PHENIX data analysis status

Genki Nukazuka

RBRC experiment group meeting,

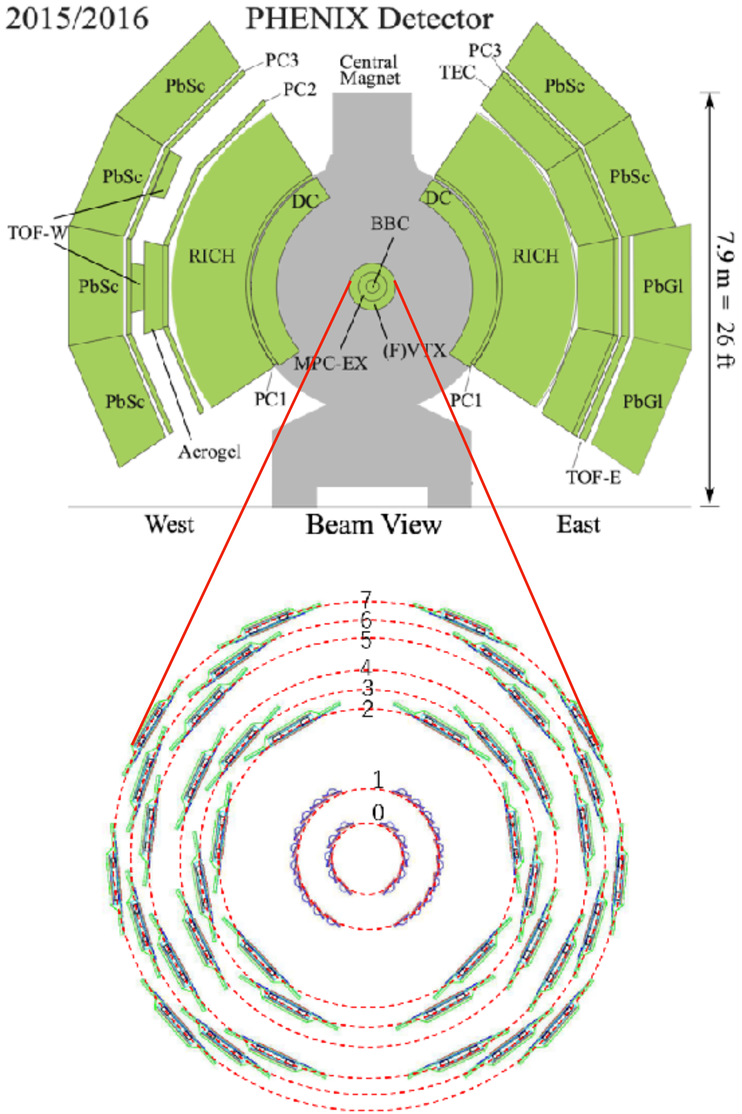
May/18/2021

List

- Alignment and recalibration of the PHENIX VTX detector for run16
- Double longitudinal asymmetry of η production with PHENIX run13 data

Alignment and recalibration of the PHENIX VTX detector for run16

with Y, Yasuyuki(RBRC), T. Hachiya(RBRC&NWU), and T. Todoroki (Tsukuba Univ.)

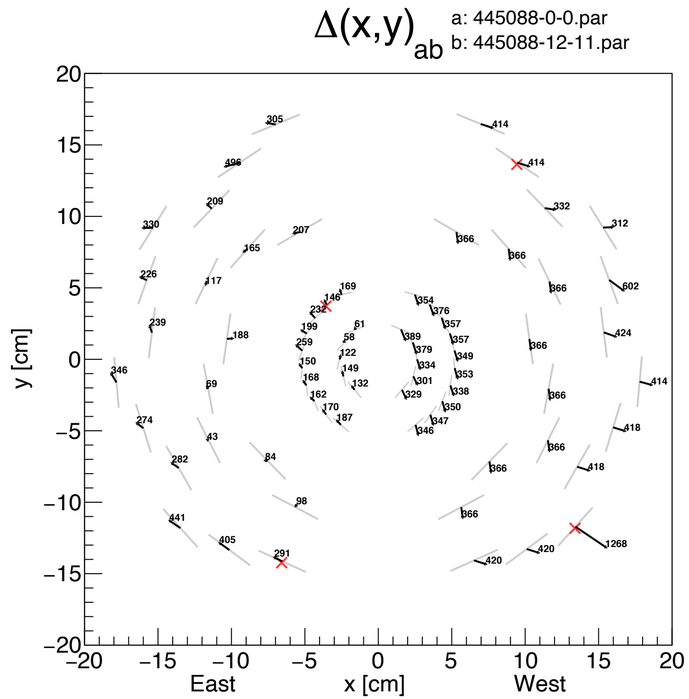


- Alignment procedures (reported at PHENIX analysis meeting on Nov/10/2020)

Prod Id	Geometry/Alignment
0-0_0~2	Run15, BC iterations
0-0_3	prod0
0-1	Arm(x, y, z)
10-0	prod1
10-1	Arm(x, y, z, pitch, yaw)
10-2	HL(s, z) HL r fixed
11-0	Prod2
11-1	Arm(x, y, z, pitch, yaw)
11-2	L(s, z) sigma = 1e-3 B2 & B3 fixed
11-3	L(s, z) sigma = 1e-3 B0 & B1 fixed
11-4	L(s, z) sigma = 1e-3 B2 & B3 fixed
11-5	L(s, z) sigma = 1e-3 B0 & B1 fixed
11-6	L(s, z) sigma = 5e-4
12-0	prod3
12-1	Arm(x, y, z, pitch, yaw)

Prod Id	Geometry/Alignment
12-1	Arm(x, y, z, pitch, yaw)
12-2	L(s, r) sigma = 5e-4 W all fixed. E B0, 1, 2 fixed
12-3	L(s, r) sigma = 5e-4 W all fixed. E B0, 1, 3 fixed
12-4	L(s, r) sigma = 5e-4 W all fixed. E B0, 1, 2 fixed
12-5	L(s, r) sigma = 5e-4 W all fixed. E B0, 1, 3 fixed
12-6	L(s, r) sigma = 5e-4 W all fixed. E B0, 1 fixed
12-7	L(s, r) sigma = 5e-4 W all fixed. E B1, 2, 3 fixed
12-8	L(s, r) sigma = 5e-4 W all fixed. E B0, 2, 3 fixed
12-9	L(s, r) sigma = 5e-4 W all fixed. E B1, 2, 3 fixed
12-10	L(s, r) sigma = 5e-4 W all fixed. E B0, 2, 3 fixed
12-11	L(s, r) sigma = 5e-4 W all fixed. E B2, 3 fixed

11/10/20 Analysis Meeting

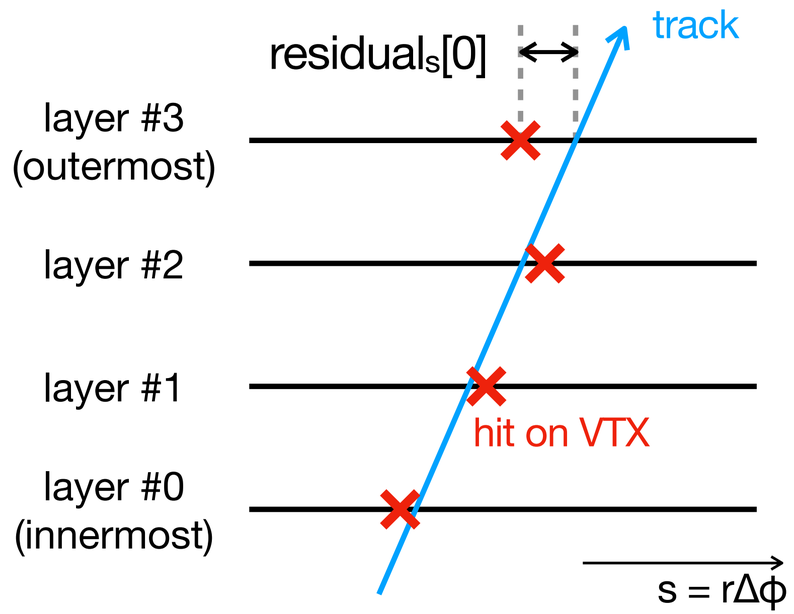


Difference b/w the ideal and the final geometry.

- Recalibration (reported at PHENIX analysis meetings Nov/10/2020 and Apr/27/2021)

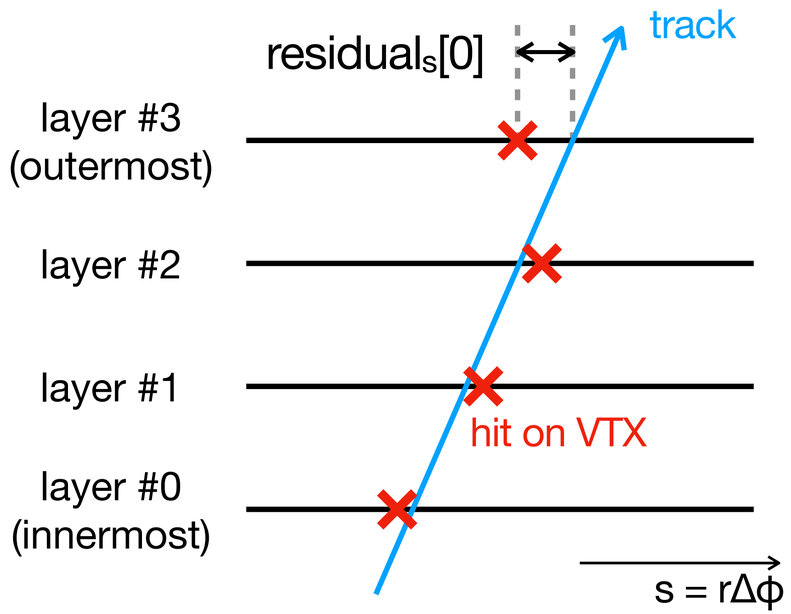
Re-calibration of VTX

- Correlation b/w DCA_{2D} and residual on VTX in *s* direction (hit position - projected position of track)

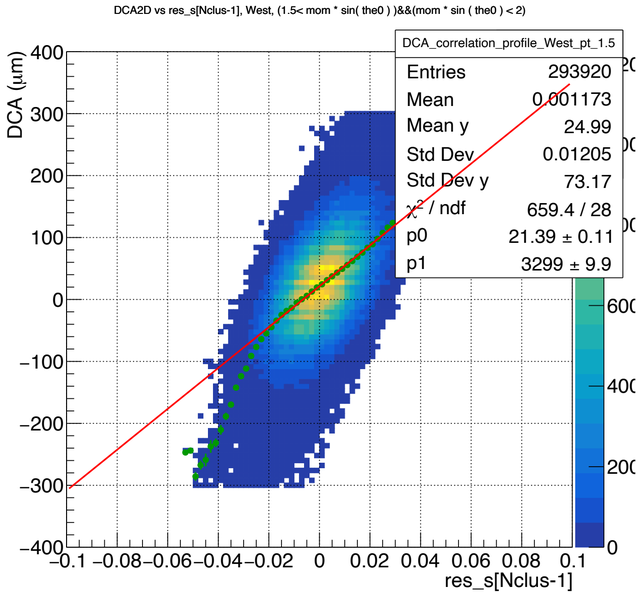


Re-calibration of VTX

- Correlation b/w DCA_{2D} and residual on VTX in *s* direction (hit position - projected position of track)
- The correlations can be estimated by fitting with linear functions.



dca2Dprimary

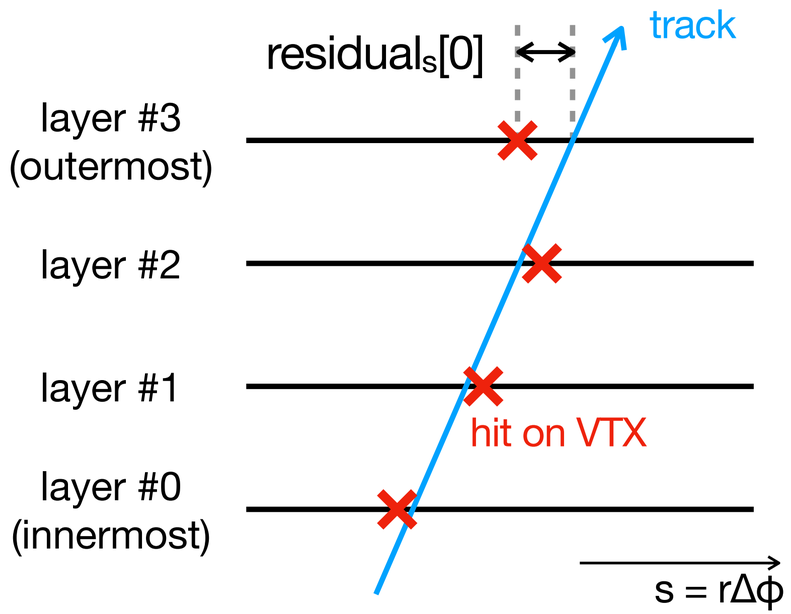


res_s[i] vs dca2DPrimary

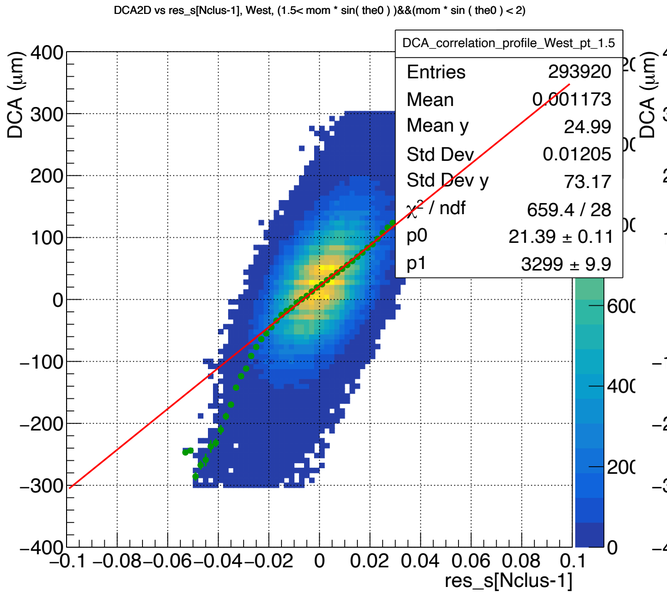
Run443780, West arm
$1.5 < p_T < 2.0$

Re-calibration of VTX

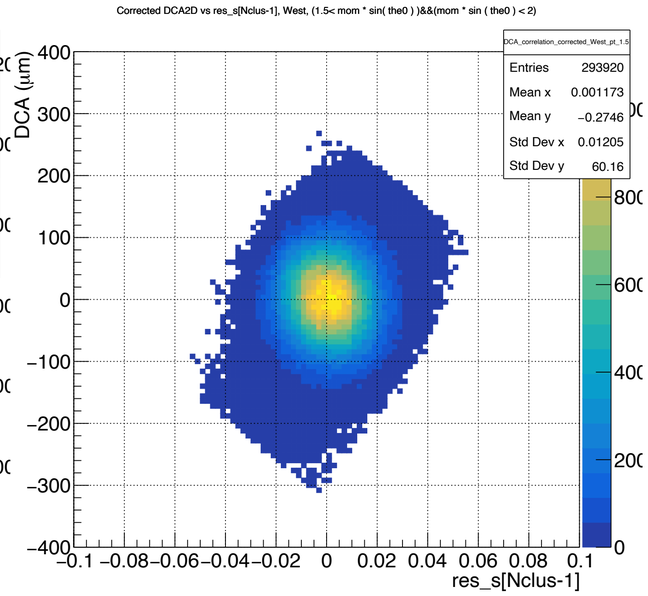
- Correlation b/w DCA_{2D} and residual on VTX in *s* direction (hit position - projected position of track)
- The correlations can be estimated by fitting with linear functions.
- Corrected DCA_{2D} distributions with the fitting function shows better DCA resolution
- The corrections can be done for all VTX planes iteratively.
- This procedure was applied to each arm and p_T bins.



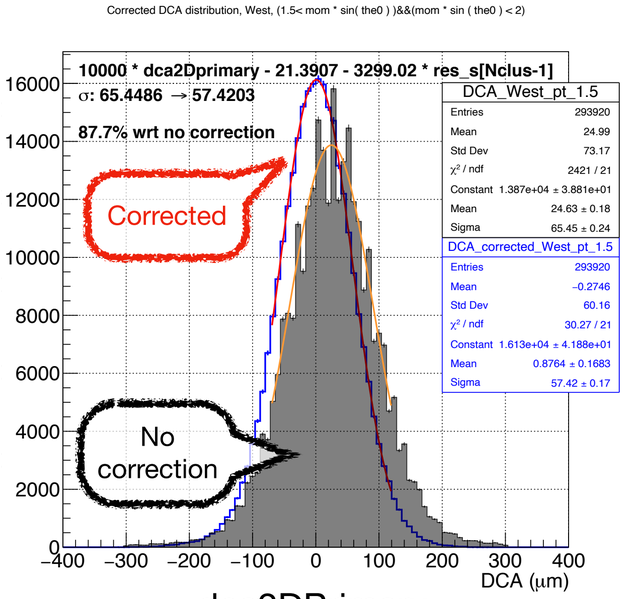
dca2Dprimary



res_s[i] vs dca2DPrimary



res_s[i] vs corrected dca2DPrimary



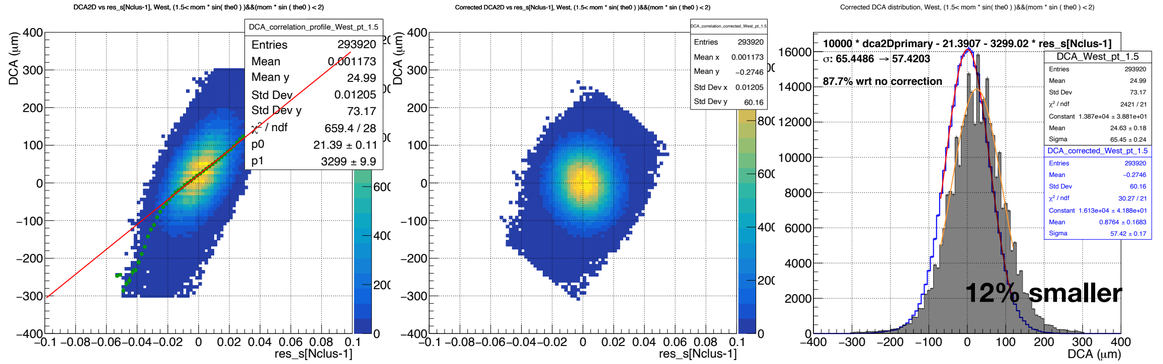
dca2DPrimary,
corrected dca2Primary

Run443780, West arm
$1.5 < p_T < 2.0$

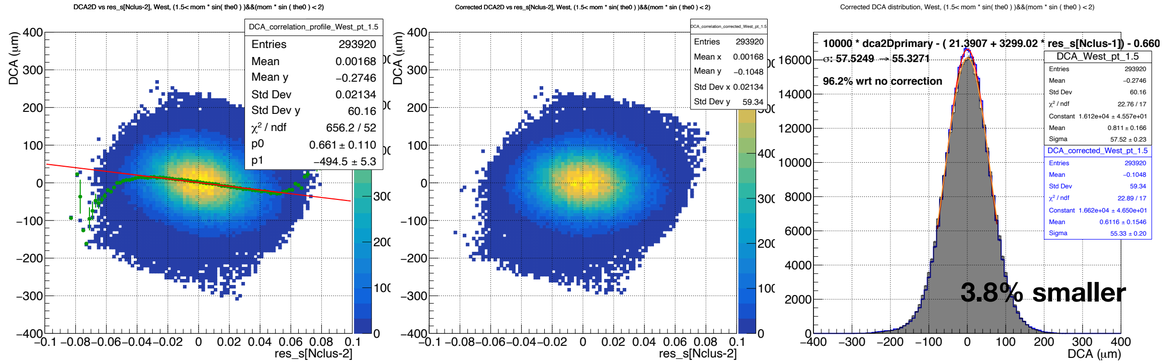
Re-calibration iteration over VTX planes

Run443780, West arm
$1.5 < p_T < 2.0$ GeV/c

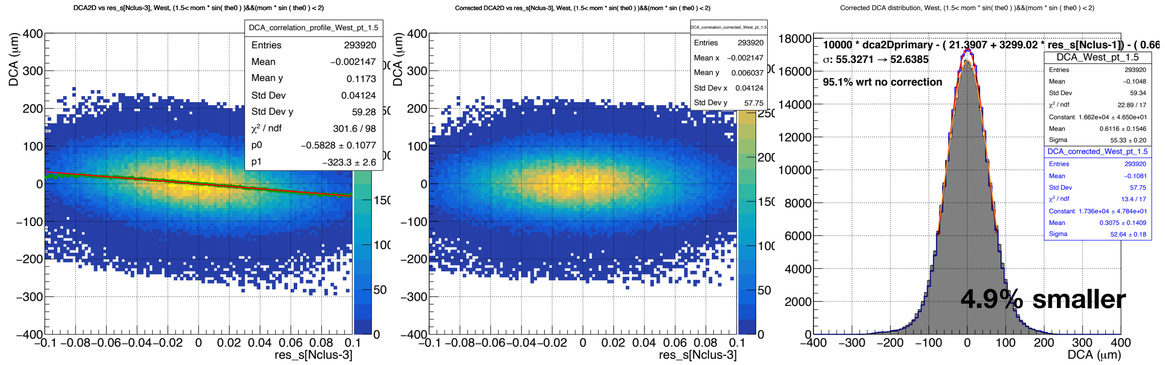
1st iteration



2nd iteration



3rd iteration



res_s[i] vs dca2DPrimary

res_s[i] vs corrected dca2DPrimary

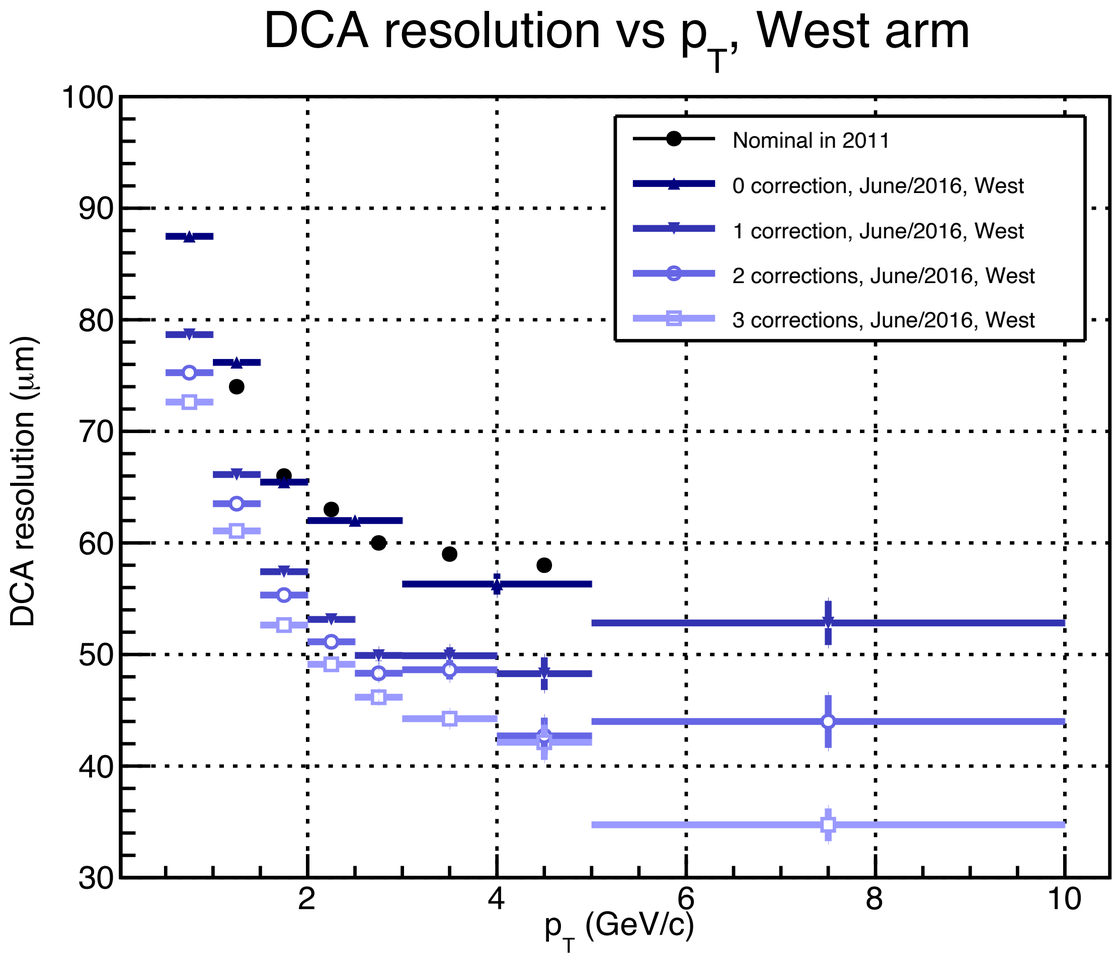
dca2DPrimary

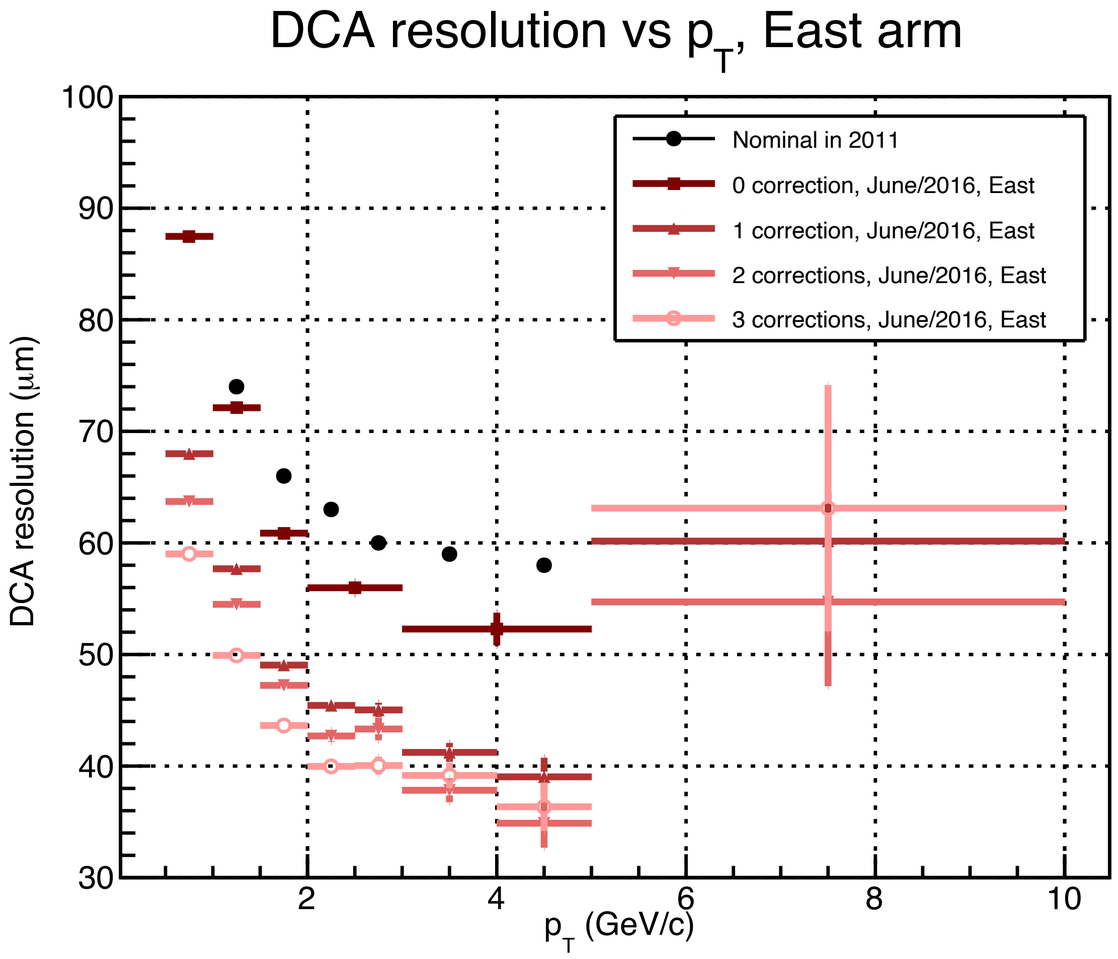
no correction: 65.5 μm

all corrections: 52.6 μm

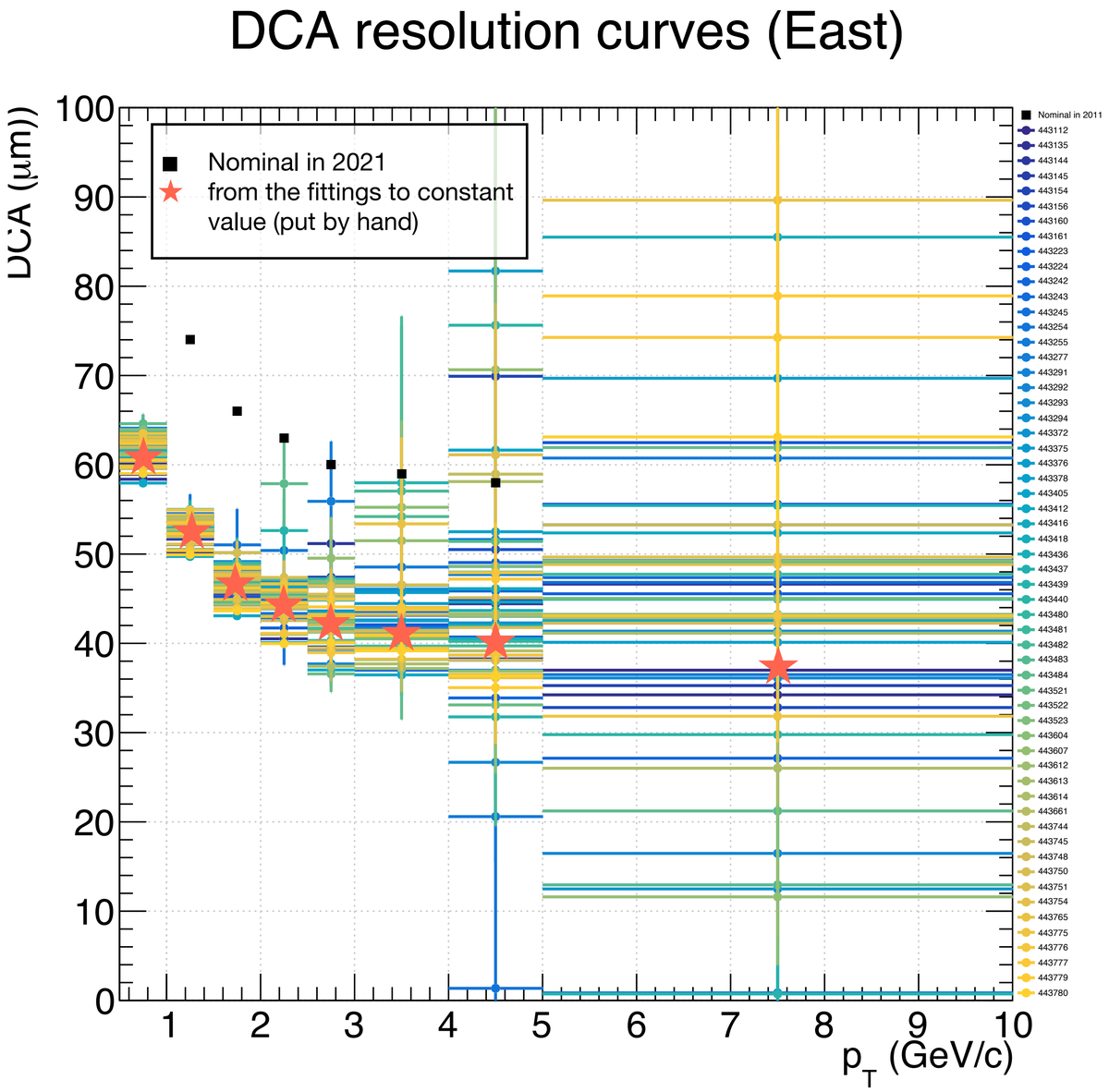
Impact of the re-calibration

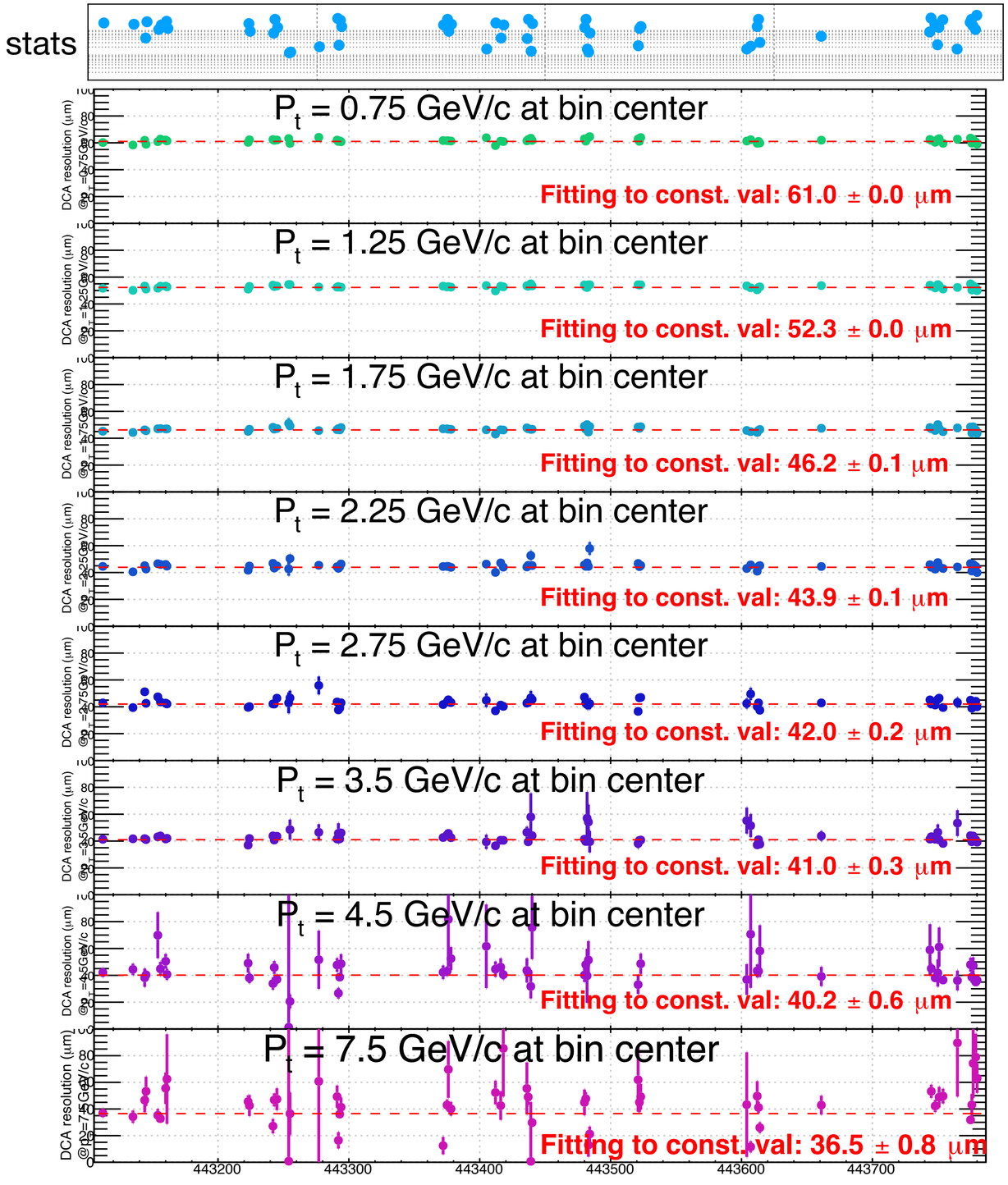
Run443780



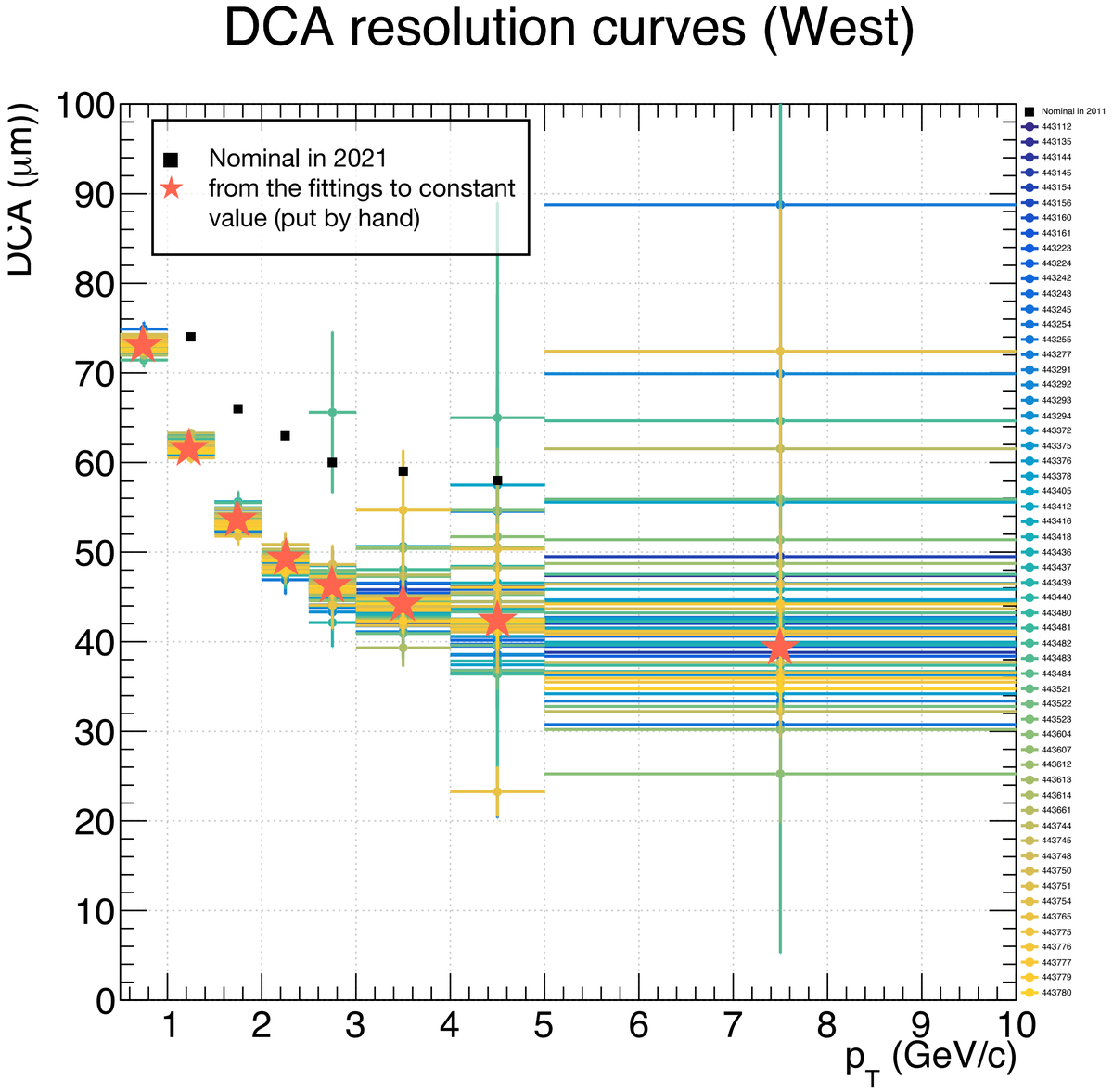


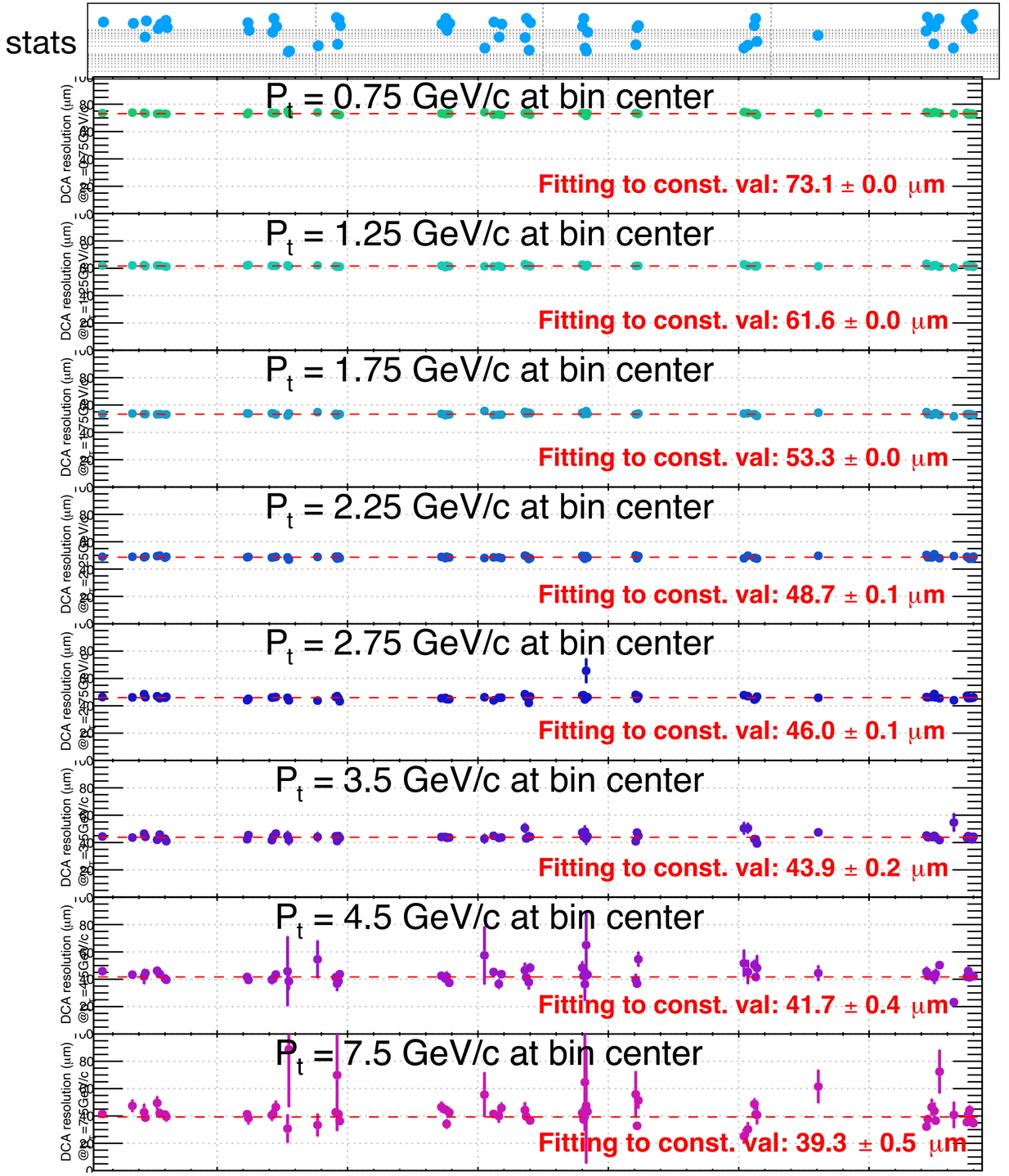
DCA resolution for many runs, East arm





DCA resolution for many runs, West arm





Alignment and recalibration of the PHENIX VTX detector for run16

Improvement on the DCA resolution for PHENIX

G. Nukazuka,[*1] Y. Akiba,[*1] T. Hachiya,[*1,*2] and T. Todoroki,[*3]

PHENIX experiment took data at RHIC in BNL since 2001 to 2016 to study quark-gluon plasma and spin structure of the nucleon.

Measurement of the distance of closest approach (DCA), which is the minimum distance from a beam collision point to trajectory of a reconstructed particle, significantly suppress background to heavy flavor production measurement in a single electron channel. The vertex tracker (VTX)[1)2)] consists of two layers with silicon pixel sensors and two layers with silicon strip sensors. VTX in each of the west and east arm measures the trajectory, and the beam-beam counter determines the Z-coordinate of the beam collision point. DCA is calculated event by event using these information.

In 2016, PHENIX measured Au-Au collisions at collision energy $\sqrt{s_{NN}} = 200$ GeV. One of tasks needed to start Data Summary Tape (DST) production of the data is the alignment of the VTX detector. In the alignment process, we found strong linear correlations between DCA in the transverse direction with respect to the beam-axis and residual in track fitting in the direction of $s = r\Delta\phi$ (Fig. 1), where r is the distance from the beam-axis, and $\Delta\phi$ is the relative azimuth angle between hits and track projections on the VTX plane. The abscissa and ordinate axes represent the residual in s direction and the transverse DCA. Only clusters with a transverse momentum p_T between 1.5 GeV/c and 2.0 GeV/c in the Fig. 1. Green points are average values over DCA of a residual bin. A linear fitting shown with the red line estimates correlation.

The correlation's strength depends on p_T, the arm, and the VTX layer. The correlations can be used to correct the DCA value and to improve the DCA resolution. The corrected DCA distribution is narrower than the raw distribution (Fig. 2). The dark and light blue histograms represent the raw and corrected DCA distributions, respectively. Fittings with a Gaussian function to the raw DCA (red) and the corrected DCA (orange) give DCA resolutions.

Figure 3 shows DCA resolution as a function of p_T. The dark and light blue graphs are the raw and the corrected DCA resolutions in the west arm, respectively, while the graphs in dark and light red are in the east arm. The black points mean the nominal DCA resolution in run 2011[2)]. By applying all corrections, the resolution is improved by 15 % to 35 %.

In 2016, VTX was operated without one strip layer in the west arm due to a beam accident in 2015. Under such severe condition, DCA resolution less than 50 µm was achieved in $p_T > 2.0$ GeV/c while it was about 60 µm in run 2011[2)].

This method may reduce background in the heavy flavor measurements since it is valid to data from the other PHENIX runs in principle.

[*1] RIKEN Nishina Center
[*2] Nara Women's University
[*3] University of Tsukuba

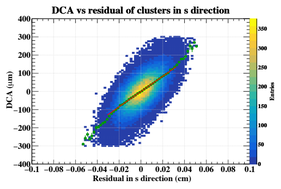


Fig. 1. Correlation between DCA and cluster residual in s direction in the innermost layer of the west arm with the selection of $1.5 < p_T < 2.0$ GeV/c.

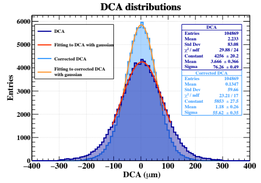


Fig. 2. DCA (dark black) and corrected DCA (light blue) distributions taken by the west arm with the selection of $1.5 < p_T < 2.0$ GeV/c.

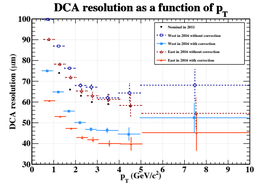


Fig. 3. DCA resolutions as a function of p_T. Points except black ones are slightly shifted for visibility.

References

1) K .Adcox *et al.*, Nucl. Instr. Meth. A **499**, 469 (2003).
2) A. Adare *et al.*, Phys. Rev. C **93**, 034904 (2016).

Status of the recalibration was summarized and submitted to RIKEN APR Jan/2021. I received comments from referee and already resubmitted.

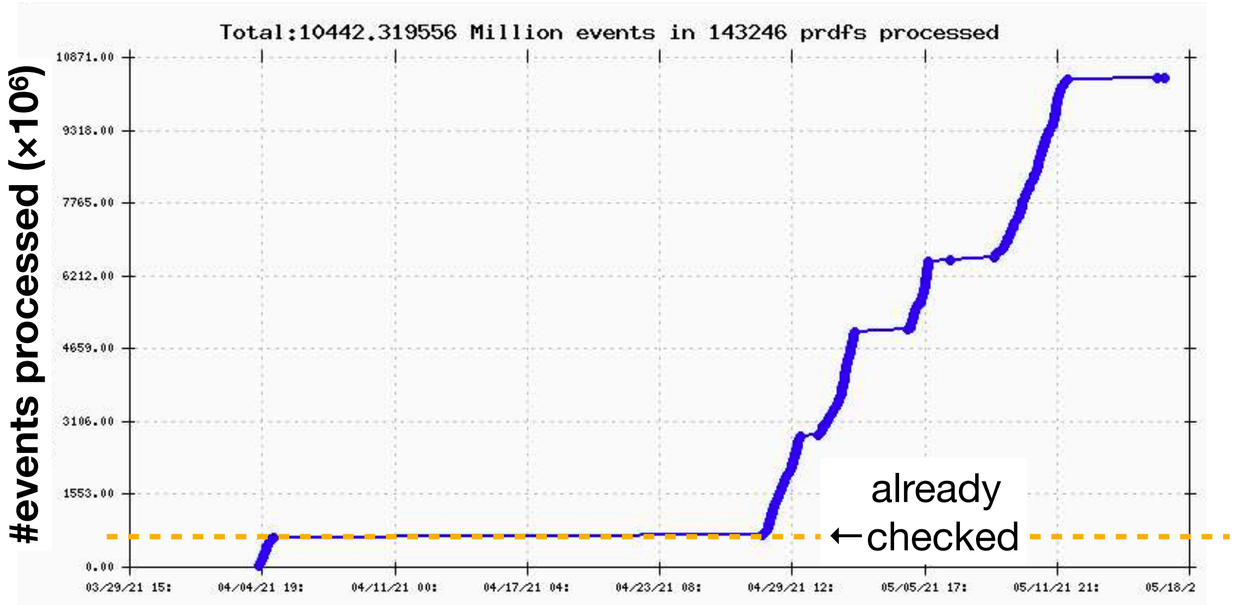
Plan

Run16

- The production is about to finish
- Parameter determination for all runs after the end of production (~5% of data already checked)
- Implementation of database for recalibration parameters
- Implementation of the official recalibrator

Run14

- Check whether the same procedure improves DCA resolution
- Parameter determination for all runs aster production
- Implementation of the official recalibrator



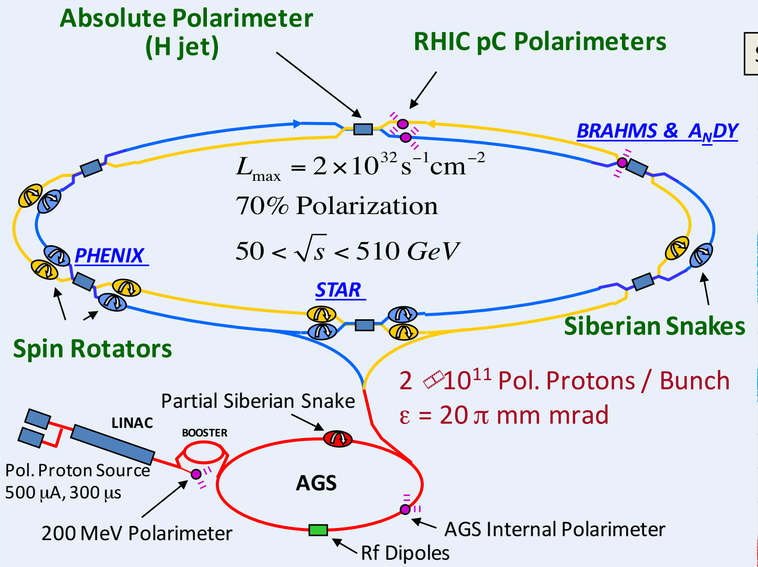
#processed events in the current production

List

- Alignment and recalibration of the PHENIX VTX detector for run16
- Double longitudinal asymmetry of η production with PHENIX run13 data

Double longitudinal asymmetry of η production with PHENIX run13 data

PHENIX Spin @ RHIC



A.Bazilevsky, WWND-2020

Spin Running in PHENIX, long./trans.

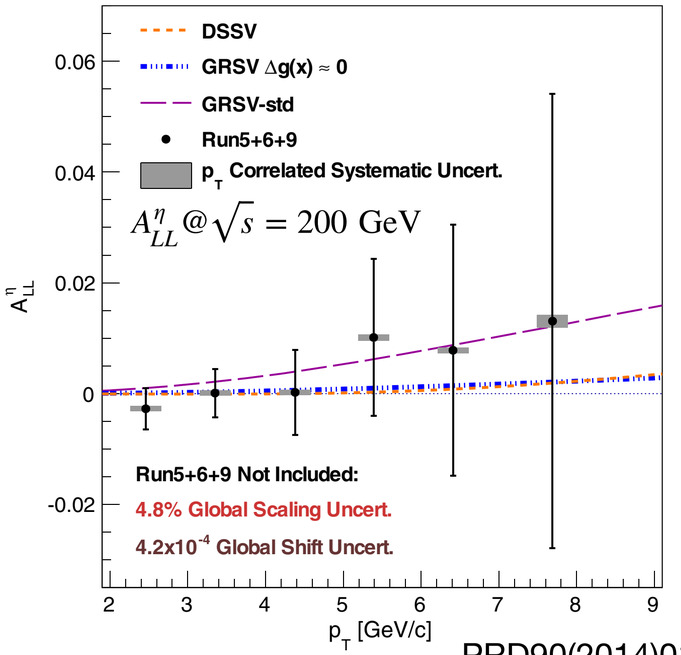
Year	√s [GeV]	L [pb^{-1}] (recorded)	Pol. [%]
2002	200	– / 0.15	15
2003	200	0.35 / –	27
2004	200	0.12 / –	40
2005	200	3.4 / 0.2	49
2006	200	7.5 / 2.7	57
2006	62.4	0.08 / 0.02	48
2008	200	– / 5.2	45
2009	200	16 / –	55
2009	**500**	**14 / –**	**39**
2011	**500**	**18 / –**	**48**
2012	200	– / 10	56
2012	**510**	**32 / –**	**56**
2013	**510**	**155 / –**	**56**
2015	200	– /60	58
2015	pAu@200	– /0.2	61
2015	pAl@200	– /0.5	58

$$A_{LL} = \frac{\Delta\sigma}{\sigma} = \frac{\sigma_{++} - \sigma_{+-}}{\sigma_{++} + \sigma_{+-}}$$

f : Parton Distribution Function (PDF)
Δf : polarized PDF
$\sigma^{a+b\to c+X}$: cross-section for a+b→c+X
$\Delta\sigma^{a+b\to c+X}$: polarized cross-section for a+b→c+X
D : fragmentation function

$$A_{LL} = \frac{\sum_{abc} \Delta f_a(x_1,\mu_F^2) \otimes \Delta f_b(x_2,\mu_F^2) \otimes \Delta\sigma^{a+b\to c+X}(x_1,x_2,p_c,\mu_F^2,\mu_R^2,\mu_{FF}^2) \otimes D_c^h(z,\mu_{FF}^2)}{\sum_{abc} f_a(x_1,\mu_F^2) \otimes f_b(x_2,\mu_F^2) \otimes \sigma^{a+b\to c+X}(x_1,x_2,p_c,\mu_F^2,\mu_R^2,\mu_{FF}^2) \otimes D_c^h(z,\mu_{FF}^2)}$$

$$S_p = \frac{1}{2} = \frac{1}{2}\Delta\Sigma + \Delta G + L_q + L_g$$



PHENIX already published A^{η}_{LL} with √s = 200 GeV. My topic is doing similarly with run13 data.

PRD90(2014)012007

Double longitudinal asymmetry of η production with PHENIX run13 data

- Run selection
  - Stability check
    - runs
    - detectors
    - other parameters
- Detectors activity
  - all: stability
  - EMcal: calibration, warn map
  - Drift chamber, Pad chamber, RICH: dead maps
- Beam polarization
- η selection
- asymmetry determination
- MC
- systematic study
- etc…

Double longitudinal asymmetry of η production with PHENIX run13 data

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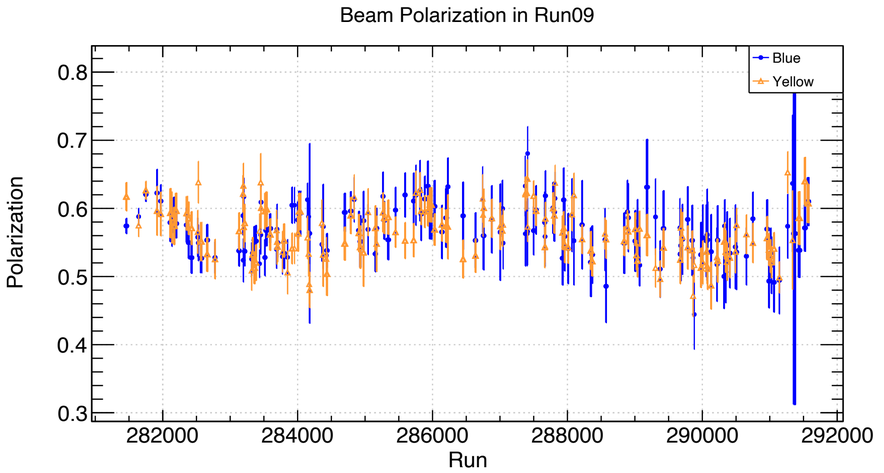
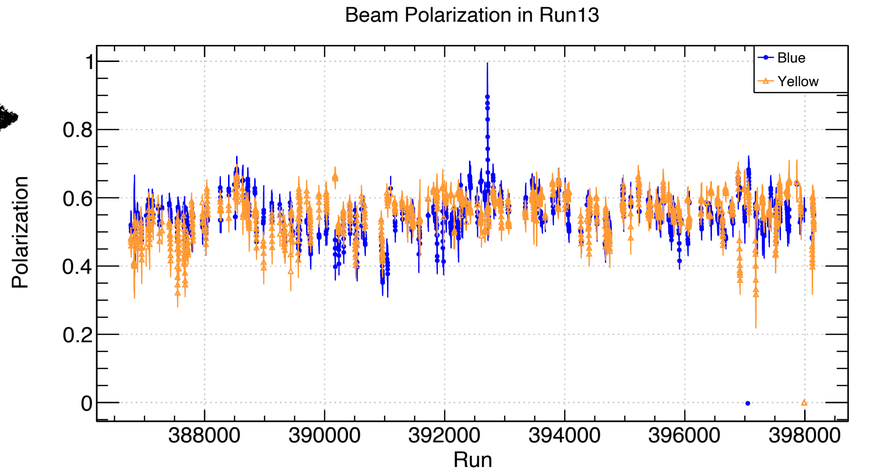
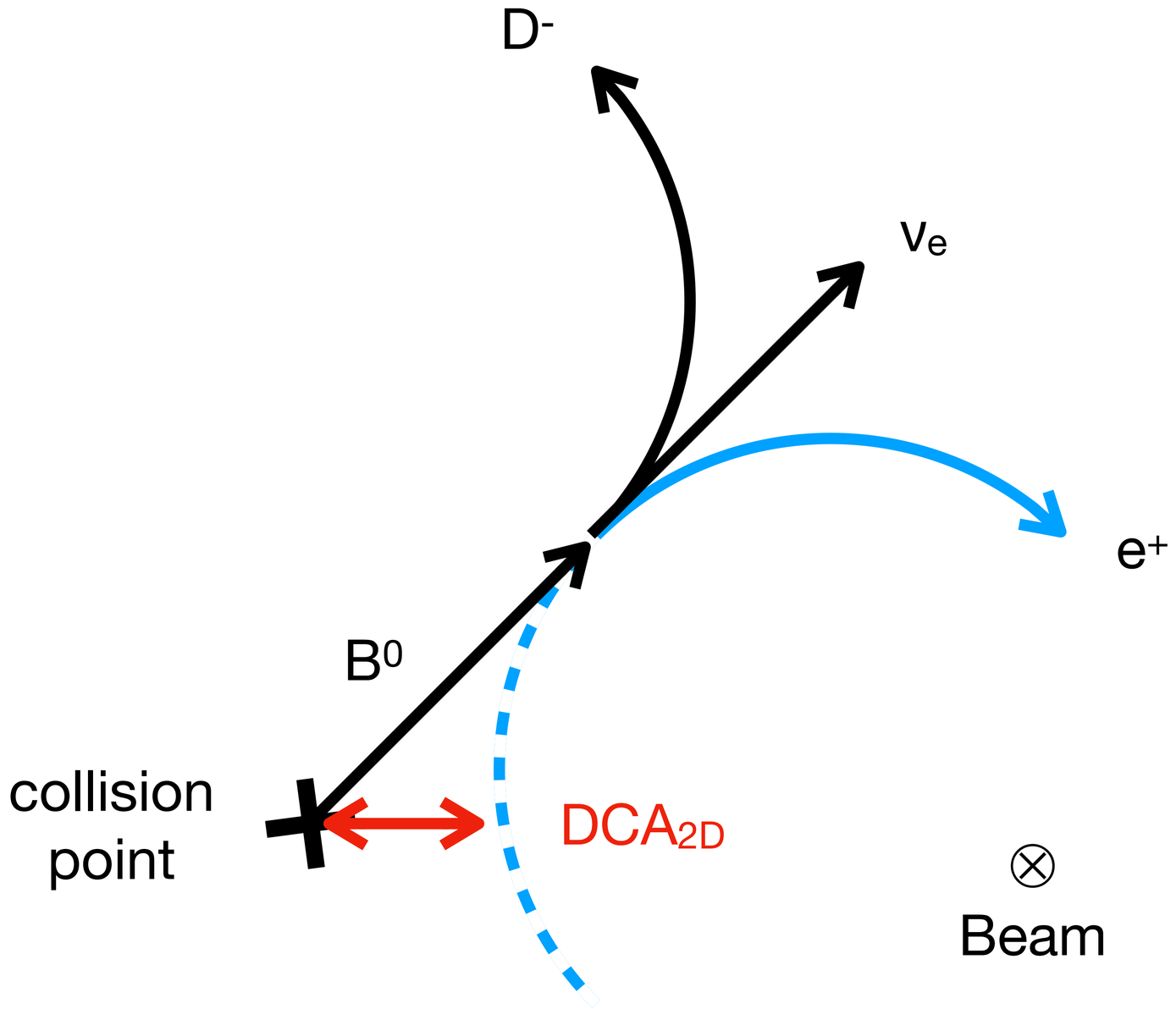
done in this month





backup

DCA_{2D}



Data, List of runs

Run	segment	#events in ntuple	Run	segment	#events in ntuple	Run	segment	#events in ntuple
443112	72	1.8E+06	443372	191	1.5E+06	443604	20	1.7E+05
443135	252	1.6E+06	443375	277	2.5E+06	443607	27	2.2E+05
443144	61	4.6E+05	443376	115	8.5E+05	443612	179	1.3E+06
443145	262	2.0E+06	443378	224	1.6E+06	443613	294	2.5E+06
443154	138	1.0E+06	443405	20	1.7E+05	443614	35	3.1E+05
443156	245	1.5E+06	443412	317	1.8E+06	443661	72	5.4E+05
443160	277	2.1E+06	443416	63	4.6E+05	443744	104	8.0E+05
443161	160	1.1E+06	443418	217	1.5E+06	443745	350	2.8E+06
443223	250	1.7E+06	443436	56	4.4E+05	443748	197	1.6E+06
443224	153	8.5E+05	443437	334	2.5E+06	443750	34	2.5E+05
443242	88	7.2E+05	443439	23	1.4E+05	443751	154	1.2E+06
443243	283	2.5E+06	443440	315	1.7E+06	443754	325	2.4E+06
443245	163	1.2E+06	443480	134	1.2E+06	443765	20	1.7E+05
443254	40	1.2E+05	443481	291	2.5E+06	443775	334	1.9E+06
443255	34	1.3E+05	443482	28	1.7E+05	443776	335	2.5E+06
443277	27	2.1E+05	443483	33	1.3E+05	443777	265	1.4E+06
443291	319	2.7E+06	443484	145	7.2E+05	443779	242	1.0E+06
443292	34	2.4E+05	443521	31	2.3E+05	443780	116	3.6E+06
443293	331	2.3E+06	443522	136	1.1E+06			
443294	192	1.3E+06	443523	212	1.3E+06