Progress on
Si Quenching Factor (QF) measurement

Marco A. Reyes[1], Federico Izraelevitch[2,3], Junhui Liao[4], Jorge Molina[5], Gaston Gutiérrez[3]

[1]University of Guanajuato, Mexico, [2]University of Buenos Aires, Argentina
[3]Fermilab, USA, [4]University of Zurich, Switzerland,
[5]National University of Asuncion, Paraguay

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Objectives

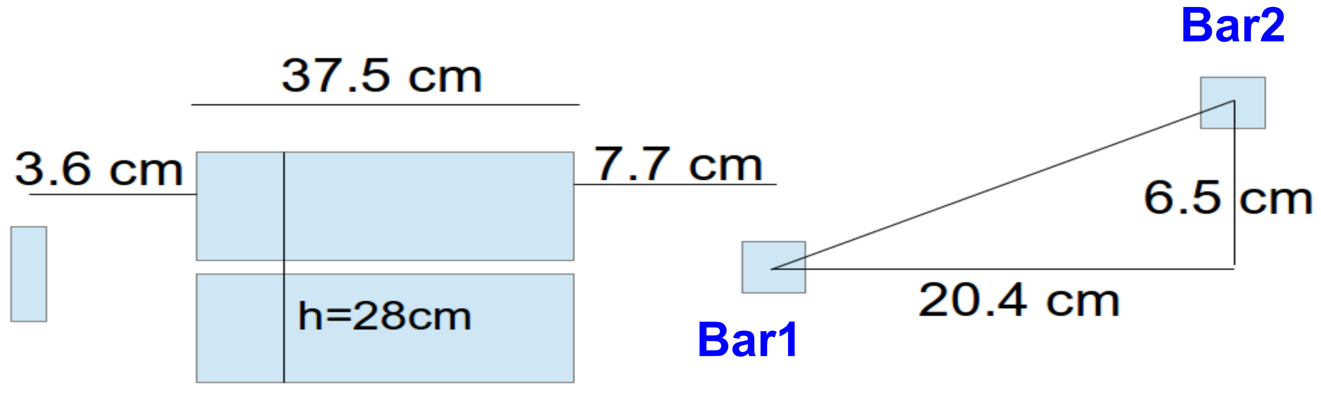
- Quantification of the Silicon QF
- Help Federico to prepare for next UND Antonella run

How?

- Follow Federico's analysis on previous UND data:
  - Two bar data
  - Si + two bar data

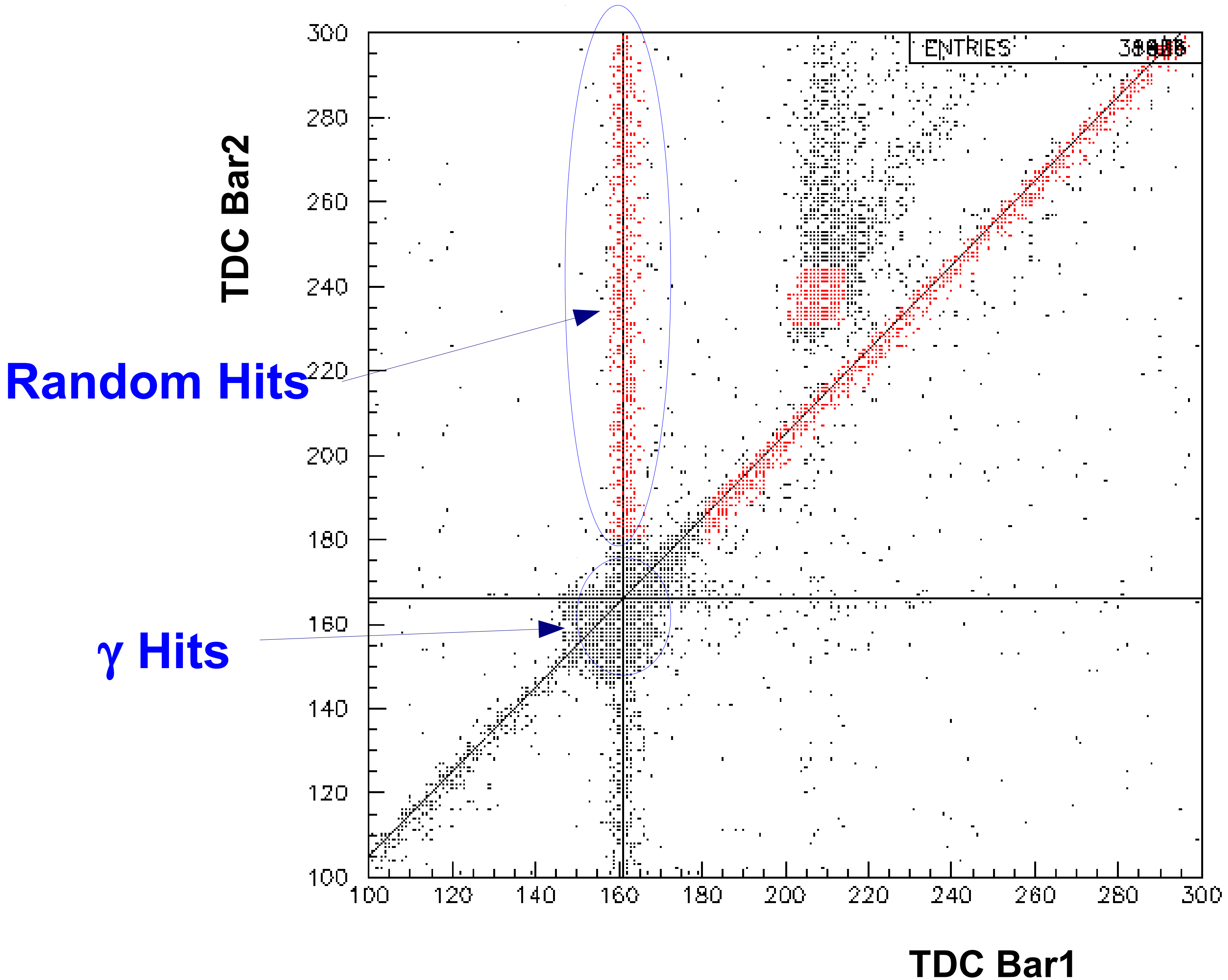
Two Bar data: Determining Neutron flux

We shall use this data to make sure we can determine the N flux, in order to use it as input in the Si detector MC



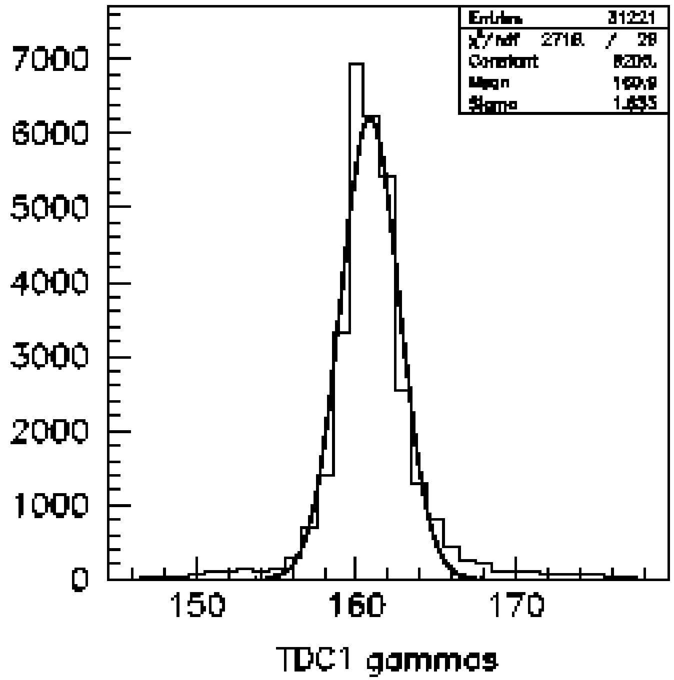
- Distance B1 to target *d*=48.8 cm
- Colimator hole diameter = 1 cm

Data: time distributions

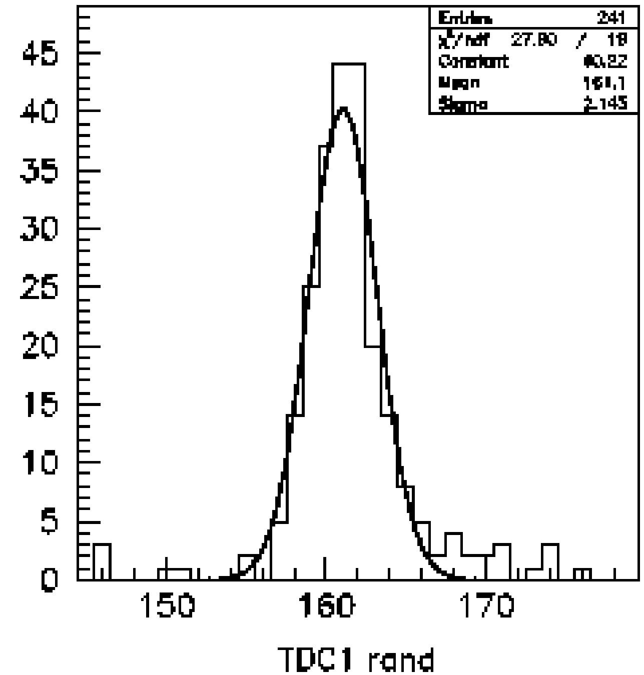


TDC: t_0 determination

γ Hits



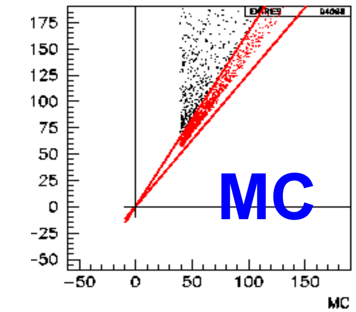
Random Hits



Gammas and ramdom hits have the same time distribution: Use these to define t_0

Add the 1.6 nsec that gammas take to get to bar1

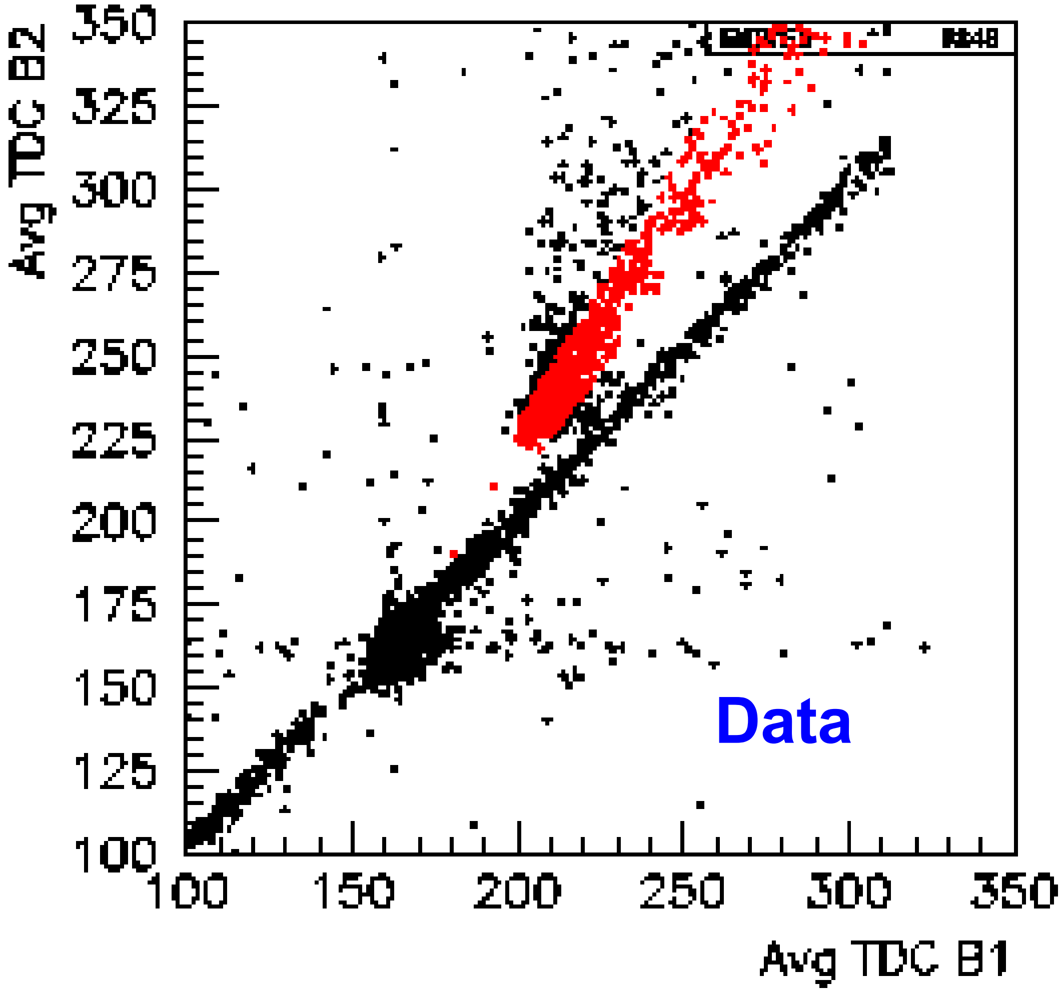
Selecting neutron events



Data cuts are:

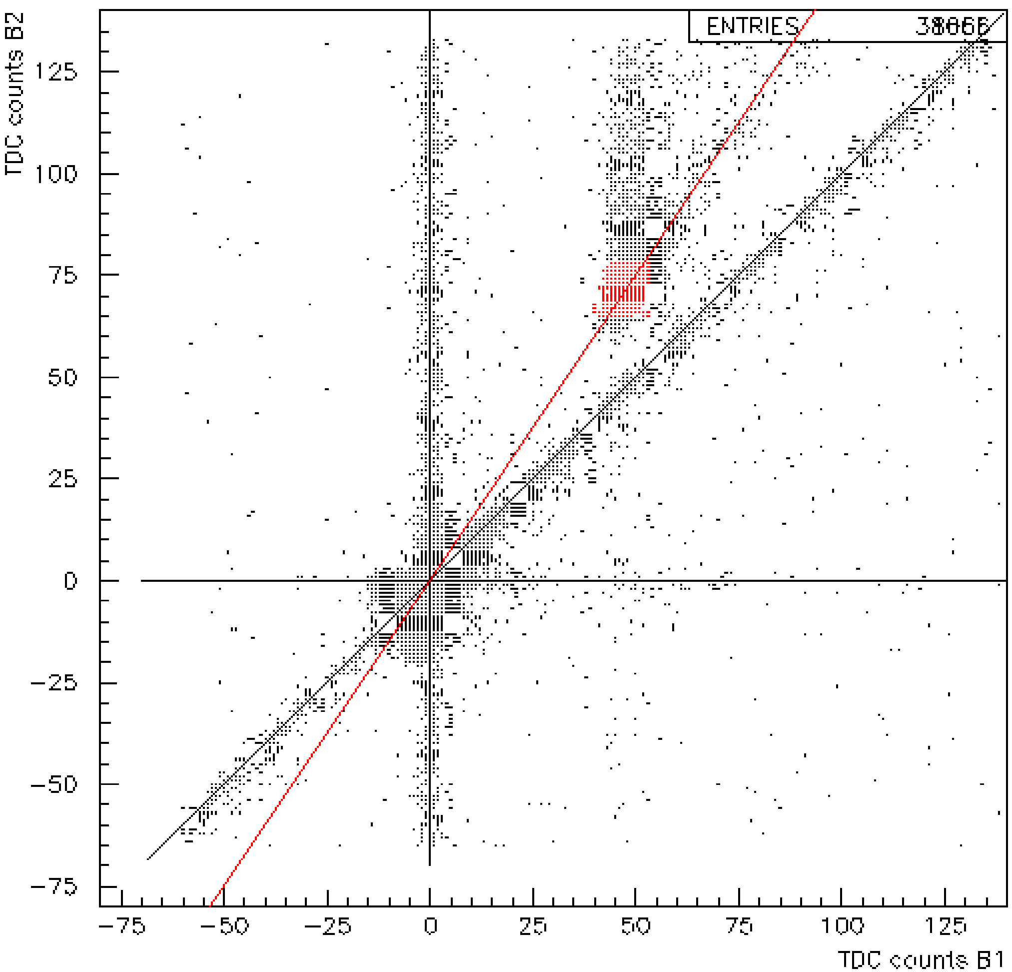
- At least one hit in both bars
- Time of first hit > T_beam_pulse
- Difference in Bar2 TDCs -16<T4-T3<10
- Angular slice cut

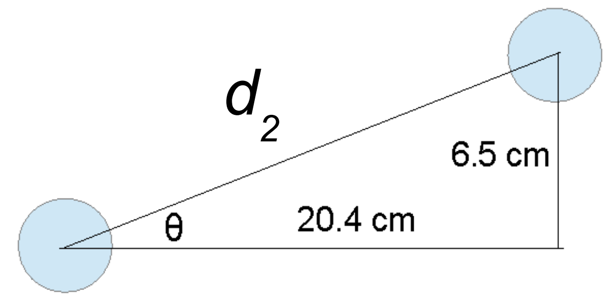
Same cuts on MC

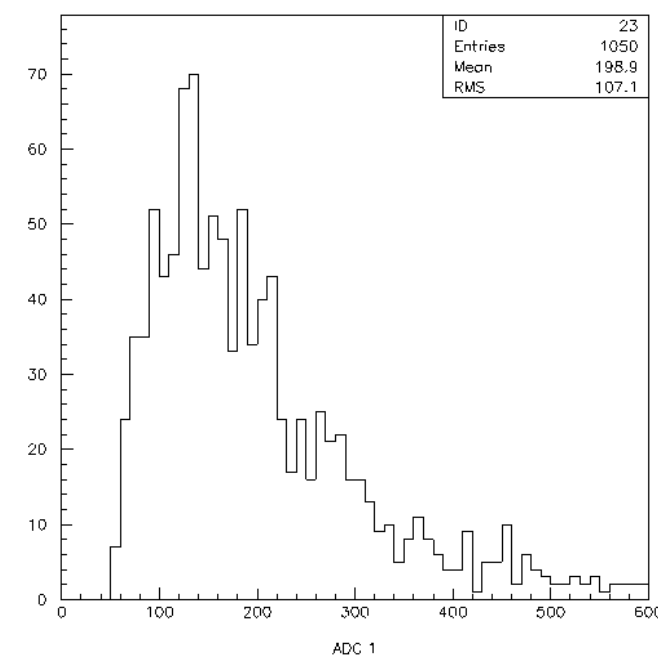


Time and ADC distributions

d_2=21.4cm, θ=17.7

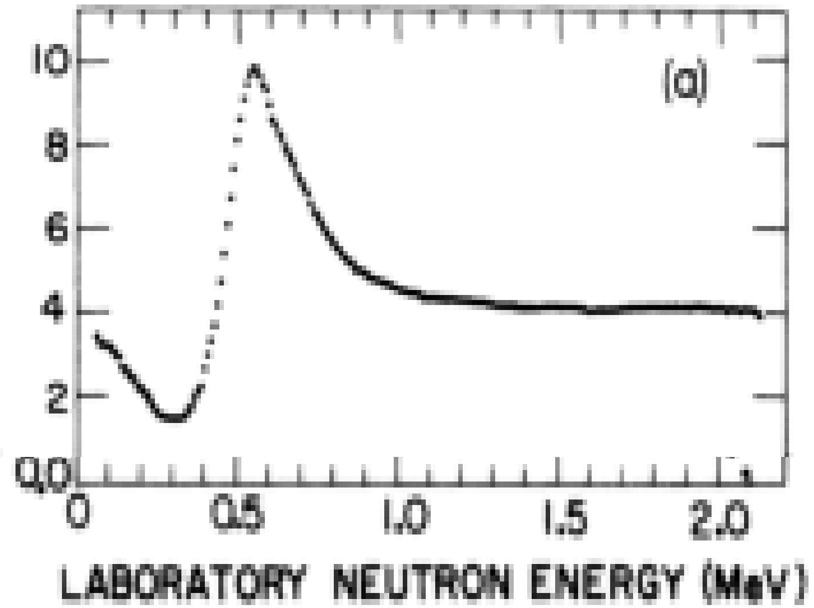


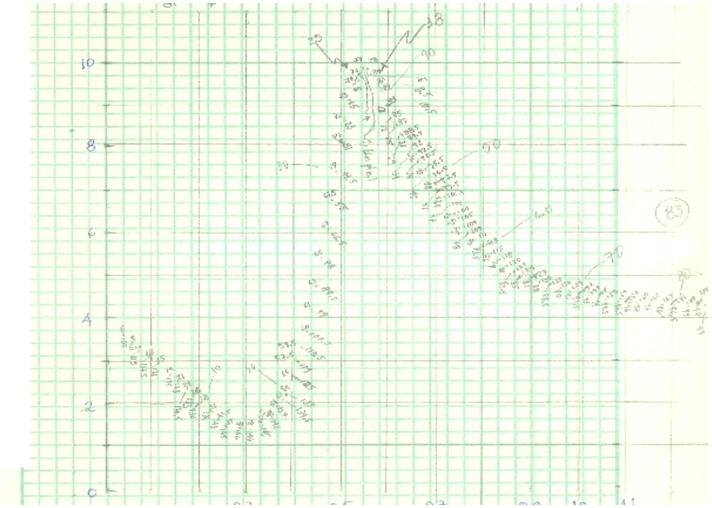




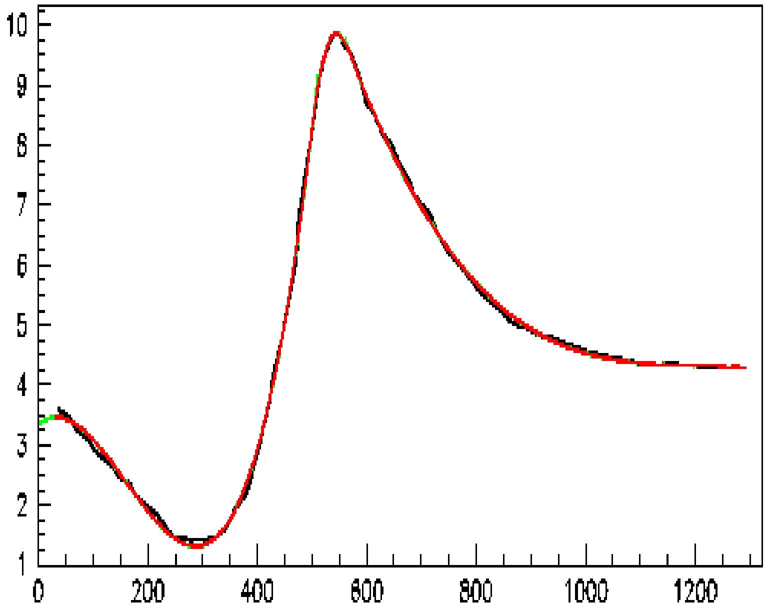
Neutron yield: p-Li

$^7Li^7Be$ angular dists. to E_p=3.8 MeV, **C.A.Burke et al., Phys. Rev. C 10, 1299 (1974)**





Fitted data points using 2 3rdO polynomials and a gaussian for the peak



Jorge Molina generated MC events (thanks!). Selected MC events using this distribution

Help from Junhui (thanks!)

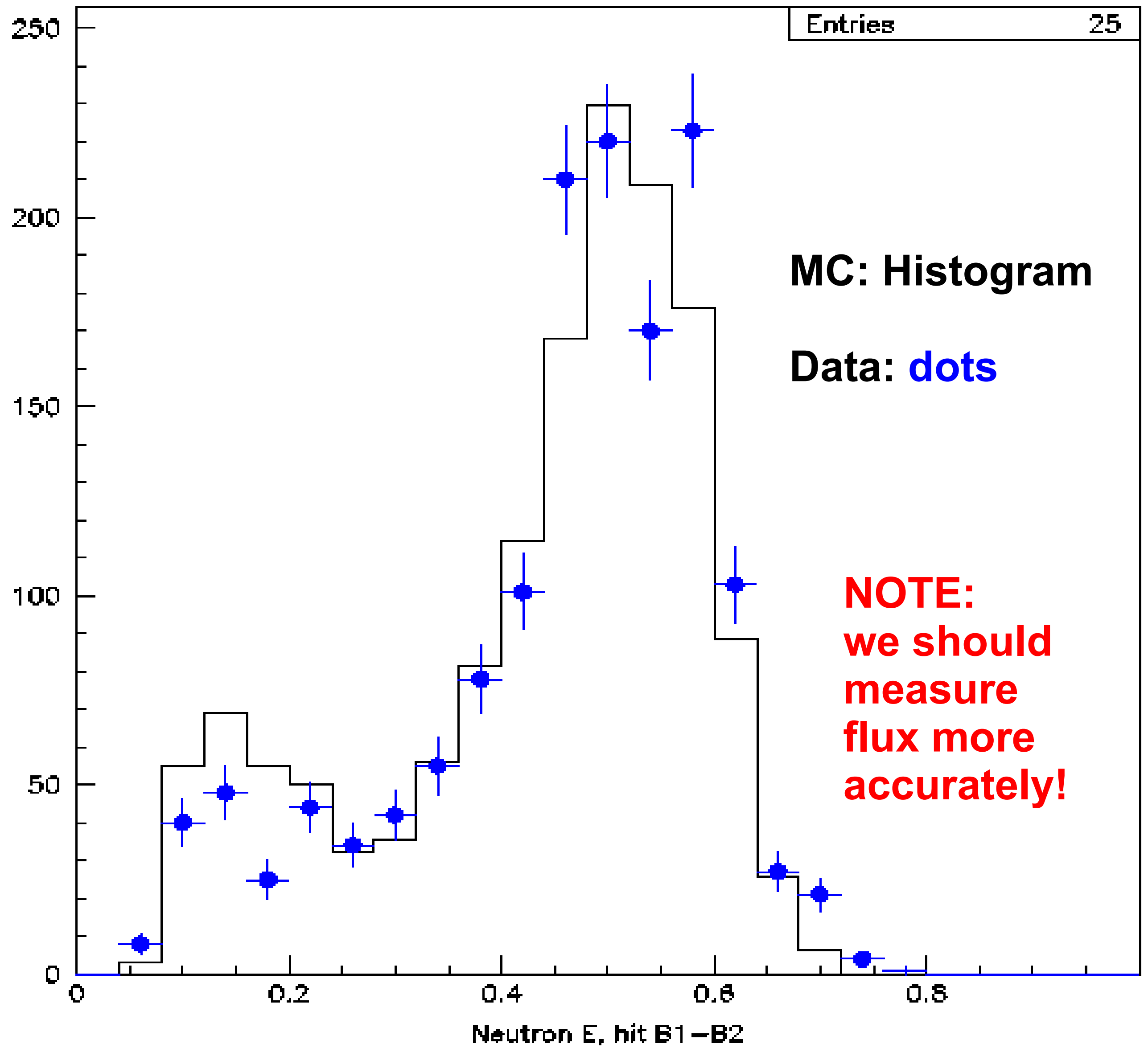
Neutron flux: Data vs MC

Used Avg B1 TDC to calculate neutron energy

Used 49 cm distance from Li target to B1

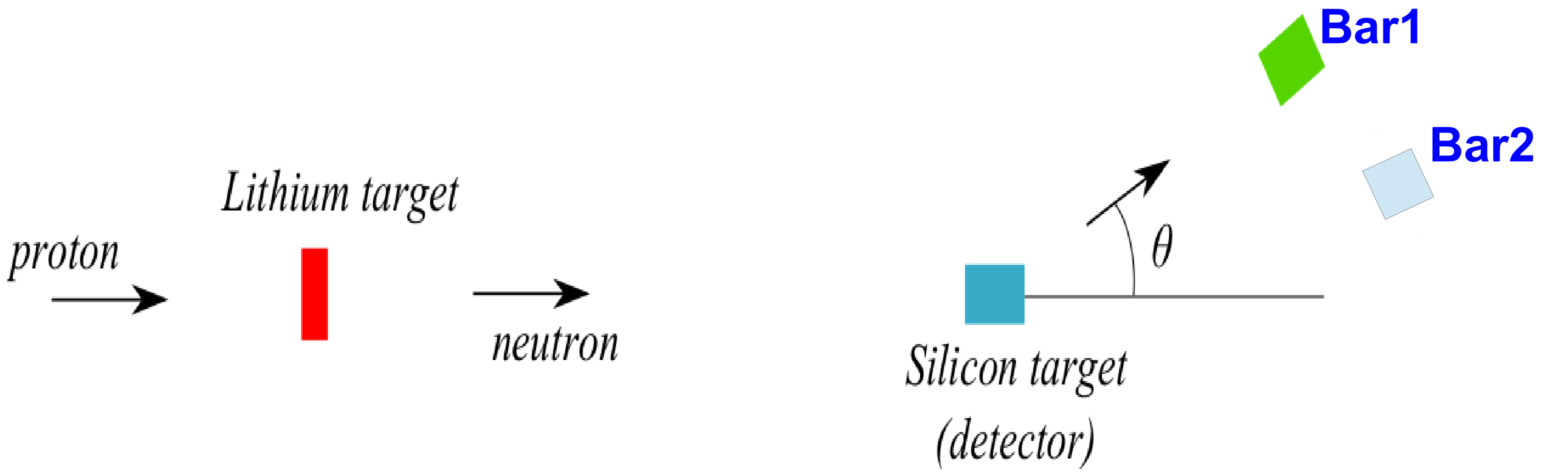
At UND, *p* on *Li* to give 600 keV *N*

Added 1.5 nsec resolution to MC time distribution



Si detector: QF

To quantify the Si QF we use the SiDet data: neutron beam incident on Si detector, Bar1 and Bar2 measure deflected neutrons

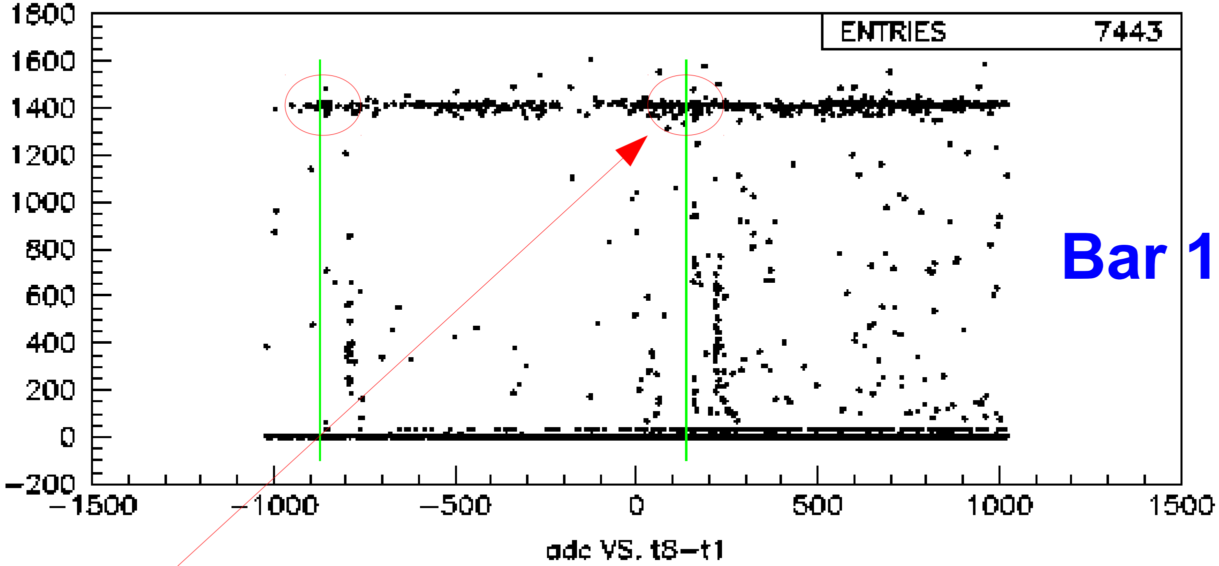


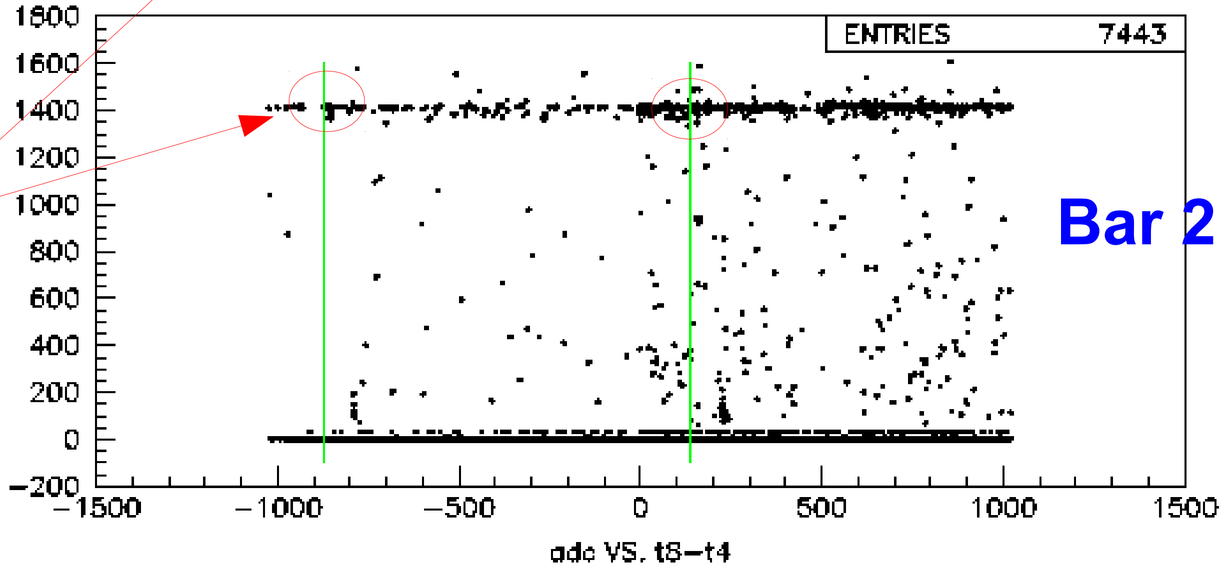
The data

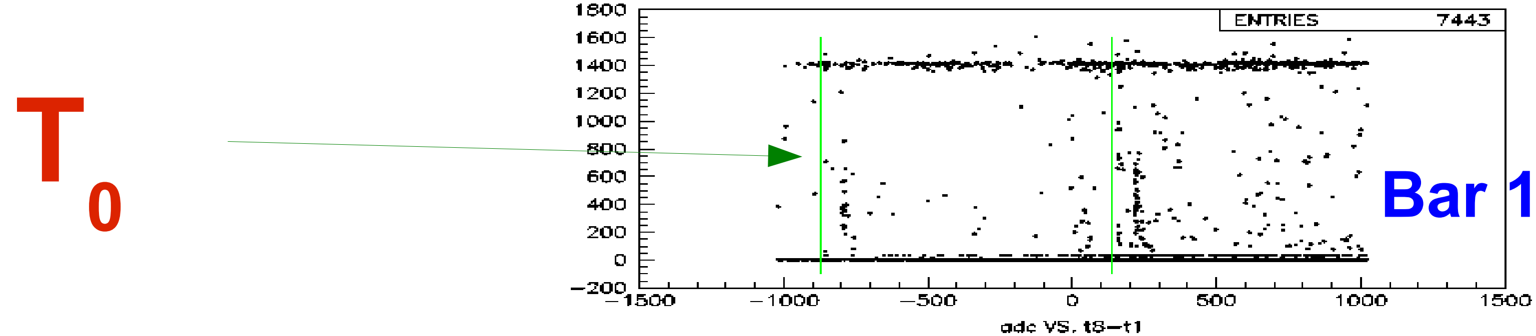
Given that the Si readout takes more than 1 μs
there are two SD cycles recorded in each event, due to the TDC window.

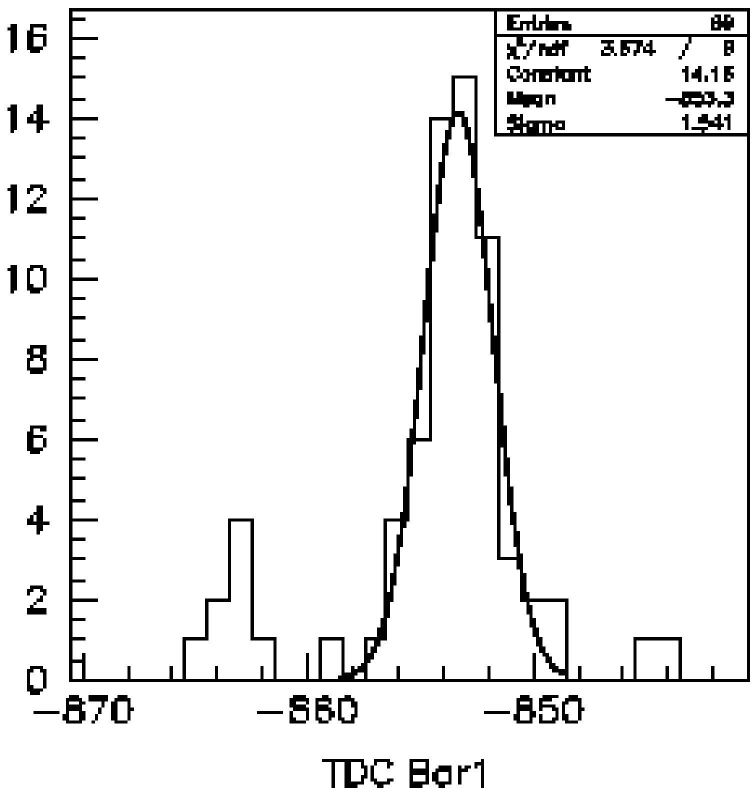
We can check this by looking at the gamma hits

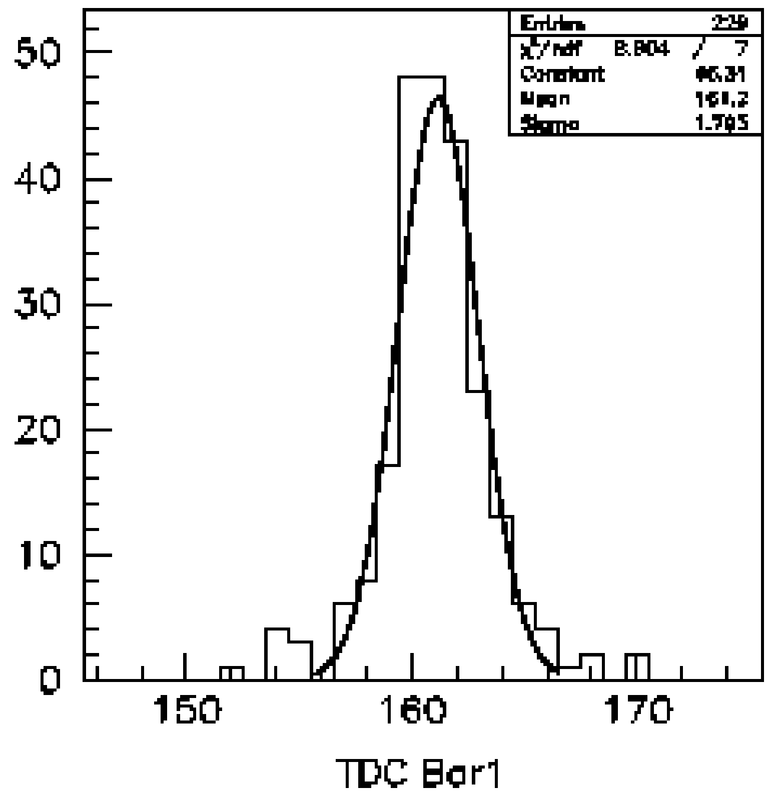
Bar1 data is easier to understand





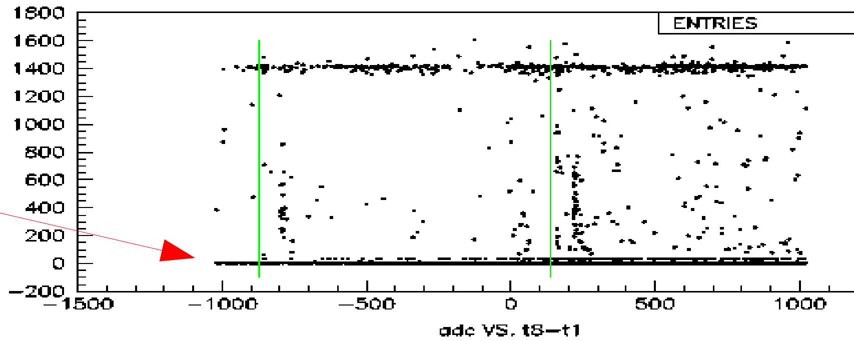




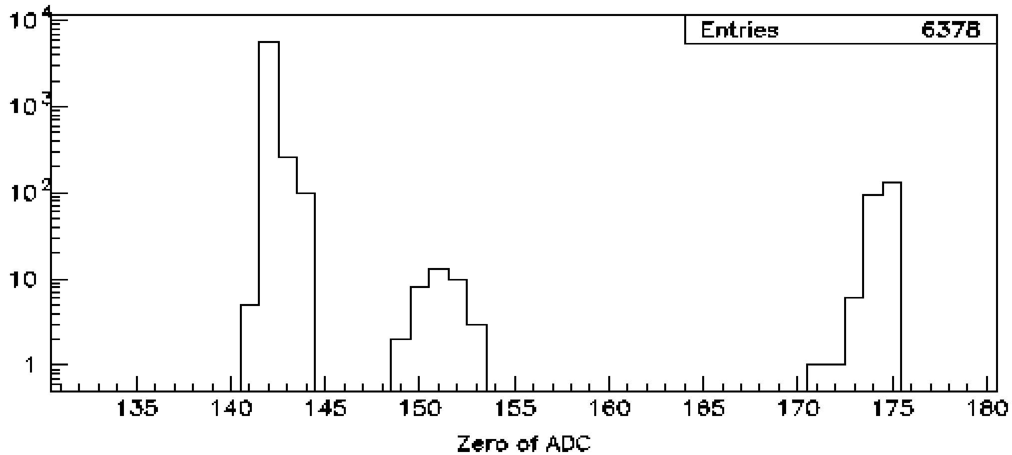


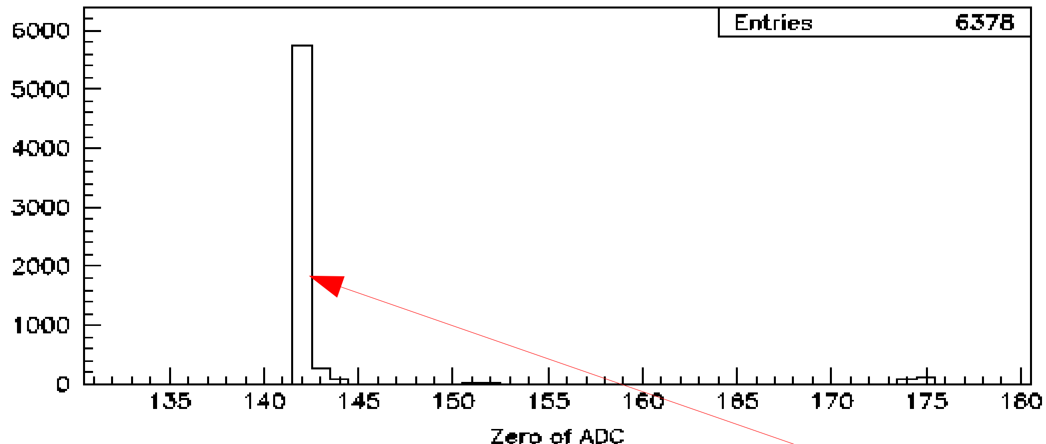
For Bar1 the two T_0's are 1014 nsec apart

ADC pedestal



Bar 1

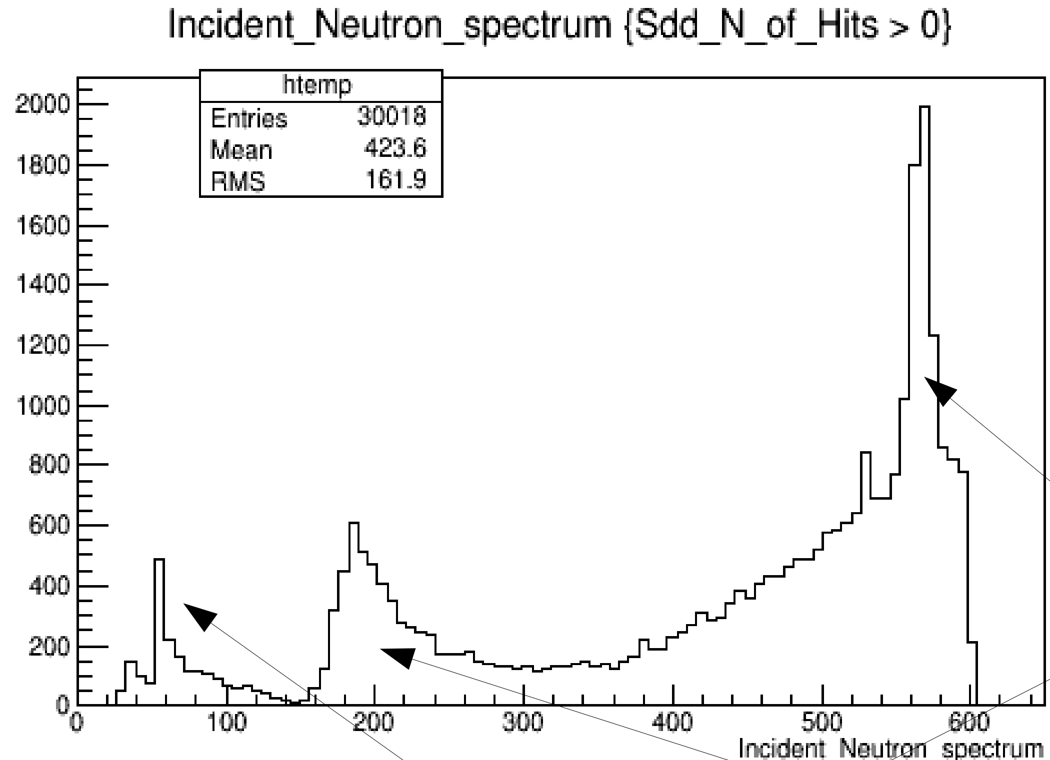


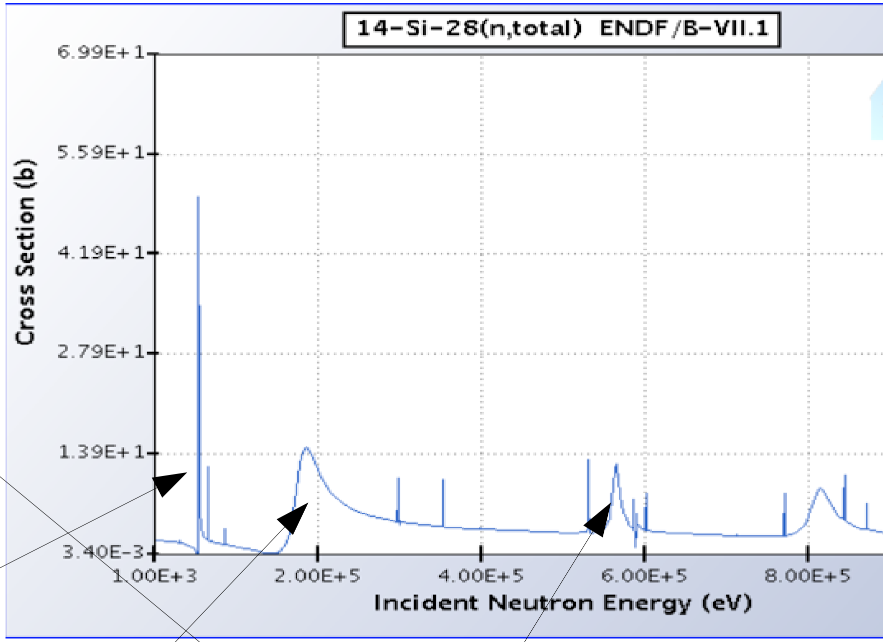


We find the Bar1 ADC pedestal at 142 counts

G4 MC

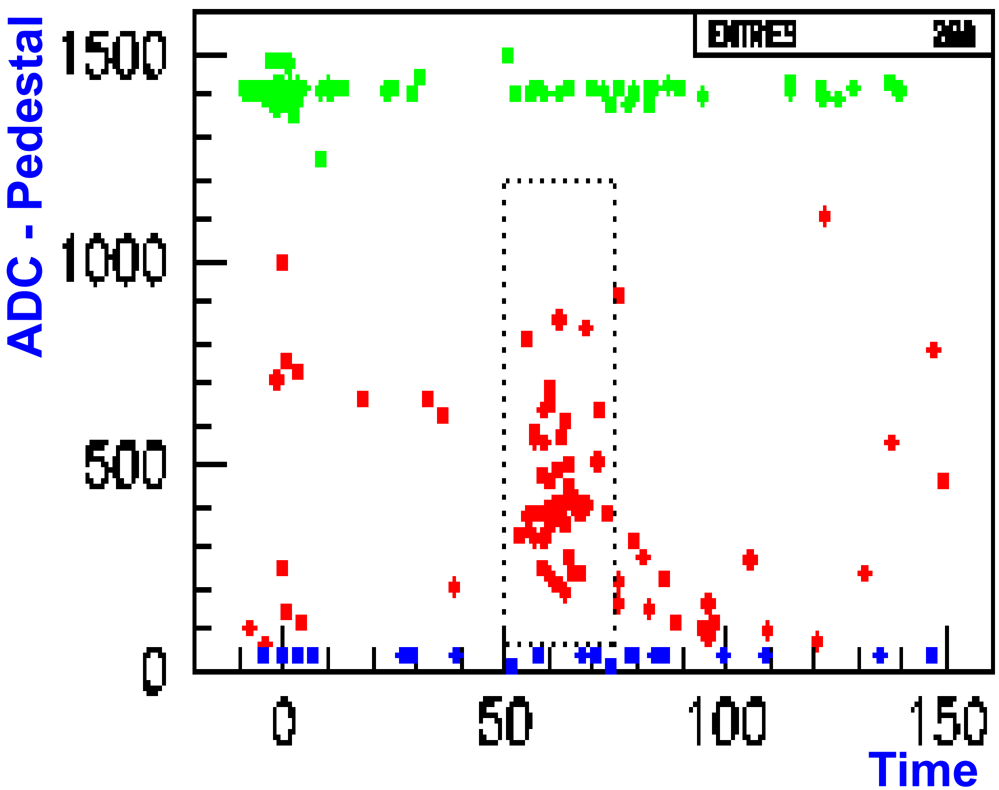
For this part of the analysis we're using Junhui's MC (Thanks!!)
We can see that G4 uses a theoretical model for the n-Si cross section

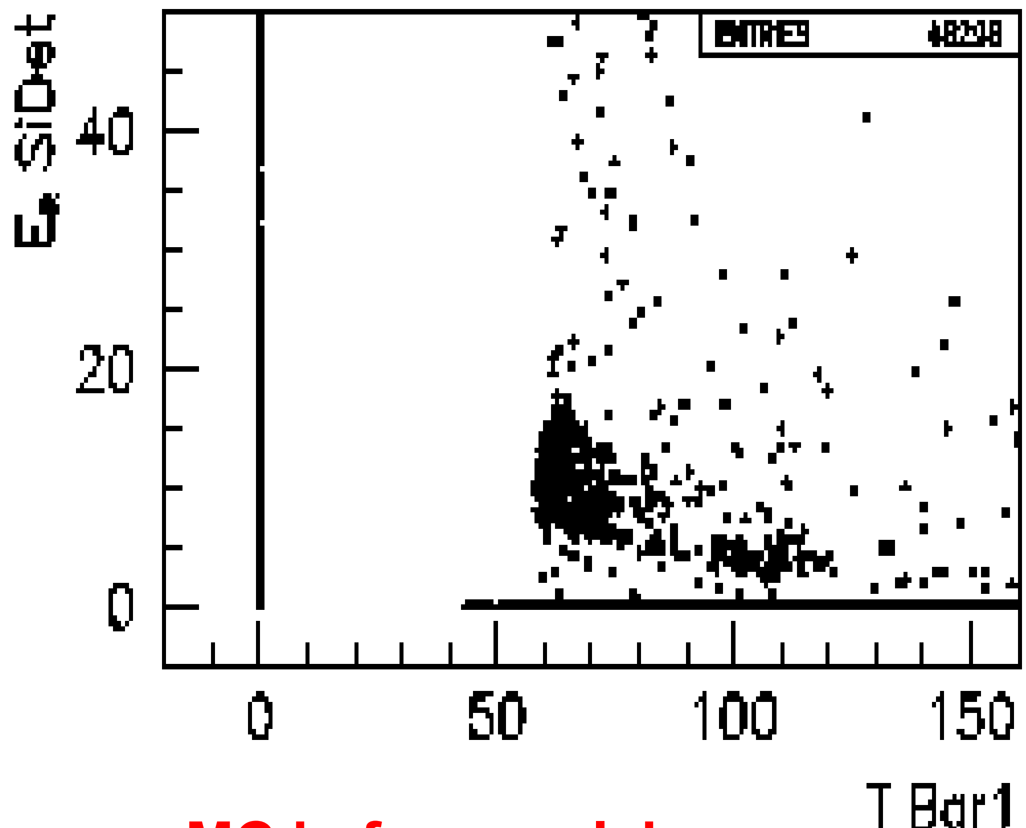




Data vs MC

After setting T0 and ADC pedestal, we can compare data and MC



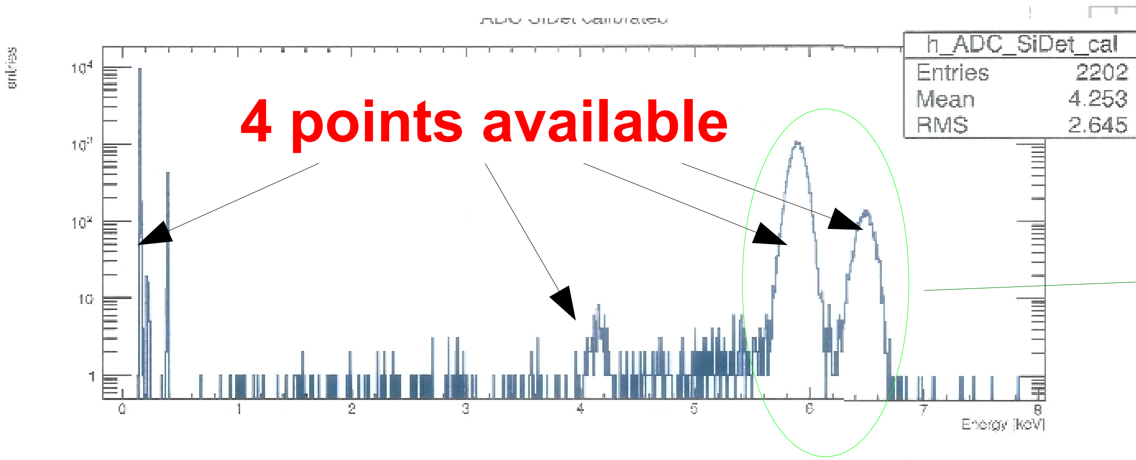


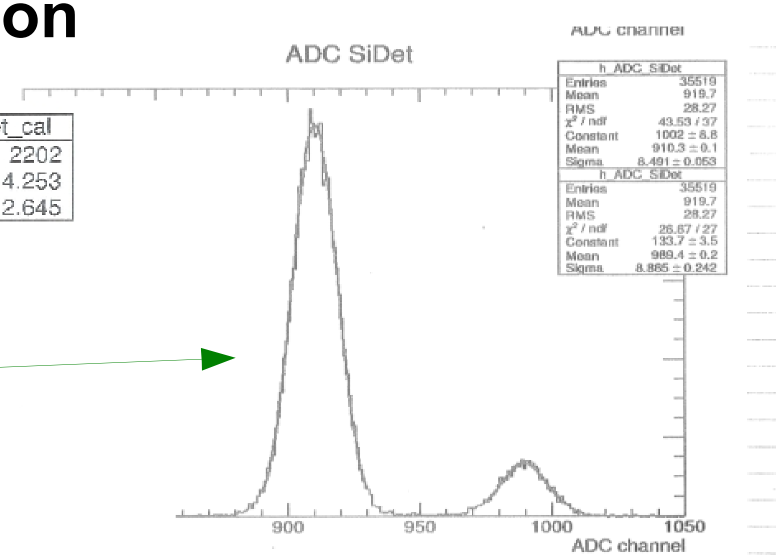
Apply ADC to E callibration

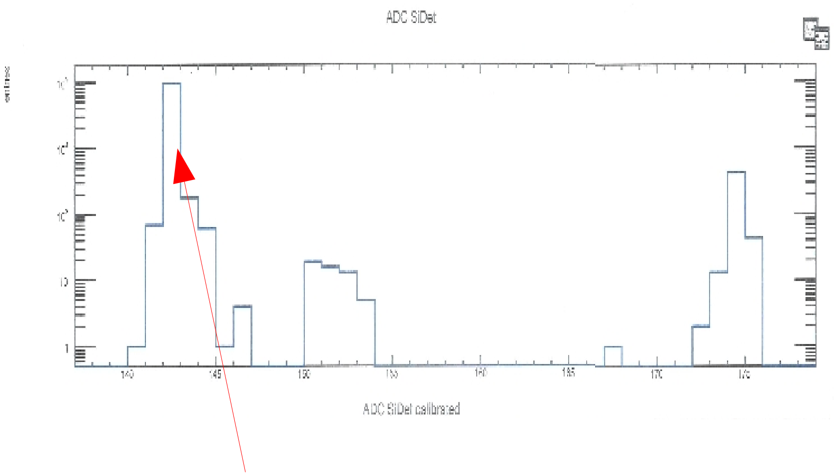
MC before applying QF model

Callibrating Si ADC

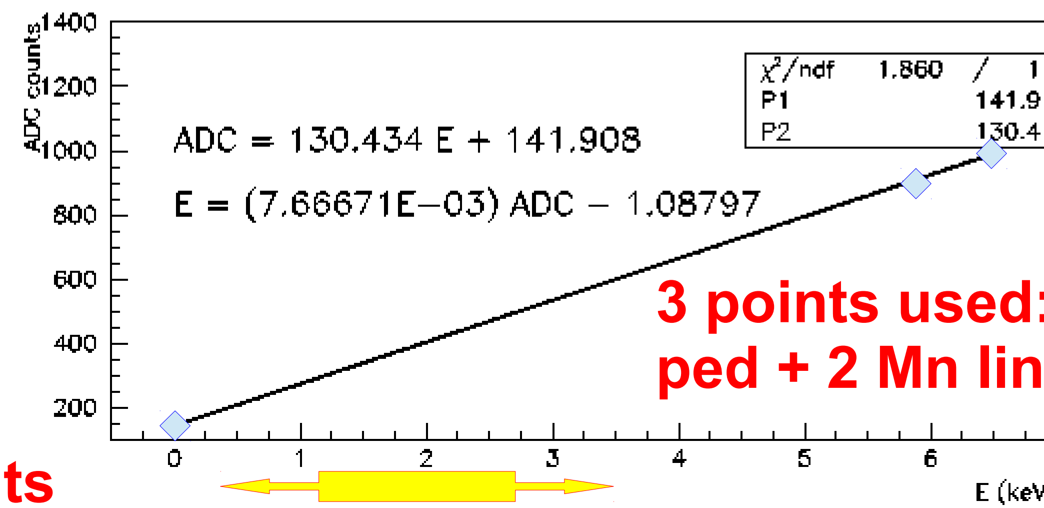
Federico measured ADC counts using an ^{55}Fe source, to callibrate ADC to E convertion







Pedestal at 142 counts

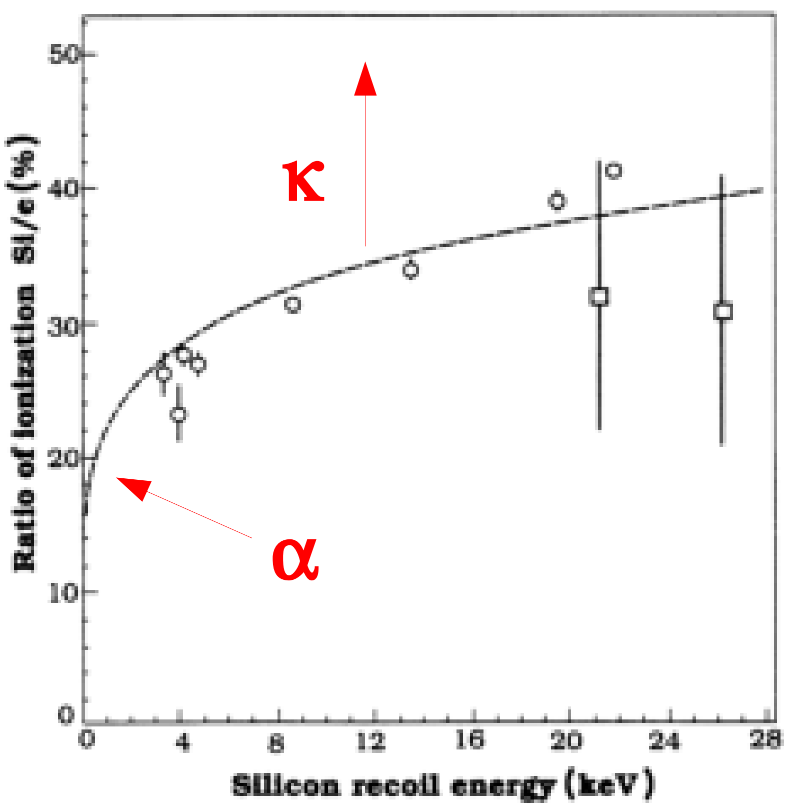


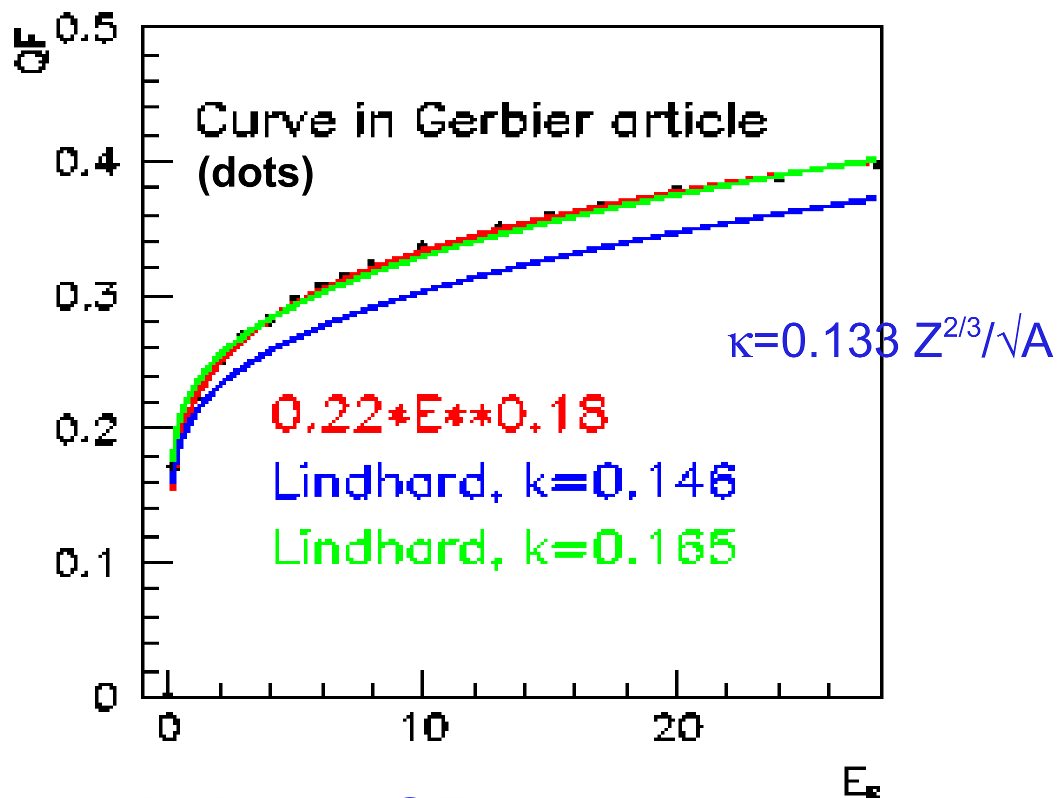
3 points used: ped + 2 Mn lines

Need more points in this region

QF: Lindhard's model

Lindhard's model: J. Lindhard et al., Mat. Fys. Medd. Dan. Vid. Selsk. 33, 10 (1963)
Experimental points: G. Gerbier et al., Phys. Rev. D 42, 3211 (1990)





Power Law κE^{α}

Lindhard: QF = $\kappa g/(1+\kappa g)$

$g=3\,\varepsilon^{0.15}+0.7\,\varepsilon^{0.6}+\varepsilon$, $\varepsilon=0.02434\,E_R$

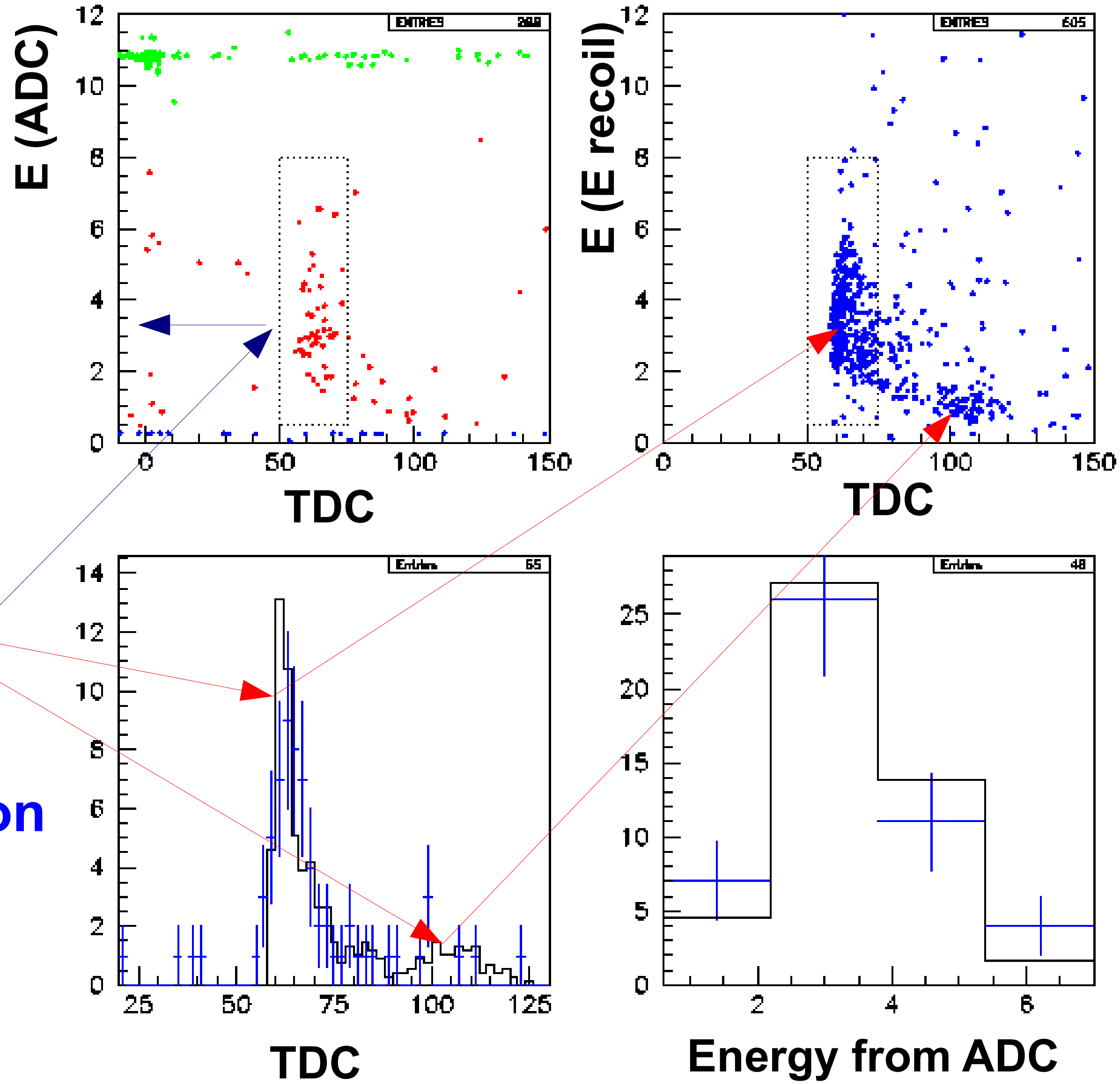
Bar1: Data vs MC

Features:

- **After callibration (data) and applying Power law as QF model (MC), very similar**

- **Need to check n-Si resonance production**

Template: the projection of the selected E-TDC distribution on the E axis



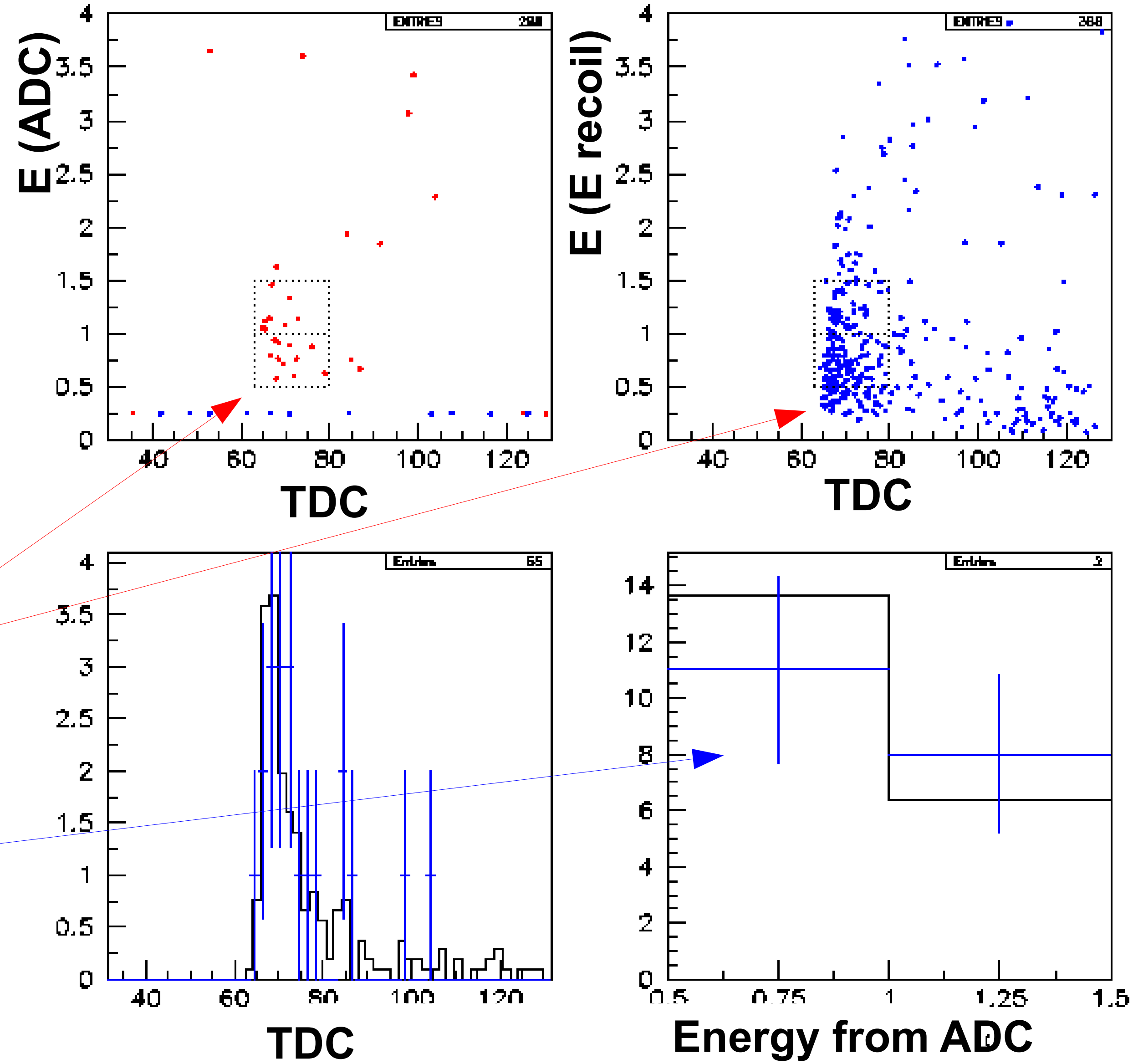
Bar2: Data vs MC

Features:

- After callibration (data) and applying Power law as QF model (MC), very similar

- ADC Gap??

- Energy plots are not fits



Analysis: use templates

For the data analysis we shall use templates:

• We consider the (fixed) data Energy distribution (after ADC callibration)

• We compare this distribution with the distribution of MC Recoil Energy multiplied by the QF: chose a model

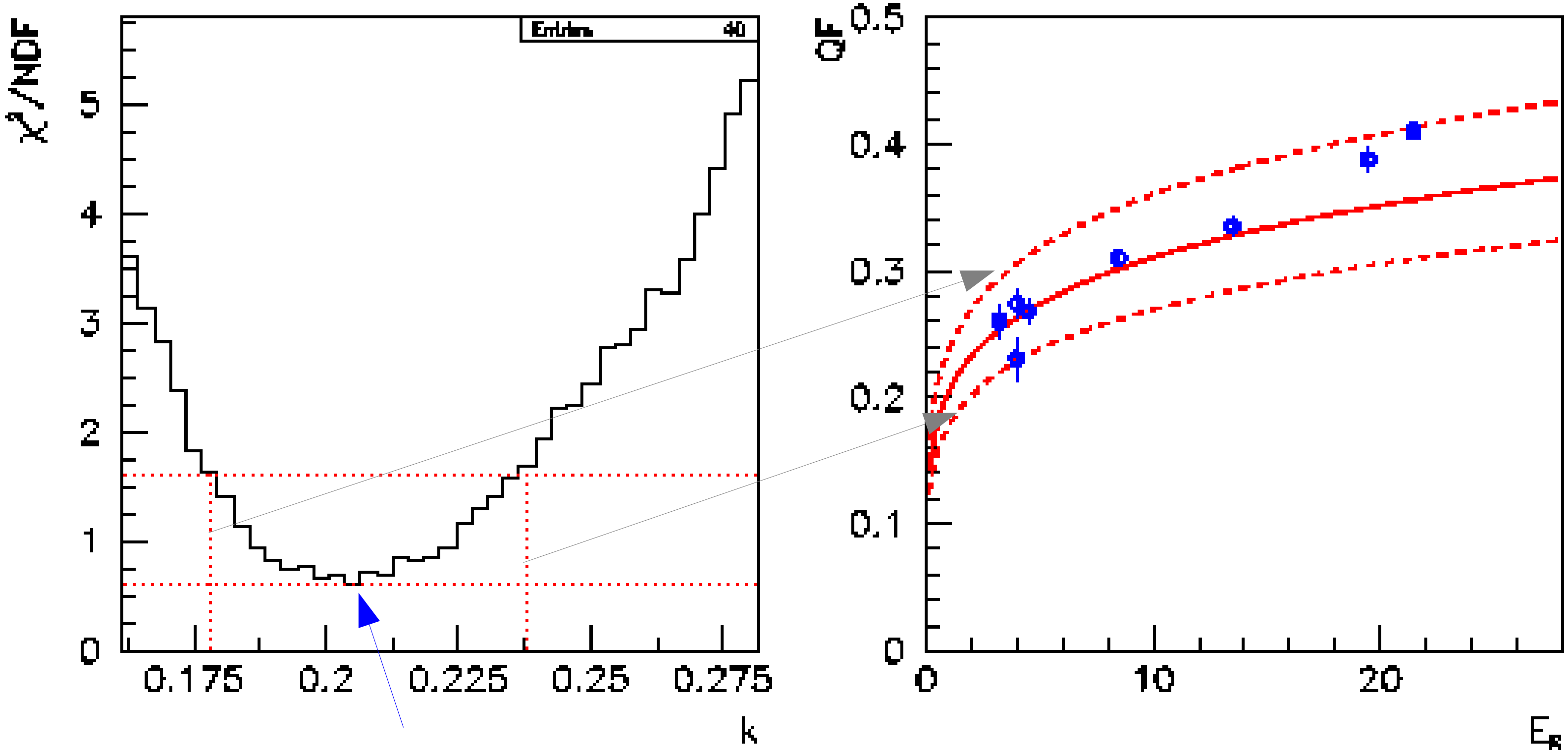
• We vary the model parameter (κ, α, in the power law model; κ in Lindhard's model), compare, and select the distribution where the χ^2 is minimum

• The 1σ curves are those where the χ^2 changes in 1 unit.

Analysis: vary κ in power law

In this case we fixed α=0.18 and let κ vary. The region where the χ^2 varies in one unit determines the 1σ region.

After the analysis we inserted the experimental points from Gerbier et al. (blue circles)

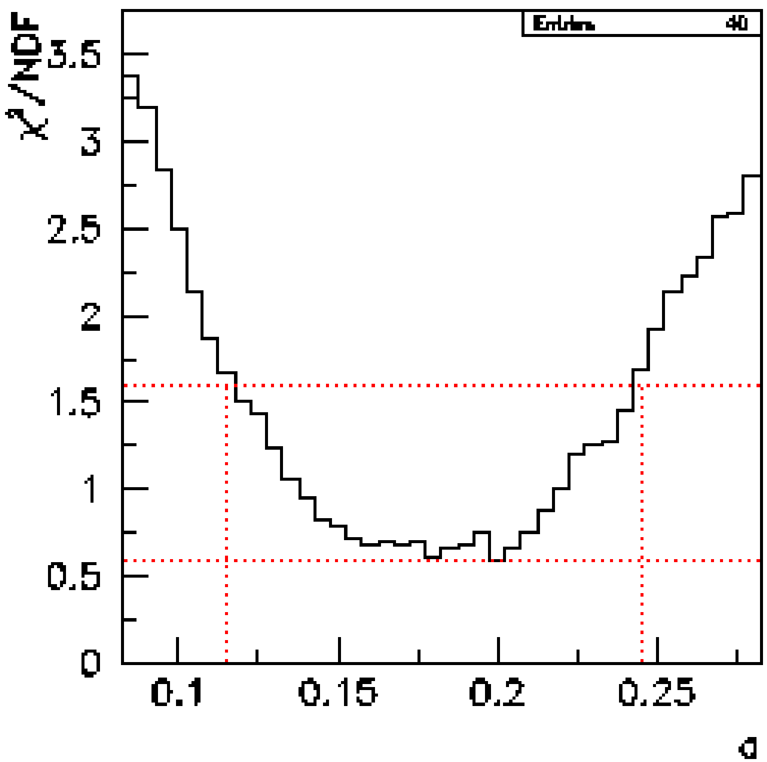


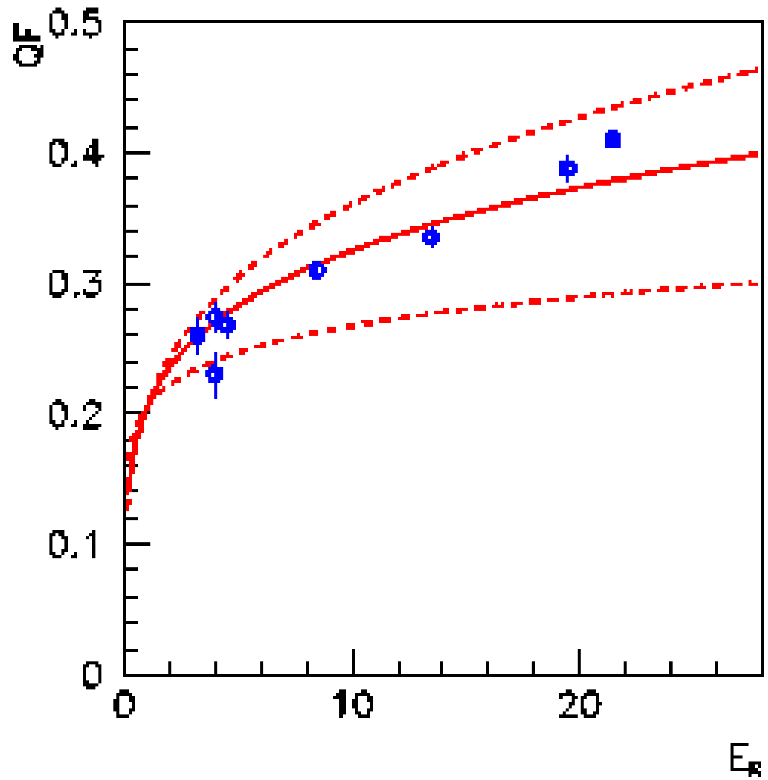
Minimum χ^2 =0.603, at κ=0.205

Analysis: vary α in power law

In this case we fixed κ =0.205 and let α vary.
The blue circles are the experimental points from Gerbier et al.

Minimum χ^2 =0.597, at α=0.20



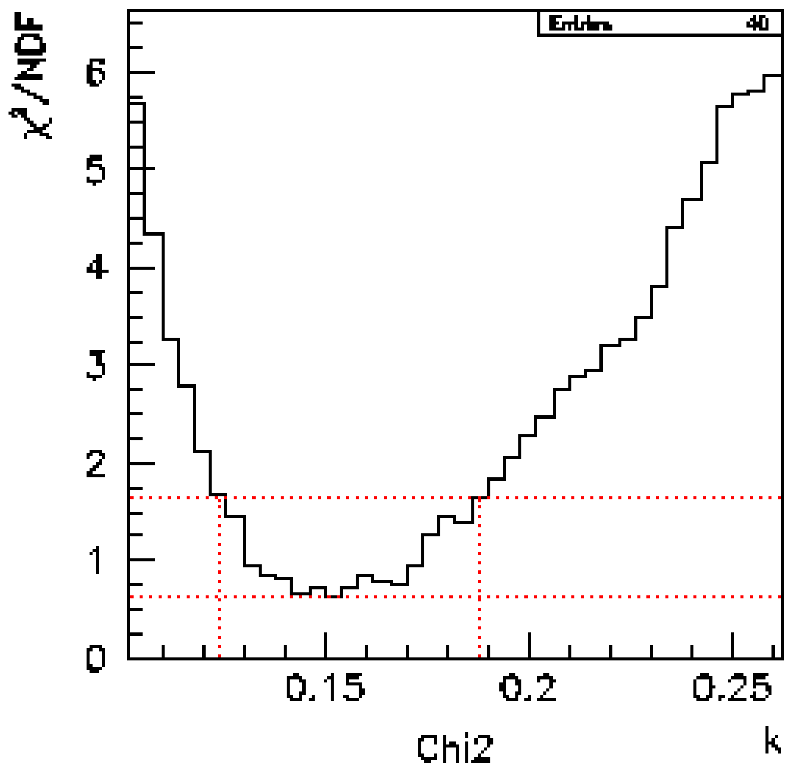


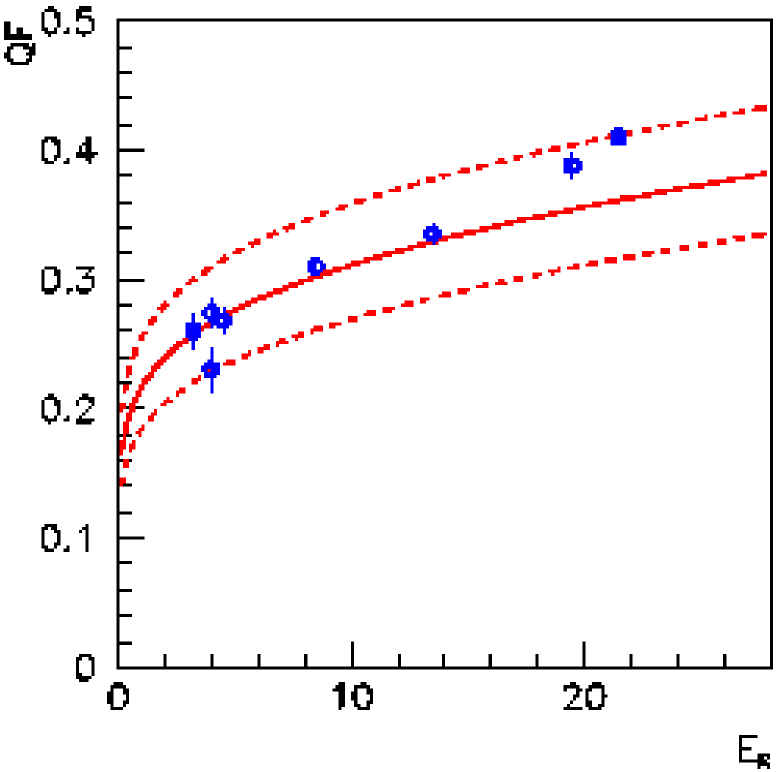
Analysis: vary κ in Lindhard's

In this case, we allowed κ to vary. This is done in other experiments

The blue circles are the experimental points from Gerbier et al.

Minimum χ^2 =0.634, at κ=0.152



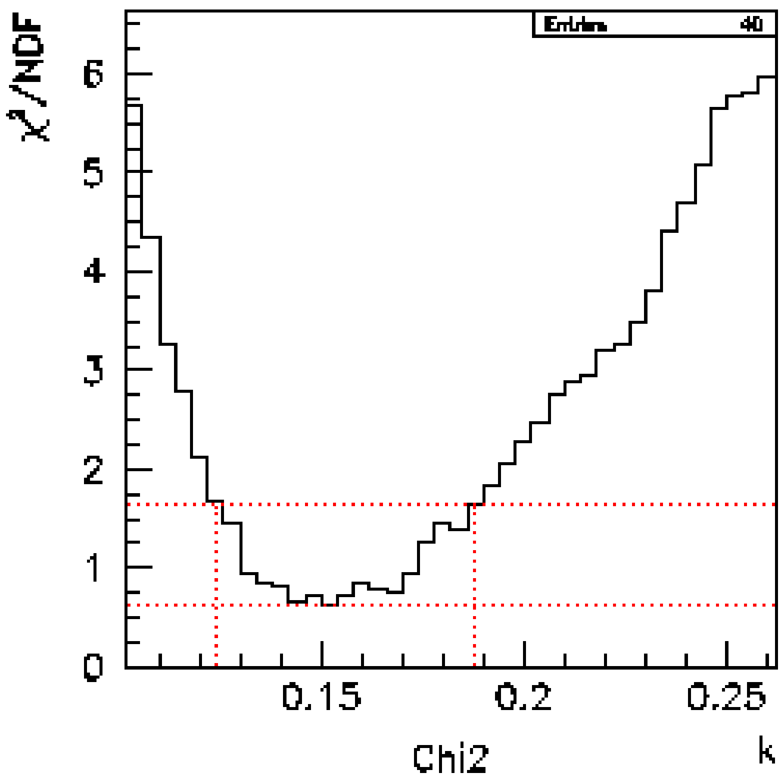


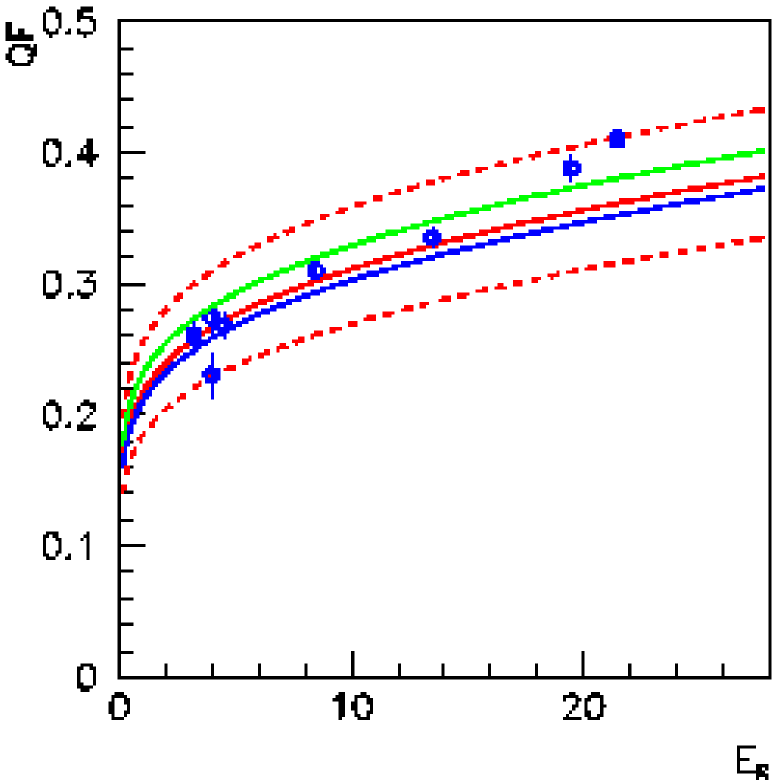
Analysis: vary κ in Lindhard's

In this case, we allowed κ to vary. This is done in other experiments

The blue circles are the experimental points from Gerbier et al.

Minimum $\chi^2 = 0.634$, at $\kappa = 0.152$





Conclusions

- Even with only these two bars the agreement with data from Gerbier et al. is excellent!
- We will have the best Si QF measurement with Antonella data
- Various possible measurements
- We need more callibration points: linearity
- We need to measure distances up to 1-2mm
- Antonella: supporting bars?

Statistics projection for December run

- We have 1400 good events in one of the Two-bar 2013 runs, which lasted 1.5hrs. B2 is 21.4cm away from B1 (tgt). Antonella bars are 90cm away from the tgt, and the collimator hole is 0.7cm. We will have in 1shift (7hrs), for scintillator QF measurement,

  $$(0.7)^2\,(21.4/90)^2\,(7/1.5)\,1400 = 181 \text{ events/bar}$$

  To reduce error bars to 1/2, we need 2-3 shits (change collimator??)

- We have 60 good events in the SD+2Bar 2013 run, in a 1shift run, on a bar that was at 16.3cm from the SiDet. If we dedicate 12 days to this run we will have

  $$(16.3/90)^2\,(36/1)\,60 = 71 \text{ events/bar}$$

- Si and C run to measure resonances: 1-2 shifts (??)
- Background estimation: 1 shift