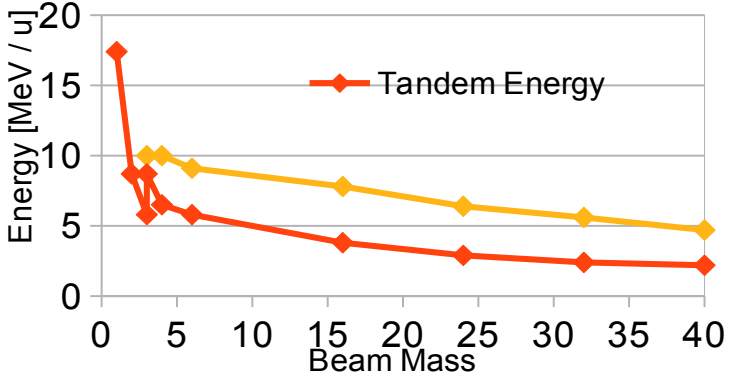
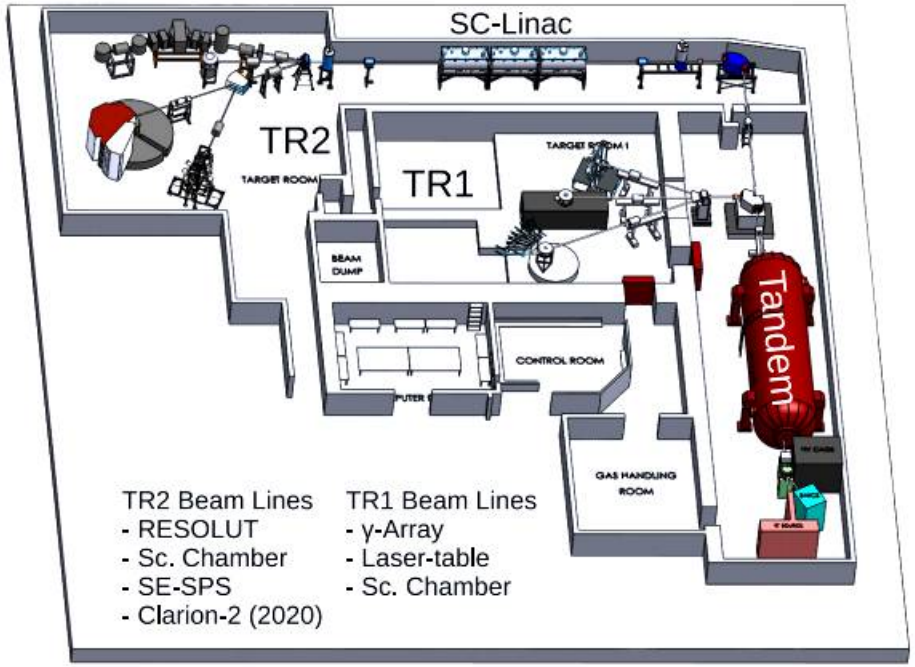
The John D. Fox Accelerator Laboratory

- 9 MV Tandem + 8 MV Linac
- Beam Energy profile

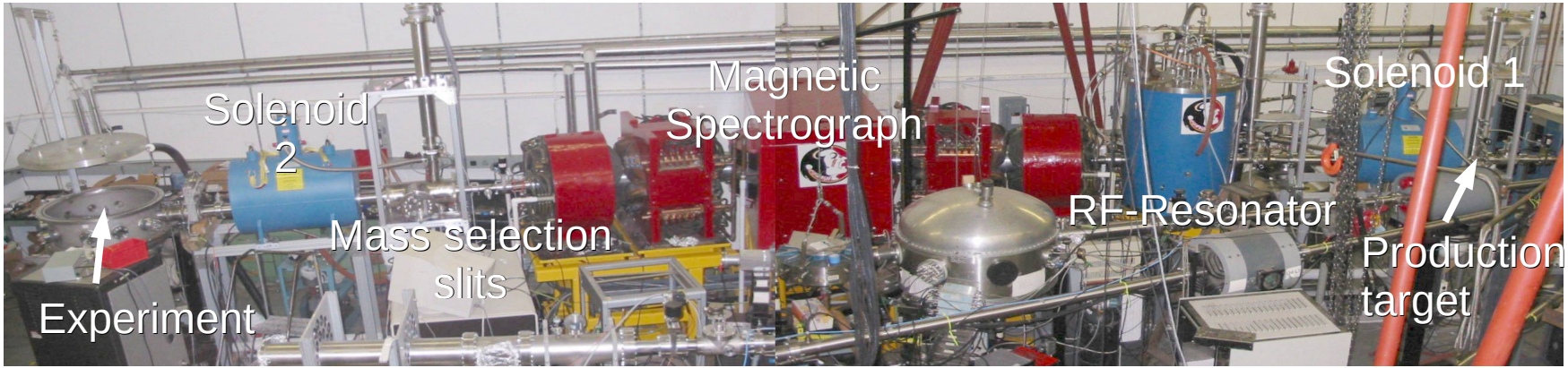


- In-flight Radioactive beams with RESOLUT
- Still kinda new: Super-Enge Split Pole Spectrograph
- New: Clarion-2



Tandem: Pelletron-charged 9 MV FN-tandem
Linac: 14 Superconducting cavities
Niobium on Cu, Split-Ring (Atlas-design)

RESOLUT: a radioactive beam facility at FSU



In-flight production of radioactive beams in inverse kinematics,

^{7}Li(d,^{3}He) ^{6}He	18-29 MeV	~1· 10^{4} pps	(40% pure)
^{7}Li(p,n) ^{7}Be	25-35 MeV	~2· 10^{5} pps	(80% pure)
^{7}Li(d,p)^{8}Li	20-30 MeV	~5 · 10^{4} pps	(90% pure)
^{7}Li(^{3}He,n)^{8}B	30-45 MeV	~1 · 10^{4} pps	(10% pure)
^{7}Li(^{3}He,n)^{10}N	27-55 MeV	~1 · 10^{3} pps	(10% pure)
^{18}O(d,n)^{17}F	80 MeV	~2 · 10^{5} pps	(80% pure)
^{18}O(d,p)^{19}O	95 MeV	~5 · 10^{4} pps	(90% pure)
^{18}O(^{3}He,n)^{18}Ne	70 MeV	~2· 10^{4} pps	(25% pure)
^{24}Mg(d,n)^{25}Al	98 MeV	~2· 10^{4} pps	(35% pure)

Beams can be “purified” off-line by tracking / rf-correlations

Radioactive-Beam Programs at FSU

RESOLUT in-flight facility and specialized detector systems:

a) ANASEN active-target detector

- ^{18}Ne(α,p)^{21}Na: Break-out from hot CNO cycles in X-ray bursts

M. Anastasiou et al.: PRC 105, 055806 (2022)

- ^{7}Be(d,α): BigBang nucleosynthesis, primordial Lithium problem

N. Rijal et al.: PRL 122, 182701 (2019)

b) ResoNeut resonance spectr.

- ^{10}Be(d,n)^{11}B for β-delayed proton decay of ^{11}Be

E. Lopez-Saveedra et al.: PRL 129, 012502 (2022)

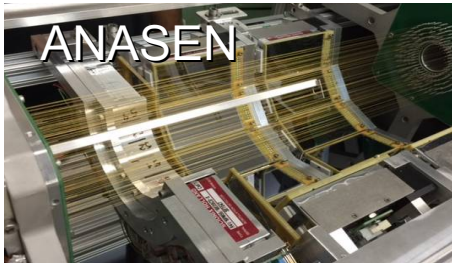
- ^{17}F(d,n)^{18}Ne for Nuclear Astrophysics

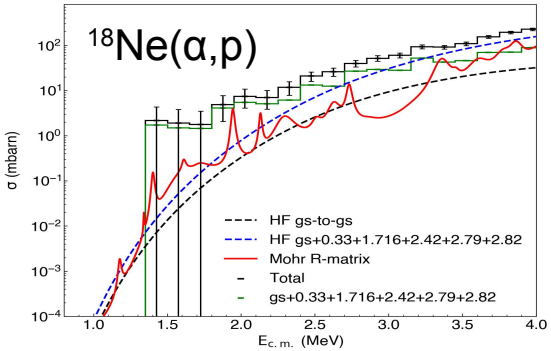
J. Belarge et al.: PRL 117, 182701 (2016)

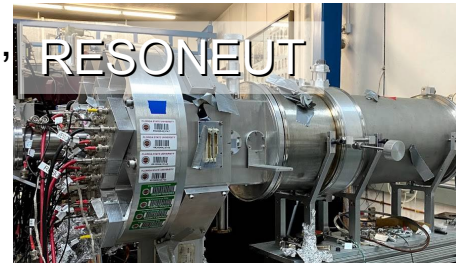
c) Encore active-target detector

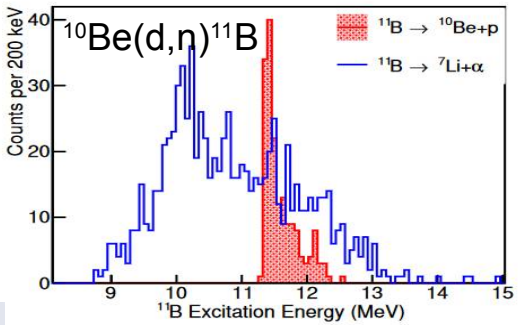
Fusion cross sections of ^{17}F+^{12}C

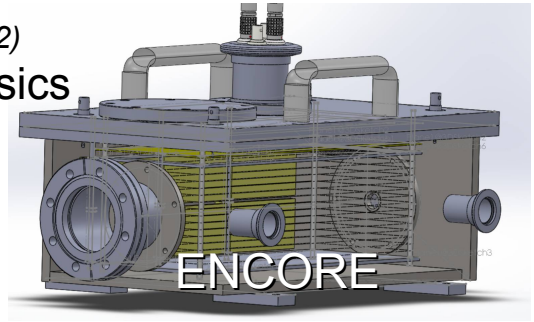
B. Asher et al.: PRC 103, 044615 (2019)

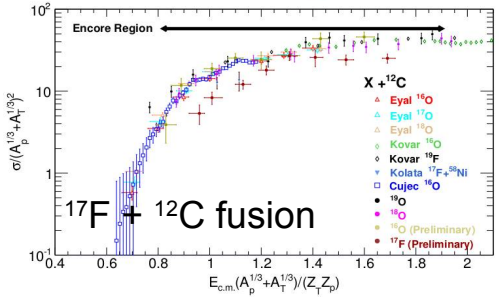










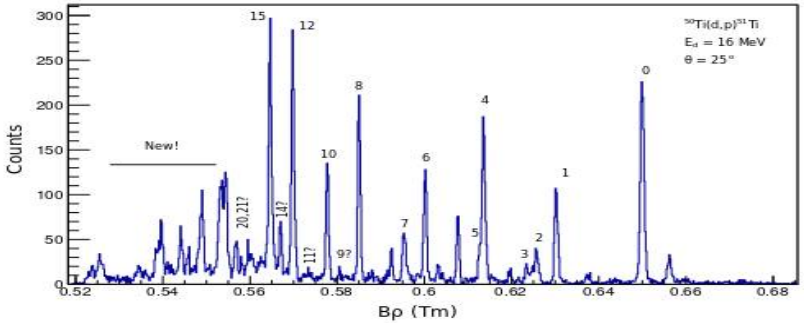


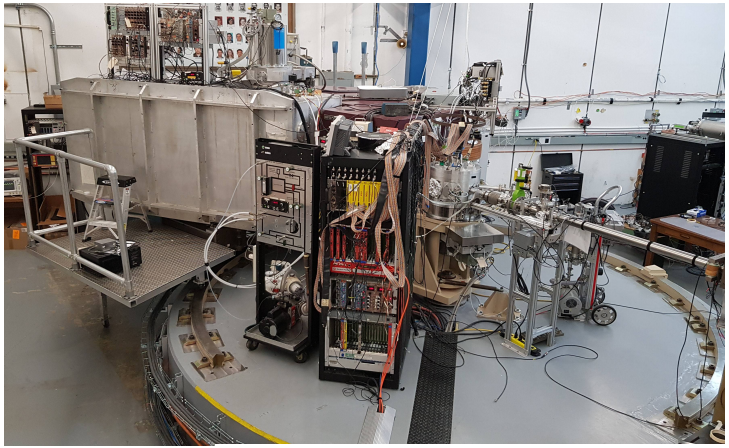
High-Resolution Magnetic Spectrograph at FSU

a) Studies of Shell Evolution

e.g. ^{50}Ti(d,p)^{51}Ti, “beyond N=28” orbitals

L. Riley at al: PRC 103, 064309 (2021)





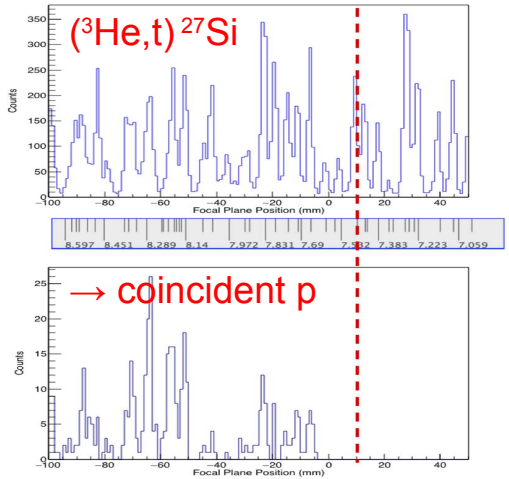
b) Resonance spectroscopy for nuclear Astrophysics

e.g. ^{10}B(^{3}He,α)^{9}B to study resonance spectrum / BBN

e.g. ^{27}Al(^{3}He,t)^{27}Si(p) → ^{26}Al$_{g,m}$ for ^{26}Al(p,g) destruction (LSU)

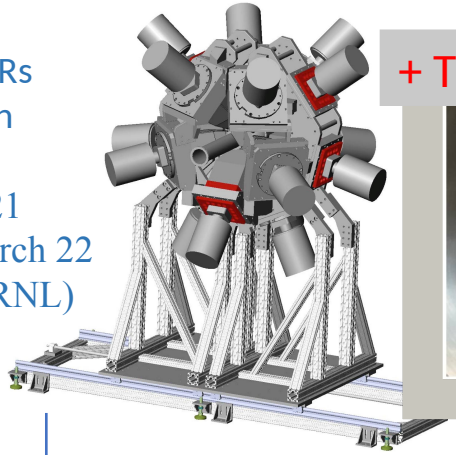
c) (Developing) Gamma-ray strength function through transfer-reaction studies

d) (Developing) Spectroscopy with tritium-beam (t,p) reactions

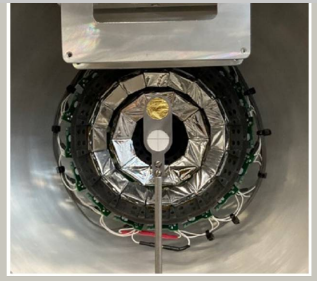


CLARION2@FSU

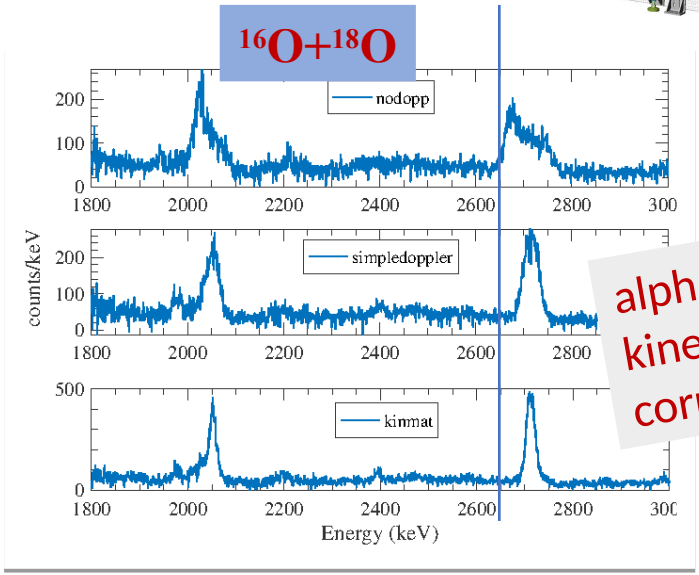
- γ-ray detection with up to 16 Compton suppressed CLOVERs
- Charged particle detection
  - TRINITY: 5 rings of GAGG+ Si
- Commissioned in Dec 2021
- First experiments: Jan-March 22
  - → Safe Coulex of ^{48,49,50}Ti (ORNL)
  - → ^{16}O+^{18}O, ^{7}Li + ^{64}Ni (FSU)

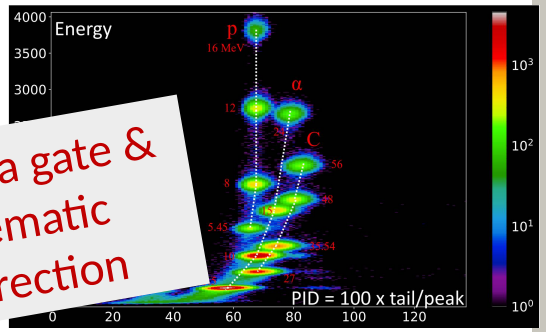


+ TRINITY GAGG det.



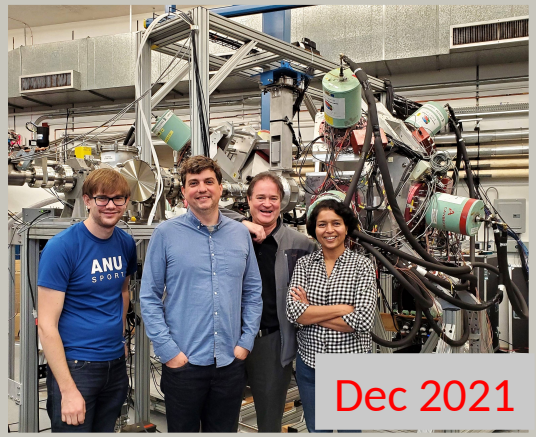
Sept 2021





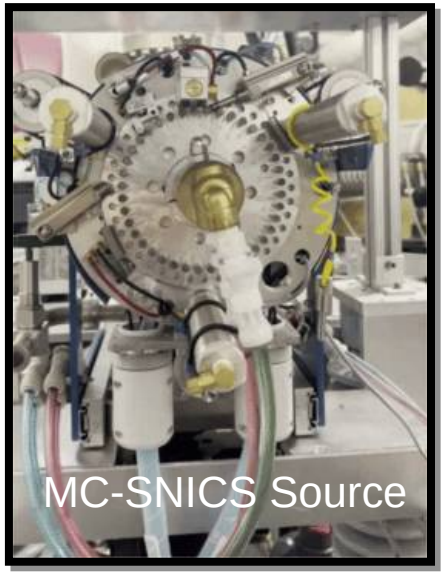
alpha gate & kinematic correction

PID capability of TRINITY



Dec 2021

The Triton-Beam Project at FSU



Centaur-project, collaboration b.w. FSU, UTK, ORNL
Built dedicated negative-ion injector for Tandem
Planned:Tritium inventory in solid state Titanium
Design-Goal: 5000 hours of 20 nA triton-beam
Energy range: 4 -17 MeV, up to 24 MeV with Linac

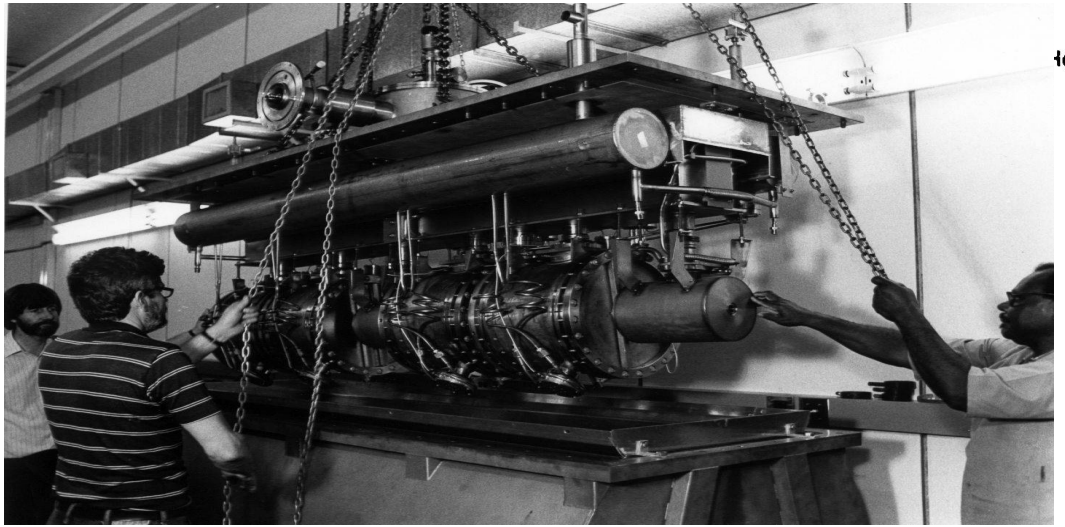
New, dedicated negative-ion injector at FSU Tandem-Linac

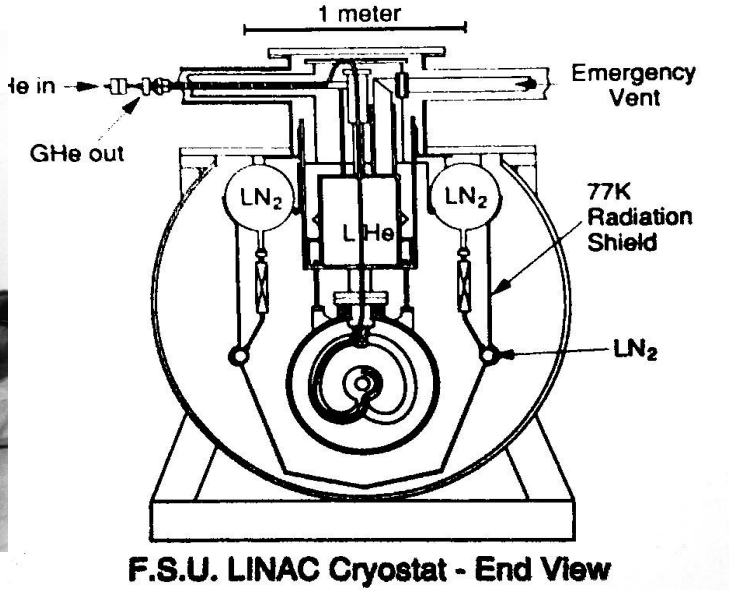
History: ~1983-1986 FSU Linac Development

1985-1989, in close collaboration with ANL / ATLAS.

Purchase ATLAS-style resonators / copy control electronics

FSU: Design and build own cryostats





F.S.U. LINAC Cryostat - End View

FSU Linac upgrade project

The current FSU linac has 12 accelerating resonators with β=0.1 natural vel.

The original design already anticipated an upgrade to 20 resonators, including 4 with β=0.07 and 16 with β=0.1

Plan A: We already acquired the missing resonators and electronics from Kansas State and Resonators from ANL => Need to build cryostats

The upgraded linac will easily support RESOLUT operations up to mass 40

MeV/u	Energy Tandem	Current Linac	Complete Upgrade
^{16}O	3.9	8.0	9.9
^{24}Mg after prod. target	2.9	6.6 5.7	8.6 7.8
^{32}S after prod. target	2.5	5.8 4.6	7.9 6.9
^{40}Ca after prod. target	2.2	4.7	6.8 5.6

What is needed ?

- Purchase Linde 400 W Helium refrigerator (ask FSU $)
- Plan A: Construction of two Cryostats
  for existing ATLAS-style split-ring resonators
  2.5 MV/m (ask NSF-MRI)

OR:

- Plan B: Would rather construct cryostat with modern, quarter-wave cavities, which reach ~7.5 MV/m acceleration for a much more compact LINAC.
  Is it possible ? Only in collaboration with a National Lab

Summary:

The FSU lab is an active, “fun” science place, with a great set of instruments and great groups & collaborators

The Tandem-Linac is doing well, but stretched to its limits by the science program, especially for RIB.

The Linac would be relatively easy to upgrade with existing (old) technlogy

It would be much more foreward-thinking to perform an upgrade with up-to-date Linac technology.

Is a collaboration on this project with National Labs possible today, like it was in 1986 ?