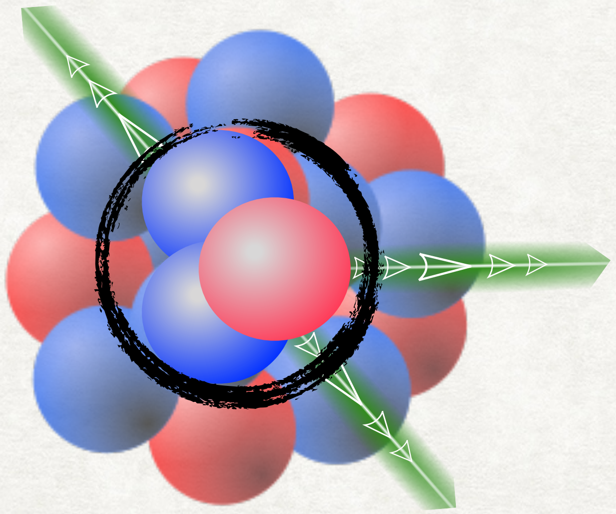
12/3/16

Search for multi-nucleon SRCs

Methods and Strategies



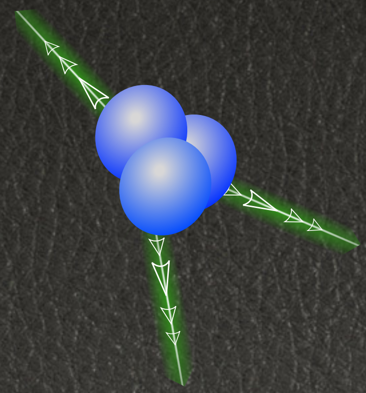
Erez. O. Cohen, M. Strikman

Tel Aviv University

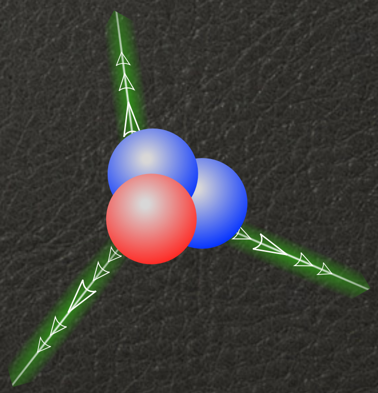
EG2 data-mining

Outline

- What are multi-nucleon SRC (e.g. 3N-SRC)
- Motivation.
- Search methods, Strategies and Issues.
- preliminary Results

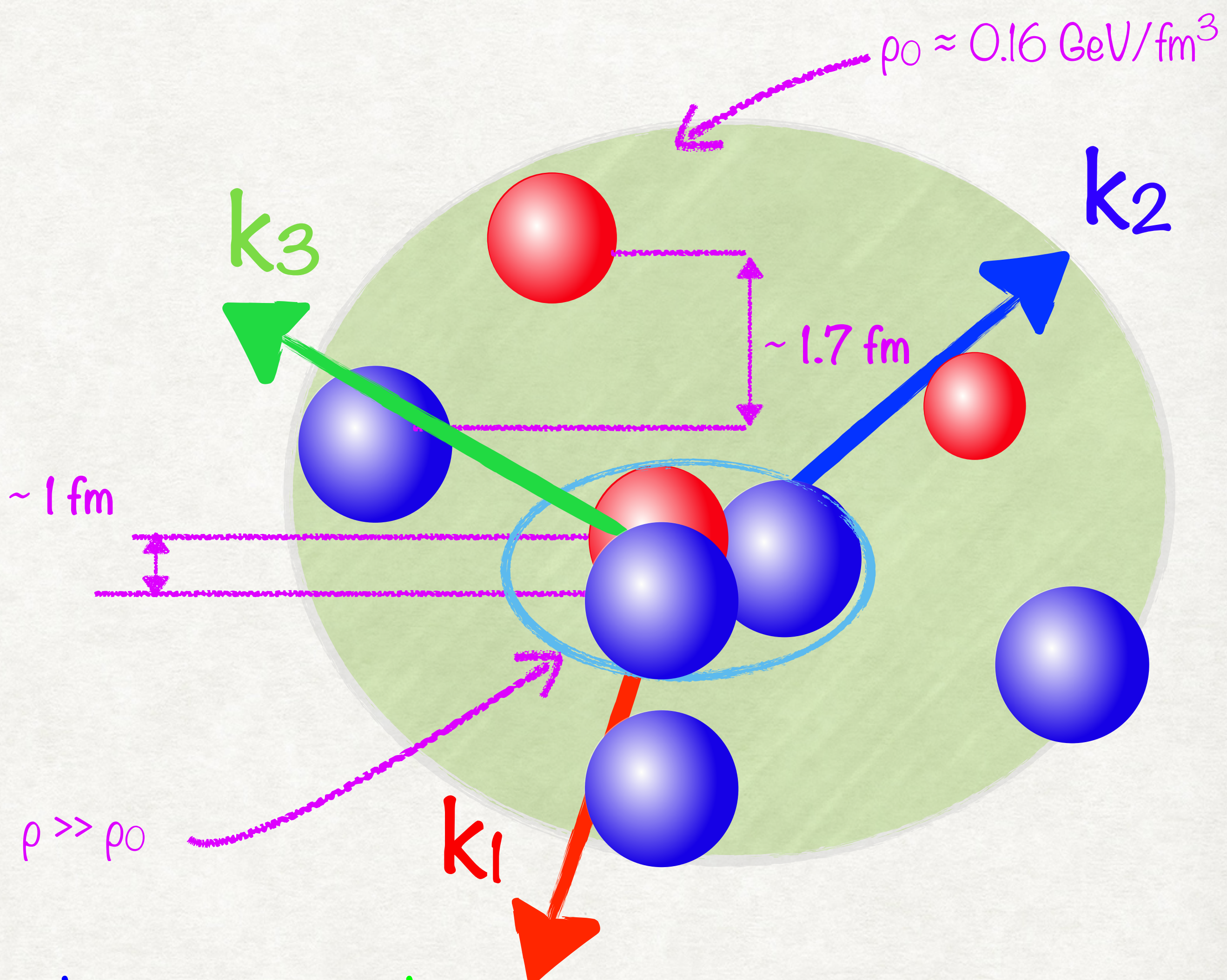


Introduction and Motivation



What are multi-nucleon SRCs ?

- Large individual momenta.
- Large relative momentum and small c.m. momentum (w.r.t Fermi momentum)

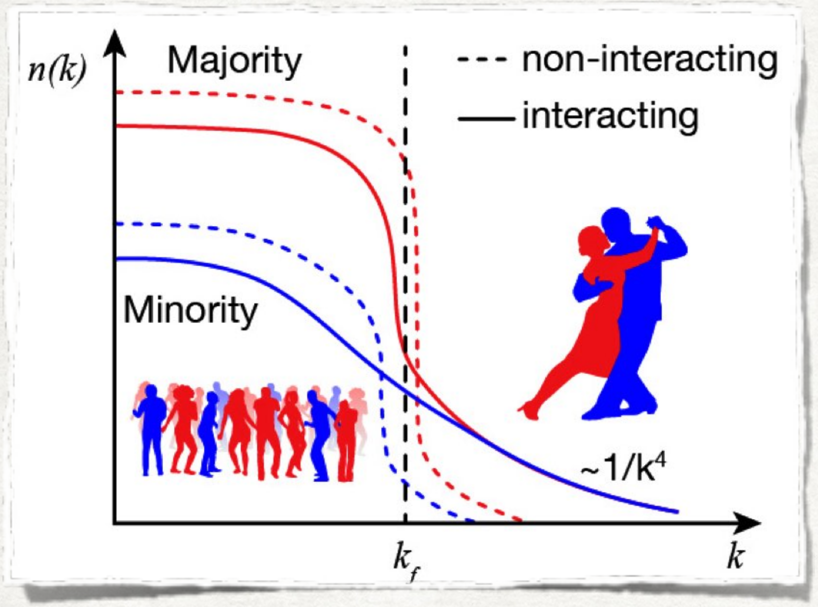


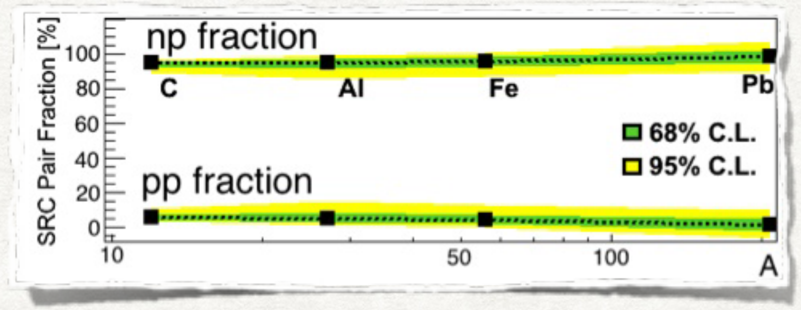
3N-SRC

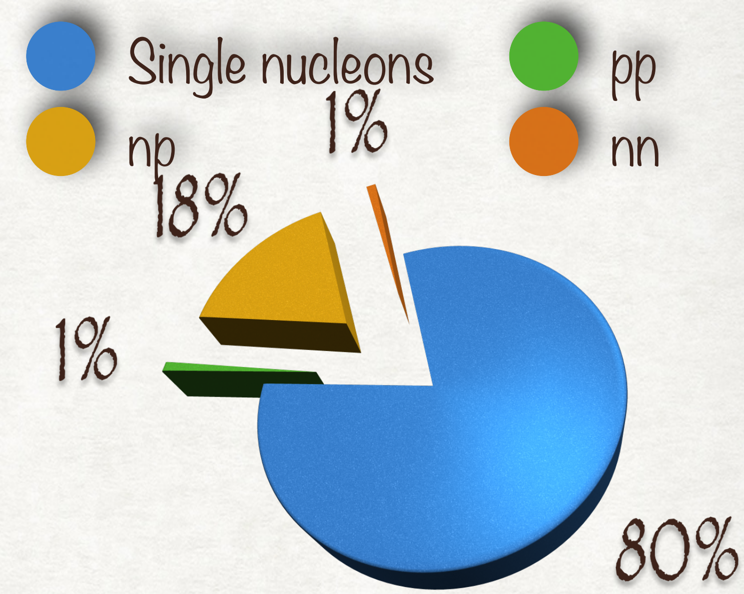
$$k(c.m.) = |\vec{k}_1 + \vec{k}_2 + \vec{k}_3| < k_F$$

$$|\vec{k}_1|, |\vec{k}_2|, |\vec{k}_3| > k_F$$

Motivation



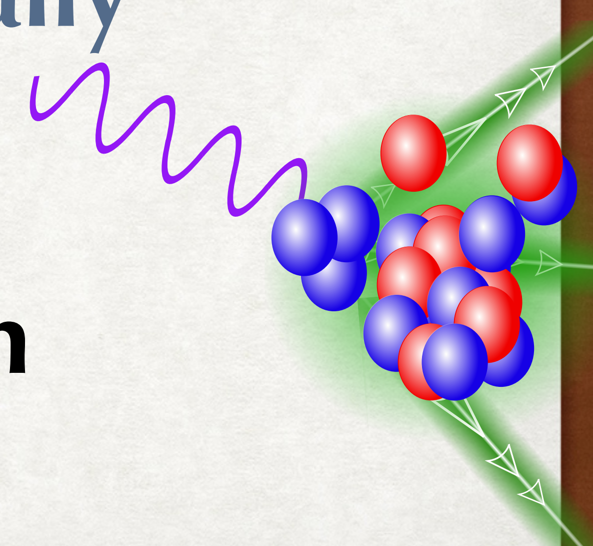




- Isospin and topological structure of 2N-SRC is known.

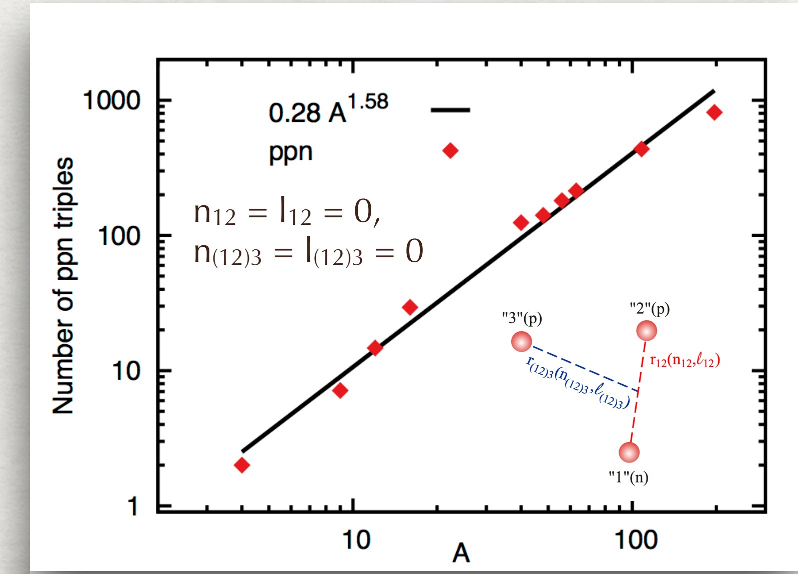
- Practically **nothing is known experimentally on multi-nucleon SRC**.

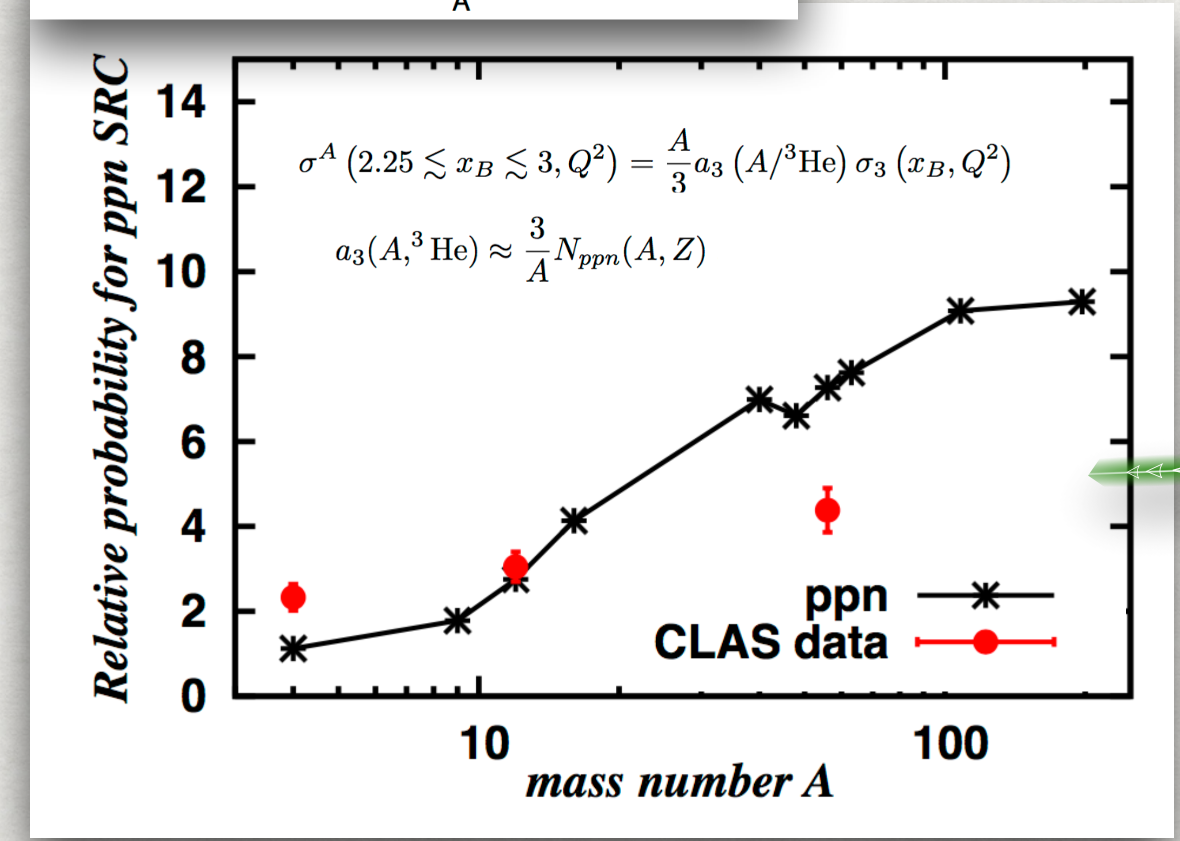
- **multi-nucleon SRC** are **more important in dense systems like n-stars**.

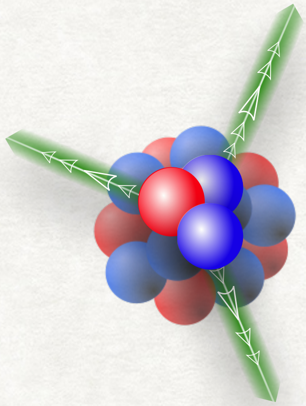


Theoretical predictions of 3N-SRC

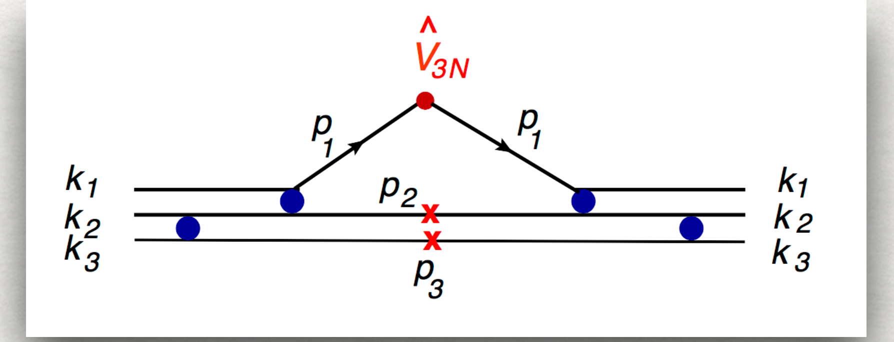
[Vanhalst, Ryckebusch ,Cosyn, PhysRevC.86.044619]

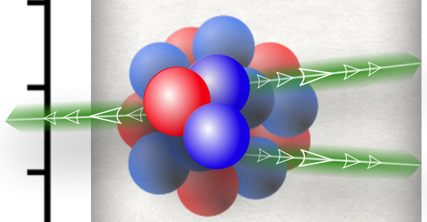




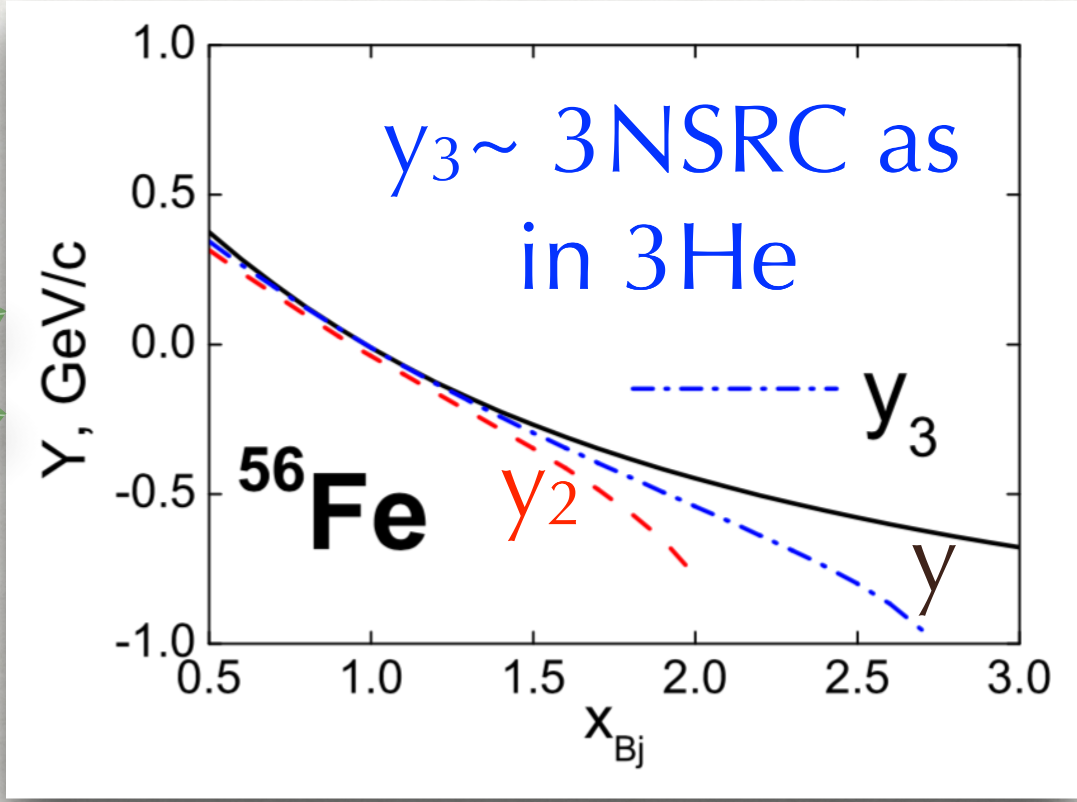


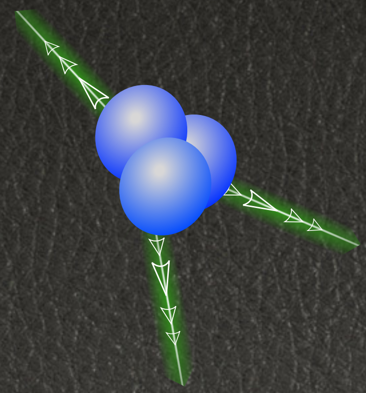
[Artiles ,Sargsian, arXiv:1606.00468v1]



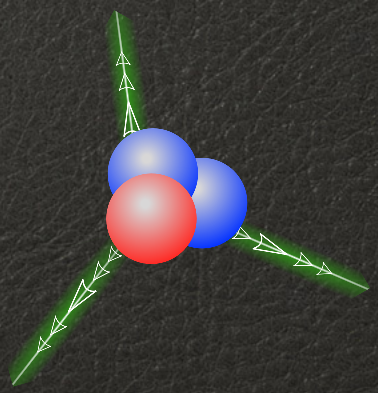


[C. B. Mezzetti, arXiv:1112.3185]





Search methods, Strategies and Issues

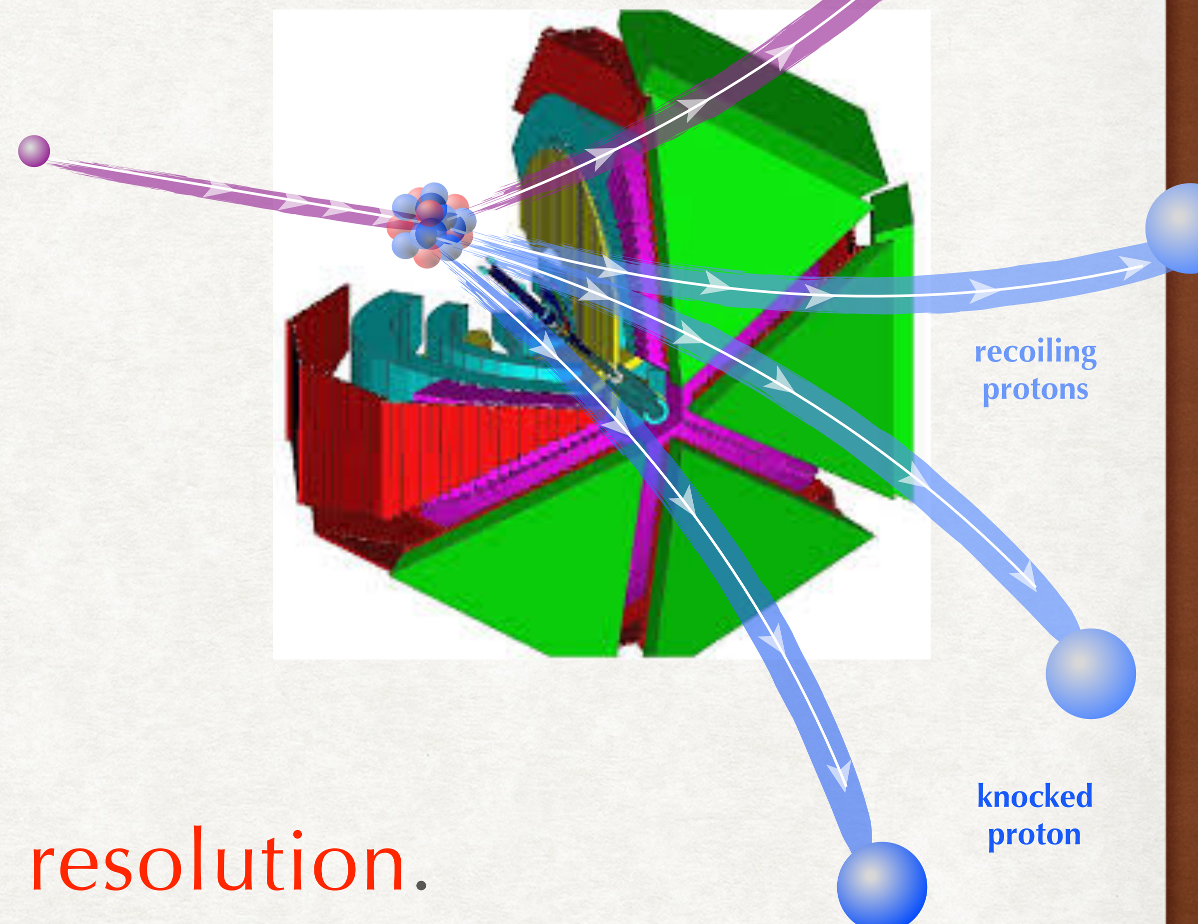


Search methods for 3N-SRC (fully exclusive)

EG2 data, within data mining initiative:

CLAS, Hall-B, JLAB (2004), 5 GeV e-beam

Target: ^{2}H + $^{12}C/^{27}Al/^{56}Fe/^{208}Pb$.

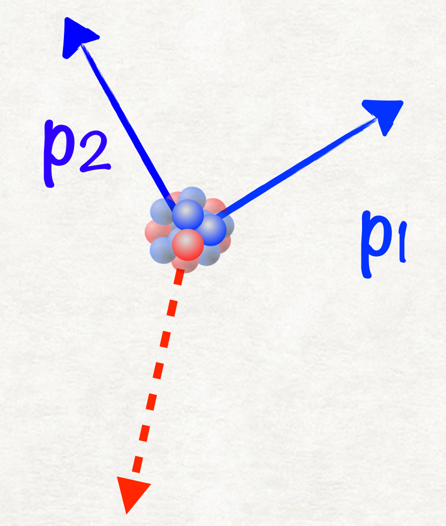


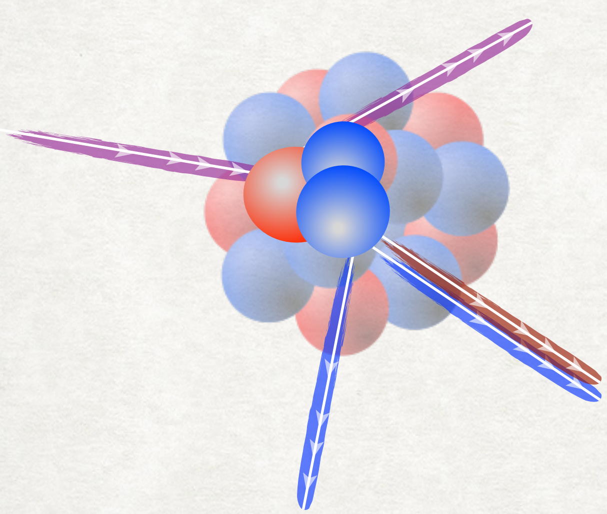
- **ppp-SRC** search in **(e,e′ppp)** data
  - proton-ID known, good resolutions.
  - poor statistics.

- **npp-SRC** search in **(e,e′npp)** data
  - neutron-ID (Meytal′ talk), and bad resolution.
  - Expected similar statistics to **ppp**-SRC: gain on #npp/#ppp ~ loss on efficiency and (e,e′n) cross-section

Search methods for 3N-SRC (triple coincidence)

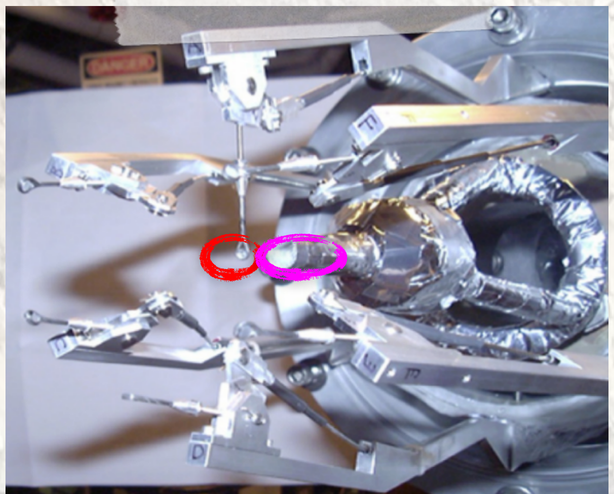
- **npp-SRC** detect **only two recoil protons**
  - Higher statistics.
  - Harder to discriminate competing channels.

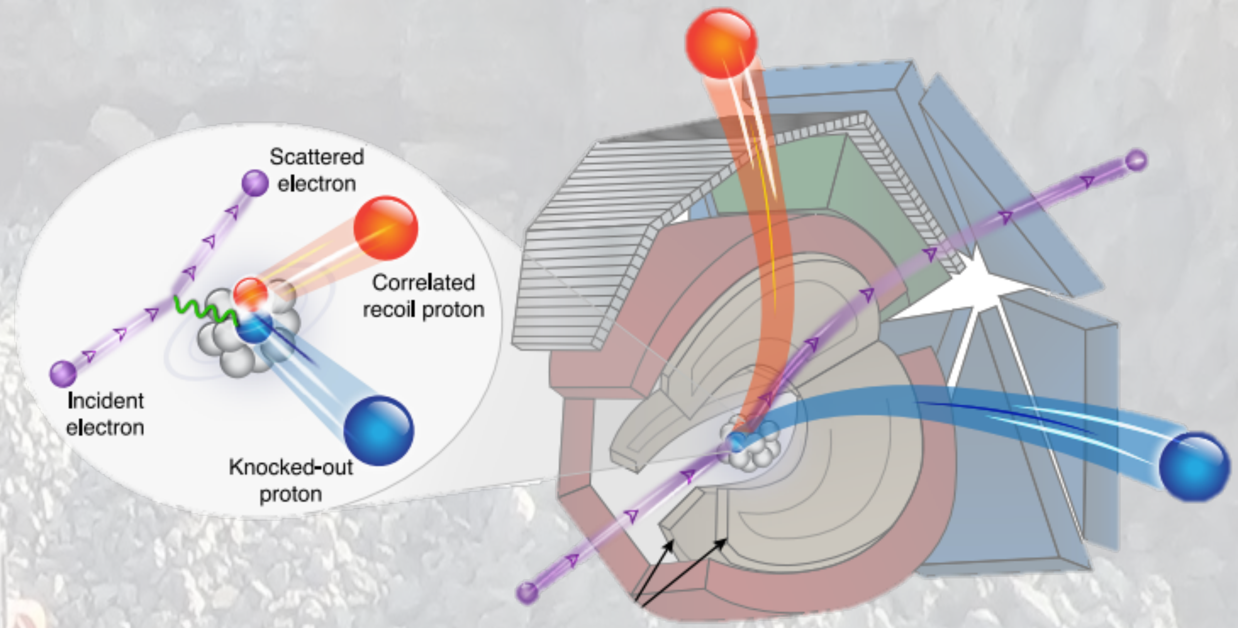




- **npp-SRC** search in **(e,e′dp) and (e,e′pd)** data

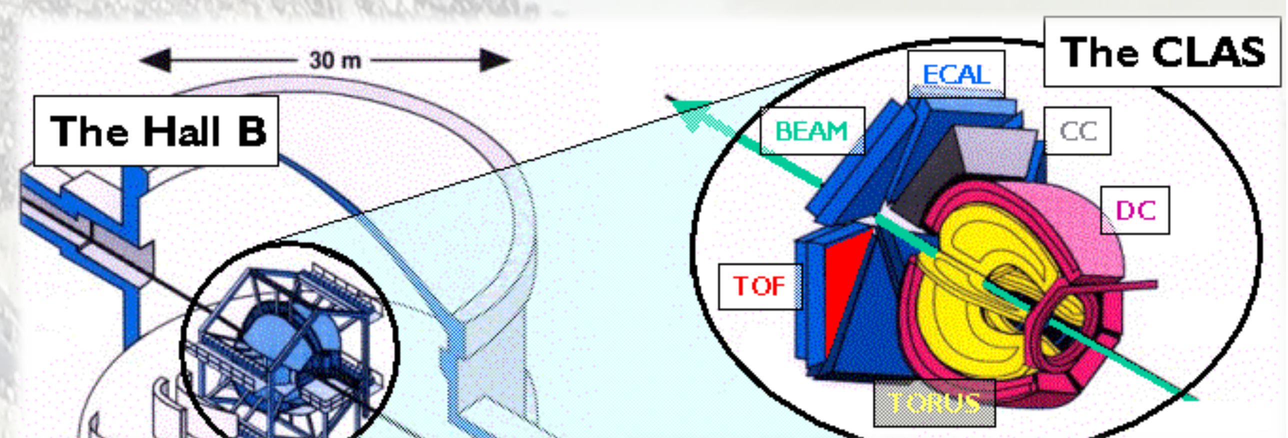
Re-Analyzing existing CLAS data via the data-mining initiative





- EG2 experiment.
- 2004 at Hall-B, JLAB.
- 5 GeV e-beam.
- Target - D + solid (simultaneously)

$^{2}H + ^{12}C/^{27}Al/^{56}Fe/^{208}Pb.$



Search methods for 3N-SRC (fully exclusive)

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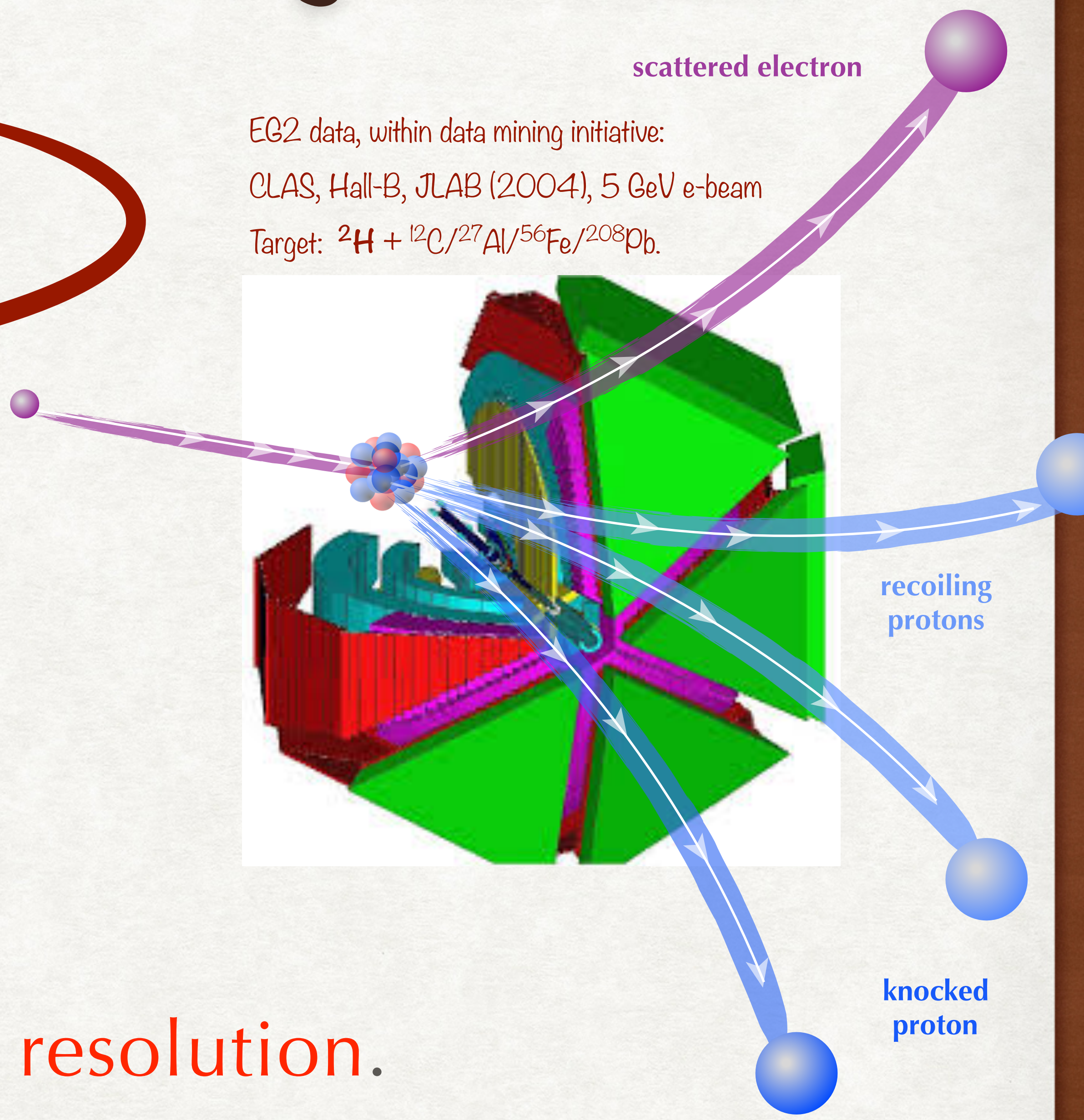
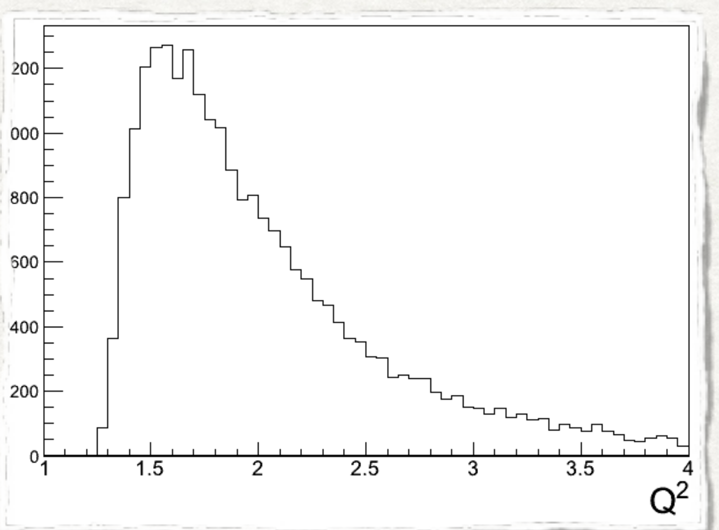


- **npp-SRC** search in **(e,e′npp)** data
  - neutron-ID (Meytal′ talk), and bad resolution.
  - Expected similar statistics - gain on #npp/#ppp ~ loss on efficiency and (e,e′n) cross-section

ppp-SRC events selection

(e,e'p) Kinematics

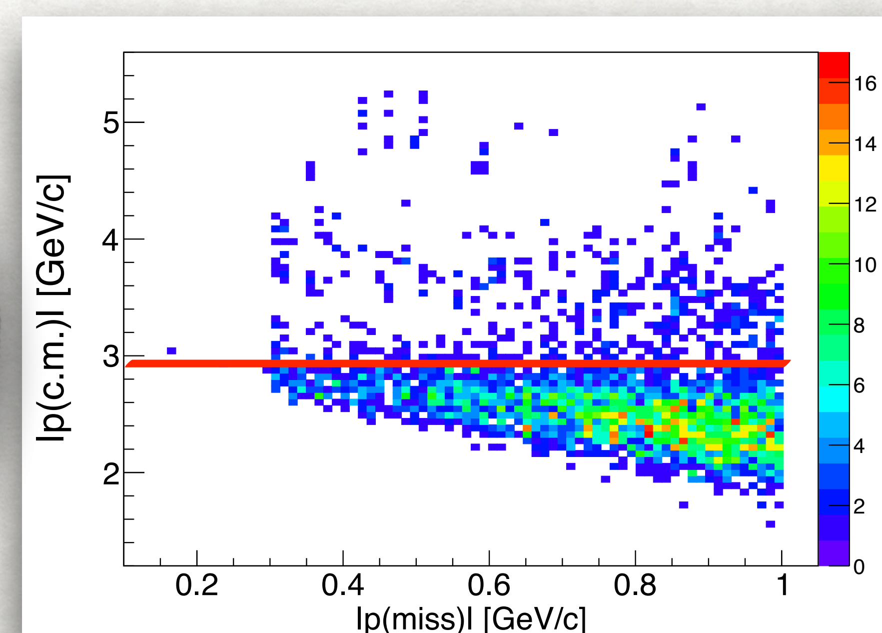
- $x_B > 1.2$
- $1 > |\mathbf{p}_{miss}| > 0.3$ GeV/c



(e,e'p) Leading proton

- $\theta_{pq} < 25^0$
- $0.62 < |\mathbf{p}|/|\mathbf{q}| < 0.96$

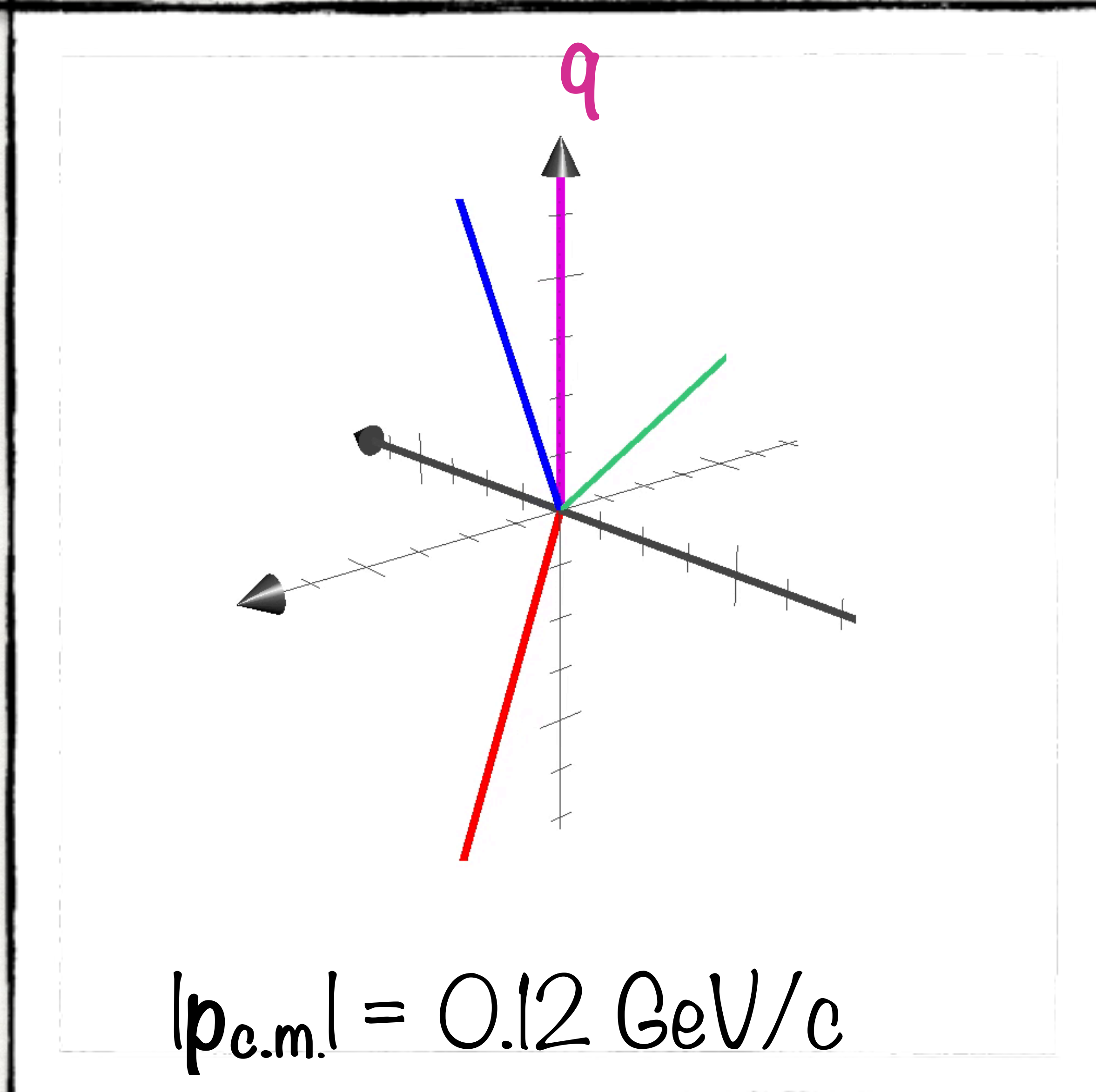
(e,e'ppp) : (e,e'p) events, in which two recoil protons were detected w/ momentum > 300 MeV/c, and $|p^{\mu}_{Lead} - q^{\mu} + p^{\mu}_{2} + p^{\mu}_{3}| \leq 3m_p$+150 MeV/c.



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

[PRL 108, 092502 (2012) , PRL 113, 022501 (2014)]

How do these events look?



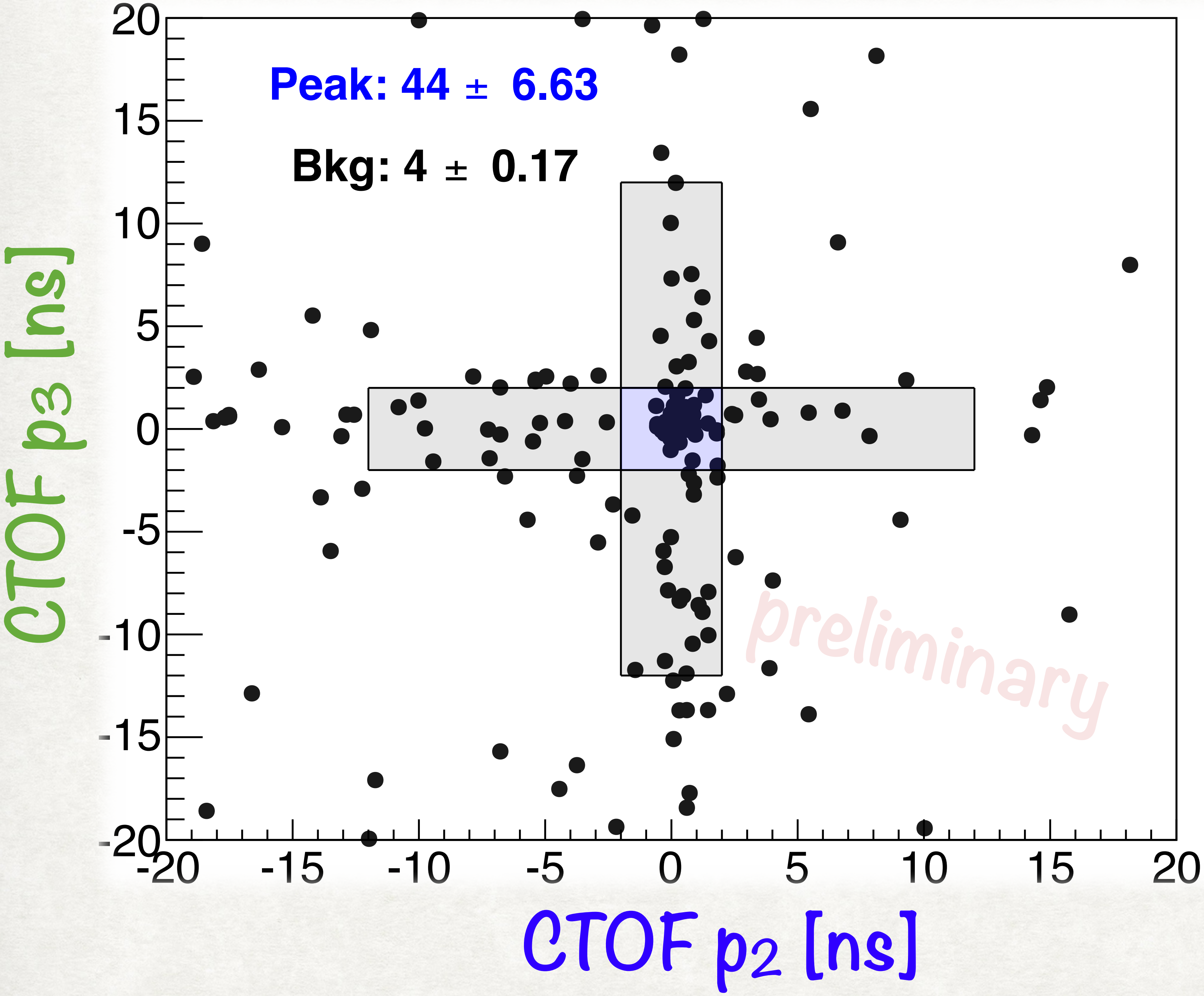
p_2 (0.55 GeV/c)

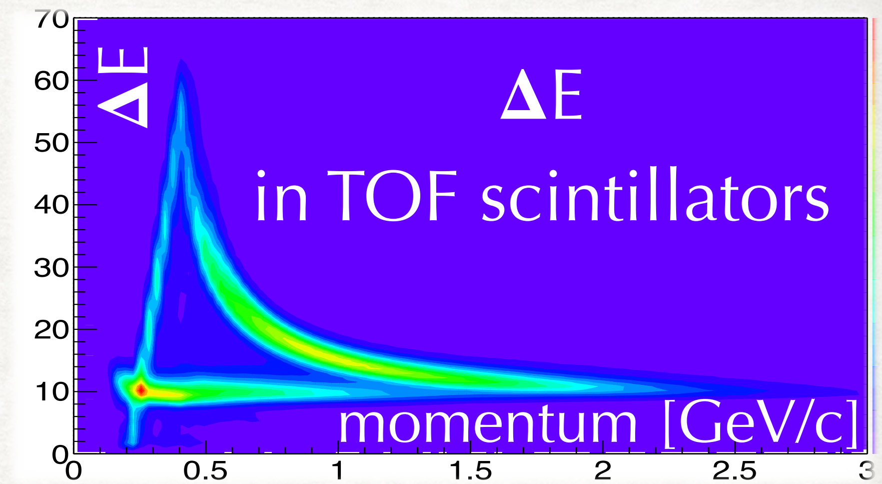
p_3 (0.47 GeV/c)

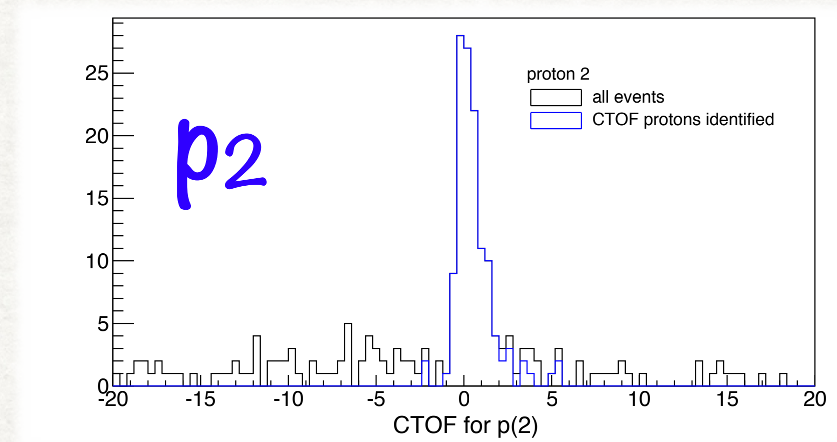
p_{miss} (0.88 GeV/c)

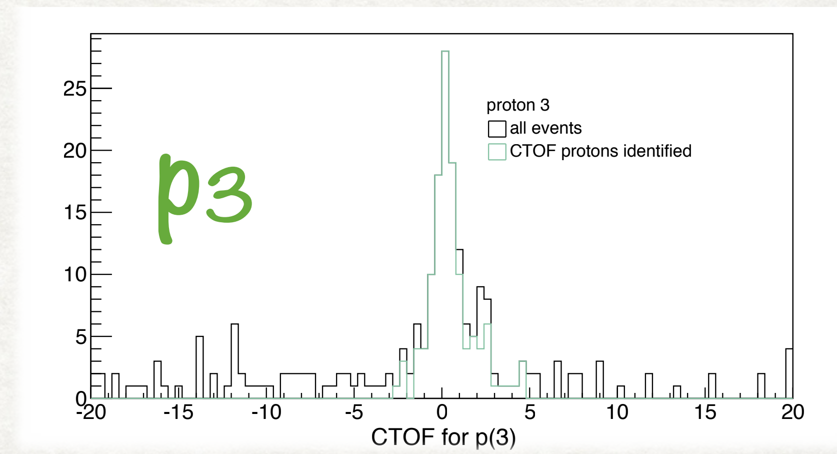
$$\vec{p}_{\text{miss}} = \vec{p}_{\text{lead}} - \vec{q}$$

Random coincidence (CTOF)



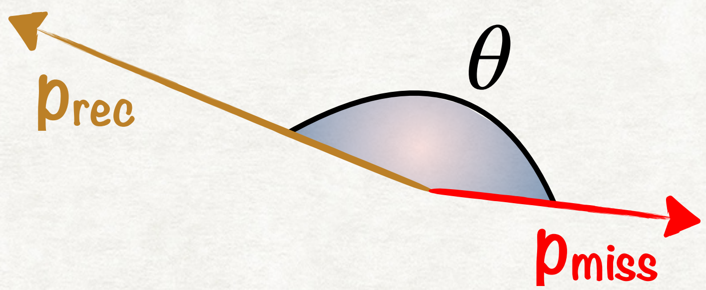


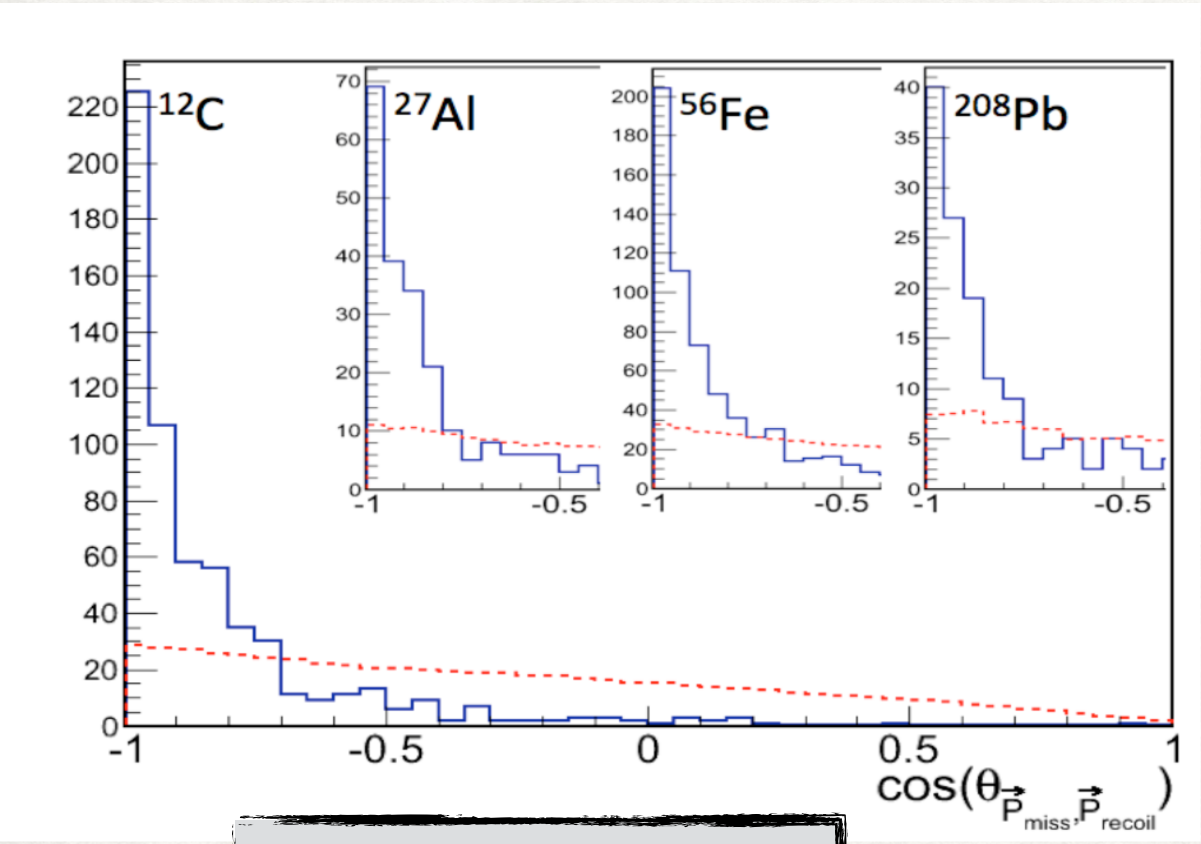




☞ **random coincidence background ~ 10%**

Opening angle





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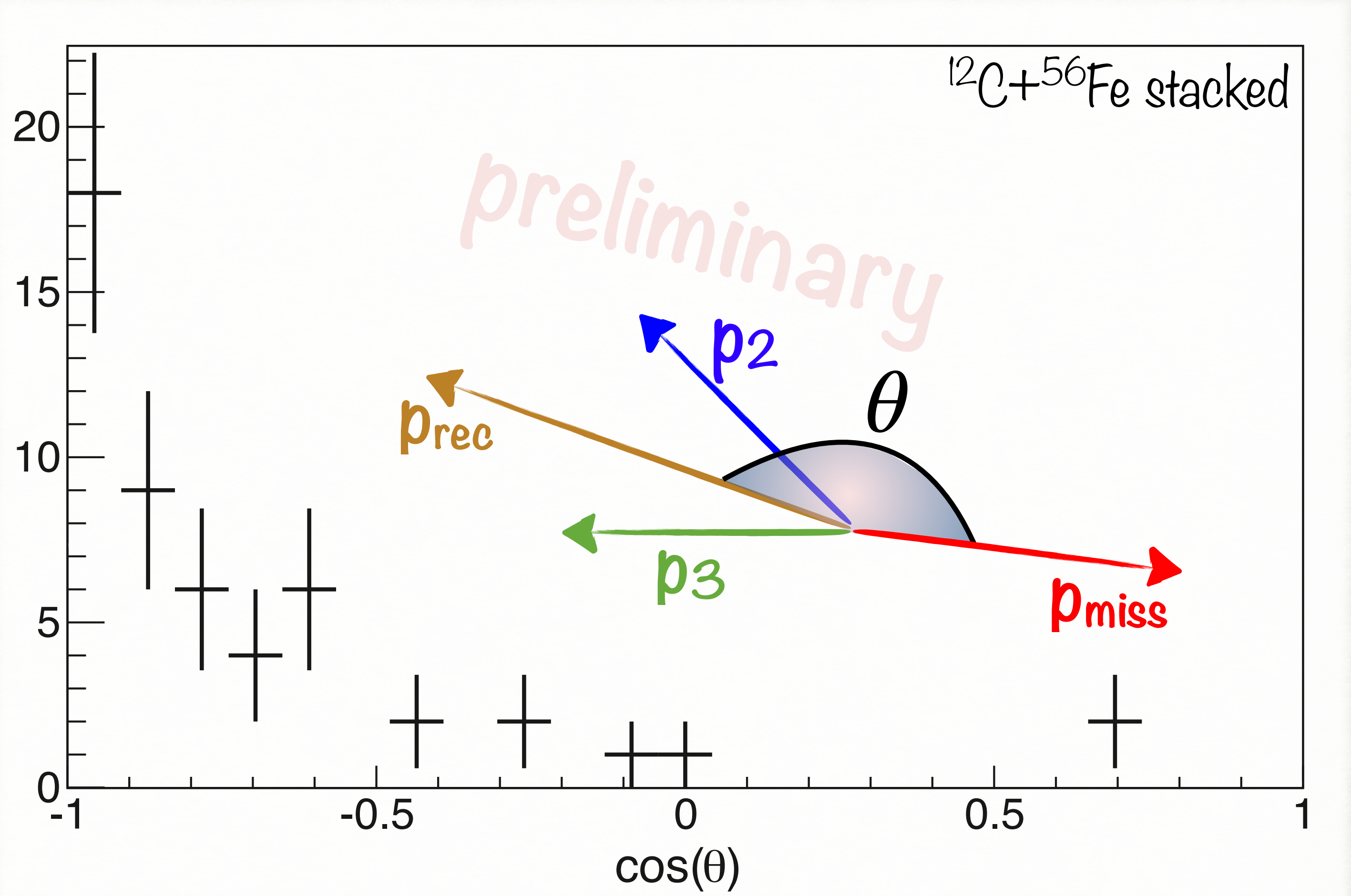
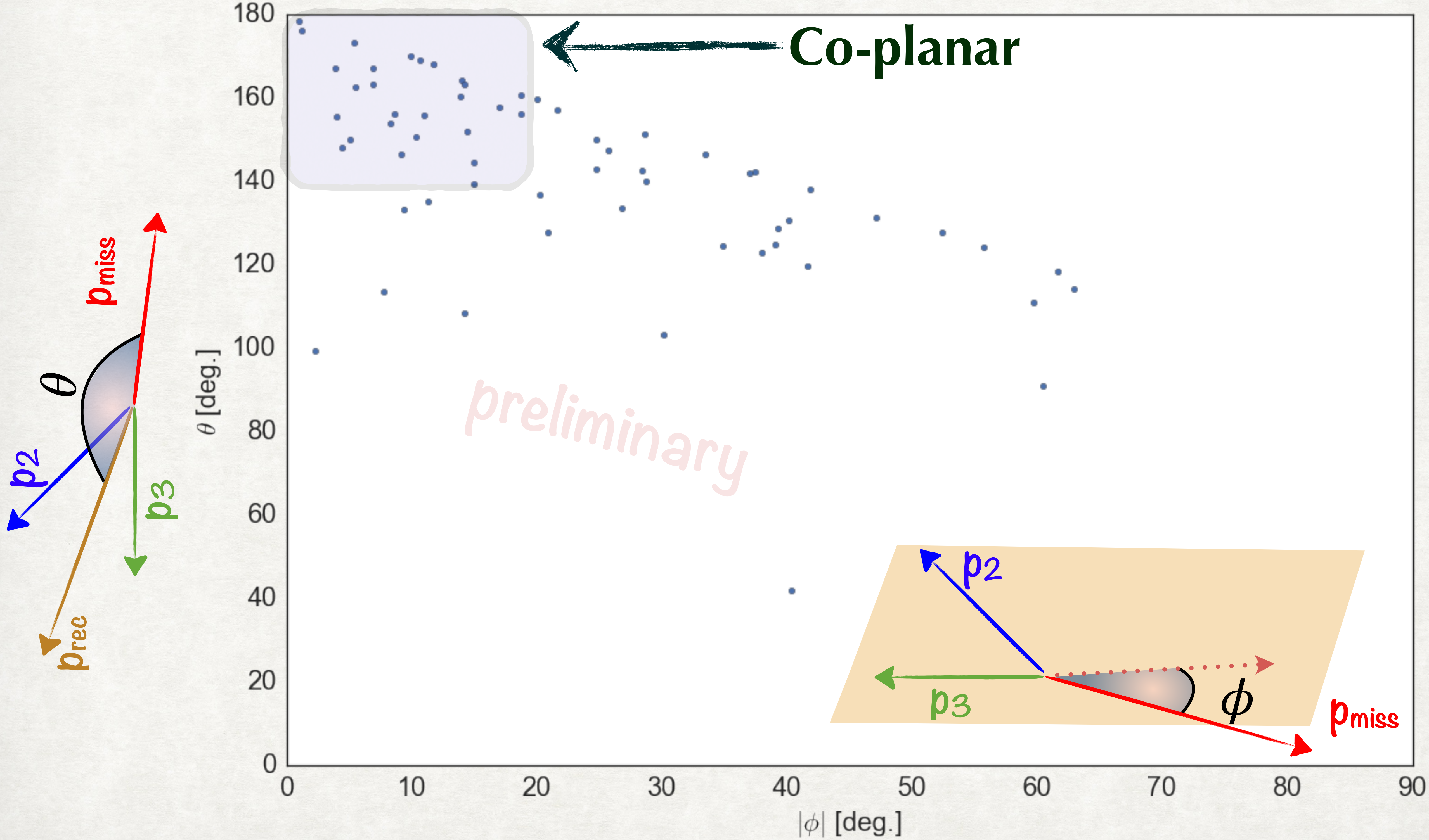
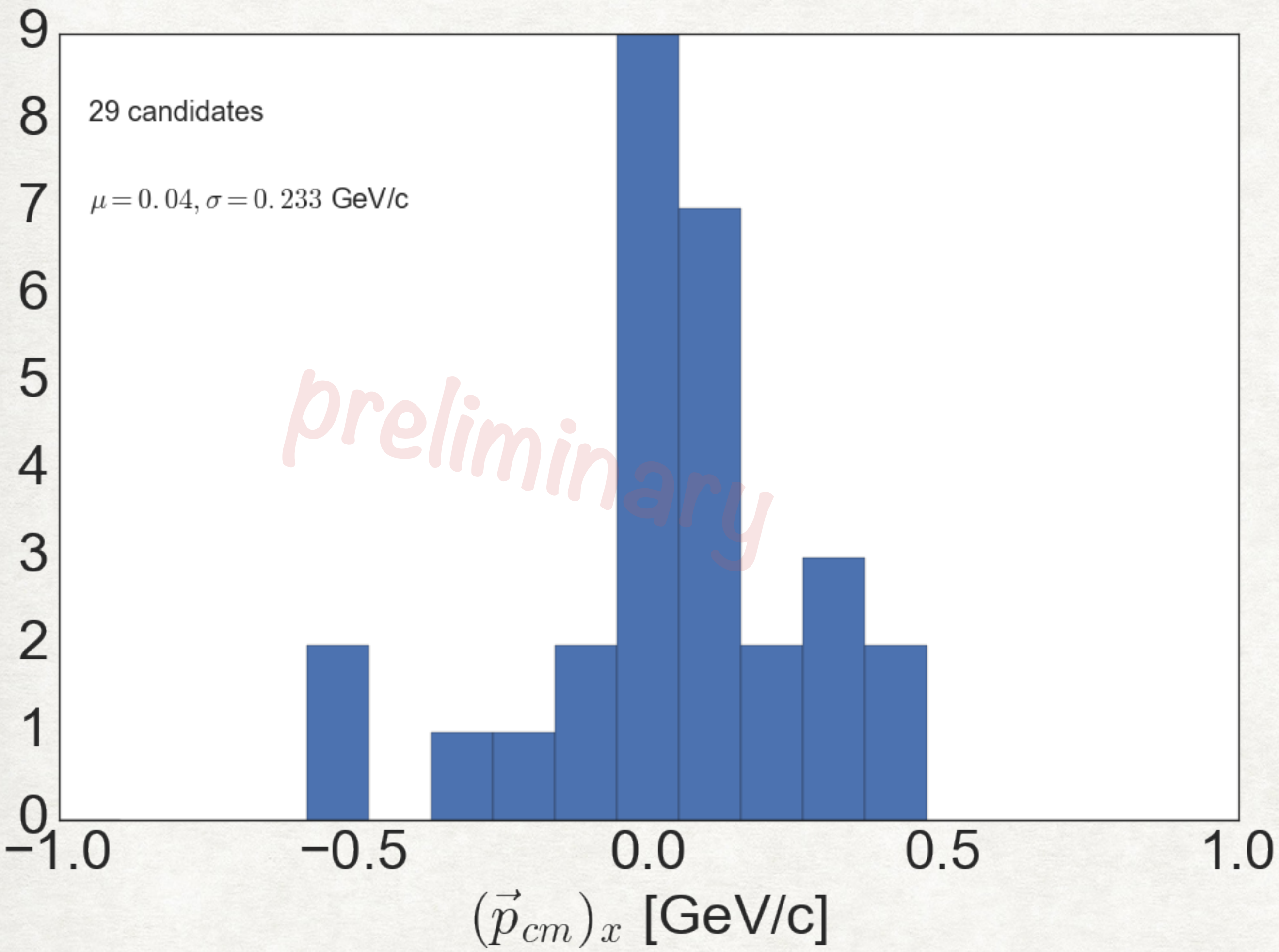


- **Back-to-back peak is not an artifact of the acceptances and selection cuts.**

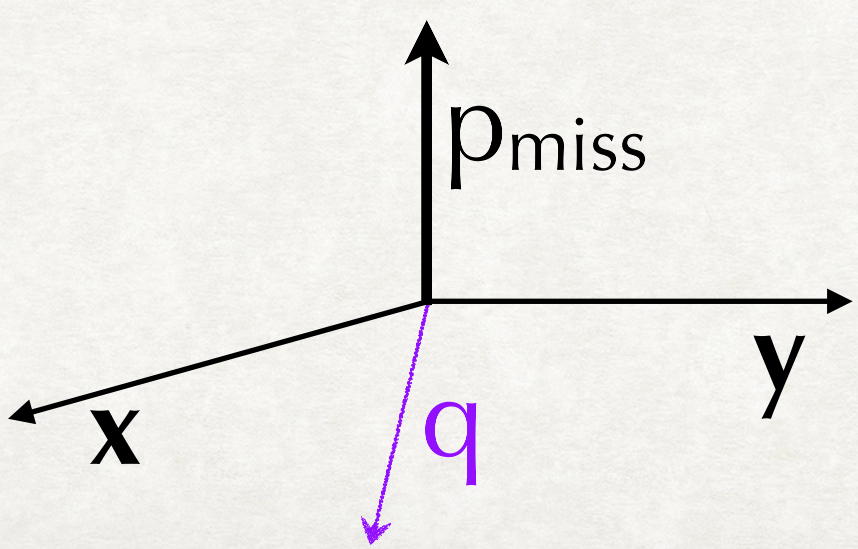
Opening angle

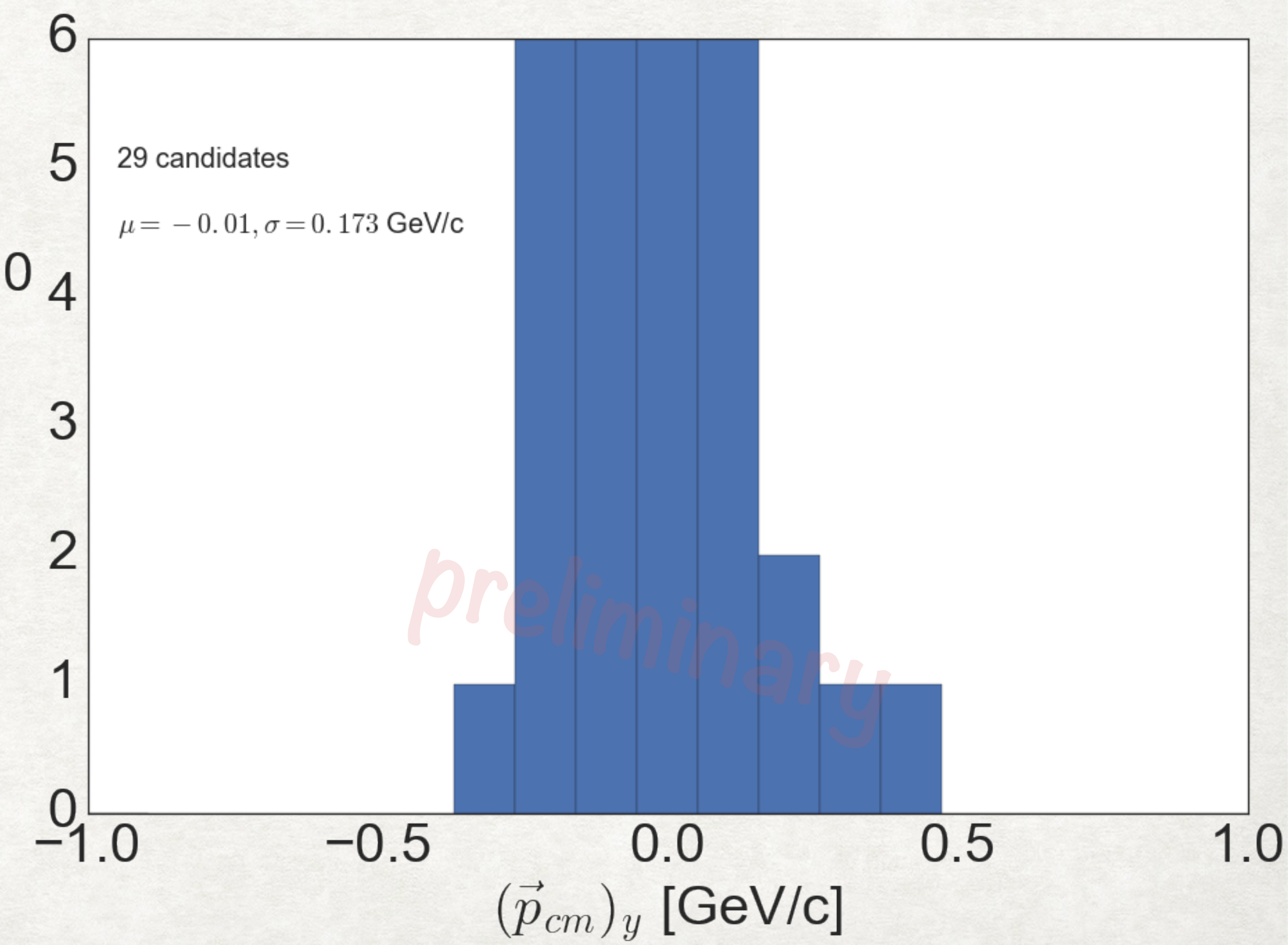


p_{cm} in the transverse directions



- The p_{cm} distributions are significantly narrower than allowed by acceptance.

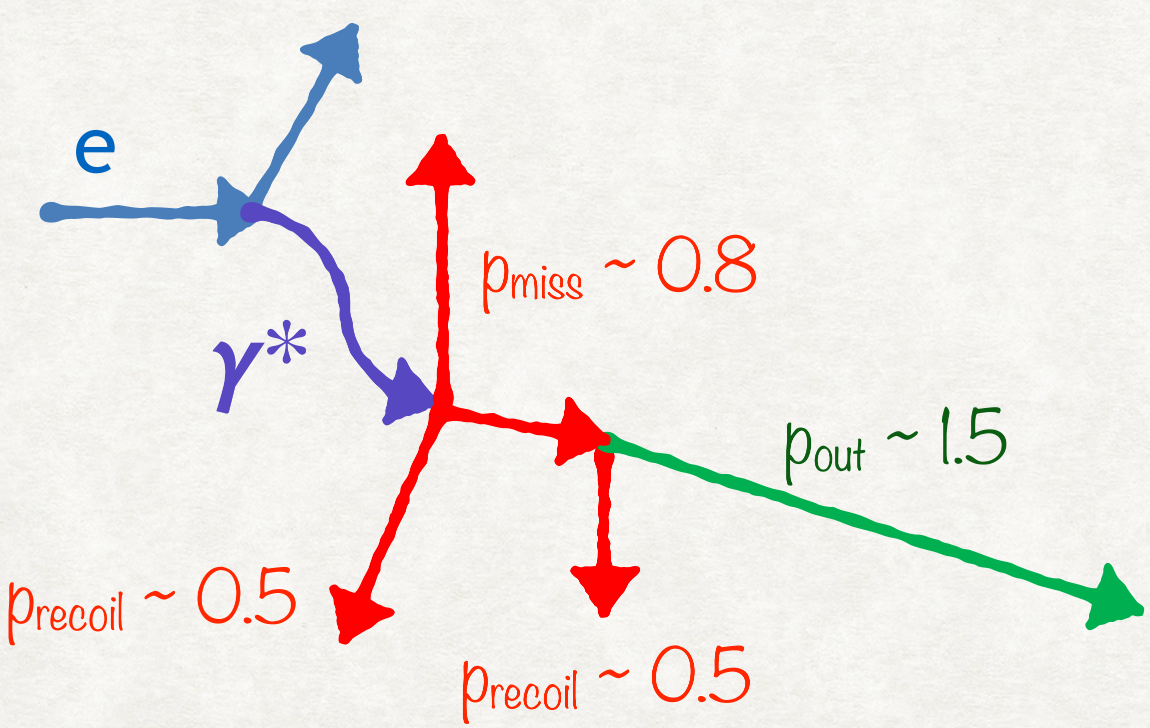


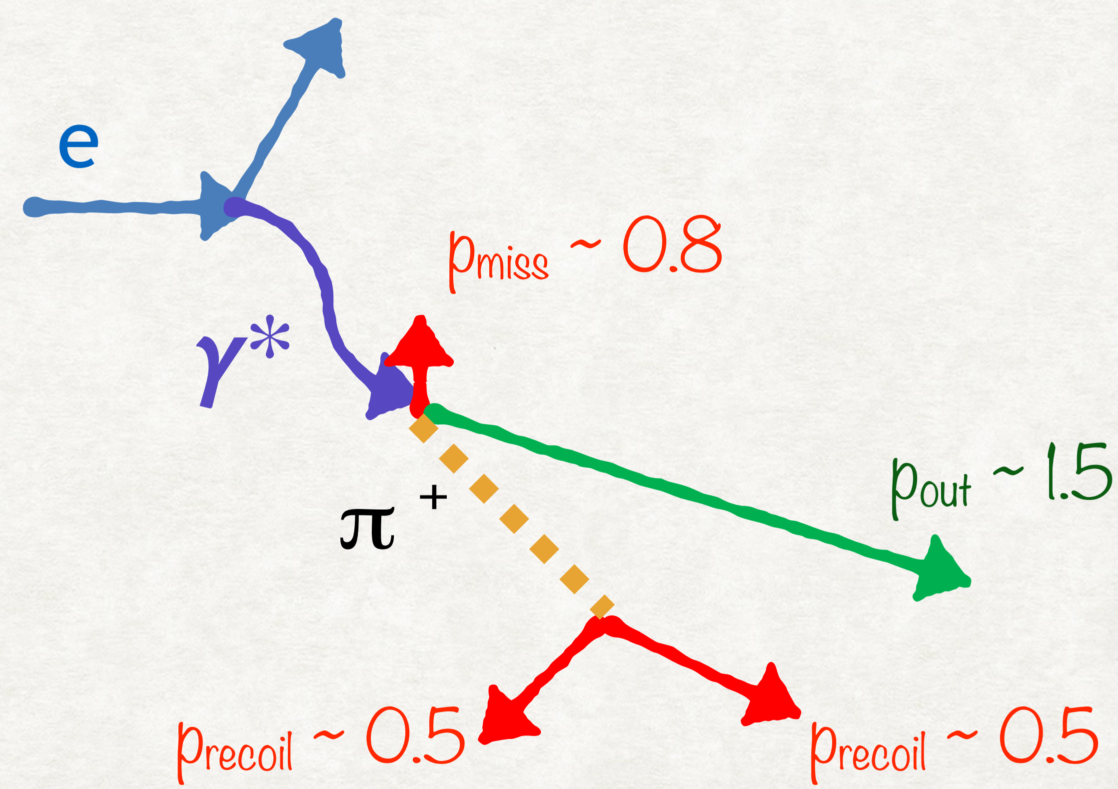


FSI - I

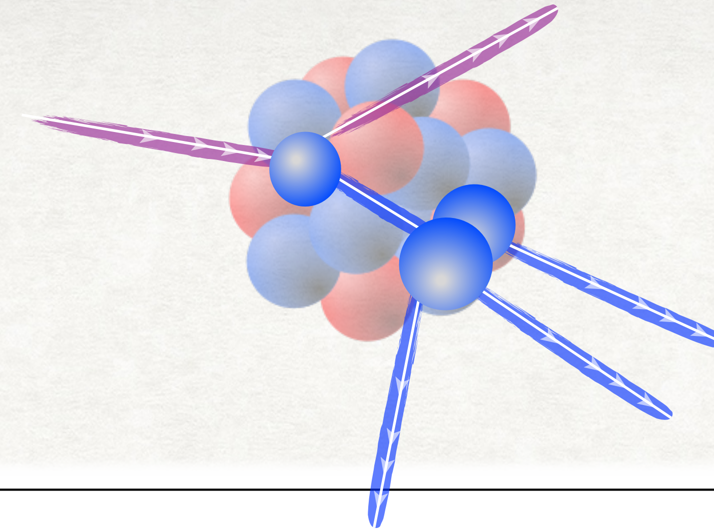
- we can not exclude FSI, but it is apparently not dominated by FSI.

- FSI that are expected to contribute isotropically to ϕ.

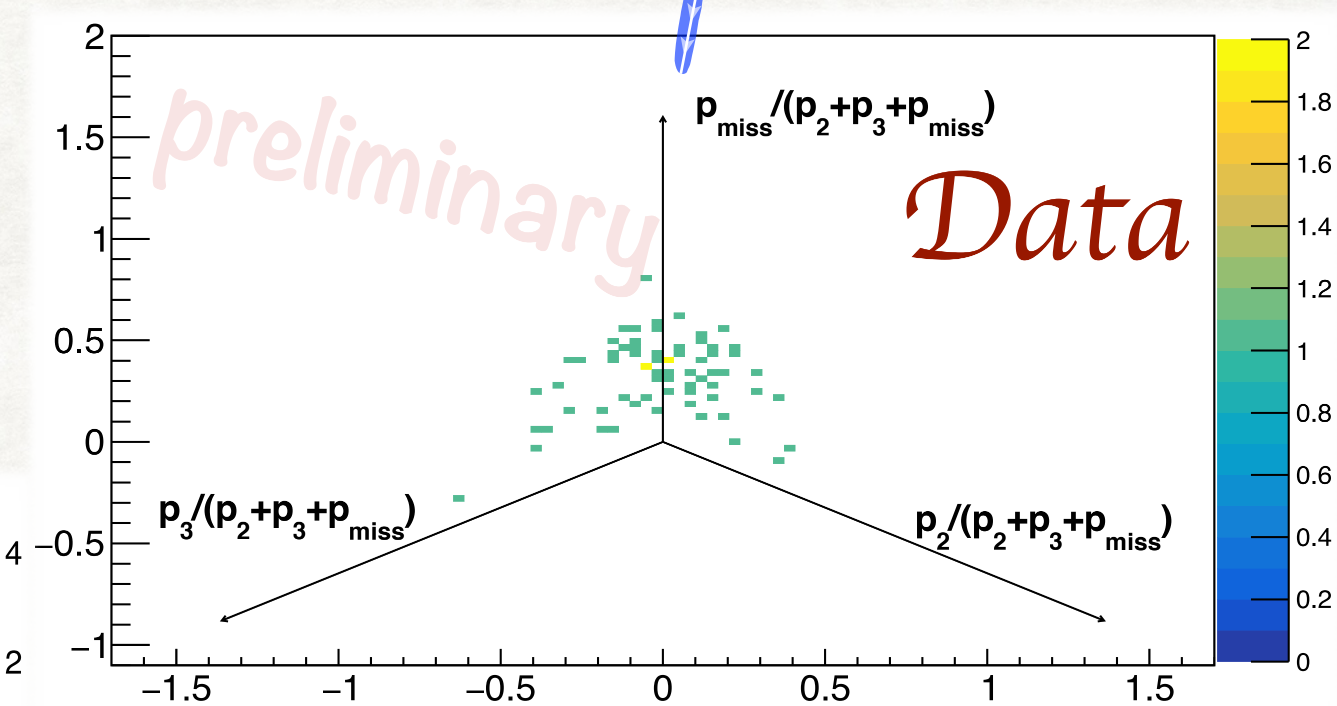


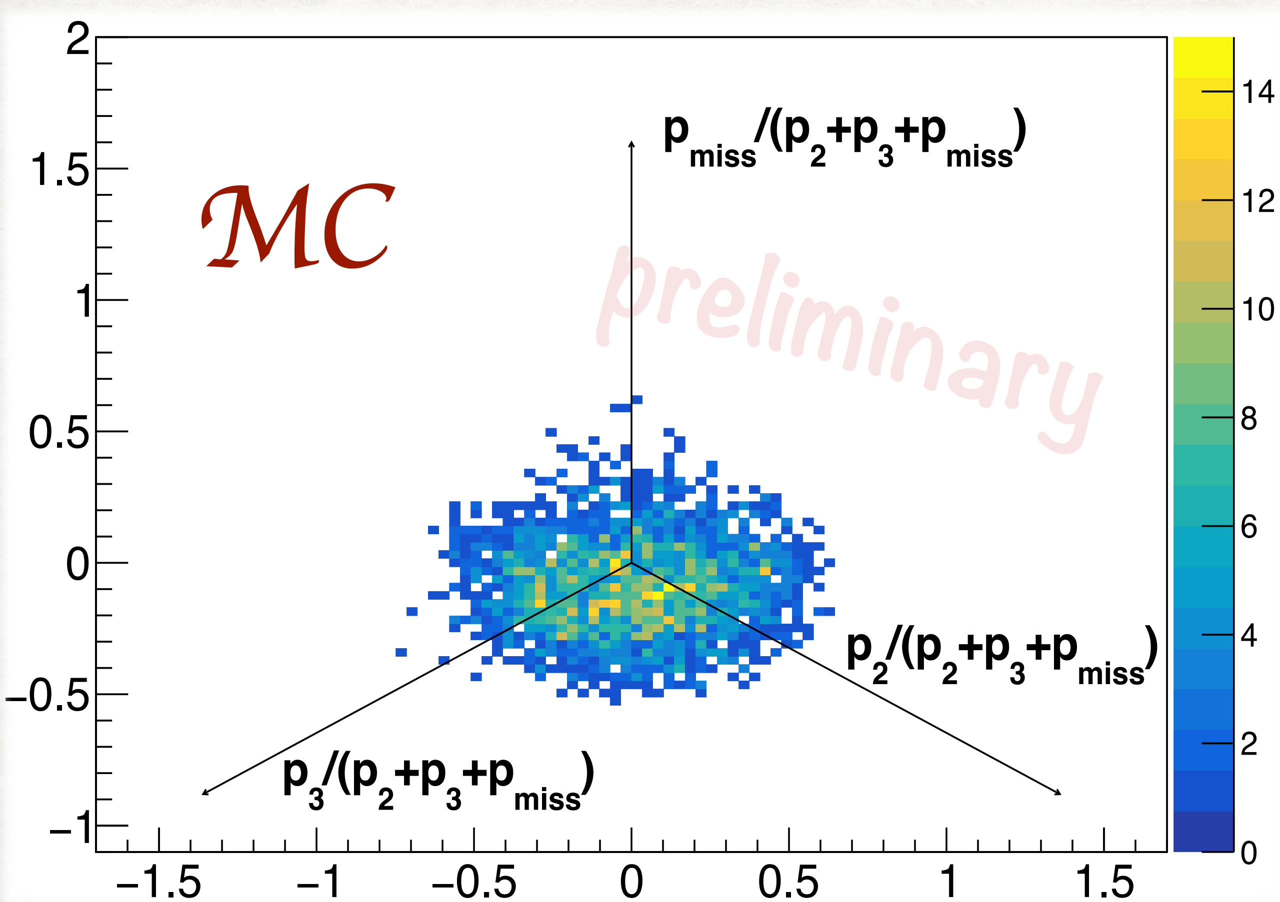


FSI - 2



- Used a **simplified on-shell scattering** model.

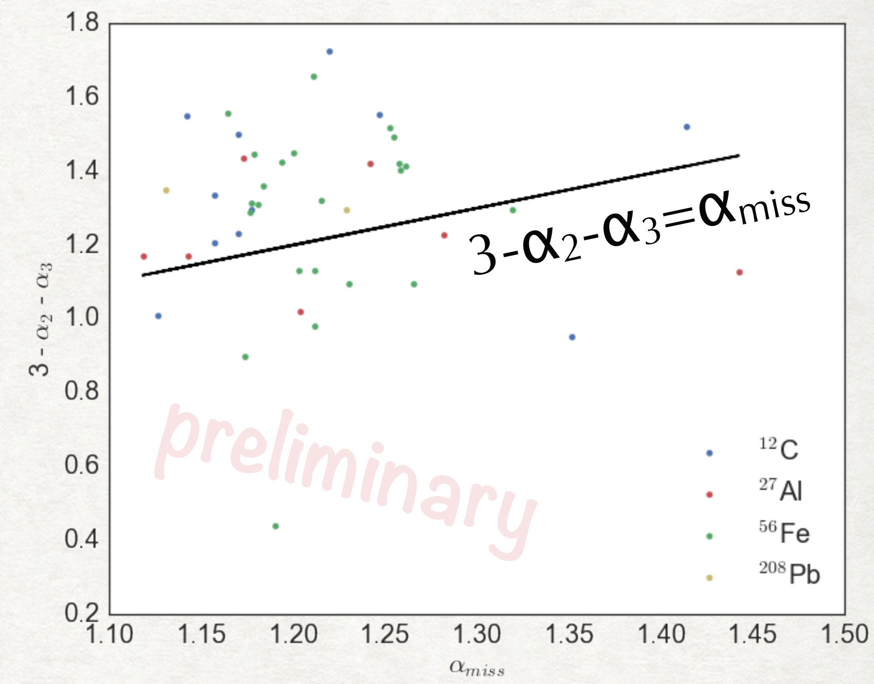


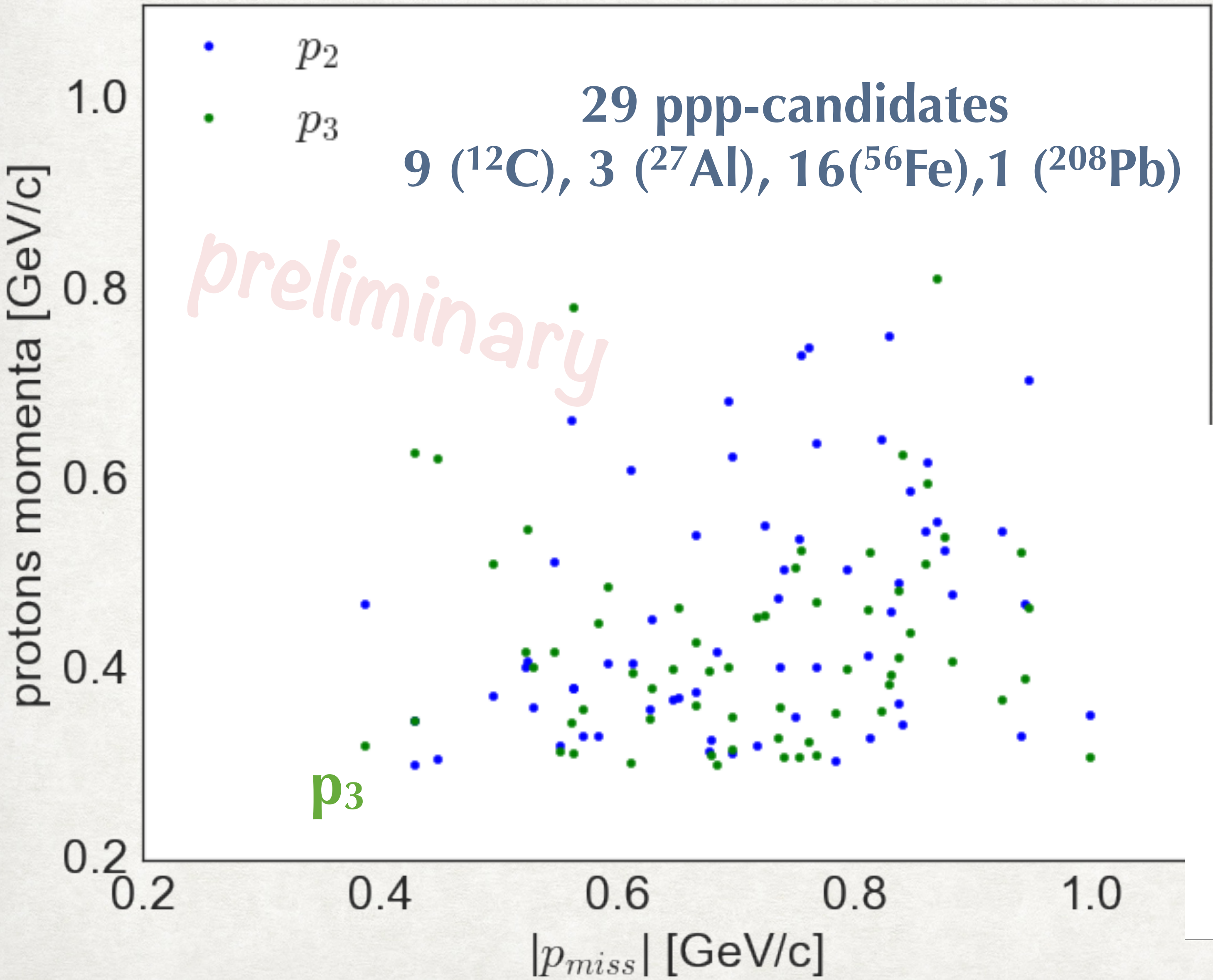


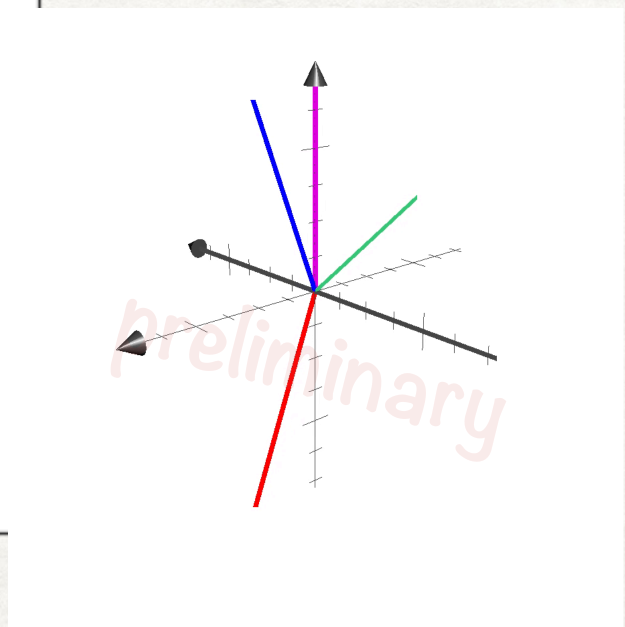
- **Scattering off low-momentum protons, followed by re-sacttering off pp-SRC**, are **dominated by star-shape configuration** different from the data.

ppp-SRC candidates

A typical event: p_{miss} balanced by 2 protons, in a co-planar but not co-linear geometry.





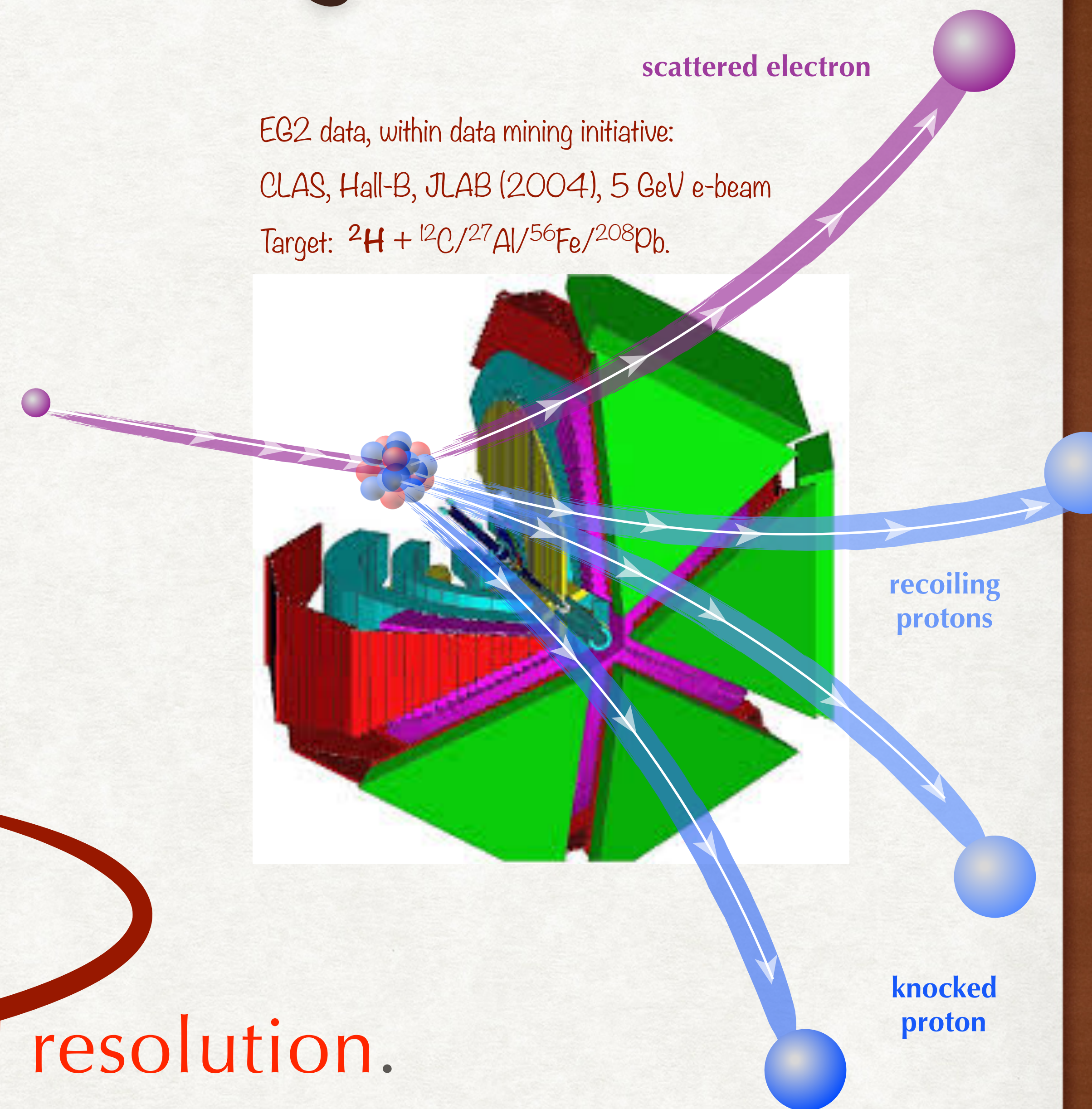


p_{miss} ~0.7 GeV/c

p_3 ~ 0.4 GeV/c

p_2 ~ 0.4 GeV/c

Search methods for 3N-SRC (fully exclusive)



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  - poor statistics.

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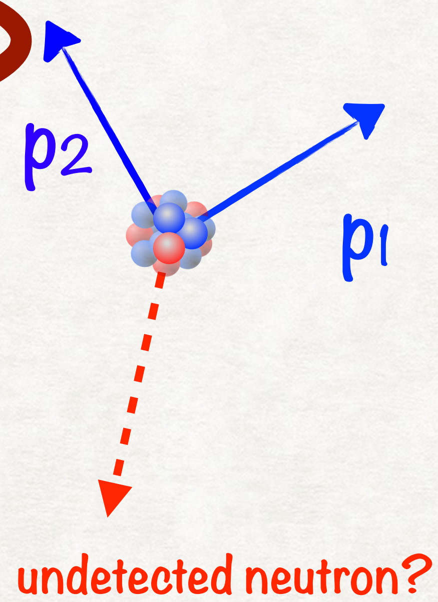

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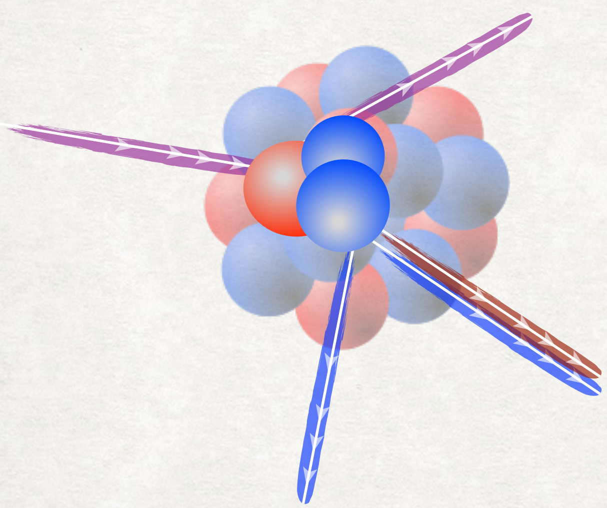
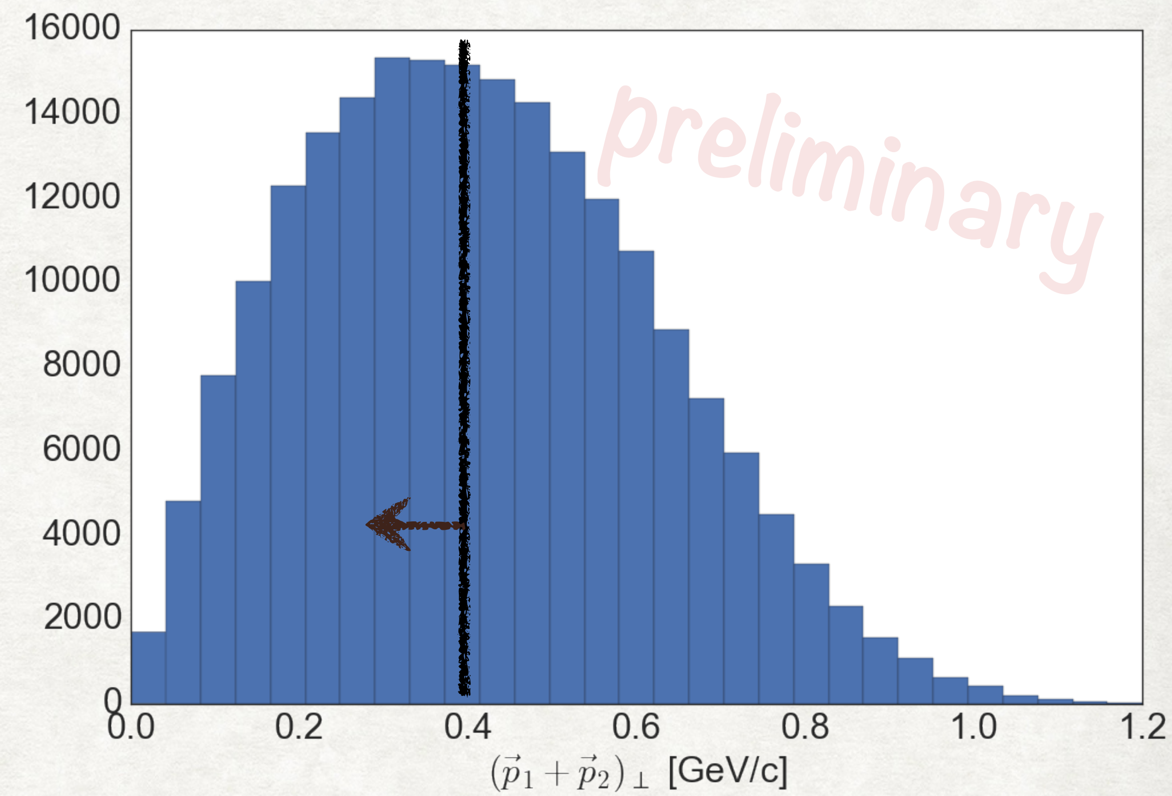
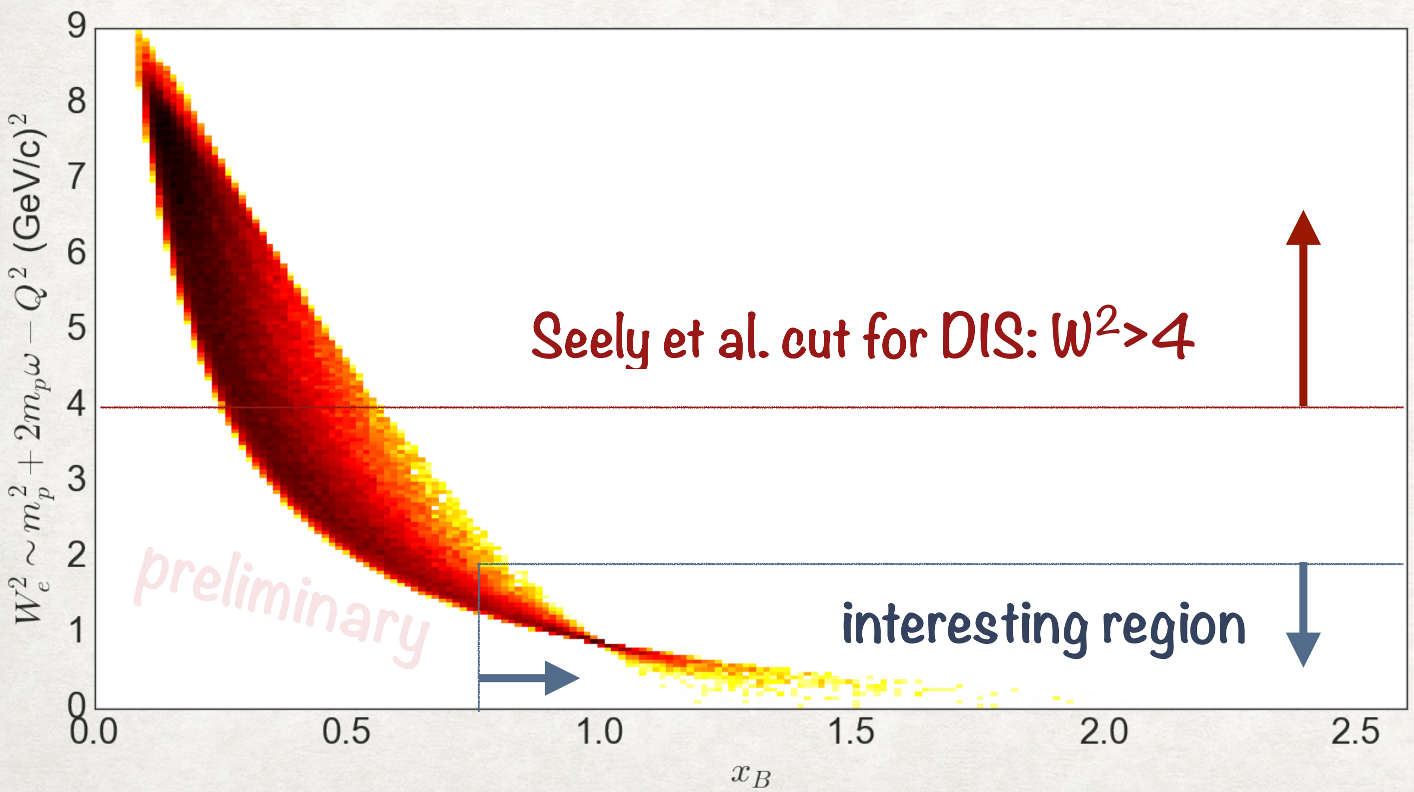


(n)pp-SRC events selection

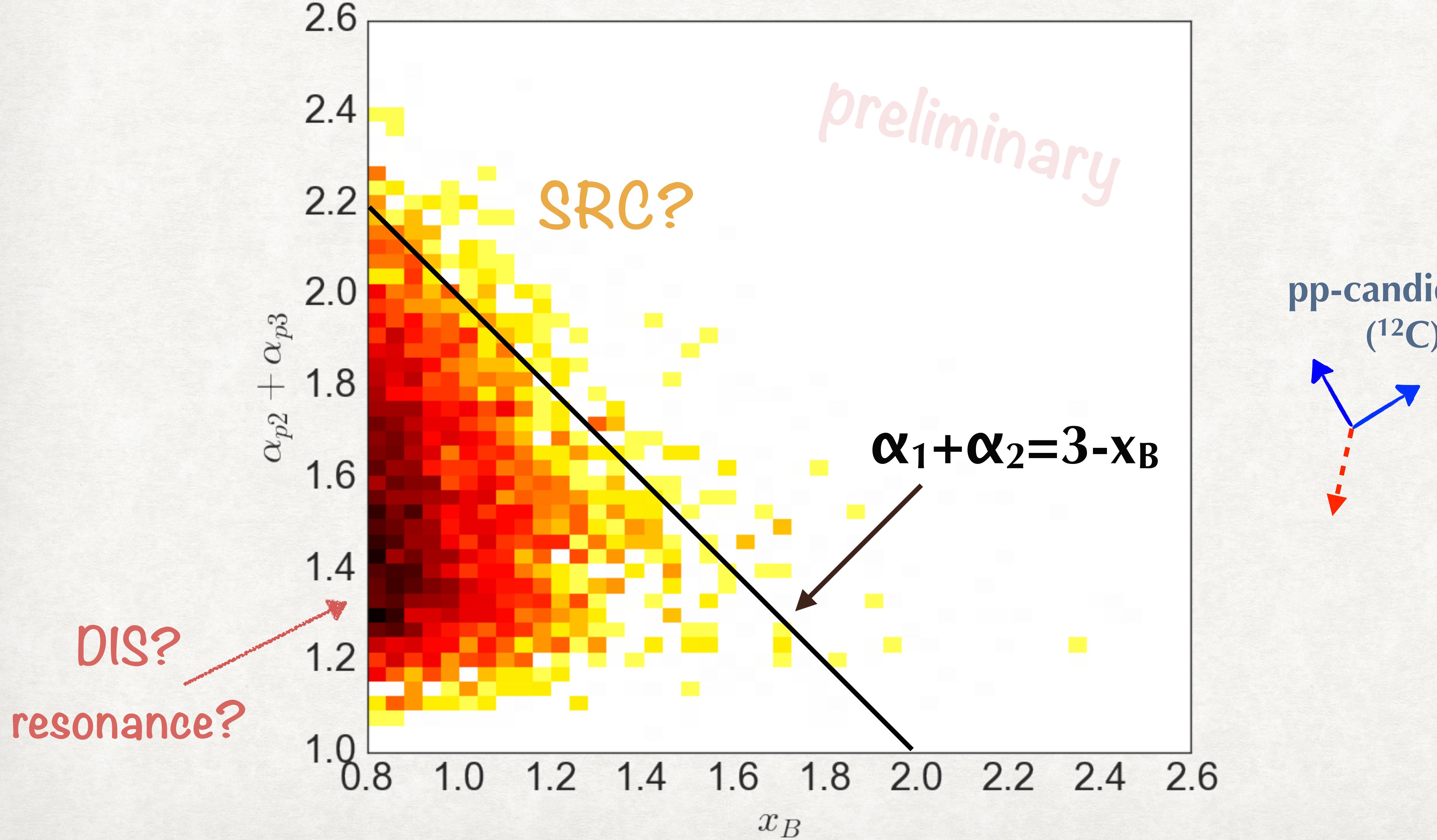
- (e,e′) kinematics $x_B > 0.8$
- two slow protons, $0.3 < p < 0.7$ GeV/c
- $(\mathbf{p_1} + \mathbf{p_2})_\perp < 0.4$ GeV/c
- $W_e \leq 2\ (\mathrm{GeV/c^2})^2$



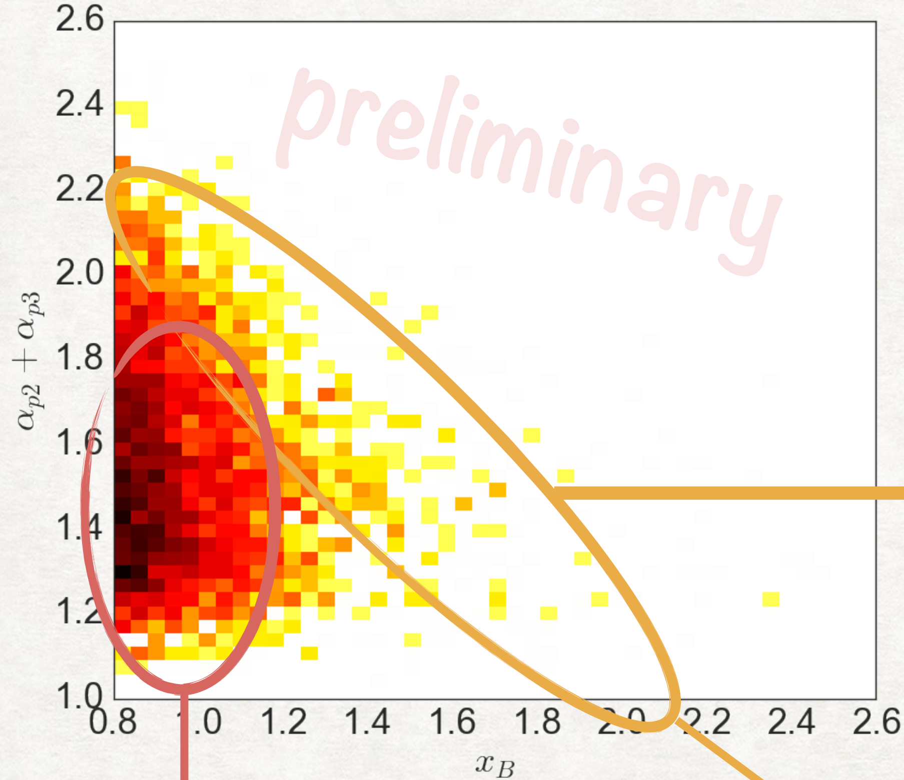


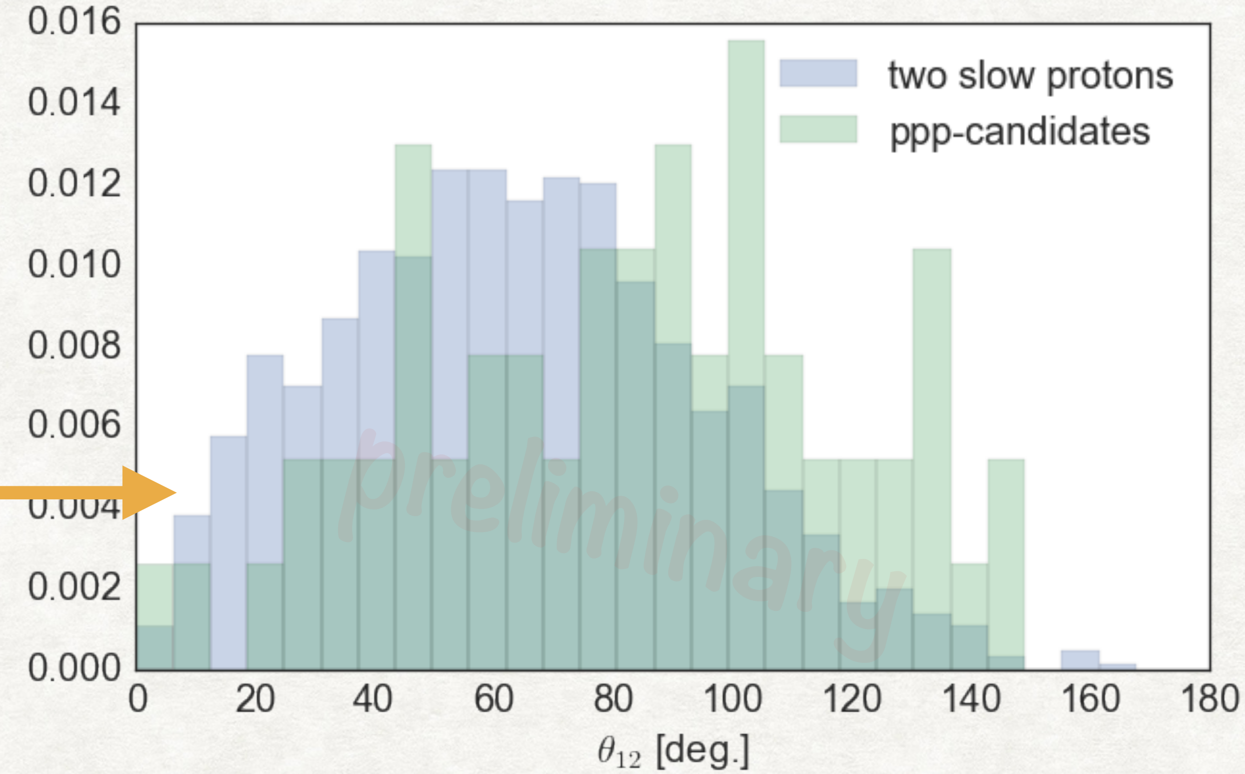
x_B - α correlation

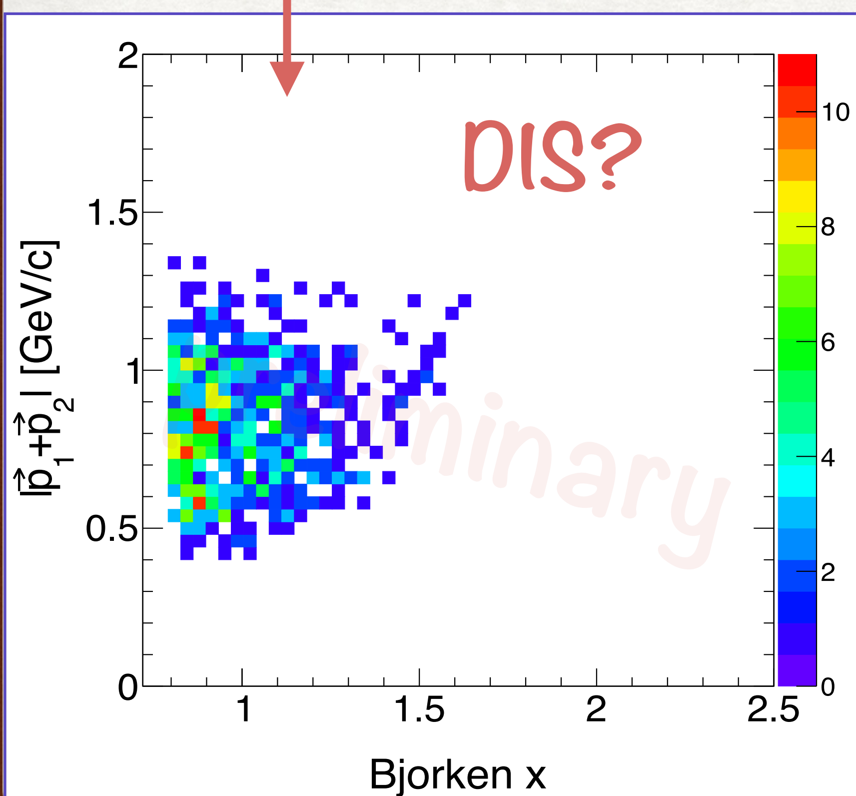
- For 3N-SRC at rest $\alpha_{miss} = 3 - \alpha_1 - \alpha_2$. For large Q^2, $\alpha_{miss} = x_B$.

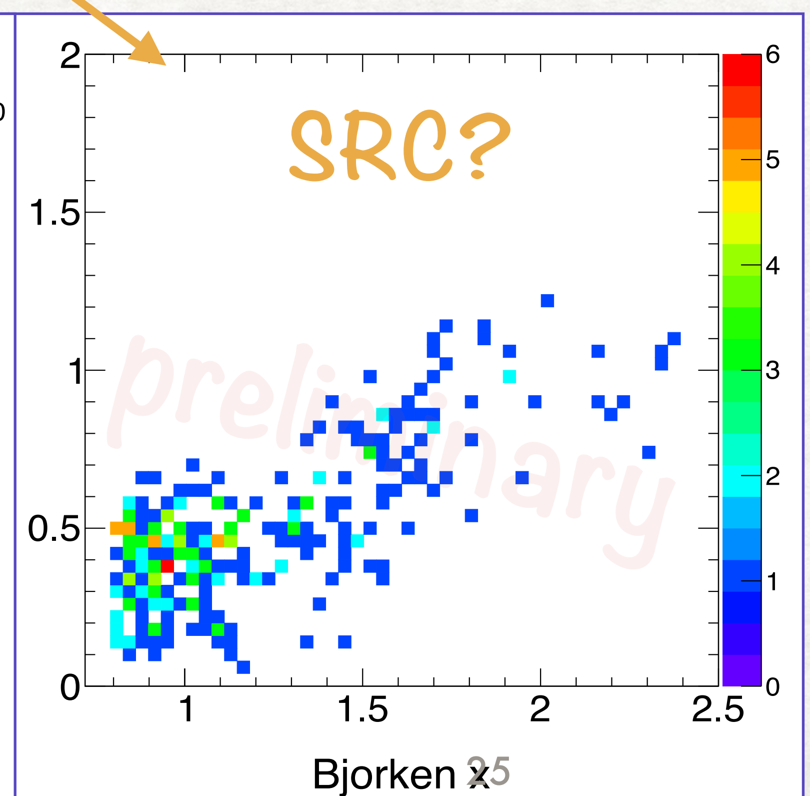


(n)pp-SRC in process

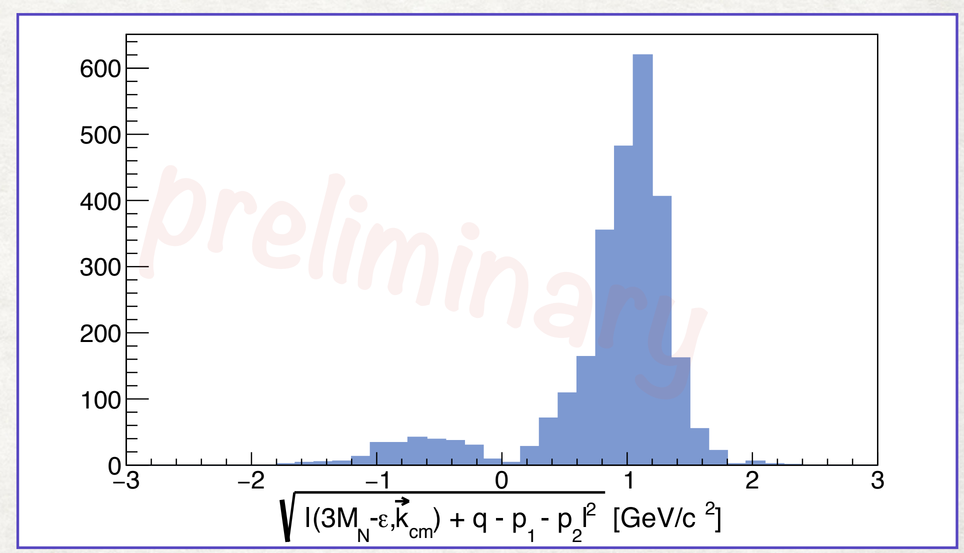








$$W^2 = |\ p(\text{c.m.}) + q - p_1 - p_2\ |^2$$



Search methods for 3N-SRC (triple coincidence)

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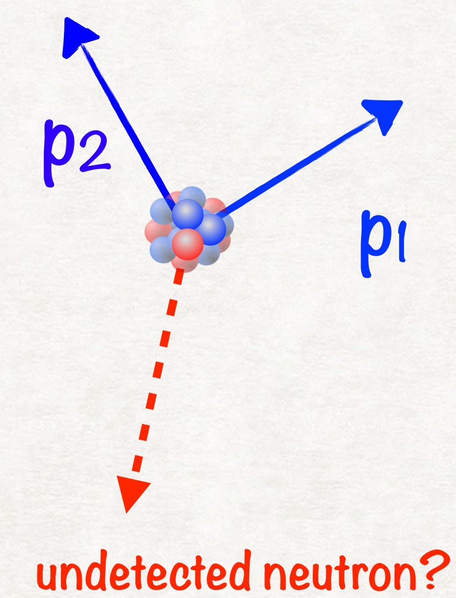

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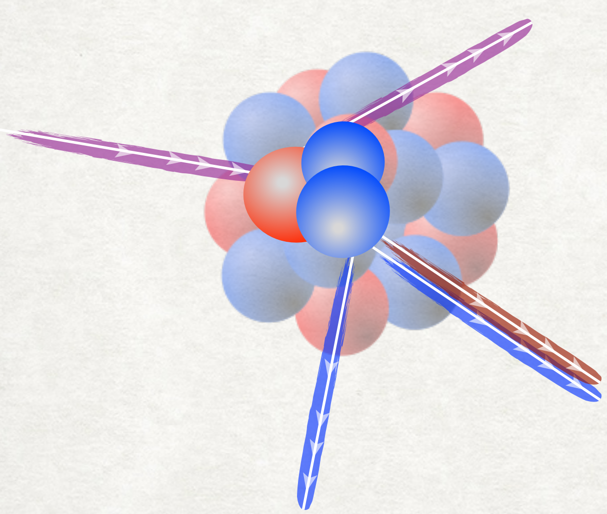
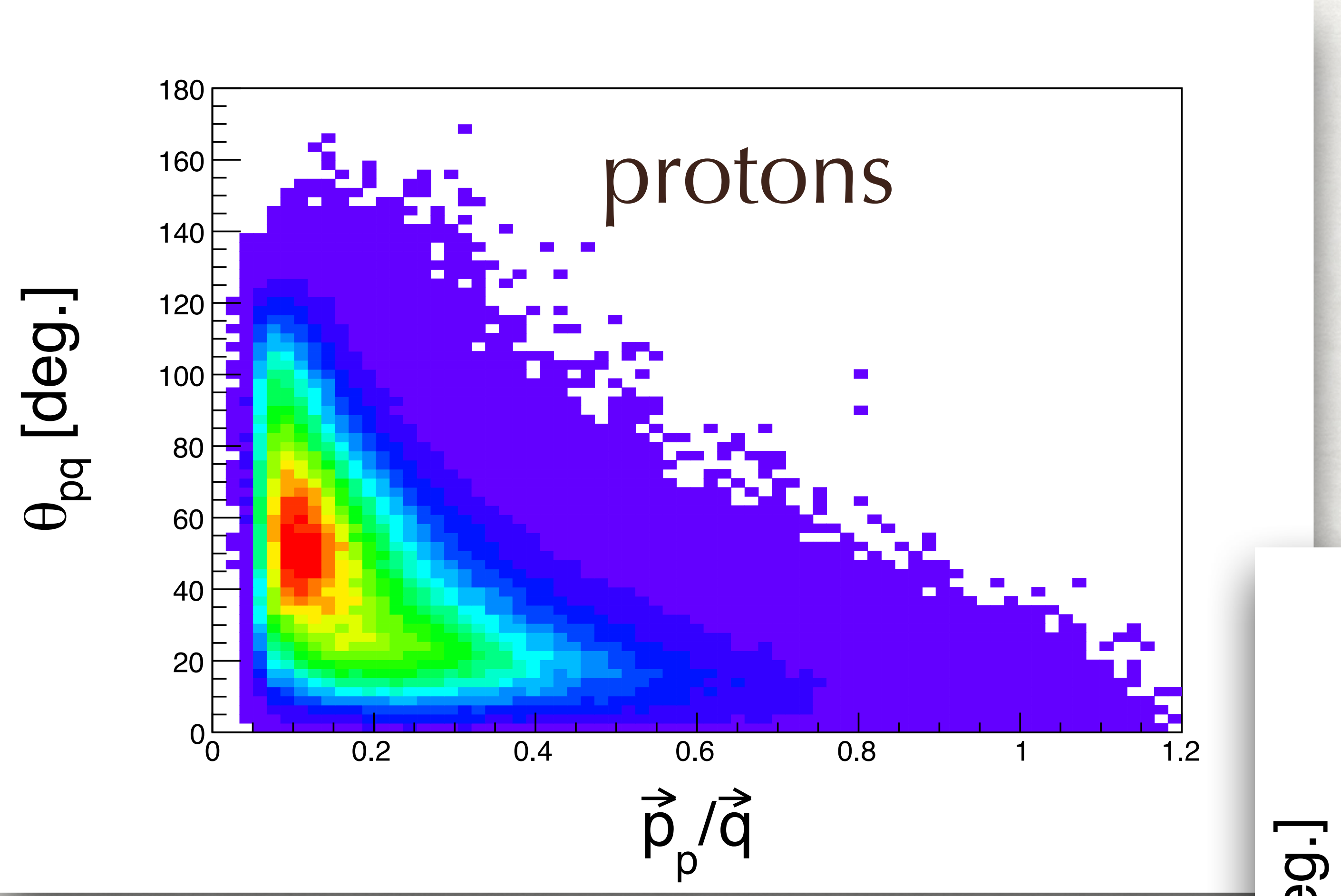
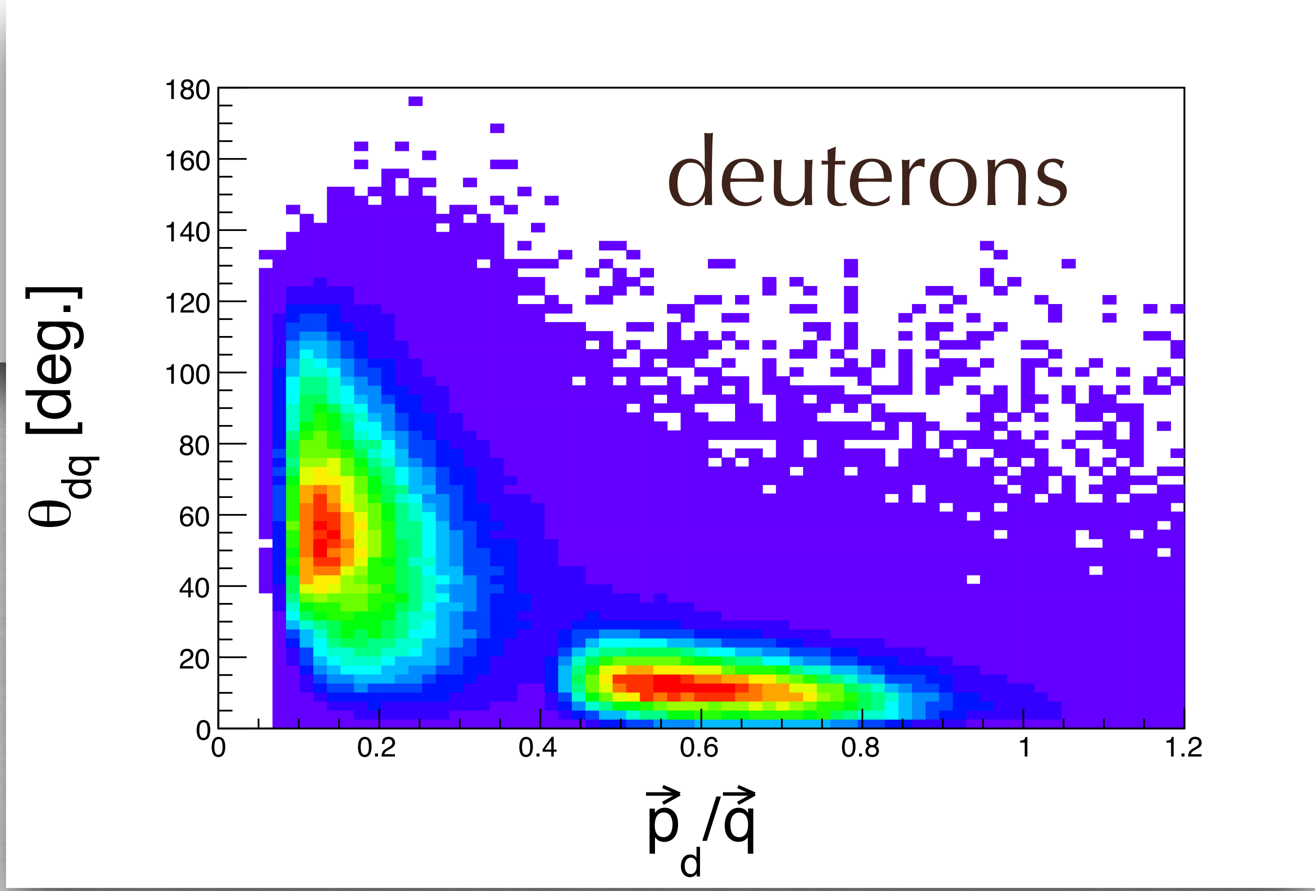


npp-SRC from (e,e'dp) in process



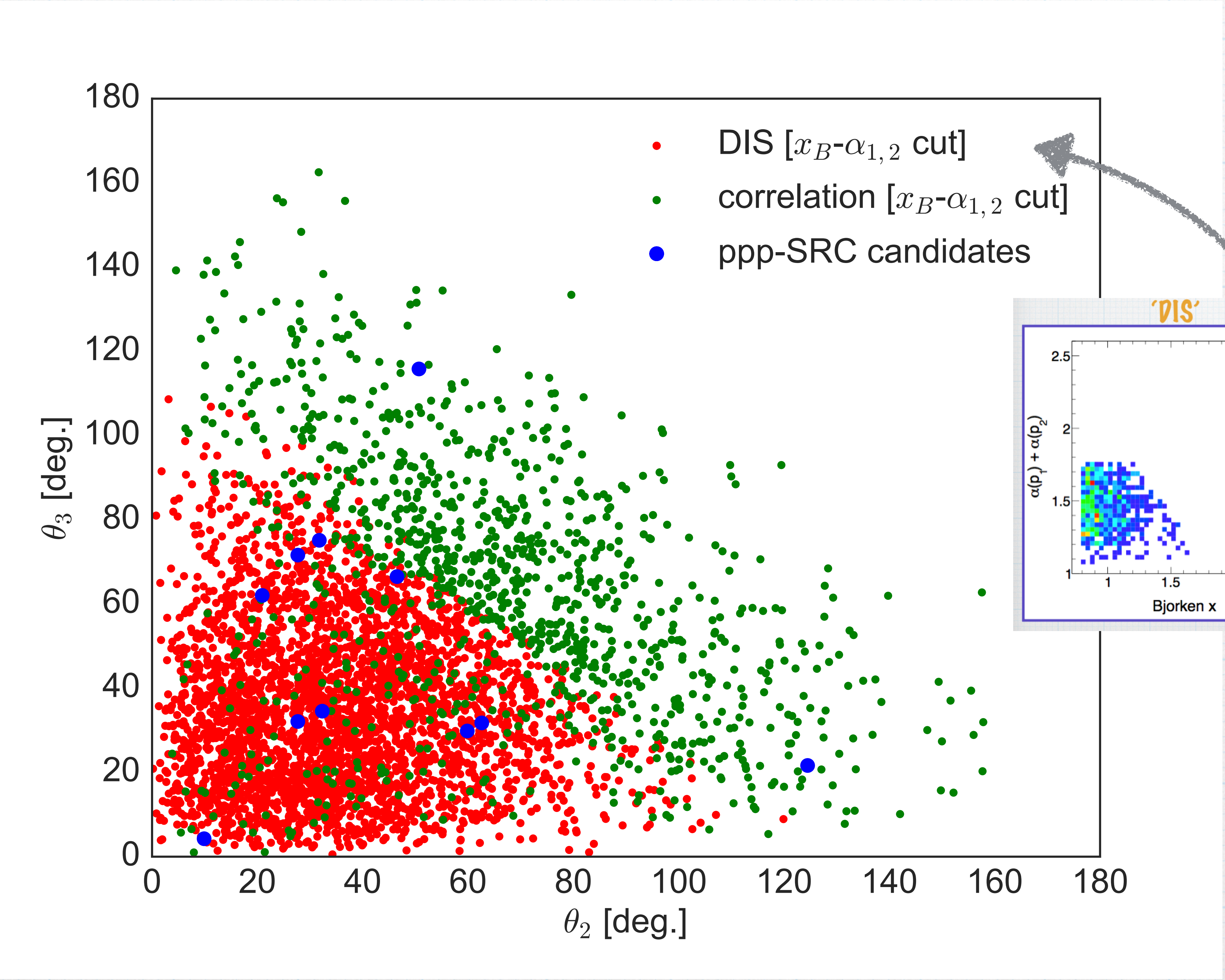


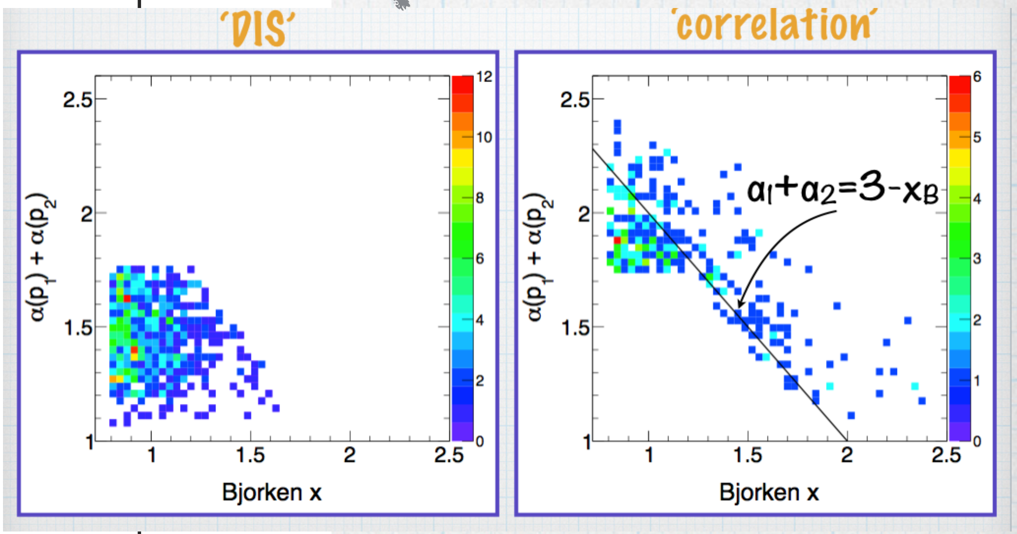
Thank you for your time…

Comments/Suggestions/Questions:
cohen.erez7@gmail.com

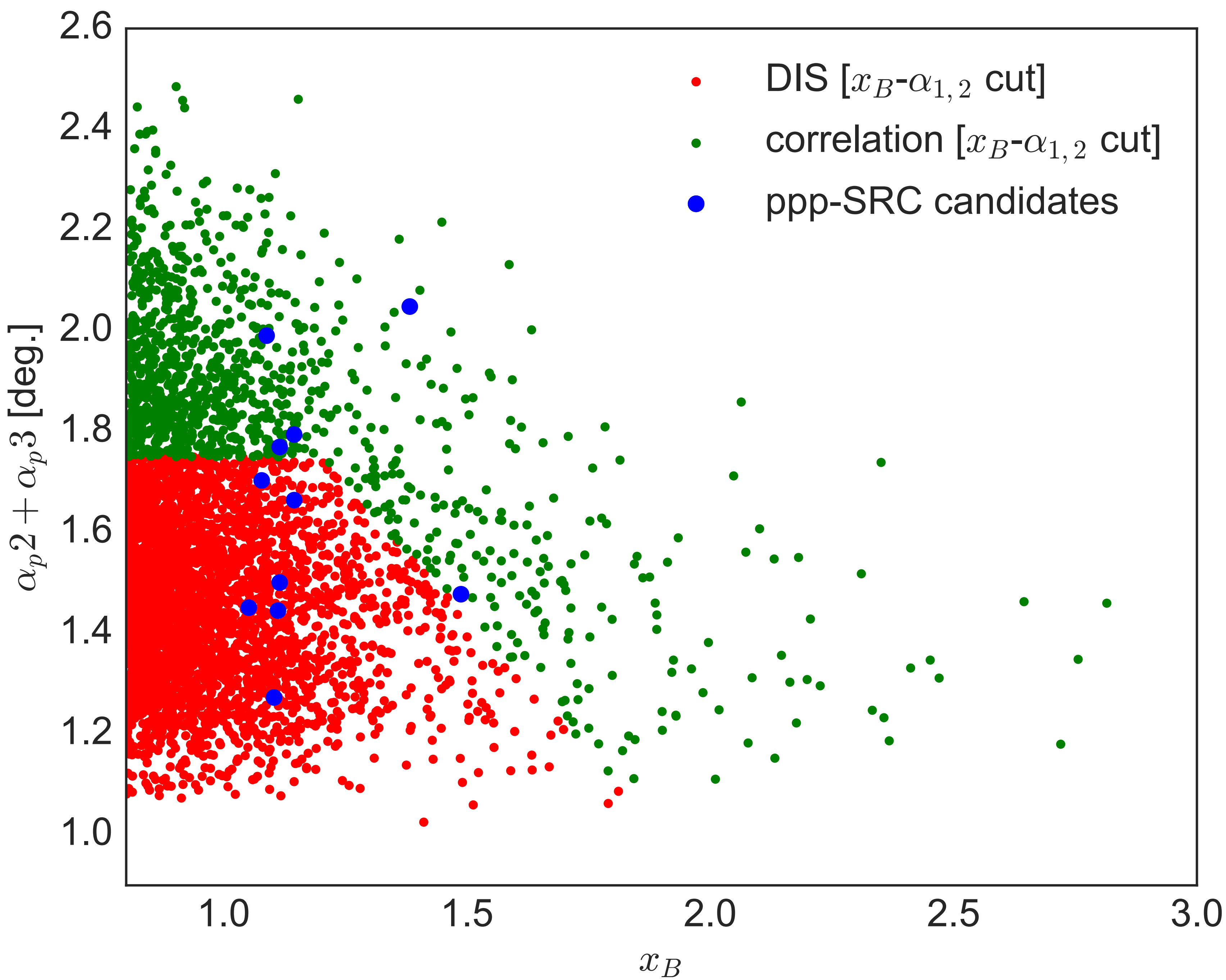
BACKUP SLIDES

protons angles with respect to momentum transfer





division of (e,e'pp?) sample



SRC vs. competing channels - ?pp sample

Using x_B-α correlation, separate DIS/res. from SRC candidates

[L. Frankfurt, M. Sargsian, and M. Strikman, International Journal of Modern Physics A 23, 2991 (2008)]

$$\alpha = x_B \left(1 + \frac{2p_z}{\omega + |\vec{q}|}\right) + \frac{W_N^2 - m^2}{2m\omega}$$

$$W_N^2 = (\vec{p} + \vec{q})$$

for QE processes, $W_N \sim m$, and for high Q^2

$$\lim_{Q^2 \to \infty} \alpha = x_B$$