Status of the TOF spectra analysis

V.I. Kolesnikov

JINR Dubna

- *K+* **at 20 AGeV**
- *p,d* **at 20, 30 AGeV**
- *pbar* **(energy & centrality dependence)**

K^+ @ 20 AGeV

- Data set, event selection, track cuts
- Calibration, PID, acceptance, corrections, ..
- Results ($K+$ *mt*-spectra, *dn/dy, T*)
- Error estimation
- dE/dx-TOF comparision
- Summary

Data set &cuts

Data set:

360k STD1 (03A) (7% 20 AGeV)

Event selection:

- vertex_fit.iflag = 0
- abs(vertex_fit.z - Z_{target}) $< 1cm$
- $(N_{TOFhits})_{\pi} > 1$

Track quality cuts:

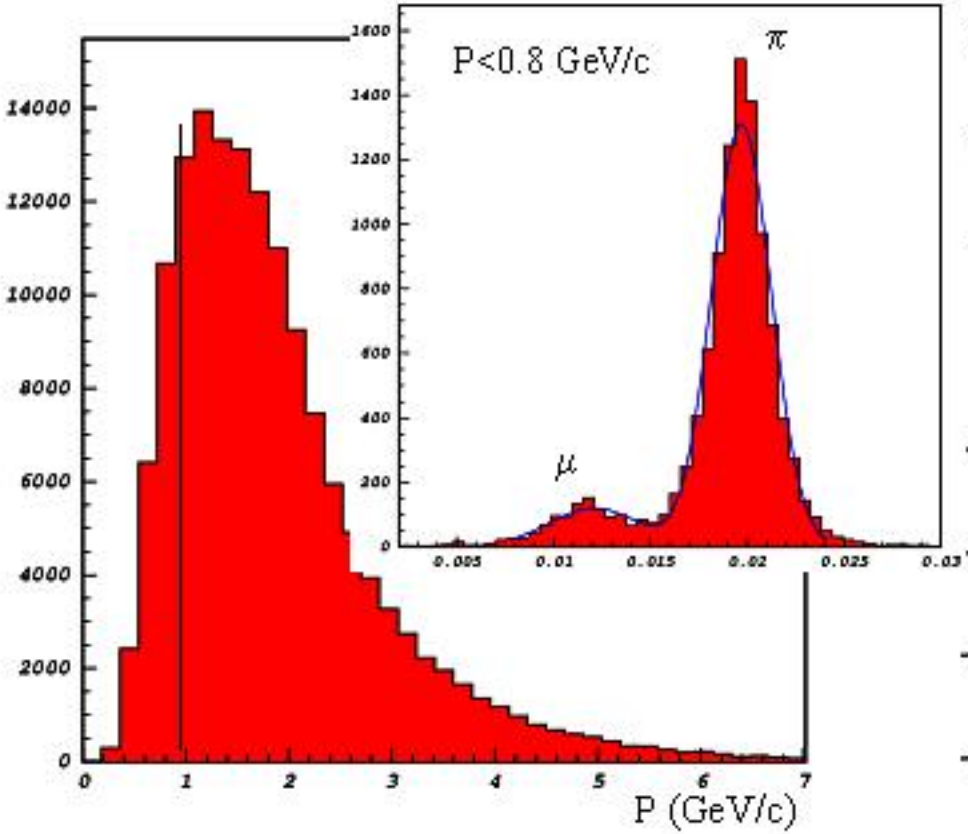
- track.px > 0.
- global tracks MTPC matched with VT1/VT2
- track.iflag = 0
- last point

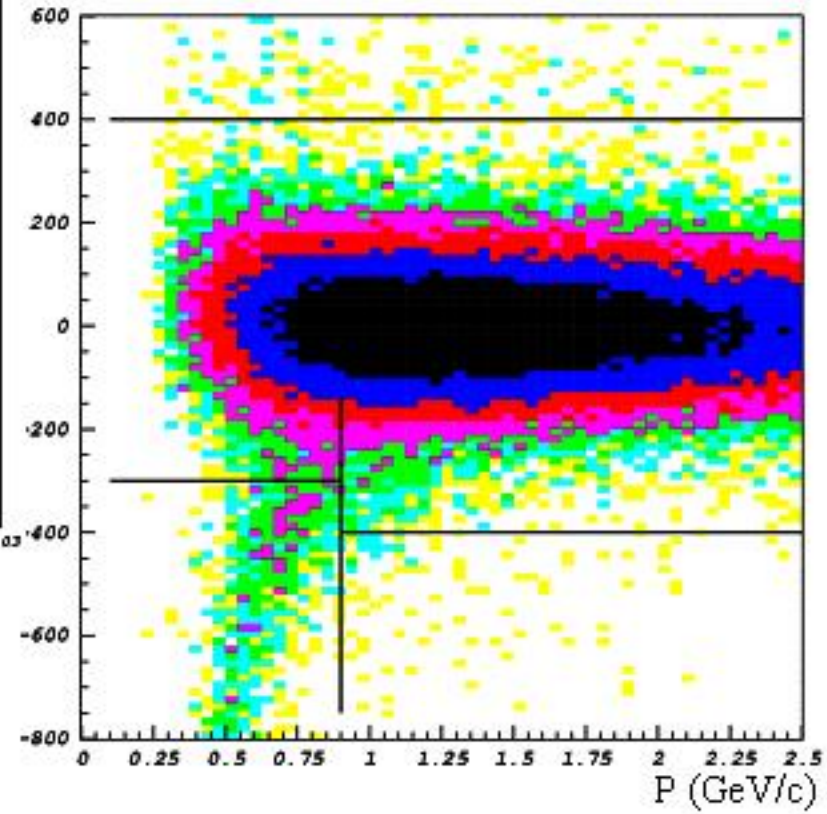
TOF cuts:

- multyhits
- edge cut (1mm)
- QDC cut (0.8 < QDC < 1.6)(1.75 for low momentum)

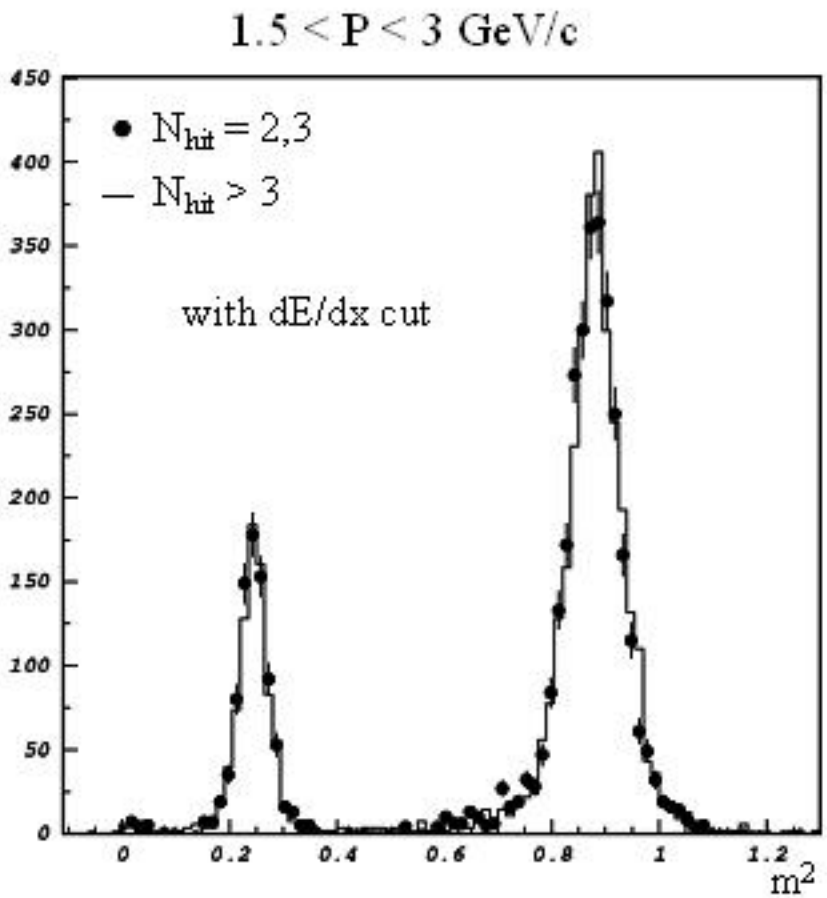
TOF calibration @ 20 AGeV

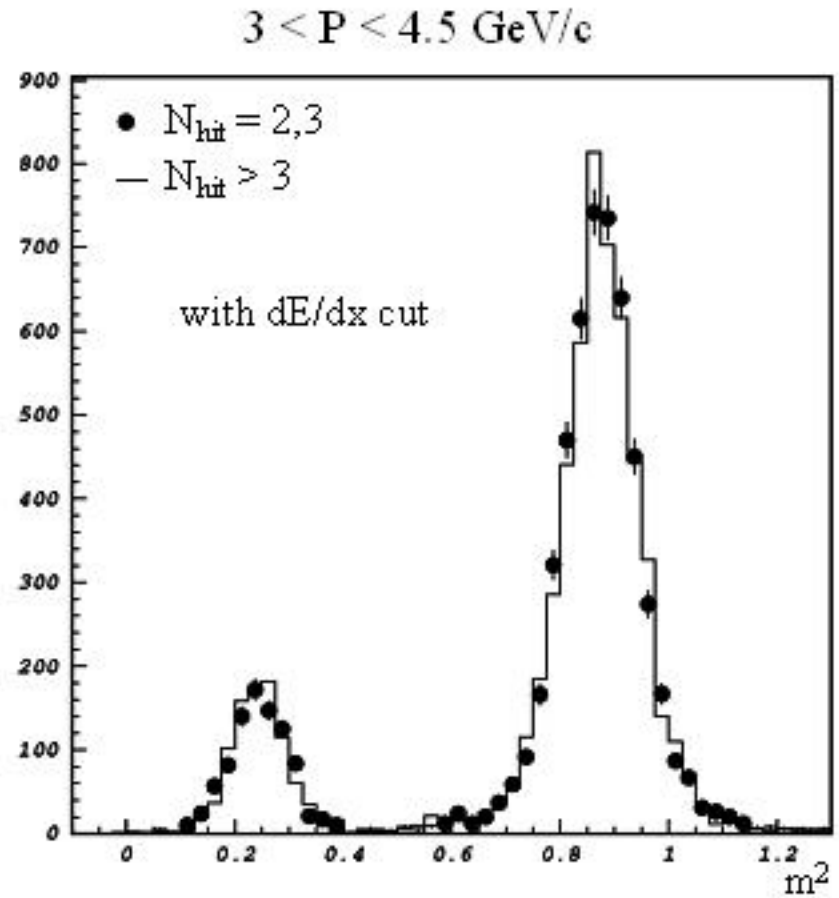
Event-by-event time correction to correct for the time drift of TOF counters parameters and for start counter signal instabilities (45-100 ps). Method – correct for the mean of the ($T-T_{\pi}$)-distribution in an predefined time window (+/- 400 ps) in each event.
At low beam energies an additional dE/dx cut is needed to reject kaons in low multiplicity events (N_{TOF} hit=2,3,4). Also low momentum cut applied to reject μ.





m^2 K^+, p distributions from 35k events @ 20 AGeV (TOF)

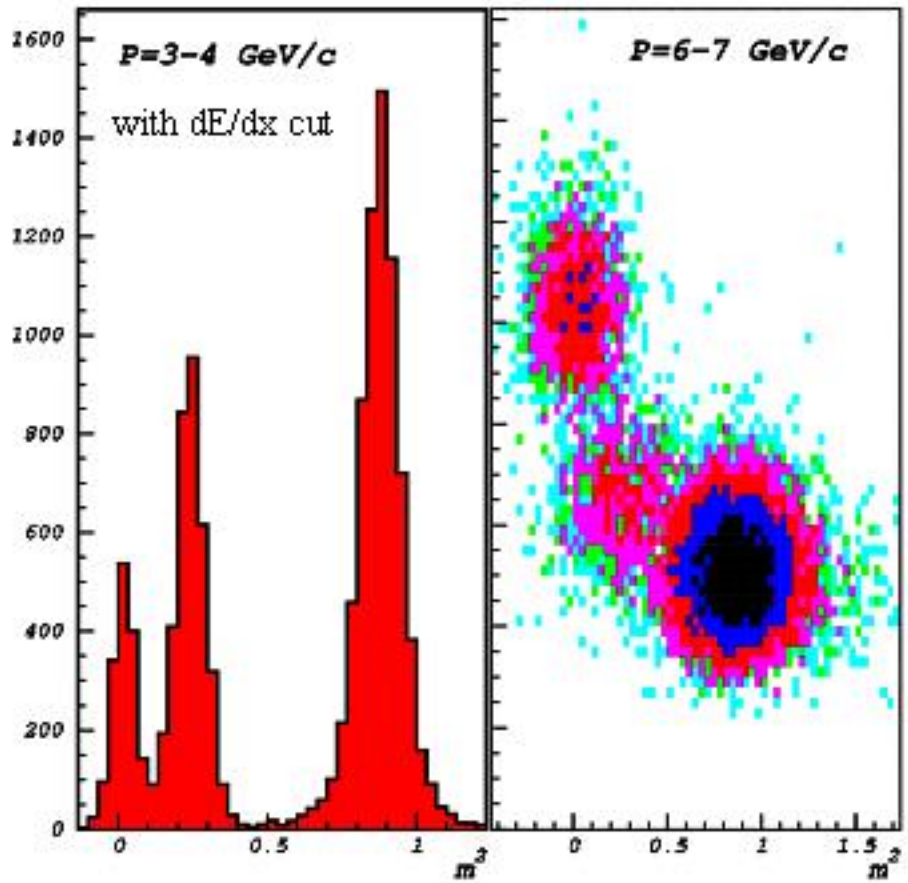


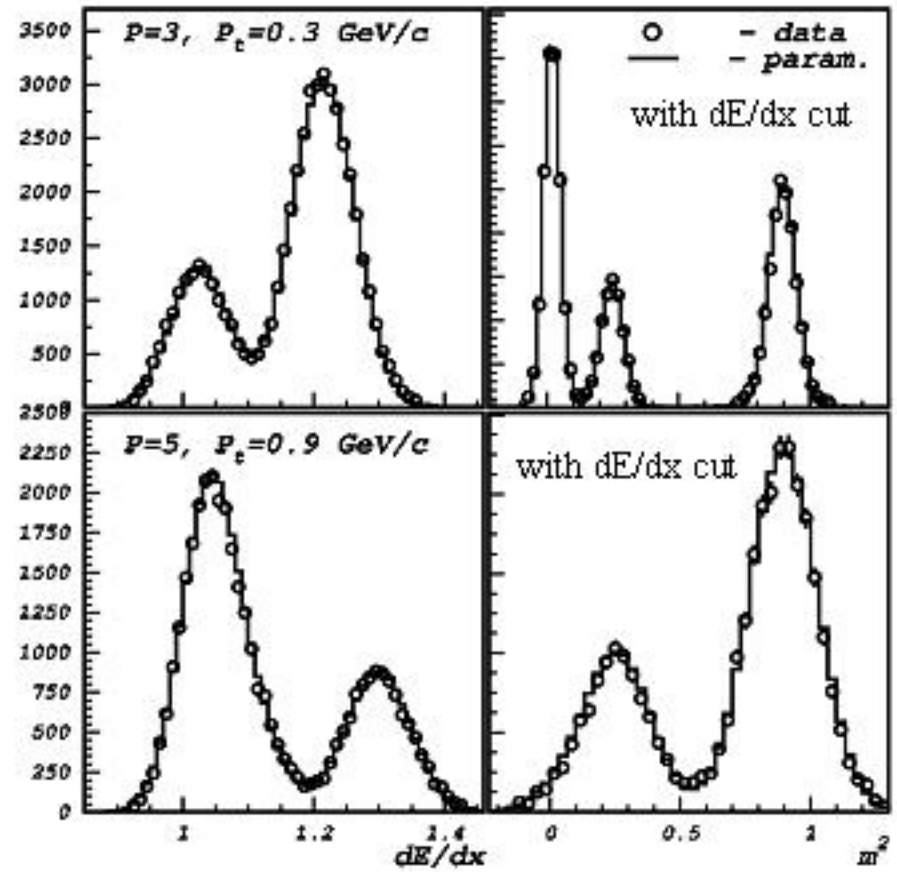


No difference in yelds of K^+, p in multiplicity selected events @ 20 AGeV

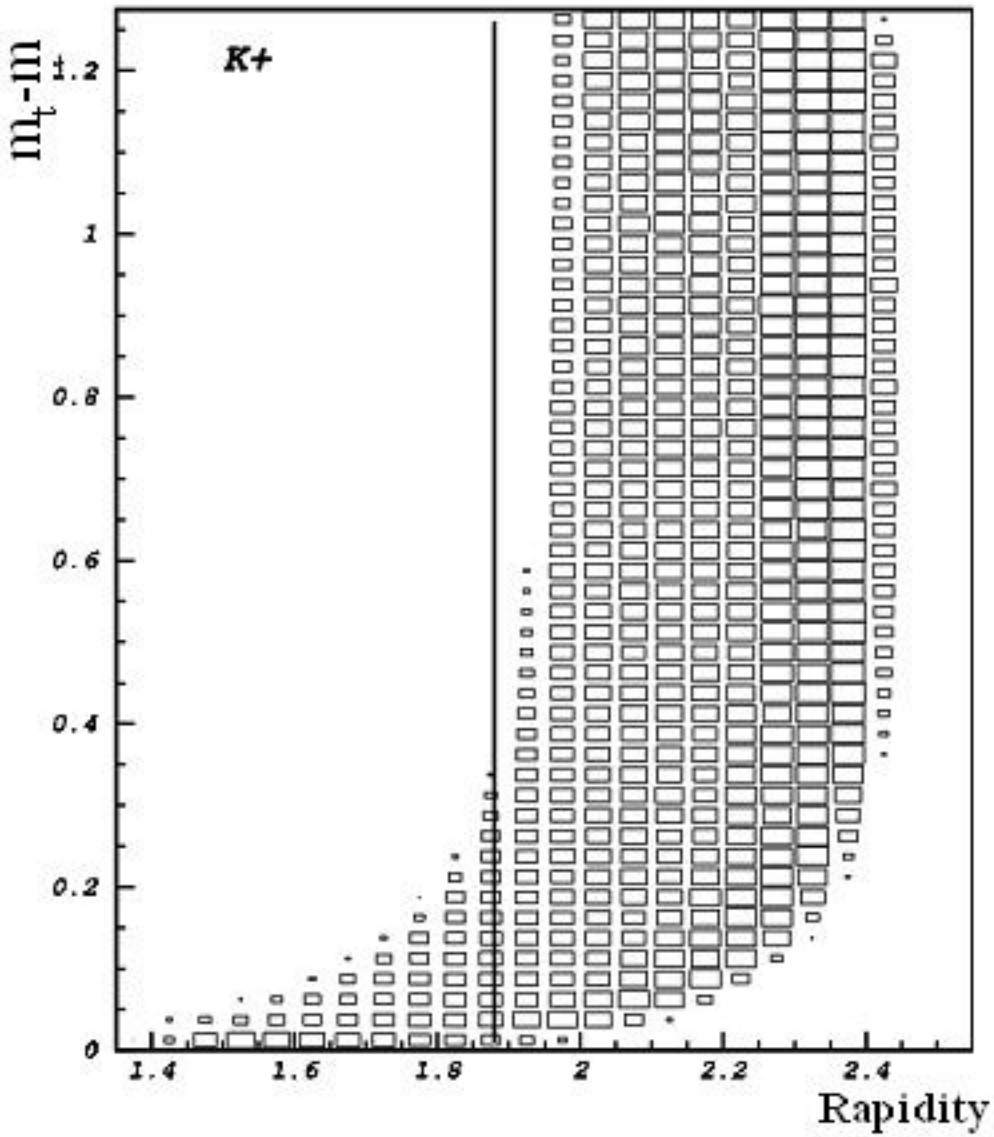
20% events (N_{hit} = 0,1) are not analysed

Particle ID @ 20 AGeV (dE/dx-TOF)



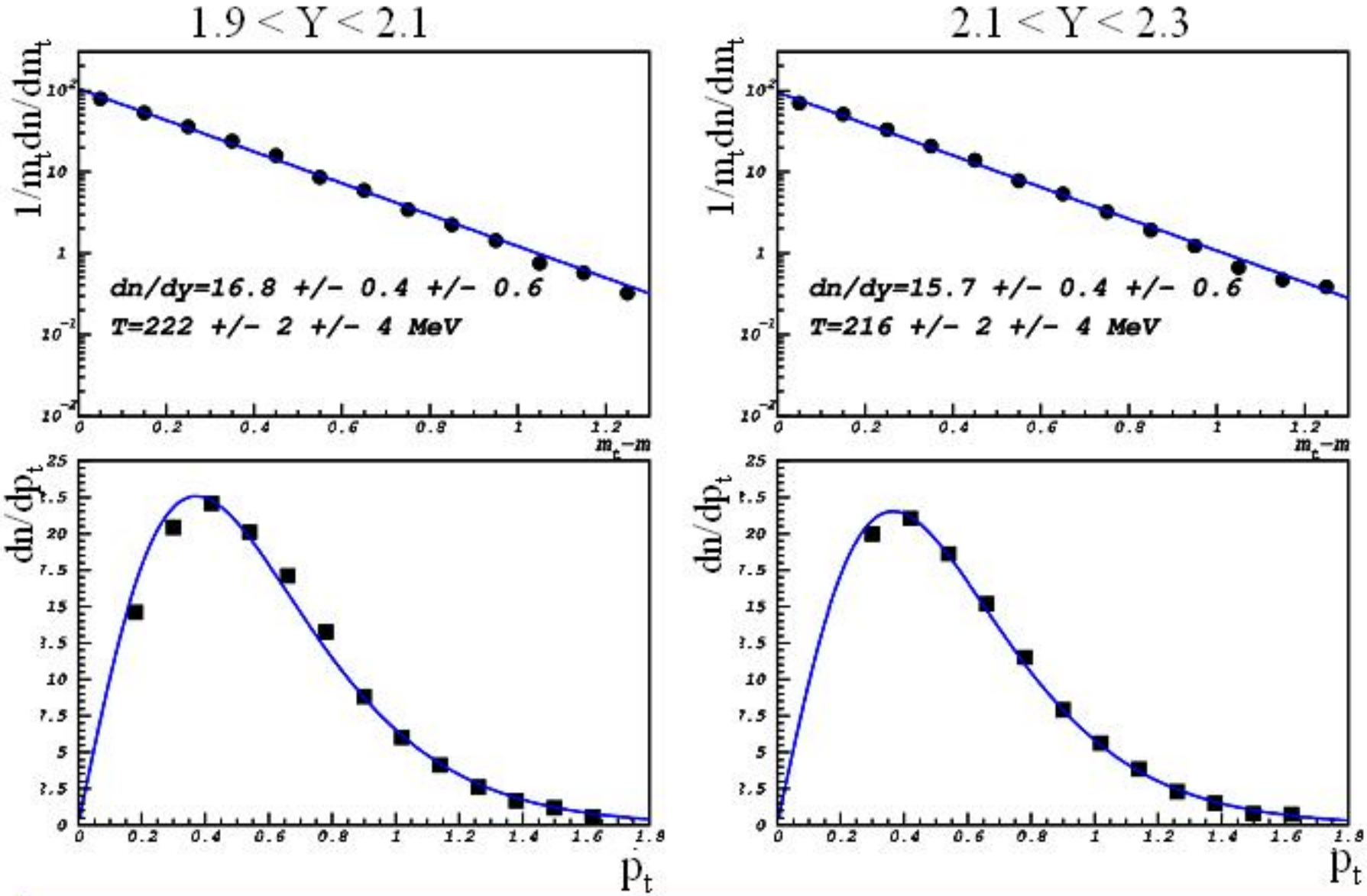


TOF kaon acceptance @ 20 AGeV

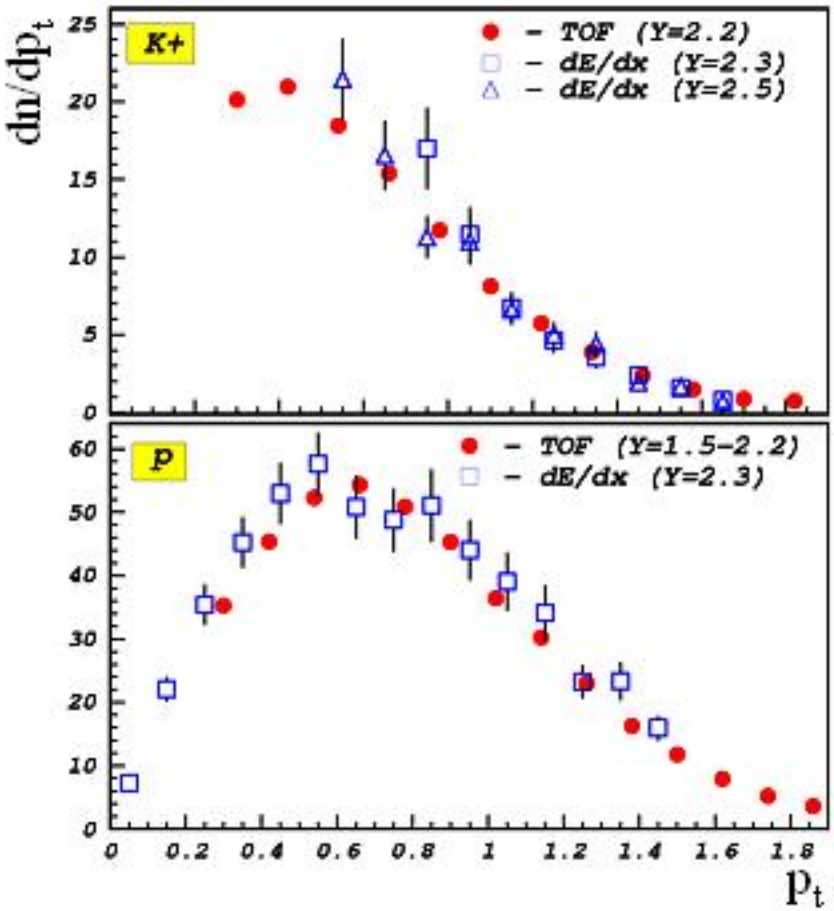


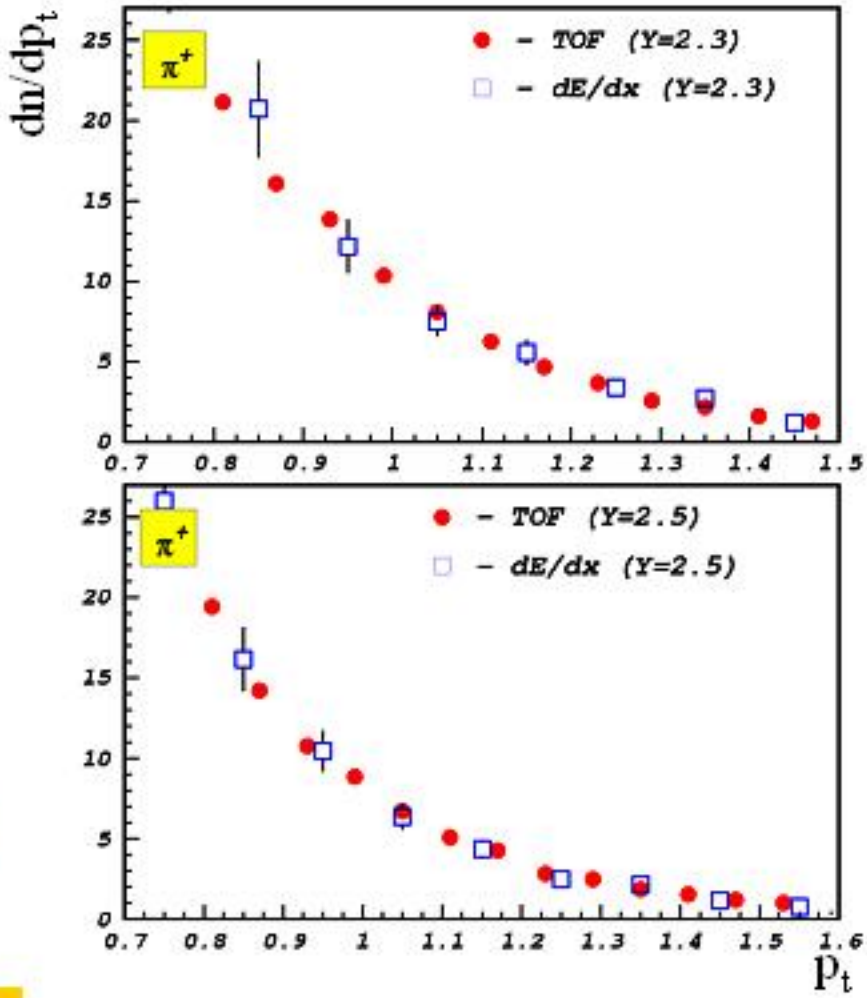
$Y_{CM} = 1.9$

K^+ m_t-spectra @ 20 AGeV



dE/dx-TOF spectra comparision (K^+, p, π^+) @ 20 AGeV

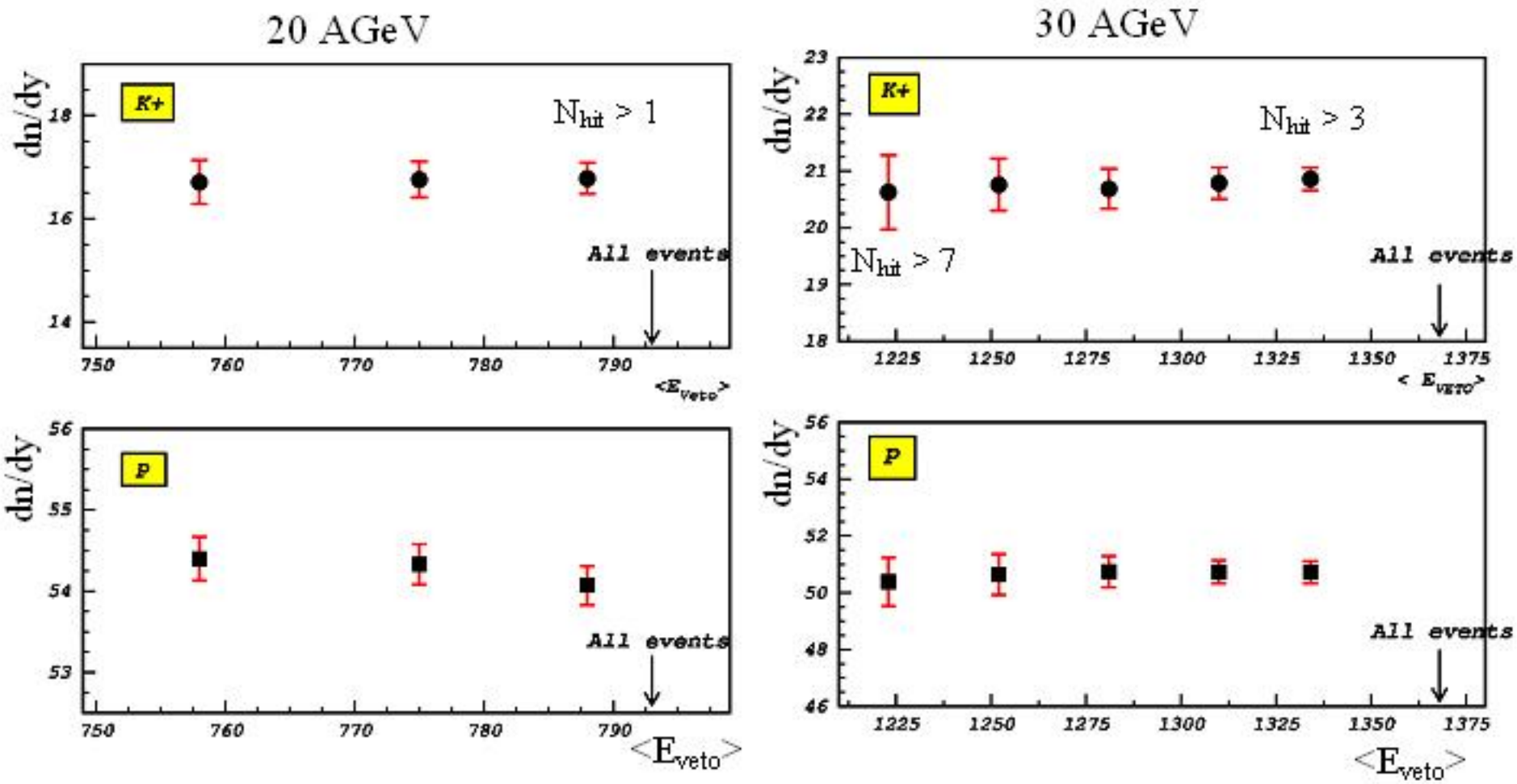




Agreement is good

Errors estimation

Correction	$\Delta\, dn/dy$ (%)	ΔT (MeV)
Identification	2%	1-2
TOF quality cuts	1.5%	2
Acceptance (decay)	0	0
$N_{hit} > 1$ cut	1-2%	1
Fitting, number of points	1%	2-3
Total (absolute value)	**0.6**	**5**



No N_{TOF} hit dependence is seen for K^+ & p

Summary

- Analysis of the energy dependence of K^+ production (TOF) is now complete
- $m_t(p_t)$ distributions of K^+ @ 20 AGeV (7% Pb+Pb) are shown
- dn/dy and slope parameter T of K^+ @ 20 AGeV are derived

$$dn/dy = 16.8 \pm 0.4 \pm 0.6$$
$$T = 222 \pm 4 \pm 5 \text{ MeV}$$

- Results are consistent with those from the dE/dx analysis at all energies.

Energy & centrality dependence of *pbar* production

Energy: 5%(10%) central @ 158 AGeV, 7% @ 40,80 AGeV.
Results (feeddown corrected *pbar*) were presented at QM02 and SQM02.
7% central @ 30,20 AGeV – analysis in progress
(Nothing new to present at the moment …)

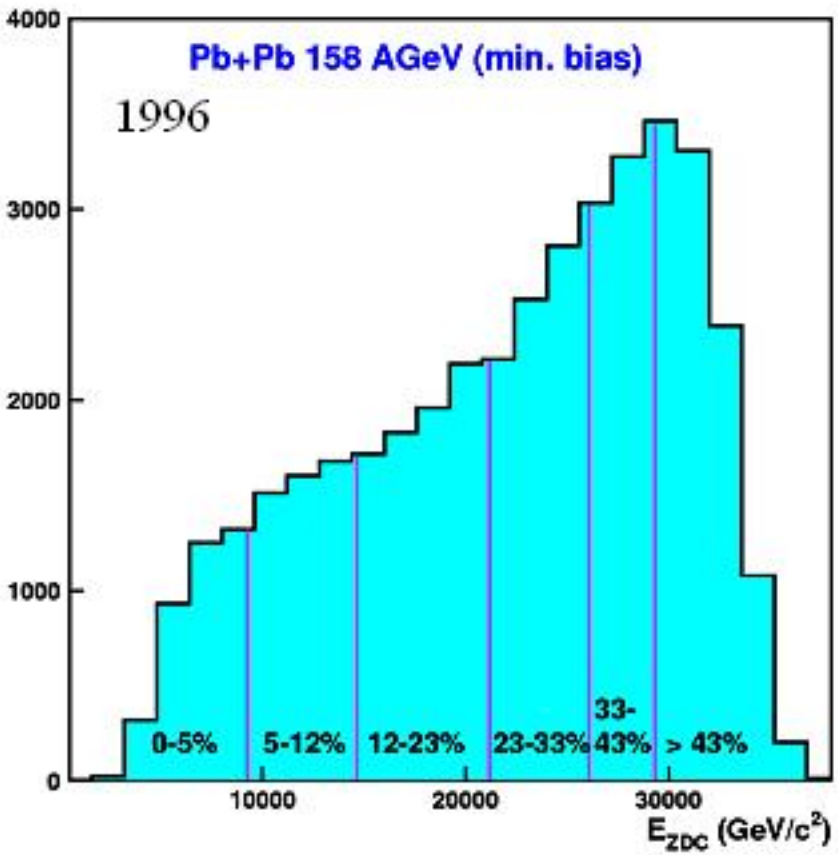
Centrality: first results from TOF in min. bias Pb+Pb @ 158 AGeV
(feeddown corrected *pbar*)

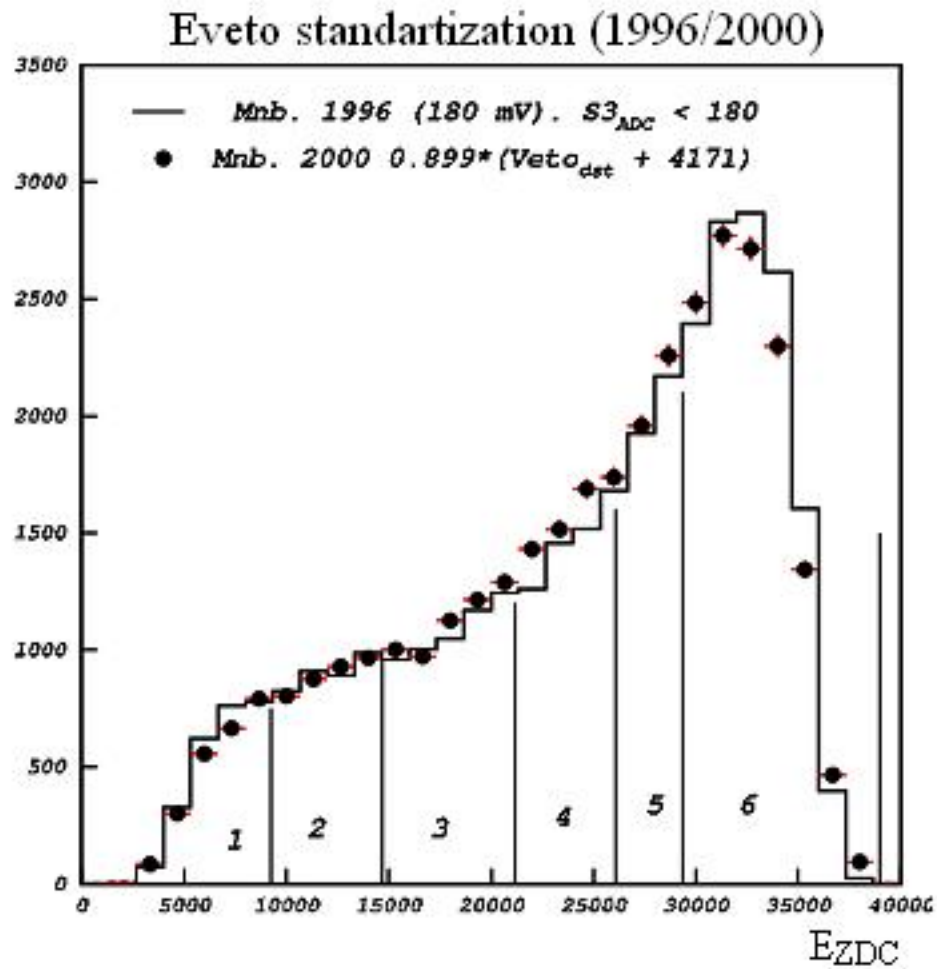
Data set: 1996 00M STD+ (100k), 2000 01C STD+ (280k)

Also results from 10% central Pb+Pb @ 158 AGeV can be used
(centrality bins 1,2)

Centrality selection

made by G.Cooper





	central	⟷	peripheral
<Npart>	366		85
b (fm)	0-3.4		10-14

The estimation of a mean number of participants

In each centrality bin a direct estimate of the number of participating nucleons was made by estimated of the net barion number carried by produced particles.

$$(B-\overline{B}) = (p-\overline{p}) + (n-\overline{n}) + (Y-\overline{Y})$$

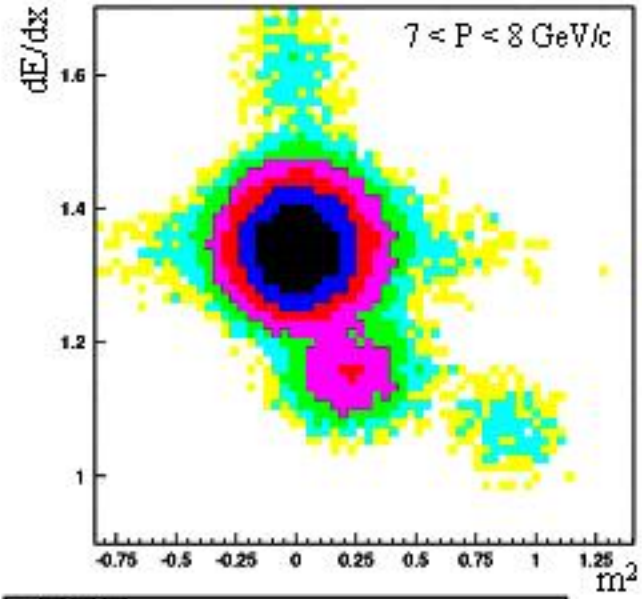
Averaging the results of several models and experimental data:

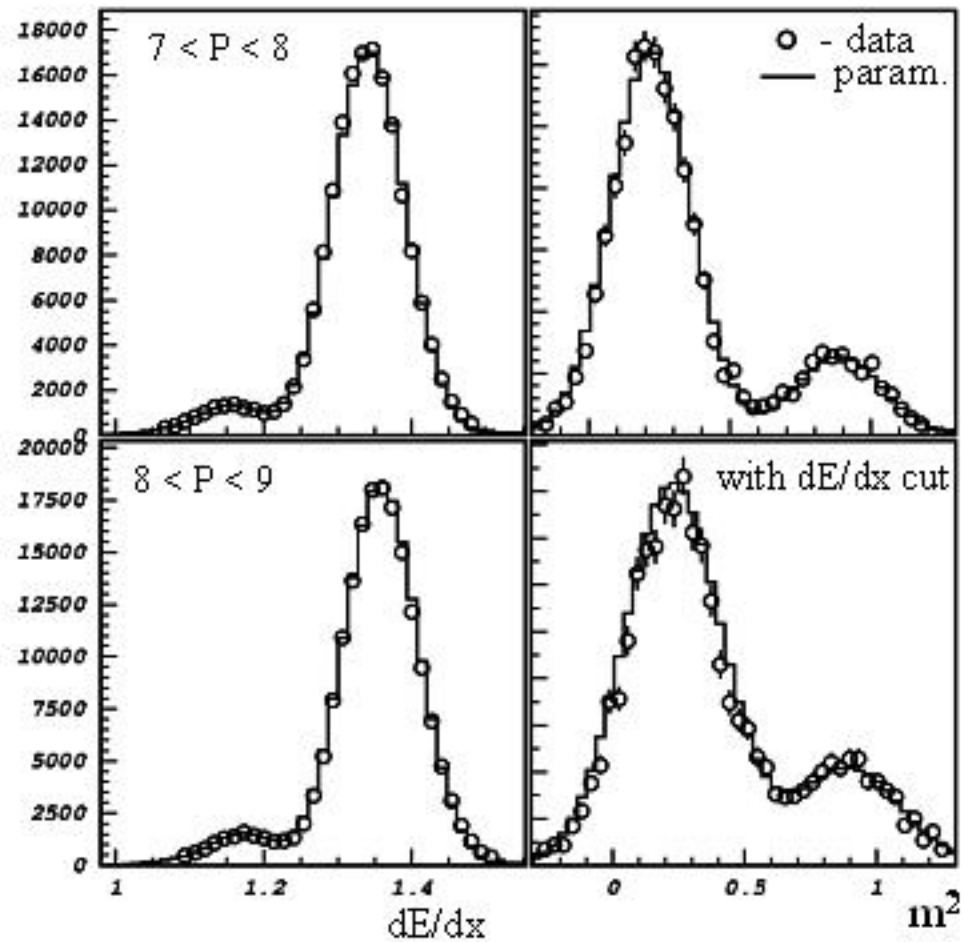
$$N_{part} = (1+\alpha)(p-\overline{p}) + 2\frac{1+\beta}{1+2\beta}\left(K^{+}-K^{-}\right)$$

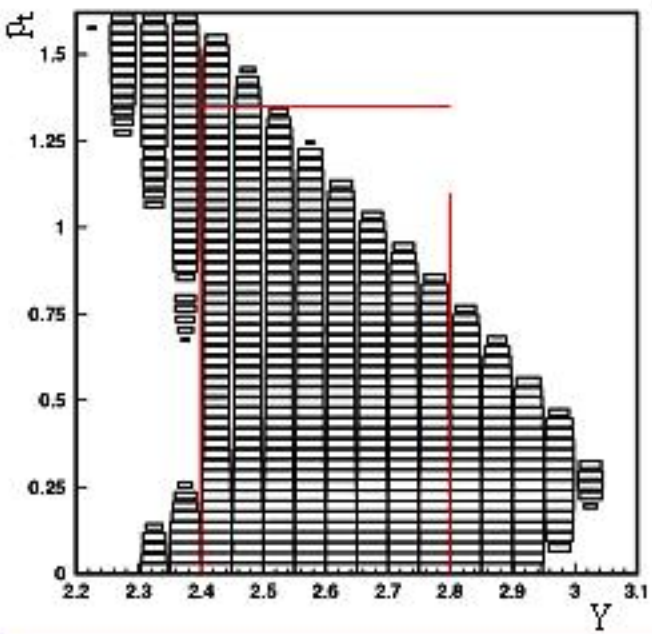
$$where \qquad \alpha = (n-\overline{n})/(p-\overline{p}) \approx 1.07 \qquad \beta = (Y-\overline{Y})_{S=2}/(Y-\overline{Y})_{S=1} \approx 0.1$$

Bin	E/E_{beam}	σ/σ_{tot}(%)	$\langle N_{part}\rangle$	$\langle N_w\rangle$	b (fm)
1	0-0.25	0-5	366 ± 8	352	0-3.4
2	0.25-0.4	5-12	309 ± 10	281	3.4-5.3
3	0.4-0.58	12-23	242 ± 10	204	5.3-7.3
4	0.58-0.71	23-33	178 ± 10	134	7.4-9.1
5	0.71-0.8	33-43	132 ± 10	88	9.1-10.2
6	0.8-1.0	43-100	85 ± 6	42	10.2-14.0

PID, acceptance, etc.







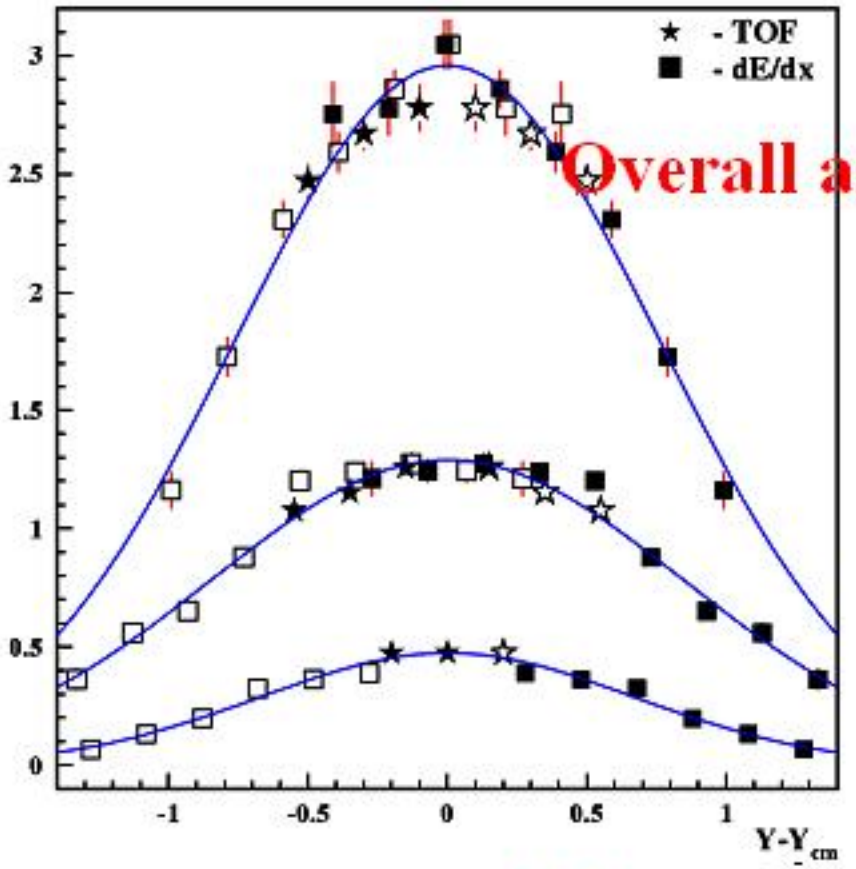
$2.4 < Y < 2.8$

$0 < p_t < 1.35$ GeV/c

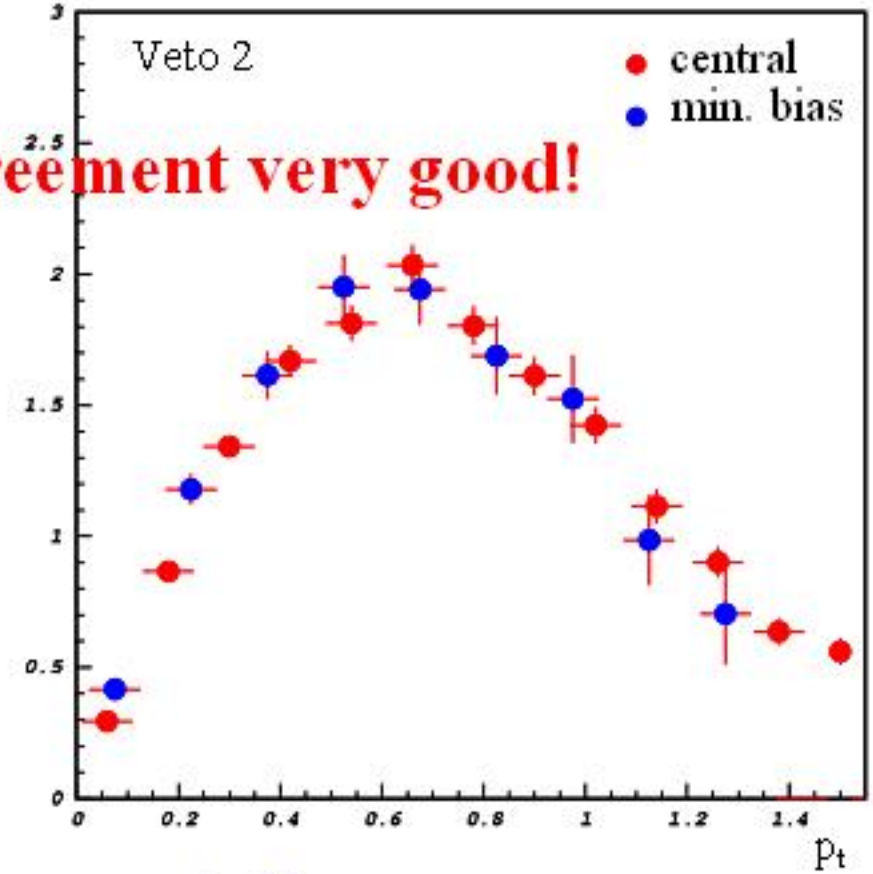
$0 < m_t - m < 0.75$ GeV/c^2

Pbar p_t-distributions (w/o feeddown)

$\bar{P}$ *yield at 40,80,160 GeV (uncorreted)*



Overall agreement very good!



central
1996
Eveto96
TOFL

min. bias
1996(35%)+2000(65%)
Eveto96 + Eveto00
TOFR

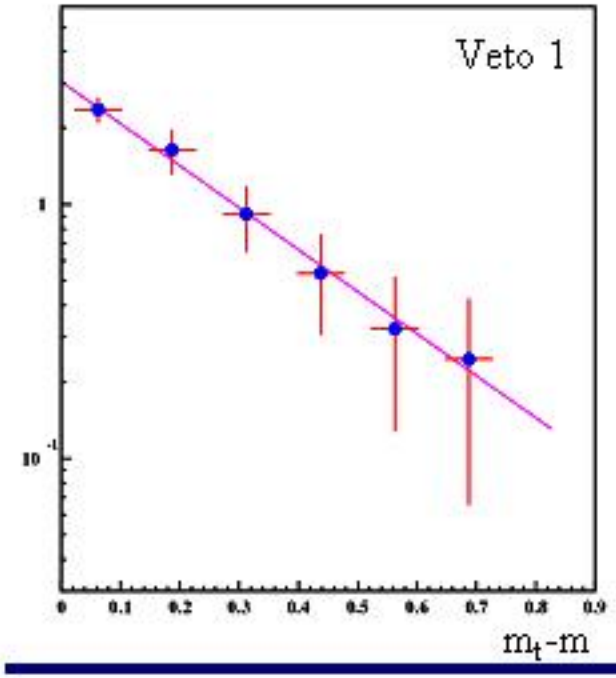
Feeddown correction

(see NA49 *p/d* publication for details)

VENUS + GEANT + reconstruction

As an input for the $\bar{\Lambda}$ phase-space distribution the following experimental data were used:

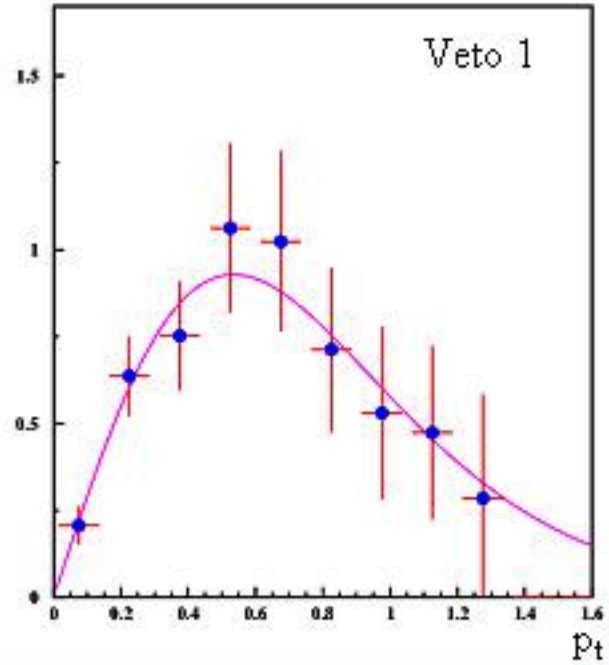
NA49 – 10% central Pb+Pb @ 158 AGeV (A.Mischke)
NA57 – min. bias Pb+Pb @ 158 AGeV ($N_{wound} = 50 \div 360$)
WA97 – min. bias Pb+Pb @ 158 AGeV ($N_{part} = 120 \div 360$)



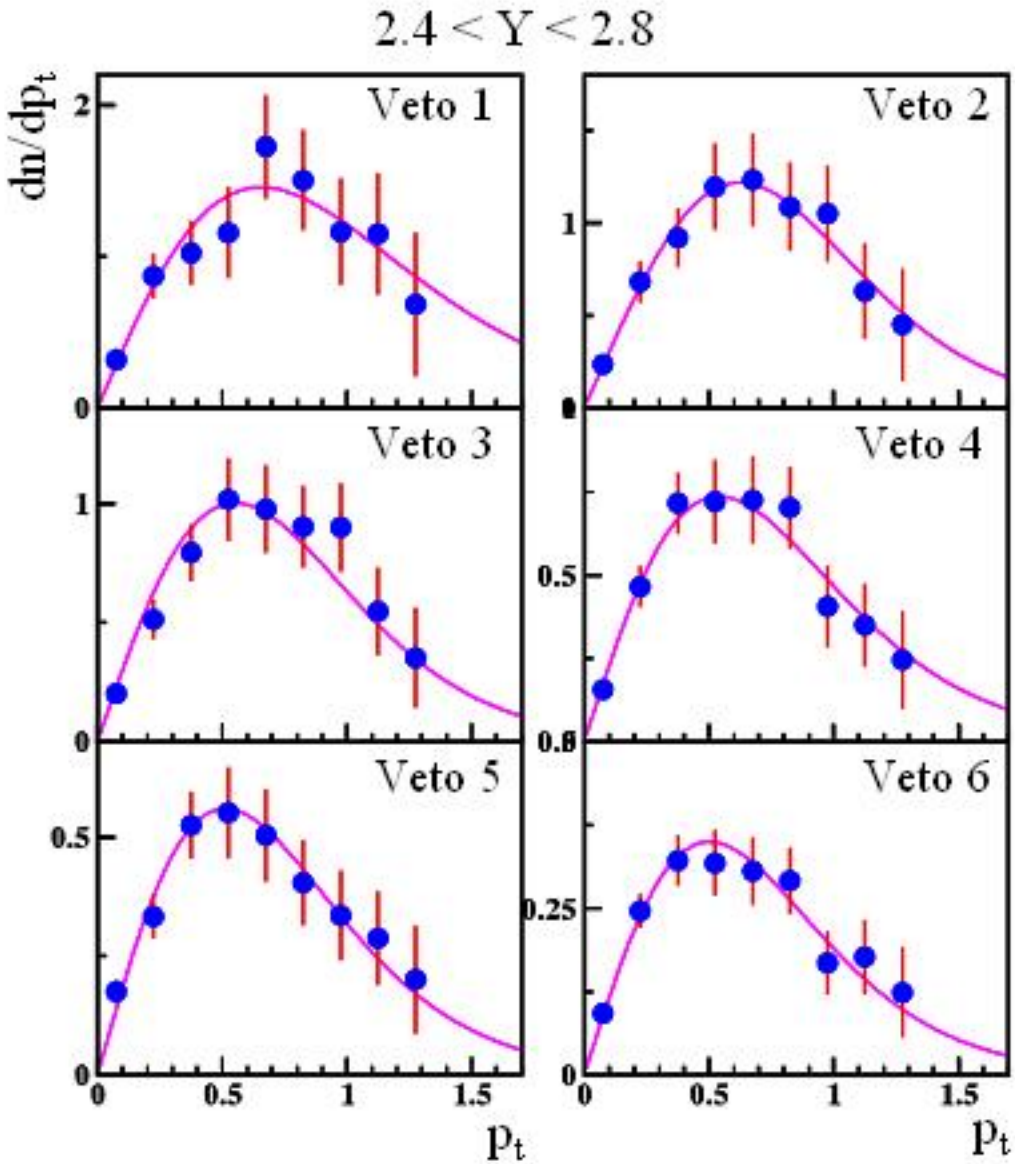
Feeddown ($\bar{\Lambda}+\bar{\Sigma}$):

$dn/dy(\%) = 25 \div 35\%$

$T = 215 \div 265$ MeV



Pbar p_t-spectra at 158 AGeV (w. feeddown)

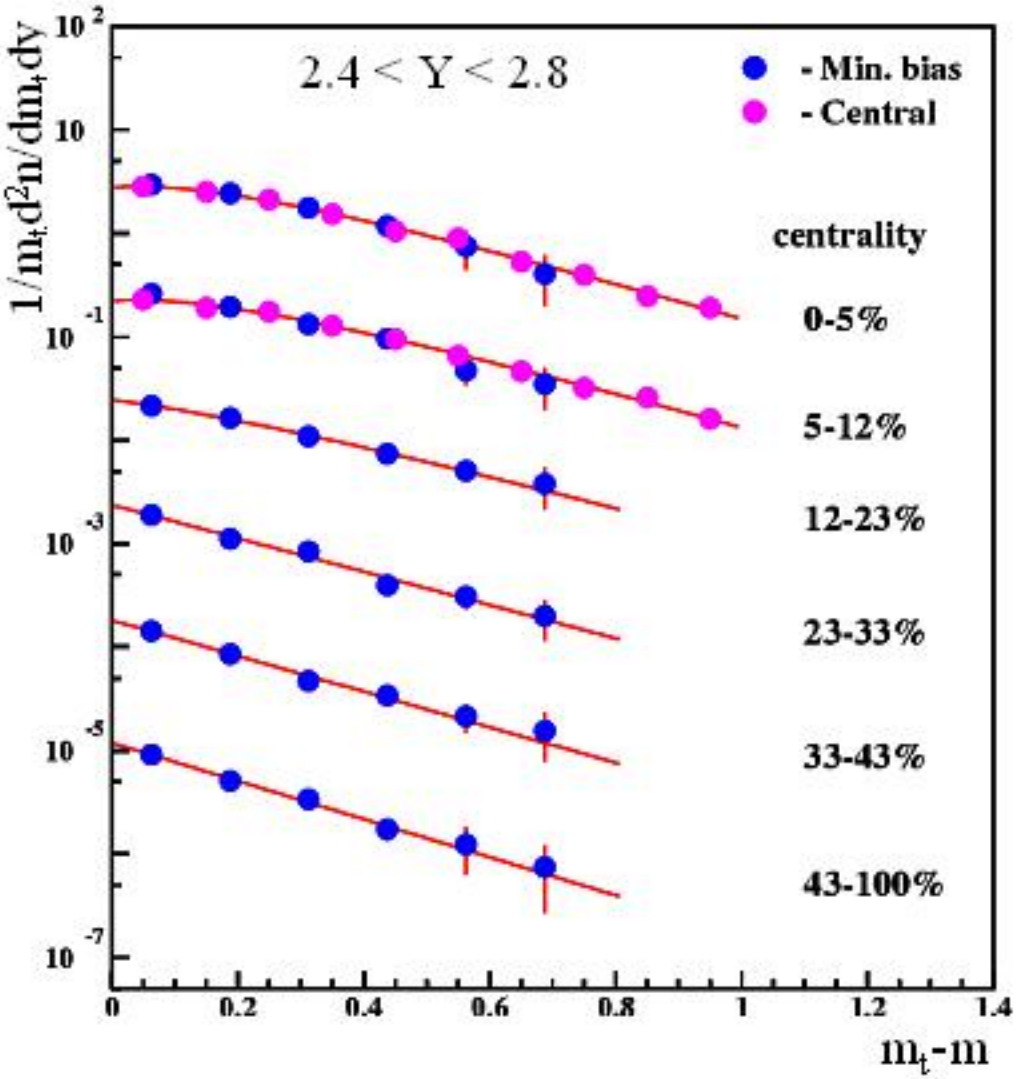


$$\frac{dn}{dy} = \sum_{i}^{1.3} y_i \cdot \Delta p_t + \underbrace{\int_{1.3}^{\infty} f(p_t)\,dp_t}_{I}$$

$$I \approx (8 \div 15)\%$$

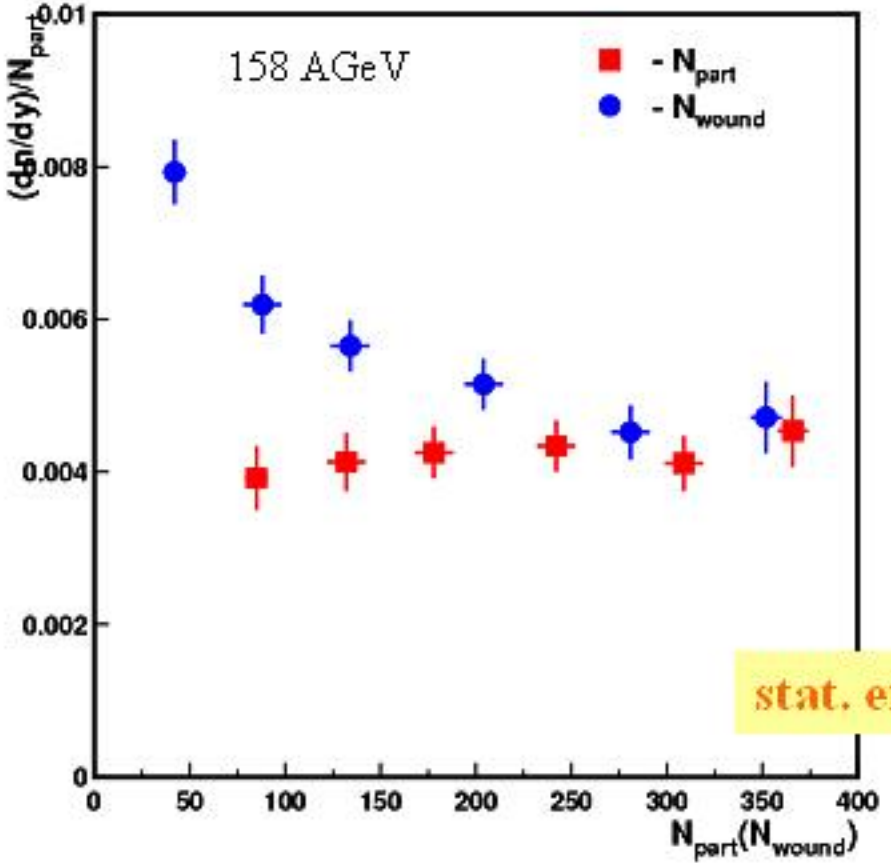
Veto #	*dn/dy*
1	1.66 ± 0.17
2	1.27 ± 0.11
3	1.05 ± 0.08
4	0.76 ± 0.06
5	0.55 ± 0.05
6	0.33 ± 0.04

Pbar mt-spectra at 158 AGeV (min.b @ central)

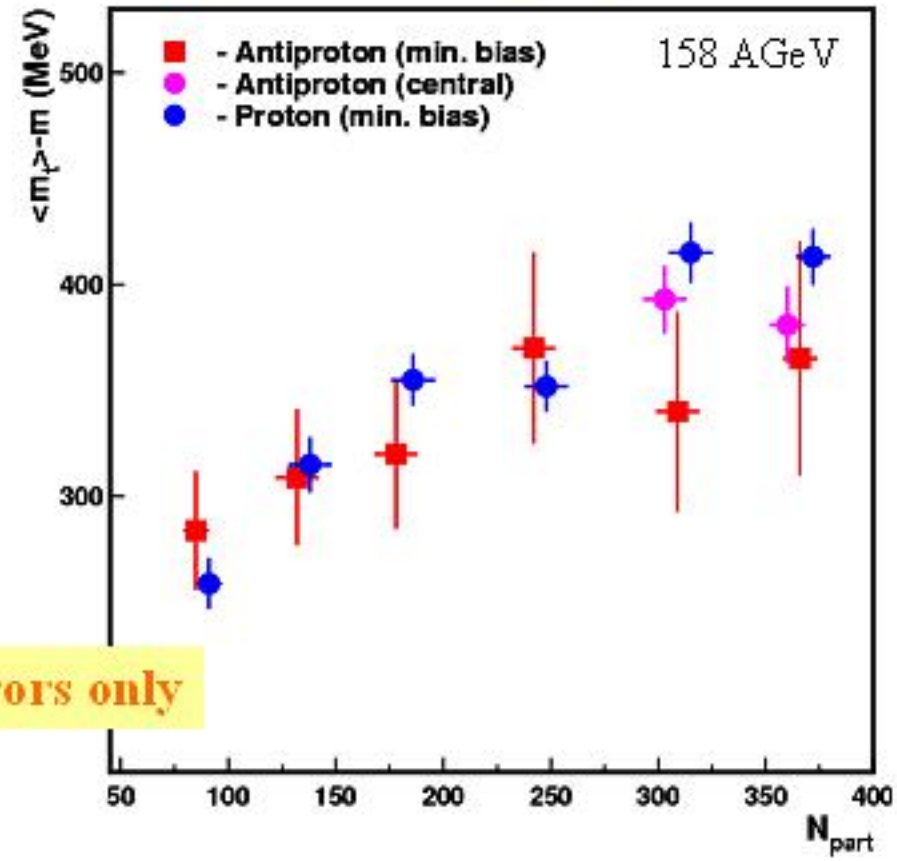


Veto #	$\langle m_t \rangle - m$ (MeV)
1	381 ± 18
2	393 ± 16
3	370 ± 45
4	326 ± 35
5	305 ± 32
6	283 ± 28

Pbar density per participant



$\langle m_t \rangle - m$ centrality dependence

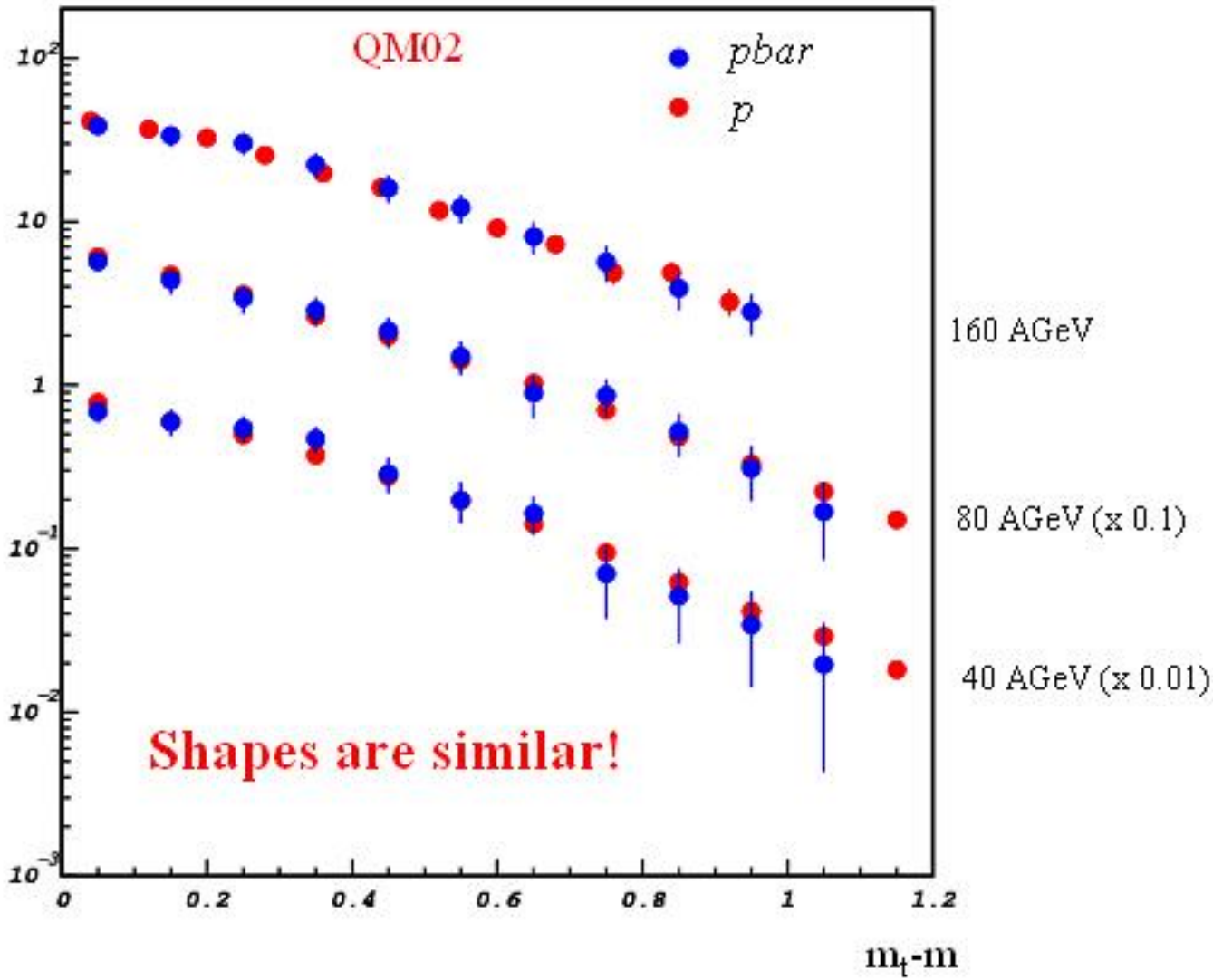


stat. errors only

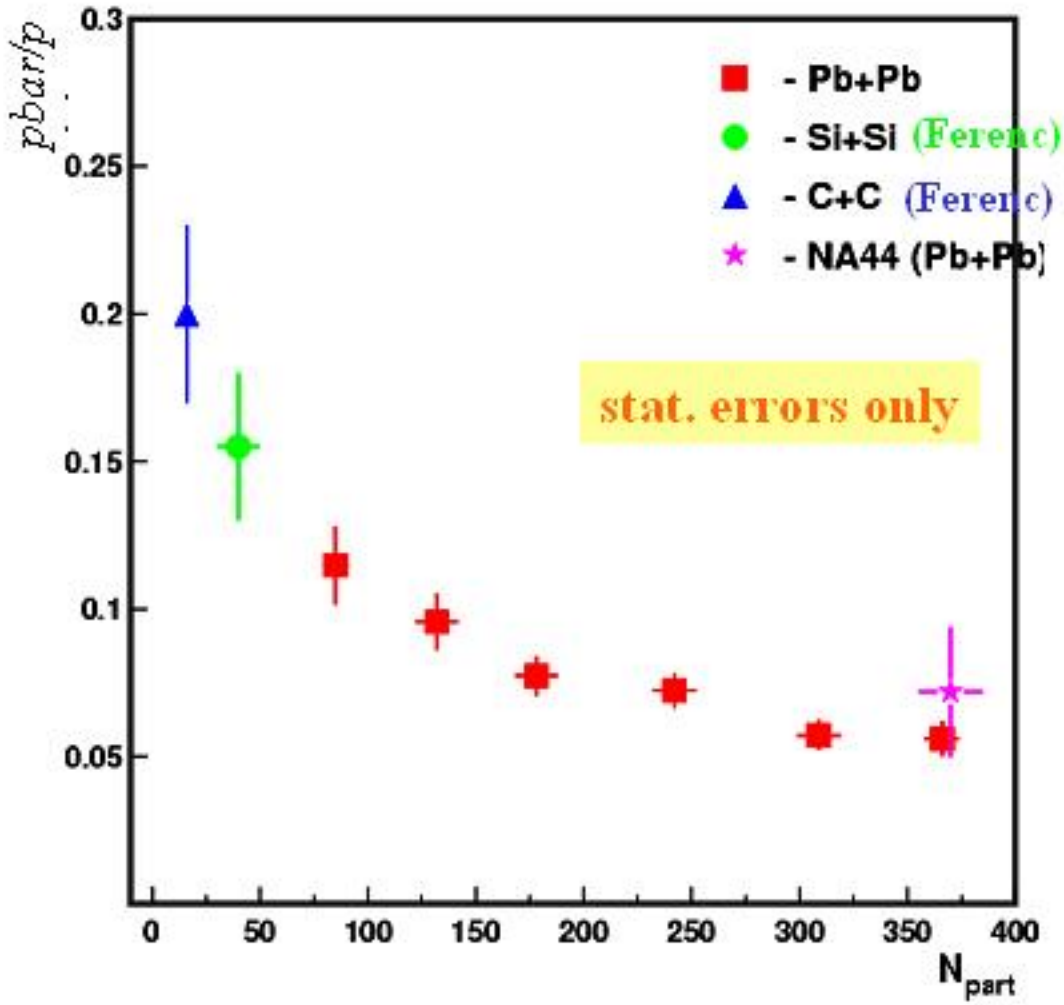
Pbar **per participant at Y_{CM} is flat as a function of N_{part}, but that increases versus N_{wound} towards peripheral collisions**

Shapes of the m_t-distributions of *p* and *pbar* are similar for all centralities

p, pbar m_t-spectra in central P+Pb



Centrality dependence of the *pbar/p* ratio @ 158 AGeV



Summary

- *Pbar* mid-rapidity spectra from the NA49 TOF detector measured in min. bias Pb+Pb collisions @ 158 AGeV are shown
- Feeddown correction is made using results on $\bar{\Lambda}$ production from NA49, WA97 and NA57 experiments
- *Pbar* midrapidity $m_t(p_t)$-spectra for six centrality bins are presented, dn/dy and $\langle m_t \rangle$-m are obtained
- Transverse mass distributions of pbars are similar to those of protons at all centralities and beam energies
- Midrapidity yield of antiprotons per participant is flat as a function of N_{part}, but grows as a function of N_{wound} towards peripheral collisions

To Do:

- *Pbar* @ 30 AGeV (analysis in progress)
- *Pbar* @ 20 AGeV (not started yet)
- For all above $\bar{\Lambda}$ @ 20,30 AGeV is needed

p, d @ 20, 30 AGeV

(the same as for K^+)

Data set:

360k STD1 (03A) (7% 20 AGeV)

Event selection:

- vertex_fit.iflag = 0
- abs(vertex_fit.z - Z_{target}) $< 1cm$
- $(N_{TOFhits})_\pi > 1$

Track quality cuts:

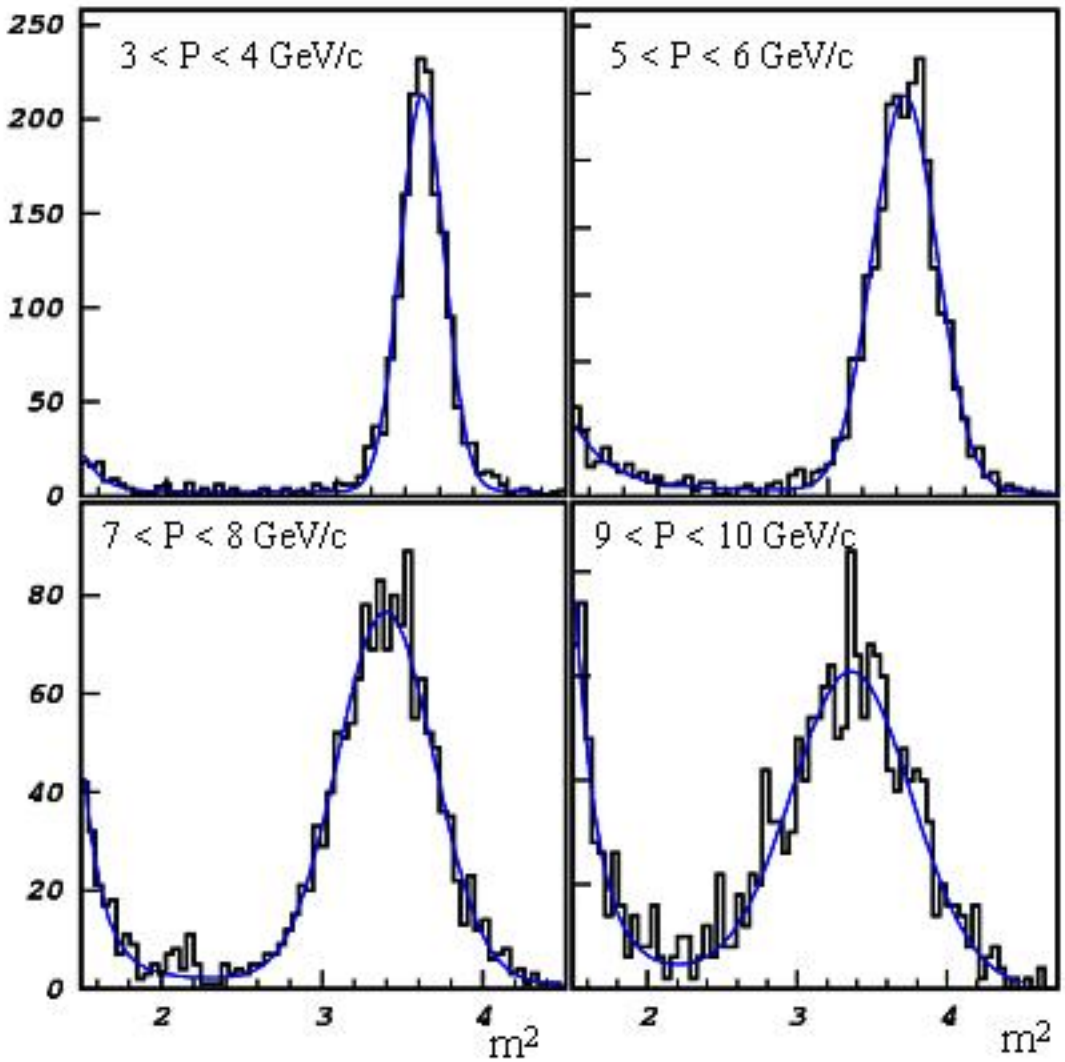
- track.px > 0.
- global tracks MTPC matched with VT1/VT2
- track.iflag = 0
- last point

TOF cuts:

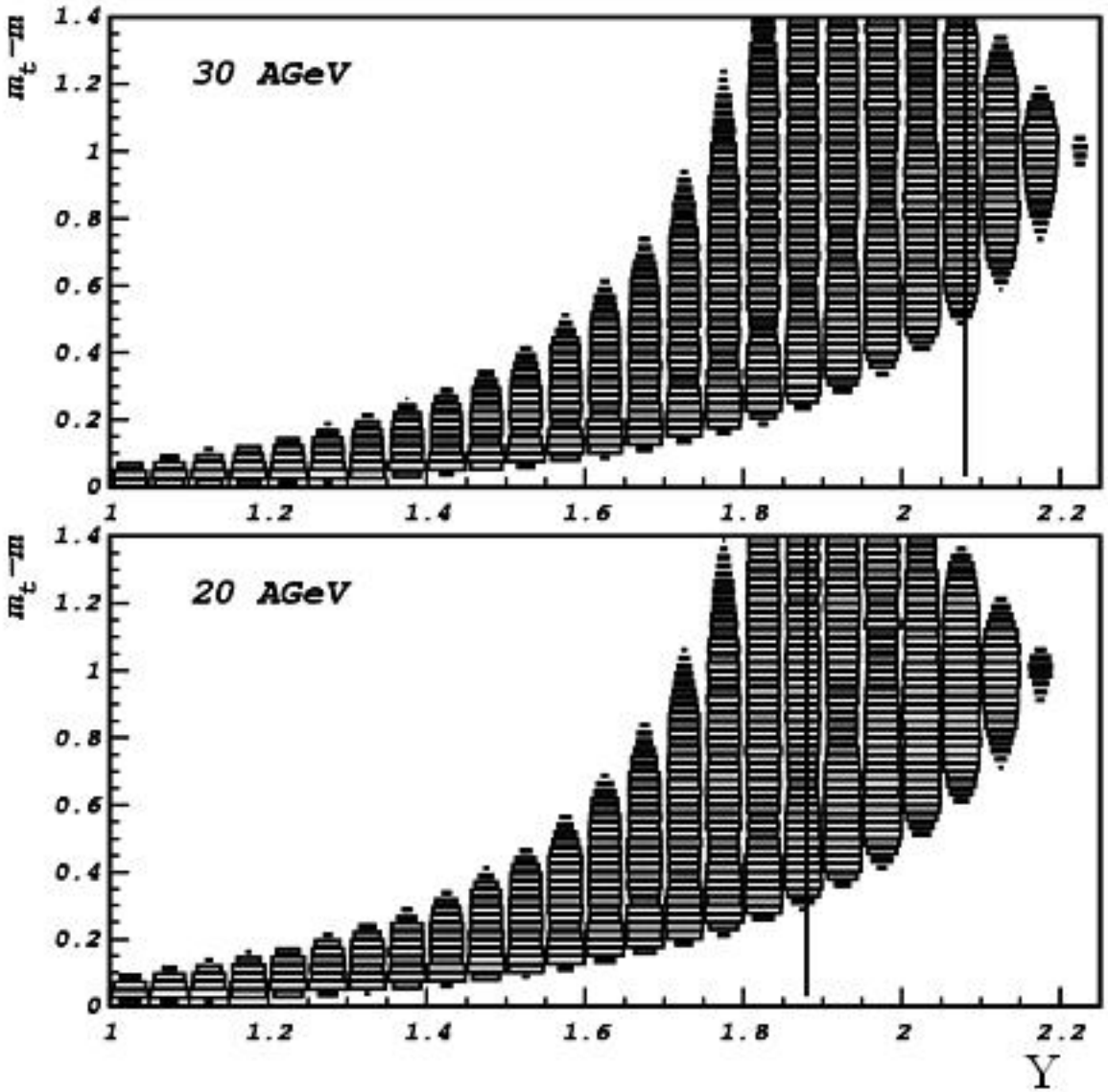
- multyhits
- edge cut (1mm)
- QDC cut (0.8 < QDC < 1.6)(<u>1.75 for low momentum</u>)

Deuteron ID @ 20, 30 AGeV

$dE/dx < (E_{mean} + 3\sigma_E)$

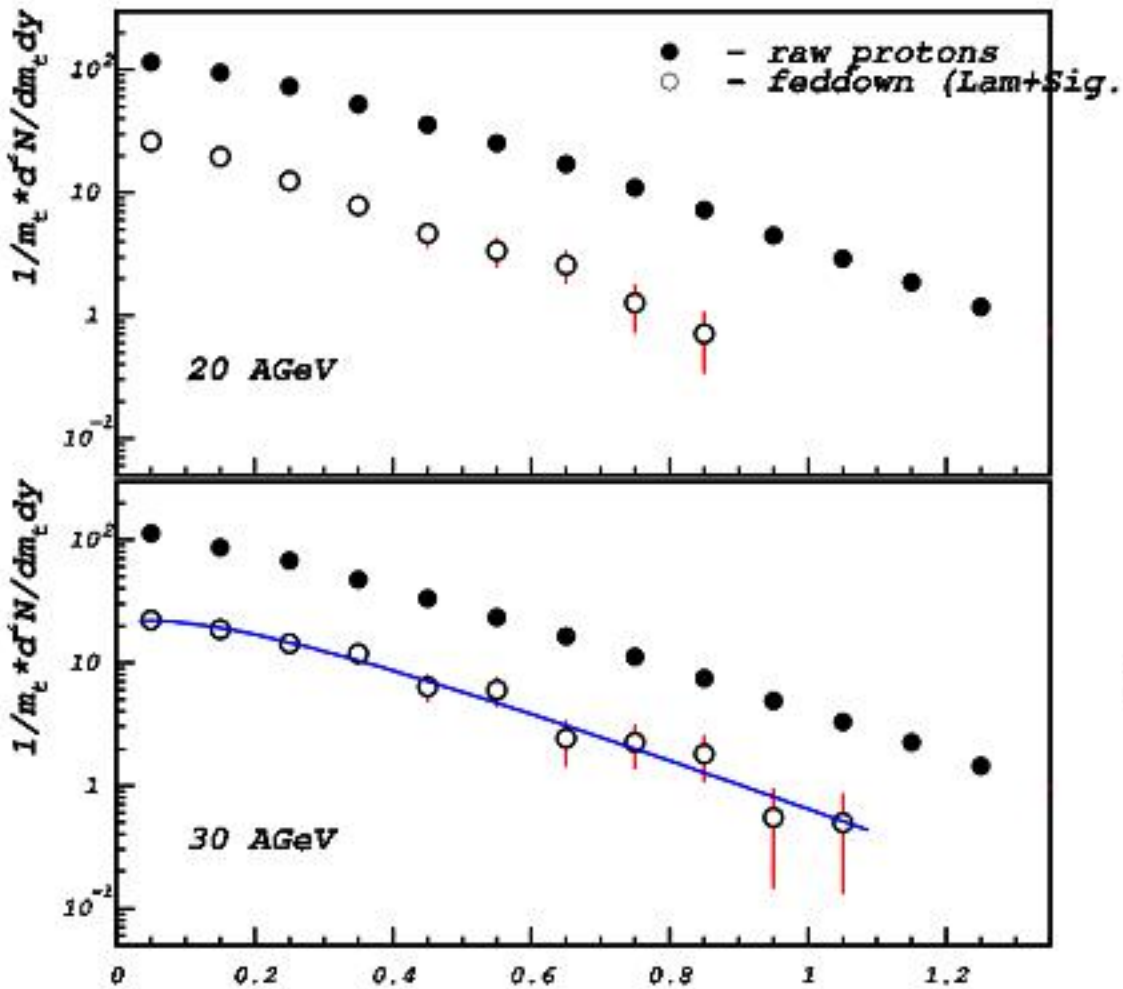


Deuteron acceptance (TOF)



Feeddown correction

(standart procedure)



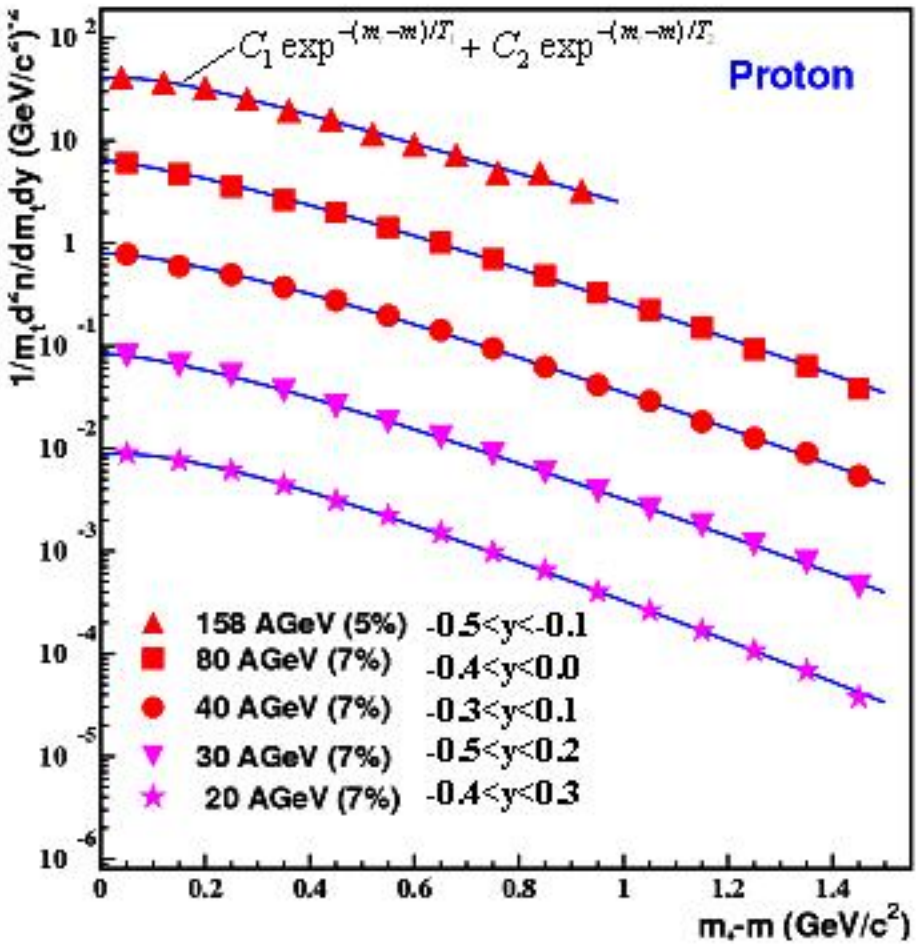
$$<\Lambda> \;=\; \frac{<K^+> - <K^->}{0.8}$$

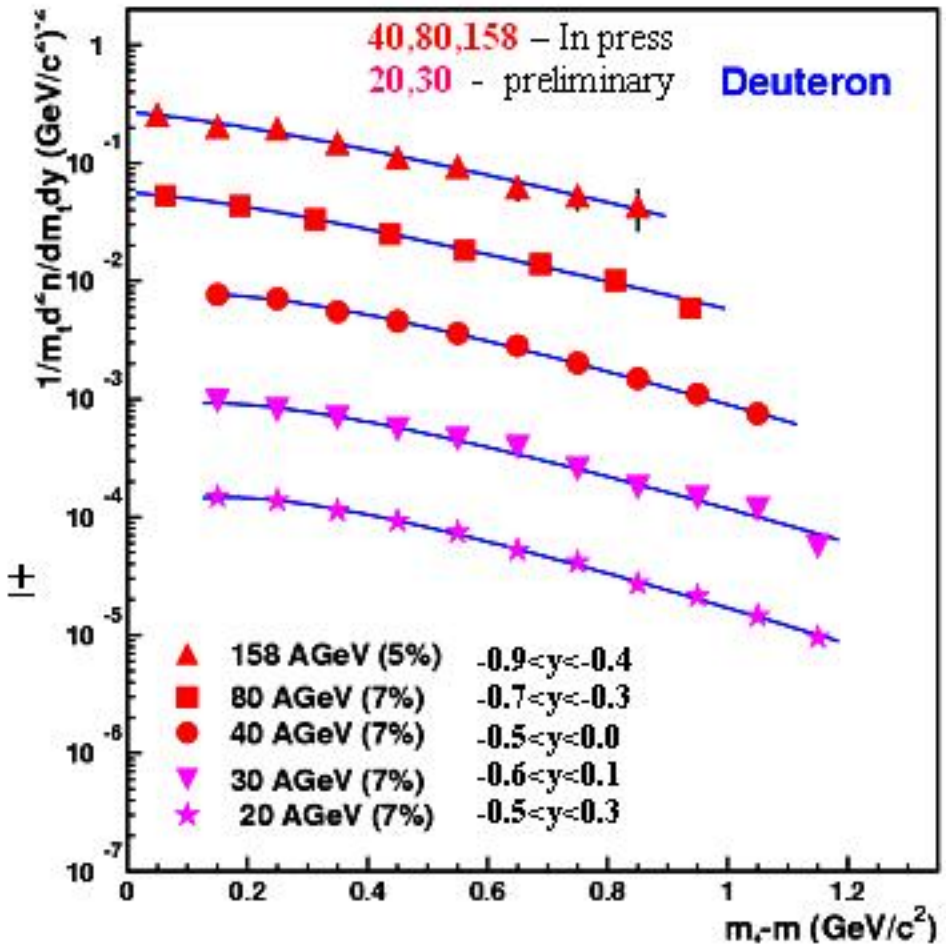
$$T_\Lambda = T_p$$

Feeddown correction:

(14 – 17)% @ 20, 30 AGeV

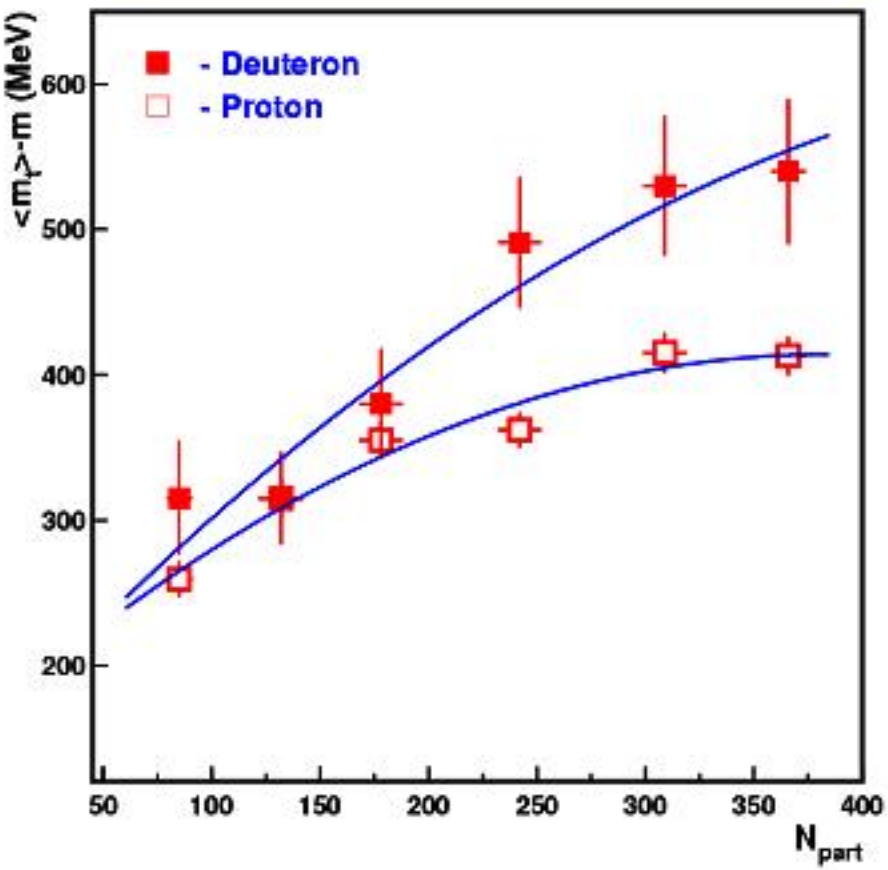
Mid-rapidity p, d m_t-spectra in central Pb+Pb @ 20-158 AGeV



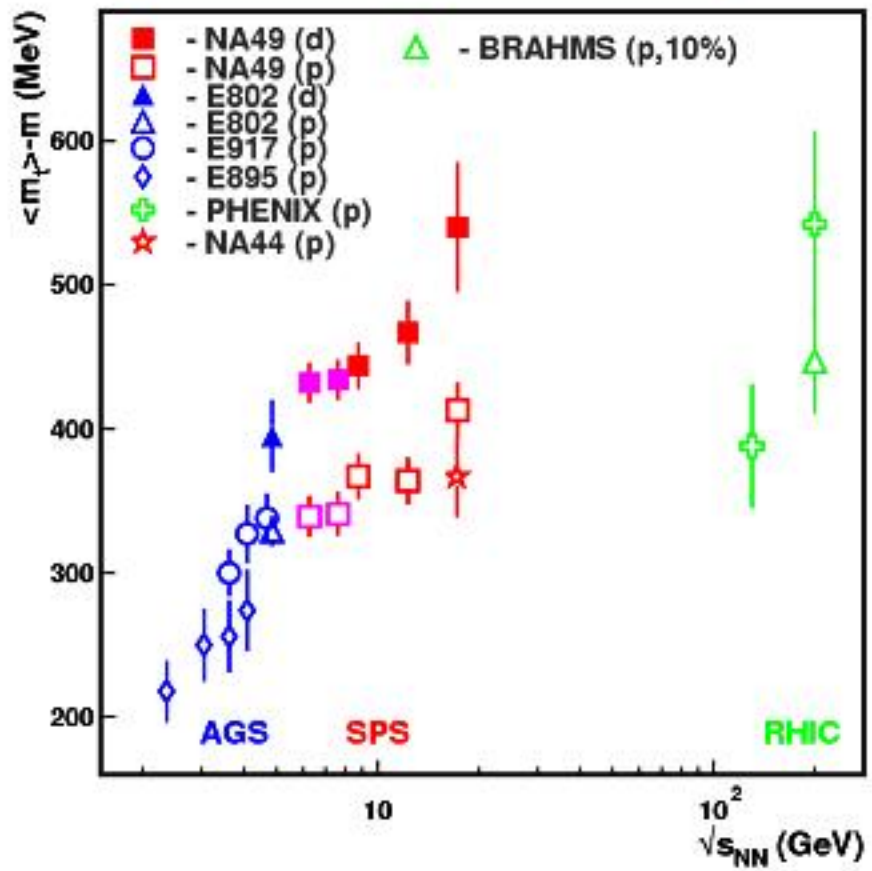


E_{beam}/A (GeV)	20	30	40	80	158
dn/dy (d)	2.11 ± 0.19	1.38 ± 0.15	1.02 ± 0.12	0.59 ± 0.08	0.33 ± 0.04
dn/dy (p)	45.0 ± 3.0	41.6 ± 3.0	41.3 ± 2.4	30.1 ± 2.0	29.6 ± 2.1

158 AGeV (Pb+Pb min. bias)

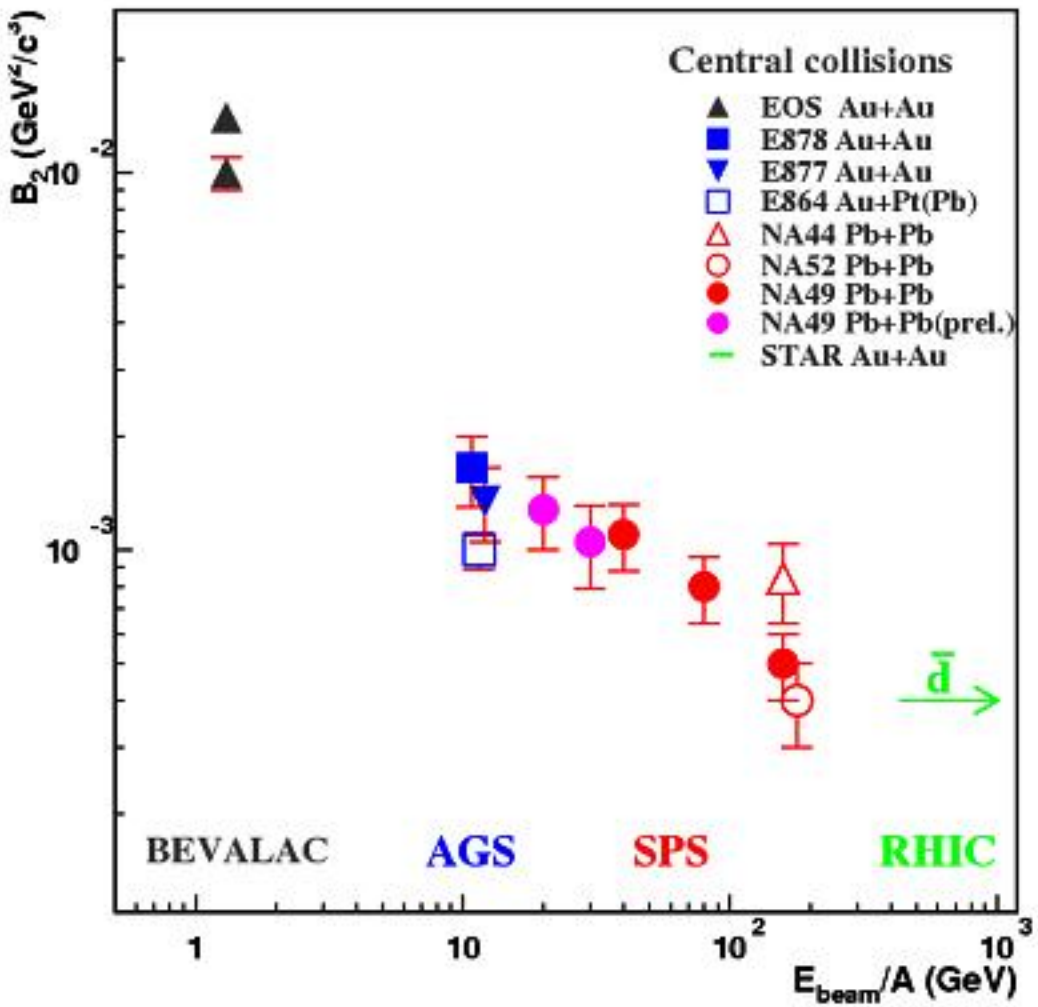


Central (Pb+Pb,Au+Au)



- $\langle m_t \rangle - m_d \gg \langle m_t \rangle - m_p$ in central A+A collisions at all energies
- $\langle m_t \rangle - m_d \approx \langle mt \rangle - m_p$ in peripheral collisions

B_2 energy dependence (Bevalac-AGS-SPS-RHIC)



Coalescence model:

$$E_d \frac{d^3 N_d}{dp_d^3} = B_2 \left(E_p \frac{d^3 N_p}{dp_p^3} \right)^2, \qquad p_d = 2 \cdot p_p$$

B_2 decreases with energy (factor of 3 at SPS)

Summary

- p,d midrapidity transverse mass spectra measured by NA49 in Pb+Pb at 20, 30 AGeV are presented

- Feeddown correction (15%) to protons based on an estimation of Λ yield obtained from the kaon results

- m_t distributions of deuterons are harder then those of protons in central A+A collisions at all energies

- B_2 decreses with increasing of beam energy (factor of 3 at SP)