The Installation of the Super-Enge Split-Pole Spectrograph at FSU

- Welcome
- The J.D. Fox laboratory
- A few pictures and stories from the installation
- What is “Super” about the “Super-Enge”
- What are we going to do with it;
- That’s where you come in, too...
FSU Timeline: The early years

- 1959 6MV EN tandem accelerator
- 1964 ... Precision is king: Investigation of isobaric analog states
- 1970 9MV FN tandem accelerator
FSU: to TAN or to LIN?

- Upgrade plan 1966 ("TU" tandem)

- Upgrade plan ~1980 (upright 15 UD Pelletron tower?)
John D. Fox (1929-2007)

- Lab director and driving force at FSU nuclear physics
- Ground-breaking work on isobaric analog resonances
- Decision to go with LINAC rather than larger Tandem
- Go with ANL technology because of long-standing scientific collaboration
Use ANL resonators and electronics,
design own cryostats
built in-house on a shoe-string
- 9 MV Tandem + 8 MV Linac
- Beam Energy profile
- In-flight Radioactive beams with Resolut
- Clover HPGe $\gamma$-array (TR1 → TR2)
- New: Super-Enge Split-Pole Spectrograph

Tandem: Pelletron-charged 9 MV FN-tandem
Linac: 14 Superconducting cavities
Niobium on Cu, Split-Ring (Atlas-design)
- 9 MV Tandem
  - $p$ 18 MeV/u
  - $d$ 9 MeV/u
  - $^3$He 9 MeV/u
  - $^3$H 6 MeV/u
  - $^4$He 6.75 MeV/u

- With Linac booster
  - $^3$H 9 MeV/u
  - $^4$He 9 MeV/u
  - $^6$Li 9 MeV/u
  - $^7$Li 9 MeV/u
  - $^{12}$C 9 MeV/u

...
The previous configuration of Target Room 2 contained three commonly used experiments; Gamma-cave, Resolut in-flight RIB facility, zero-degree chamber. Also: a clean room for Linac maintenance. The gamma-cave had to be removed and the gamma-setup temporarily relocated to Target Room 1. Later this year, we will re-install the Gamma-setup in TR2, on a new beam line.
2013: Enge-SPS disassembled at WNSL Yale
Disassembly of the “Gamma-cave”
Making old plans new...
Finding Money... (NSF MRI + FSU)
June 2016: Enge is in the Building...
$\text{Fe}_2\text{O}_3$ : not your friend...

Re-condition the surfaces
It takes a village...
In-between the Concrete Cables
1/2017: Assembly and Alignment
- Study $^{50}\text{Ti}(d,p)$ to establish orbital energies for RPA-calculations
- Impact on octupole excitations in neutron-rich Ti-nuclei
Spectrograph specs

<table>
<thead>
<tr>
<th>Type</th>
<th>Location</th>
<th>Reference</th>
<th>Max. Bp [Tm]</th>
<th>Range $p_{\text{max}} / p_{\text{min}}$</th>
<th>Resolution (first order)</th>
<th>Acceptance [msr]</th>
</tr>
</thead>
<tbody>
<tr>
<td>SE-SPS</td>
<td>FSU (Yale)</td>
<td>[2]</td>
<td>1.5</td>
<td>1.8</td>
<td>4290</td>
<td>12.8</td>
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<tr>
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<td>Q3D</td>
<td>MLL Munich</td>
<td>[3]</td>
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<td>14.7</td>
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<td>Grand Raiden</td>
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<td>[?]</td>
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<td>1.05</td>
<td>37000</td>
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<tr>
<td>RITU</td>
<td>Jyväskylä</td>
<td>[7]</td>
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<td>N/A</td>
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<tr>
<td>AGFA</td>
<td>ANL (proposed)</td>
<td>[?]</td>
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</tbody>
</table>

Table 3: Performance characteristics of various spectrographs.

- SE-SPS has larger solid angle, aberrations corrected to $\sim 1/2000$ @ 12.8 msr
Superradiance – Open systems

- Unbound states mix through decay channel
- Decay-width concentrates in few states
- General property in the quantum mechanics of open systems;
- Q: What happens to wave-function of bound states?
- Central ingredient in structure and stability of exotic nuclei !?
- Natural ingredient of continuum shell model
- Develop experimental program to study

Volya and Zelevinsky: Continuum Shell Model PRC 74,064314 (2006)
Resonance Spectroscopy: Investigation of Super-radiance

Left: $^{12}\text{C}(d,p)^{13}\text{C}$ measure n-strength $3/2^+_1$ vs $3/2^+_2$
Right: $^{9}\text{Be}({^7}\text{Li},t)^{13}\text{C}$ measure $\alpha$-strength
Repeat experiment with decay-channel coincidence (DAFNE)

Competition between both open channels ($E_x > 10.7$ MeV)
Study influence of multiple open channels on bound-state wavefunctions
Experiments: see above, also $^{12}\text{C}({^3}\text{He},d)^{13}\text{N}(p)$ as mirror $^{12}\text{C}(p,d)^{11}\text{C}$, $^{10}\text{B}({^3}\text{He},d)^{11}\text{C}$, $^{10}\text{B}(d,p)^{11}\text{B}$ as mirror

Ohnuma et al. (1986)
Snyder, Waggoner (1969)
The SE-SPS is optimal for coincident high-resolution $\gamma$-spectroscopy with FSU Clover-array (V. Tripathi, S.L. Tabor)

Also: Develop as gas-filled recoil-separator for reaction-channel separation

(Simulations using Raytrace-GF)
Summary

- The Super-Enge SPS is back at FSU.
- Currently working on:
  - FP detector electronics
  - Beam line with 2 Q-triplets: better beam spot
  - Tandem beam stabilization-tests
  - Linac-beam tests
  - Heavy-Ion Focal plane detector development
  - High-rate Focal plane detector
- .... Your Ideas!
Special Thanks to Powell Barber
"Augen zu und durch!"