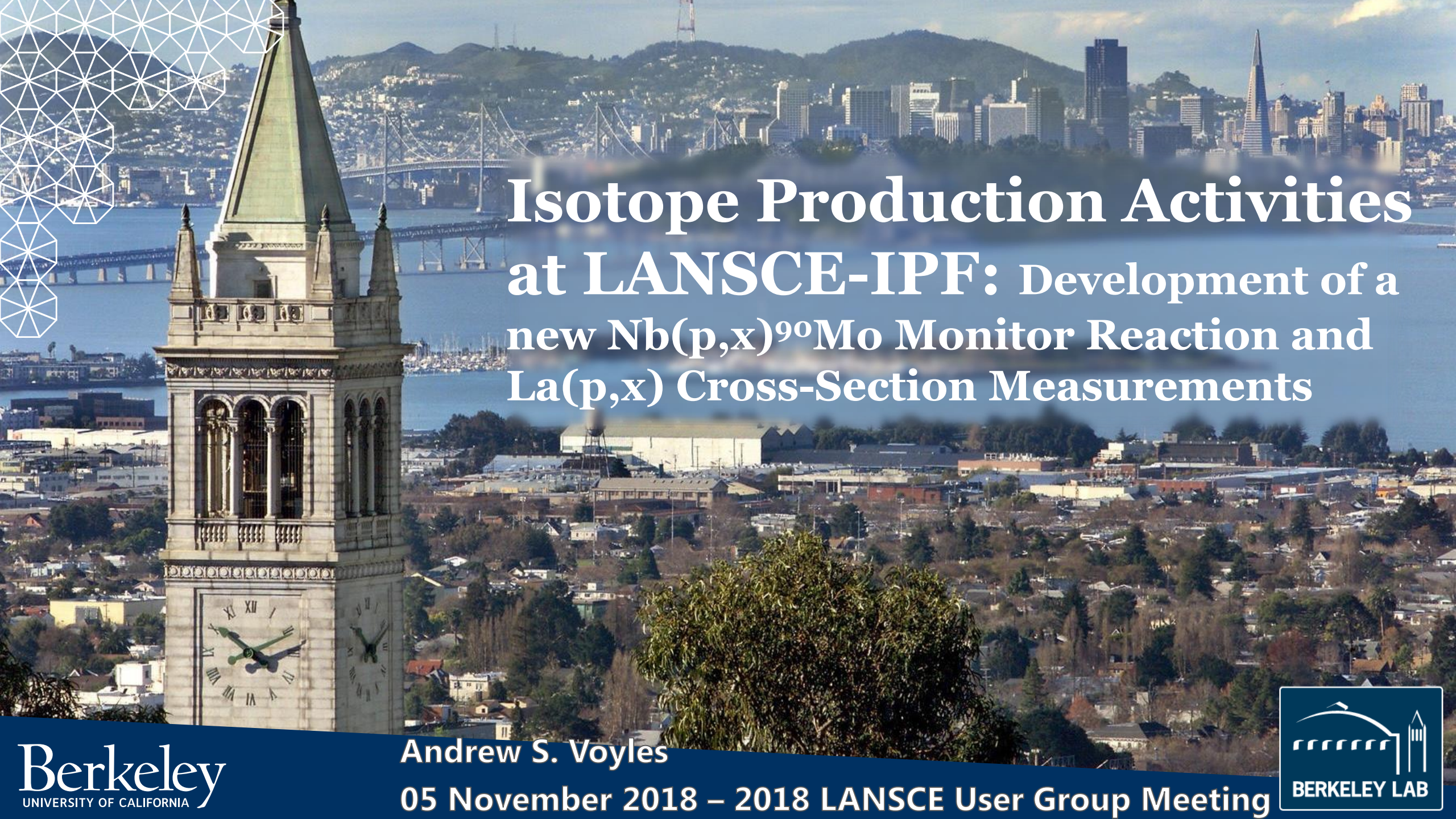


Isotope Production Activities at LANSCE-IPF: Development of a new Nb(p,x)^{90}Mo Monitor Reaction and La(p,x) Cross-Section Measurements

Andrew S. Voyles

05 November 2018 – 2018 LANSCE User Group Meeting

Berkeley UNIVERSITY OF CALIFORNIA

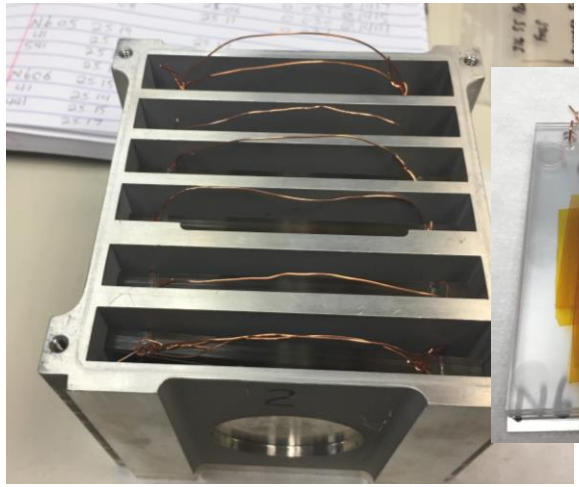
BERKELEY LAB

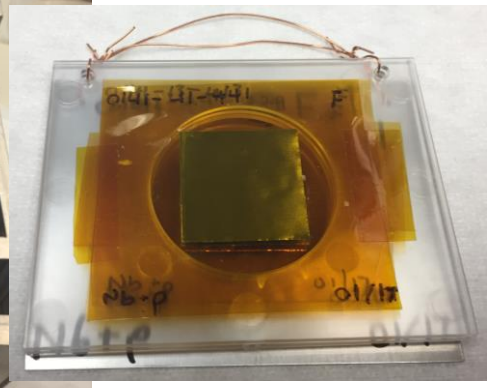
Development of a new Nb(p,x)^{99}Mo Monitor Reaction

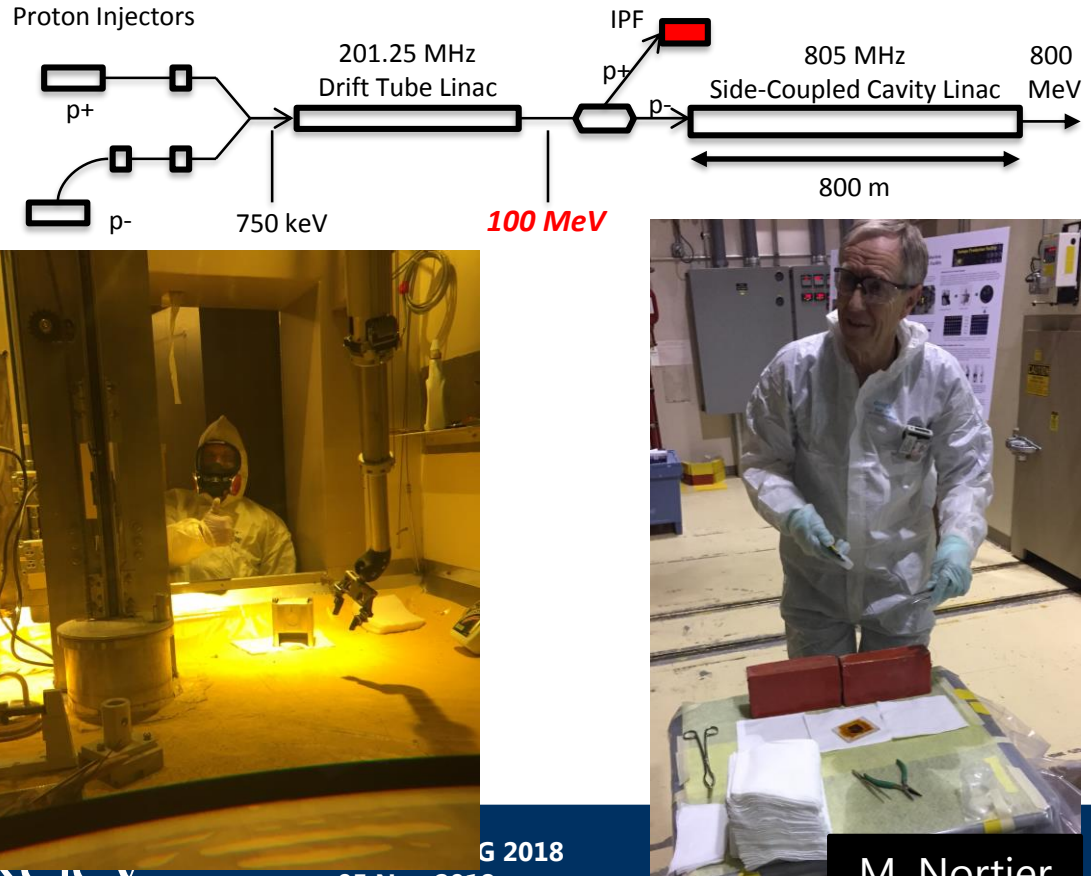
Intermediate Energy – LANL

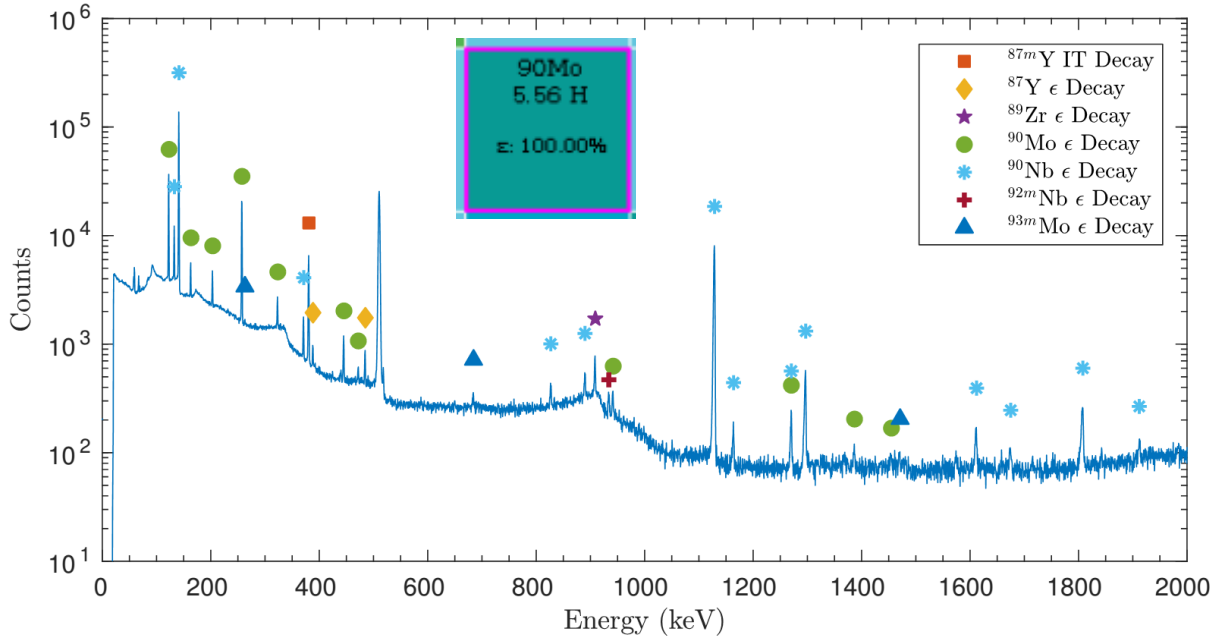
Measurements @ LANL – Nb(p,x)

- Well-characterized monitor reaction data is a top-priority objective
  - Vital for determination of fluence, energy for isotope production
  - Current data are deficient for E_p>30 MeV
- A stacked target measurement was run at LANSCE-IPF to help develop the ^{93}Nb(p,4n)^{90}Mo reaction as a new 30-200 MeV proton standard



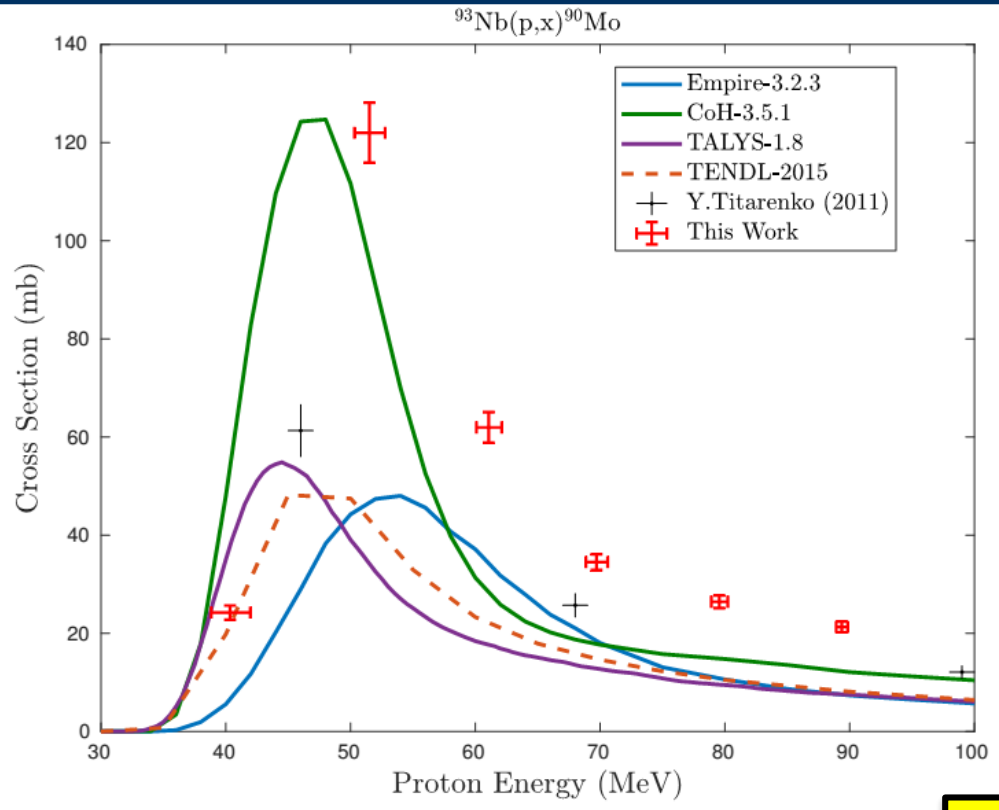




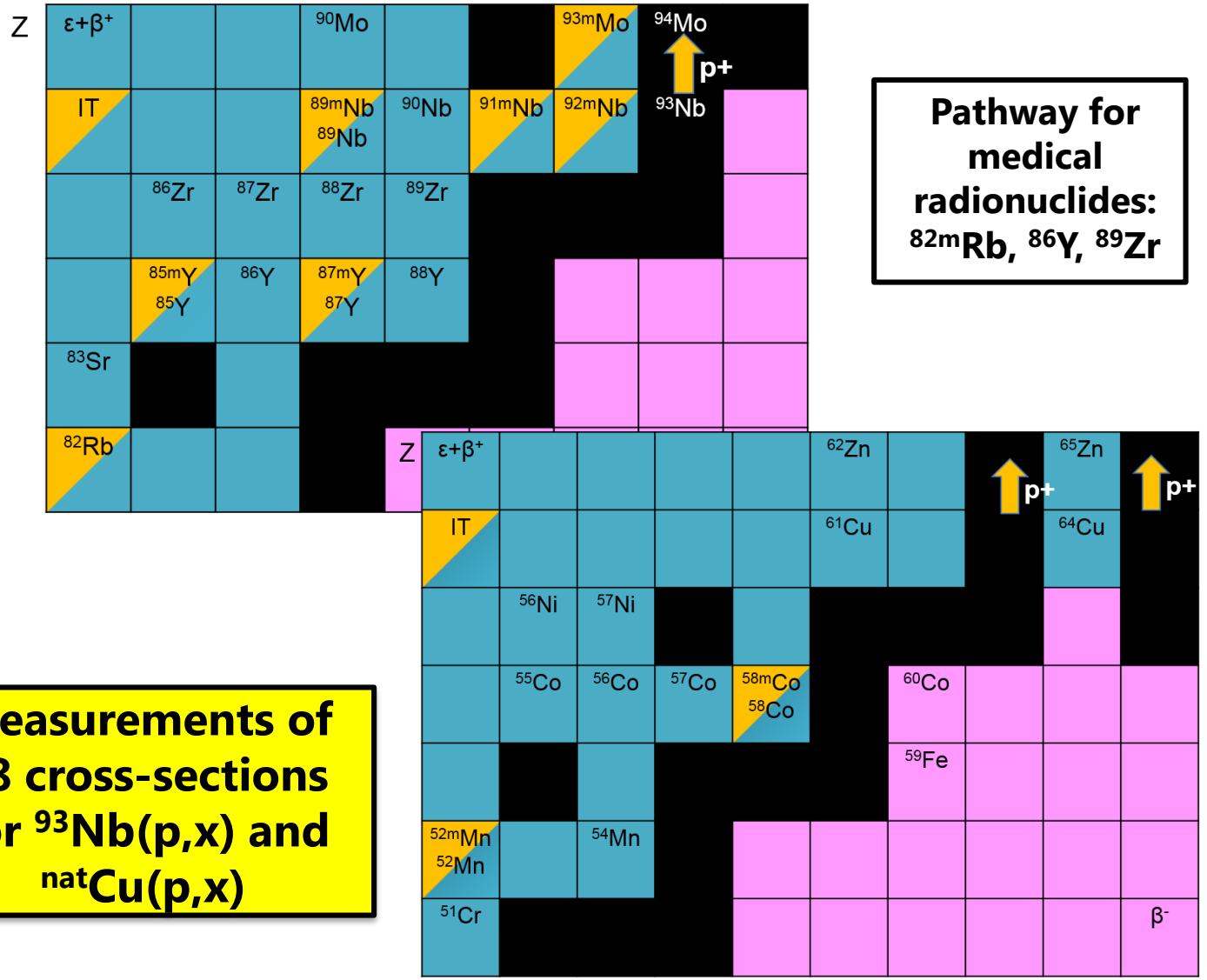


[1] A.S. Voyles, NIM B 429 (2018)

Measurements @ LANL – Nb(p,x)



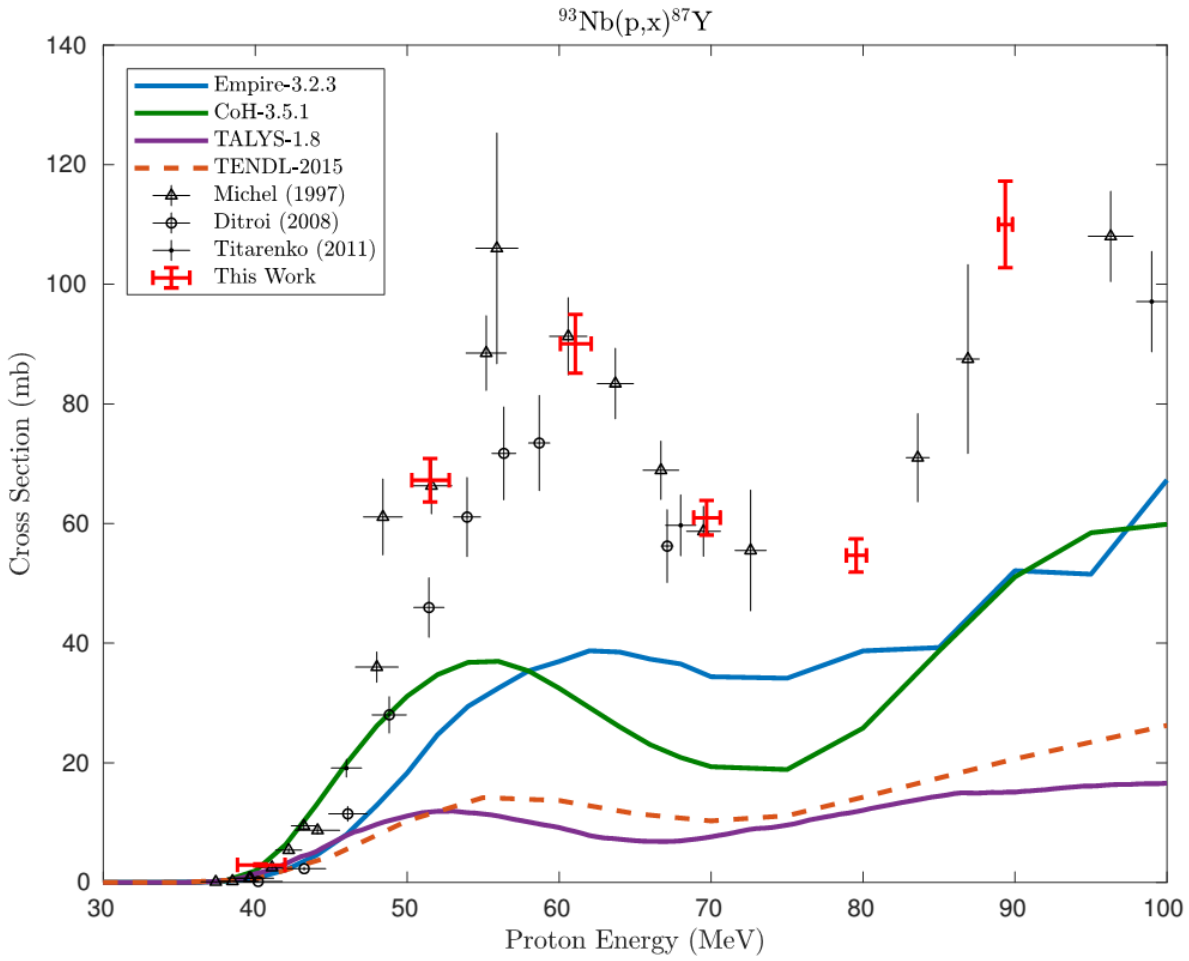
A.S. Voyles et al., "Excitation functions for (p,x) reactions of niobium in the energy range of E_p = 40–90 MeV", NIM B 429 (2018) 53–74. June 2018

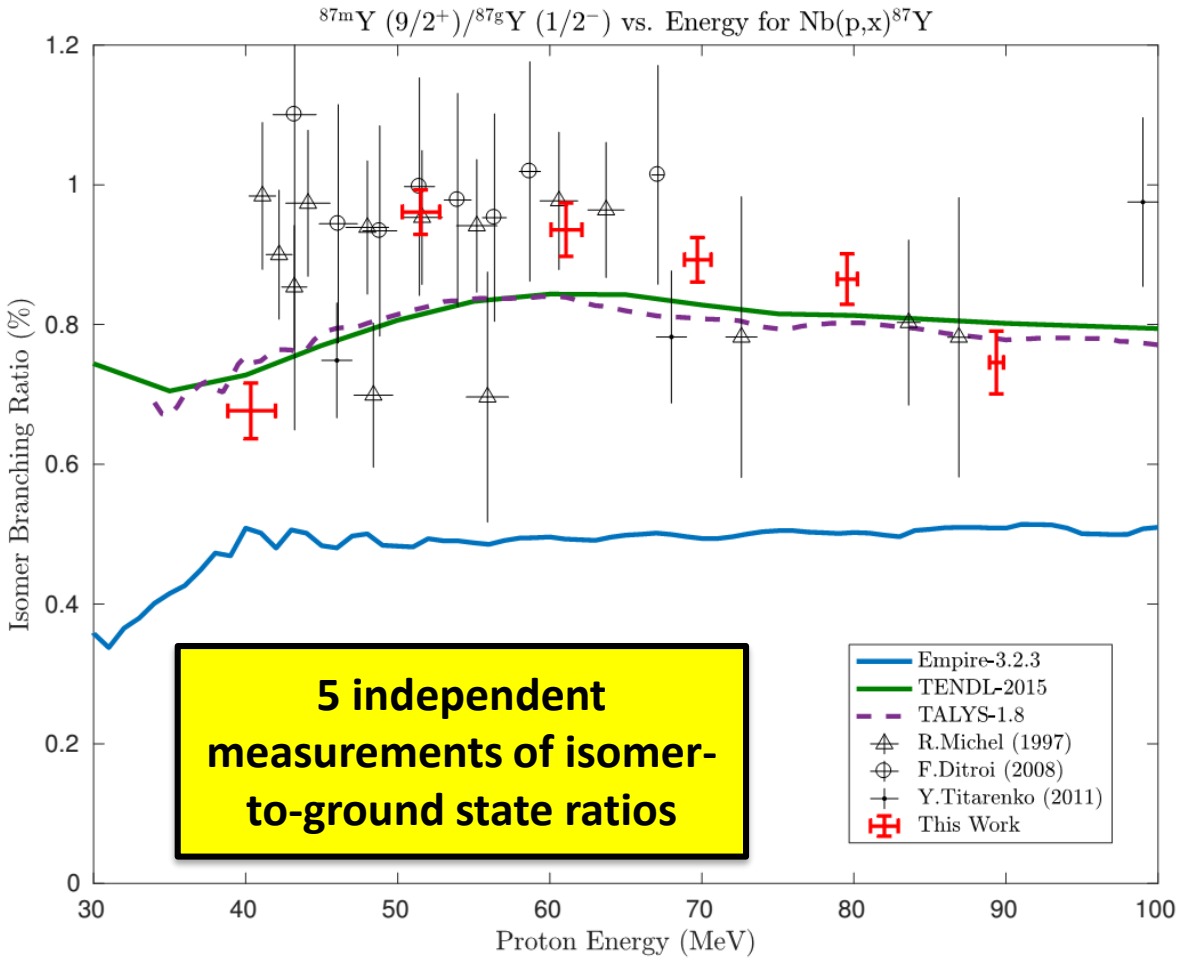


Pathway for medical radionuclides: ^{82m}Rb, ^{86}Y, ^{89}Zr

Measurements of 38 cross-sections for ^{93}Nb(p,x) and ^{nat}Cu(p,x)

Measurements @ LANL – Nb(p,x)

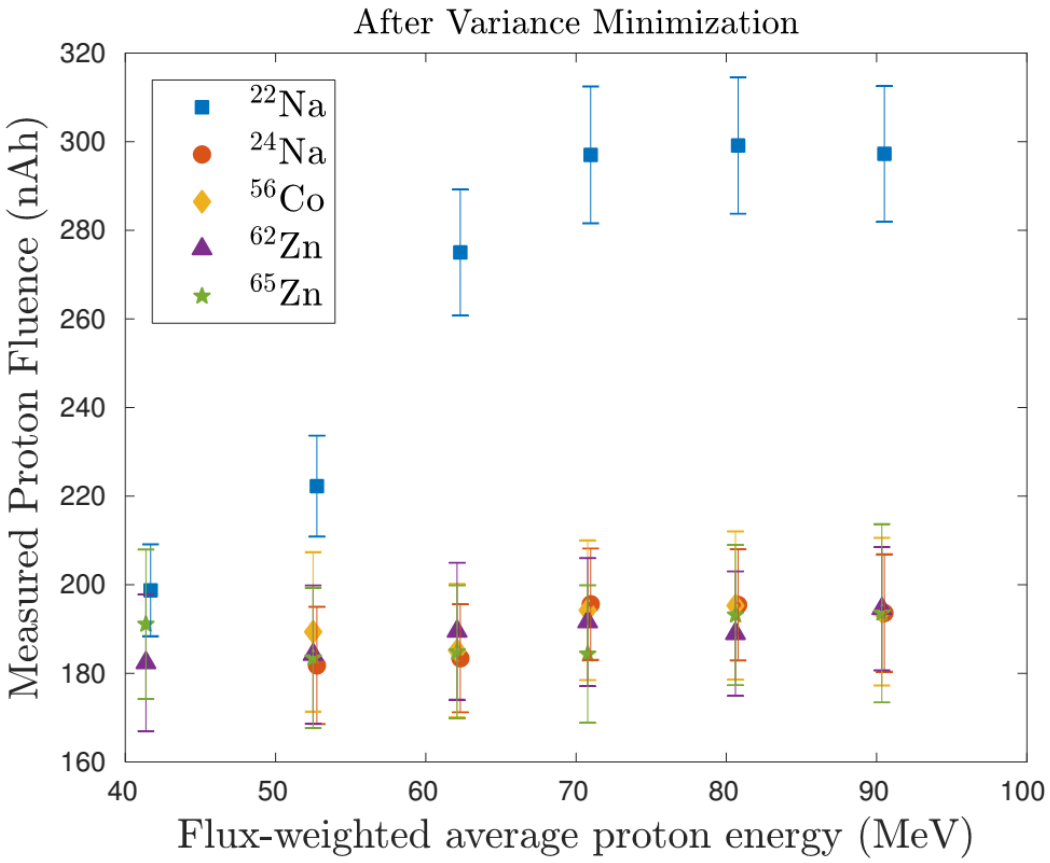


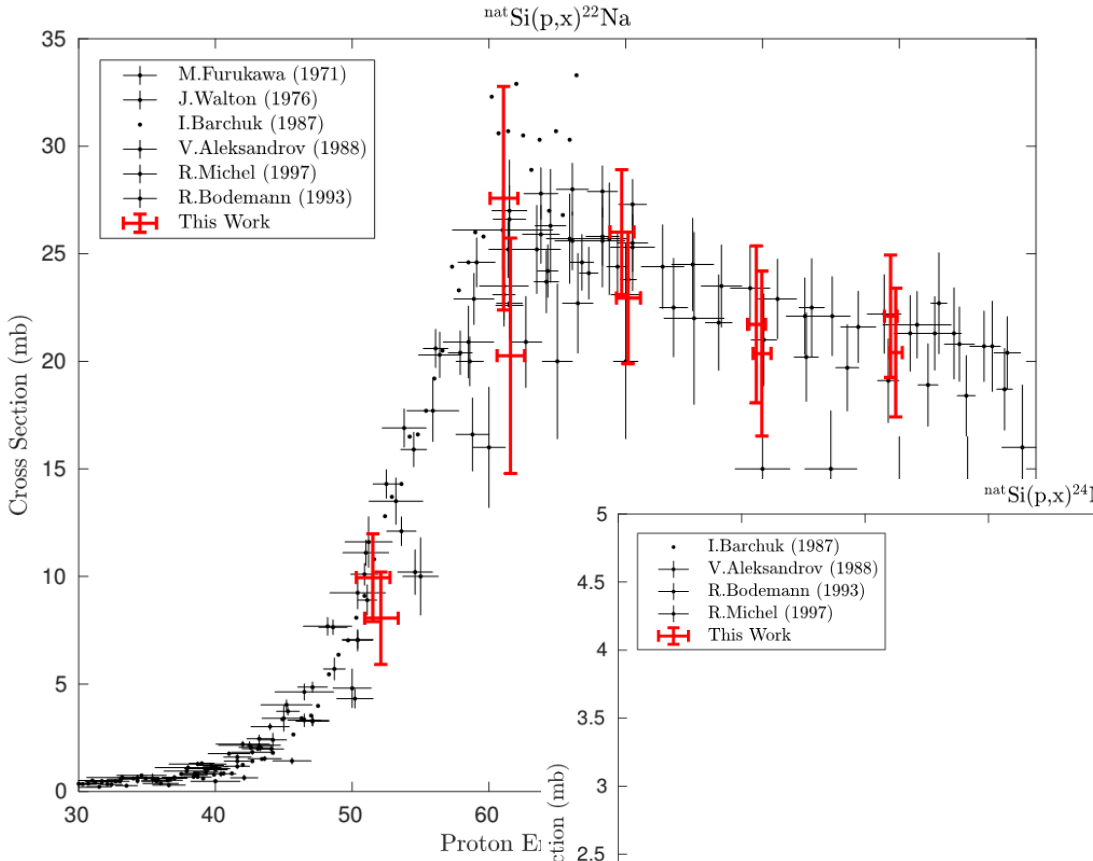


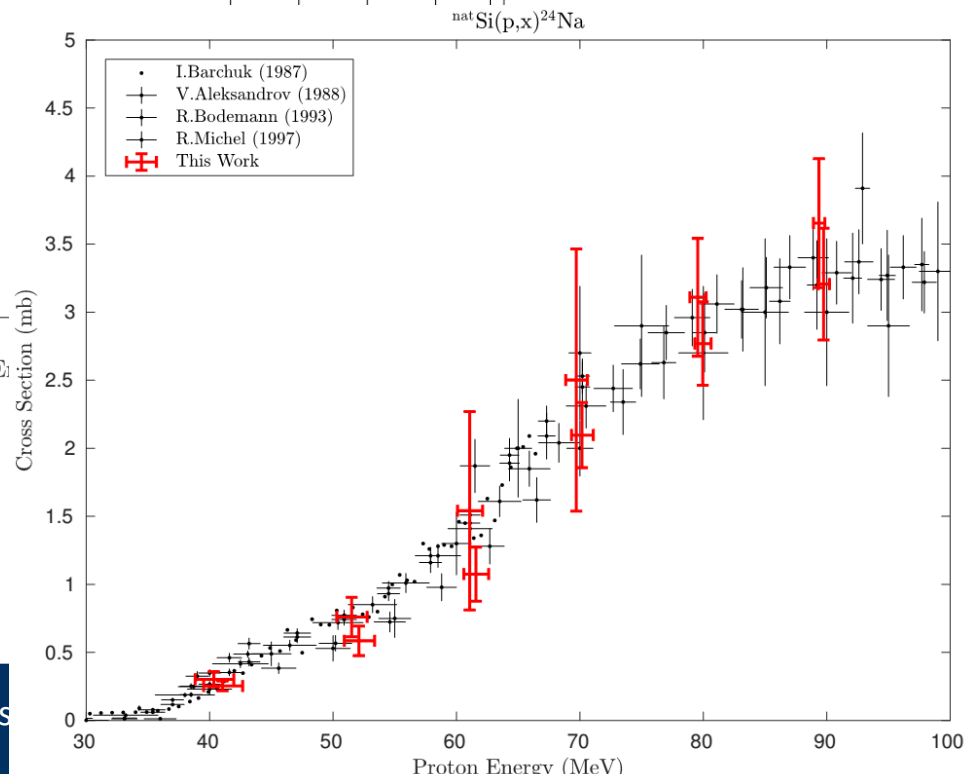
5 independent measurements of isomer-to-ground state ratios

[1] A.S. Voyles, NIM B 429 (2018)

Measurements @ LANL – Nb(p,x)







"Excess" fluence seen in ^{22,24}Na consistent with production via Si(p,x)

[1] A.S. Voyles

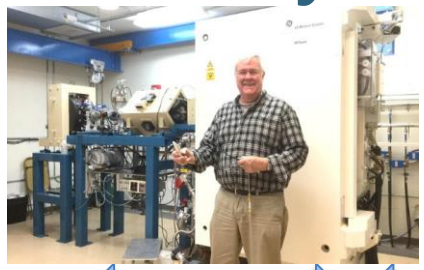
La(p,x) Stacked-Target Excitation Functions

Intermediate Energy – LANL

Low(er) Energy – LBNL

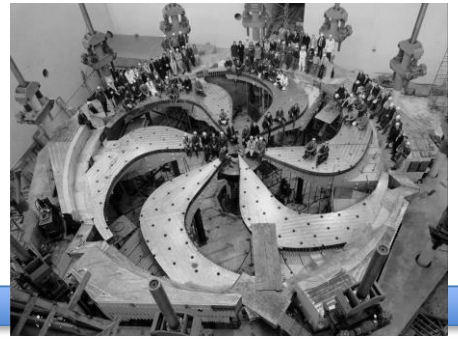
LANSCE-IPF: A Valuable "Link" in the Accelerator Ecosystem

University & Medical Cyclotrons



LANSCE-IPF

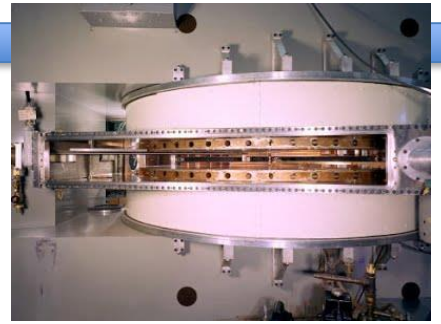
TRIUMF



18 35 50 MeV

100 MeV

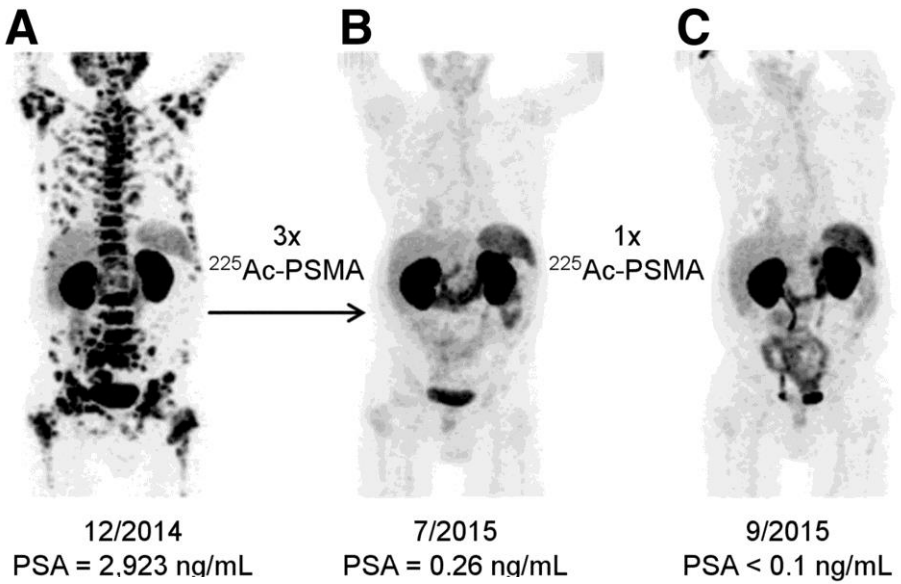
200 MeV



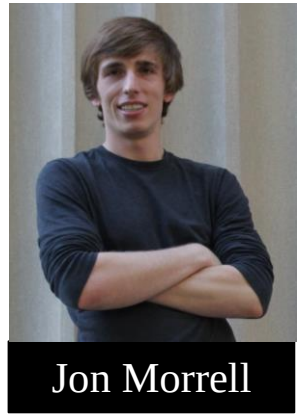
LBNL 88-Inch Cyclotron

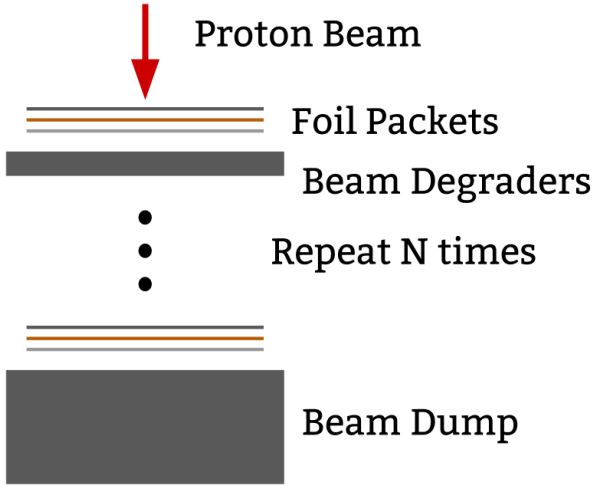
BLIP

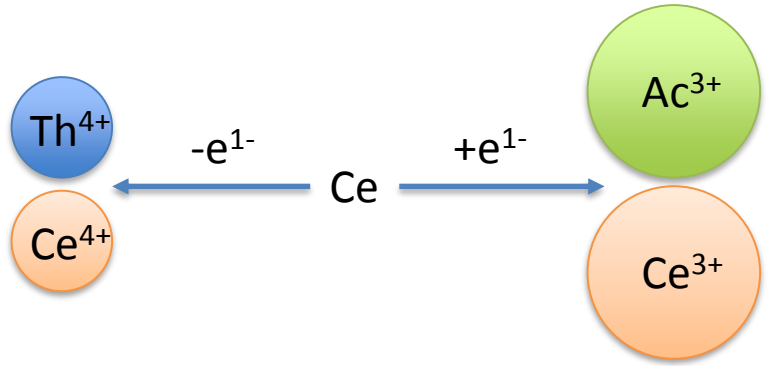
$^{140}La(p,6n)^{134}Ce$ - a PET analogue for ^{225}Ac



- ^{225}Ac decay chain lacks sufficient positrons to produce a signal that can be detected by PET.
  - In order to employ PET to explore new uses of alpha emitters, positron-emitting, surrogate radionuclides will have to be developed.
  - $^{134}Ce/^{134}La$: $t_{1/2}$ = 75.9 h / 6.67 m, 2.7 MeV β^+ (62.0%)
- Cross sections un-measured and reaction modeling predictions (EMPIRE/TALYS) differ by >10x


Jon Morrell





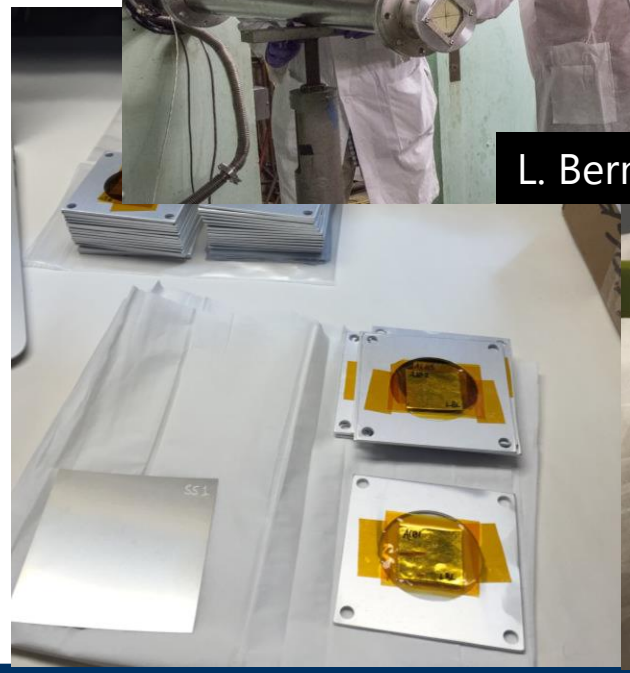
^{134}Ce as a ^{227}Th mimic

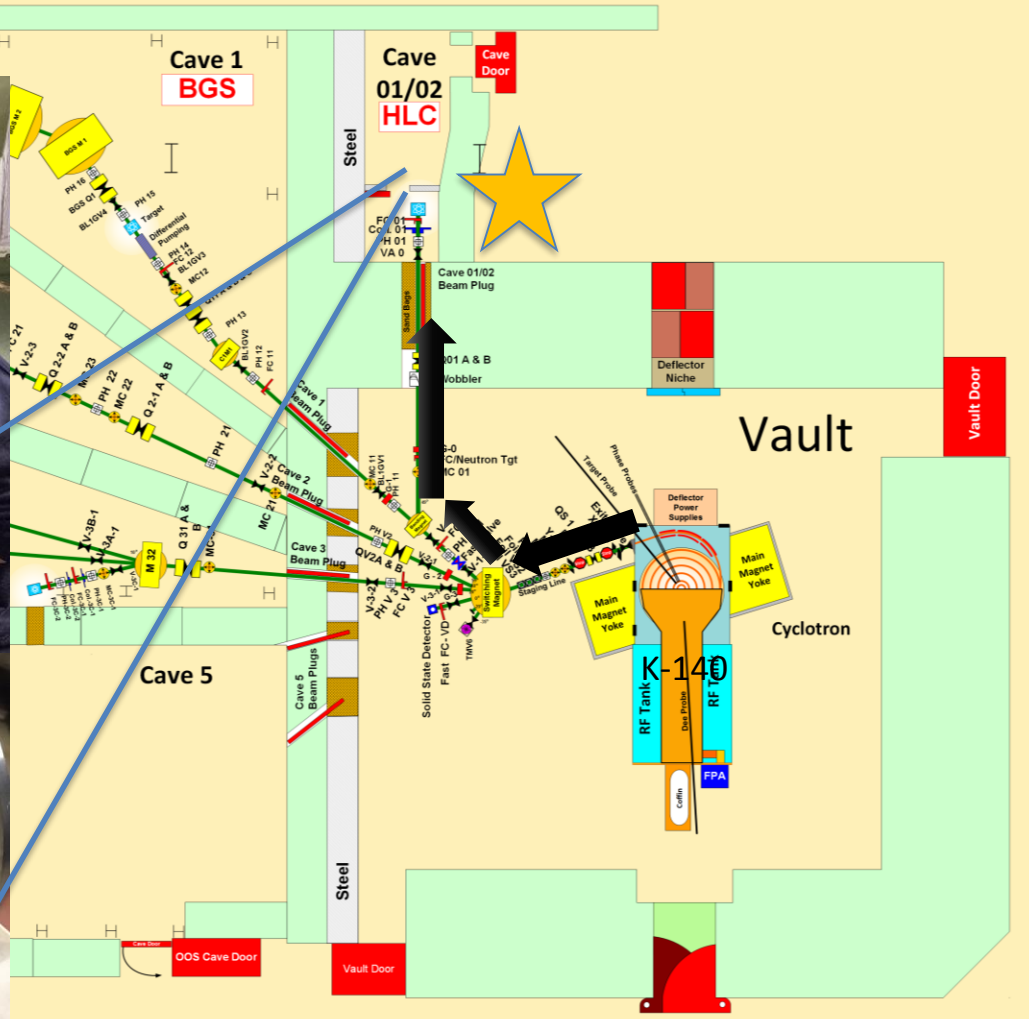
^{134}Ce as an ^{225}Ac mimic

[2] Kratochwil, Clemens, *Journal of Nuclear Medicine* 57.12 (2016).

Stacked-target Charged Particle Excitation Functions

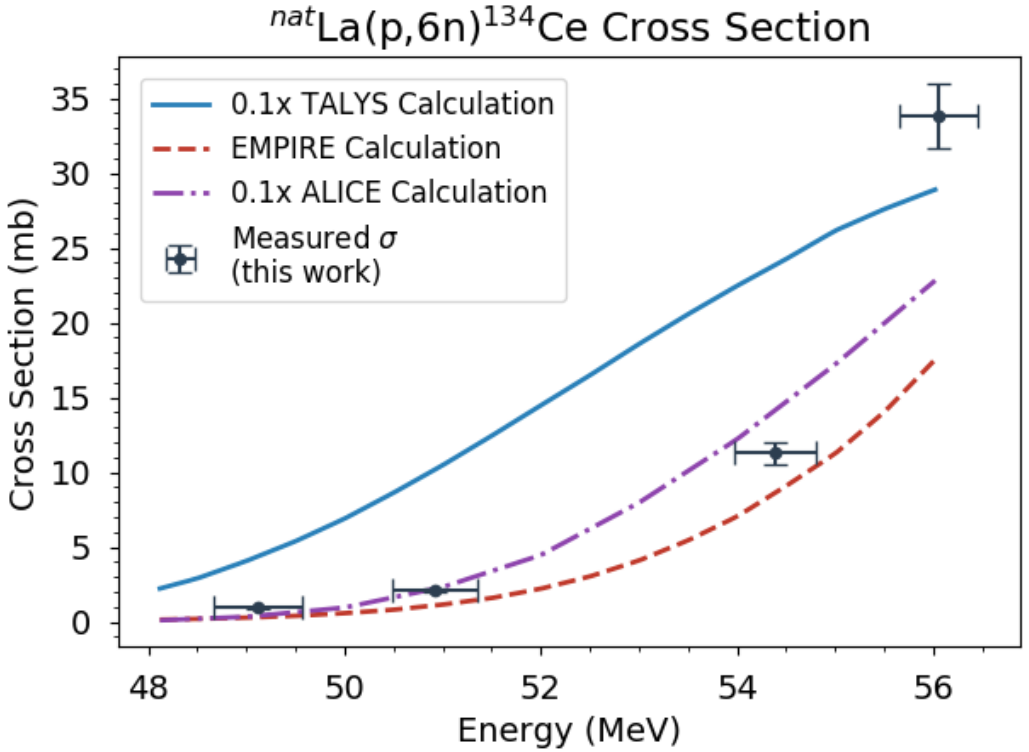
88-Inch Cyclotron

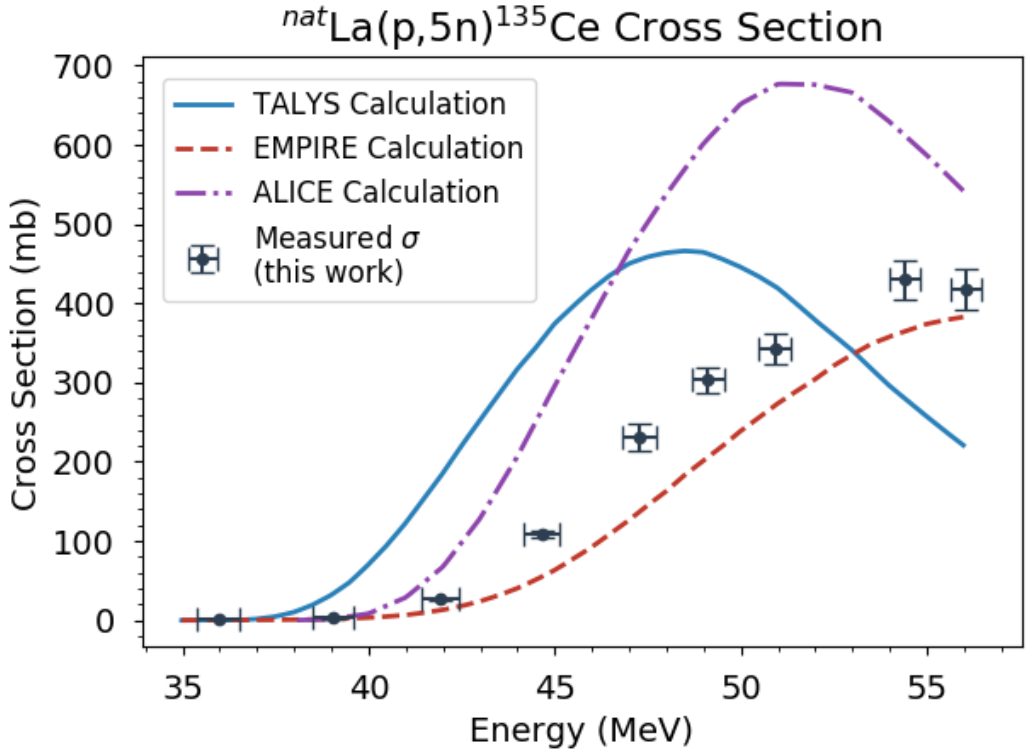




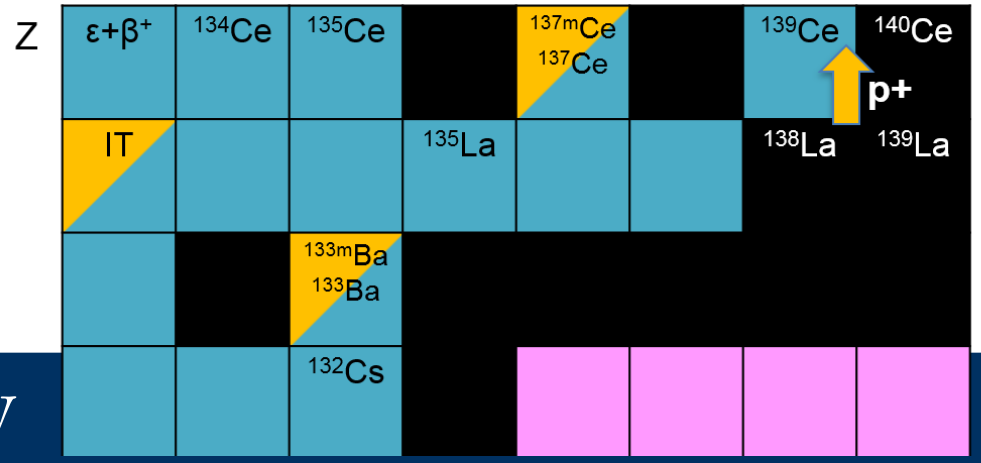
2016: Launched a complementary nuclear data measurement campaign at the LBNL 88-Inch cyclotron to address gaps in reaction data at E<60-110 MeV/A

^{140}La(p,6n)^{134}Ce - a PET analogue for ^{225}Ac





^{135}Ce is major contaminant: higher-energy ≈70 MeV beam required for clean production of ^{134}Ce

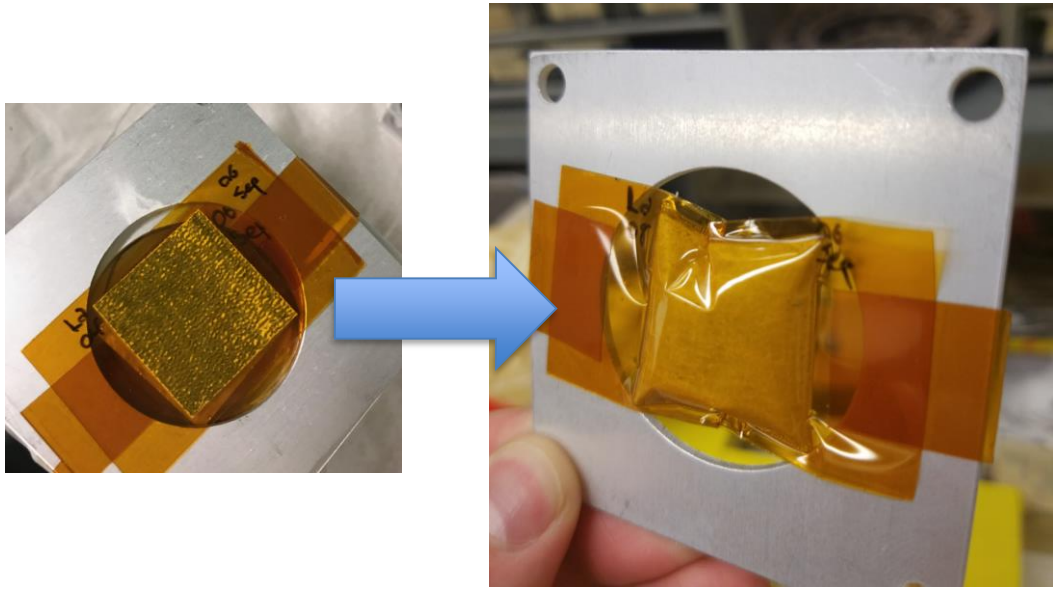


- TALYS and ALICE overpredict (p,6n) cross section by >10x, XS peaks 8-10 MeV higher than predicted
- Reaction code differences: Hybrid Monte-Carlo pre-equilibrium (EMPIRE) vs. Exciton model (TALYS, ALICE)

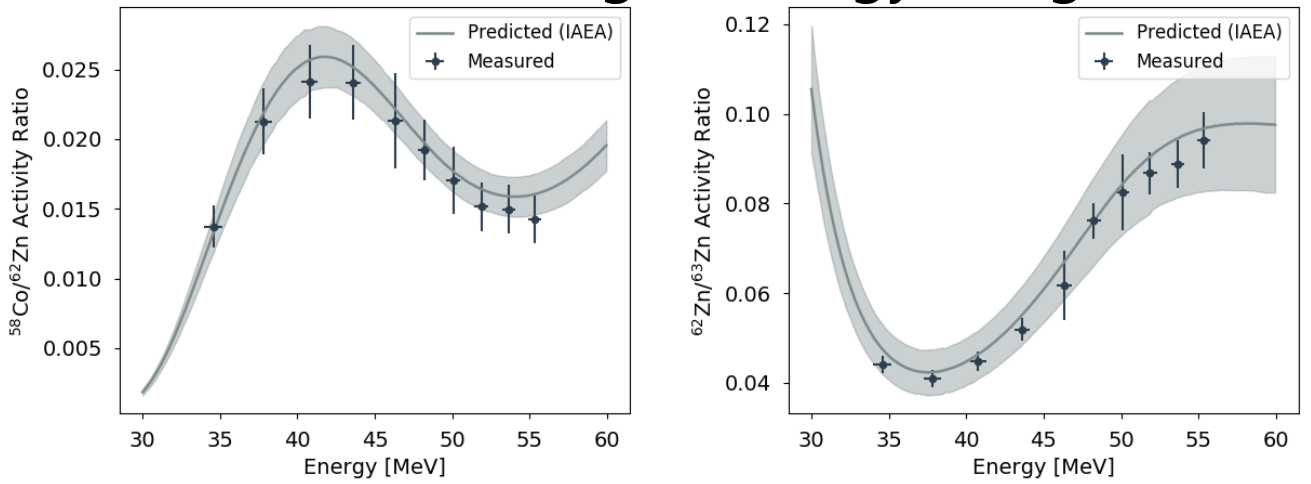
^{140}La(p,6n)^{134}Ce - a PET analogue for ^{225}Ac

Major takeaways:

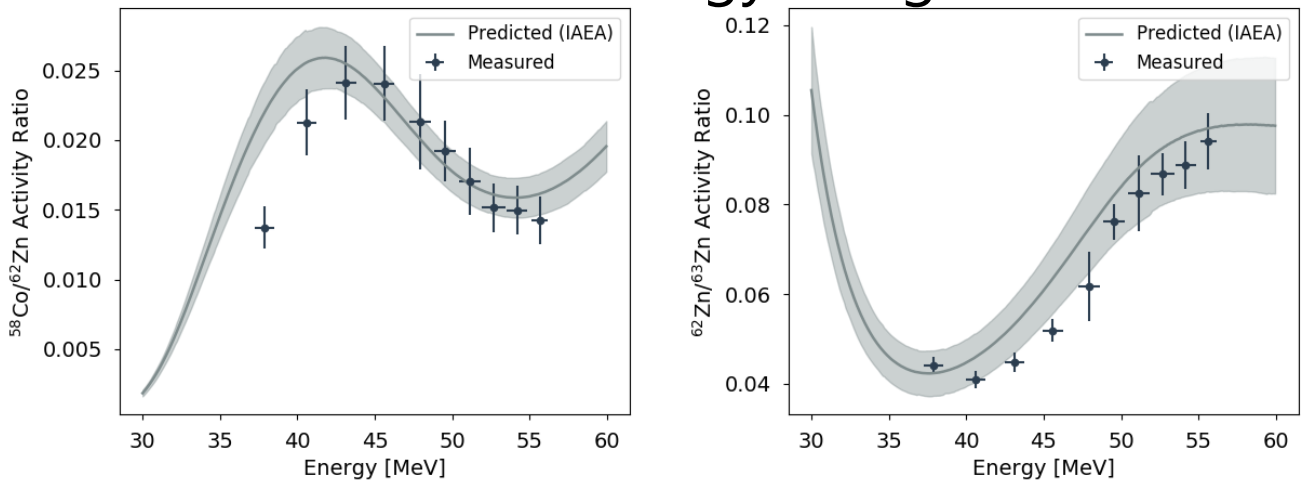
- Significant deviation (>20%) between Anderson & Ziegler and MCNP6/X
  - Future work: explore in depth with other stacked target data
- La metal targetry concerns:
  - Significant decomposition, outgassing post-EoB



Anderson & Ziegler Energy Assignment



MCNP6 Energy Assignment



Collaborators on this work

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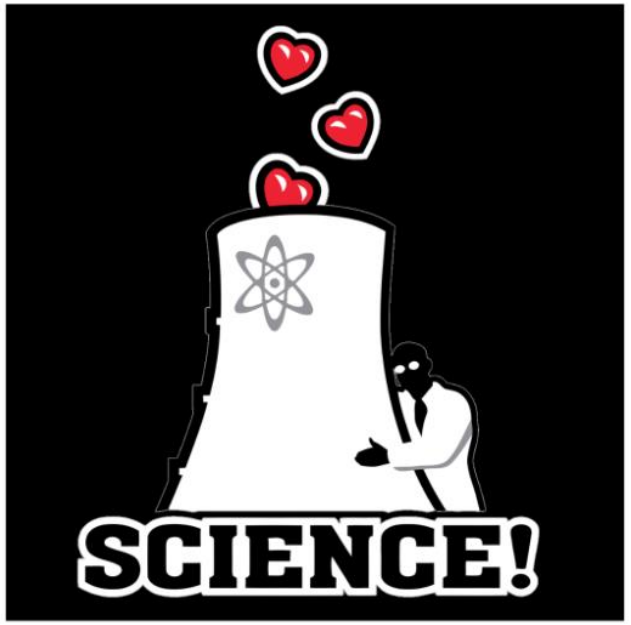
[4] *University of Wisconsin – Madison*
[5] *University of Iowa – Department of Radiation Oncology*
[6] *Karlsruhe Institute of Technology*



U.S. DEPARTMENT OF ENERGY

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- U.S. Nuclear Regulatory Commission


Questions?
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