

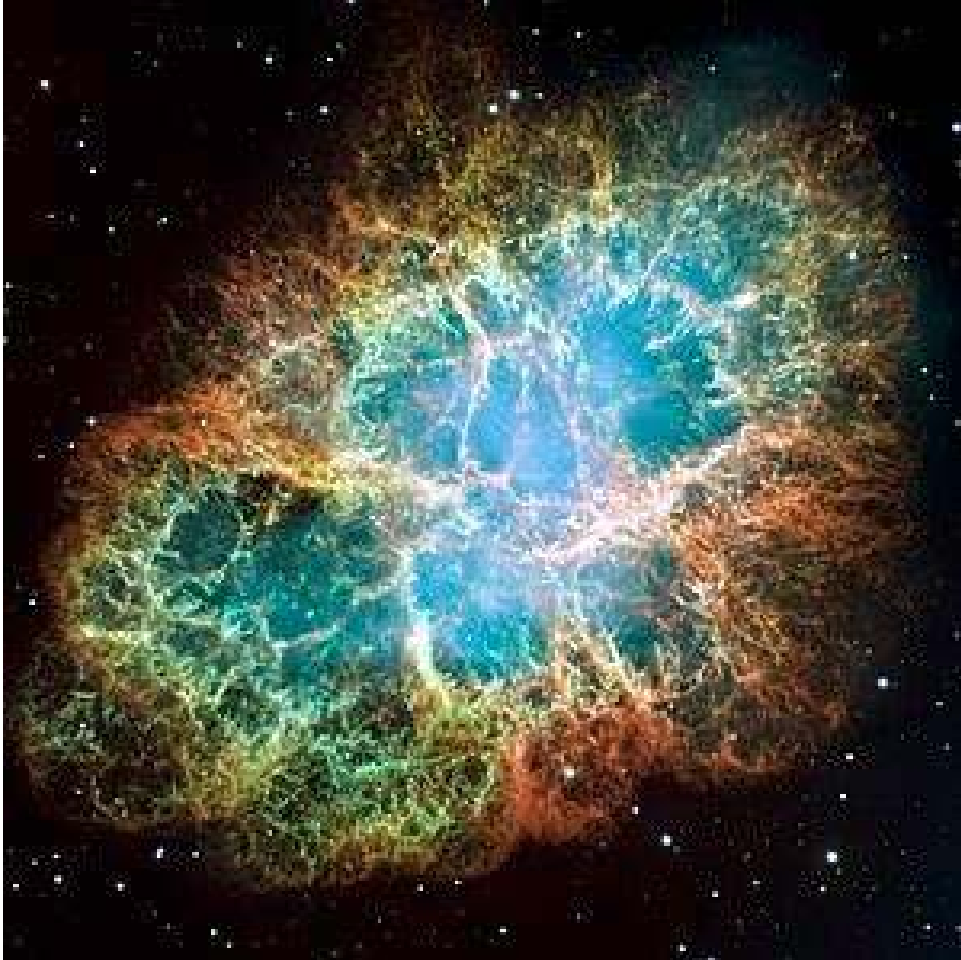
Developing a Framework for Analysis of γ -Induced Cross Sections

K.A. Chipps

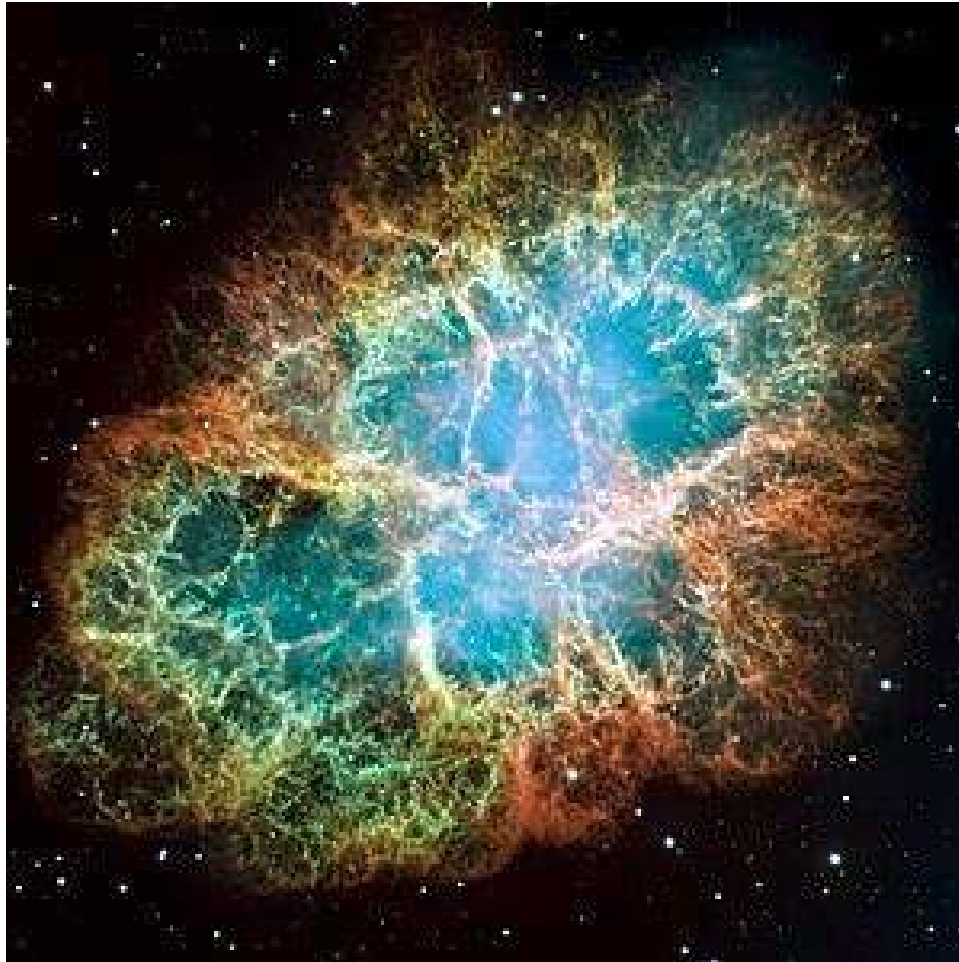
Oak Ridge National Laboratory

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What are γ -induced reactions, and why should you care?



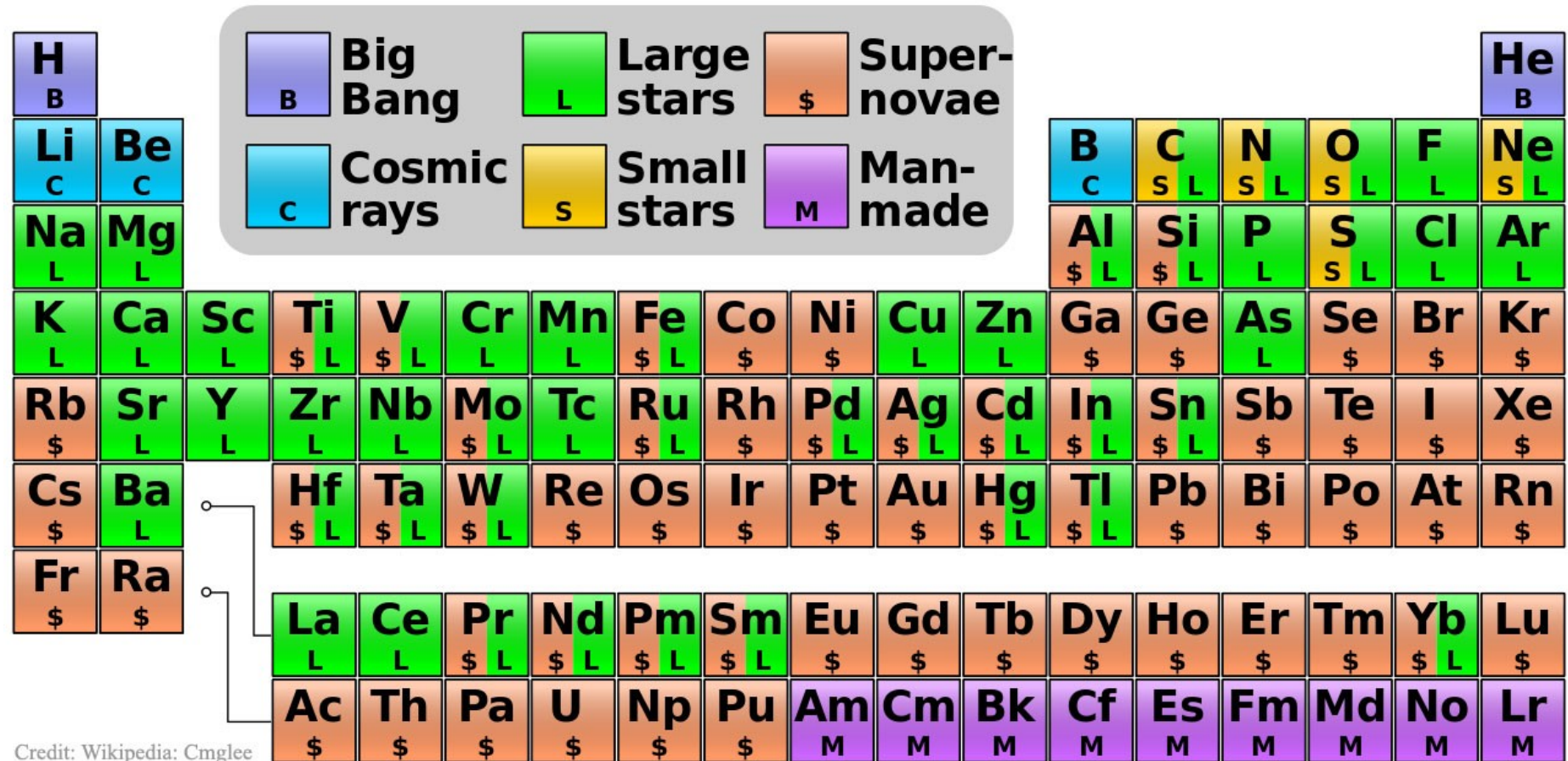
What are γ -induced reactions, and why should you care?



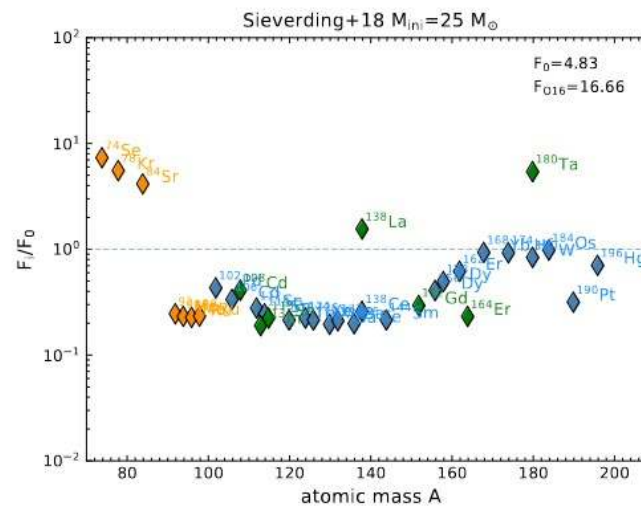
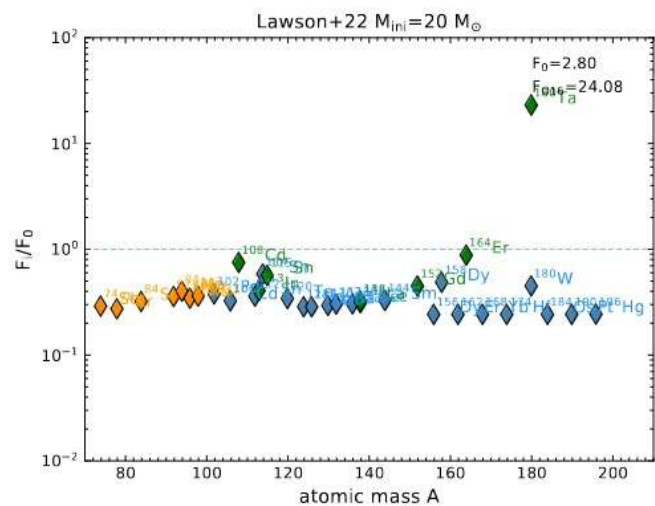
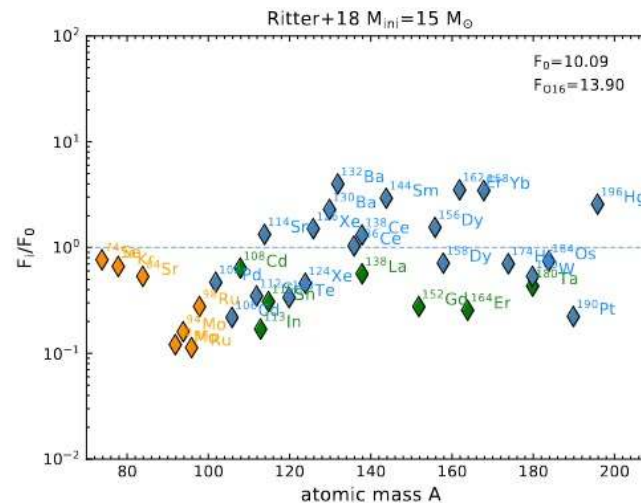
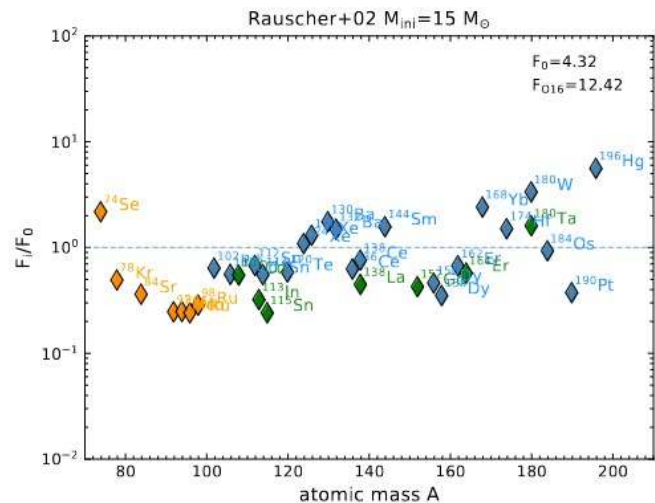
A screenshot of the National Isotope Development Center (NIDC) website. The header includes the NIDC logo, the text "NATIONAL ISOTOPE DEVELOPMENT CENTER" and "MANAGED BY THE U.S. DEPARTMENT OF ENERGY ISOTOPE PROGRAM", a search bar, and buttons for "SUPPLY CHAIN CONCERN" and "AVAILABLE ISOTOPES". A navigation menu contains "PRODUCT CATALOG", "HOW WE OPERATE", "ISOTOPE INFORMATION", "NEWS", "EVENTS", and "ABOUT US". The main content area features a grid of medical CT scans of skulls with red highlights, and a hand pointing at one of them. Below the grid, the text reads "Medical Isotopes" and "With more than 35 medically relevant isotopes available and others under investigation, the NIDC is committed to supplying the world with the highest quality isotopes for medical use." A "Download Brochure" button is also present.

Gamma-induced reactions may help explain the production of rare, stable, proton-rich nuclei in astrophysical environments

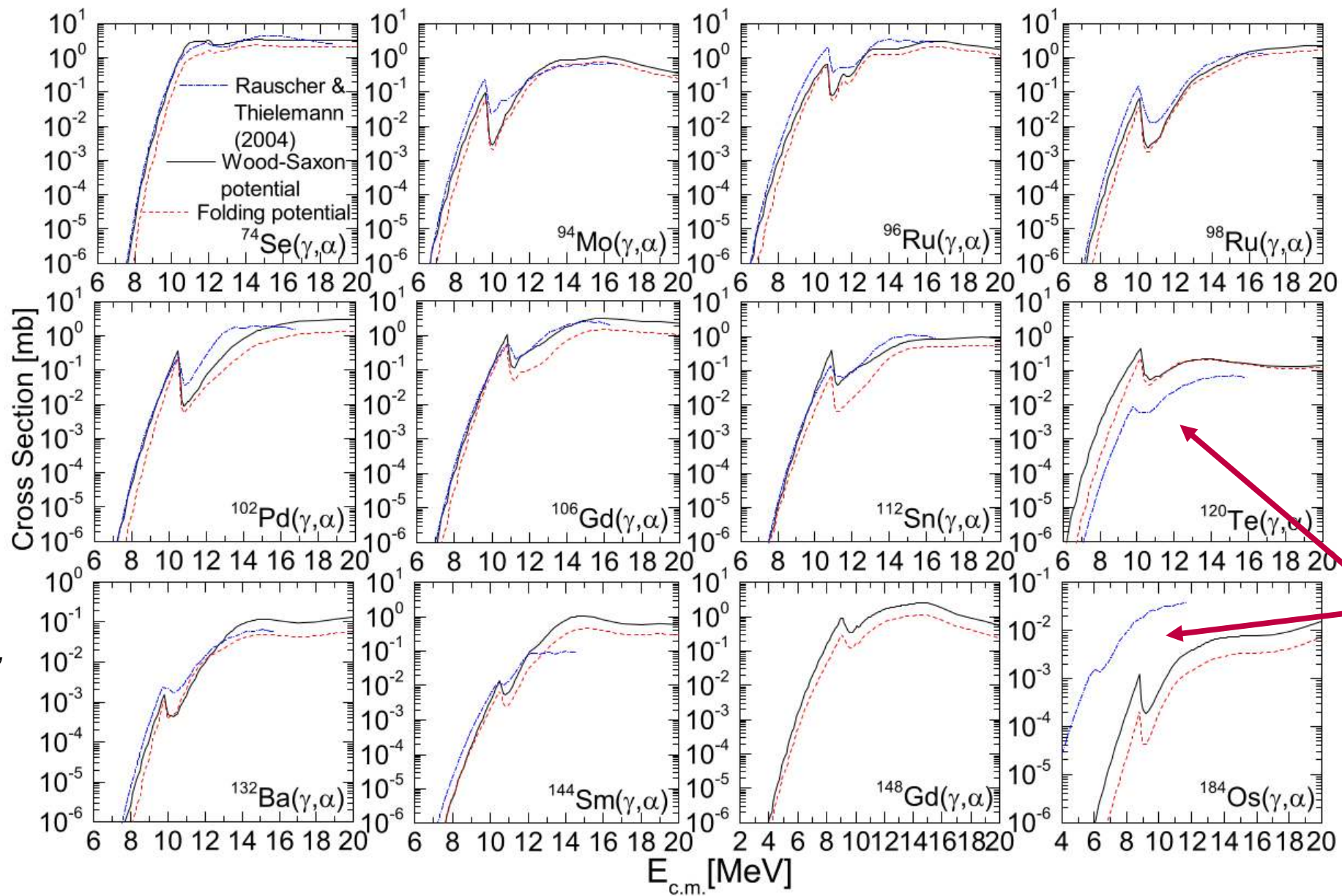
The so-called *p nuclei* can't be explained solely by neutron capture processes



Predicting the abundances of p nuclei depends on many different inputs, including γ -induced reaction cross sections



Variation in predicted abundance vs observed abundance (note log scale!)

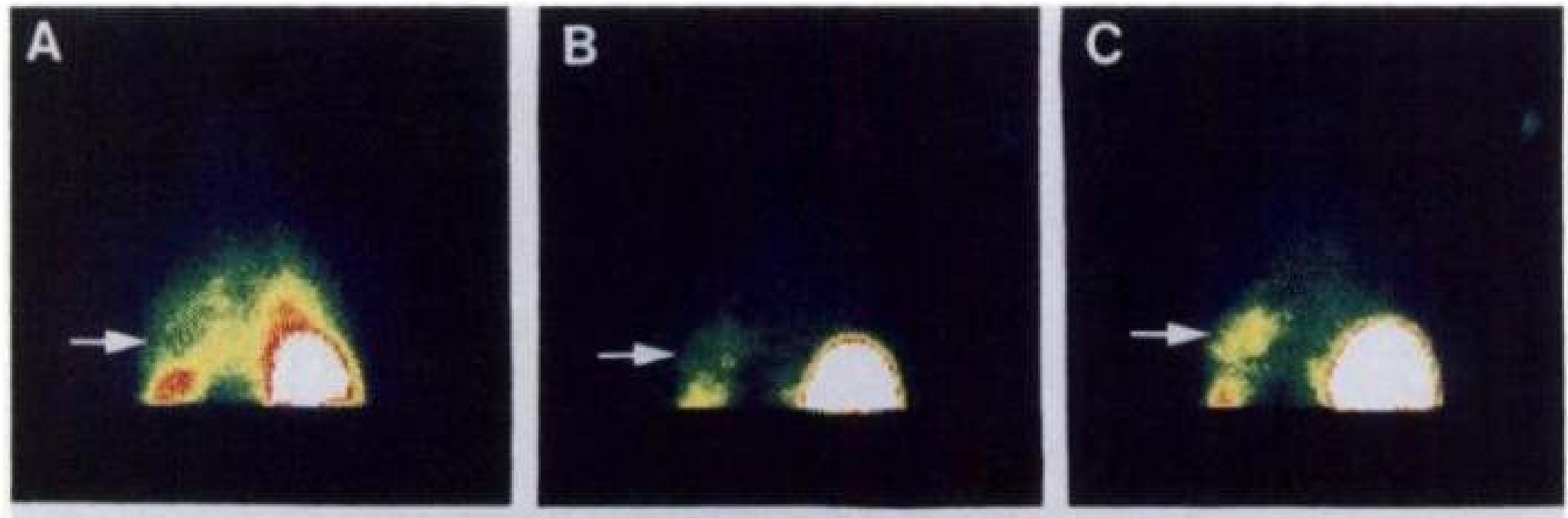


H.Y. Lan et al,
 Phys Rev C 98,
 054601 (2018)

FIG. 2. Comparisons of the (γ, α) cross sections calculated by the phenomenological Woods-Saxon and the M3Y folding potentials for twelve p -nuclei targets of ^{74}Se , ^{94}Mo , ^{96}Ru , ^{98}Ru , ^{102}Pd , ^{106}Cd , ^{112}Sn , ^{120}Te , ^{132}Ba , ^{144}Sm , ^{148}Gd , and ^{184}Os . The results calculated by the Woods-Saxon and the M3Y OMPs are respectively shown as the black solid lines and the red dashed lines. The computations of Ref. [18] are shown as the blue dash-dotted lines for comparisons.

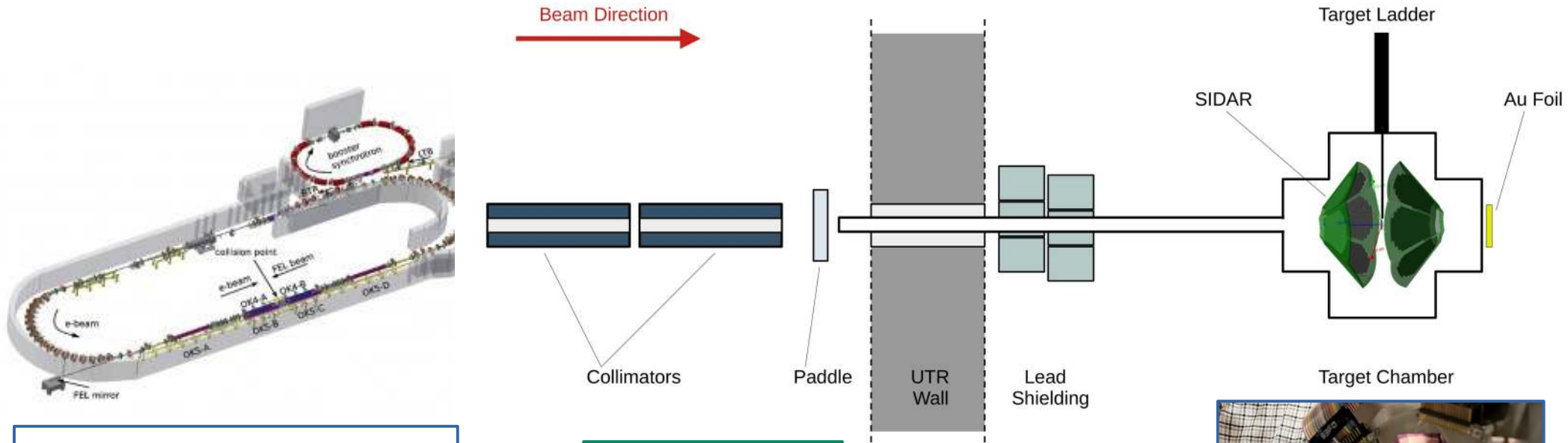
Poorly constrained gamma-induced reaction cross sections are preventing scale-up of production of medical isotopes

^{67}Cu is interesting for cancer treatment as a theranostic

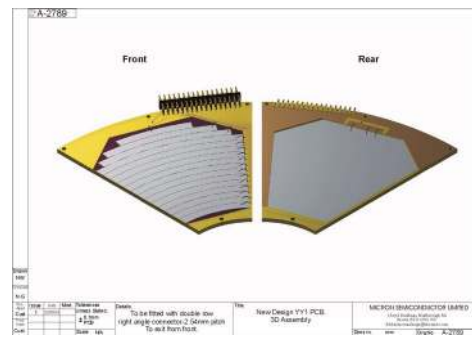


*Targeting of non-Hodgkins lymphoma
immediately (A), 3 days (B), and 6 days (C) after infusion
O'Donnell et al, J. Nucl. Medicine 40, 2014-2020 (1999)*

Measuring γ -induced reactions is clearly important. So how do we do it?



Monoenergetic γ beams between 10-19 MeV produced at Hi γ S (TUNL)



Home > [The European Physical Journal A](#) > Article

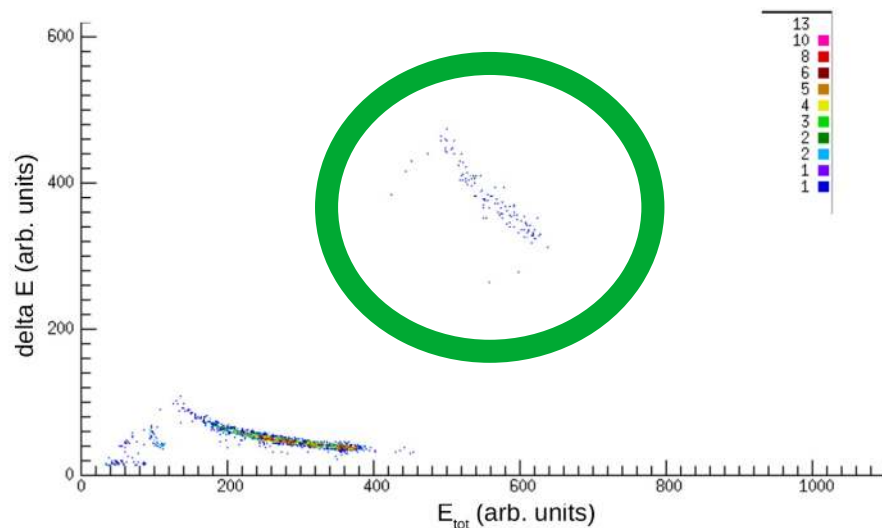
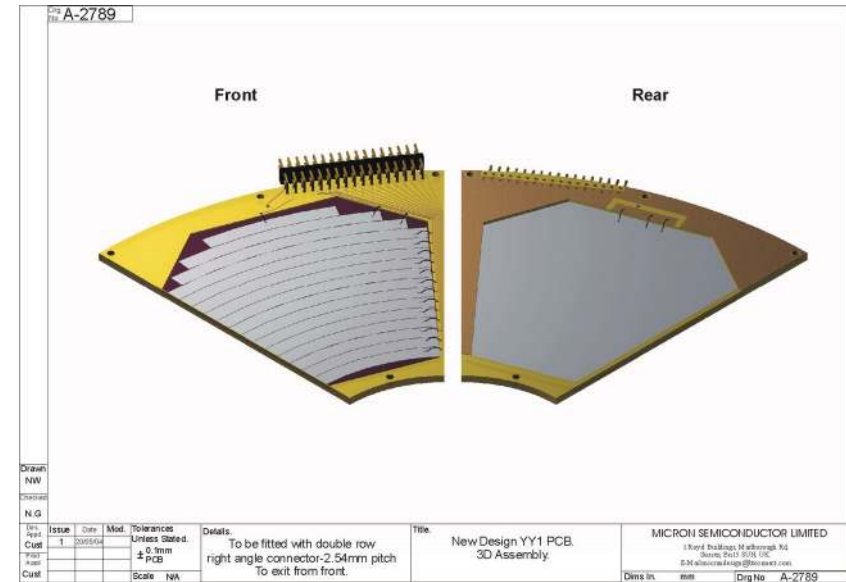
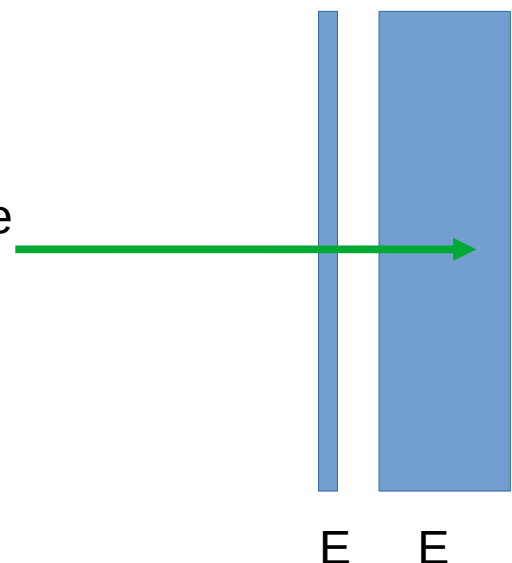
Photonuclear reactions with charged particles detection for nuclear astrophysics studies

Review | Published: 19 July 2023

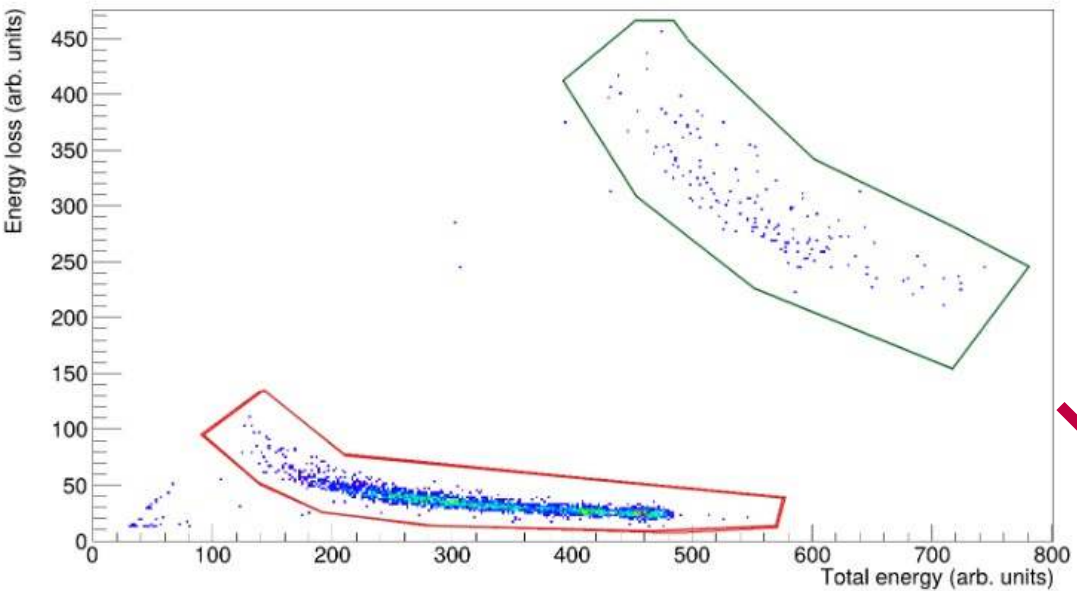
Volume 59, article number 165, (2023) [Cite this article](#)

A new idea is needed to address a gap in traditional particle ID techniques

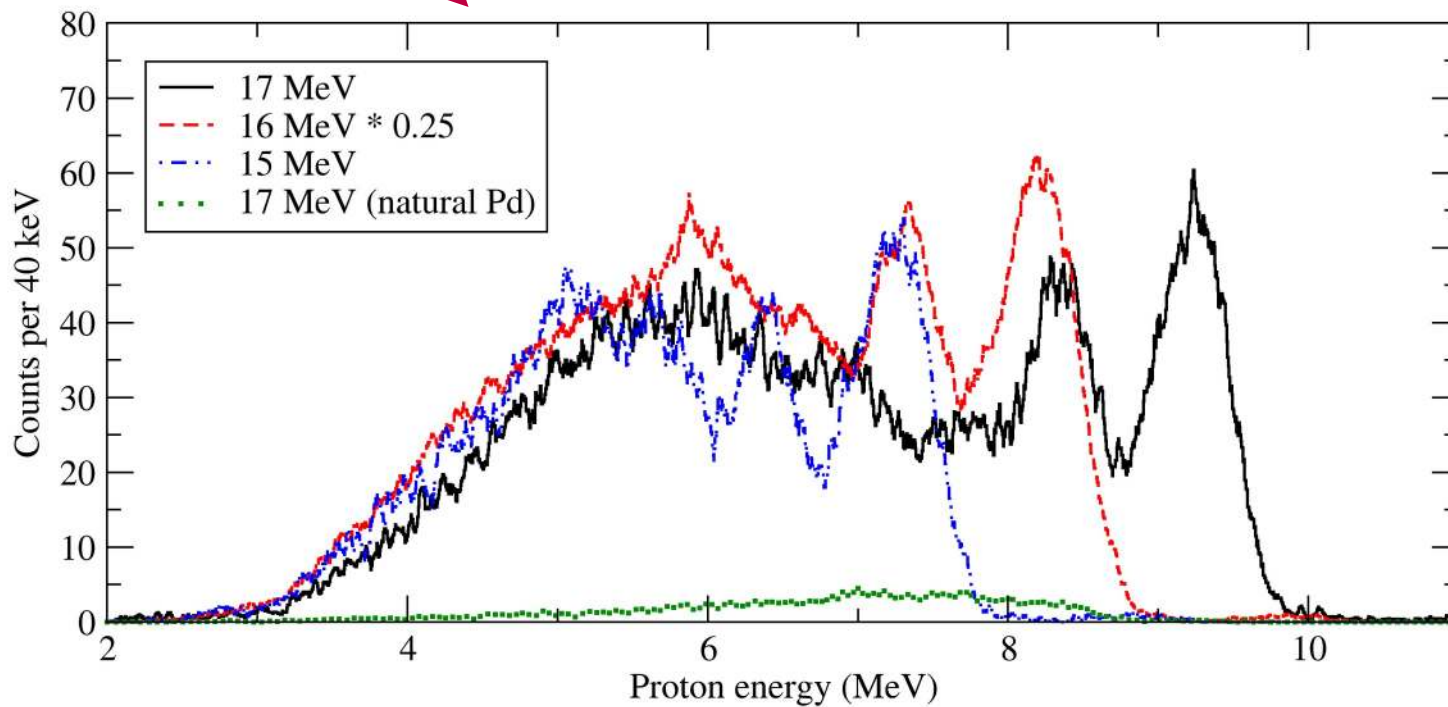
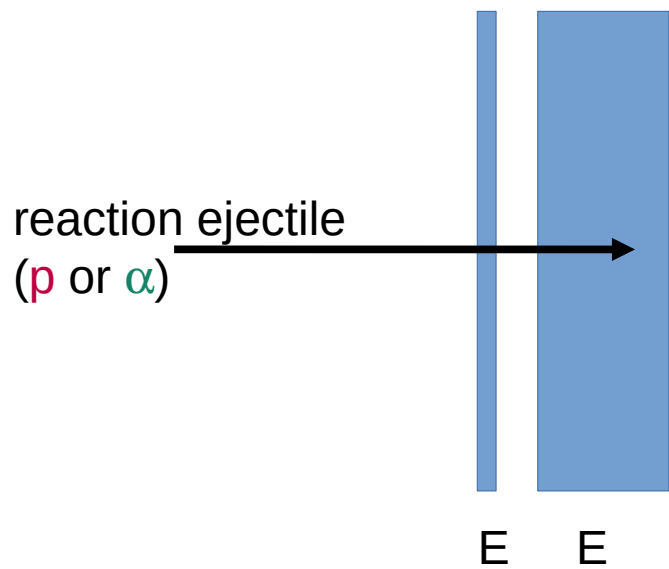
reaction ejectile
(like protons)



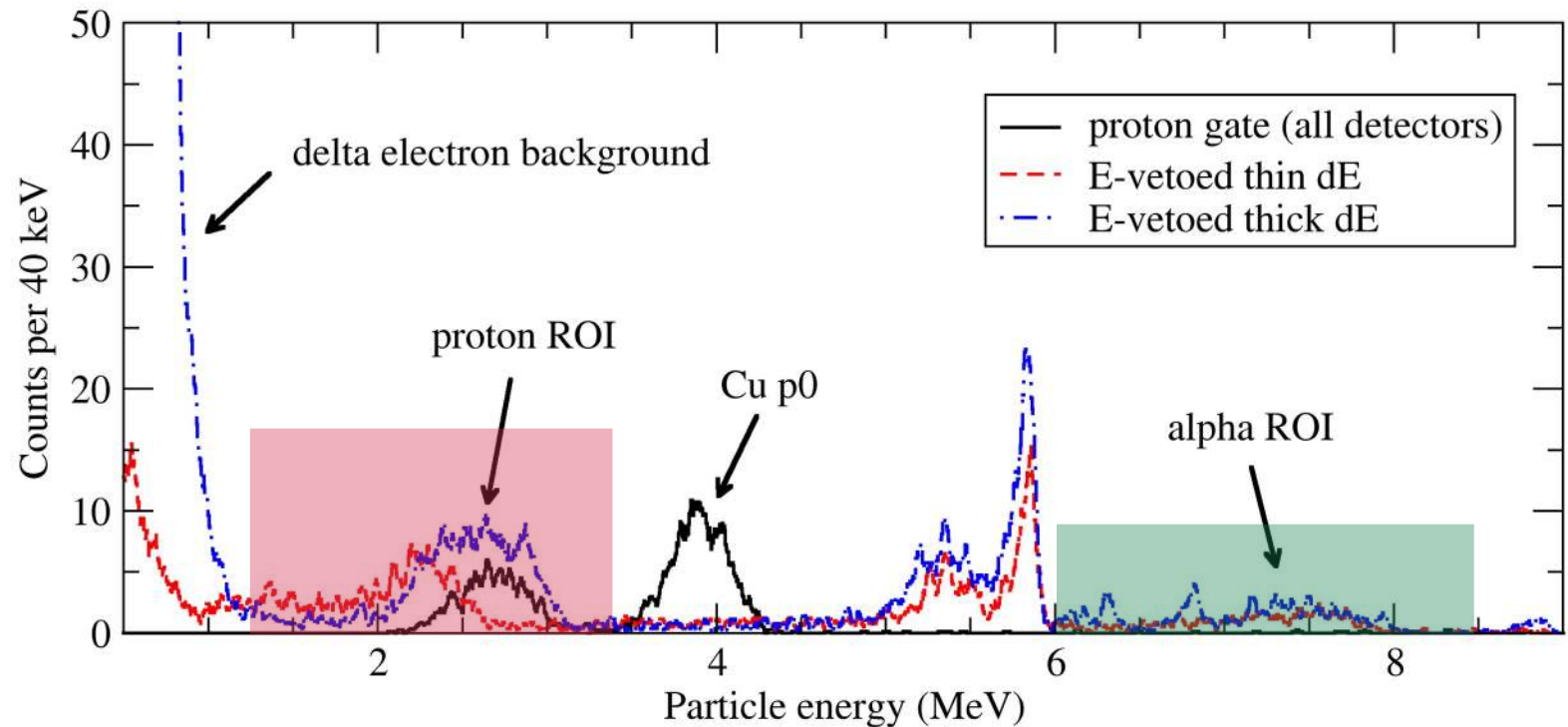
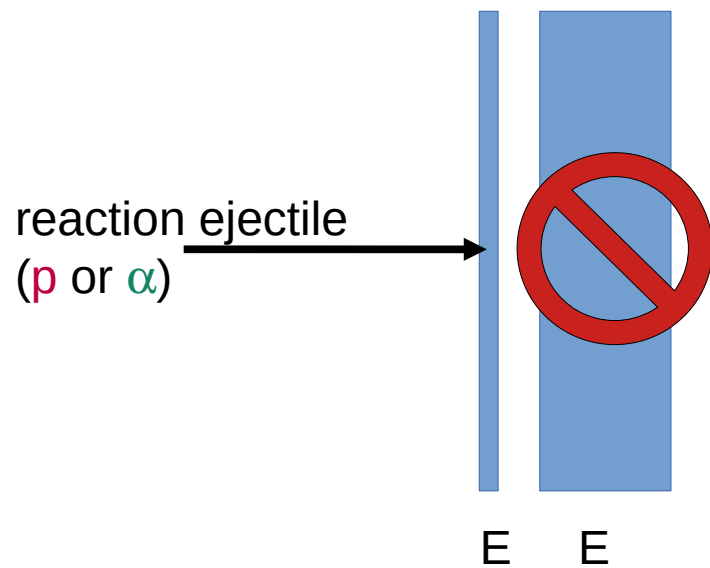
20 MeV gamma – 8 MeV Q value
= 12 MeV particles (E and E)



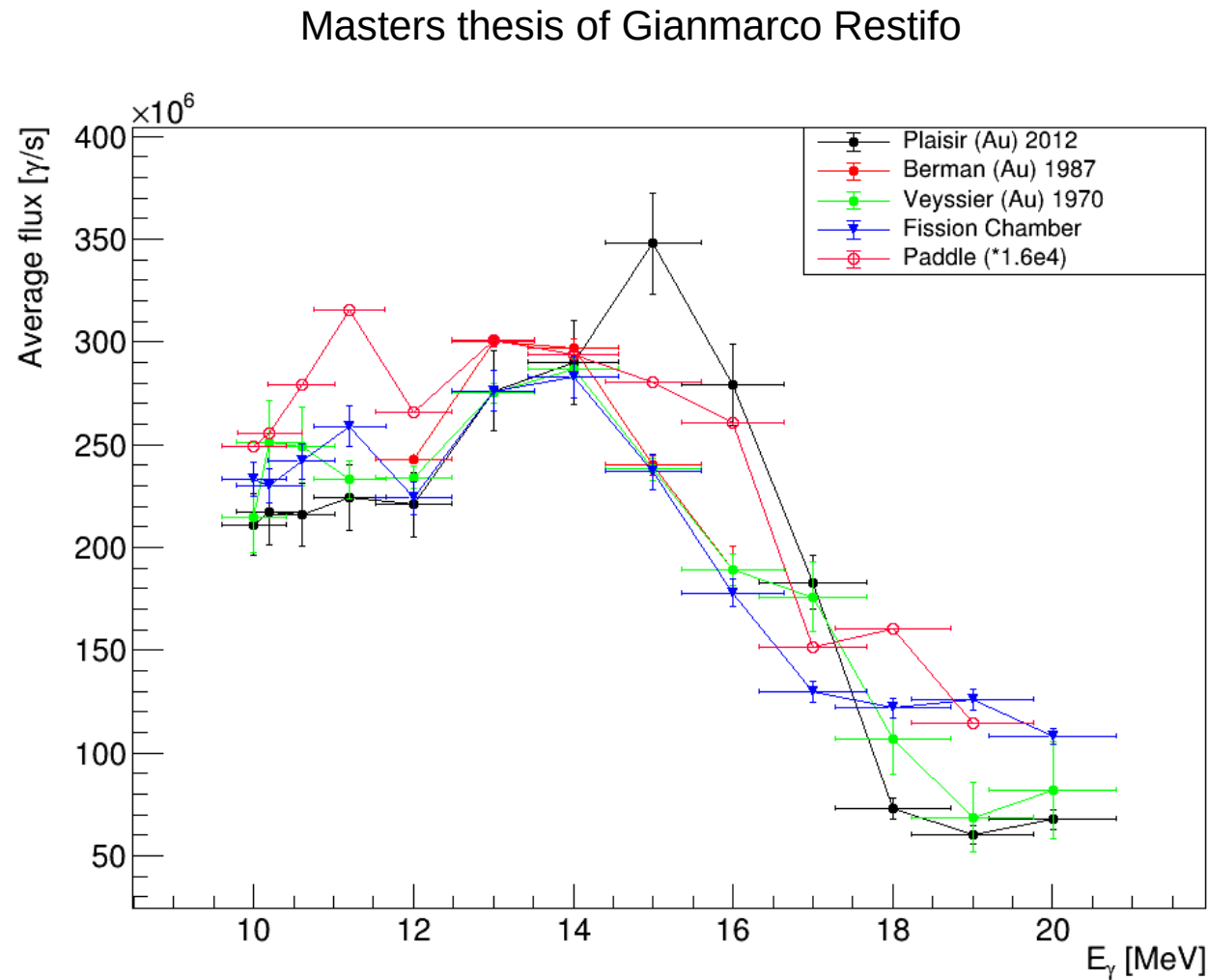
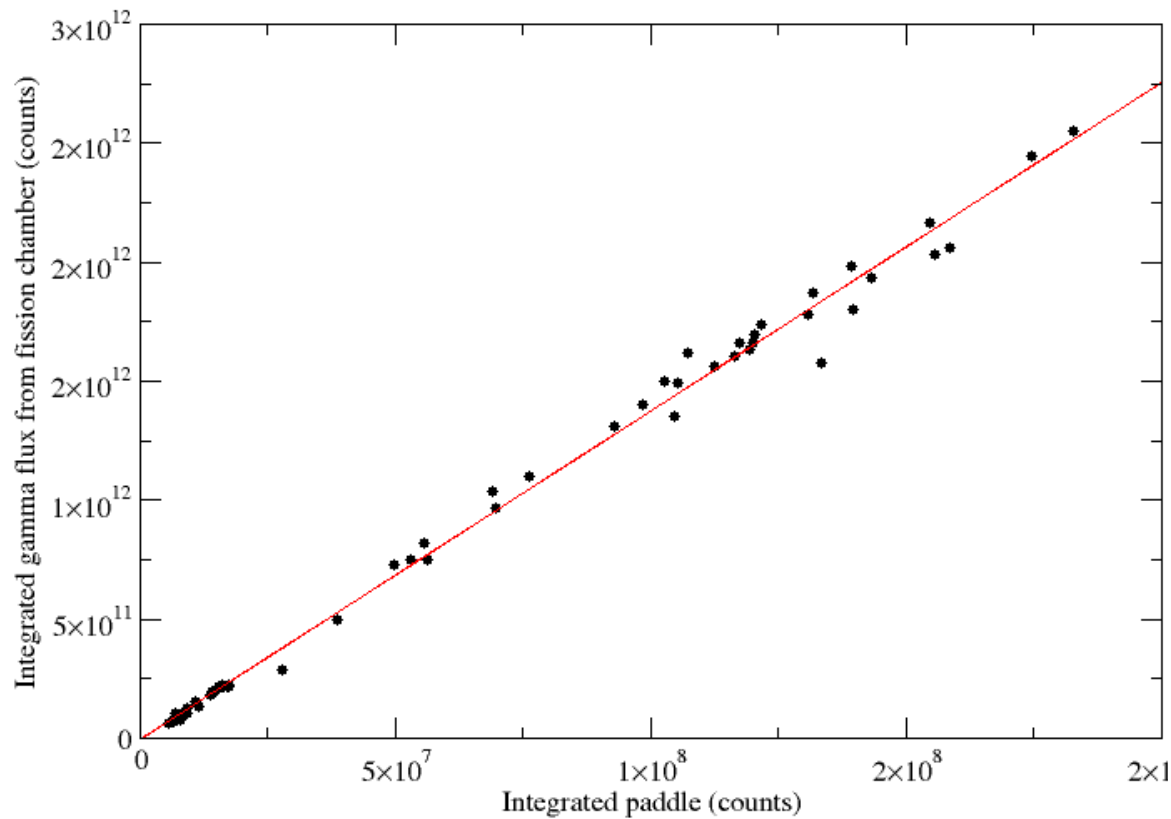
Traditional particle ID
(protons and alphas)



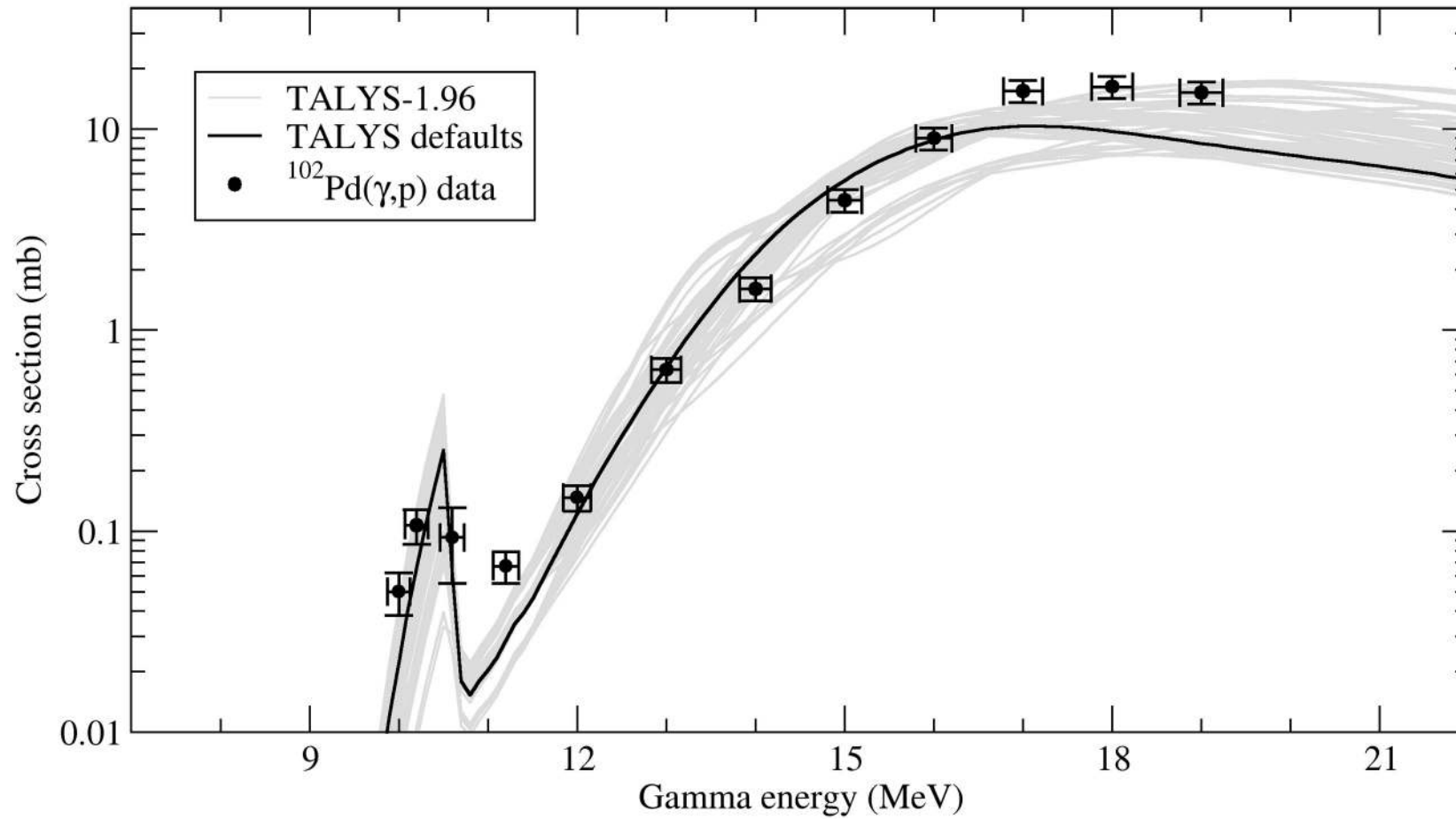
Our alternative algorithm for particle ID relies on electrons not stopping in the dE detector – and it works (protons and alphas)



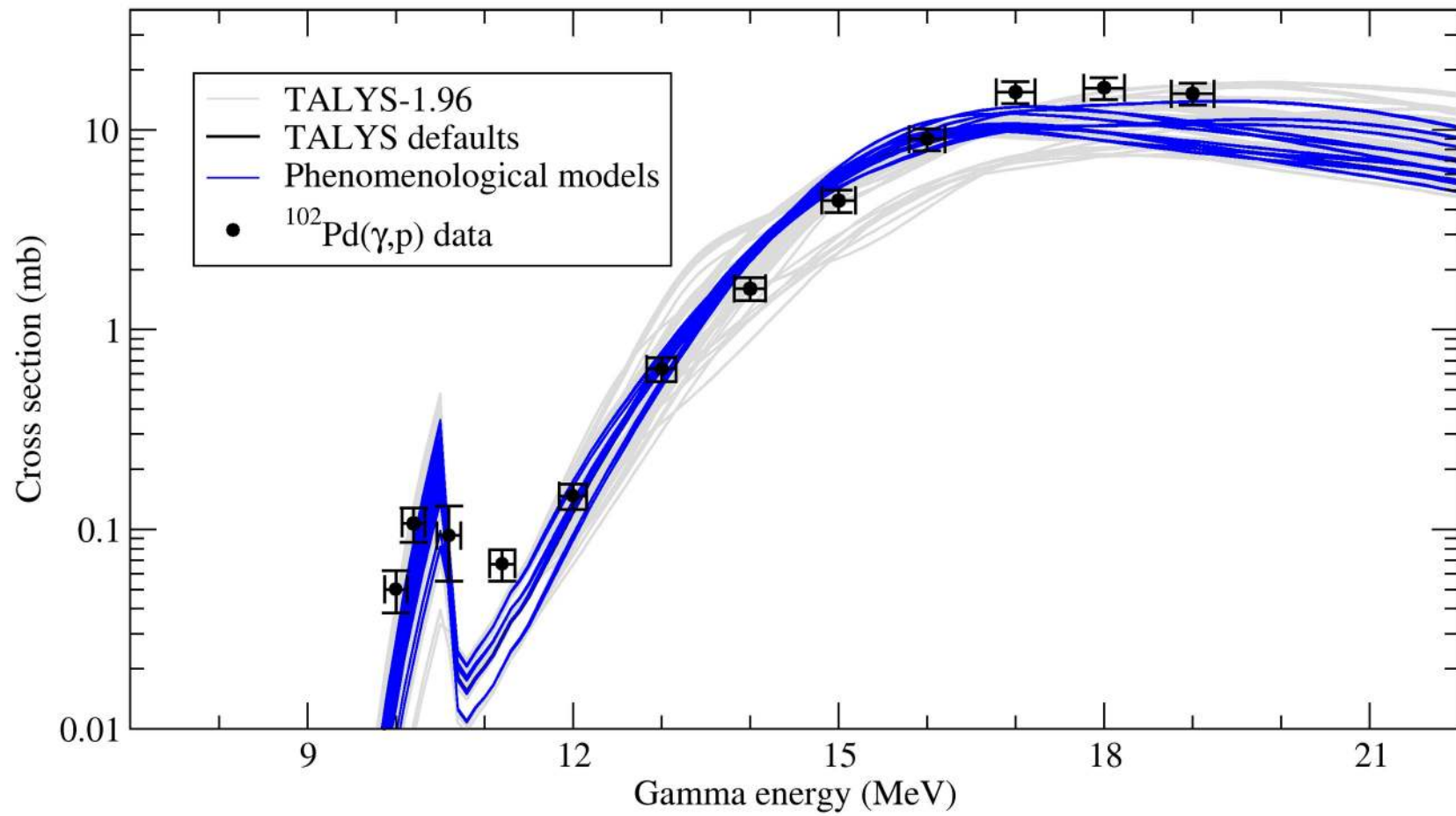
Calculating absolute cross sections from raw yields can be done with multiple methods to ensure fidelity

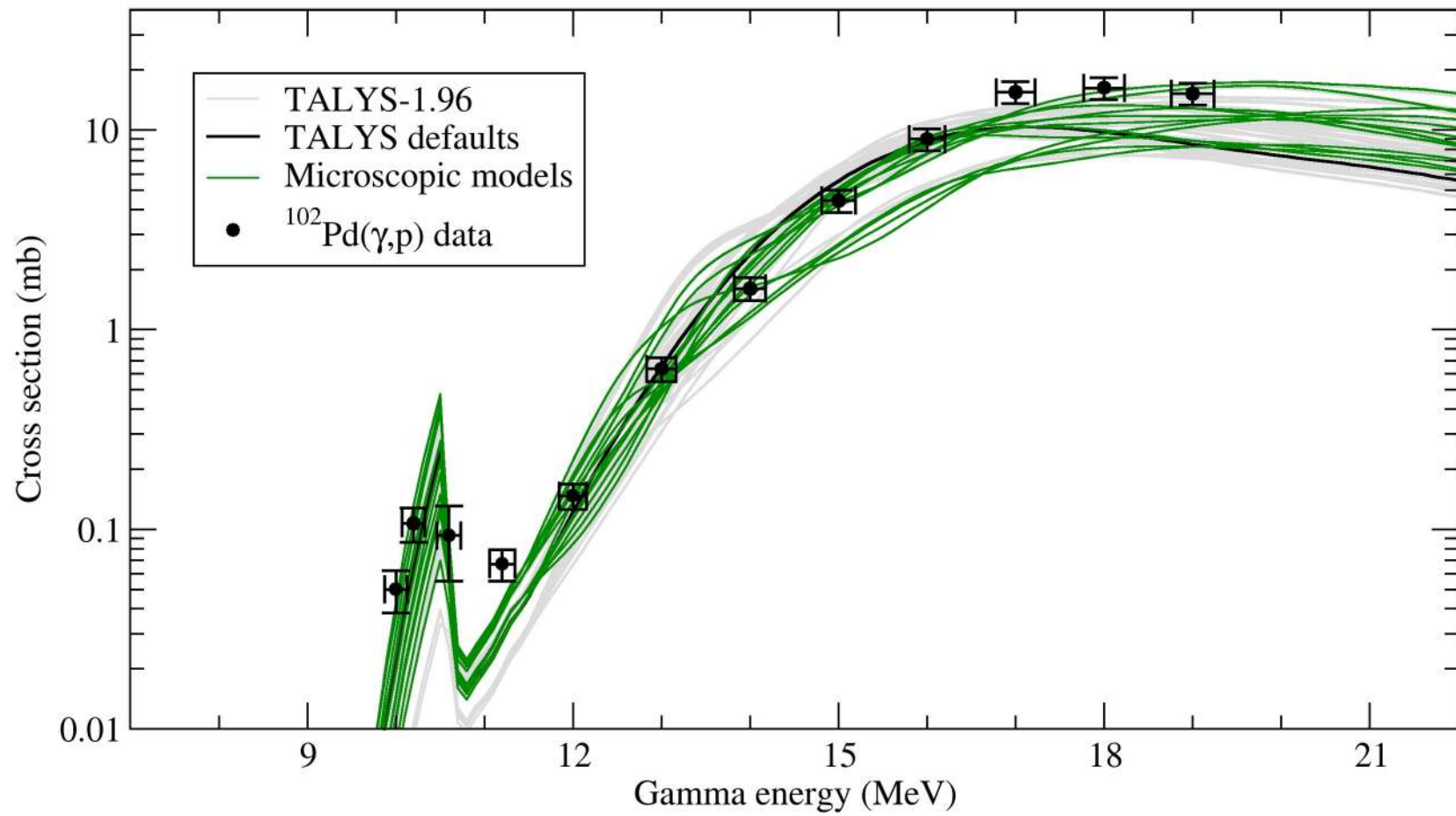


Cross sections - proton emission

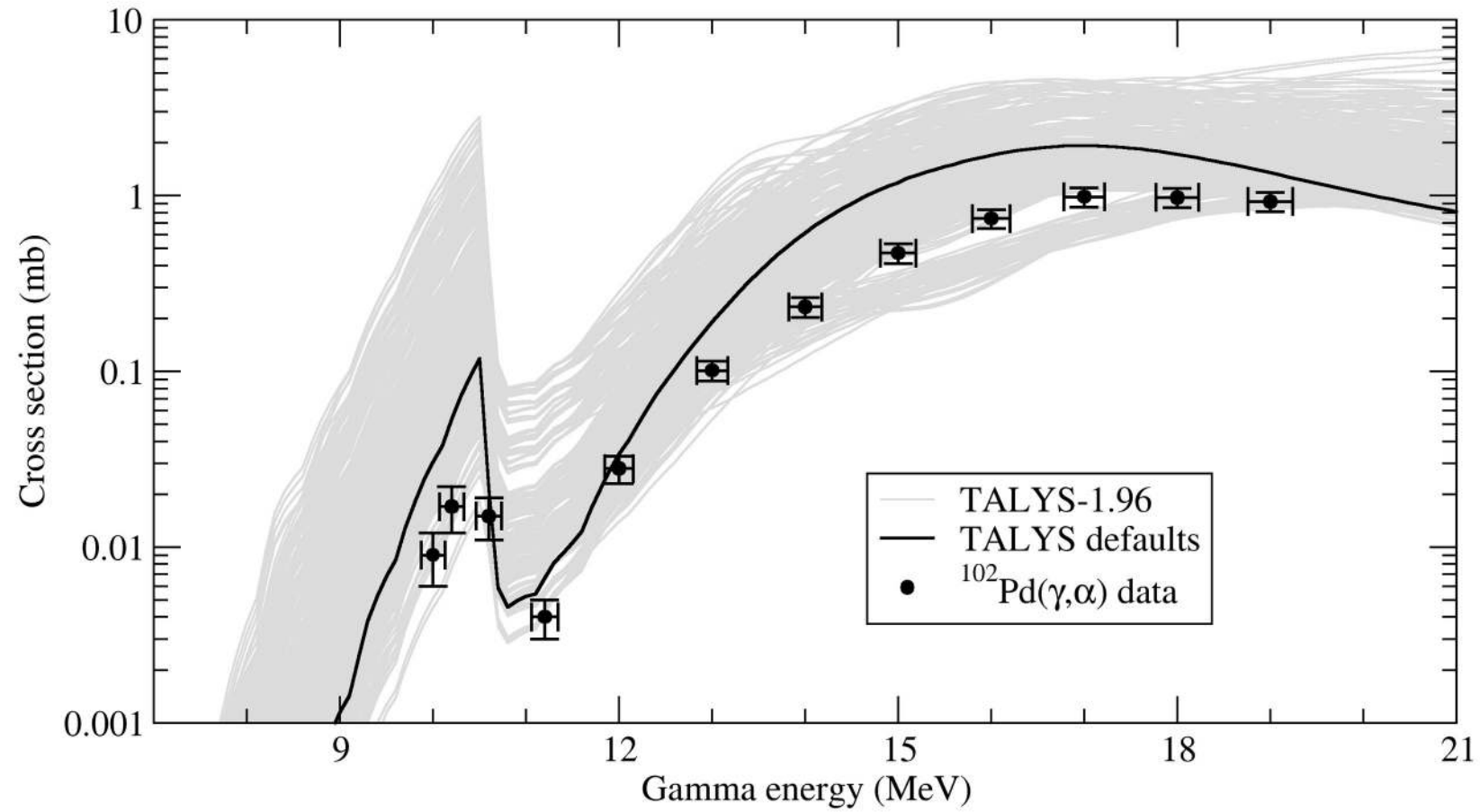


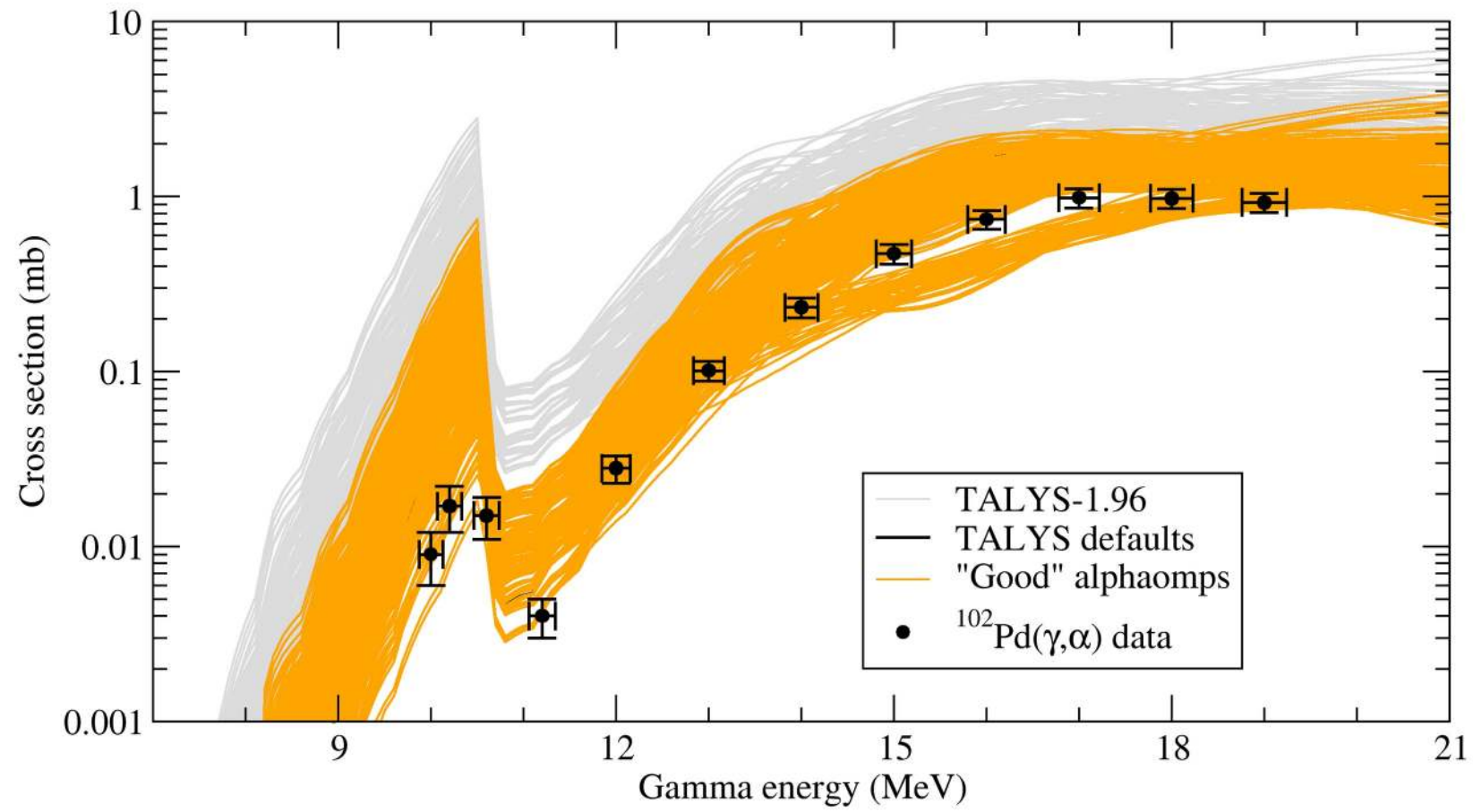
Chipps et al, submitted to PRC

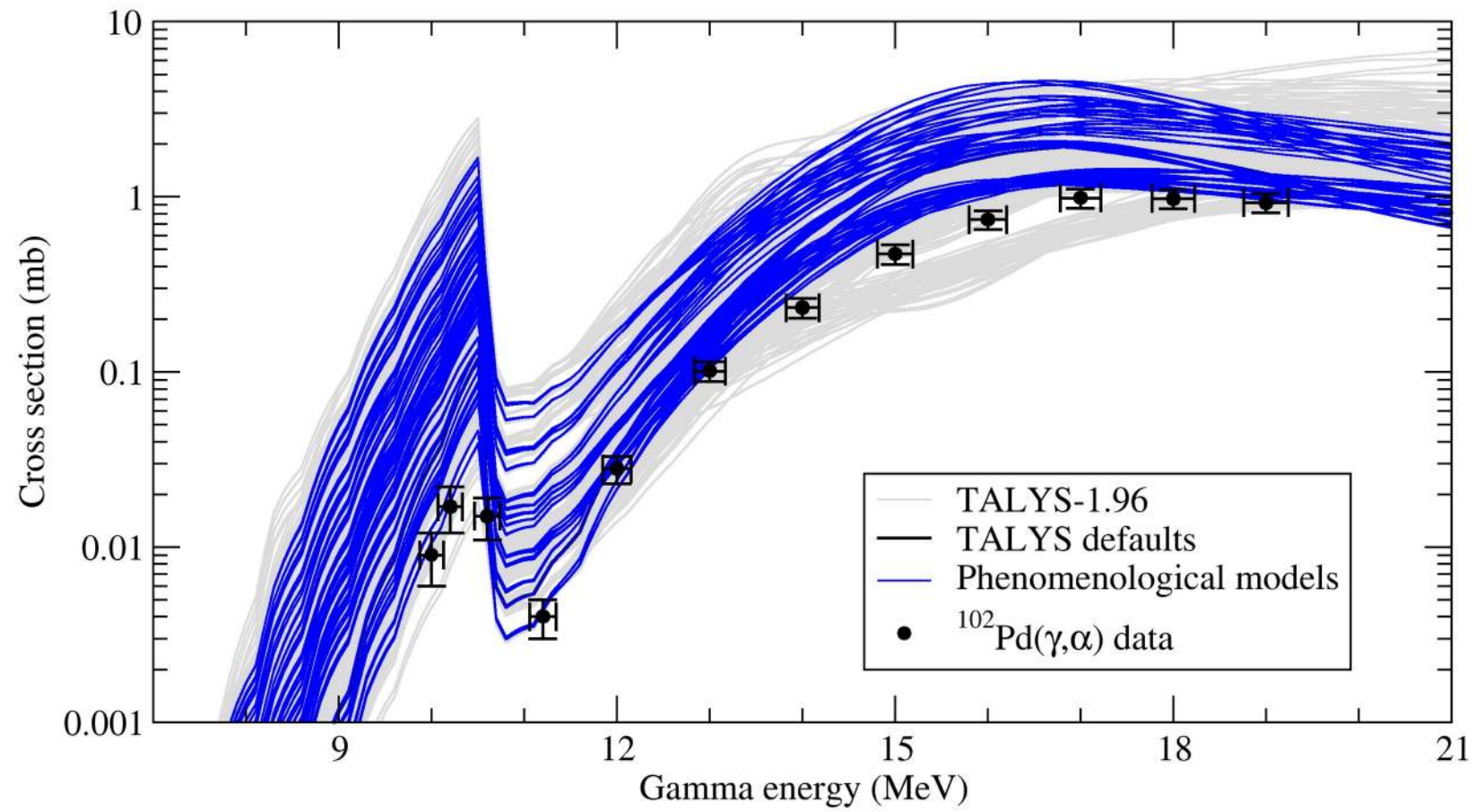


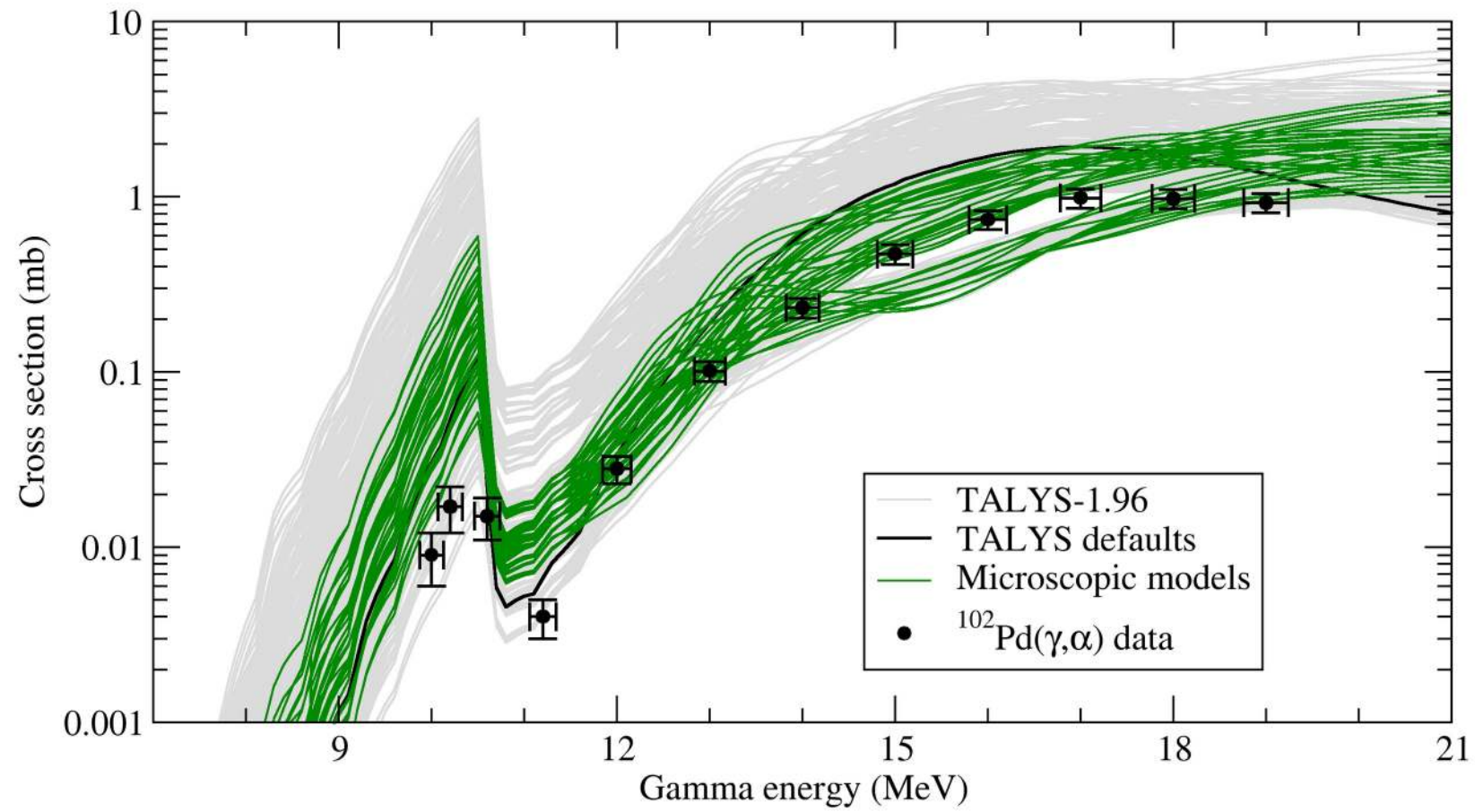


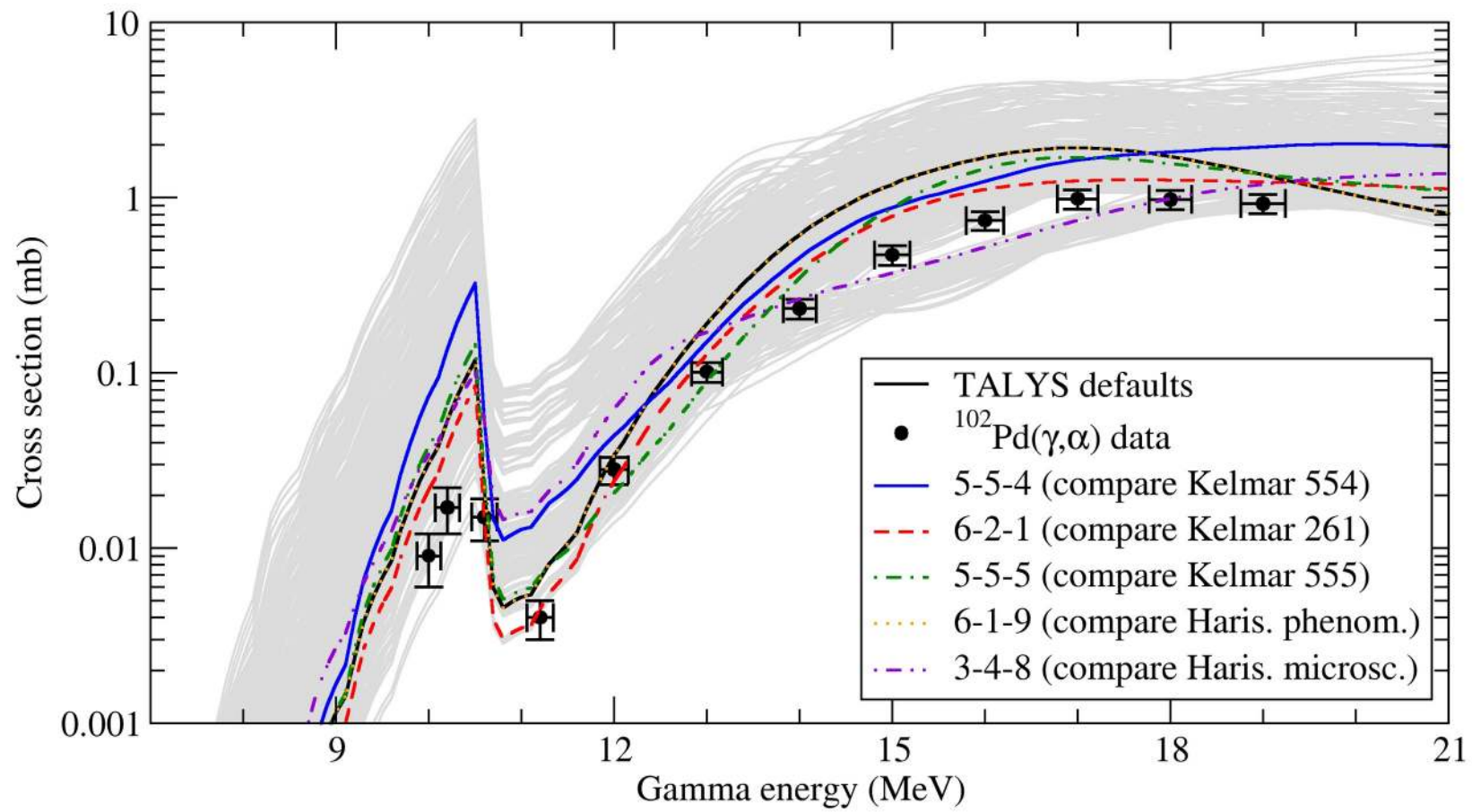
Cross sections – alpha emission

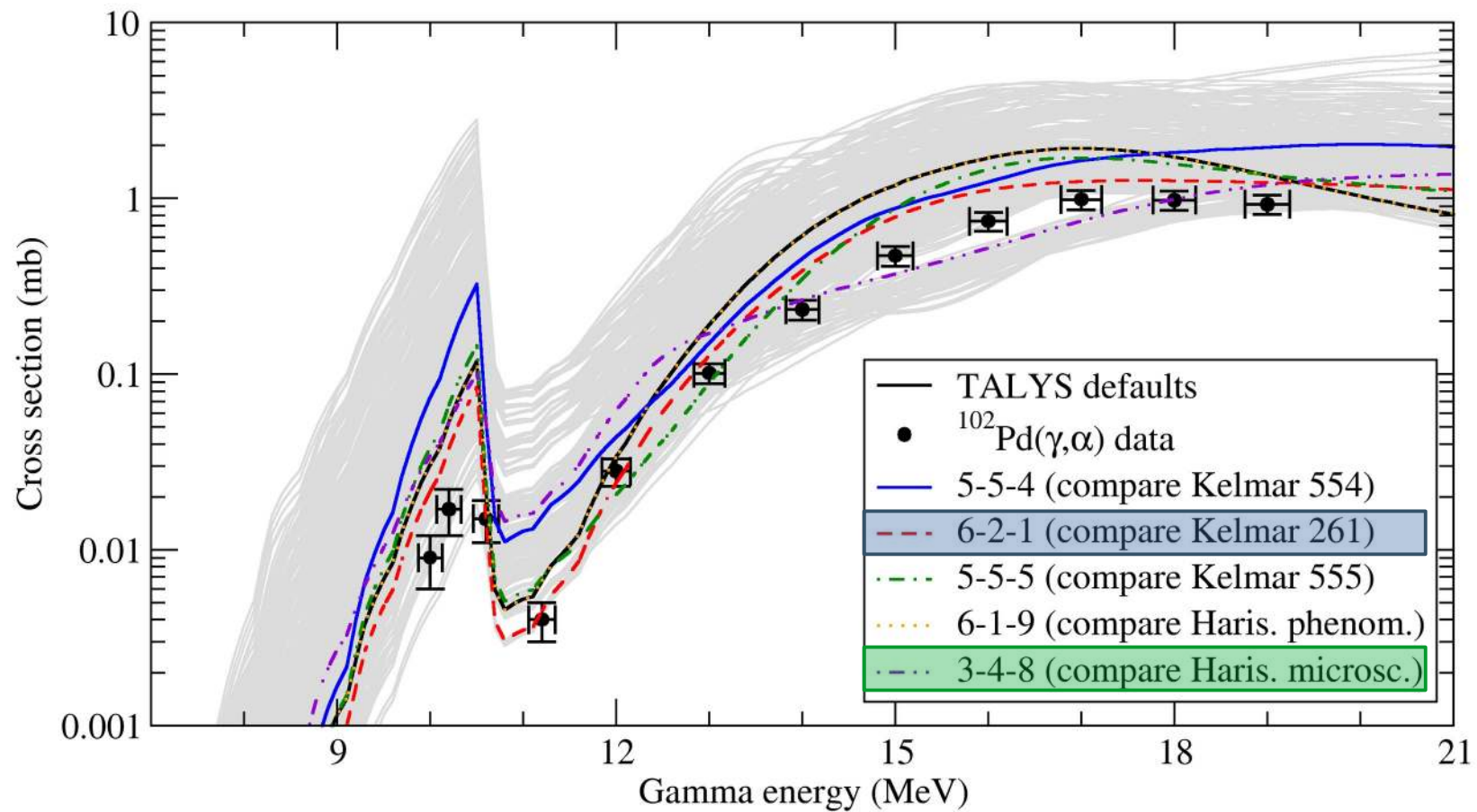






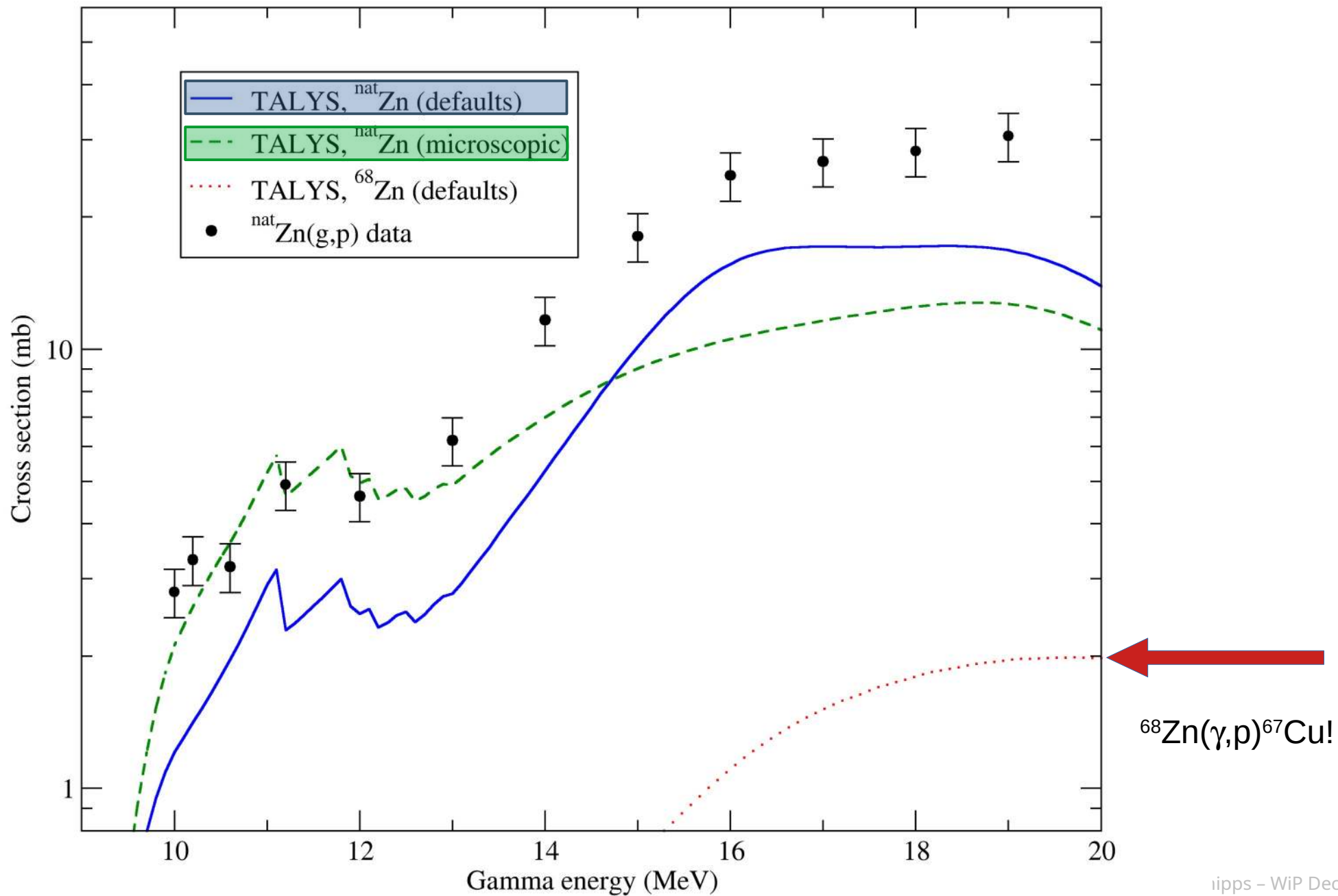






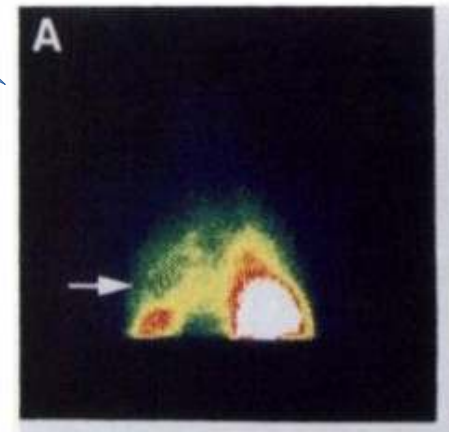
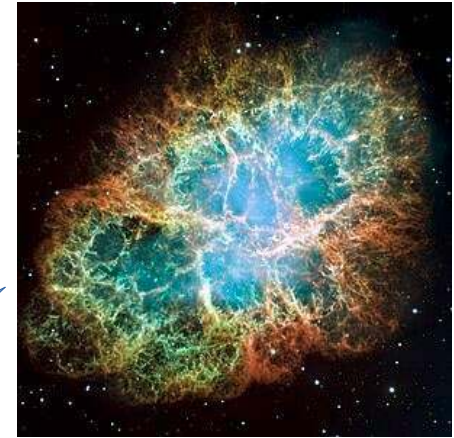
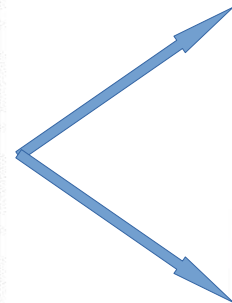
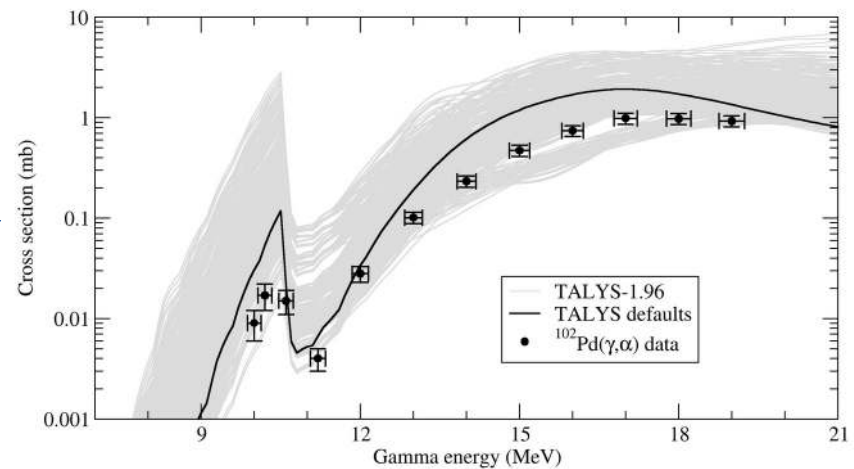
Alpha-nucleus optical model (6)
 Level density model (2)
 Photon strength function model (1)
All phenomenological

Alpha-nucleus optical model (3)
 Level density model (4)
 Photon strength function model (8)
All microscopic



Chipps et al,
submitted to ARI

Lessons learned: our analysis is robust, and shows that the standard theoretical predictions might be close, *but it may simply be luck*



Future measurements across isotopic chains will help to better inform and refine theory

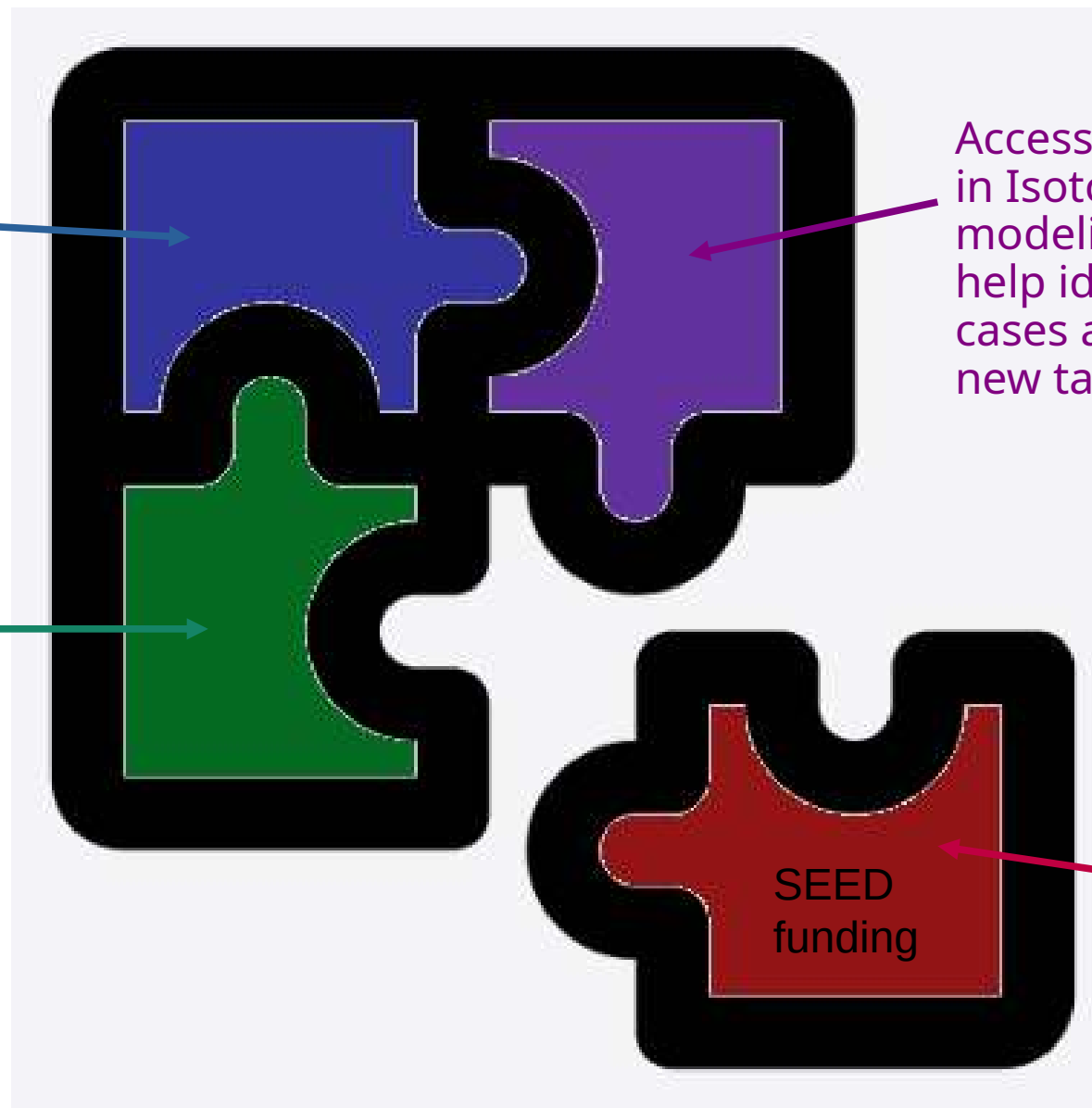
The ORNL Physics Division is uniquely poised to pursue this effort

Expertise in the techniques and equipment

World's brightest monoenergetic gamma beam right down the street (HIgS Facility, Duke)

Access to the experts in Isotopes and astro modeling (OLCF) to help identify priority cases and develop new targets

We want to be as responsive as possible to the next FOA



Thanks to my collaborators

K.A. Chipps,^{1,*} S.D. Pain,¹ D. Lattuada,^{2,3} C. Matei,⁴ G.L. Guardo,² A. Psaltis,^{5,6} D.L. Balabanski,⁴ B. Sudarsan,⁷ C.R. Brune,⁸ K. Chae,⁹ J.D. Conner,¹⁰ H.I. Garland,⁷ M.M. Grinder,⁷ G.M. Gu,⁹ W.R. Hix,^{1,11} H. Karwowski,^{12,13} T.T. King,¹ I. Kuncser,⁴ M. La Cognata,² A.O. Macchiavelli,¹ C. Marshall,^{14,13} M. Mazzocco,^{15,16} H. Pai,⁴ S. Palmerini,^{17,18} A.D. Pappalardo,⁴ T. Petruse,⁴ R.G. Pizzone,^{19,2} G.G. Rapisarda,^{19,2} A. Ratkiewicz,²⁰ M.L. Sergi,^{2,19} E. Torres,^{21,1} A. Tumino,^{3,2} A.V. Voinov,⁸ W.B. Williams III,^{22,1} Y. Xu,⁴ and Michael P. Zach¹⁰

