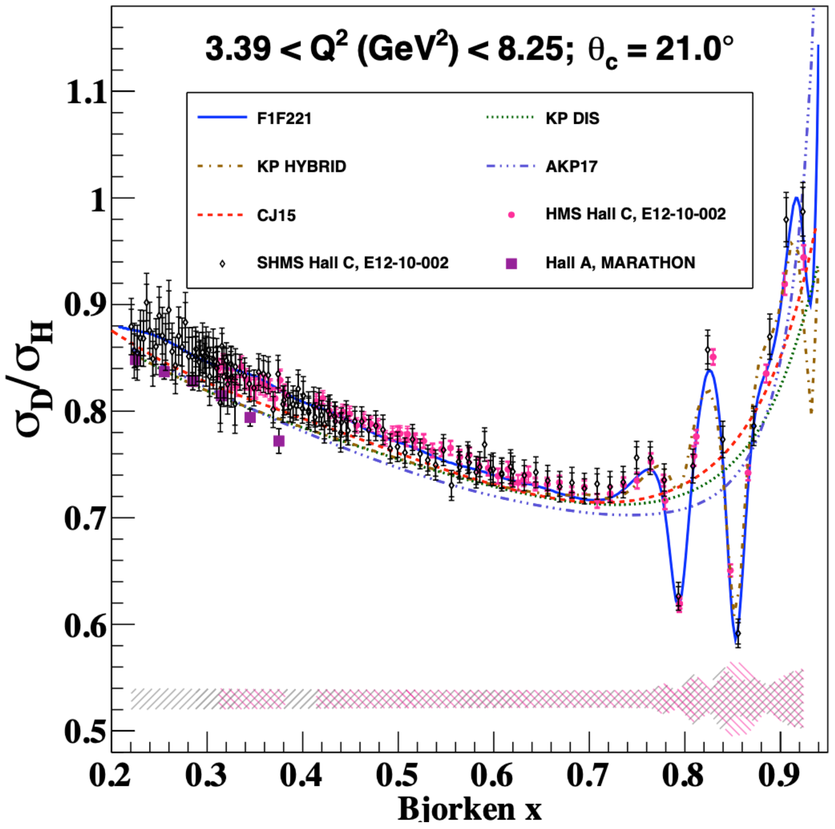
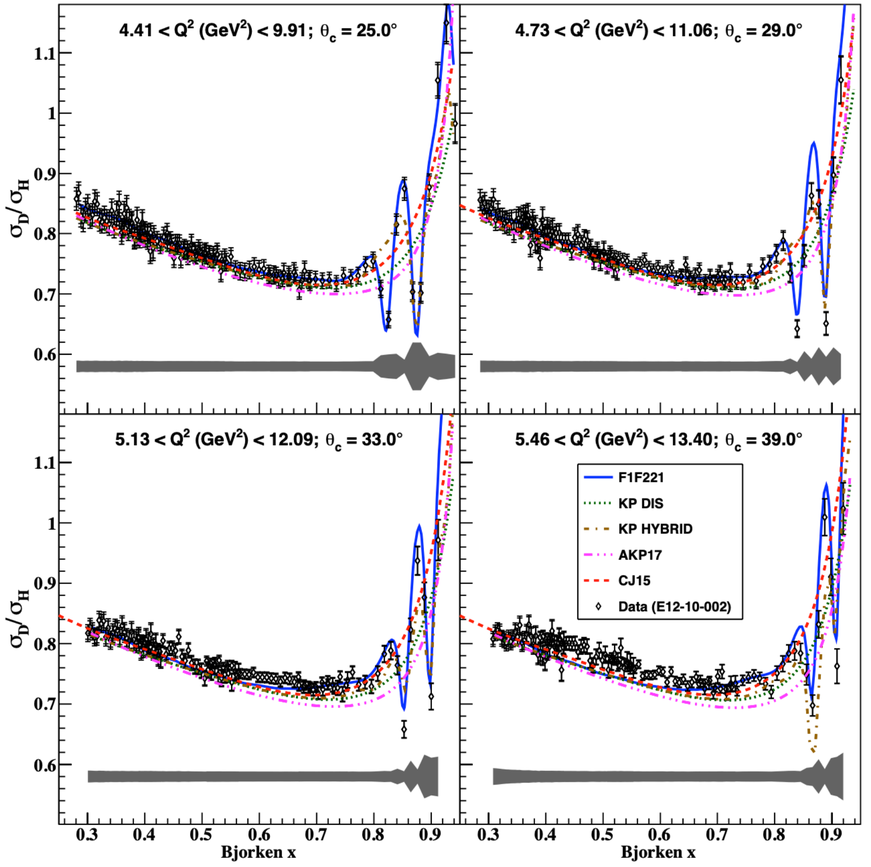
F2 Analysis in Hall C

Precision measurements of the F_2 structure function at large x in the resonance region and beyond

E12-10-002



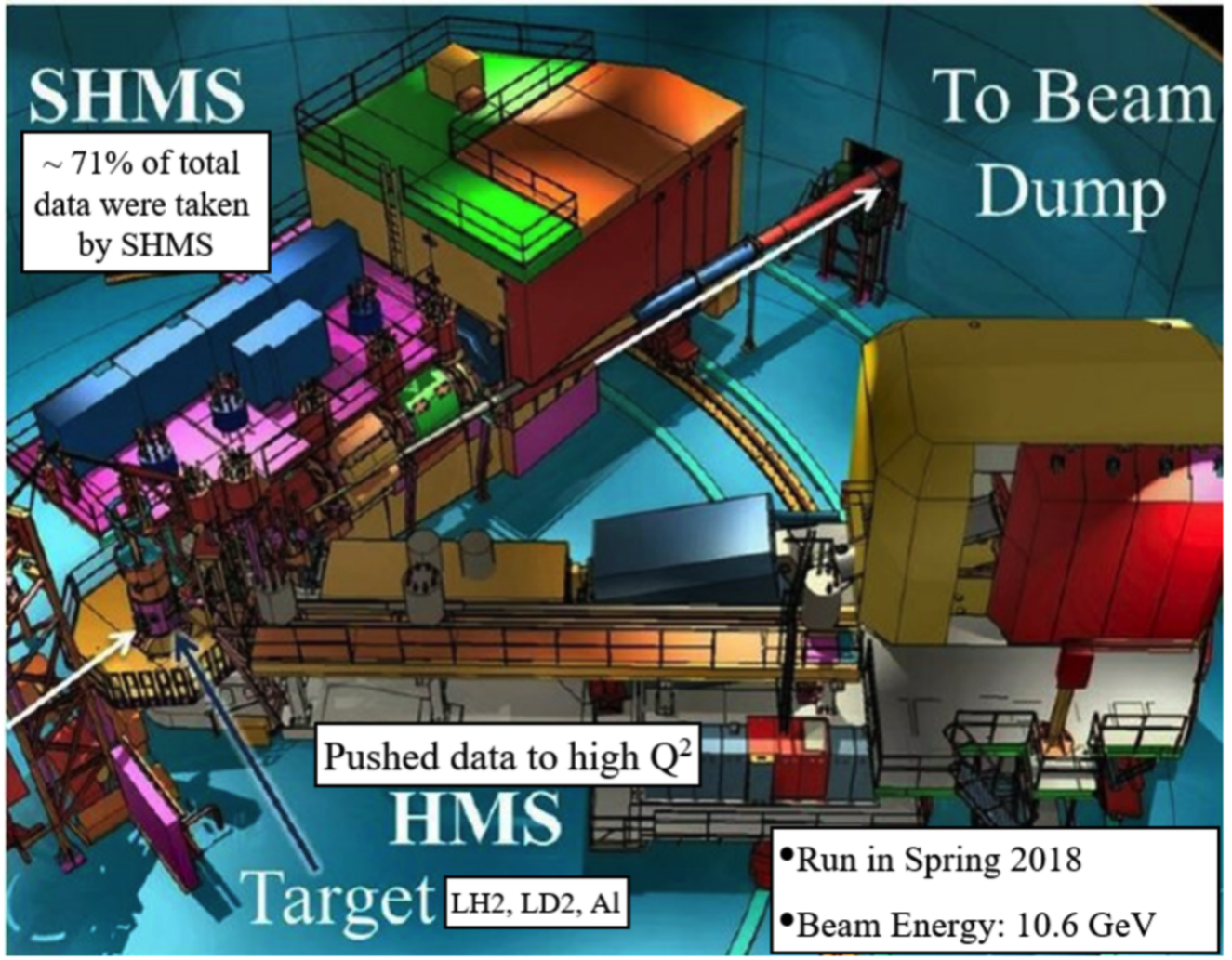
Bill Henry
July 8th, 2021

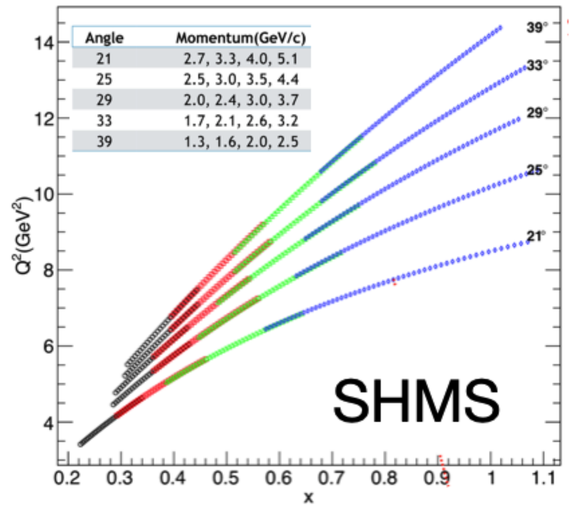


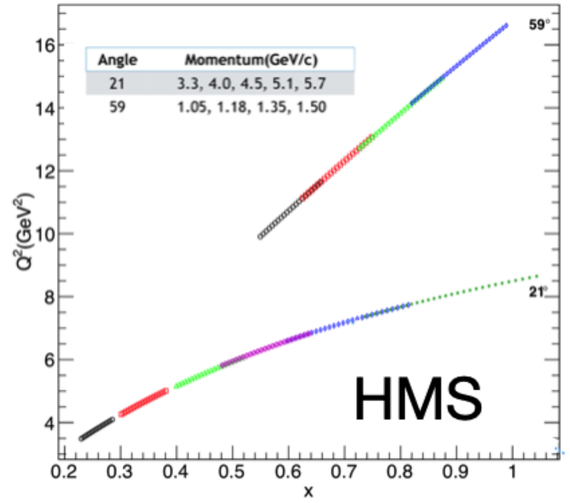
Experiment Overview

- Hall C Commisioning experiment
- Electrons detected in both SHMS and HMS
- Ran with E12-10-008 (EMC ratios in lighter nuclei)

See Abishek's talk next!







Cross Section Extraction: Data Yields

$$Y_{data}^{corrected} = \frac{Y_{data}^{Raw} * Prescale * (1 - \pi^{0}_{contamination})}{\epsilon_{cer} * \epsilon_{tracking} * \epsilon_{boiling} * LT}$$

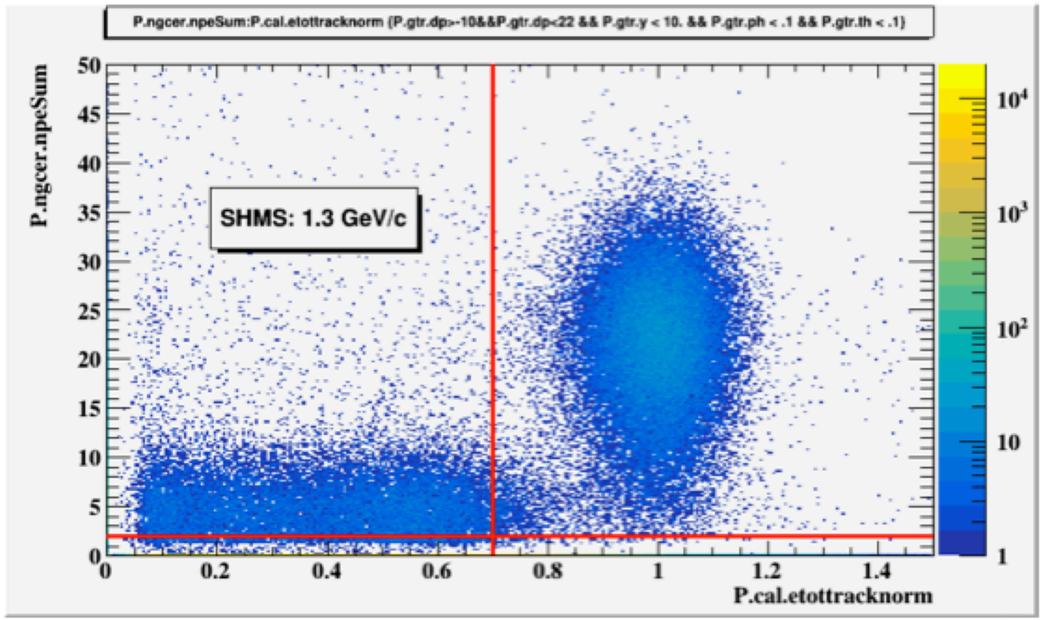
See Hall C Winter 2021 talk for details

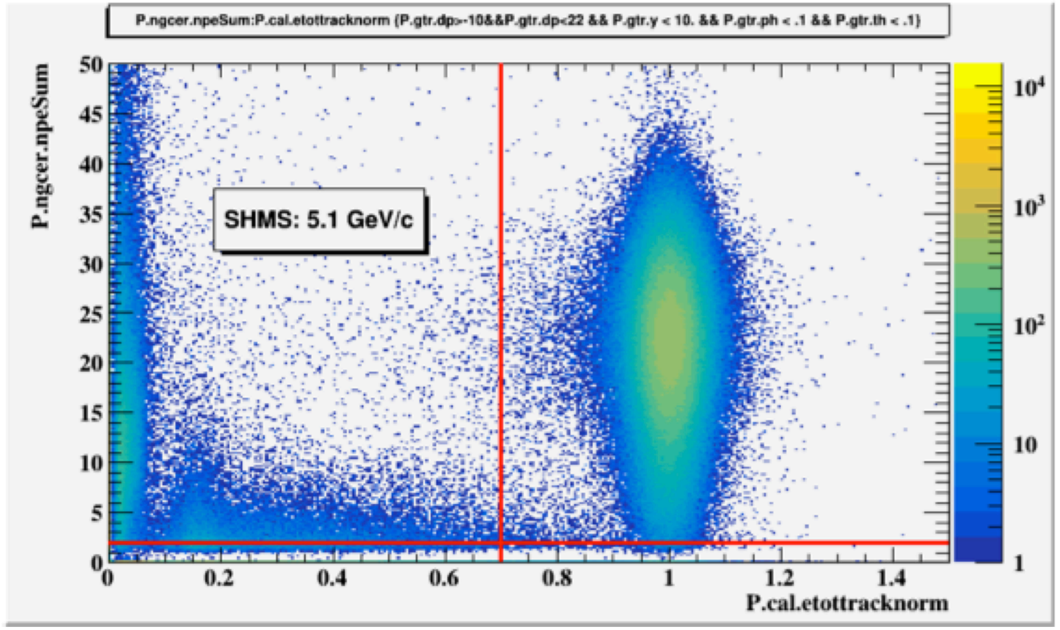
SHMS PID cuts:

- E/p > 0.7 (etottracknorm)
- Npe > 2.0 (ngcer.npeSum)

SHMS Acceptance cuts:

- -10 < delta < 22
- |ytar| < 10 cm
- |xptar| < 100 mr
- |yptar| < 100 mr

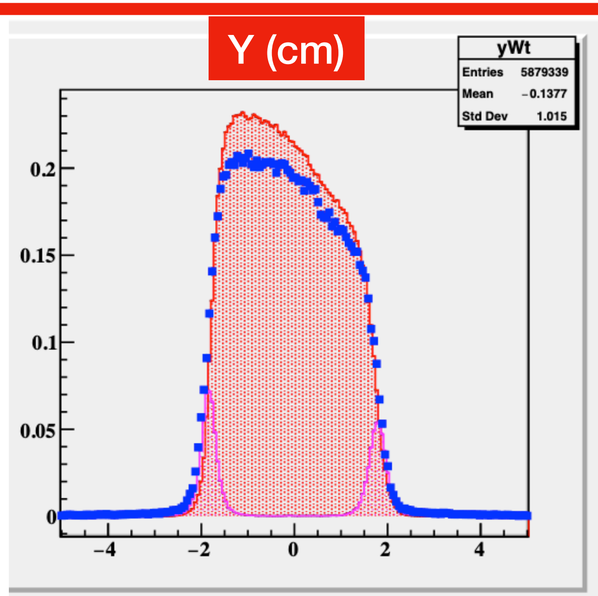


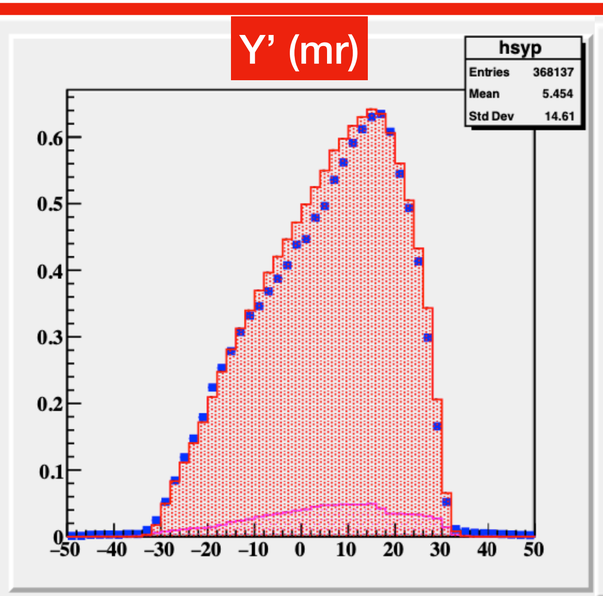


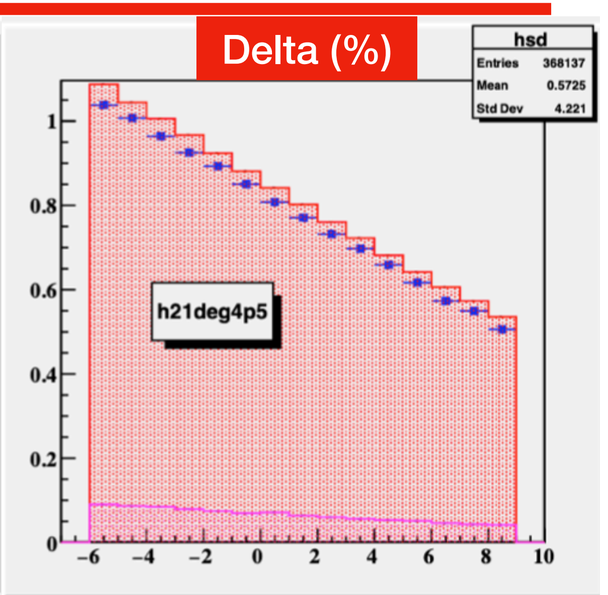
Cross Section Extraction: Monte Carlos Ratio Method

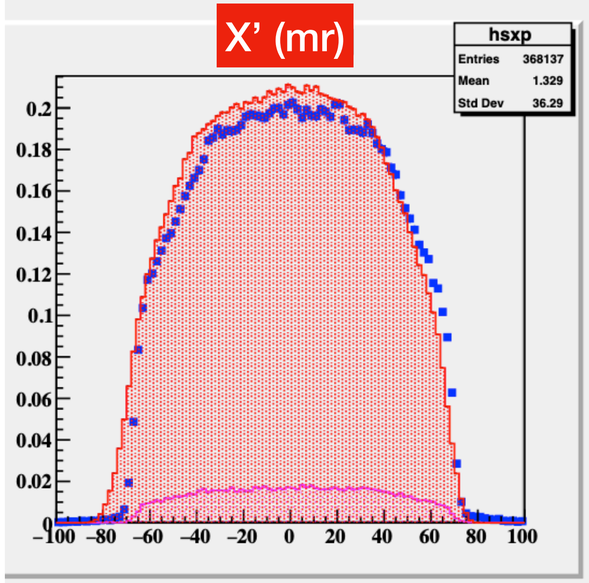
HMS

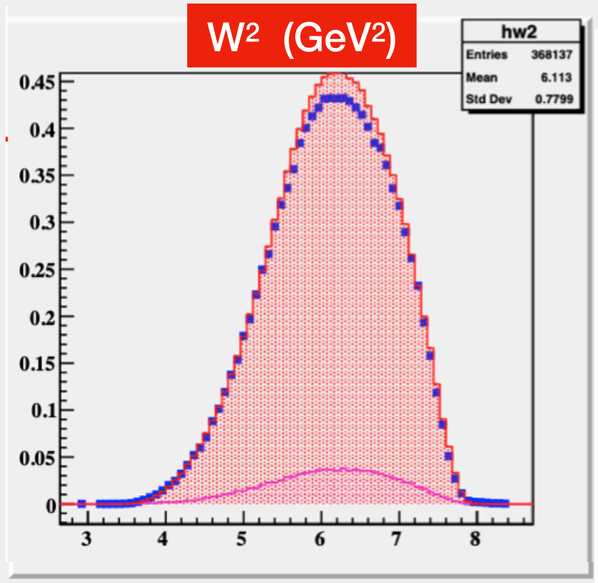
- MC simulation: mc_single_arm
- model: f1f221 (M.E. Christy)
- radiative corrections: rc_externals
- After cross section weighting the MC is scaled by $MC_{ScaleFact}$

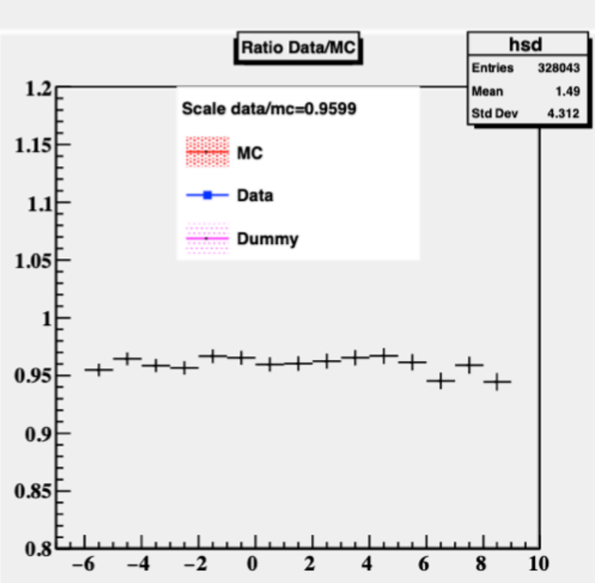












$$MC_{ScaleFact} = \frac{L_{Data}}{L_{MC}}$$

$$L_{Data} = \frac{N_A * L_{tgt} * \rho_{tgt} * Q}{M_{tgt} * e}$$

$$L_{MC} = \frac{N_{gen}}{\Delta E \Delta \Omega}$$

Cross Section Extraction: Monte Carlos Ratio Method

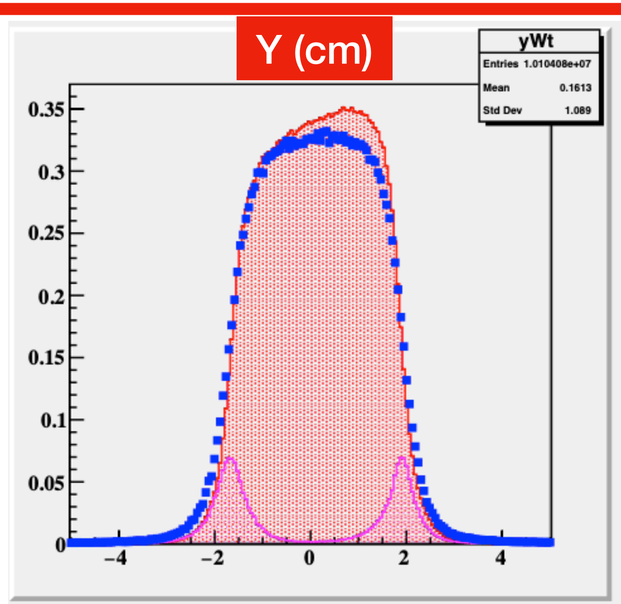
SHMS

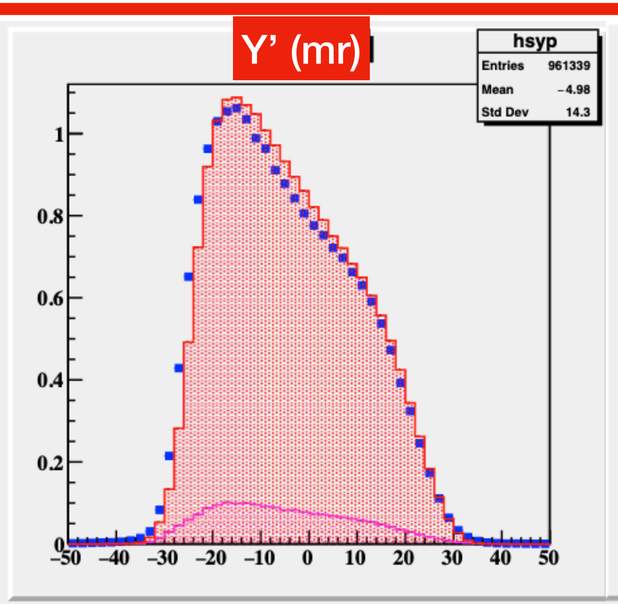
- MC simulation: mc_single_arm
- model: f1f221 (M.E. Christy)
- radiative corrections: rc_externals
- After cross section weighting the MC is scaled by $MC_{ScaleFact}$

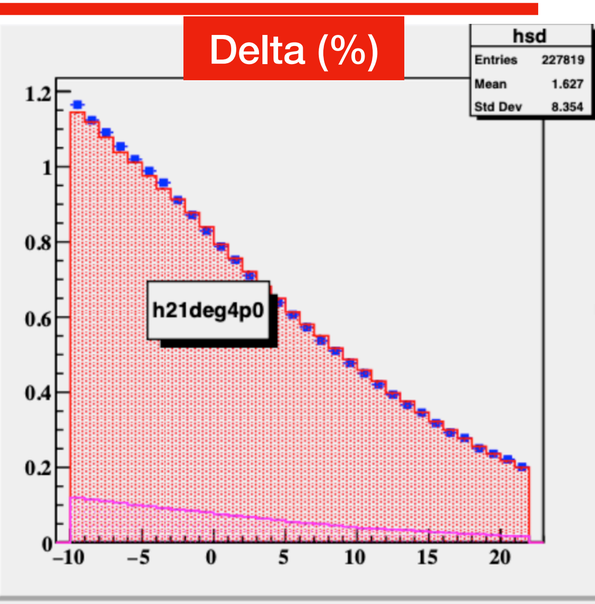
$$MC_{ScaleFact} = \frac{L_{Data}}{L_{MC}}$$

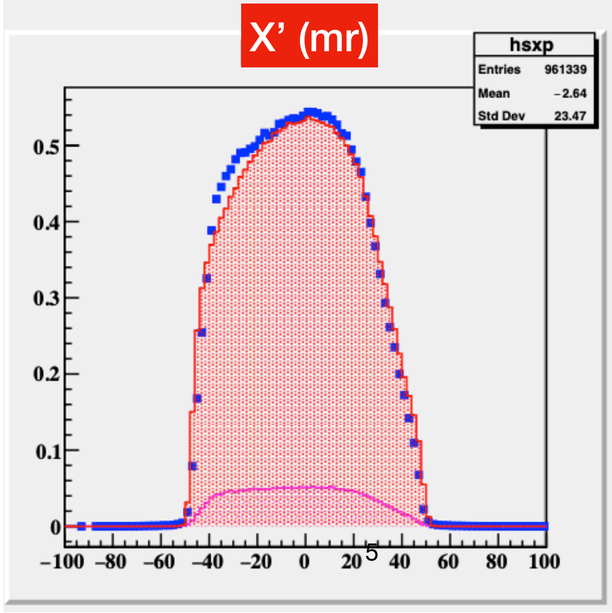
$$L_{Data} = \frac{N_A * L_{tgt} * \rho_{tgt} * Q}{M_{tgt} * e}$$

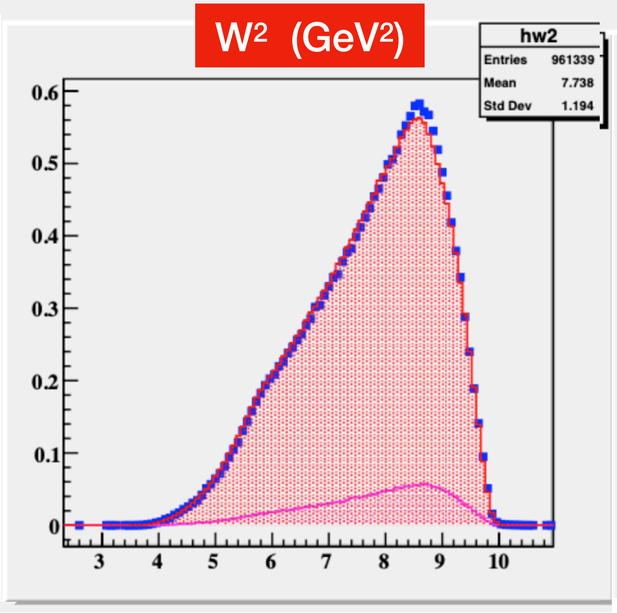
$$L_{MC} = \frac{N_{gen}}{\Delta E \Delta \Omega}$$

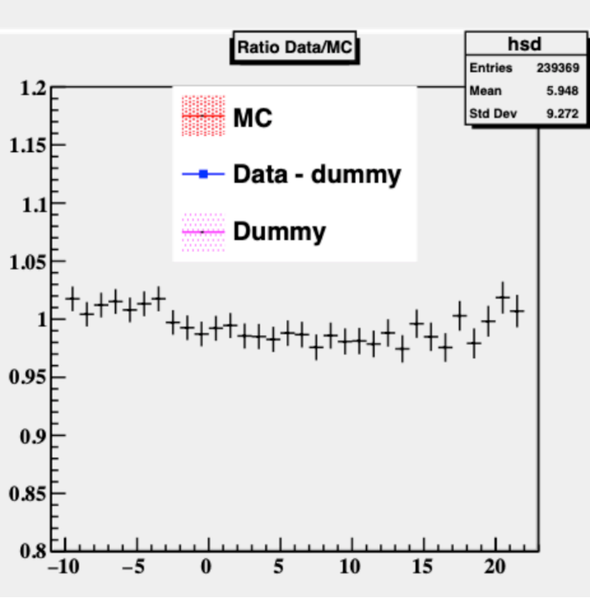




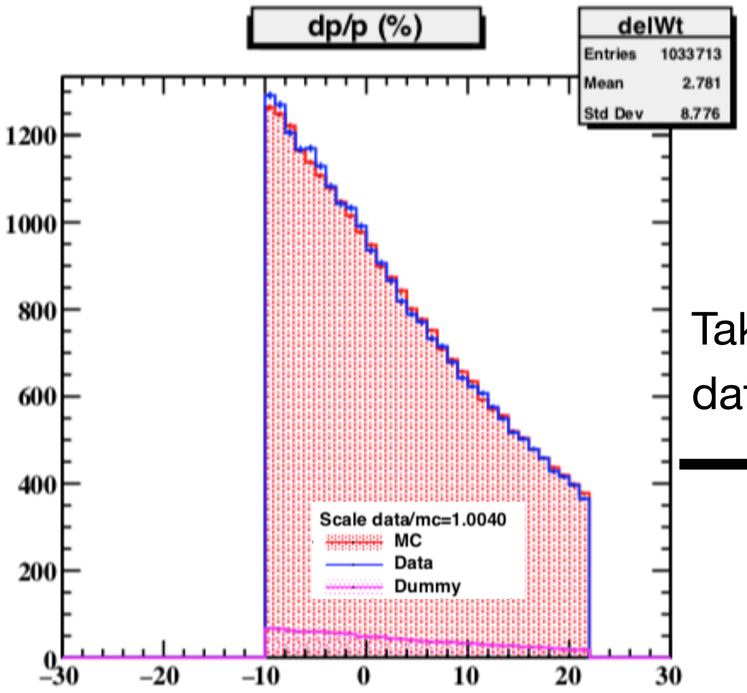






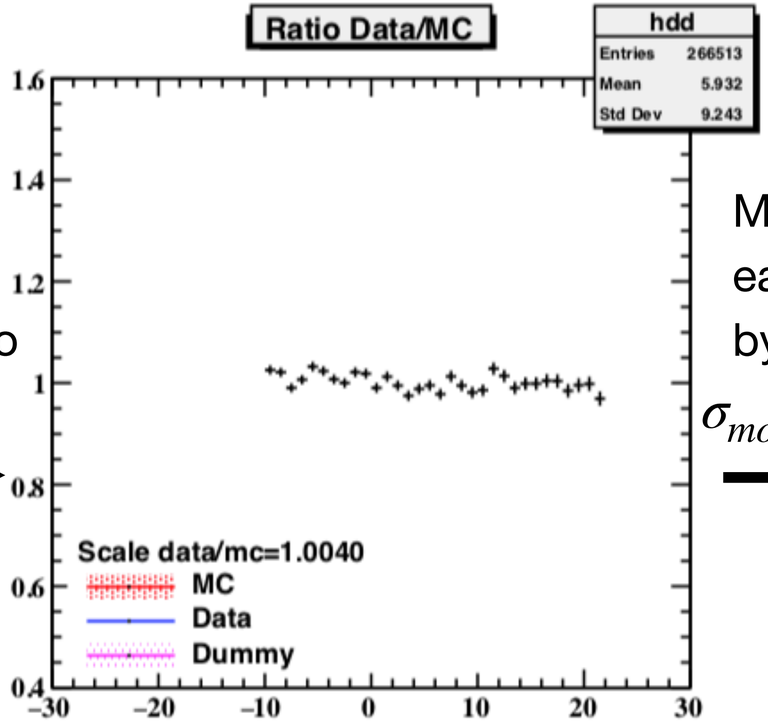


Cross Section Extraction: Monte Carlos Ratio Method

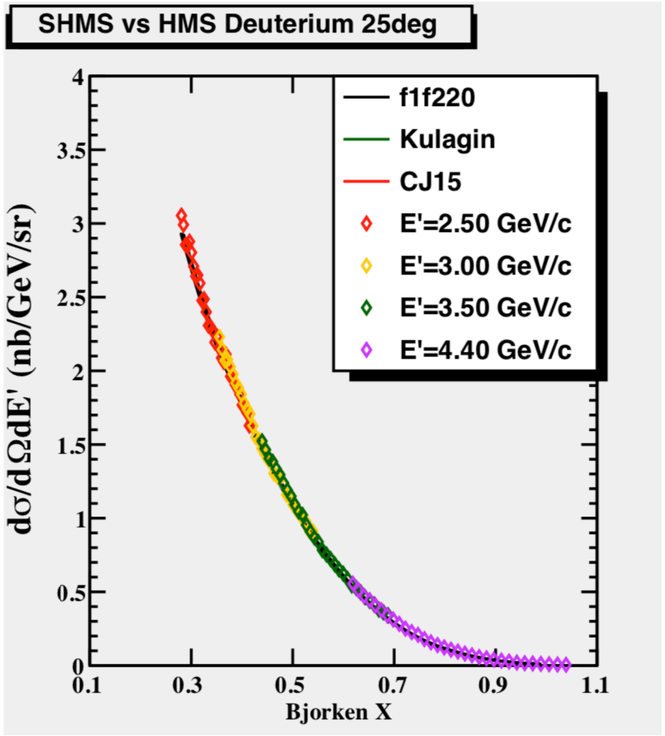


(Data is dummy subtracted)

Take Ratio data/MC



Multiply each bin by $\sigma_{model}(E', \theta)$



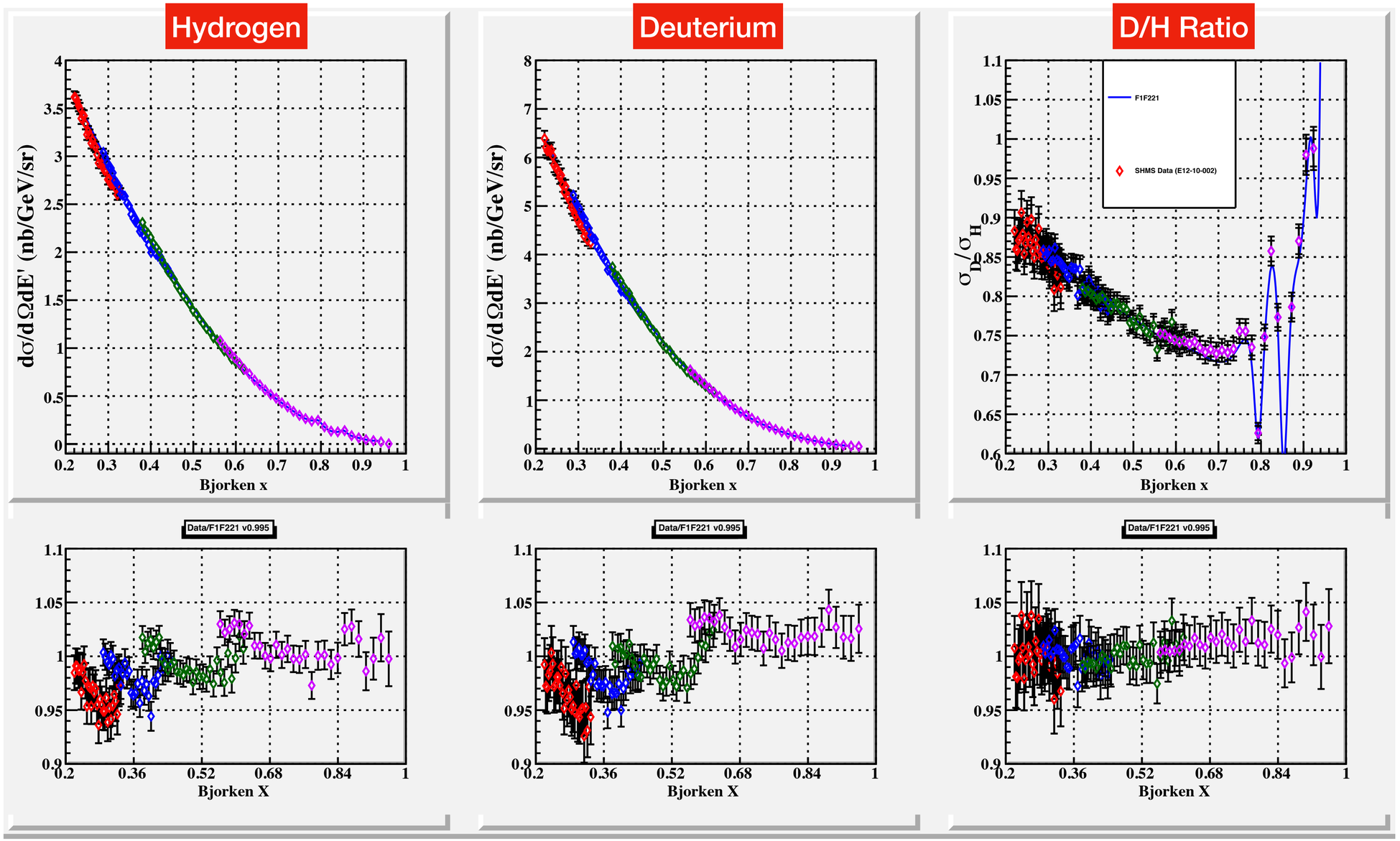
1)Weight MC with radiative cross section, add CSB, bin in delta

2) Take ratio of data to MC

3) Multiply each bin by born cross section

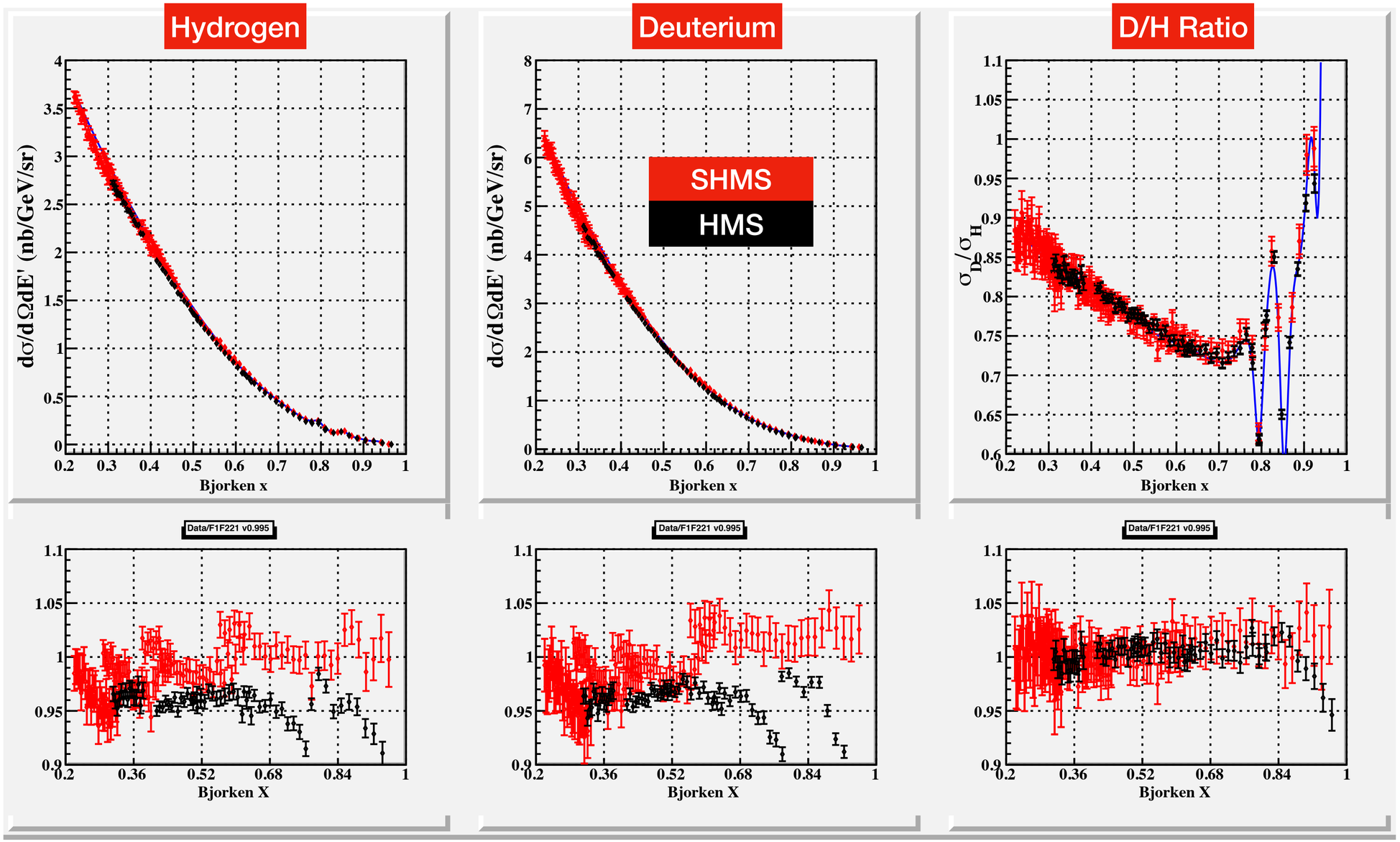
Cross Sections for SHMS 21 degree settings

- Colors represent different momentum settings
- Percent level differences between settings in overlap regions and the shape across delta seen in each setting suggest further study of the acceptance is required
- Acceptance mostly cancels in D/H ratio
- Note: Calorimeter efficiency not yet included in cross sections



Cross Sections HMS vs SHMS @ 21degrees

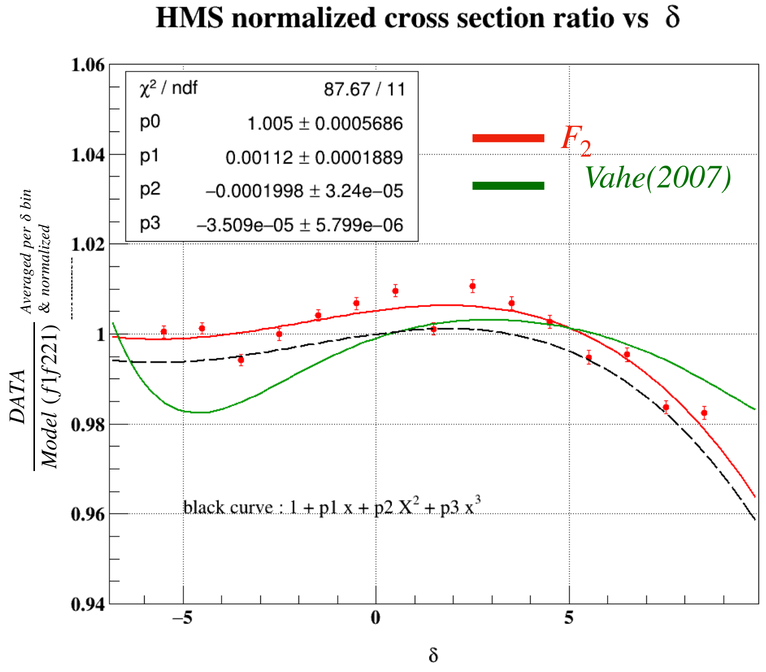
- Data was taken in both the SHMS and HMS at 21 degrees to provide a cross check
- Excellent agreement in the D/H resonance region suggests momentum and spectrometer angles are well understood
- HMS optics above x=0.68 (E’ > 5 GeV) needs to be revisited
- A slight shape across delta in the HMS was corrected for and has been a feature since the 6 GeV era (next slide)

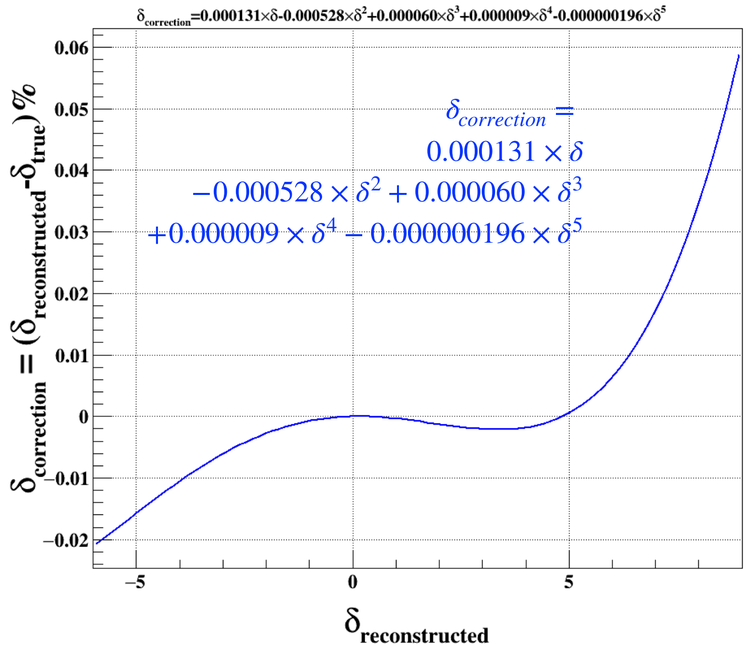


HMS δ correction

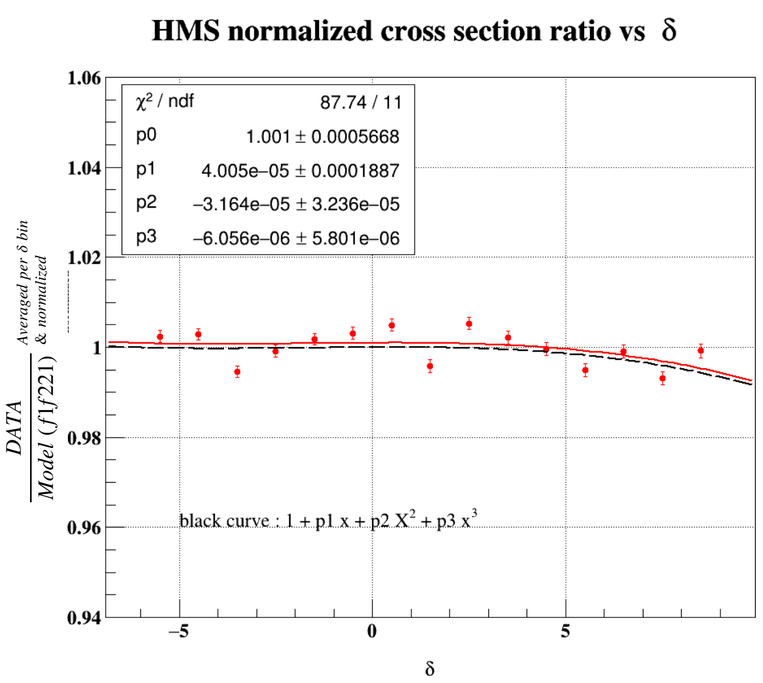
- DATA/MC vs δ plot irrespective of all kinematics and targets shows a systematic variation in data reconstructed quantities compared to MC
- This is an known issue for the HMS form 6 GeV era and can be corrected by remapping the δ bins
- Similar δ dependence has been found in SHMS data that can be fixed in a similar method
- This δ dependence is visible only for individual cross sections and cancels out for d/p ratios

NO δ Correction





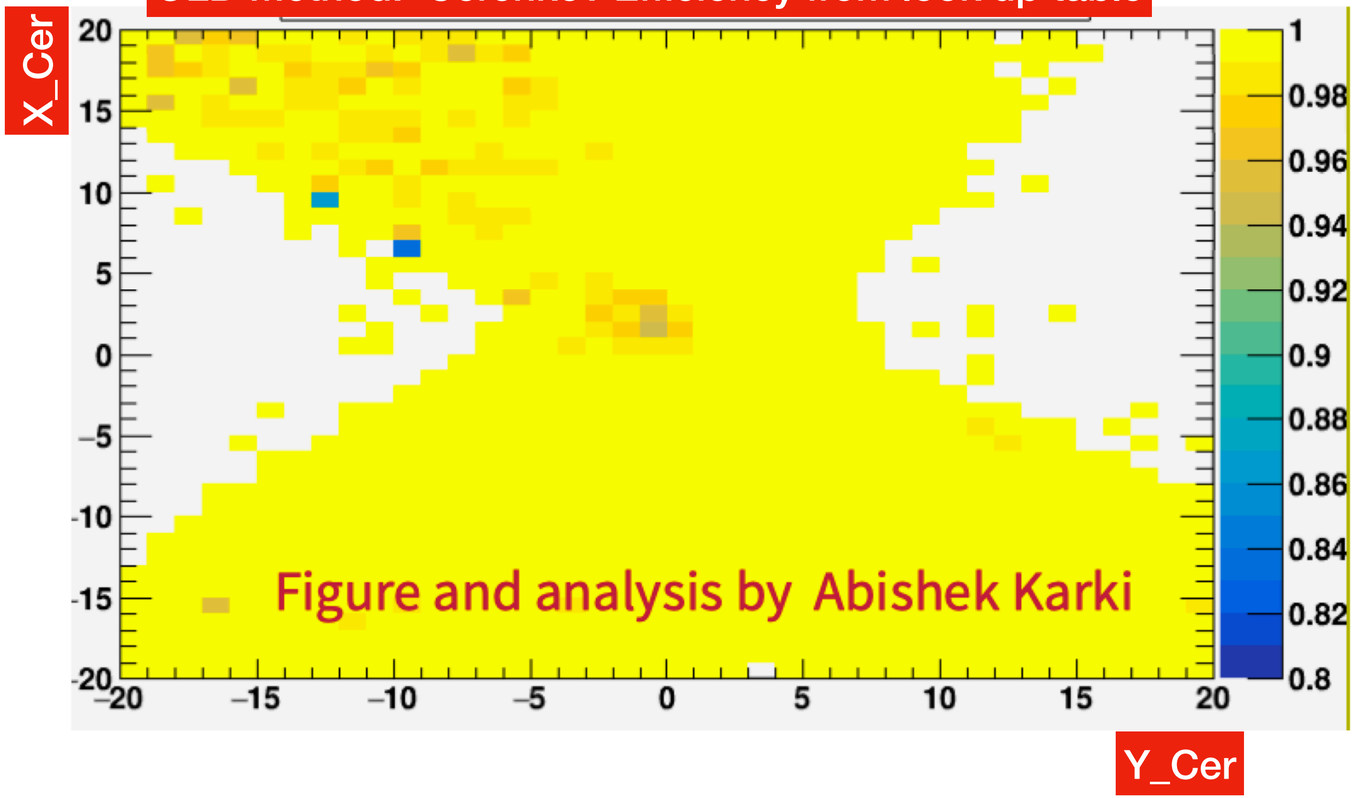
After δ Correction



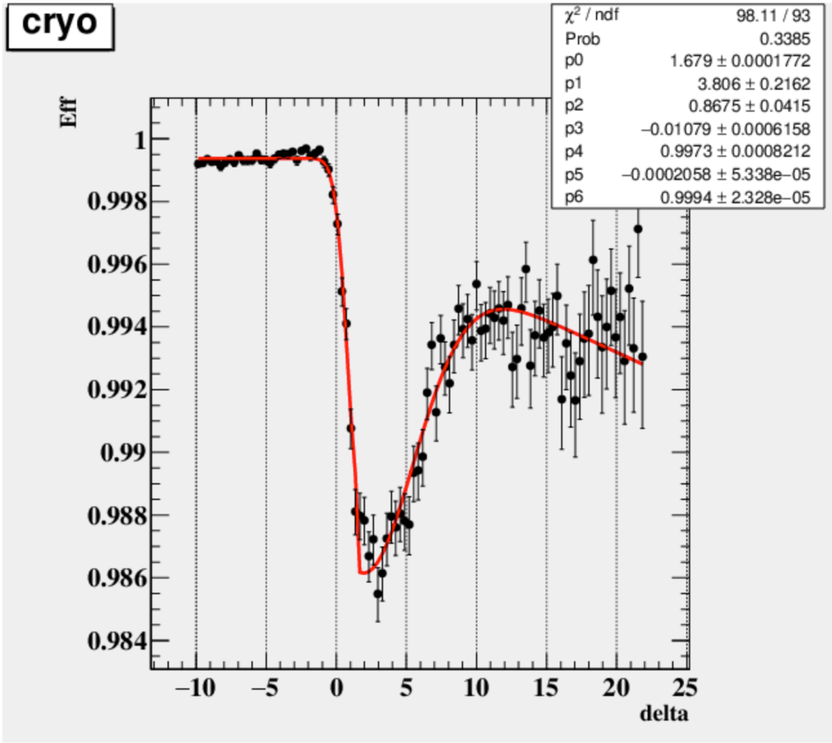
New SHMS Noble Gas Cerenkov Efficiency

- Previous analysis used a look up table to determine the noble gas Cherenkov Efficiency as a function of X_{Cer} and Y_{Cer}.
- Recently, by looking at the efficiciency corrected efficiency, it was discovered that the old method didn't work uniformly across delta.
- New efficiency is now parameterized as a function of delta.

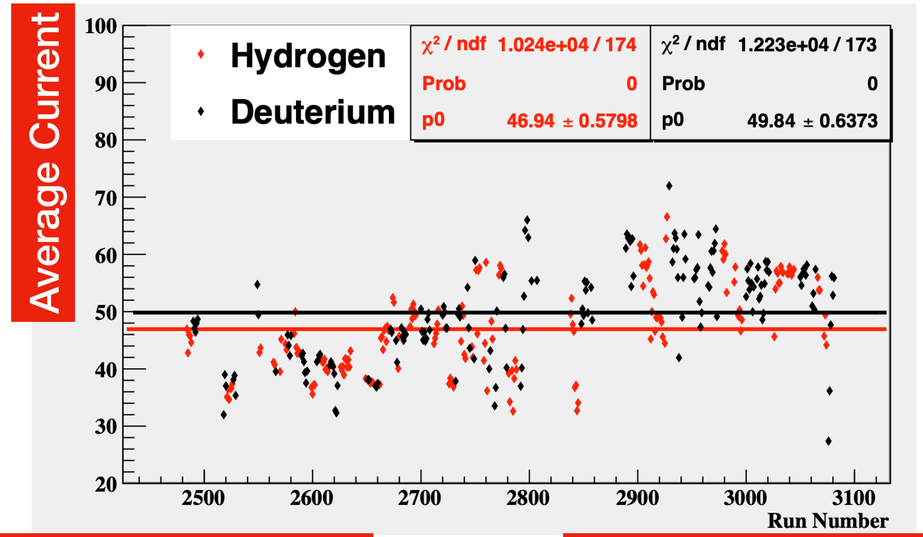
OLD Method: Cerenkov Efficiency from look up table



NEW Method: Cerenkov Efficiency in terms of delta

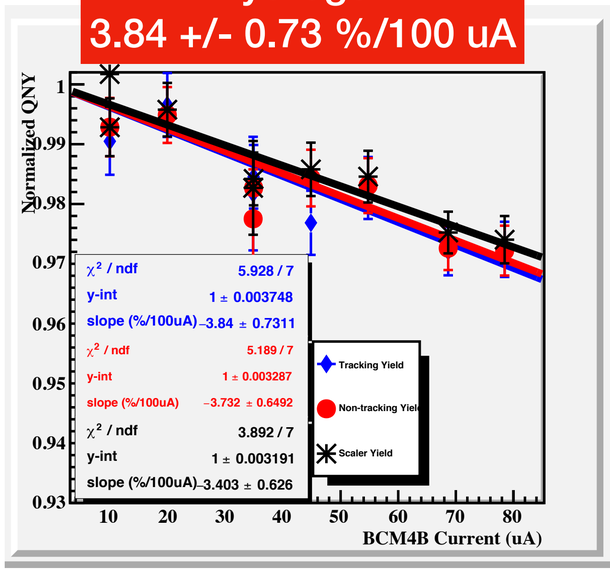


Error Analysis: Target Density

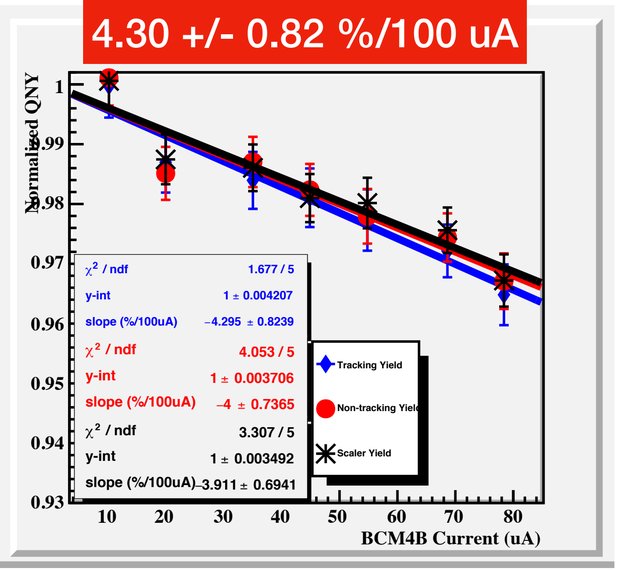


Error	Value	Uncertainty	$\frac{\delta\rho t}{\rho t}$
Temperature	19 K	$\pm 182mK$	0.27%
Pressure	25 psia	$\pm 2psia$	0.02%
Equation of State			0.1%
Length Measurement Precision	100 mm	$\pm 0.26mm$	0.26%
Length (Inner or Outer?)	100 mm	$\pm 0.26mm$	0.26%
Target Contraction	99.6%	$\pm 0.1\%$	0.1%
Beam Position	0	$\pm 3mm$	0.2%
Avg Boiling Correction LH2(LD2)			0.30% (0.36%)
Total LH2 (LD2)			0.60% (0.63%)

Hydrogen
3.84 +/- 0.73 %/100 uA



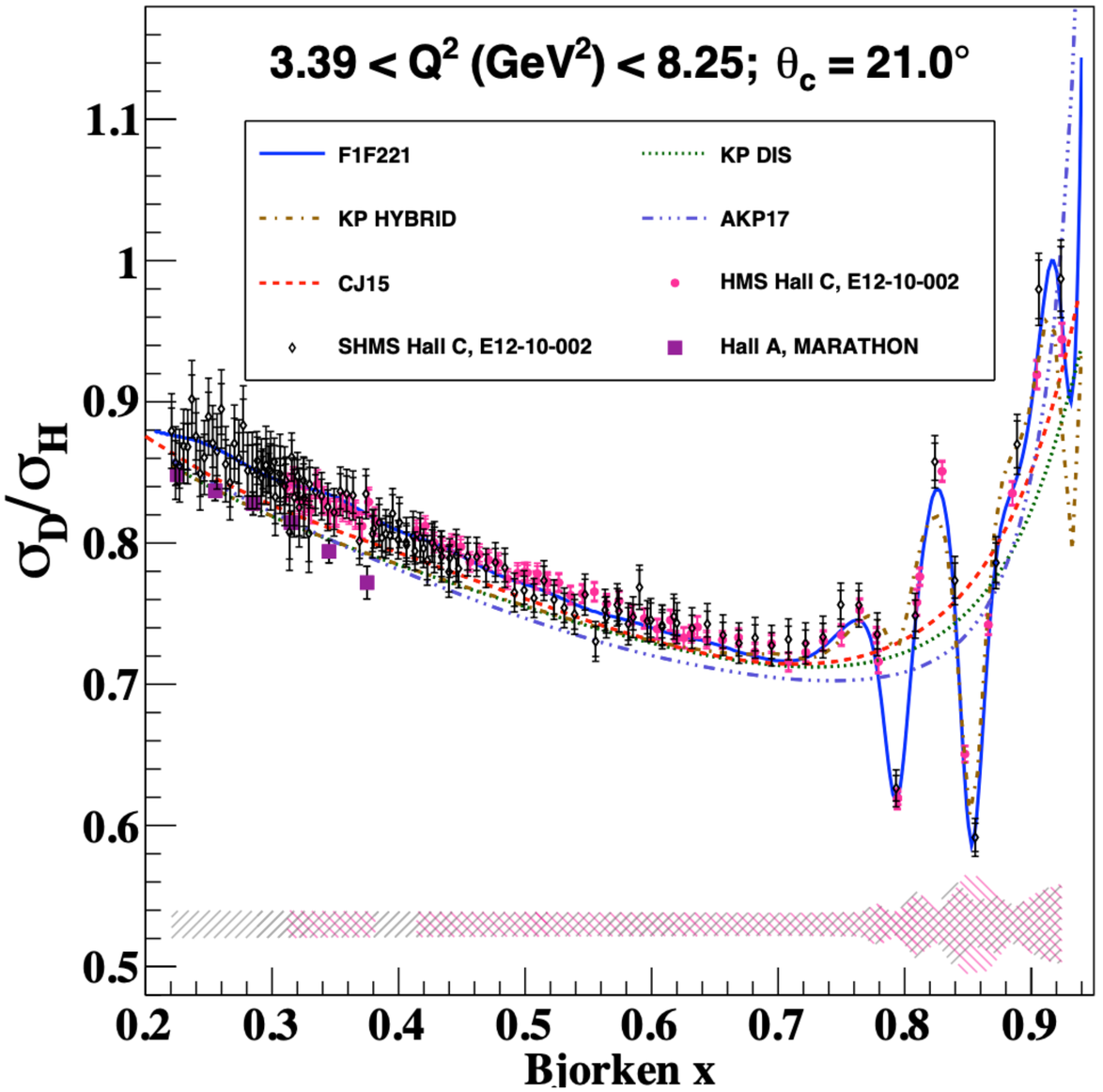
Deuterium
4.30 +/- 0.82 %/100 uA



- The overall normalization uncertainty used is slightly larger than the table above; 0.75% in cross sections and 1.1% in D/H ratio.
- Global error reflects our lack of knowledge to the target boiling, temperature, density, length and beam position.
- An additional point to point uncertainity is calculated by taking the difference with the average current

Looking Ahead

- Item required for 1st publication D/H ratio
  - Comparisons between 6 GeV and SLAC data
- Items required for highest Q2 setting in (HMS @ 60 degress)
  - Charge Symmetric Background
  - Pion contamintion
- Items required for precision absolute cross sections
  - Revisit Calorimeter efficiency
  - Overlaps in SHMS cross sections
  - SHMS delta correction
  - HMS optics for momentums > 5 GeV
  - Incorporate latest updates to analyzer (hcana)
- Exciting physics to follow! (See Aruni's talk)



Acknowledgements

Experiment Spokespeople

Eric Christy

Thia Keppel

Simona Malace (contact)

Ioana Niculescu

Gabriel Niculescu

Dave Gaskell (EMC)

Graduate Students

Deb Biswas

Aruni Nadeeshani

Abel Sun

Abishek Karki (EMC)

Casey Morean (EMC)

Post Doc

Bill Henry

Special Thanks to

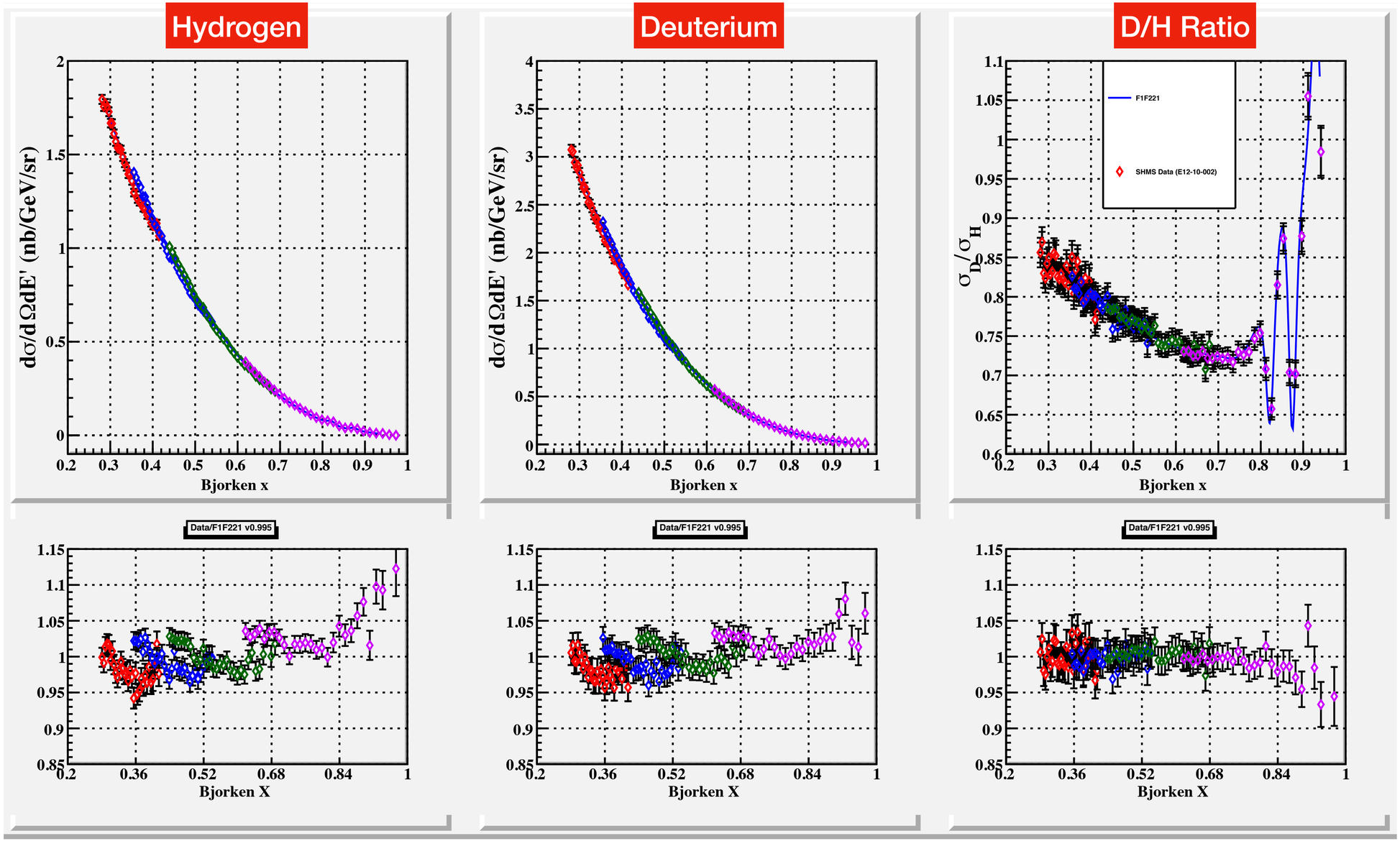
Mark Jones

Carlos Yero

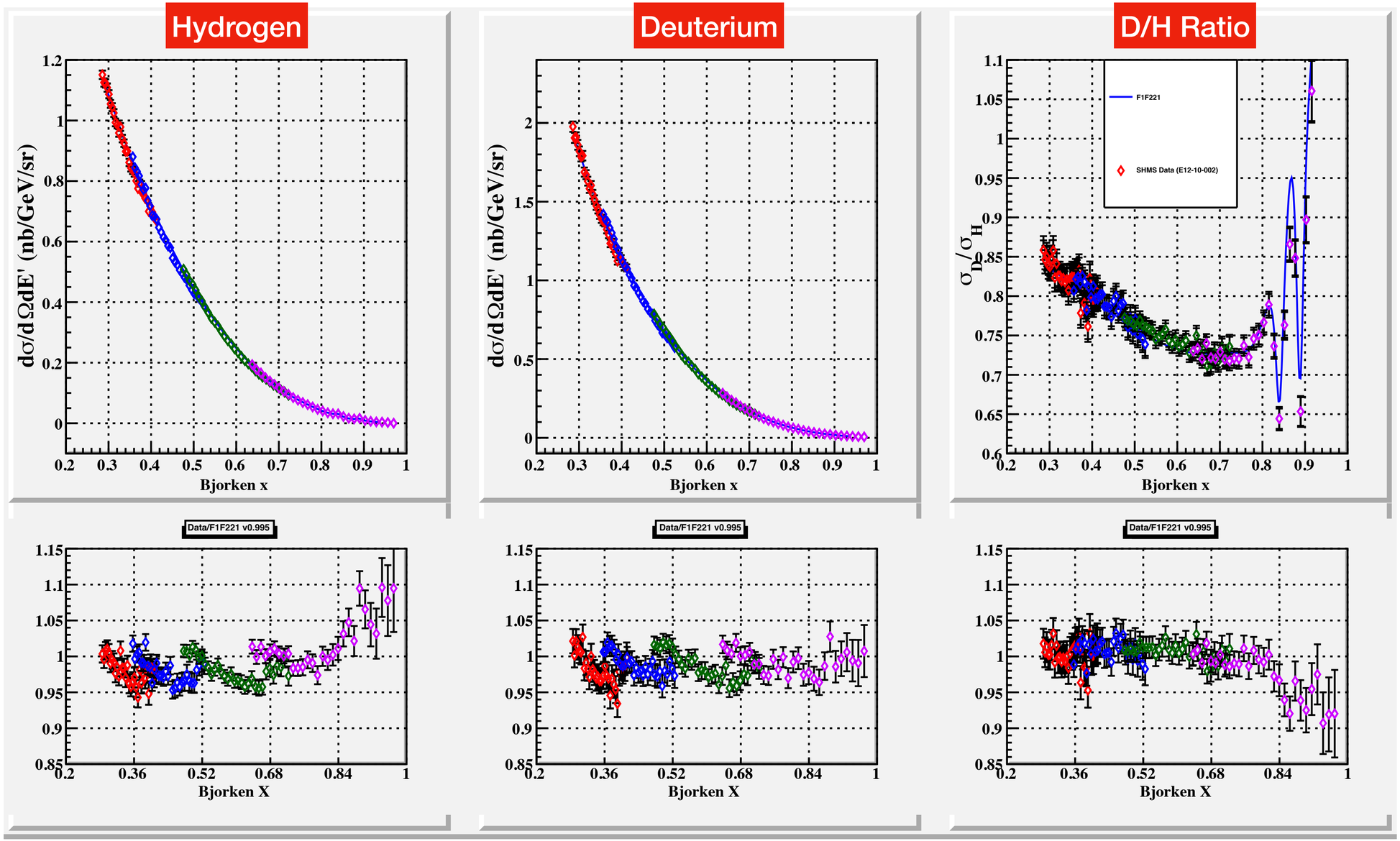
Greg Smith

Back Up Slides

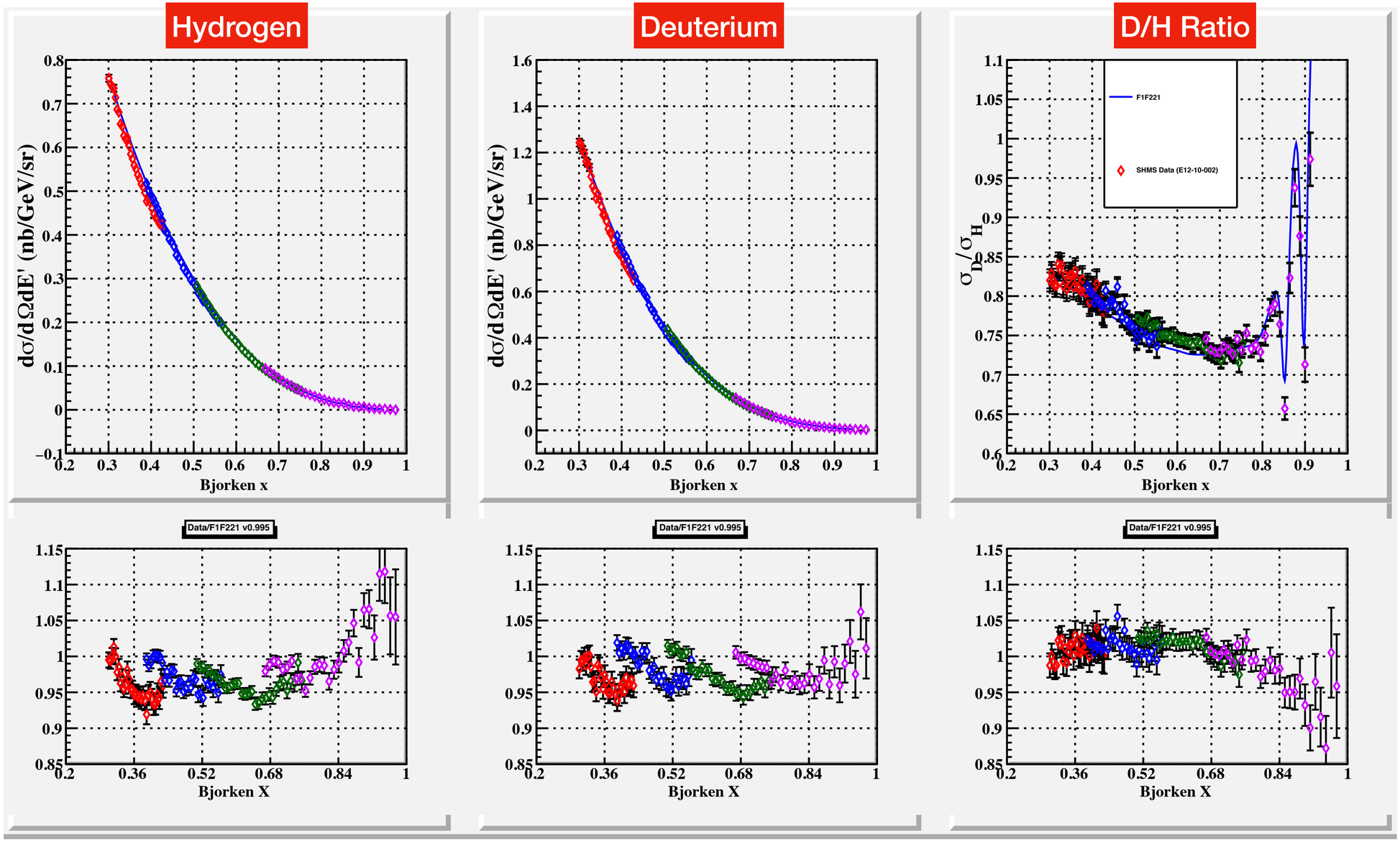
Cross Sections for SHMS 25 degree settings



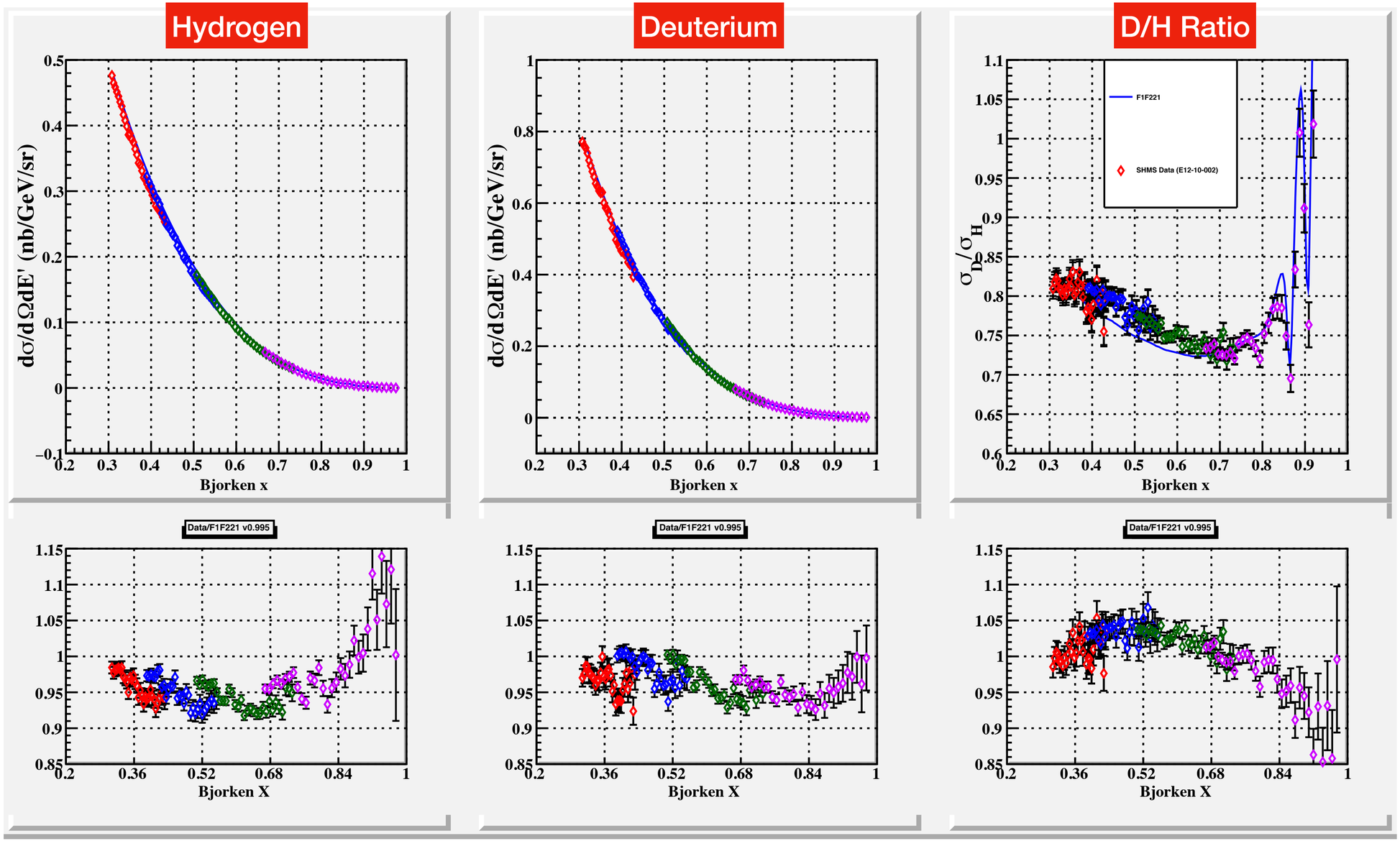
Cross Sections for SHMS 29 degree settings



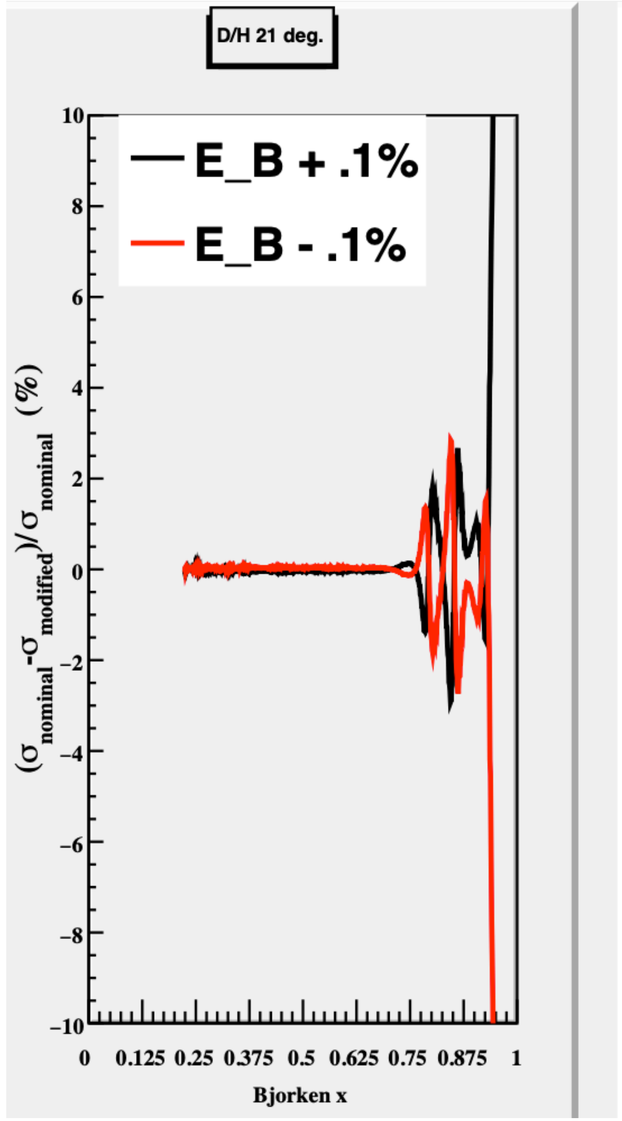
Cross Sections for SHMS 33 degree settings

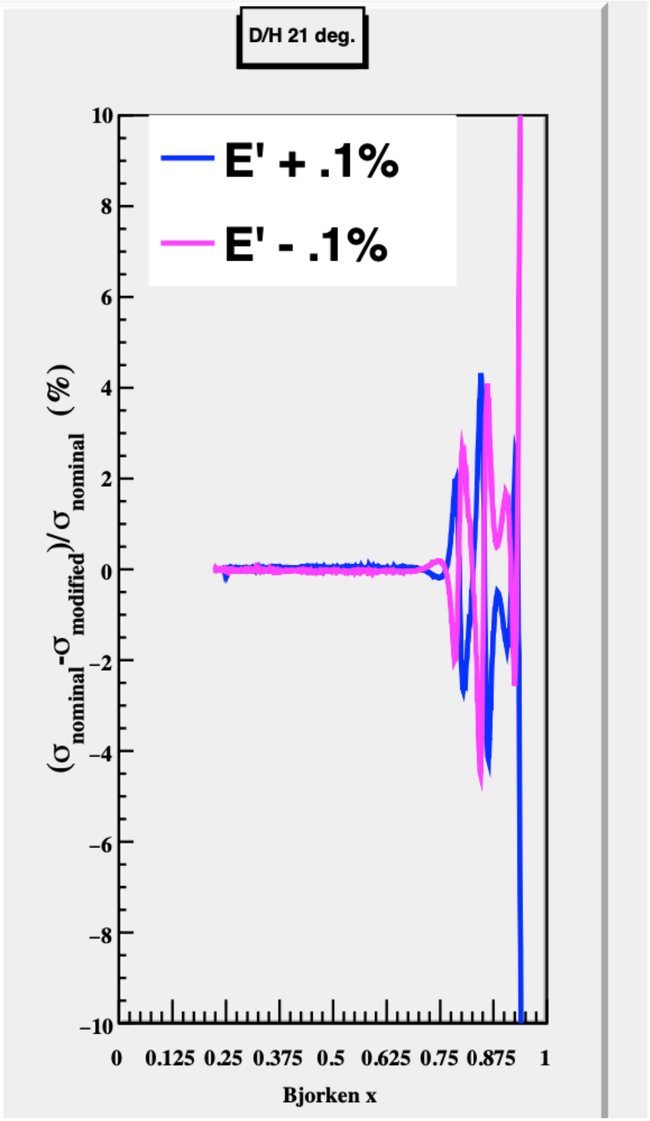


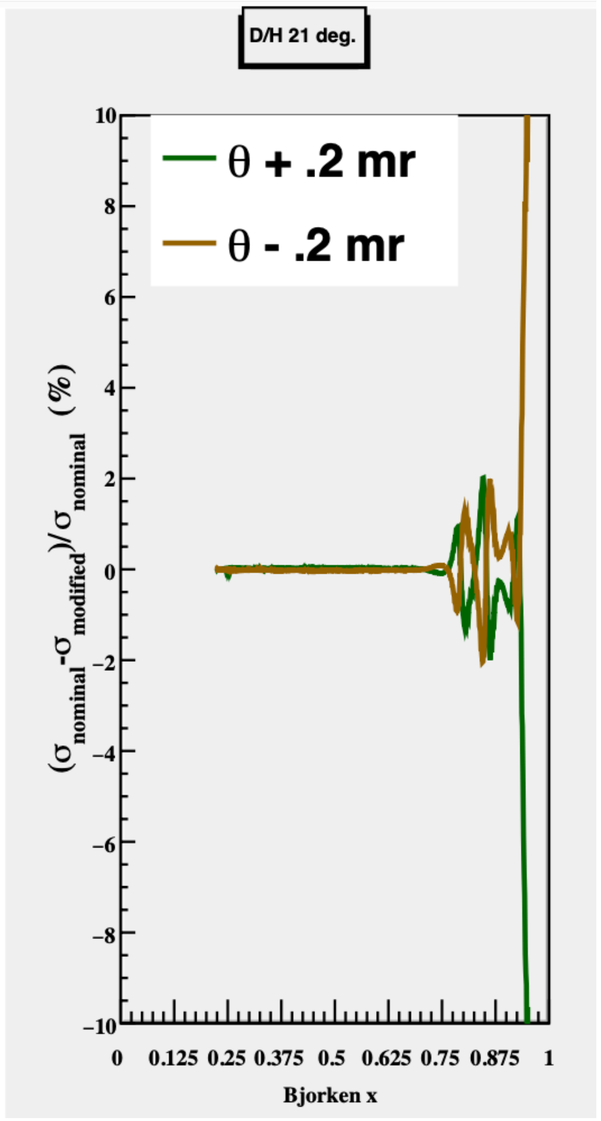
Cross Sections for SHMS 39 degree settings



Error Analysis: Kinematic Uncertainties







Error Analysis: Acceptance