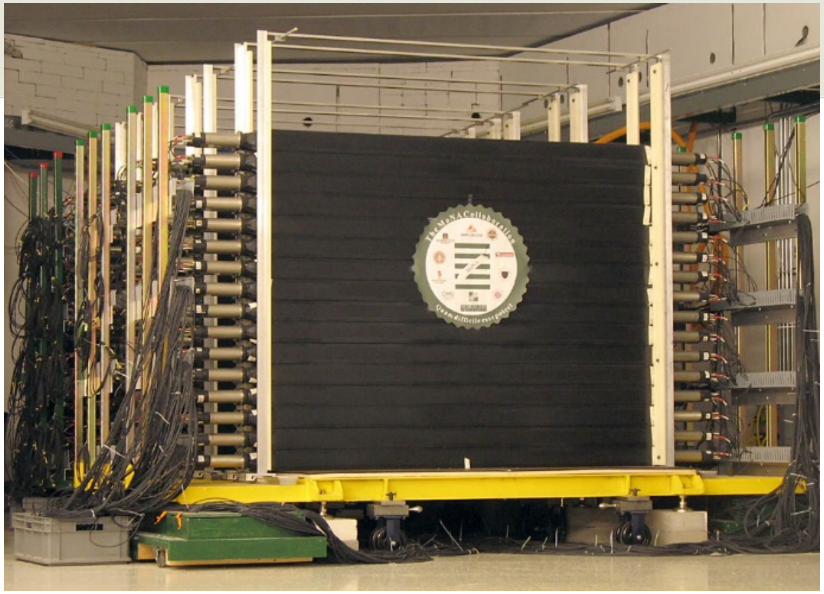
The MoNA-LISA Detector Array

Outline:

- The MoNA Collaboration
- MoNA Physics Highlights
- The Detector
- Better Neutron Simulations
- Future Plans

The MoNA Collaboration



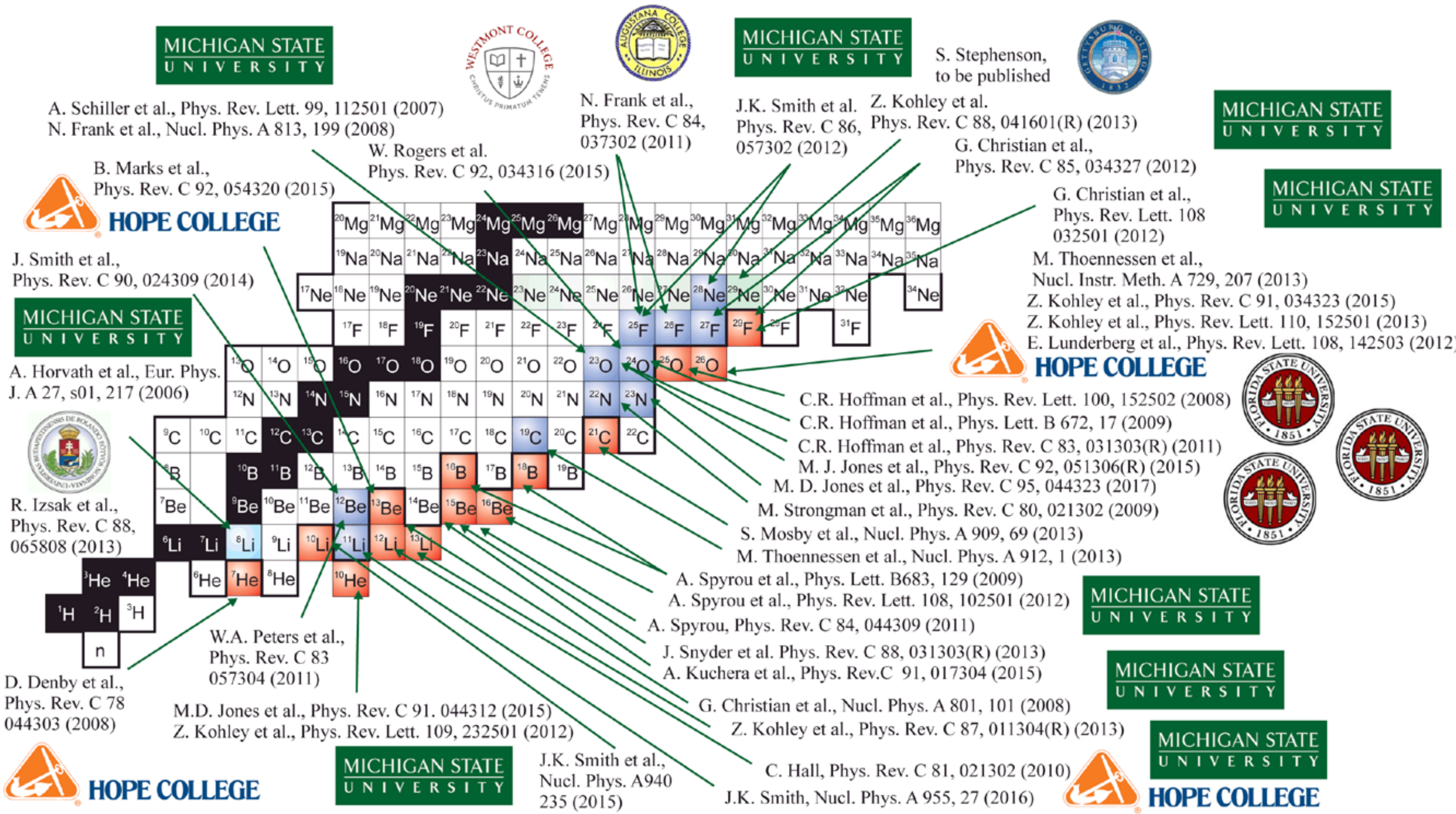
The detector:

- MoNA-LISA is a large, highly efficient neutron time-of-flight detector array.
- It consists of 288 plastic scintillator detector modules.
- It is used to detect fast neutrons stemming from breakup reactions of neutron-unbound states.
- It measures flight time and position.

The collaboration:

- The MoNA collaboration was formed in 2001 when a joint MRI proposal was submitted to fund the Modular Neutron Array.
- The collaboration assembled and tested the detector modules, and continues to this day with a cutting-edge research program.

MoNA Collaboration Physics Highlights

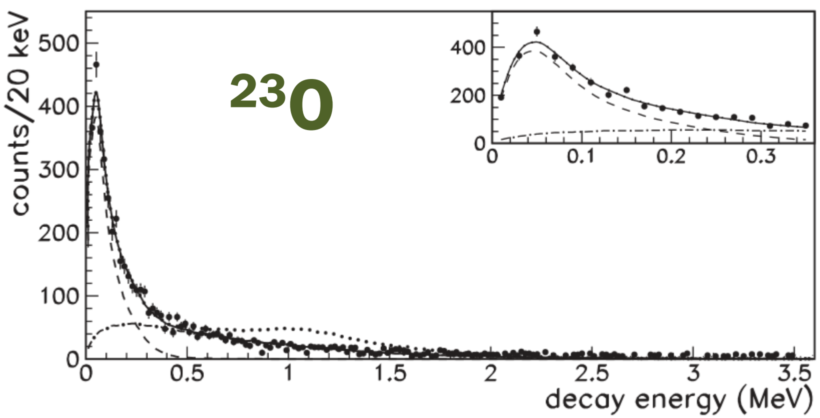


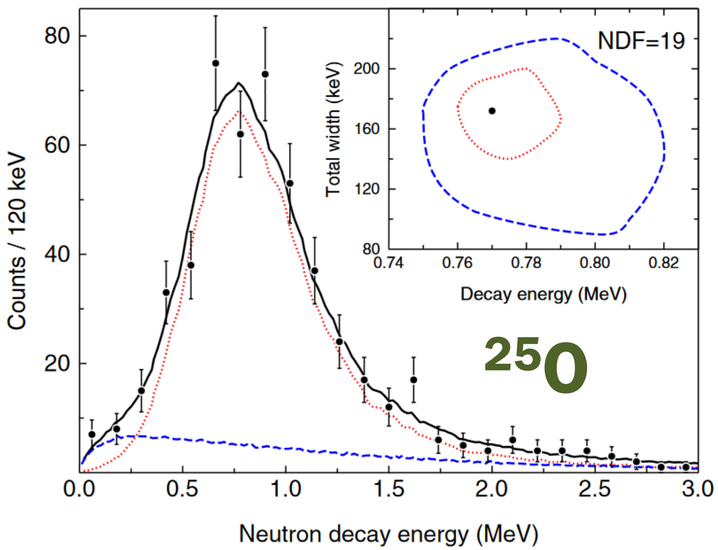
MoNA Collaboration Physics Highlights

The MoNA physics program focuses on the reconstruction of neutron unbound states using invariant mass analysis. This offers insights into the nuclear structure of isotopes that are inaccessible by any other means.

Highlights:

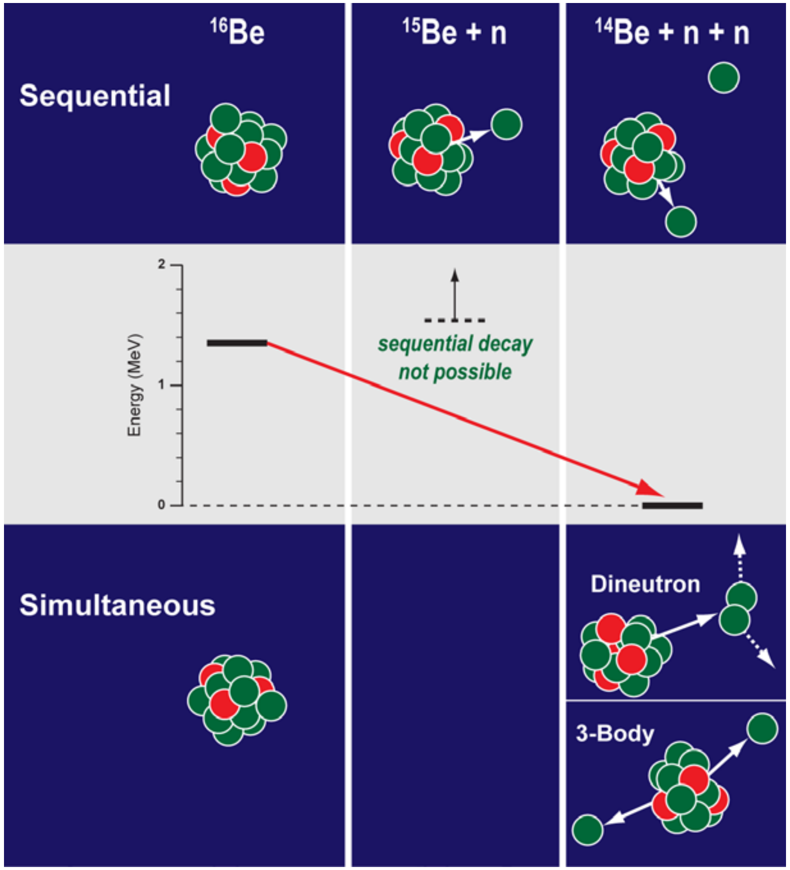
- **$^{23,\,25}O$ n-unbound states:** Schiller *et al.* Phys. Rev. Lett. 99 112501 (2007) and Hoffman *et al.* Phys. Rev. Lett. 100, 152502 (2008)

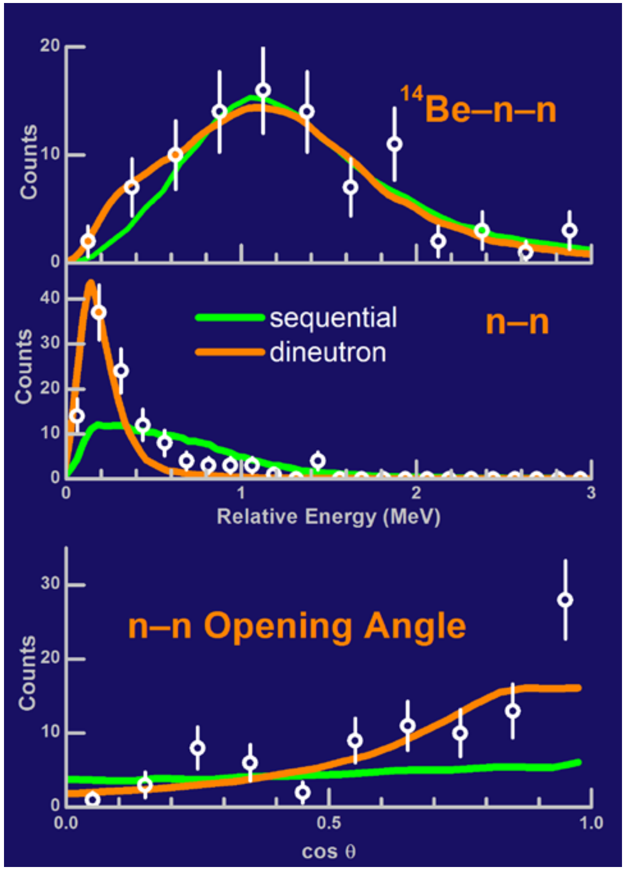




MoNA Collaboration Physics Highlights

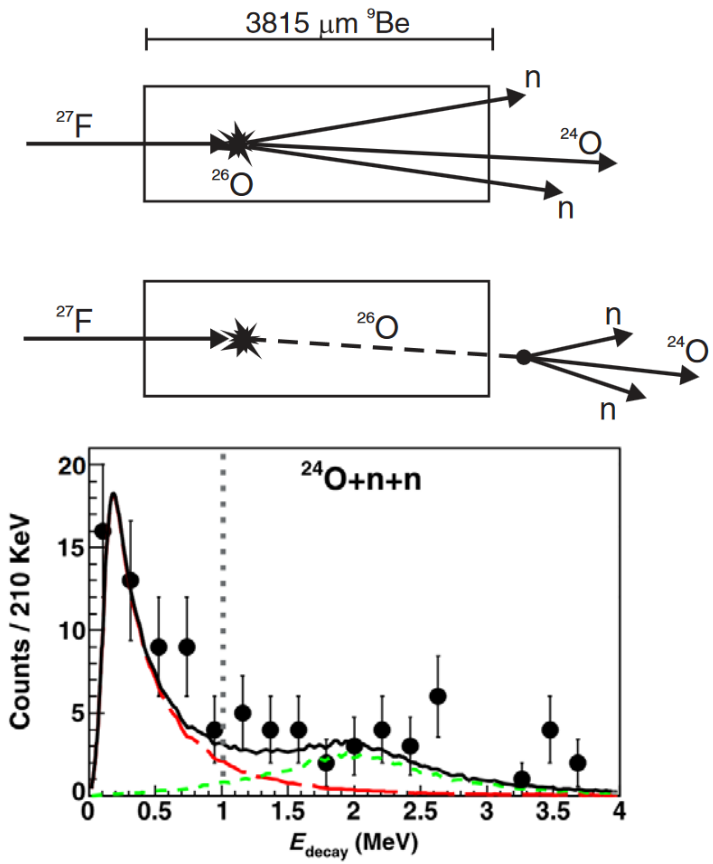
- **Dineutron decay of ^{16}Be:**
  Spyrou *et al.* Phys. Rev. Lett. 108, 102501 (2012)

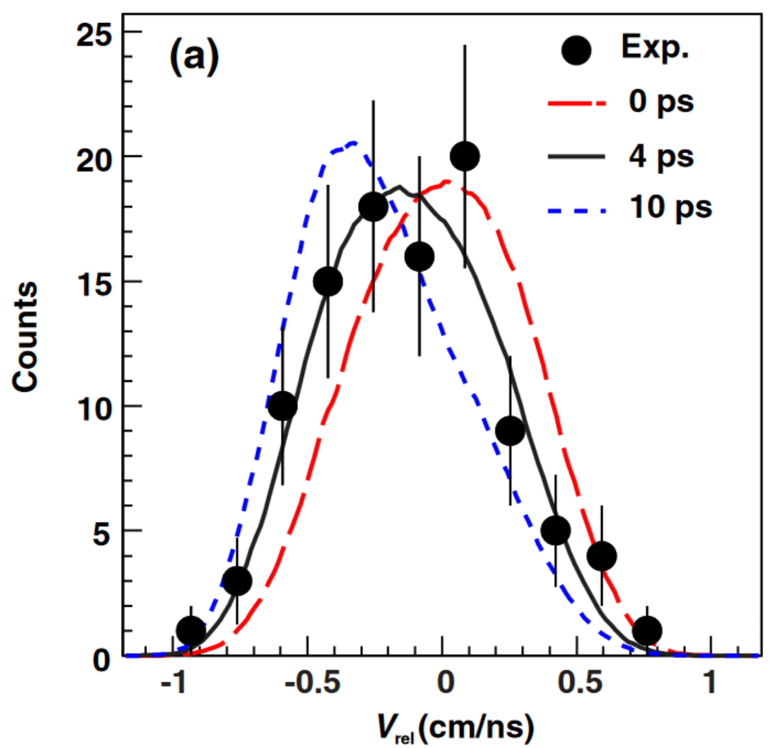




MoNA Collaboration Physics Highlights

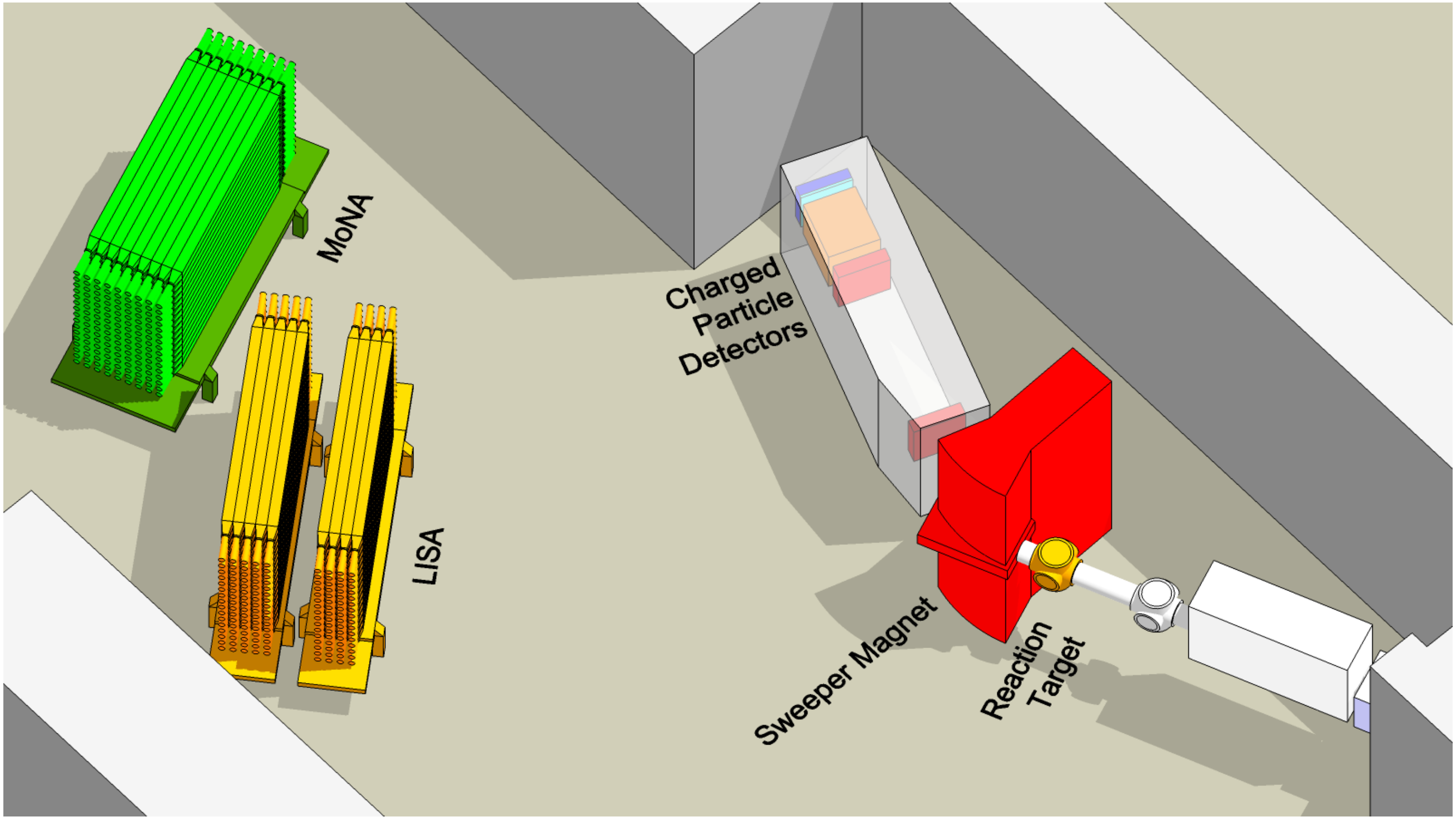
- **Two-neutron radioactivity in the decay of ^{26}O:**
  Kohley *et al.* Phys. Rev. Lett. 110, 152501 (2013)





The MoNA-LISA Detector

Former MoNA-LISA-Sweeper setup in N2:



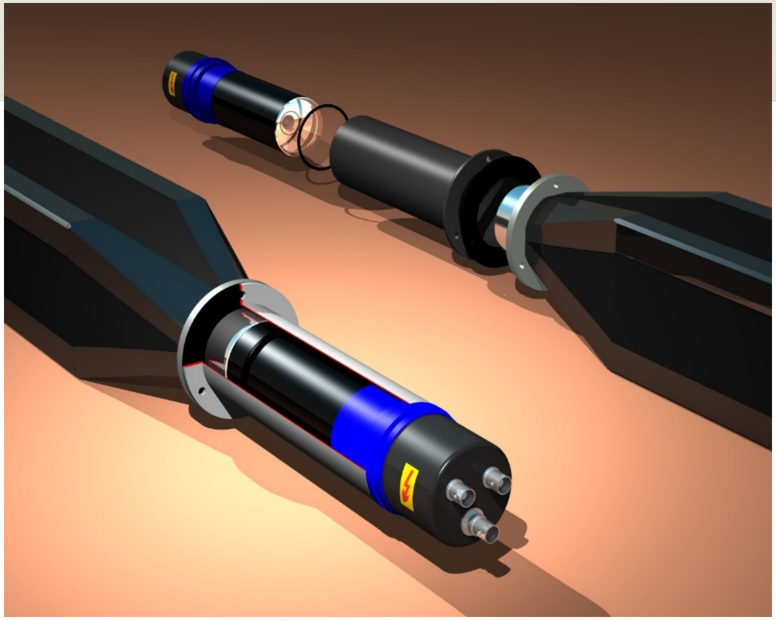
The MoNA-LISA Detector

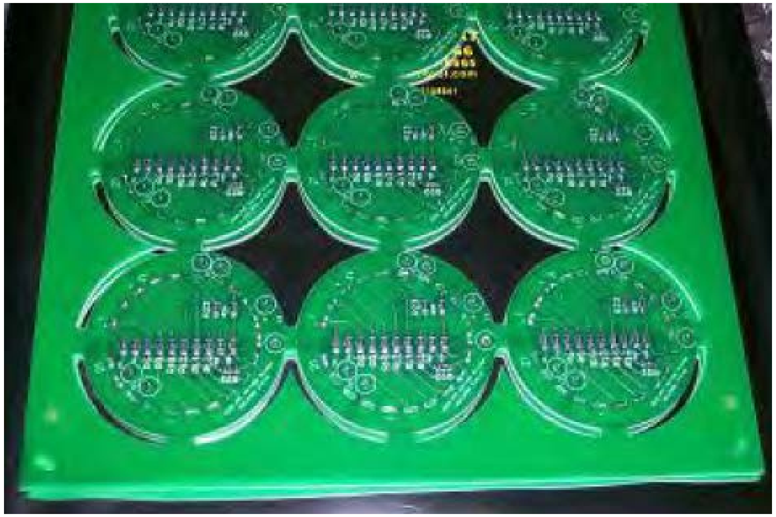
MoNA:
Modular **N**eutron **A**rray

- 144 modules,
  200 cm ×10 cm × 10 cm each, BC-408
- Photonis XP 2262/B, 2" 12-stage PMTs
- VD122K/B voltage dividers

LISA:
Large Multi-**I**nstitutional **S**cintillator **A**rray

- 144 modules,
  200 cm ×10 cm × 10 cm each, EJ-200
- Hamamatsu R329-02, 2" 12-stage PMTs
- "home-built" voltage dividers





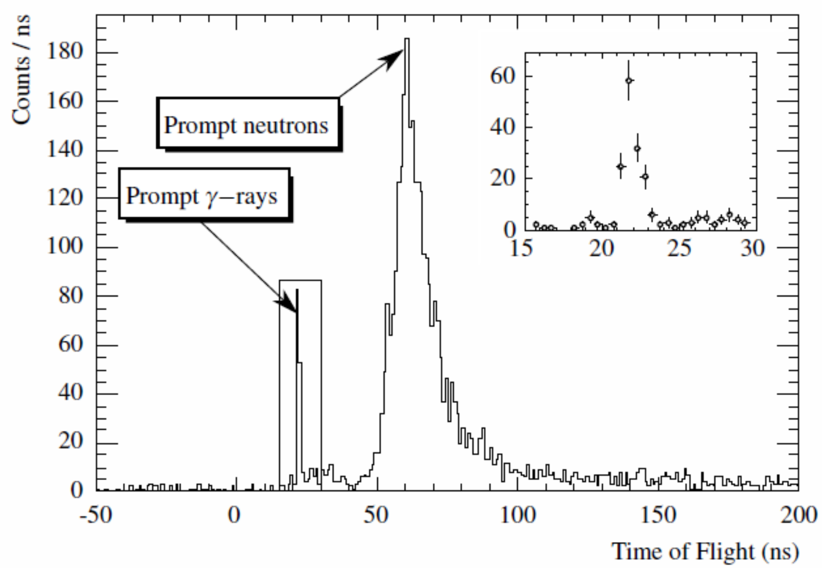
The MoNA-LISA Detector

Use cosmic-ray muons to calibrate:

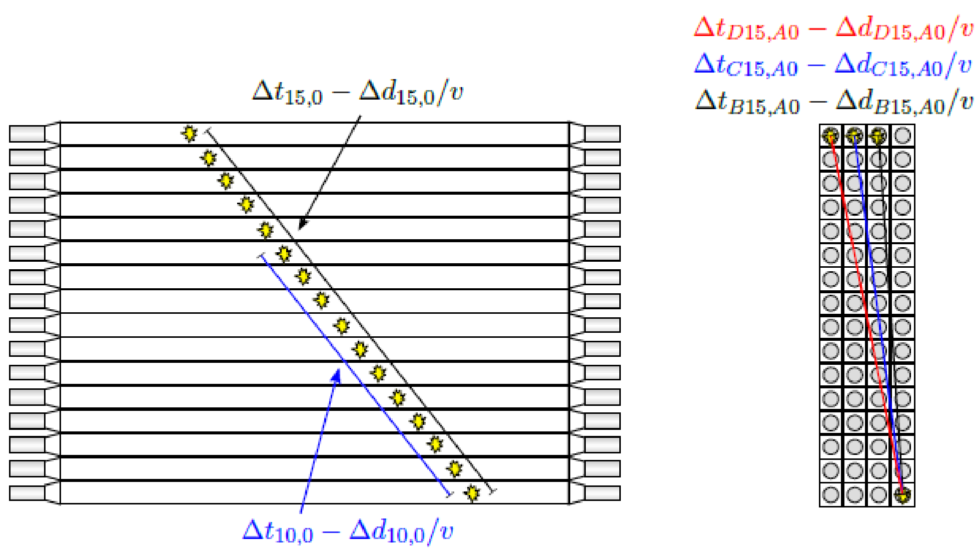
- PMT gain matching
- relative timing

Use γ-flash from beam to determine:

- absolute timing



G. A. Christian, PhD thesis 2011

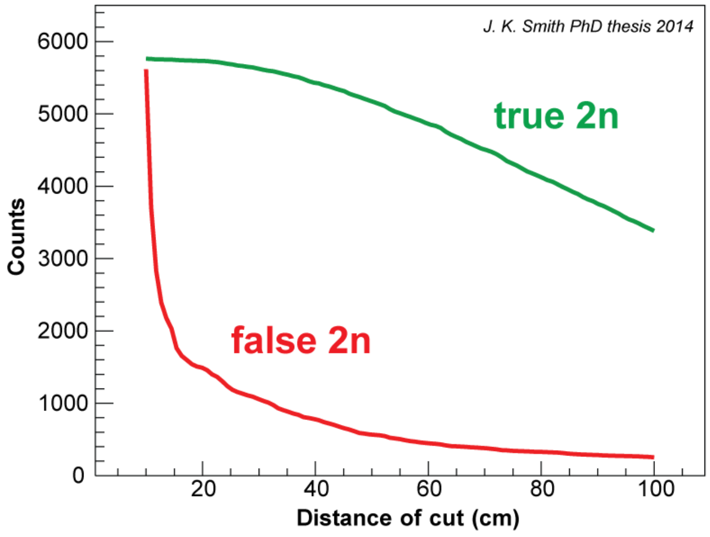


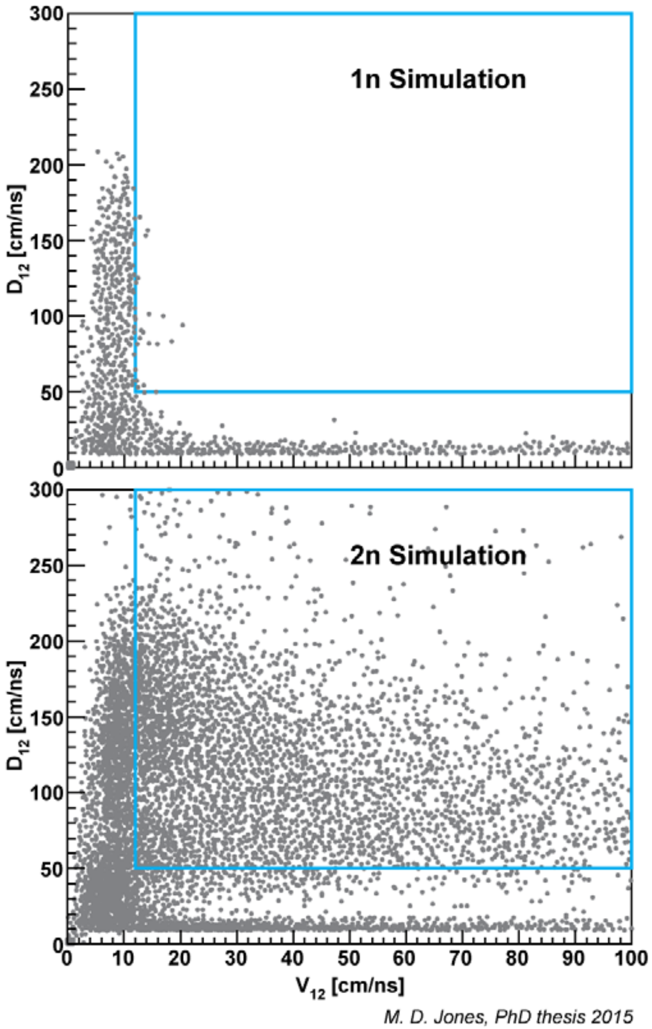
J. K. Smith, PhD thesis 2014

The MoNA-LISA Detector

How to discriminate false 2n events:

- 2 locations and 2 times define distances and velocities.
- Scattered neutron velocity has to be less than incoming neutron velocity.
- Larger distance between events results in better accuracy.

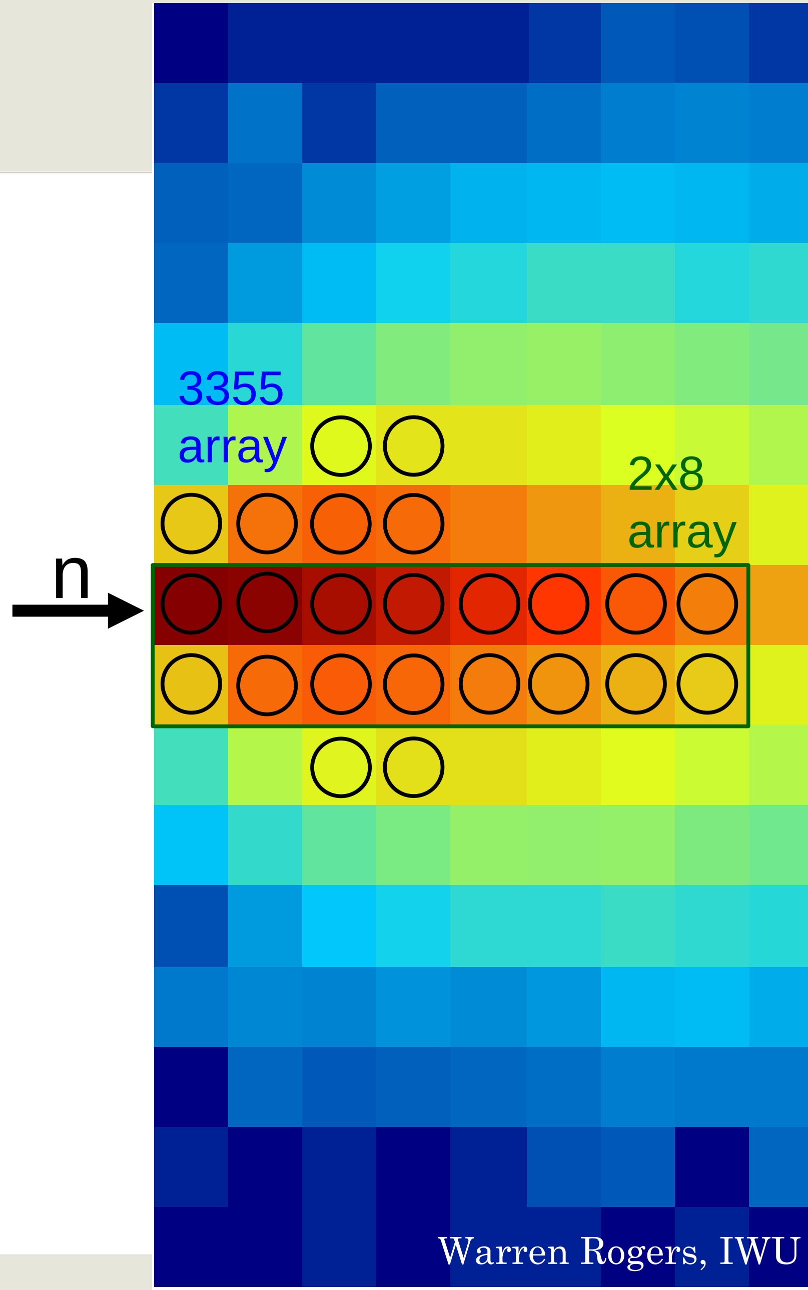




Better Neutron Simulations

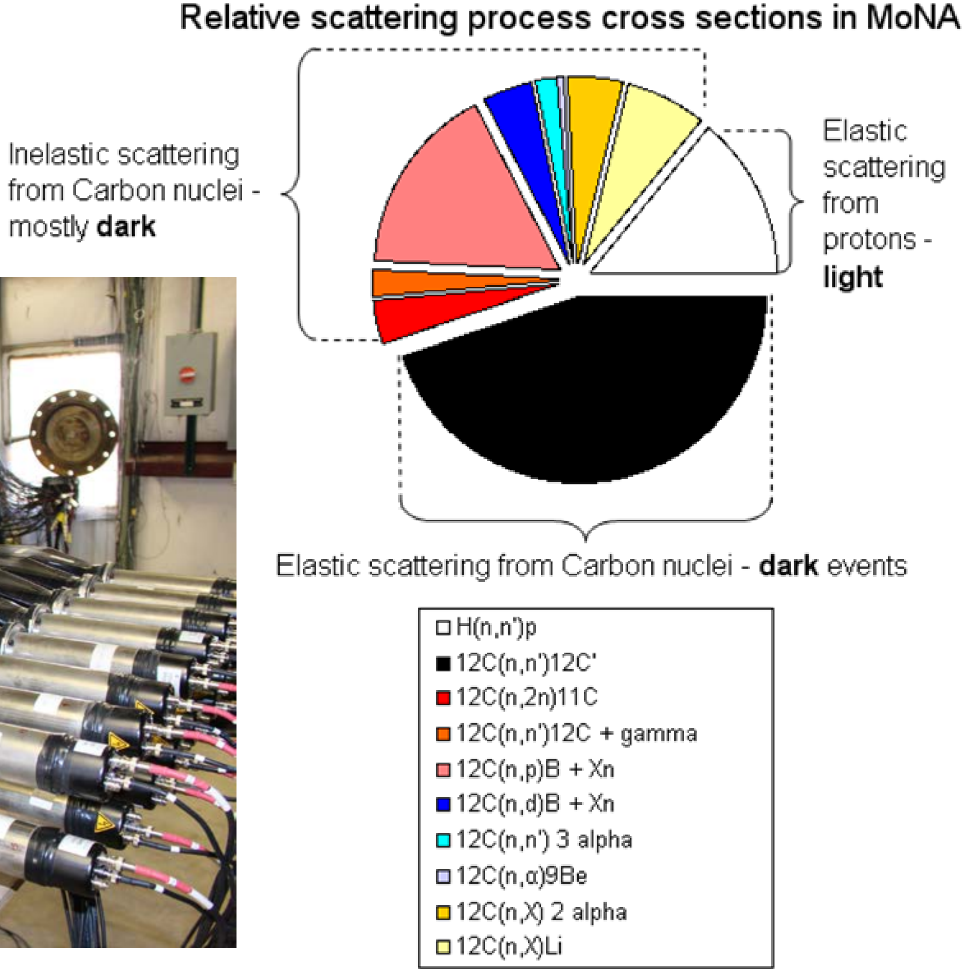
Collect data to refine simulation

- Using GEANT4 - MENATE_R
- Using LANSCE neutron beams



Better Neutron Simulations

90 m from spallation target,
3 mm collimator!

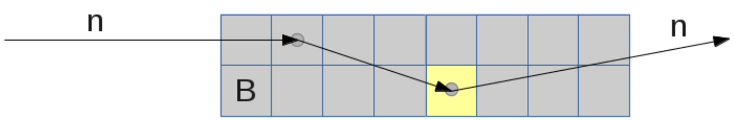


Warren Rogers, IWU

Better Neutron Simulations

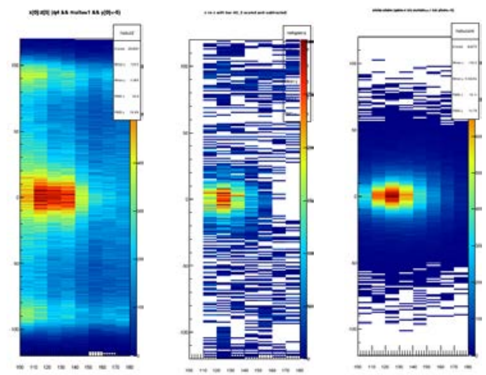
Elastic scattering from C
("dark" scattering)

- Beam enters upper layer, dark scatters, and produces first light in lower layer



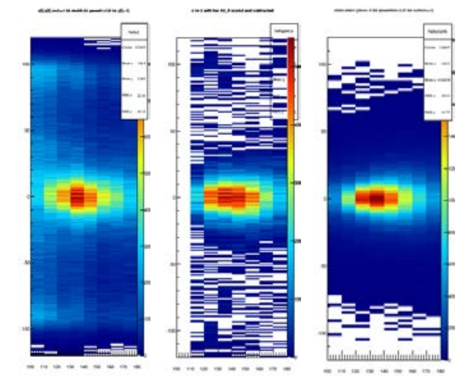
mult==1

20 MeV neutrons



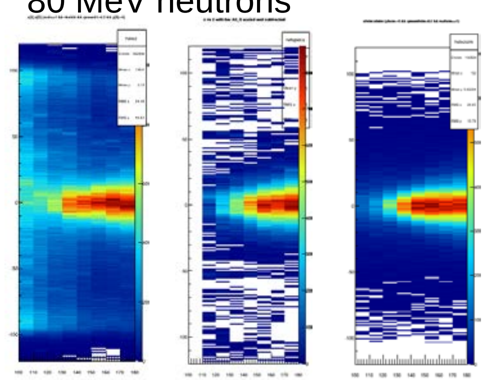
Before Bkg Subtraction | Halo Bkg Subtracted | Simulation

40 MeV neutrons



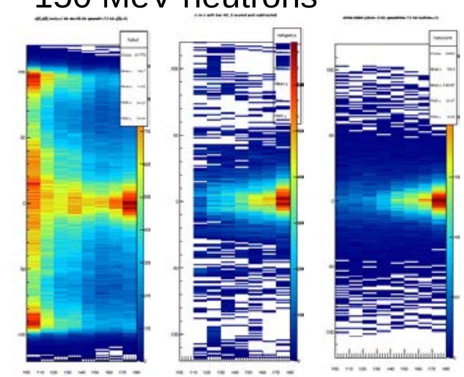
Before Bkg Subtraction | Halo Bkg Subtracted | Simulation

80 MeV neutrons



Before bkg subtraction | Halo bkg subtracted | Simulation

150 MeV neutrons



Before bkg subtraction | Halo bkg subtracte d | Simulation

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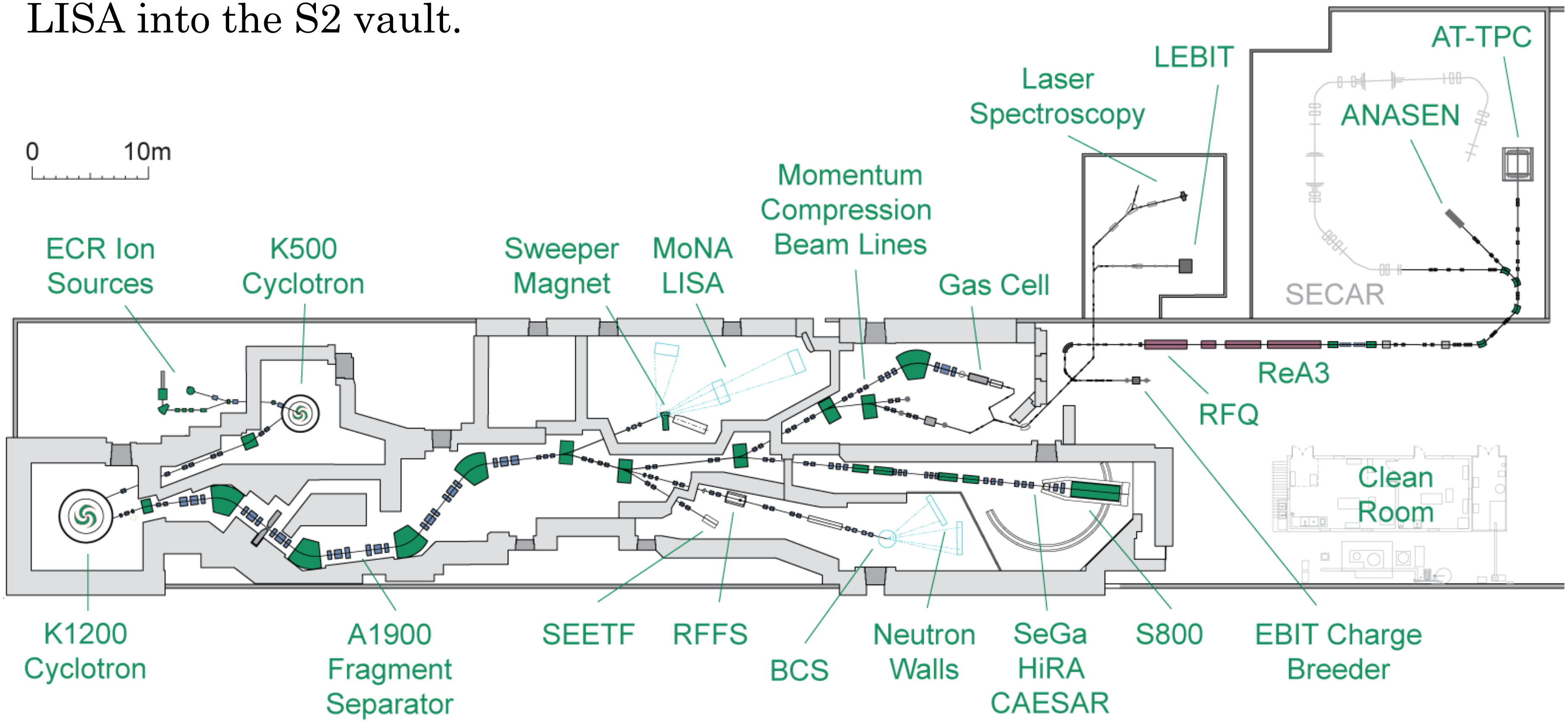
Future Plans: NSCL

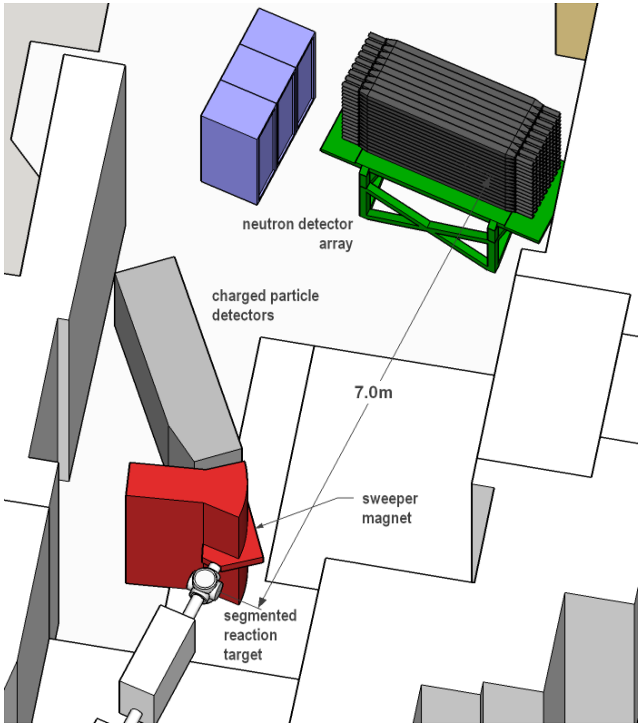
Currently the N2 vault is being reconfigured. The plan is to move the Sweeper and MoNA-LISA into the S2 vault.



Future Plans: NSCL

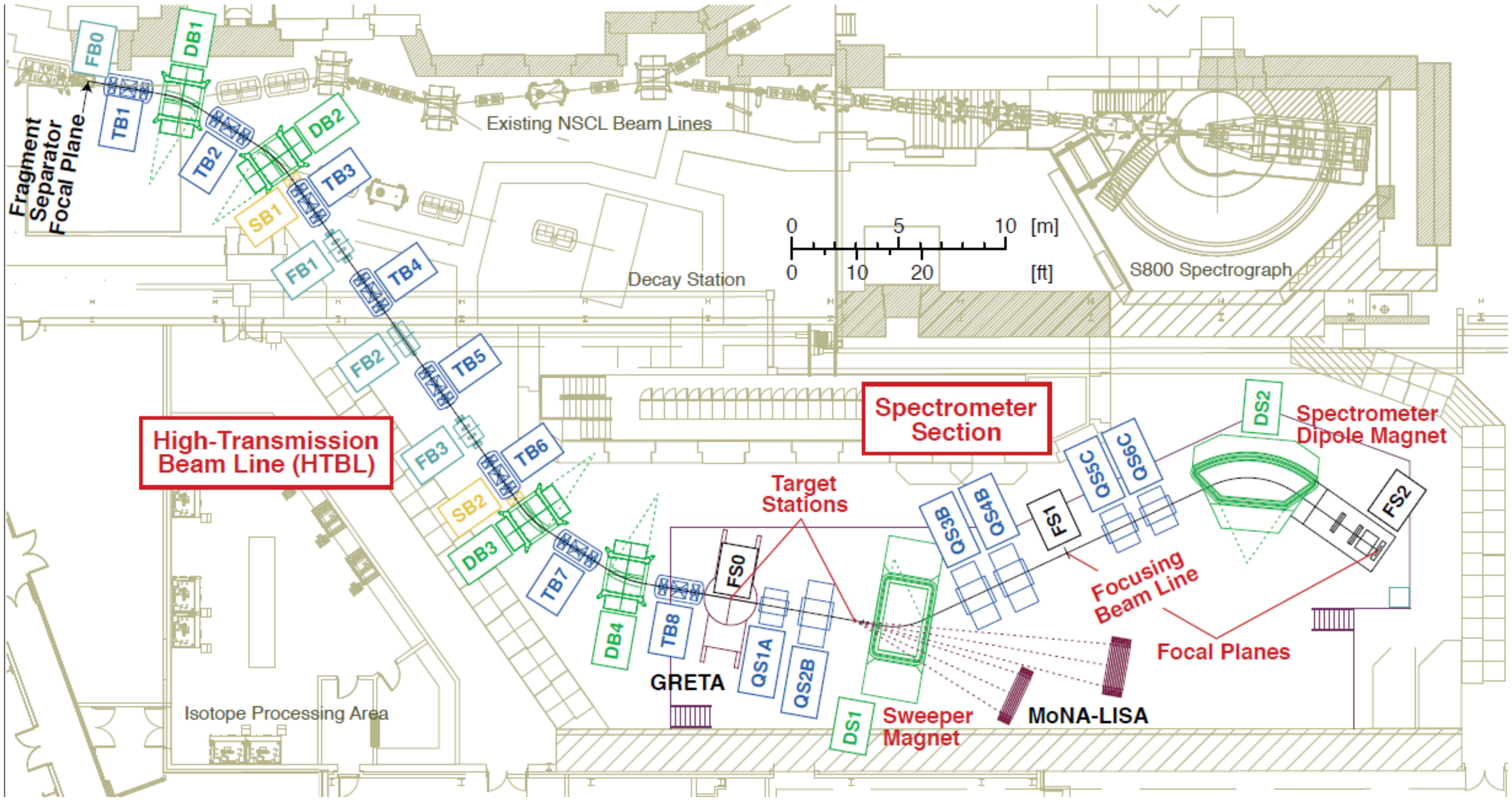
In order to reach higher masses, an improved charged-particle detector setup is needed:

- The MoNA Collaboration is in the process of designing a detector telescope consisting of Si (dE) and CsI (TKE) detectors.



Future Plans: FRIB

The High Rigidity Spectrometer (HRS)



Future Plans: FRIB

The HRS will start a new era of measurements:

- Higher intensities and rigidities will make more neutron-rich isotopes accessible.
- The combination with other powerful detector systems will offer new possibilities.

To make optimum use of these new capabilities, we need to consider improvements of the neutron detector:

- Improved electronics (DDAS)
- Investigate advanced materials (for a next-generation array)

Acknowledgement

The MoNA project thrives because of the dedication and support of its collaboration members and outstanding students:

J. Brown, P. A. DeYoung, J. Finck, N. Frank, P. Gueye, J. Hinnefeld, R. A. Kaye, B. A. Luther, W. F. Rogers, A. Spyrou, S. Stephenson, M. Thoennessen