The future of $e4\nu$: eA analysis

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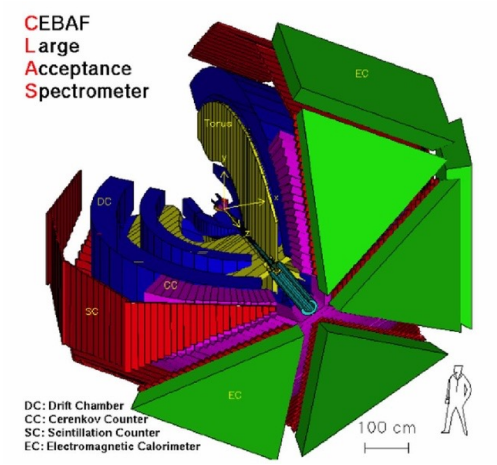
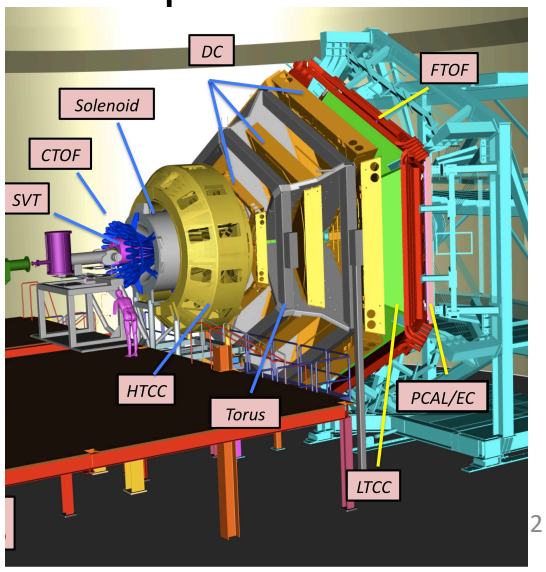
Lots of data!

- CLAS (1999)
- 1, 2, and 4 GeV beams
  - $Q^2 > 0.2\ \mathrm{GeV}^2$
- ^{3}He, ^{4}He, C, Fe targets
- Similar charged particle thresholds to ν expts
- γ and n: $\theta < 45^\circ$



- CLAS12 (2022) [next run]
- [1], 2, 4, and 6 GeV beams
  - $Q^2 > 0.03$ [0.008] GeV^2
- d, C, [O], Ar, ^{40}Ca, ^{48}Ca, Sn targets
- Similar charged particle thresholds to ν expts
- $\theta_\gamma < 35^\circ$
- $\theta_n < 130^\circ$

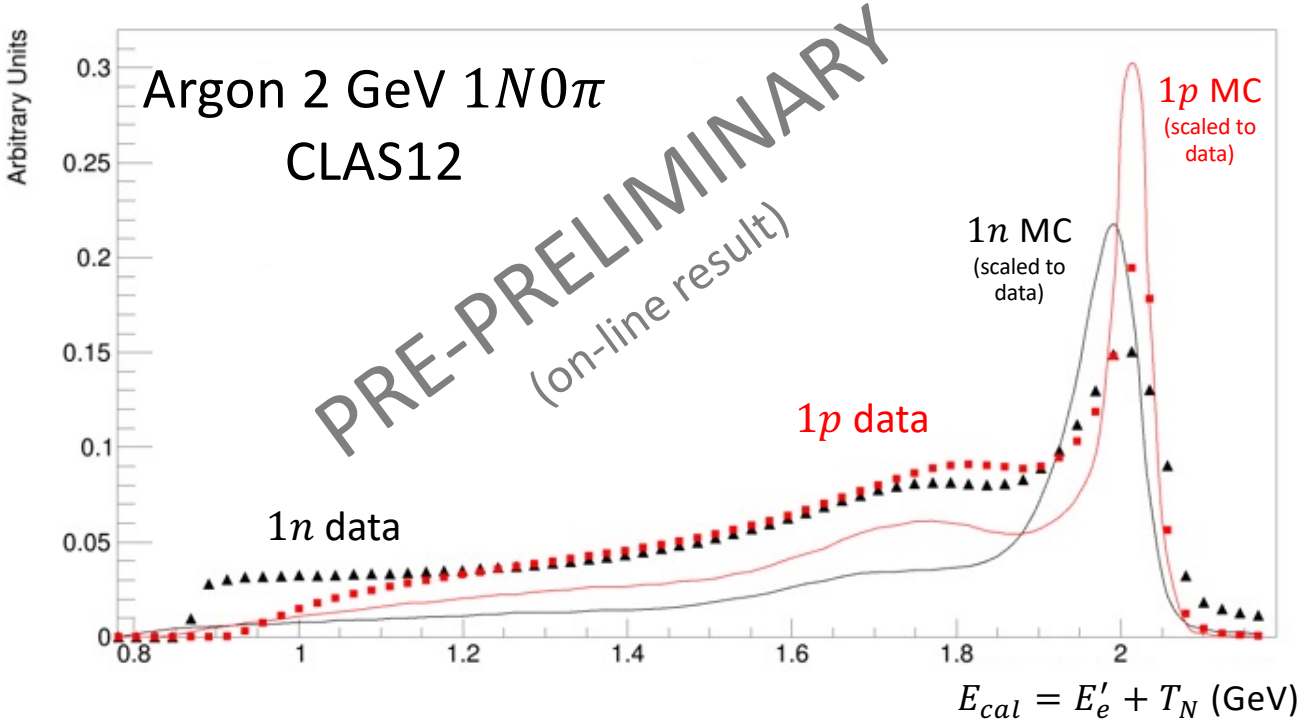


What can we achieve?

- Low Q^2
- Better neutron coverage*
- Study specific topologies
  - $1p1\pi$*
  - $2p$
  - $1p1n$, …
- Multidimensional cross sections (lots of statistics!)
- Select reaction mechanism (QE, Delta, etc) via kinematics*
  - (e, e') $[Q^2, \omega]$
  - $(e, e'p)$ $[p_{miss}, E_{miss}]$
  - ➢ map event topologies
  - ➢ study energy reconstruction

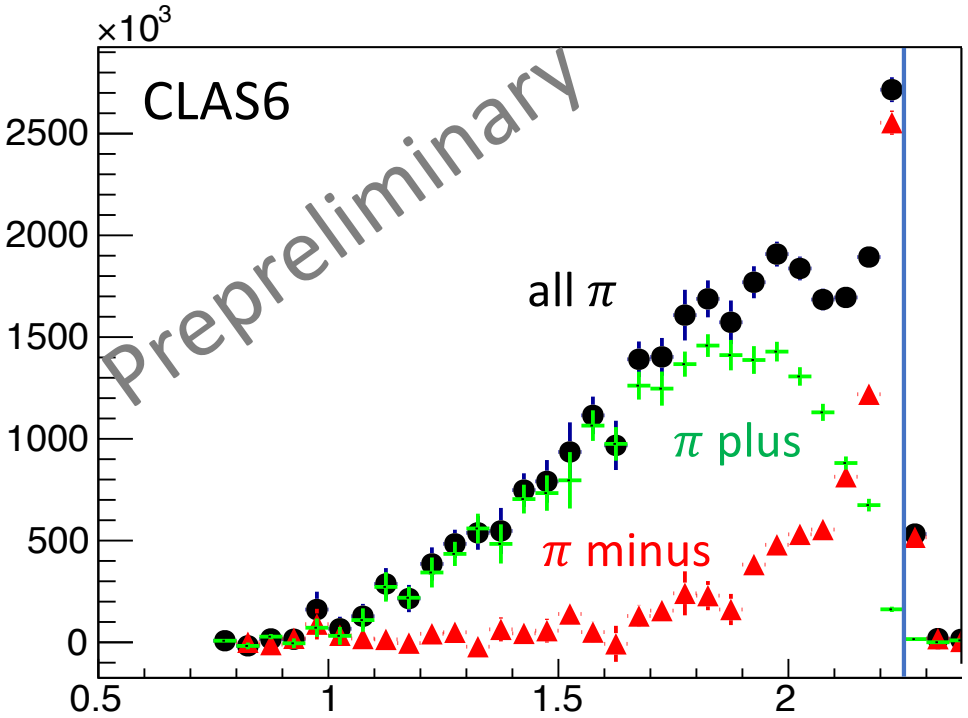
- Measure pion transparency
- Identify νA events to reject*
  - Statistical – systematic uncertainty tradeoff
  - Reject events that provide zero information about E_ν
    - Large p_T events?
- CLAS Weakness: poor π^0 coverage

CLAS12 neutron detection



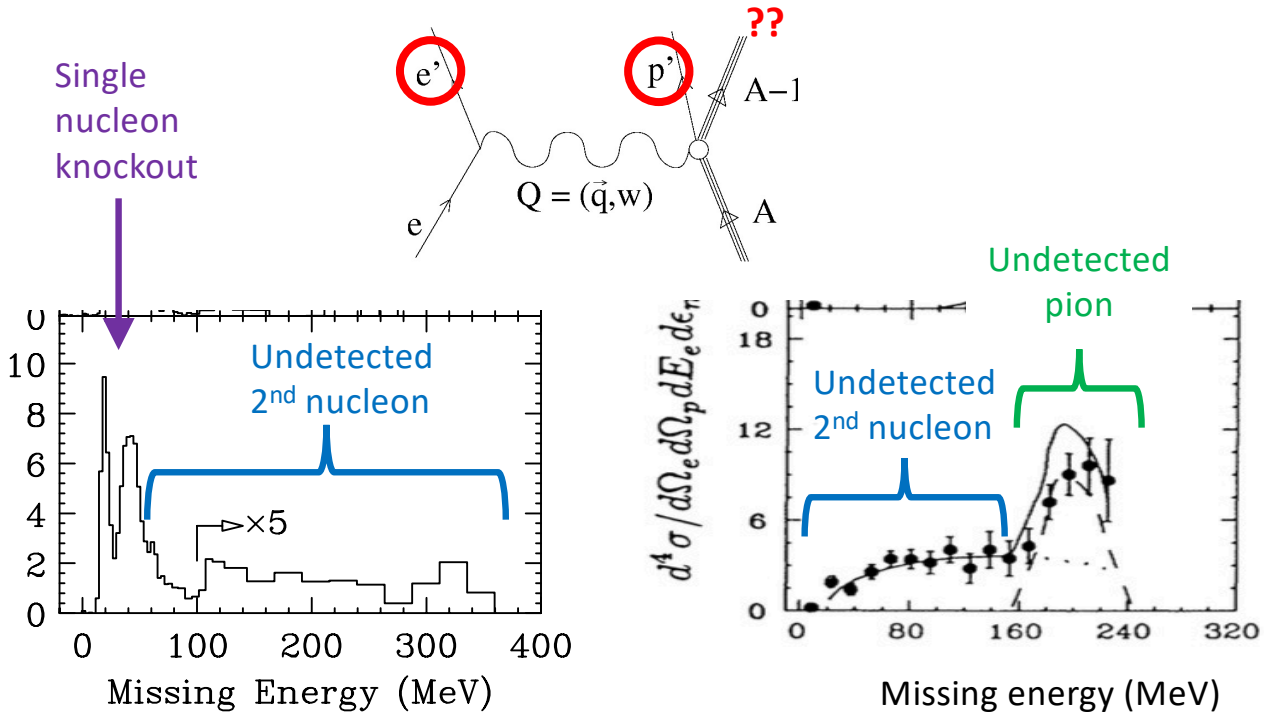
NOT background subtracted, $0\pi^{\pm}$ in CLAS12 acceptance
MC = GENIE V3 / SuSAV2

New topologies: $1p1\pi$: C(e,e'pπ) 2.2 GeV



Calorimetric energy: $E = E'_e + E_\pi + T_p$

Select reaction mechanisms using $A(e,e'p)$

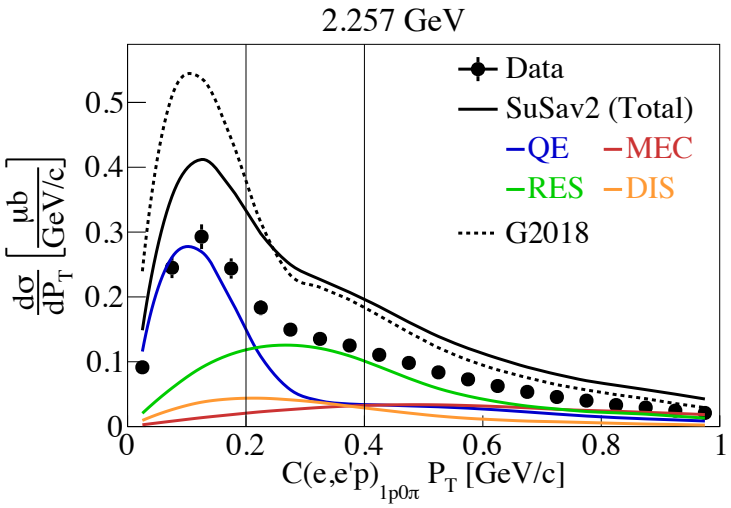


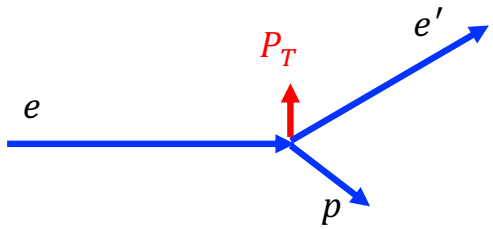
$W \approx m_N$ (QE)

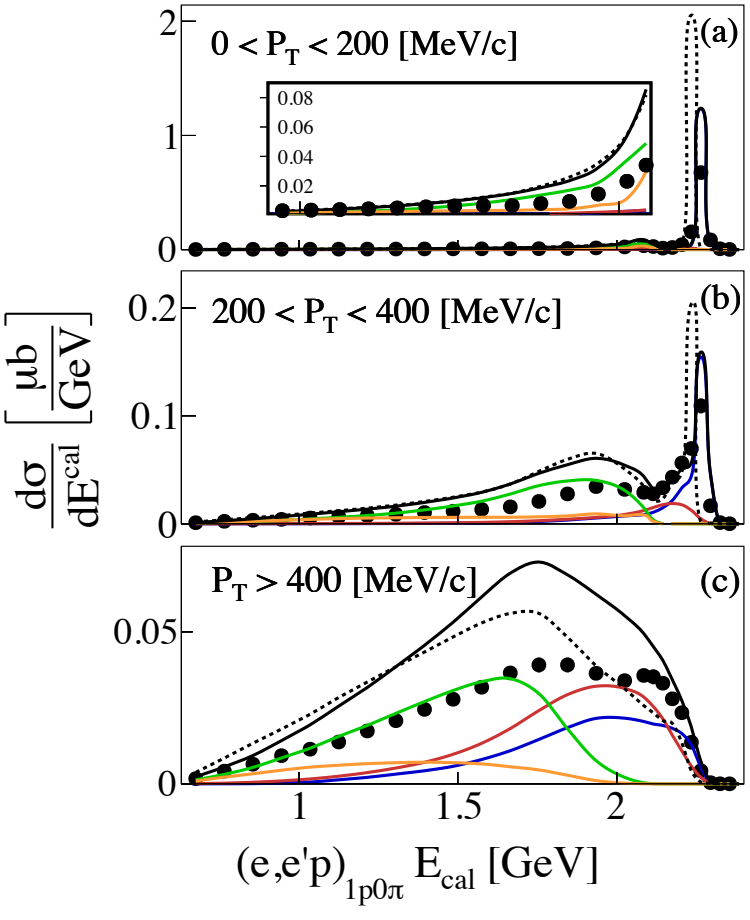
$W \approx m_\Delta$ (RES)

Events to reject?

2.2 GeV
C $1p0\pi$



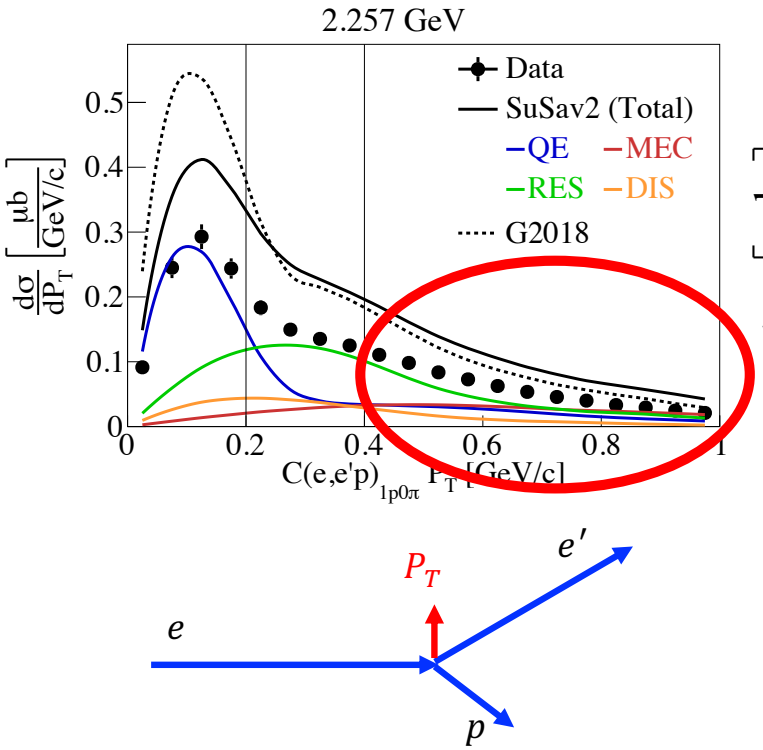


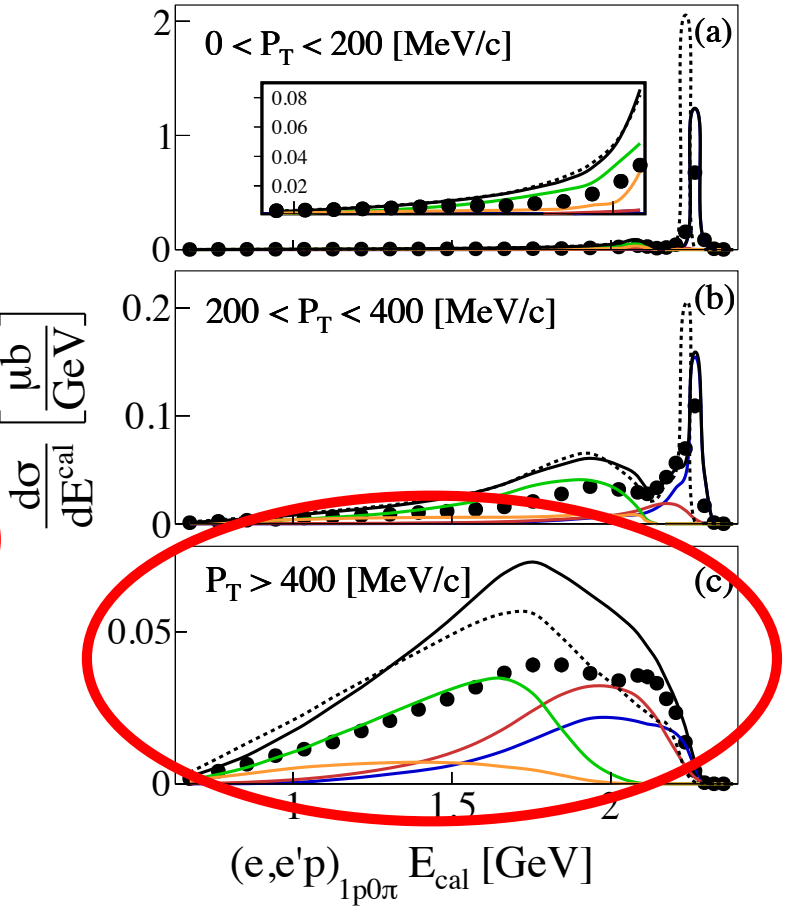


Khachatryan, Papadopoulou et al, Nature (2021)

Events to reject?

2.2 GeV
C $1p0\pi$





Khachatryan, Papadopoulou et al, Nature (2021)

Identify specific generator weaknesses

❖Need much better radiative corrections for better $e - \nu$ comparison

❖ Need more neutrino models available for electrons

- Resonances / DIS
  - Known issues
- $2p2h$
- Hadronization of inclusive models (e.g.: SuSAV2)
- FSI
  - Cross section/momentum shift (real part of $V_{optical}$)
  - Transparency/rescattering/multiplicity (complex part of $V_{optical}$)
    - Multiplicity plots for different W, α_T, p_T, …
    - α_T, etc dependence

Topics:

- Study specific event topologies
- Multidimensional cross sections (lots of statistics!)
- Select reaction mechanism (QE, Delta, etc) via e or ep kinematics
- Measure pion transparency
- Identify νA events to reject
- Identify specific generator weaknesses

- Lots of data
- Lots of opportunities
- Limited personnel

Where should we start?