Large Area Continuous Position Sensitive Diamond Detector: First tests

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GSI-Darmstadt

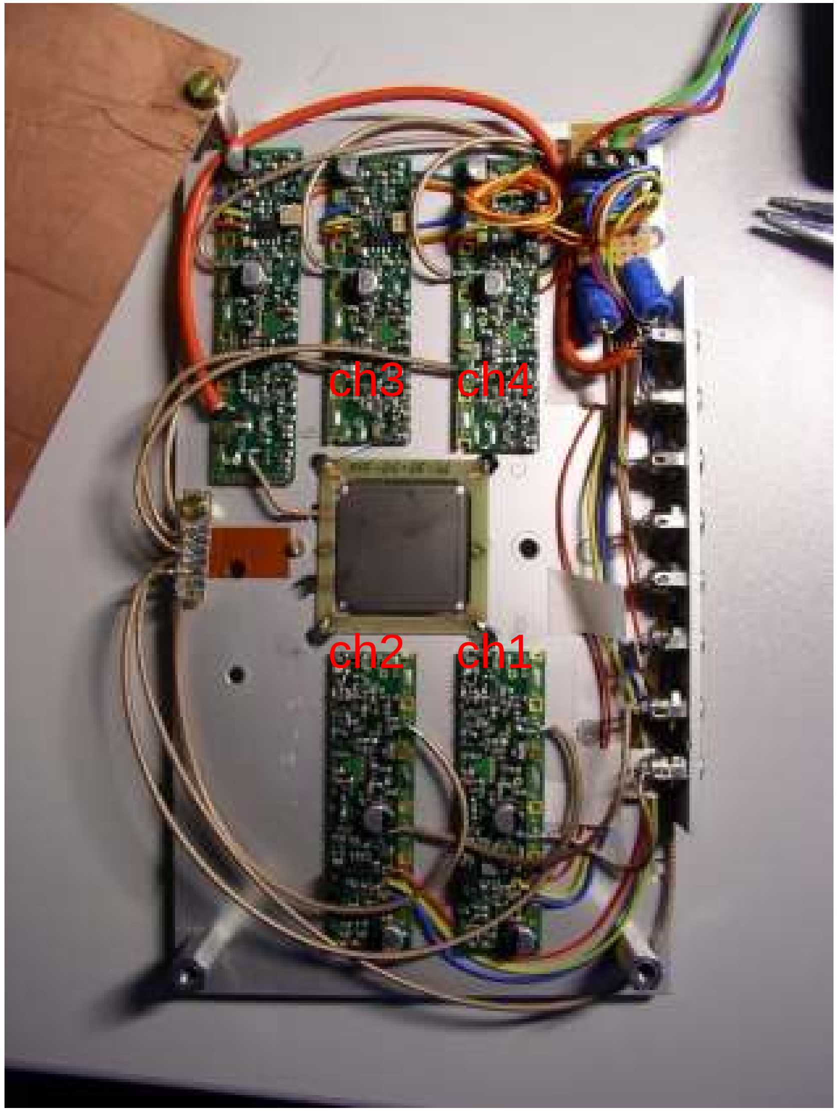
Outline

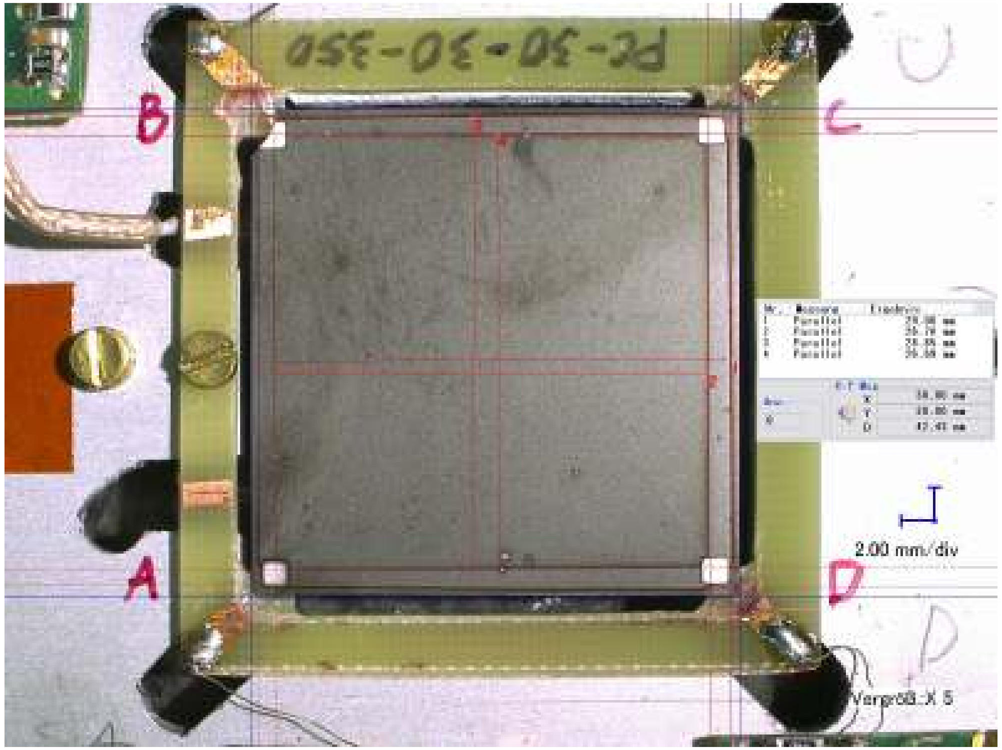
Preparatory work for understanding how to make a Large Area Position Sensitive Diamond Detector.

The final target is to use the new Diamond on Iridium material.

1. Set-up description
2. In-beam tests
3. Summary and outlook

Position Sensitive Detector – Overview

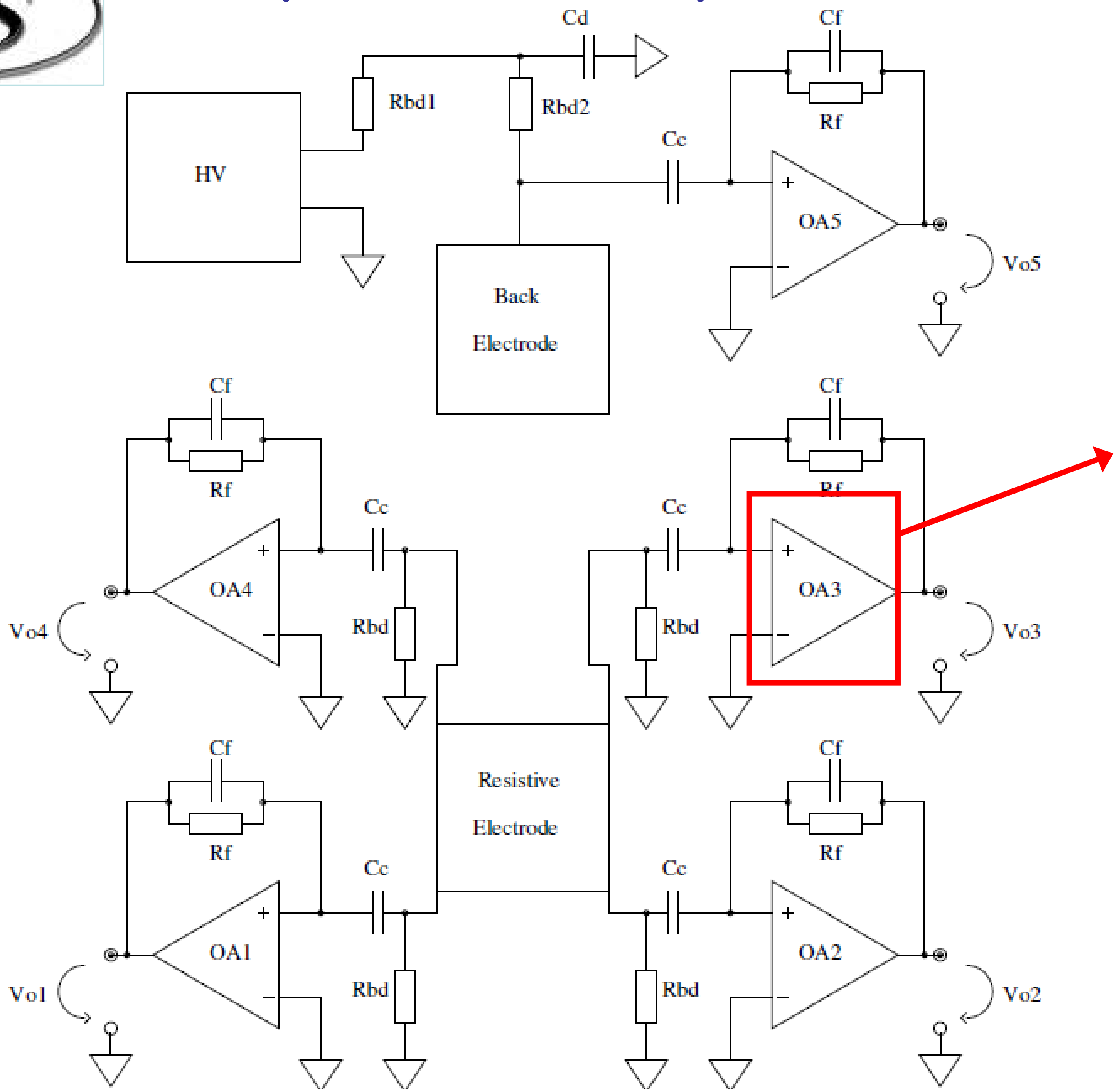




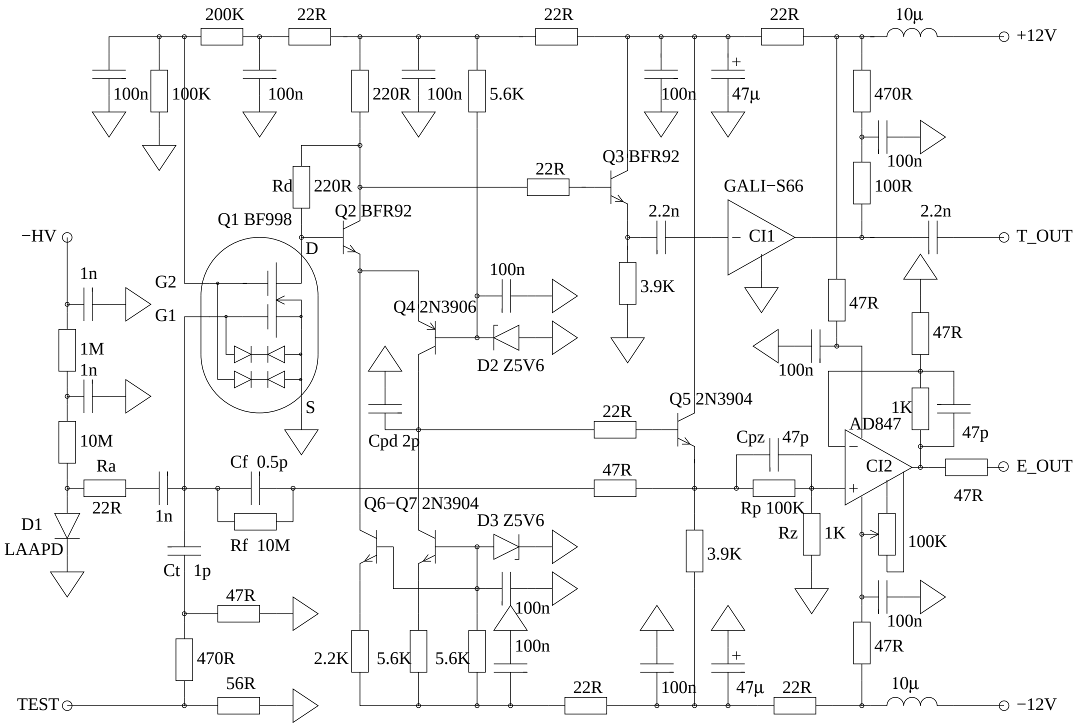
PSD diamond detector

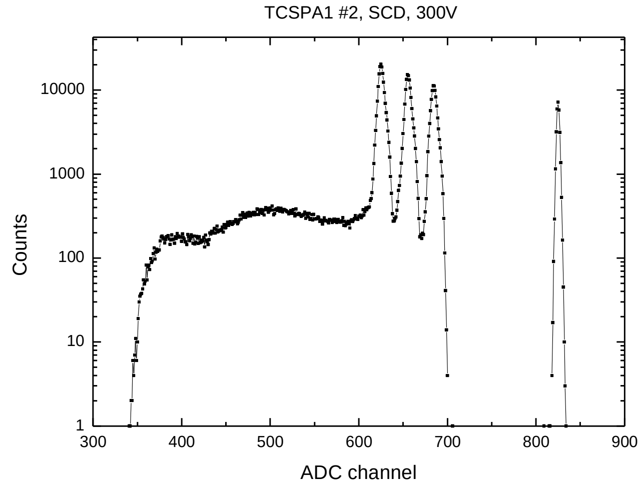
- diamond size: 30.0mm x 30.0mm
- sensitive area: 27.0mm x 27.0mm

Experimental Setup Schematics

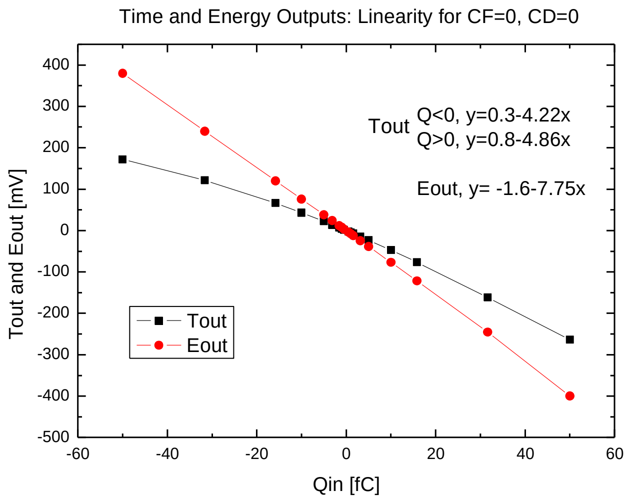


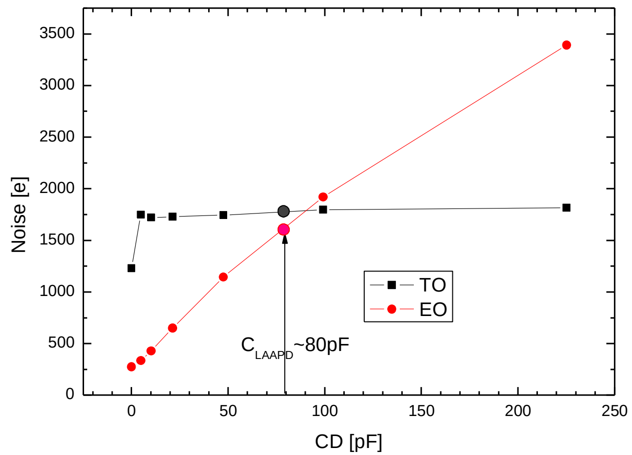
Details on next slide





3-line α source scCVD DD (0.4 mm). The wide background is due to edge effects in the DD, which also widens the α lines. Test sig. has ΔE/E ~0.44 %.

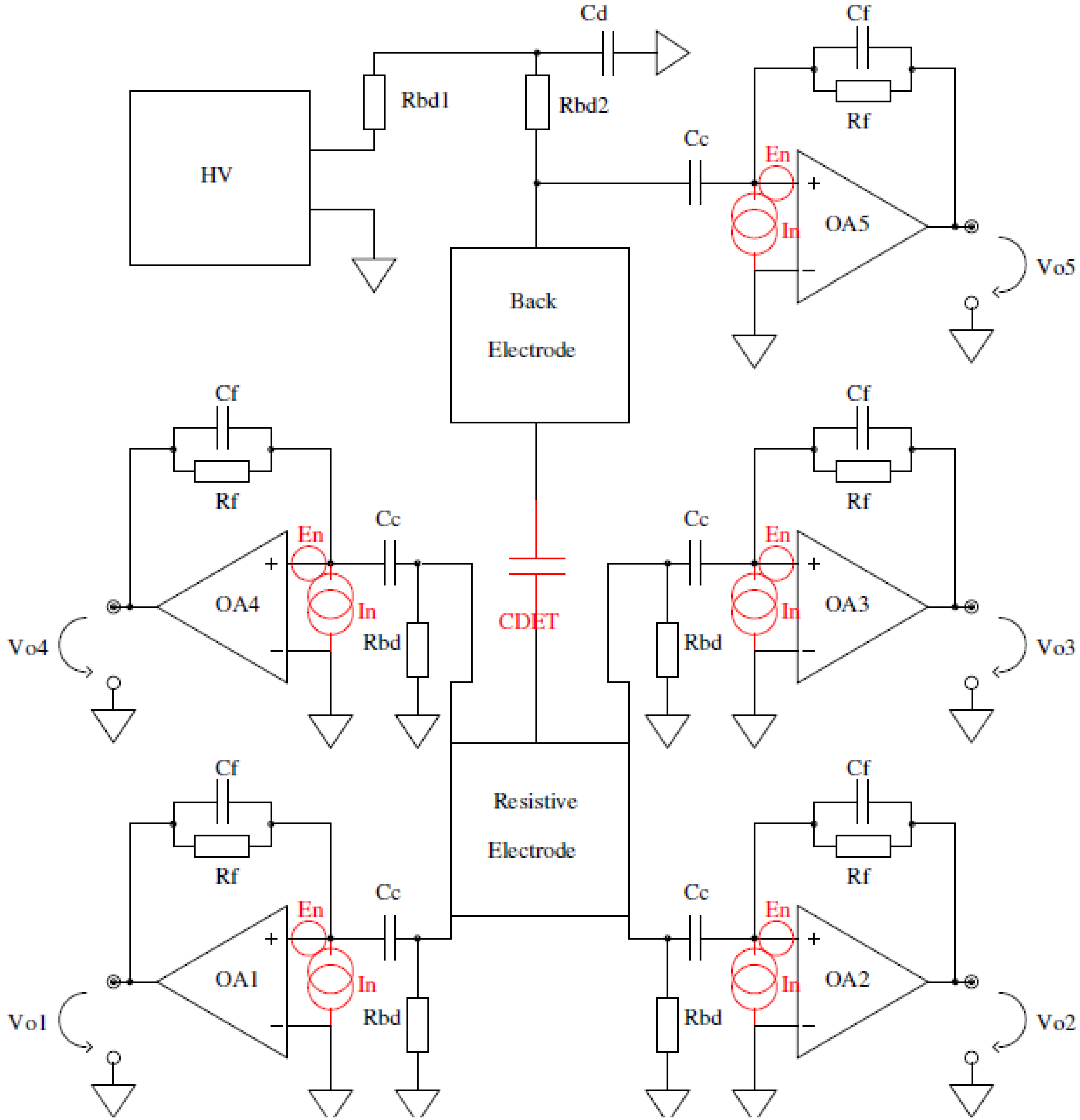




- Equivalent noise for the lumped capacity of detector.

M. Ciobanu et all., A Charge Sensitive Amplifier for Time and Energy Measurements IEEE-Nuclear Science Symposium, Conf. Rec., pp. 2028-2032, 2008

Schematics Including the CSA Noise Generators



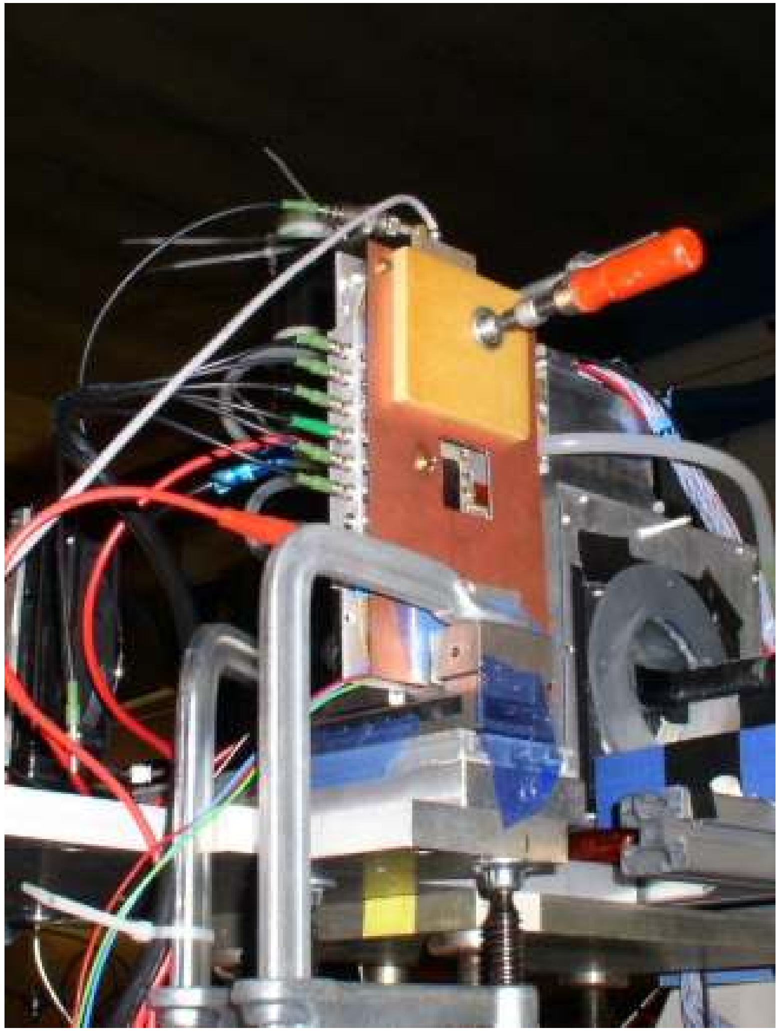
- The ideal CSA has 0Ω input impedance. The real one has ~ kΩ.
- The resistance of the resistive electrode and the capacitance C_{DET} connects together all amplifiers. The noise generators En and In contribute over the whole network and the first connection test showed a factor of 7 increase in the noise of the CSA output.
- In order to decrease this effect, we have reduced Rf and increased Cf, with the drawback of additional loss in responsivity and resolution.

Ni-58 @ 1.7GeV/u??

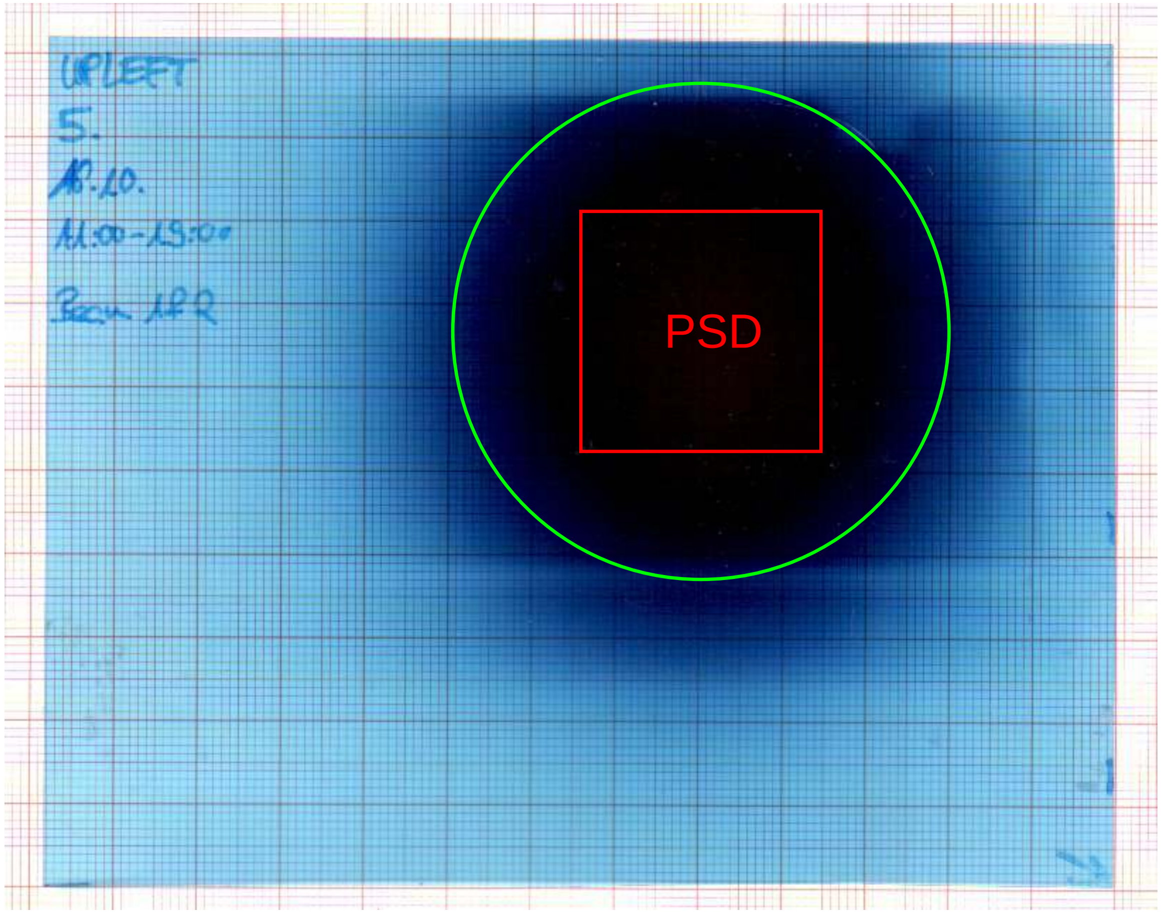
Beamtimes in CaveB (FOPI)

16.10. - 19.10.12 (high rate)

Trigger : Back electrode

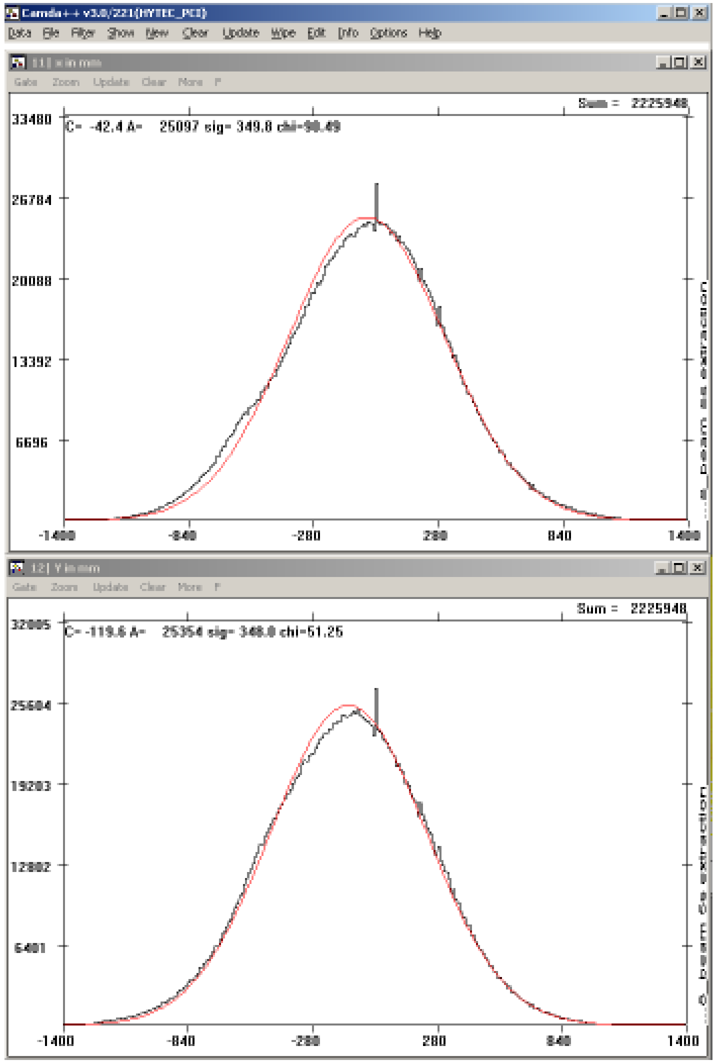


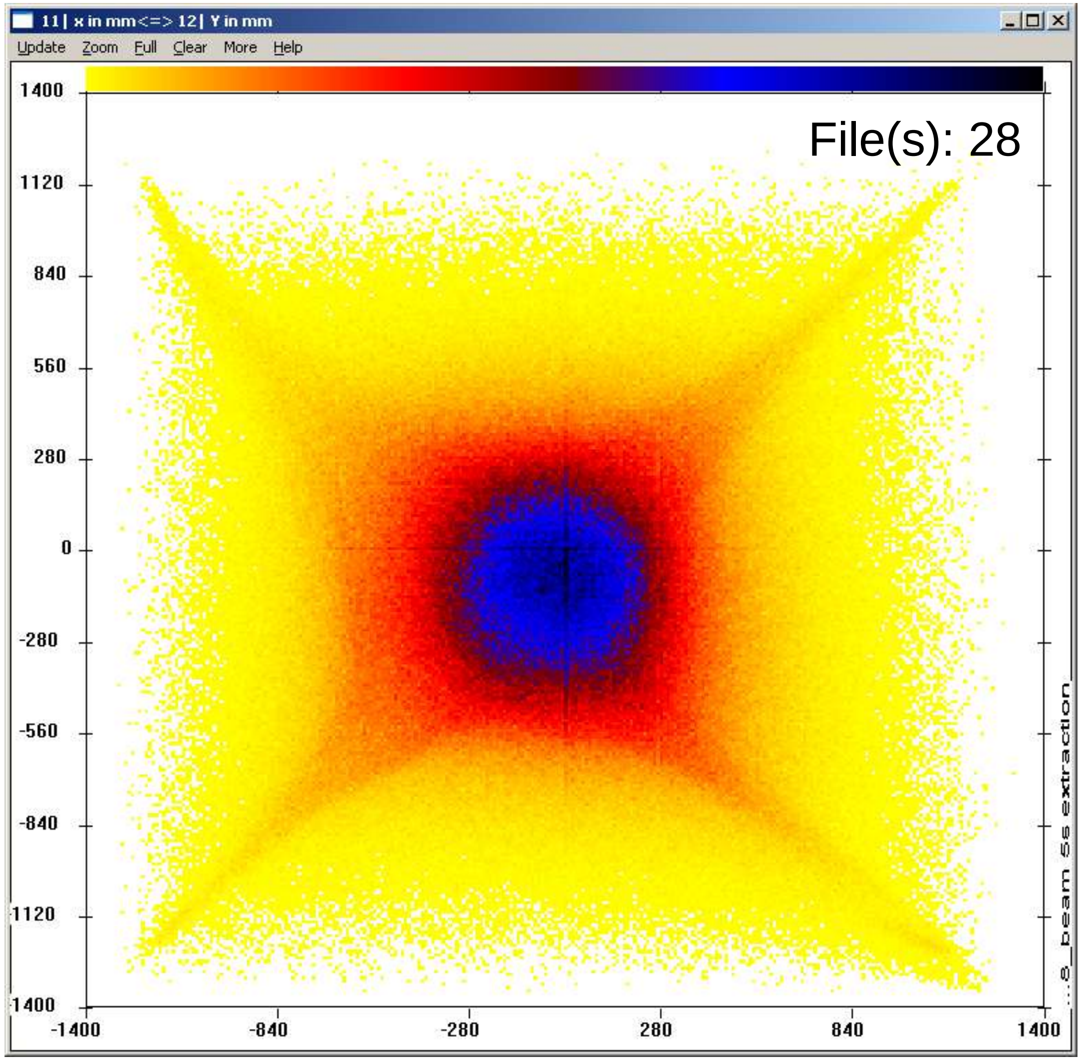
Beam



- beam: Ni-58 @ 1.7GeV/u
- detector position: beam center, ~2m before beam dump in FOPI Cave (B)
- beam diameter at detector position ~60mm

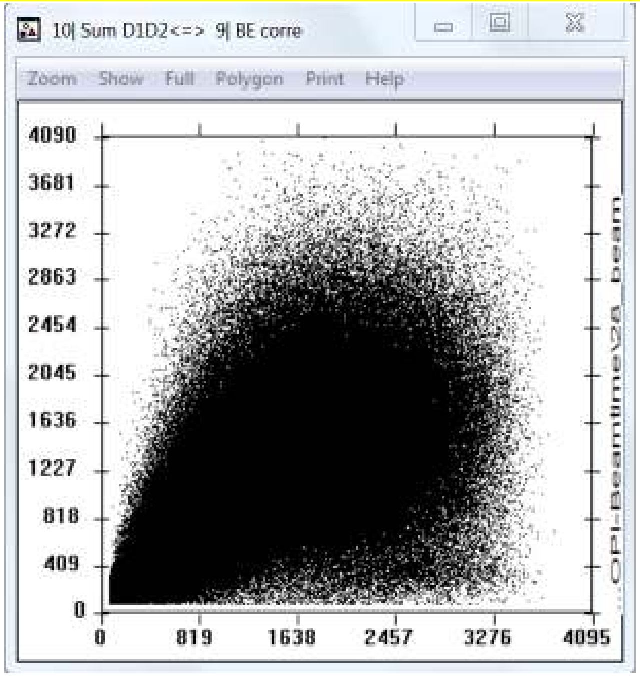
Gate from PSD Back Electrode (BE)

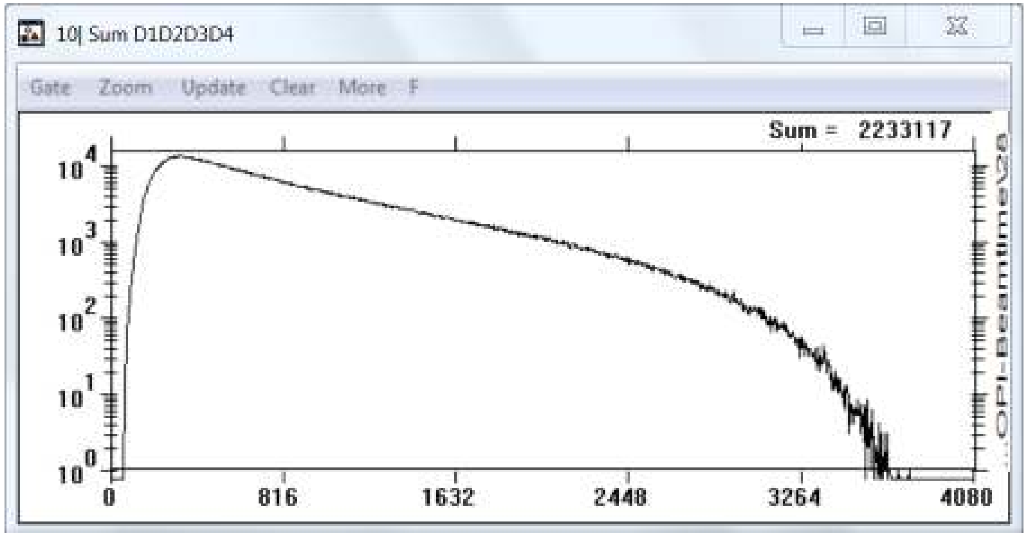




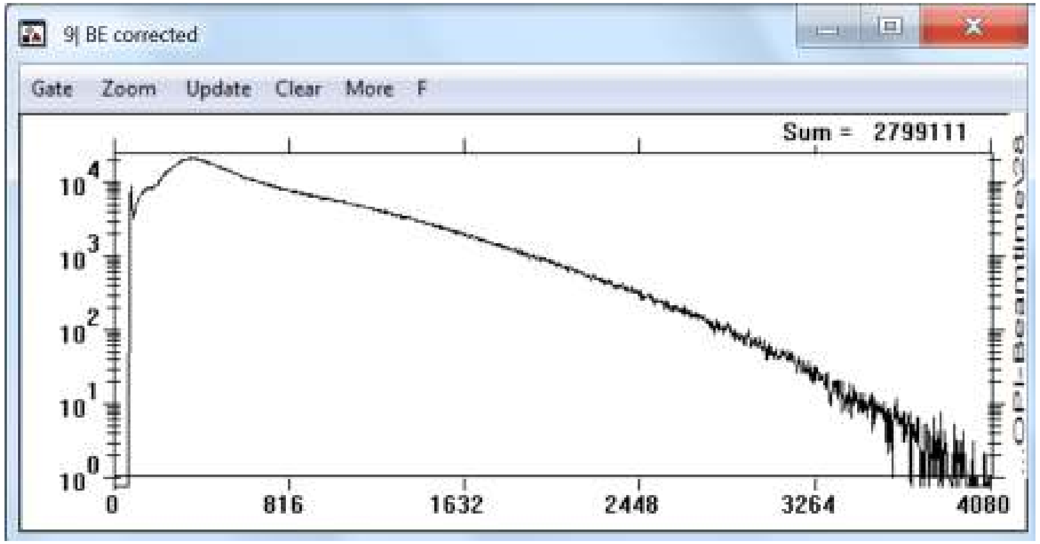
- not pin-cushion corrected spectra of x- , y-position
- no amplitude filter

Events depending on energy – all energies

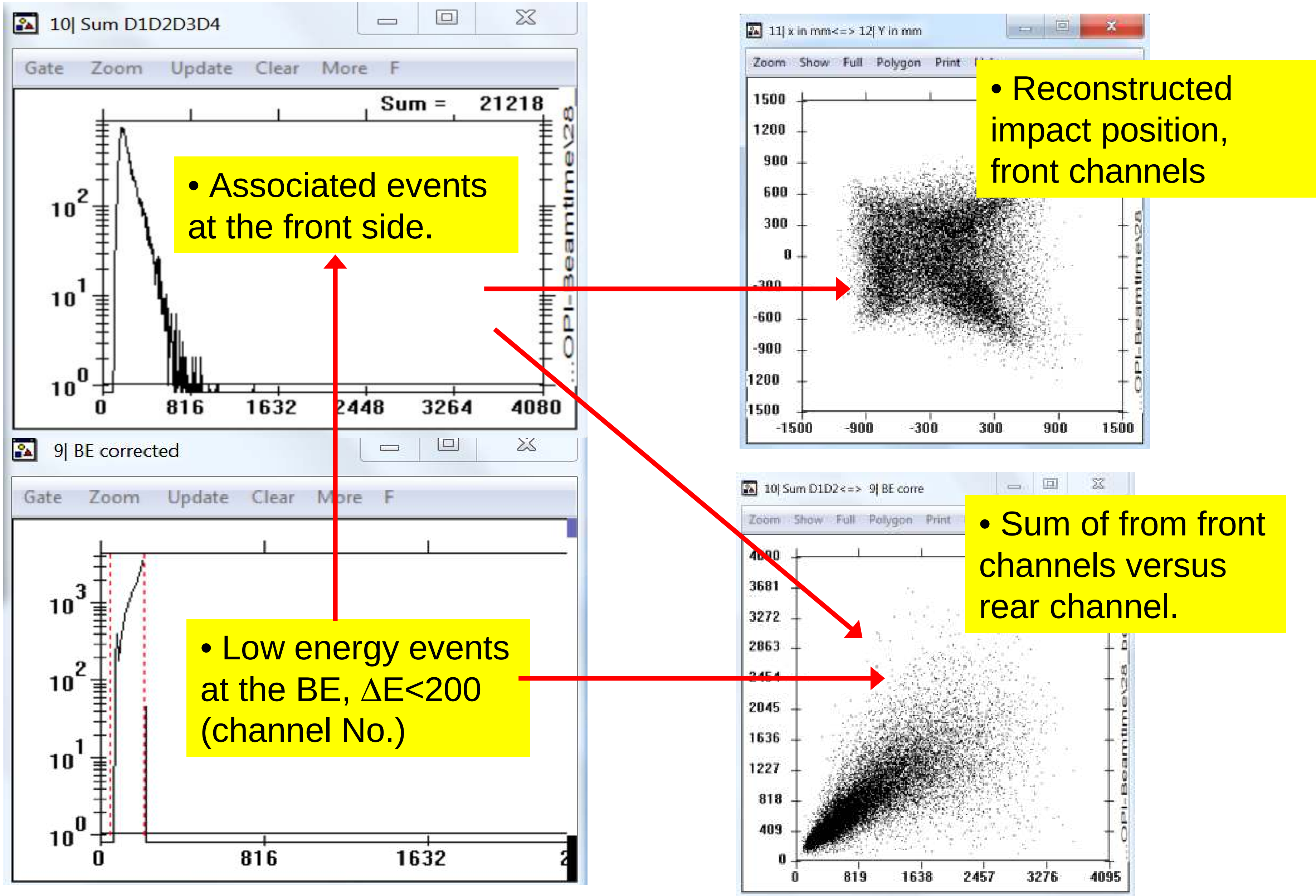




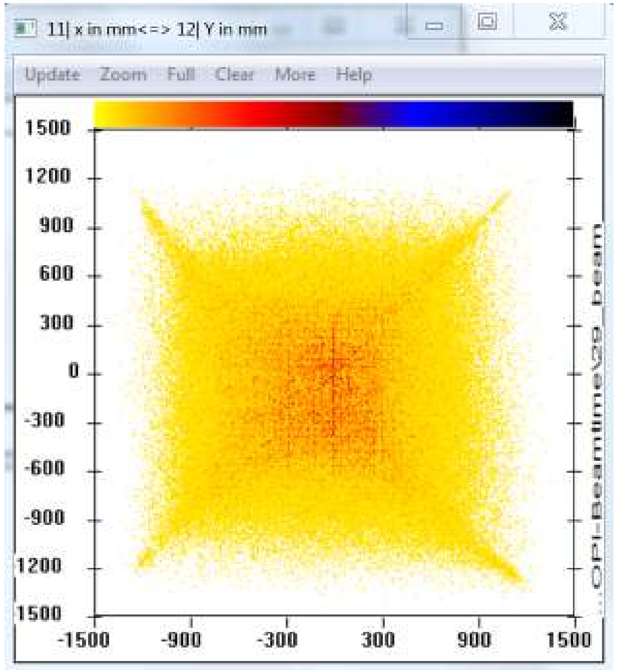
- Right: Histogram of events depending on energy deposition (top=sum of front channels, bottom=rear chanel)
- Left: Scatter plot of rear channel versus sum of the front channel => ideally, the points should line up along the diagonal



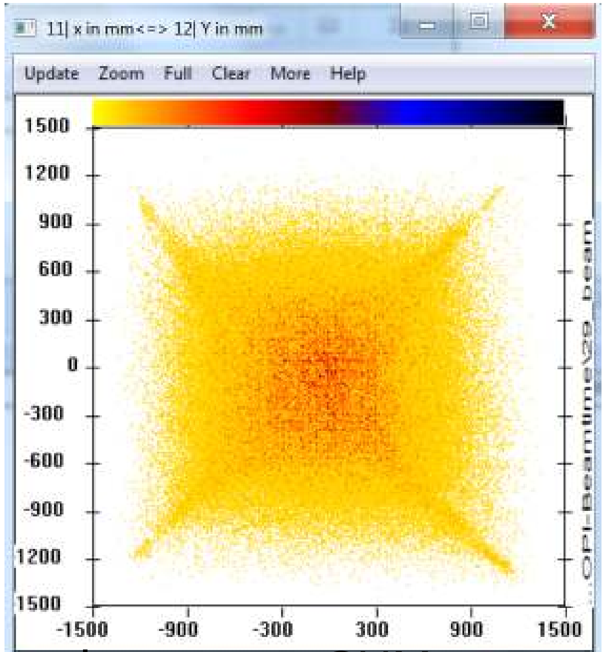
Events depending on energy – low energies



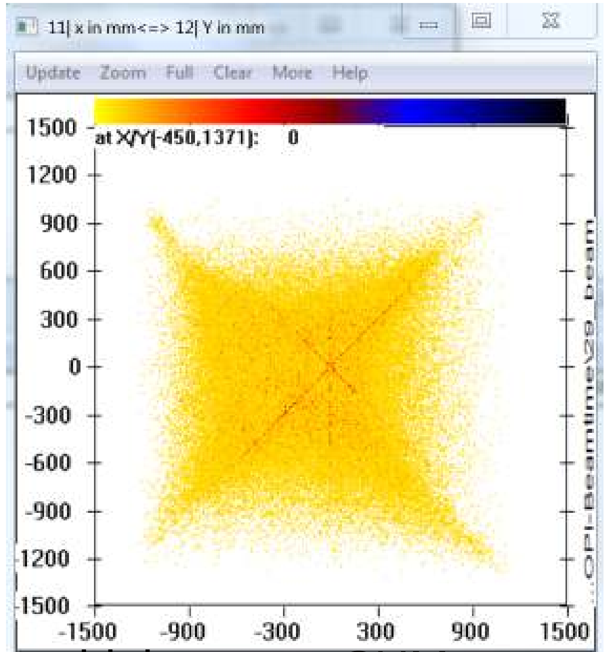
- Associated events at the front side.
- Reconstructed impact position, front channels
- Low energy events at the BE, ΔE<200 (channel No.)
- Sum of from front channels versus rear channel.



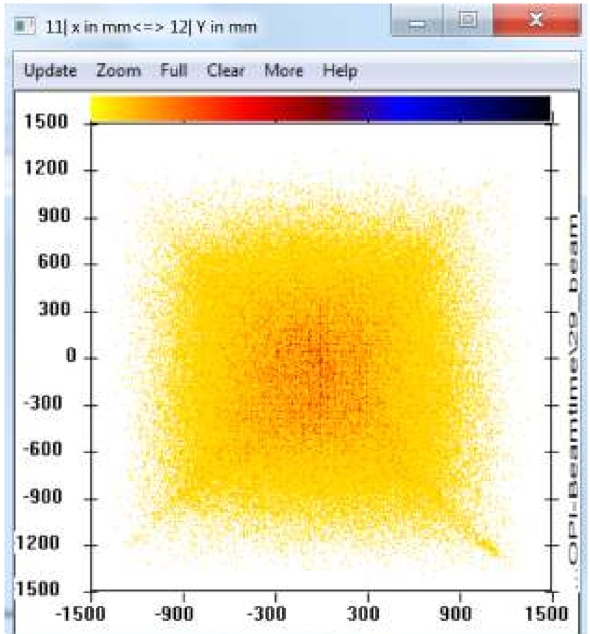
All 29_data, no cut



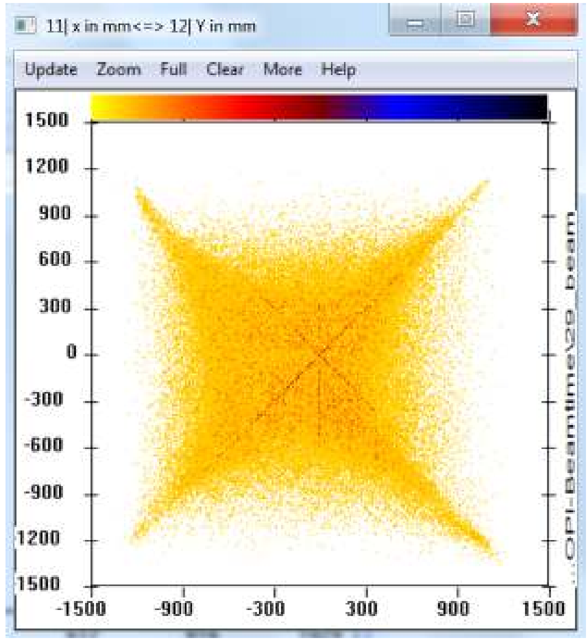
low energy SUM cut



high energy SUM cut



low energy BE cut



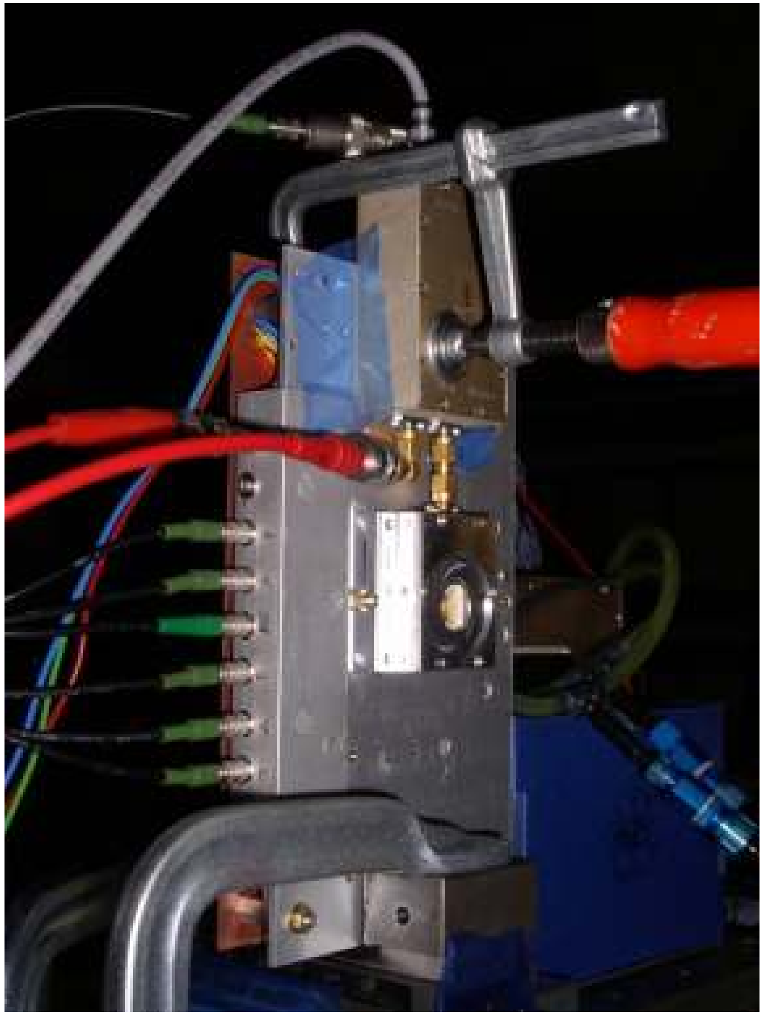
high energy BE cut

Ni-58 @ 1.7GeV/u??

Beamtimes in CaveB
(FOPI)

29.10. - 5.11.12
(low rate)

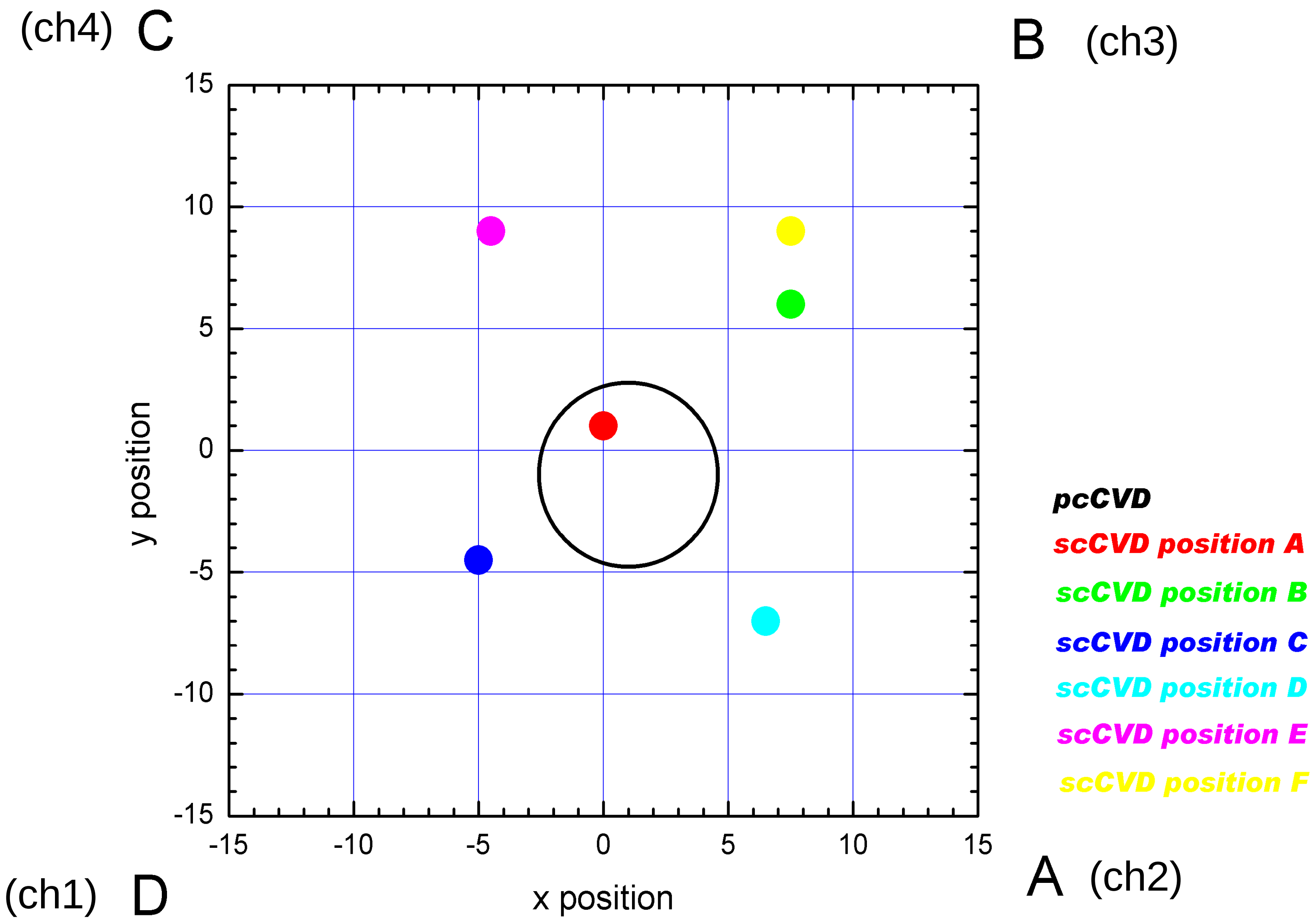
Trigger: pcCVD 8mm
or scCVD 1.2mm



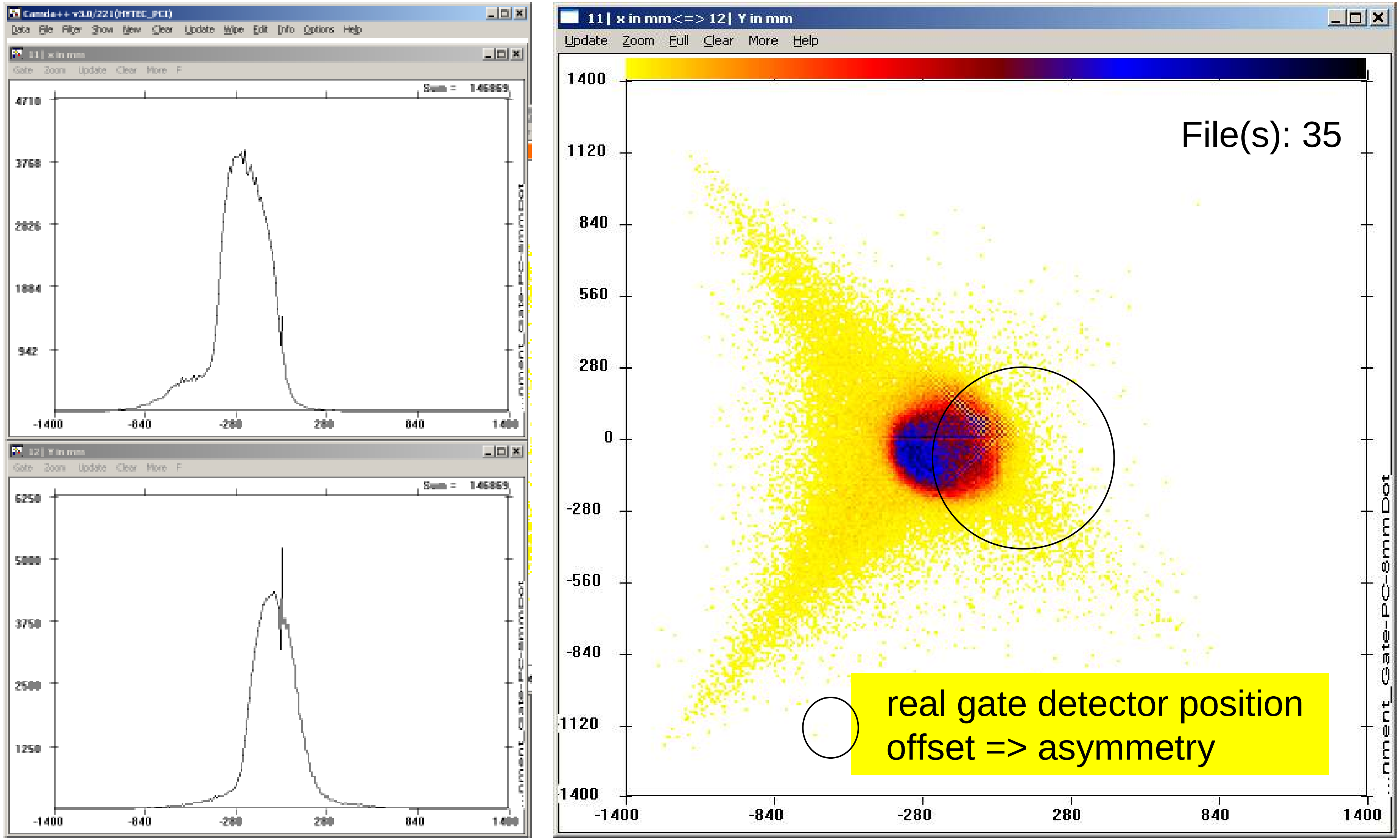
scCVD diamond 10B50 Gate detector

- 1.25mm circular electrode

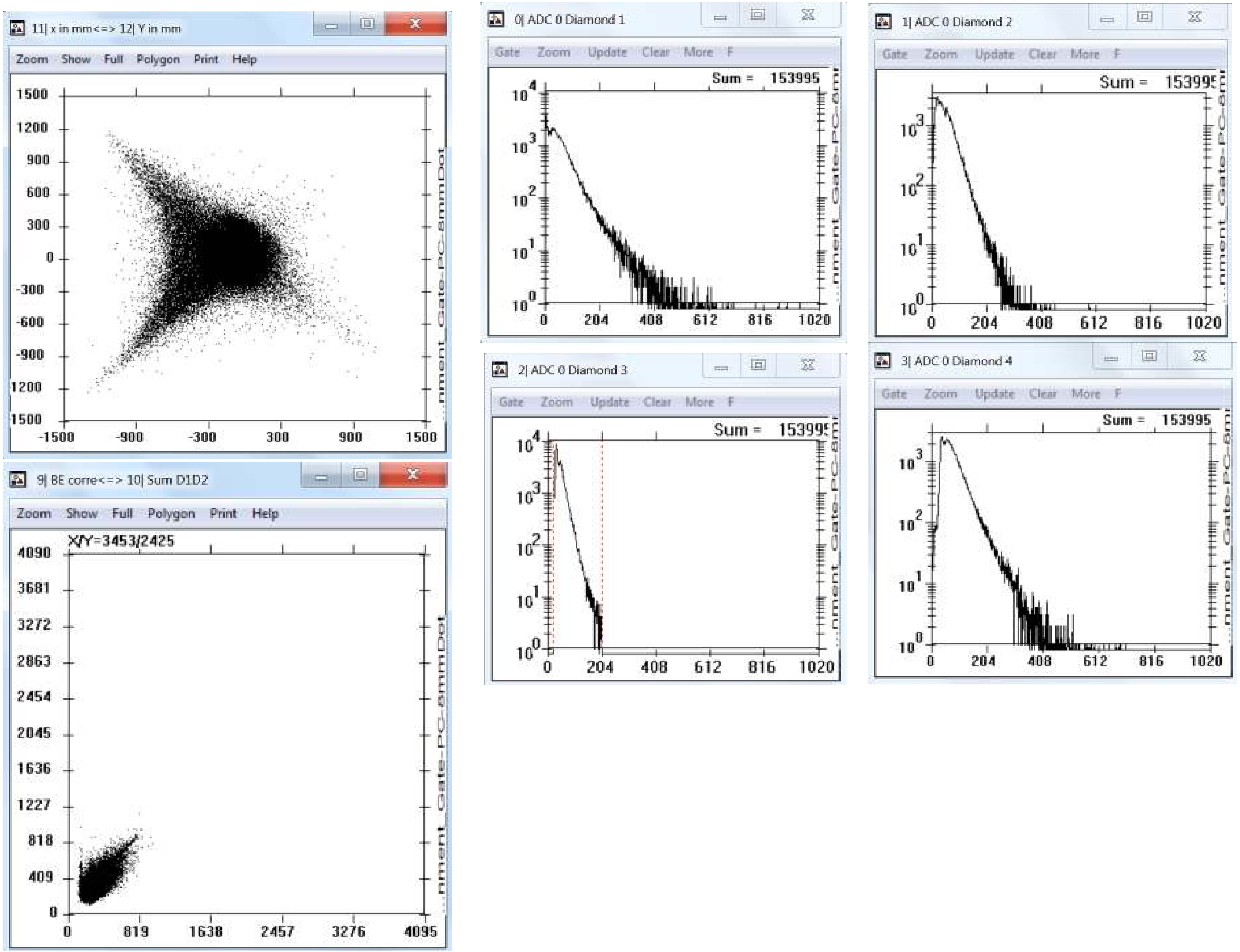
Gate detector positions relative to PSD

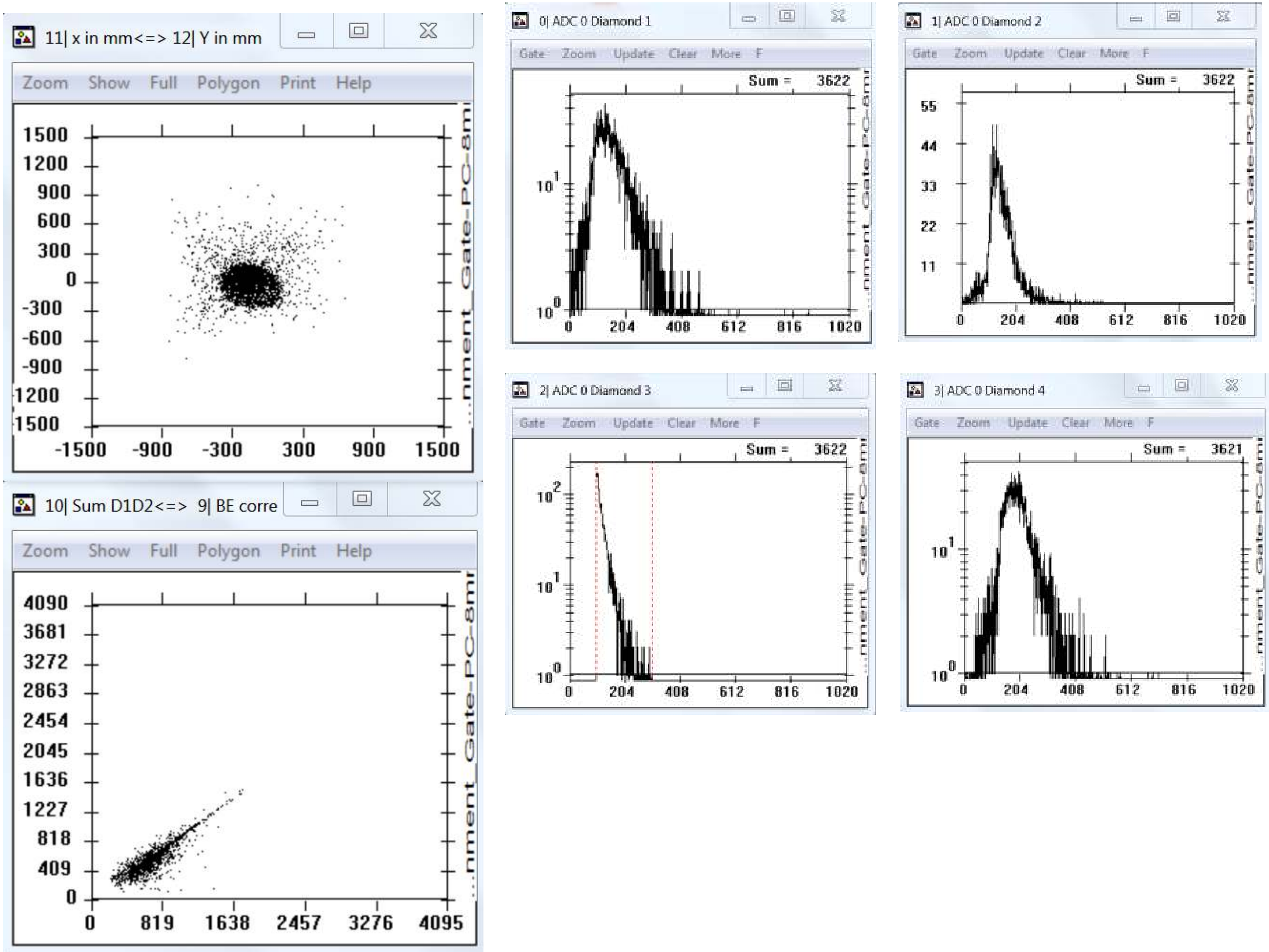


Gate from pcCVD 210um with circular 8mm electrode

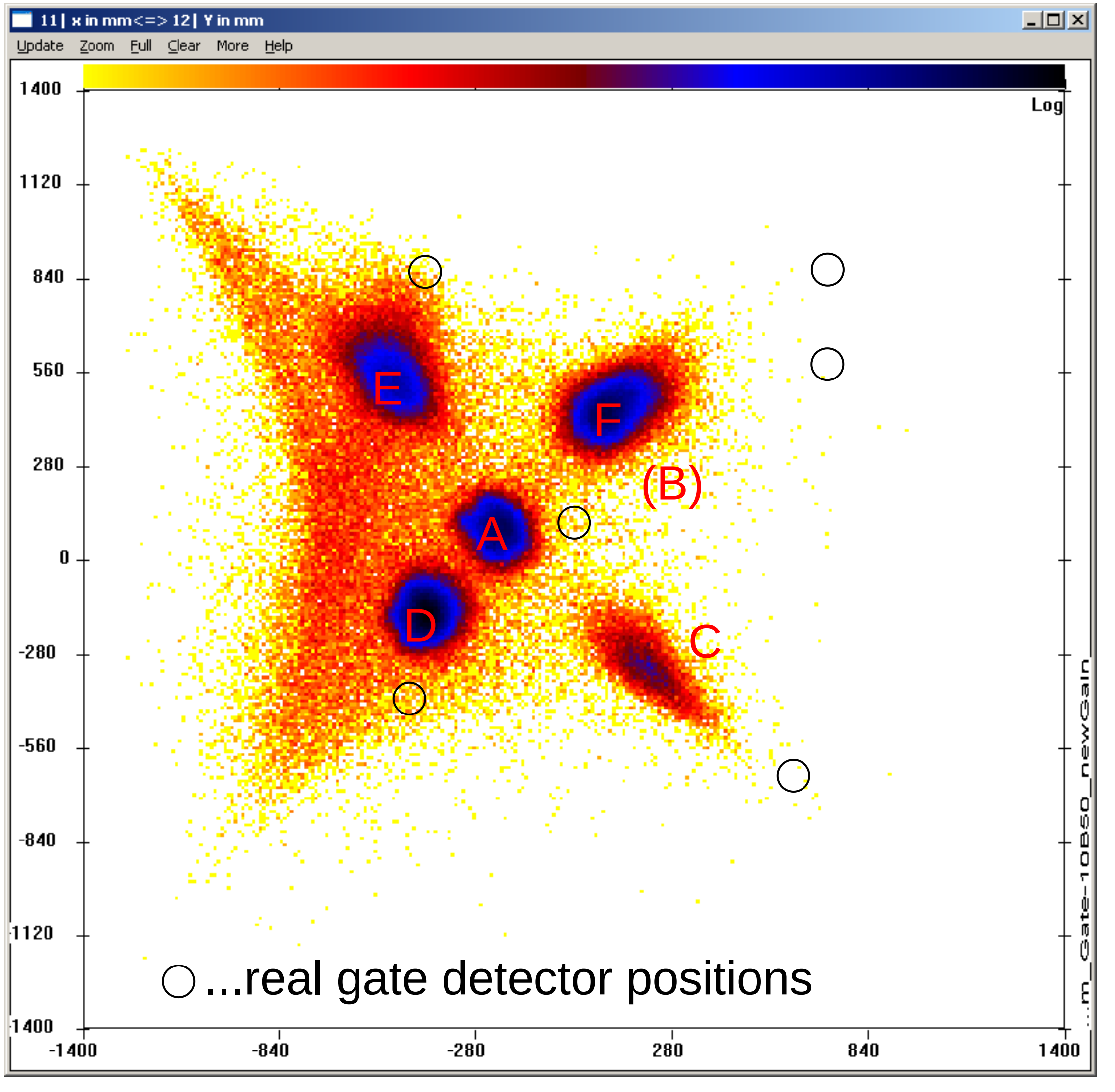


- not pin-cushion corrected spectra of x- , y-position
- no amplitude filter


11| x in mm<=> 12| Y in mm
Zoom Show Full Polygon Print Help
1500 1200 900 600 300 0 -300 -600 -900 -1200 -1500
-1500 -900 -300 300 900 1500
9| BE corre<=> 10| Sum D1D2
Zoom Show Full Polygon Print Help
X/Y=3453/2425
4090 3681 3272 2863 2454 2045 1636 1227 818 409 0
0 819 1638 2457 3276 4095
0| ADC 0 Diamond 1
Gate Zoom Update Clear More F
Sum = 153995
1| ADC 0 Diamond 2
Gate Zoom Update Clear More F
Sum = 153995
2| ADC 0 Diamond 3
Gate Zoom Update Clear More F
Sum = 153995
3| ADC 0 Diamond 4
Gate Zoom Update Clear More F
Sum = 153995
0 204 408 612 816 1020

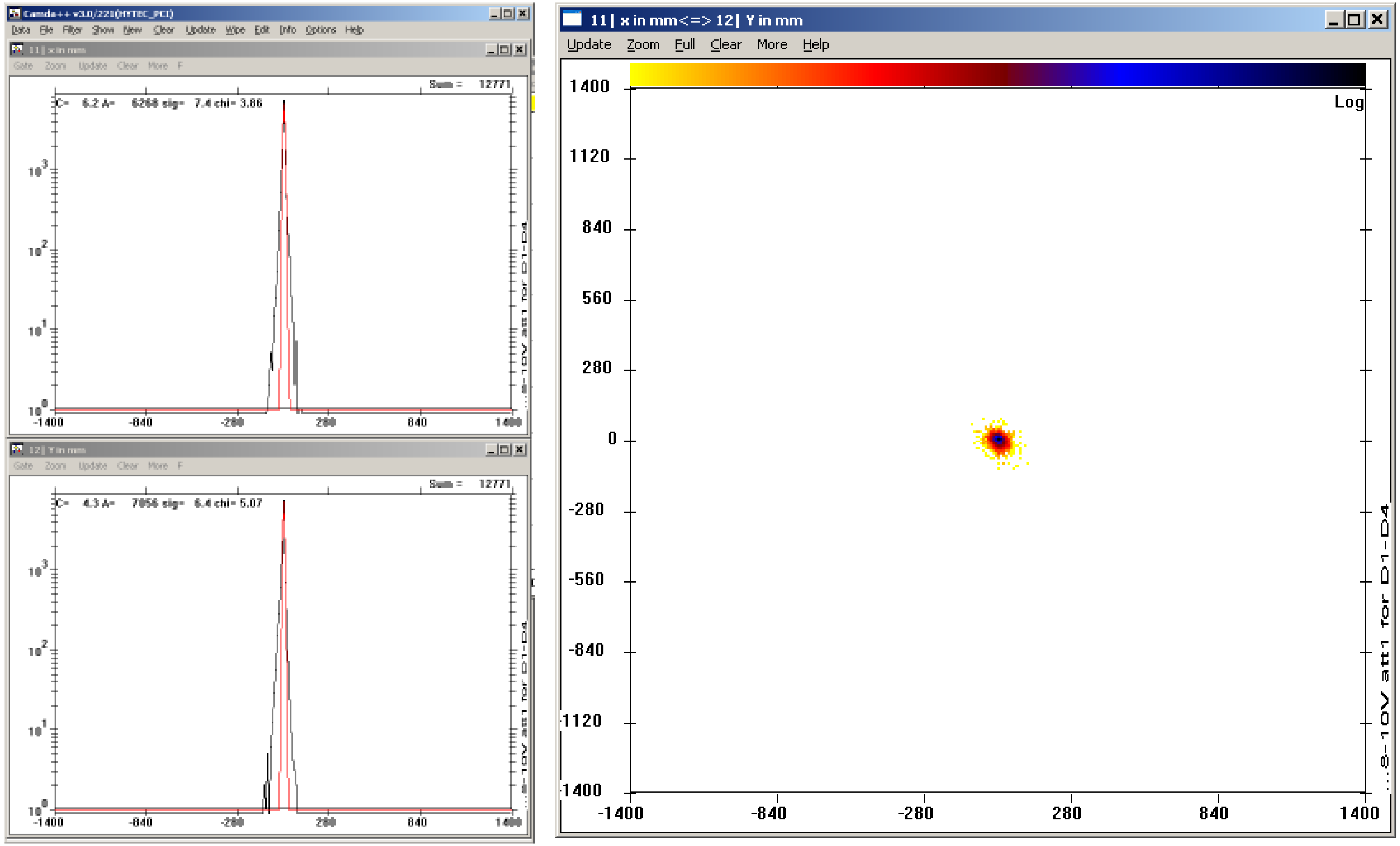

11| x in mm<=> 12| Y in mm
Zoom Show Full Polygon Print Help
1500 1200 900 600 300 0 -300 -600 -900 -1200 -1500
-1500 -900 -300 300 900 1500
10| Sum D1D2<=> 9| BE corre
Zoom Show Full Polygon Print Help
4090 3681 3272 2863 2454 2045 1636 1227 818 409 0
0 819 1638 2457 3276 4095
0| ADC 0 Diamond 1
Gate Zoom Update Clear More F
Sum = 3622
0 204 408 612 816 1020
1| ADC 0 Diamond 2
Gate Zoom Update Clear More F
Sum = 3622
55 44 33 22 11
0 204 408 612 816 1020
2| ADC 0 Diamond 3
Gate Zoom Update Clear More F
Sum = 3622
0 204 408 612 816 1020
3| ADC 0 Diamond 4
Gate Zoom Update Clear More F
Sum = 3621
0 204 408 612 816 1020

Gate from scCVD 10B50 with circular 1.25mm electrode for different relative positions (A-F)



- not pin-cushion corrected spectra of x- , y-position
- amplitude filter: sum of all 4 channels within +/-5% of BE signal

Pulser calibration



- no filter
- all pulser signals (same amplitude for all channels) after correction at "center position")
- Message: the FEE cannot be responsible for the effects observed

Summary

- The first LACPSDD experimental set-up has been made and tested.
- The main results obtained in the described tests confirms that the detector has a high-rate capability. Due to the distributed resistance and capacitance, the lumped equivalent scheme of the detector should use resistor and capacitor with values less then R□ and CDET.
- The 5 CSA used have an significant increase of the noise level when connected to the detector. We have decreased the feedback resistance and increased the feedback capacitance in order to decrease the crosstalk between channels, with additional decrease of the charge responsivity and increase in the noise level.
- We have tried to use low noise broadband amplifiers with the same set-up. The cabling of the experimental set-up was not sufficiently clean to avoid oscillations.
- The in-beam tests have shown two types of signals:
  1) lower amplitudes signals which give a position error with cushion shape
  2) higher amplitudes signals which give a random position error
  We do not know what is the origin of the two types of signal

Outlook 1

- For the next step, the most important task will be to change the amplifier type to avoid the crosstalk between channels and to have enough charge responsivity to measure alpha particles. The picking time <10 ns.

- We must validate the 3D simulation environment needed for the optimization of the experimental set-up, in particular to take into account the distributed character of the electrical parameters.

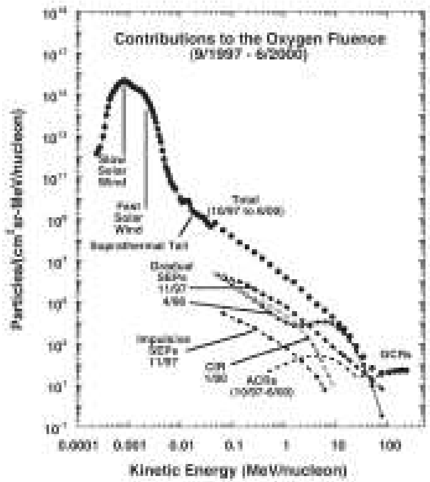
- For in-beam tests we need a position etalon.

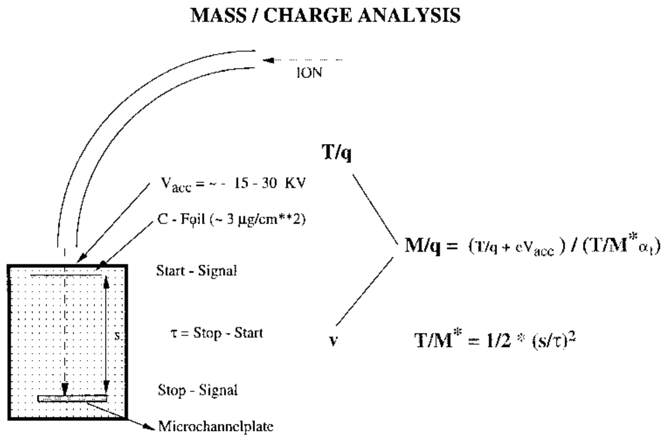
  With a 10mm x10mm pcCVD electronic grade from the last productions of Element 6, one could make a 2D duo-lateral LACPSDD with very small position error.

- The comparative tests with alpha particles of the two types of LAPSDD can give the optimum algorithm for the minimal systematic error of position reconstruction. After in-beam tests we shall choose the final structure.

- At that moment we shall be ready to finally use the DoI material.

Outlook 2 : Prospects for Application to Space Experiments





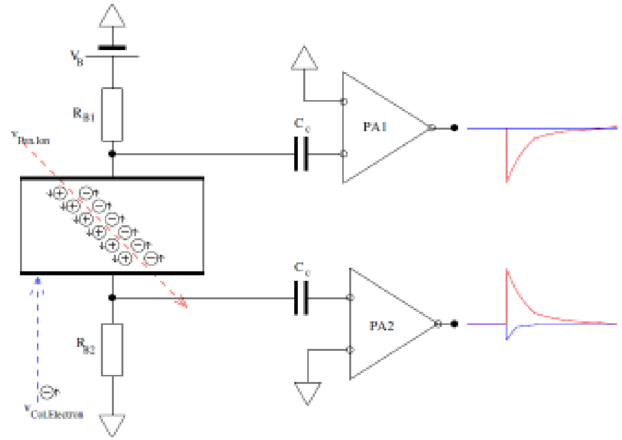


Figure 1. Fluence of energetic oxygen nuclei from solar wind to galactic cosmic ray energies measured by the Advanced Composition Explorer (ACE) satellite. From *Mewaldt et al. (2006)*.

Figure 2. Schematic view of a mass spectrometer, including a curved plate electrostatic analyzer and a time-of-flight section (From *Klecker, 2001*).

Figure 3. Electrical scheme that allows the rejection of penetrating radiation, by collecting the signal from both sides of the DD in conjunction with microchannel plates, in particle spectrometry.

People:

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