Biweekly GBP meeting

Frascati data analysis

Frascati test beam

Status of the analysis

Few points to account

1. MC estimate to be improved (~ **30%**)
   - Detailed geometry
   - Beam misalignment and/or profile smearing
2. Data points must be corrected (min<CH>, 8-bit, pickup noise) (**<15%**)
3. Fit model must be revised
4. Allpix^2 simulation for the charge collected

Current status

MC improved with all the details of the geometry. Data biasing (min<CH>, 8-bit) studied in detail and error constrained to 15%. Analysis of the BTF data ongoing, data correction to be accounted yet. Fit model worked out in the general case of uniform initial charge distribution, moving in an arbitrary $E(z) = E_0 + E_1 z + E_2 z^2$ field; implementation of the fit model in ROOT ongoing.

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- Detailed geometry
- Beam misalignment and/or profile smearing

✓ Data points corrected (min<CH>, 8-bit, pickup noise) (**<15%**)

✓ ~~Fit model must be revised~~

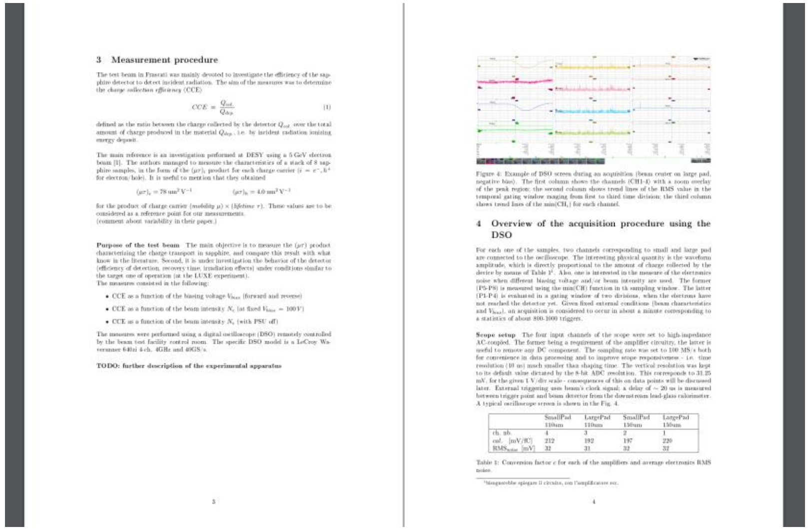
Allpix^2 simulation for the charge collected

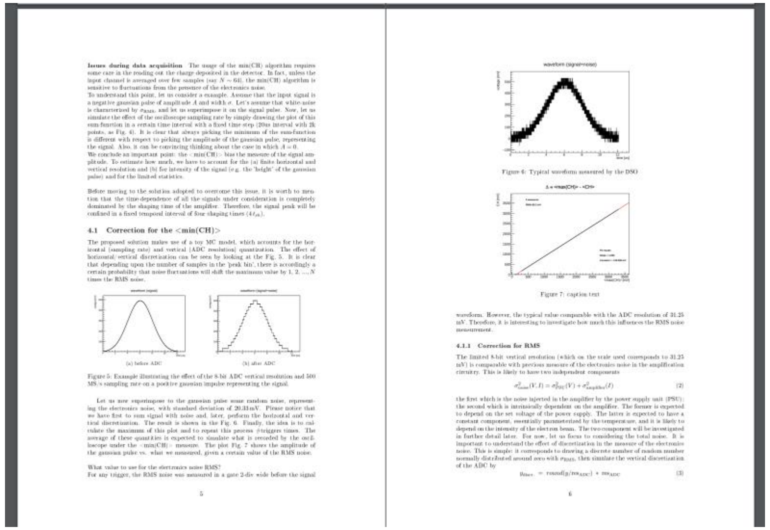
Current status

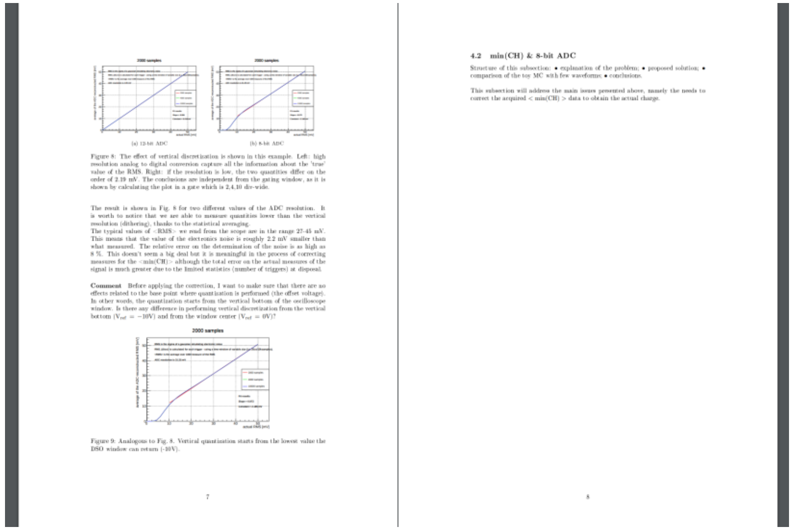
MC improved with all the details of the geometry. Data biasing (min<CH>, 8-bit) studied in detail and error constrained to 15%. Data corrections accounted. Analysis of the BTF data completed. Fit model worked out in the general case of uniform initial charge distribution. Fit results for uniform E in the next slides. Allpix^2 simulation under development.

Overview of ’data corrections’

1. Mostly accounted to fix the bias we introduced when measuring the signal using the <min(CH)> function. More details will be available in a report of the Frascati testbeam I’m writing







2. At very HV, many acquisitions were polluted by internal discharges. In these cases it is recorded a saturation signal of the amplifier, which clearly affects the average over N triggers. In an ensemble of 0.8-1k triggers, this matters and these signals have to be removed in order to read an accurate value of the average signal.

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LargePad
HV = 800V

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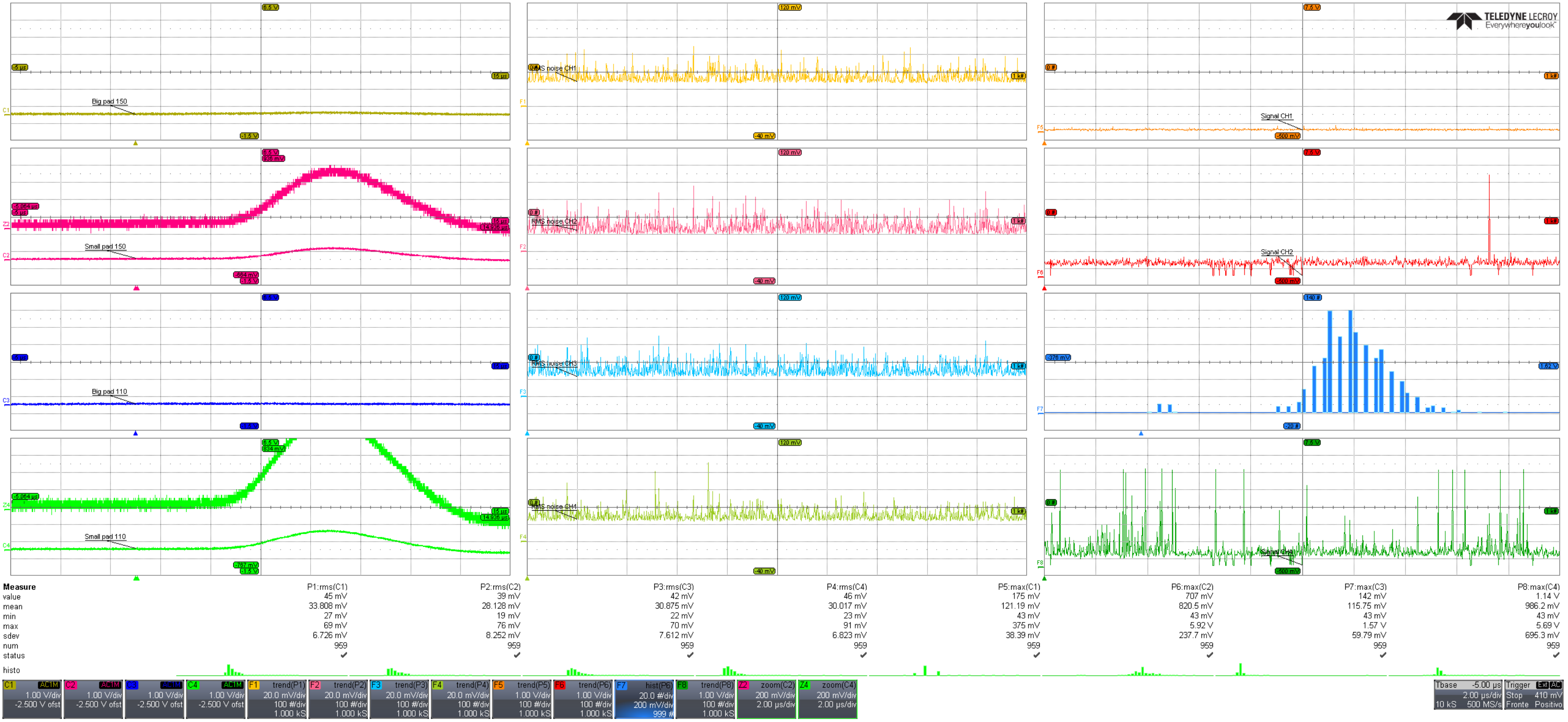

SmallPad
HV = 800V

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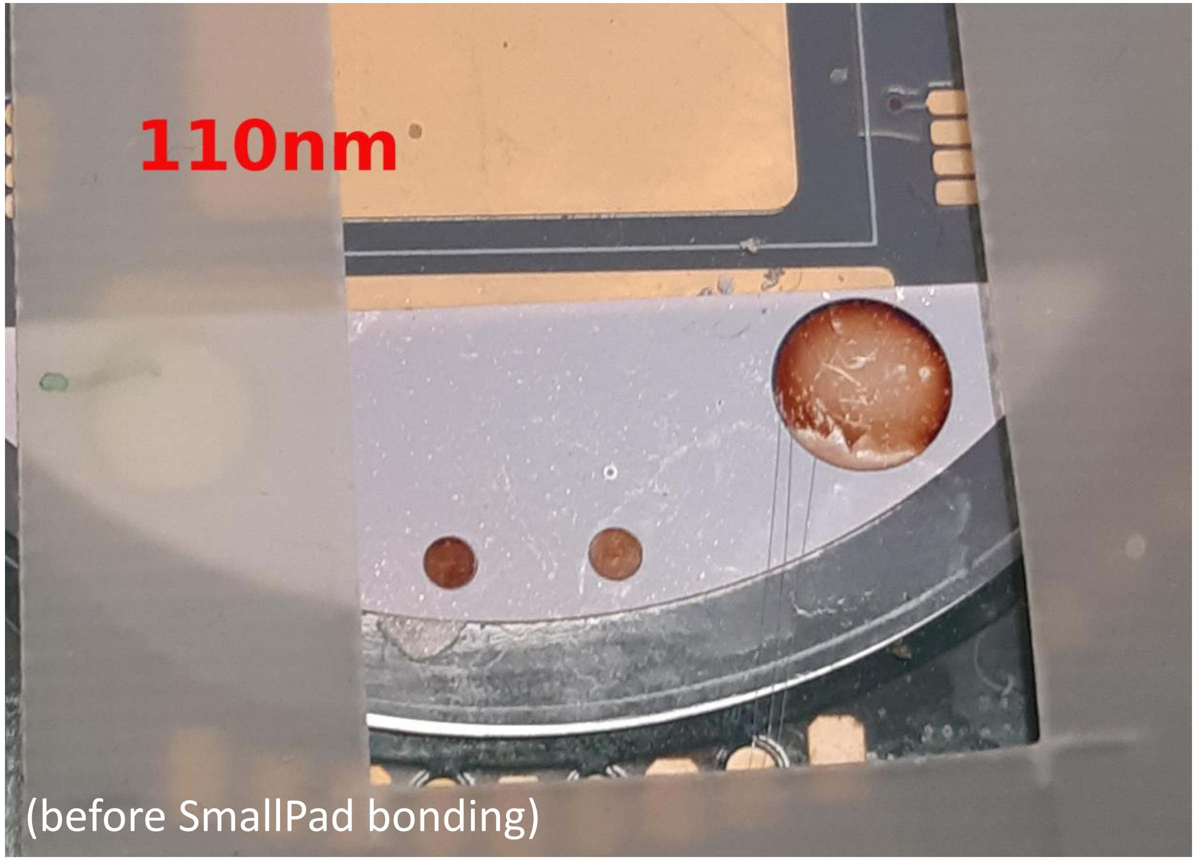
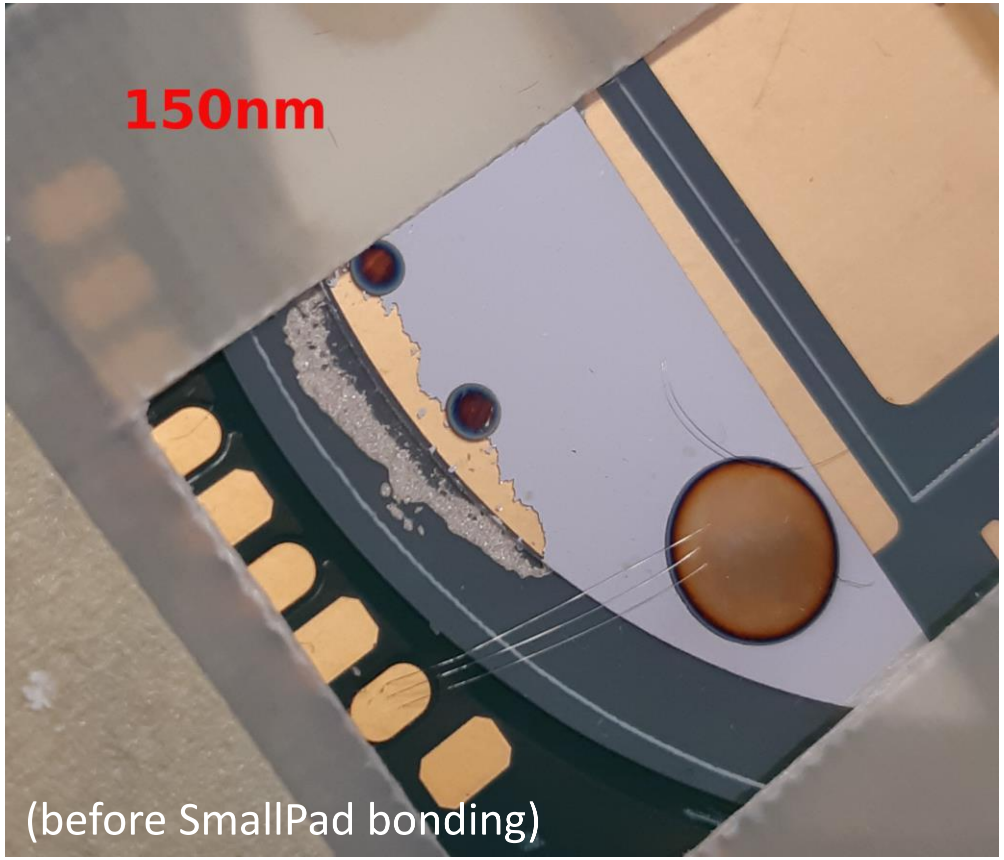
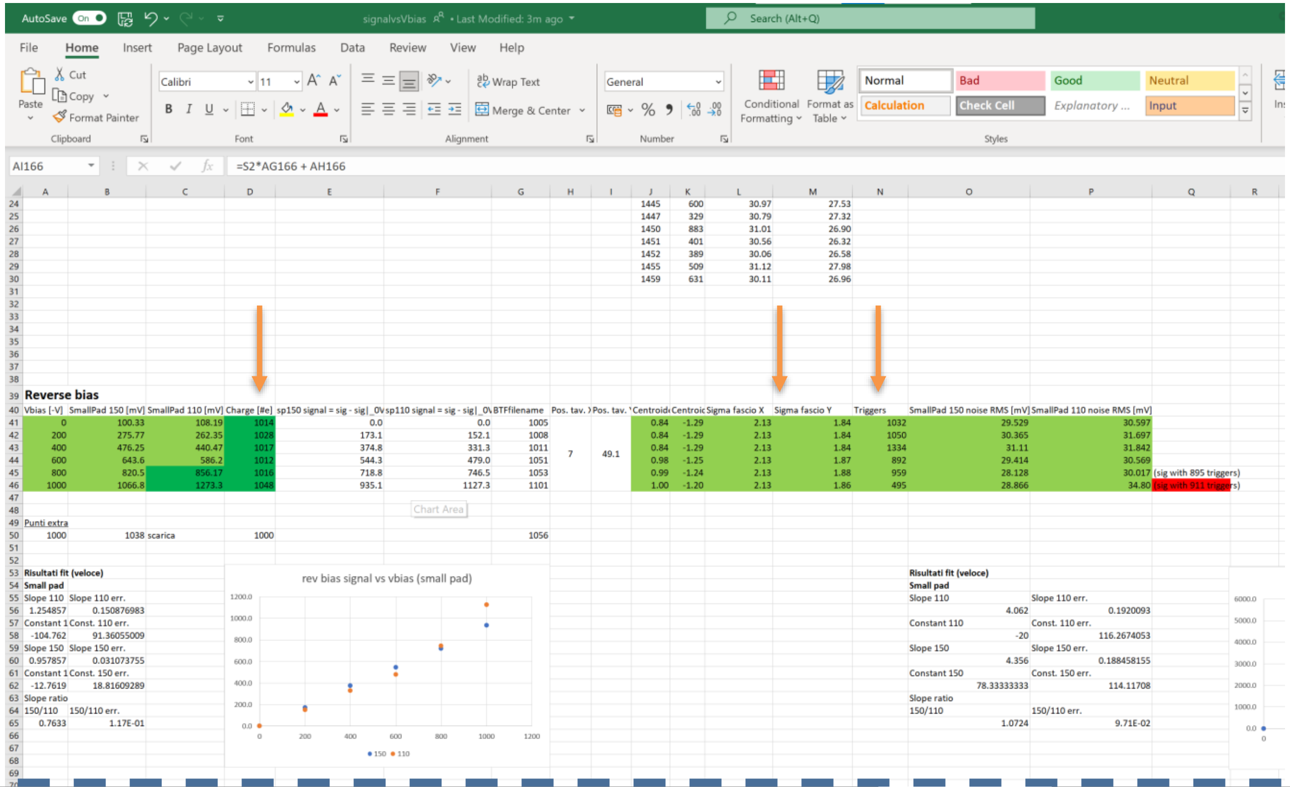
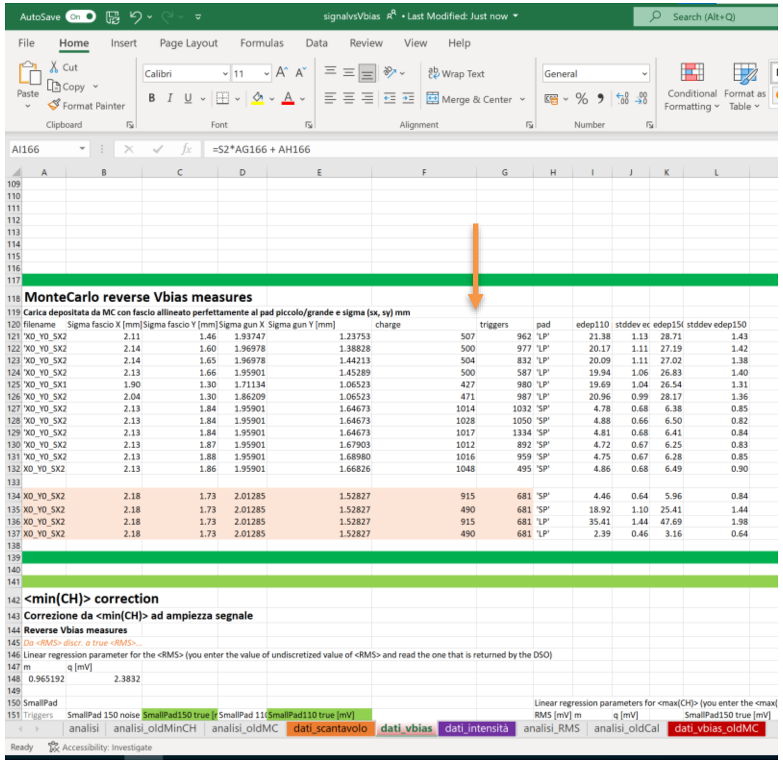




Overview of ’data corrections’

3. Charge multiplicity has been corrected using recorded average data by the lead-glass calorimeter (BTF data).
4. Beam characteristics (sigma X, sigmaY) variations have been accounted in the estimate of deposited charge.





Fit model

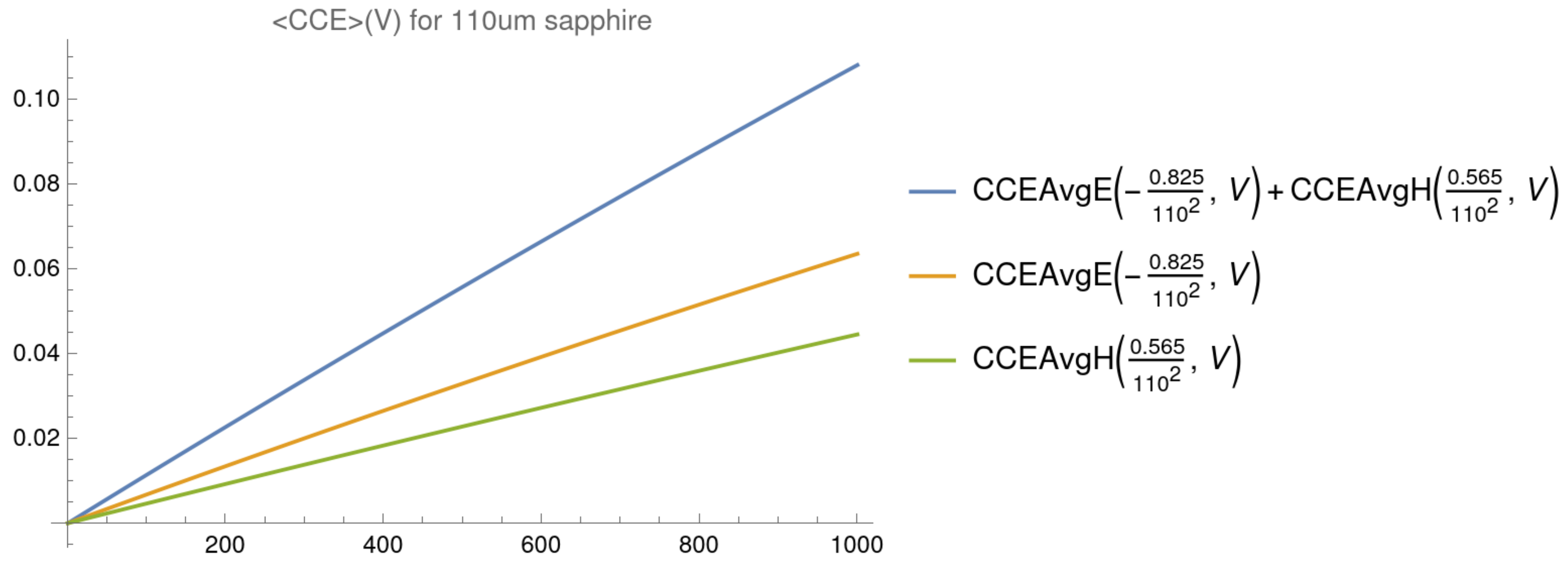
```
CCEAvgE[k_, V_] := Abs[k V (1 - k V (Exp[1/(k V)] - 1))];

CCEAvgH[k_, V_] := Abs[k V (1 - k V (1 - Exp[-1/(k V)]))];

Hecht[k_, V_] := Abs[k V (1 - Exp[1/(k V)])];
```

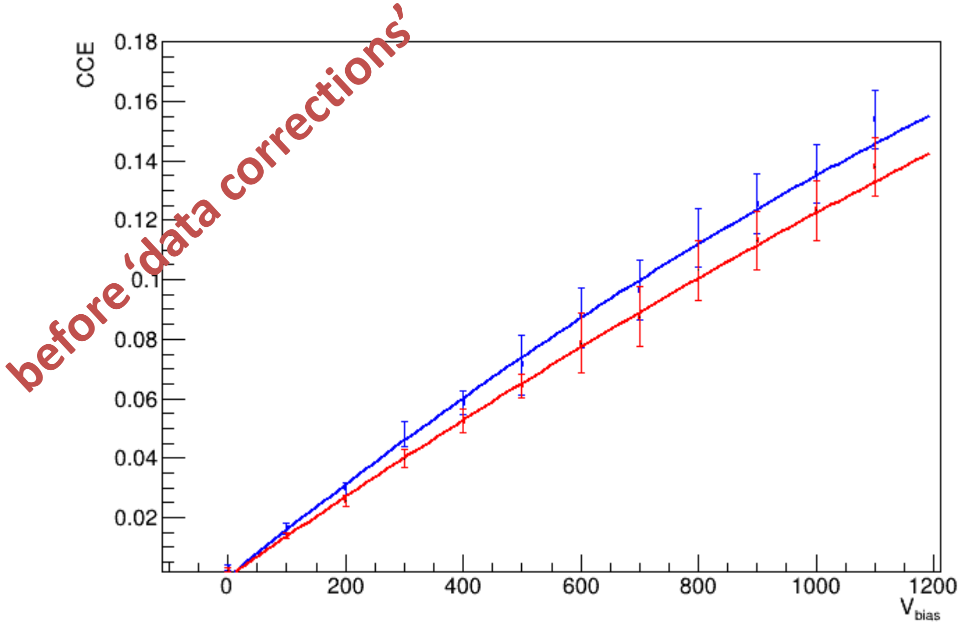
Energy deposited uniformly over thickness d(MIP) → Carriers generation (Q= E / 27eV) → Propagation in uniform field E=V/d

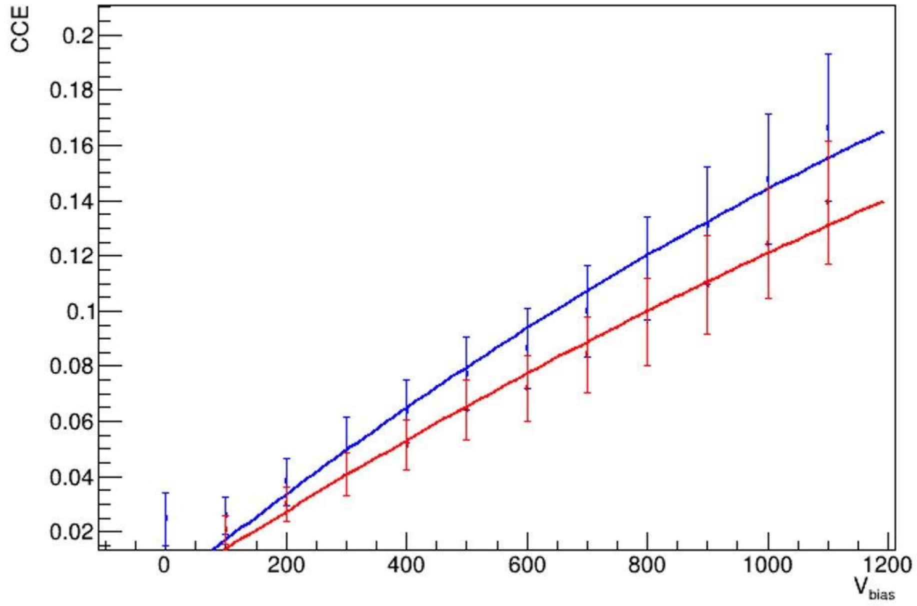
Problem
The hole contribution cannot be clearly distinguished from the electron one.

Fitting data, by assuming hole's contribution is negligible, can give an idea of the (\mu\tau)$_e$ product.

Comparison with both alpha experiments parameter and literature can be useful to test the Hecht assumptions for the internal field.







2.Fitting <CCE(V)>

Forward bias

LargePad

110 um wafer

Giving for the mutau product:
1.94 +/- 0.05 um2/V

150 um wafer

Giving for the mutau product:
3.16 +/- 0.08 um2/V

before ‘data corrections’

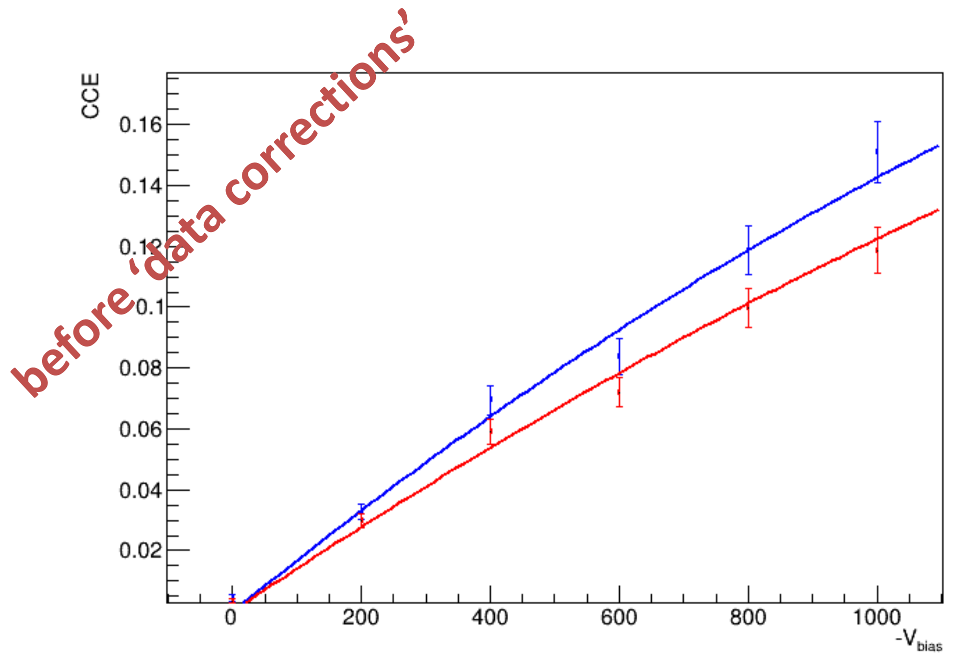
SmallPad

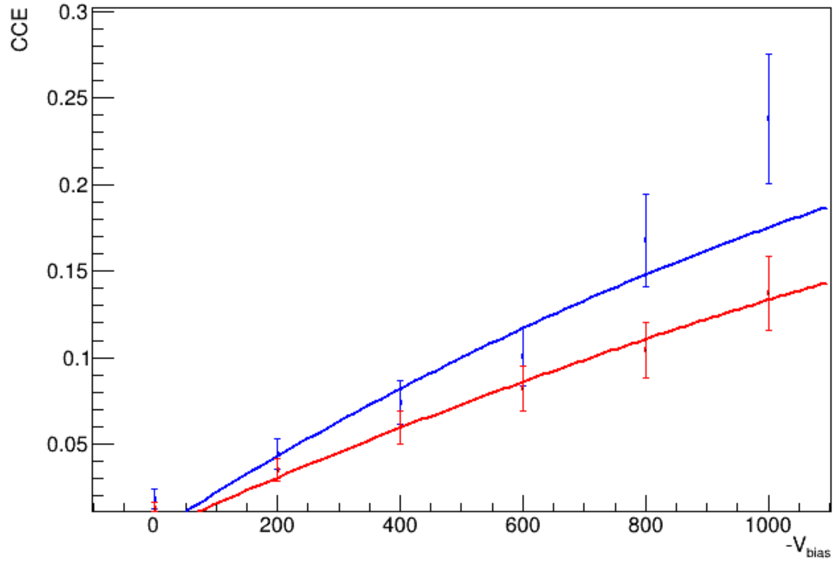
110 um wafer

Giving for the mutau product:
2.11 +/- 0.13 um2/V

150 um wafer

Giving for the mutau product:
3.2 +/- 0.2 um2/V





2.Fitting <CCE(V)>

Reverse bias

LargePad

110 um wafer

Giving for the mutau product:
2.08 +/- 0.07 um2/V

150 um wafer

Giving for the mutau product:
3.22 +/- 0.11 um2/V

SmallPad

110 um wafer

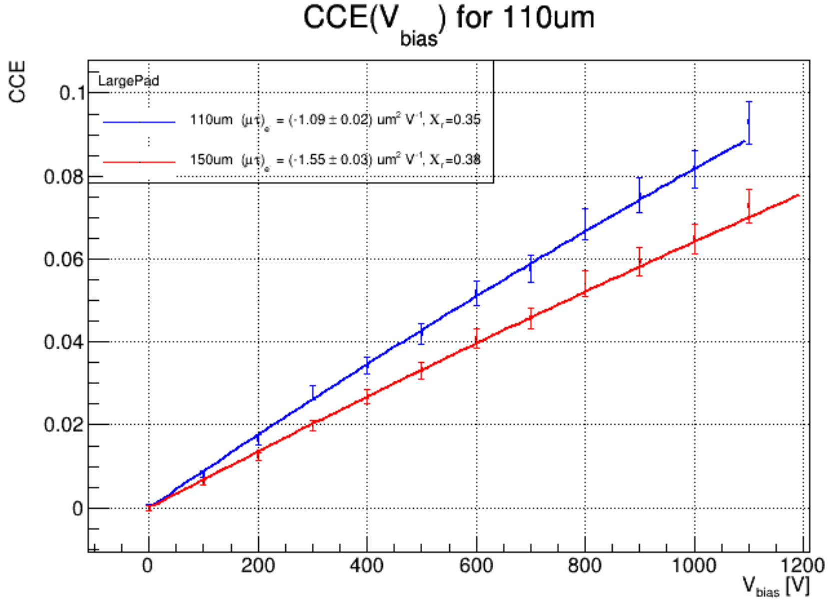
Giving for the mutau product:
2.7 +/- 0.2 um2/V

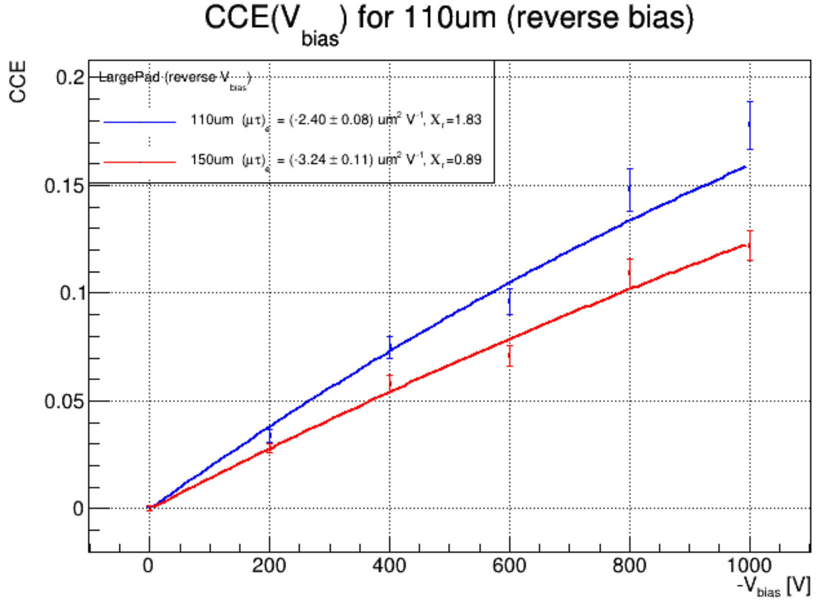
150 um wafer

Giving for the mutau product:
3.3 +/- 0.3 um2/V

before 'data corrections'

Fit results

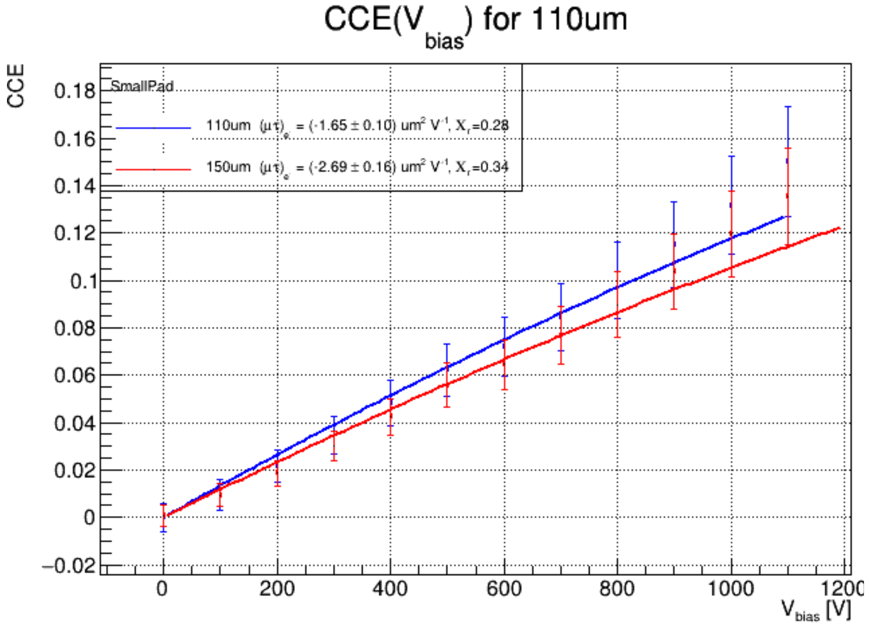


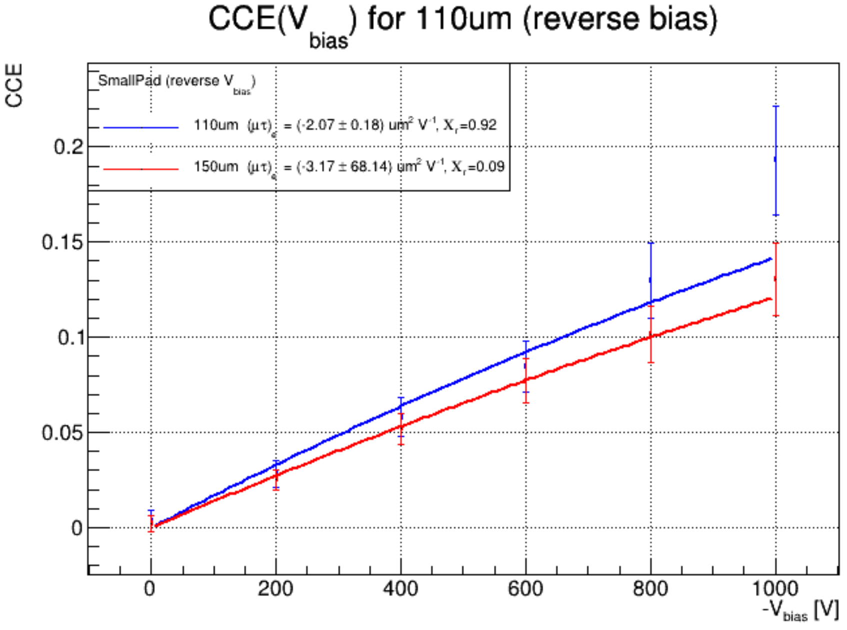


-\mu\tau [um2 V-1]	110um	150um
LargePad	1.09 +/- 0.02	1.55 +/- 0.03
-HV	2.40 +/- 0.08	3.24 +/- 0.11
SmallPad	1.65 +/- 0.10	2.69 +/- 0.16
-HV	2.07 +/- 0.18	(fit failed)

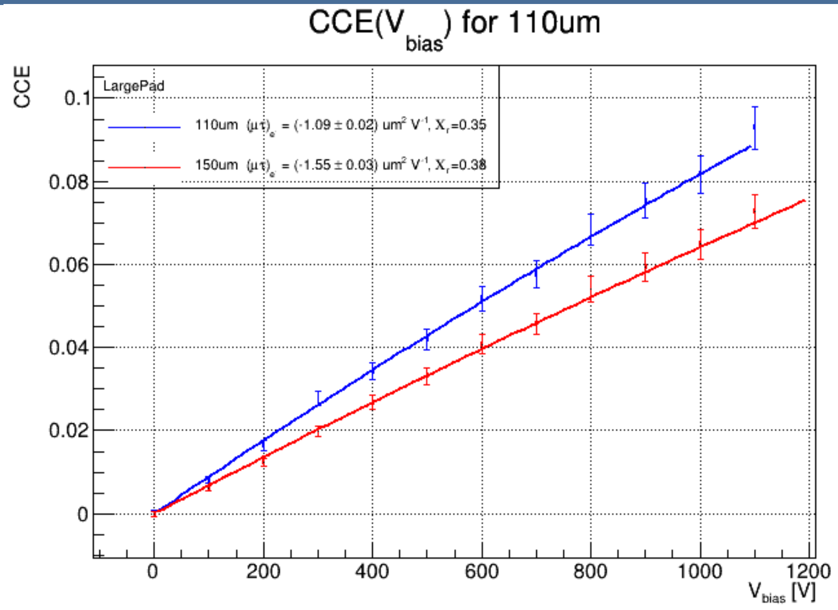
Reverse bias measures are believed to be most accurate given

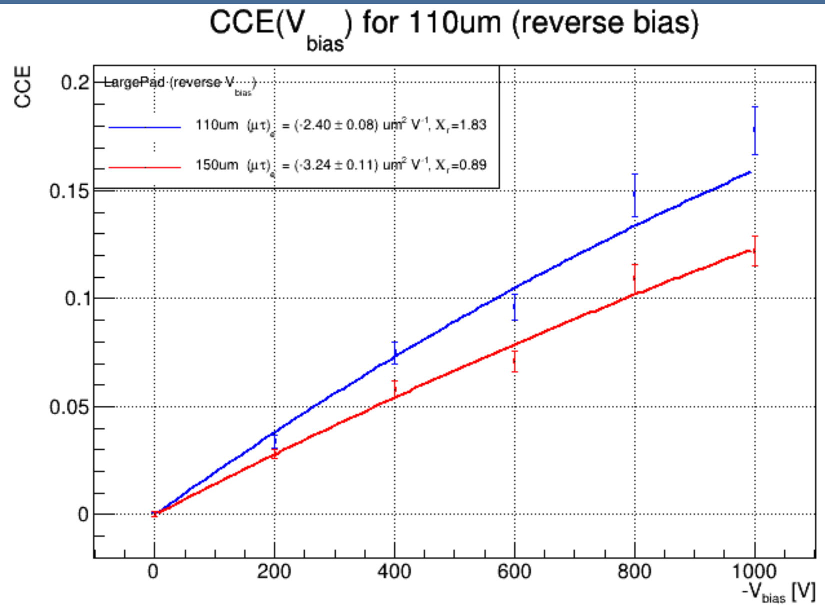
1. the availability of calorimeter data an d LeCroy notebooks data;
2. the 1k triggers statistics





Fit results





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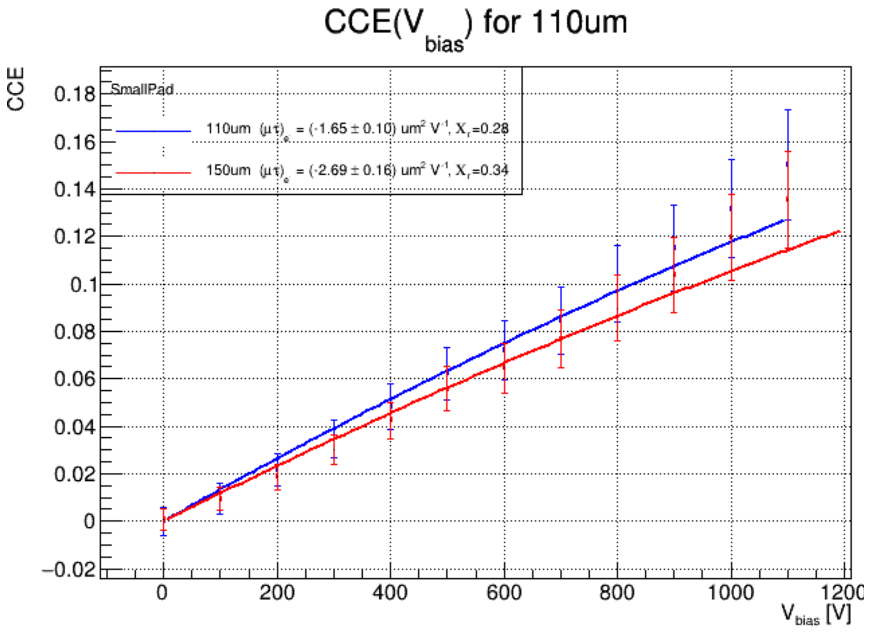
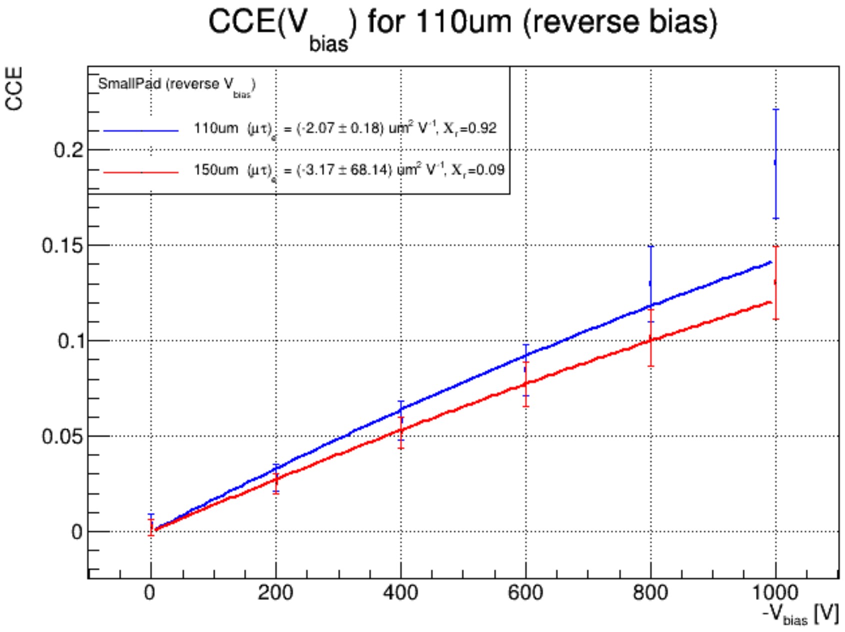
Fit results confirmed the preliminary analysis with a

$\mu\tau = 1.0 \div 3.3\ um^2\ V^{-1}$

However, data points have large uncertainties due to the lack of statistics and auxiliary data (fitpix) for deposited charge reconstruction.





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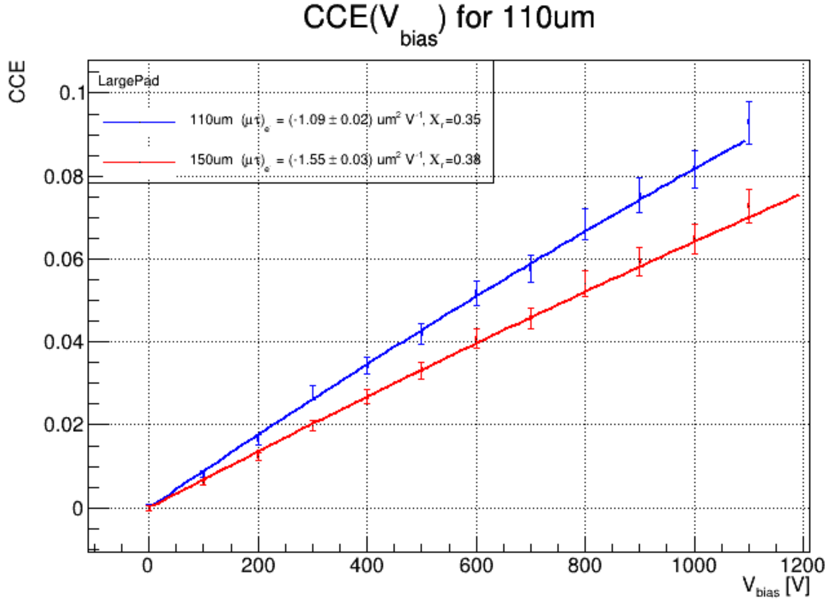

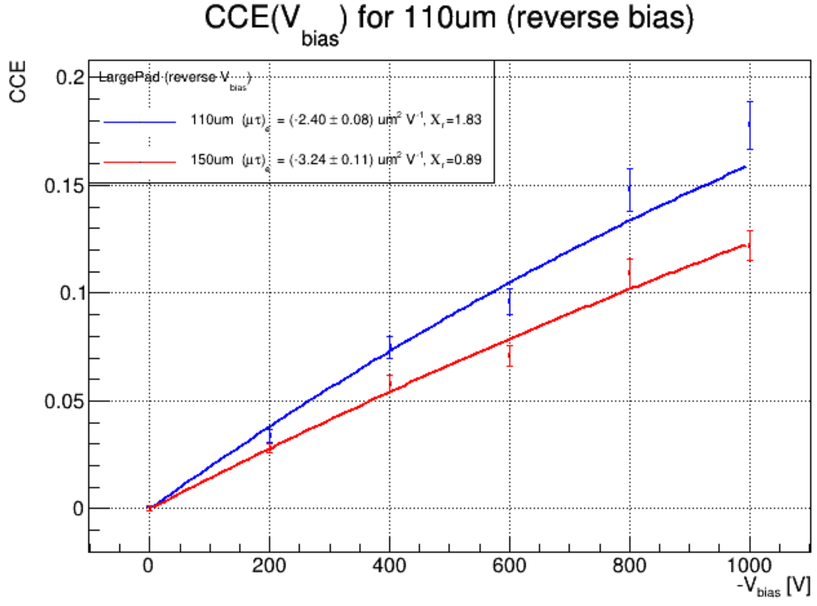

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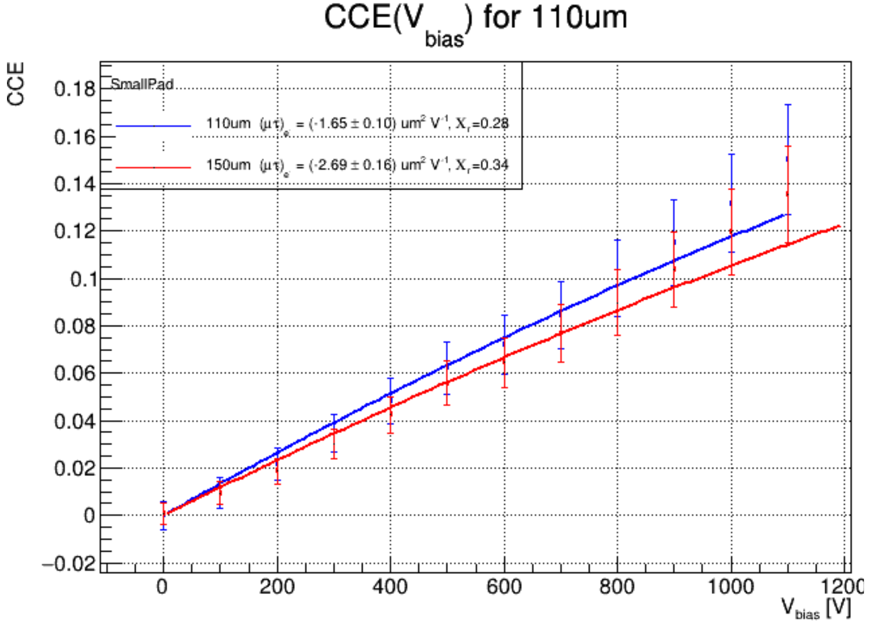
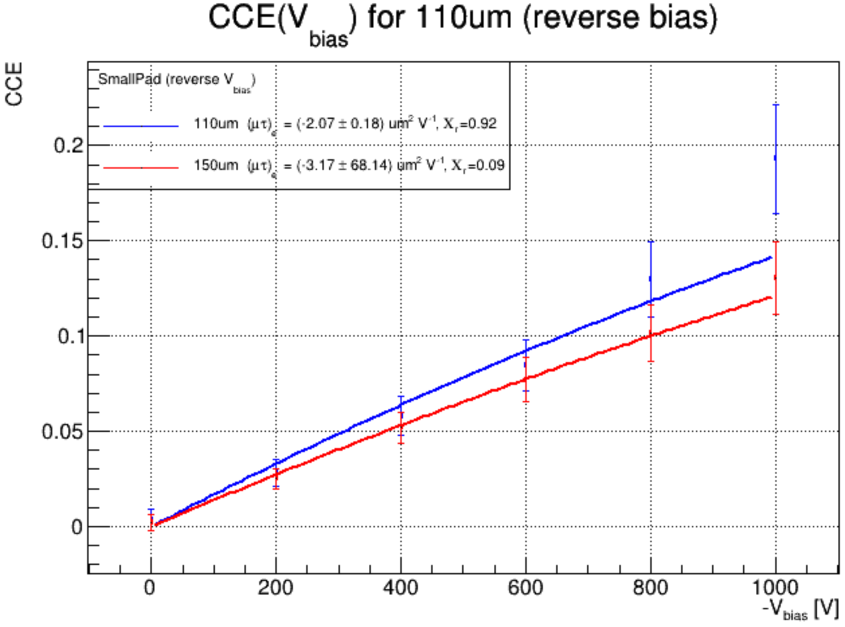
- Consistent higher detection efficiency for the 110um detector.
- Unable to determine if Small/Large pad difference is physical or not.



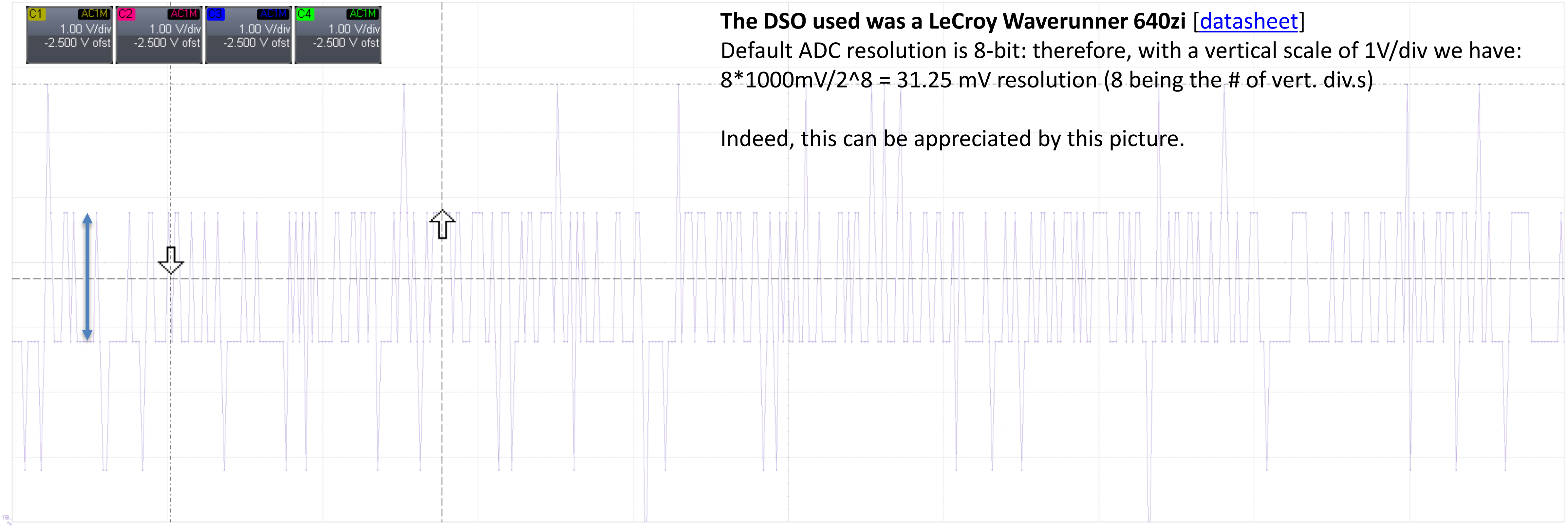


backup

DSO ADC resolution

The DSO used was a LeCroy Waverunner 640zi [datasheet]
Default ADC resolution is 8-bit: therefore, with a vertical scale of 1V/div we have:
8*1000mV/2^8 = 31.25 mV resolution (8 being the # of vert. div.s)

Indeed, this can be appreciated by this picture.



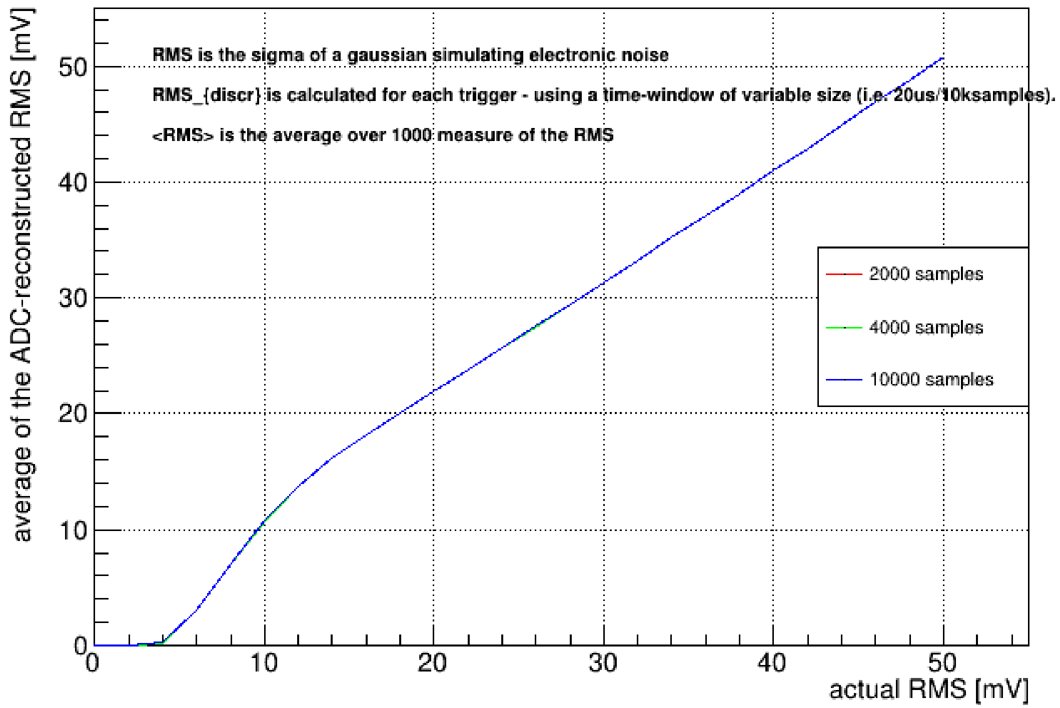
Cursors	X1	X2	DeltaX	Y1@X1	Y2@X2	DeltaY	Y3	Y4
value	7.5249 µs	7.6912 µs	166.3 ns	226 mV	242 mV	16 mV	275.1 mV	224.7 mV

Measurements	Amplitude	Max	Mean	Min	Area	Base	Top	Rms
value	133 mV	275 mV	220 mV	142 mV	209.020 nWb	142 mV	275 mV	221 mV

Measurements	Delay	Duty	Fall 90-10	Fall 80-20	Rise 10-90	Rise 20-80	Period	Frequency
value	7.44801 µs	85.000 %	364.80 ns	363.61 ns	19.20 ns	18.40 ns	40.00 ns	25.00 MHz

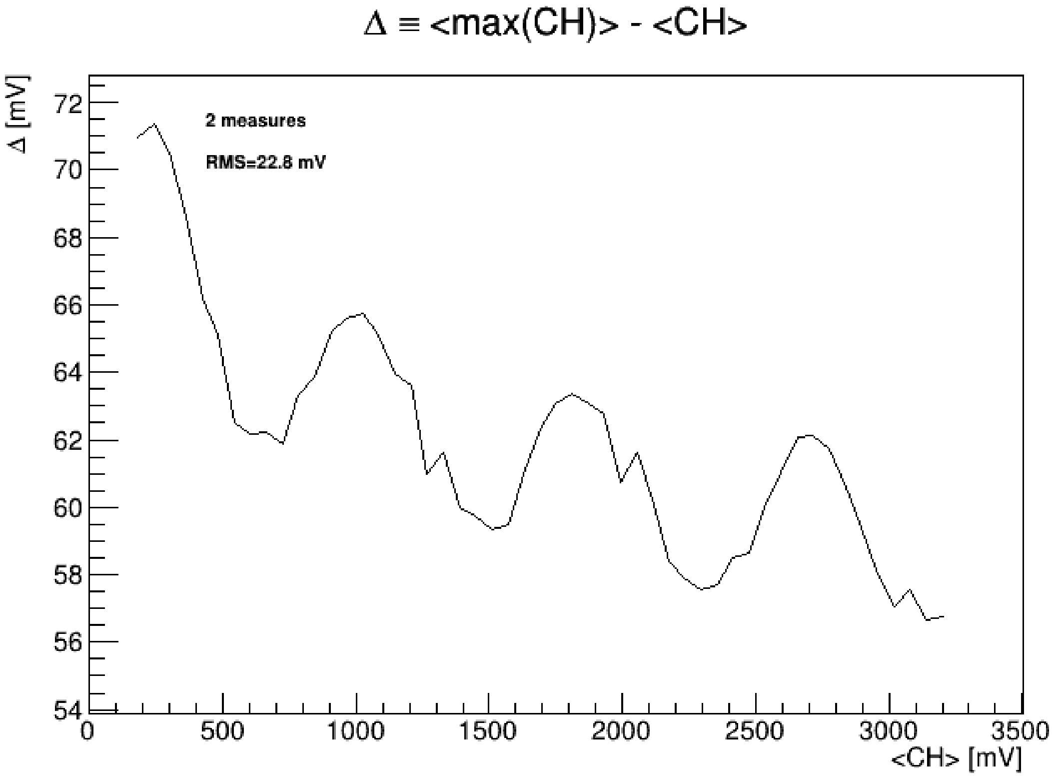
This matter for the measurement of
- the electronic noise
- the signal, which we measured using <min(CH)> and which is a function of **f(<min(CH)>)**

ADC biasing with an example 1/2
The electronics noise



- Assume that the electronics noise is completely randomic, and it's normally distributed with a certain sigma ('actual RMS').
- This noise overlays the actual signal, and this waveform is then fed in the DSO front-end where the analog signal is quantized over the 8-bit resolution (31.25 mV)
- Dithering from signal+noise sampling make the measure of the RMS noise meaningful, as illustrated here

The Fig. shows that if we read <RMS> = 32 mV – e.g. the RMS is calculated in a 2k sample window (2us) and the average over 1k triggers – the true unbiased RMS value is 32 – 2.67 = 29.3 mV.



- Incidentally, this toy model shows that dithering allows to measure the <RMS> noise with a precision smaller than the ADC resolution.
- However, to the pure electronics noise we have to add another noise distrubing the signal measure: the noise from the environment
  - Waveforms (right)
  - Trace of RMS noise (left)

The difference Δ depends from the intensity of the <CH> itself, given that the sampling rate is fixed and the shaping time determines the temporal width of the peak.