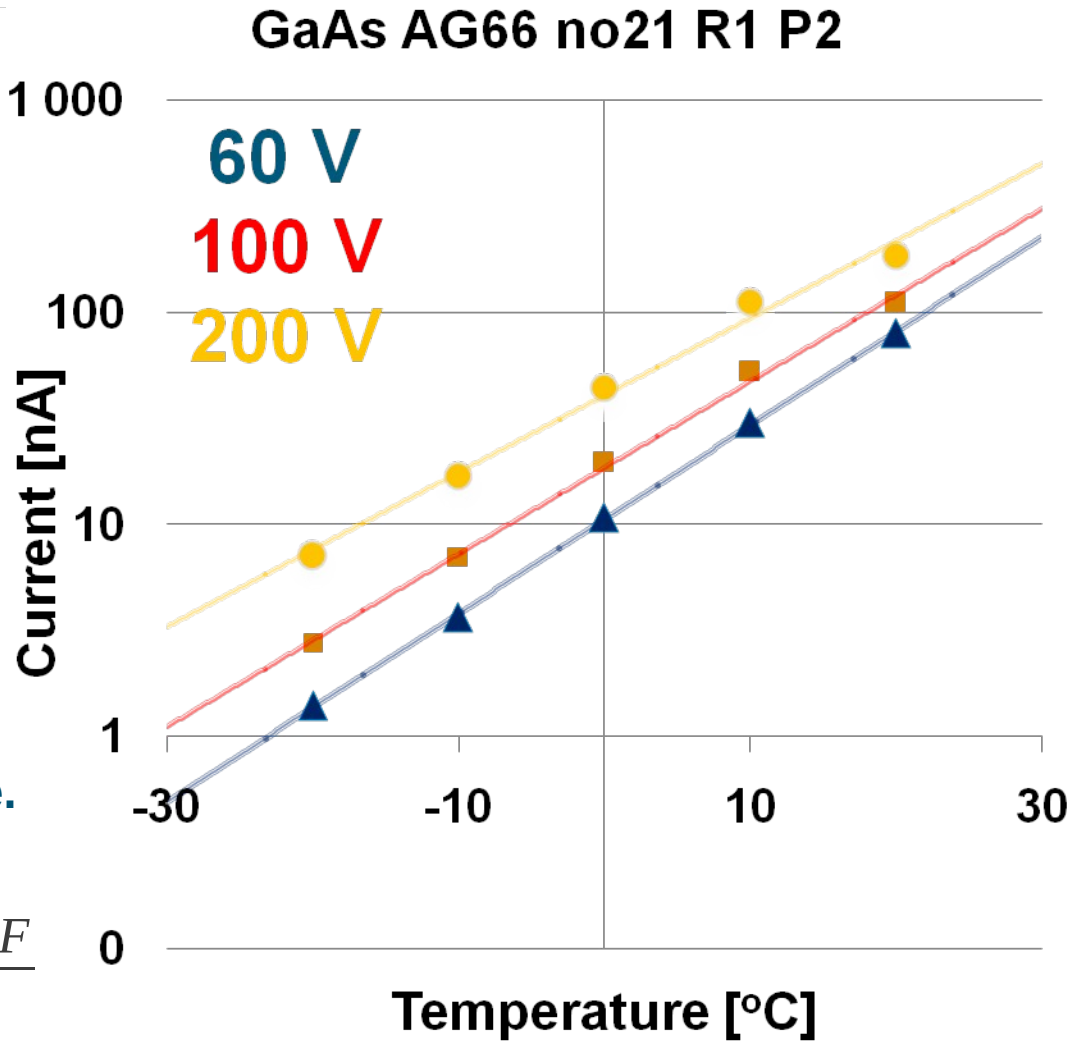
$$\mathrm{S/N} = \frac{\mathrm{MPV}_{\mathrm{Landau}} - \mathrm{MPV}_{\mathrm{Ped}}}{\sigma_{\mathrm{Ped}}}$$



Temperature dependence – IV measurements



$$\rho = \frac{RS_{pad}}{L_{pad}}$$



The leakage current of a GaAs pad sensor as a function of the voltage.

$$\bar{n} = \frac{2}{h^3}\left(2\pi mkT\right)^{\frac{2}{3}} e^{-\frac{E_c - E_F}{kT}}$$

Collaboration Activity

> GaAs sensors (measurements and analysis for leakage current and capacitances)

> ASICs + DAQ + Test Beam

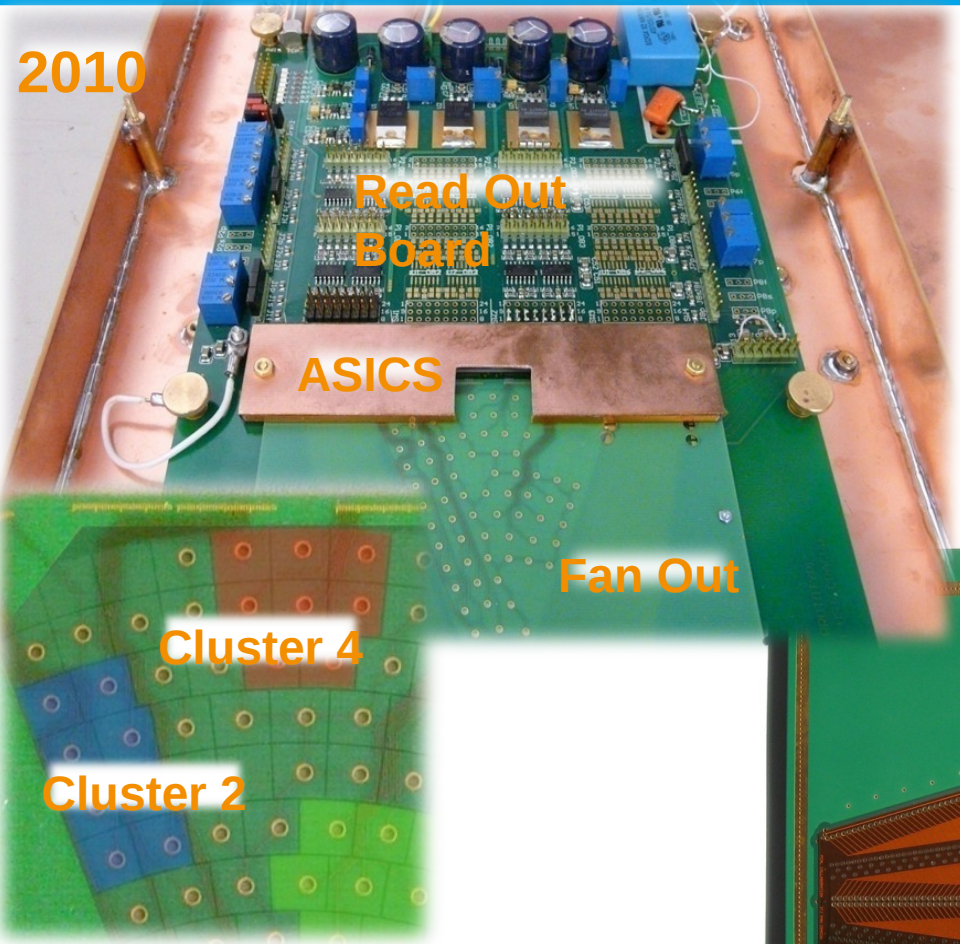
> Test Beam preparation + participation + Analysis (currently collaboration for 2011 data analysis)

> Test Beam Participation

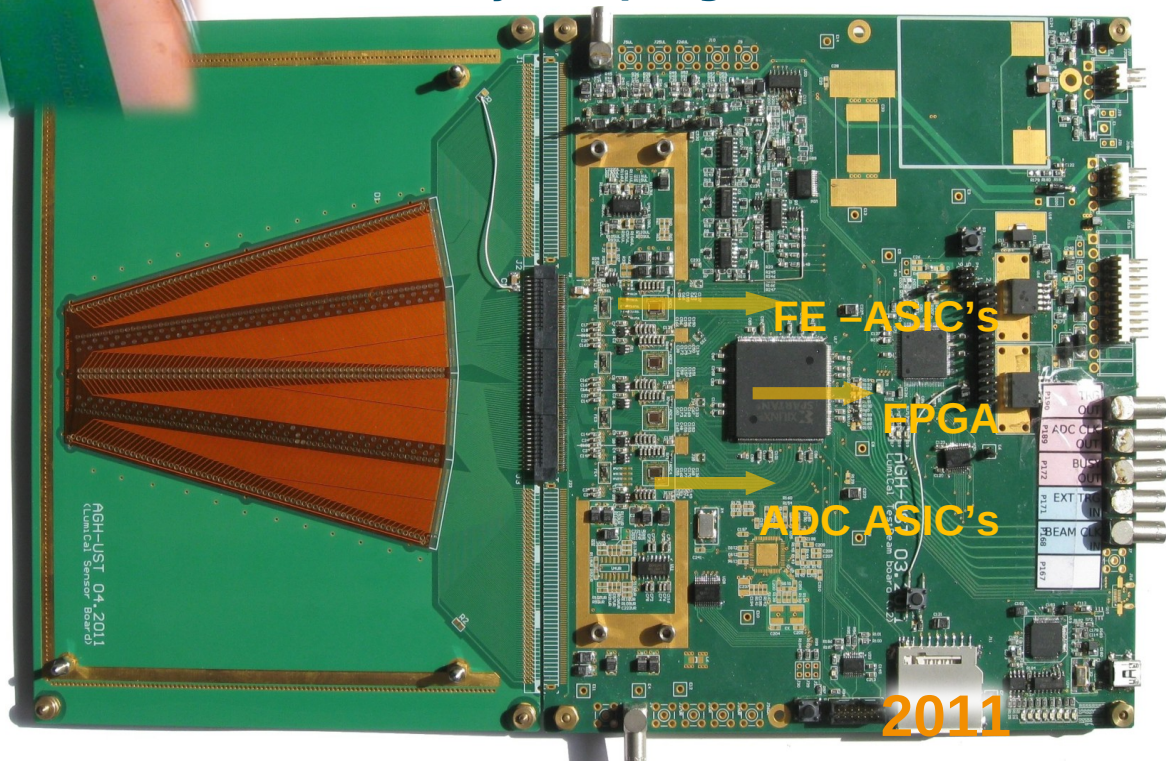
> Beam & Radiation Monitoring – BCM1F project

Application of radiation hard sensors for bunch by bunch beam monitoring

Prototype description

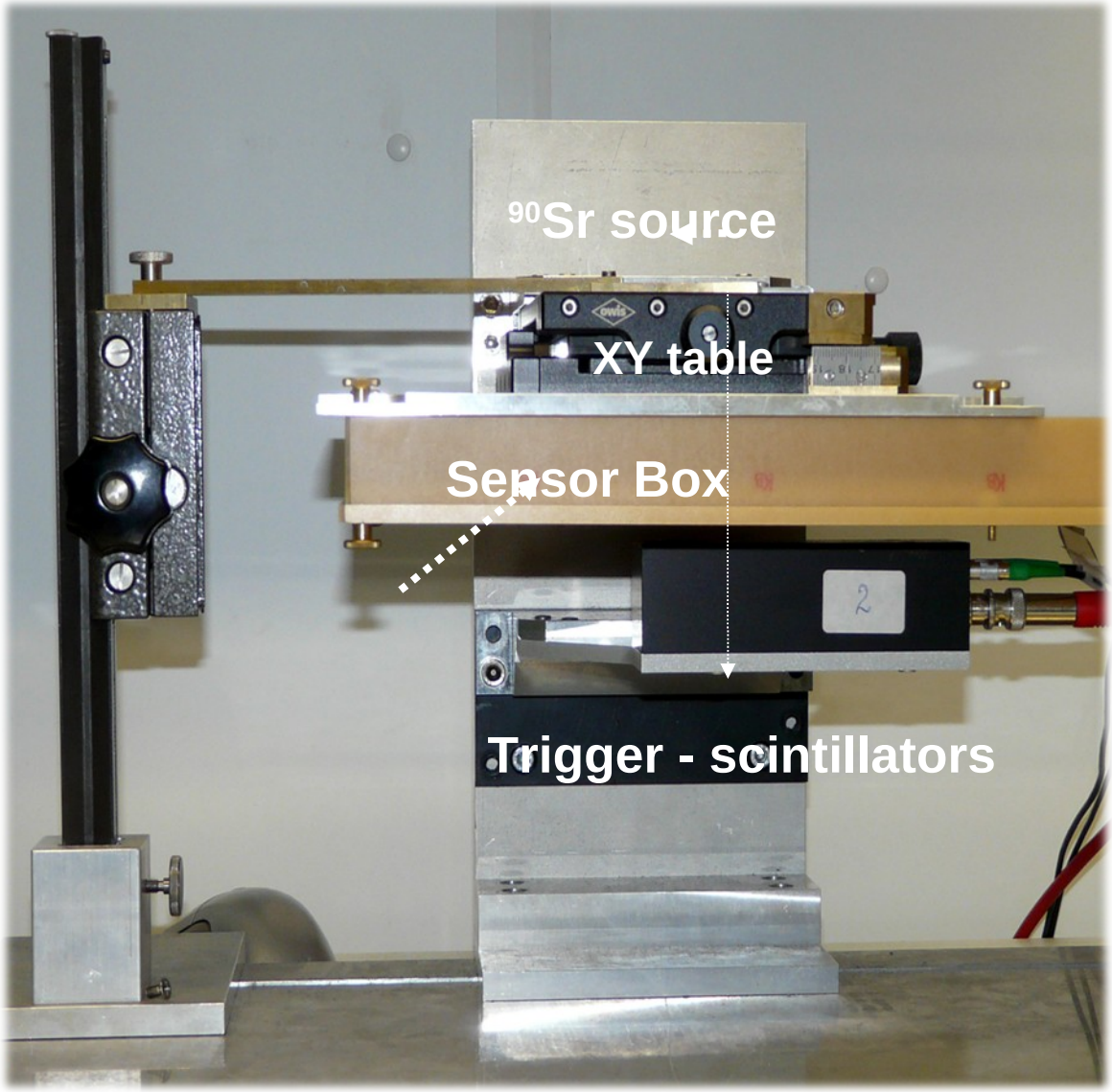


- Common read-out board for Si and GaAs sensor plates
- GaAs sensor plane (2 clusters irradiated)
- PCB fan-out provides connection between sensor and front-end electronics - ASICs (RC, FET technologies)
- Power supply and biasing circuits for transporting signals to ADC
- Read out by Sampling ADC v1721, CAEN

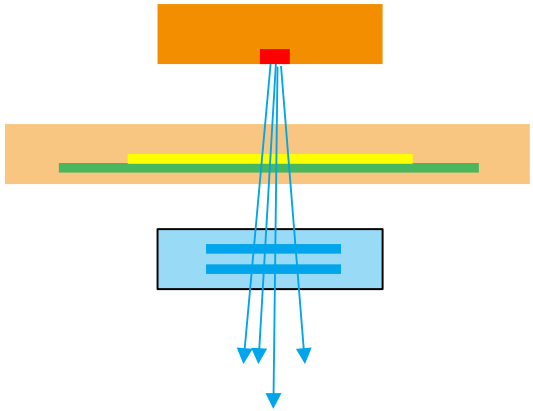


- 2011: + ASIC ADC 4x8channels chips
- 32 channel read-out

CCE set-up



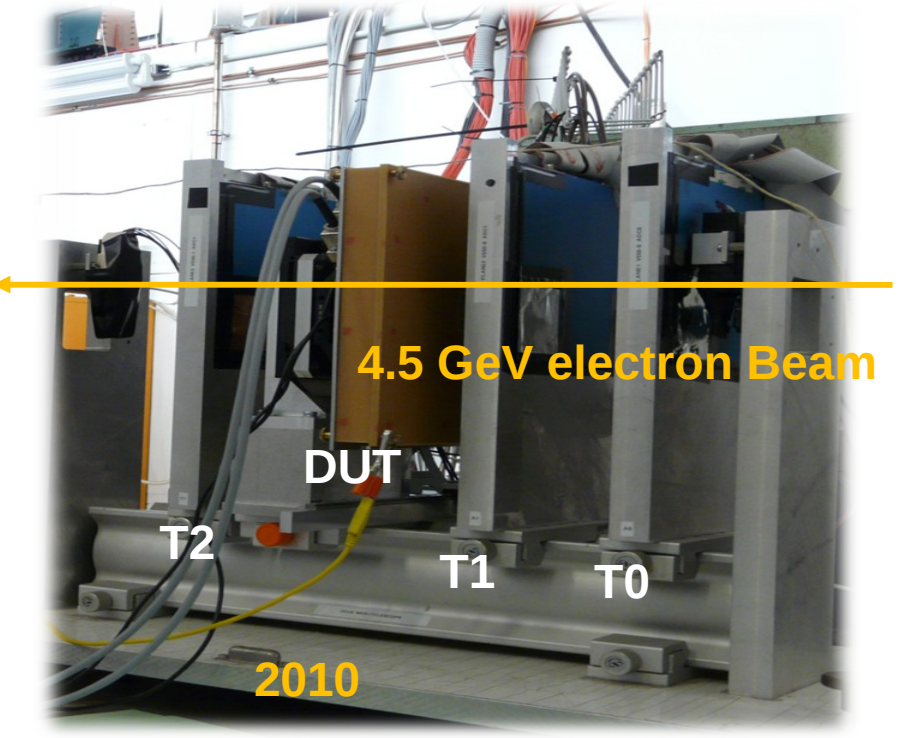
Move DUT under ^{90}Sr for CCE measurements of each pad

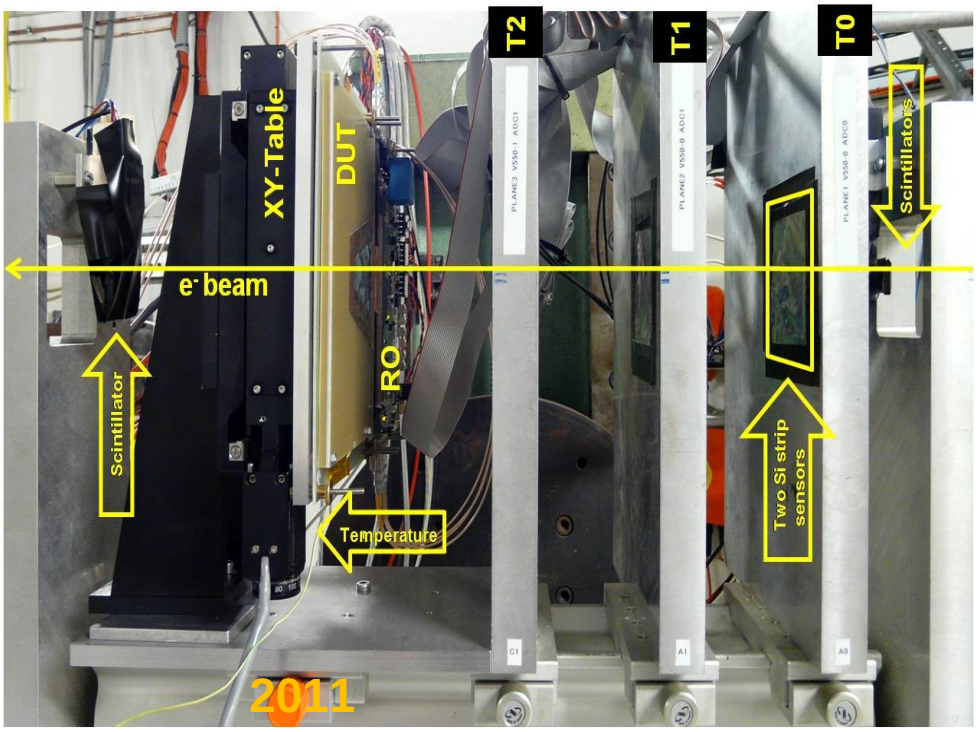


Set-up has to be compact for higher collected statistics.

Large multiple scattering due to material amount (500 µm GaAs, PCB…)

Test beams – Hamburg (DESY II)





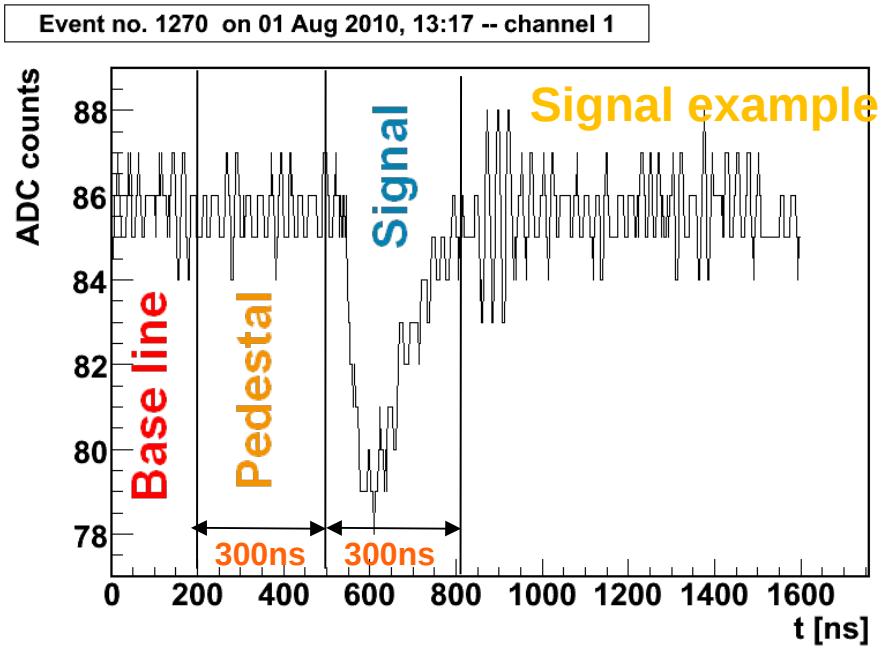
- 3 scintillators for trigger
- 3 pairs of single sided Si strip detectors (3x3 cm²)
- Strip pitch of 25µm, readout pitch of 50 µm
- Signal to noise ratio ~80
- Intrinsic resolution < 3µm

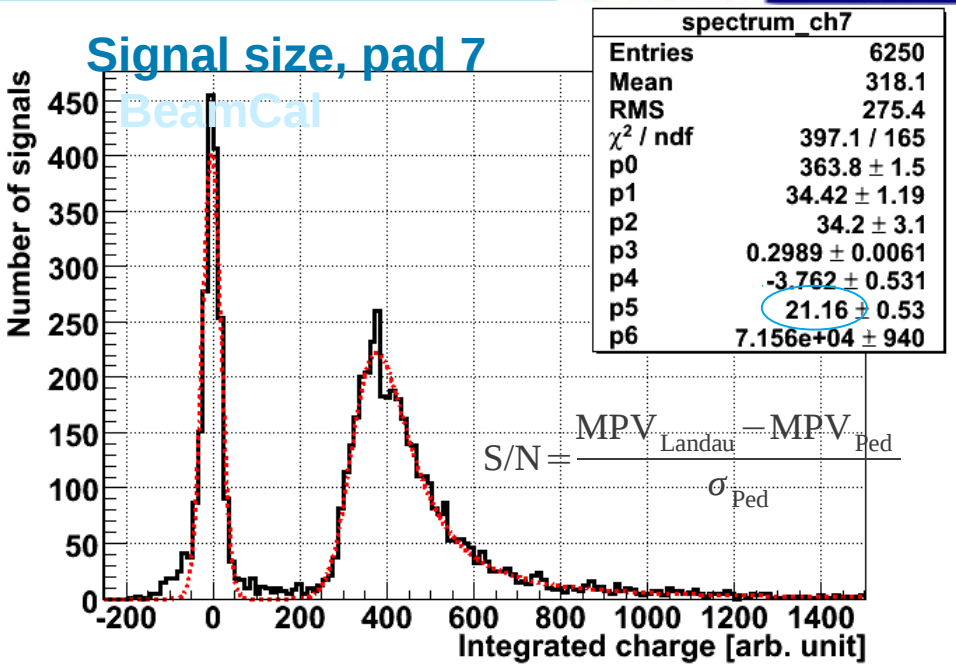
2010: GaAs + Fanout + FE ASIC

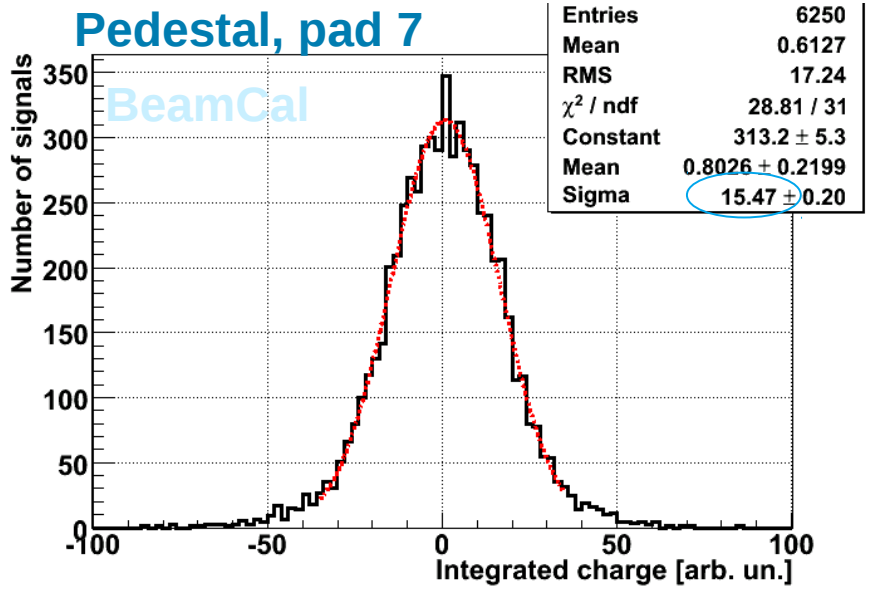
2011: GaAs + Fanout + FE ASIC + ADC ASIC

2012: Analysis (group of 5 people)

Signal processing

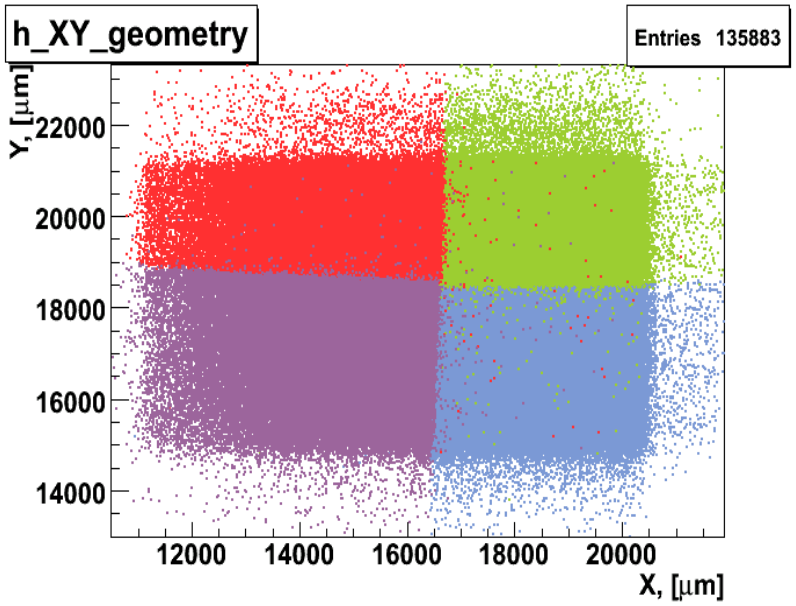


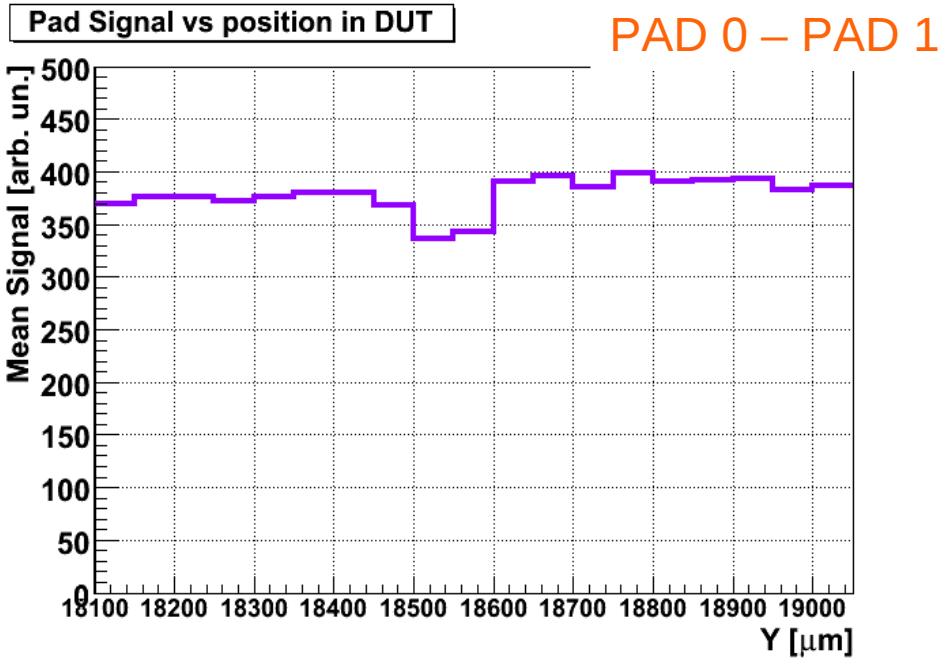




- Signal and pedestal were integrated in respect to base line
- Window optimization defines the S/N ratio and signal collection efficiency
- Pedestal, calculated before signal comes, has smaller sigma

Pads gap investigations



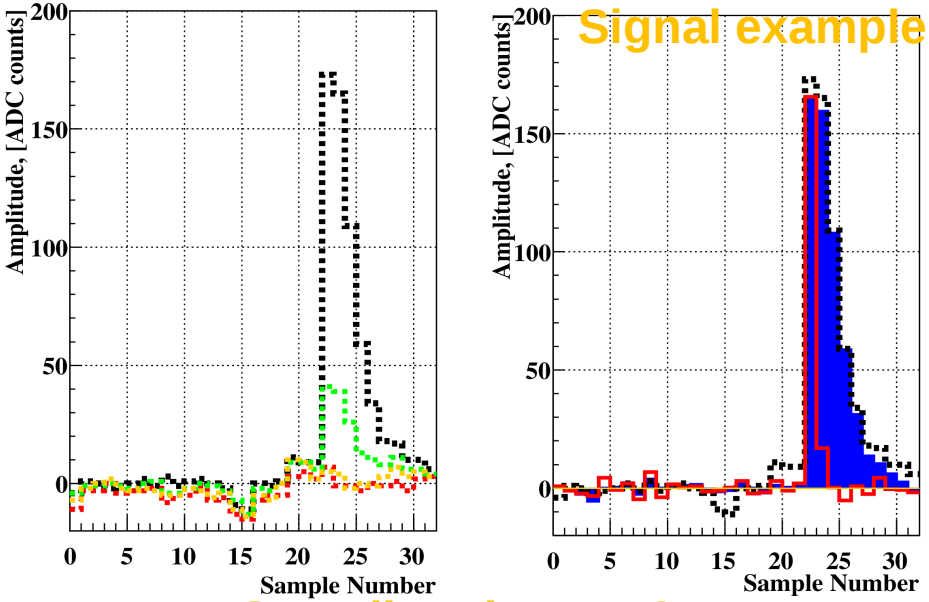


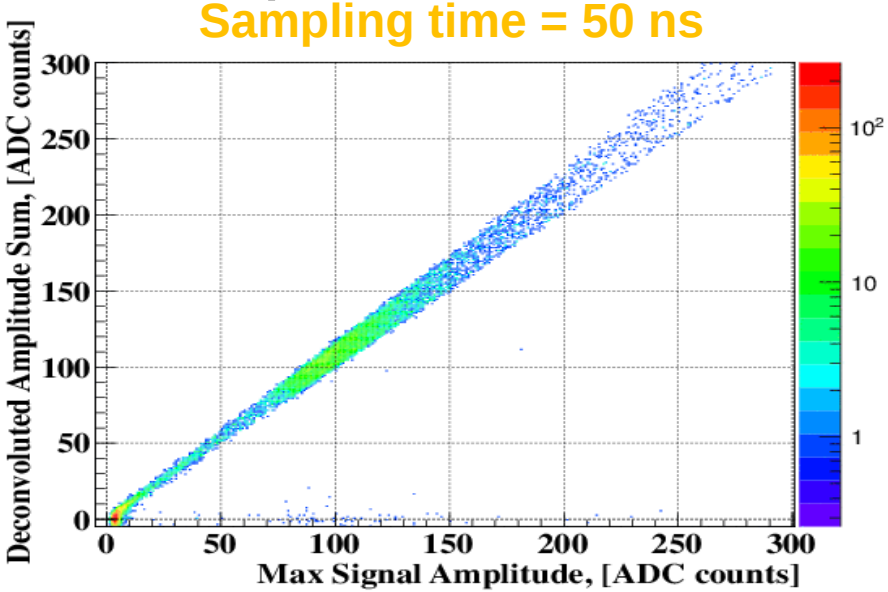
- ~ 2 millions events (2010)
- ~ 70% selected with one track in telescope
- Tracks are reconstructed from 3 telescope planes with linear fit
- TB2011 – in process...

- Signal sum (MPV) in stripes between 2 pads is presented, between pad 0 and pad 1.
- Signal sum (MPV) of two pads shows decrease on ~10% in 100um gap out of 200um gap between pads

2011 TB - Analysis

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





3 Methods:

- Amplitude, Integral, Deconvolution
- Measurements with CAEN ADC (2 ns) and ASIC ADC (50 ns) were compared and correlated ti each other.
- Measurements were done synchronized to the beam clock and not
- Unsynchronized measurements for sum of two deconvoluted amplitudes over zero are in good correlation to the maximum signal.
- Allowance to reduce pile up.

Conclusions

- Two GaAs sensor planes were tested at the electron beam in 2010-2011.
- Both detectors show perfect performance, S/N ~20 for different methods
- Functionality of the chain: FE ASIC + ADC ASIC + fan-out + sensors, positively verified on test beam

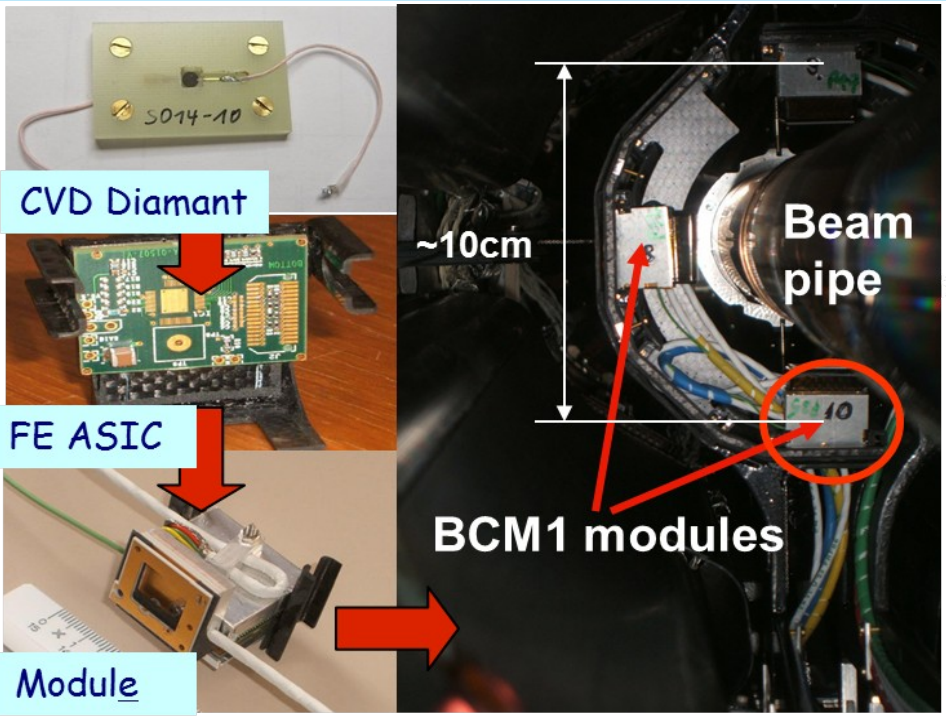
In 2010:

- Operation at room temperature
- Low leakage current ~200nA
- CCE up to 50% in the HV – saturation: CCE ~33% at -60V
- Radiation hardness up to 1.5MGy
- Spectra uniformity in central part of pads
- ~10-20% loss of signals in gaps between pad

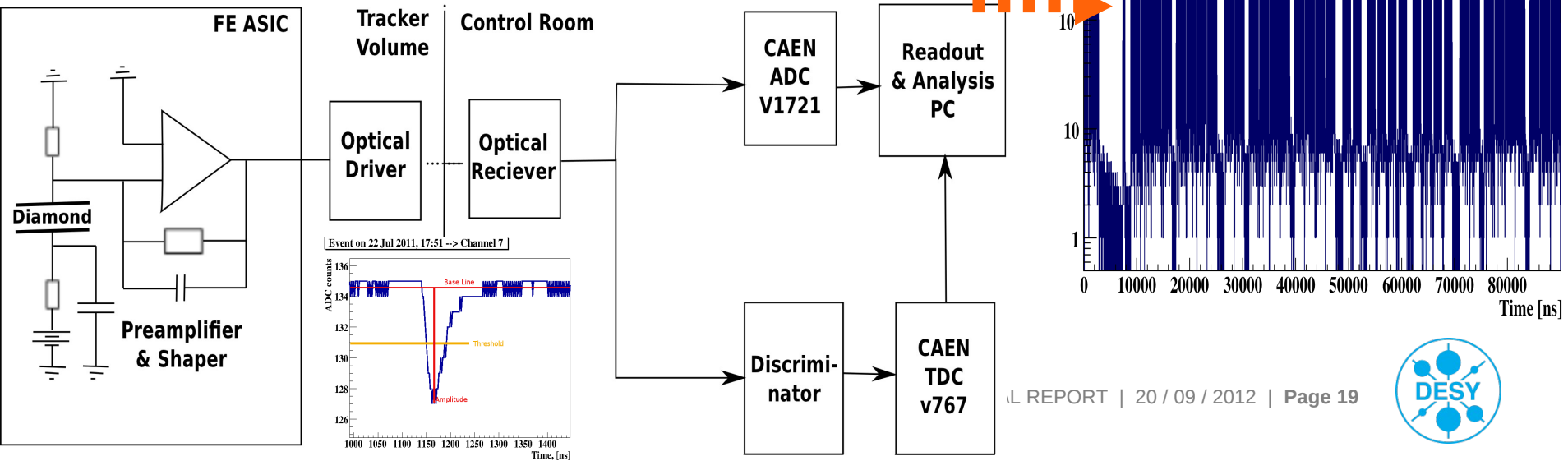
In 2011:

- 3 methods with similar S/N
- Analysis is ongoing
- …

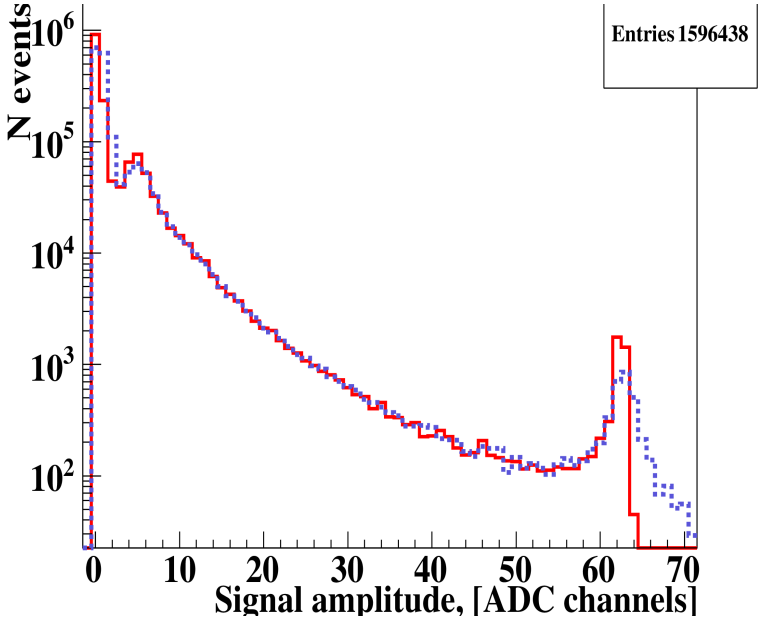
Beam Condition Monitor



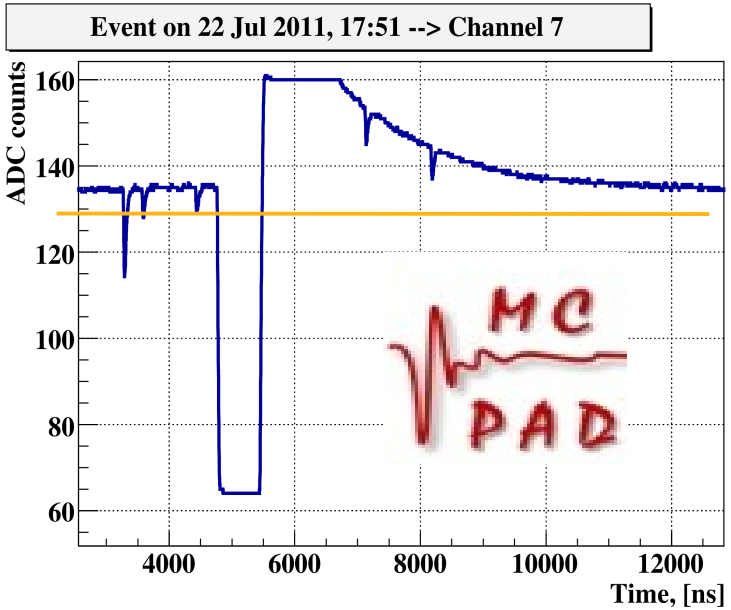
Application of rad. hard sensors and beam optimization, designed for beam halo and collision losses measurements.
8 sCVD diamonds near to beam pipe
FE – shaping time 22 ns
Work with CAEN ADC

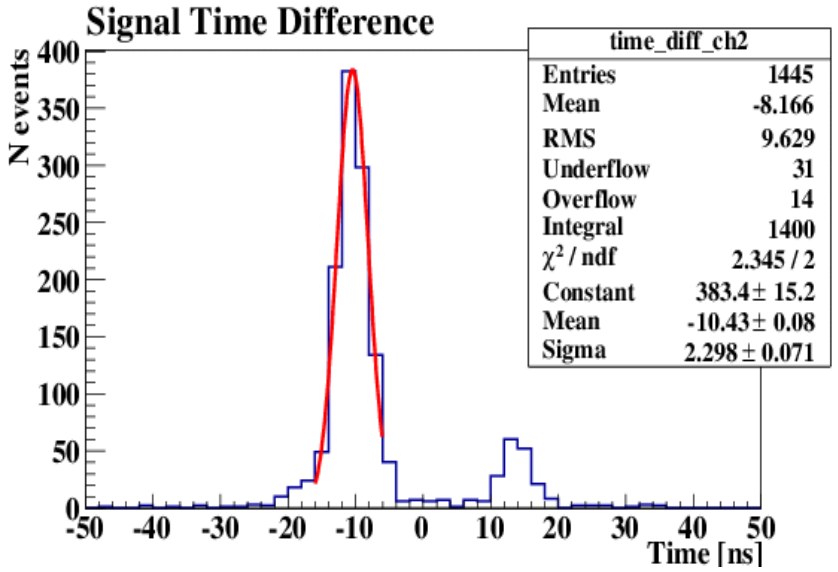


BCM1F a bit more



System validation studies and improvements (Microscope - ADC)
Amplitude spectrum – low S/N
Discriminator with fixed threshold simulation
Sensitive to all LHC beam modes
Luminosity measurements for CMS
Radiation degradation studies
...





Evolution

Relationships – work within DESY group (students teaching), work with Engineers and Workshop

Networking – work within FCAL & BRM Collaborations

Self - C++, GEANT4, German & English improvement, Presentation Skills, Group organization Skills

Mobility - ~40% of time

Teaching – Lectures at Brandenburg University of Technology

Ideas – Self organization

Where to go?

Prolonged for 7 months by DESY

Up to end of the year – to finish the thesis

My current plan is to apply to post-doc positions

Thank You for your attention

> **Thank you for the Network**