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Status of the miniBETA experiment.

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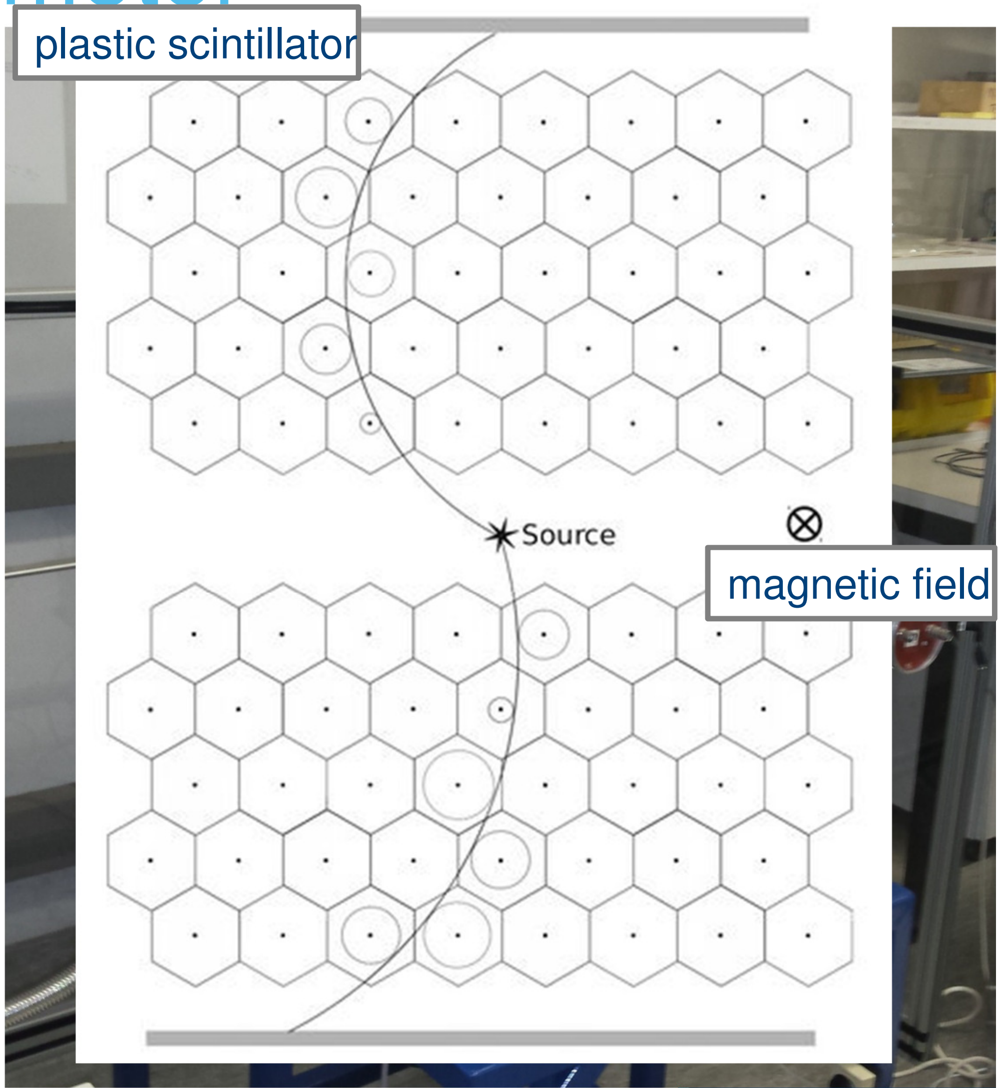
Outline

- miniBETA spectrometer
- Optimization of the efficiency:
  - single plane HV scans
    - miniBETA and FASTER DAQs
      - ADC range issues
      - TDC artificial structure in miniBETA
    - discrepancies with the simulation
- Scintillators characterization
  - Scintillator energy and position efficiency dependency
- Summary and future plans

miniBETA spectrometer

-Modular reconfigurable
 drift chamber
-beta source inside
-energy from curvature of trajectory in mag. field (~0.01T)
-trigger from scintillators (start signal for TDC)
-operates with light gas at low pressure (~300mbar)
-80 hexagonal cells (10 signal planes with 8 wires)
-X-Y space resolution 0.5mm
- Z position from charge division

Goal:
Precise measurements of β –spectrum - compare with SM looking for New Physics



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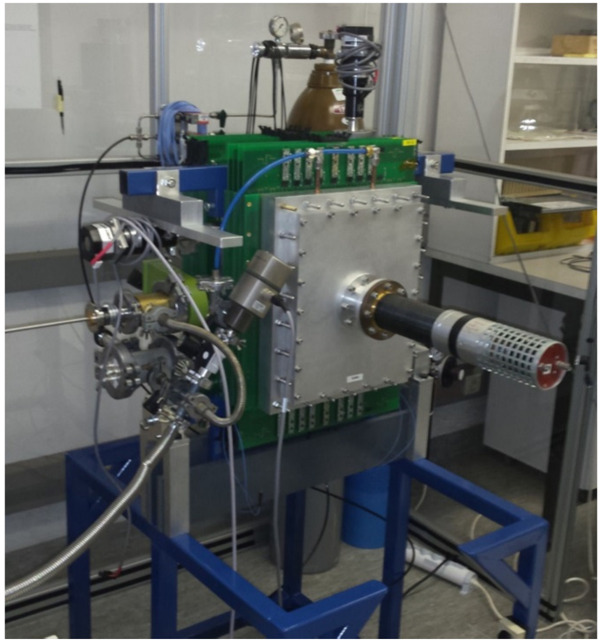

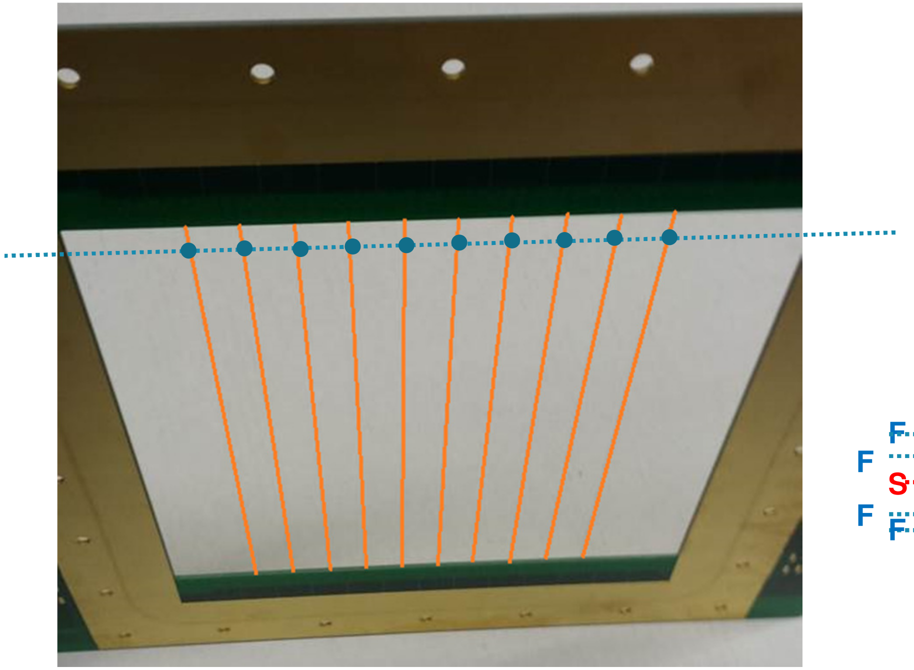

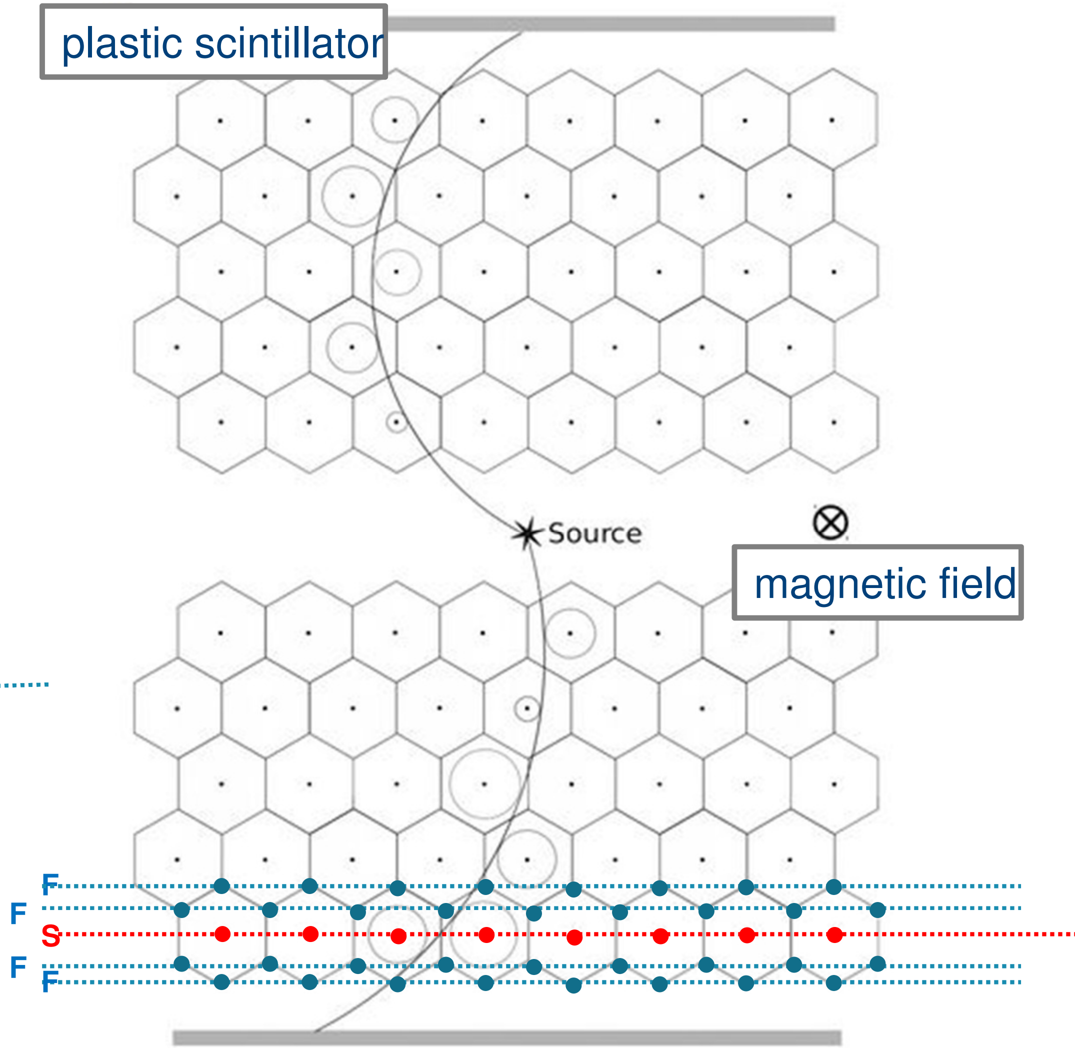
plastic scintillator
Source
magnetic field
F
F
S
F
F

Efficiency optimization:

Very high single cell efficiency e required for proper track fitting:

$$E = e^x$$

E – chamber eff.
x - number of cells

If $E > 90\%$, $x = 5$ then $e > 98\%$

e depends on the conditions inside the chamber:
gas mixture, pressure, electric field (voltage applied to the wires) …

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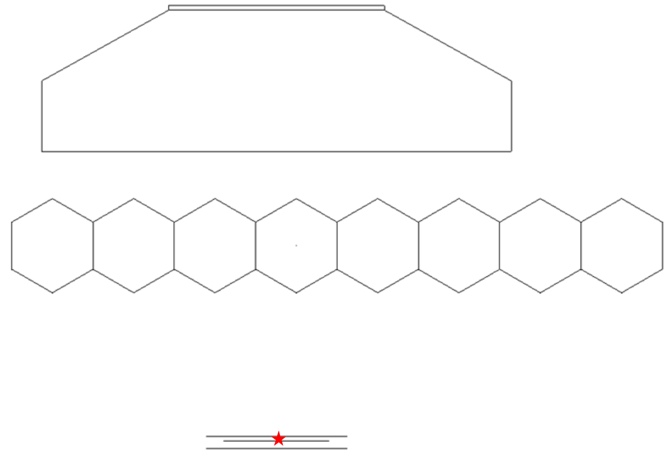
Single plane HV scans.



HV scans: gas mixture and pressure fixed, changing the voltage on the wires.

Tested mixtures of helium – isobutane: 0-100%, 50-50%, 70-30%, 90-10%
at 300 mbar and 600 mbar

Two DAQ system used: miniBETA dedicated one and FASTER

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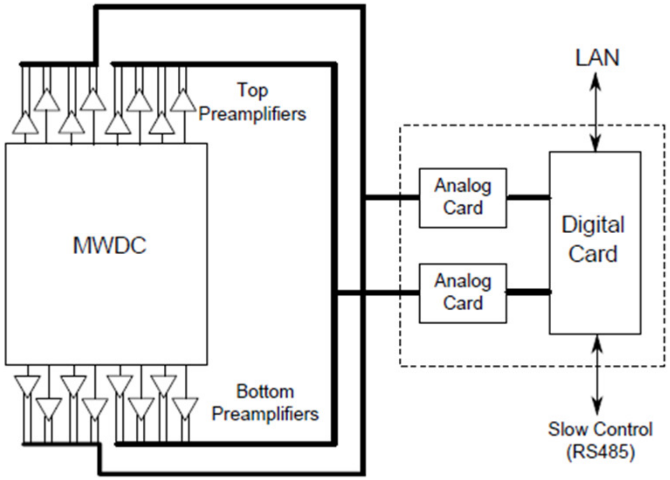


Fig. 1: Schematic of the data acquisition architecture.

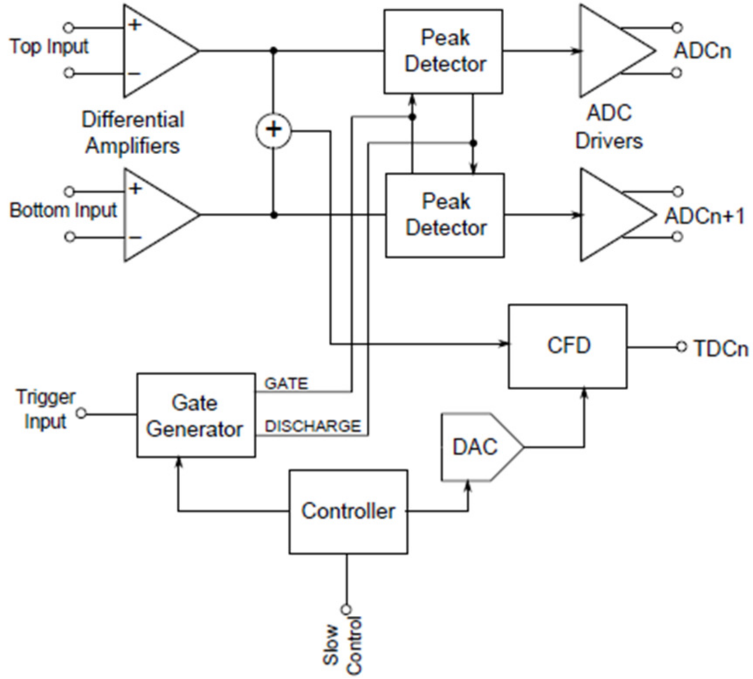
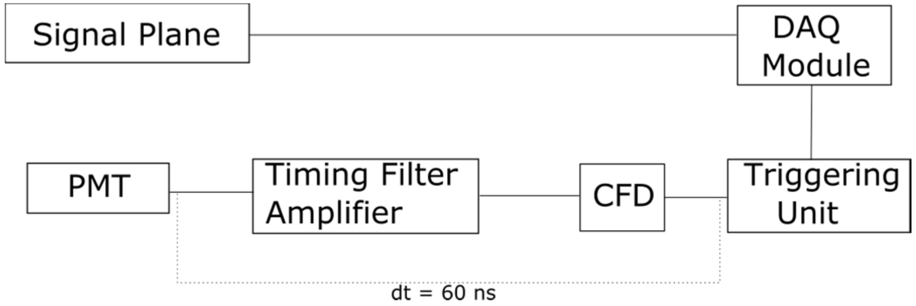


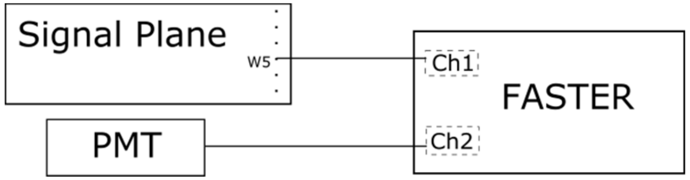
Fig. 4: Block diagram of the analog board.

miniBETA setup



- PMT signal needs amplification and translation into logic pulse.
- Only coincidences recorded:
  - time stamp, TDC and ADC.

FASTER setup



- 2 channels recorded individually:
  - time stamp,
  - ADC.
- Coincidences found offline:
  - $TDC = time_2 - time_1,$

  if: $(time_2 - time_1) \in (T_{min}, T_{max})$

Results obtained with both DAQs were compared.

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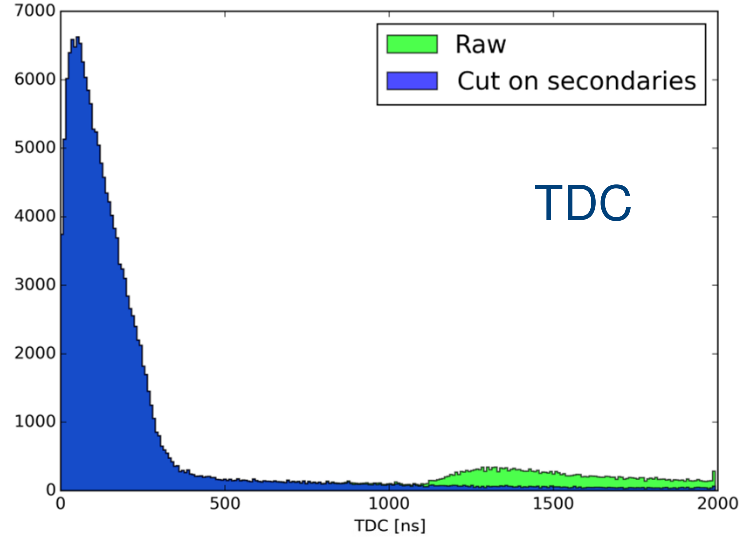
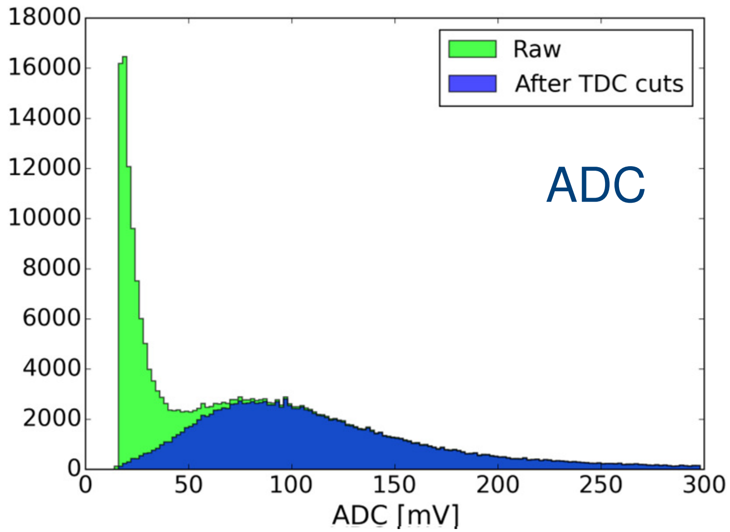
He-Iso 70-30% @ 300 mbar, 1580V

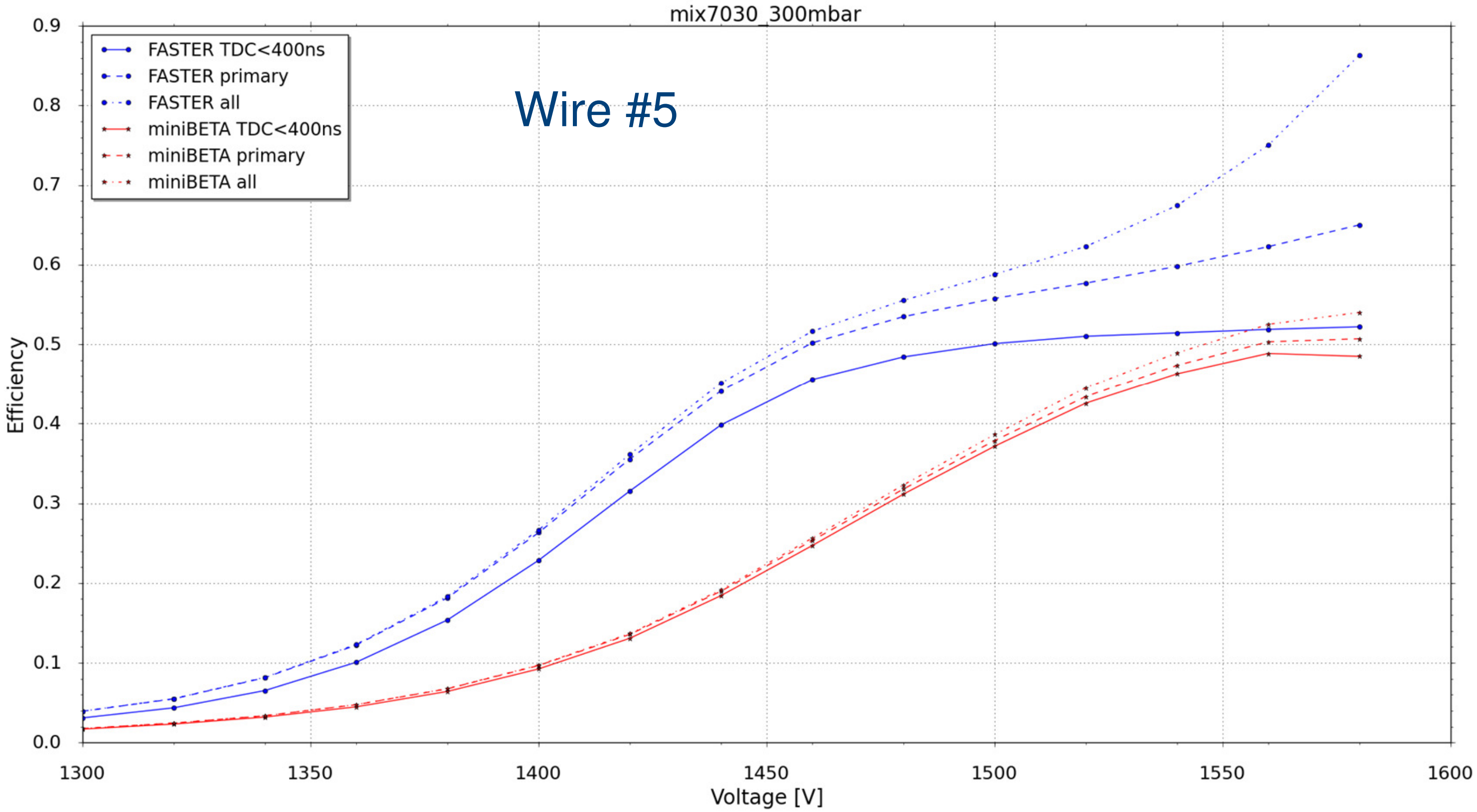




Necessary cuts:

- Secondaries
- TDC > 400 ns

He-Iso 70-30% @ 300 mbar

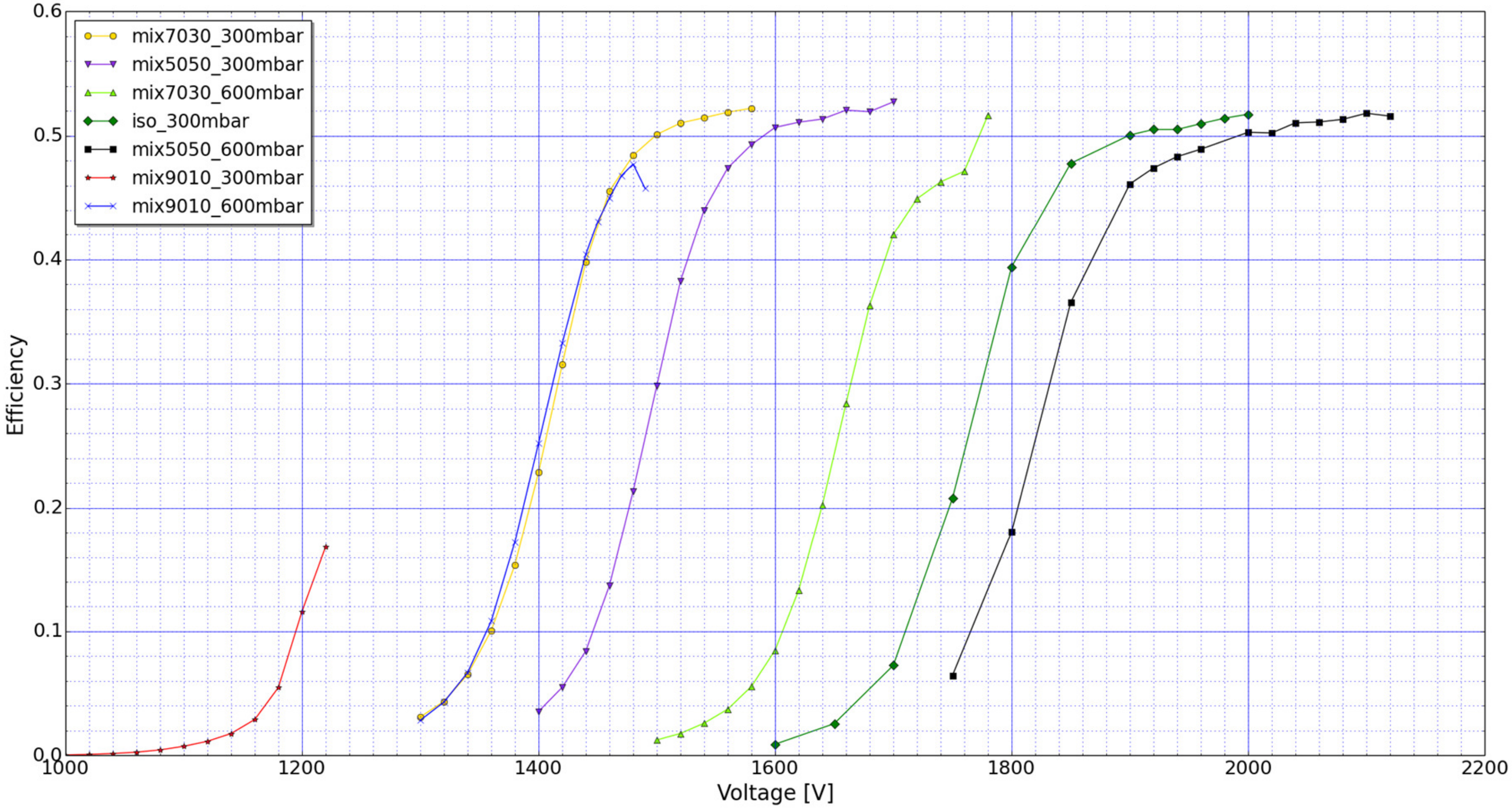


$$e = \frac{N_{coincidences}}{N_{triggers}}$$

Geometry not included

Efficiency as a HV function.

FASTER eff with TDC cut



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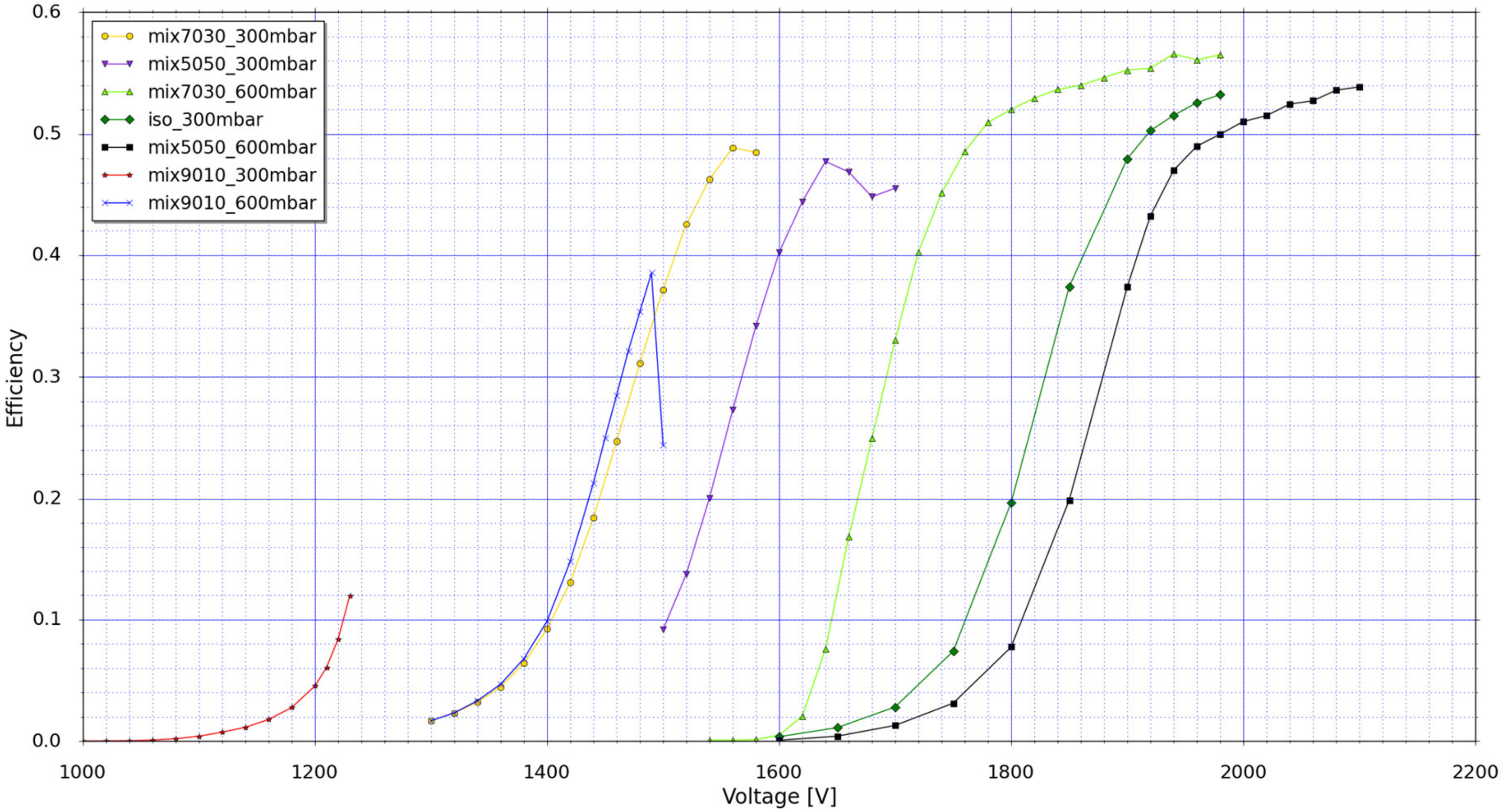
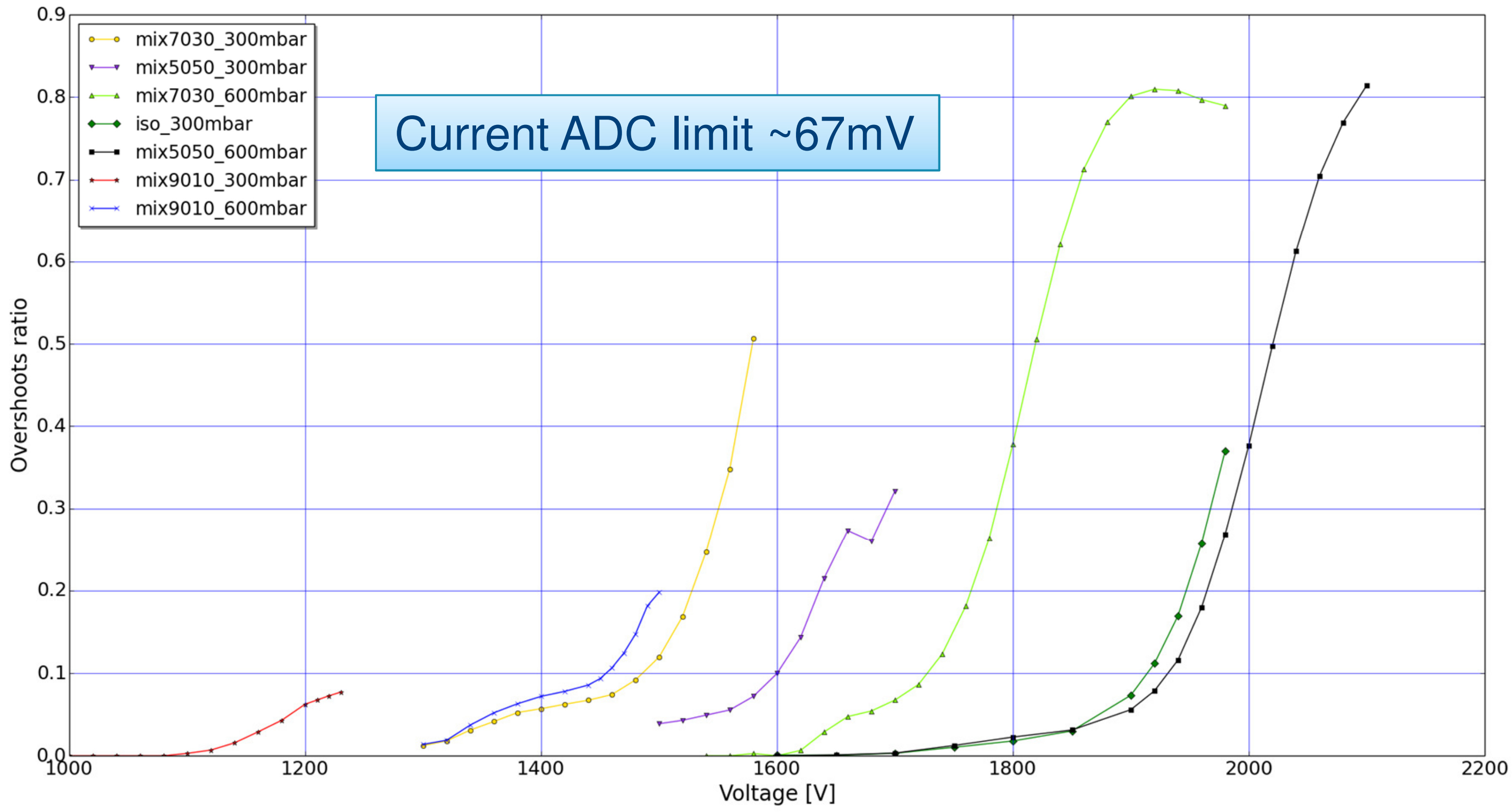
miniBETA eff with TDC cut



miniBETA issue with ADC range.



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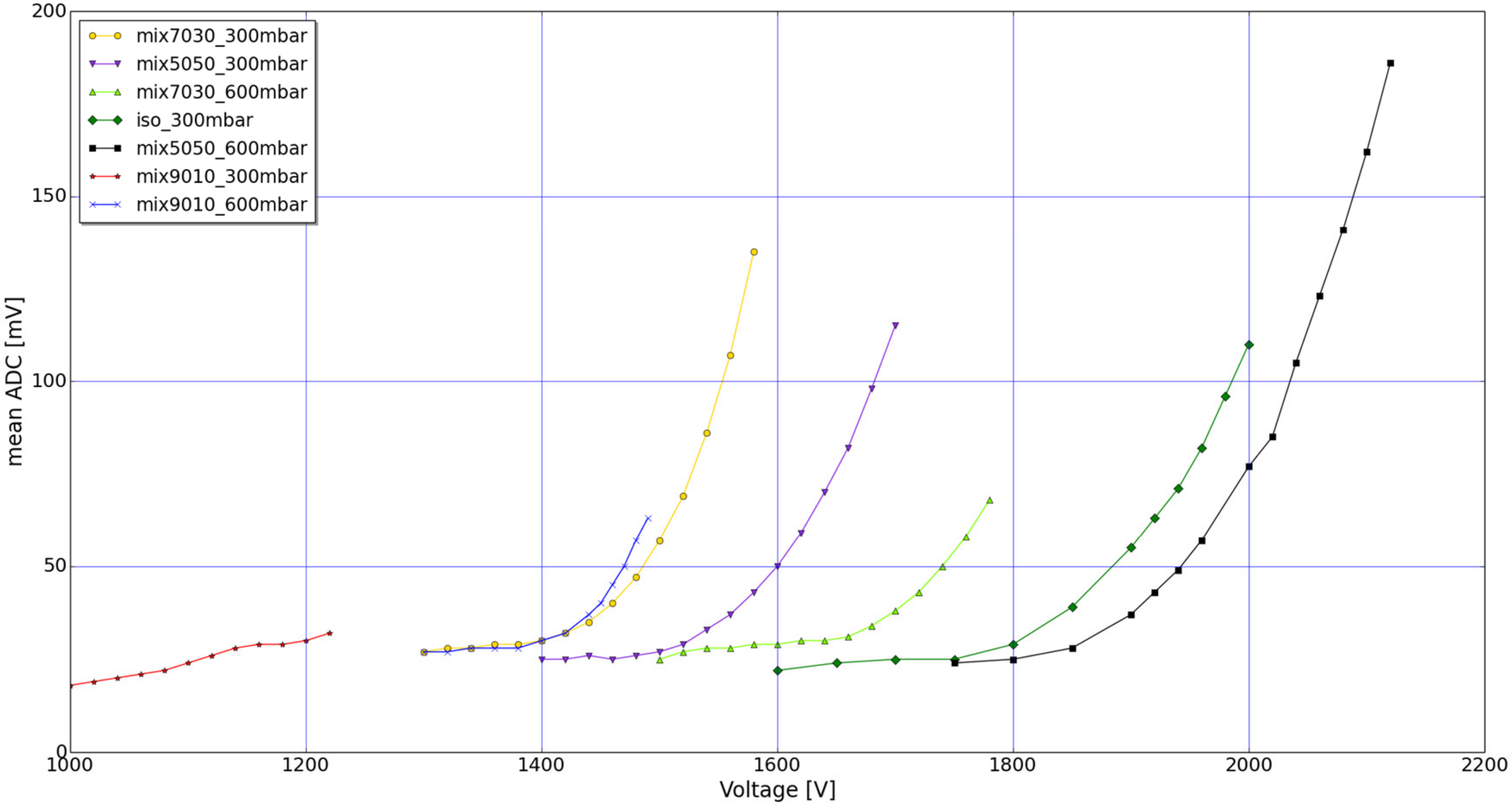
Signal height vs HV.

FASTER



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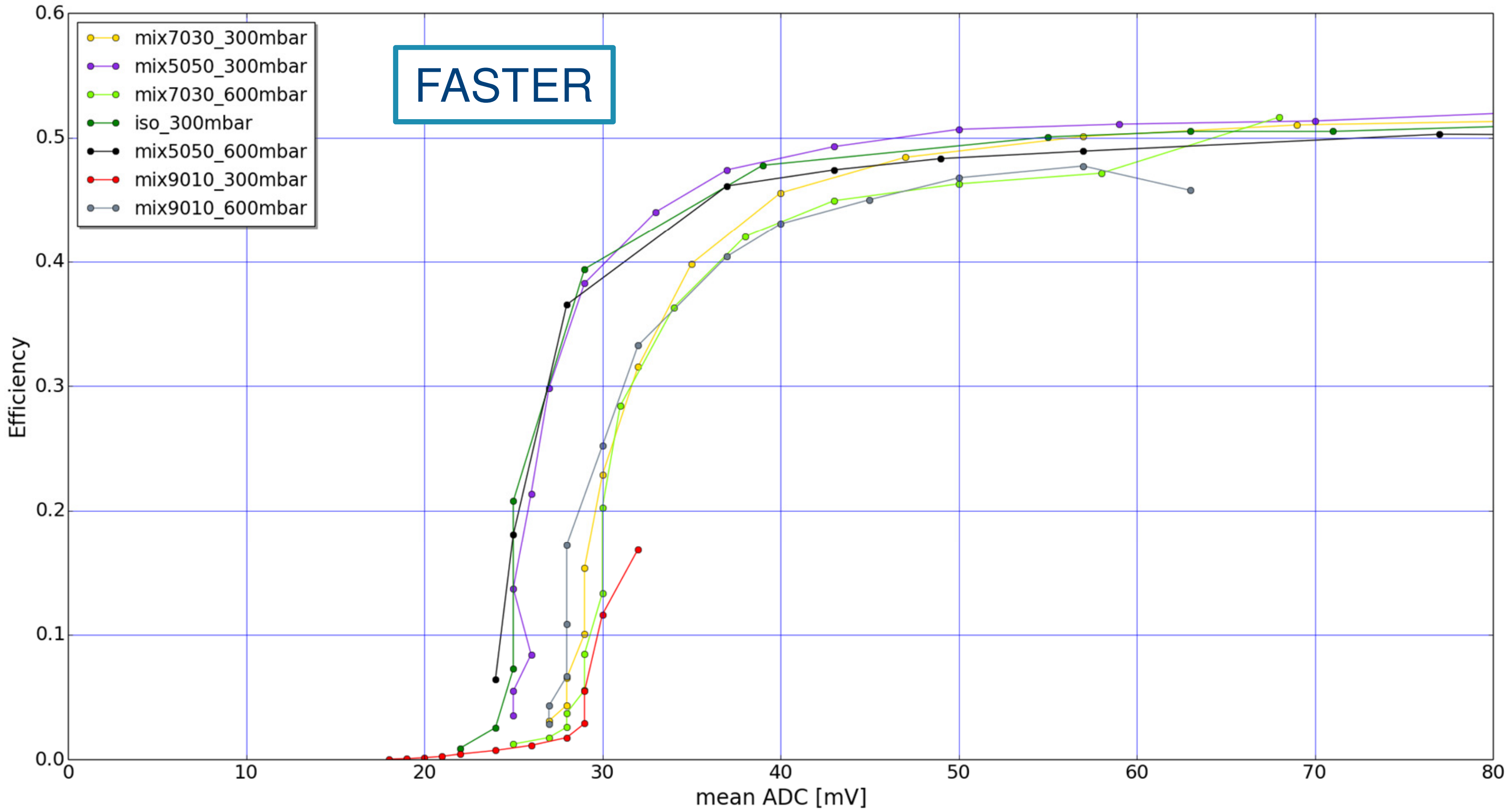
Efficiency as a signal height function.



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Differencies in mB and FASTER efficiencies: - ADC thresholds?

Two approaches to test hypothesis:

- Recalculate FASTER efficiency with different offline thresholds on ADC value and see if miniBETA behavior can be mimic,

$$eff_{Frec}(th, HV) = \frac{N_{ADC>th}(HV)}{N_{All}(HV)} \cdot eff_{org}(\mathrm{HV})$$

- Remeasure with miniBETA changing the threshold level of the electronics.

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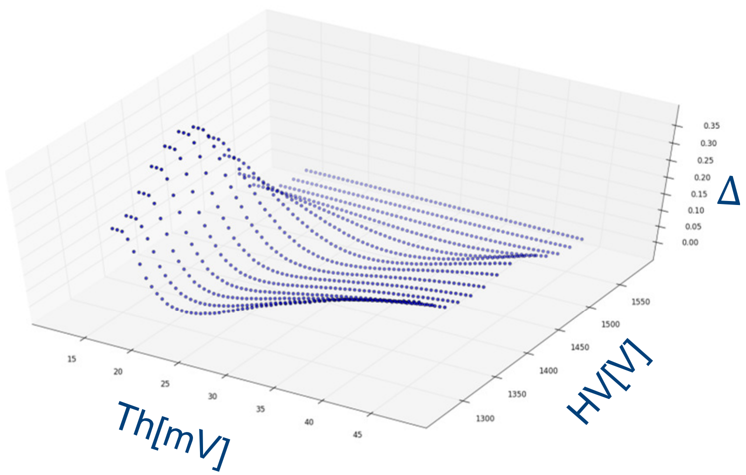
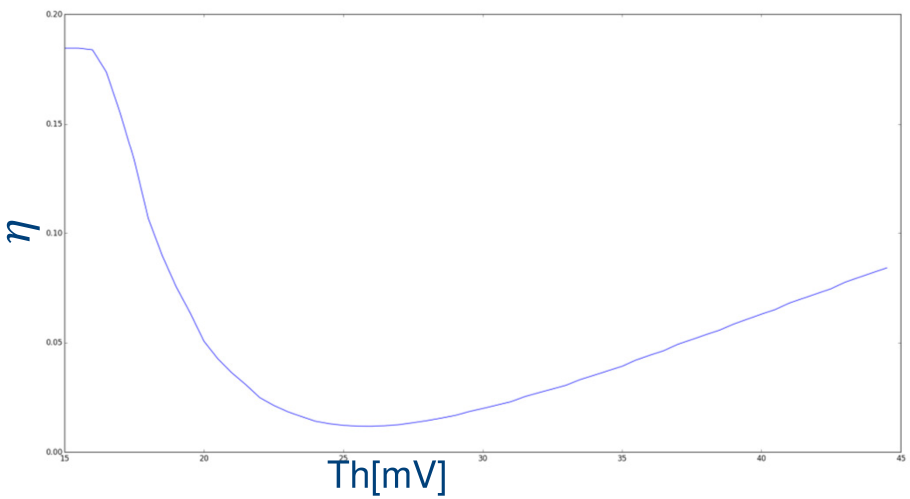
He-Iso 70-30% @ 300 mbar

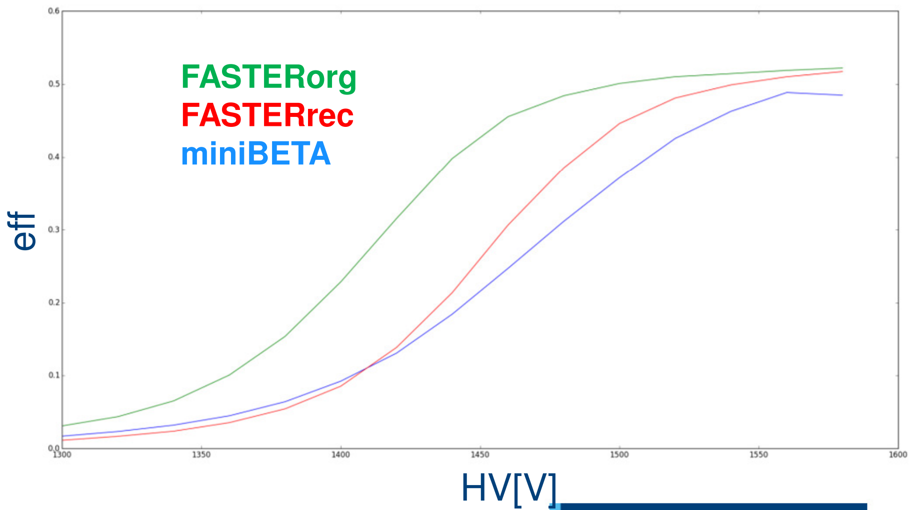


$$eff_{Frec}(th, HV) = \frac{N_{ADC>th}(HV)}{N_{All}(HV)} \cdot eff_{org}(\mathrm{HV})$$

$$\Delta(HV, th) = \left(eff_{Frec}(HV, th) - eff_{mB}(HV)\right)^2$$

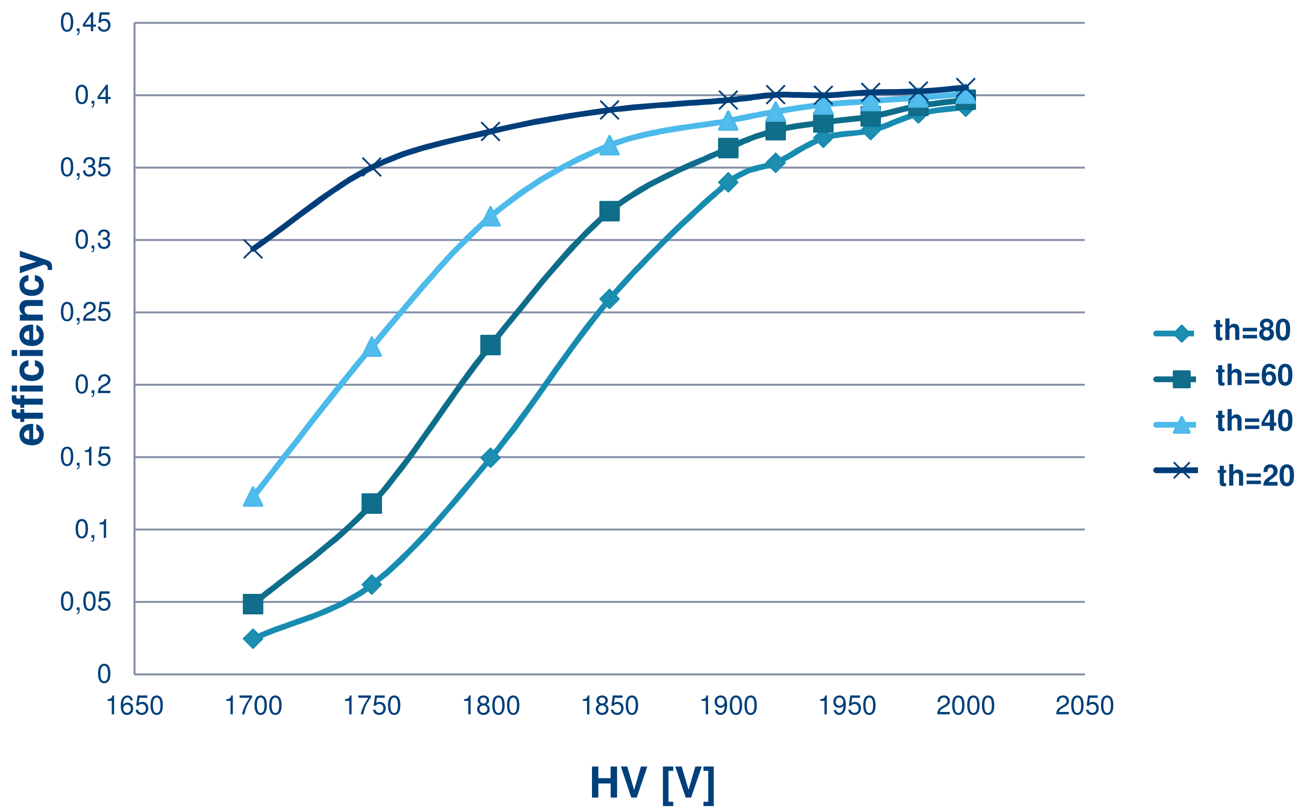
$$\eta_{th} = \sum_{HV} \Delta(\mathrm{HV})/N_{HV}$$





Remeasured efficiency (different DAQ thresholds)

Pure Isobutane, 300mbar



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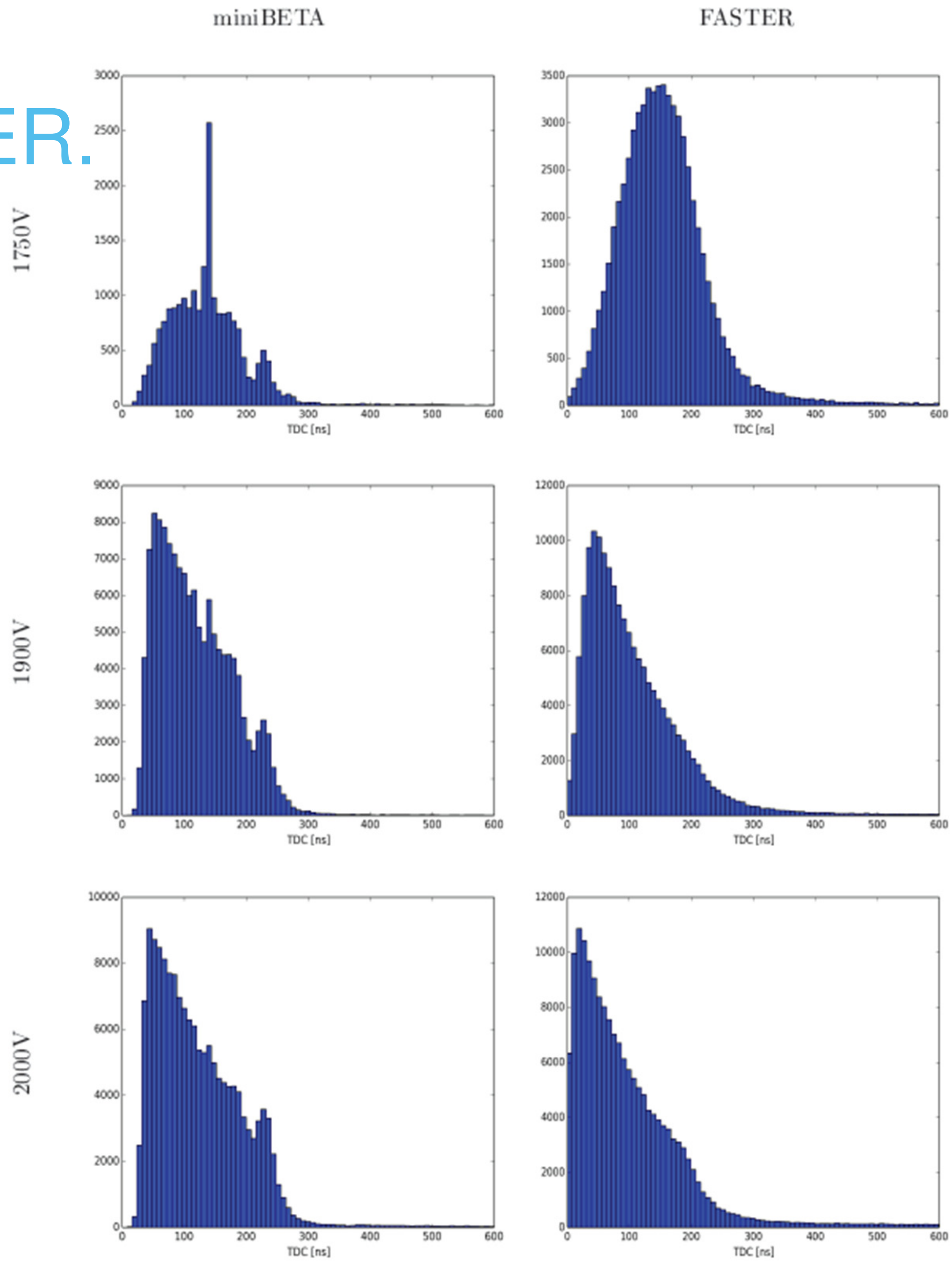
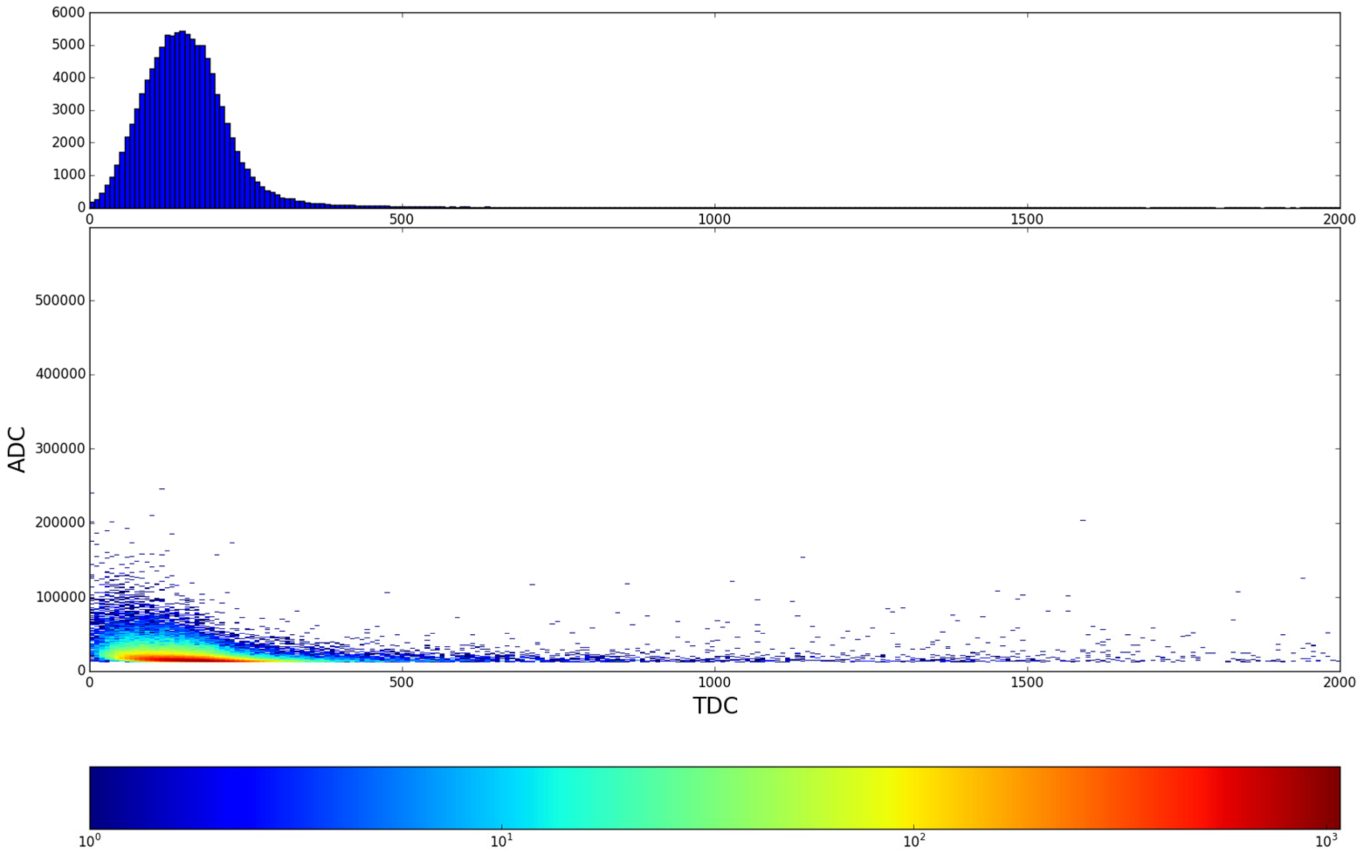
TDC spectrum: miniBETA vs FASTER.



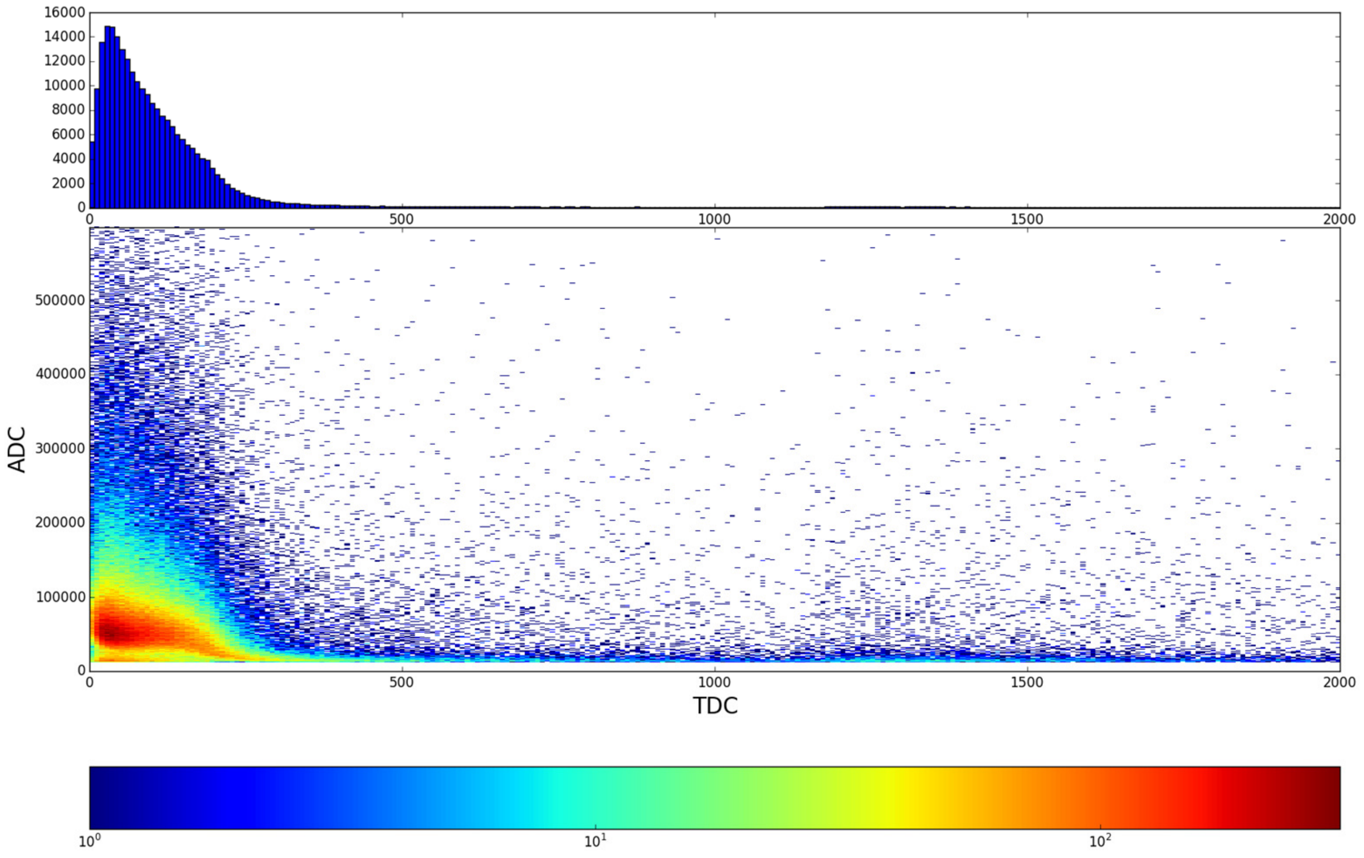
ADC vs TDC with FASTER



Iso300mbar

Lower voltage

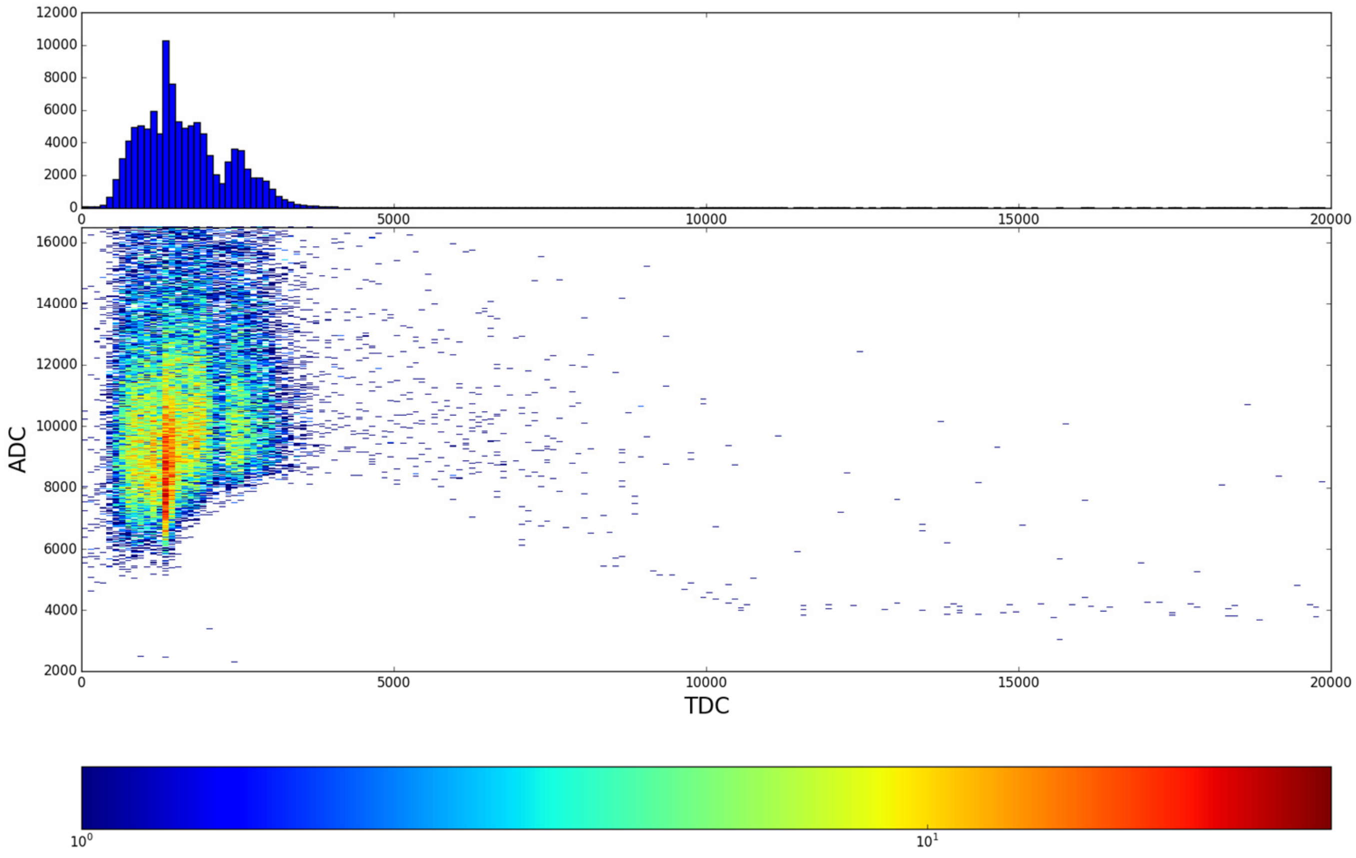
ADC vs TDC with FASTER



Iso300mbar

Higher voltage

ADC vs TDC with miniBETA



Iso300mbar

Lower voltage
High threshold

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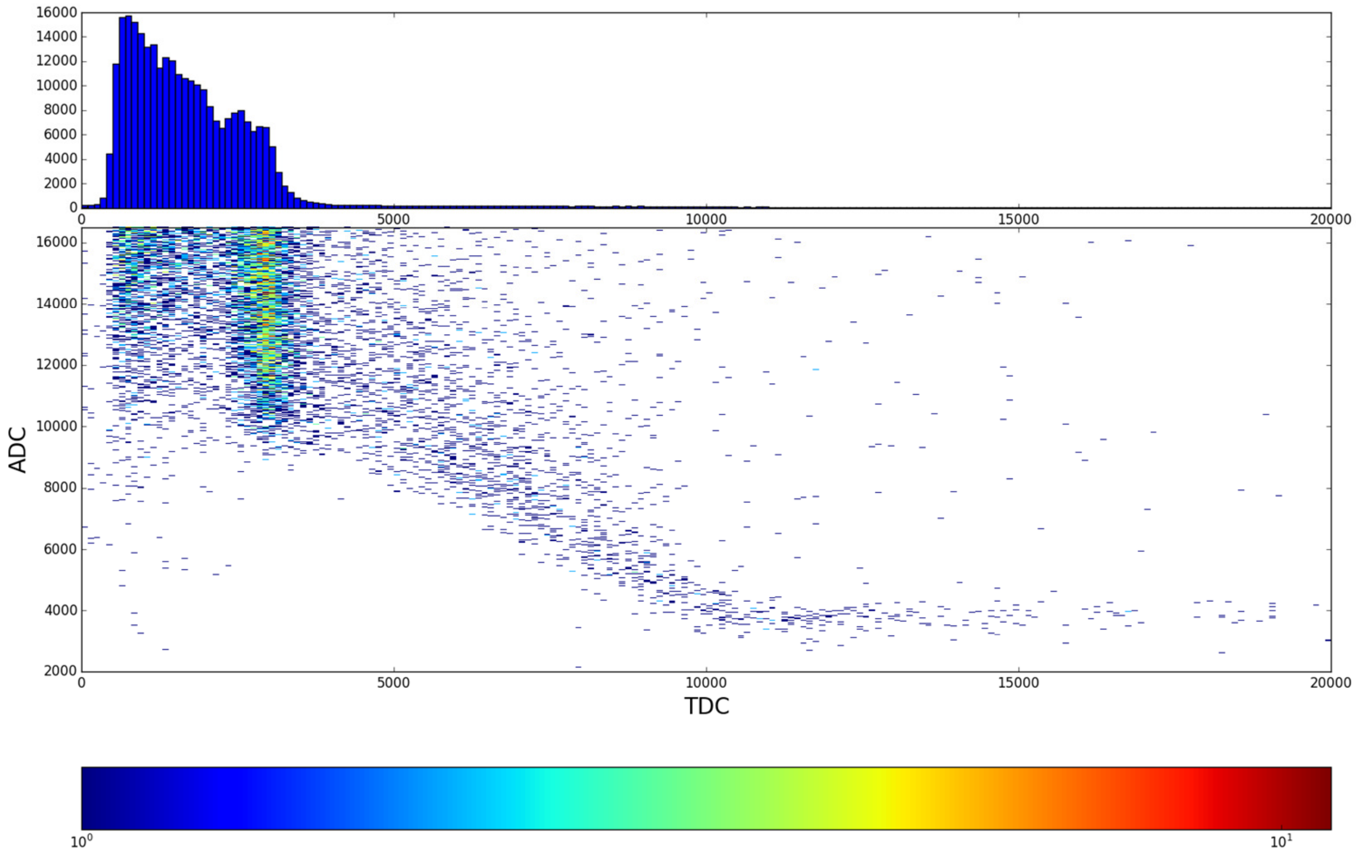
ADC vs TDC with miniBETA



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Higher voltage
High threshold

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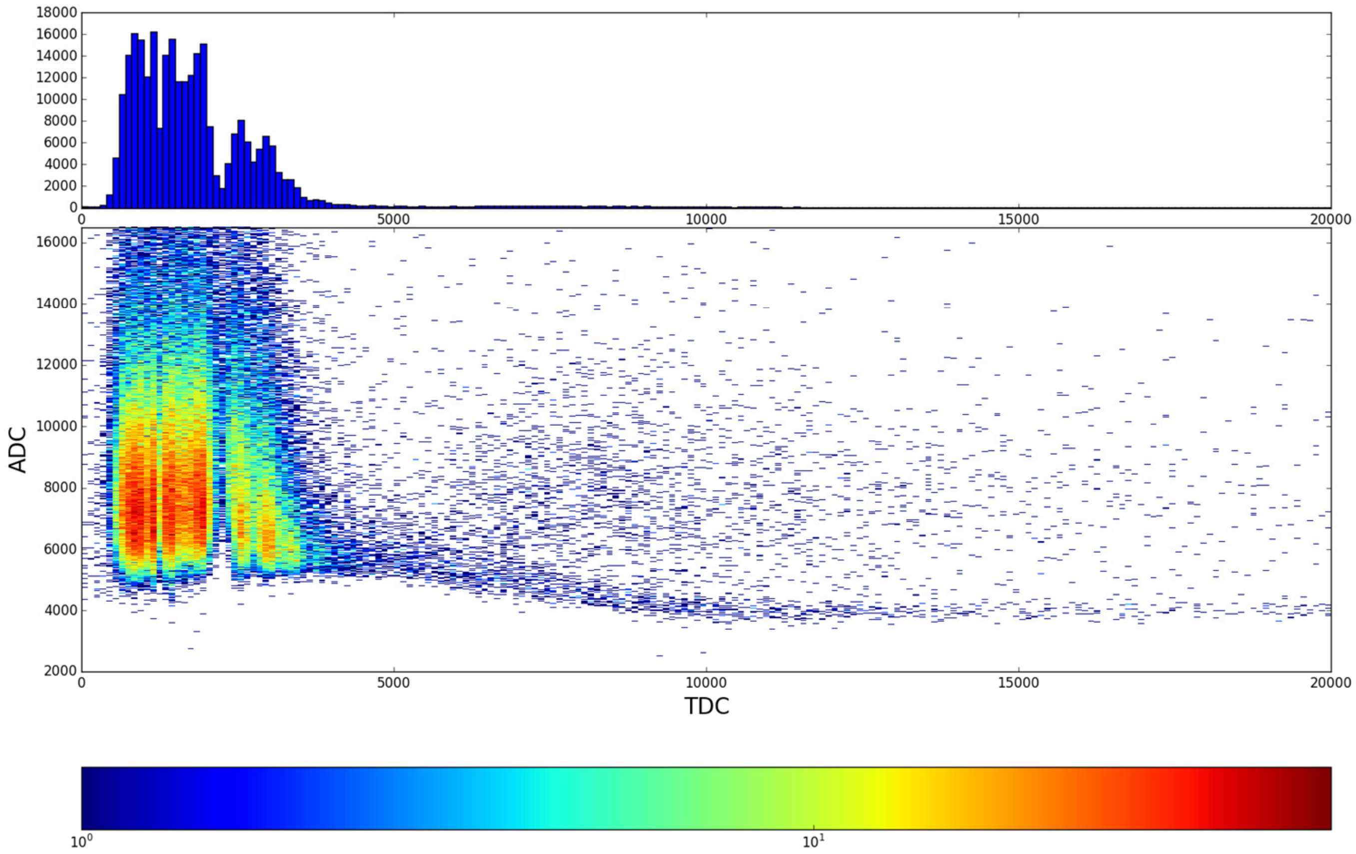
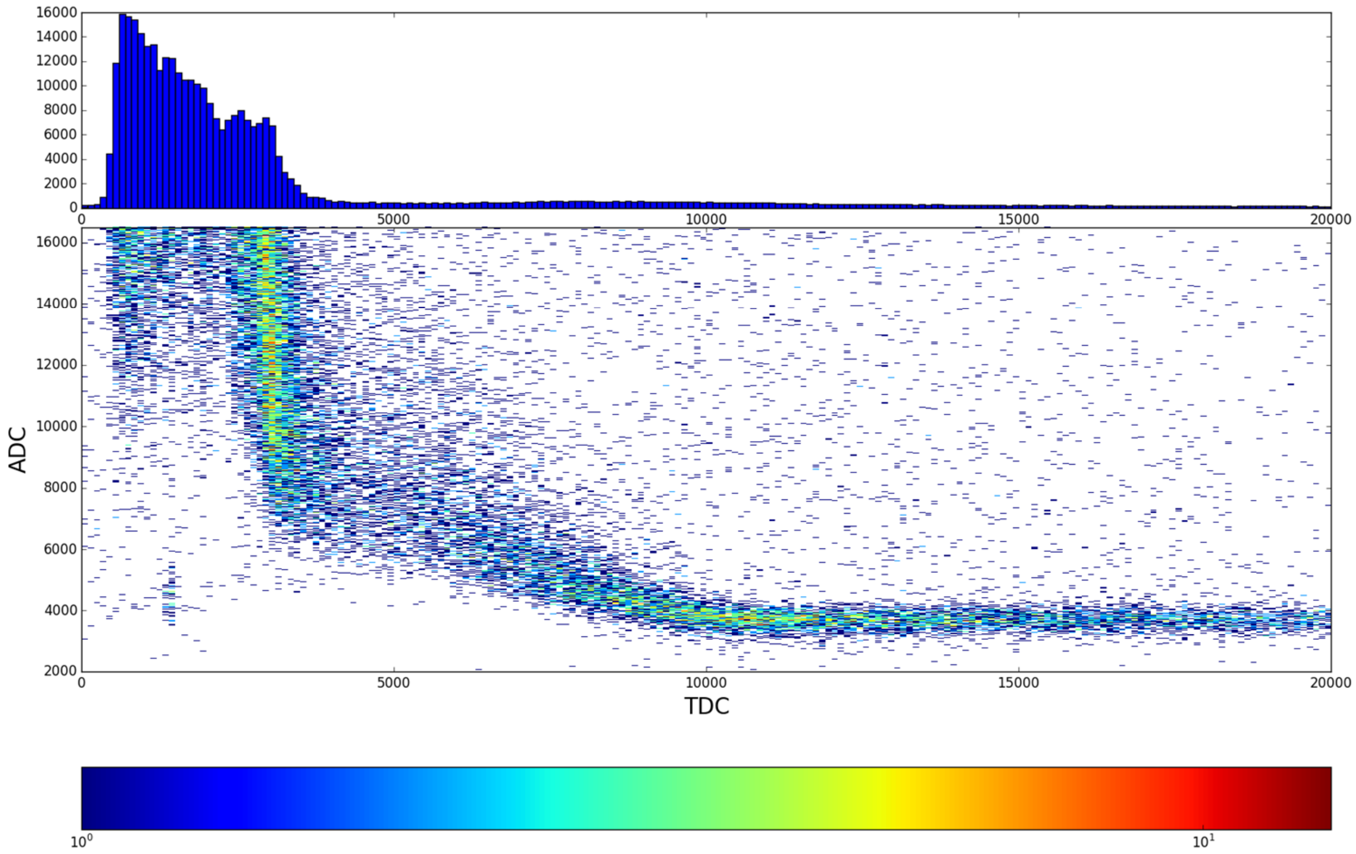
ADC vs TDC with miniBETA



Iso300mbar

Lower voltage
Low threshold

ADC vs TDC with miniBETA



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Higher voltage
Low threshold

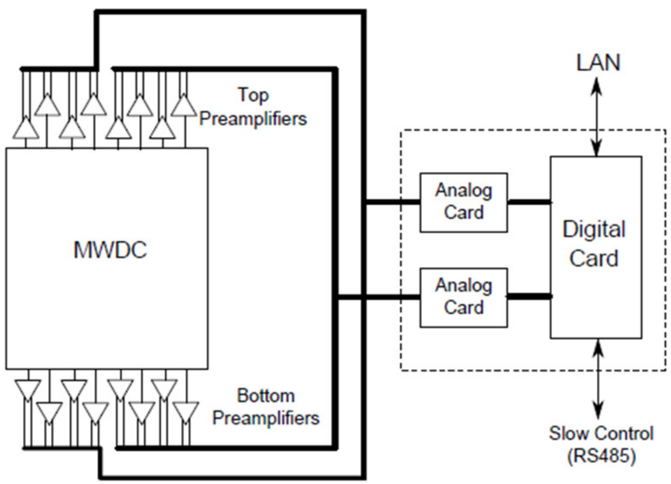


Fig. 1: Schematic of the data acquisition architecture.

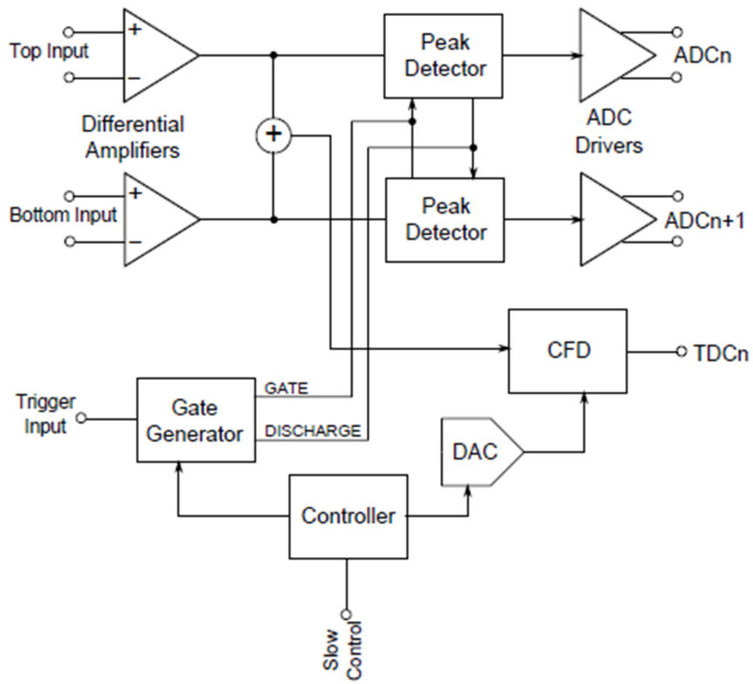
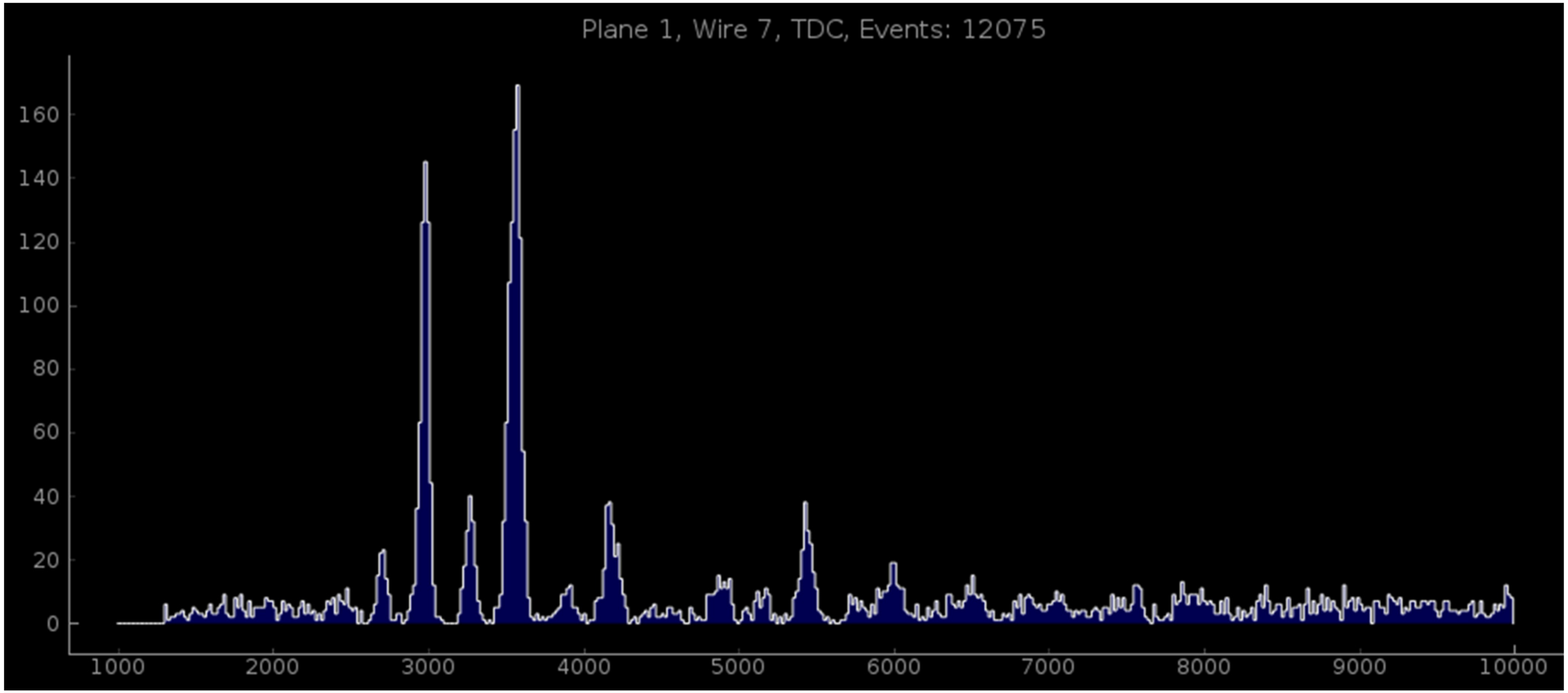


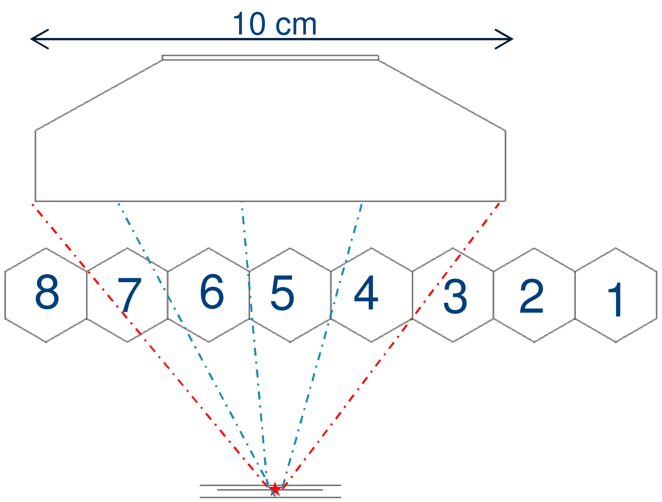
Fig. 4: Block diagram of the analog board.

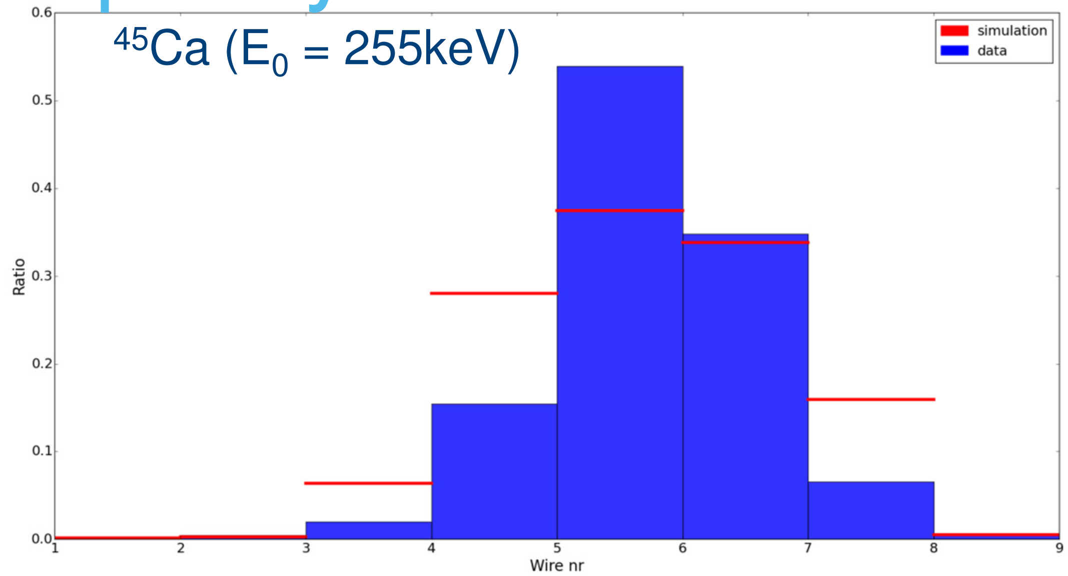
TDC structure of miniBETA “noise”



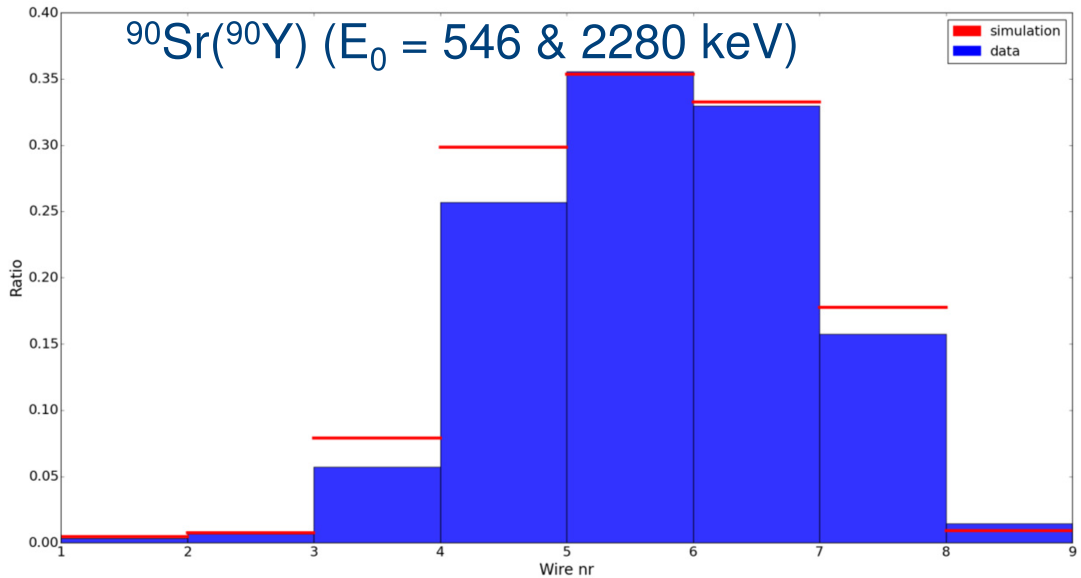
TDC

Efficiency discrepancy with simulations

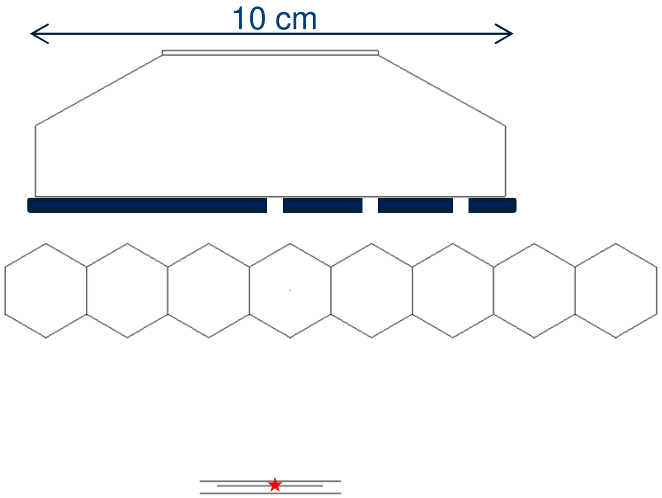




$$e_i = \frac{N_i}{N_{all}}$$



Scintillator energy and position efficiency dependency



Measuring counting rates with different masks:

- slit at center,
- 2 cm away
- 4 cm away,

At the edge only 40% (!) efficiency relative to the center for ^{45}Ca (90% for ^{90}Sr)

Electrons from ^{90}Sr produce more photons
→ higher chance of detection.

Scintillator from polyvinyltoluene with short absorption length 43mm.

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Summary:

- Maximal detection efficiency is very similar for different gas mixtures, but different V is required.
- Efficiencies for FASTER and miniBETA DAQs are converging;
  - miniBETA requires higher V, probably signal height threshold issue.
- We need to understand the miniBETA TDC behavior.
- Efficiency of our scintillators are highly energy and position dependent (for ^{45}Ca up to 60% losses at edges).

(Near) Future plans:

- Scans with multiple planes:
  - Track fitting:
    - proper efficiency
    - spatial resolution

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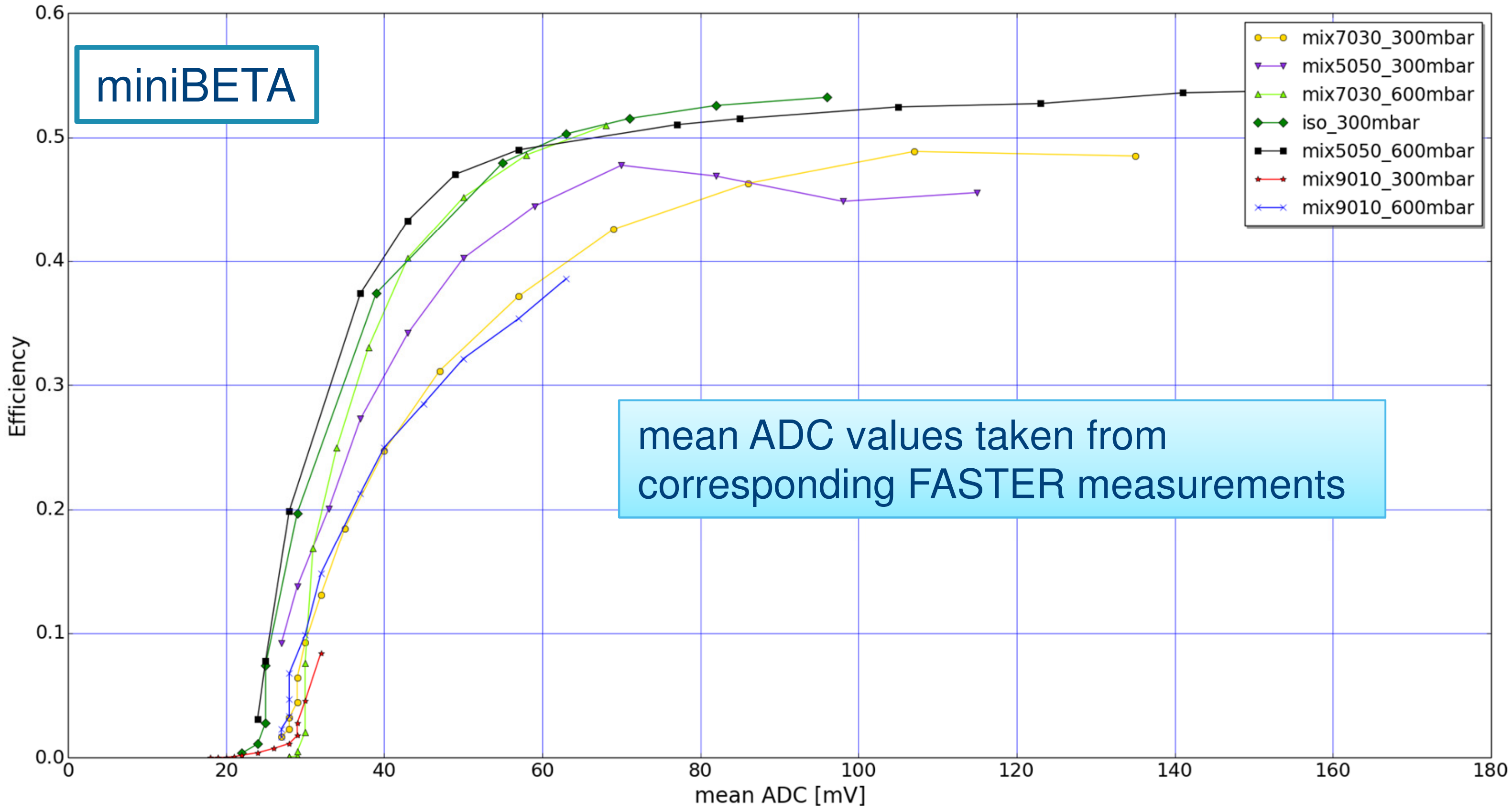
Thank you.

Efficiency as a signal height function.



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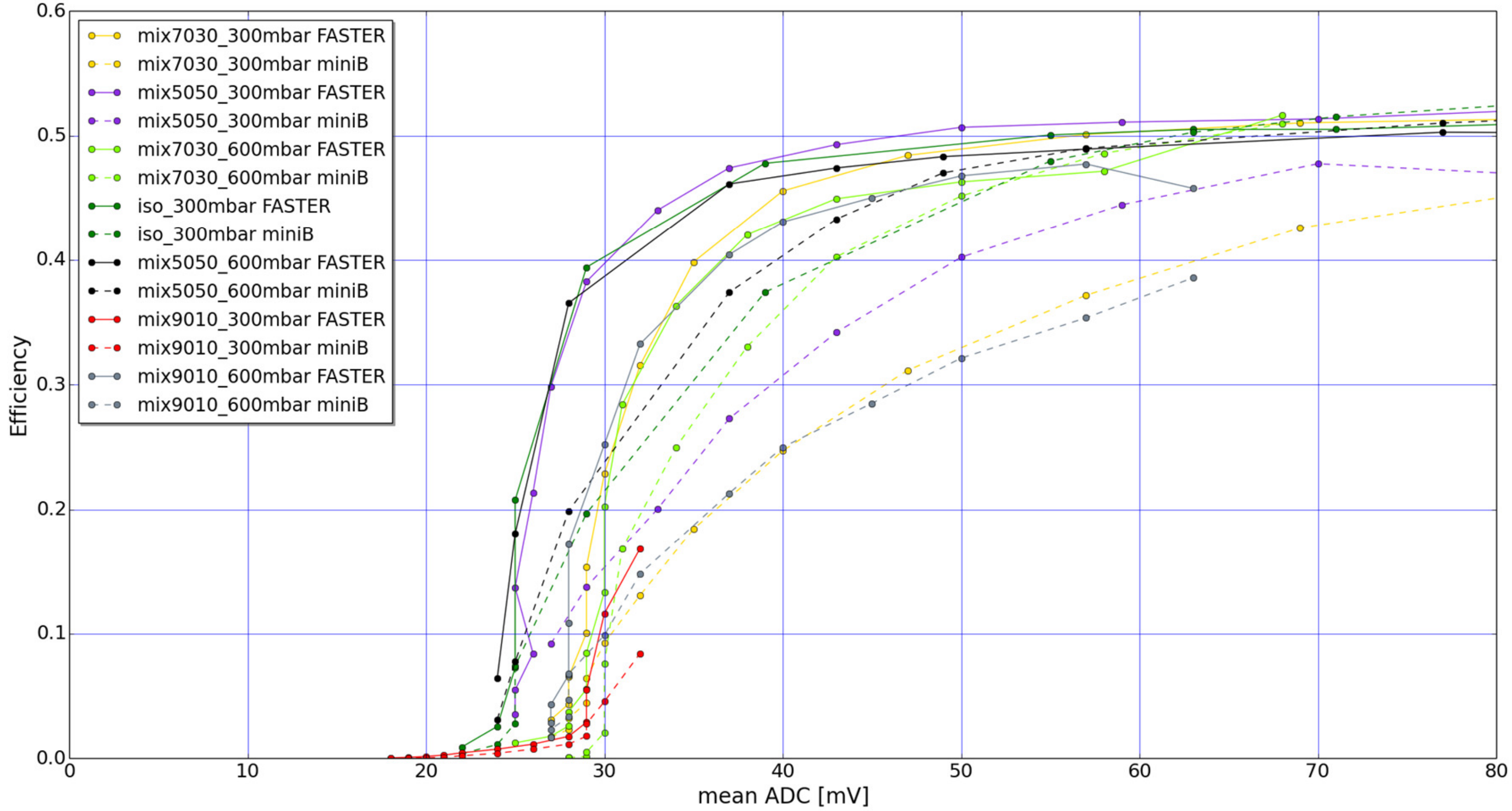

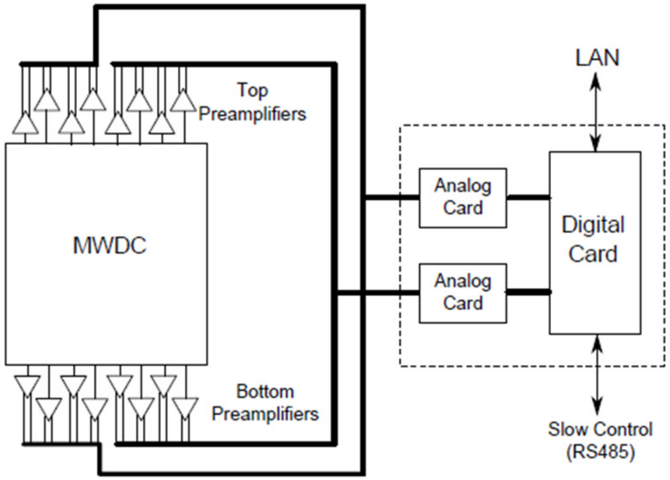

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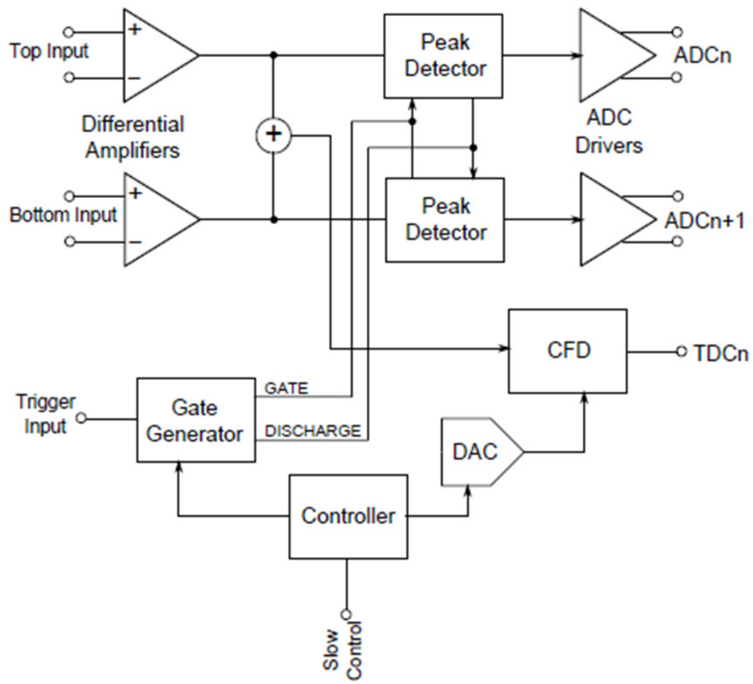
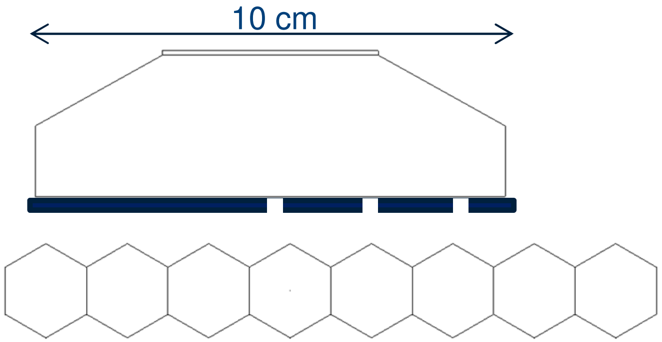


Fig. 4: Block diagram of the analog board.

Scintillator energy and position efficiency dependency



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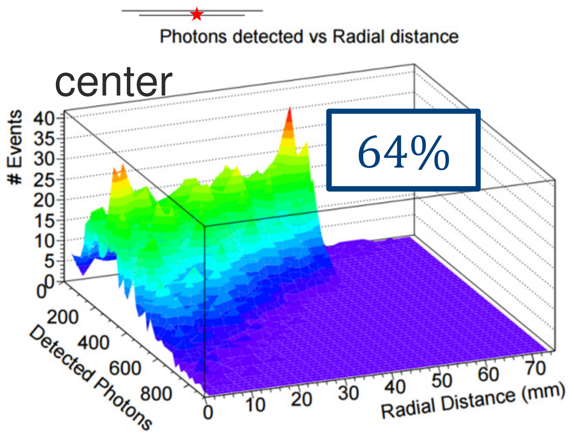
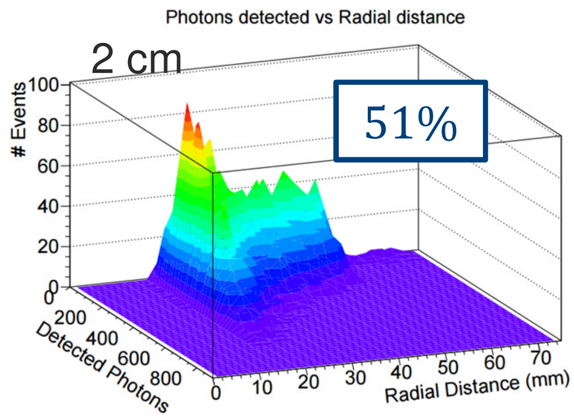
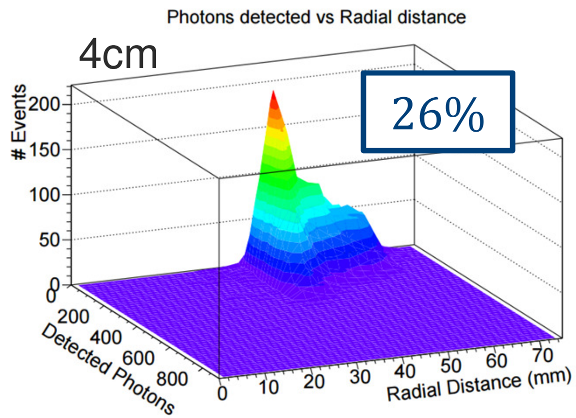
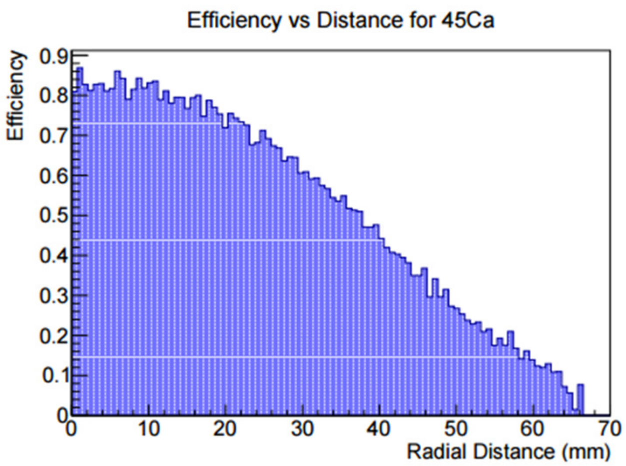
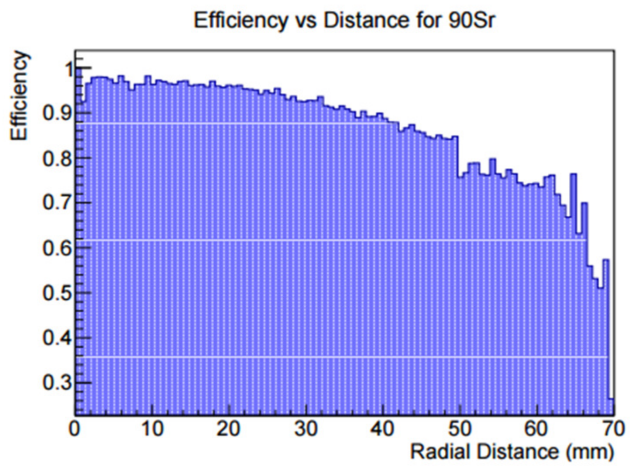


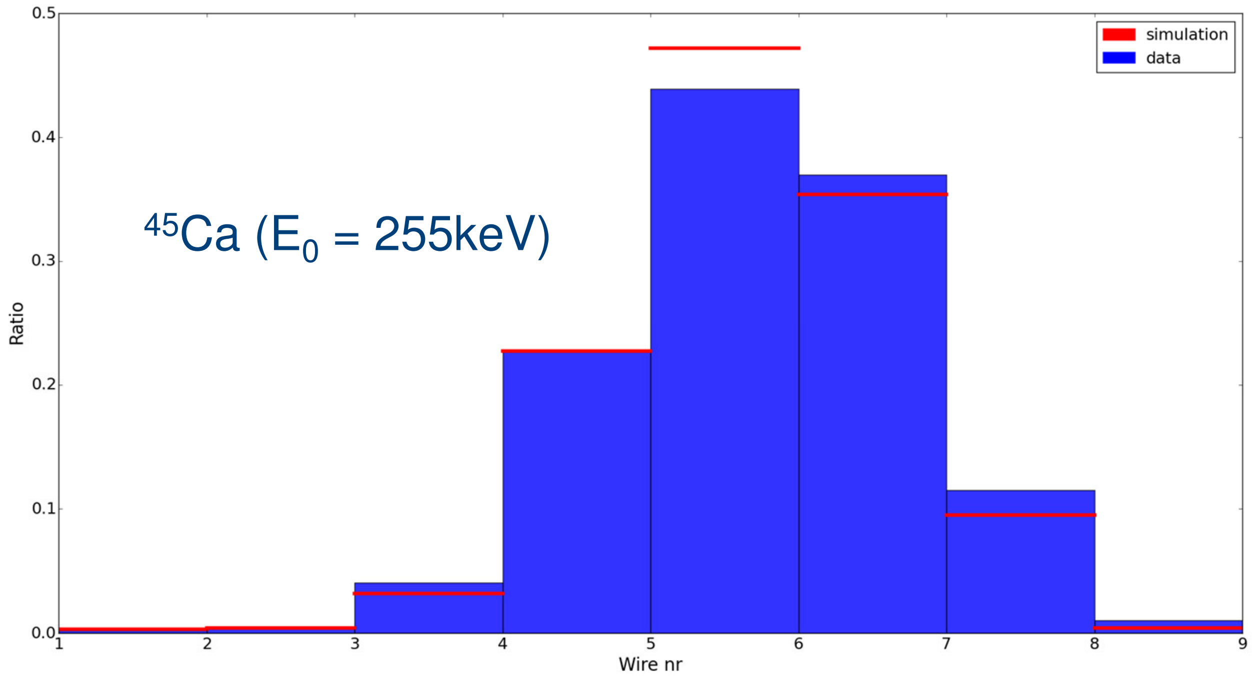




Required # photons >150: nice agreement of simulations with measurements.


Efficiency vs Distance for 45Ca
Efficiency
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
Radial Distance (mm)


Efficiency vs Distance for 90Sr
Efficiency
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0
10
20
30
40
50
60
70
Radial Distance (mm)


simulation
data
^{45}Ca (E_0 = 255keV)
Ratio
0.5
0.4
0.3
0.2
0.1
0.0
1
2
3
4
5
6
7
8
9
Wire nr