JLab in 2037: Complete the Program on SFs for $x \rightarrow 1$

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- Structure Functions at x -> 1: Dominated by **up and down valence quarks** => quantum numbers of the nucleon
- Important for higher power x^n moments => Mellin Moments, LQCD
- Related to high-Q^2, moderate x through DGLAP => relevant for LHC Physics
- F_{2n} at large x is crucial to truly study the EMC effect and to extract n SSFs/A_1
- **MANY predictions based on models, pQCD, DS equation and Lattice QCD** *):

SU(6)-symmetric proton wave function in the "naïve" quark model:

$$|p\uparrow\rangle = \frac{1}{\sqrt{18}}\left(3u\uparrow[ud]_{S=0} + u\uparrow[ud]_{S=1} - \sqrt{2}u\downarrow[ud]_{S=1} - \sqrt{2}d\uparrow[uu]_{S=1} - 2d\downarrow[uu]_{S=1}\right)$$

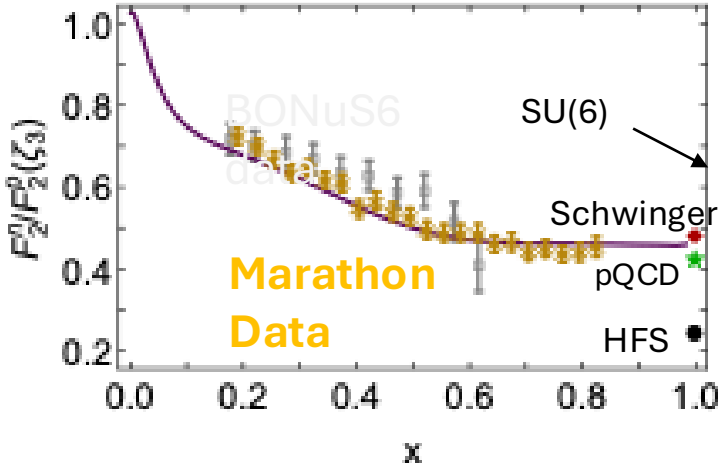
In this model: $d/u = 1/2$, $\Delta u/u = 2/3$, $\Delta d/d = -1/3$ for all x

Hyperfine structure effect in QM: S=1 diquark suppressed => d/u = 0, Δu/u = 1, Δd/d = -1/3 for $x \rightarrow 1$

pQCD: helicity conservation ($q\uparrow\uparrow p$) => d/u -> 2/(9+1) = 1/5, $\Delta u/u \rightarrow 1$, $\Delta d/d \rightarrow 1$ for $x \rightarrow 1$

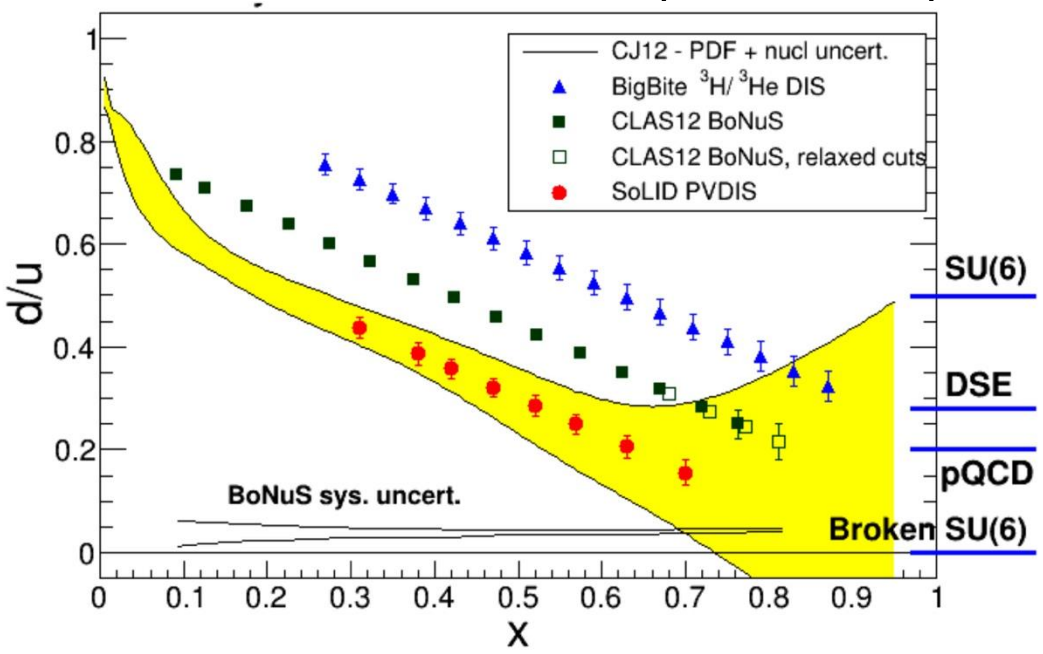
Other approaches: Dyson-Schwinger Equation, statistical models, pQCD + orbital angular momentum, AdS (Light-front holographic QCD)

Y.Lu,L.Chang, K.Raya, C.D.Roberts, J.Rodríguez-Quintero, Proton and pion distribution functions in counterpoint, Phys. Lett. B**830** (2022)137130.

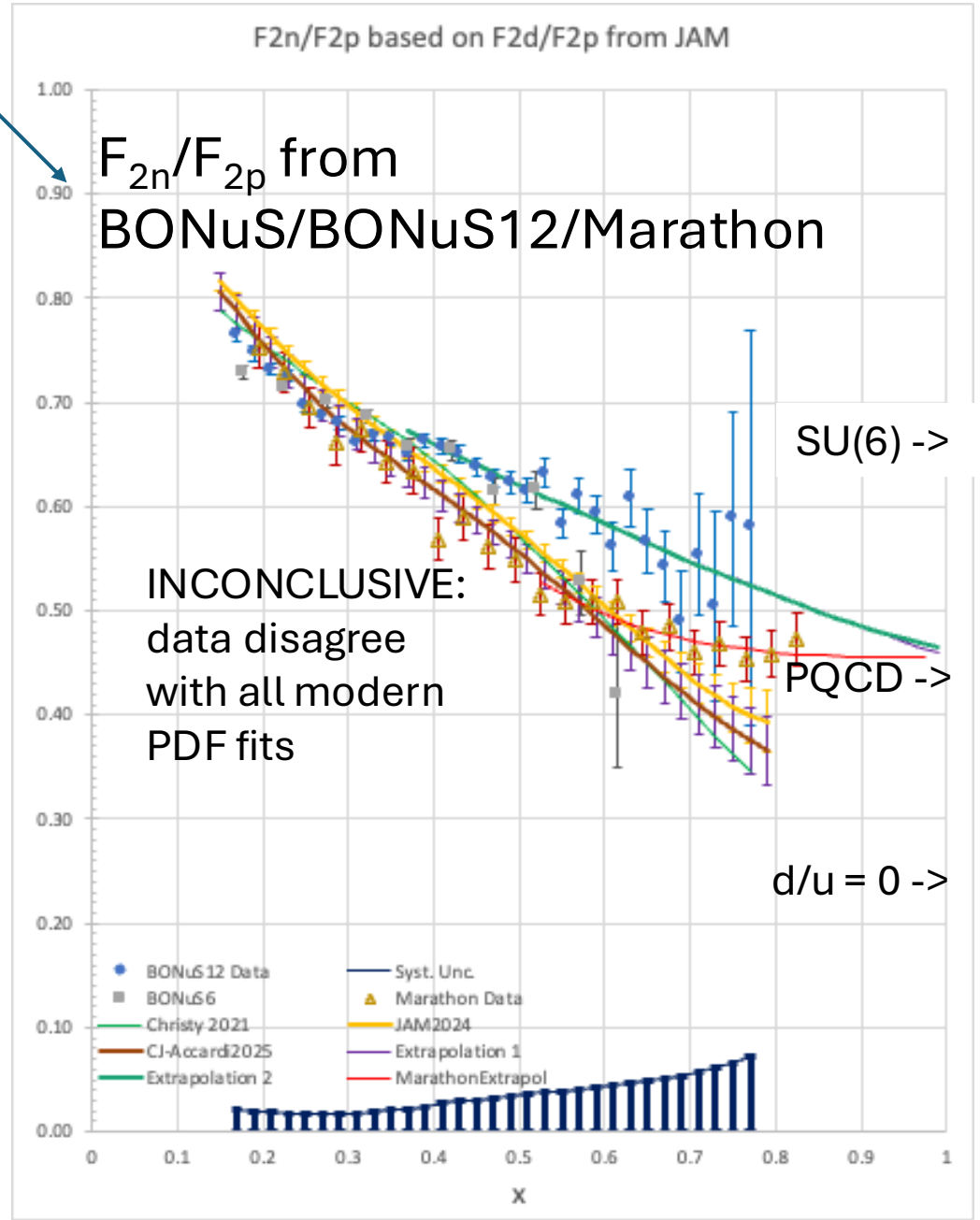


*) Moments, quasi-PDFs, pseudo-PDFs

What we PROMISED (2017 LRP):

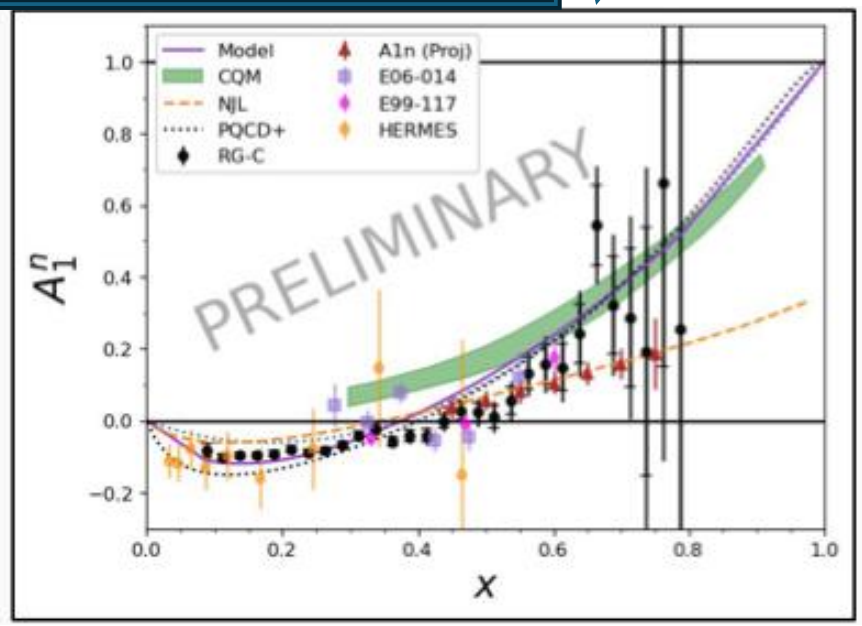


What we have achieved so far

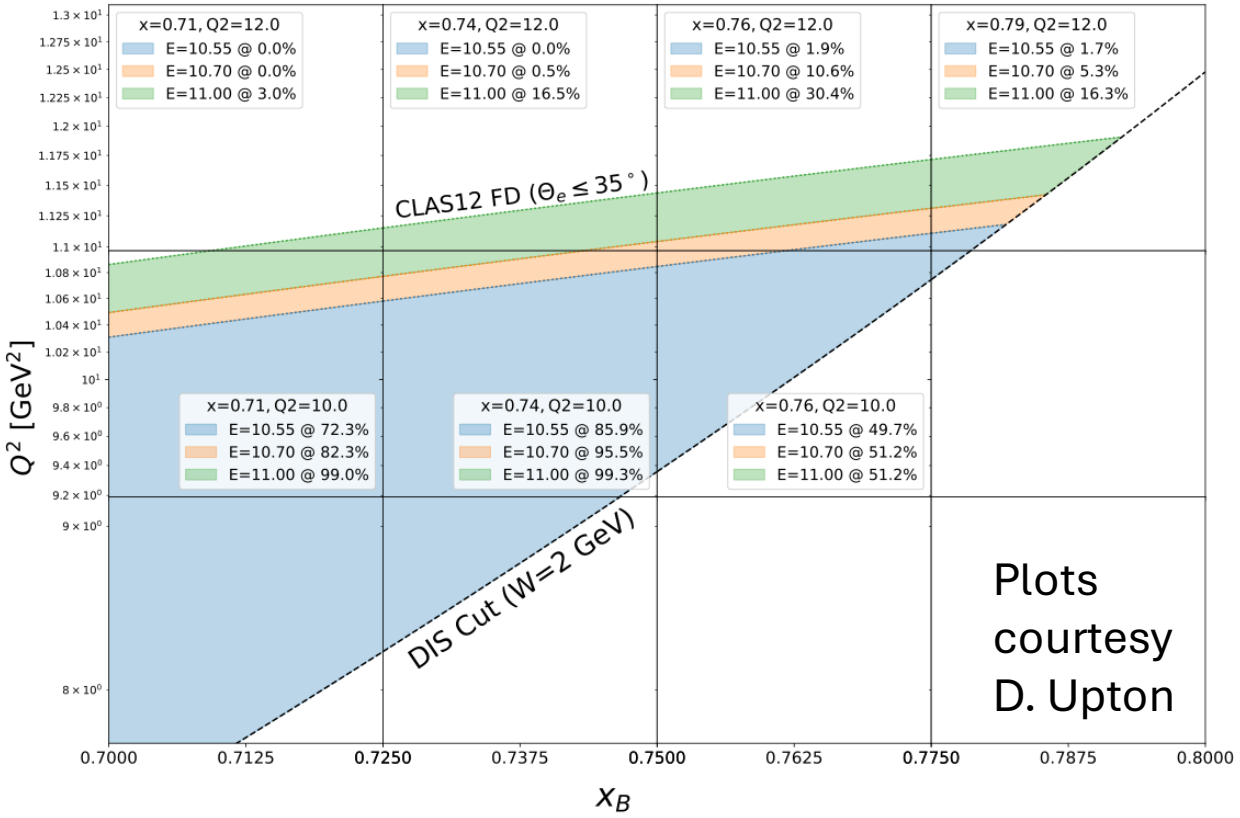


Expected Precision on A_{1n} extracted from p and d (RGC) and ^{3}He data

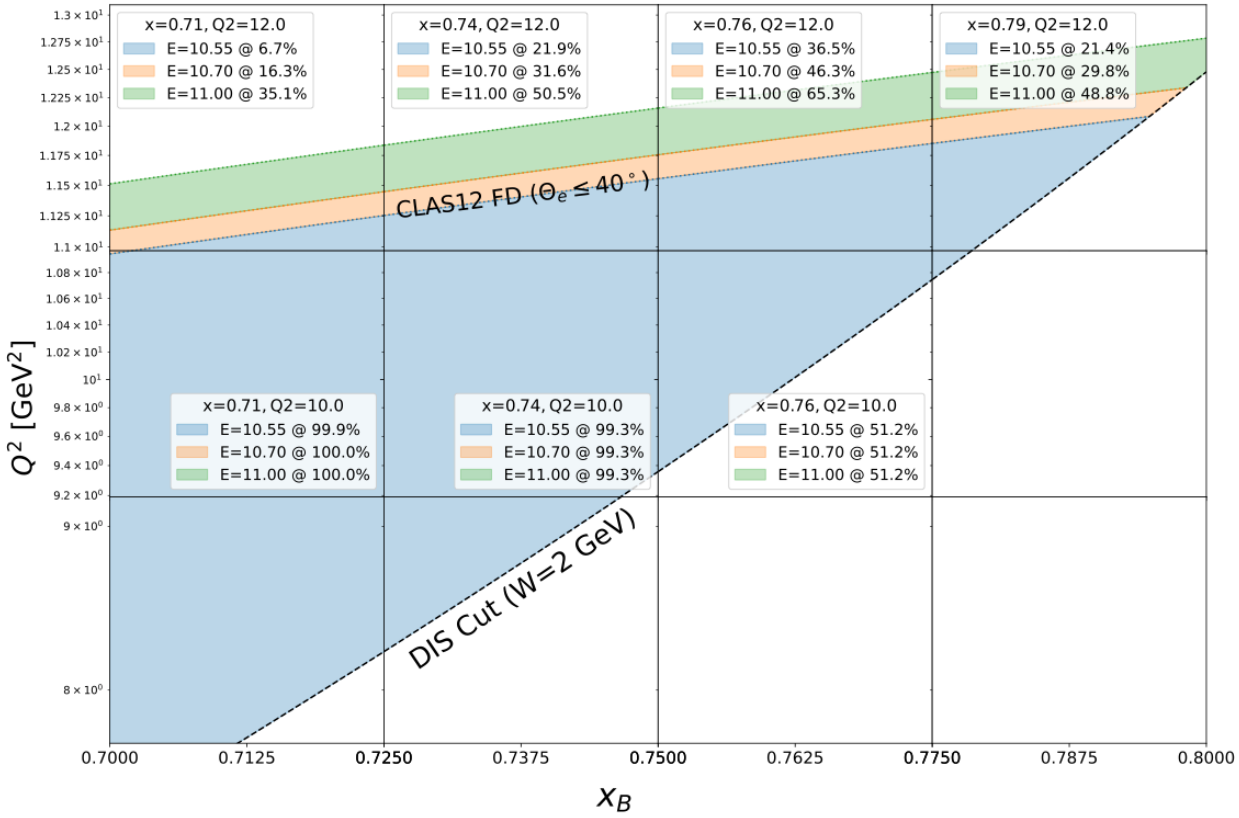
INCONCLUSIVE:
A_{1n} -> 1 as x -> 1?



Even a MODEST increase in beam energy (15 GeV? or at least 12 GeV in all Halls?) plus significant increase in luminosity would help!



Plots courtesy D. Upton



Note how even just going to ACTUAL 11 GeV beam could significantly increase statistics for highest x-bin