Self triggered readout of GEM in CBM

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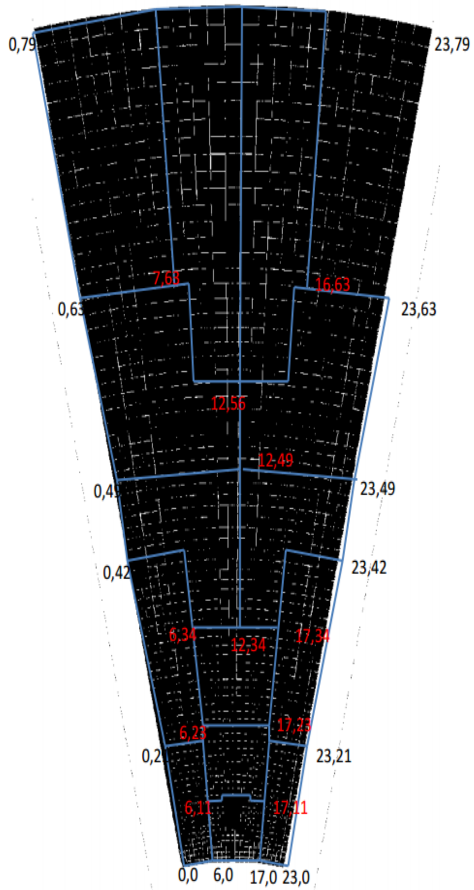
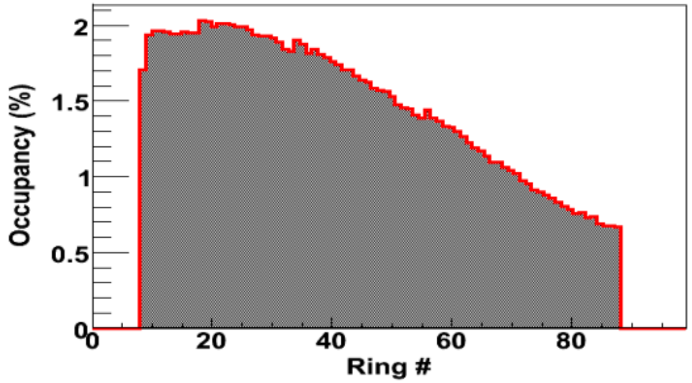
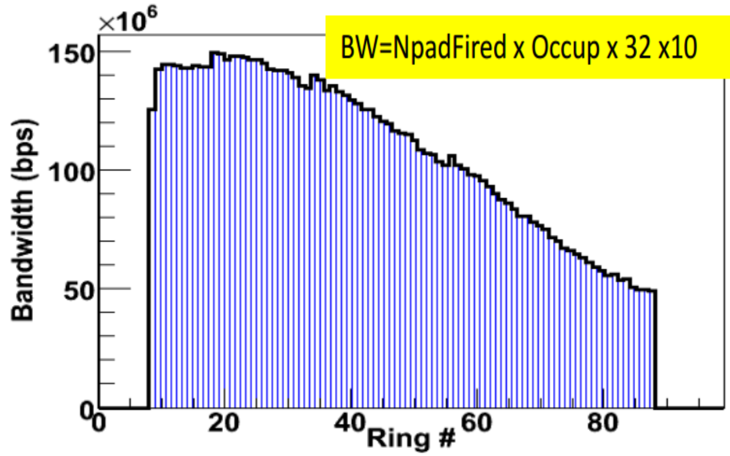
CBM-MUCH Environment

- Interaction rates of the primary particle is 10MHz
- First station with the present detector PCB layout, occupancy per channel is as high as 2% (i.e. hit rate 200KHz/channel) in innermost region.
- To acquire the data with such a high rate, triggered electronics is no more useful.
- The electronics should be fast enough to avoid pileup due to high rate.
- Radiation hardness is another big criterion to be considered, but is not discussed now.

For MUCH Station-1







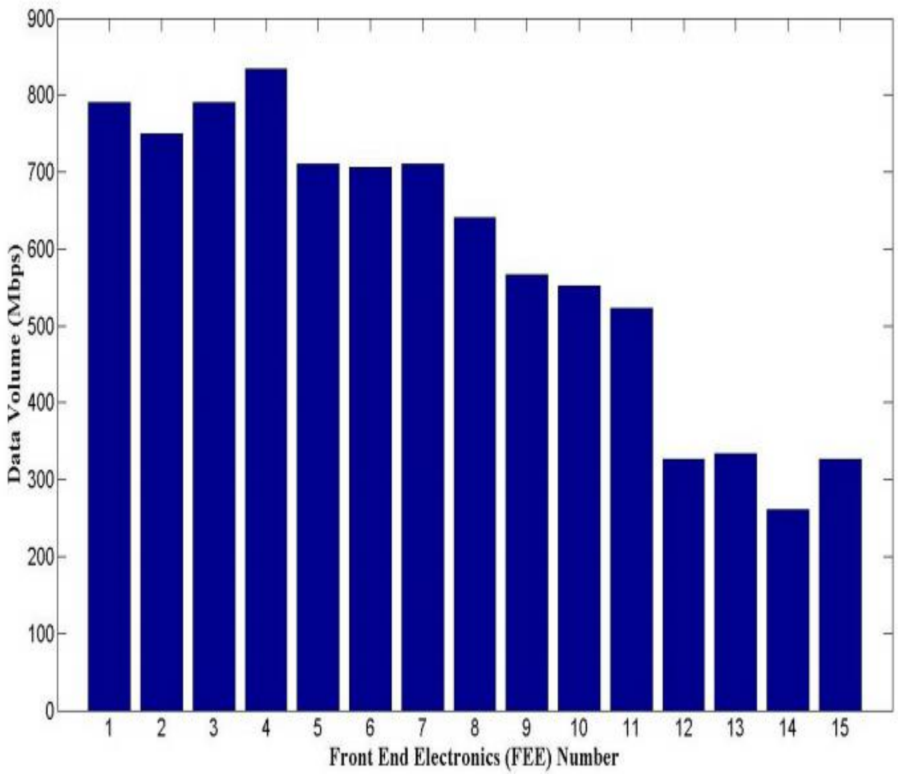
- One sector is having multiple rings (~90)
- Pads in a ring are of same size (square)
- Size of the pads vary with radius
- (1 deg. azimuthal segmentation)

Based on 25 AGeV min Bias Au-Au

- Maximum occupancy in a sector ~ 2%
- Total Bandwidth in a sector ~8.5 Gbps

Occupancy plot prepared with the help of Partha Pratim Bhaduri

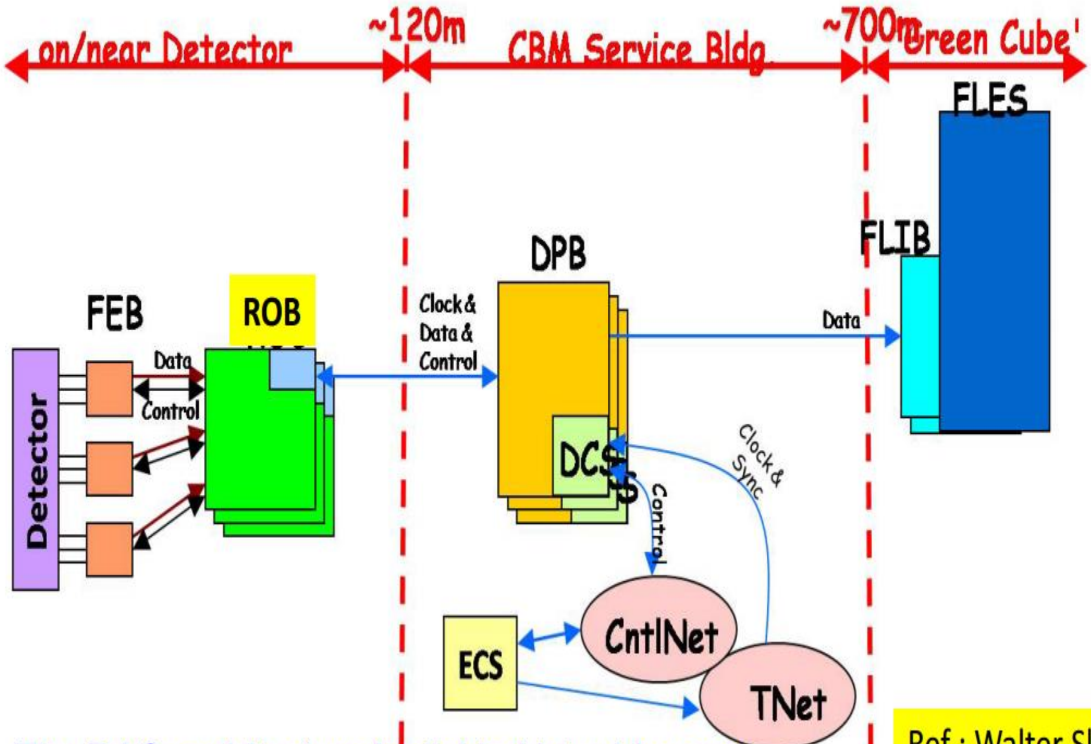
FEB number wise bandwidth requirements



Total BW of a Sector : 8.5 Gbps
Station-1 : 16 Sectors
Total BW for Stn-1 : 16 x 8.5 X 3= 408 Gbps
Actual BW required ~ 1.5 x 408 ~ 612 Gbps

Occupancy plot prepared with the help of Partha Pratim Bhaduri

Proposed readout architecture for GEM detector based first two MUCH stations

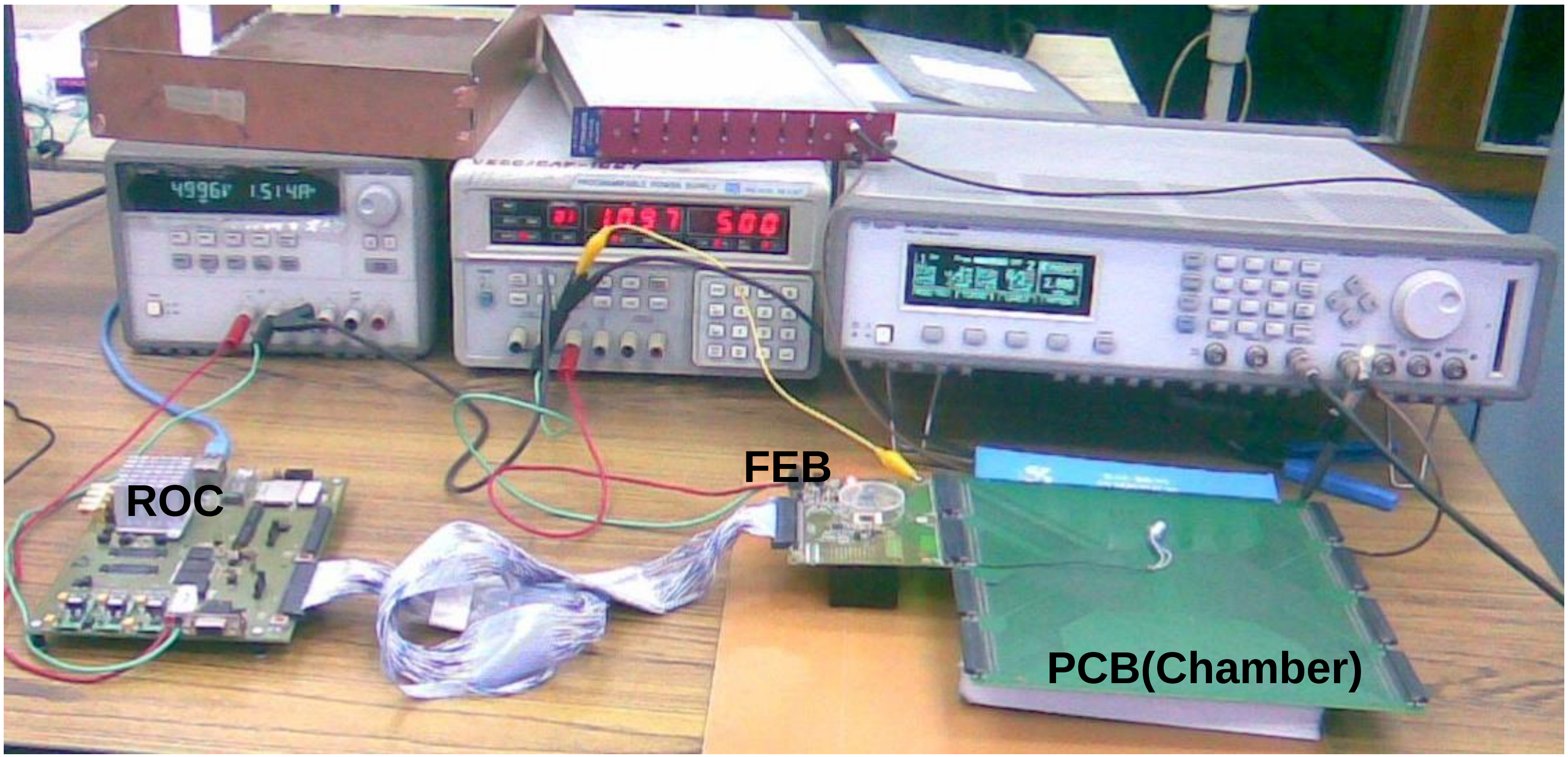


Ref : Walter Slide

The DAQ architecture is divided into 4 layers:

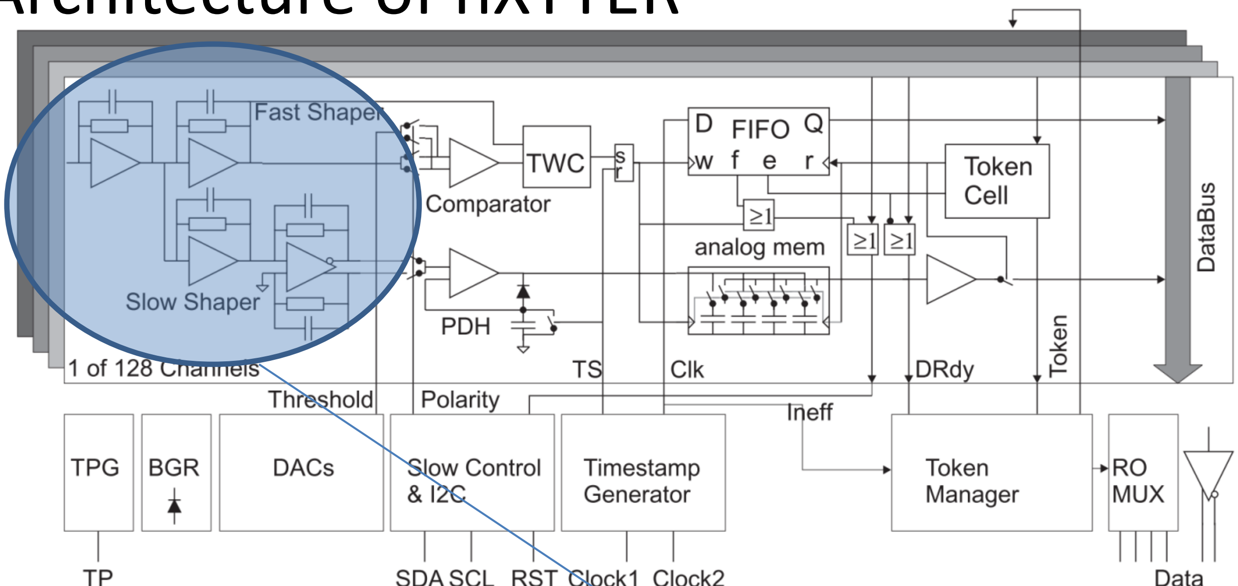
- FEB (Front End Board)
- ROB (GBTx with VTRx and VTTx)
- DPB (Data processing board)
- FLES (First Level Event Selector) with storage.

Present nXYTER based readout chain used for prototype GEM chamber tests

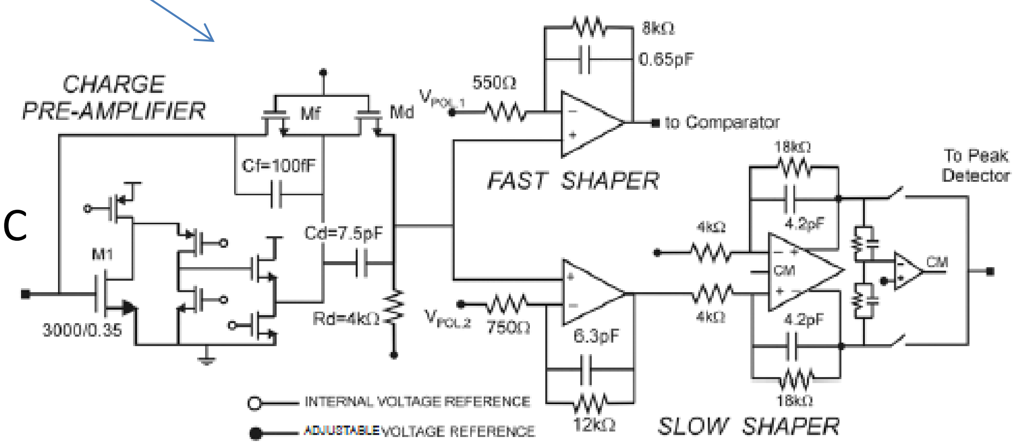


Electronics used for the prototype testing of GEM based MUCH detector

Architecture of nXYTER



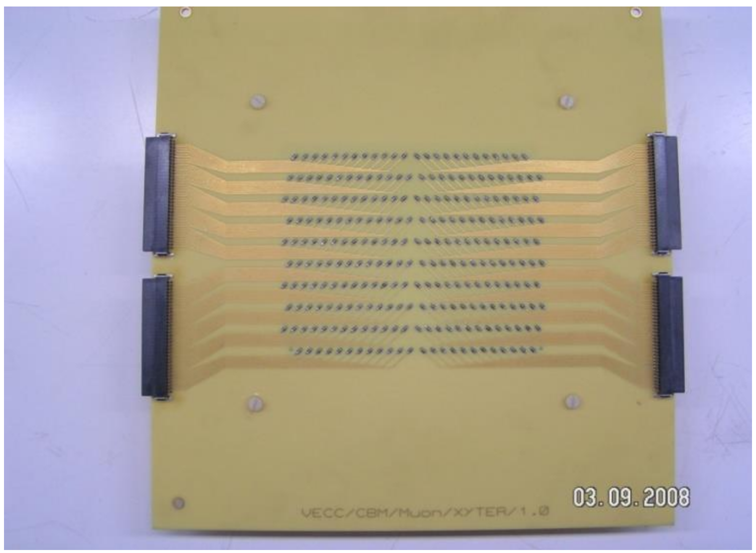
More insight of nXYTER ASIC



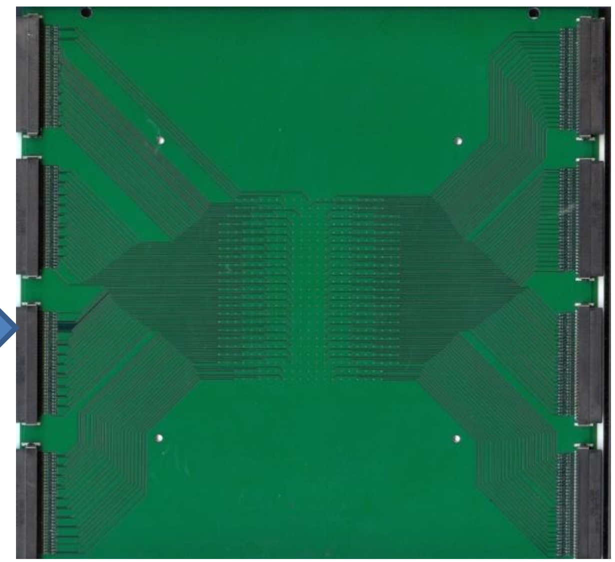
Self Triggered Electronics integration with GEM detector

- Self-triggered electronics is more prone to noise, hence a much more careful grounding scheme was developed.
- Introduction of ground plane on detector readout PCB
- HV grounding isolation with the detector ground to make the detector ground less noisy

This ground plane was introduced for some different purpose but it worked very good for noise performance



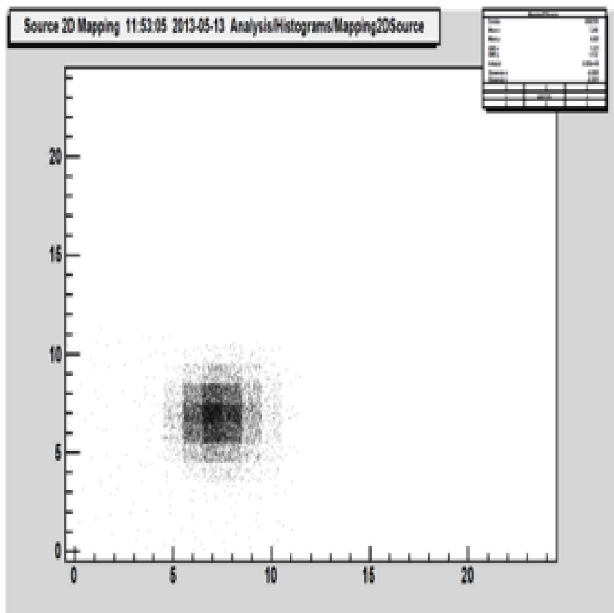
Earlier design with no ground plane with two layer design

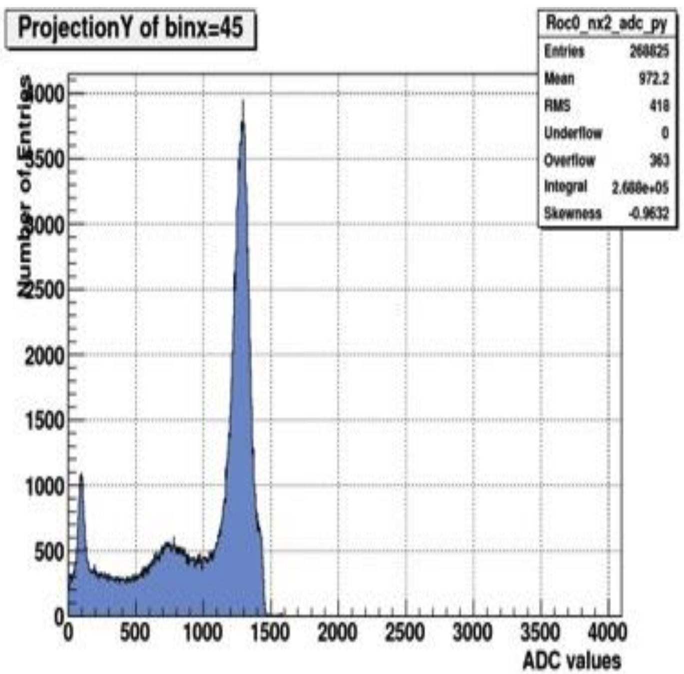


Later design with adapted ground plane with four layer design

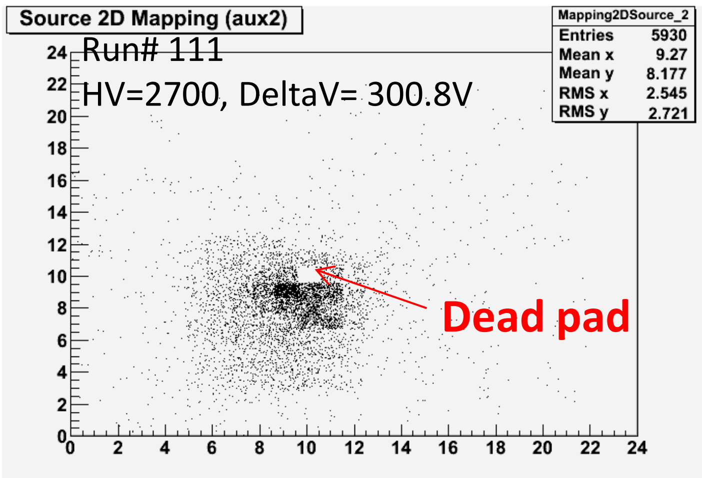
Low intensity incident beam results with self triggered nXYTER ASIC and GEM detector

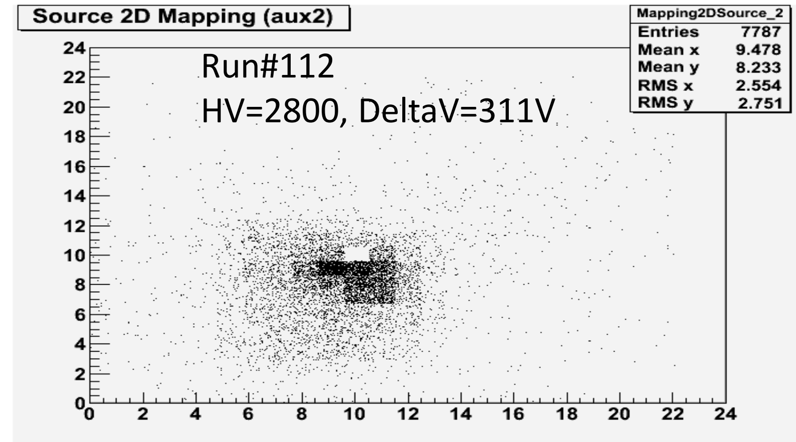
Fe55 source test results with collimator in front

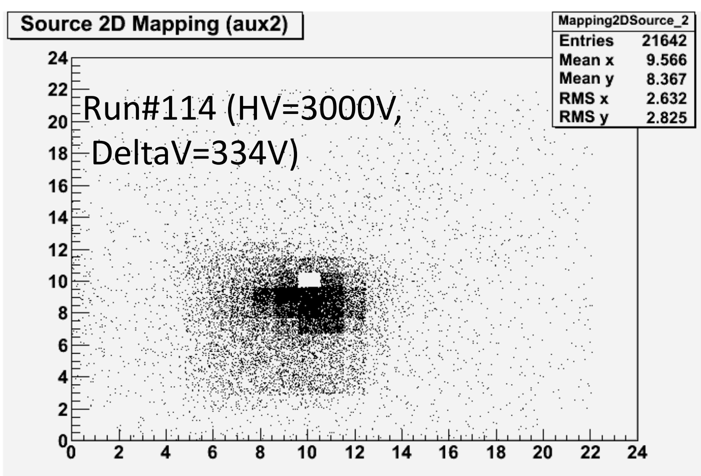


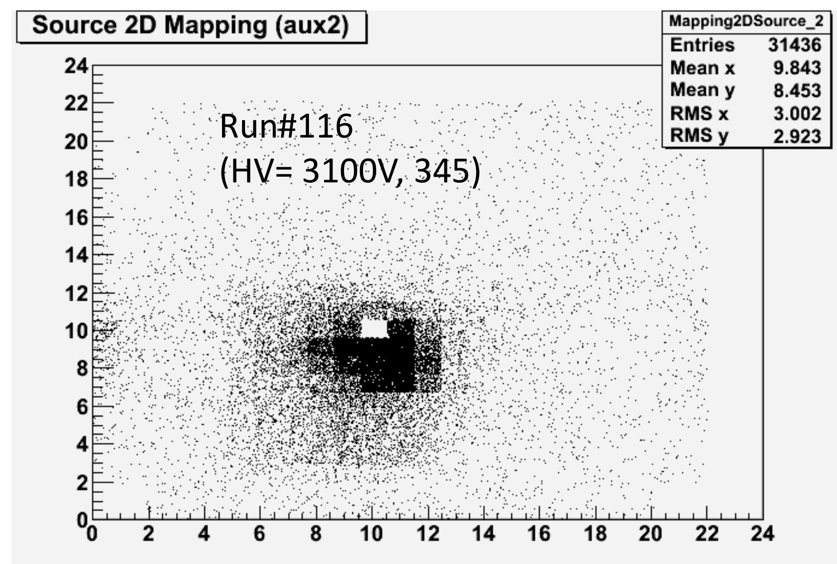


CERN Beamtest Nov-2012 (Low intensity runs)







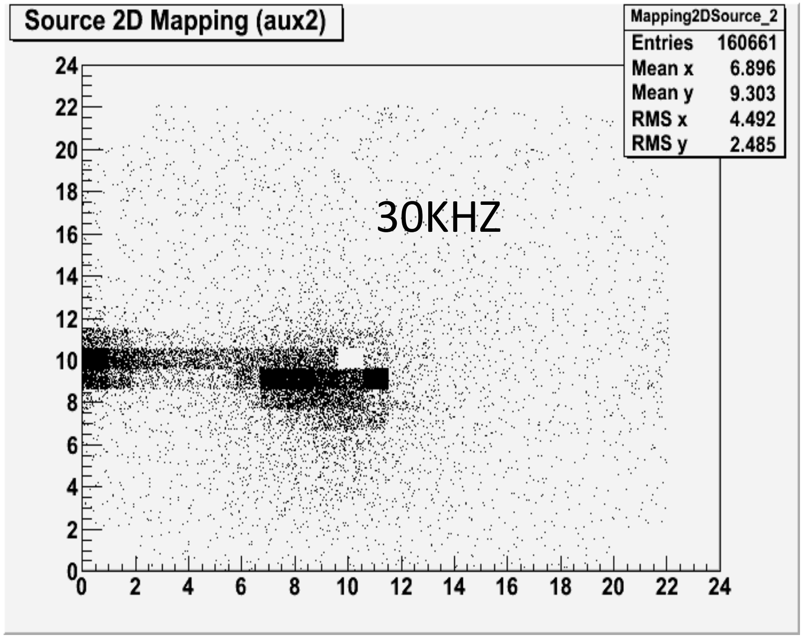


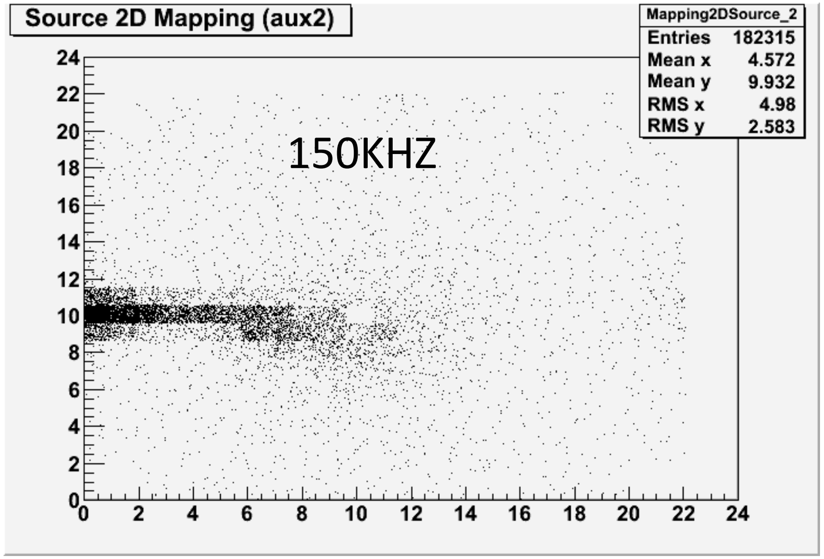
High intensity study of nXYTER with GEM detector

Problem faced in the test beam

- In CERN test beam Nov-2012, we got good efficiency with the detector and nXYTER electronics but hits are centered for low intensity run and hits are not centered for high intensity runs.
- Looking carefully, we saw that hits which are at the edges of the detector looks like the effect of cross talk but at the same time we didn’t saw hit in the center cell where principle hits are taking place.
- ADC with the low intensity run shows saturated pulses but with the high intensity run we saw drop in ADC.

CERN Beamtest Nov-2012 (High intensity runs)



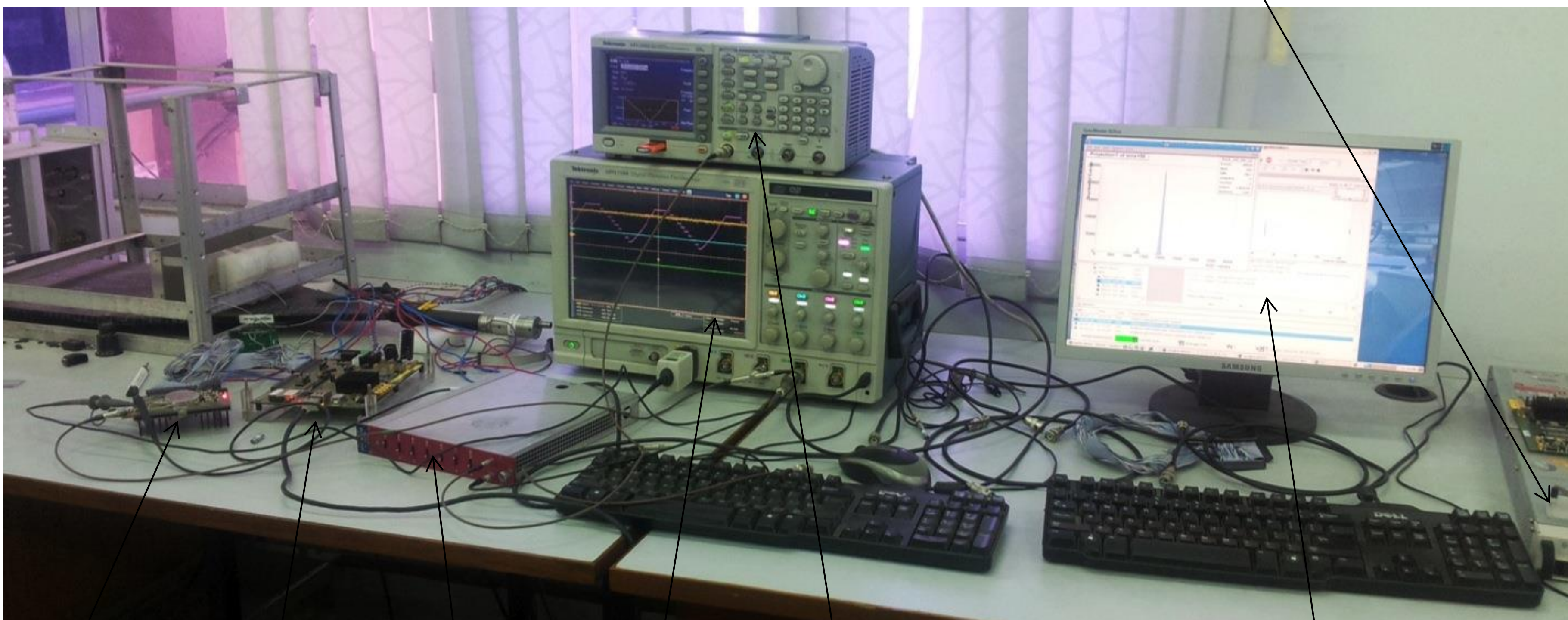


Tests done in VECC to diagnose this problem

- We made a step pulse as shown in next slide using an arbitrary pulse generator, to simulate detector pulse. Step is chosen to avoid discharge of the pulse and we can analyze consecutive detector pulse effect on the electronics.
- Next slides shows the setup information used for debugging the problem.

Full test setup for the test is shown below

Power supply for FEE and ROC



FEE baord

ROC board

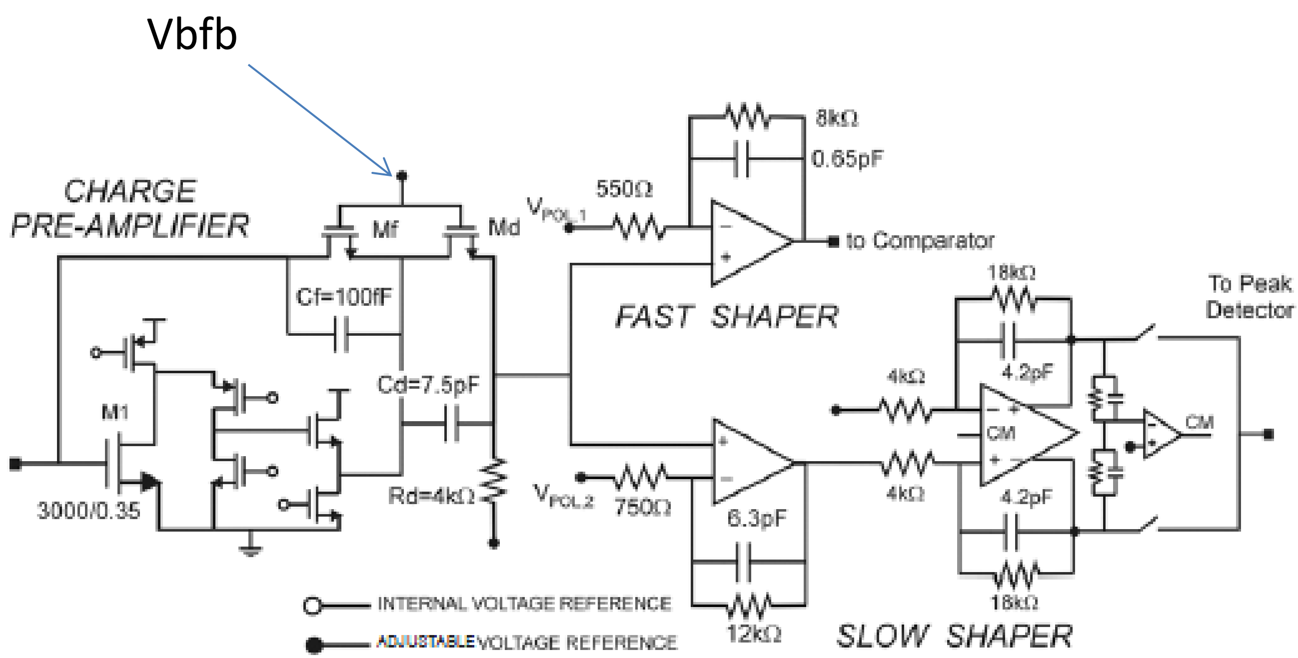
Attenuator

Scope to test Analog channel

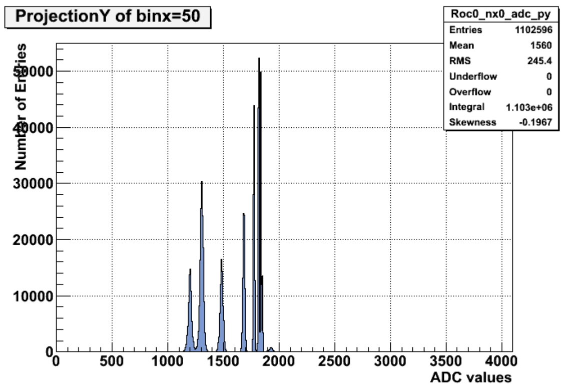
Arbitrary waveform generator

DAQ to configure FEE board and ROC and acquire data to analyze

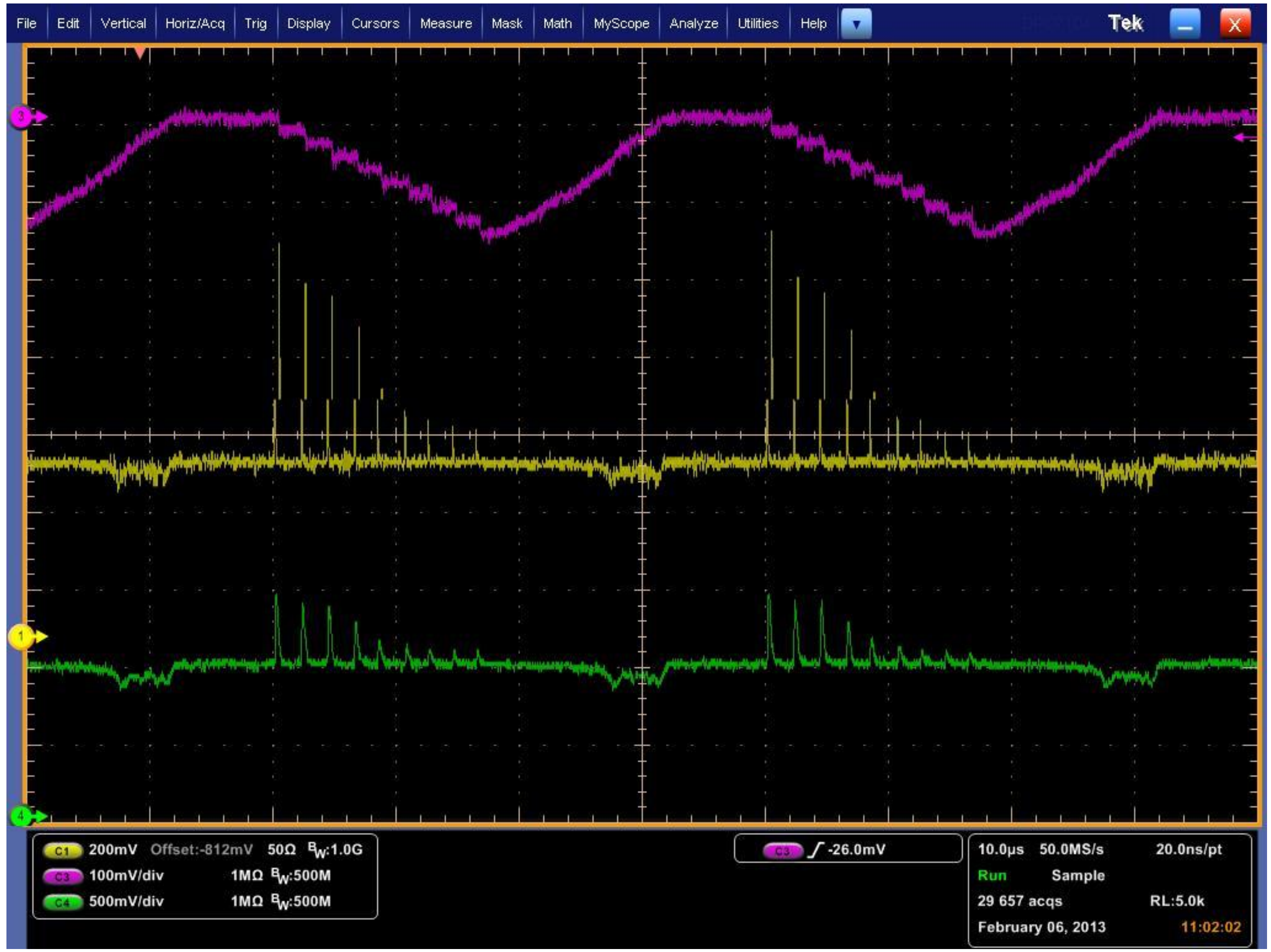
What is Vbfb used in next slides..??



Frequency=500Khz Vbfb=25, Charge input = 15fc/step

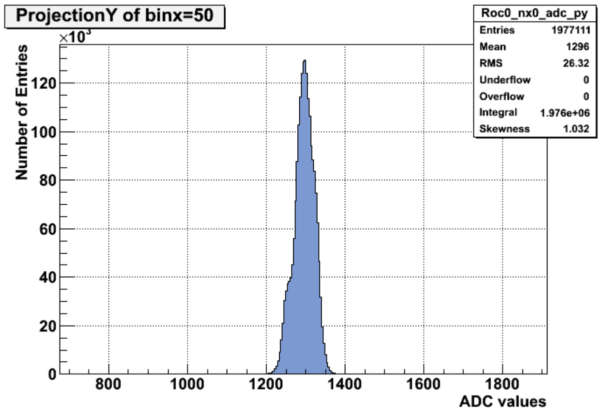


DAQ output

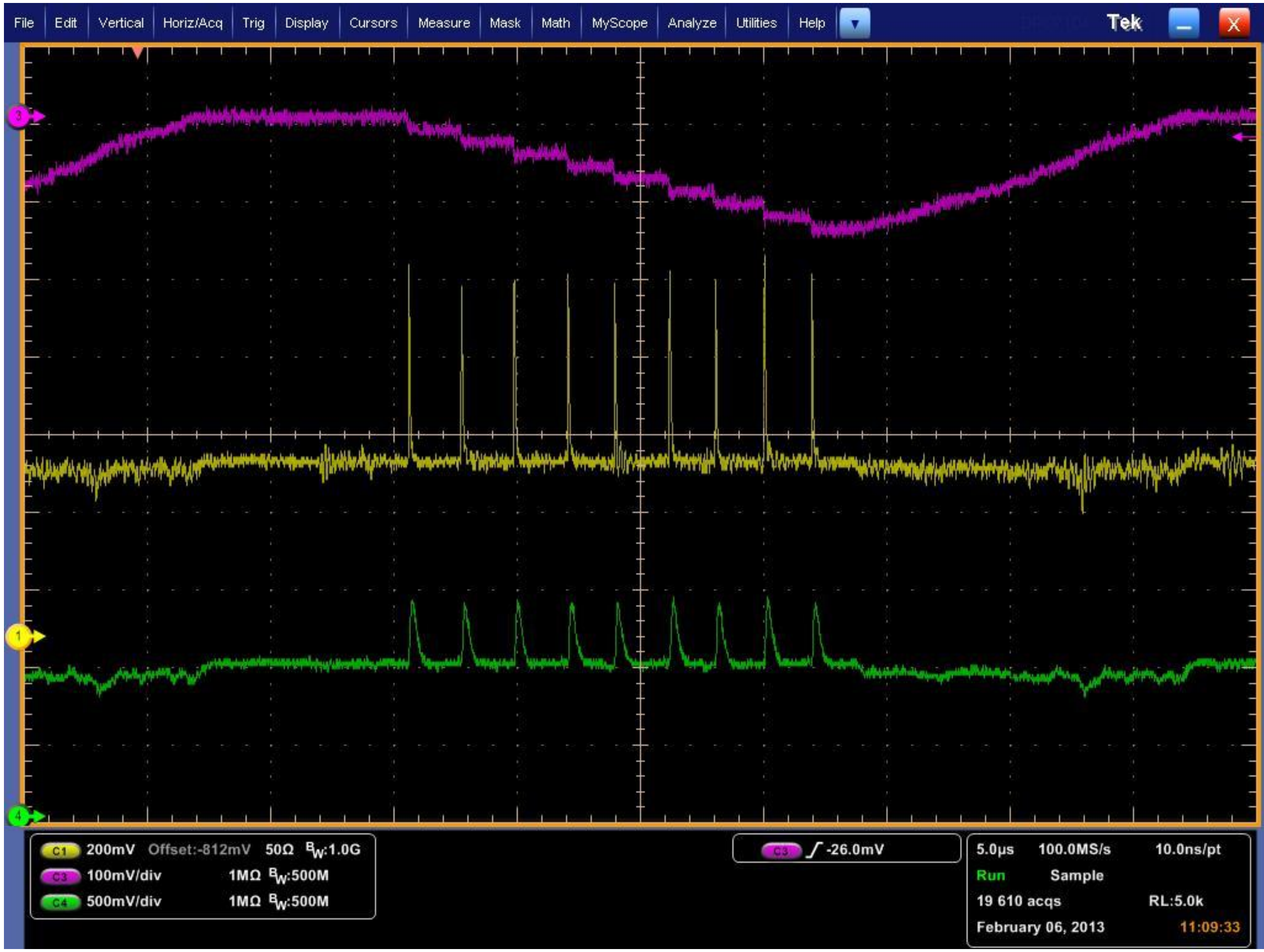


Screen shot from Scope for the nXYTER test channel

Frequency=500Khz Vbfb=90, Charge input = 15fc/step



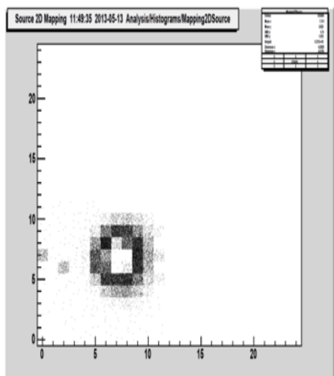
DAQ output



Screen shot from Scope for the Nxyter test channel

Fe55 source test at VECC without collimator

to see the saturation effect with respect to Vbfb



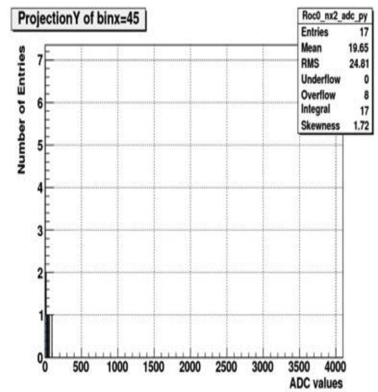
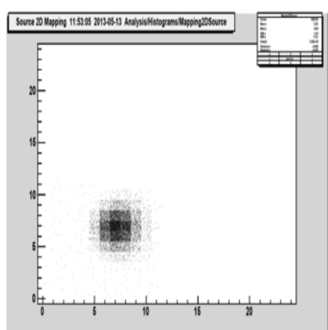


Fig.1 DAQ 2D plot with Fe55 at Vbfb=6 Fig.2 DAQ 2D plot with Fe55 Vbfb=6



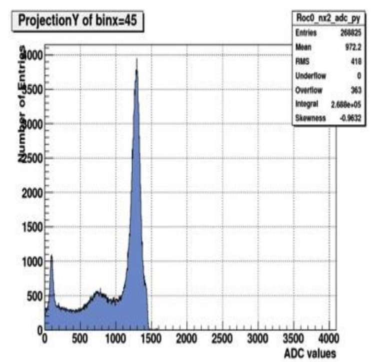
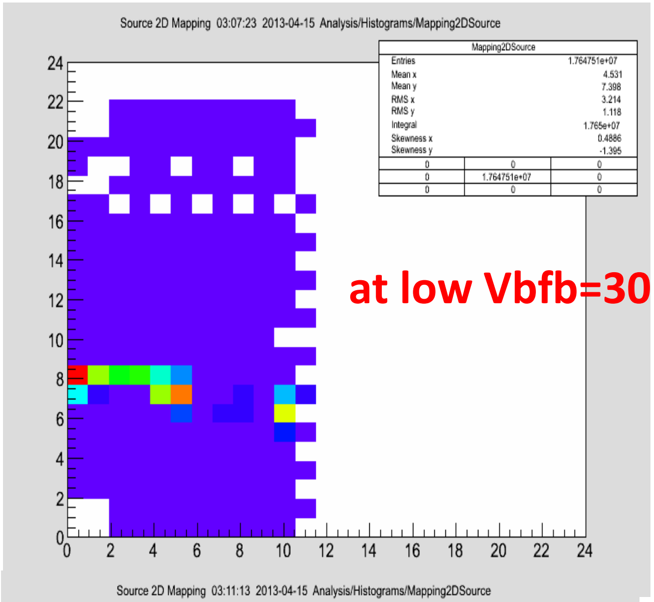
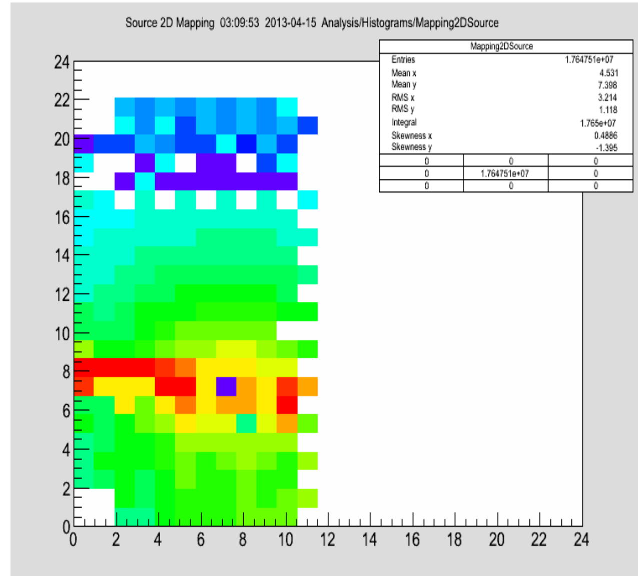


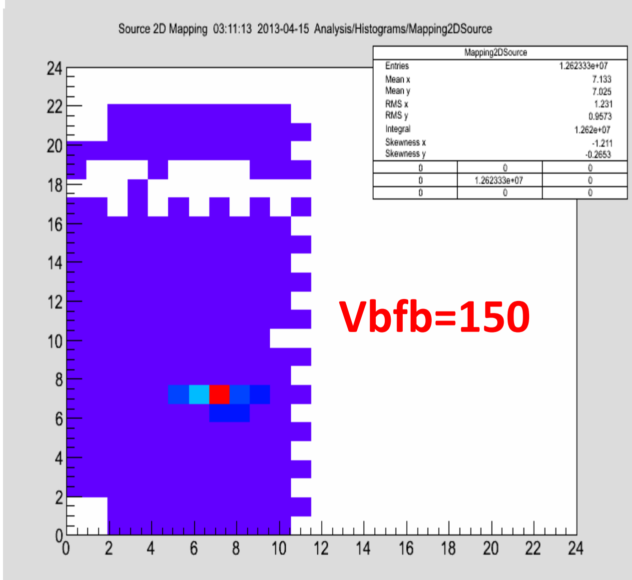
Fig.3 DAQ 2D plot with Fe55 at Vbfb=55 Fig.4 DAQ 2D plot with Fe55 Vbfb=55

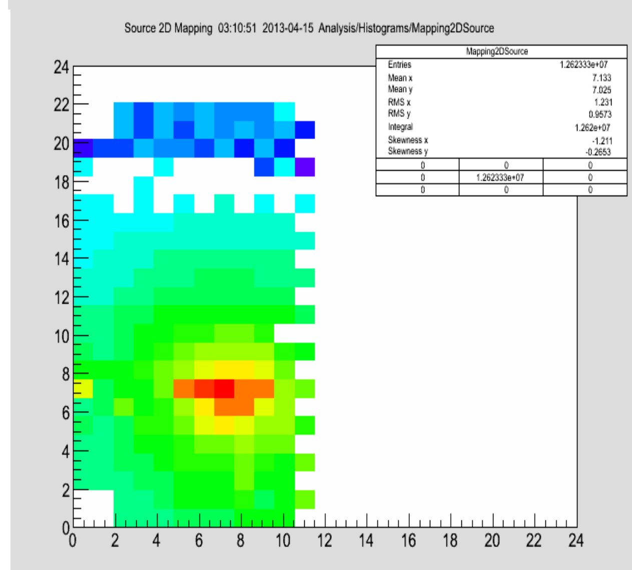
Reproduction of high frequency effect seen at CERN SPS tests.

with Mini X-ray frequency (350KHz), VECC chamber





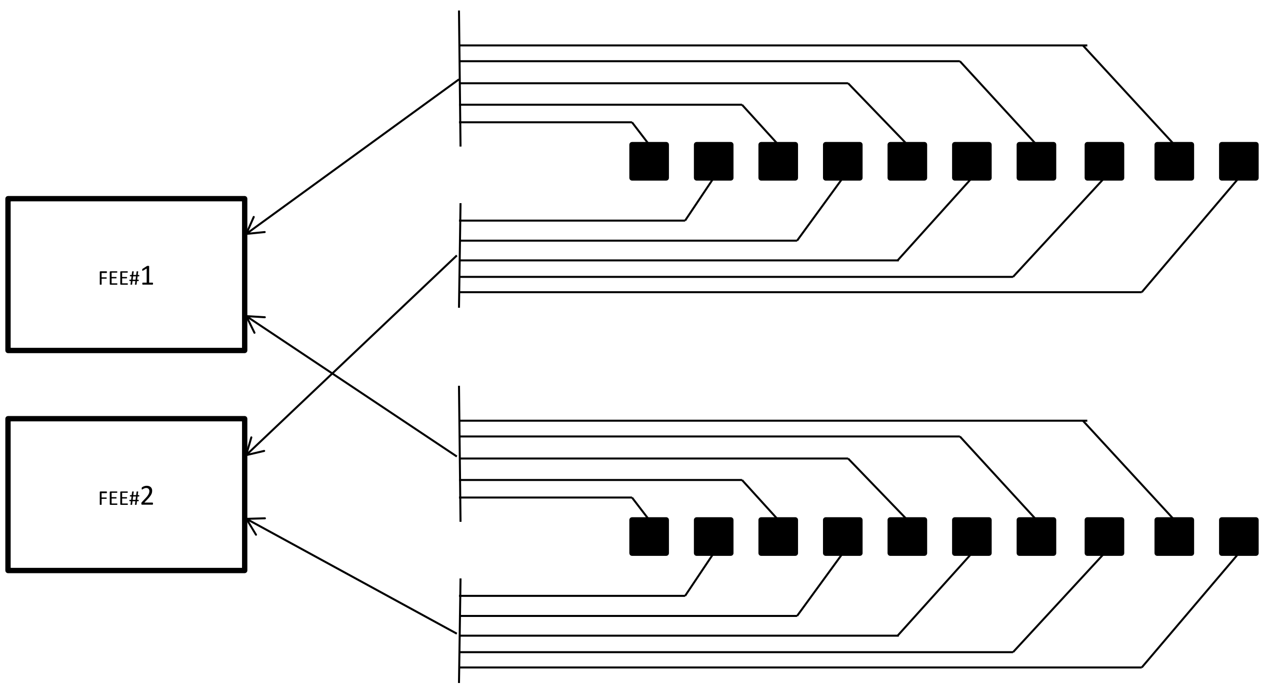




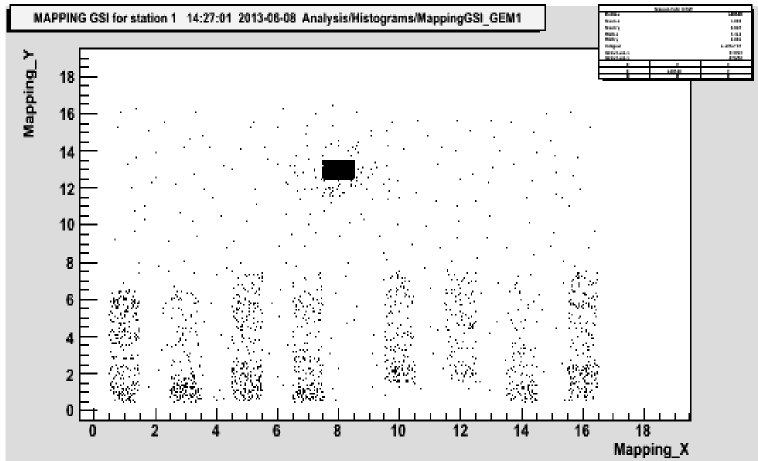
2D plot in linear scale **logarithmic scale**

Study of crosstalk effect with Vbfb parameter done at GSI detector lab

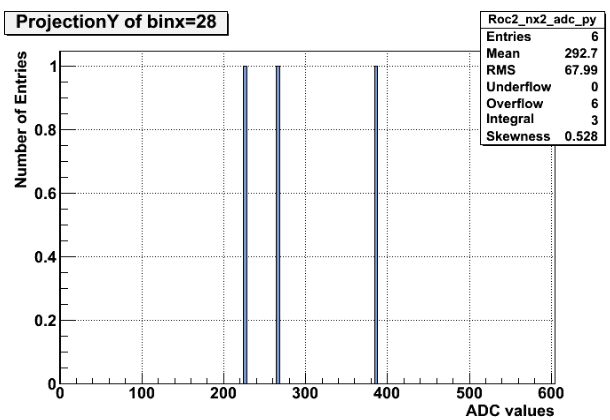
Small illustrative section of GSI GEM chamber PCB



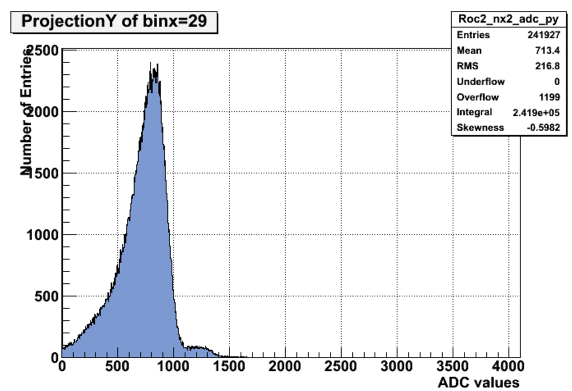
HV3100V, X-ray setting 15KV/5mA, frequency of 5KHz(avg) and Vbfb 50, with GSI GEM chamber. We can see the center cell is receiving all the hits while crosstalk cell rarely getting any hits.



2D plot of the data

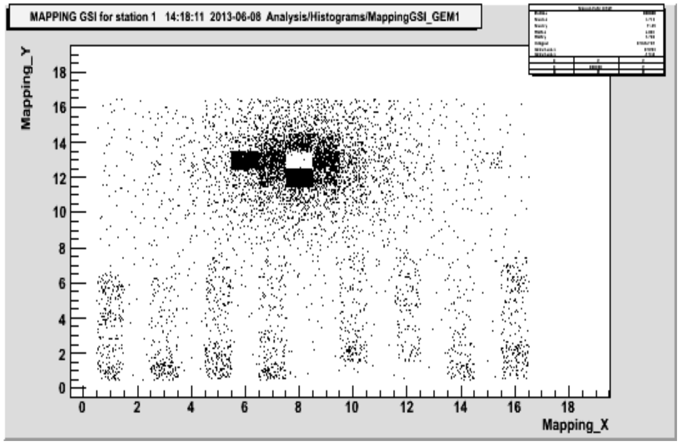


Crosstalk cell ADC plot of the data

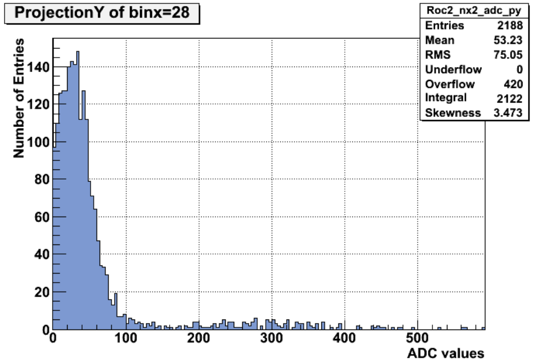


Center cell ADC plot of the data

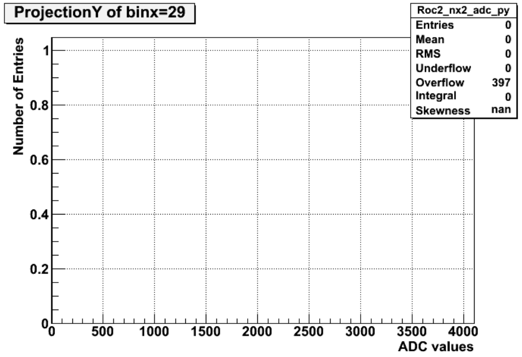
HV3100V, X-ray setting 15KV/200mA, frequency of 350KHz(avg) and Vbfb 50, with GSI GEM chamber. We can see the center cell is not receiving any hit while crosstalk cell is getting more and more hits.



2D plot of the data

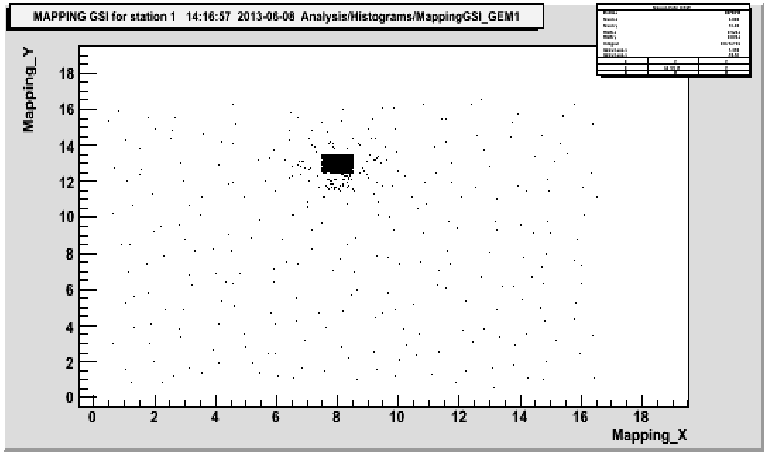


Crosstalk cell ADC plot of the data

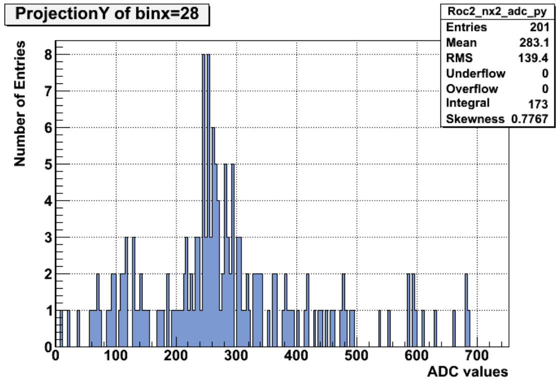


Center cell ADC plot of the data

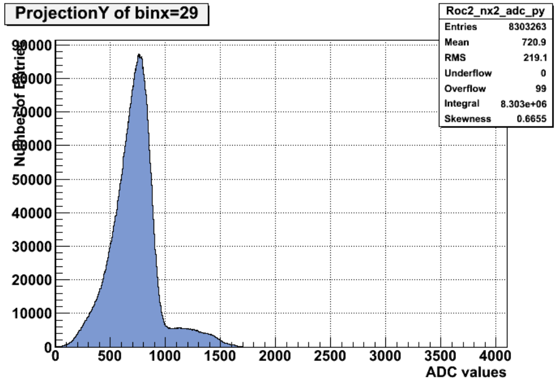
HV3100V, X-ray settings 15KV/200mA, frequency of 350KHz(avg) and Vbfb 150, with GSI GEM chamber. We can see the center cell is receiving all the hits after changing Vbfb, while crosstalk cell rarely getting any hits



2D plot of the data

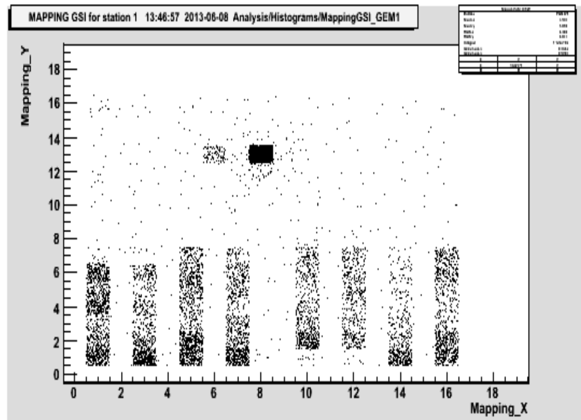


Crosstalk cell ADC plot of the data

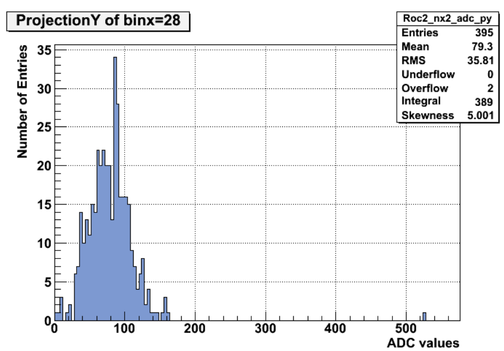


Center cell ADC plot of the data

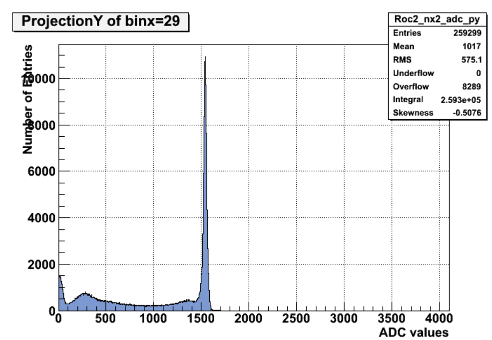
HV3300V, X-ray settings 15KV/5mA, frequency of 5KHz(avg) and Vbfb 50, with GSI GEM chamber. As compare to slide 14, we can see now the center cell as well as crosstalk cell are receiving the due to higher gain of chamber.



2D plot of the data

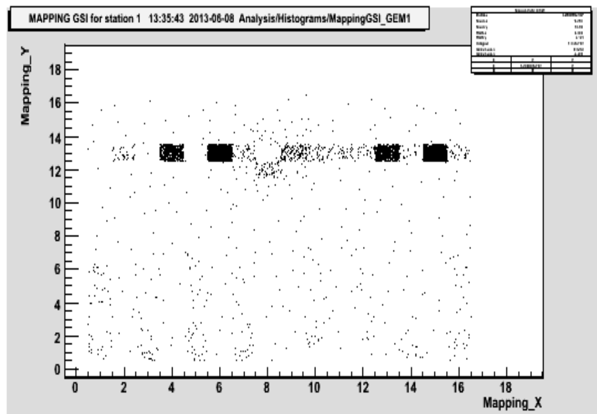


Crosstalk cell ADC plot of the data

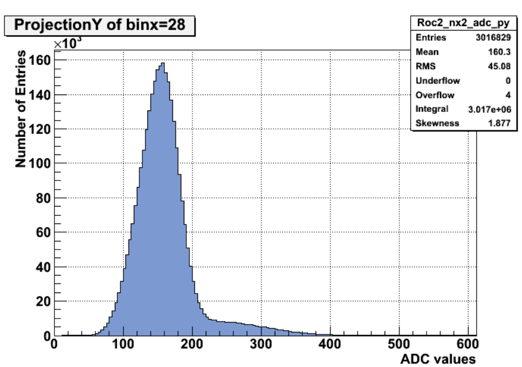


Center cell ADC plot of the data

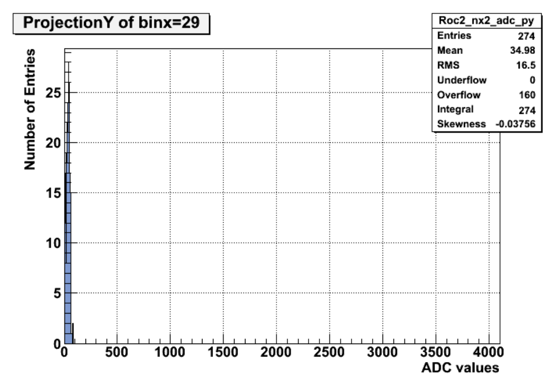
HV3300V, X-ray settings 15KV/100mA, frequency of 100KHz(avg) and Vbfb 50, with GSI GEM chamber. We can see the center cell is rarely receiving hits, while crosstalk cell rarely maximum hits



2D plot of the data

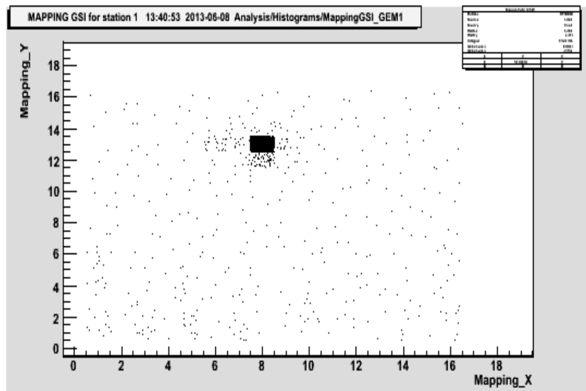


Crosstalk cell ADC plot of the data

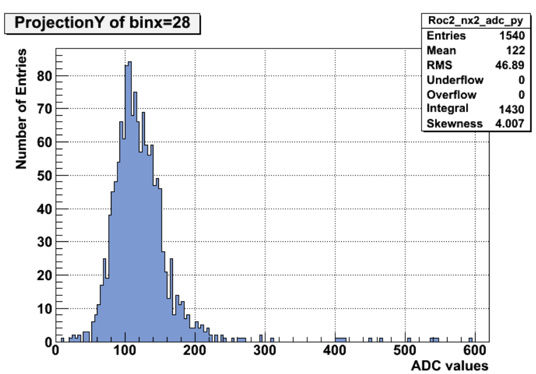


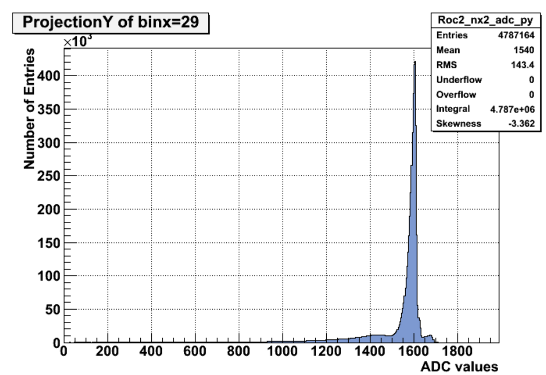
Center cell ADC plot of the data

HV3300V, X-ray settings 15KV/100mA, frequency of 100KHz(avg) and Vbfb 150, with GSI GEM chamber. We can see the center cell receiving all the hits, but crosstalk cell is still receiving hits with lower ADC value peak as compare Vbfb setting of 50.



2D plot of the data

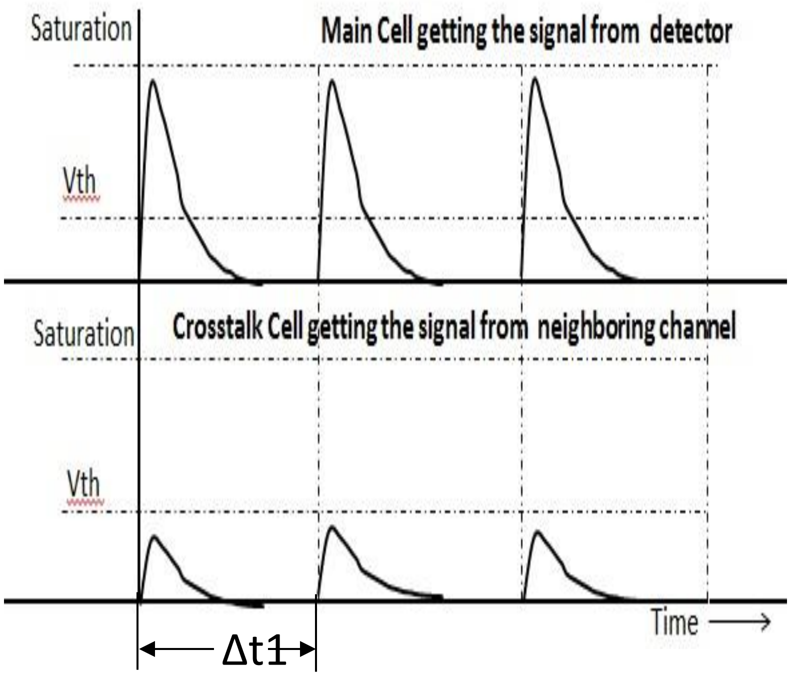




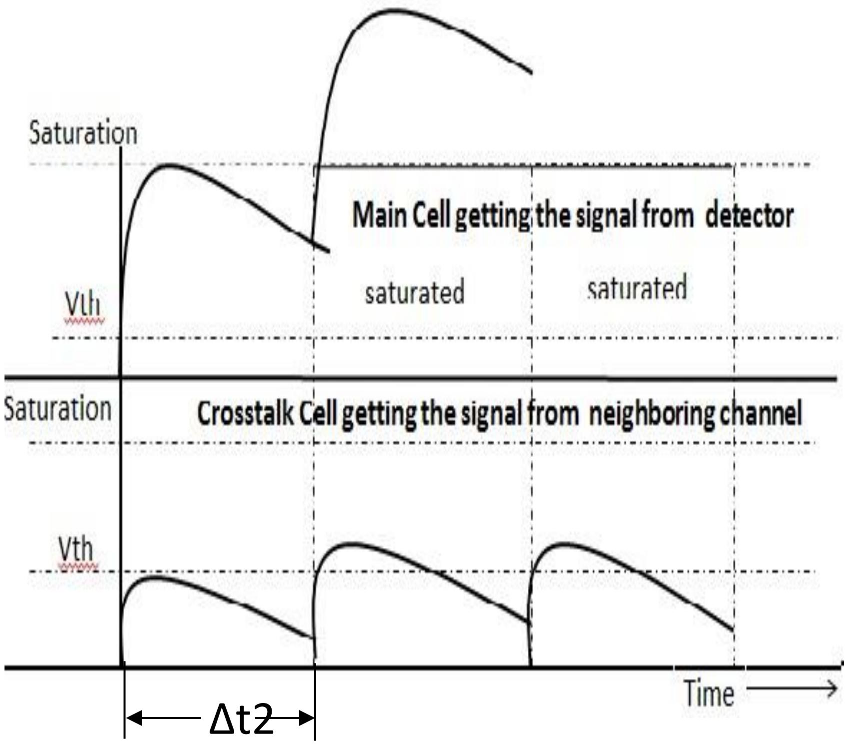
Crosstalk cell ADC plot of the data

Center cell ADC plot of the data

At low frequency

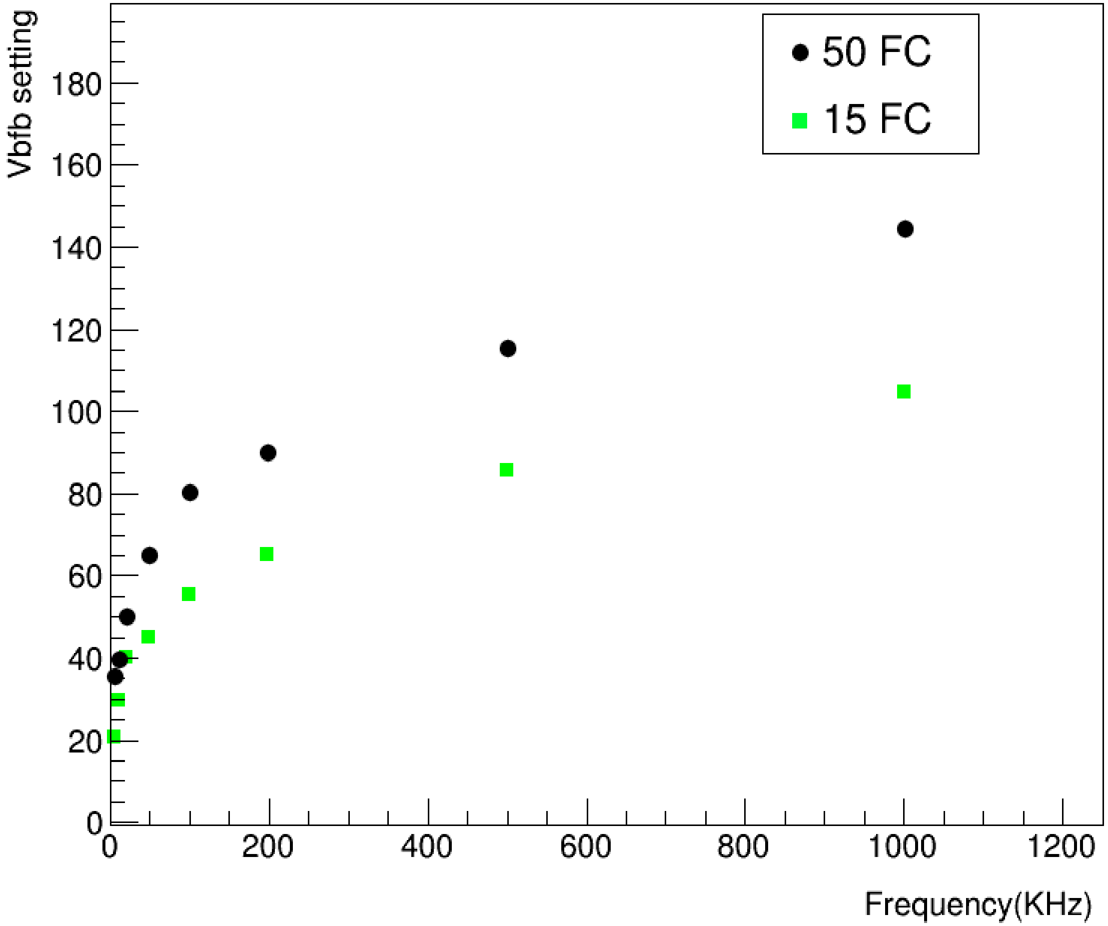


At high frequency



Here Δt1 > Δt2

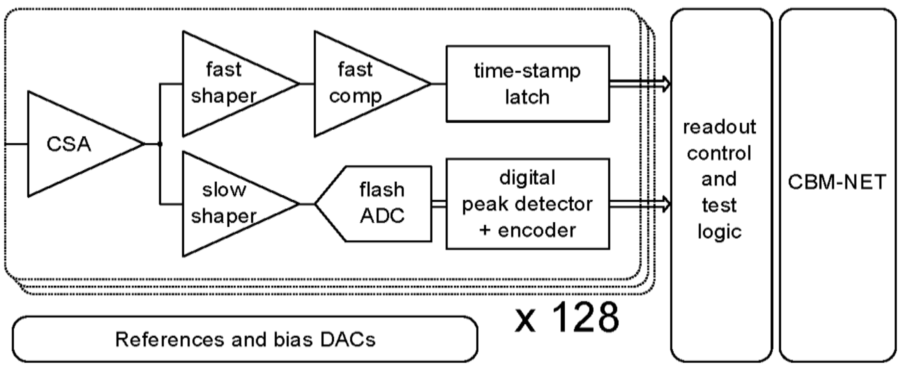
We further see the minimal Vbfb setting change with increase in charge input. Figure below shows the minimum Vbfb required with the varying frequency and with two different setting of charge input

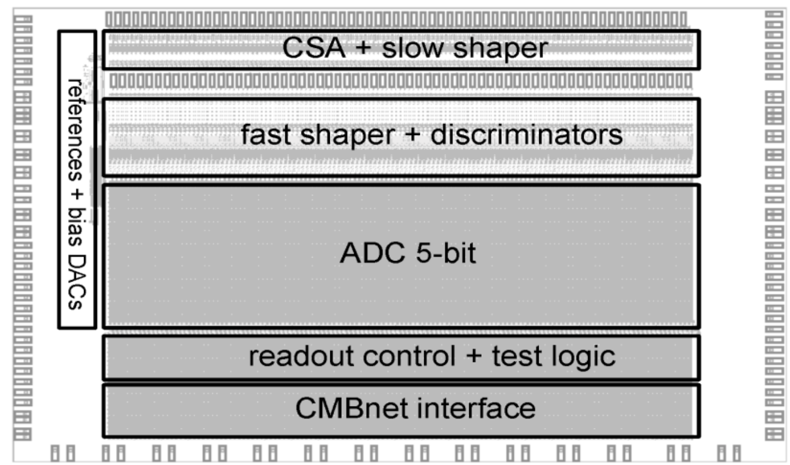


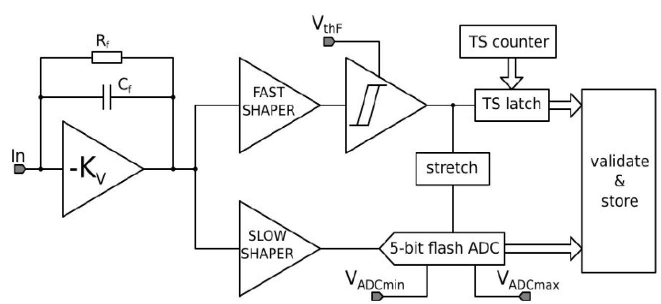
New ASIC development for CBM-MUCH GEM based detector

- STS group of CBM with collaboration with AGH Krakow is designing a new chip.
- This ASIC will have the similar front end architecture like nXYTER.
- This is built with the in build 32 channel ADC.
- This new ASIC is readout with the CBM-net backend designed by the collaboration.
- To meet the requirement of the GEM based MUCH detector, this ASIC will be made with dual gain having mode 1x and 4x with 1x equals to 8.4mV/fc.

Basic architecture of the new development







Parameters OF MUCH ASIC

parameter	value
number of channels	128+ 2 test channels depending on the test results of new STSXYTER
input pad pitch	116 um staggered in two rows
input signal polarity	negative
accepted input leakage current	10 nA
input capacitance (detector + cable)	30 pF
ENC @ 30 pF input capacitance	1000e
gain	8.4mv/fC
Dynamic range	1.5 - 48 fC
ADC channel	1.5fC
input clock frequency	250 MHz
timing resolution	~10 ns
power dissipation per channel:	< 10 mW
operating temperature range	Delta(T)< 40 degree C
technology	UMC 180 nm
Maximum hit rate/ channel	2 MHz
Shaping time constant	40ns
Spark protection	yes (HBM)
ADC	32 channel

Present status

- 1st version of STS-XYTER is already on table and tested with existing DAQ and preliminary tests were done with this ASIC.
- 2nd version of STS-XYTER with dual gain version to be used as a MUCH-XYTER is under design and submission is expected in Jan-2015

Thanks