Gamma Detection for Transfer Reactions in Inverse Kinematics

David Radford / Felix Liang
ORNL Physics Division

Outline:

- **Experimental goals and challenges**
- **(^{9}Be,^{8}Be) neutron transfer on ^{134}Te with CLARION**
- **Use of the Spin Spectrometer for transfer reactions**

Experimental Goals

Want to measure:

- **Angular distributions of outgoing light charged particles**

  - Range of θ_{lab} ~ 40 - 110 degrees?

- **Cross-sections, spectroscopic factors**

- **Need to select (resolve) levels of interest** in the product nuclei

Experimental Challenges

Consider, for example, d(^{134}Te, p)^{135}Te

- **Inverse kinematics leads to large kinematic broadening of proton energy**
  - Even with ~mm position resolution, beam spot gives large E_p spread
- **Energy loss of heavy beam in target also spreads proton energy**
  - Weak beam intensity prohibits use of very thin targets.

These effects lead to poor resolution in Q-value, *i.e.* excitation energy of product

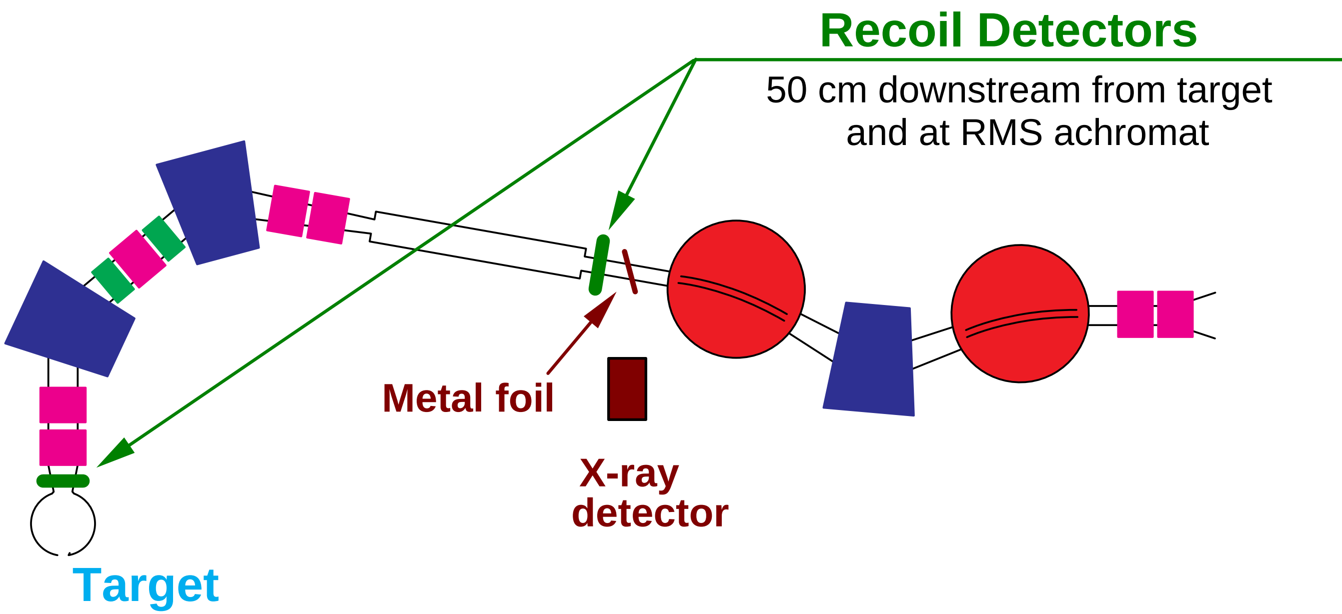
- Cannot resolve states that are closer than ~300 keV at best.
- Therefore cannot measure required angular distributions etc.

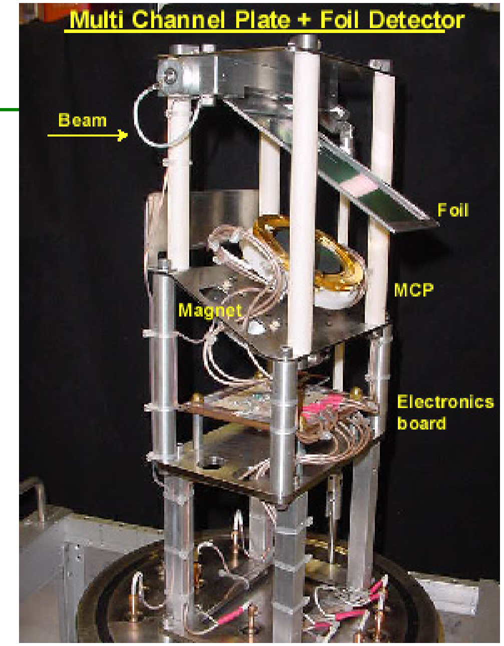
- **Beams are weak**
  - Require large proton and γ efficiency

  - Detection of proton provides clean trigger
- **Beams are isobar cocktails, *i.e.* contaminated**

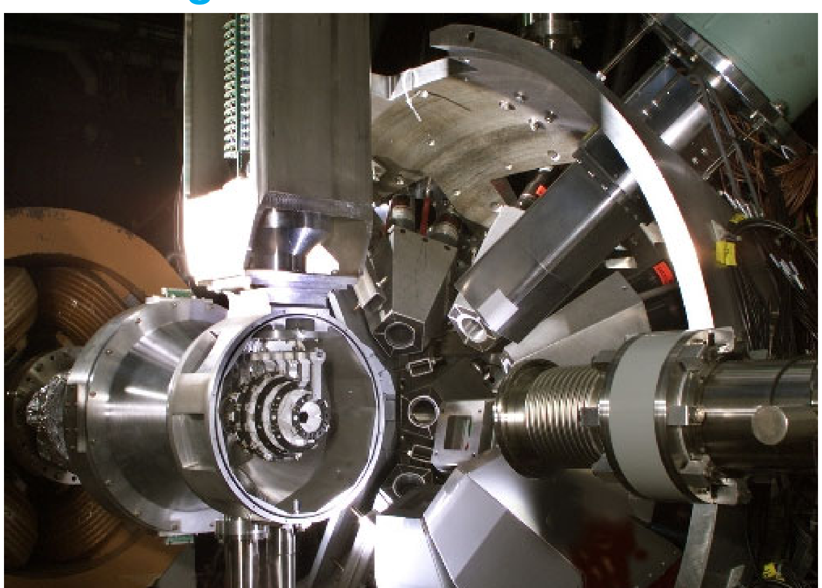
  - Energy resolution of protons is good enough to separate isobars, if excitation energy can be determined independently.

Setup for experiments with neutron-rich RIBS





Foil plus multichannel plate



CLARION

11 segmented clover Ge detectors

10 smaller Ge detectors

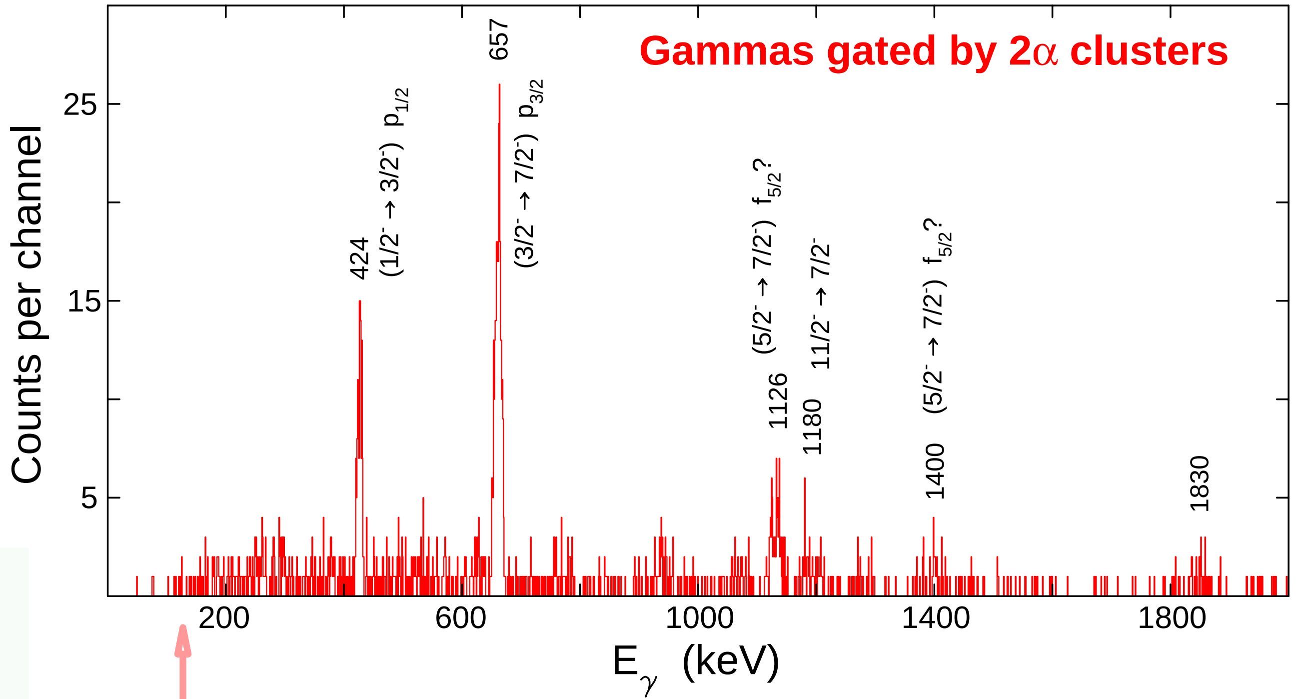
HyBall

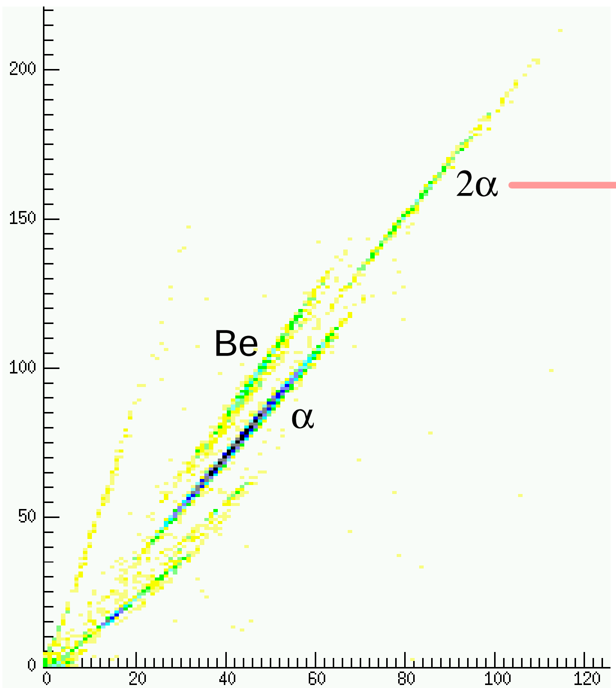
95 CsI detectors with photodiodes

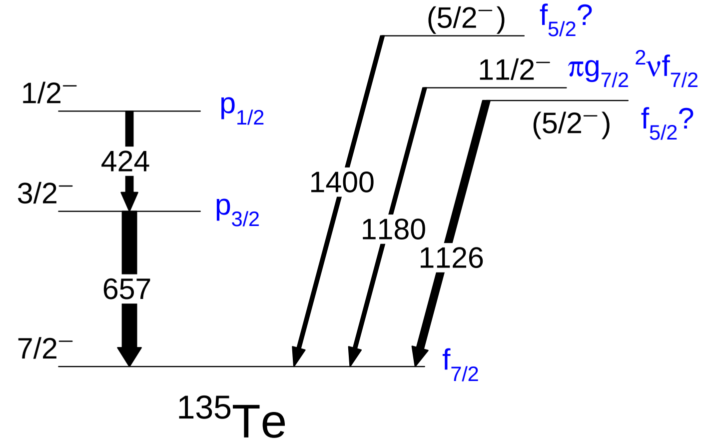
Transfer Reactions with Neutron-Rich RIBS

$^{9}Be(^{134}Te,^{8}Be)^{135}Te$ → 2α

~4 MeV per nucleon

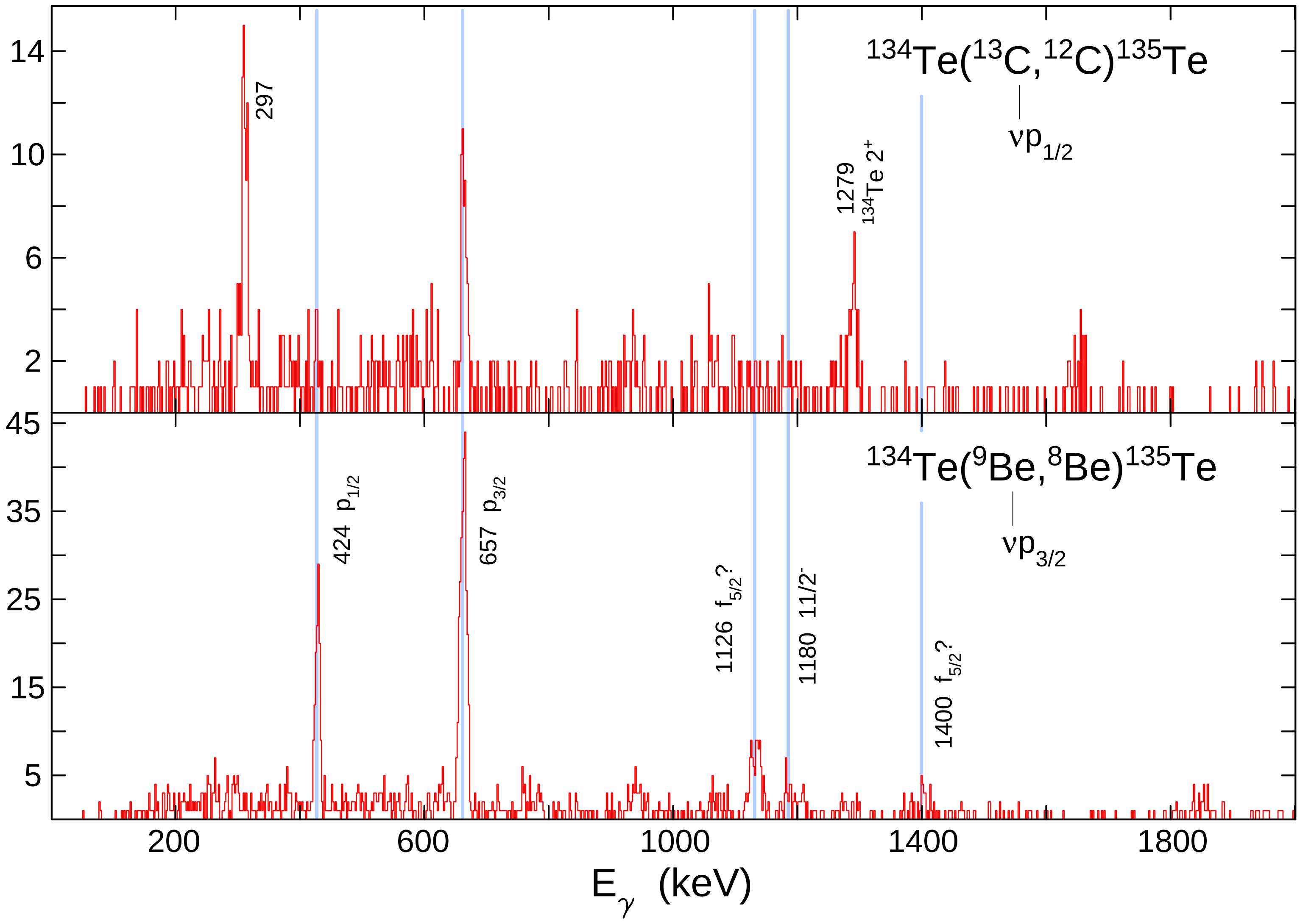






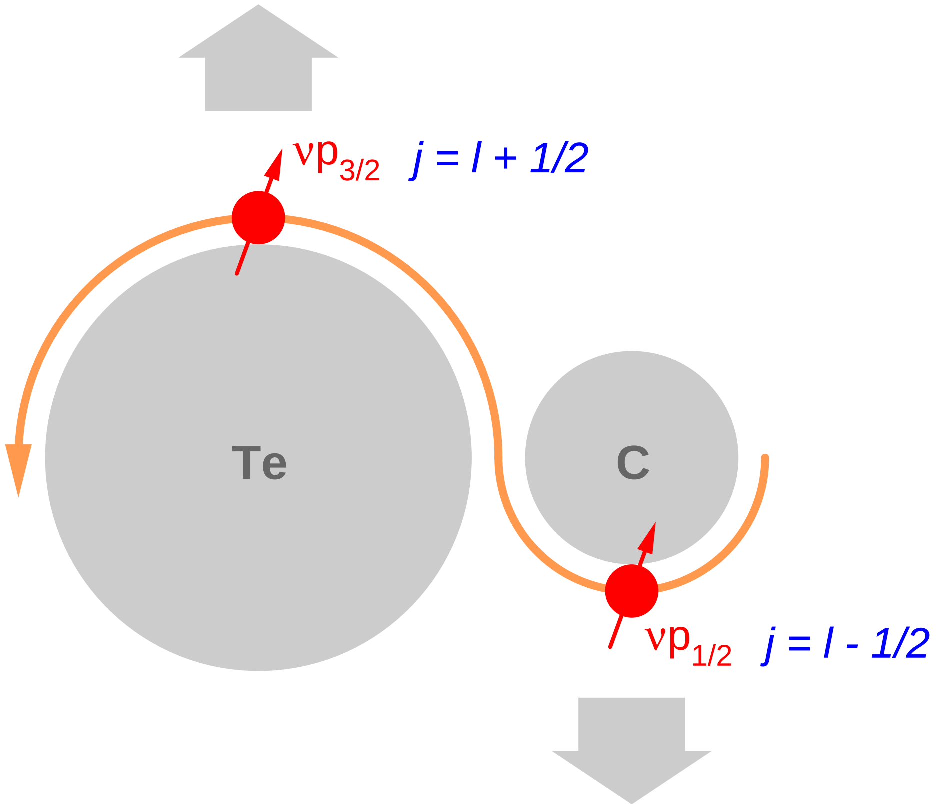
Neutron Transfer: different targets

We were able to collect some n-transfer data with a ^{13}C target



Neutron Transfer: different targets

Are $j = l - 1/2 \longleftrightarrow j = l + 1/2$ transitions preferred?



New Idea: Use the Spin Spectrometer

- **Have seen that gamma detection can be used to identify excited states**
  - But CLARION efficiency is too small (~ 3%) for angular distribution/correlation measurements.
  - Do not require Ge energy resolution; ~ 10% energy resolution sufficient to resolve many states
  - For moderate resolution but high efficiency, can select levels using sum energy $\sum E_\gamma$ as well as individual cascades

- **Spin Spectrometer: an ideal gamma calorimeter for these experiments?**
  - 72 large NaI crystals
    - two removed for beam entry and exit
  - Energy resolution ~ 10-12%
  - Excellent efficiency, ~ 85%

So use Spin Spectrometer to select levels of interest,
then measure proton cross-sections and angular distributions/correlations
with DSSDs or position-sensitive Si detectors in coincidence.

Present Status of the Spin Spectrometer

- **Spin Spectrometer has not been used for about 10 years**
  - New electronics and data acquisition system being assembled
  - Washington University (St. Louis) helping with support and electronics
  - HV has been applied to all 70 detectors as of last week;
    nine bases were repaired;
    all detectors are now giving output pulses
  - Next step: resolution and efficiency tests for all detectors
    to see if any need to be repaired or replaced.
  - Tests of subset gave promising results; 8-14% resolution for ^{137}Cs
- **Spectrometer will need to be moved to a new beam line**
  - Present target room needed for second RIB platform
  - Currently plan to use Beam Line 21 on temporary basis
- **Any assistance will be welcomed**

Plans for Spin Spectrometer Experiments

- If all goes well, Spin Spectrometer could be ready for test experiments in 2 to 3 months
- Initially expect to test with SIBs (e.g. ^{124}Sn) on deuterated hydrocarbon target
- If those tests go well, will ask for development time to test with ^{134}Te RIB
- Si detectors will be required
  - could use DSSD Forward Array for tests if necessary