Angular distributions and Angular correlations in the GRETINA array

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First, the good news about tracking arrays:

$$\omega(\theta) = A0 + \alpha_2 A2 P_2(cos\theta) + \alpha_4 A4 P_4(cos\theta),$$

The alphas are attenuation coefficients which take into account the opening angle of your detector. In Gammaspere, this angle is ~6 degrees.

In tracking arrays, this is the angle resolution, which in turn is determined by the position resolution of the first interaction point for a tracked gamma ray: the angle resolution is the order of 0.15/0.12 degrees for GT (r=18.5 cm)/AG(r=23.5 cm).

Thus, the attenuation is down by a factor of ~1/40 and can practically be ignored

We assumed ~5mm FWHM resolution. This may not hold!
Mitch will discuss this in the next talk

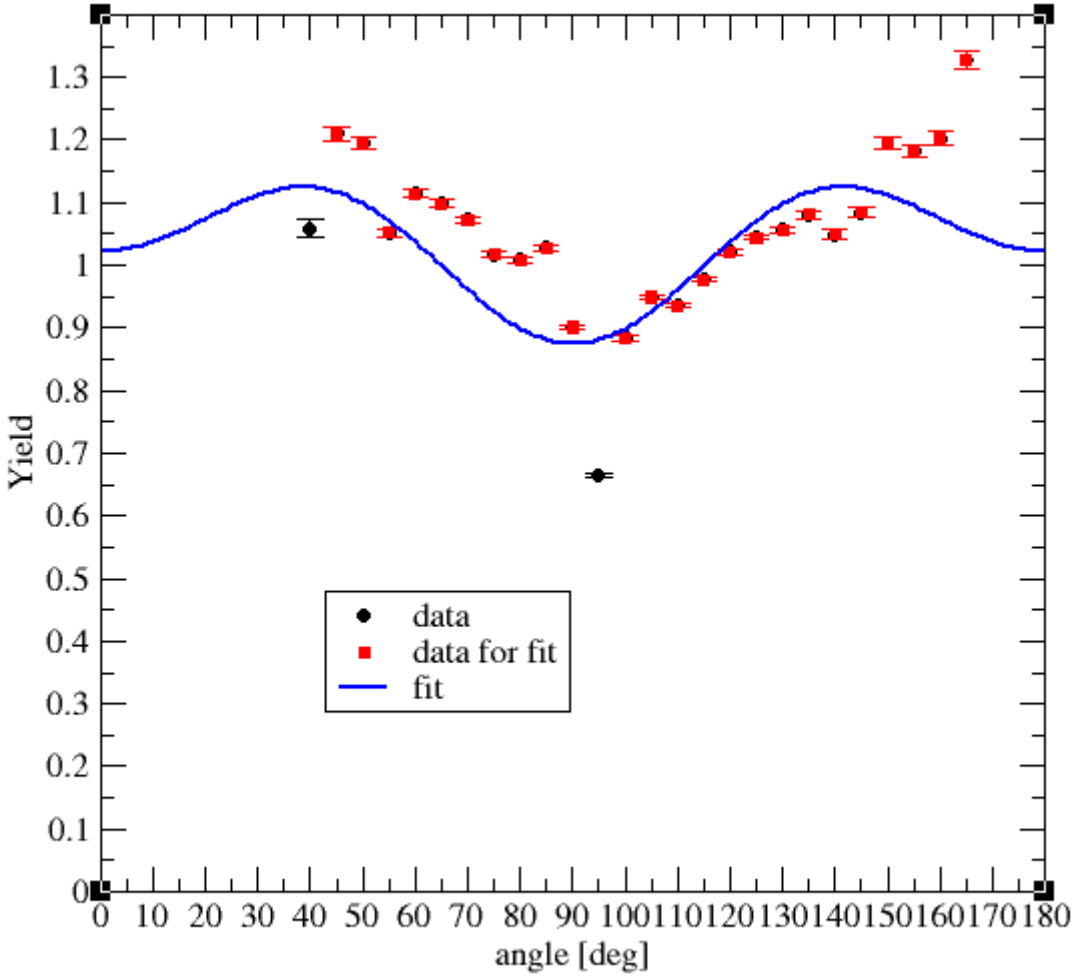
Angular distributions and Angular correlations in the GRETINA array

Work in progress...

Start with ***angular distributions***
Should be easy, right?

Bin the angle of first hit in GT of tracked gamma rays vs beam axis and normalize with a source.
Nothing could be easier, right?

We found: All lines look a bit like this or worse:



Mon Jan 29 15:31:01 2018

443.3 line
in 158Er

chi**2: 328.522
a0: 1.014 +/- 0.002
a2: 0.160 +/- 0.005
a4: -0.151 +/- 0.006

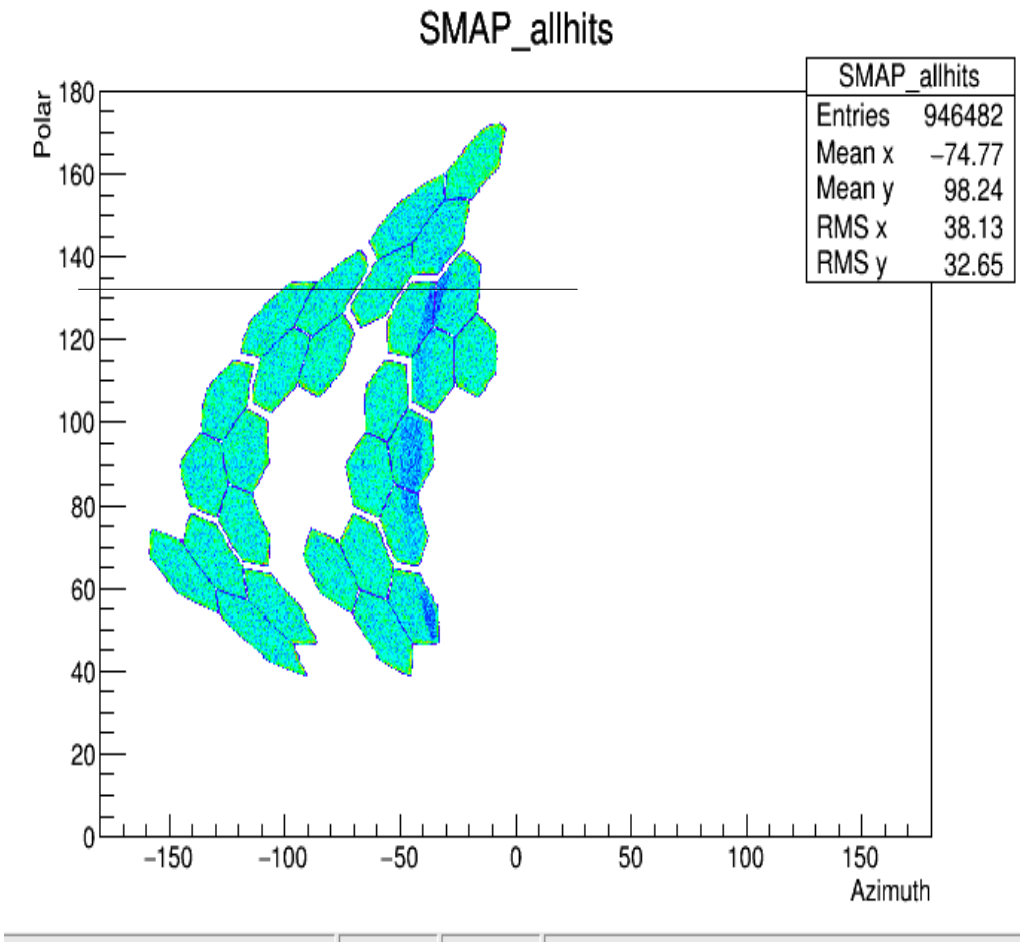
Why does it not work out?

What is the problem?

Low and higher energy world maps

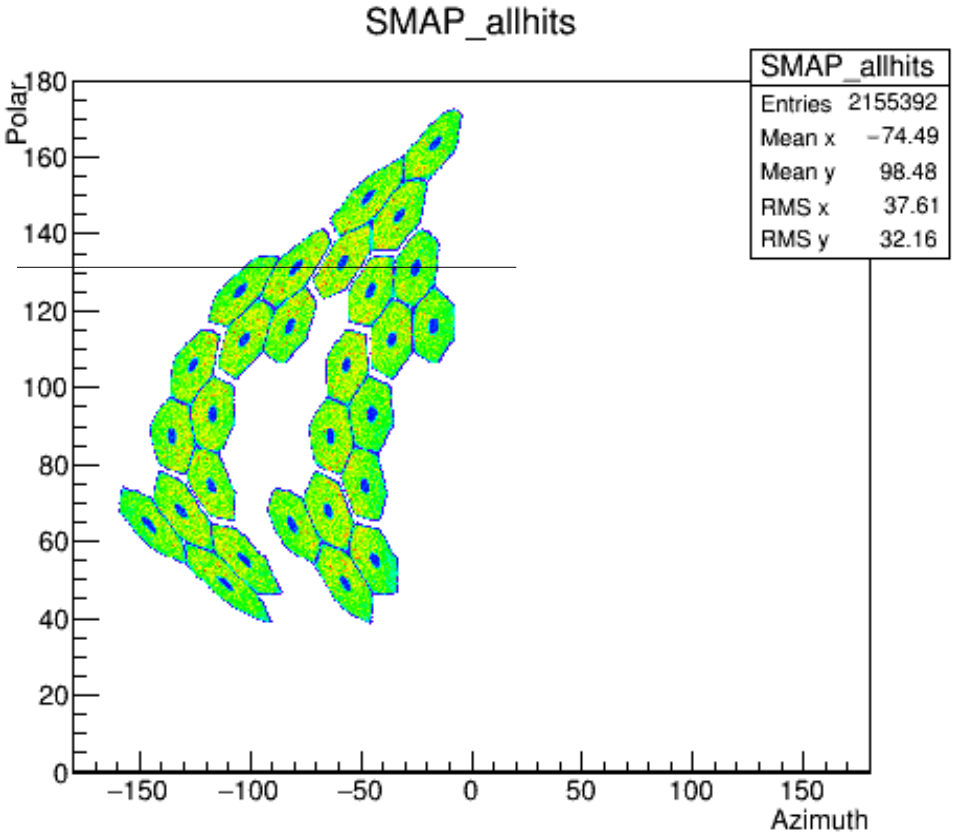
(UCGretina simulations, ^{166}Ho)

80 keV, see target chamber, but not holes



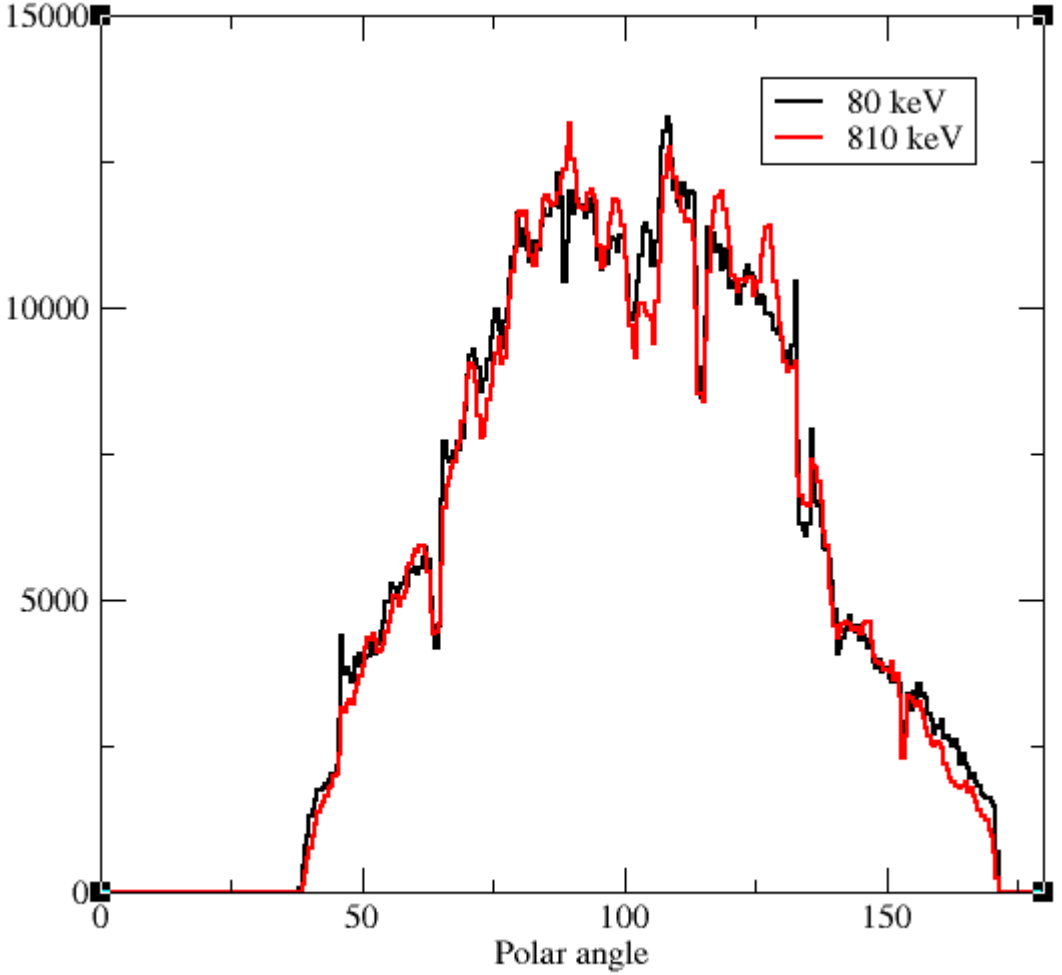
[1] The gamma rays will see different arrays as function of energy!!

810 keV, does not see target chamber, but see holes



[2] Holes and spaces pop in and out as function of polar angle!! + outside deadlayers on tapered surfaces

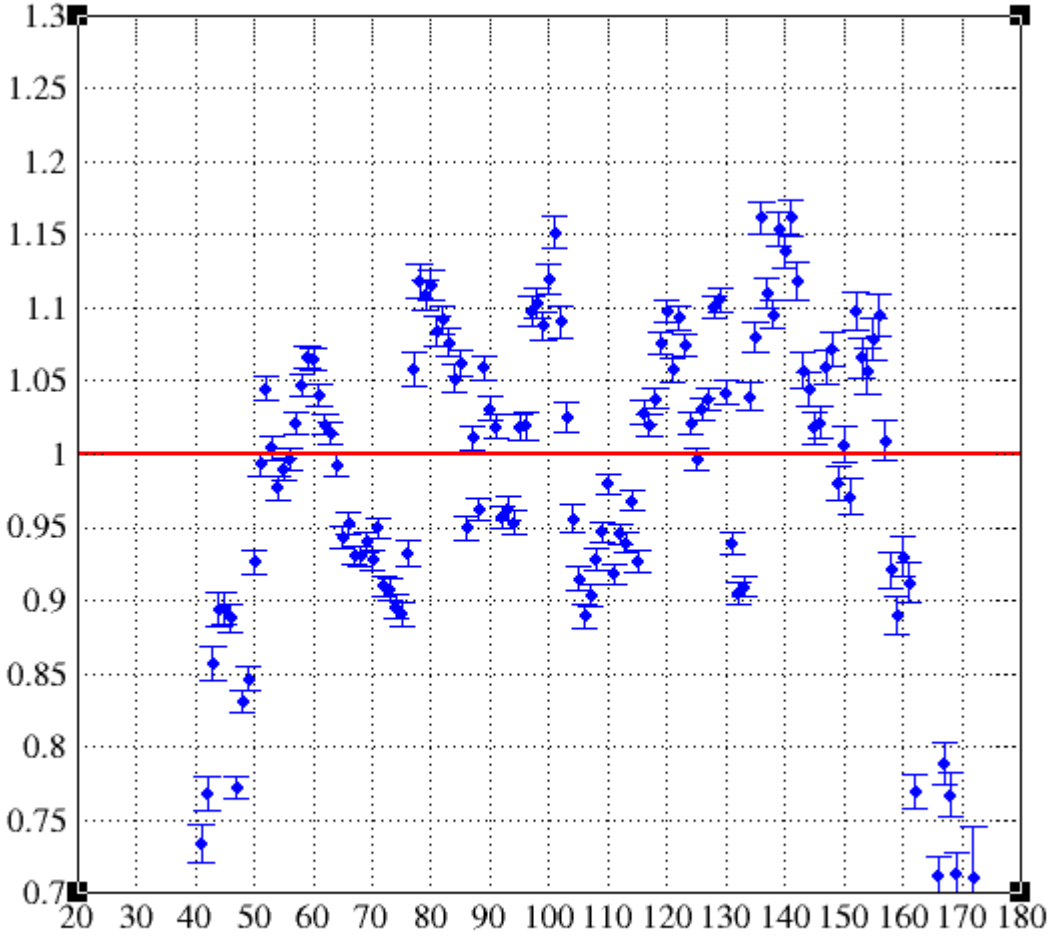
Projections, 810 vs 80 keV



Wed Mar 28 11:58:29 2018

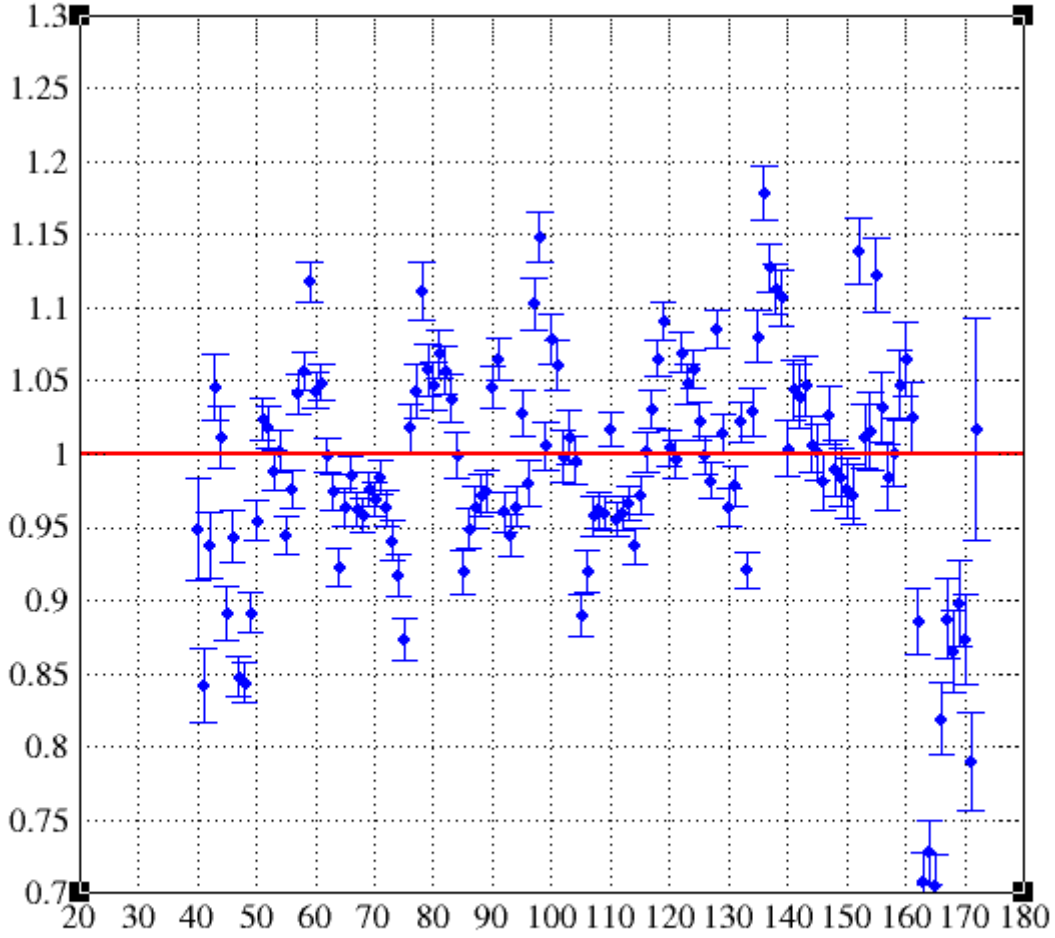
To illustrate the problem: Ratio of polar angle spectra in ^{166}Ho

rat.sh isotropic_810 isotropic_80



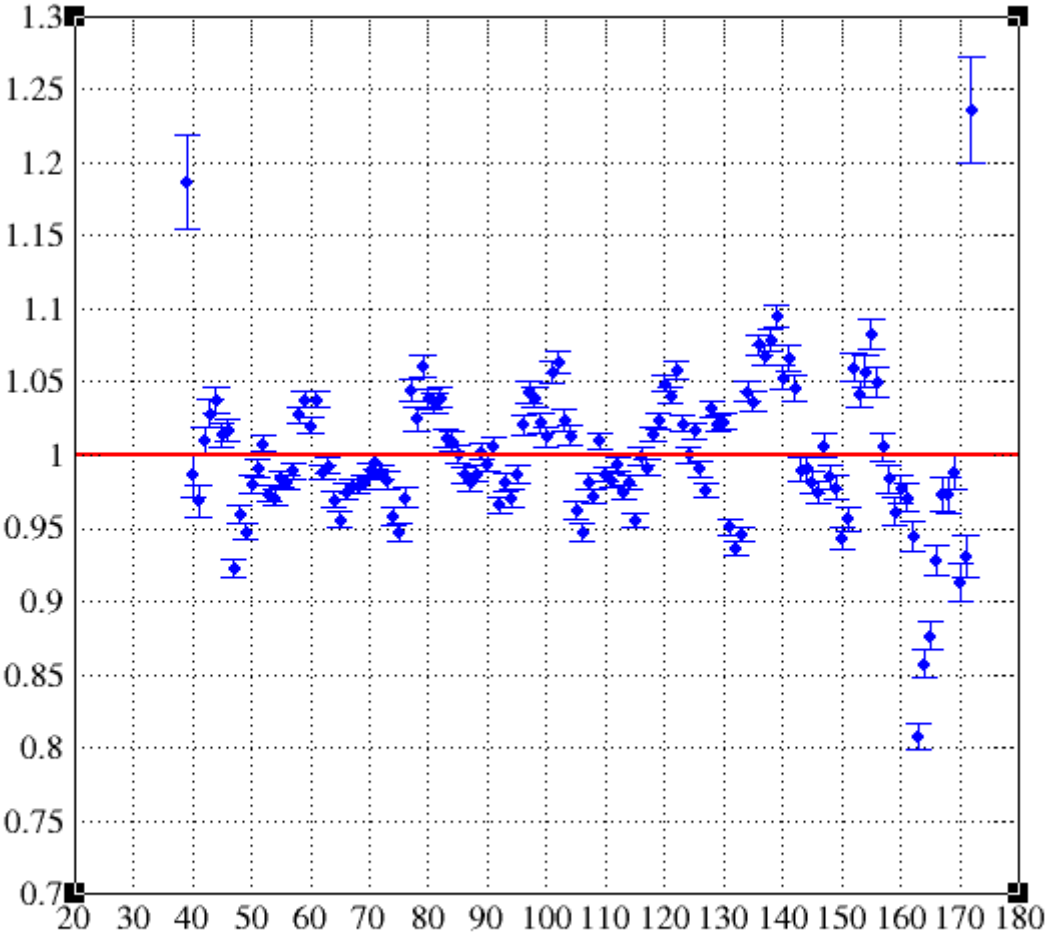
Mon Feb 5 14:06:39 2018

rat.sh isotropic_411 isotropic_80



Mon Feb 5 13:59:41 2018

rat.sh isotropic_184 isotropic_80



Mon Feb 5 13:57:23 2018

It is difficult to construct a good normalization spectrum

- Why was this not a problem in Gammaspere?
- Because we go by rings, and each ring has the same hole to Germanium ratio
- Thus, the polar angle spectrum for different energies only has an offset to them, but no structure with respect to polar angle
- ----------

- **The tiling of tracking arrays makes it more difficult to construct a proper normalization spectrum.**

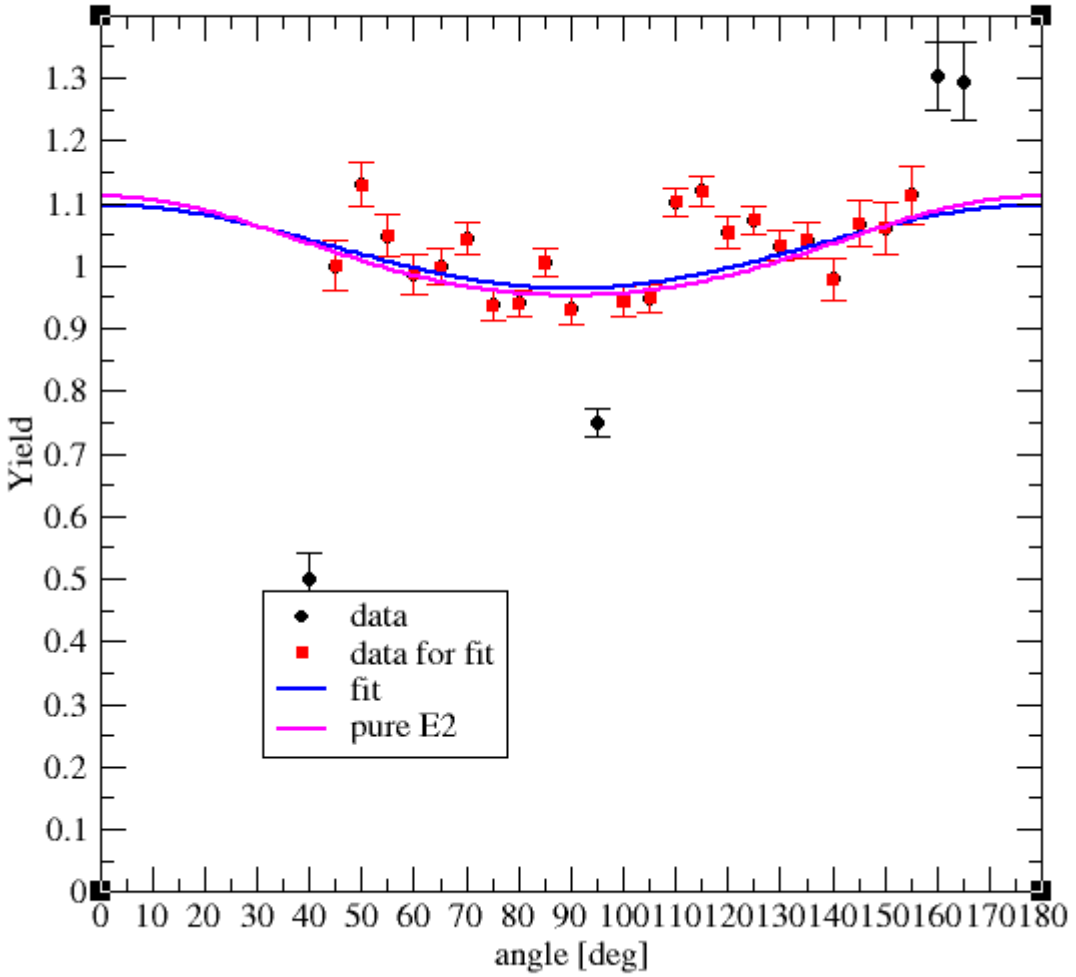
Solutions?

O use simulations to normalization (nope...)
O use nearby source lines (better)
O use *energy weighted source lines* to recreate the energy of interest
O for thick targets, use activation line(s)

Background subtraction becomes important as the Compton background originates from lines at higher energies and therefore see a different array compare to the line above it

Stay tuned for new results... ongoing

Gretina:443 keV line in ^{158}Er in-beam angular distribution extraction



Used 411 and 451 keV angular distributions in ^{166}Ho for normalization (energy weighted)

a0,a2 fit>>>

chi**2: 16.748
a0: 1.008 +/- 0.007
a2: 0.088 +/- 0.020

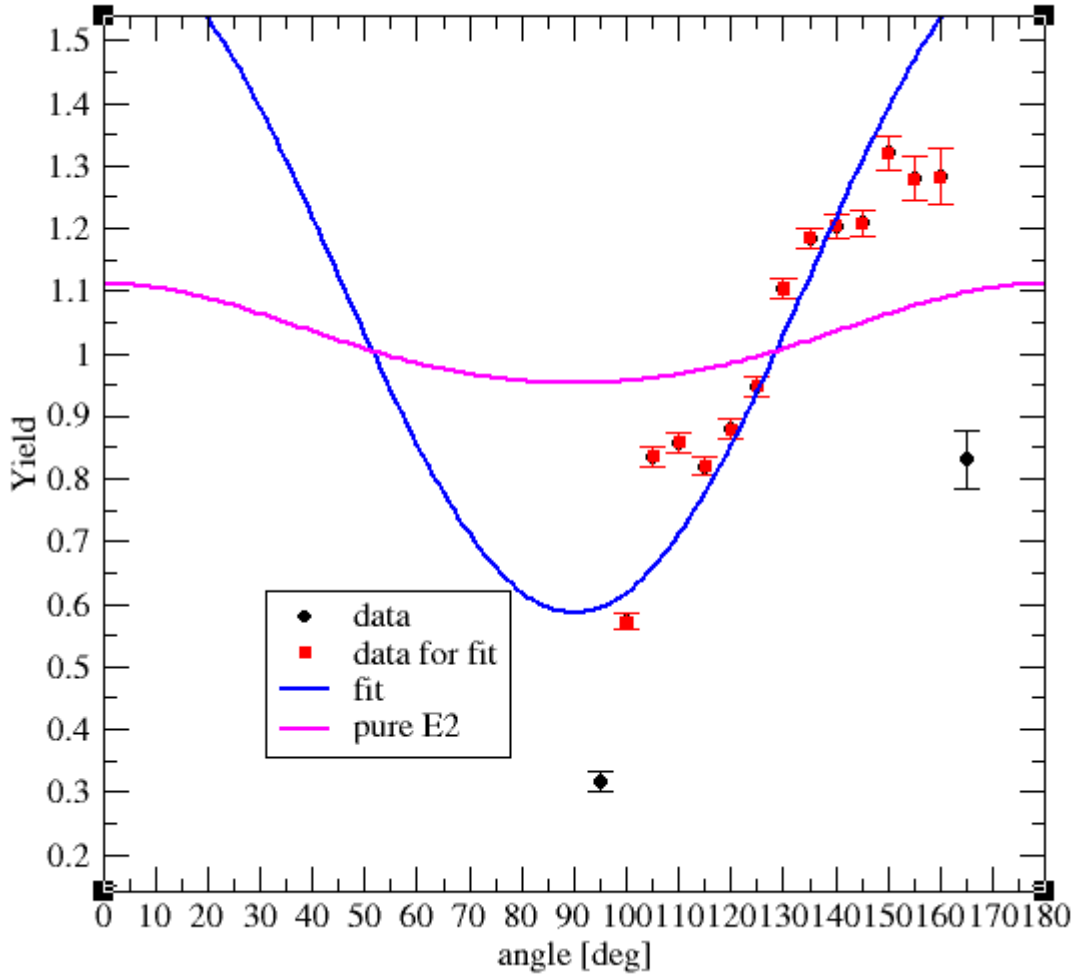
8+ to 6+ line

First look

AGATA: 158Er 443 keV line

with 413 KeV activation line as reference

May not be OK...

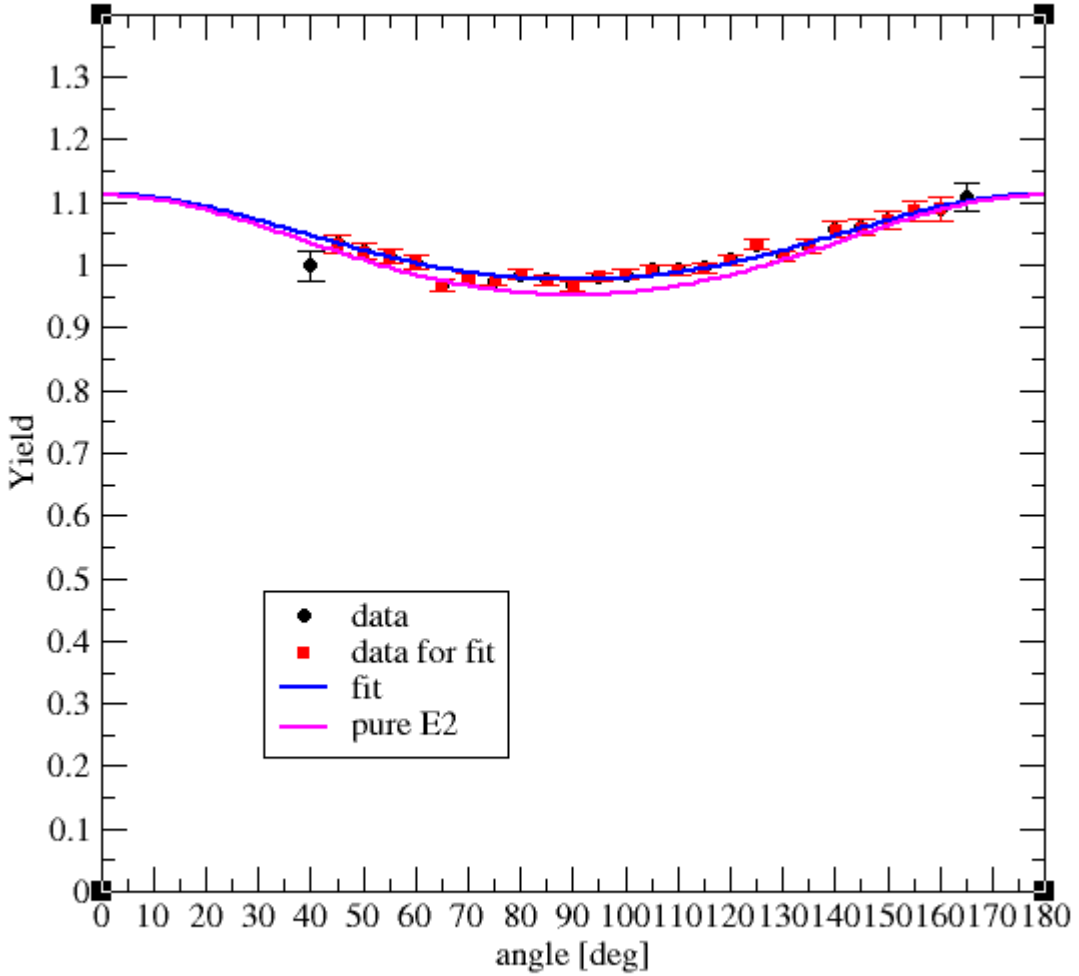


chi**2: 54.806
a0: 0.945 +/- 0.005
a2: 0.759 +/- 0.015

software check

UCGretina simulation, 443 Kev line in ^{158}Er

(ref spectrum simulated with A2=A4=0)



Sat Feb 24 15:16:32 2018

chi**2:	1.176	
a0:	1.017 +/-	0.003
a2:	0.086 +/-	0.008
a4:	0.009 +/-	0.009

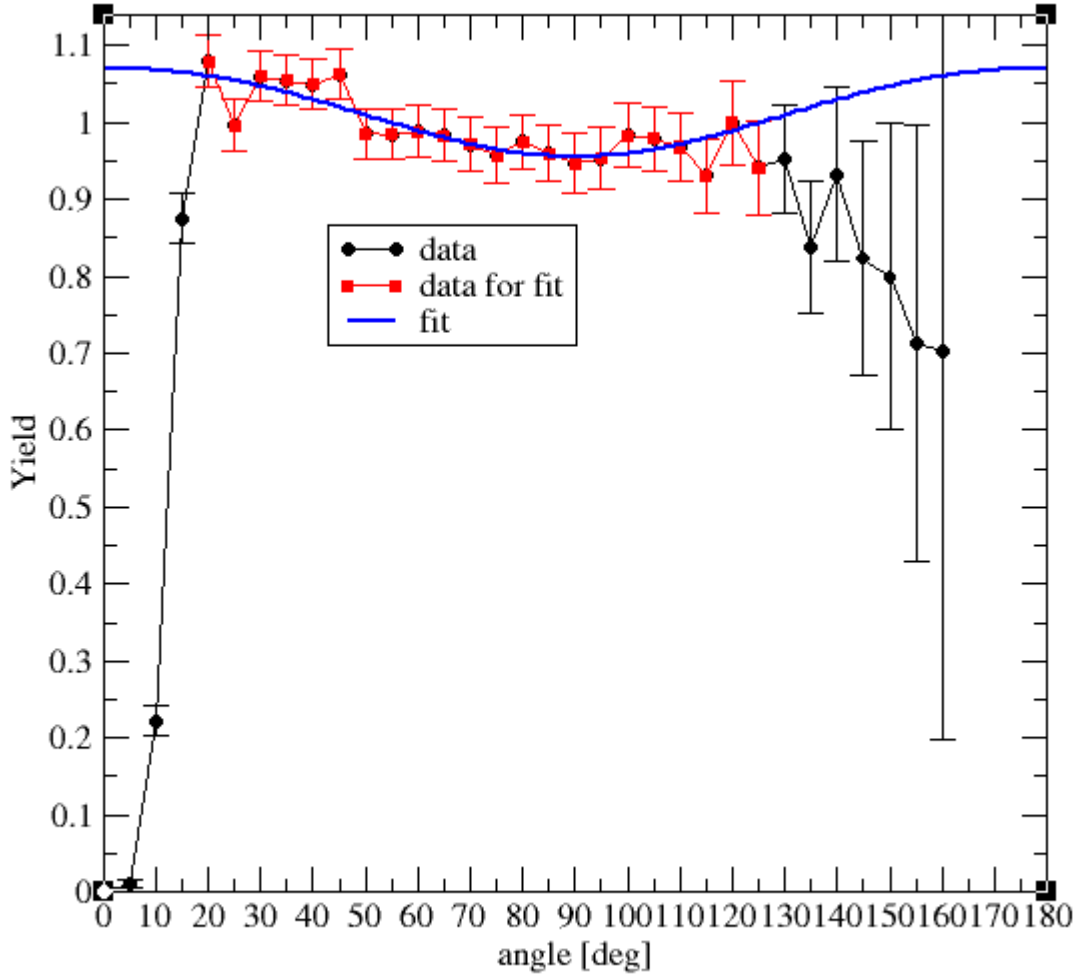
The way we extract the angular distribution seems OK.

How about angular correlations

- Here we have two things going for us:
-
- [1] Since we bin the angle between gamma rays, the problems we just discussed gets '**averaged out**'
- [2] We can make a very good normalization spectrum, from the in-beam data itself, by mixing events that are not in coincidence (and therefore cannot have an angular correlation)

with background subtraction: 10-8-6 in ^{158}Er

angcor_par 523.3 579.3 490 590 2 6



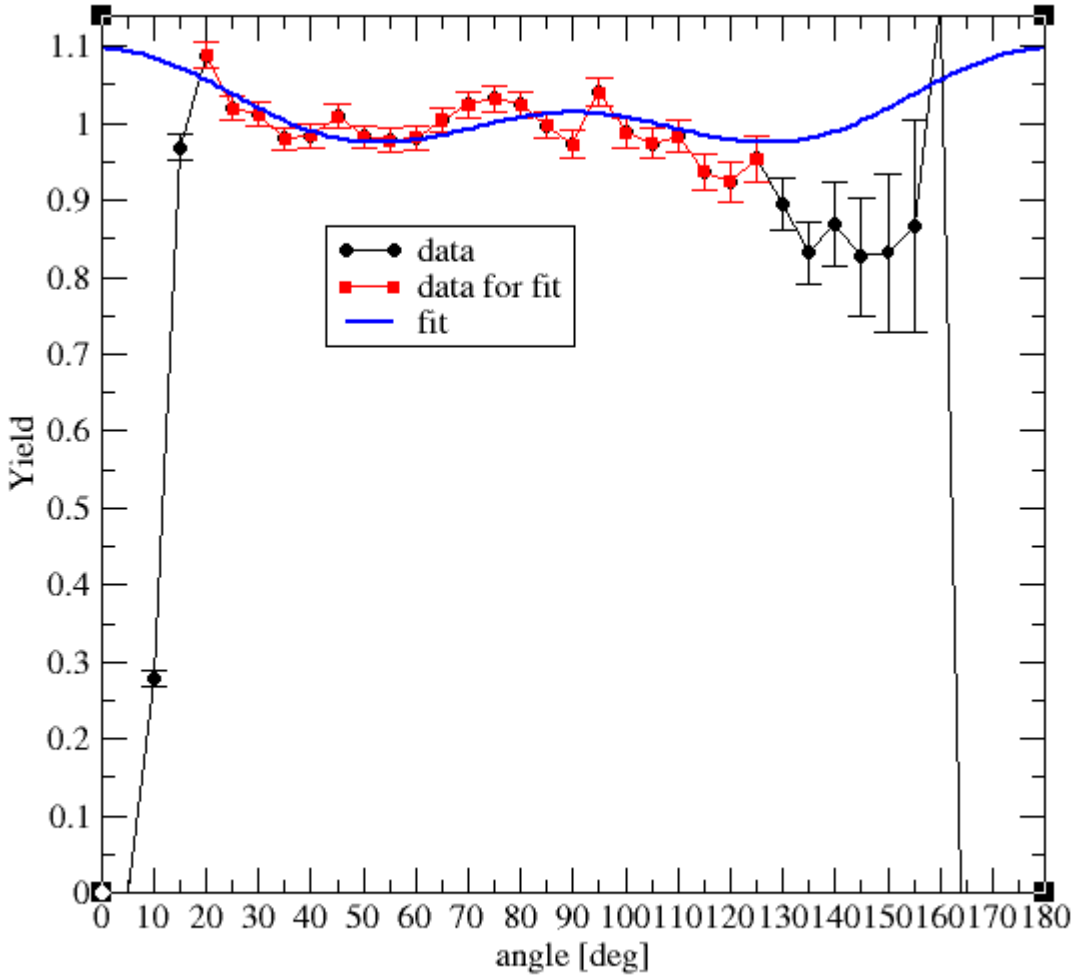
Thu Jan 25 15:38:35 2018

chi**2: 0.468
a0: 0.997 +/- 0.008
a2: 0.080 +/- 0.018
a4: -0.006 +/- 0.027

Seems the errors are overestimated, why!?

with background subtraction sum67.root, 4-2-0

angcor_par 192.3 335.3 180 325 2 6



Thu Jan 25 15:49:07 2018

chi**2: 2.122
a0: 1.002 +/- 0.004
a2: 0.027 +/- 0.008
a4: 0.068 +/- 0.013

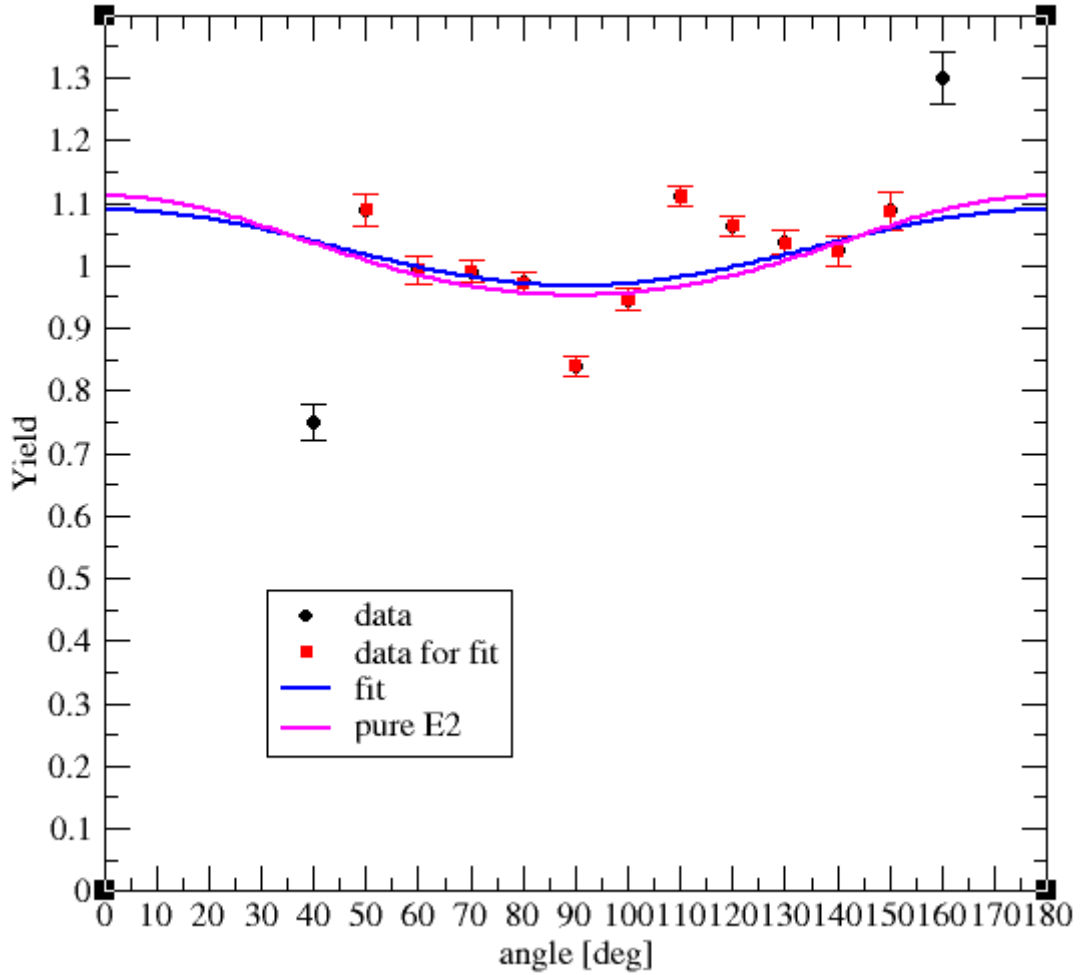
This is clearly not good....
Maybe too much background?
(Mitch next)

Conclusions

- Angular distributions using tracked data from tracking arrays is tricky because of the tiling
- Angular correlations do better; but we find problems at low energies/spins (see Mitch talk next)
- Clearly, we have to works more on this, stay tuned...
- We need to do same analysis for AGATA which has a different tiling.

Extra slides

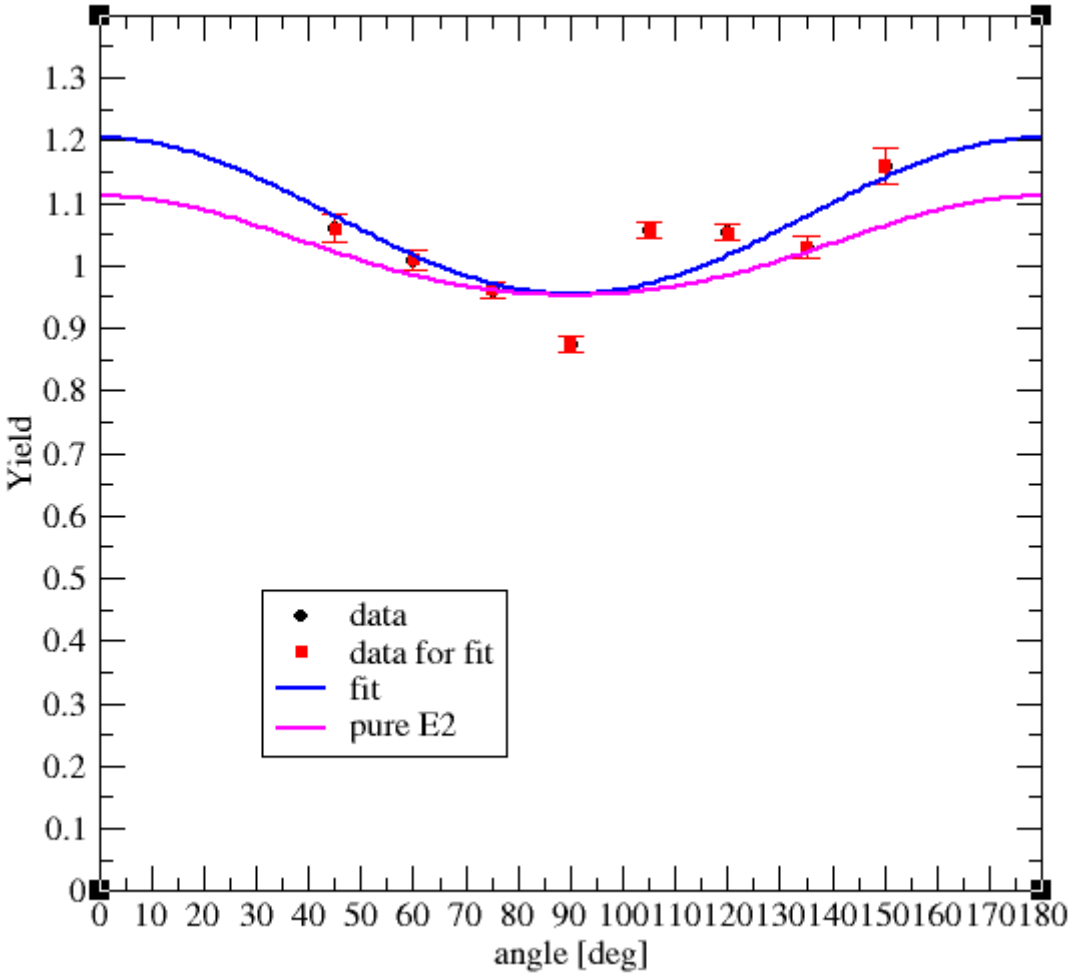
Angdis 10 deg binning



a0,a2 fit>>>

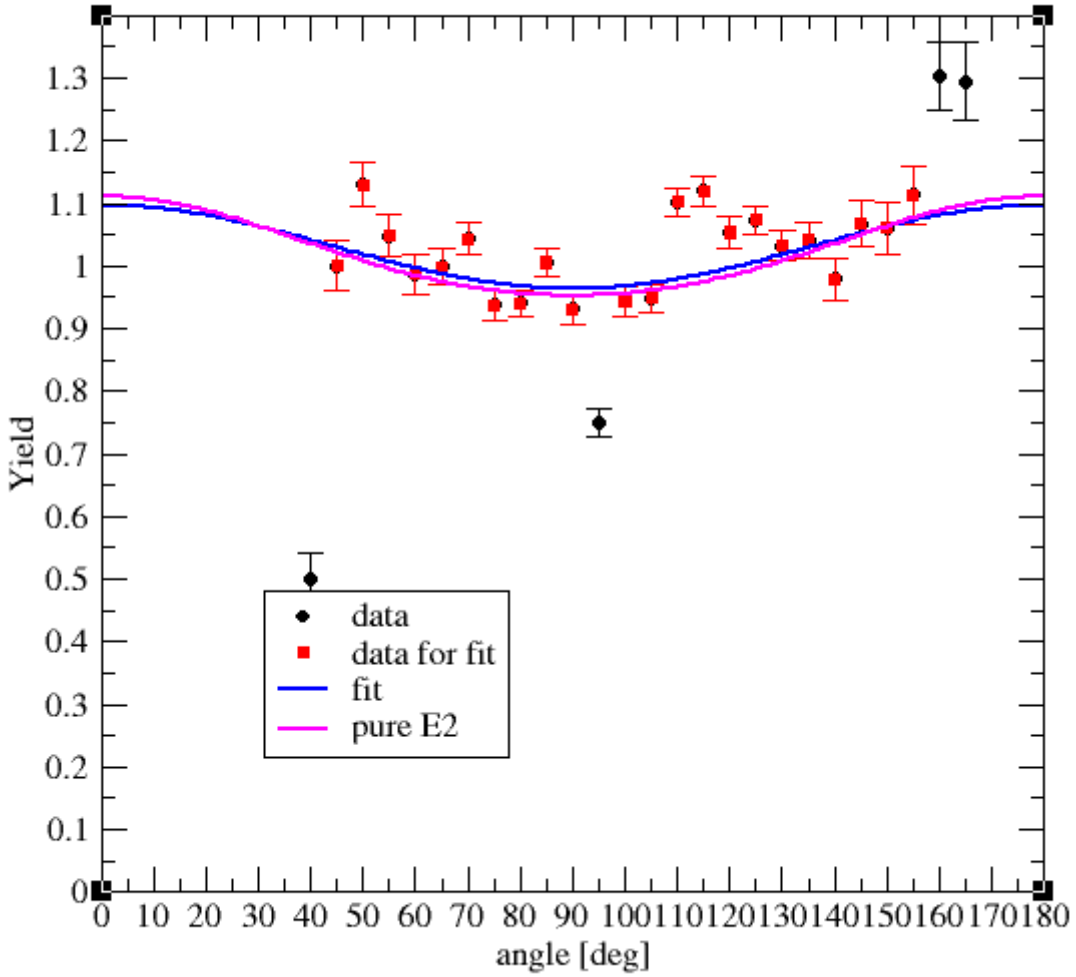
chi**2: 22.367
a0: 1.008 +/- 0.007
a2: 0.080 +/- 0.018

Angdis 15 deg



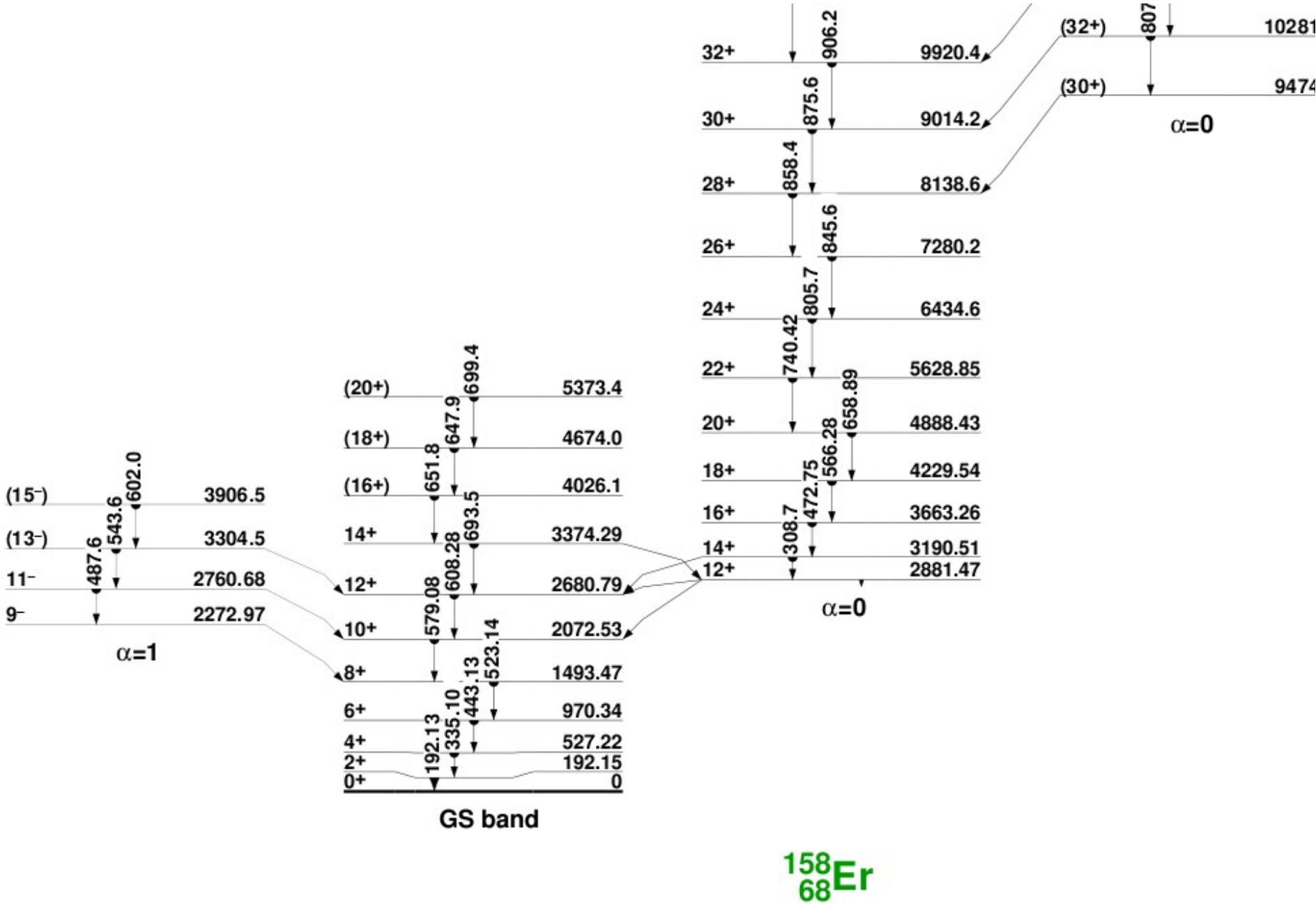
chi**2: 13.314
a0: 1.038 +/- 0.007
a2: 0.160 +/- 0.018

Use background spectrum as the 'isotropic'



...Not a good thing to do since we do not know the background spectrum well

chi**2: 16.748
a0: 1.008 +/- 0.007
a2: 0.088 +/- 0.020


(15⁻)
3906.5
602.0
(13⁻)
3304.5
543.6
11⁻
2760.68
487.6
9⁻
2272.97
α=1
(20+)
5373.4
699.4
(18+)
4674.0
647.9
(16+)
4026.1
651.8
14+
3374.29
693.5
12+
2680.79
608.28
10+
2072.53
579.08
8+
1493.47
523.14
6+
970.34
443.13
4+
527.22
335.10
2+
192.15
192.13
0+
0
GS band
32+
9920.4
906.2
30+
9014.2
875.6
28+
8138.6
858.4
26+
7280.2
845.6
24+
6434.6
805.7
22+
5628.85
740.42
20+
4888.43
658.89
18+
4229.54
566.28
16+
3663.26
472.75
14+
3190.51
308.7
12+
2881.47
α=0
(32+)
10281
807
(30+)
9474
α=0
158 68 Er