Primary Vertexing with Machine Backgrounds

Shyam Kumar*, Annalisa Mastroserio, Domenico Elia

INFN Bari, Italy

Reconstruction of D^0 meson

Primary Vertex Reconstruction:

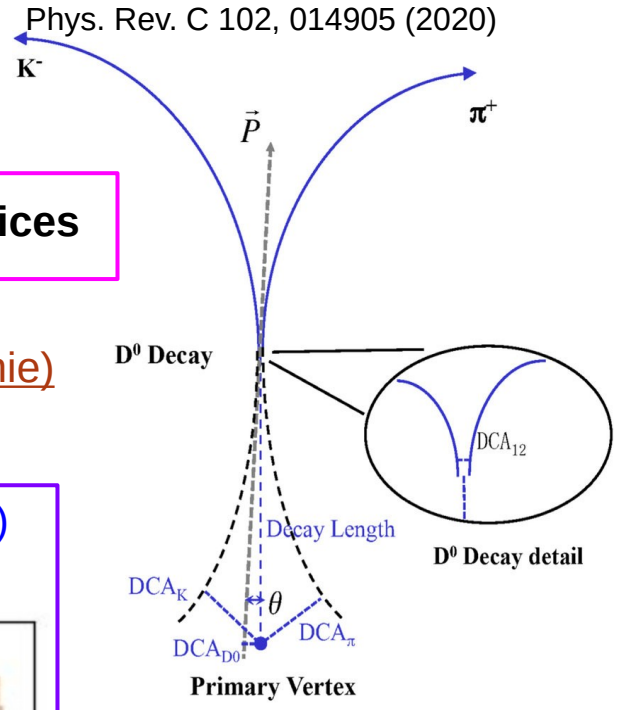
Reconstructed Tracks → **CentralTrackVertices** → **PrimaryVertices**

Seed Vertices indices (0,1,2,...)

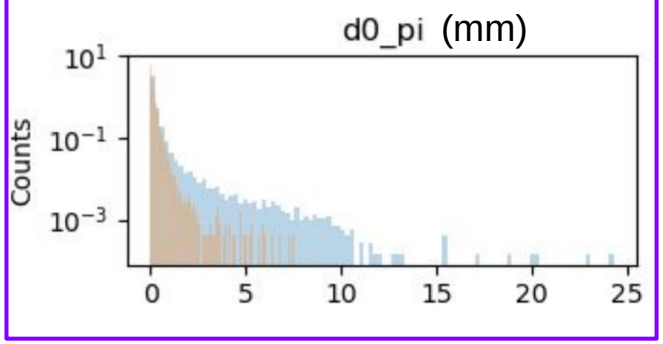
Slides (connie)

10x100 ep, $Q^2 > 1$ (5 μm Au coating)

Phys. Rev. C 102, 014905 (2020)

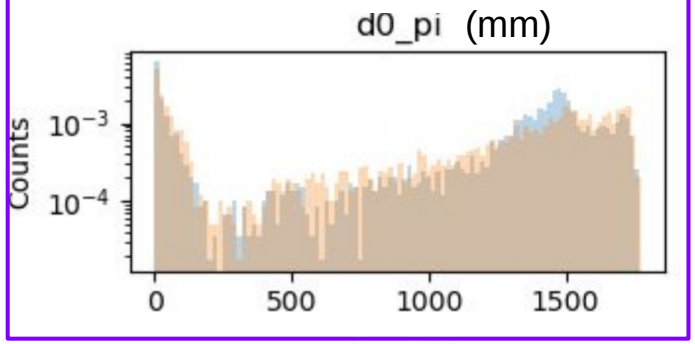


w/o Machine bkg



Signal (D^0 sample)

w Machine bkg (nhits>3)



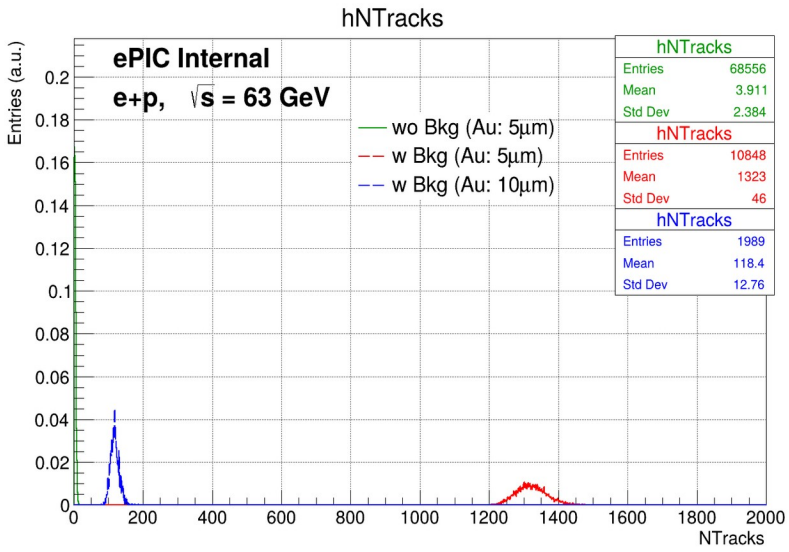
Bkg (DIS Sample)

d0_pi = DCA_π (plot)

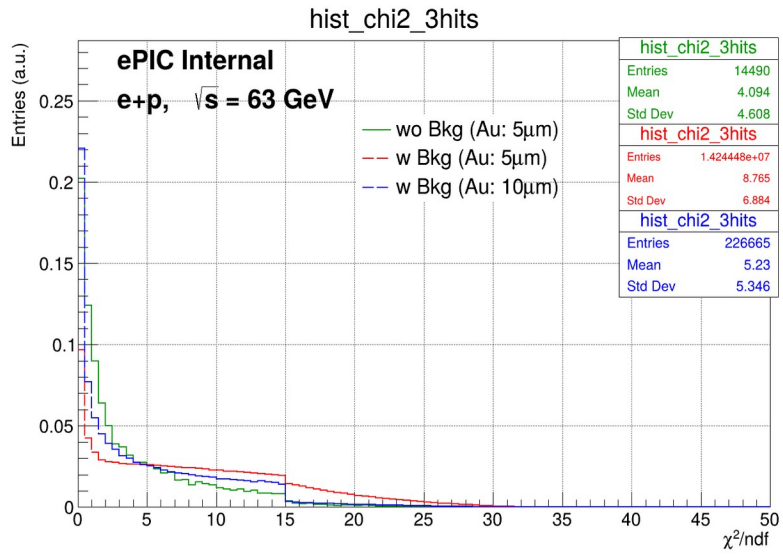
Broadening of d0_pi distribution points some issue in the primary vertex position **(DIS Sample)**

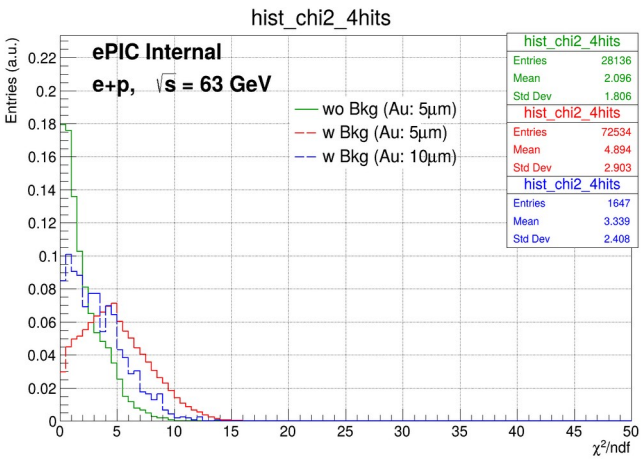
/volatile/eic/EPIC//RECO/**26.03.0**/epic_craterlake/Bkg_Exact1S_2us/GoldCt/10um/DIS (DISSample)

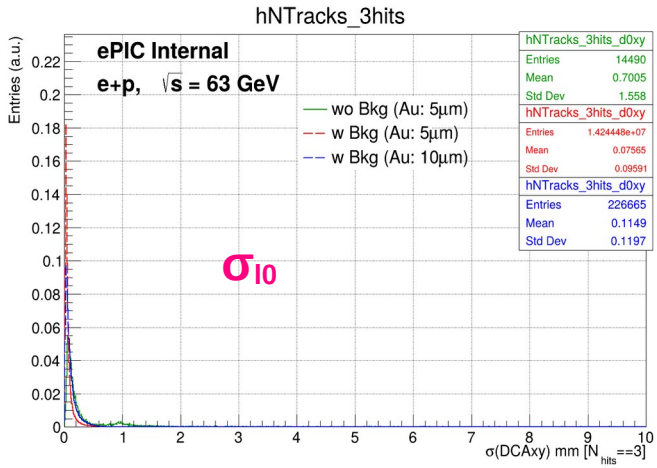
Reconstructed Tracks (CentralCKFTrackParameters)

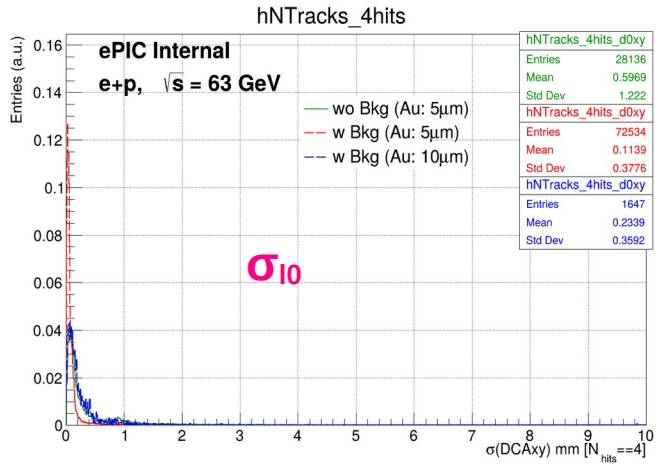


ndf = 2*Nhits-5



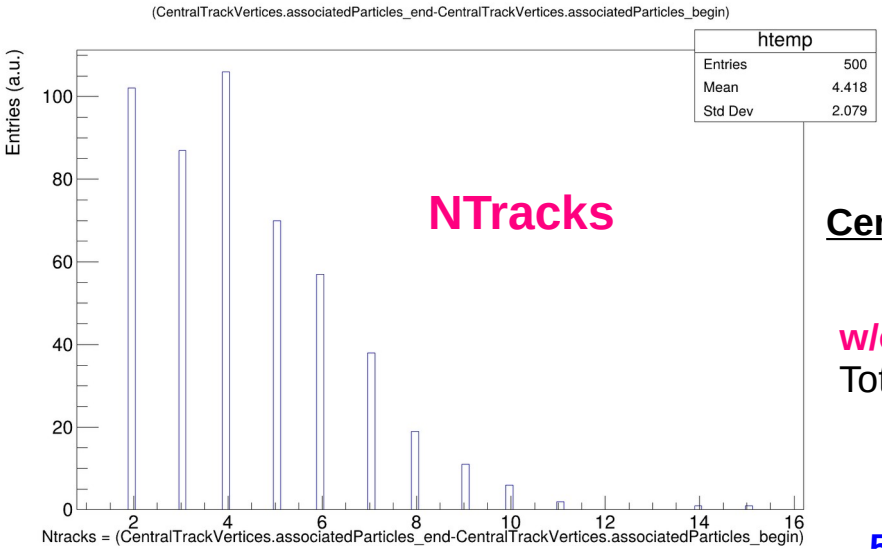






Ntracks refer to the number of reconstructed tracks

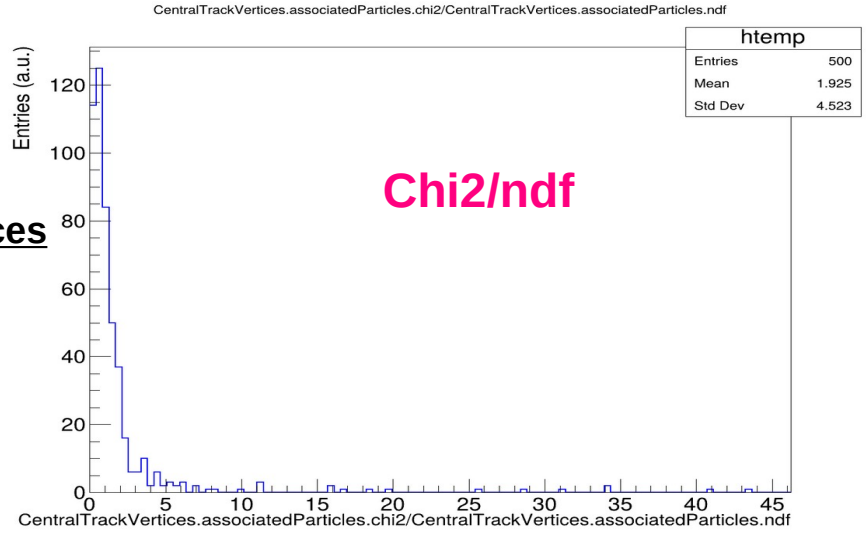
Primary Vertex w/o and w Machine Backgrounds (**October 2025**)



NTracks

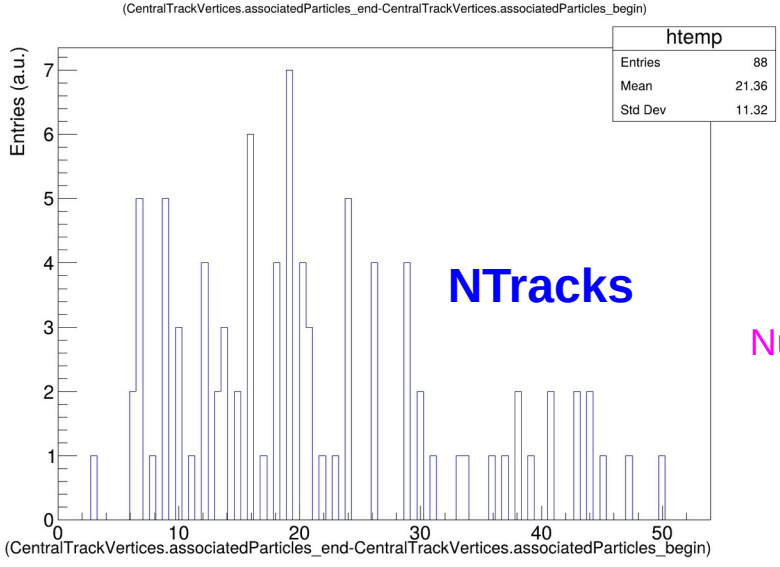
CentralTrackVertices

w/o Machine Bkg
Total events = 591



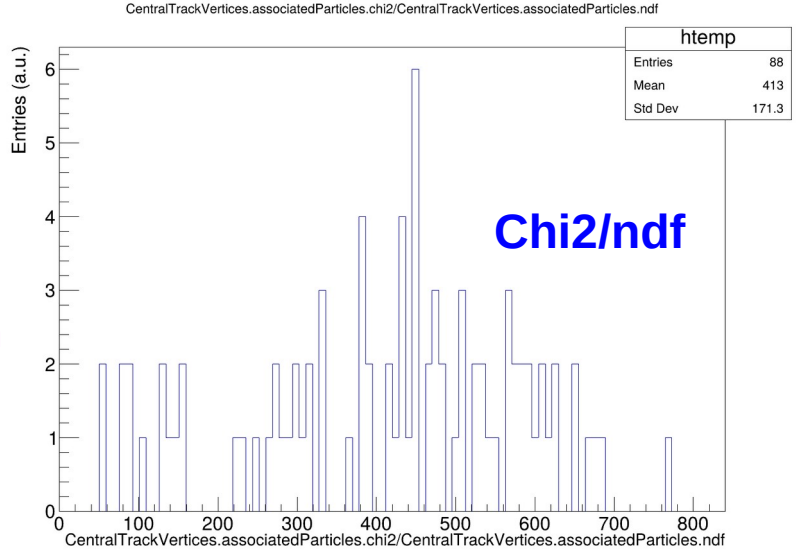
Chi2/ndf

5 µm Au coating
w Machine Bkg
Total events = 48



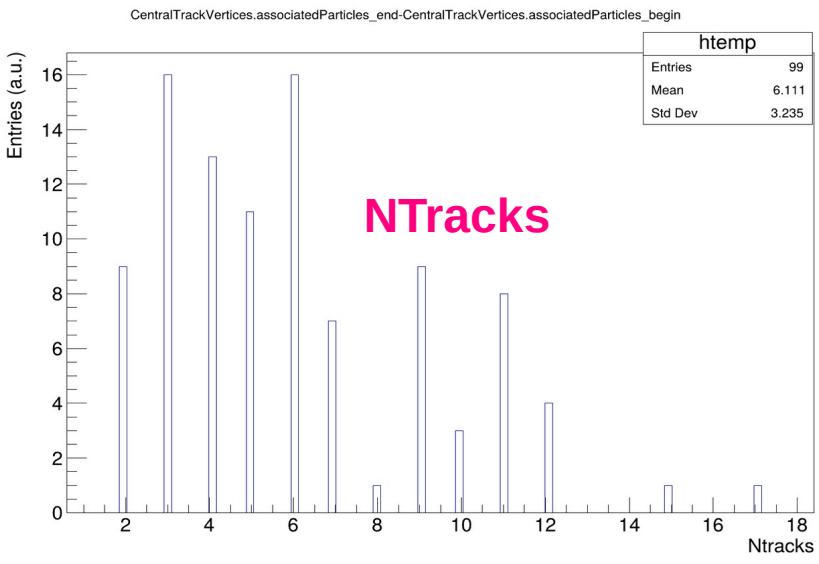
NTracks

NTracks:
Number of tracks used in
Primary Vertex fit



Chi2/ndf

Primary Vertex w Machine Backgrounds (**March 2026**)

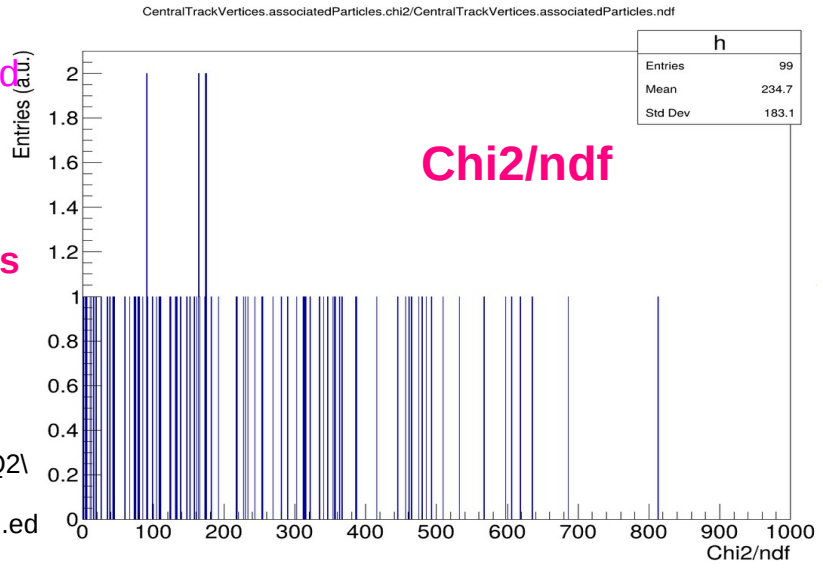


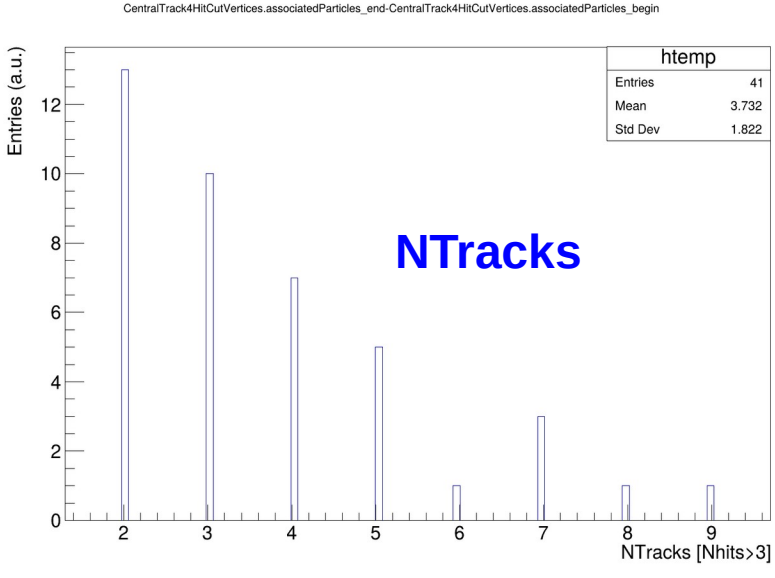
NTracks:
Number of tracks used in Primary Vertex fit

10 µm Au coating
CentralTrackVertices
Total events = 39

Min 3 hits

pythia8NCDIS_10x100_minQ2\=1_beamEffects_xAngle\=-0.025_hiDiv_1.0000.eicrecon.edm4eic.root

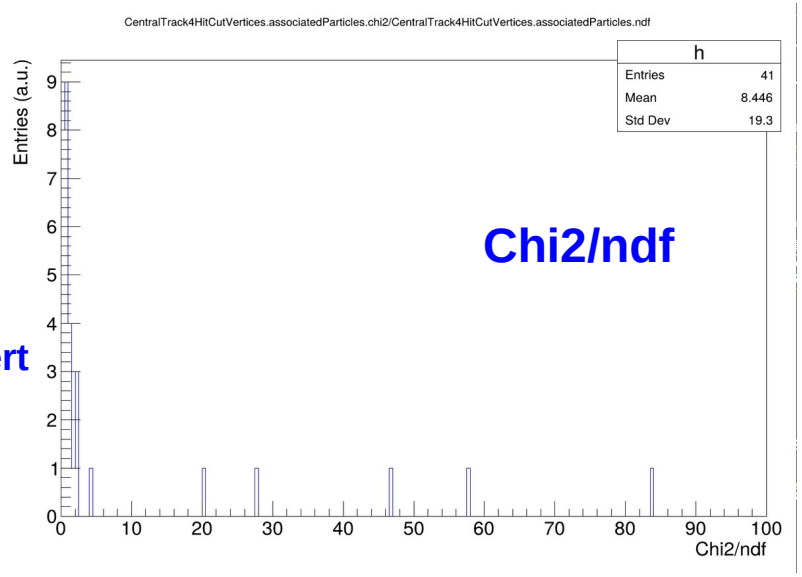




ndf = 3*Ntracks -3

Min 4 hits

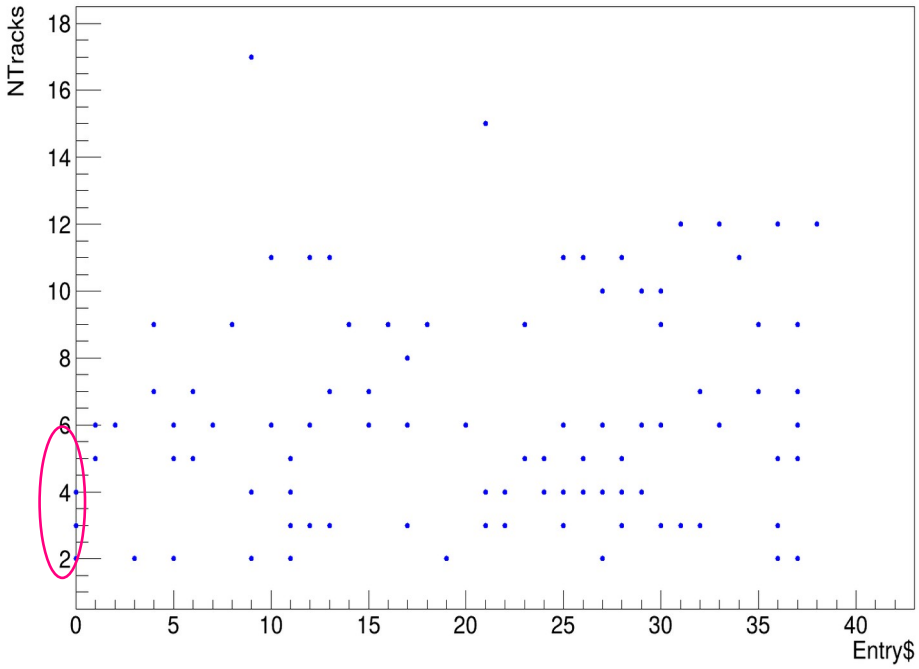
10 µm Au coating
CentralTrack4HitCutVertices
Total events = 39



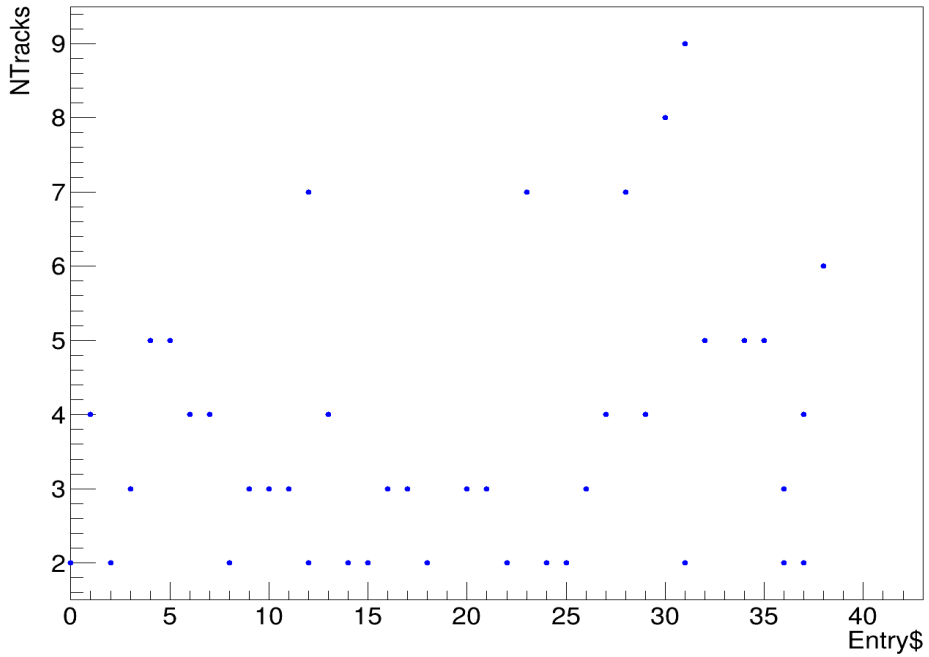
Primary Vertex w Machine Backgrounds (March 2026)

pythia8NCDIS_10x100_minQ2\=1_beamEffects_xAngle\=-0.025_hiDiv_1.0000.eicrecon.edm4eic.root

10 μm Au coating
CentralTrackVertices
Total events = 39
Min 3 hits



10 μm Au coating
CentralTrack4HitCutVertices
Total events = 39
Min 4 hits



Event: 19 and 33, no reco vertex

Ntracks: Number of tracks used in Primary Vertex fit

Primary Vertices Contributors

Event	CTVId	NTracks	Chi2/ndf	PVId
0	0	4	44.825731	0
0	1	3	90.776652	1
0	2	2	77.564951	2
1	0	6	461.18099	0
1	1	6	227.18324	1
1	2	5	66.449620	2
2	0	6	164.00677	0
3	0	2	0.6729135	0
4	0	7	334.86699	1
4	1	9	252.62992	*
5	0	2	1100.7133	2
5	1	5	72.928309	1
5	2	6	164.69259	0
6	0	7	415.92431	0
6	1	5	133.38862	1
7	0	6	91.522347	0
8	0	9	686.48974	*
9	0	17	445.32601	1
9	1	4	345.55279	3
9	2	2	1.2486989	2
9	3	4	90.243611	*
10	0	11	474.59833	1
10	1	6	567.28242	*
11	0	2	108.01118	4
11	1	3	38.399136	2
11	2	4	635.13232	1
11	3	3	10.546546	3
11	4	5	42.583948	0
12	0	11	108.86196	0
12	1	3	25.849917	2
12	2	6	98.848673	1
13	0	7	385.74727	2
13	1	3	509.25791	0
13	2	11	243.47840	1
14	0	9	268.61698	0
15	0	6	163.52770	1
15	1	7	172.94673	0

Reconstructed Tracks

↓

CentralTrackVertices (CTVId)

↓

PrimaryVertices (PVId)

CentralTrackVertices
PV with min 3hits tracks

CentralTrack4HitCutVertices
PV with min 4hits tracks

Ntracks: Number of tracks used in Primary Vertex fit

Event	CTVId	NTracks	Chi2/ndf	PVId
0	0	2	1.0719711	0
1	0	4	2635.9275	*
2	0	2	0.0866628	0
3	0	3	20.336893	0
4	0	5	0.2696957	0
5	0	5	0.2708678	0
6	0	4	0.5854042	0
7	0	4	12114.903	*
8	0	2	0.3486811	0
9	0	3	460.04321	0
10	0	3	0.6729670	0
11	0	3	1.7874186	0
12	0	7	0.6600161	0
12	1	2	716362.58	*
13	0	4	1959.6536	*
14	0	2	2.2963560	0
15	0	2	83.748352	0
16	0	3	57.517700	0
17	0	3	1.0059920	0
18	0	2	0.0144712	0
19	0	*	*	*
20	0	3	3464.5979	*
21	0	3	0.5398761	0
22	0	2	27.915715	0
23	0	7	0.9096813	0
24	0	2	0.1016478	0
25	0	2	0.4814544	0
26	0	3	9385.5514	*
27	0	4	17896.444	*
28	0	7	2.0060723	0
29	0	4	4.2534730	0
30	0	8	1.2561947	0
31	0	9	2.1425058	0
31	1	2	46.846593	1
32	0	5	0.9432613	0
33	0	*	*	*
34	0	5	0.8746768	0
35	0	5	0.6816328	0
36	0	2	0.2007146	1
36	1	3	1017.6177	0

Primary Vertices (Nhits>3)

CentralTrack4HitCutVertices

----------MC Vertex Information: Event No = 0----------
(-0.231462 0.00100639 38.5155)
----------Reco Vertex Information: Event No = 0----------
Ntracks ndf chi2ndf Vx Vy Vz
2 3 1.07197 (-0.104322 -0.00727957 38.1831)

----------MC Vertex Information: Event No = 1----------
(0.202966 -0.00577033 -58.893)
----------Reco Vertex Information: Event No = 1----------
Ntracks ndf chi2ndf Vx Vy Vz
4 9 2635.93 (4.89686 9.51209 85.3213)

----------MC Vertex Information: Event No = 2----------
(0.158751 0.00679257 37.3814)
----------Reco Vertex Information: Event No = 2----------
Ntracks ndf chi2ndf Vx Vy Vz
2 3 0.0866628 (0.285242 0.151963 38.3611)

----------MC Vertex Information: Event No = 3----------
(0.183743 0.003125 7.09439)
----------Reco Vertex Information: Event No = 3----------
Ntracks ndf chi2ndf Vx Vy Vz
3 6 20.3369 (0.461803 -0.221672 11.2171)

----------MC Vertex Information: Event No = 4----------
(-0.0738131 -0.00324729 -13.3178)
----------Reco Vertex Information: Event No = 4----------
Ntracks ndf chi2ndf Vx Vy Vz
5 12 0.269696 (-0.0298807 0.0170503 -13.3665)

----------MC Vertex Information: Event No = 5----------
(-0.275477 0.00666589 -15.8192)
----------Reco Vertex Information: Event No = 5----------
Ntracks ndf chi2ndf Vx Vy Vz
5 12 0.270868 (-0.289045 -0.0145419 -15.7855)

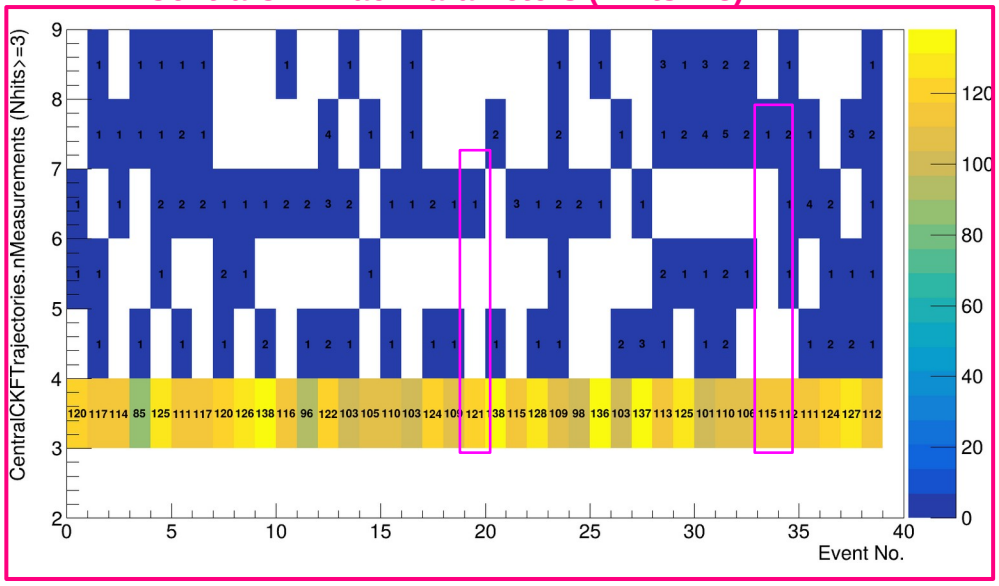
----------MC Vertex Information: Event No = 6----------
(0.0532232 0.00333409 45.716)
----------Reco Vertex Information: Event No = 6----------
Ntracks ndf chi2ndf Vx Vy Vz
4 9 0.585404 (0.0160037 0.0129135 45.7058)
----------MC Vertex Information: Event No = 7----------
(-0.237821 0.000122148 10.7846)
----------Reco Vertex Information: Event No = 7----------
Ntracks ndf chi2ndf Vx Vy Vz
4 9 12114.9 (2.16906 2.1681 -116.202)
----------MC Vertex Information: Event No = 8----------
(0.275048 0.00679094 -12.0624)
----------Reco Vertex Information: Event No = 8----------
Ntracks ndf chi2ndf Vx Vy Vz
2 3 0.348681 (0.264058 0.0199597 -12.8984)
----------MC Vertex Information: Event No = 9----------
(-0.287426 -0.00715041 -15.4685)
----------Reco Vertex Information: Event No = 9----------
Ntracks ndf chi2ndf Vx Vy Vz
3 6 460.043 (-6.48096 -4.86581 -93.2527)

----------MC Vertex Information: Event No = 10----------
(0.137061 -0.00632873 -61.8435)
----------Reco Vertex Information: Event No = 10----------
Ntracks ndf chi2ndf Vx Vy Vz
3 6 0.672967 (0.0912301 0.0255716 -60.9041)
----------MC Vertex Information: Event No = 11----------
(0.00958197 -0.0106679 18.6299)
----------Reco Vertex Information: Event No = 11----------
Ntracks ndf chi2ndf Vx Vy Vz
3 6 1.78742 (0.905683 0.697314 27.4747)
----------MC Vertex Information: Event No = 36----------
(-0.0610349 0.0115863 -20.6609)
----------Reco Vertex Information: Event No = 36----------
Ntracks ndf chi2ndf Vx Vy Vz
2 3 0.200715 (-0.376867 -0.040876 -21.5385)
3 6 1017.62 (2.97613 -18.6836 -171.324)

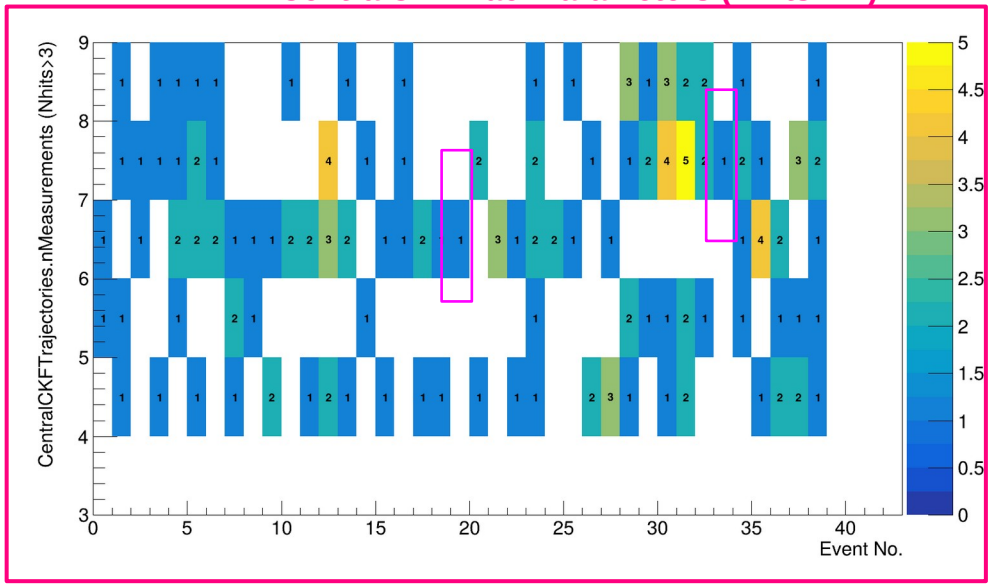
```
************************************************
*  Event  * TrackId * Nhits * Chi2 *
************************************************
*     0 *      55 *      5 * 4.4196262 *
*     0 *      57 *      6 * 7.6431851 *
*     1 *       0 *      5 * 8.6493148 *
*     1 *      85 *      4 * 20.910108 *
*     1 *     119 *      7 * 11.793979 *
*     1 *     120 *      8 * 16.327873 *
*     2 *       0 *      7 * 7.1690044 *
*     2 *     114 *      6 * 16.016607 *
*     3 *      44 *      8 * 6.1279707 *
*     3 *      54 *      7 * 6.2611932 *
*     3 *      87 *      4 * 1.0953295 *
*     4 *      37 *      7 * 20.842987 *
*     4 *      64 *      8 * 8.0038480 *
*     4 *      65 *      5 * 6.9875216 *
*     4 *      86 *      6 * 4.2209997 *
*     4 *      88 *      6 * 3.7294812 *
*     5 *      53 *      7 * 7.8209075 *
*     5 *      66 *      6 * 8.0232114 *
*     5 *      90 *      4 * 6.7664561 *
*     5 *      92 *      8 * 10.912979 *
*     5 *     114 *      6 * 5.2496824 *
*     5 *     116 *      7 * 12.528110 *
*     6 *      34 *      6 * 9.4138450 *
*     6 *      56 *      6 * 3.4257941 *
*     6 *      93 *      8 * 20.849609 *
*     6 *     120 *      7 * 7.7397232 *
*     7 *       3 *      4 * 11.869610 *
*     7 *      58 *      5 * 6.7706537 *
*     7 *      59 *      5 * 9.6291151 *
*     7 *      85 *      6 * 4.1013822 *
*     8 *       0 *      6 * 2.9771082 *
*     8 *      60 *      5 * 13.690158 *
*     9 *       0 *      6 * 8.0454978 *
*     9 *      25 *      4 * 12.031891 *
*     9 *     140 *      4 * 4.4382290 *
*    10 *      31 *      6 * 9.3696870 *
*    10 *     116 *      6 * 9.2136974 *
*    10 *     118 *      8 * 11.858556 *
*    11 *       0 *      6 * 6.1546158 *
*    11 *      97 *      6 * 11.150712 *
*    11 *      98 *      4 * 6.0085473 *
```

Reconstructed Tracks (CentralCKFTrajectories)

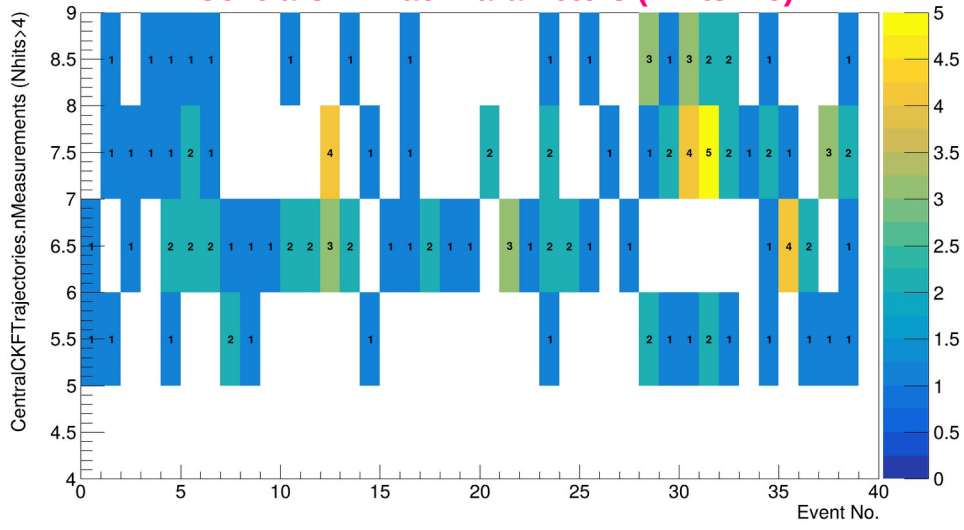
CentralCKFTrackParameters (Nhits>=3)



CentralCKFTrackParameters (Nhits>=4)



CentralCKFTrackParameters (Nhits>=5)



10 μm Au coating (DIS sample, March 2026)

MC Vertex Information: Event No = 19----------
(-0.174177 0.00111422 -56.8539)
No Reco vertex

		Nhits	Chi2
* 19 *	0 *	6 *	15.154603

MC Vertex Information: Event No = 33----------
(-0.0153674 0.00483565 25.7409)
No Reco vertex

		Nhits	Chi2
* 33 *	0 *	7 *	8.7572078 *

Summary and Future Plan

- Primary vertex reconstruction with four hits show improvement in chi2 and the number of tracks
- We can recover 3 hits tracks pointing to primary vertex at the analysis level applying significance of impact parameter (dca_{xy}/sigma(l_0)) cut
- Further to look at D^0 reconstruction performances by Connie with machine background.

Thank you for your attention!