



百年
物理

1926 - 2026

TSINGHUA PHYSICS

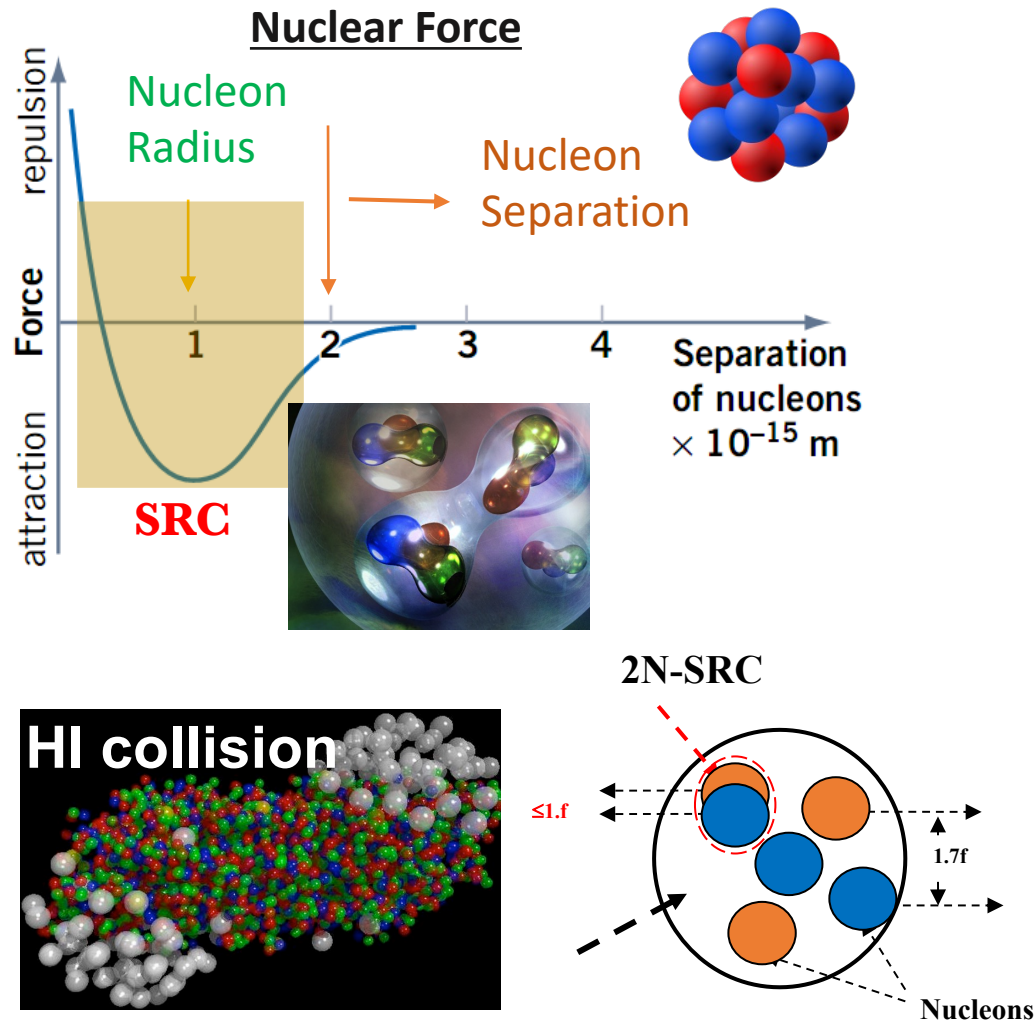


短程关联研究实验进展

叶志鸿, 清华大学物理系

第20届中高能核物理大会, 2025年4月27号, 上海嘉定区

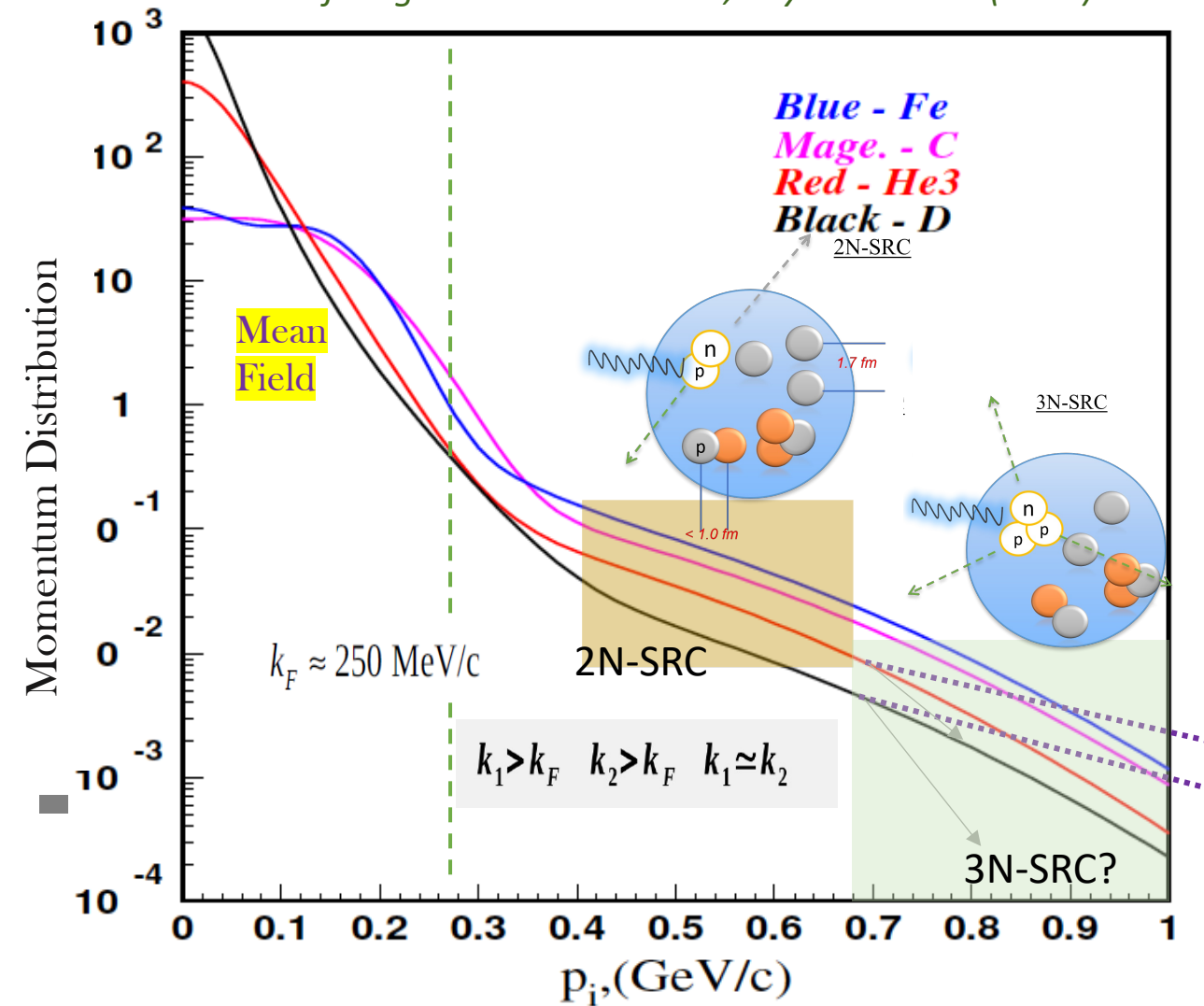
Short-Range Correlations (SRC)



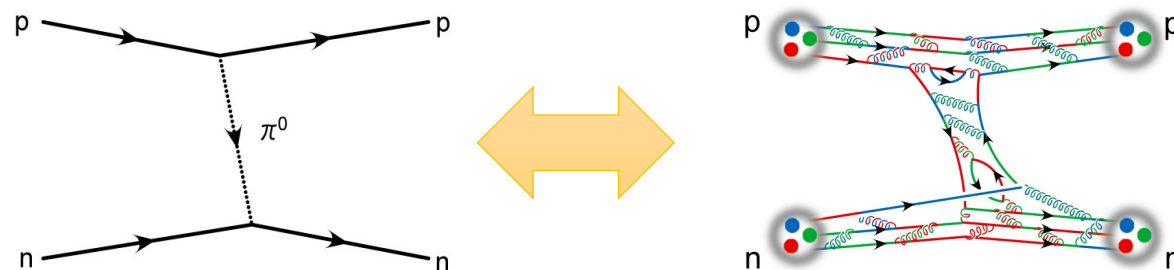
Hot dense
nuclear matter

Cold dense
“nuclear matter”

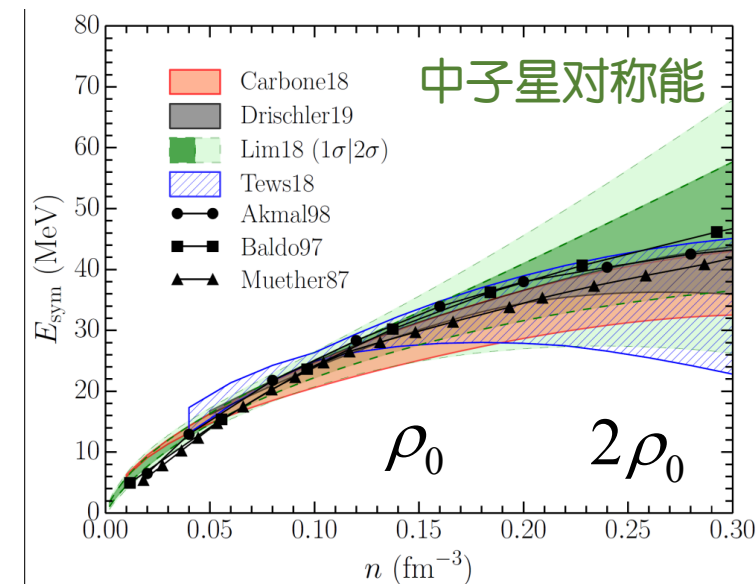
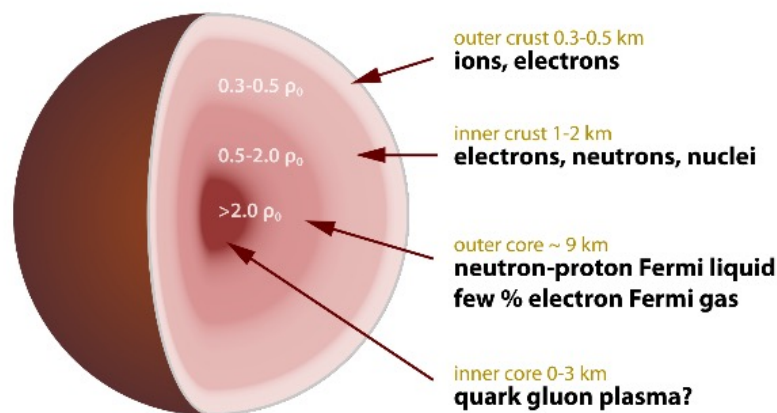
C. Ciofi degli Atti and S. Simula, Phys. Rev. C 53 (1996).



□ 原子核结构&核力起源：平均场→长程关联→短程关联→原子核的QCD结构



□ 低温高密度→中子星 (SRC密度 $\rho = 2 - 5 \rho_0$)

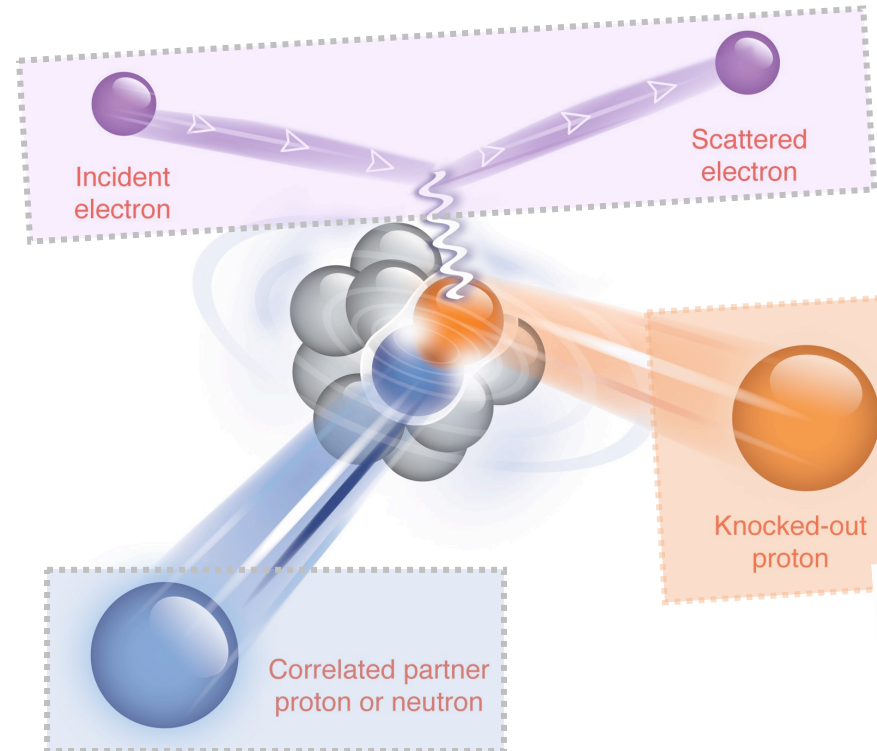
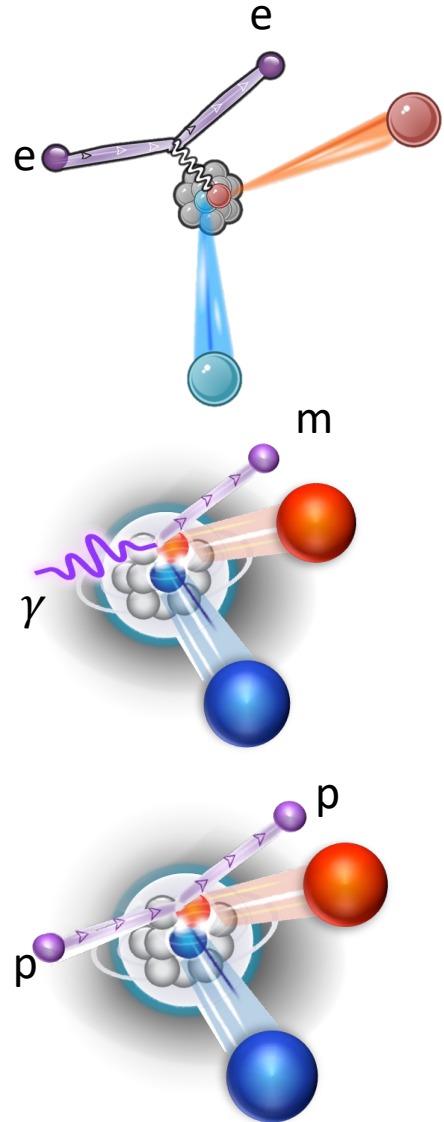


□ SRC团簇占原子核基态的20%→无中微子双Beta衰变的质量矩阵

Wang, Zhao, Meng, arXiv: 2304.12009, Song, Yao, Ring, Meng, Phys. Rev. C **95**, 024305



□ 准弹性敲出(Quasi-Elastic Scattering, QES): 高能粒子直接敲出高动量核子, 剩余基态 $A-1/A-2$ 原子核

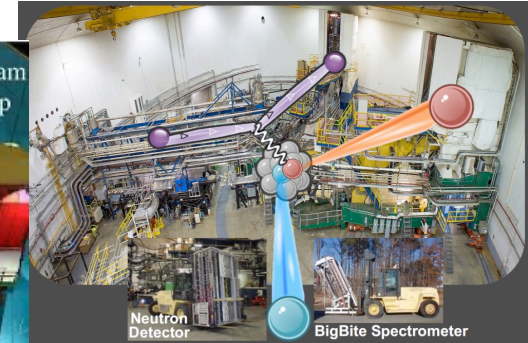
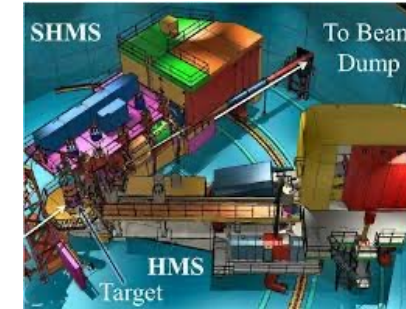


Inclusive $(e,e') (p,p')$

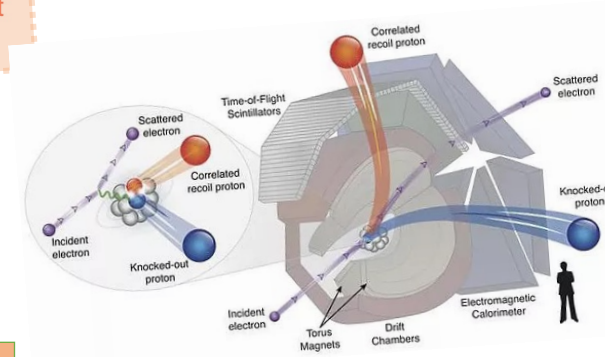
Semi exclusive $(e,e'p) (p,2p) (\gamma, mN)$

exclusive $(e,e'pN) (p,2pN)$

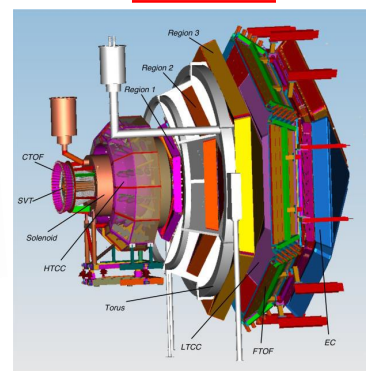
✓ 高精度



✓ 大接收度



CLAS12



❑ 2N-SRC核子对处于原子核的平均场中 → 多种过程中分离QES

- ❑ 直接观测条件:
- ✓ 只击中单个SRC核子, 剩余核为基态 (假设)
 - ✓ 高动量核子出射, 配对核子反方向 (背靠背)
 - ✓ SRC核子不再与剩余核再次碰撞 (假设或理论修正)
 - ✓ 探测/重建的核子动量≈初始值 (理论修正)

❑ 满足条件的实验动量区间: $q \gg P_{relative} \gg P_{cm}$

Inclusive (e,e') (p,p'): $Q^2 = 4E_0E'\sin^2(\theta/2) > 1.3\text{GeV}^2, x = \frac{Q^2}{2m_p\nu} > 1.2$

Semi exclusive (e,e'p) (p,2p): $p_p > 300\text{MeV}/c$

exclusive (e,e'pN) (p,2pN): $|p_{cm}| = |p_{A-2}| < \sim 100\text{MeV}/c, \vec{p}_p = -\vec{p}_N$

❑ SRC观测量 vs 理论计算 (可因子化假设)

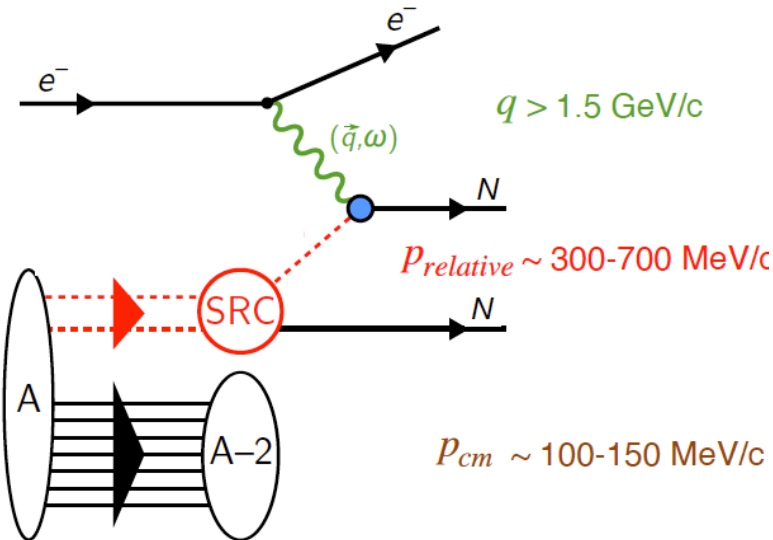
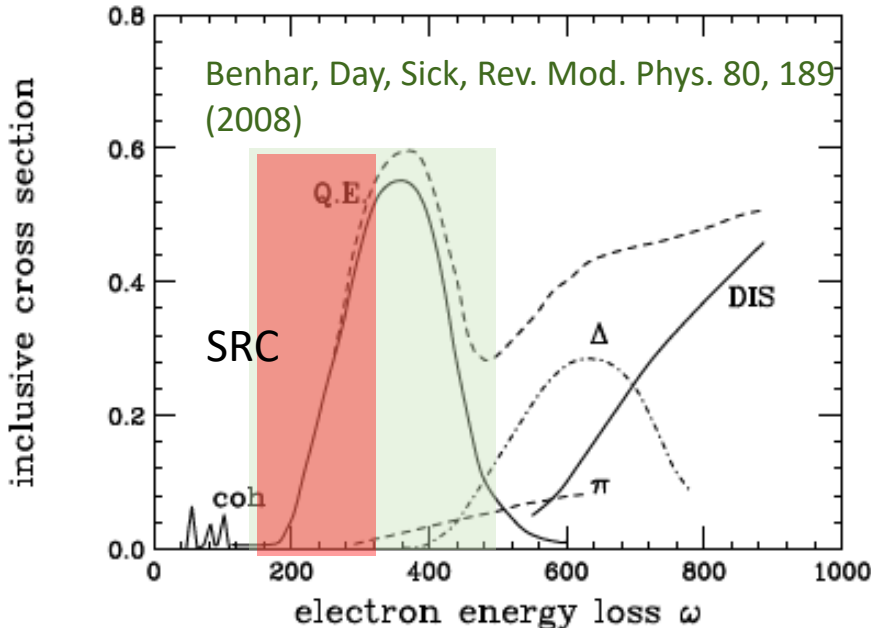
Elementary
eN cross section

Nuclear
Contacts

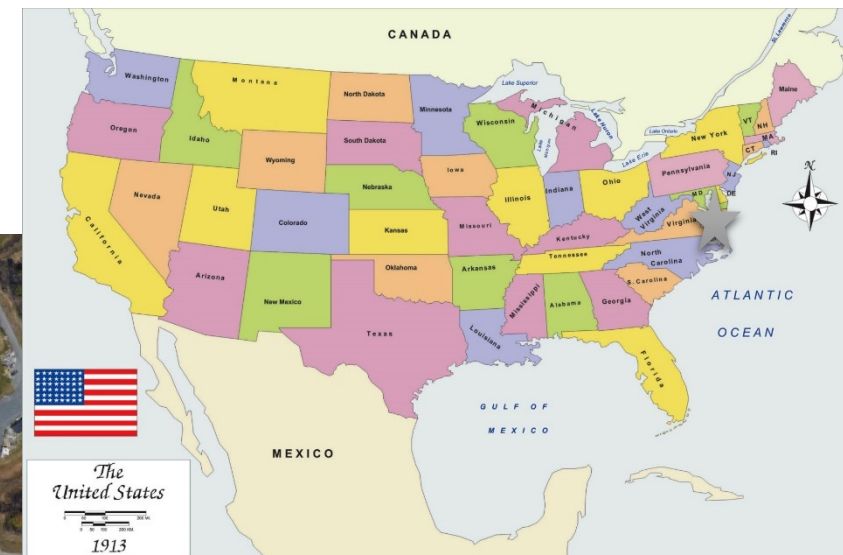
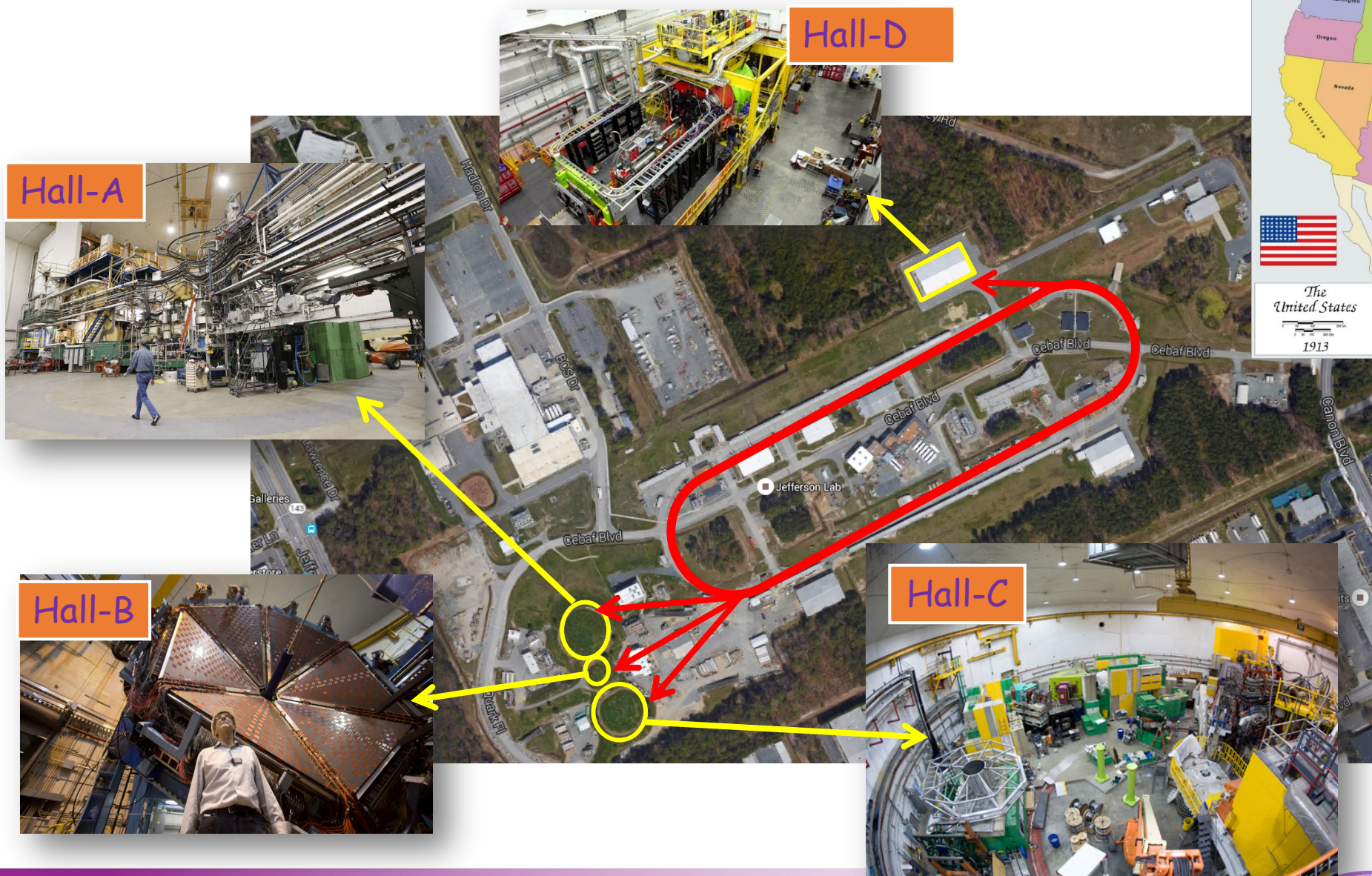
Two-body
wave function

Center of mass
motion

$$\sigma_{eA} = \sigma_{eN}(q) \cdot \sum_{NN\text{-pairs}} \cdot C_A^{NN} \cdot |\phi(p_{relative})|^2 \cdot n(p_{cm})$$



□ Thomas Jefferson Lab



Jefferson Lab
Thomas Jefferson National Accelerator Facility



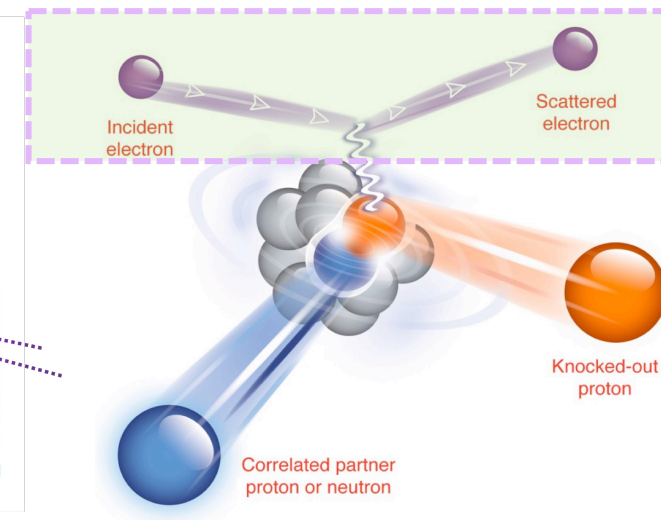
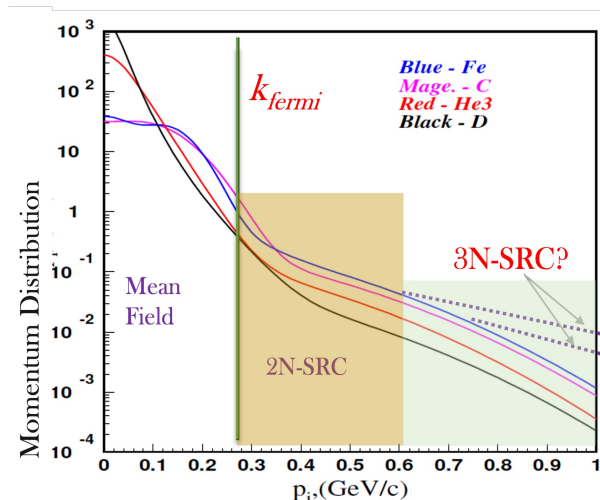
□ A(e,e')反应:

- ✓ QES反应截面 $\sim \propto$ 动量分布 $\sim n(k)$

$$\frac{d\sigma_{QE}}{dE' d\Omega}(Q^2, x_{bj}) = 2\pi\sigma_{eN} \int_{p_{min}}^{p_{max}} k dk \int_{E_S^{min}}^{E_S^{max}} S(k, E_S) dE_S$$

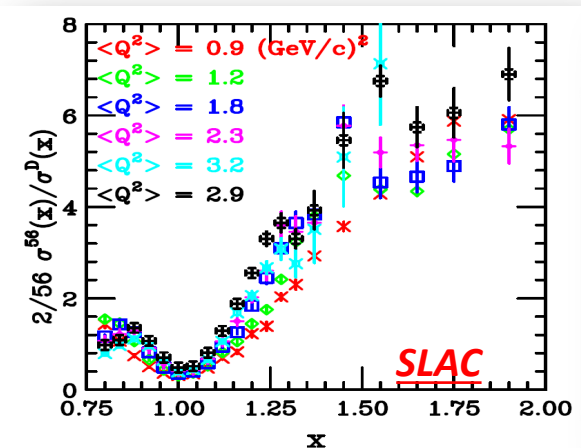
- ✓ 寻找相似动量尾巴构成的平台

$$a_2(A, D) = \frac{2 \sigma_A(x, Q^2)}{A \sigma_D(x, Q^2)}, \quad 2N-SRC (1.3 < x_{bj} < 2):$$

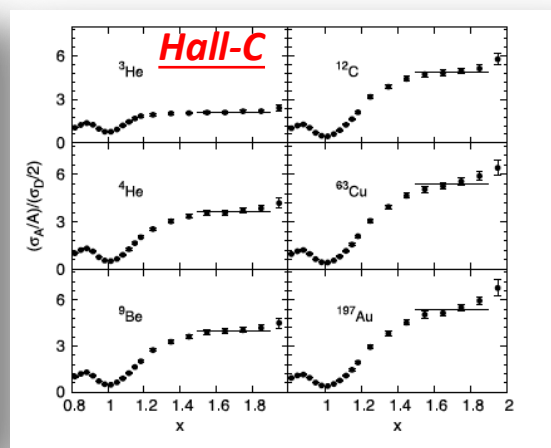


Y.P. Zhang, Z. Ye, et. al,
arXiv:2504.17462 submitted

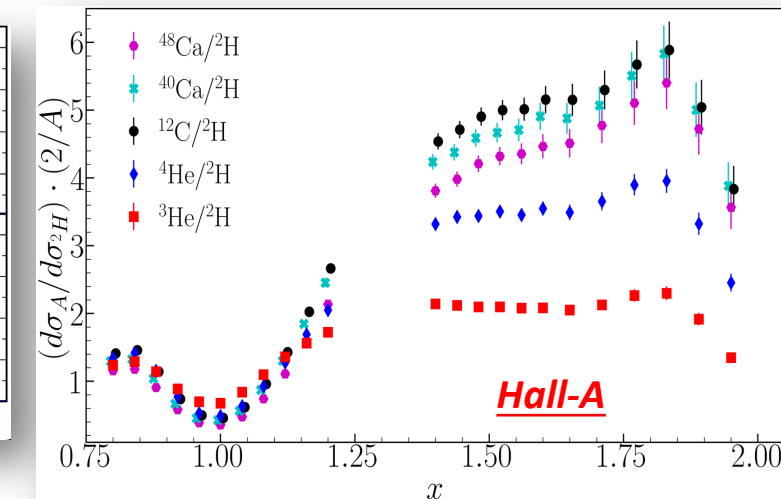
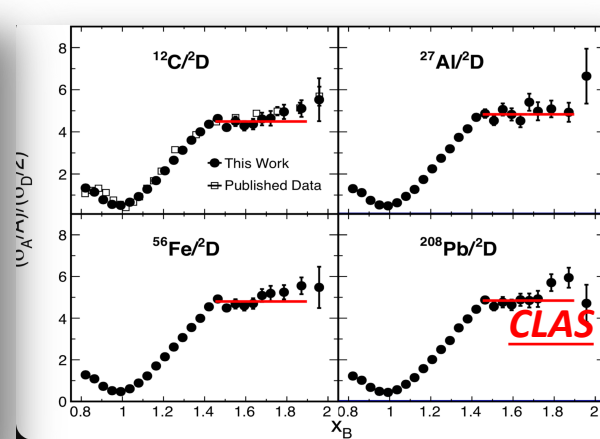
Schmookler et al., Nature (2019)



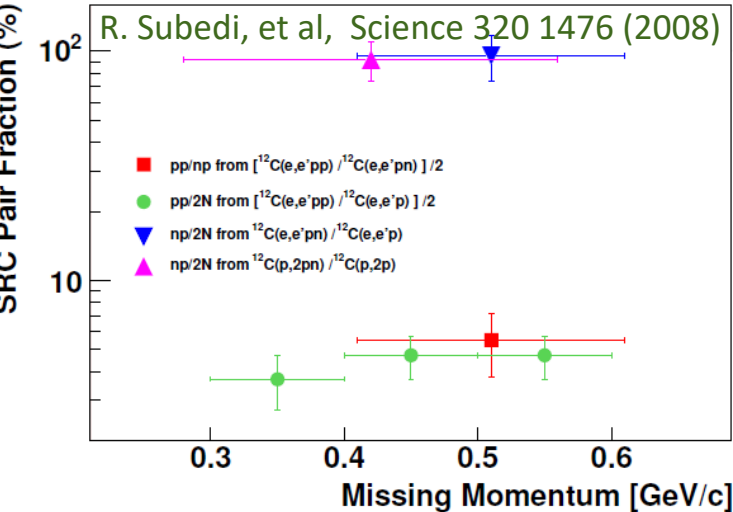
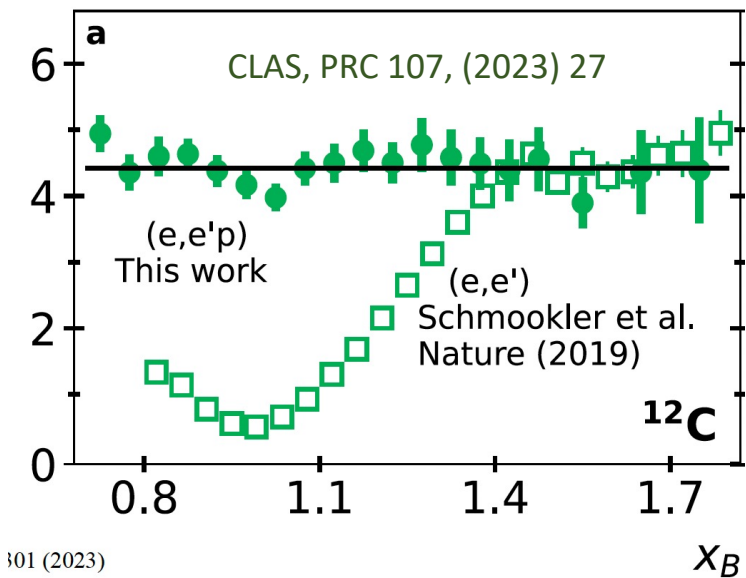
Frankfurt, Strikman, Day,
Sargsian, PRC48, 2451 (1993)



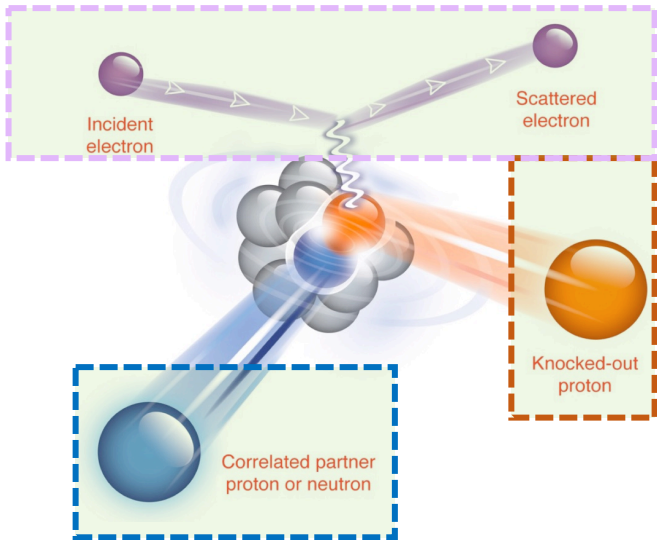
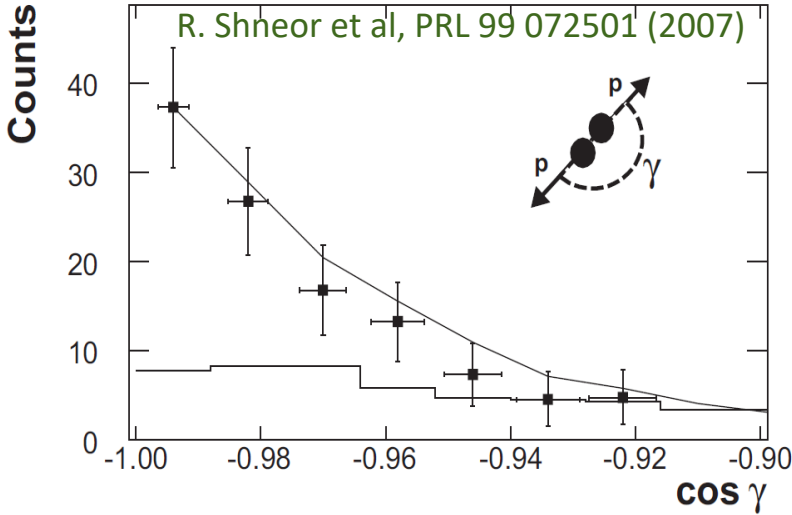
N. Fomin et al, PRL 108,092502 (2012)



A(e,e'p) & A(e,e'pN) 反应:

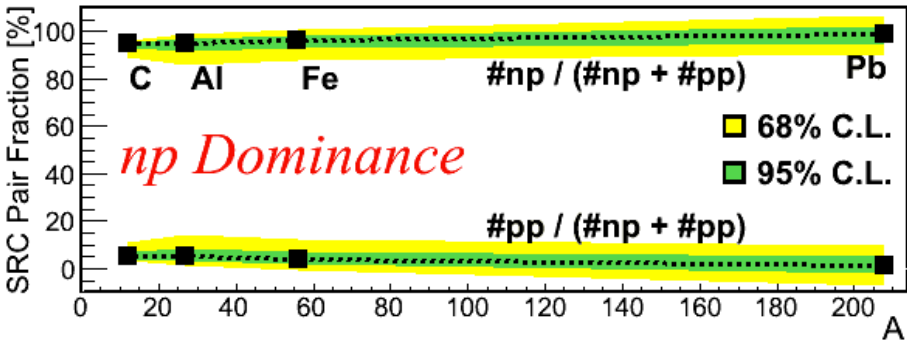


- 在A(e,e')中寻找高动量质子
- 额外寻找背靠背的质子/中子



- ✓ 90% SRC对为np(张量力)
- ✓ 重核拥有相似的np-SRC主导

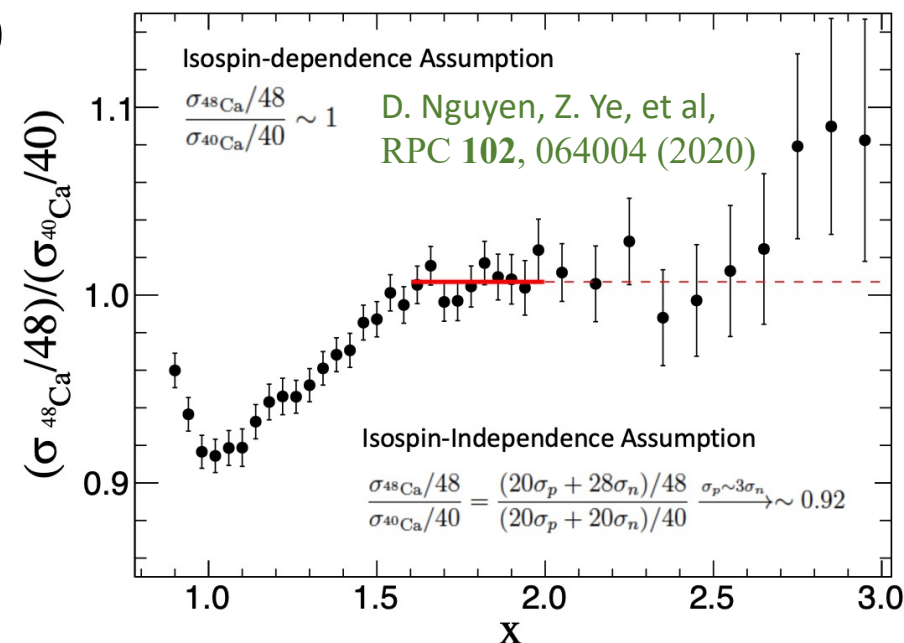
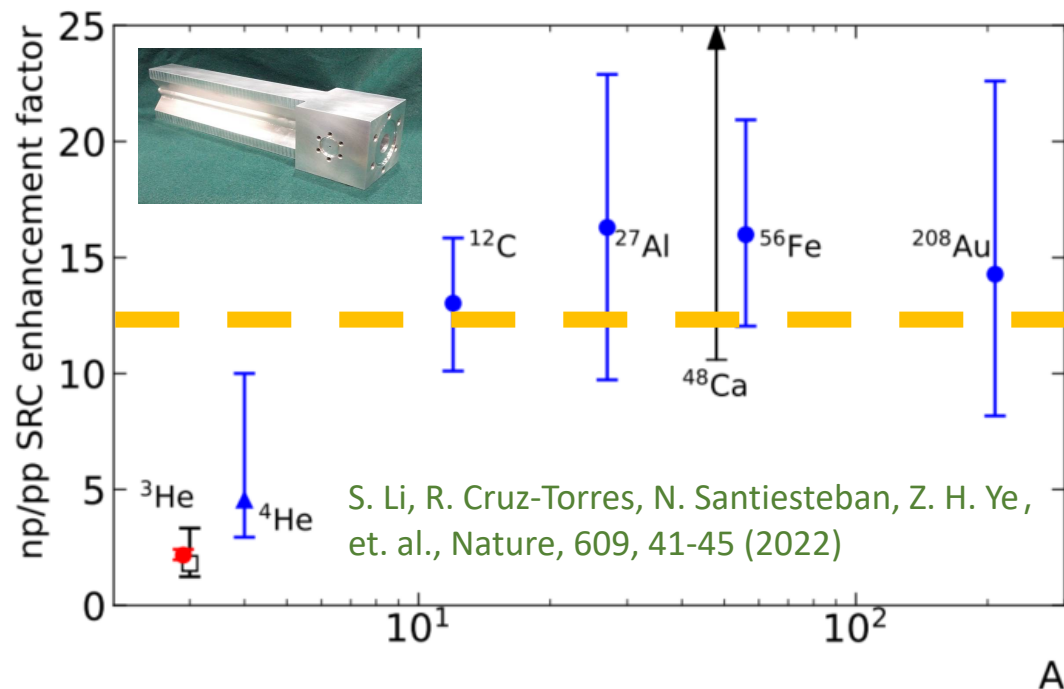
O. Hen et al., CLAS Science (2014), M. Duer et. al., Nature (2018), B. Schmoockler et. al. Nature (2019), A. Schmidt et. al Nature (2020) + many others



□ 在A(e,e')中初步验证np-SRC主导性→ Ca48 & Ca40 (0.92 vs 1.0)

□ 最精密测量：利用镜像原子核 (H3&He3)

$$R_{pp/np} = \frac{\left(1 + \frac{\sigma_{ep}}{\sigma_{en}}\right) \left(1 - \frac{\sigma_{H3}}{\sigma_{He3}}\right)}{2\left(\frac{\sigma_{H3}}{\sigma_{He3}} \cdot \frac{\sigma_{ep}}{\sigma_{en}} - 1\right)}$$



□ 发现：np-SRC主导性在A=3原子核远小于重核

✓ 丰中子原子核的特殊性？

✓ 少体原子核结构??

□ 需要系统性研究轻到重的丰中子原子核的SRC效应

R. Cao, S. Zhang, Y.G Ma, PRC 108 (2023) 6, 064906

Q. Meng, Z. Lu, C. Xu, PRC. 108 (2023) 1, 014001

B. Hong, T. Liang, Z. Ren, PLB 860 (2025) 139225



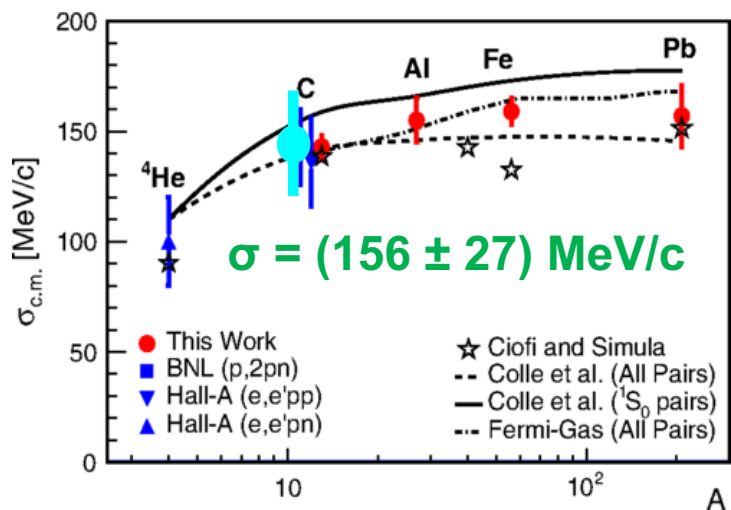
2N-SRC

□ $A(e,e'p)$ & $A(e,e'pN)$ 反应:

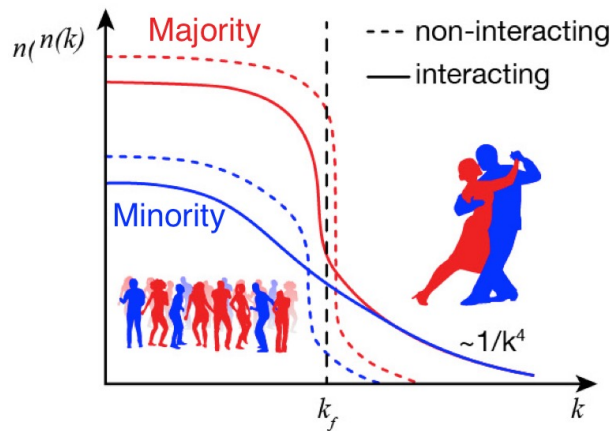
✓ 丰中子原子核中, 质子带有更高动量 (与纯平均场相反)

✓ SRC何时出现? 何时消失?

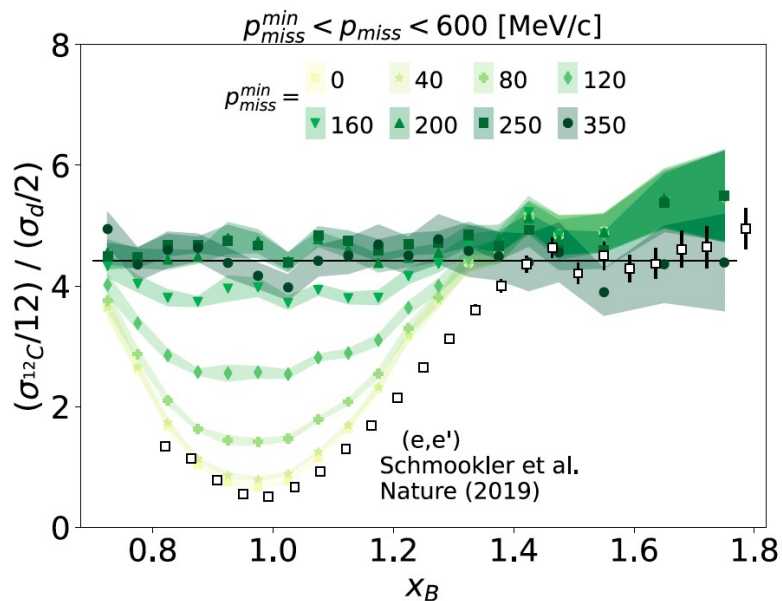
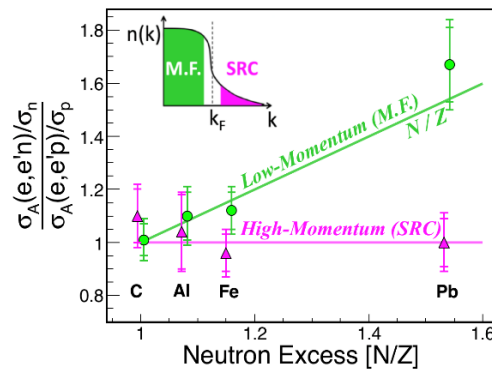
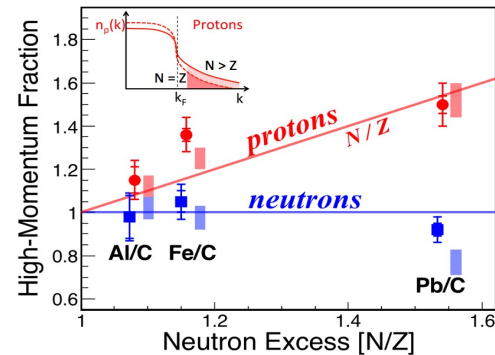
- SRC vs. C.M.动量
- SRC vs. p_{miss}
- SRC vs. 长程关联



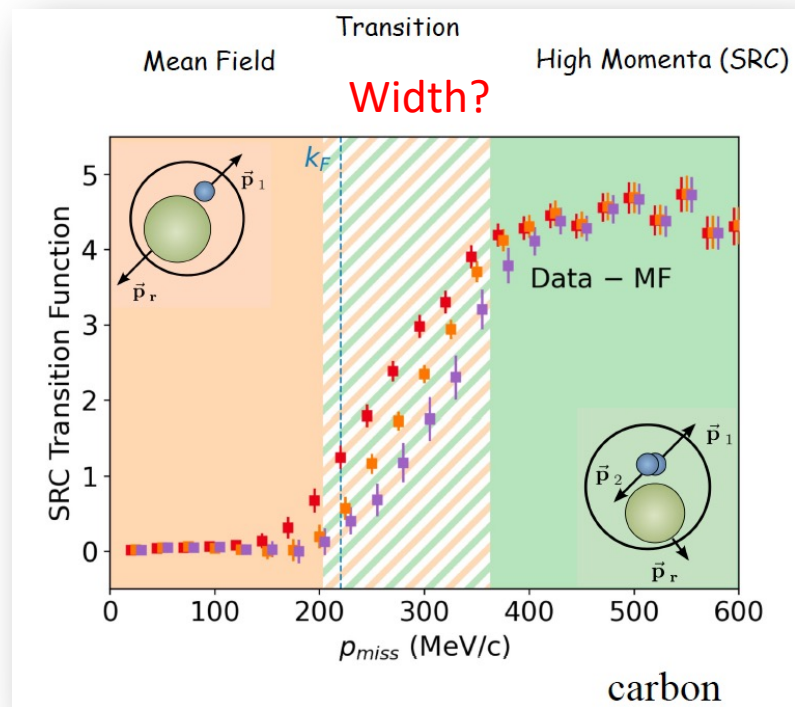
M. Patsyuk, J. Kahlbow et al. (BM@N),
Nature Physics 17 (2021).



O. Hen et al, Science 346 614 (2014)



CLAS, Nature '20, Phys. Rev. Lett. '20, Phys. Lett. B '20, Phys. Lett. B '21

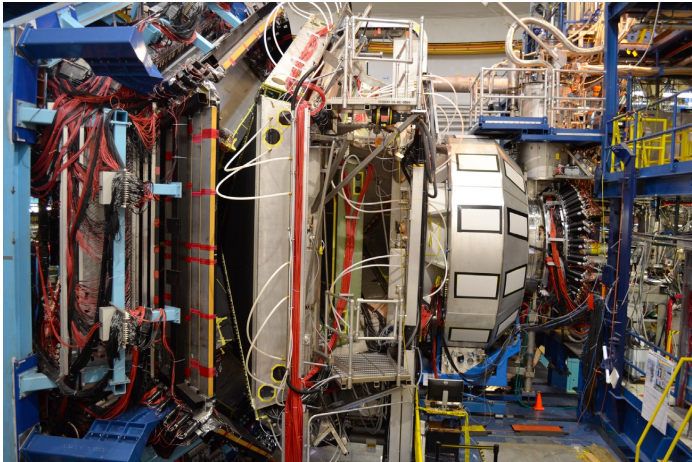
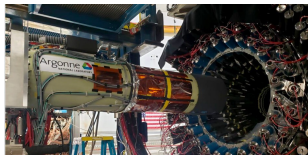
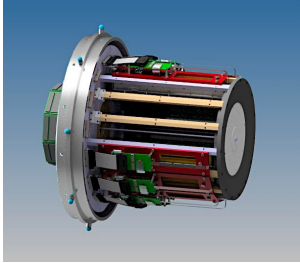
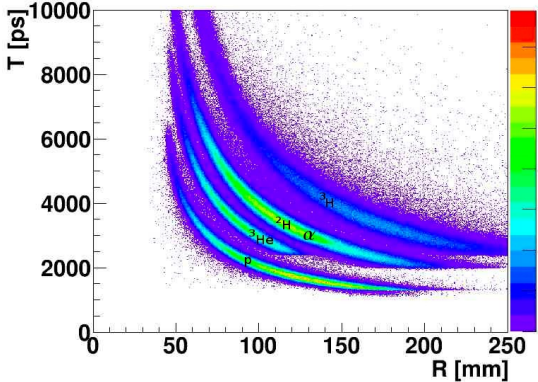


最新实验: ALERT-SRC w/ CLAS12 in Hall-B

6.6 GeV 电子轰击He4, CLAS12测量散射电子和质子

用ALERT测量碎片, 寻找完整的³He & ³H & ²H碎片,并测量其动量

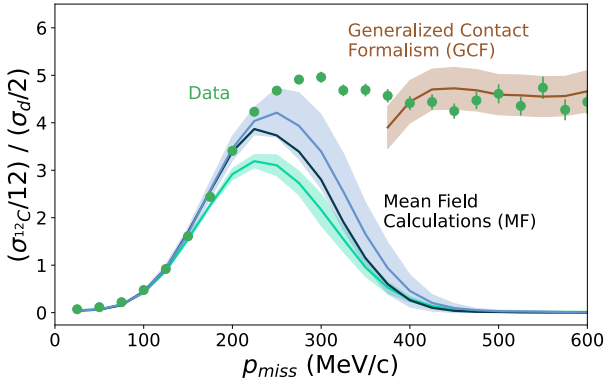
目标1: 验证QES测量SRC可因子化假设



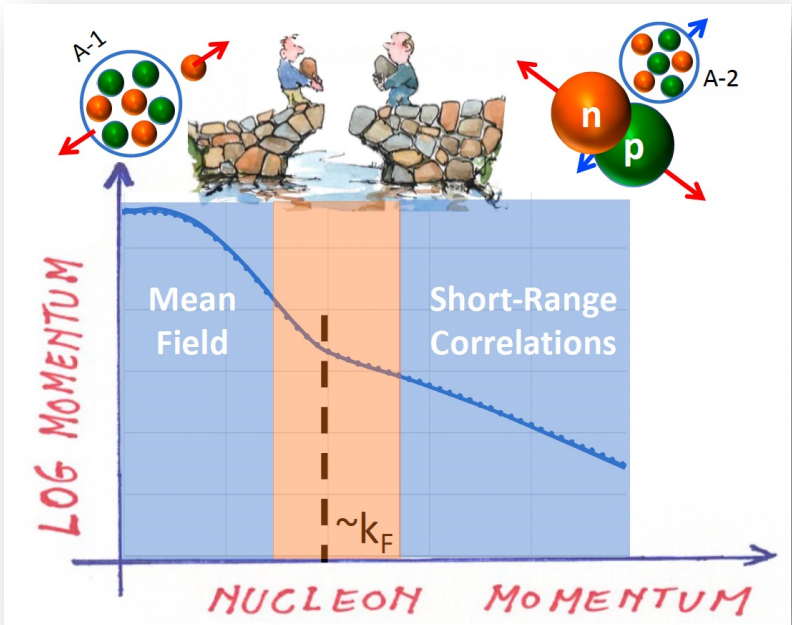
论文博士生 (张泽宇&赵皓岑)

Elementary eN cross section Nuclear Contacts Two-body wave function Center of mass motion

$$\sigma_{eA} = \sigma_{eN}(q) \cdot \sum_{NN\text{-pairs}} C_A^{NN} \cdot |\phi(p_{\text{relative}})|^2 \cdot n(p_{\text{cm}})$$

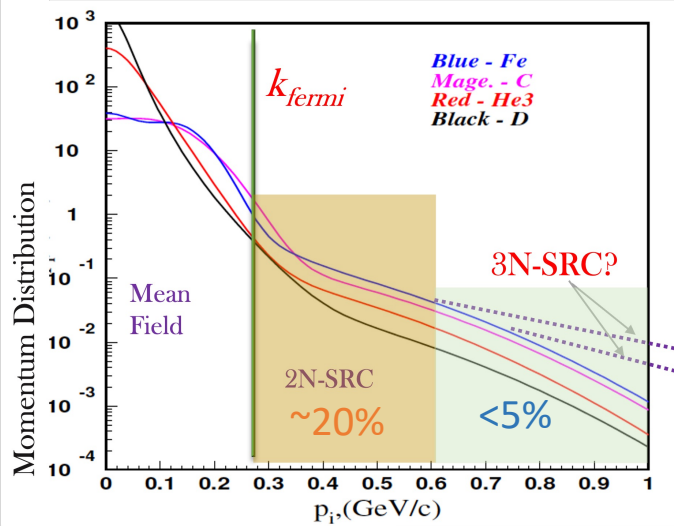
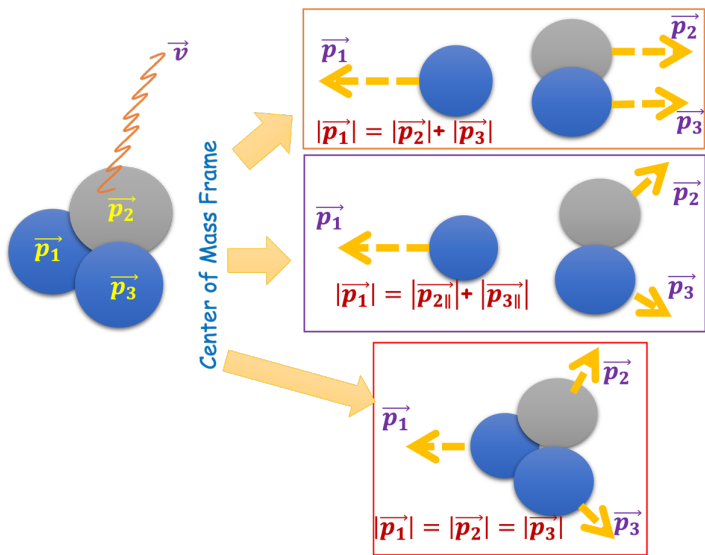


目标2: 寻找从平均场过度到SRC的动量空间

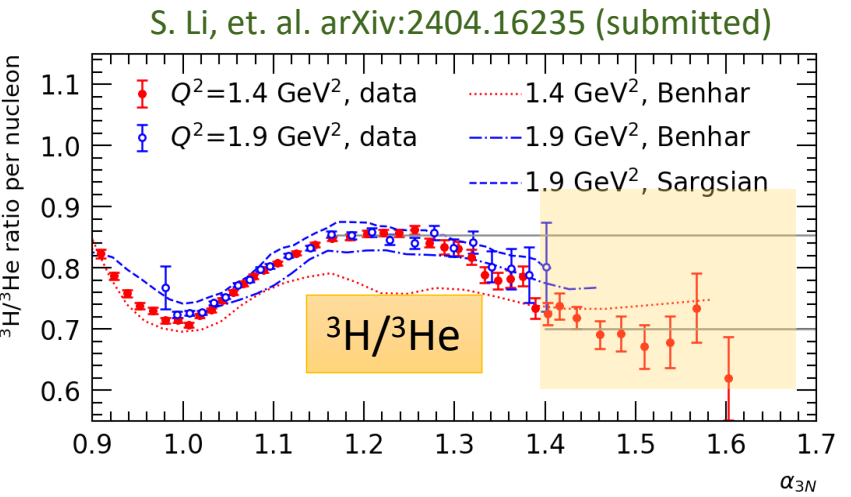
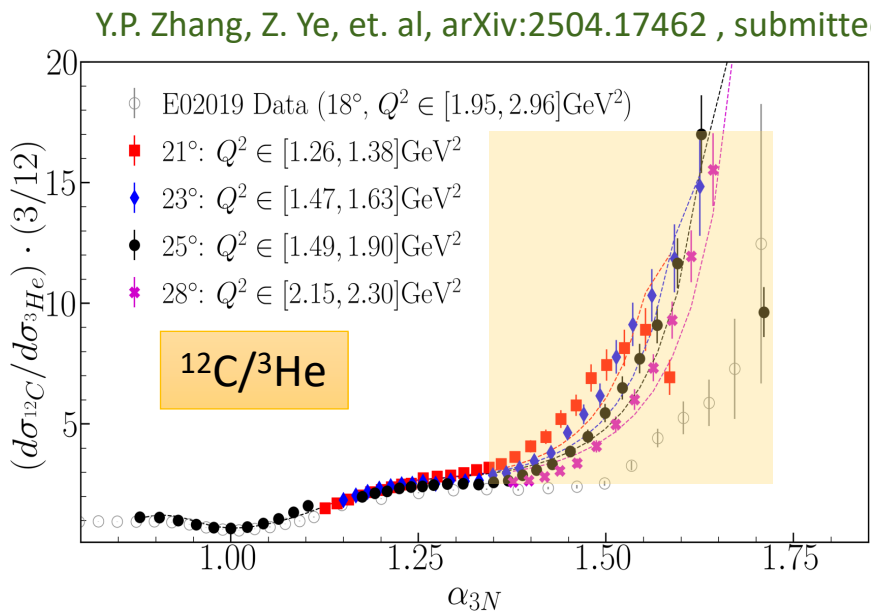
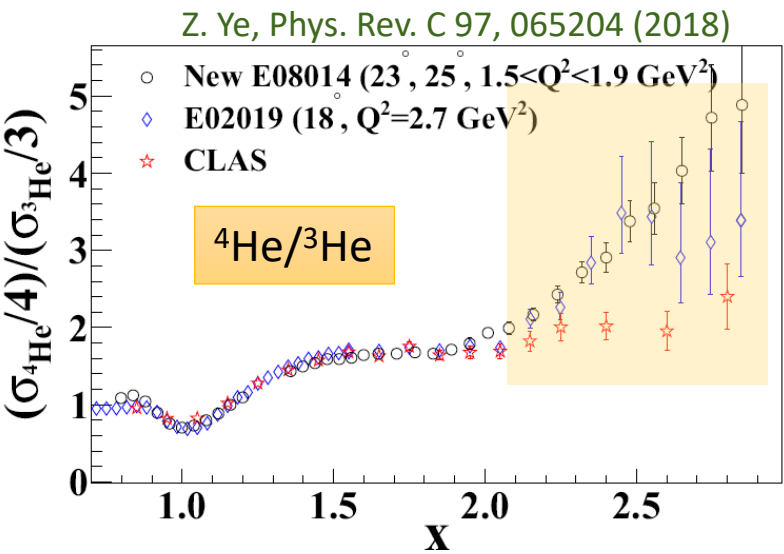


Missing 3N-SRC

- 更高动量, 更大密度, 极强三体力
- 可能解释超重 ($M > 2.4 M_S$)?
- 缺乏三体力的理论计算
- 结构复杂, 从2N过度到3N的机制未知
- 目前只通过 $A(e,e')$ 寻找第二平台



$$a_3(A, {}^3\text{He}) = K \cdot \frac{3\sigma_A}{A\sigma_{{}^3\text{He}}} \quad 3\text{N-SRC } (2 < x < 3)$$

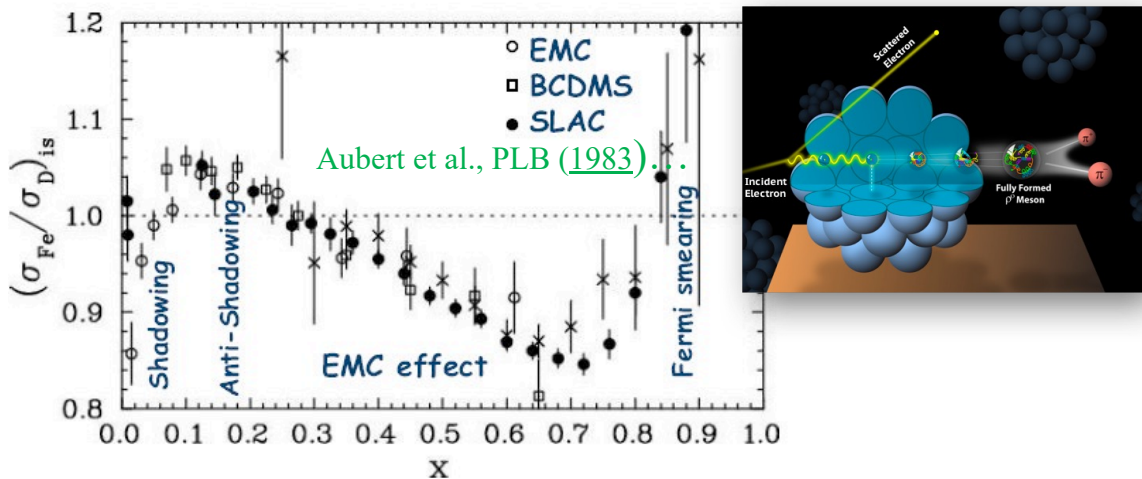


□ 没有3N-SRC信号?!



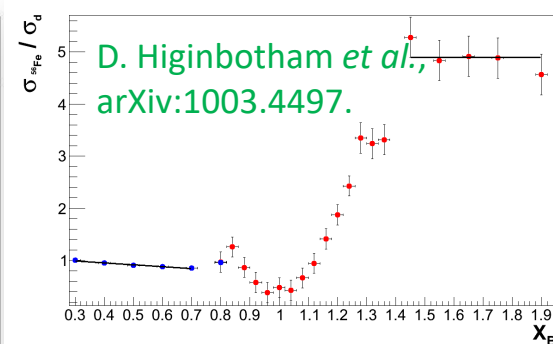
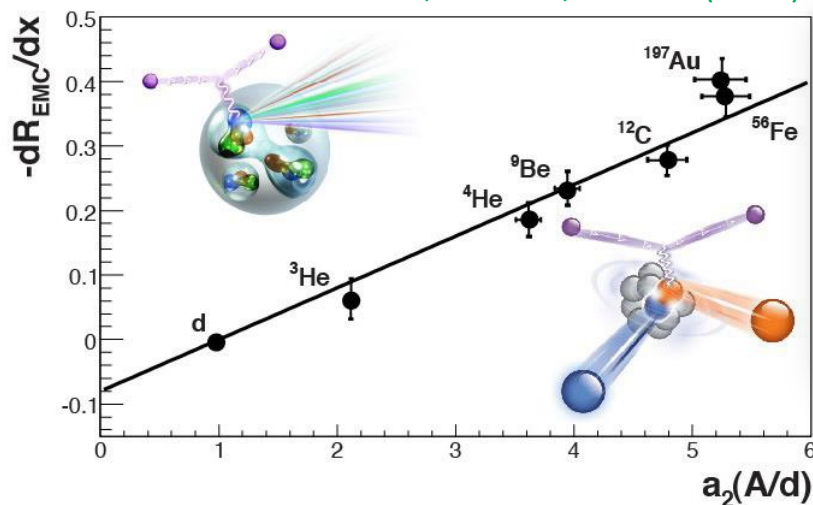
SRC与原子核的夸克结构

- ❑ **EMC效应**: 重核相较于²D的深度非弹碰撞 (DIS) 截面在 $0.3 < x < 0.7$ 区间内线性下降



- **EMC效应与SRC效应相关?**

L. Weinstein et al, PRL 106, 052301 (2011)



- ❑ 束缚于原子核的核子结构不同于自由核子

$$F_2^A \neq Z \cdot F_2^p + N \cdot F_2^n$$

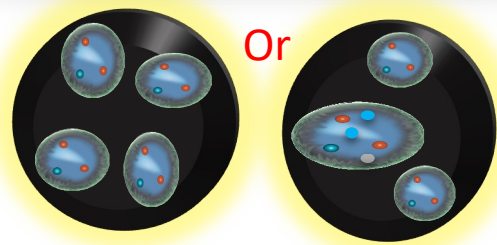
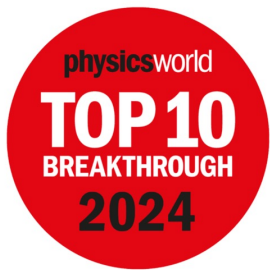
- ❑ EMC发现40余年至今仍为谜题

- ❑ 哪个核子的结构改变?
- ❑ u或d夸克的改变哪个大?
- ❑ 海夸克和胶子有没有类似效应?

- **仅SRC核子的PDFs被修改?**

$$f_i^A(x, Q) = \frac{Z}{A} \left[(1 - C_p^A) \times f_i^p(x, Q) + C_p^A \times f_i^{\text{SRC}p}(x, Q) \right] + \frac{N}{A} \left[(1 - C_n^A) \times f_i^n(x, Q) + C_n^A \times f_i^{\text{SRC}n}(x, Q) \right]$$

MIT team, PRL 133, 152502 (2024)



测量原子核的夸克 vs SRC

✓ nPDF & nTMD & nFF (JLab11Gev & 22GeV & EicC)

$$\frac{d\sigma_{eA\rightarrow h}}{dx_B dQ^2 dz_h} = \frac{2\pi\alpha_e^2}{Q^4} \sum_{i,j} e_q^2 \left\{ \left\{ f_{j/A} \otimes C_{ij} \right\}_{x_B} \otimes d_{h/i} \right\}_{z_h},$$

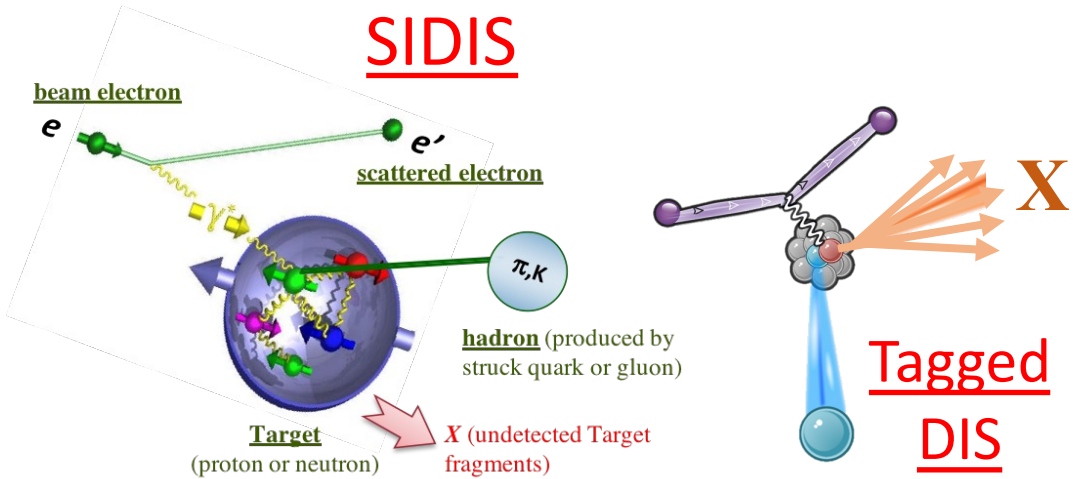
nPDF/nTMD nFF

Gao, Liang, Wang RPC 81, 065211 (2010)

M. Alrashed et. al. PRL 129 (2022) 24, 242001

JAM PRL 127 (2021) 24, 242001

W. Ke, I. Vitev, PLB 854 (2024) 138751



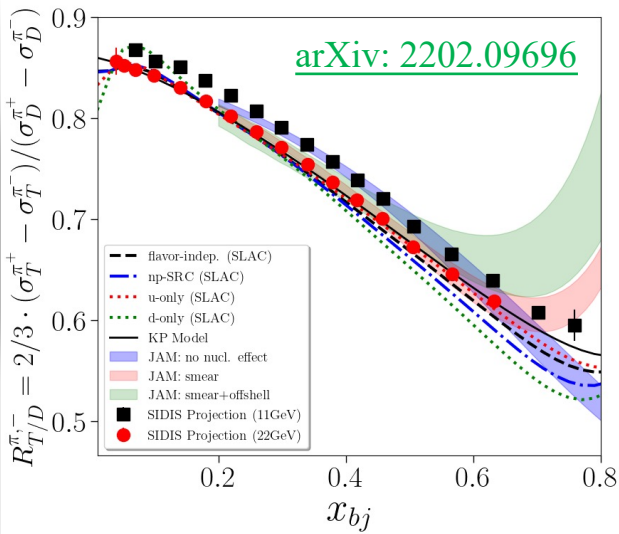
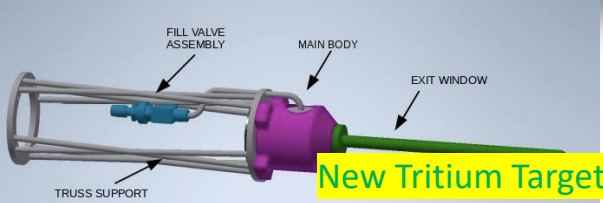
大会报告	11:30-12:00	邢宏喜	华南师范大学	Physics at future EIC and EicC
4.25				

新实验 (Tritium-CLAS12)

SIDIS Measurement of A=3 Nuclei with CLAS12 in Hall-B

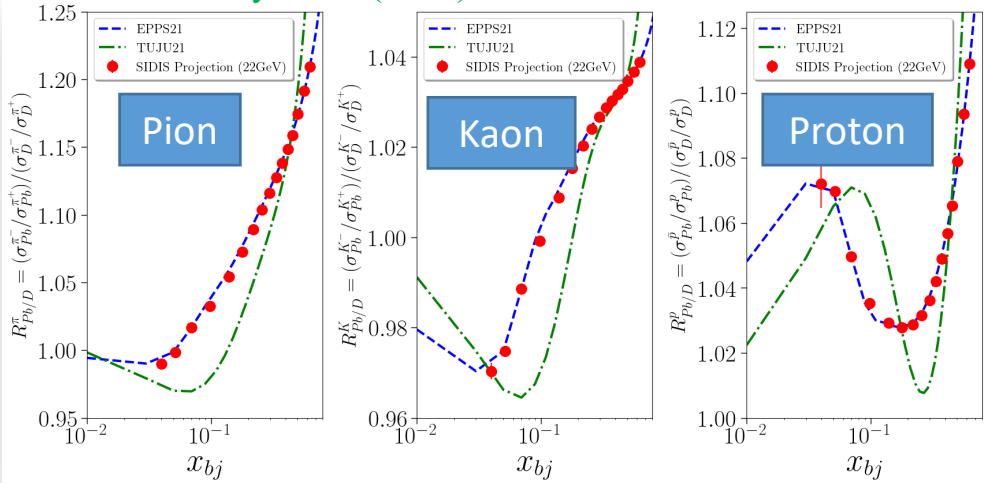
Conditionally approved in PAC49

On behalf of the spokespeople:
D. Dutta, D. Gaskell, O. Hen, D. Meekins, D. Nguyen, L. Weinstein*, J. R. West, Z. Ye,
and the CLAS Collaboration



✓ JLab 22GeV升级白皮书

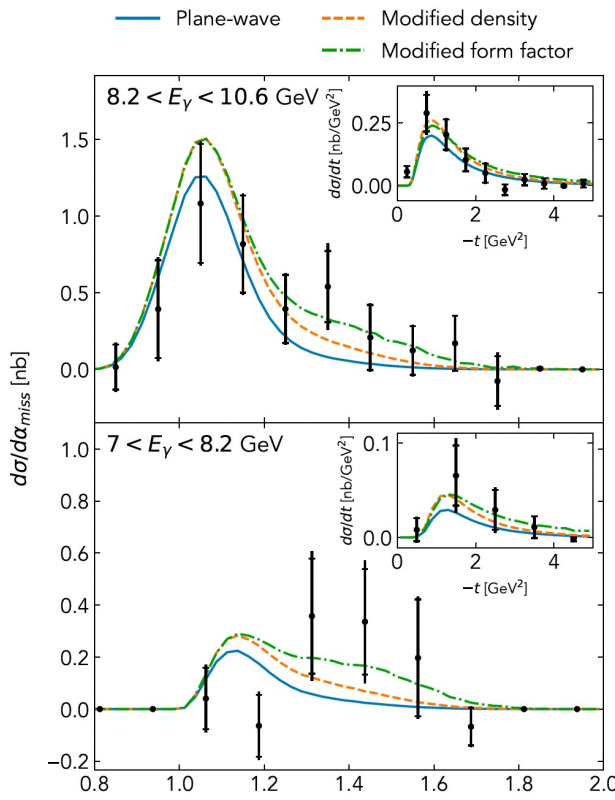
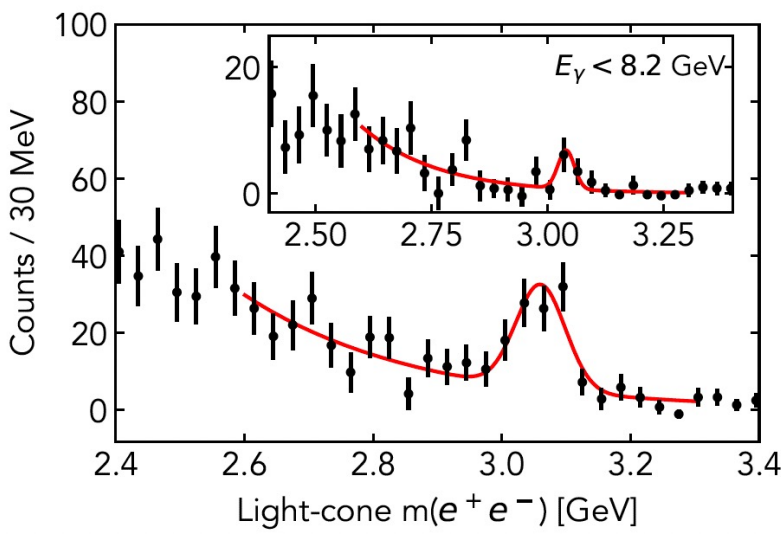
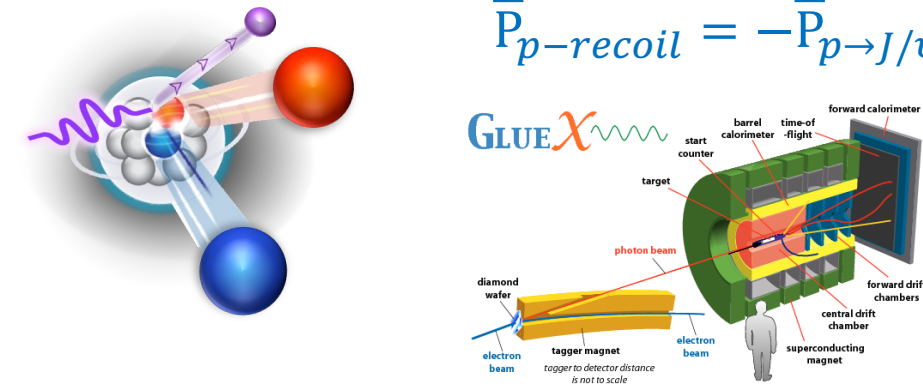
Eur. Phys. J. A (2024) 60:173



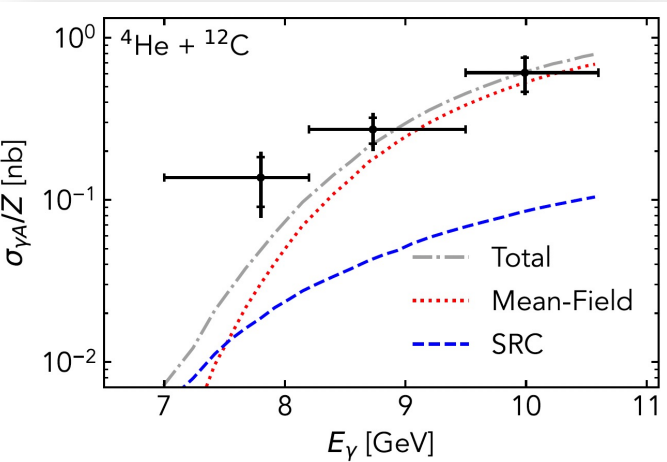
□ $A(\gamma, J/\psi p)X$ 反应:

- 高能光子与He4&C12反应, 在阈值~ (8.2GeV) 附近产生J/ψ

$$\vec{p}_{p-recoil} = -\vec{p}_{p \rightarrow J/\psi}$$



- 同时测量高动量核子与反应截面的关联



J.R. Pybus, O. Hen, H. Gao, et. al. arXiv:2409.18463, accepted by PRL w/ editor suggestion.

- 高虚度核子的质量半径改变→胶子分布的核效应?

(全新GLUX实验: Or Hen & Haiyan Gao) Hall-C J/Psi007, Nature 615, 813 (2023)

□ 分析BESIII数据 (能否提取高动量质子?)

□ SHINE的光核物理项目 (符长波, 复旦)?

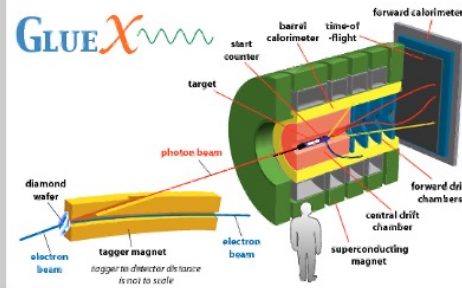
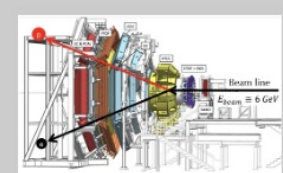
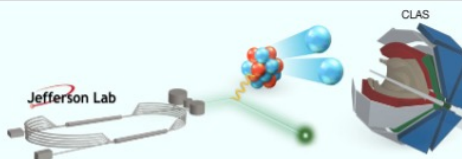
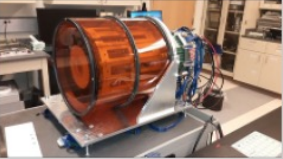
$$\alpha_{miss} = \frac{E_{miss} - p_{z,miss}}{m_A/A}$$



Science (2008), Science (2014), Nature (2018),
Nature (2019), Nature (2020), Nature (2022)
+ many PRL & others

- ❑ 少体和丰中子核的np-SRC主导性?
- ❑ 平均场过度到2N-SRC?
- ❑ 3N-SRC的形成机制?
- ❑ SRC vs 原子核的夸克胶子结构?
- ❑ 干净SRC信号? 消除末态效应?
- ❑ 高能电子散射反应截面极小
(JLab11&22GeV, EicC, EIC)
- 需要全新的实验方法→高能质子-原子核碰撞!

Jefferson Lab Hall D

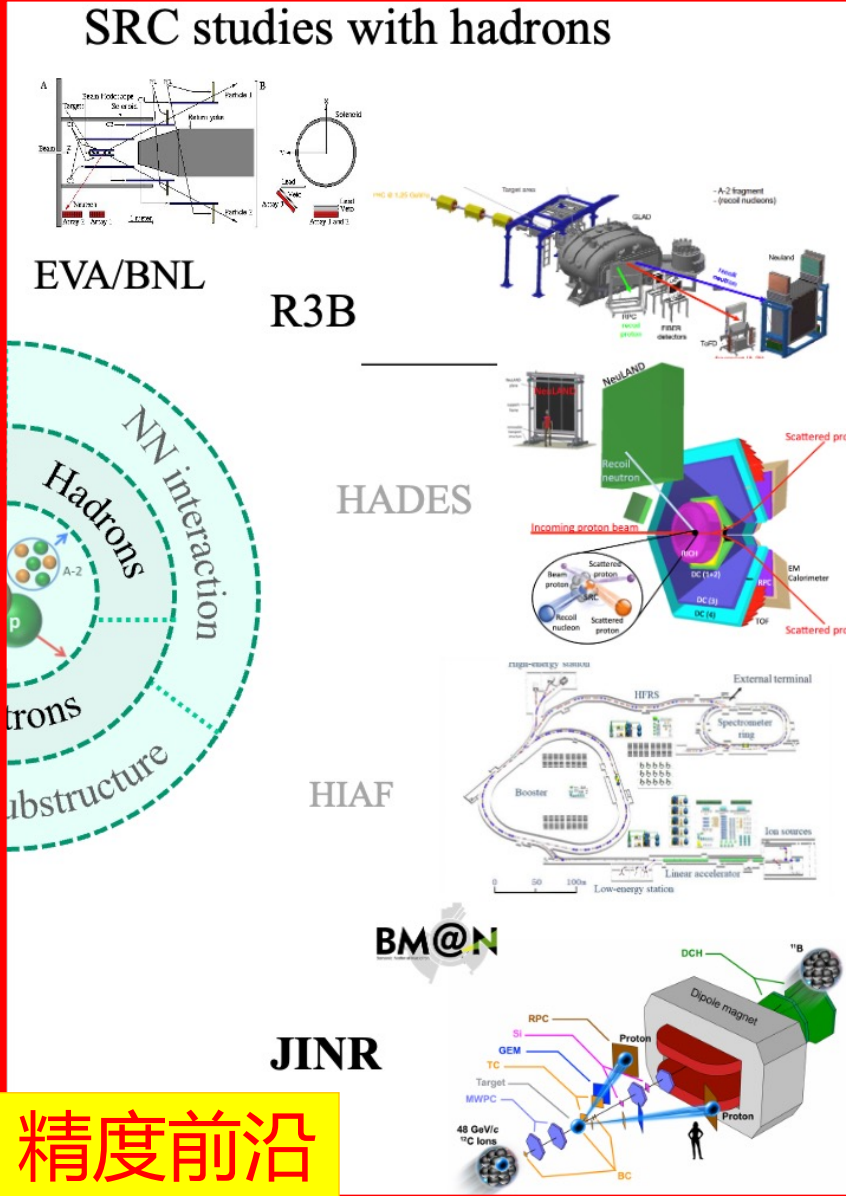





Jefferson Lab Halls A, B, C



ALERT

SRC studies with hadrons



EVA/BNL

R3B

HADES

HIAF

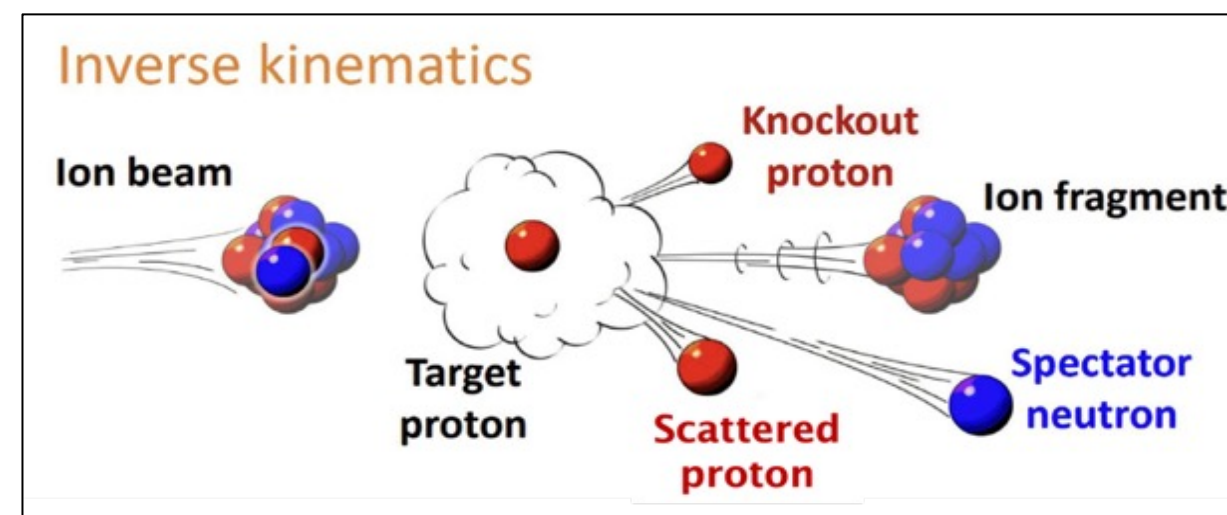
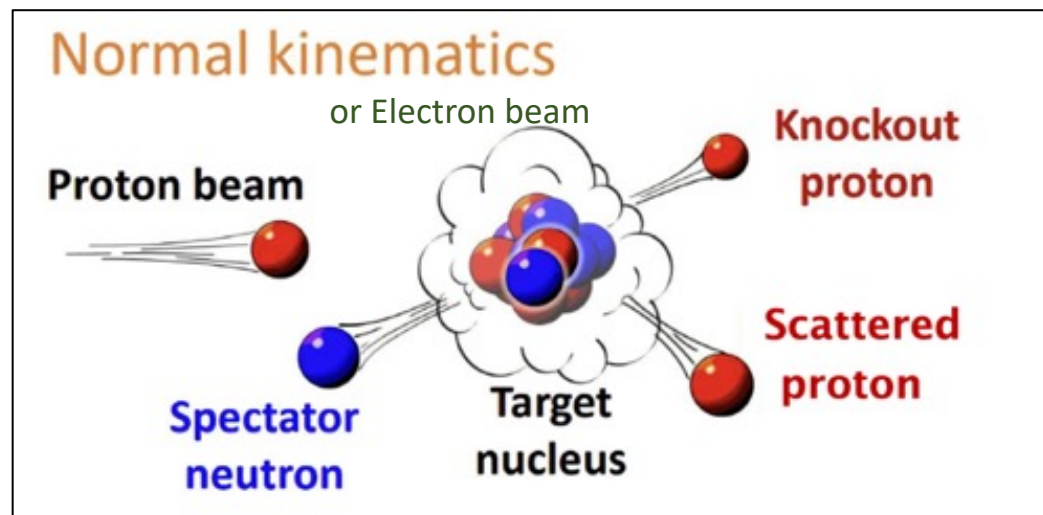
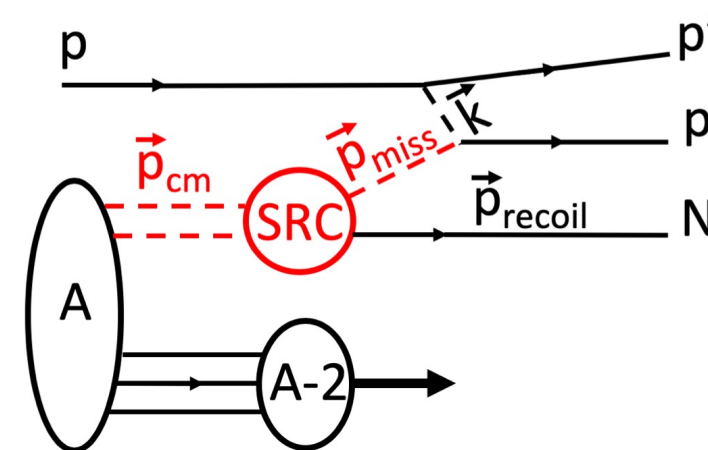
BM@N

JINR

精度前沿

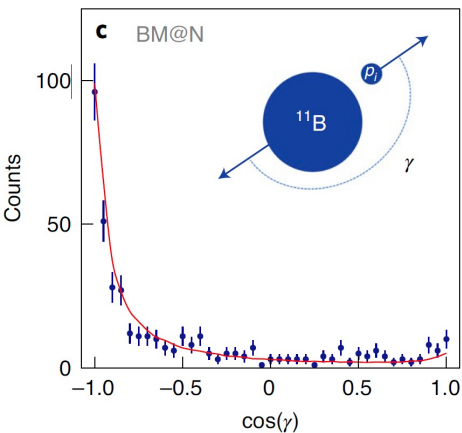
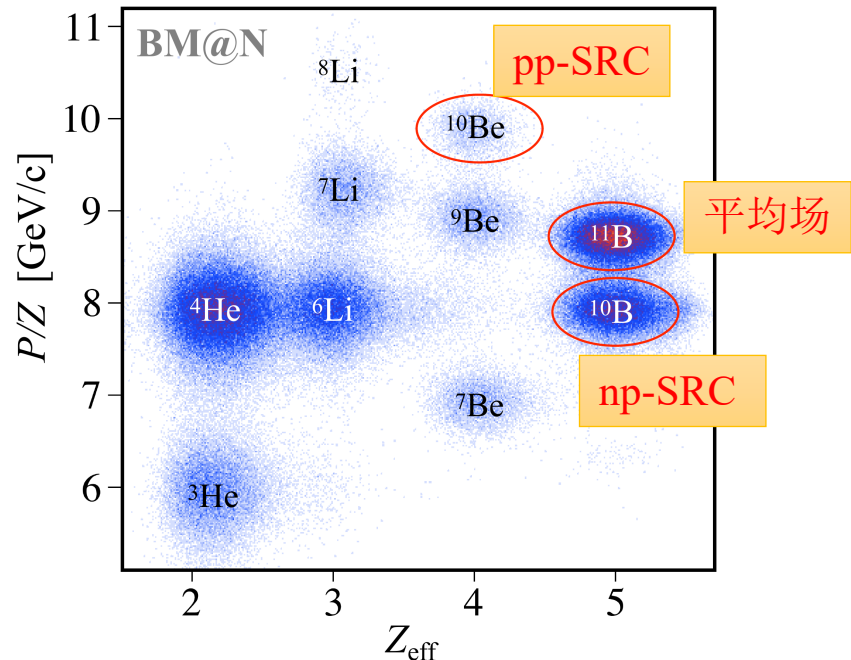
□ 优势:

- ✓ 强作用反应截面更大→大统计量
- ✓ 出射粒子携带大动量→容易测量，压低末态次级反应
- ✓ 末态碎片可以精确测量→平均场vs SRC
- ✓ 次级离子源可以分离更多丰中子同位素

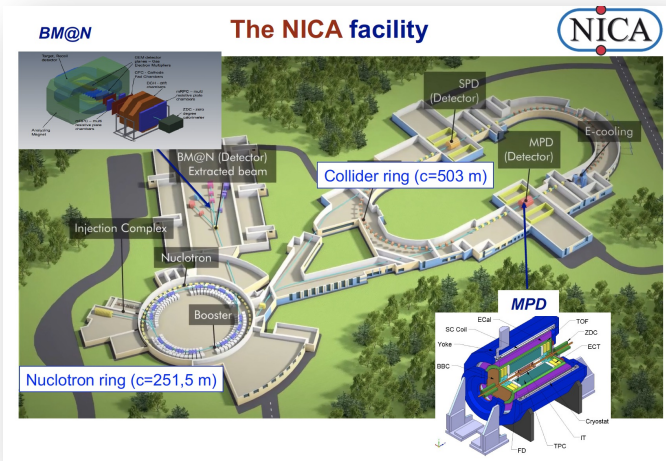
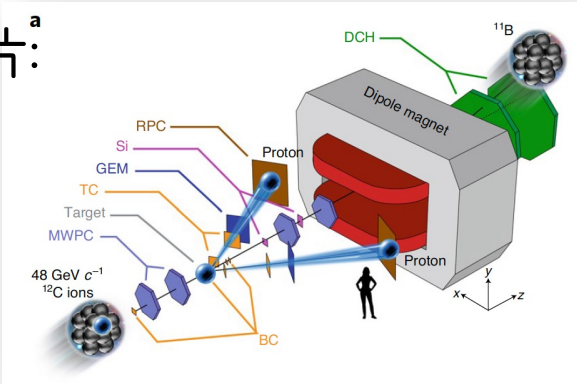


首次BM@N (Dubna) 验证 (2018)

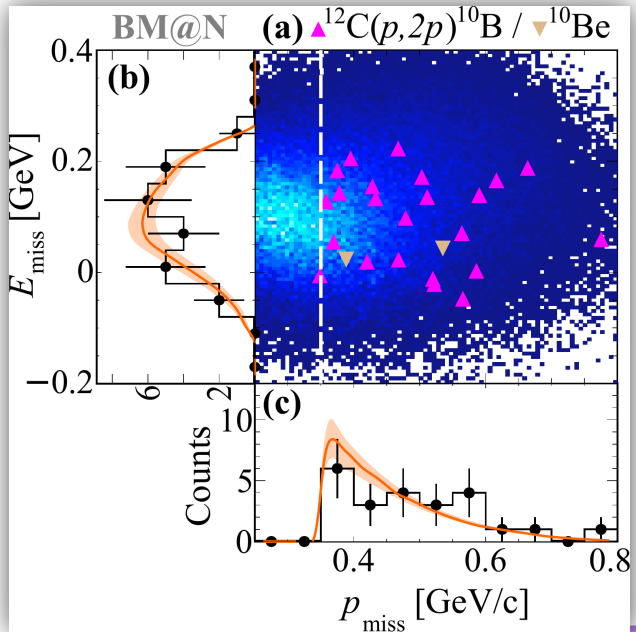
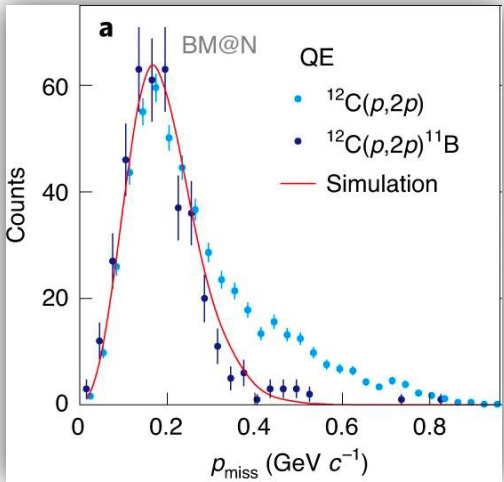
- ^{12}C 束流, 3.5 - 4 GeV/u, 探测质子和末态碎片:



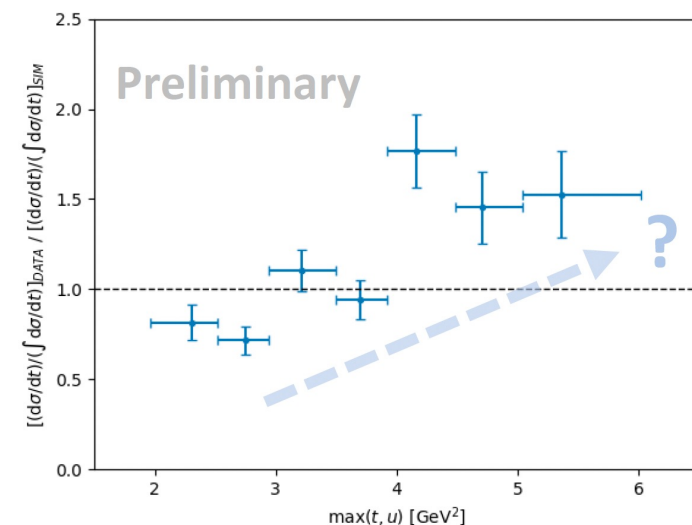
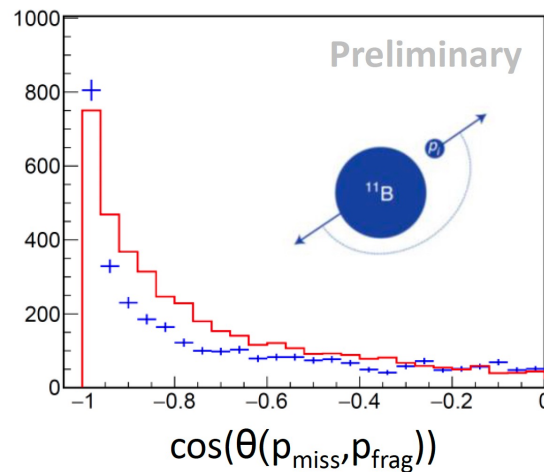
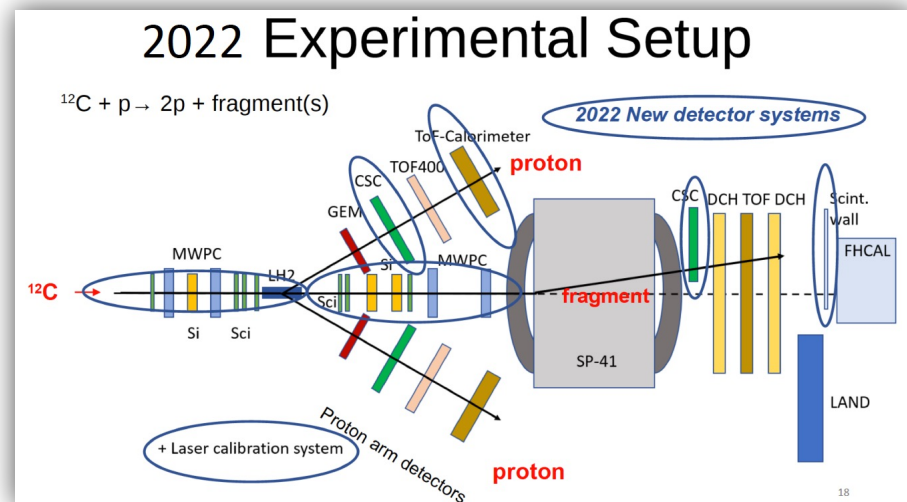
- 重建缺失核子动量和夹角:
 $P_{\text{miss}} = P_1 + P_2 - P_{\text{beam}}$
- 寻找高动量动量核子:
- 通过筛选 ^{10}B 和 ^{10}Be 寻找np-SRC和pp-SRC事件:



M. Patsyuk et al. Nature Physics 17, 693 (2021)



BM@N 2022年实验



- ✓ 增加x10倍统计 (vs 2018)
- ✓ 首次提取pA碰撞的SRC反应截面

✓ 新一代实验：测量²D的非核子自由度



Maria Patsyuk
(JINR)



Julian Kahlbow
(MIT)



Göran Johansson
(TAU)



Timur Atovuallev
(JINR)



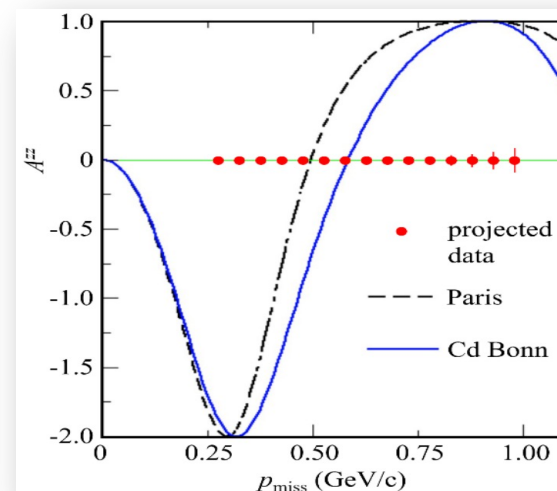
Sergey Nepochatykh
(JINR)



Yaopeng Zhang
(Tsinghua U)



Vasilisa Lenivenko
(JINR)

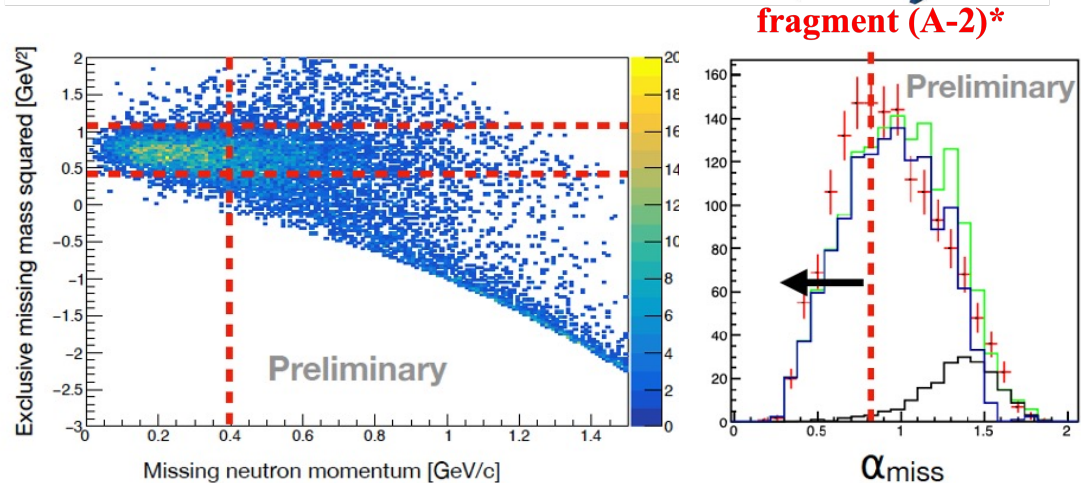
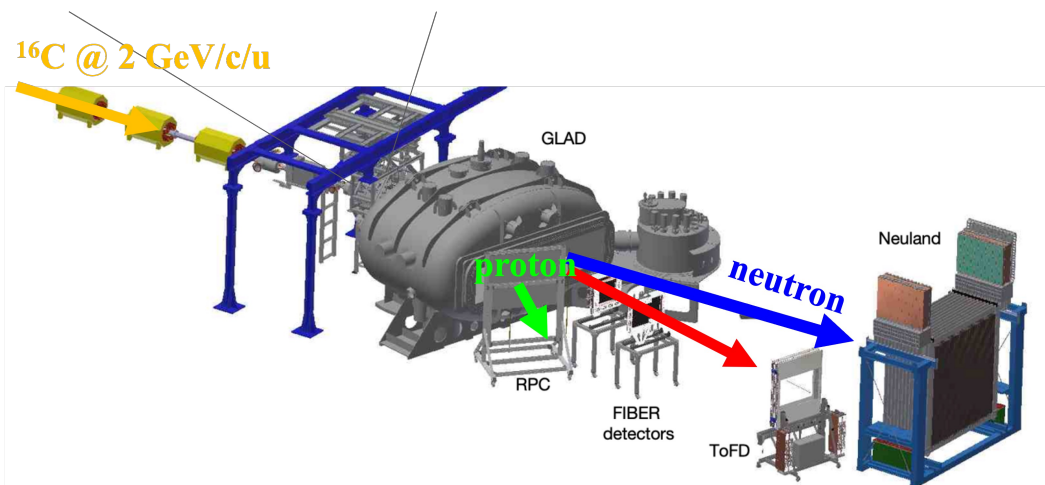


$$A_{zz} = \frac{(\sigma_- + \sigma_+ - 2\sigma_0)}{\sigma_{\text{unpol}}}$$

(合作组: JINR, MIT, Tel Aviv, 北师大, 清华, etc.)

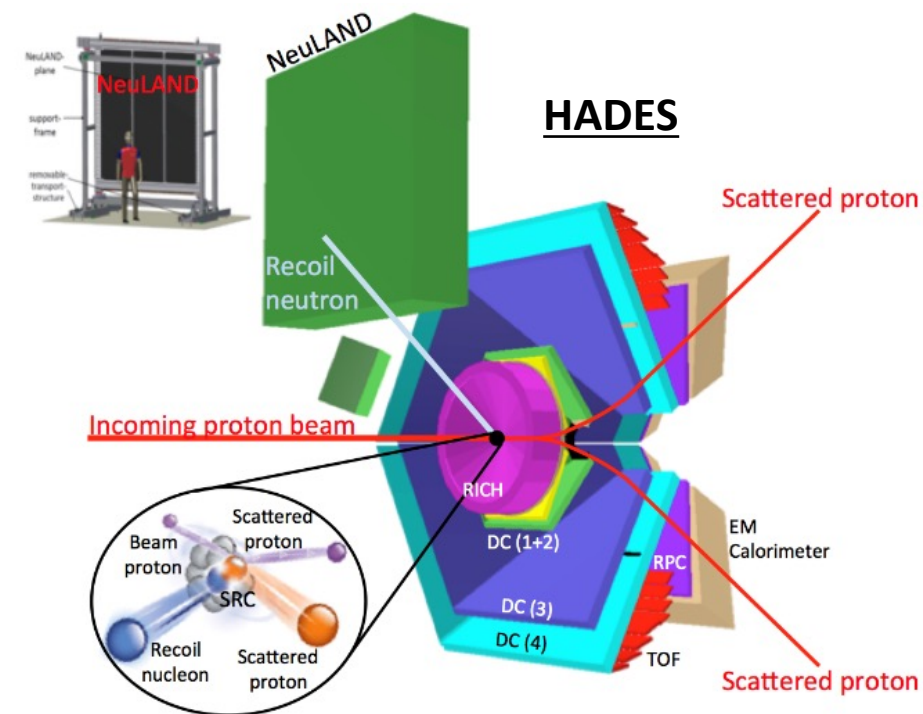
□ 放射性同位素研究SRC ($R^3B@GSI$)

- $^{16}\text{C}(p,2pN)A-2^*$ (2022).
- 未来: $^{110,120,132}\text{Sn}$ ($N/Z = 1.20, 1.40, 1.64$)



□ SRC at HADES@GSI

- 4.5GeV 质子轰击固定靶
- $A(p,2pNN)$ 寻找3N-SRC



1st SRC-China Workshop: Opportunities of SRC Study with New Accelerator Facilities in China

Location: SCNT, Huizhou, Guangdong

Time: Nov 4-7 2023

Web: <https://indico.impcas.ac.cn/event/50/>

Organizing Committee:

Lisheng Geng (Beihang U)

Jie Zhao (Fudan U)

Xinle Shang (IMP, CAS)

Zhihong Ye (Tsinghua U)



Z. Ye, et. al. Eur.Phys.J.A 60 (2024) 6

- Link: <https://indico.impcas.ac.cn/e/src>
- Recording:
<https://cloud.tsinghua.edu.cn/d/0cdcfe10e90046d49f4b/>



- HIRFL-CSR 束流条件与GSI类似:
 - ✓ 1.0GeV/u @ 10^5 pps vs 1.25GeV/u@ 1×10^5 pps

- CSR External-Target Experiment (CEE):

- ✓ 物理目标: QCD相变, 状态方程, etc.
- ✓ 安装调试中

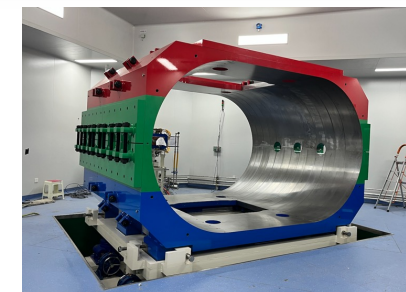
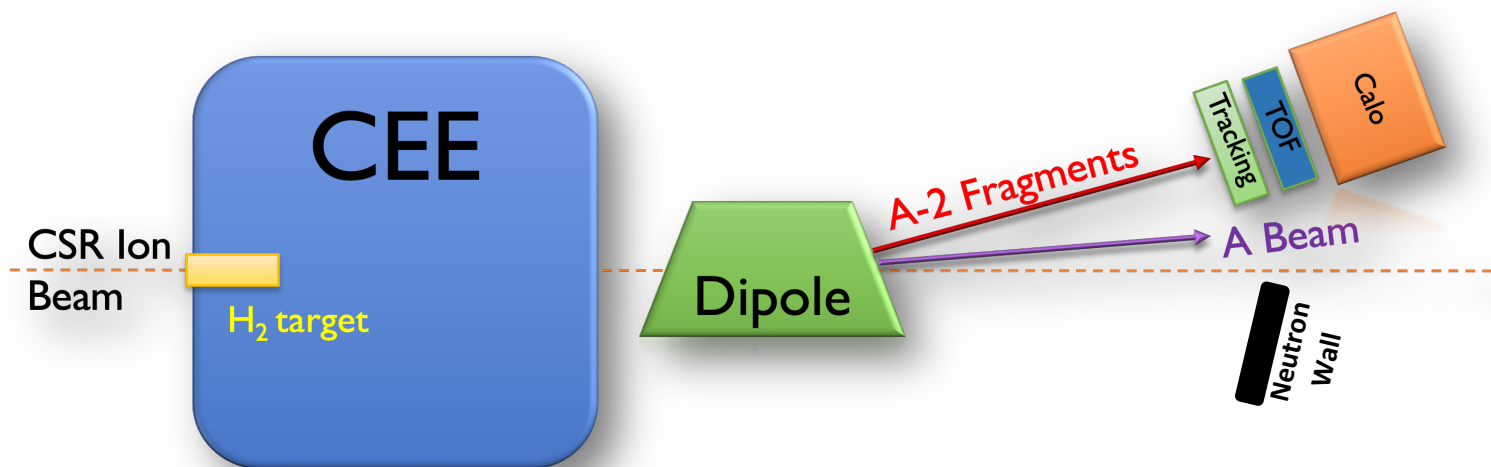
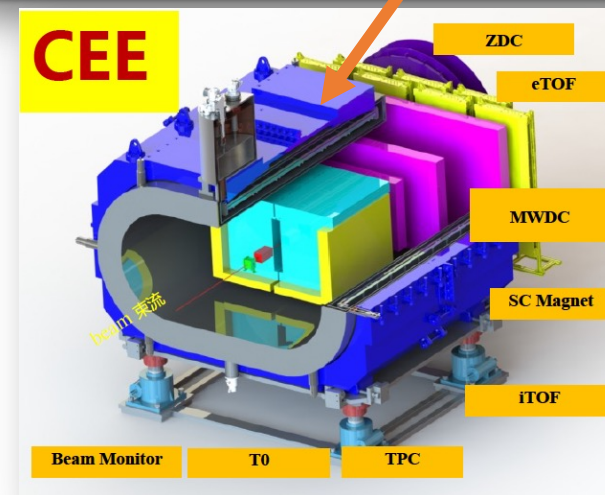
分会场1报告(04.26) by 张亚鹏

- 利用CEE进行pA碰撞初步研究SRC

- ✓ 增加: 氢靶(或CH₂), A-2碎片探测器, 次级磁铁+中子墙?
- ✓ 目标: 平均场→SRC的过渡区间, 少体力, 重离子碰撞的SRC?

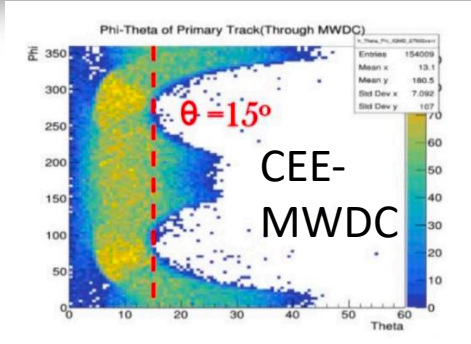
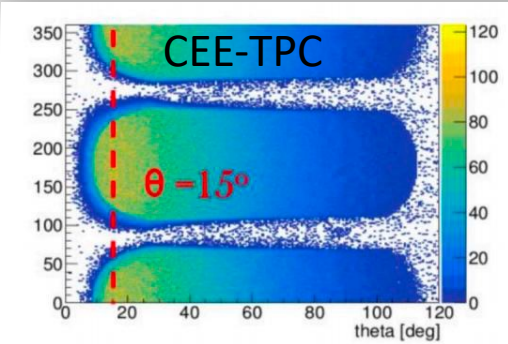
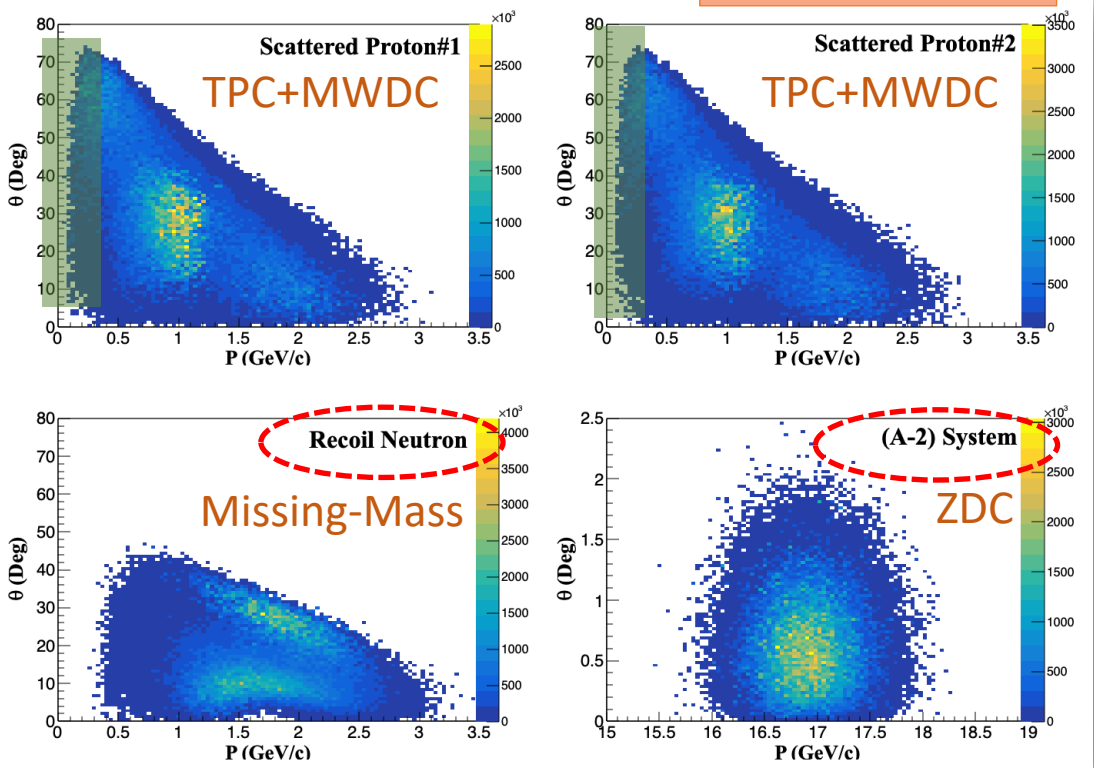
HIRFL-CSR beam

- P : 2.8 GeV
- $^{12}\text{C}^+$: 1 GeV/u
- $^{238}\text{U}^+$: 0.5 GeV/u

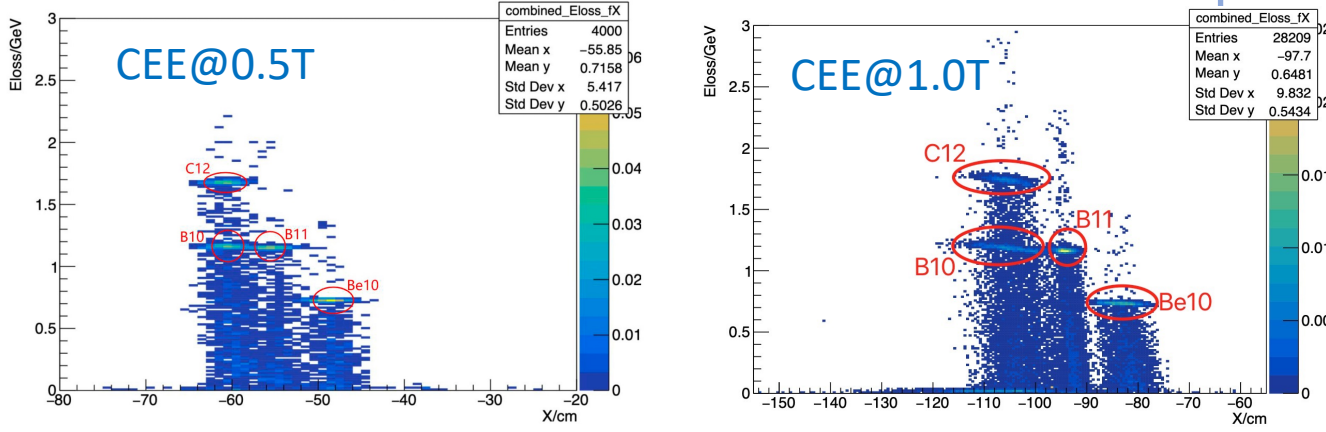
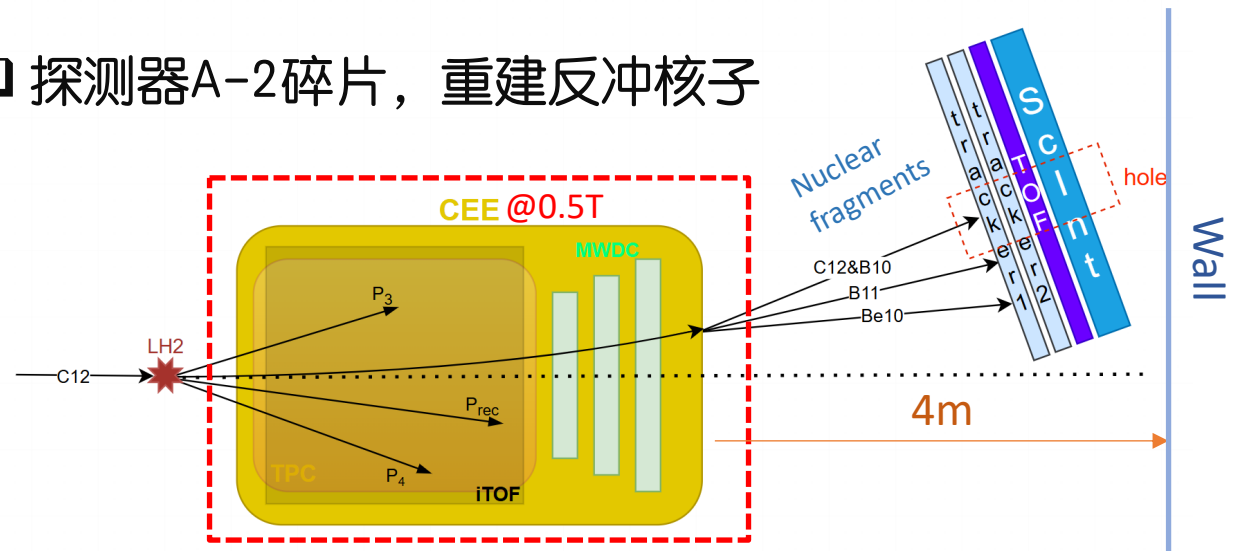


□ 末态质子在CEE的接受范围

$^{12}\text{C}^+ (p, \text{ppn}) ^{10}\text{B}^+$



□ 探测器A-2碎片，重建反冲核子



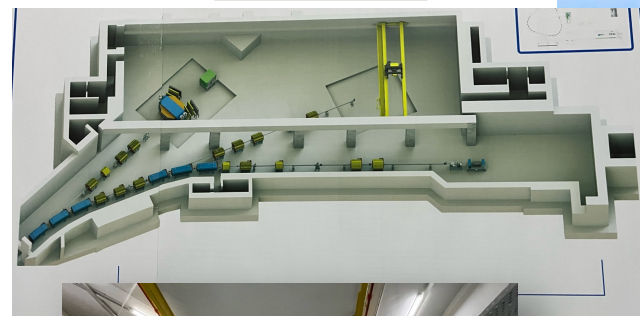
□ 增加碎片探测性能：可提升CEE磁场+增加次级磁铁



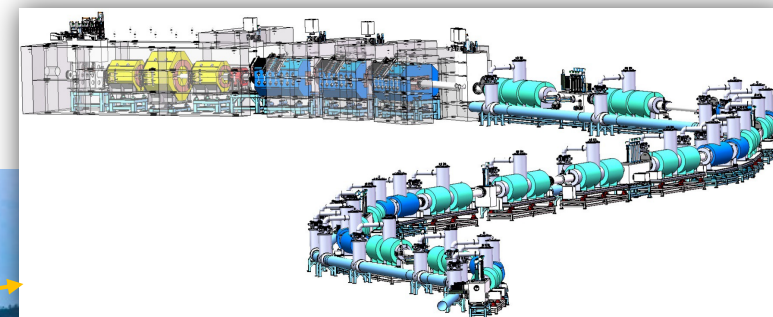
□ HIAF基本建设完成, 预计于2025底完成束流调试:

- 束流能量: 如C12, $E=51 \text{ GeV/c}$ (4.25 GeV/c/u) $\rightarrow$ 类似于JINR
- 束流亮度: $1.8 \times 10^{12} \text{ pps}$ (快引出), $4.5 \times 10^{11} \text{ pps}$ (慢引出) $\rightarrow$ vs. $3.5 \times 10^4 \text{ pps}$ at JINR
- 氢气靶: $\text{LH2} = 0.073 \text{ g/cm}^3 \times 15 \text{ cm}$
- 总亮度 = $3 \times 10^{35} \text{ cm}^{-2} \text{ s}^{-1}$ (慢引出)

高能终端



束流方向



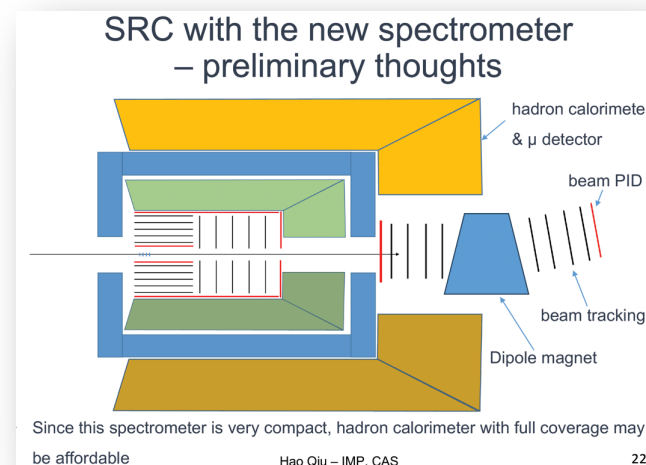
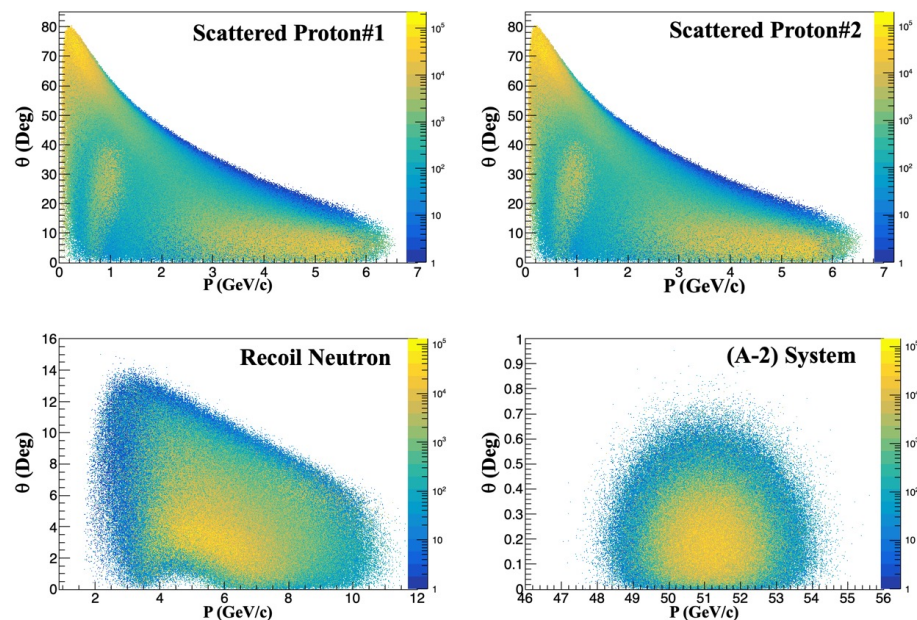
次级束流线+终端



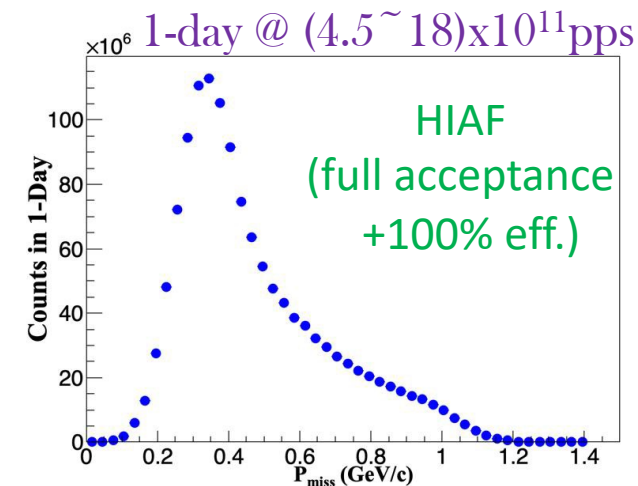
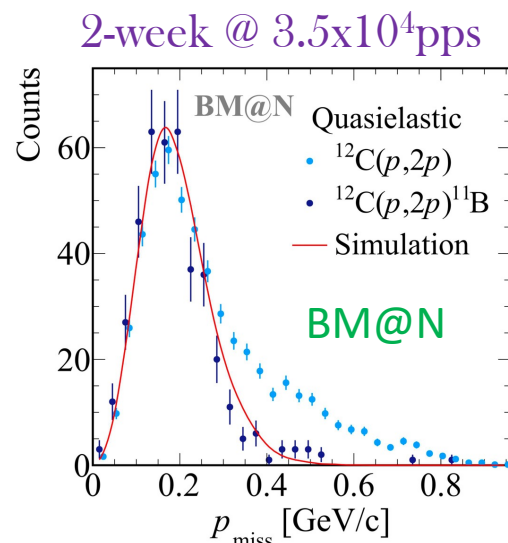
□ 高能终端+全覆盖词谱仪:

- 4.25GeV/u 离子束流轰击氢靶
- 精密测量2N-SRC的动态空间和反应截面
- 寻找缺失的3N-SRC

□ pA实验模拟($^{12}\text{C}^{6+}$ at 51GeV/c)



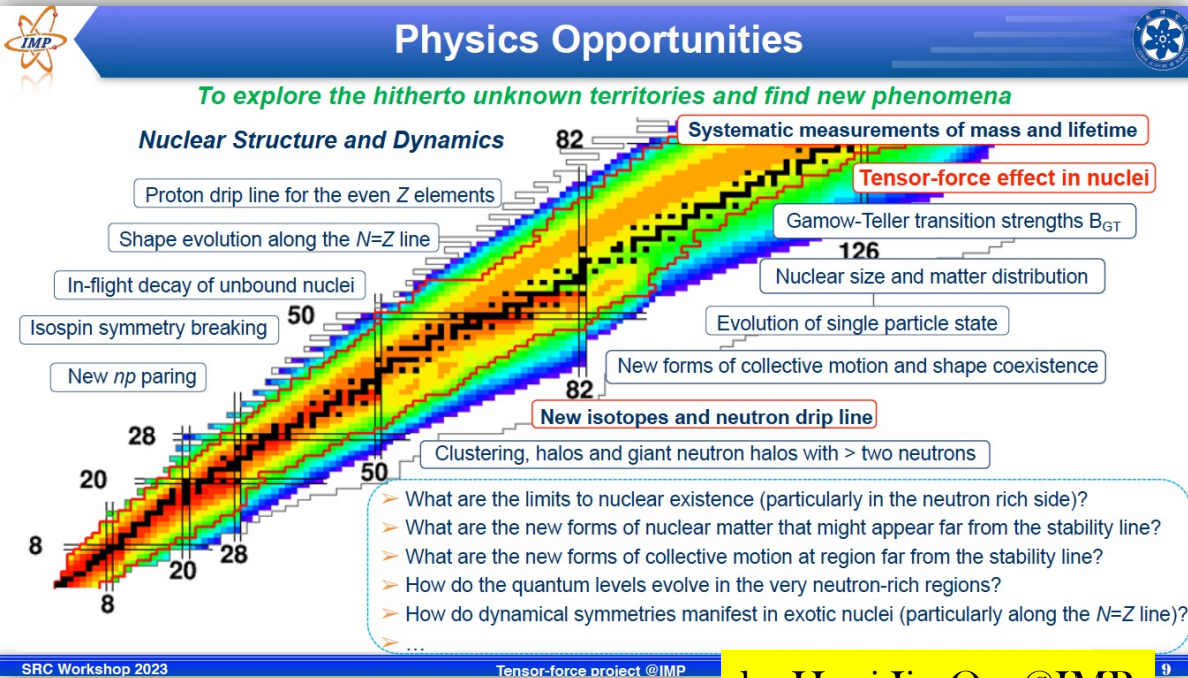
分会场1报告(04.26) by 仇浩, 赵宇翔



□ 挑战: 探测效率, DAQ速度

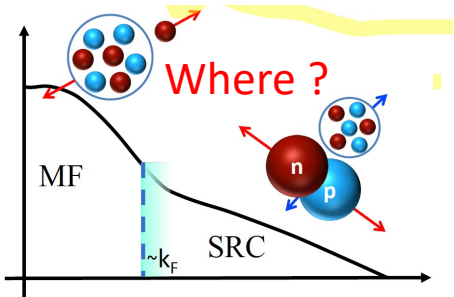


次级束流线(HIRIBL)可产生高能丰中子放射性束



by Hooi-Jin Ong@IMP

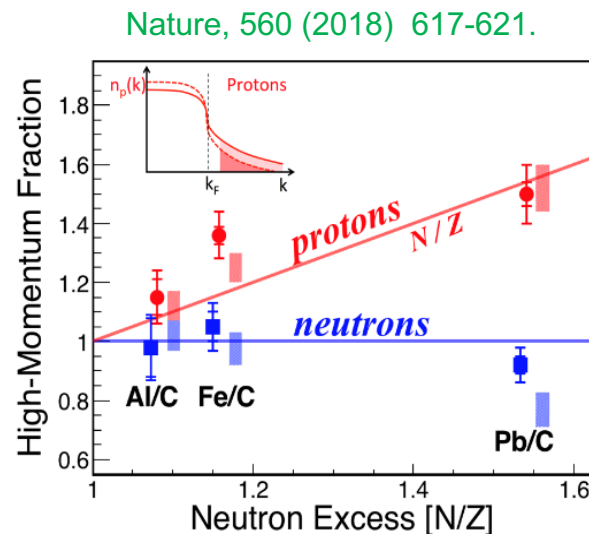
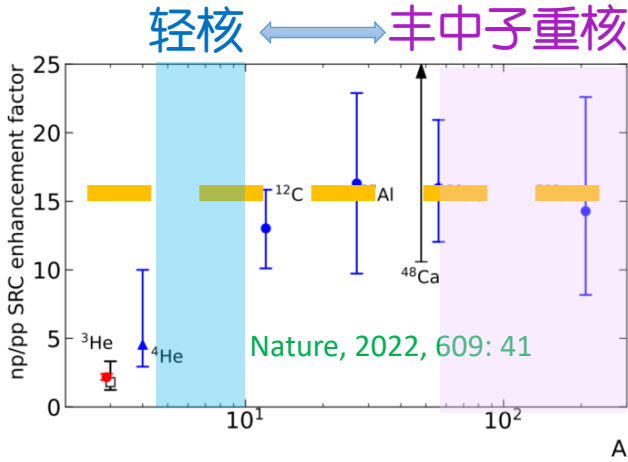
Maximum rigidity	25 Tm
Resolving power	800, 700, 1100
Momentum acceptance	$\pm 2.0\%$
Angular acceptance	± 30 mrad (x) ± 15 mrad (y)
Beam size	± 1 mm (x) ± 2 mm (y)
Total length	192 m



在HIRIBL实验终端精密研究丰中子核素的SRC

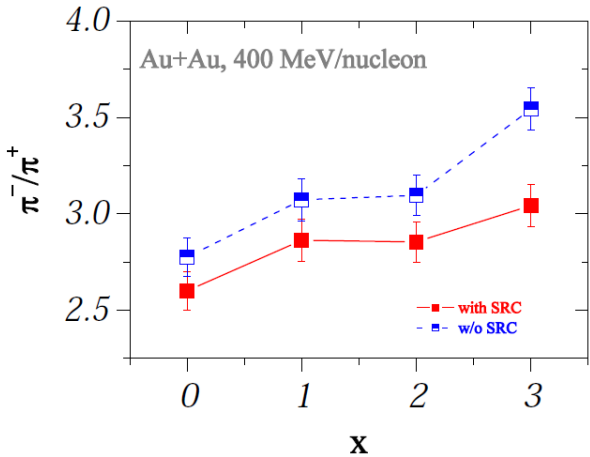
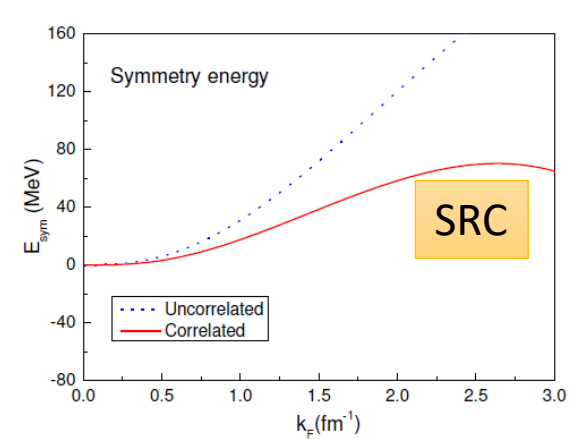
- ✓ 少体核力, 丰中子核的np-SRC
- ✓ 平均场→长程关联→短程关联

J. Yu & B. Long, arXiv:2501.00283, H. Shang & J. Pei et. al. arXiv:2503.17119

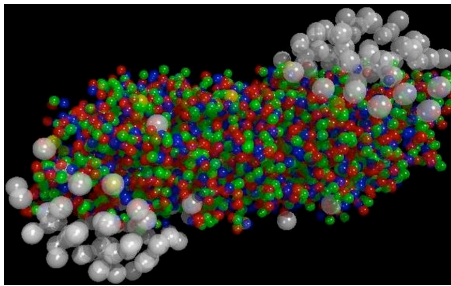


中低能区重离子碰撞中的SRC

✓ 对称能 vs. SRC G.C. Yong, L.W. Chen, B.A. Li et al., PRC93 044610 (2016), PRC, 96 (2017) 064614



相对论重离子碰撞中的SRC

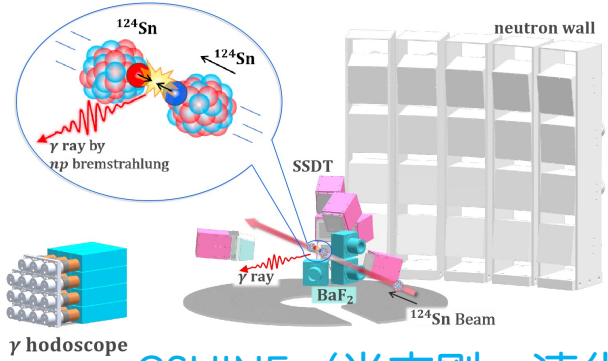


✓ 高能重离子碰撞仍带初态原子核信息, e.g. 核形变 (mean-field), 团簇, 高动量尾巴 EMC, etc.

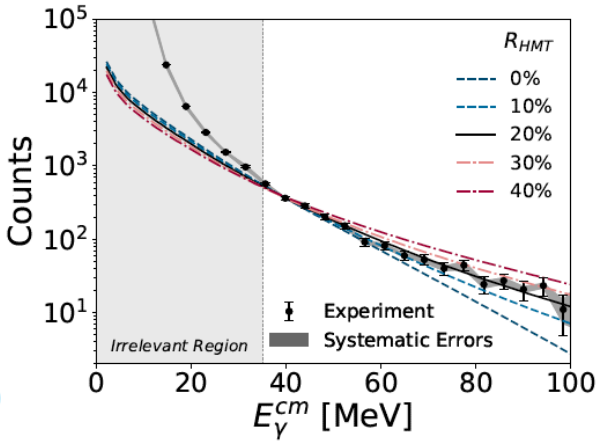
C.J. Zhang, et.al. PLB v862 139322 (2025), R. Cao et.al. PRC 108 064906, L. Shen et. al. PRC 105 014603 (2022)

14:30-15:00	张春健	复旦大学 大会报告 4.25	Nuclear structure through heavy-ion collisions
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✓ 高能γ出射 vs SRC

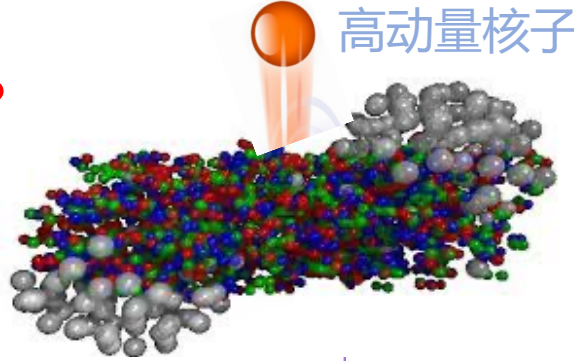


CSHINE (肖志刚, 清华)



✓ 是否可以直接观测?

✓ CEE & HIAF?
(需要理论支持) !



理论: H. Xue, et. al., PLB 755,486 (2016), Z. Wang, et. al.
实验: J. Xu, et.al., PLB 857 139009 (2024), 2504.13929



- 短程关联研究: 研究原子核的核子结构和夸克结构: 横跨多个子领域 & 能区!
- 2N-SRC已经被精确观测, 发现np-SRC主导性, 发现与EMC效应相关
- 未知: 1) 平均场过度到短程关联; 2) 少体丰中子核的SRC特性; 3) 3N-SRC; 4) 夸克&胶子分布
- 精密测量前沿: 高流强重离子与质子碰撞 (pA过程)
- JINR/GSI/CEE → HIAF/EicC



Collaborators: Eli Piasetzky (Telv Aviv), Maria Patsyuk (Dubna), Hongna Liu (BNU), Or Hen&Julian Kahlbow & Hang Qi (MIT), Xionghong He & Hao Qiu & Hooi-Jin Ong & Yapeng Zhang (IMP), ...

感谢自然科学基金委项目的支持 (面上: 12275148 & 中以地区合作-12361141822) !



感谢聆听！

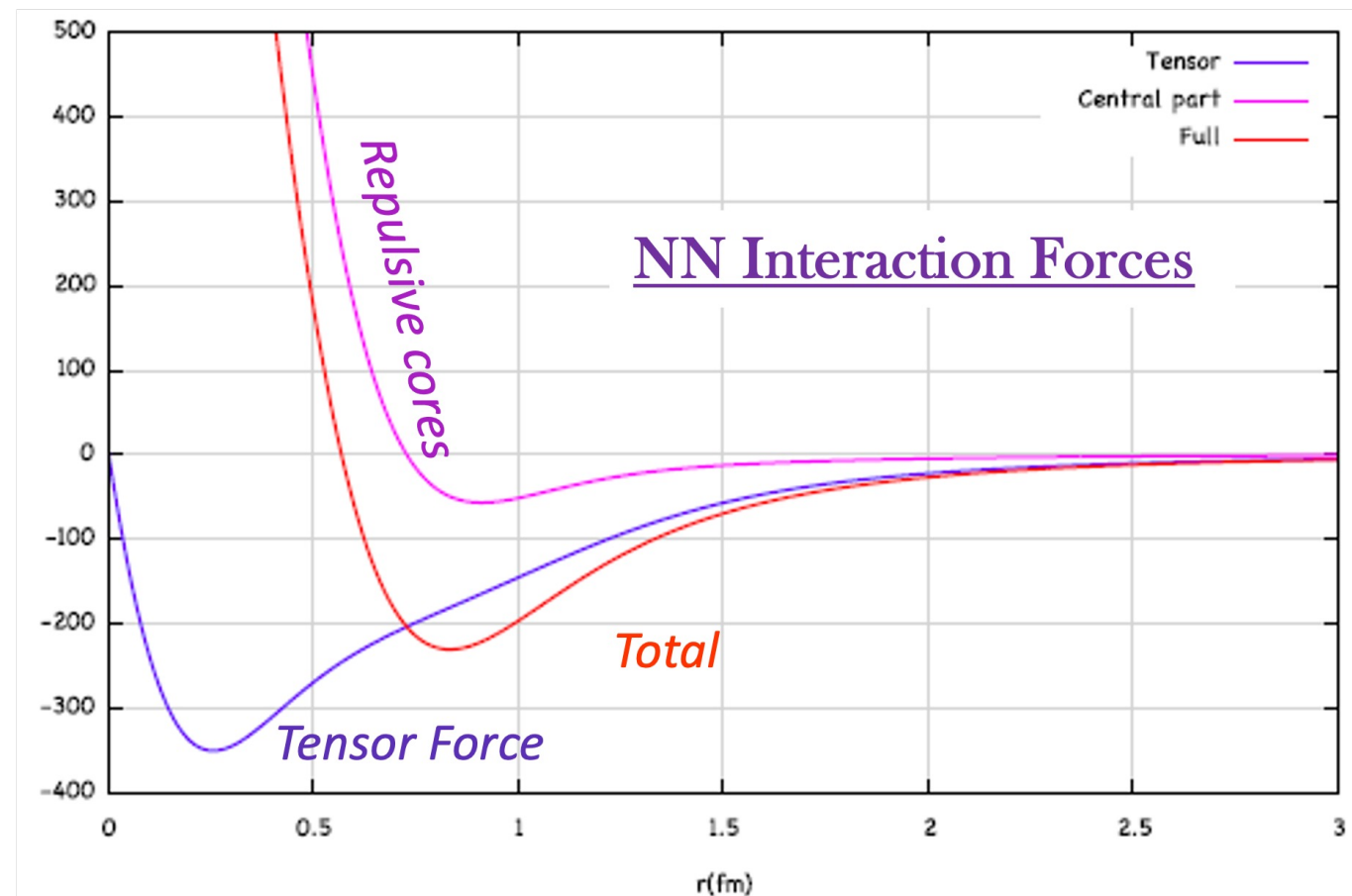
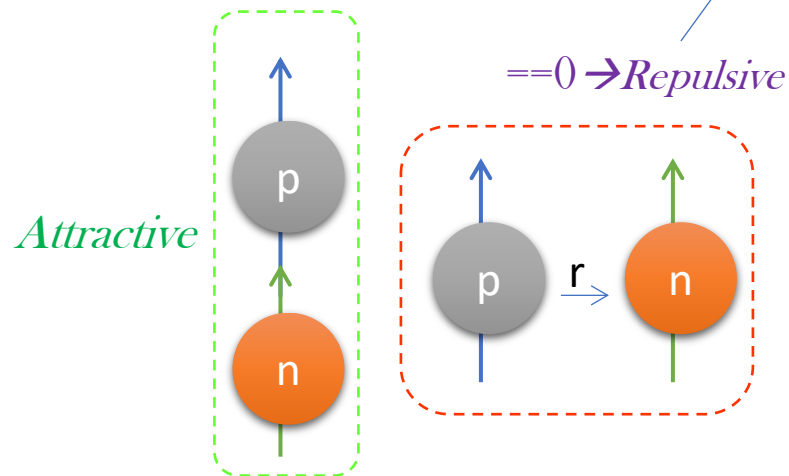


清华大学
Tsinghua University

□ 张量力引起np-SRC的主导性?

$$-S_{12} = -3(\vec{\sigma}_1 \cdot \hat{r})(\vec{\sigma}_2 \cdot \hat{r}) + (\vec{\sigma}_1 \cdot \vec{\sigma}_2)$$

$$= -3 \sigma_1 \sigma_2$$



□ Tensor force favor neutron-proton pairs

Proton $\rightarrow T = 1/2$, Neutron $\rightarrow T = -1/2$

Isospin Singlet: $T = 0$, n-p pairs ✓ Stable! due to Pauli Principle

Isospin Triplet: $T = 1$, p-p ($T_z=1$), n-p ($T_z=0$), and n-n ($T_z=-1$)



- Only knock out 1 or few nucleons, remanent are intact & in ground state → QES tail on the low-E side

- Experimental Quantities:

Momentum Fractions: $x = \frac{Q^2}{2m_p v}$

Four Momentum Transfer: $Q^2 = 4E_0 E' \sin^2(\theta/2)$

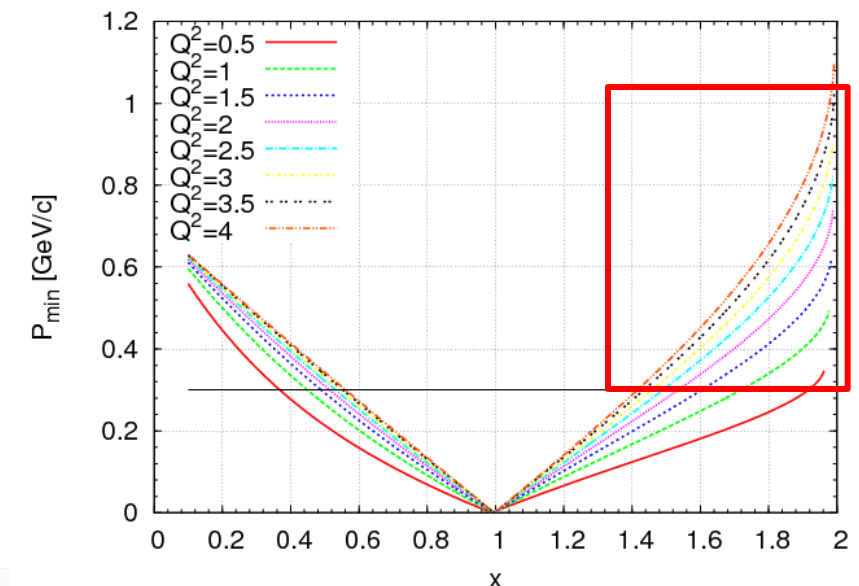
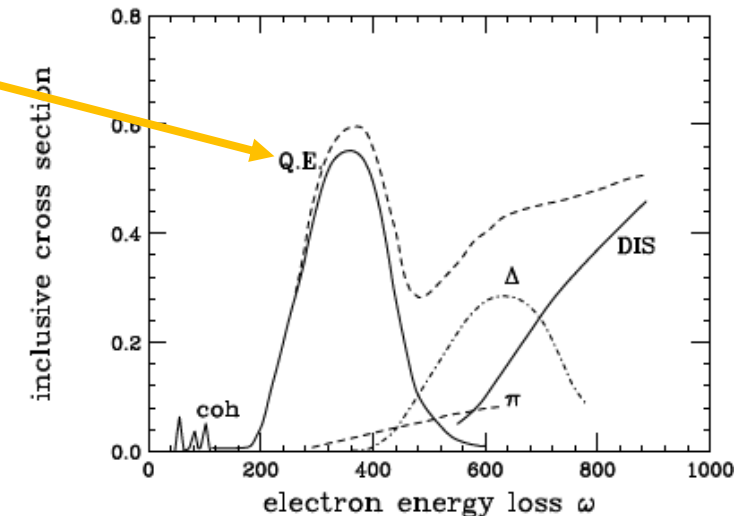
- Remove mean-field contribution → $k > k_{\text{Fermi}}$

- Directly measure high-P nucleons
- $x > 1.2 \rightarrow$ "quark" takes addition momenta from nucleon-motion

- Control FSI in semi-(exclusive) measurements (**very hard!**):

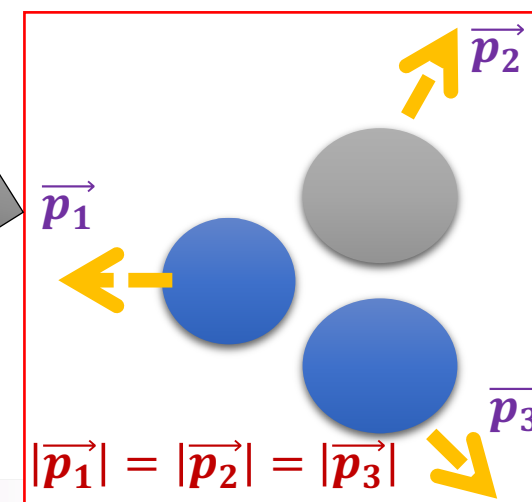
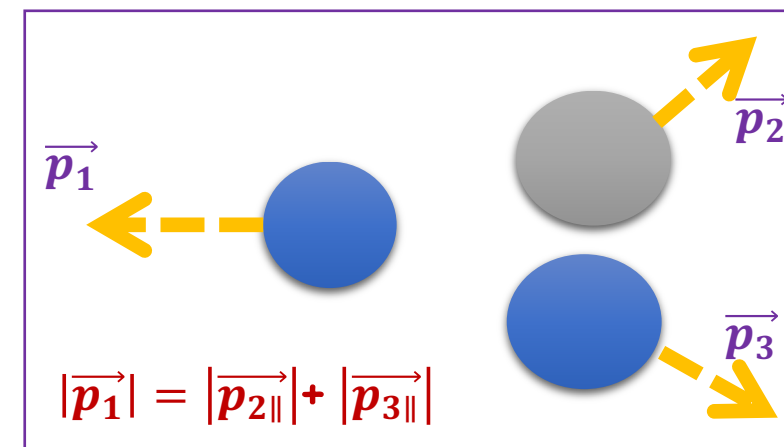
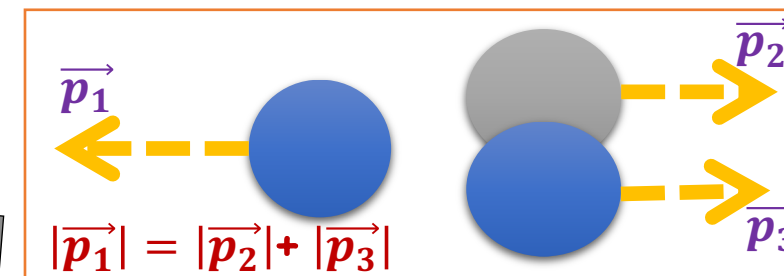
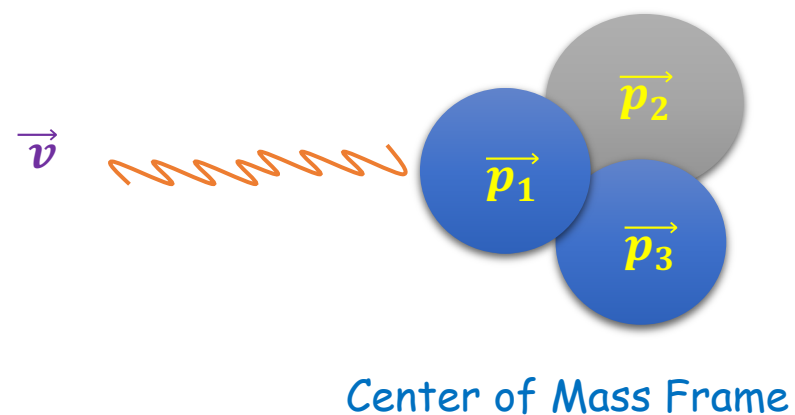
- $Q^2 > 1$ to reduce escaping time
- Measure nucleons at special kinematics to minimize FSI
- Theories models for additional corrections

Benhar, Day, Sick, Rev. Mod. Phys. 80, 189 (2008)



- ❑ Much higher relative momenta
- ❑ Much denser cluster (Neutron-Star, Nuclear Matter)
 - Bi-neutron-stars merger: neutron star > 2.4 solar mass
→ Short-Range 3-body force?

- ❑ Complicated 3N-SRC breakup

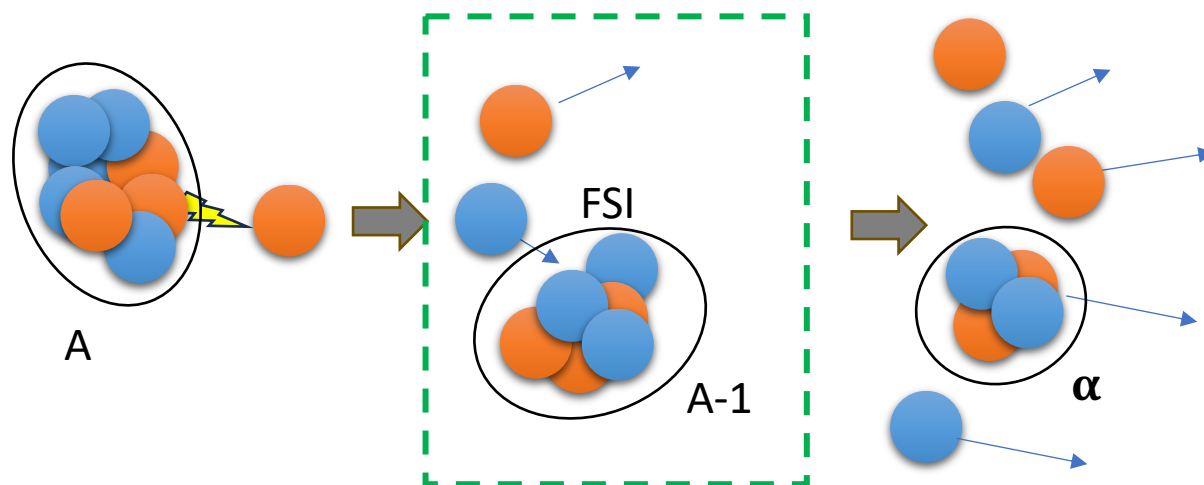
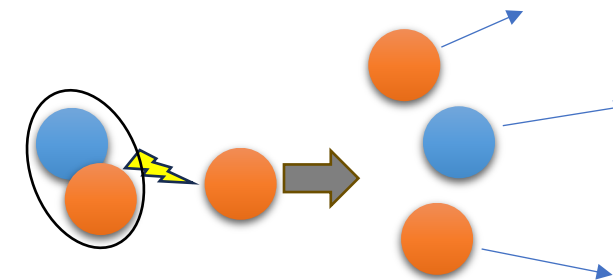


- ❑ Impossible w/ eA exclusive measurement



□ Goals:

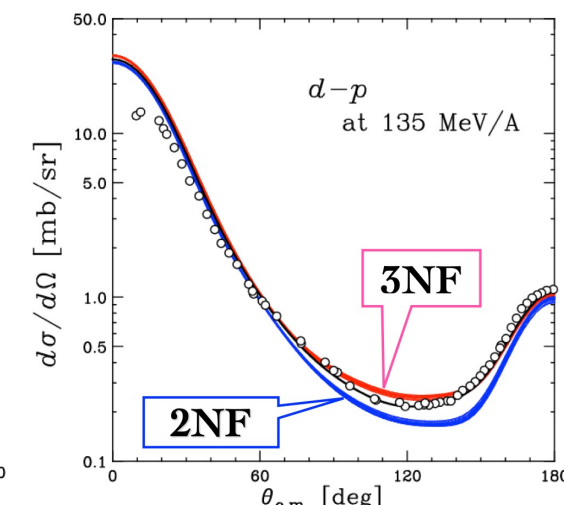
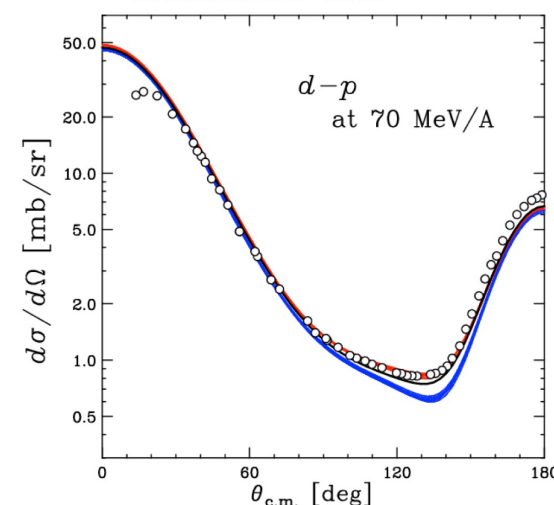
- ✓ Precision nuclear wave functions
- ✓ Cleanly define MF & SRC transition regions for the first time
- ✓ Few-body forces via $p\text{-}^2\text{D}^+$, $p\text{-}^3\text{He}^+/\text{}^3\text{H}^+$, $p\text{-}^4\text{He}^+$
- ✓ Direct study of Final-State Interaction (FSI) vs. *ab initio* calculations



■ NN (CDBonn, AV18, Nijm I,II)
 ■ TM'(99) 3NF +
 ■ NN(CD Bonn, AV18, Nijm I,II)
 ■ Urbana IX 3NF+AV18

K. Sekiguchi et al. PRC 65, 034003 (2002)
 K. Sekiguchi et al. PRL 95, 162301 (2005)

Calculations by Bochum-Cracow Gr.



2NF (CDBonn, AV18, Nijmegen I,II)
 : Large discrepancy in Cross Section Minimum (~ 30%)

2π-exchange 3NFs (Tucson-Melbourne, Urbana IX) : Good Agreement
 : First Clear Signatures of 3NF effects in 3-Nucleon Scattering

Slide form Kimiko Sekiguchi at FB2023