中国科学院
CHINESE ACADEMY OF SCIENCES

中国科学院近代物理研究所
Institute of Modern Physics, Chinese Academy of Sciences

CEE Alignment

Zhi-Hui Xu (徐志会)

xuzh@impcas.ac.cn

Institute of Modern Physics, CAS

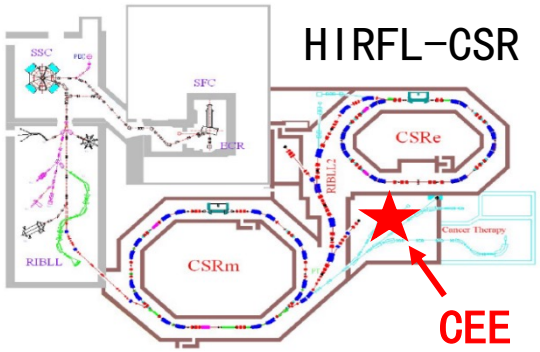
2026-11-21. Hui Zhou

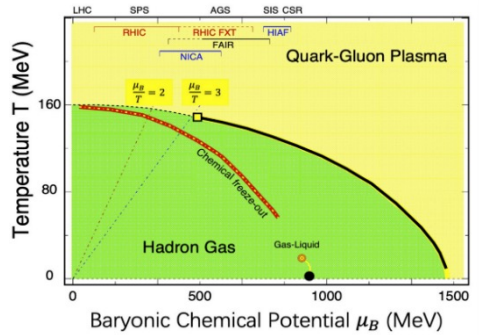
Outline

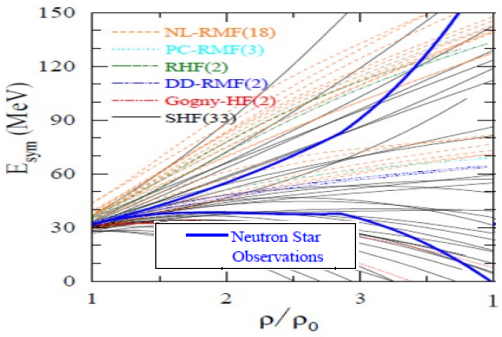
- CEE谱仪
- TPC左右对齐
- TPC-TOF 对齐
- TPC-MWDC对齐
- 总结与展望



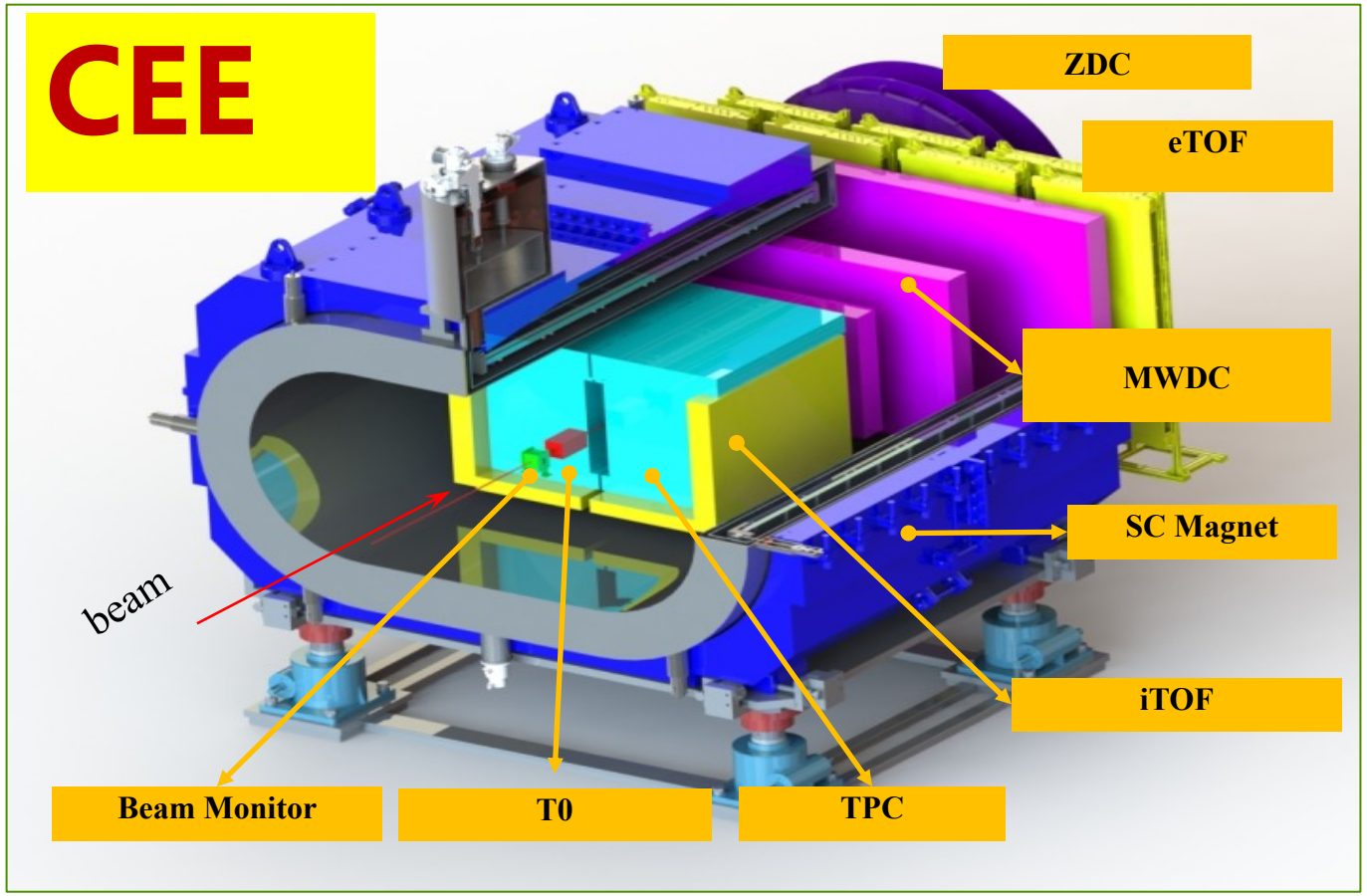
CEE (External-target Experiment) 谱仪







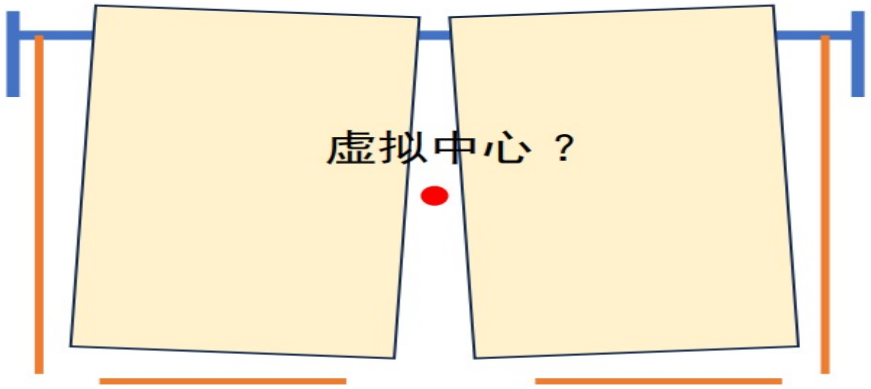
中国首个大型高能核物理谱仪

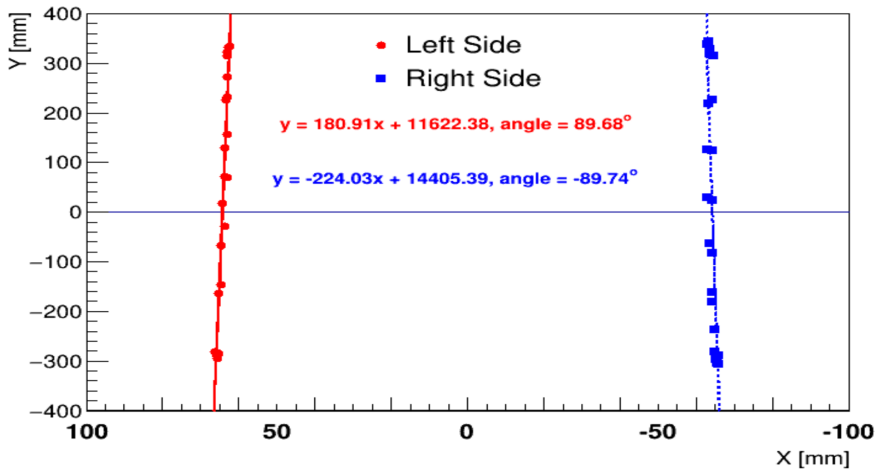


CEE谱仪是设计运行于HIRFL-CSR装置**自主建造**的大型高能核物理实验谱仪，用于核物质相结构、核物质状态方程、短程关联、超核等核物理前沿课题研究。

探测器安装

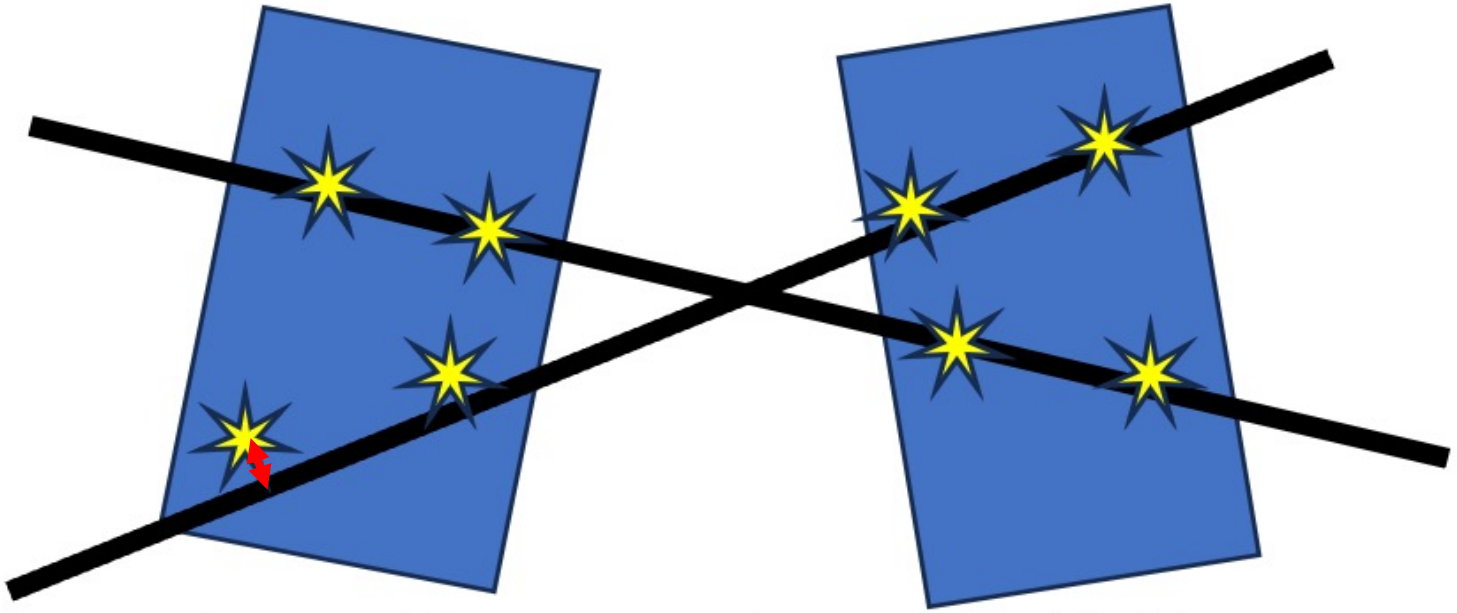


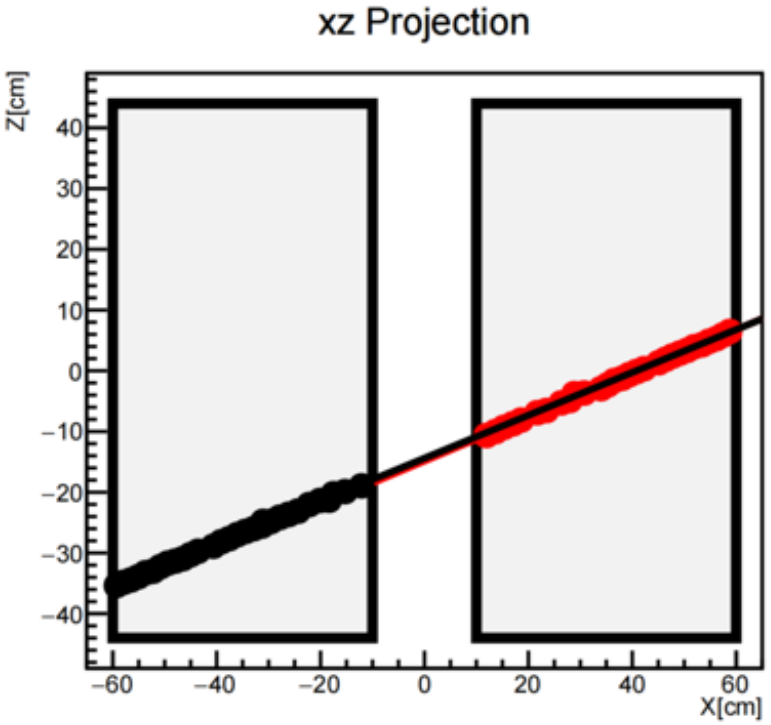




束流实验中探测器摆放：由于环境和工程精度。探测器灵敏单元位置会出现偏差。影响事例重建、读出、分析。

CEE对齐方案





1，左边的Hits移动之后与右边TPC径迹的距离最短。
2，左右两边TPC的Hits重新拟合空间直线，Hits到径迹的总距离最短。

数学问题：最小化参数。
方法：MCMC，iminuit等

蒙特卡洛-马尔科夫链（MCMC）

likelihood $\mathcal{L}(\theta \mid x) = p_\theta(x) = P_\theta(X = x),$

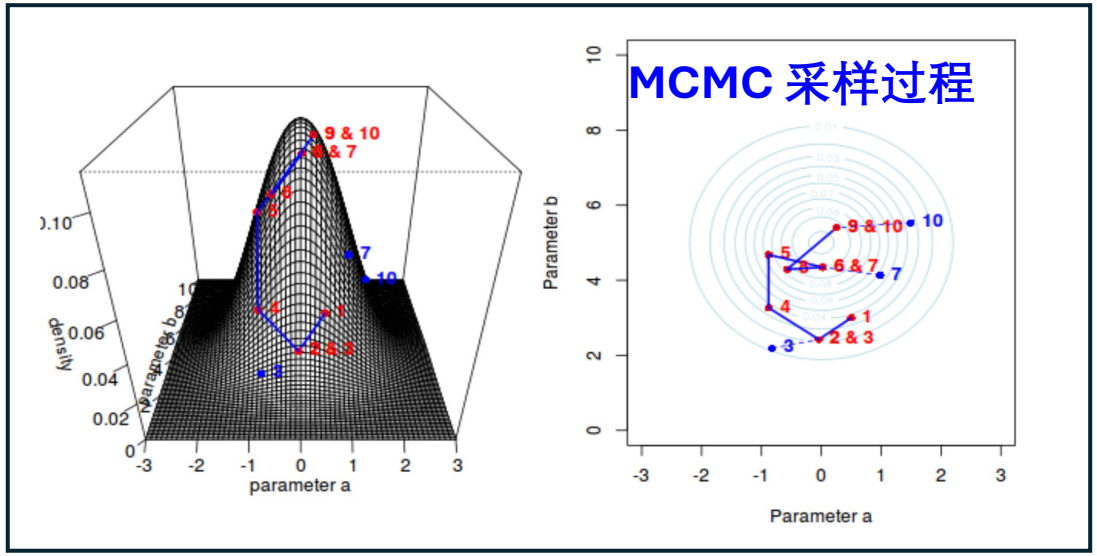
Markov chain Monte Carlo, (MCMC): 一个方位取决于当前状态和随机变量.

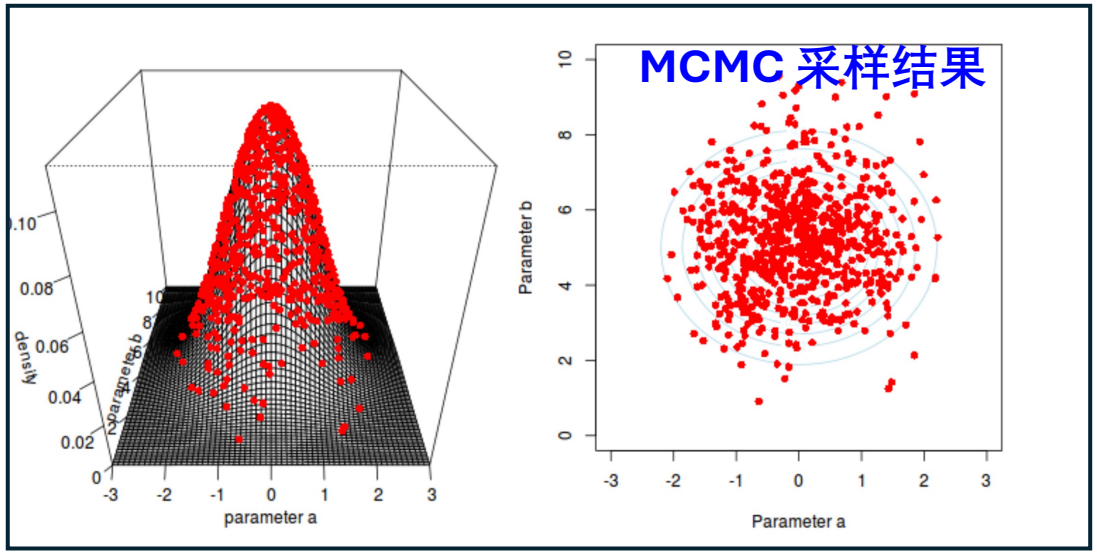
给出一个初始参数和likelihood ，参数在likelihood大的区域被接受的概率更大。到最后，参数会在使得likelihood最大的区域附近分布。

优点：可以处理非线性和高维参数空间，提供参数的不确定性分析，

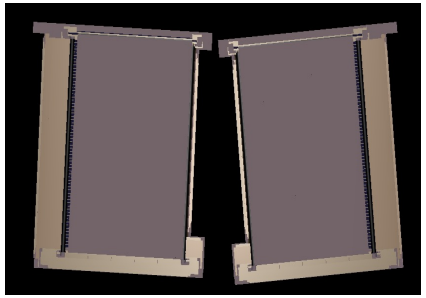
量化不确定性（例如，通过后验分布得到置信区间以及相关矩阵）。

缺点：计算资源需求高，可能需要较长的采样时间。



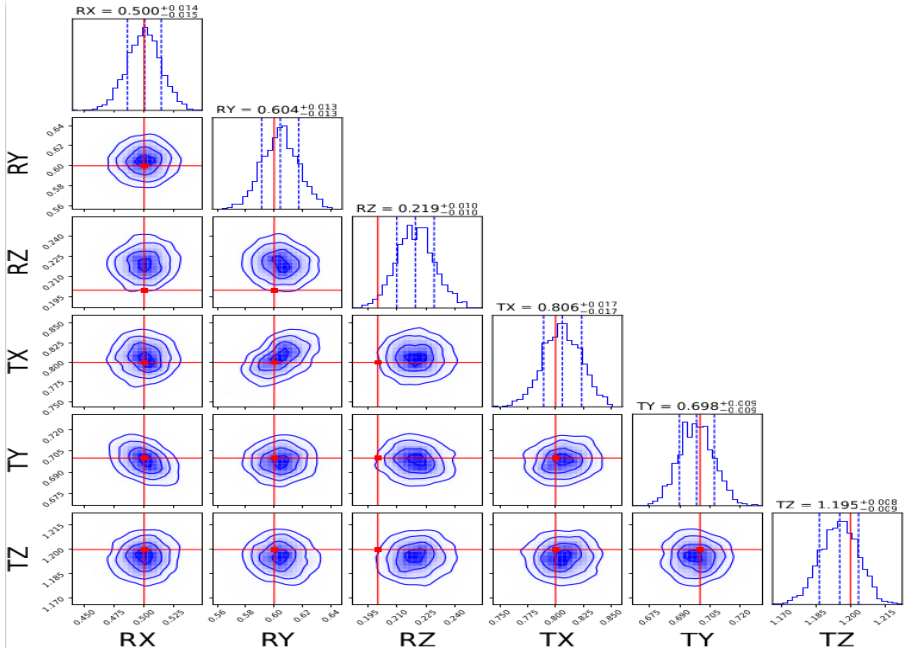


模拟数据验证方法可靠性

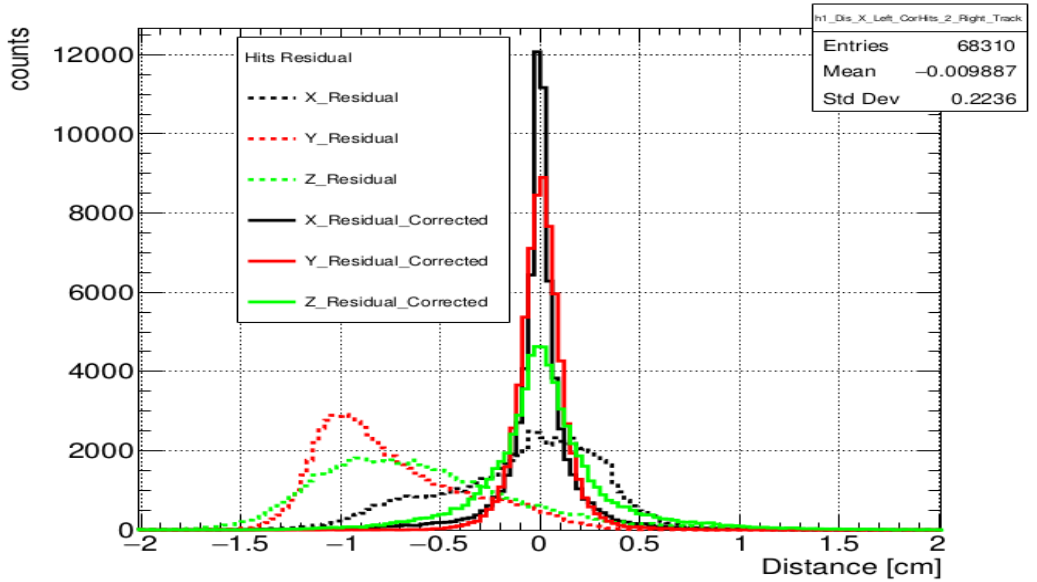


重建参数误差在小数点后第三位。

输入位移与旋转：0.5 cm， 0.6 cm， 0.2 cm， 0.8°， 0.7°， 1.2°
重建位移与旋转：0.500 cm, 0.604 cm，0.219 cm，0.806°，0.698，1.195°

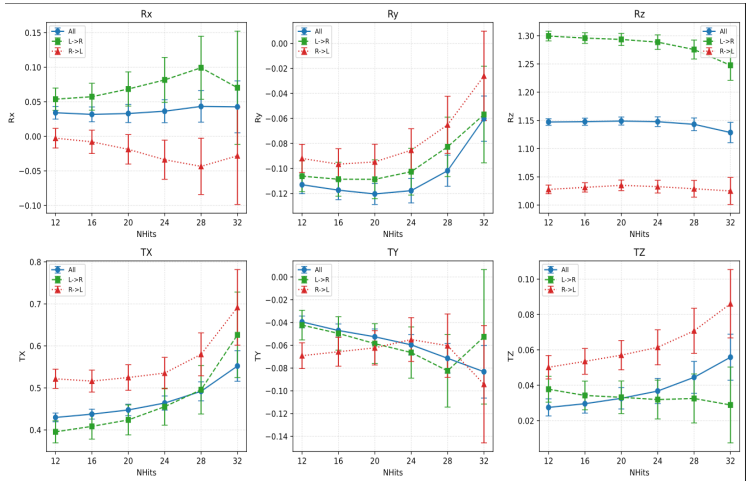


重建参数的二维分布及相关关系

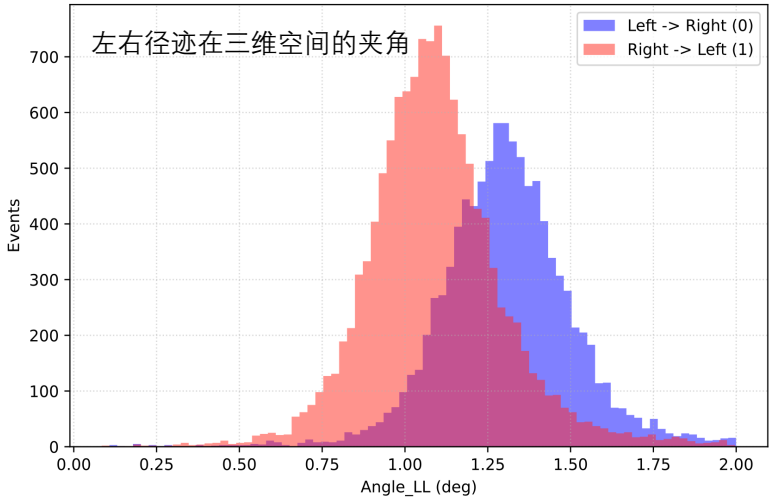


左边Hits到右边径迹距离的修正

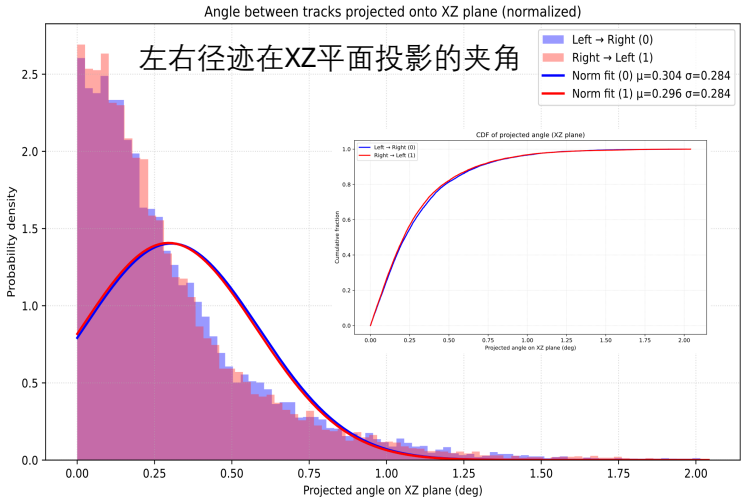
TPC Alignment



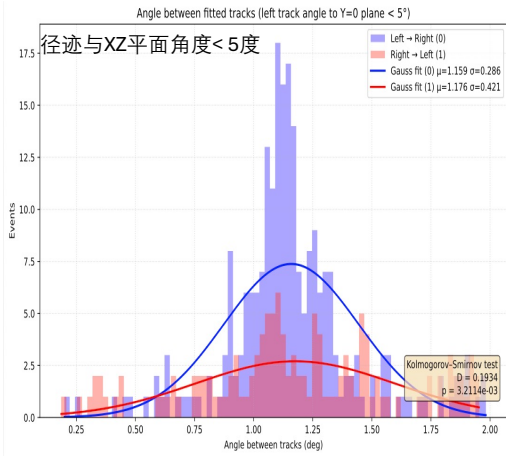
基于从左到右和从右到左的宇宙线得到的Alignment参数略有不同。

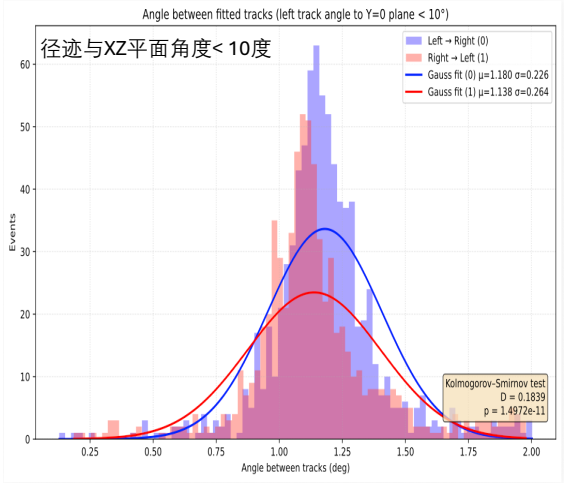


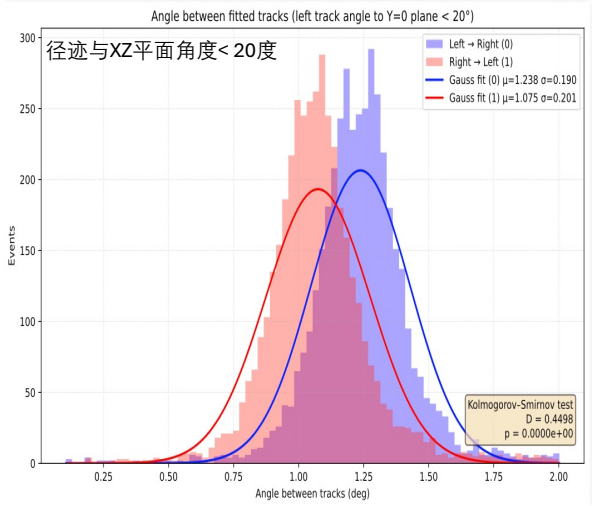
从左到右和从右到左的宇宙线角度差不同。



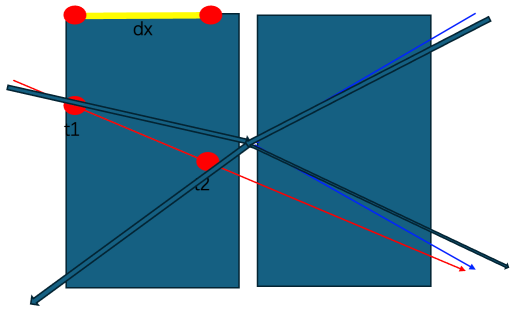
从左到右和从右到左的事例分布相同。





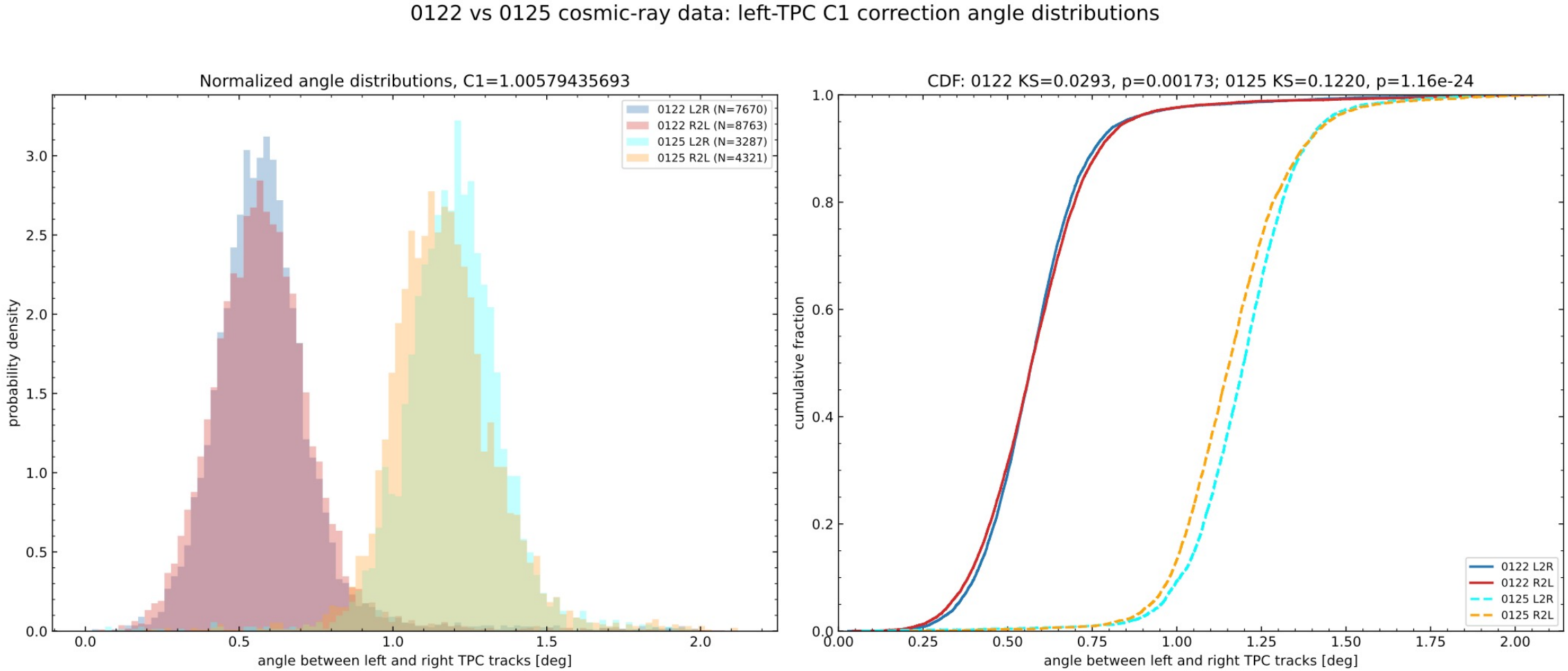


平行于XZ平面的事例，左右径迹夹角与方向无关，
倾斜入射事例左右径迹夹角随倾斜角变化。



分析可能是因为右边TPC径迹的漂移速度重建偏大？

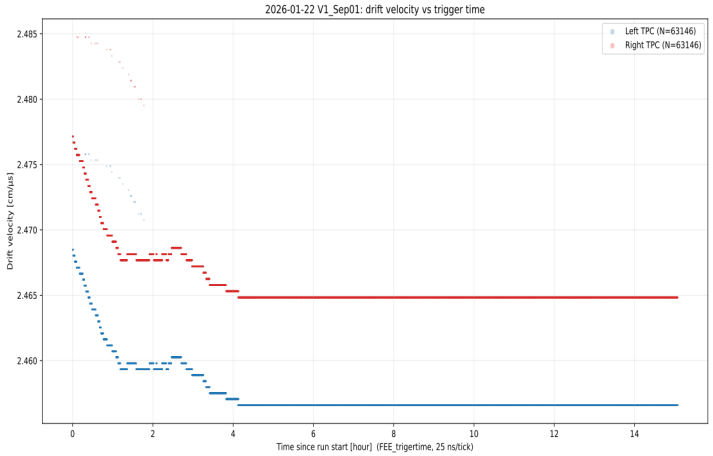
两次数据生产存在差异。

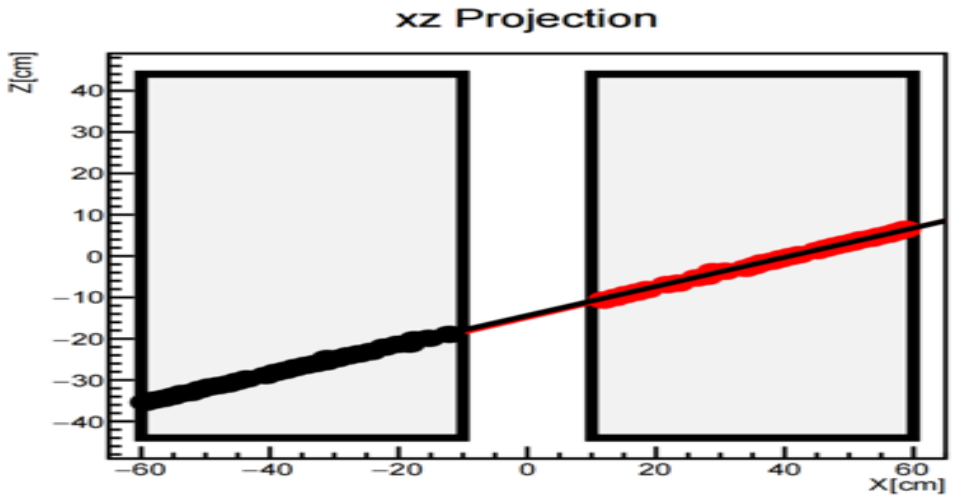


第一次数据重建版本：2025.0125, 两个TPC径迹的角度大约1.1度

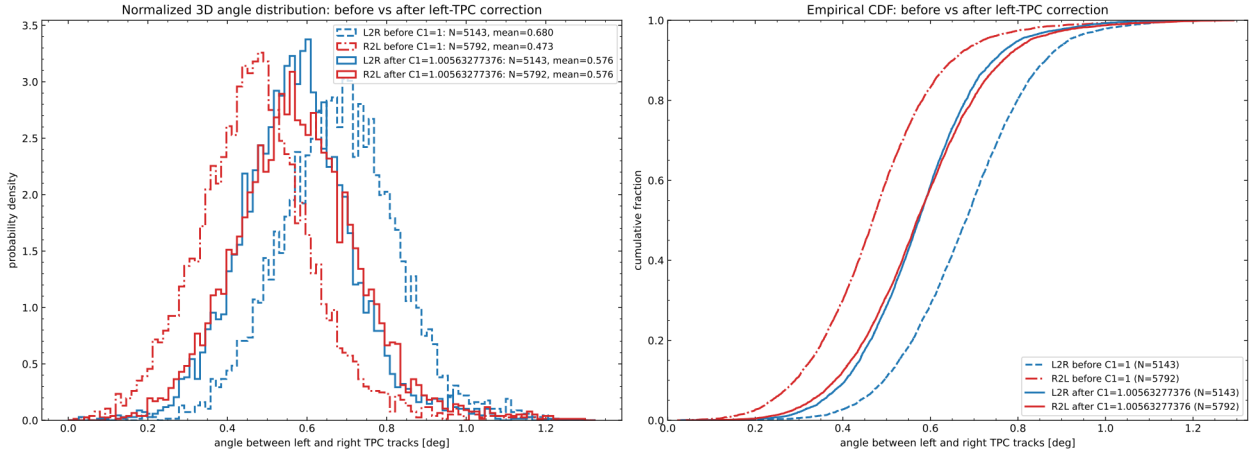
第二次数据重建版本：2025.0122, 两个TPC径迹的角度大约0.6度

漂移速度刻度存在小于1%的误差

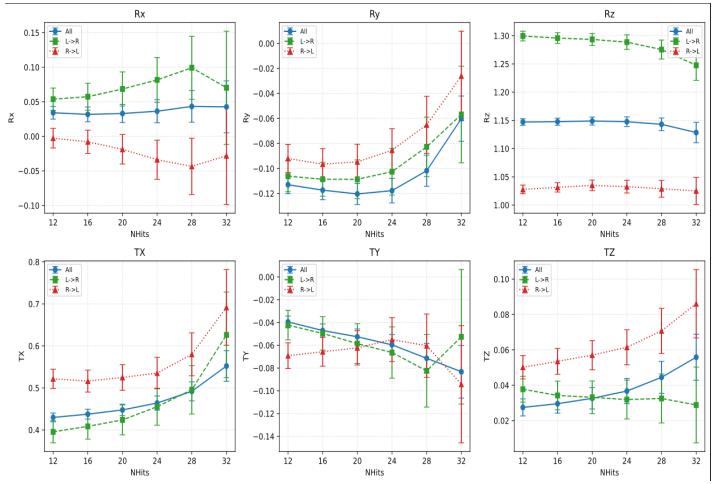




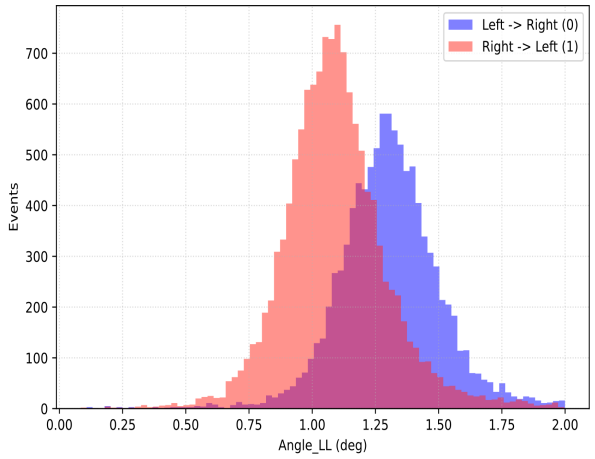
0122 data, left-TPC correction C1=1.00563277376: 3D angle L2R vs R2L



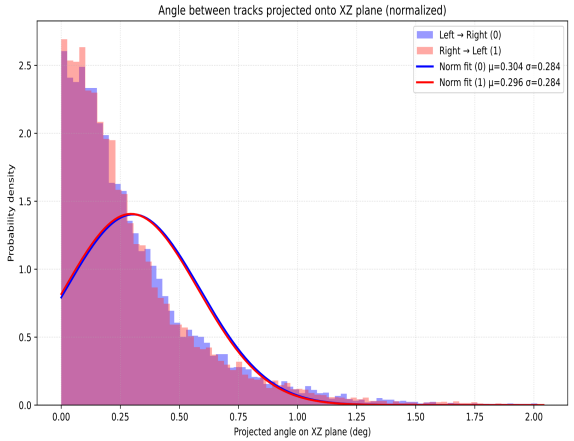
基于宇宙线标定漂移速度



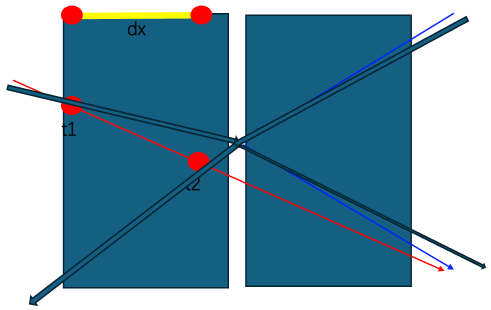
从左到右和从右到左的宇宙线得到的Alignment参数略有不同。



从左到右和从右到左的宇宙线角度差不同。



从左到右和从右到左的事例分布相同。



分析可能是因为右边TPC径迹的漂移速度重建偏大？

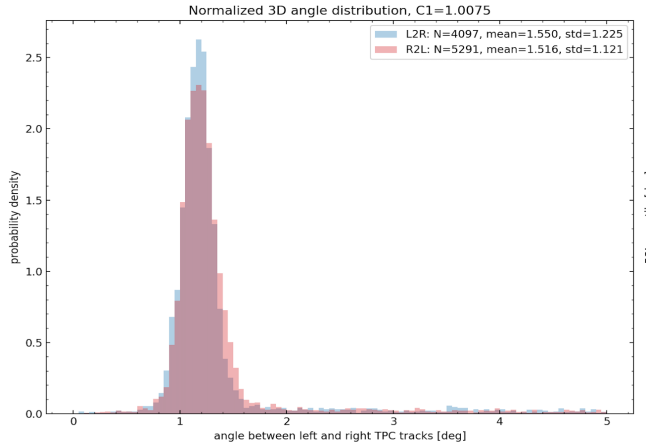
$$Y' = -tBin \times 0.1 \times (DriftV \times C) + (DriftV \times C) \times fDriftCor + 40.9$$

A = L2R 从左到右的宇宙线事例的左右TPC的径迹角度的平均值。

B = R2L从右到左的宇宙线事例的左右TPC的径迹角度的平均值。

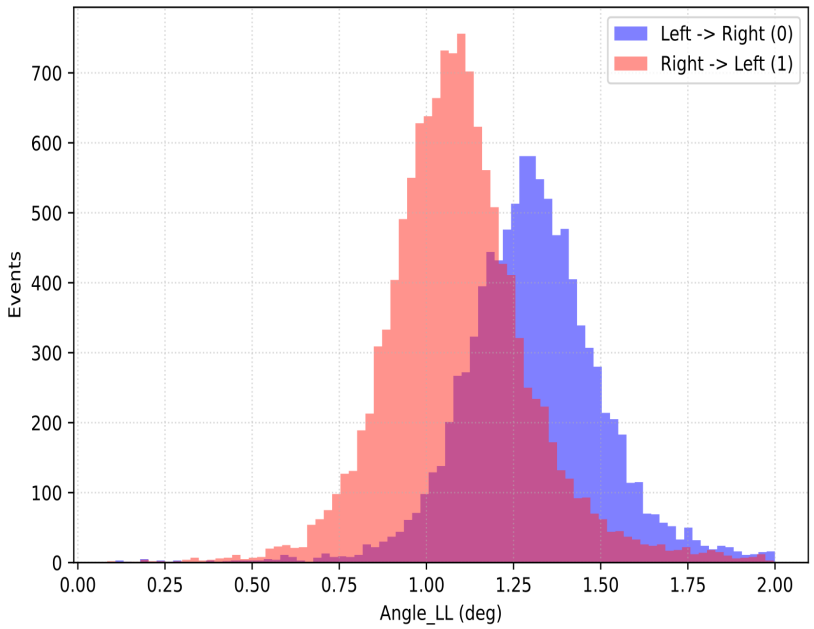
通过给DriftV_Left 一个修正系数C1，使得|A-B|的结果最小。

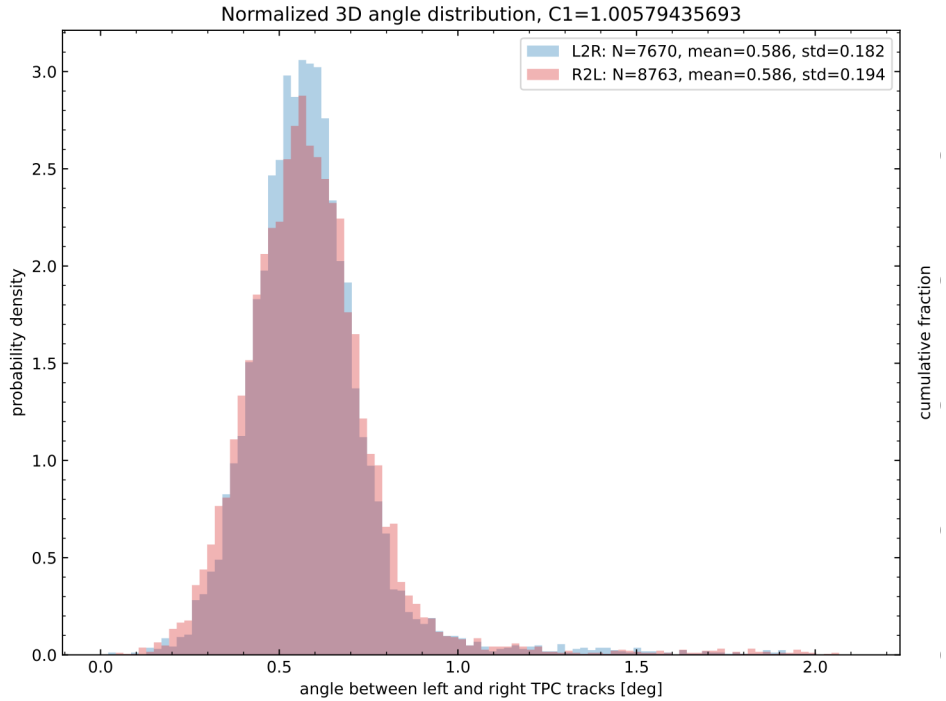
发现C1=1.0075，这与分析的右边TPC漂移速度重建偏大一致。



C1=1.0075，从左到右和从右到左，左右TPC径迹直接角度分布一致。

左右两个TPC径迹的夹角。





第一次数据重建版本：2025.0125

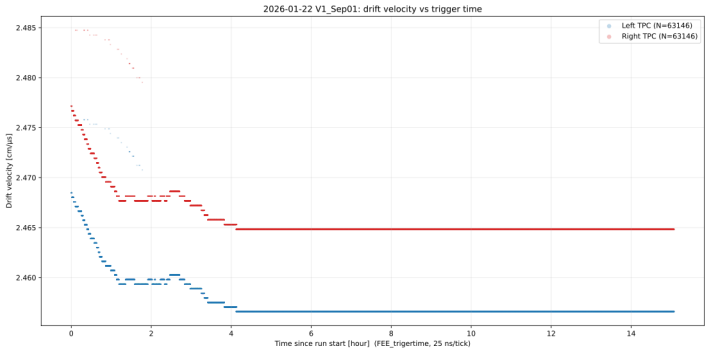
第二次数据重建版本：2025.0122

七个参数同时拟合

参数	C1 + 6	C0 + 6
C1 / C0	1.00564882 ± 0.000358	0.99387332 ± 0.000355
Rx [°]	0.04009 ± 0.01644	0.03898 ± 0.01652
Ry [°]	0.07066 ± 0.01025	0.07077 ± 0.01026
Rz [°]	0.54022 ± 0.00945	0.53888 ± 0.00945
Tx [cm]	0.44760 ± 0.01622	0.45020 ± 0.01628
Ty [cm]	−0.00012 ± 0.01864	0.02221 ± 0.01863
Tz [cm]	0.03079 ± 0.00707	0.03051 ± 0.00706
chi2	14422.877	14375.257

Fit_Alignment_SevenParam_Joint.py
Fit_Alignment_C0PlusSixParam.py

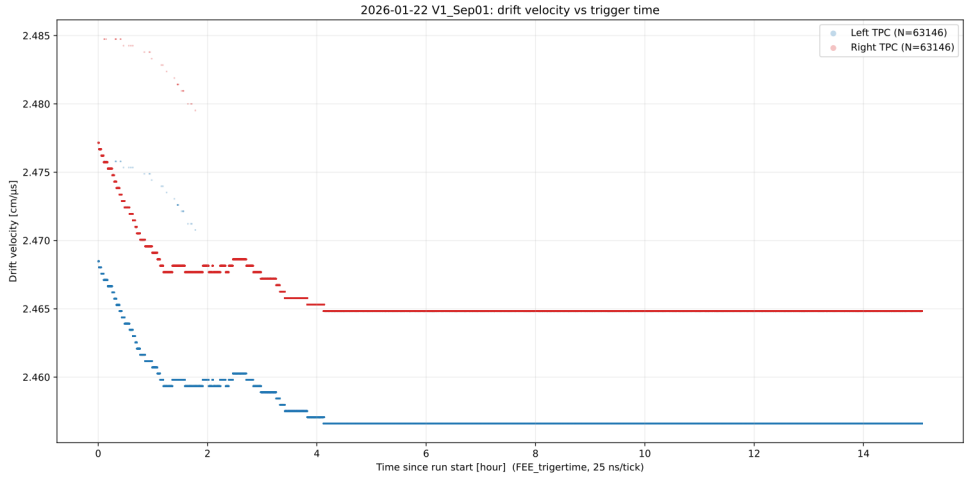
修正左侧和右侧TPC的漂移速度，结果很一致。

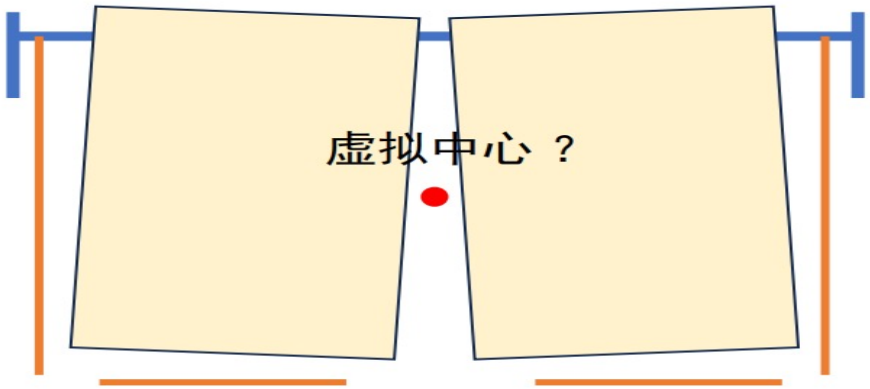


D	chi2	Rx	Ry	Rz	Tx	Ty	Tz
0.99	14341.81	0.0395±0.0166	0.0708±0.0103	0.5369±0.0095	0.4516±0.0163	-0.0006±0.0103	0.0305±0.0071
1.00	14422.88	0.0399±0.0164	0.0707±0.0103	0.5403±0.0094	0.4476±0.0162	-0.0007±0.0103	0.0308±0.0071
1.01	14504.18	0.0401±0.0163	0.0706±0.0103	0.5436±0.0094	0.4436±0.0161	-0.0006±0.0102	0.0311±0.0071

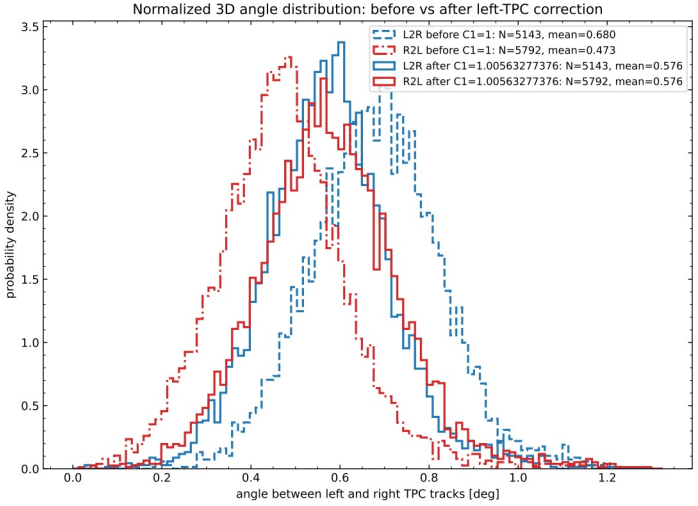
左侧和右侧TPC的漂移速度同时扩大和缩小1%，结果很一致。

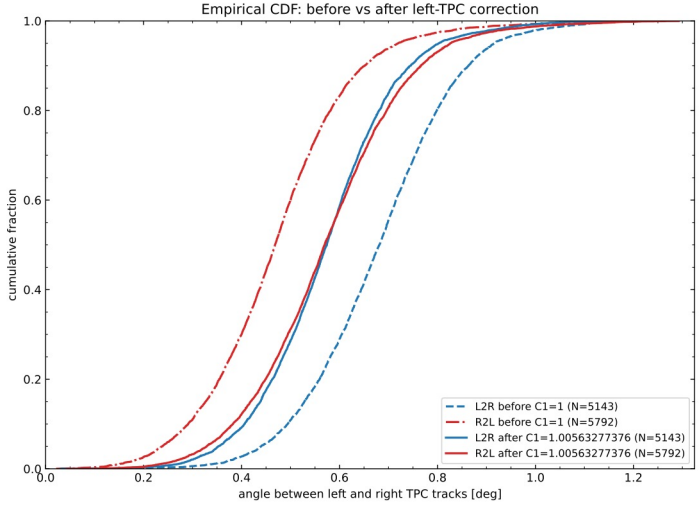
确定TPC1的漂移速度修正系数C1

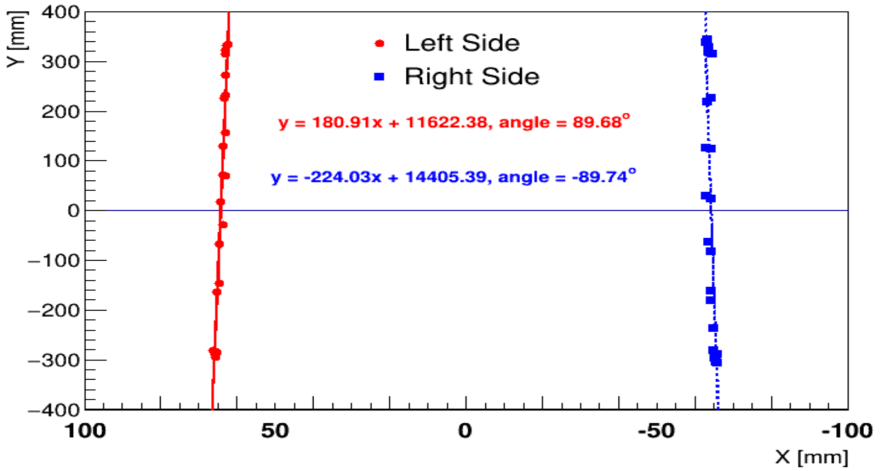




0122 data, left-TPC correction C1=1.00563277376: 3D angle L2R vs R2L







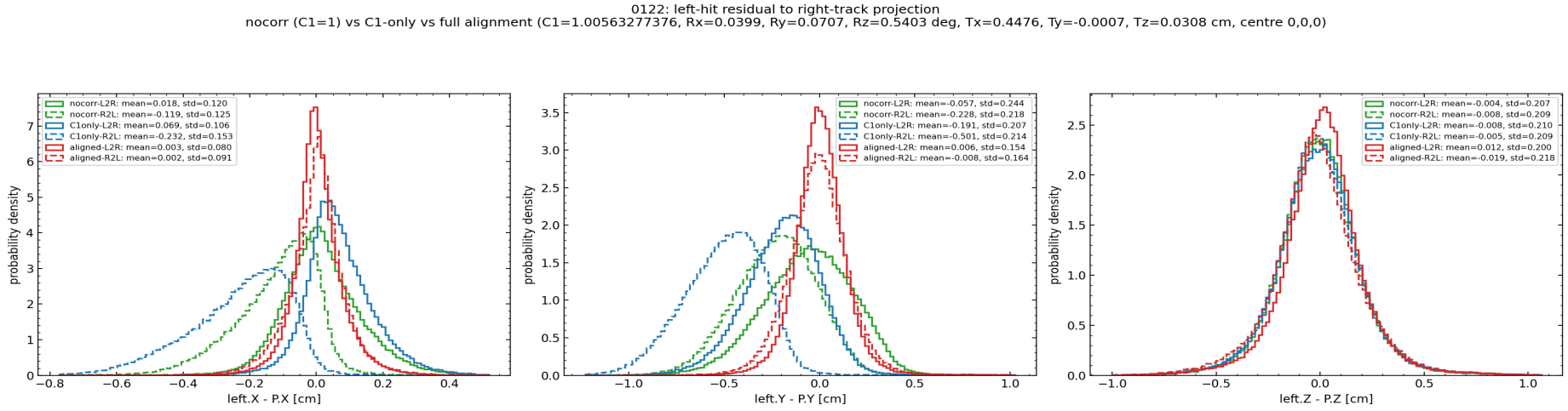
测量两个TPC相对旋转是：0.26+0.32=0.58度

六个参数同时拟合

关键结论：加入平移后，`Rx/Ry` 收敛到一致了

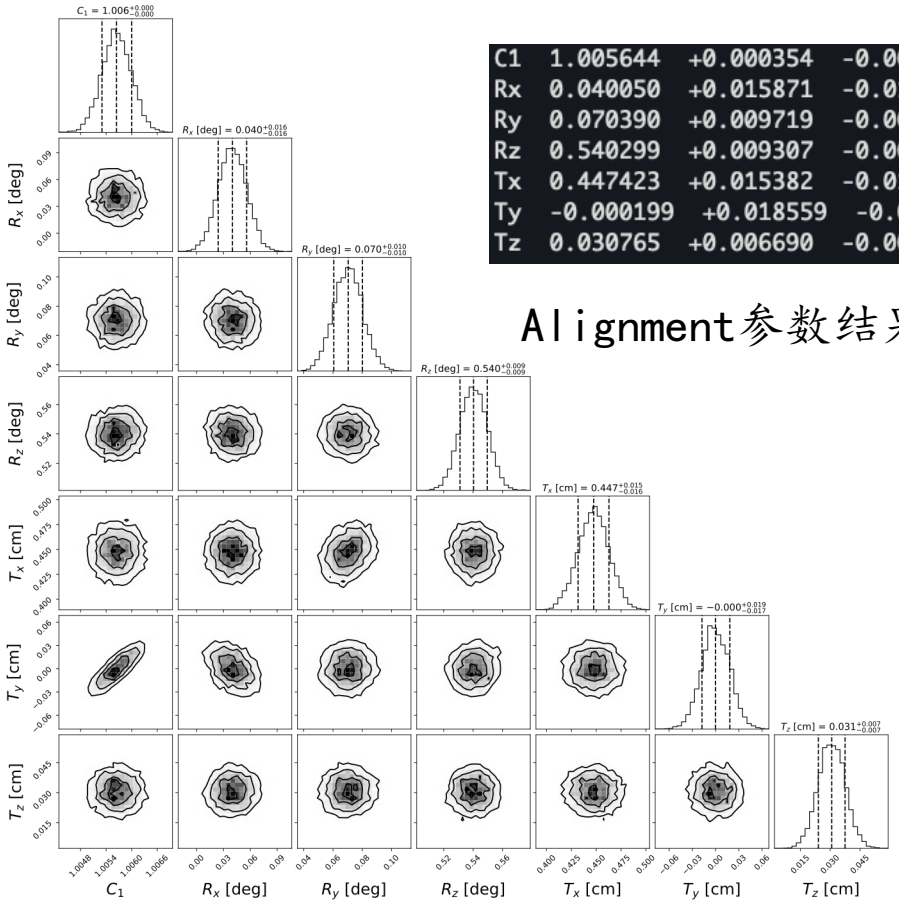
参数	L2R	R2L	all
Rx [°]	0.0551 ± 0.0321	−0.0062 ± 0.0299	0.0399 ± 0.0164
Ry [°]	0.0657 ± 0.0199	0.0987 ± 0.0188	0.0707 ± 0.0103
Rz [°]	0.5466 ± 0.0139	0.5350 ± 0.0130	0.5403 ± 0.0094
Tx [cm]	0.4126 ± 0.0430	0.4553 ± 0.0396	0.4476 ± 0.0162
Ty [cm]	−0.0246 ± 0.0248	0.0243 ± 0.0224	−0.0007 ± 0.0103
Tz [cm]	0.0128 ± 0.0107	0.0478 ± 0.0098	0.0308 ± 0.0071

/public/home/xuzh/Cee_Work/Match_and_Alignment/Cosmic_Ray/Fit_Alignment_SixParam_PointLine.py



C1_Alignment_HitResidual_0122_Aligned_C1only_NoCorr

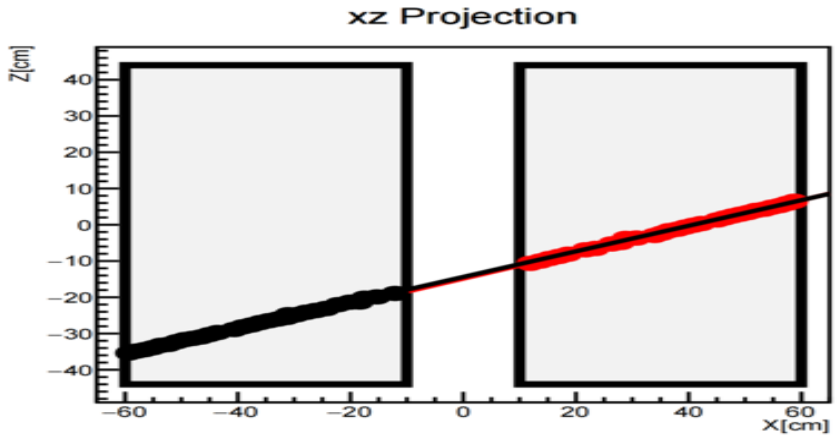
宇宙线数据得到对齐参数



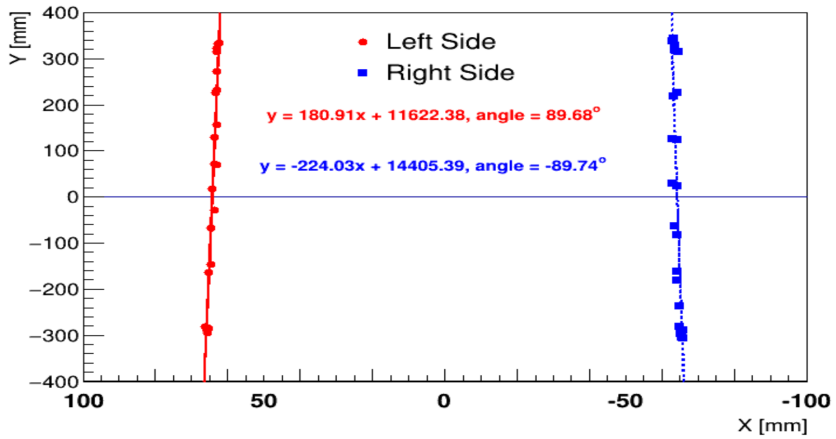
Alignment参数的二维分布及相关关系

C1	1.005644	+0.000354	-0.000342
Rx	0.040050	+0.015871	-0.015951
Ry	0.070390	+0.009719	-0.009868
Rz	0.540299	+0.009307	-0.009228
Tx	0.447423	+0.015382	-0.015706
Ty	-0.000199	+0.018559	-0.017410
Tz	0.030765	+0.006690	-0.006734

Alignment参数结果



Alignment 候选事例展示



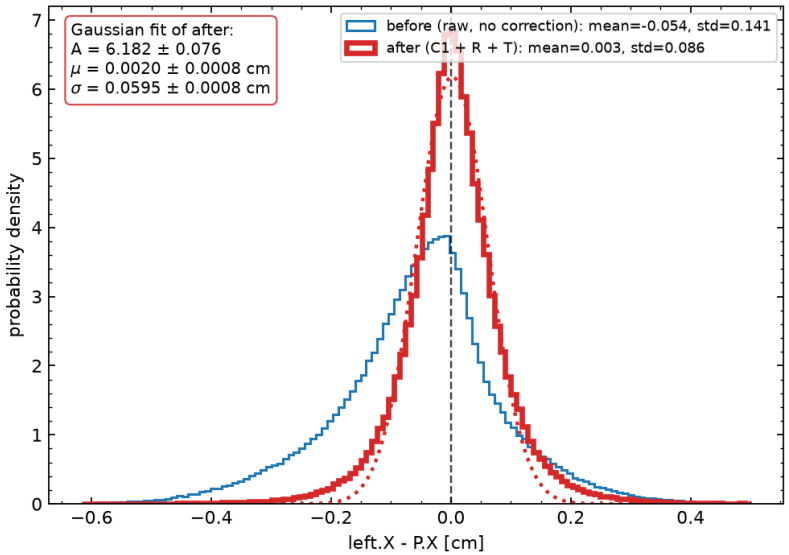
测量两个TPC相对旋转是：0.26+0.32=0.58度

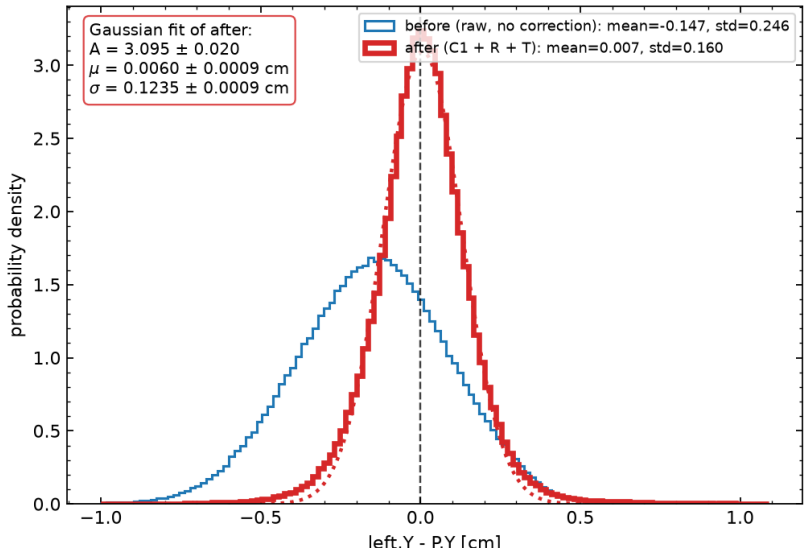
参数结果与测量一致：绕Z轴旋转约0.58度

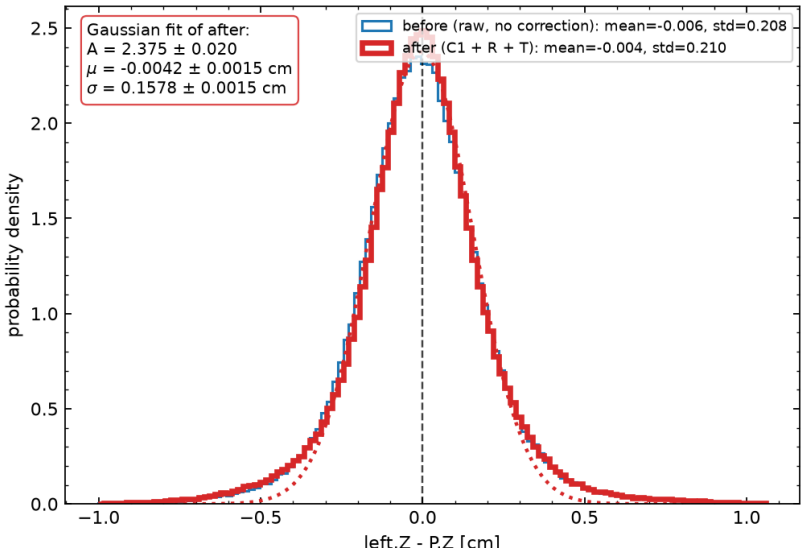
检验Alignment效果：宇宙线检验

0122 all events: before (raw) vs after full correction
C1=1.0056488; Rx=0.0395, Ry=0.0707, Rz=0.5395 deg; Tx=0.4489, Ty=0.0111, Tz=0.0307 cm; rotation centre (0,0,0) cm

Cosmic_Ray/C1_Alignment_HitResidual_0122_BeforeAfter_All_AveragedParams_Fit.pdf







蓝色：什么都不修正的原始残差。

红色粗线：完整修正后的残差。

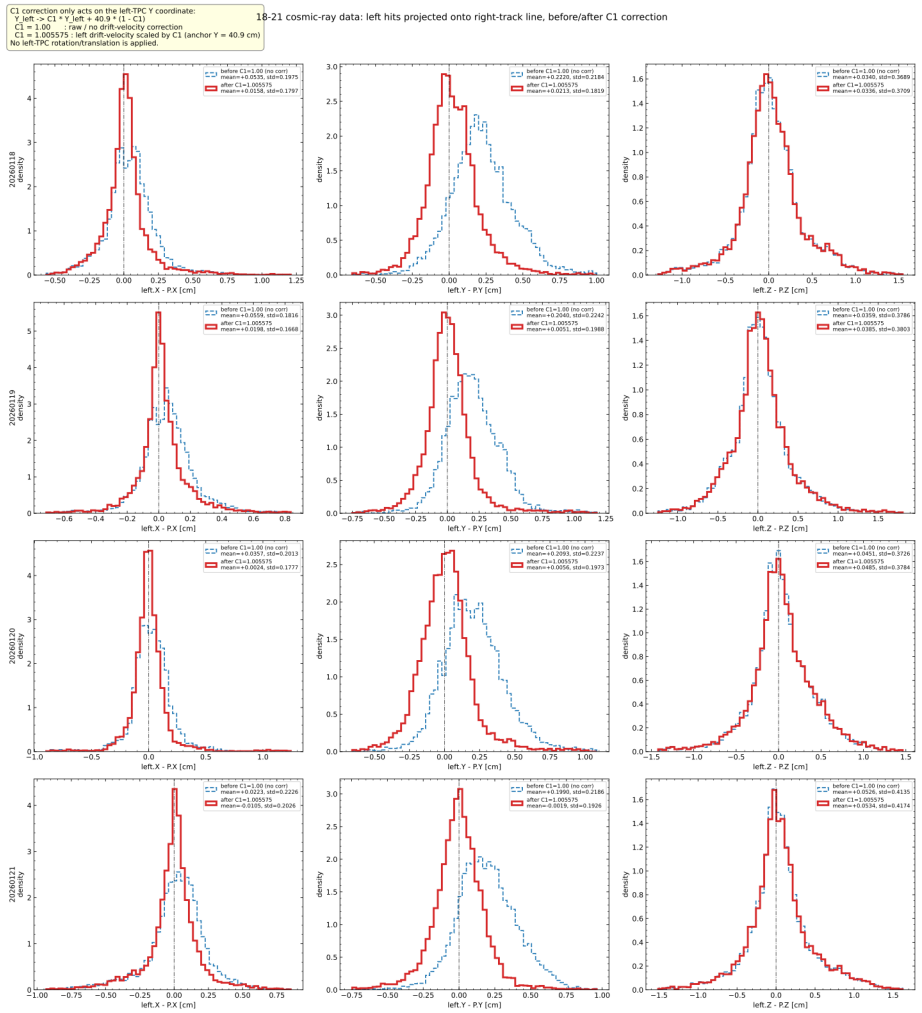
黑色虚线：`x = 0`。

红色点线：修正后残差的高斯拟合。

修正后高斯拟合参数：

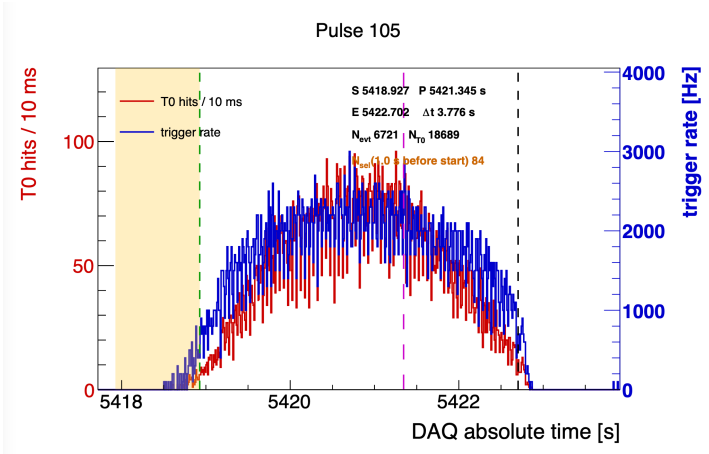
分量	A	μ [cm]	σ [cm]
X	`6.182 ± 0.076`	`0.0020 ± 0.0008`	`0.0595 ± 0.0008`
Y	`3.095 ± 0.020`	`0.0060 ± 0.0009`	`0.1235 ± 0.0009`
Z	`2.375 ± 0.020`	`-0.0042 ± 0.0015`	`0.1578 ± 0.0015`

重建宇宙线数据验证Alignment参数

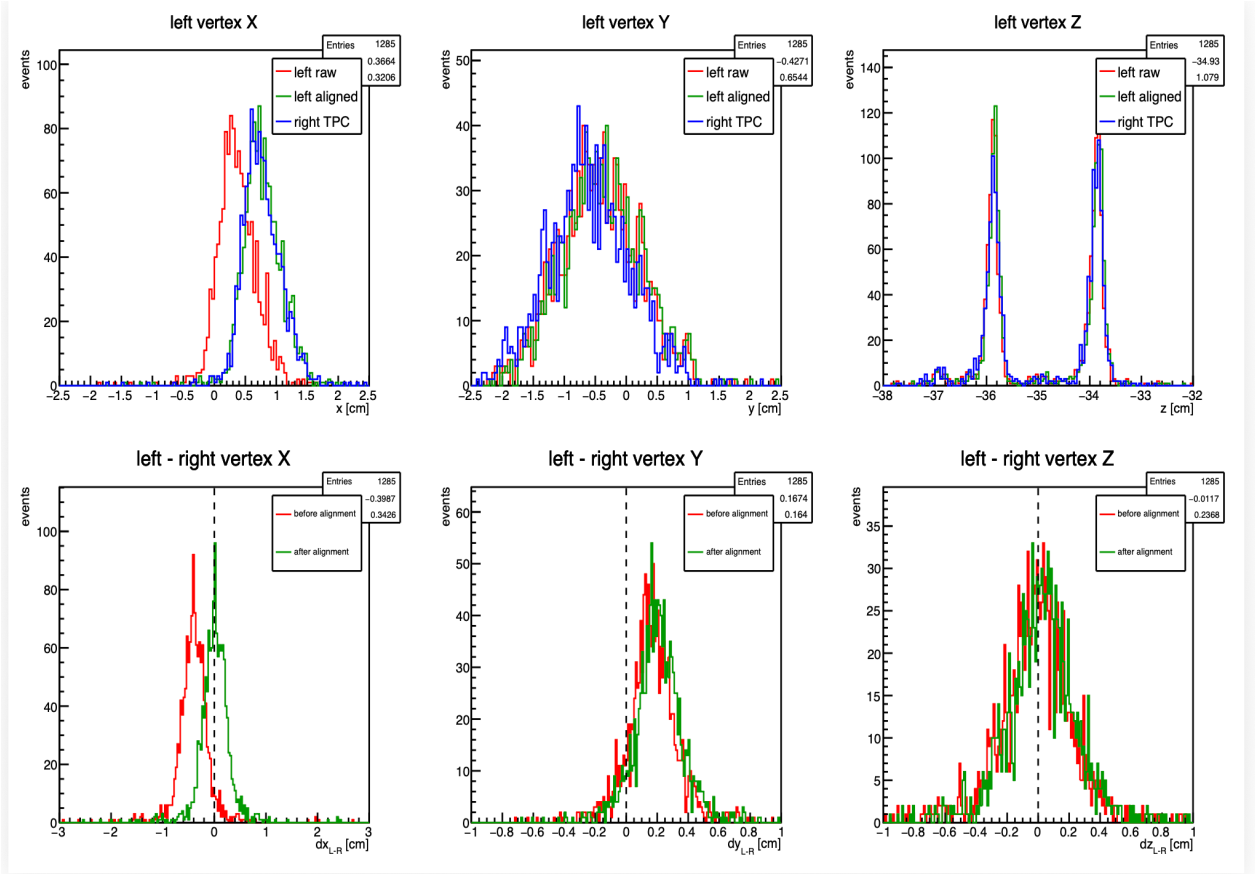


18-21共享一个C1修正。

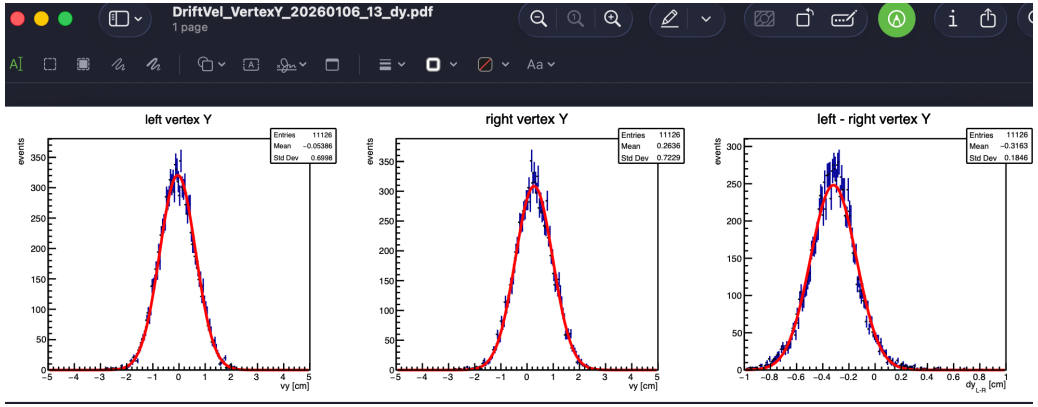
检验Alignment效果：束流检验

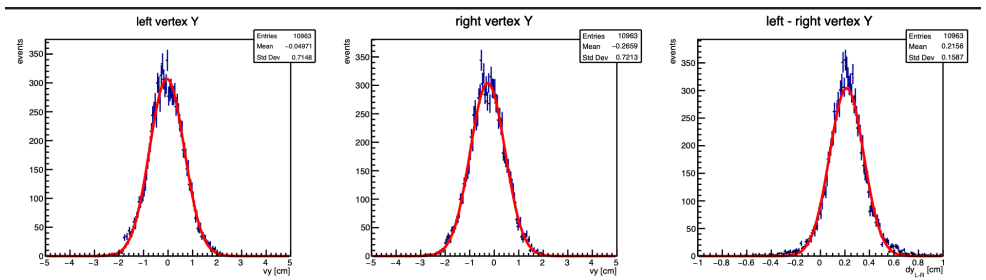


事例选择，脉冲开始前1s，黄色阴影区域。

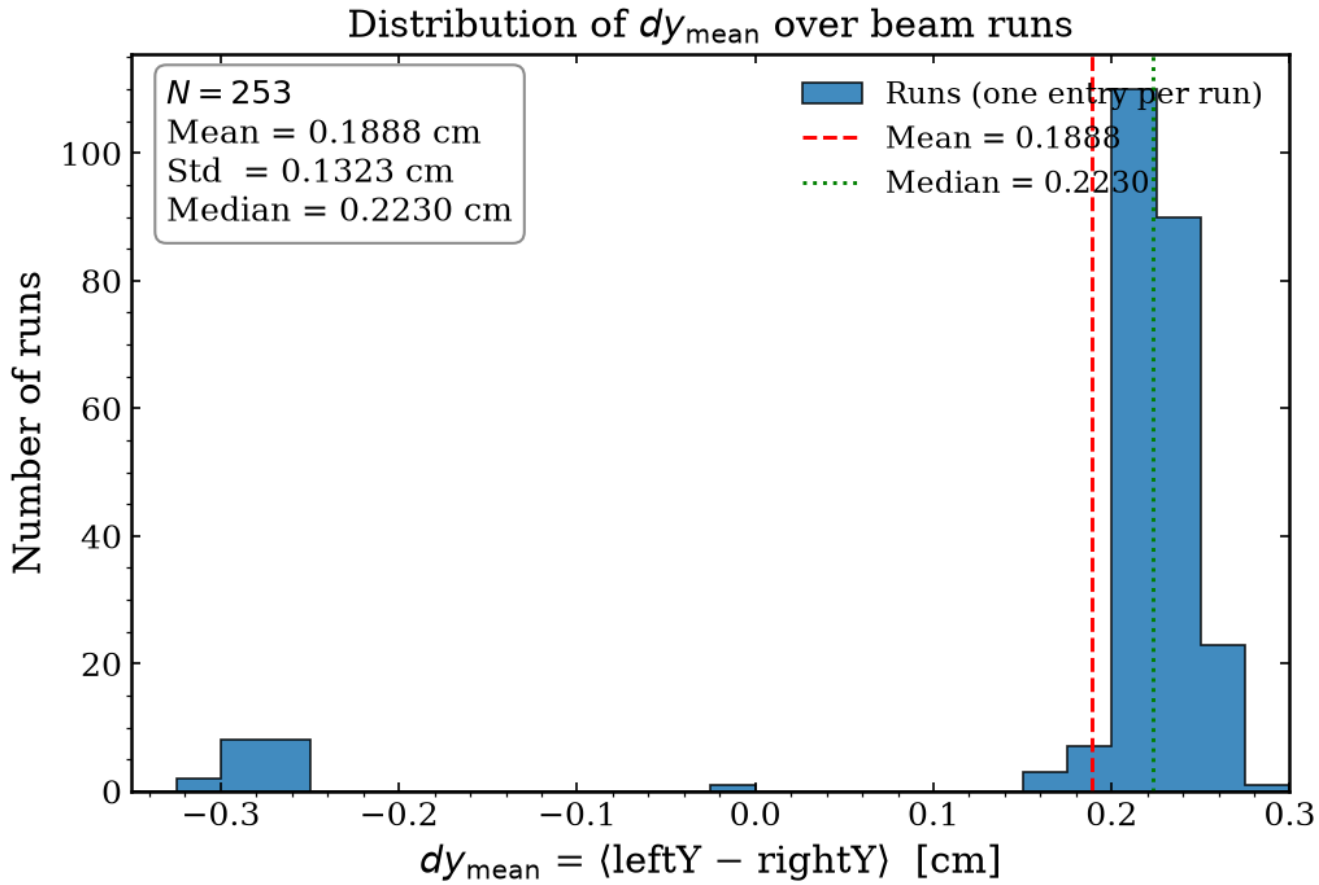


左右TPC vertex 的相对差异。

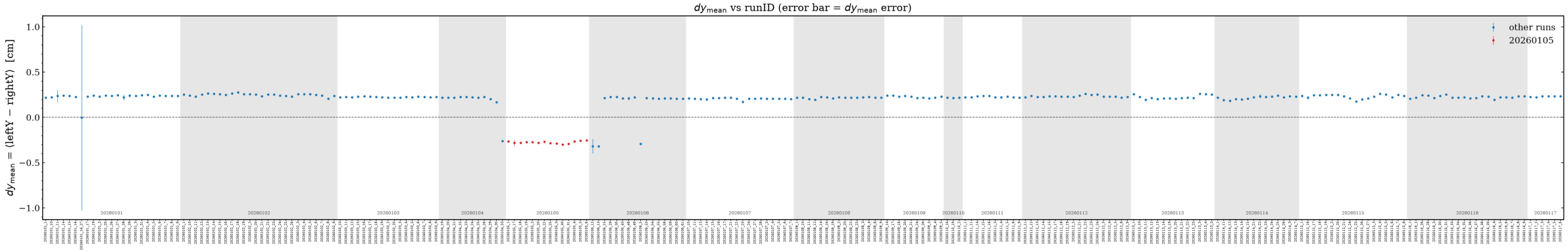


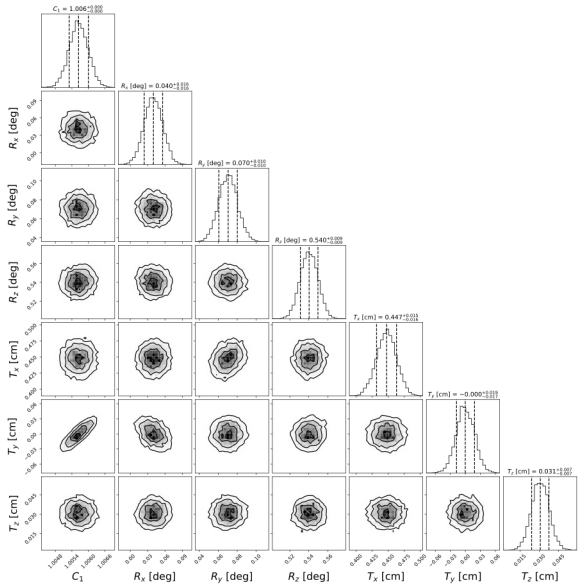


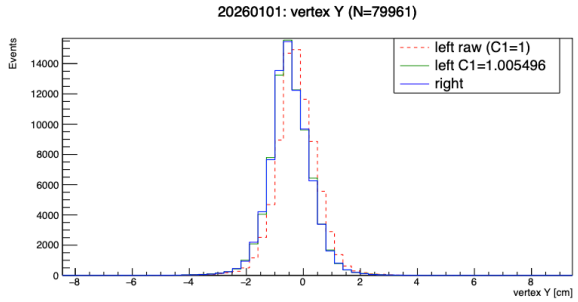
06_15

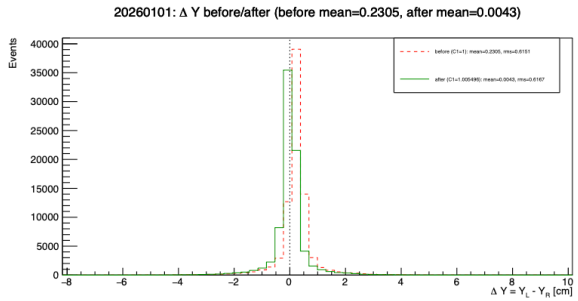


Delta Vertex Y 随run ID的变化



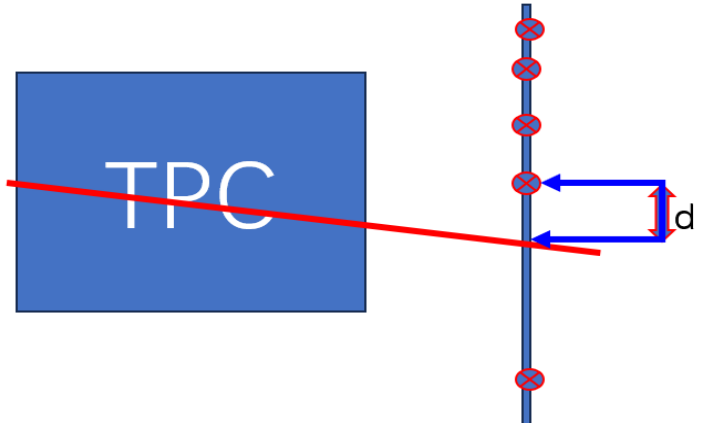




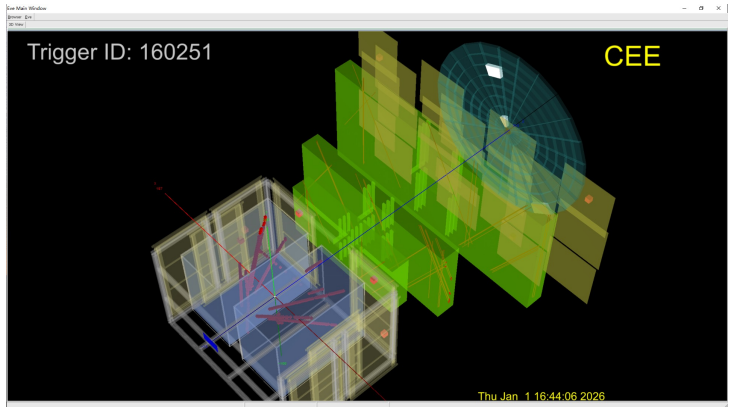


宇宙线和数据都需要左边TPC的漂移速度修正0.5%

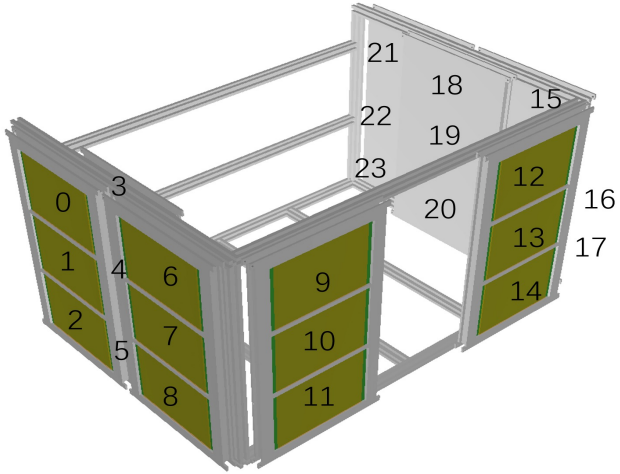
TOF探测器匹配



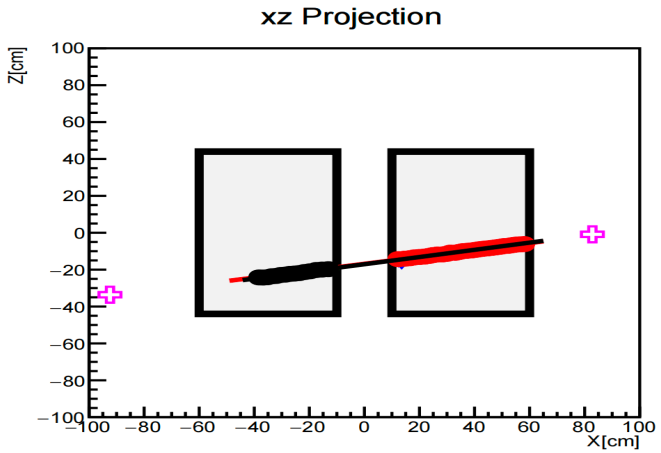
TPC和TOF读出匹配。



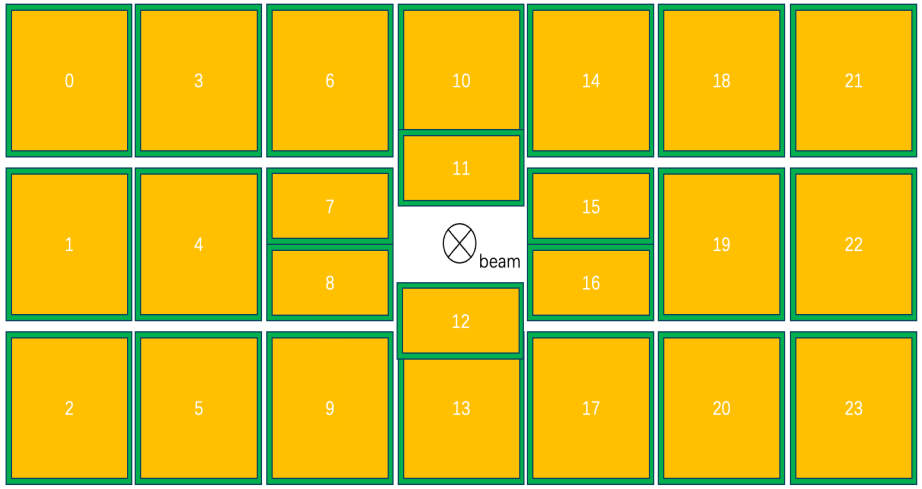
束流事例显示



iTOF 几何示意图

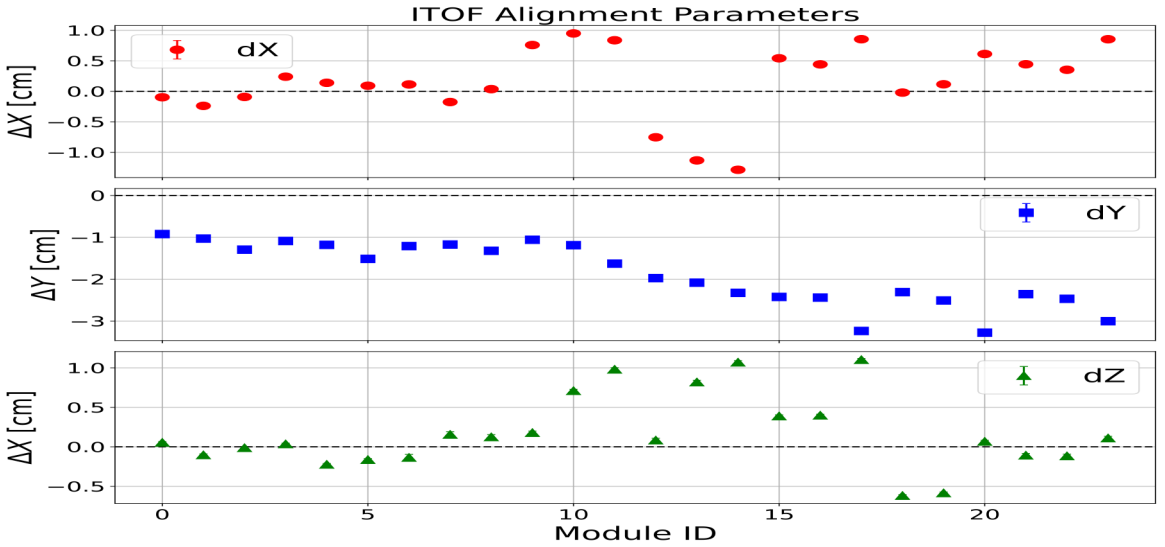


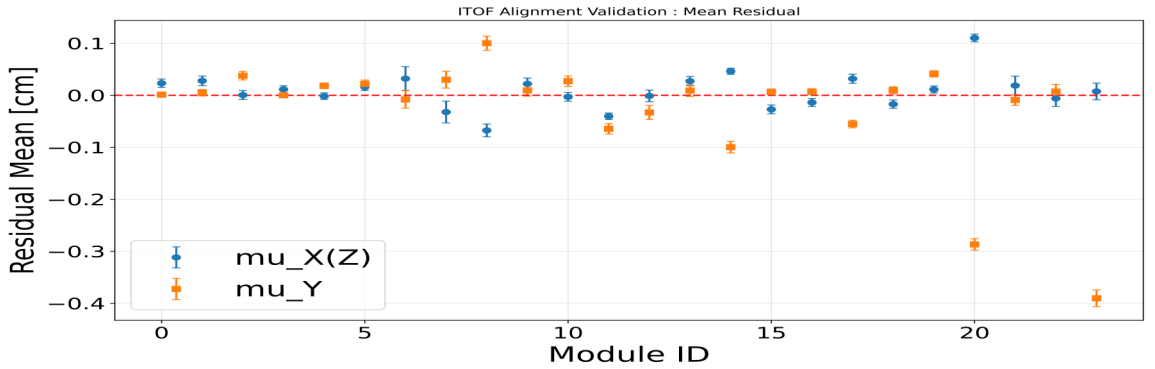
宇宙线事例TPC径迹和iTOF Hits匹配显示



ETOF分布示意图

ITOF Hits Match with TPC Track

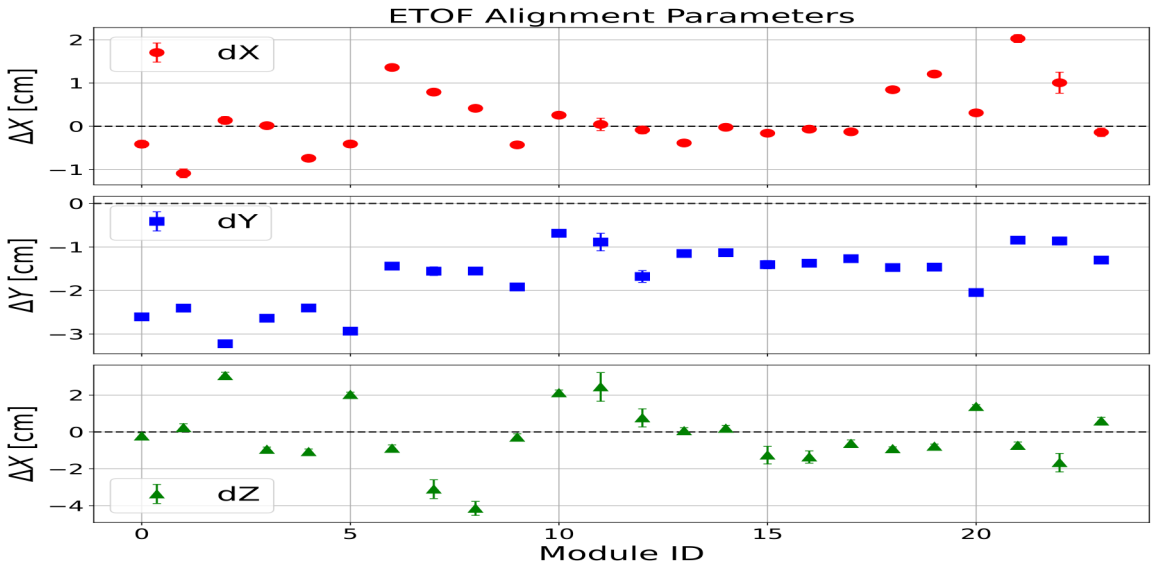


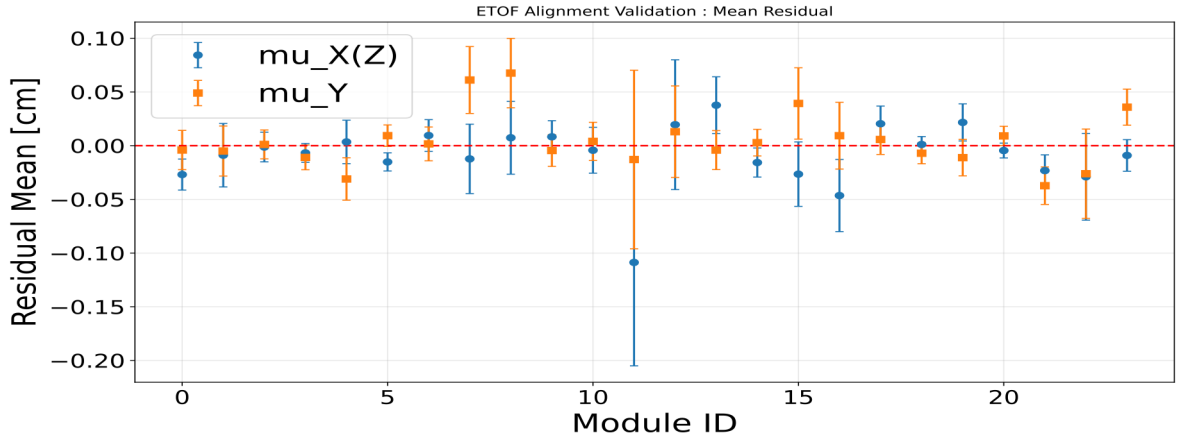


ITOF修正效果

修正后的分布均值

ETOF Hits Match with TPC Track

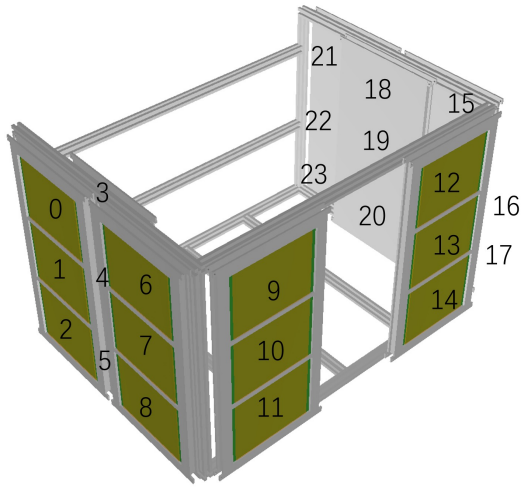


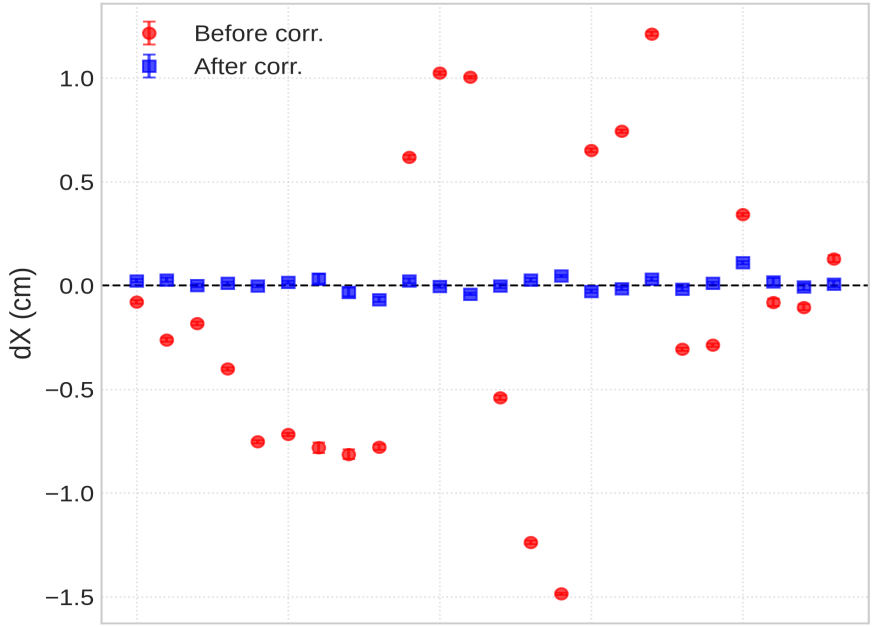


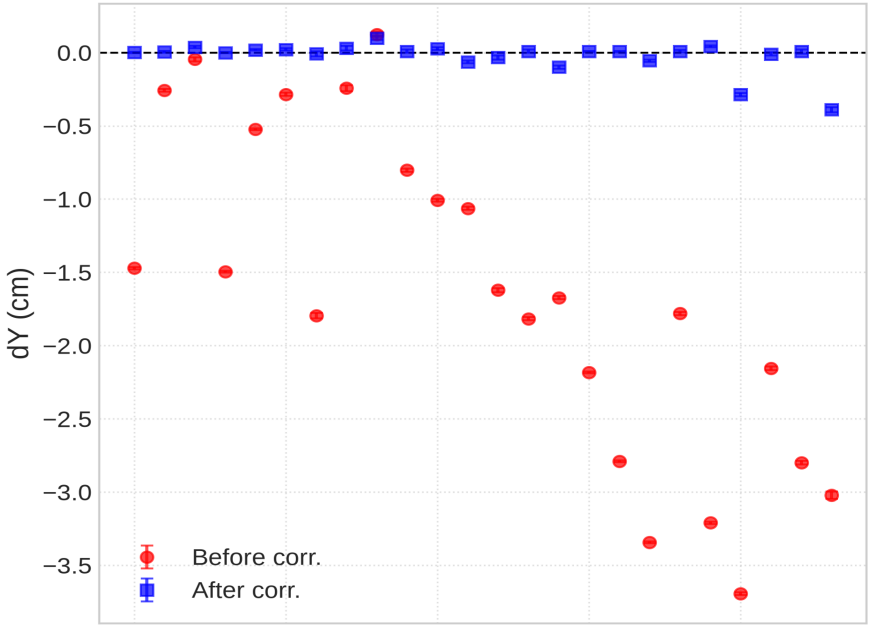
ETOF修正效果

修正后的分布均值

TOF Hits Match with TPC Track







ITOF 匹配后，TOF Hits到TPC径迹的距离减小。

TOF Alignment task

- CeeRoot/Alignment

  CeeTOFAlignmentTask.h，CeeTOFAlignmentTask.cxx

  run_TOF_alignment.C example macro

```
// ============================================================
// iTOF alignment task
// ============================================================
CeeTOFAlignmentTask* alignTask_iTOF =
    new CeeTOFAlignmentTask("CeeTOFAlignmentTask_iTOF", 1);

alignTask_iTOF->SetInputBranchName("CeeiTOFHit");
alignTask_iTOF->SetOutputBranchName("CeeiTOFHit");

// 如果参数文件中没有某个 module 的修正量，则使用默认 shift
alignTask_iTOF->SetShift(0.0, 0.0, 0.0);

// 如果 detID = moduleID * 100 + stripID，建议打开
// alignTask_iTOF->SetDetIdDivisor(100);

// 如果需要指定模块数，打开
// alignTask_iTOF->SetNModules(24);

alignTask_iTOF->SetAlignmentParFile(
    "3D_ITOF_Results.dat"
);

run->AddTask(alignTask_iTOF);
```

```
// ============================================================
// eTOF alignment task
// ============================================================
CeeTOFAlignmentTask* alignTask_eTOF =
    new CeeTOFAlignmentTask("CeeTOFAlignmentTask_eTOF", 1);

alignTask_eTOF->SetInputBranchName("CeeEtofHit");
alignTask_eTOF->SetOutputBranchName("CeeEtofHit");

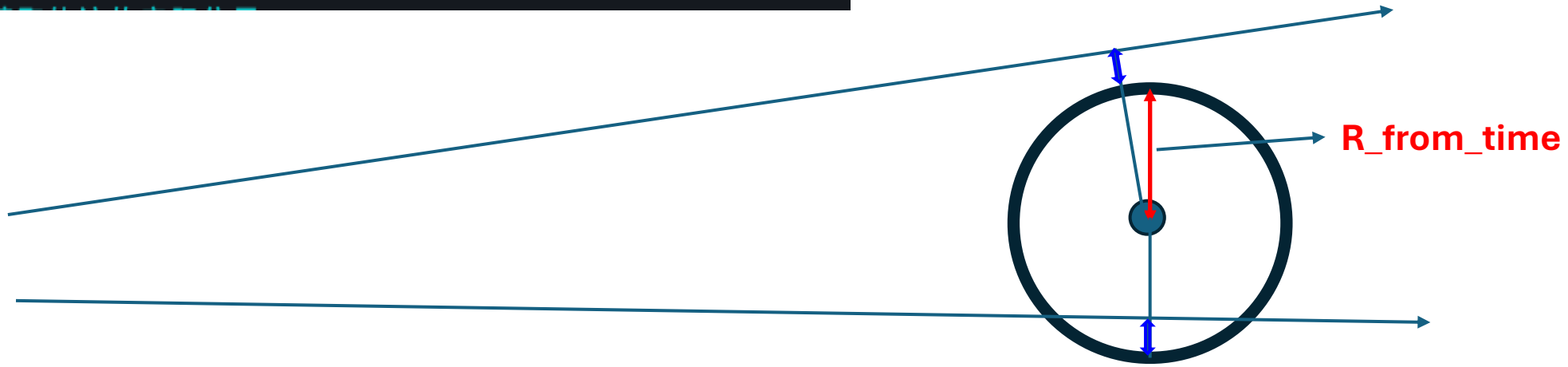
alignTask_eTOF->SetShift(0.0, 0.0, 0.0);


alignTask_eTOF->SetAlignmentParFile(
    "3D_ETOF_Results.dat"
);

run->AddTask(alignTask_eTOF);
```

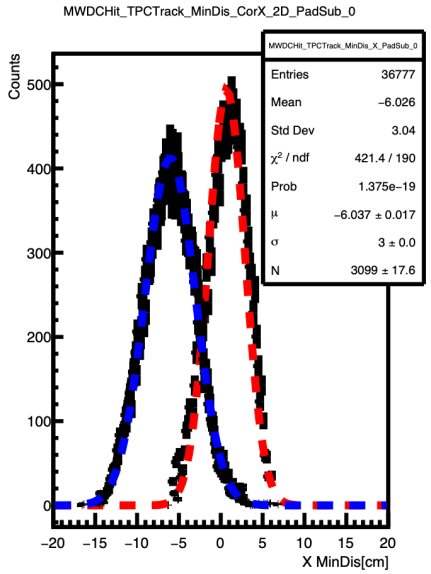
MWDC匹配算法

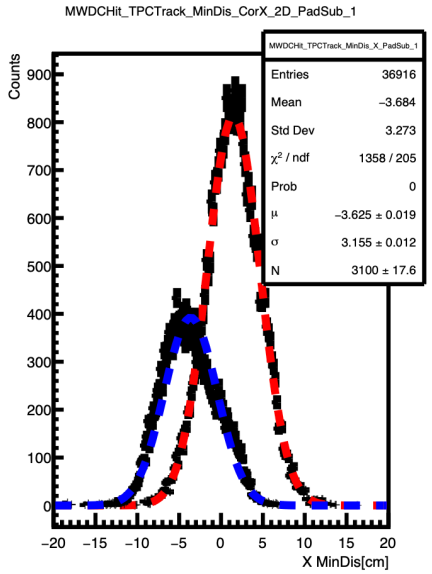
```
//MWDC1灵敏区域X(-68cm, +68cm),Y(-31.5cm,+31.5cm), Z(80cm, 100cm)。
//MWDC2灵敏区域X(-95cm, +95cm),Y(-44cm,+44cm), Z(115cm, 136cm)。
//MWDC3灵敏区域X(-137cm, +137cm),Y(-63cm,+63cm), Z(195cm, 216cm)。
```

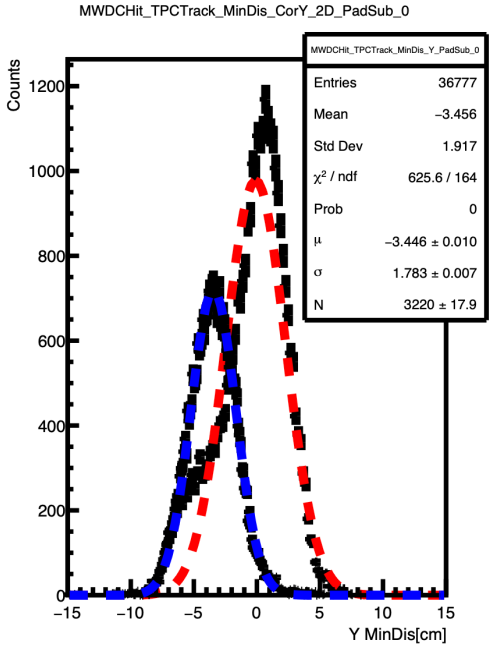


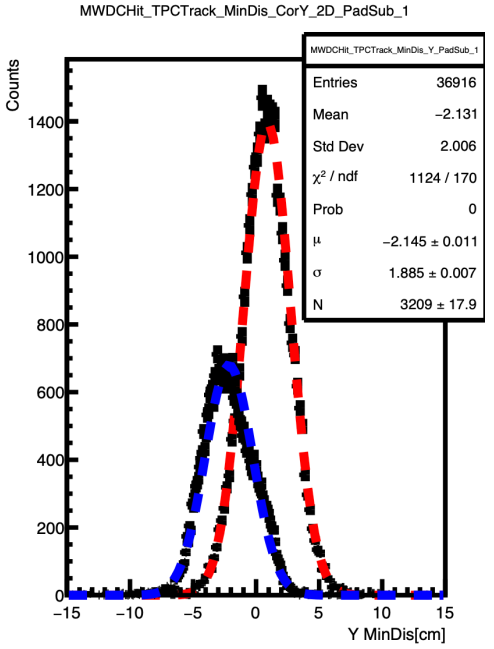
TPC径迹到MWDC Wire的距离计算示意图

Compare of Match Situation in X Drection

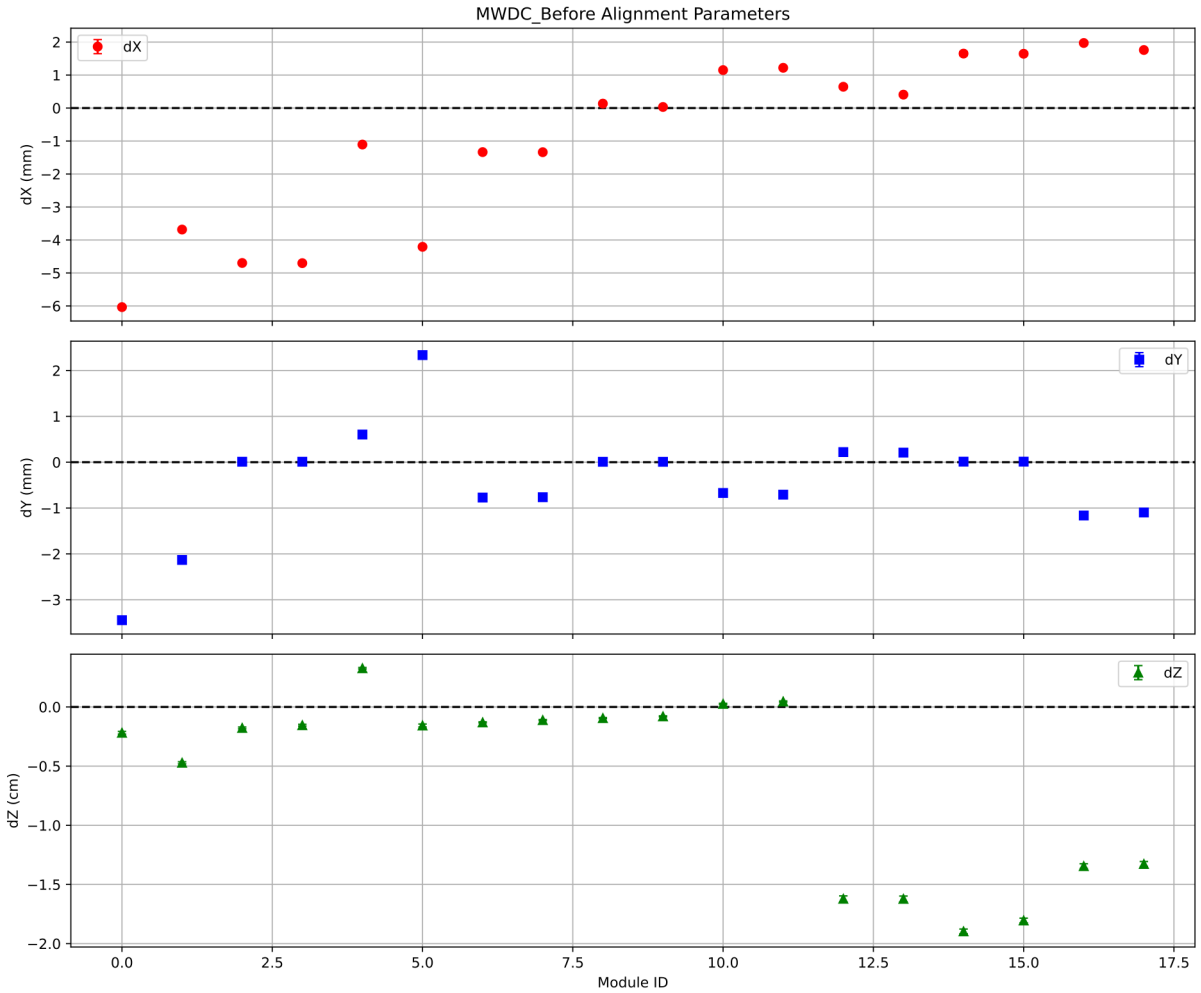


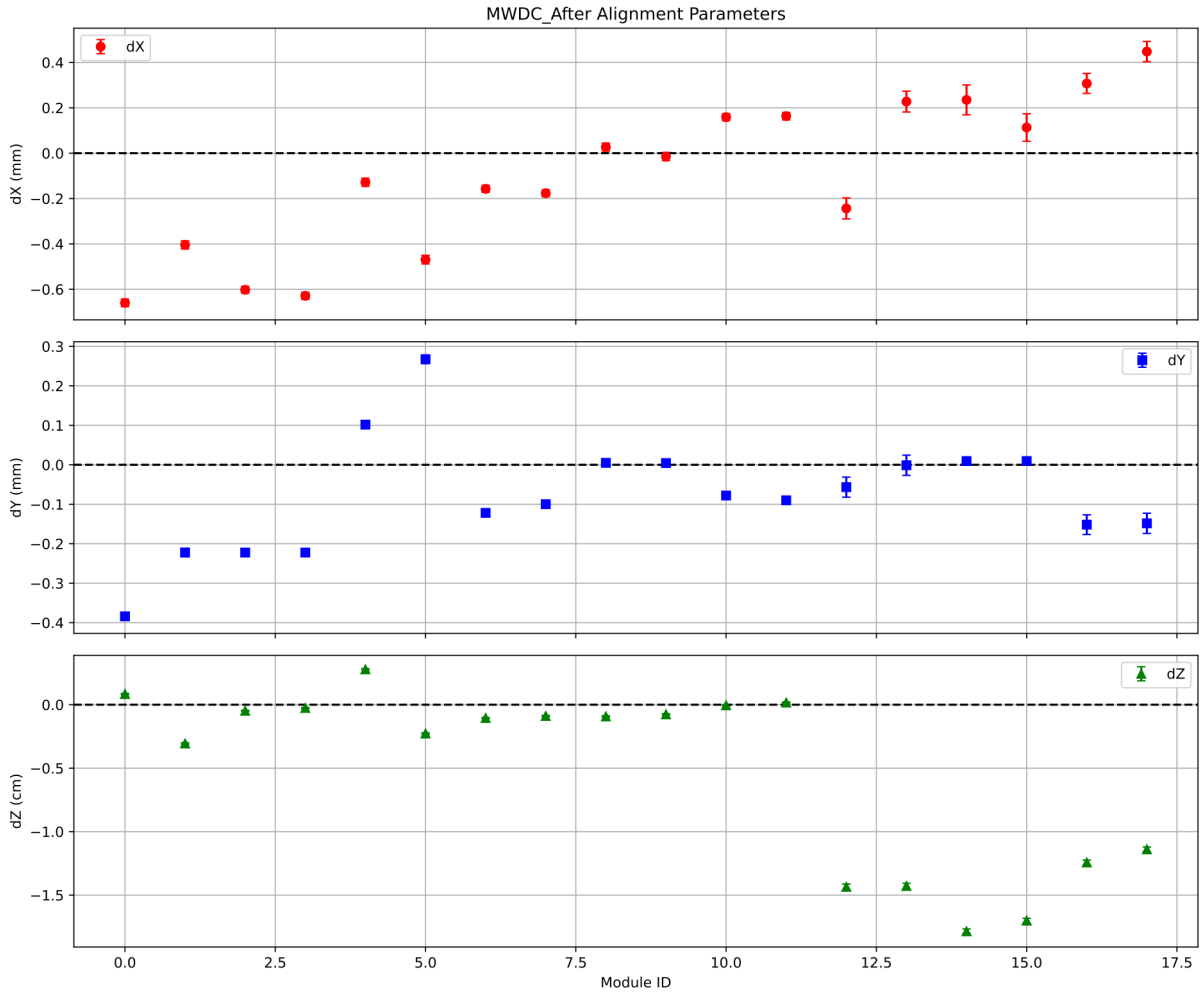






MWDC 修正前后匹配情况



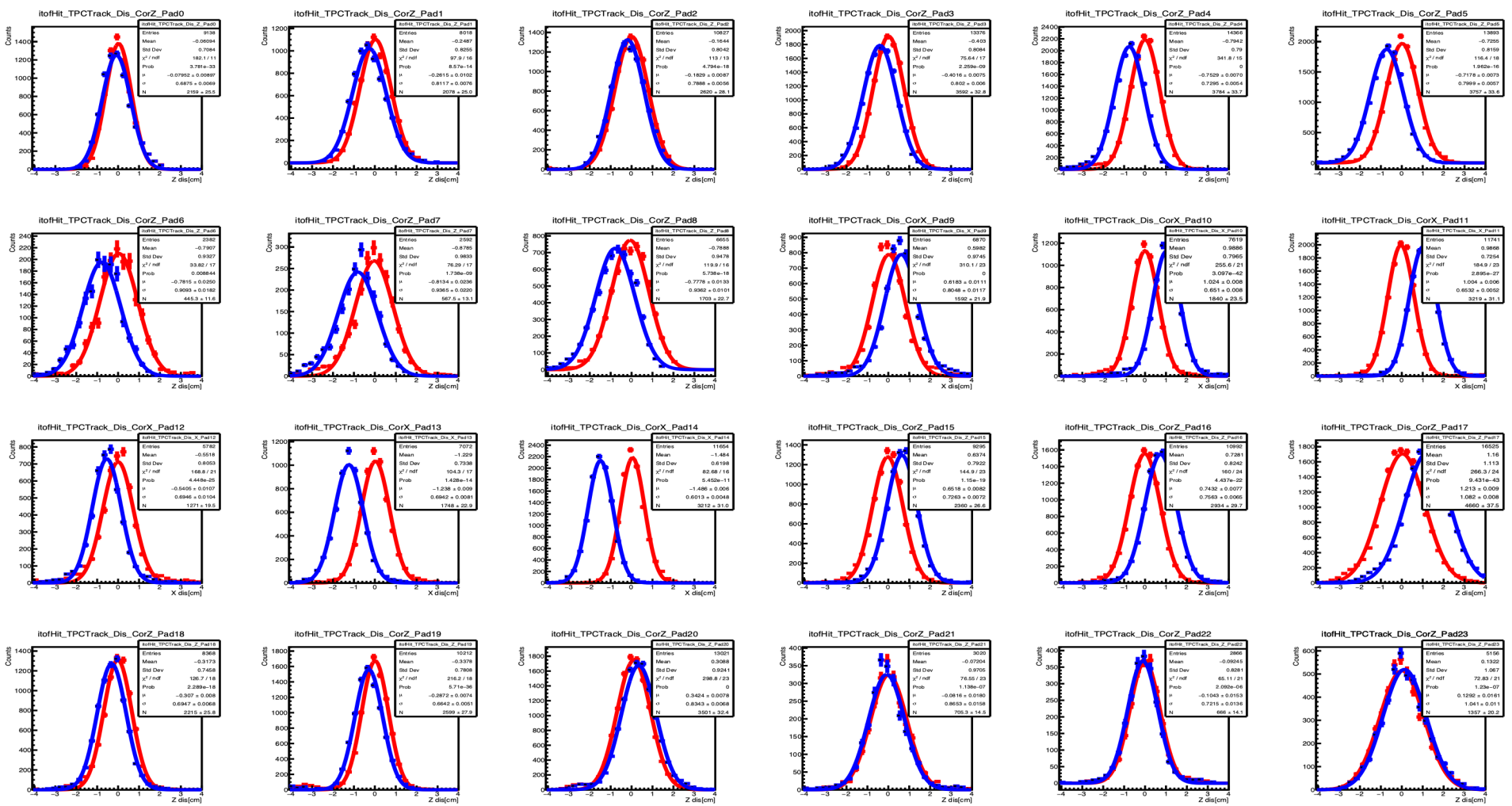


总结和展望

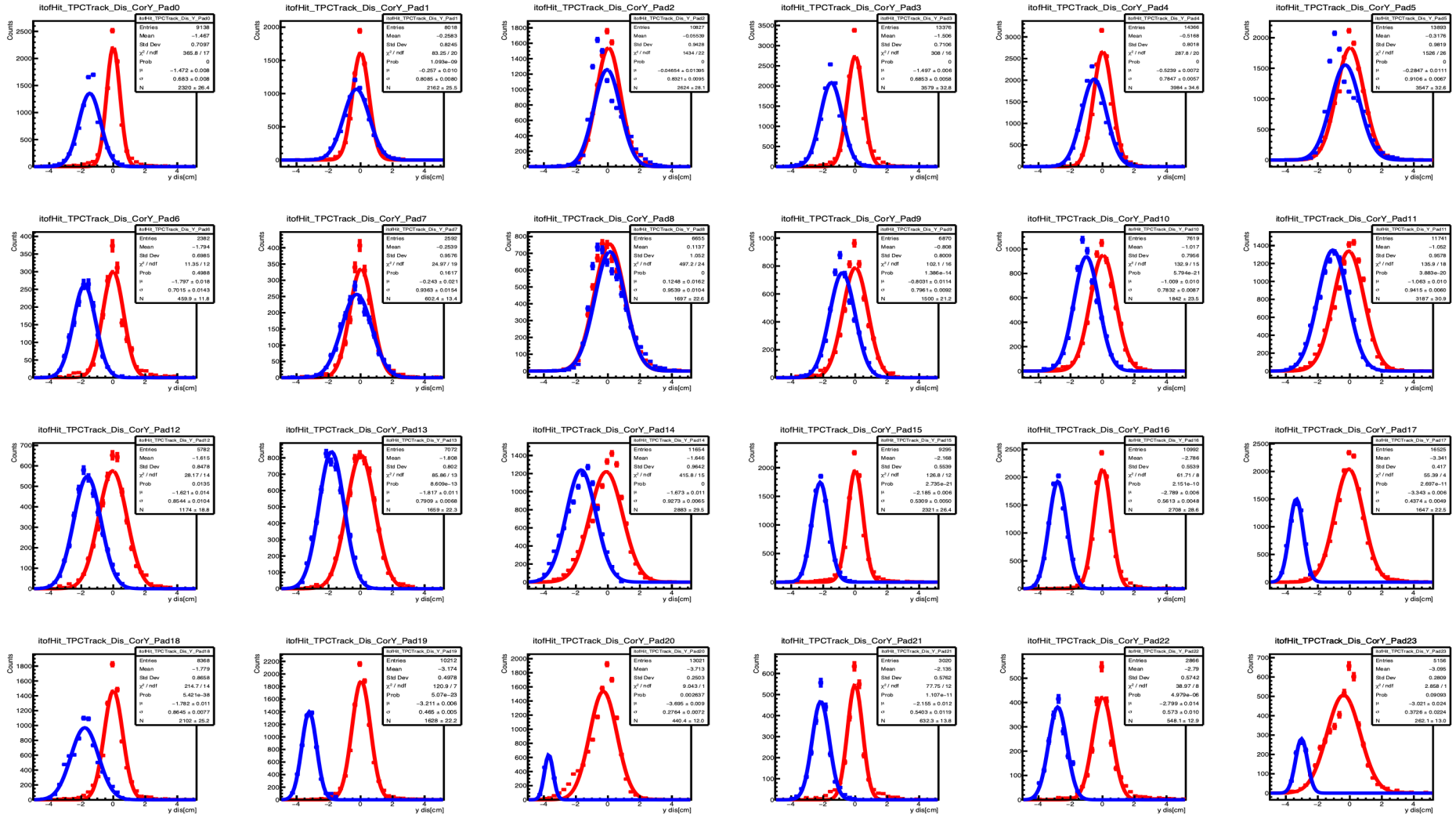
- CEE 探测器算法完备，TOF探测器匹配良好，需进一步优化MWDC匹配细节。
- 空间电荷修正取得实质性进展。对事例重建优化巨大。
- 进一步深挖探测器匹配细节，优化匹配结果。

Backup

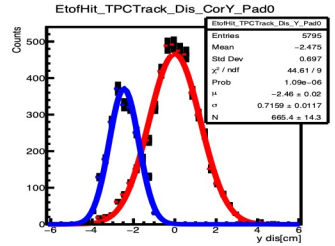
iTof Hits Match with TPC Track(XZ)

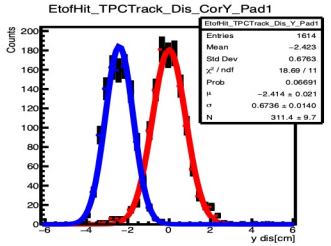


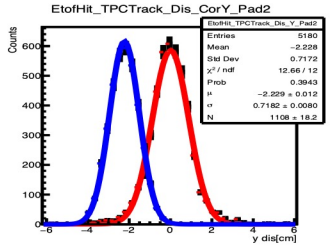
iTof Hits Match with TPC Track(Y)

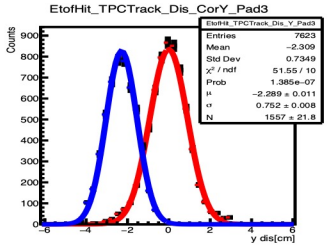


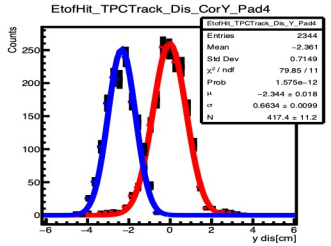
ETof Hits Match with TPC Track(Y)

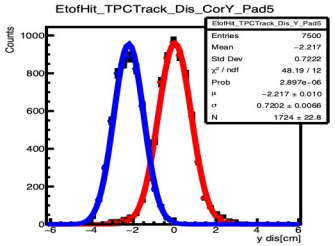


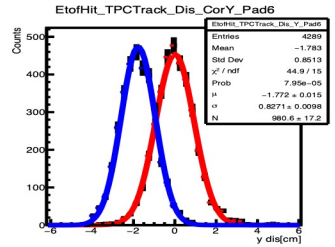


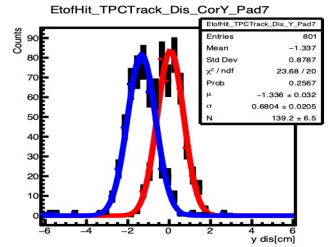


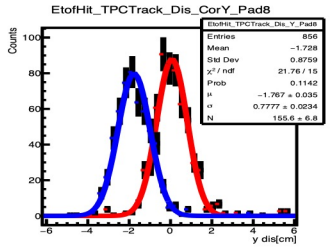


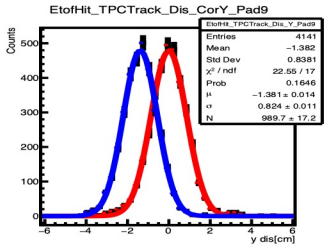


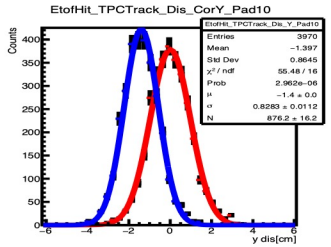


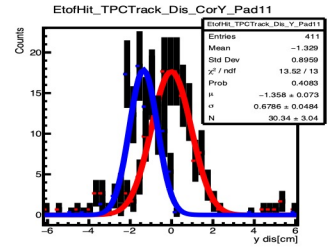


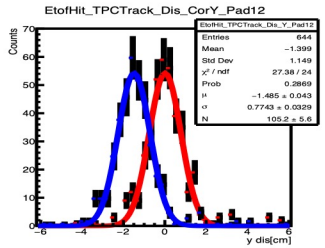


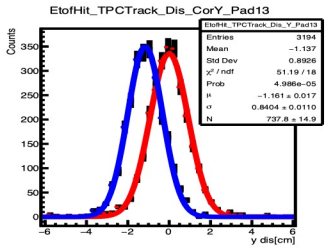


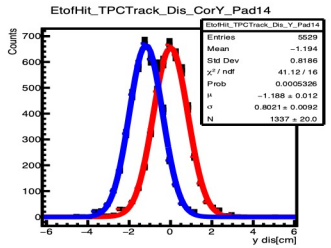


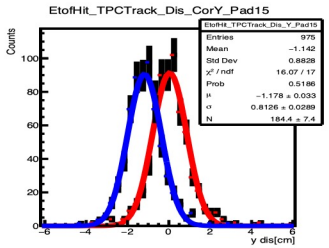


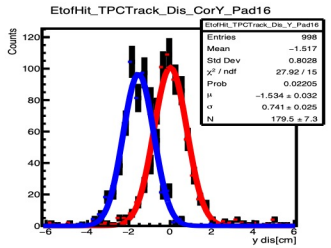


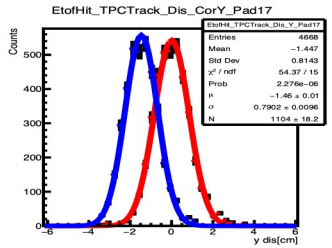


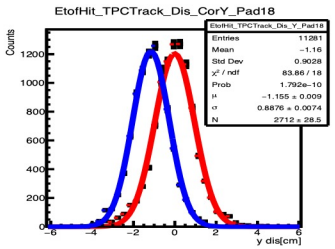


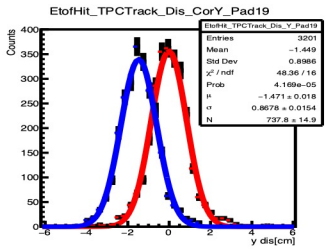


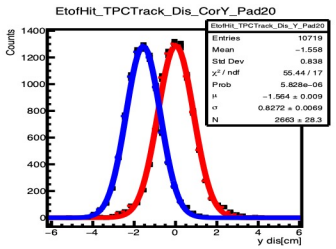


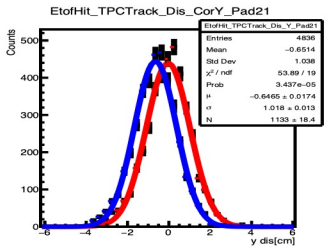


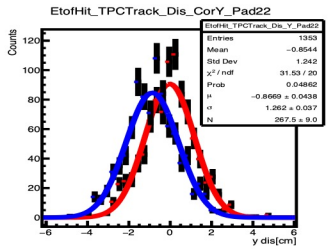


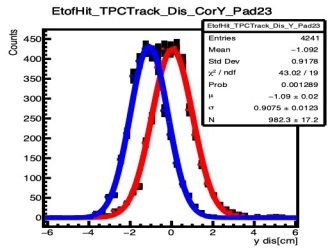




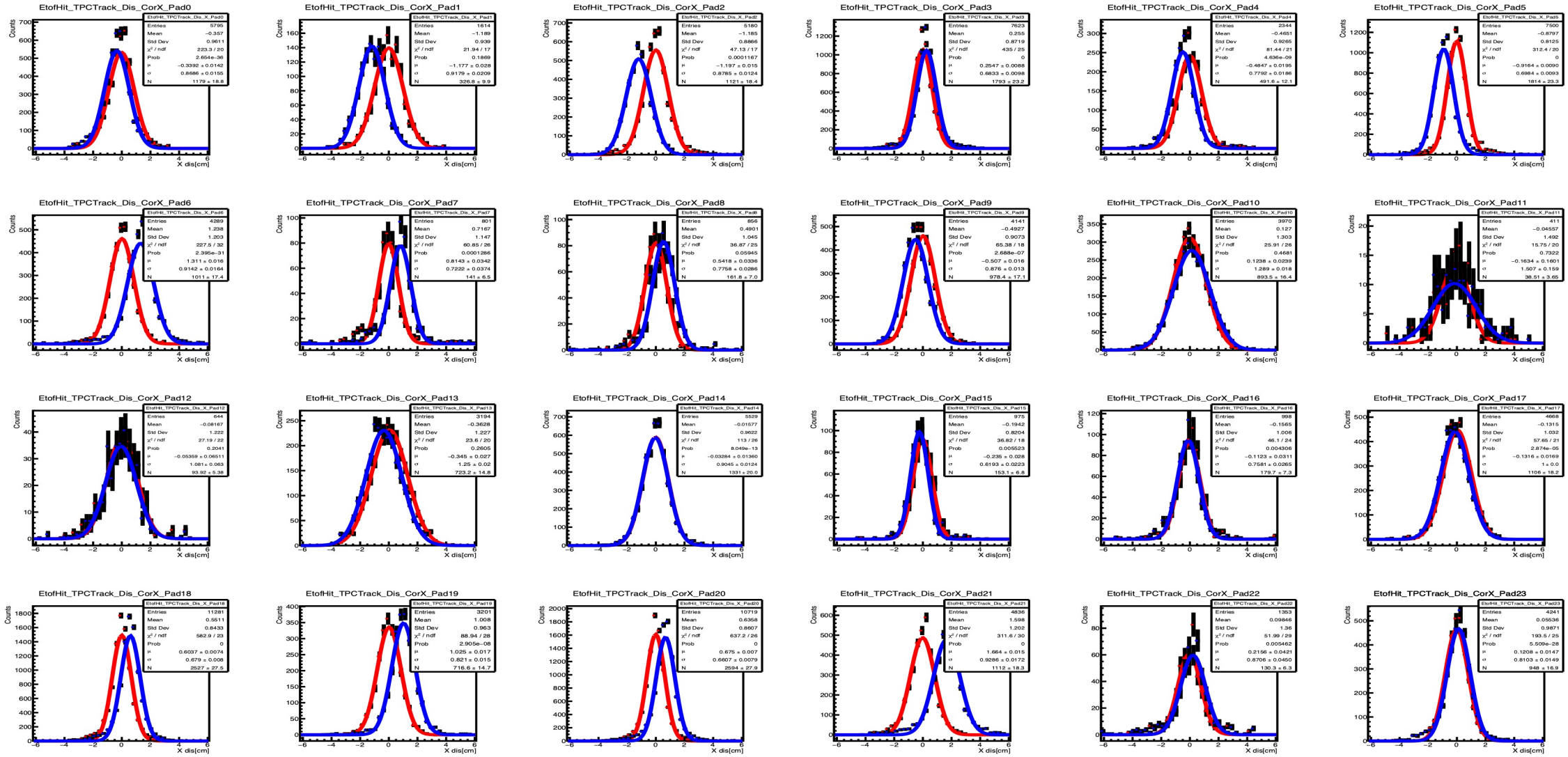




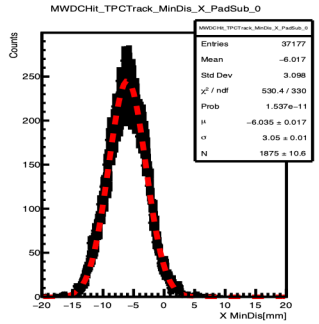


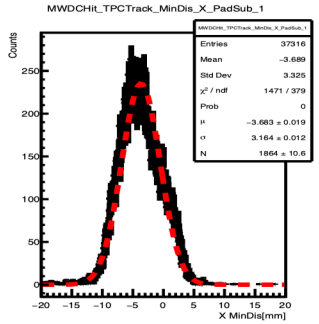


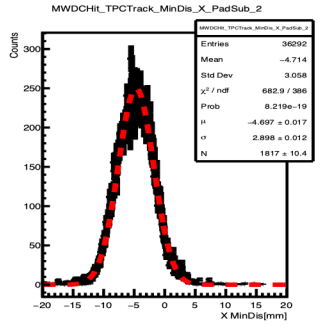
EToF Hits Match with TPC Track(X)

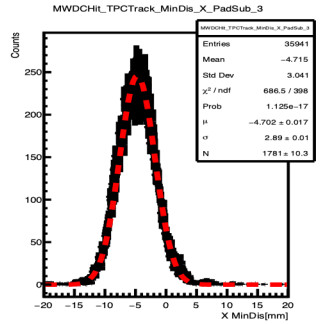


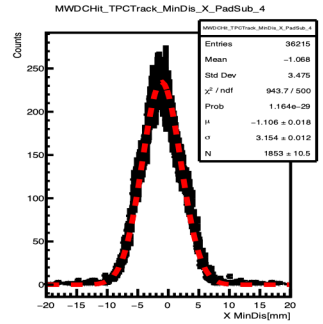
TPC Track Match MWDC Wire (X Direction)

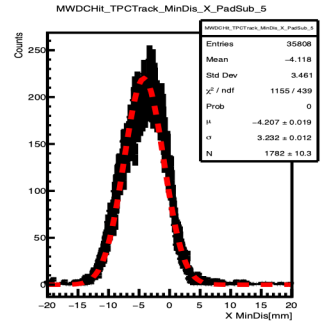


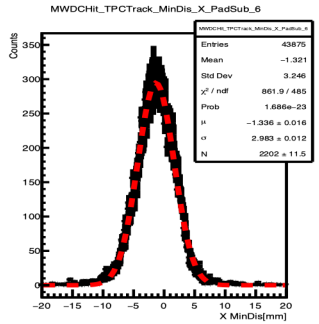


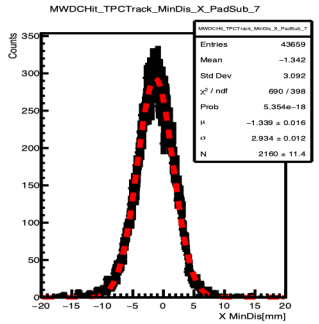


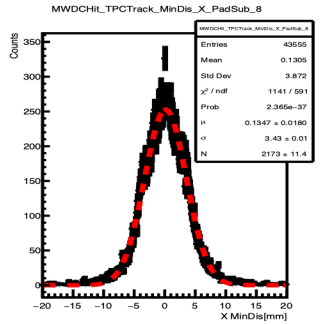


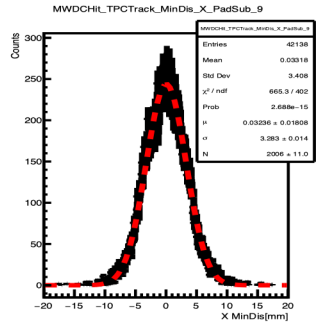


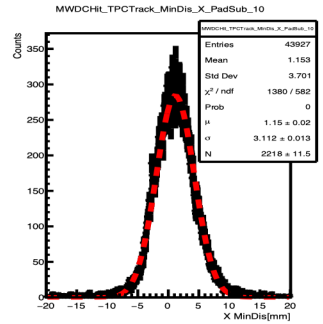


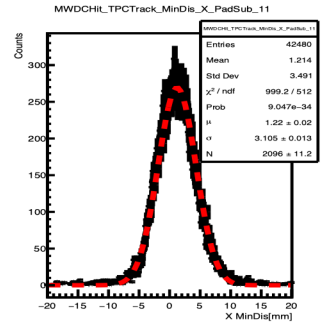


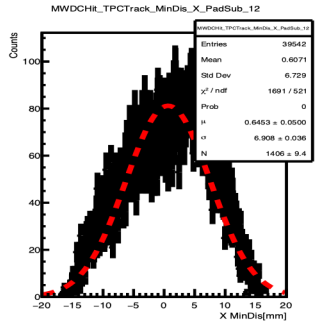


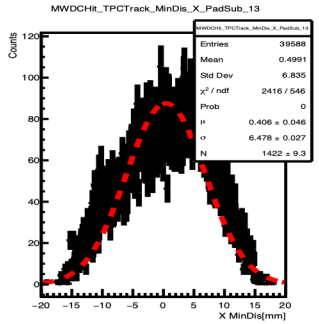


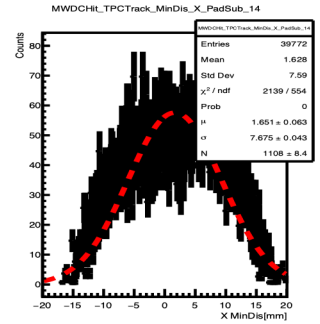


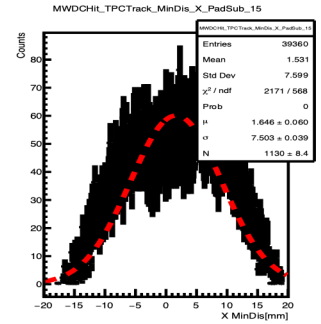


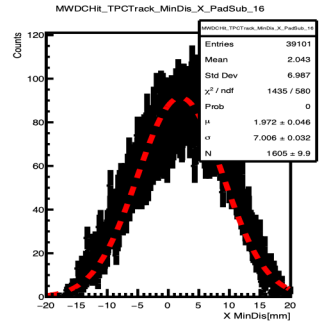


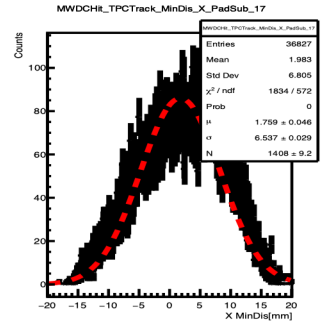




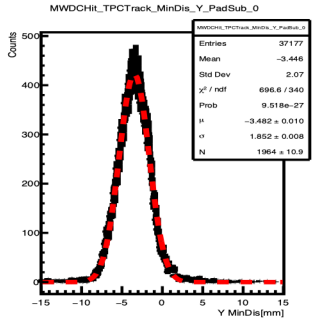


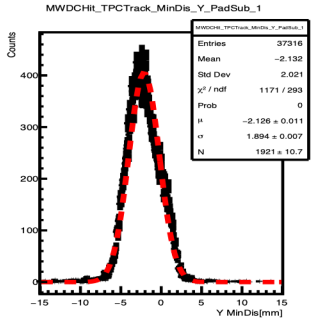


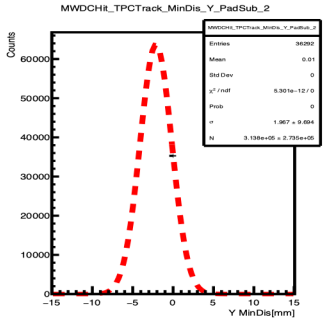


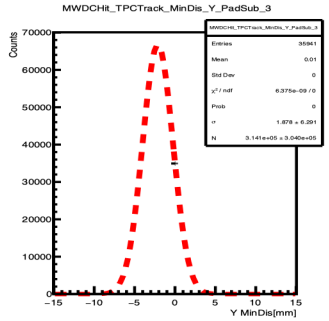


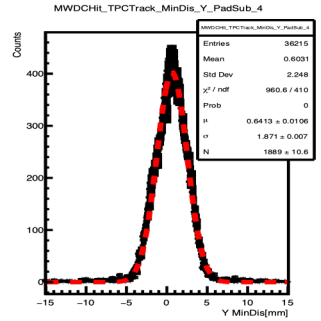
TPC Track Match MWDC Wire (Y Direction)

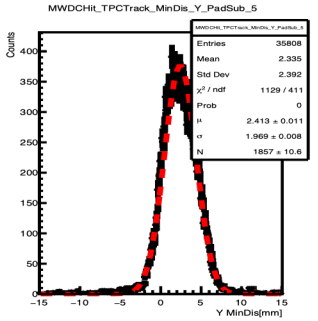


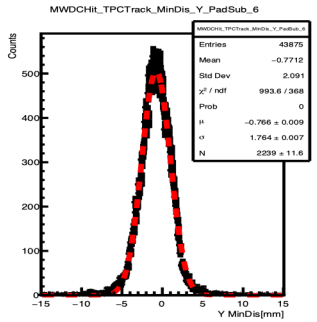


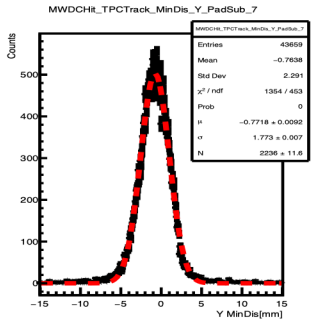


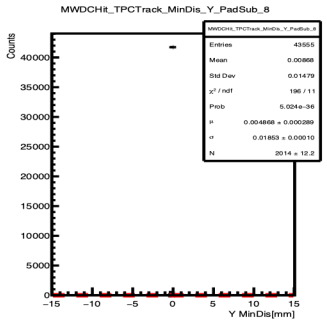


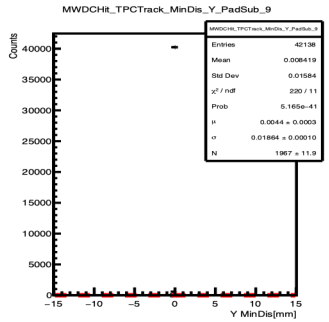


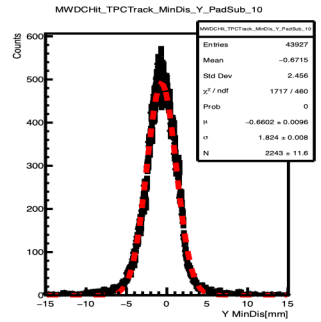


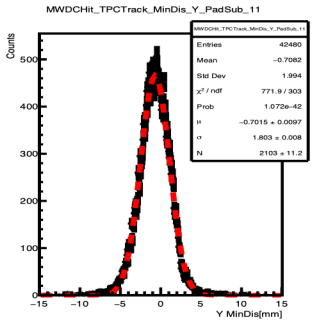


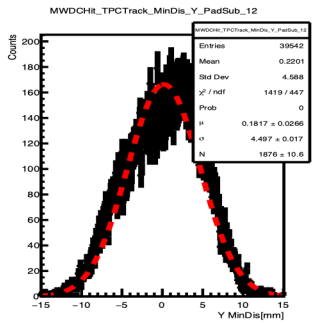


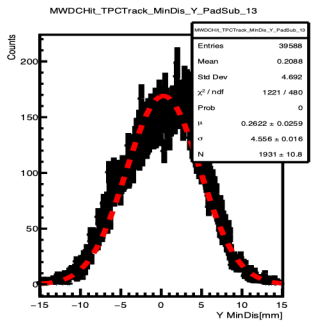


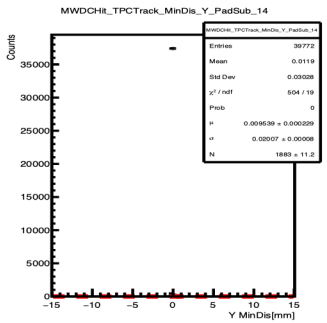


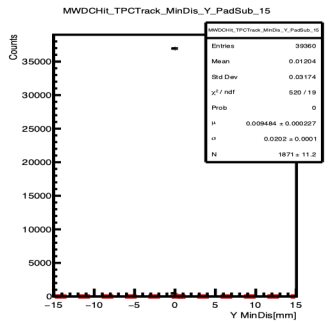


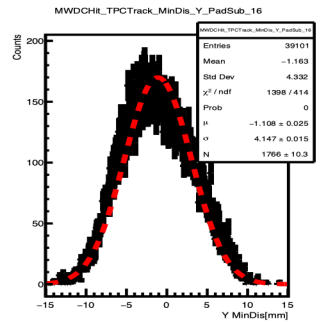


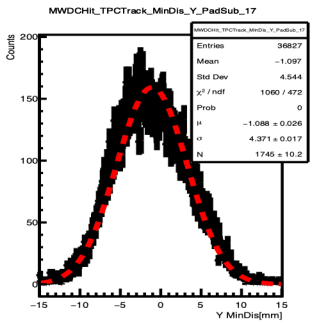




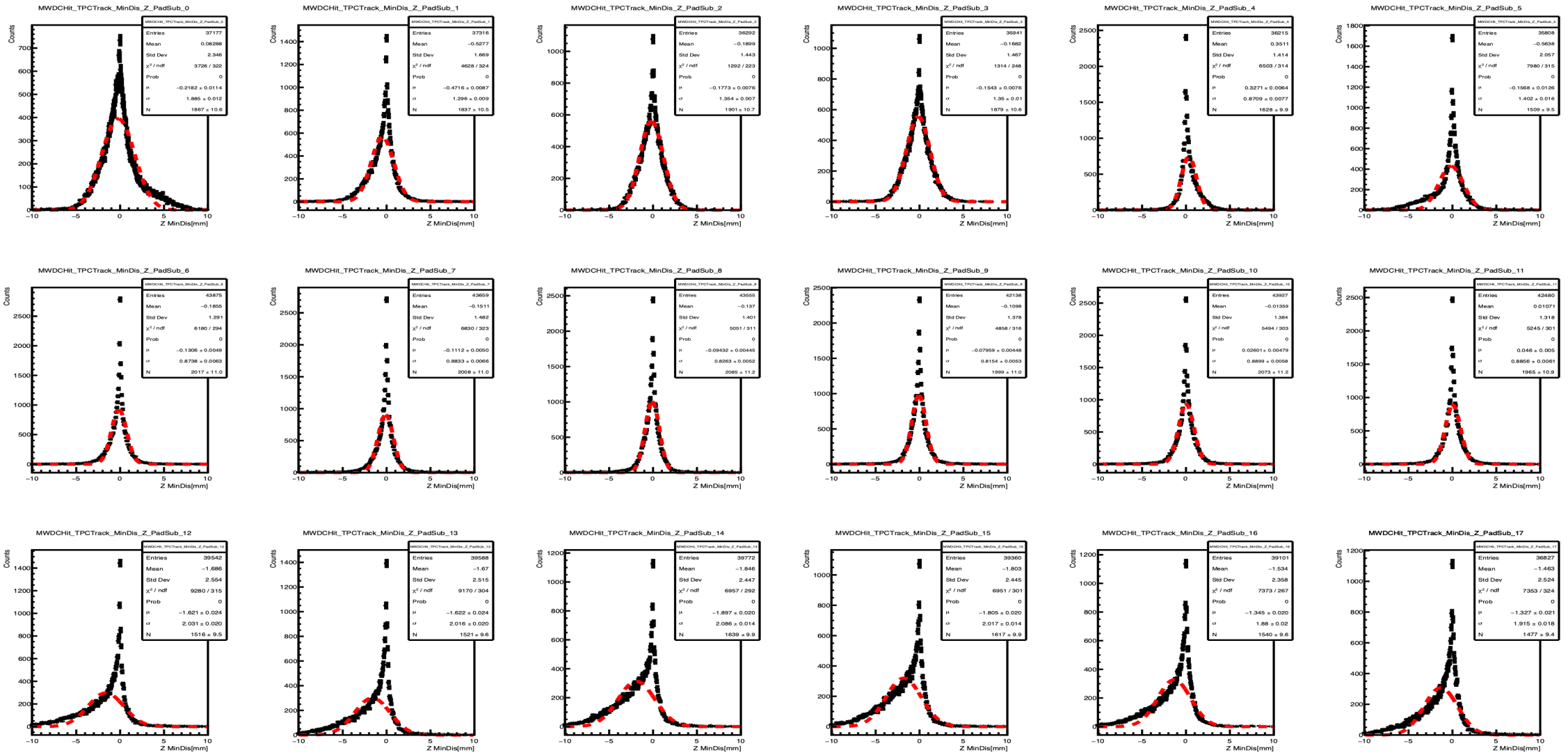




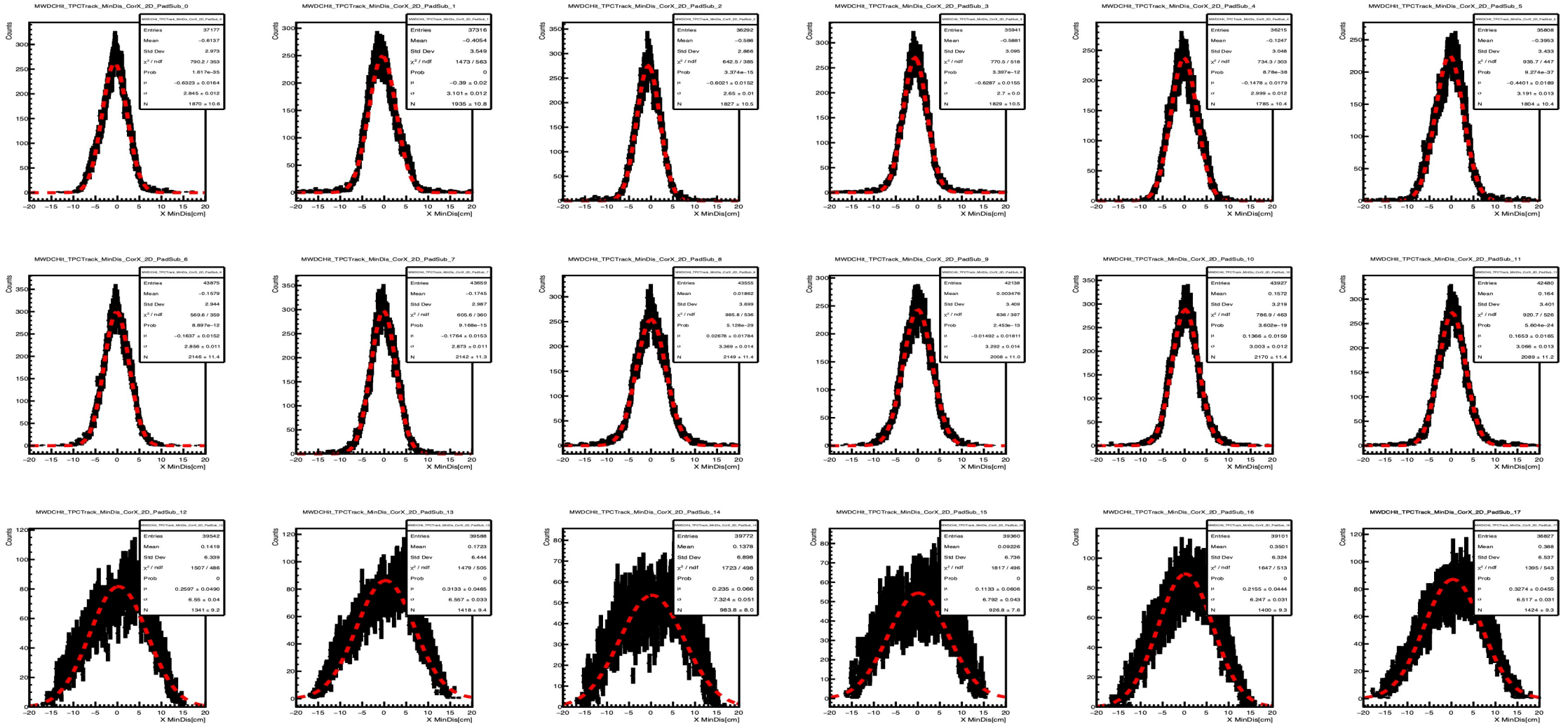




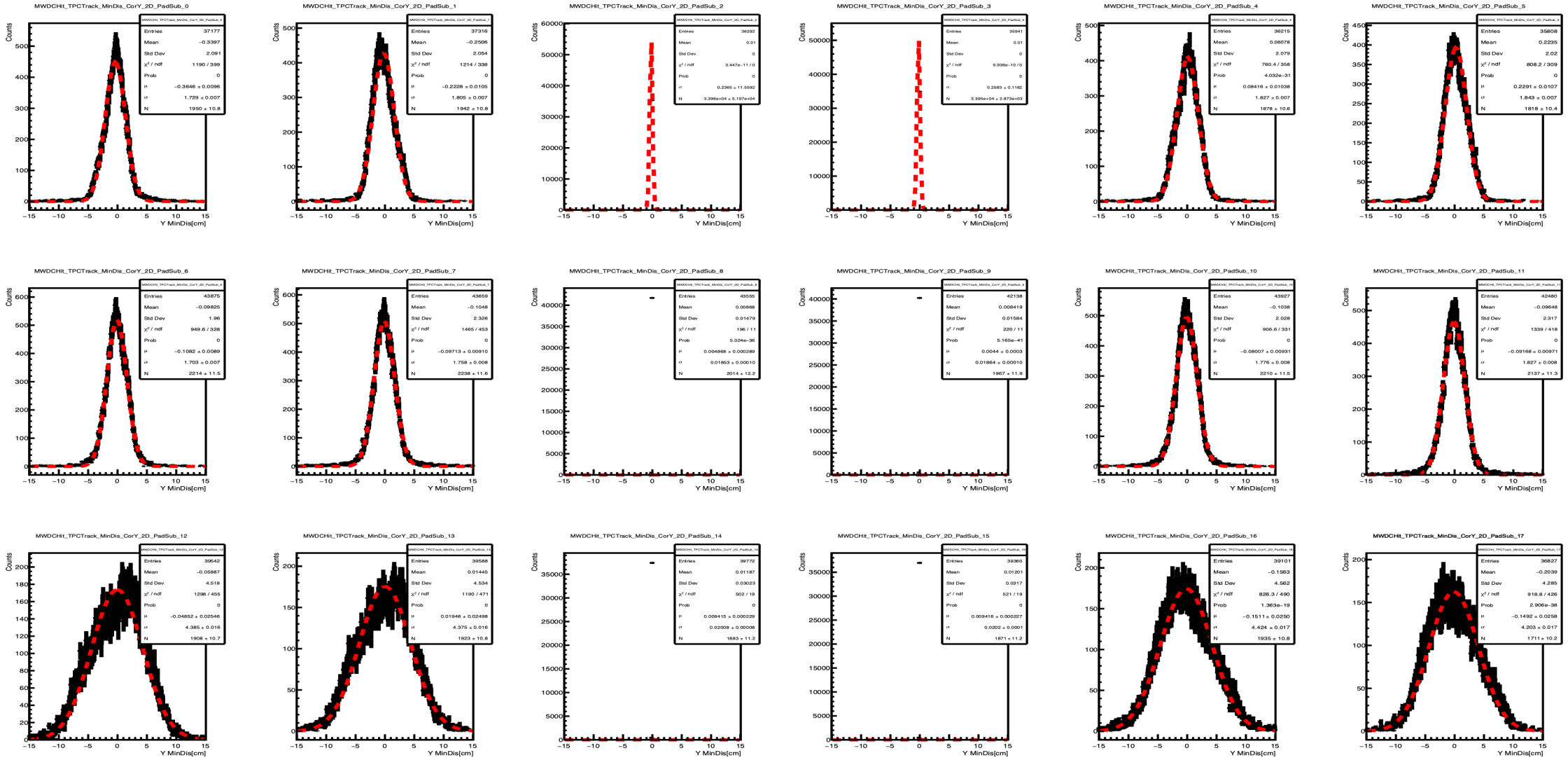
TPC Track Match MWDC Wire (Z Direction)



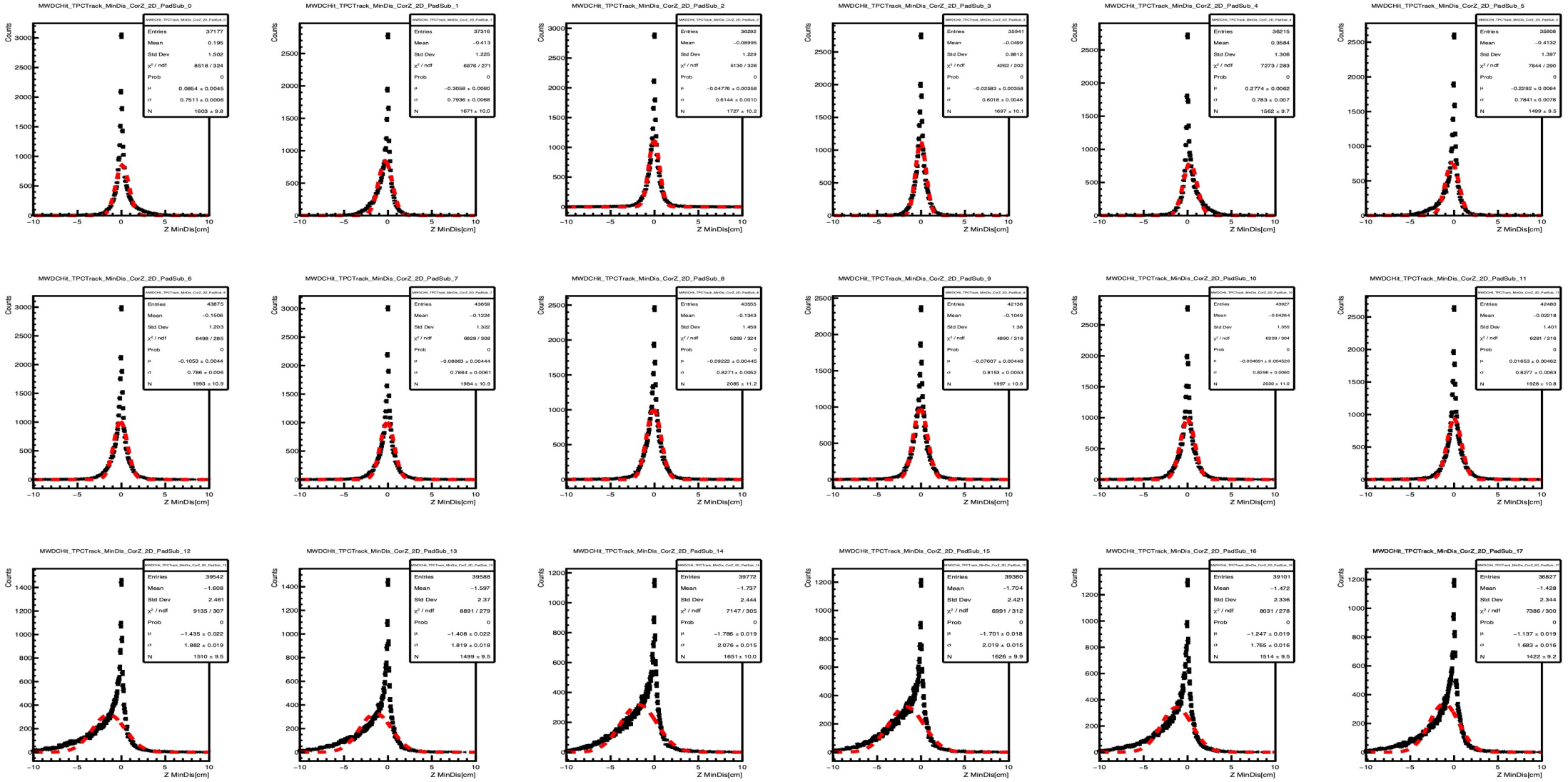
TPC Track Match MWDC Wire (X Direction After shift Correction)



TPC Track Match MWDC Wire (X Direction After shift Correction)



TPC Track Match MWDC Wire (X Direction After shift Correction)



估计出K

$$m\frac{\mathrm{d}\boldsymbol{u}}{\mathrm{d}t} = e\boldsymbol{E} + e[\boldsymbol{u}\times\boldsymbol{B}] - K\boldsymbol{u},$$

根据束流实验:

稳态: du/dt=0

无磁场: B=0

$eE = Ku$ $K = eE/u$

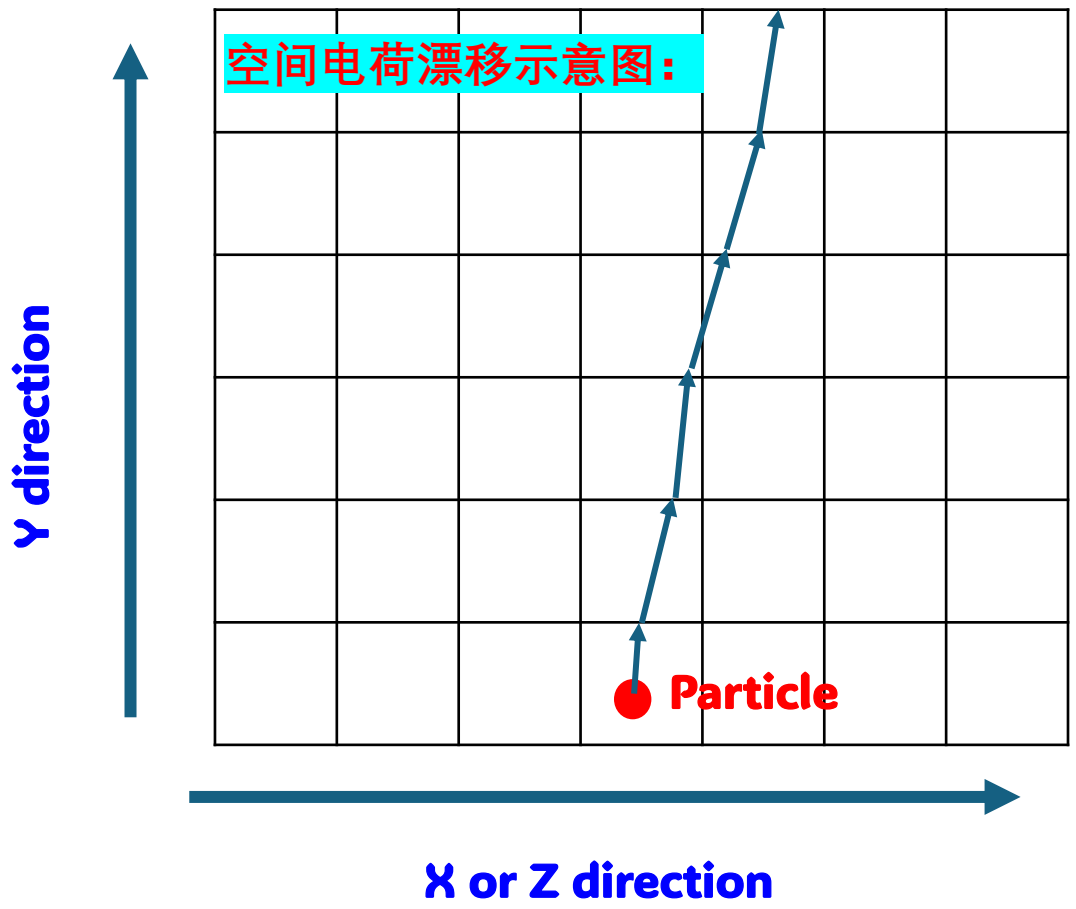
e= 1.602e-19 C E = 3000 V

u=2.2 cm/um = 2.4e4 m/s

RunName	time-start	time-end	length	Velocity[cm/μs]
20240529_26	157.01	496.538	81.8	2.409227
20240529_29	158.801	510.401	81.8	2.326507
20240529_31	158.804	513.779	81.8	2.304388
20240529_73	161.278	552.66	81.8	2.09003
20240601_22	158.872	547.557	81.8	2.104532
20240602_51	160.115	551.822	81.8	2.088296
20240602_88	161.922	552.955	81.8	2.091895

K= 2.2e-20

Space Chare



- 空间位置分格子，粒子每次漂移到下一个y格子坐标位置。
- 根据插值或者临近值得到估计的电荷。
- 根据电场和磁场写出逆矩阵，矩阵相乘得到速度的方向向量。
- 根据速度的方向向量预计下一步的x和z坐标。

Spatial accumulation of particles within the TPC. The self-generated electric fields of these particles distort the original electric field configuration.

TOF Alignment task

- CeeRoot/Alignment

  CeeTOFAlignmentTask.h, CeeTOFAlignmentTask.cxx

  run_TOF_alignment.C example macro

```
-------------------------------------------------------------------------------------------
Event Hit  detID module strip | RawX RawY RawZ | AliX AliY AliZ | dX dY dZ | parDX parDY parDZ | check
-------------------------------------------------------------------------------------------
    0   0    719      7    19 | -92.400002 -15.300000  48.174957 | -92.618973 -16.624699  48.335373 |  -0.218971  -1.324698   0.160416 |  -0.218969  -1.324699   0.160415 | OK
    1   0   1330     13    30 |  40.308899  -3.810507  69.000000 |  39.185043  -5.398081  69.727783 |  -1.123856  -1.587574   0.727783 |  -1.123854  -1.587574   0.727786 | OK
    2   0      7      0     7 | -92.400002   6.910000  -9.656379 | -92.508034   5.891075  -9.640934 |  -0.108032  -1.018925   0.015445 |  -0.108029  -1.018925   0.015445 | OK
    2   1     18      0    18 | -92.400002  17.910000 -10.663907 | -92.508034  16.891075 -10.648462 |  -0.108032  -1.018925   0.015445 |  -0.108029  -1.018925   0.015445 | OK
    3   0   1713     17    13 |  92.400002 -55.509998  37.624680 |  92.889183 -57.745087  38.472176 |   0.489182  -2.235088   0.847496 |   0.489178  -2.235088   0.847495 | OK
    4   0    319      3    19 | -82.800003  19.398764   2.777696 | -82.618011  18.228975   2.841833 |   0.181992  -1.169788   0.064137 |   0.181988  -1.169788   0.064137 | OK
    5   0    827      8    27 | -92.400002 -41.982536  22.657652 | -92.493668 -43.504848  22.842419 |  -0.093666  -1.522312   0.184767 |  -0.093663  -1.522312   0.184766 | OK
    5   1   1012     10    12 | -54.306507 -22.299999  69.000000 | -53.346962 -23.576576  69.655418 |   0.959545  -1.276577   0.655418 |   0.959545  -1.276577   0.655422 | OK
    6   0   1400     14     0 |  69.101830 -68.510002  69.000000 |  67.789803 -70.078316  69.938683 |  -1.312027  -1.568314   0.938683 |  -1.312024  -1.568314   0.938685 | OK
    7   0    510      5    10 | -82.800003 -58.509998 -18.166559 | -82.903610 -60.332676 -18.257788 |  -0.103607  -1.822678  -0.091228 |  -0.103609  -1.822679  -0.091228 | OK
-------------------------------------------------------------------------------------------
Printed 10 hits.
```

Alignment task useage

- alignTask->SetAlignmentParFile(“”） // Read the alignment parameter of each module
- alignTask->SetOutputBranchName("CeeiTOFHit"); // Set the name of the output branch
- alignTask->SetShift(0.0, 0.0, 0.0); // Global default alignment parameter

```
-------------------------------------------------------------------------------------------
Event Hit  detID module strip | RawX RawY RawZ | AliX AliY AliZ | dX dY dZ | parDX parDY parDZ | check
-------------------------------------------------------------------------------------------
    0   0    719      7    19 | -92.400002 -15.300000  48.174957 | -92.618973 -16.624699  48.335373 |  -0.218971  -1.324698   0.160416 |  -0.218969  -1.324699   0.160415 | OK
    1   0   1330     13    30 |  40.308899  -3.810507  69.000000 |  39.185043  -5.398081  69.727783 |  -1.123856  -1.587574   0.727783 |  -1.123854  -1.587574   0.727786 | OK
    2   0      7      0     7 | -92.400002   6.910000  -9.656379 | -92.508034   5.891075  -9.640934 |  -0.108032  -1.018925   0.015445 |  -0.108029  -1.018925   0.015445 | OK
    2   1     18      0    18 | -92.400002  17.910000 -10.663907 | -92.508034  16.891075 -10.648462 |  -0.108032  -1.018925   0.015445 |  -0.108029  -1.018925   0.015445 | OK
    3   0   1713     17    13 |  92.400002 -55.509998  37.624680 |  92.889183 -57.745087  38.472176 |   0.489182  -2.235088   0.847496 |   0.489178  -2.235088   0.847495 | OK
    4   0    319      3    19 | -82.800003  19.398764   2.777696 | -82.618011  18.228975   2.841833 |   0.181992  -1.169788   0.064137 |   0.181988  -1.169788   0.064137 | OK
    5   0    827      8    27 | -92.400002 -41.982536  22.657652 | -92.493668 -43.504848  22.842419 |  -0.093666  -1.522312   0.184767 |  -0.093663  -1.522312   0.184766 | OK
    5   1   1012     10    12 | -54.306507 -22.299999  69.000000 | -53.346962 -23.576576  69.655418 |   0.959545  -1.276577   0.655418 |   0.959545  -1.276577   0.655422 | OK
    6   0   1400     14     0 |  69.101830 -68.510002  69.000000 |  67.789803 -70.078316  69.938683 |  -1.312027  -1.568314   0.938683 |  -1.312024  -1.568314   0.938685 | OK
    7   0    510      5    10 | -82.800003 -58.509998 -18.166559 | -82.903610 -60.332676 -18.257788 |  -0.103607  -1.822678  -0.091228 |  -0.103609  -1.822679  -0.091228 | OK
-------------------------------------------------------------------------------------------
Printed 10 hits.
```

Alignment task useage

```
// ============================================================
// iTOF alignment task
// ============================================================
CeeTOFAlignmentTask* alignTask_iTOF =
    new CeeTOFAlignmentTask("CeeTOFAlignmentTask_iTOF", 1);

alignTask_iTOF->SetInputBranchName("CeeiTOFHit");
alignTask_iTOF->SetOutputBranchName("CeeiTOFHit");

// 如果参数文件中没有某个 module 的修正量，则使用默认 shift
alignTask_iTOF->SetShift(0.0, 0.0, 0.0);

// 如果 detID = moduleID * 100 + stripID，建议打开
// alignTask_iTOF->SetDetIdDivisor(100);

// 如果需要指定模块数，打开
// alignTask_iTOF->SetNModules(24);

alignTask_iTOF->SetAlignmentParFile(
    "3D_ITOF_Results.dat"
);

run->AddTask(alignTask_iTOF);
```

```
// ============================================================
// eTOF alignment task
// ============================================================
CeeTOFAlignmentTask* alignTask_eTOF =
    new CeeTOFAlignmentTask("CeeTOFAlignmentTask_eTOF", 1);

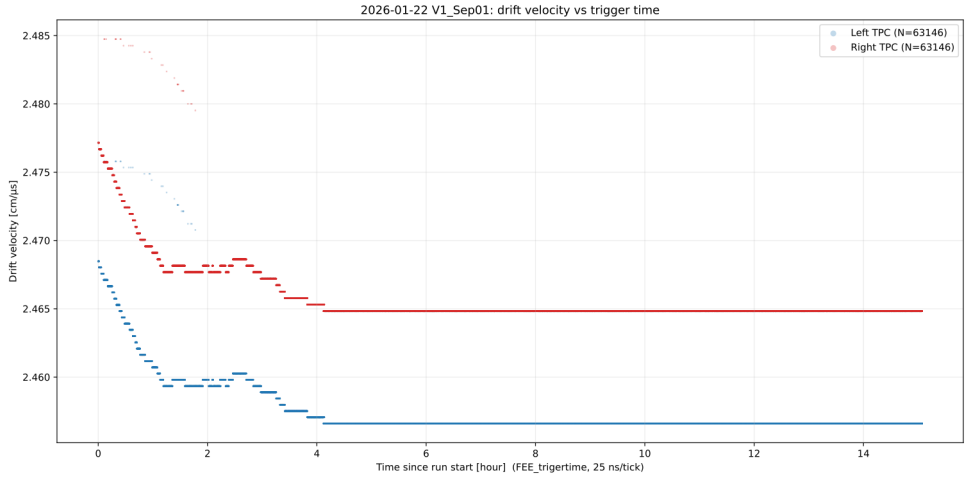
alignTask_eTOF->SetInputBranchName("CeeEtofHit");
alignTask_eTOF->SetOutputBranchName("CeeEtofHit");

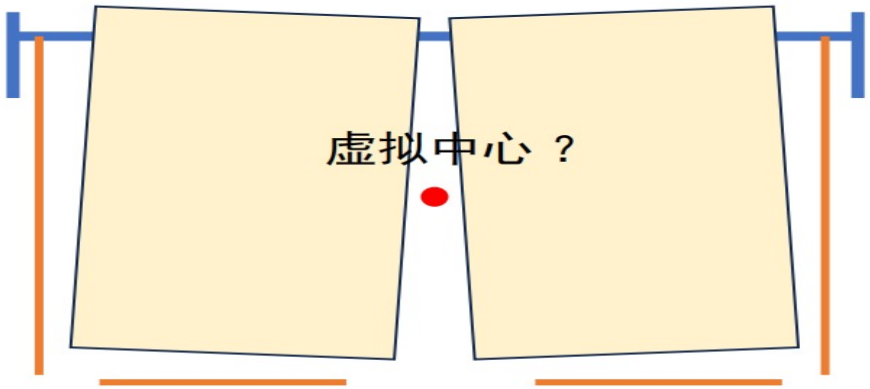
alignTask_eTOF->SetShift(0.0, 0.0, 0.0);


alignTask_eTOF->SetAlignmentParFile(
    "3D_ETOF_Results.dat"
);

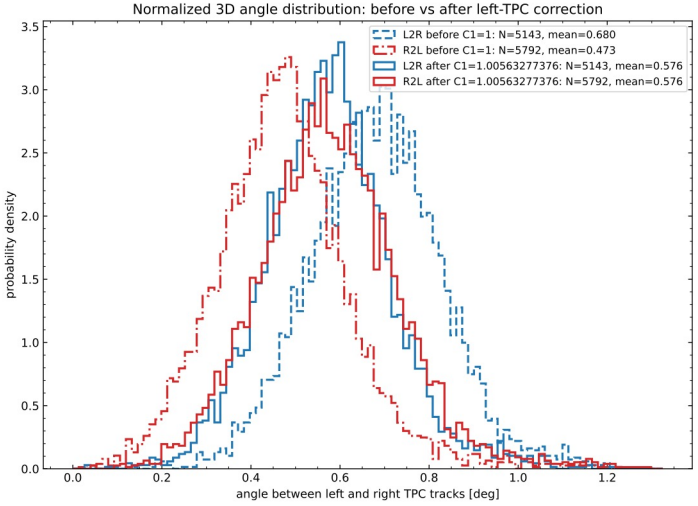
run->AddTask(alignTask_eTOF);
```

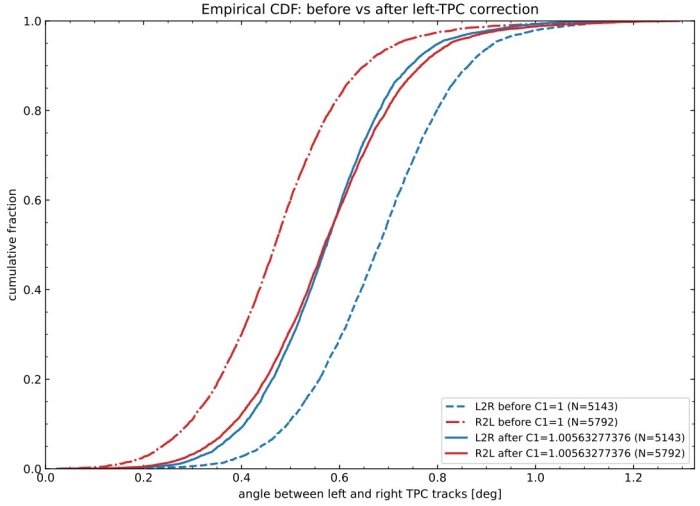
确定TPC1的漂移速度修正系数C1

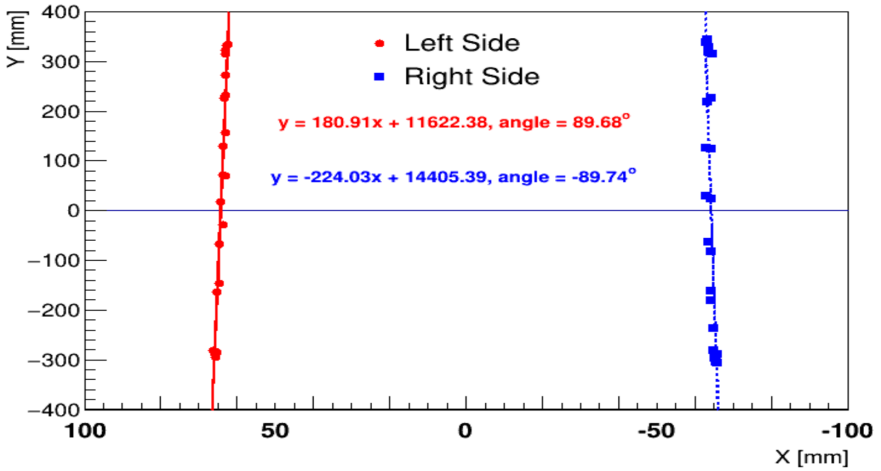




0122 data, left-TPC correction C1=1.00563277376: 3D angle L2R vs R2L







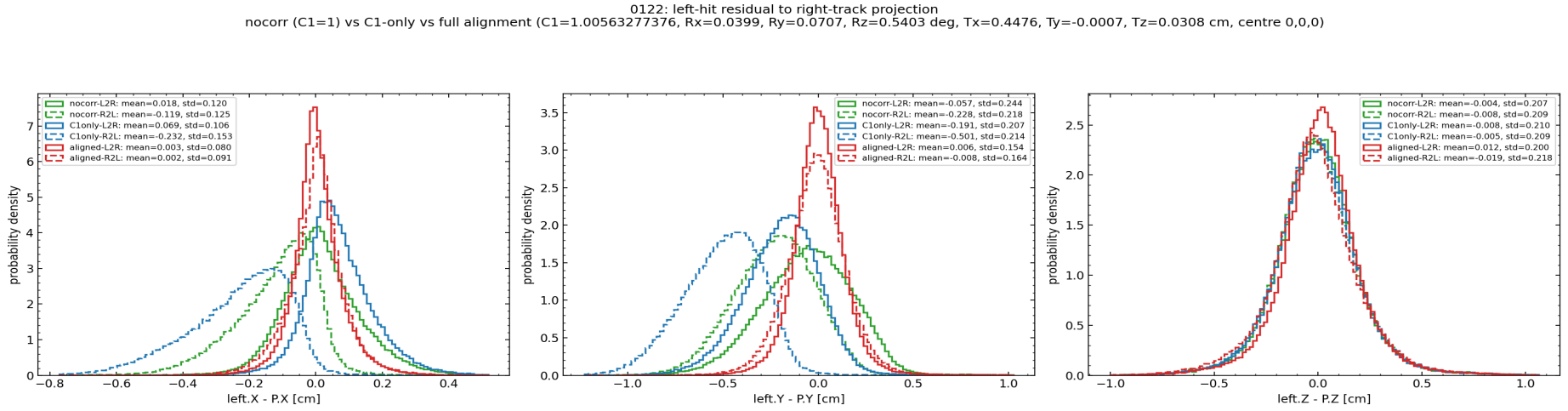
测量两个TPC相对旋转是：0.26+0.32=0.58度

六个参数同时拟合

关键结论：加入平移后，`Rx/Ry` 收敛到一致了

参数	L2R	R2L	all
Rx [°]	0.0551 ± 0.0321	−0.0062 ± 0.0299	0.0399 ± 0.0164
Ry [°]	0.0657 ± 0.0199	0.0987 ± 0.0188	0.0707 ± 0.0103
Rz [°]	0.5466 ± 0.0139	0.5350 ± 0.0130	0.5403 ± 0.0094
Tx [cm]	0.4126 ± 0.0430	0.4553 ± 0.0396	0.4476 ± 0.0162
Ty [cm]	−0.0246 ± 0.0248	0.0243 ± 0.0224	−0.0007 ± 0.0103
Tz [cm]	0.0128 ± 0.0107	0.0478 ± 0.0098	0.0308 ± 0.0071

/public/home/xuzh/Cee_Work/Match_and_Alignment/Cosmic_Ray/Fit_Alignment_SixParam_PointLine.py



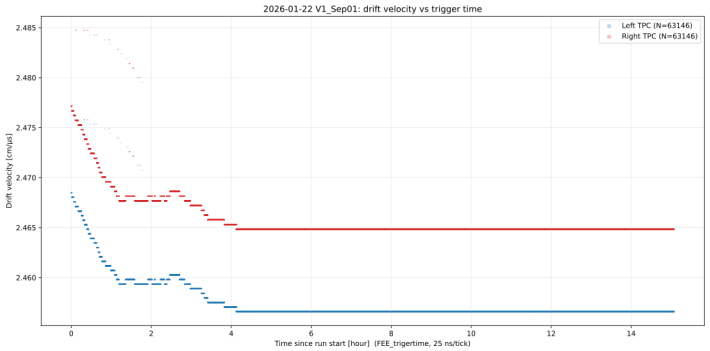
C1_Alignment_HitResidual_0122_Aligned_C1only_NoCorr

七个参数同时拟合

参数	C1 + 6	C0 + 6
C1 / C0	1.00564882 ± 0.000358	0.99387332 ± 0.000355
Rx [°]	0.04009 ± 0.01644	0.03898 ± 0.01652
Ry [°]	0.07066 ± 0.01025	0.07077 ± 0.01026
Rz [°]	0.54022 ± 0.00945	0.53888 ± 0.00945
Tx [cm]	0.44760 ± 0.01622	0.45020 ± 0.01628
Ty [cm]	−0.00012 ± 0.01864	0.02221 ± 0.01863
Tz [cm]	0.03079 ± 0.00707	0.03051 ± 0.00706
chi2	14422.877	14375.257

Fit_Alignment_SevenParam_Joint.py
Fit_Alignment_C0PlusSixParam.py

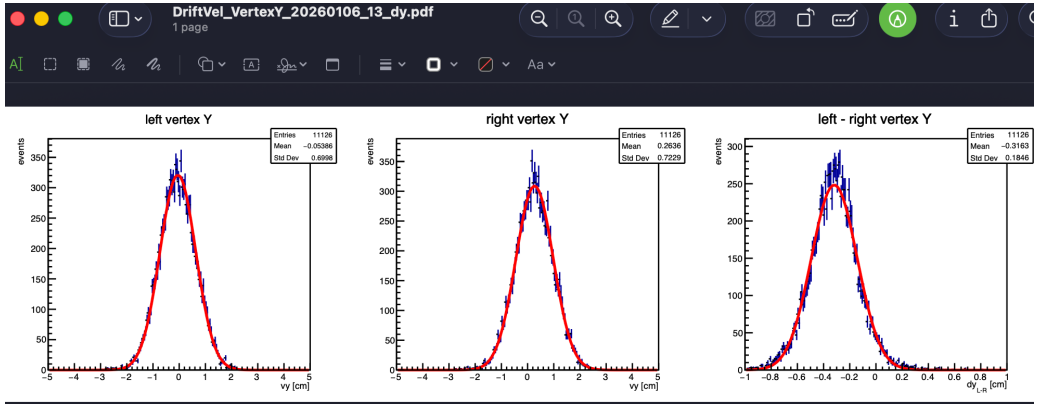
修正左侧和右侧TPC的漂移速度，结果很一致。



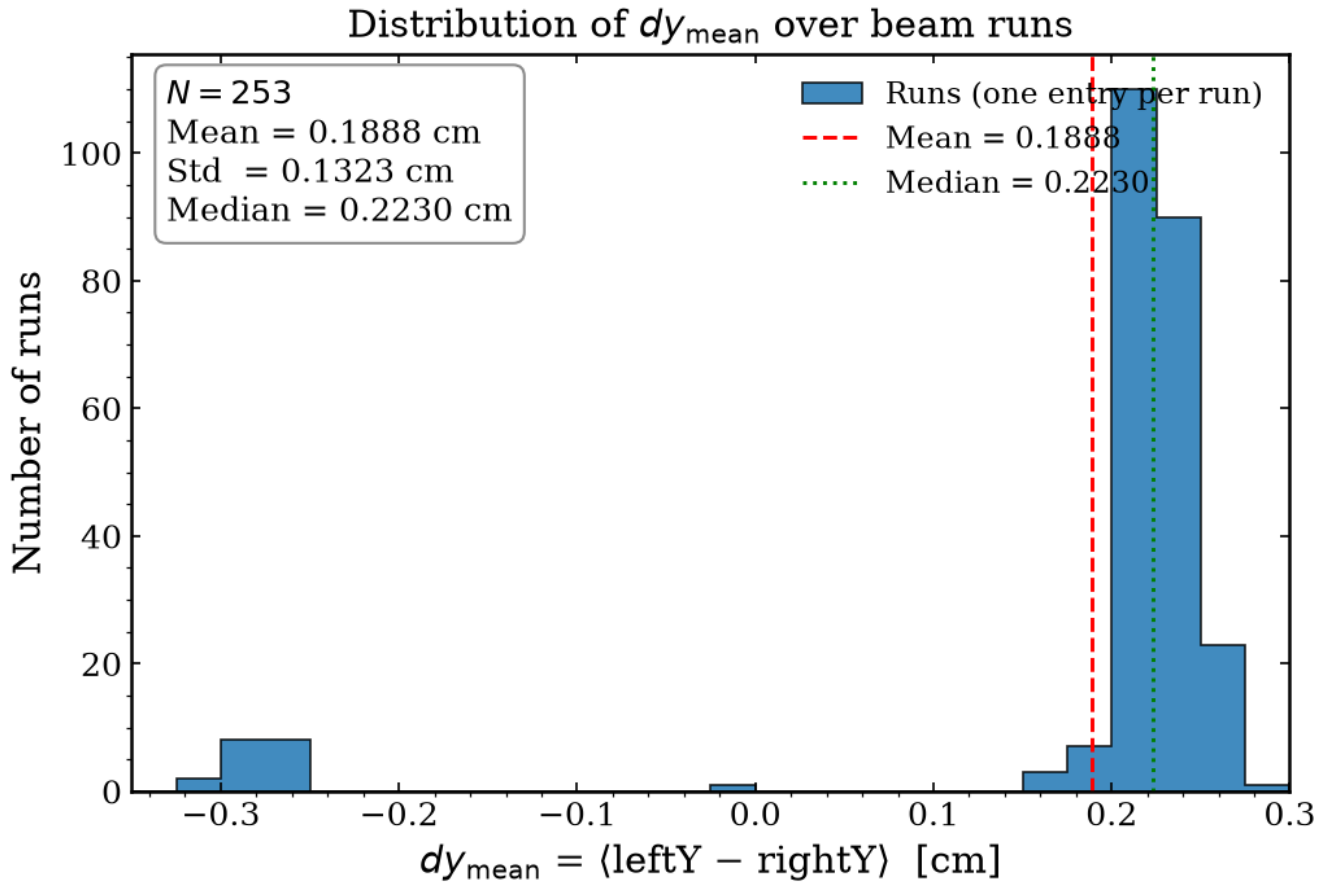
D	chi2	Rx	Ry	Rz	Tx	Ty	Tz
0.99	14341.81	0.0395±0.0166	0.0708±0.0103	0.5369±0.0095	0.4516±0.0163	-0.0006±0.0103	0.0305±0.0071
1.00	14422.88	0.0399±0.0164	0.0707±0.0103	0.5403±0.0094	0.4476±0.0162	-0.0007±0.0103	0.0308±0.0071
1.01	14504.18	0.0401±0.0163	0.0706±0.0103	0.5436±0.0094	0.4436±0.0161	-0.0006±0.0102	0.0311±0.0071

左侧和右侧TPC的漂移速度同时扩大和缩小1%，结果很一致。

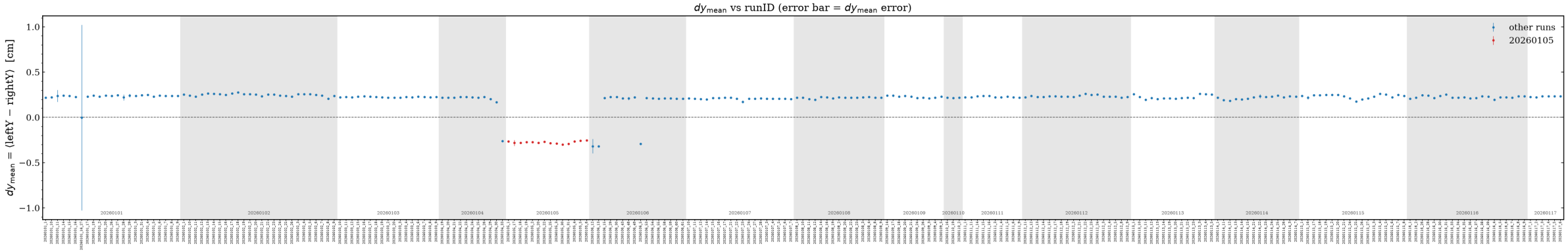
左右TPC vertex 的相对差异。

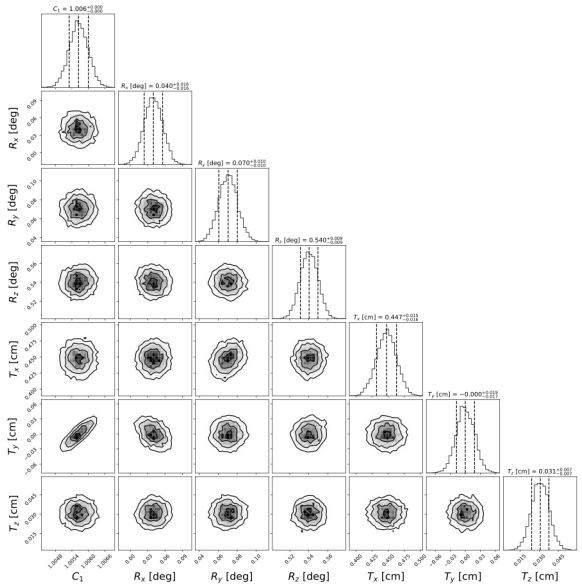


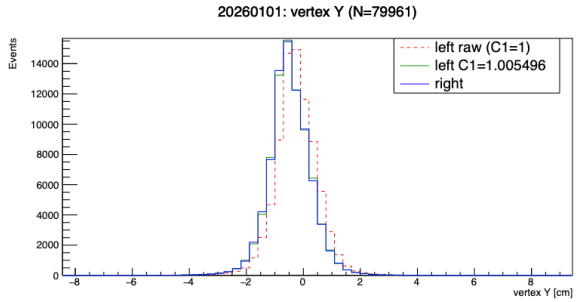
06_15

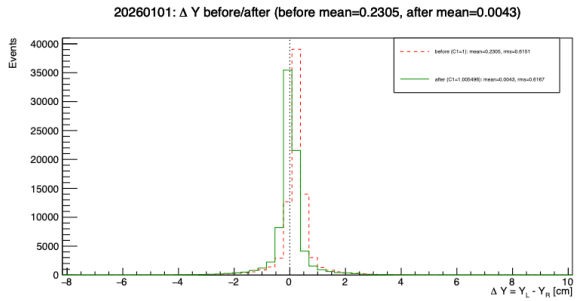


Delta Vertex Y 随run ID的变化



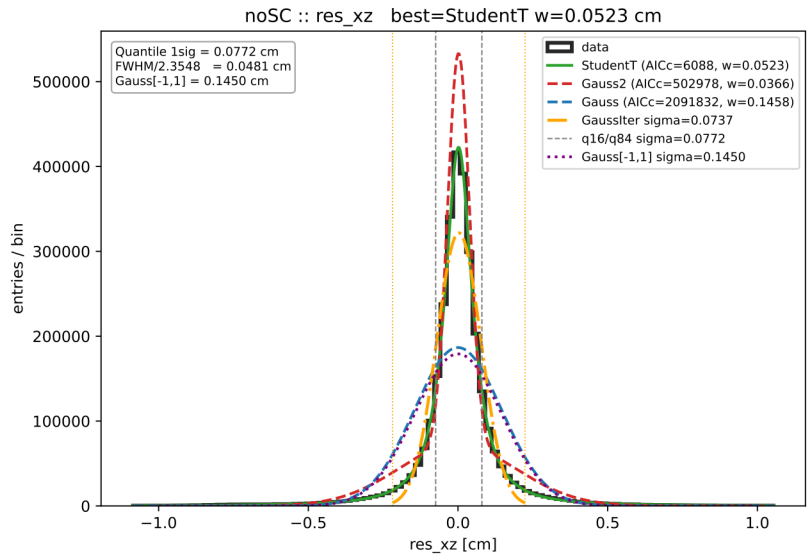


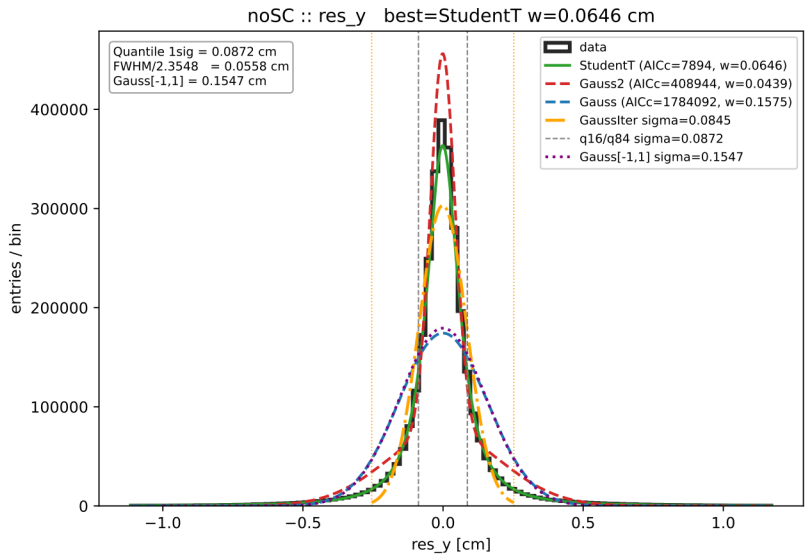


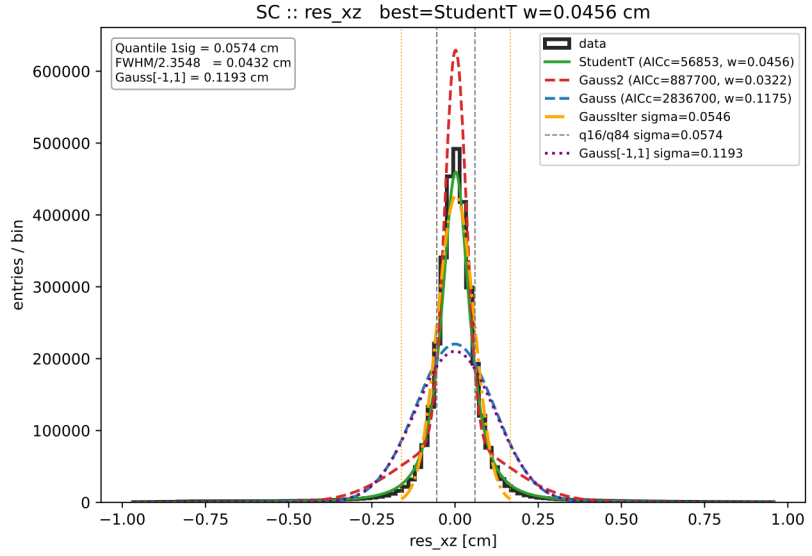


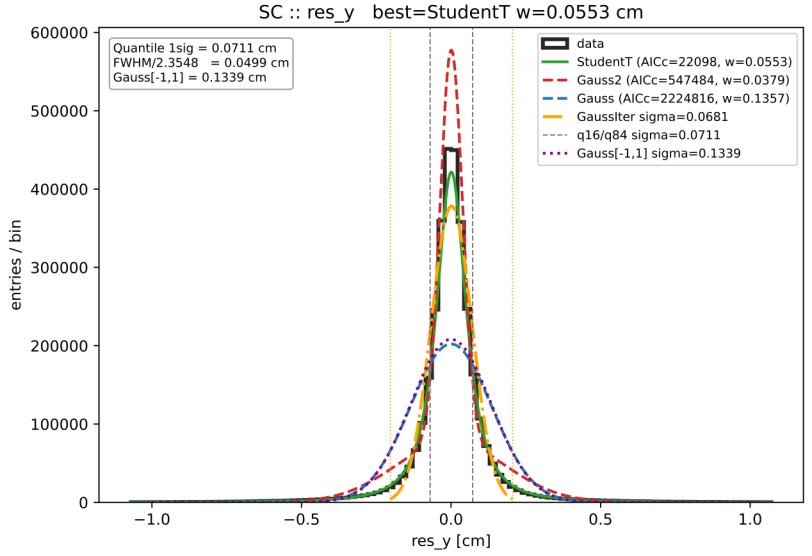
宇宙线和数据都需要左边TPC的漂移速度修正0.5%

空间电荷修正后径迹残差分辨达标，t分布拟合。

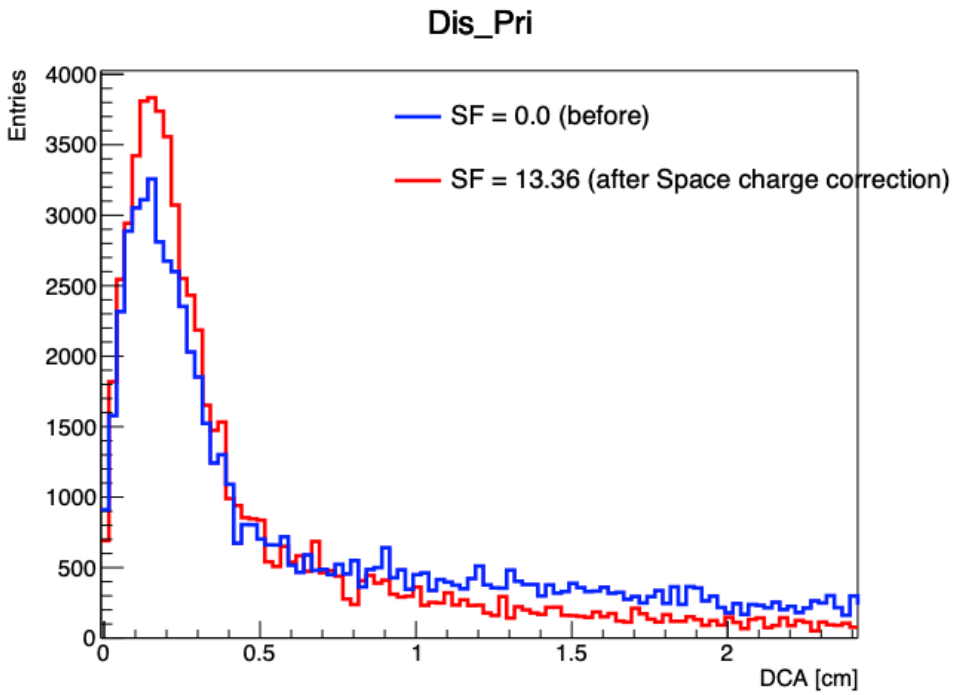


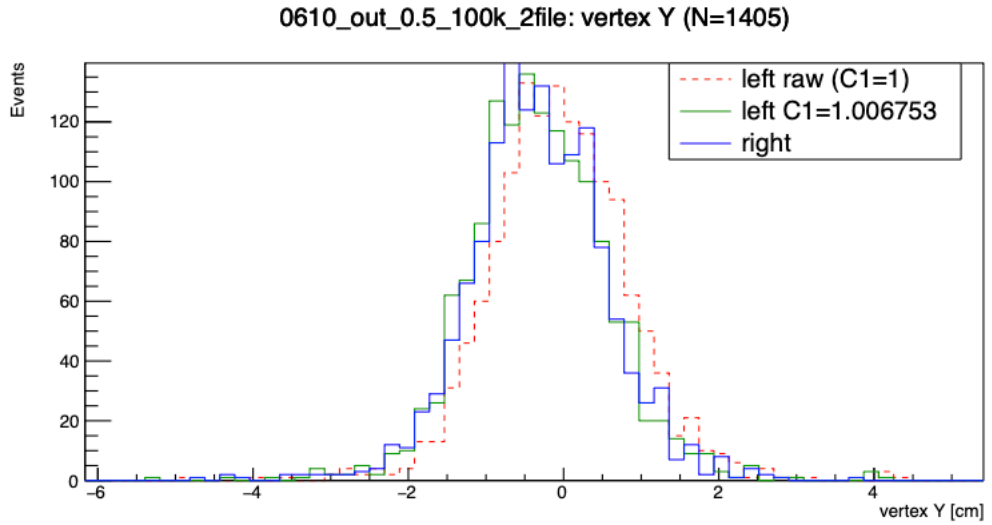


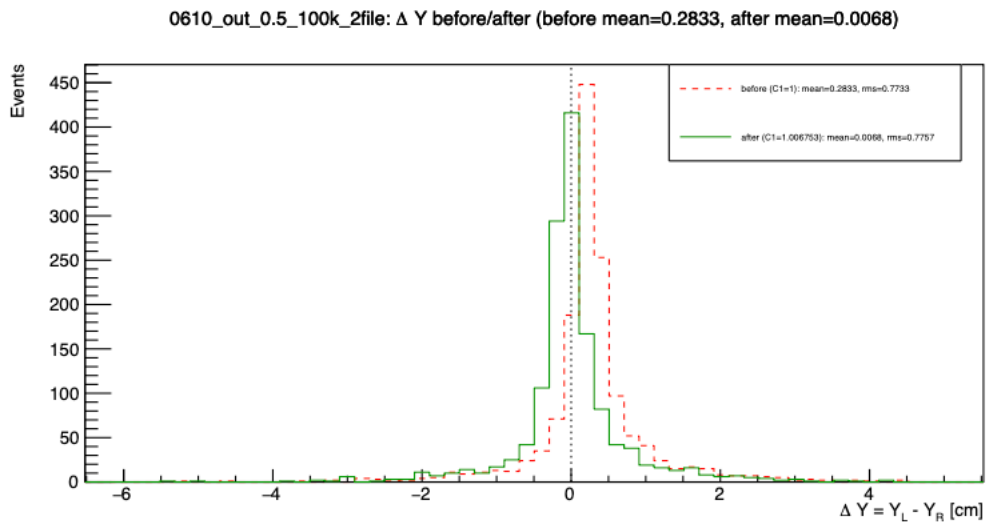




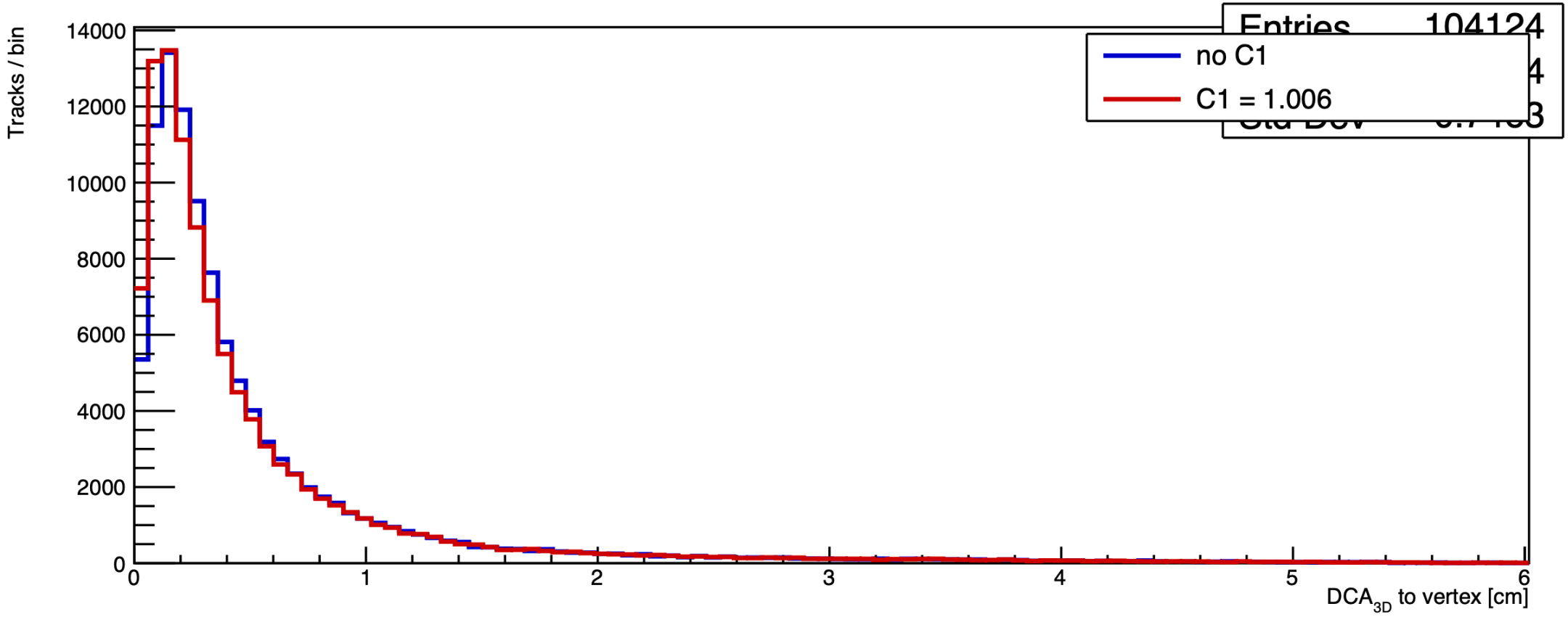
DCA需要做C1修正


Dis_Pri
Entries
SF = 0.0 (before)
SF = 13.36 (after Space charge correction)
DCA [cm]

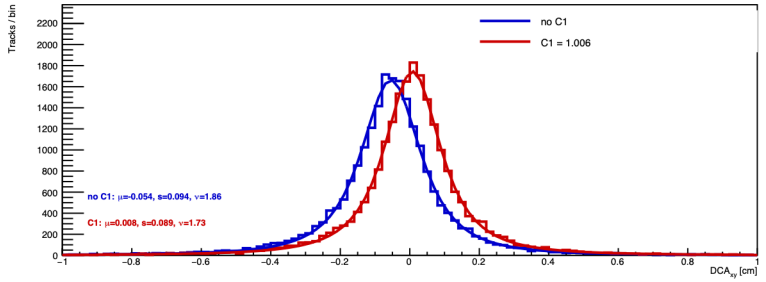

0610_out_0.5_100k_2file: vertex Y (N=1405)
Events
left raw (C1=1)
left C1=1.006753
right
vertex Y [cm]

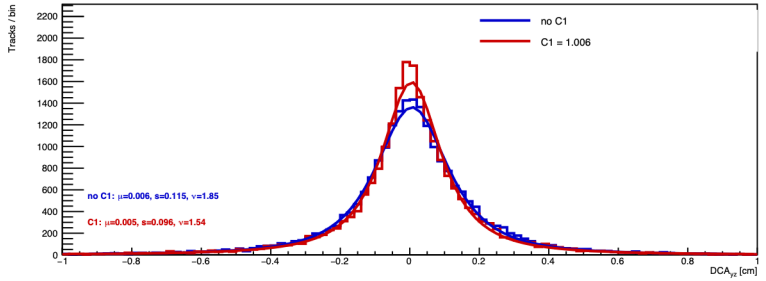

0610_out_0.5_100k_2file: Δ Y before/after (before mean=0.2833, after mean=0.0068)
Events
Δ Y = Y_L - Y_R [cm]

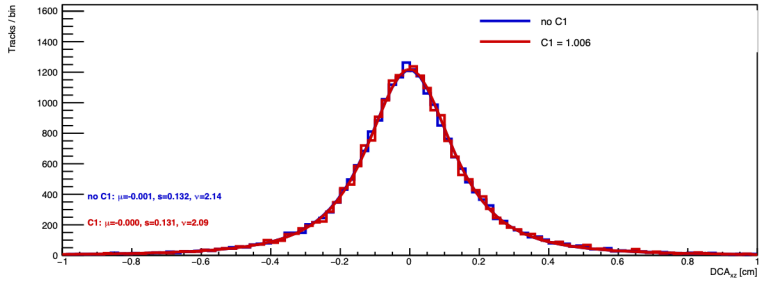
DCA3D 没cut

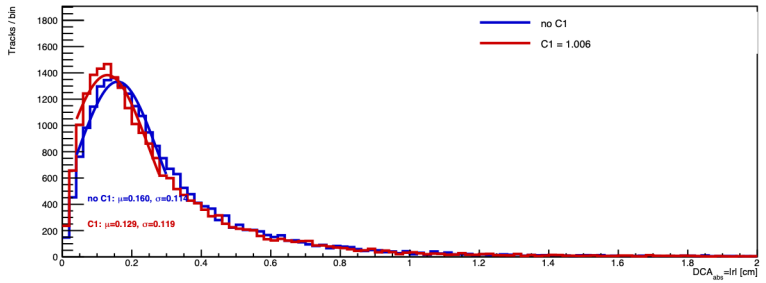

Entries 104124
no C1
C1 = 1.006
Tracks / bin
14000
12000
10000
8000
6000
4000
2000
0
0
1
2
3
4
5
6
DCA3D to vertex [cm]

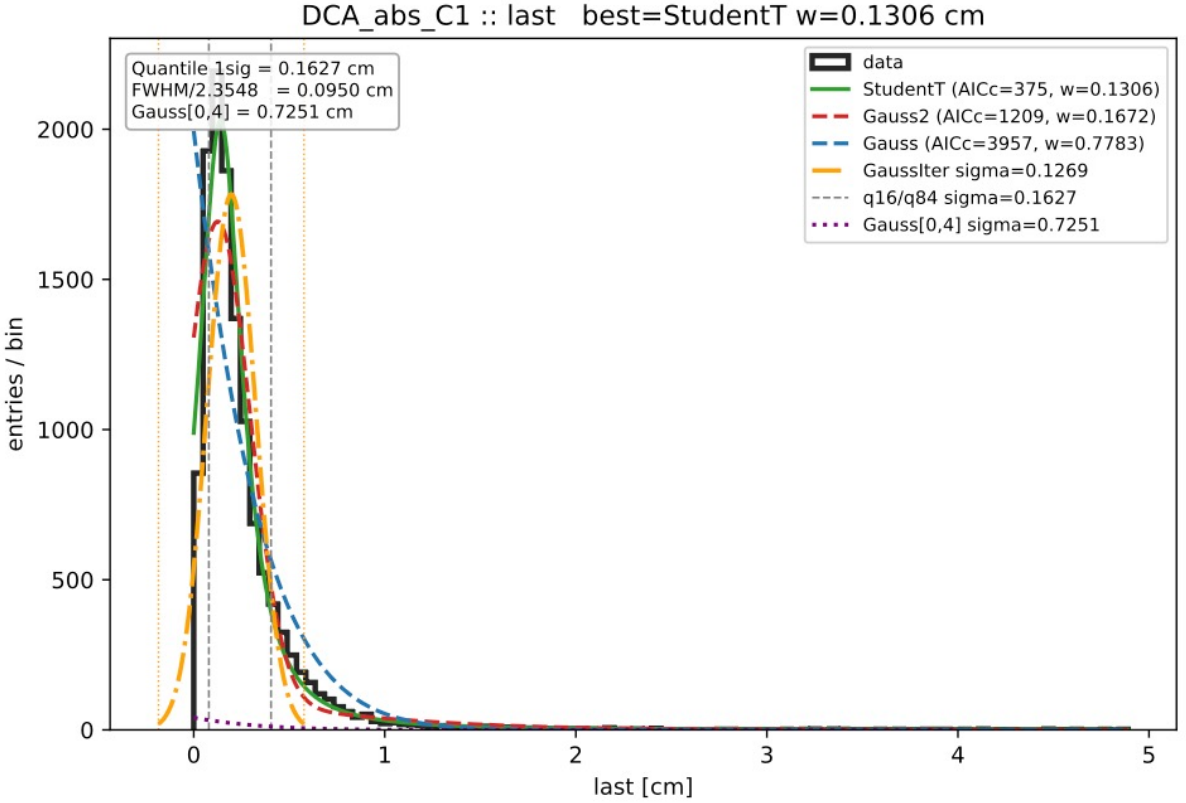
DCA3D


Tracks / bin
no C1
C1 = 1.006
no C1: μ=-0.054, s=0.094, ν=1.86
C1: μ=0.008, s=0.089, ν=1.73
DCA_xy [cm]

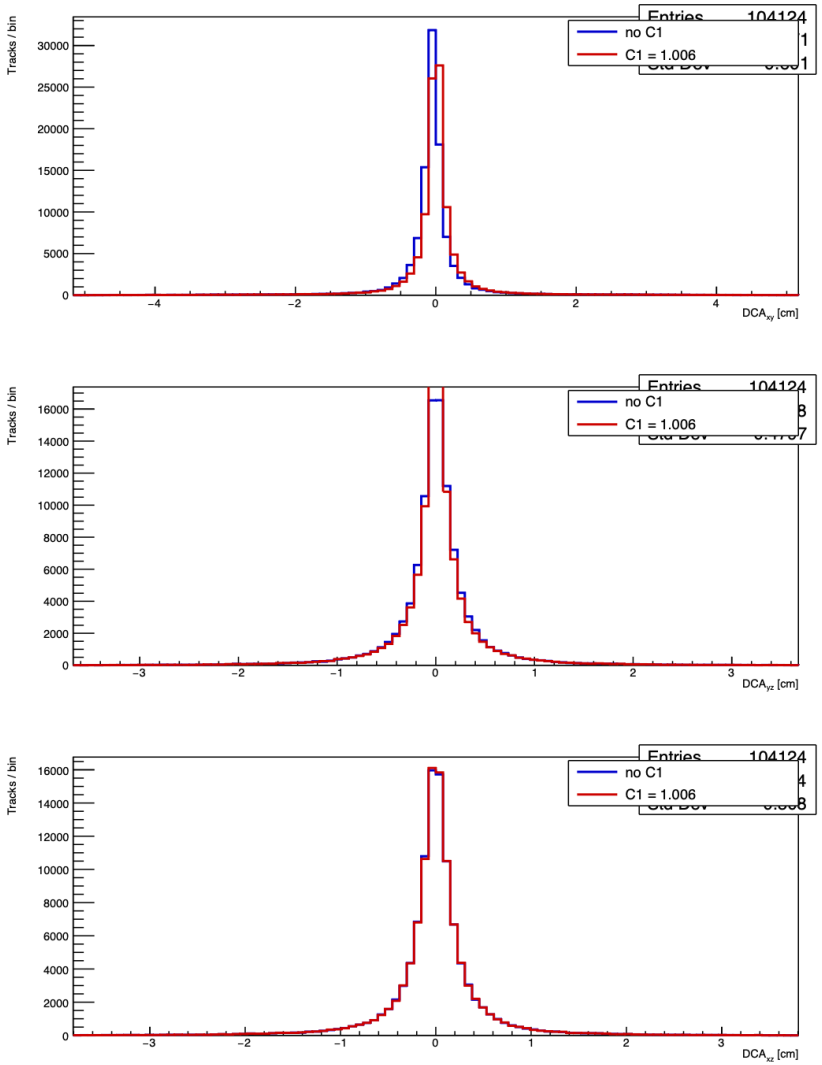

Tracks / bin
no C1
C1 = 1.006
no C1: μ=0.006, s=0.115, ν=1.85
C1: μ=0.005, s=0.096, ν=1.54
DCA_yz [cm]

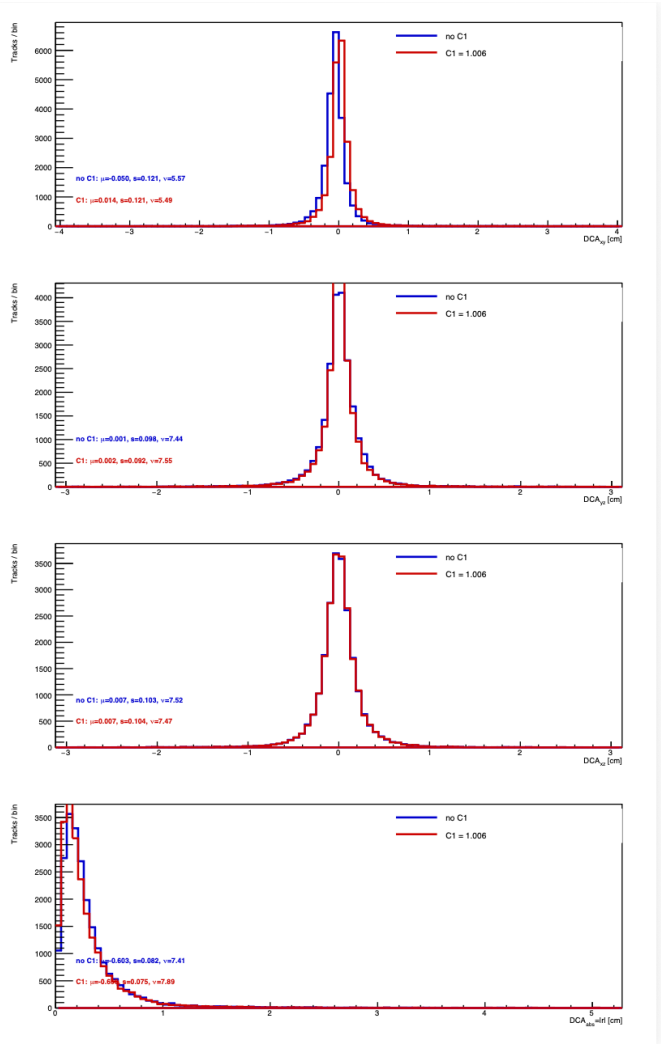

Tracks / bin
no C1
C1 = 1.006
no C1: μ=-0.001, s=0.132, ν=2.14
C1: μ=-0.000, s=0.131, ν=2.09
DCA_xz [cm]


Tracks / bin
no C1
C1 = 1.006
no C1: μ=0.160, σ=0.117
C1: μ=0.129, σ=0.119
DCA_abs=|r| [cm]


DCA_abs_C1 :: last best=StudentT w=0.1306 cm
Quantile 1sig = 0.1627 cm
FWHM/2.3548 = 0.0950 cm
Gauss[0,4] = 0.7251 cm
data
StudentT (AICc=375, w=0.1306)
Gauss2 (AICc=1209, w=0.1672)
Gauss (AICc=3957, w=0.7783)
GaussIter sigma=0.1269
q16/q84 sigma=0.1627
Gauss[0,4] sigma=0.7251
entries / bin
last [cm]

DCA3D 没cut


Entries 104124
no C1
C1 = 1.006
Tracks / bin
DCA_xy [cm]
DCA_yz [cm]
DCA_xz [cm]


no C1
C1 = 1.006
Tracks / bin