Light hadron spectra obtained with MPDRoot

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LHEP, JINR

8.10.2024

The task

- Obtain spectra of $\pi^{\pm}$, $K^{\pm}$, and p with MPDRoot.
- Fit spectra, obtain physical parameters.
- Integrate spectra and obtain yields.

- See into PID by STAR as an alternative method.

Contents

MpdHadronSpectra wagon

Initial developer: Alexander Mudrokh

mpdroot/physics/MpdHadronSpectra/

- MpdHadronSpectraParams.h (*.cxx): input file readers
- MpdHadronSpectra.h (*.cxx): main source files
- MpdHadronSpectraLinkDef.h
- CMakeLists.txt

How to run the MpdHadronSpectra wagon:

- In mpdroot/physics/CMakeLists.txt add line

```
add_subdirectory(MpdHadronSpectra)
```

- In mpdroot/physics/pairKK/macros/RunAnalyses.C add lines

```
MpdHadronSpectra pSpec("pHS", "pHS");
man.AddTask(&pSpec);
```

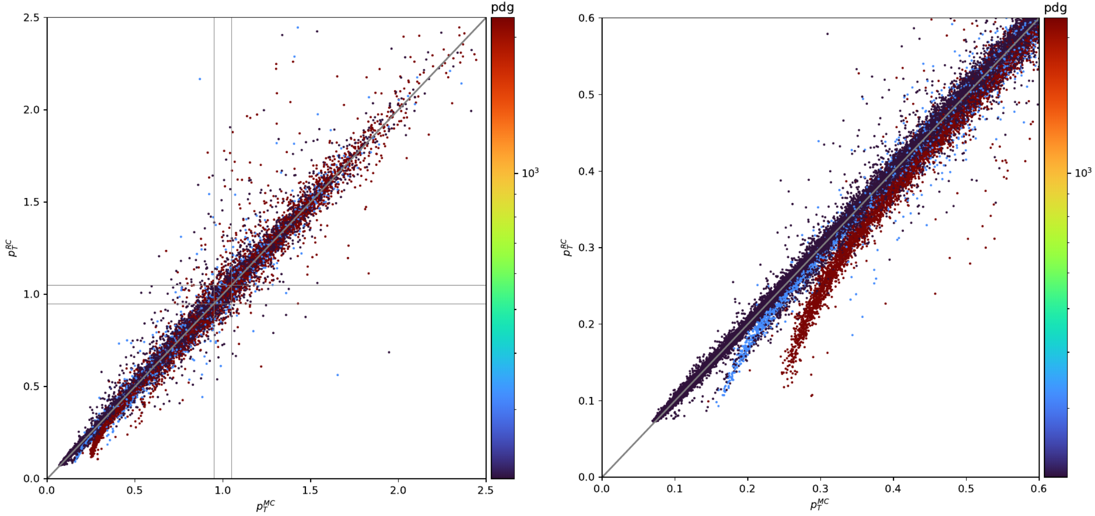
- `$ root -b -q -l RunAnalyses.C`

MpdHadronSpectra.cxx (principally)

```
#include "MpdTrack.h"
#include "MpdMCTrack.h"
#include "MpdVertex.h"

ClassImp(MpdHadronSpectra);

void ProcessEvent(MpdAnalysisEvent &event){...}

void FillMcSpectra(MpdAnalysisEvent &event){...}
void FillMcTOFSpectra(MpdAnalysisEvent &event){...}
void FillRcSpectra(MpdAnalysisEvent &event){...}

void FillTPCefficiency(MpdAnalysisEvent &event){...}
void FillTOFefficiency(MpdAnalysisEvent &event){...}
void FillTOFMCefficiency(MpdAnalysisEvent &event){...}
void FillPIDefficiency(MpdAnalysisEvent &event){...}
void FillDCAcontribution(MpdAnalysisEvent &event){...}
void FillCoordEfficiency(MpdAnalysisEvent &event){...}
void FillSplitting(MpdAnalysisEvent &event){...}

bool selectEvent(MpdAnalysisEvent &event){...}

double Eloss_Pi(double *x, double *par){...}
double Eloss_Kplus(double *x, double *par){...}
double Eloss_Kminus(double *x, double *par){...}
double Eloss_Proton(double *x, double *par){...}
double Eloss_AntiProton(double *x, double *par){...}
```

$p_t^{(RC)}$ vs $p_t^{(MC)}$

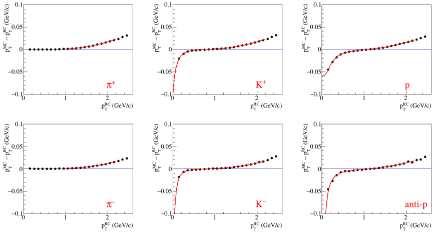
$|y| < 0.1$, centrality 0-10% (4000 events)



MpdHadronSpectra wagon

A. Mudrokh:

evSpecs wagon: Energy loss corrections



EnLoss functions are included within MpdHadronSpectra.h (*.cxx) – hardcoded.
In **void MpdHadronSpectra::UserInit()** function:

fEloss_Piplus = new TF1("fEloss_Piplus", this, &MpdHadronSpectra::Eloss_Pi, PtMin, PtMax, 3, "MpdHadronSpectra", "Eloss_Pi");
fEloss_Piplus->SetParameters(0.0117, -0.0235021, 0.0130318); - *already fitted in external analysis*

P_T corrections are using within each RcTrack loop

PWG-II meeting November 16, 2023 7

$$p_T = p_T^{Rc} + \texttt{Eloss}(p_T^{Rc}); \quad E = \sqrt{m^2 + {p_T}^2 + (p_z^{Rc})^2}; \quad y = \frac{1}{2}\ln\frac{E + p_z^{Rc}}{E - p_z^{Rc}}$$

MpdHadronSpectra.cxx (principally)

```
#include "MpdTrack.h"
#include "MpdMCTrack.h"
#include "MpdVertex.h"

ClassImp(MpdHadronSpectra);

void ProcessEvent(MpdAnalysisEvent &event){...}

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void FillMcTOFSpectra(MpdAnalysisEvent &event){...}
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void FillTPCefficiency(MpdAnalysisEvent &event){...}
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void FillDCAcontribution(MpdAnalysisEvent &event){...}
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bool selectEvent(MpdAnalysisEvent &event){...}

double Eloss_Pi(double *x, double *par){...}
double Eloss_Kplus(double *x, double *par){...}
double Eloss_Kminus(double *x, double *par){...}
double Eloss_Proton(double *x, double *par){...}
double Eloss_AntiProton(double *x, double *par){...}
```

MpdHadronSpectra wagon

pHS.txt

```
#-------Parameters used for analysis------
# Abs[pdg] for considered particles:
mAbsPDGs      211 321 2212
# Event selection:
mZvtxCut      100 //  cut on vertex z coordinate
# Centrality binning
mCentMin      0   10  20  30  40
mCentMax      10  20  30  40  80
# Track cuts:
mNofHitsCut   20   // minimal number of hits for a track
mDCAMax       3.0  // maximal |DCA|
#
mUseELC       true
# Pt for hists
mPtMin        0.05  // minimal pt for a track
mPtMax        4.05  // maximal pt for a track
mPtWidth      0.1  // GeV
# Rapydity for hists
mRapMin      -2.5
mRapMax       2.5
mRapWidth     0.1
# PID cuts:
mSigE         3.0  // non-zero distance
//                  from the average dE/dx (in sigmas)
//
mSigB         3.0  // non-zero distance
//                  from the average beta (in sigmas)
```

pHS.root

hMcd2Ndydpt_<particle>_k
hMcd2Nptdydpt_<particle>_k

hMcTOFd2Ndydpt_<particle>_k
hMcTOFd2Nptdydpt_<particle>_k

hRcd2Ndydpt_<particle>_k
hRcd2Nptdydpt_<particle>_k

hEv_k

h<FracPart><EffCont>_<particle>_k

<EffCont>:

TPCeff,	PIDeff	CoordEff	SecondariesEff	TOFMatchEff	TOFMatchMCEff
	PIDcont	CoordCont	SecondariesCont	TOFMatchCont	

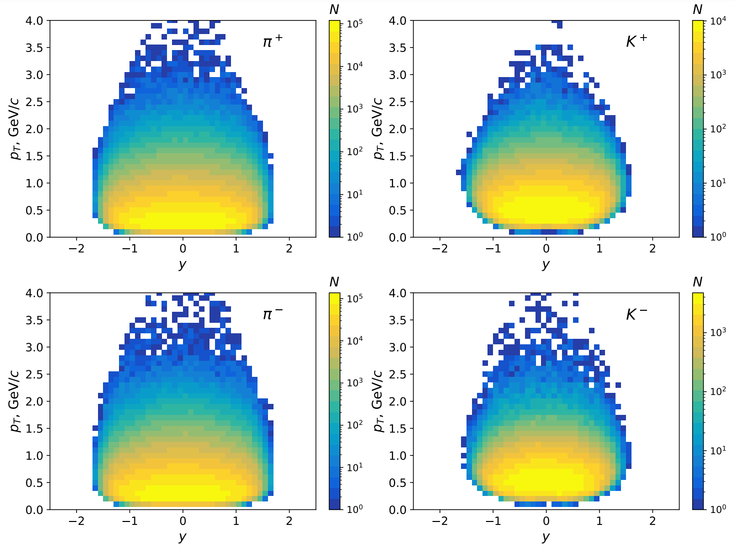
<particle>: Piplus, Piminus, Kplus, Kminus, Proton, AntiProton

<FracPart>: Num, Denom

k – number of centrality bin

Example:
hNumPIDeff_Kplus_4

Phase Spaces



Bi+Bi @ 9.2 GeV/A

Centrality 0-10%

Efficiencies & Contaminations

Total efficiency:

$$W = \frac{\prod_i \mathrm{Eff}_i}{\prod_j (1 - \mathrm{Cont}_j)}$$

$$\mathrm{TPCeff} = \mathrm{TPCeff} = \frac{N_{\mathrm{RC}}[\mathrm{TOFMC},\ \mathrm{PRIMMC},\ \mathrm{PIDMC},\ \mathrm{CELLMC}]}{N_{\mathrm{MC}}[\mathrm{TOFMC},\ \mathrm{PRIMMC},\ \mathrm{PIDMC},\ \mathrm{CELLMC}]}$$

$$\mathrm{TOFeff} = \frac{N_{\mathrm{RC}}[\mathrm{TOFRC\&TOFMC},\ \mathrm{PRIMMC},\ \mathrm{PIDMC},\ \mathrm{CELLMC}]}{N_{\mathrm{RC}}[\mathrm{TOFMC},\ \mathrm{PRIMMC},\ \mathrm{PIDMC},\ \mathrm{CELLMC}]}$$

$$\mathrm{TOFcont} = \frac{N_{\mathrm{RC}}[\mathrm{TOFRC\&(!TOFMC)},\ \mathrm{PRIMMC},\ \mathrm{PIDMC},\ \mathrm{CELLMC}]}{N_{\mathrm{RC}}[\mathrm{TOFRC},\ \mathrm{PRIMMC},\ \mathrm{PIDMC},\ \mathrm{CELLMC}]}$$

$$\mathrm{SecEff} = \frac{N_{\mathrm{RC}}[\mathrm{TOFRC},\ \mathrm{PRIMRC\&PRIMMC},\ \mathrm{PIDMC},\ \mathrm{CELLMC}]}{N_{\mathrm{RC}}[\mathrm{TOFRC},\ \mathrm{PRIMMC},\ \mathrm{PIDMC},\ \mathrm{CELLMC}]}$$

$$\mathrm{SecCont} = \frac{N_{\mathrm{RC}}[\mathrm{TOFRC},\ \mathrm{PRIMRC\&(!PRIMMC)},\ \mathrm{PIDMC},\ \mathrm{CELLMC}]}{N_{\mathrm{RC}}[\mathrm{TOFRC},\ \mathrm{PRIMRC},\ \mathrm{PIDMC},\ \mathrm{CELLMC}]}$$

$$\mathrm{PIDeff} = \frac{N_{\mathrm{RC}}[\mathrm{TOFRC},\ \mathrm{PRIMRC},\ \mathrm{PIDRC} = \mathrm{PIDMC},\ \mathrm{CELLMC}]}{N_{\mathrm{RC}}[\mathrm{TOFRC},\ \mathrm{PRIMRC},\ \mathrm{PIDMC},\ \mathrm{CELLMC}]}$$

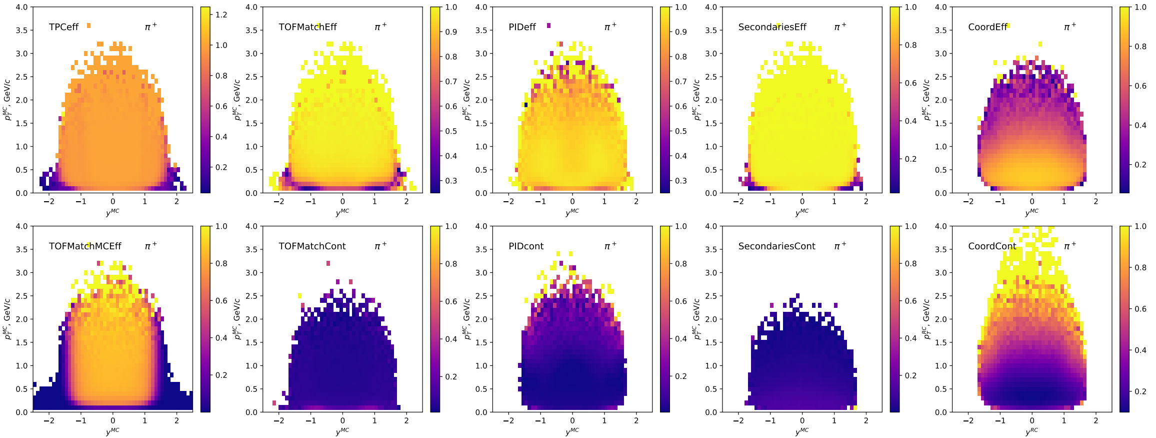
$$\mathrm{PIDcont} = \frac{N_{\mathrm{RC}}[\mathrm{TOFRC},\ \mathrm{PRIMRC},\ \mathrm{PIDRC} \neq \mathrm{PIDMC},\ \mathrm{CELLMC}]}{N_{\mathrm{RC}}[\mathrm{TOFRC},\ \mathrm{PRIMRC},\ \mathrm{PIDRC},\ \mathrm{CELLMC}]}$$

$$\mathrm{CELLeff} = \frac{N_{\mathrm{RC}}[\mathrm{TOFRC},\ \mathrm{PRIMRC},\ \mathrm{PIDRC},\ \mathrm{CELLRC{=}CELLMC}]}{N_{\mathrm{RC}}[\mathrm{TOFRC},\ \mathrm{PRIMRC},\ \mathrm{PIDRC},\ \mathrm{CELLMC}]}$$

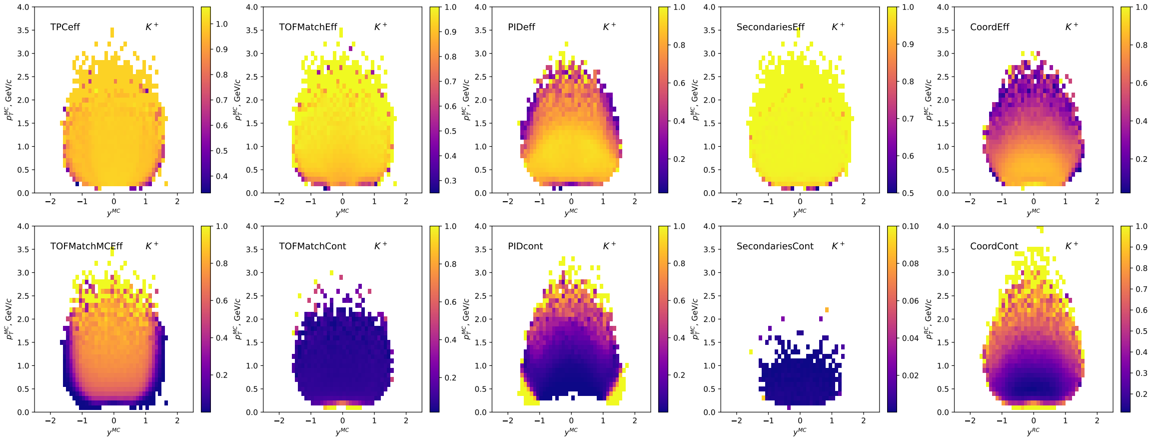
$$\mathrm{CELLcont} = \frac{N_{\mathrm{RC}}[\mathrm{TOFRC},\ \mathrm{PRIMRC},\ \mathrm{PIDRC},\ \mathrm{CELLRC{\neq}CELLMC}]}{N_{\mathrm{RC}}[\mathrm{TOFRC},\ \mathrm{PRIMRC},\ \mathrm{PIDRC},\ \mathrm{CELLRC}]}$$

$$\mathrm{TOFMCeff} = \frac{N_{\mathrm{MC}}[\mathrm{TOFMC},\ \mathrm{PRIMMC},\ \mathrm{PIDMC},\ \mathrm{CELLMC}]}{N_{\mathrm{MC}}[\mathrm{PRIMMC},\ \mathrm{PIDMC},\ \mathrm{CELLMC}]}$$

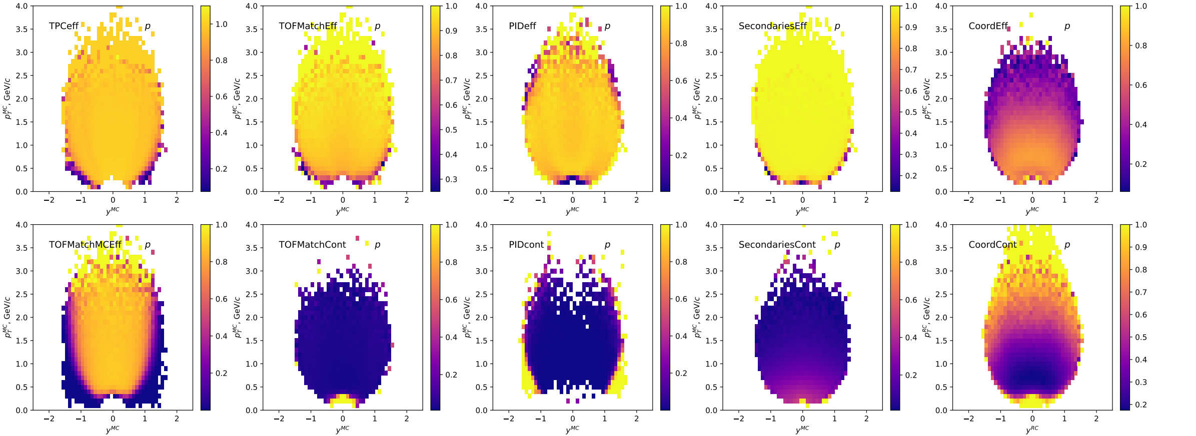
Efficiencies & Contaminations: π^+



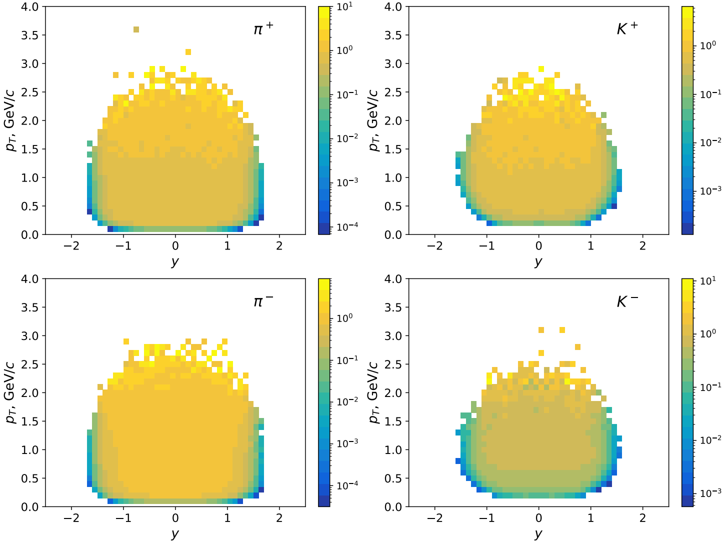
Efficiencies & Contaminations: K^+



Efficiencies & Contaminations: Proton



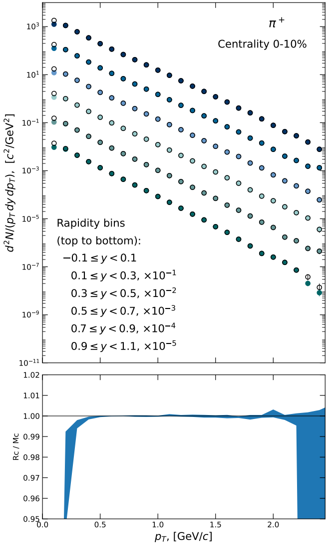
Total Efficiency



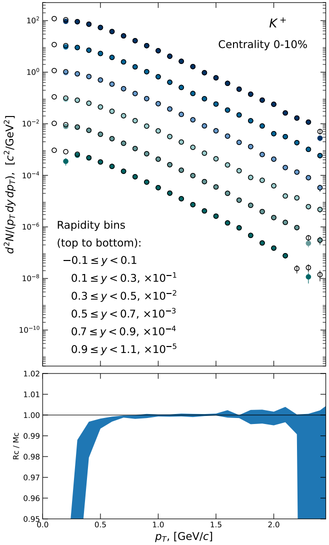
Bi+Bi @ 9.2 GeV/A

Centrality 0-10%

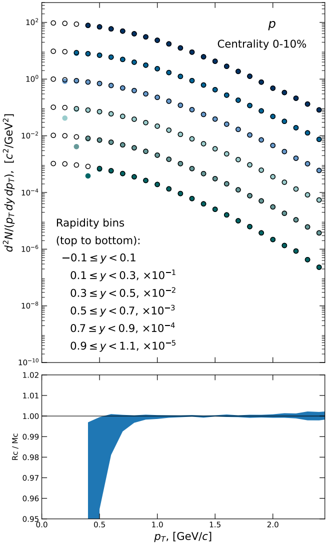
Spectra



π^+
Centrality 0-10%
Rapidity bins
(top to bottom):
$-0.1 \leq y < 0.1$
$0.1 \leq y < 0.3, \times 10^{-1}$
$0.3 \leq y < 0.5, \times 10^{-2}$
$0.5 \leq y < 0.7, \times 10^{-3}$
$0.7 \leq y < 0.9, \times 10^{-4}$
$0.9 \leq y < 1.1, \times 10^{-5}$
$d^2N/(p_T\,dy\,dp_T)$, $[c^2/\mathrm{GeV}^2]$
Rc / Mc
p_T, [GeV/c]

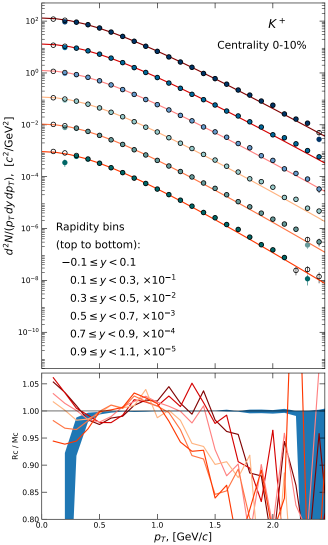


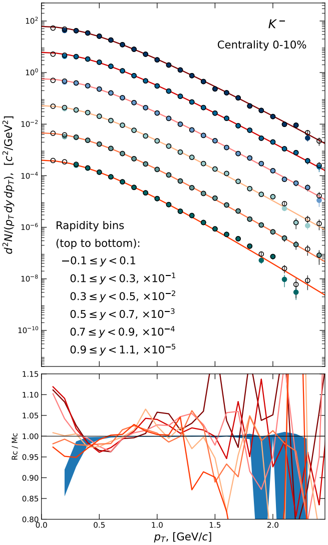
K^+
Centrality 0-10%
Rapidity bins
(top to bottom):
$-0.1 \leq y < 0.1$
$0.1 \leq y < 0.3, \times 10^{-1}$
$0.3 \leq y < 0.5, \times 10^{-2}$
$0.5 \leq y < 0.7, \times 10^{-3}$
$0.7 \leq y < 0.9, \times 10^{-4}$
$0.9 \leq y < 1.1, \times 10^{-5}$
$d^2N/(p_T\,dy\,dp_T)$, $[c^2/\mathrm{GeV}^2]$
Rc / Mc
p_T, [GeV/c]



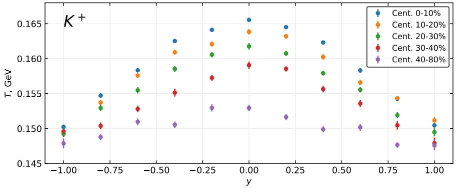
p
Centrality 0-10%
Rapidity bins
(top to bottom):
$-0.1 \leq y < 0.1$
$0.1 \leq y < 0.3, \times 10^{-1}$
$0.3 \leq y < 0.5, \times 10^{-2}$
$0.5 \leq y < 0.7, \times 10^{-3}$
$0.7 \leq y < 0.9, \times 10^{-4}$
$0.9 \leq y < 1.1, \times 10^{-5}$
$d^2N/(p_T\,dy\,dp_T)$, $[c^2/\mathrm{GeV}^2]$
Rc / Mc
p_T, [GeV/c]

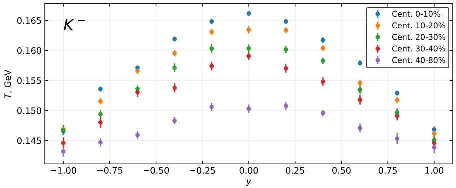
Spectra Fitting: Thermal Exponential



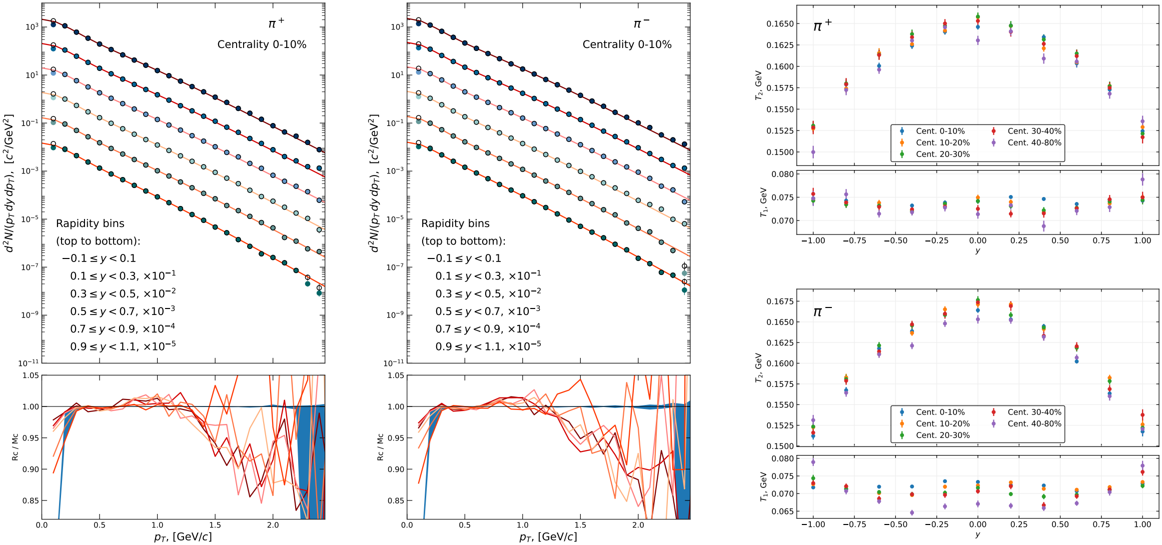


$$f(p_T) = \frac{dN/dy}{T[(m+T)^2 + T^2]} \cdot m_T \cdot \mathrm{e}^{-(m_T - m)/T}$$

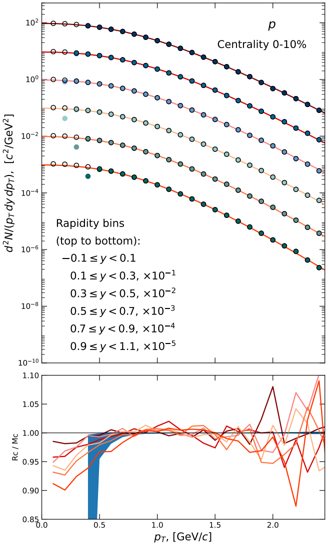




Spectra Fitting: Sum of Two Thermal Exponentials



Spectra Fitting: Blast Wave



$$\frac{\mathrm{d}^2 N}{p_T \mathrm{d}p_T\,\mathrm{d}y} = C(y)\cdot m_T \int_0^1 \chi \mathrm{d}\chi \exp\left[-\frac{m_T\,\mathrm{ch}\,\rho\,\mathrm{ch}(y-\eta)}{T}\right] I_0\left(\frac{p_T\,\mathrm{sh}\,\rho}{T}\right)$$

Boost angles: $\rho = \mathrm{arth}\,\beta_r, \qquad \eta = \mathrm{arth}\,\beta_z$

Parametrization of transverse velocity:

$$\beta_r(r) = \beta_{\mathrm{max}}\left(\frac{r}{R}\right)^n = \beta_{\mathrm{max}}\cdot\chi^n; \qquad n = 1 \quad \Rightarrow \quad \text{linear BW model}$$

$r \in [0; R]$; R is the radius of freeze-out surface.

$C(y) \Leftrightarrow$ shape of freeze-out surface and chemical potential.

I_0 – modified Bessel function.

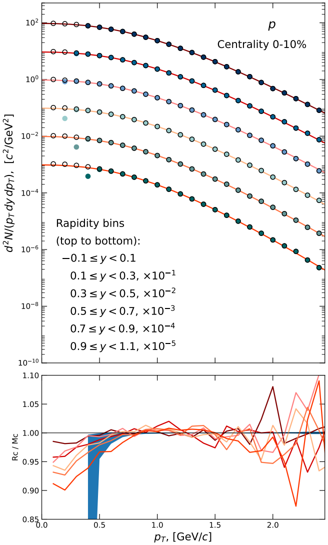
For our spectra $\mathrm{ch}(y-\eta) = 1$ is kept fixed.

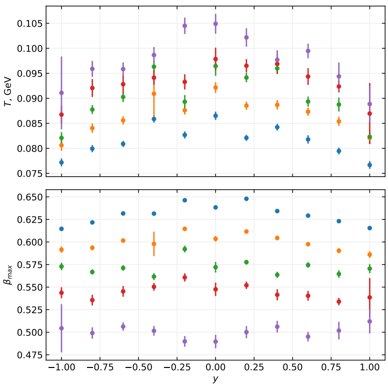
Fit parameters: $C(y)$, T, β_{max}.

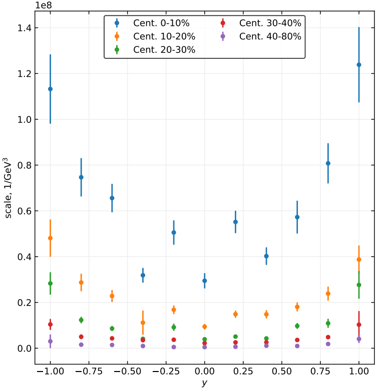
Based on

[1] E. Schnedermann, J. Sollfrank and U. W. Heinz, Phys. Rev. C **48**, 2462-2475 (1993) [arXiv:nucl-th/9307020 [nucl-th]].

Spectra Fitting: Blast Wave







Spectra Fitting: Estimation of Errors

The Jackknife method:

- data are divided into K portions;
- error for estimated parameter $\hat{A}$:

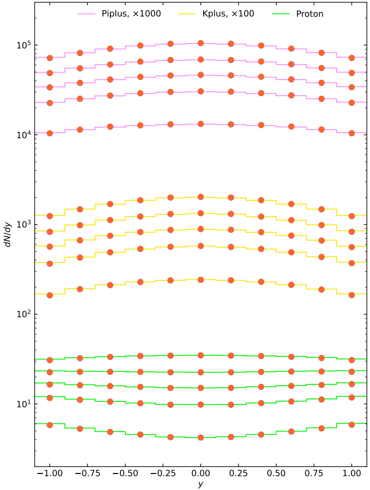
$$\delta\hat{A} = \sqrt{\frac{K-1}{K}\sum_{k=1}^{K}\left(\hat{A}_{(k)} - \hat{A}\right)^2},$$

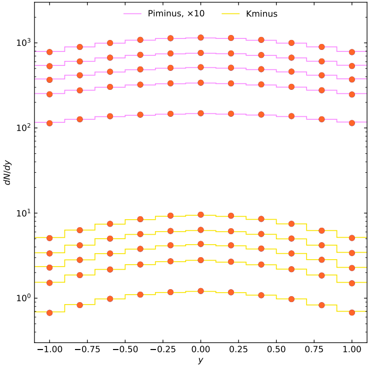
$\hat{A}_{(k)}$ – estimate of A without k-th portion.

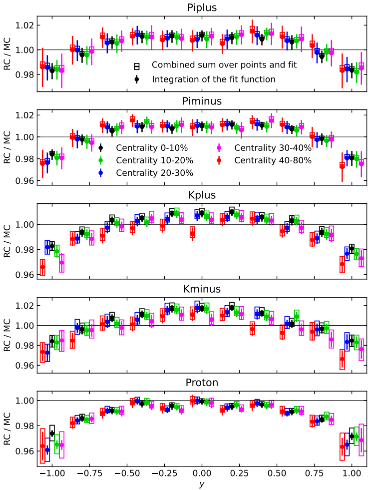
- The method is not sensitive to the distribution of data.
- For uncorrelated data the result does not depend on K.
- For normally distributed uncorrelated data $\delta\hat{A} \to$ standard deviation.
- The method requires large enough statistics.

[2] B. Efron, SIAM Review, 21(4), 460–480 (1979)
[3] B. Efron, "The Jackknife, the Bootstrap and Other Resampling Plans", SIAM (1982)
[4] M. Fukugita, M. Okawa and A. Ukawa, Nucl. Phys. B **337**, 181-232 (1990)

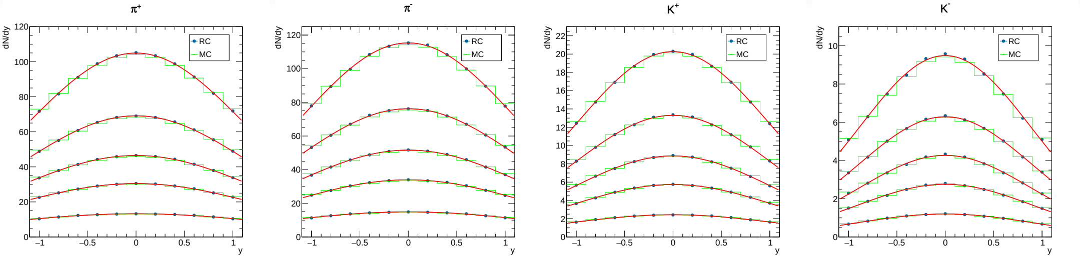
dN/dy


Piplus, ×1000
Kplus, ×100
Proton
dN/dy
y


Piminus, ×10
Kminus
dN/dy
y


Piplus
Combined sum over points and fit
Integration of the fit function
Piminus
Centrality 0-10%
Centrality 10-20%
Centrality 20-30%
Centrality 30-40%
Centrality 40-80%
Kplus
Kminus
Proton
RC / MC
y

Yields



Cent.	N	$\tilde{N}$	$\tilde{N}_{MC}$	N	$\tilde{N}$	$\tilde{N}_{MC}$	N	$\tilde{N}$	$\tilde{N}_{MC}$	N	$\tilde{N}$	$\tilde{N}_{MC}$
0-10%	300(2)	199.6	199.3	325(1)	218.5	218.1	51.1(1)	37.1	37.1	21.04(5)	16.5	16.5
10-20%	208(2)	133.3	132.9	226(1)	146.3	146.1	34.2(1)	24.5	24.6	14.06(4)	11.0	11.0
20-30%	146(1)	90.5	90.3	158(1)	100.0	99.7	23.3(1)	16.4	16.5	9.42(3)	7.43	7.42
30-40%	99(1)	59.9	59.7	107(1)	66.2	66.1	15.3(1)	10.7	10.7	6.22(3)	4.84	4.85
40-80%	49(1)	26.7	26.1	52(1)	29.7	29.6	6.86(3)	4.61	4.65	2.80(1)	2.14	2.15

$$f(y) = \frac{N}{\sqrt{2\pi\sigma^2}} \exp\left[-\frac{y^2}{2\sigma^2}\right] \quad \Rightarrow \quad N \qquad\qquad \tilde{N} = \int_{-1.1}^{1.1} f(y)\, dy$$

pidAM vs pidSTAR: General Remarks

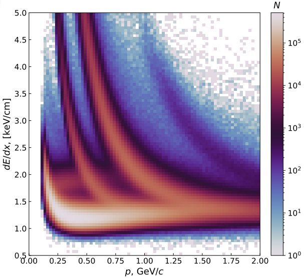
PID is based on 2 devices: TPC and ToF

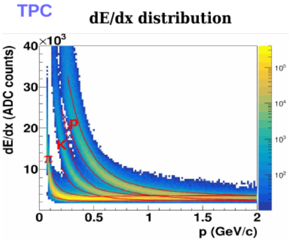
pidAM (AM = A. Mudrokh) [MpdPid class]	pidSTAR
• based on $p = \|\vec{p}\|$.	• based on p_T.
• both TPC and ToF information is used for all p.	• TPC at low p_T, ToF at high p_T.
• PID is applied to each track.	• PID is applied to the final set of tracks.
$\Downarrow$	$\Downarrow$
For each track we know 'who' is it	We know, how many particles of a given sort are in the sample.
• Requires less memory/disk space.	• May be implemented in model-independent way.

pidSTAR implementation is based on

[5] L. Adamczyk *et al.* [STAR], Phys. Rev. C **96**, no.4, 044904 (2017) [arXiv:1701.07065 [nucl-ex]].
[6] B. I. Abelev *et al.* [STAR], Phys. Rev. C **79**, 034909 (2009) [arXiv:0808.2041 [nucl-ex]].
[7] J. Adam *et al.* [STAR], Phys. Rev. C **101**, no.2, 024905 (2020) [arXiv:1908.03585 [nucl-ex]].
[8] M. S. Abdallah *et al.* [STAR], Phys. Rev. C **107**, no.2, 024901 (2023) [arXiv:2208.00653 [nucl-ex]].
[9] [STAR], [arXiv:2311.11020 [nucl-ex]].

pidAM vs pidSTAR: dE/dx





(Plot by AM)

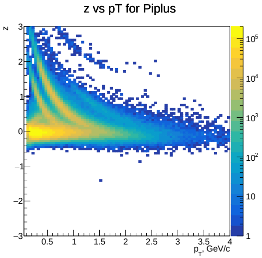
Parametrization of the Bethe-Bloch (BB) formula

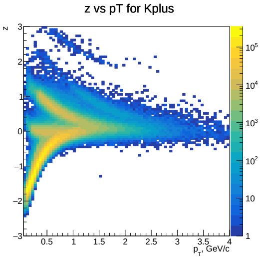
↓

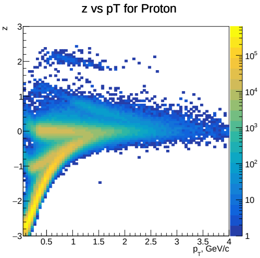
Parametrization of deviations from BB

↓

$N\sigma$ method / Bayes method







$$z_i = \ln\left(\frac{\langle dE/dx \rangle}{\langle dE/dx \rangle_i^{BB}}\right)$$

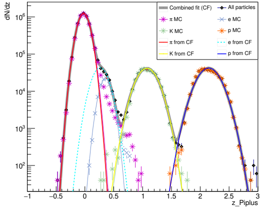
i – type of particle

For a given particle at given p_T
z_i has Gauss distr. with $\langle z_i \rangle \sim 0$.

pidAM vs pidSTAR: dE/dx Results

Piplus

$0.25 < p_T < 0.35$ GeV/c



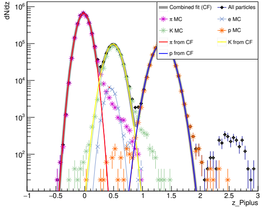
$$f(x) = N \exp\left[-(x-\mu)^2/(2\sigma^2)\right] / \sqrt{2\pi\sigma^2}$$

	N	μ	σ
π	273790 ± 569	-0.025 ± 0.000	0.087 ± 0.000
π (MC)	271475 ± 520	-0.020 ± 0.000	0.090 ± 0.000
N (MC)	275900	$[N_{MC} - N]/N = 0.01$	
e	13056 ± 210	0.264 ± 0.003	0.121 ± 0.000
e (MC)	4856 ± 70	0.358 ± 0.001	0.088 ± 0.001
N (MC)	4911		
K	16386 ± 128	1.08 ± 0.00	0.157 ± 0.001
K (MC)	16121 ± 127	1.08 ± 0.00	0.154 ± 0.001
N (MC)	16380	$[N_{MC} - N]/N = -0.00$	
p	18429 ± 136	2.15 ± 0.00	0.175 ± 0.001
p (MC)	18371 ± 136	2.15 ± 0.00	0.173 ± 0.001
N (MC)	19009	$[N_{MC} - N]/N = 0.03$	

Notes:
Repeated fit with fixed $\sigma_e = (\sigma_\pi + \sigma_K)/2$.

Piplus

$0.45 < p_T < 0.55$ GeV/c



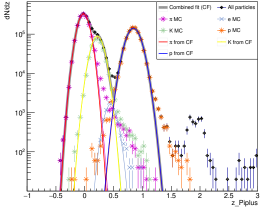
$$f(x) = N \exp\left[-(x-\mu)^2/(2\sigma^2)\right] / \sqrt{2\pi\sigma^2}$$

	N	μ	σ
π	149785 ± 388	-0.018 ± 0.000	0.090 ± 0.000
π (MC)	147305 ± 382	-0.017 ± 0.000	0.091 ± 0.000
N (MC)	149905	$[N_{MC} - N]/N = 0.00$	
e	—	—	—
e (MC)	1354 ± 37	0.446 ± 0.002	0.085 ± 0.002
N (MC)	1383		
K	27180 ± 166	0.493 ± 0.001	0.112 ± 0.000
K (MC)	23941 ± 155	0.507 ± 0.001	0.111 ± 0.001
N (MC)	24251	$[N_{MC} - N]/N = -0.11$	
p	36165 ± 190	1.35 ± 0.00	0.135 ± 0.001
p (MC)	36041 ± 190	1.35 ± 0.00	0.134 ± 0.001
N (MC)	36201	$[N_{MC} - N]/N = 0.00$	

Notes:
Kaon result contains also Electrons!
Repeated fit with fixed $\sigma_K = (\sigma_\pi + \sigma_p)/2$.

Piplus

$0.65 < p_T < 0.75$ GeV/c

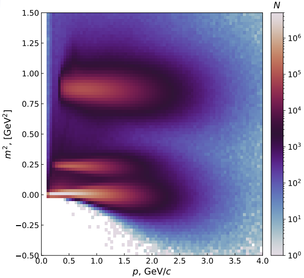


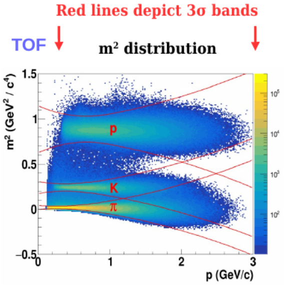
$$f(x) = N \exp\left[-(x-\mu)^2/(2\sigma^2)\right] / \sqrt{2\pi\sigma^2}$$

	N	μ	σ
π	71752 ± 364	-0.022 ± 0.001	0.087 ± 0.000
π (MC)	72516 ± 268	-0.018 ± 0.000	0.091 ± 0.000
N (MC)	73805	$[N_{MC} - N]/N = 0.03$	
e	—	—	—
e (MC)	369 ± 19	0.448 ± 0.005	0.090 ± 0.004
N (MC)	390		
K	21612 ± 296	0.219 ± 0.002	0.095 ± 0.000
K (MC)	18700 ± 137	0.220 ± 0.001	0.098 ± 0.001
N (MC)	19034	$[N_{MC} - N]/N = -0.12$	
p	40821 ± 202	0.846 ± 0.001	0.114 ± 0.001
p (MC)	40423 ± 201	0.847 ± 0.001	0.113 ± 0.000
N (MC)	40908	$[N_{MC} - N]/N = 0.00$	

Notes:
Electrons are excluded from fit (too few of them).
Repeated fit with fixed $\sigma_K = (\sigma_\pi + \sigma_p)/2$.

pidAM vs pidSTAR: m^2





(Plot by AM)

Parametrization of deviations

↓

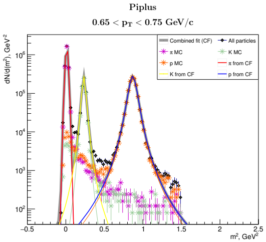
$N\sigma$ method / Bayes method

Fit p_T sections with sum of StudentT PDFs.

$$f(x) = N \cdot \frac{\left(\frac{\nu}{\nu + (x-\mu)^2/\sigma^2}\right)^{(1+\nu)/2}}{\sqrt{\nu}\sigma\, \mathrm{B}\left(\frac{\nu}{2}, \frac{1}{2}\right)}$$

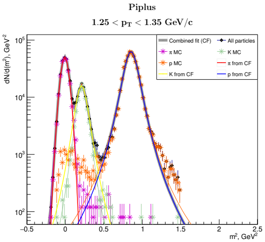
$$\mathrm{B}(a,b) = \frac{\Gamma(a)\,\Gamma(b)}{\Gamma(a+b)} = \int_0^1 t^{a-1}(1-t)^{b-1} dt$$ – beta-function

pidAM vs pidSTAR: m^2 Results



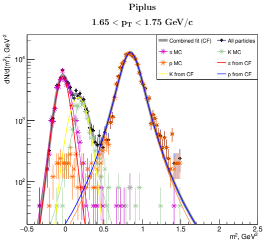
$f(x) = \mathrm{StudentT}(x, N, \mu, \sigma, \nu)$

	N	μ	σ	ν
π	66964 ± 256	0.012 ± 0.000	0.016 ± 0.000	29.9 ± 2.1
π (MC)	64714 ± 254	0.012 ± 0.000	0.016 ± 0.000	36.8 ± 3.3
N (MC)	65971	$[N_{\mathrm{MC}} - N]/N = -0.01$		
K	14621 ± 121	0.234 ± 0.000	0.020 ± 0.000	3.00 ± 0.01
K (MC)	13759 ± 118	0.234 ± 0.000	0.020 ± 0.000	5.19 ± 0.36
N (MC)	14529	$[N_{\mathrm{MC}} - N]/N = -0.01$		
p	32080 ± 180	0.868 ± 0.000	0.043 ± 0.000	2.88 ± 0.07
p (MC)	31861 ± 179	0.868 ± 0.000	0.043 ± 0.000	3.06 ± 0.08
N (MC)	33512	$[N_{\mathrm{MC}} - N]/N = 0.04$		



$f(x) = \mathrm{StudentT}(x, N, \mu, \sigma, \nu)$

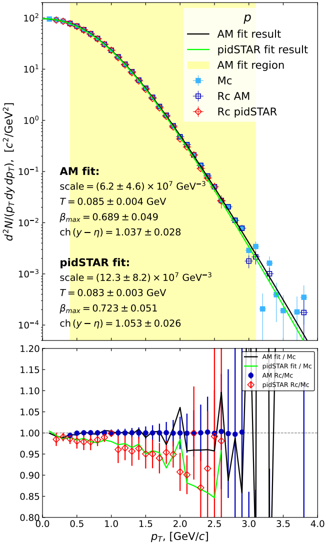
	N	μ	σ	ν
π	5872 ± 83	-0.007 ± 0.001	0.046 ± 0.001	45.6 ± 35.2
π (MC)	5790 ± 76	-0.005 ± 0.001	0.046 ± 0.001	14.4 ± 2.9
N (MC)	5905	$[N_{\mathrm{MC}} - N]/N = 0.01$		
K	2622 ± 70	0.211 ± 0.002	0.061 ± 0.002	3.51 ± 0.74
K (MC)	2207 ± 47	0.217 ± 0.001	0.052 ± 0.002	4.34 ± 0.56
N (MC)	2249	$[N_{\mathrm{MC}} - N]/N = -0.14$		
p	12674 ± 115	0.854 ± 0.001	0.074 ± 0.001	3.11 ± 0.18
p (MC)	12688 ± 113	0.854 ± 0.001	0.072 ± 0.001	2.66 ± 0.12
N (MC)	13131	$[N_{\mathrm{MC}} - N]/N = 0.04$		

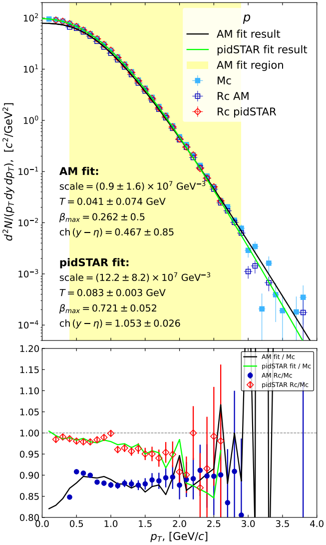


$f(x) = \mathrm{StudentT}(x, N, \mu, \sigma, \nu)$

	N	μ	σ	ν
π	933 ± 81	-0.039 ± 0.006	0.068 ± 0.005	8.95 ± 6.44
π (MC)	1035 ± 33	-0.025 ± 0.003	0.077 ± 0.003	7.63 ± 3.19
N (MC)	1072	$[N_{\mathrm{MC}} - N]/N = 0.15$		
K	594 ± 81	0.169 ± 0.017	0.099 ± 0.013	434 ± 86165
K (MC)	436 ± 21	0.205 ± 0.005	0.076 ± 0.004	3.00 ± 1.90
N (MC)	449	$[N_{\mathrm{MC}} - N]/N = -0.24$		
p	3673 ± 63	0.844 ± 0.002	0.104 ± 0.002	3.21 ± 0.40
p (MC)	3609 ± 60	0.845 ± 0.002	0.103 ± 0.002	3.51 ± 0.37
N (MC)	3793	$[N_{\mathrm{MC}} - N]/N = 0.03$		

pidAM vs pidSTAR: Comparison of Results





Right plot: w/o PID corections

Conclusions

- MpdHadronSpectra wagon is updated.
- Efficiency corrected invariant spectra for $\pi^{\pm}$, $K^{\pm}$, p are obtained.
- Yields for $\pi^{\pm}$ and $K^{\pm}$ are obtained.

- Trial implementation of STAR PID method is done. The results are compared with ones of pidAM method.