Scintillator calibration for the AMS prototype test at CERN: further results

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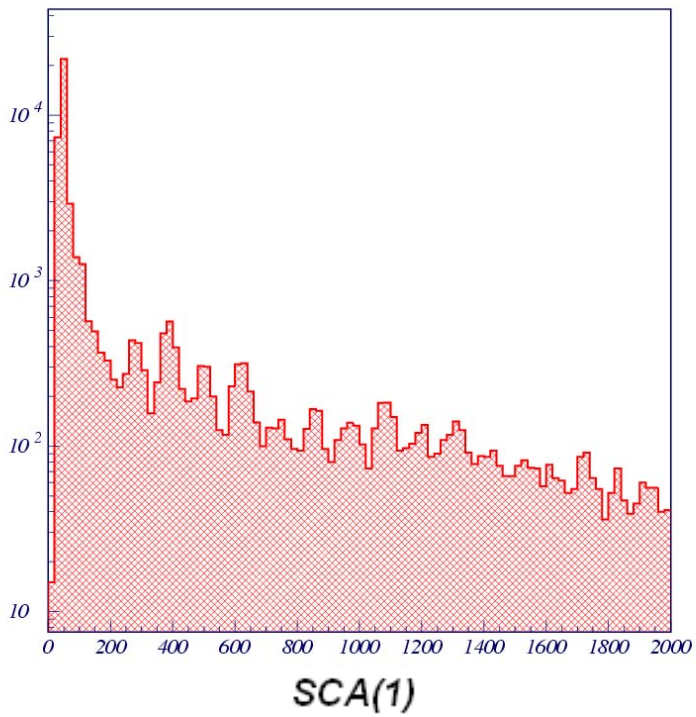
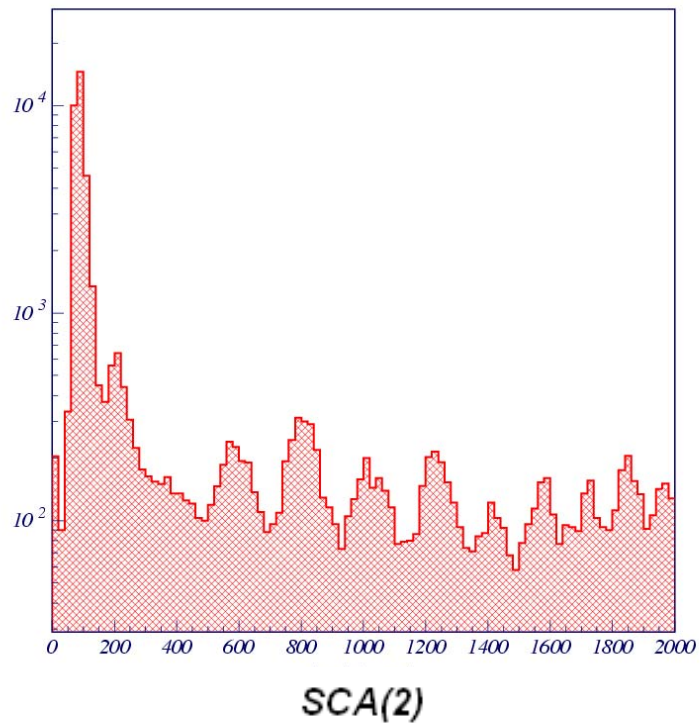
Starting data

- Data: spectra for ADC readings of scintillator anodes (or dinodes)
- Several peaks are usually visible in both scintillator spectra



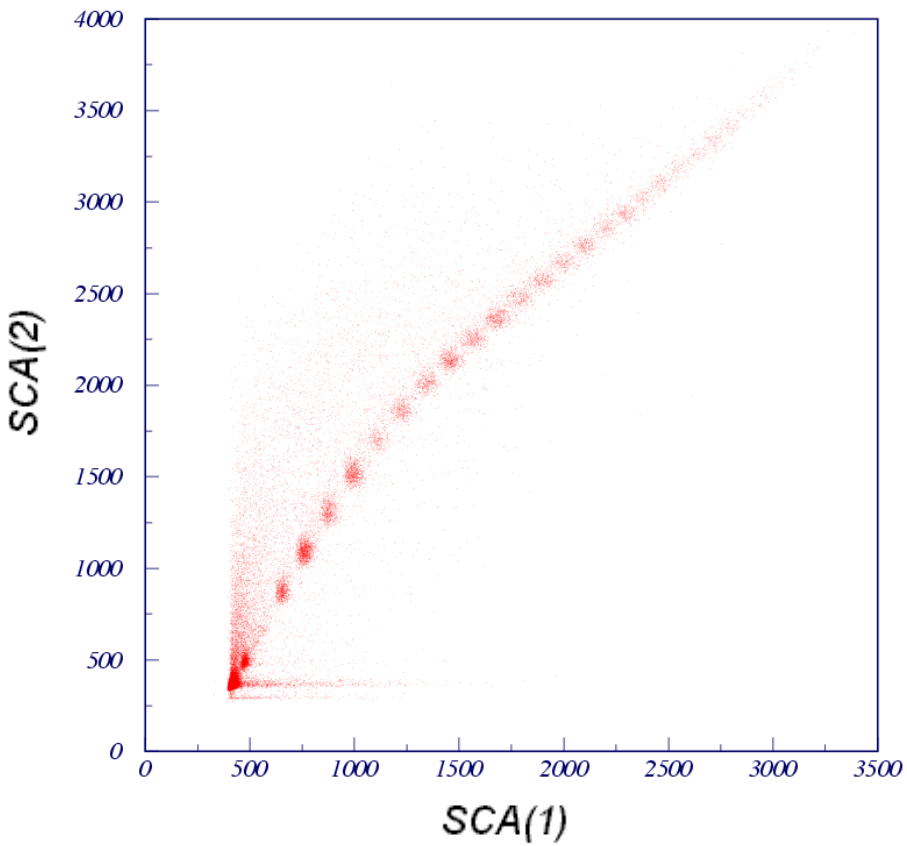


run 510

Starting data

- Good correlation (but not quite linear) between scintillators

- Visible charge separation up to Z ~ 20 (for runs with A/Z=2)



Data for run 510 (anode readings)

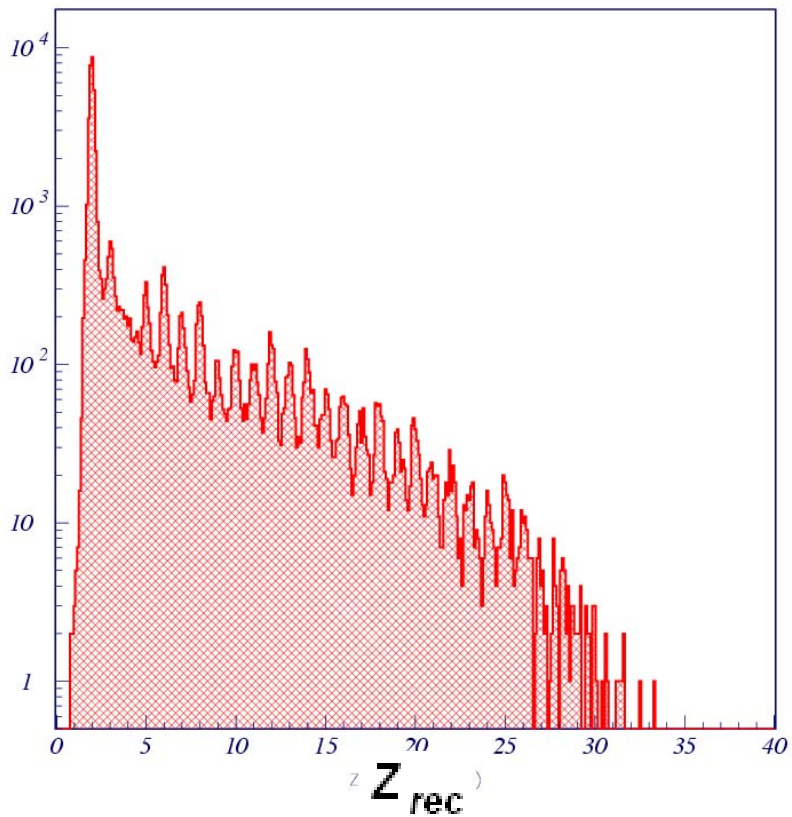
Calibration procedure

- Fits performed on 1-D distribution peaks for SCA(1) & SCA(2)
- Peak coordinates used for calibration up to $Z \sim 18$ (limit depends on run and scintillator), reconstructed charge Z_{rec} is average of Z_1 & Z_2
- No visible peaks in 1-D distributions for higher Z, linear extrapolation of calibration functions used as starting point for extension
- Distribution for ΔZ ($\equiv Z_1 - Z_2$) used for cross calibration: function for Z_2 is tuned so that ΔZ distribution always peaks at zero for any selected region of Z
- Estimates are now compatible for Z_1 & Z_2

Calibration procedure

- Further peaks become visible in Z_{rec} spectrum, but may move away from integer values as Z increases

- Peak positions used to correct values on calibration functions, so that peaks move to integer values of Z

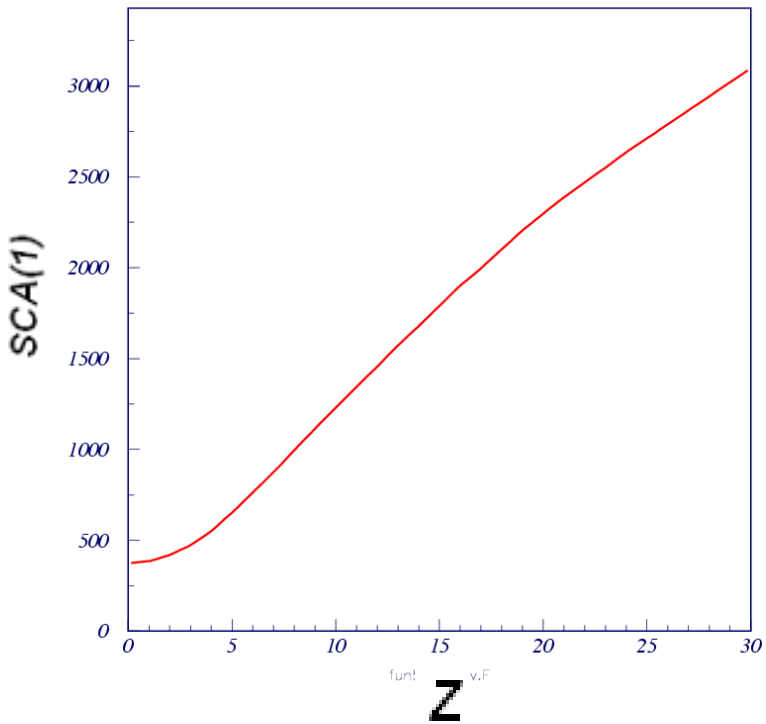


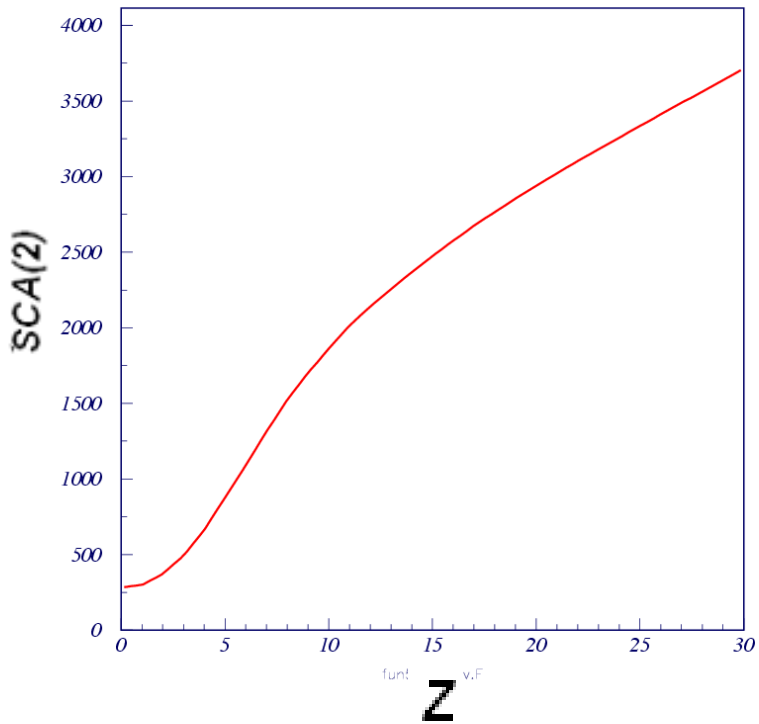
Z_{rec} spectrum

run 510

Calibration results

- An example of final calibration functions for SCA(1) and SCA(2):





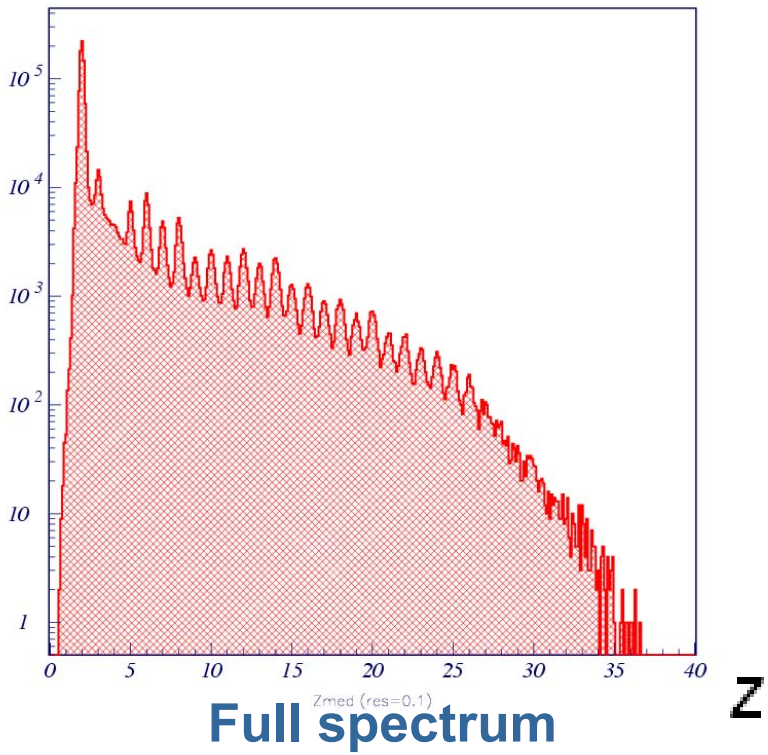
run 510

Calibration for A/Z=2

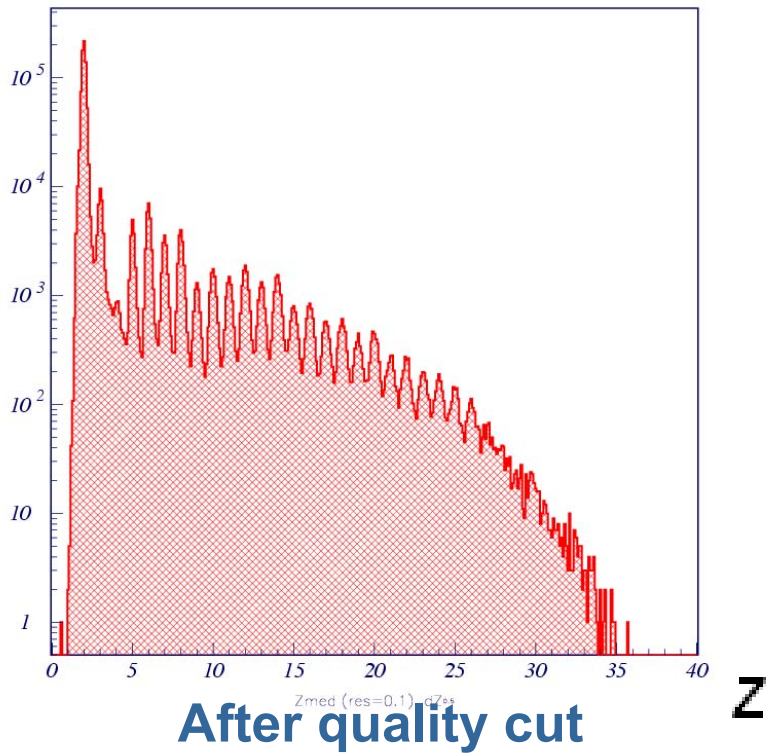
- Scintillator calibration was made for 27 runs with A/Z=2:
  - 506, 510-511, 513-520, 525-527, 529-533, 538-540, 542-546
- Calibration data for a given run cannot be used in following runs if accuracy is needed: changes are small but still significant
- Change in Z_{rec} between consecutive runs for the same scintillator reading is usually in the 0.1 – 1 range
- Calibration made from scratch for runs 510 and 538
- Calibration data from runs 510 and 538 used as starting point for fine calibration of remaining runs:
  - 510 for another 18 runs (506-533)
  - 538 for another 7 runs (539-546)
- Total of 1.70×10^6 events processed

Calibration results: A/Z=2

- Full spectrum for Z_{rec} (all events): very good peaks up to Z = 26
- Spectrum after quality cut (Z_1 & Z_2 compatible, i. e., $|\Delta Z| < 0.5$): 78% of events kept



Full spectrum

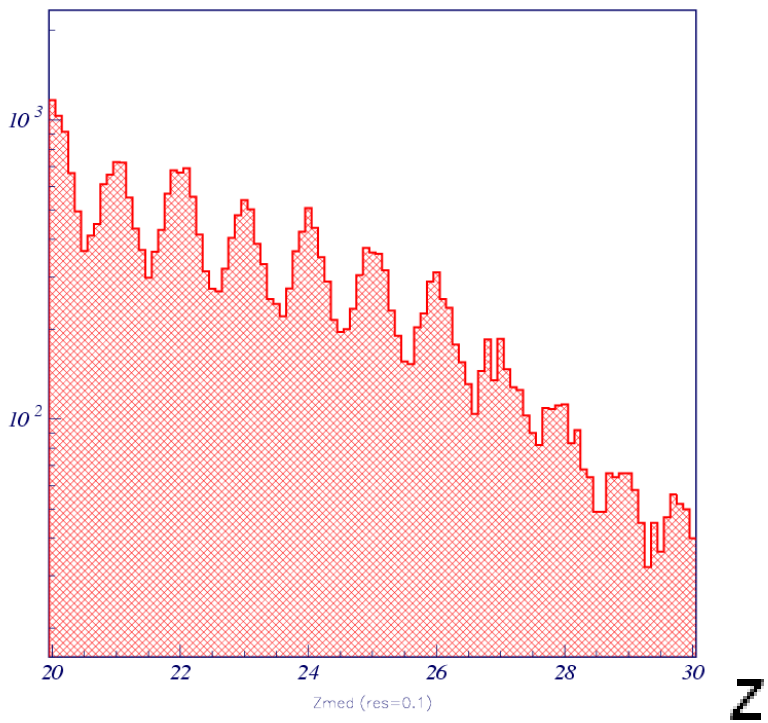


After quality cut

27 runs

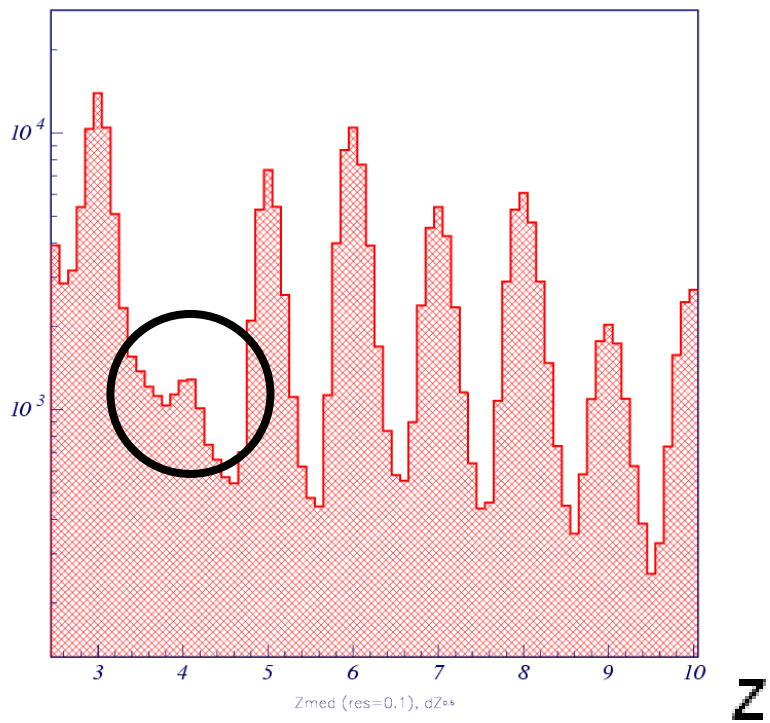
Calibration results: A/Z=2

- Full spectrum tail: peaks seen up to Z = 30
- Beryllium peak clearly visible after quality cut



Full spectrum (Z=20-30)

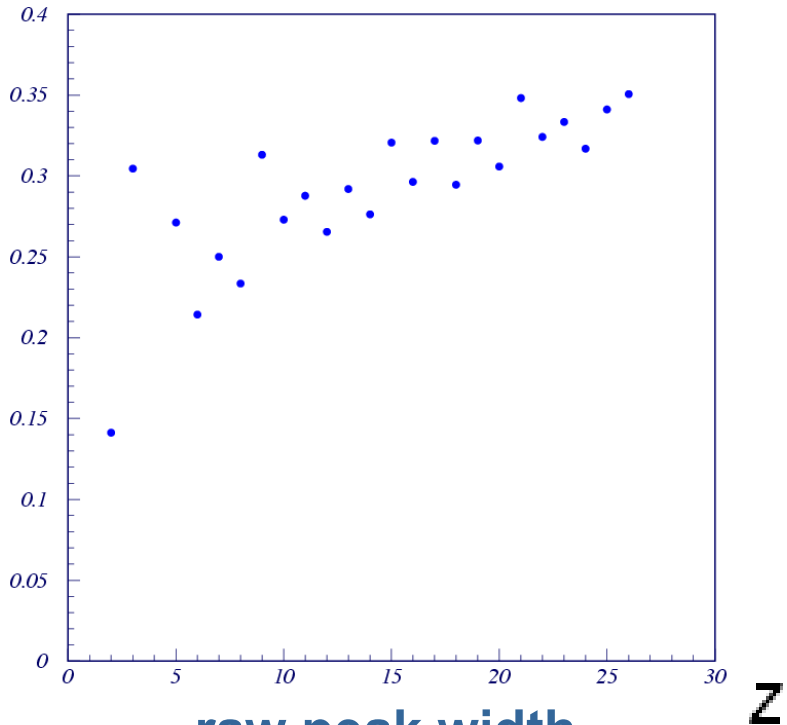
27 runs



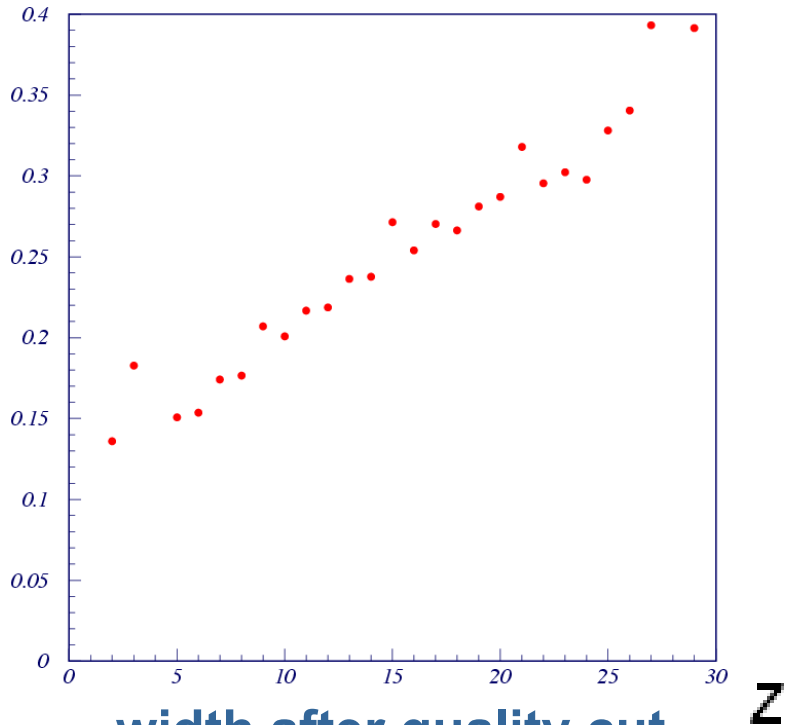
Beryllium peak

Calibration results: A/Z=2

- Gaussian fit performed over peaks in Z ± 0.4 region
- Raw peaks: width shows some increase with Z, but correlation is not very clear
- After quality cut: clear correlation between Z and peak width



raw peak width



width after quality cut

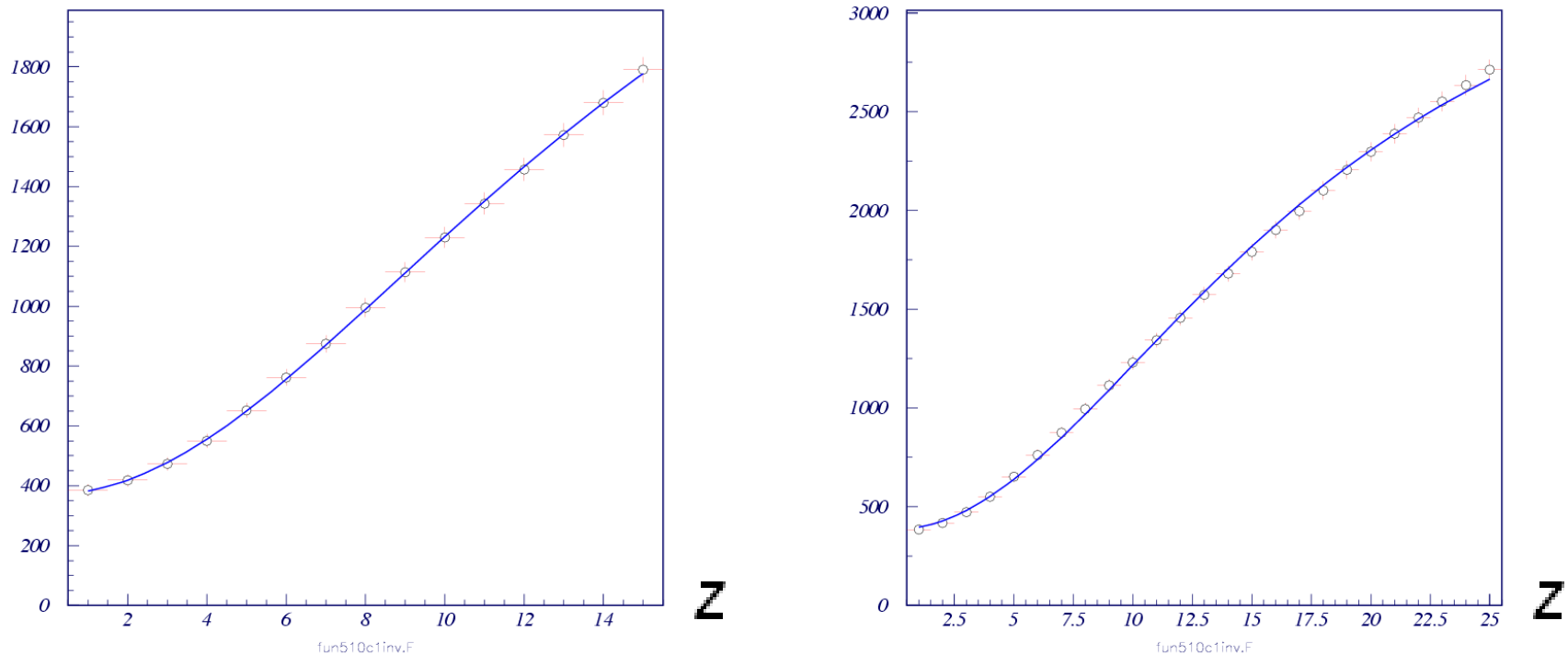
27 runs

Data fitting: Birks' law

- Three parameters including pedestal:

$$f(Z) = a + bZ^2/(1+cZ^2)$$

- Very good agreement for Z between 0 and 15, some problems if region up to Z=25 is included



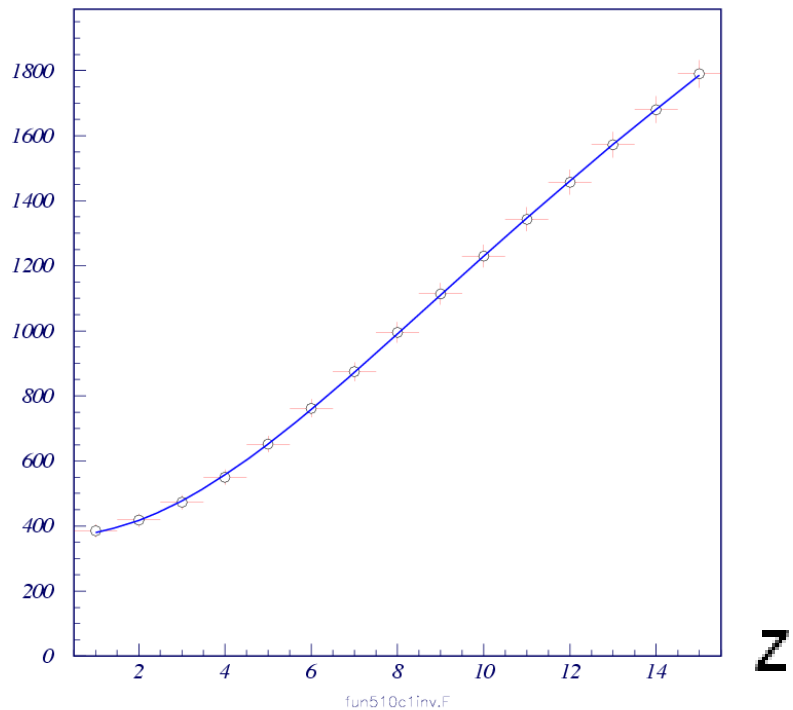
run 510, SCA(1)

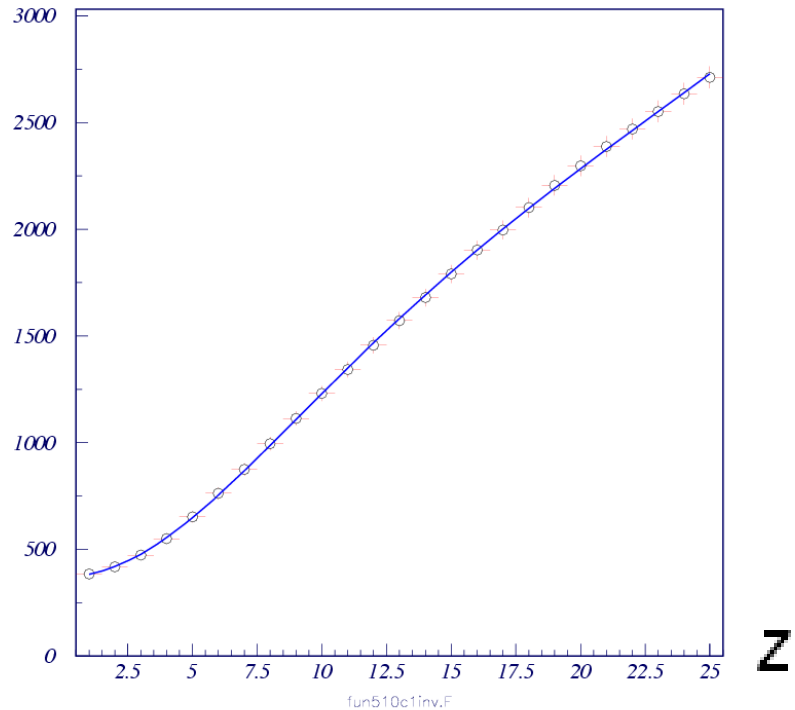
Data fitting: Birks' law, extended

- Four parameters including pedestal:

$$f(Z) = a + bZ^2/(1+cZ^2+dZ^4)$$

- Agreement with data is clearly improved for fits including higher Z





run 510, SCA(1)

Limits to data fitting

- Problem with extended Birks' law: parameter d is usually negative for $f(Z) = a + bZ^2/(1+cZ^2+dZ^4)$

- $\Rightarrow$ as Z increases, decreasing inverse fraction $(1+cZ^2+dZ^4)/bZ^2$ reaches a saddle point

$$Z_{saddle} = (-3/d)^{1/4}$$

and growth of f starts to accelerate

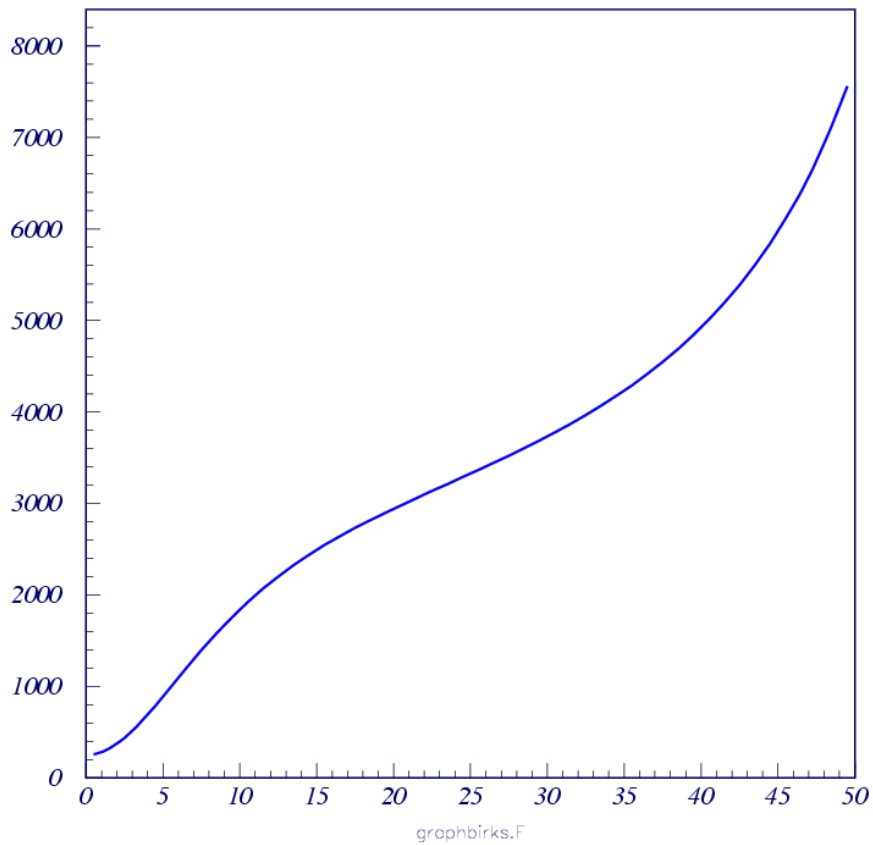
- $\Rightarrow$ further increase in Z brings $1+cZ^2+dZ^4$ to zero: function f reaches a singularity point

$$Z_{sing} = \{[c+(c^2-4d)^{1/2}]/(-2d)\}^{1/2}$$

Limits to data fitting

- For most fits performed on A/Z=2 runs,
  - Z_{saddle} ~ 30-40
  - Z_{sing} ~ 50-70

- **Extended Birks' law is not reliable for very high Z!**

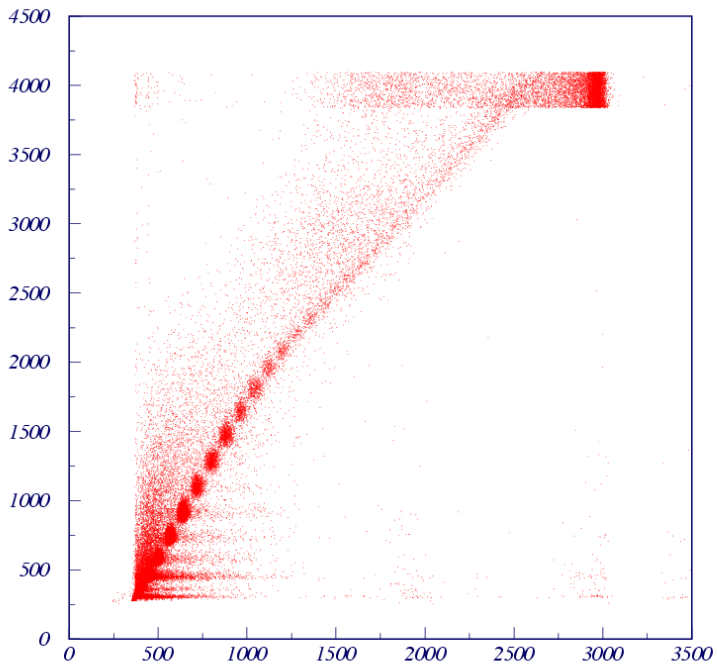


Run 510, fit for Z = 0-25:

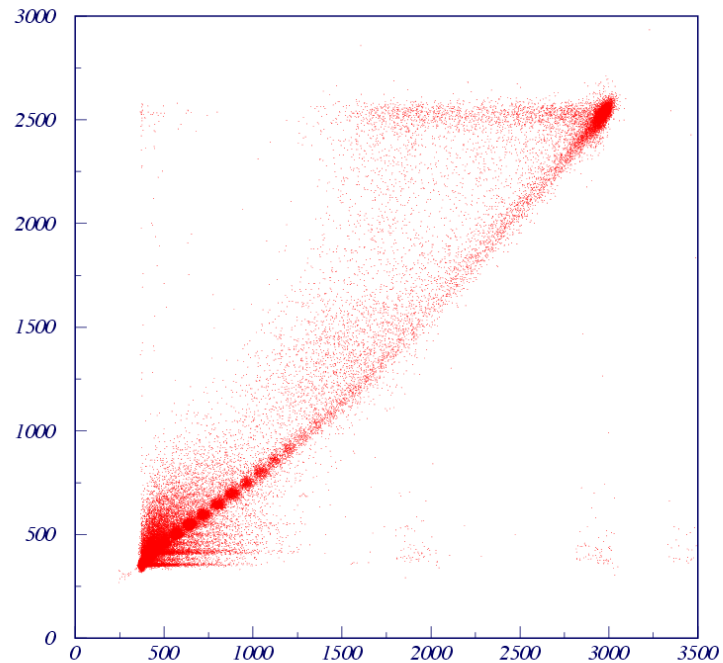
Z_{saddle} = 38.3 Z_{sing} = 58.6

Calibration for indium runs

- Same procedure was used, saturation seen on SCA(2), SCD(2) must be used for high Z
- 2-D plots show high number of bad events (no correlation)



SCA(1) vs. SCA(2)

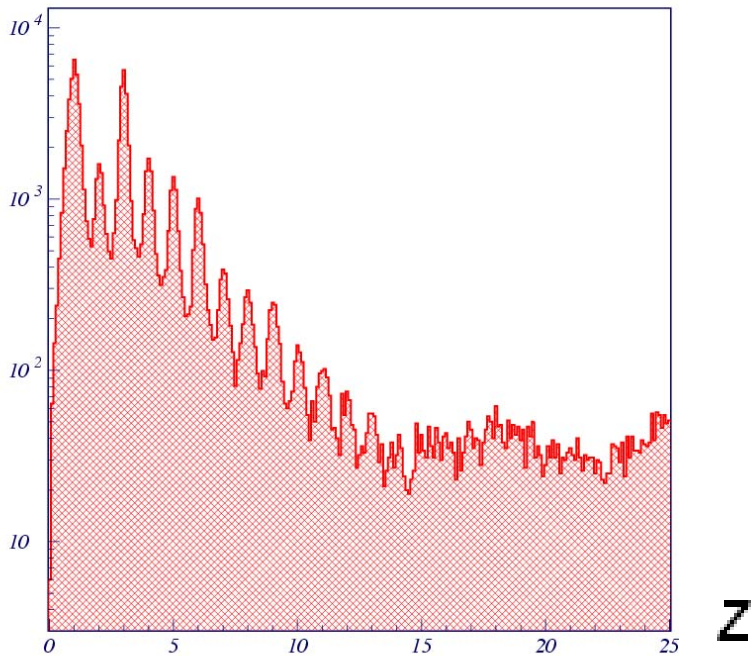


SCA(1) vs. SCD(2)

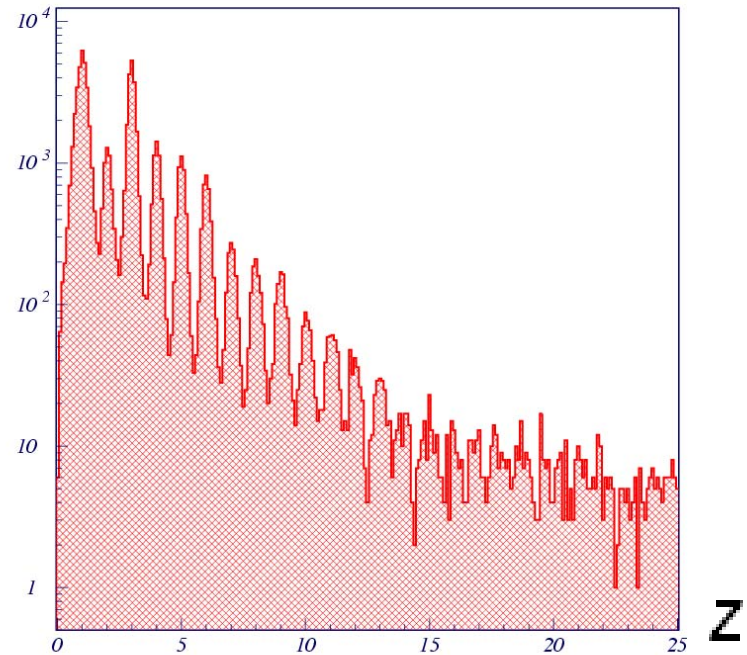
run 639

Calibration for indium runs

- Run 639 was chosen (higher statistics for low Z)
- For low Z, SCA(2) can still be used, peaks up to Z ~ 14 (full spectrum), Z ~ 20 (after quality cut)



Full spectrum

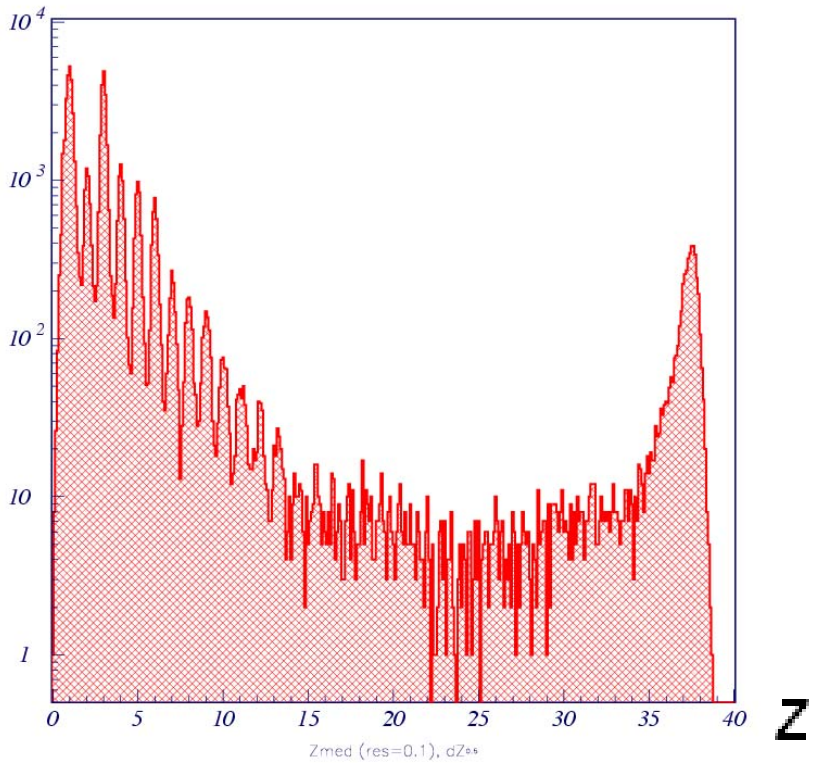


After quality cut

run 639, SCA(2) used

Calibration for indium runs

- Full spectrum based on low Z calibration using SCD(2) shows clear peak at very high Z (indium)
- Number of good events at intermediate Z is too small to have a complete calibration up to this peak
- Z for indium could not be determined by this calibration procedure (peak counting cannot be used)



Spectrum after quality cut

run 639, SCD(2) used

Conclusions

- Scintillator calibration must be performed for each run individually
- 27 runs with A/Z=2 were analyzed, with a total of more than 10^6 events, combined data show peaks up to Z=30, peak width increases with Z
- Birks' law gives a good description of scintillator response up to Z=15, extended law may be used for higher Z but is not reliable beyond Z=30
- Bad events and low statistics at intermediate Z pose a problem in indium runs, peaks still seen up to Z=20, clear indium peak seen but its Z could not be determined using this procedure