Preliminary Results on Beam Halo Measurement using Diamond Sensor

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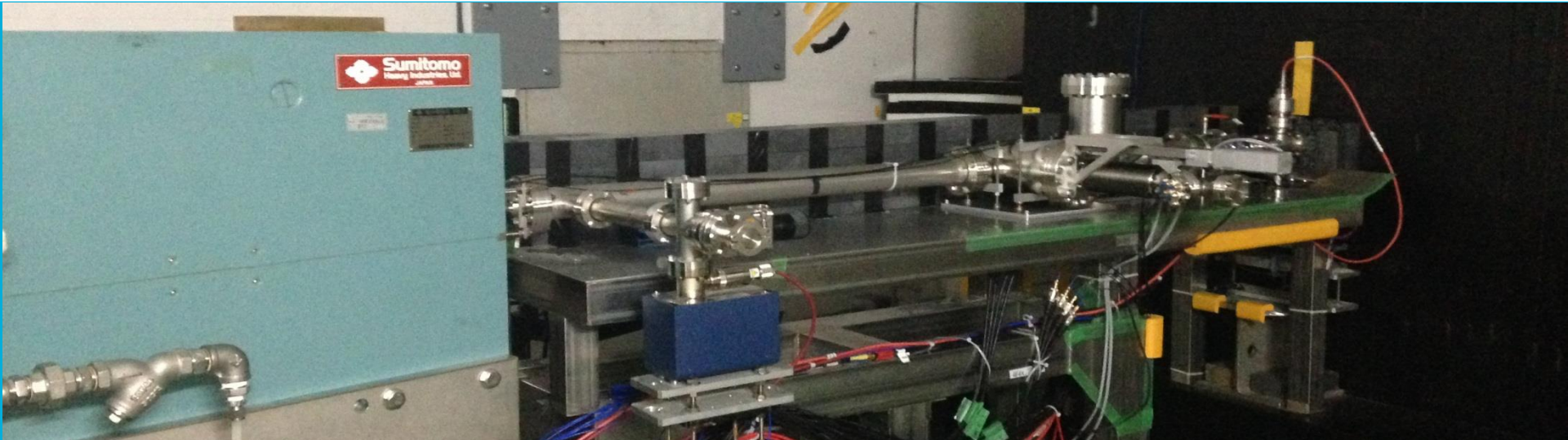
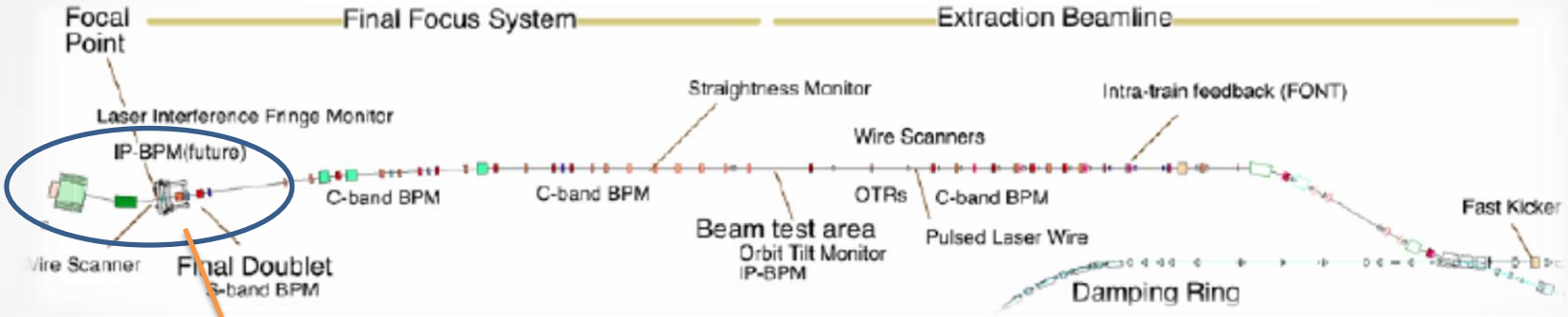
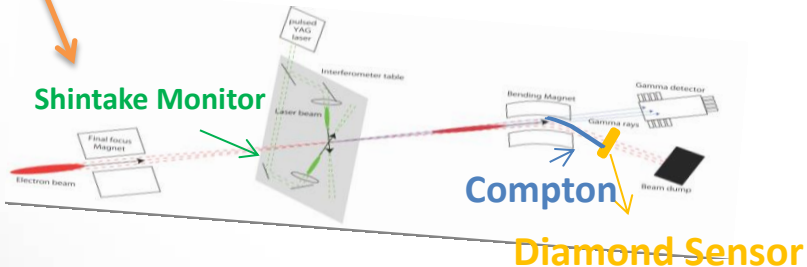
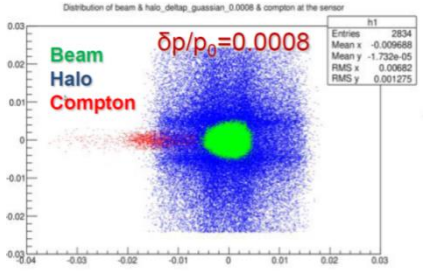


- Motivations
- In Vacuum Diamond Sensor @ATF2
- Experiments done
  - November Run
  - December Run
- Characterization of Diamond Sensor
- Beam Halo Measurements
- Issues and Prospects

Motivations

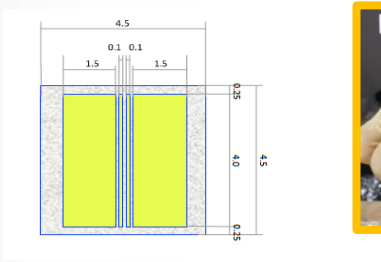


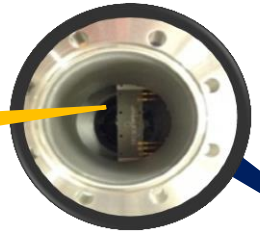


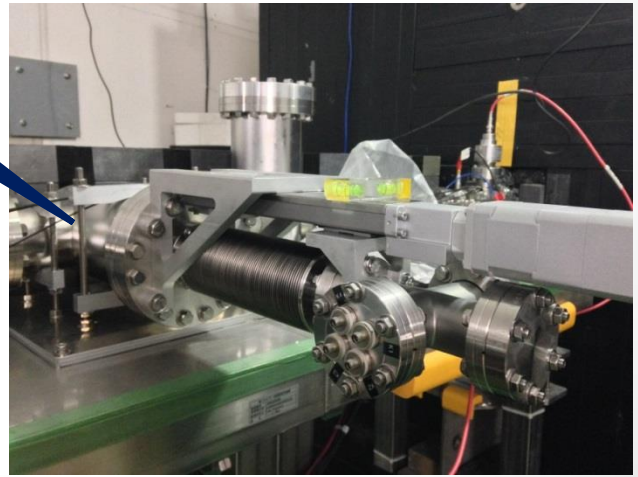


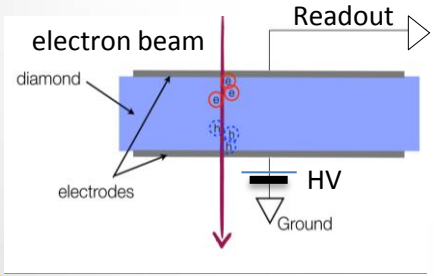
- ***Beam halo transverse distribution unknown → investigate halo model***
- ***Probe Compton recoiled electron→ investigate the higher order contributions to the Compton process (in the future)***

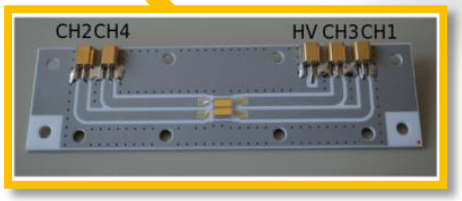
In Vacuum Diamond Sensor @ATF2











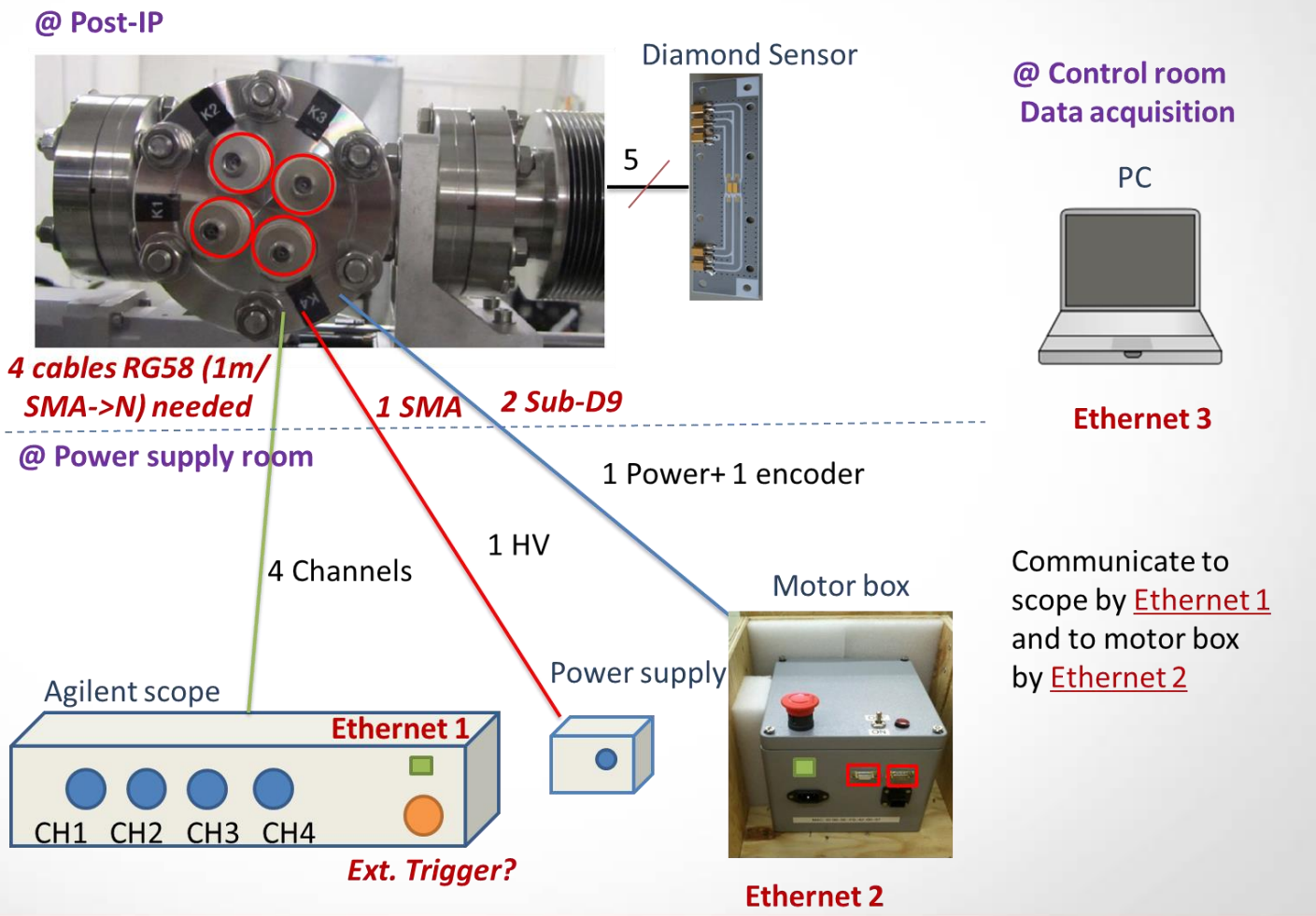
@CIVIDEC

The first Diamond Sensor is installed horizontally at ATF2.

The main purpose is to **measure the beam halo distribution**.

Data Acquisition System

Tests of the system were done at PHIL in Nov. 2014 before installation at ATF2



Communicate to scope by Ethernet 1 and to motor box by Ethernet 2

Experiments Done at ATF2 : November Run (5 shifts)

Tests and improvements of data acquisition system (DAS)

- Pick-up study
- Study of correlation between DS, ICT and BPM data
- Beam core and halo scan with different HV
- Background study (background signal from cables observed)
- Vertical alignment (VA) applied
- Tests of auto vertical range setting

-> DAS works well and the data acquisition procedure was defined

Experiments Done at ATF2 : December Run (6 shifts)

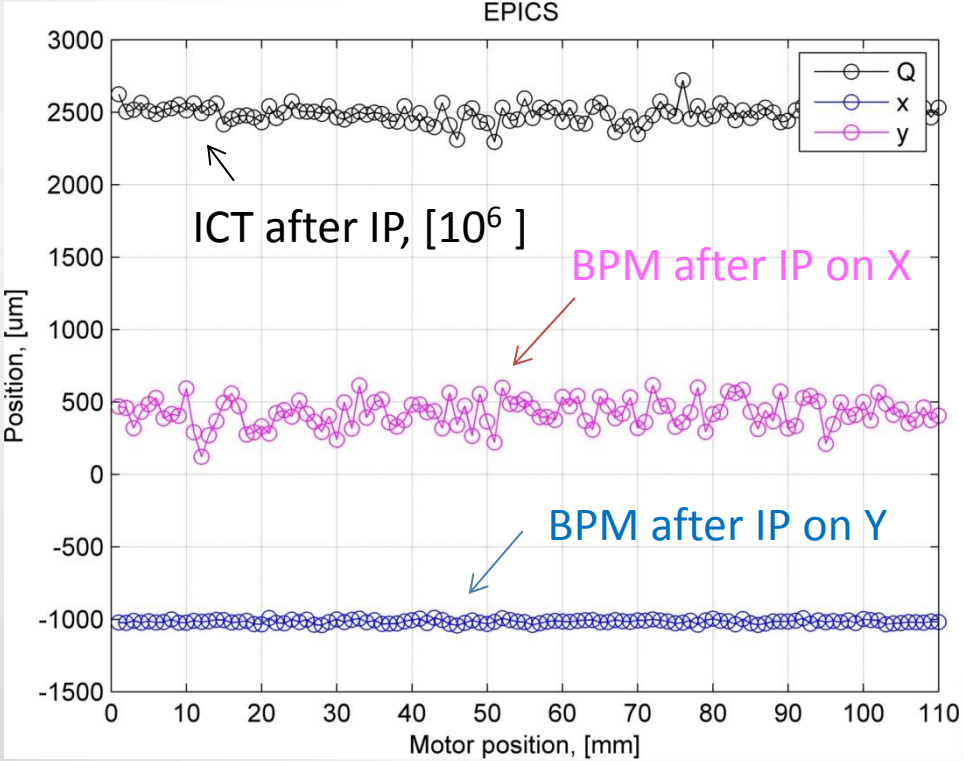
Characterization of DS performance and measurements of horizontal beam halo

- CCE study with attenuators(with different HV)
- Beam halo scan for different beam intensity ($1.1*10^9$,$2.5*10^9$,$4.9*10^9$)
- Beam halo scan for different beam optics (low energy side)
- Study the background from cables
- Study the cut of beam halo by upstream apertures
- Compton recoil electrons

Characterization of Diamond Sensor (DS)

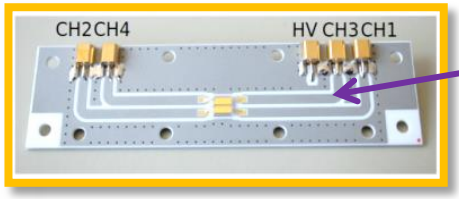
- Calibration of DS: ICT data taking
- Lower limit of DS : pick-up study
- Higher limit of DS : linearity study

Information from ICT and BPMs

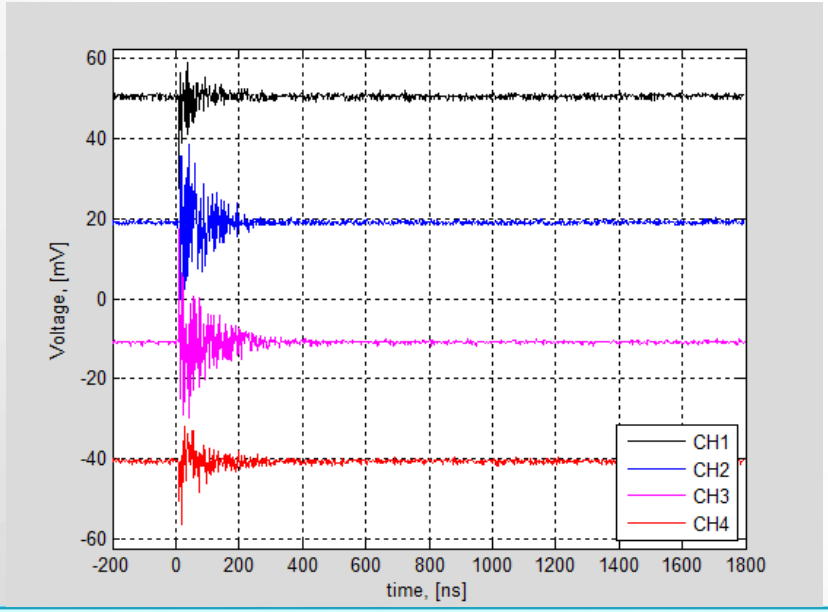


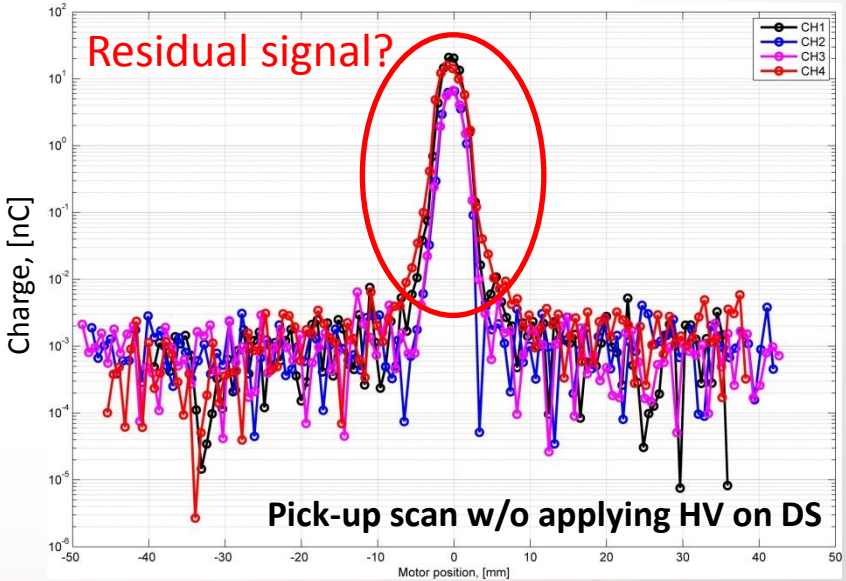
- ICT correction and beam position jitter (4-6 µm) can be taken into account in data analysis
- We read the data from Epics via SSH, but it is possible to use Labca to get data directly from Matlab
- In the future we can also input data from DS to the Epics system

Signal Pick-up Study

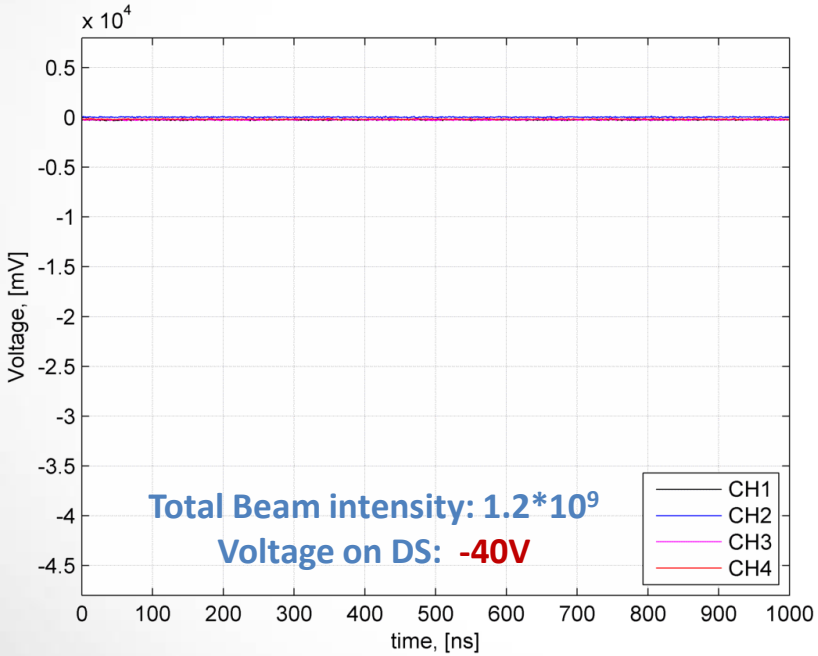


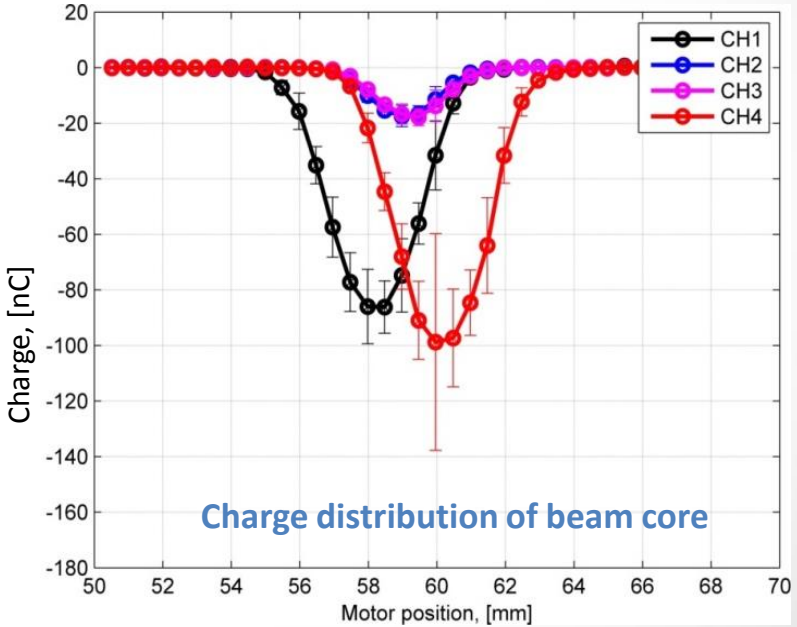
Signal pick-up by the strip lines on the PCB was observed as the PCB is not shielded





Initial Waveforms and Charge Distribution

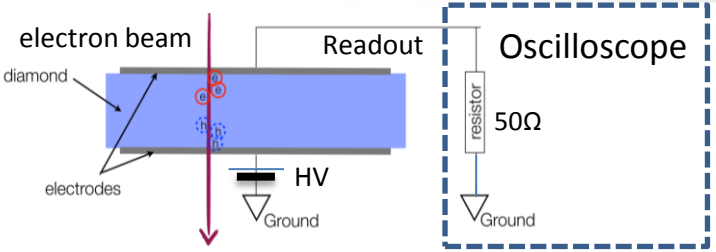


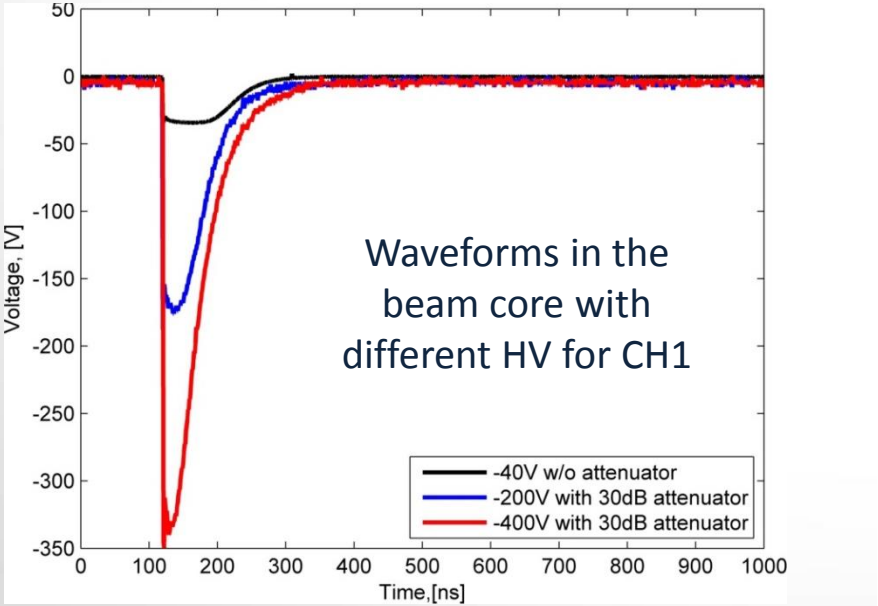


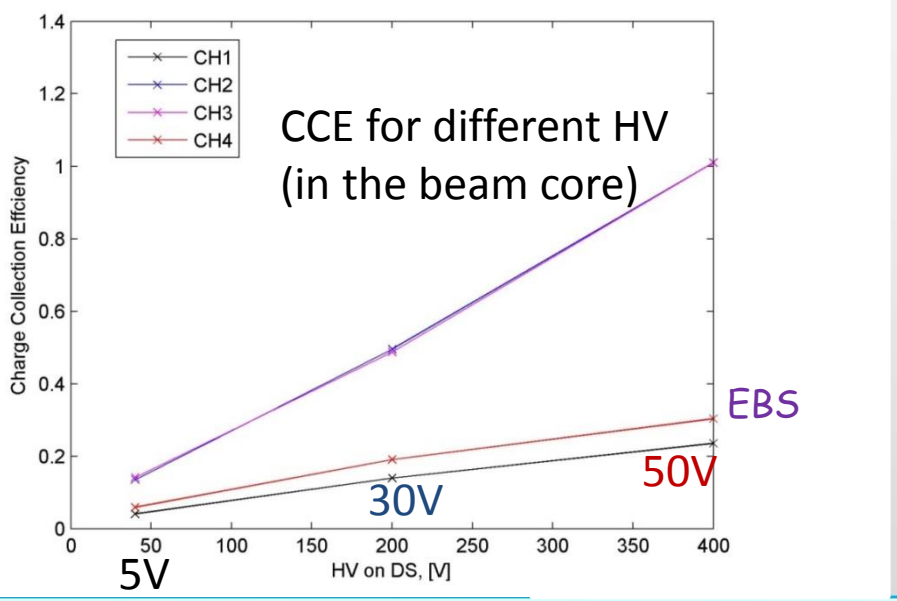
- The beam core is scanned by DS by applying low voltage
- The charge of waveform at each position is integrated to get the distribution

Charge Collection Efficiency

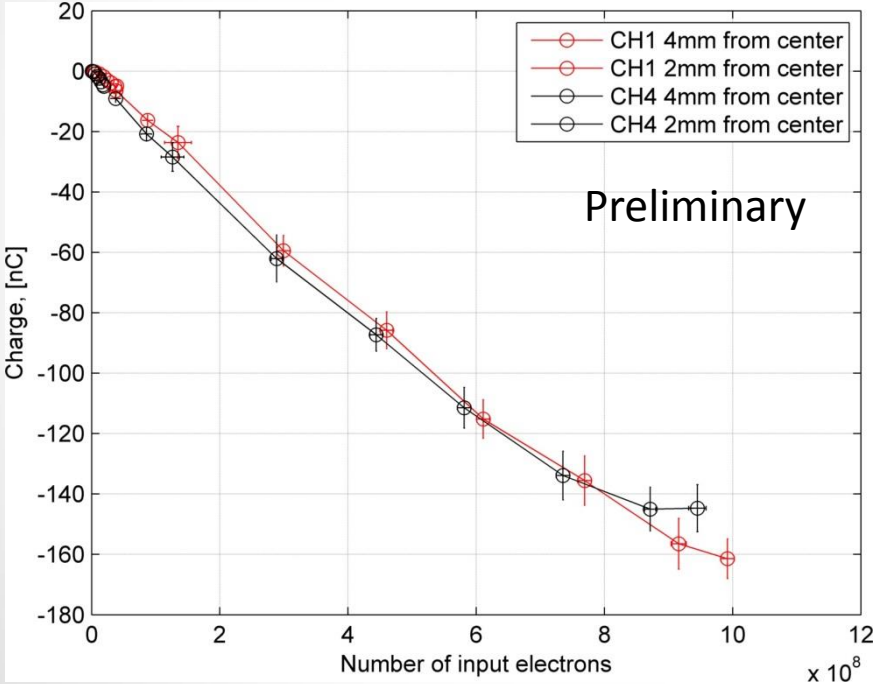
- Charge collection efficiency (CCE) depends on the "effective" bias voltage (EBS) on DS
- EBS = applied HV – voltage drop on the 50Ω

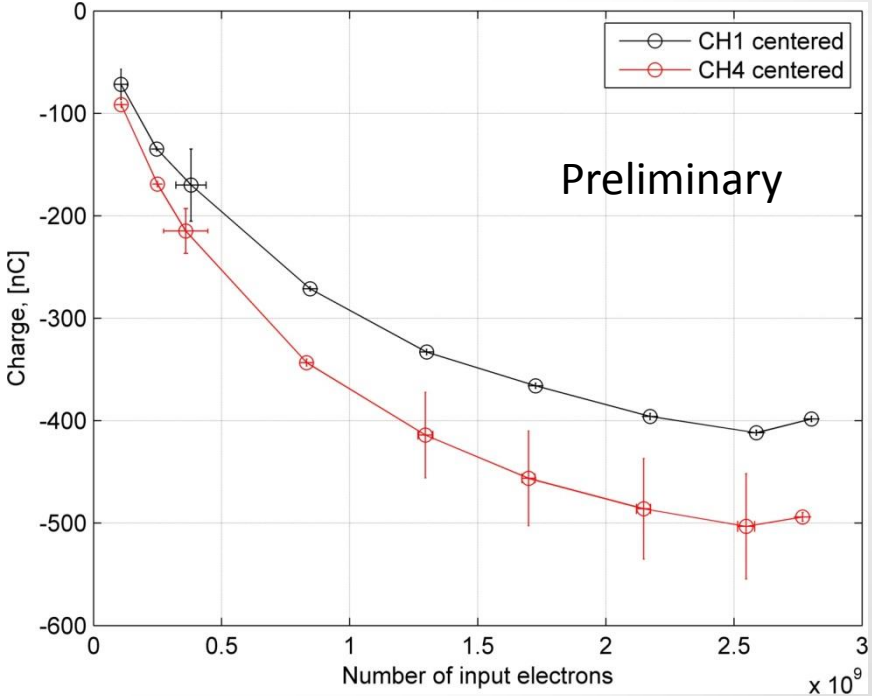






Linearity of DS Response





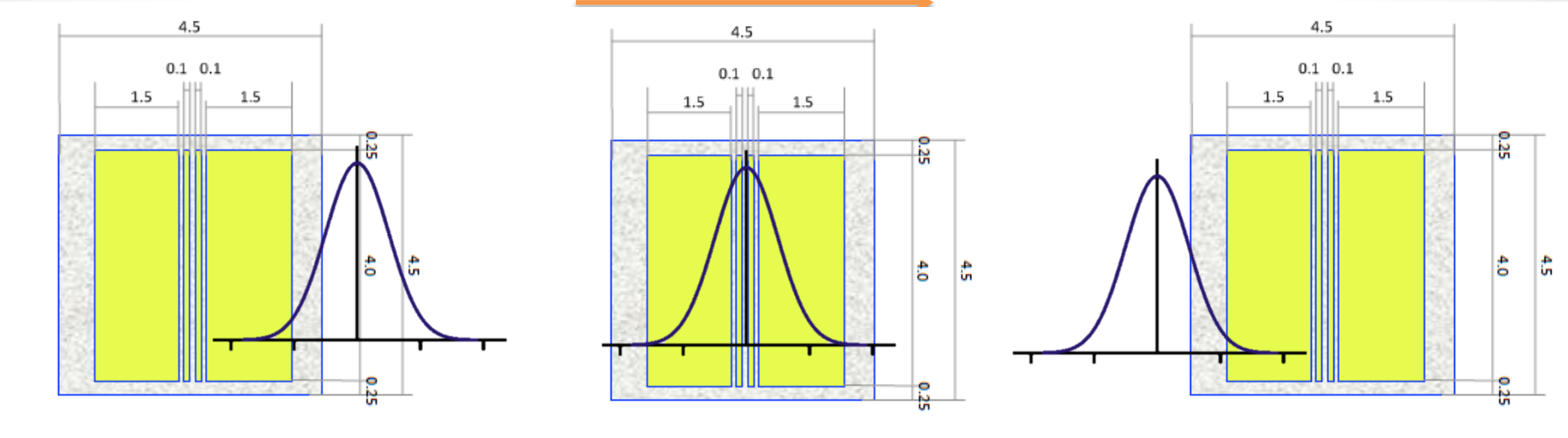
- Response is linear when the voltage drop is not significant
- In the beam core we observed an obvious non-linear response due to large voltage drop

Beam Halo Measurements

- Beam core scan and beam core distributions
- Beam size verification
- Beam halo scan and beam halo distributions

Beam Core Scan

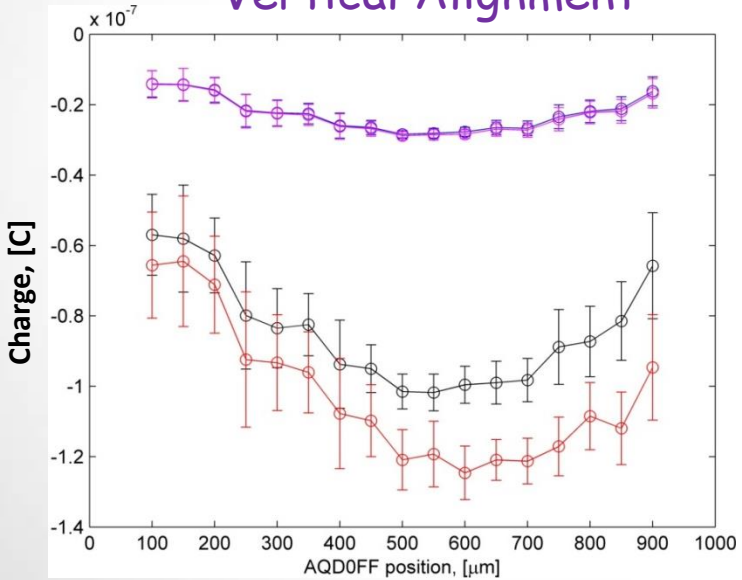
Scan direction



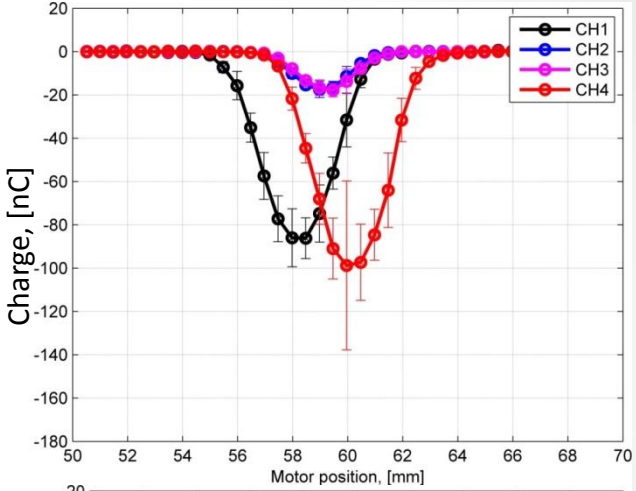
- Signal at each channel is a convolution of beam (Gaussian) with strip (rectangular shape)
- Fit function: F(d1,a1,b1,s1) = d1+a1*(**erf**(((x+0.75-b1)/(sqrt(2)*s1)))-**erf**(((x-0.75-b1)/(sqrt(2)*s1))))

Beam Core Scan

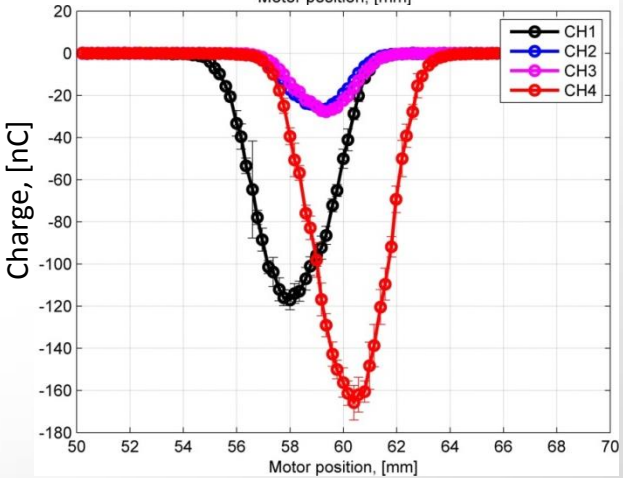
Vertical Alignment



Before Alignment



After Alignment



We move the AQD0FF magnet mover vertically to find the max. charge collected on DS

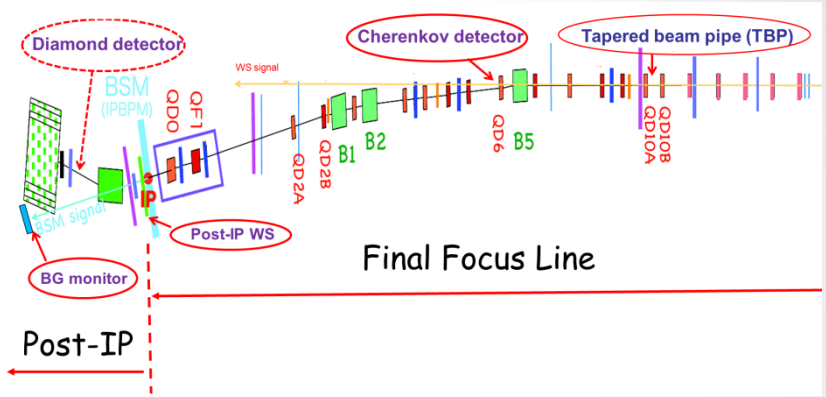
Beam Size Verification

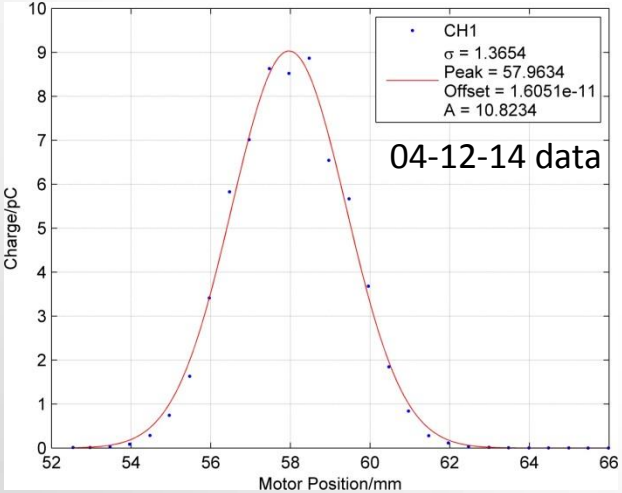
Post-IP wire scanner (WS) measured beam size:

σ_x= 265.6 μm σ_y=425.4 μm

Calculated beam size @ Post-IP WS:

σ_x= 139.25 μm σ_y= 250.00 μm





Calculated beam size @DS: σ_x=1.31 mm , σ_y=1.54mm

take into account β_x mismatch factor: 4.527

take into account β_y mismatch factor: 2.895

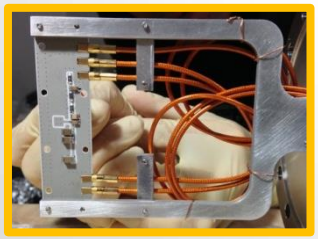
→ σ_x=1.997 mm @DS, σ_y=2.63mm @DS

	CH1	CH2	CH3	CH4
DS measured σ_x	1.37 mm	1.23 mm	1.21 mm	1.35 mm

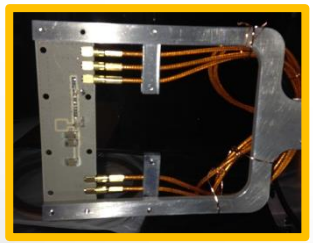
Beam Halo Scan

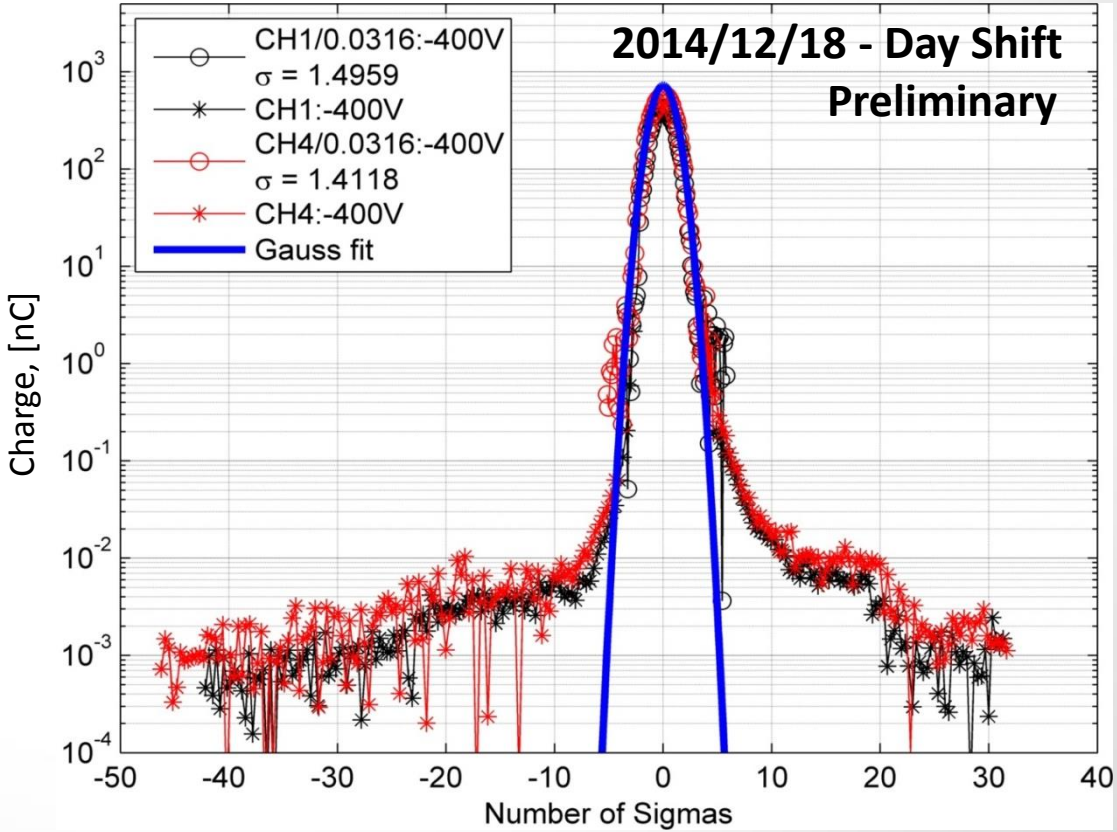
- Beam halo scan were done for different beam intensities and different beam optics
- Asymmetry of beam halo distribution might be due to the background generated by the cables on the right side

Before fixing

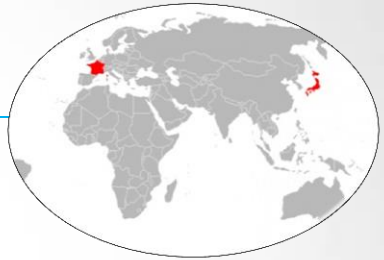


After fixing





Conclusions and Prospects



In Nov. and Dec. Run at ATF2 we performed:

- ✓ Studies to characterize the in vacuum DS performance
- ✓ Measurements of horizontal beam halo distribution

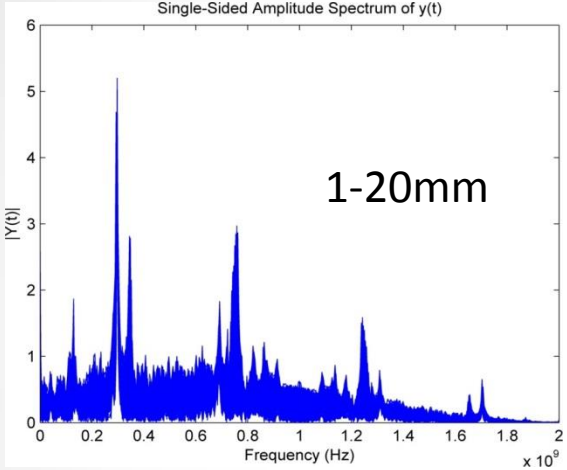
Studies to be continued:

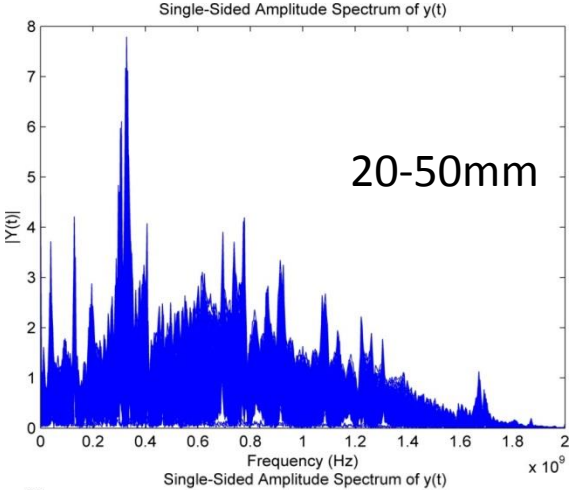
- Dynamic range of 10^6 was confirmed (with 30dB attenuator) *-> saturation of charge collection and effect of voltage drop will be studied in detail*
- Study of beam halo distribution dependence on beam intensity and beam optics *-> data to be analyzed*
- *Further study to check the possibility of measuring Compton recoil electrons will be carried out*

Thank you!

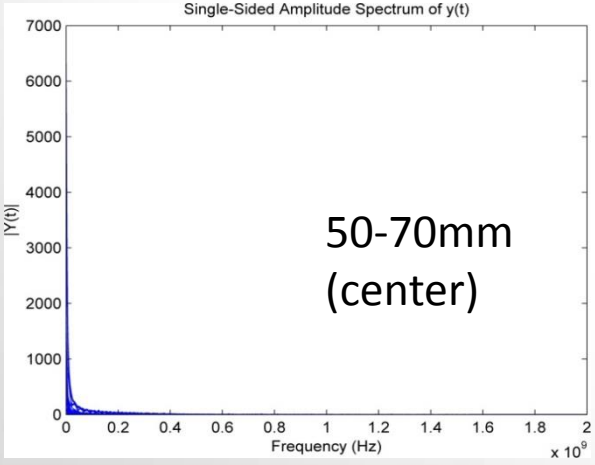
Back up …

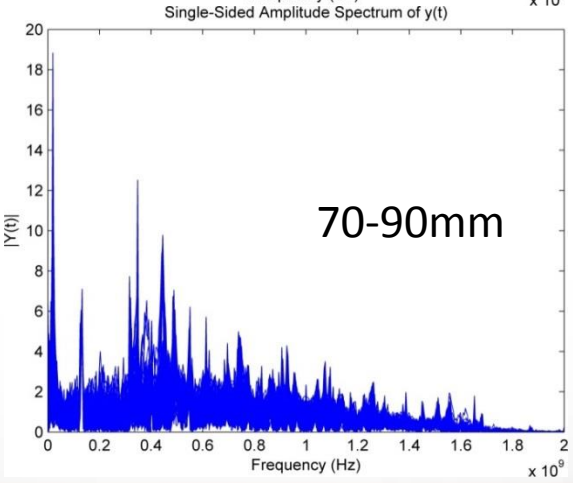
FFT of Pick-up

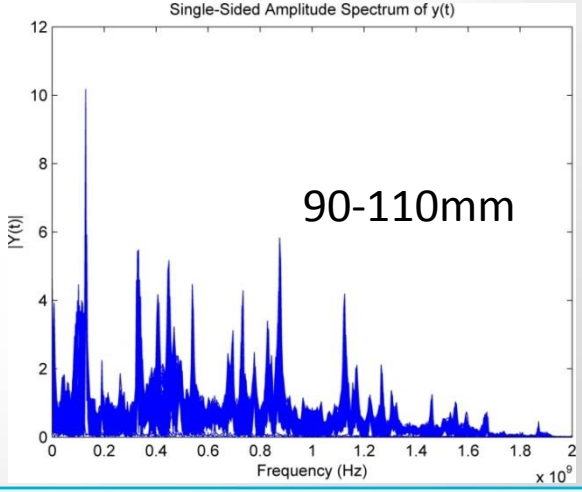


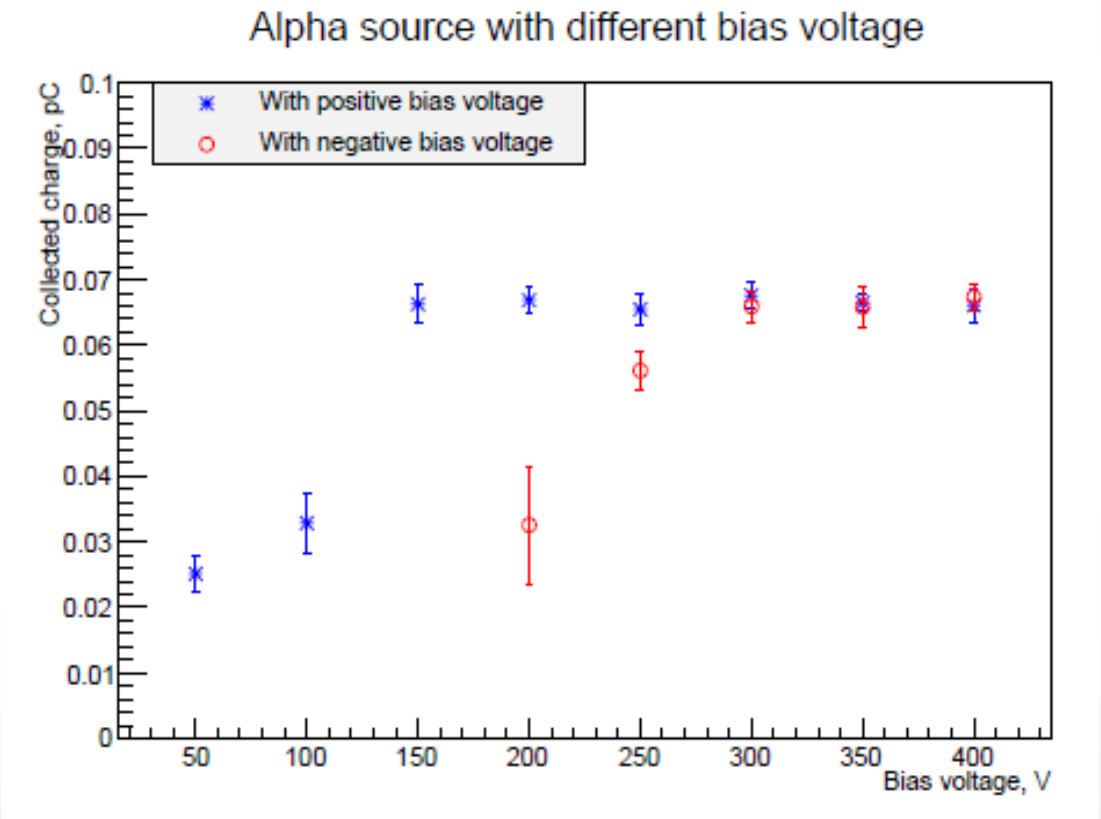


Asymmetry in frequency domain observed

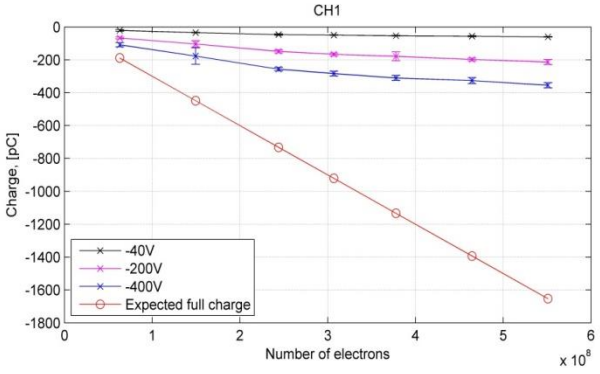


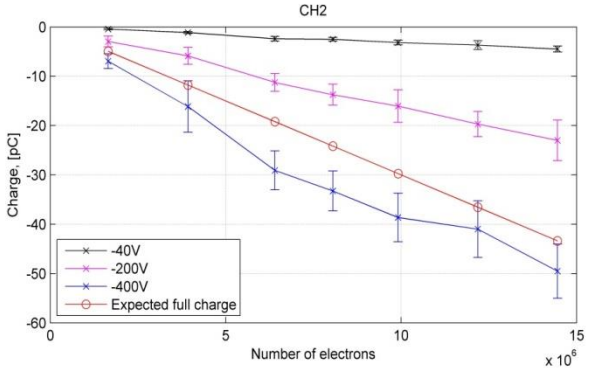


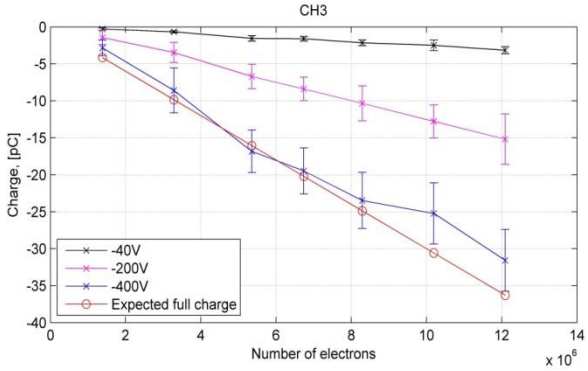


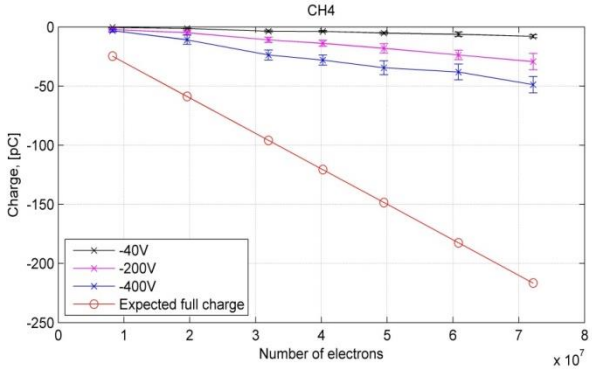

Alpha source with different bias voltage
With positive bias voltage
With negative bias voltage
Collected charge, pC
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.1
50
100
150
200
250
300
350
400
Bias voltage, V

Charge collected as a function of number of incident electrons

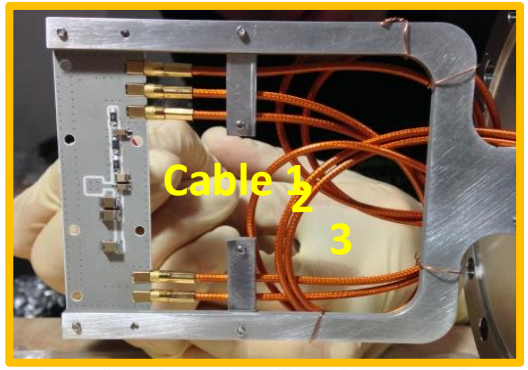


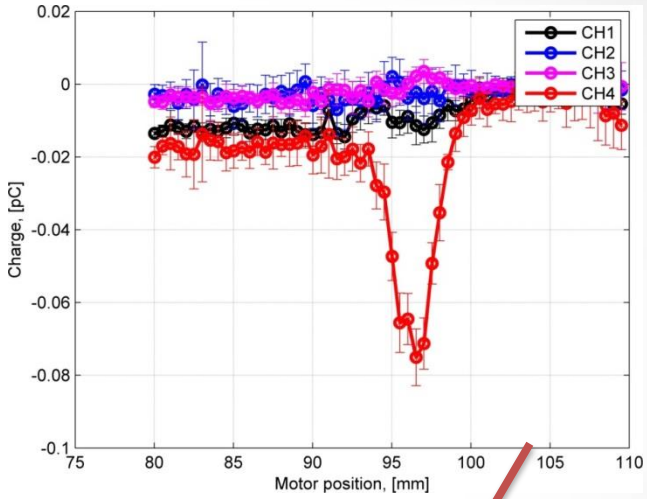




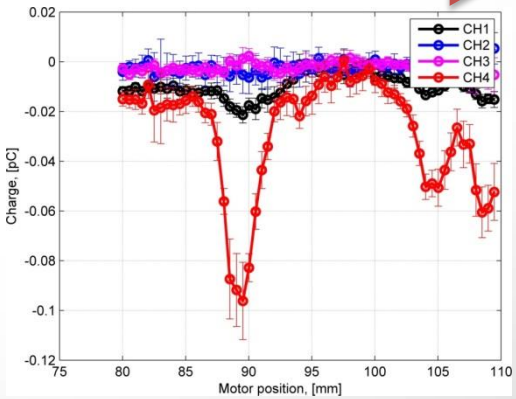


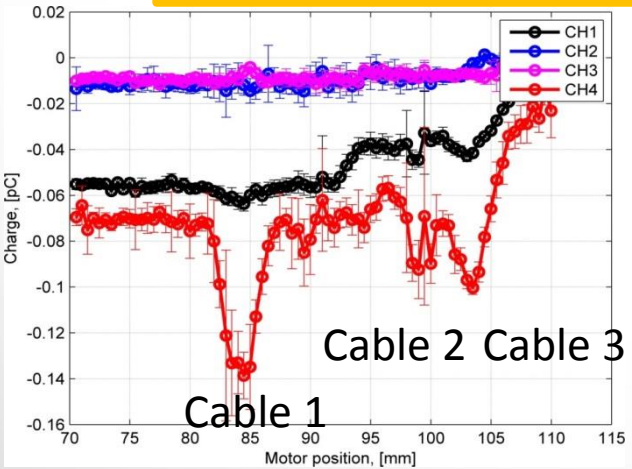
Background from cables



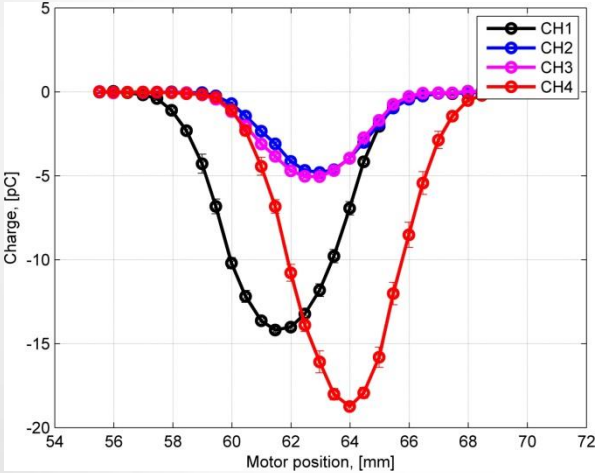


Move the beam step by step





Expected signal (400V)

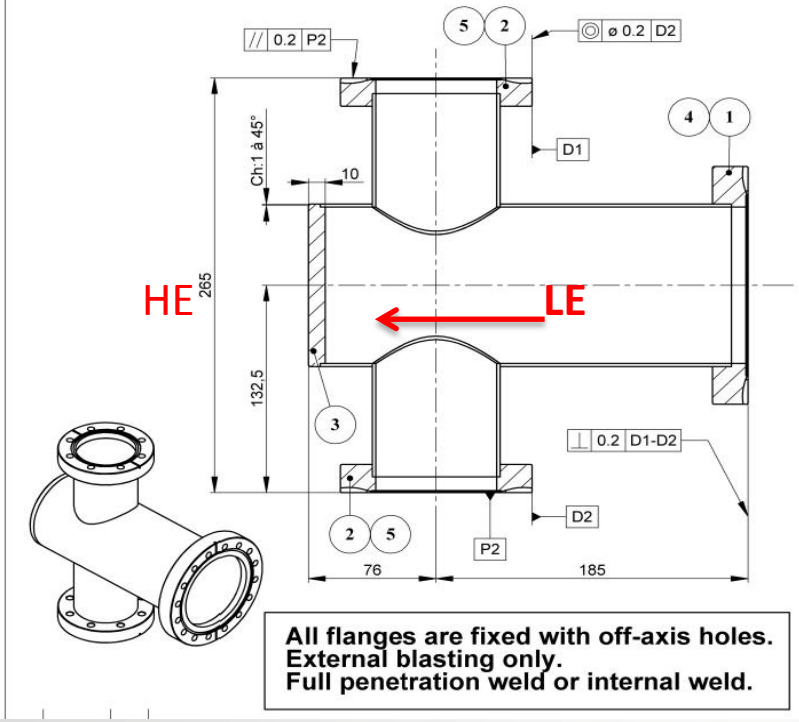


	CH1	CH2	CH3	CH4
Measured σ_x	1.70 mm	1.49 mm	1.53 mm	1.61 mm
Ratio of collected e-	13.34%	1.04%	1.02%	14.07%
Expected full charge (3fC/MIP)	1.88μC	147.21nC	143.68nC	1.98μC
Max. charge collected	442.72nC	151.79nC	158.11nC	600.8nC
Corresponding CCE	23.55%	101%	101%	30.35%

Data taken with 30dB attenuator
Total e- number: $4.8*10^9$

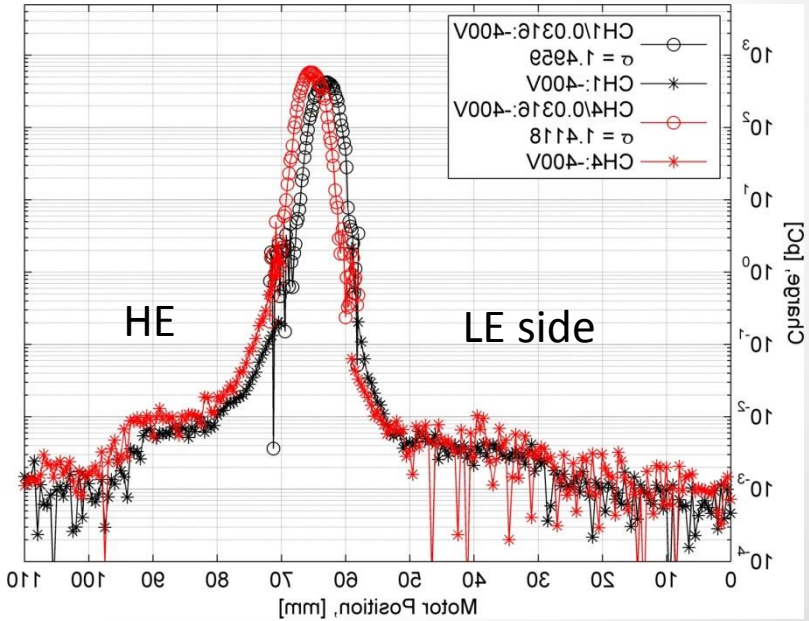
Scan_Run60_12-12-2014_143616_core_400V

Item	Qty	Description
1	1	Flange DN100CF
2	2	Flange DN63CF
3	1	Flat bottom
4	1	Tube DN100 (ø104x2)
5	2	Tube DN63 (ø76.1x2)



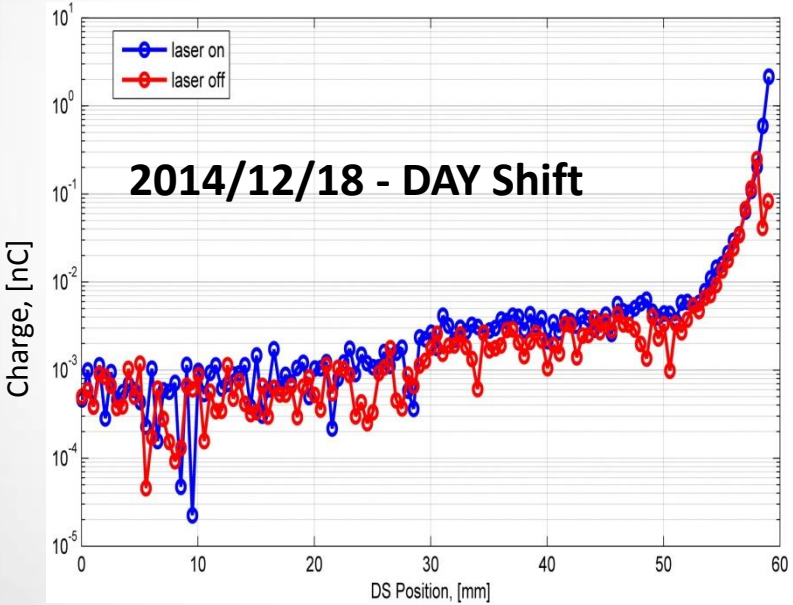
All flanges are fixed with off-axis holes.
External blasting only.
Full penetration weld or internal weld.

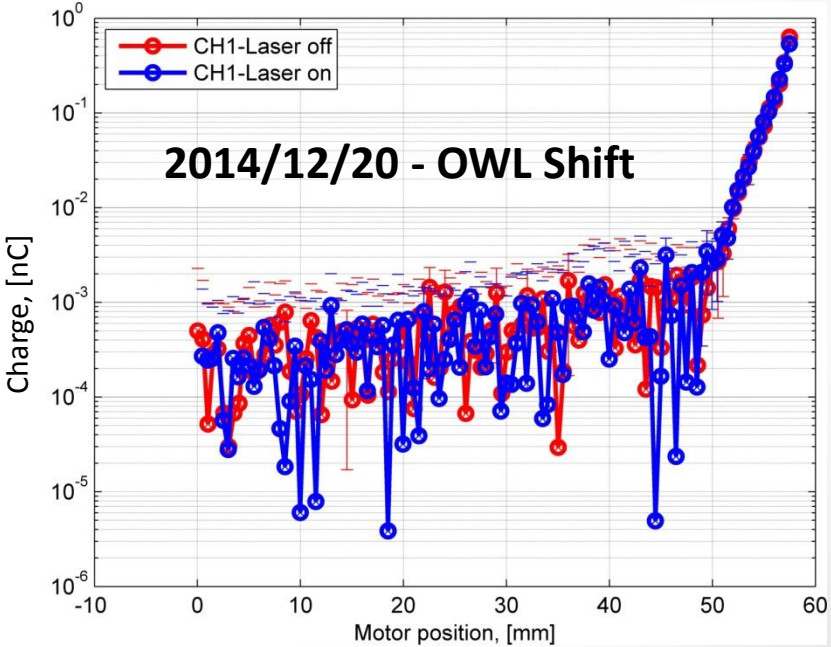
Cut due to beam pipe???



95mm – 30mm = 65mm

COMPTON RECOIL ELECTRONS STUDY





- Perform simulations in CAIN and Mad-X for different optics
- Compare the estimated signal level with the background/pick-up signal level