Analysis of the Beam Test data for the Beam Calorimeter Prototype

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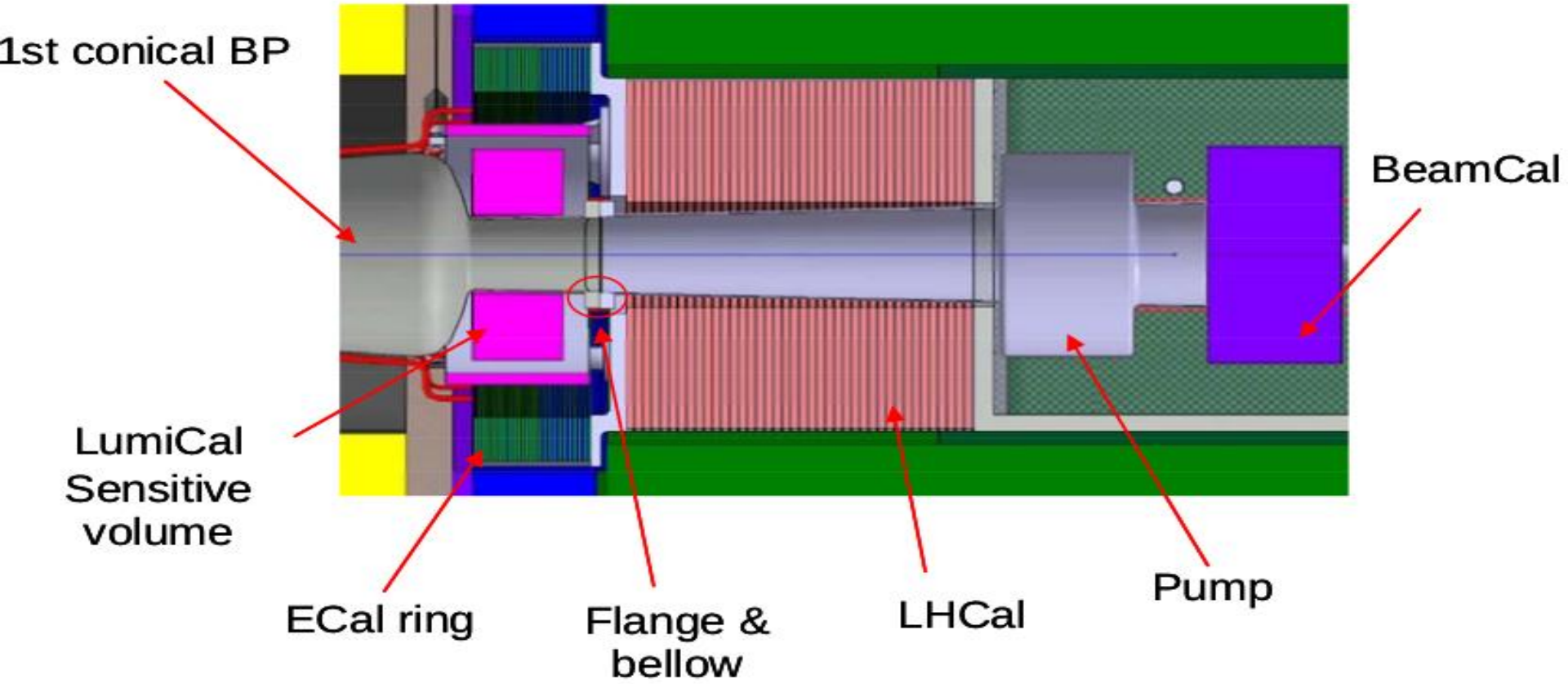
DESY

Outline

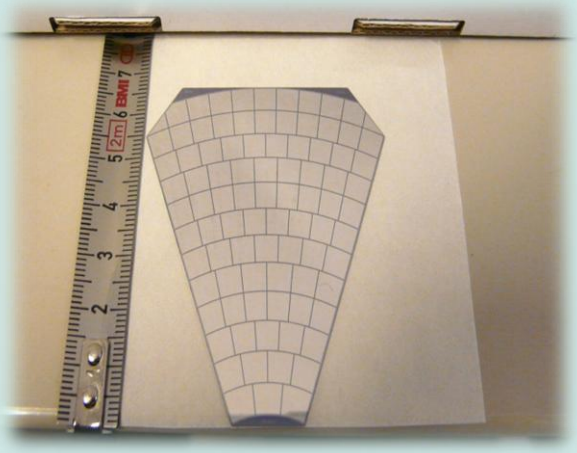
- Forward Calorimeters
- Test Beam Measurements
- CAEN ADC Analysis
- Common Mode Noise
- Deconvolution Method
- Deposition Simulation
- Conclusions

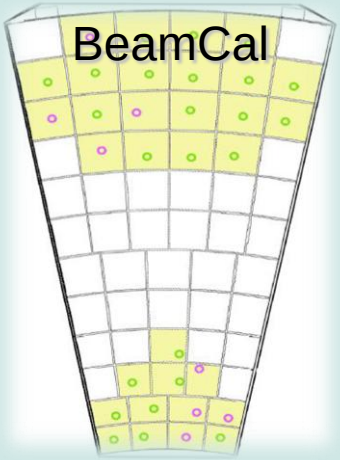
Forward calorimeters

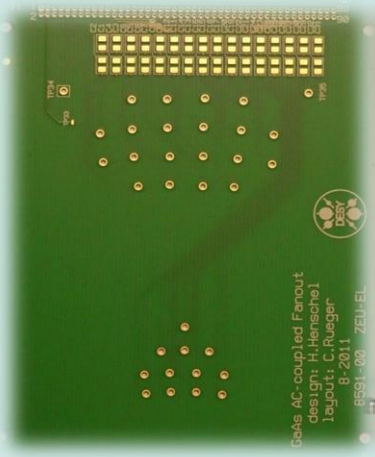


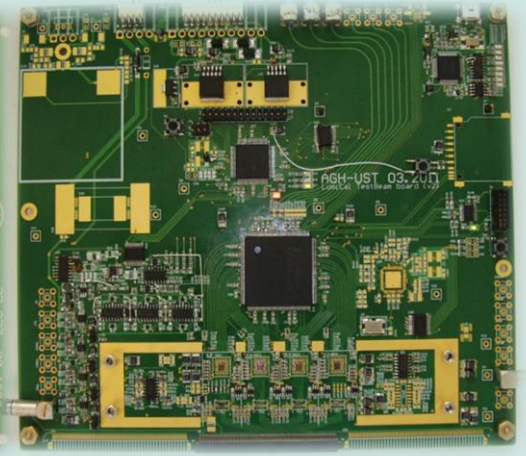
Precise luminosity measurement,
Hermeticity (electron detection at low polar angles),
Assisting beam tuning (fast feedback of BeamCal data to machine)
Challenges: radiation hardness (BeamCal), high precision (LumiCal) and fast readout (both)

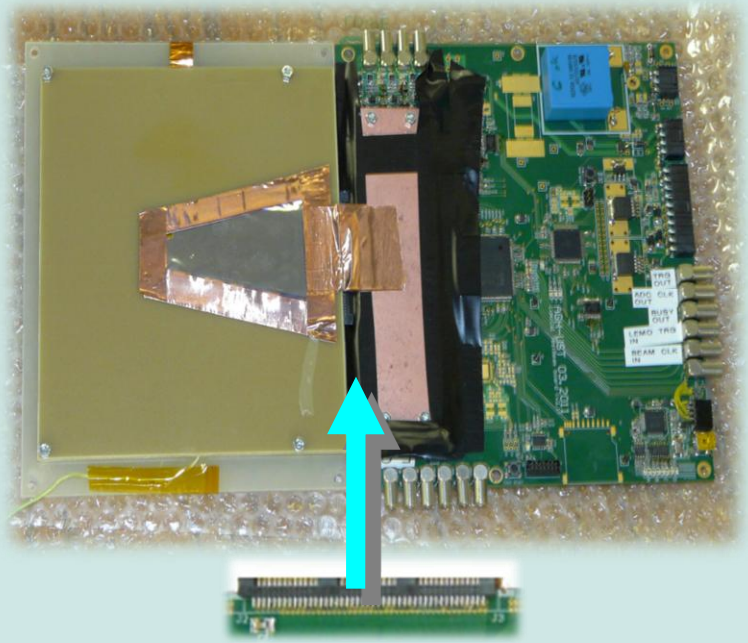
Beam Cal Prototype





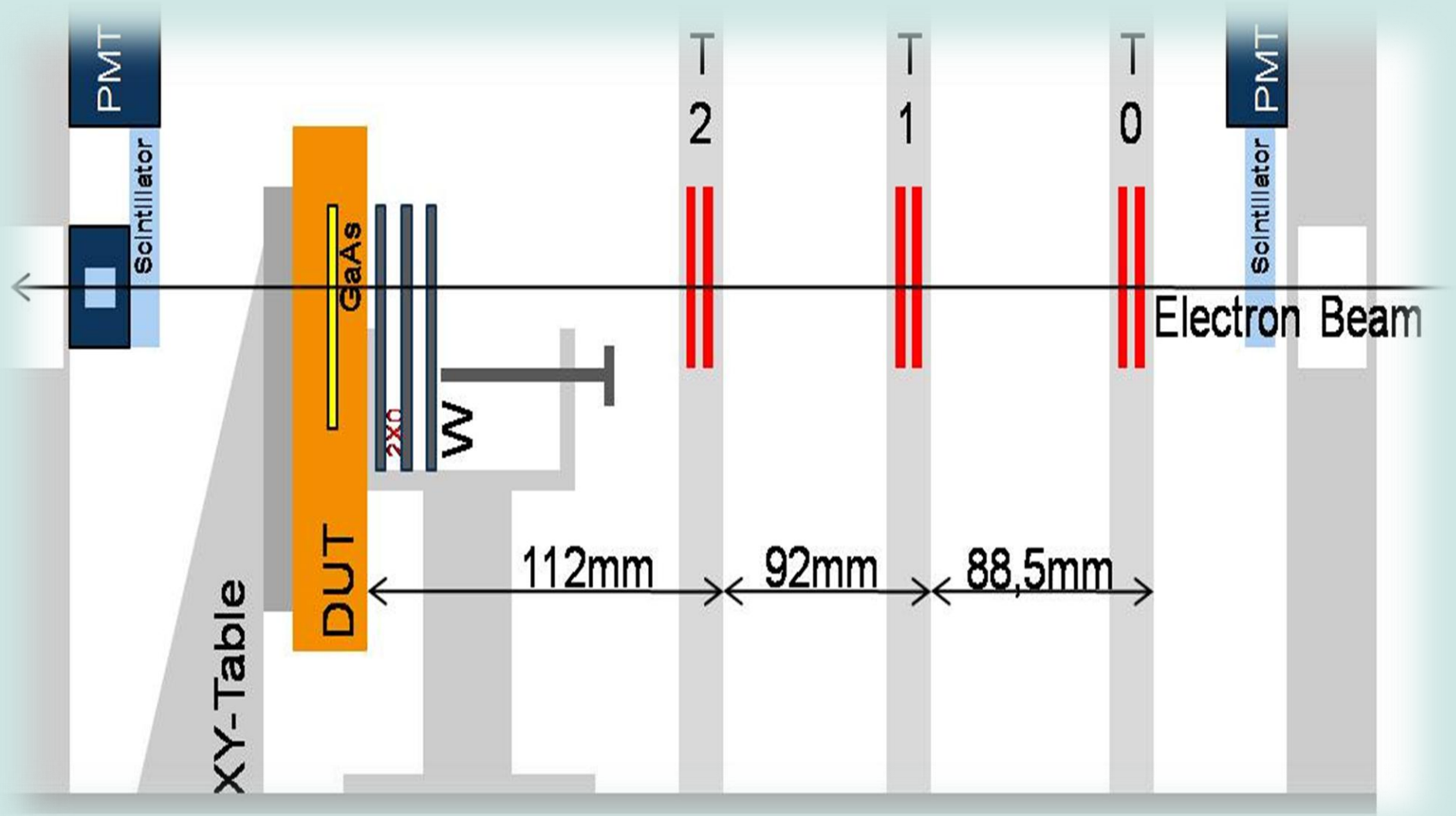




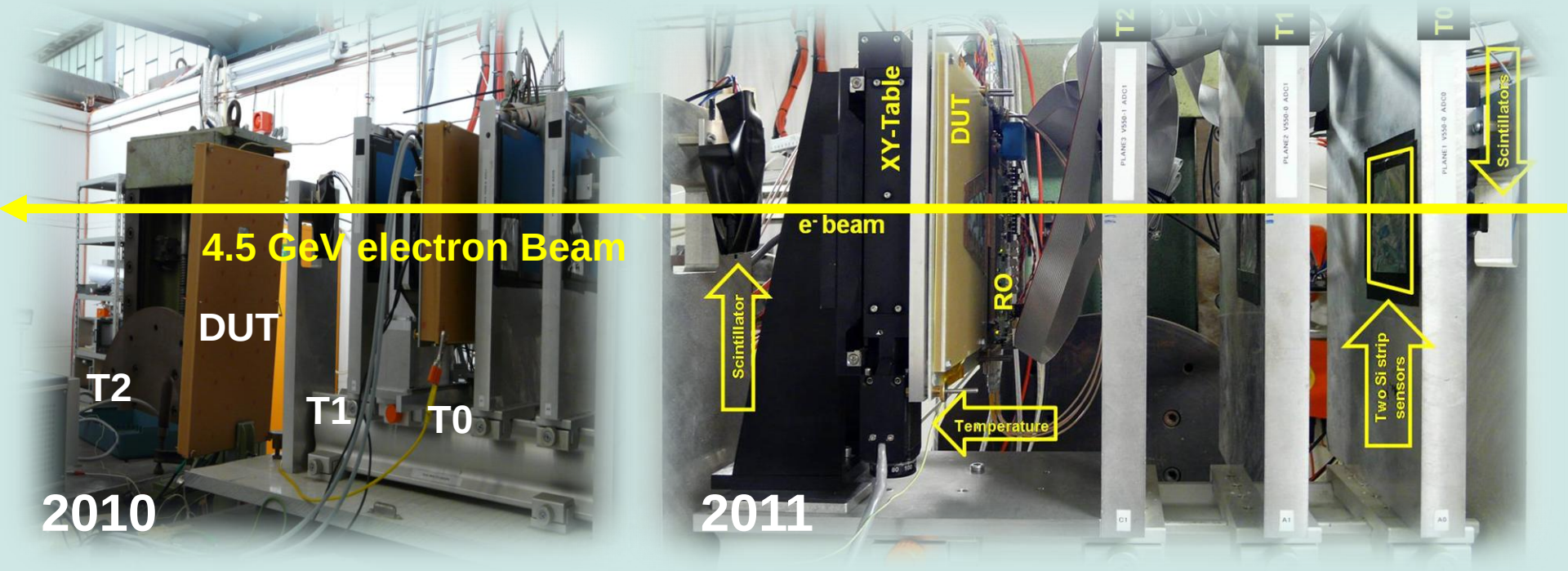


- GaAs (BeamCal) New Segmentation
- Fan Out (DC → AC)
- 4 8 channel FE ASIC's (AMS 0.35um) + 4 8 channel ADC ASIC's + FPGA concentrator (Xilinx Spartan 3E) + Power pulsing
- Connector between RO and Sensor board. 3 Read Out boards were equipped (LumiCal 2; BeamCal 1) All connect-able to each other
- ASIC's with two technologies

Test Beam Set UP



Test Beams



Test Beams DESY II 2010 – 2011(Summer – Autumn)

LumiCal & BeamCal prototypes + Strip MVD ZEUS Telescope

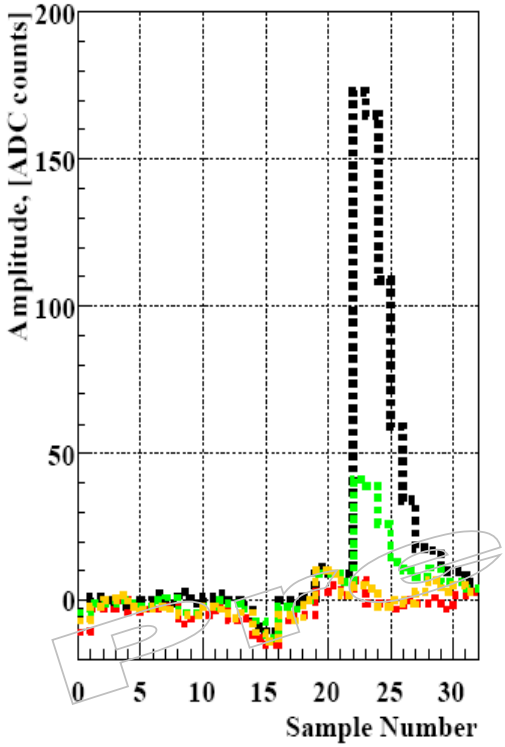
Validation of chain (Sensor + Fan Out + FE ASIC's + CAEN ADC)– 2010

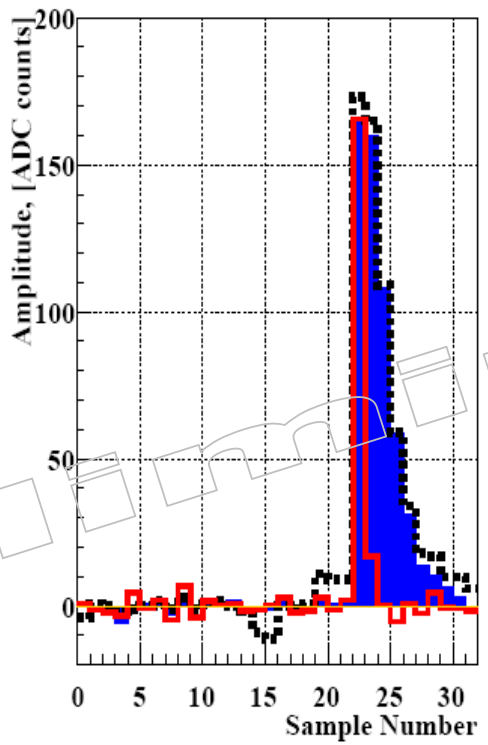
Validation of chain (Sensor + Fan Out + FE ASIC's +ASIC's ADC)– 2011

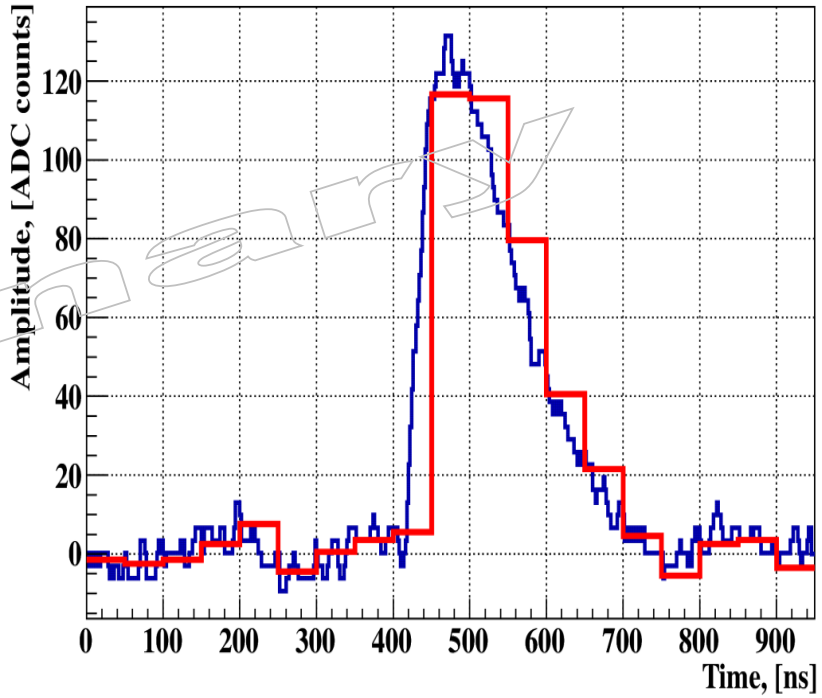
What was Planed

- TB Plans:
  - S/N ratio,
  - CCE,
  - Position sensitivity,
  - Homogeneity for 32 channel system,
  - Crosstalk.
  - Behavior on the edges between pads,
  - 4 gains operation & Multi-particle irradiation.
  - Comparison with 2010 Test Beam Data.

Signal Analysis

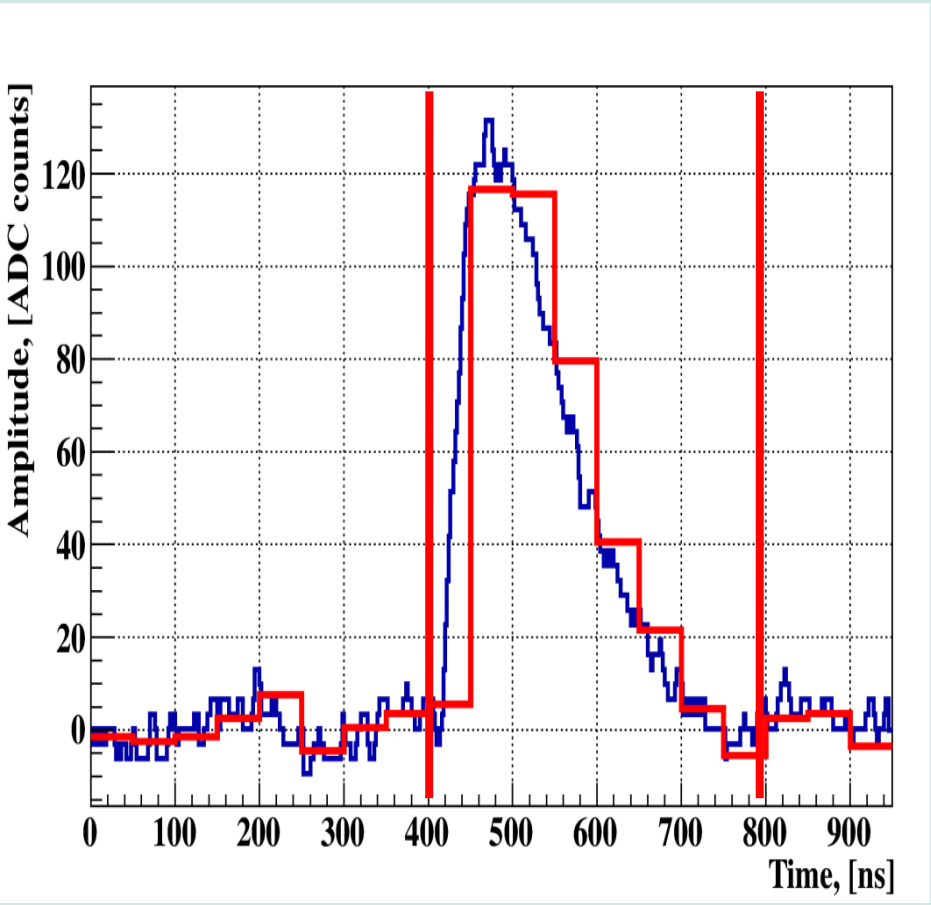






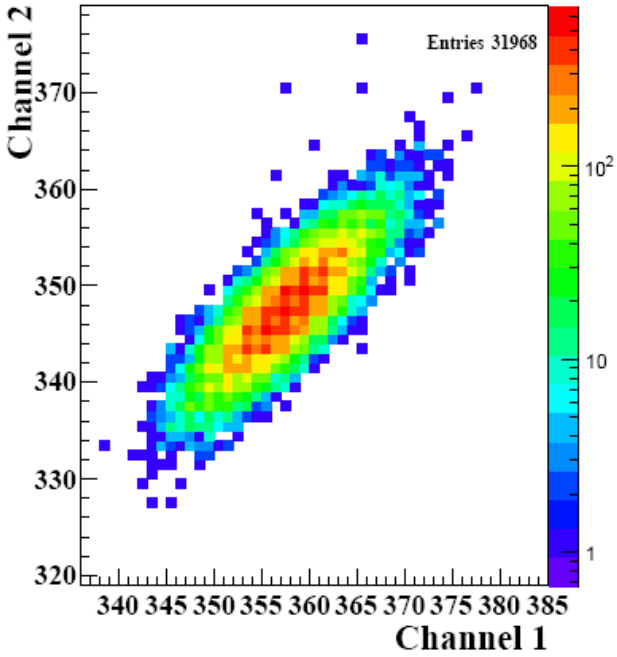
- Two ADC's were used (CAEN ADC – 2ns & on Board ASIC's ADC 50ns sampling (ADC sampling rate is up to 20 MS/s)
- 32 pads were read simultaneously (2011), 8 channels in 2010
- Two different front-end electronics - RC, FET
- CMN observed

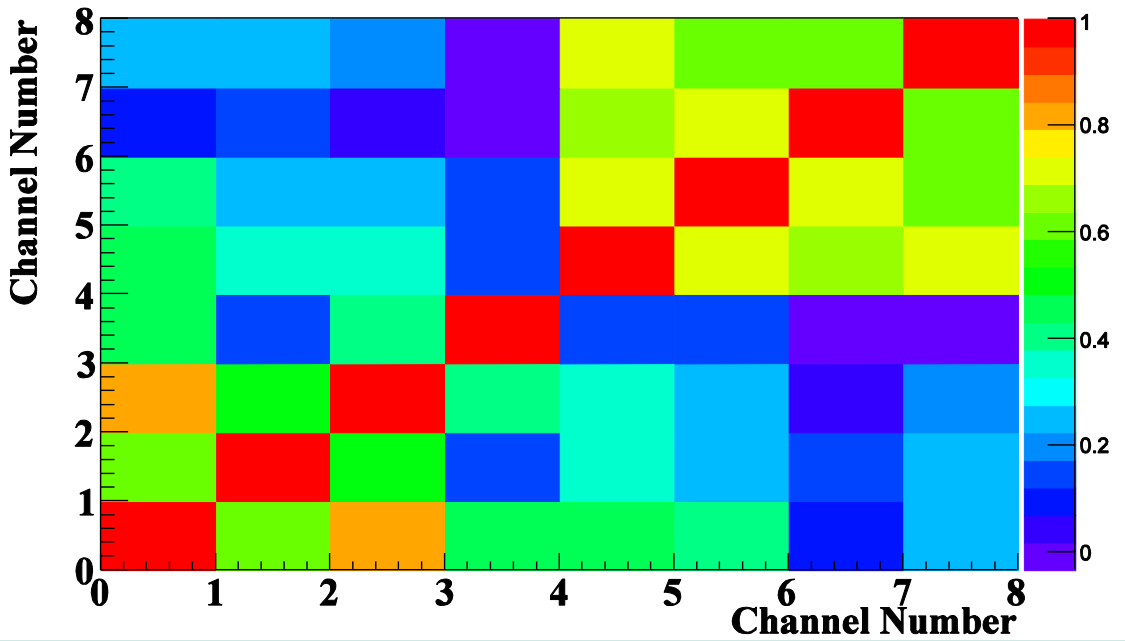
Signal Analysis Methods

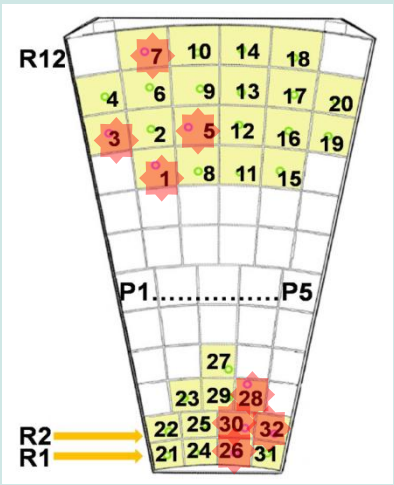


- 3 Analysis Methods
  - Signal Amplitude (Veta, Titi),
  - Signal Integral (Eliza),
  - Deconvolution Amplitude(Olga)
- Two independent ADC's (shifted in respect to the trigger)
- Time window is divided in 2 for baseline and signal calculations:
  - 0-400 and 400-800 ns for CAEN ADC
  - 0-16 and 16-32 sample ASIC's ADC
- Amplitude – sample with maximum value
- Integral – As a Fitting of the Signals
- Deconvolution Amplitude – Sum of two non zero bins

Common Mode Noise CAEN ADC

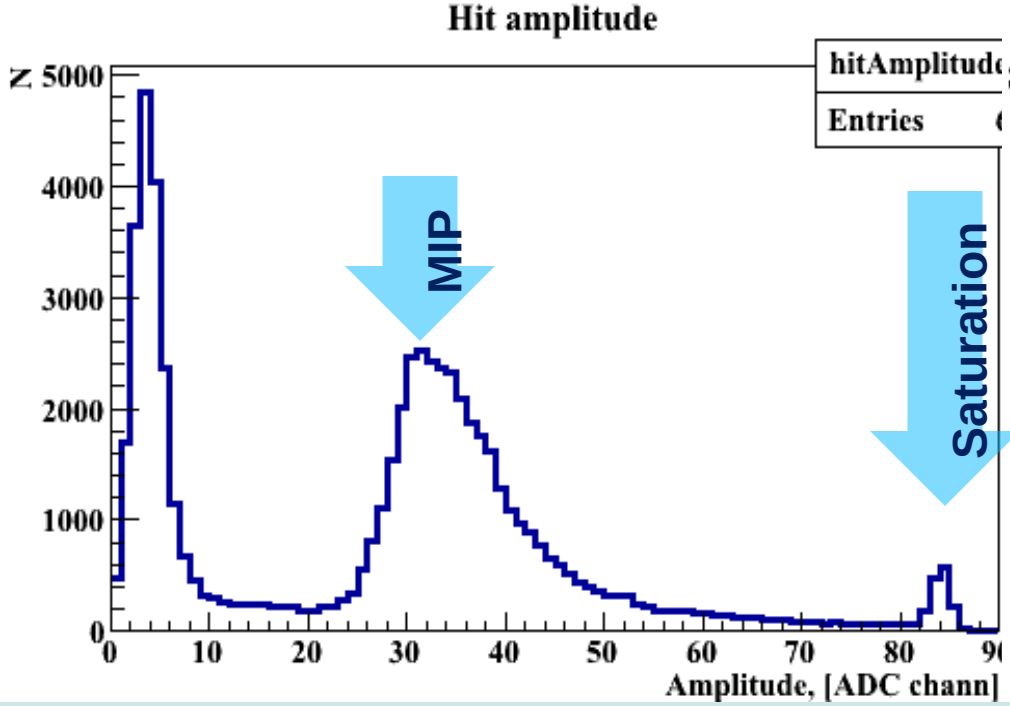


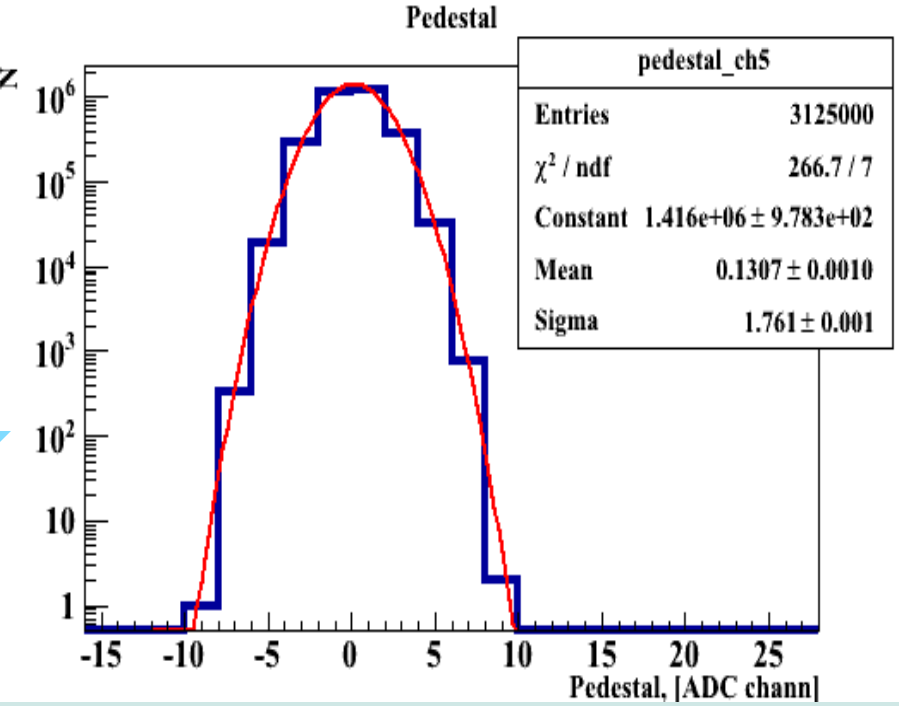




- Correlation between pedestals values within 8 CAEN ADC channels and within 32 channels of ASIC's ADC
- CAEN ADC was connected to 2 FE ASIC's, odd and even channels. Two channels with high gain and two low gain.
- Correlation is found to be within one FE ASIC's.
- For 32 channels results will be shown below.

CAEN ADC Amplitude

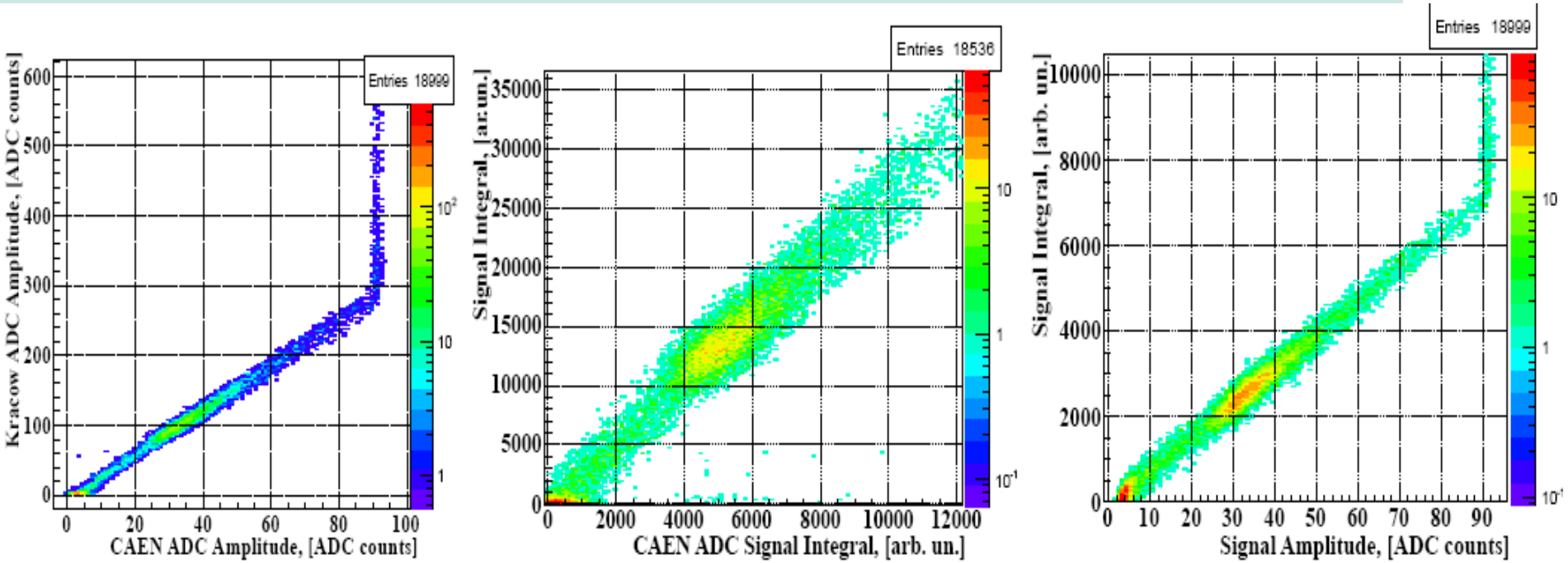




- Saturation is a result of CAEN ADC dynamic range (0-255 ADC counts)
- MPV is stable, S/N varies between 10 to 20
- CMN was not subtracted

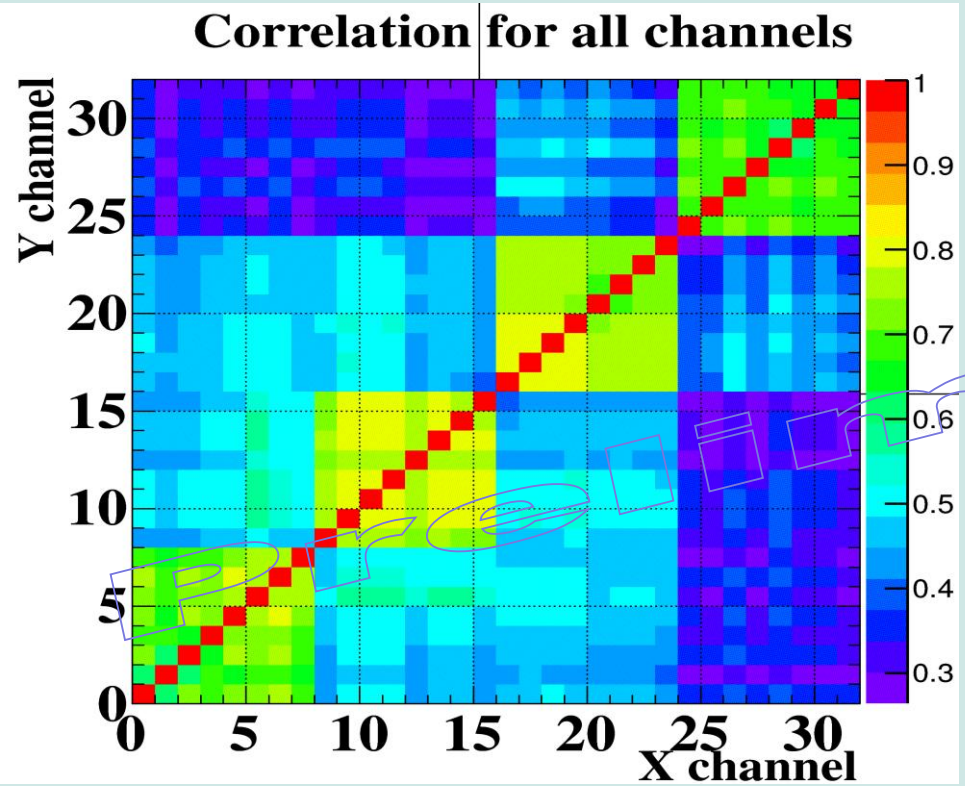
CAEN ADC Ch N	0	1	2	3	4	5	6	7
MPV	32.1	32.0	15.6	15.9	16.1	32.2	32.3	16.2
σ	1.43	1.42	1.01	1.4	1.14	1.74	165	0.99
S/N	22.4	22.5	15.0	11.4	14.1	18.5	19.57	16.4
Pad Number	26	30	28	32	7	1	3	7

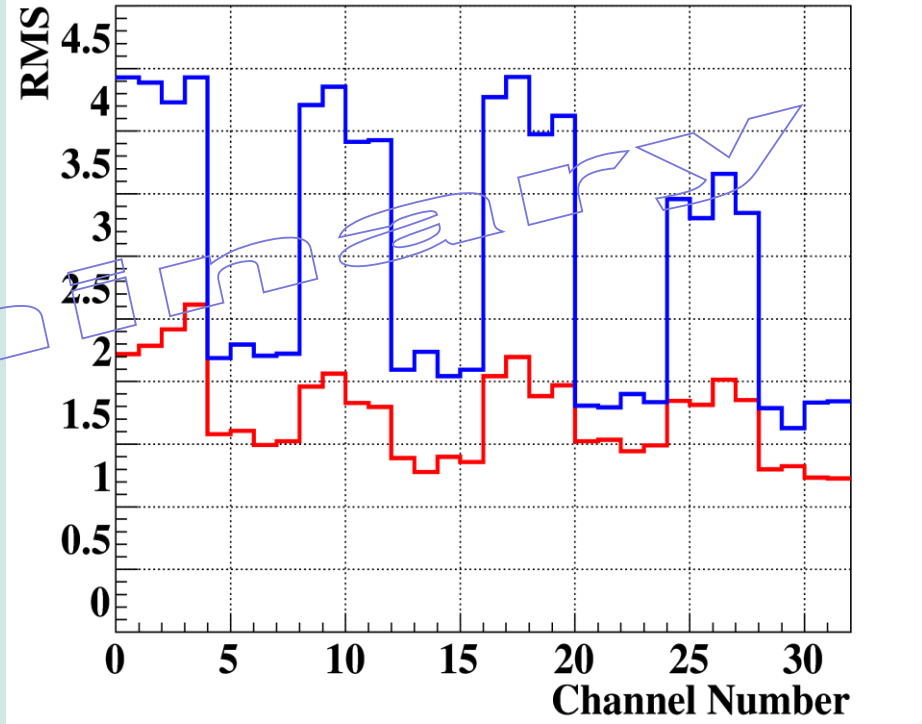
Proportionality



- Correlations between different methods (from left to right):
- FE ASIC's Amplitude vs CAEN ADC Amplitude
- CAEN ADC Integral vs FE ASIC's Integral (integrals by summing up signal under curve)
- CAEN ADC Amplitude vs FE ASIC's Integral

Common Mode Noise



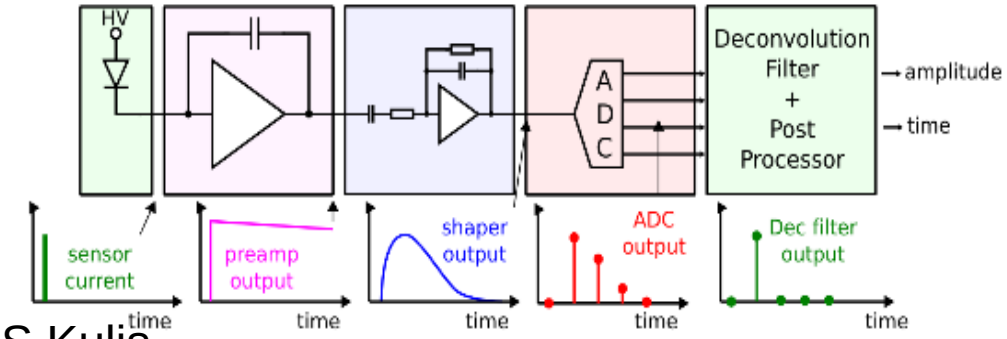


- Two different front-end electronics - RC, FET
- CMN over each ASIC's – CMN subtraction algorithm from non hit channels – Red Curve after CMN subtraction (Deconvolution mode requires noise reduction)

Common Mode Noise Subtraction

- 0-1000 samples to calculate averaged pedestal for full event and for each sample.
- Subtraction of the averaged pedestal values for each sample
- Calculation of the CMN for each sample – for each FE ASIC's, taking into account gains between 0-3 and 4-7 channels of each FE ASIC's
- CMN is calculated for the channels which were not hit (maximum value of the channel has to be less then 5 Pedestal Sigma)
- CMN is subtracted for each chip individually.

Deconvolution Mode

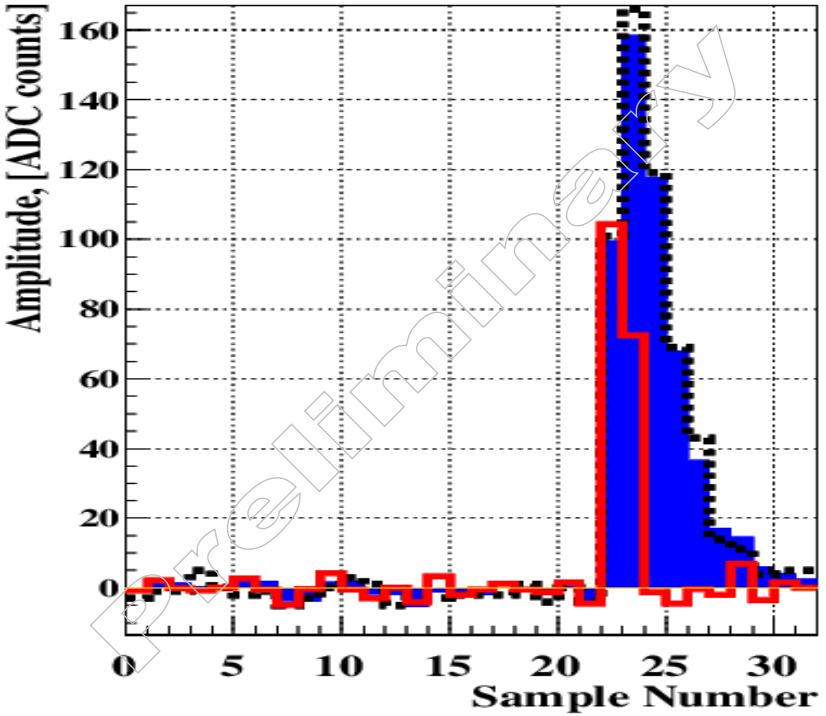


S.Kulis

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

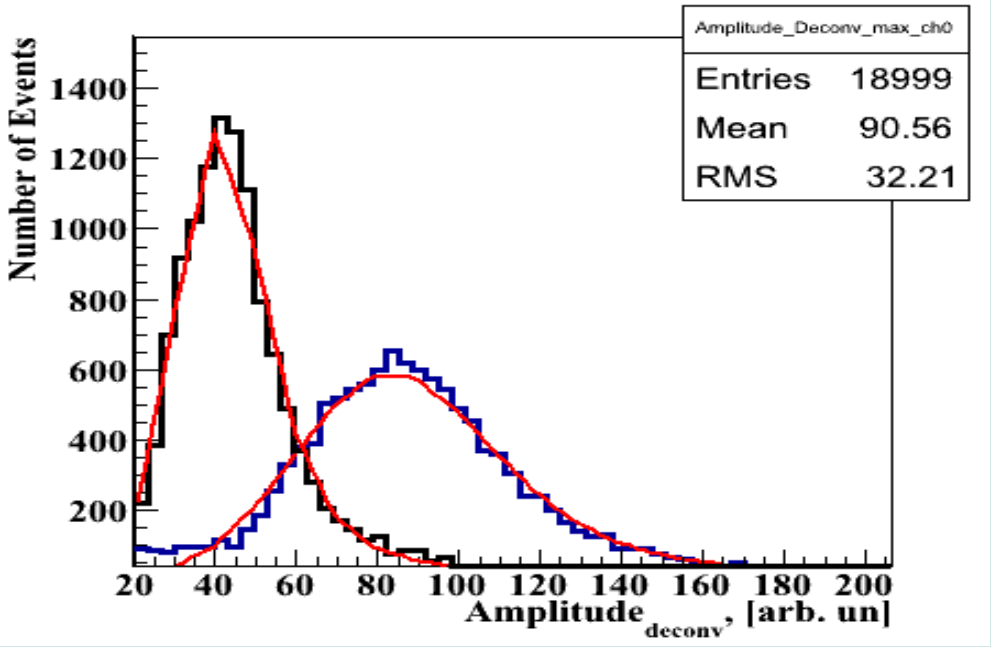
with the weights

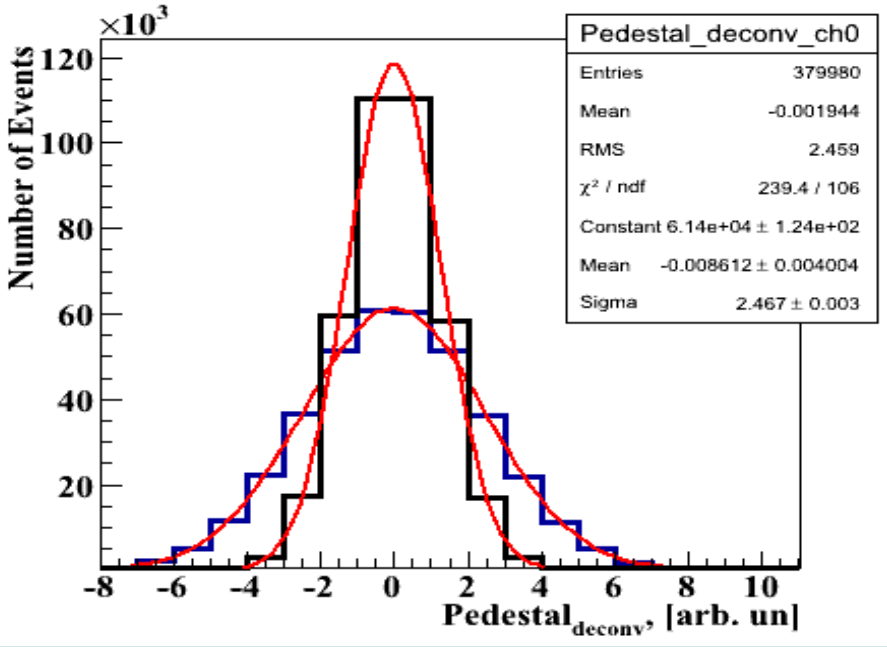
$$w_1 = \frac{1}{x} e^{x-1}, \quad w_2 = -\frac{2}{x} e^{-1}, \quad w_3 = \frac{1}{x} e^{-(x+1)}$$



- Deconvolution method was tried
- Deconvolution formula works better after CMN subtraction
- One or two non zero bins were found
- Runs with synchronized and unsynchronized ADC Clock source
  - Internal (asynchronous with beam operation)
  - External (beam clock used to synchronize with beam)

Deconvolution Mode

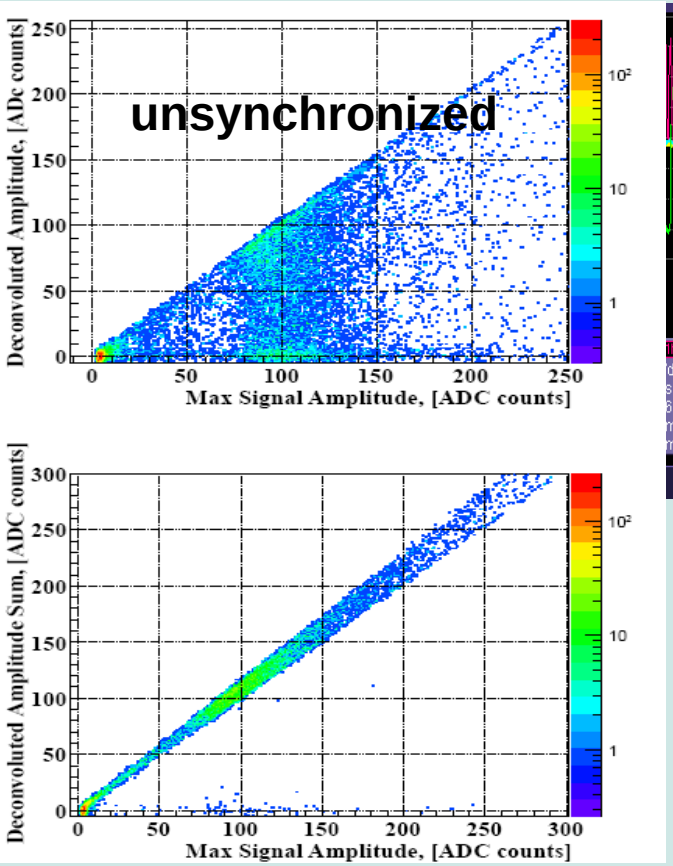


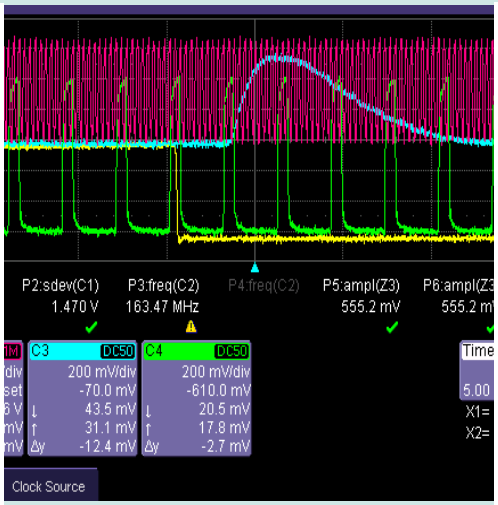


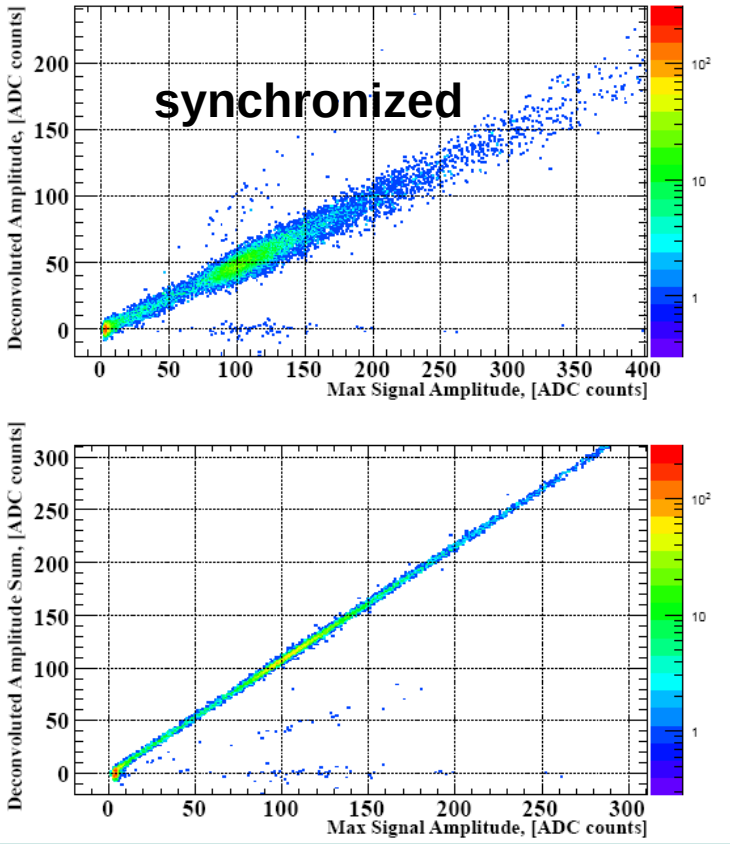
- Sum of two non zero bins for two gains (Blue – first, Black second) – asynchronous
- S/N ~30 for both gains

- Pedestal distribution(Blue – first, Black second gain) – asynchronous
- For the window before the signal collect deconvoluted values for each bin
- Pedestal Sigma differs in factor 2

Deconvolution



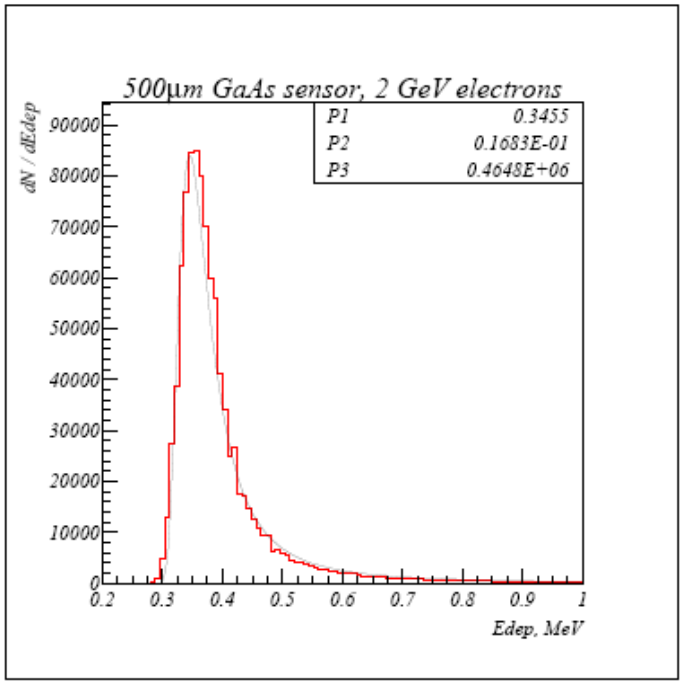


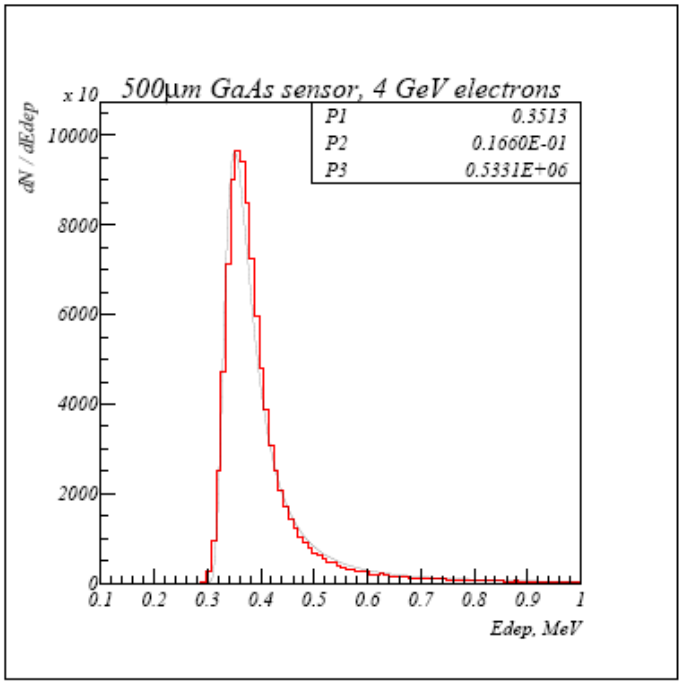


- **ADC Clock source**
  - **Internal (asynchronous with beam operation)**
  - **External (beam clock used to synchronize with beam)**

- **Synchronized data show perfect correlation.**

Deposition in GaAs





Thickness	Dep. En.	e-h energy	e-h pairs per mkm
500 mkm GaAs	0.3455 MeV	4.3 eV	160,7 (2.0 GeV)
500 mkm GaAs	0.3513 MeV	4.3 eV	163,4 (4.0 GeV)
500 mkm GaAs	0.3526 MeV	4.3 eV	164,0 (4.5 GeV)

- Test Beam and Sr90 Setup were simulated with Geant3 (S.Schuwalow)
- Deposition in the GaAs sensors were collected for different electron energies

Conclusions

BeamCal prototypes were tested at the 2 - 4,5GeV electron beam in 2010 - 2011. It is showing perfect performance, S/N ~20-30

Functionality of the chain: ASIC's ADC + ASIC's FE + fan-out + sensors, positively verified on test beam

Beam test of 32 channel prototypes were successfully tested in 2011 including new ASIC's ADC with S/N > 20 and analysis is ongoing

CAEN ADC data is in agreement between 2010 and 2011

CMN was observed

Deconvolution method showed to be correlated with amplitude

Plans are to finish Test Beam Data analysis in this summer.