GRETINA high-energy efficieny

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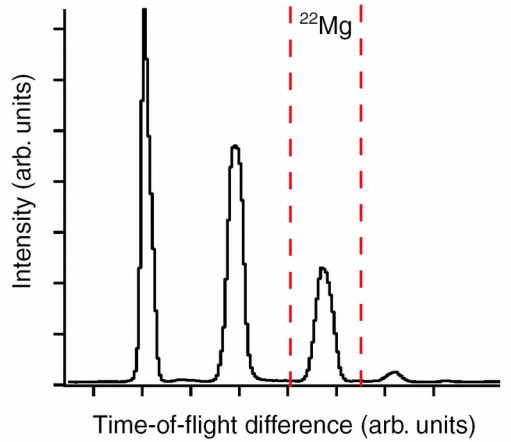
GRETINA was funded by U.S. DEPARTMENT OF ENERGY

Layout of a fast-beam experiment at NSCL…

…involving the S800 spectrograph

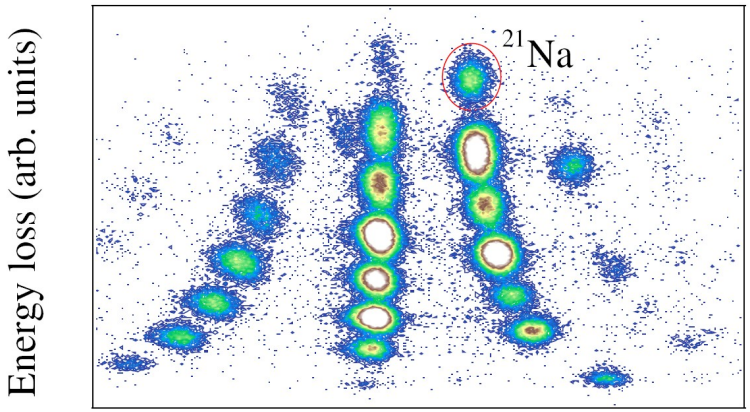


Identification and beam transport
80-100MeV/nucleon
100-10^6 pps

Reaction target
100-400mg/cm^2

A1900 fragment separator

Reaction product identification
S800 spectrograph

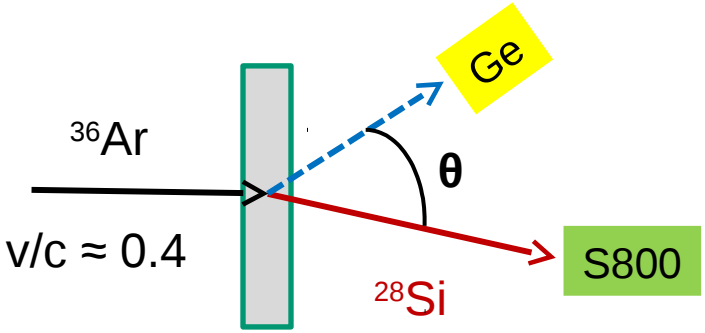


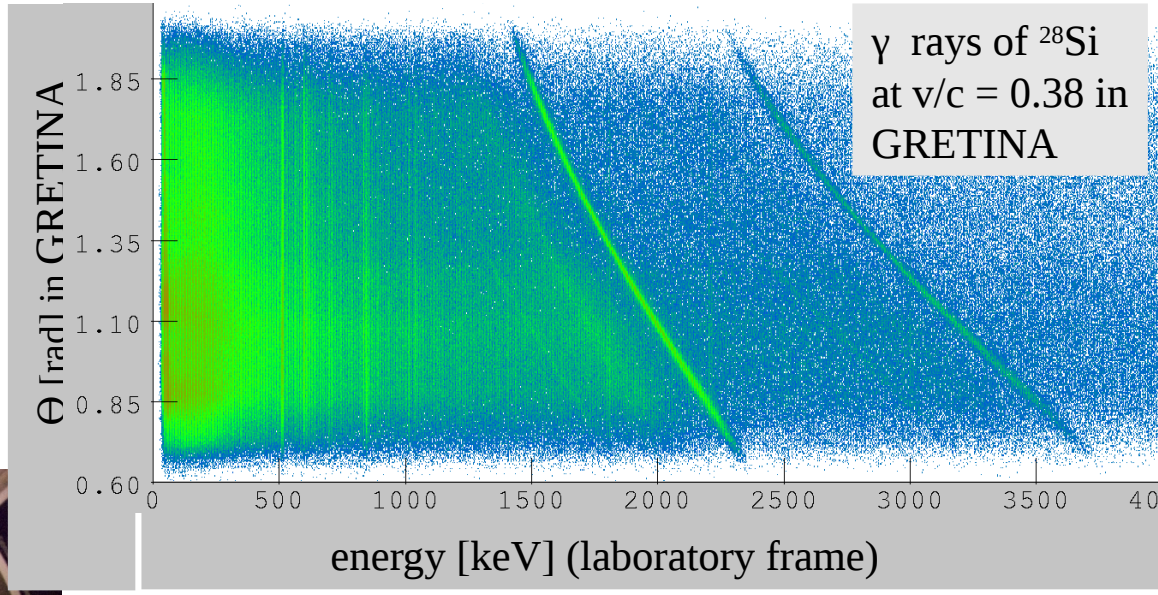
Production target
Beam energy from cyclotrons 100-150MeV/nucleon

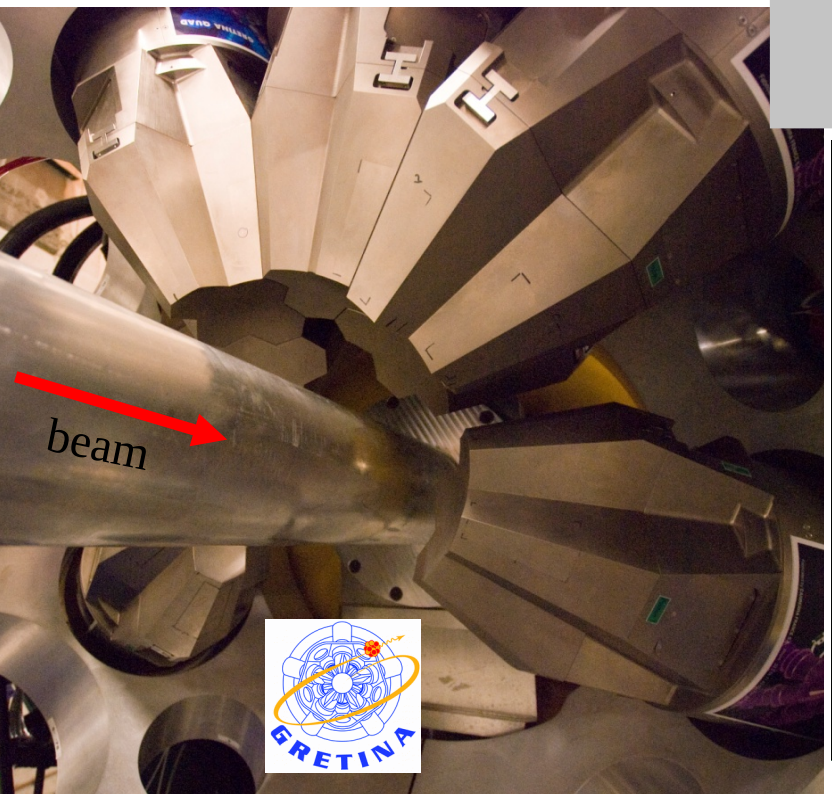
D. J. Morrissey, NIM B **204**, 90 (2003)
D. Bazin, NIM B **204**, 629 (2003)

Length ~80m (260 ft)
(linear distance)

Gamma spectroscopy with fast beams







(Obvious) requirements for a spectrometer:

Doppler-shift correction

→ Spatial resolution

Lorentz Boost

→ Detection efficiency at forward angle

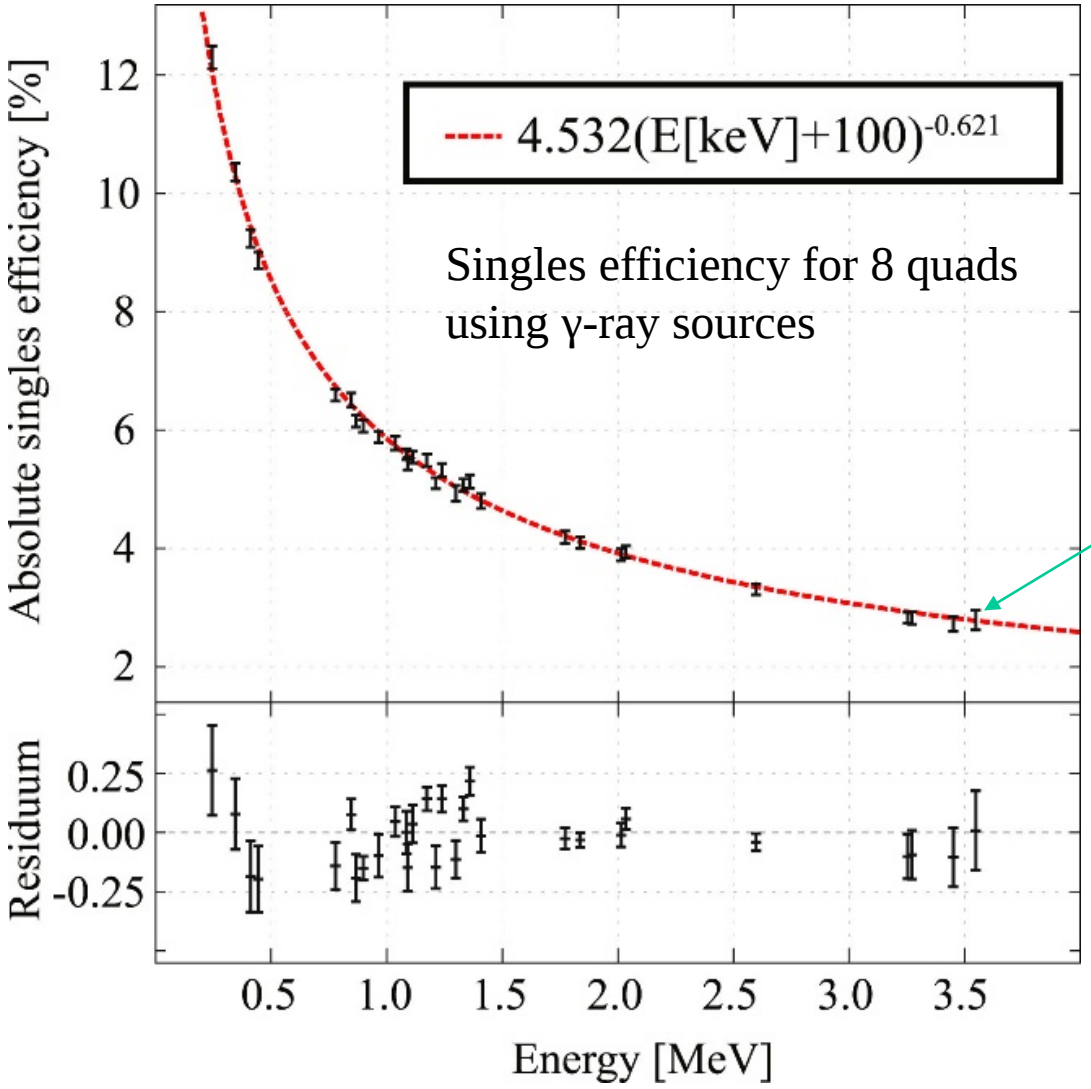
…and GRETINA is a perfect match

FWHM in-beam ~1.5%*, efficiency 8.4% at 1.3MeV**

for details see **NIM 847 (2017), 187-198**

*usually limited by E-loss in target **add-back and 10 modules

Efficiency with (calibrated) sources



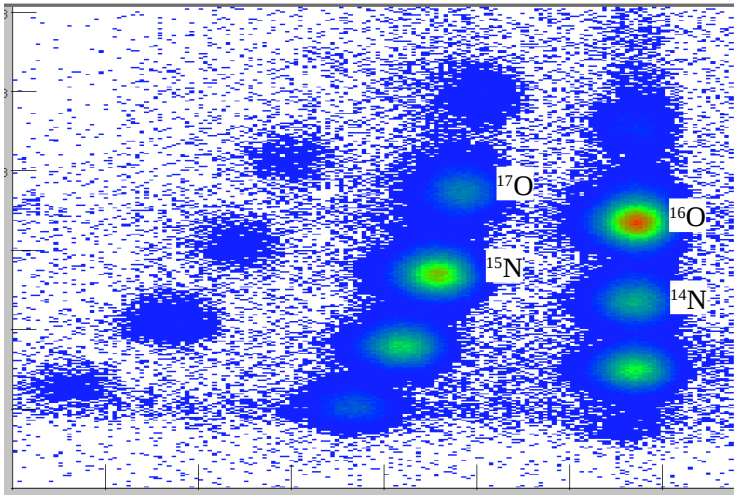
Standard sources:
^{152}Eu, ^{226}Ra, ^{60}Co, ^{88}Y, ^{56}Co, ….

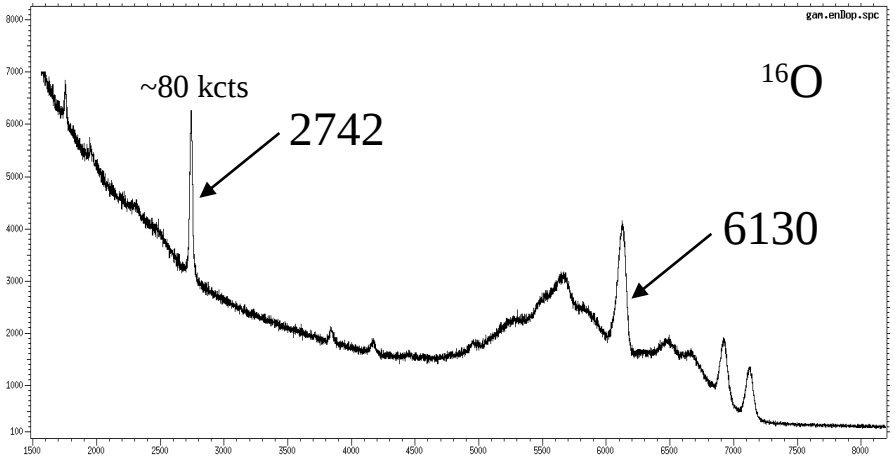
Highest calibration point at 3.5MeV

Many fast-beam experiment have interesting γ rays far beyond 4MeV!

NIM 847 (2017), 187-198

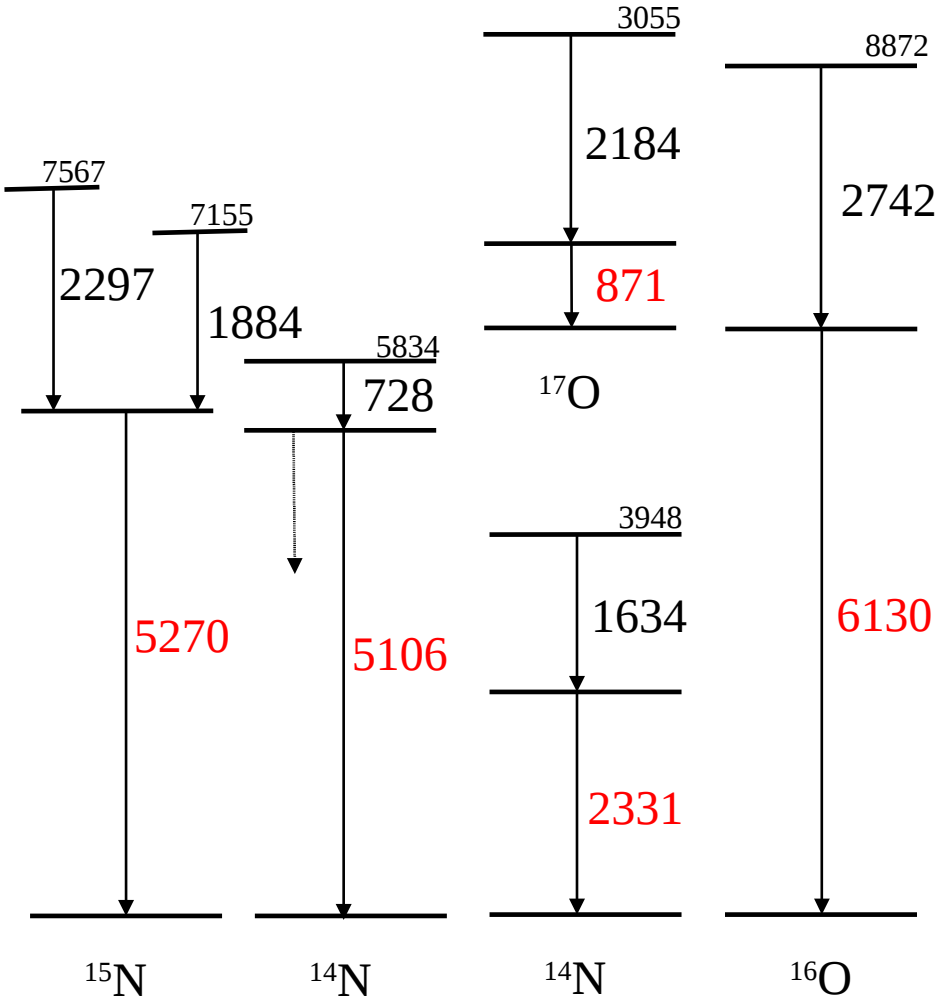
Use high-energy in-beam coincidences



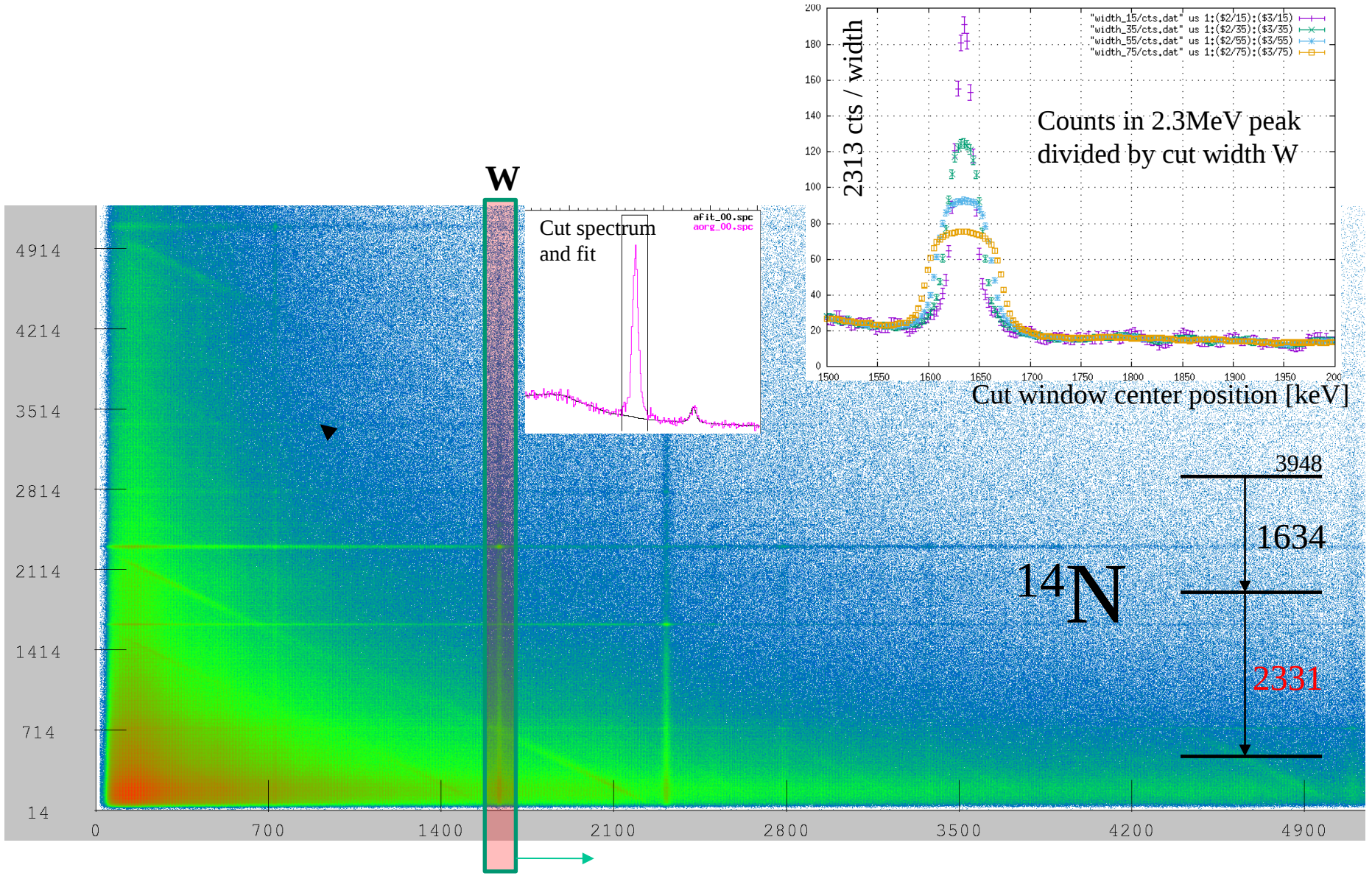


'Simply' count the γ's feeding the state and look in coincidence for amount of γ's depopulating the state.

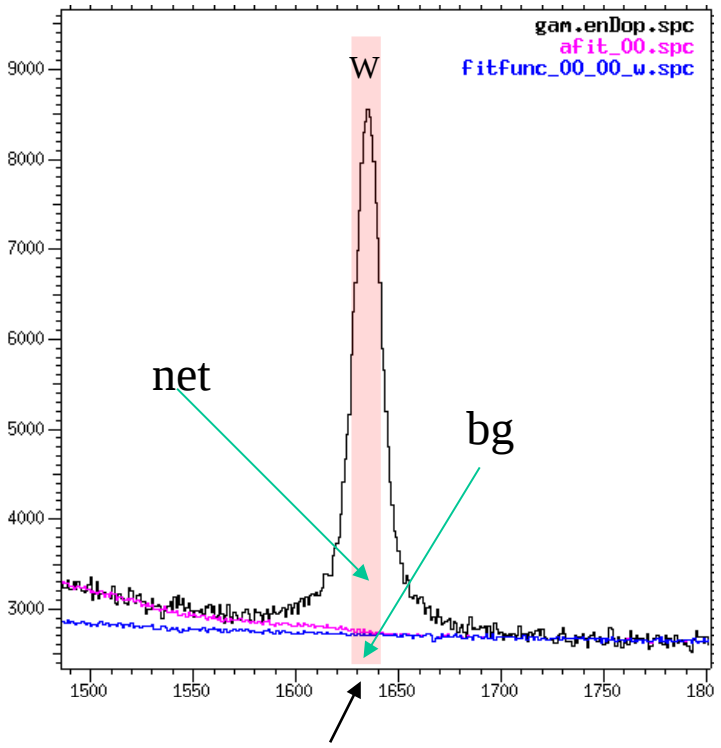
Provides efficiency data points at:
871, 2331, 5106, 5270, and 6130keV



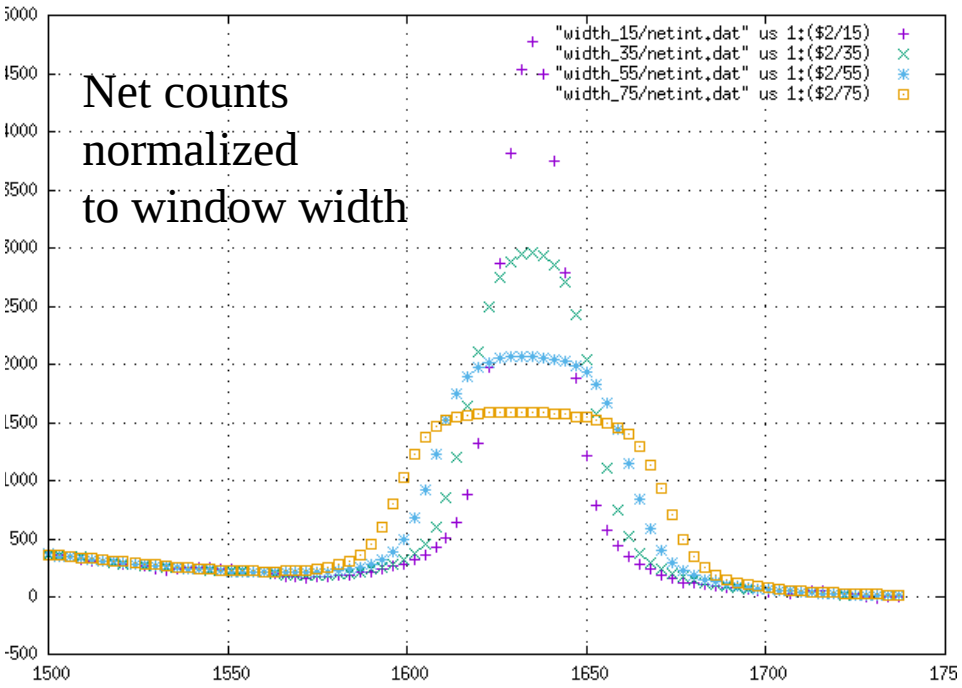
Getting coincident counts



Getting the corresponding singles counts

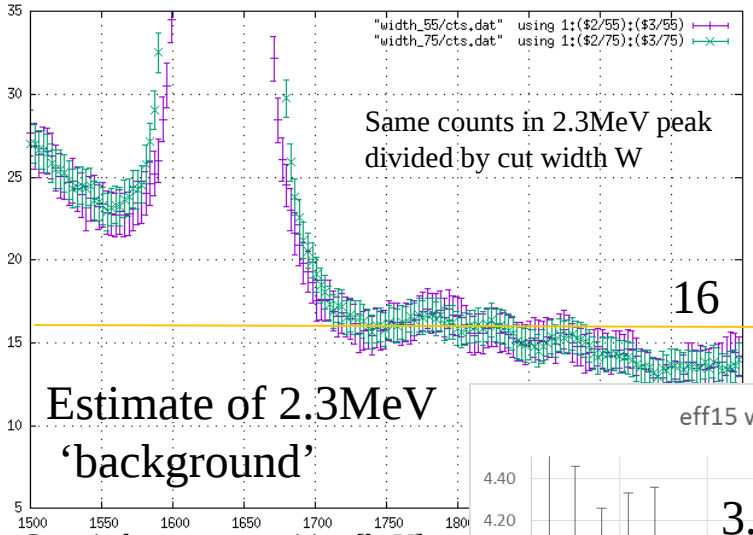


Same position as cut window

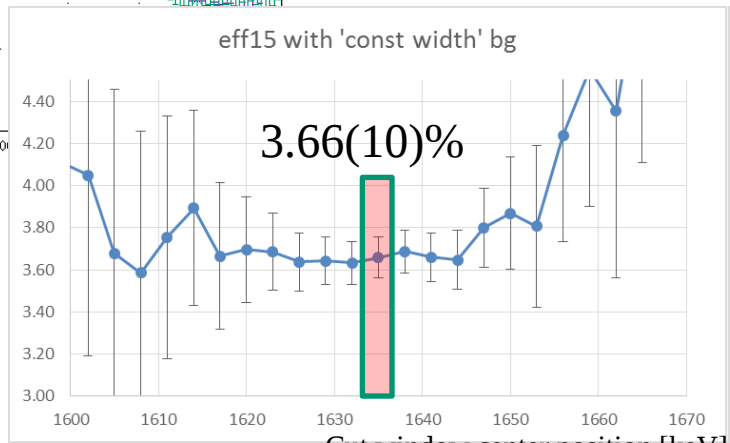


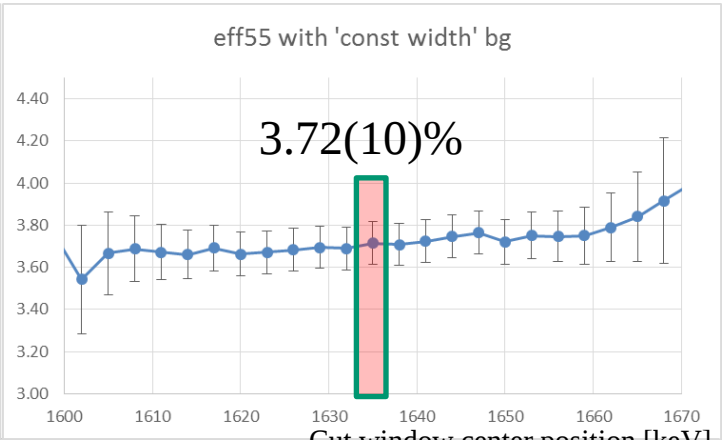
Cut window center position [keV]

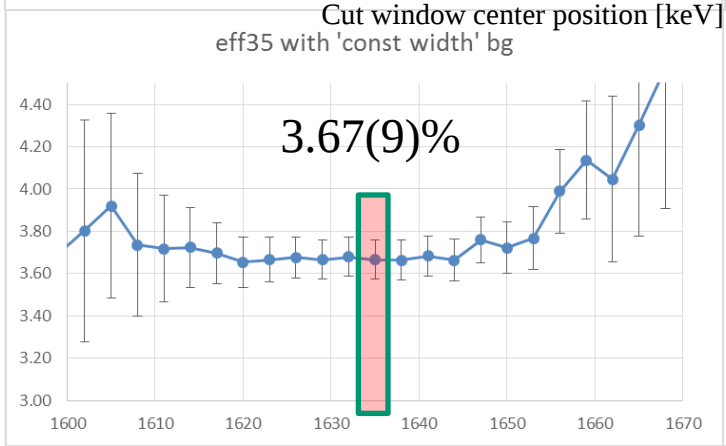
…and extracting an efficiency

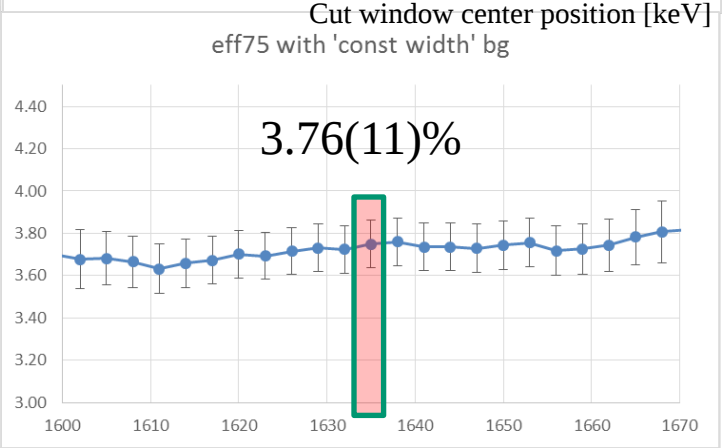


Efficiency from counts in 2312keV corrected for bg cts weighted by cut width (as done in 'standard' cutting):
(2312keV cts – **width** x **16.0**) / net_singles with 16(1).

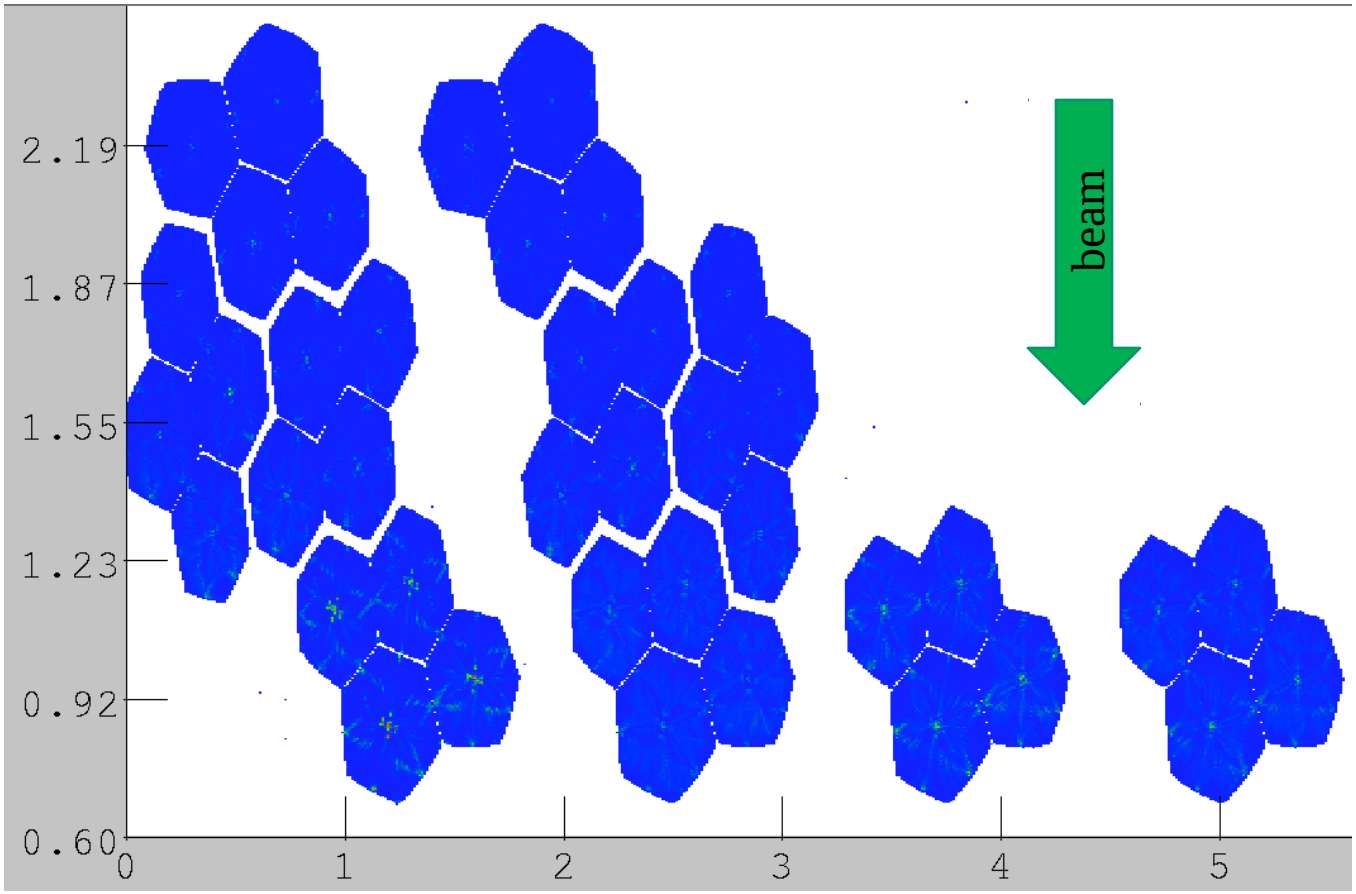








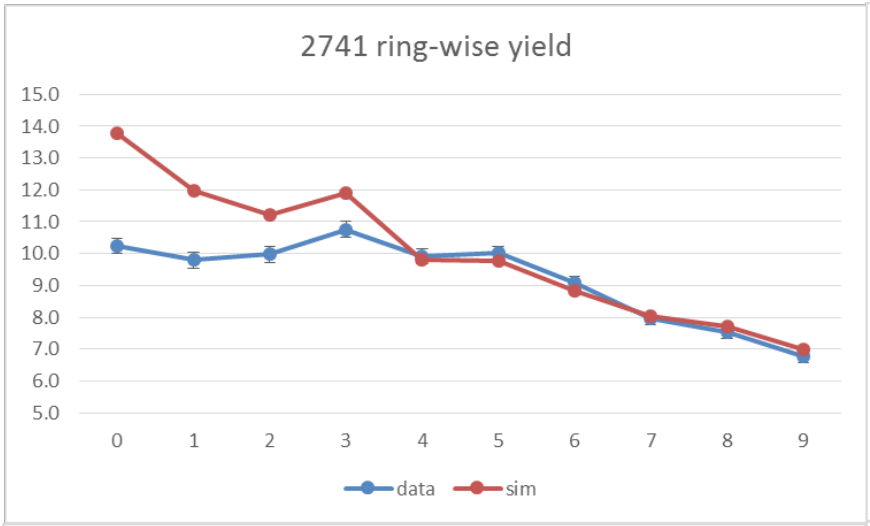
But 3.76(11)% is not enough..

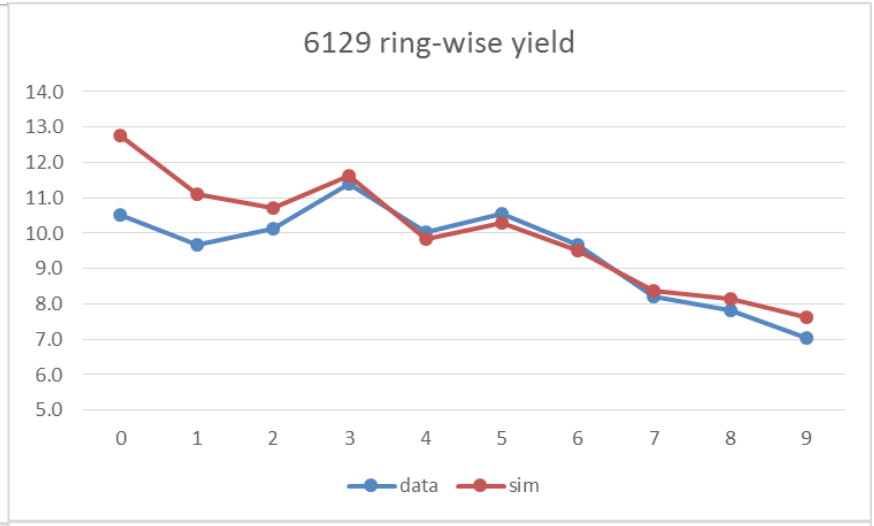


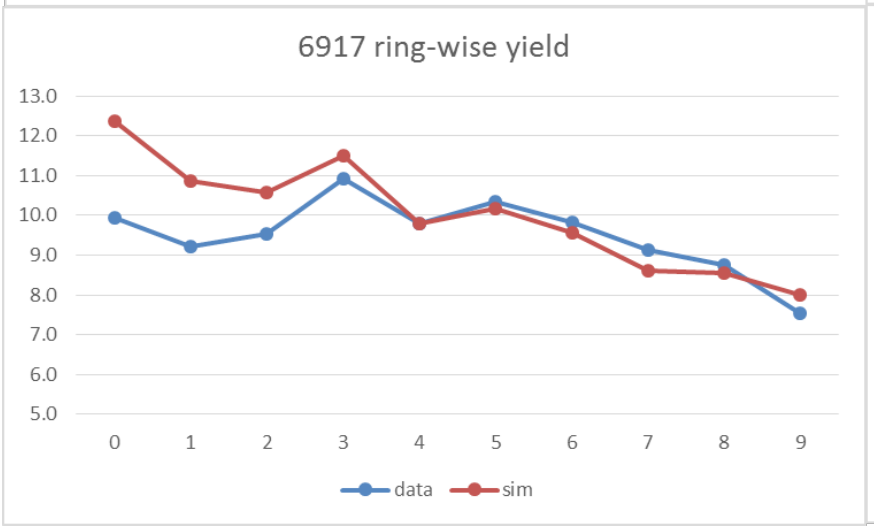
For 10 quads in this configuration we expect to see ~4.1% (GEANT γγ)!

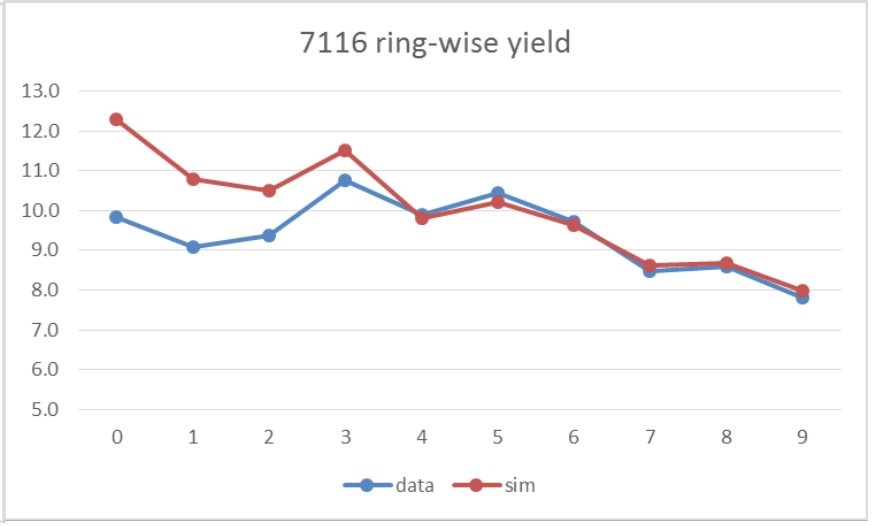
GEANT also considers the angular correlation, though here the cascade is 1-0-1 (i.e. isotropic)

Smoking gun: loss in forward detectors









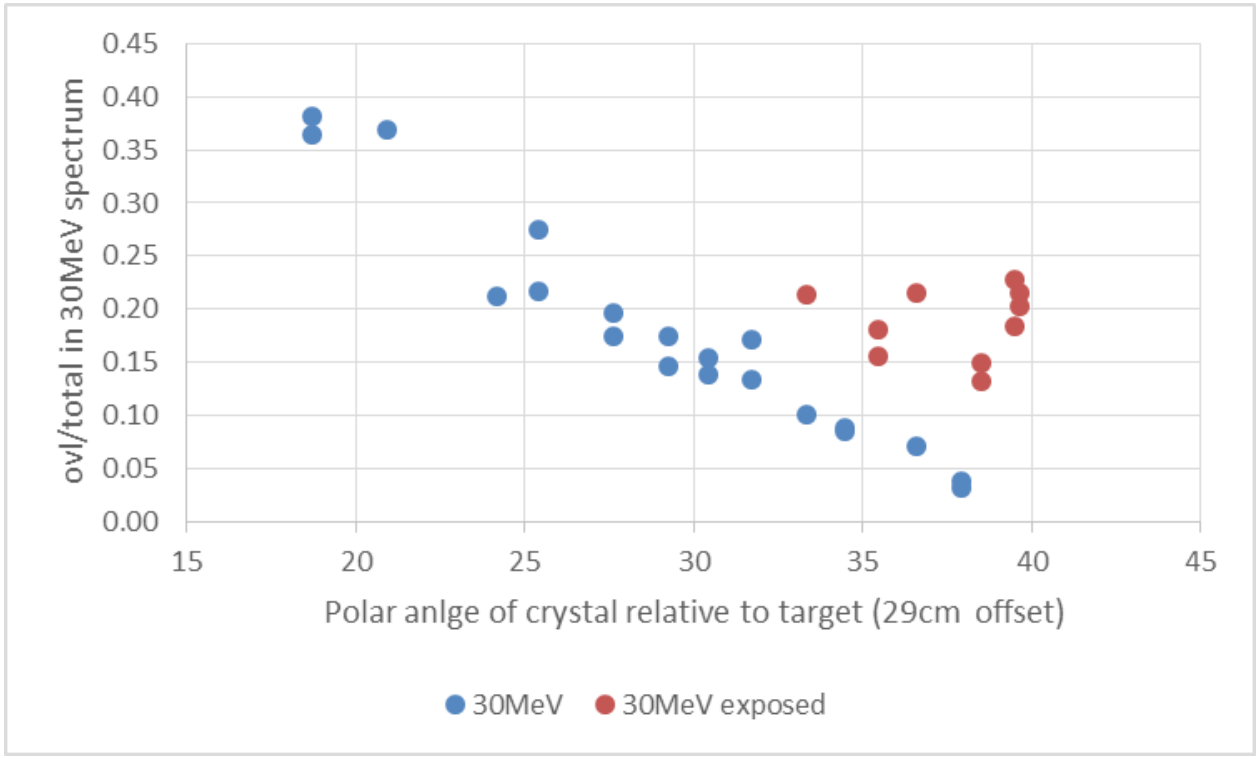
Smoking gun: γ-γ not involving fw is ok

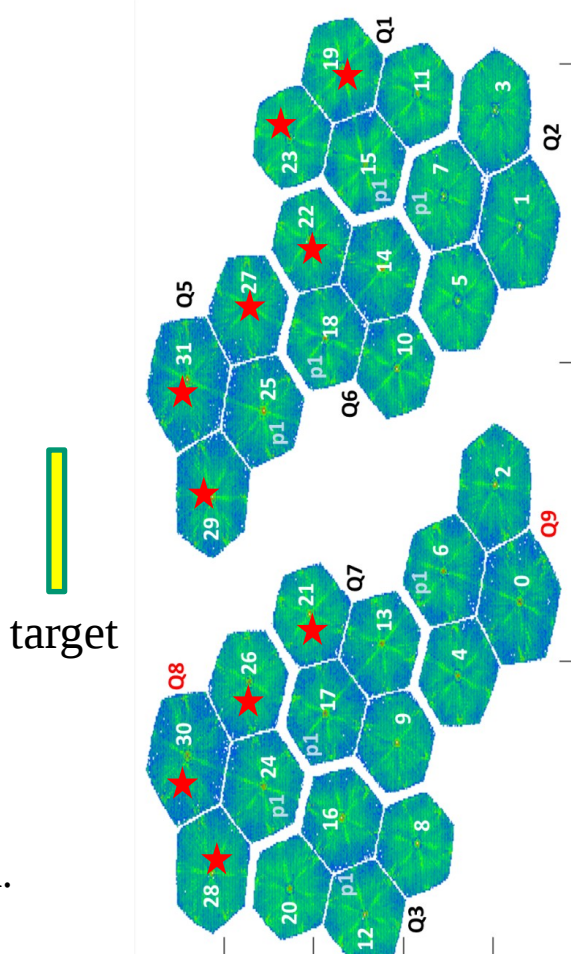
Gate [name]	Gate [detectors]	Experiment	GEANT
all	gg det 00-39	3.76(11)	4.10(2)
bw	32-39 vs 00-31	0.64(4)	0.61(1)
mi	16-31 vs 0-15,32-39	1.55(3)	1.52(2)
fw	00-15 vs 16-39	1.81(10)	2.09(2)
3qFW	As fw w/o Q8	1.37(8)	1.57(2)
NotFW	gg det 16-39	2.05(11)	2.04(2)
Not_00_11	gg det 12-39	2.40(10)	2.52(2)
NotFWvsAll	16-39 vs 00-39	2.04(7)	2.09(2)

Good news: It is not a ‘global’ loss of counts which would hint to an overall GT DAQ problem!

Question: What’s wrong with the forward detectors?

‘Saturation’ events in-beam





In the high-efficiency experiment polar angles from 40° to 140° are covered. From that plot we expect (much) less than 5% of the events saturating the preamp and/or 30MeV channel of the digitizers.

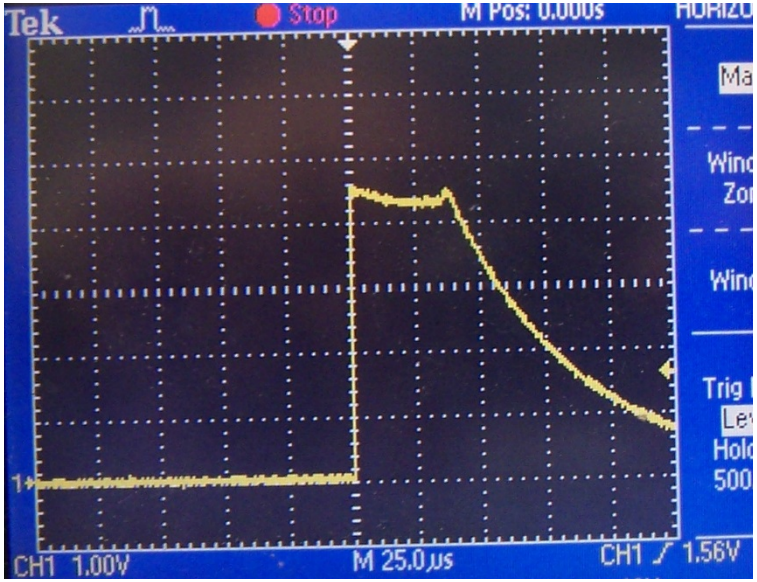
Why do we worry about ‘saturation’?

Answer: (unaccounted) dead time!

The preamp saturates at around 3-4V (terminated) which is about 30MeV.

A 100MeV event would take about 4 preamp decay cycles to reach the 10MeV range, i.e. ~150µs

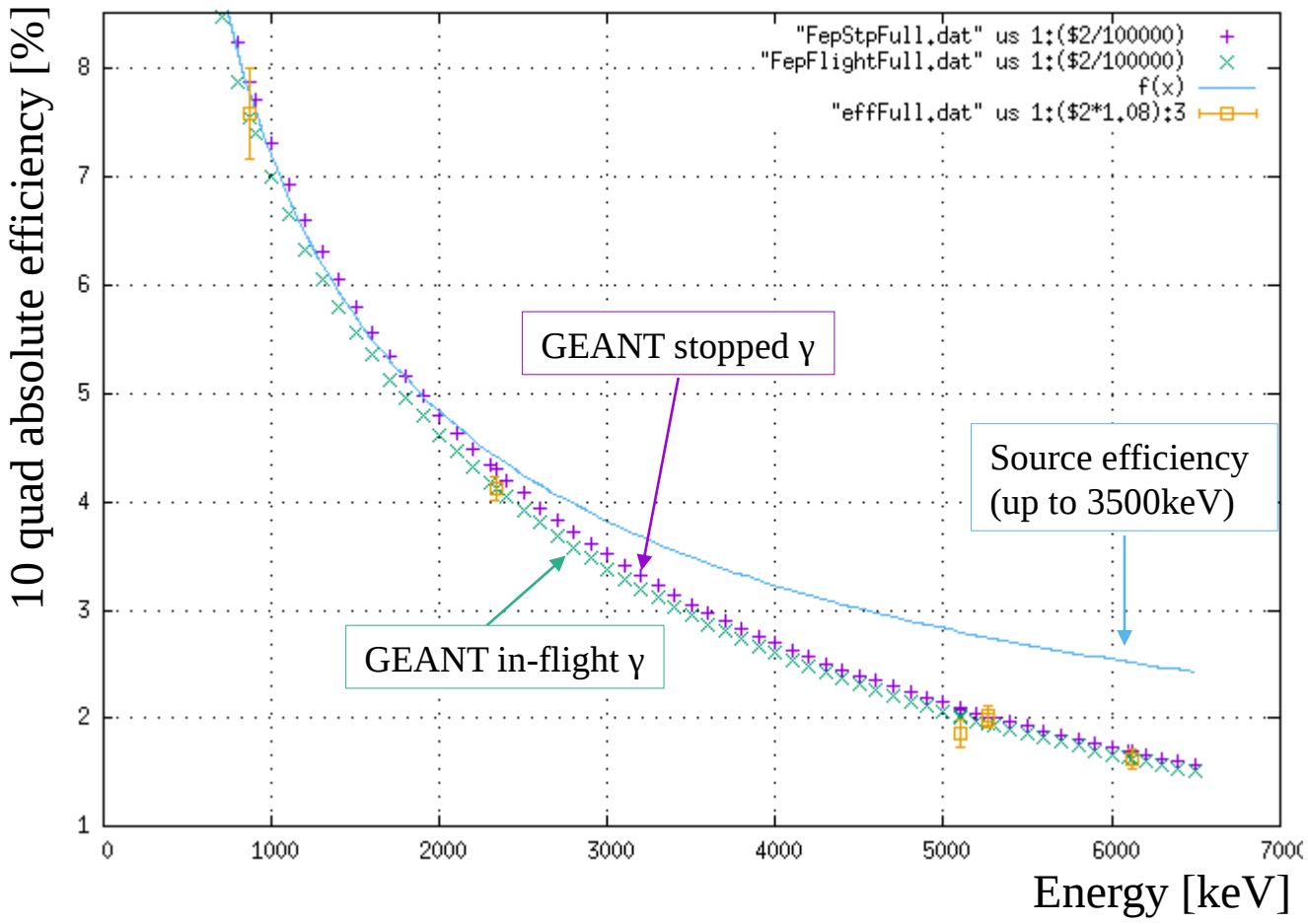
Xtal rates were 5kHz, lets assume 5% were saturations, so 250 x 150µs = 37ms unaccounted dead time (3%).
→This doesn’t explain our efficiency loss



BUT: In GRETINA we have a baseline restorer algorithm which has a long time constant. This BLR doesn’t know about saturation, i.e. keeps ‘calculating’ even if the digitized signal is out of the sampling ADC range. Likely the resulting completely wrong BLR filter value compromises the energy determination long after the saturation event happened.

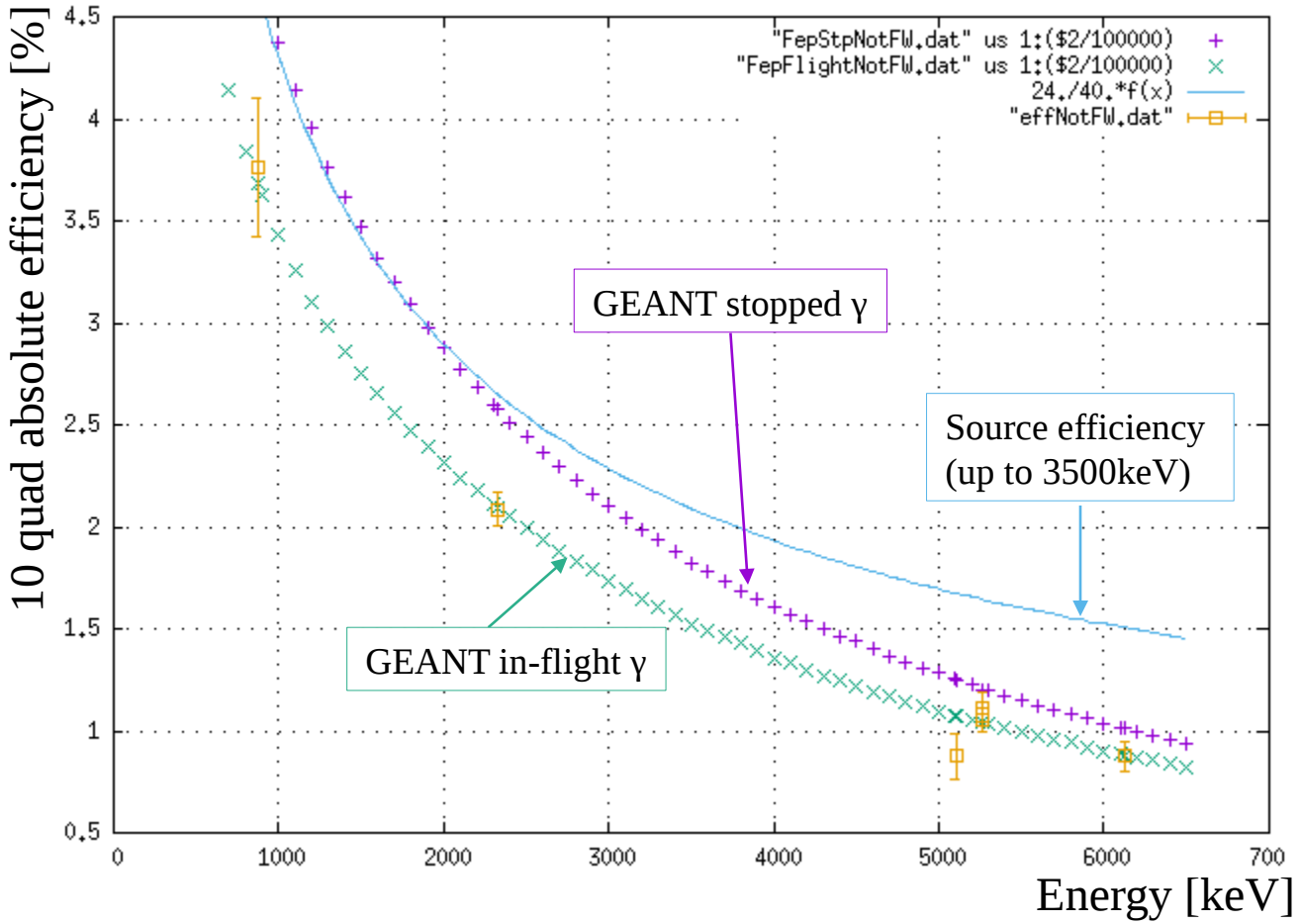
Result for 10 quads

Measured data points scaled by 1.08!

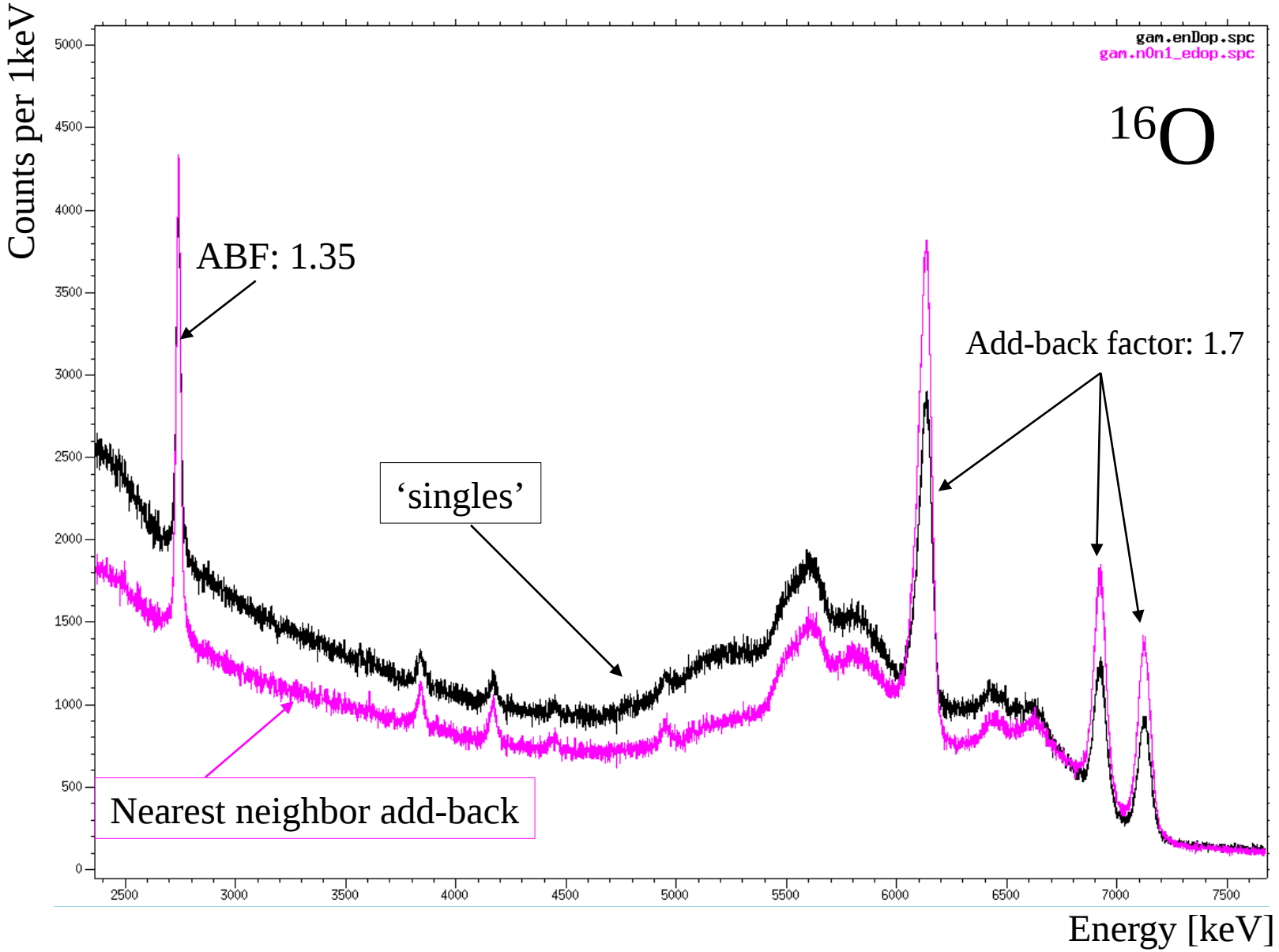


Result for 6 quads (not forward)

Measured data points NOT scaled!



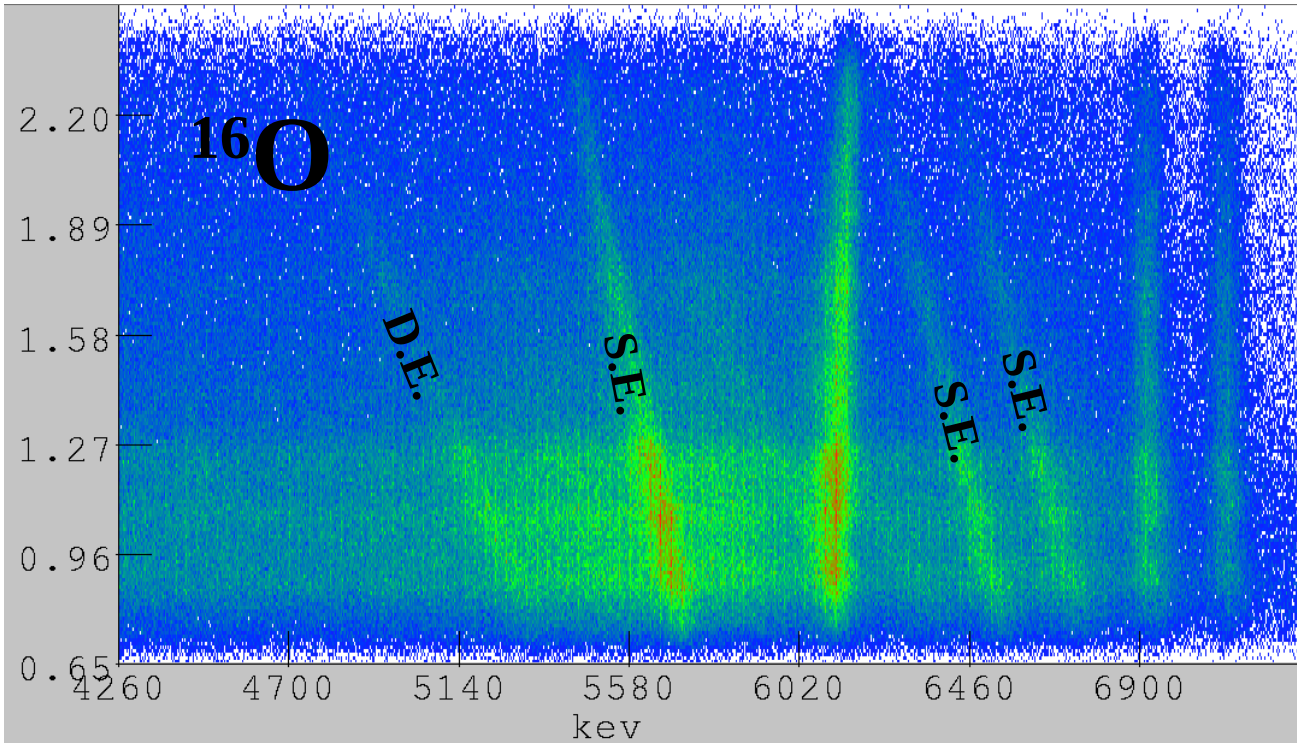
Not tracking, but add-back



Conclusion

GEANT (ucgretina from Lew) seems to describe the high-energy efficiency pretty well!

I'm happy to provide those data to anybody who like to 'track with it'. Certainly this is a nice data set to look at tracking of pair-production/escape events.



Energy (Doppler corrected)