Constraining the Astrophysical R-Process

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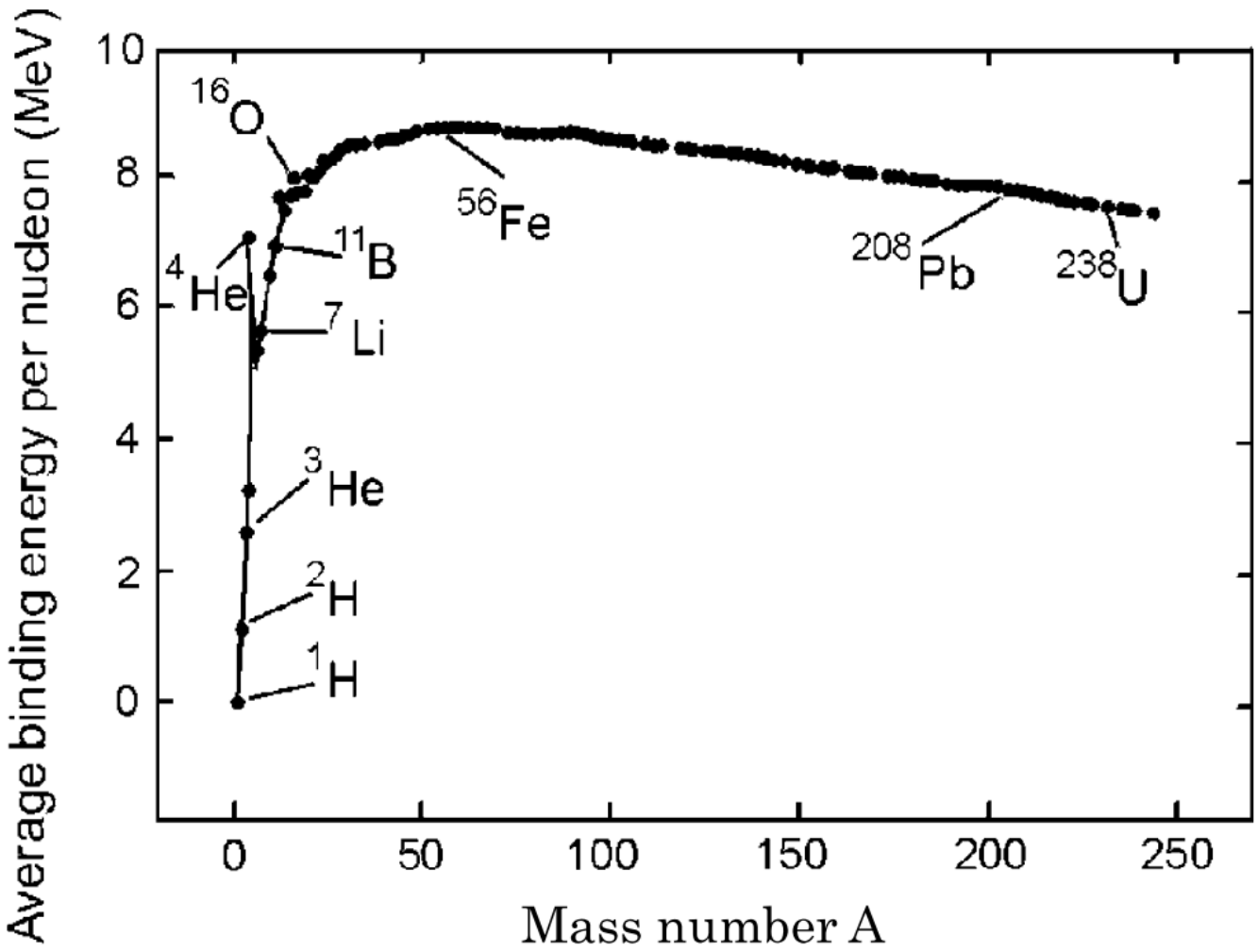
This Project

- Analyse data from proton knockout experiments using ^{208}Pb and ^{12}C targets.
- Determine masses of residual exotic nuclei.
- Study how number of events changes with number of protons knocked out.
- (Possibly deduce energy level structures.)
- Provide experimental data to constrain path of the r-process and test theoretical models.

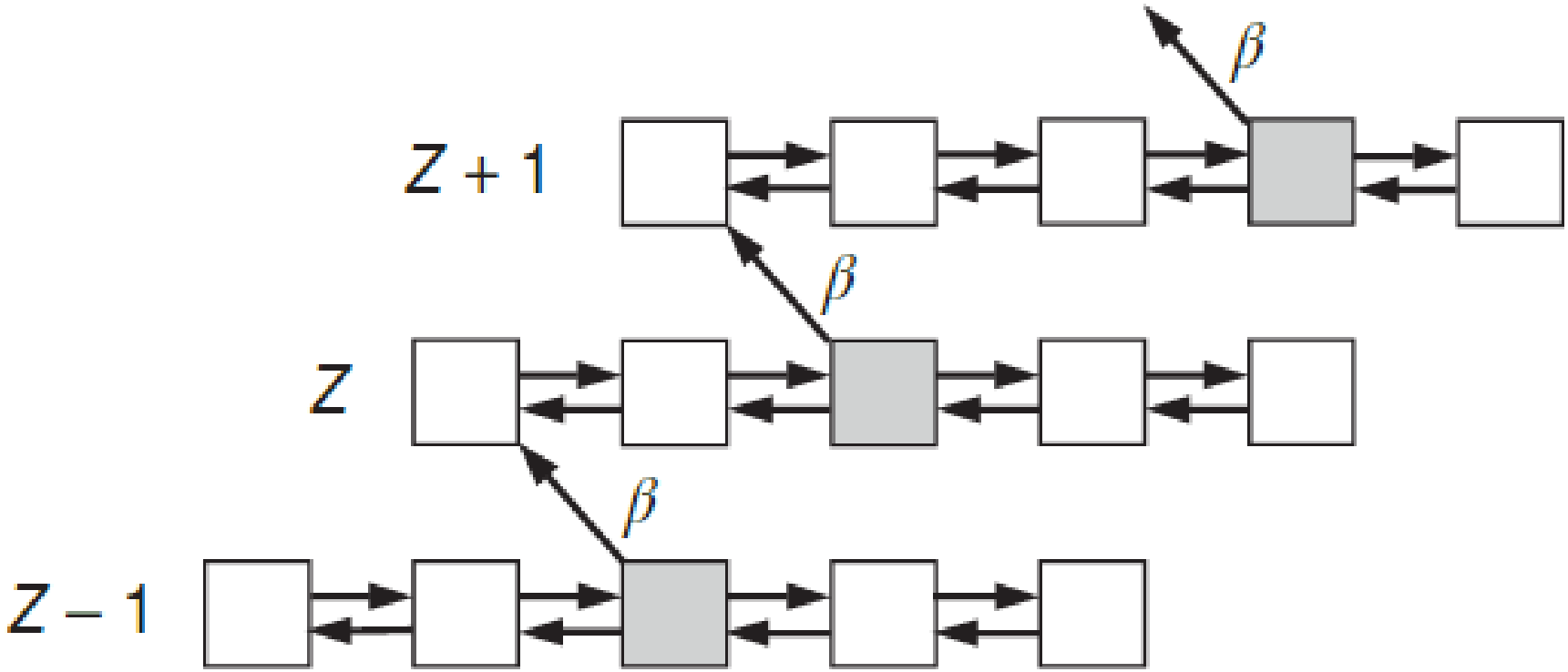
Stellar Nucleosynthesis



Kamal, A. "Nuclear Physics", Berlin : Springer (2014).

R-Process

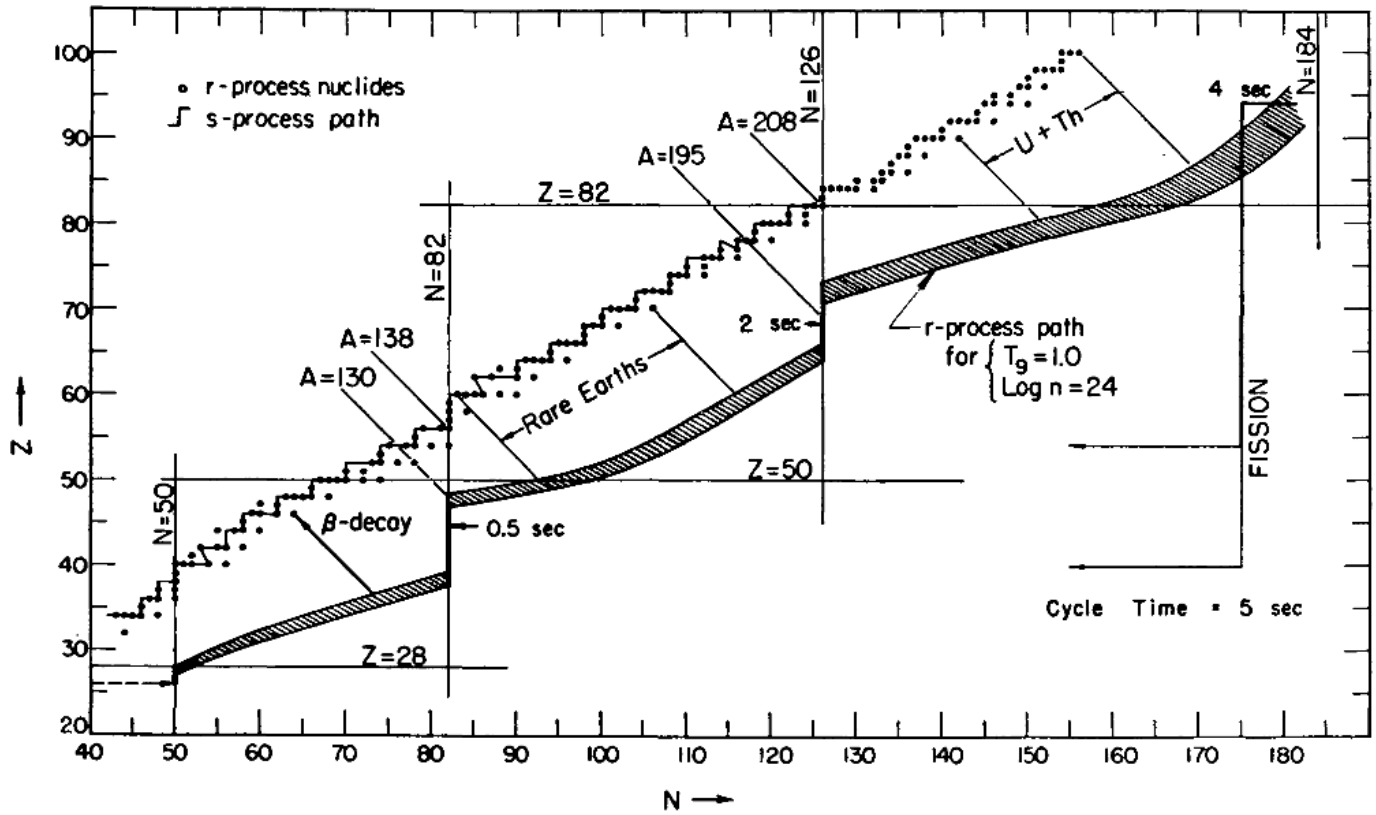
- Very high flux of neutrons available.
- Neutron capture rate"rapid" relative to β-decay rate.



Iliadis, C. "Nuclear Physics of Stars", Weinheim, Germany : Springer (2015).

Shell Influences

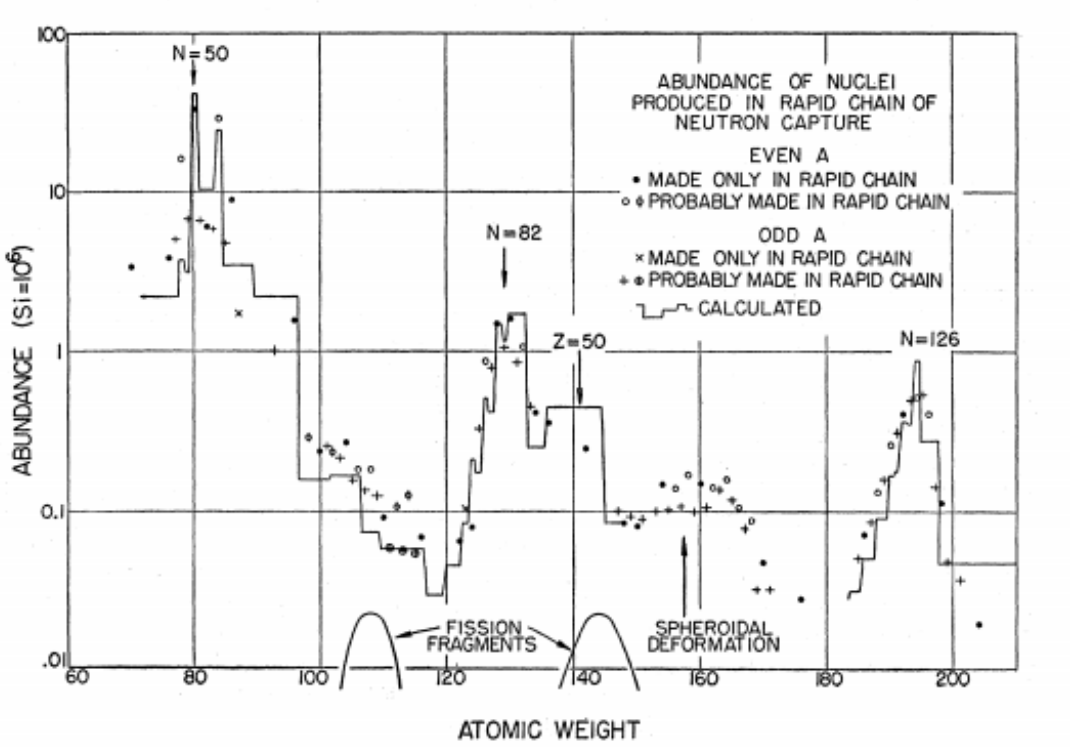
- Pile up of abundance along shell closures.



Seeger, P.A., Fowler, W.A., Clayton, D.D. *AstroPhys. J. Suppl* **11** (1965).

The Problem

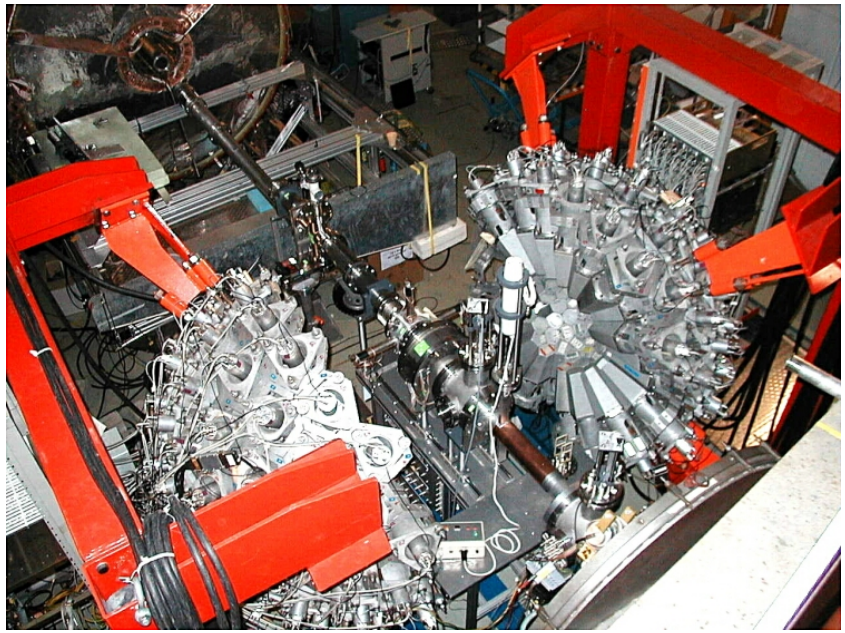
- R-Process path wonders very far from stability.
- Theoretical models do not predict observed abundance correctly.
- Majority of nuclei never observed.
- Very little experimental data on exotic nuclei.
- Does shell structure even persist for exotic nuclei?



Burbidge, E.M., Burbidge, G.R., Fowler, W.A., Hoyle, F. *Rev. Mod. Phys.* **29** (1957).

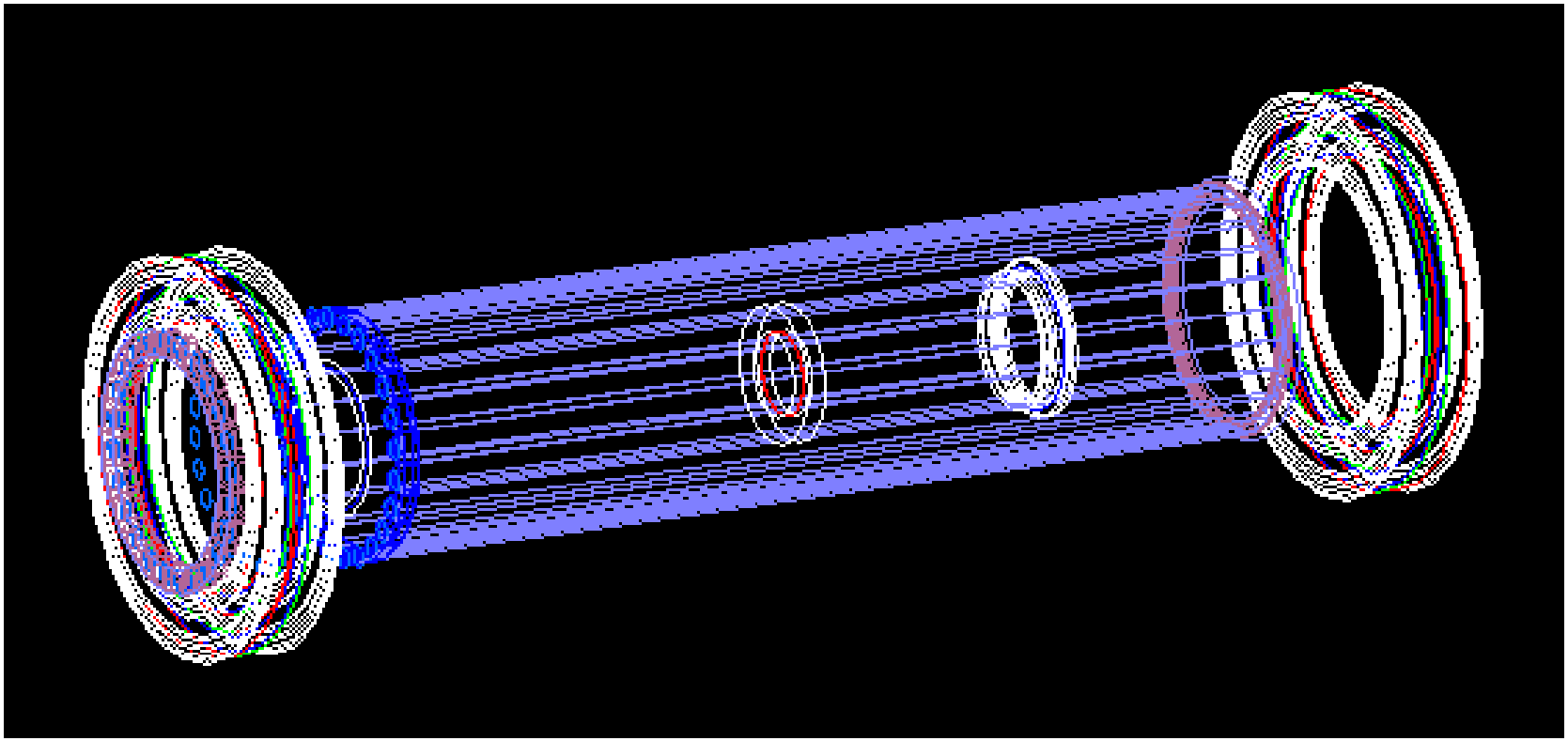
Proton Knockout At MAMI

- Use electron beam to produce photons by Bremstrahlung and direct onto target.
- Photons knockout nucleons via several processes (eg. π^0 production).
- Use Crystal Ball detector and Particle Identification Detector (PID) to measure knockout proton energies.
- Reconstruct missing mass of nuclei.



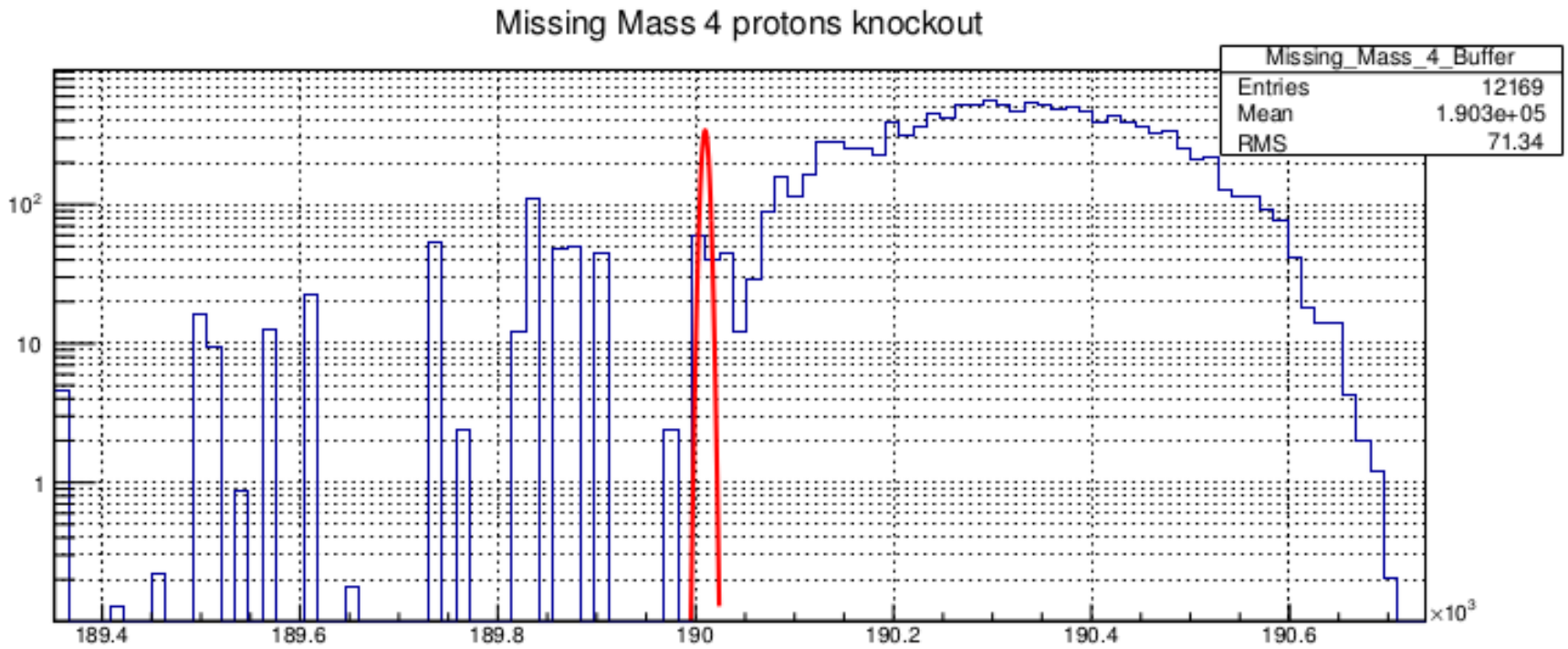
Energy Calibration

- Energy lost escaping target, travelling through PID etc.
- "Interesting" signal lost in noise.
- Use Geant4 Monte-Carlo simulation to model energy losses and calculate corrections.



Initial Results

- Fresh from GoAT, courtesy of Prof. Dan Watts.
- Possible first measurement of ^{204}Pb mass!



Conclusions and Future Work

- Will hopefully measure masses of exotic nuclei south of ^{208}Pb!
- Equivalent data for ^{12}C ready to go.
- Provide constraints for r-process path.
- Possible implications for neutron stars (^{7}H).
- Possible implications for neutrino physics.