INT Workshop
EW and BSM physics at the EIC

Kaori Fuyuto, Ciprian Gal, Sonny Mantry

Workshop goals

- How can we take full advantage of the EIC collider ?

Survey EW&BSM physics

- What are the planned studies and sensitivities planned in the next decade?

Current state of EW&BSM physics studies

- Can the studies already completed be improved?

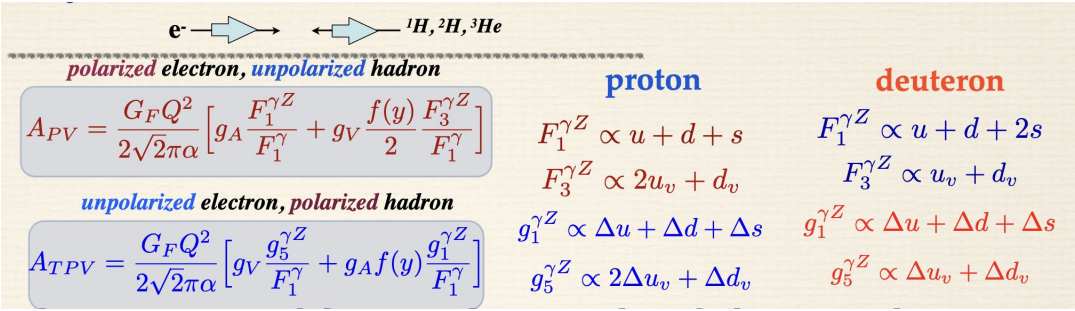
Explore novel ideas for the EIC

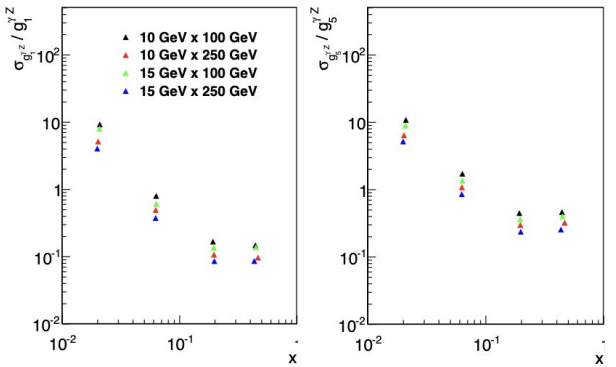
- What new measurements can the EIC deliver?

Parity violating neutral current measurements

- ***EIC EW precision tests as a BSM probe: may have limited impact***

- There are two ways to look at the NC measurements
  - A test of the running: “pin the z-pole and low Q2 and any deviation in the middle is BSM”
  - The fundamental quantity that we really measure are the structure functions
- This measurement will NOT determine the detector configuration but will be as close to free as one can get



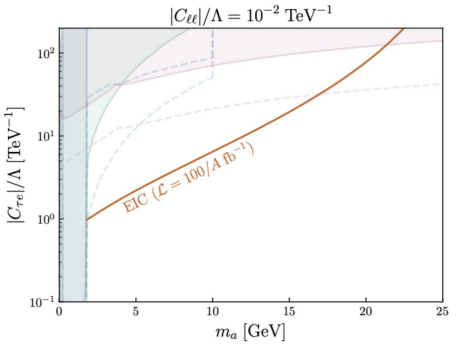


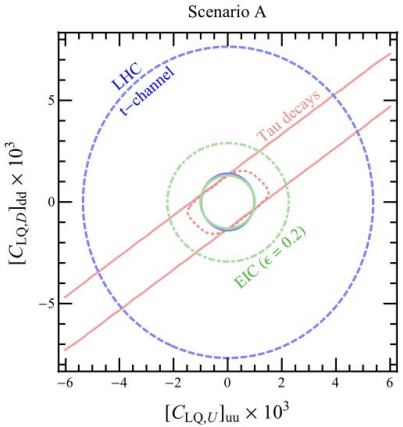
https://arxiv.org/pdf/1612.06927.pdf

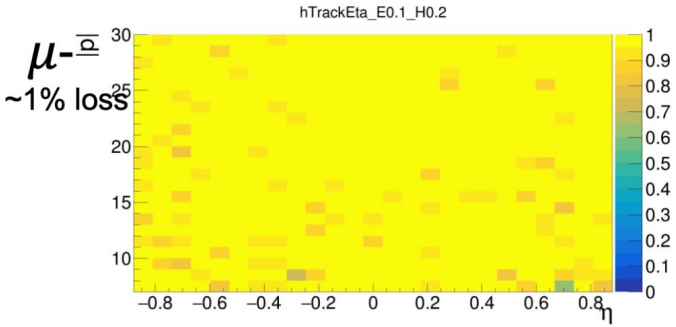
Charged lepton flavor/number violation

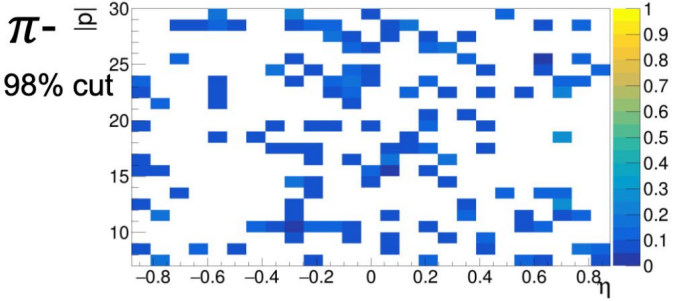
- CLFV is proving to be a clear way for the EIC to make an impact on BSM searches
- The theory and SMEFT analyses are in good shape but experimental estimations need to catch up
  - One piece of good news is that CLNV is almost free once CLFV is done
- More complicated identification of events with taus can lead to constraints on ALPs

- Searches for rare / SM-forbidden processes:
  - LNV: $0\nu\beta\beta$ $e^-p \to \mu^+X$ $e^-p \to \tau^+X$?
  - EDMs: neutron, nuclei



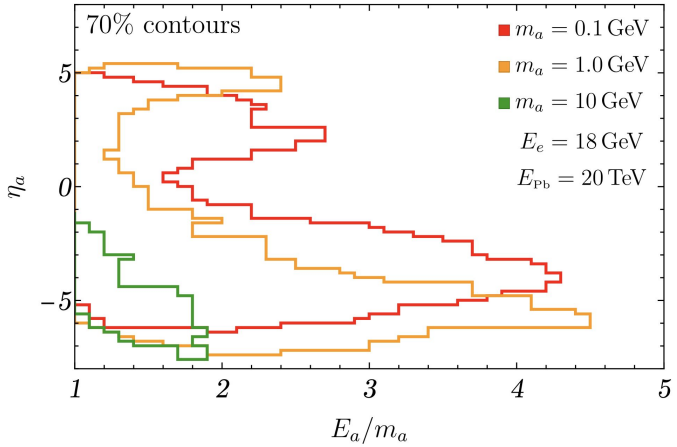


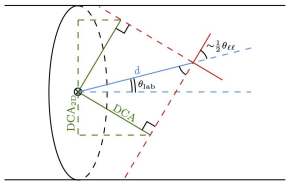


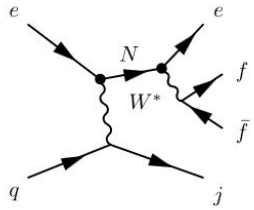


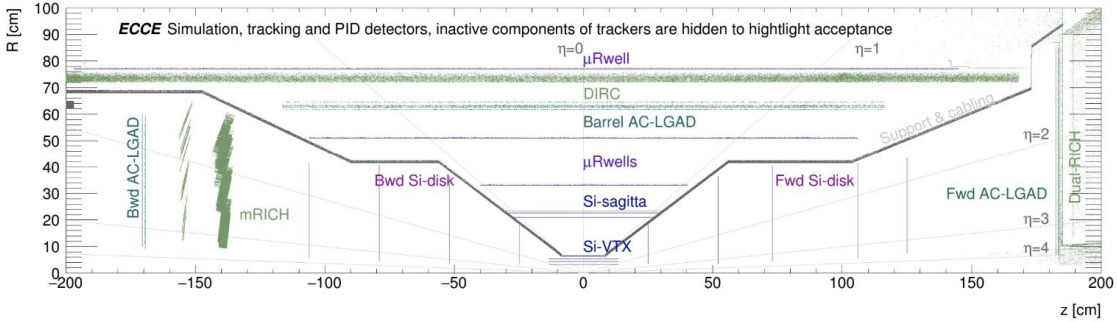
Backwards physics - B0 is in the wrong place!

- eA collisions can be leveraged to significantly improve the chances to observe BSM effects (Z^2 scaling)
- Better estimations are needed for DCAs with/without tracking for ePIC
- Evaluation of backgrounds in the backwards region will be critical to ensure we can make this measurement





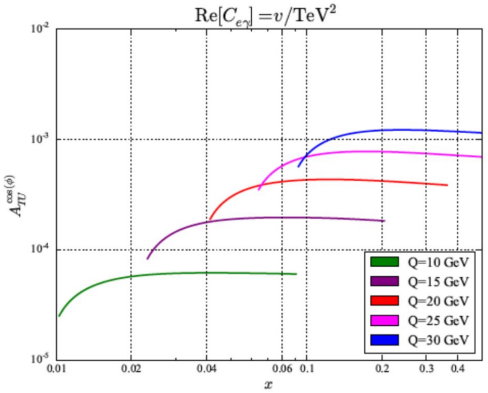


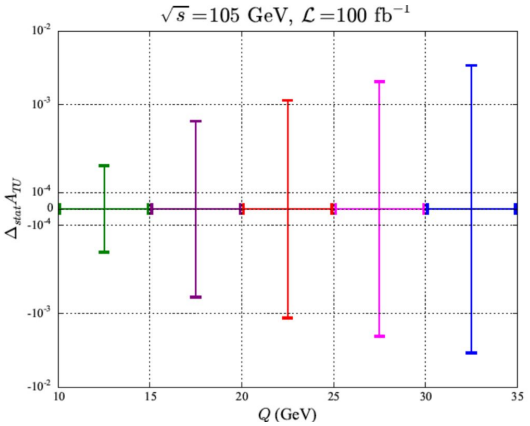


- We also considered a detector at $z = -5$ m
- Assumed: $\mathrm{DCA}_{\mathrm{2D}}^{\mathrm{min}} = 200\,\mu$m, $d_{\mathrm{max}} = 5$ m
- Covering far backwards (FB): $\boxed{-6 < \eta < -4}$
- Coupling limits: $\mathcal{L}\sigma(g_{A'}) \geq n_{\mathrm{max}}$

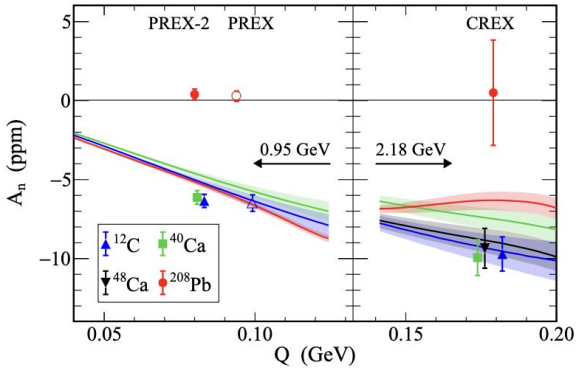
A_TU

- Transverse beam asymmetries have the promise to unambiguously reach TeV scales with constraints on certain couplings in SMEFT
  - Rates, background should be x-checked for ePIC
  - The asymmetry adding up/averaging should be x-check on the theory side





- There is potential to measure this at JLab with SoLID, but will require high precision and careful x-checks
- Has PREX already discovered BSM?



$$A_n \approx A_0(Q)(1 - C \cdot Z^2\alpha),$$

https://arxiv.org/pdf/2111.04250.pdf

Thoughts and Path forward

- We still have quite a way to go to make sure everyone's work is recognized properly and we have a welcoming environment for anyone who wants to help to push science forward
- Expect some nagging emails about the "homework" over the next year
- If we can make enough progress on the experimental estimations we should meet again to set the bounds of what will be possible with ePIC (and maybe the 2nd detector)
  - In a year or two
- Some time after that we can pin down realistic theoretical limits at another workshop that will result in a white paper
  - Hopefully in time for the next Snowmass/LRP process
- We are looking forward to the path ahead and the next workshop!

Vincenzo's overview

The Intensity Frontier and the EIC

- IF in the 2023 NSAC Long Range Plan (NP)
  - Searches for rare / SM-forbidden processes:
    - LNV: 0νββ $e^- p \to \mu^+ X$ $e^- p \to \tau^+ X$?
    - EDMs: neutron, nuclei
  - Precision measurements of SM-allowed processes:
    - Muon g-2
    - Weak charged current (mesons, neutron, nuclei)
    - Weak neutral current (PVES)
  - Search / characterization of light weakly coupled particles
    - Absolute neutrino mass
    - Sterile neutrinos
    - Neutrino scattering

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- IF in the 2023 P5 report (HEP)** (my very rough 'binning')
  - Searches for rare / SM-forbidden processes:
    - LFV in muon (Mu2e) and tau decays (Belle-II)
    - Flavor physics: Belle-II, LHCb
    - EDMs: proton
  - Precision measurements of SM-allowed processes:
    - High-Luminosity LHC (ATLAS, CMS)
    - Higgs factory
    - …
  - Search / characterization of light weakly coupled particles
    - Neutrino oscillations
    - Forward physics facility at LHC
    - …

The EIC not on the map yet. But can directly or indirectly lead to advances in several areas.