Direct Reactions With Light Radioactive Beams

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COPIGAL collaboration with:
CEA Saclay (contact Alain Gillibert)
IPN Orsay (Freddy Flavigny)

POLITA collaboration with:
INFN Padua/University of Padua (contact Marco Mazzocco)

COPIGAL focussed on light-ion reactions for charged particle spectroscopy. Experiments at GANIL-SPIRAL

POLITA focussed on heavy-ion reactions with stable and radioactive beams for reaction mechanism studies. Experiments at INFN LNL

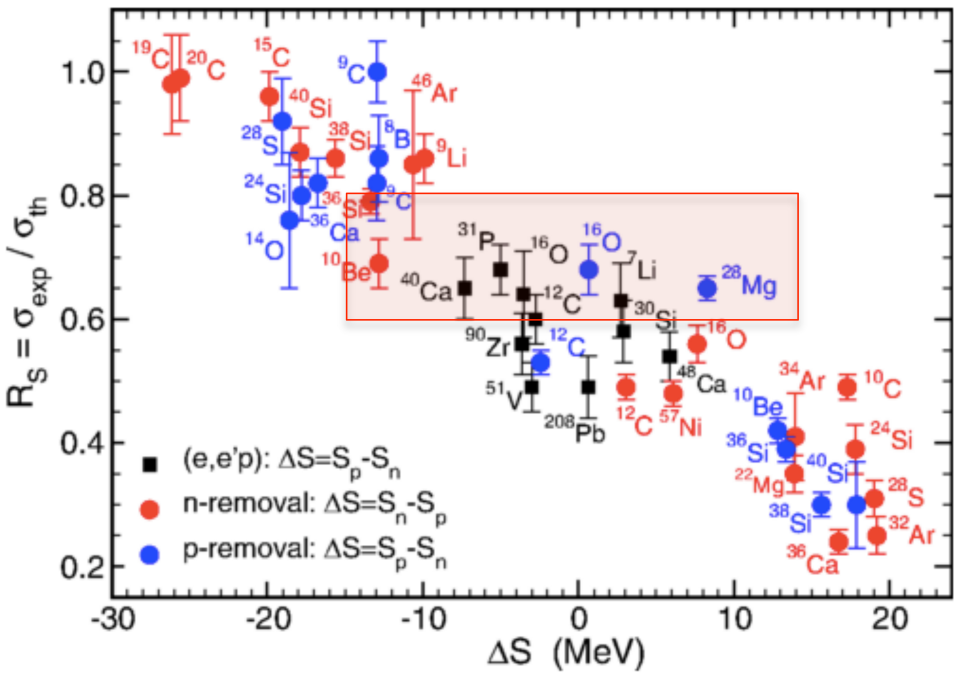
Main axis of Polish contribution interpretation of results with direct reaction codes, mostly FRESCO

Work in hand under COPIGAL

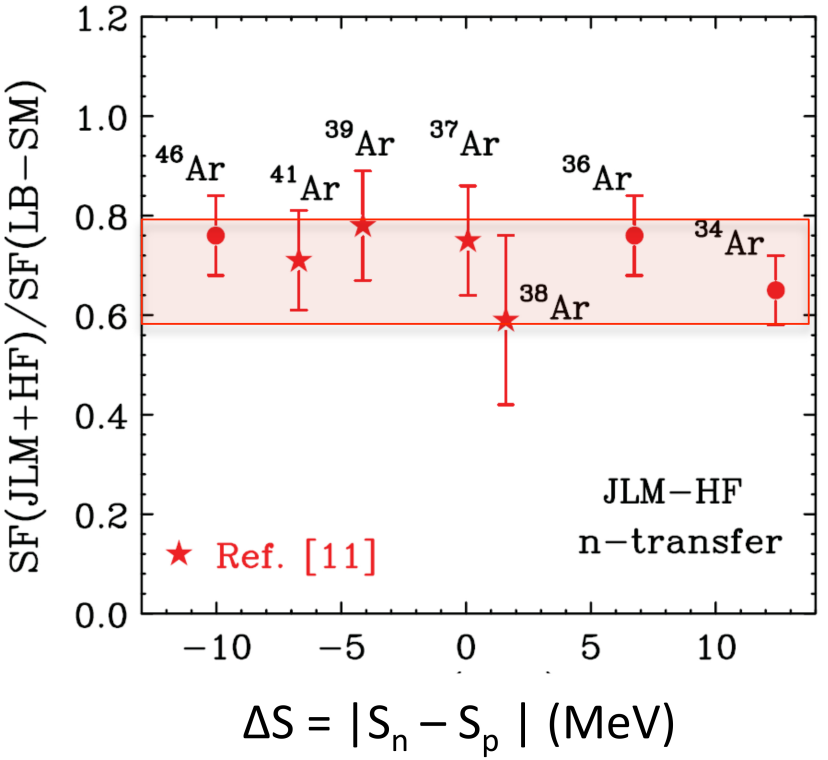
Knockout reactions find significant variation in "reduction factor" of extracted spectroscopic factors compared to shell model as a function of ΔS ($\Delta S = S_n - S_p$ for n-removal, $S_p - S_n$ for p-removal)

Low-energy pickup – (p,d) – did not see such a variation, but range of ΔS was smaller than the knockout study …

J.A. Tostevin and A. Gade, Phys. Rev. C **90**, 057602 (2014)



J. Lee et al., PRC 83, 014606 (2011)



Need an extended ΔS range for the low-energy reactions to confirm the difference

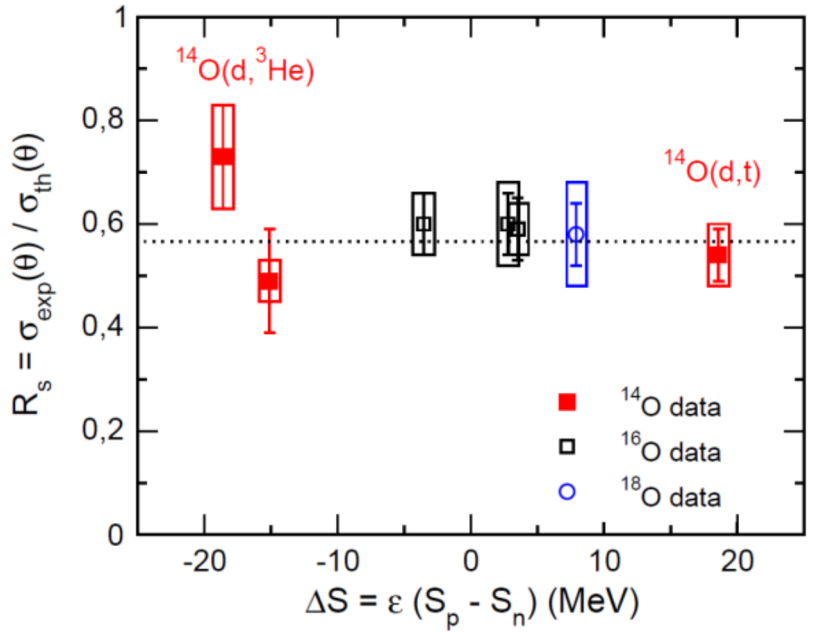
^{14}O is a good nucleus for this test: ΔS range is approximately ± 20 MeV

Combine new data for ^{14}O(d,t) and (d,^{3}He) from GANIL with existing ^{16}O data. Results published in F. Flavigny *et al.*, Phys. Rev. Lett. **110**, 122503 (2013).

No significant variation of reduction factor with ΔS, unlike knockout.

Remember that spectroscopic factors are not observables, they are model dependent. How sensitive is this result to the choices made in the analysis?

Results with WS overlap functions



δ (RMS) → δr_o → box

Error bars due to exp. Uncertainties

OFs : WS (HFB constrained)
C^2S_{th}: Shell model with WBT interaction

$$\sigma_{th}(\theta) = C^2S_{th}\,\sigma_{sp}(\theta)$$

48 analysis:

- **2 sets of C^2S_{th}**
- **3 HF calculations** for radii
- **8 combinations of optical potentials**

χ^2_{min}

$$R_s = \alpha \,.\, \Delta S + \beta$$

α = +0.0004(24)(12) MeV^{-1}

$\beta = R_s(0) = 0.538(28)(18)$

Exp. Error (1 set)

Stdrd. error from 48 data sets

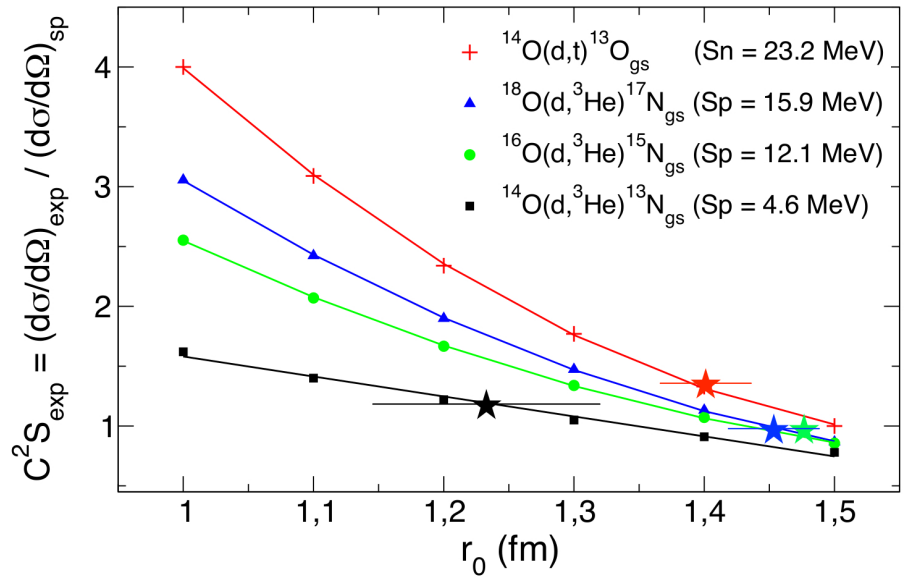
Follow-up paper in preparation. Check sensitivity to:

- Reaction model: CRC vs. DWBA
- Radius of binding potential well
- Incorrect asymptotic fall-off of calculated OFs

Also check region of sensitivity of OFs by “notch” tests

Hope finally to publish results this year!

r_0 dependence



Potentials used: (KD+GDP08)

Linear fit (a*r0+b) between 1.3 fm and 1.5:

Reaction	$S_{n,p}$ (MeV)	a (slope)
^{14}O(d,t)^{13}O	23.2	-3.85
^{18}O(d,^{3}He)^{17}N	15.9	-3.00
^{16}O(d,^{3}He)^{15}N	12.1	-2.4
^{14}O(d,^{3}He)^{13}N	4.6	-1.35

- The $C^2S_{exp}(r_0)$ dependence is enhanced if the transfer nucleon is more bound
  - For r_0 in [1; 1.25] fm, this effect becomes even larger (non linear)

Ex. for 14O(d,t): for r_0= 1.40 fm ⇒ $C^2S_{exp} \approx 1.3$
for r_0= 1.25 fm $C^2S_{exp} \approx 2.1$

(≈ 11% change) (≈ 60% change)

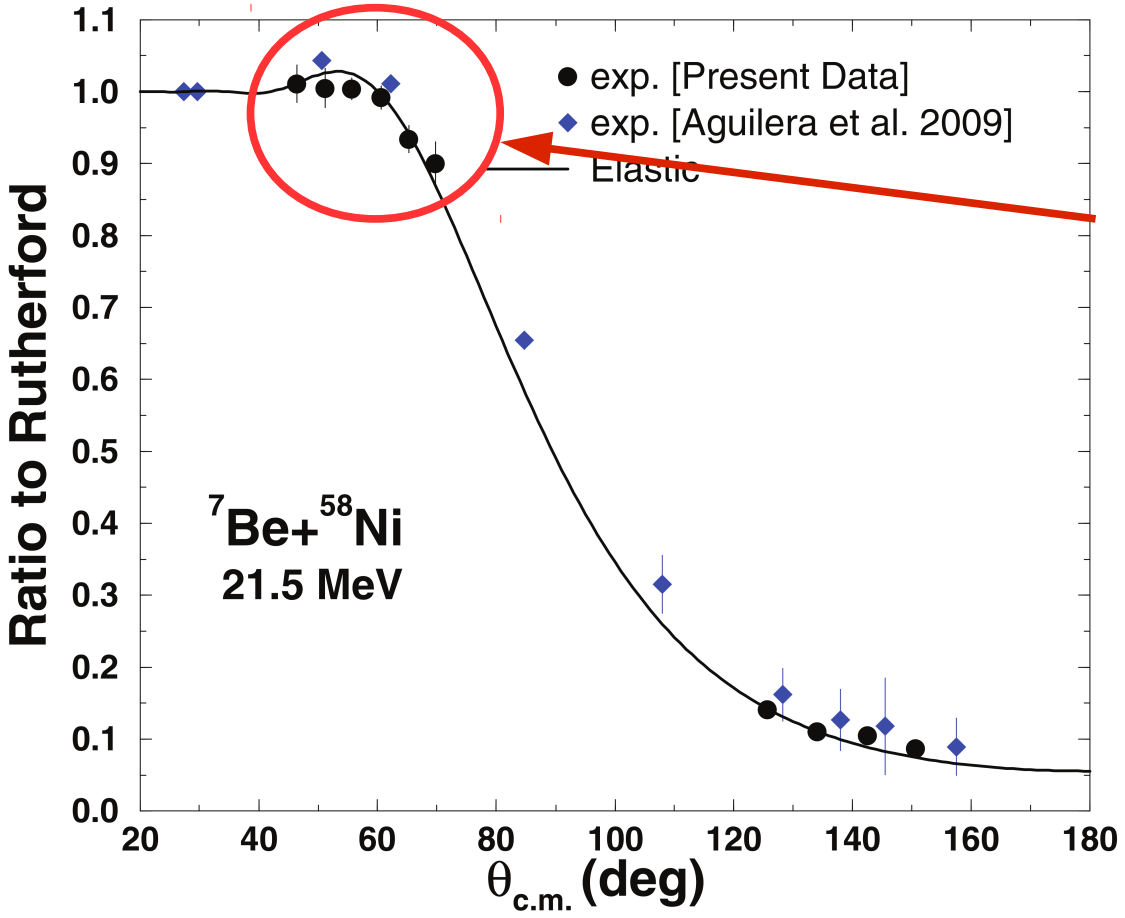
Work in hand and completed under POLITA

21.5 MeV ^{7}Be + ^{58}Ni: quasi-elastic scattering and inclusive ^{3}He and ^{4}He production angular distributions.

Investigation of reaction mechanisms: ^{4}He yield 4-5 times greater than ^{3}He => breakup is not the main source

^{3}He yield mainly from ^{4}He stripping, ^{4}He yield mainly from fusion-evaporation

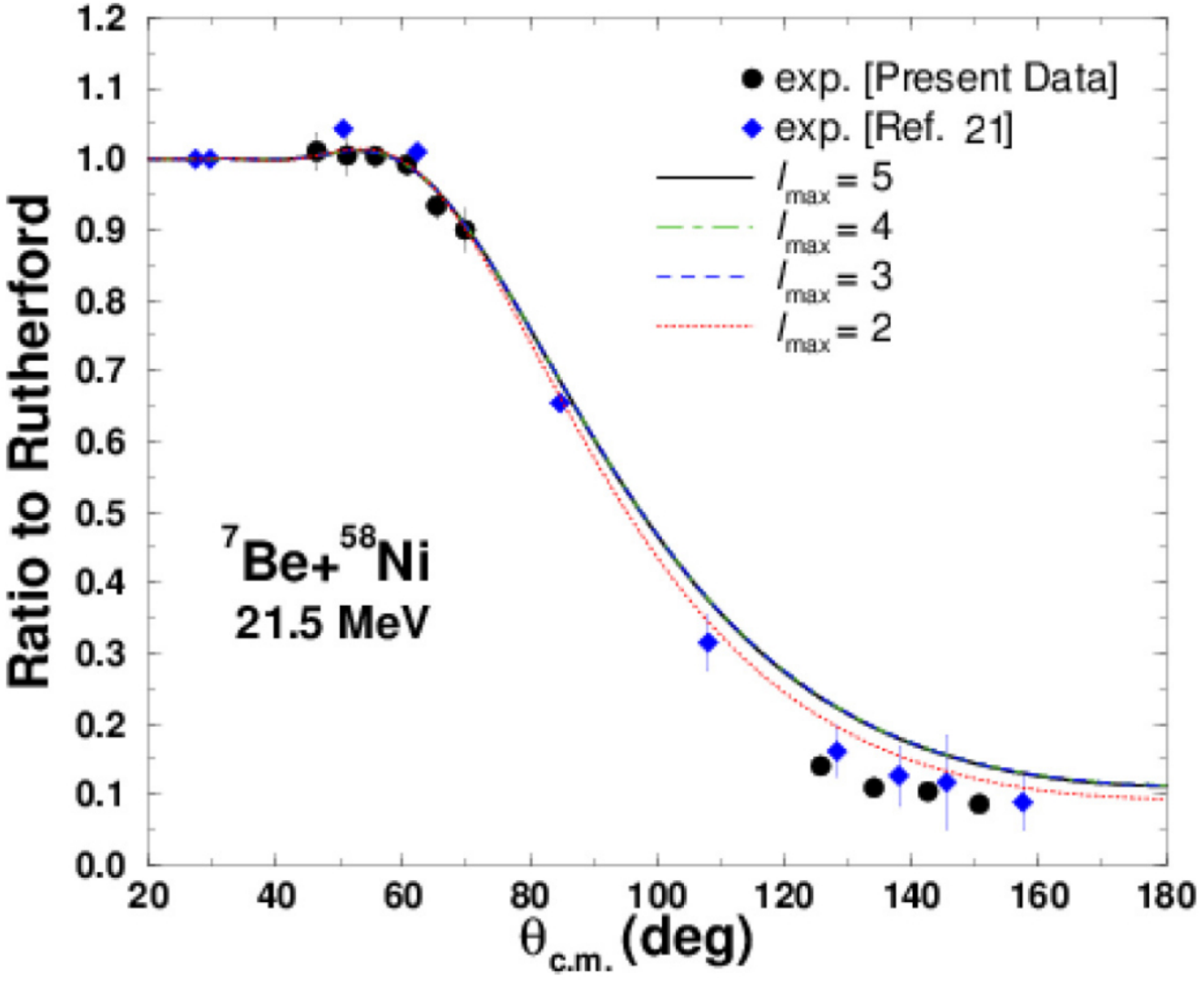
Quasi-elastic scattering well described by optical model calculations with global ^{7}Li parameters [Cook, Nucl. Phys. A **388**, 153 (1982)]:



V probably slightly smaller than for ^{7}Li due to increased importance of breakup

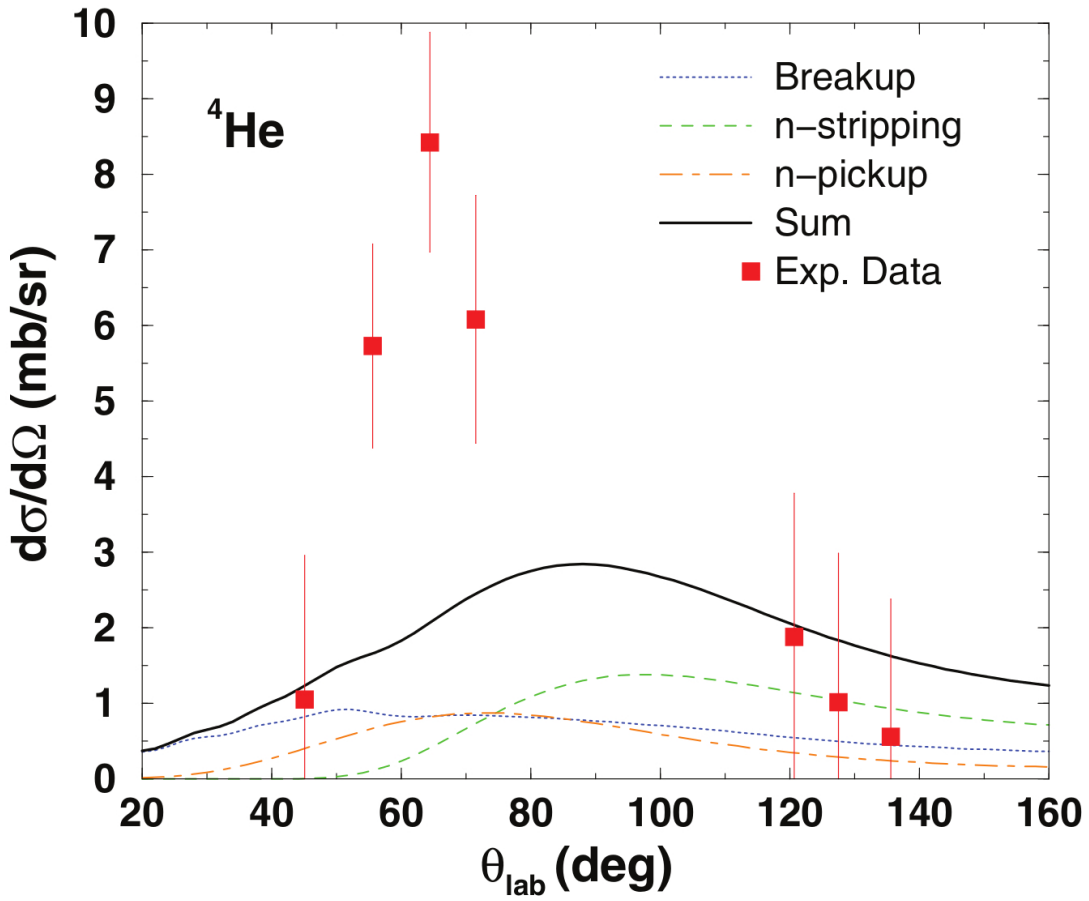
New data agree well with previous work of Aguilera *et al.*, Phys. Rev. C. **79**, 021601(R) (2009)

Quasi-elastic data also well described by CDCC calculations with no free parameters:



^{3}He production under control: only breakup and ^{4}He-stripping can contribute

^{4}He production more complicated. After extracting ^{4}He from fusion evaporation we are left with:

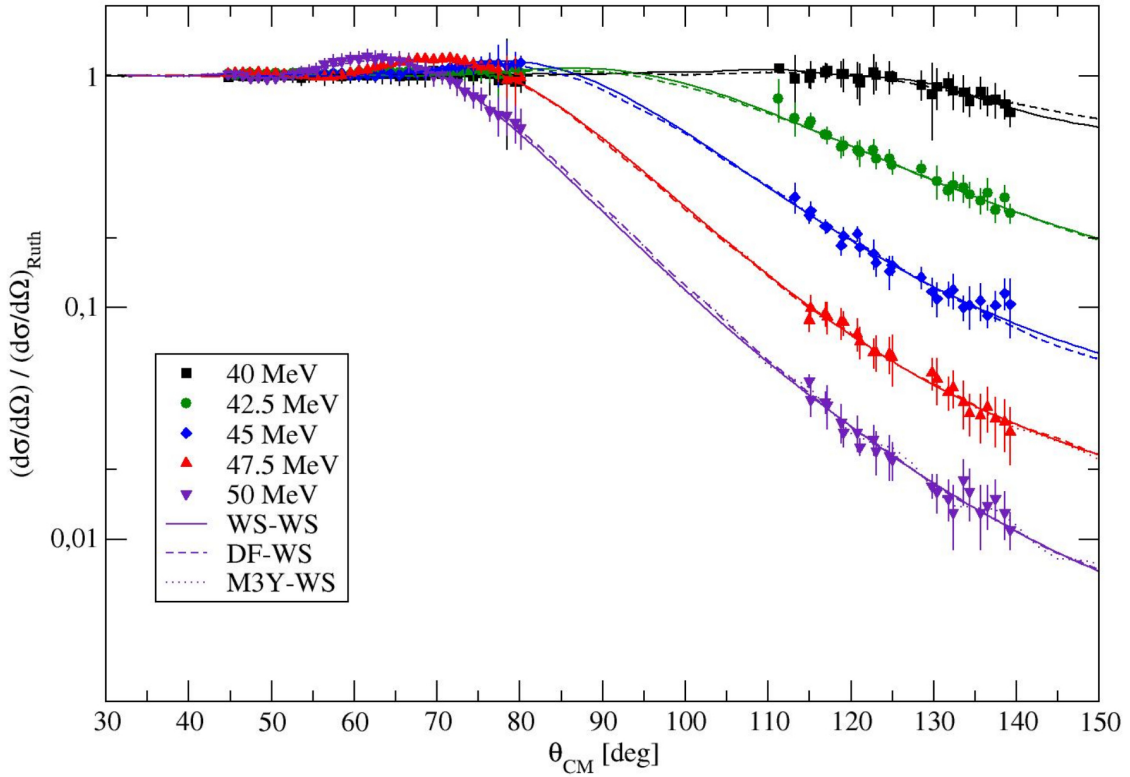


Remainder probably ^{3}He-stripping

Results published in M. Mazzocco *et al.*, Phys. Rev. C **92**, 024615 (2015)

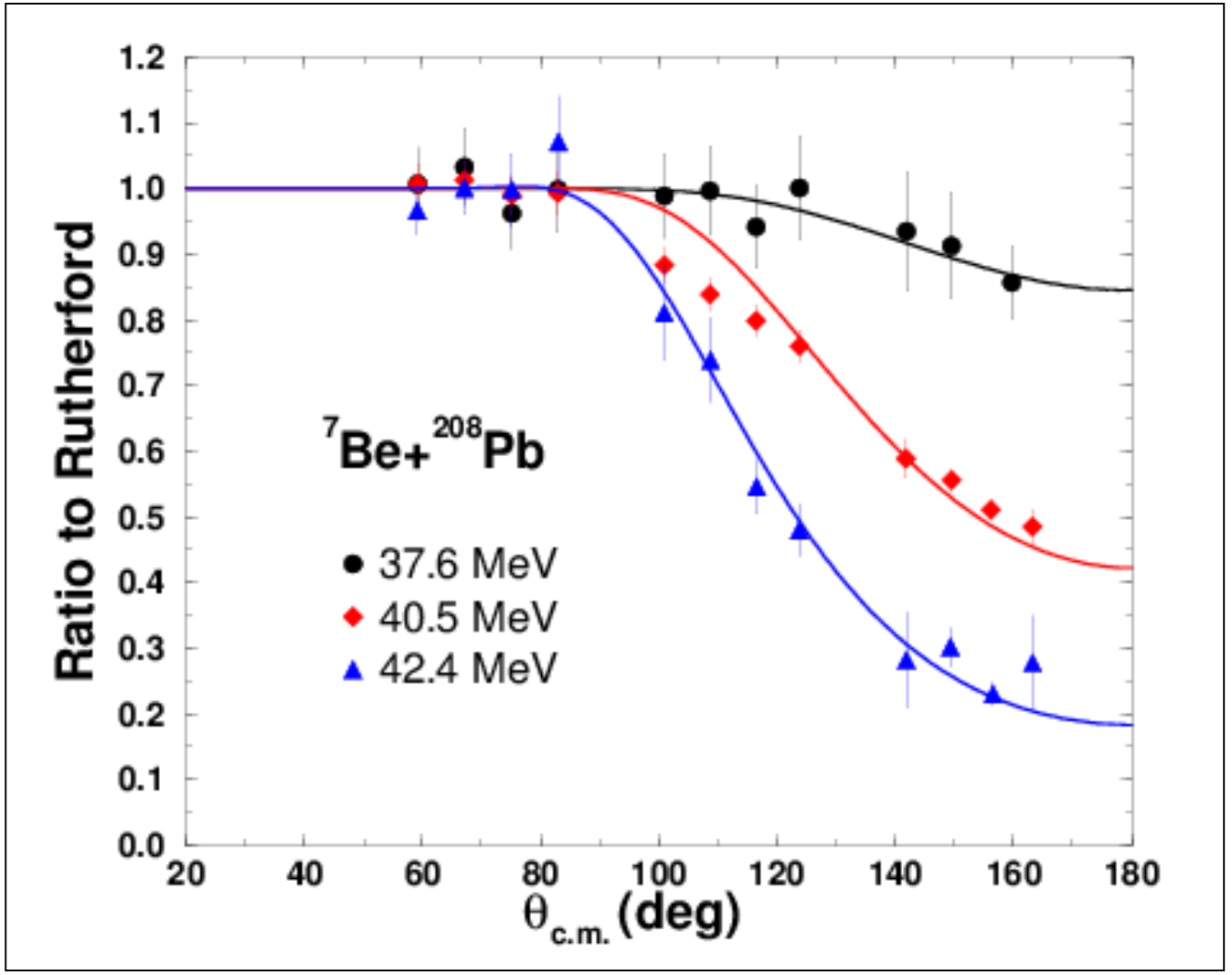
Work in hand: near-barrier ^{17}O + ^{58}Ni elastic scattering

Peaks do not resolve inelastic excitations or (^{17}O,^{16}O) 1n-stripping. Combination of calculations and Monte Carlo simulations to extract these contributions in a self-consistent way. Led by Emanuele Strano

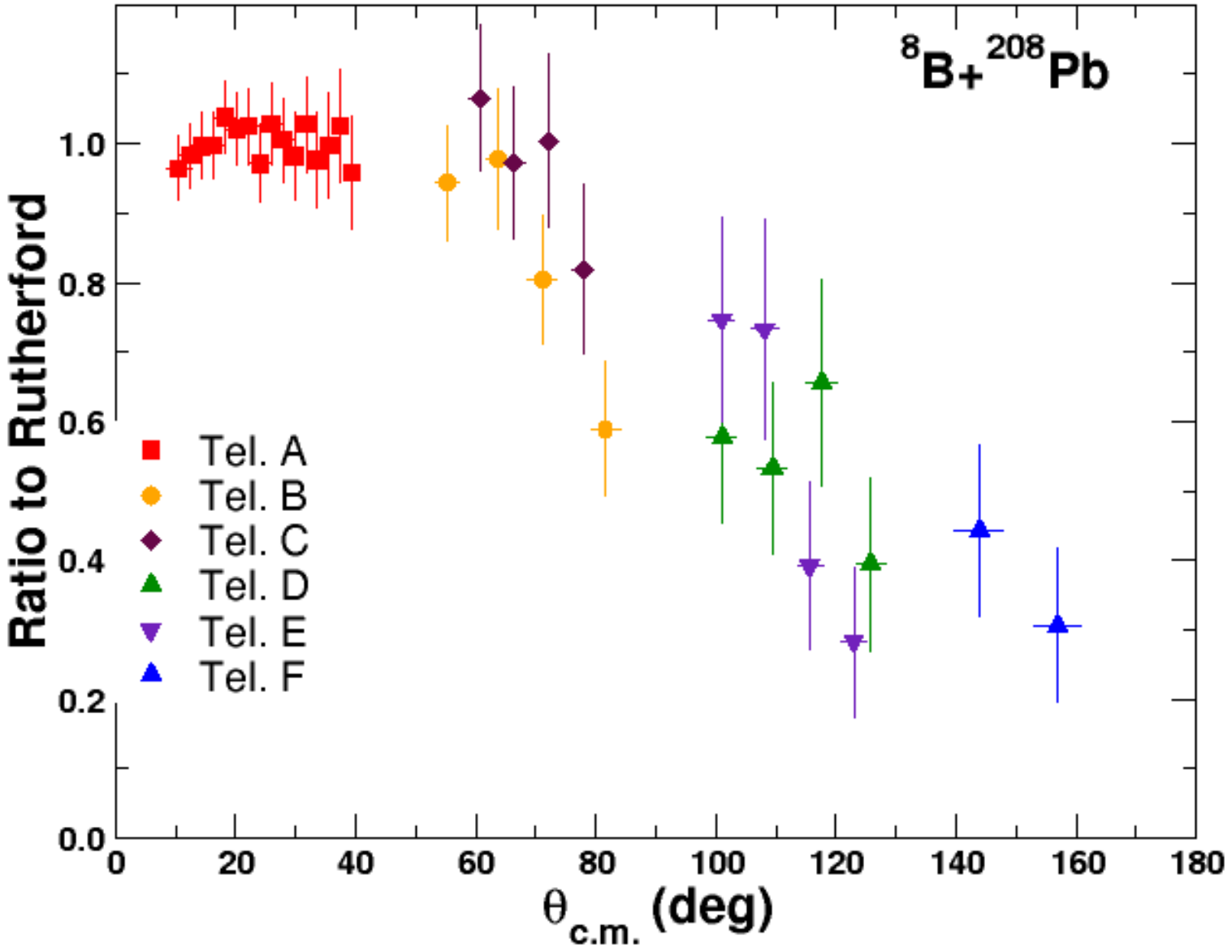


Preliminary ADs. Analysis will form interesting comparison with existing ^{16}O + ^{58}Ni data at similar energies

^{7}Be + ^{208}Pb quasi-elastic scattering at near-barrier energies: interesting in its own right and also as the "core" potential for ^{8}B + ^{208}Pb scattering. Experiment at EXOTIC, LNL. Preliminary ADs:



$^{8}B + ^{208}Pb$ data from RIKEN, preliminary ADs. Both these activities led by Marco Mazzocco.



Dziękuję za uwagę

Merci pour votre attention

Grazie per l'attenzione