Transparency Studies using A(e,e'p) & A(e,e'n) reactions

A data-mining project using CLAS EG2 data

Meytal Duer

Tel-Aviv University

Single Nucleon Transparency

averaged probability of the incident and outgoing particles to emerge from the nucleus

A(e,e'N)   N = p/n

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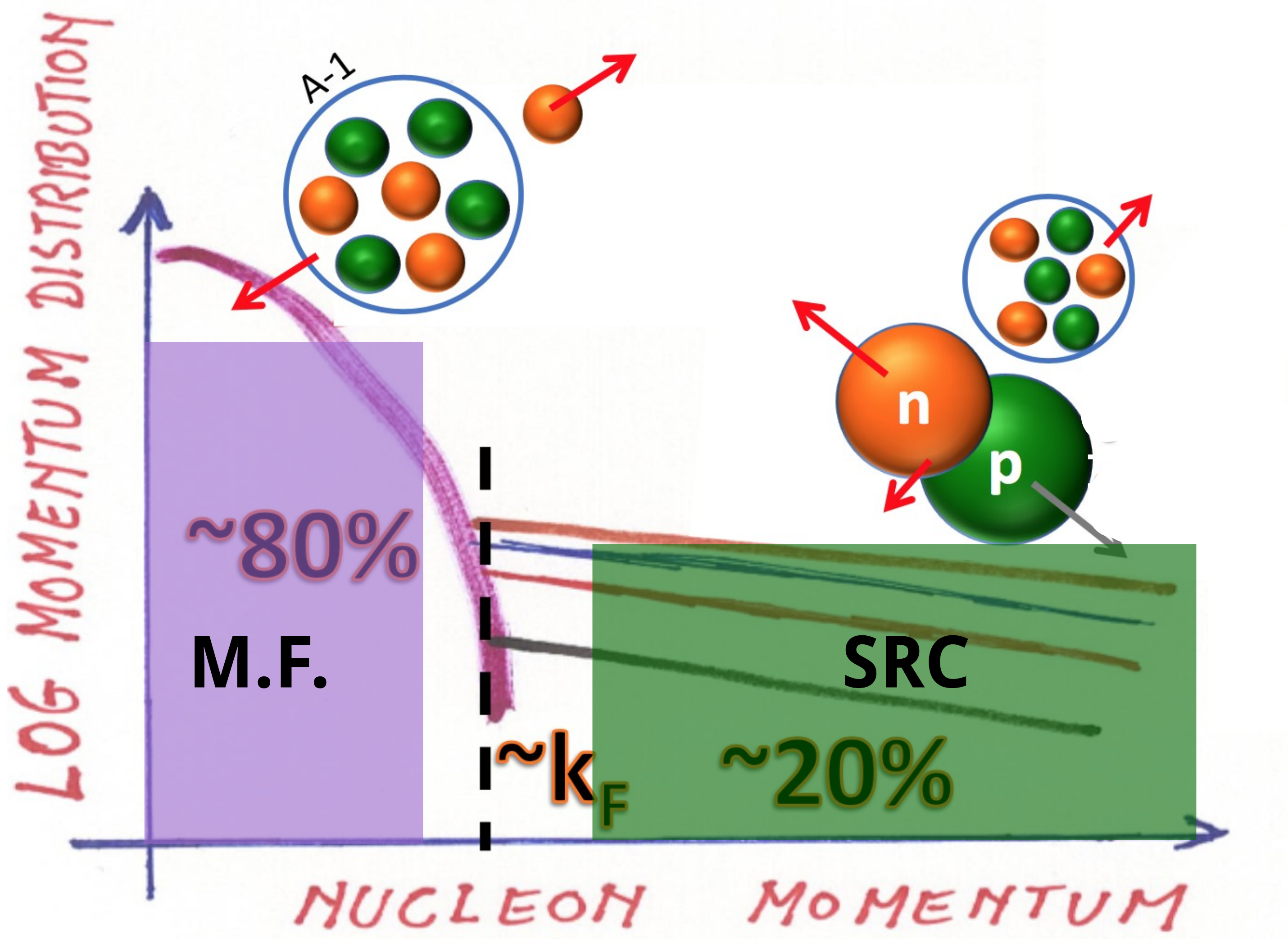
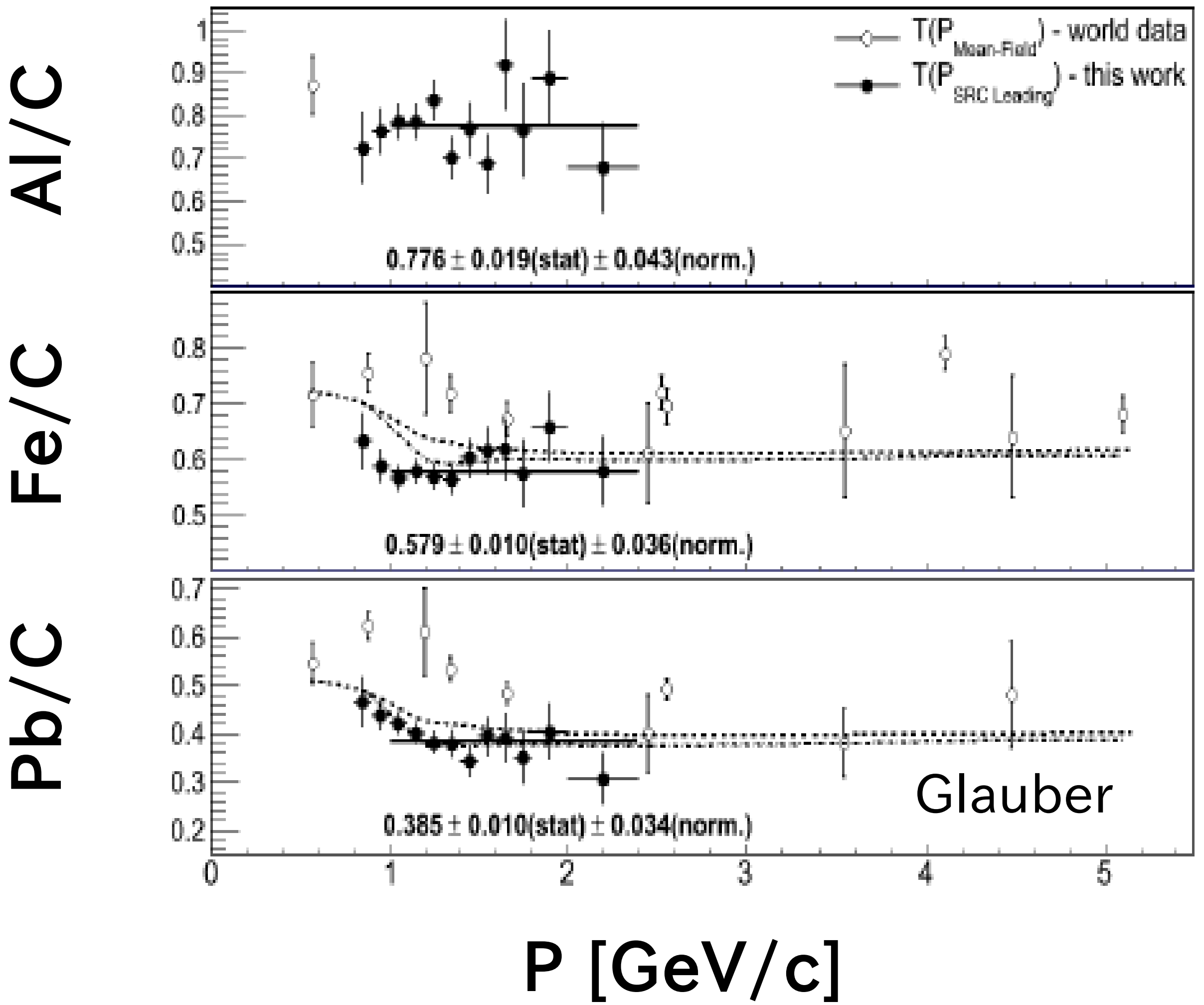

LOG MOMENTUM DISTRIBUTION
A-1
~80%
M.F.
~k_F
n
p
SRC
~20%
NUCLEON MOMENTUM

Existing data from A(e,e'p) measurements

T(A) / T(C)



Hen, et al., Phys. Lett. B 772, 63 (2013)

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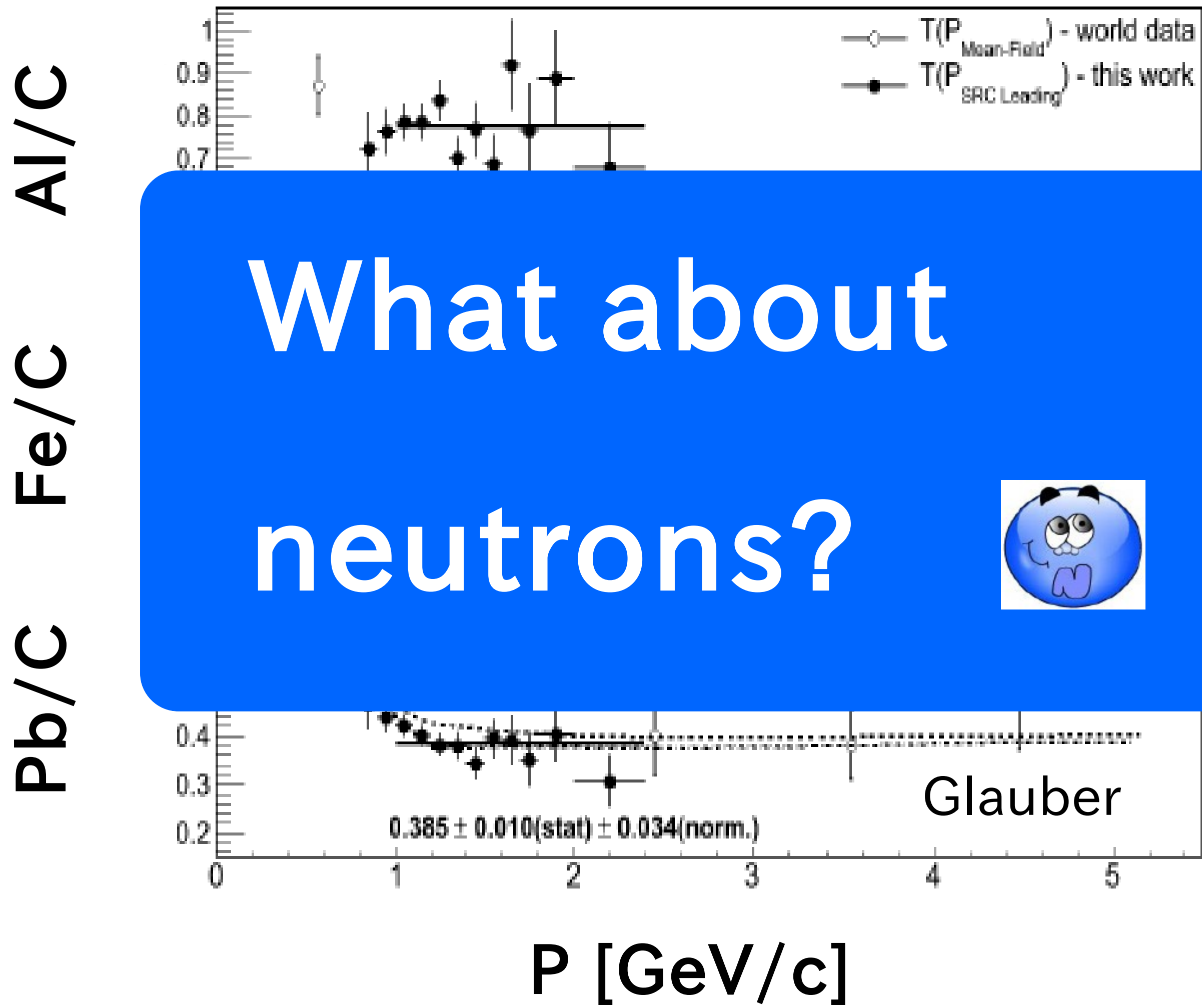

What about neutrons?

Hen, et al., Phys. Lett. B 772, 63 (2013)

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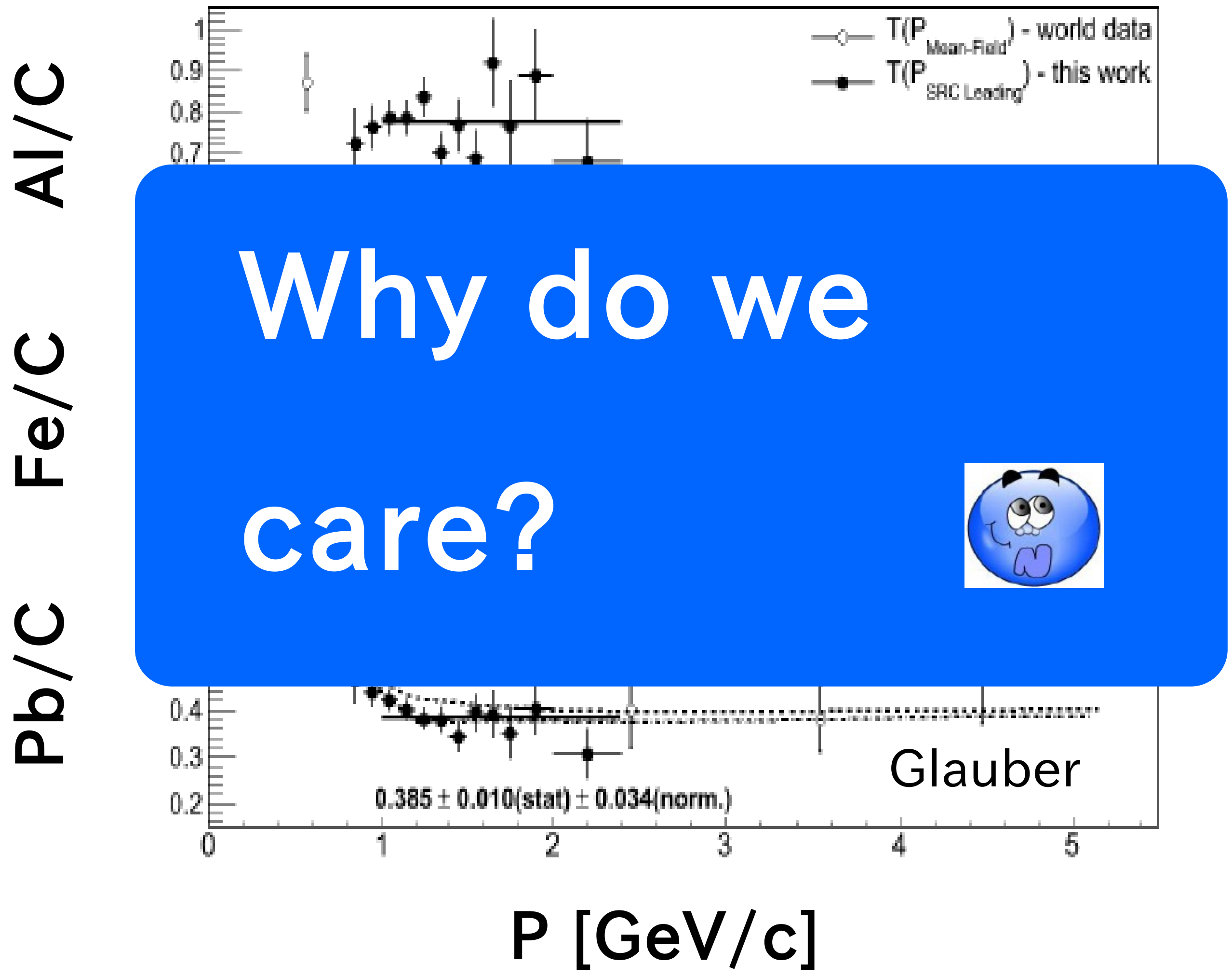
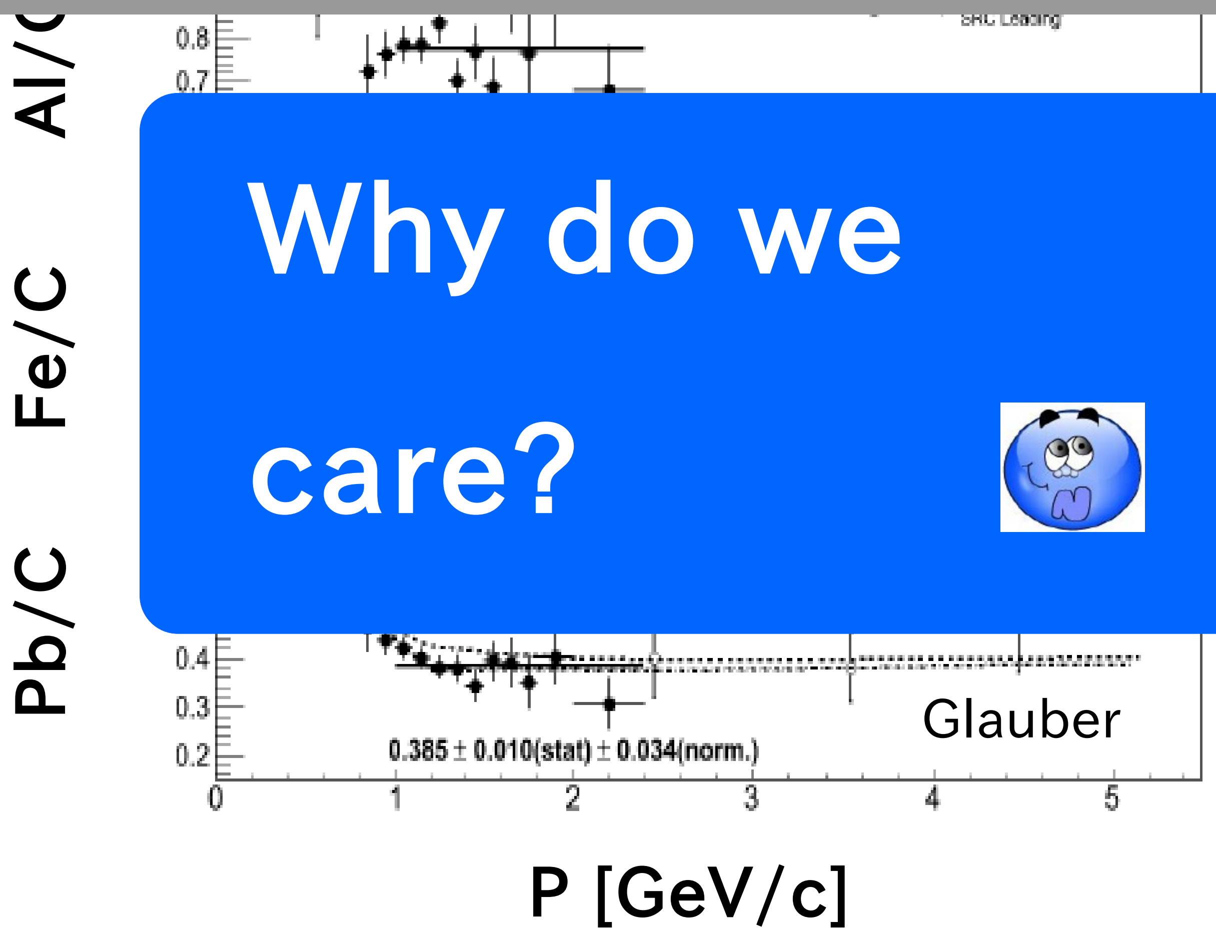


Hen, et al., Phys. Lett. B 772, 63 (2013)

Existing data from A(e,e'p) measurements

T(A) / T(C)

Fundamental for the nucleus description



Why do we care?

Hen, et al., Phys. Lett. B 772, 63 (2013)

Existing data from A(e,e'p) measurements

T(A) / T(C)

Fundamental for the nucleus description

Why do we care?

More important: we assume $T_p = T_n$

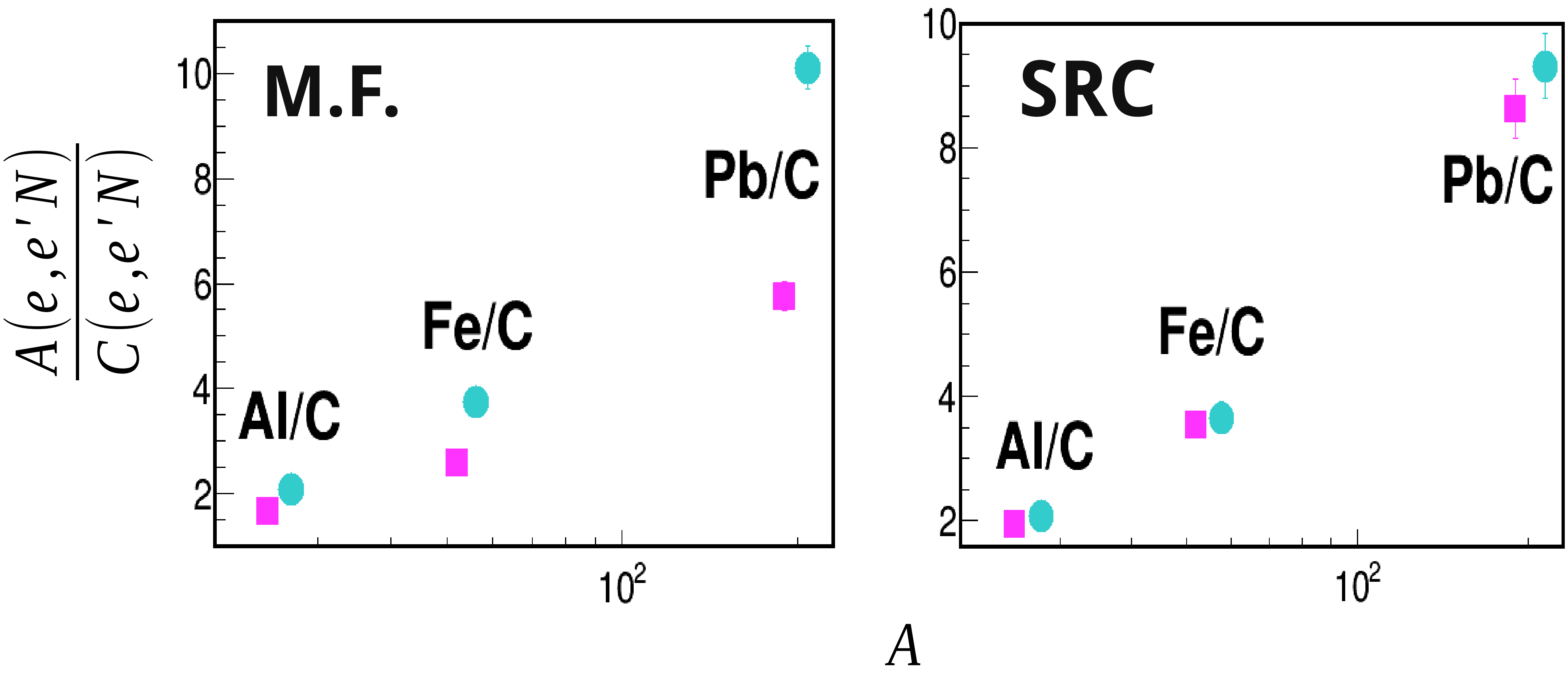
Hen, et al., Phys. Lett. B 772, 63 (2013)

A(e,e'N)/C(e,e'N) cross-sections

N=p/n

Duer, Approved CLAS analysis note

neutrons protons



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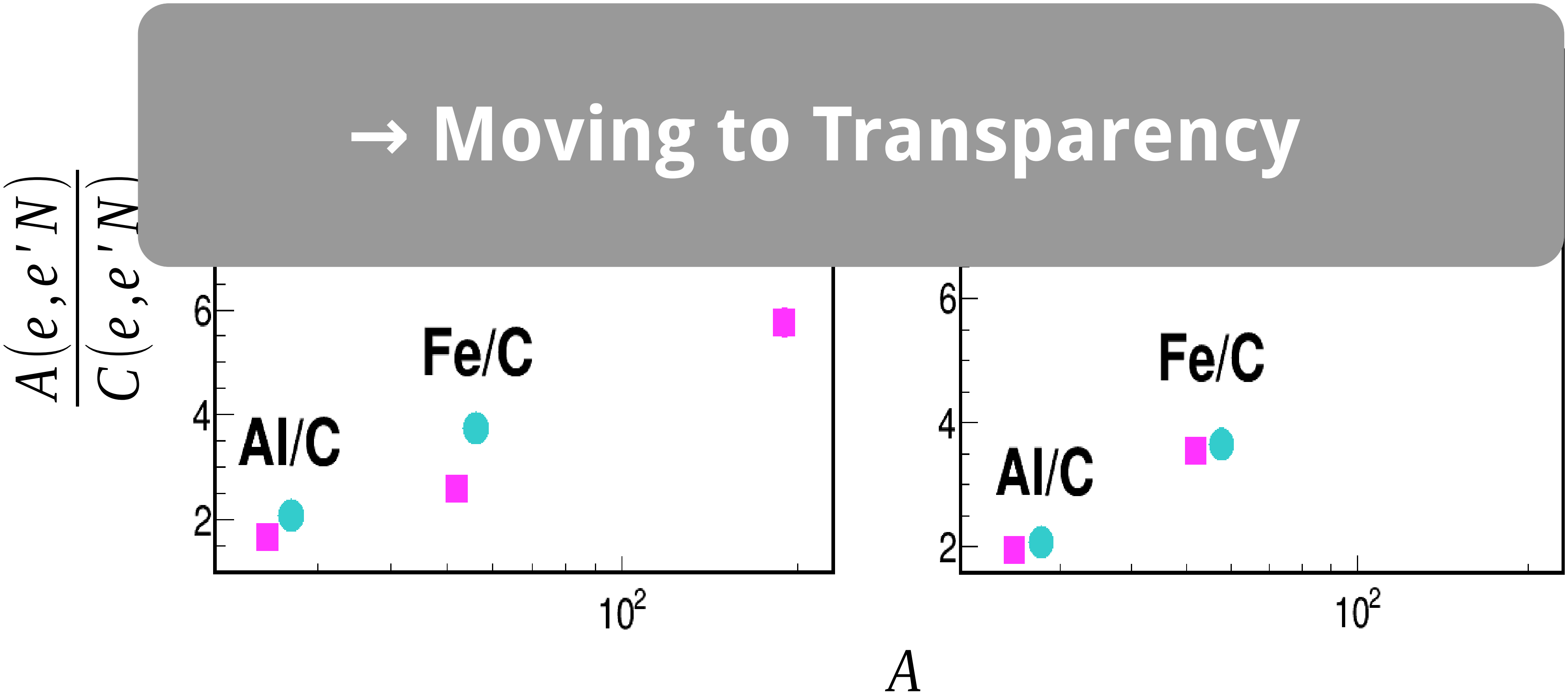

Formal Definition

$$T_N(A) = \frac{\sigma_{\exp} A(e, e' N)}{\sigma_{PWIA} A(e, e' N)}$$

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Following Ref. [1] using factorized approximation for large Q²:

$$\sigma_{PWIA} = \frac{K}{\# N} \cdot E_N \cdot \sigma_{eN} \cdot \oint S_A(E, p_i)$$

[1] De Forest, Nucl. Phys. A 392, 232 (1983)

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Moving to ratios:

$$\frac{T_N(A)}{T_N(C)} = \frac{\sigma_{\exp} A(e,e'N) / \oint S_A(E,p_i)}{\sigma_{\exp} C(e,e'N) / \oint S_C(E,p_i)}$$

[1] De Forest, Nucl. Phys. A 392, 232 (1983)

M.F.

$$\frac{T_N^{M.F.}(A)}{T_N^{M.F.}(C)} = \frac{\sigma_{\exp} A(e,e'N) / \int_0^{k_0} n_A(p_i)}{\sigma_{\exp} C(e,e'N) / \int_0^{k_0} n_C(p_i)}$$

$$n_A(p_i) = \int_0^{\infty} S_A(E, p_i)\, dE \quad [2]$$

k_0: 300 MeV/c, k_F

$n_A(p_i)$: Wood-Saxon [3]
Serot- Walecka [4]
Ciofi & Simula [5]

[2] Frankfurt, Strikman, Zhalov 503, 73, PRB 503, 73 (2000)
[3] Vanhalst, Ryckebusch, Cosyn, PRC 86, 044619 (2012) [4] Furnstahl, Serot, Tang, Nucl. Phys. A615, 441 (1997)
[5] Ciofi, Simula, PRC 53, 1689 (1996)

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SRC

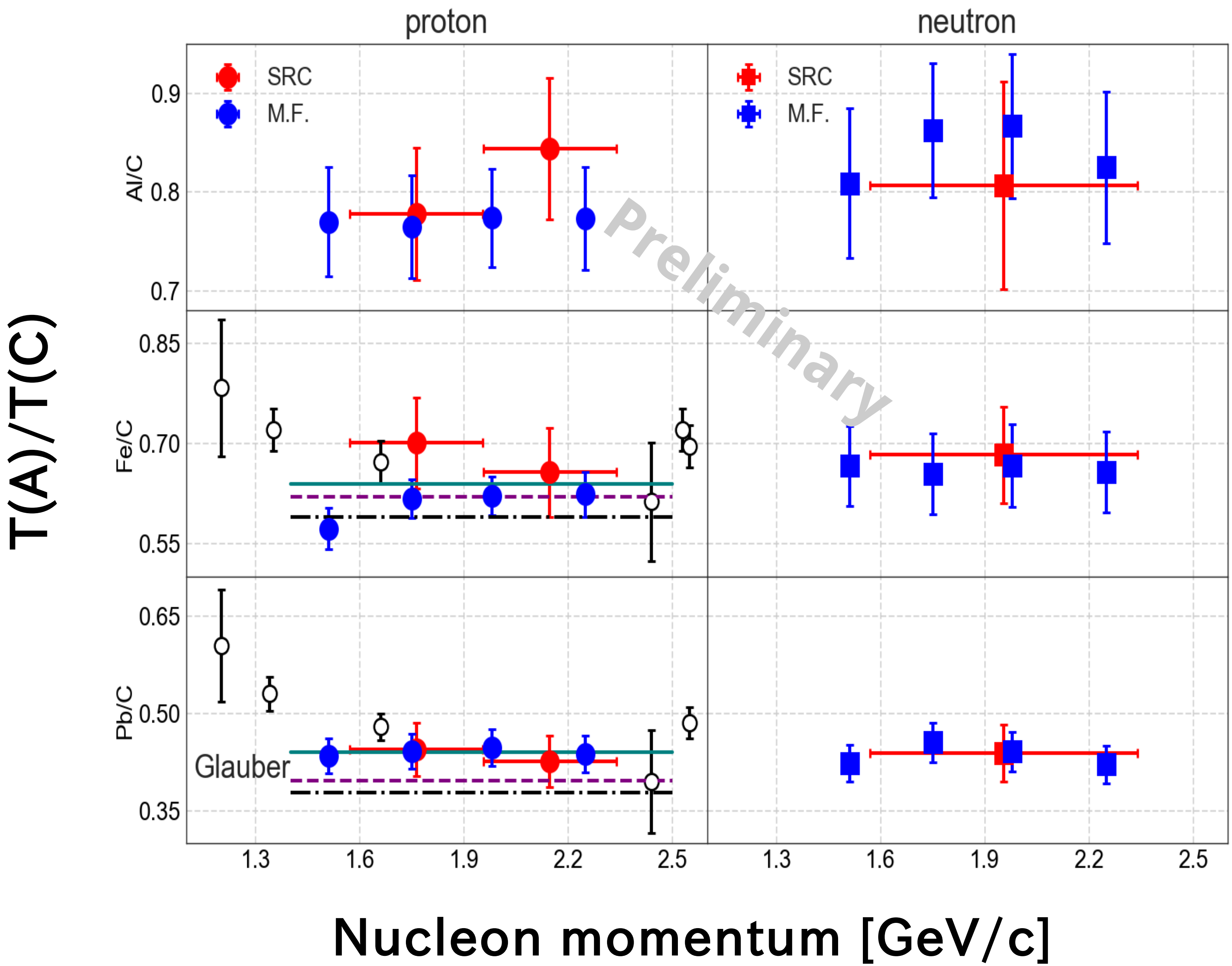
Following Ref. [6]:

$$\frac{T_N^{SRC}(A)}{T_N^{SRC}(C)} = \frac{1}{a_2(A/C)} \cdot \frac{\sigma_{\exp} A(e,e'N)/A}{\sigma_{\exp} C(e,e'N)/12}$$

a_2 probabilities taken from Ref. [7]

[2] Frankfurt, Strikman, Zhalov 503, 73, PRB 503, 73 (2000)
[3] Vanhalst, Ryckebusch, Cosyn, PRC 86, 044619 (2012) [4] Furnstahl, Serot, Tang, Nucl. Phys. A615, 441 (1997)
[5] Ciofi, Simula, PRC 53, 1689 (1996) [6] Hen et al., PLB 722, 63 (2013) [7] Schmoolker et al., to be submitted

Results



C. Colle, W. Cosyn, Phys. Rev. C 93, 034608 (2016).
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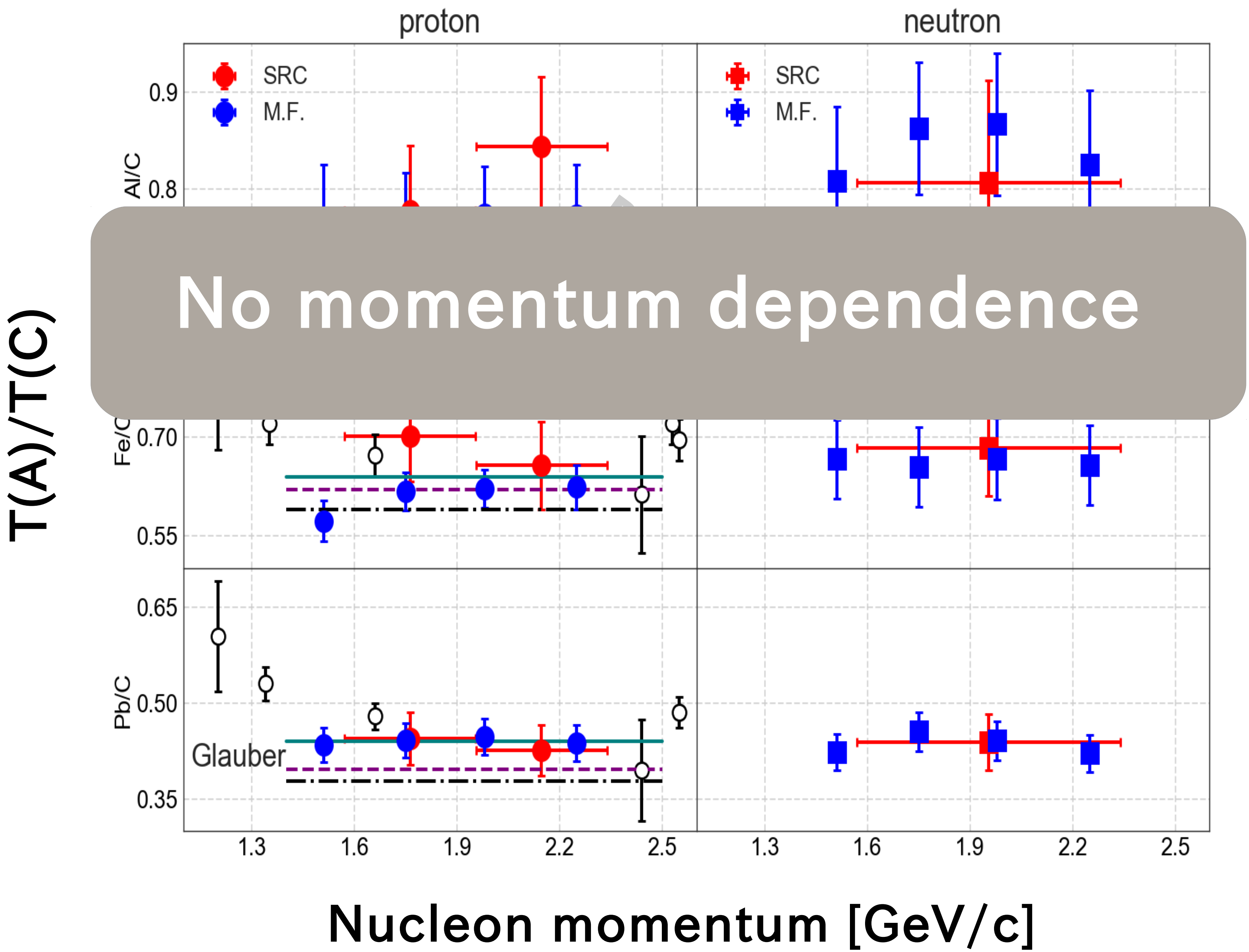

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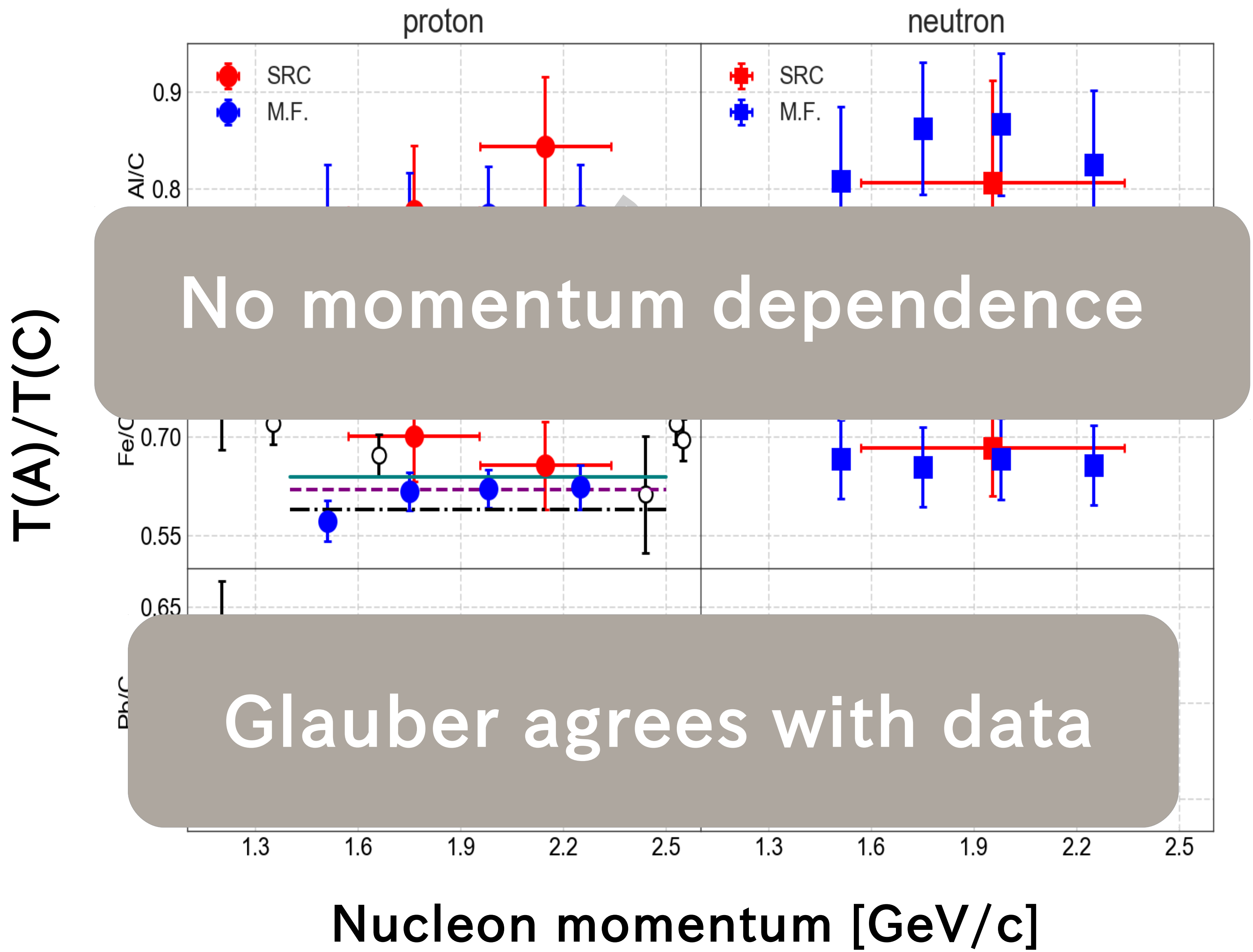

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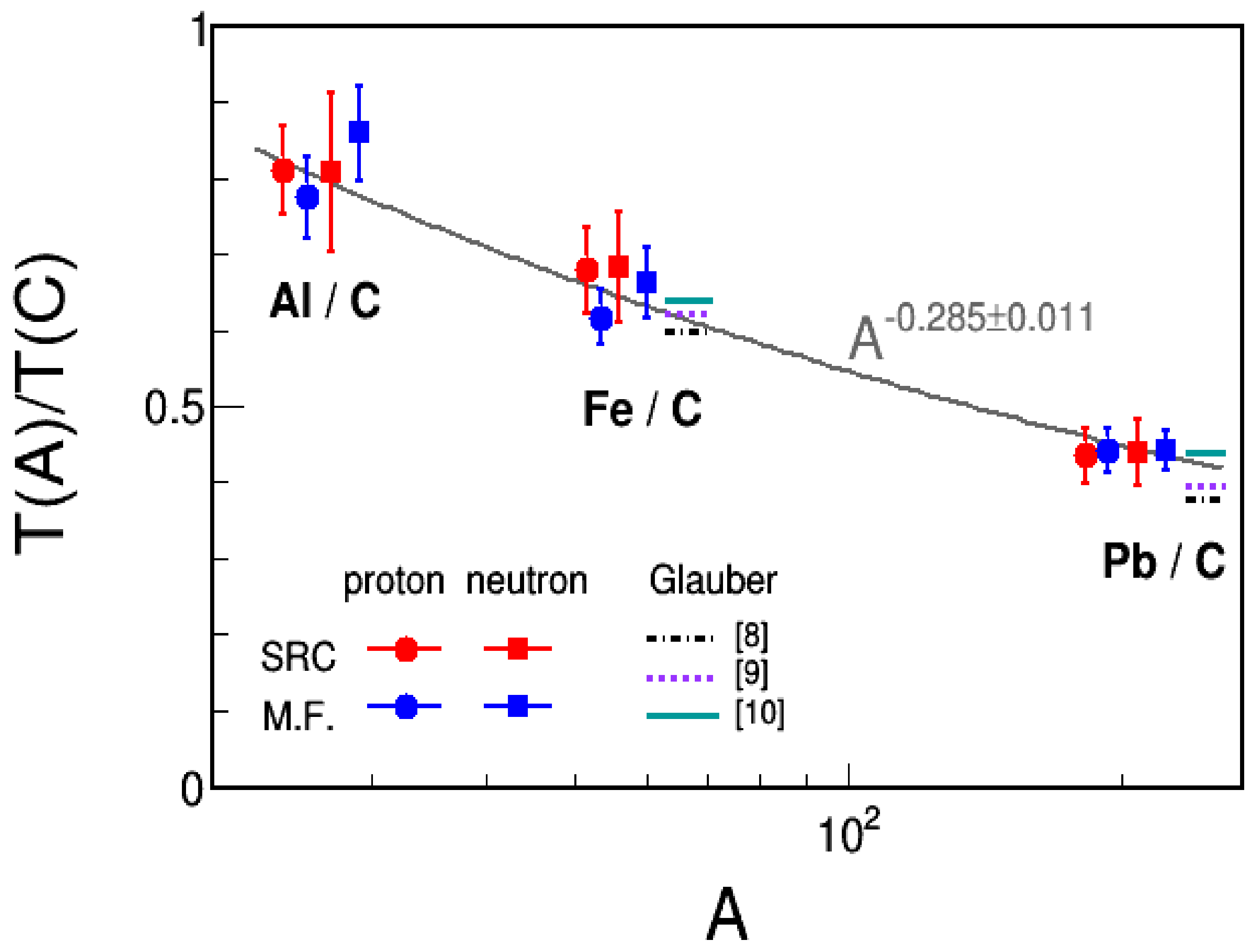

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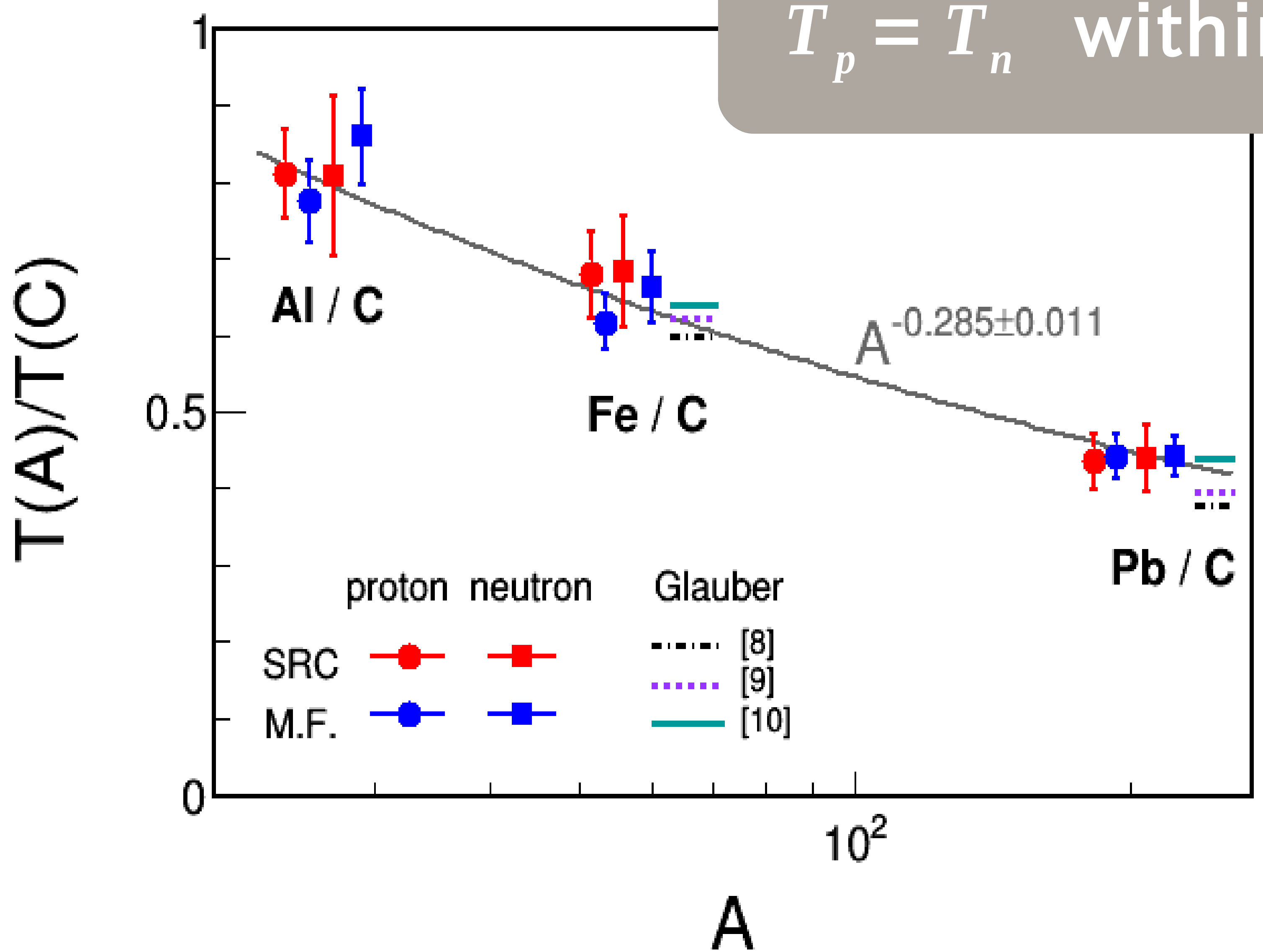
$T_p = T_n$ within 5%



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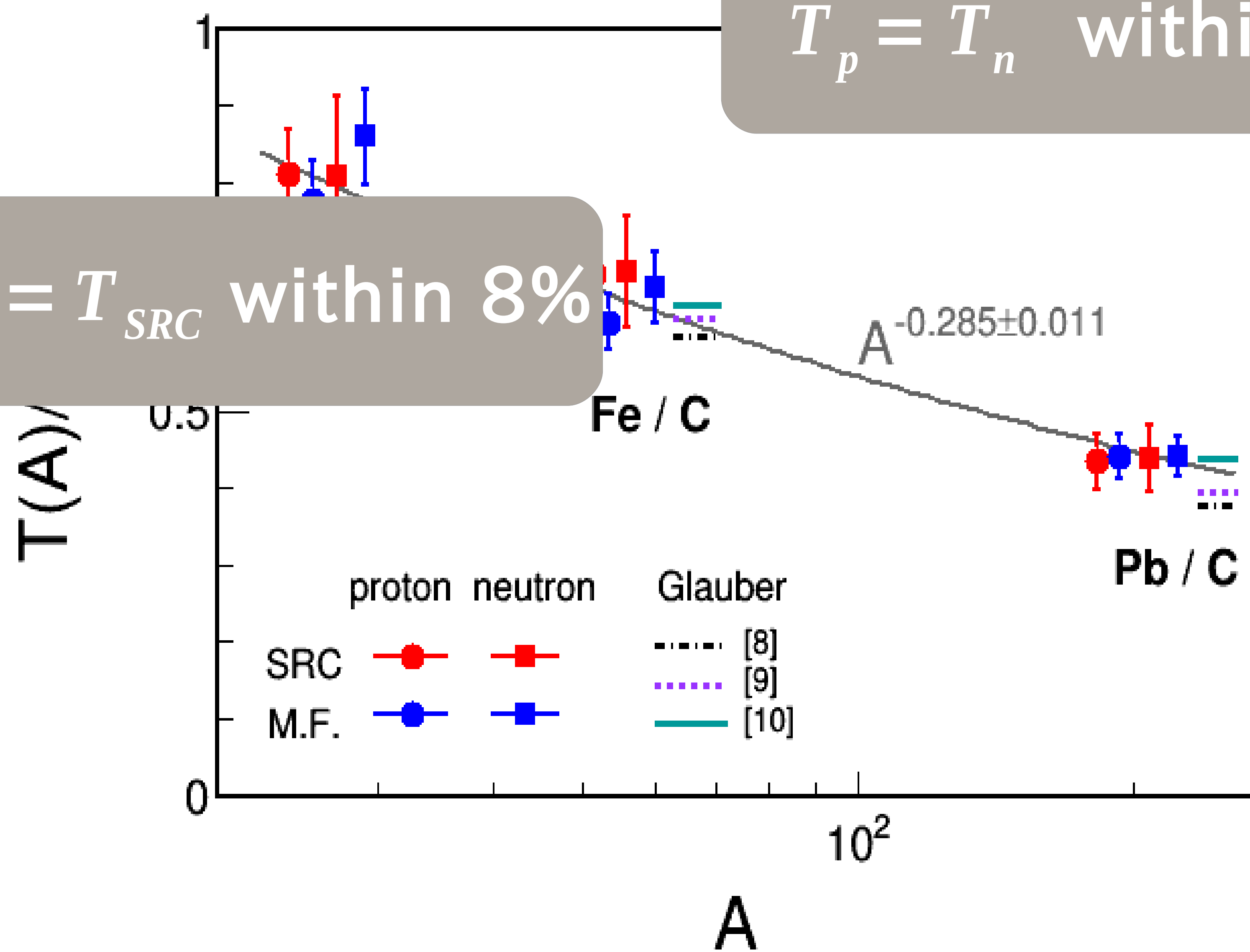
$T_p = T_n$ within 5%

$T_{M.F.} = T_{SRC}$ within 8%



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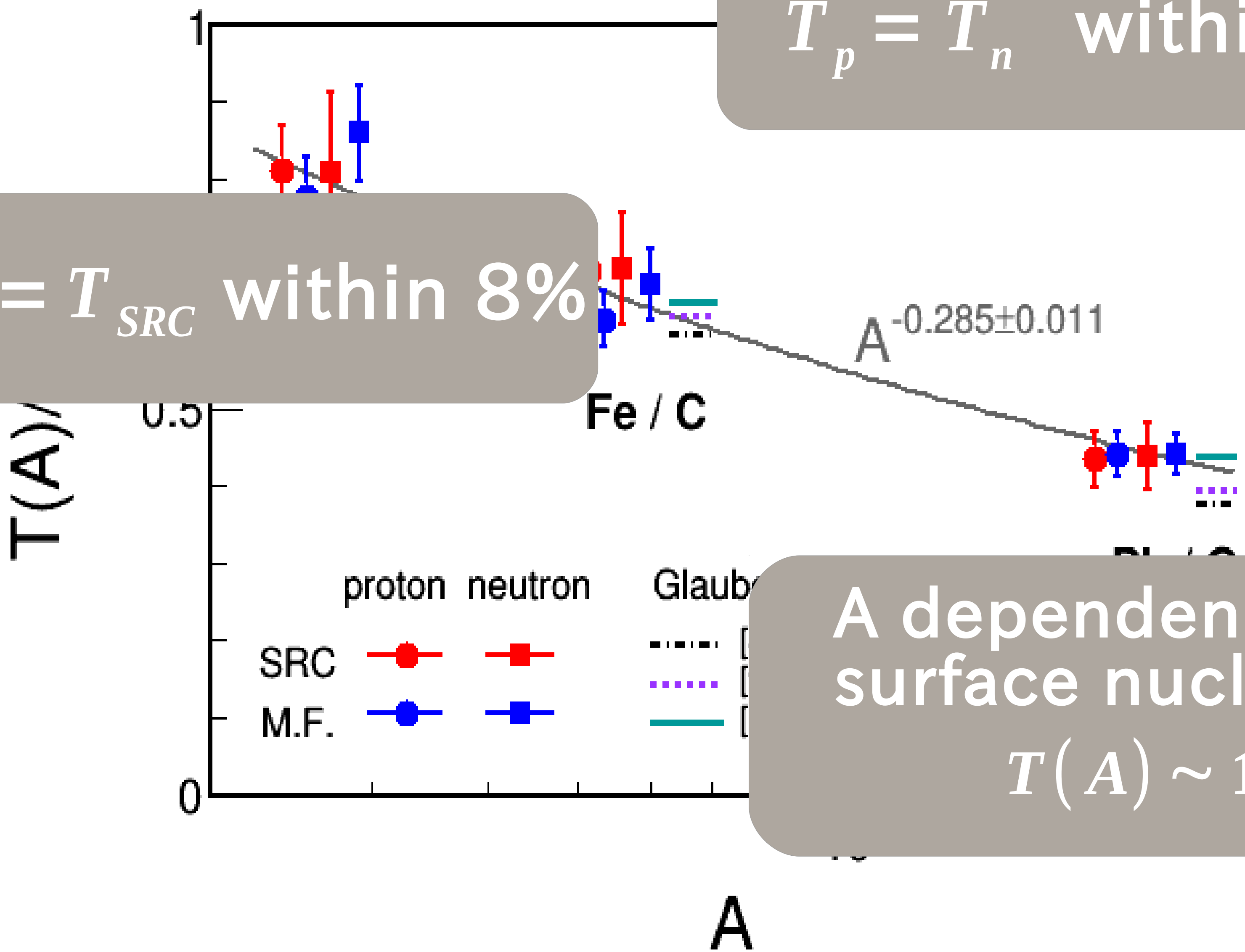

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A dependence → surface nucleons

$T(A) \sim 1/r$

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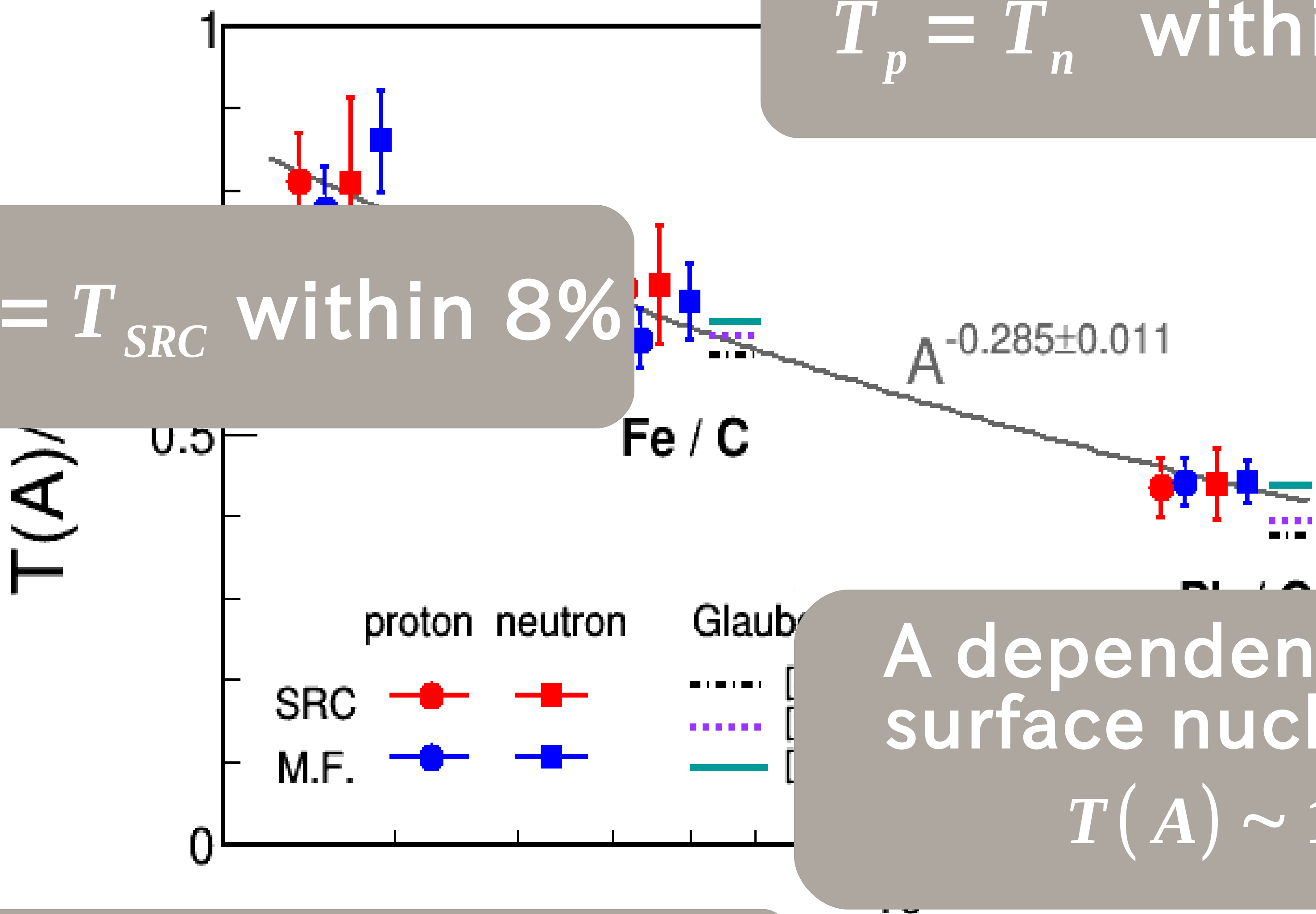

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Glauber agrees with data

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Analysis Status

Analysis review committee – (almost) Done

Paper draft (to be submitted for PRL)

Measurement of Transparency Ratios for Protons and Neutrons

M. Duer,[1] O. Hen,[2,*] E. Piasetzky,[1] L.B. Weinstein,[3] A. Schmidt,[2] E. O. Cohen,[1] I. Korover,[1] and H. Hakobyan[4]
(The CLAS Collaboration)

[1]School of Physics and Astronomy, Tel Aviv University, Tel Aviv 69978, Israel
[2]Massachusetts Institute of Technology, Cambridge, Massachusetts 02139, USA
[3]Old Dominion University, Norfolk, Virginia 23529
[4]Universidad Técnica Federico Santa María, Casilla 110-V Valparaíso, Chile

Knowledge of nuclear transparency for single-nucleon knockout reactions is fundamental for their theoretical description and interpretation. It serves as a baseline in the search for in-medium bound nucleon modifications, study of color-transparency effects, reaction rate calculations, and more. This paper presents, for the first time, measurements of neutron transparency ratios for nuclei relative to C measured using the $A(e,e'n)$ reaction, spanning measured neutron momenta of 1.4 to 2.4 GeV/c. The transparency ratios were extracted in two kinematical regimes, corresponding to knockout of mean-field nucleons and to the breakup of Short-Ranged Correlated nucleon pairs. The extracted neutron transparency ratios are consistent for the two kinematical regimes and also agree with proton transparencies extracted from new and previous $A(e,e'p)$ measurements, even for asymmetric nuclei like lead. The nuclear-mass dependence of the extracted transparencies scale as A^{α} with $\alpha = -0.285 \pm 0.011$, which is consistent with nuclear surface dominance of the reactions.

Ad-hoc committee for the paper – Pending

Thank you!


Acknowledgment

Analysis review committee

Data-Mining collaboration

CLAS collaboration

OLD DOMINION UNIVERSITY

Massachusetts Institute of Technology

Jefferson Lab

EX UMBRA IN SOLEM

UNIVERSIDAD TECNICA FEDERICO SANTA MARIA

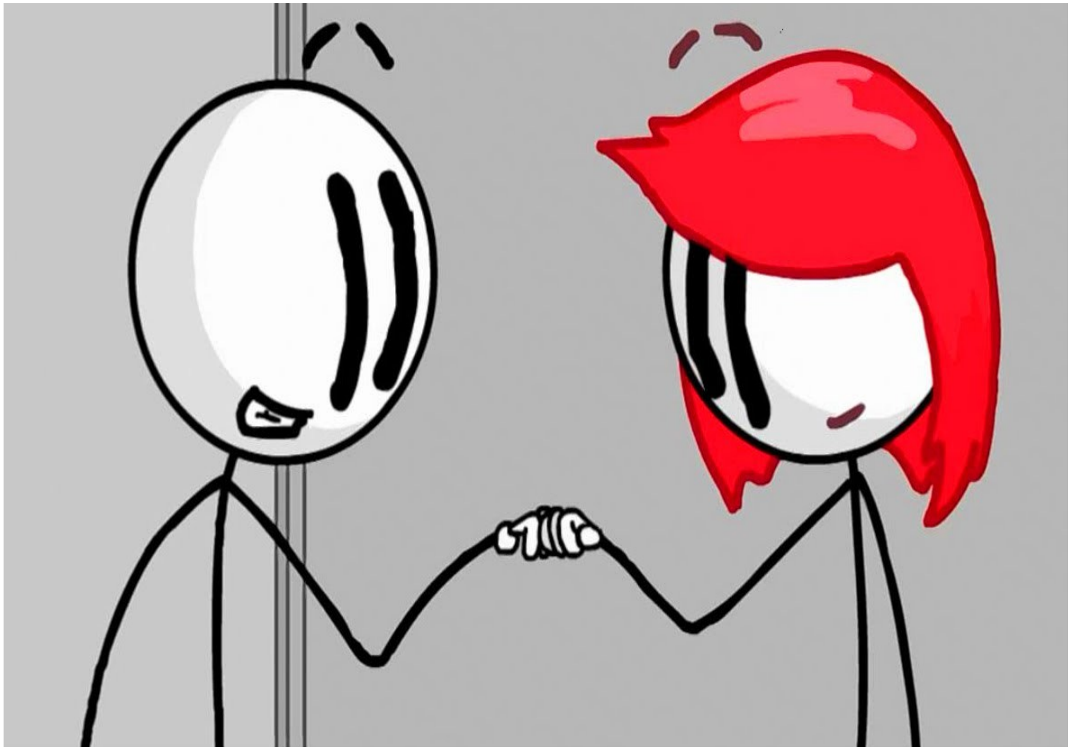
protons	measured ratio	Event selection	False positive and negative	Statistics	Prediction
Al/C	1.15 ± 0.09	± 0.06	± 0.01	± 0.06	$1.06 - 1.17$
Fe/C	1.36 ± 0.08	± 0.07	± 0.01	± 0.03	$1.20 - 1.30$
Pb/C	1.50 ± 0.10	± 0.09	± 0.02	± 0.04	$1.44 - 1.60$

neutrons	measured ratio	Event selection	False positive and negative	Statistics	Prediction
Al/C	0.99 ± 0.10	± 0.05	± 0.01	± 0.09	$0.97 - 1.07$
Fe/C	1.05 ± 0.08	± 0.06	± 0.01	± 0.05	$0.92 - 1.03$
Pb/C	0.92 ± 0.06	± 0.05	± 0.01	± 0.03	$0.71 - 0.83$

Single Nucleon Transparency

averaged probability of the incident and outgoing particles to emerge from the nucleus

A(e,e'N)   N = p/n



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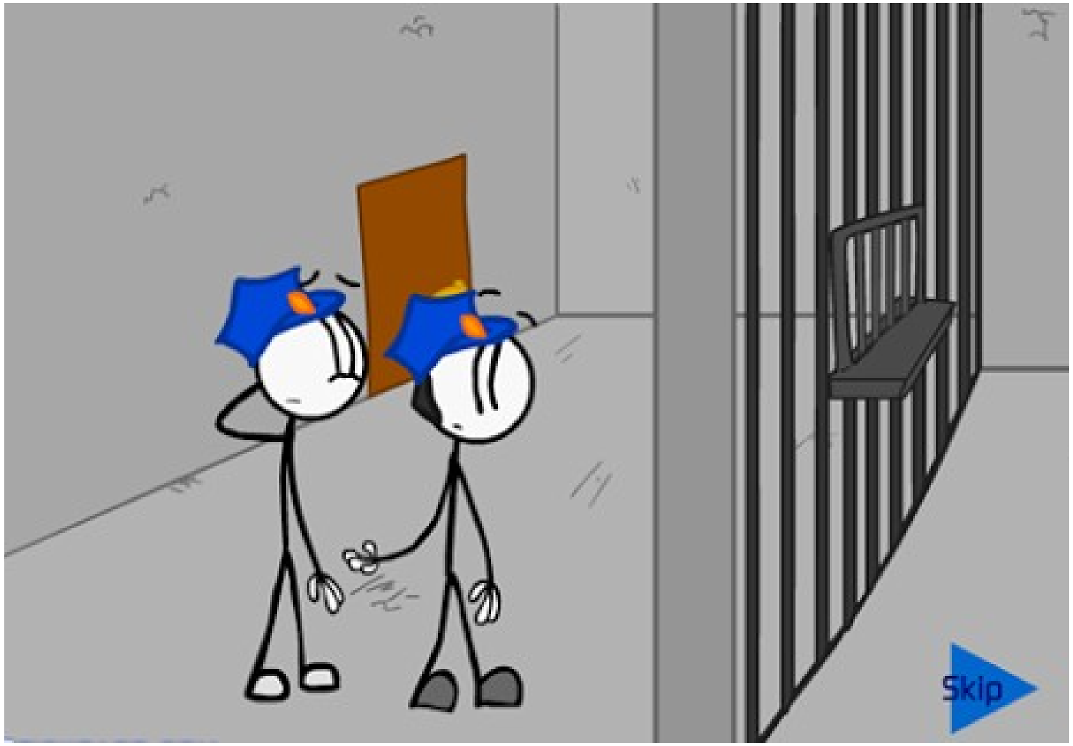

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