Elastic analysis (Electrons detected in HMS)

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Elastic Electron Runs (e^- in HMS)

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- **Run ranges:** 6828–6843
- **HMS momentum:** –4.042 GeV
- **HMS angle:** 24.86°
- **Target:** LH_2
- **Ps4 setting:** 0

Methodology

- Use a script to compute electron scattering angle and momentum for a given beam energy
- Run **SIMC** with calculated kinematics
- Apply cuts to select clean electron events
- Perform **dummy subtraction** to remove background
- Compare dummy-subtracted yields with **SIMC** predictions

Cuts to select elastic events

- **Selection Criteria:**
  - $|H.kin.W - 0.938| < 0.02$
  - $|H.cal.etottracknorm - 1| < 0.4$
  - H.cer.npeSum>0.5
  - $|H.gtr.dp| < 8.5$
  - $|H.gtr.th| < 0.09$
  - $|H.gtr.ph| < 0.055$

Dummy Subtraction

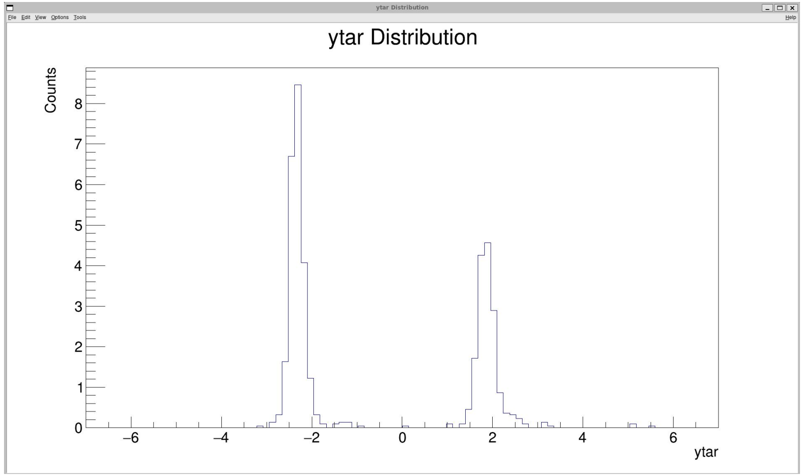

Fig: Unscaled ytar for dummy target.
The peak difference arises from the different thickness of the two dummy target walls.

Run 6705 (dummy)
The dummy contribution is divided into two components:

- **Upstream wall**: ytar < 0
- **Downstream wall**: ytar > 0

This separation helps isolate the background originating from each endcap of the dummy target.

Target	Thickness Total (g/cm^2)	Material
10 cm Dummy Upstream	0.1703 ± 0.0002	Al 7075
10 cm Dummy Downstream	0.1677 ± 0.0002	Al 7075

Report

Dummy Subtraction

- Dummy targets are intentionally thicker than real target walls to accumulate sufficient statistics.
- To estimate the true wall background, dummy yields are scaled to match actual wall thicknesses.
- **Scaling applied to dummy histograms:**
  Scaled Yield ∝ 1/(Scale Factor×Effective Charge)
- **Scale Factors:**
  - Upstream wall: **8.467**
  - Downstream wall: **4.256**
- The scaled dummy contribution is subtracted from all relevant observables.

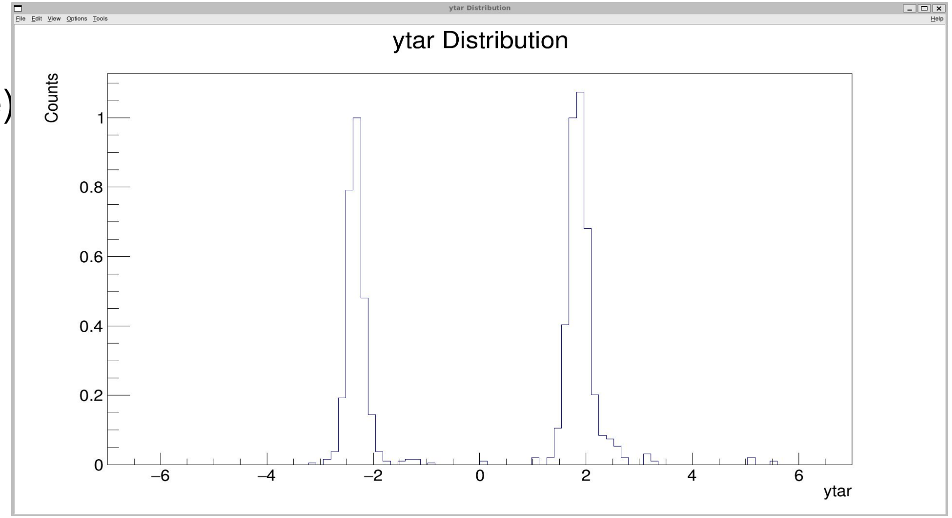

Fig. Scaled ytar dummy.

SIMC input files

```
[singhav@ifarm2401 elastic_analysis]$ python3 elastic_analysis_e_hms.py
Enter the initial beam energy in GeV: 6.3967
Enter the scattered electron angle (theta_e) in degrees: 24.86
Enter the scattered electron momentum (P_e) in GeV/c: 4.042
initial momentum:  6.396699979589397

Proton Angle (theta_p): 30.13 degrees
Proton Momentum (P_p): 3.283339 GeV/c
Calculated scattered electron momentum: 3.920200 GeV/c
```

Fig: Calculate the expected proton arm angle and proton arm momentum

```
begin parm kinematics_main
  Ebeam = 6396.7      ;  (MeV)
  dEbeam = 0.05     ;  beam energy variation (%)
  electron_arm = 1               ;  1=hms,2=sos,3=hrsr,4=hrsl
  hadron_arm = 2                 ;  1=hms,2=sos,3=hrsr,4=hrsl
  spec%e%P = 4042.0    ;  e arm central momentum (MeV/c)
  spec%e%theta = 24.860    ;  e arm angle setting (degrees)
  spec%p%P = 3284.0    ;  p arm central momentum (MeV/c)
  spec%p%theta = 30.12     ;  p arm angle setting (degrees)
end parm kinematics_main
```

Fig: Give the input kinematic variables to SIMC

```
begin parm spect_offset
  spec%e%offset%x = 0.0973664   ;  x offset (cm)
  spec%e%offset%y = 0.145772    ;  y offset (cm)
  spec%e%offset%z = 0.    ;  z offset (cm)
  spec%e%offset%xptar = 0.0 ;  xptar offset (mr)  !x(y)ptar is slope, so
  spec%e%offset%yptar = 0.0 ;  yptar offset (mr)  !it's really unitless.
```

Fig: Apply the relevant offsets.

x offset and y offset

The y-mispointing and x-mispointing values are already integrated into the `THcHallCSpectrometer.cxx` source file for hcana. These values need to be manually implemented in SIMC.

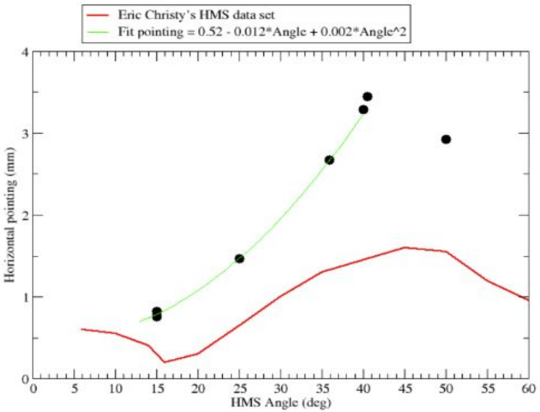

Figure 1: HMS horizontal pointing versus HMS angle. The fit is to the data points at 35 degrees and below.

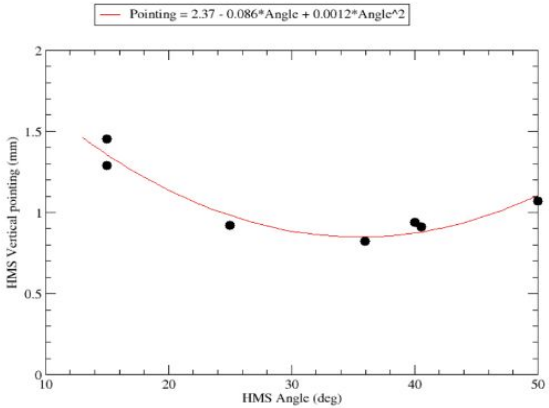

Figure 2: HMS vertical pointing versus HMS angle. The fit is to all the data points.

Reference: https://github.com/MarkKJones/fall2017-plans/blob/master/Surveys/survey-summary.pdf

Energy offset correction

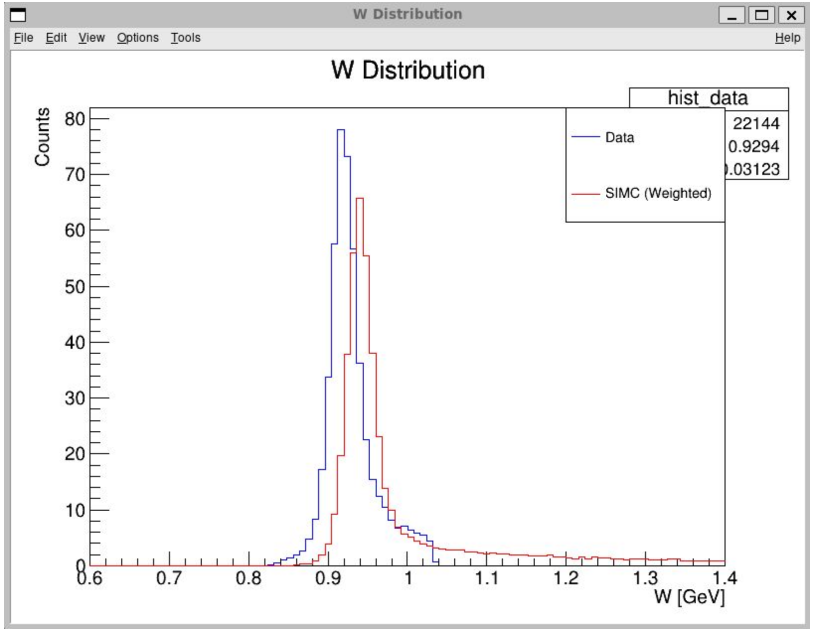

Fig: Reference plot for W with beam energy E = 6.370 GeV, before the correction.
Note: Do not infer anything beyond the location of peaks from this plot.

- Beam energies in `standard_coin.kinematic` showed significant deviation at the W peak.
- Recorded energies required correction:
  - E = 6.370 GeV → E = 6.39670 GeV (for the elastic setting) as per Mark Jones suggestion.
- Data and SIMC were replayed with the updated energy value (plots on later slides).
- Christine Ploen has completed the energy calibrations for all the runs.

Final offsets applied in SIMC input file

- Fast Raster Pattern: targ%fr_pattern = 3. ; raster pattern: 1=square bedpost, 2=circular, 3= square new flat
  - It is essential to apply the correct raster pattern as not doing to result in absurd yields.

- targ%xoffset = 0.023 ; target x-offset (cm): +x = beam right
- targ%yoffset = 0.024 ; target y-offset (cm): +y = up
- targ%zoffset = -0.357 ; target z-offset (cm): +z = downstream

From target study.
(had a discussion with Dave Gaskell, this method is not correct.)

- spec%e%offset%x = 0.0973664 ; x offset (cm)
- spec%e%offset%y = 0.145772 ; y offset (cm)

From mispointing calculations

- spec%e%offset%z = 0. ; z offset (cm)
- spec%e%offset%xptar = 0.0 ; xptar offset (mr) !x(y)ptar is slope, so
- spec%e%offset%yptar = 0.0 ; yptar offset (mr) !it's really unitless.

W distribution

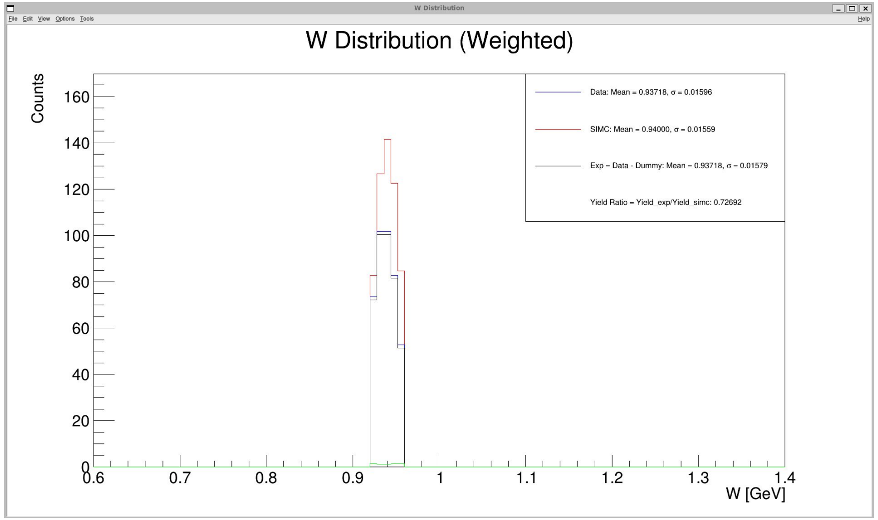

Fig: without offsets

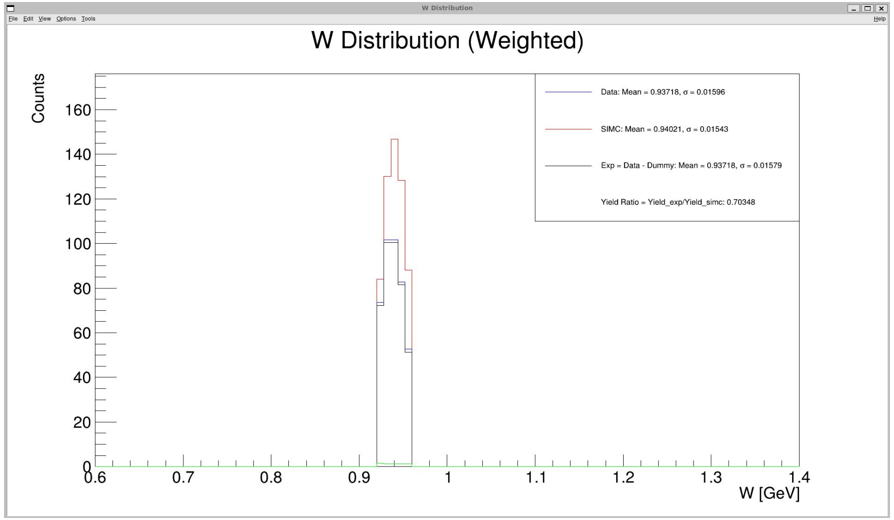

Fig: with offsets

Charge normalized Yield = 0.70 counts/mC
This aligns with the yield values of ~0.64 counts/mC found by Mark Mathison for DIS.

Ytar distribution

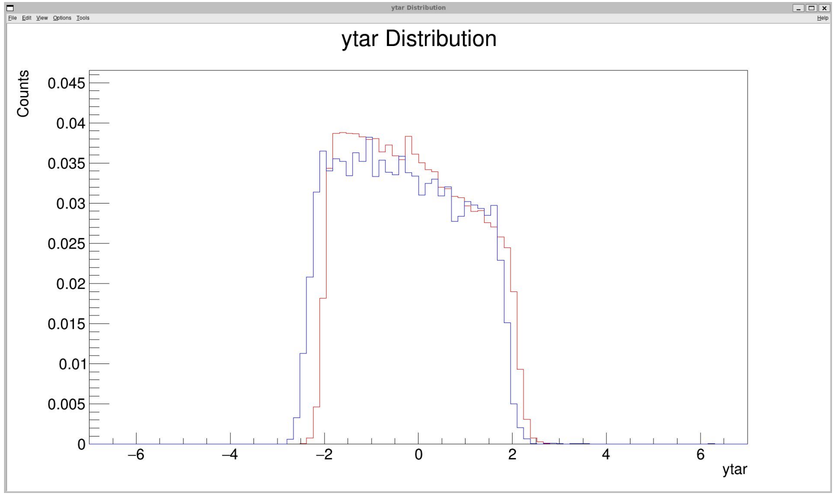

Fig: without offsets

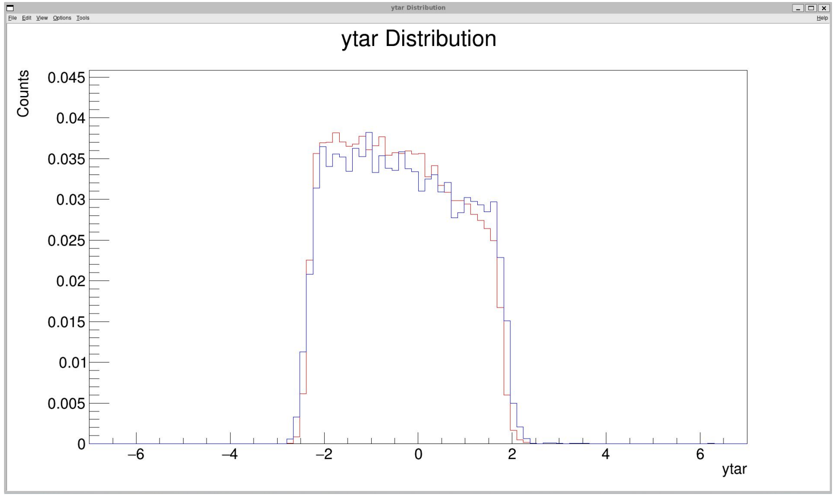

Fig: with offsets

Q2 distribution

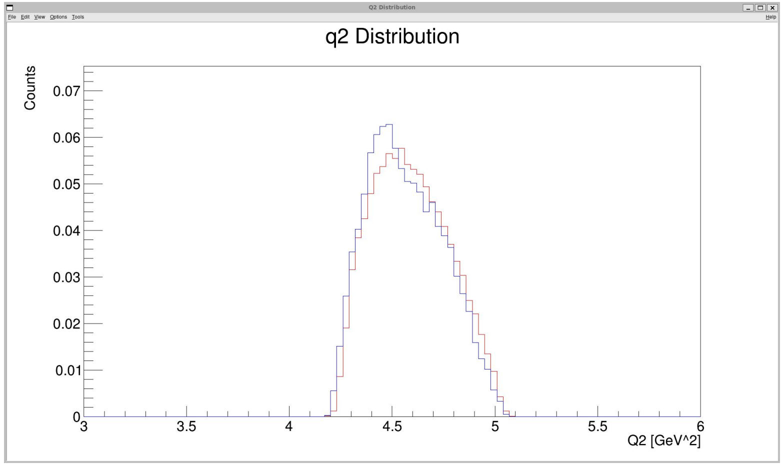

Fig: without offsets

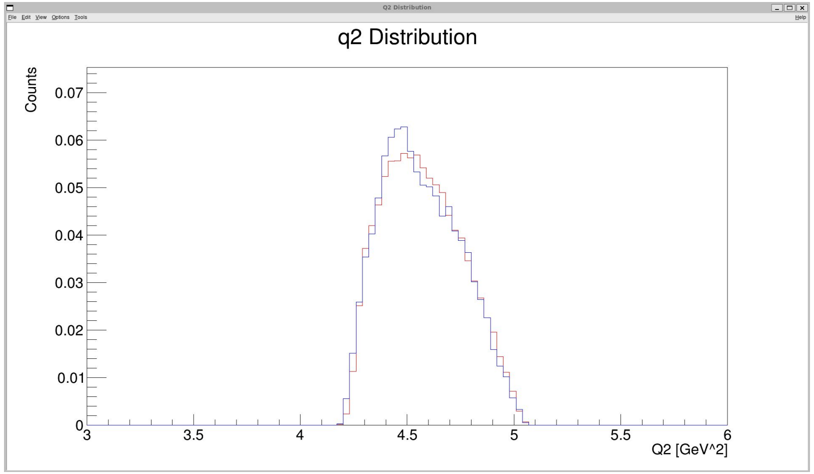

Fig: with offsets

Delta distribution

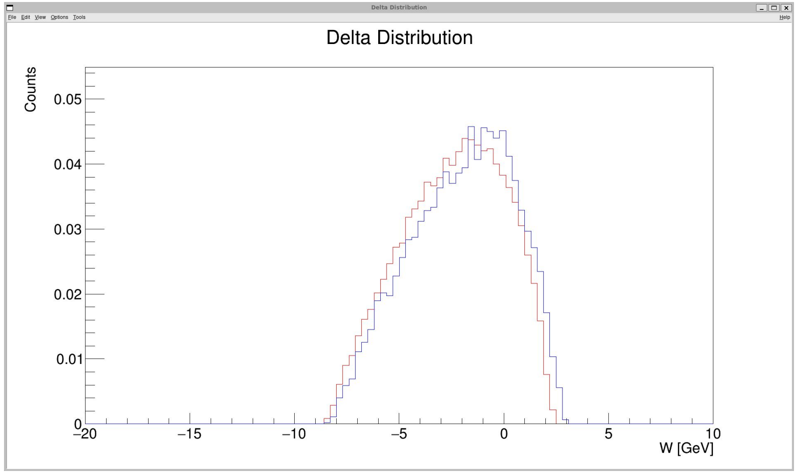

Fig: without offsets

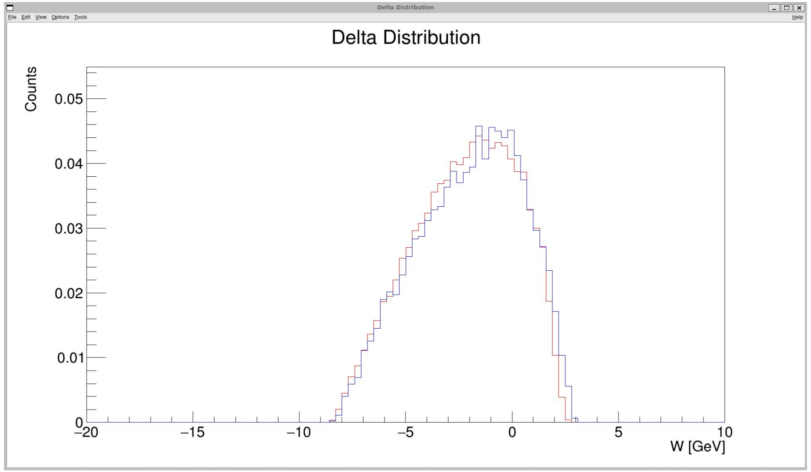

Fig: with offsets

Yptar distribution

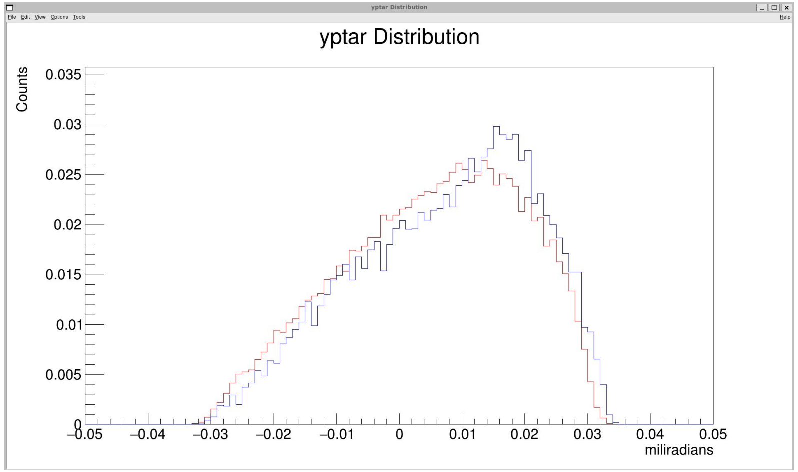

Fig: without offsets

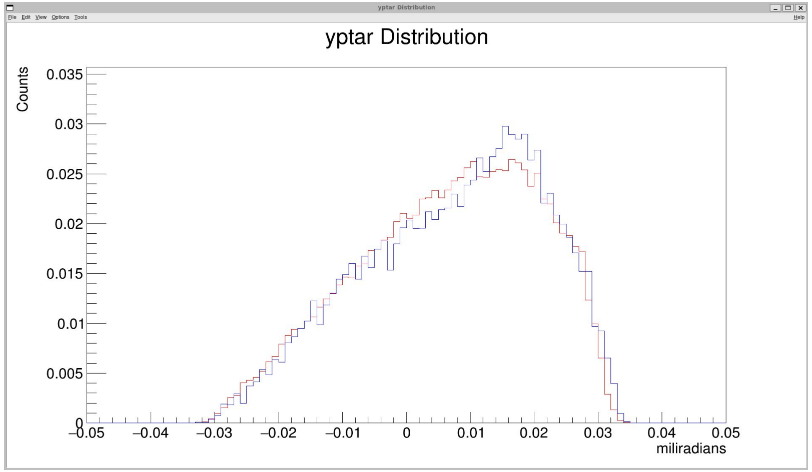

Fig: with offsets

Remarks

- Use runs commented as “HMS Optics” for investigating further any remaining offsets as the delta optimization moves forward.
  - Runs: 1534, 35,36; 1251, 52, 53, 59; and 1716, 15, 14 will be used.
- Yields for the elastic setting are found to be **0.70 counts/mC** offsets.
- These values align with the yield of **0.62** found by Mark Mathison for DIS kinematics, as presented at the Hall C Winter Meeting 2025.