



HEEP Studies

Mr. Muhammad Junaid
Ph.D. Student
Department of Physics,
University of Regina, Canada

HEEP Study

PionLT Experiment

Beam Energy (GeV)	Setting (HeePCoin - 9)	Run Numbers
9.177	HMS_p = -3.738, HMS_theta = 31.645, SHMS_p = 6.265, SHMS_theta = 18.125	11846 - 11879
5.986	HMS_p = -3.271, HMS_theta = 29.170, SHMS_p = 3.493, SHMS_theta = 27.495	13058 - 13062, 13128
9.876	HMS_p = -5.366, HMS_theta = 23.050, SHMS_p = 5.422, SHMS_theta = 23.050	13164 - 13169
7.937	HMS_p = -3.280, HMS_theta = 33.645, SHMS_p = 5.512, SHMS_theta = 19.265	14589 - 14600
10.549	HMS_p = -5.878, HMS_theta = 21.670, SHMS_p = 5.539, SHMS_theta = 23.110	14986 - 14993
8.479	HMS_p = -5.587, HMS_theta = 19.560, SHMS_p = 3.731, SHMS_theta = 30.020	16162 - 16165
6.395 (s1)	HMS_p = -4.752, HMS_theta = 18.595, SHMS_p = 2.412, SHMS_theta = 37.970	16277 - 16279
6.395 (s2)	HMS_p = -4.391, HMS_theta = 21.095, SHMS_p = 2.792, SHMS_theta = 34.470	16280 - 16282
6.395 (s3)	HMS_p = -3.014, HMS_theta = 33.350, SHMS_p = 4.220, SHMS_theta = 23.115	16512 - 16517

- Cuts for HeeP data.

HMS Cuts (Electrons)

$$-8 < H_gtr_dp < 8$$

$$-0.08 < H_gtr_th < 0.08$$

$$-0.045 < H_gtr_ph < 0.045$$

$$HMS_Cal_etottracknorm > 0.7$$

$$H_Cer_npeSum > 1.5$$

SHMS Cuts (Protons)

$$-10 < P_gtr_dp < 20$$

$$-0.06 < P_gtr_th < 0.06$$

$$-0.04 < P_gtr_ph < 0.04$$

Ctime_epCoinTime_ROC1 – Prompt Peak

- Cuts for HeeP SIMC.

HMS Cuts (Electrons)

$$-8 < hsdelta < 8$$

$$-0.08 < hsxpfp < 0.08$$

$$-0.045 < hsyfp < 0.045$$

SHMS Cuts (Protons)

$$-10 < ssdelta < 20$$

$$-0.06 < ssxpfp < 0.06$$

$$-0.04 < ssypfp < 0.04$$

- Global In-Plane Offset from Garth:

Global In-Plane Offsets – Momentum and Energy offsets in 0.1% unit, Angle offset in mrad unit

dthe	1.2000	dpe	-0.1000	dthp	1.6000	dpp	-0.1000		
BE	5984.8	6394.7s1	6394.7s2	6394.7s3	7937.6	8478.6	9171.3	9876.9	10546.8
dE	-0.5000	-0.5000	-0.5000	-0.5000	-0.4000	-0.4000	-0.5000	-0.6000	-0.0000

- Implemented energy, momentum and angle offset to both DATA and SIMC.
- Implemented Out-of-plane offsets to DATA (**HMS = +0.0019rad** and **SHMS = -0.00007rad**).

- Corrected Beam Energy values after Global Offsets:

Beam Energy (GeV)	Global Offset (0.1%)	Global Offset Value	Corrected Beam Energy (GeV)
5.984804	-0.5000	-0.002992402	5.981812
6.394701	-0.5000	-0.0031973505	6.391504
7.9375695	-0.4000	-0.0031750278	7.934395
8.478619	-0.4000	-0.0033914476	8.475228
9.171305	-0.5000	-0.0045856525	9.166719
9.876908	-0.6000	-0.0059261448	9.870982
10.546755	0.0	0.0	10.546755

- Global Angle Offsets:**
 - Offset on HMS_theta = 1.2000mrad and equal to **+0.0012rad** for all beam energies.
 - Offset on SHMS_theta = 1.6000mrad and equal to **+0.0016rad** for all beam energies.

Global Momentum Offsets:

Corrected Beam Energy (GeV)	HMS_p (GeV/c)	HMS_p Offset (1%)	HMS_p Offset Value (GeV/c)	HMS_p Value (GeV/c)	SHMS_p (GeV/c)	SHMS_p Offset (1%)	SHMS_p Offset Value (GeV/c)	SHMS_p Value (GeV/c)
5.981812	-3.271	-0.01	0.0003271	3.2706729	3.493	-0.01	0.0003493	3.4926507
6.391504_s1	-4.752	-0.01	0.0004752	4.7515248	2.412	-0.01	0.0002412	2.4117588
6.391504_s2	-4.391	-0.01	0.0004391	4.3905609	2.792	-0.01	0.0002792	2.7917208
6.391504_s3	-3.014	-0.01	0.0003014	3.0136986	4.220	-0.01	0.0004220	4.219578
7.934395	-3.283	-0.01	0.0003283	3.2826717	5.512	-0.01	0.0005512	5.5114488
8.475228	-5.587	-0.01	0.0005587	5.5864413	3.731	-0.01	0.0003731	3.7306269
9.166719	-3.738	-0.01	0.0003738	3.7376262	6.265	-0.01	0.0006265	6.2643735
9.870982	-5.366	-0.01	0.0005366	5.3654634	5.422	-0.01	0.0005422	5.4214578
10.546755	-5.878	-0.01	0.0005878	5.8774122	5.530	-0.01	0.0005530	5.529447

- Confusion in implementing momentum offset.
- Needs to be implemented in GEV units or % units.
- Compared param files and hcana.
- Screenshot of Param file:

```
; h_oopcentral_offset = 0.0 ; (rad)
;; sets hpcentral = hpcentral * ( 1. + hpcentral_offset / 100. )
;;      htheta_lab=htheta_lab + hthetacentral_offset/degree
```

- Screenshot of hcana:

```
grep: build/lib64/libHallC.so.1.0: binary file matches
build/include/THcHallCSpectrometer.h:151: Double_t fPCentralOffset; // Offset Central spectrometer momentum (%)
grep: build/src/CMakeFiles/HallC.dir/THcHallCSpectrometer.cxx.o: binary file matches
grep: build/src/libHallC.so.1.0: binary file matches
src/THcHallCSpectrometer.h:151: Double_t fPCentralOffset; // Offset Central spectrometer momentum (%)
src/THcHallCSpectrometer.cxx:251: {"pcentral_offset", &fPCentralOffset, kDouble },
src/THcHallCSpectrometer.cxx:381: cout << "fPcentral = " << fPcentral << " " <<fPCentralOffset << endl;
src/THcHallCSpectrometer.cxx:383: fPcentral= fPcentral*(1.+fPCentralOffset/100.);
(replay_lt_env) [junaid@ifarm180302 hcana_27_05_24_Root6_24_08_Alma9]$
```

- **Implemented in % units in param files.**

- Did calculation to confirm the offset values.
- Let's assume:

$$P_{shms} = 3.271$$

$$\text{Offset} = -0.1 \text{ (0.1\%)}$$

Calculation:

$$\text{Offset} = -3.271 \times 0.1 \times 0.1 \% = -3.271 \times 0.01\% = -0.0003271$$

$$\text{Corrected momentum} = 3.271 - 0.0003271 = \mathbf{3.2706729}$$

- Calculations from HCANA:

$$P_{shms} = 3.271$$

$$\text{Offset} = -0.1 \text{ (0.1\%)} = 0.01 \text{ (1\%)}$$

$$\text{Corrected momentum} = P_{shms} \times (1 + \text{offset}(1\%)/100)$$

$$= 3.271 \times (1 - 0.01/100) = \mathbf{3.2706729}$$

- Both calculations matches.

- Made HeeP comparison plots of other variables (delta, target, focal plane)
- SIMC is normalized.
- Data is normalized (BCM calibrations are not correct)

$$\text{Effective charge} = \frac{1}{\text{Charge} \times \text{Tracking Eff} \times \text{Detector Eff} \times \text{Hodo}^{\frac{3}{4}} \text{Eff} \times \text{EDTM Live Time} \times \text{Boiling Corr.}}$$

- In data normalization, Following quantities are included:
 - Charge (run-by-run)
 - Tracking Efficiencies (HMS and SHMS run-by-run)
 - Detector Efficiencies (HMS Cer and HMS Cal run-by-run)
 - Hodo ³/₄ Efficiencies (HMS and SHMS run-by-run)

In progress:

- Needs to do offset calculation again b/c during the first replays there were already offsets implemented in the param files.
- Working on in-plane offset study.