Update on the SIDIS-TMD Experiment

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Hall C Winter Collaboration Meeting
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Outline

- Overview of experiment & physics
- Run overview
- What we’ve done
- What we’ll do

E12-09-017

Spokespersons: P. Bosted, R. Ent, H. Mkrtchyan, E. Kinney

- Little is known about…
  1. Orbital angular motion of partons
  2. PDF dependence on transverse momentum

- Significant orbital angular momentum → significant transverse momentum of quarks

Goal: To map P_T dependence of cross section ratios of π^+ to π^- electroproduced off proton & deuteron targets.

Why?

Knowledge of $R = \sigma_L/\sigma_T$ in SIDIS is virtually non-existent:

- Does R_{SIDIS} vary with z?
- Is $R_{SIDIS}^{\pi+} = R_{SIDIS}^{\pi-}$?
- Is $R_{SIDIS}^{H} = R_{SIDIS}^{D}$?
- Is $R_{SIDIS}^{K+(-)} = R_{SIDIS}^{\pi+(-)}$?

There are both theoretical and experimental indications of a quark flavor distribution dependence on k_T.

Hall C SIDIS program focuses on transverse momentum dependence of unpolarized SIDIS cross sections.

JLab 12GeV goal: Precision 3D momentum imaging of the nucleon, e.g. quark transverse momentum dependence on spin & flavor.

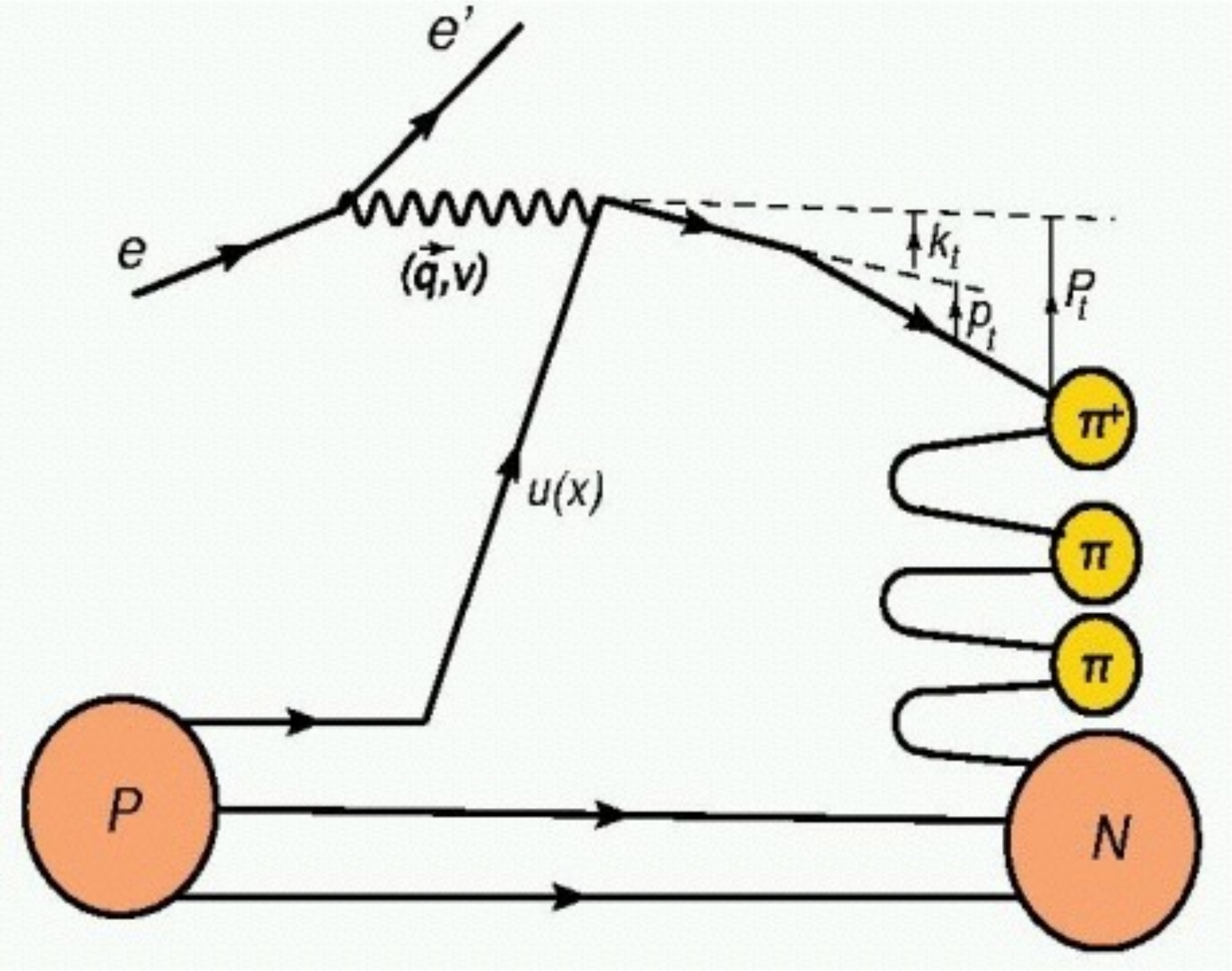
SIDIS Formalism

$$\frac{d\sigma}{dx\,dy\,d\psi\,dz\,d\phi_h\,dP_{h,t}^2} = \frac{\alpha^2}{xyQ^2}\frac{y^2}{2(1-\varepsilon)}\left(1+\frac{\gamma^2}{2x}\right)\Big\{\boxed{F_{UU,T}+\varepsilon F_{UU,L}} +$$

only surviving terms if unpolarized beam

$$\sqrt{2\varepsilon(1+\varepsilon)}\,\boxed{\cos\phi_h F_{UU}^{\cos\phi_h}} + \varepsilon\,\boxed{\cos(2\phi_h) F_{UU}^{\cos(2\phi_h)}} + \boxed{\lambda_e}\sqrt{2\varepsilon(1+\varepsilon)}\,\boxed{\sin\phi_h F_{LU}^{\sin\phi_h}}\Big\}$$

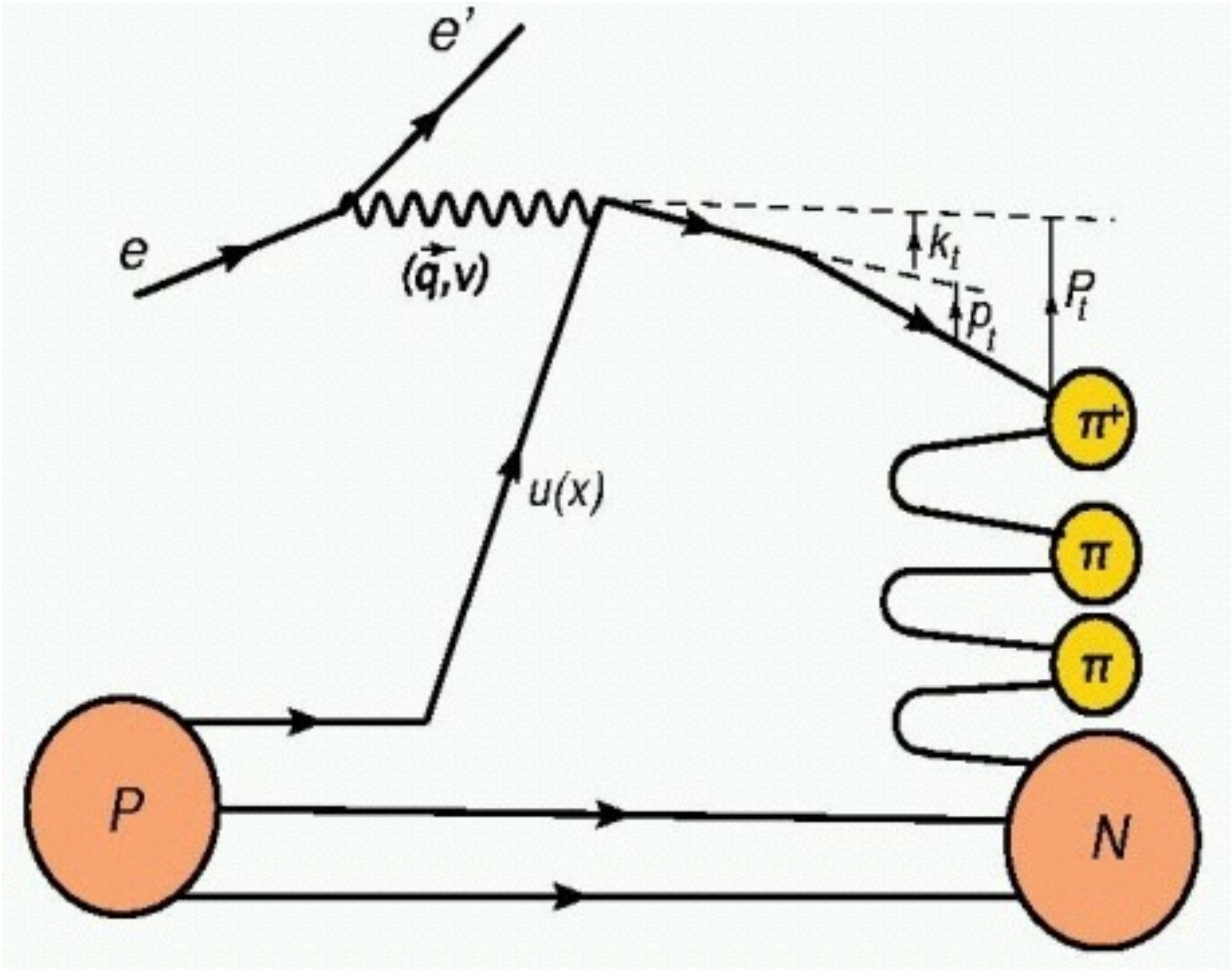
Polarized beam for k_T dependence: Transverse momentum widths of quarks with different flavors can be different. Azimuthal beam asymmetry measurements complement CLAS12 data.



$P_t = p_t + z\,k_t + O(k_t^2/Q^2)$

Final transverse momentum of the detected pion P_t arises from convolution of the struck quark's transverse momentum k_t with the transverse momentum p_t generated during the fragmentation.

SIDIS Formalism (cont.)

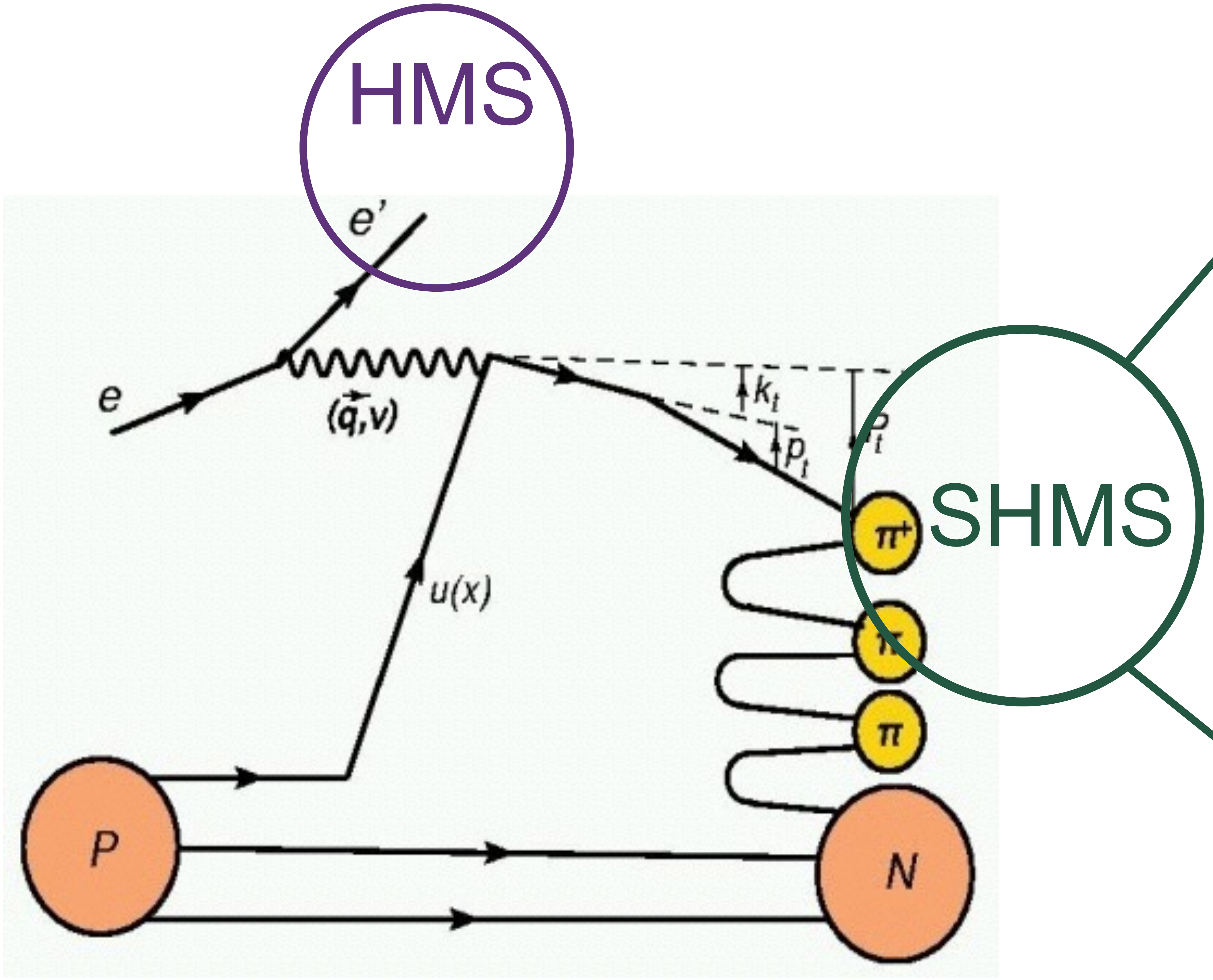


$P_t = p_t + z\, k_t + O(k_t^2/Q^2)$

The transverse momentum distribution of partons is correlated with:

- **The spin orientation of the parent hadron & the parton**
- **Flavor**
- **Longitudinal momentum**
- **Spin & momentum of struck quark**

Experiment Overview



- Scan through angles from 8 through 30 degrees in 2 degree increments for each HMS setting on LH2, LD2, and Al targets at both positive and negative polarity.
- Angle scan = P_T scan

Run Overview: Planned

E (GeV)	Target	Time (Hours)
8.8	LH2	54
	LD2	54
	Al	14
11.0	LH2	206
	LD2	206
	Al	52
	Checkout	0 (overlap with E12-06-104)
	Momentum Changes (36)	18
	Angle Changes (306)	20
	Target Changes (918)	150
	Pass Changes (1)	0 (overlap with E12-06-104)
	Beam Energy Measurements (2)	0 (overlap with E12-06-104)
	Total Request	774

= 32 PAC days

Run Overview: Planned

E (GeV)	E' (GeV)	θ_e (deg)	W^2 (GeV^2)	θ_γ (deg)	q_γ (GeV)	Kinematics	x	Q^2 (GeV^2)
11.0	5.67	10.27	8.88	10.57	5.513	I	0.20	2.0
11.0	5.67	12.59	7.88	12.75	5.603	II	0.30	3.0
11.0	5.67	14.55	6.88	14.49	5.692	III	0.40	4.0
11.0	5.67	16.28	5.88	15.96	5.779	IV	0.50	5.0
8.8	5.60	10.96	5.08	17.90	3.467	V	0.30	1.8
11.0	5.67	21.26	11.38	7.57	8.270	VI	0.30	4.5

Total Request 774

= 32 PAC days

Run Overview: Real

E (GeV)	E' (GeV)	θ_e (deg)	W^2 (GeV^2)	θ_γ (deg)	q_γ (GeV)	Kinematics	x	Q^2 (GeV^2)
~~11.0~~	~~5.67~~	~~10.27~~	~~8.88~~	~~10.57~~	~~5.513~~	~~I~~	~~0.20~~	~~2.0~~
11.0	5.67	12.59	7.88	12.75	5.603	II	0.30	3.0
11.0	5.67	14.55	6.88	14.49	5.692	III	0.40	4.0
11.0	5.67	16.28	5.88	15.96	5.779	IV	0.50	5.0
~~8.8~~	~~5.60~~	~~10.96~~	~~5.08~~	~~17.90~~	~~3.467~~	~~V~~	~~0.30~~	~~1.8~~
11.0	5.67	21.26	11.38	7.57	8.270	VI	0.30	4.5

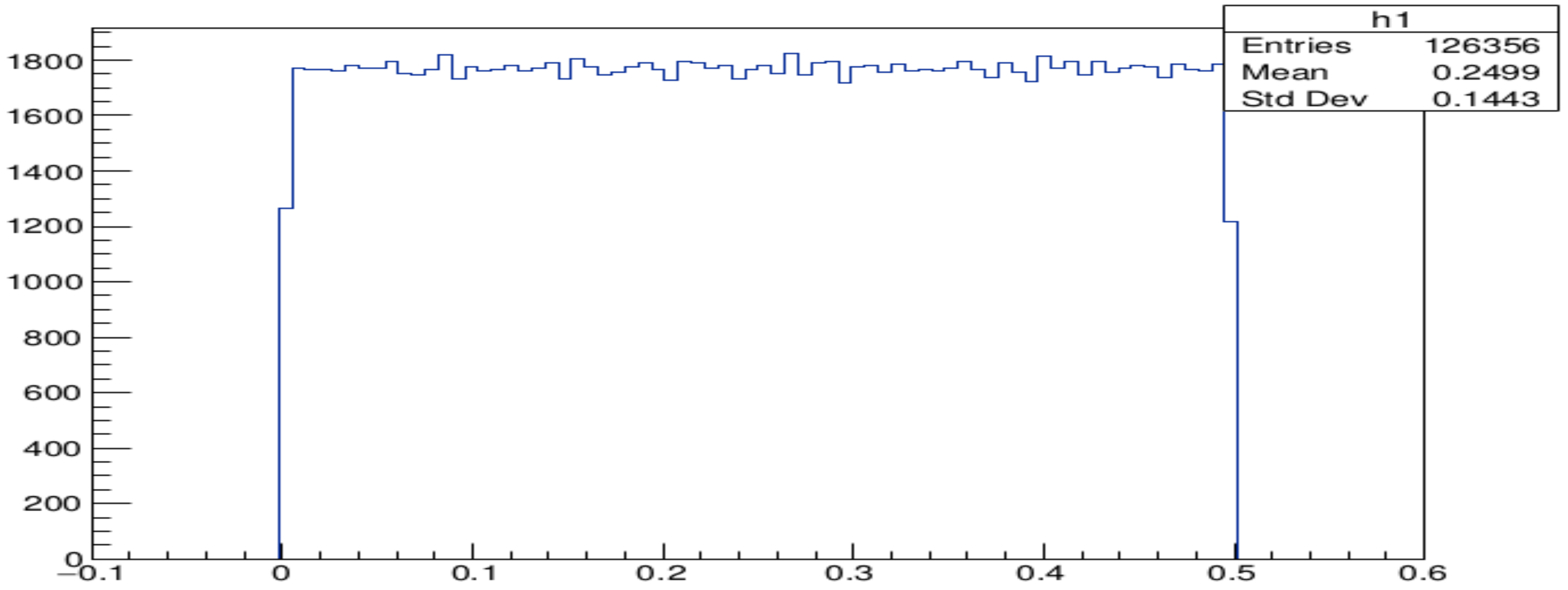
Plus additional setting:

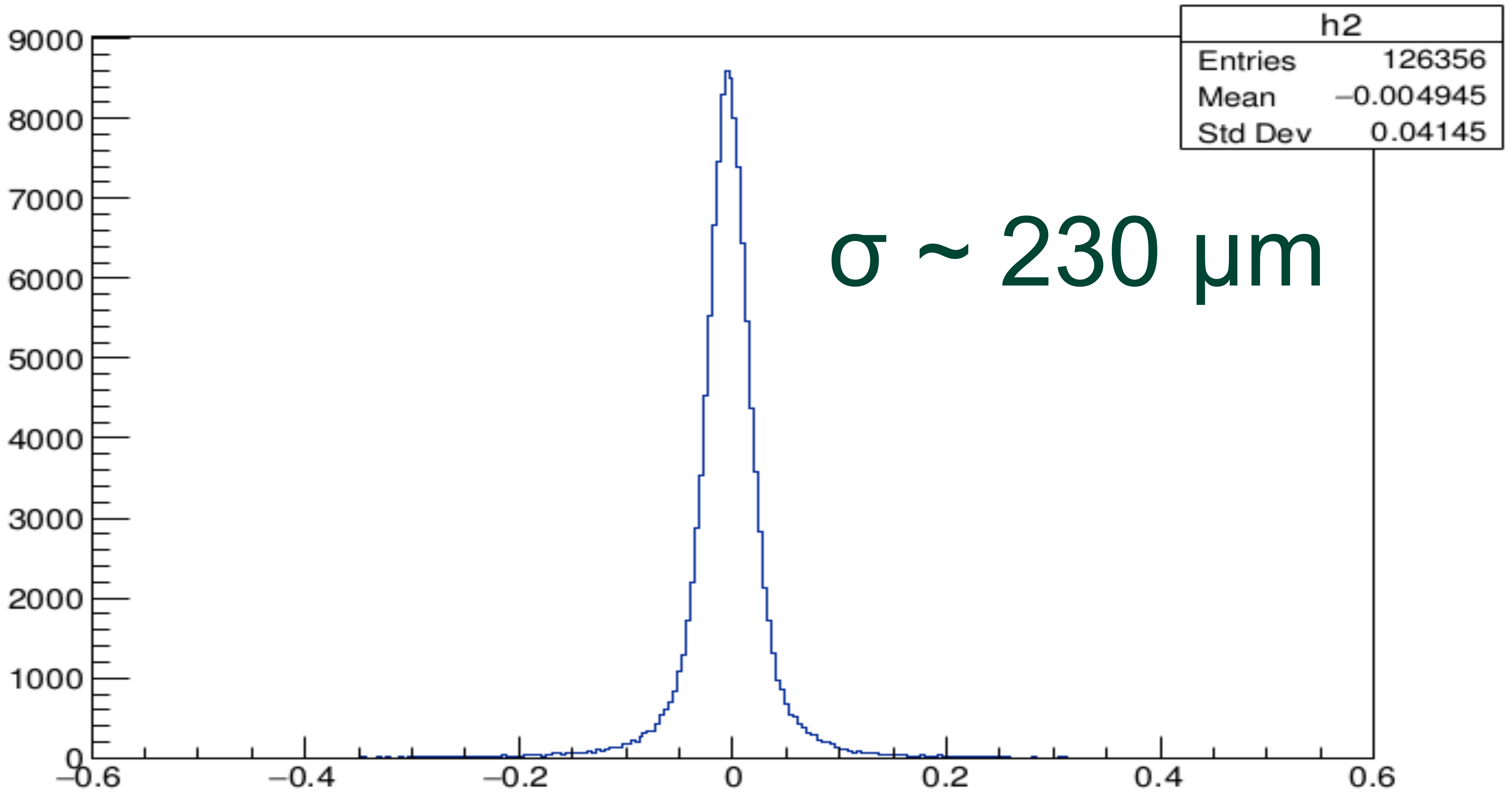
W^2 = 8.29 Gev^2
x = 0.4
Q^2 = 5.0 GeV^2

= 44 actual days

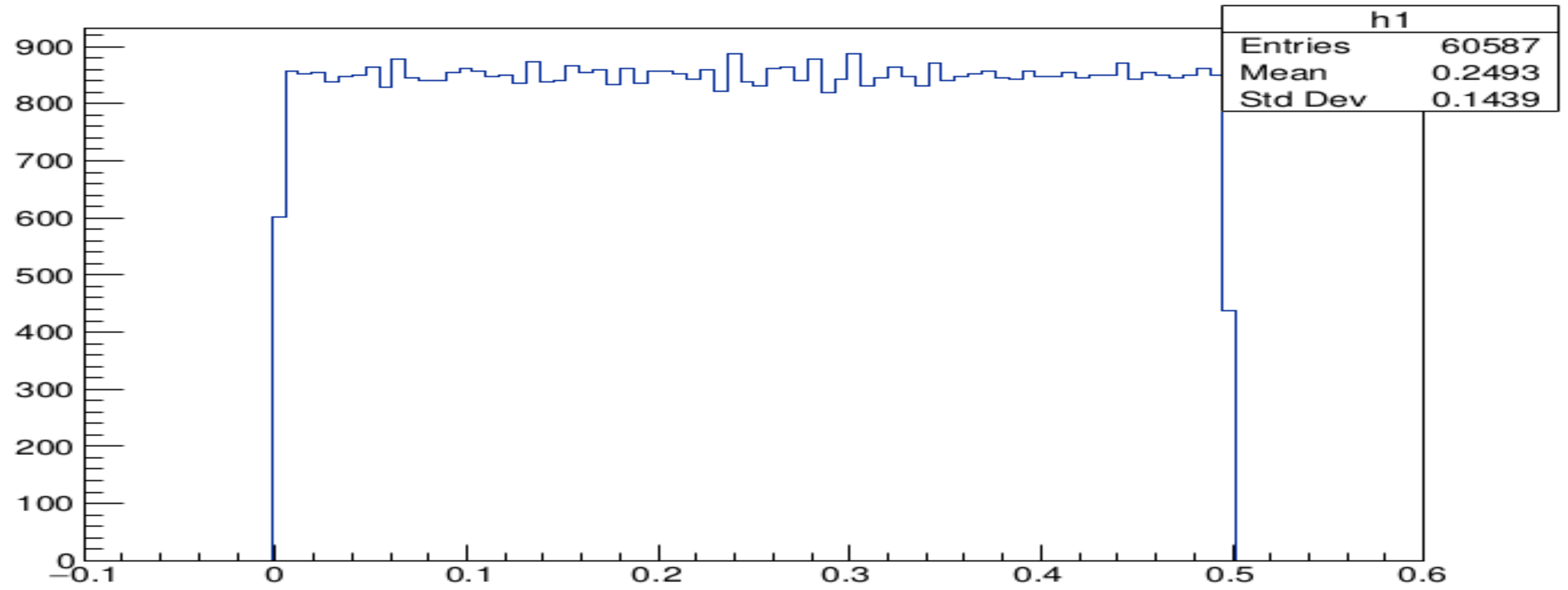
Calibrations — DC

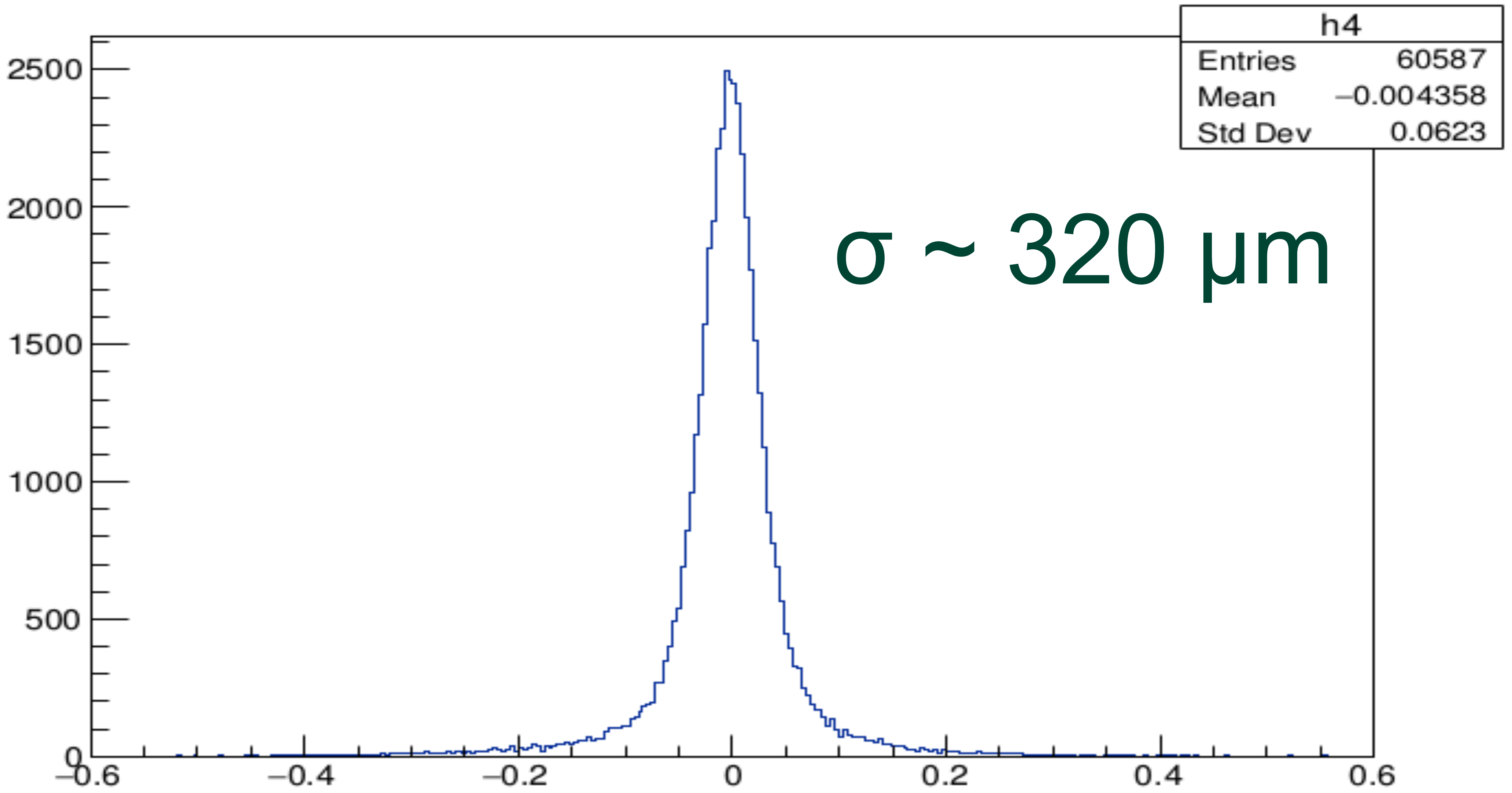
HMS





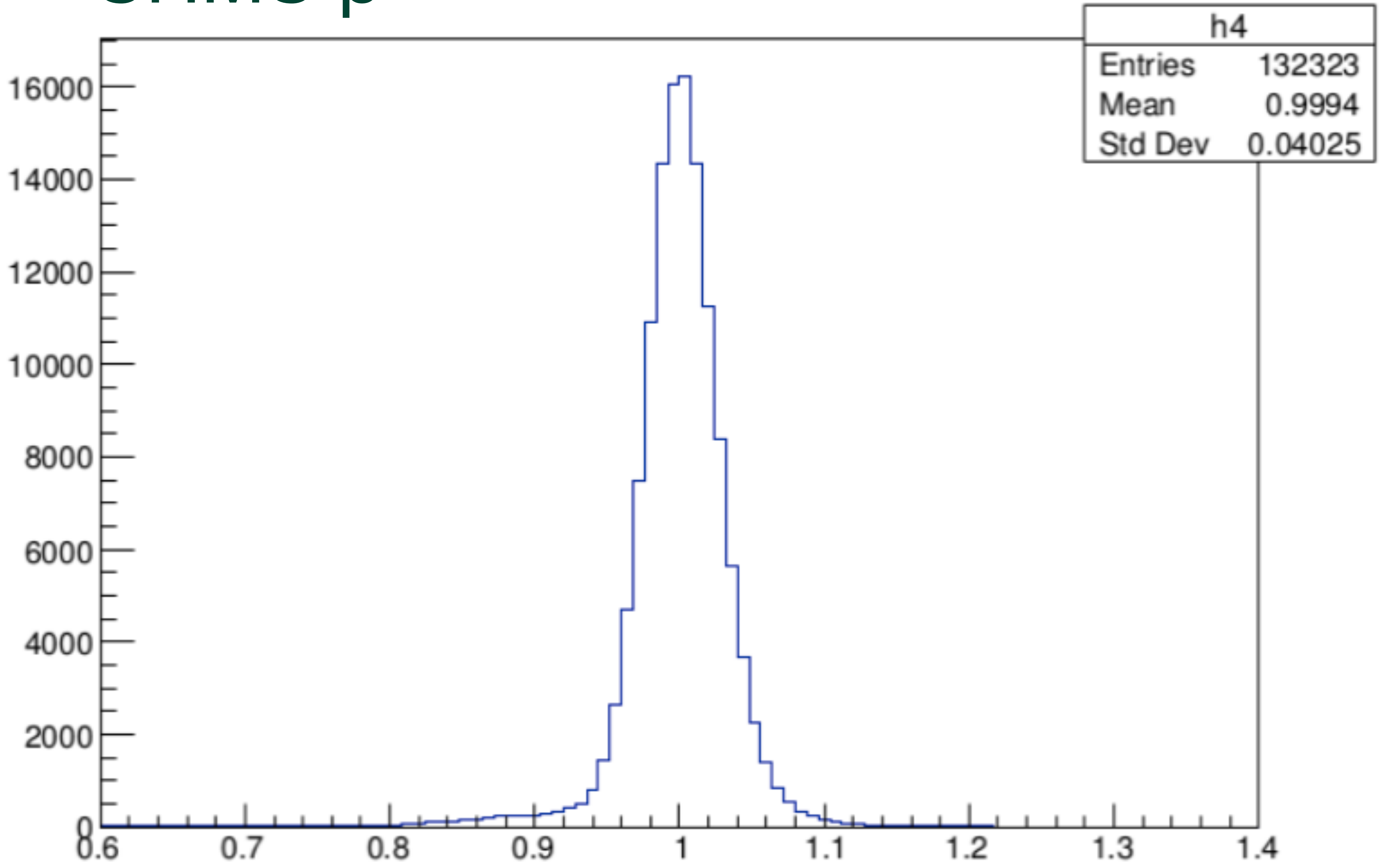
SHMS





Calibrations — Hodoscope & Calorimeter

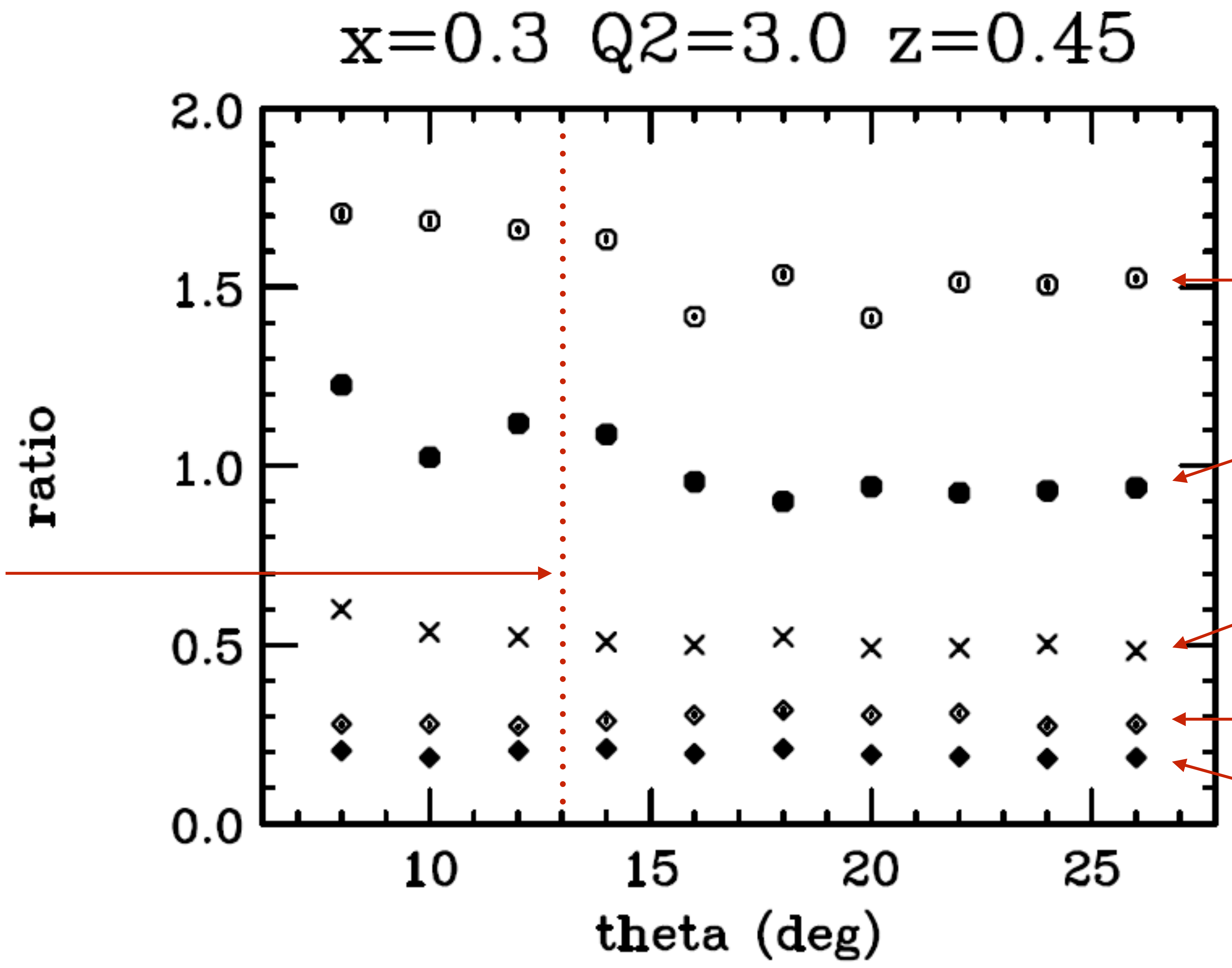
SHMS β



Calorimeter: Shuo Jia doing studies!

Ratios of Rates — Spring

SHMS P = 2.58



$P_T = 0$

Ratios to π^+ off LH2 of rates of:

π^+ off LD2

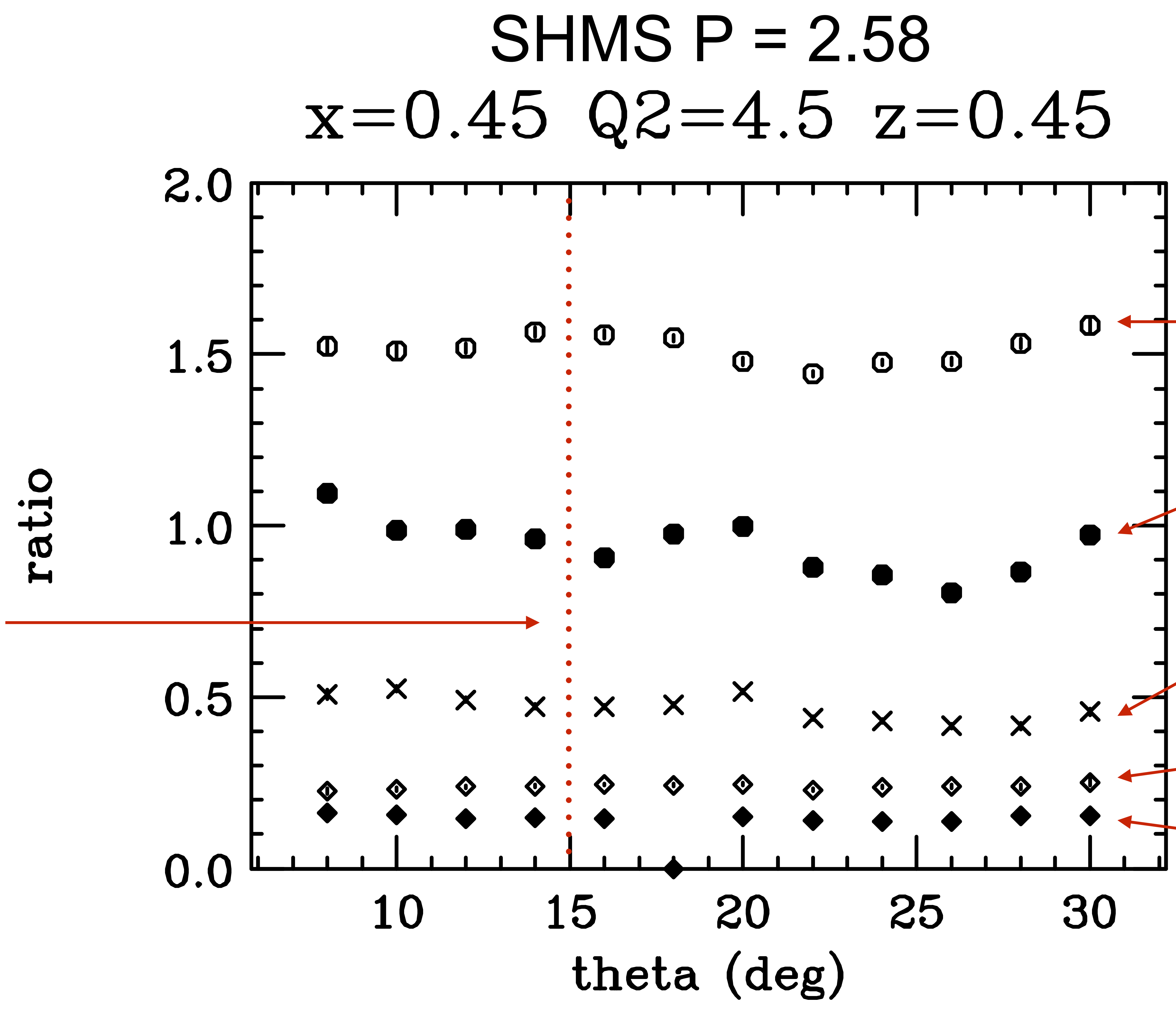
π^- off LD2

π^- off LH2

π^+ off Al

π^- off Al

Ratios of Rates — Fall



$P_T = 0$

Ratios to π^+ off LH2 of rates of:

π^+ off LD2

π^- off LD2

π^- off LH2

π^+ off Al

π^- off Al

What Next? (Short(ish) Term)

Spring data:

- Wrapping up calibrations
- Corrections to do: Target thickness/density, radiative corrections
- (Done: corrected for computer dead time)
- Almost ready to replay!

Fall data:

- Calibrations: with E12-09-002 (CSV)
- Coincidence timing issues?
- (Done: subtracted accidentals, SHMS tracking efficiency is roughly accounted for)

What Next? (Long(er) Term)

- Currently only looking at pions → eventually also kaons
- Main goal: Ratios of ***cross sections***, not just ***rates***
- Absolute cross sections as well as ratios?