

St. George and SECAR

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Outline

- Facilities
- Ideas behind design
- Status of St. George
- Status of SECAR
- Questions/Discussion





St. George Science goals

- Study (with stable beam)
 - Reaction involved in Helium burning
 - Reaction involved in s-process
 - α radiative capture
 - Negative q-value (α ,n) (at low energy)





SECAR Science Takes Advantage of Unique FRIB Capabilities

From H. Schatz

- SECAR enables the FRIB user community to take advantage of NSCL/FRIB's unique low energy RIB production capabilities to directly measure astrophysical reaction rates
- Focus on p/α induced reactions on neutron-deficient unstable nuclei
- Addresses a long standing goal of the community not reached because of limited radioactive beam production capabilities, FRIB with SECAR addresses this



Accreting compact objects

- X-ray bursts
- Novae



Supernovae

- vp-process
- p-process
- Explosive burn



Extreme Stars

- Thorne Żytkow objects?
- Massive first stars



St. George

- 5 MV single ended electrostatic accelerator
- ECR source with 4
 gas
 bottles connected
- Intensity for Z>2
 ~50 pµA
- $\Delta E_{max} = 1 \text{keV}$





St. George







SECAR Layout

- SECAR consists of:
 - 2 Wien filters (VF1, VF2)
 - 8 Dipole magnets
 - 14 Quadrupoles ٠
 - 1 Quadrupole+Hexapole Q1(+Hex)
 - 3 Hexapoles
 - 1 Octupole



Max magnetic rigidity: 0.8 Tm



Gas Targets

- Jet important for mass separation
- St. George: HIPPO jet gas target ~10¹⁷ at/cm²
- SECAR: JENSA (See K. Schmidt talk)
 - Jet gas target ~ 10^{19} at/cm²
 - Extend gas target under construction
- γ-ray detection
 - St. George: Large Nal
 - SECAR: BGO array similar to DRAGON





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Objective Criteria for Design of the Electromagnetic Separator

- 100% transmission of selected charge state
- Start with Charge state selection
 - Separation outside the envelop of the recoils
 - "Clean capture" of the other charge state
- Criteria for mass selection based on mass resolving power
 - All spectrometers are designed with this approach
 - Scaled resolving power of DRAGON (for SECAR)
 - Compatible with Gaussian approximation for beam
- The tune for the worse case scenario need to be fully scalable for all electric and magnetic rigidities
 - One can find different/better tune for the other less demanding cases





Mass Resolving Power

• $x_1 = x_0(x|x) + a_0(x|a) + \frac{\delta E}{E} (x|E) + \frac{\delta M}{M} (x|M)$

We want mass selection to be accomplished at a point were (x|a) = 0 a focus and (x|E) = 0 achromatic

We also want to maximize (x|M)

Resolving power
$$\sim R_m = \frac{M}{\delta M} = \frac{(x|M)}{Recoil \ spot \ size}$$



Mass Separation Approach

- Both separators use Wien filter
 - In combination with the preceding magnetic elements, achromatic focus is achieved
 - St. George +/-100 kV
 - SECAR +/-270 kV
 - SECAR uses two Wien filter sections
- A "Clean-up section" following the mass separation provides additional momentum selection





Particle ID Detection Systems

- The energies involved in the planned St. George measurements is too low for ∆E-E technique →tof vs E (1D) method
 1Dx1D position sensitivity 1mm resolution
- For SECAR a full portfolio of detectors
 - Tof
 - Ionization chamber
 - Silicon detector





St. George ToF



SECAR: Strategies Adopted to Meet Requirements

From Jeff Blackmon

- Z selection via relative energy loss in gas (DE-E)
 - Provides isotopic selection when combined with A/q
 - $\ensuremath{\text{\tiny *}}$ 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) for velocity selection
 - SECAR time of flight
 - » Gamma detectors, target monitor or accelerator
 - Local TOF at 2 positions at focal plane

- Position
 - Position for A/q discrimination
 - Measure trajectory (2 or more positions)
 » Correct aberrations
 - » Improve background rejection
- Different techniques are better suited to different cases
- Design allows for flexibility to optimize system to experimental requirements





Focal Plane Overview

From Jeff Blackmon



Kyle Joerres, M.S. (LSU, 2017)



Separator for Capture Reactions

Status of St. George

- 100% Energy acceptance over +/-8%
 - Over the whole electric/magnetic rigidity







Status of St. George

- 100% Energy acceptance over +/-8%
 - Over the whole electric/magnetic rigidity
- Measurement of the angular acceptance





Status of St. George

- 100% Energy acceptance over +/-8%
 - Over the whole electric/magnetic rigidity
- Measurement of the angular acceptance
- Future: Focus on know reaction and rejection





Status of SECAR

- All the magnets are constructed, delivered, accepted
- First 12 magnets installed



Status of SECAR

The first Wien filter is under conditioning at the constructor



Status of SECAR

The first Wien filter is under conditioning at the constructor





Questions/Discussion

- Gas target (after Konrad's talk)
 - Characterization of the variable shape of jet
 - Fluid dynamic calculations
 - Limit of 2D
 - Post stripper
- Vacuum effect on rejection
- Method to tune aberration correction magnets
- Charge state distribution
 - Measurements and predictions
 - Joint effort? e.g. Slack Channel to share info & "track" progress





ETACHA

E. Lamour, P. D. Fainstein, M. Galassi, C. Prigent, C. A. Ramirez, R. D. Rivarola, J.-P. Rozet, M. Trassinelli, and D. Vernhet

PHYSICAL REVIEW A 92, 042703 (2015)

-Accounts for density of the ta -Accounts for correct energy lo -At low thickness shows/confir sensitivity to initial charge stat -Don't account for product of nuclear reaction

LISE++ [Noname]

Target St Stripper

D1 D, S II I1_sits

D2

S T FP_sits

M FP_PIN

Projectile

Options Experiment Settings Phy

48Ca20-140 MeV/u 1 pnA Fragment 42S16+

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http://www.insp.jussieu.fr/ETACHA-a-code-to-predict-the.html?lang=en



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