Understanding the Transient Sky

Thanks to Sergio Almaraz-Calderon, Manoel Couder, Kelly Chipps, Heshani Jayatissa, Sean Kuvin, Ernst Rehm, Melina Avila, Zach Meisel

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*non-exhaustive list

Developments since 2015 LRP

**order doesn't correlate with importance

***shout-out to DAQs

FRIB operational

- ^{92}Mo (PAC1) and ^{58}Ni (PAC2) primary beams

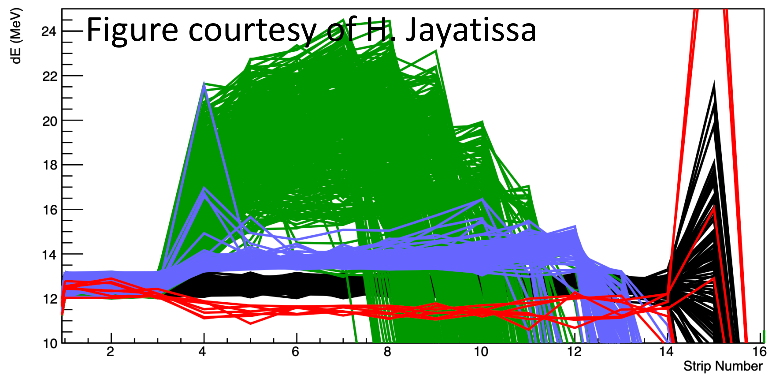

Figure courtesy of H. Jayatissa

RAISOR at ATLAS

- Light beams up to ~Ti
- Beams of nuclei along rp-process path >1 kHz

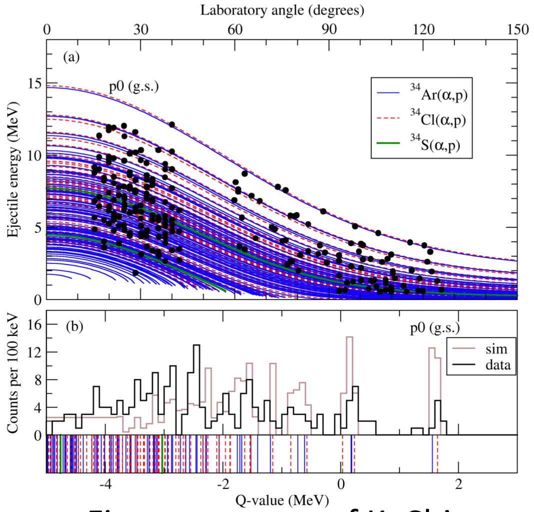

Figure courtesy of K. Chipps

ReA3/6

- 2016 campaign had a lot of X-ray burst, novae focused experiments
  - JENSA commissioning [K. Schmidt, K. A. Chipps et al 2018 NIMA 911 1-9, K. A. Chipps 2017 NIMB 407 297-303]
  - ^{34}Ar(alpha,p) with JENSA [J. Browne PhD thesis, J. Browne, K. A. Chipps, K. Schmidt et al. 2022 submitted]
  - ^{37}K+ p with ANASEN [A. Lauer PhD thesis]

CASPAR

- Low-energy, high-intensity underground accelerator first beams [D. Robertson et al. 2016, EPJconf, 109 09002], [B. Frentz et al. 2022 submitted]

Radioactive targets

- Neutron-induced measurements on ^{56}Ni, ^{26}Al (e.g.) [S. Kuvin, H.Y. Lee et al.]

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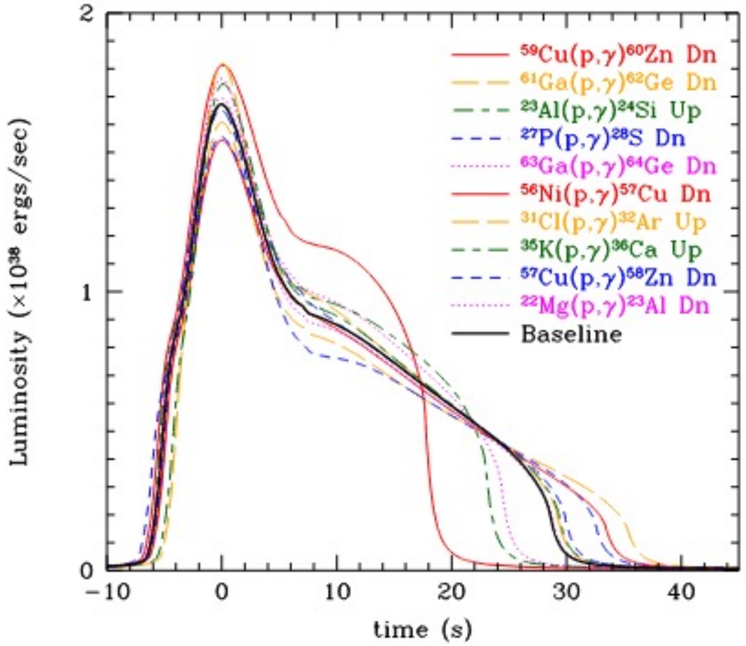
X-ray burst sensitivity studies

- Zero-D and 1-D sensitivity studies pinpointed most important reaction rates and masses [R. Cyburt et al. 2016 APJ 830:55, H. Schatz et al. 2017 APJ 844:139]
- We have been hammering away at this list quite diligently

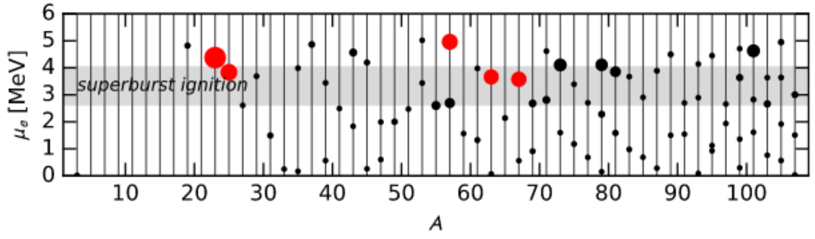


Multi-D modelling (see M. Zingale's talk earlier today)

- Flame propagation [M. Zingale et al. 2018 J. Phys Conf. Ser. 1031 012024]

Neutron Star Crust Physics

- Crustal and oceanic Urca cooling and impact on quiescent accreting neutron stars [A. Deibel et al. 2016 APJ 831 13, Z. Meisel et al. 2018 J Phys G 45 093001]
- TAS to find ground state to ground state strength [W.-J. Ong et al. 2020 PRL 125, 262701]
- Carbon/Oxygen/Neon fusion cross-sections towards more neutron-rich [R. Lau et al. 2018 APJ 859:62, A. Hood PhD thesis]



Most compelling scientific questions and opportunities in US

Leverage new and improved observables (e.g. LSST/Vera Rubin observatory, eROSITA)

- What do observations of X-ray bursts and crust cooling tell us about neutron stars?
- What is the mechanism for the unexplained strong shallow heating in accreting neutron stars?
- Can we finally definitively identify presolar nova grains?

Much-increased availability of beams of proton-rich nuclei and improvements in detectors

- How much of galactic ^{7}Li and ^{26}Al are produced by novae, and what is the limit of nucleosynthesis in novae?
    - $^{26}Al^{g,m}$(n,p) and $^{26}Al^{g,m}$(n,a) – also rad targets
- What are the abundances of iron-group elements produced in thermonuclear supernovae, and do thermonuclear supernovae contribute to the origin of the p-nuclei?
- ^{15}O(a,g), ^{30}P(p,g) !!!

Advances in modeling and computational power

- What creates the diversity of observed X-ray bursts and associated phenomena such as burst oscillations?
- What is the role of multi-dimensional effects such as burning front propagation across the neutron star surface (including on rp-process path)?
- What are the impacts of progenitor(s) and binary properties (singly vs doubly degenerate) on thermonuclear supernovae?
- What material gets ejected into the interstellar medium?

Strategy

*We need something like JINA/JINA-CEE

- Push boundaries on proton-rich side with FRIB, RAISOR
- Continue support for university and other smaller facilities to produce high-precision high-quality reaction rates (ARUNA labs, CASPAR)
- Radioactive targets (e.g. from isotope harvesting, also increased activity in US with isotope production)
- Multi-messenger collaborations (esp. presolar grain community)
- High-intensity beams, hydrogen (the element) targets to take advantage of instruments such as SECAR: Radiative captures require beam intensity of $\sim 10^{7\text{-}8}$ pps minimum to leverage the full capabilities of SECAR
- Take advantage of GRETA+S800/HRS, FDSi/FDS and other crowd-sourced instruments
- Continue investment in active target instruments such as ANASEN, TexAT, AT-TPC, MUSIC
- Measurement/calculations of cross-sections for astromers and inclusion of astromers in models
    - Isomerically pure beams (resonantly ionised source?)

Potential Pitfalls

- Need to ensure that measurements with a given nucleus is not 1-and-done
- Need to ensure de-centralisation of NA efforts

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