Breakout from the hot-CNO Cycle via the $^{18}Ne(\alpha,p)^{21}Na$ reaction

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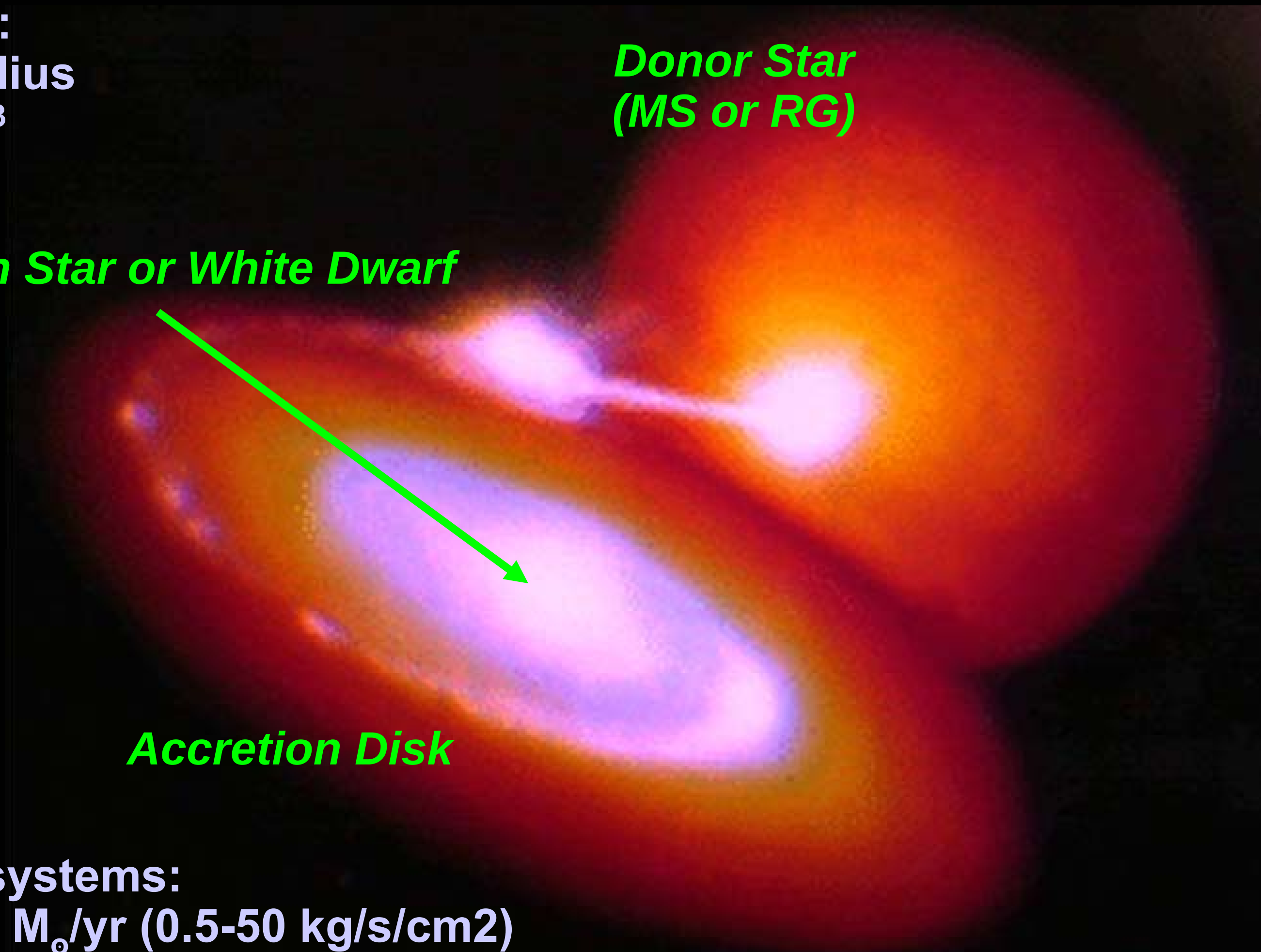
- Motivation: astrophysical and previous experiments
- How we do it
- Preliminary results and what's next

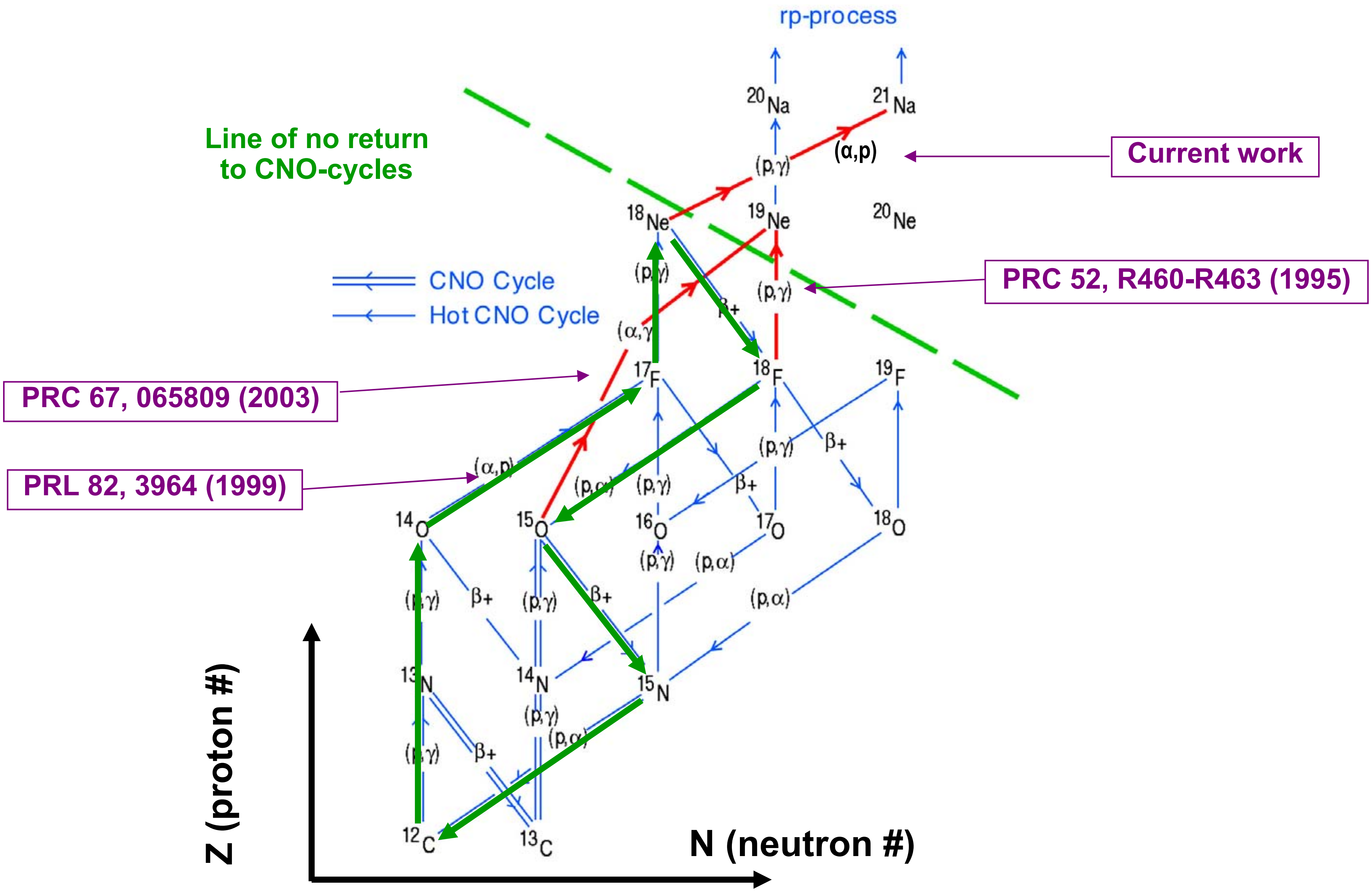
X-ray Burst Scenario Model

Neutron stars:
1.4 $M_\odot$, 10 km radius
$\rho \sim 10^{14}$ g/cm^3



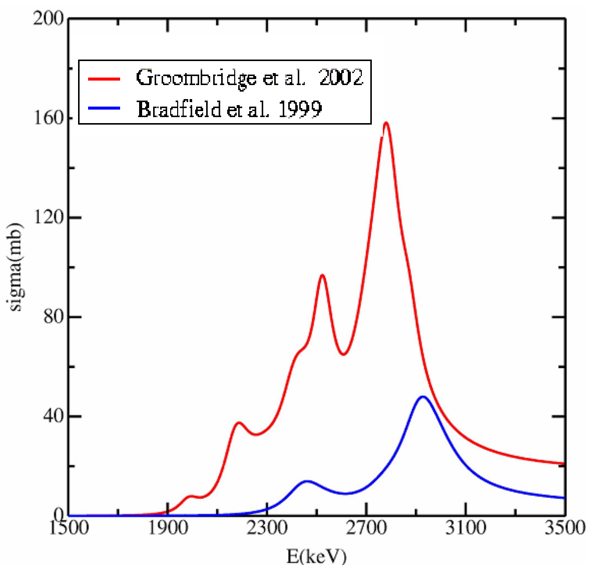
Typical systems:
accretion rate 10^{-8}-10^{-10} $M_\odot$/yr (0.5-50 kg/s/cm2)
orbital periods 0.01-100 days
orbital separations 0.001-1 AU

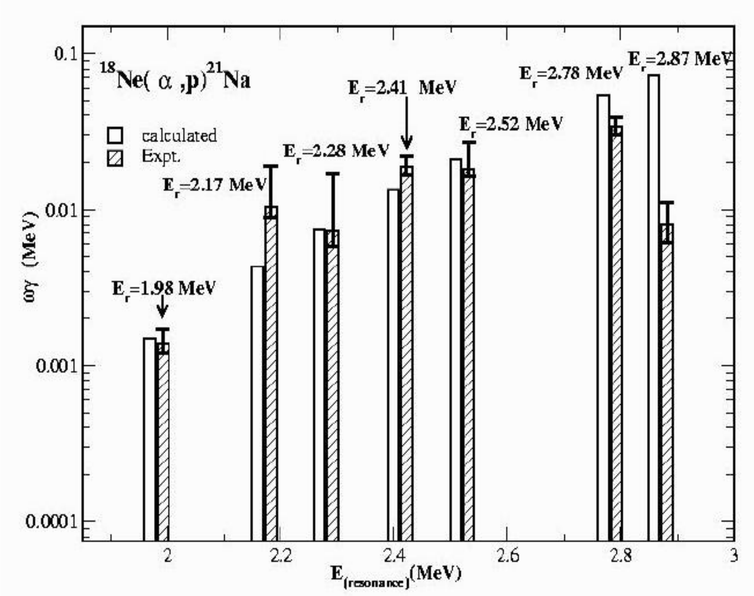
The CNO-cycles & Breakout reactions

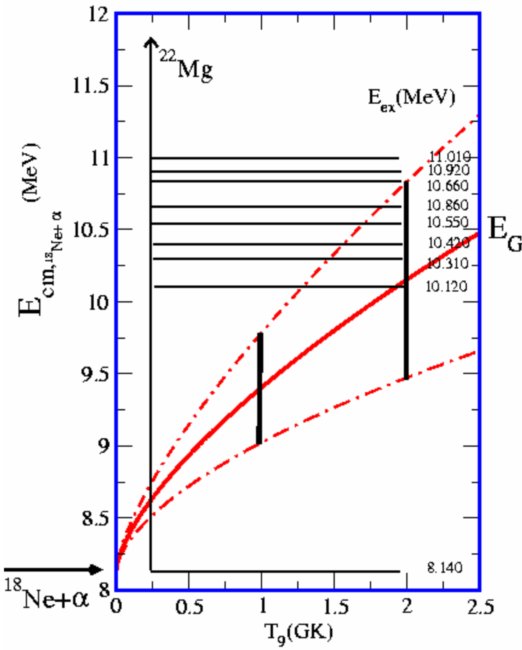


Previous studies of $^{18}Ne(\alpha,p)^{21}Na$

W. Bradfield et al.(PRC,59,3402,1999)
D.Groombridge et al. (PRC 66,055802,2002)







- Two measurements disagree
- The α-widths exhaust the Wigner limit
- The levels are not in the Gamow window

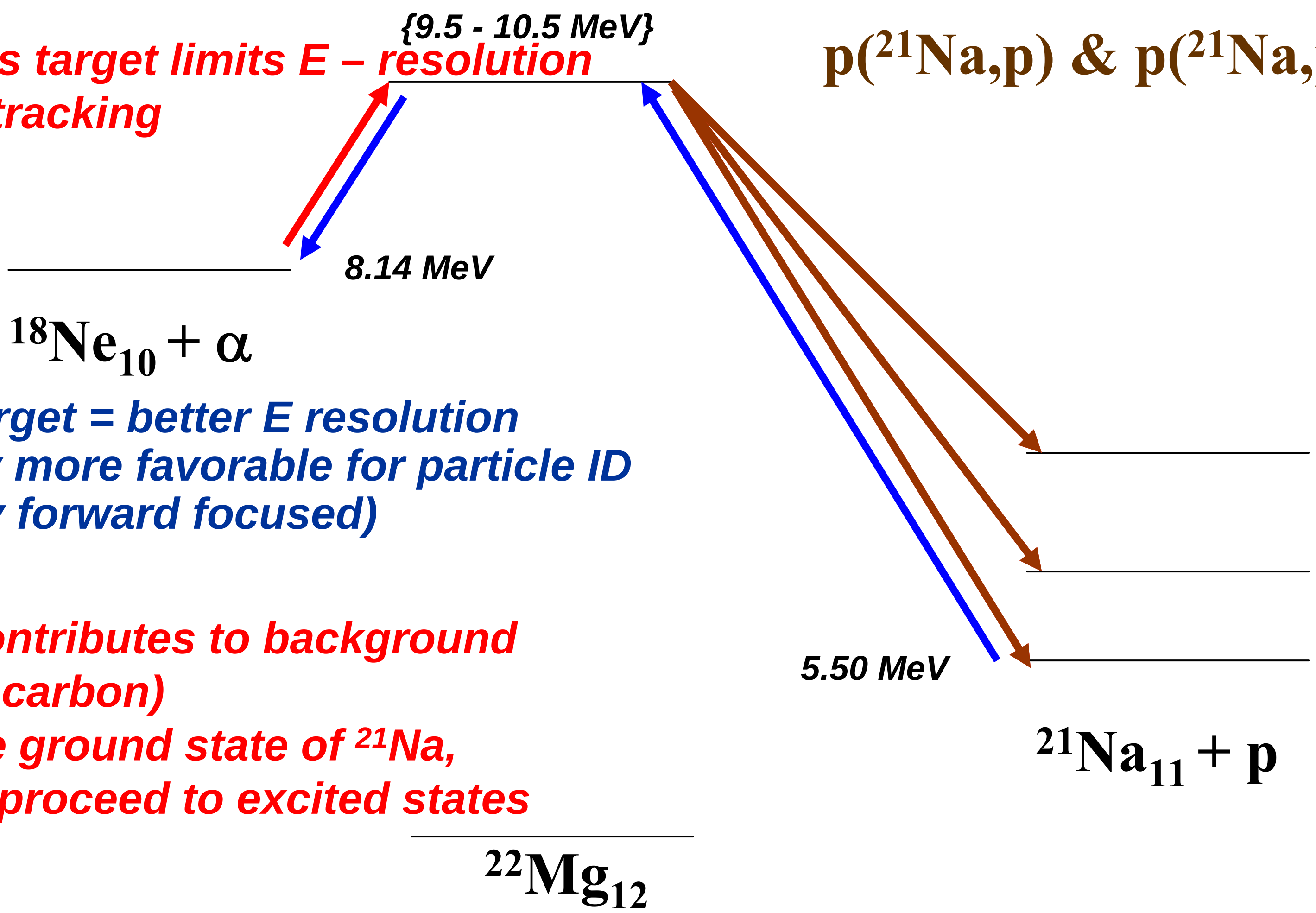
Lab Measurement via time inverse reaction

$\alpha(^{18}Ne,^{21}Na)p$

$p(^{21}Na,^{18}Ne)\alpha$

$p(^{21}Na,p)$ & $p(^{21}Na,p')$

-Extended Gas target limits E – resolution and requires tracking
- RIB



-Solid, thin target = better E resolution
-Energetically more favorable for particle ID (kinematically forward focused)

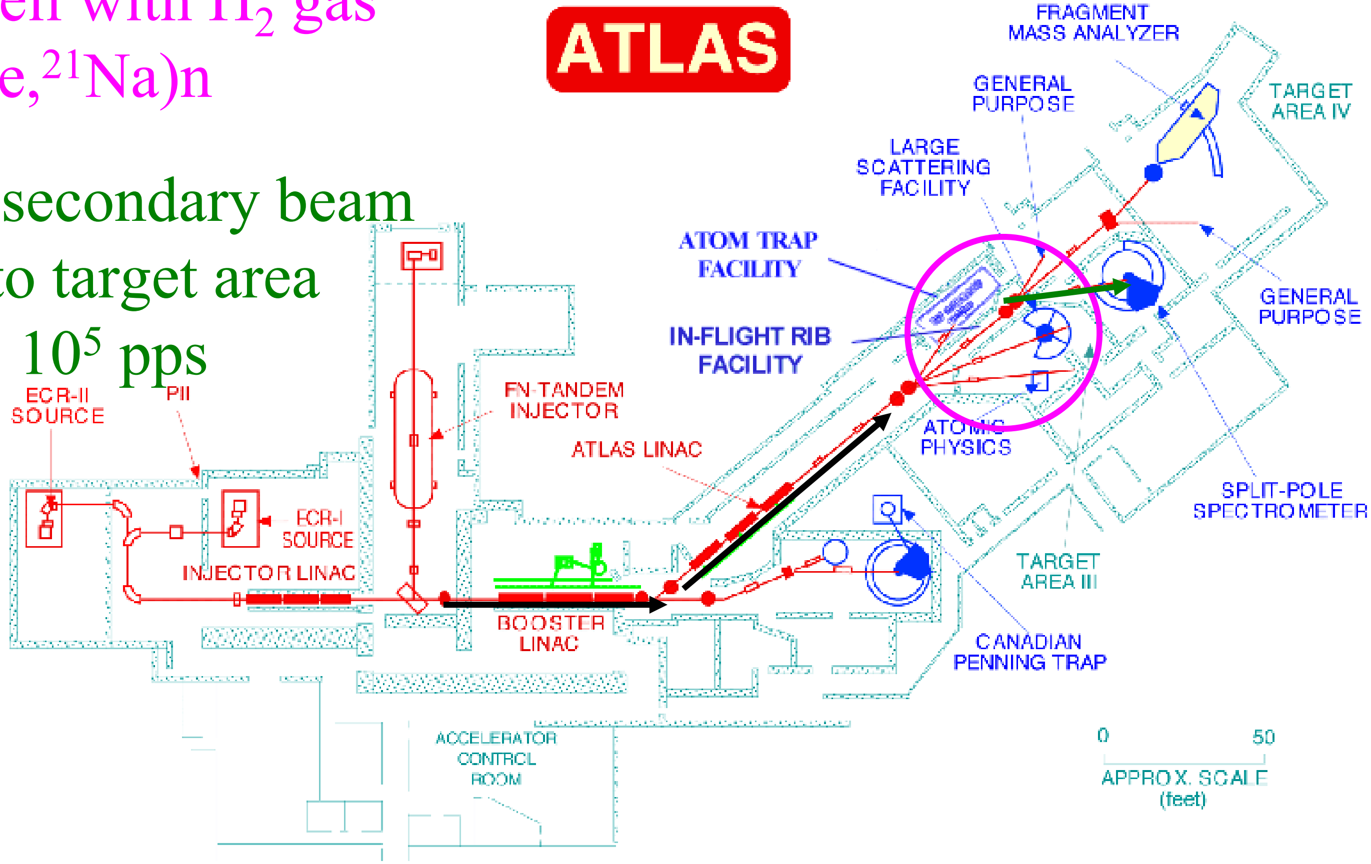
-CH_2 target contributes to background (reactions on carbon)
-Start with the ground state of ^{21}Na, reaction may proceed to excited states

First we need a beam! ATLAS

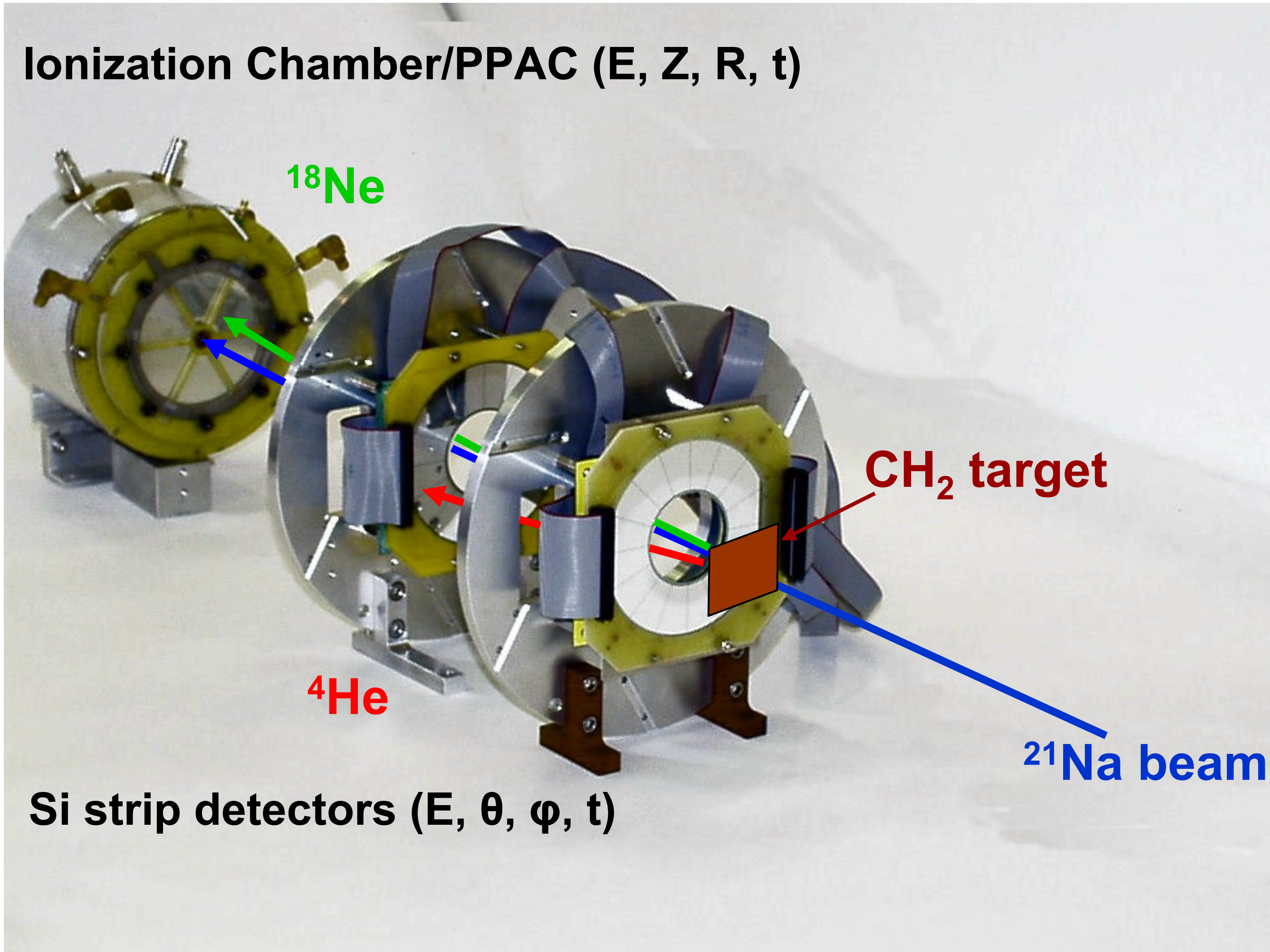
^{21}Ne primary beam ~5 × 10^{11} pps

Gas cell with H_2 gas
p(^{21}Ne,^{21}Na)n

^{21}Na secondary beam
sent to target area
~ 5 × 10^{5} pps

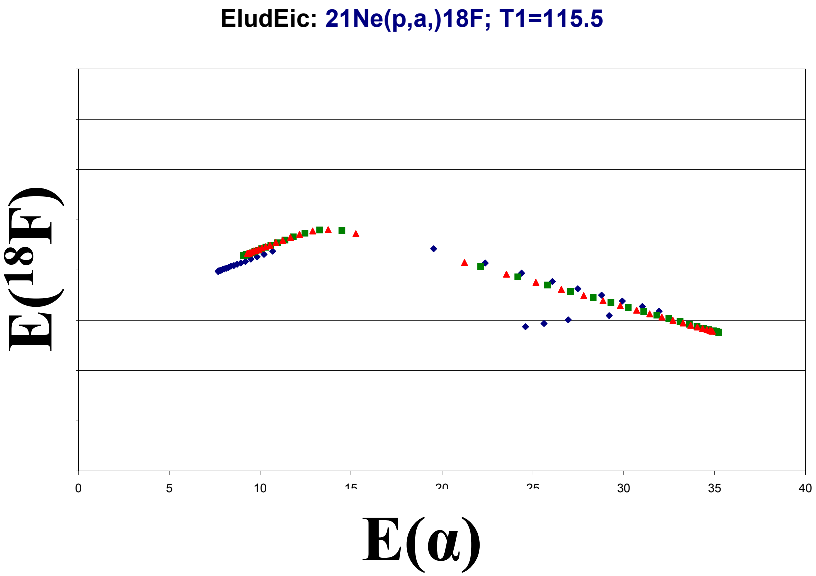


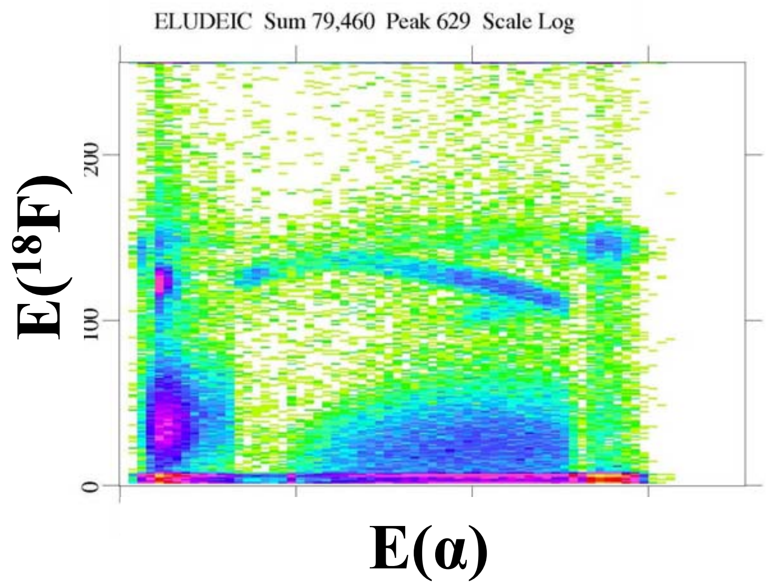
"Ludwig" Detectors

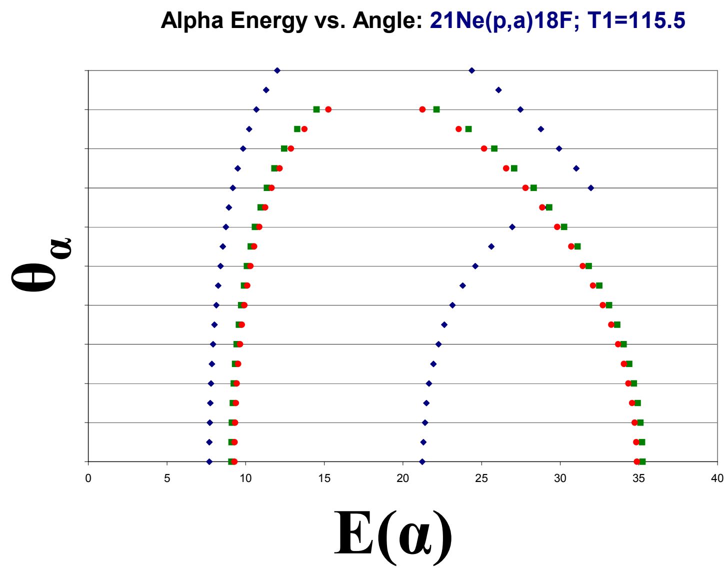


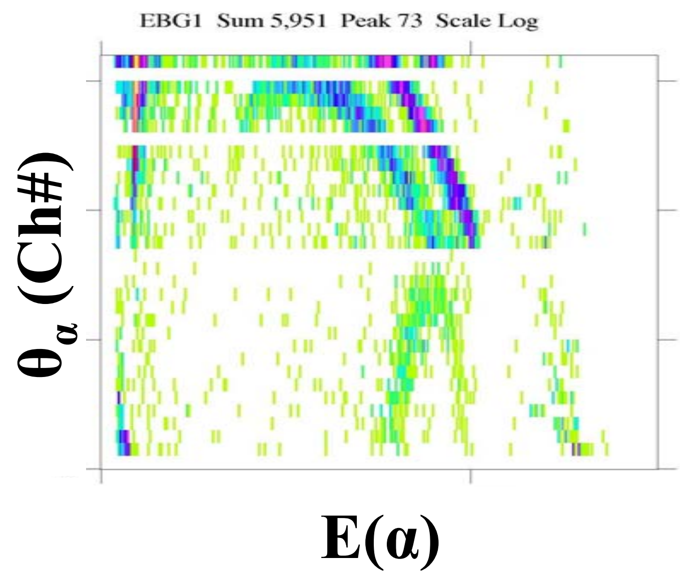
detection efficiency > ~60%

Kinematic calculations/data
Life is easy with calibration reaction: p(^{21}Ne,^{18}F)α

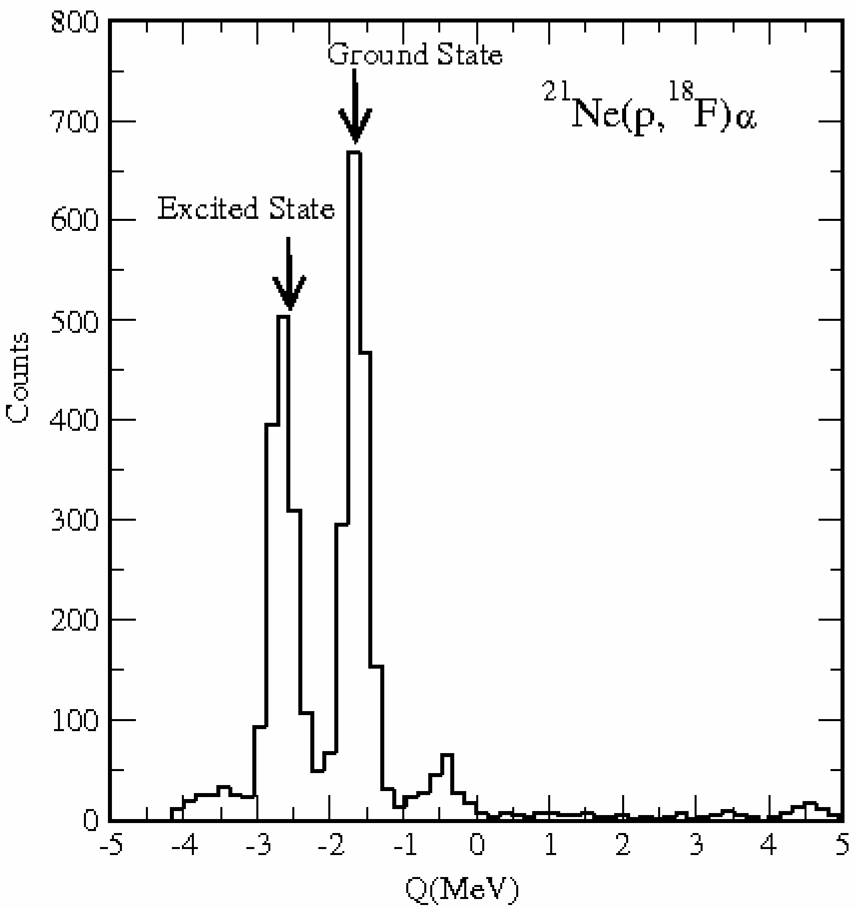


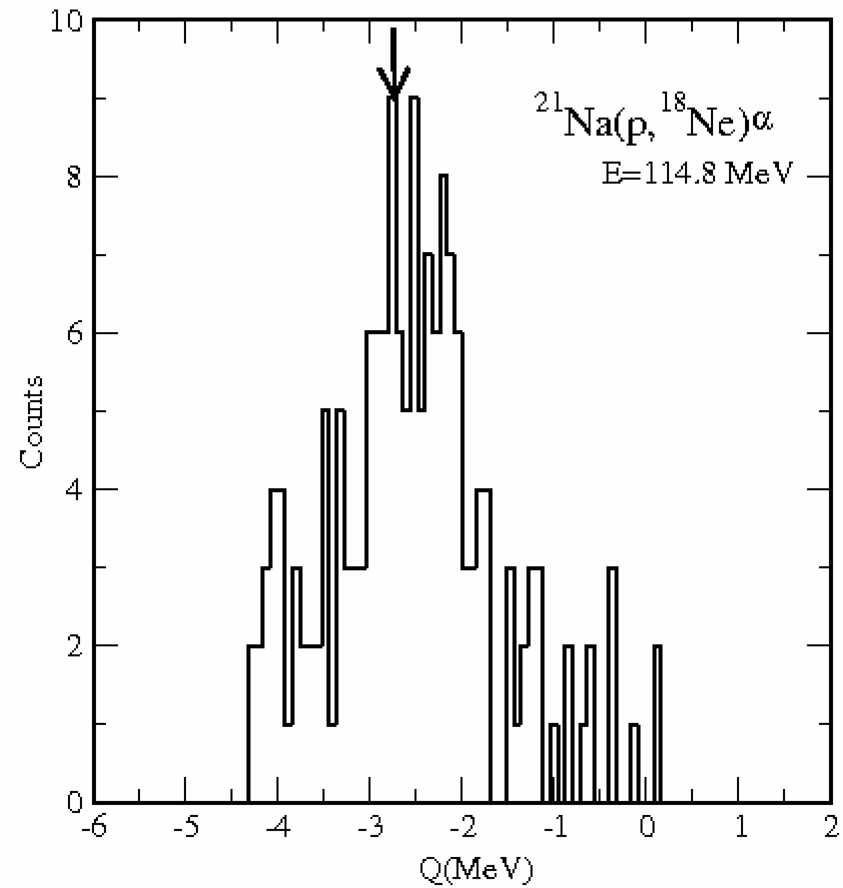




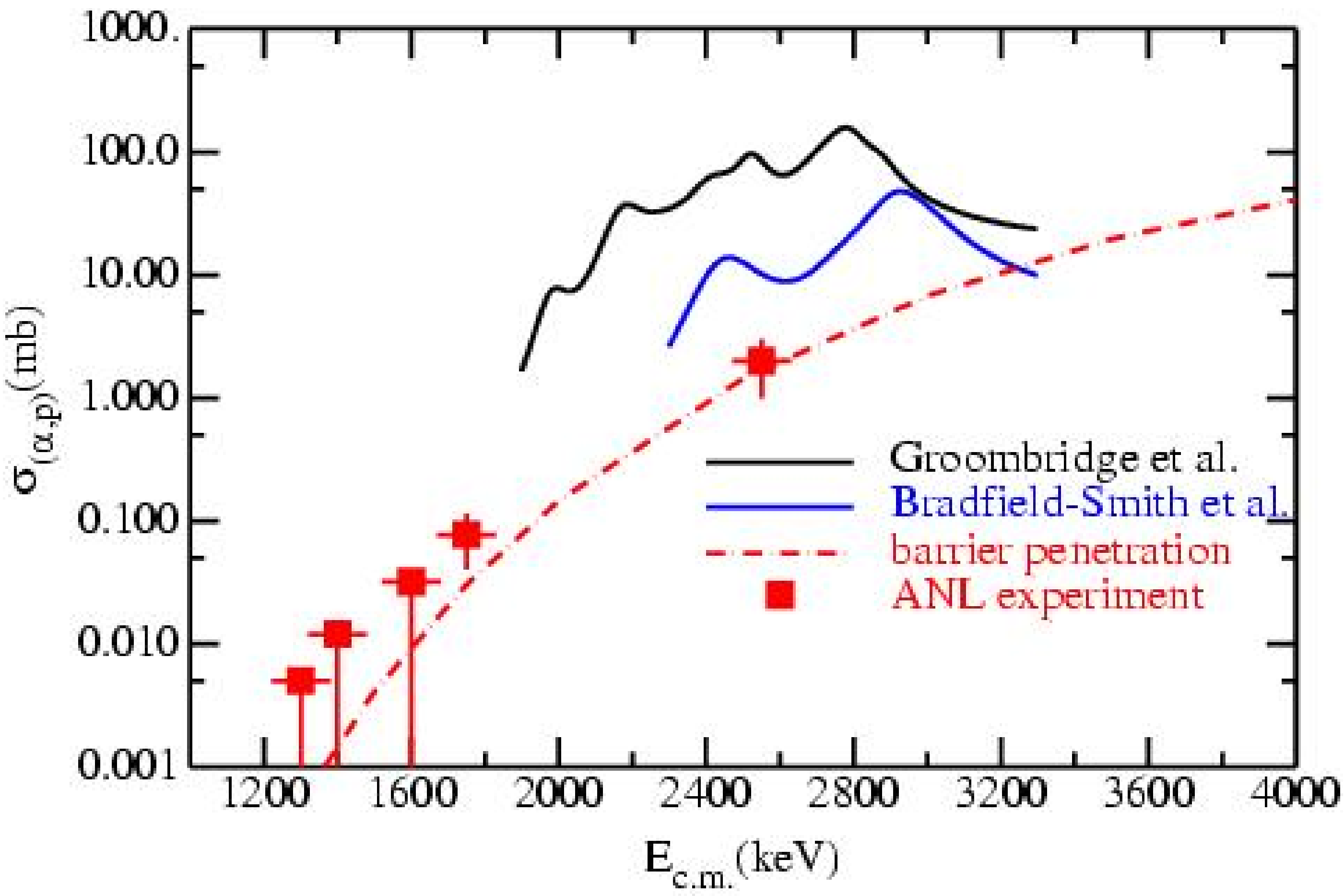


Q-value spectrum: Not so easy with ^{21}Na



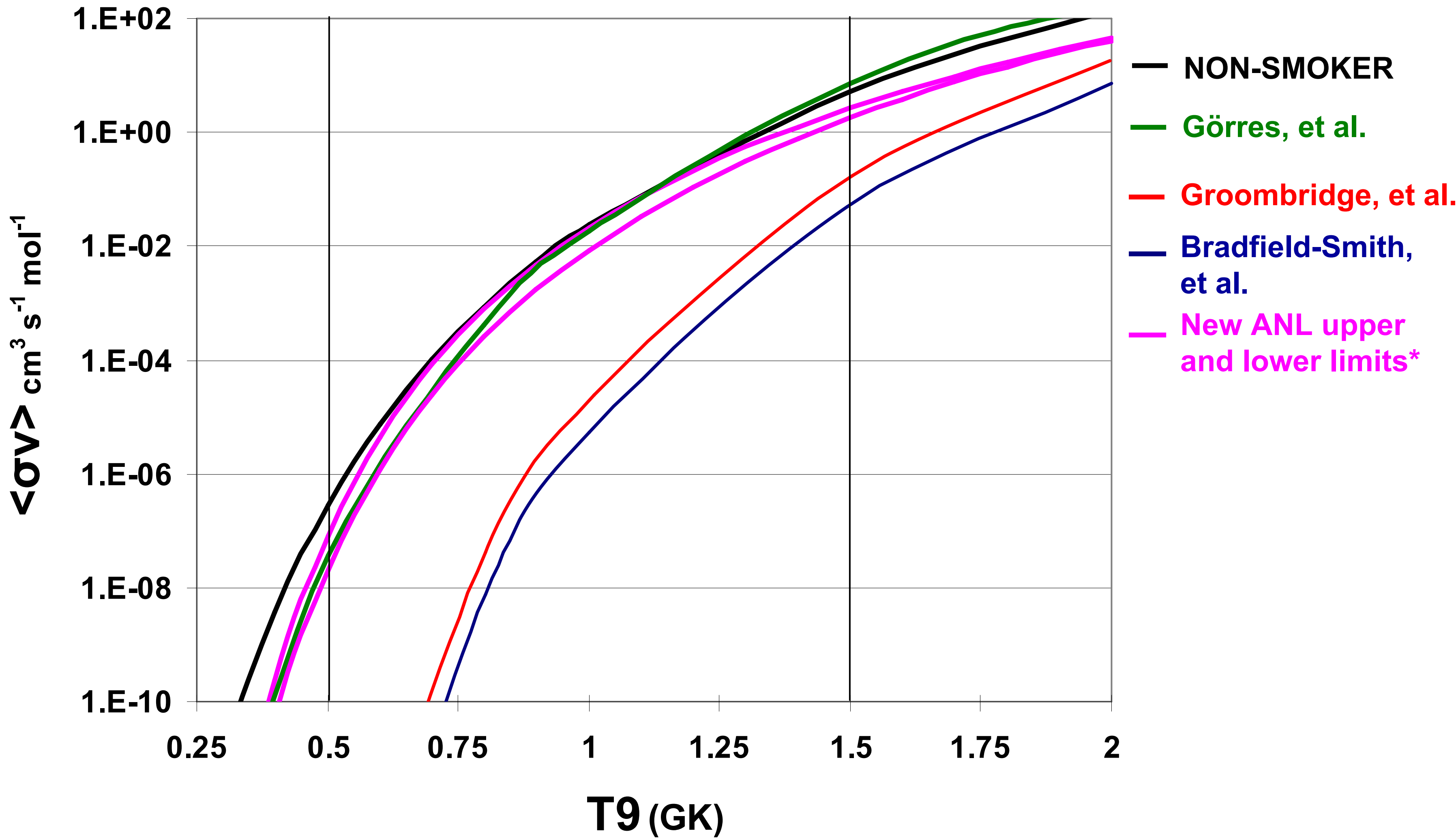


$^{18}Ne(\alpha,p)^{21}Na$ cross sections



*Lowest energy point was taken over a period of 3 days with a beam intensity of ~ 5 × 10^5 pps on target, with an upper limit for σ ~ few μb.

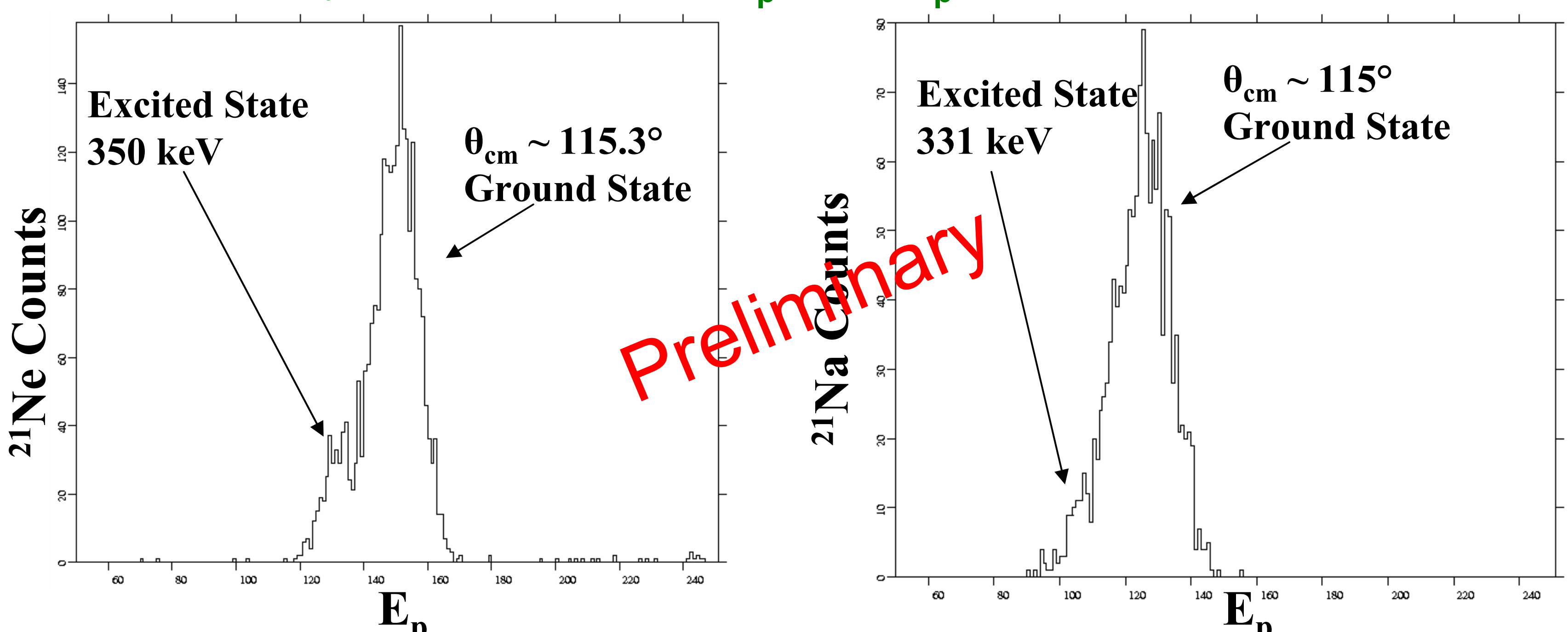
Stellar Reaction Rates: *Preliminary Results



Summary/Outlook for $^{18}Ne(\alpha,p)^{21}Na$

- **Direct comparison at one energy, where only the ground state contributes reveals a smaller cross-section than previous measurements (by a factor of ~50)**
- **Extended measurement to astrophysical energy regime, preliminary results for reaction rate are in good agreement with theoretical models from NON-SMOKER and Görres, et al.**

Next: Determine contributions from elastic and inelastic scattering in both ^{21}Ne and ^{21}Na systems and extract Γ_p and $\Gamma_{p'}$.



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In-Flight Secondary Beam Production at ATLAS

"In-Flight"

+: fast (< μs, short life times)

beam properties good enough to measure resonances in inverse kinematics