Short-Range Correlation Studies @ HADES/GSI using protons

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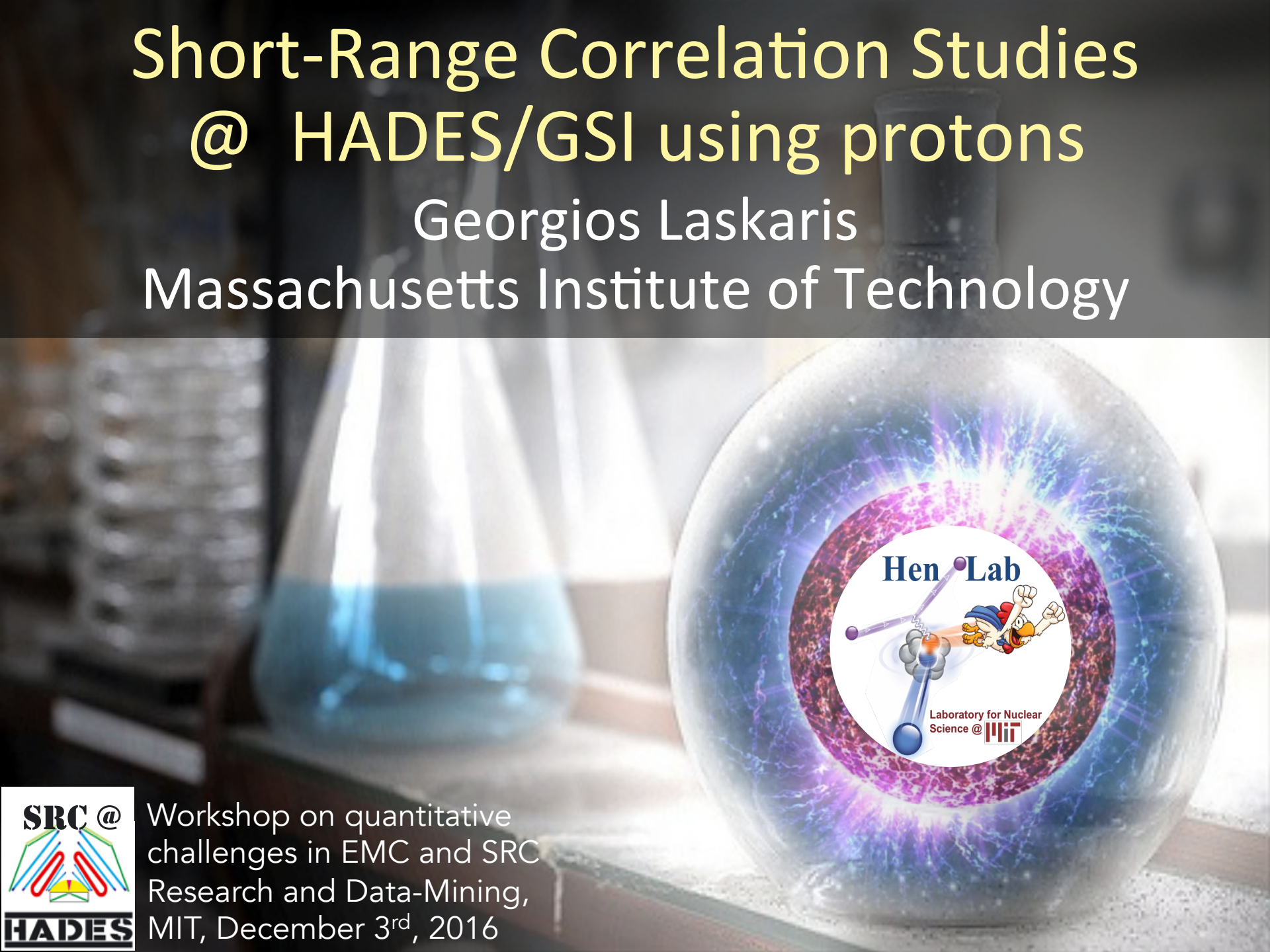
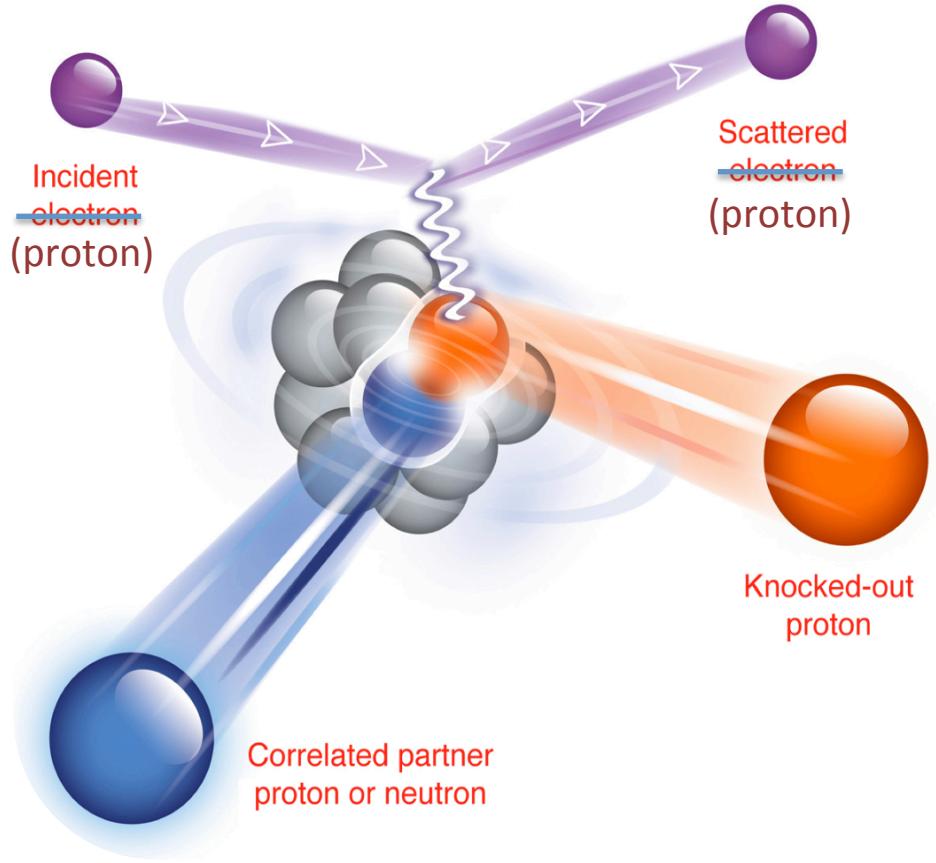


SRC @ HADES

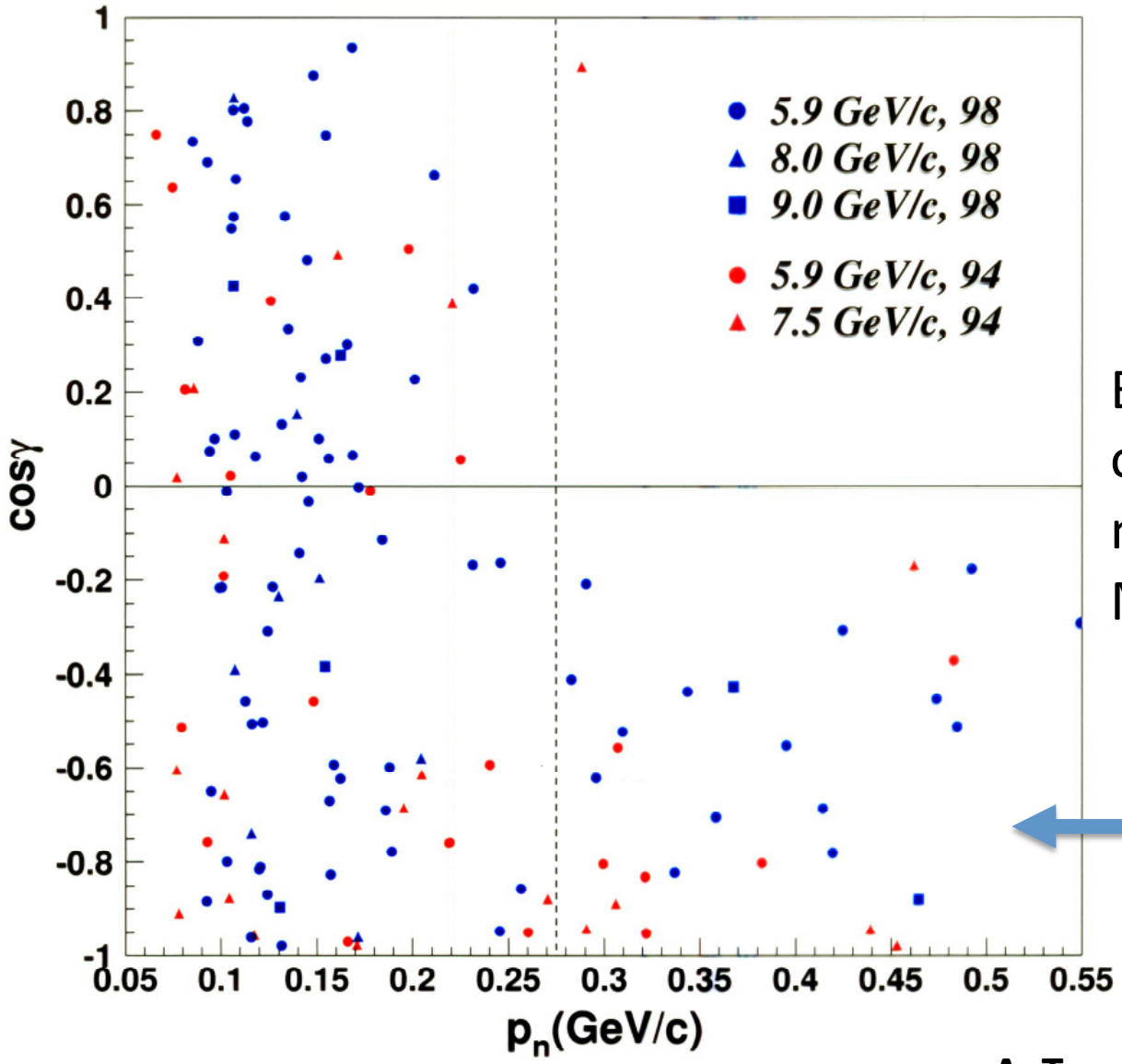
Workshop on quantitative challenges in EMC and SRC Research and Data-Mining, MIT, December 3rd, 2016

Probing SRCs

Breakup the pair =>
Detect both nucleons =>
Reconstruct 'initial' state



First Observation @ BNL

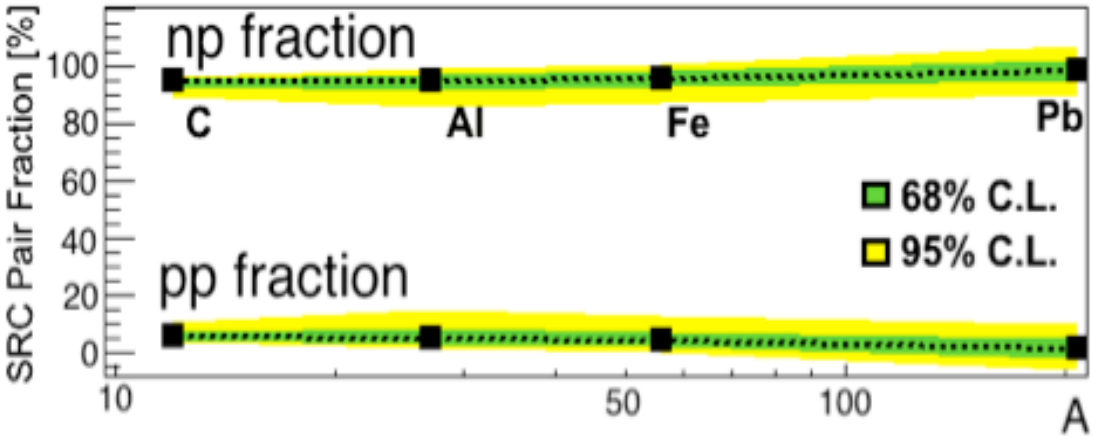


^{12}C(p,2pn)

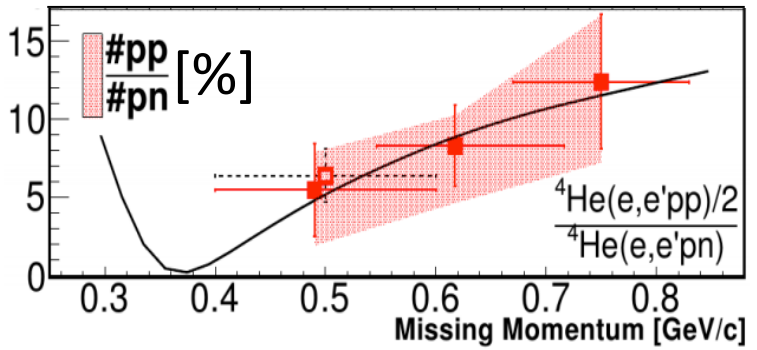
Back-to-back correlation observed for recoiling neutrons above k_F (270 MeV/c)

A. Tang *et al.*, PRL 90, 042301 (2003)
E. Piasetzky *et al.*,PRL 97, 162504 (2006)

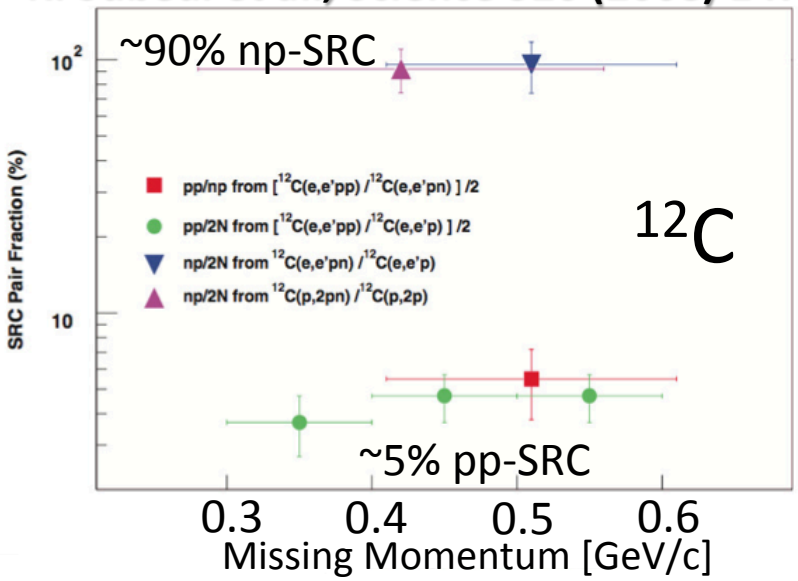
Isospin Structure (BNL and JLab)

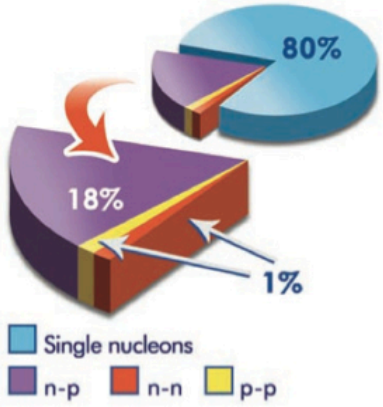


O. Hen et al., Science 364 (2014) 614

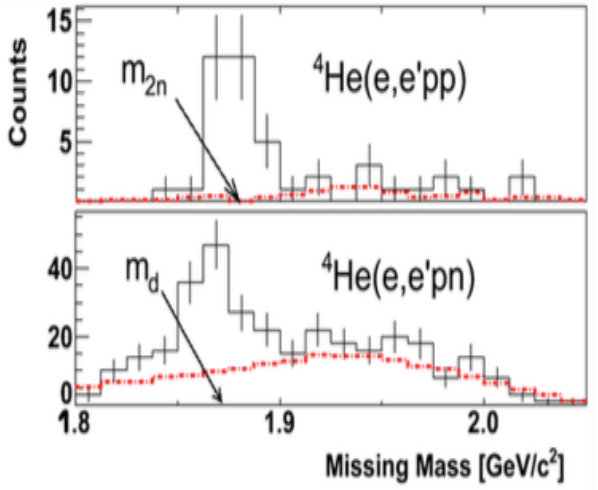


R. Subedi et al., Science 320 (2008) 1476





I. Korover et al., PRL 113 (2014) 022501



A. Tang *et al.*, PRL (2003); **E. Piasetzky *et al.*, PRL (2006);** **R. Shneor *et al.*, PRL (2007)**

But….. Very Low Statistics!

experiment	pp pairs	np pairs	nn pairs
EVA/BNL	-	18	-
E01-015/JLab	263	179	-
E07-006/JLab	50	223	-
CLAS/JLab	1533	-	-
Total	<2000	<450	0

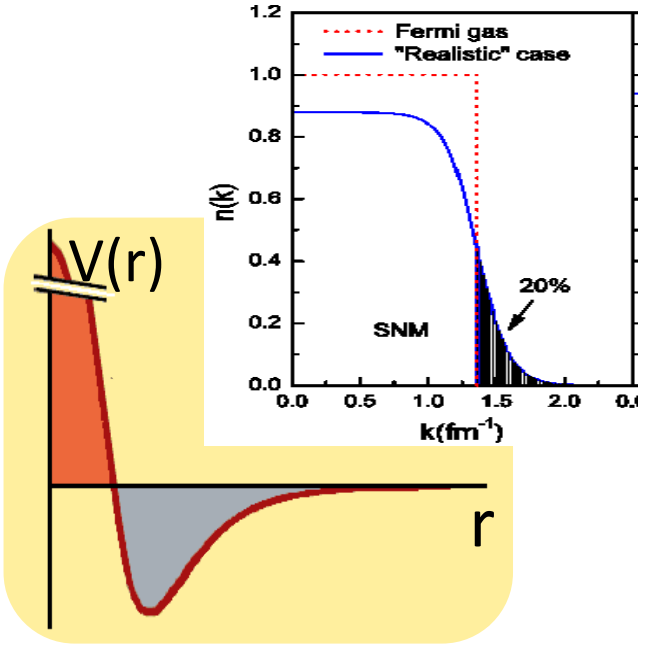
=> Need 1-2 orders of magnitude improvement to address next generation BIG questions

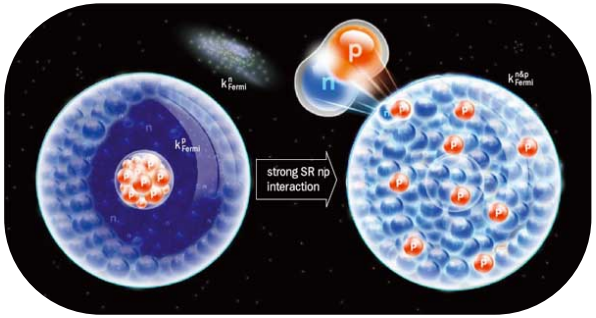
SRC@HADES: Physics Highlights

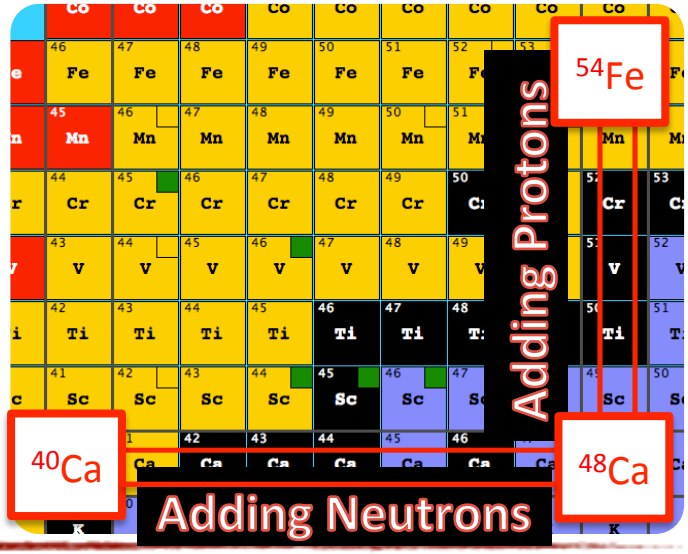
- Onset of SRC dominance.
  ('Migdal Jump' in nuclei)
- Repulsive core of NN interaction.
  (Transition from np-dominance)
- SRCs in asymmetric nuclei.
  (number of pairs and c.m. motion in nuclei)
- 3N-SRC.

+ FAIR feasibility

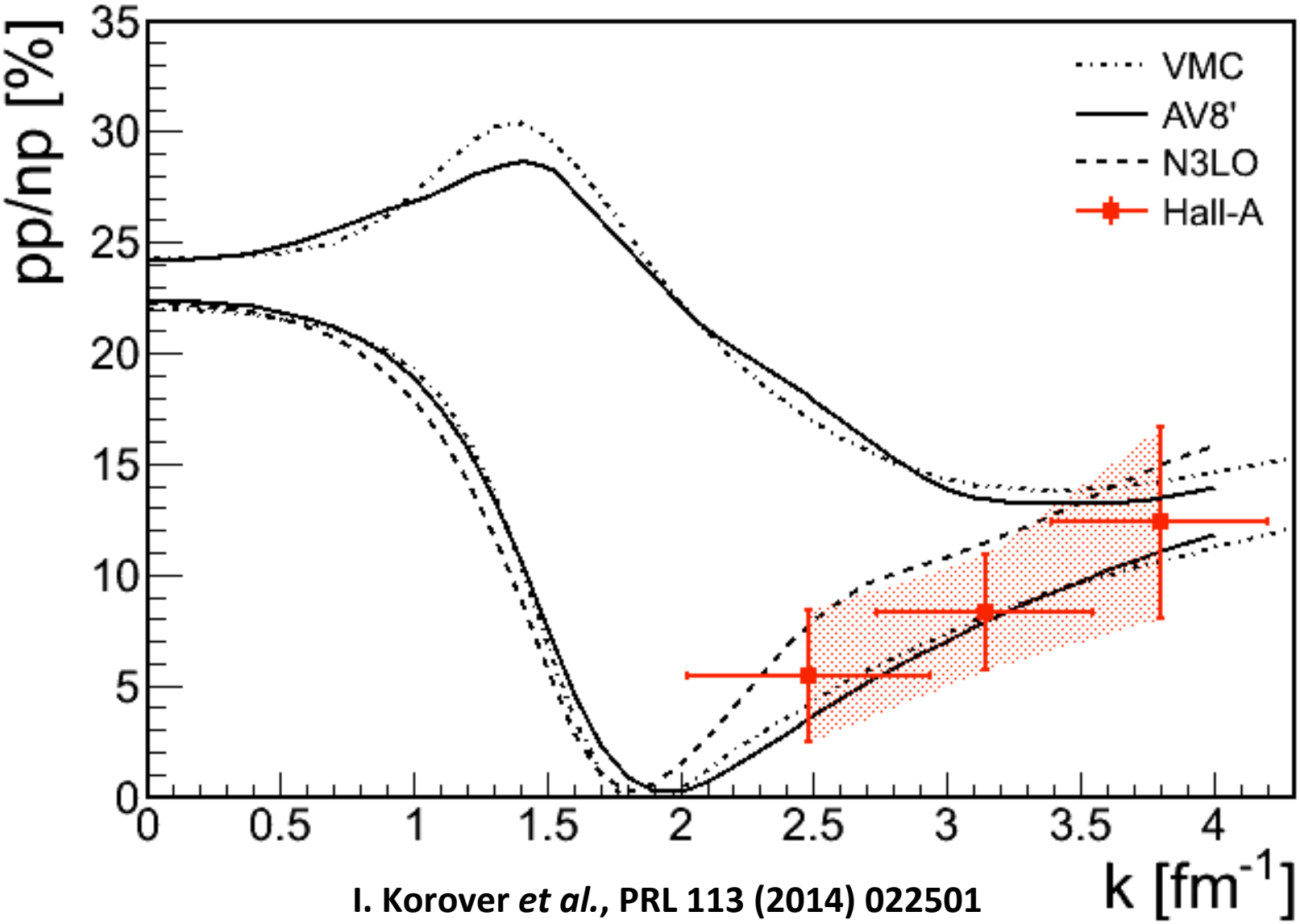
(inverse kinematics)







Tensor Dominance

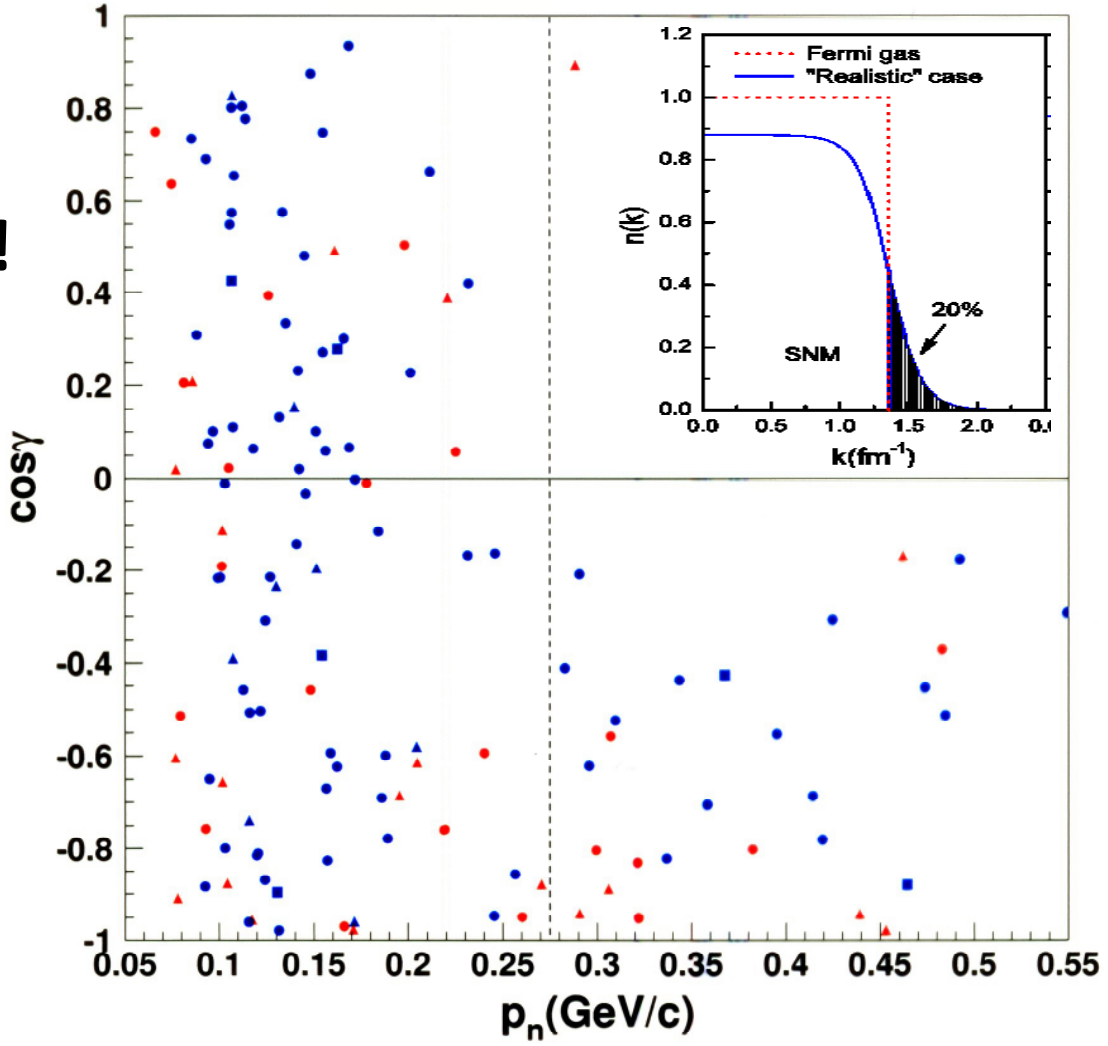


I. Korover *et al.*, PRL 113 (2014) 022501

Example: Migdal Jump

- Migdal Jump: transition between mean-field to SRC dominated region.
- **Never observed before!**
- BNL observed clear onset of back-to-back pairs dominance at high recoil momentum.
- But…. Inconclusive (~30 Events).

How will it look with ~10k events?



A. Tang *et al.*, PRL 90, 042301 (2003)
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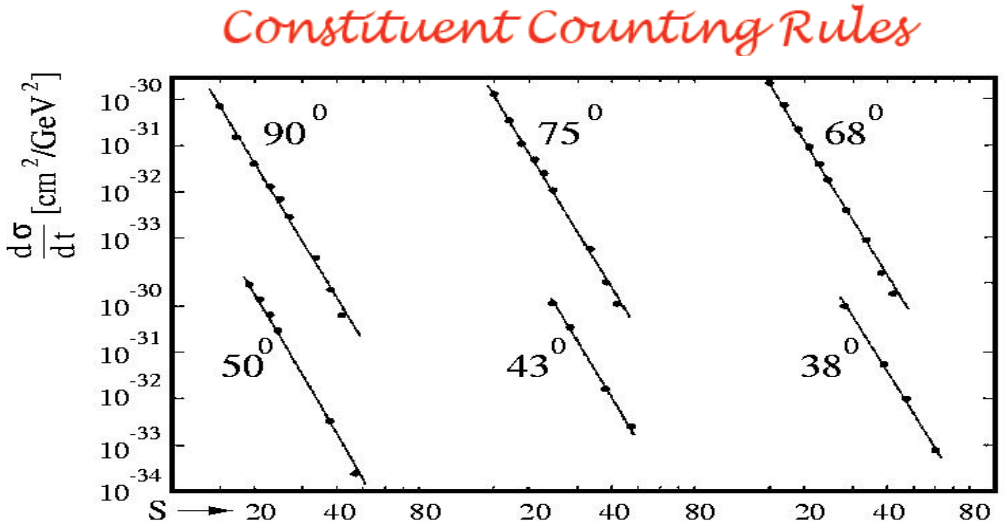
Proton beam advantage:

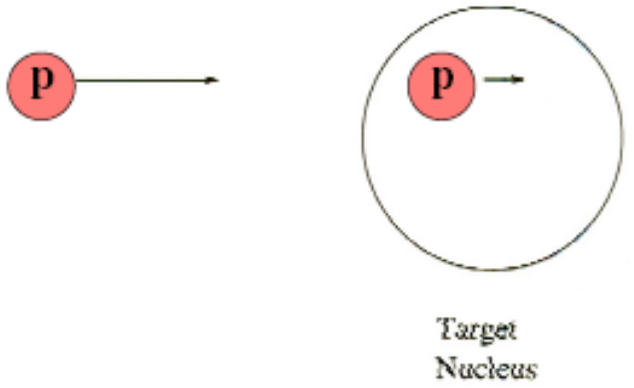
Selective Attention!

pp → pp elastic scattering near 90^0 c.m:

$$\frac{d\sigma}{dt} \propto s^{-10}$$



Incident proton prefers to interact with forward going high momentum nuclear protons



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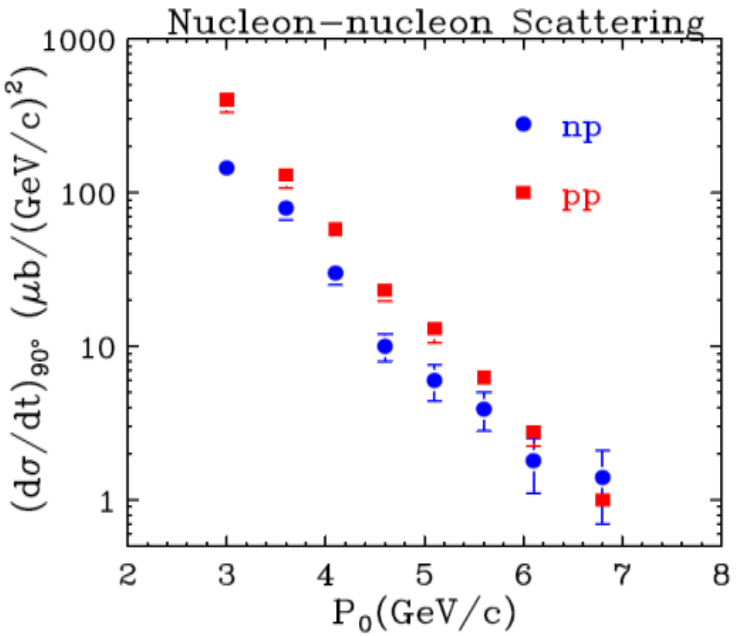
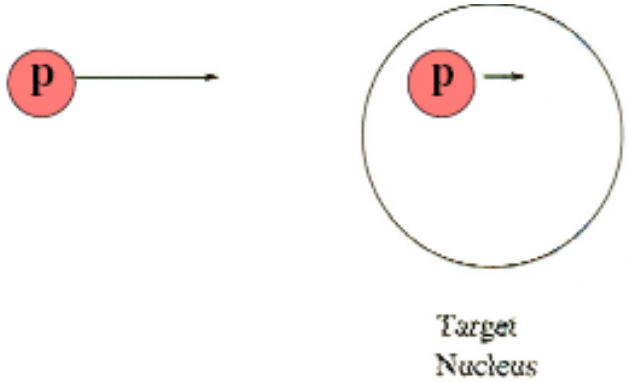


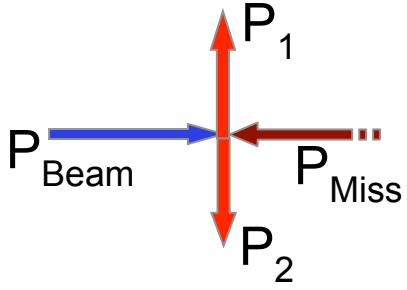
Lower energy increase the cross-section and the sensitivity to SRC via s weighting. But… **need to keep a hard process (s,t,u > 2 GeV²)**.



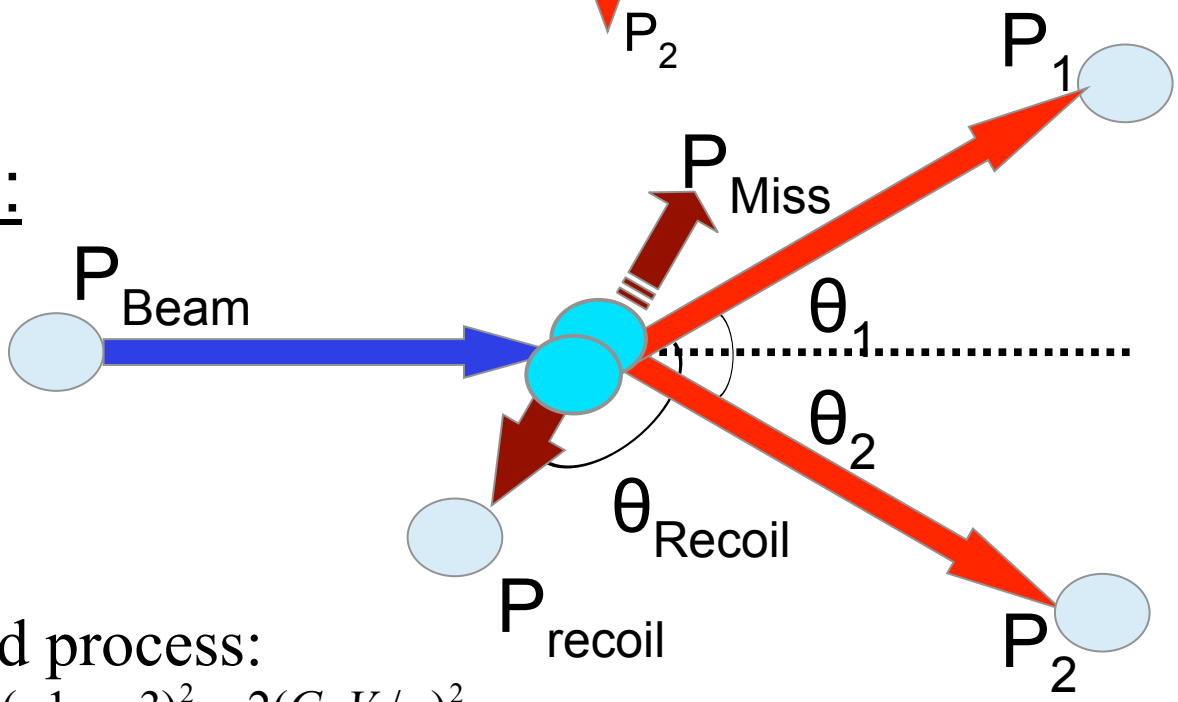
3.5 – 5 GeV beams are ideal!

SRC Kinematics

C.M. Frame (80°~90° scattering):



Lab Frame:



- SRC dominance:

$$|p_{recoil}| \geq 250 MeV/c$$

$$\theta_{recoil} \geq 90^0$$

- Hard process:

$$-t = -(p1 - p3)^2 > 2(GeV/c)^2$$

$$-u = -(p1 - p2)^2 > 2(GeV/.c)^2$$

$$s > 7(GeV/c)^2$$

$$\theta_1 = 27.5^0 \pm 7.5^0, \theta_2 = -27.5^0 \pm 7.5^0 \ (\vartheta_{cm} \approx 90^0)$$

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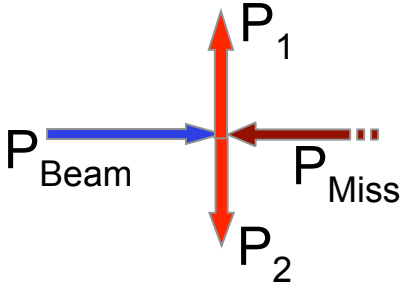

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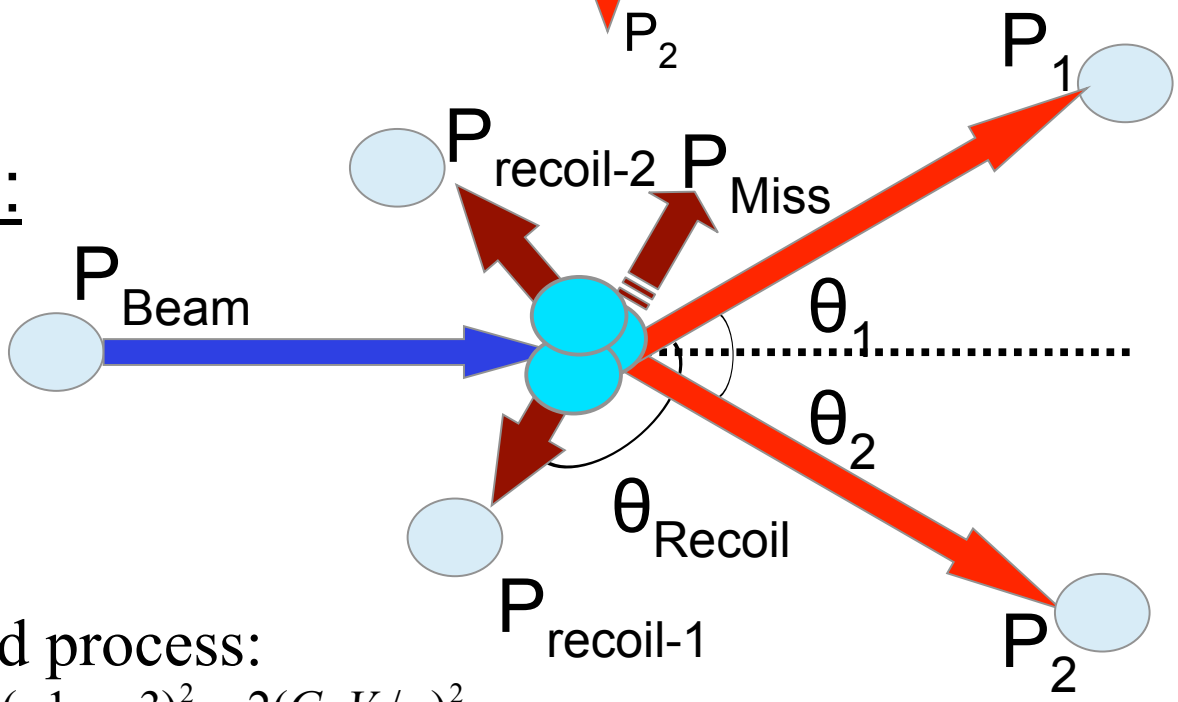

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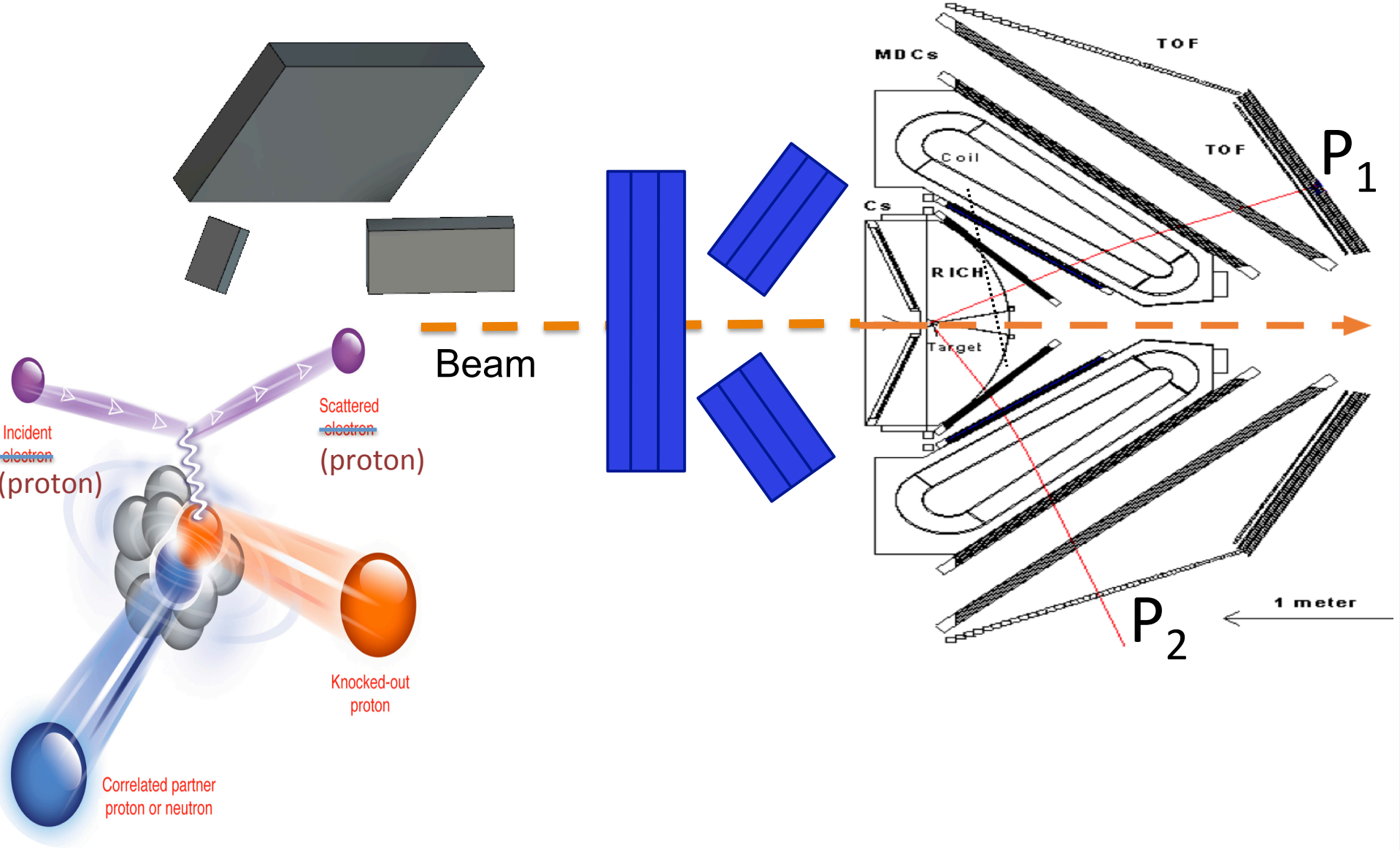
Experimental Setup



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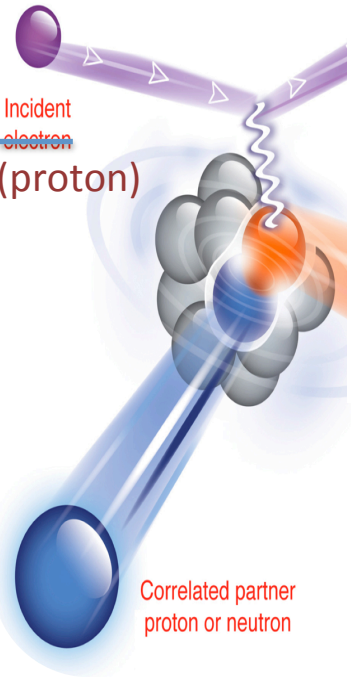
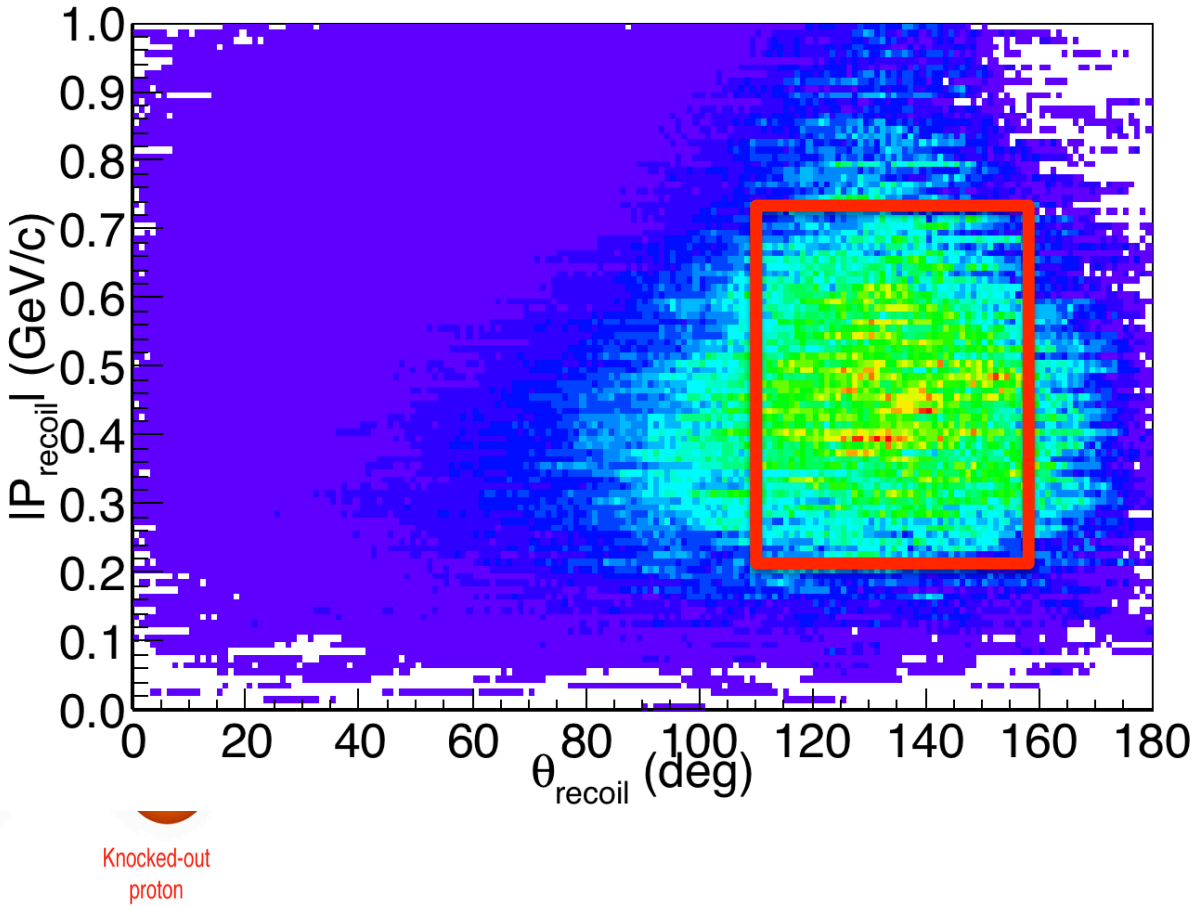
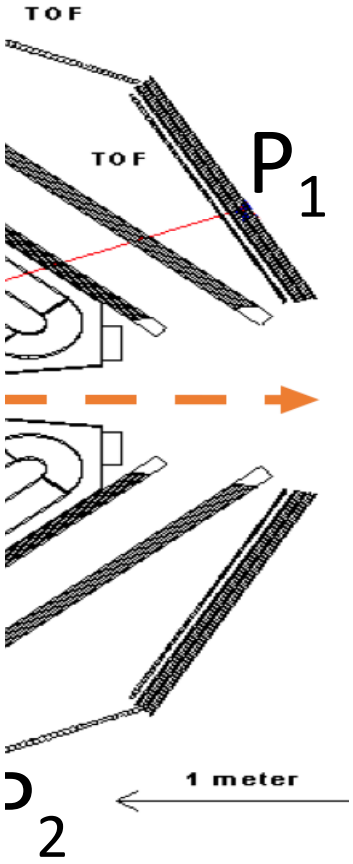






Experimental Setup

$\Delta\Omega \approx 20\%$

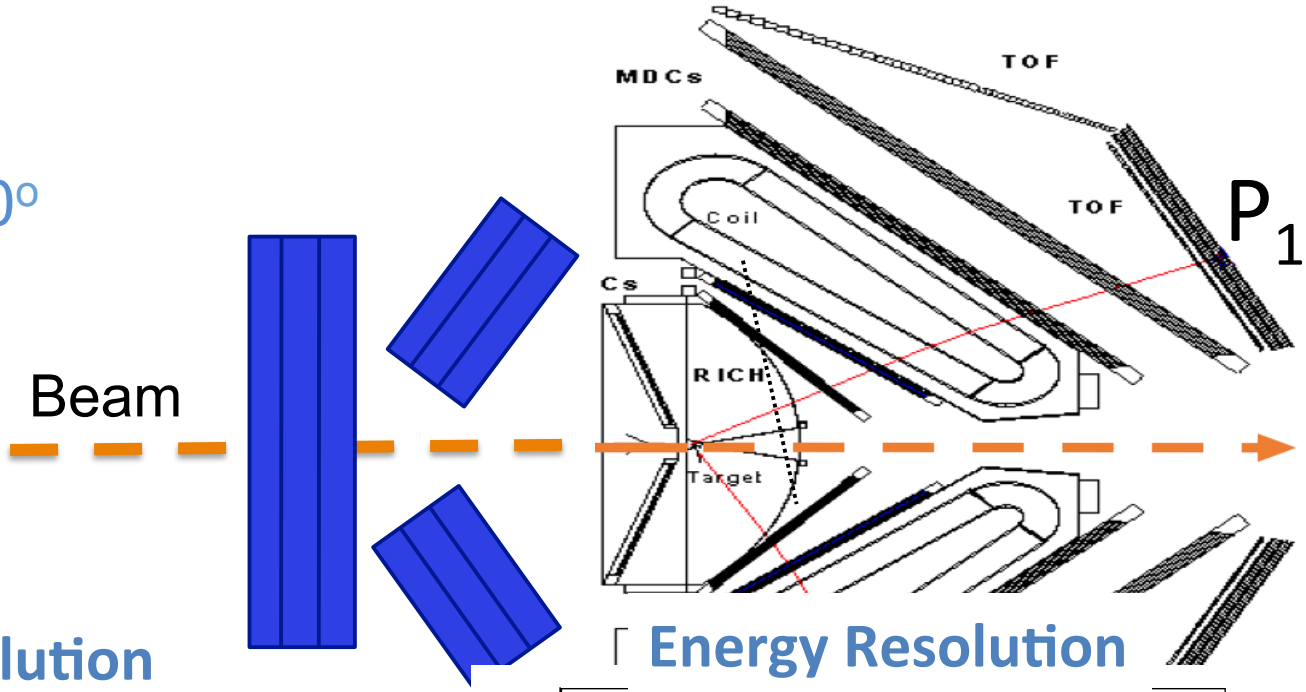
$\varepsilon \approx 30\text{-}50\%$

$110^{o} \le \theta_{recoil} \le 160^{o}$

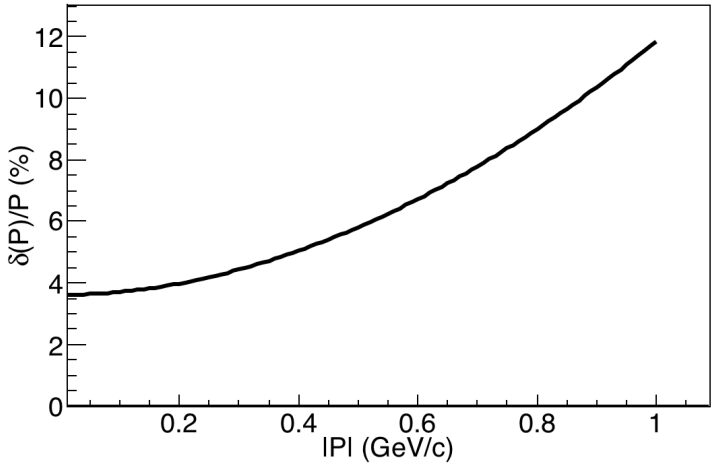
d=2.0 m

$\delta(d)=7.5$ cm

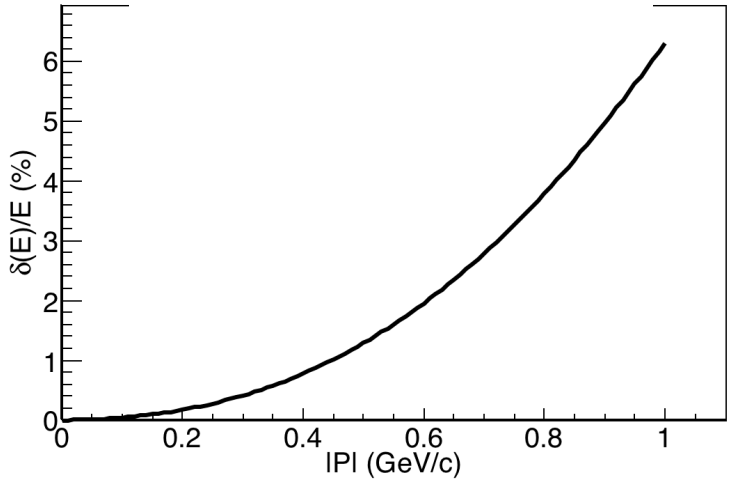
$\sigma_{TOF} \sim 400$ ps



Momentum Resolution



Energy Resolution



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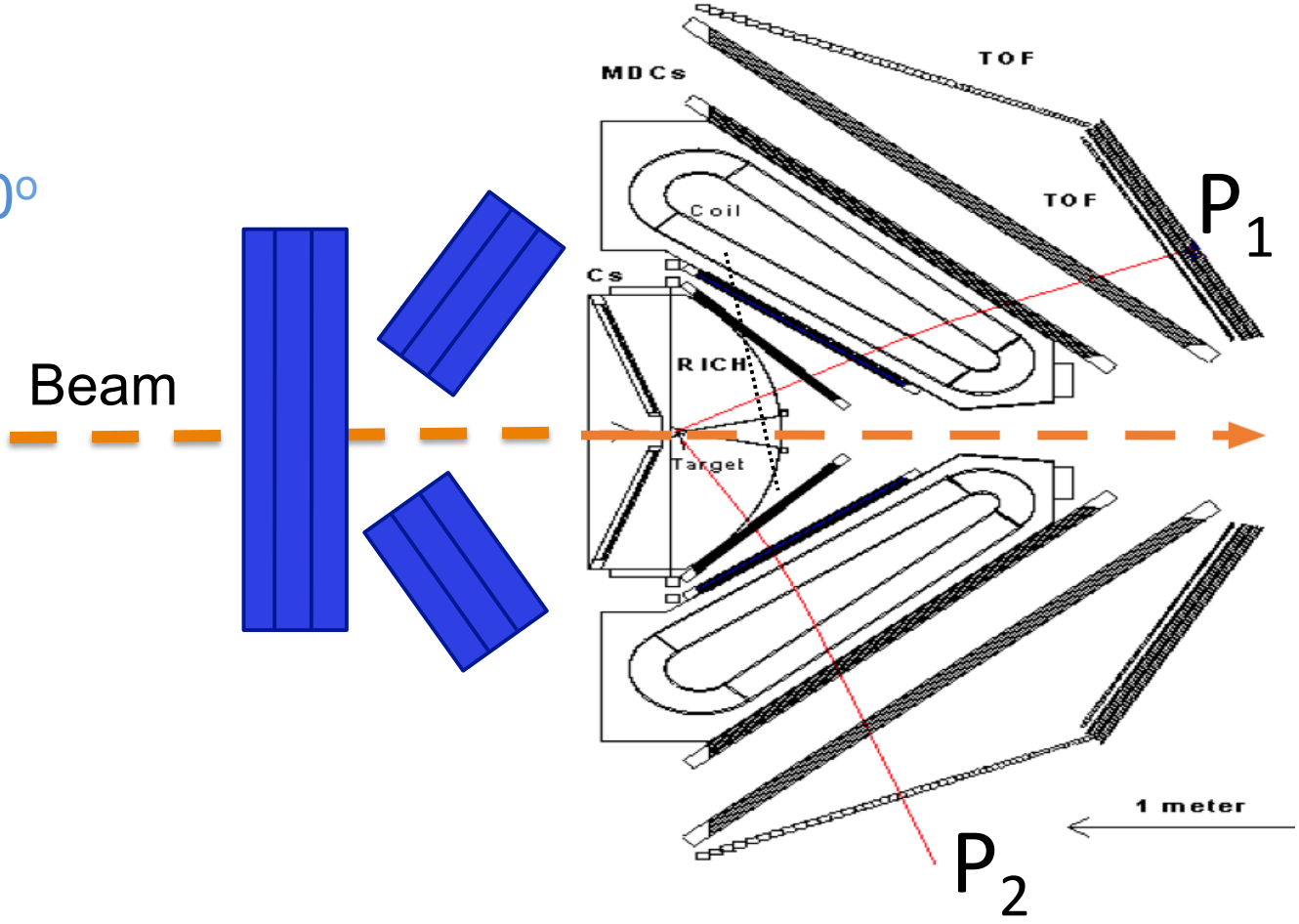
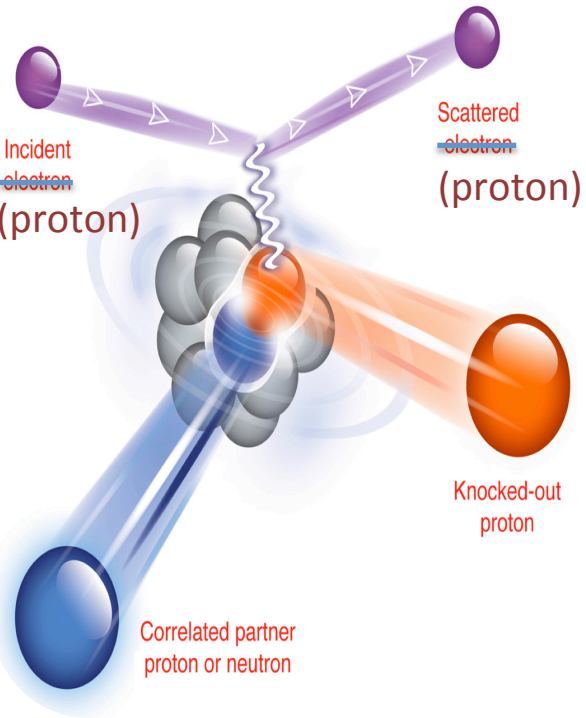
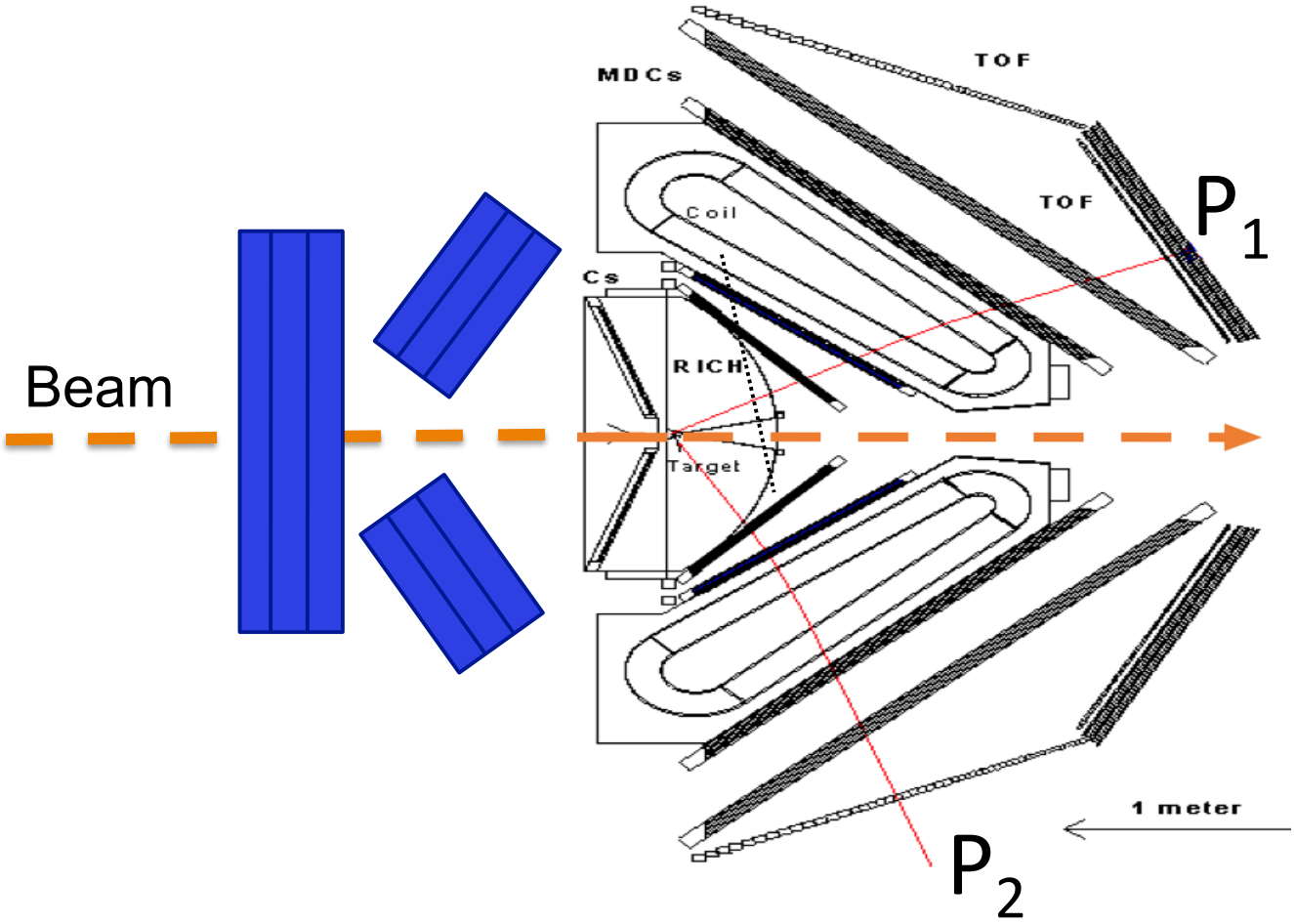


Targets:

- Multi-foil like HADES did in the past
- Prefer to 'split' the foils to different nuclei, e.g. C, Ca, Nb, …

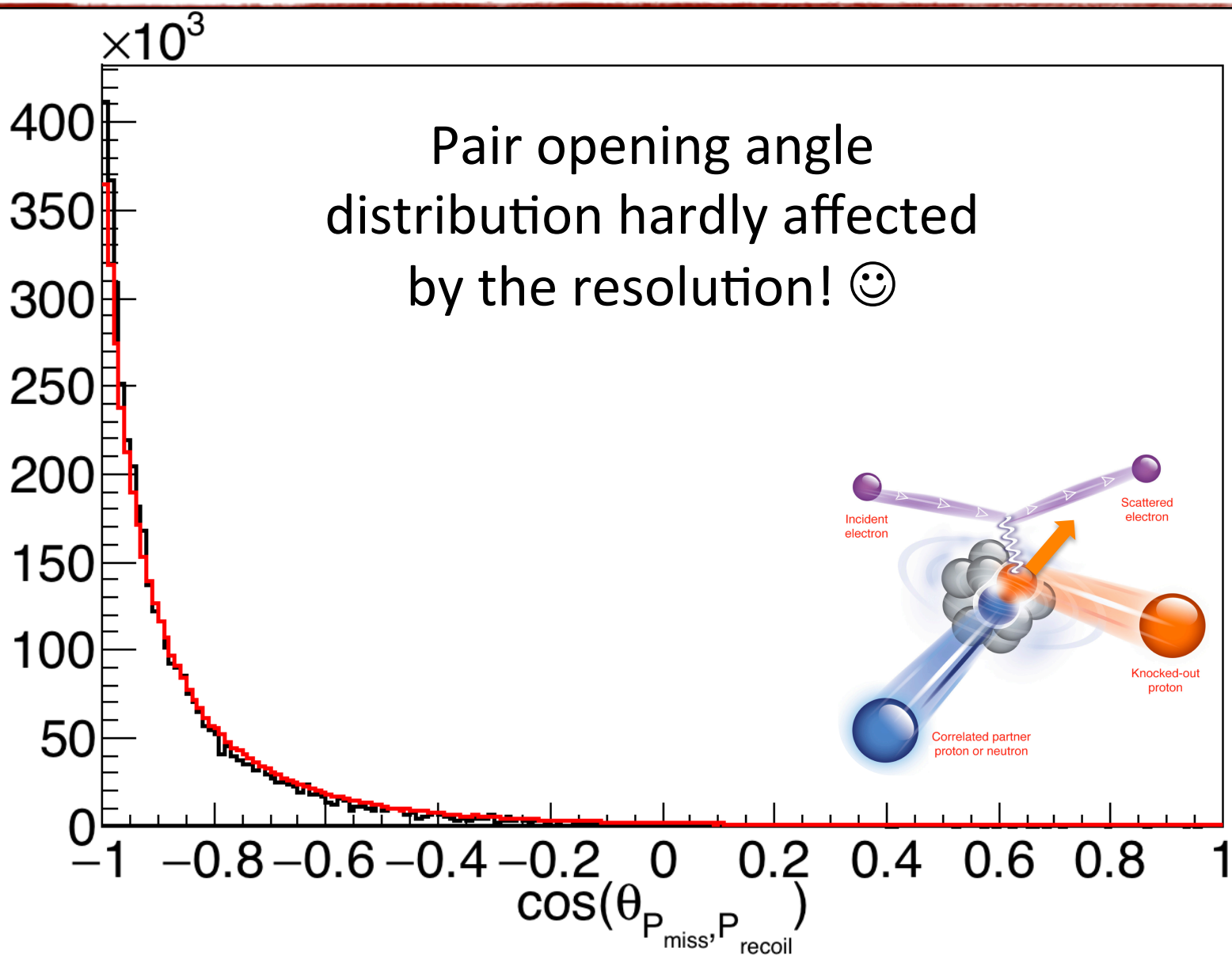
Experimental Setup





Add a Si (or Diamond) detector into the beam pipe to measure protons (ppp)

Observables: Pair Opening Angle



Pair opening angle distribution hardly affected by the resolution! ☺

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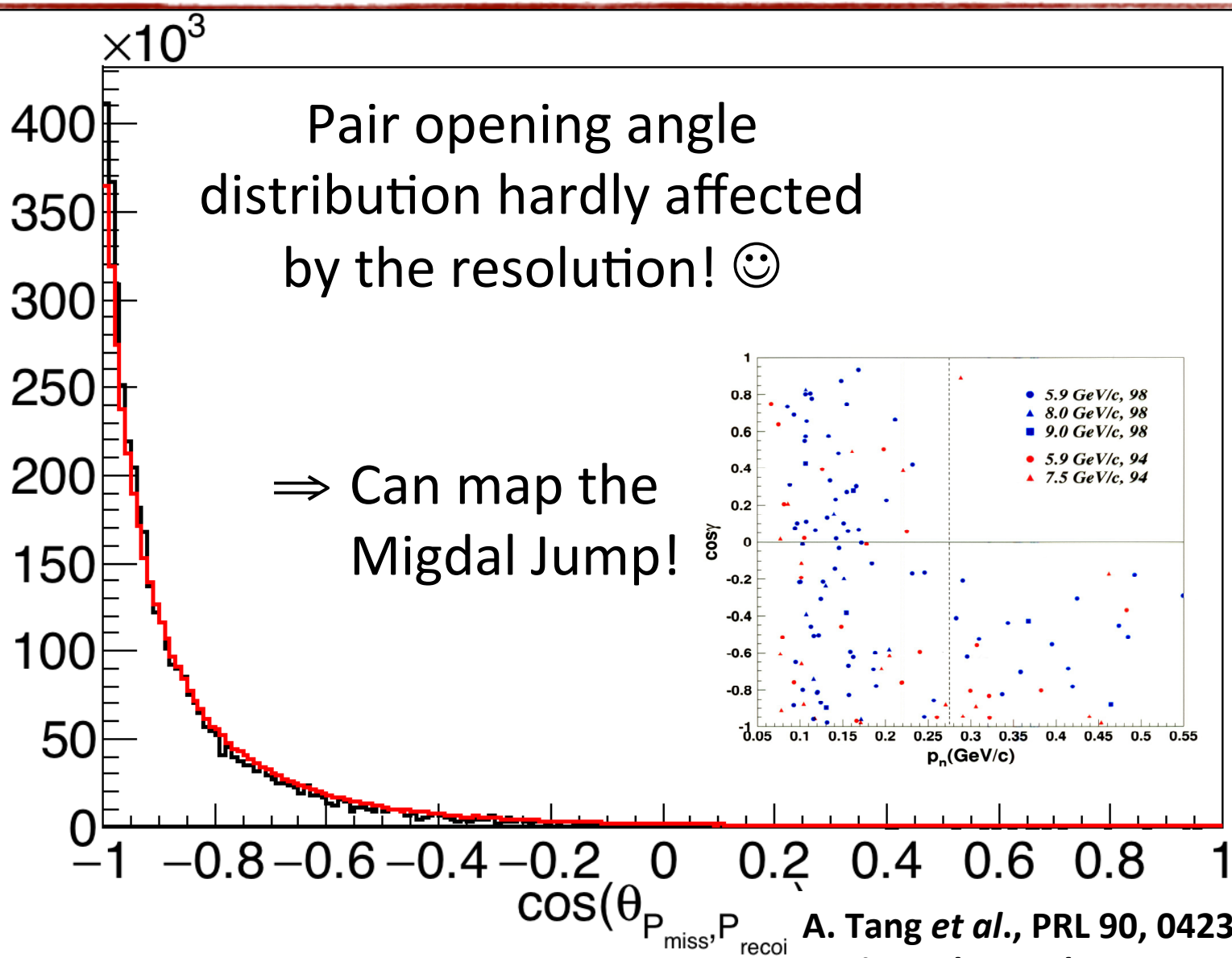

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⇒ Can map the Migdal Jump!

A. Tang *et al.*, PRL 90, 042301 (2003)
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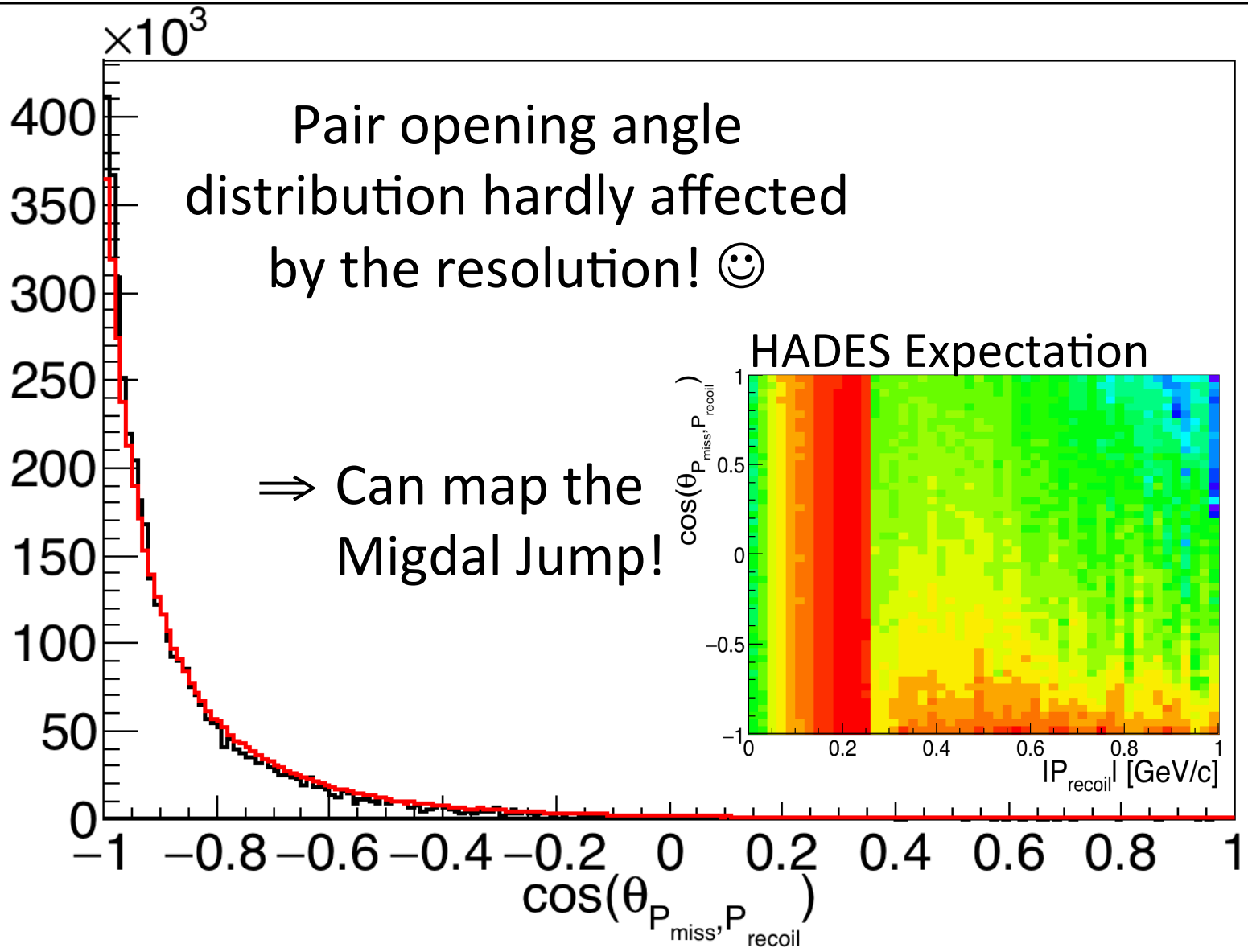

Rate Estimate: 4 GeV (p,2pN)

Rates (4 GeV, 5×10^7 protons/sec beam):

np pairs Triple coincidence $^{12}C(p,2pn)$

~150 events/hour

=> 30 days (50% beam availability) **50,000 events total**

pp pairs Triple coincidence $^{12}C(p,ppp)$

~60 events/hour

=> 30 days (50% beam availability) **20,000 events total**

Reminder – we want to run ~4 target nuclei so the rate per-target will be x4 less.

Thank You!

Questions and Discussion ?

SRC @

HADES