Update Pisa group

News

We were trying to analyse/publish the GSI fragmentation data (TOF and energy), using an energy calibration mostly based on CNAO data (1 only energy at GSI, not enough)

Since last meeting (06-05-2020) there were at least 3 points to resolve:

- ✓ Didn't take into account yet the fact that fragments before target were oxygen, and afterwards something else → correct TOF for this →no difference in final spectrum
- Take into account experimental resolution in MC (easy, Gaussian smearing) → easy, suspended for the moment
- Understand the discrepancy in between data-MC for fragmentation measurements at GSI in the energy spectrum
  - TOF is fine!
  - Energy spectrum is not → see next
  - Many tests done, try to shortly summarize some of them here
  - Focus for the moment on well calibrated positions

Calibration

Calibration: relate the deposited charge to a real deposited energy value (or anything related to that)

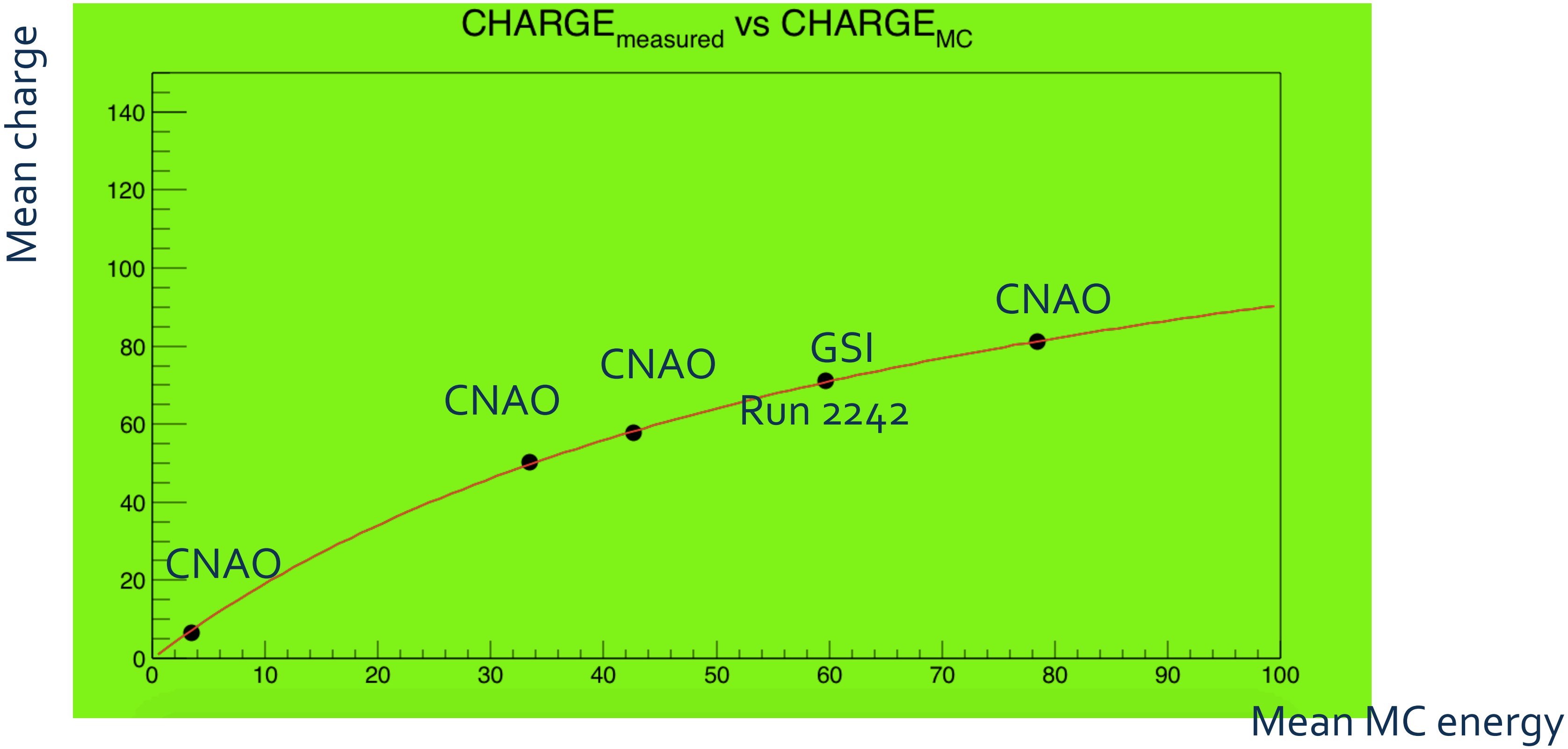
2 totally independent calibration methods tested

1. Position-by-position: equalize each position (determined with cross position of 2 planes) with MC, apply Birks in all positions hit
   - Advantage:
     - All positions studied independently
     - Most precise: best energy resolution
   - Disadvantage:
     - Ideally, all positions should be irradiated with say >40 events per energy
2. In the center, equalize all charges to the values in the center, apply Birks once per plane
   - Advantage: somewhat simpler
   - Disadvantage:
     - a bit less precise (loose resolution)
     - depends strongly on charge in 1 position

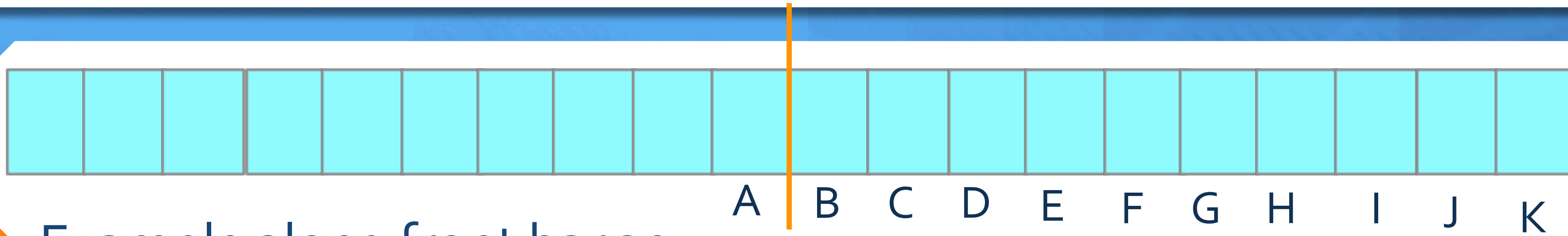
- NB1: We tested both. Note that in the end, it's similar; parameterize the response of the bars in some way to a reference value (MC, central value, respectively).
- NB2: We can use only GSI data and "tune" the calibration. But that would not be a real calibration, it would be better to do it from real calibration data…

Calibration

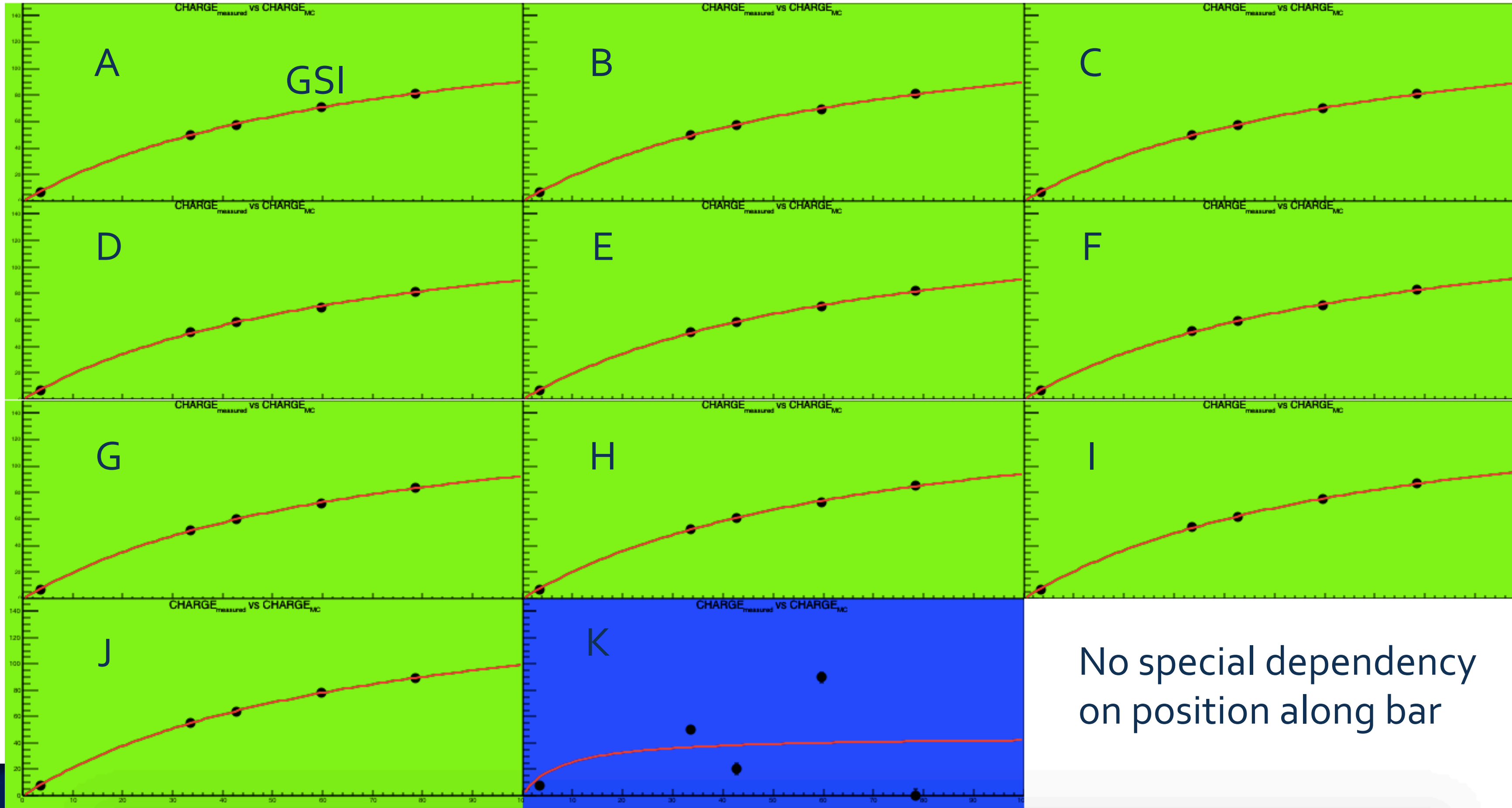
- Calibrate with data without target, known particles and energies that hit bars
- In a given position, take mean charge values and relate to mean MC
- Example of calibration in one position→ GSI point fits generally in OK
- This is the case in most positions, not in all → used the ones where it was good



Along the bar



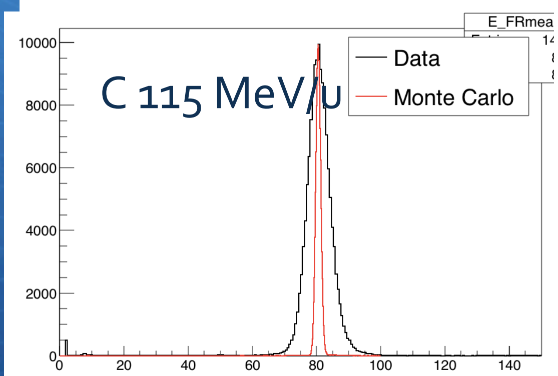
- Example along front bar 30

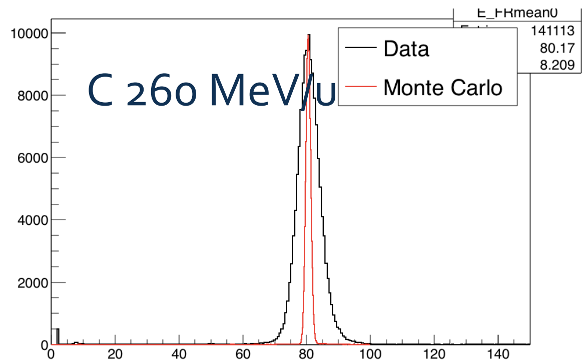


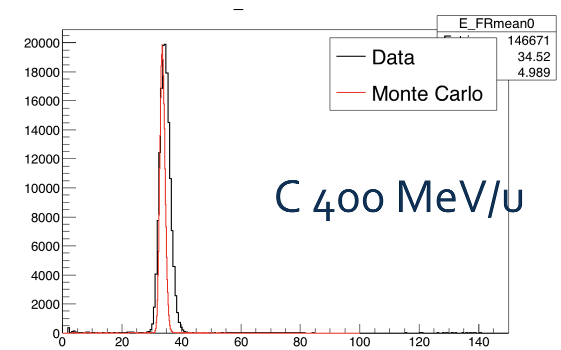
No special dependency on position along bar

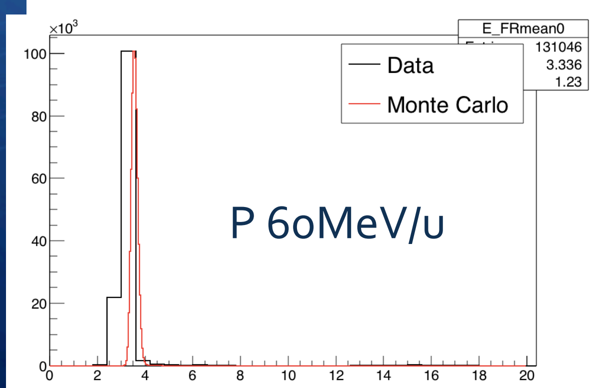
Calibration validation on measurements without target → Energy spectra

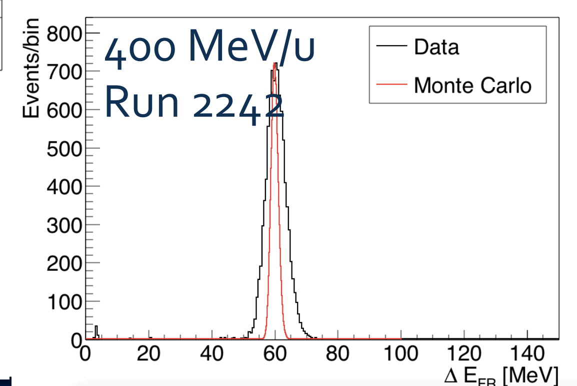
- Now apply the calibration to our measurements without target
- Sum all well-calibrated positions, apply cut (E_F-E_R)/((E_F+E_R)/2)<0.2
  → overall spectra with linear y scale look VERY NICE for CNAO and GSI
- Looks very good in all bars, both in the central and all other bars!!!!











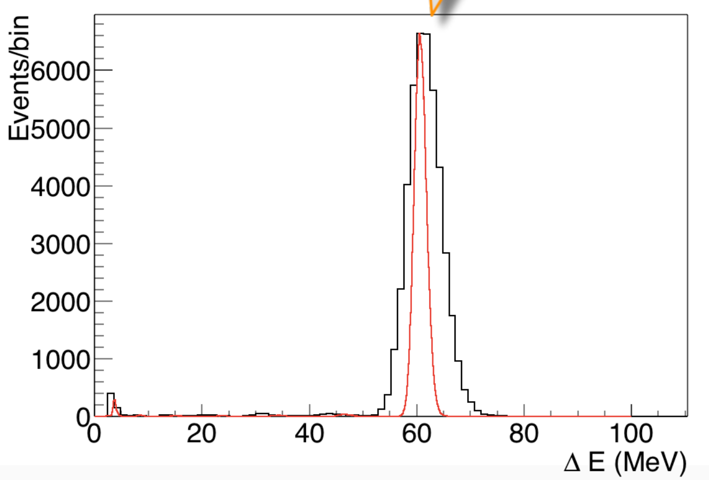
We would expect a very nice energy calibration, at least in the range with energy losses from 35-80 MeV

GSI 400 MeV/u with target

Data: runs 2239, 2240, 2241

Oxygen peak ok

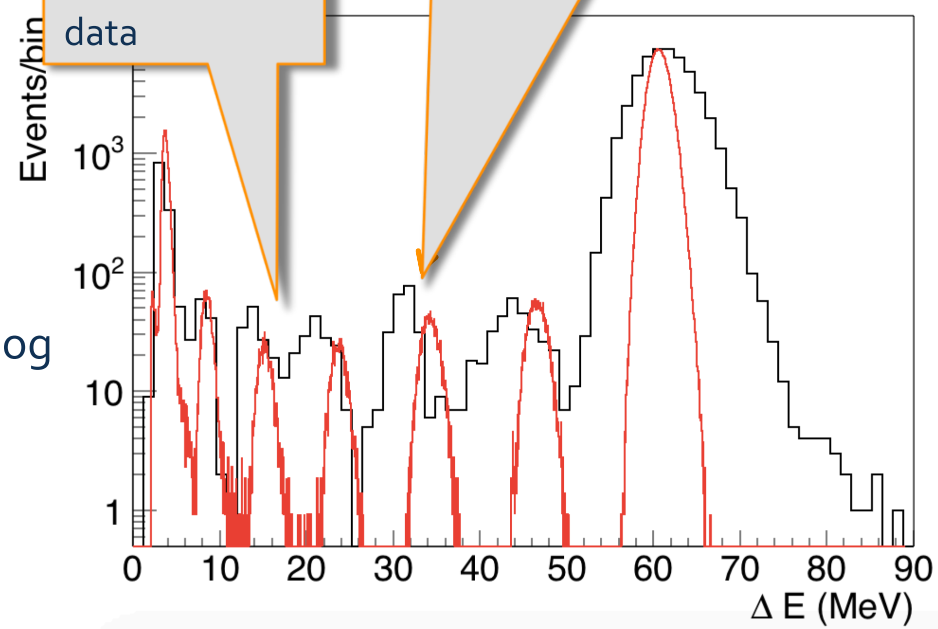
Linear



These are carbon fragments,
Energy close to 400 MeV,
Should be well-calibrated!
BUT SHIFTED!!!!!!

Zone without calibration data

Log



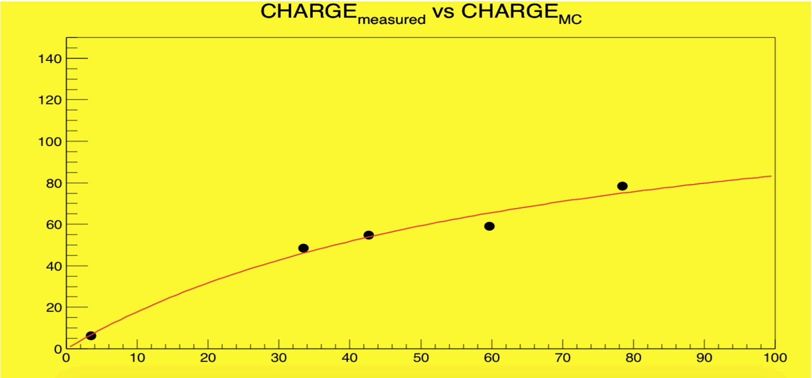
What's wrong? (1)

The calibration run without target *seemed* OK. Was something wrong with the fragmentation run?

- Verified all distances, detectors, simulation, etc.
- Verified separately Front and Rear energies, problem is in both
- Presence of vertex detector: tested with and without
- Target size? Verified with Giuseppe
- Beam energy? Uli Weber verified that energy was precisely 400 MeV/u
- And actually, the OXYGEN in the fragmentation run, hitting bars 9 and 29/30, was OK and more or less on the right position. But not the fragments, that mostly hit off-center bars (remember: off-center positions were nicely calibrated in several bars).
- "Cartoncino" in front of bars (CNAO+GSI)→ tested, no effect
- Beam energy at CNAO? (ripple filter/exit window) (changes curve)
- Effect of ghost cut was investigated (tried 5 different values) in data and MC→ no effect on shift
- Tried to isolate fragments far away from primary beam (difficult, large beam…) → no conclusion

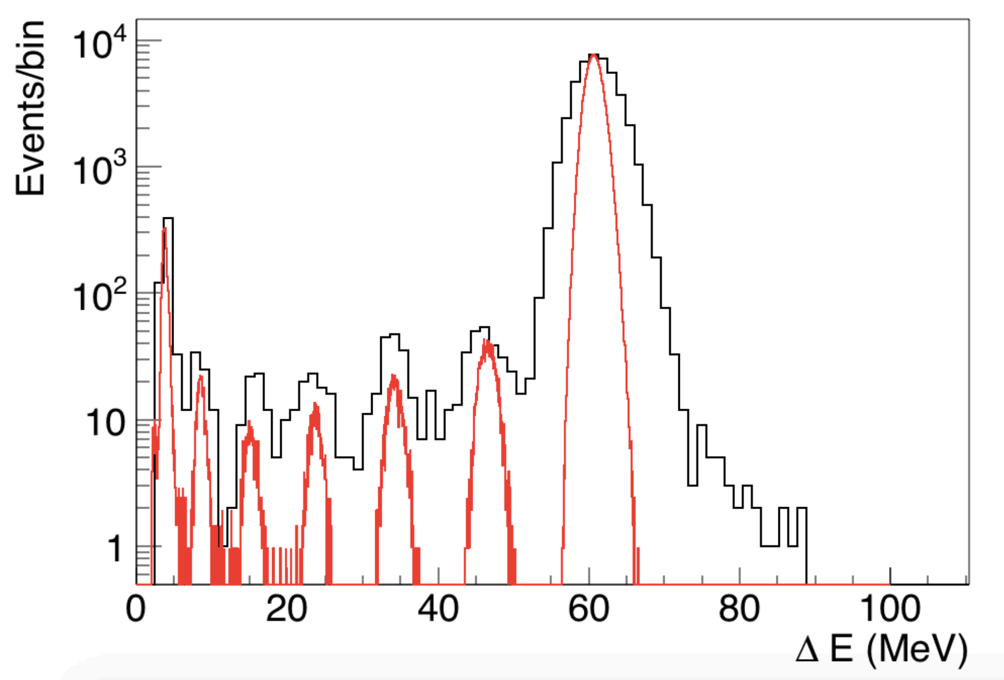
What's wrong? (2)

- Beam-size? 400 MeV beam at CNAO is small, some effect? We tested optical transport of photons → should not matter at all
- Effect of Birks (2 more Birks' models tested) → managed to fit slightly better the 400 MeV point, and Z=3 peak slightly improves, but no effect on Z=6 peak
- Gains different at CNAO and GSI?
  - We noticed that we had a few bars (connected to the same board) that gave a charge that was too small
  - Those positions weren't used
  - And from the calibration run, oxygen point is OK for many positions
  - Tried also to multiply gains of GSI wrt CNAO with different factors



What's wrong? (3)

- What if the gain of the 400 MeV/u measurement at CNAO was wrong? (crucial given that Z=6 fragments seem wrong)→ change it slightly (~0.9)
- This is a tune, not a real calibration… but it is an illustration that that the gain in the bars is important

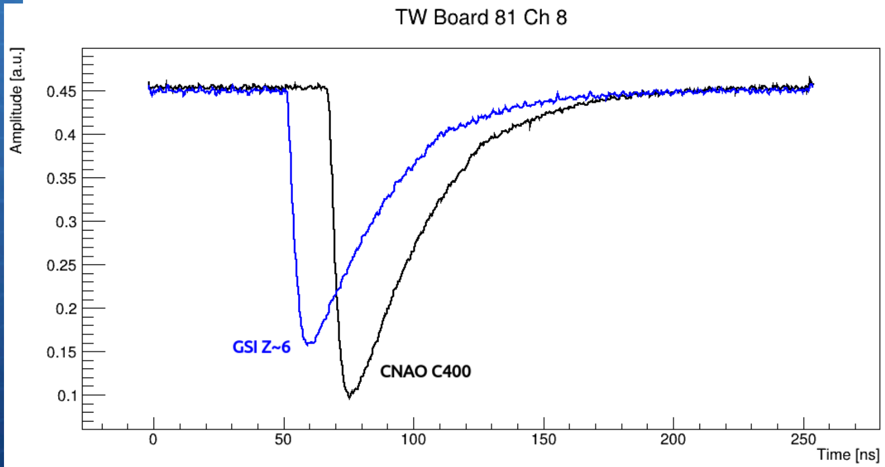


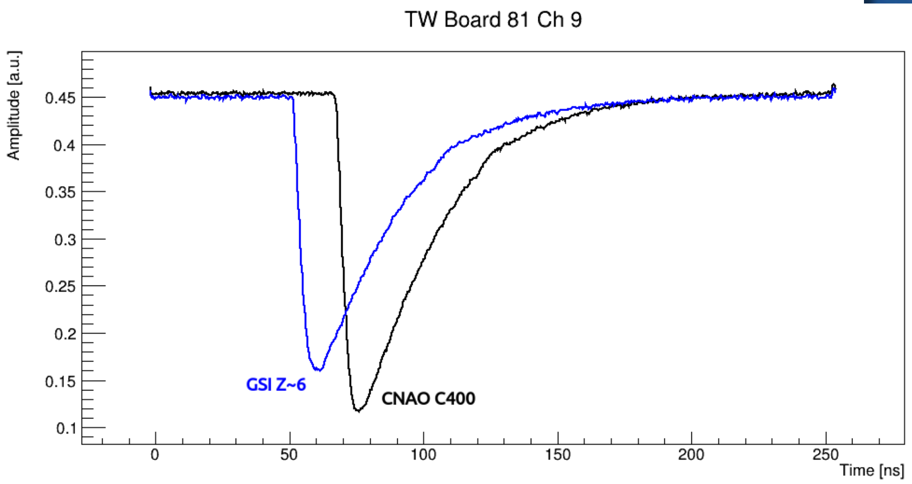
Or, the measurements with high deposit are problematic? Those could also change the curve…

What's wrong? (4)

Bug in calibration code, fits, etc?

- Independent code without any calibration came to same conclusion
- Isolated the **waveforms** that belonged to these fragments, going back to the charge.
- Checks done in various bars, all looked very similar.



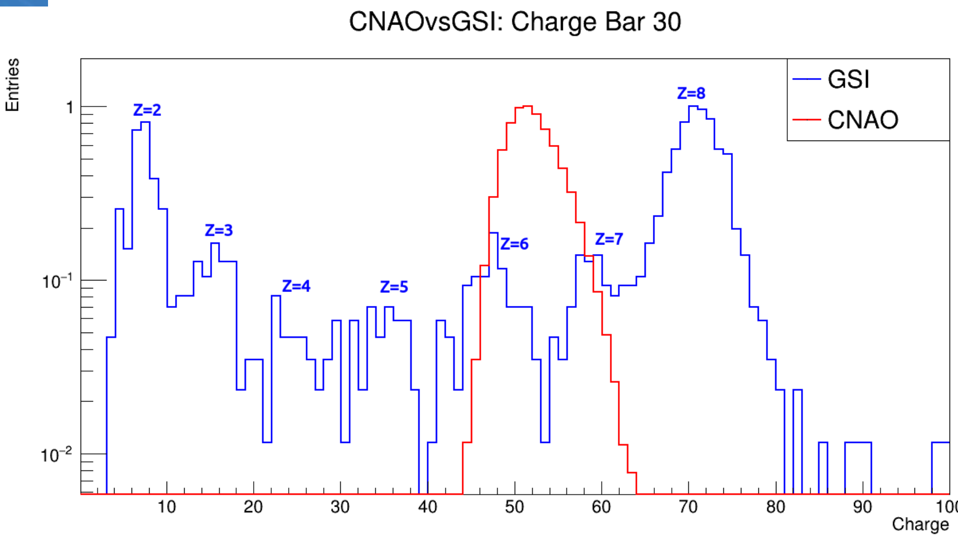


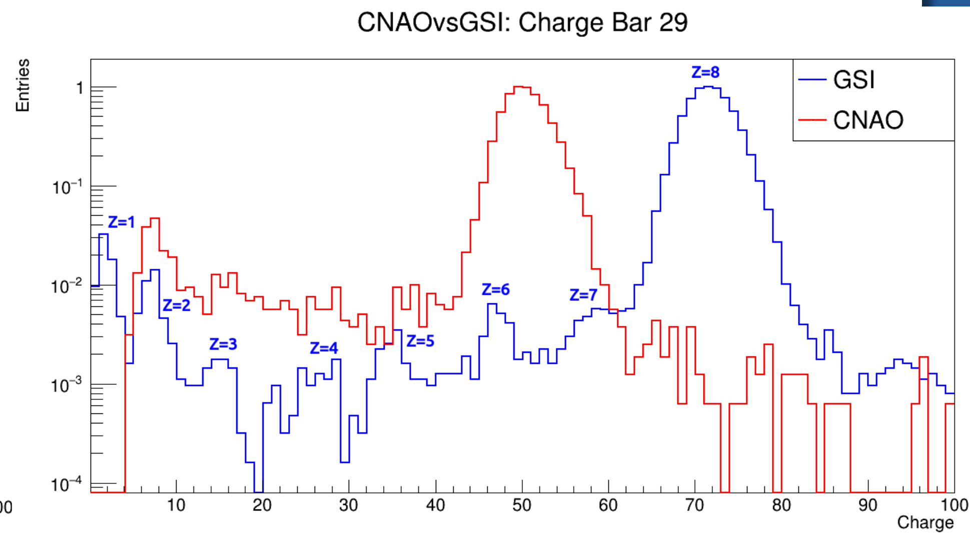
Seems charge is systematically off…
Should be similar, as fragments typically have velocities close to primary particle, so carbon should be around 400 MeV/u (verified with MC)

What's wrong? (5)

Bug in calibration code, fits, etc?

- Independent code came to same conclusion (looking purely at charge)
- Charges

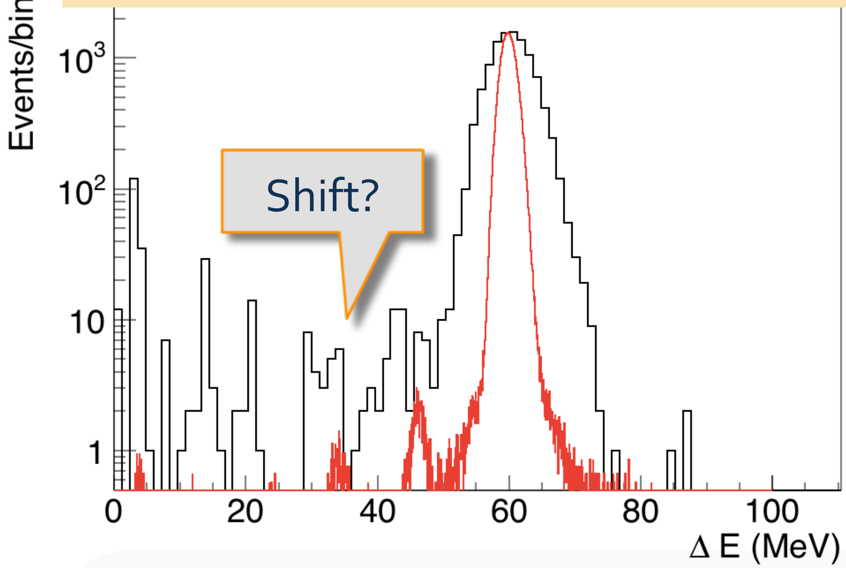




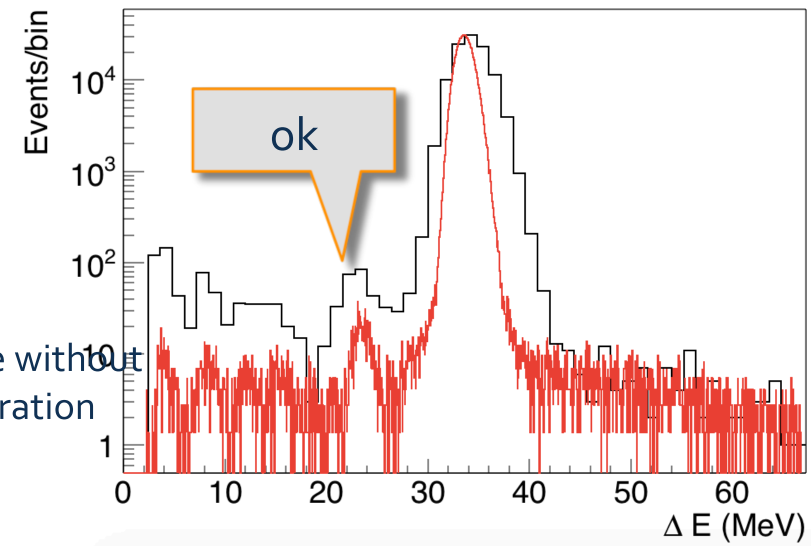
Seems charge is systematically off…
Should be similar, as fragments typically have velocities close to primary particle, so carbon should be around 400 MeV/u (verified with MC)

Look at the spectra of fragmentation in air

No target, GSI: logarithmic→ small statistics

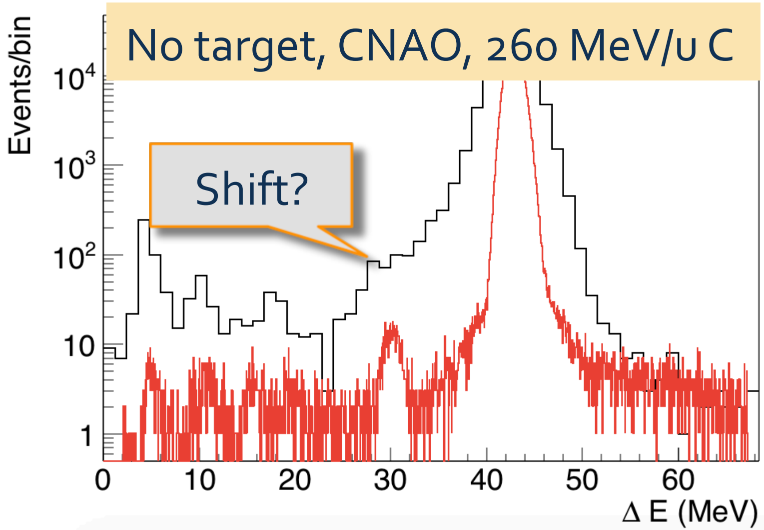


No target, CNAO, 400 MeV/u C

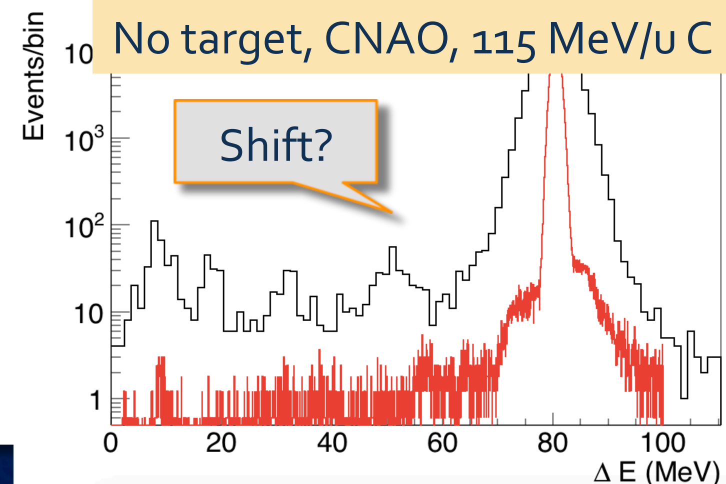


Zone without calibration data

No target, CNAO, 260 MeV/u C

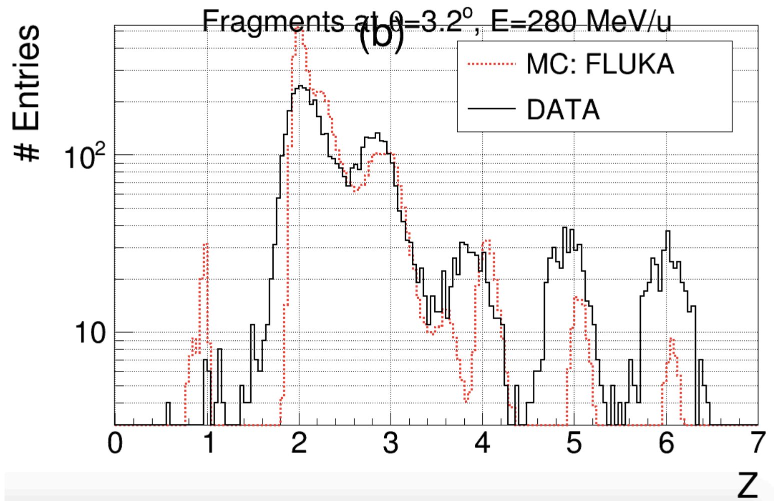


No target, CNAO, 115 MeV/u C

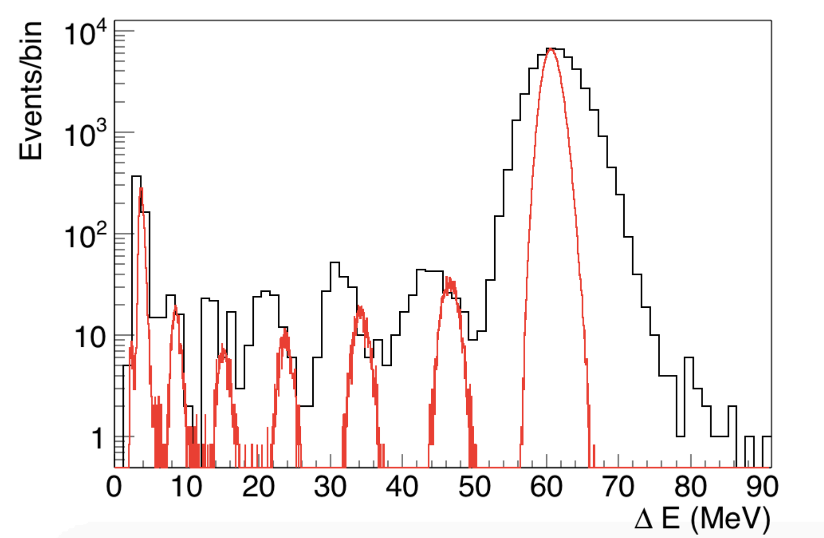


Past situation

- In setup with 2 bars, calibrated only in center, didn't have this problem at Z=6, but setup was different: 2 bars off-axis, CNAO

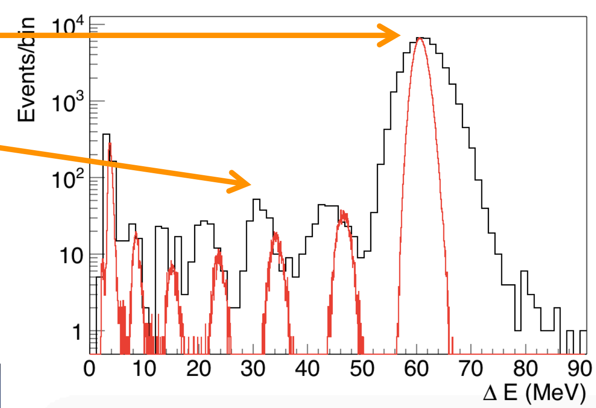


- Tried to repeat strategy by using again **only central value in calibration** → doesn't solve…



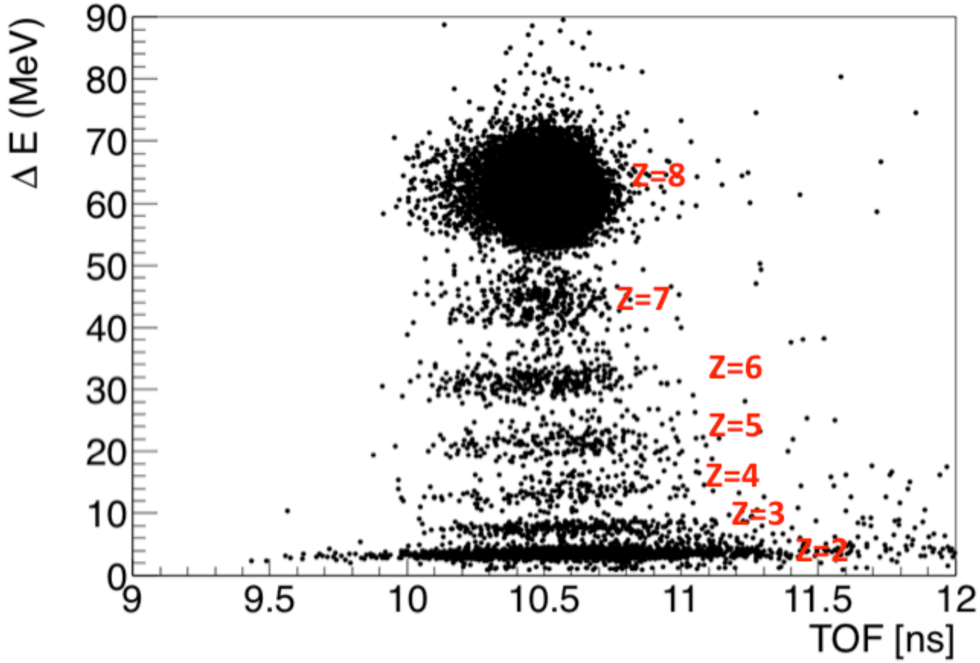
Reasons left to test

- Check HV used at CNAO and GSI
- Gains not fully reliable?? For instance, if CNAO measurement at 400 MeV (CRUCIAL HERE) was somewhat off, things change.
- Maybe the measurements with high deposits were not reliable→ calibration curve changes
  - study by Marco (Pisa) may be helpful
  - to test during next data taking
- Some kind of dependence on particle type …Height of signal depends on instantaneous event rate?? → to test during next data taking
  - Different at CNAO and GSI? (probable)
  - Different during fragmentation and calibration at GSI?
  - Different bars are hit with different frequency→ influences the amplitude?
    - Central bars are heavily hit
    - Bars around it are less frequently hit



The good news

- We learned a lot and have many ideas for tests to do in future
- The TOF is fine
- Even tough the absolute energy response is somewhat dubious, **we can easily discriminate the charges!!!**
- We don't strictly need an energy spectrum that fits with MC, we just need a way to separate the charge…



Conclusion

- Any suggestions?
- The only way to understand is to take more data, to study:
  - More data with more energies (curves based on 4-5 measurements)
  - Dependence on particle type
  - Effect of quenching at high E losses
  - Dependence of signal amplitude on event rate
  - (Dependence on hit position transversally)
  - ?