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

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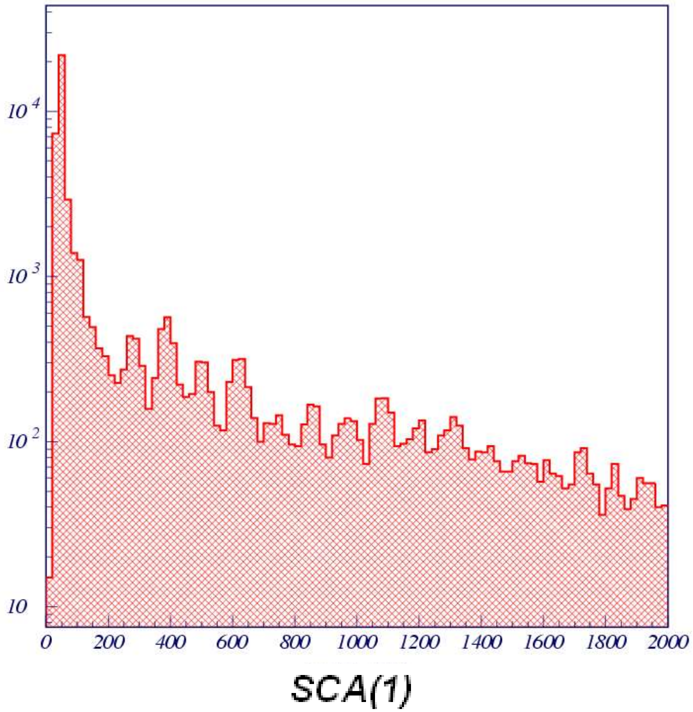
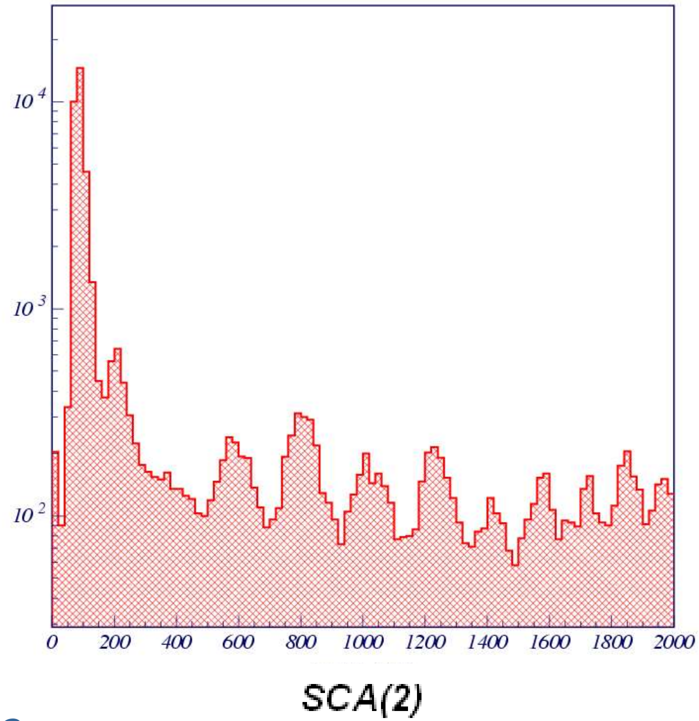
AMS RICH meeting, Grenoble, 8-9 June 2004

Starting data

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





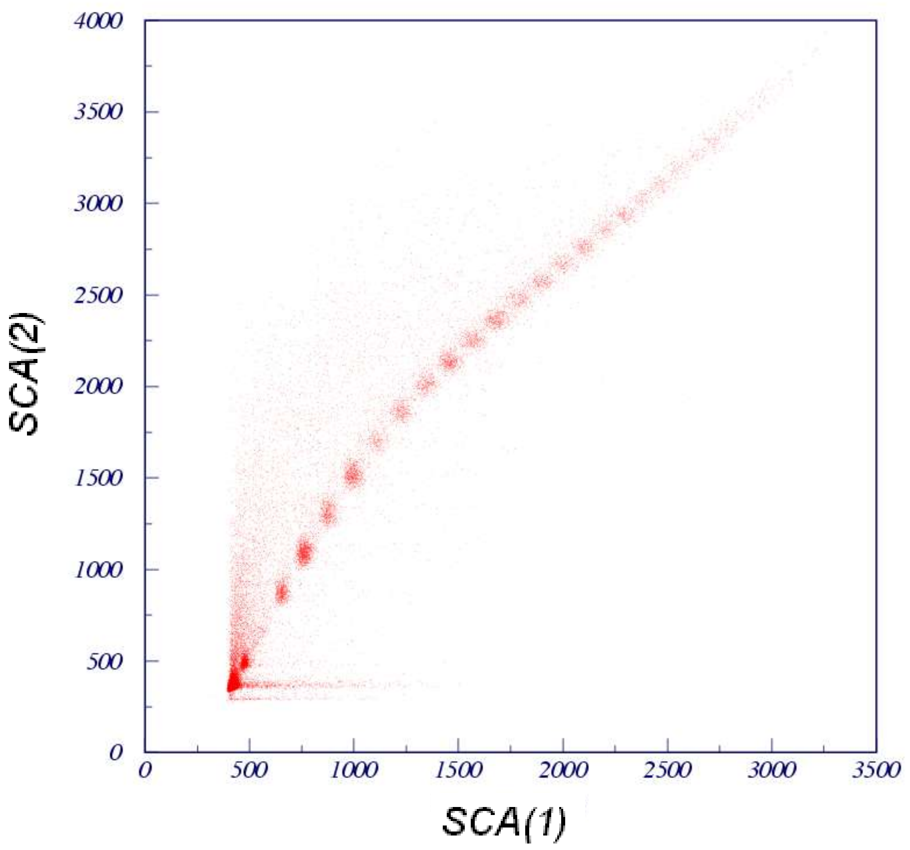
run 510

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)



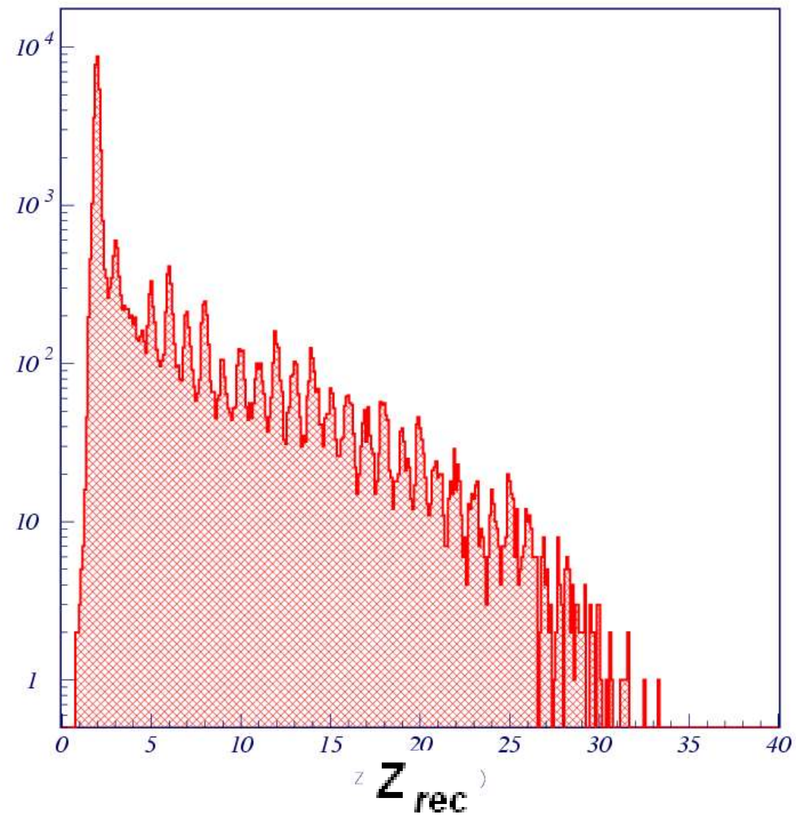
Calibration procedure

- 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

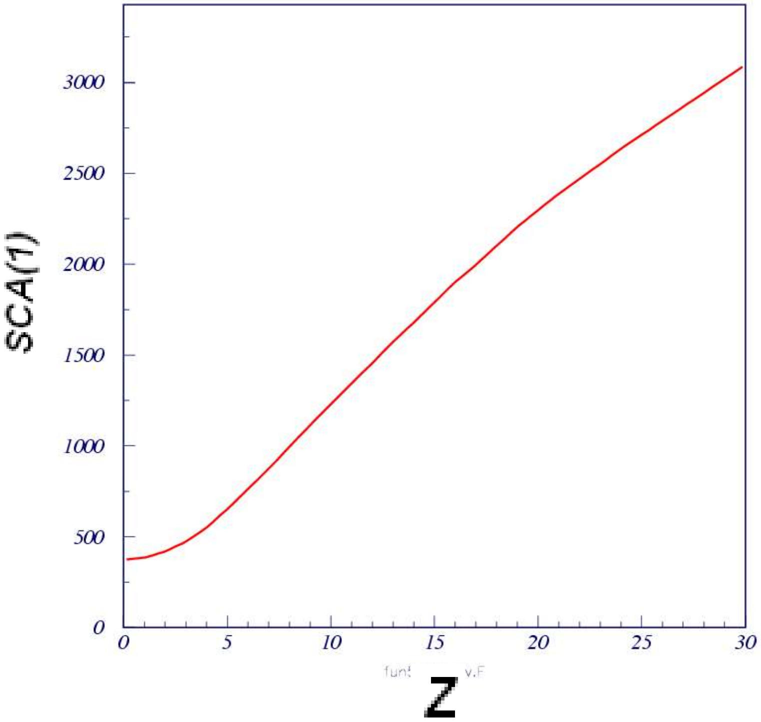


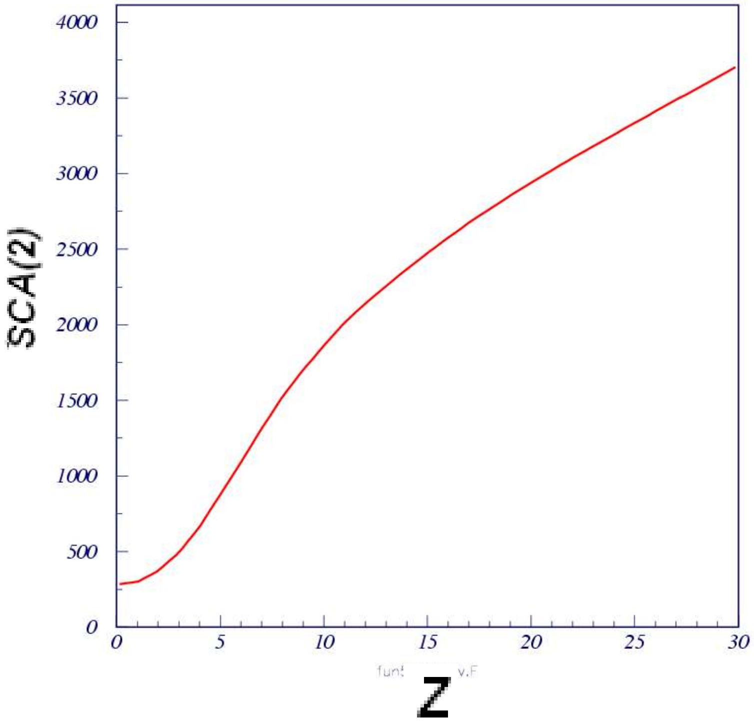
Z_{rec} spectrum

run 510

Calibration results

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





run 510

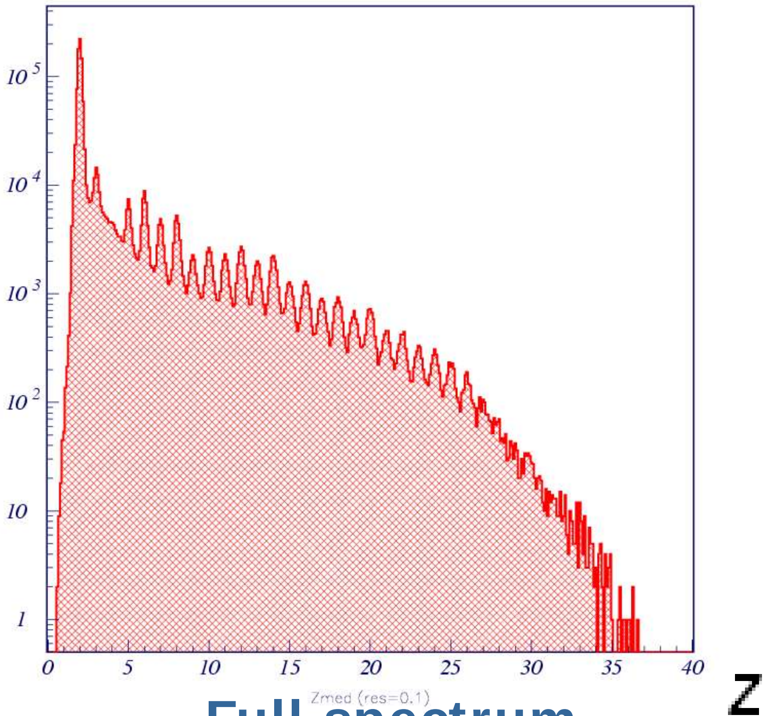
Calibration for A/Z=2

- 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

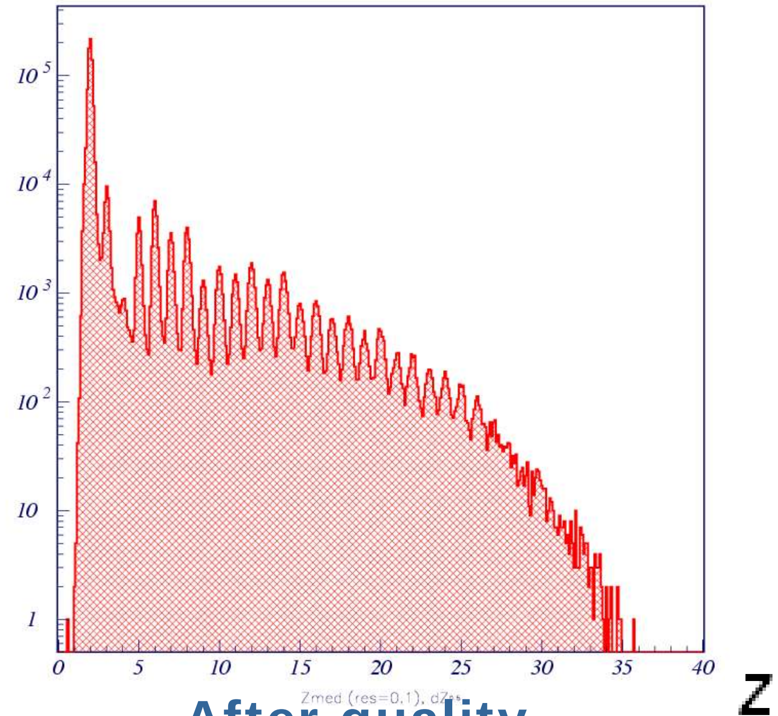
Calibration results: A/Z=2

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



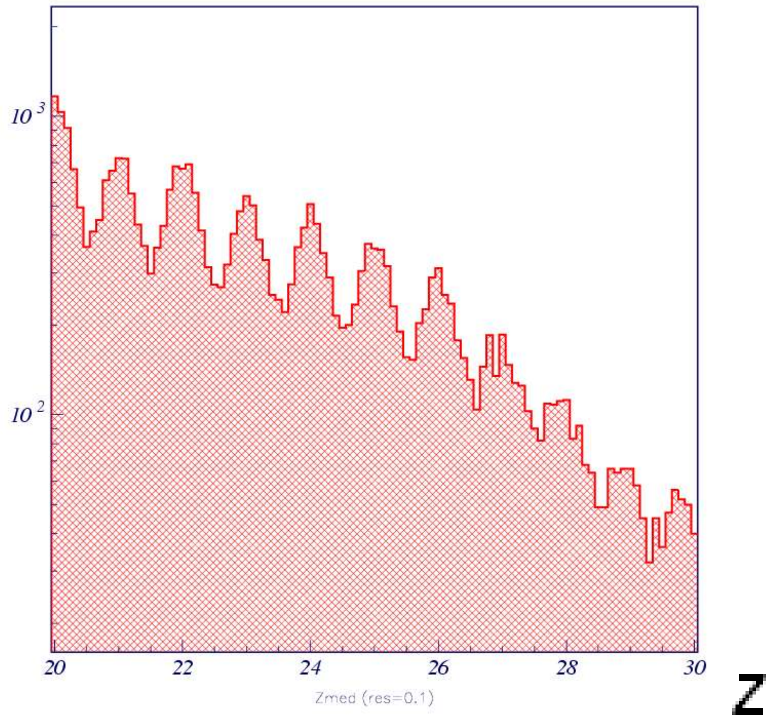
After quality cut

27 runs

Calibration results: A/Z=2

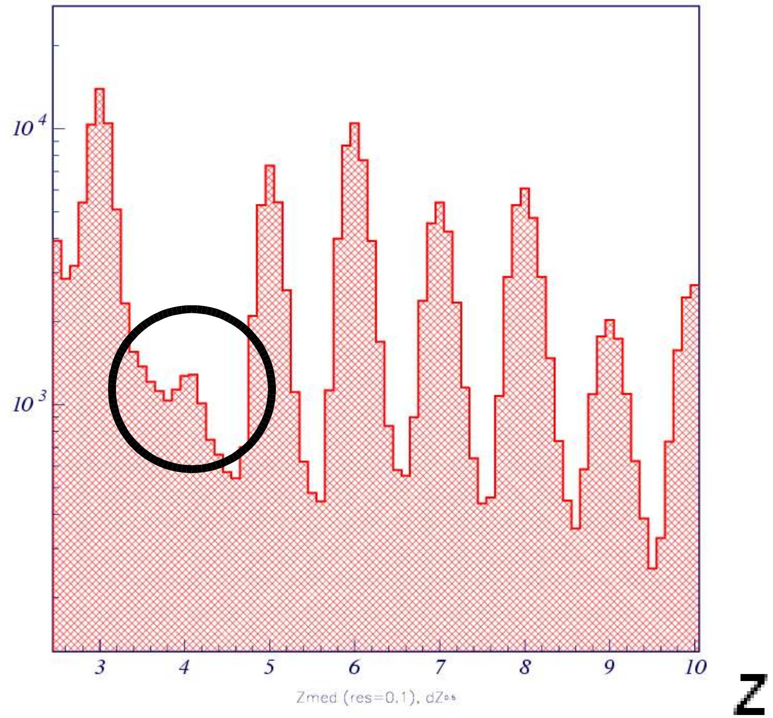
Full spectrum tail: peaks seen up to Z = 30

Beryllium peak clearly visible after quality cut



Full spectrum (Z=20-30)

27 runs



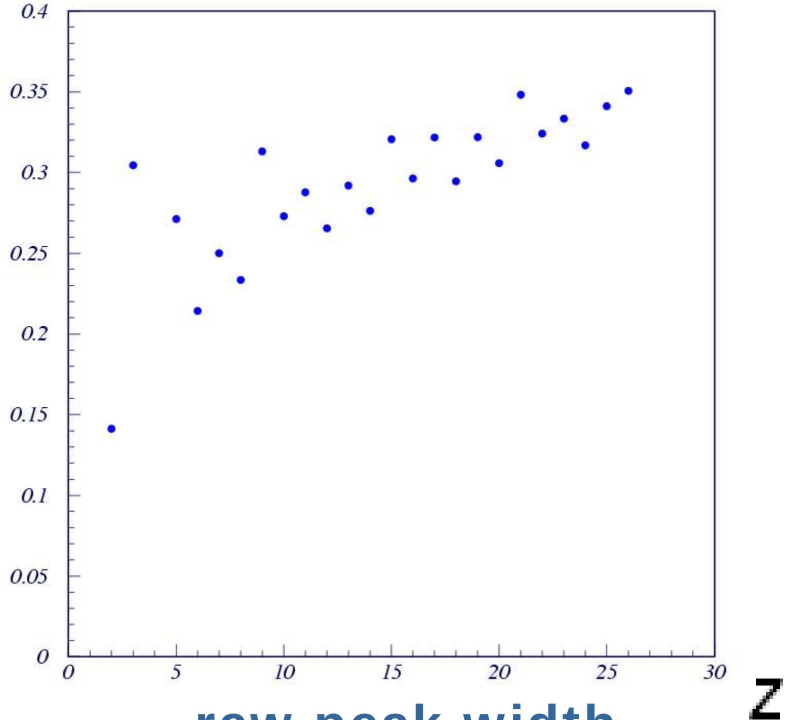
Beryllium peak

Calibration results: A/Z=2

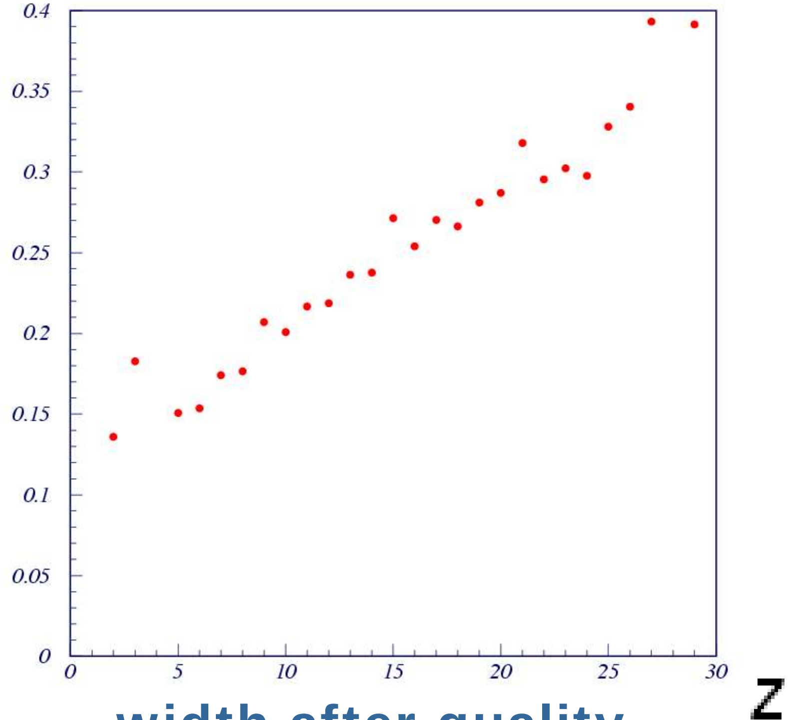
Gaussian fit performed over peaks in Z ±0.4 region

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

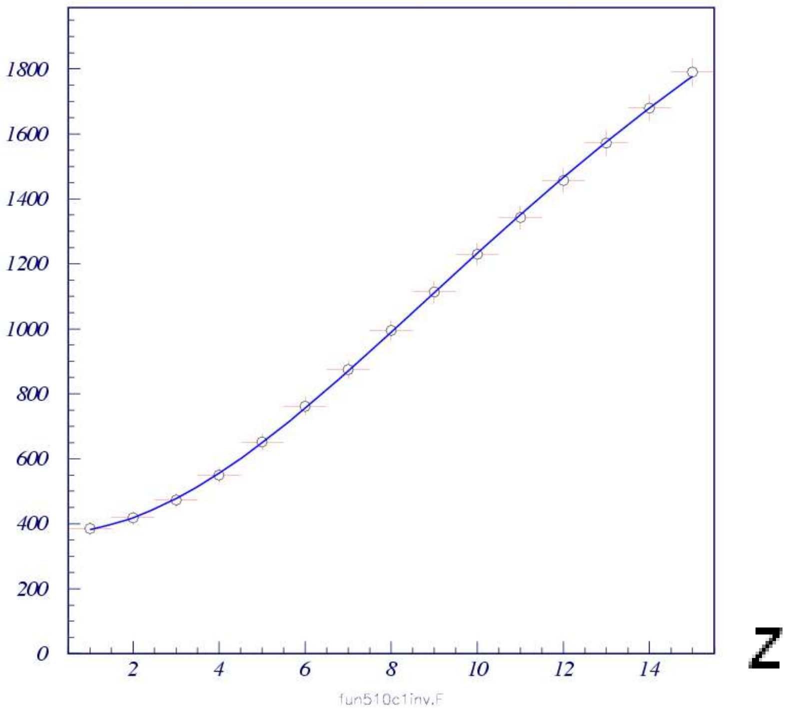
27 runs

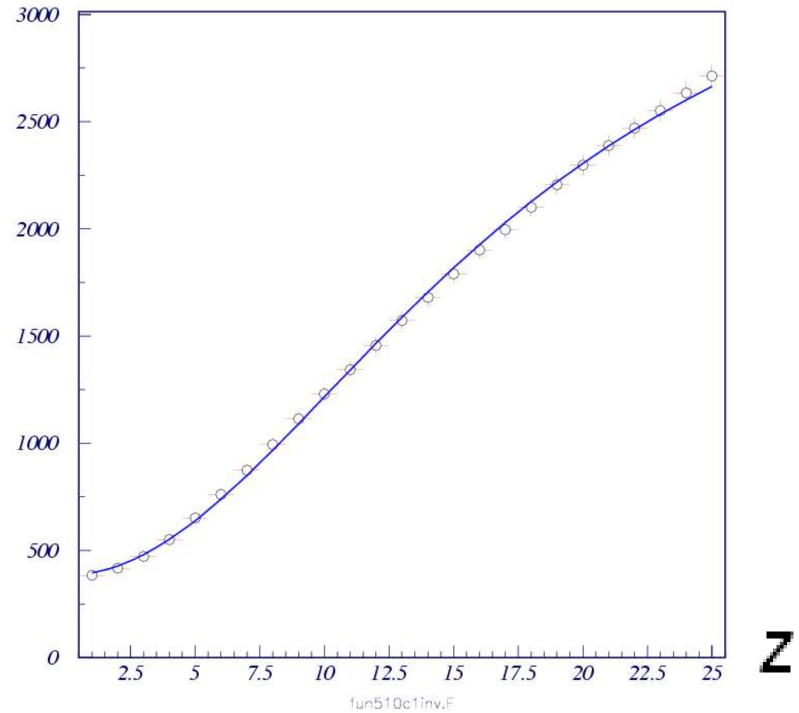
Data fitting: Birks' law

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





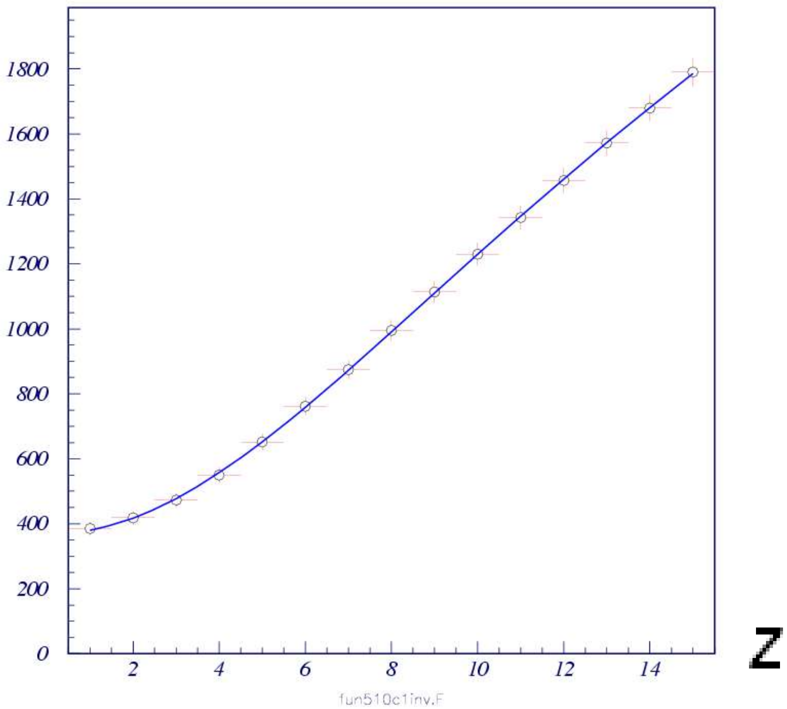
run 510, SCA(1)

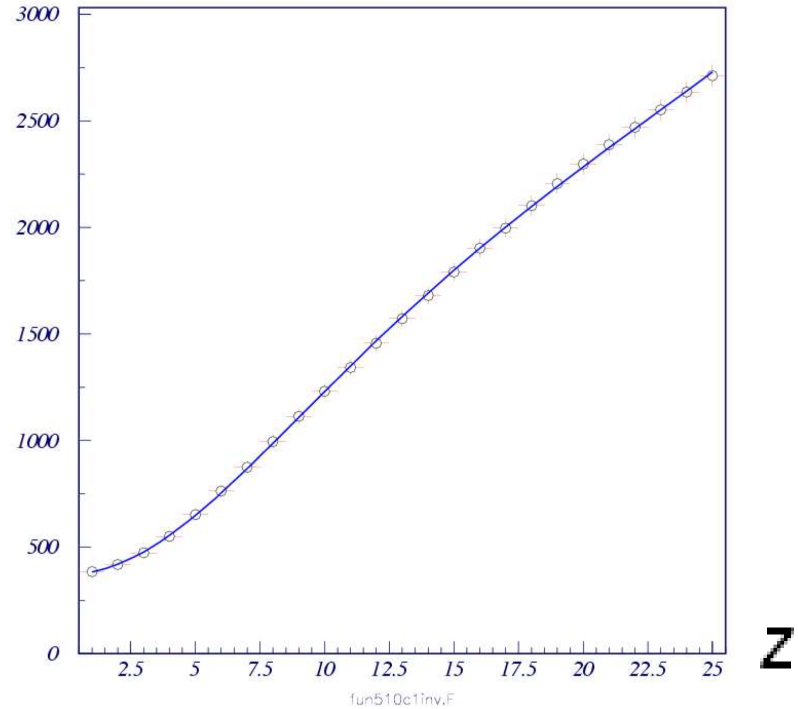
Data fitting: Birks' law, extended

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

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

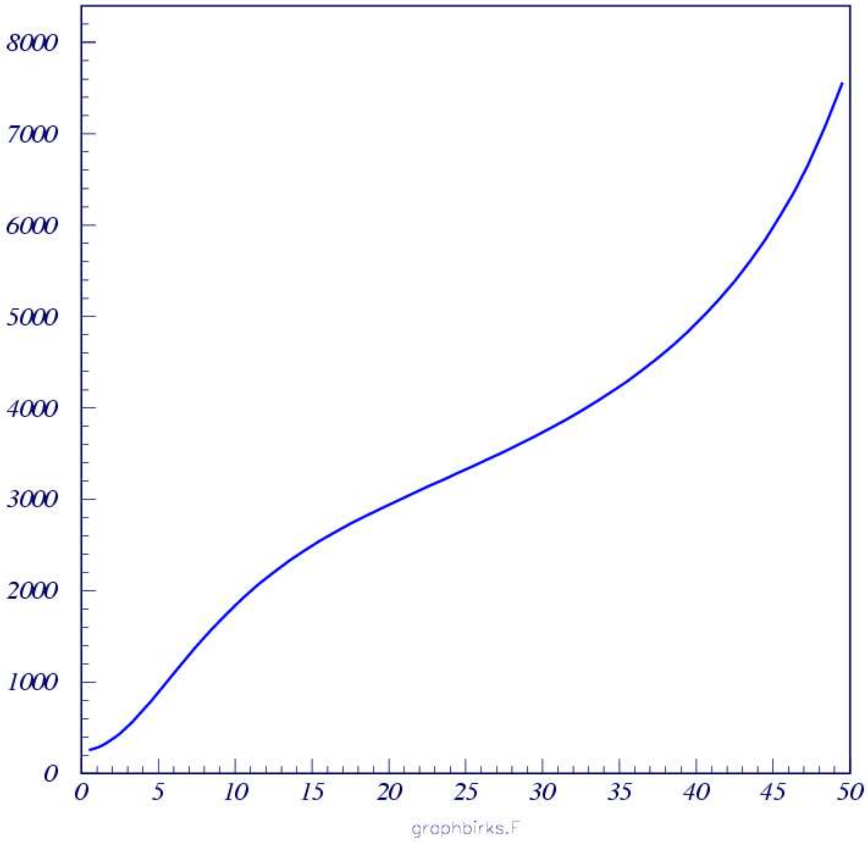
Limits to data fitting

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!

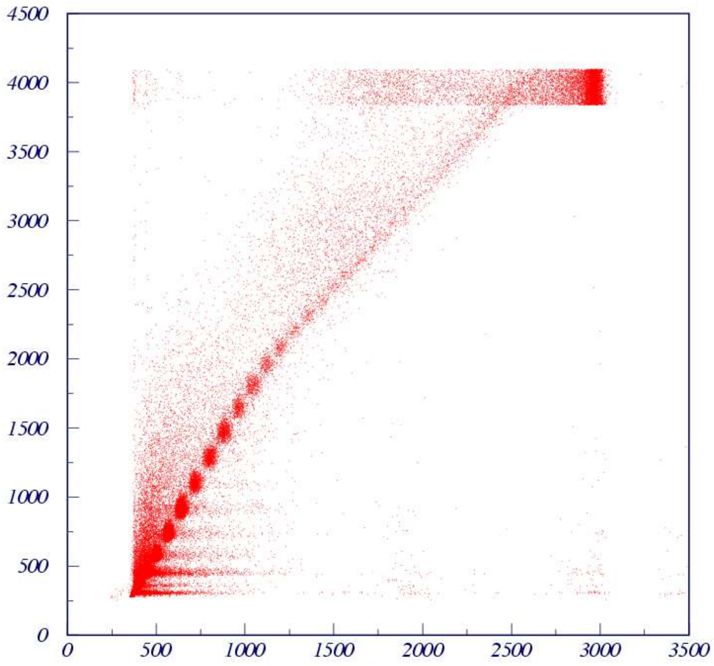


Run 510, fit for Z = 0-25:

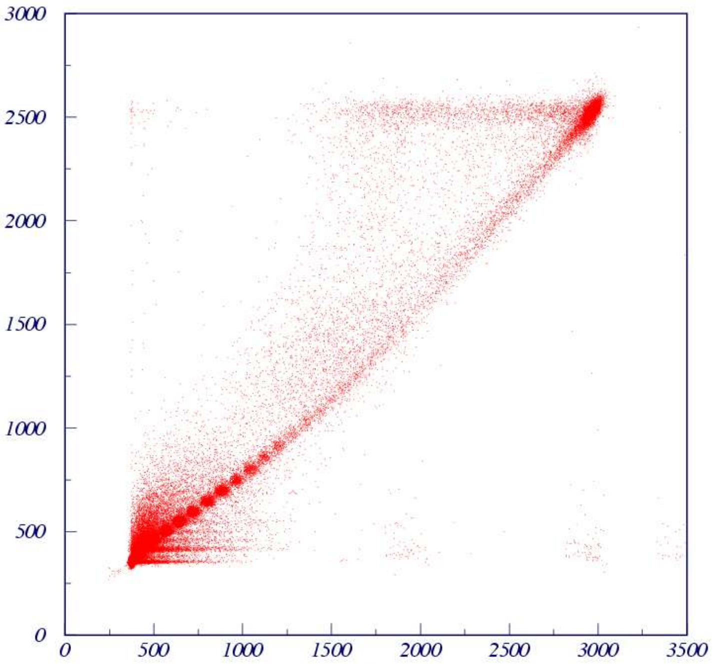
Z_{saddle} = 38.3 Z_{sing} = 58.6

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)



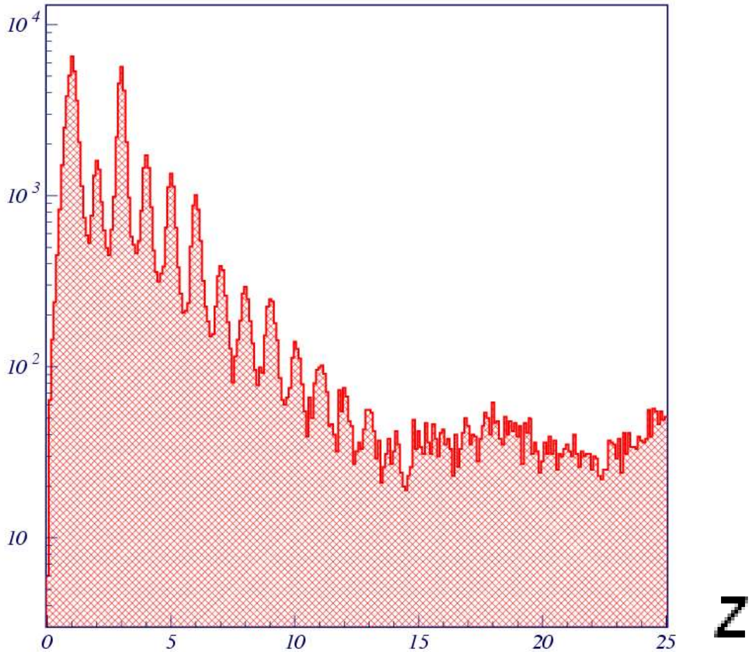
SCA(1) vs. SCD (2)

run 639

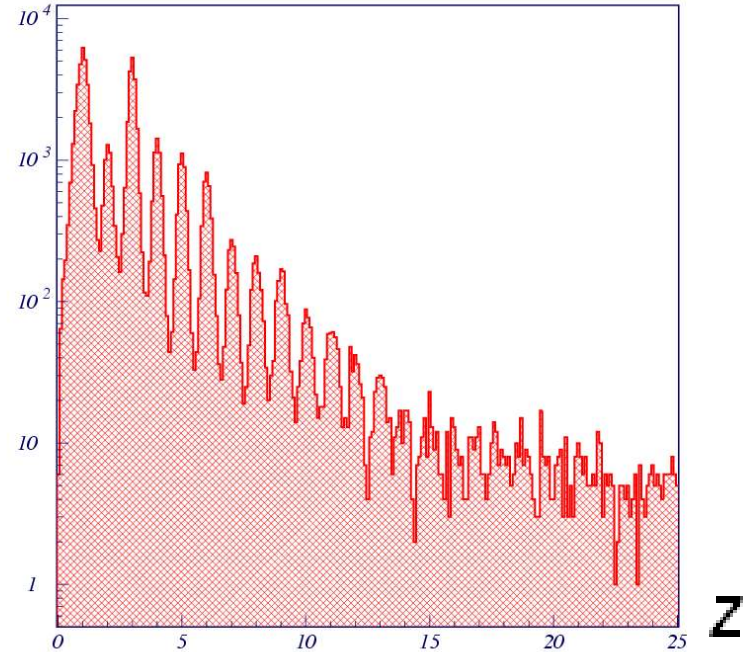
Calibration for indium runs

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

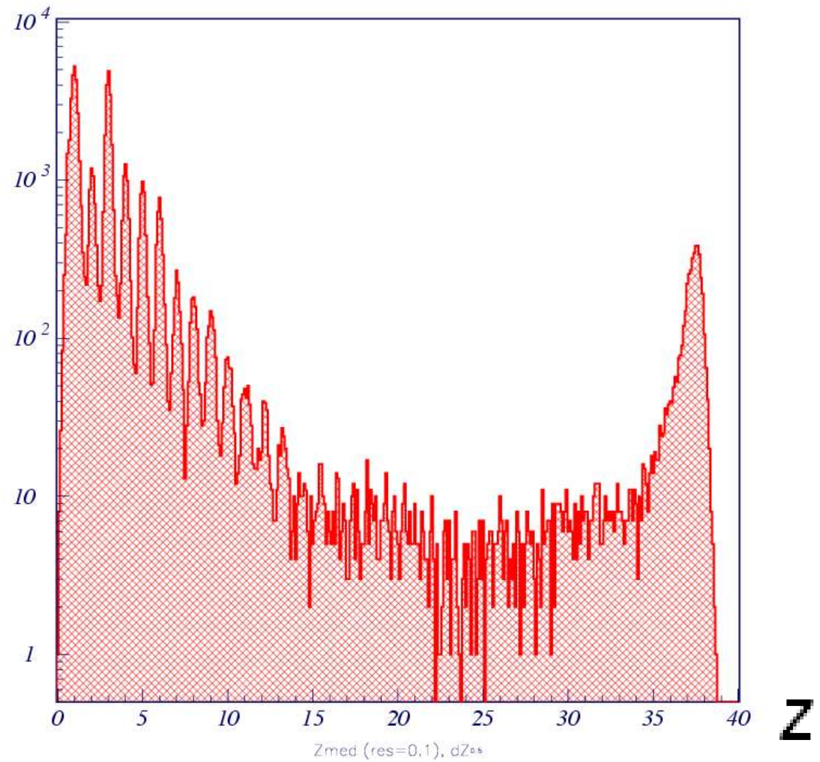
run 639, SCA(2) used

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