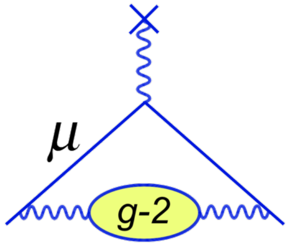
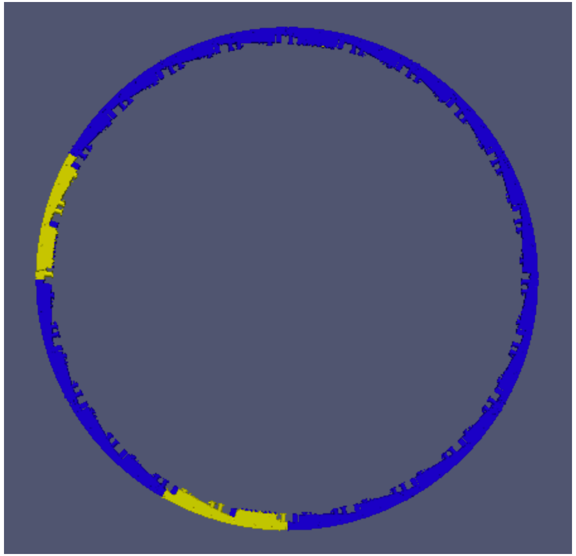
Gain studies using the straw trackers

Sam Grant



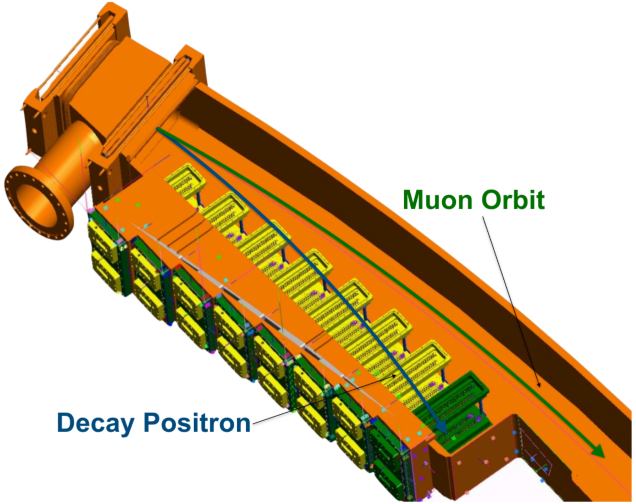
24th October 2019
MUSE general meeting

The straw trackers



- Two straw tracking stations at approximately 180° and 270° (stations 12 and 18)

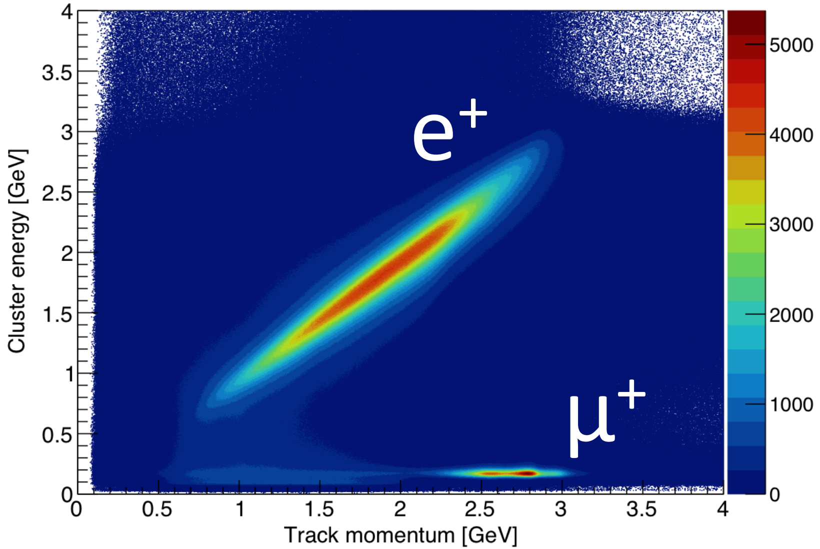
- Layers of high-voltage wire encased in Mylar straws, containing a 50:50 gas mix of argon and ethane

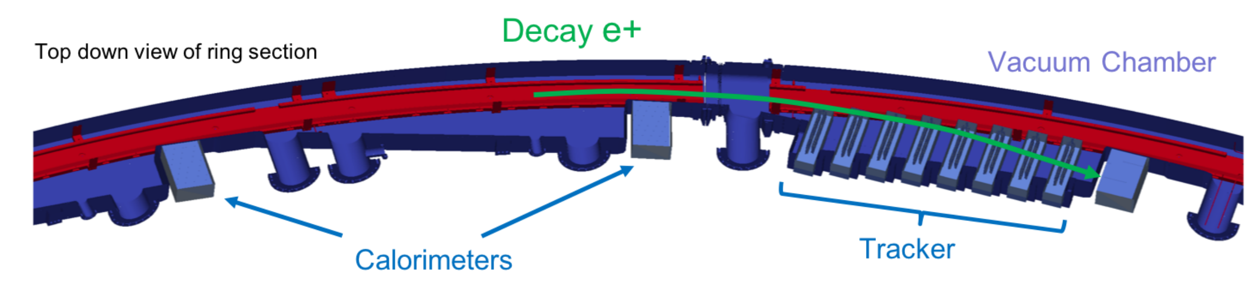


- The drift times of the ionisation products falling onto the cathode wires are reconstructed to form a track

Track-cluster matching

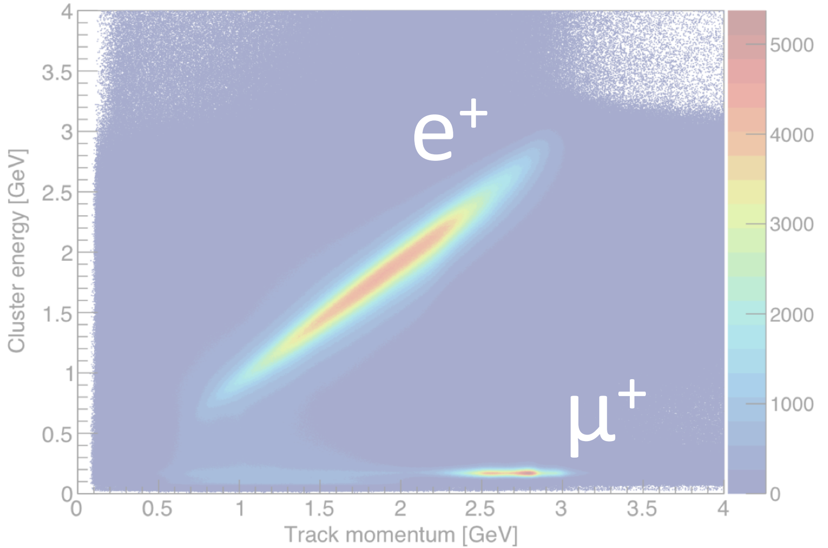
- A *track* can be matched with a *cluster* in a downstream calorimeter
- From the trackers we obtain track position and curvature (momentum), from the calorimeters we obtain the energy
- For each track-cluster matched event we have E and p

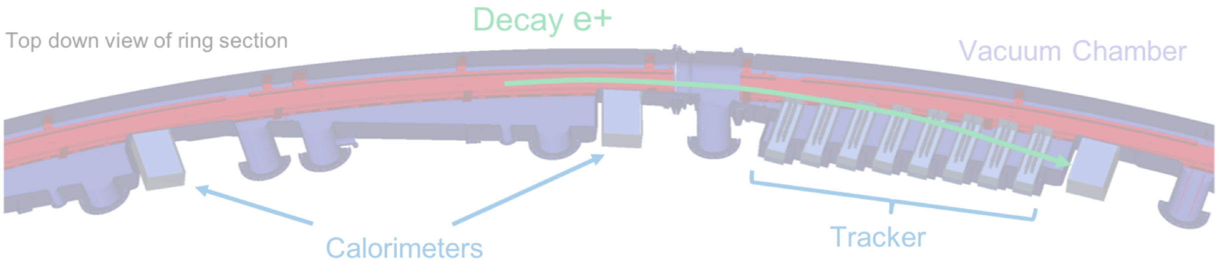




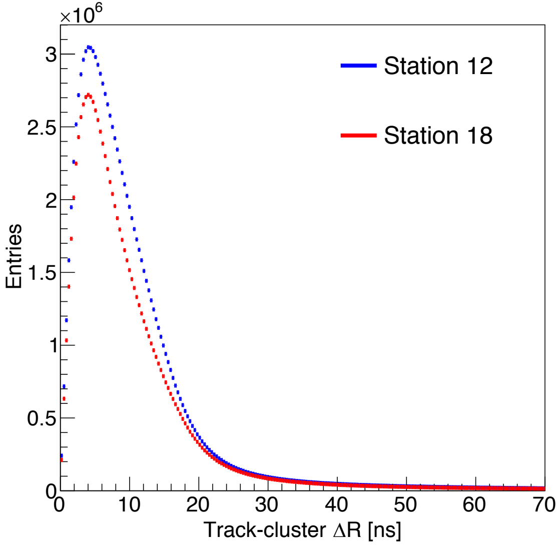
Track-cluster matching

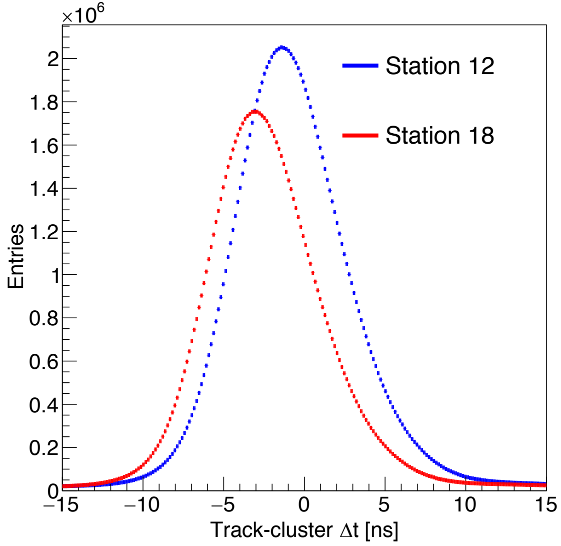
- A *track* can be matched with a *cluster* in a downstream calorimeter
- From the trackers we obtain track position and curvature (momentum), from the calorimeters we obtain the energy
- **For each track-cluster matched event we have E and p, we'll come back to this!**





Track-cluster matching, quality cuts





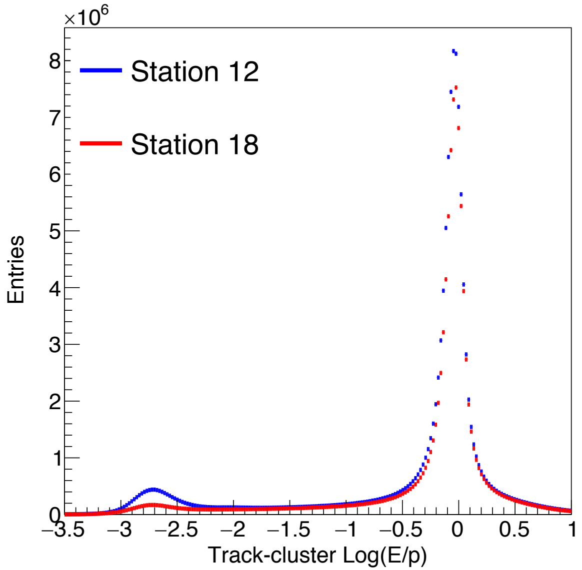
1. Radial difference, $\Delta R < 30\ \mathrm{mm}$

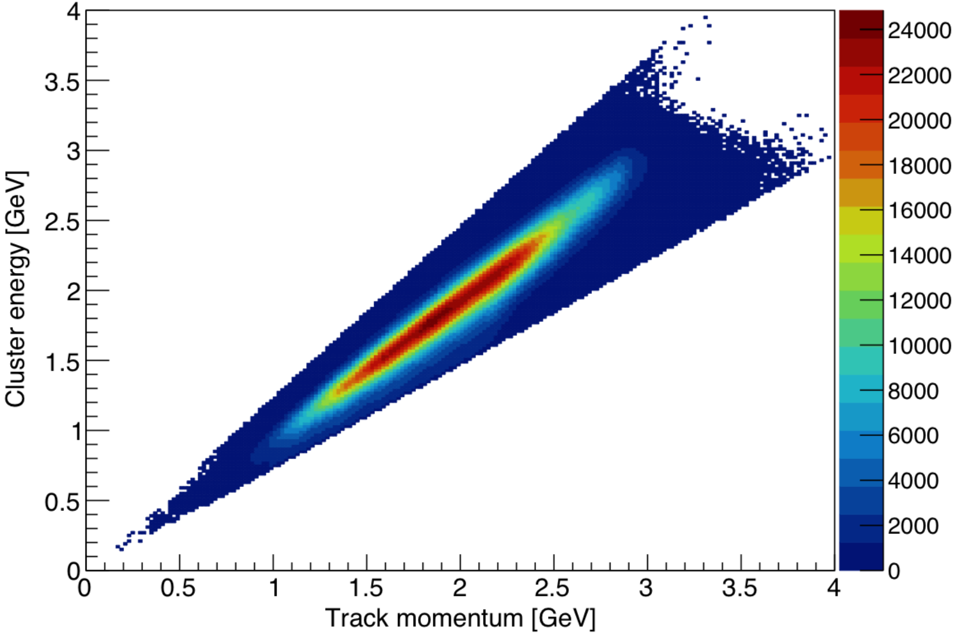
2. A time difference window, $-8 < \Delta t\ [\mathrm{ns}] < 3$ for station 12 and $-9 < \Delta t\ [\mathrm{ns}] < 1$ for station 18

Cuts developed by Gavin Hesketh (UCL)

Track-cluster matching, quality cuts

We can select a pure sample of positrons as well, via $-0.3 < \log(E/p) < 0.2$





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Gain-sag

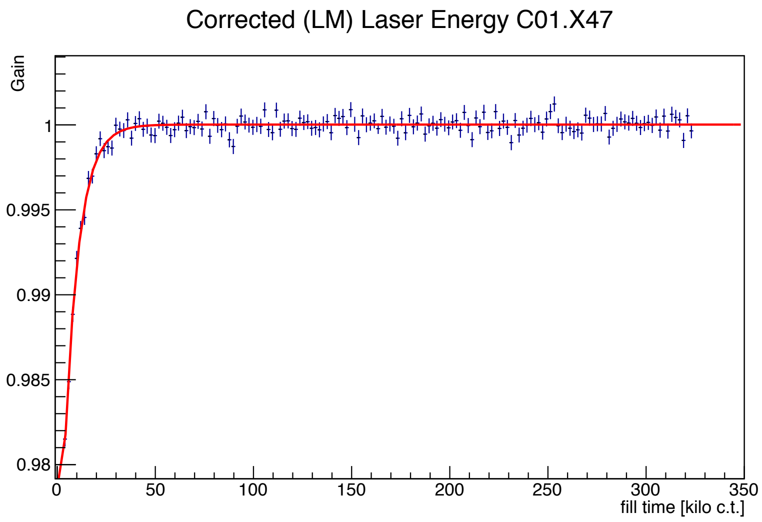
- Tight bunching and losses from un-storable particles at early times (the splash) causes a drop in gain, *gain-sag*, of the form

$$G(t) = G_0(1 - \alpha e^{-t/\tau_r}).$$

Amplitude   Recovery time

- Time dependent gain biases the anomaly frequency, ω_a, between early and late times!

- The uncertainty on the gain correction must be carefully measured, as it contributes to the uncertainty on ω_a



Gain-sag is monitored and corrected by use of our laser monitoring system

The E/p ratio

$$\text{Gain} = \frac{\text{Measured energy}}{\text{True energy}}$$

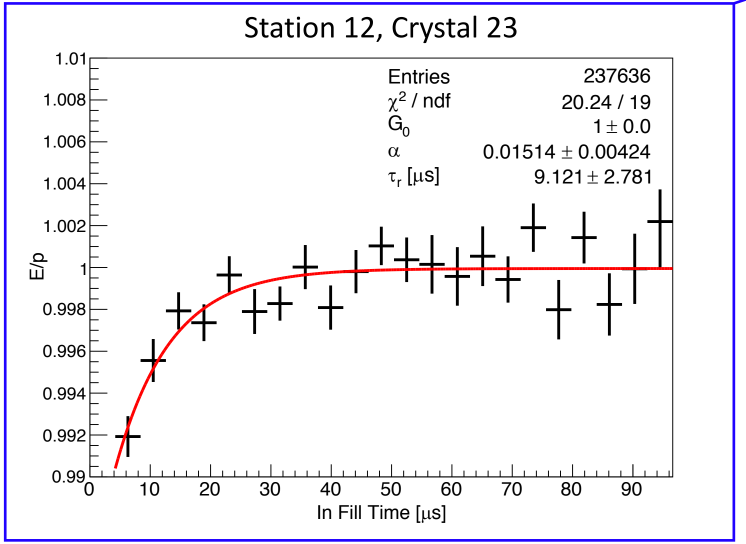
$$\text{Gain} \equiv \frac{\text{Cluster energy}}{\text{Track momentum}}$$

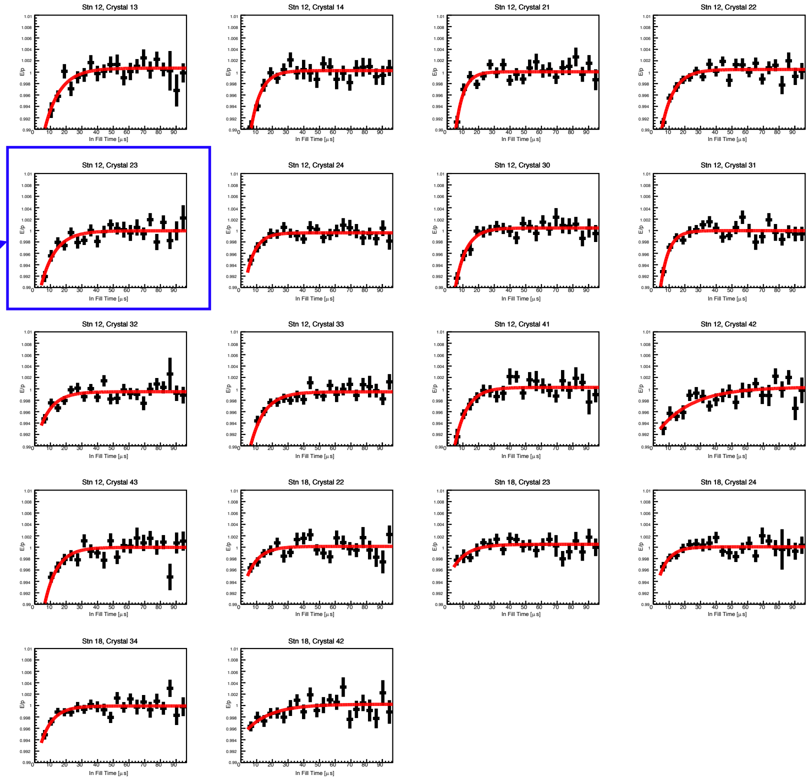
$$\text{Gain} \equiv E/p$$

- E and p are equivalent for relativistic positrons
- We get momentum from track curvature, which is not altered by the splash
- We use the E/p ratio to cross check the laser!

E/p gain fits per calorimeter crystal (60 hour dataset)

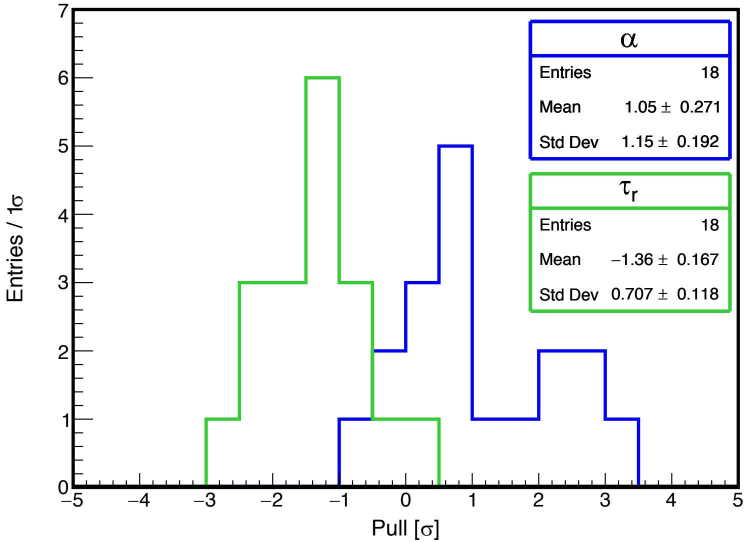
- Gain-sag is measurable by this method!
- Smallest dataset: low numbers of high quality track-cluster matches is limiting
- 18 crystals make adequate fits





Pull between E/p and the laser (60 hour)

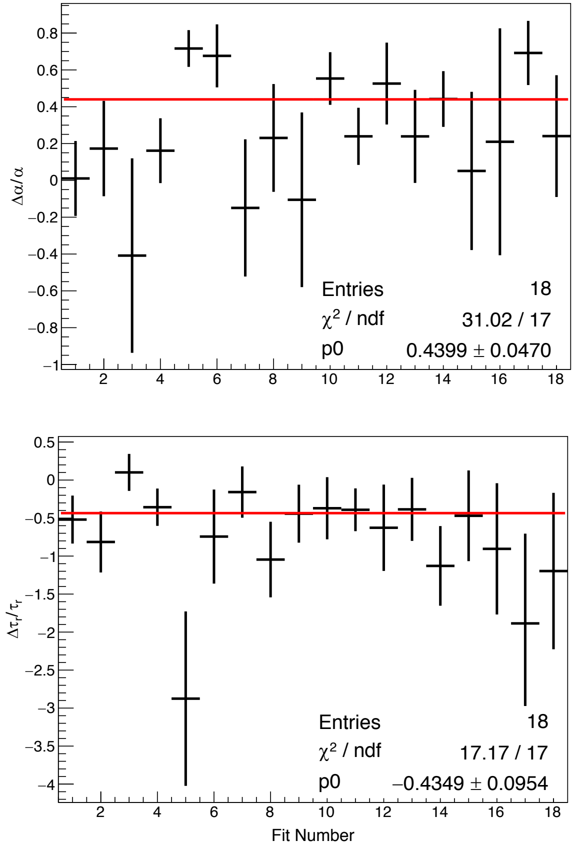
As a figure of merit, we can define the pull per fit parameter to be $\frac{\text{Laser} - E/p}{\sqrt{\delta\text{Laser}^2 + \delta E/p^2}}$



- $\boldsymbol{E/p}$ is reasonably consistent with the laser, widths are close to 1σ
- Bias in the means: $\boldsymbol{E/p}$ is less sensitive than the laser
- Laser parameters are preliminary

Estimating the gain correction contribution to $\delta\omega_a$ (60 hour)

- Fit flat line to the fractional uncertainty per fit parameter, $(\text{Laser} - E/p)/\text{Laser}$
- Take p_0 as the average uncertainty on each parameter, about 40%
- Using a preliminary multiplier, gives uncertainty on ω_a from the gain correction of $58\ \text{ppb}$
- This is **negligible for the 60 hour**, which is dominated by statistical uncertainties



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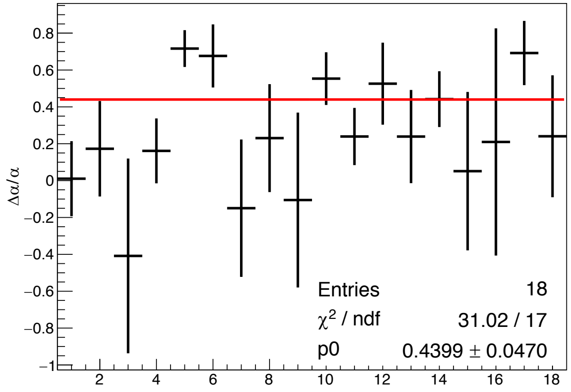
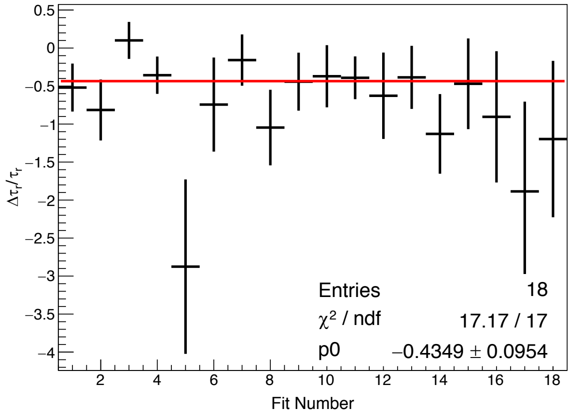
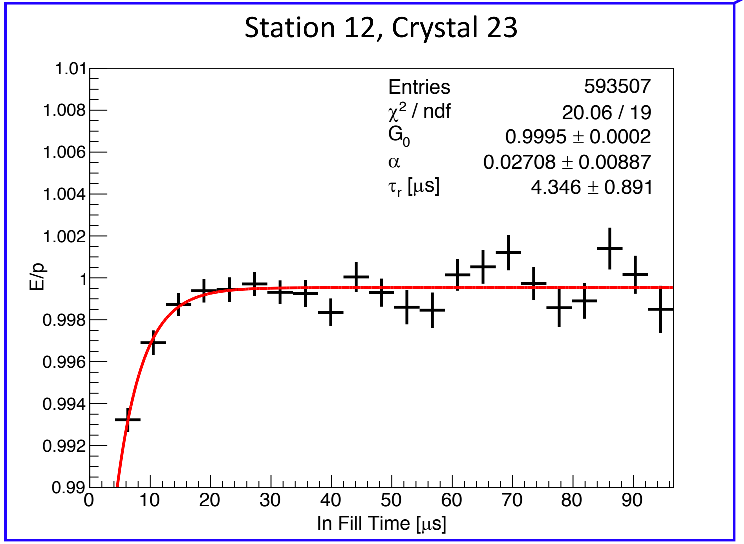
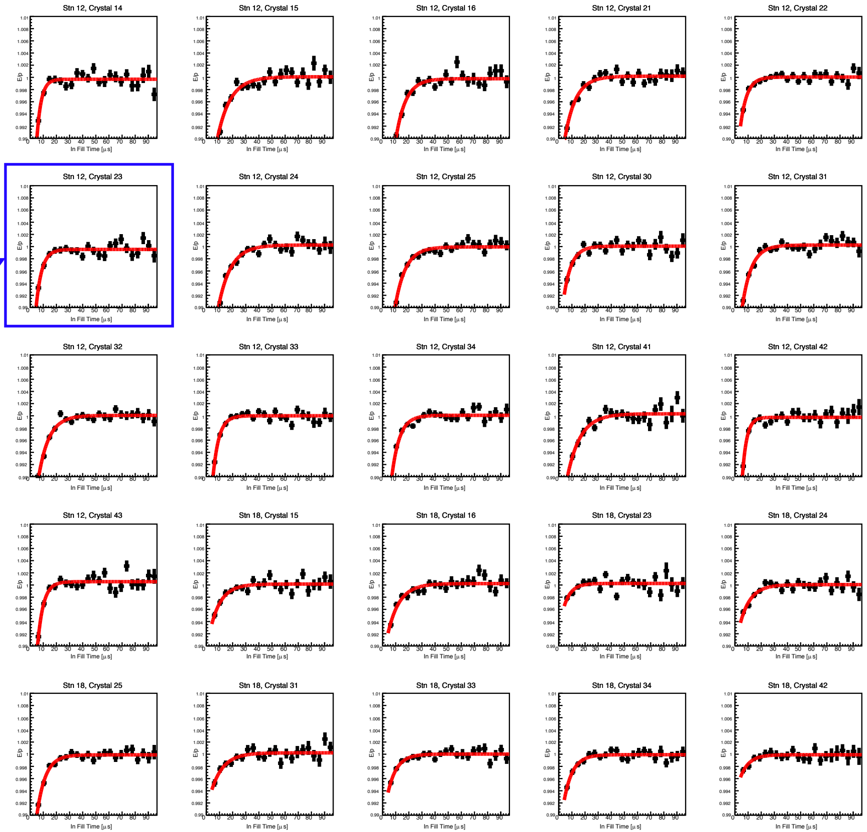




E/p gain fits per calorimeter crystal (9 day)

- Easy to re-run over a larger dataset
- 25 crystals, up from 18, make adequate fits using the 9 day dataset (our second smallest)
- I will compare this fits to the laser results when they are finalised for the 9 day





E/p fits: 60 hour compared with the 9 day

- We can compare the mean uncertainties and χ^2/ndf values for the two sets of fits

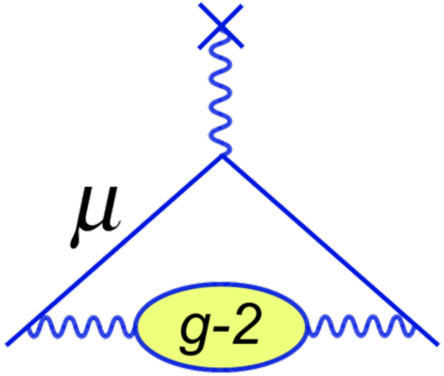
	60 hour	9 day
$\delta\tau_r$ [µs]	2.81	1.17
$\delta\alpha$	0.005	0.005
χ^2/ndf	0.91	1.03

- The uncertainties either decrease or remain constant, and the χ^2/ndf improves

- This is encouraging for E/p method, moving forward

Conclusion

- Track-cluster matching can be used to measure gain effects, and cross check the laser system
- The E/p method is found to be consistent with the laser
- It can be used to estimate the uncertainty on the gain correction, which is found to be negligible
- It is shown to improve with the use of larger datasets



Thanks for listening!

No positron selection