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on High Energy Physics Problems
Relativistic Nuclear Physics & Quantum Chromodynamics
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JINR

Exclusive studies of Short Range Correlations (SRC) in nuclei

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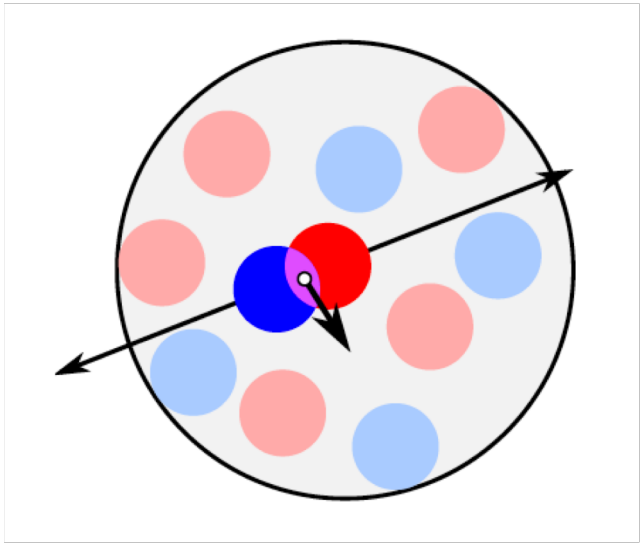
Short Range Correlated (SRC) pairs

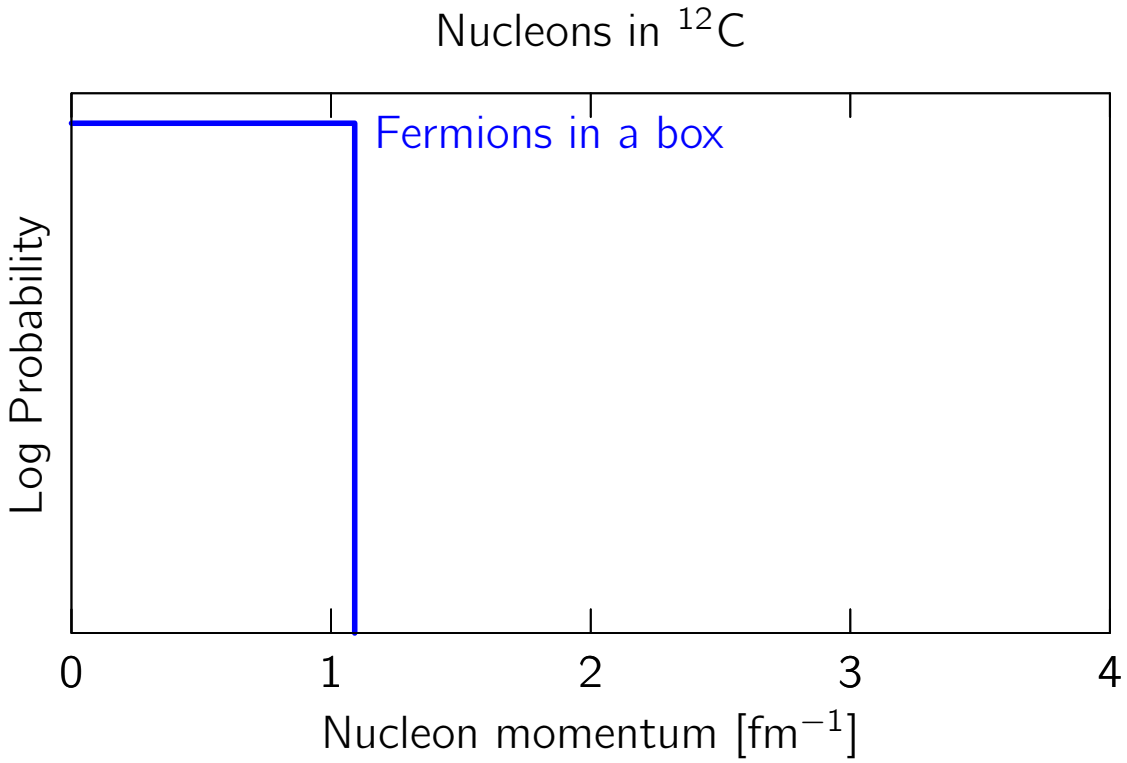


Relative momentum > 300 MeV/c

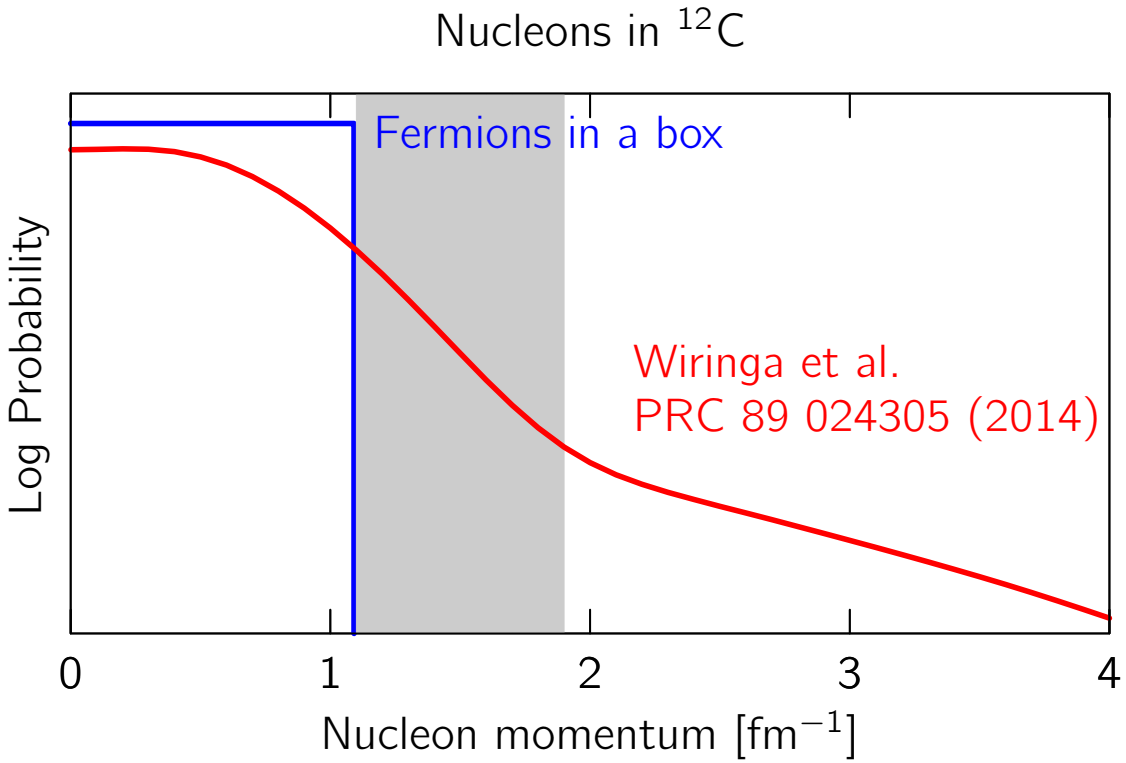
CM momentum O(150 MeV/c)

~20 % of nucleons

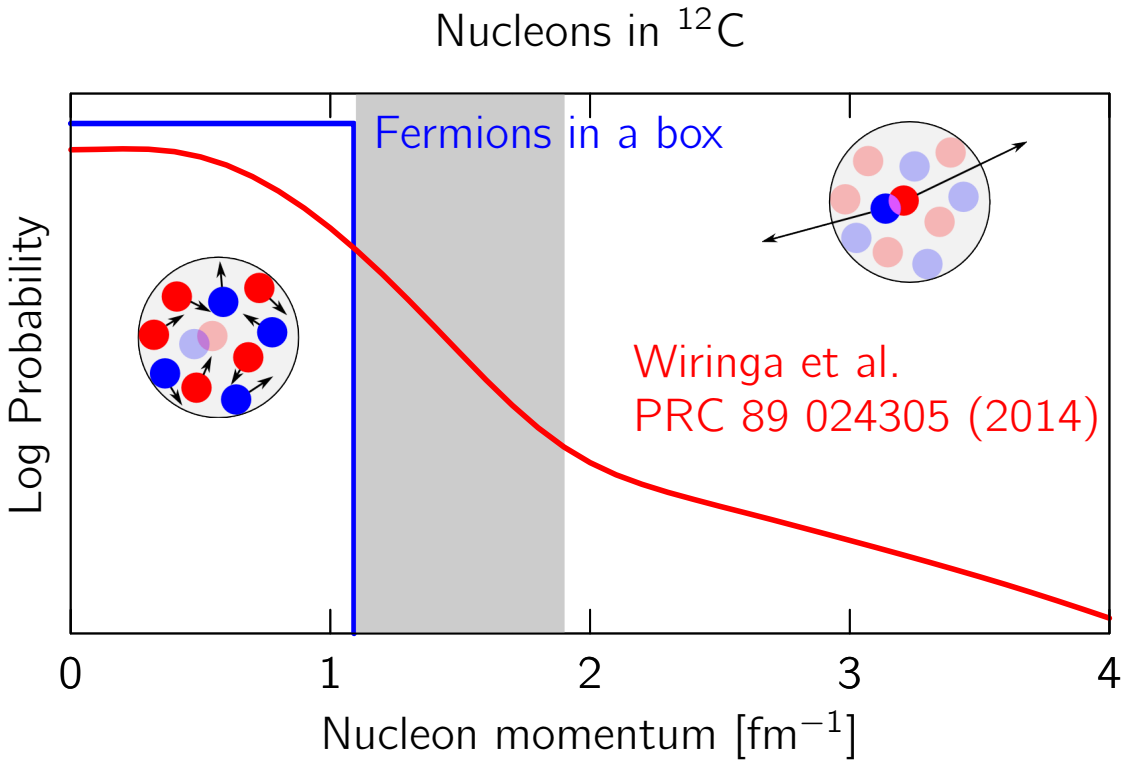
Nucleon momentum distribution for uncorrelated nucleons



In reality about 20% of nucleons have $k > k_F$



All nucleons with $k > k_F$ belong to SRC pairs



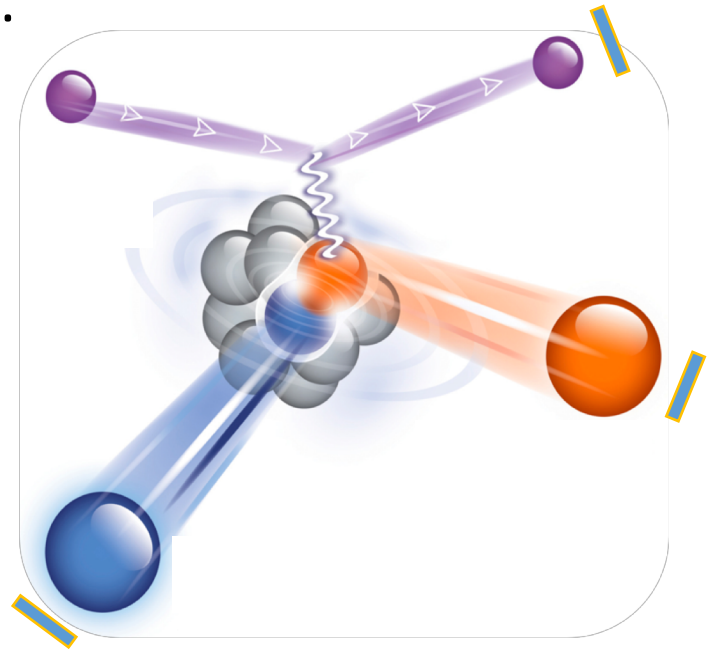
Exclusive hard scattering reactions are a perfect tool to study SRC properties

Interact with a single nucleon and
detect 3 particles (triple coincidence):

the scattered probe,

the knocked-out nucleon,

and the recoil



A(p, 2pn) – BNL
A(e, e'pp) - JLab
A(e, e'pn) - JLab

p(^{12}C, 2p A-2) - JINR

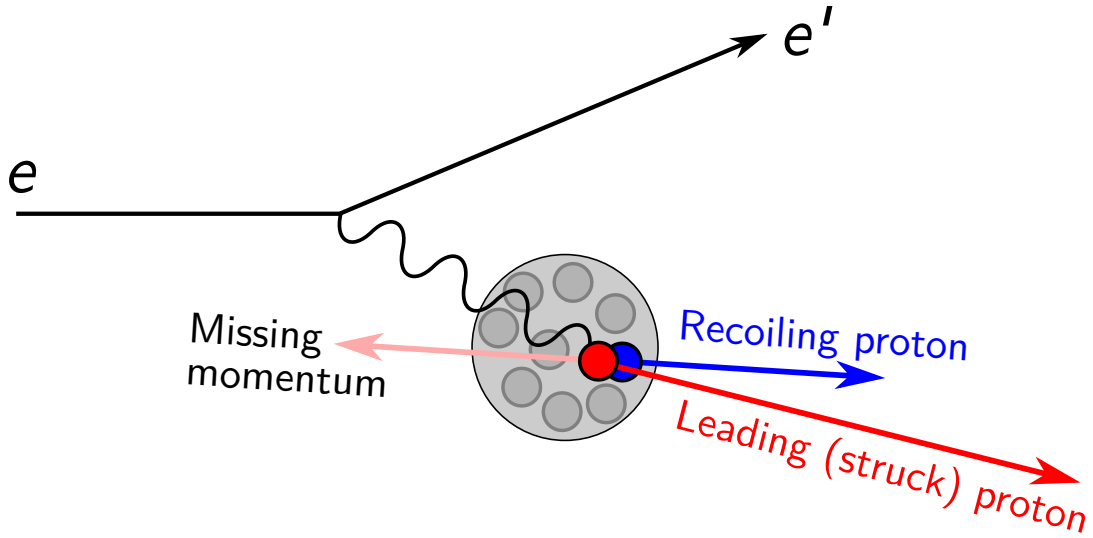
Choose kinematics where Final State Interactions (FSI) are confined to the pair

$x > 1.2$

$M_{miss} < 1.1$ GeV

$Q^2 > 1.8$ GeV^2

$\theta_{pq} < 25°$



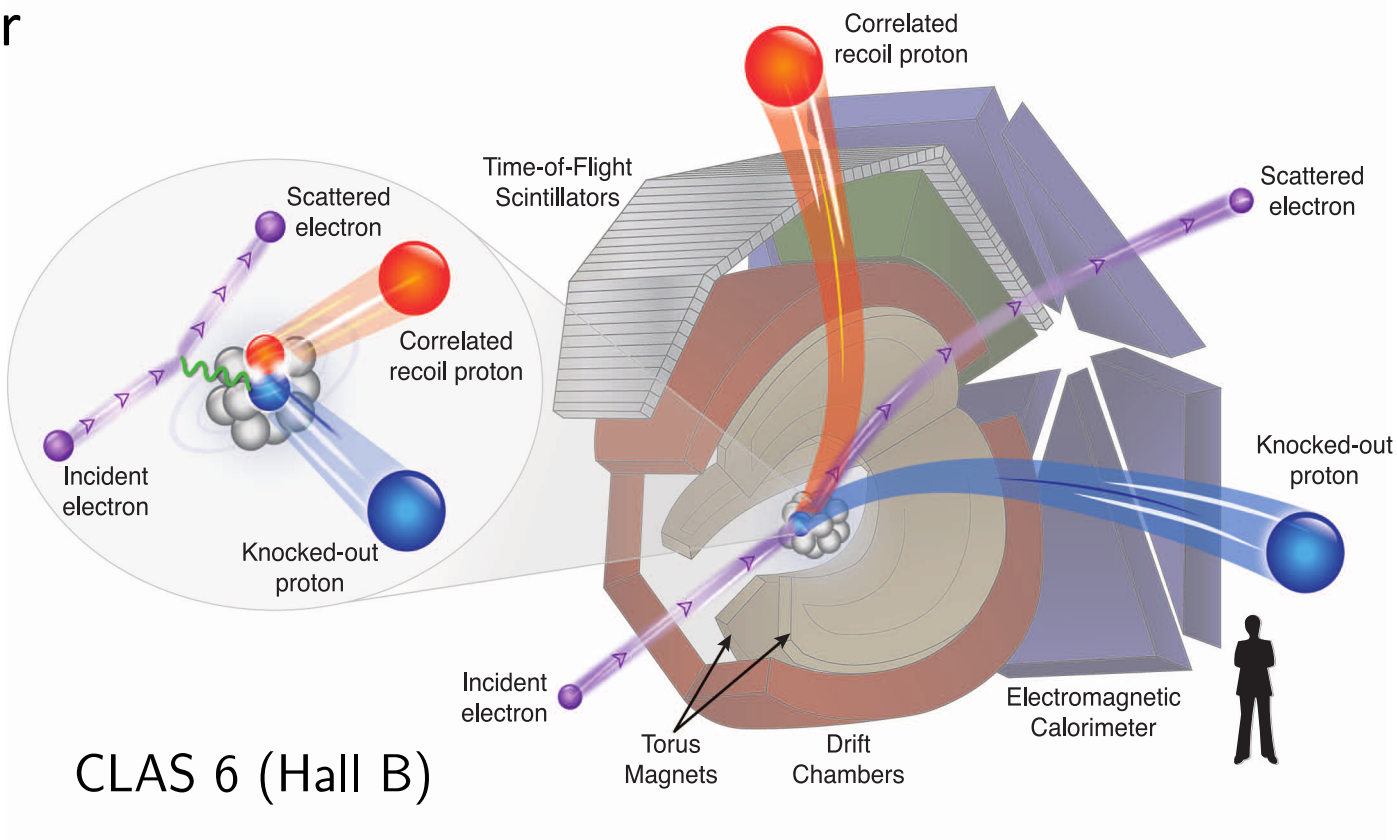
FSI do not impact isospin structure

FSI do not impact pair total momentum

JLab: CLAS-6 setup – base for the newest SRC results

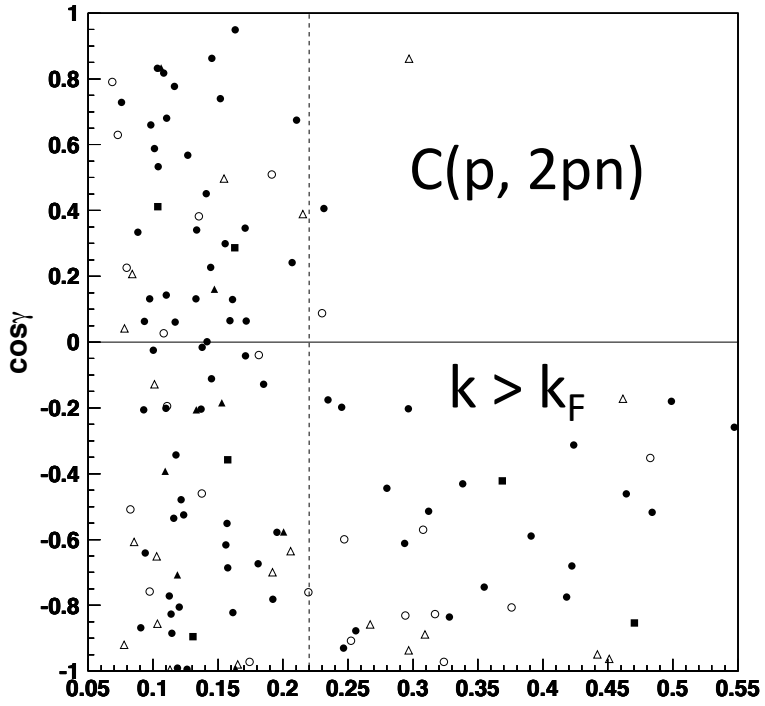
Large acceptance

Open trigger

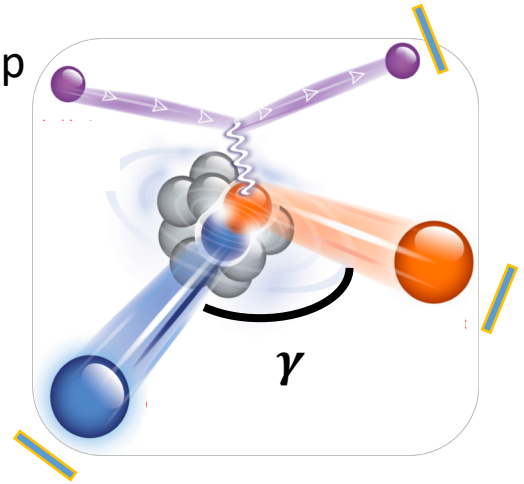


CLAS 6 (Hall B)

BNL: 92% of high momentum protons have a recoil



Recoil neutron momentum [GeV]

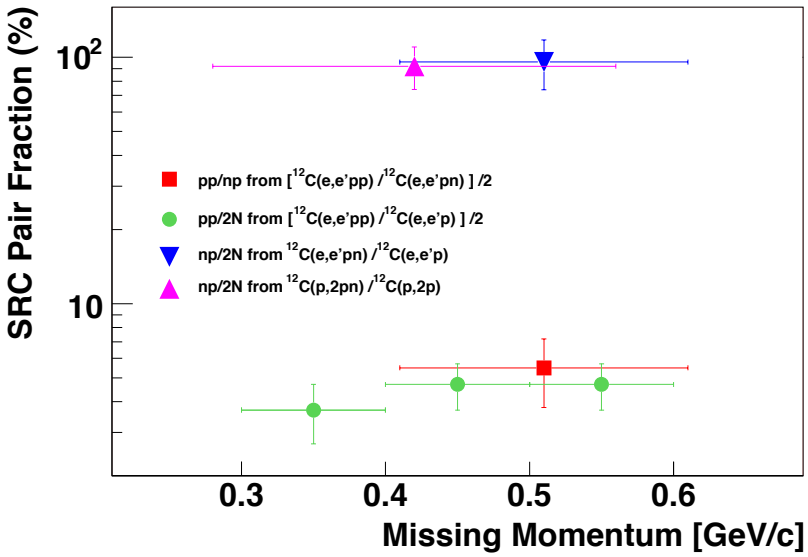


- Recoil has high momentum
- $k < k_F$ – isotropic, $k > k_F$ – back to back

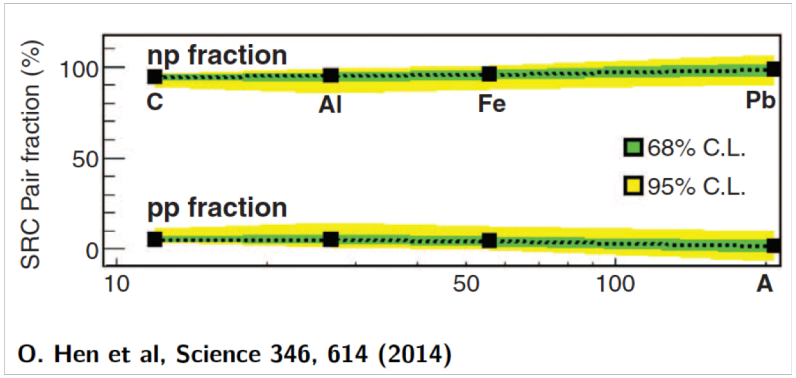
Aclander, PRL (1999); Tang, PRL (2003); Piasetzky, PRL (2006)

JLab: np-pairs dominate pp by a factor of 20

^{12}C(e, e'pn), ^{12}C(e, e'pp)



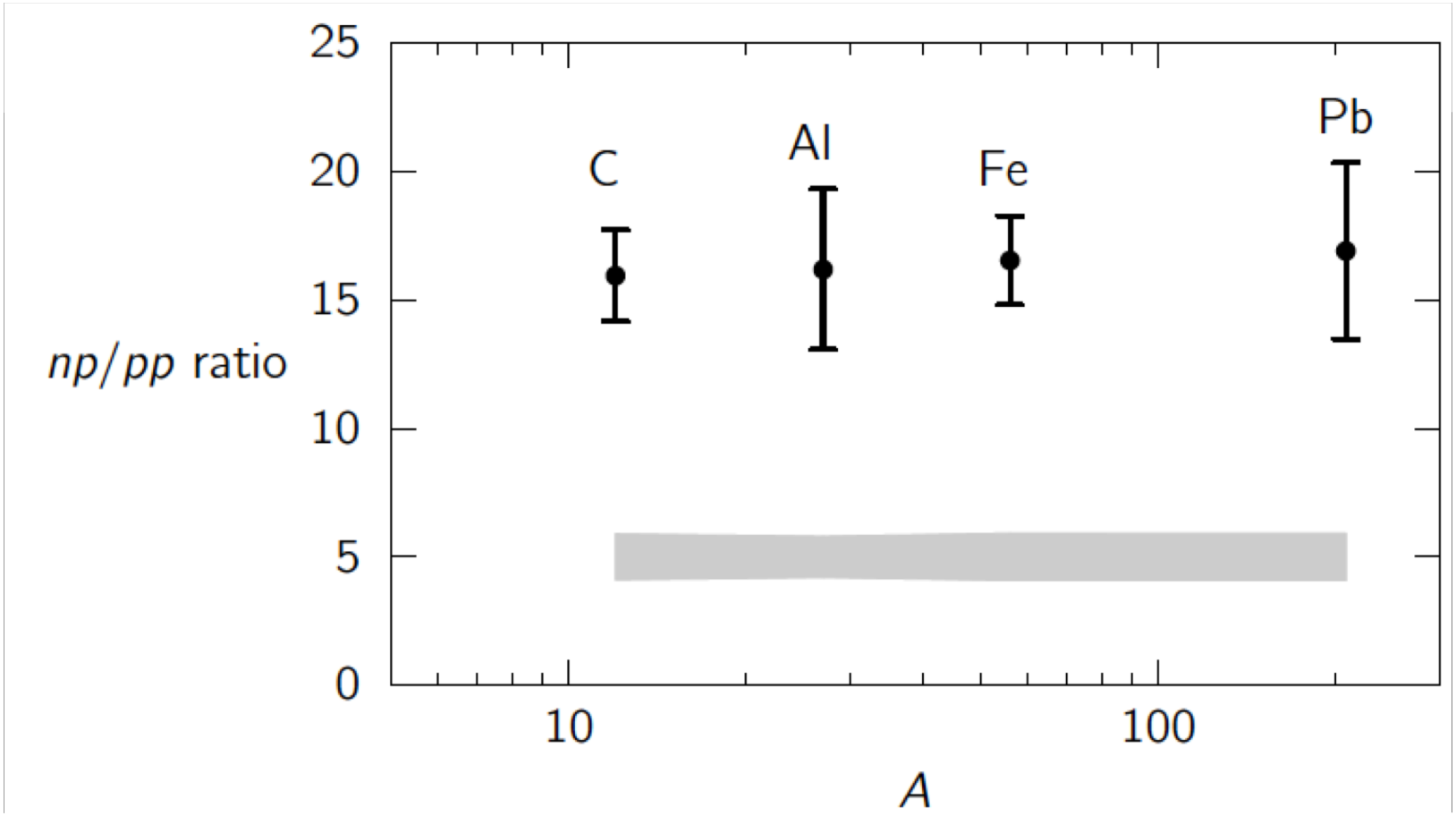
C, Al, Fe, Pb (e, e'pp) or (e, e'p)



"np-dominance" --> tensor, spin-dependent interaction within SRC

Piasetzky, PRL (2006); Shneor, PRL (2007); Subedi, PRL (2008)

np-dominance established for a wide range of A



Duer, Nature 560 (2018)

Where we stand:

SRC exist in nuclei and account for

~ 20 % on nucleons

~ 100% of high momentum (k > kF) nucleons

Have high relative momentum and low c.m. momentum

np-dominance is established for C, Al, Fe, Pb

Tensor, spin-dependent interaction within SRC

Much has been learned from very few events

experiment	nuclei	pairs	Pmiss [MeV/c]	# of pp-events	# of np-events	# of nn-events
EVA/BNL	^{12}C	pn only	300-600	**0**	**16**	**-**
E01-015/ JLab	^{12}C	pp and np	300-600	**263**	**179**	**-**
E07-006/ JLab	^{4}He	pp and np	400-850	**50**	**223**	**-**
CLAS/JLab	C, Al, Fe, Pb	pp and np	300-700	**~ 400 / nucleus**	**~200 / nucleus**	**-**

proton beam A(p, 2pN)

Electron beam A(e, e'pN)

SRC in inverse kinematics at JINR
A(p, 2p n A-2) : **detecting the nuclear remnant**

4 GeV/c ^{12}C beam on LH target

Probe universality

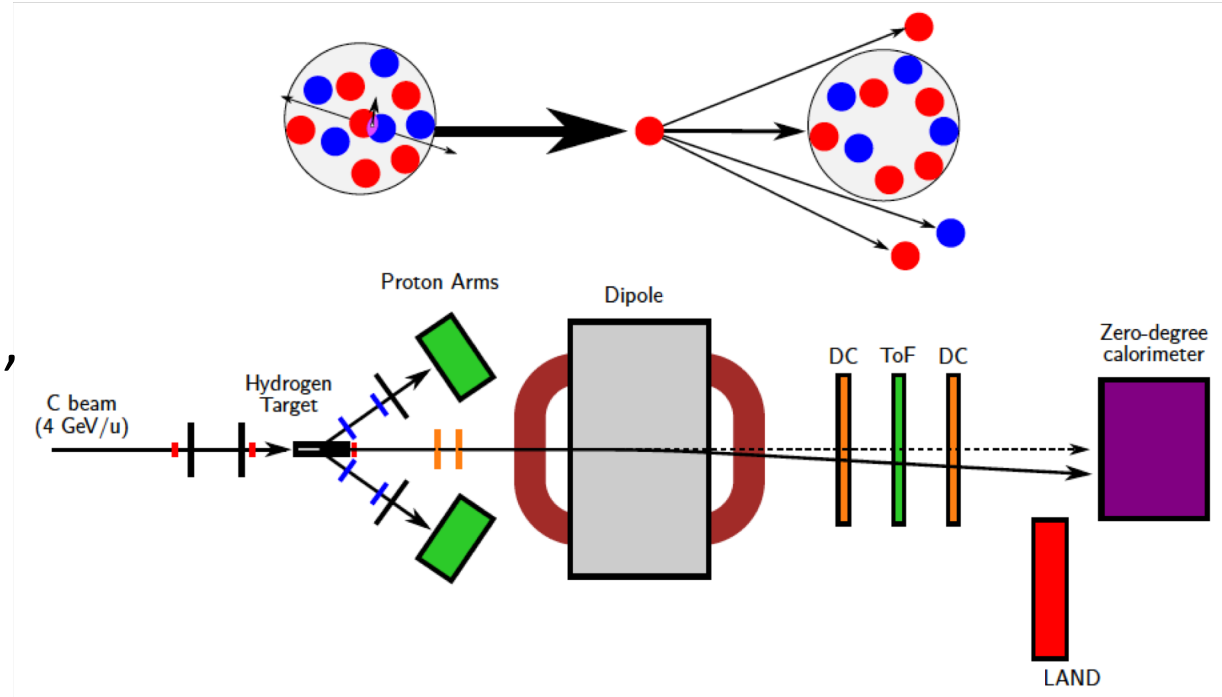
Detect 4 particles:

the scattered probe,

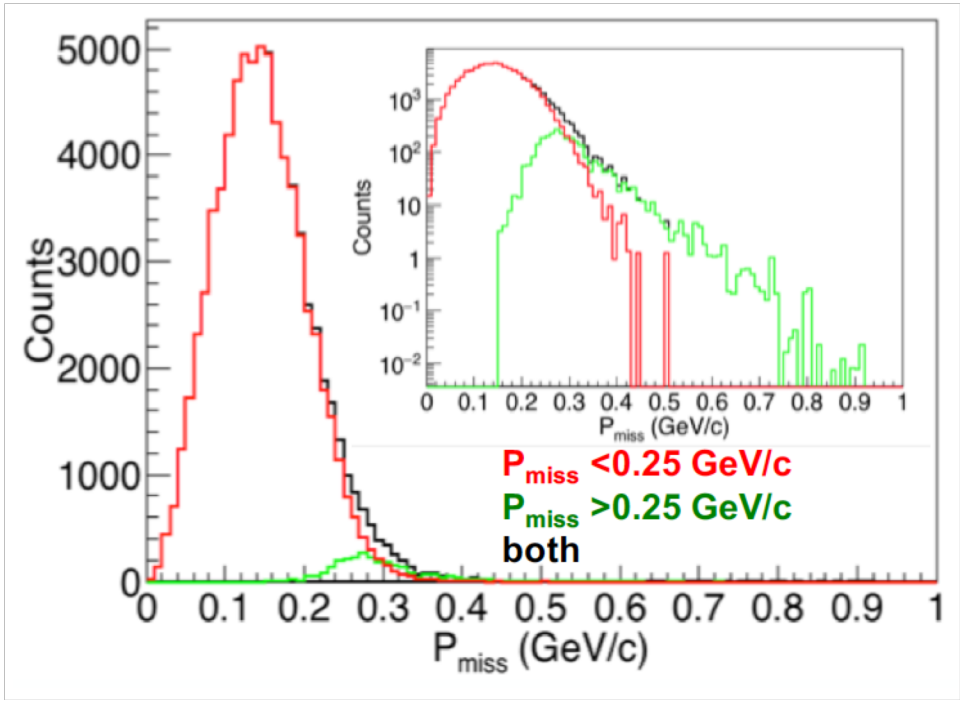
the knocked-out nucleon,

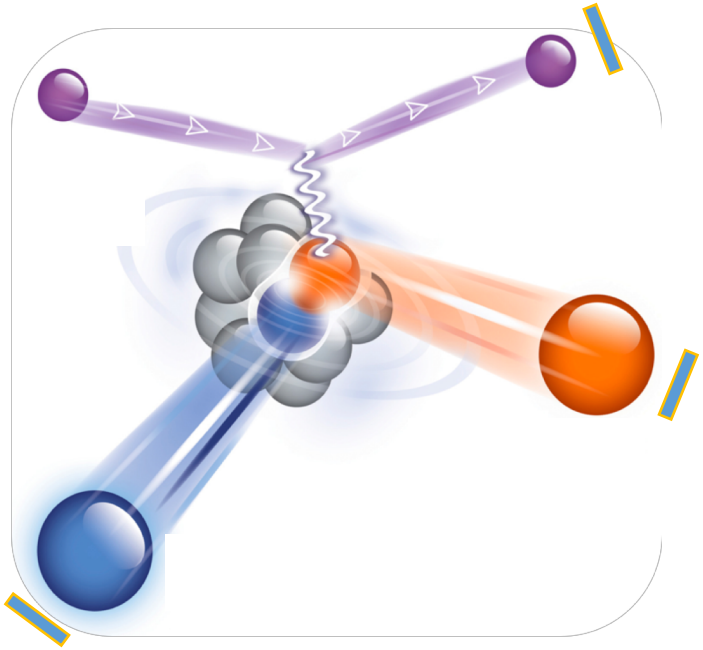
the recoil,

and the **A-2 system**!



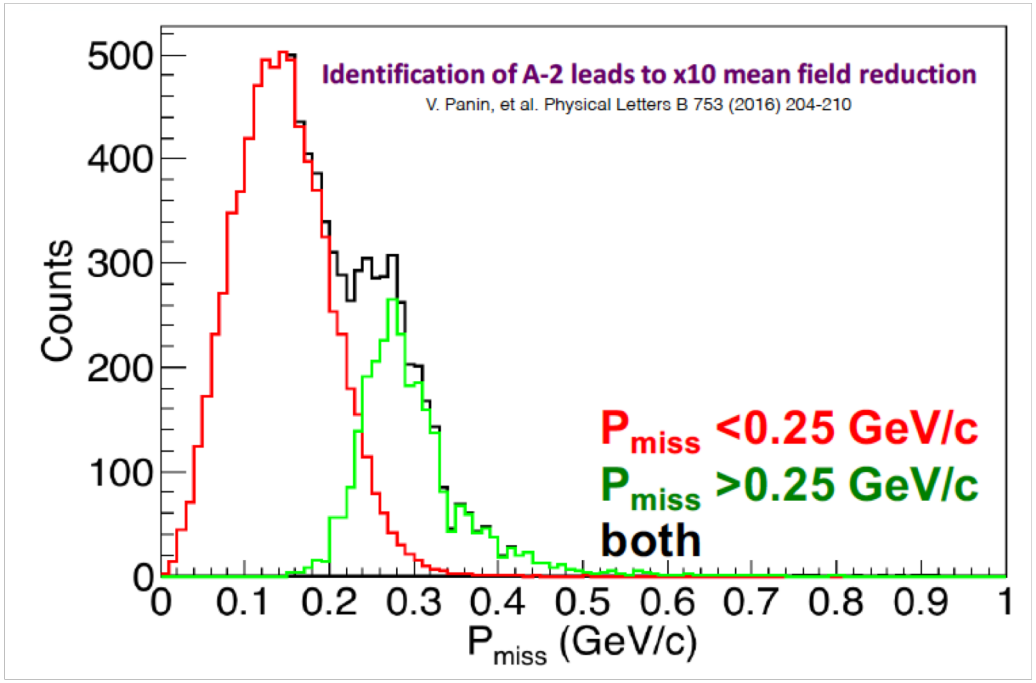
Detecting the A-2 system is essential for rejecting non-SRC background

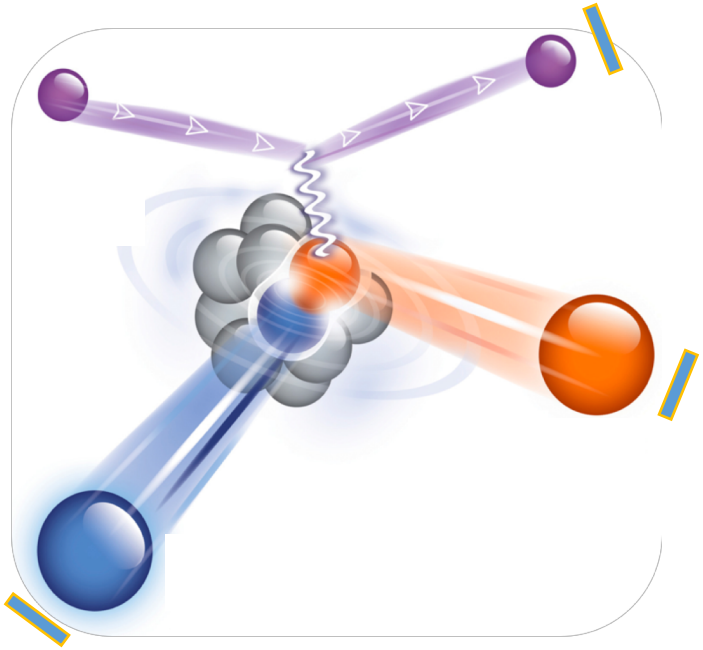




P_{miss} – momentum of the struck nucleon before interaction

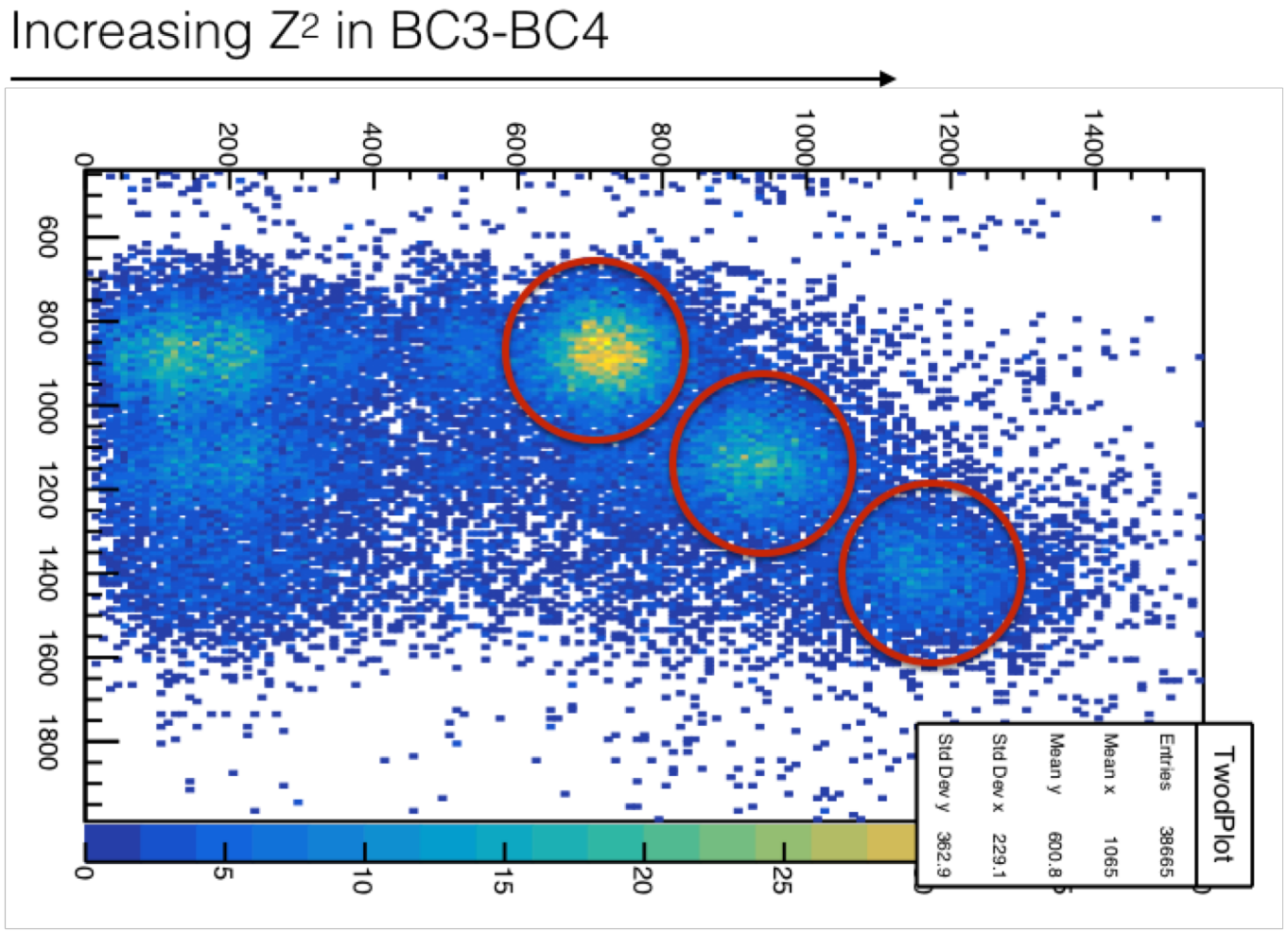
Identification of A-2 rejects the mean field component by 10 times



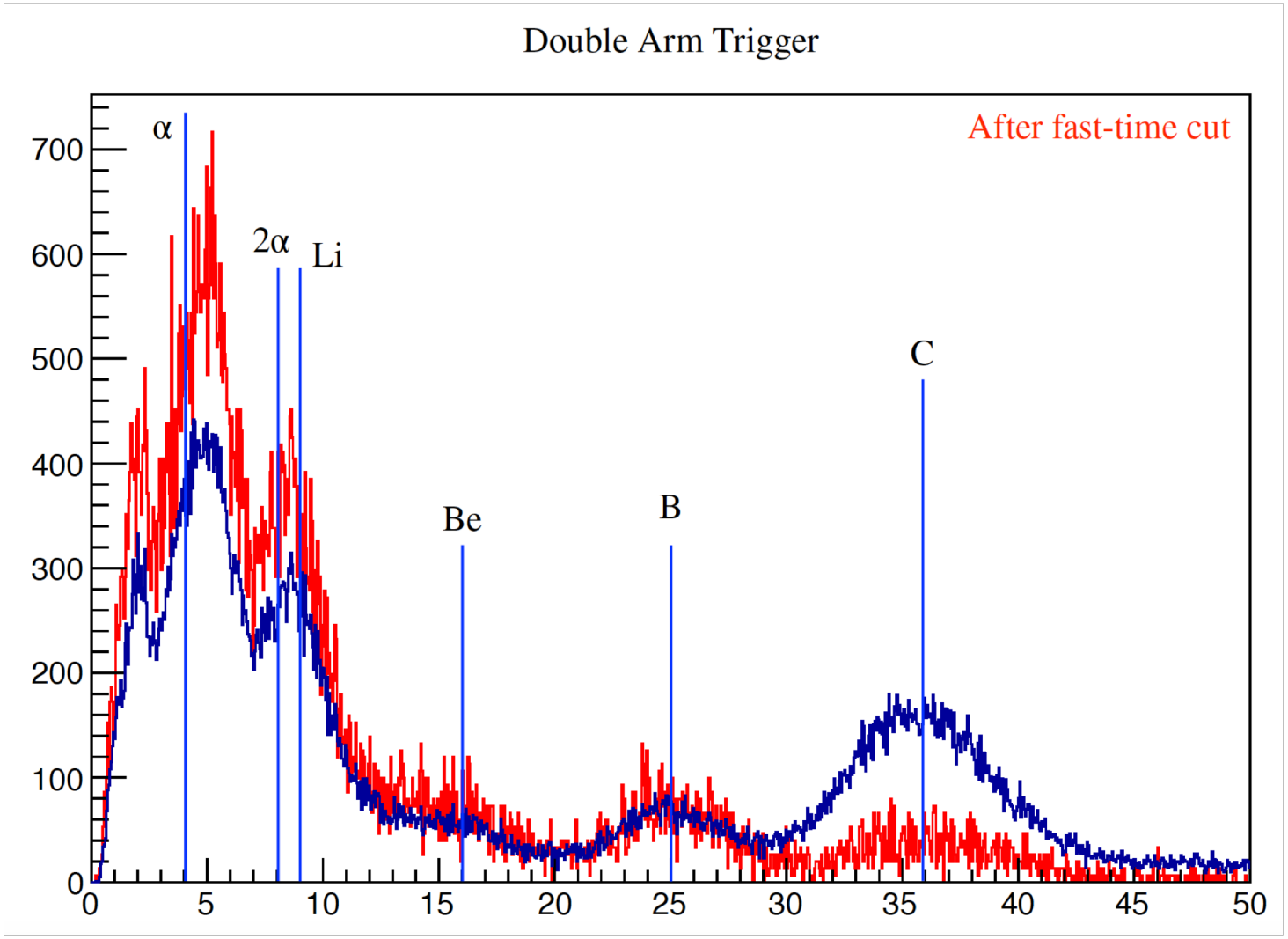


P_{miss} – momentum of the struck nucleon before interaction

Z from the scintillator counter: calibration

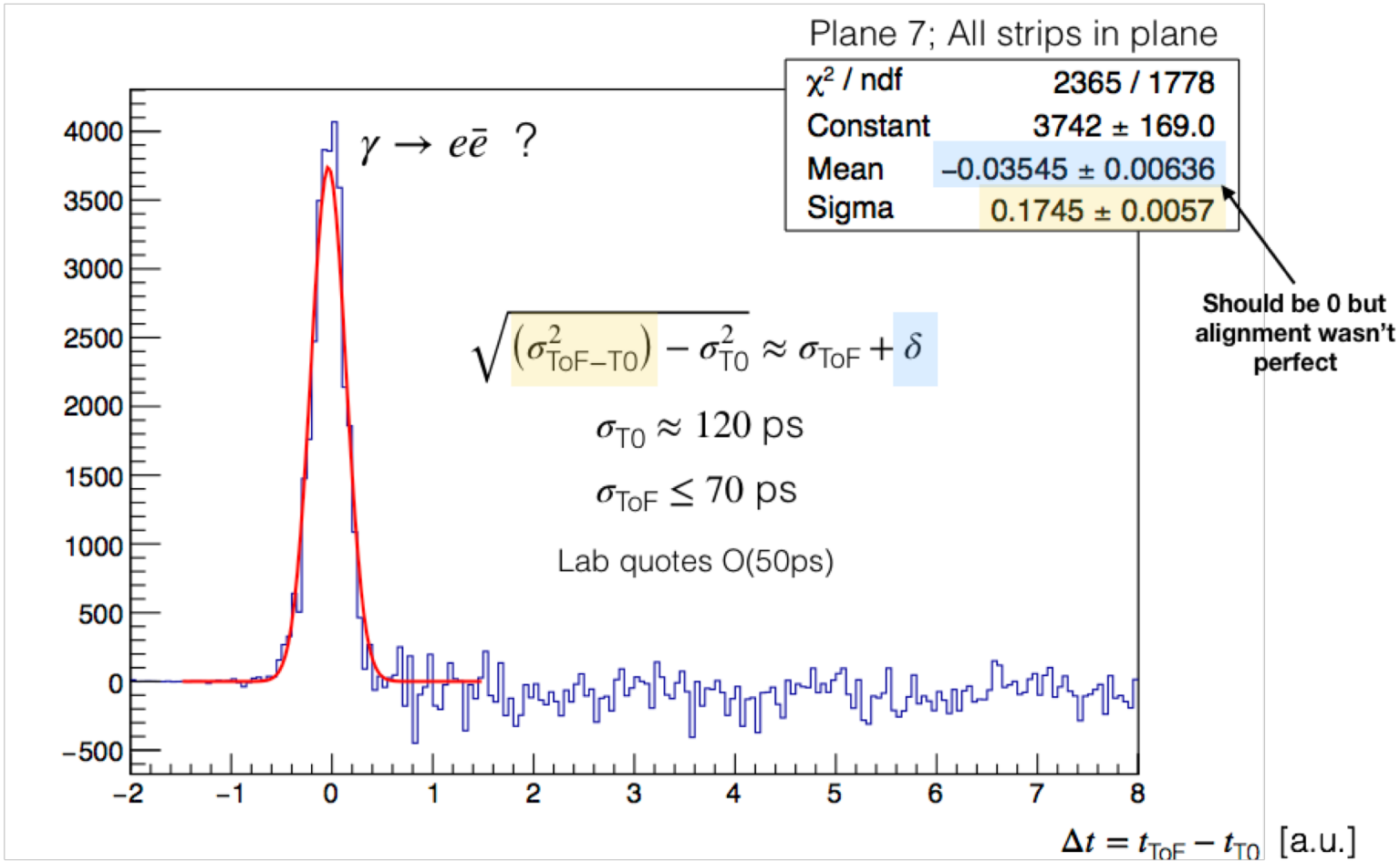


Residual nucleus can be identified from dE/dx

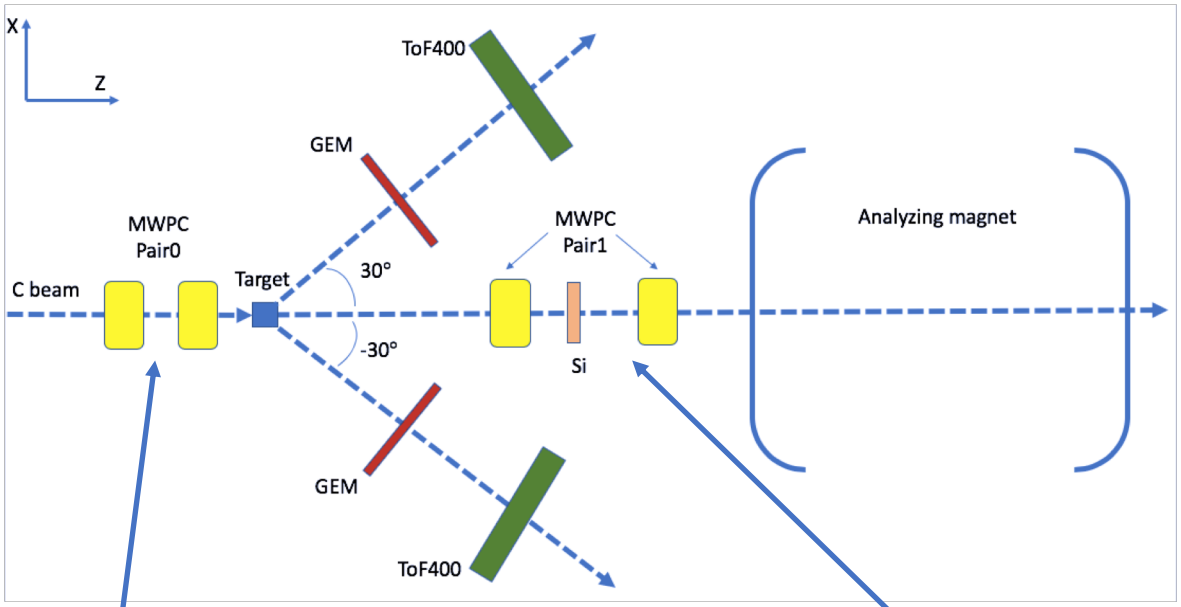


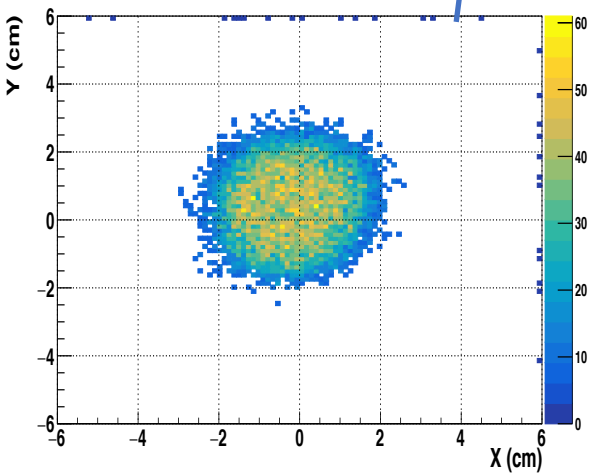
Analysis is going on: TOF400 calibration

After strip alignment, clustering, time-walk (T0 and ToF400)
Pb Wall Data - No-Pb Wall Data

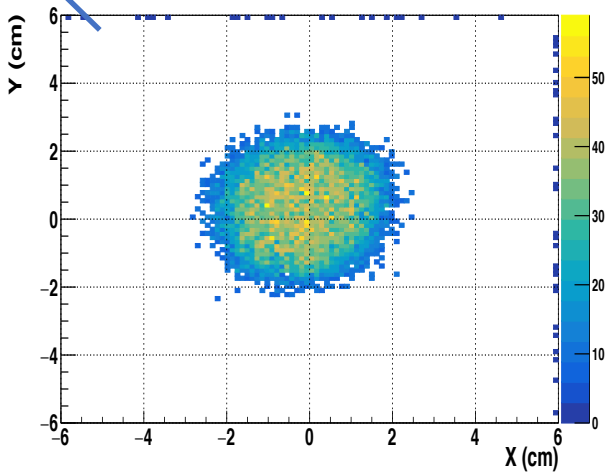


Analysis is going on: MWPC reconstruction





^{12}C beam
Empty target



Conclusions

SRC is a vibrant fast developing field of studies on the border between nuclear and particle physics

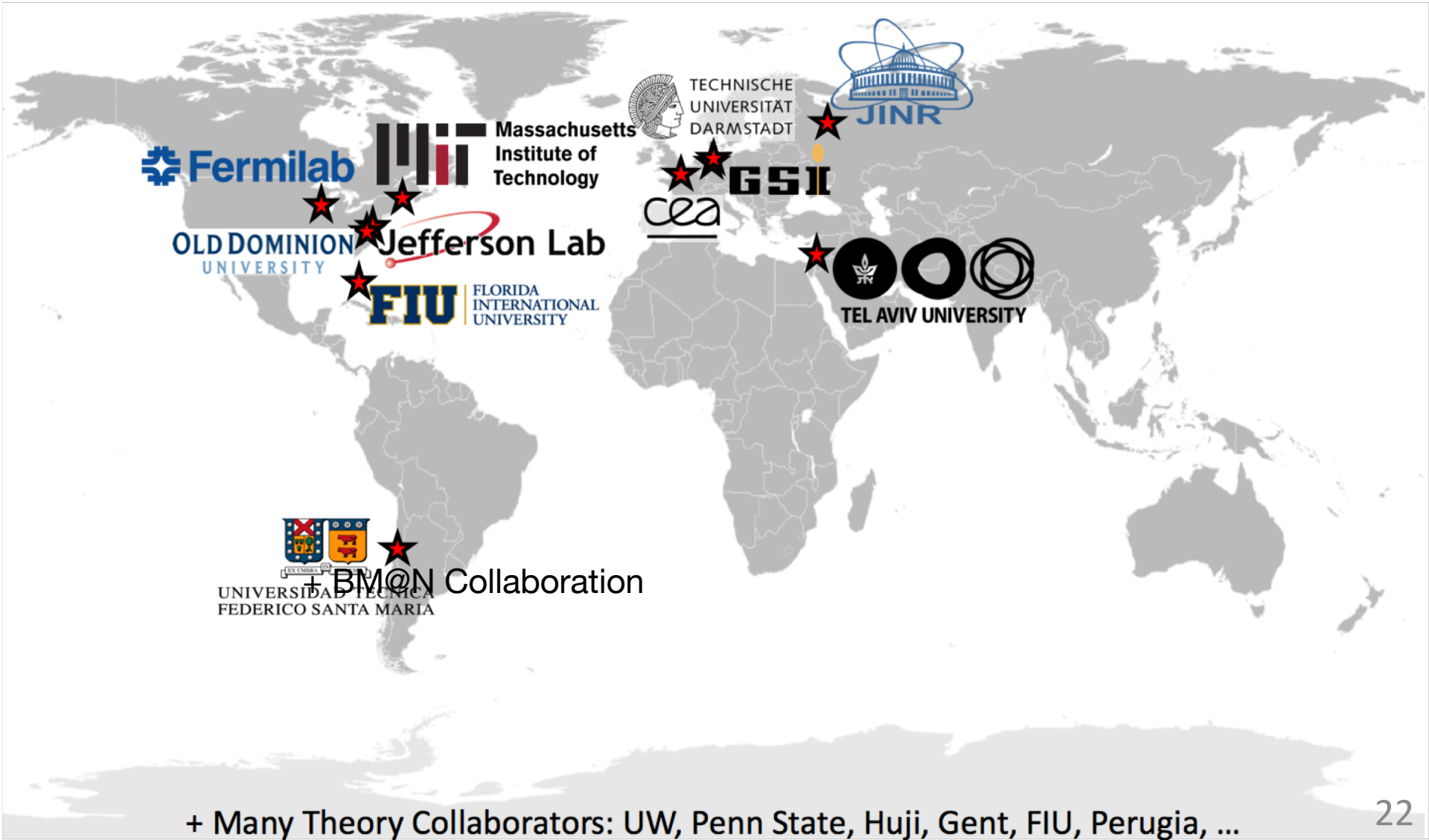
New insights about SRC:

- np dominance confirmed over a wide range of A
- SRC hypothesis for EMC explanation is stronger with the new data
- SRC pair formation and NN repulsive core

New exclusive experiments are designed to test new SRC ideas:

- disentangle mass and asymmetry, EMC/SRC (JLab)
- detect the residual nucleus for the first time (JINR)

The SRC World



+ Many Theory Collaborators: UW, Penn State, Huji, Gent, FIU, Perugia, …

Looking at Z2 After Target

1 and 2 tracks look identical — need to clean up selection
3 tracks is different event topology