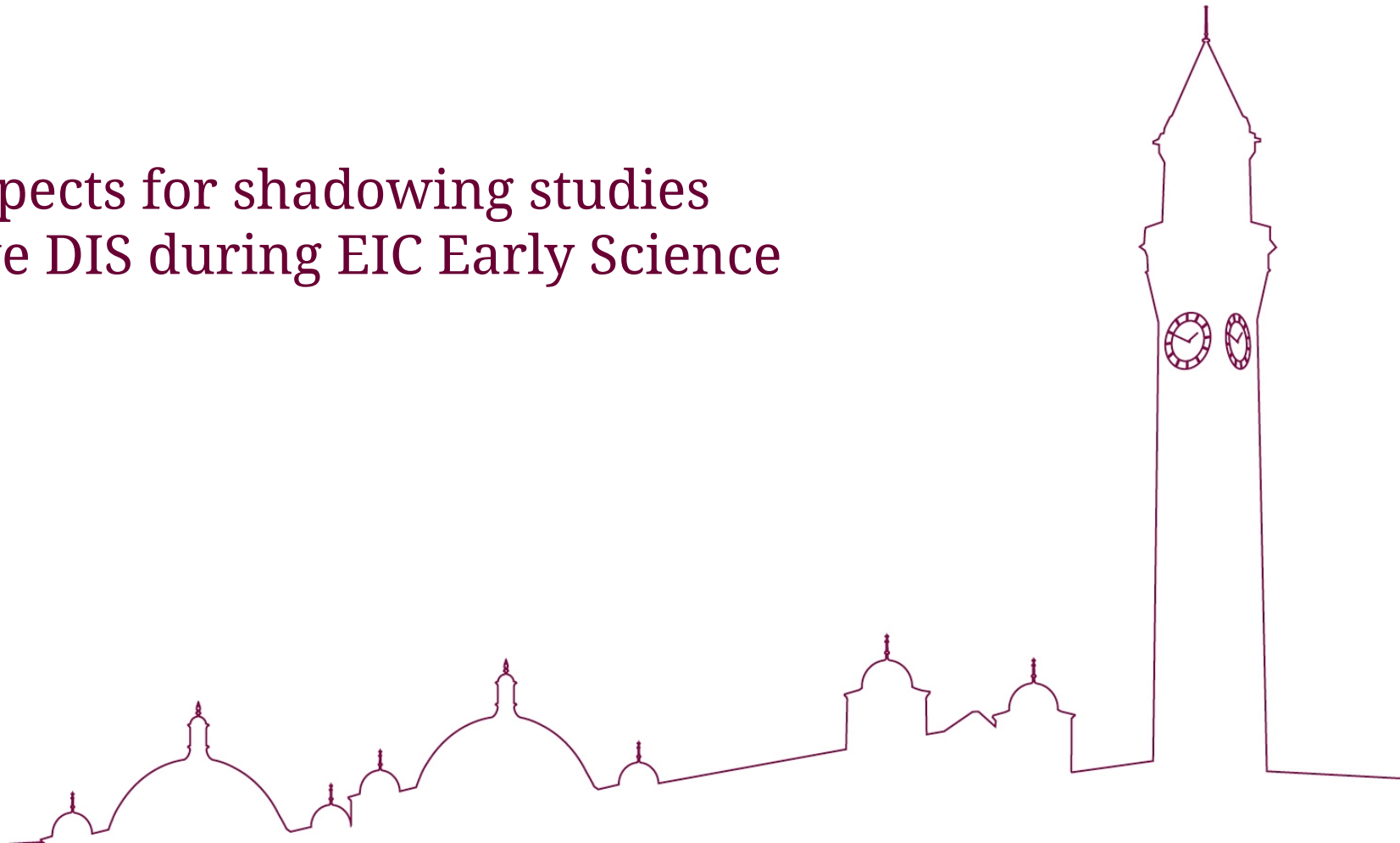
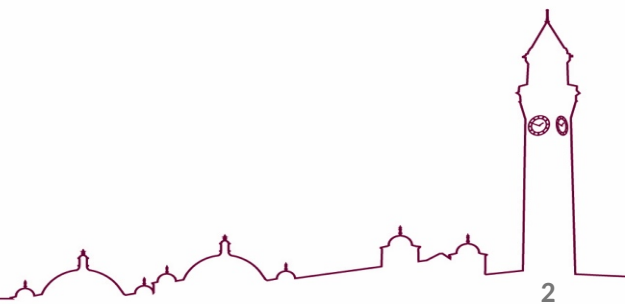
UNIVERSITY OF BIRMINGHAM | SCHOOL OF PHYSICS AND ASTRONOMY

Update: prospects for shadowing studies with inclusive DIS during EIC Early Science

S. Maple



Last time



Early Science – what we have so far

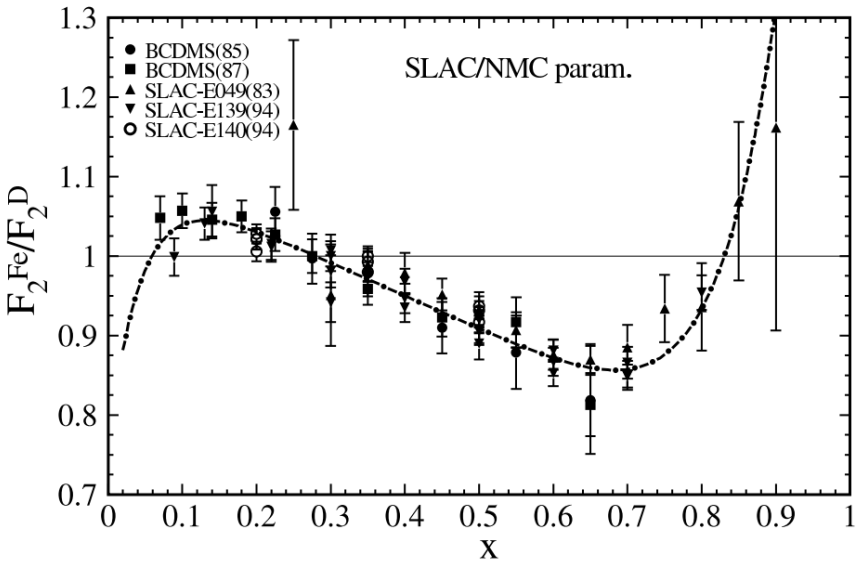
	Species	Energy (GeV)	Luminosity/year (fb-1)	Electron polarization	p/A polarization
YEAR 1	e+Ru or e+Cu	10 x 115	0.9	NO (Commissioning)	N/A
YEAR 2	e+D e+p	10 x 130	11.4 4.95 - 5.33	LONG	NO TRANS
YEAR 3	e+p	10 x 130	4.95 - 5.33	LONG	TRANS and/or LONG
YEAR 4	e+Au e+p	10 x 100 10 x 250	0.84 6.19 - 9.18	LONG	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					

- e-p cross sections, F_2, (F_L?)
- Impact on proton PDFs, α_s
- A_1^p, g_1^p
- $A_1{}^3He$, A_1^n, g_1^n

We have some interesting projections to include for e-p and e-^{3}He runs so the goals should be:
→ Get something together for e-(heavy)A

What can we do in time?

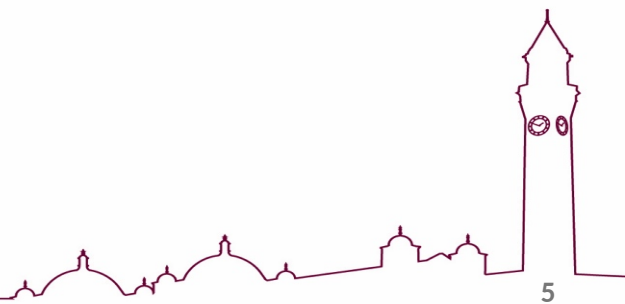
- Time scale is short – will need to prioritise
  - Important to get **something** for eRu/eCu or eAu produced
  - To me, a cross section/structure function ratio plot would be ideal
  - Also need to make sure that are systematics estimates are as well justified as we can make them in this time
  - Several studies are possible



Systematic uncertainty	Achieved at H1/ZEUS*	Expected at EIC†	Possible studies
Electron finder efficiency	0.2-5% (increase w y)	???	Tighten and relax cuts used in e-finding → study variation in efficiency
Electron energy scale	0.5-1.9% (increase w y) (1-5% on σ)	???	Take a guess – using 0.5% for now?
Electron polar angle	1mrad	???	Take a guess – use track angle reso for now?
Hadronic energy scale	2% (0.5-4% on σ)	???	Take a guess – using 1% for now?
Photoproduction background	10% (0.5-3% on σ)	2% on σ	Compare number of events produced by different generators that are reconstructed as DIS
QED radiative corrections	0.3-2% (increase w x,y)	1%	Compare size of radiative correction in bins with different event generators/generator settings
Luminosity	1.5%	1%	Use ~~1%~~ 1.5%?
Polarisation	N/A	<1% ?	Use ~~1%~~ 1.5%?

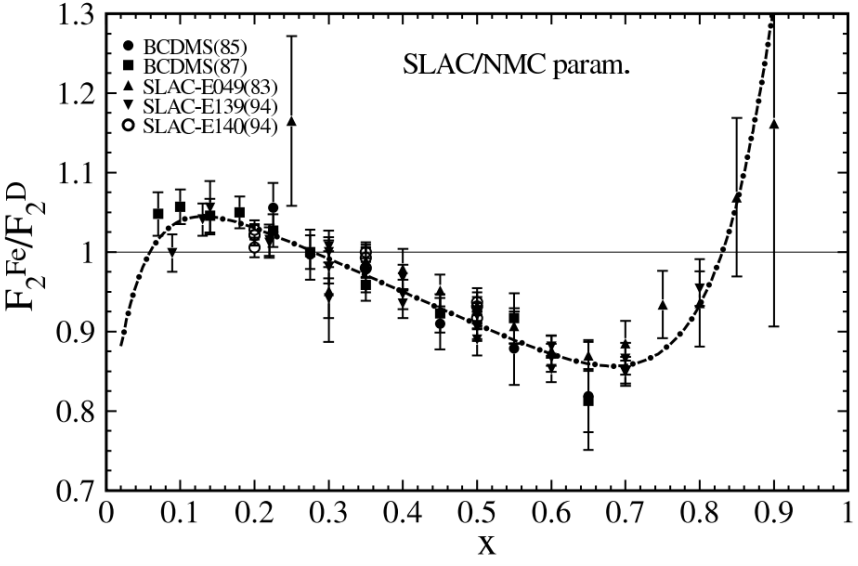
Thoughts?

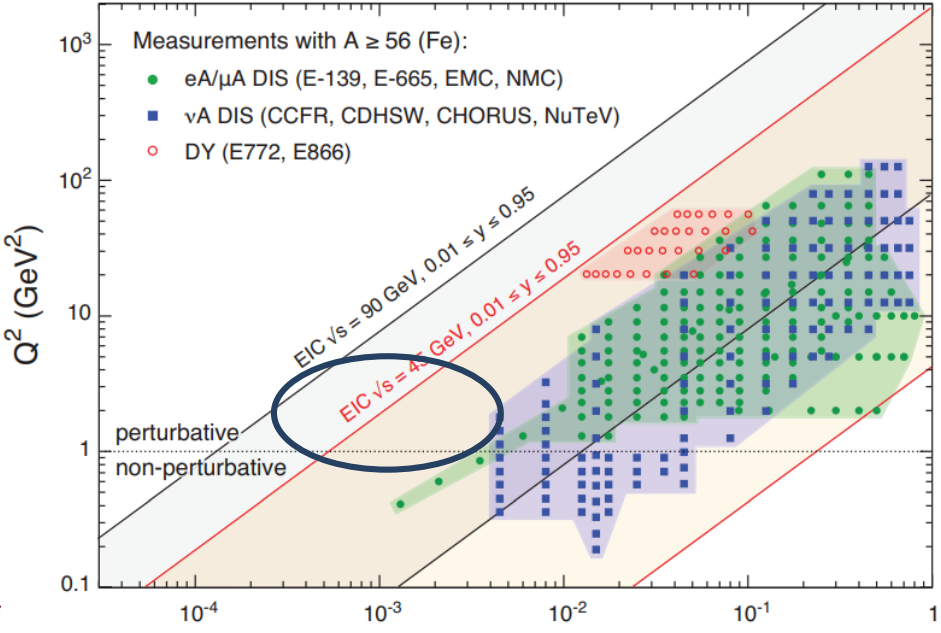
This time



Nuclear shadowing at the EIC

- Last time: below plot shown as example of kind of measurement we may target
- Slightly misleading – Fixed target and collider probe different regions of phase space → don't want EMC effect plot in the x>0.1 region → want the first ever structure fn ratios down to x~10^{-3} (or beyond?)
  - Compare to different shadowing models





Measurement phase space

- Reduced cross section measurements can be used to extract F_2

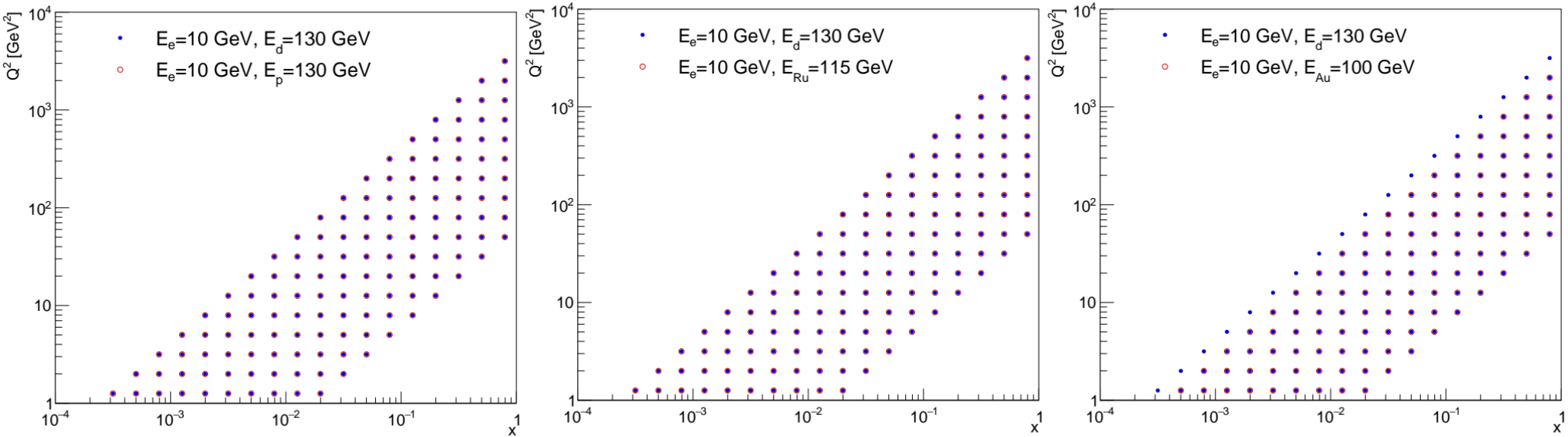
$$\sigma_r = \frac{xQ^4}{2\pi\alpha^2 Y_+}\left[\frac{d^2\sigma}{dxdQ^2}\right] = F_2(x,Q^2) - \frac{y^2}{Y_+}F_L(x,Q^2) + \frac{Y_-}{Y_+}xF_3$$

- ...using a model to obtain FL. F_3 can be neglected at low Q^2

- For each cross section I will assume (based on YR estimates)
  - 1.9% totally uncorrelated point-to-point uncertainties
  - 3.4% normalisation uncertainty that is correlated between all points of a given beam configuration and totally uncorrelated between beam configurations
  - … leading to 3.9% total uncertainty per cross section measurement
- Neglecting uncertainties from the modelling of F_L I will use 3.9% uncertainty on each F_2

Measurement phase space

- Our measurement phase space for e-p events has been 5 bins per decade in x and Q^2 (informed by kinematic resolution studies) over the range 0.01<y<0.95
  - Keep this binning + range for now
- Shared phase space of early science beam configurations:



→ **Phase space for e-p and e-d same for early science**

→ **eRu close enough to share all bins, eAu loses lowest x bin for each Q^2 bin**

Structure function ratio predictions

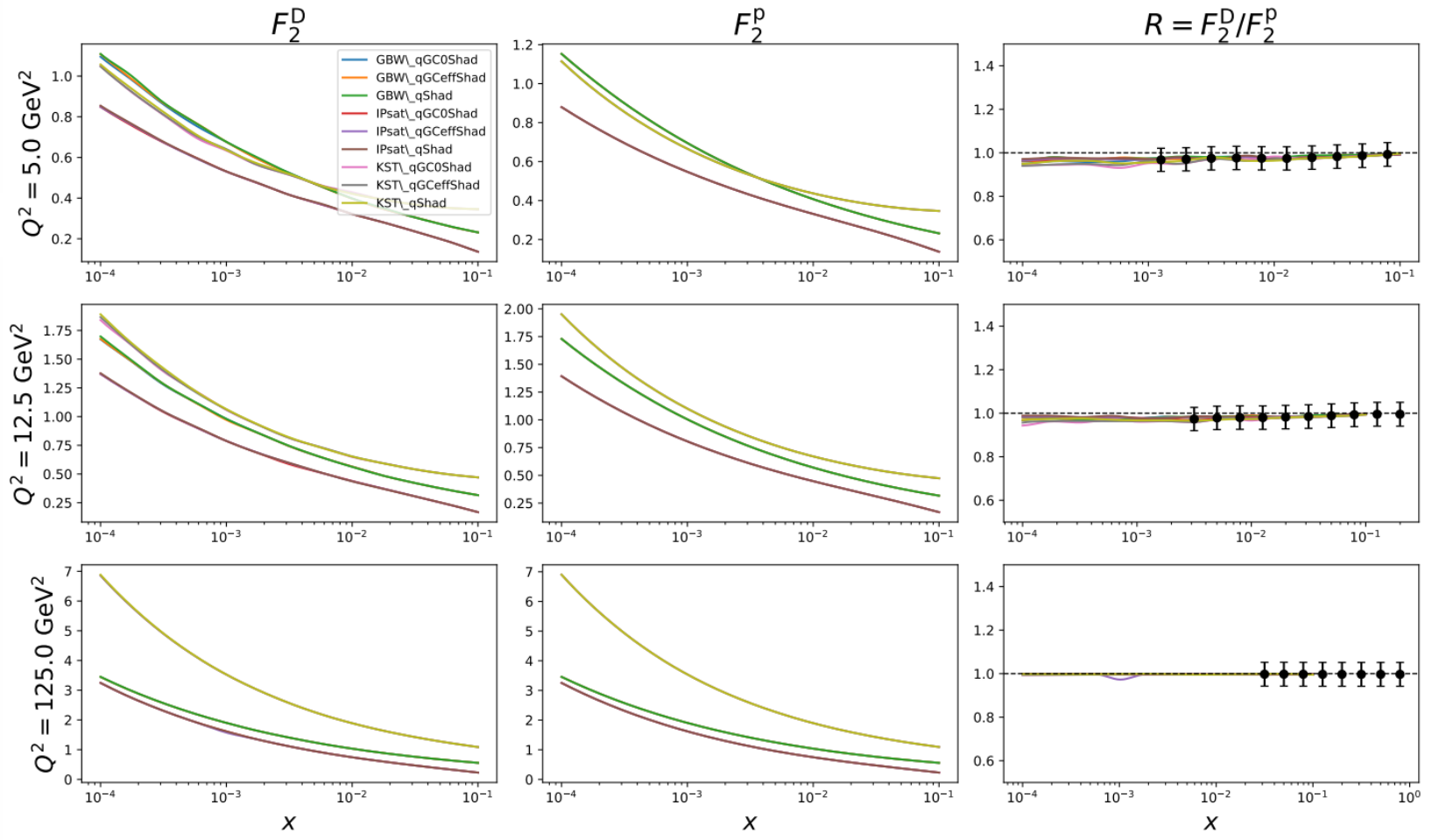
- We can study shadowing through the ratio $(F_2^A/A)/F_2^{(n)}$ where $F_2^{(n)}$ is the F_2 structure function for a free nucleon
  - Can approximate this by either F_2^p or $F_2^D/2$

- Different shadowing models will give different results for different structure function ratios

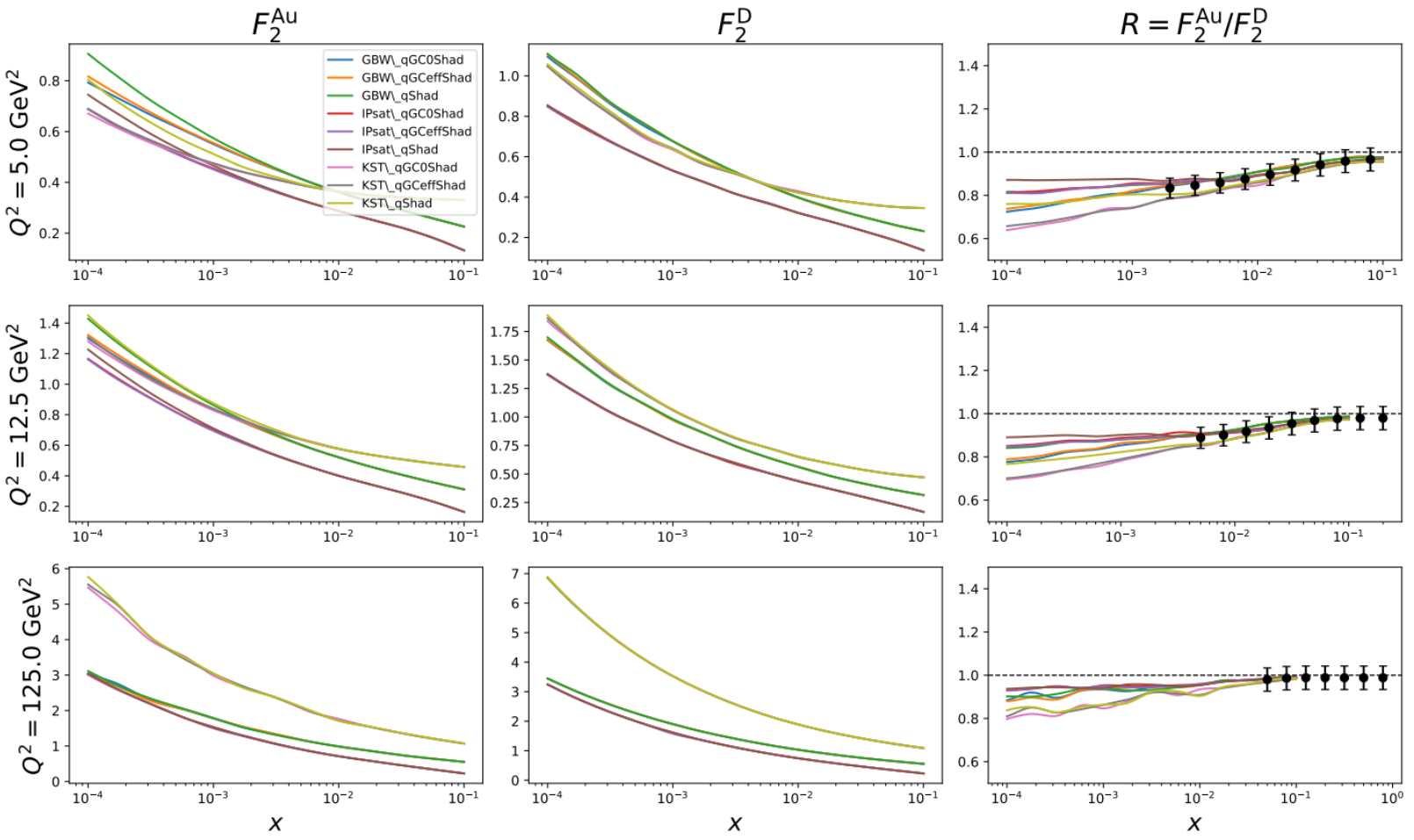
- I will obtain my estimates using structure function grids provided by M. Krelina and J. Nemchik which were linked to in their paper

- To obtain the structure functions interpolated to the x and Q^2 values of our EIC bins I will use Jefferson lab's txgrids program

Structure function ratio predictions



Structure function ratio predictions



The takeaway…

- The first few years of EIC running will give us our first ever eA collider data!
- Amongst other things, this will give us a rather direct method to probe the modification of the F_2 structure function…
- Different shadowing models give very different results particularly at low x → EIC data will offer the opportunity to better understand shadowing through measuring structure function ratios towards $x \sim 10^{-3}$