The Joint Institute for Nuclear Astrophysics

Weak interaction rates for Supernovae calculations measured via the (t,^{3}He) reaction

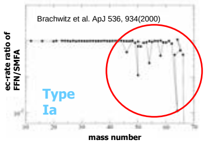
R.G.T. Zegers, S.M. Austin, D. Bazin, B.A. Brown, A. L. Cole, C. Guess, Sanjib Gupta, G.W. Hitt, M. E. Howard (OSU), H. Schatz, Y. Shimbara

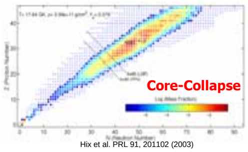
How do stars explode?

Currently, the Supernovae explosion mechanism is not fully understood and models built to simulate them fail to produce explosions. One major astronomical observable of supernovae is the nucleosynthesis output and it has been shown that weak interactions, particularly electron capture, strongly effect isotope production during late-stage stellar evolution.

•Type Ia Supernovae (accreting white dwarfs)

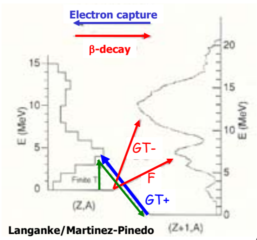
- e-capture controls isotopic composition
- e-capture constrains ignition density & burning front speed





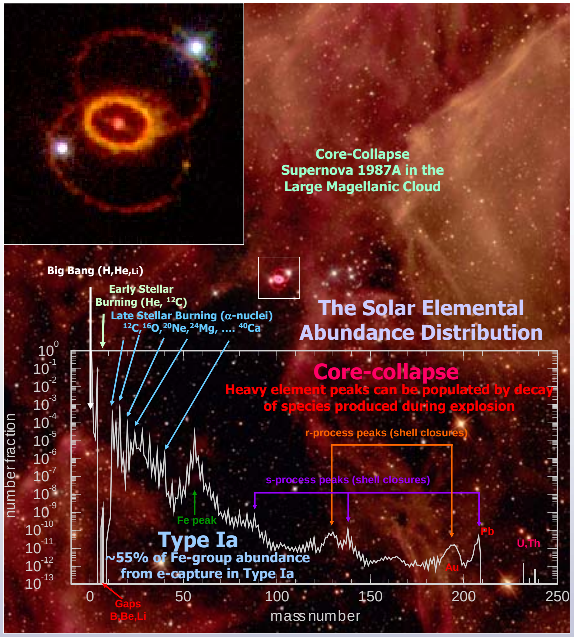
• Core Collapse Supernovae

- e-capture strongly affects pre-collapse dynamics
- e-capture modifies properties of the core
- nuclei of importance: **pf and sdg shell nuclei (stable & unstable)**
- β-decay important in later stage (n-rich nuclei)
- model dependence of rates (IPM, LSSM, SMMC) leads to large differences in stellar evolution



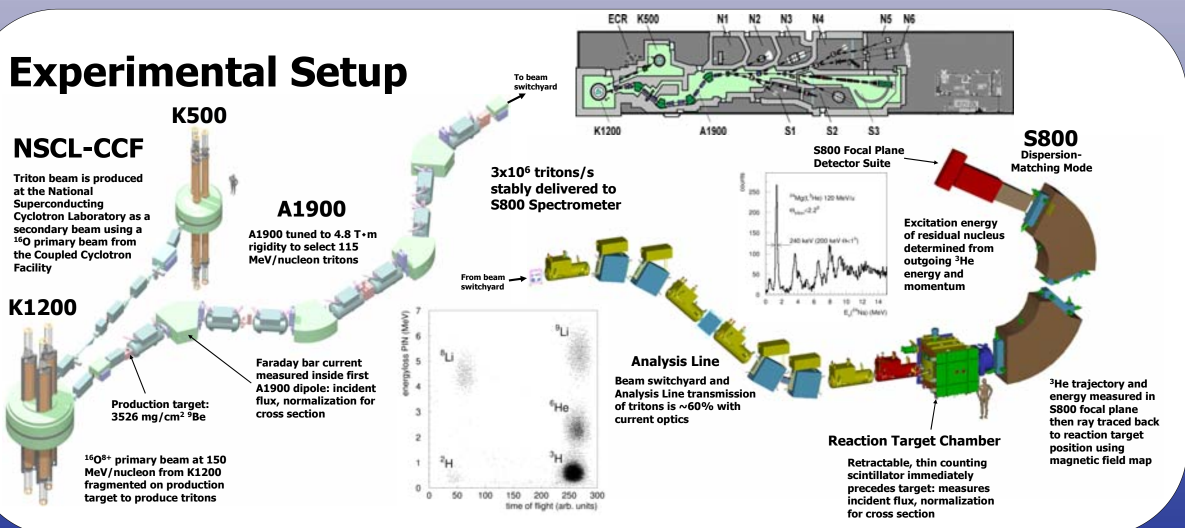
• Large fraction of weak strength in both cases lies in Gamow Teller Transitions

- much more difficult to treat theoretically
- Charge-Exchange experiments crucial for validating modern calculations of weak rates



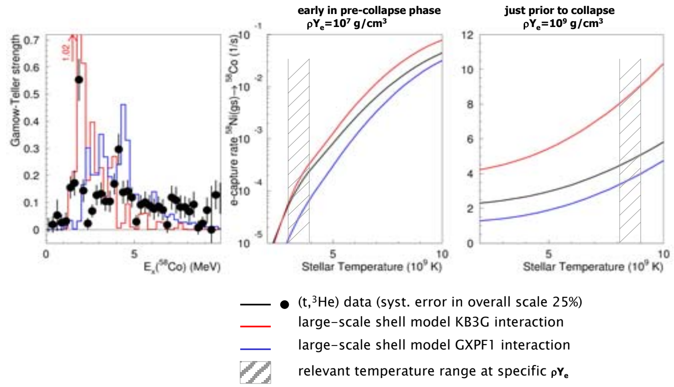
Supernova 1987A As seen by the Hubble Space Telescope WFP Camera 2 (background and insert, upper left). Solar system elemental abundance distribution (H. Schatz; bottom overlay).

Experimental Setup



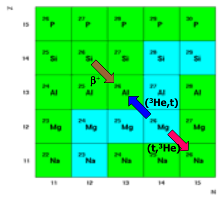
Results

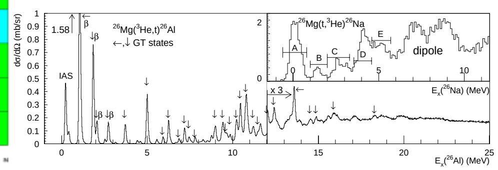
Gamow-Teller Strength in ^{58}Co via ^{58}Ni(t,^{3}He)

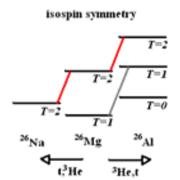


Analysis Methods

$$\frac{d\sigma}{d\Omega}(q=0) = KN_D\left|J_{\sigma\tau}\right|^2 B(GT)$$

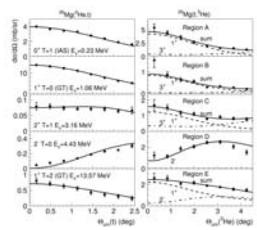


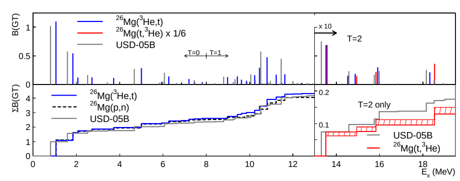




Known GT-rates from β-decay data can be used for strength calibration in Charge-Exchange reactions.

Multipole decomposition of angular distributions allows for identification of GT-states (ΔL=0).





This project is funded by the NSF through grant PHY0216783, and the Universities of JINA. The NSCL is funded by the NSF