

New F3-polarimeter, 54-th session, 2017

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LPHE JINR

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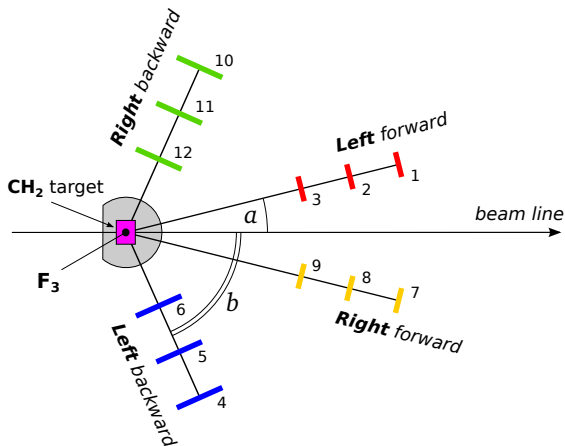
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- 5 Appendix, Proton Beam
 - Simple processing

Focus 3



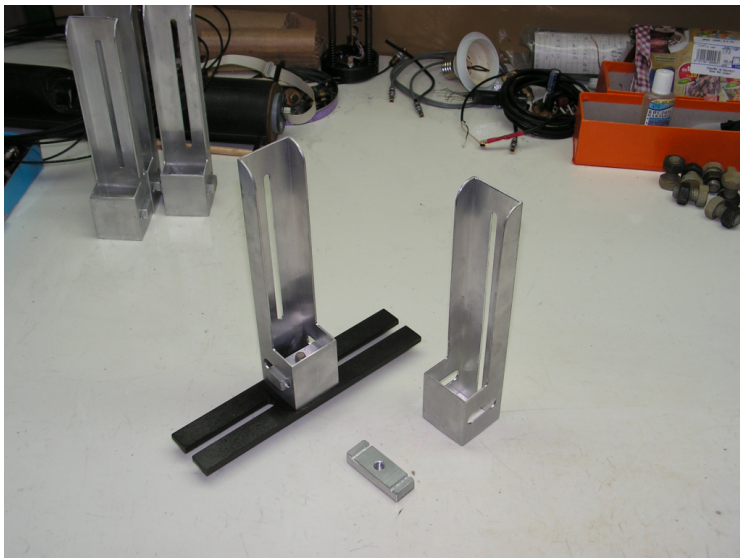
Schem of F3-polarimeter



Counter and its binding



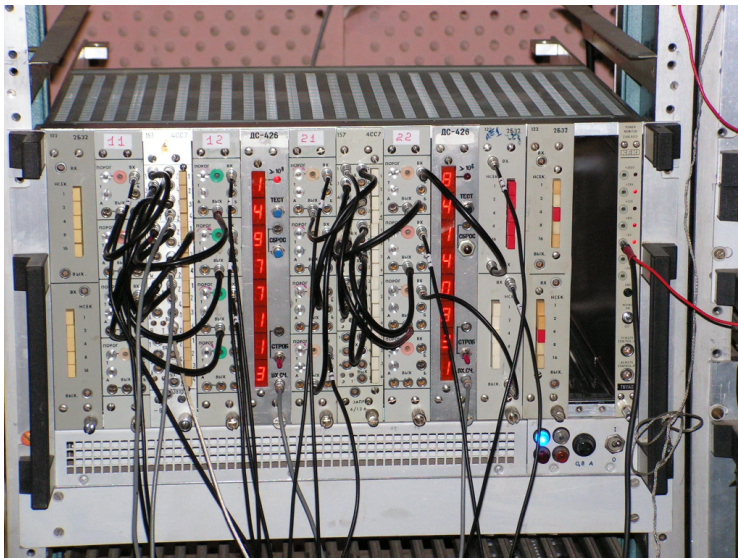
Counter and its binding



HV-power supply



Data aquisition system

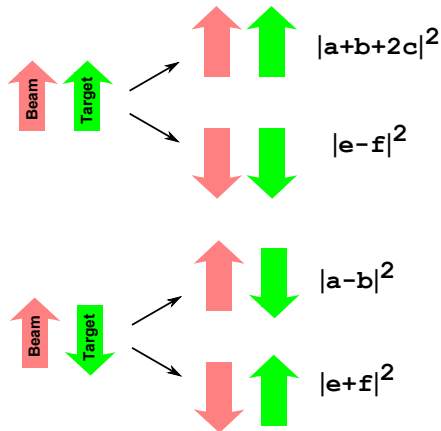


View of F3-polarimeter

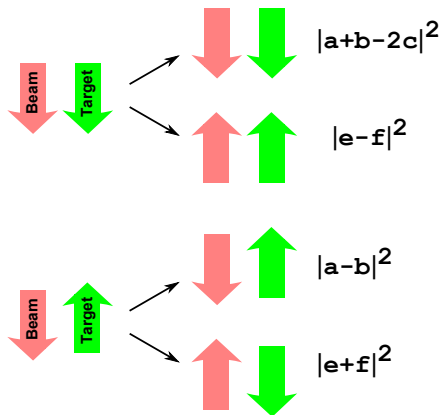


What we measure?

beam-up: $\cos^2 \frac{\lambda}{2}$



beam-down: $\sin^2 \frac{\lambda}{2}$



$$\text{to Left : } d\sigma/d\Omega + 4 \operatorname{Re}[(a+b)c^*] \cos \lambda$$

$$\text{to Right : } d\sigma/d\Omega - 4 \operatorname{Re}[(a+b)c^*] \cos \lambda$$

$$\cos \lambda \frac{4 \operatorname{Re}[(a+b)c^*]}{d\sigma/d\Omega} = P_z A_y = \frac{N_L - N_R}{N_L + N_R} \quad (1)$$

DEUTRON BEAM

Data RUNs 1–167, 24–27.02.2017

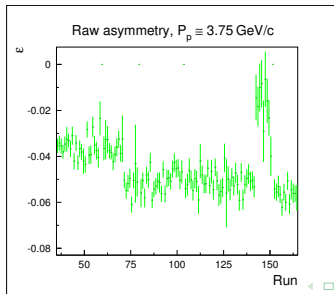
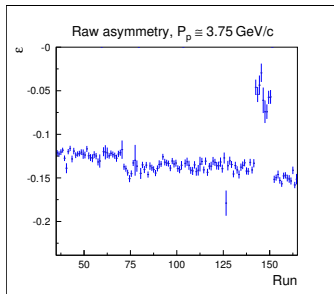
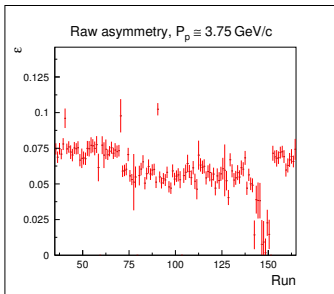
Deuteron beam $P_d = 7.5 \text{ GeV}/c$

Proton momentum $P_p \sim 3.75 \text{ GeV}/c$

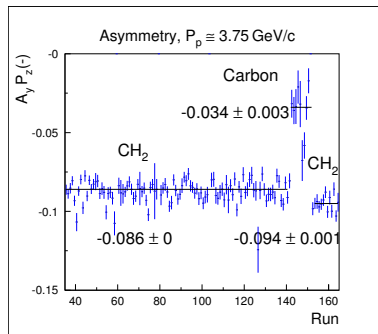
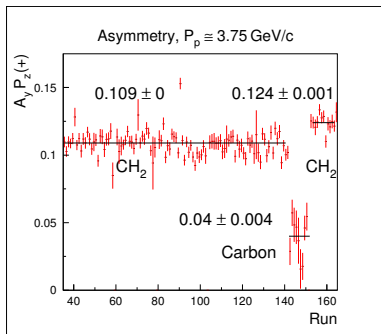
Labels of polarization and their meaning:

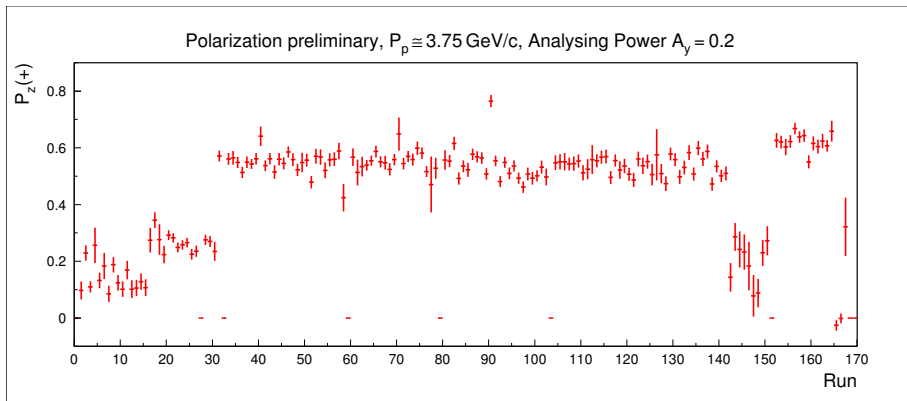
“+”, “0”, “−” $\equiv$ +, 0, −

Raw asymmetries

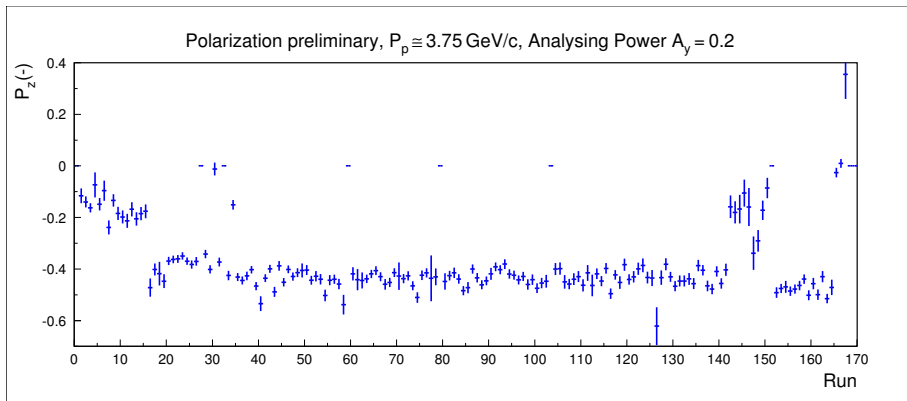


Asymmetries by the Zero correction

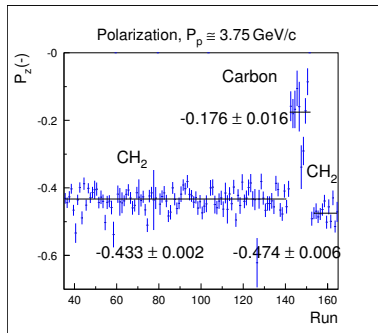
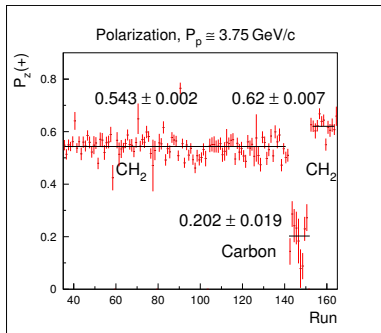




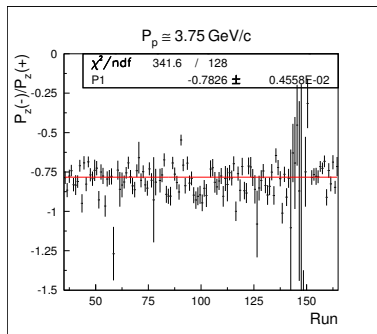
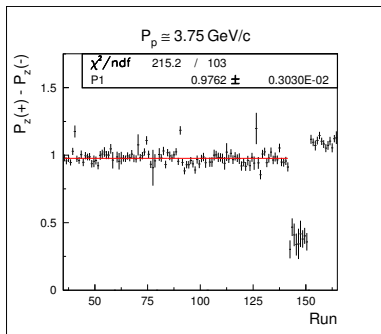
$P_z(-)$



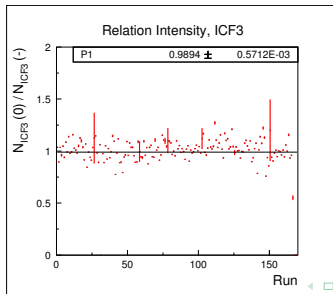
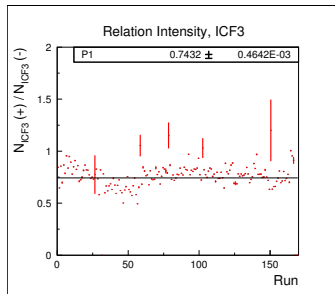
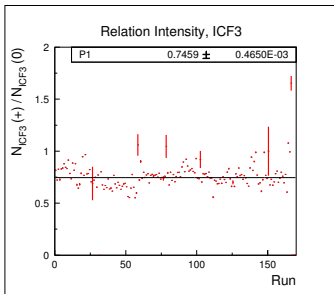
Polarization estimations, $A_y \cong 0.2$



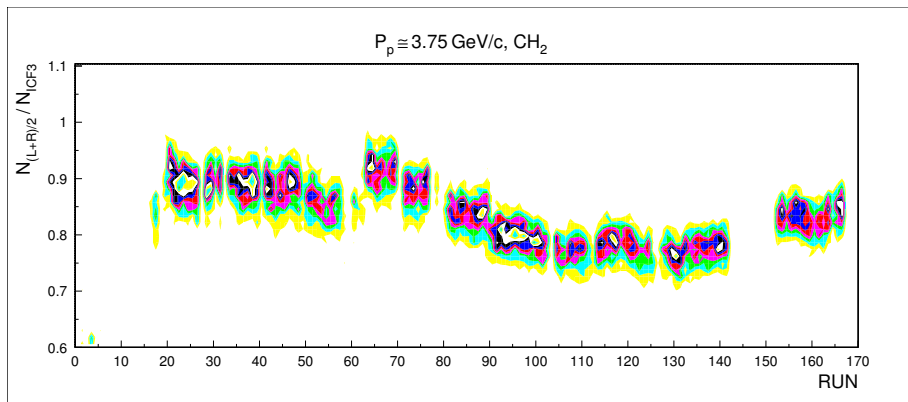
Difference and Relation



Intensity control using ICF3



Relation between the F3-polarimeter and ICF3

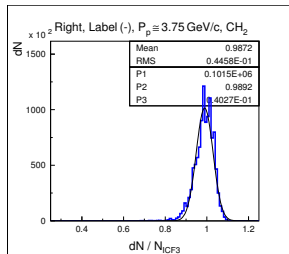
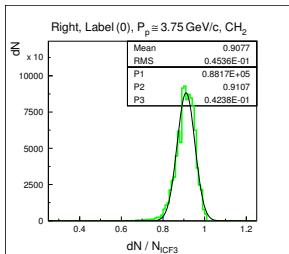
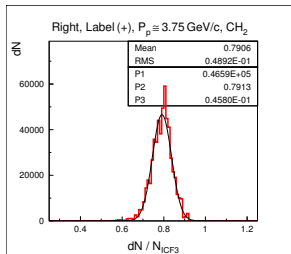
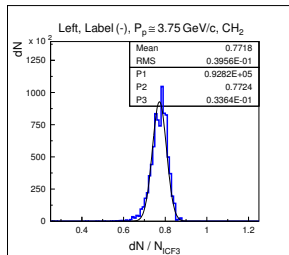
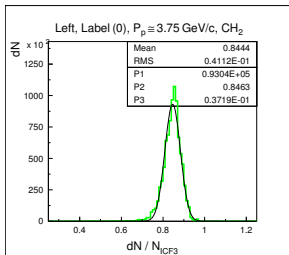
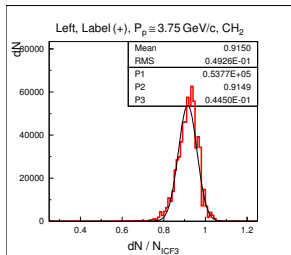


The relation between number of events of polarimeter arms and count of ionized chamber show some problem with the deuteron beam in the F3-focus. This relation can't depend from the polarization and in ideal case it should be stable.

Table 1
Data separation using the relation $\frac{L+R}{2} / \text{ICF3}$
(February 2017 year)

RUNs	Target	Begin	End	Gate, sec
35–62	CH ₂	24 20:11	25 10:14	7.4
63–69	CH ₂	25 10:14	25 13:44	7.4
71–78	CH ₂	25 16:22	25 20:35	7.4
80–89	CH ₂	25 20:52	26 01:53	7.4
90–141	CH ₂	26 01:53	27 03:48	7.4
142–151	Carbon	27 06:43	27 12:07	7.4
152–164	CH ₂	27 12:12	27 19:08	3.3
165–167	CH ₂	27 19:10	27 20:11	3.3

RUNs 35–62, Target CH₂ 3 cm



$$\varepsilon(0) = \frac{N_L^0 - N_R^0}{N_L^0 + N_R^0} \quad (2)$$

$$A_y P_z(\pm) = \left(\frac{N_L^\pm}{N_L^0} - \frac{N_R^\pm}{N_R^0} \right) / \left(\frac{N_L^\pm}{N_L^0} + \frac{N_R^\pm}{N_R^0} \right) \quad (3)$$

$$\varepsilon(L, R) = \frac{N_{L,R}^+ - N_{L,R}^-}{N_{L,R}^+ + N_{L,R}^-} \quad (4)$$

$$N_{L,R}^0 \equiv N_{L,R}^0 / N_{ICF3}^0 \quad N_{L,R}^\pm \equiv N_{L,R}^\pm / N_{ICF3}^\pm \quad (5)$$

$$\varepsilon(0) = -0.035 \pm 0.001$$

$$A_y P_z(+)= 0.109 \pm 0.001$$

$$A_y P_z(-)= -0.086 \pm 0.001$$

$$\varepsilon(L) = 0.085 \pm 0.001$$

$$\varepsilon(R) = -0.11 \pm 0.001$$

Data Table 2, RUNs 35–167

For detailed information about the RUNs 63–167 see Appendix D

RUNs	Tar	$\varepsilon(0)$	$A_y P_z(+)$	$A_y P_z(-)$	$\varepsilon(L)$	$\varepsilon(R)$
35–62	CH ₂	−0.035	+0.109	−0.086	+0.085	−0.11
63–69	CH ₂	−0.035	+0.11	−0.085	+0.089	−0.106
71–78	CH ₂	−0.052	+0.111	−0.087	+0.096	−0.103
80–89	CH ₂	−0.051	+0.109	−0.087	+0.094	−0.103
90–141	CH ₂	−0.049	+0.105	−0.085	+0.09	−0.101
142–151	C	−0.02	+0.04	−0.035	+0.017	−0.058
152–164	CH ₂	−0.055	+0.124	−0.094	+0.103	−0.116
165–167	CH ₂	−0.053	−0.002	0	−0.001	0

RUNs 164–167 — Polarized Ions Source OFF

Subtraction the Carbon background

$$V(\text{CH}_2) = 140 \times 40 \times 30 \text{ mm}^3, \quad V(\text{C}) = 140 \times 40 \times 14 \text{ mm}^3$$

Both targets have the same quantities of Carbon. Then:

$$N_{\text{L,R}}(\text{H}_2) = N_{\text{L,R}}(\text{CH}_2) - N_{\text{L,R}}(\text{C}) \quad (6)$$

For each target we take into account the normalization (5):

$$N_{\text{L,R}}^0 \equiv N_{\text{L,R}}^0 / N_{\text{ICF3}}^0 \quad N_{\text{L,R}}^\pm \equiv N_{\text{L,R}}^\pm k_{\text{L,R}}^\pm / N_{\text{ICF3}}^\pm$$

And put the $k_{\text{L,R}}^\pm$ as Zero Asymmetry correction:

$$k_{\text{L,R}}^\pm = \frac{1}{N_{\text{L,R}}^0} \frac{(N_{\text{L}}^0 + N_{\text{R}}^0)}{2} \quad (7)$$

Subtraction the Carbon background

Pure asymmetry ϵ_{H_2} for (+) and (−) separately
can be expressed as:

$$\begin{aligned}\epsilon_{H_2} &= \frac{(N_{L,CH_2} - N_{R,CH_2}) - (N_{L,C} - N_{R,C})}{(N_{L,CH_2} + N_{R,CH_2}) - (N_{L,C} + N_{R,C})} = \\ &= \frac{\epsilon_{CH_2} M_{CH_2} - \epsilon_C M_C}{M_{CH_2} - M_C},\end{aligned}\quad (8)$$

where: $M = (N_L + N_R)$ for each target.

Note: $\epsilon_{H_2} \equiv A_y(H_2) \cdot P_z$

Subtraction the Carbon background

For simplification
the error $\delta(\epsilon_{H_2})$ of asymmetry estimation
will be define by:

$$\delta(\epsilon_{H_2}) = \frac{\sqrt{\delta^2(\epsilon_{CH_2}) M_{CH_2}^2 + \delta^2(\epsilon_C) M_C^2}}{M_{CH_2} - M_C} \quad (9)$$

Data Table 3, RUNs 35–164

If else the $A_y(\text{H}_2) \cong 0.2$

RUNs	Tar	$P_z(+)$	$P_z(-)$
35–62	CH ₂	$+0.642 \pm 0.008$	-0.508 ± 0.007
63–69	CH ₂	$+0.644 \pm 0.011$	-0.497 ± 0.009
71–78	CH ₂	$+0.656 \pm 0.012$	-0.519 ± 0.01
80–89	CH ₂	$+0.648 \pm 0.011$	-0.522 ± 0.009
90–141	CH ₂	$+0.632 \pm 0.008$	-0.515 ± 0.007
152–164	CH ₂	$+0.746 \pm 0.01$	-0.567 ± 0.009

During all time of data taking it was about +0.64 and -0.51 but in the end (Runs 152–164) its value had grown up to +0.75 and -0.57 respectively. May be this deviation is related with some tune-up (corrections) of polarized ions source SPI.

PROTON BEAM

Data RUNs 1–5, 4.03.2017

RUN 1: $T_p = 2$ GeV, tune-up of beam extraction

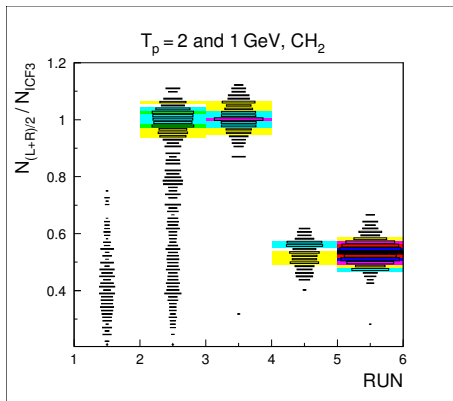
RUNs 2–3: $T_p = 2$ GeV, test-work

RUNs 4–5: $T_p = 1$ GeV, test-work

Labels of polarization and their meaning:

“+”, “0”, “-” $\equiv$ -, 0, -

Relation between the F3-polarimeter and ICF3



Data Table 5, RUNs 1–5

For detailed information about the RUNs 1, 3–5 see Appendix P

RUN	Tar	$\varepsilon(0)$	$A_y P_z(+)$	$A_y P_z(-)$	$\varepsilon(L)$	$\varepsilon(R)$
1	CH ₂	-0.019	+0.004	-0.034	-0.003	-0.041
2	CH ₂	-0.039	-0.024	-0.025	-0.004	-0.005
3	CH ₂	-0.049	-0.025	-0.013	-0.009	+0.002
4	CH ₂	-0.038	+0.029	+0.041	0	+0.01
5	CH ₂	-0.055	+0.051	+0.049	-0.003	-0.005

RUN 1 — tune-up of beam extraction

Data Table 6, RUNs 1–5

For estimations we use Anylizing Power from SAID

$$A_y(1\text{ GeV}) = 0.44 \text{ and } A_y(2\text{ GeV}) = 0.33$$

and koefficient 1.15 like as a correction of C-yield extraction
(see analysis for deuteron beam and Table 2, Table 3)

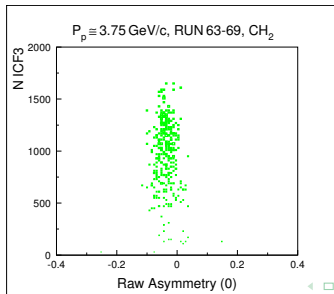
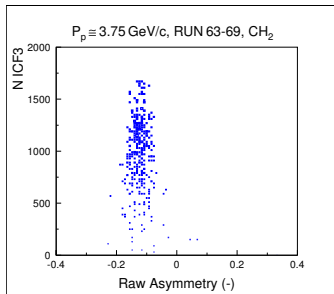
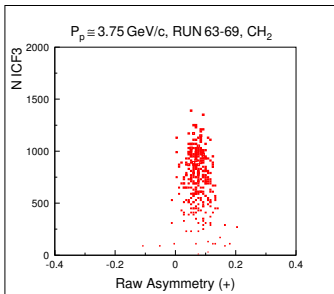
RUN	Tar	T_p , GeV	$P_z(+)$	$P_z(-)$
1	CH ₂	2.0	$+0.014 \pm 0.072$	-0.122 ± 0.072
2	CH ₂	2.0	-0.089 ± 0.02	-0.093 ± 0.02
3	CH ₂	2.0	-0.092 ± 0.023	-0.048 ± 0.023
4	CH ₂	1.0	$+0.077 \pm 0.028$	$+0.107 \pm 0.029$
5	CH ₂	1.0	$+0.135 \pm 0.016$	$+0.128 \pm 0.015$

:)

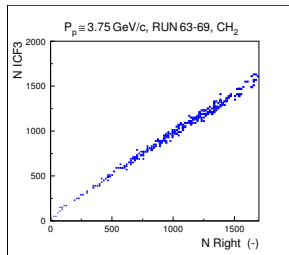
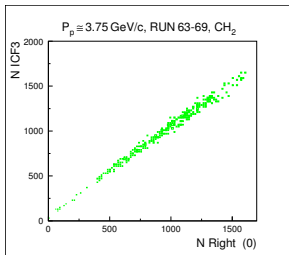
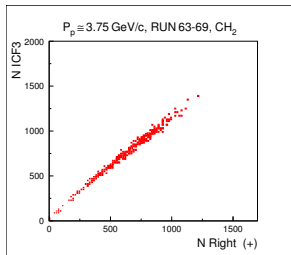
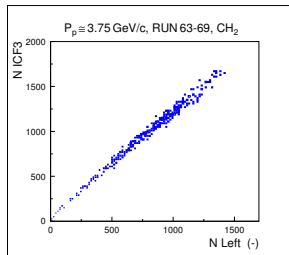
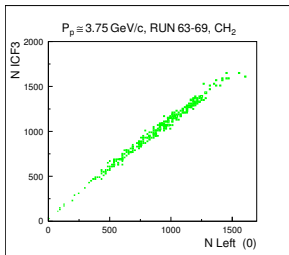
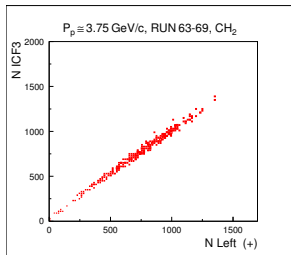
Thanks You
for attantion

Complex data analysis of RUNs 63–167

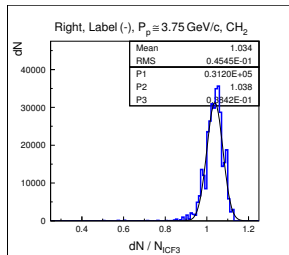
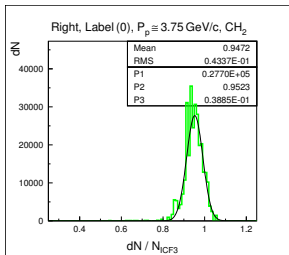
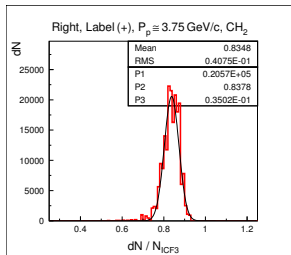
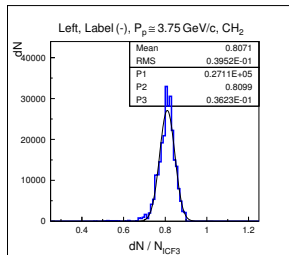
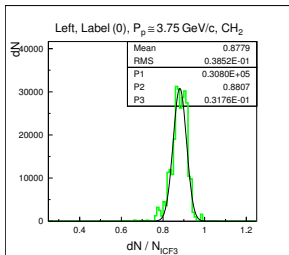
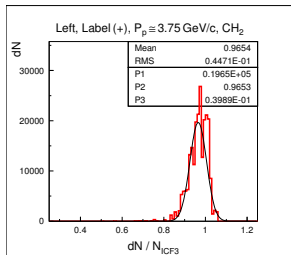
RUNs 63–69, Target CH₂ 3 cm



RUNs 63–69, Target CH₂ 3 cm



RUNs 63–69, Target CH₂ 3 cm



$$\varepsilon(0) = -0.037 \pm 0.001$$

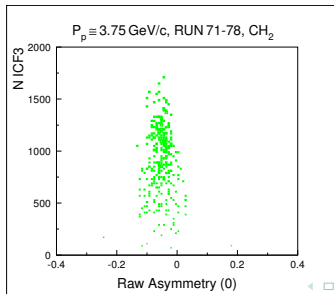
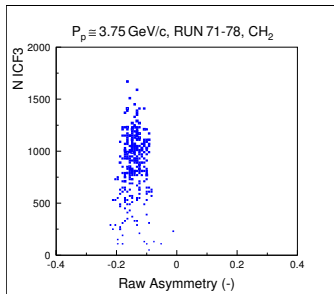
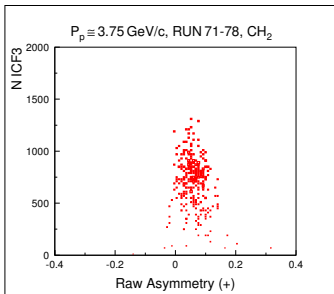
$$A_y P_z(+) = 0.11 \pm 0.002$$

$$A_y P_z(-) = -0.085 \pm 0.001$$

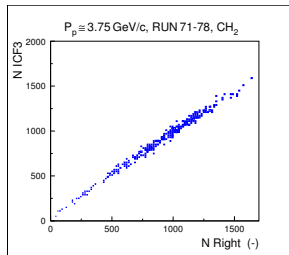
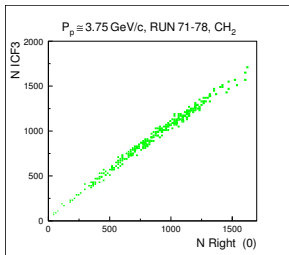
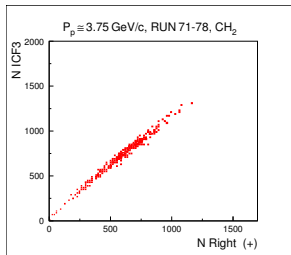
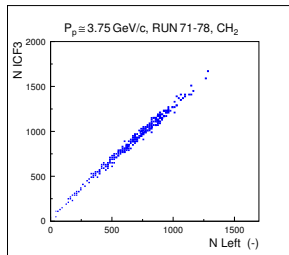
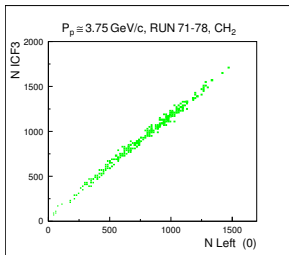
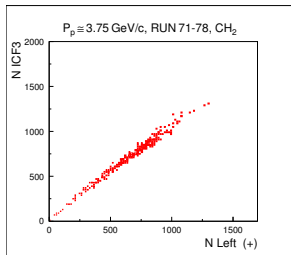
$$\varepsilon(L) = 0.089 \pm 0.001$$

$$\varepsilon(R) = -0.106 \pm 0.001$$

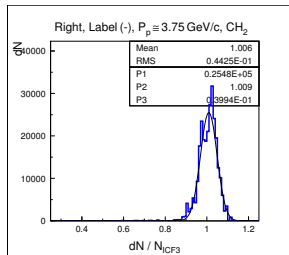
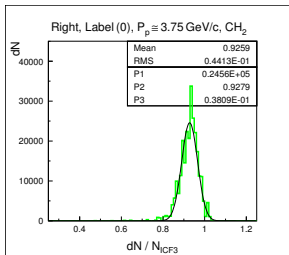
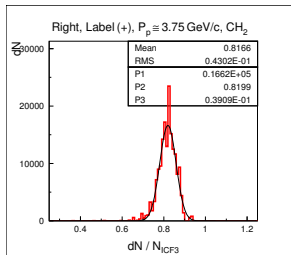
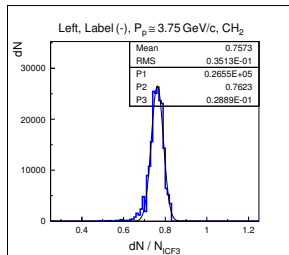
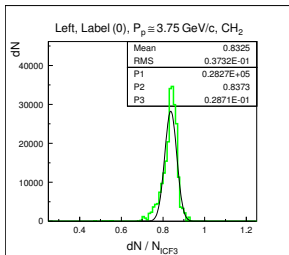
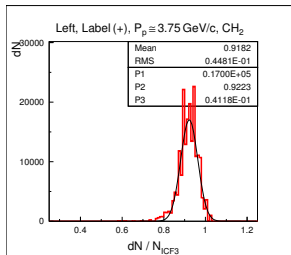
RUNs 71-78, Target CH₂ 3 cm



RUNs 71-78, Target CH₂ 3 cm



RUNs 71–78, Target CH₂ 3 cm



$$\varepsilon(0) = -0.052 \pm 0.001$$

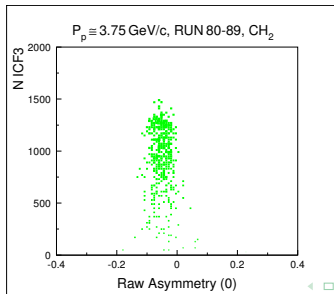
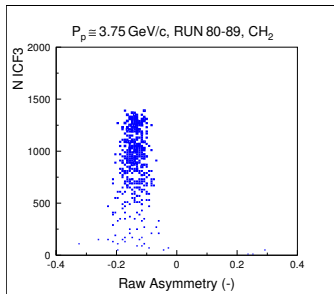
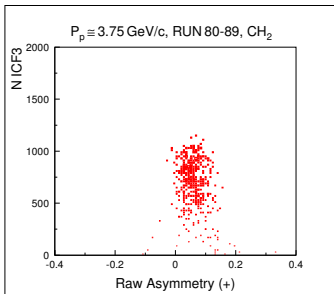
$$A_y P_z(+)= 0.111 \pm 0.002$$

$$A_y P_z(-)= -0.087 \pm 0.001$$

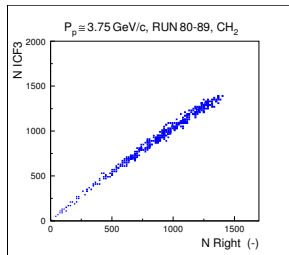
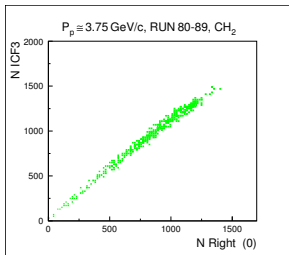
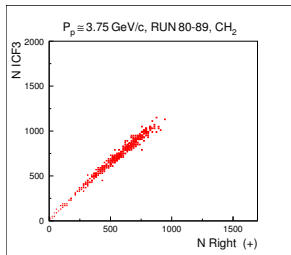
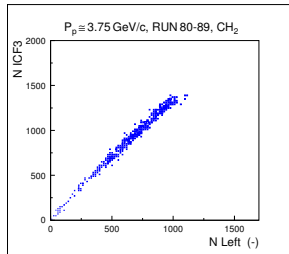
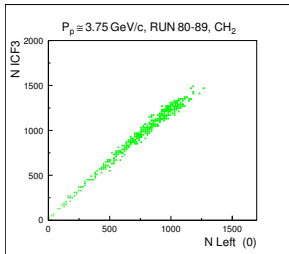
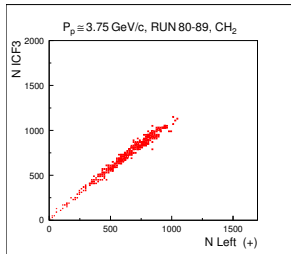
$$\varepsilon(L) = 0.096 \pm 0.002$$

$$\varepsilon(R) = -0.103 \pm 0.001$$

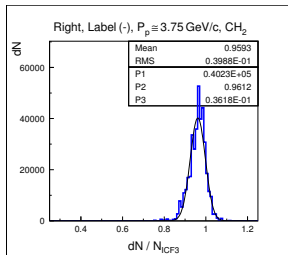
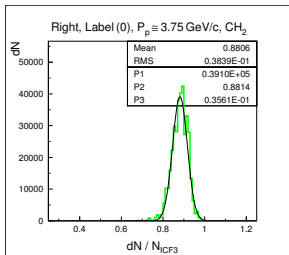
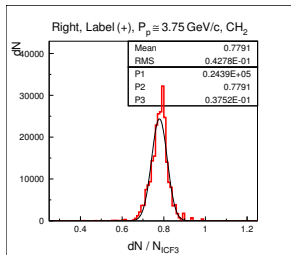
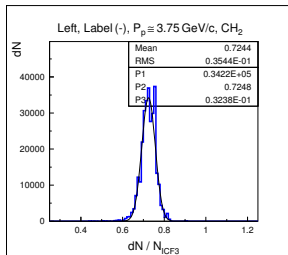
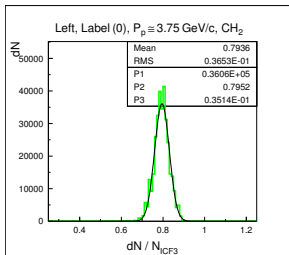
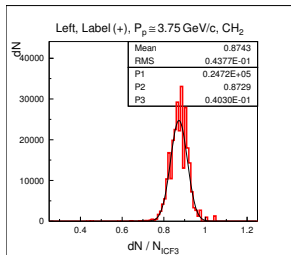
RUNs 80–89, Target CH₂ 3 cm



RUNs 80–89, Target CH₂ 3 cm



RUNs 80–89, Target CH₂ 3 cm



$$\varepsilon(0) = -0.051 \pm 0.001$$

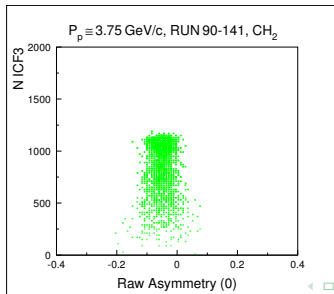
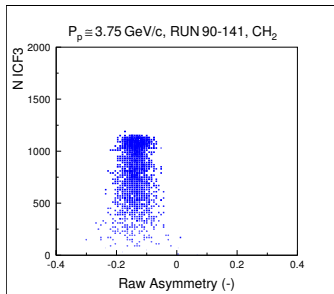
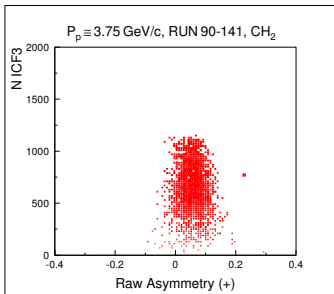
$$A_y P_z(+) = 0.109 \pm 0.001$$

$$A_y P_z(-) = -0.087 \pm 0.001$$

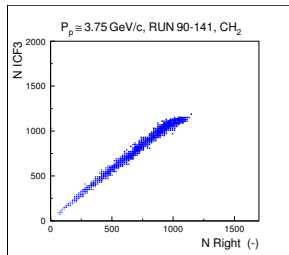
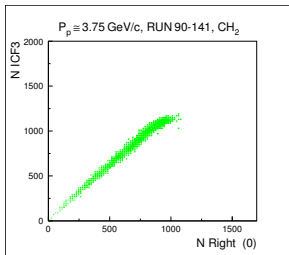
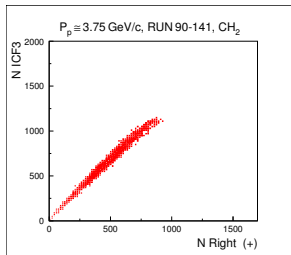
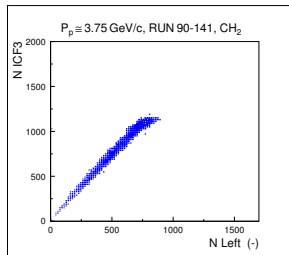
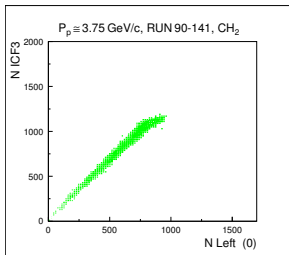
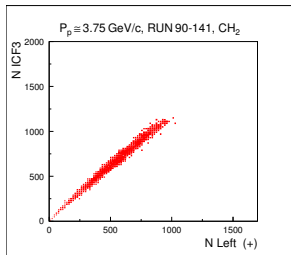
$$\varepsilon(L) = 0.094 \pm 0.001$$

$$\varepsilon(R) = -0.103 \pm 0.001$$

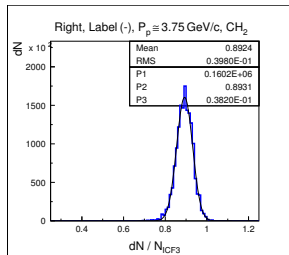
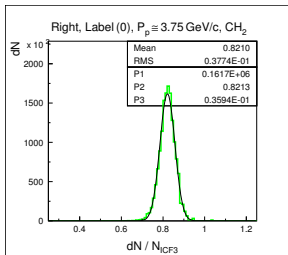
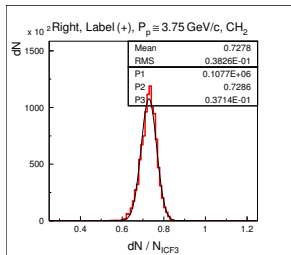
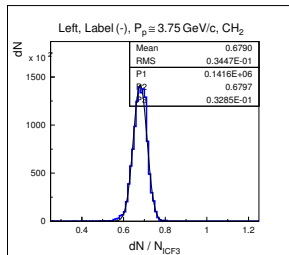
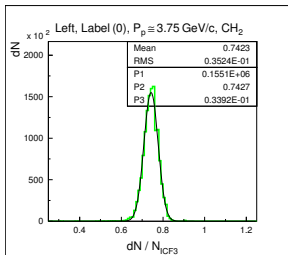
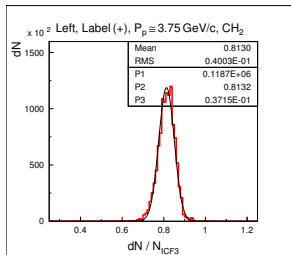
RUNs 90–141, Target CH₂ 3 cm



RUNs 90–141, Target CH₂ 3 cm



RUNs 90–141, Target CH₂ 3 cm



$$\varepsilon(0) = -0.049 \pm 0.001$$

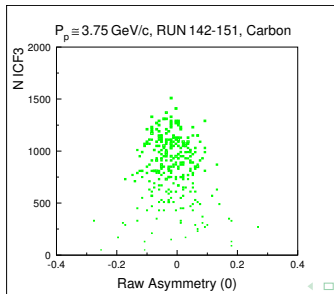
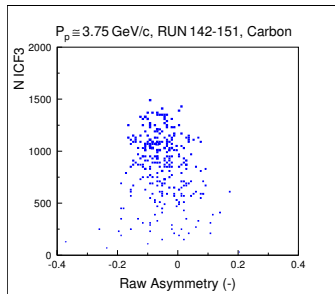
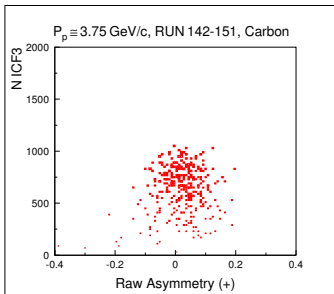
$$A_y P_z(+) = 0.105 \pm 0.001$$

$$A_y P_z(-) = -0.085 \pm 0.001$$

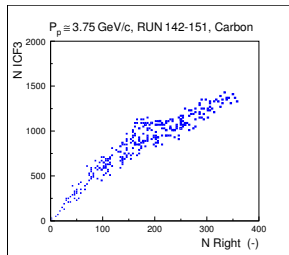
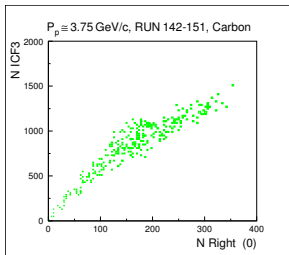
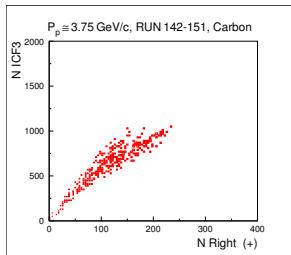
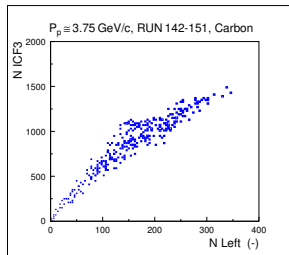
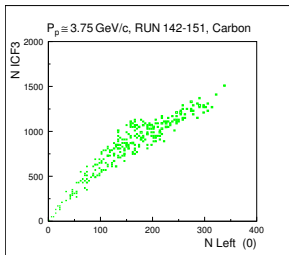
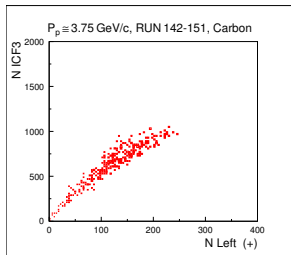
$$\varepsilon(L) = 0.09 \pm 0.001$$

$$\varepsilon(R) = -0.101 \pm 0.001$$

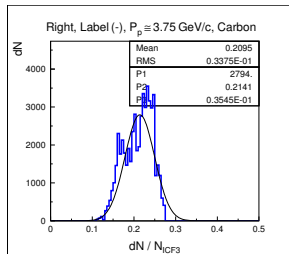
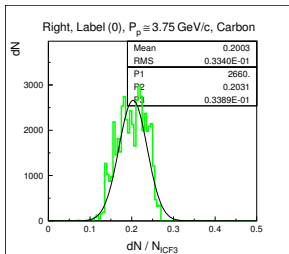
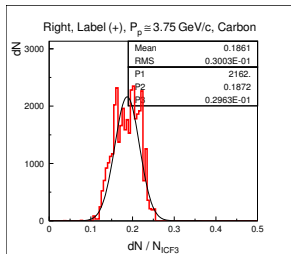
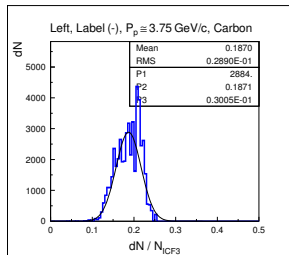
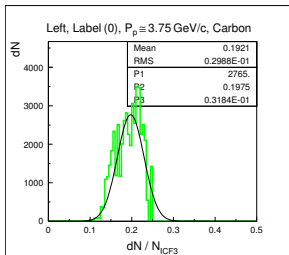
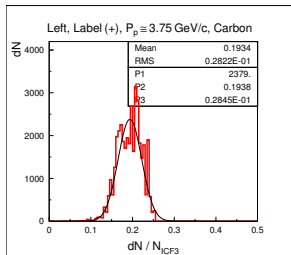
RUNs 142–151, Target Carbon 1.4 cm



RUNs 142–151, Target Carbon 1.4 cm



RUNs 142–151, Target Carbon 1.4 cm



$$\varepsilon(0) = -0.02 \pm 0.003$$

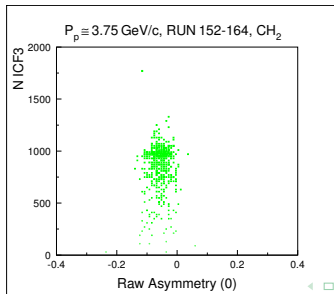
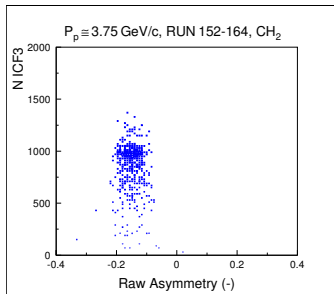
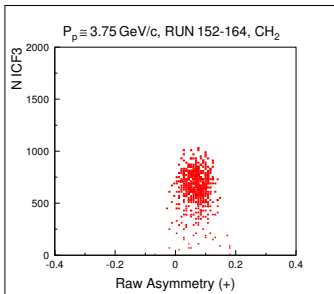
$$A_y P_z(+) = 0.04 \pm 0.004$$

$$A_y P_z(-) = -0.035 \pm 0.003$$

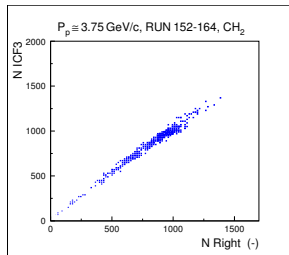
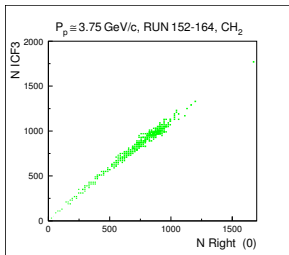
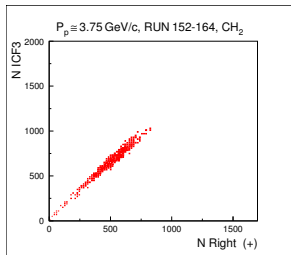
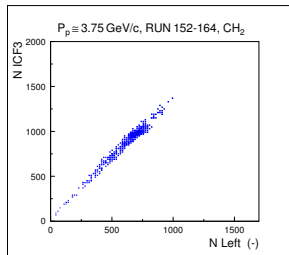
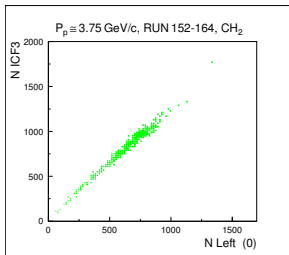
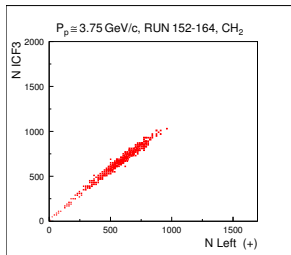
$$\varepsilon(L) = 0.017 \pm 0.003$$

$$\varepsilon(R) = -0.058 \pm 0.003$$

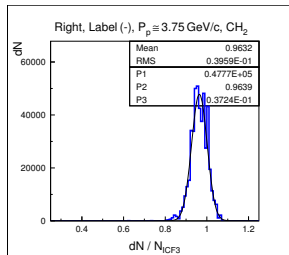
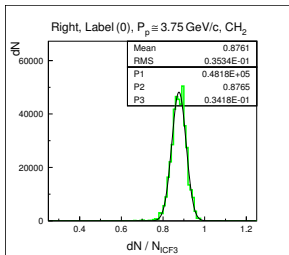
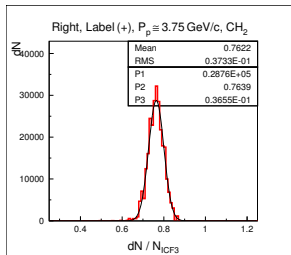
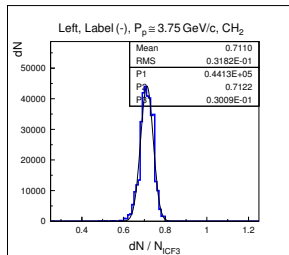
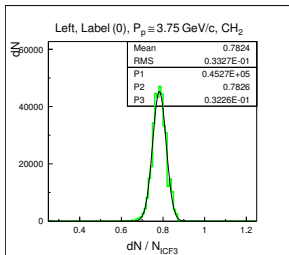
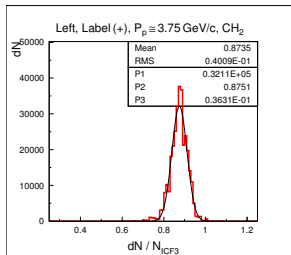
RUNs 152–164, Target CH₂ 3 cm



RUNs 152–164, Target CH₂ 3 cm



RUNs 152–164, Target CH₂ 3 cm



$$\varepsilon(0) = -0.055 \pm 0.001$$

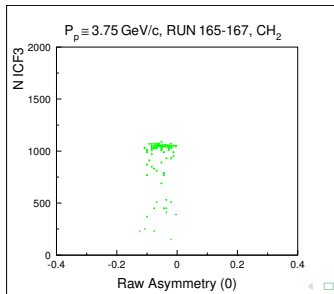
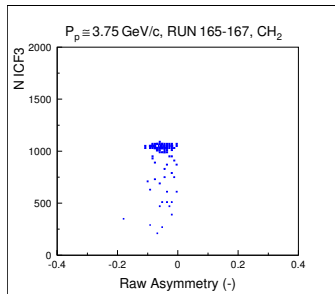
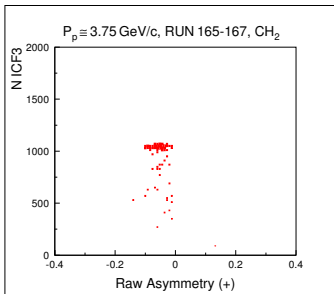
$$A_y P_z(+)= 0.124 \pm 0.001$$

$$A_y P_z(-)= -0.094 \pm 0.001$$

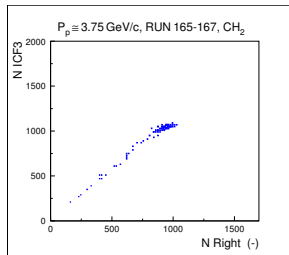
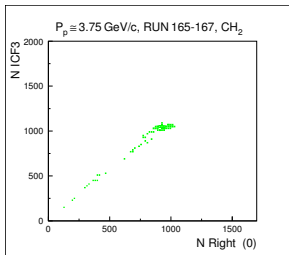
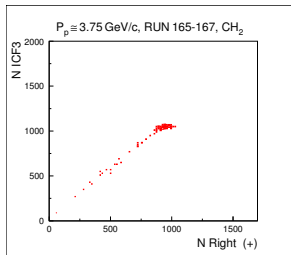
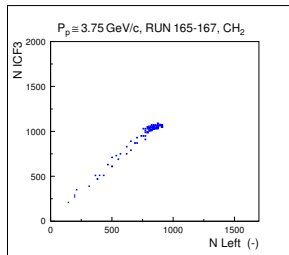
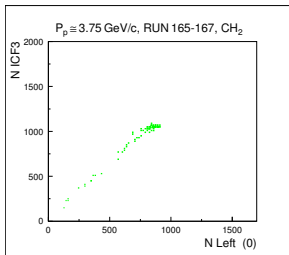
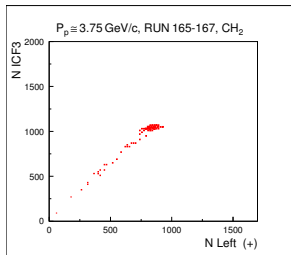
$$\varepsilon(L) = 0.103 \pm 0.001$$

$$\varepsilon(R) = -0.116 \pm 0.001$$

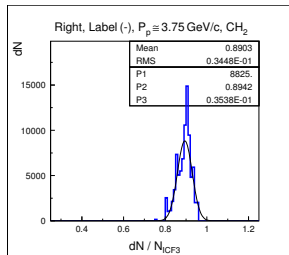
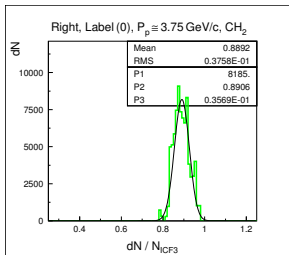
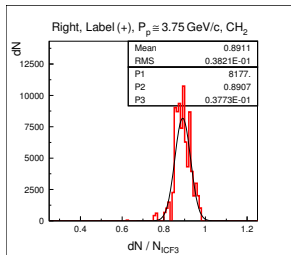
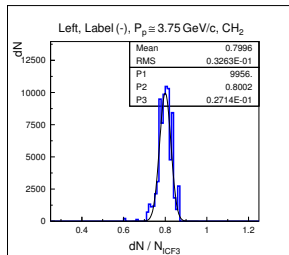
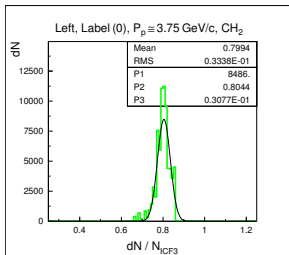
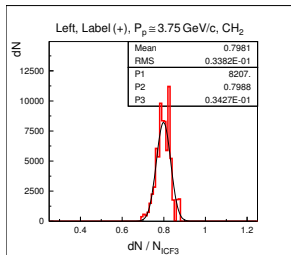
RUNs 165–167, Target CH₂ 3 cm, SPI OFF



RUNs 165–167, Target CH₂ 3 cm, SPI OFF



RUNs 165–167, Target CH₂ 3 cm, SPI OFF



$$\varepsilon(0) = -0.0531 \pm 0.0026$$

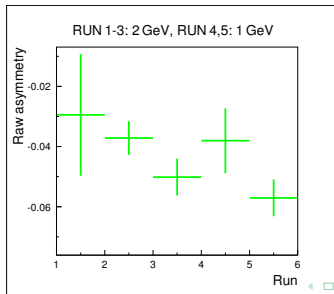
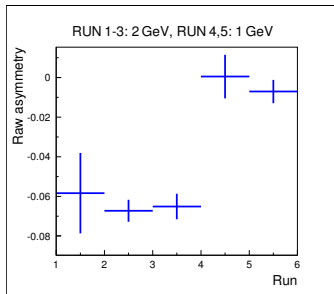
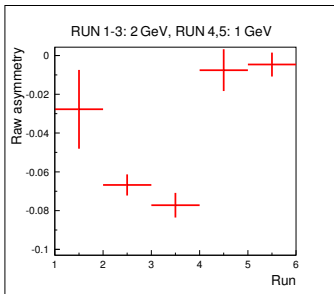
$$A_y P_z(+) = -0.0018 \pm 0.0025$$

$$A_y P_z(-) = -0.0004 \pm 0.0025$$

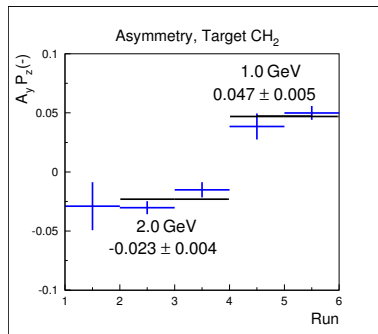
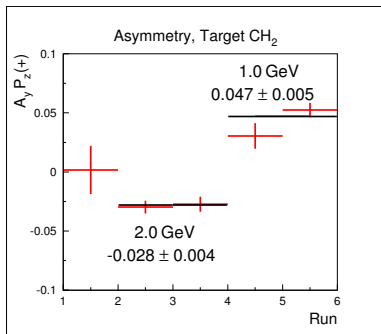
$$\varepsilon(L) = -0.0009 \pm 0.0026$$

$$\varepsilon(R) = 0.0004 \pm 0.0024$$

Raw assymetries

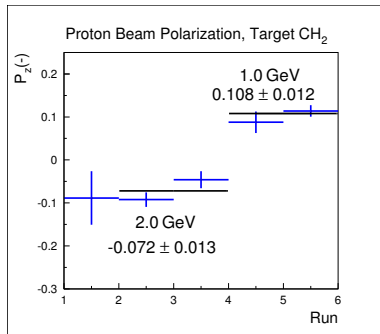
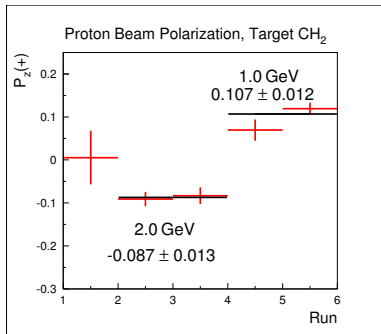


Asymmetries by the Zero correction

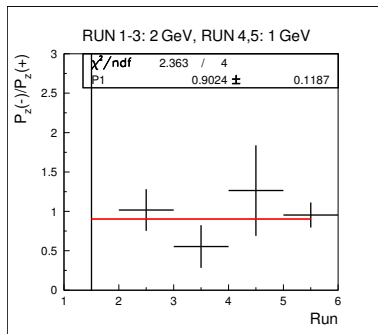
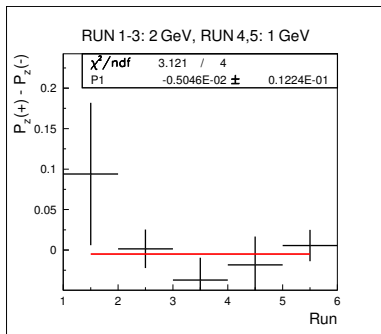


Polarization estimations, Analyzing Power from SAID

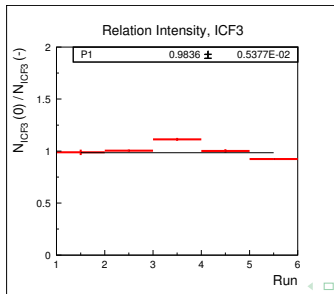
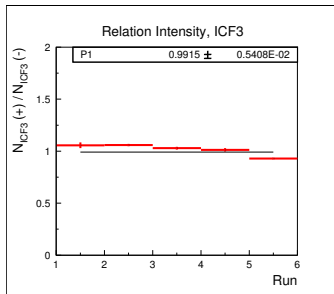
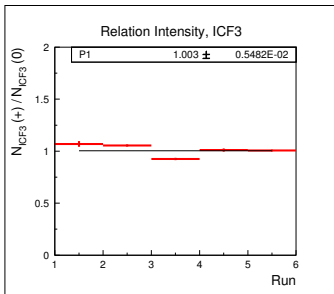
$A_y(1\text{ GeV}) = 0.44$ and $A_y(2\text{ GeV}) = 0.33$



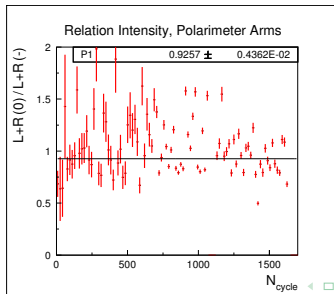
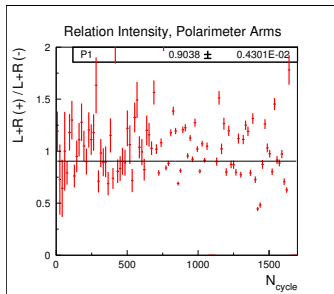
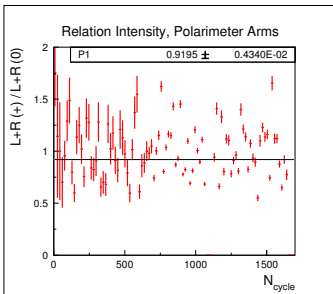
Difference and Relation estimations



Intensity control using ICF3



Intensity control using F3-polarimeter arms

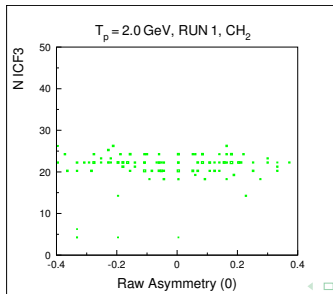
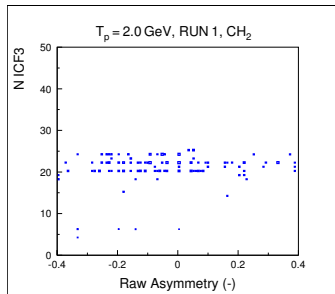
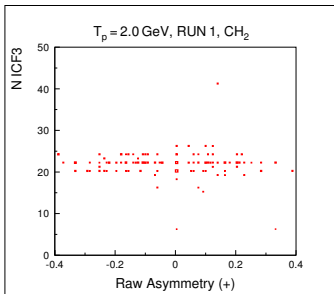


Complex data analysis of RUNs 1–5

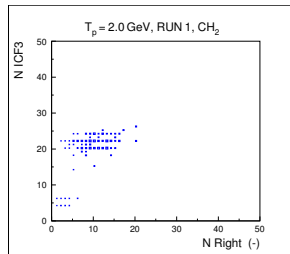
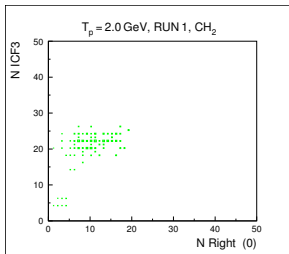
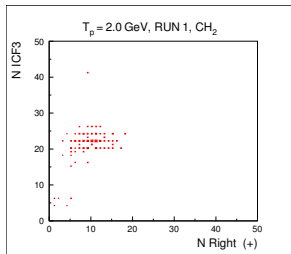
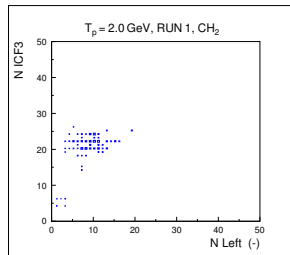
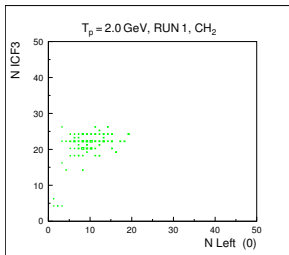
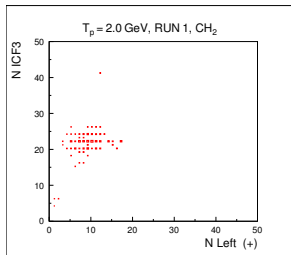
Table 4
Separation of pp -data (4 March 2017)

RUN	Target	T_p , GeV	Begin	End	Gate, sec
1	CH ₂	2.0	09:11	10:11	3.3
2	CH ₂	2.0	10:11	11:11	3.3
3	CH ₂	2.0	11:11	—	3.3
4	CH ₂	1.0	12:42	—	3.3
5	CH ₂	1.0	13:24	14:15	3.3

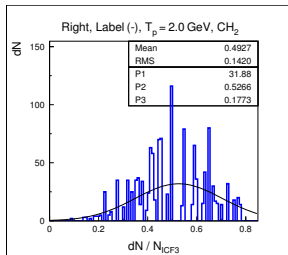
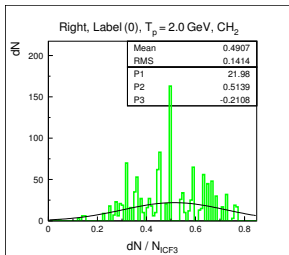
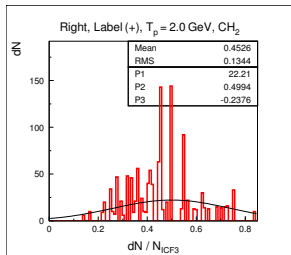
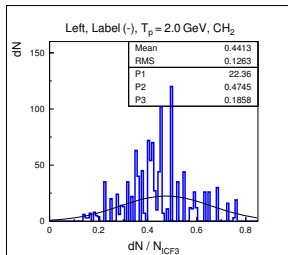
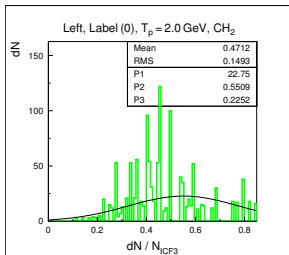
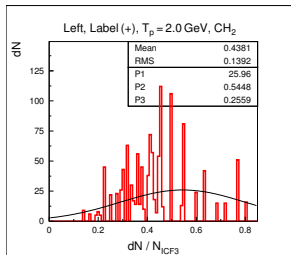
RUN 1, Target CH₂ 3 cm



RUN 1, Target CH₂ 3 cm



RUN 1, Target CH₂ 3 cm



$$\epsilon(0) = -0.019 \pm 0.02$$

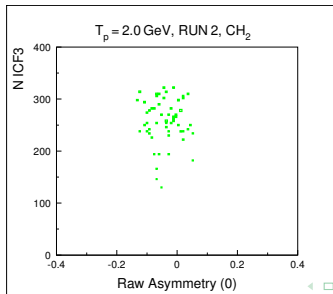
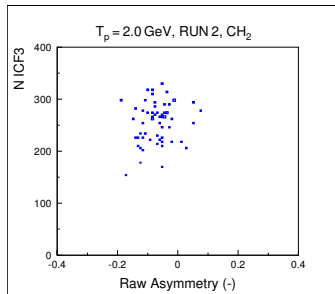
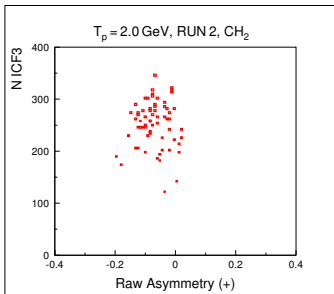
$$A_y P_z(+)= 0.004 \pm 0.02$$

$$A_y P_z(-)= -0.034 \pm 0.02$$

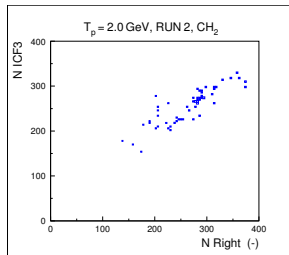
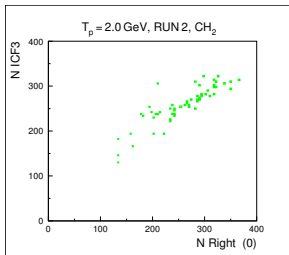
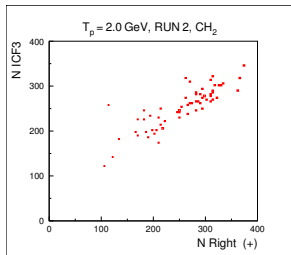
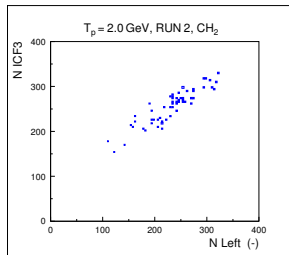
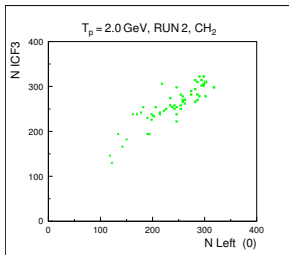
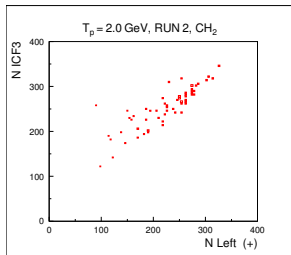
$$\epsilon(L) = -0.003 \pm 0.021$$

$$\epsilon(R) = -0.041 \pm 0.02$$

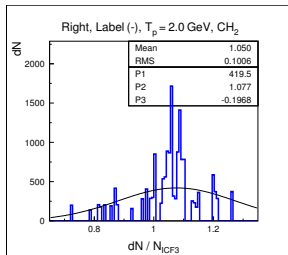
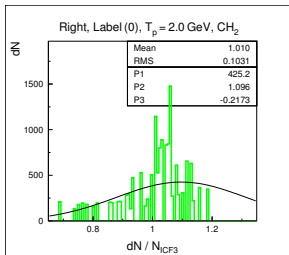
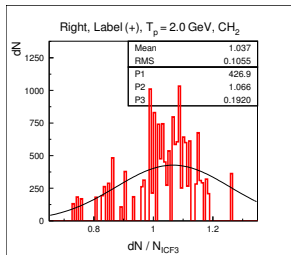
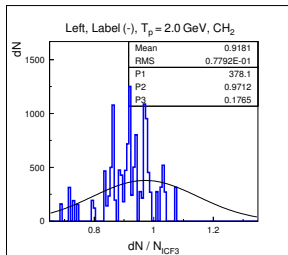
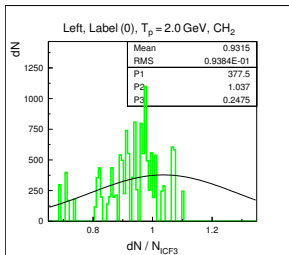
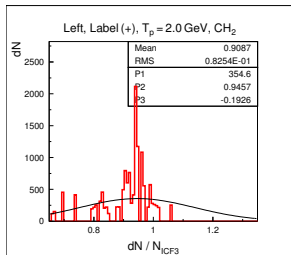
RUN 2, Target CH₂ 3 cm



RUN 2, Target CH₂ 3 cm



RUN 2, Target CH₂ 3 cm



$$\varepsilon(0) = -0.039 \pm 0.006$$

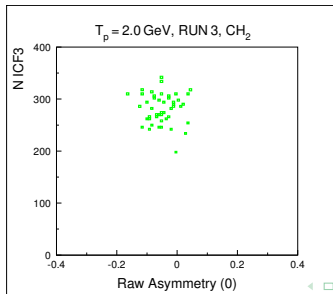
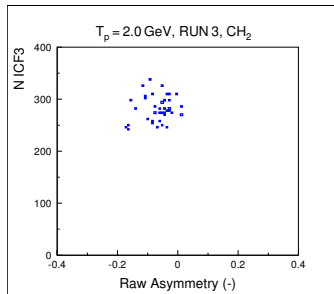
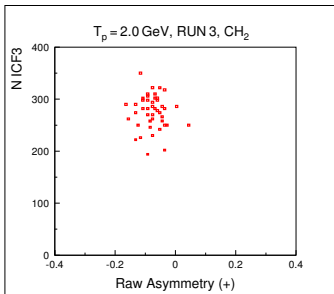
$$A_y P_z(+) = -0.024 \pm 0.006$$

$$A_y P_z(-) = -0.025 \pm 0.006$$

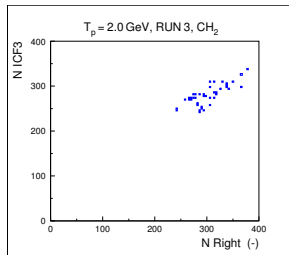
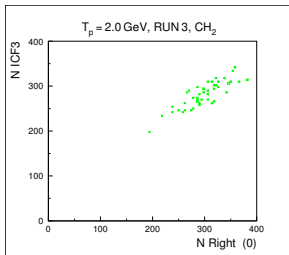
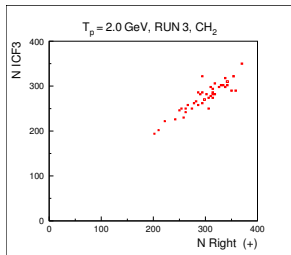
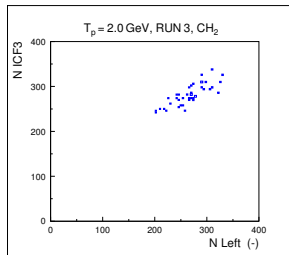
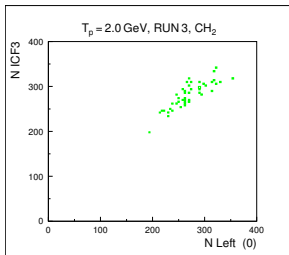
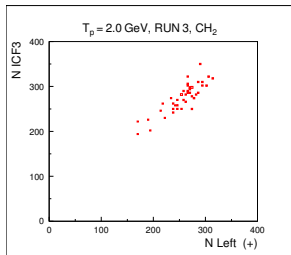
$$\varepsilon(L) = -0.004 \pm 0.006$$

$$\varepsilon(R) = -0.005 \pm 0.006$$

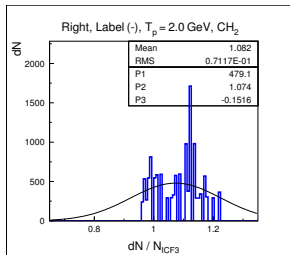
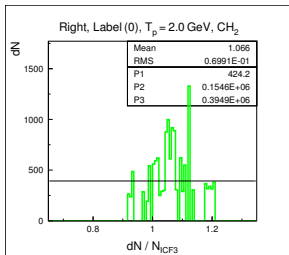
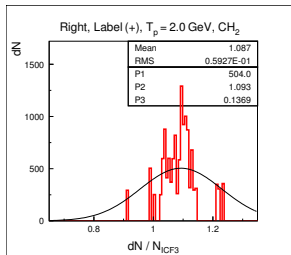
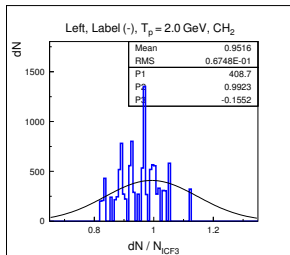
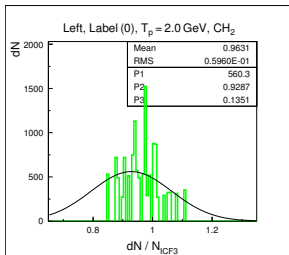
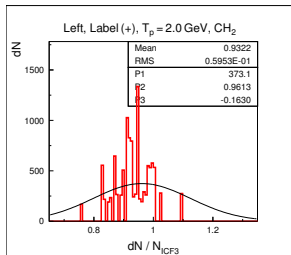
RUN 3, Target CH₂ 3 cm



RUN 3, Target CH₂ 3 cm



RUN 3, Target CH₂ 3 cm



$$\varepsilon(0) = -0.049 \pm 0.006$$

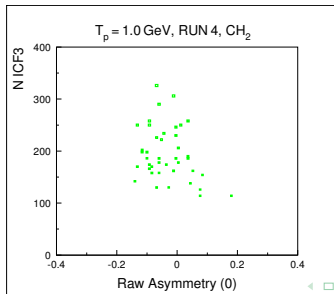
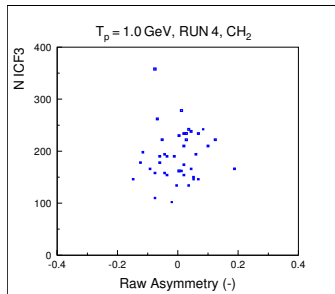
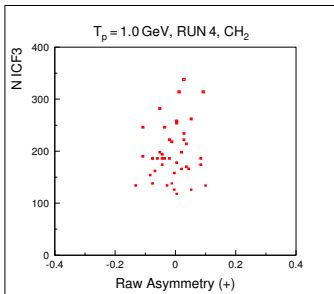
$$A_y P_z(+) = -0.025 \pm 0.006$$

$$A_y P_z(-) = -0.013 \pm 0.006$$

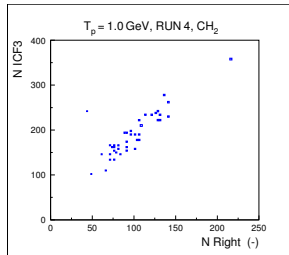
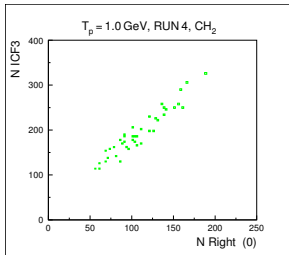
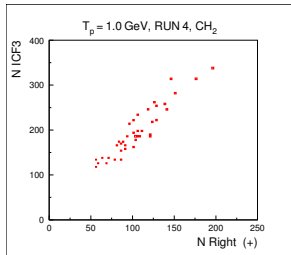
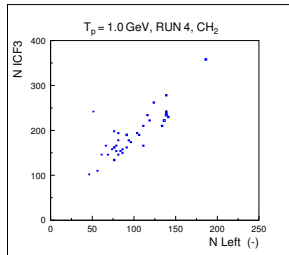
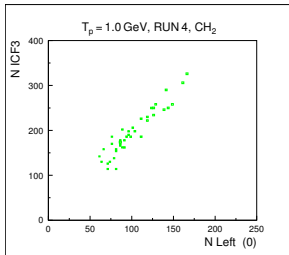
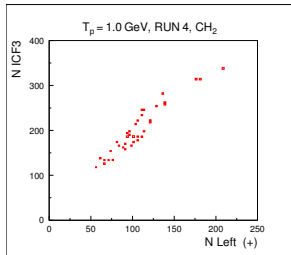
$$\varepsilon(L) = -0.009 \pm 0.007$$

$$\varepsilon(R) = 0.002 \pm 0.006$$

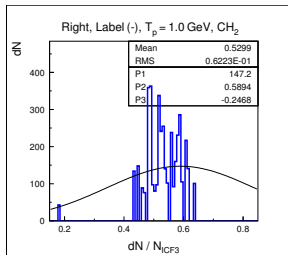
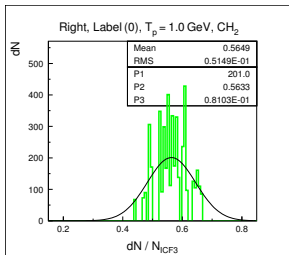
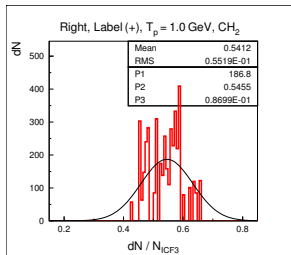
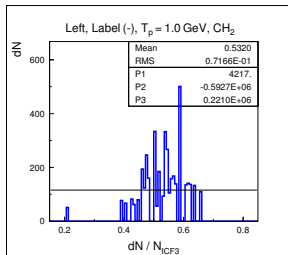
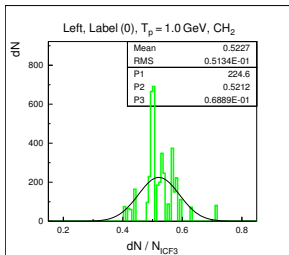
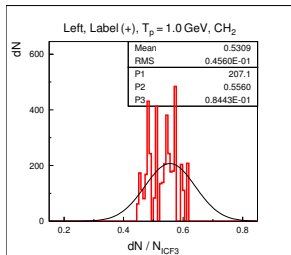
RUN 4, Target CH₂ 3 cm



RUN 4, Target CH₂ 3 cm



RUN 4, Target CH₂ 3 cm



$$\varepsilon(0) = -0.038 \pm 0.011$$

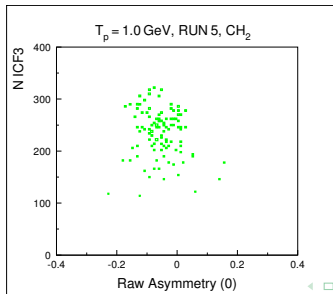
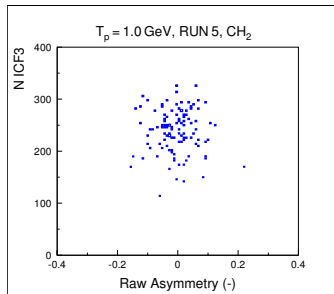
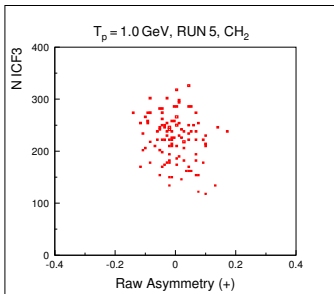
$$A_y P_z(+) = 0.029 \pm 0.011$$

$$A_y P_z(-) = 0.041 \pm 0.011$$

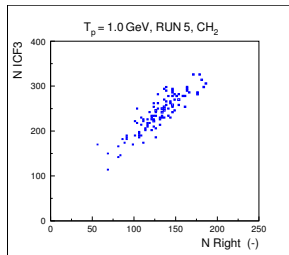
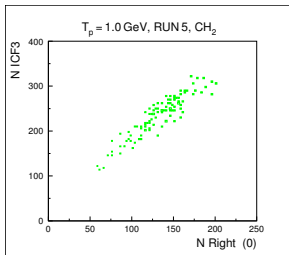
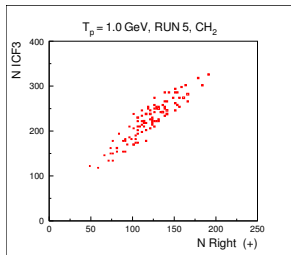
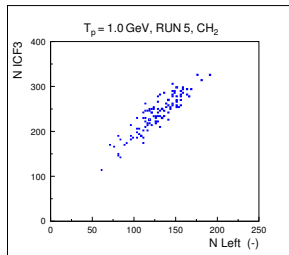
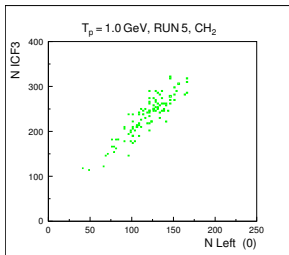
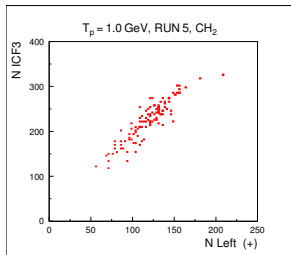
$$\varepsilon(L) = 0 \pm 0.011$$

$$\varepsilon(R) = 0.01 \pm 0.011$$

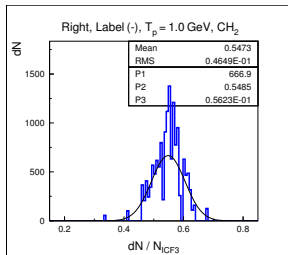
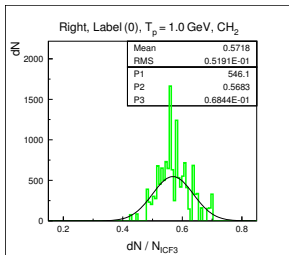
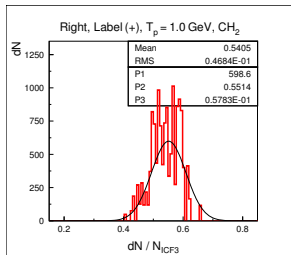
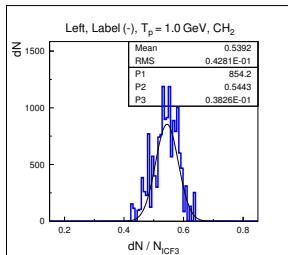
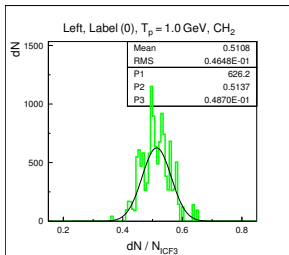
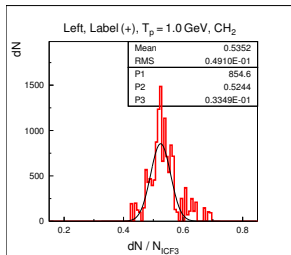
RUN 5, Target CH₂ 3 cm



RUN 5, Target CH₂ 3 cm



RUN 5, Target CH₂ 3 cm



$$\varepsilon(0) = -0.038 \pm 0.011$$

$$A_y P_z(+)= 0.029 \pm 0.011$$

$$A_y P_z(-)= 0.041 \pm 0.011$$

$$\varepsilon(L) = 0 \pm 0.011$$

$$\varepsilon(R) = 0.01 \pm 0.011$$