

SECAR Focal Plane Systems

Jeff Blackmon (LSU) *et al.*

- Goal: factor of 10^4 discrimination for recoils of interest
- “leaky” beam at the focal plane is expected, sometimes complicated by beam impurities
- Overall design
 - Flexible configuration for optimization to varying experimental conditions
 - » Mass (10 – 65 A)
 - » Energy (0.15 – 3.0 MeV/A)
 - » Purity (1 – 100 %)
 - Flexibility for future upgrades

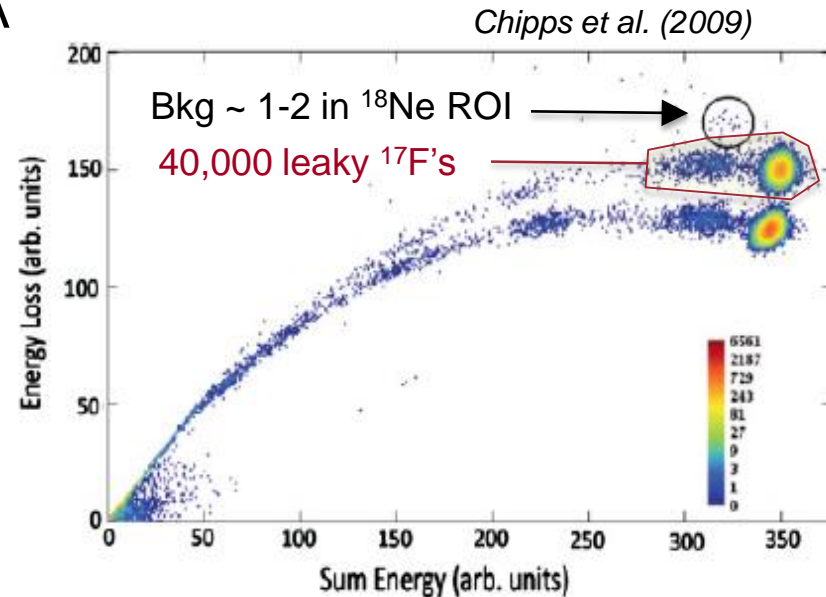
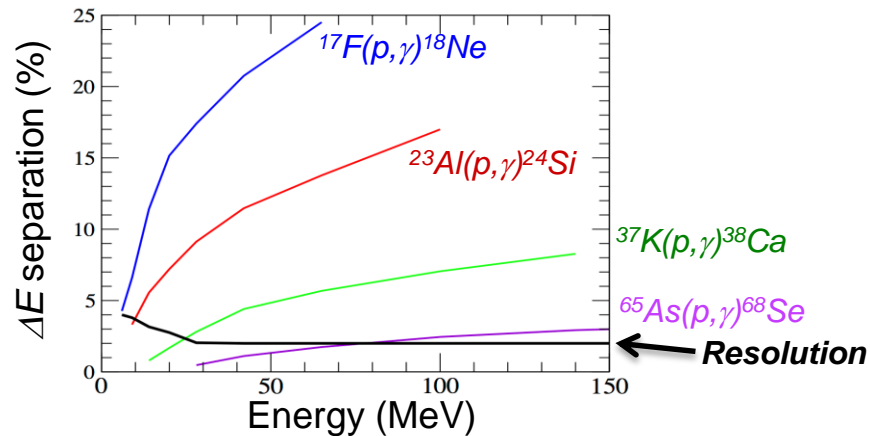
PID parameters

- Z selection via relative energy loss in gas ($\Delta E-E$)
 - Provides isotopic selection when combined with A/q
 - » Most effective for lower Z and higher E
- Total energy
 - Good discrimination between recoils and “leaky beam”
 - » Recoils have lower energy than beam
- Time-of-Flight (TOF) → velocity selection
 - SECAR time of flight
 - » Gamma detectors, target monitor or accelerator
 - Local TOF at 2 positions at focal plane
- Position
 - Position → A/q discrimination
 - Measure trajectory (2 or more positions)
 - » Correct aberrations
 - » Improve background rejection
- Radioactive decay
 - Reaction products typically have much shorter half-lives than beam/contaminants

ΔE - E for low Z

- Z identification by relative energy loss in gas-filled detector

- Example: $^{17}\text{F}(p,\gamma)^{18}\text{Ne}$ w/ DRS @ 0.6 MeV/A
- $>10^4$ suppression for F/O @ 0.6 MeV/A
- Z resolution $\sim 1.6\%$ for this case



- Less effective for lower energy or higher Z

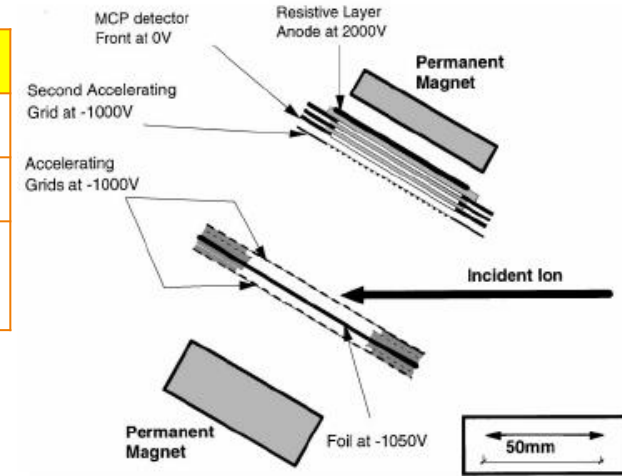
- Some drawbacks:

- Poor timing information (slow ion drift) and pileup at high rates
- Modest energy resolution (few % at best)

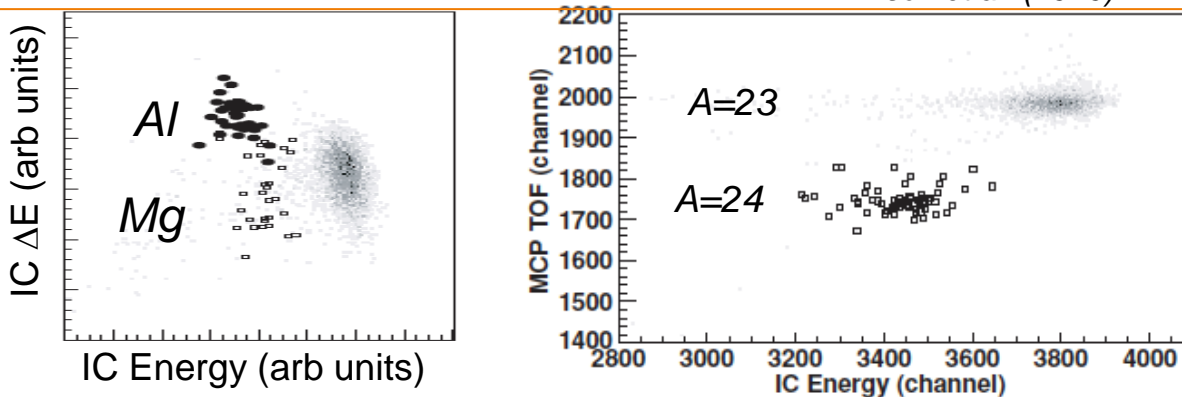
Time-Of-Flight

- Foil-MicroChannel Plate (MCP) detectors provide excellent time resolution
 - Time resolution < 1 ns and position resolution ~ 1 mm
 - Can be used with a variety of stopping detectors
 - » Example: $^{23}\text{Mg}(p,\gamma)^{24}\text{Al}$ w/ DRAGON @ 0.5 MeV/A
 - » High contamination of ^{23}Na in beam ~ 1% ^{23}Mg

Shapira et al., NIMA (2000)

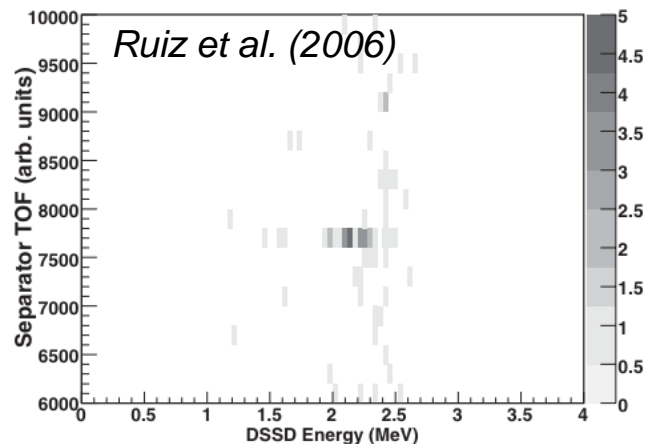


Erikson et al. (2010)



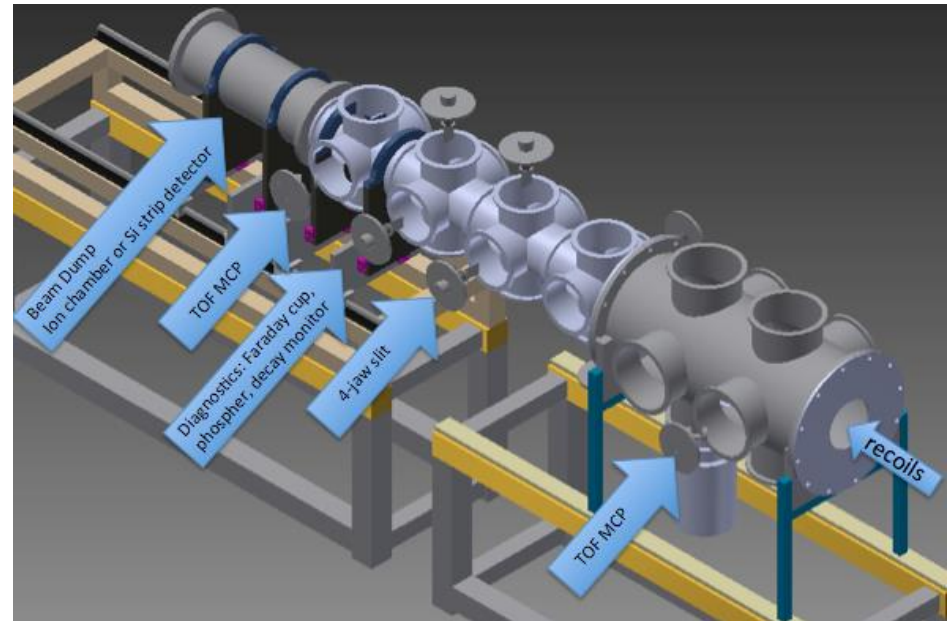
Total energy measurement

- Total Energy and TOF cleanly discriminate reaction products
- Neighbouring Z's cannot be resolved at lower energies by $\Delta E-E$
- Silicon strip detectors provide better energy resolution (<1%)
 - Example: $^{26}\text{Al}(p,\gamma)^{27}\text{Si}$ w/ DRAGON @ 0.2 MeV/A
- Better for radioactive decay counting (β^+/γ) counting



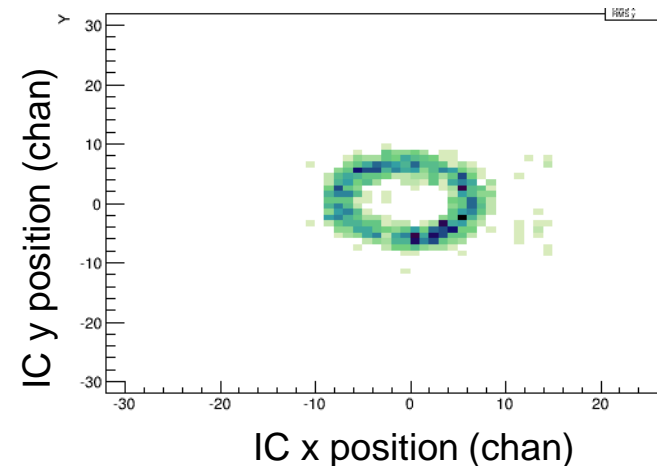
Focal plane configuration

- Focal plane hardware designed for flexibility
 - Area downstream of focus on rail system
 - » Allows easy change of entire components
 - Many free ports available
 - Two pumping stations
- Initial suite of instruments
 - 2 Foil-MCPs ~ 2m apart
 - » Timing
 - » Position
 - Gas ionization detector
 - Silicon strip detector
 - Scintillator



Position measurements

- Position measurements are important
 - SECAR is dispersive in A/q
 - Need position information to:
 - » Properly setup slits to reduce leaky beam
 - » Correct higher order aberrations & improve energy/time resolution
- All detectors will have position sensitive capability
 - MCPs
 - » Excellent ($< 1\text{ mm}$) position resolution
 - » But sensitive to electronic gain \rightarrow good internal calibration needed
 - Silicon strip detectors
 - » “Digital” position information
 - » Limited only by strip pitch ($\sim 2\text{-}3\text{ mm}$)
 - Gas ionization detectors
 - » New LSU design in regular use for ANASEN
 - » Provides $\sim 2\text{ mm}$ position resolution
 - » 64+2 electronics channels



Summary

- Focal plane will provide $> 10^4$ selectivity in nearly all cases
 - Variety of complementary techniques needed that can be optimized to experimental conditions
 - Flexible system also allows for new techniques and future upgrades
 - Some challenging cases involve low energies with contaminated beams
 - » Not likely to be first experiments
 - » Some new approaches may be developed beyond the initial suite
- Engineering designs for the initial detectors are being developed
 - Ion chamber design is finished
 - We welcome your suggestions and input
 - Now is a good time to get involved!