Element Identification Using an Active Target

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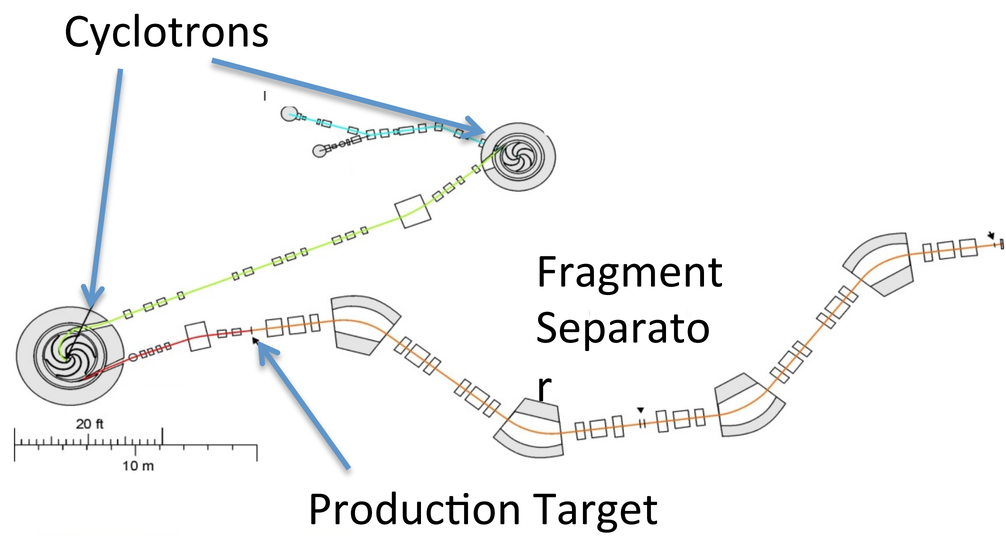
Nuclear Group

Motivation

- Physics
  - Improve our understanding of nuclear matter
    - Nucleon forces
    - Unbound states at and beyond the neutron drip line
  - Technique: invariant mass distributions
  - Tools
    - National Superconducting Cyclotron Laboratory, NSCL
    - MoNA/LISA Detectors
    - Segmented Be/Si Active target
- Education
  - Increase African American participation
    - MSU/NSCL research
    - Establish low energy nuclear physics program
  - Collaboration with other minority institutions

Experimental Facility

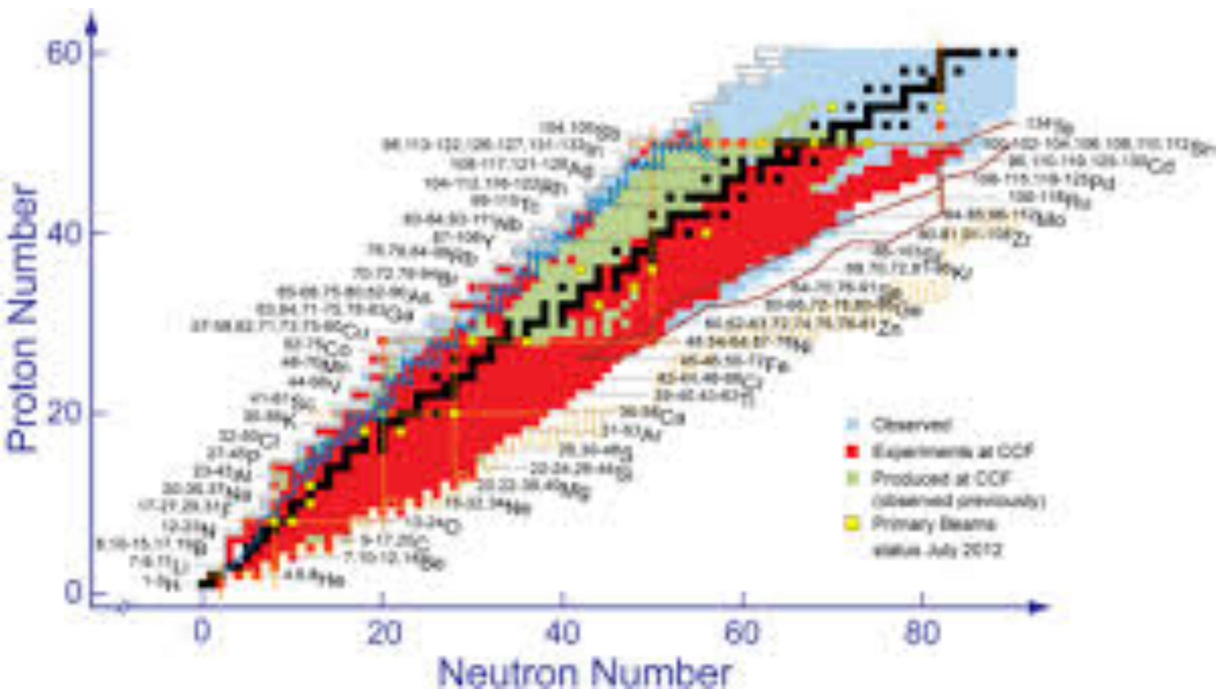
- *National Superconducting Cyclotron Laboratory* (*NSCL*) Lansing, Michigan
- Coupled cyclotrons, particle accelerators, accelerate a beam of heavy nuclei.
- Secondary ions are produced by a nuclear reactions between the beam and the production target
- These nuclei are separated by a magnetic beam line.
- The beam is then directed to a experimental target where nuclear reactions occur to make nuclei for study.



National Superconducting Cyclotron Laboratory at MSU

– Houses the MoNA/LISA setup for the detection of neutrons
  - MONA = Modular Neutron Array
  - LISA = Large multi-Institutional Scintillator Array

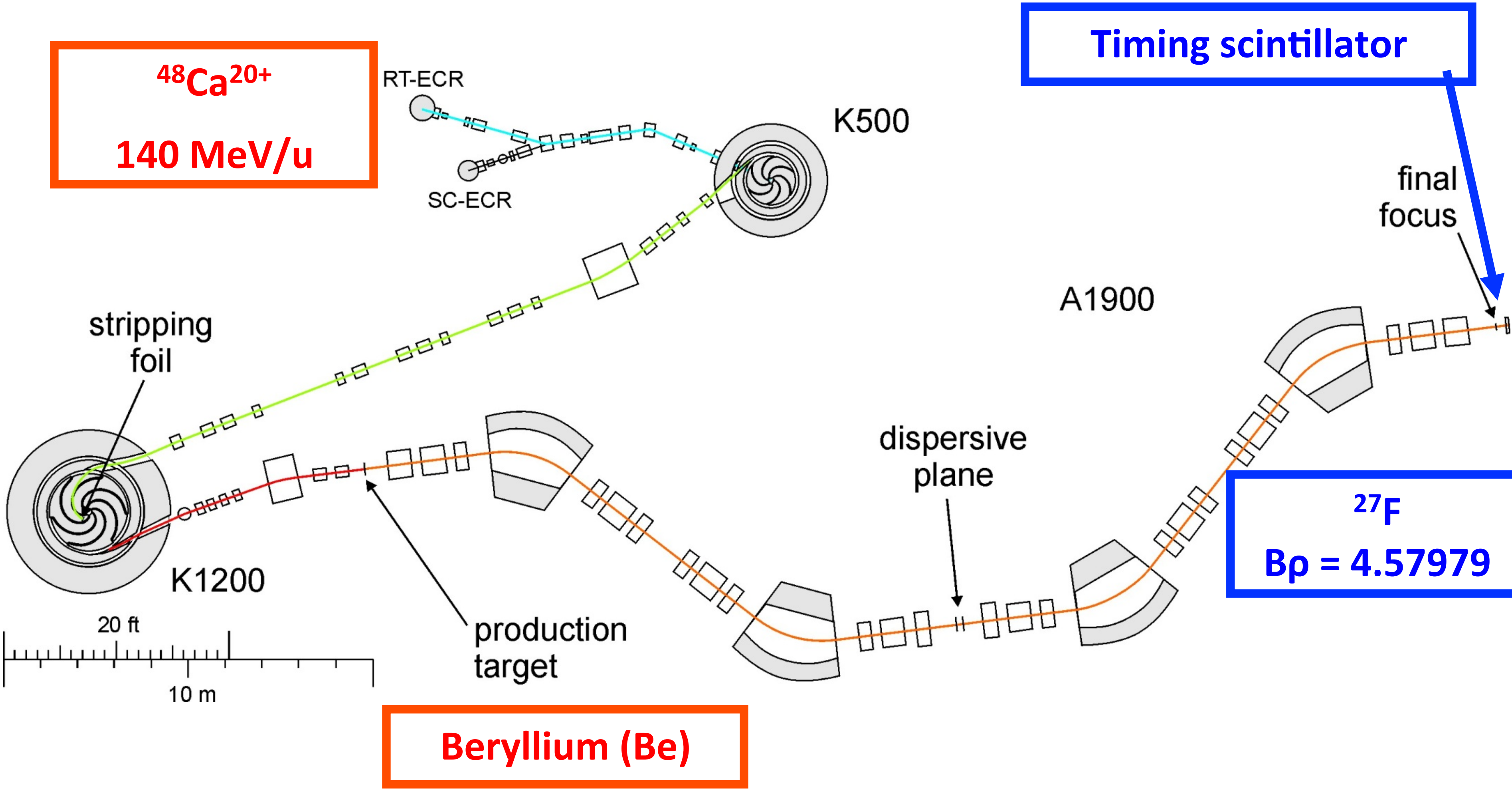
– Study of the nuclear structure of unbound states/nuclei at and beyond the neutron dripline for the past decade



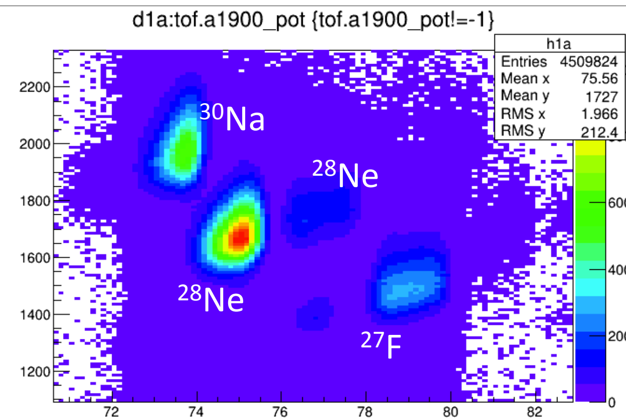
What Type of Experiments are we Exploring?

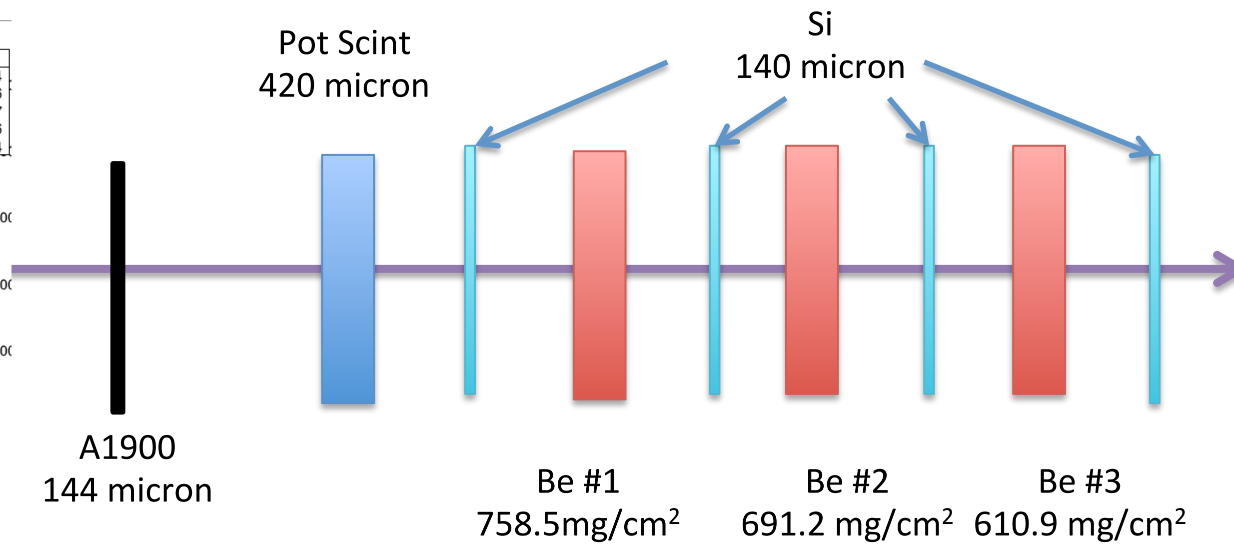
- Neutron-unbound experiments
  - Reconstruct the decay energy from fragments-neutron coincidence measurements
  - Typically low in count rate
- Multi-layered Si/Be active target
  - Will allow the use of thicker targets to increase the reaction rates
  - Enable to study currently out of reach nuclei: ^{21}C, ^{23}C and ^{24}N …

Radioactive Beam Production



Beam Production

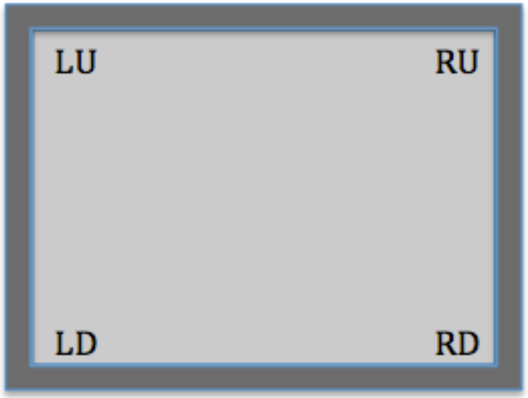


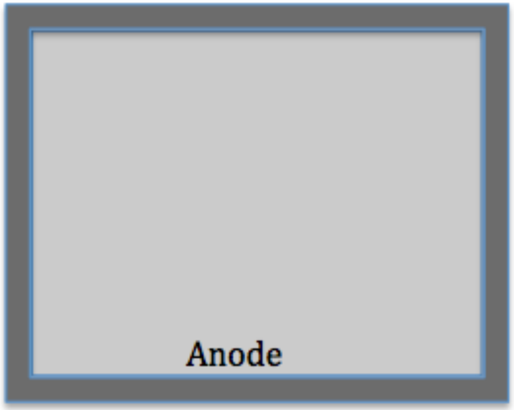


	E Loss A1900	E Loss Pot
F27	8.3667	24.507
Ne28	9.3851	27.474
Ne29	9.8448	20.847
Na30	10.47	30.634

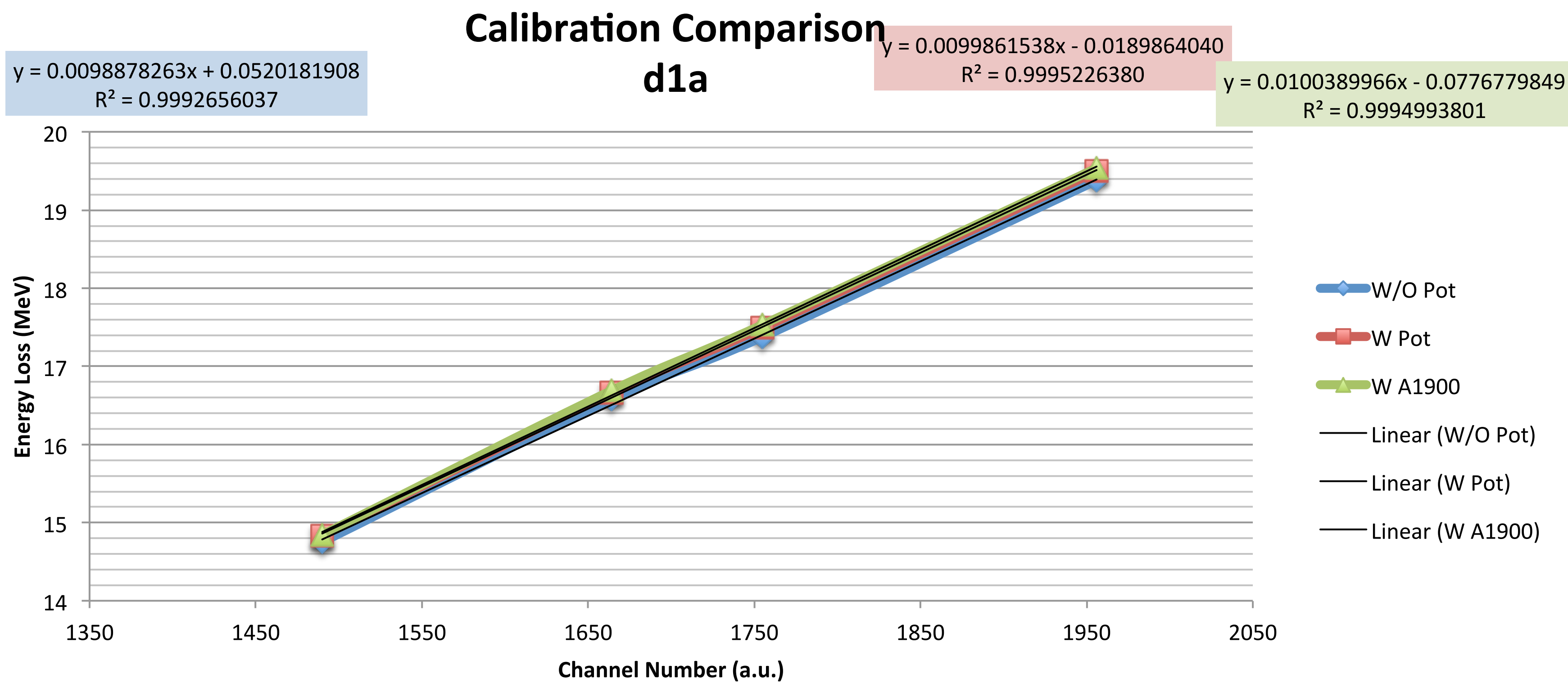
Silicon Detectors

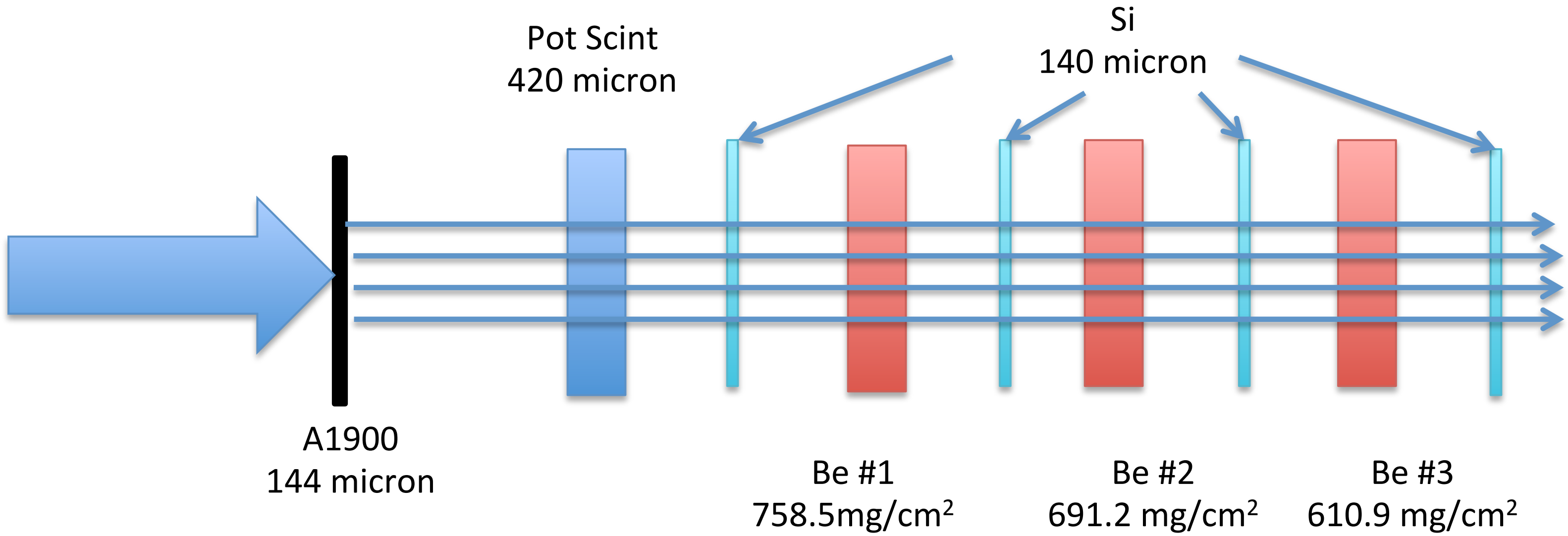
- Each of the silicon detectors in the experiment setup records the **energy deposited** by the secondary beam in five channels, A channel at each corner of the detector
- The channels located in the four corners read the position of the incident beam.
- The anode records the total energy deposited in the silicon.



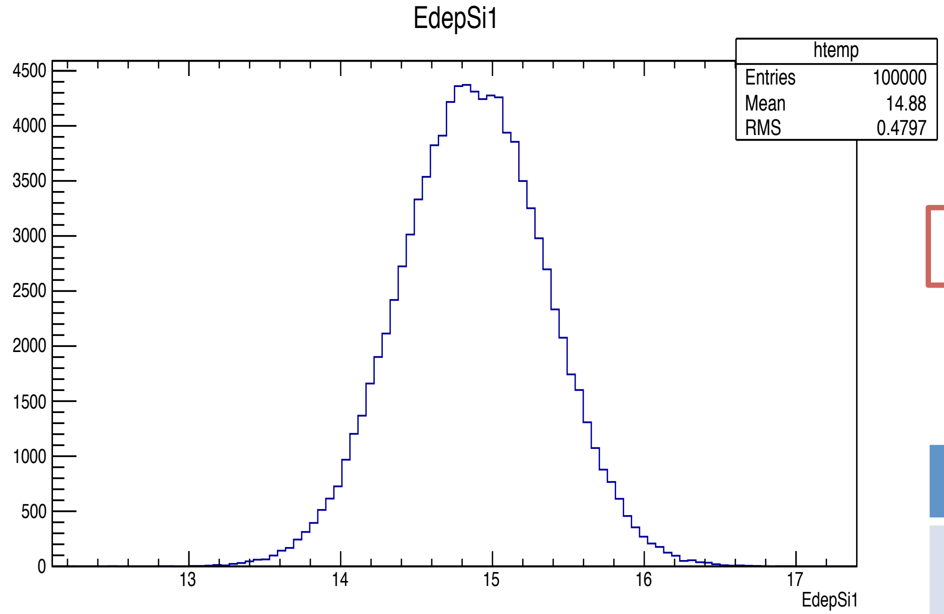


	Si #1		Si #2		Si #3		Si #4	
Particle ID	Channel Number	Energy (MeV)	Channel Number	Energy (MeV)	Channel Number	Energy (MeV)	Channel Number	Energy (MeV)
F27	1490	14.844	1626	16.559	1652	18.919	2060	22.44
Ne28	1664	16.69	1803	18.42	1812	20.773	2226	24.145
Ne29	1755	17.534	1906	19.569	1935	22.385	2442	26.89
Na30	1956	19.539	2153	21.616	2162	24.542	2698	28.756



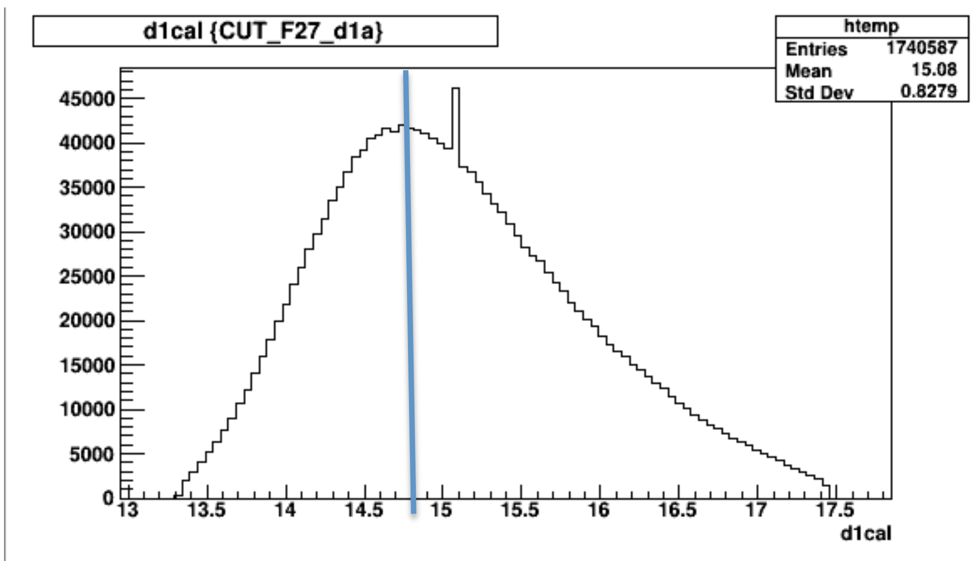


	F27	Ne28	Ne29	Na30
Brho [Tm]	4.57979	4.58009	4.57955	4.57983
TKE [MeV]	2869	3392.8	3287.2	3819.8



Simulated

	LISE ++	Geant4	Data
E loss Si1 [MeV]	14.827	14.88	15.08

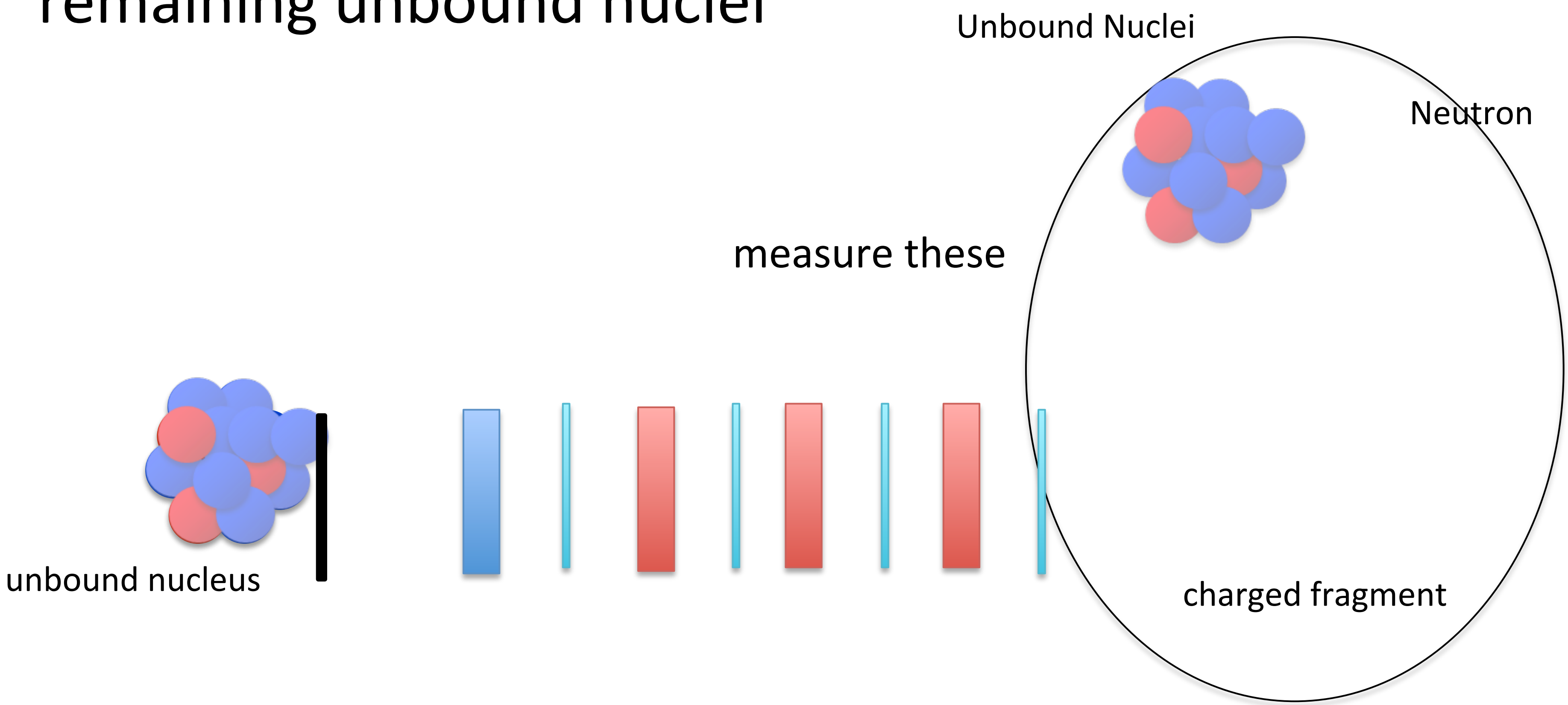


The tail of the histogram denotes that there needs to be a calibration in position. The "seen" peek corresponds with 14.8 MeV which confirms the calculated data

Data

The Proposal of this Experiment

- Produce short lived isotopes with a radioactive beam
- Detect and identify charged fragment and the remaining unbound nuclei



Element Identification

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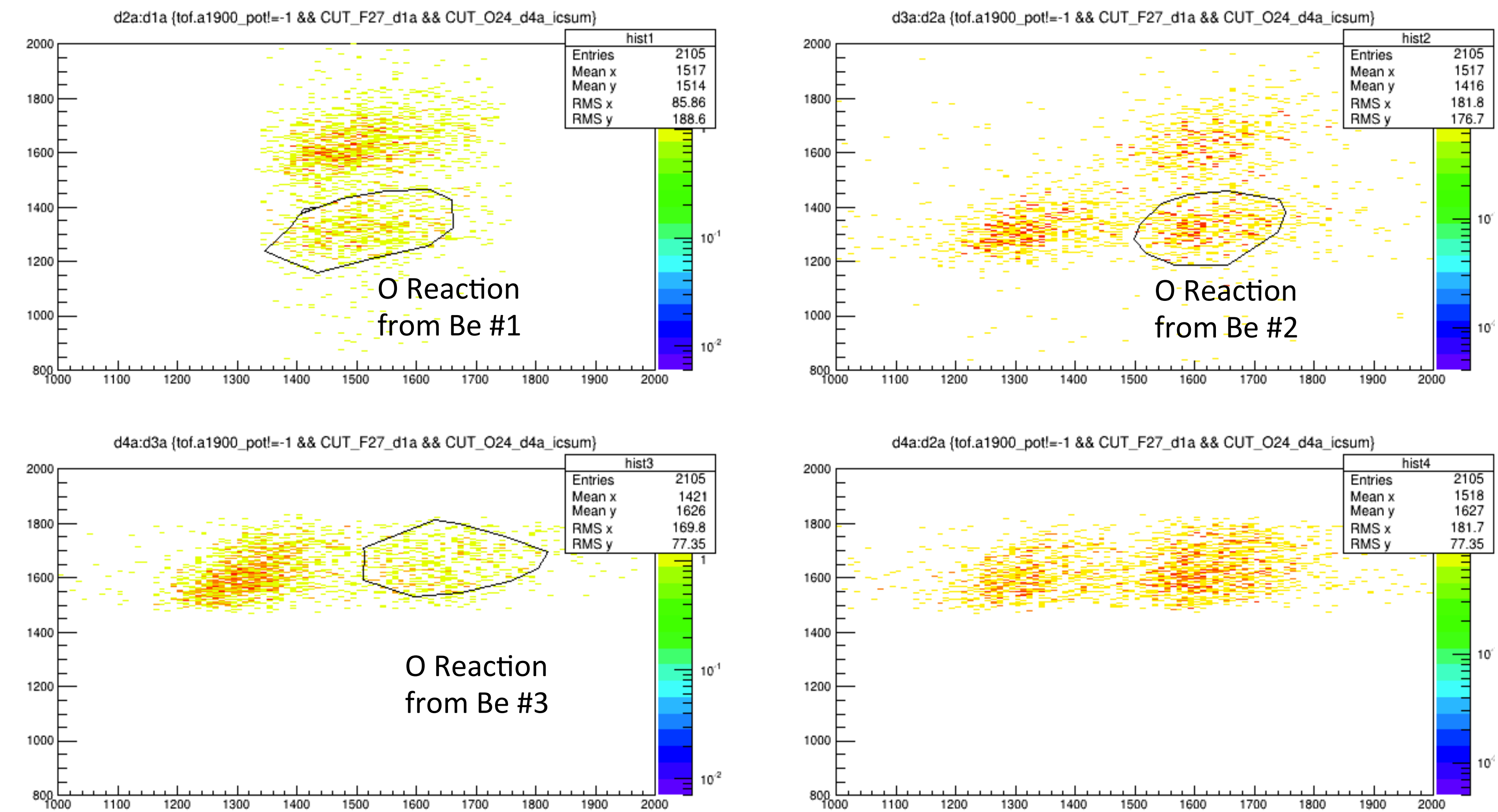
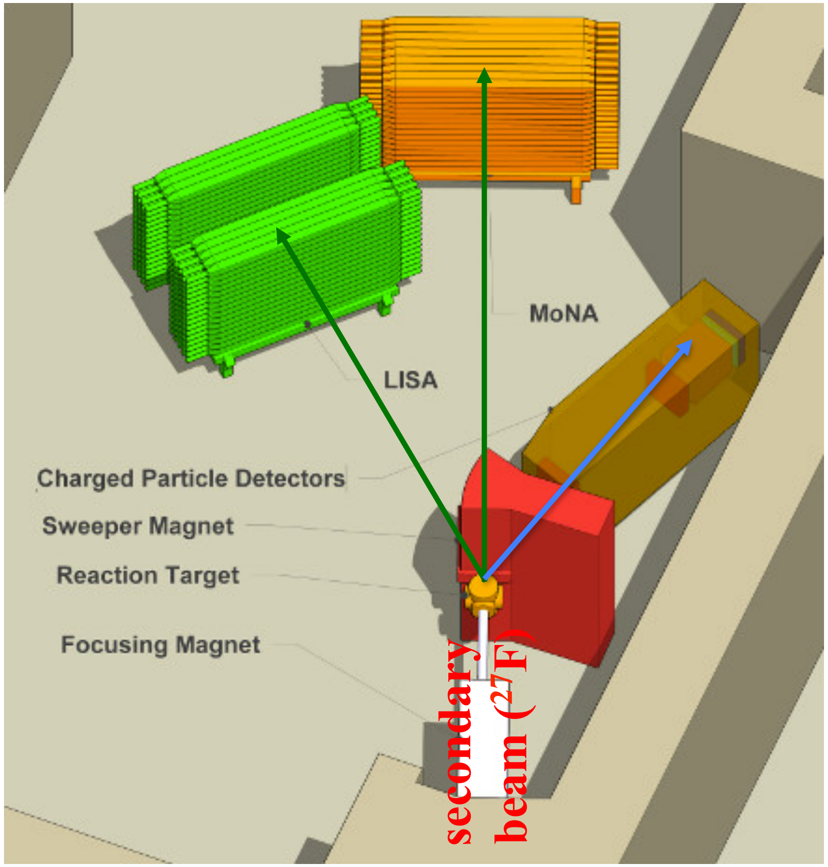
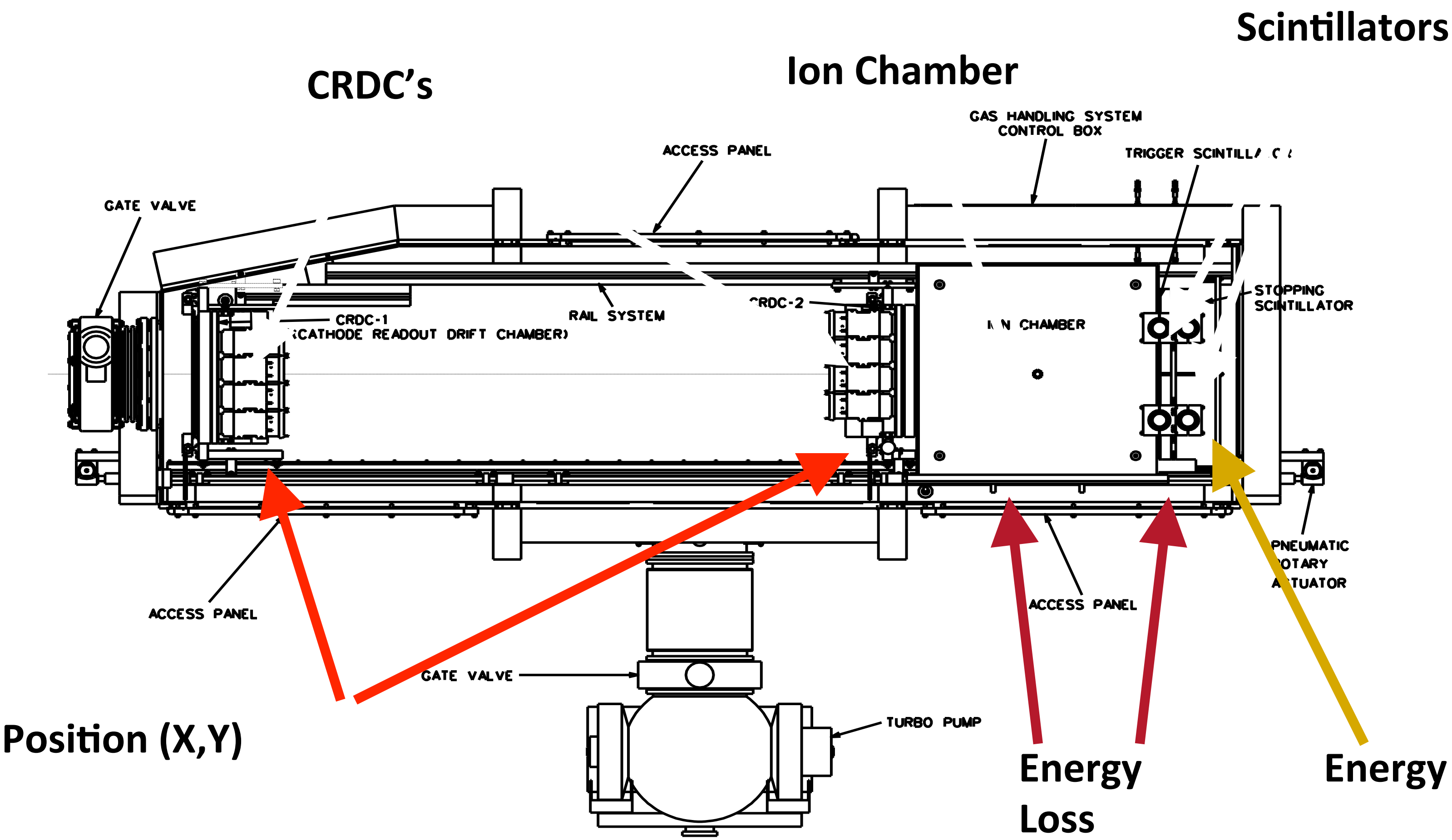


MoNa/LISA Setup

- The neutron-rich nuclei are separated into a charge fragment and a neutron
  => $^{27}F + ^{9}Be \rightarrow ^{24}O + n + n$
- The charged fragment and the neutron are detected in coincidence
- The charged fragment is bent by the Sweeper magnet into a suite of detectors
- Neutrons travel to the MoNa/LISA neutron detectors
- The energy of the unbound state can be reconstructed from the measurement of the momentum of both the charged fragment and the neutron



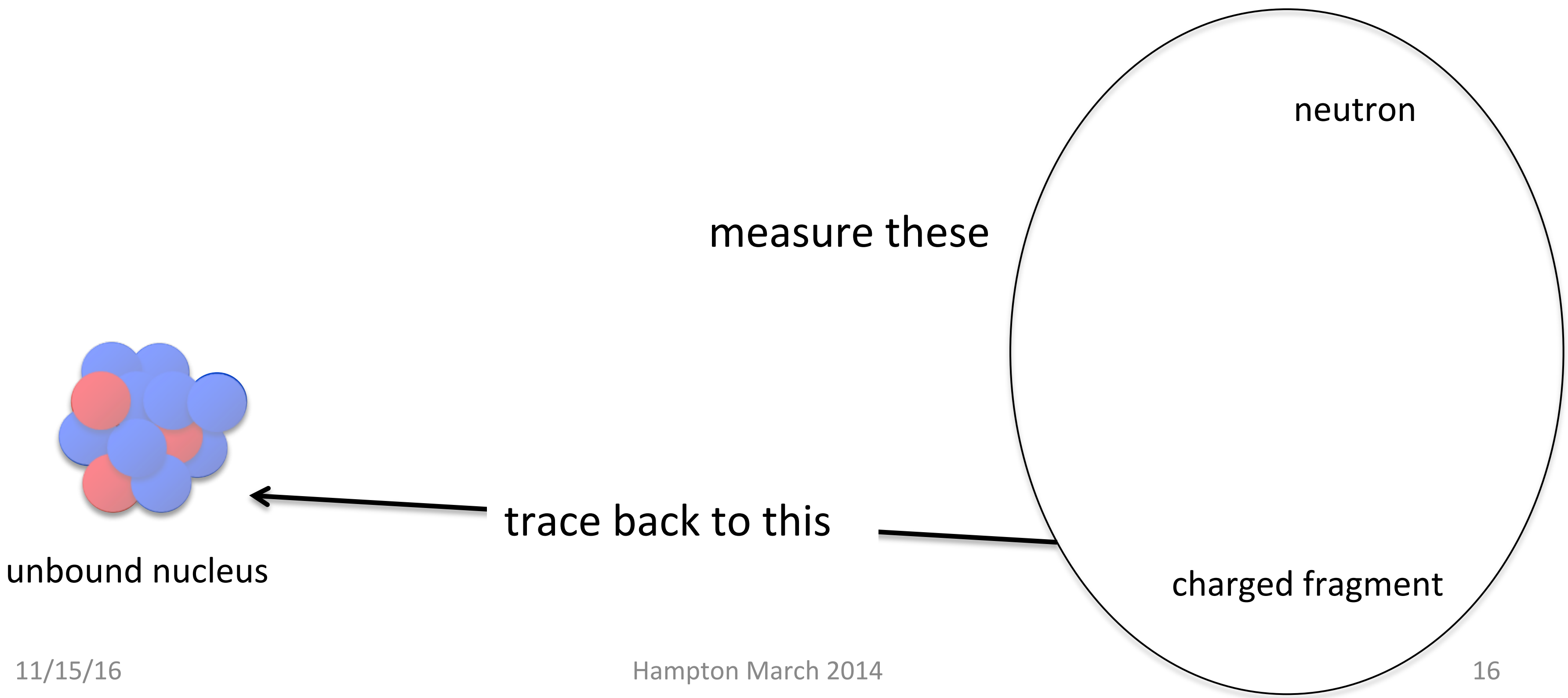
Charged Particle Detectors



Top view of the focalplane detector showing the detector system layout.

How our experiments have been performed?

- Produce short lived isotopes with a radioactive beam
- Detect and identify charged fragment and neutron and work backward.



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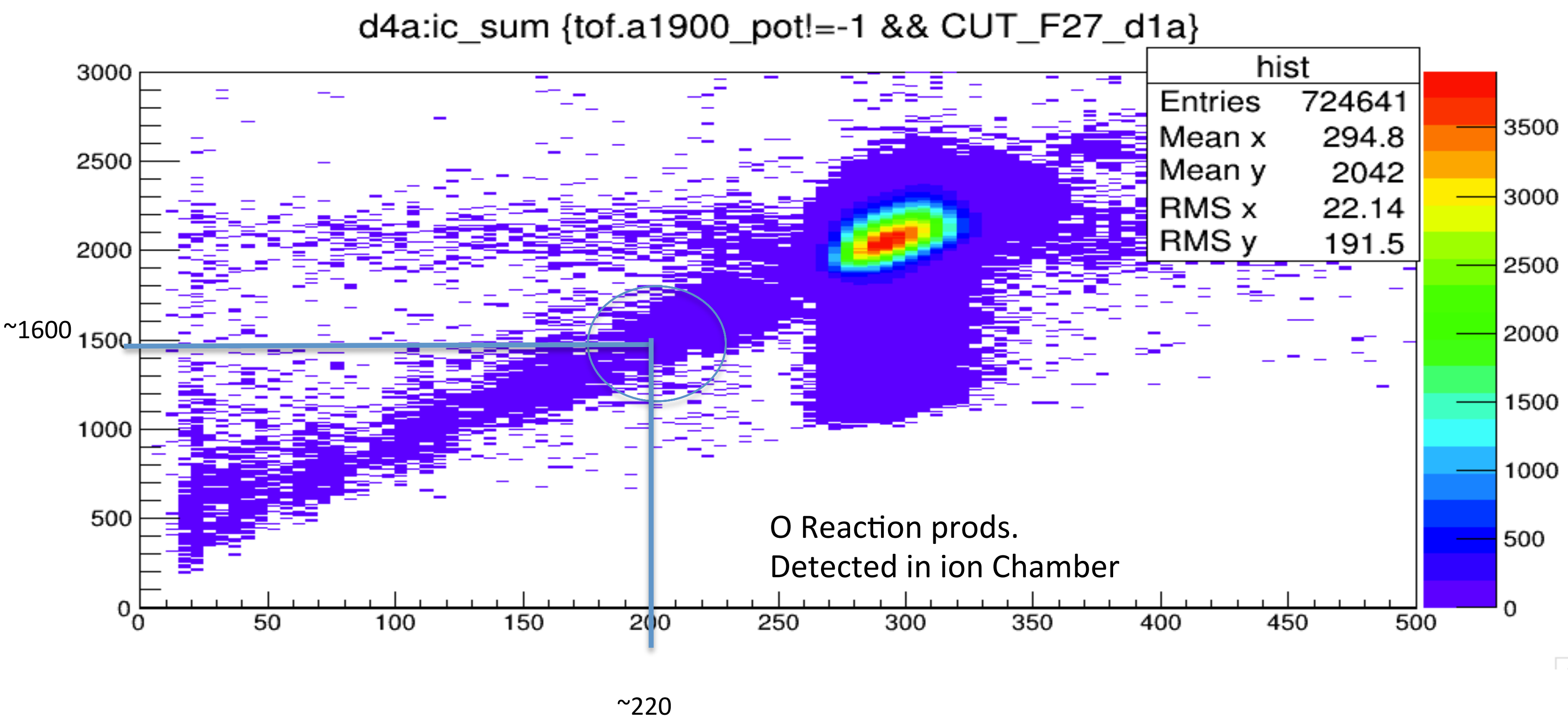

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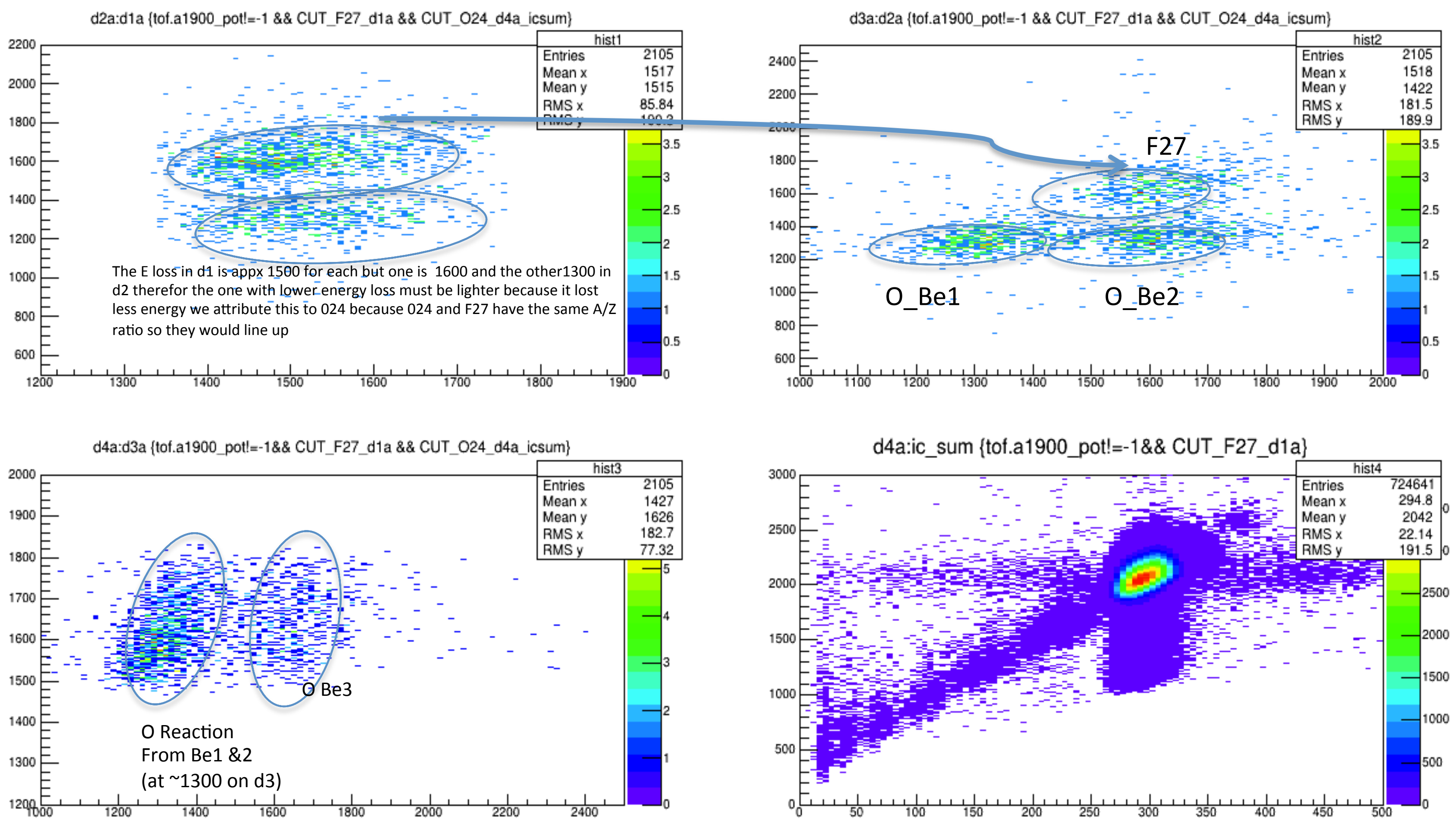

Summary and Future Work

- Summary
  - Experiment took place June and July of 2016 at NSCL
  - Energy Loss simulations corresponded with experimental data
  - Primary data shows element separation and identification within the target
- Future Work
  - Position Calibration for ^{27}F will be completed
  - Element identification using the other contaminant beams will also be analyzed

Thank You

- Paul Gueye
- Michael Thoennessen
- Nathan Frank
- The Mona Collaboration
- Hampton University Nuclear Group