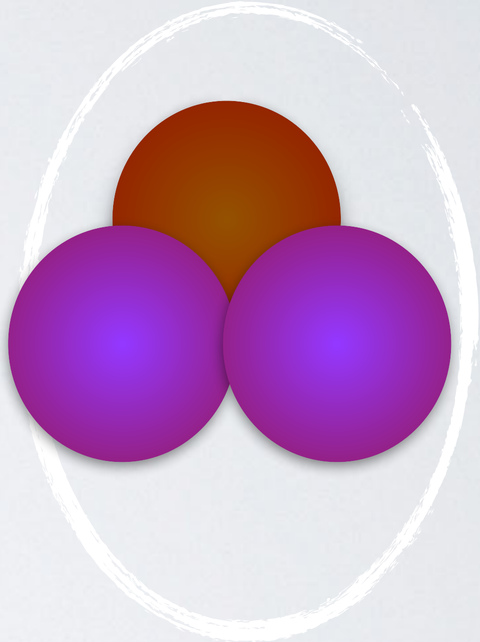
$^{3}H/^{3}He$ Quasi-elastic Analysis

On behalf of the E12-11-112 Collaboration



Nathaly Santiesteban

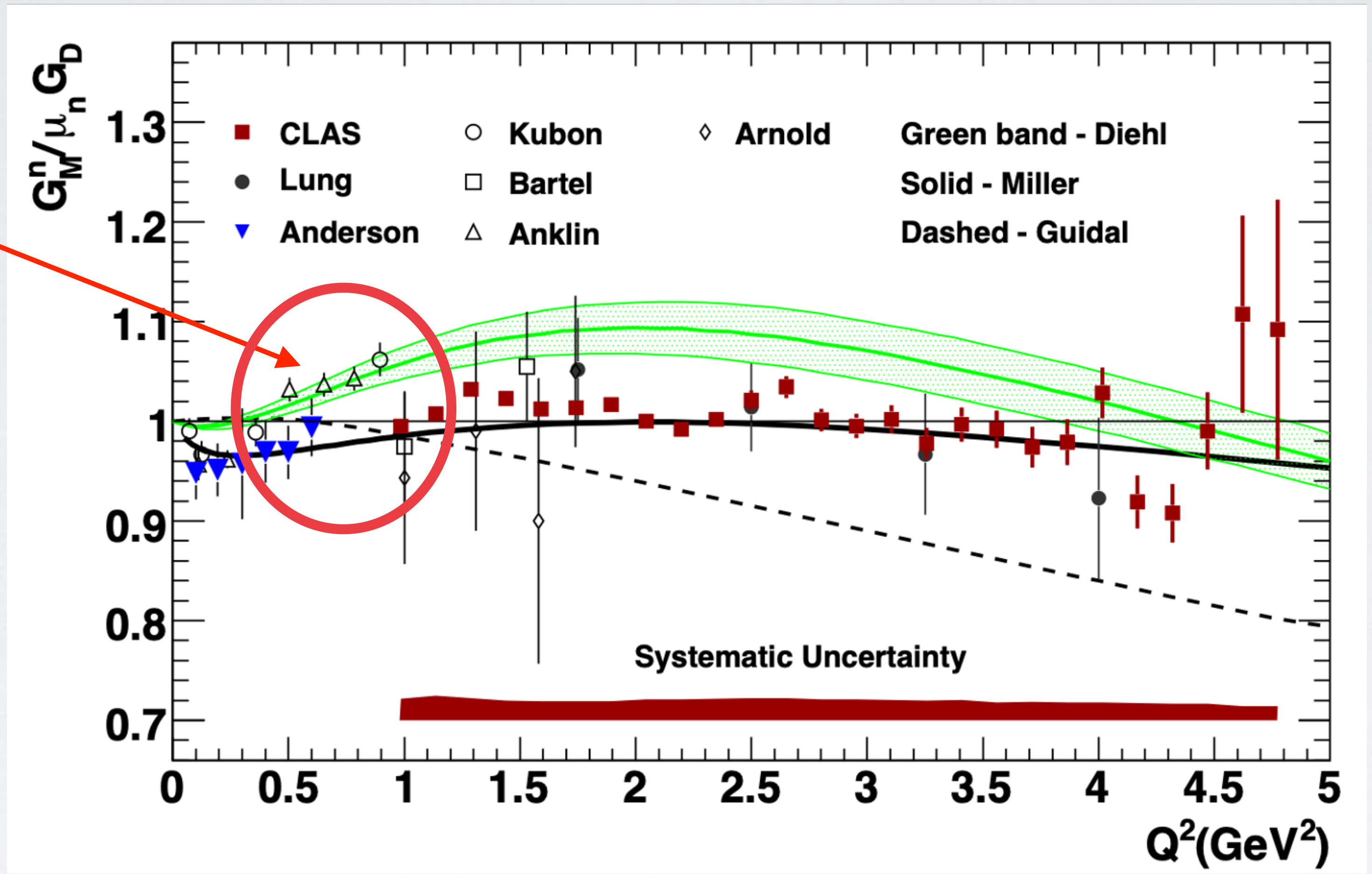
University of New Hampshire

Hall A/C Collaboration Meeting
07/17/2020

E12-11-112 Motivation

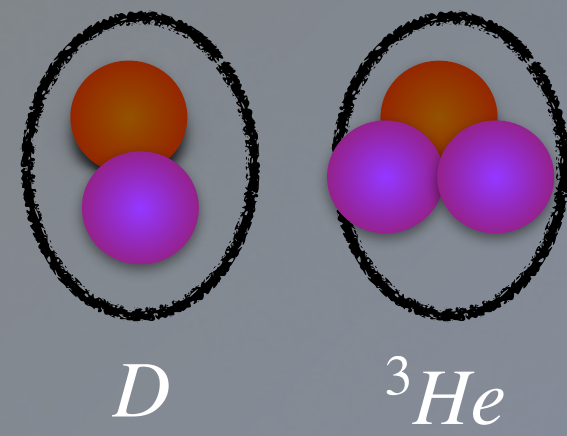
CLAS Collaboration. Phys.Rev.Lett. 102 (2009)

Discrepancy in the data



$Q^2 < 1$ region has ~8% discrepancy between the Anklin, Kubon data and the CLAS ratio and the Hall A polarized ^3He extraction.

No free Neutron Target



No Charge:

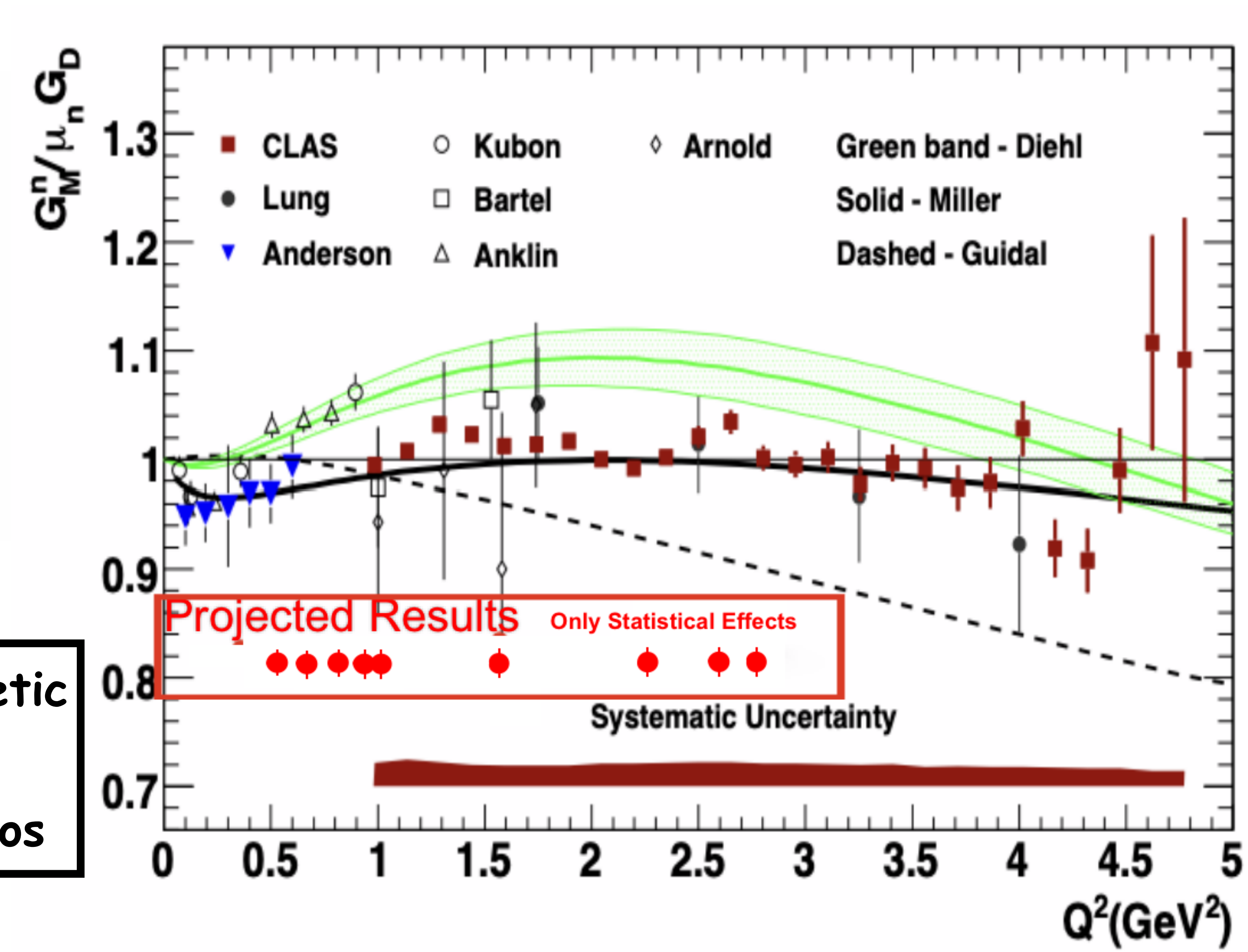
- Energy Information from time of Flight
- Requires precise measurement of Hadron detection Efficiencies

Measurement Corrections:

- Reaction Mechanisms FSI and MEC
- Nuclear Structure

E12-11-112 Projected Results

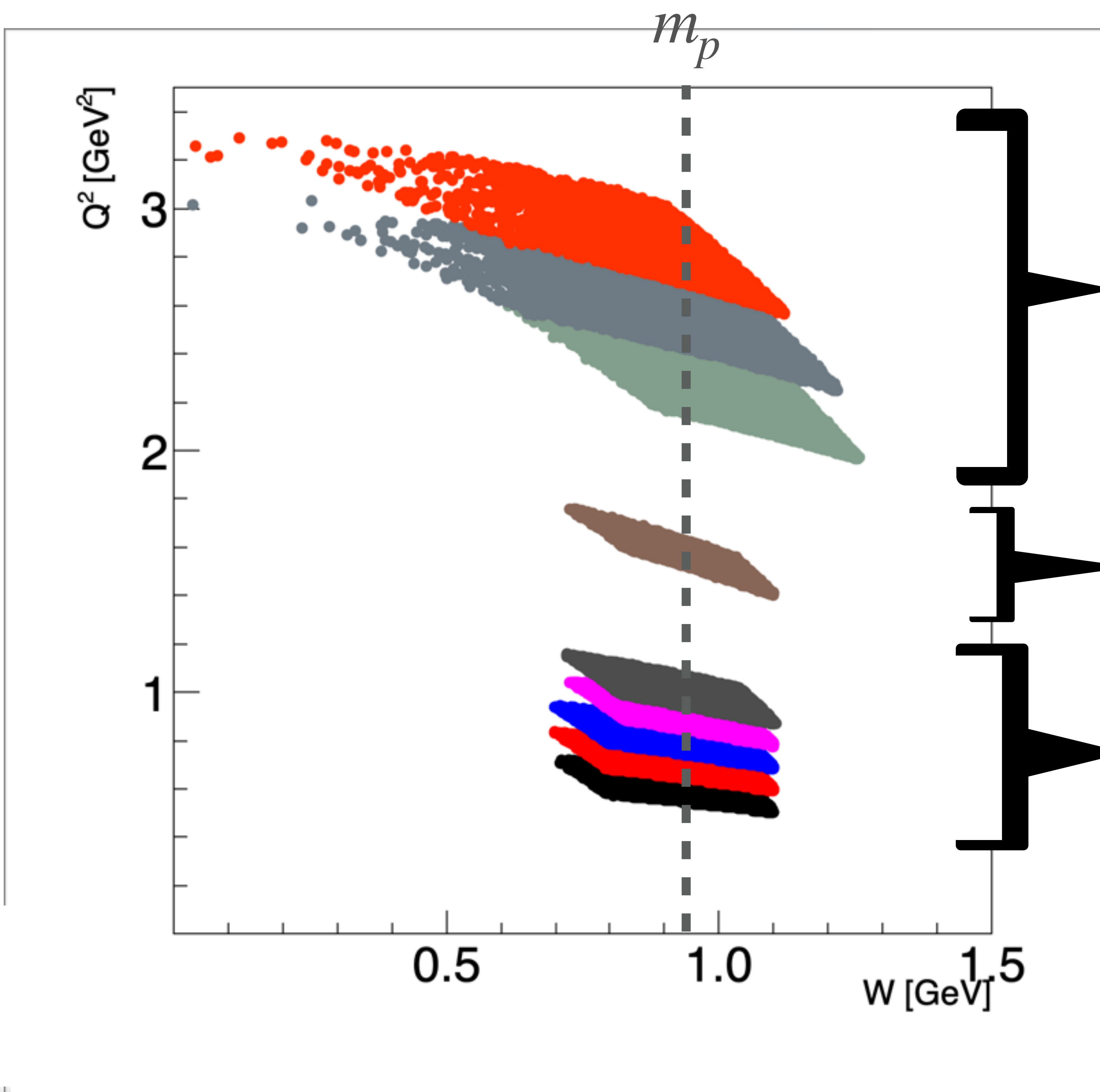
P. Solvignon, J.Arrington, D.B.Day, D. Higinbotham, Z. Ye (Spokepeople)



Measure the neutron magnetic form factor using the $^3H/^3He$ cross-section ratios

E12-11-112 Kinematics

P. Solvignon, J.Arrington, D.B.Day, D. Higinbotham, Z. Ye (Spokepeople)



RHRS
E = 4.3 GeV
θ = 24°, 26°, 28°
Fall 2018

RHRS
E = 2.2 GeV θ = 42°

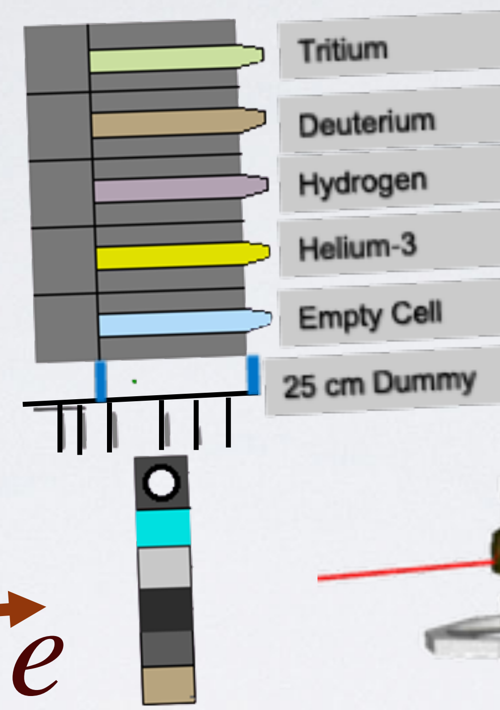
LHRS
E = 2.2 GeV
θ = 21.7°, 23.8°, 25.9°, 28°, 30°
Spring 2018

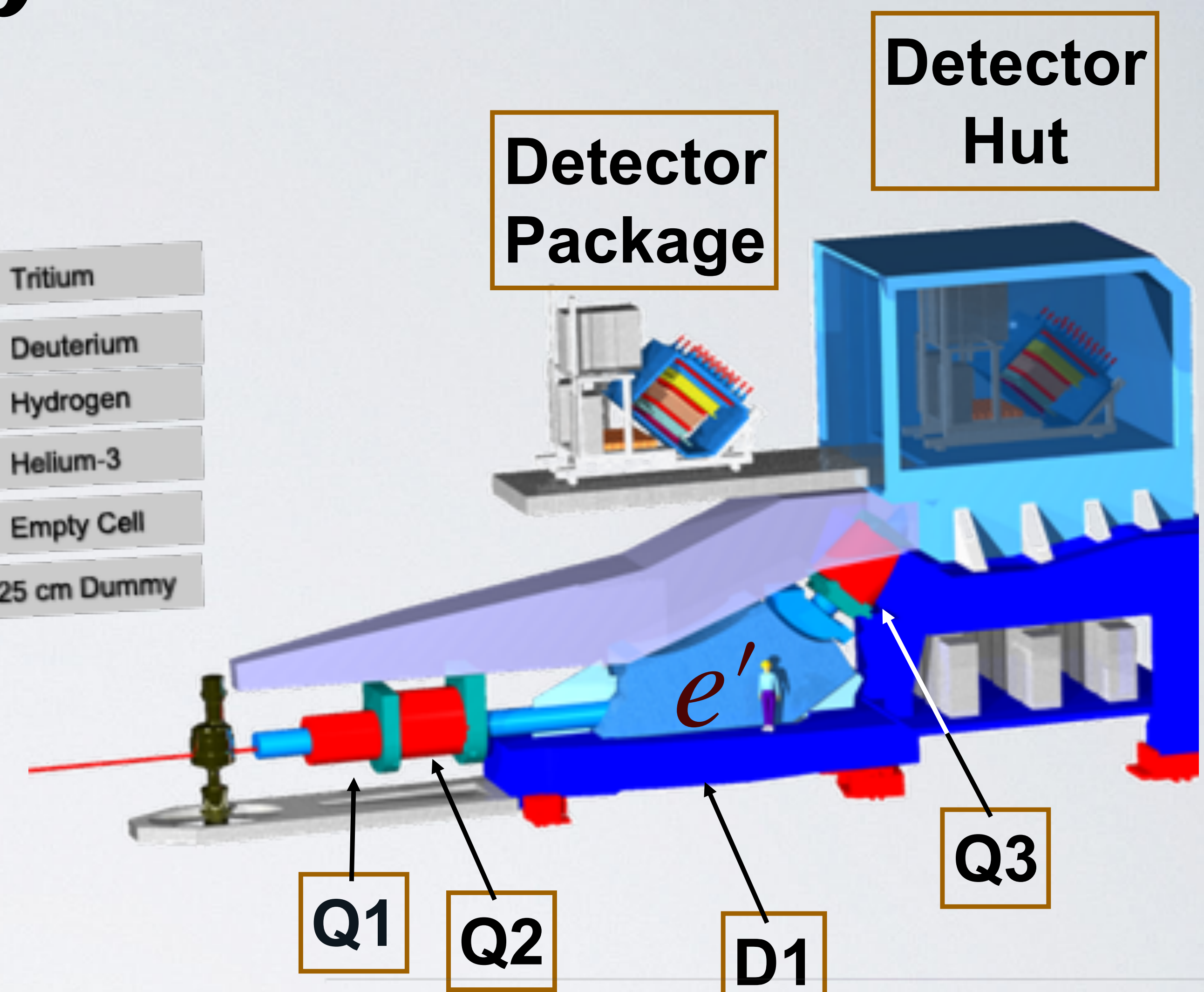
Experimental Setup

Hall A

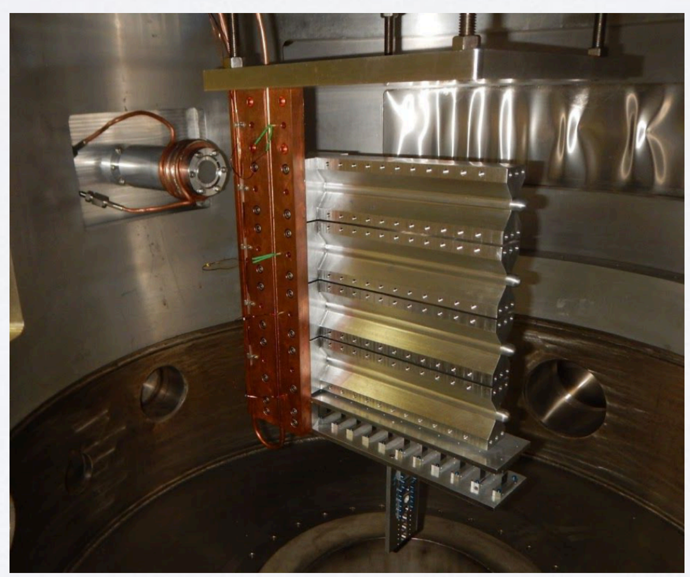
E = 2.2 Gev
E = 4.3 Gev

Electron Beam e

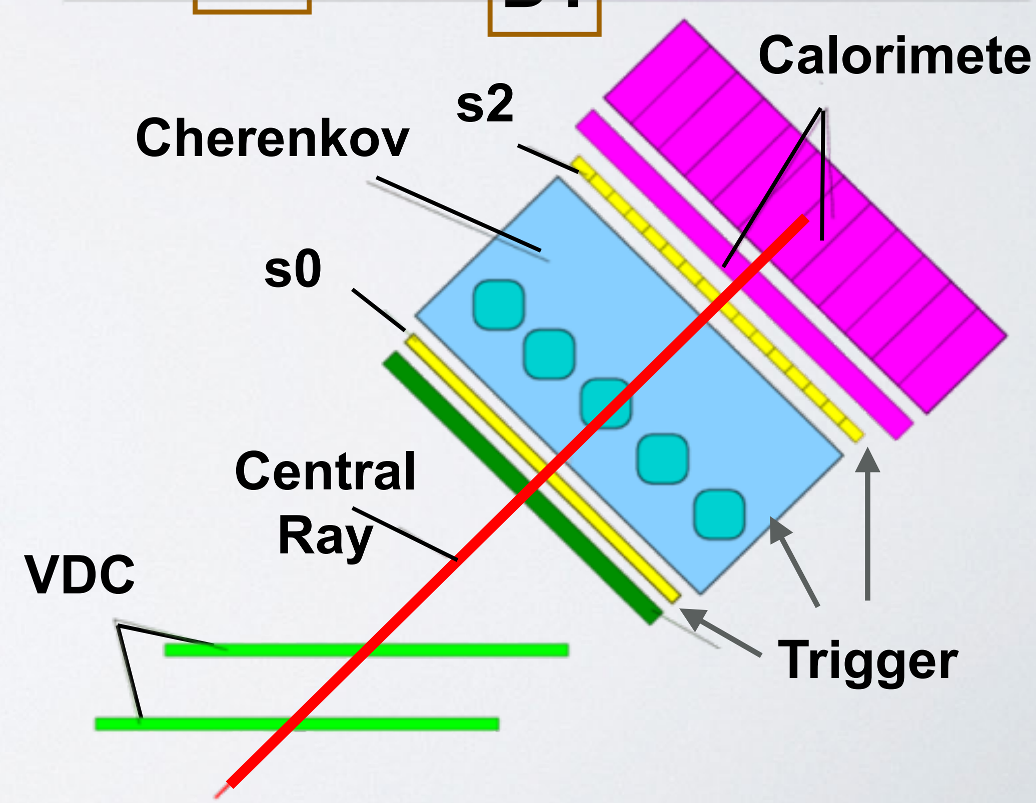




LHRS and RHRS
*10 different Q^2 Points
1 Commissioning Kinematic
*2-3 Kinematics Settings per Q^2 point.
*2 Tritium Cells



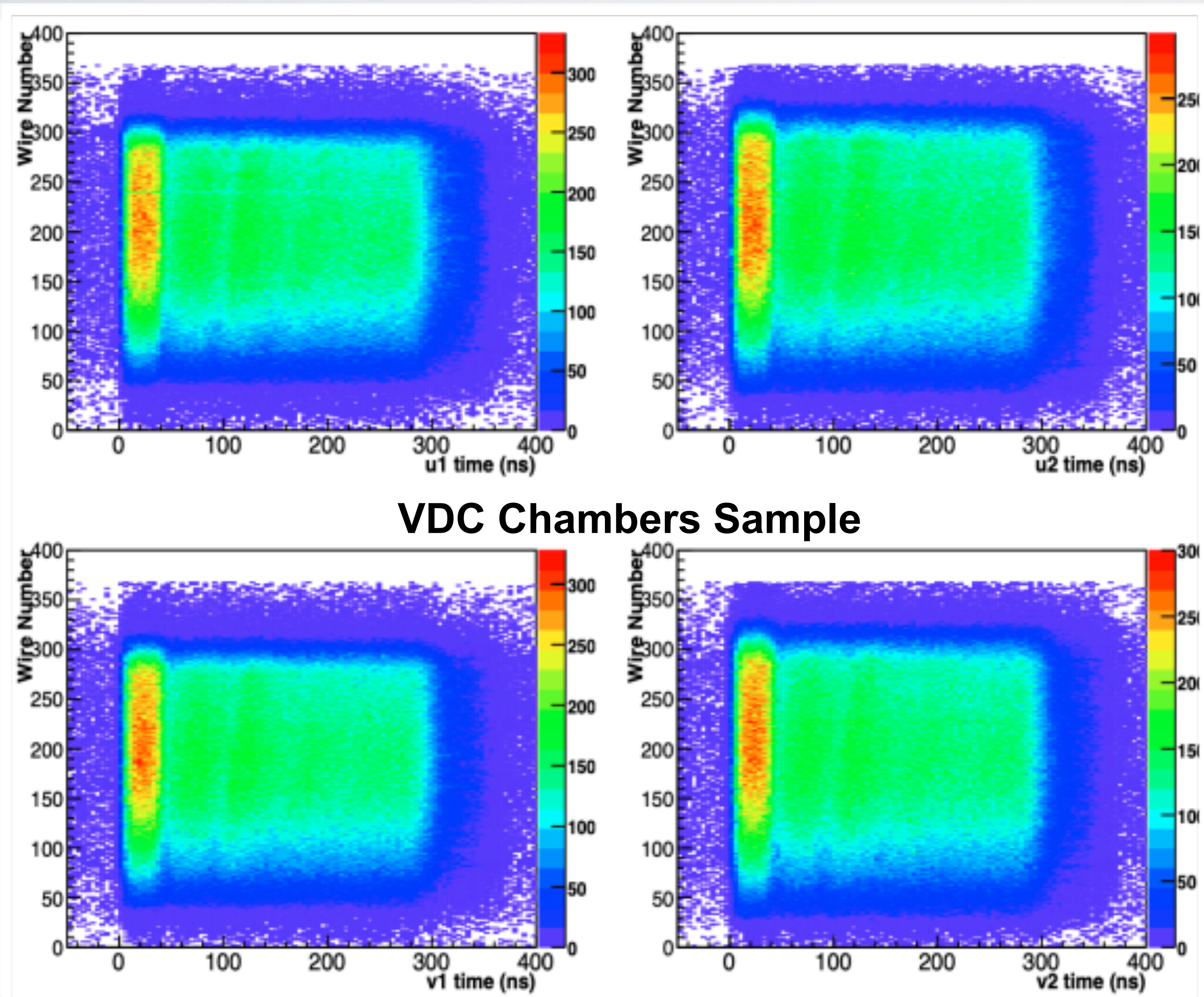
Target System

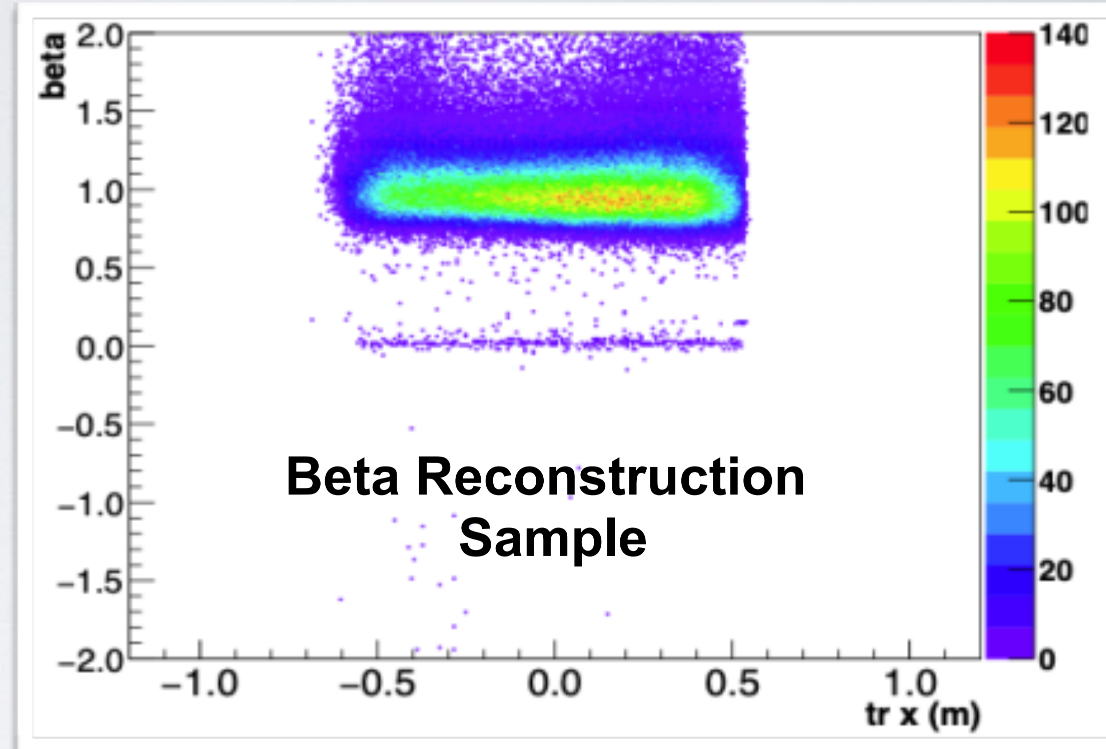


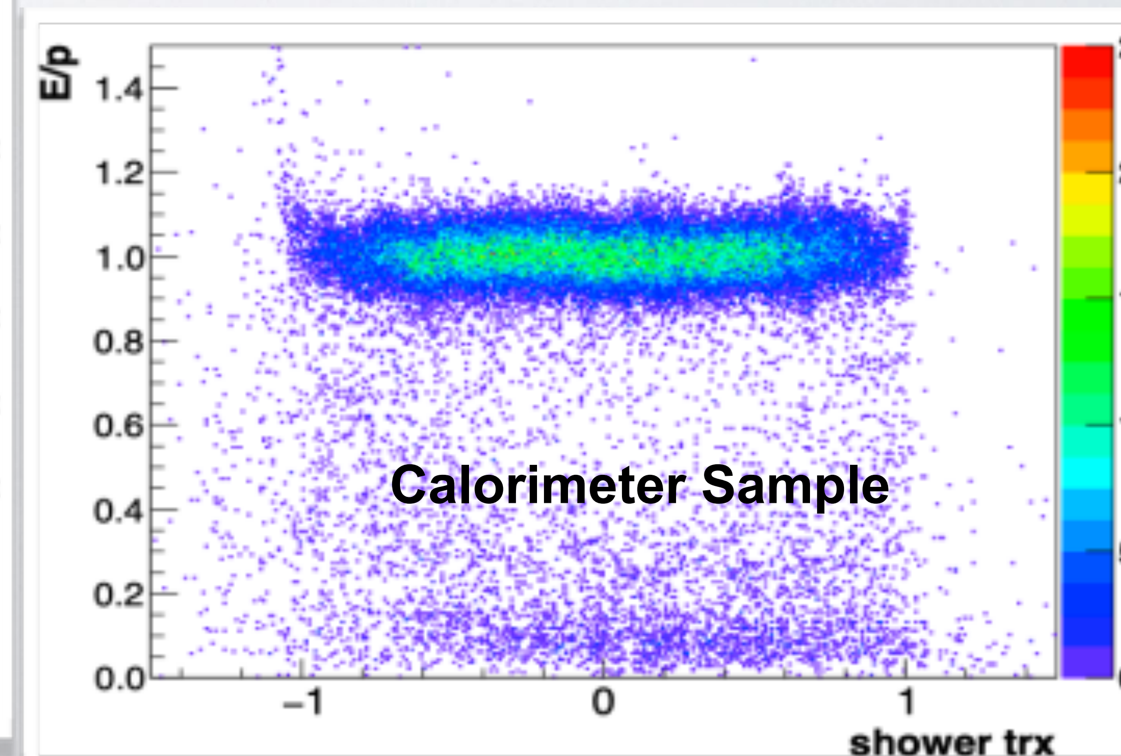
Detector Calibration

BCM
BPM (Jason Bane)
Raster (Tyler Hague)
Beam Energy (Douglas H.)

VDC (All Students)
Scintillators (All Students)
Cherenkov (All Students)
Calorimeters (All Students)

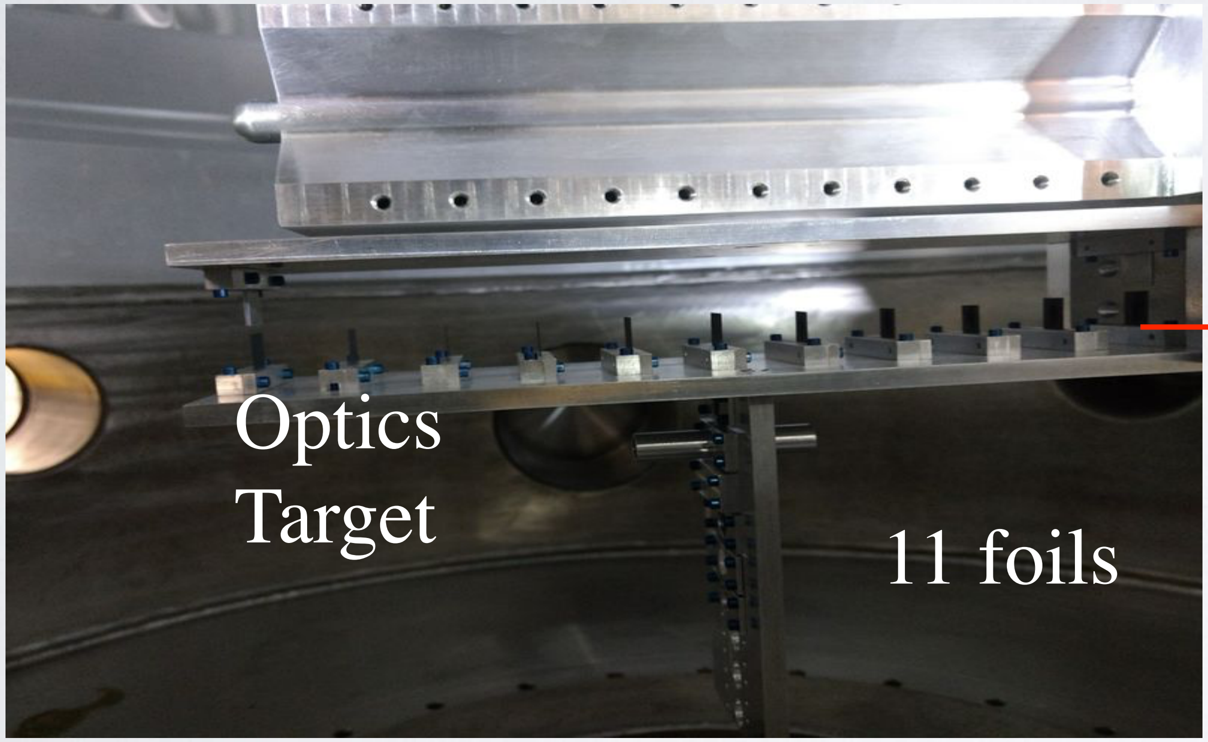


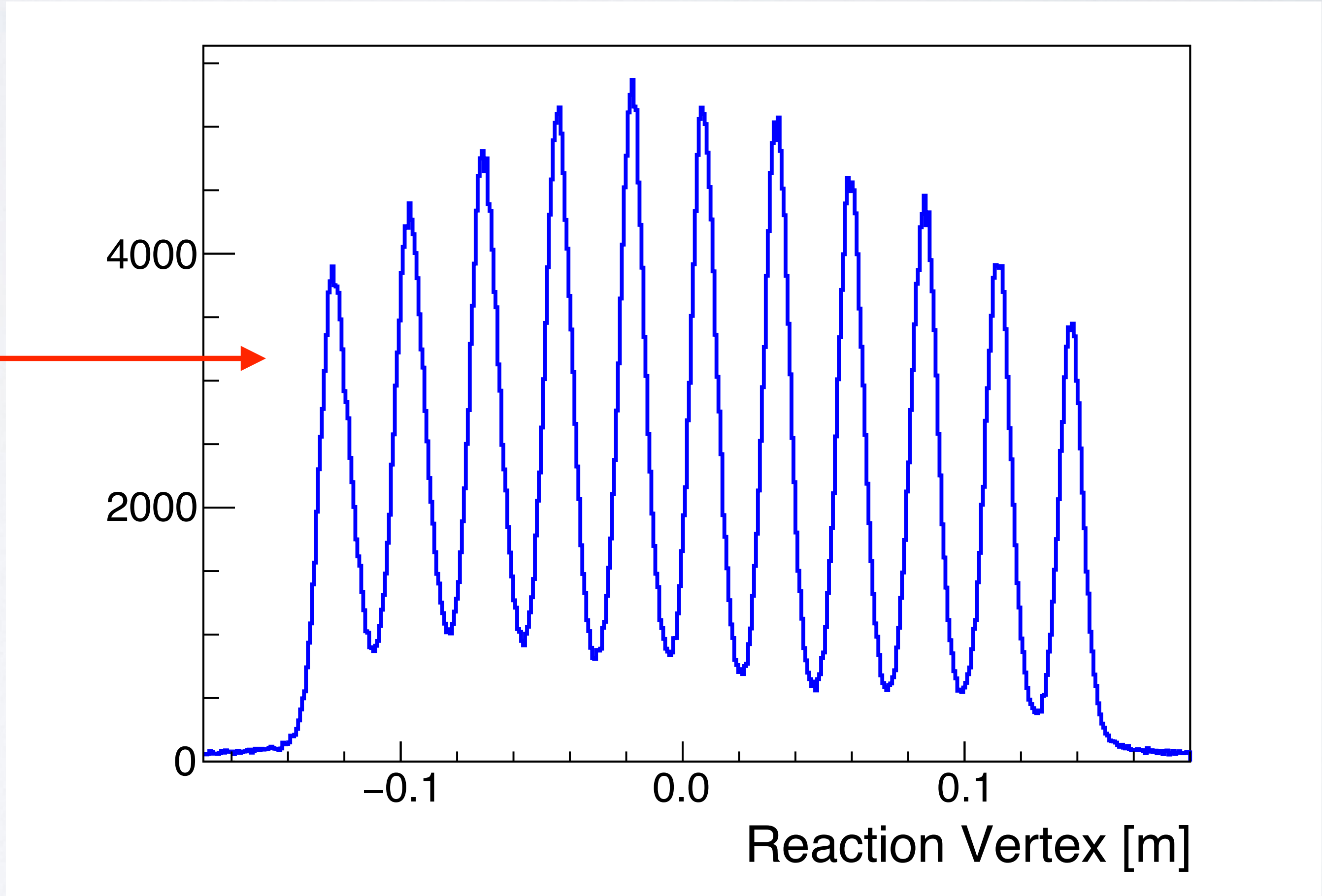




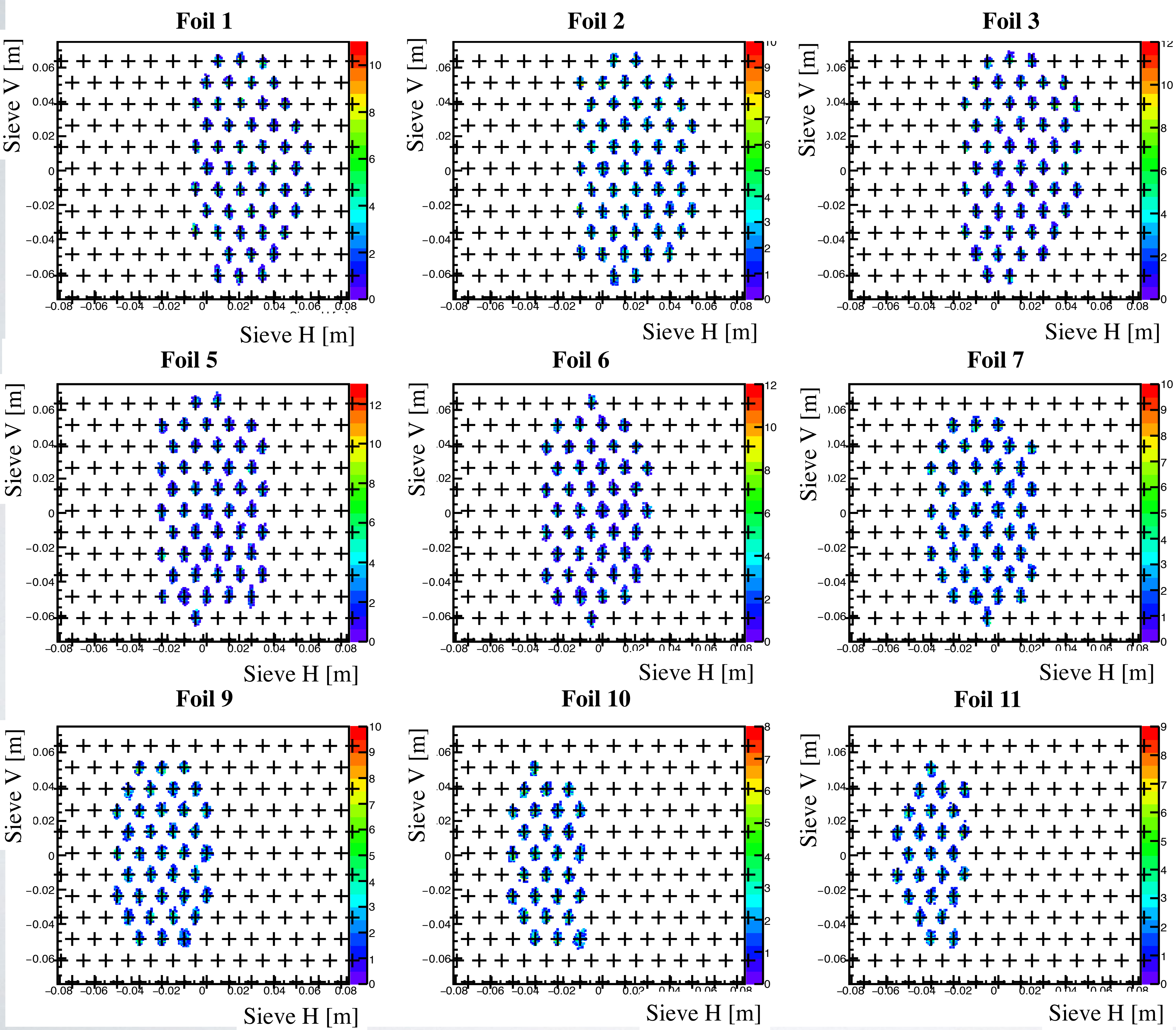
Optics Optimization

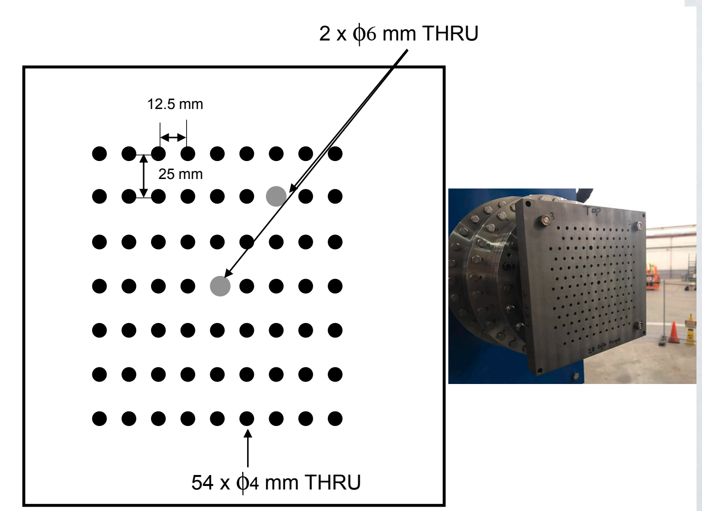
Lowest Q^2 Data had a different Spectrometer Tuning
Required Optics Optimization





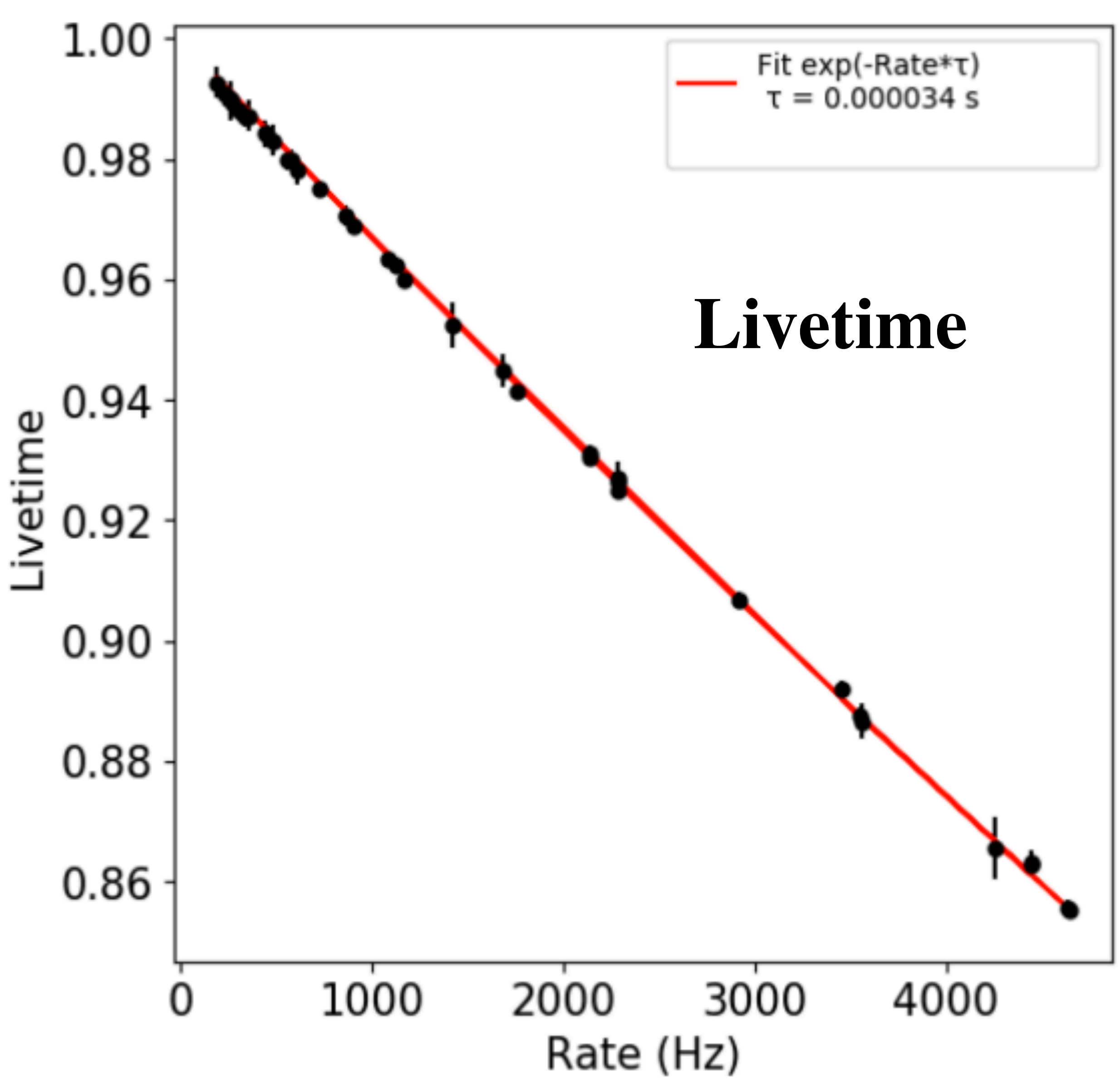
Sieve Plane Projection for each Foil

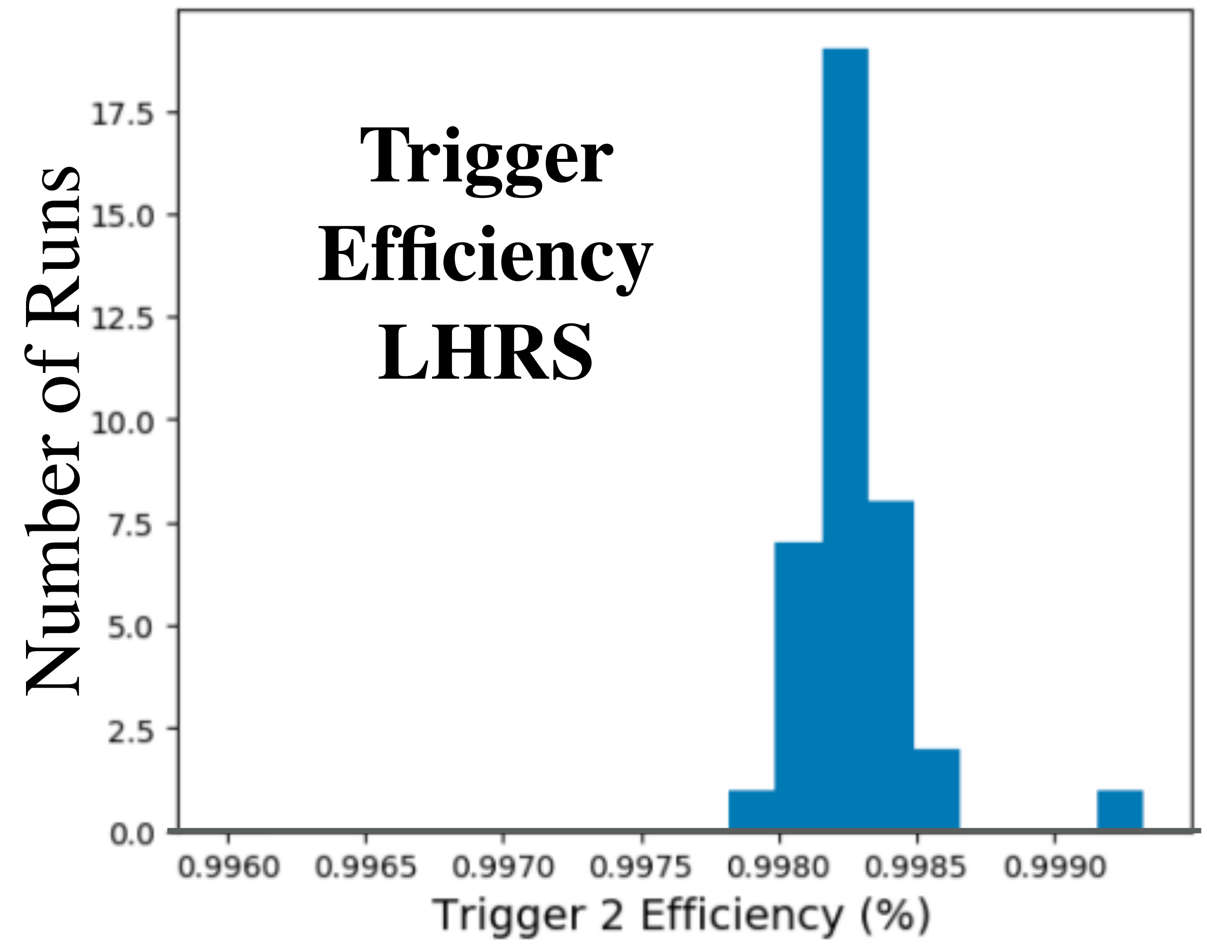


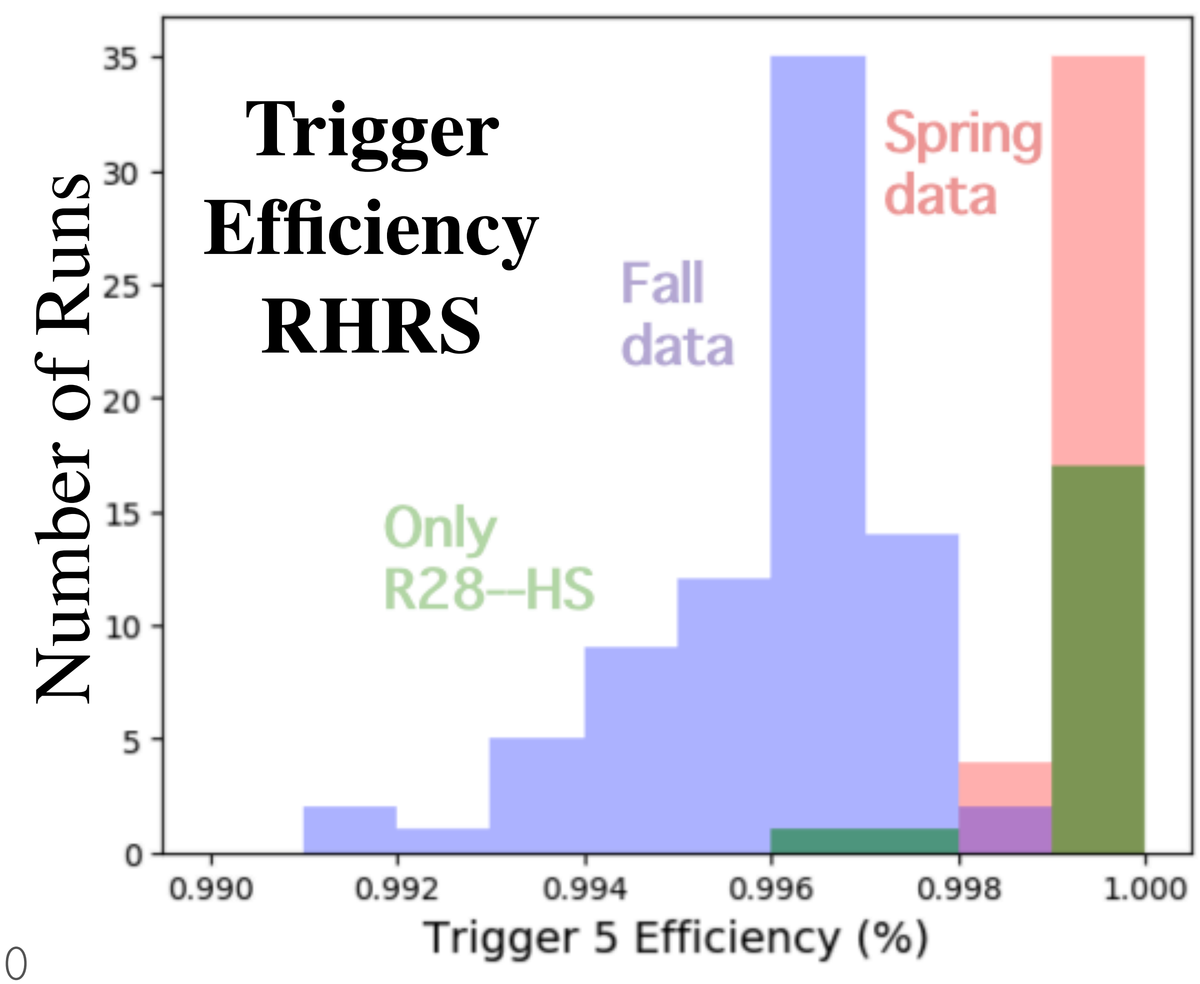


Sieve on Spectrometer LHRS

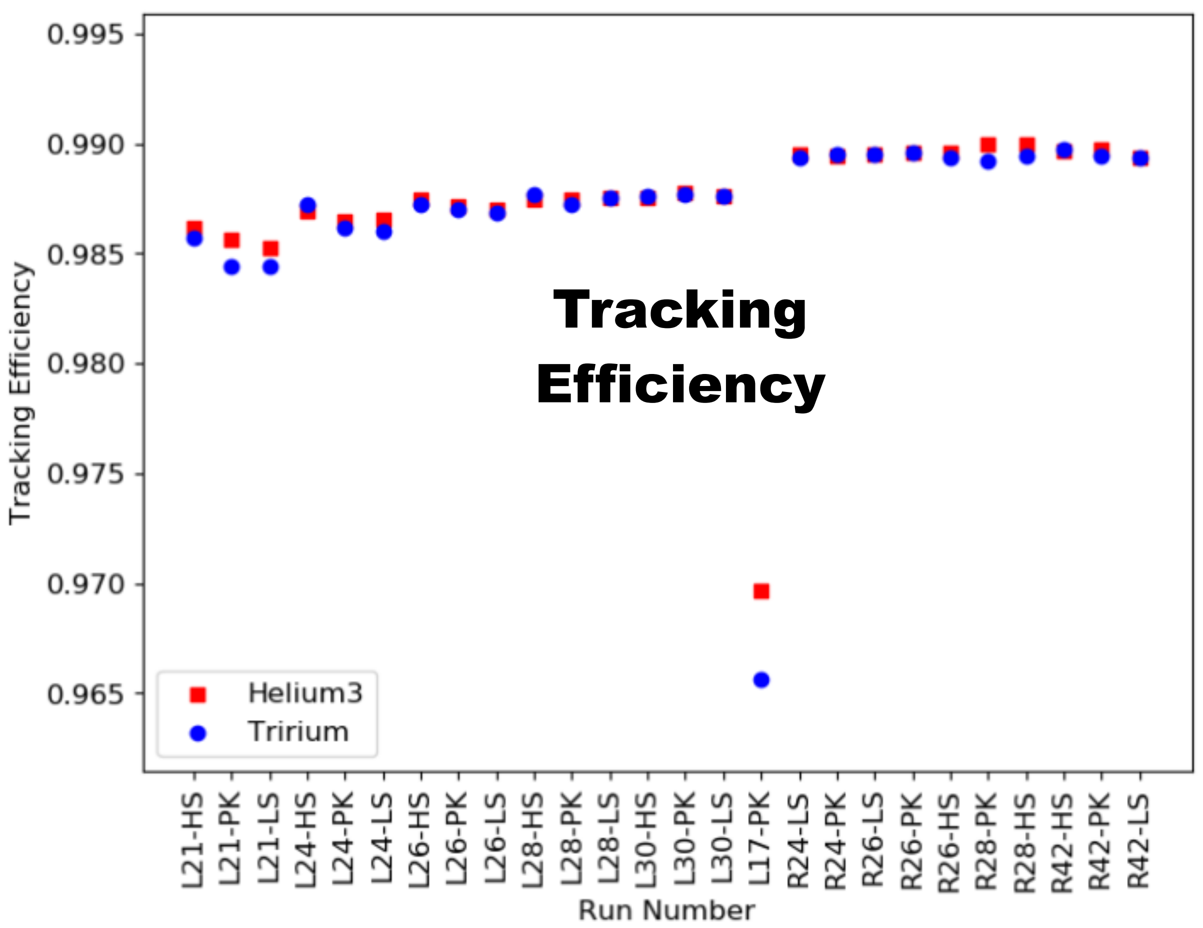
Data Quality

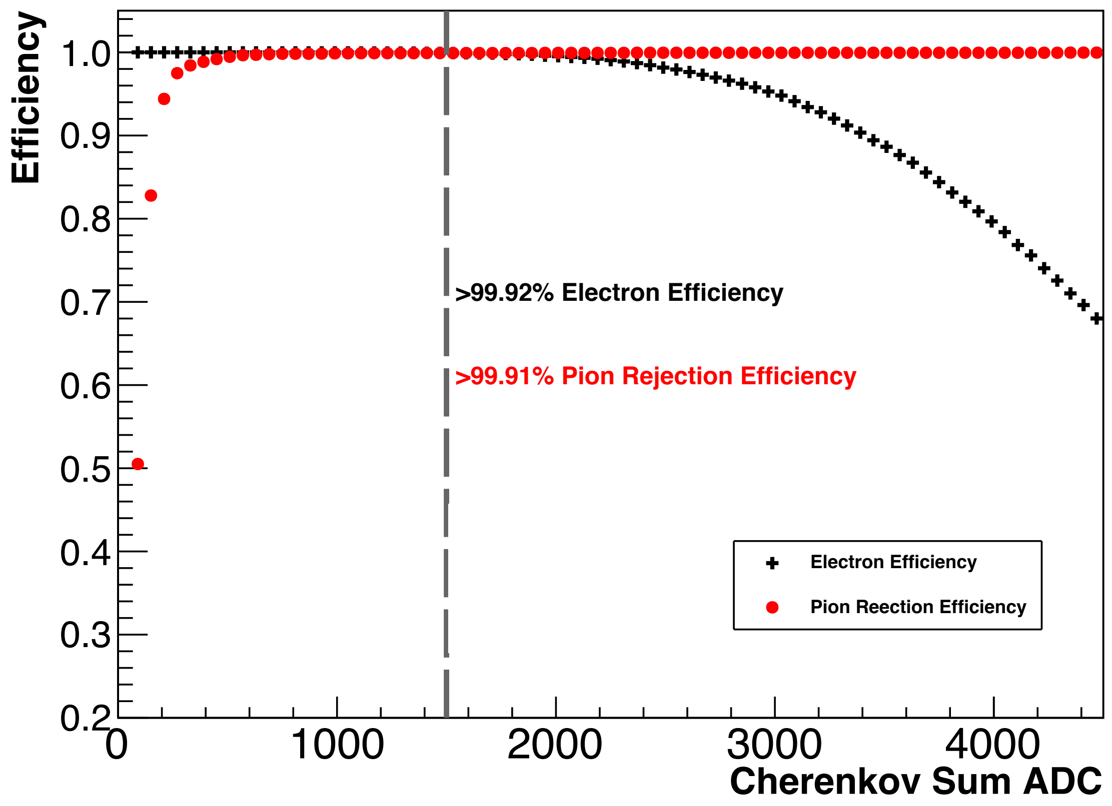


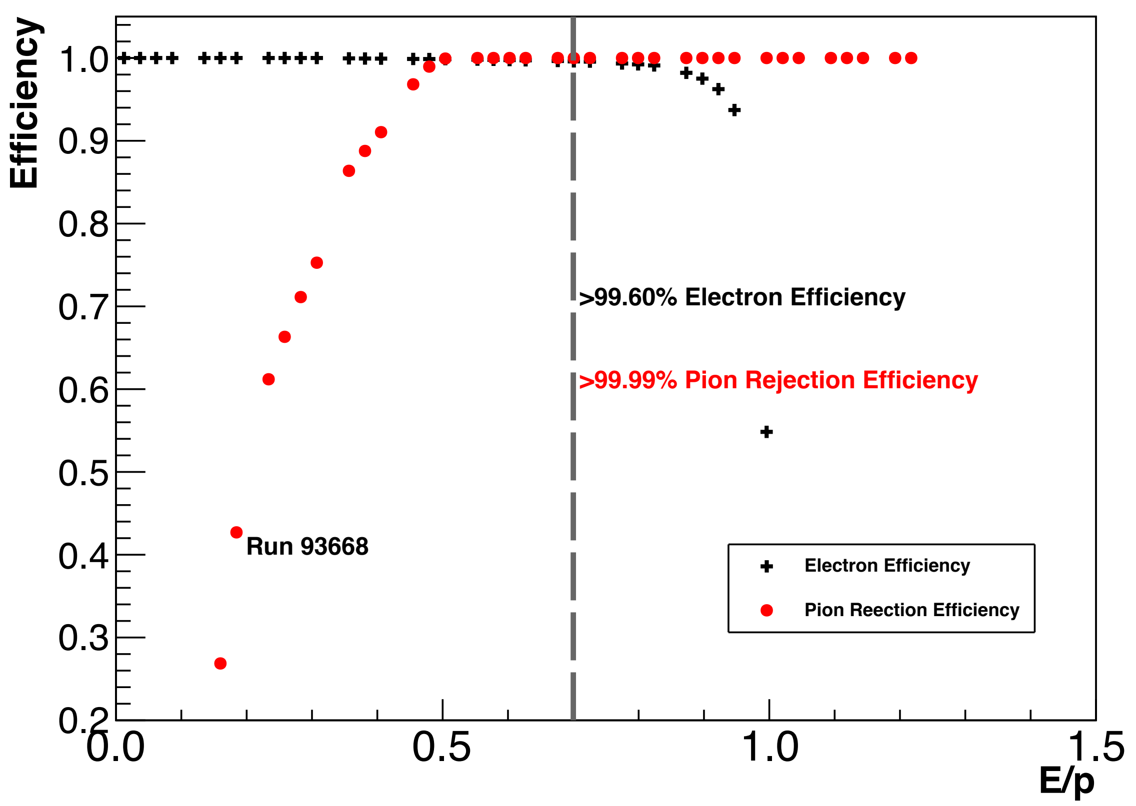




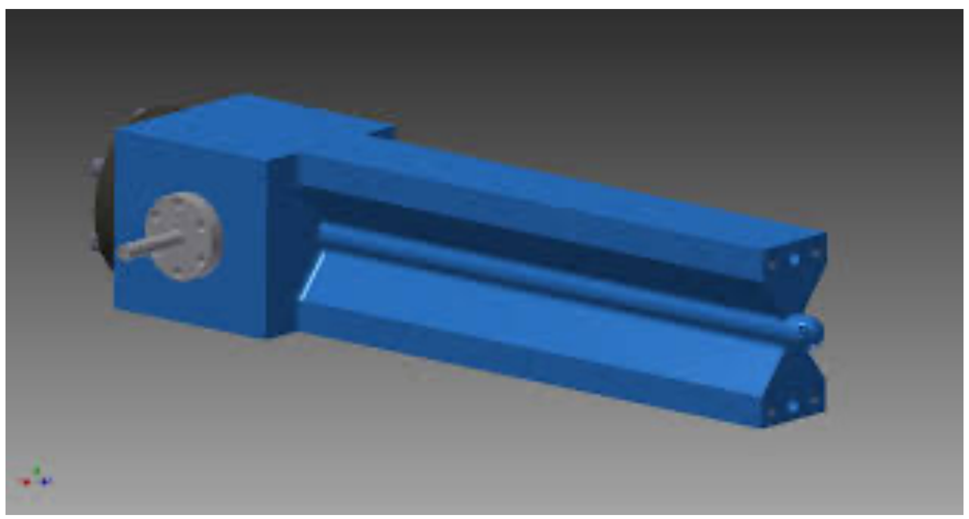
Data Quality

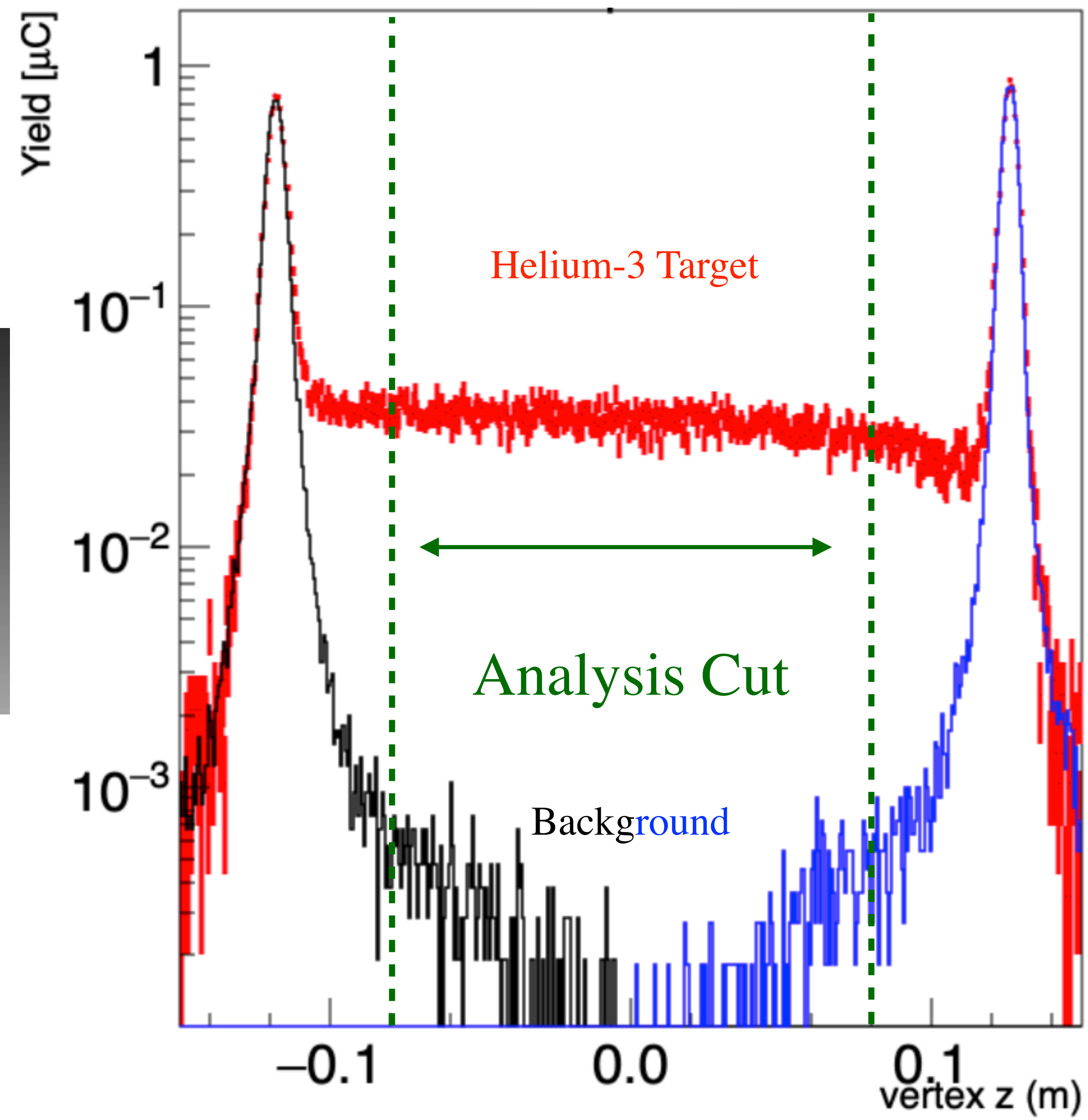






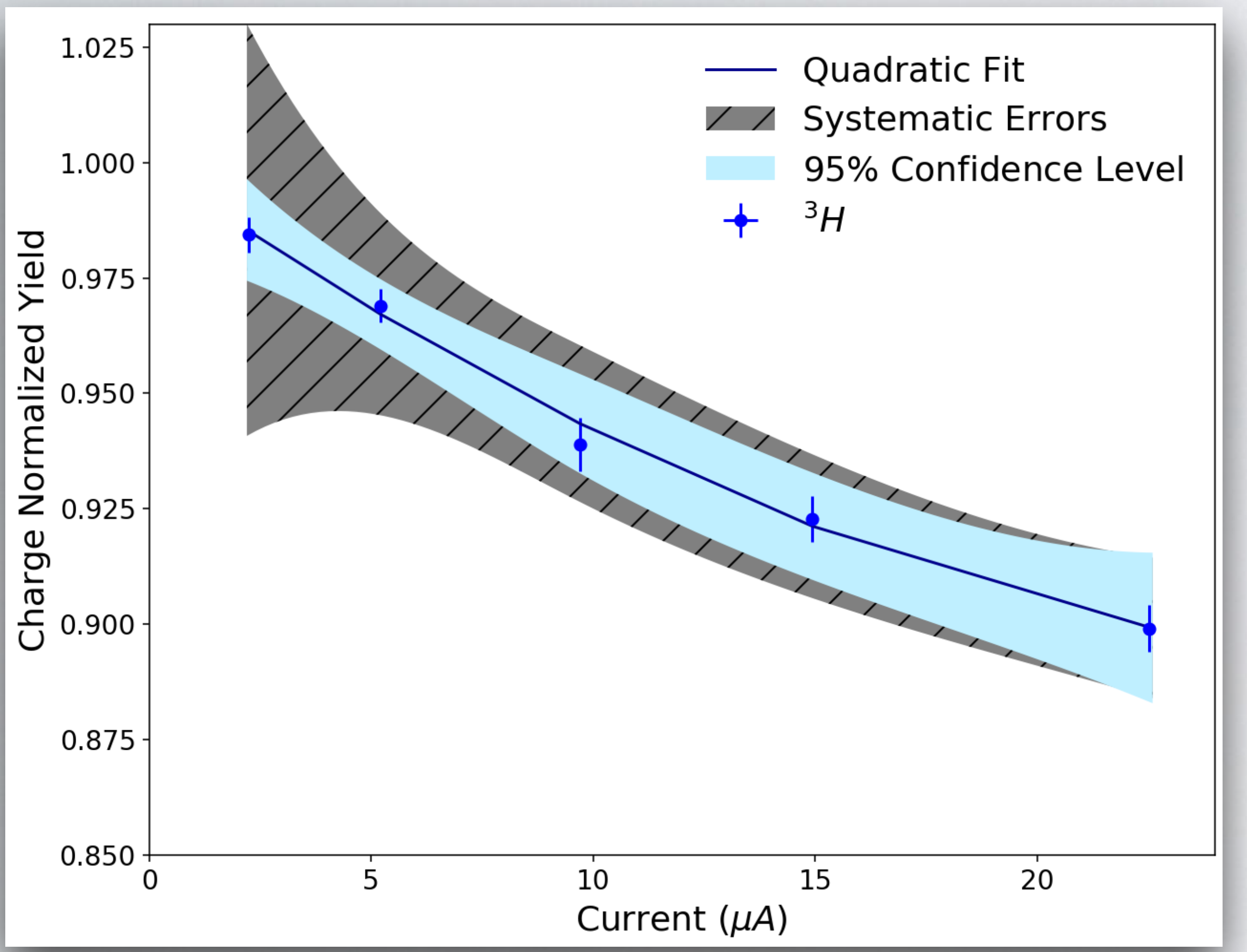
Background Contamination

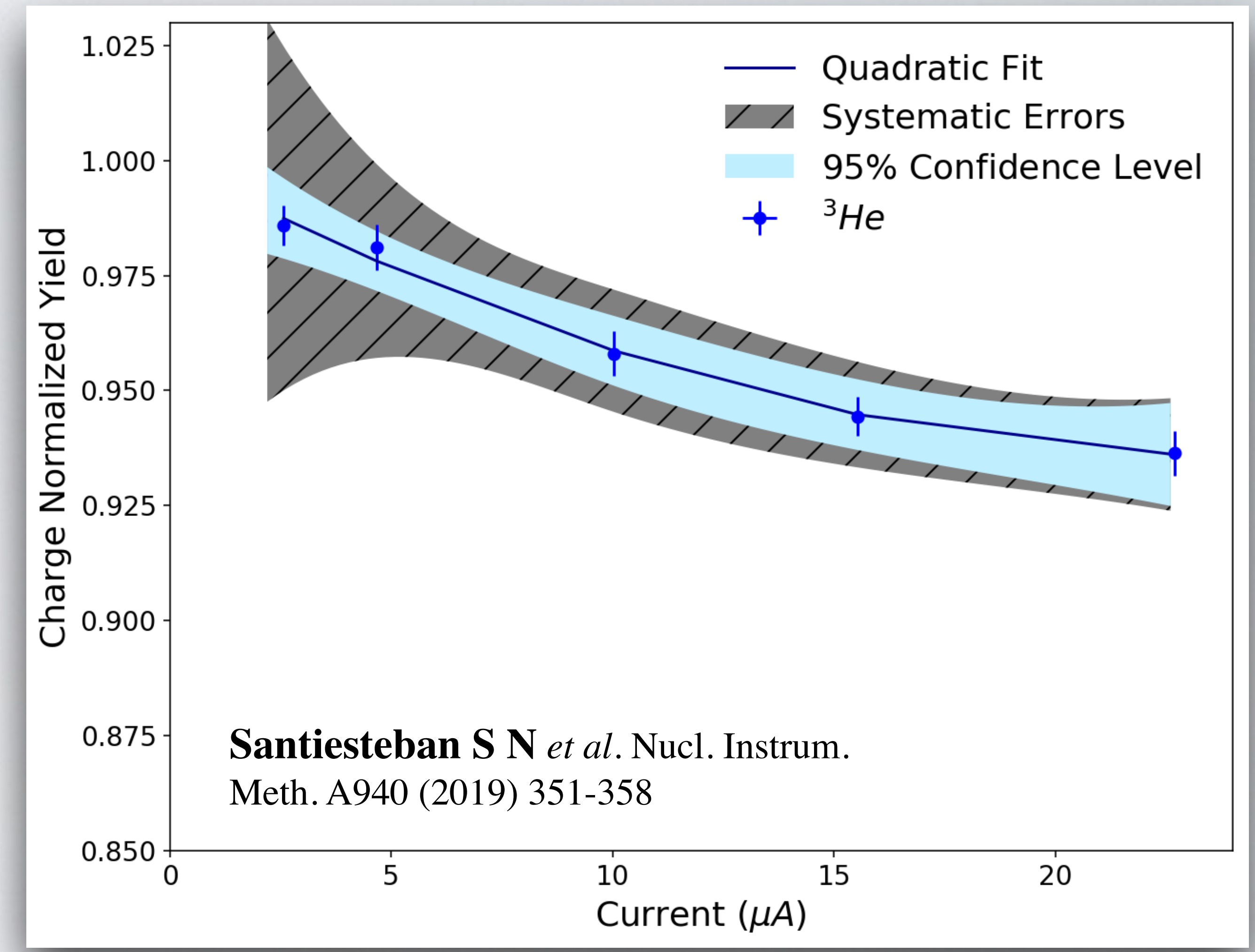




Maximum ~3% contamination
In the lowest Q^2 kinematic

Gas Density Correction





Density Reduction in the targets for $22\mu A$:

$^3H \sim 10\ \%$

$^3He \sim 6\%$

Tritium Decay

First Cell:

Filling Date
10/23/2017
100% Tritium

98.83% Tritium
E12-11-112
Commissioning
One day 12/15/2017

97.76 -96.27% Tritium
E12-010-103
Marathon
02/02/2018-04/12/2018

96.25 -95.74% Tritium
E12-14-011
(e,e'p)
04/13/2018-05/02/2018

95.82 -95.73% Tritium
E12-11-112
05/03/2018-05/06/2018

Tritium ($\tau = 4500 \pm 8$ days): $n_{^3H}(t) = n_0 e^{-t/\tau}$

What is measured: $\sigma^{measured} = \sigma^{^3H} e^{-t/\tau} + \sigma^{^3He}(1 - e^{-t/\tau})$

What is wanted: $Y^{^3H} = \dfrac{Y^{measured}}{1 - f(t)} - Y^{^3He}\dfrac{f(t)}{1 - f(t)}$

if $f(t) = \dfrac{n_{^3H}(t)}{n_0} = 1 - e^{-t/\tau}$

Tyler Kutz

Second Cell:

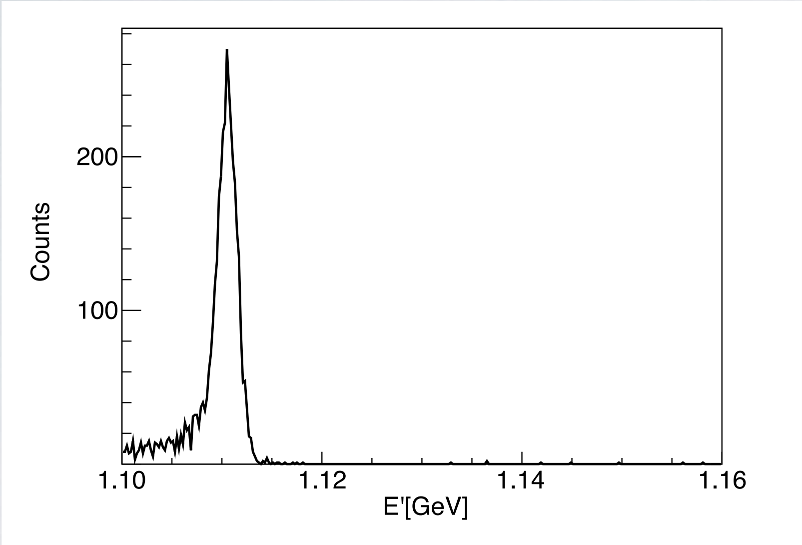
Filling Date
08/24/2018
100% Tritium

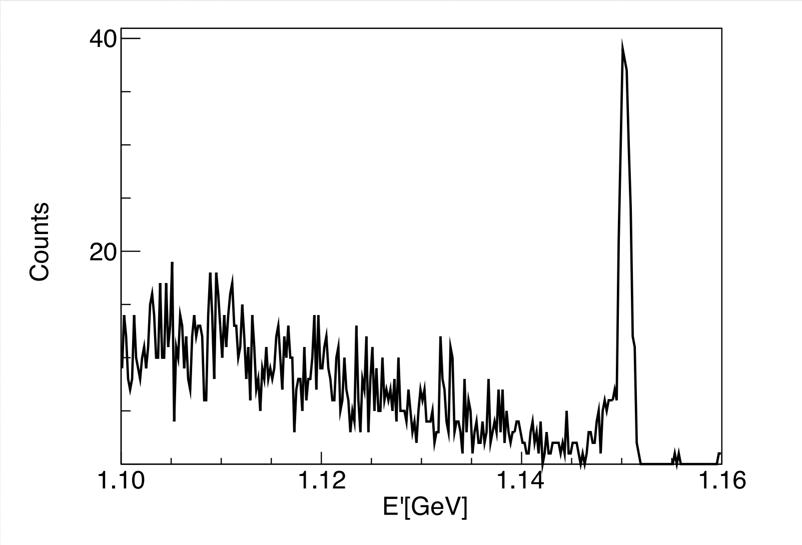
99.27-98.55% Tritium
E12-11-112
09/26/2018-10/29/2018

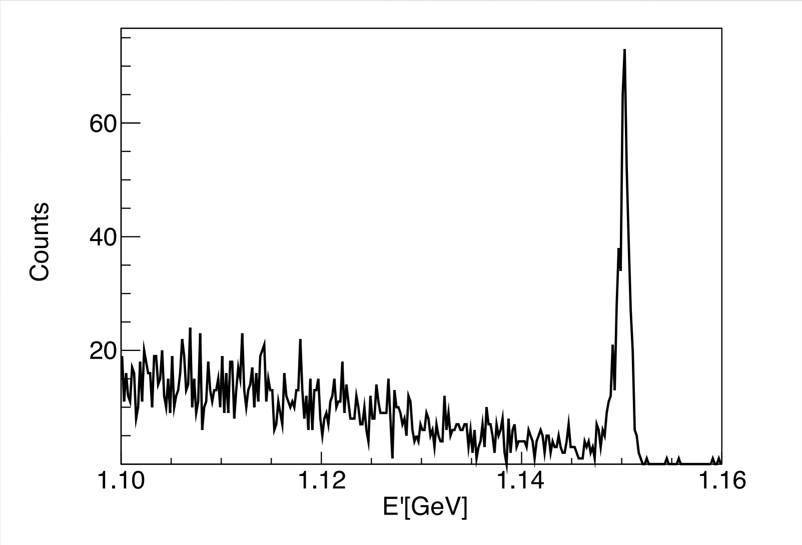
98.52 -97.95% Tritium
E12-17-003
(e,'K)
09/26/2018-10/29/2018

Beam Energy Measurement with Elastic Data

$$E = \frac{E_i - E_{loss1}}{1 + \frac{(E_i - E_{loss1})sin^2(\theta/2)}{M_t}} + E_{loss2}$$

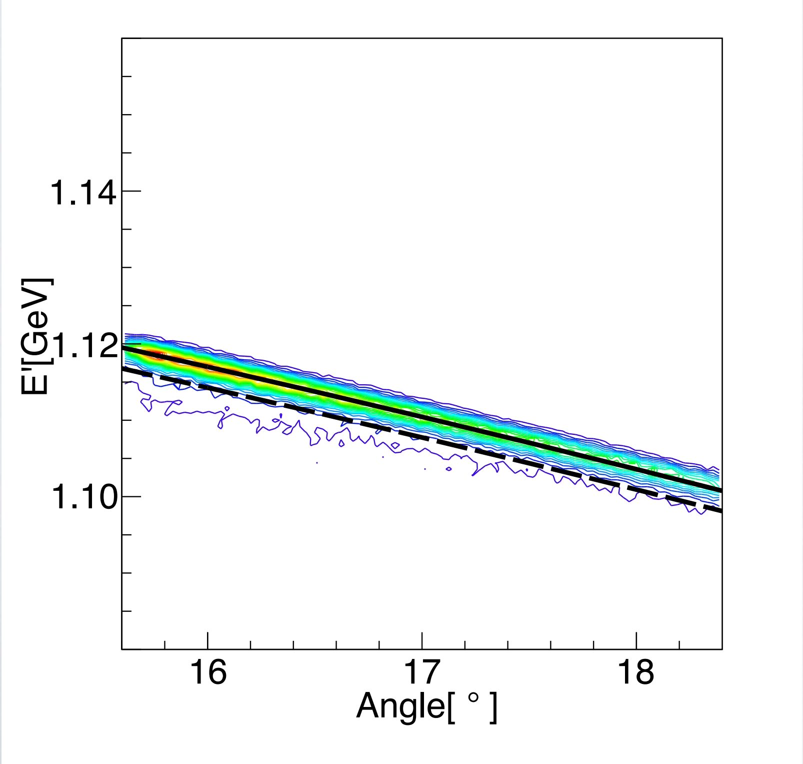


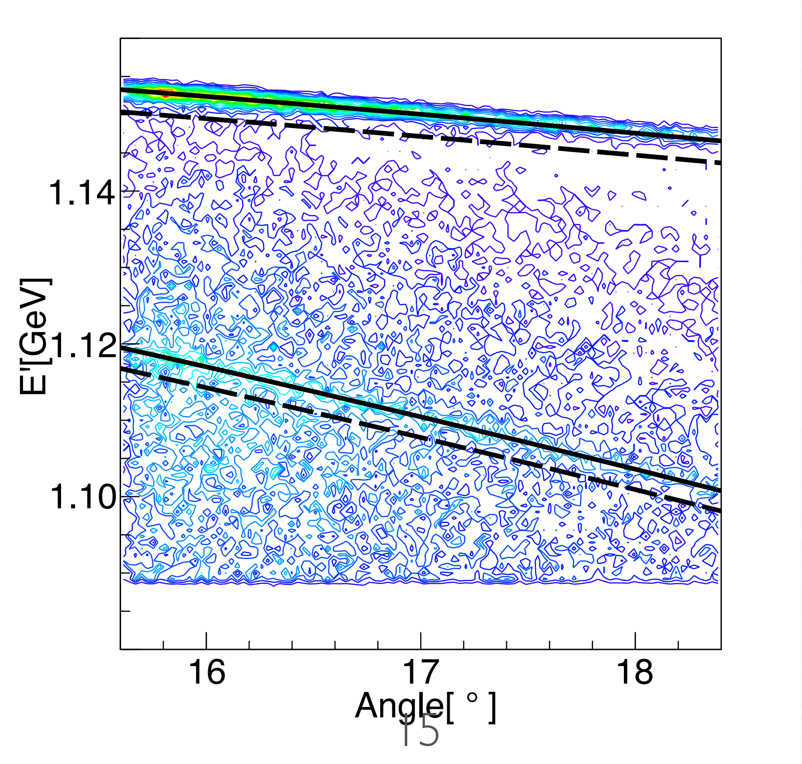


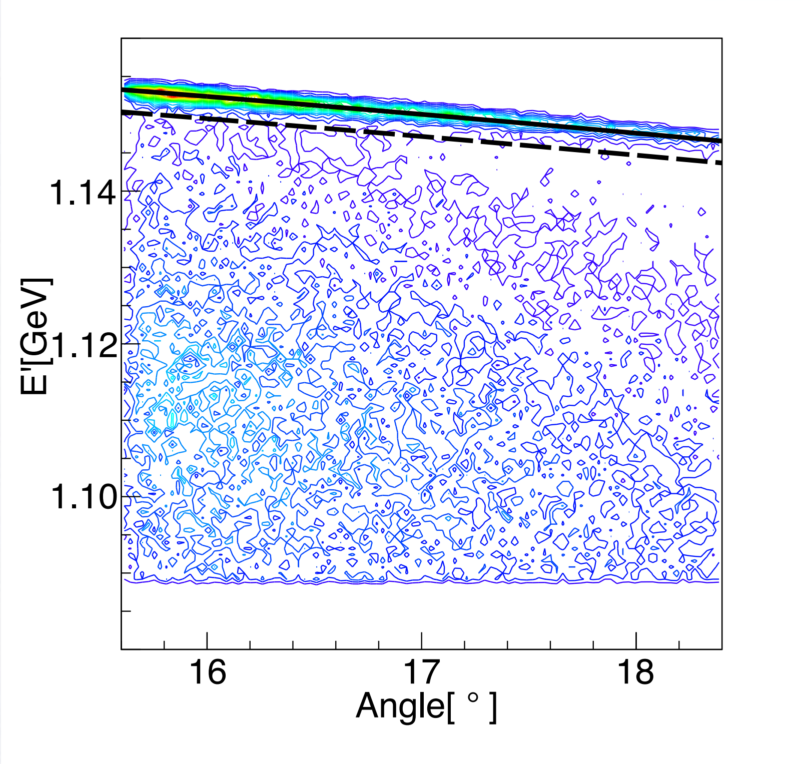


Scattering Angle 17° ± 0.1°

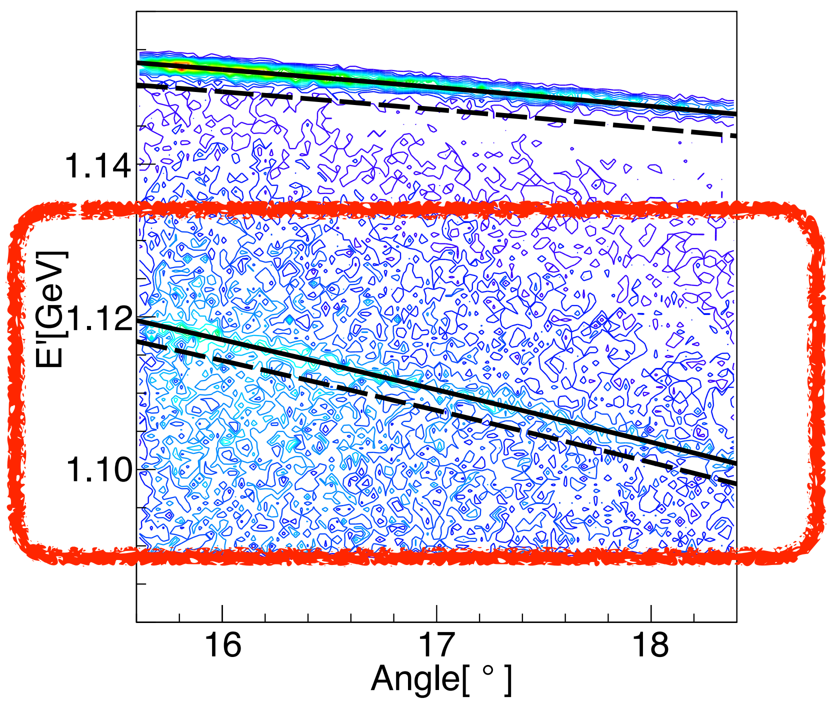
Target	E(GeV)
^{1}H and ^{3}He	$1.17125 \pm 2\text{x}10^{-5}$
^{1}H and ^{3}H	$1.17134 \pm 3\text{x}10^{-5}$

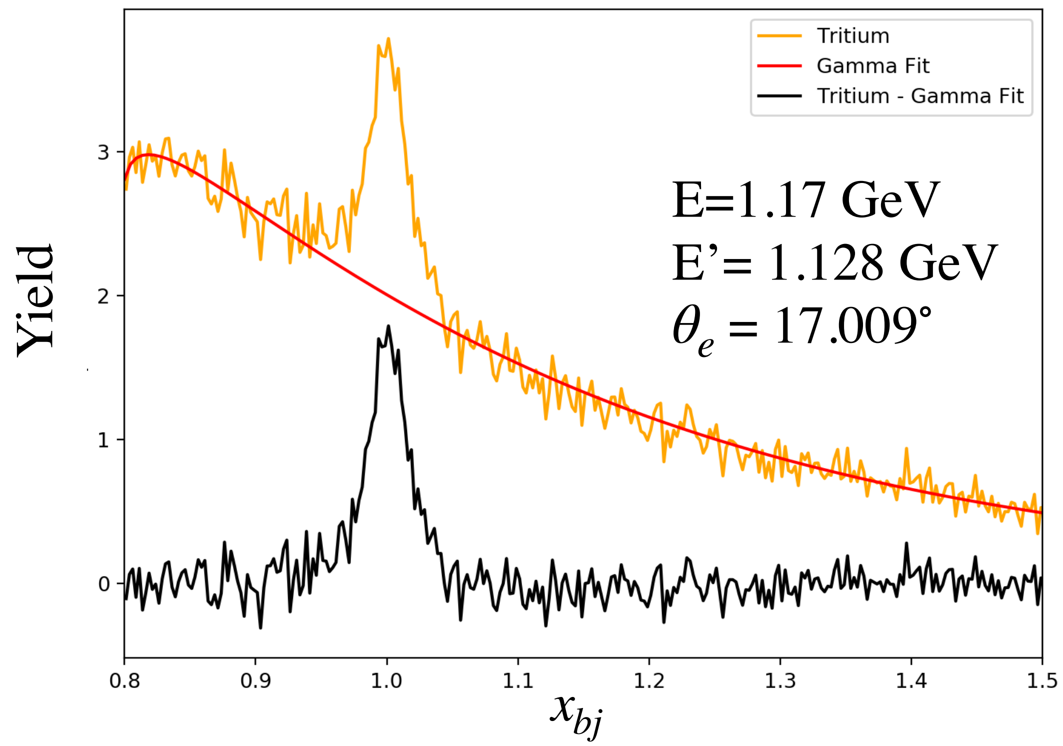






Hydrogen in the Second Tritium Target Cell



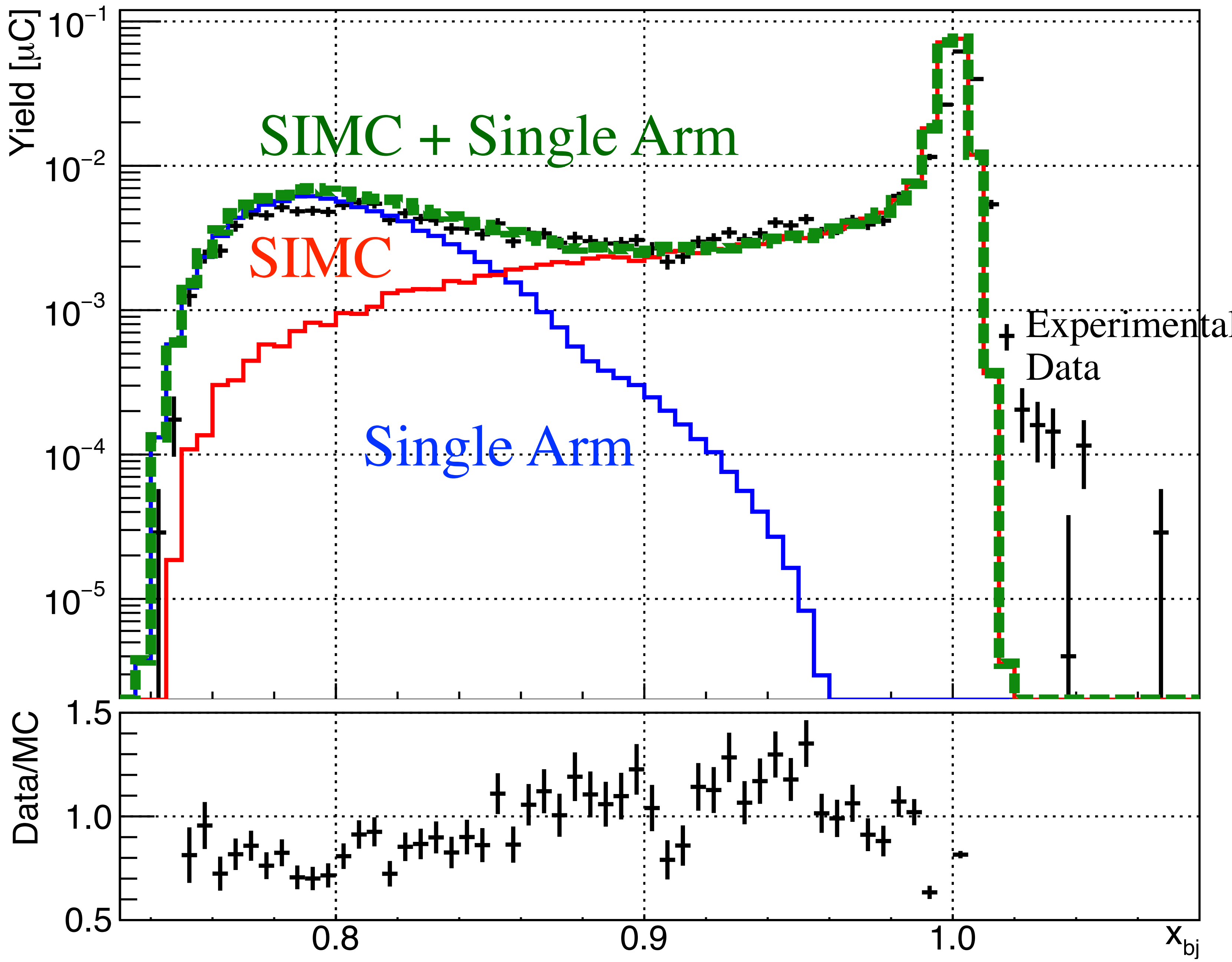


4.12% Hydrogen Contamination

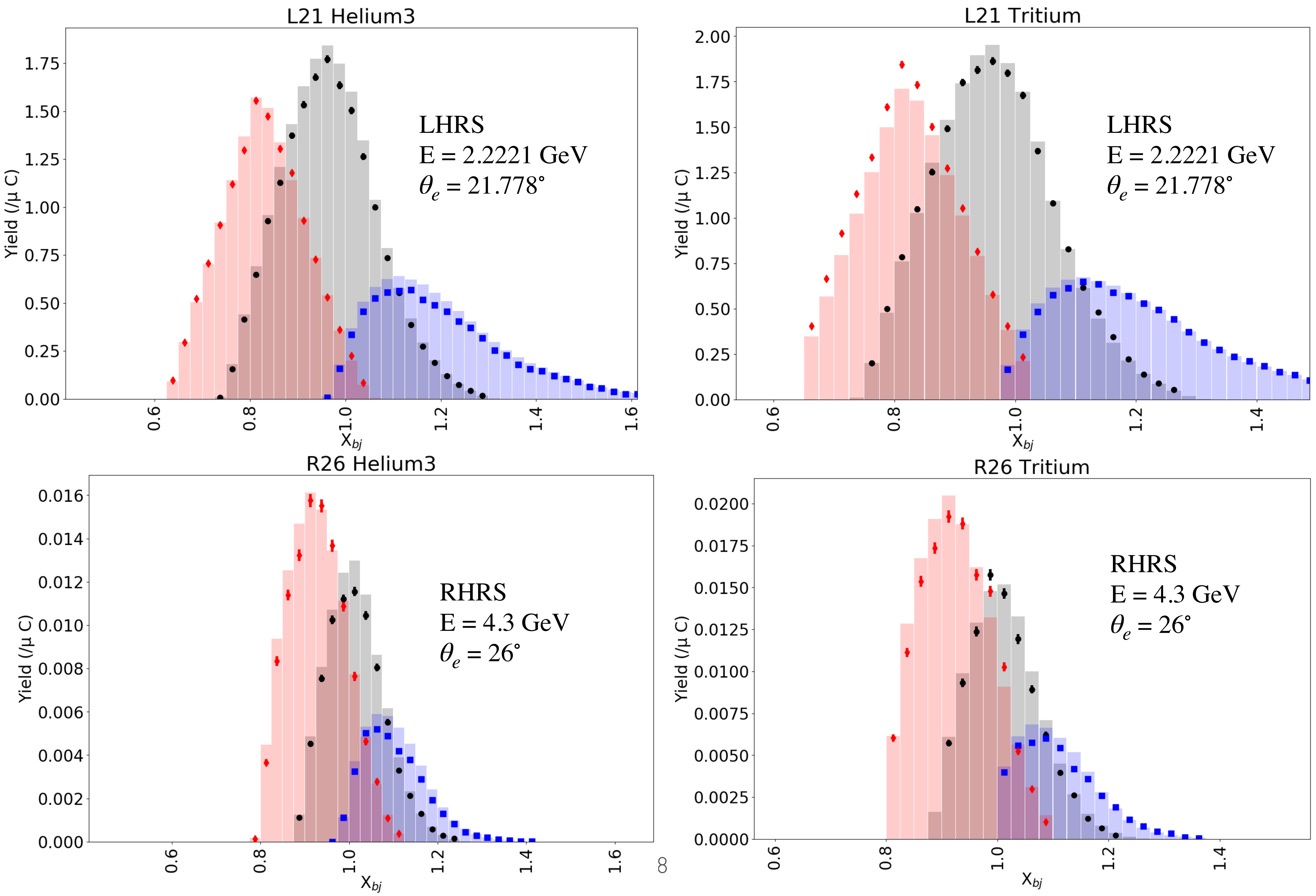
But: Not all the QE kinematics had Hydrogen data.
Need: Simulation to reproduce the Hydrogen data in those kinematics, to subtract the contamination from the Tritium data

Hydrogen Contamination in the Tritium Target

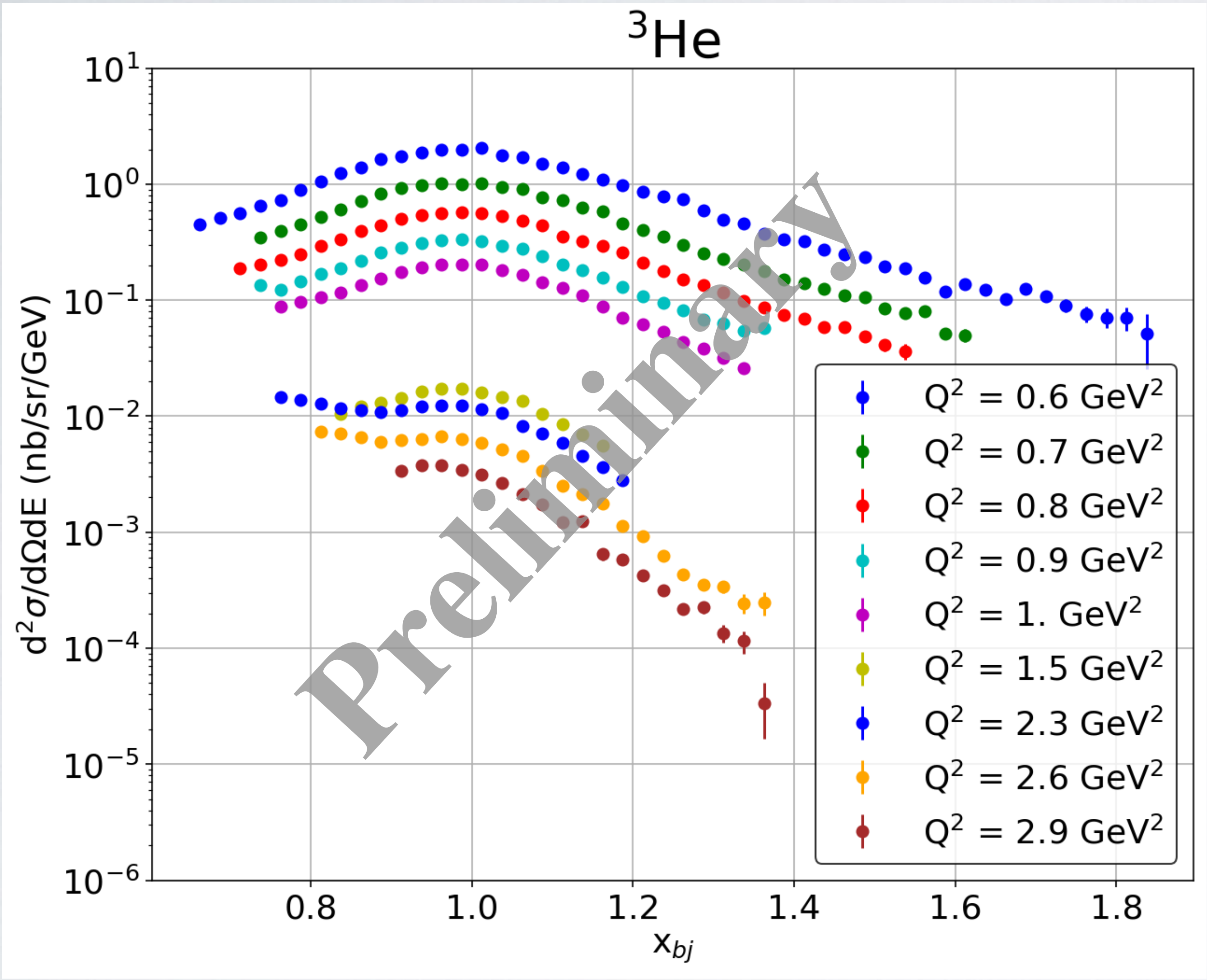
Simulate the Hydrogen contamination for the kinematics with no available data with SIMC for the elastic part and the Single Arm simulation for inelastic part.

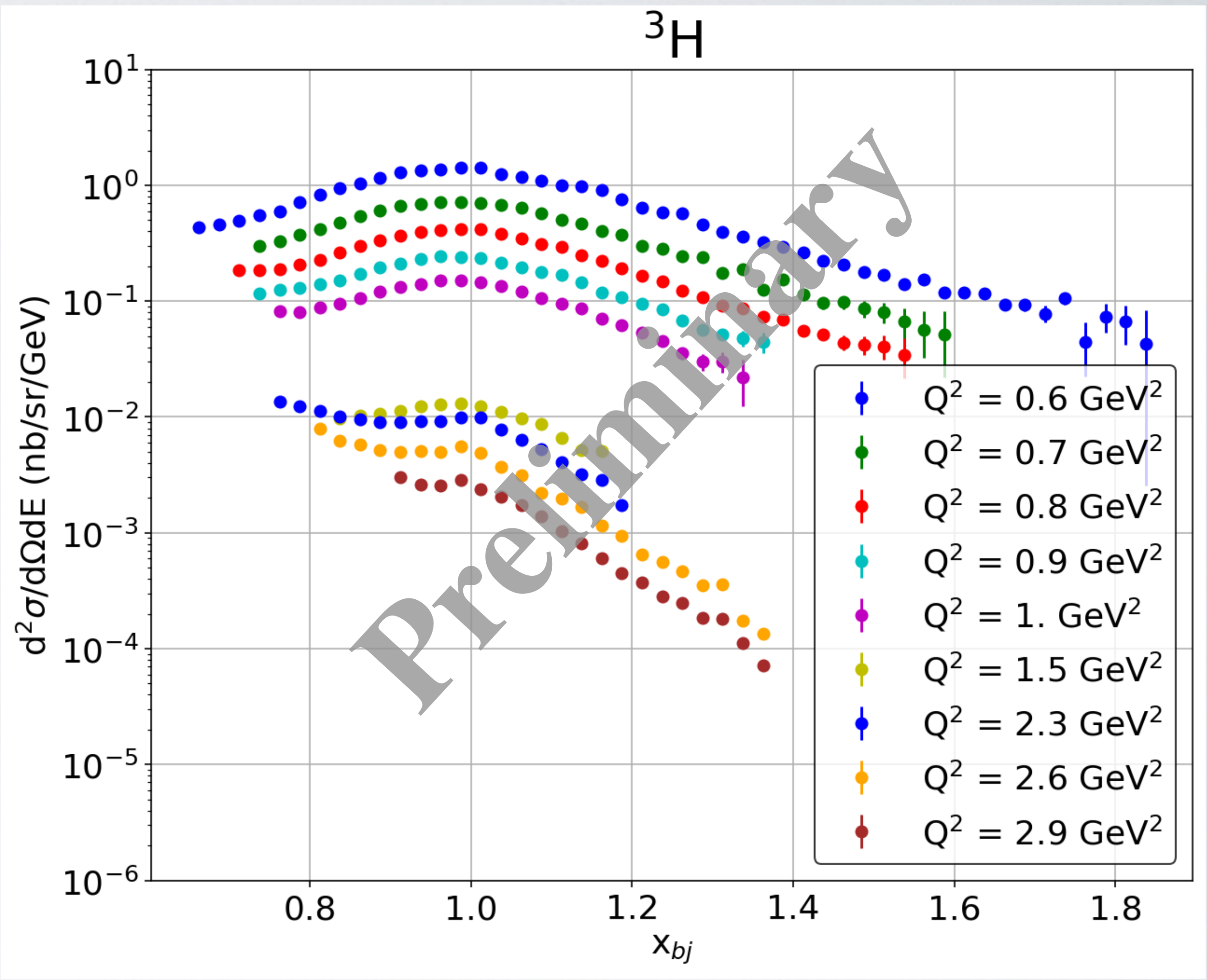


Simulation vs Data



Preliminary Cross Sections





Using the Monte-Carlo ratio method

$$\frac{d^2\sigma}{d\Omega dE'} = \sigma_{model}\left(\frac{Y_{Data}(E',\theta)}{Y_{MC}(E',\theta)}\right)$$

Preliminary Cross Section Uncertainties

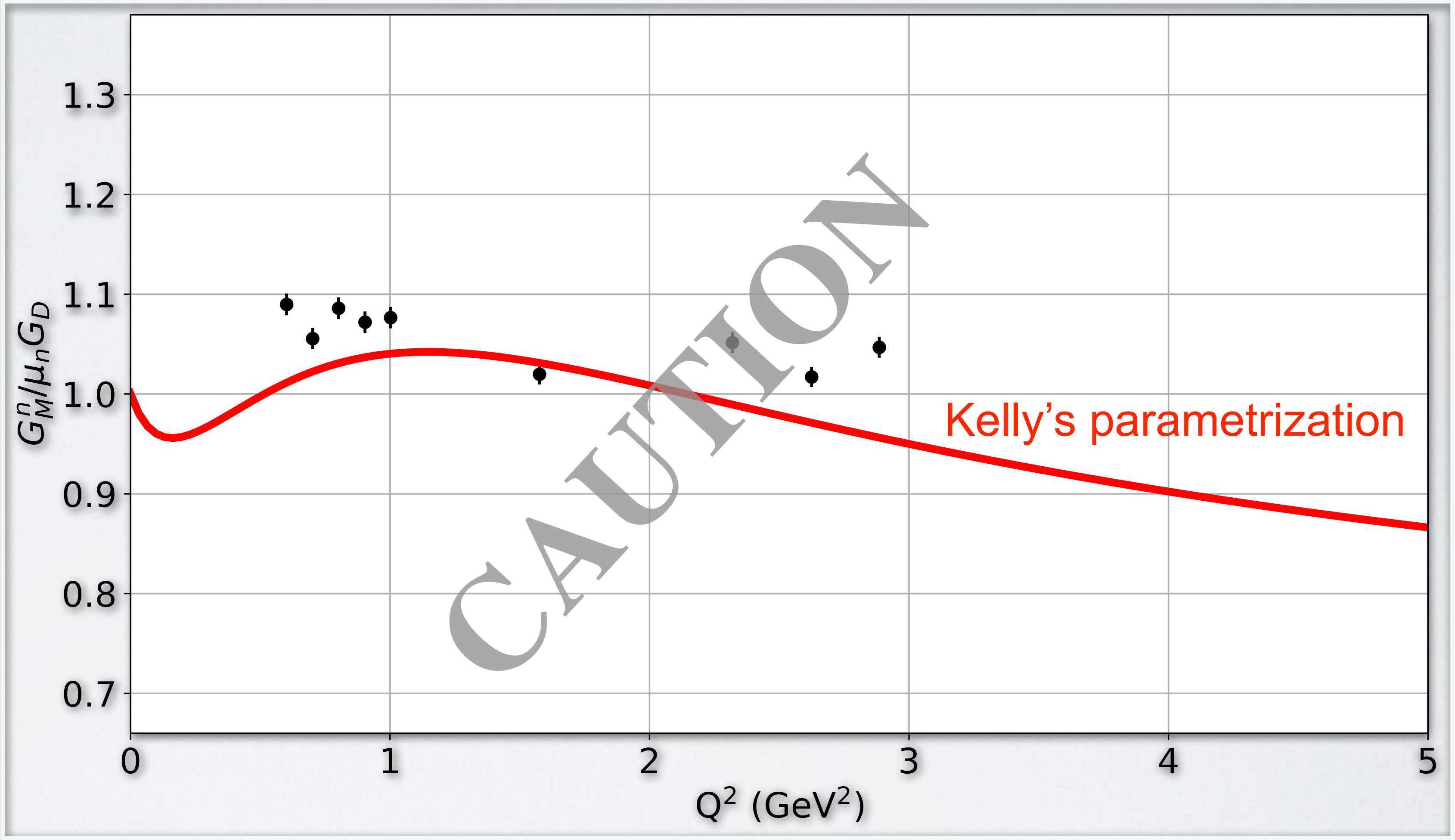
Source	Normalization(%)	Point-to –Point (%)
Charge	1	---
Target Density	1.5	---
Tracking	0.3	---
Beam Energy	0.1-05	0.3-2
Scattering Angle	---	0.5-4
Spectrometer Momentum	---	0.5-4
Radiative Corrections	1	1
Hydrogen Contamination in the Tritium Target	---	0.1-2.5%
Helium3 Contamination in the Tritium target	---	0.1-1%
PID and Efficiencies	<0.5	---
Aluminum Background (endcaps)	---	1-3

At the moment the systematic effects are being calculated kinematic by kinematic.

Naive $G_M^n(Q^2)$ extraction

$$R(Q^2) = \frac{[d^2\sigma/dEd\Omega]_{^3H}}{[d^2\sigma/dEd\Omega]_{^3He}} \approx \frac{2(d\sigma/d\Omega)_n + (d\sigma/d\Omega)_p}{(d\sigma/d\Omega)_n + 2(d\sigma/d\Omega)_p}$$

$$^3H \rightarrow 1p + 2n$$
$$^3He \rightarrow 2p + 1n$$



Note:

Only statistical uncertainties

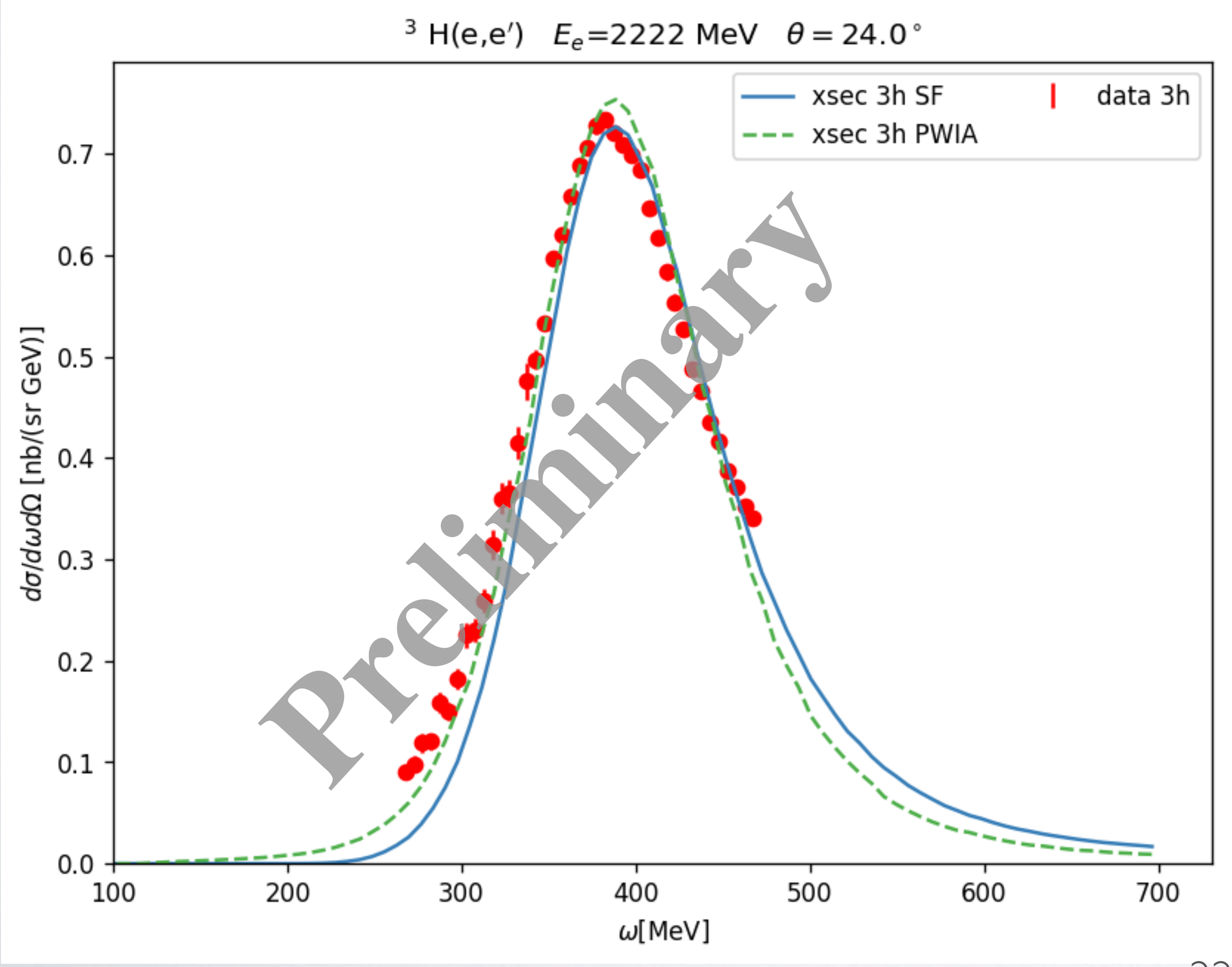
Uncorrected for nuclear effects:

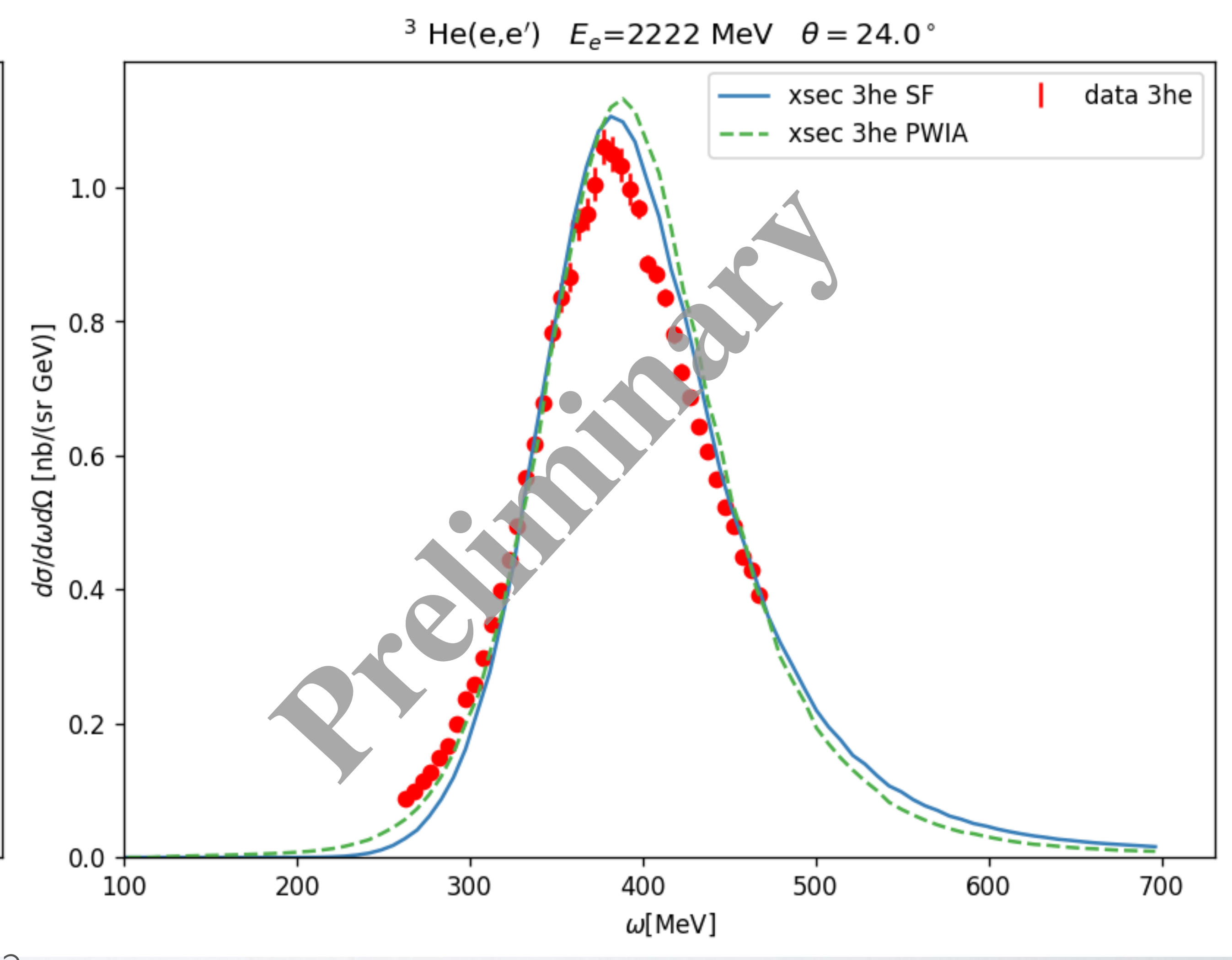
- **Inelastic contribution**
- **Fermi smearing**

Theory Input

Noemi Rocco
Alessandro Lovato
Argonne National Laboratory

Goal: Use cross-section ratio to cancel systematic uncertainties and model effects.



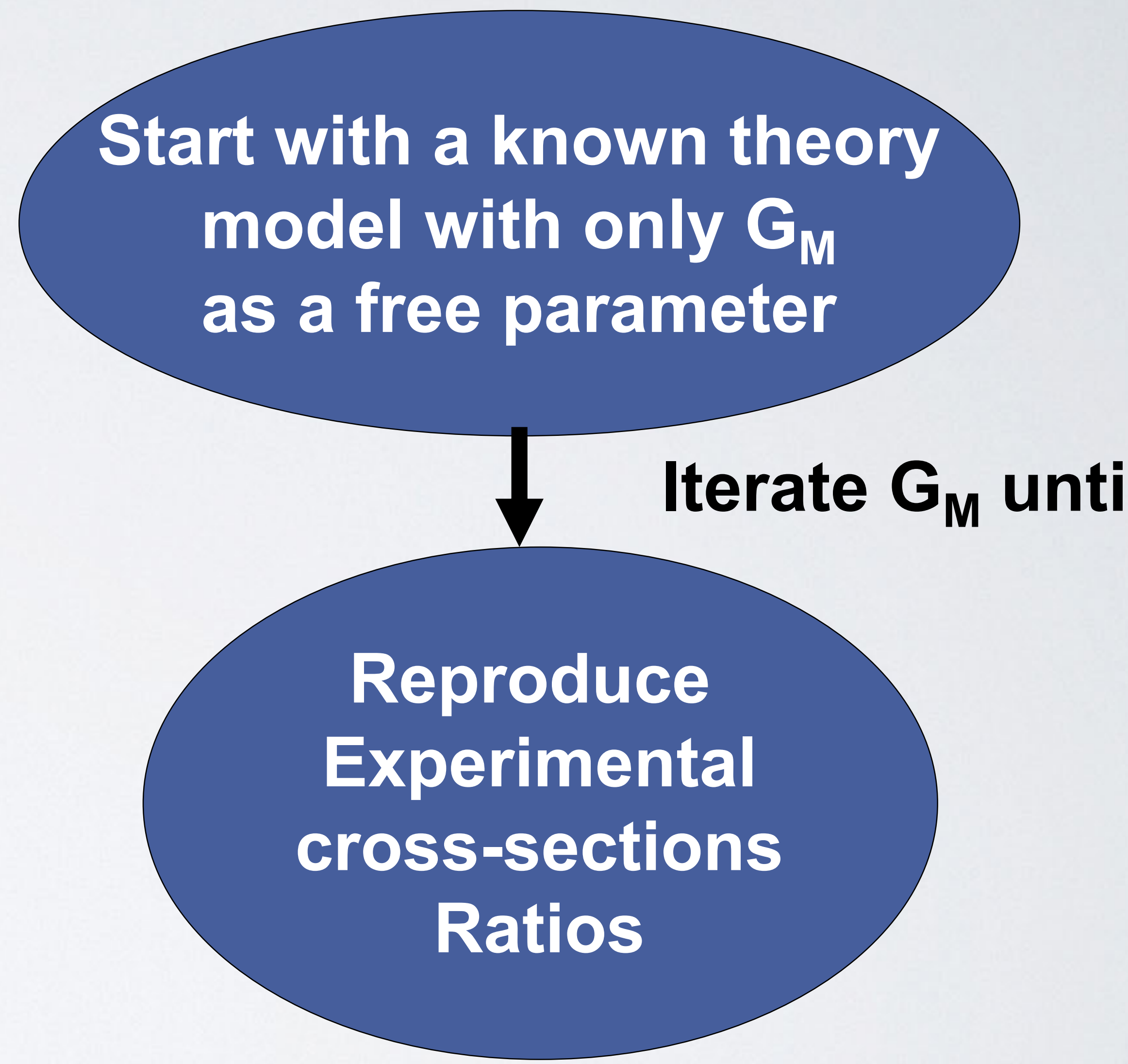


Summary

- [x] ^{3}He and ^{3}H Cross-Sections are in a final stage. Systematics are being pinned down. Total: 30 Kinematics, 2 arms, 3 different run periods

- [x] Naive model shows promising results for the measurement.

- [ ] Theory input: In progress…



Thank you!