F2 Analysis

Hall C Winter Collaboration Meeting

Bill Henry (Hall C PostDoc)
January, 28th 2021

OUTLINE

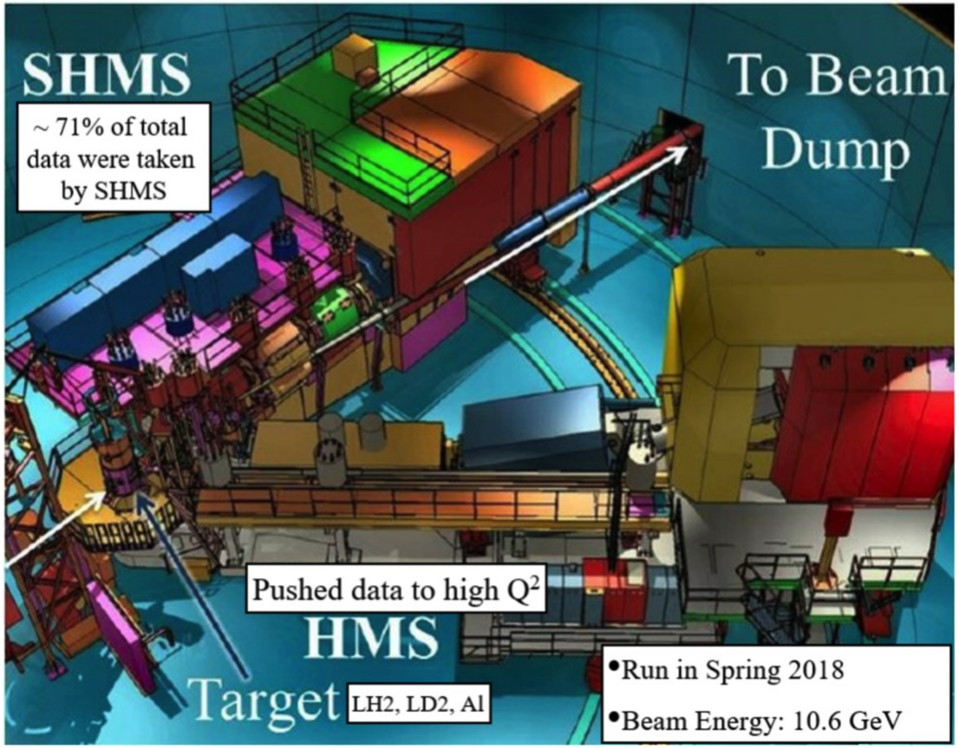
- Brief Experimental Overview
- Data Yield extraction (PID, corrections, efficiencies)
- Monte Carlo Simulation and physics weighting
- Cross section extraction
- Physics talk by Deb immediately after

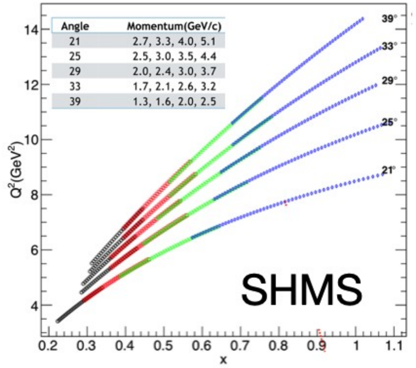
Overview (E12-10-002)

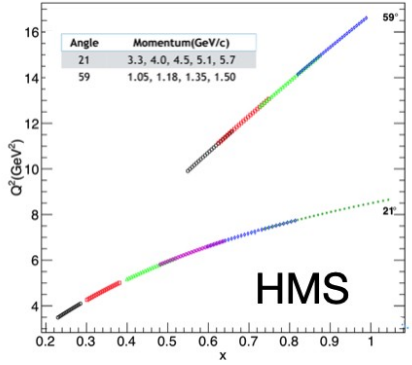
- Hall C Commisioning experiment
- Electrons detected in both SHMS and HMS
- Ran with E12-10-008 (EMC ratios in lighter nuclei)

See Abishek's talk tomorrow!

Hall C Spectrometers







This talk Focuses on the SHMS data

Data Yields

- Data Yields are calculated for LH2, LD2, and AL (dummy) targets, run by run
- The output Root files are combined (hadd) for each kinematic
- Analysis is done with ROOT/c++ script which includes
  - Pion contamination
  - Deadtime/Livetime corrections
  - Target boiling correction
  - Tracking Efficiency
  - Cerenkov Efficiency

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

5 spectrometer angle
4 momentum settings/angle
3 targets per setting
= 60 different kinematic setting to analyze

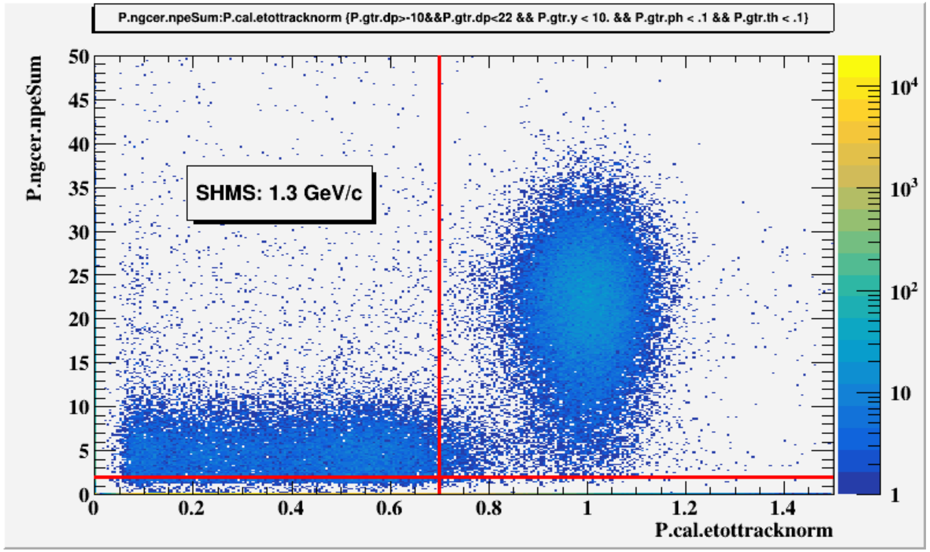
PID/ Acceptance Cuts

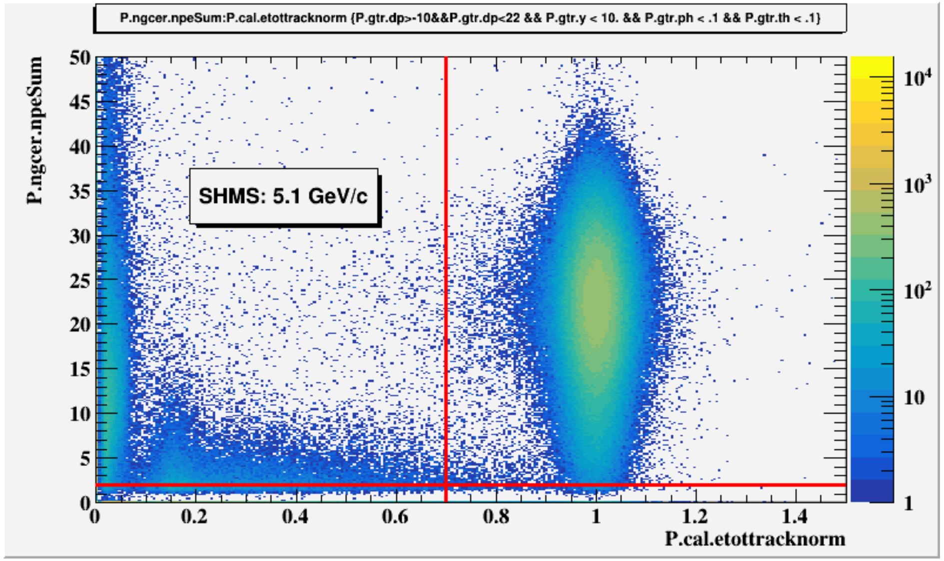
SHMS PID cuts:

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

SHMS Acceptance cuts:

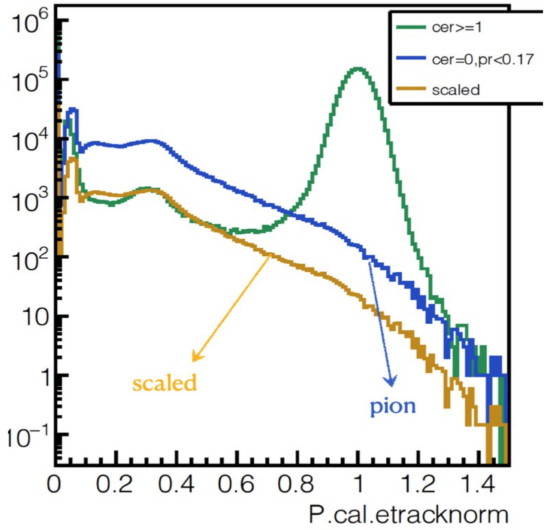
- -10 < delta < 22
- |ytar| < 10 cm
- |xptar| < 100 mr
- |yptar| < 100 mr

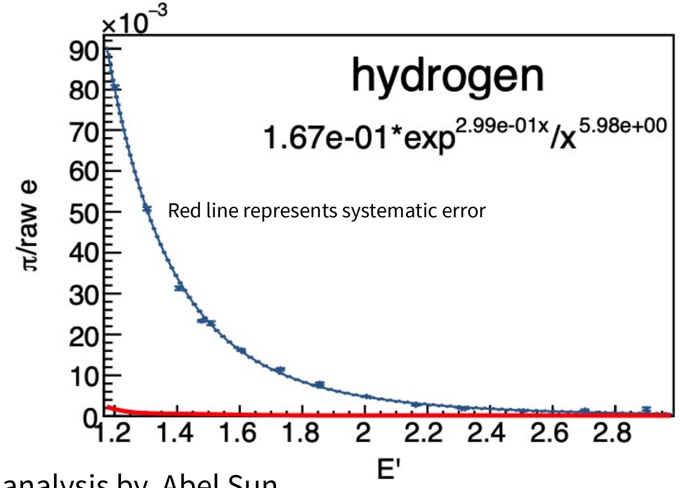




Corrections: Pion Contamination

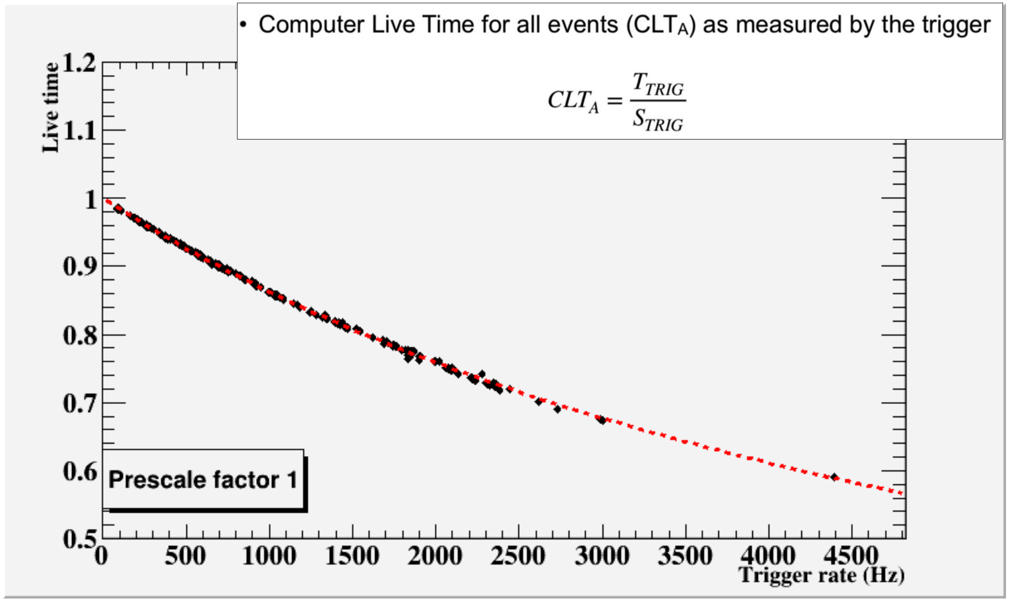
- Pions that pass the electron cuts need to be removed from yields
- The π/e ratio was calculated for each spectrometer angle and parameterized as a function of E’
- Analysis was done for each target (LH2, LD2, C12, AL)
- For large angle/ small E’ this can be very large (~10 % effect)

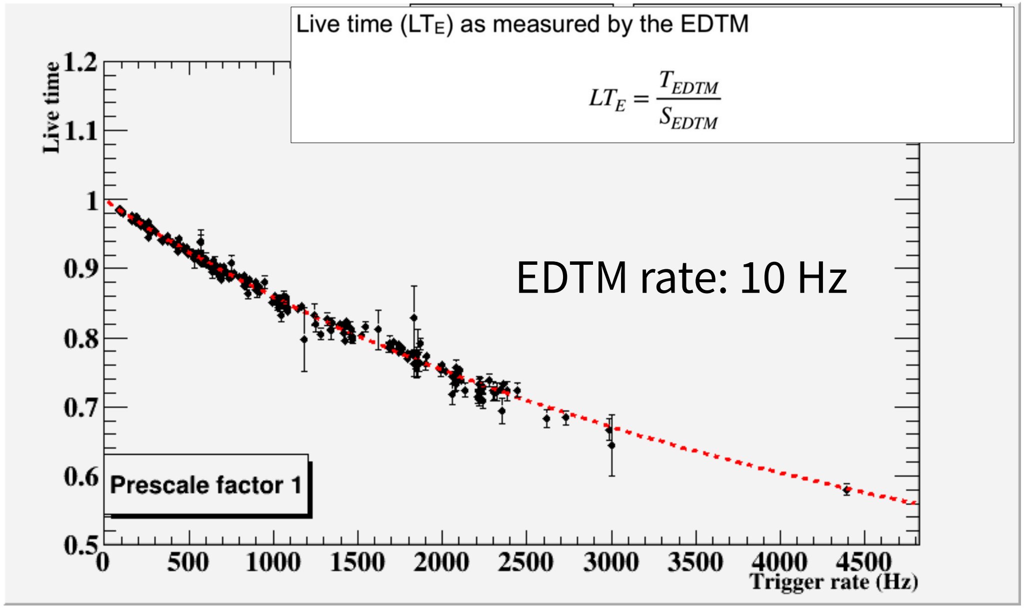




Figures and analysis by Abel Sun

Livetimes

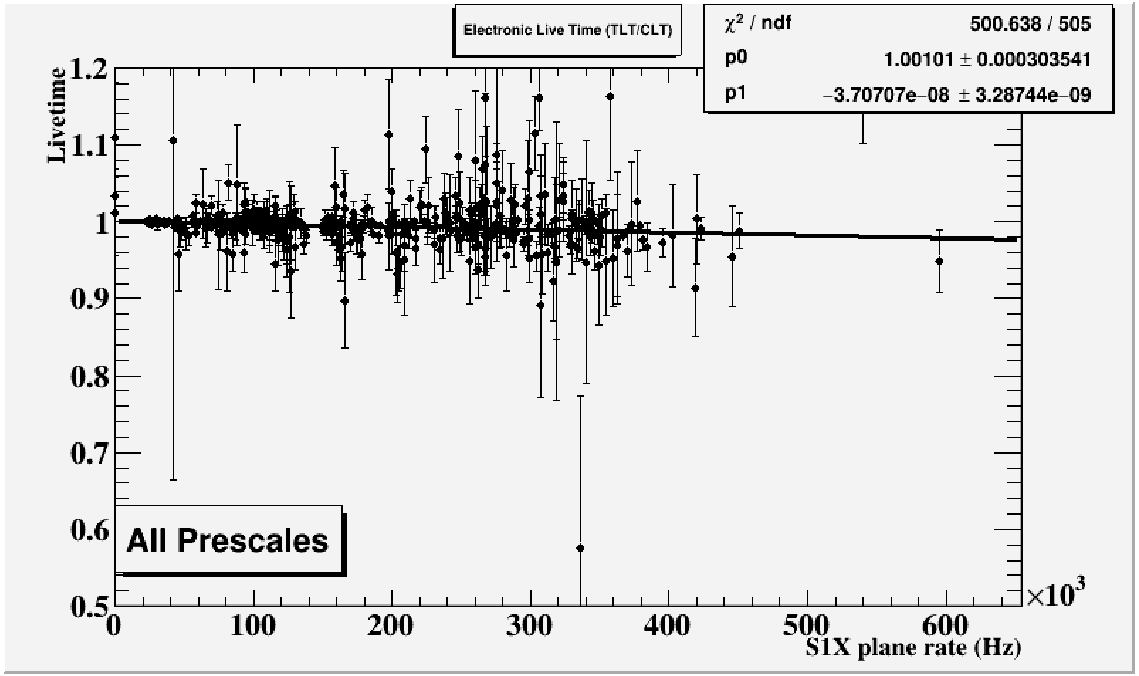




Since a relatively low EDTM rate was of 10 Hz used statistics were low, especially when the data was pre-scaled. The computer live time had sufficient statistical precision and was used in this analysis. The EDTM was used to verify the electronic dead time was small (next slide).

Livetimes

- Since (total live time) = (cpu live time) * (electronic live time) we can use the edtm and CLT to calculate the electronic livetime.
- The electronic livetime was close to 100%
- The result of a pol1 fit will be used as a systematic

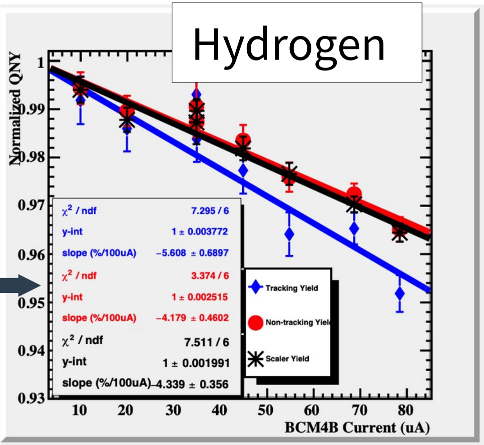


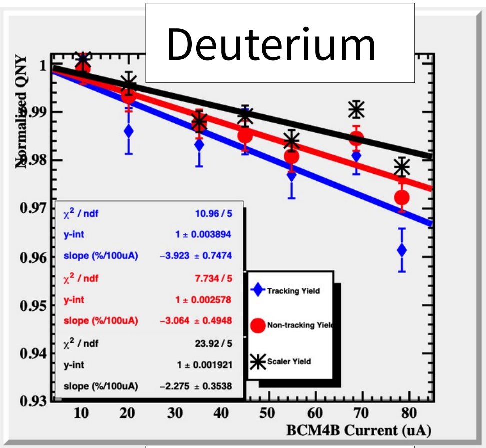
Pol0 fit (not shown)

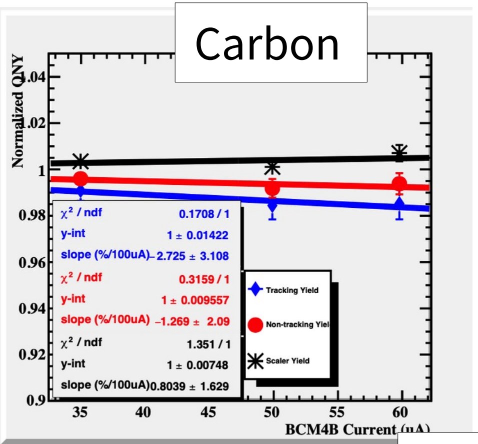
χ^2 / ndf	627.797 / 506
p0	0.998263 ± 0.000181029

Target Density

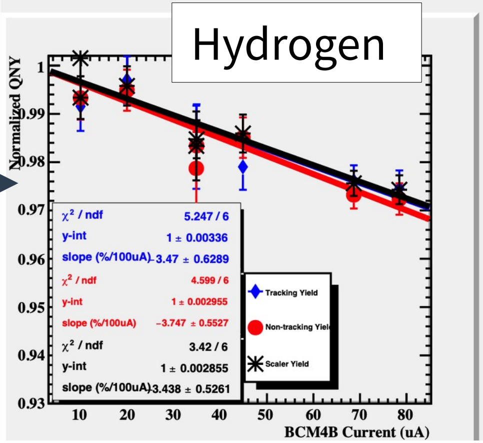
SHMS

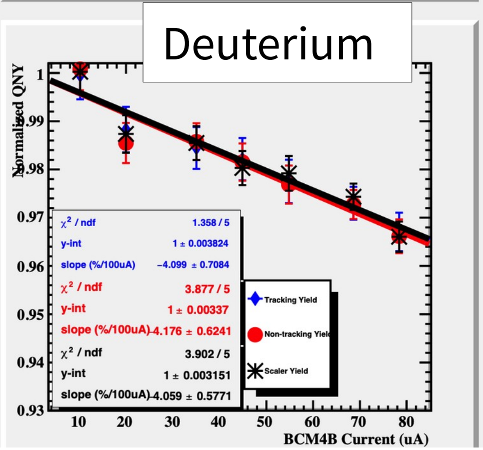


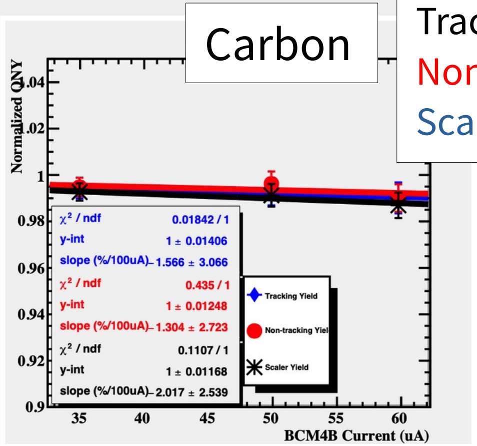




HMS







Tracking Yield
Non Tracking Yield
Scaler Yield

Tracking Efficiency

- Tracking efficiency from report file is used
- 95 % -96 % for SHMS

$$\boxed{FID\ TRACK\ EFFIC = \frac{did}{should + 0.0001} \pm \frac{\sqrt{should - did}}{should + 0.0001}}$$

<u>For electrons:</u>

Should

- 0.6 < P.cal.etotnorm < 1.6
- P.hgcer.npeSum > 0.5
- P.hod.goodscinhit == 1
- 0.5 < P.hod.betanotrack < 1.4
- ~~Number of hits in all 6 layers of each DC < 20~~

DID

- Should && P.dc.ntrack > 0

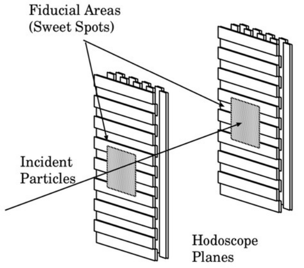


Figure 4.23: Illustration of the fiducial areas on the scintillator hodoscopes used for determination of the tracking efficiency.

Goodscinhit criteria

- Is there a good cluster in each plane?
- Do the x/y positions in each plane coincide?
- Is the cluster position within the "sweet spot"

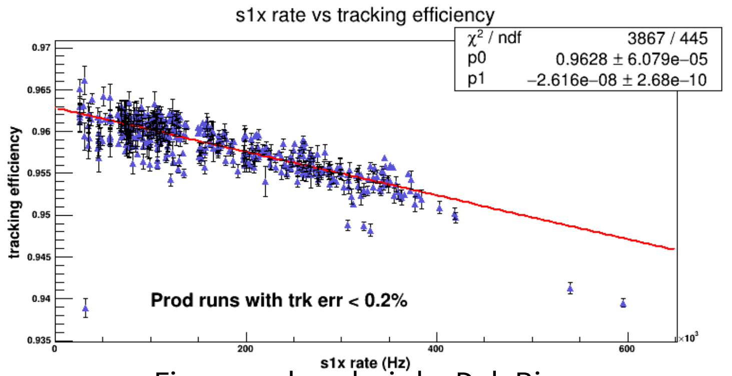
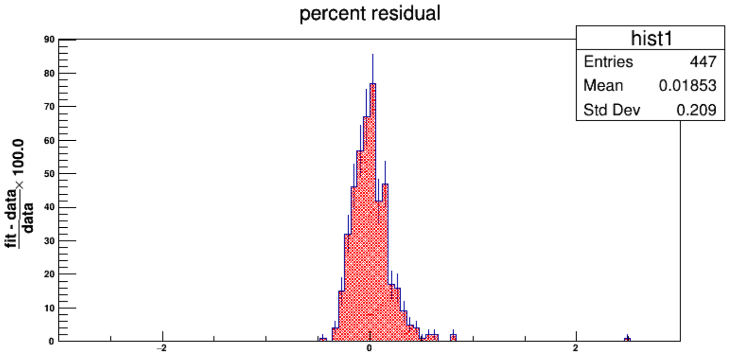


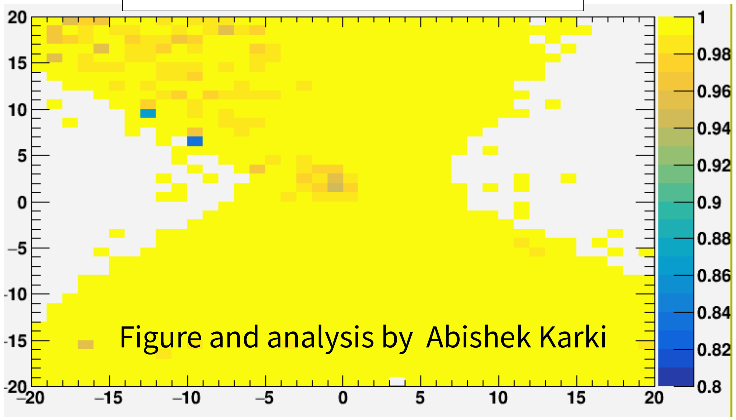
Figure and analysis by Deb Biswas

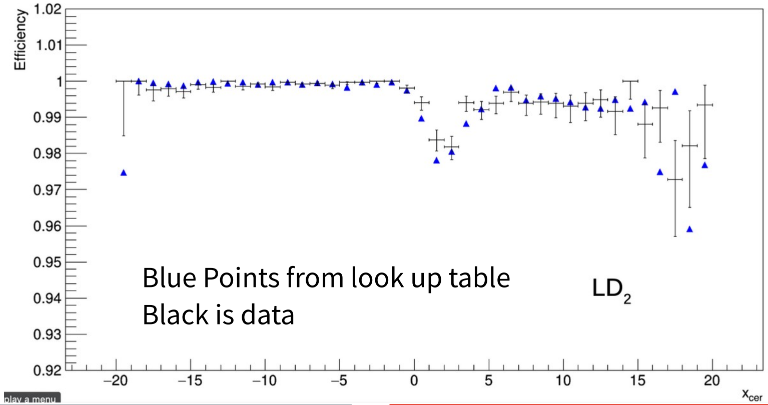


Cerenkov Efficiency

- Cerenkov Efficiency = Did / Should
- Should = elHi > 100 && E/p > 1. && preshower > 0.3 && -10 delta < 22
- Did = should && ngcer.npeSum > 2
- Using our highest momentum setting, a look-up table was created: efficiency(X_cer, Y_cer)
- The shape of the efficiency vs Cerenkov position was also checked with elastic data @ 8.5 GeV (from D(e,e'p)n data set)
- Efficiency generally high (99.5% +), except at center where mirrors meet.

Cerenkov efficiency Vs position at Cerenkov

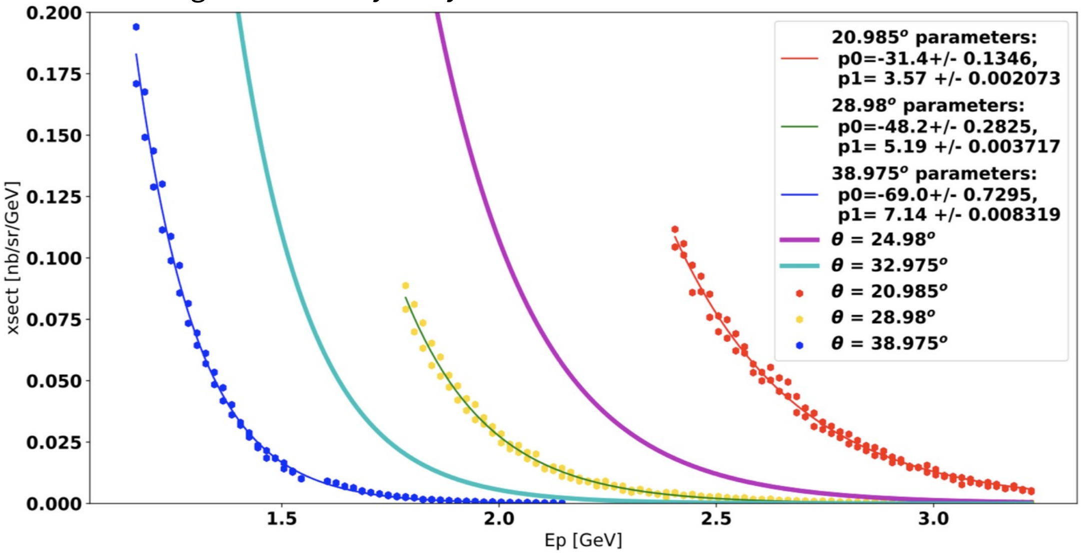




Charge Symmetric Background (CSB)

- Electrons can be produced from charge symmetric processes
- e.g. ($\pi_0 \rightarrow 2\,\Upsilon \rightarrow 2\,(e+e-)$)
- These events can look like inclusive scatterers
- Positron runs were taken at several kinematics in order to measure the CSB
- The results were parametrized and extrapolated to all kinematics were positron runs was not taken
- The background was added into the MC weighting

Figure and analysis by Gabriel and Ioana Niculescu



Monte Carlo : mc-single-arm

Mc-single-arm notes from Dave Gaskell's talk

- Intended for use with inclusive (single arm) experiments
- Single arm Monte Carlos used to determine/simulate spectrometer acceptance and resolution only
- Event generation based on spectrometer phase space (ztarget, xprime, yprime, delta)
- Includes multiple scattering at target and in spectrometer → No radiative effects
- **No** physics generators – to get realistic yields, need a separate model with which to weight the output

https://hallcweb.jlab.org/DocDB/0008/000866/002/hallc_mc_overview_v2.pdf

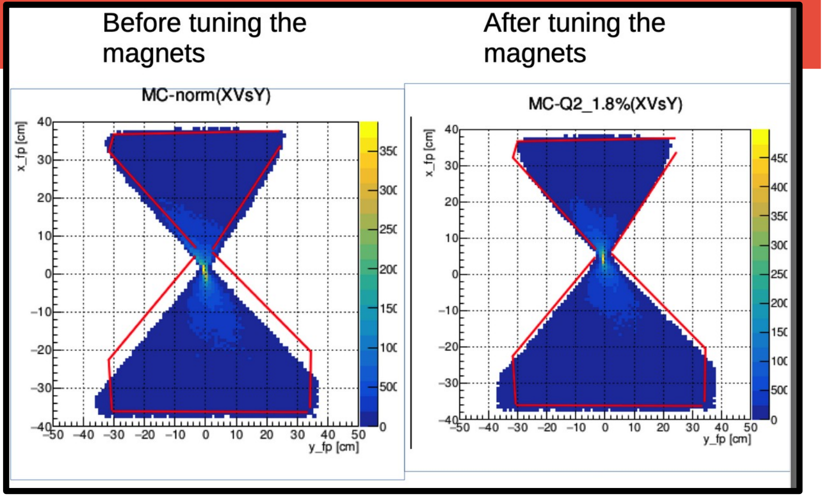
Optics and MC work done by Aruni N.

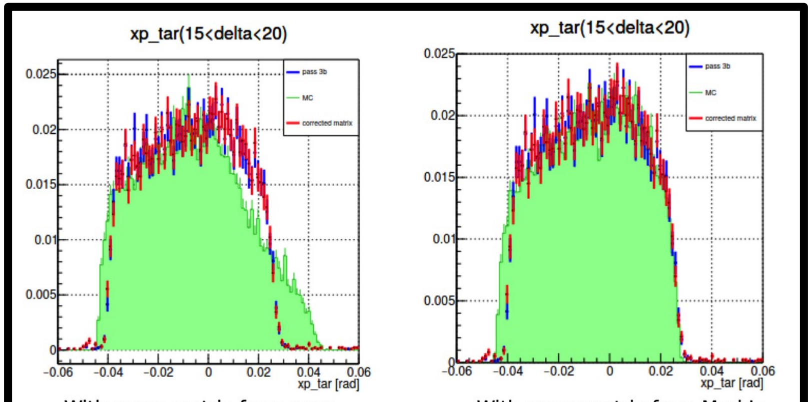
•Forward transport studies

•Geometry and aperture checks

•Focal plane comparisons

•Reconstruction matrix validation

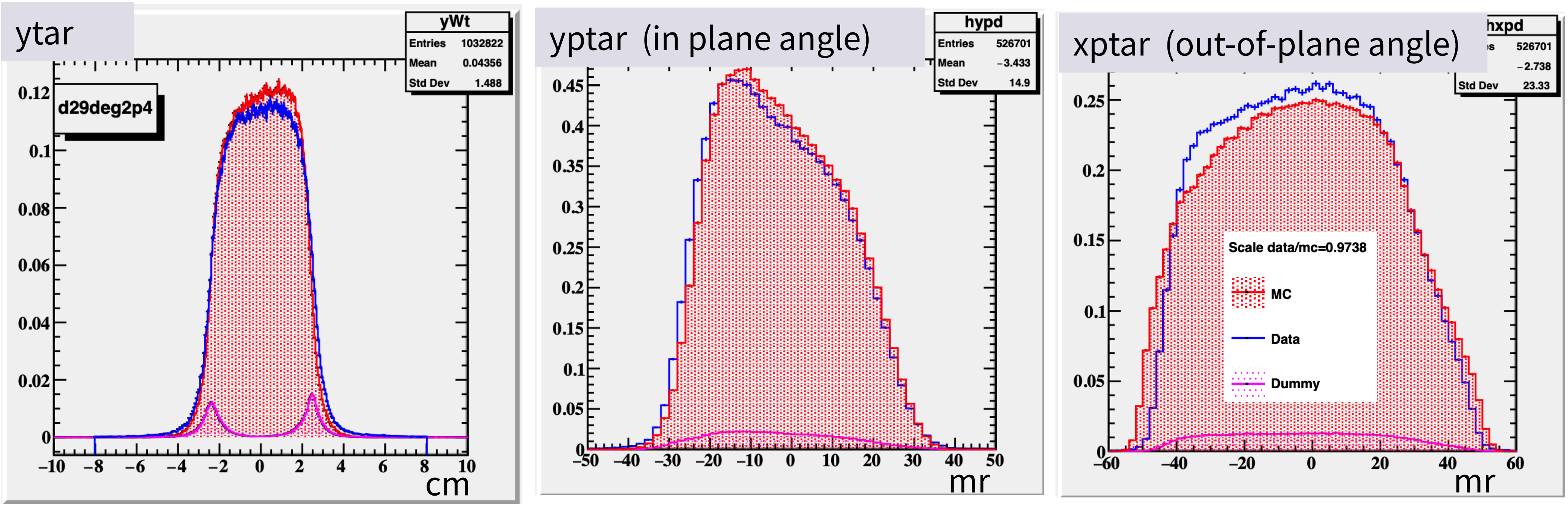




With recon matrix from cosy

With recon matrix from Mark's new fit

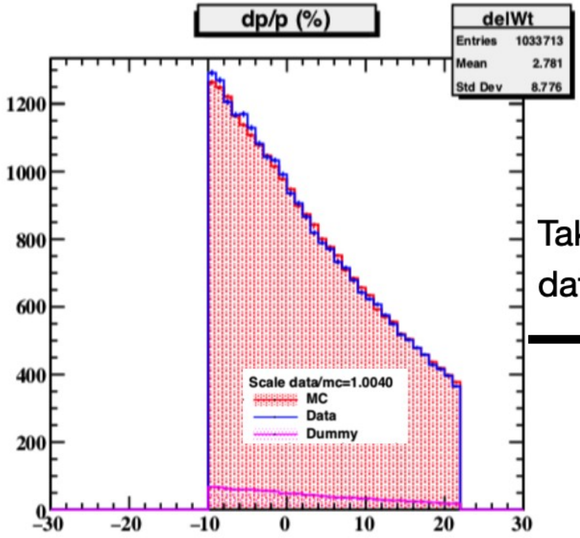
Data vs MC comparisons



Please note:

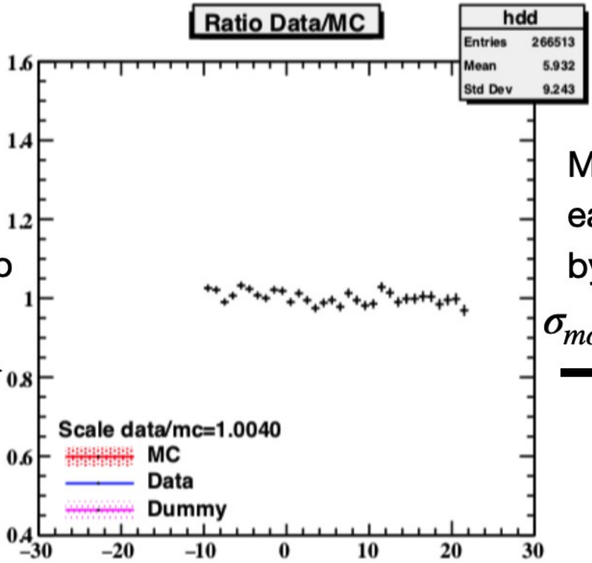
- Some recent updates to mc-single-arm still need to be incorporated
- No MC offsets (ytar, theta, etc) are shown here. They are currently being finalized.

Cross sections using MC ratio method

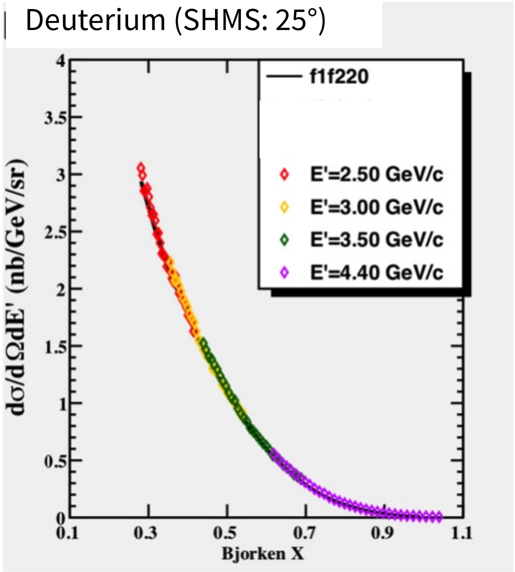


(Data is dummy subtracted)

Take Ratio data/MC



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



1) MC (weighted with radiative cxsec) and corrected data yields are binned in delta

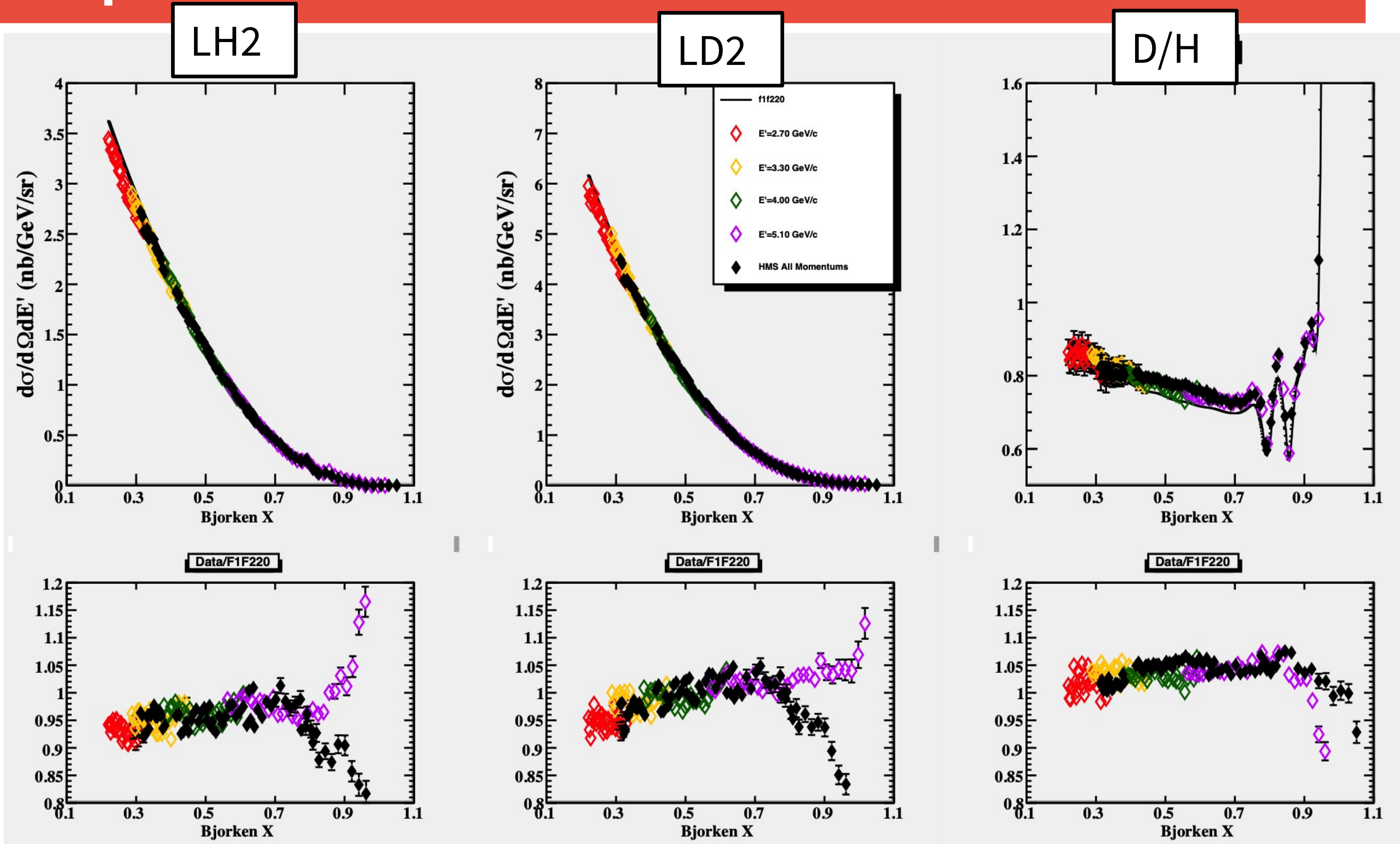
2) Take ratio of data and MC

3) Multiply each bin by model (not radiated) to get cross section

HMS vs SHMS comparison at 21°

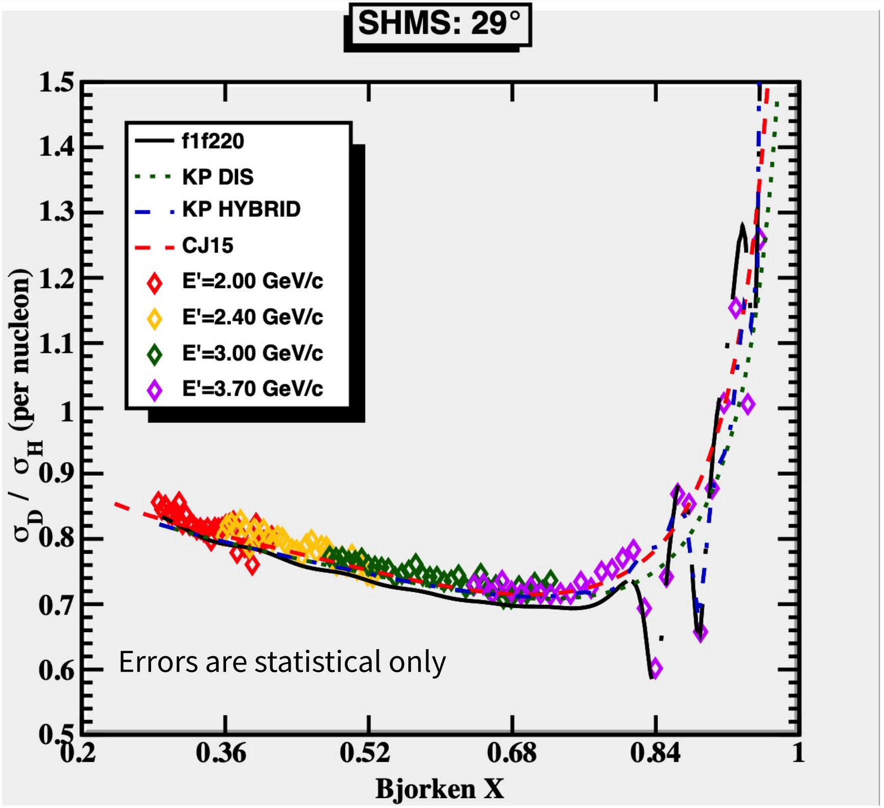
- 21 degree data was taken with both spectrometers

- Large x disagreement is from a momentum offset that needs to be removed (5.7 GeV setting)



Outlook

- First publication, D/H ratios paper, is nearly ready to be circulated to the collaboration. (~ weeks)
- An absolute cross sections paper to follow. Will require more work, calorimeter efficiency, acceptance studies, additional systematics etc. Most items have been started, but results need to be verified and understood. (~ months)
- Lots of exciting physics to follow (See Deb's talk next)



Acknowledgments

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

BACK UP Target Density

- F2 ran at currents from 30 uA to 60 uA. Target density decreases as current is increased.
- Luminosity runs from April 2018 were used to study target density/boiling
- Three methods were used:
  - Scaler analysis using the el-clean scaler branch
  - Non-tracking analysis including non-tracking based PID cuts and deadtime corrections.
  - Tracking Analysis which used track based PID cuts, deadtime, and tracking efficiency corrections
  - Tight +/- current cuts used in all
- For the HMS, all three methods produced similar results
- Significant disagreements between other analyses exists (using the same runs). This is currently being looked.
- The SHMS results also differ and is being studied

Average Boiling Result

LH2: 3.55 % +/- 0.33 per 100 uA

LD2: 4.11 % +/- 0.36 % per 100 uA

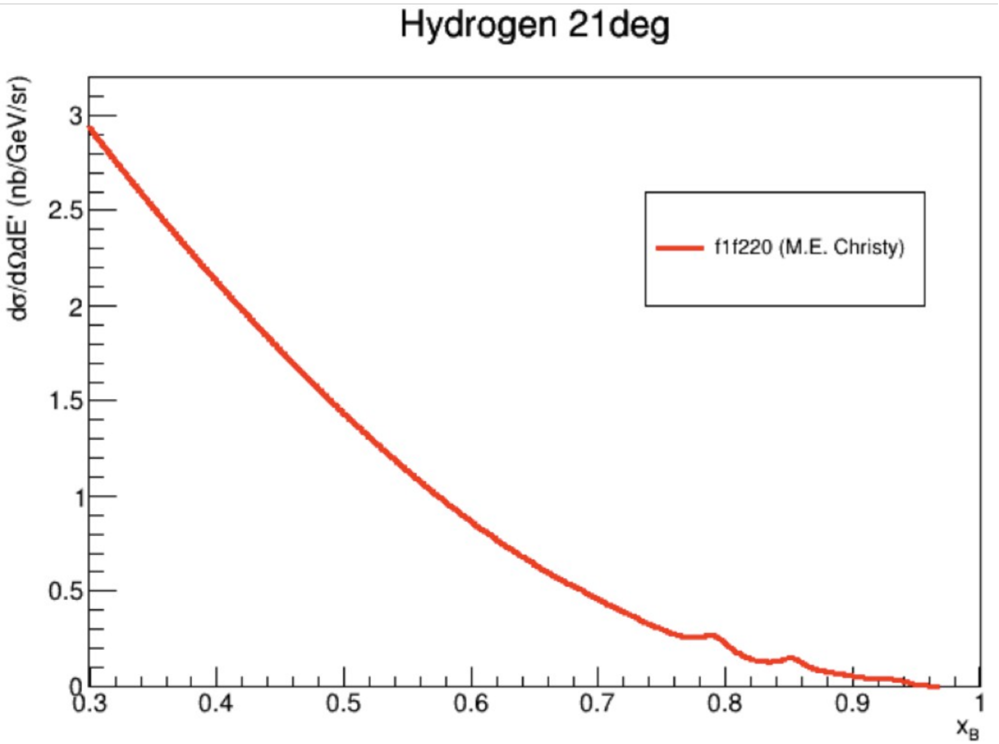
BACK UP Monte Carlo Weighting

- This analysis uses mc-single-arm (generates in a flat phase space)
- The MC output is weighted using a radiated cross section grid. (W2, x)
- The model is f1f220 (M.E. Christy)
- Radiative corrections are done with rc_externals code
- MC is scaled by

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

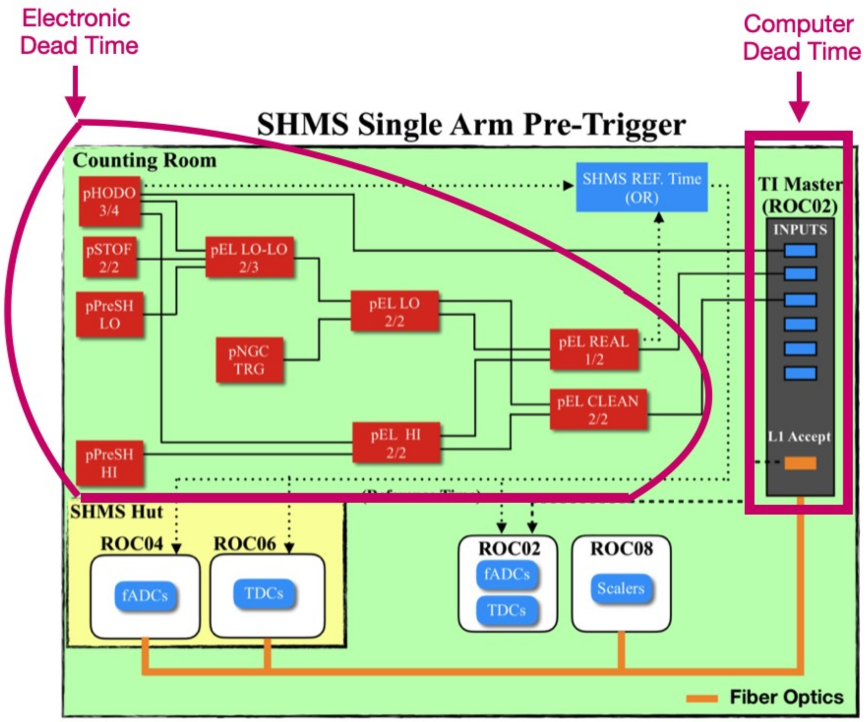
$$L_{Data} = \frac{N_A * L_{tgt} * \rho_{tgt}}{M_{tgt} * e}$$

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



BACK UP Livetime

- Deadtime: Is the time after each event where the system is not able to record another event
- Computer Deadtime: The deadtime associated with the recording of an event. This is the amount of time it takes to write the data (scalers, TDCs, fADCs), during which another trigger will not be accepted
- Electronic Deadtime: Deadtime associated with the formation of triggers. Sources of electronic deadtime include discriminators and trigger logic.
- Total Deadtime: TLT = ELT * CLT. The EDTM system in Hall C was designed to directely measure the TLT.
- Livetime = (1 - Deadtime)



Original Figure by Carlos Yero