XEM2 Analysis Update

SHORT RANGE CORRELATIONS

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XEM

Jefferson Lab

What is XEM?

What is XEM?

$x_{bj} > 1$

- Short Range Correlations
- Superfast quarks

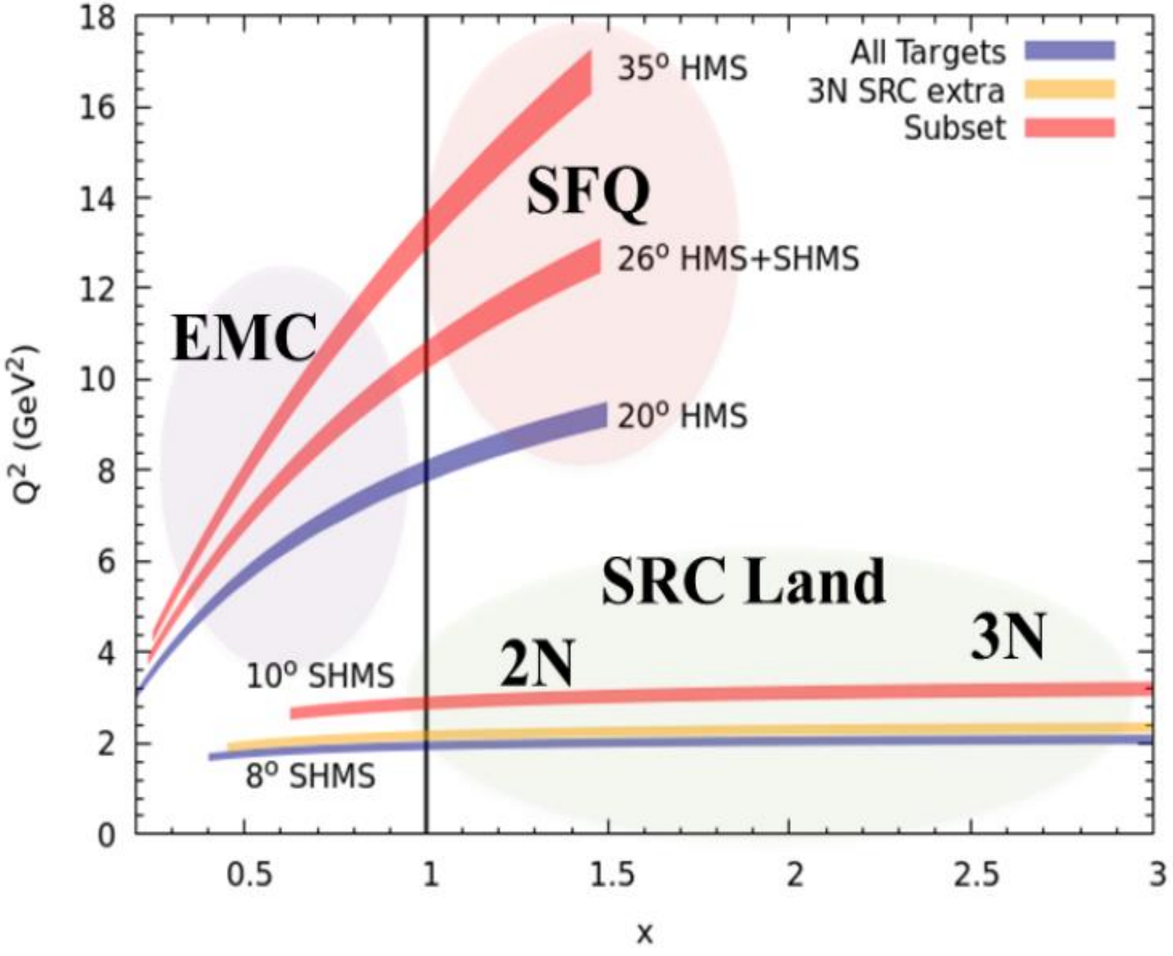
EMC effect

- EMC effect

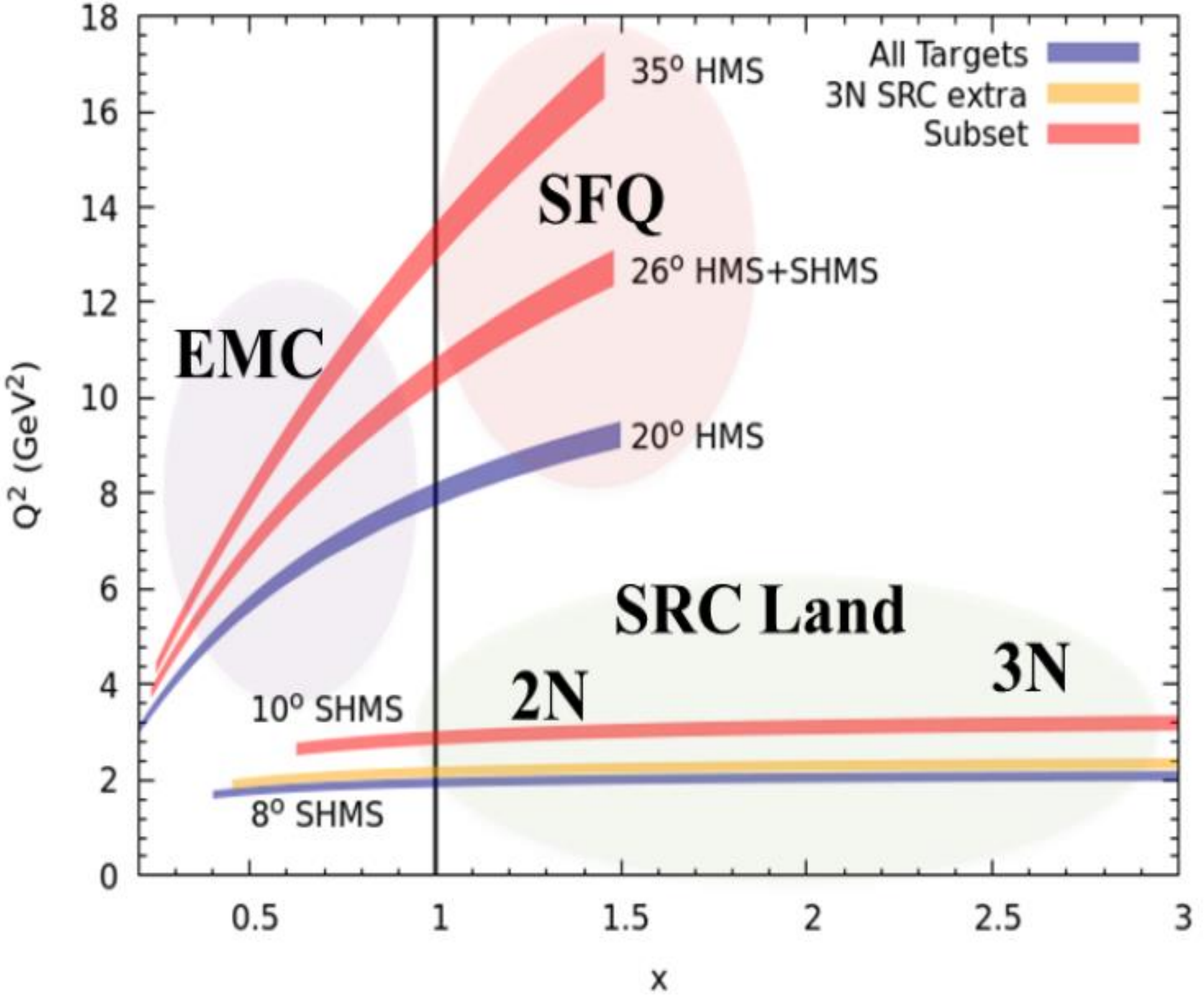
XEM2 Experiments (Oct 2022 - Feb 2023)

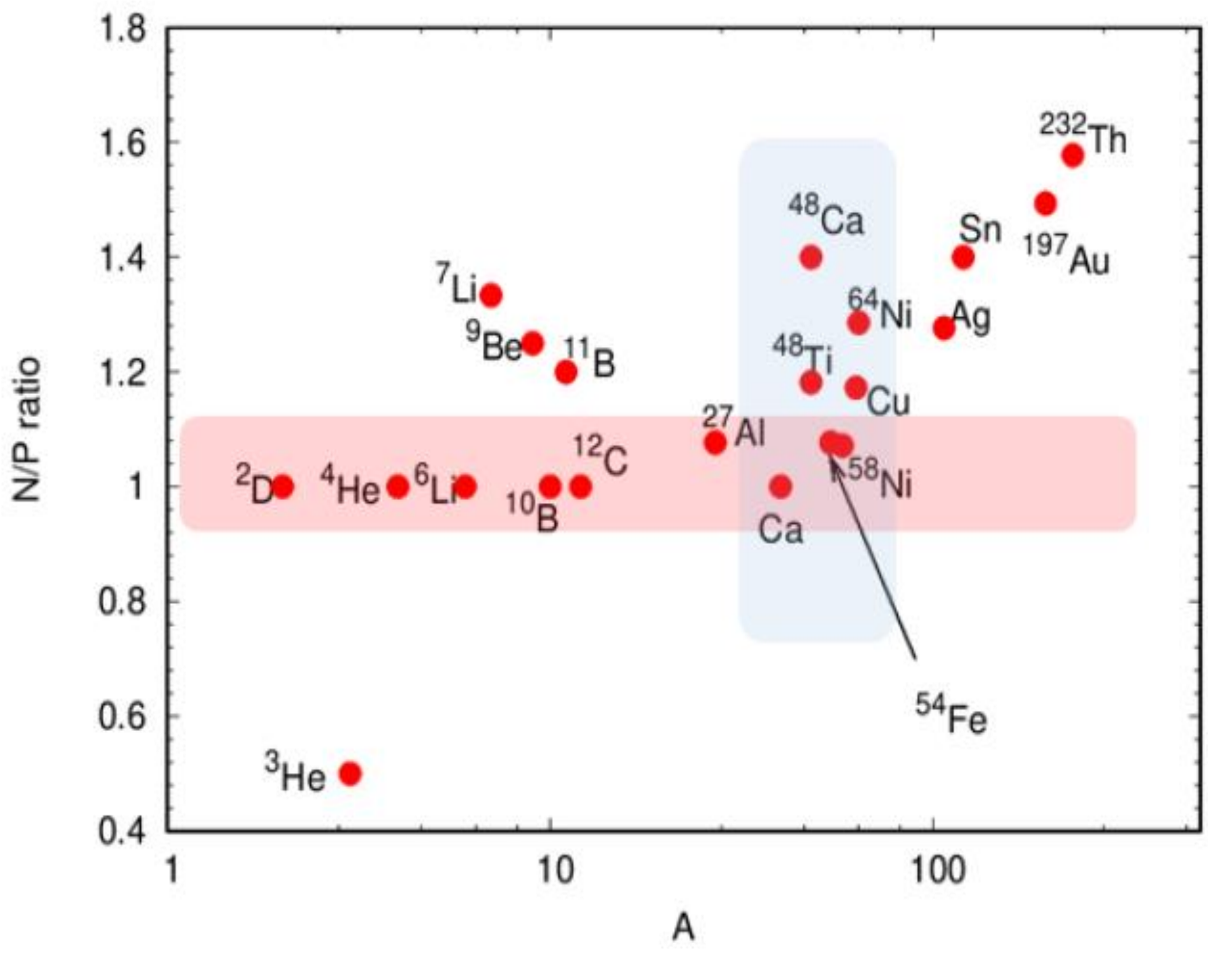
- E12-06-105:
  - Studies of SRCs (SHMS)
  - Super fast quarks (HMS)
- E12-10-008: (HMS)
  - Studies of the EMC effect

(See Tyler Hague's talk after)

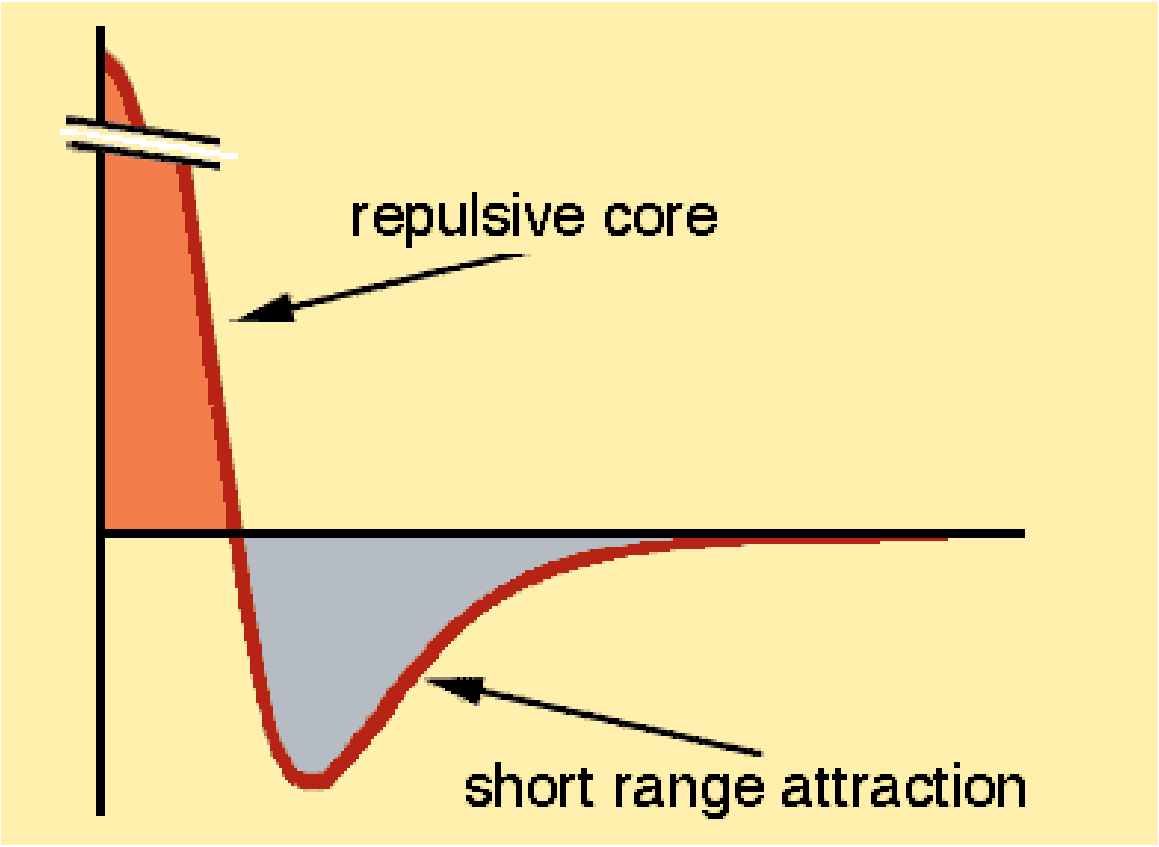


Experimental landscape

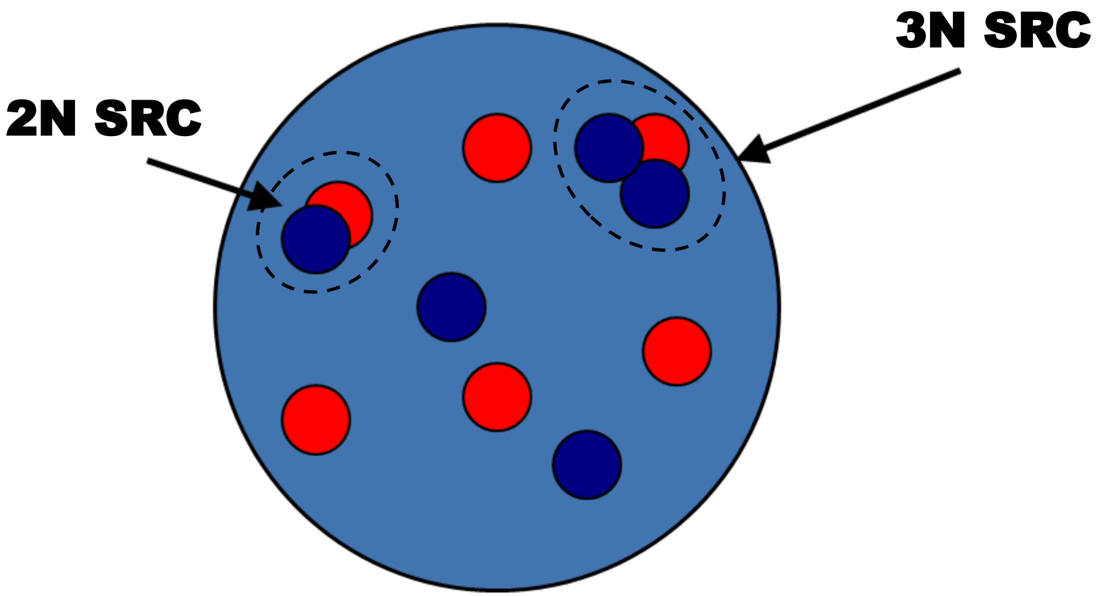




What are SRCs?



- Short distance interaction generates high momentum nucleons
- Nuclear structure below fermi energy k_f dominated by mean field
- Nuclear structure above fermi energy k_f dominated by 2 (or possibly 3) body physics



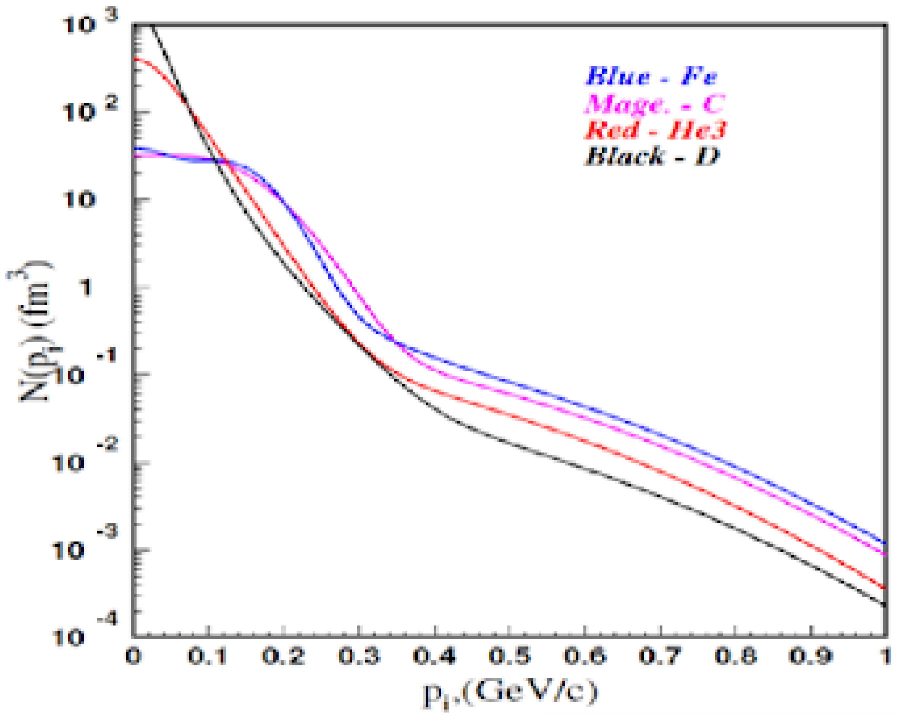
Picture credit: Nadia Fomin

Two Nucleon Short Range Correlations (2N SRCs)

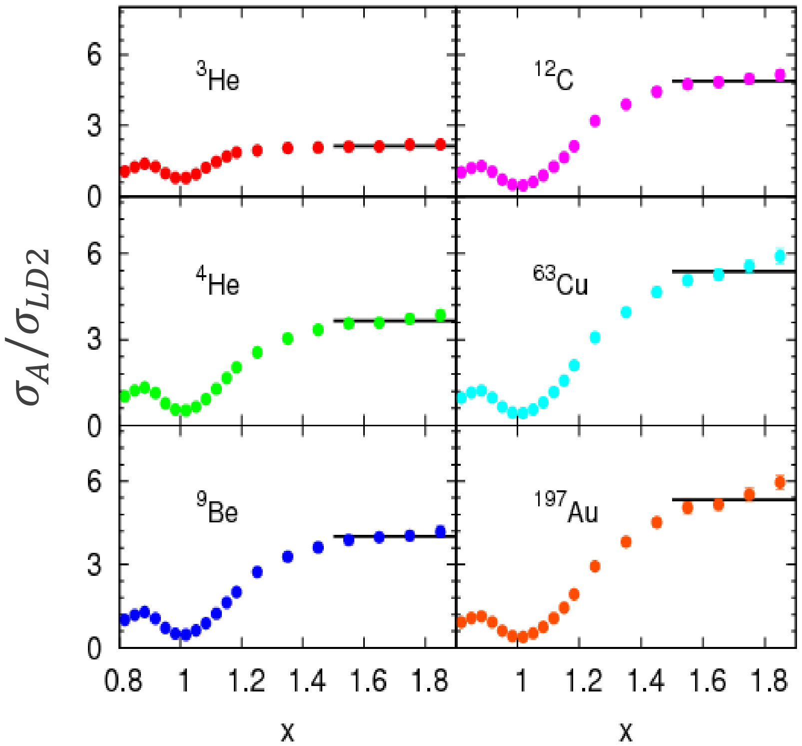
$$\sigma(x,Q^2) = Aa_1\sigma_1(x,Q^2) + \frac{A}{2}a_2\sigma_2(x,Q^2) + \ldots$$

Previously looked for 2N SRCs

$1.4 < x_{bj} < 2.0$



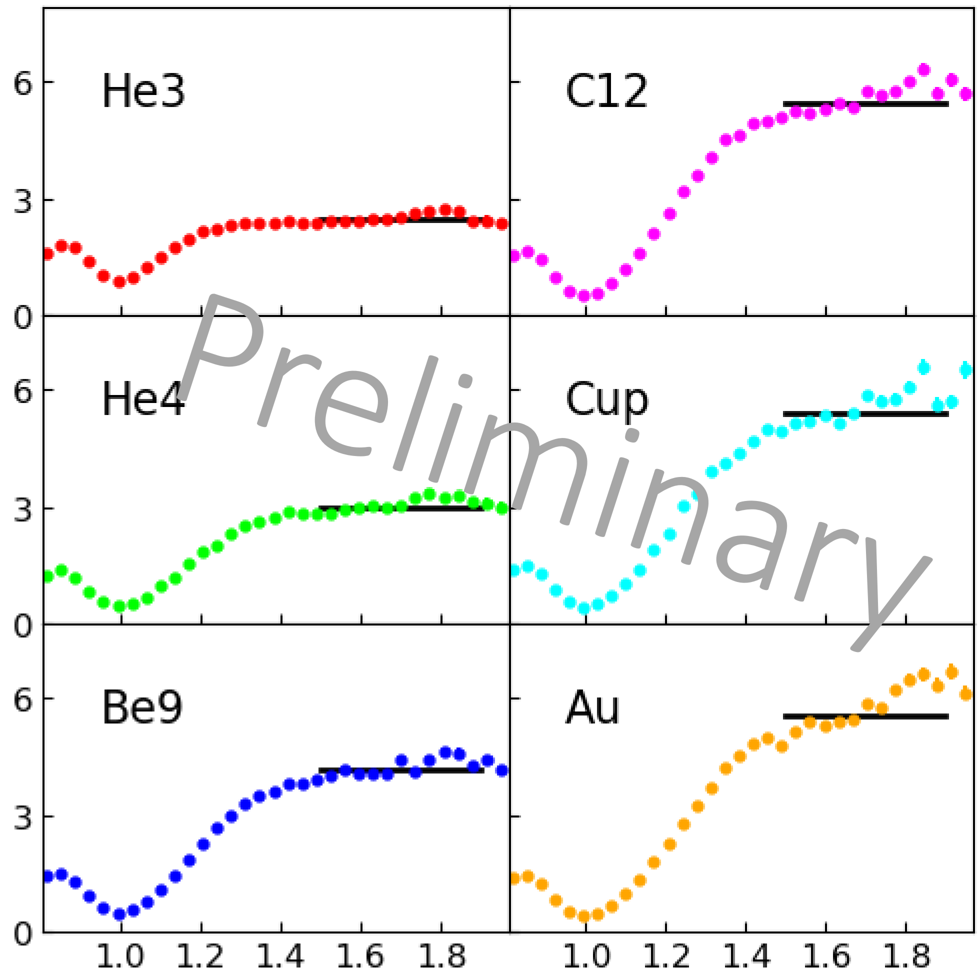
C. Ciofi degli Atti and S. Simula, Phys. Rev. C 53 (1996).



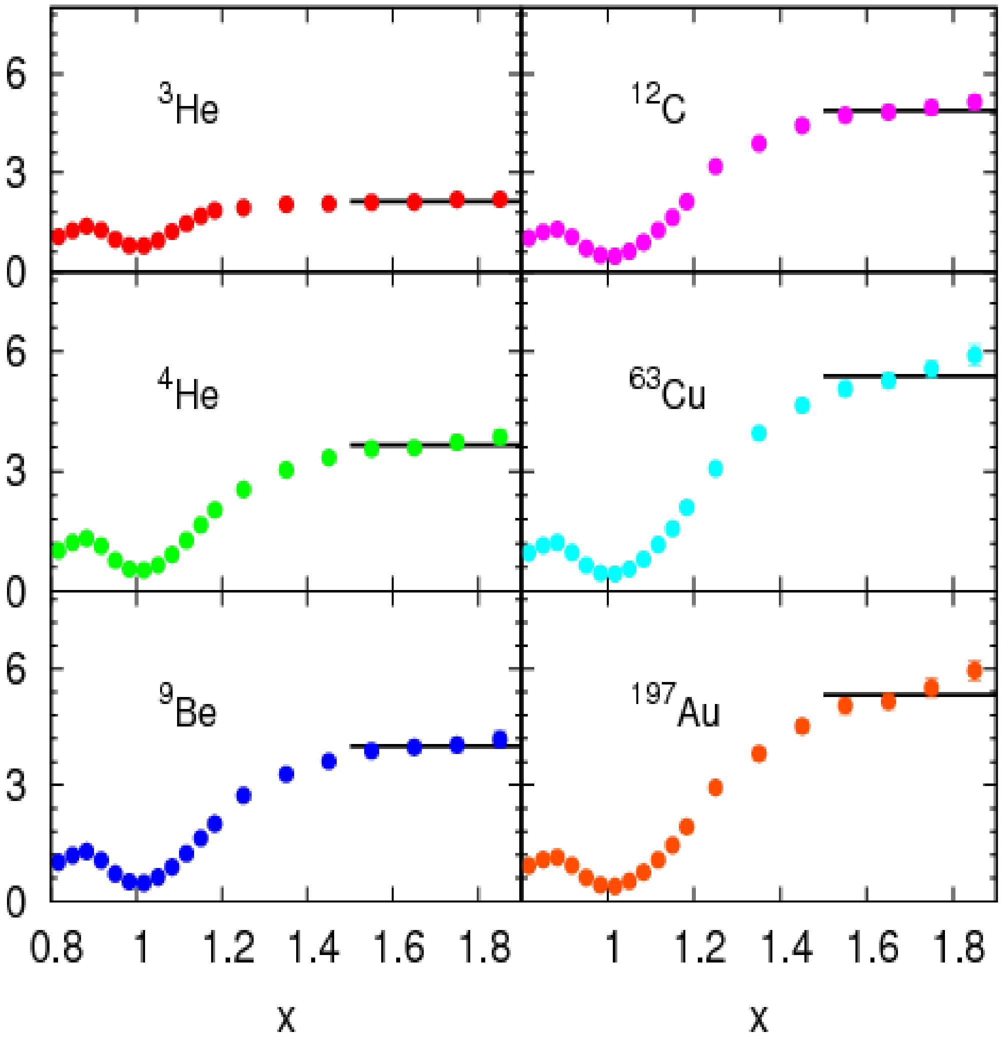
*Fomin et al, PRL **108** (2012) Jlab E02-019*

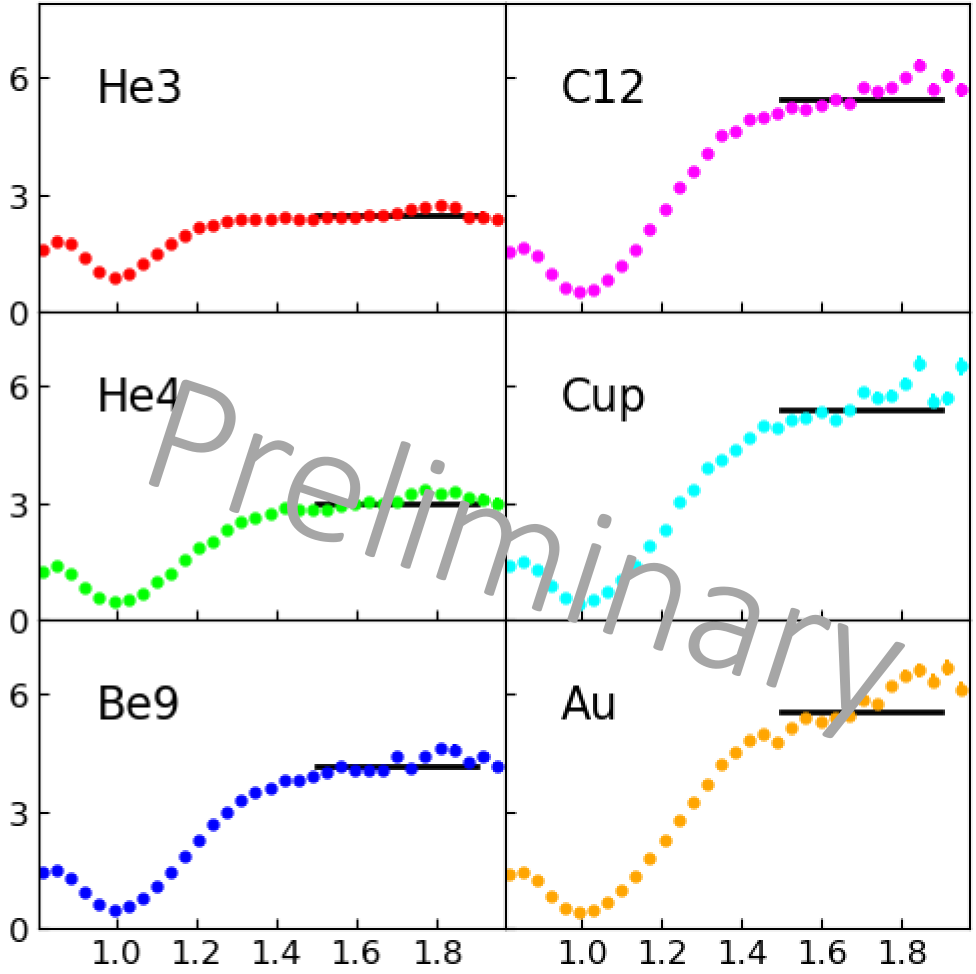
A brief look at our data

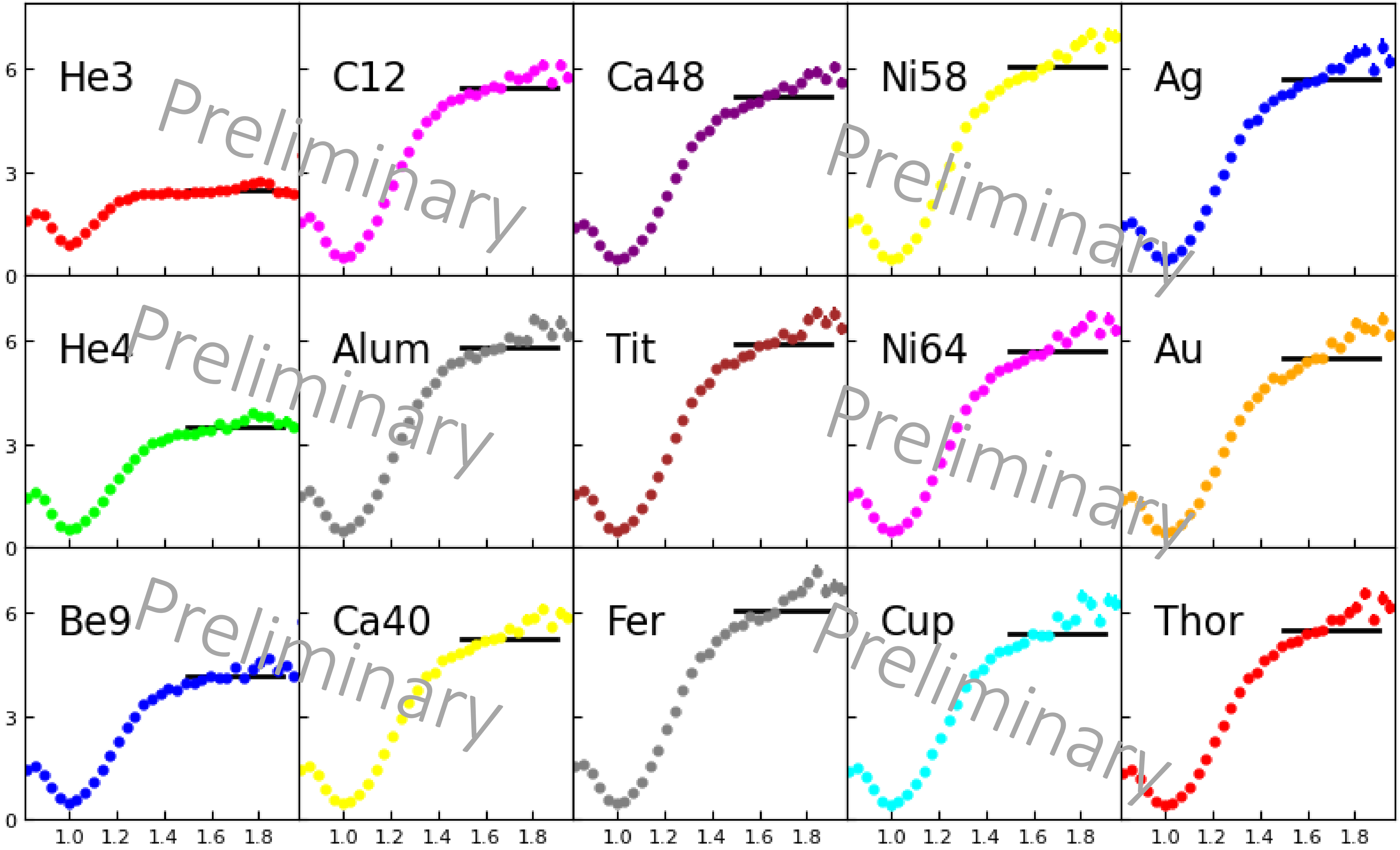
Previously measured a_2	NEW targets
^{3}He	^{10}B
^{4}He	^{11}B
^{9}Be	^{6}Li*
^{12}C	^{7}Li*
^{63}Cu	^{48}Ti
^{197}Au	Sn*
^{40}Ca	^{232}Thor
^{48}Ca	^{58}Ni
^{54}Fe	^{64}Ni
Al	Ag

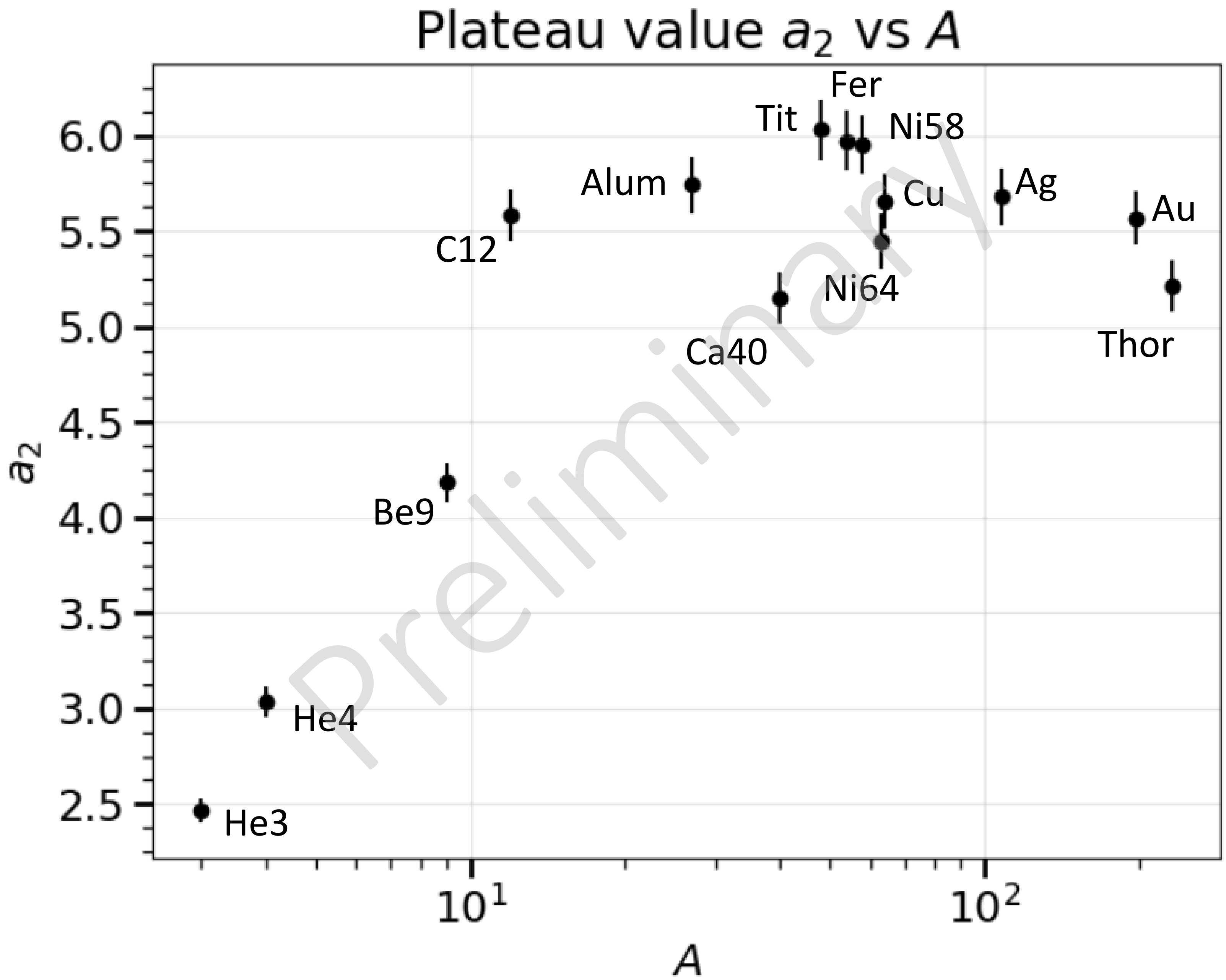


Comparison to previous data






He3
C12
Ca48
Ni58
Ag
He4
Alum
Tit
Ni64
Au
Be9
Ca40
Fer
Cup
Thor
Preliminary
0
3
6
1.0
1.2
1.4
1.6
1.8

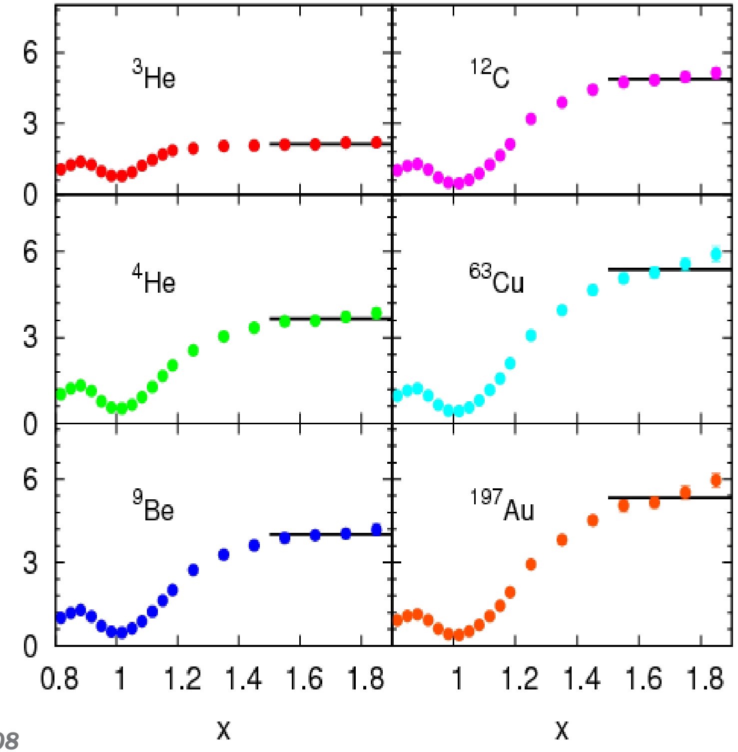


Errors are statistical + estimated systematic from XEM1

Three Nucleon Short Range Correlations (3N SRCs)

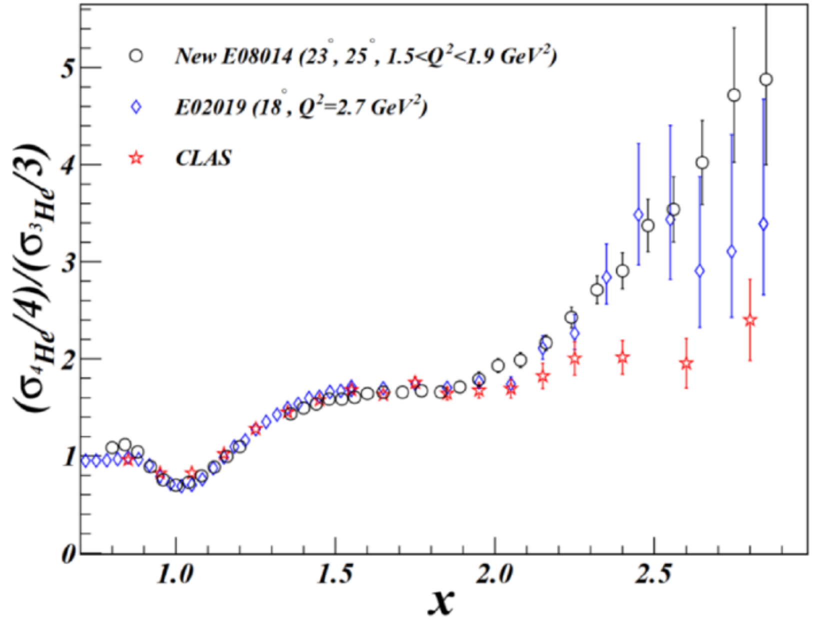
$$\sigma(x,Q^2) = Aa_1\sigma_1(x,Q^2) + \frac{A}{2}a_2\sigma_2(x,Q^2) + \frac{A}{3}a_3\sigma_3(x,Q^2) + \ldots$$

- Previously looked for 2N SRCs
  - $1.4 < x_{bj} < 2.0$



Fomin et al, PRL **108** (2012) Jlab E02-019

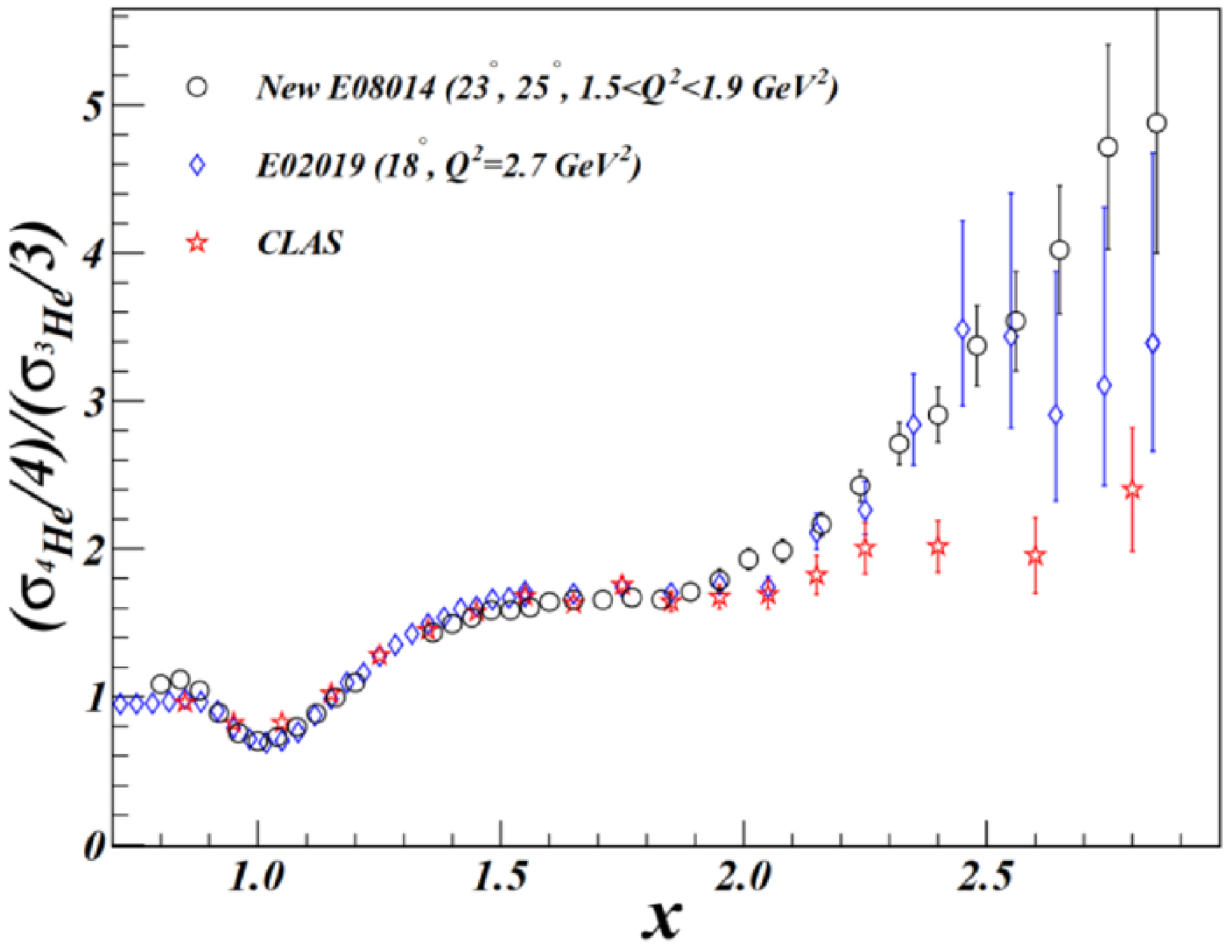
- Where to look for 3N SRCs?
  - $2.4 < x_{bj} < 3.0$



Z. Ye et al, PRC 97 (2018) 6

Previous searches

- ^{3}He is a stable 3 nucleon system
- Measure by taking cross section ratios to ^{3}He
- a 3N SRC plateau should form
  - similar to the 2N SRC plateau



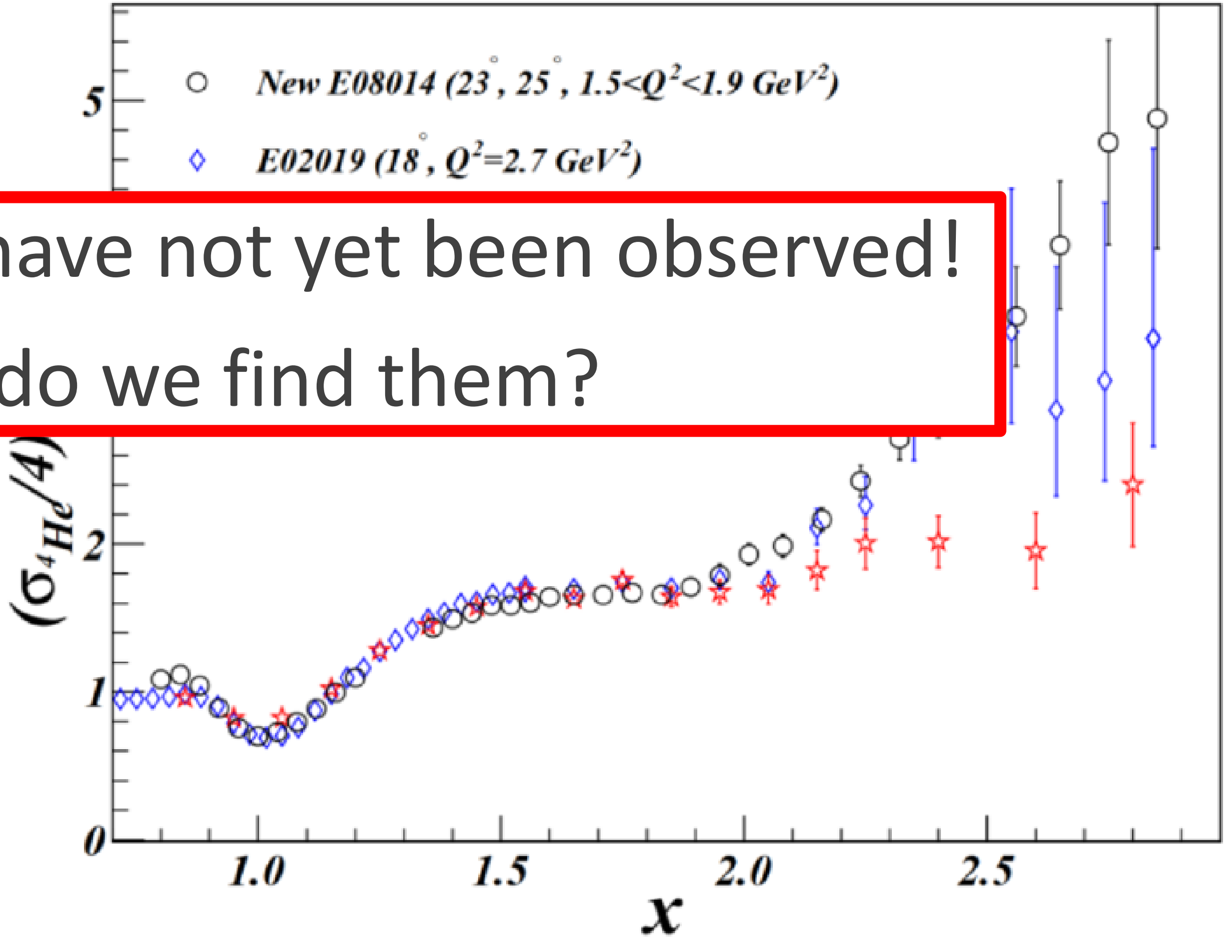
Z. Ye et al, PRC 97 (2018) 6

Previous searches

- ^{3}He is a stable 3 nucleon system
- Measur
section
- a 3N SRC plateau should form
  - similar to the 2N SRC plateau

3N SRCs plateaus have not yet been observed!

So how do we find them?

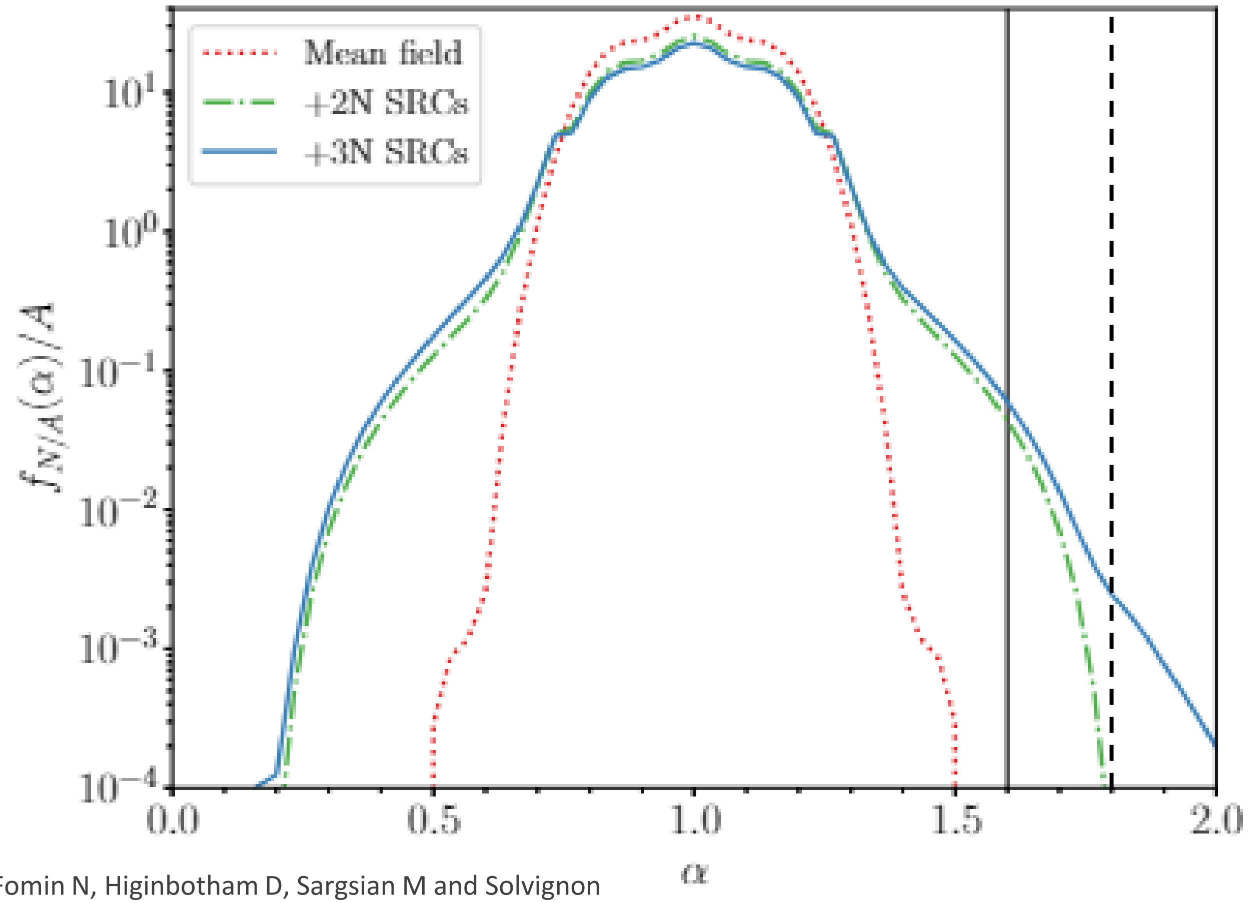


Z. Ye et al, PRC 97 (2018) 6

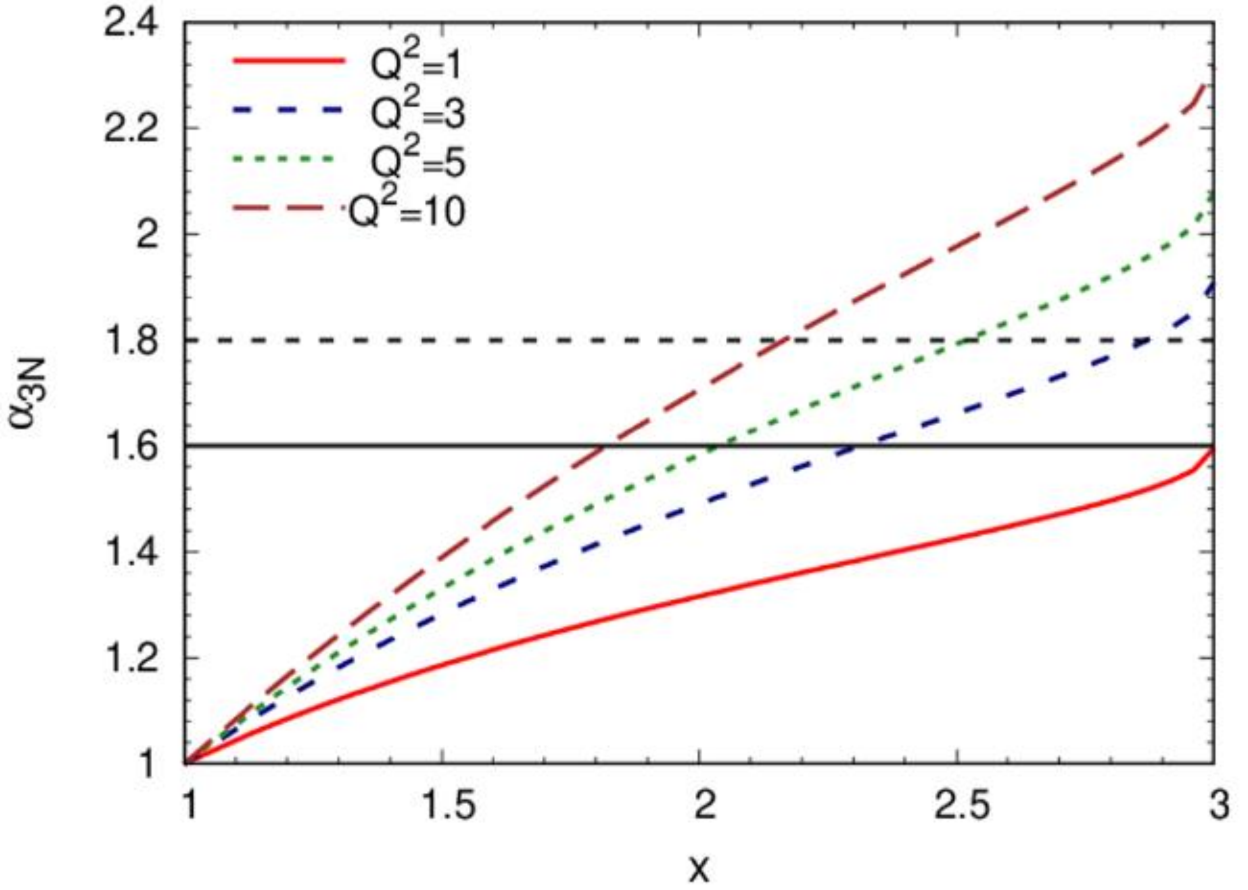
Let's consider another useful parameter

Light cone momentum fraction in a 3N system

$$\alpha_{3N} = 3 - \frac{q_- + 3m_N}{2m_N}\left[1 + \frac{m_S^2 - m_N^2}{W_{3N}^2} + \sqrt{\left(1 - \frac{(m_S^2 + m_N^2)^2}{W_{3N}^2}\right)\left(1 - \frac{(m_S^2 - m_N^2)^2}{W_{3N}^2}\right)}\right]$$

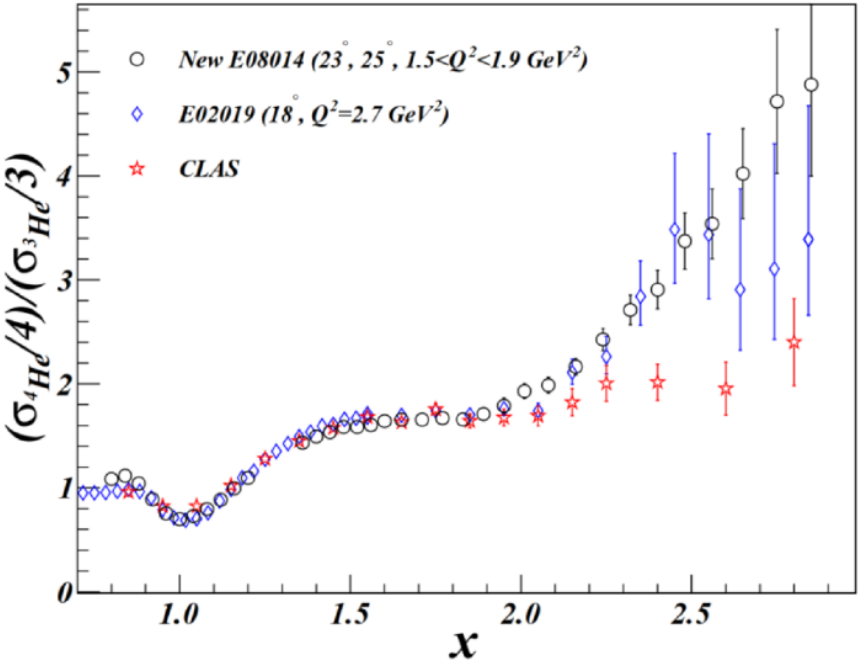


Fomin N, Higinbotham D, Sargsian M and Solvignon P 2017 Ann. Rev. Nucl. Part. Sci. 67 129–159

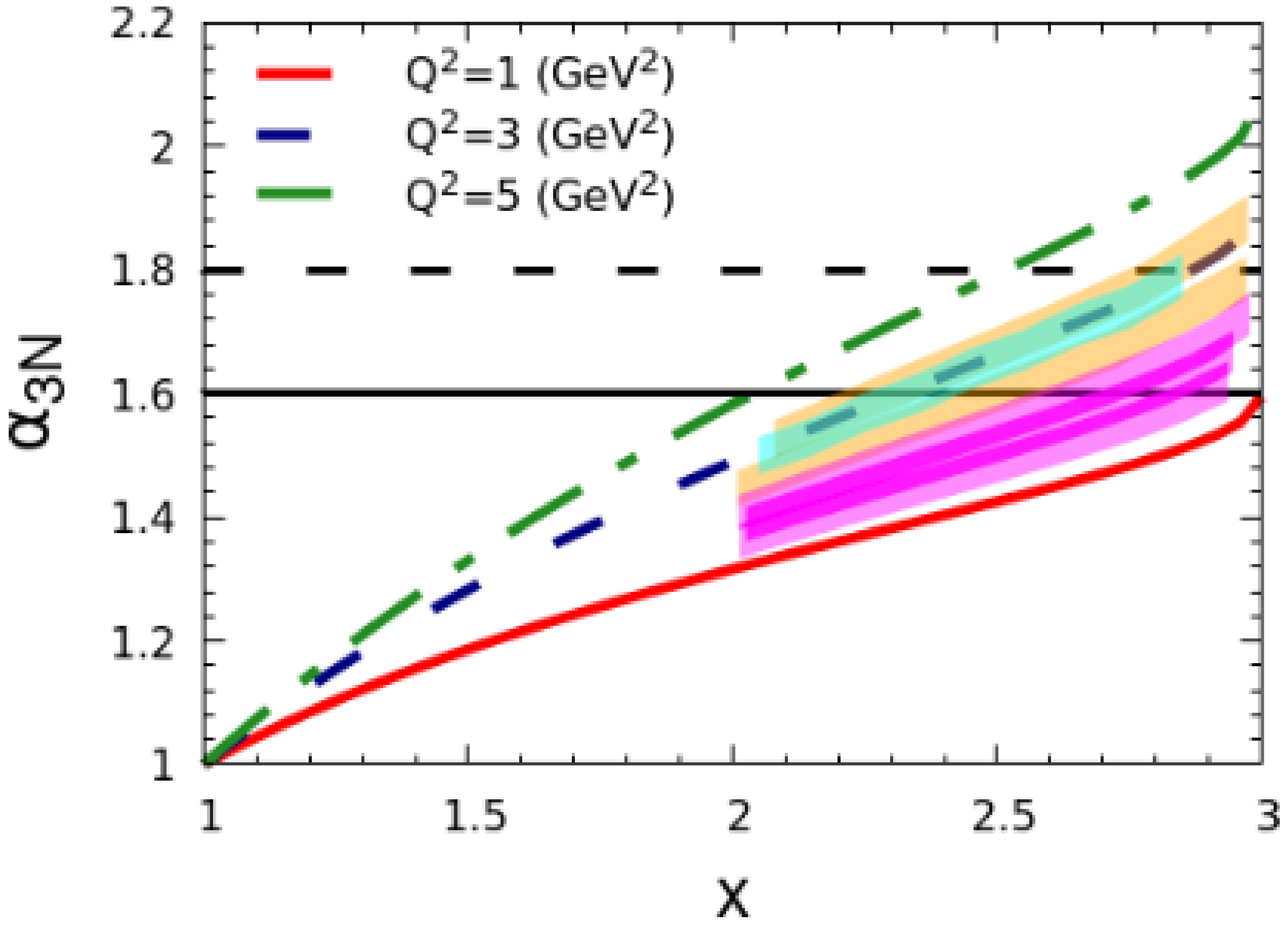


Where have we looked?

- Hall A data
- Hall C data
- Hall C (current) data (XEM2)

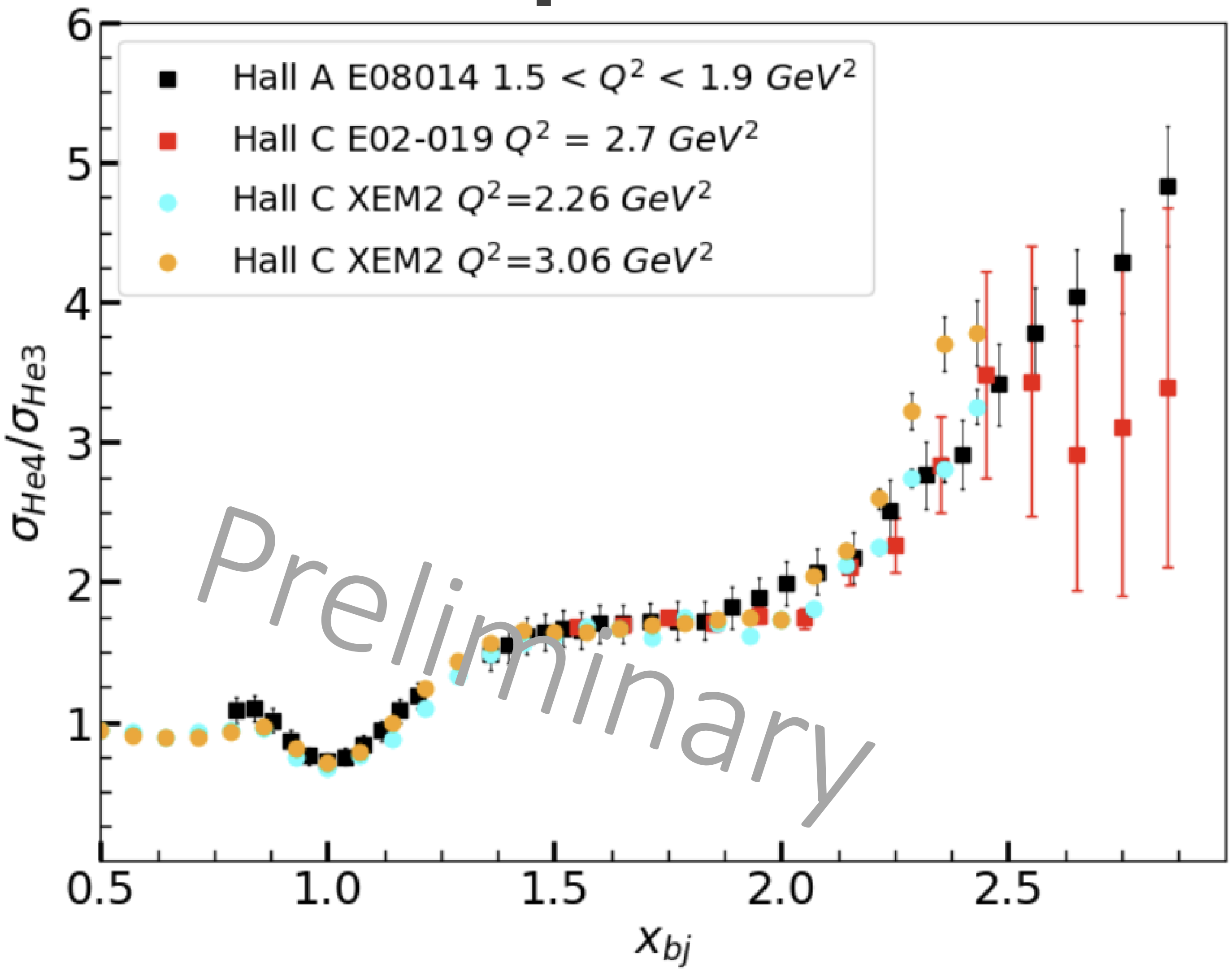


Z. Ye et al, PRC 97 (2018) 6



How does our data compare?

XEM Q^2=3.06 GeV^2 targets
^{3}He
^{4}He
^{9}Be
^{10}B
^{11}B
^{12}C
^{40}Ca
Cu
Au

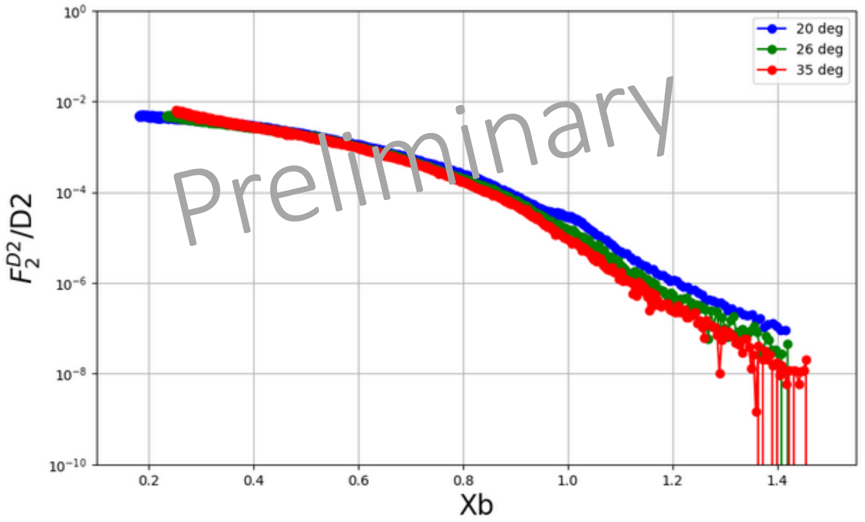


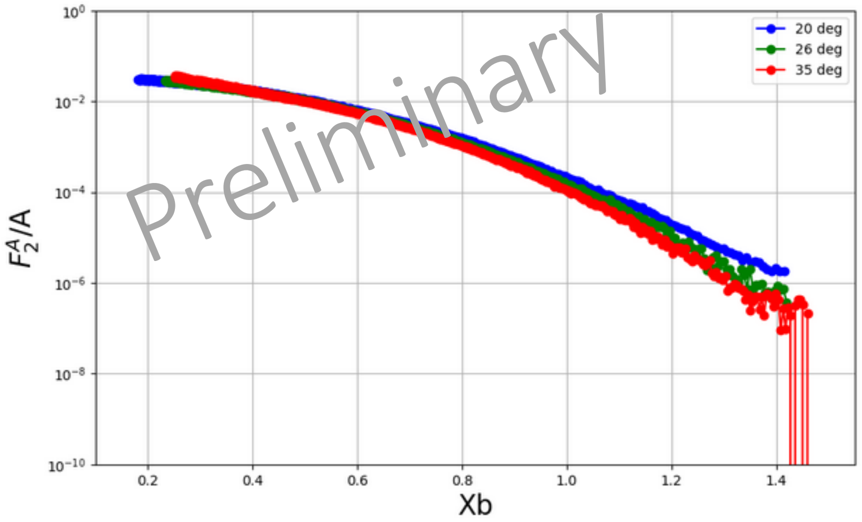
Nuclear structure function for x>1? Super Fast Quarks

Preliminary deuteron and carbon structure functions up to x = 1.4

Scaling of F(x, Q^2) is observed up to x ≈ 0.7-0.8 (depending on Q^2)

Large QE contribution at x ≈ 1 and above destroys the DIS scaling





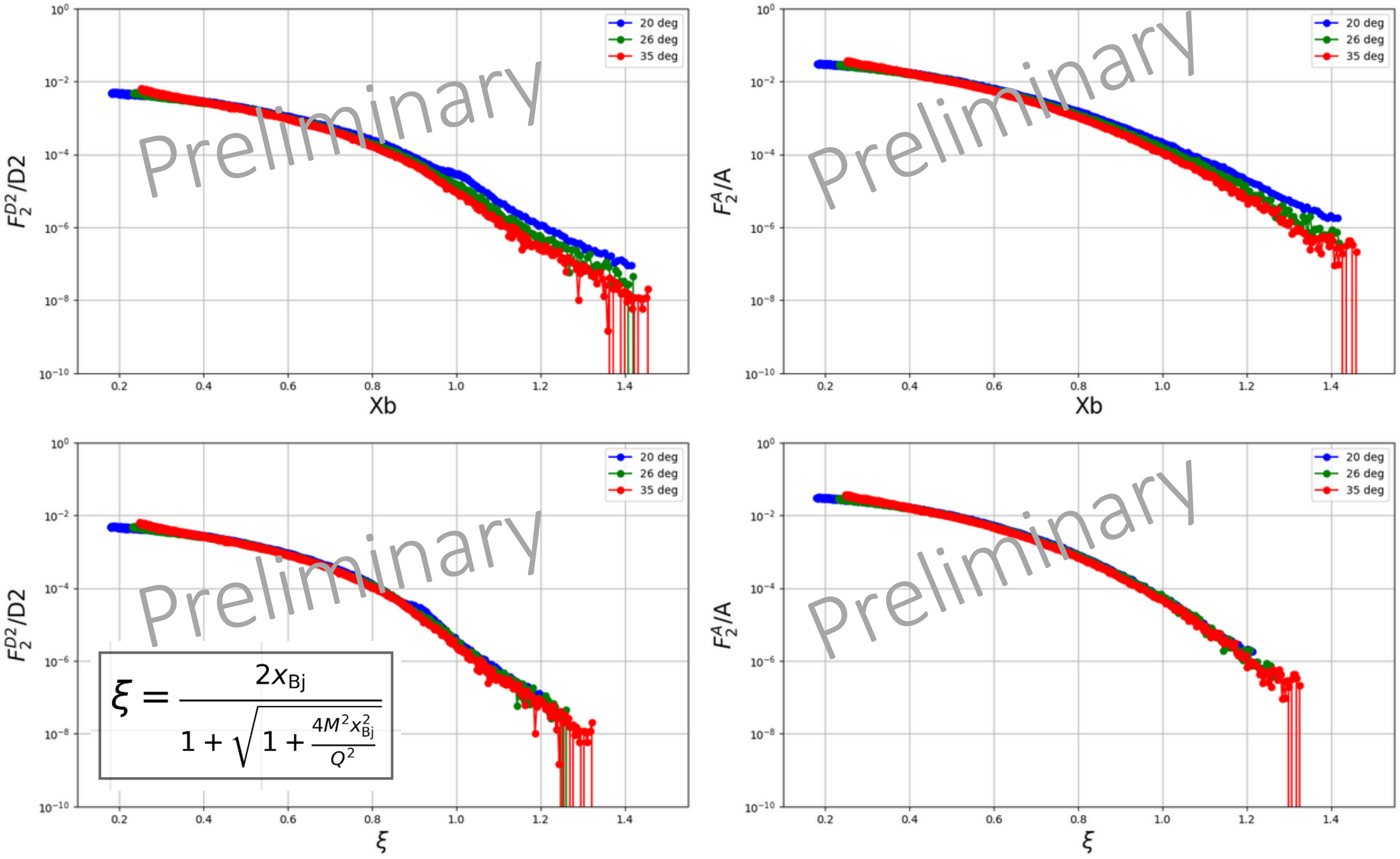
Nuclear structure function for x>1? Super Fast Quarks

Preliminary deuteron and carbon structure functions up to x = 1.4

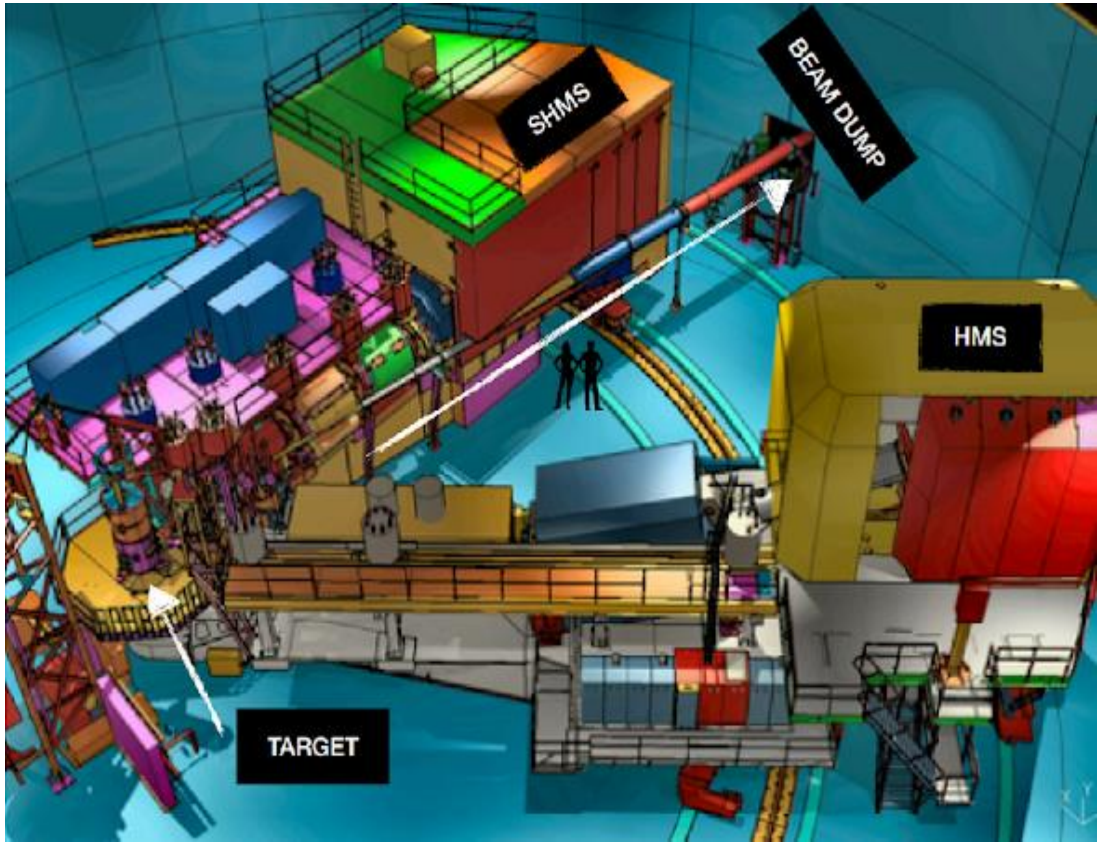
Scaling of F(x, Q^2) is observed up to x ≈ 0.7-0.8 (depending on Q^2)

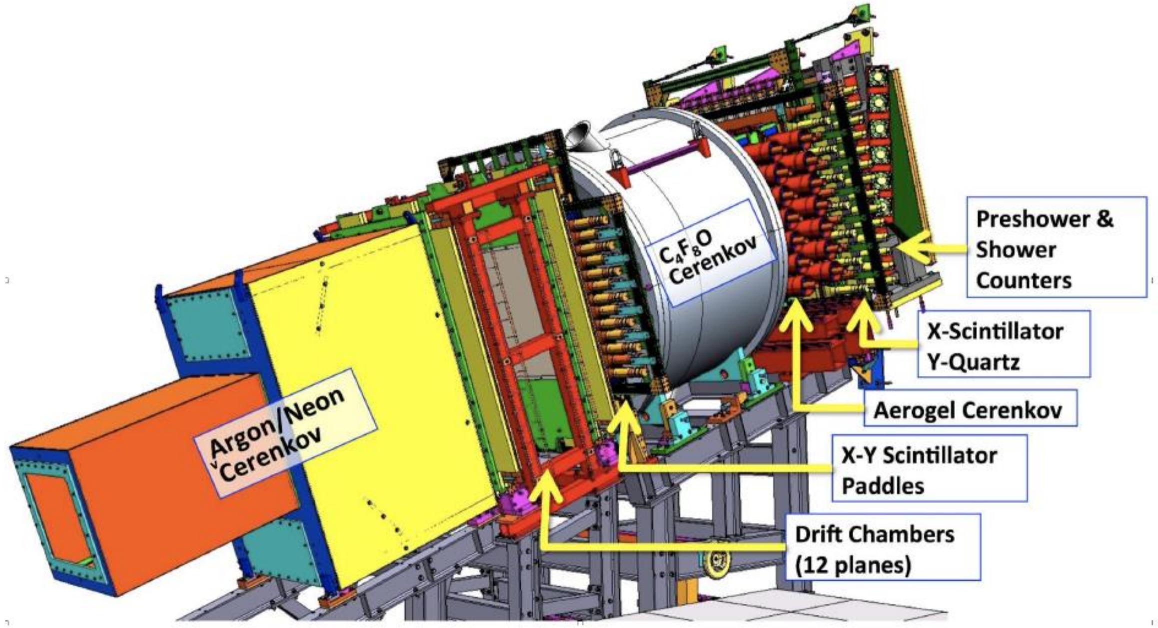
Scaling vs Nachtmann ξ (an improved version of Bjorken x) extends to ξ > 1, with small hint of QE peak in deuteron at 20^o

A natural consequence of quark-hadron duality, which may allow us to probe the distribution of super-fast quarks in nuclei (quarks with x>1)



Analysis updates



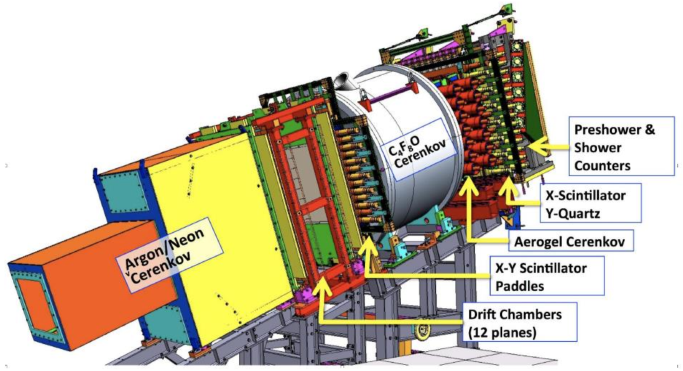


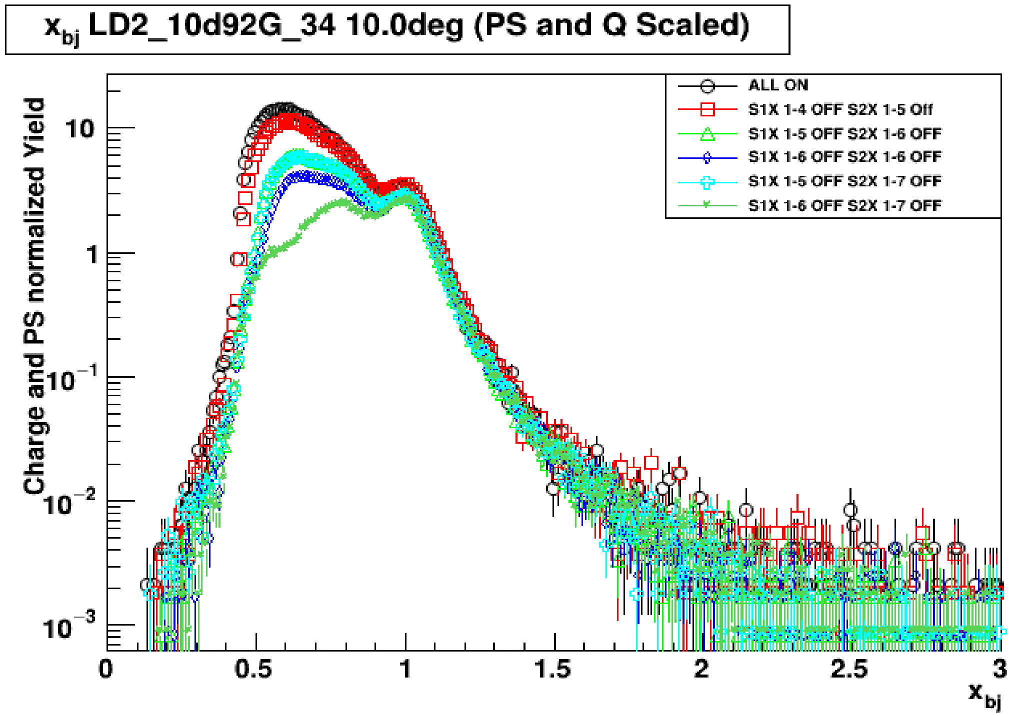
SHMS detector stack

Very unique configuration

- Want to measure $x_{bj} > 1$ events
- Most events are $x_{bj} < 1$ events **<-** we don't particularly care about these
- Disabling hodoscope paddles and preshower blocks reduces the number of low x_{bj} events
- Causes some headaches for analysis

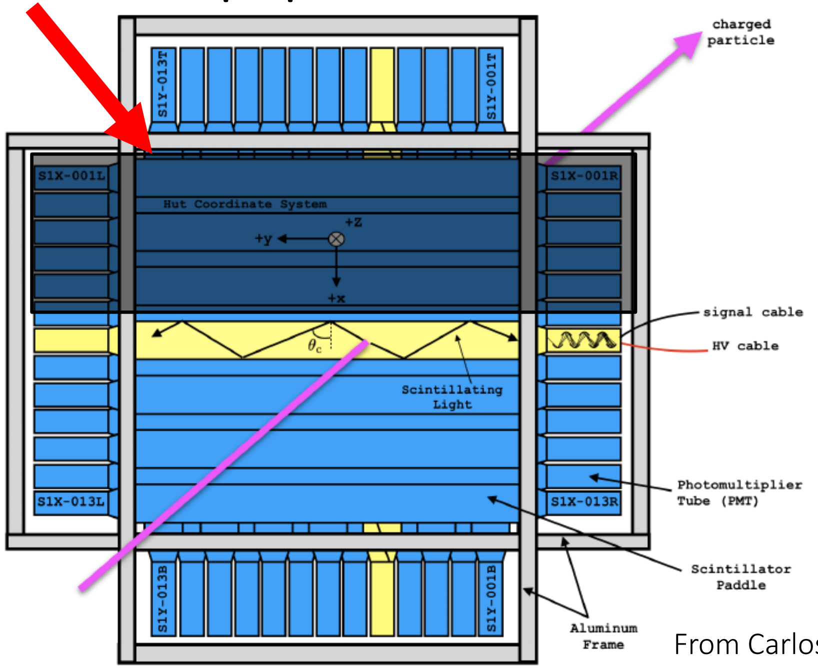
SHMS detector stack





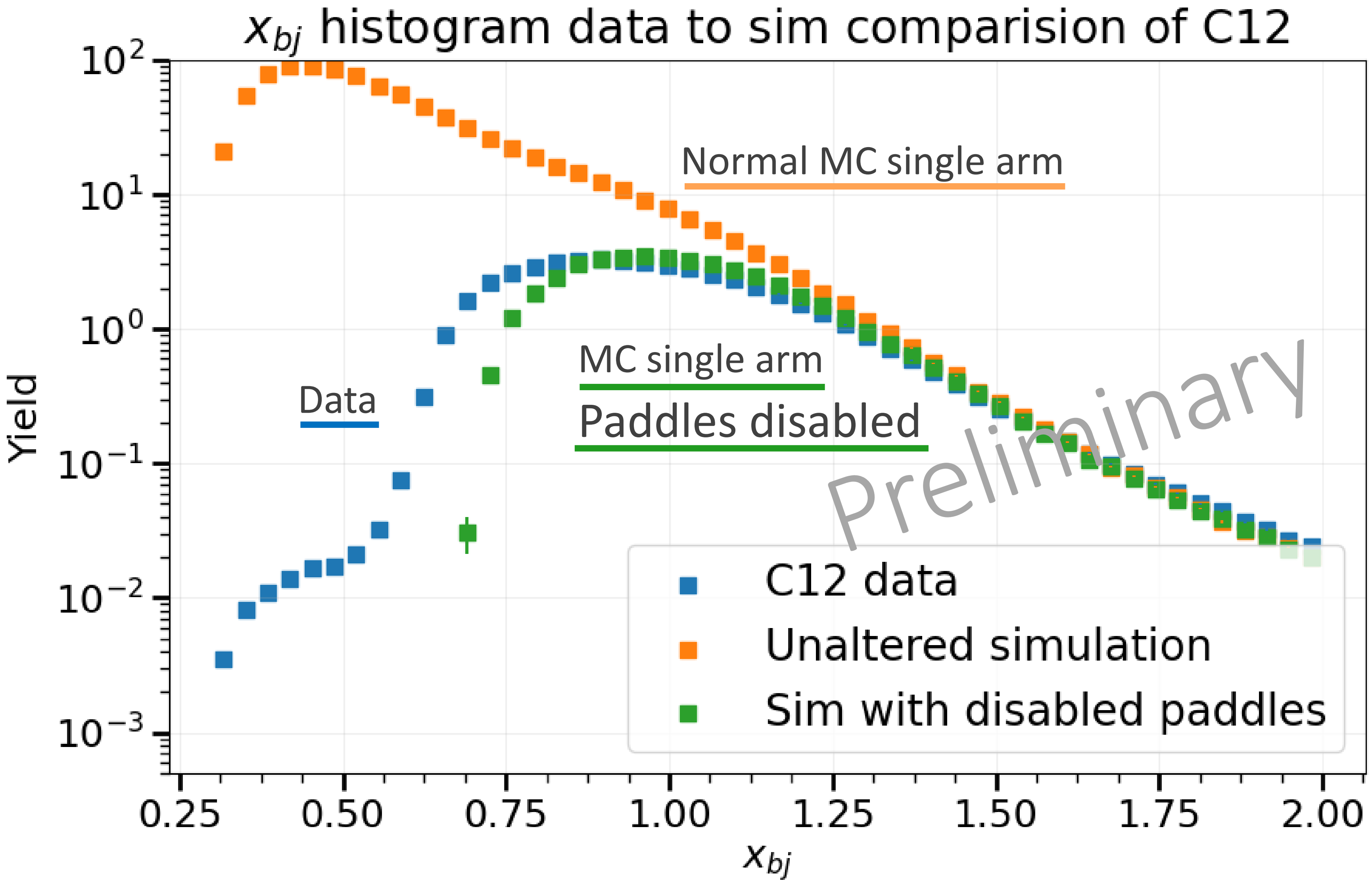
Tyler Hague

Disabled hodoscope paddles



From Carlos Yero's Thesis

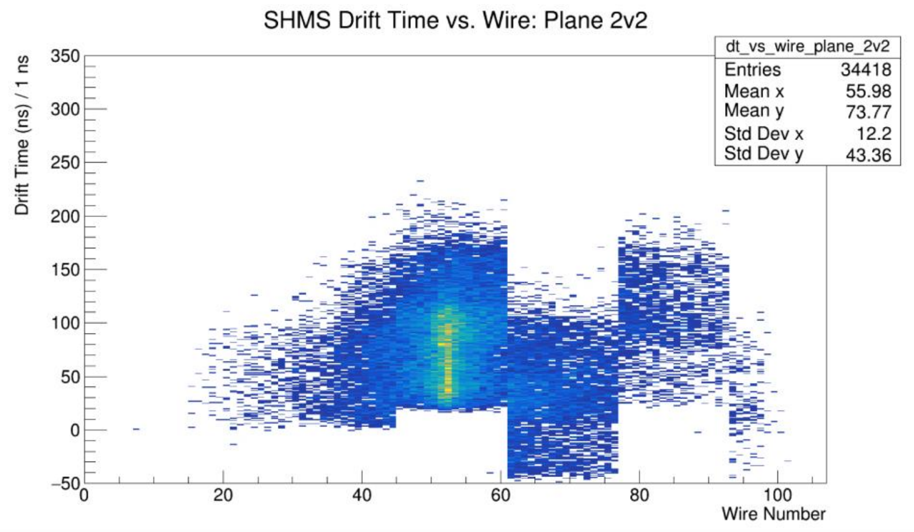
Simulation comparison



Drift chamber calibration

- Typical drift chamber calibration led to large shifts in the drift time
- Generally, the "uncalibrated" planes did not have these shifts

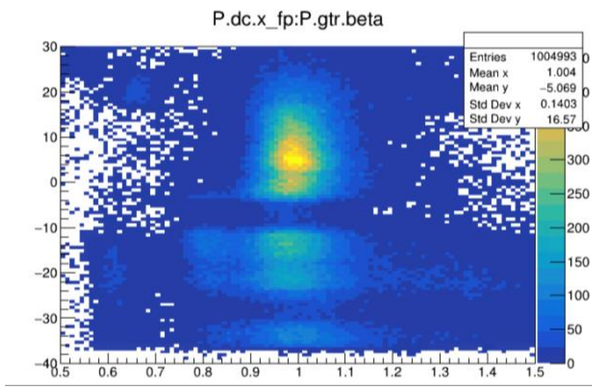
"Calibrated" Plot



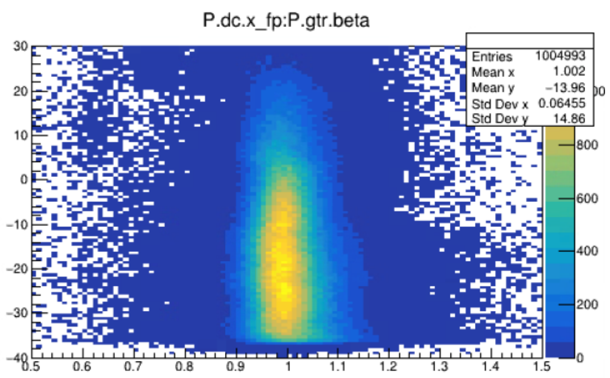
Zoe Wolters

- Clear Issue with drift times
- DC calibration relies heavily on the Hodoscope Calibration
- Hodoscope was recalibrated

Previous hodoscope calibration



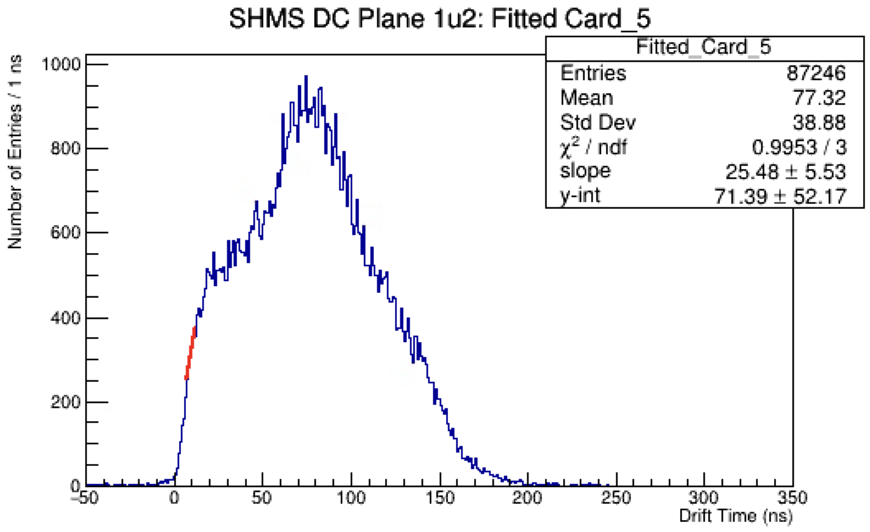
New hodoscope calibration

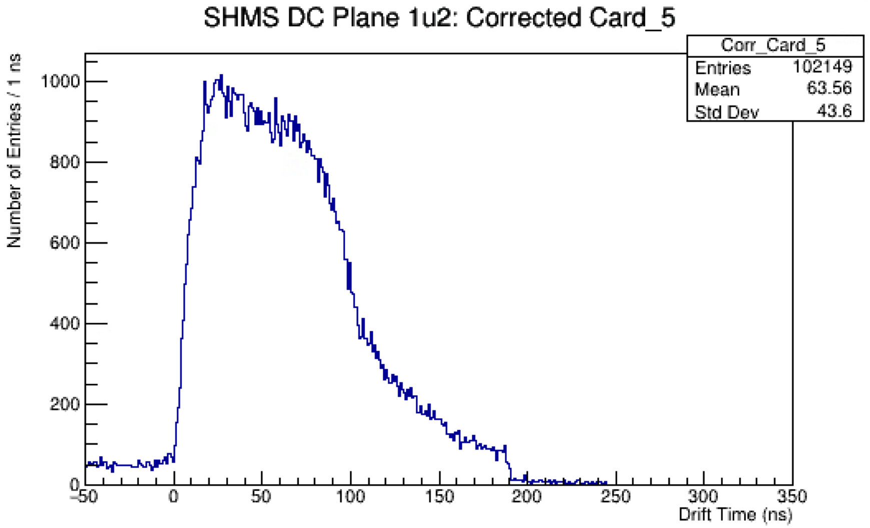


Drift chamber calibration

- The drift times now include two peaks
- Which peak needs to be fitted for the drift distances?
- To Get Rid of this Secondary Peak

- Calibrate DC with a SHMS run that has:
  - Low current
  - Low rate
  - Thin target
  - Use a run early within the experiment
- Drift times no longer the secondary peak
- A fit can now be done along the straight line



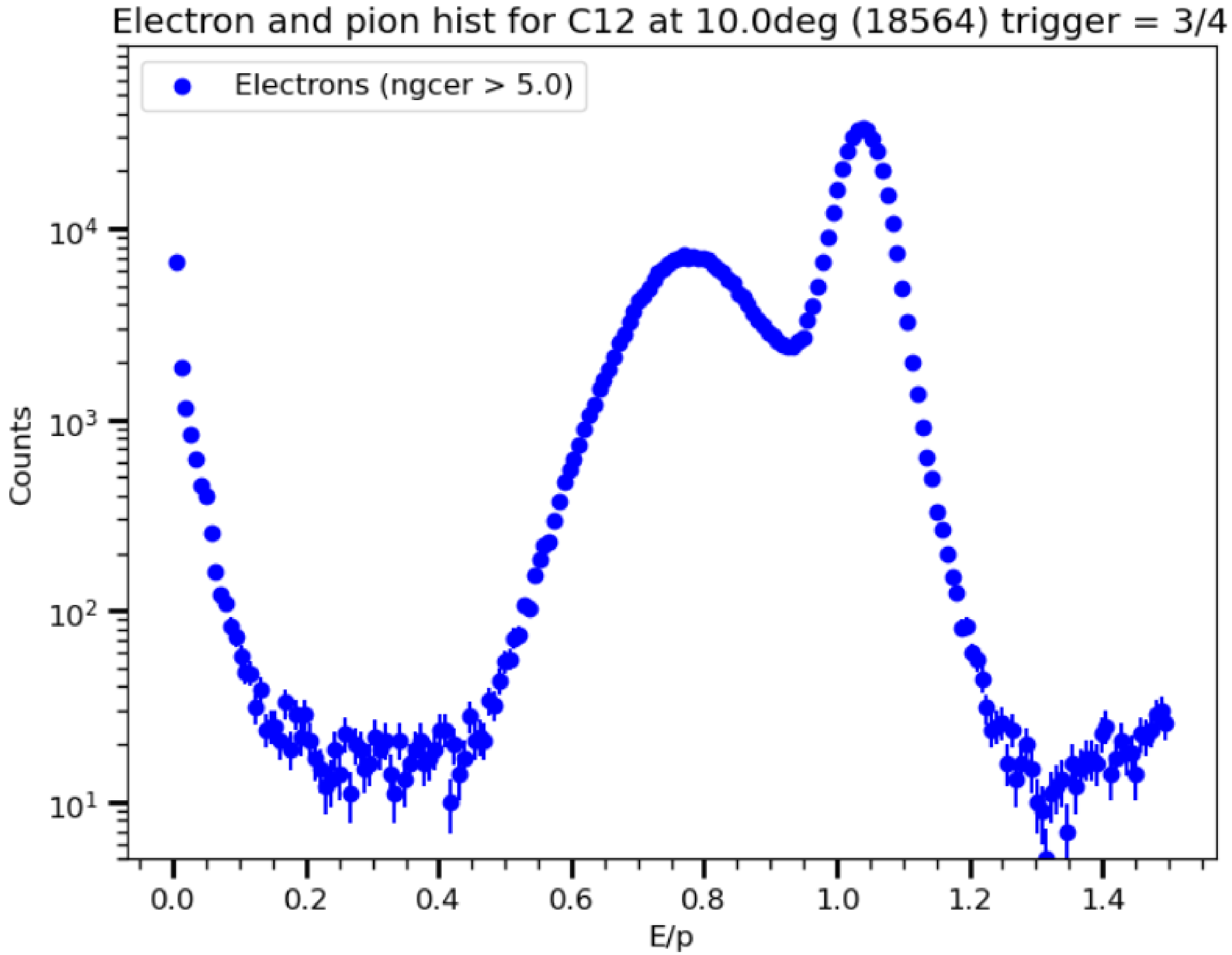


Zoe Wolters

Calorimeter calibration

- Double peak structure in energy/momentum distribution
- Disabled preshower blocks capture less of the electron's energy
- Careful calibration gets true electron peak be centered at E/p = 1
- Second peak is significantly reduced in stronger triggers (Elreal, ELclean)

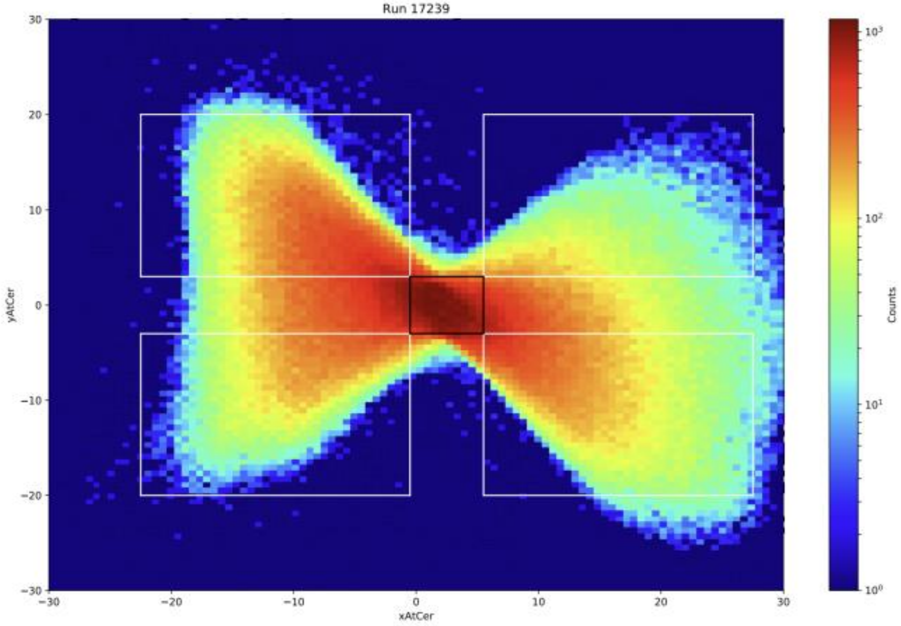
Ramon Ogaz

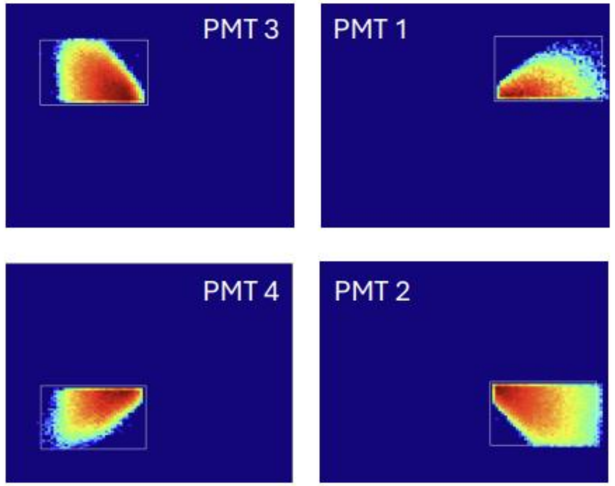


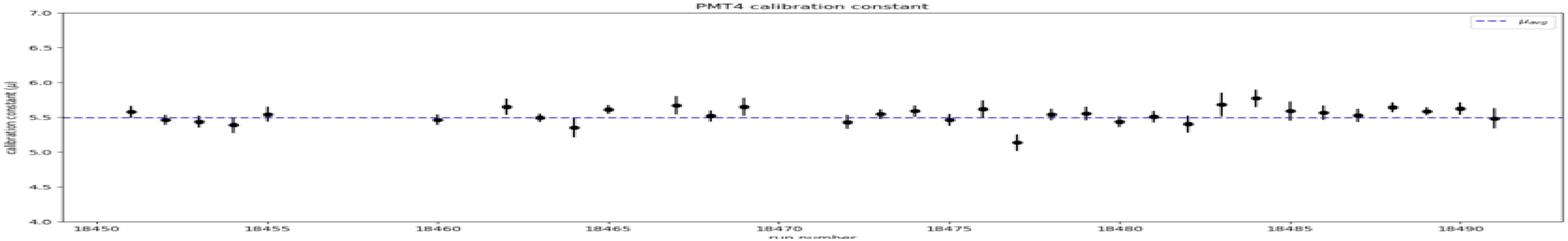
Cherenkov calibration

Each PMT constant calibrated and checked for stability over many runs

Julio Gutierrez

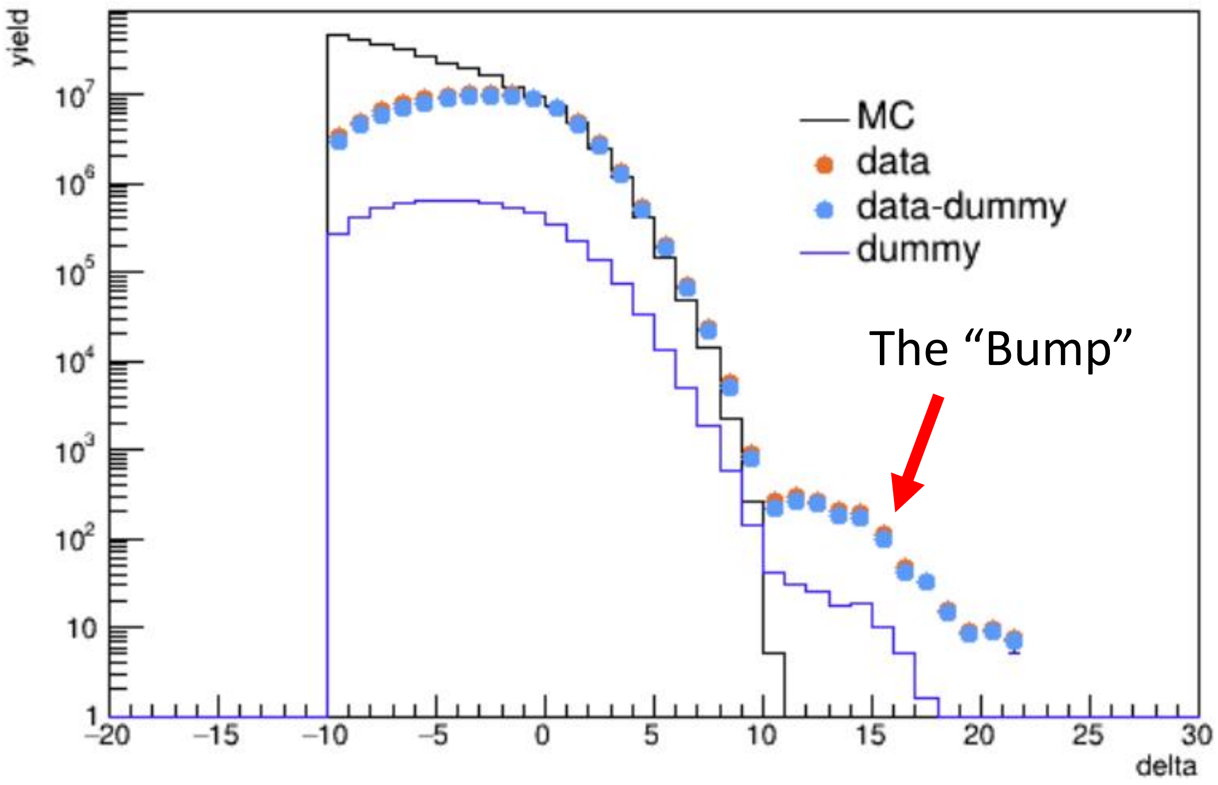




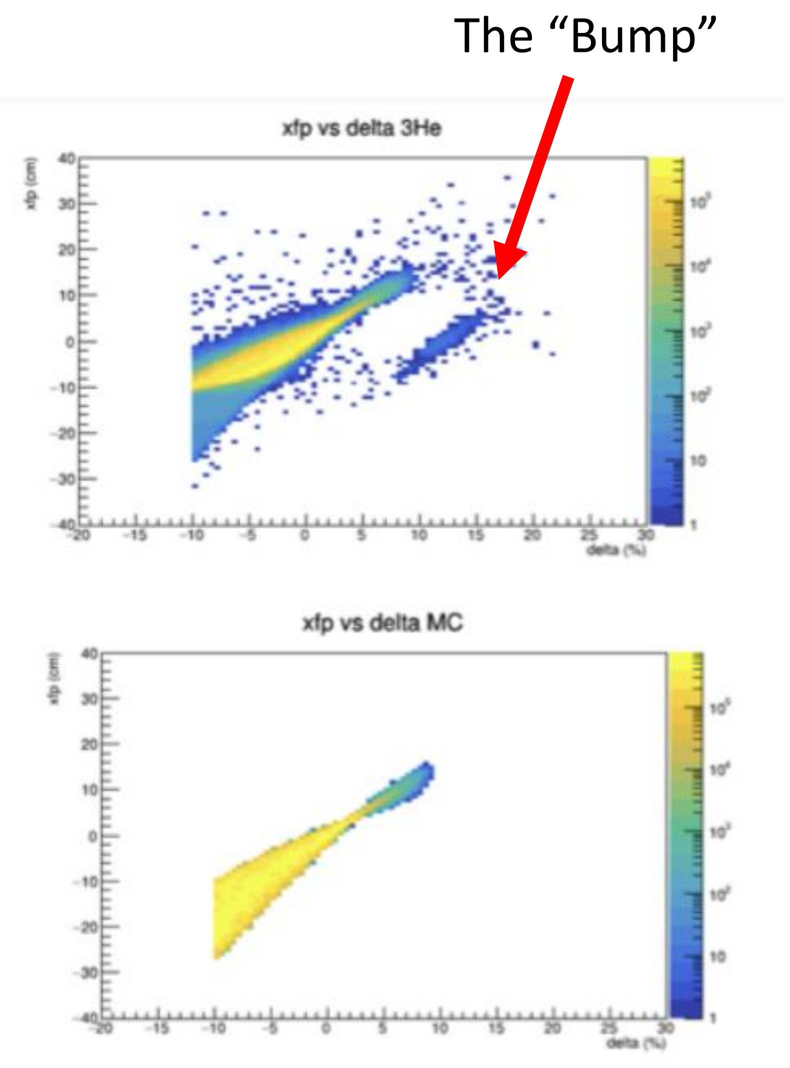


Interesting mystery: Extended target "bump"

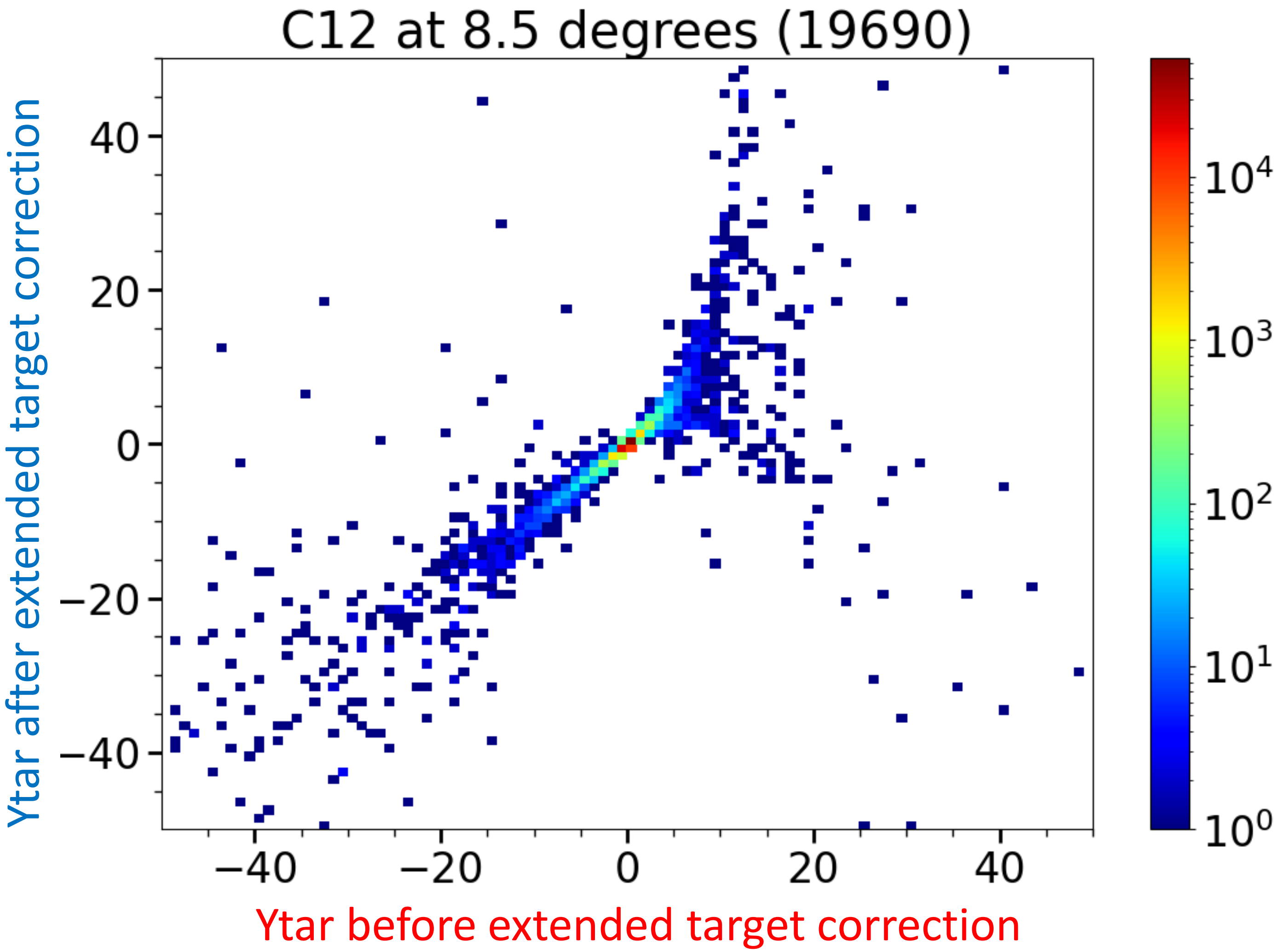
- Excess data at higher delta not seen in simulation
- Excess data is in SRC region of our datasets



Burcu Duran

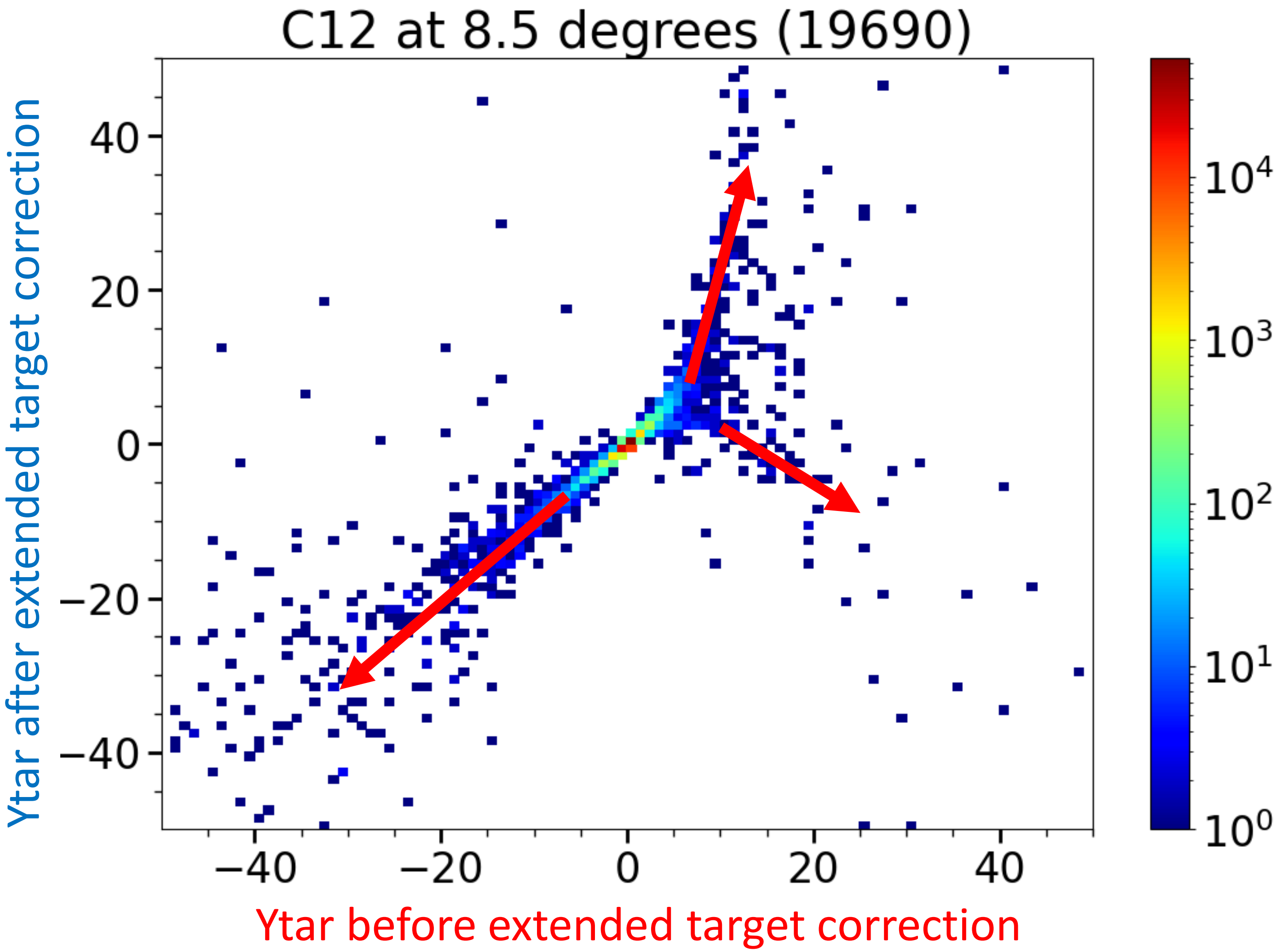


Interesting mystery: Extended target “bump”



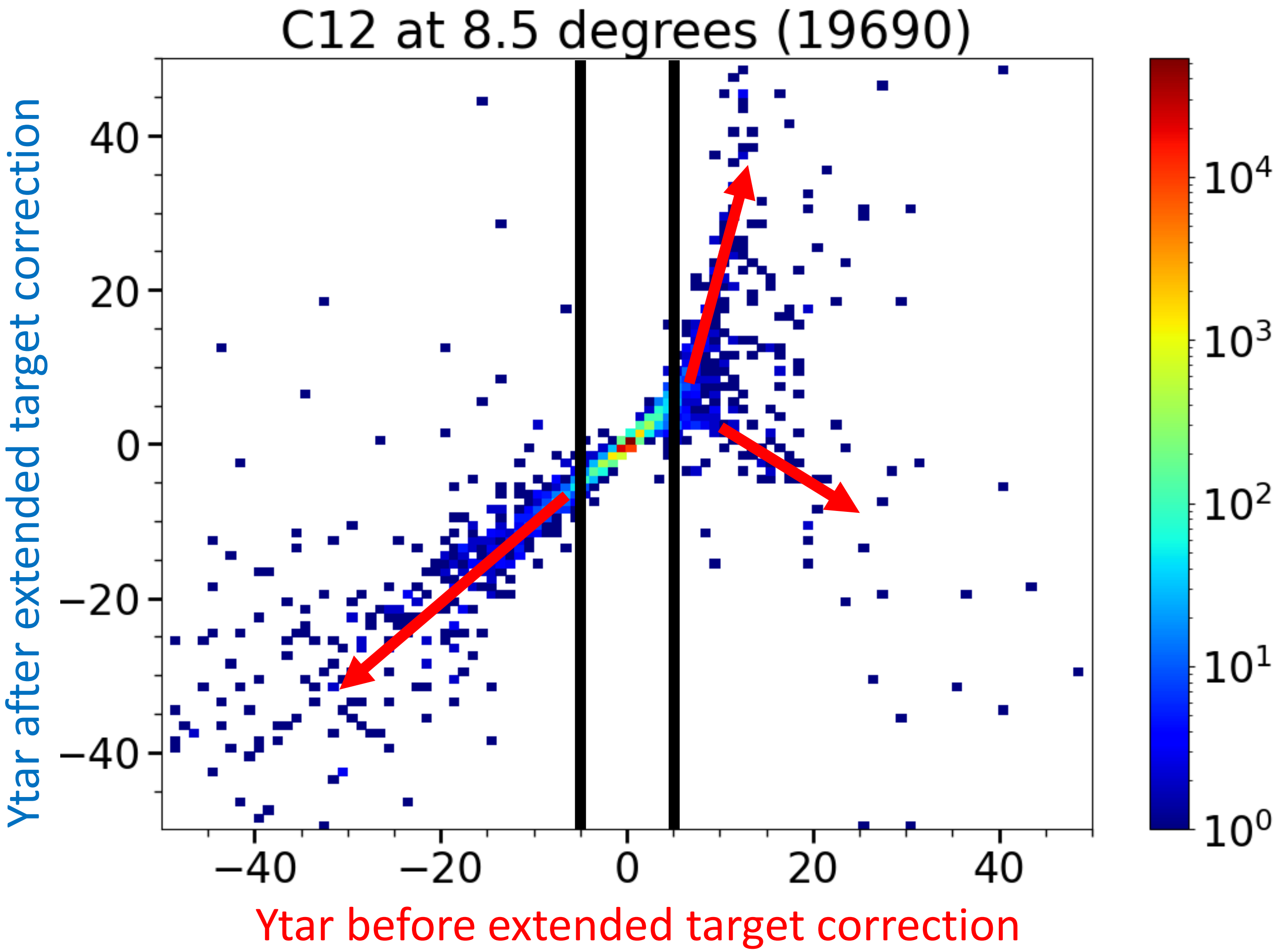
Interesting mystery: Extended target "bump"

- Upper ytar region forks



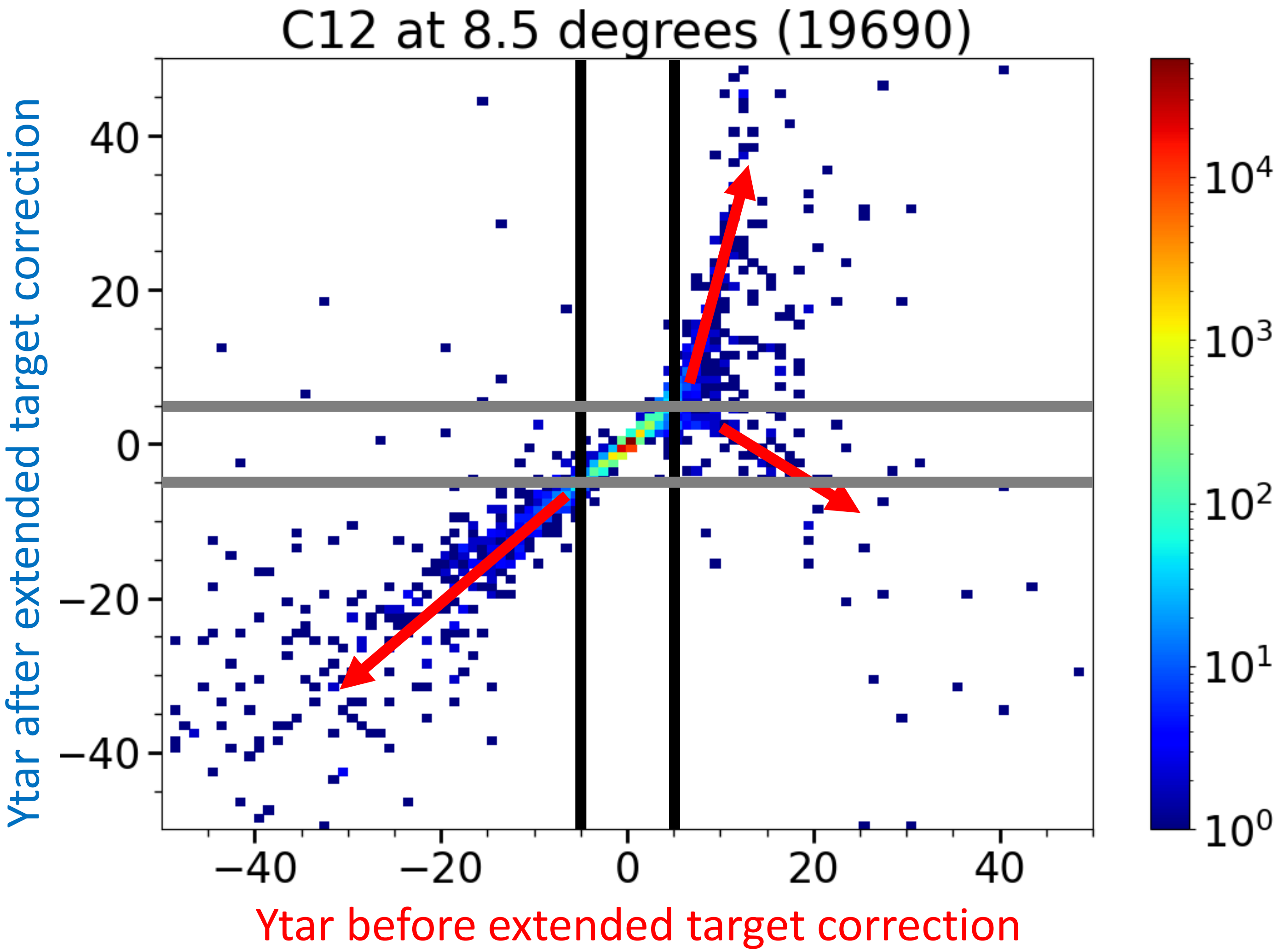
Interesting mystery: Extended target "bump"

- Upper ytar region forks
- Consider ytar cut before the extended target correction



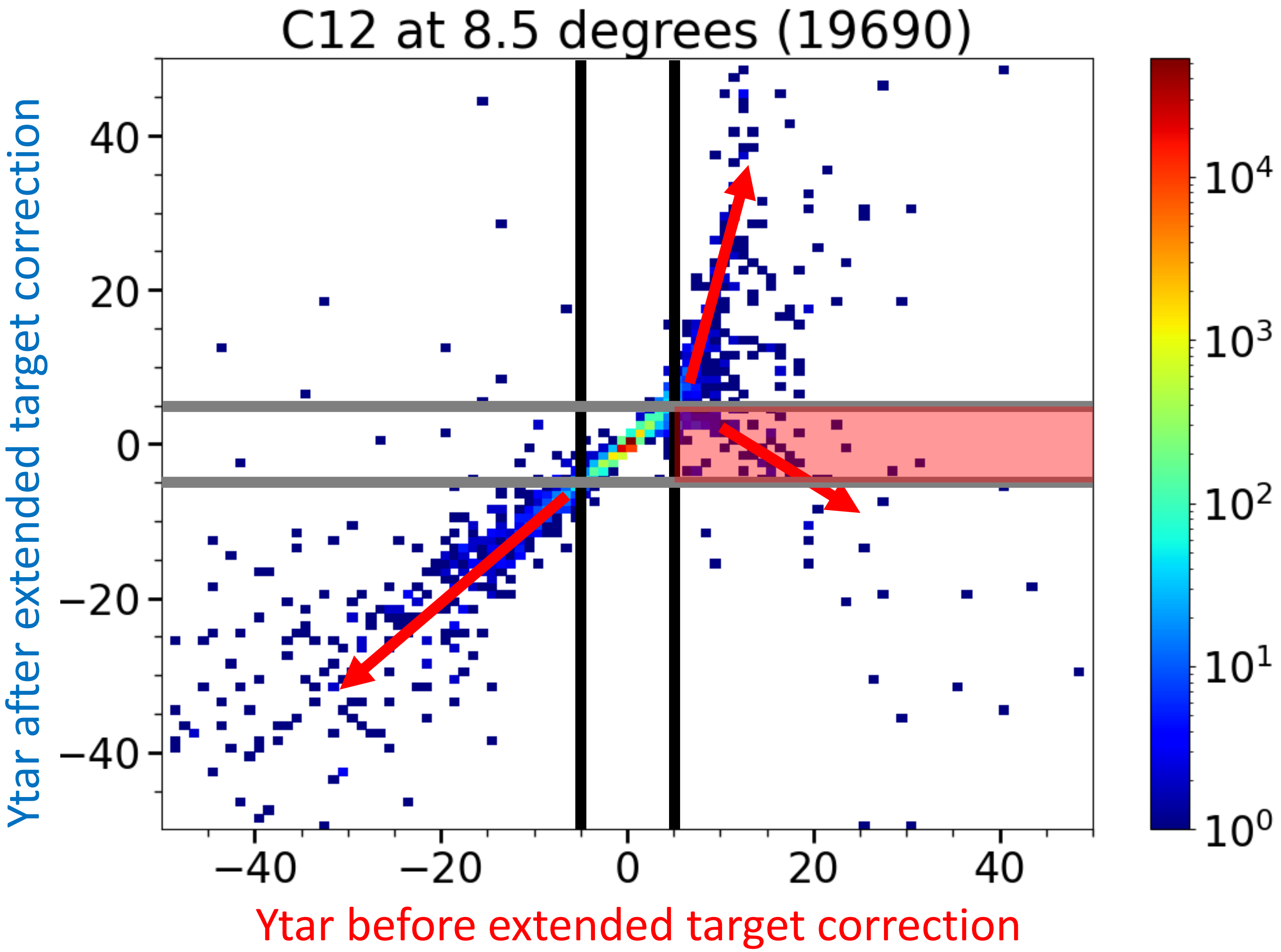
Interesting mystery: Extended target "bump"

- Upper ytar region forks
- Consider ytar cut before the extended target correction
- Now consider ytar cut after extended target correction



Interesting mystery: Extended target “bump”

- Upper ytar region forks
- Consider ytar cut before the extended target correction
- Now consider ytar cut after extended target correction
- Events far beyond the initial cut now survive due to the lower branch in the fork
- Testing solutions:
  - Cut along react.z variable
  - Confining ytar during extended target correction



Ongoing progress:

Pass0.5

- Implemented calibrations
- Calibrations checks
- Spectrometer settings

Tyler Hague

Pass1

- Finalize calibrations
- Implement energy and angle offsets
- Proper treatment of extended target correction?

Outstanding (Pending/Active) Batch Farm Jobs

Outstanding Jobs | Recent Jobs | Mem Efficiency | CPU Efficiency

Filter

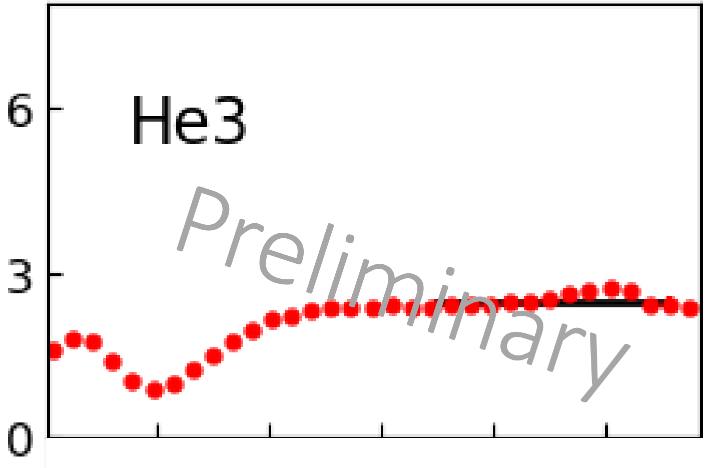
User Name	Account	Pending	Running	Holding	Other Jobs
aaustreg	halld	15	25	0	0
agsandov	hallc	0	1	0	0
alessio	clas12	0	1	0	0
alfab	halld	0	6	0	0
asportes	clas12	1,976	5,332	0	1
atac	hallc	7,815	46	0	0
barryp	jam	0	1	0	0
ccocuzza	jam	0	1	0	0
clas12-2	hallb-pro	0	101	0	0
clas12-4	hallb-pro	0	2	0	0
		17,846	**10,327**	**294**	**3**

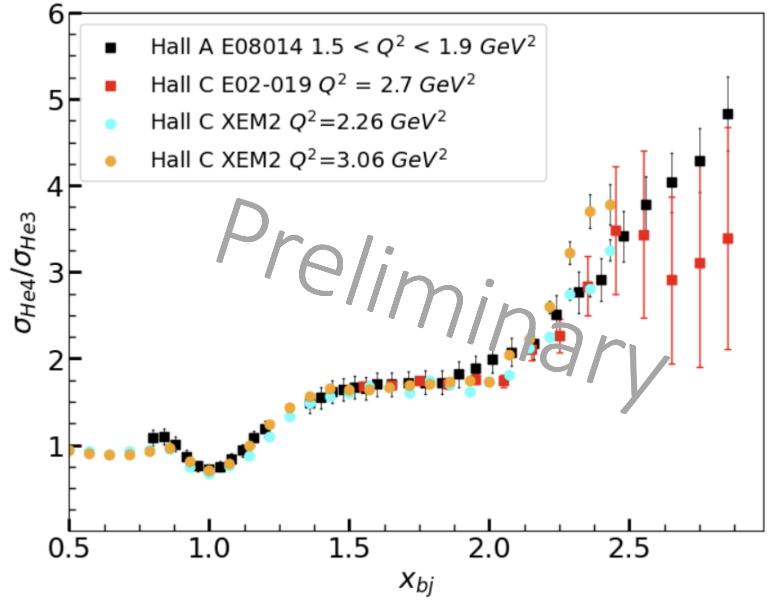
Sorry if we use a lot of HallC cache space in the near future :(

We have a lot of data

Conclusion and future work:

- “Calibrations are finished”!
- Replaying pass 1 of data
- Finalize energy and angle offsets
- Include 200 missing runs
- Ongoing systematic studies
- Extract a_2 plateau values!
- Observe(?) a 3N SRC plateau!





Acknowledgement

Spokespeople:

John Arrington (LBL), Nadia Fomin (UTK) & Dave Gaskell (JLab)

Graduate Students:

Cameron Cotton (UVA)*, Abishek Karki* (MSU), Casey Morean* (UTK), Jordan O'Kronley (UTK), Ramon Ogaz (UTK), Abhyuday Sharda (UTK), Sebastian Vasquez (UCR), Zoe Wolters (UNH)

* = Graduated/Escaped

Other Collaborators:

Miguel Arratia (UCR), Dipangkar Dutta (MSU), Shujie Li (LBL), Dien Nguyen (UTK),
Nathaly Santiesteban (UNH), Xiaochao Zheng (UVA), Burcu Duran (NMSU), Tyler Hague (JLab)

XEM

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