Update on A1 study with polarized eHe3 DIS for EIC early science

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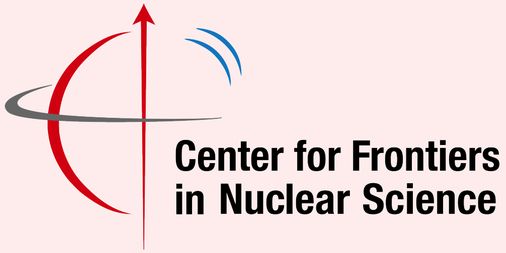
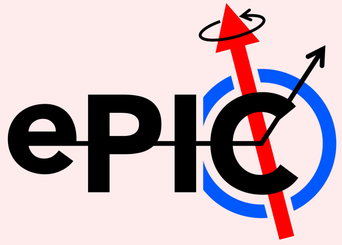
Stony Brook University

CFNS Friday Meeting
05/02/2025



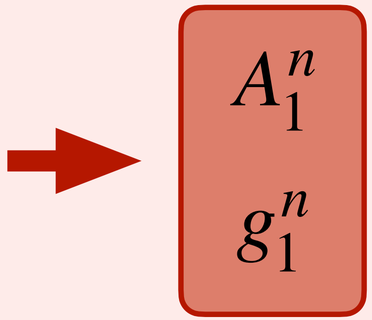


What is available for the first 5 years:

EIC Early Science Timeline

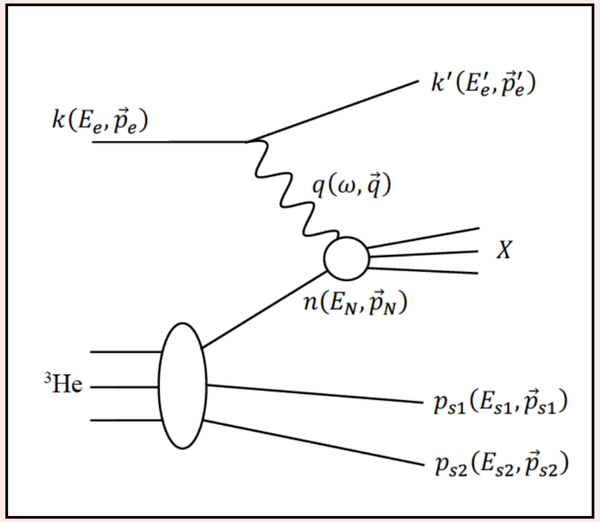
	Species	Energy (GeV)	Luminosity/year (fb-1)	Electron polarization	p/A polarization
YEAR 1	e+Ru or e+Cu	10 x 115	0.9	NO (Commissioning)	N/A
YEAR 2	e+D e+p	10 x 130	11.4 4.95 - 5.33	LONG	NO TRANS
YEAR 3	e+p	10 x 130	4.95 - 5.33	LONG	TRANS and/or LONG
YEAR 4	e+Au e+p	10 x 100 10 x 250	0.84 6.19 - 9.18	LONG	N/A TRANS and/or LONG
YEAR 5	e+Au e+3He	10 x 100 10 x 166	0.84 8.65	LONG	N/A TRANS and/or LONG
Note: the eA luminosity is per nucleon					

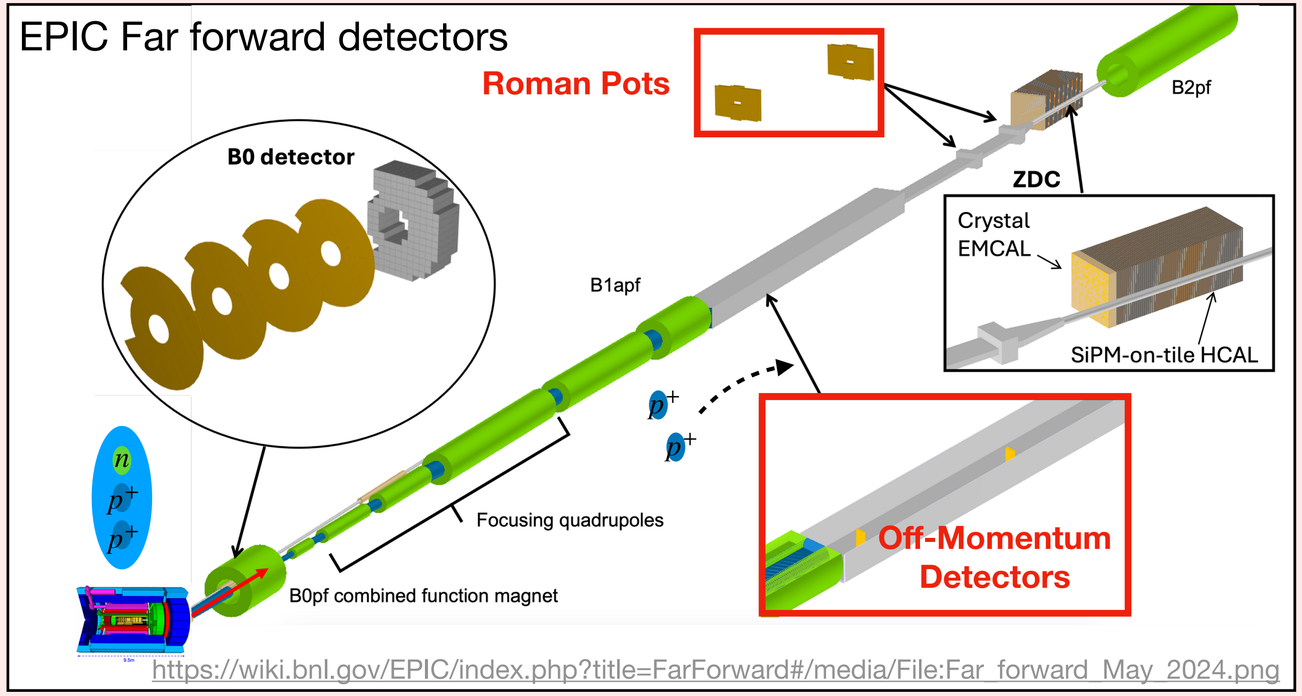
RP and OMD will be installed



A_1^n Double spectator tagging

Diagram of the DIS process

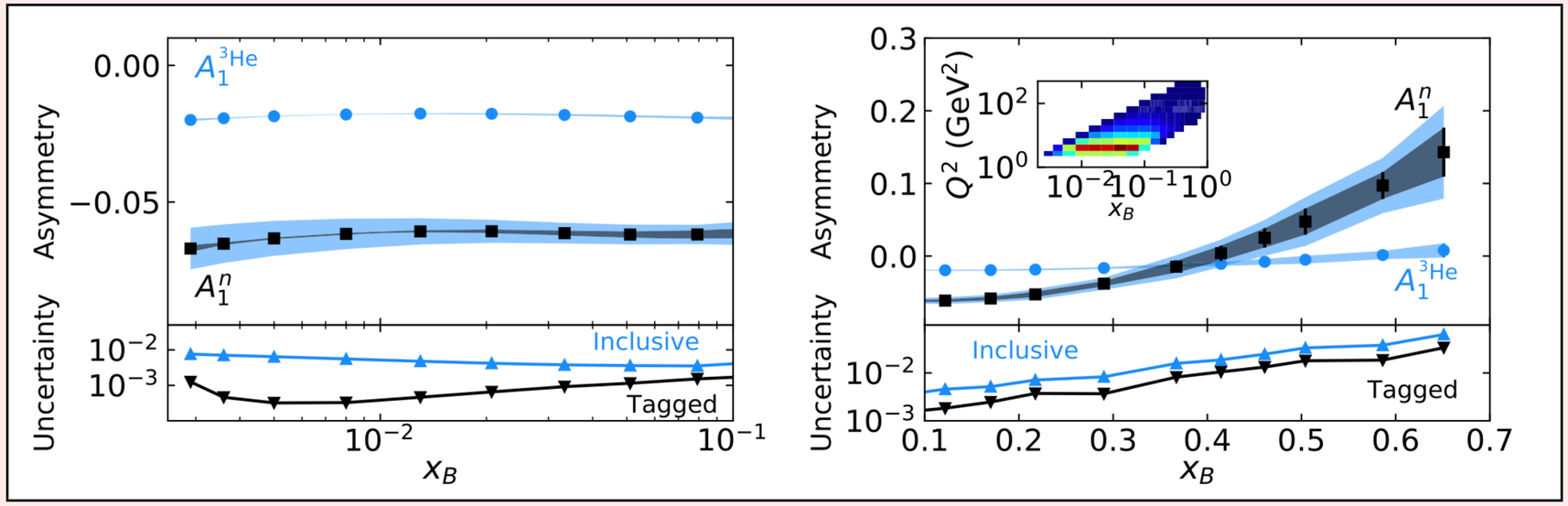




https://wiki.bnl.gov/EPIC/index.php?title=FarForward#/media/File:Far_forward_May_2024.png

Comparison of A_1^n extracted from inclusive (blue band) vs tagged (black square) measurements

5x41 GeV, $\mathscr{L} = 100\ \mathrm{fb}^{-1}$



https://doi.org/10.1016/j.physletb.2021.136726

Extracting A_1^n : the traditional way

Doi: 10.2172/824895

Nuclear effect to be considered:

- Spin depolarization
- Blinding
- Fermi motion
- Off-shell effect
- Non-nucleonic degrees of freedom
- Nuclear shadowing and anti-shadowing

$$g_1^{^3\mathrm{He}}(x, Q^2) = P_n \tilde{g}_1^n(x, Q^2) + 2P_p \tilde{g}_1^p(x, Q^2)$$

$$P_n = 0.86 \pm 0.02 \quad P_p = -0.028 \pm 0.004$$

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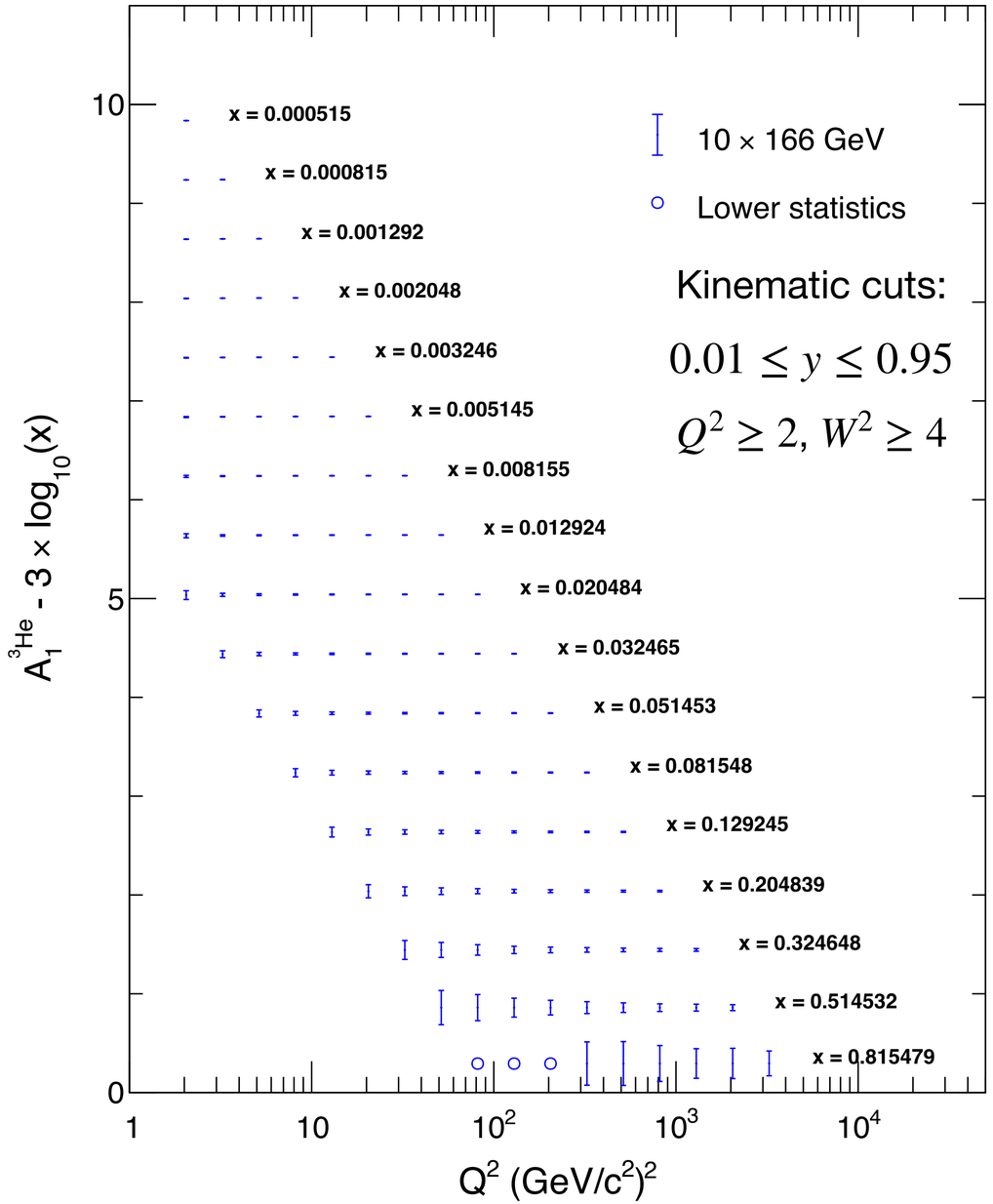
$$A_1^n = \frac{1}{P_n}\frac{F_2^{^3\mathrm{He}}}{F_2^n}(A_1^{^3\mathrm{He}} - 2P_p\frac{F_2^p}{F_2^{^3\mathrm{He}}}A_1^p)$$

$A_1^{^3\mathrm{He}}$ for early science

- $A_1(x,Q^2) \equiv \dfrac{\sigma_{1/2}-\sigma_{3/2}}{\sigma_{1/2}+\sigma_{3/2}} = \dfrac{A_\parallel}{D(1+\eta\xi)} - \dfrac{\eta A_\perp}{d(1+\eta\xi)}$
- $\mathscr{L} = 8.65\ \mathrm{fb}^{-1}$, $P_e = P_n = 70\,\%$
- Data split evenly between $A_\parallel$ and $A_\perp$
- $\delta A_{\parallel,\perp} = \dfrac{1}{\sqrt{N} P_e P_N}$
- $A_1^{^3\mathrm{He}} = P_n \dfrac{F_2^n}{F_2^{^3\mathrm{He}}} A_1^n + 2P_p \dfrac{F_2^p}{F_2^{^3\mathrm{He}}} A_1^p$
- Bin A_1^n calculated from: Doi: 10.2172/824895
- $F_2^{^3\mathrm{He}} = F_2^D + F_2^p$, all F_2's are taken from JAM22
- Statistical uncertainty only, correction not yet applied



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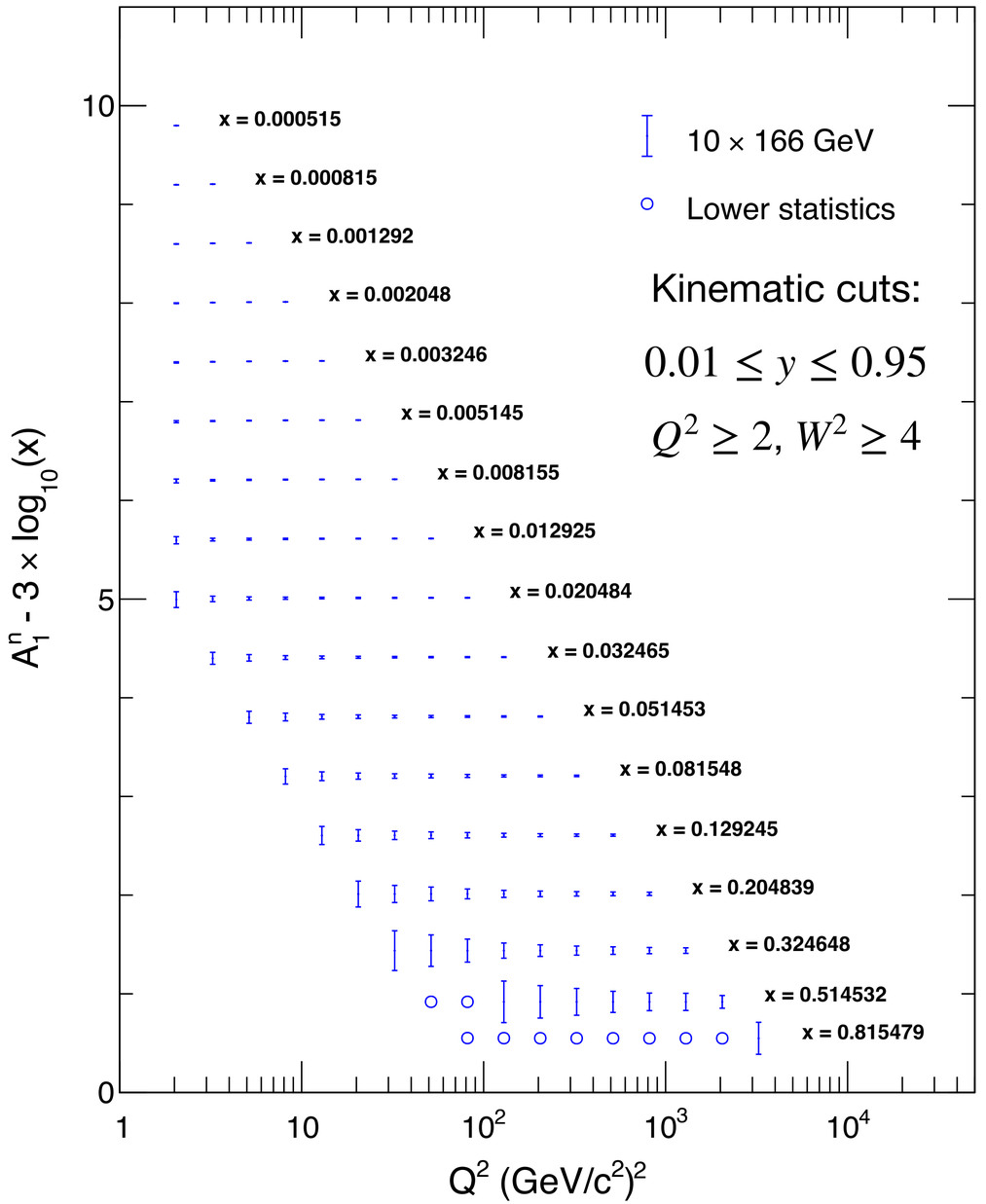
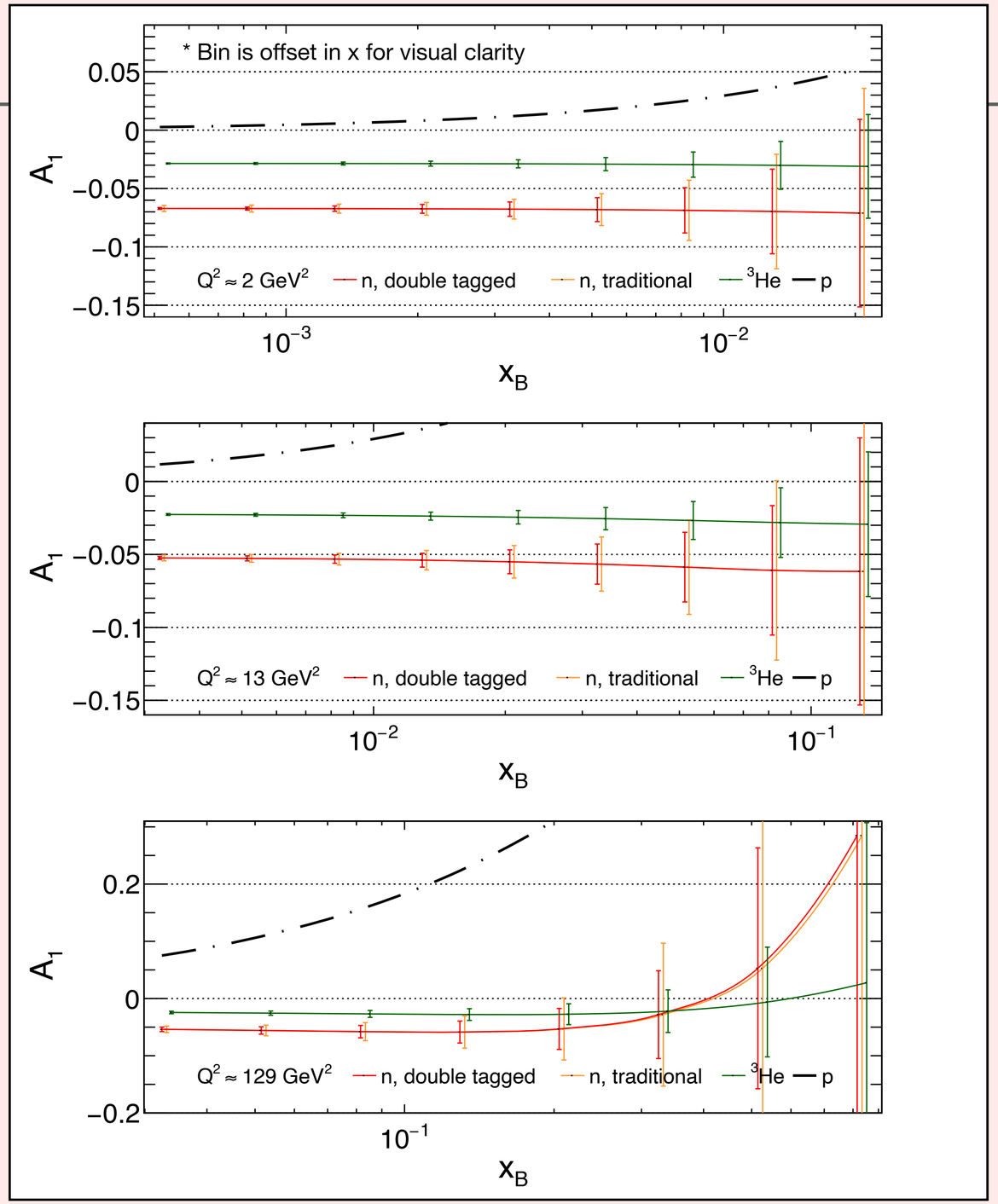


Comparison

- Comparison of A_1^n extracted from $A_1^{^3\mathrm{He}}$ (traditional) vs. extracted from double tagging

Calculation QA checklist:

- Error propagation ✓
- F2 for n, p, deuteron ✓
- A1 for n, p, He3 ✓



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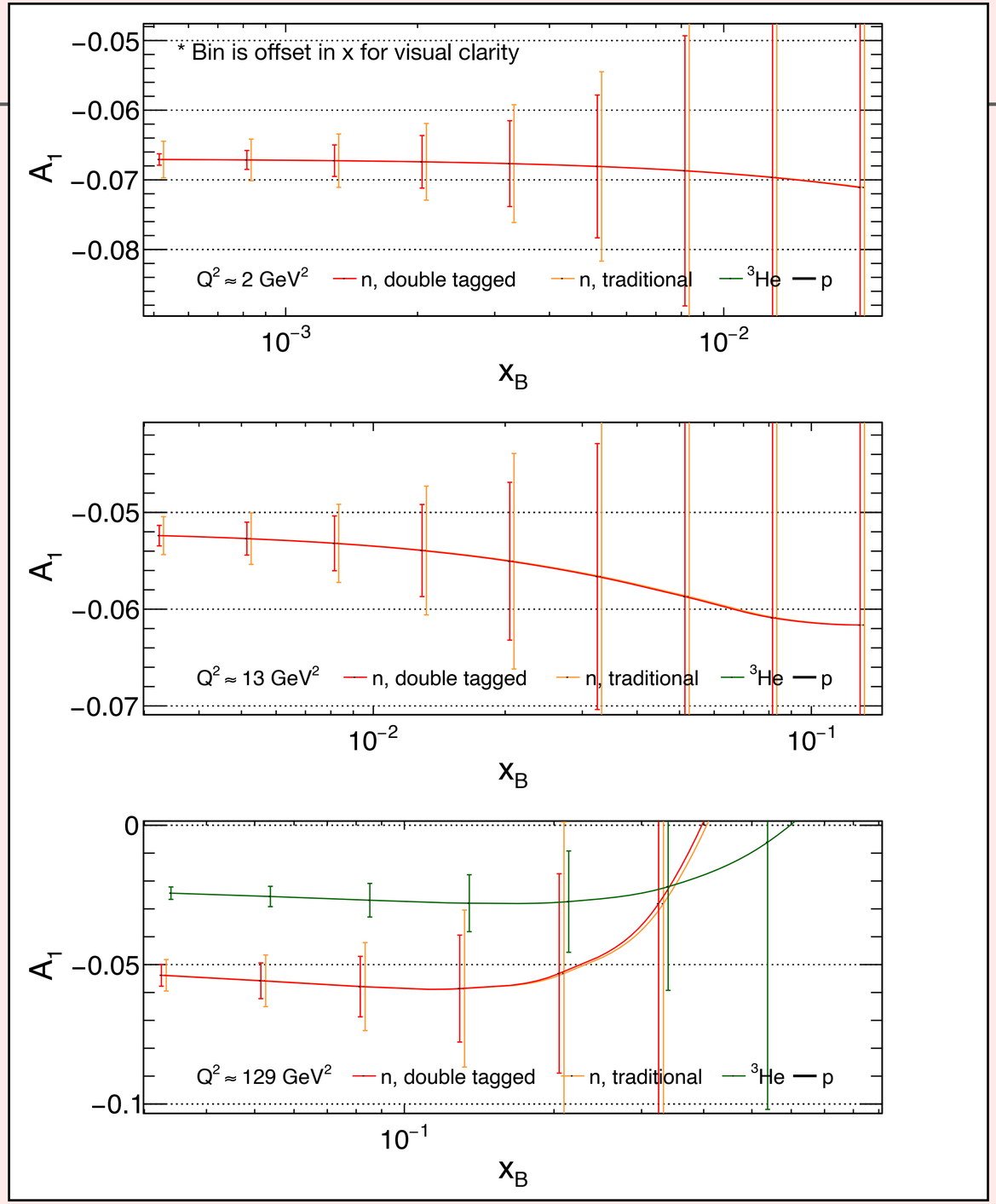
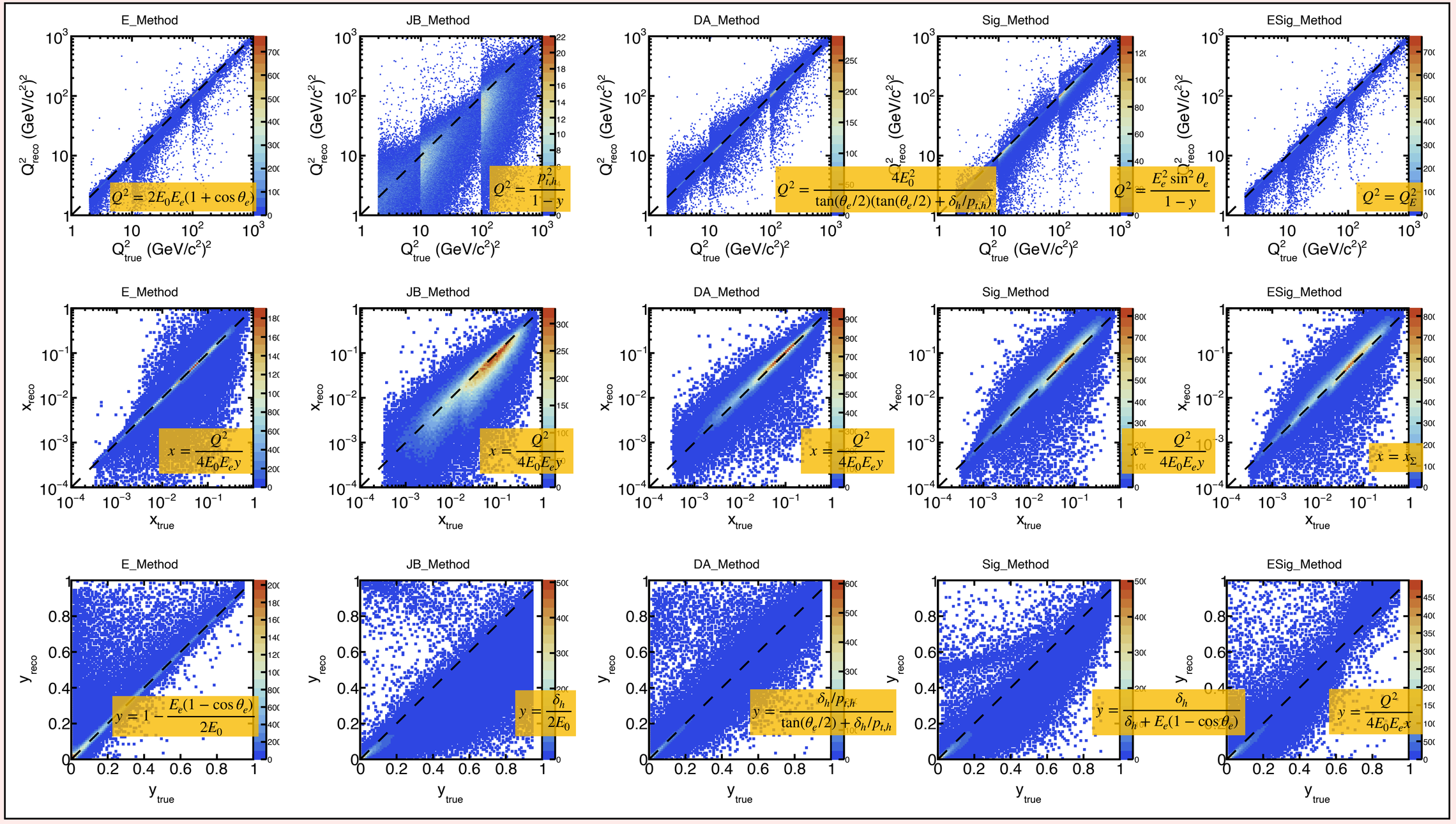
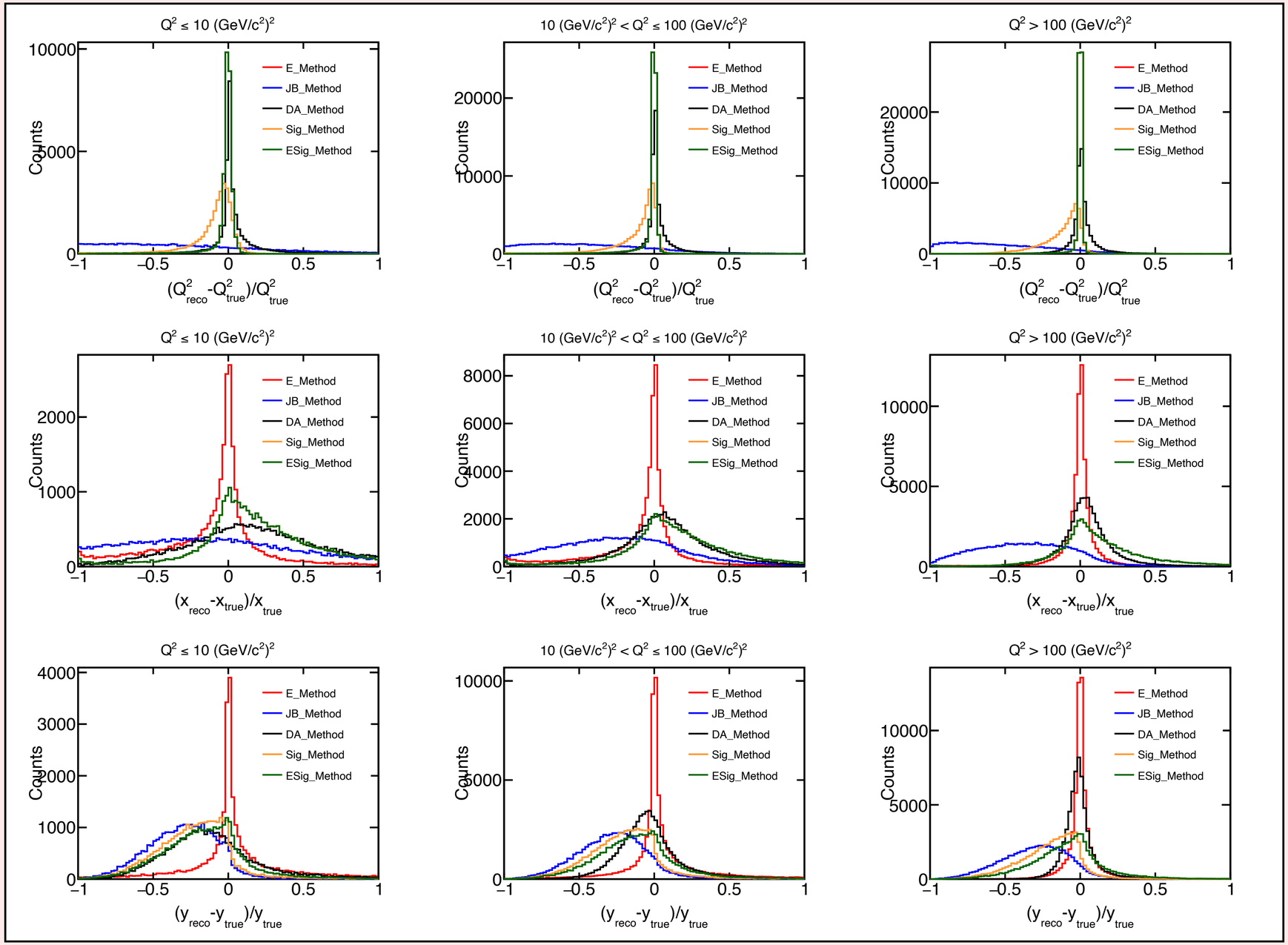


Electron kinematic reconstruction

$$p_{t,h}^2 = (\sum_h p_{x,h})^2 + (\sum_h p_{y,h})^2 \qquad \delta_h = \sum_h E_h - p_{z,h}$$



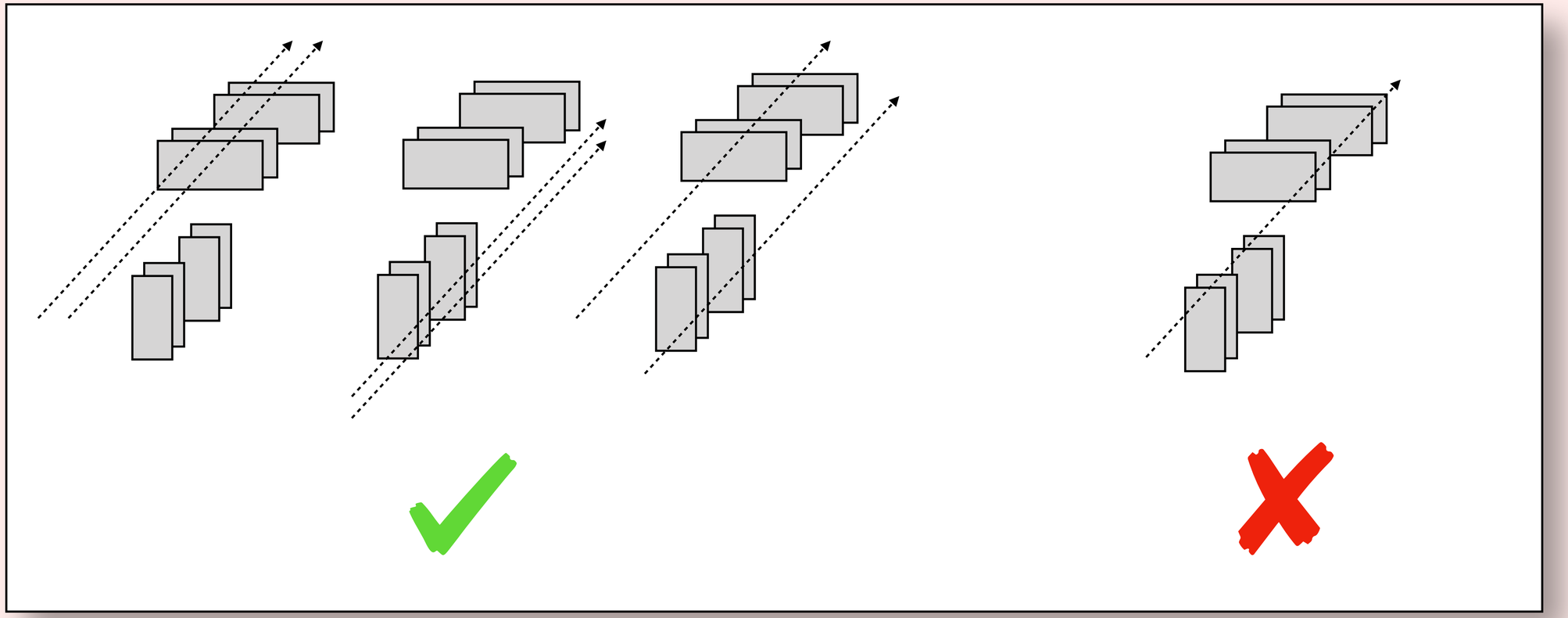
Electron kinematic reconstruction



- Use MC info to find reconstructed electrons
- BeAGLE does not include radiative effect
- Currently using “electron method” only

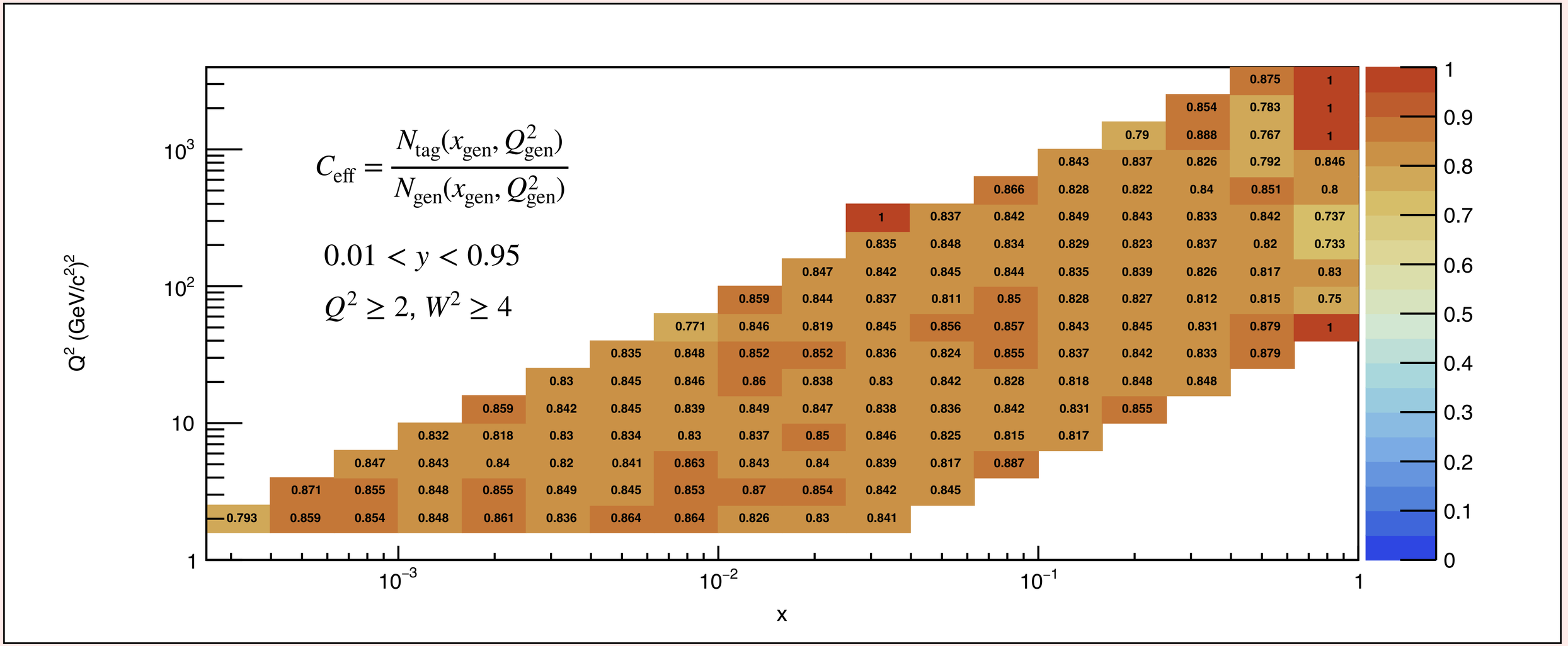
Spectator tagging

- Track reconstruction is not ready for e^{3}He events, so currently:
- Define proton track: at least one hit per plane per detector (either RP or OMD)
- If there are two proton tracks, then the event is tagged as en scattering.



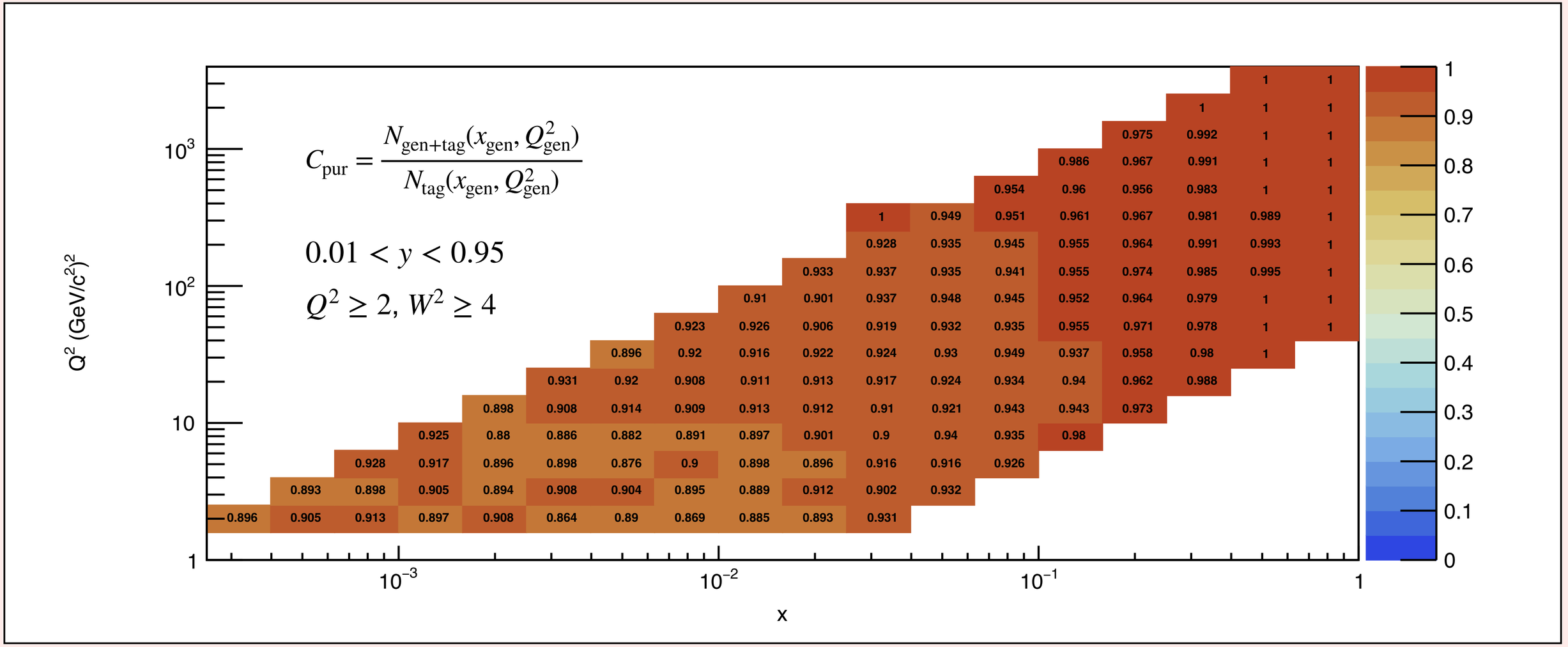
Tagging efficiency

- Overall uniform with bin efficiency $\gtrsim 80\,\%$

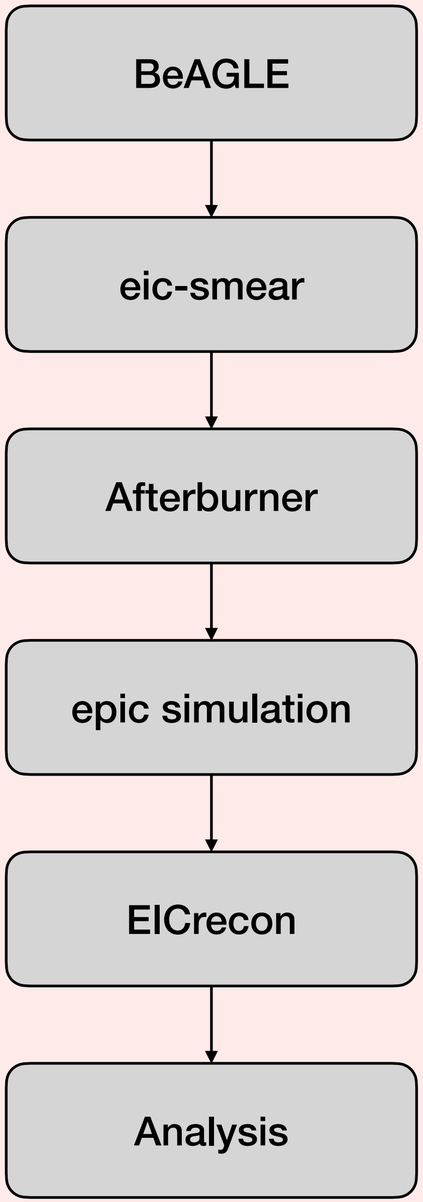


Tagging purity

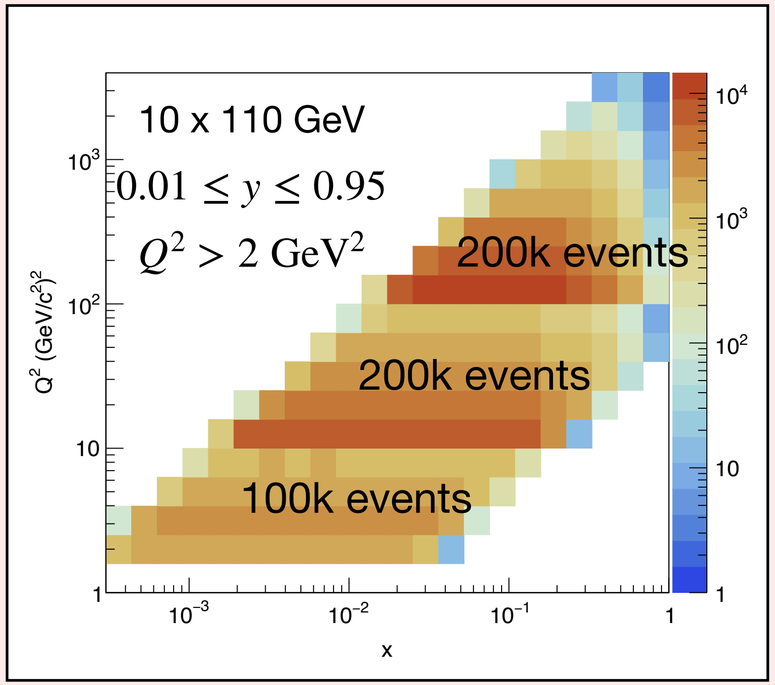
- Overall uniform with bin purity $\gtrsim 90\,\%$



Analysis procedure



e^{3}He events (not polarized):



- EPIC 25.03.1 simulation campaign
- Later scaled to $\mathscr{L} = 8.65\ \mathrm{fb}^{-1}$

- Electron identification and kinematic reconstruction was done outside of ElCrecon