Mainz Test Beam analysis review

S. Fiore

Spring time checks

Test beam anomalies investigated

Linearity:

- Low- and high-energy runs seem to have different calibration factors, and show a discontinuity in the charge-energy linearity

Resolution:

- discrepancies between the stochastic term in $\sigma(E)/E$ vs E and the expected photostatistics
- overall resolution higher than expected

Check on the pedestals

Present analysis searches the maximum of the waveform in a predefined time range after the trigger, for each channel;

this value is used as input for the energy reconstruction:

- the pedestal is subtracted to the peak (=an average over 20 samples on pre-defined time window) on an event-by-event basis
- resulting amplitude value for the on-beam (=central) crystal is equalized to the others, using the factors extracted by dedicated calibration runs;
- this value is then summed to the others (ped-subtracted and equalized as well), when these are above a threshold;
- the resulting cluster energy enters the reconstructed energy spectrum for the corresponding trigger energy.

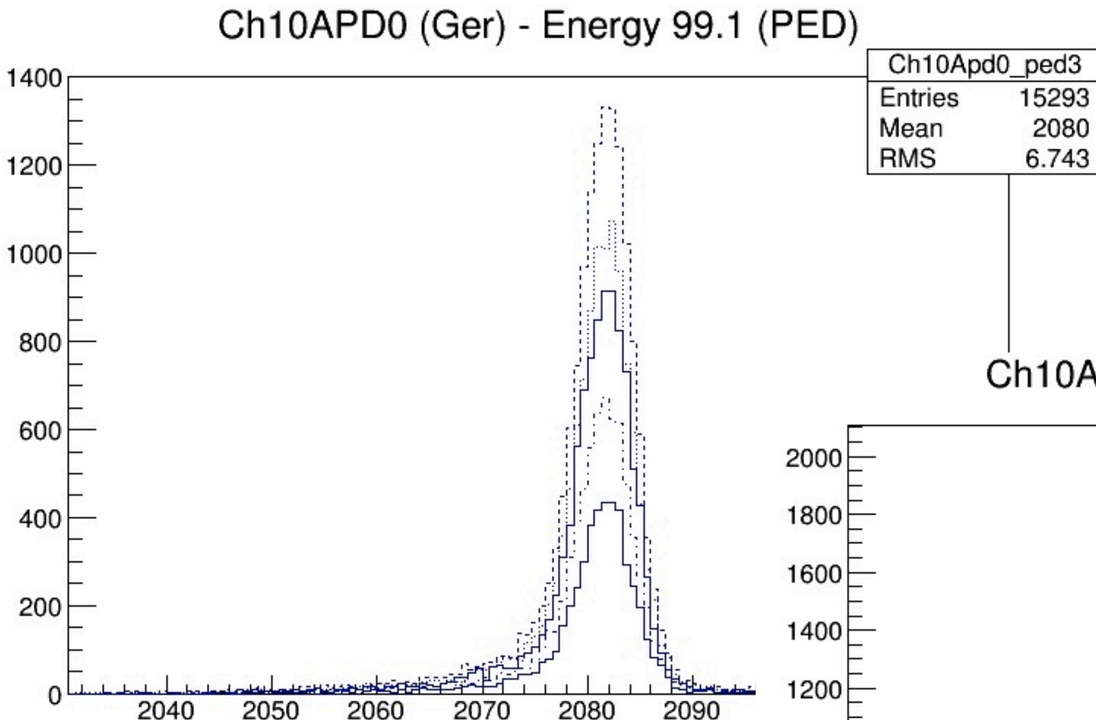
Check on the pedestals II

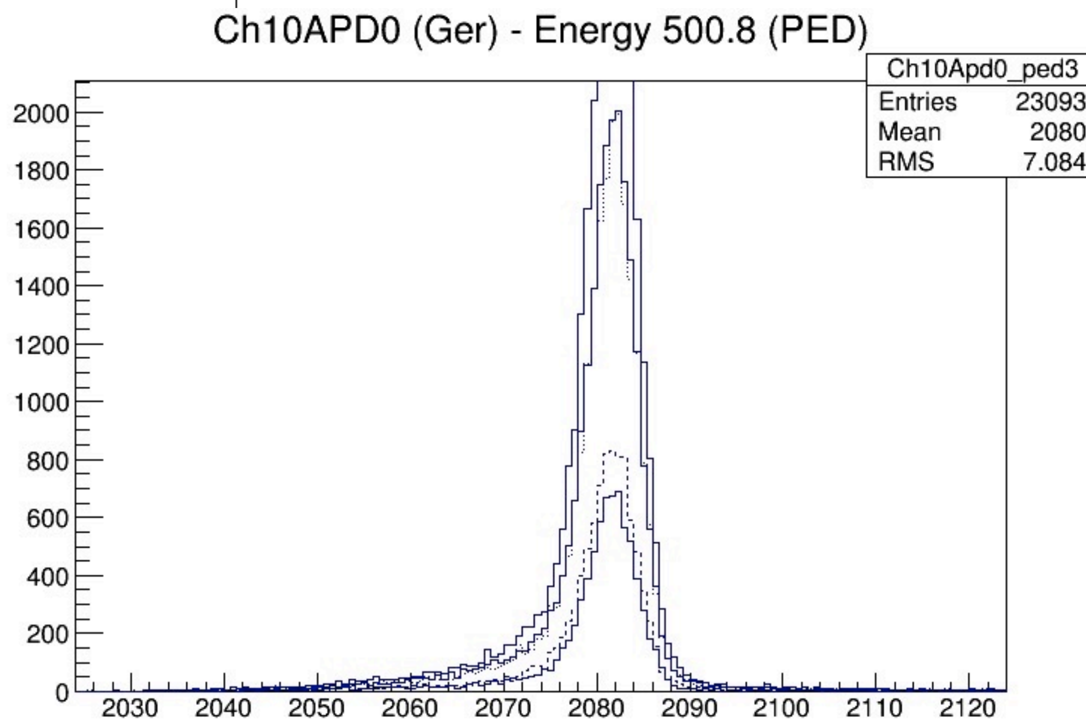
- A correlated shift of the signal baseline, depending on the trigger energy, could cause a systematic error on the evaluation of the reconstructed energies. This would be masked by the event-by-event subtraction of the pedestal.

- In order to check if this correlated shift is present, pedestal distributions have been plotted for each trigger energy, using the same evaluation as for the event-by-event subtraction (i.e. the fixed time window after the trigger)

Check on the pedestals III

- The pedestal distributions did not show systematic deviations with respect to the trigger energy





Homogeneous value of 2082 counts, error on the 2nd decimal (fit not shown)

Single crystal vs cluster

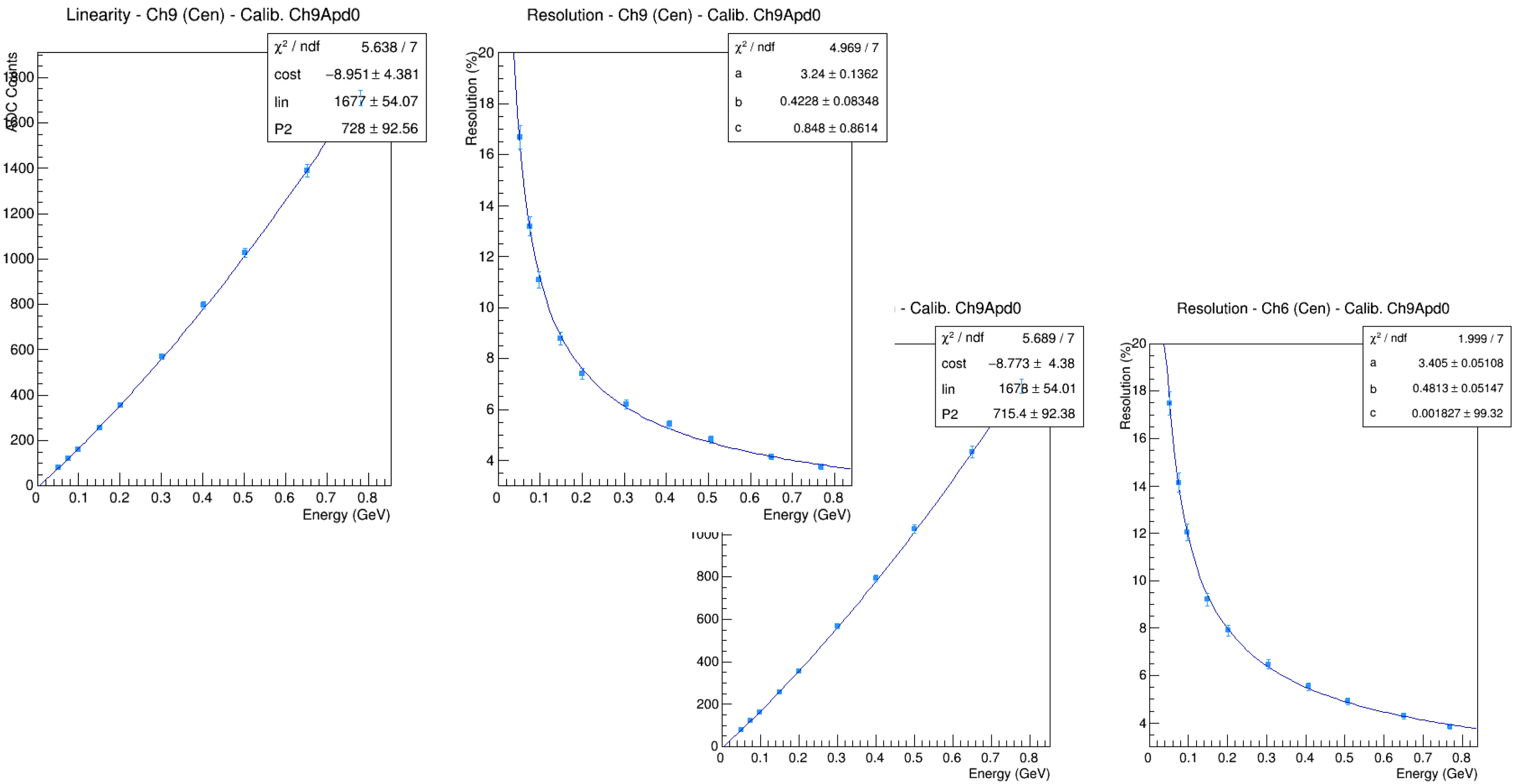
- The cluster size has an increasing number of crystals for increasing energy (expected)
- The energy share between the central cluster and the surrounding ones is instead larger for smaller energies, and this arose some doubts concerning possible low-energy photon background
- Started analyzing the energy resolution using only the central crystal: larger leakage contribution expected but other contribution could give useful hints

Compensating the electronics non-linearity

- Lab measurements by Rossi-Tagnani, igniting test signals in the preamps used for the test beam, shown that the FEE is indeed non –linear
- Given this result, a correction to the amplitude-energy plot to account for it seems reasonable (it remains to explain why it happens)
- By using a 2nd degree polynomial function, it is possible to well reproduce the data points and extract a parametrization for the energy calibration of the calorimeter in our experimental conditions.

Pol2 fit and resolution

- By using the value extrapolated from the fit, for each energy, I have performed the resolution fit on Ch6 and 9 (reference ch9 for equalization)

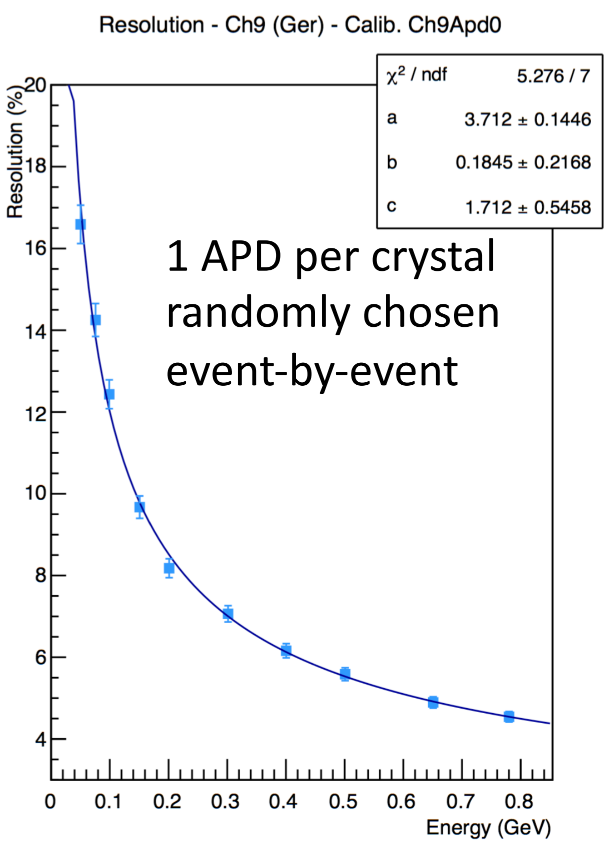


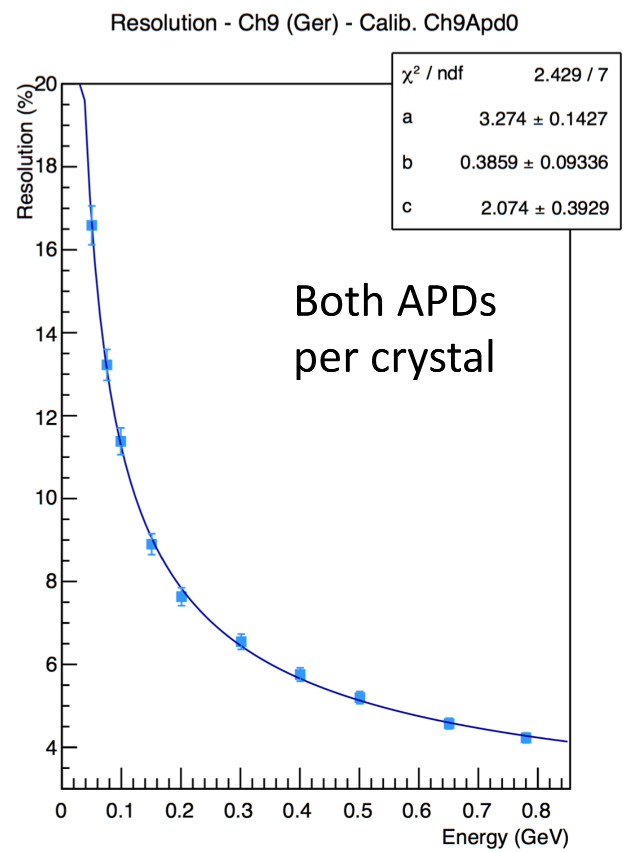
Conclusions

- Calorimeter energy calibration can rely on a good fit with a polynomial curve, without “manual” shifts
- Non-linearity due to FEE, specific reason unknown but accountable for the effect seen at the test beam

Fall improvements

- In order to cross-check the photostatistics, I tried "blinding" one APD per crystal, randomly on an event-by-event basis
- The stochastic term (and the 1/electronic term) in the resolution should scale accordingly: sqrt(2)





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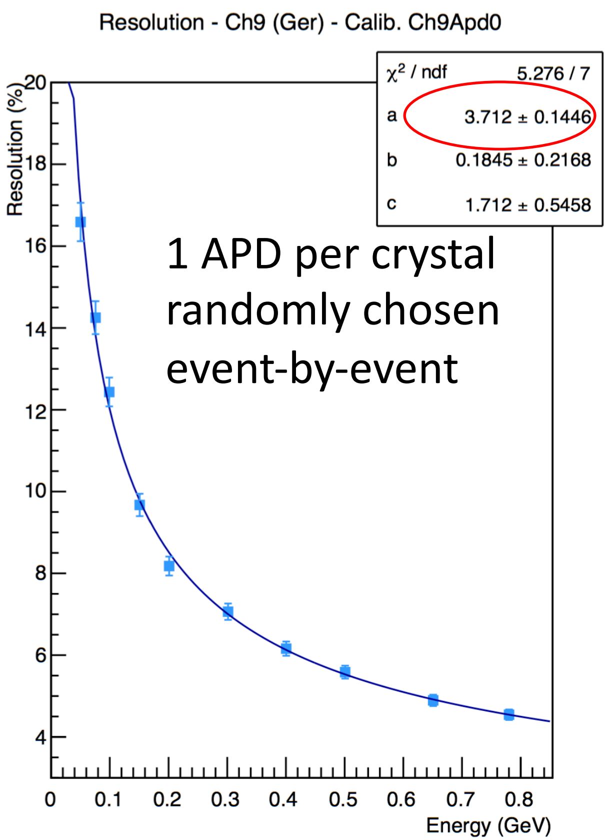


if a = stochastic term, scaling only with photostatistics

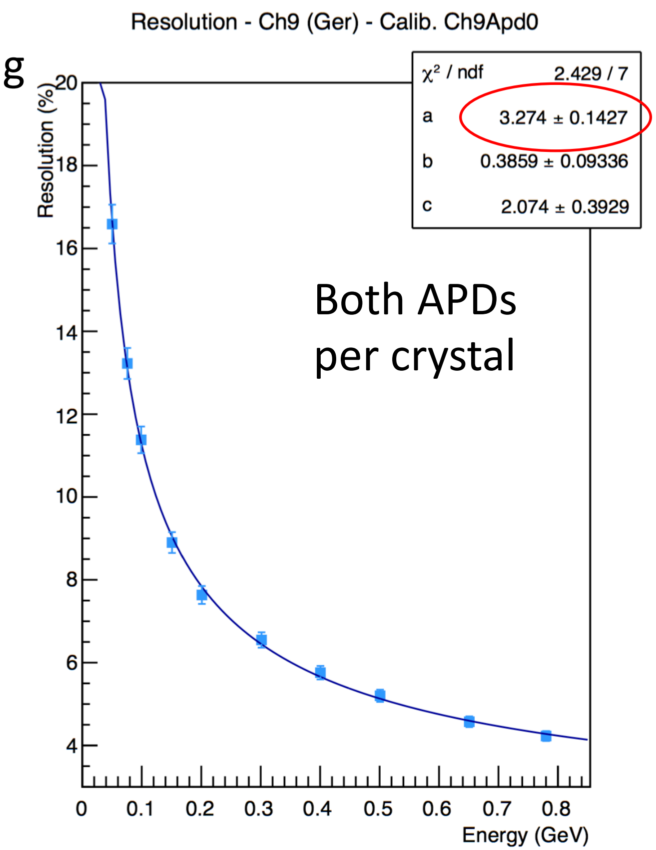
$$a = \frac{1}{\sqrt{n}}$$

so that

$$a_{1APD} = \sqrt{2} a_{2APD}$$

<u>But this is not the case!</u>

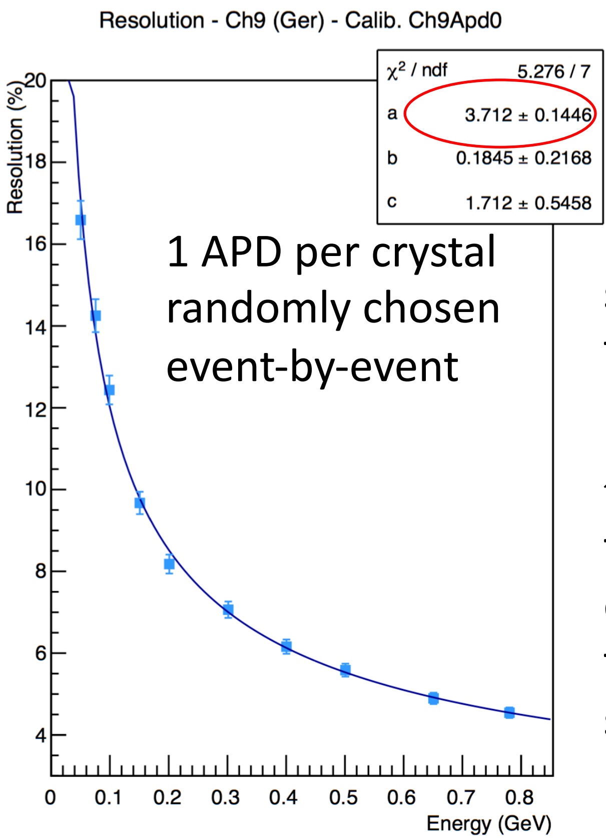
$$\frac{\sigma E}{E} = \frac{\sigma N}{N} = \frac{1}{\sqrt{N}} = \frac{1}{\sqrt{nE}} = \frac{1}{\sqrt{n}} \cdot \frac{1}{\sqrt{E}}$$



- Let's suppose that a second term g scaling as $\frac{1}{\sqrt{E}}$ exists:

$$a = \frac{1}{\sqrt{n}} \oplus g$$

$$a^2_{1APD} = \frac{1}{n} + g^2 \qquad a^2_{2APD} = \frac{1}{2n} + g^2 \qquad a^2_{1APD} - a^2_{2APD} = \frac{1}{n} - \frac{1}{2n} = \frac{1}{2n}$$

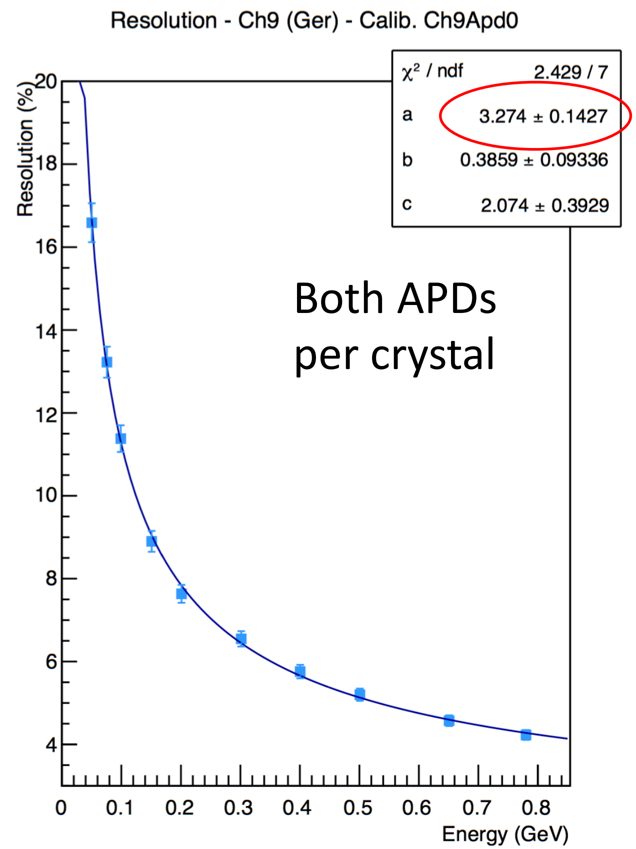


1 APD per crystal randomly chosen event-by-event

so I can evaluate n (1APD) by the difference $a^2_{1APD} - a^2_{2APD}$

$0.03712^2 - 0.03274^2 = \frac{1}{2n} \Leftrightarrow$

$n = 1634$ calculated for one APD, instead of n=725 evaluated from the stochastic term for 1 APD random selection



Both APDs per crystal

- from A. Rossi measurements, plus new PMT QE measurements by M. Montecchi

- QE LAAPD/QE PMT = 50/15 (60/15) at 315 (340) nm = 3.33 (4)
- S_{APD}/S_{PMT} = 1/16.6 for 1 APD
- average LY on xtals : 81 pe/MeV PMT
- for each APD expected: 81 * 3.33 * 0.06 = 16 pe/MeV

APD L.O. Evaluation

- $LO_{APD} = LO_{PMT} \times (QE_{APD}/QE_{PMT}) \times (S_{APD}/S_{PMT})$
  - QE ratio = 3
  - Surface ration = 1/16.6 = 0.06

- Crystal SN4 : LO_{APD} = **17±1 pe/MeV**
- Crystal SN8 : LO_{APD} = **14±1 pe/MeV**
- Crystal SN20 : LO_{APD} = **13±1 pe/MeV**

- Crystal SN4 : LO = 24.99/0.21/1.25 = **95 ± 5 pe/MeV**
- Crystal SN8 : LO = 20.10/0.21/1.25 = **77 ± 4 pe/MeV**
- Crystal SN20 : LO = 18.53/0.21/1.25 = **71 ± 4 pe/MeV**

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- from previous slide calculation, 1.63 pe/MeV expected
- incompatible, even with ENF

The g-factor shows that we need an additional 1/sqrtE term to explain the difference between 1- and 2-APD result

- could the g-factor be due to electronics?

There is still a factor 10 difference between lab-measured and TB-measured photostatistics

- Could we take into consideration an additional effect mimicking an 1/sqrt(n) ? due to electronics? maybe not
- is there room for an additional term with different E-dependance in the resolution curve? We could try to include in the fit a term that reproduces the front-end dependance from input signals, as measured in lab