Electroweak and BSM physics at the EIC

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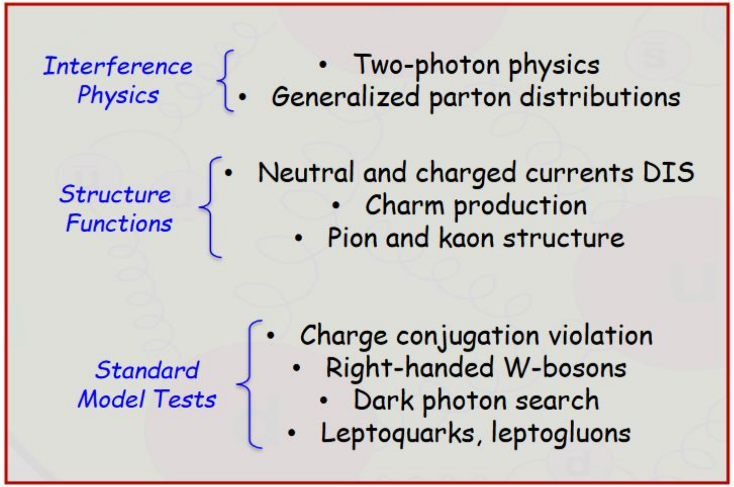
on behalf of the LOI authors

https://www.snowmass21.org/docs/files/summaries/EF/SNOWMASS21-EF5_EF9-210.pdf

Positron beams

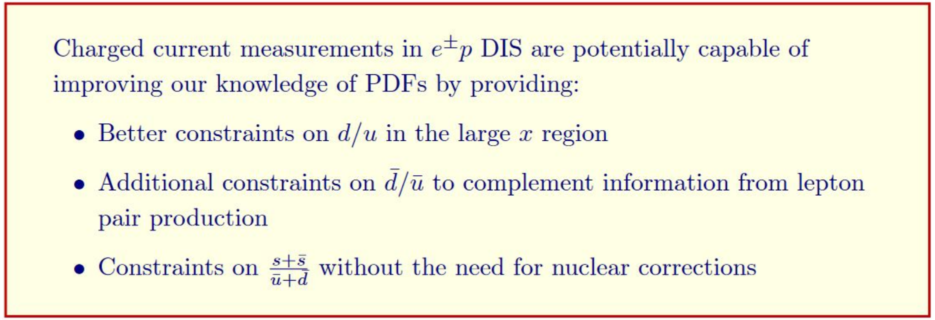
Wally Melnitchouk



Interference Physics
- Two-photon physics
- Generalized parton distributions

Structure Functions
- Neutral and charged currents DIS
- Charm production
- Pion and kaon structure

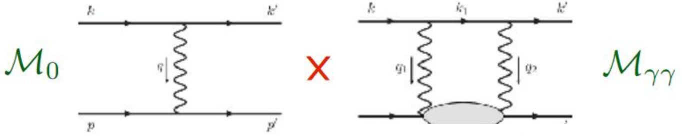
Standard Model Tests
- Charge conjugation violation
- Right-handed W-bosons
- Dark photon search
- Leptoquarks, leptogluons



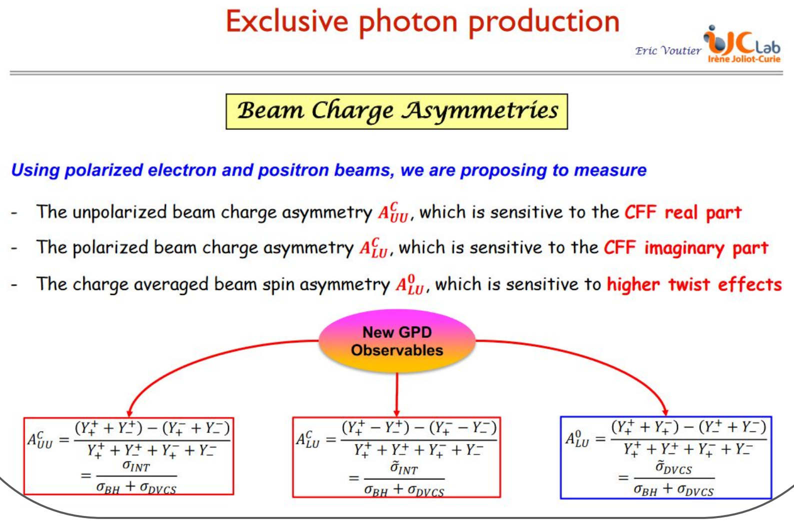
Charged current measurements in $e^{\pm}p$ DIS are potentially capable of improving our knowledge of PDFs by providing:

- Better constraints on d/u in the large x region
- Additional constraints on $\bar{d}/\bar{u}$ to complement information from lepton pair production
- Constraints on $\frac{s+\bar{s}}{\bar{u}+\bar{d}}$ without the need for nuclear corrections

Two photon exchange contribution changes sign for e+ and e-



$$R_{2\gamma} = \frac{\sigma^{e^+}}{\sigma^{e^-}} \approx 1 - 2\delta_{\gamma\gamma} \qquad \delta^{(2\gamma)} = \frac{2\mathcal{R}e\left\{\mathcal{M}_0^\dagger\,\mathcal{M}_{\gamma\gamma}\right\}}{|\mathcal{M}_0|^2}$$



Exclusive photon production

Eric Voutier

Beam Charge Asymmetries

Using polarized electron and positron beams, we are proposing to measure

- The unpolarized beam charge asymmetry A^C_{UU}, which is sensitive to the **CFF real part**
- The polarized beam charge asymmetry A^C_{LU}, which is sensitive to the **CFF imaginary part**
- The charge averaged beam spin asymmetry A^0_{LU}, which is sensitive to **higher twist effects**

New GPD Observables

$$A^C_{UU} = \frac{(Y^+_+ + Y^+_-) - (Y^-_+ + Y^-_-)}{Y^+_+ + Y^+_- + Y^-_+ + Y^-_-} = \frac{\sigma_{INT}}{\sigma_{BH} + \sigma_{DVCS}}$$

$$A^C_{LU} = \frac{(Y^+_+ - Y^+_-) - (Y^-_+ - Y^-_-)}{Y^+_+ + Y^+_- + Y^-_+ + Y^-_-} = \frac{\tilde{\sigma}_{INT}}{\sigma_{BH} + \sigma_{DVCS}}$$

$$A^0_{LU} = \frac{(Y^+_+ + Y^-_+) - (Y^+_- + Y^-_-)}{Y^+_+ + Y^+_- + Y^-_+ + Y^-_-} = \frac{\tilde{\sigma}_{DVCS}}{\sigma_{BH} + \sigma_{DVCS}}$$

NC extractions

Yuxiang Zhao

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With parity violation and $Q^2 << Z^2$

Inclusive electron measurements

pol. electron & unpol. nucleon:

$$A_{beam} = \frac{G_F Q^2}{2\sqrt{2}\pi\alpha}\left[g_A^e \frac{F_1^{\gamma Z}}{F_1^{\gamma}} + g_V^e \frac{Y_-}{2Y_+}\frac{F_3^{\gamma Z}}{F_1^{\gamma}}\right]$$

unpol. electron & pol. nucleon:

$$A_L = \frac{G_F Q^2}{2\sqrt{2}\pi\alpha}\left[g_V^e \frac{g_5^{\gamma Z}}{F_1^{\gamma}} + g_A^e \frac{Y_-}{Y_+}\frac{g_1^{\gamma Z}}{F_1^{\gamma}}\right]$$

$$F_1^{\gamma Z} = \sum_f e_{q_f}(g_V)_{q_f}(q_f + \bar{q}_f)$$

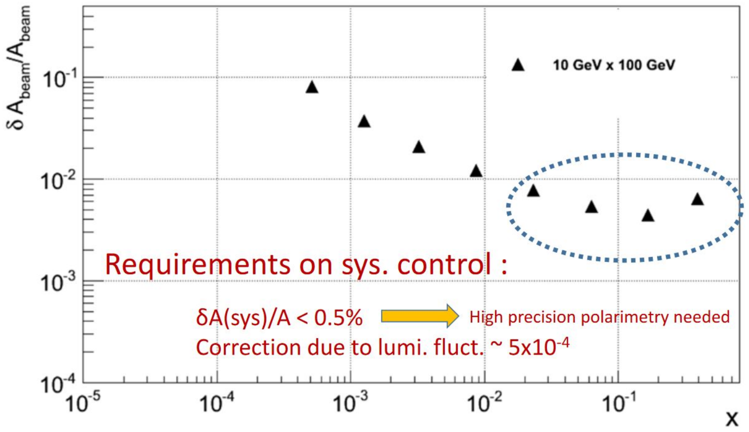
$$F_3^{\gamma Z} = 2\sum_f e_{q_f}(g_A)_{q_f}(q_f - \bar{q}_f)$$

$$g_1^{\gamma Z} = \sum_f e_{q_f}(g_V)_{q_f}(\Delta q_f + \Delta\bar{q}_f)$$

$$g_5^{\gamma Z} = \sum_f e_{q_f}(g_A)_{q_f}(\Delta q_f - \Delta\bar{q}_f)$$

e-p collisions	10x100, 10x250, 15x100, 15x250
Integrated luminosity	500 fb^{-1}
Proton (electron) beam polarization	70% (80%)

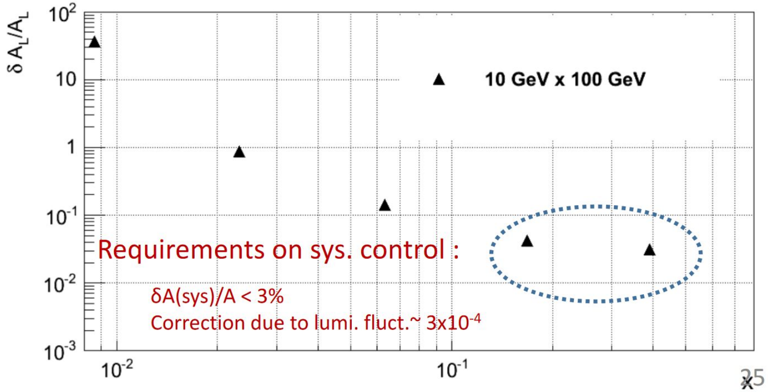
		Barrel ($-1.1< \eta <1.1$)	electron going direction
Tracking	θ (mrad)	10	1
	ϕ (mrad)	0.3	0.3
	$\frac{dp_T}{p_T}$	$0.65\% (+) 0.09\% * p_T$	$0.65\% (+) 1\% * p_T$
EMCal:	$\frac{dE}{E}$	$3\% (+) 11.7\%/\sqrt{E}$	$1\% (+) 2.5\%/\sqrt{E}$



Requirements on sys. control :

δA(sys)/A < 0.5% → High precision polarimetry needed

Correction due to lumi. fluct. ~ 5×10^{-4}



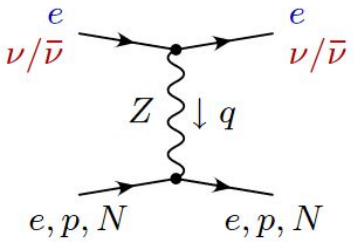
Requirements on sys. control :

δA(sys)/A < 3%

Correction due to lumi. fluct.~ 3×10^{-4}

Weak mixing angle extractions

Ayres Freitas



$$A_{\mathrm{LR}}^{ep} \approx \frac{\sigma_{\mathrm{L}} - \sigma_{\mathrm{R}}}{\sigma_{\mathrm{L}} + \sigma_{\mathrm{R}}} = \frac{G_\mu(-q^2)}{4\sqrt{2}\pi\alpha} Q_{\mathrm{W}}(p)$$

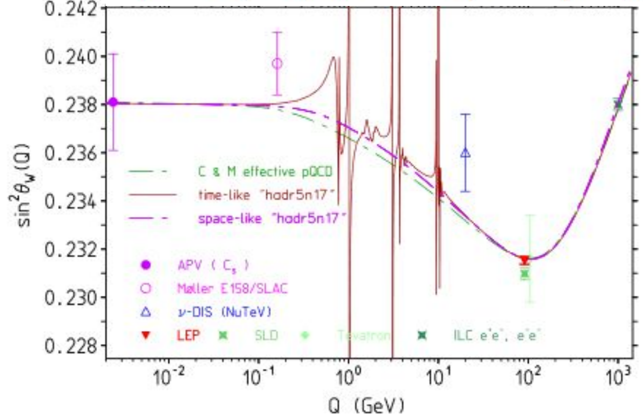
$$y \approx \tfrac{1}{2}(1 - \cos\theta_{\mathrm{CM}})$$

$$Q_W(e) = Q_W(p) = 1 - 4\sin^2\theta_{\mathrm{W}}$$

- Radiative corrections must be included:

$$1 - 4\sin^2\theta_{\mathrm{W}} \quad \rightarrow \quad [1 - 4\kappa(\mu)\sin^2\bar{\theta}(\mu)] + \Delta Q(\mu)$$

$$\Delta_{\gamma Z} = \textstyle\sum_f (I_{3f}Q_f - 2s^2Q_f^2)\ln m_f^2/M_Z^2$$



At the EIC

$$A_{\mathrm{LR}}^{ep} \approx \frac{\sigma_{\mathrm{L}} - \sigma_{\mathrm{R}}}{\sigma_{\mathrm{L}} + \sigma_{\mathrm{R}}} = \frac{G_\mu(-q^2)}{4\sqrt{2}\pi\alpha}\left[\frac{F_1^{\gamma Z}}{F_1^{\gamma}} + (1 - 4\sin^2\theta_{\mathrm{W}})\frac{y(1-y)}{1+(1-y)^2}\frac{F_3^{\gamma Z}}{F_1^{\gamma}}\right]$$

$$y = 1 - E'_e/E_e$$

Need precise knowledge of PDFs for
100 GeV^2 < Q2 < 5000 GeV^2

$$F_1^{\gamma} = \textstyle\sum_q q_q(f_q + f_{\bar{q}})$$
$$F_1^{\gamma Z} = \textstyle\sum_q q_q\, g_V^q(f_q + f_{\bar{q}})$$
$$F_1^{\gamma Z} = 2\textstyle\sum_q q_q\, g_A^q(f_q + f_{\bar{q}})$$

- Polarized e^- on d for $Q^2 \gg \Lambda_{\mathrm{QCD}}$
- d is iso-singlet $\longrightarrow$ PDF dependence approximately cancels in LR asymmetry:
- Assuming valence quark dominance and charge symmetry:

$$f_u \approx f_d,$$
$$f_{\bar{u}} \approx f_{\bar{d}} \approx f_{s,c,b} \approx f_{\bar{s},\bar{c},\bar{b}} \approx 0$$

$$A_{\mathrm{LR}}^{ep} \approx \frac{G_\mu(-q^2)}{4\sqrt{2}\pi\alpha}\left[\frac{9}{5} - \sin^2\theta_{\mathrm{W}} + \frac{9}{5}(1 - 4\sin^2\theta_{\mathrm{W}})\frac{y(1-y)}{1+(1-y)^2}\right]$$

- Extractions from different ion will need a more complicated analysis

NC extractions

Yuxiang Zhao

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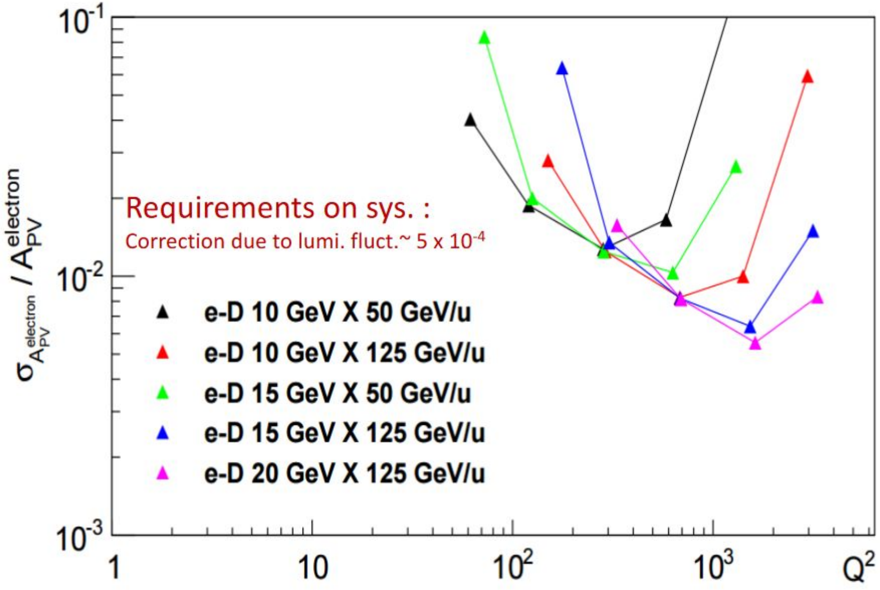
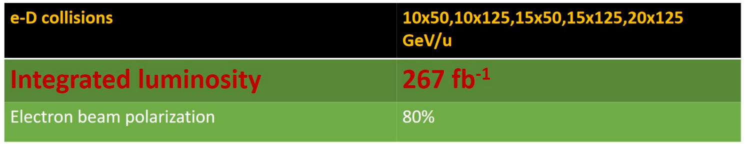


Requirements on sys. :

Correction due to lumi. fluct.~ 5 x 10^{-4}



e-D collisions	10x50,10x125,15x50,15x125,20x125 GeV/u
Integrated luminosity	**267 fb^{-1}**
Electron beam polarization	80%

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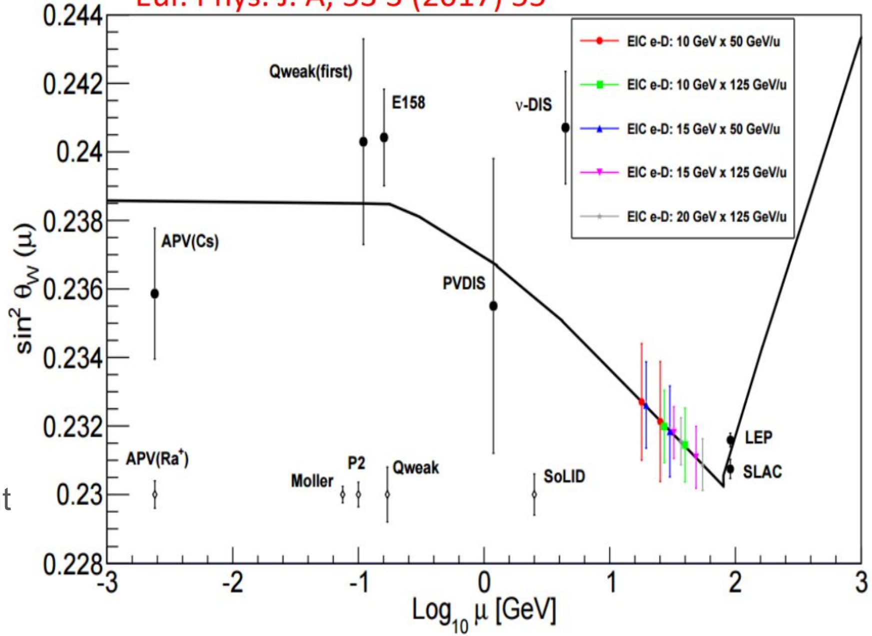
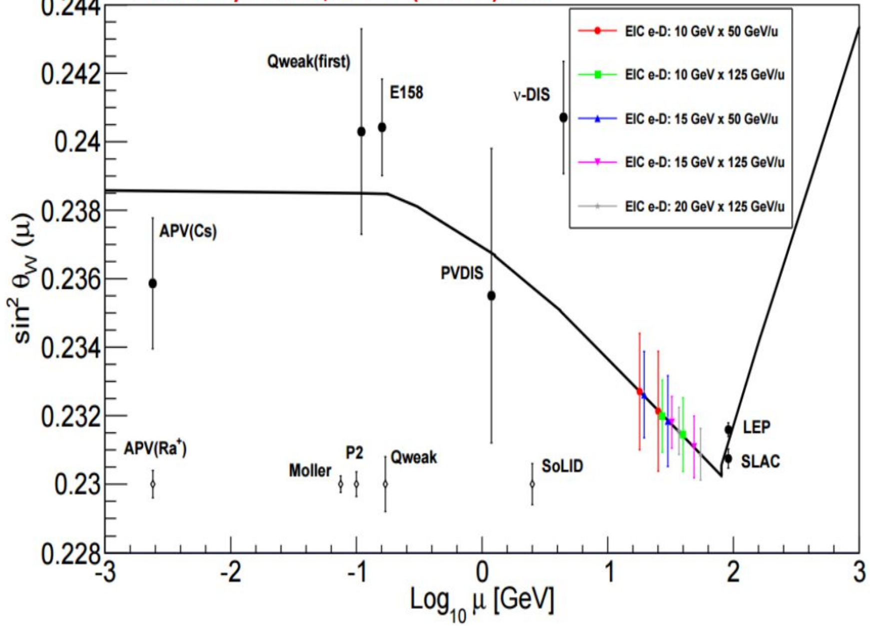


- The weak mixing angle extractions are in a region that has not been probed before and overall reach similar precisions as SoLID
- Beyond the weak mixing angle extractions Yuxiang made the point that together with the CC current measurements on deuteron we can obtain similar if not better precision than with positron beams

NC extractions

Jinlong Zhang



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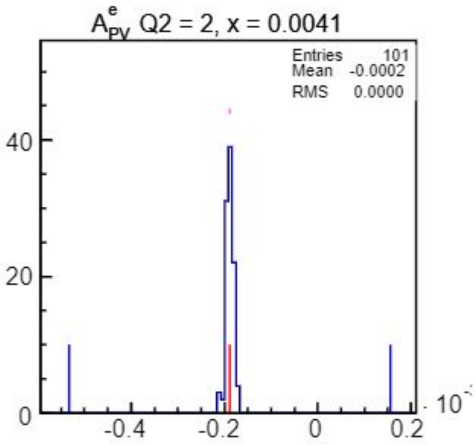
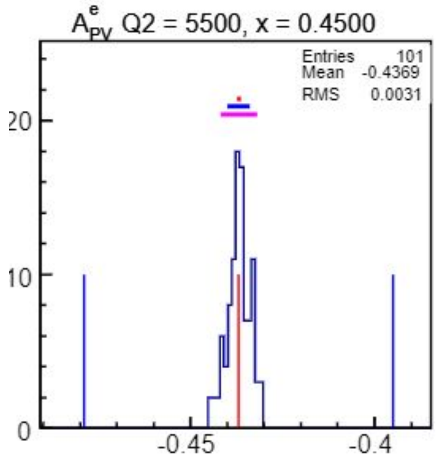


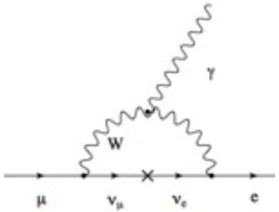


- PDF uncertainties are fairly small compared to the statistical precision of the data
- We are working to understand if we can use the proton data to extract sin2tw on top of the deuteron result published by Yuxiang
- This data should allow us to get larger statistical precision and have a larger reach in Q
- We expect to get an estimate by the January workshop
- For the low Q data we may be able to finish the study of the impact of the weak neutral current couplings (for both p and d data)

Charged Lepton Flavor Violation

Sonny Mantry

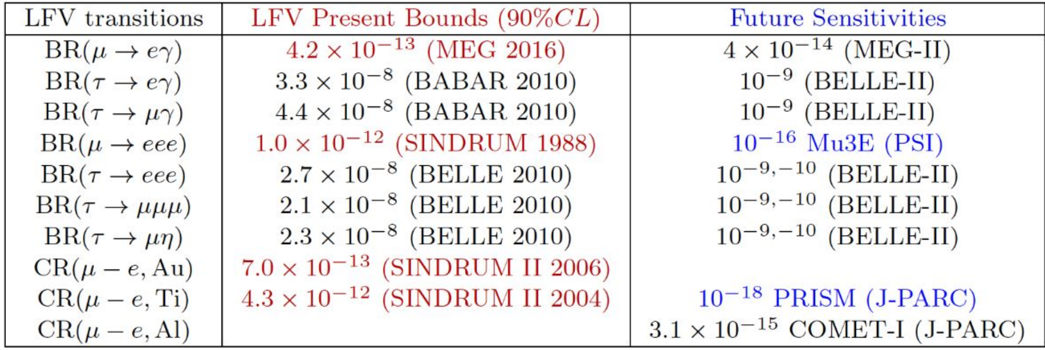
- LFV in the neutrinos also implies Charged Lepton Flavor Violation (CLFV):



$$\mathrm{BR}(\mu \to e\gamma) < 10^{-54}$$

However, SM rate for CLFV is tiny due to small neutrino masses

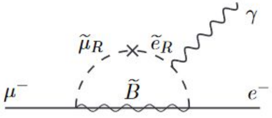
- No hope of detecting such small rates for CLFV at any present or future planned experiments!

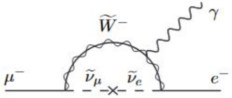


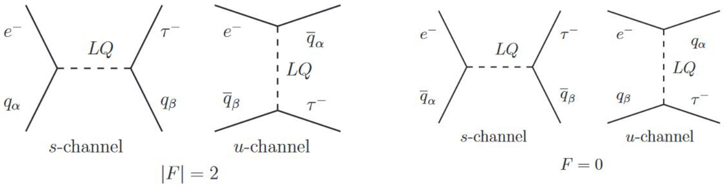
LFV transitions	LFV Present Bounds (90%CL)	Future Sensitivities
$\mathrm{BR}(\mu \to e\gamma)$	4.2×10^{-13} (MEG 2016)	4×10^{-14} (MEG-II)
$\mathrm{BR}(\tau \to e\gamma)$	3.3×10^{-8} (BABAR 2010)	10^{-9} (BELLE-II)
$\mathrm{BR}(\tau \to \mu\gamma)$	4.4×10^{-8} (BABAR 2010)	10^{-9} (BELLE-II)
$\mathrm{BR}(\mu \to eee)$	1.0×10^{-12} (SINDRUM 1988)	10^{-16} Mu3E (PSI)
$\mathrm{BR}(\tau \to eee)$	2.7×10^{-8} (BELLE 2010)	$10^{-9,-10}$ (BELLE-II)
$\mathrm{BR}(\tau \to \mu\mu\mu)$	2.1×10^{-8} (BELLE 2010)	$10^{-9,-10}$ (BELLE-II)
$\mathrm{BR}(\tau \to \mu\eta)$	2.3×10^{-8} (BELLE 2010)	$10^{-9,-10}$ (BELLE-II)
$\mathrm{CR}(\mu - e, \mathrm{Au})$	7.0×10^{-13} (SINDRUM II 2006)	
$\mathrm{CR}(\mu - e, \mathrm{Ti})$	4.3×10^{-12} (SINDRUM II 2004)	10^{-18} PRISM (J-PARC)
$\mathrm{CR}(\mu - e, \mathrm{Al})$		3.1×10^{-15} COMET-I (J-PARC)

[taken from a talk by Y. Furletova]

- However, many BSM scenarios predict enhanced CLFV rates:
  - SUSY (RPV)
  - SU(5), SO(10) GUTS
  - Left-Right symmetric models
  - Randall-Sundrum Models
  - LeptoQuarks
  - ...







F= 3B+L

- With electron beams, LQs couple to:

|F|= 2:
-quarks in s-channel
-antiquarks in u-channel

F= 0:
-antiquarks in s-channel
-quarks in the u-channel

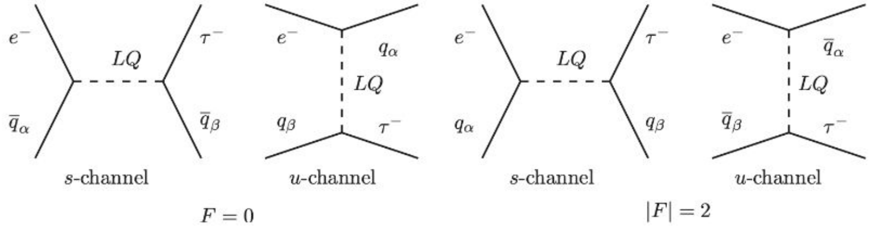
- With positron beams, LQs couple to:

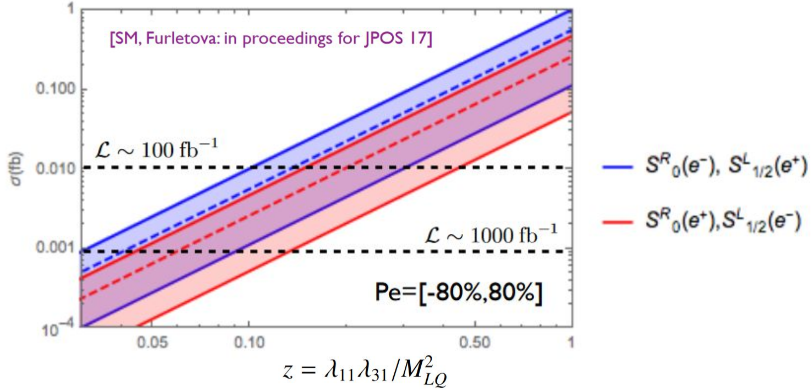
|F|= 2:
-antiquarks in s-channel
-quarks in u-channel

F= 0:
-quarks in s-channel
-antiquarks in the u-channel

CLFV: e to tau (lepto-quarks)

Jinlong Zhang



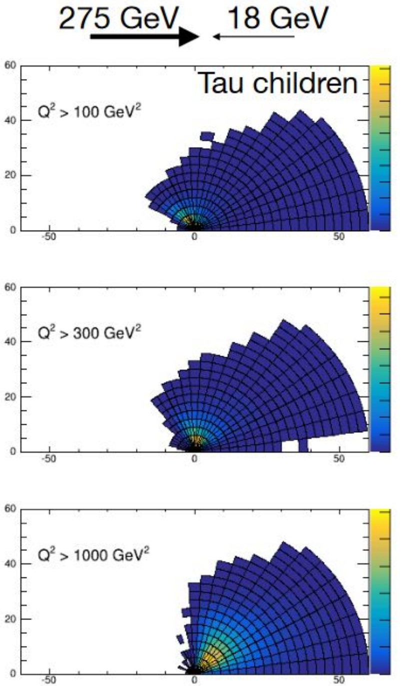


- Sensitivities to the CLFV(1,3) would be enhanced with positron beams (can search for specific LQ)
- Current limits set by HERA sitting at sensitivities of a few fb
  - The high luminosity of the EIC will gain us 2 orders of magnitude

Tau decay mode and branching ratio

3-prong	**15.21 (0.06)%**
$\pi^-\pi^+\pi^-\nu_\tau$	9.31 (0.05)%
$\pi^-\pi^+\pi^-\pi^0\nu_\tau$	4.62 (0.05)%
others (kaon, etc)	1.28%
1-prong	**84.58 (0.06)%**
$\mu^-\bar{\nu}_\mu\nu_\tau$	17.39 (0.04)%
$e^-\bar{\nu}_e\nu_\tau$	17.82 (0.04)%
$\pi^-\nu_\tau$	10.82 (0.05)%
$\pi^-\pi^0\nu_\tau$	25.49 (0.09)%
$\pi^-2\pi^0\nu_\tau$	9.26 (0.10)%
$\pi^-3\pi^0\nu_\tau$	1.04 (0.07)%
others (kaon, etc)	3.24%
others	0.21%

- **Tau vertex displaced at cm level**
  - 3-prong tau jet; decay topology important for τ jet ID
  - 1-prong: recovering higher branching ratios; but background control is much more demanding

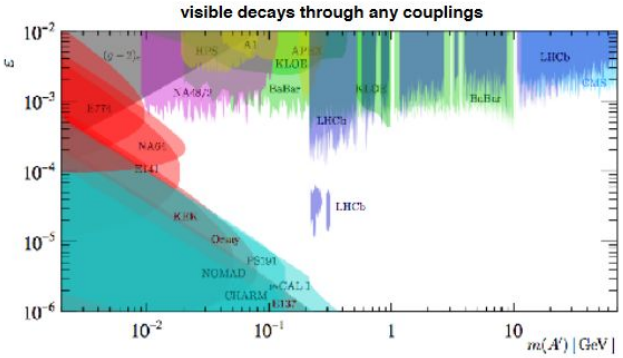


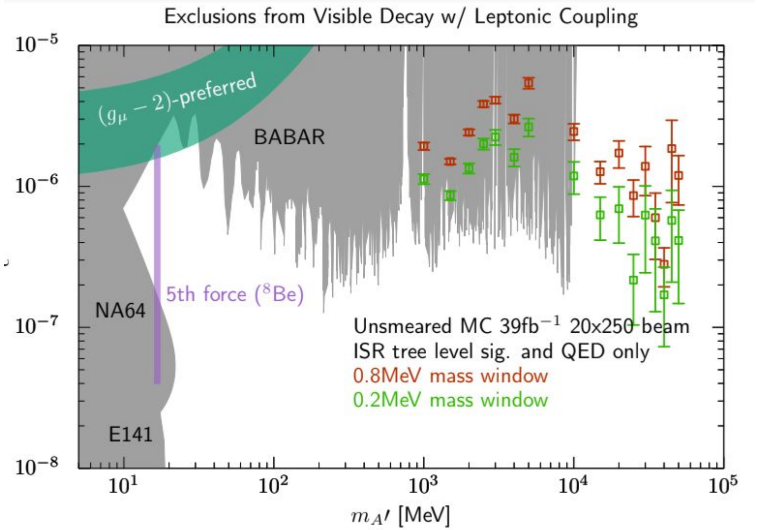
Angle for theta, radius for momentum

- Assumes hadron calorimetry in the central barrel
- 1-prong analysis is actively being worked on and should have results by January workshop

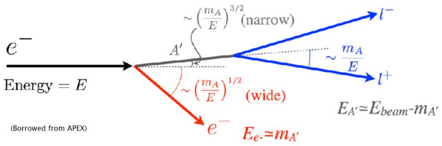
Dark photons

Ross Corliss

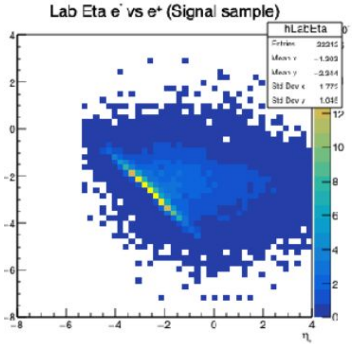


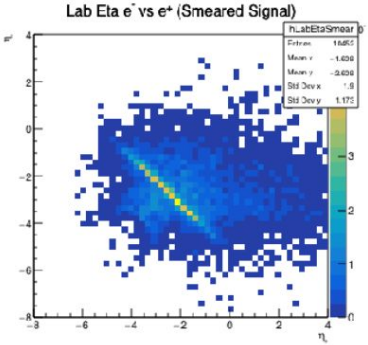


$$\alpha_D = S\frac{\alpha_{D0}}{\sqrt{L}}\frac{\sqrt{\sigma_{QED}}}{\sigma_{A0}}$$



- First analysis looks at e+e- decay, but hadronic final states could be investigated as well
- The boosted kinematics significantly opens up the angle between the decay leptons creating a specific topology
- Only consider QED background for now
- With 6 months of running 25 on 250 (~39 fb^{-1}) we could reach similar sensitivities than BABAR but in a wider mass range
    - Handbook detector used for initial smearing studies
- Measurement would benefit from improved charge sign reconstruction (PID)
- Higher eta coverage would lead to access to lower mass dark photons
- There is still the possibility that the muon g-2 anomaly could be explained by a dark photon with a purely leptonic coupling
- Ross discussed with Stefan Prestel about moving event generation from madgraph to pythia and they plan to have analysis ready by January workshop

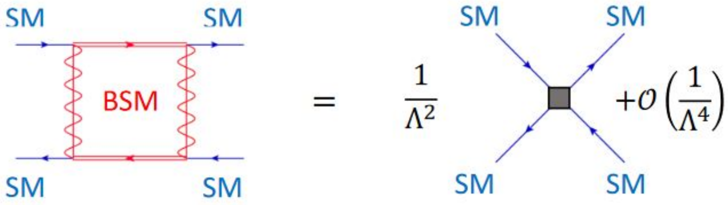




SMEFT

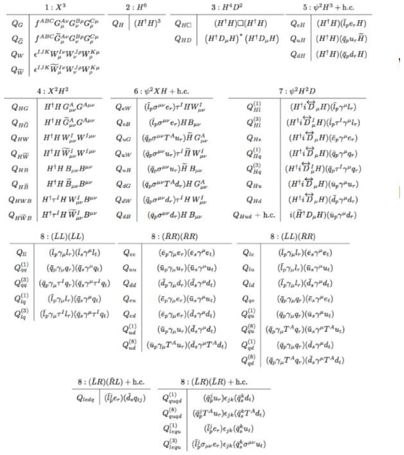
Daniel Wiegand

Boughezal/Petriello/DW - (arXiv: 2004.00748)



Non-SM operators **suppressed by powers of $\frac{1}{\Lambda}$:**

- Higher dimensional operators built from SM fields
- Modification of SM couplings/EWSB/…



1 : X^3	
Q_G	$f^{ABC}G_\mu^{A\nu}G_\nu^{B\rho}G_\rho^{C\mu}$
$Q_{\widetilde{G}}$	$f^{ABC}\widetilde{G}_\mu^{A\nu}G_\nu^{B\rho}G_\rho^{C\mu}$
Q_W	$\epsilon^{IJK}W_\mu^{I\nu}W_\nu^{J\rho}W_\rho^{K\mu}$
$Q_{\widetilde{W}}$	$\epsilon^{IJK}\widetilde{W}_\mu^{I\nu}W_\nu^{J\rho}W_\rho^{K\mu}$

2 : H^6	
Q_H	$(H^\dagger H)^3$

3 : H^4D^2	
$Q_{H\Box}$	$(H^\dagger H)\Box(H^\dagger H)$
Q_{HD}	$(H^\dagger D_\mu H)^*(H^\dagger D_\mu H)$

5 : ψ^2H^3 + h.c.	
Q_{eH}	$(H^\dagger H)(\bar{l}_p e_r H)$
Q_{uH}	$(H^\dagger H)(\bar{q}_p u_r \widetilde{H})$
Q_{dH}	$(H^\dagger H)(\bar{q}_p d_r H)$

4 : X^2H^2	
Q_{HG}	$H^\dagger H\, G_{\mu\nu}^A G^{A\mu\nu}$
$Q_{H\widetilde{G}}$	$H^\dagger H\, \widetilde{G}_{\mu\nu}^A G^{A\mu\nu}$
Q_{HW}	$H^\dagger H\, W_{\mu\nu}^I W^{I\mu\nu}$
$Q_{H\widetilde{W}}$	$H^\dagger H\, \widetilde{W}_{\mu\nu}^I W^{I\mu\nu}$
Q_{HB}	$H^\dagger H\, B_{\mu\nu}B^{\mu\nu}$
$Q_{H\widetilde{B}}$	$H^\dagger H\, \widetilde{B}_{\mu\nu}B^{\mu\nu}$
Q_{HWB}	$H^\dagger\tau^I H\, W_{\mu\nu}^I B^{\mu\nu}$
$Q_{H\widetilde{W}B}$	$H^\dagger\tau^I H\, \widetilde{W}_{\mu\nu}^I B^{\mu\nu}$

6 : ψ^2XH + h.c.	
Q_{eW}	$(\bar{l}_p\sigma^{\mu\nu}e_r)\tau^I H W_{\mu\nu}^I$
Q_{eB}	$(\bar{l}_p\sigma^{\mu\nu}e_r)H B_{\mu\nu}$
Q_{uG}	$(\bar{q}_p\sigma^{\mu\nu}T^A u_r)\widetilde{H}\, G_{\mu\nu}^A$
Q_{uW}	$(\bar{q}_p\sigma^{\mu\nu}u_r)\tau^I\widetilde{H}\, W_{\mu\nu}^I$
Q_{uB}	$(\bar{q}_p\sigma^{\mu\nu}u_r)\widetilde{H}\, B_{\mu\nu}$
Q_{dG}	$(\bar{q}_p\sigma^{\mu\nu}T^A d_r)H\, G_{\mu\nu}^A$
Q_{dW}	$(\bar{q}_p\sigma^{\mu\nu}d_r)\tau^I H\, W_{\mu\nu}^I$
Q_{dB}	$(\bar{q}_p\sigma^{\mu\nu}d_r)H\, B_{\mu\nu}$

7 : ψ^2H^2D	
$Q_{Hl}^{(1)}$	$(H^\dagger i\overleftrightarrow{D}_\mu H)(\bar{l}_p\gamma^\mu l_r)$
$Q_{Hl}^{(3)}$	$(H^\dagger i\overleftrightarrow{D}_\mu^I H)(\bar{l}_p\tau^I\gamma^\mu l_r)$
Q_{He}	$(H^\dagger i\overleftrightarrow{D}_\mu H)(\bar{e}_p\gamma^\mu e_r)$
$Q_{Hq}^{(1)}$	$(H^\dagger i\overleftrightarrow{D}_\mu H)(\bar{q}_p\gamma^\mu q_r)$
$Q_{Hq}^{(3)}$	$(H^\dagger i\overleftrightarrow{D}_\mu^I H)(\bar{q}_p\tau^I\gamma^\mu q_r)$
Q_{Hu}	$(H^\dagger i\overleftrightarrow{D}_\mu H)(\bar{u}_p\gamma^\mu u_r)$
Q_{Hd}	$(H^\dagger i\overleftrightarrow{D}_\mu H)(\bar{d}_p\gamma^\mu d_r)$
Q_{Hud} + h.c.	$i(\widetilde{H}^\dagger D_\mu H)(\bar{u}_p\gamma^\mu d_r)$

8 : $(\bar{L}L)(\bar{L}L)$	
Q_{ll}	$(\bar{l}_p\gamma_\mu l_r)(\bar{l}_s\gamma^\mu l_t)$
$Q_{qq}^{(1)}$	$(\bar{q}_p\gamma_\mu q_r)(\bar{q}_s\gamma^\mu q_t)$
$Q_{qq}^{(3)}$	$(\bar{q}_p\gamma_\mu\tau^I q_r)(\bar{q}_s\gamma^\mu\tau^I q_t)$
$Q_{lq}^{(1)}$	$(\bar{l}_p\gamma_\mu l_r)(\bar{q}_s\gamma^\mu q_t)$
$Q_{lq}^{(3)}$	$(\bar{l}_p\gamma_\mu\tau^I l_r)(\bar{q}_s\gamma^\mu\tau^I q_t)$

8 : $(\bar{R}R)(\bar{R}R)$	
Q_{ee}	$(\bar{e}_p\gamma_\mu e_r)(\bar{e}_s\gamma^\mu e_t)$
Q_{uu}	$(\bar{u}_p\gamma_\mu u_r)(\bar{u}_s\gamma^\mu u_t)$
Q_{dd}	$(\bar{d}_p\gamma_\mu d_r)(\bar{d}_s\gamma^\mu d_t)$
Q_{eu}	$(\bar{e}_p\gamma_\mu e_r)(\bar{u}_s\gamma^\mu u_t)$
Q_{ed}	$(\bar{e}_p\gamma_\mu e_r)(\bar{d}_s\gamma^\mu d_t)$
$Q_{ud}^{(1)}$	$(\bar{u}_p\gamma_\mu u_r)(\bar{d}_s\gamma^\mu d_t)$
$Q_{ud}^{(8)}$	$(\bar{u}_p\gamma_\mu T^A u_r)(\bar{d}_s\gamma^\mu T^A d_t)$

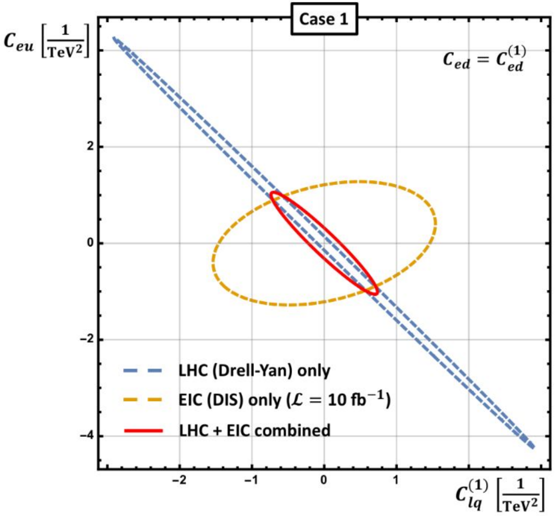
8 : $(\bar{L}L)(\bar{R}R)$	
Q_{le}	$(\bar{l}_p\gamma_\mu l_r)(\bar{e}_s\gamma^\mu e_t)$
Q_{lu}	$(\bar{l}_p\gamma_\mu l_r)(\bar{u}_s\gamma^\mu u_t)$
Q_{ld}	$(\bar{l}_p\gamma_\mu l_r)(\bar{d}_s\gamma^\mu d_t)$
Q_{qe}	$(\bar{q}_p\gamma_\mu q_r)(\bar{e}_s\gamma^\mu e_t)$
$Q_{qu}^{(1)}$	$(\bar{q}_p\gamma_\mu q_r)(\bar{u}_s\gamma^\mu u_t)$
$Q_{qu}^{(8)}$	$(\bar{q}_p\gamma_\mu T^A q_r)(\bar{u}_s\gamma^\mu T^A u_t)$
$Q_{qd}^{(1)}$	$(\bar{q}_p\gamma_\mu q_r)(\bar{d}_s\gamma^\mu d_t)$
$Q_{qd}^{(8)}$	$(\bar{q}_p\gamma_\mu T^A q_r)(\bar{d}_s\gamma^\mu T^A d_t)$

8 : $(\bar{L}R)(\bar{R}L)$ + h.c.	
Q_{ledq}	$(\bar{l}_p^j e_r)(\bar{d}_s q_{tj})$

8 : $(\bar{L}R)(\bar{L}R)$ + h.c.	
$Q_{quqd}^{(1)}$	$(\bar{q}_p^j u_r)\epsilon_{jk}(\bar{q}_s^k d_t)$
$Q_{quqd}^{(8)}$	$(\bar{q}_p^j T^A u_r)\epsilon_{jk}(\bar{q}_s^k T^A d_t)$
$Q_{lequ}^{(1)}$	$(\bar{l}_p^j e_r)\epsilon_{jk}(\bar{q}_s^k u_t)$
$Q_{lequ}^{(3)}$	$(\bar{l}_p^j\sigma_{\mu\nu}e_r)\epsilon_{jk}(\bar{q}_s^k\sigma^{\mu\nu}u_t)$

Warsaw Basis: 59 Operators $(\delta B = 0, \delta L = 0)$

Grzadkowski/Iskrzynski/Misiak/Rosiek (1008.4884)



Quantify deviation from SM through comparison with data

- **Model independent constraints** on new physics
- Maximal gain from data
- Part of the **LHC legacy**

SMEFT suffers from a large number of flat directions

↳ We presented a strategy to lift 4-Fermi **flat directions**

The future **EIC** will complement LHC data

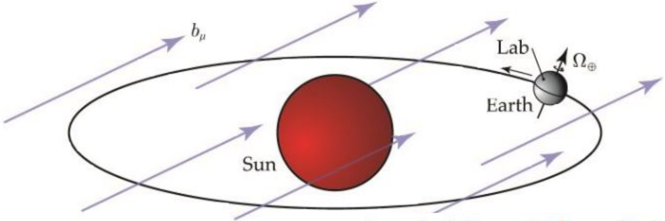
↳ Combine EIC observables with **different polarizations** additionally to LHC measurements

↳ Interplay of different measurements improve bounds significantly

Lorentz violating effects

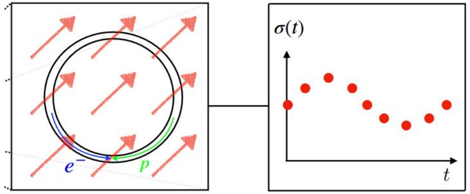
Based on:
A. Kostelecky, E.L. and A. Vieira [1610.09318]
E.L. and N. Sherrill [1805.11684]
A. Kostelecky, E.L., N. Sherrill and A. Vieira [1911.04002]

Enrico Lunghi



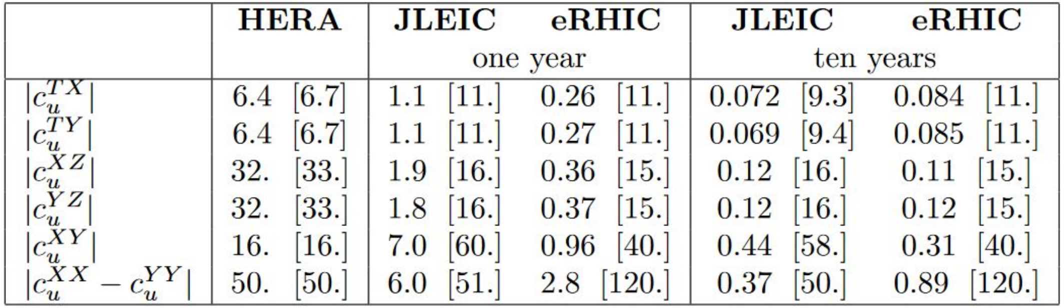
- **local sidereal time** ($T_\oplus$)

$$\sigma(T_\oplus) \sim \sigma_{\text{SM}} \left(1 + c_0 + c_1 \cos(\omega_\oplus T_\oplus) + c_2 \cos(2\omega_\oplus T_\oplus) + \cdots\right)$$



- Construct an extension to the SM where the vacuum expectation of a constant background field is not Lorentz invariant
    - For example: the lifetime of a boosted muon and the lifetime of a muon at rest but measured in a boosted frame would differ
- This would lead measurements varying with sidereal time

- Expected bounds in units of 10^{-5}



	HERA	JLEIC	eRHIC	JLEIC	eRHIC
		one year		ten years	
$\lvert c_u^{TX}\rvert$	6.4 [6.7]	1.1 [11.]	0.26 [11.]	0.072 [9.3]	0.084 [11.]
$\lvert c_u^{TY}\rvert$	6.4 [6.7]	1.1 [11.]	0.27 [11.]	0.069 [9.4]	0.085 [11.]
$\lvert c_u^{XZ}\rvert$	32. [33.]	1.9 [16.]	0.36 [15.]	0.12 [16.]	0.11 [15.]
$\lvert c_u^{YZ}\rvert$	32. [33.]	1.8 [16.]	0.37 [15.]	0.12 [16.]	0.12 [15.]
$\lvert c_u^{XY}\rvert$	16. [16.]	7.0 [60.]	0.96 [40.]	0.44 [58.]	0.31 [40.]
$\lvert c_u^{XX} - c_u^{YY}\rvert$	50. [50.]	6.0 [51.]	2.8 [120.]	0.37 [50.]	0.89 [120.]

- Coefficients in the photon, electron, muon, proton and neutron sectors are strongly constrained.
- The quark sector is much harder to constraint because of the nature of QCD
- We focused on electron-proton Deep Inelastic Scattering and Drell-Yan for which high statistics measurements exist (and are possible in the future) and found that bounds in the $10^{-5,6}$ range are attainable using existing HERA/LHC and future EIC data.
- Analysis of a subset of Zeus data is undergoing
- Future studies include
    - Impact on PDFs (standard and polarization dependent)
    - Inclusion of weak effects (Z-pole observables, ...)

Ciprian Gal