Charge identification analysis with the ΔE-TOF detector prototype

Pisa group

Outline

- Introduction
- Experimental setups
- Results
  - Calibrations
  - Fragmentation analysis 8 degrees
  - Fragmentation analysis 4 degrees
- Conclusions and future plans

Introduction

* Goal today: show the performance of charge identification measurements done with the dE/dx-TOF prototype at CNAO

* Reminder: dE/dx-TOF essential for measuring Z of fragments
  * TOF
  * Energy deposition

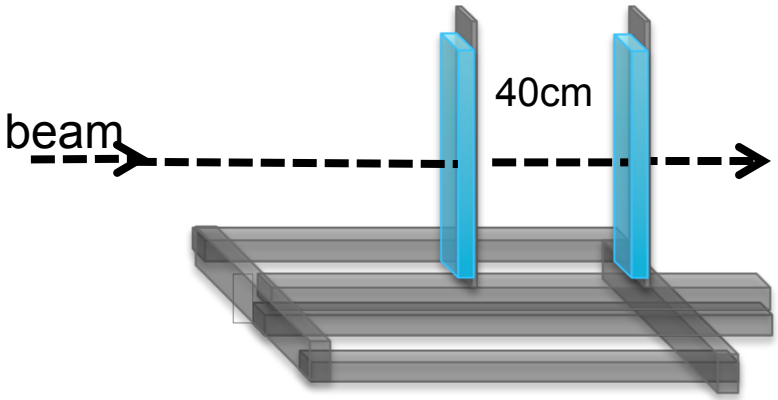
* Today: show snapshot of measurements done in 2018
  * February 2018
    * Calibration measurements: protons & carbon ions
  * June 2018
    * Calibration measurements: carbon ions
    * Fragmentation measurements: 8 degrees
  * December 2018
    * Calibration measurements: carbon ions
    * Fragmentation measurements: 4 degrees (2 degrees only few events)

Experimental setups

- First tests with 2 bars only, performed at CNAO
- 2 experimental setups

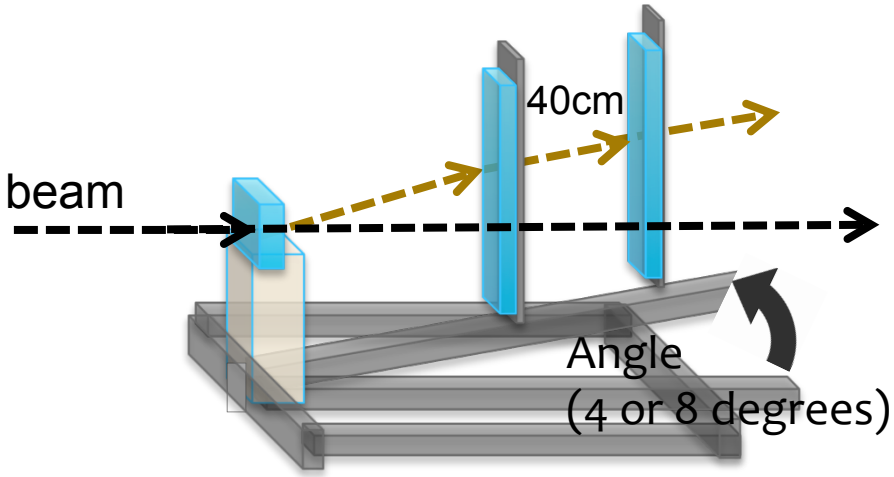
Calibration measurements

- p, C beams, directly shot on bars
- Energies: up to 250 MeV/u (p) and up to 400 MeV/u (C)
- Time and energy resolution and calibration measurements
- Direct charge Z determination
- Comparison with FLUKA MC code (no detector resolution included)



Fragmentation identification

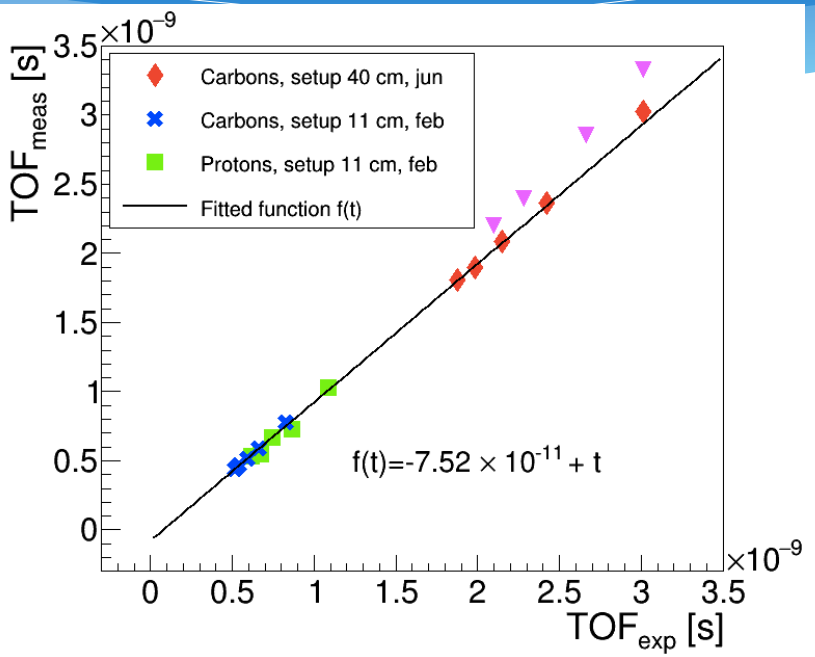
- C beam, 115- 330 MeV/u
- Bars at angle: no primary particles
- First fragment identification measurements
- Comparison with FLUKA MC code (no detector resolution included)



Results: calibration

TOF measurement should be corrected for delays in cables etc.

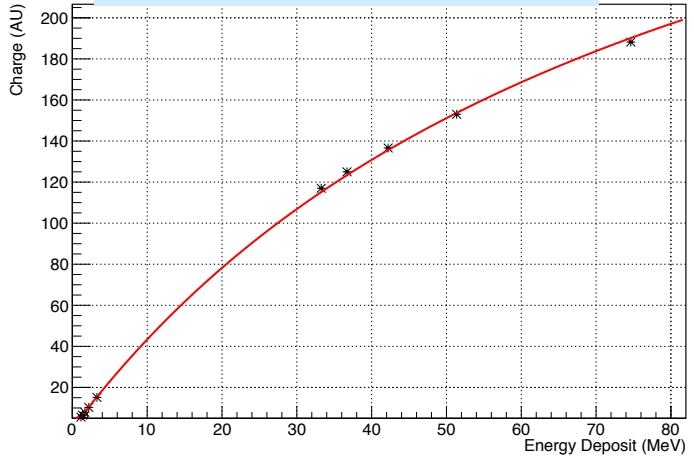
- From MC simulations get expected TOF
- Plot expectation vs measurement
- Determine offset → to
- Different setup used in December, so calibrated separately



Measured charge should be related to energy deposit

- From MC simulations get expected deposit
- Plot expectation vs measurement
- Determine relationship
- Each bar has its own calibration
- Each data-taking (Feb, Jun, Dec) has its own calibration

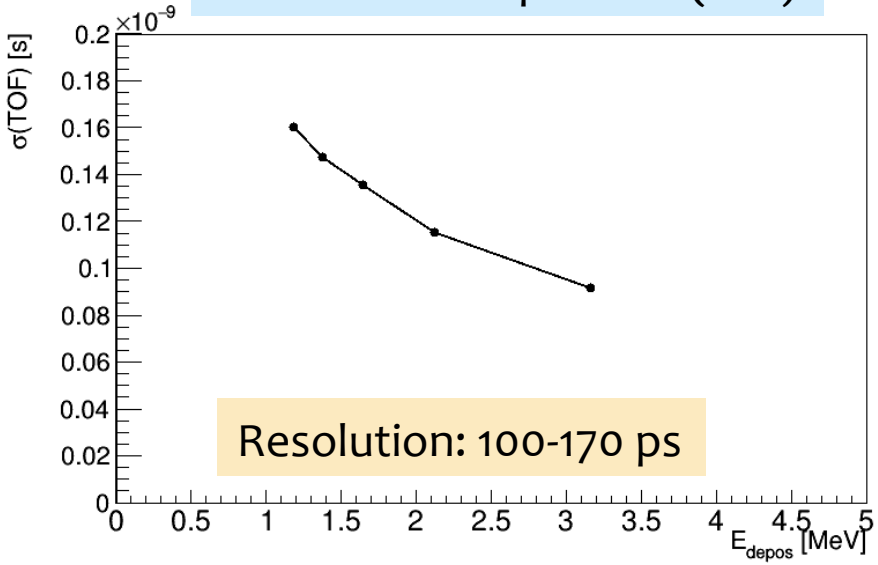
Example first bar, June



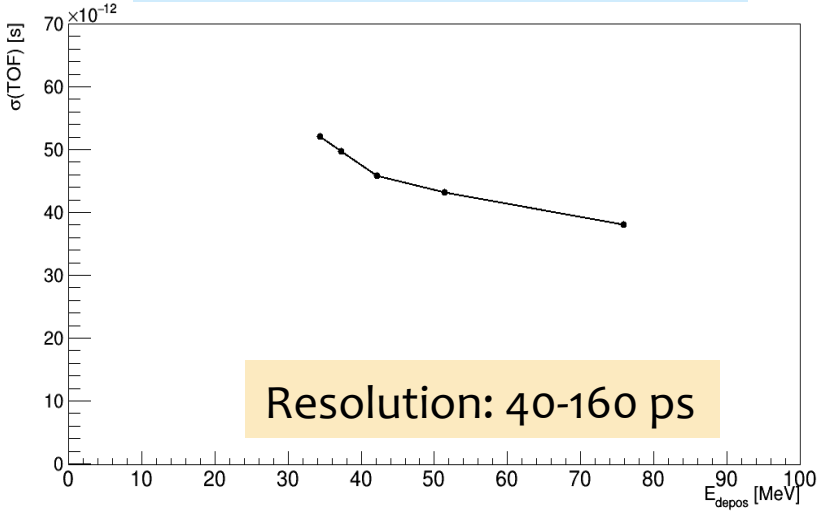
Results: Energy and TOF resolution

Just a few examples….

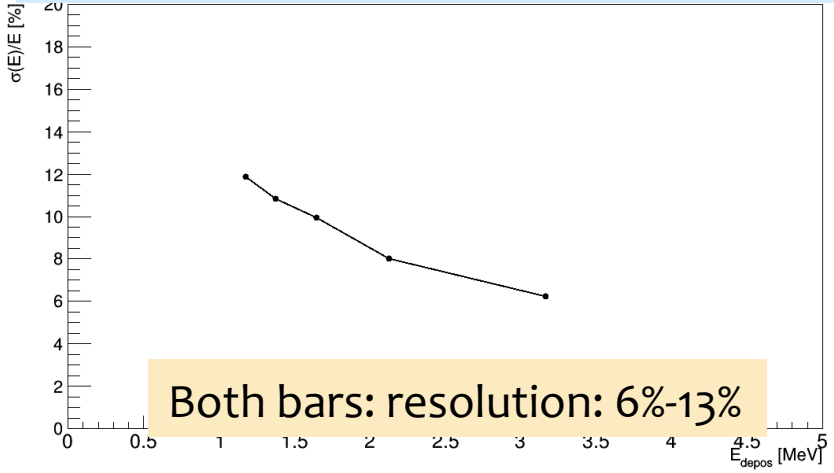
TOF resolution protons (Feb)



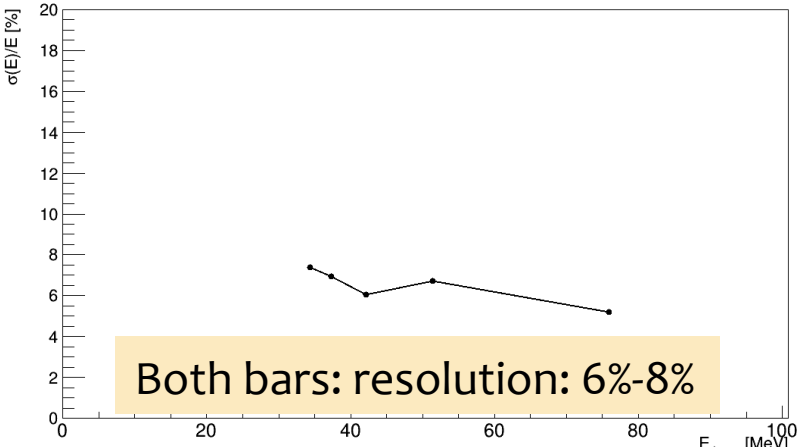
TOF resolution Carbon (Jun)



(bar 1) Energy resolution protons (Feb)



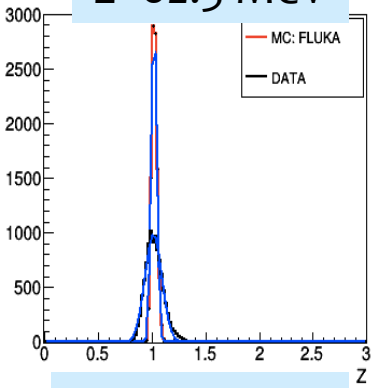
(bar 1) Energy resolution Carbon (Jun)



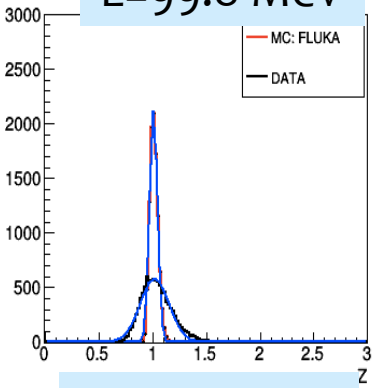
Z-plots

Protons, February 2018 (bar 1)

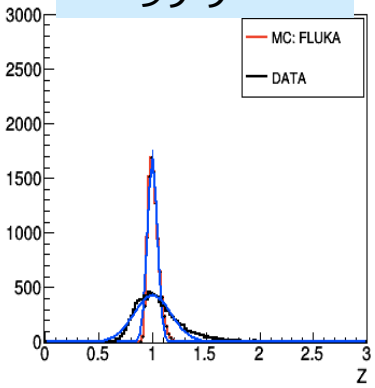
E=62.3 MeV



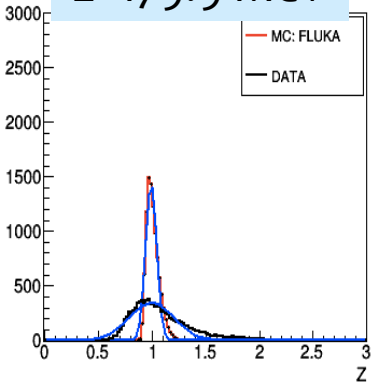
E=99.8 MeV



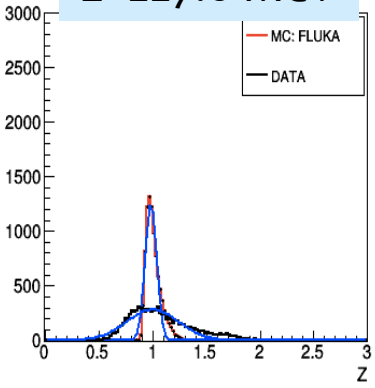
E=139.9 MeV



E=179.9 MeV



E=227.0 MeV



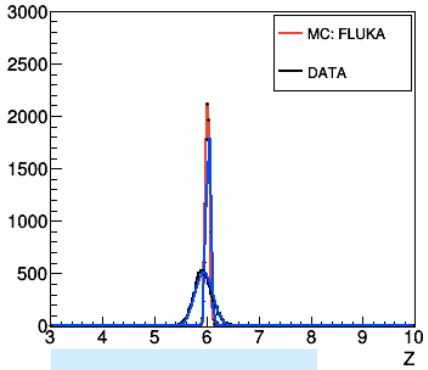
Beam	Energy [MeV/u]	$\sigma(Z)/\mu(Z)$ [%] bar 0	$\sigma(Z)/\mu(Z)$ [%] bar 1
protons	62	7.79	7.81
	100	12.86	13.23
	140	16.88	17.32
	180	20.38	20.99
	227	24.06	24.57

- Bar 1 and bar 2: resolutions in data: sigma(Z)/mu(Z)from 8% → 25%
- Non-gaussian shape at higher energies → should use the 'Langaus' function

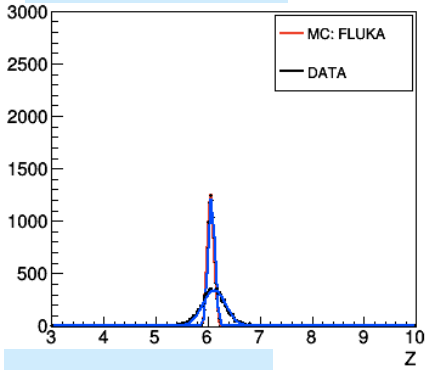
Z-plots

Carbon, June 2018 (bar 1)

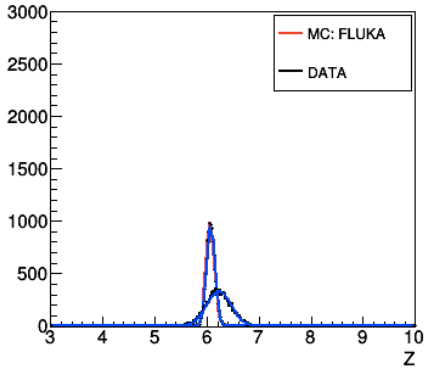
E=115 MeV



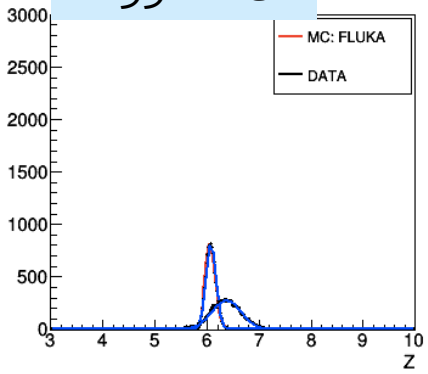
E=190 MeV



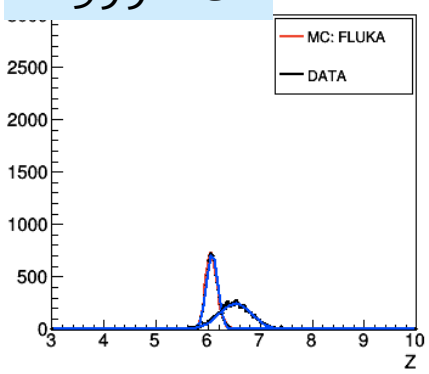
E=260 MeV



E=330 MeV



E=399 MeV



Beam	Energy [MeV/u]	$\sigma(Z)/\mu(Z)$ [%] bar 0	$\sigma(Z)/\mu(Z)$ [%] bar 1
carbon	115	2.83	2.66
	190	3.65	3.64
	260	3.73	3.81
	330	4.44	4.35
	399	4.79	4.79

- Bar 1 and bar 2: resolutions in data: sigma(Z)/mu(Z)from 3% → 5%

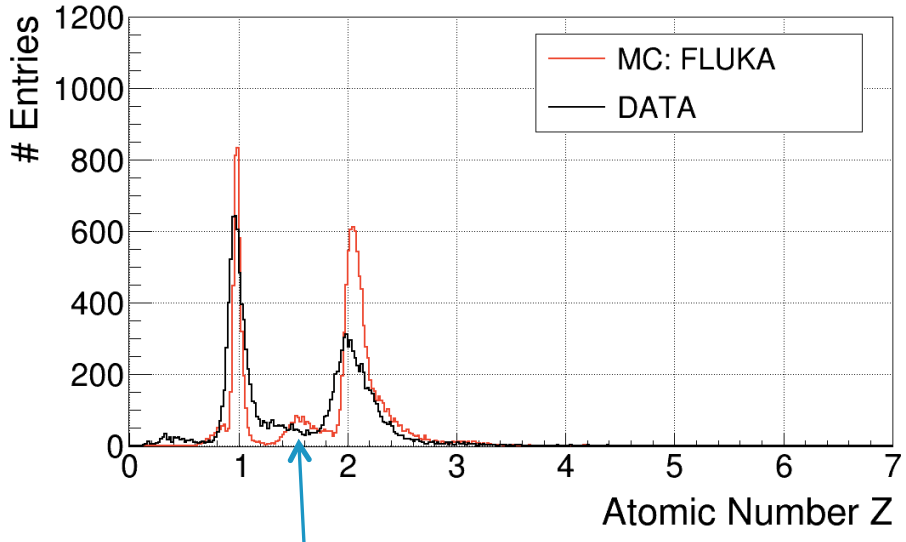
Fragmentation: 8 degrees

Data available: Carbon, 330 MeV/u
Event selection: E> 2 MeV in both bars, and fabs(Ebar1-Ebar2)<5 MeV

Normalized MC to have same integral as data.

Bar 1

MC: >=1 hit in each bar

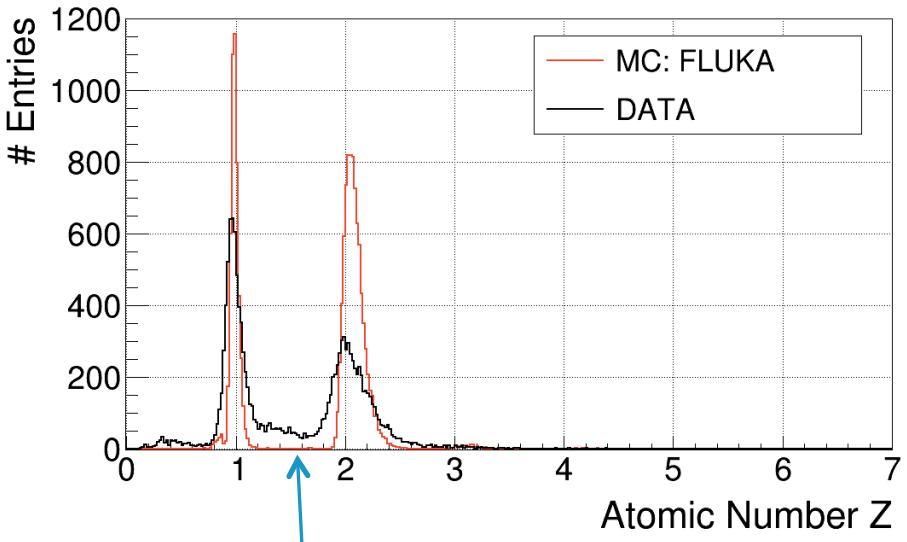


Events with >1 hit in one of bars

Normalized MC to have same integral as data.

Bar 1

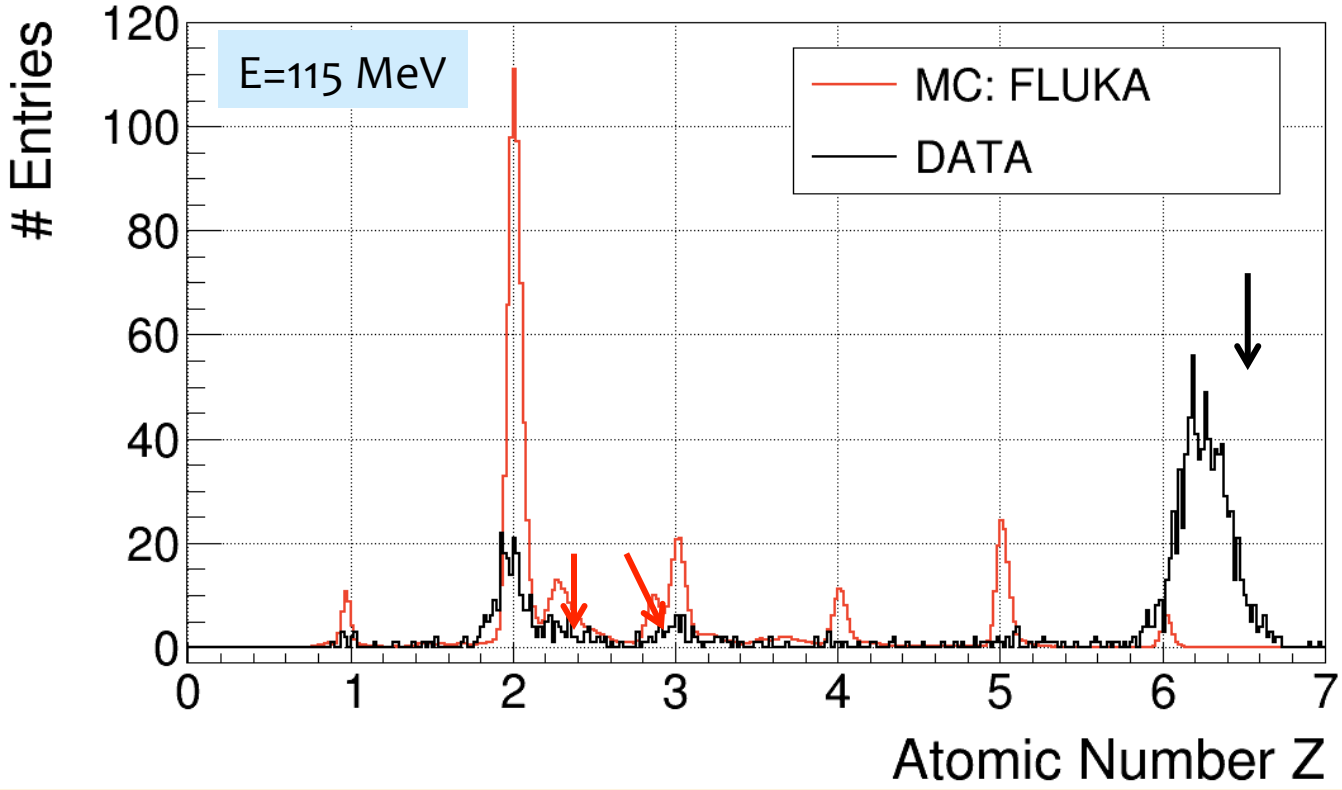
MC: 1 hit in bar 1 and 1 hit in bar 2



Only Z=1 and Z=2 at this angle (8.3 degrees)

Fragmentation: 4 degrees

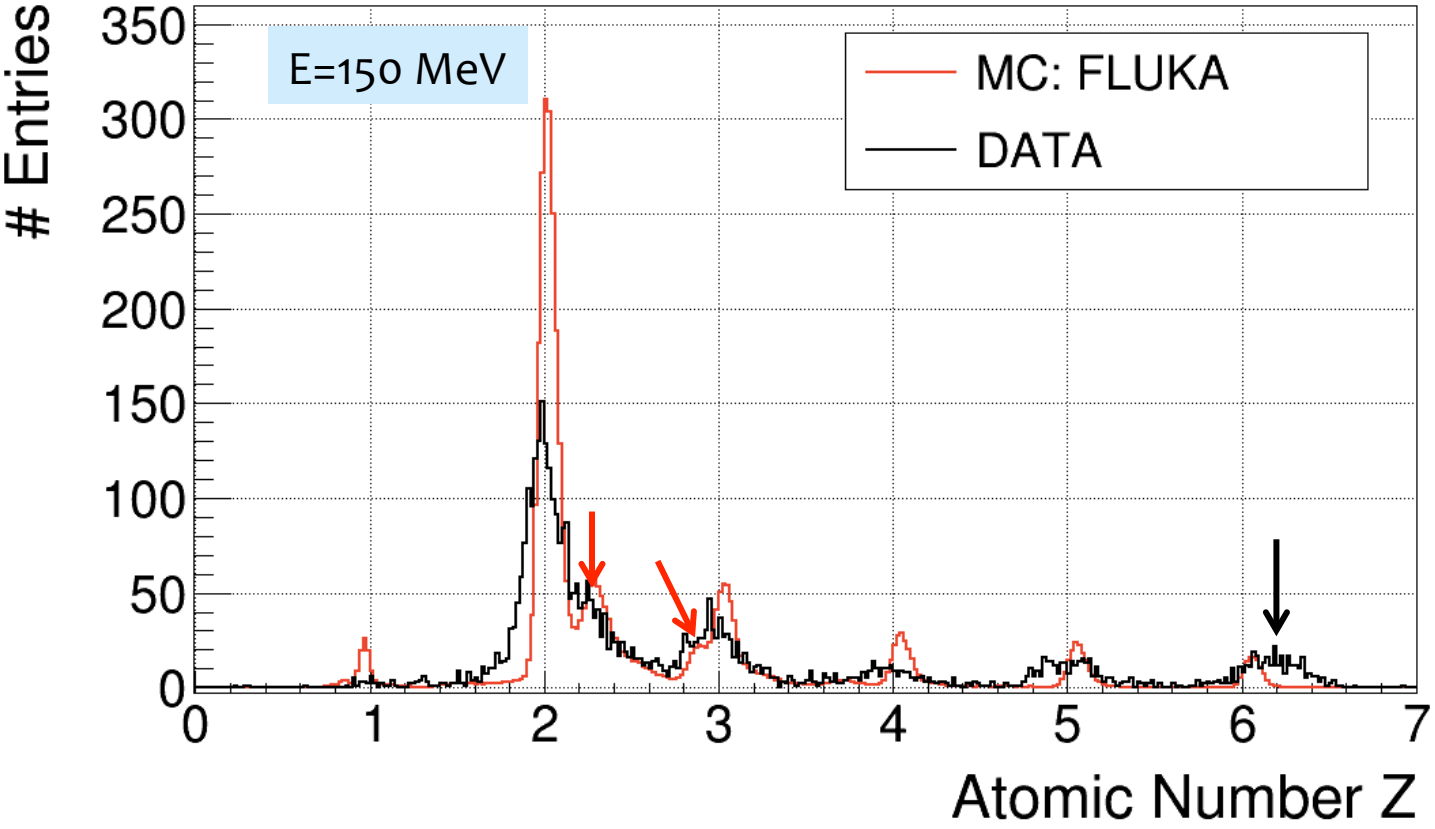
Carbon ions: 115 MeV/u
Event selection: E> 4 MeV in both bars, and fabs(Ebar1-Ebar2)<5 MeV



MC: -Events with >1 hit in one of the bars dirty Z distribution
-Experimental setup modeled too approximately
Data: - see Z=1, Z=2 and Z=3, a few events with Z=4 and Z=5
- Z=6: Primary beam, beam-width not modeled correctly
- Energy and time calibration not great

Fragmentation: 4 degrees

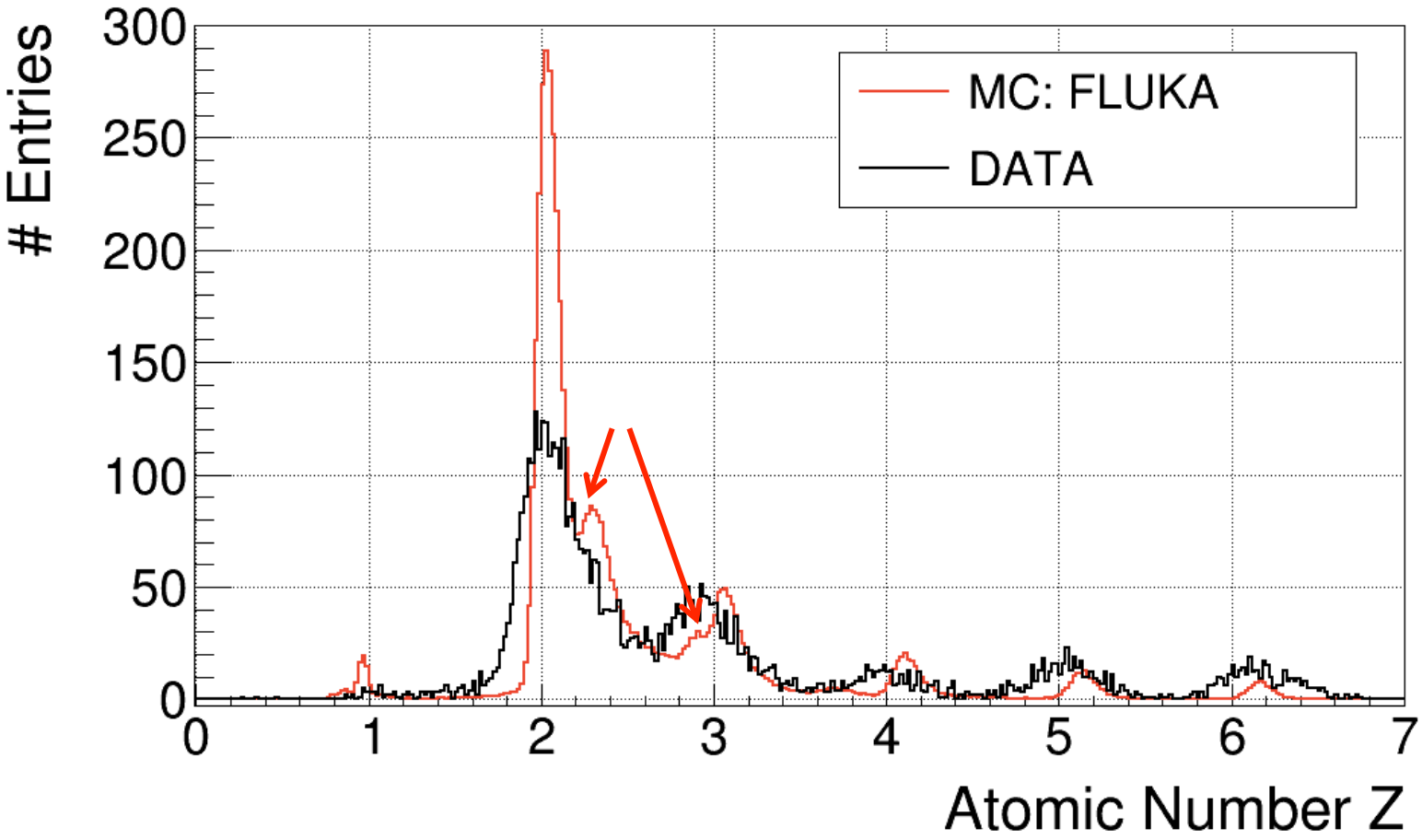
Carbon ions: 115 MeV/u
Event selection: E> 4 MeV in both bars, and fabs(Ebar1-Ebar2)<5 MeV



Fragmentation: 4 degrees

Carbon ions: 115 MeV/u
Event selection: E> 4 MeV in both bars, and fabs(Ebar1-Ebar2)<5 MeV

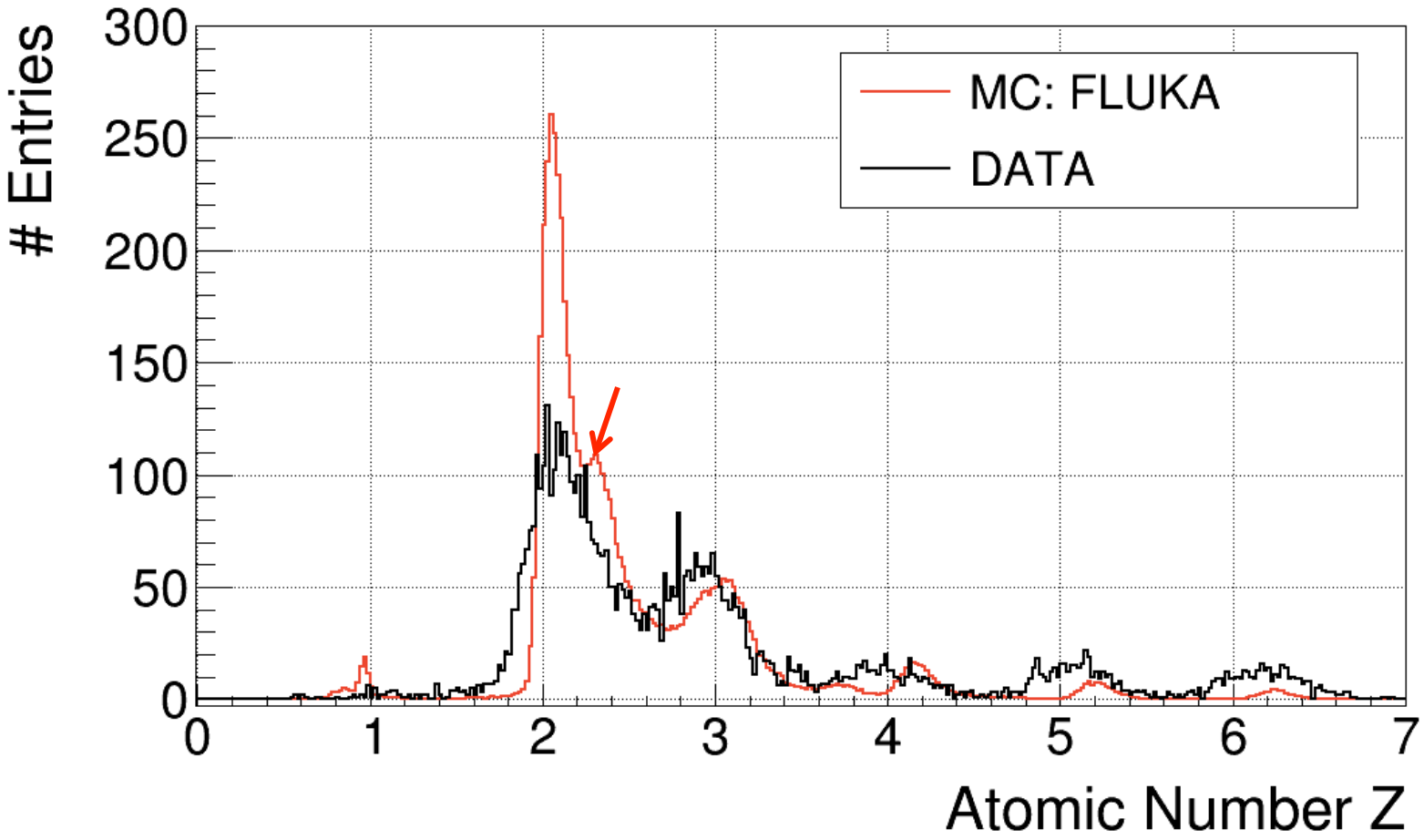
E=221 MeV



Fragmentation: 4 degrees

Carbon ions: 115 MeV/u
Event selection: E> 4 MeV in both bars, and fabs(Ebar1-Ebar2)<5 MeV

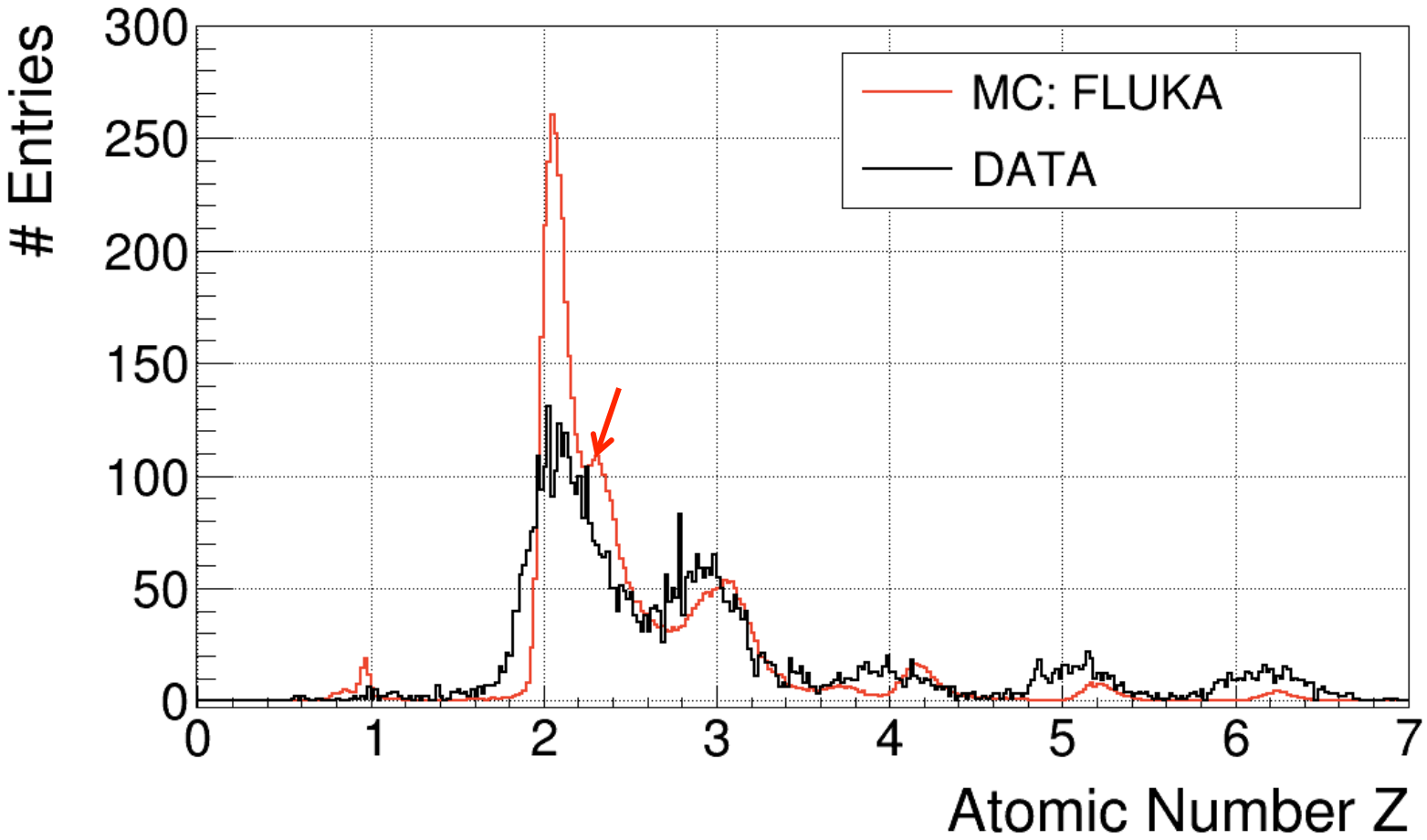
E=280 MeV



Fragmentation: 4 degrees

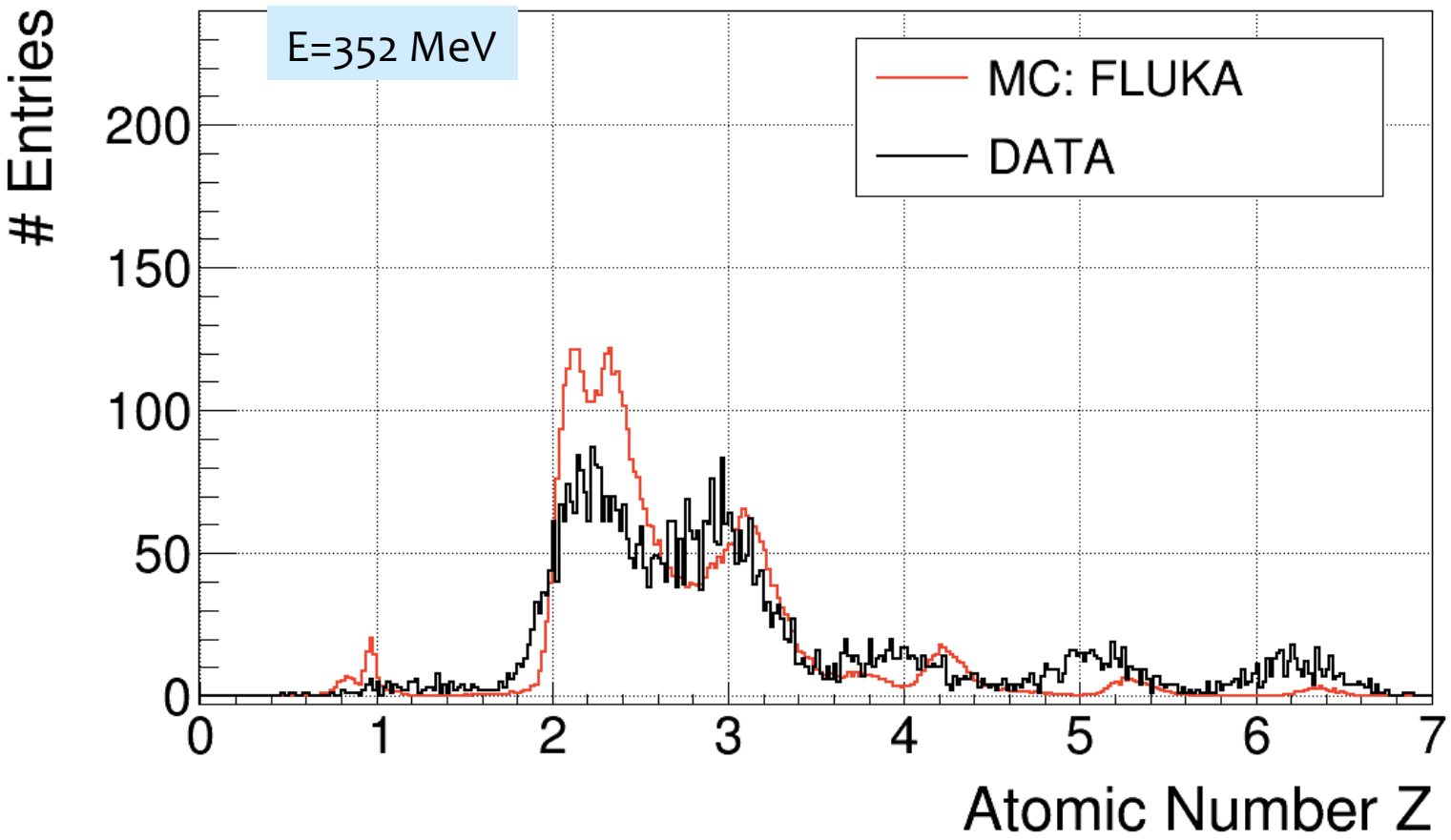
Carbon ions: 115 MeV/u
Event selection: E> 4 MeV in both bars, and fabs(Ebar1-Ebar2)<5 MeV

E=280 MeV

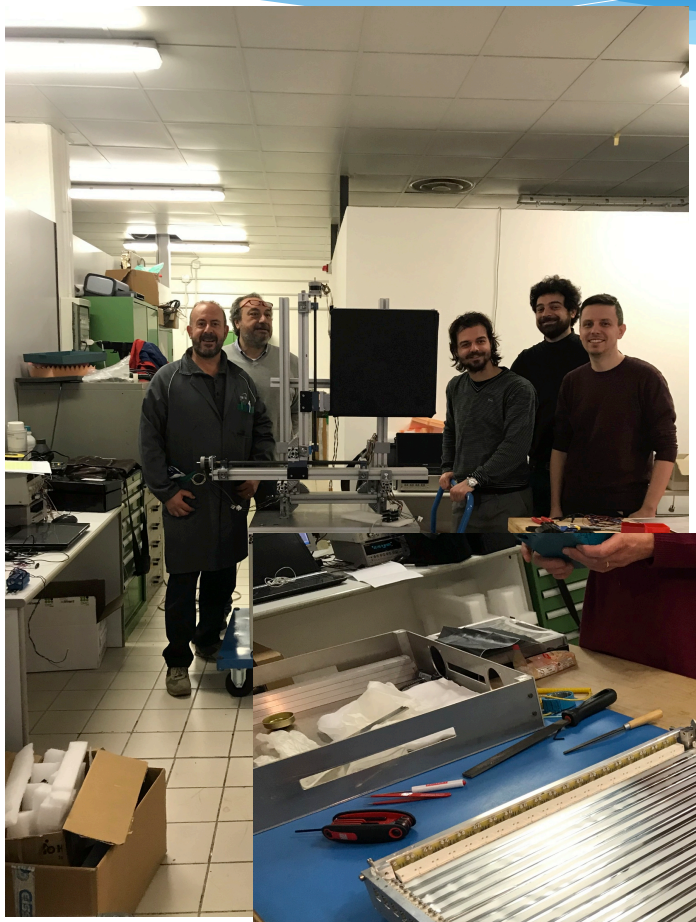


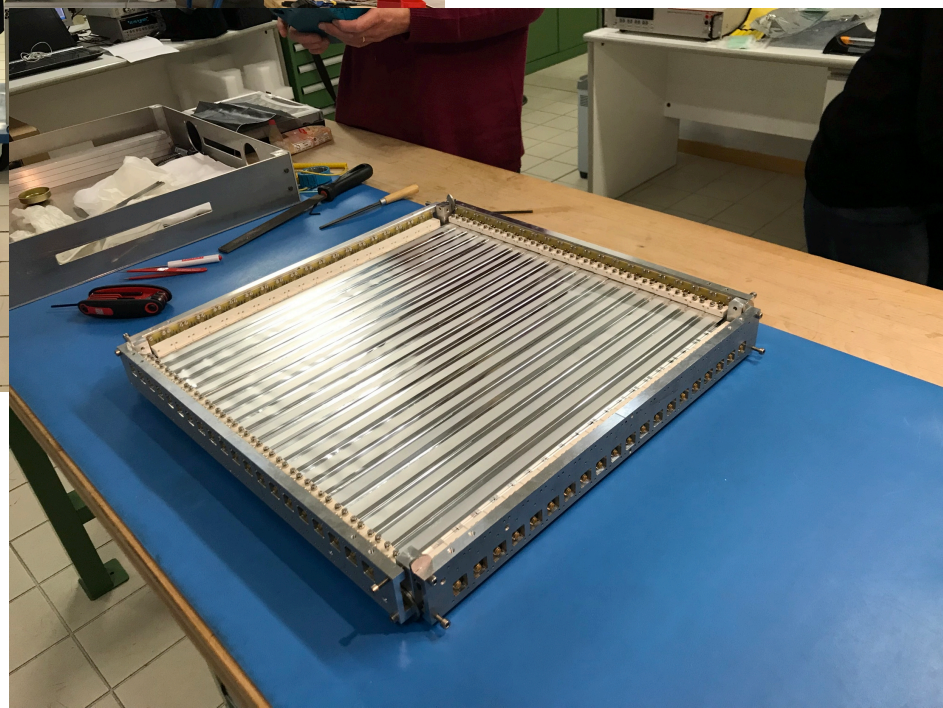
Fragmentation: 4 degrees

Carbon ions: 115 MeV/u
Event selection: E> 4 MeV in both bars, and fabs(Ebar1-Ebar2)<5 MeV



Good news!





Scintillator bars ready for GSI!!

Calibration data taken at CNAO

Plans & Conclusions

* Refine calibration procedure
* Problem to be solved: why MC gives systematically a Z that is too large (seen also by Roberto).
  * Not seen so pronounced when looking at the truth (crossings)
  * Will have a detailed look friday with Giuseppe
* Fragmentation data at 4 and 8 degrees: a few cross checks are still to be done.