MUSE
H2020-MSCA-RISE-2015 – Grant Agreement N° 690835

Results on ω_a fit

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on behalf of the ω_a Europa Group

MUSE General Meeting

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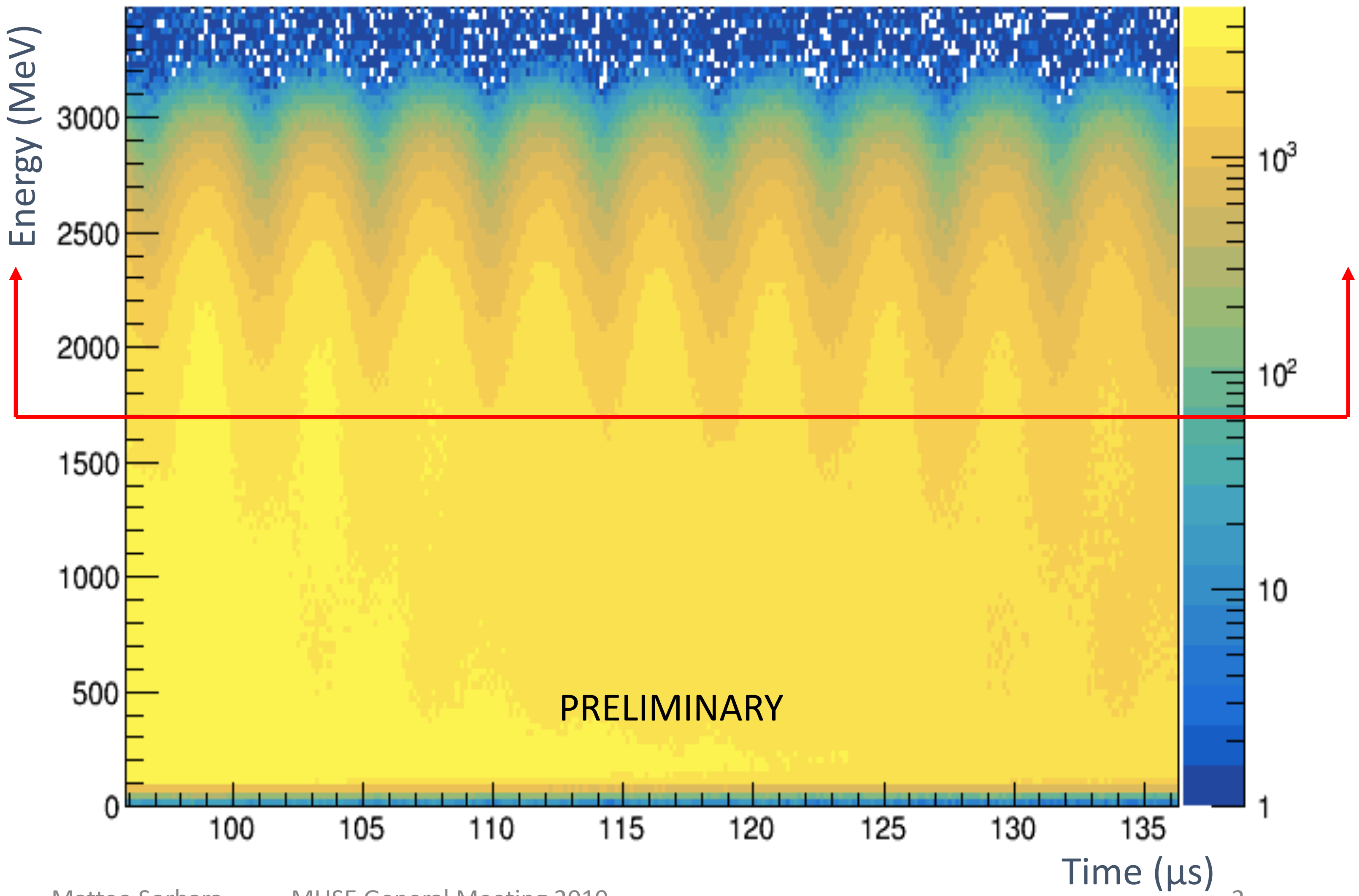
Overview

- Building the wiggle plot
  - (Gain Corrections)
  - Pileup subtraction
  - R-wave correction
- Fitting for ω_a
  - From 5 parameters to full fit
  - Asymmetry weighted fit
  - Main systematics analysis
- (Blinded!) Result

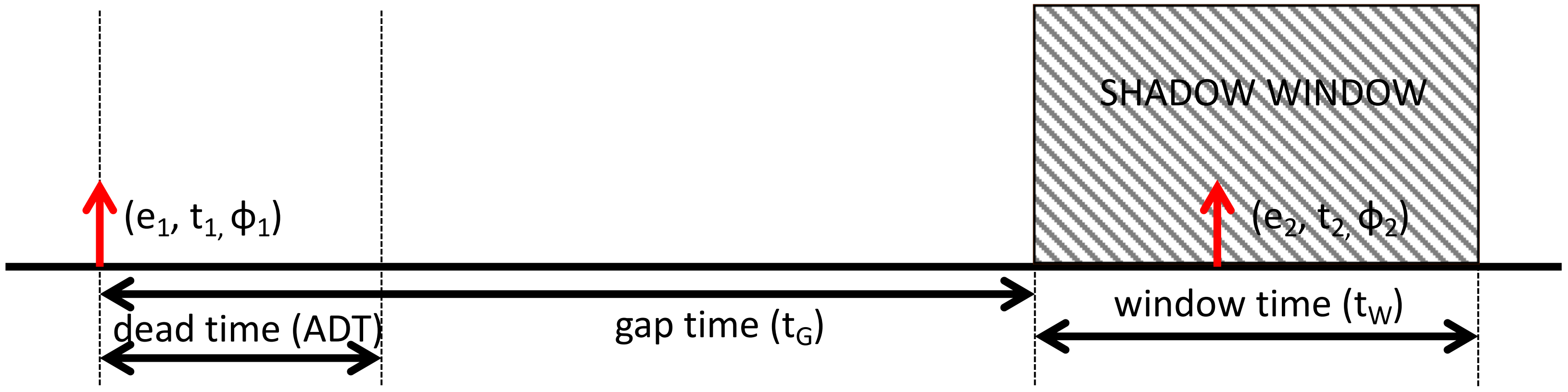
Building the wiggle plot

Calorimeters measure time and energy* of the incoming positrons. We integrate all positrons above our threshold energy

$E_{th} = 1.68\ GeV$, or $E_{th} = 1.10\ GeV$ for the A-Method, and construct the wiggle plot.



Pileup subtraction:



ADT = 5 ns
t_G = 149.1 ns
t_W = 5 ns

- Based on the shadow window method
- All events in the ADT window are merged together, then look for events in the shadow window
- The singles and doubles that are constructed with time:

$$t_d = \frac{t_1 e_1 + (t_2 - t_G) e_2}{e_1 + e_2} + t_{shift}$$

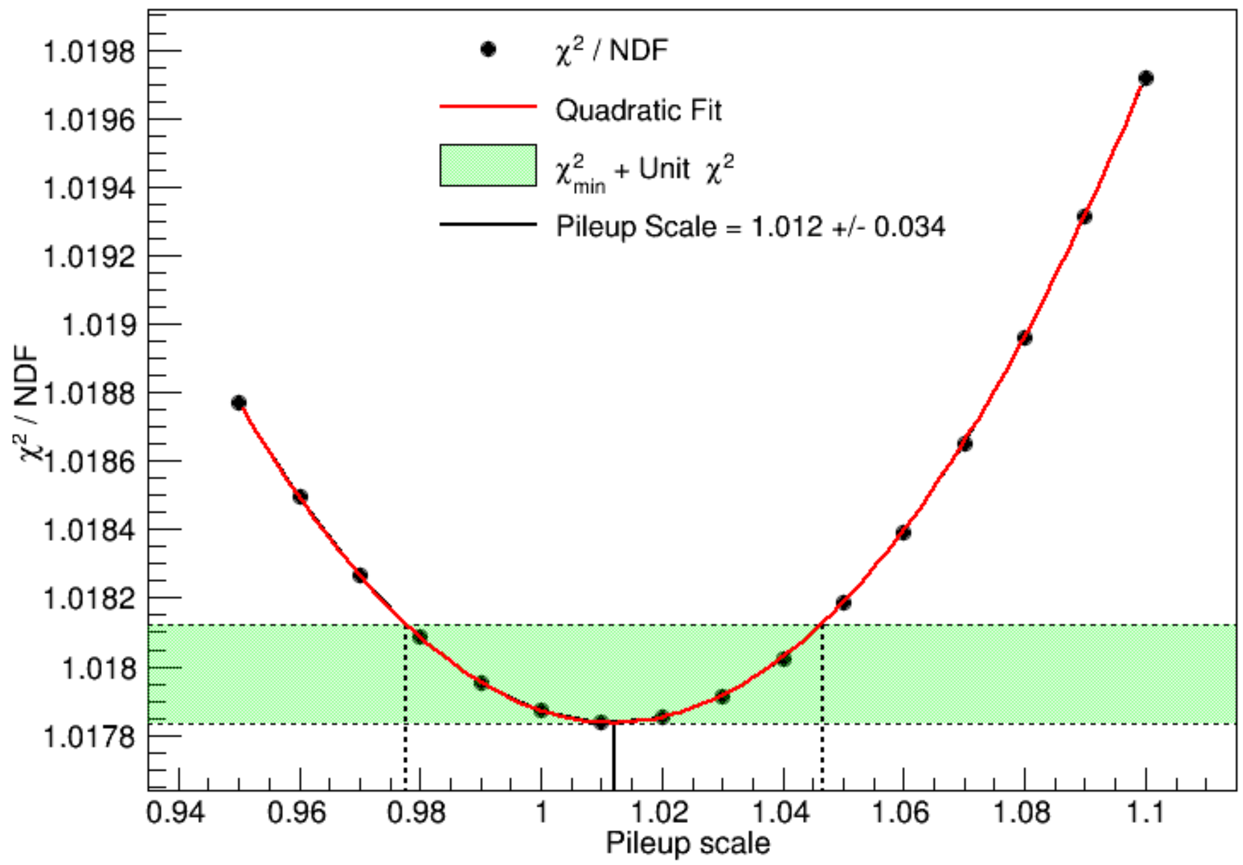
- t_{shift} is used to match the phase of t_1 and t_2 events.

Pileup subtraction:

The constructed doubles histograms are then subtracted from the data histograms and singles are added back:

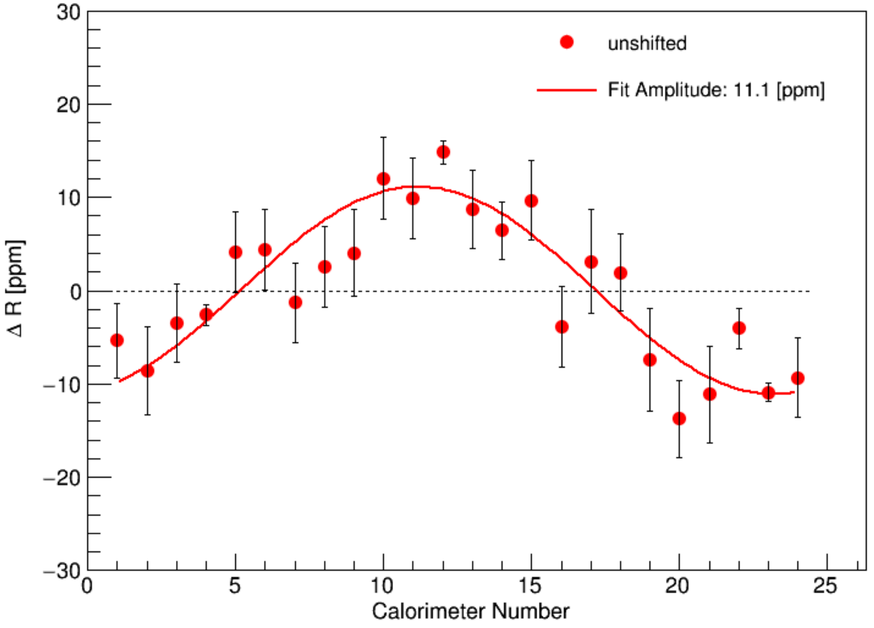
$$H = S - \alpha D$$

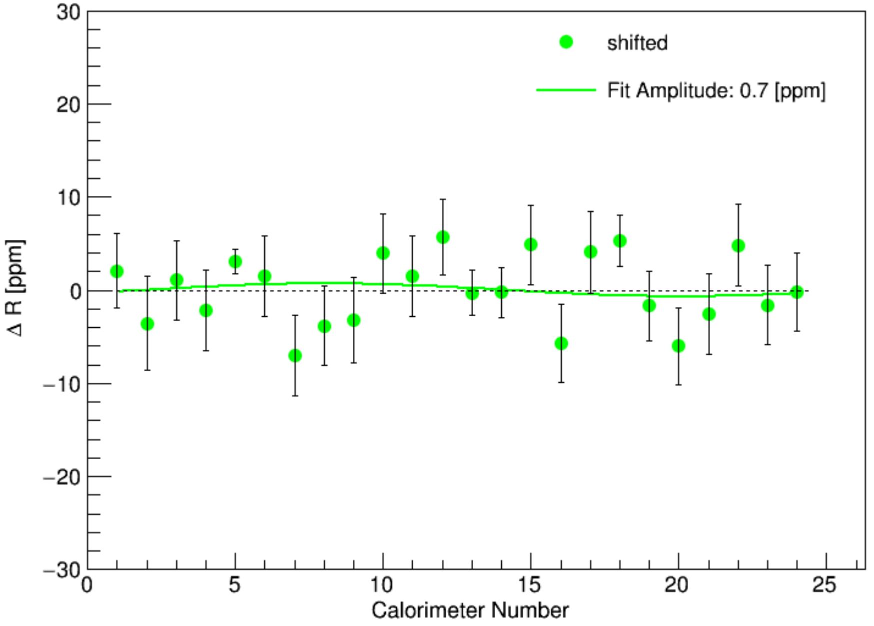
where α is a scaling factor to optimise the correction. To get the optimal α value, a scan of this parameter is performed and the minimum χ^2 value is used.



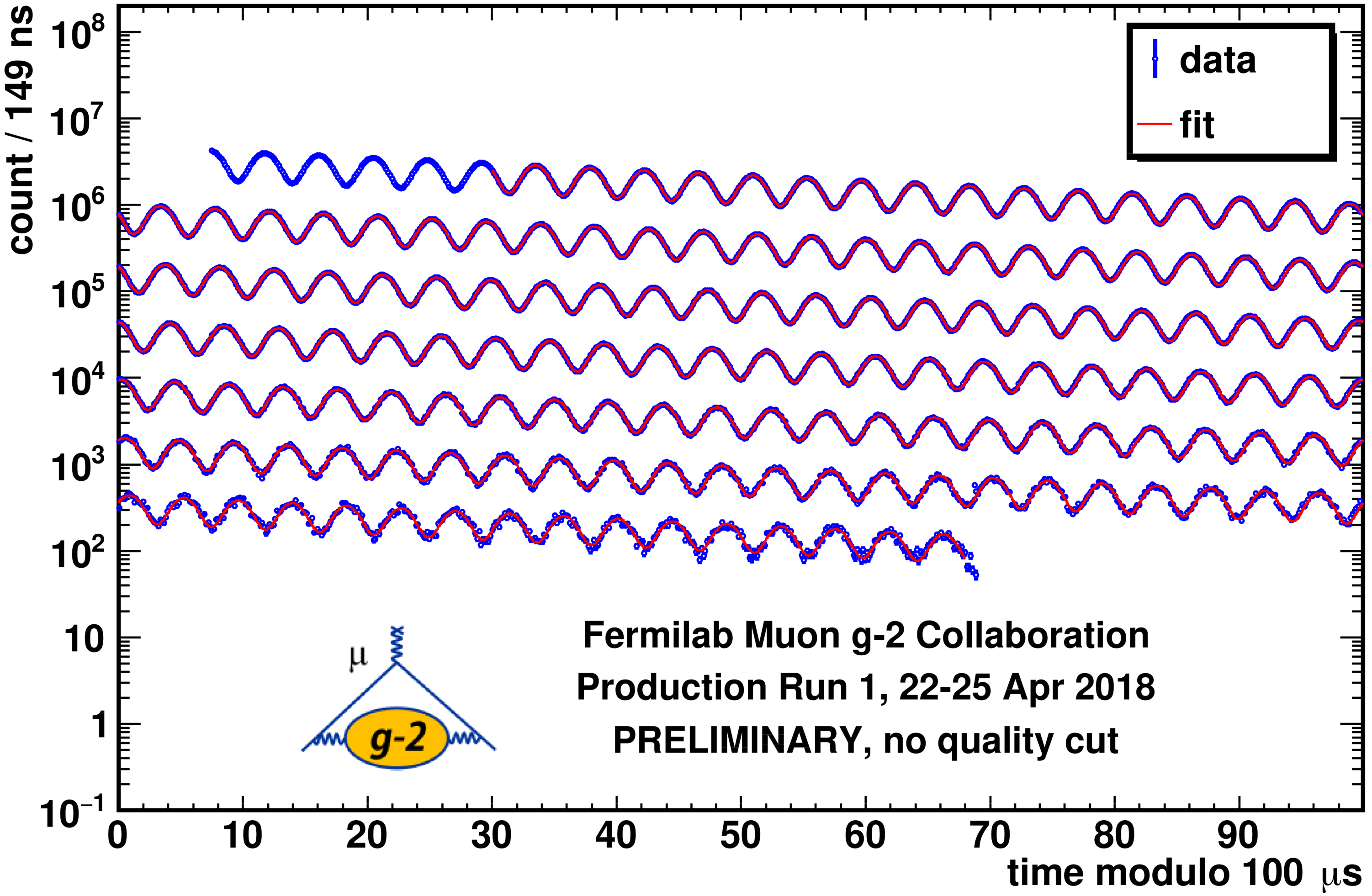
R-wave correction

- Due to beam bunching the per calorimeters fit presents a “wave”
- A first correction to this effect is choosing a time binning of 149.1 ns (same as the fast rotation period)
- The fit still presents the wave, so a random shift is applied to each event in the range of $\pm\frac{149.1}{2}\,ns$ to remove residual fast rotation effects.





Wiggle Plot



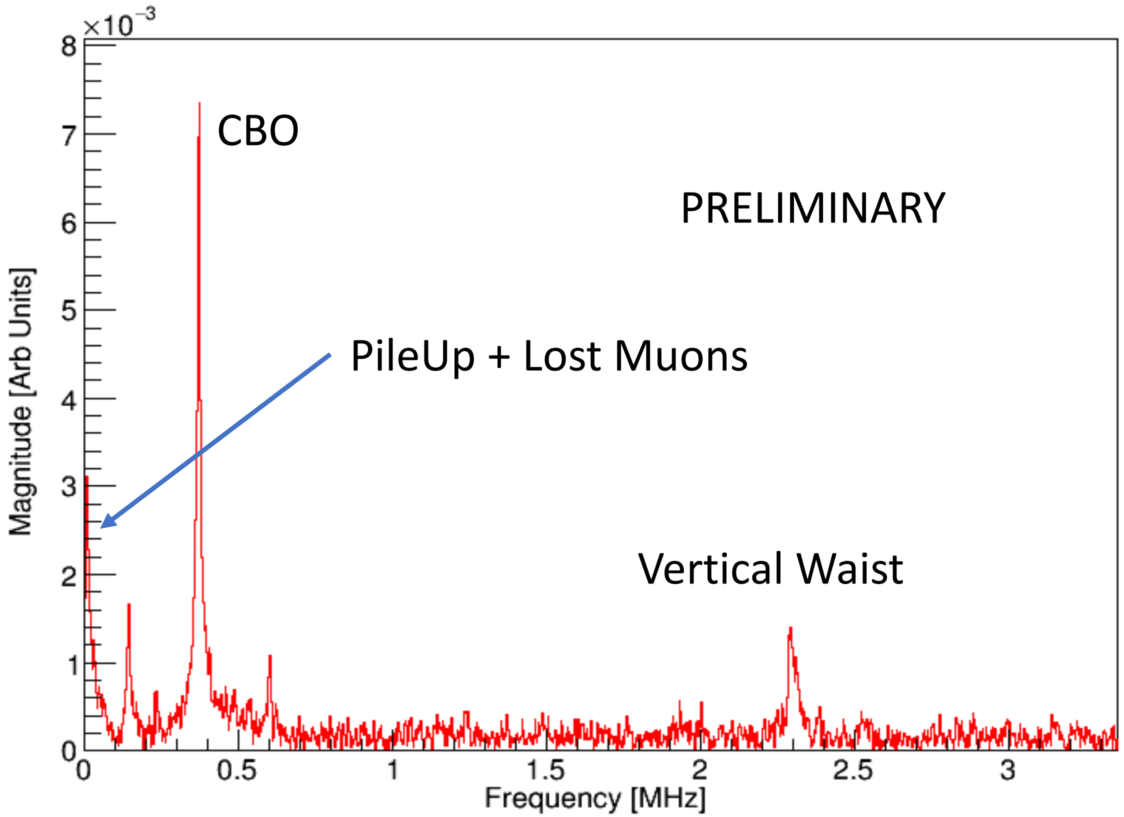
count / 149 ns
10^8
10^7
10^6
10^5
10^4
10^3
10^2
10
1
10^{-1}
0
10
20
30
40
50
60
70
80
90
time modulo 100 μs
data
fit
Fermilab Muon g-2 Collaboration
Production Run 1, 22-25 Apr 2018
PRELIMINARY, no quality cut
μ
g-2

The ω_a fit

- The wiggle plot is fitted with a decay exponential modulated by the precession frequency:

$$f_5(t) = N_0 e^{-t/\tau}[1 - A\,cos(\omega_a t + \phi)]$$

- The 5 parameters function presents peaks in the residuals FFT due to beam dynamics effects
- Increasing the number of corrections in order to remove peaks from the FFT residuals



The ω_a fit: corrections

23 parameters function:

$$N(t) = N_0 e^{-t/\tau}[1 - A\cos(\omega_a t + \phi)] \cdot \mathrm{C(t)} \cdot \Lambda(t) \cdot V(t)$$

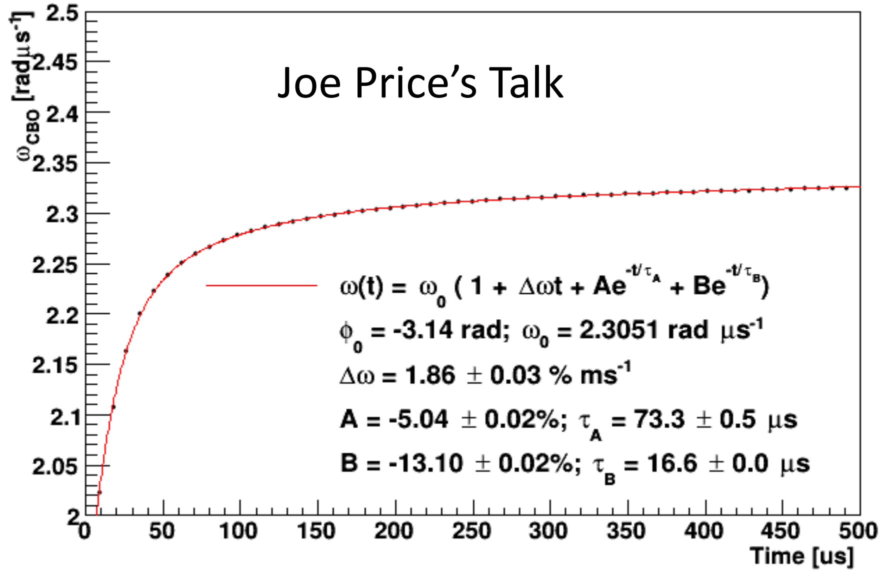
From trackers data:

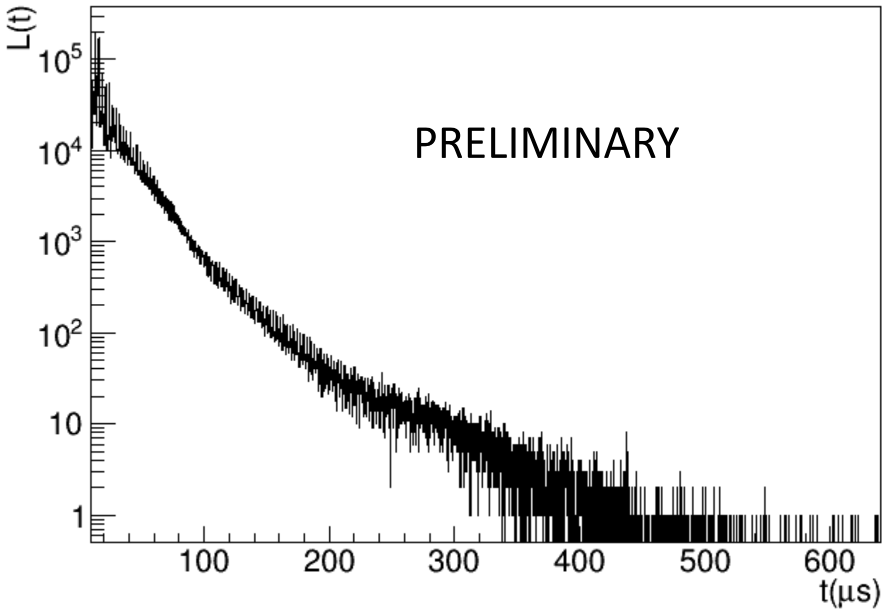
$\mathrm{C(t)}$: variable CBO correction

$V(t)$: vertical oscillations terms

From calorimeters coincidences (and tracker cuts)

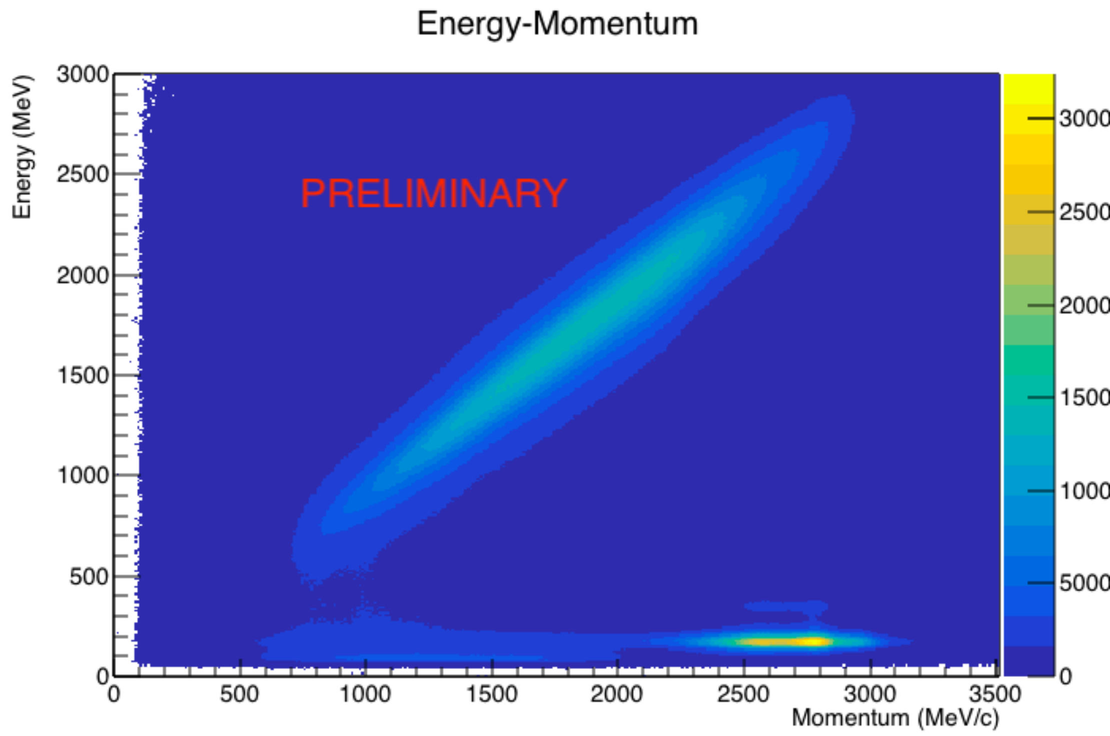
$$\Lambda(t) = 1 - K_{LM} \int_0^t e^{\frac{t'}{\tau}} L(t')dt'$$: lost muons

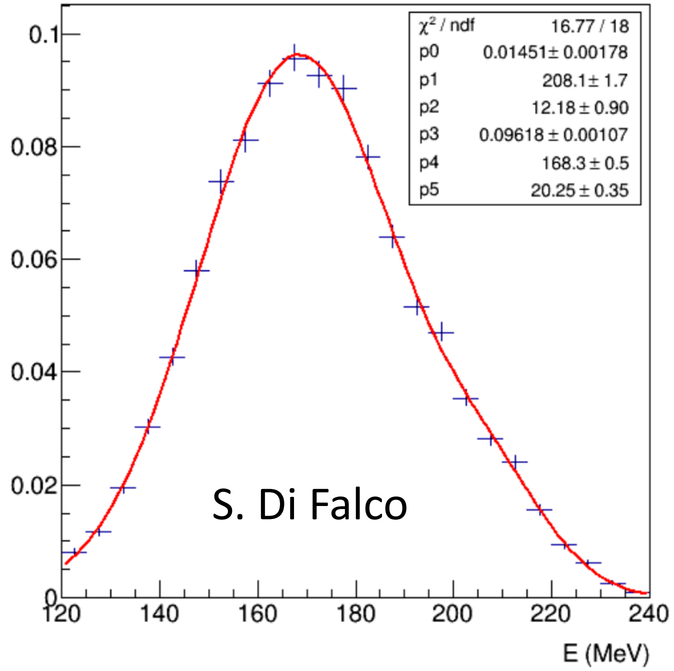




Lost Muons

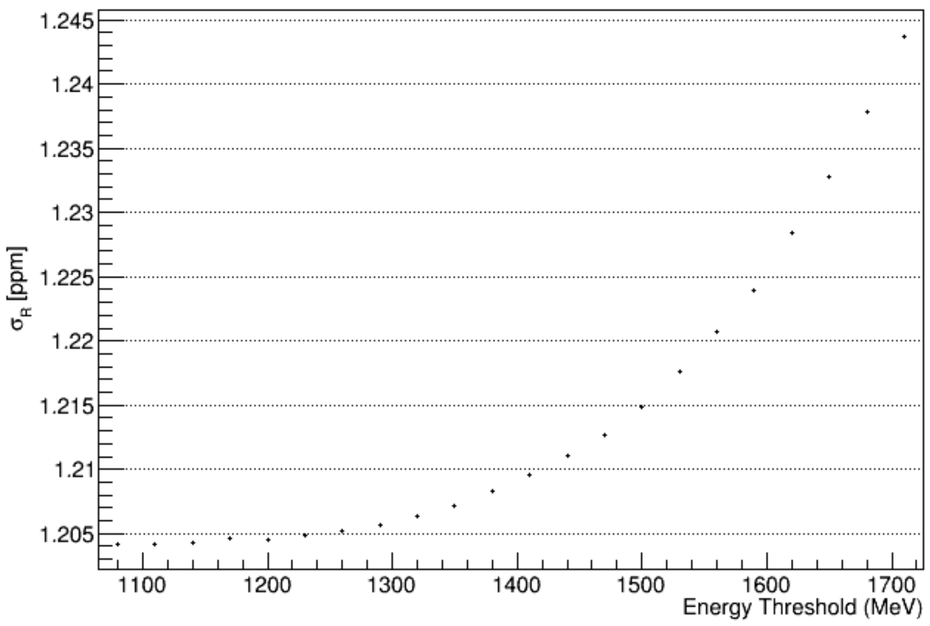
- Based on the detection of Minimum Ionizing Particles in the calorimeters
- Triple (+ 4 + 5) coincidences in consecutive calorimeters with timing $\Delta t = 6.2\ ns$
- Tracker identification is used to build energy distribution of the lost muons

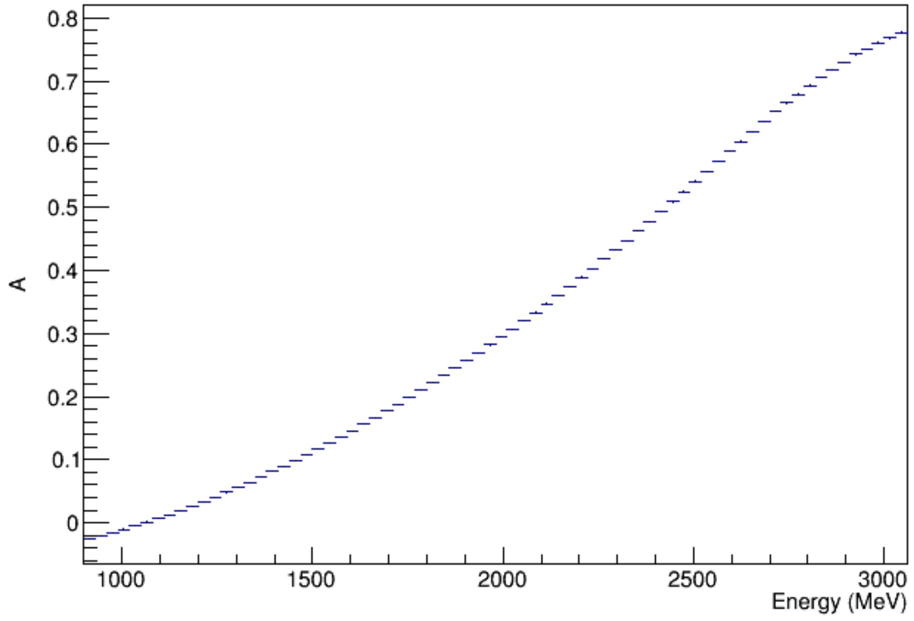




Asymmetry weighted fit

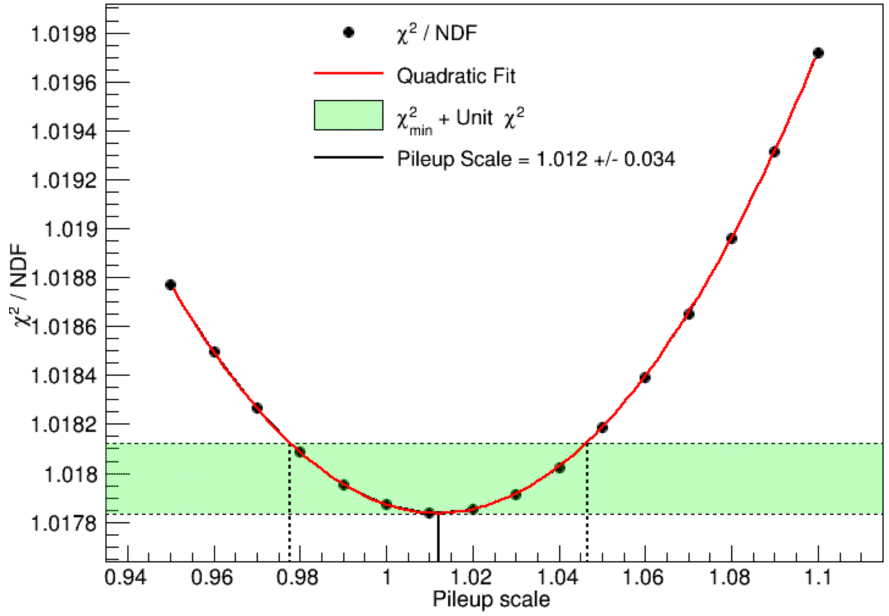
- Get a lower threshold weighting events with their asymmetry value
- Improve the statistical uncertainty
- The pileup subtracted histogram is binned in energy (30 MeV) and each bin is separately fitted. Asymmetry is then extracted and the A-weighted histogram is constructed

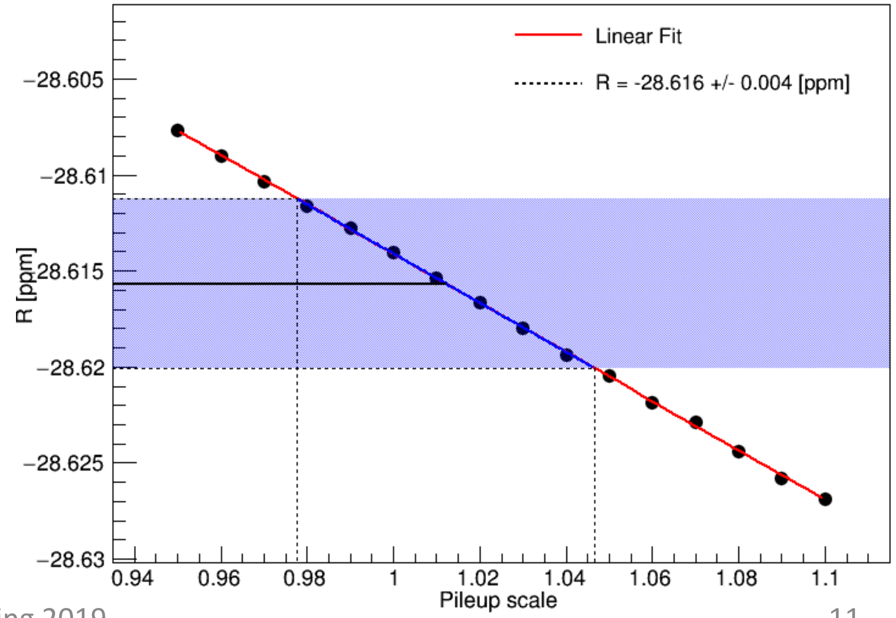




Systematics: pileup

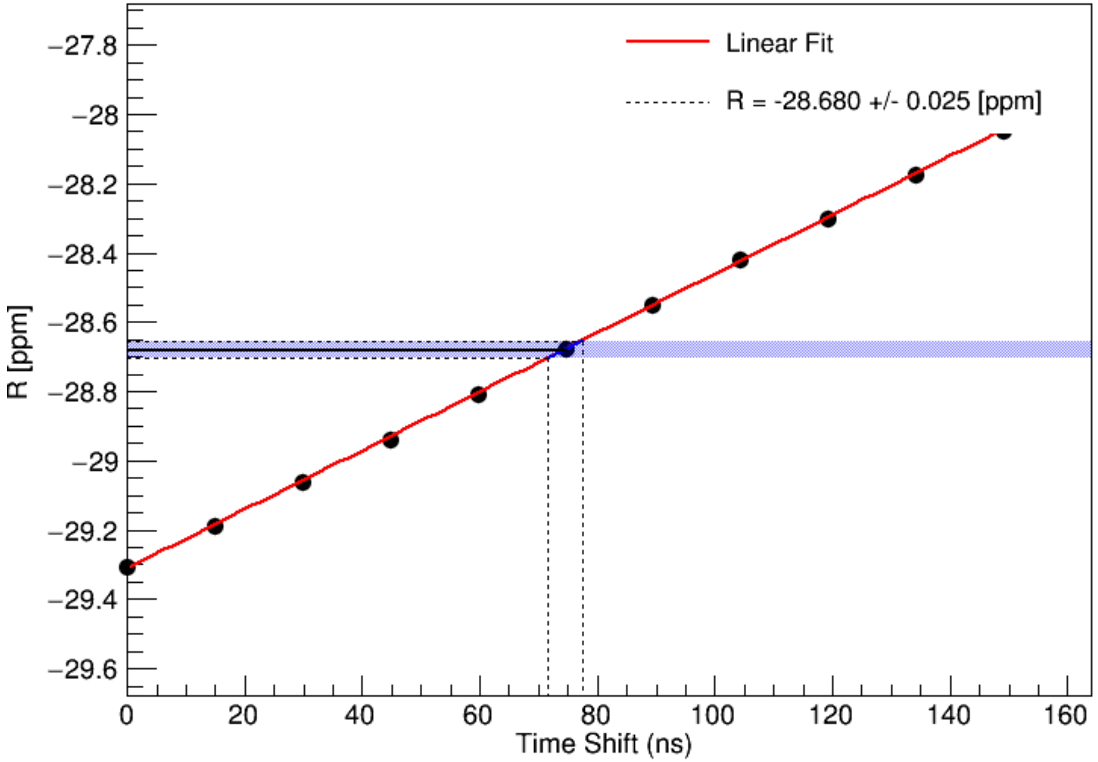
- The pileup amplitude uncertainty is estimated taking the variation corresponding to a unit of χ^2 around the minimum (green)
- The green band gives the interval in which R varies due to the pileup multiplier choice (blue)





Systematics: pileup (2)

- The systematic uncertainty related to the t_{shift} is evaluated scanning this time in the interval $[0, t_G]$
- For now the uncertainty is taken as the variation on R in a $\pm 3\ ns$ interval around $t_G/2$ (chosen as our optimal t_{shift})
- Further analyses are ongoing to determine which is the optimal t_{shift} and the associated uncertainty.

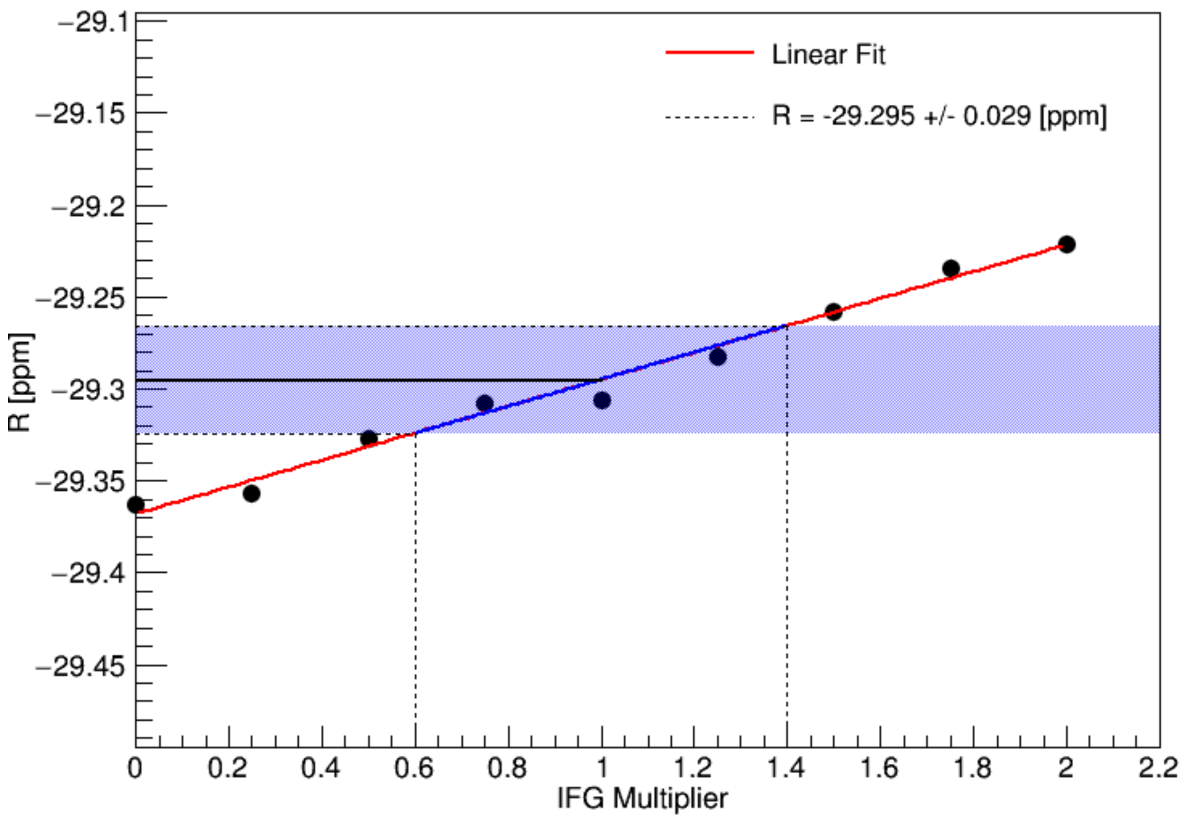


Systematics: Gain

- IFG correction is applied to all crystal (i) hits:

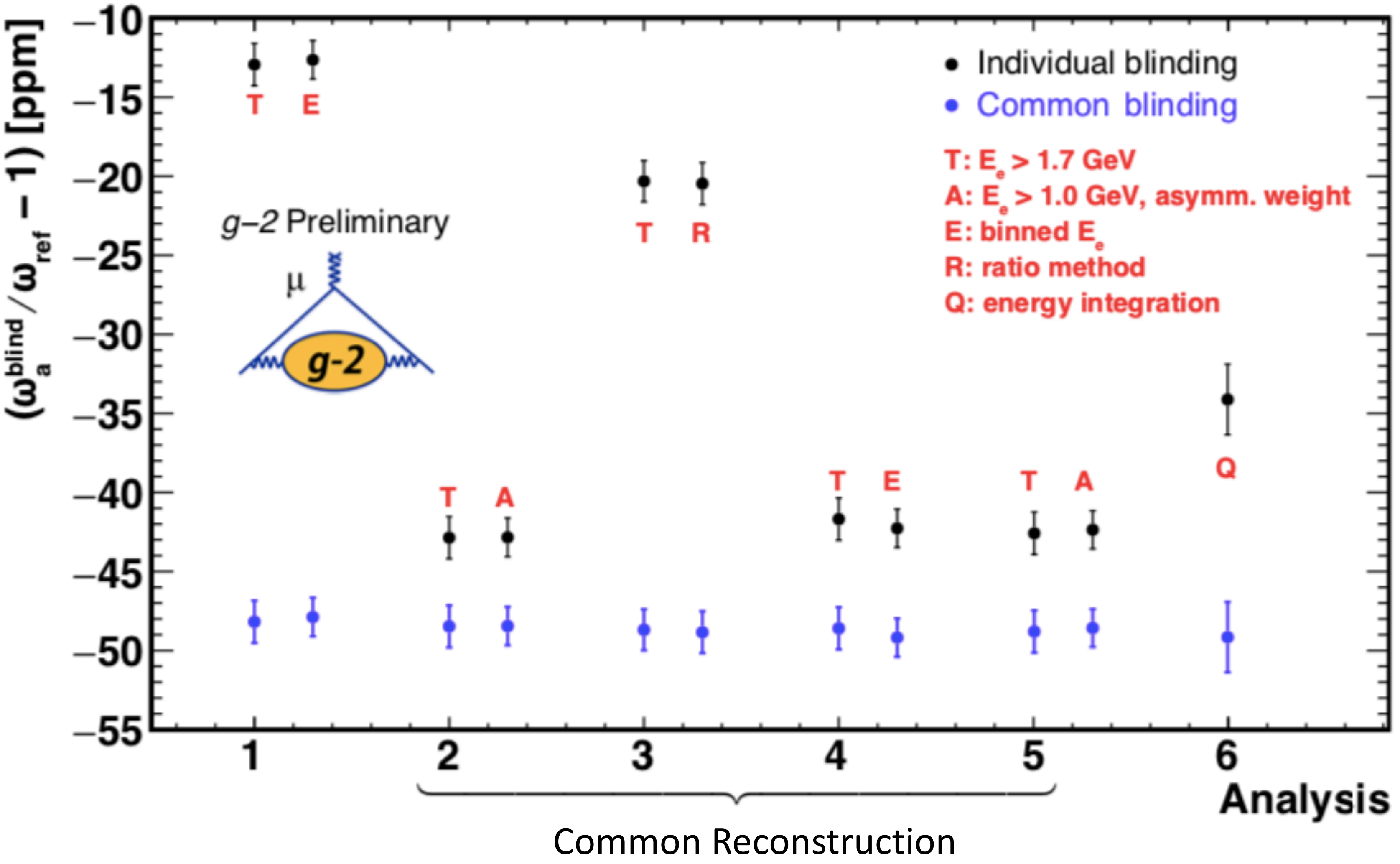
$$E_i \rightarrow E_i \cdot \frac{1}{1 - A_i e^{-t/\tau_i}}$$

- Where A_i and τ_i are evaluated with the laser system and depend on the crystal
- The systematic effect of this correction is evaluated scanning the A parameter in the interval [0, 2A].



The systematic uncertainty estimation for the IFG correction is evaluated taking 40% (see Sam Grant's talk) of the variation on R per unit multiplier.

First result: 60h relative unblinding



1. Cornell
2. Washington
3. Boston
4. Shangai
5. Europa
6. Kentucky

Conclusions

- Run 1 analysis is ongoing
- The overall fitting framework is ready
- Still few topics under investigation:
  - Optimal t_{shift}
  - Pileup systematics
  - IFG
- Path to publication will be the main topic of the collab. Meeting (end of November)