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Update on di-electron analysis

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MPD Cross-PWG meeting

Content

- New production dedicated to di-electrons: Request 34
- Comparison with Request 25 results
- Conclusions and Outlook

Request 34

Request 34: General-purpose, 15M UrQMD BiBi@9.2 (dielectron enhanced)

Monte-Carlo productions

riabovvg Management of Physics Working Groups May 20

UrQMD + Geant-4 based general-purpose simulation project for minbias (b = 0-16 fm) Bi (83/209) +Bi (83/209) collisions at 9.2 GeV, full detector configuration. The basic configuration repeats Request25 with several fixes: vacuum in the beam pipe instead of the air; fixes for cascade decays of strongly decaying particles/resonances; new variables to control track quality.

Please find below the request details:

inputfile (444 Bytes)
MpdDecayConfig.txt (569 Bytes)
runMC.C (11.7 KB)
reco.C (8.8 KB)

- New production dedicated to di-electrons $\rightarrow$ enhanced branching ratios of dielectron sources.

What has changed in 34 with respect to 25?

- Changes in the MPDROOT
  - Beam pipe without air is used.
  - Conversions inside beam pipe due to malfunction with the pythia decayer is fixed.
  - Issue of lost electrons is fixed.
  - New variables are introduced for better track quality, though not applied in the analysis at the moment.
  - The branching ratios of dielectrons 5 decay channels (ρ, ω and ϕ mesons) are enhanced by factor 20.
- Pointers regarding Request 25 (since last meeting) and Request 34 analyses.
  - Wider vetex cut $|Vz| < 130$ cm in both Request 25 and 34 analysis.
  - Use of parameterizations from PID wagons $\rightarrow$ in both request 25 and 34 analysis.
  - Same trained MLP algotrithm is used in Request 25 and 34 $\rightarrow$ new separate algorithms in progress.

Train: Request 34

Request 9, input - Request 34

Analysis Train Requests

R **riabovvg** Management of Physics Working Groups 2 29d

Request details:

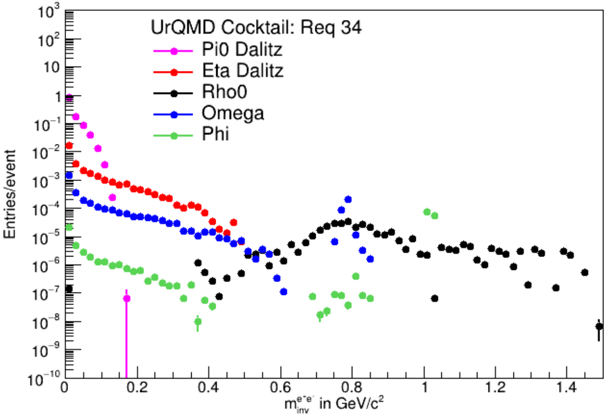
Please use the latest -dev version of the MpdRoot from July 16 or later.

The Train will run over the files listed in file list.txt file. The file provided is for example only. Each job should run over 50,000 events to properly fill in the pools for event mixing. It means that list.txt file for each job should contain ~100 unique DST files. This Train run is for **Request 34** mass production, please use DST files from this production.

Please, first process ~1M events for QA.

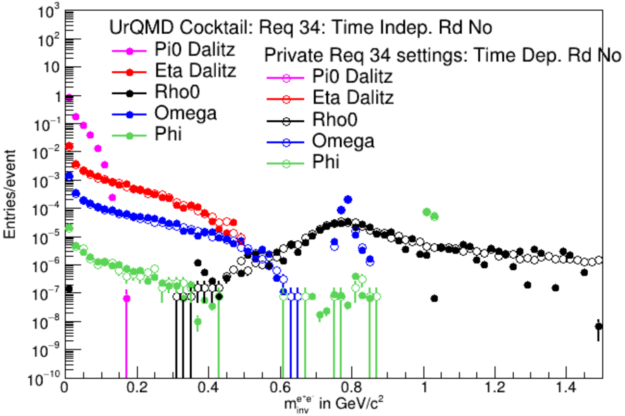
- New official train on Request 34 production $\rightarrow$ found an issue with dielectron cocktail shape.

Cocktail shape UrQMD in Request 34



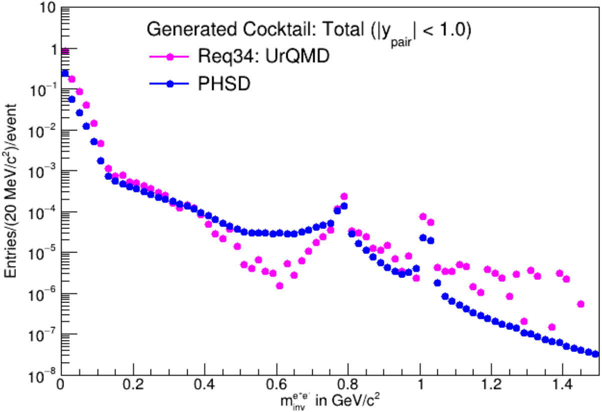
- "Ragged" shape of the di-electron cocktail.
- Random seeds in pythia8 decayer were kept time independent for dubugging → now turned back to time dependent.

Cocktail shape UrQMD in Request 34



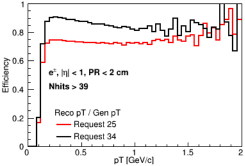
- As a result, "Ragged" shape of the di-electron cocktail can be restored.
- Should it be a huge concern since reweighted to PHSD shape?

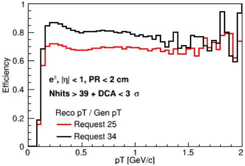
Cocktail shape UrQMD: Request 34

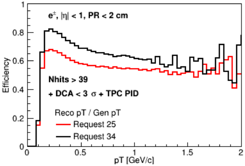


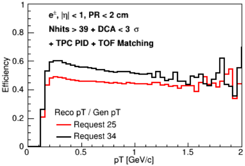
- Ratio of PHSD to UrQMD is used as weights to get PHSD shape.
- Apart from this, there were few bugs in my task, so, could not use train output.
- Ran my task privately and results are shown from next slides.

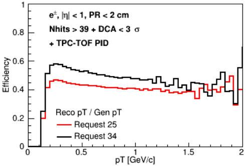
Request 25 and 34: Efficiency using 1D cuts

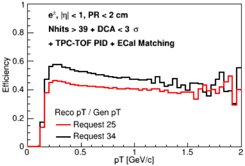


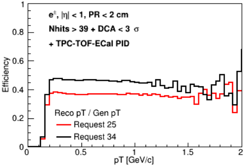












Revised Analysis Strategy

⇒ Three electron pools:

→ Pool-1 for fully reconstructed tracks[1] in fiducial area ($|\eta| < 0.7$)

→ Pool-2 for fully reconstructed tracks in veto area $0.7 < |\eta| < 1.0$.

→ Pool-3 with tracks reconstructed in TPC only.

- $p_{\mathrm{T}} <= 110$ MeV/c → not reaching the TOF.
- $p_{\mathrm{T}} > 110$ MeV/c → reaching the TOF.

- Step 1 - No further pairing (NFP): Tagging between Pool 1 and Pool 2.
- Step 2 - Close TPC cut (CTC): Tagging between Pool 1 and 3, and pairs with $M_{\mathrm{inv}} < 80$ MeV/c^2 and opening angle < 10 degrees, removed.
- Rest of the tracks with $p_{\mathrm{T}} > 200$ MeV from Pool-1 are paired among themselves to build ULS and LS pair spectra.

[1] TOF and ECal matched tracks identified in the TPC, TOF and ECal

Track selection - 1D cuts analysis

$\rightarrow$ Pool-1 for fully reconstructed tracks[2] in fiducial area ($|\eta| < 0.7$)

- NHits $>$ 39, DCA $< 3\sigma$, TPC dEdX (p $>$ 0.8, -1 to 2σ), TOF Matching (d$\phi < 2\sigma$ and dz $< 2\sigma$), TOF (-2 to 2σ), ECal PID (p dep. $<$ E/p $<$ 1.5 and $\mathrm{m}^2 < 2\sigma$, ECal Matching ($< 3\sigma$)).

$\rightarrow$ Pool-2 for fully reconstructed tracks in veto area $0.7 < |\eta| < 1.0$.

- Same cuts.

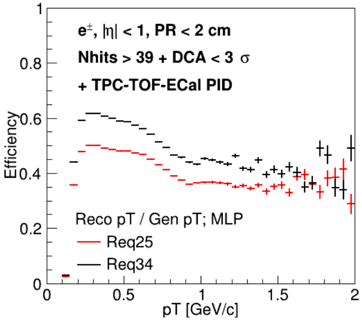
$\rightarrow$ Pool-3 with tracks reconstructed in TPC only.

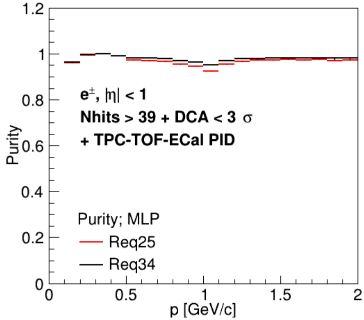
- $p_{\mathrm{T}} <= 110$ MeV/c $\rightarrow$ not reaching the TOF - ($|\eta|$ <2.5, NHits $>$ 10, DCA $< 5\sigma$, TPC dEdX (-4 to 4σ)).
- $p_{\mathrm{T}} > 110$ MeV/c $\rightarrow$ reaching the TOF - ($|\eta|$ <2.5, NHits $>$ 10, DCA $< 5\sigma$, TPC dEdX (-3 to 3σ or -1 to 2σ), ECal PID (p dep. $<$ E/p $<$ 1.5 and $\mathrm{m}^2 < 2\sigma$, ECal Matching ($< 3\sigma$)), TOF PID (if matched).

- No further pairing (NFP): $M_{\mathrm{inv}} < 120$ MeV/c^2.
- Close TPC cut (CTC): $M_{\mathrm{inv}} < 80$ MeV/c^2 and opening angle $<$ 10 or 5^o.

[2]TOF and ECal matched tracks identified in the TPC, TOF and ECal

Request 25 and 34: Efficiency and Purity with MLP





- Efficiency was falling sharply after $p_{\mathrm{T}} > 1$ GeV/c, therefore, 1D cuts were applied after that region.
- Larger efficiency and better purity in case of Request 34.
- Same MLP response cut in both Request 25 and 34.

S/B - 1D Cuts (Fid. < 0.7): Request 25 (34), 33.2M (12.9M) Mass range: $0.2 < m_{inv}^{e^+e^-} < 1.5$ GeV/c^2

	Bef. NFP	Aft. NFP	Aft. CTC[3]
Mass	-	120	80
Angle	-	-	10 or 5
U-B	1671±560	1479±480	1472±316 (2021)
U-B	1183±291	986±200	912±173 (876)
(U-B)/B (%)	1.07±0.00	1.29±0.01	3.00±0.02 (4.11)
(U-B)/B (%)	2.83±0.02	3.53±0.03	6.30±0.07 (6.05)
BFE	9	9	22 (41)
BFE	16	19	28 (26)

← 1D cuts

← Req 25

← Req 34

	Bef. NFP	Aft. NFP	Aft. CTC
Mass (MeV)	-	120	80
Angle	-	-	10 or 5
U-B	3146±752	2995±605	2710±407 (3395)
U-B	1331±377	1386±308	1298±216 (1387)
(U-B)/B	1.12±0.00	1.65±0.01	3.33±0.02 (4.17)
(U-B)/B	1.89±0.01	2.96±0.02	5.75±0.05 (6.14)
BFE	18	25	44 (69)
BFE	12	20	36 (41)

← MLP

← Req 25

← Req 34

- B - Combinatorial background approximated by like sign pairs.

[3]different selection cuts on associated tracks with $p_T <$ and > 110 MeV/c

S/B - 1D cuts and MLP (Fid. < 0.7): Req. 34, 12.9M

Mass range: $0.2 < m_{inv}^{e^+e^-} < 1.5$ GeV/c^2

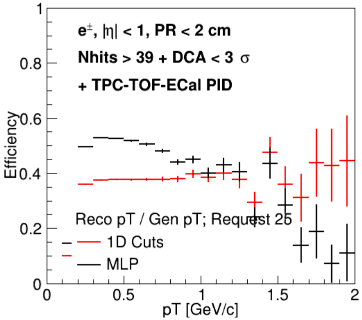
	Bef. NFP	Aft. NFP	Aft. CTC
Mass	-	120	80
Angle	-	-	10 or 5
U	43033±207	32287±180	15392±124
U	71830±268	48252±220	23889±155
B	41851±205	31187±177	14480±120
B	70499±266	46866±216	22590±150
U-B	1183±291	1100±252	912±173 (876)
U-B	1331±377	1386±308	1298±216 (1387)
(U-B)/B (%)	2.83±0.02	3.53±0.03	6.30±0.07 (6.05)
(U-B)/B (%)	1.89±0.01	2.96±0.02	5.75±0.05 (6.14)
BFE	16	19	28 (26)
BFE	12	20	36 (41)

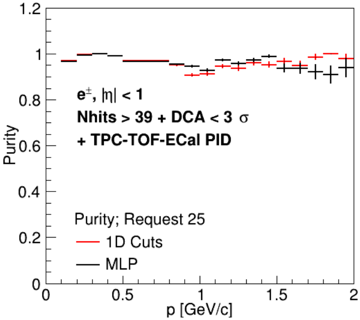
← 1D cuts

← MLP

- B - Combinatorial background approximated by like sign pairs.
- Use Machine learning improves the signal, i.e. Background Free Equivalent signal.
- S/B ratio is expected to stay unaffected.

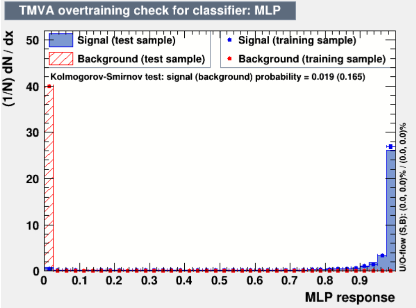
MLP

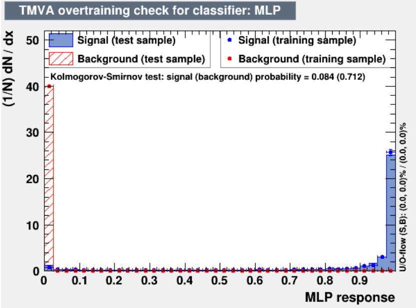




- Efficiency was falling sharply after $p_T > 1$ GeV/c $\rightarrow$ $p-$integrated training of the sample.
- $p-$differential training can help in better signal and background separation.

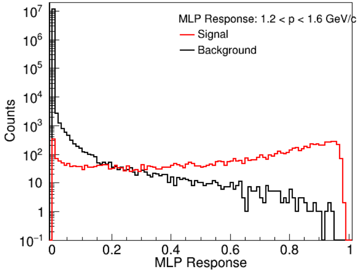
MLP: $p-$differential training

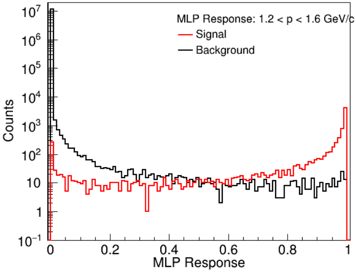


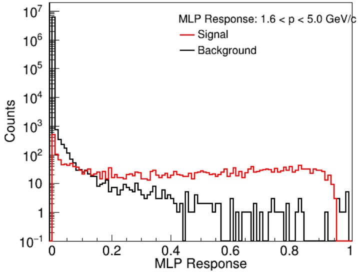


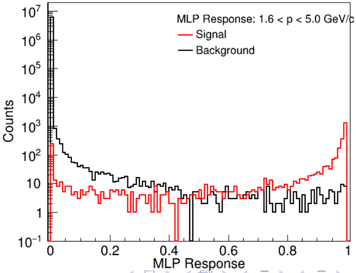
- $p < 0.3$ GeV/c.
- $0.3 < p < 0.6$ GeV/c.
- $0.6 < p < 0.9$ GeV/c.
- $0.9 < p < 1.2$ GeV/c.
- $1.2 < p < 1.6$ GeV/c.
- $1.6 < p < 5.0$ GeV/c.

MLP response: $p-$integrated vs $p-$differential training

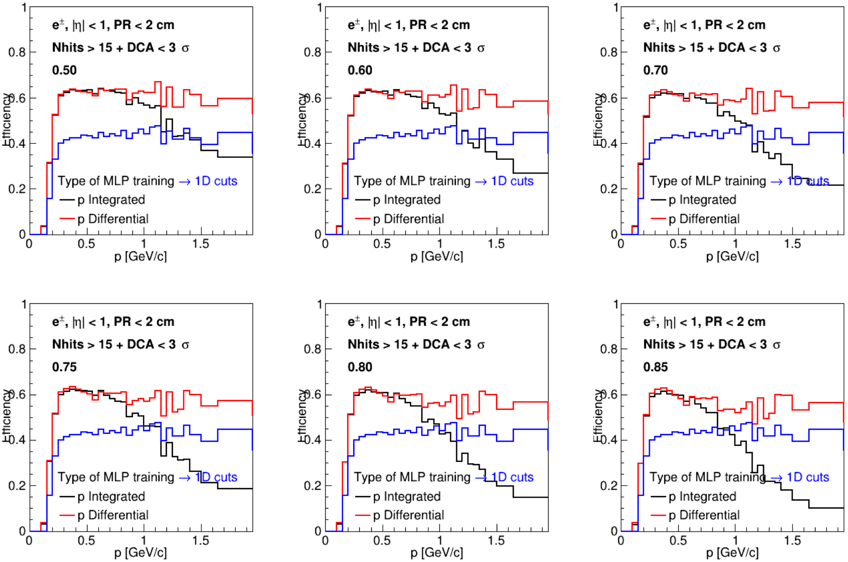




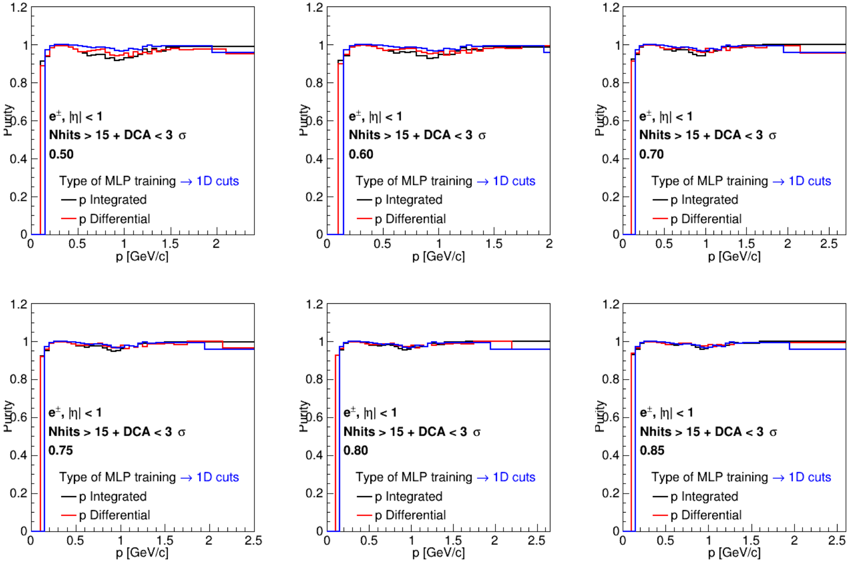




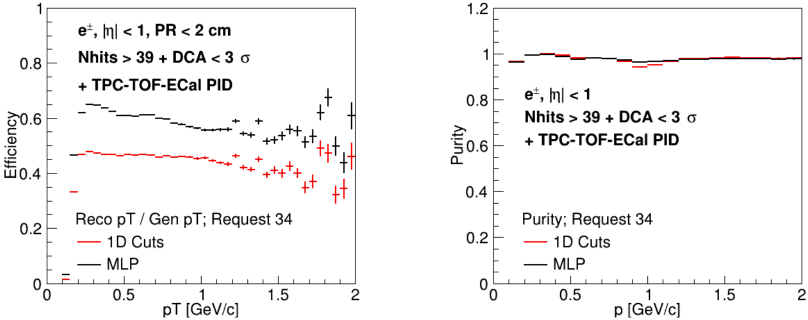
Request 34 Efficiency: p Integrated vs Differential training



Request 34 Purity: p Integrated vs Differential training



Request 34: Efficiency and Purity



- Efficiency remains flat for all p_{T} in case of $p-$differential training.

S/B - MLP (Fid. < 0.7): Request 34, (12.9M), (12.6M)

Mass range: $0.2 < m_{inv}^{e^+e^-} < 1.5$ GeV/c^2

	Bef. NFP	Aft. NFP	Aft. CTC
Mass	-	120	80
Angle	-	-	10 or 5
U	71830±268	48252±220	23889±155
U	81159±285	53254±231	26785±164
B	70499±266	46866±216	22590±150
B	79840±283	51843±228	25344±159
U-B	1331±377	1386±308	1298±216 (1387)
U-B	1319±401	1412±324	1442±228 (1556)
(U-B)/B (%)	1.89±0.01	2.96±0.02	5.75±0.05 (6.14)
(U-B)/B (%)	1.65±0.01	2.72±0.02	5.69±0.05 (6.14)
BFE	12	20	36 (41)
BFE	11	19	40 (46)

← MLP

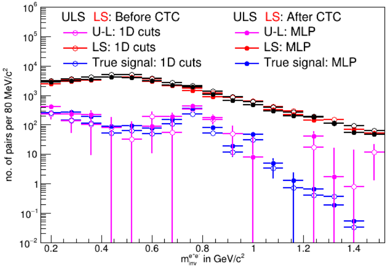
← p integrated

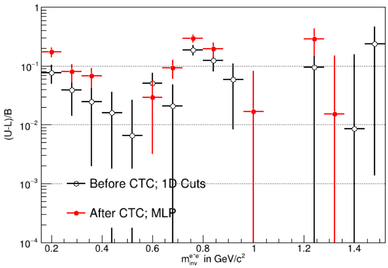
← p differential

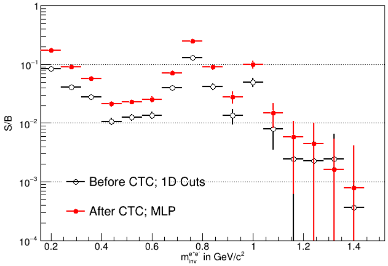
- $p-$differential training helps in getting better signal.
- Flat MLP response cut in $p-$differential case.

Request 34: ULS, LS and Signal

Mass range: $0.2 < m_{inv}^{e^+e^-} < 1.5$ GeV$/c^2$







	Bef. CTC w/ 1D Cuts	Aft. CTC w/ MLP
$\frac{(U-B)}{B}$ (%)	3.53±0.03 (3.10)	5.69±0.05 (6.14)
BFE	19 (15)	40 (46)

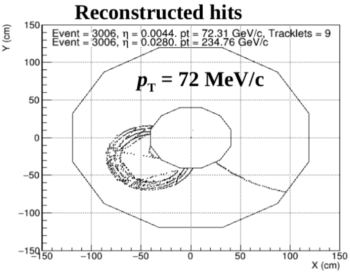
- Values with respect to true reconstructed signal are quoted in parentheses.

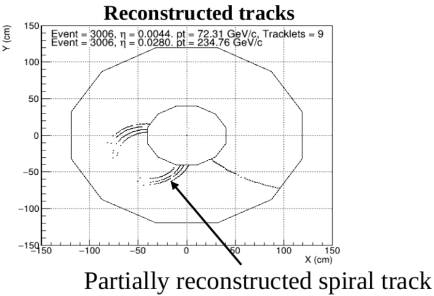
Conclusions and Next steps

- Generated UrQMD cocktail shape has "ragged" features which can be fixed by using time-dependent random seeds in pythia8 decayer → currently working with this feature.
- Changes in New Request 34 production helps in improving the signal and S/B.
- MLP assists in improving the single electron efficiency → Still working with request 25 trained MLP algrothm for request 34.
- Momentum differential training of the MC sample helps improving the efficiency at high p_{T}.
- Reconstructed signal is to be quantified → low mass region (0.3 to 0.7 GeV/c) and ϕ meson peak.
- New and separate MLP training for request 34 is in progress.

BACK-UP

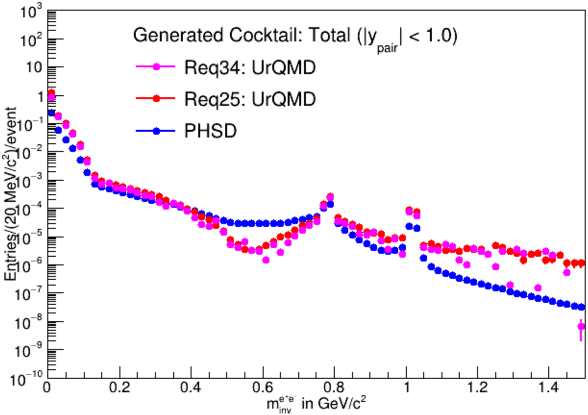
Quick recap





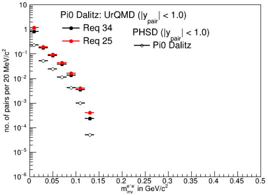
- With current track reconstruction algorithm, low p_T tracks are not reconstructed properly even though full hit information is available in the detector for tracks that enter the TPC ($p_T >\approx 30$ MeV/c).
- Question is, in an ideal detector, what would be the maximum possible benefit in the combinatorial background (CB) reduction, if we were to detect these tracks.
- As per our principle study, potentially, there is about 5-8 factor improvement possible in CB rejection.

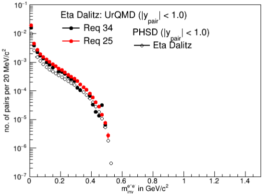
Cocktail shape UrQMD and PHSD: Request 34 and 25

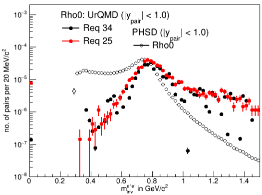


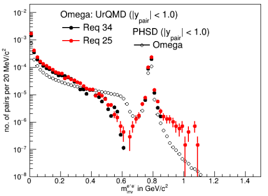
- Ratio of PHSD to UrQMD is used as weights to get PHSD shape.
- Apart from this, there were few bugs in my task, so, could not use train output.
- Ran my task privately and results are shown from next slides.

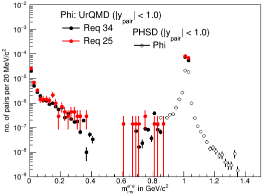
Cocktail shape UrQMD and PHSD: Request 34 and 25

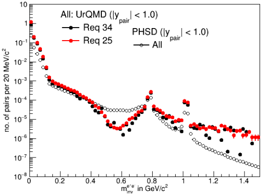




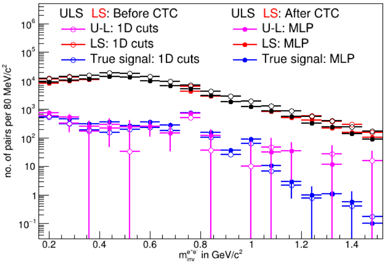


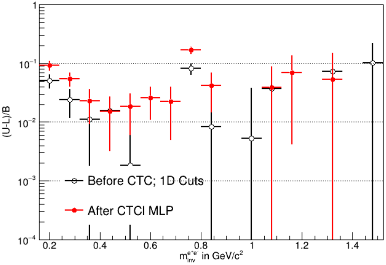


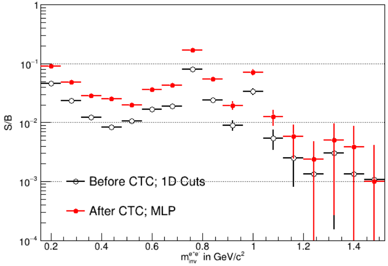




Request 25: ULS, LS and Signal







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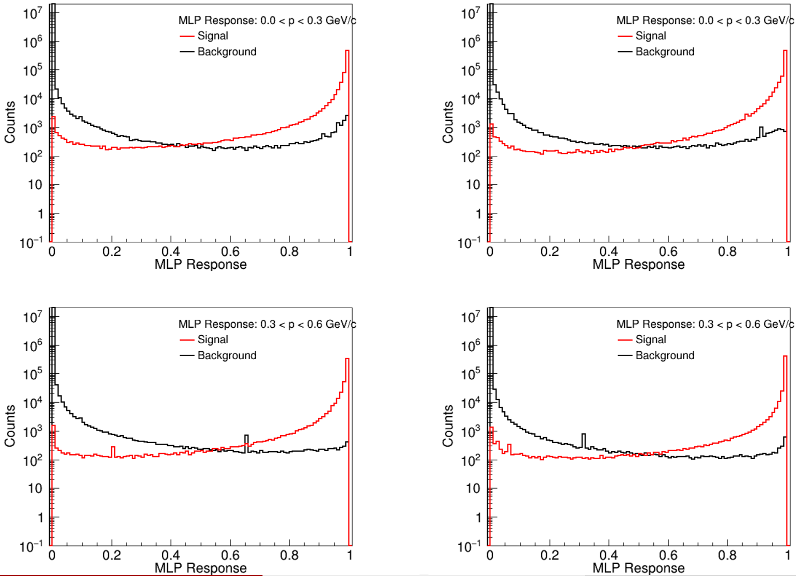
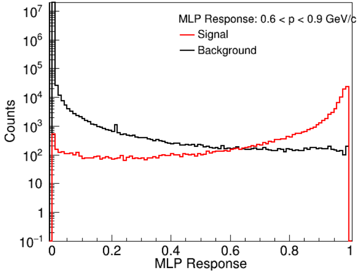
BFE	9 (21)	44 (69)

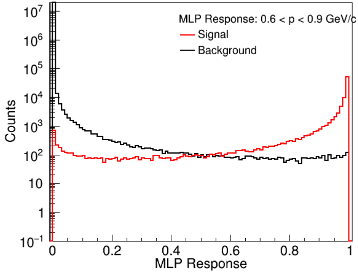
- Values with respect to true reconstructed signal are quoted in parentheses.

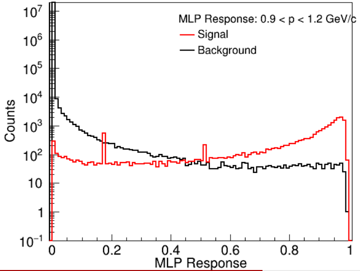
MLP response: pT Integrated vs Differential training

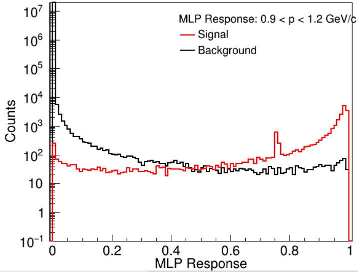


MLP response: pT Integrated vs Differential training

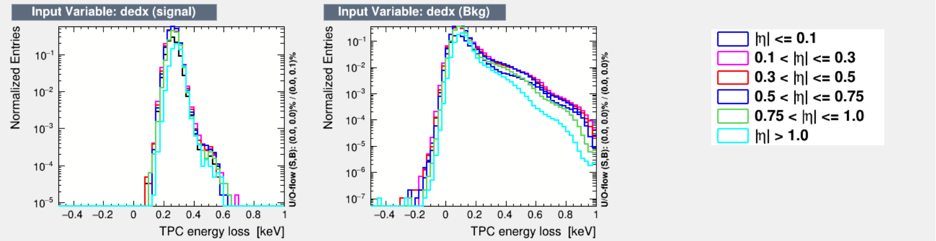








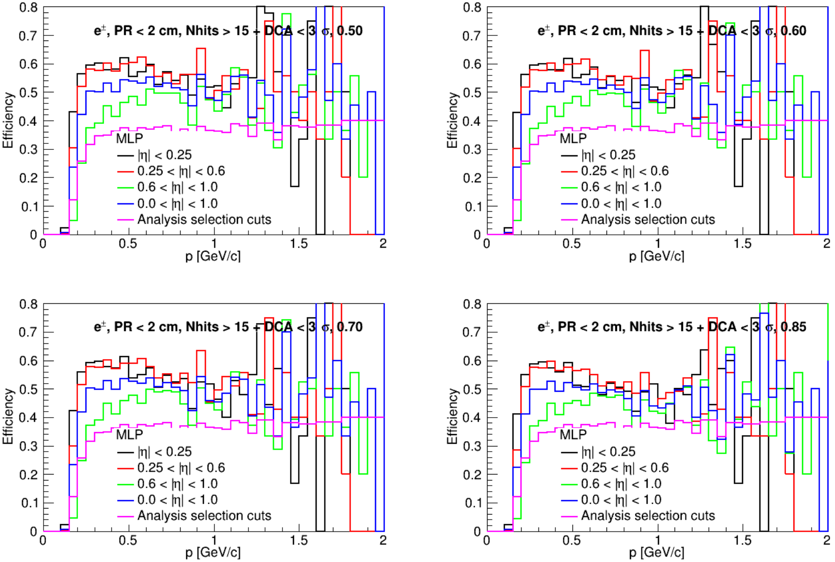
Request 34: dEdX



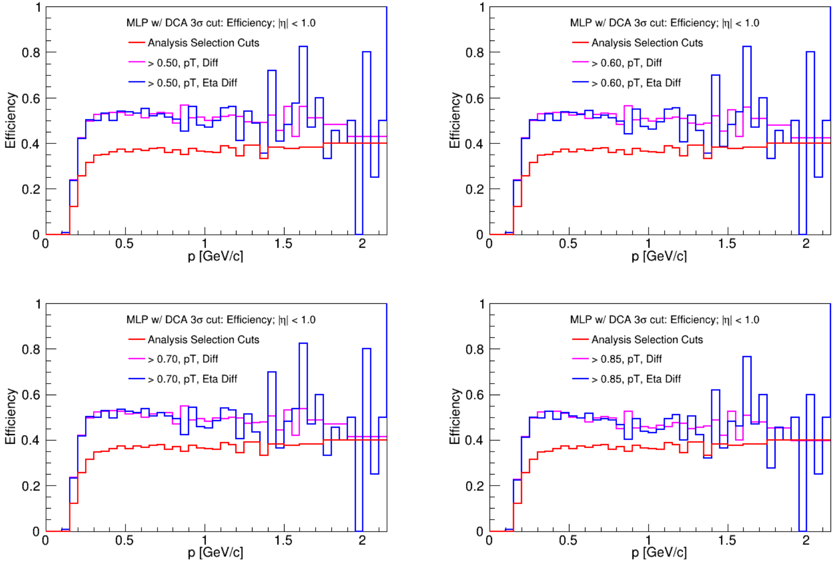
: Ranking input variables (method specific)...
: Rank : Variable : Importance
: 1 : p : 6.361e+03
: 2 : Ebyp : 9.083e+02
: 3 : Tofbeta : 3.677e+02
: 4 : dedx : 2.927e+02
: 5 : TrackChi2Vert : 2.800e+02
: 6 : NHits : 3.498e+01
: 7 : DCAz : 2.297e+01
: 8 : Phi30 : 2.050e+01
: 9 : TofbetaECal : 9.065e+00
: 10 : pseudorapid : 1.057e+00
: 11 : DCAx : 4.475e-02
: ____________________________

: Ranking input variables (method specific)...
: Rank : Variable : Importance
: 1 : p : 8.799e+03
: 2 : Ebyp : 1.679e+03
: 3 : TrackChi2Vert : 1.050e+03
: 4 : Tofbeta : 6.696e+02
: 5 : dedx : 4.771e+02
: 6 : NHits : 1.730e+01
: 7 : Phi30 : 1.326e+01
: 8 : TofbetaECal : 5.420e+00
: 9 : pseudorapid : 1.028e+00
: 10 : DCAz : 1.425e-01
: 11 : DCAx : 3.592e-04
: ____________________________

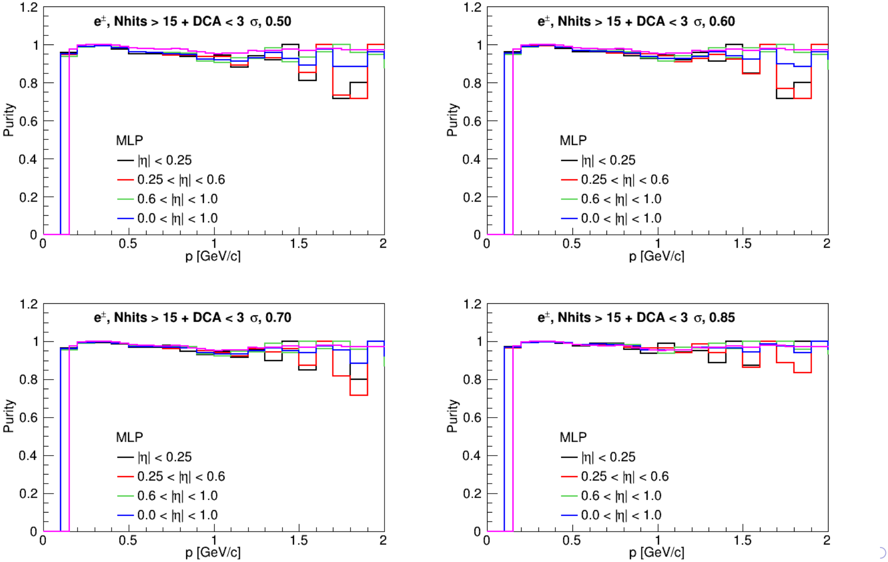
Request 34: Eta and pT differential



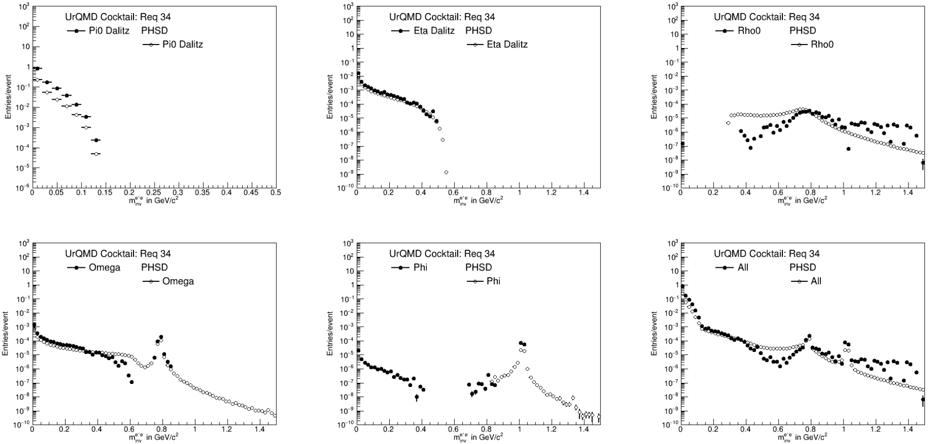
Request 34: Eta and pT differential



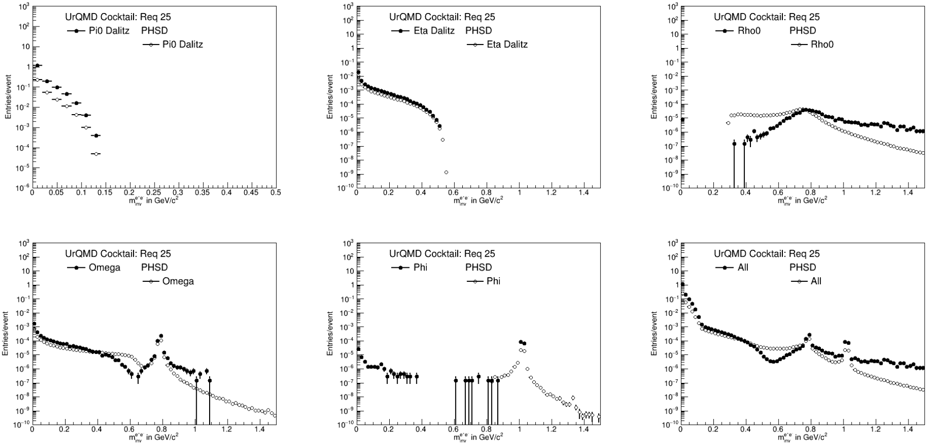
Request 34: Eta and pT differential



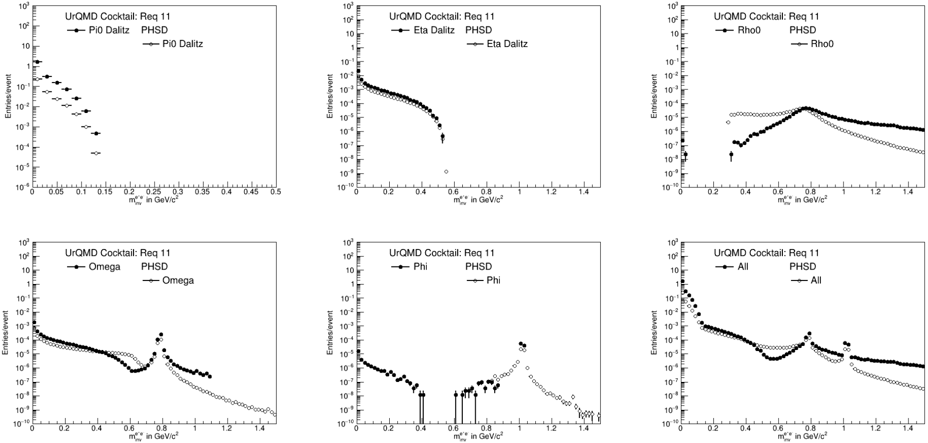
Cocktail shape UrQMD: Request 34



Cocktail shape UrQMD: Request 25



Cocktail shape UrQMD: Request 11



S/B - 1D Cuts (Fid. < 0.7): Request 25 (34), 33.2M (12.9M)

	Bef. NFP	Aft. NFP	Aft. CTC (p_T <= 110 MeV)	Aft. CTC (p_T > 110 MeV)
Mass cut (MeV/c^2)	-	120	80	80
Opening angle	-	-	10	10
U	157453±397	116046±341	85349±292	70723±266
U	43033±207	32287±180	24310±156	20510±143
B	155782±395	114567±338	83892±290	69267±263
B	41851±205	31187±177	23199±152	19525±140
U-B	1671±560	1479±480	1458±411	1456±374
U-B	1183±291	1100±252	1111±218	986±200
(U-B)/B	0.0107±0.0000	0.0129±0.0001	0.0174±0.0001	0.0210±0.0001
(U-B)/B	0.0283±0.0002	0.0353±0.0003	0.0479±0.0004	0.0505±0.0005
BFE	9	9	13	15
BFE	16	19	26	24
S	2252	2215	2170	2073
S	992	967	941	900
S/B	0.0145	0.0193	0.0259	0.0299
S/B	0.0237	0.0310	0.0406	0.0461
BFE	16	21	28	31
BFE	12	15	19	20

- B - Combinatorial background approximated by like sign pairs.

S/B - 1D cuts and MLP (Fid. < 0.7): Req. 34, 12.9M

1D cuts
MLP

	Bef. NFP	Aft. NFP	Aft. CTC (p_T <= 110 MeV)	Aft. CTC (p_T > 110 MeV)	Res. CTC (p_T > 110 MeV)
Mass	-	120	80	80	80
Angle	-	-	10	10	5
U	43033±207	32287±180	24310±156	20510±143	15392±124
U	71830±268	48252±220	35727±189	29328±171	23889±155
B	41851±205	31187±177	23199±152	19525±140	14480±120
B	70499±266	46866±216	34355±185	28114±168	22590±150
U-B	1183±291	1100±252	1111±218	986±200	912±173
U-B	1331±377	1386±308	1372±265	1214±240	1298±216
(U-B)/B	0.0283±0.0002	0.0353±0.0003	0.0479±0.0004	0.0505±0.0005	0.0630±0.0007
(U-B)/B	0.0189±0.0001	0.0296±0.0002	0.0399±0.0003	0.0432±0.0004	0.0575±0.0005
BFE	16	19	26	24	28
BFE	12	20	27	26	36
S	992	967	941	900	876
S	1586	1529	1489	1426	1387
S/B	0.0237	0.0310	0.0406	0.0461	0.0605
S/B	0.0225	0.0326	0.0433	0.0507	0.0614
BFE	12	15	19	20	26
BFE	18	25	32	35	41

- B - Combinatorial background approximated by like sign pairs.

S/B - MLP (Fid. < 0.7): Request 34, (12.9M), (12.6M)

p_T integrated ML training
p_T differential ML training

	Bef. NFP	Aft. NFP	Aft. CTC (p_T <= 110 MeV)	Aft. CTC (p_T > 110 MeV)	Res. CTC (p_T > 110 MeV)
Mass	-	120	80	80	80
Angle	-	-	10	10	5
U	71830±268	48252±220	35727±189	29328±171	23889±155
U	81159±285	53254±231	39587±199	32542±180	26785±164
B	70499±266	46866±216	34355±185	28114±168	22590±150
B	79840±283	51843±228	38106±195	31135±176	25344±159
U-B	1331±377	1386±308	1372±265	1214±240	1298±216
U-B	1319±401	1412±324	1480±279	1407±252	1442±228
(U-B)/B	0.0189±0.0001	0.0296±0.0002	0.0399±0.0003	0.0432±0.0004	0.0575±0.0005
(U-B)/B	0.0165±0.0001	0.0272±0.0002	0.0389±0.0003	0.0452±0.0004	0.0569±0.0005
BFE	12	20	27	26	36
BFE	11	19	28	31	40
S	1586	1529	1489	1426	1387
S	1786	1712	1669	1599	1556
S/B	0.0225	0.0326	0.0433	0.0507	0.0614
S/B	0.0224	0.0330	0.0438	0.0514	0.0614
BFE	18	25	32	35	41
BFE	20	28	36	40	46

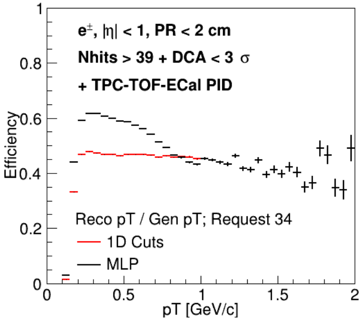
- B - Combinatorial background approximated by like sign pairs.

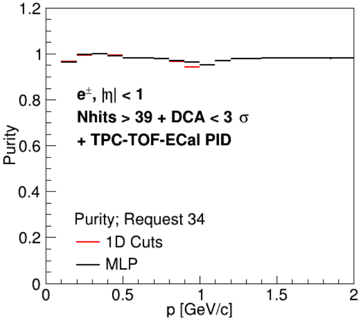
S/B - MLP (Fid. $<$ 0.7): Request 25 (34), 33.1M (12.9M)

	Bef. NFP	Aft. NFP	Aft. CTC (p_T $<=$ 110 MeV)	Aft. CTC (p_T $>$ 110 MeV)	(p_T $>$ 110 MeV)
Mass (MeV)	-	120	80	80	80
Angle	-	-	10	10	5
U	259058±509	167986±410	121660±349	97181±312	76650±277
U	71830±268	48252±220	35727±189	29328±171	23889±155
B	256155±506	165384±407	118751±345	94511±307	74059±272
B	70499±266	46866±216	34355±185	28114±168	22590±150
U-B	2903±718	2602±577	2909±490	2670±438	2591±388
U-B	1331±377	1386±308	1372±265	1214±240	1298±216
(U-B)/B	0.0113	0.0157	0.0245	0.0282	0.0350
(U-B)/B	0.0189	0.0296	0.0399	0.0432	0.0575
BFE	16	20	35	37	45
BFE	12	20	27	26	36
S	3377	3280	3206	3028	2970
S	1586	1529	1489	1426	1387
S/B	0.0132	0.0198	0.0270	0.0320	0.0401
S/B	0.0225	0.0326	0.0433	0.0507	0.0614
BFE	22	32	43	48	58
BFE	18	25	32	35	41

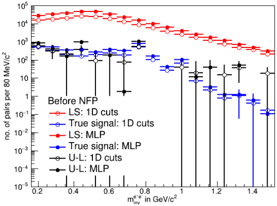
- B - Combinatorial background approximated by like sign pairs.

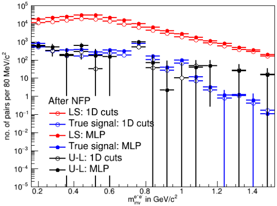
Request 34: Efficiency and Purity

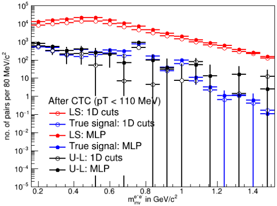


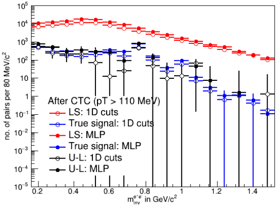


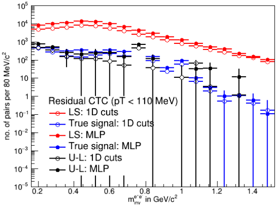
Req 25 with Req25 weights



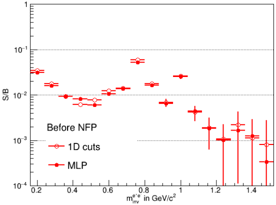


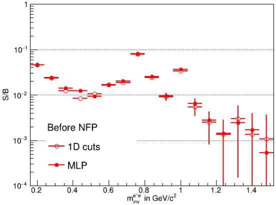


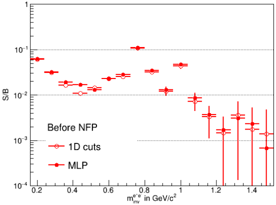


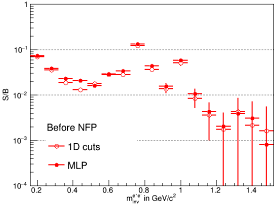


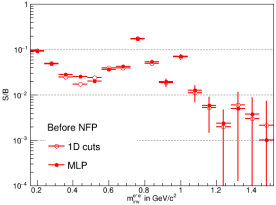
Req 25 with Req25 weights



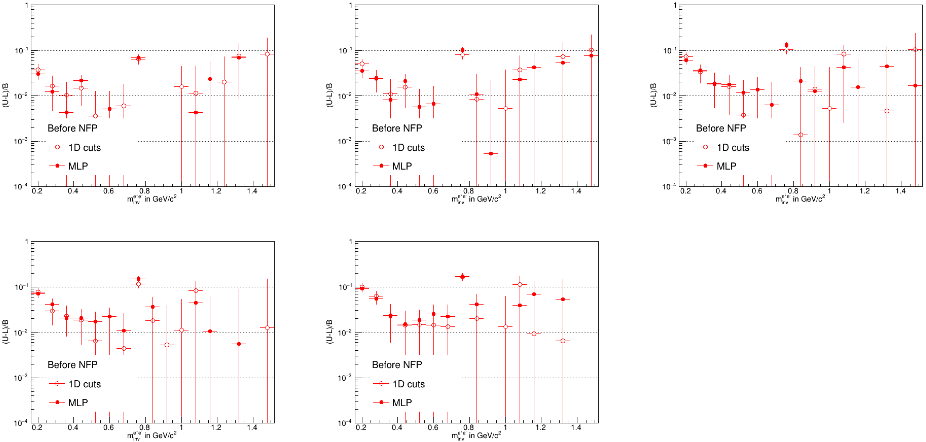




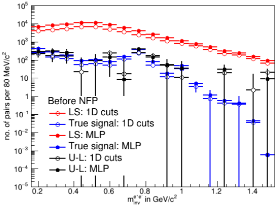


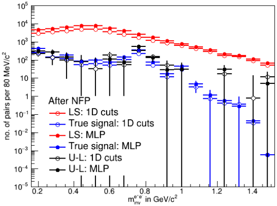


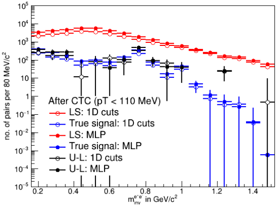
Req 25 with Req25 weights

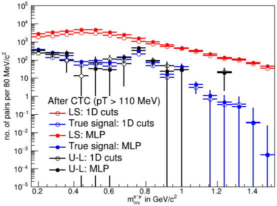


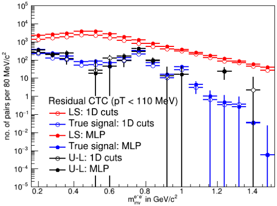
Req 34 with p_{T}-integrated MLP training



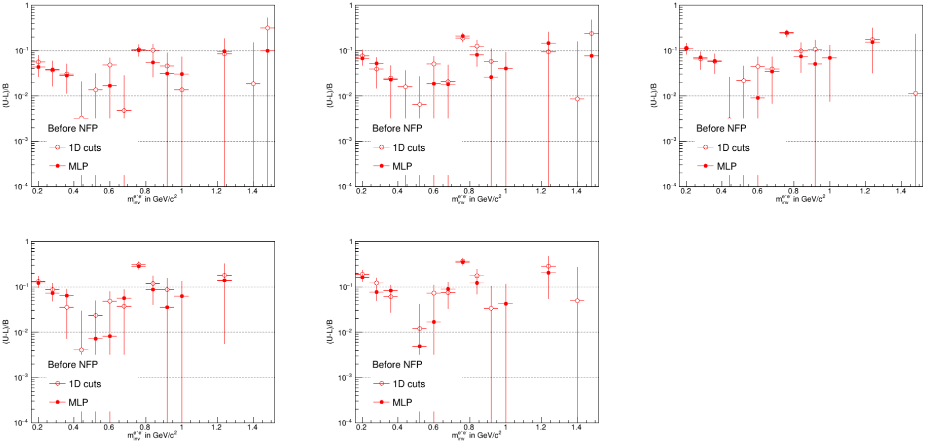




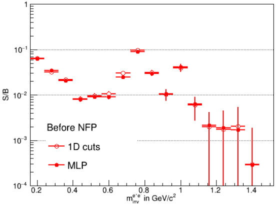


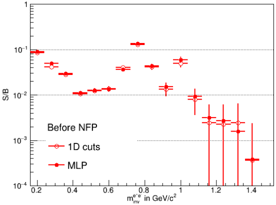


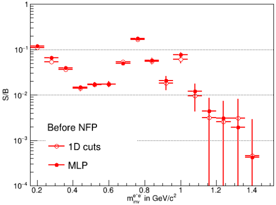
Req 34 with p_{T}-integrated MLP training

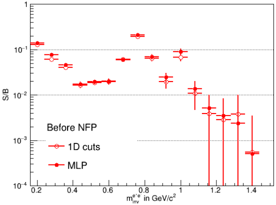


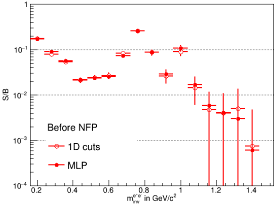
Req 34 with p_{T}-integrated MLP training



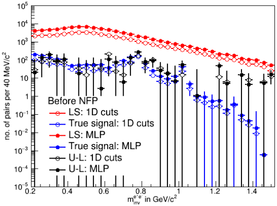


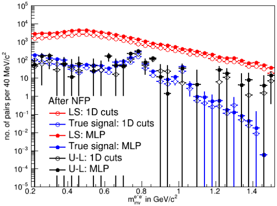


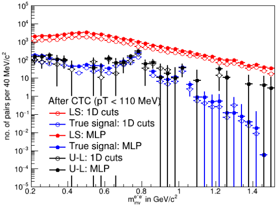


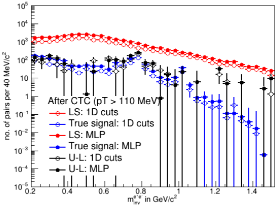


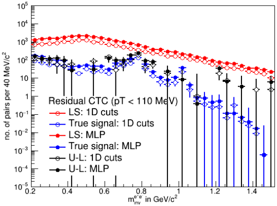
Req 34 with p_{T}-differential MLP training



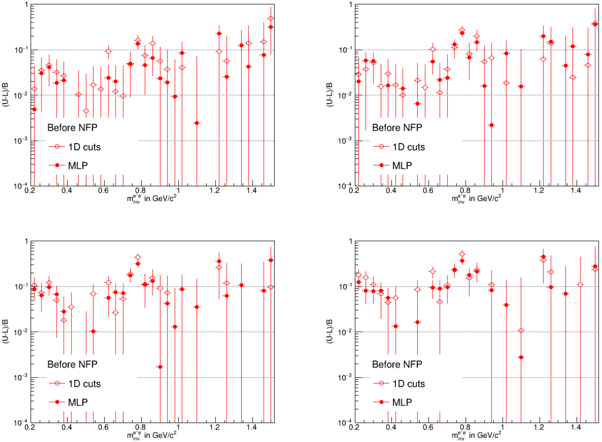




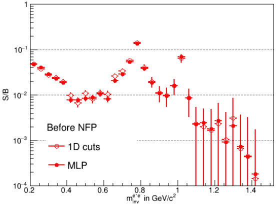


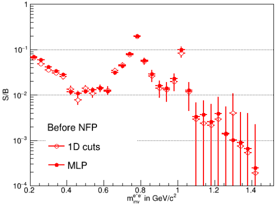


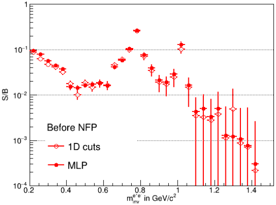
Req 34 with p_T-differential MLP training

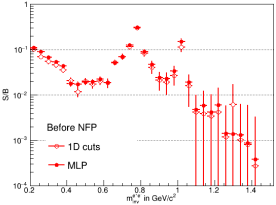


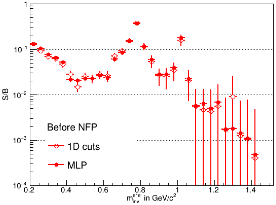
Req 34 with p_T-differential MLP training



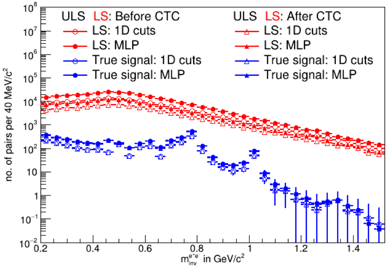


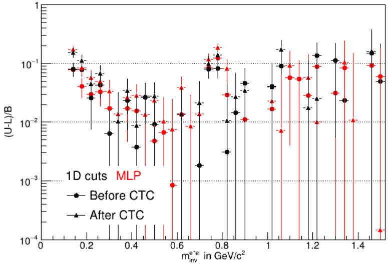


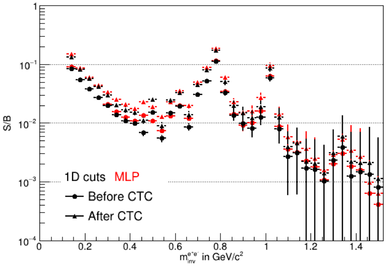




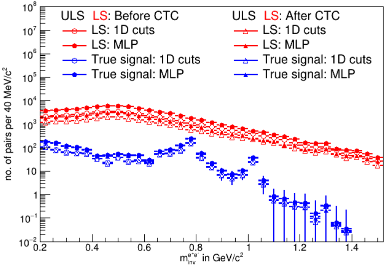
Request 25: Request 25 weights for cocktail

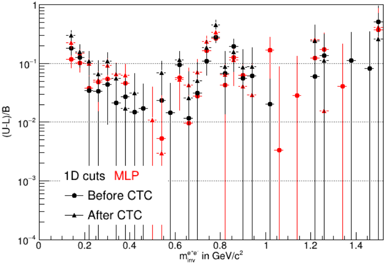


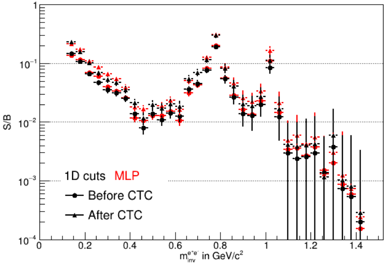




Request 34: Request 34 weights for cocktail







Request 34: Request 34 weights for cocktail