TRIFECTA

Preliminary Results of the Triple Fission-Ejecta Correlations Trial @ ORNL

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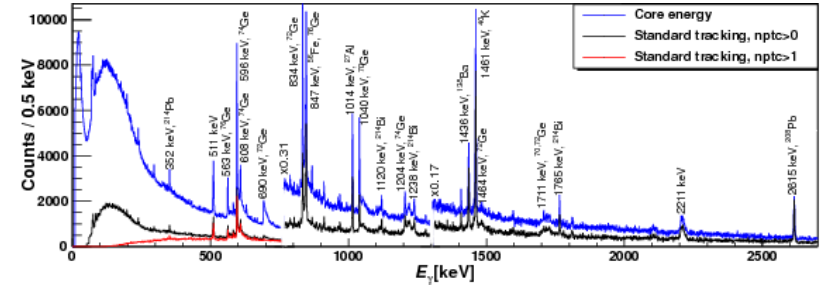
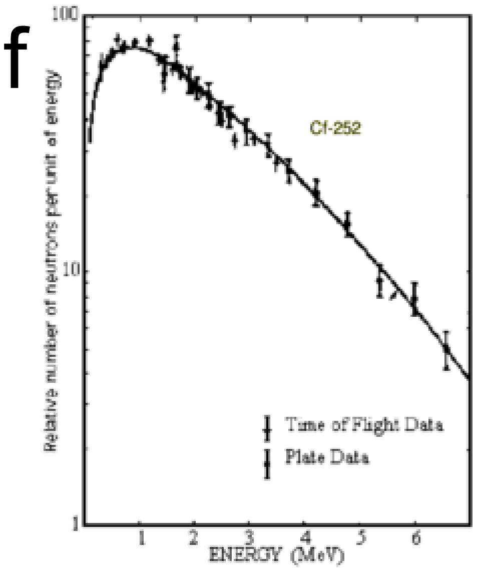
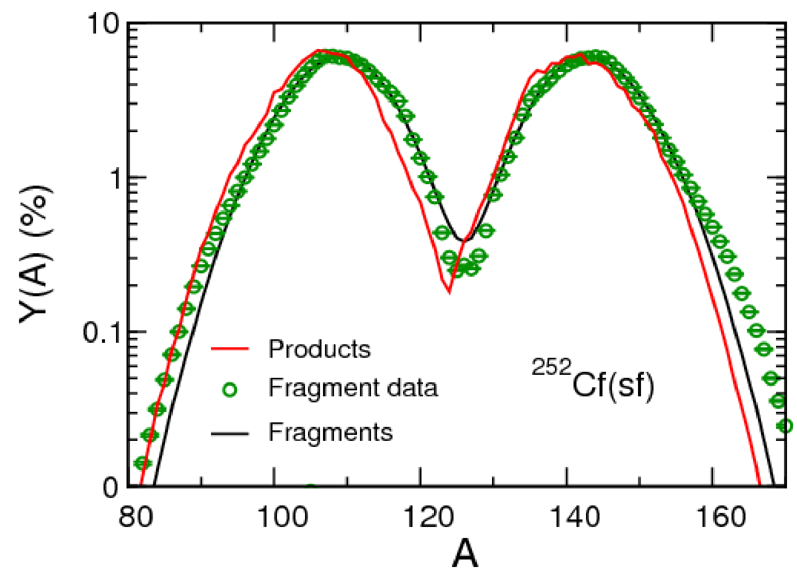
Motivation





- Many efforts focusing on averages of certain fission products
  - High precision
- Triple-correlations needed
  - Energy balance
  - Scission neutrons?
  - New fission ID methods?
  - Benchmark new models
- More correlations & less precision?

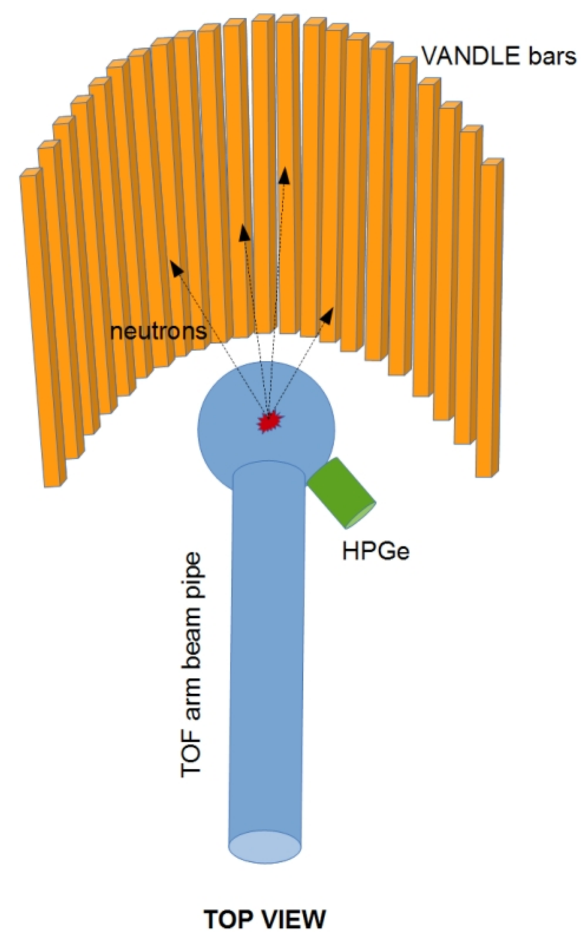


Goals of TRIFECTA

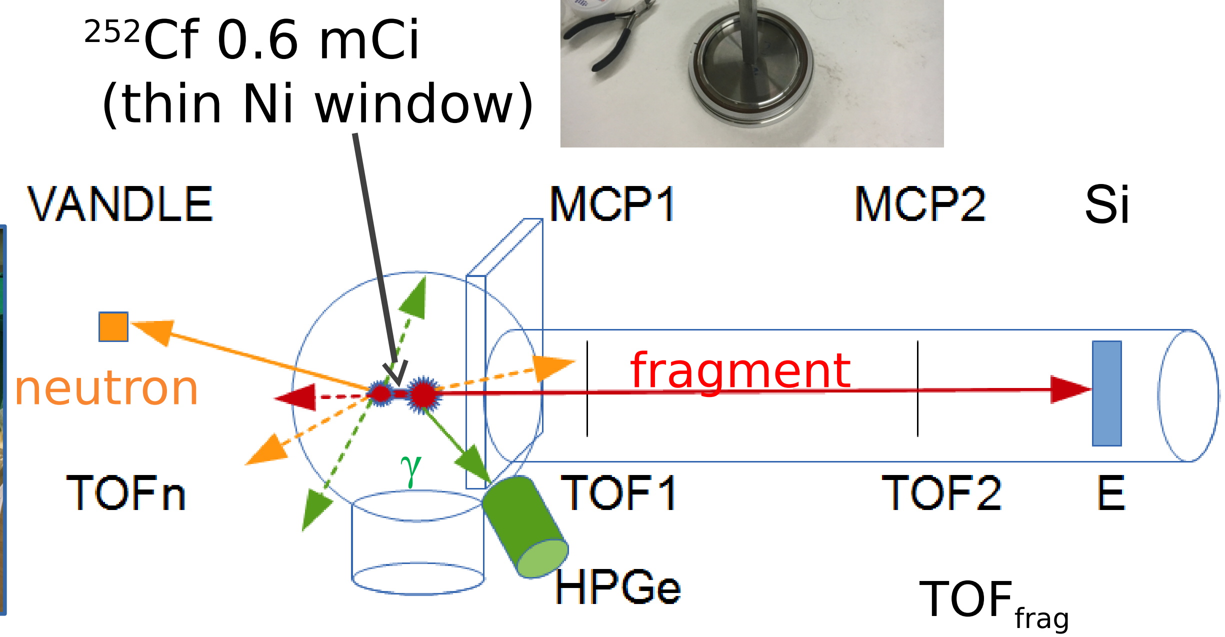
- LDRD (1-yr) from ORNL
- Will ^{252}Cf activity dominate background?
  - 0.6 mCi
- Can coincidences be made?
- What is resolution of data?
- Can correlations be extracted?
  - Compare to previous data
  - Triple coincidences?

Design Plan

- Measure fragment mass of one fragment
  - Using 1E1v method
  - Determine fission axis
- Measure opposite neutron
  - Energy and angle (not just count)
  - Hit multiplicity
  - VANDLE (TOF for γ/n discrim.)
- Measure coincident γ-rays
- Correlate all three with
  - Energies
  - Angles
  - Multiplicities

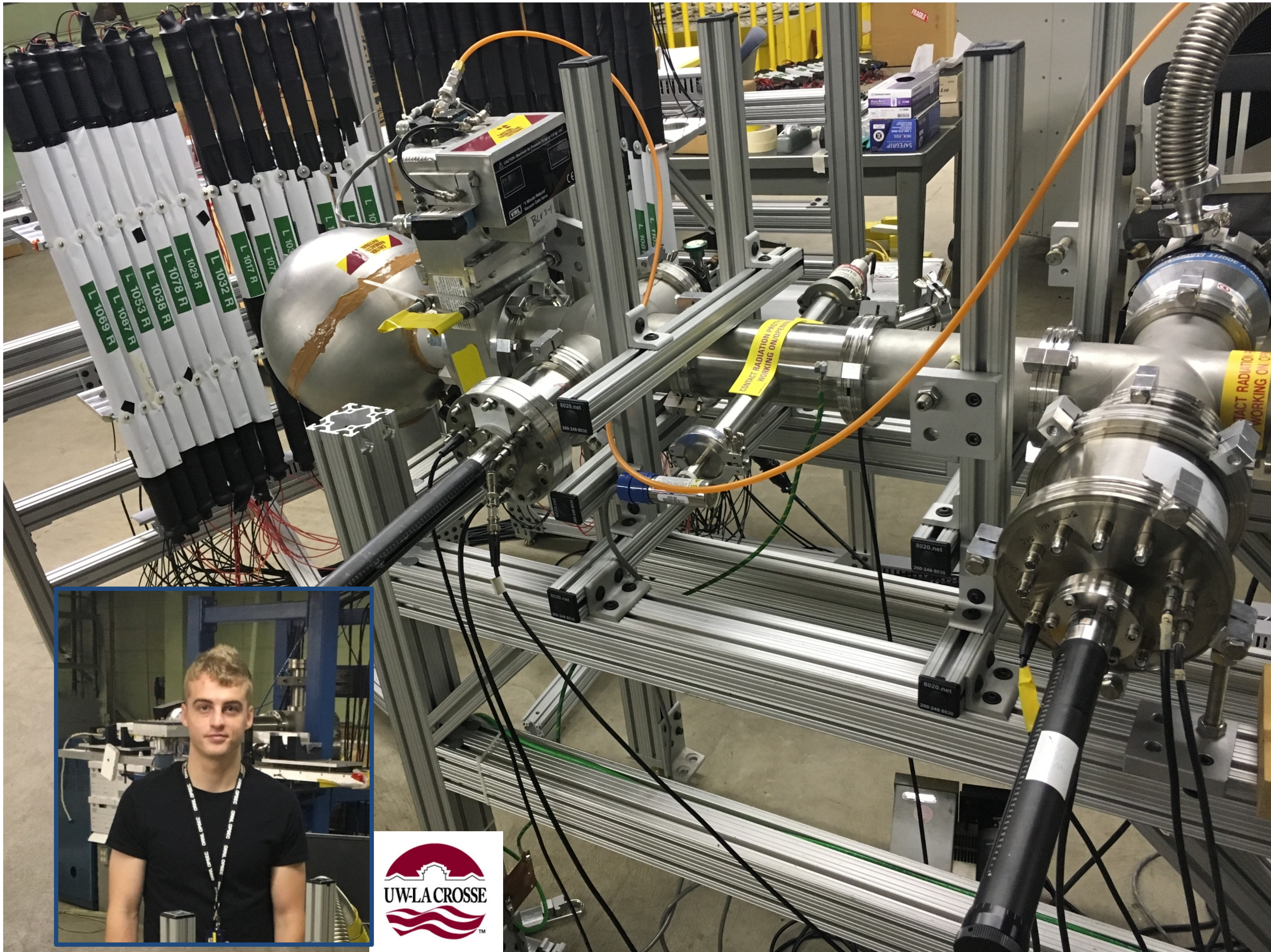


Setup

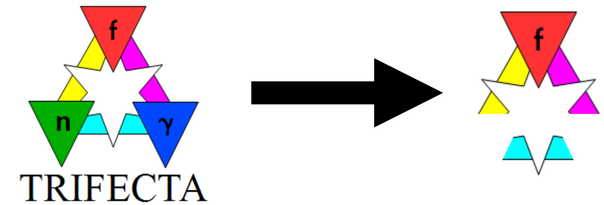


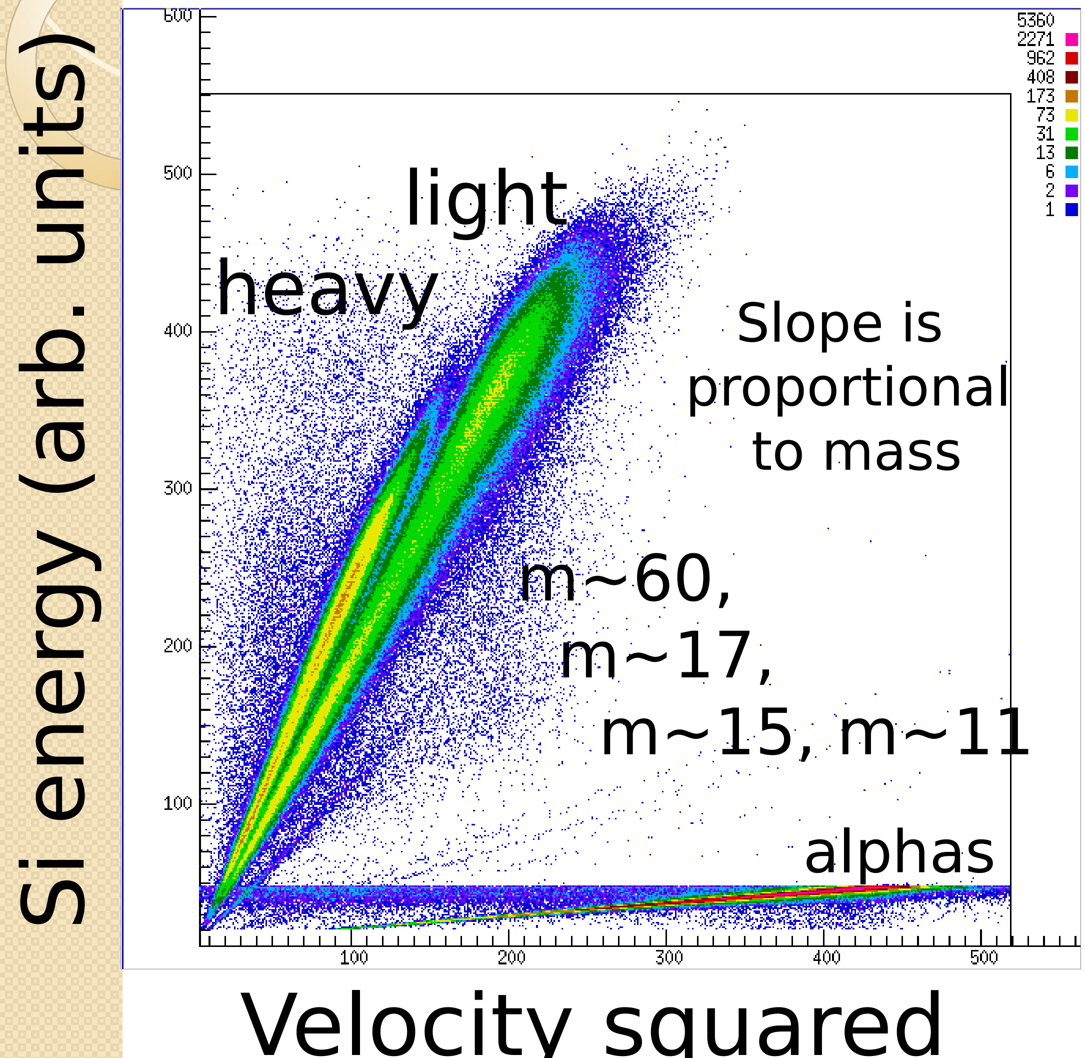
- Use TOF$_{frag}$ to get T$_{fission}$ time for VANDLE
  - Constrains fission axis
  - Unmeasured second fragment
  - Forward neutrons from opposite fragment
- Digital DAQ
  - Control coincidence window
  - 250 Ms/s, 12-bit

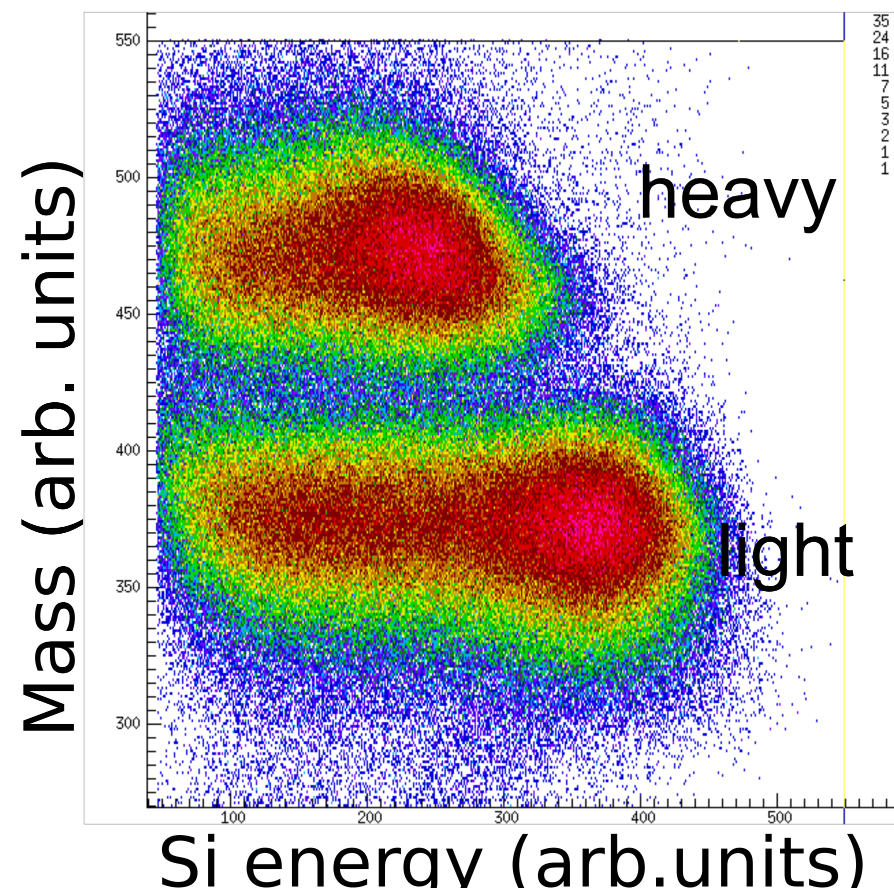
Setup_2


L 1069 R
L 1087 R
L 1053 R
L 1038 R
L 1078 R
L 1029 R
L 1032 R
L 1017 R
8020.net

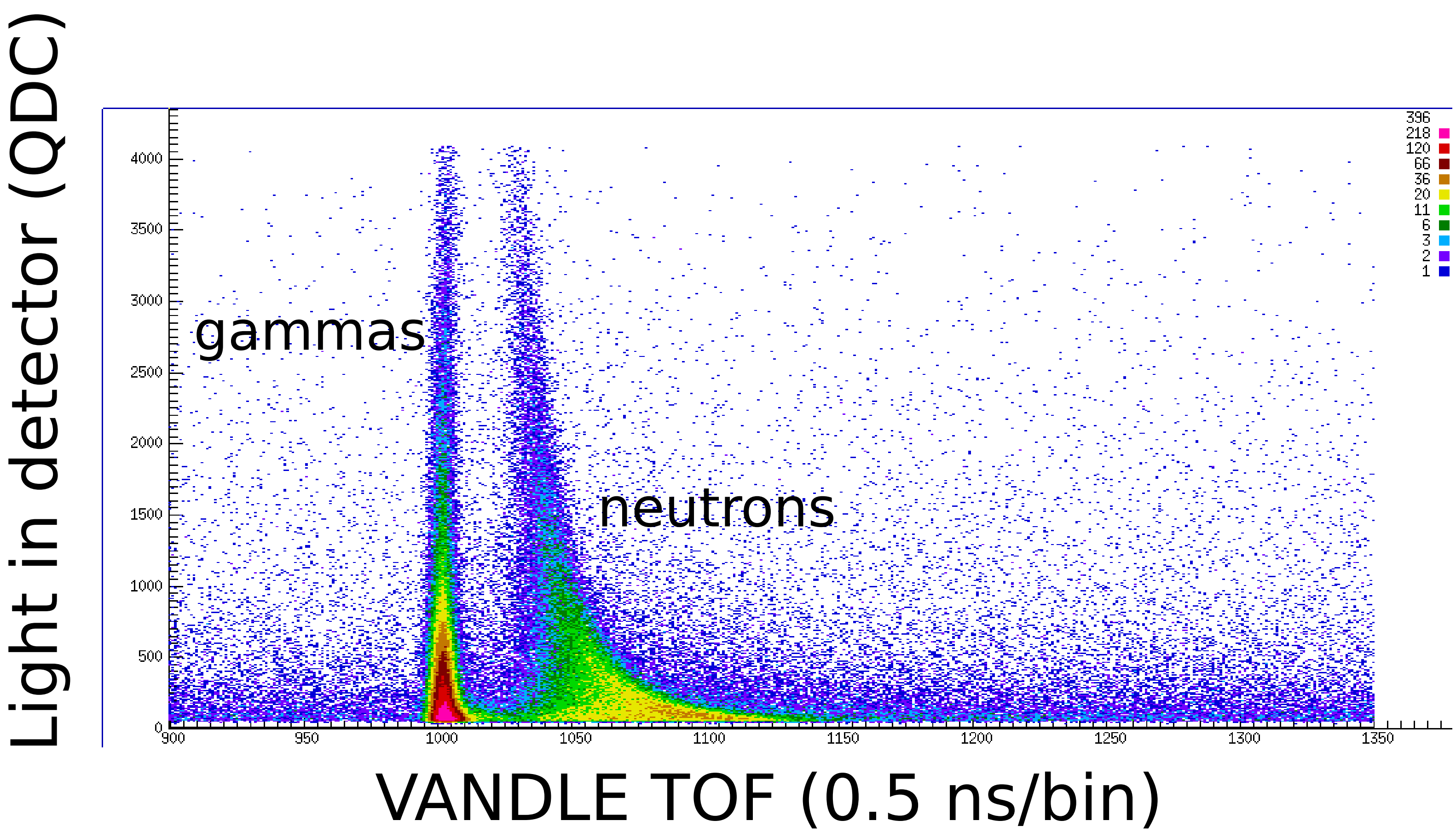
Fragments


TRIFECTA
f
n
γ
f


Si energy (arb. units)
light
heavy
Slope is proportional to mass
m~60,
m~17,
m~15, m~11
alphas
Velocity squared


Mass (arb. units)
heavy
light
Si energy (arb.units)

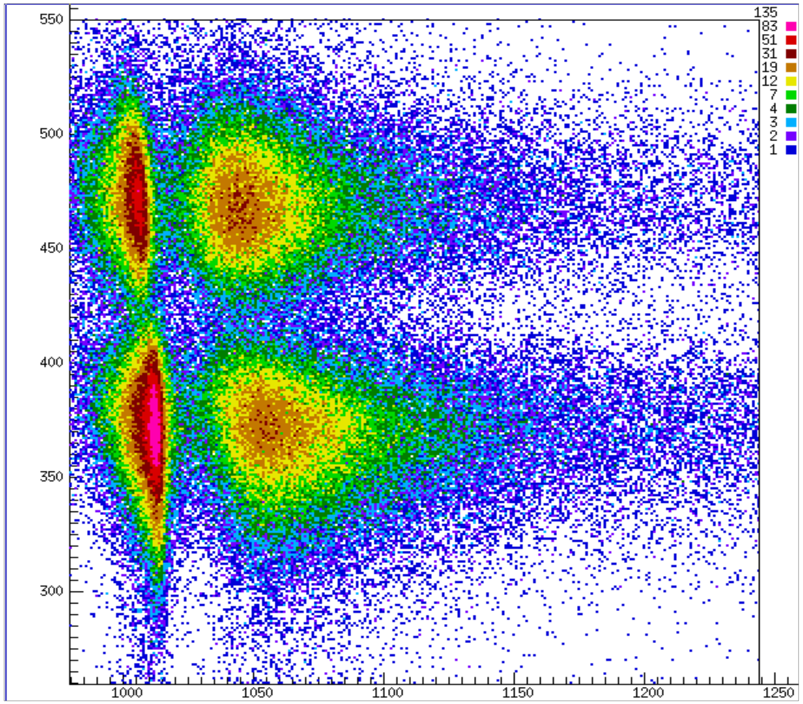
Neutrons



Light in detector (QDC)
0
500
1000
1500
2000
2500
3000
3500
4000
gammas
neutrons
900
950
1000
1050
1100
1150
1200
1250
1300
1350
VANDLE TOF (0.5 ns/bin)
396
218
120
66
36
20
11
6
3
2
1

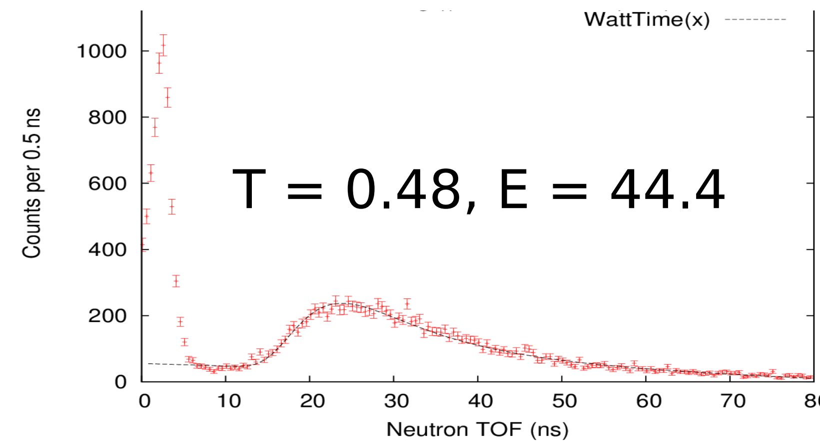
Mass vs. neutrons

Mass (arb. units)

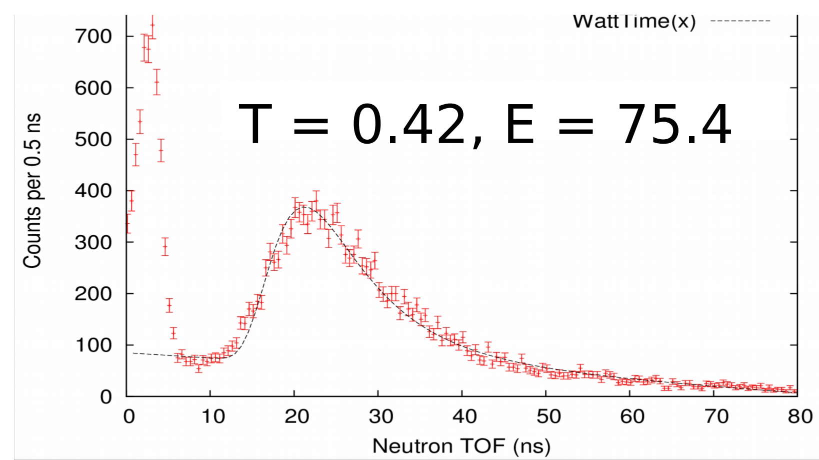


VANDLE TOF (on axis)

Forward (on axis) VANDLE TOF coincident with masses 99-103



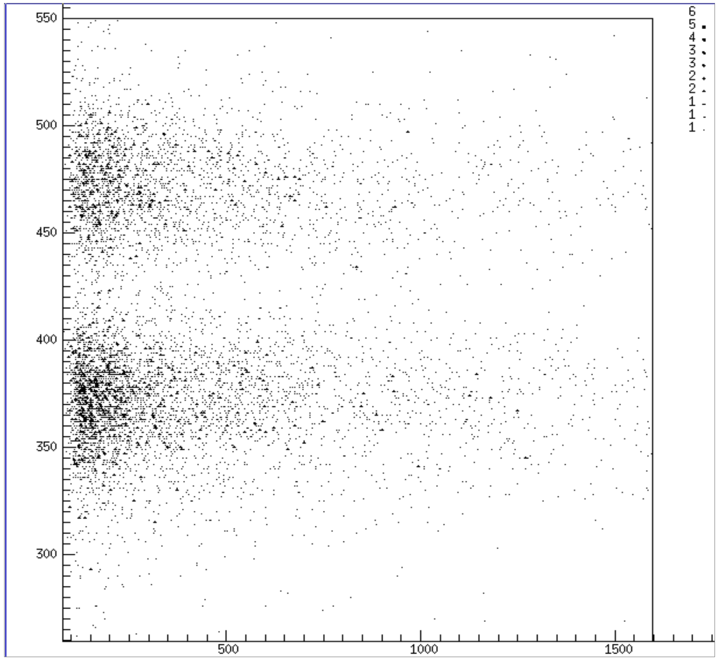
... coincident with masses 137-141



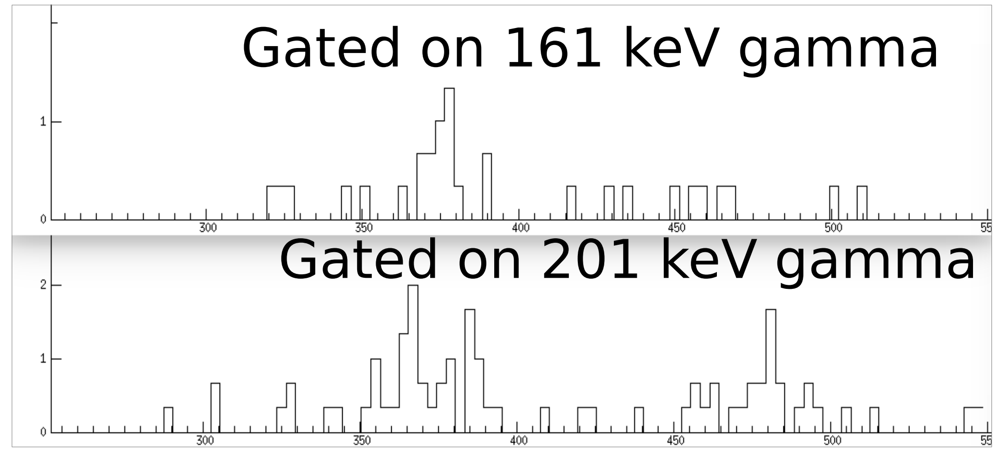
- Neutron c.o.m. energies
  - Fit with Watt dist.
- Gamma vs. neutron
  - relative intensities

Mass vs. Gammas

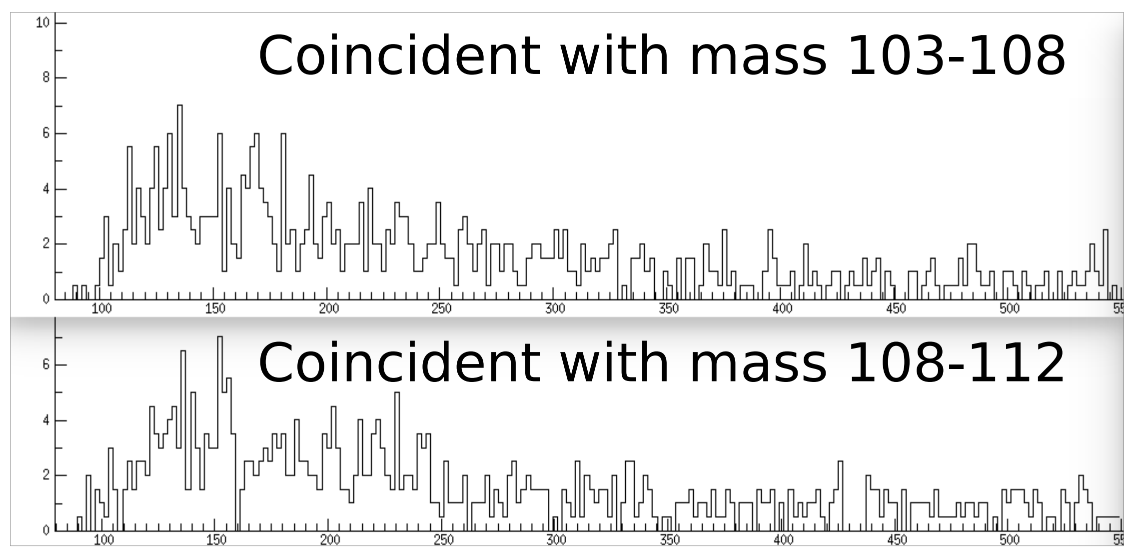
Mass (arb. units)



Eγ (keV)



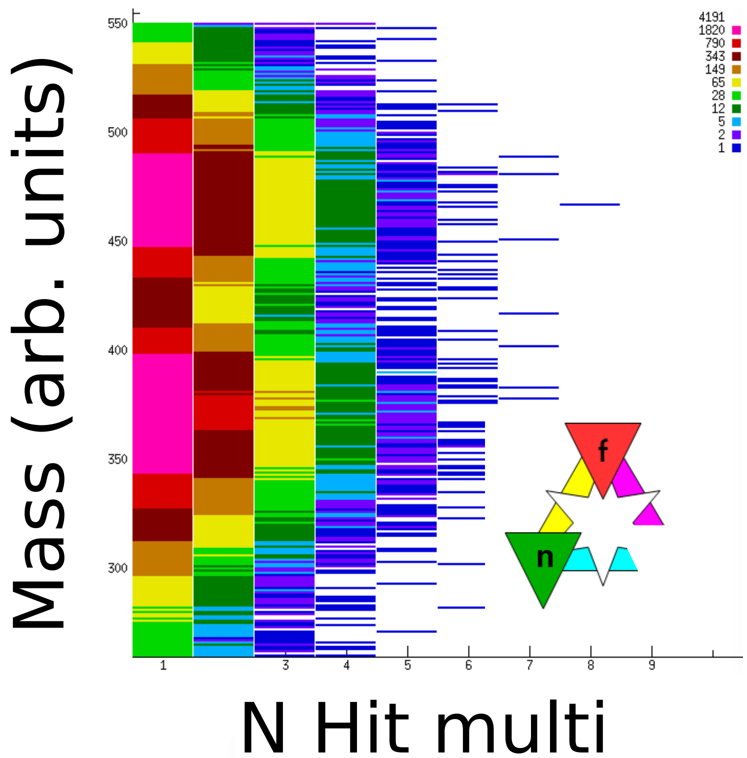
Mass (arb. units)

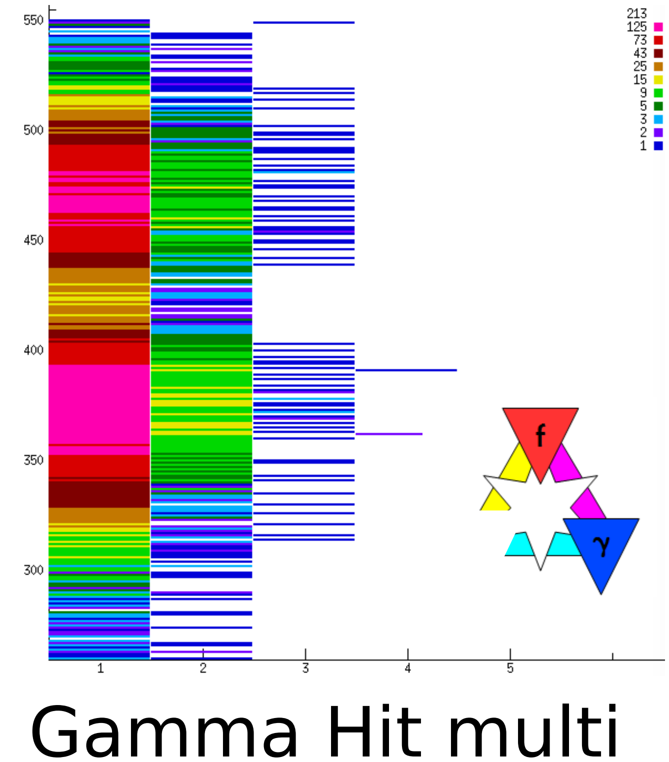


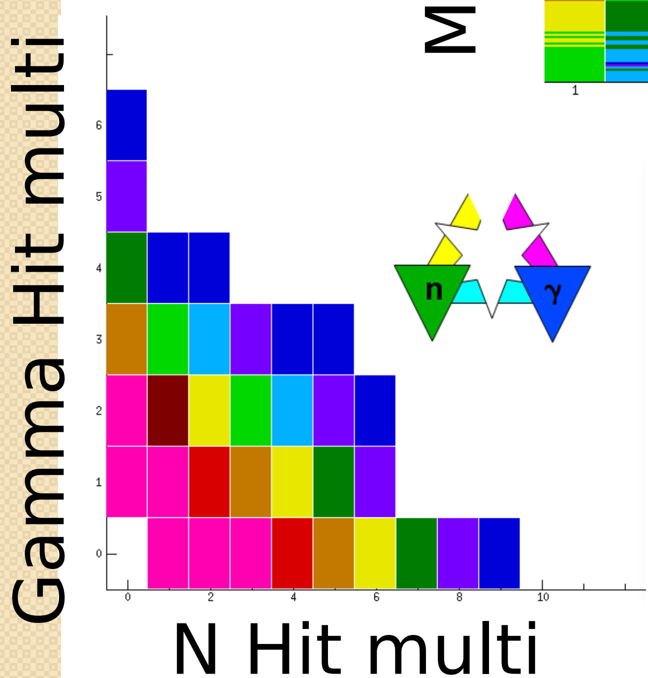
Eγ (keV)

- 3 amu resolution
- Over 20 individual nuclei identified

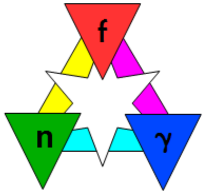
Multiplicity



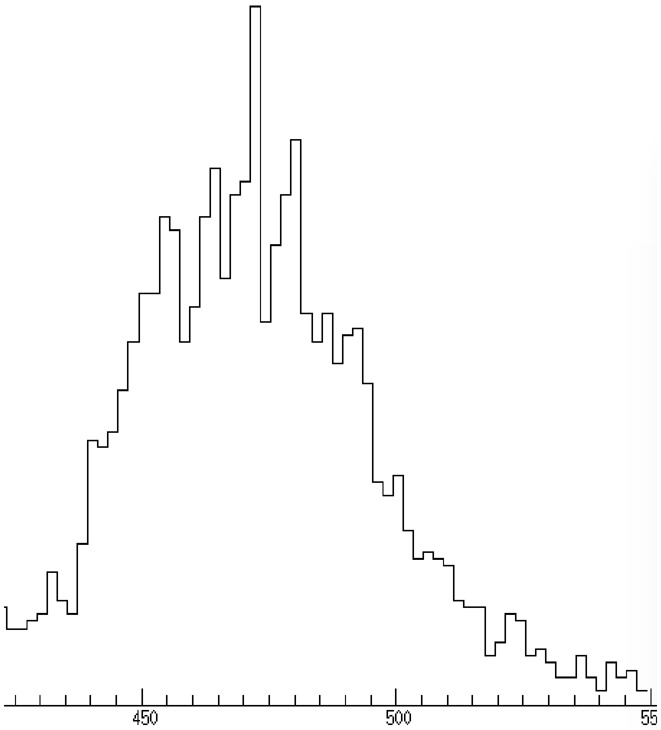




Triples!

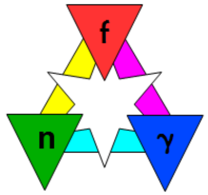


Heavy fragment masses,
gated on TOF = 16 (±2) ns and gammas

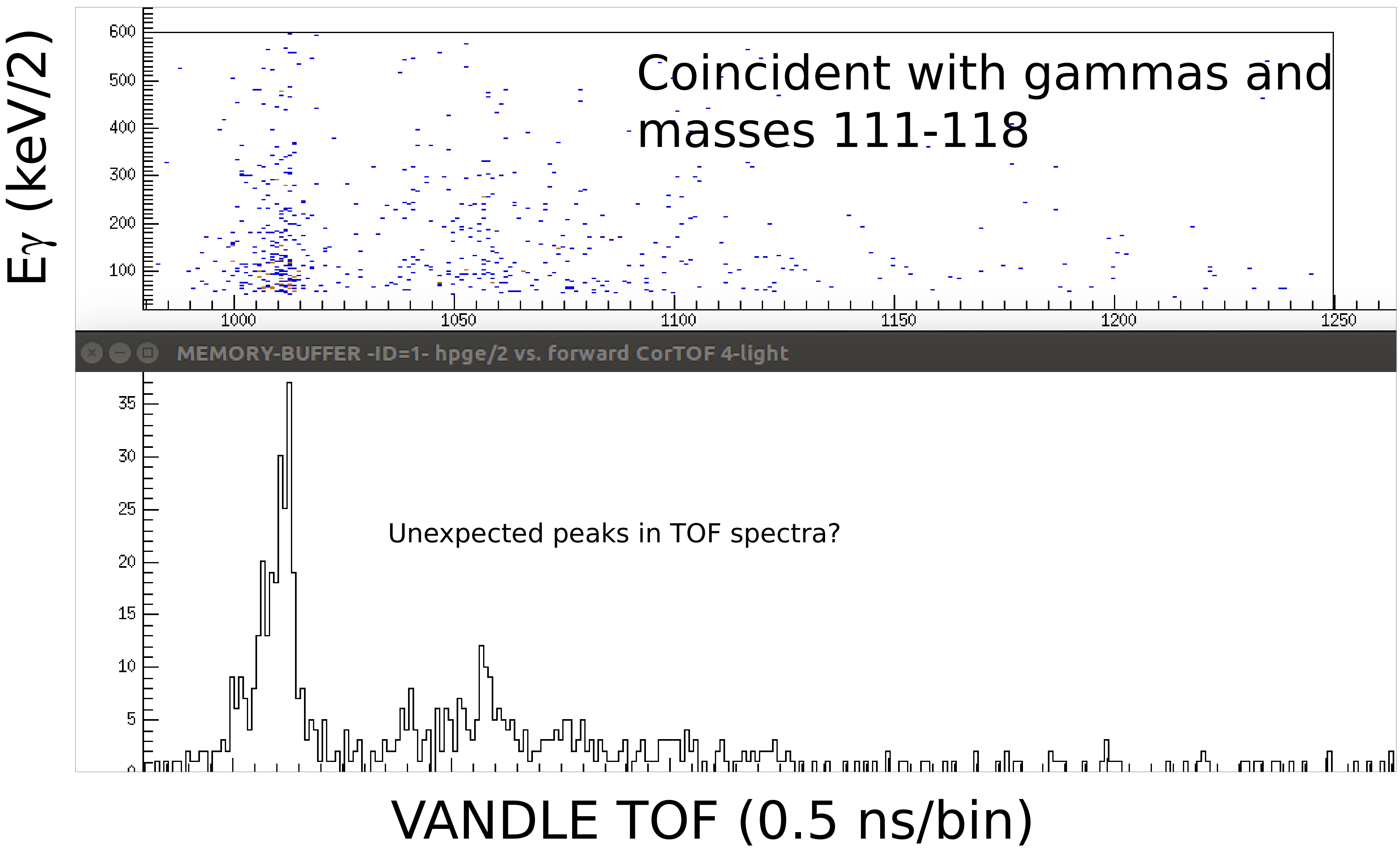


Mass (arb. units)

Triples!



Neutron TOF gated on coinc. mass range and gammas.

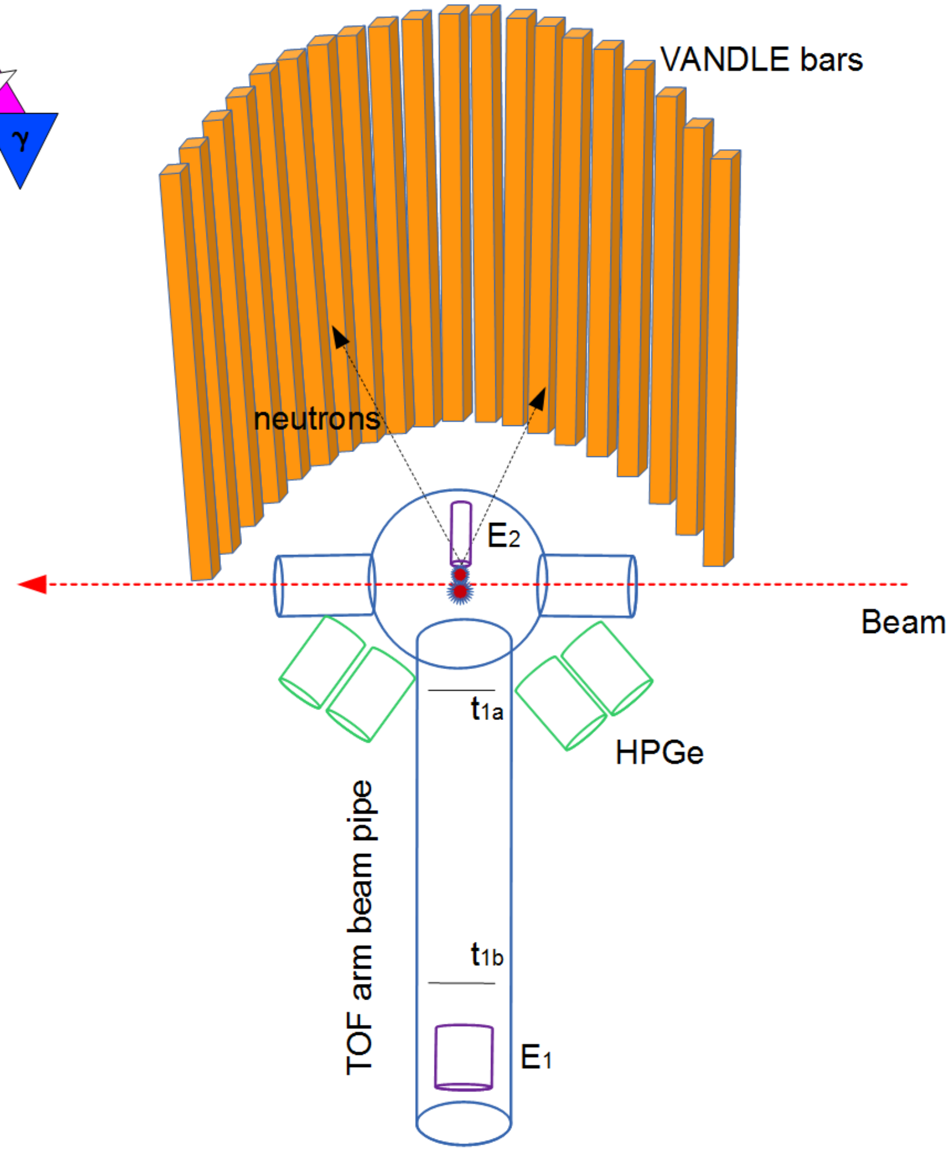


Highlights

- Coincident data not swamped by background
- 3 amu mass resolution
- 3 ns neutron timing resolution
  - Confirm c.o.m. changes with mass
- 8 weeks of 24-7 data
- Multiplicities, Energies, Angles, 2N corr, etc.
- All with coincident fragment mass!
- Curious preliminary results
- More data could yield results for specific nuclei

Future?

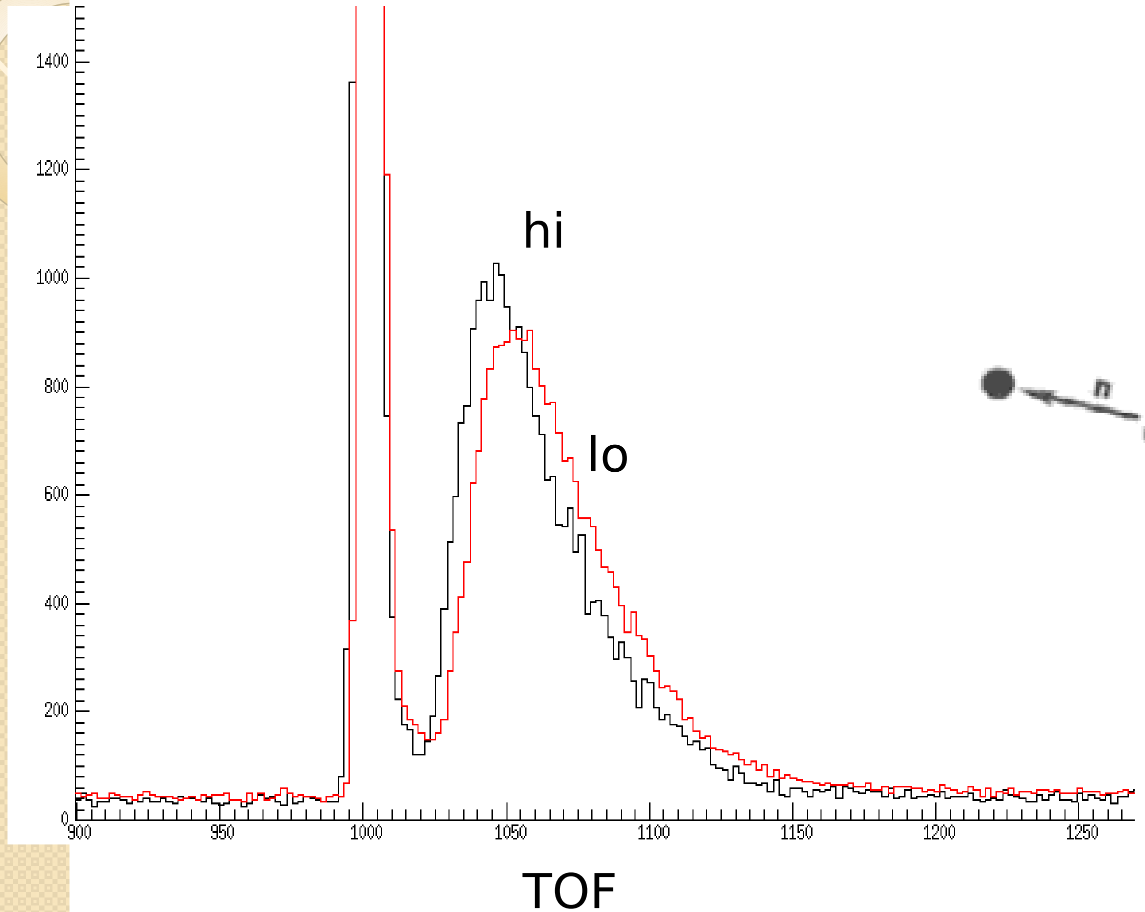
- Continue to analyze data
  - 2N neutron angles
  - Multiplicities
  - Look at Triples more
  - Publish relative correlations
- Upgrade options
  - More gamma-ray detectors
  - Gas-filled Bragg detector (E1)
  - Beam line for induced fission
  - E2 detector for TKE
- Compare to models
  - MCNP
  - FREYA, CGMF, others?
- Need Partners and Collaborators



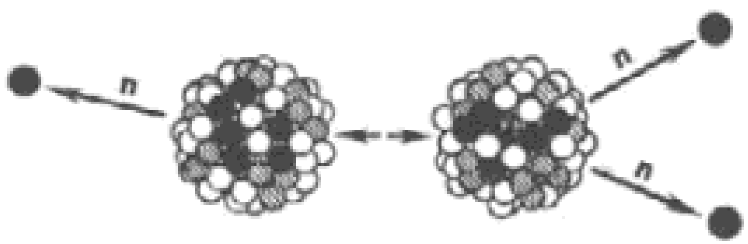
Possible Future Setup

Reserve slides

Preliminary Data



TOF_n from opposite fragment than one detected in Si, so TOF_hi is neutrons from light fragment.



Peaks:

TOF_hi = 21.5 ns (3.4 MeV)

TOF_lo = 24.8 ns (2.6 MeV)

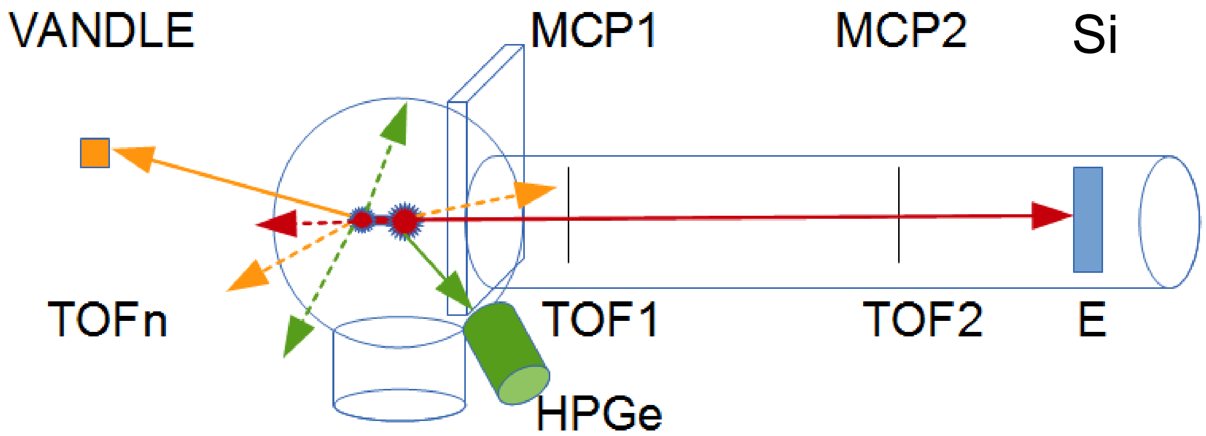
Edge:

TOF_hi = 15 ns (7.0 MeV)

TOF_lo = 17 ns (5.5 MeV)

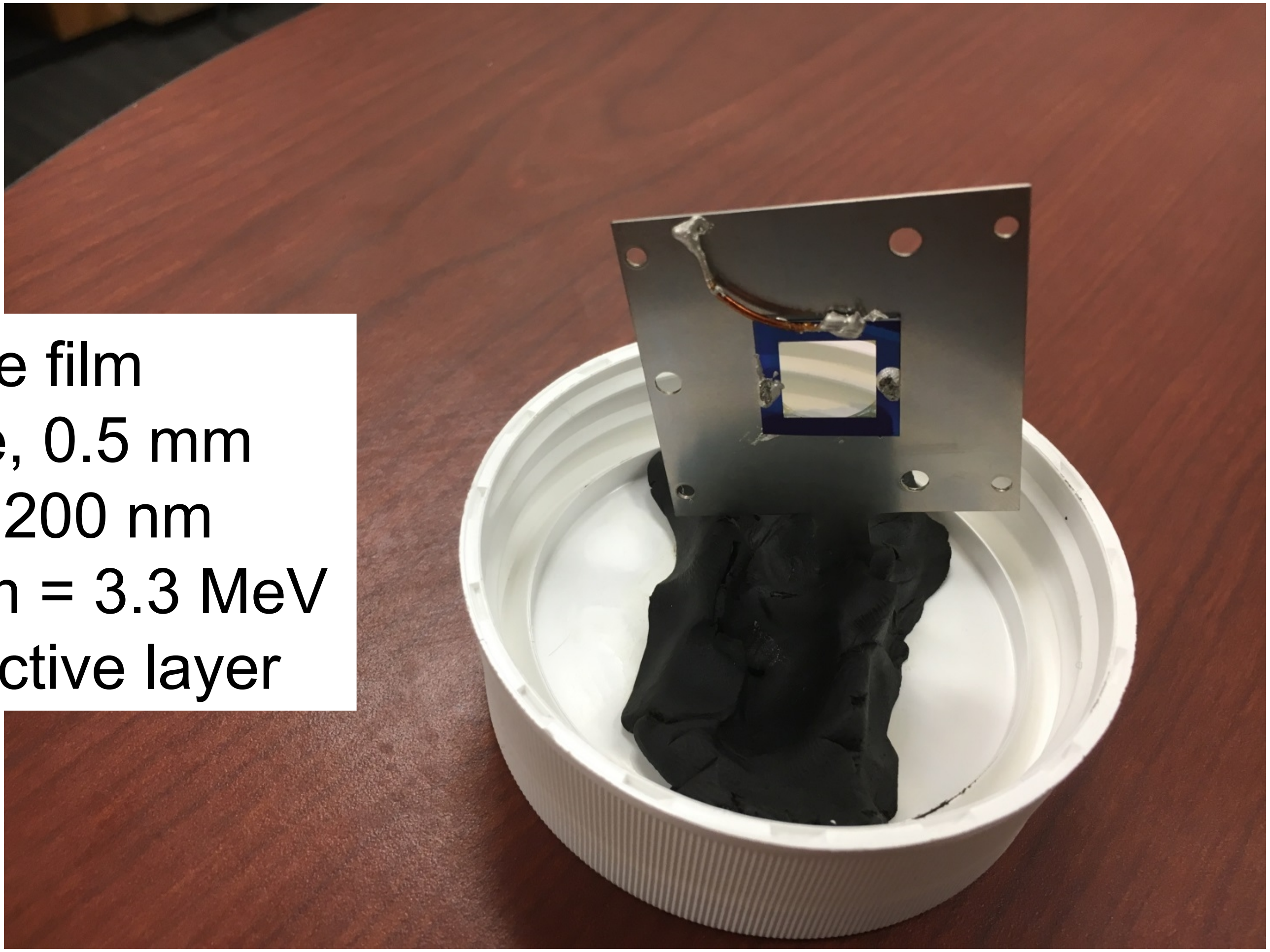
Most experiments get only integrated TOF spectrum from all fragments, so this data is a subset of the normal ^{252}Cf neutron spectrum that is approximated by a Maxwell distribution.

MCP Foils Too Thick



dE in ^{252}Cf source Ni window = ~30 MeV
dE in MCP1 foil = ~50 MeV
dE in MCP2 foil = ~50 MeV
E total = ~140 MeV

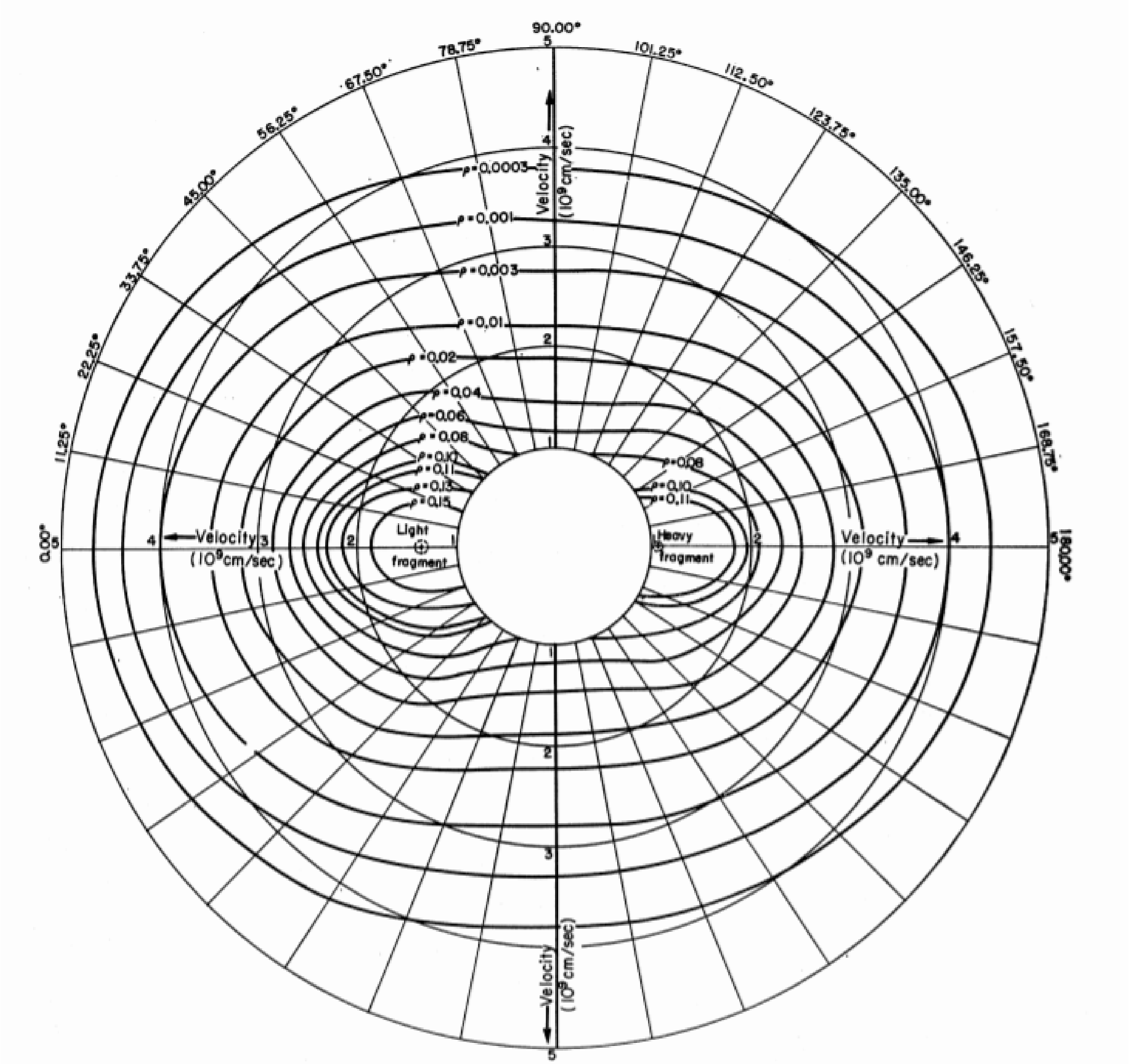
Improved Equipment



- Silicon Nitride film
- Silicon frame, 0.5 mm
- SiN window, 200 nm
- dE in SiN film = 3.3 MeV
- Add a conductive layer

Oak Ridge National Laboratory

Early Coincident Work



-H.R. Bowman *et al.* Physical Review, 129 (1963)

Fission

- Heavy nucleus break up
  - Spontaneous
  - Induced
- Coulomb repulsion
- Fragments “cool”
  - Neutrons
  - Gamma rays
- Nearly 80 years of study
  - Limited data on all 3 products in coincidence