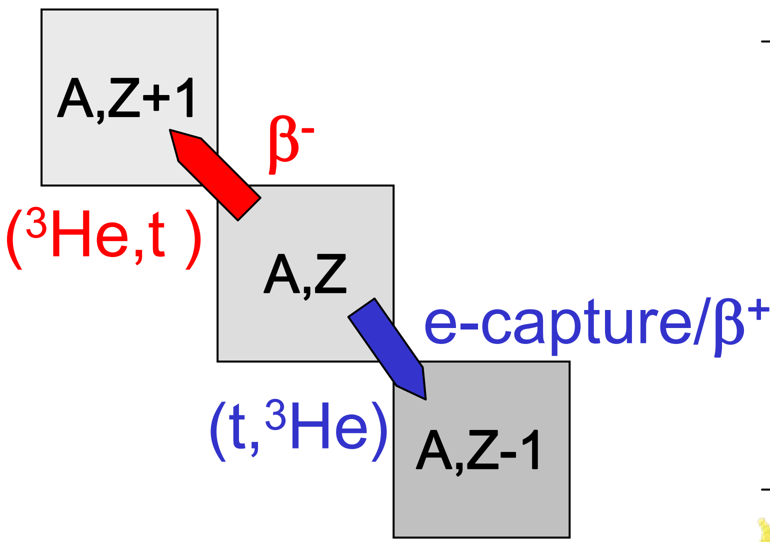
Measuring Gamow-Teller Strength with the (t,^{3}He) Charge-Exchange Reaction at 115 MeV/u



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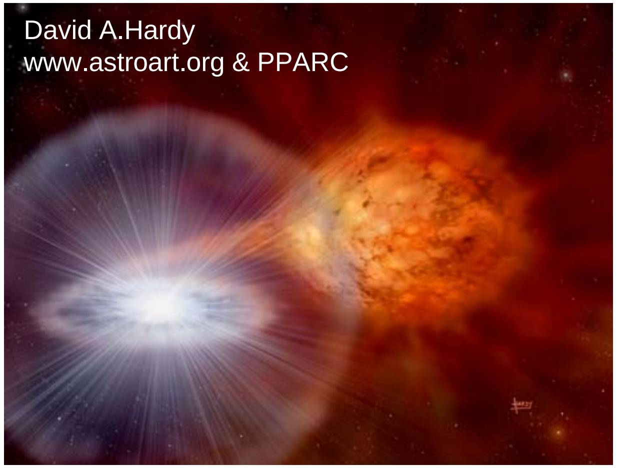
Motivation

Electron-capture(EC) in high-density, electron-degenerate environments

Large-Scale Shell-Model interactions used for nuclear structure input

Can never measure all transitions, but can test LSSM interactions

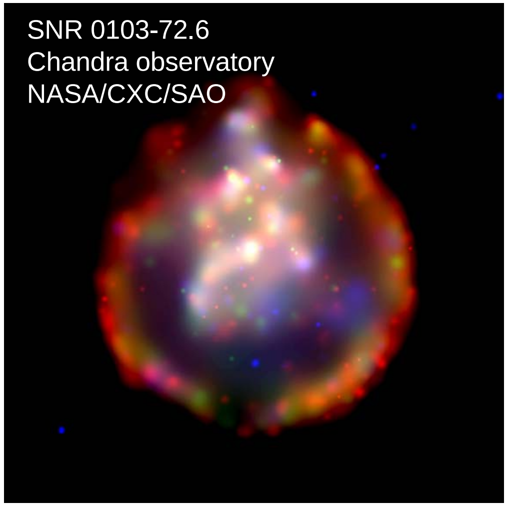


Type Ia

- **EC** reduces Y_e
- Affects ignition density, flame propagation speed, turbulent density
- **A = 55-65** Nuclei (~ 40% of captures on pf-shell nuclei)

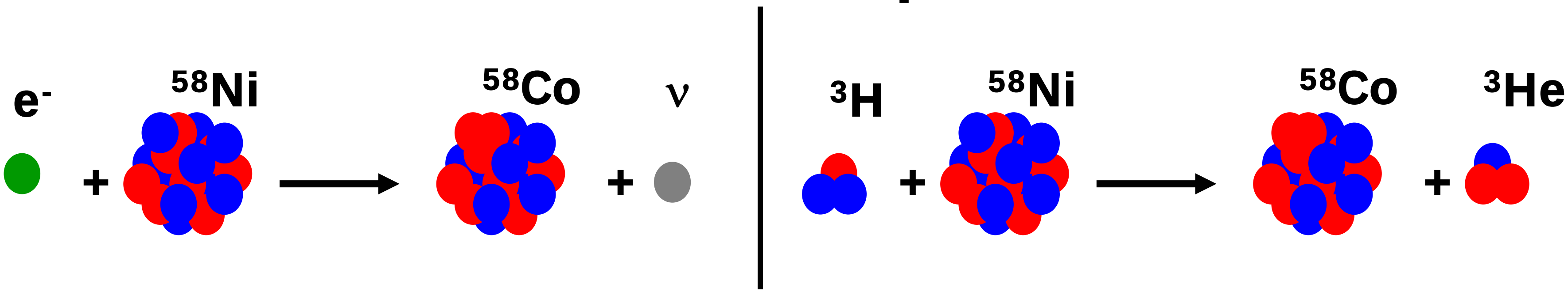
Core-Collapse

- **EC** reduces Y_e, degeneracy pressure
- neutrino emission cools and carries entropy from core
- accelerates collapse
- **A ~55 to 100+** (EC's can happen on wide mass range)



Brachewitz,Martinez-Pinedo,
Langanke and many others

Technique



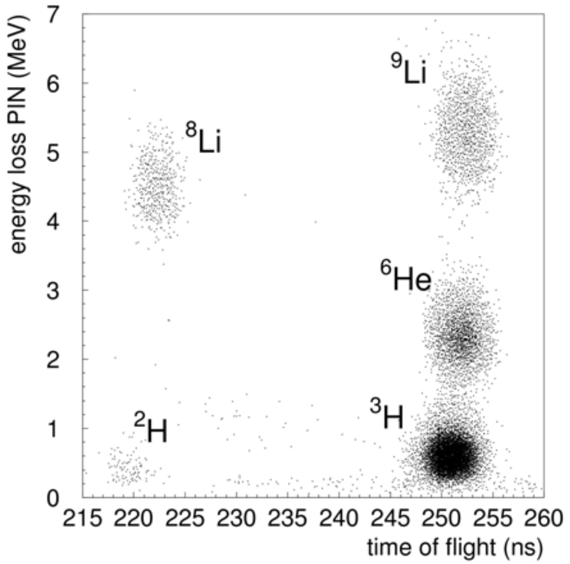
- **EC** can proceed by Fermi(F) or Gamow-Teller(GT) transition ($\Delta L=0$, $\Delta S=0$, $\Delta T=0$ or $\Delta L=0$, $\Delta S=1$, $\Delta T=1$)
- Large amount of strength energetically inaccessible in β-decay measurement
- Charge-Exchange(CE) reaction only way to probe full GT-strength
- CE reaction calibrated with β-decay; extraction in first order model-independent

$$\left.\frac{d\sigma}{d\Omega}\right|_{\Theta=0} \propto B(GT)$$

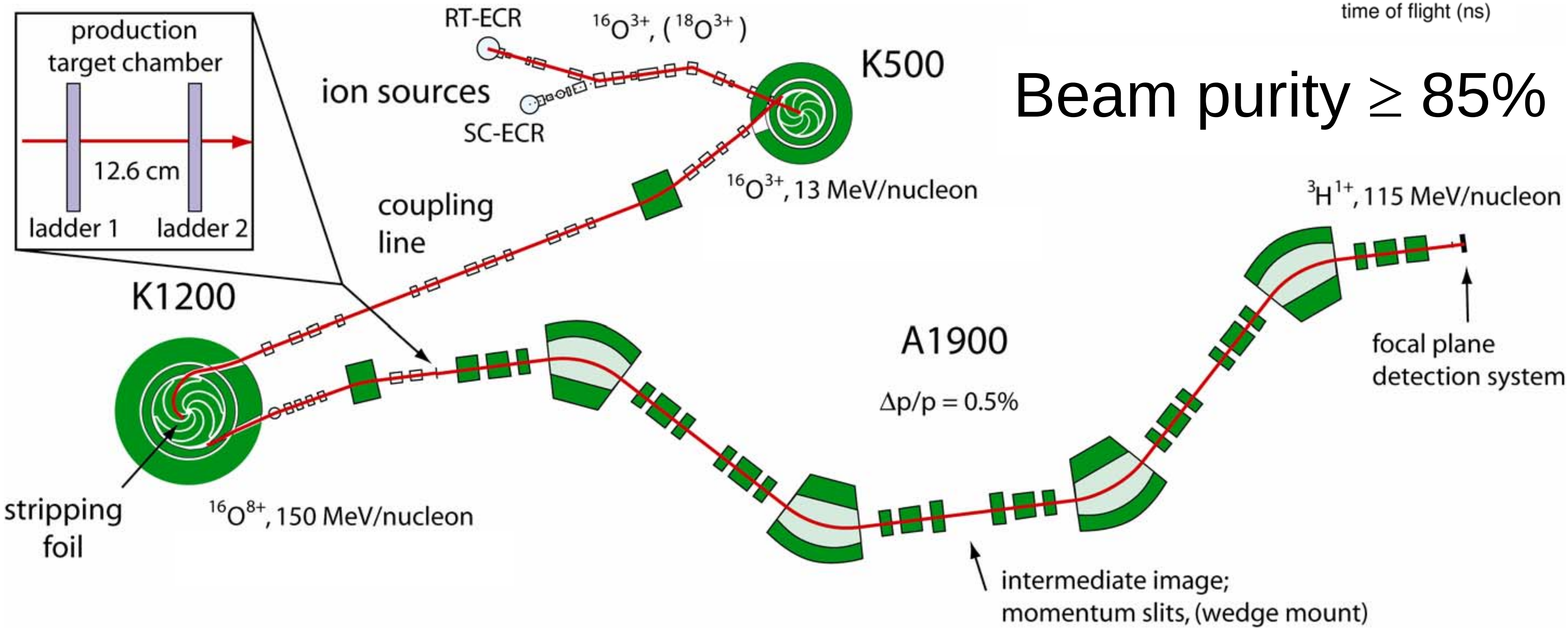
T.N. Taddeucci, et.al. Nucl.Phys. A469 (1987) 125-172.

Tritons from ^{16}O Fragmentation

~200 keV resolution achievable at NSCL-CCF, must make secondary triton beam



Beam purity ≥ 85%



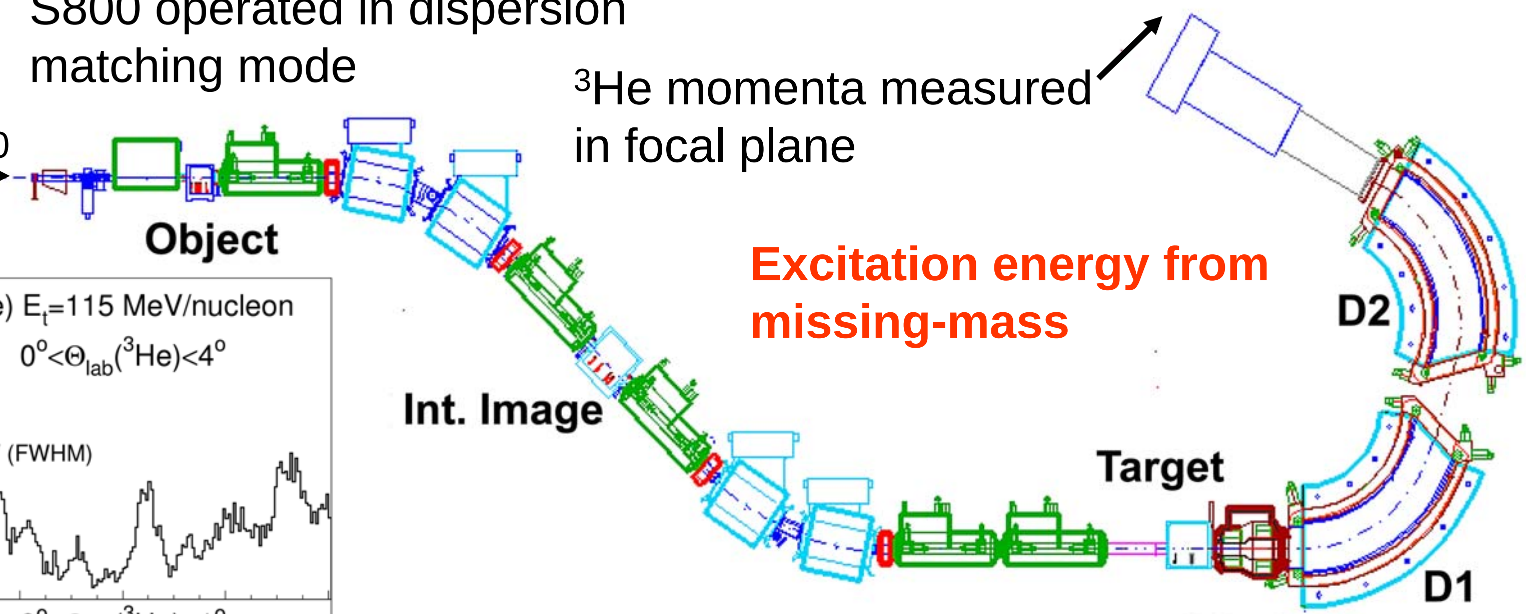
GT Cross-Section Measurement

$^{12}CD_2$, ^{58}Ni, $^{24,26}Mg$, (^{64}Zn)

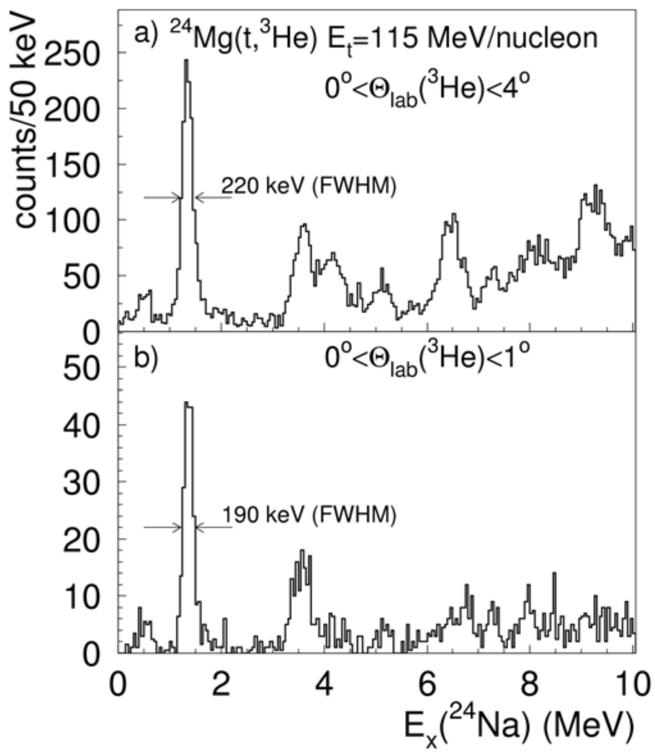
Part of thesis experiments of M. Howard, G.W. Hitt

S800 operated in dispersion matching mode

^{3}He momenta measured in focal plane



Excitation energy from missing-mass



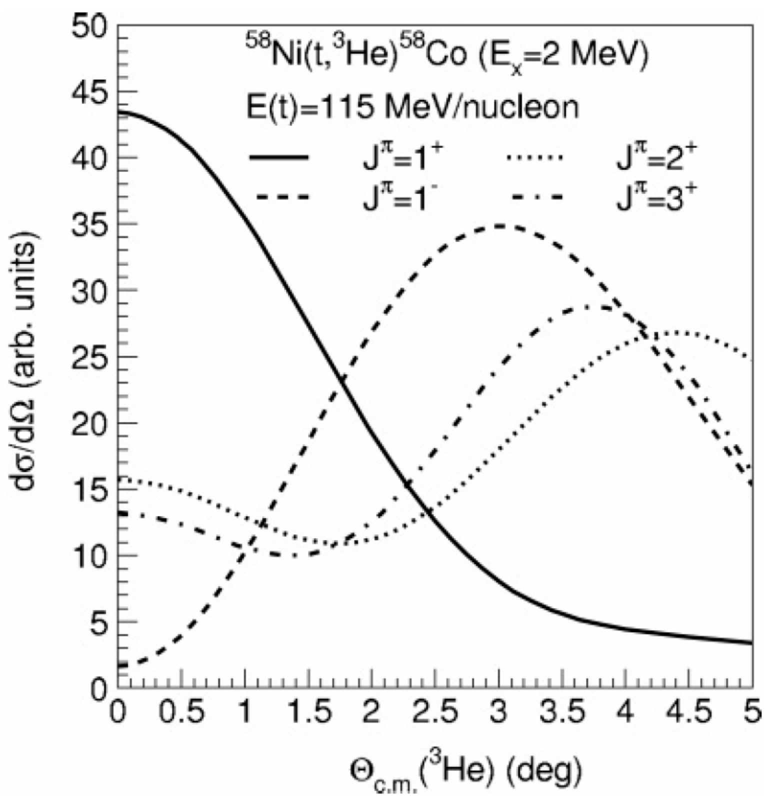
Resolution competitive; ~200 keV(FWHM), ~0.5° in scattering angle

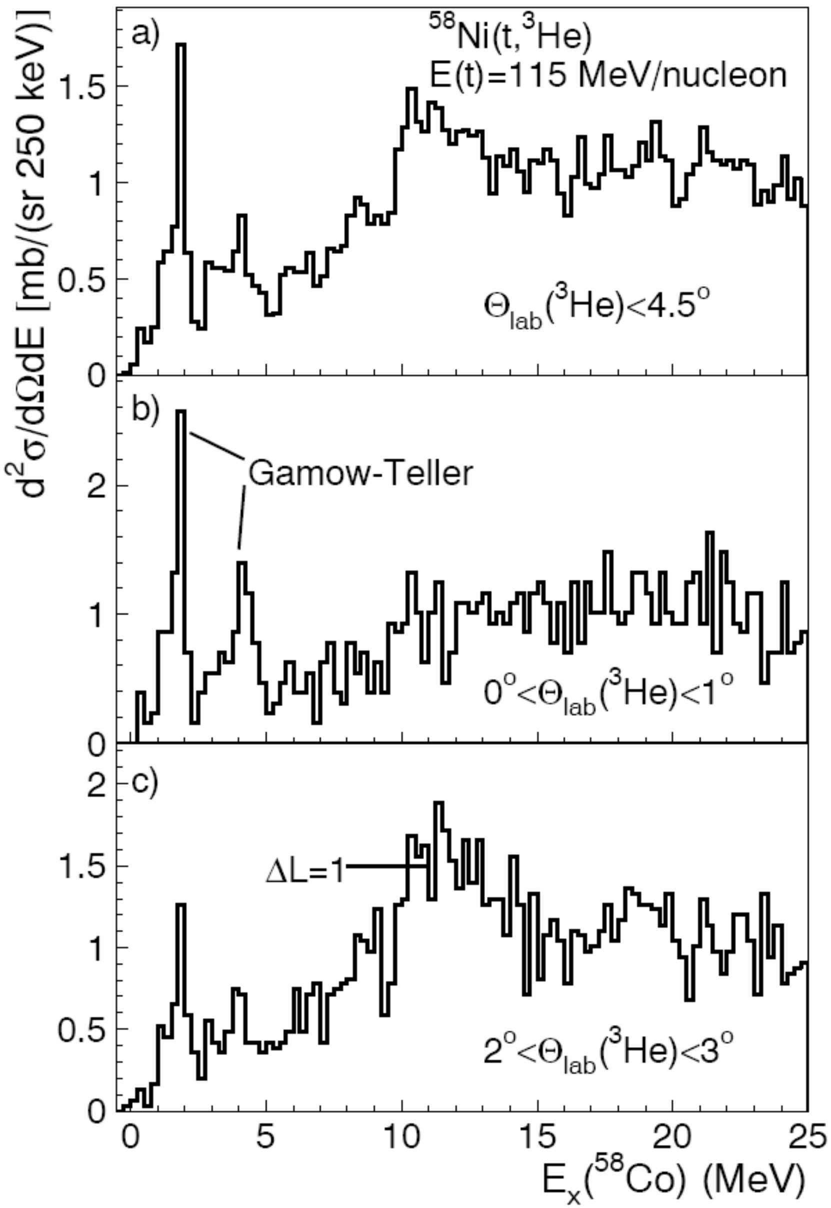
Comparable to stable beams (with work on optics, raytracing)

Triton intensity at target: ~(4-5) x 10^6 pps

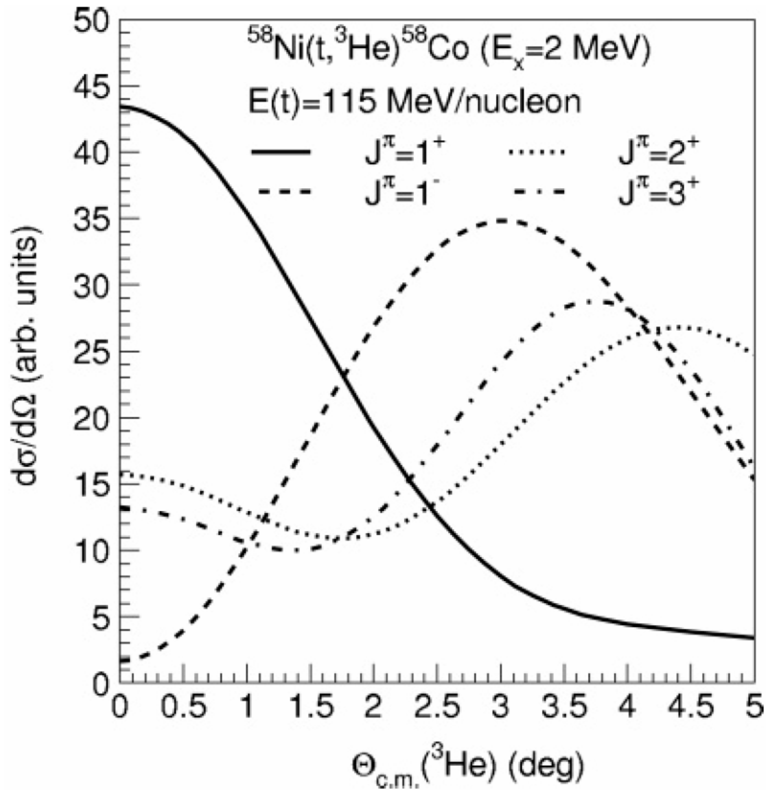
Data Analysis

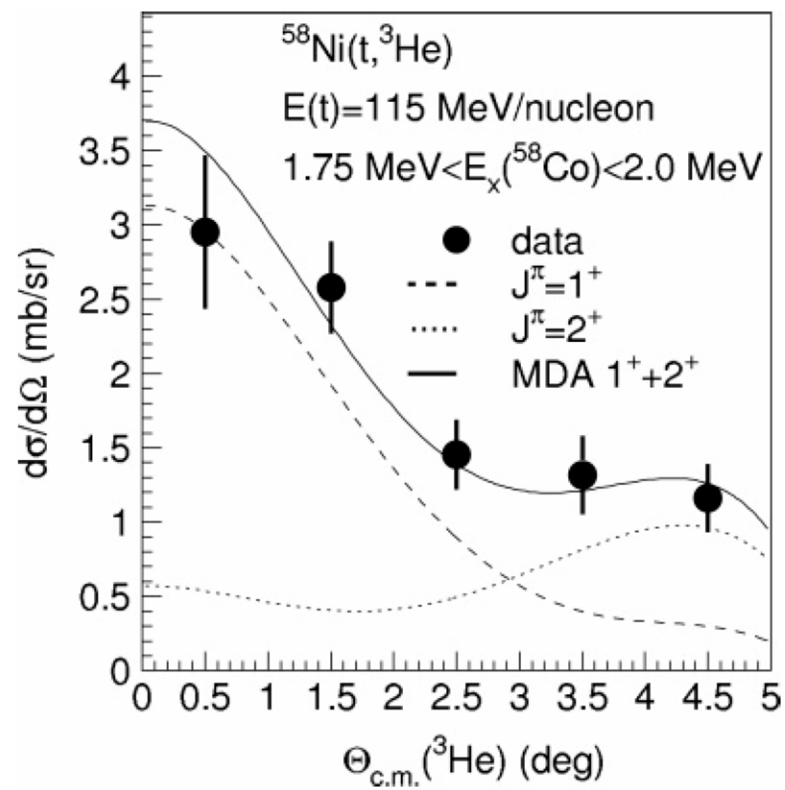
- Identify GT states from angular distribution





Extracting B(GT)



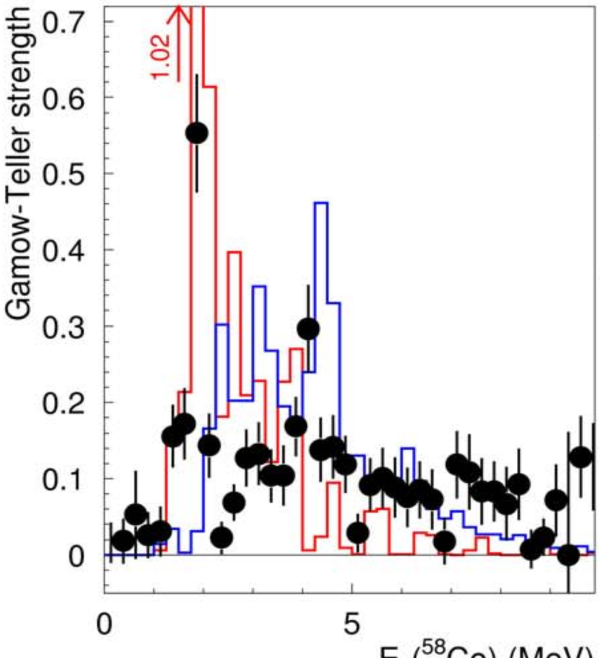


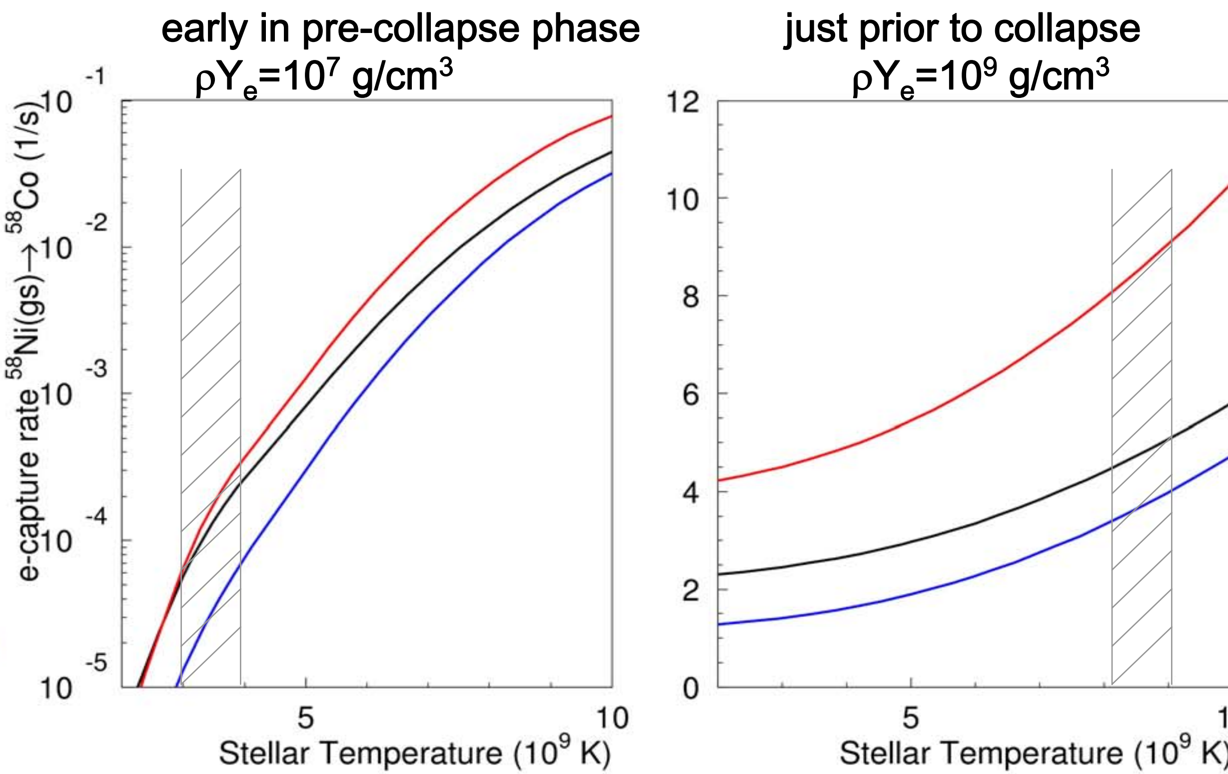
Select GT states, in case where state is separable, from its shape (ΔL=0)

In cases where state is not separable, determine GT strength content, from fitted ΔL=0 component

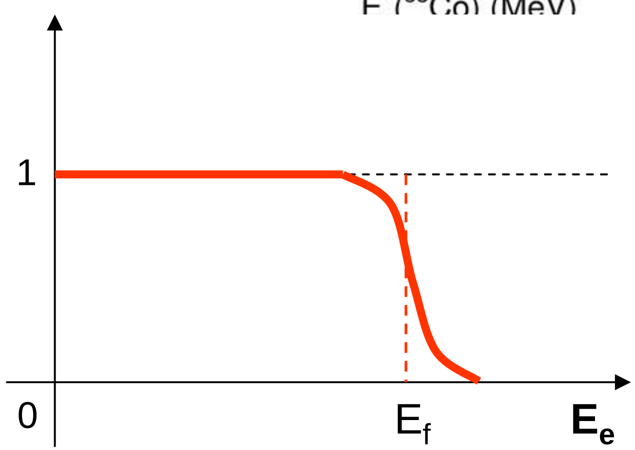
$$\left.\frac{d\sigma}{d\Omega}\right|_{\Theta=0} \propto B(GT)$$

EC Calculation Example





EC rate calculations by Sanjib Gupta



- ● (t,^{3}He) data
- large-scale shell model KB3G interaction
- large-scale shell model GXPF1 interaction
- relevant temperature range at specific ρY_e

Conclusion & Outlook

- Successful development of (t,^{3}He) probe at NSCL-CCF, useful for determining B(GT) distribution, as shown in ^{58}Co example
- Comparison with predicted strength using KB3G and GXPF1 LSSM interactions
  - Highlights need for improved interactions
  - Highlights sensitivity of EC rate on B(GT)
- Outlook: currently analyzing ^{64}Zn
- CE group at NSCL
  - $0\nu\beta\beta$ – decay using (t,^{3}He) and (^{3}He,t)
  - (p,n) CE in inverse kinematics
  - (^{7}Li,^{7}Be) CE in inverse kinmatics