Possible improvement in CB reduction and current status

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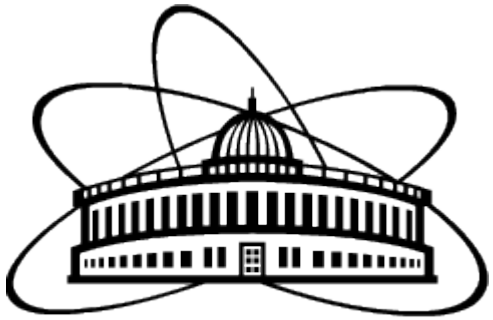


Outline

- Possible improvement in the CB reduction.
  - Ideal Pluto and UrQMD with no detector effect
  - Realistic case with Detector effect
- Improvement with current reconstruction algorithm.
  - Pair analysis in UrQMD

Motivation and Pre-requisite

- Major source of combinatorial background: pi0 Dalitz decays (and conversions in beam pipe) where only one track is reconstructed whereas its partner is not.

- Partial information available on the partner. Important to study maximum possible benefit in the CB reduction.

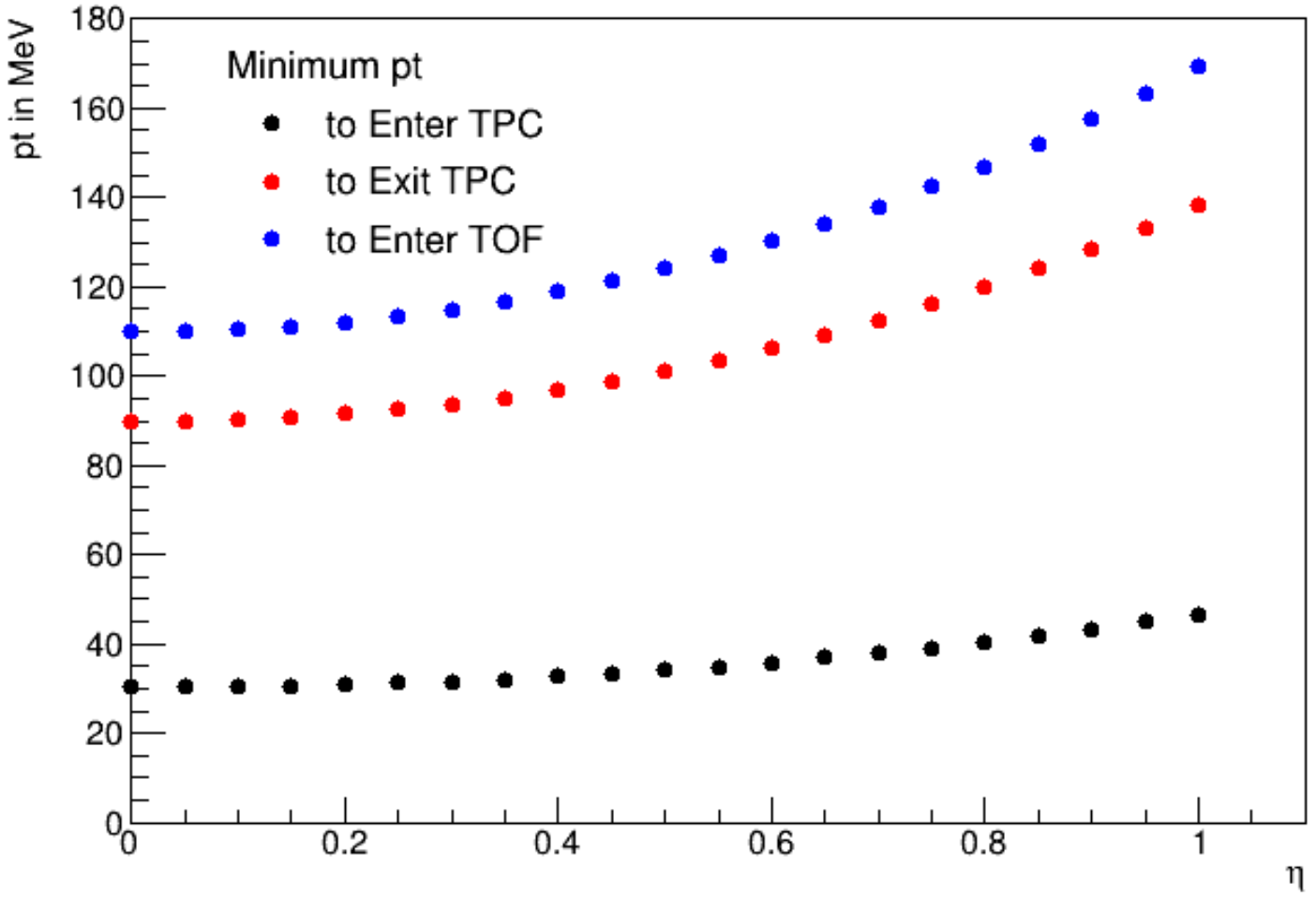
- In this study use :
  - Pluto: single pi0 Dalitz decay
  - UrQMD: Min. Bias BiBi at 9.2 GeV

ρ^0 -> e+e- (x20)
ω -> e+e- (x20)
ω -> $л^0$ e+e- (x20)
φ -> e+e- (x20)
φ -> η e+e- (x20)

- Divide the acceptance into the fiducial and veto area.

  - In this study, we use a very conservative fiducial region, |y| < 0.3 and veto is 0.3 < |y| < 1.0.

Minimum pt required to enter or exit TPC and TOF



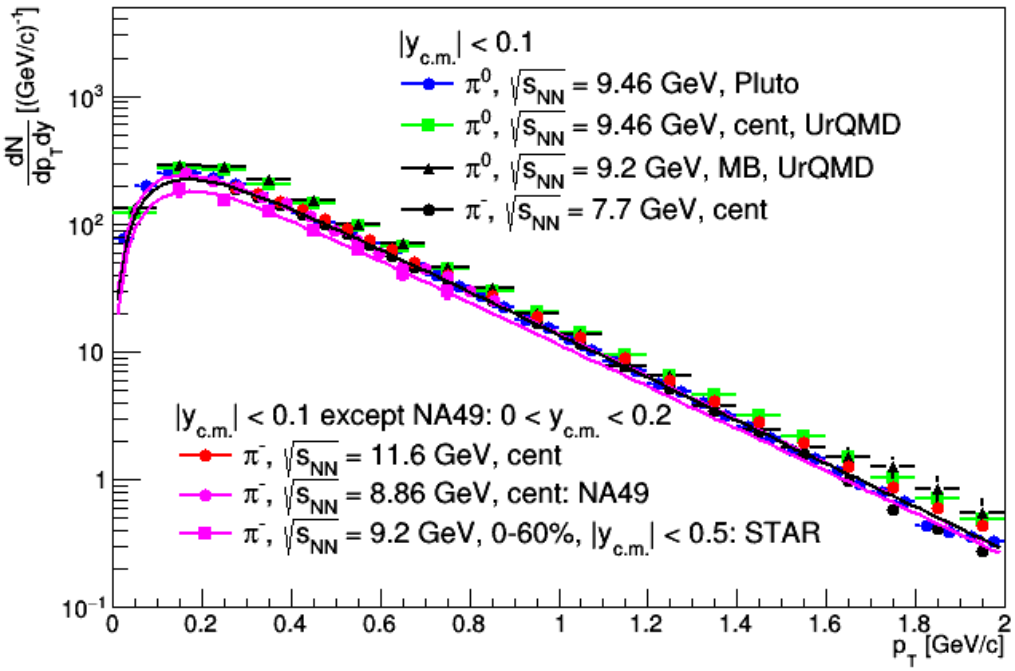
Assuming the TPC Inner radius to be 40.3 cm and outer radius to be 119.5 cm as well as TOF inner radius is 146.5 cm which is taken from its TDR.

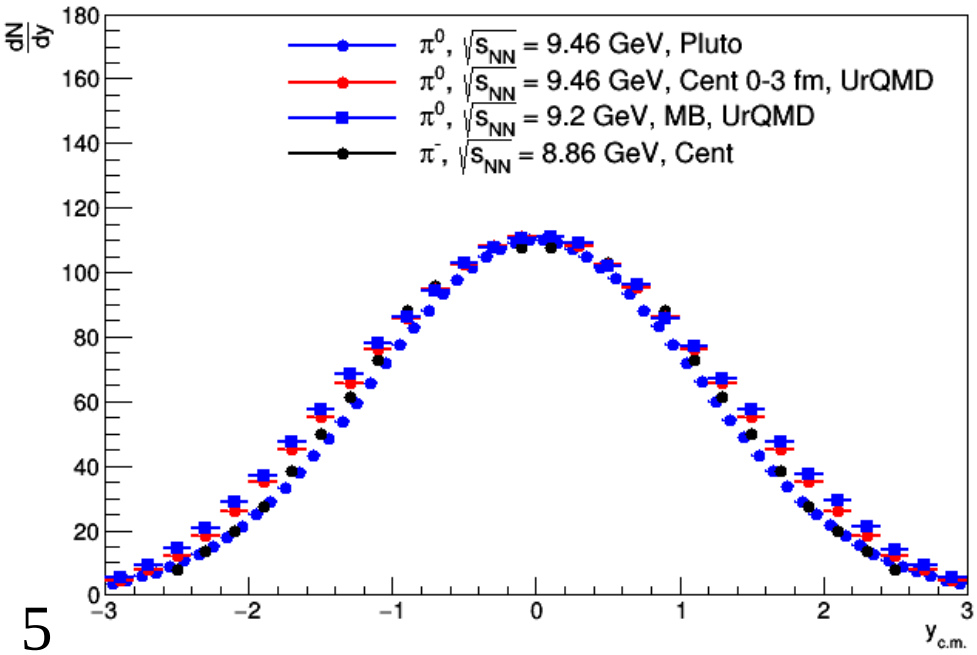
Comparison with data

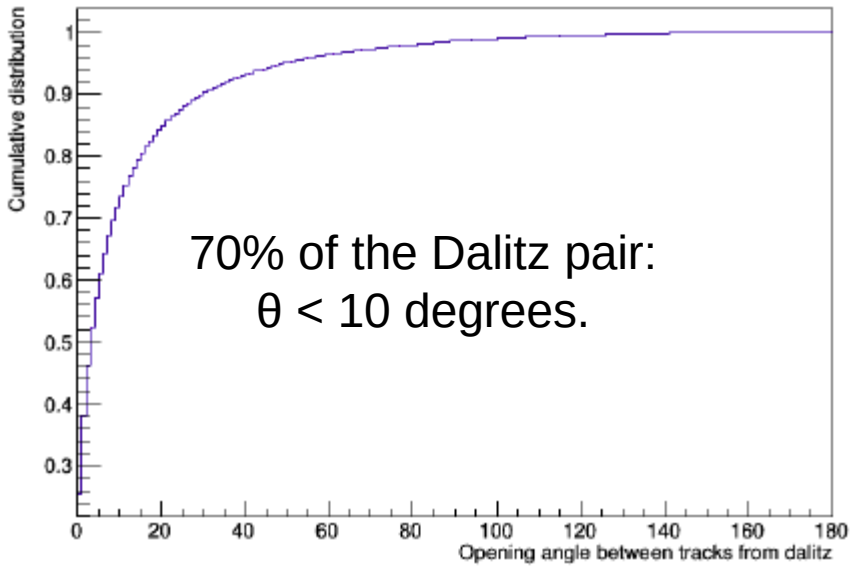
1) Analysis maybe sensitive to the shape of the pT and rapidity spectra.

2) pT spectra of pions in Pluto is rescaled to match with the data.

3) Rapidity spectra is reasonably reproduced without rescaling.







70% of the Dalitz pair:
θ < 10 degrees.

1. Strategy: Ideal case with no detector effect

1) Assume that electron is fully reconstructed if it has a pt > 110 MeV and it is reconstructed in TPC only if it has a 30 < pt < 110 MeV.

2) Assume signal (N_s) is proportional to the number Dalitz pairs with both legs p_T > 200 MeV and within |y| < 0.3

3) Assume background (N_b) is proportional to square of single tracks originating from Dalitz decay where one leg is pT > 200 MeV in |y| < 0.3 and other leg is not fully reconstructed (TPC only track or Spiral track that is not reconstructed at all), can be anywhere in fiducial or veto area.

4) Absolute values of S/B in these slides have no meaning, however, the relative difference between the two values is meaningful.

5) Close TPC cut: Electrons with 30 < pt < 110 MeV and within an opening angle of 10 degrees.

Possible improvement in S/B

S = N_s = No of Dalitz pair in |y| < 0.3 with both legs pt > 200 MeV

B = $(N_b)^2$ = (No of single tracks from Dalitz in |y| < 0.3 with pt > 200 MeV with partner anywhere in fid. or veto

Pluto

Acc. |y| < 0.3 S/B = = 323 **(For representation only)**

Maximum gain in S/B (assuming partner with pT > 30 MeV and opening angle <10 deg is fully recognized)**:**
|y| < 0.3 S/B = 1259 ← **factor 4 improvement**

UrQMD

Acc. |y| < 0.3 S/B = 142 **(For representation only)**

Maximum gain in S/B (assuming partner with pT > 30 MeV and opening angle <10 deg is fully recognized):
|y| < 0.3 S/B = 692 ← **factor 5 improvement**

2. Strategy: Realistic case with detector

1)Now with more realistic case, with detector effect.

2)UrQMD: Request 11 production: Min. Bias BiBi at 9.2 GeV

3)Pluto using MPD ROOT used for request 11: pi0 Dalitz decay.

4)Applied track selection and PID cuts.

1)|Vz| < 50 cm

2)Nhits > 39

3)DCA < 3σ

4)-1 < TPC nSigma_e < 2σ

5)|TOF beta| < 2σ

6)TPC-TOF matching 2σ for dφ and dz.

5)Close TPC cut: Electron pool without TOF (TPC only tracks) and opening angle < 10 degrees.

Mpdroot dev branch: 50110a2507fc3da34d55648c9e7912f319af5455

Possible improvement in S/B

S = N_s = No of Dalitz pair in |y| < 0.3 with both legs pt > 200 MeV

B = $(N_b)^2$ = (No of single tracks from Dalitz in |y| < 0.3 with pt > 200 MeV with partner anywhere in fid. or veto

Pluto

Acc. |y| < 0.3 S/B = = 229 **(For representation only)**

Maximum gain in S/B (assuming partner with pT > 30 MeV and opening angle <10 deg is fully recognized)**:**
|y| < 0.3 S/B = 1080 ← **factor 5 improvement**

Gain in S/B (i.e. using TPC current reconstruction software and requiring Nhits > 39 and opening angle < 10 deg.)**:**
|y| < 0.3 S/B = 326 ← **factor 1.42 improvement**

UrQMD

Acc. |y| < 0.3 S/B = 101 **(For representation only)**

Maximum gain in S/B (assuming partner with pT > 30 MeV and opening angle <10 deg is fully recognized)**:**
|y| < 0.3 S/B = 8308 ← **factor 8 improvement**

Gain in S/B (i.e. using TPC current reconstruction software and requiring Nhits > 39 and opening angle < 10 deg.)**:**
|y| < 0.3 S/B = 128 ← **factor 1.26 improvement**

3. Improvement in CB rejection: Current Status

1) UrQMD production Min. Bias BiBi@9.2 GeV: Request 11,
   Events approx. 8.7 M

2) Single event and track selection criteria for creating pools:

   1)$|Vz| < 50$ cm

   2)Nhits > 39

   3)DCA < 3σ

   4)-1 < TPC nSigma_e < 2σ

   5)|TOF beta| < 2σ

   6)TPC-TOF matching 2σ for dφ and dz.

Mpdroot dev branch: 50110a2507fc3da34d55648c9e7912f319af5455

Strategy: Pair analysis using UrQMD

- Two electron pools, Pool-1 for fiducial and Pool-2 for veto area, of fully reconstructed electron tracks.

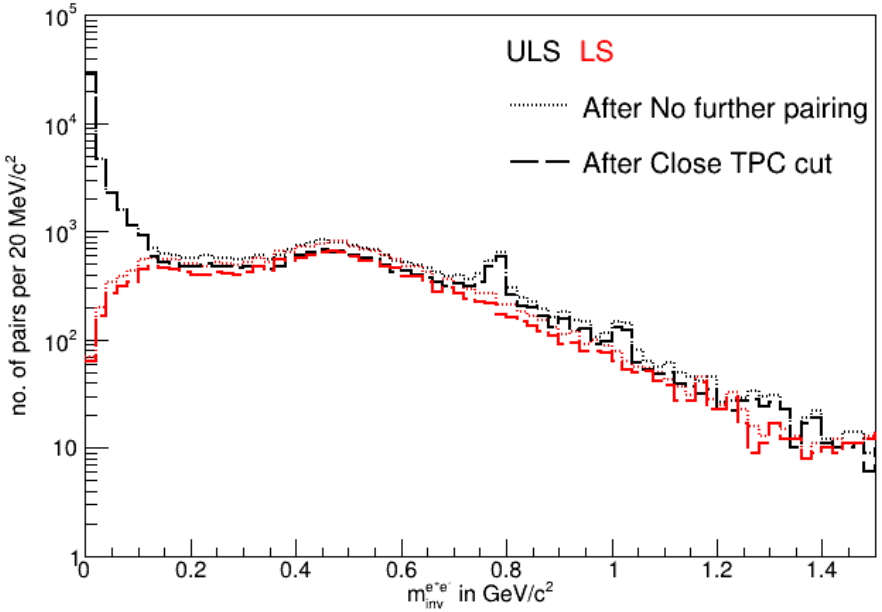
- Pool-3 with TPC only tracks.

- No further pairing: Tracks belonging to fully reconstructed π^0 Dalitz are tagged and not used for further pairing.

- Close TPC cut: Track from Pool-1 is paired with tracks from Pool-3 and both tracks are removed as a potential Dalitz pair if they have M_{inv} < 120 MeV/c2 and opening angle < 10 degrees.

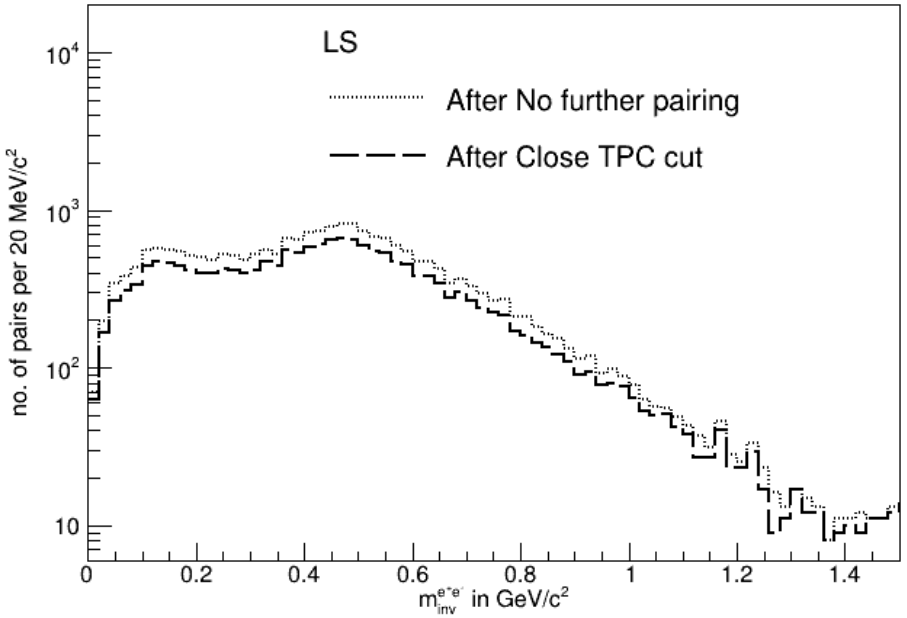
- Rest of the tracks with pt > 200 MeV from Pool-1 are paired among themselves to build ULS and LS pair spectra.

ULS and LS spectra



- DCA cut < 3 sigma eliminates most of the conversion electrons.
- No further pairing: fully reconstructed pi0 Dalitz pairs are recognized and not used for pairing.

- Close TPC cut: Fully reconstructed track is paired with TPC only track to recognize potential Dalitz track.
- Some improvement can be visibly observed.



Improvement in S/B

S = (ULS -LS) in $0.2 < M_{inv} < 0.6$ GeV/c^2

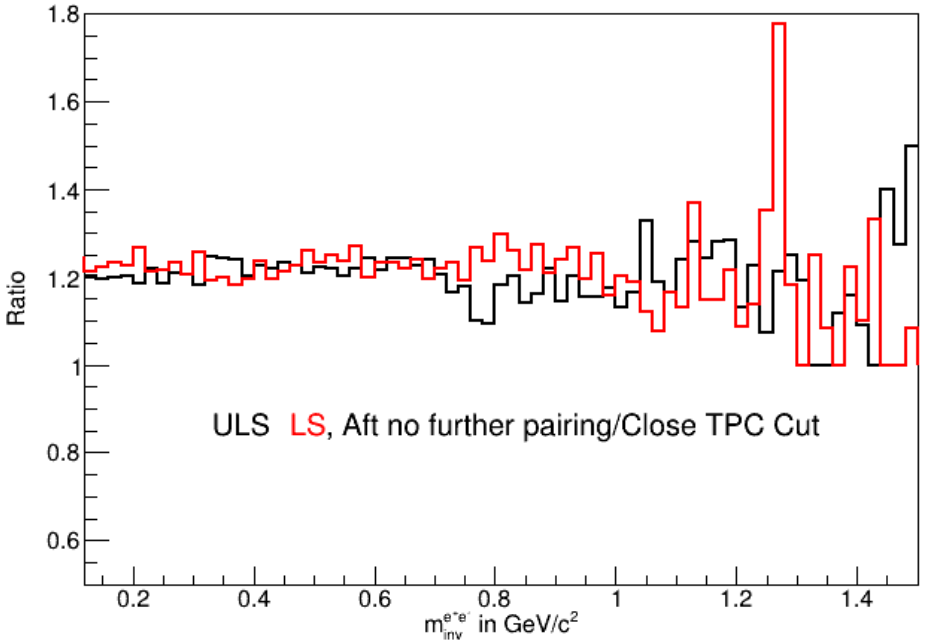
B = LS in $0.2 < M_{inv} < 0.6$ GeV/c^2

UrQMD

Acc. |y| < 0.3 S/B = 0.049 **(for representation only)**

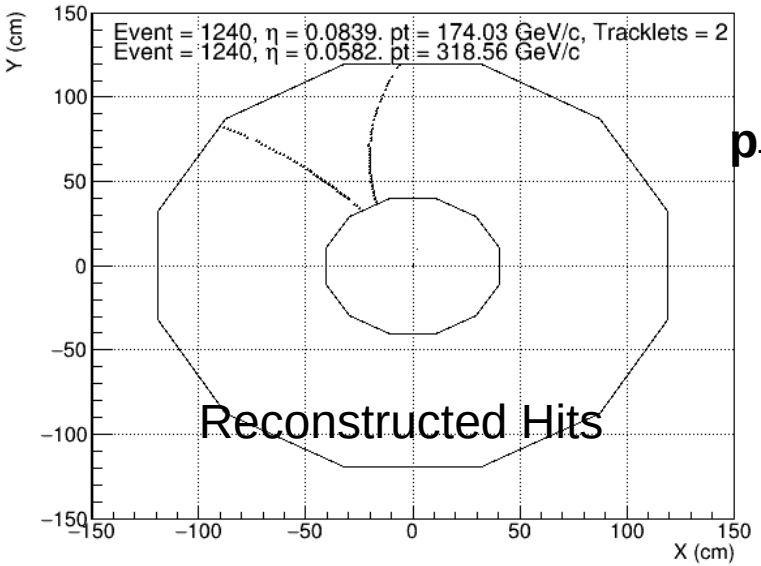
Gain in S/B (i.e. With current reconstruction algorithm)**:**

|y| < 0.3 S/B = 0.055 ← **factor 1.12 improvement**

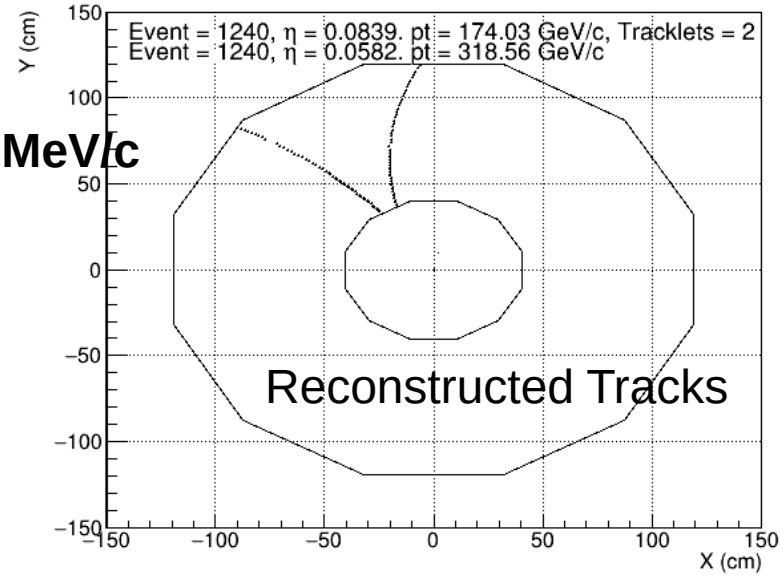


- About 20% reduction in combinatorial background.

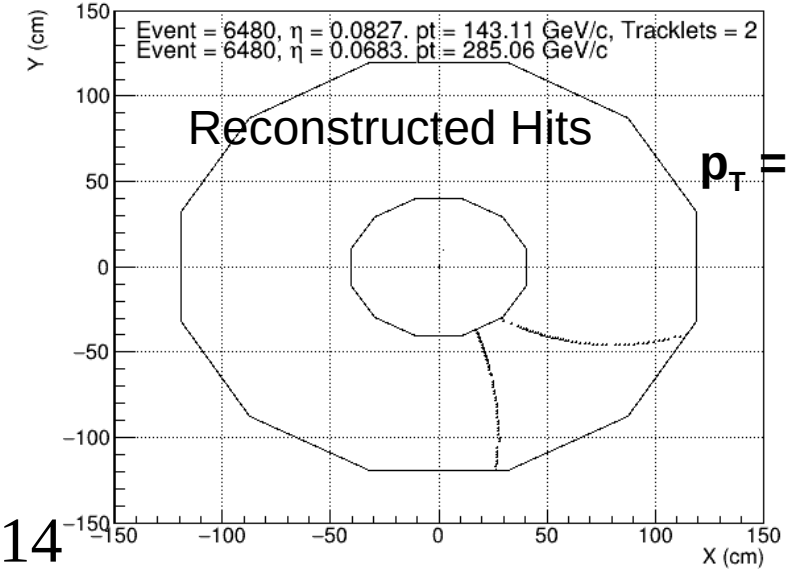
Low pt track reconstruction with current algorithm



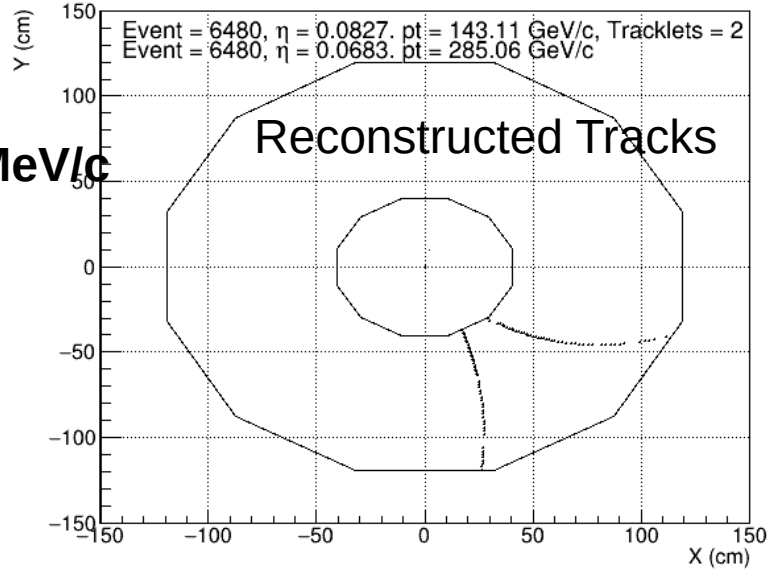
p_T = 174 MeV/c



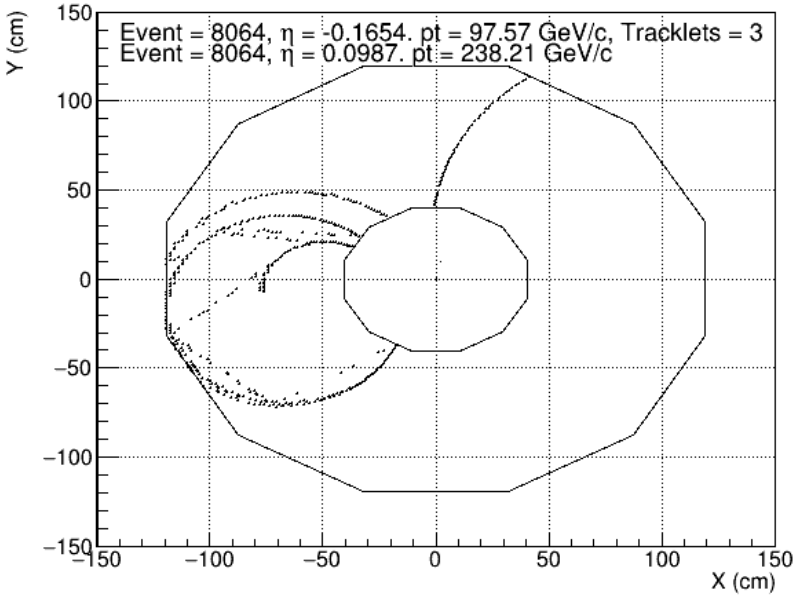
In all the plots one leg has p_T > 200 MeV and 0 < η < 0.1

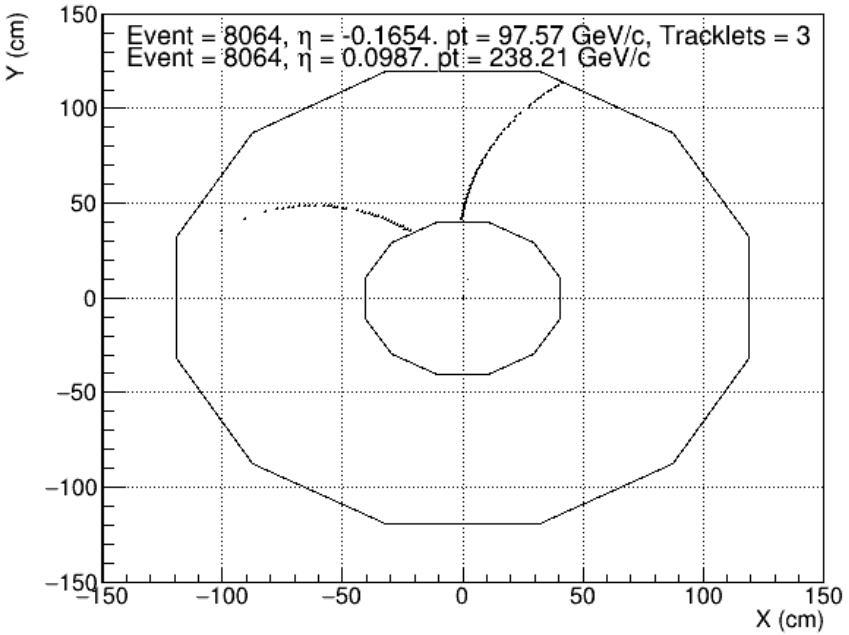


p_T = 143 MeV/c

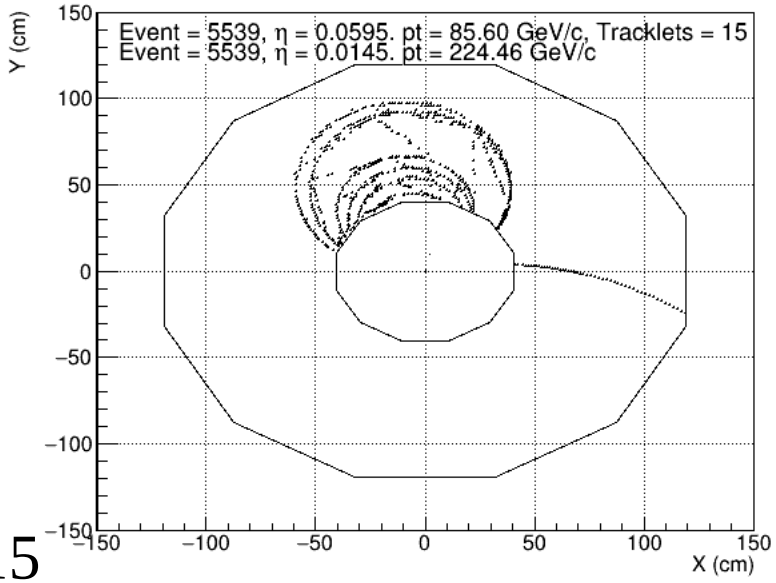


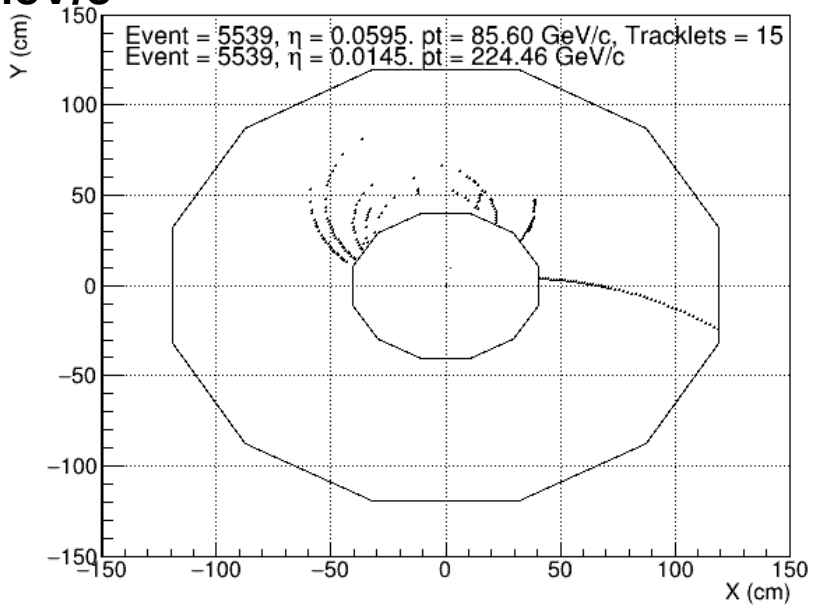
p_T = 98 MeV/c



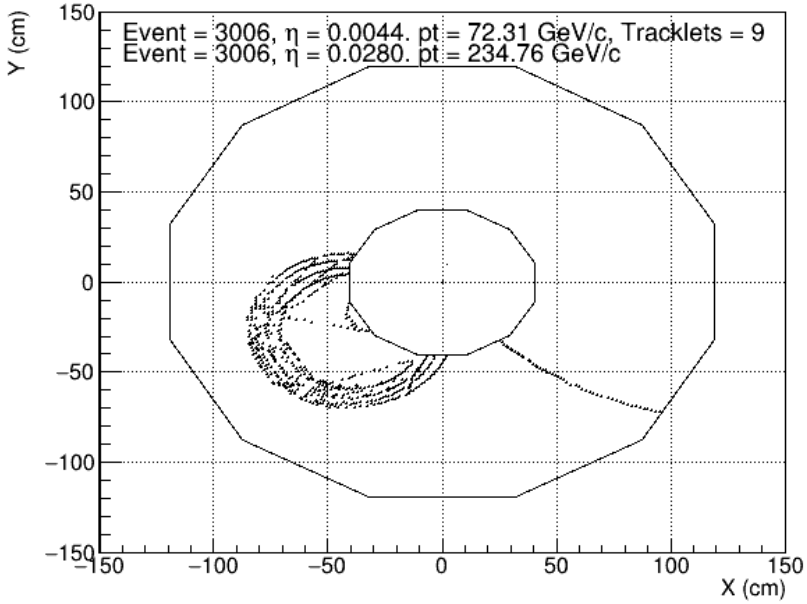


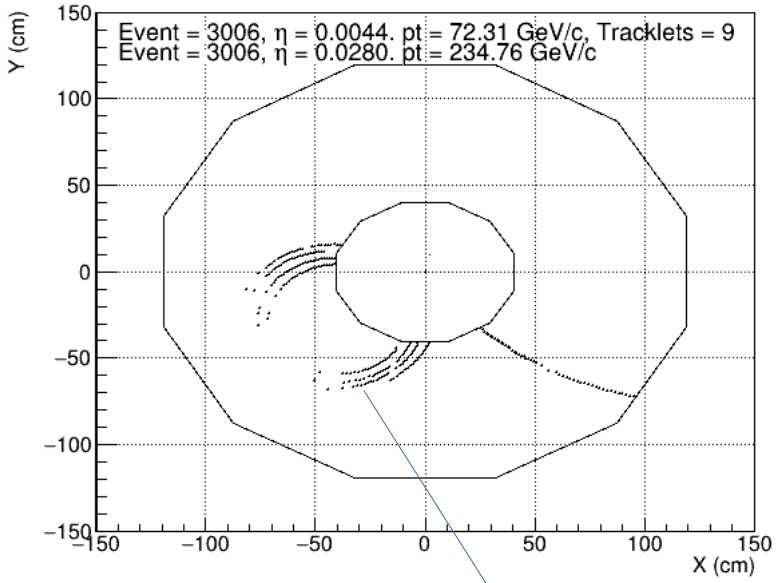
p_T = 86 MeV/c





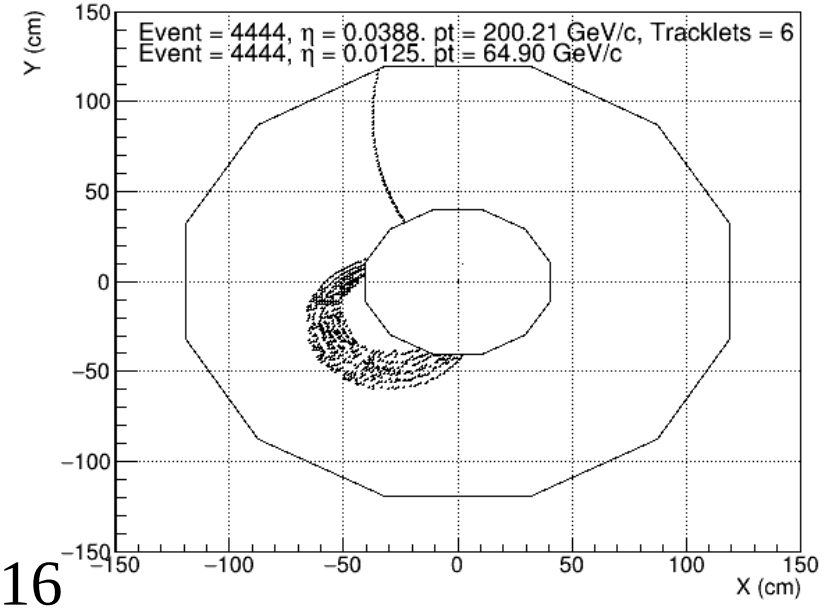
p_T = 72 MeV/c

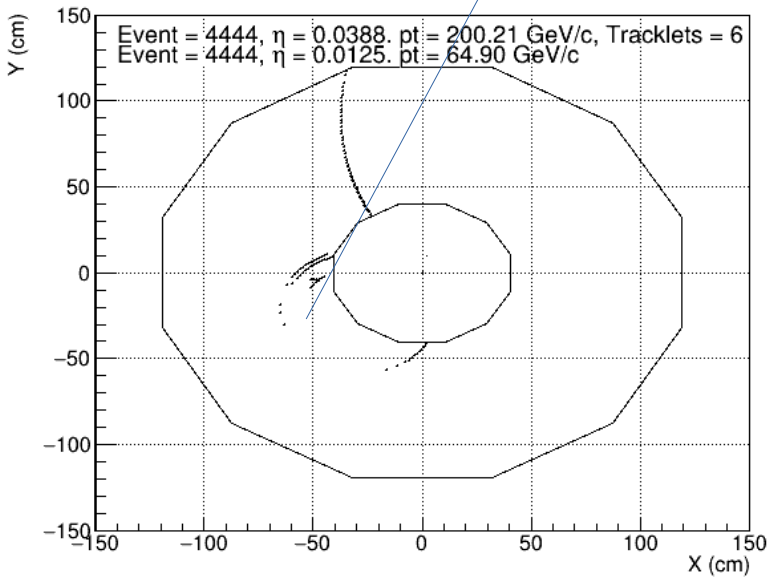




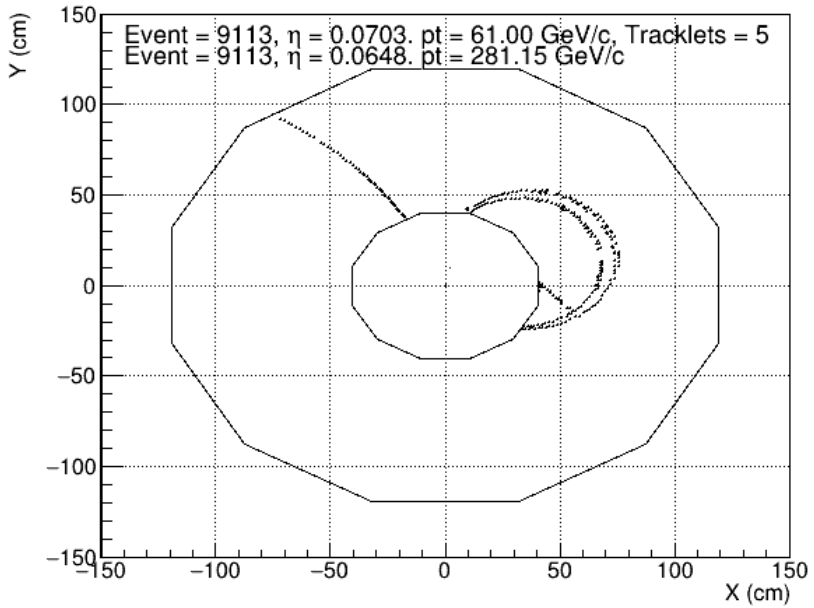
p_T = 65 MeV/c

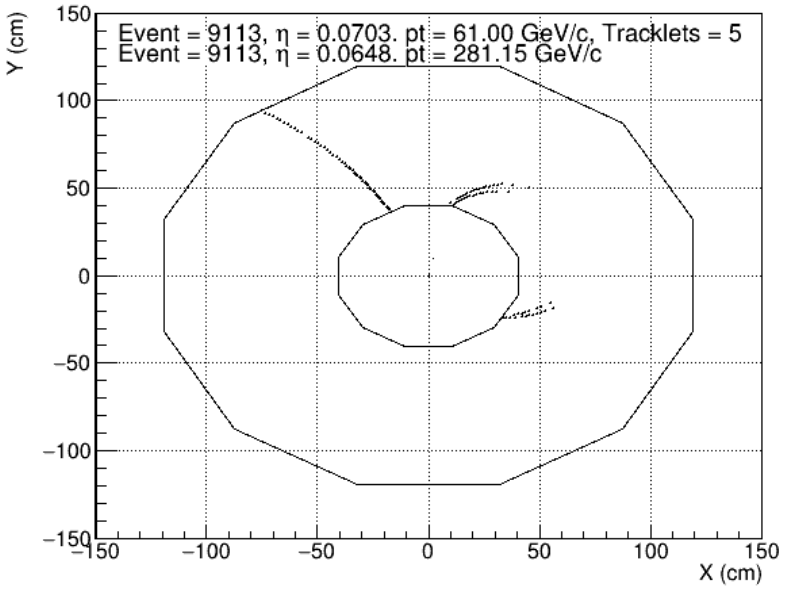
Partially reconstructed spiral track



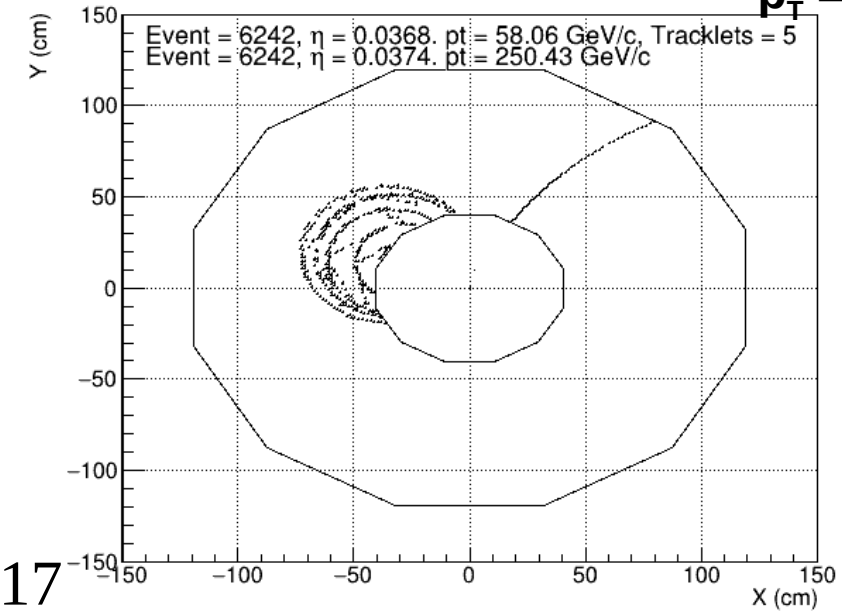


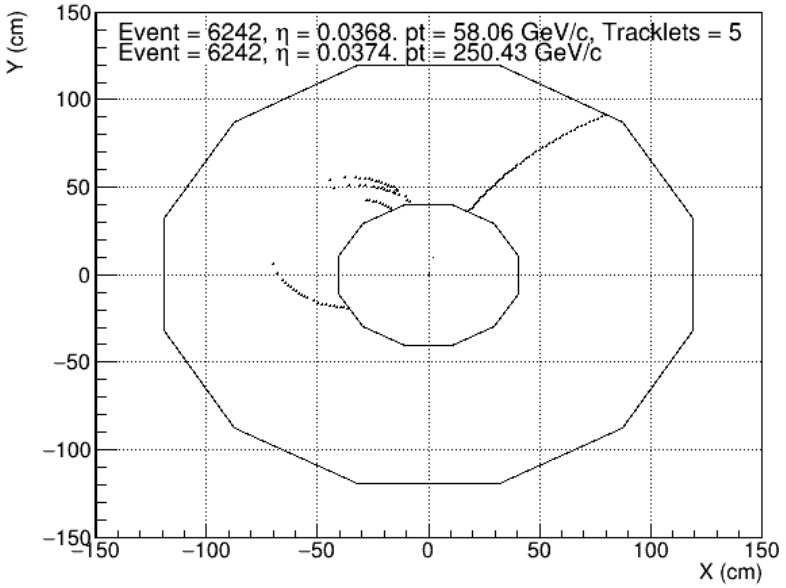
p_T = 61 MeV/c



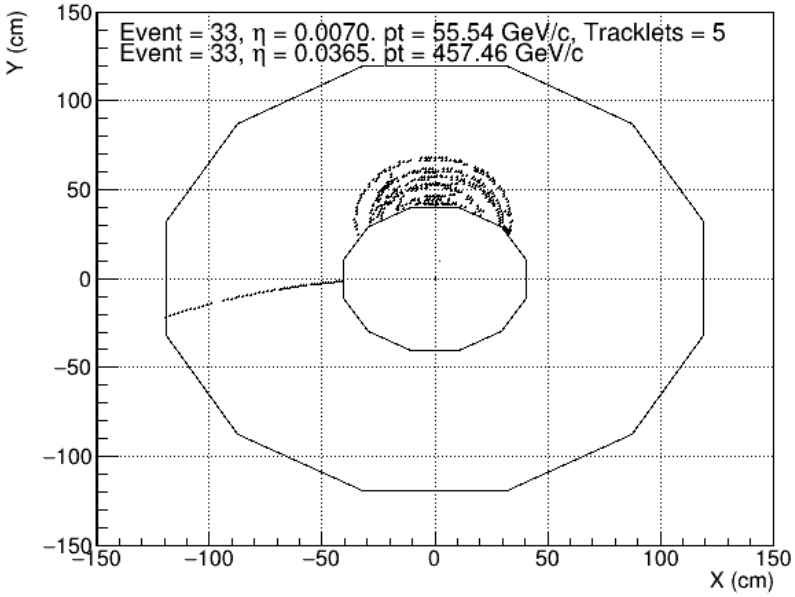


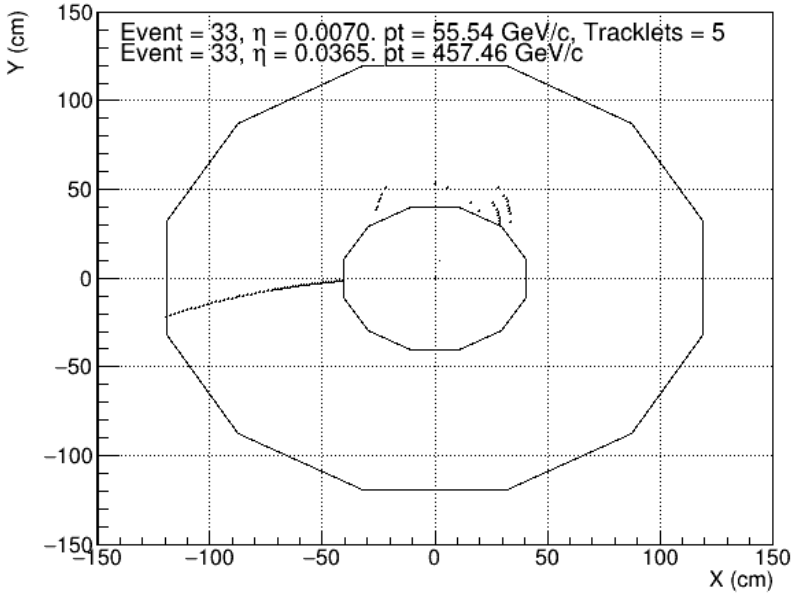
p_T = 58 MeV/c



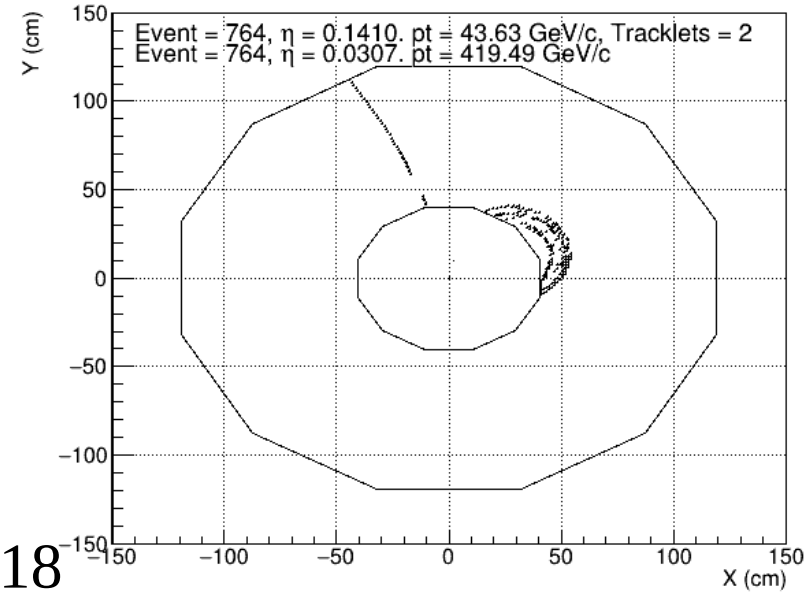


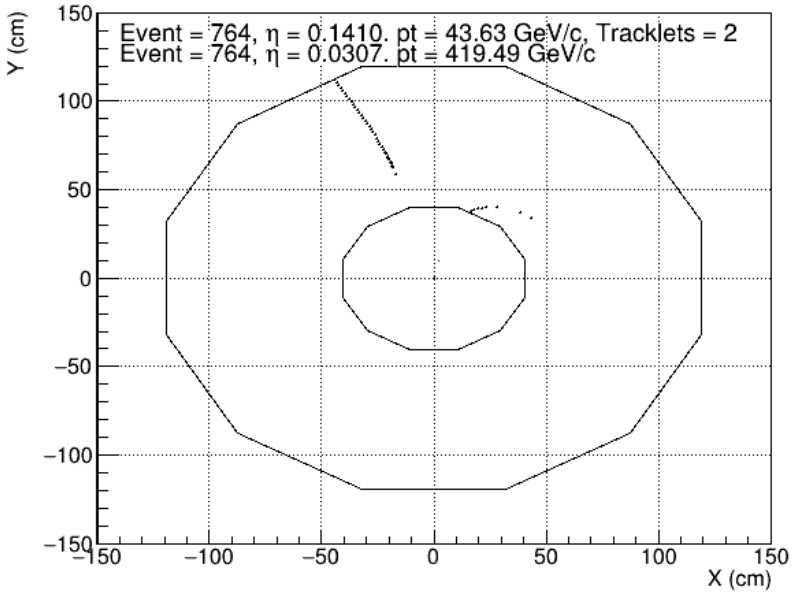
p_T = 56 MeV/c





p_T = 44 MeV/c





Conclusions

1) With a improved track reconstruction, especially for low pT spiral tracks, a significant improvement in the S/B can be obtained.

2) Current tracking algorithm bring about ~10% improvement only.

Outlook

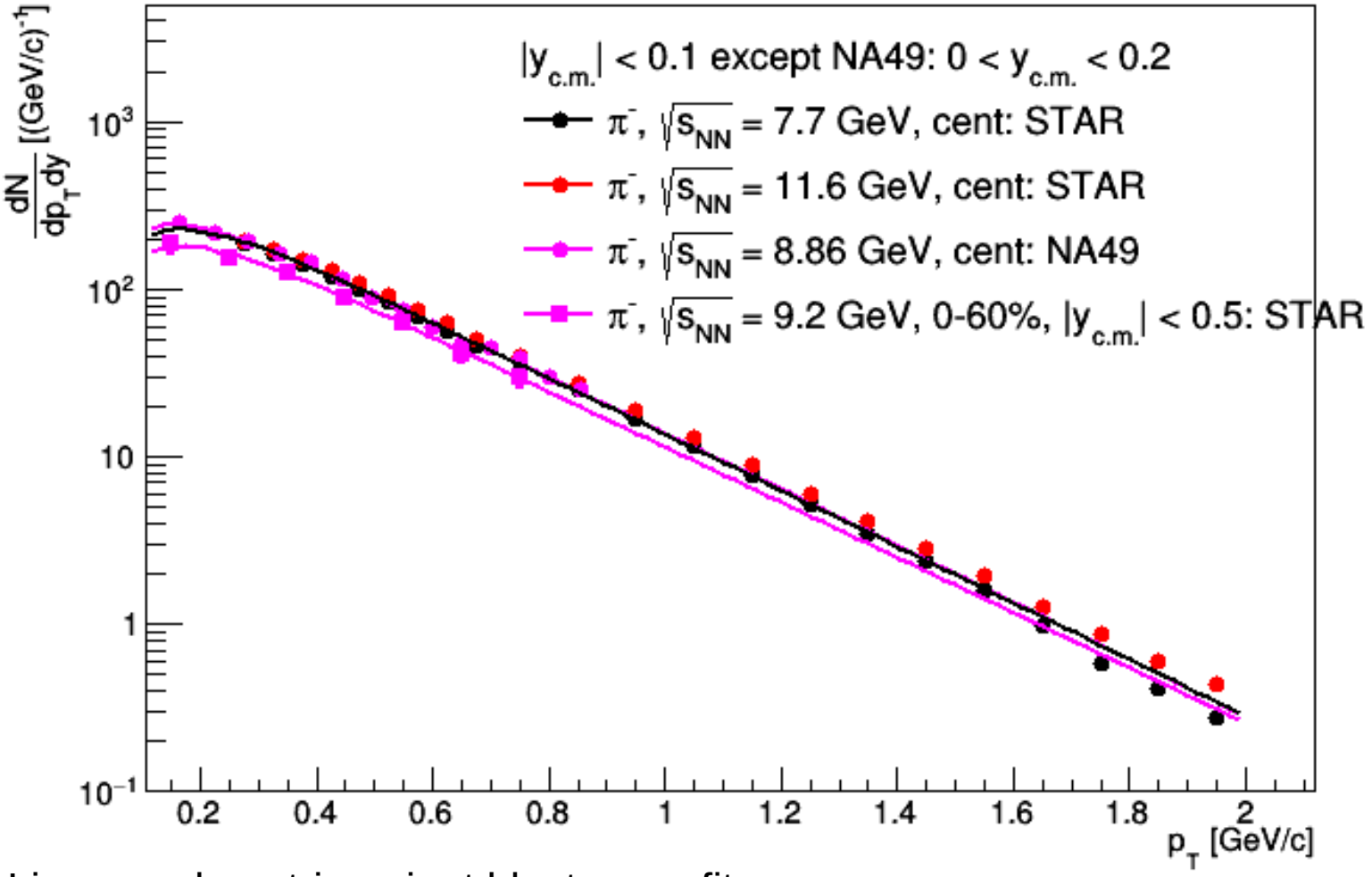
1) Improve current tracking algorithm

2) Fit the branches of the same spiral tracks

3) Use ML techniques to identify the partially reconstructed partner.

BACK-UP

Y-axis is scaled with an arbitary factor

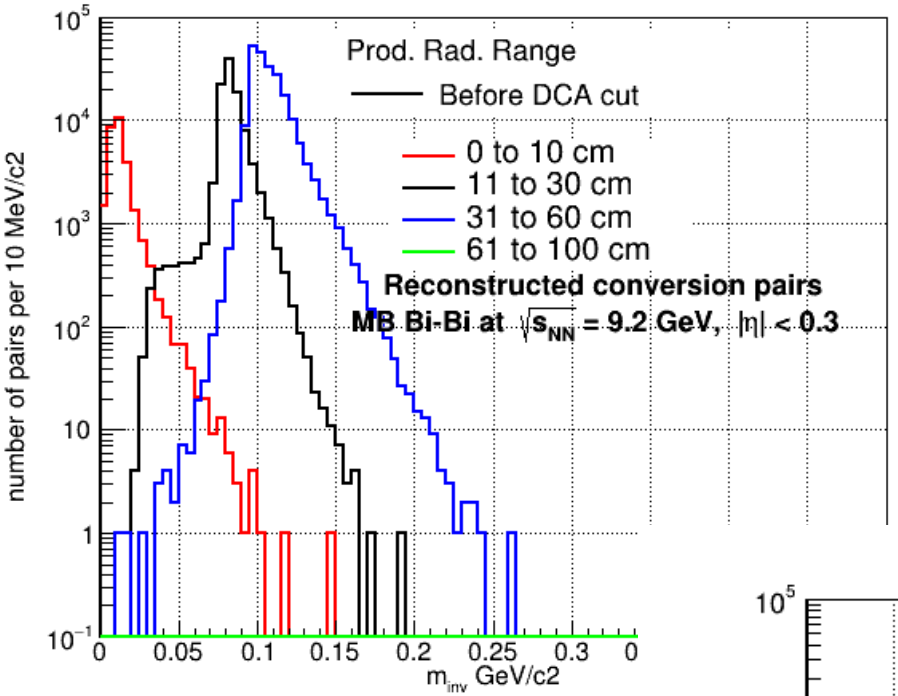


Lines are boost-invariant blast wave fits.

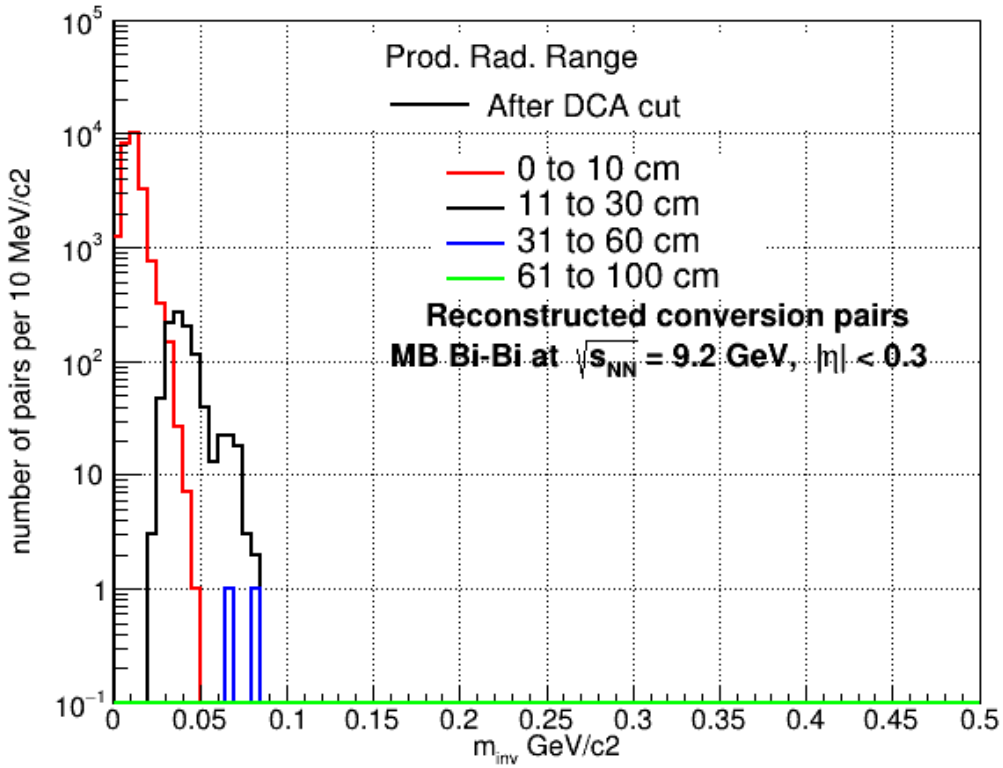
Minimum pt (in MeV) to enter TPC and TOF and exit TPC in various eta regions

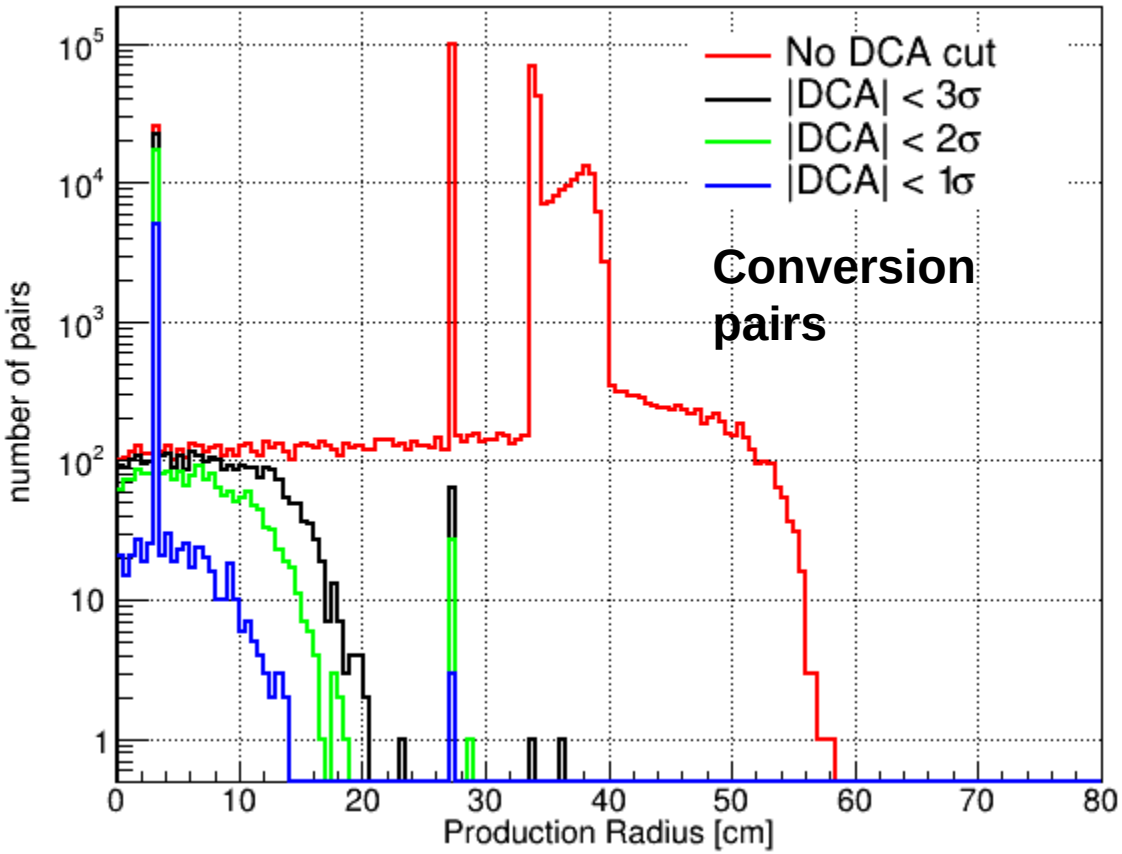
Eta	theta	Min. Rad. of curv at TPC entrance	Min. pt to enter TPC	Min. Rad. of curv. at TPC exit	Min. pt to exit TPC	Min. Rad. at TOF entrance	Min. pt to enter TOF
0.000	90.00	20.15	30.22	59.75	89.62	73.25	109.88
0.050	87.14	20.18	30.26	59.82	89.74	73.34	110.01
0.100	84.28	20.25	30.38	60.05	90.07	73.62	110.42
0.150	81.44	20.38	30.57	60.42	90.64	74.08	111.11
0.200	78.62	20.55	30.83	60.95	91.42	74.72	112.08
0.250	75.82	20.78	31.17	61.63	92.44	75.55	113.33
0.300	73.06	21.06	31.60	62.46	93.69	76.57	114.86
0.350	70.34	21.40	32.10	63.45	95.17	77.78	116.67
0.400	67.67	21.78	32.68	64.59	96.89	79.19	118.78
0.450	65.05	22.22	33.34	65.90	98.85	80.79	121.19
0.500	62.48	22.72	34.08	67.38	101.06	82.60	123.90
0.550	59.97	23.28	34.91	69.02	103.53	84.61	126.92
0.600	57.52	23.89	35.83	70.83	106.25	86.84	130.25
0.650	55.13	24.56	36.84	72.82	109.23	89.28	133.91
0.700	52.82	25.29	37.94	75.00	112.49	91.94	137.91
0.750	50.57	26.09	39.13	77.36	116.04	94.84	142.25
0.800	48.39	26.95	40.42	79.91	119.87	97.97	146.95
0.850	46.29	27.88	41.82	82.67	124.00	101.34	152.02
0.900	44.25	28.88	43.32	85.63	128.44	104.97	157.46
0.950	42.29	29.95	44.92	88.80	133.20	108.87	163.30
1.000	40.40	31.09	46.64	92.20	138.30	113.03	169.55
1.050	38.57	32.32	48.47	95.83	143.74	117.48	176.22
1.100	36.82	33.62	50.43	99.69	149.54	122.22	183.33
1.150	35.14	35.01	52.51	103.8	155.72	127.27	190.90
1.200	33.52	36.48	54.73	108.2	162.28	132.63	198.95

NOTE: TPC Inner (40.3 cm) and outer radius (119.5 cm) values are taken from the analysis code and TOF inner radius (146.5 cm) value is taken from its TDR.



Invariant mass spectra of reconstructed conversion pairs in different production radius regions, before and after applying DCA selection.




No DCA cut
|DCA| < 3σ
|DCA| < 2σ
|DCA| < 1σ
Conversion pairs
number of pairs
Production Radius [cm]
10^5
10^4
10^3
10^2
10
1
0
10
20
30
40
50
60
70
80