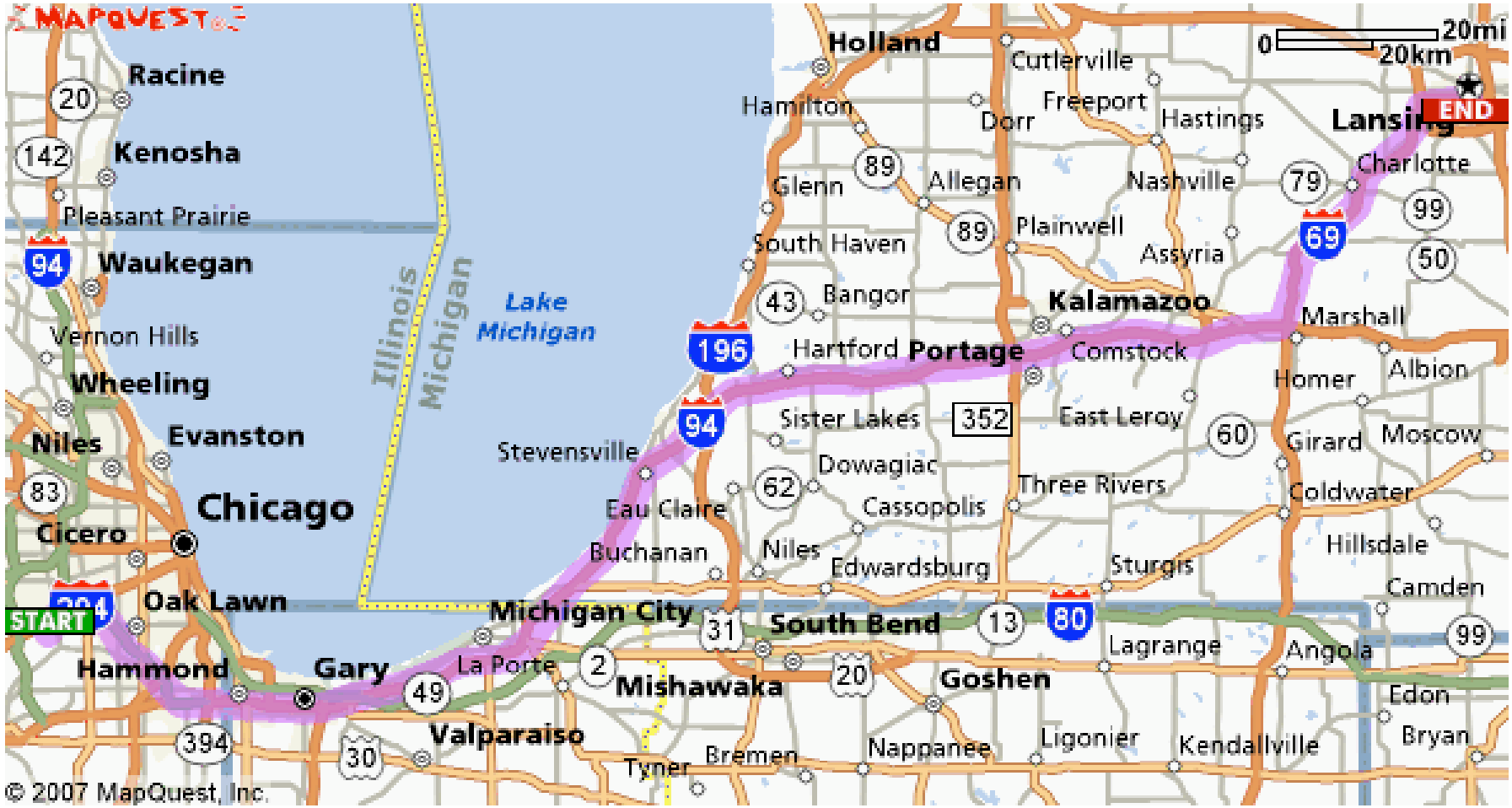
MSU to Argonne: 3:44:00 (13440 s)



desired mass resolution: 1x10^-4 => dt/t =1.5 s

desired accuracy: 1x10^-6 (~100 keV) => t centroid to 15 ms

Time of Flight Mass Measurements at the NSCL

Alfredo Estrade

why bother?: theory

$$E=mc^2$$

$$M_{nuclear} \neq Z*m_p + N*m_n$$

binding energy!!

"the mass of the nucleus must be regarded as one of its basic characteristics"

almost any paper...

why bother? astrophysics

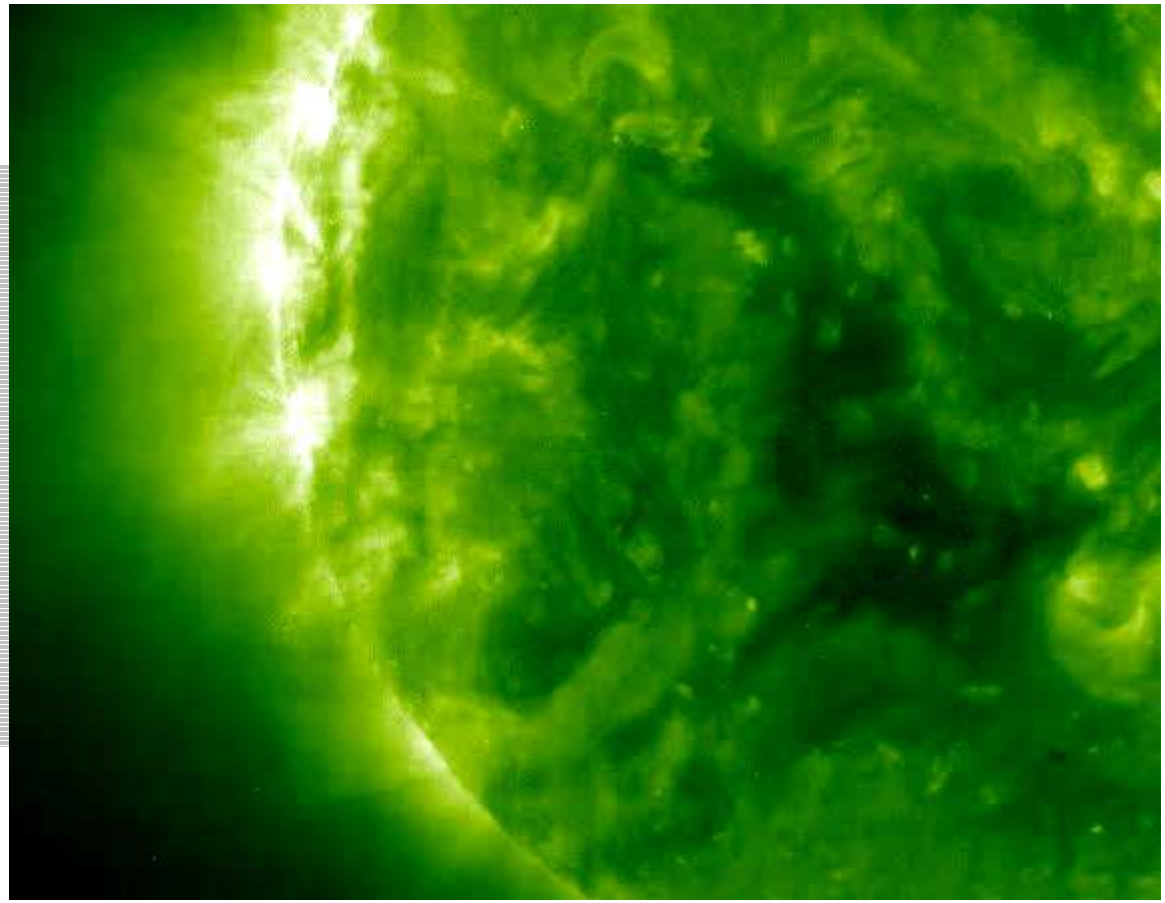
1920's...

Aston: discovered mass defect

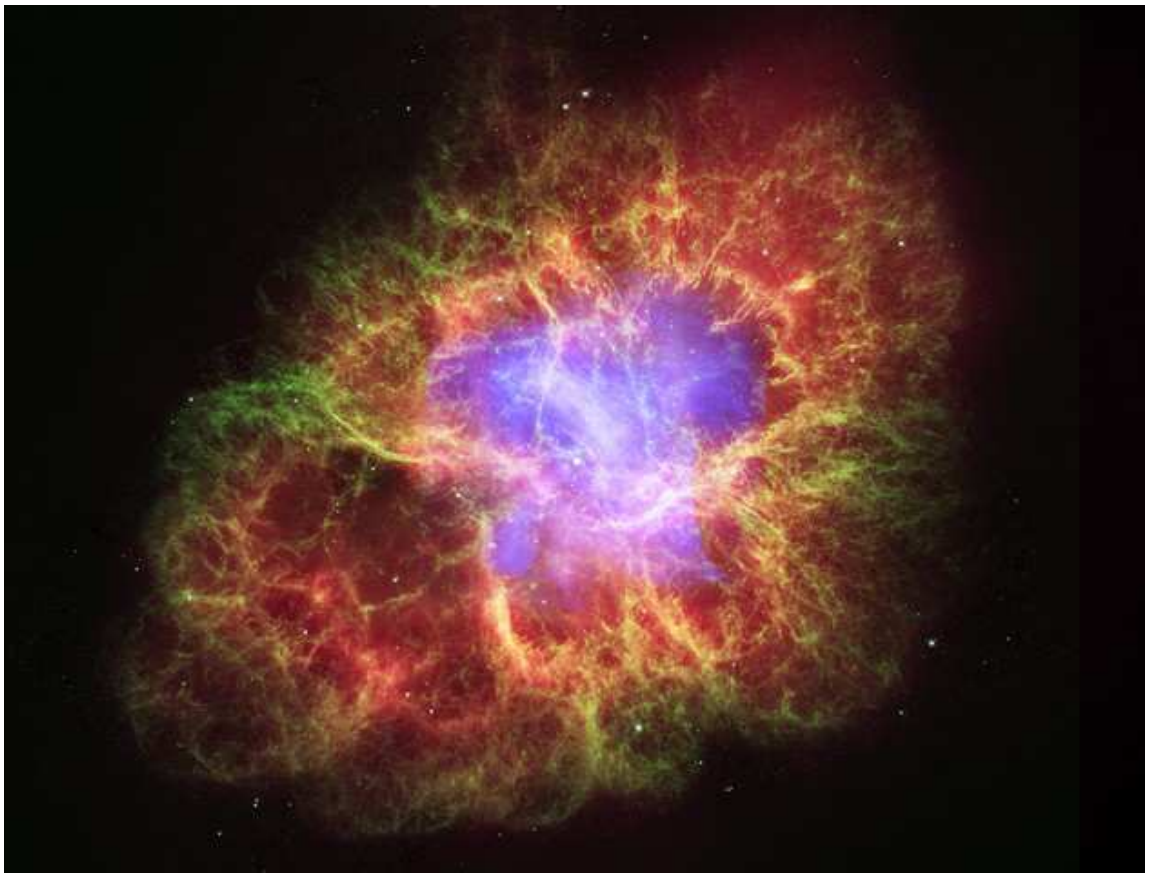
mHe - mH ~ .032 u

Edington (et al): source of stellar energy!

"*what is possible in the Cavendish Laboratory may not be too difficult in the sun*"

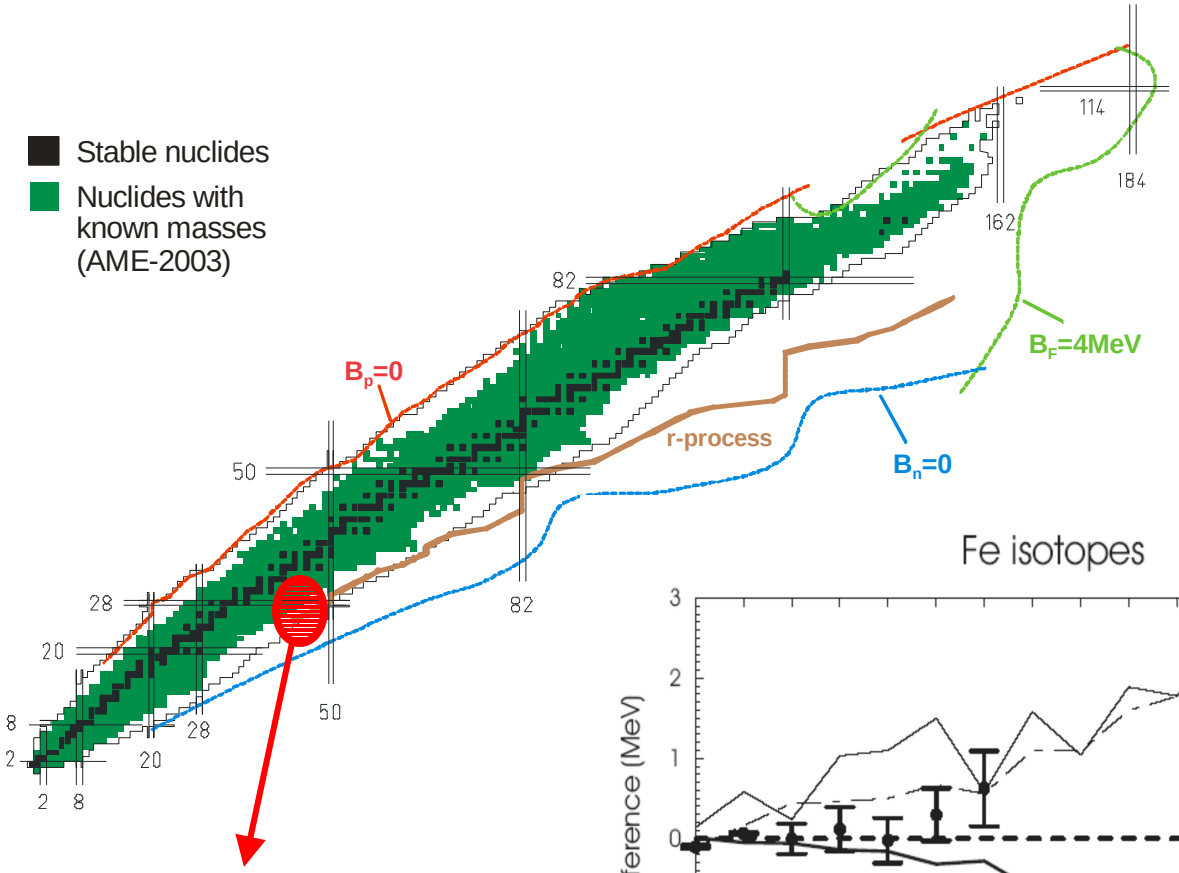


why bother? astrophysics

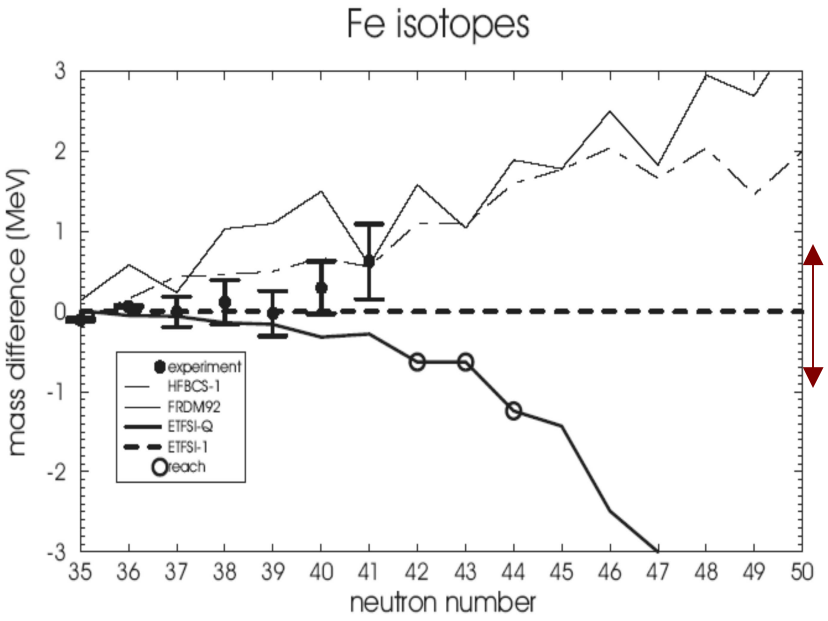


Explosive nucleosynthesis >> we need masses of unstable isotopes

what do we know...

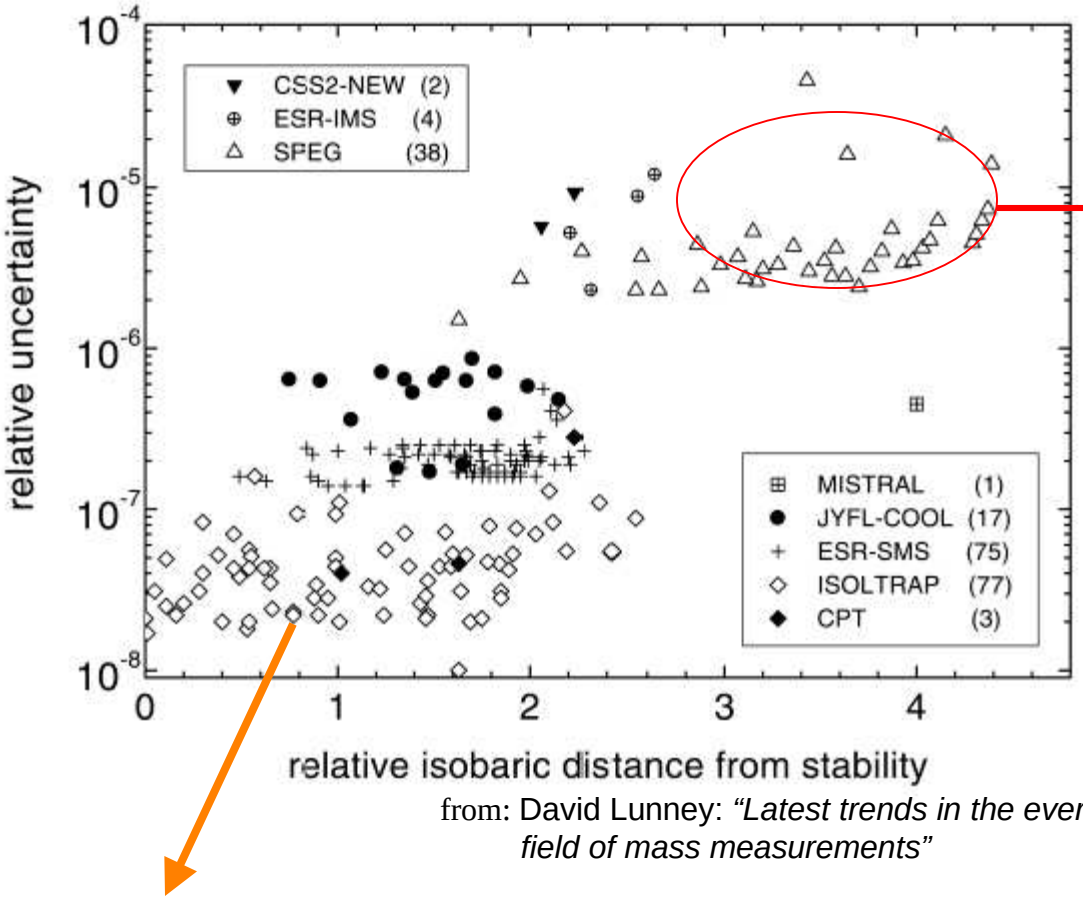


Experiment 01035
^{68}Fe region



note the scale!
100s keV is a good test for mass models

experimental techniques

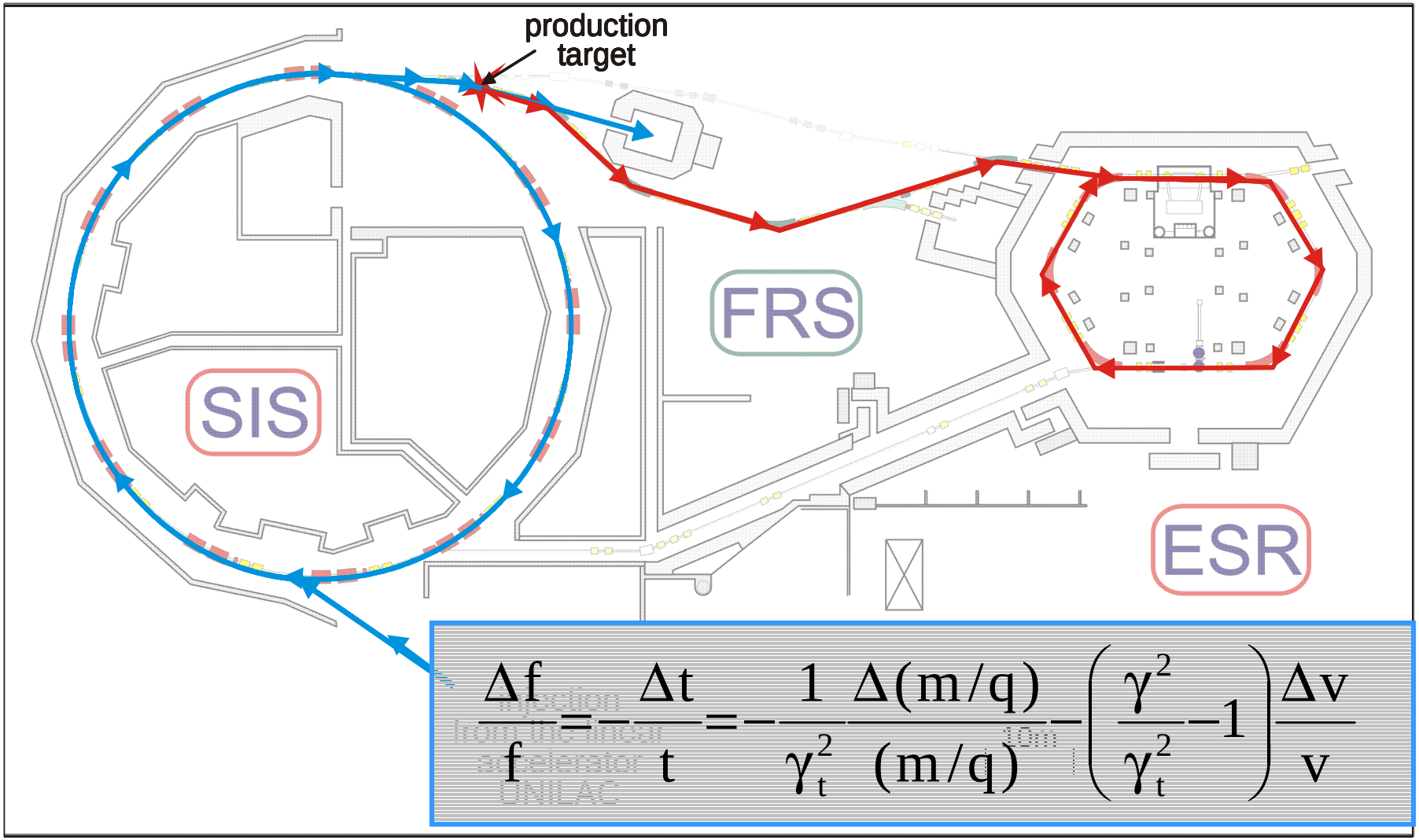


time-of-flight (TOF) measurements

from: David Lunney: *"Latest trends in the ever-surprising field of mass measurements"*

penning traps kick butt, but...

Mass Measurements at the GSI Storage Ring - ESR



$$\frac{\Delta f}{f} = \frac{\Delta t}{t} = -\frac{1}{\gamma_t^2}\frac{\Delta(m/q)}{(m/q)} - \left(\frac{\gamma^2}{\gamma_t^2} - 1\right)\frac{\Delta v}{v}$$

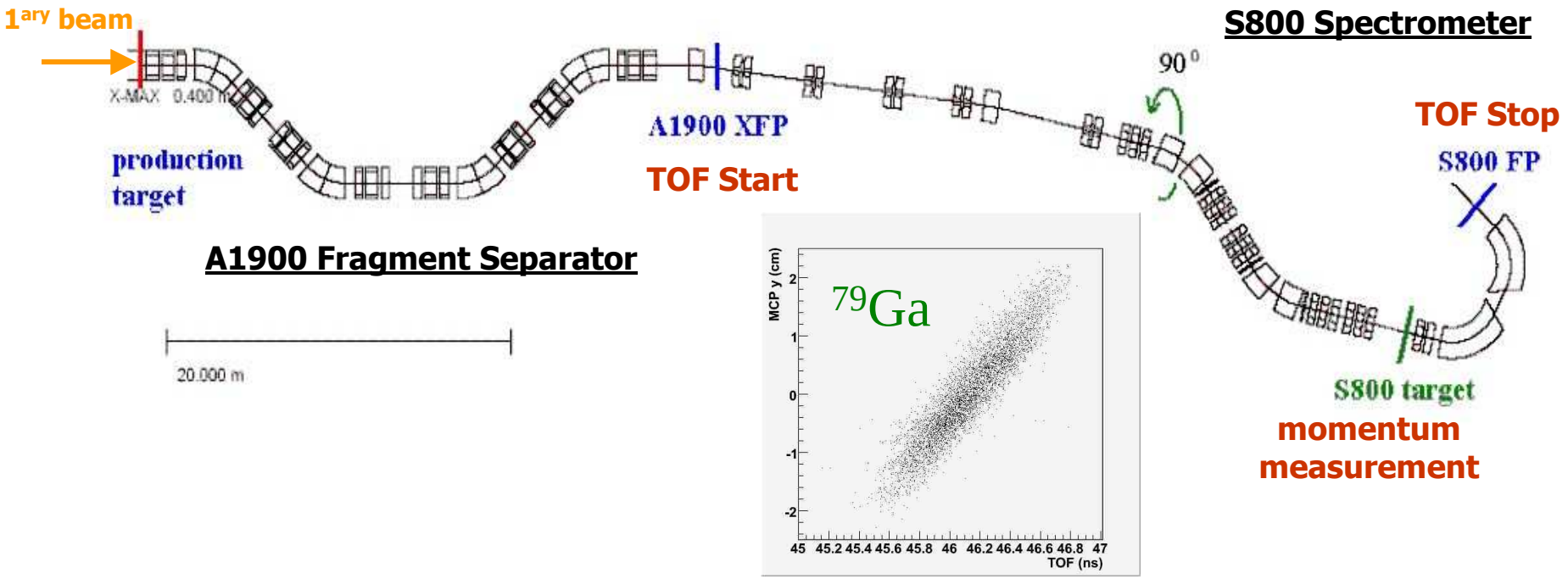
Time-of-flight (TOF) Mass Measurements

Simultaneous measurement of magnetic rigidity (Bρ), and velocity:

$$B\rho = \frac{\gamma m}{q}\left(\frac{dx}{dt}\right)$$

Advantages:

- measure several isotopes simultaneously.
- short lived isotopes (half life ~1 μs).
- precision of ~200 keV for A ~ 100.

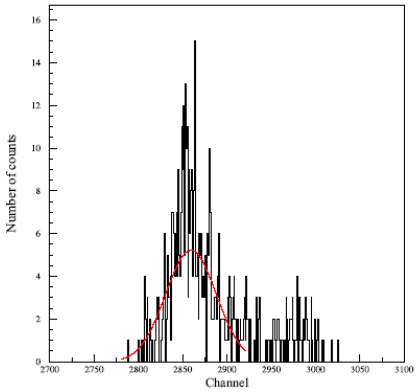


exp01035: cronica de una muerte anunciada

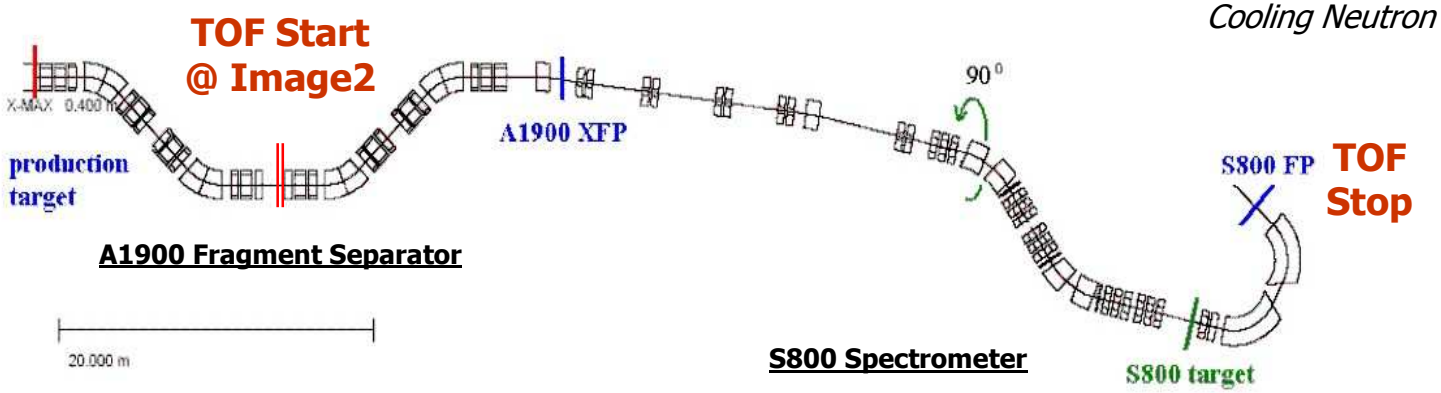
2001(?) proposal: D. Bazin, RRC. Clement, J. Gorres, P.T. Hosmer, M. Ouellette, P. Santi, H. Schatz, BM. Sherril, M. Wiescher.

"Thanks to John Yurkon for bestowing on me all his expertise in gas detectors and to Alfredo Estrade for his help in building and rebuilding the same detectors." – from Acknowledgments

>> PPAC x 8

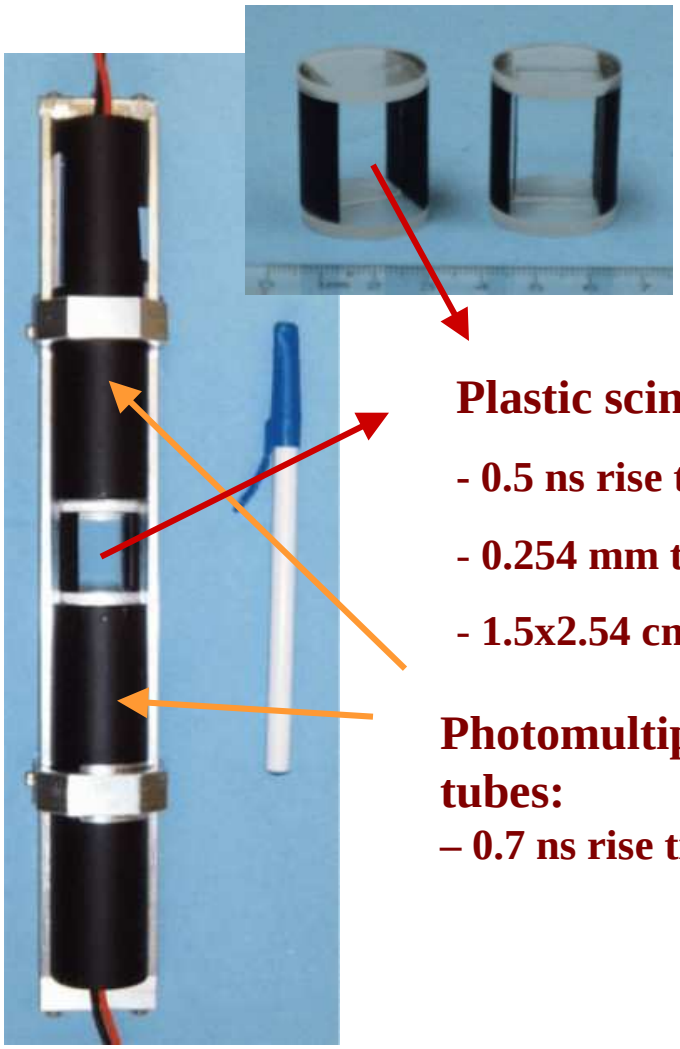


Michelle Ouellete's thesis title: " Heating and *Cooling Neutron Star Crusts*" (2005)



exp01035: con't

2004 proposal: Milan Matos, JINA postdoc to work on mass measurements;
I became an RA ...



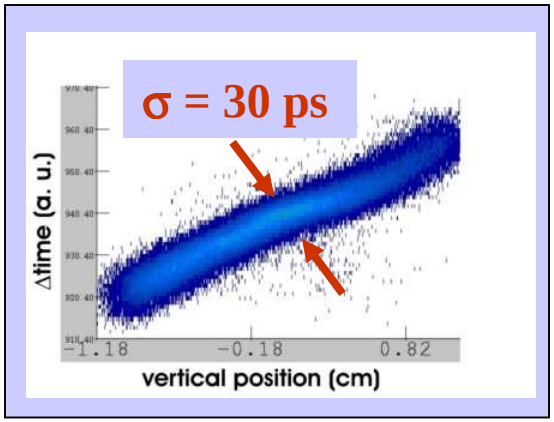
Plastic scintillator:

- 0.5 ns rise time
- 0.254 mm thick
- 1.5x2.54 cm

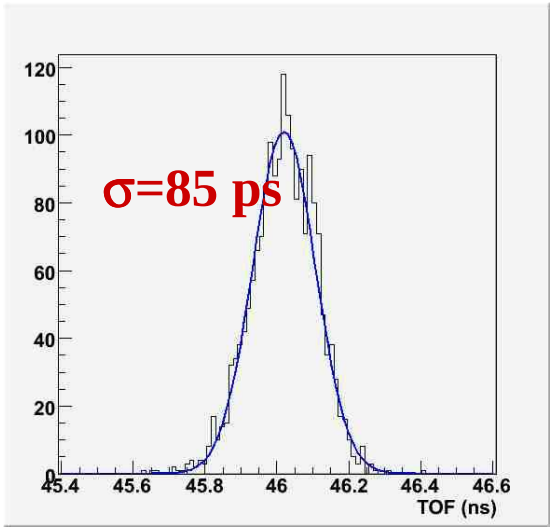
Photomultiplier tubes:

– 0.7 ns rise time

Test Run with ^{136}Xe primary beam

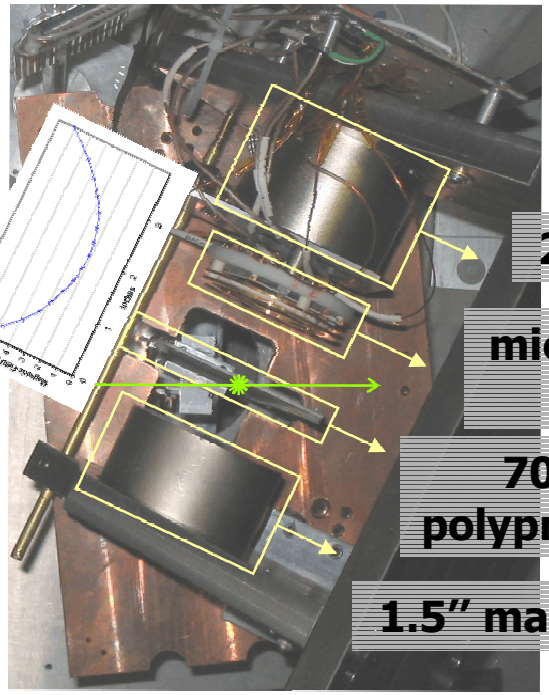


experiment 01035



exp01035: the mighty MCPs

Microchannel Plate Detectors (MCP)

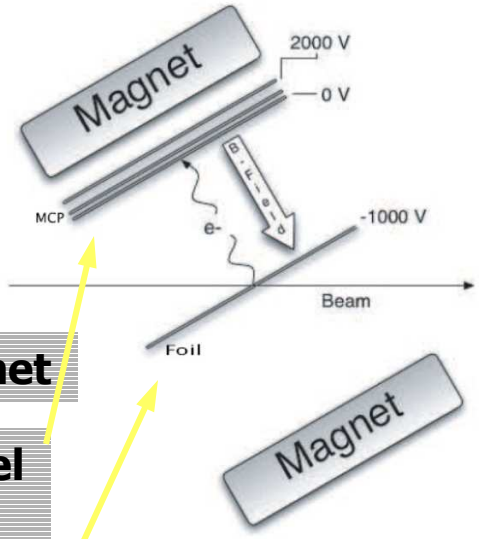


2.0" magnet

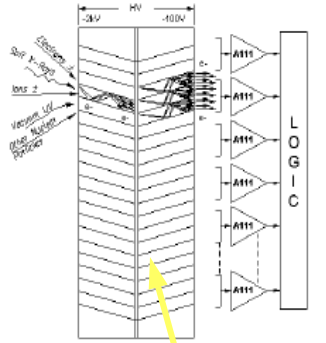
microchannel plate

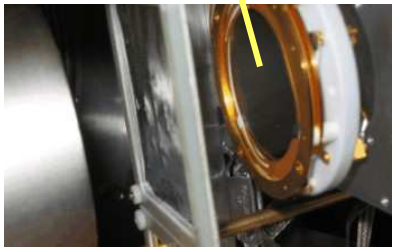
70 μg/cm² polypropylene foil

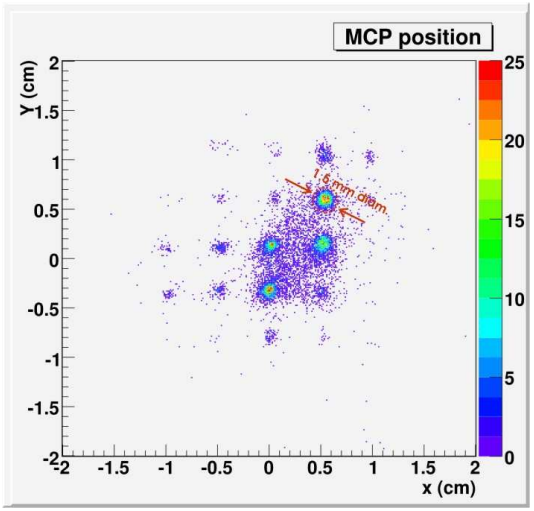
1.5" magnet

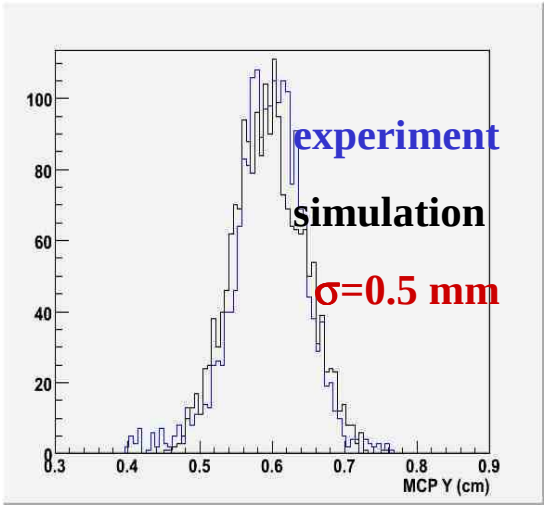


Electron multiplication



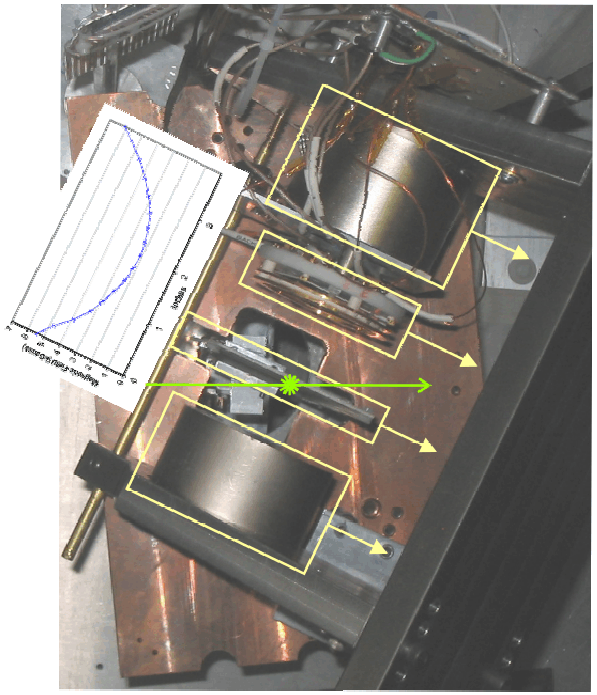


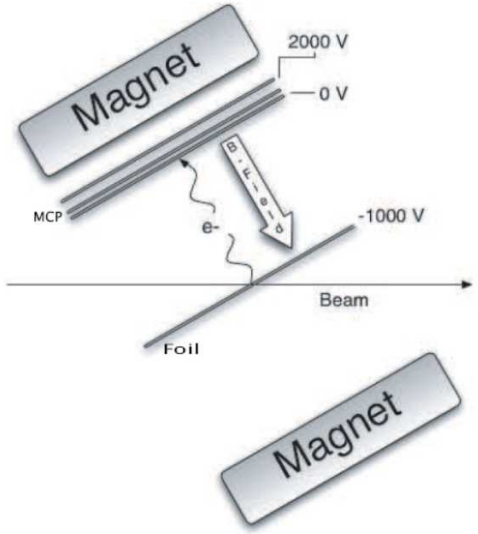


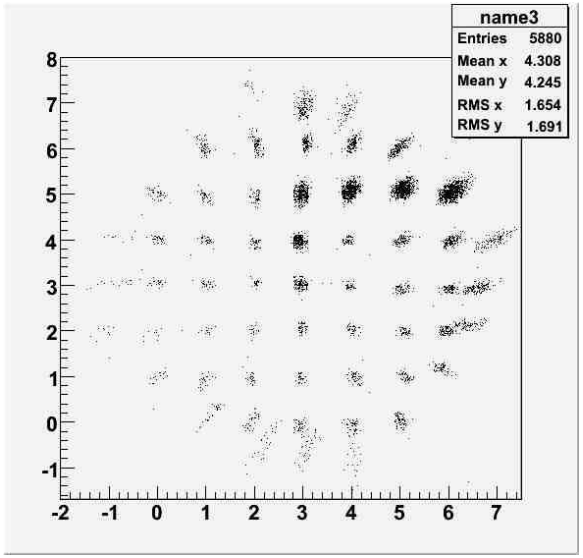


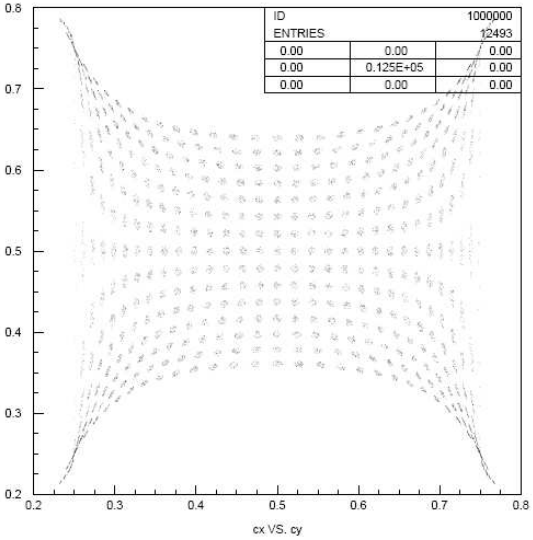
exp01035: the mighty MCPs

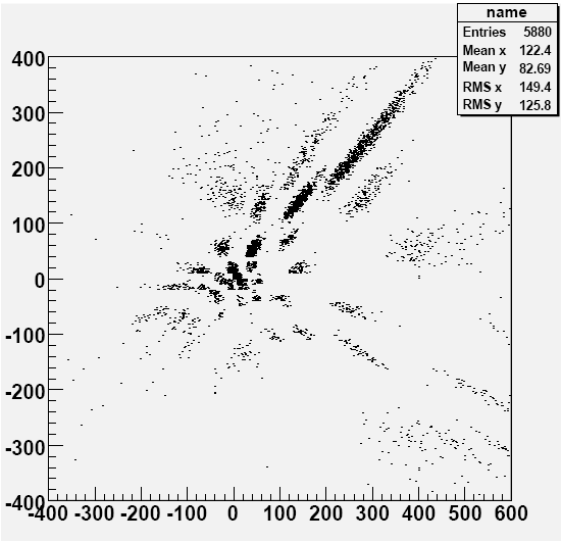
Microchannel Plate Detectors (MCP)









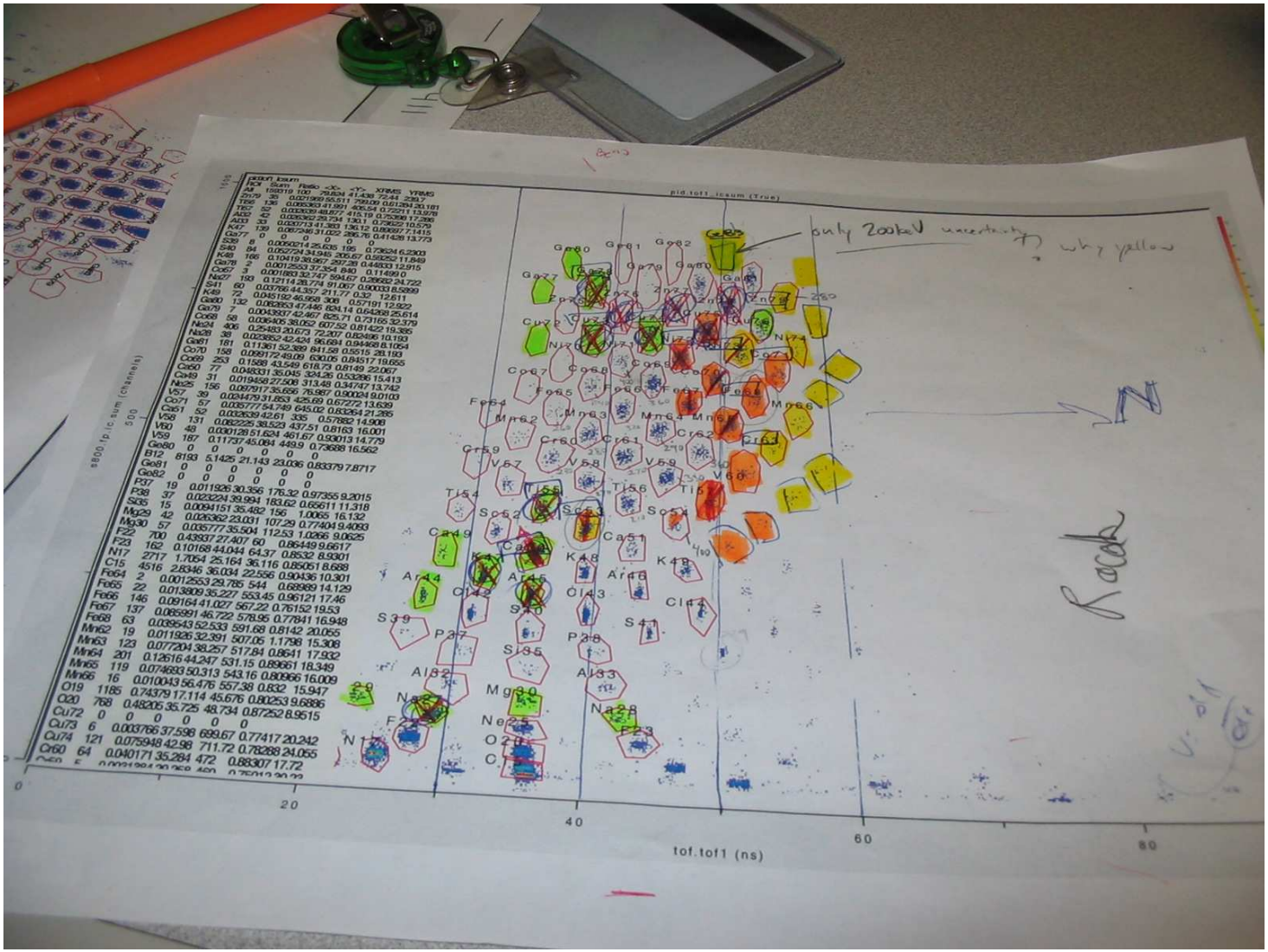


exp01035: con't

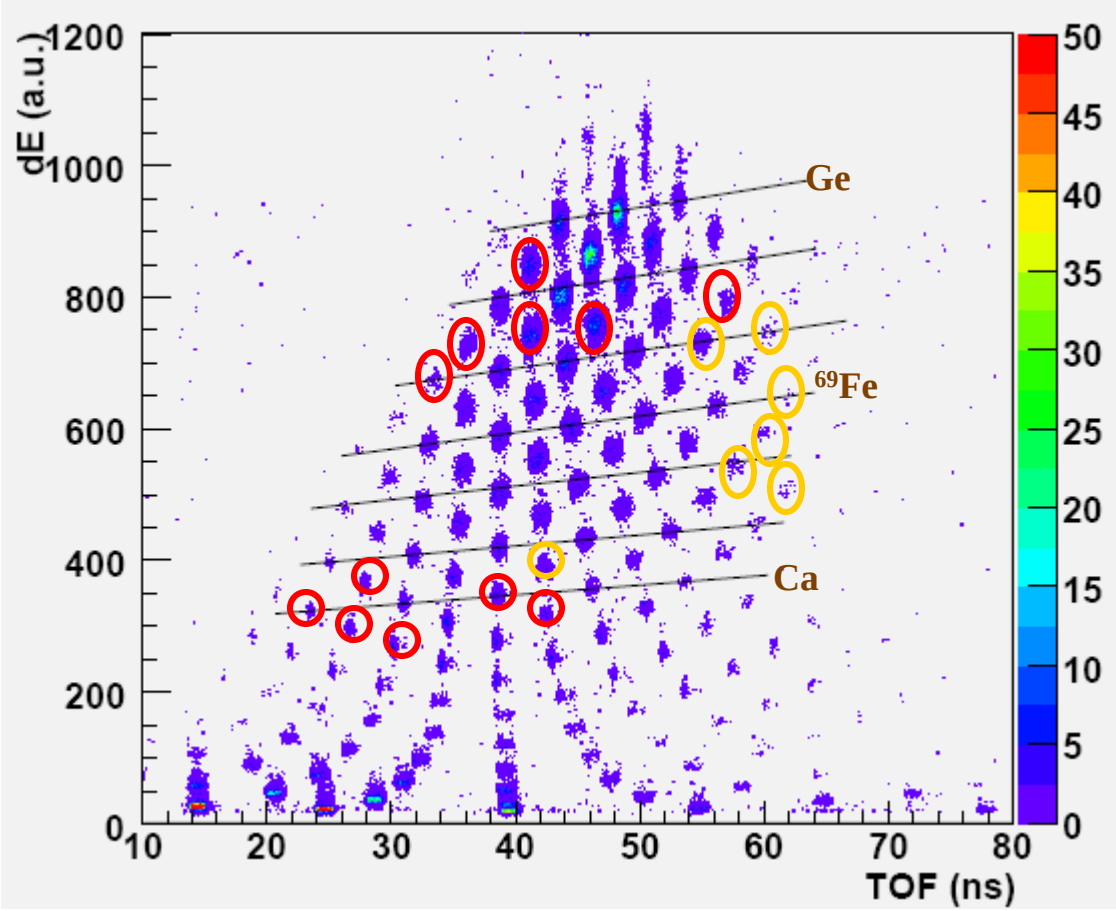
Feb 2006: we RUN!

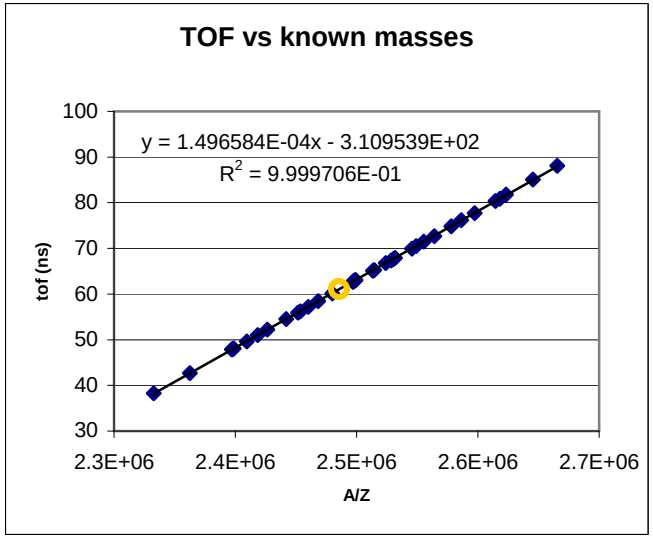
exp01035: con't

RESULTS!!



exp01035: PID

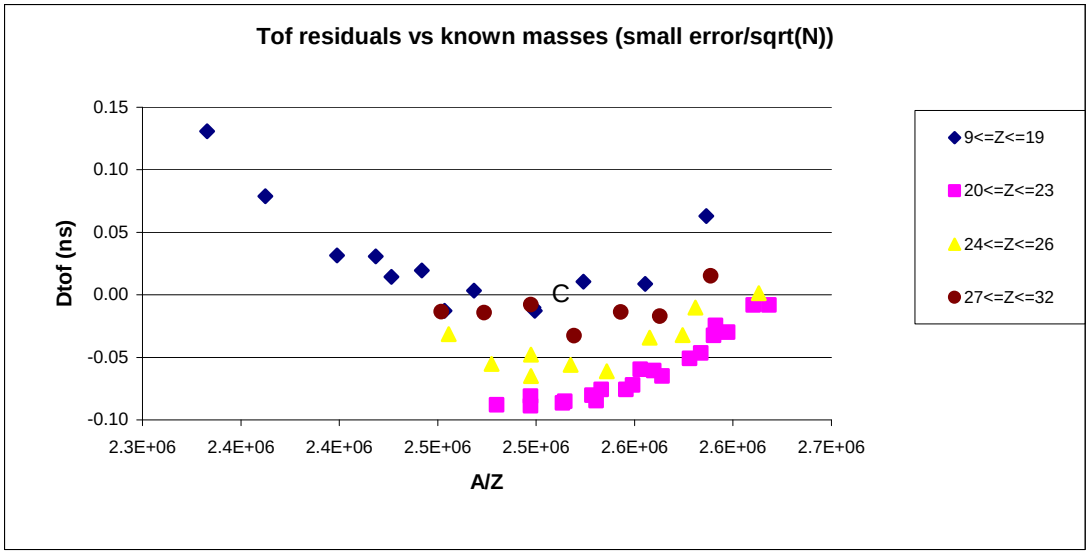


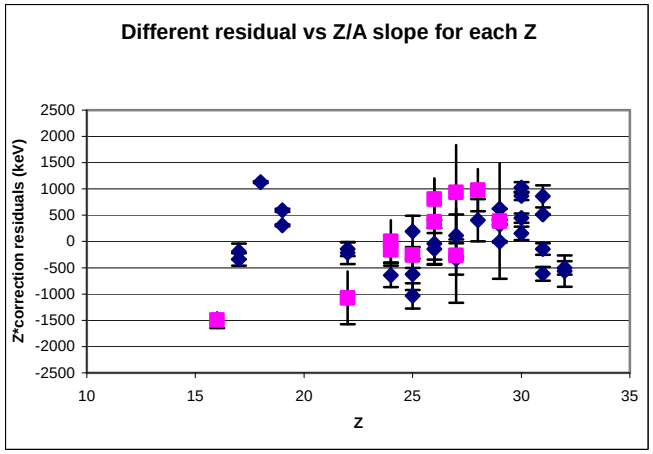


AME2003 mass compilation:

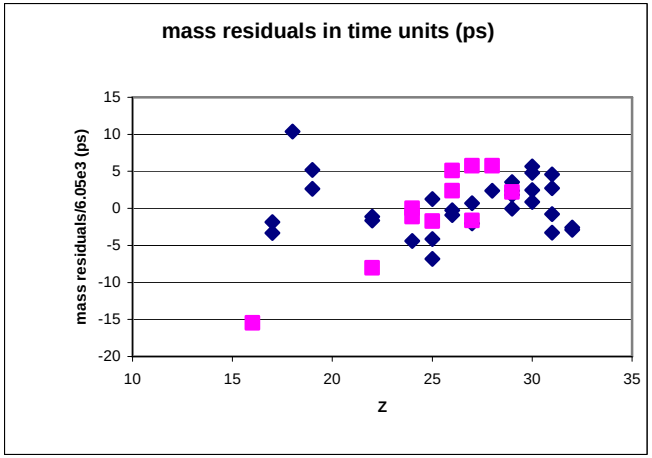
- -error < 30 keV
- - unknown masses: 53Sc, 61V, 63Cr, 66Mn, 69Fe, 72Co, 73Ni, 74Ni

exp01035: VERY preliminary results

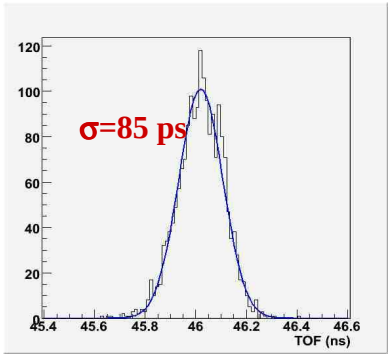




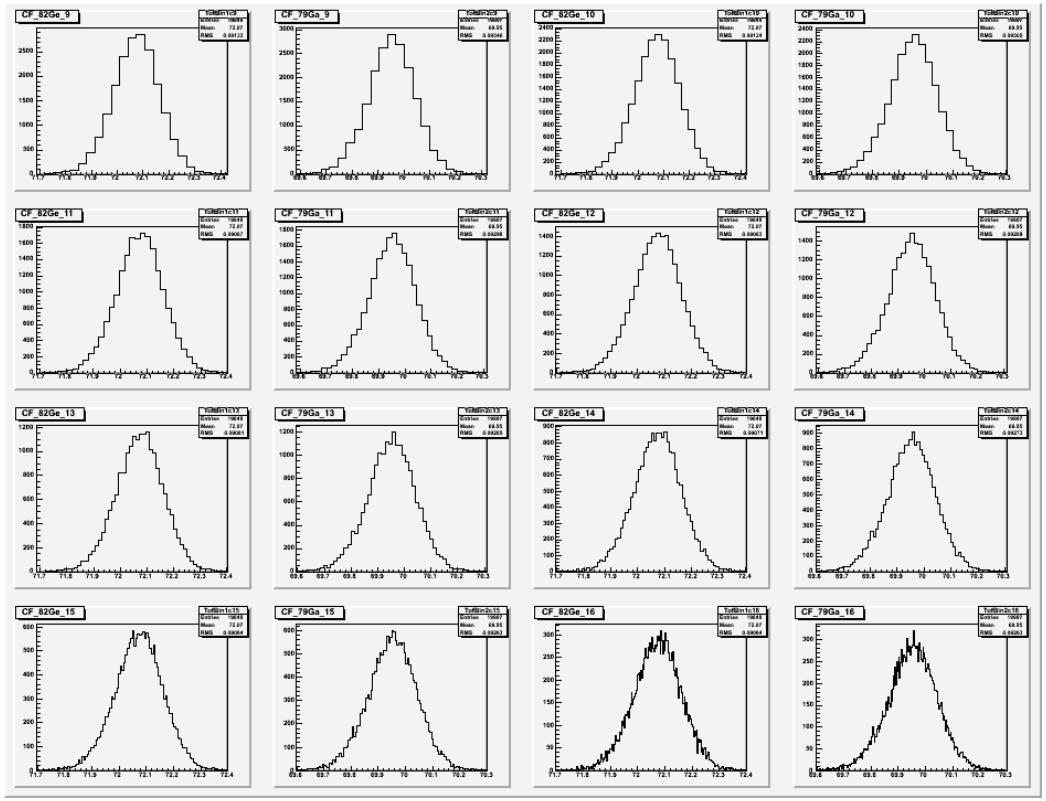
in tof units

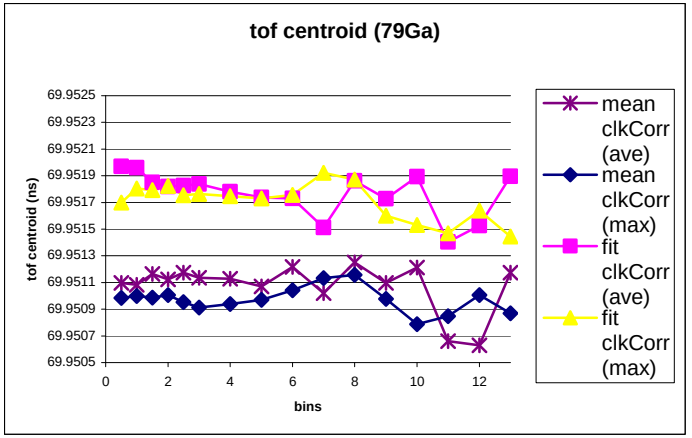


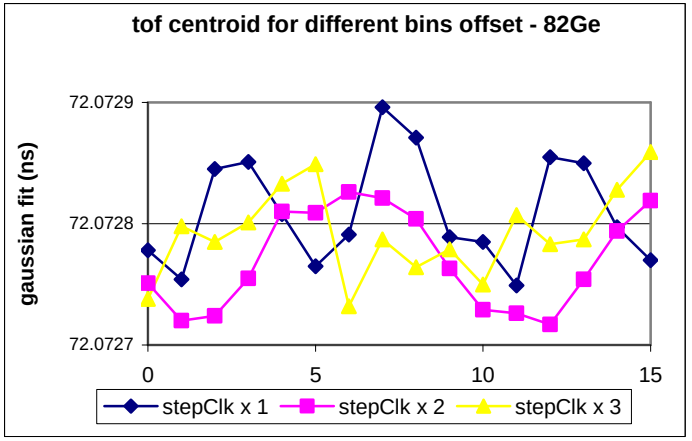
exp01035: further analysis



so what's the centroid?

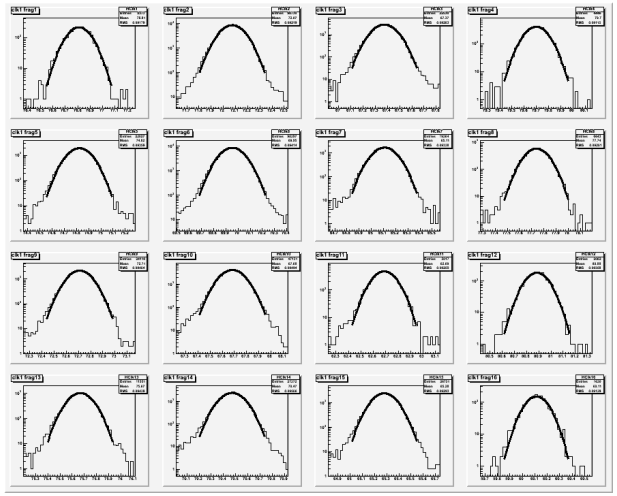


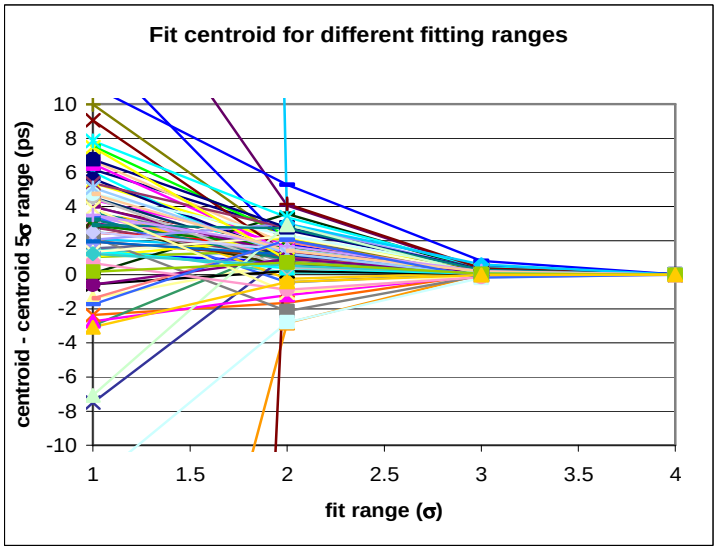


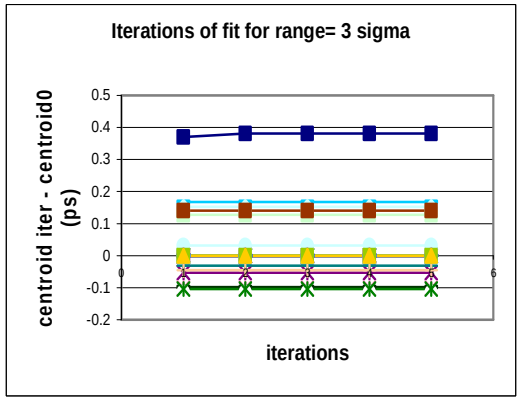


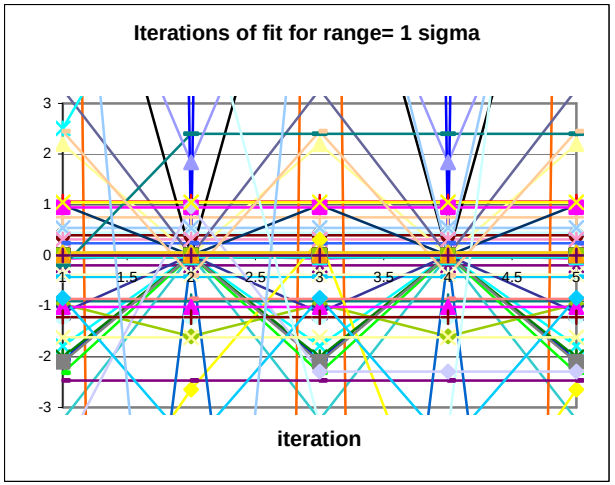
exp01035: further analysis

Gaussian fit…

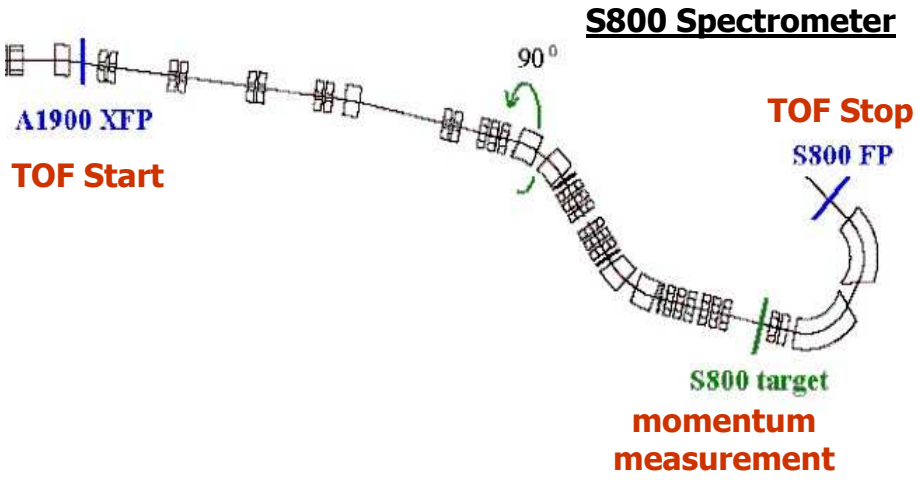




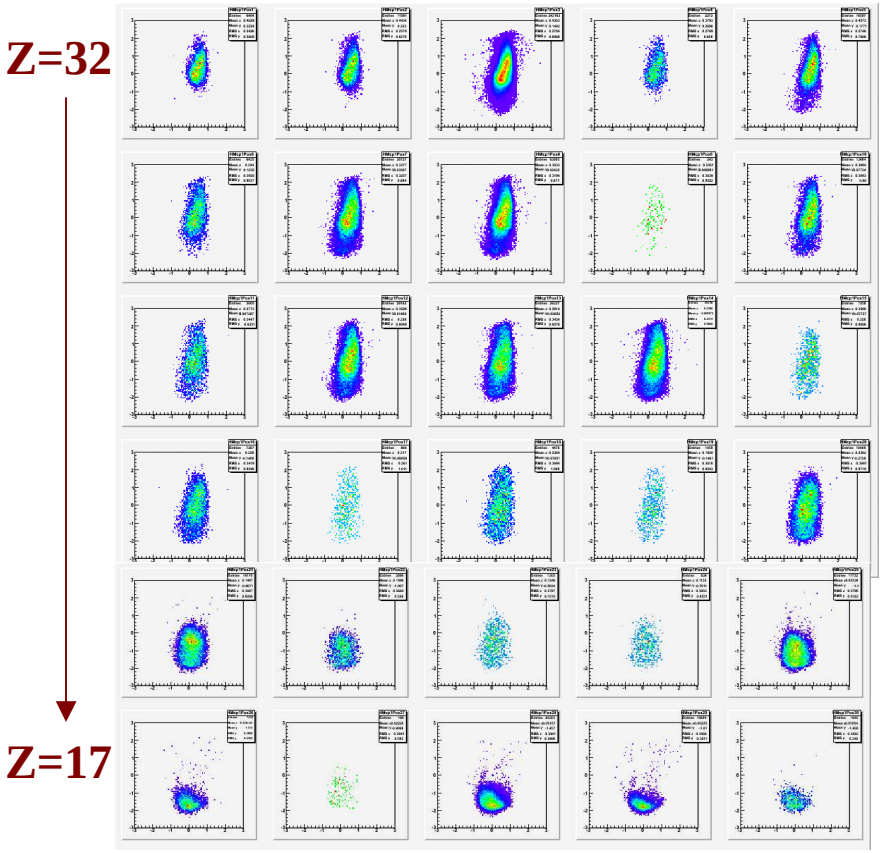




exp01035: further analysis

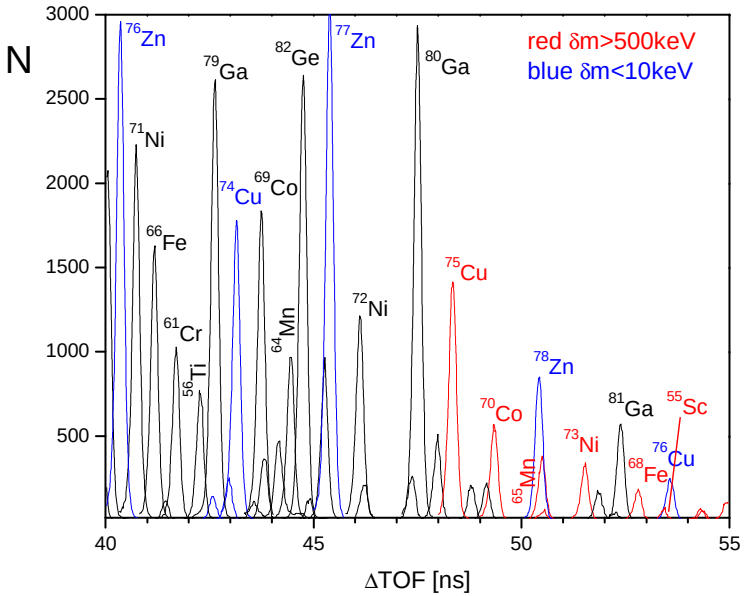


Position @ S800 target plane



tof vs Bρ ~ 300 ps/cm !

Conclusion: for the next time Wess need a volunteer speaker…



- We've demonstrated the feasibility of TOF mass measurements at the NSCL.
- Further analysis in progress to reach desired mass uncertainty.

Thanks!!

Milan Matos, Hendrik Schatz, Matt Amthor, Daniel Bazin, Ana Beceril, Thom Elliot, Alexandra Gade, Giuseppe Lorusso, Mauricio Portillo, Andrew Rogers, Dan Shapira, Ed Smith, Andreas Stolz, John Yurkon, Daniel Galaviz, Jorge Pereira, Mark Wallace.

web: **http://groups.nscl.msu.edu/nero/**

JINA

NSCL

Experiments at the NSCL

SET UP:

- 100 MeV/u ^{86}Kr primary beam, ^{9}Be target (45 mg/cm^2 & 94 mg/cm^2).
- Path length = 58 m => TOF ~ 500 ns.
  - => **100 ps** time resolution for 200 keV mass uncertainty
- Momentum dispersion at S800 11 cm/%.