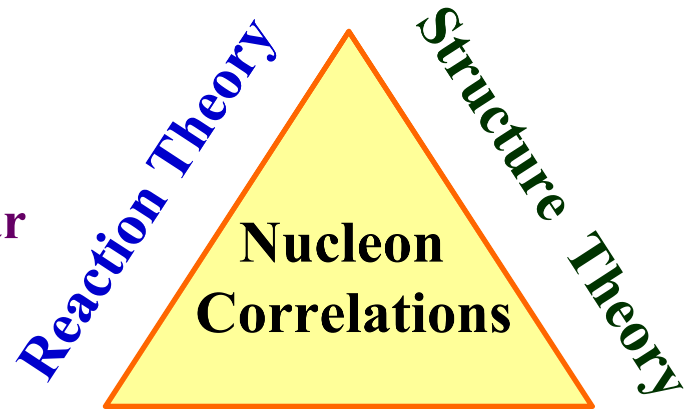
Nucleon Correlation Studies

Cross Section Measurements coupled with Reaction & Structure Theories

Reaction Model :
Interface between Observables ↔ Nuclear Structure Knowledge



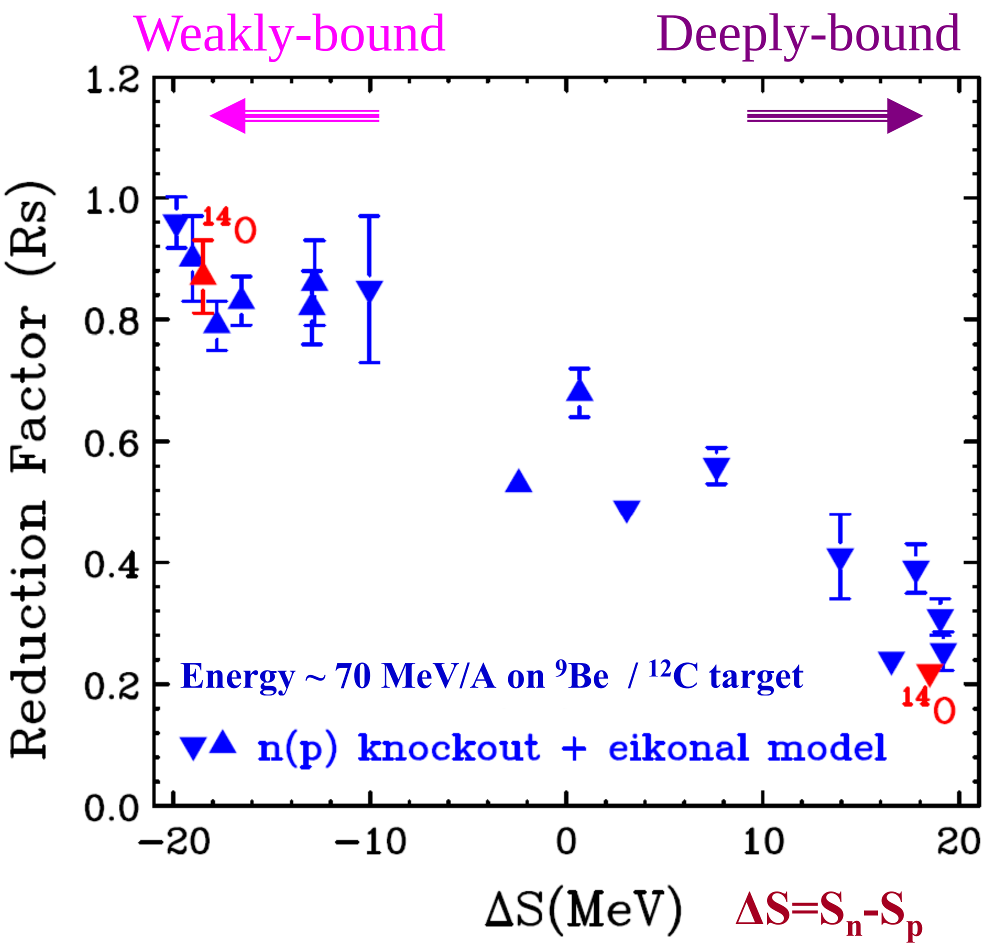
- *Conventional SM*
- *Monte Carlo SM*
- *Tensor-optimized SM*
- *ab-initio Calc.*
- *Mean-Field*

Direct Reaction Data

- Transfer reactions
- Knockout reaction using Be / C target
- Knockout reaction using proton target

^{14}O : ΔS ~20 MeV , p-shell spherical (*ab initio Calc*)
→ reliable Structure to test Reaction Models

Asymmetry Dependence of Nucleon Correlations



Understanding Nucleon Removal from Exotic Nuclei at Intermediate Energy (deeply-bound) !

Knockout Reaction Theory:
Eikonal & Sudden Approximations

J. Tostevin et al., J. Phys. G, Part. Phys. 25, 735 (1999)

A. Gade et al., Phys. Rev. C 77, 044306 (2008)
and reference therein

Rs **: Strong Asymmetry Dependence**

^{14}O knockout : F. Flavigny, A. Obertelli et al.,
Paper in preparation

Transfer Reaction: Weak Dependence

p(^{34,36,46}Ar,d) at 33 MeV/A

J. Lee et al., Phys. Rev. Lett 104, 112701 (2010)

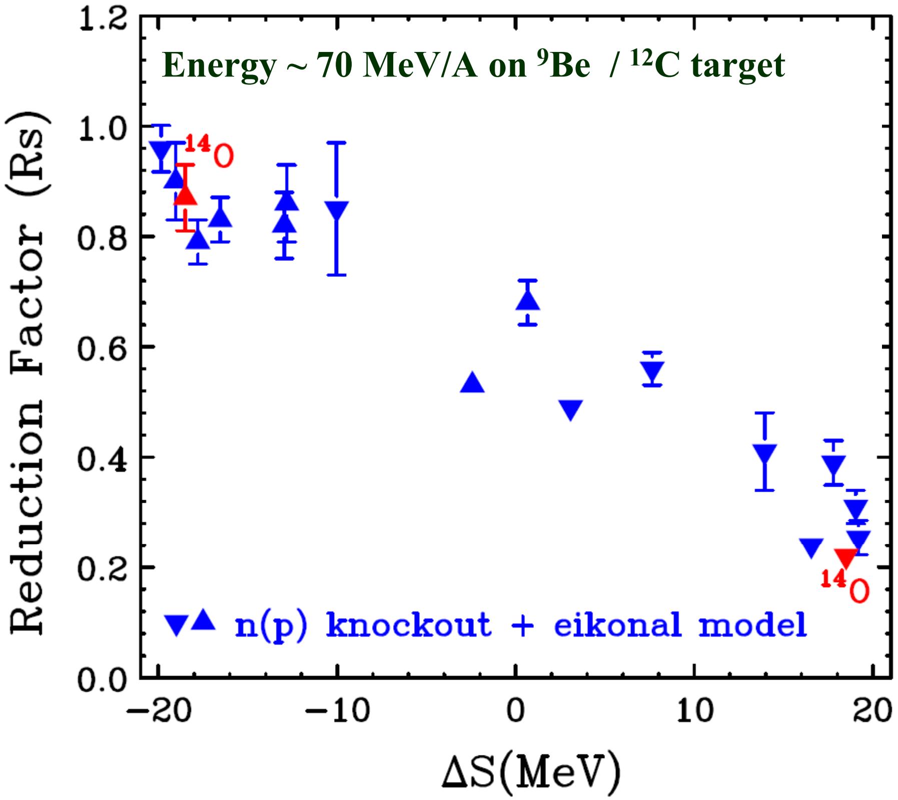
GANIL E569S – SPIRAL Beam

d(^{14}O,t) ^{13}O at 18 MeV/A

Rs **: No Strong Reduction**

F. Flavigny, A. Obertelli, L. Nalpas et al. (CEA Saclay).,
paper in preparation

Composite (^{9}Be, ^{12}C) - Knockout Reaction Model



Inert-core assumption ?

^{12}N: 1n-knockout + 1p evaporation

^{11}C: 1n-knockout + 2p evaporation

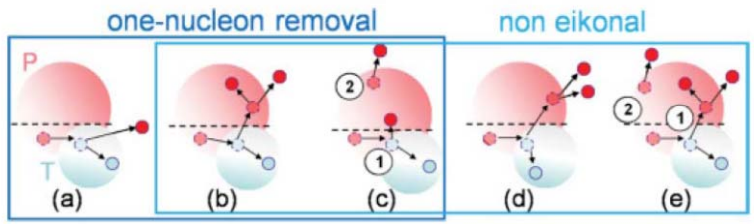
^{12}C(^{14}O, ^{13}N), ^{12}C(^{14}O, ^{13}O),
^{12}C(^{14}O, ^{12}N), ^{12}C(^{14}O, ^{11}C)

✓ **Other Reaction Model: TDSE**

Invariant with beam energy ?

→ Data at energies of 200-300 MeV/A needed

Inert-core ? (reaction mechanism)



Direct KO | Multiple scattering/ Evaporation | Core excitation

Intranuclear Cascade Model (*INC*)

(with nuclear-structure input)

Proj.		ℓj	C^2S	σ_{exp} (mb)	σ_{casc}	σ_{evap} (mb)	σ	σ_{eik} (mb)	δ
^{14}O	$-n$	$p_{3/2}$	3.7	13.4 ± 1.4	11.6	4.2	15.8	50	0.3
	$-p$	$p_{1/2}$	1.8	67 ± 6	22.5	31.4	53.9	41.2	1.3
^{24}Si	$-n$	$d_{5/2}$	1.7	9.8 ± 1.0	9.7	2.6	12.3	23.3	0.5
	$-p$	$d_{5/2}$	3.4	67.3 ± 3.5	24.8	19.7	44.5	65.5	0.7
^{24}O	$-n$	$s_{1/2}$	1.8	63 ± 7	34.3	4.2	38.5	51.2	0.8
^{28}S	$-n$	$d_{5/2}$	3.1	11.9 ± 1.2	12.6	3.2	15.8	33.2	0.5
^{32}Ar	$-n$	$d_{5/2}$	4.1	10.4 ± 1.3	11.2	7.1	18.3	34.6	0.5

C. Louchart, A. Obertelli et al., Phys. Rev. C 83, 011601 (R) (2011)

Proton-induced Knockout Reactions

"**Proton" target – structure-less probe**
→ simpler reaction mechanism
→ sensitive to larger part of wave function

Data needed to **Benchmark Framework**:
(p,pN) Experimental Technique coupled w/ Reaction Theory for Nuclear Correlation Studies in Exotic Nuclei!

Active Developments of Proton targets

→ Powerful technique for spectroscopy at high energy

Reaction Theory:

CDCC, DWIA, AGS/ Faddeev

$p(^{14}O, 2p)^{13}N$, $p(^{14}O, pn)^{13}O$, $p(^{14}O, p)^{14}O$, $p(^{14}O, X)^{12}N$, $p(^{14}O, X)^{11}C$

Fully Exclusive Measurements with Detection of Knocked-out protons & neutrons

Elastic proton-Scattering → Reliable extraction of Distorted Potentials for DWIA

Studies of Multiple-nucleon Knockout & Evaporation Channels

Possible Questions for Discussion

- How well do we understand reaction mechanisms for nucleon-removing reactions (deeply bound nucleon) – empirically and fundamentally ?

- How reliable are spectroscopic factors from knockout (light-nuclus (^{9}Be/ ^{12}C) targets & single-nucleon (hydrogen) targets) ?

- What are the uncertainties in reaction models -- do they change the reliability of spectroscopic information ?

This discussion bring together experimenters and theorists to discuss the needs from each side and offer guidance for future research efforts.

✓ **Comments & Criticisms to Reaction Models**
→ What Data are needed to Verify Models & Benchmark Direct Nuclear Reaction Mechanisms (deeply-bound nucleons)

Understanding Reaction Mechanism → Nucleon Correlation Studies