Centrality questions & answers

V. Riabov

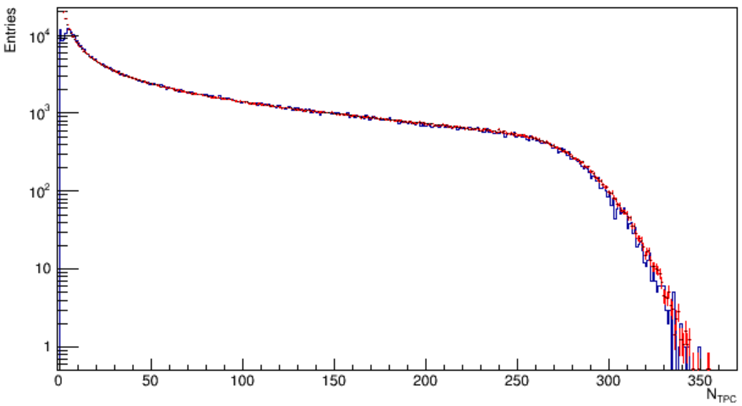
Number of ancestors

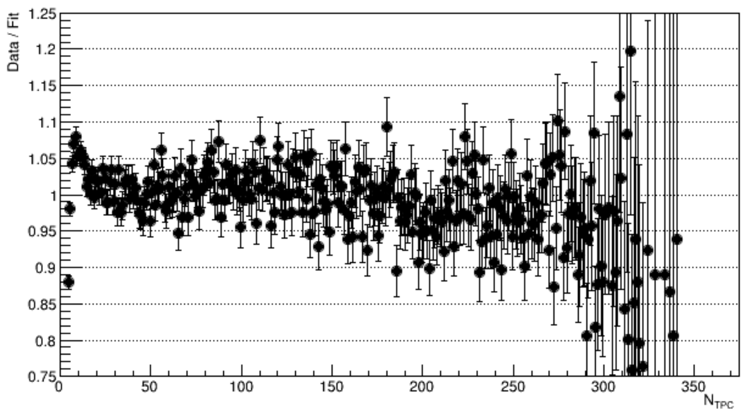
Selections

- UrQMD (Request 25 mass production)
- Event selections:
  - ✓ generated, |z-vertex| < 50 cm
  - ✓ reconstructed, z-vertex != 0
- Track cut variations:
  - ✓ nhits > 10; p_T > 0.05 GeV/c; DCA < 2.0 cm; |η| < 0.5
- Fit range: 20-340
- Centrality methods - default with N_a:
  - Default : $N_a = fN_{part} + (1-f)N_{coll}$
  - PSD : $N_a = f - N_{part}$
  - Npart : $N_a = (N_{part})^f$
  - Ncoll : $N_a = (N_{coll})^f$
  - STAR : $N_a = \frac{(1-f)}{2}N_{part} + fN_{coll}$.

UrQMD: Default and N_{part}

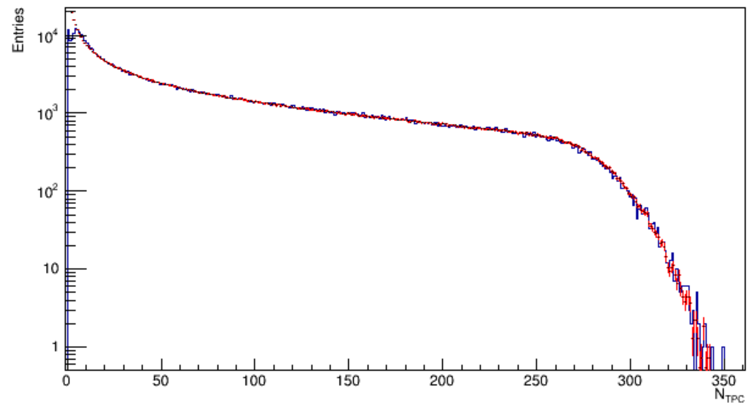
Default

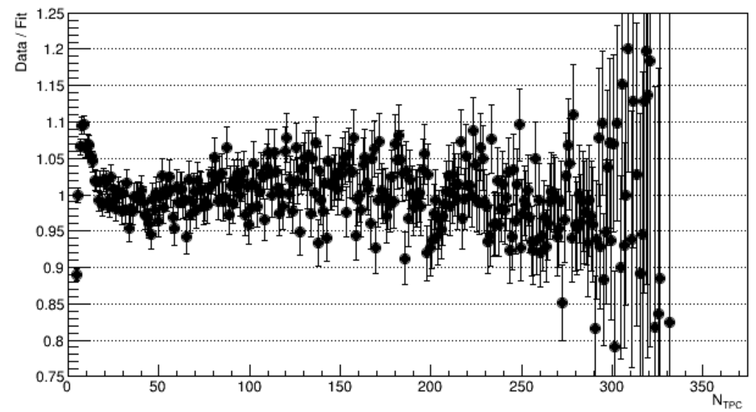




f = 0.35+/-0.14 mu = 0.35+/-0.28
k = 7+/-61 **chi2 = 0.9**

N_{part}

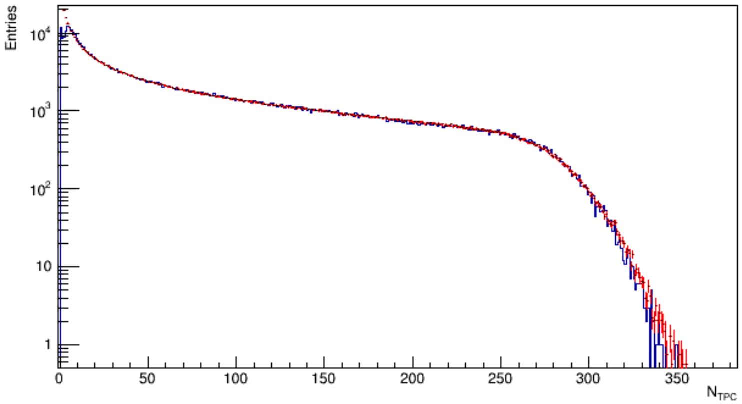


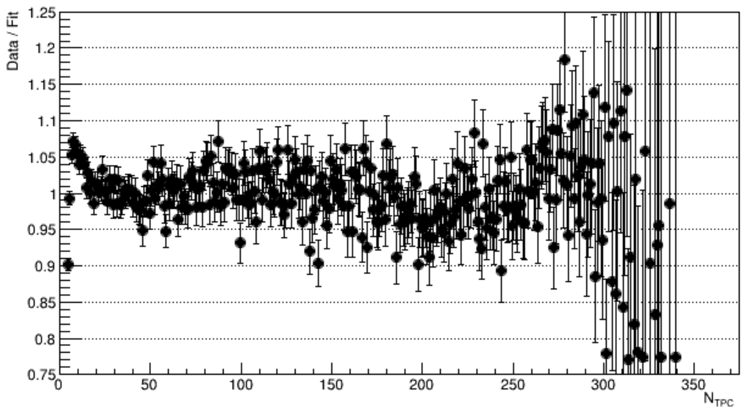


f = 1.27+/-0.02 mu = 0.14+/-55.89
k = 1+/-4 **chi2 = 1.03**

UrQMD: N_{coll} and STAR

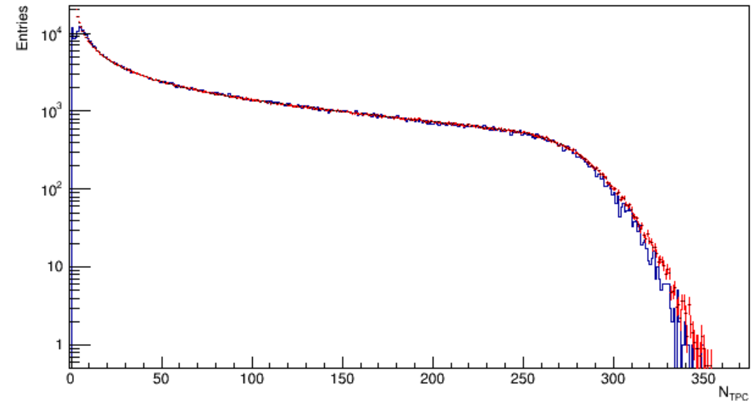
N_{coll}

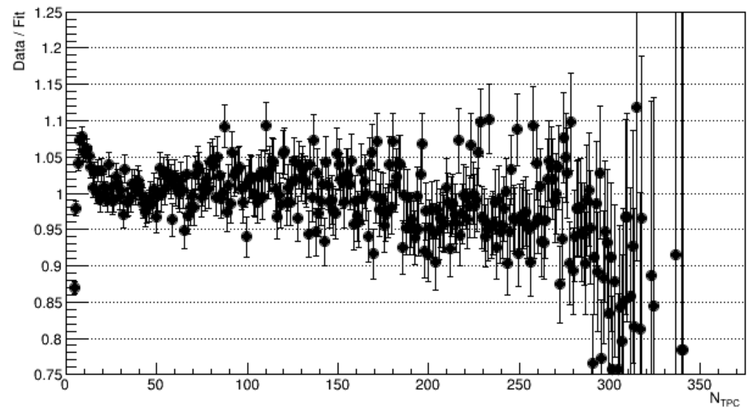




f = 0.99+/-0.01 mu = 0.3+/-46.1673
k = 55+/-41 **chi2 = 1.02+/-0.06**

STAR

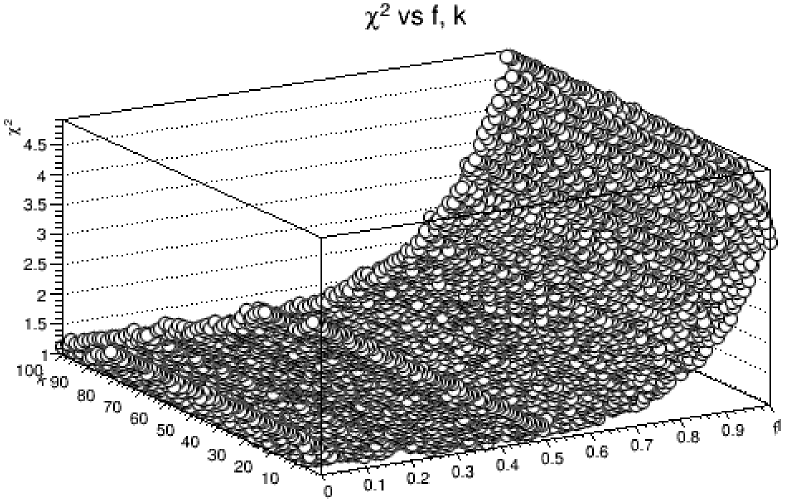




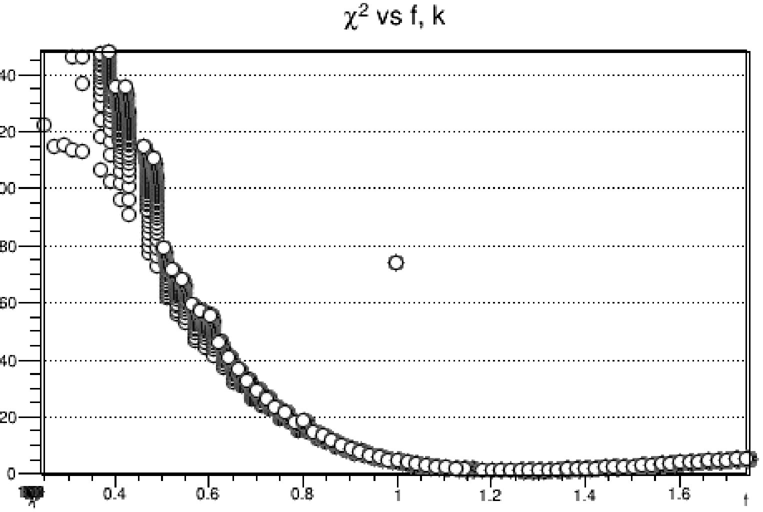
f = 0.73+/-0.17 mu = 0.4+/-1.0
k = 59+/-9 **chi2 = 0.96+/-0.07**

UrQMD: Default and N_{part}

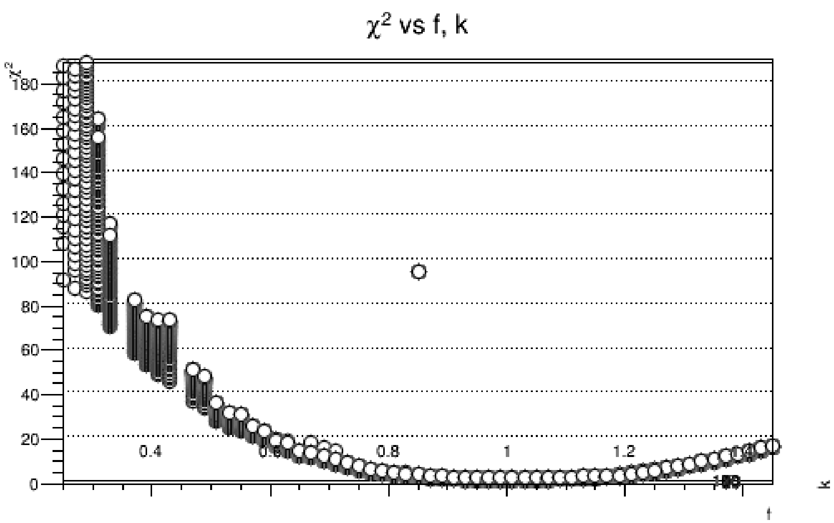
Default



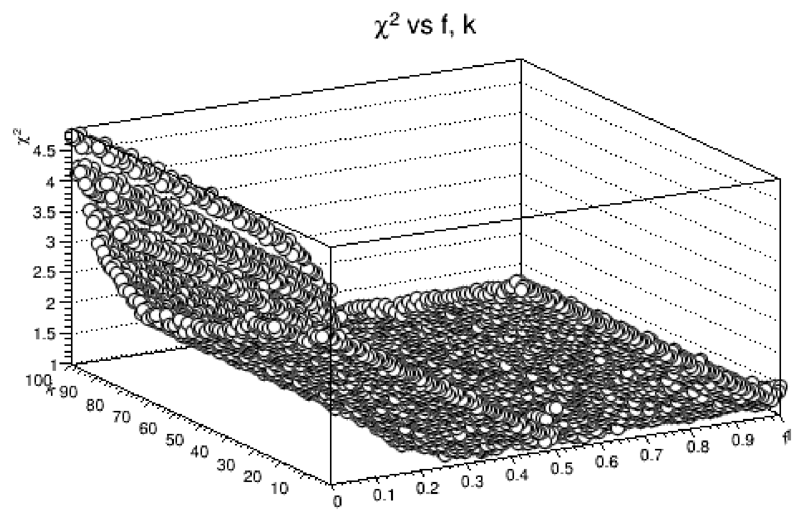
N_{part}



N_{coll}



STAR



UrQMD

Default

Cent, %	Mult_min	Mult_max	<b>, fm	RMS	bmin, fm	bmax, fm	<Npart>	RMS	Npart_min	Npart_max	<Ncoll>	RMS	Ncoll_min	Ncoll_max
0 - 10	196	356	2.95	1.10	1.30	4.24	337.69	34.28	292.37	391.05	725.80	92.96	604.14	869.27
10 - 20	138	196	5.27	0.71	4.24	6.11	253.47	29.10	219.57	292.37	501.28	67.81	417.40	604.14
20 - 30	96	138	6.83	0.60	6.11	7.48	190.03	24.09	163.80	219.57	345.94	51.88	284.52	417.40
30 - 40	65	96	8.09	0.56	7.48	8.64	140.49	20.13	119.76	163.80	233.46	39.94	188.97	284.52
40 - 50	42	65	9.19	0.56	8.64	9.70	101.04	16.93	84.68	119.76	151.48	30.74	120.28	188.97
50 - 60	26	42	10.17	0.56	9.70	10.65	70.12	13.80	57.31	84.68	93.62	22.67	72.13	120.28
60 - 70	15	26	11.07	0.59	10.65	11.49	46.53	11.25	36.98	57.31	54.65	16.45	40.44	72.13
70 - 80	8	15	11.92	0.65	11.49	12.29	28.94	8.90	22.60	36.98	29.63	11.32	21.49	40.44
80 - 90	4	8	12.71	0.75	12.29	13.30	17.00	6.76	11.63	22.60	15.24	7.41	9.98	21.49
90 - 100	1	3	14.04	1.01	13.30	15.02	6.00	4.00	-0.85	11.63	4.47	3.59	-2.86	9.98

N_{part}

Cent, %	Mult_min	Mult_max	<b>, fm	RMS	bmin, fm	bmax, fm	<Npart>	RMS	Npart_min	Npart_max	<Ncoll>	RMS	Ncoll_min	Ncoll_max
0 - 10	195	351	2.91	1.09	1.31	4.18	339.91	32.51	294.97	392.43	726.13	95.97	608.06	865.59
10 - 20	136	195	5.21	0.70	4.18	6.04	256.15	27.00	222.28	294.97	507.83	76.95	424.00	608.06
20 - 30	94	136	6.76	0.60	6.04	7.42	192.77	22.37	166.39	222.28	352.96	60.62	291.46	424.00
30 - 40	63	94	8.02	0.57	7.42	8.57	142.91	18.99	122.25	166.39	239.51	47.72	195.27	291.46
40 - 50	41	63	9.11	0.55	8.57	9.62	103.48	15.96	87.01	122.25	157.24	36.47	125.52	195.27
50 - 60	25	41	10.09	0.57	9.62	10.57	72.43	13.53	59.20	87.01	98.66	27.42	76.01	125.52
60 - 70	14	25	11.01	0.60	10.57	11.44	47.90	11.26	38.03	59.20	57.58	19.59	42.67	76.01
70 - 80	7	14	11.89	0.67	11.44	12.30	29.51	9.10	22.59	38.03	30.95	13.24	22.01	42.67
80 - 90	3	7	12.76	0.79	12.30	13.34	16.58	7.03	11.10	22.59	15.14	8.42	9.59	22.01
90 - 100	1	2	14.06	1.02	13.34	14.98	5.86	3.91	0.16	11.10	4.42	3.72	-1.58	9.59

N_{coll}

Cent, %	Mult_min	Mult_max	<b>, fm	RMS	bmin, fm	bmax, fm	<Npart>	RMS	Npart_min	Npart_max	<Ncoll>	RMS	Ncoll_min	Ncoll_max
0 - 10	195	356	2.90	1.09	1.29	4.16	339.29	33.85	295.41	390.52	731.46	90.30	612.53	871.42
10 - 20	137	195	5.17	0.72	4.16	6.00	257.47	29.85	224.12	295.41	511.57	66.75	428.44	612.53
20 - 30	95	137	6.71	0.61	6.00	7.36	194.86	25.04	168.83	224.12	357.34	51.42	295.93	428.44
30 - 40	64	95	7.95	0.57	7.36	8.51	145.54	21.13	124.74	168.83	244.39	39.86	199.34	295.93
40 - 50	41	64	9.05	0.56	8.51	9.55	105.88	17.97	89.27	124.74	160.96	31.09	128.79	199.34
50 - 60	25	41	10.03	0.57	9.55	10.51	74.42	14.82	61.16	89.27	101.09	23.27	78.35	128.79
60 - 70	14	25	10.94	0.60	10.51	11.37	49.84	12.20	39.74	61.16	59.64	17.21	44.26	78.35
70 - 80	7	14	11.81	0.65	11.37	12.21	31.07	9.68	24.03	39.74	32.31	12.04	23.15	44.26
80 - 90	3	7	12.66	0.76	12.21	13.27	17.80	7.37	11.93	24.03	16.06	7.90	10.22	23.15
90 - 100	1	2	14.03	1.02	13.27	15.02	6.07	4.10	-0.58	11.93	4.49	3.60	-2.56	10.22

STAR

Cent, %	Mult_min	Mult_max	<b>, fm	RMS	bmin, fm	bmax, fm	<Npart>	RMS	Npart_min	Npart_max	<Ncoll>	RMS	Ncoll_min	Ncoll_max
0 - 10	196	356	2.92	1.09	1.31	4.19	338.75	33.94	294.10	390.84	729.45	91.14	608.80	871.44
10 - 20	137	196	5.22	0.72	4.19	6.05	255.56	29.59	221.94	294.10	506.67	67.23	423.10	608.80
20 - 30	95	137	6.77	0.60	6.05	7.42	192.42	24.52	166.39	221.94	351.58	51.12	290.44	423.10
30 - 40	64	95	8.01	0.56	7.42	8.57	143.26	20.65	122.43	166.39	239.39	39.68	194.52	290.44
40 - 50	41	64	9.11	0.56	8.57	9.61	103.73	17.46	87.23	122.43	156.71	30.79	124.94	194.52
50 - 60	25	41	10.10	0.57	9.61	10.57	72.44	14.38	59.39	87.23	97.62	22.97	75.41	124.94
60 - 70	14	25	11.01	0.60	10.57	11.45	48.10	11.79	38.13	59.39	57.00	16.85	42.03	75.41
70 - 80	7	14	11.89	0.66	11.45	12.30	29.62	9.36	22.59	38.13	30.46	11.67	21.49	42.03
80 - 90	3	7	12.77	0.78	12.30	13.35	16.51	7.07	11.03	22.59	14.69	7.53	9.31	21.49
90 - 100	1	2	14.08	1.01	13.35	15.02	5.76	3.84	0.05	11.03	4.23	3.38	-1.85	9.31

Conclusions

- Different options for N_a result in similar quality of the fits
- Different options for N_a give identical results for centrality classes in terms of N_{TPC}
- Different options for N_a give identical distributions of N_{part} , N_{coll} and b
- Why f→0 for Default option is not understood

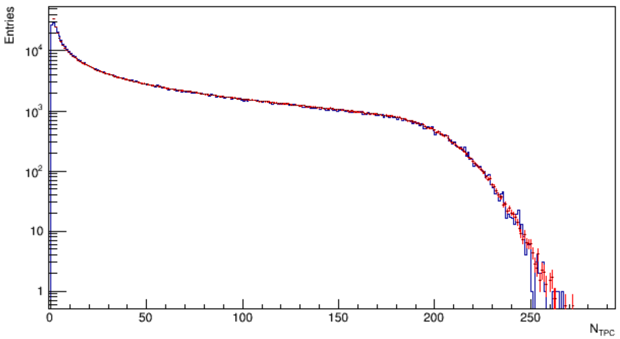
Centrality vs. track cuts

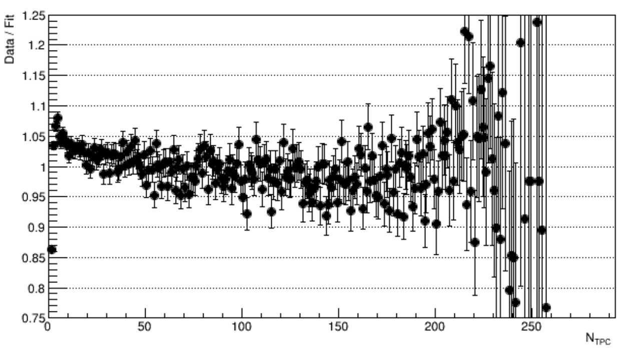
Selections

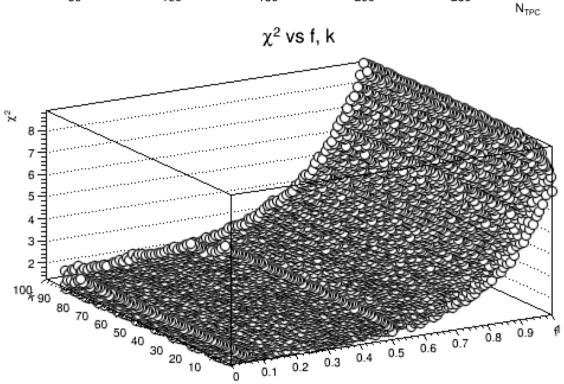
- DCM-QGSM-SMM (Request 26 mass production)
- Event selections:
  - ✓ generated, |z-vertex| < 50 cm
  - ✓ reconstructed, z-vertex != 0
- Track cut variationsT_0 resolution:
  1. nhits > 16; p_T > 0.15 GeV/c; DCA < 1.0 cm; $|\eta| < 0.5$
  2. nhits > 10; p_T > 0.05 GeV/c; DCA < 1.0 cm; $|\eta| < 0.5$
  3. hits > 10; p_T > 0.05 GeV/c; DCA < 2.0 cm; $|\eta| < 0.5$
  4. nhits > 10; p_T > 0.05 GeV/c; DCA < 3.0 cm; $|\eta| < 0.5$
  5. nhits > 10; p_T > 0.05 GeV/c; DCA < 4.0 cm; $|\eta| < 0.5$
- Centrality method: default
- Fit range: N_{min} – N_{max}, where N_{max} is defined by cuts, N_{min} is proportionally scaled

Track cuts 1, 2

Fit range: 15 – 258

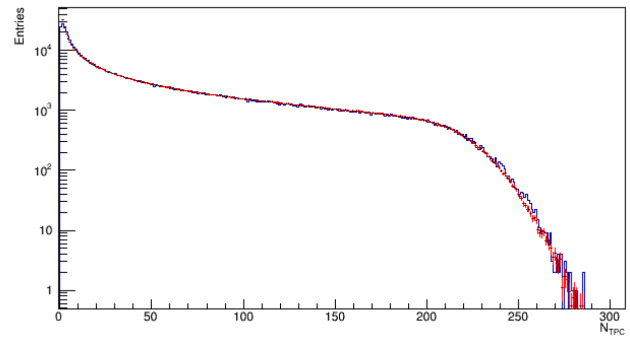


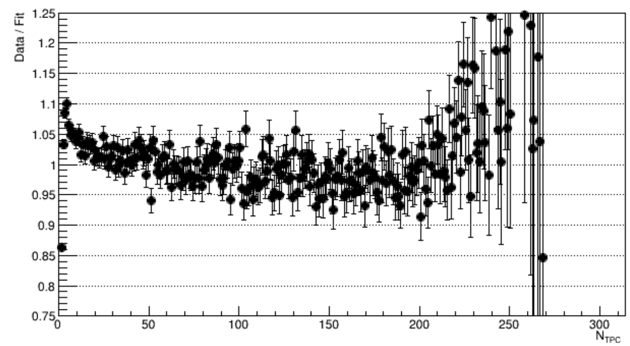


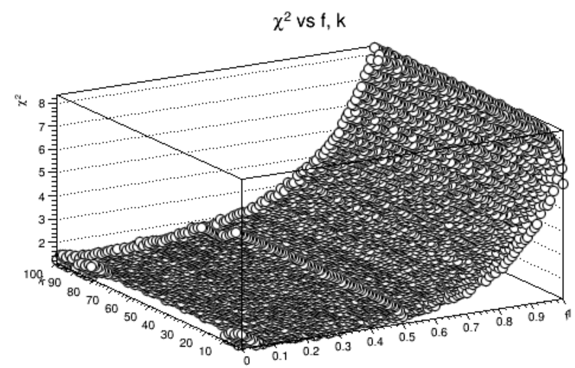


f = 0+/-0 mu = 0.23+/-0.29 k = 89+/-10 **chi2 = 1.2+/-0.1**

17 - 277



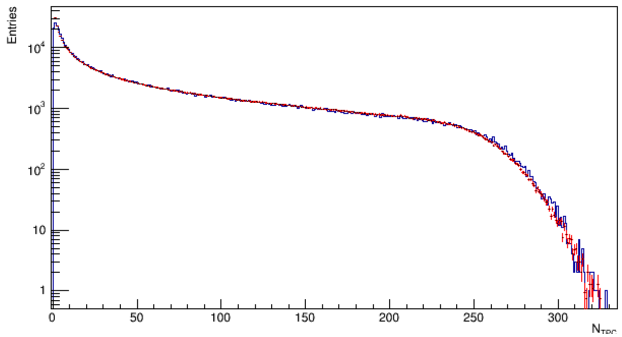


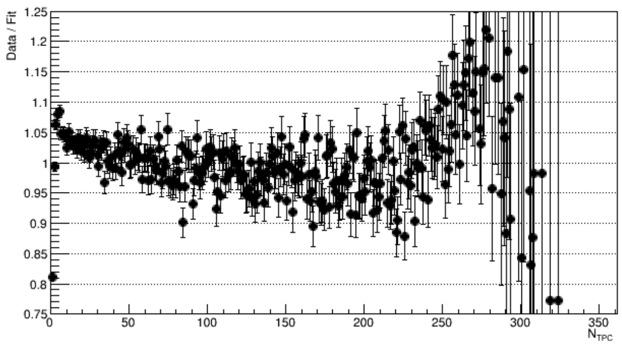


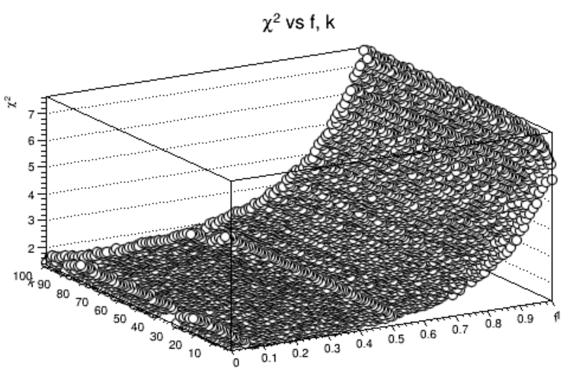
f = 0.09+/-0.02 mu = 0.3+/-0.3 k = 49+/-11 **chi2 = 1.1+/-0.1**

Track cuts 4, 5

Fit range: 19 – 324

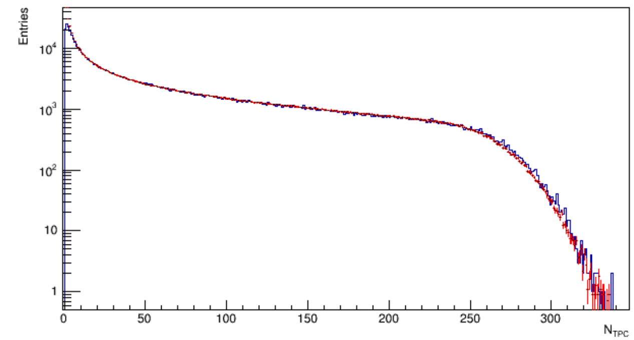


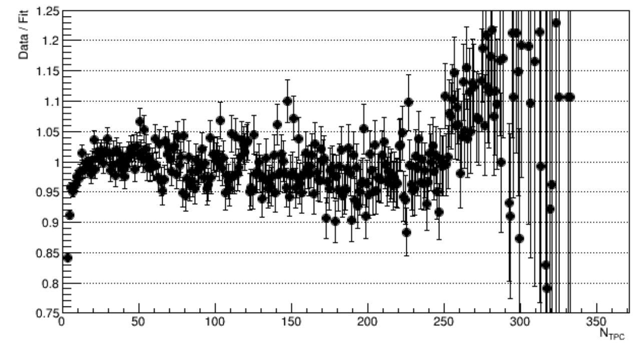


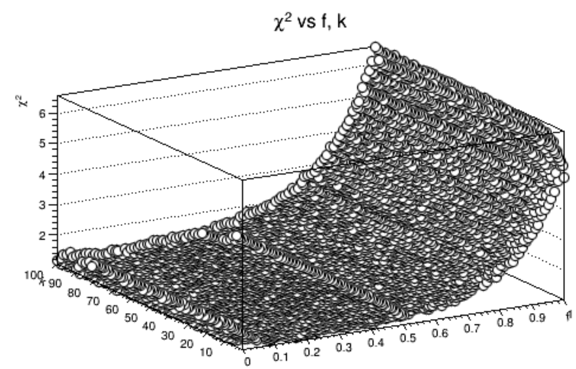


f = 0.11+/-0.03 mu = 0.3+/-0.3 k = 8+/-46 **chi2 = 1.3+/-0.1**

19 - 333



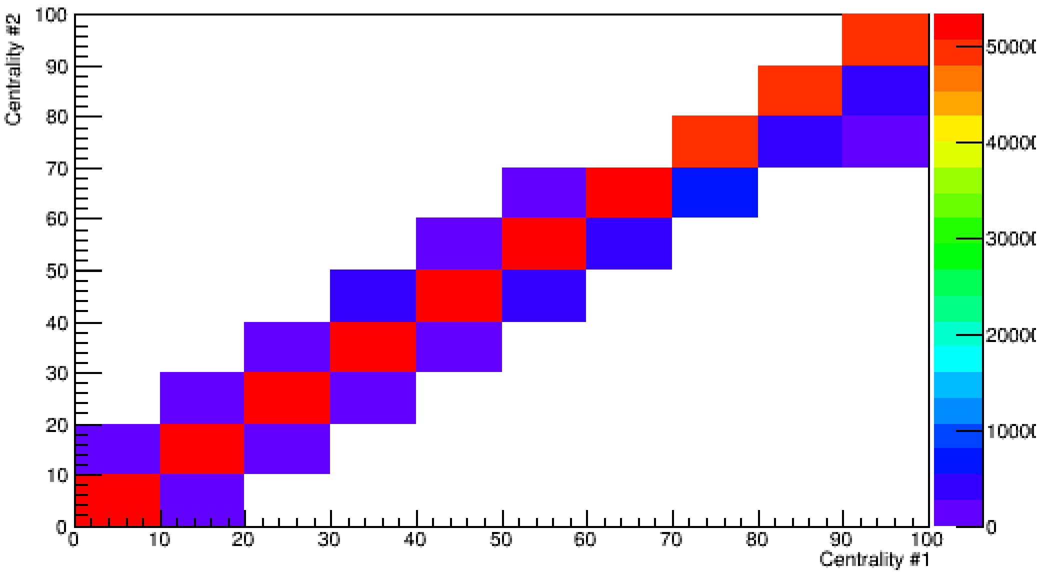


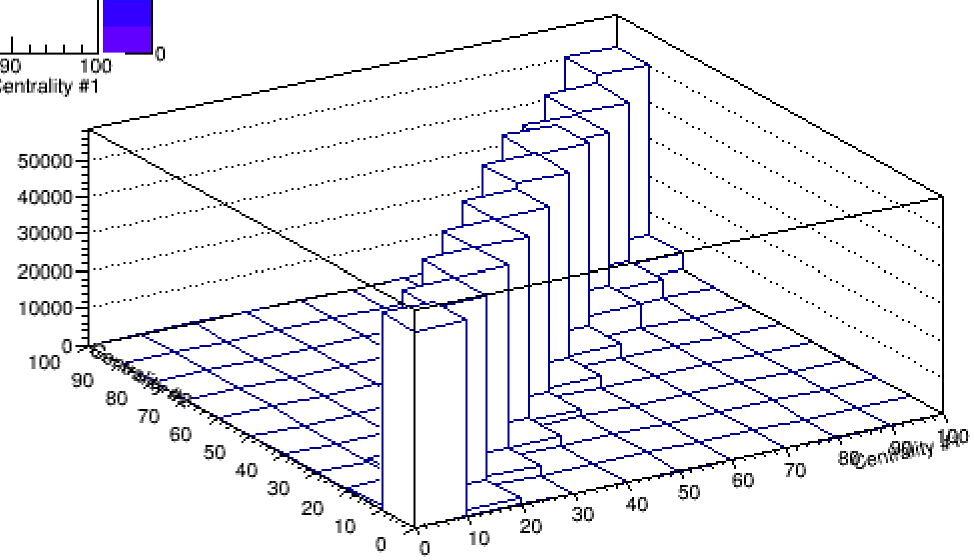


f = 0.12+/-0.1 mu = 0.3+/-0.3 k = 38+/-52 **chi2 = 1.03+/-0.10**

Centrality definitions, cut#1 vs. cut#2

1. nhits > 16; p_T > 0.15 GeV/c; DCA < 1.0 cm; $|\eta|$ < 0.5
2. nhits > 10; p_T > 0.05 GeV/c; DCA < 1.0 cm; $|\eta|$ < 0.5

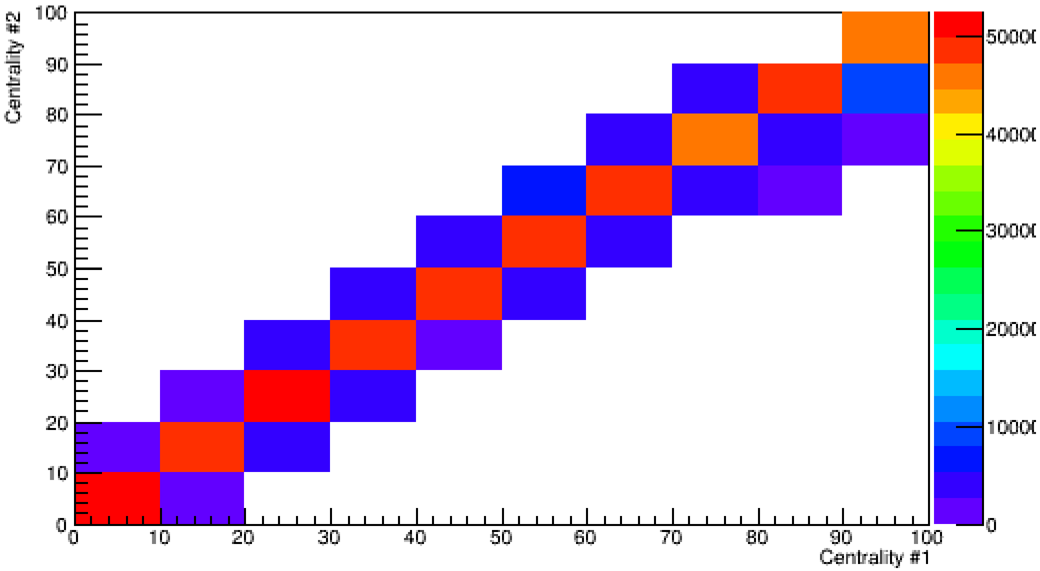


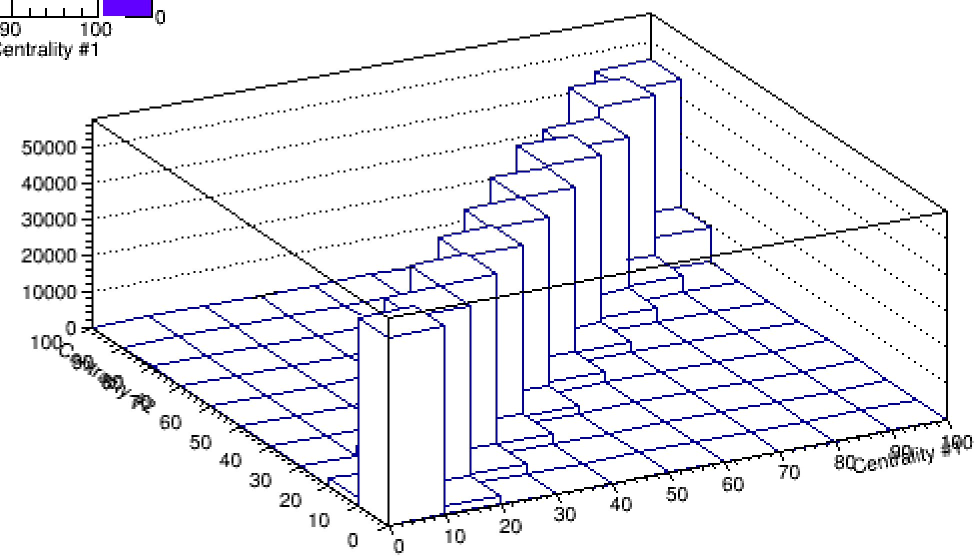


Minimal difference, minor smearing

Centrality definitions, cut#1 vs. cut#3

1. nhits > 16; p_T > 0.15 GeV/c; DCA < 1.0 cm; |η| < 0.5
2. nhits > 10; p_T > 0.05 GeV/c; DCA < 2.0 cm; |η| < 0.5

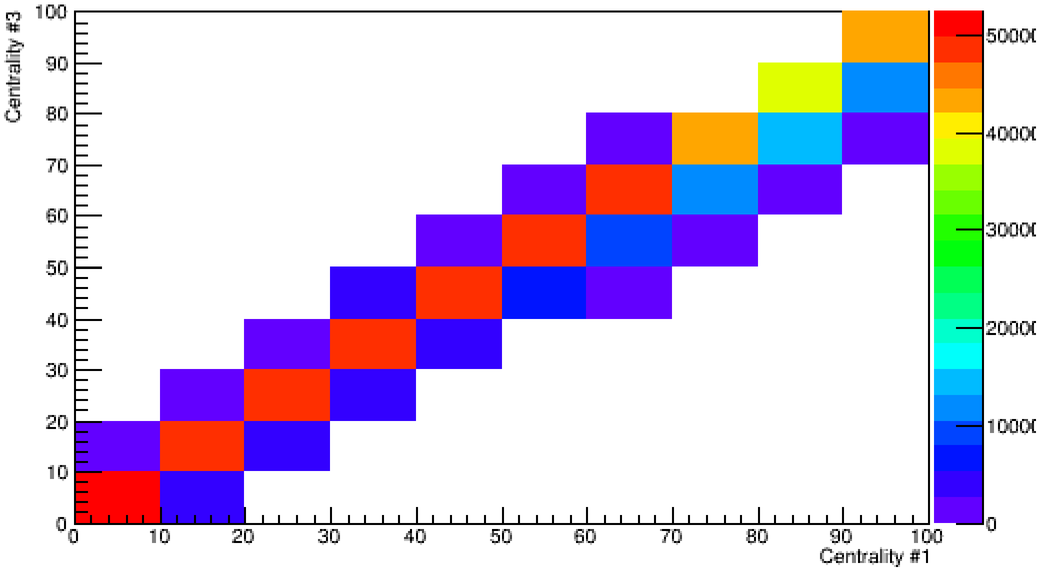


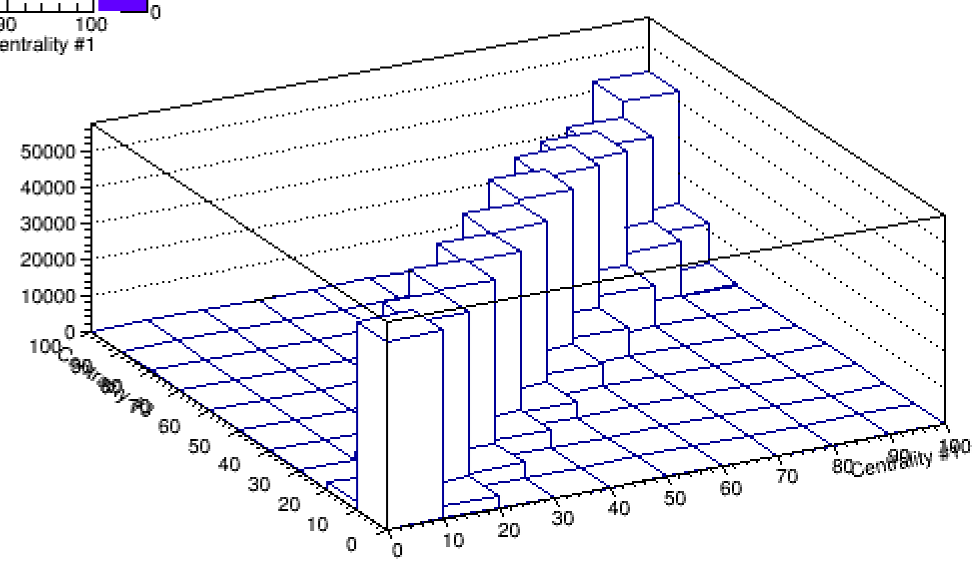


Minimal difference, minor smearing

Centrality definitions, cut#1 vs. cut#3

1. nhits > 16; p_T > 0.15 GeV/c; DCA < 1.0 cm; $|\eta|$ < 0.5
3. nhits > 10; p_T > 0.05 GeV/c; DCA < 3.0 cm; $|\eta|$ < 0.5

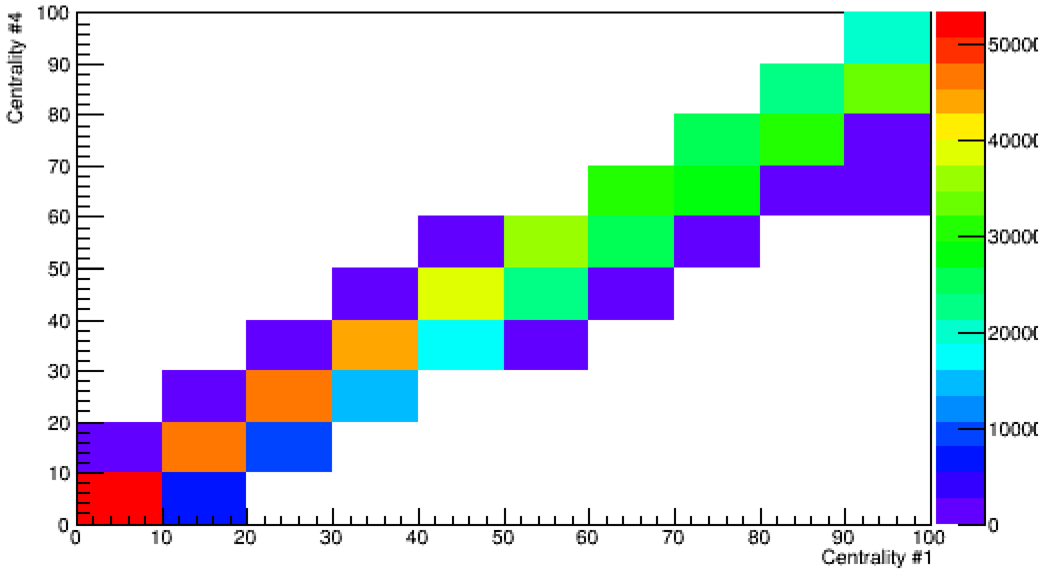


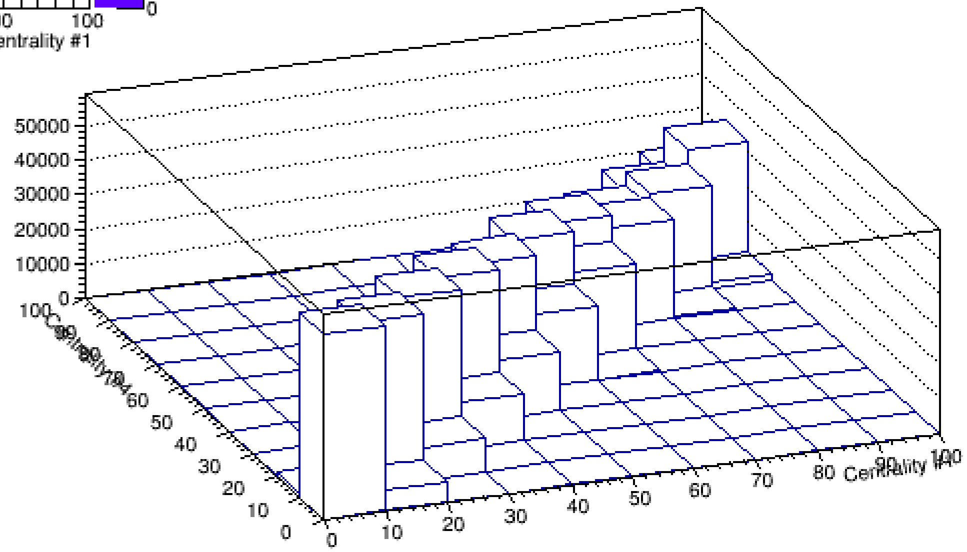


Modest difference, noticeable smearing

Centrality definitions, cut#1 vs. cut#4

1. nhits > 16; p_T > 0.15 GeV/c; DCA < 1.0 cm; $|\eta|$ < 0.5
4. nhits > 10; p_T > 0.05 GeV/c; DCA < 4.0 cm; $|\eta|$ < 0.5

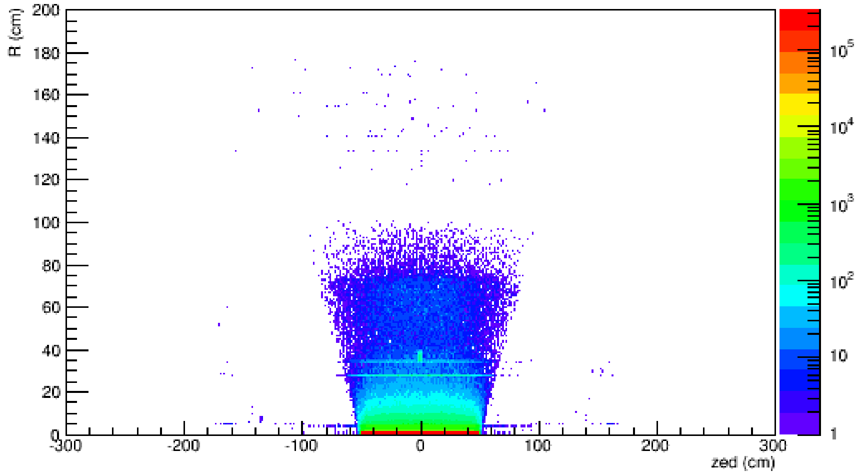




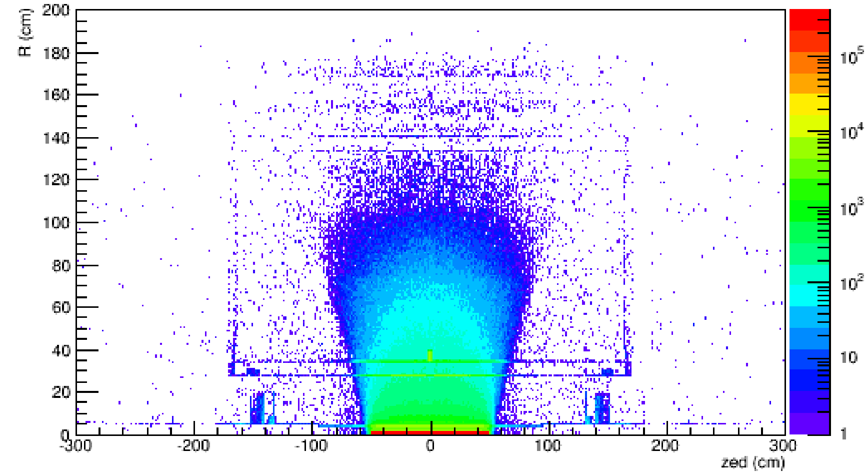
Significant difference

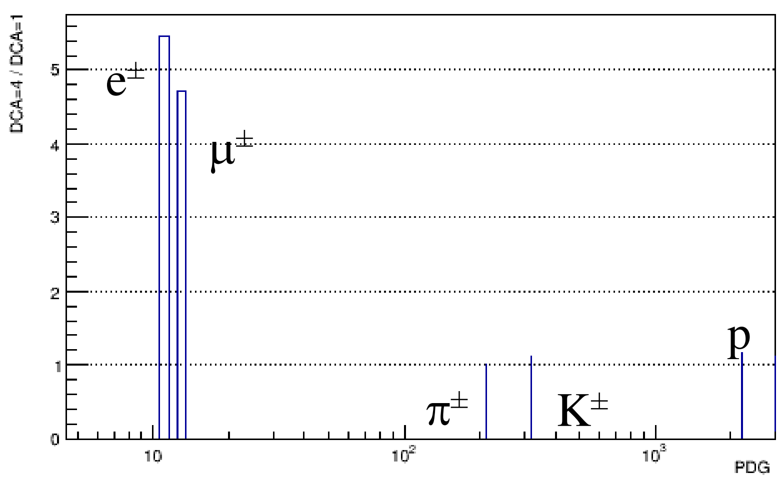
Origin of accepted tracks

1. nhits > 16; p_T > 0.15 GeV/c; DCA < 1.0 cm; $|\eta|$ < 0.5



4. nhits > 10; p_T > 0.05 GeV/c; DCA < 4.0 cm; $|\eta|$ < 0.5





- With looser cuts we accept more conversion electrons and muons (?) produced outside of the primary vertex → correlation between initial multiplicity and impact parameter/centrality gets distorted
- With tighter cuts we reduce mean event multiplicity → 1) a larger fraction of peripheral events have zero multiplicity and no centrality; 2) larger fluctuations

No good or bad solutions → need compromise !!!

Conclusions

- Optimal track selection cuts ???

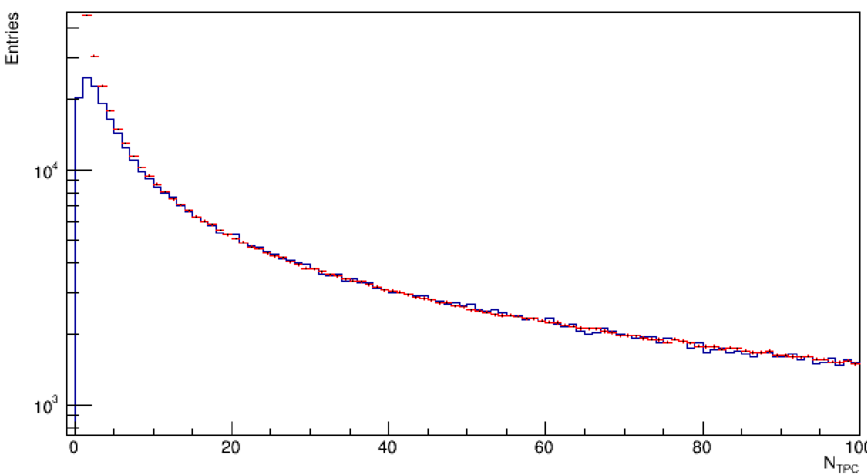
nhits > 10; p_T > 0.05 GeV/c; DCA < 2.0 cm; $|\eta|$ < 0.5

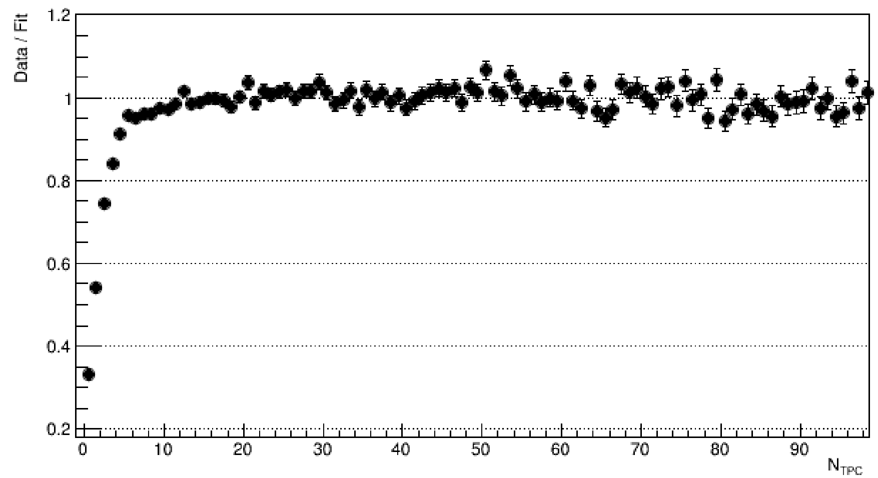
- Reasonable multiplicity, modest smearing
- Looser cuts result in smearing of correlation between multiplicity and centrality

Which of N_a models is better?

Glauber fit vs. multiplicity distribution

- In real data, Glauber fits are limited to N_{TPC} > XXX, where XXX must be large enough to guarantee that trigger efficiency has reached saturation (~ 100%)
- Ratio (data)/(fit) is used to estimate the trigger efficiency and the sampled fraction of the total inelastic cross section





- The method works under assumption that Glauber fit correctly reproduces (predicts) the unbiased multiplicity distribution at N_{TPC} < XXX
- The hypothesis can be tested with the simulated data samples by fitting the generated multiplicity distributions: trigger efficiency = const = 100%, no track selection inefficiencies → fit must reproduce the multiplicity distribution at N_{TPC} < XXX

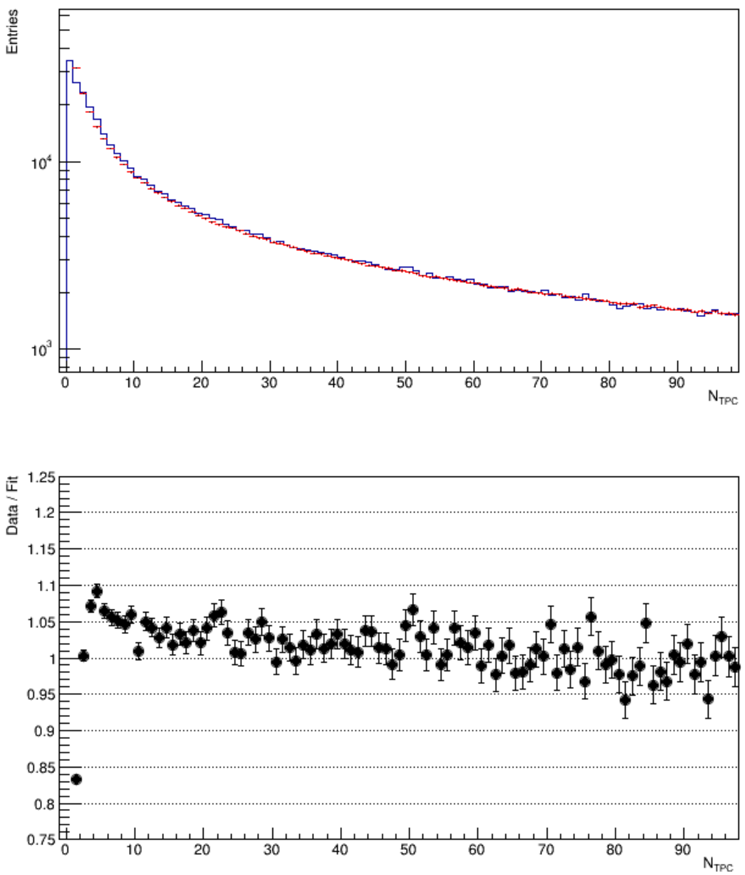
Generated distributions

- DCM-QGSM-SMM (Request 26 mass production)
- Event selections:
  - ✓ generated, |z-vertex| < 50 cm
- Track cut variationsT_0 resolution:
  - ✓ p_T > 0.05 GeV/c; DCAto-PV < 2.0 cm; $|\eta|$ < 0.5
- Fit range: 20-329
- Centrality methods - default with N_a:

  - Default : $N_a = fN_{part} + (1-f)N_{coll}$
  - PSD : $N_a = f - N_{part}$
  - Npart : $N_a = (N_{part})^f$
  - Ncoll : $N_a = (N_{coll})^f$
  - STAR : $N_a = \frac{(1-f)}{2}N_{part} + fN_{coll}.$

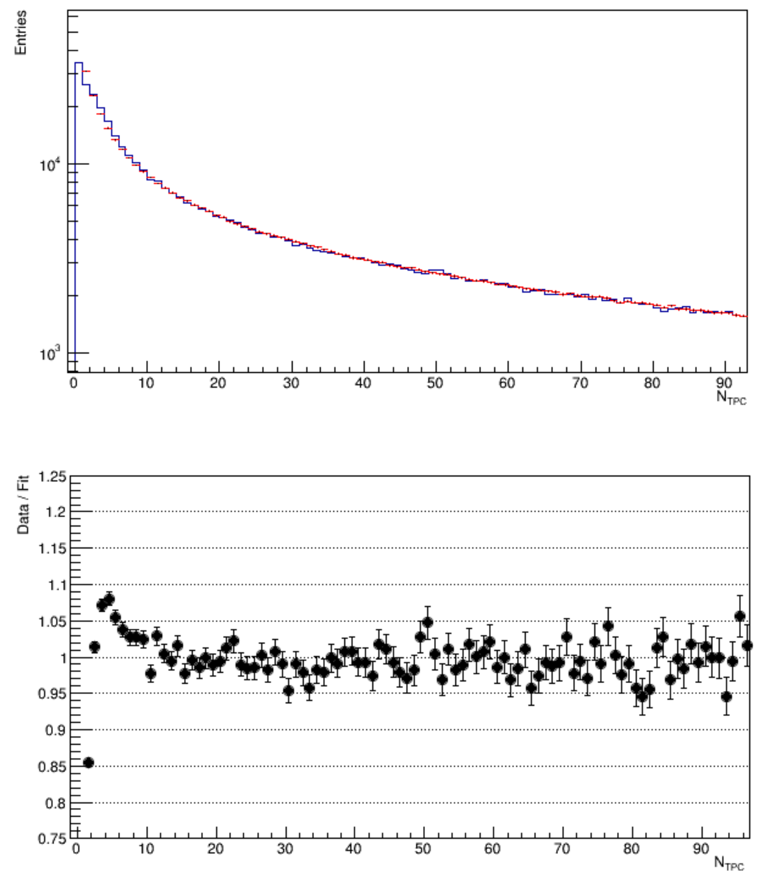
Fits: Default and N_{part}

Default



f = 0+/-0. mu = 0.3+/-0.3
k = 42+/-9 **chi2 = 1.3+/-0.1**

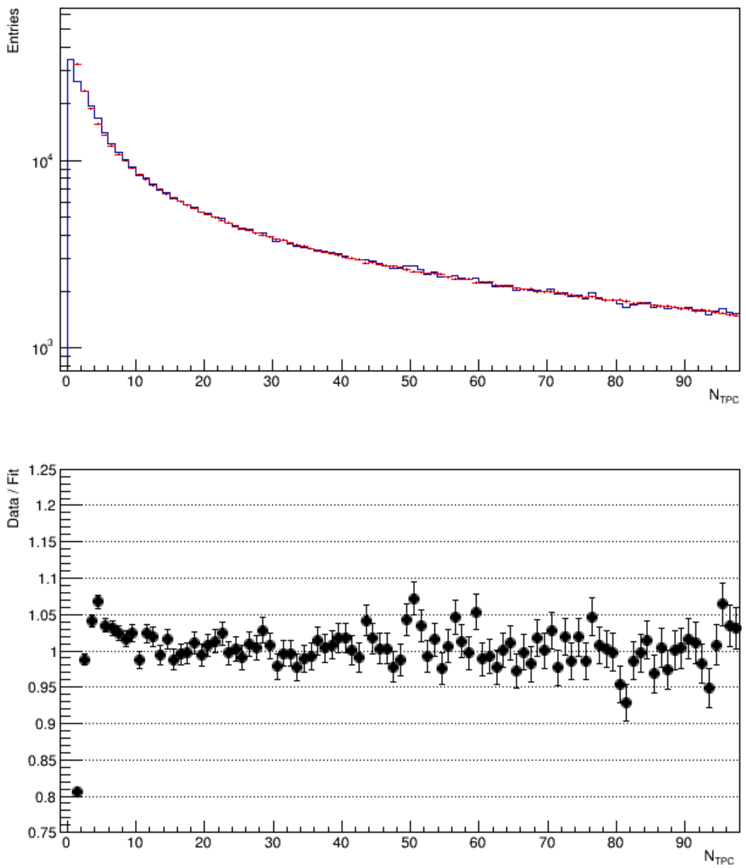
N_{part}



f = 1.39+/-0.04 mu = 0.07+/-52.62
k = 82+/-15 **chi2 = 1.06+/-0.08**

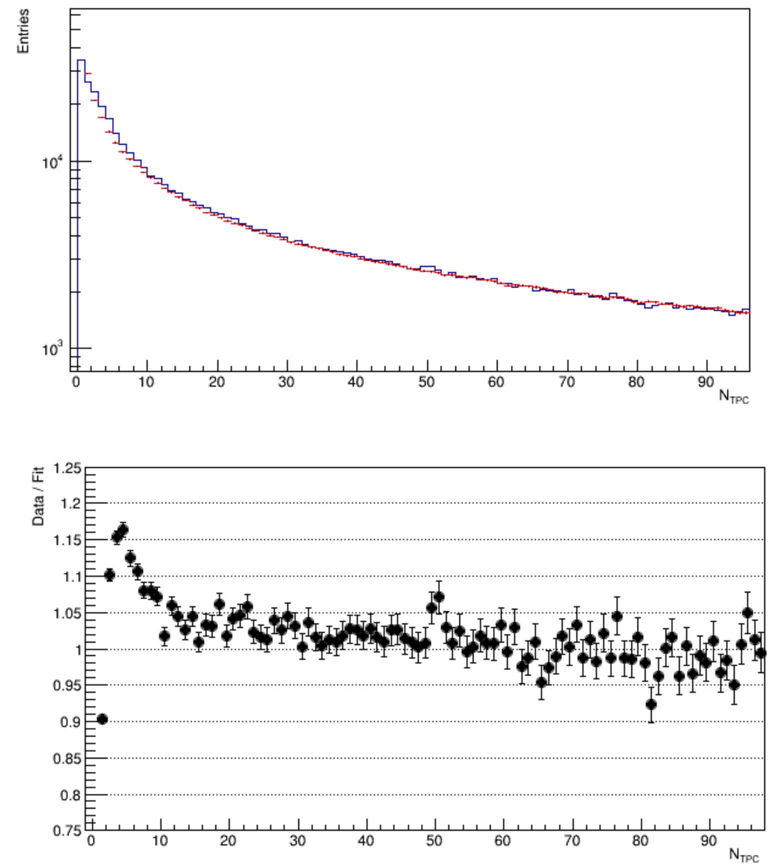
Fits: N_{coll} and STAR

N_{coll}



f = 1.09+/-0.09 mu = 0.17+/-43.9
k = 24+/-10 **chi2 = 1.07+/-0.77**

STAR



f = 0.96+/-0.06 mu = 0.3+/-1.1
k = 7+/-89 **chi2 = 1.3+/-0.1**

Conclusions

- Fits in general reproduce multiplicity distribution in the extrapolated region
- Default, N_{part} and N_{coll} options are nearly identical, STAR is somewhat worse