Large Multi-institutional Scientific Collaboration Ensures Active Scientific Program

- Current SECAR scientific collaboration: 60 members
SECAR is coupled to ReA3 to study $p$ or $\alpha$ radiative capture reactions induced by unstable beam

Gas Jet target JENSA fully commissioned and used in standalone mode

Magnets and associated equipment are in place

First commissioning in July 2018

Wien filter 1 will be under conditioning by end of October at FRIB/NSCL
  - Clean room installation undergoing

Wien filter 2 factory acceptance test undergoing

Wien filter 2 acceptance at MSU start by March 2019
Determine composition of ejecta from
• Spectral lines
• Pre solar grains
• $\gamma$-rays?

From H. Schatz
SECAR Fully Integrated into FRIB
Enables Direct Measurements of Astrophysical Rates
SECAR Takes Advantage of Unique FRIB Capabilities

- SECAR is matched to unique FRIB capabilities
  - Intense low energy radioactive beams for a broad range of important reactions
    - Along the rp-process path up to \( A \approx 65 \)
    - Intensity range \( 10^7 \) pps – \( 10^{11} \) pps
  - Unique radioactive beam production from fragmentation, stopping, and reacceleration
    - Beams that are not available with ISOL
    - Flexibility to react to new discoveries

(Difficult with other facilities)
Step 1: Dipoles Charge state selection

Step 2: Wien Filter Mass resolution 510 Recoil selection

Step 3: Wien Filter Mass resolution 770 Remove leaky beam

Step 4: Dipoles Cleanup scattered beam

Step 5: Focal Plane Detectors

Separator Systems

Target γ-Detectors

Technical Solution
Ion Optics Optimized

- **Section 1: Charge Selection**
- **Section 2: Mass separation**
  - Mass Resolv. Power $R_m = 747$
  - Mass Resolution $R_{HO} = 510$
  - Achromatic focus
- **Section 3: Second stage of mass separation**
  - Mass Resolv. Power $R_m = 1283$
  - Mass Resolution $= 770$
  - Disp. R16=0, focus R12 = 0
- **Section 4: Momentum dispersion**
  - Angular acceptance: +/-25mrad
  - Energy Acceptance: +/-3.1%
All Magnets are Delivered and Installed

- 8 Dipole magnets with embedded higher order corrections
- 14 Quads + 1 with hexapole
- 3 hexapoles and 1 octupole
Wien Filters: E&M Fields Shape and Ratio

- EFL = 2.36m
- Operation Fields:
  - E=+/-250kV
  - B=0.12T
- Good field region:
  - 11cm (H)x7cm(V)
- Common mirror plate
- E-field defines EFL
  - Moveable magnetic field clamp to match B field length to E (Range +/-1.25 cm)
Wien Filter Transversal Homogeneity

- Integrated Field*dz compared to the center line
  - Calculated for E-field
  - Calculated for B-field and compared to measurement
    - Probe position sensitivity limited
    - integrated in ion optics calculation

**Graphs:**
- E-Field Homogeneity
- B_y-Field Homogeneity
  - 40% excitation
### Wien Filter 1 Factory Acceptance

- Factory conditioning demonstrated +/-270kV
  - Full magnetic field (0.12T)
  - Stable (1 spark/hour) at +/-250 kV
- Shipped to MSU this week

![Graph and images showing conditioning results and equipment]

- Voltage (kV)/Current (mA): $3 \times 10^{-9}$ mbar
First Commissioning Beam

- $H_2^+$ from ReA3 stable ion source
- Beam tune to first focal point
  - Dispersion measured comparable to calculations
- Beam tuned to SECAR from ReA3
  - With help of Matt Amthor


Experimental test of an online ion-optics optimizer

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Charge State of Recoil

• The efficiency of a SECAR experiment is:
  – $\epsilon = \text{Charge State Fraction} \times \text{Transmission} \times \text{Detection Efficiency}$

• Nuclear reaction can take place anywhere in the gas target
  – Part of the product will NOT cross enough material to reach charge state equilibrium
  – Solution by various group: Post stripper and measurements
  – Charge state model are failing to predict charge state in gas at low energy (~0.2-3 MeV/u)
    • ETACHA requires modification for gas
    • RISP/Seoul National University ETACHA4E (extended)
Hendrik Schatz (project manager, MSU)
Michael Smith (deputy project manager, ORNL)
Georg Berg (project physicist, UND)
Aftab Hussein (project engineer, MSU)
Fernando Montes (deputy project physicist, infrastructure, installation, commissioning, MSU)
Manoel Couder (separator system, UND)
Jeff Blackmon (experimental system, LSU)
Kelly Chipps (jet gas target, gamma detection, ORNL)
Uwe Greiffe (extended gas target, CSM)