Measurements of Minbias rapidity and p_T distributions in p+p 62.4 and 200 GeV at RHIC and comparison to models

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Motivation

- *p+p min bias distributions*

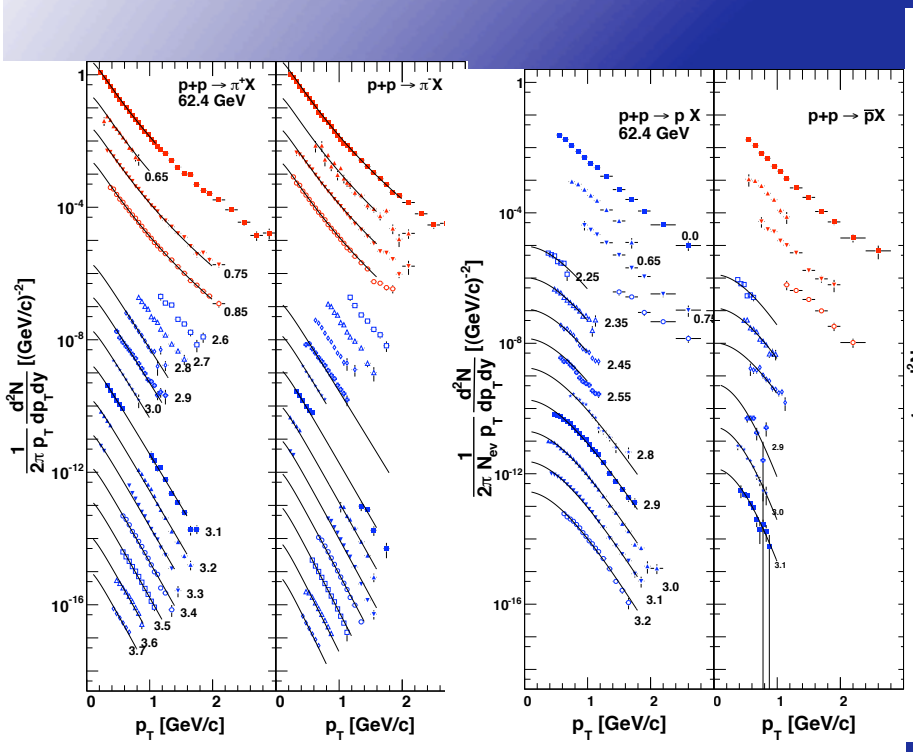
  Energy dependence of basic cross sections

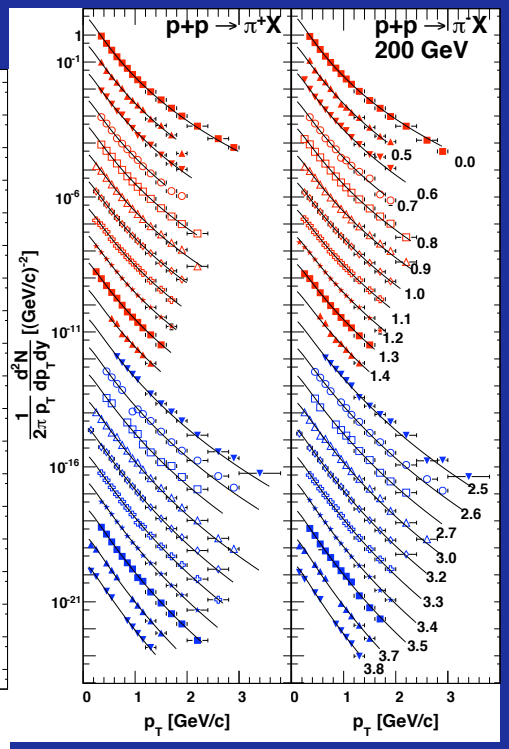
  Explore Data trends

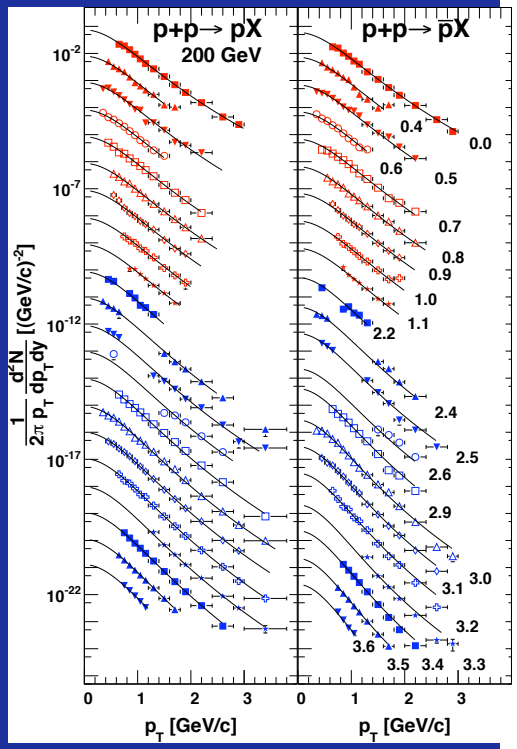
  Comparison data for Heavy Ion experiments
- *PYTHIA – Is often used as underlying description for HI event generators. Is this reasonable?*
- *pQCD – also basis for transverse spin modeling? Is it valid at high y (x_F)*

BRAHMS

Sample Spectra







$$\frac{1}{2\pi p_T}\frac{d^2N}{dy dp_T} = \frac{1}{2\pi}\frac{dN}{dy}\frac{(n-1)(n-2)}{nT(nT+m_0(n-2))} \times \left(1+\frac{(m_T-m_0)}{nT}\right)^{-n}$$

- Functional form that of Levy (Tsallis)
- Thermal at low p_T, power-law at high.

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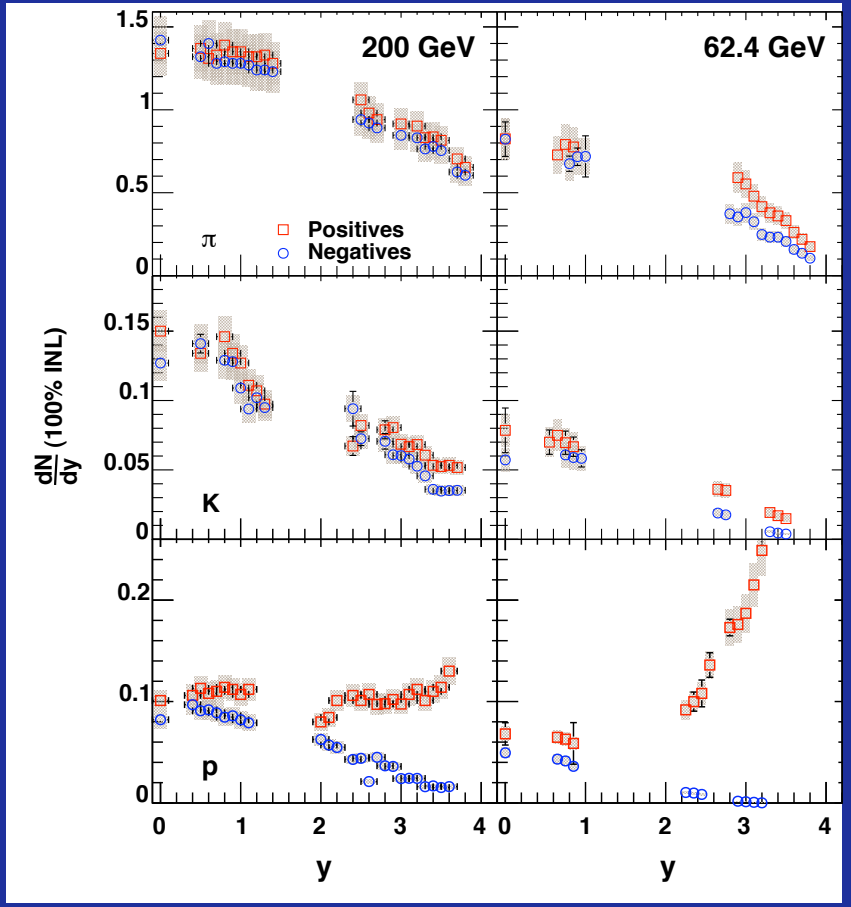
Rapidity Densities

- Extrapolate to unmeasured region using fct form.
- Uncertainties are fairly large for pions
- <pt> yield coverage.
  - Lowest pt 300-400 MeV/c
  - P 60-80%
  - Pi 40-60%
- Overall normalization error is ~15% from Vernier scan and simulations These are not correlated between the two energies



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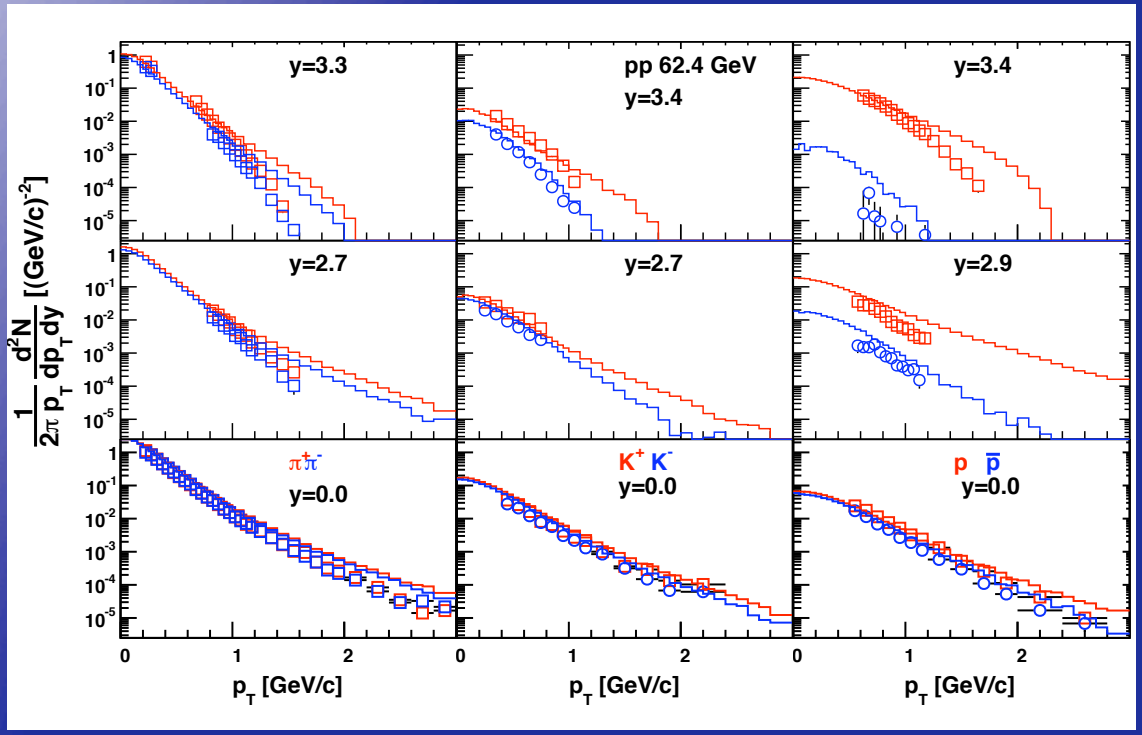
62.4 GeV



These are for tune perugi0 (320).Agreement for pions and kaons is satisfactory, but not for protons.

Default tune and Tune A that described CDF-RHIC at y~0 well give similar description

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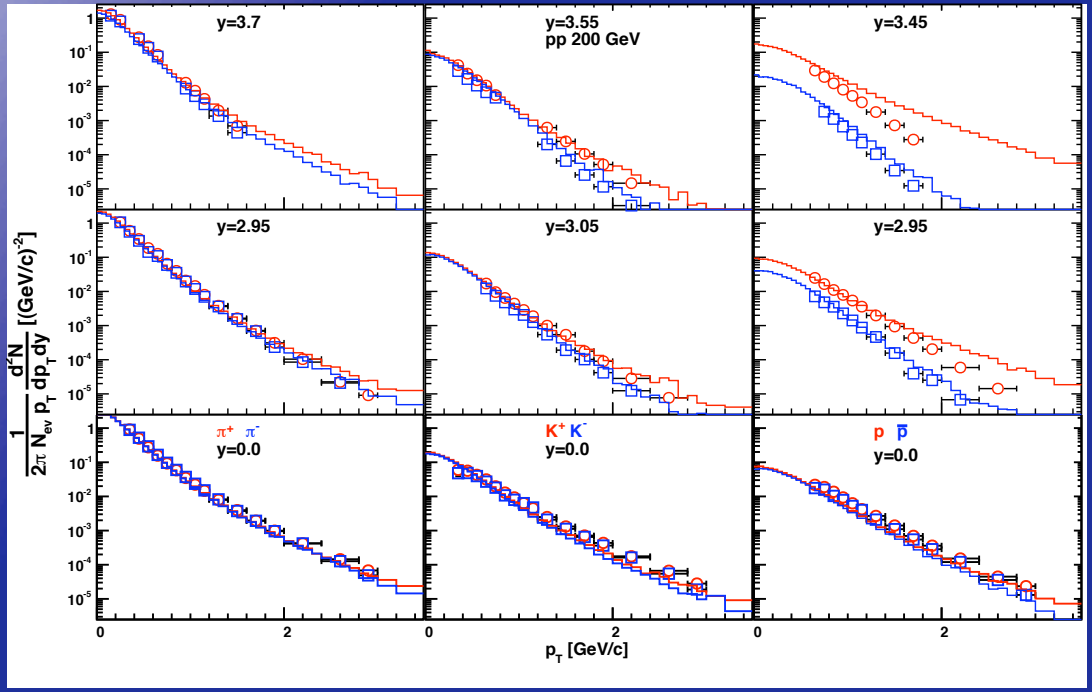
200 GeV



Comparison to PYTHIA 6.421 calculations. Many tunes, here shown Perugia 0) gives reasonable description of pions and kaons at y~0 and high y.

P and p-bar is a different matter.

Some tunes exhibit too hard spectra (321,322) as well a bad flavor seperation (pi+,pi- and K+,K- (too much)) at high rapidity particular.

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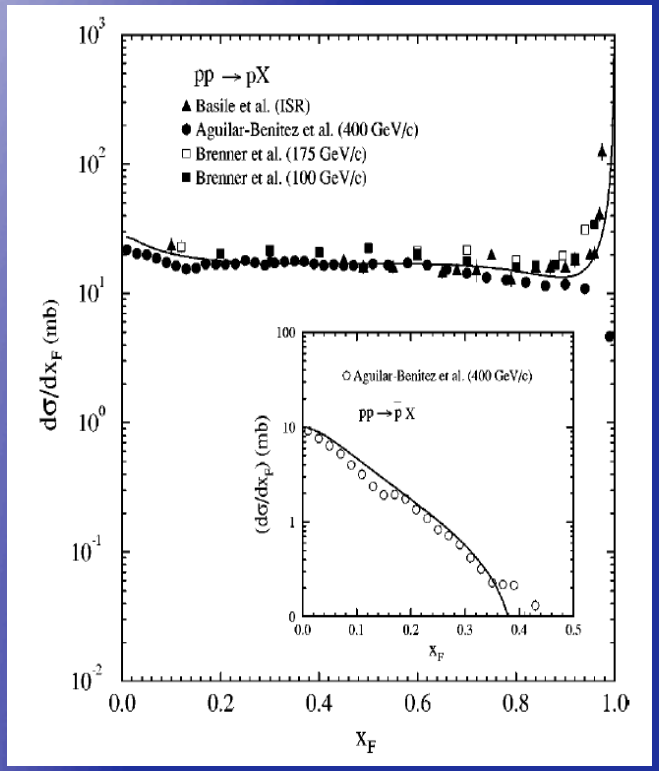
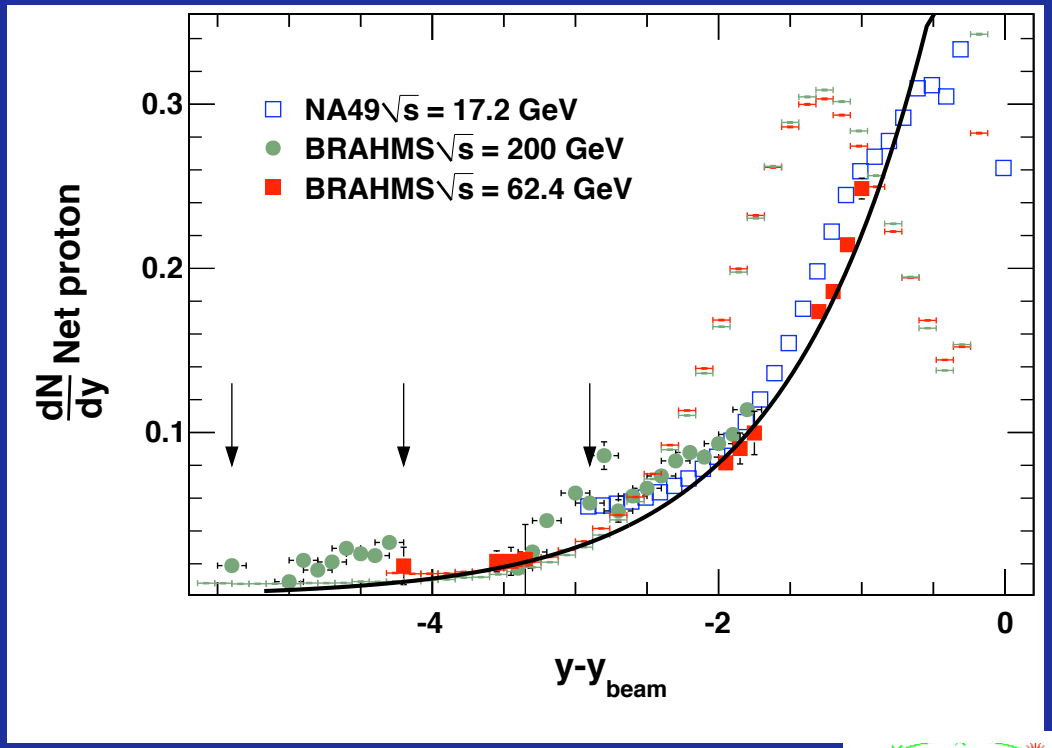
Net-proton Distributions

- Pion, kaon distribution exhibits longitudinal scaling. So do net-protons. There is no sign of additional baryon stopping from 17 to 200 GeV
- The Pythia model fails badly in describing net-p dN/dy.
- Data close to dn/dx~c. Other e.g. models HIJING ok for this.





pQCD

- Early BRAHMS measurements 200 GeV were published, comparing to mKKP. Since then data used for tuning DSS fragmentation functions (deFlorian, Sassot and Stratmann, PRD75,114010 (2007))
- Following slides compares to recent calculations by Werner Vogelsang for both 200 and 62.4 GeV

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PQCD 200 GeV

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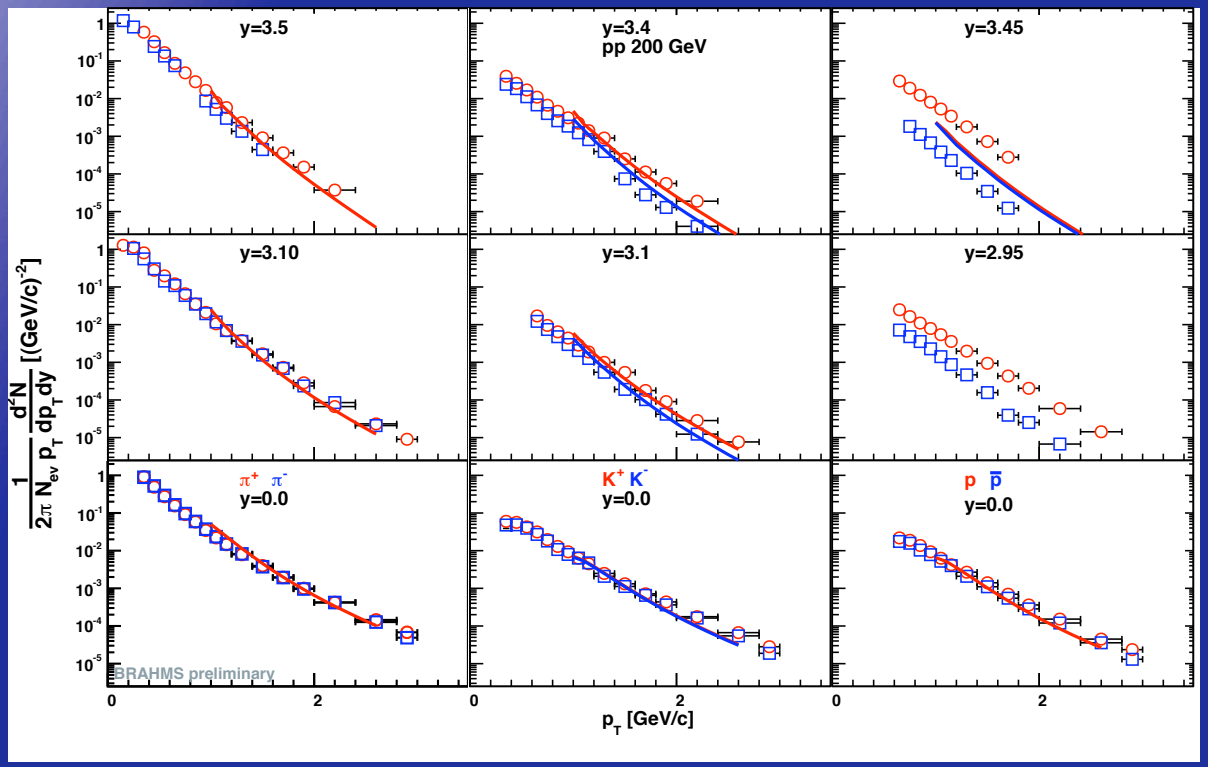
NLO calculations by Werner Vogelsang



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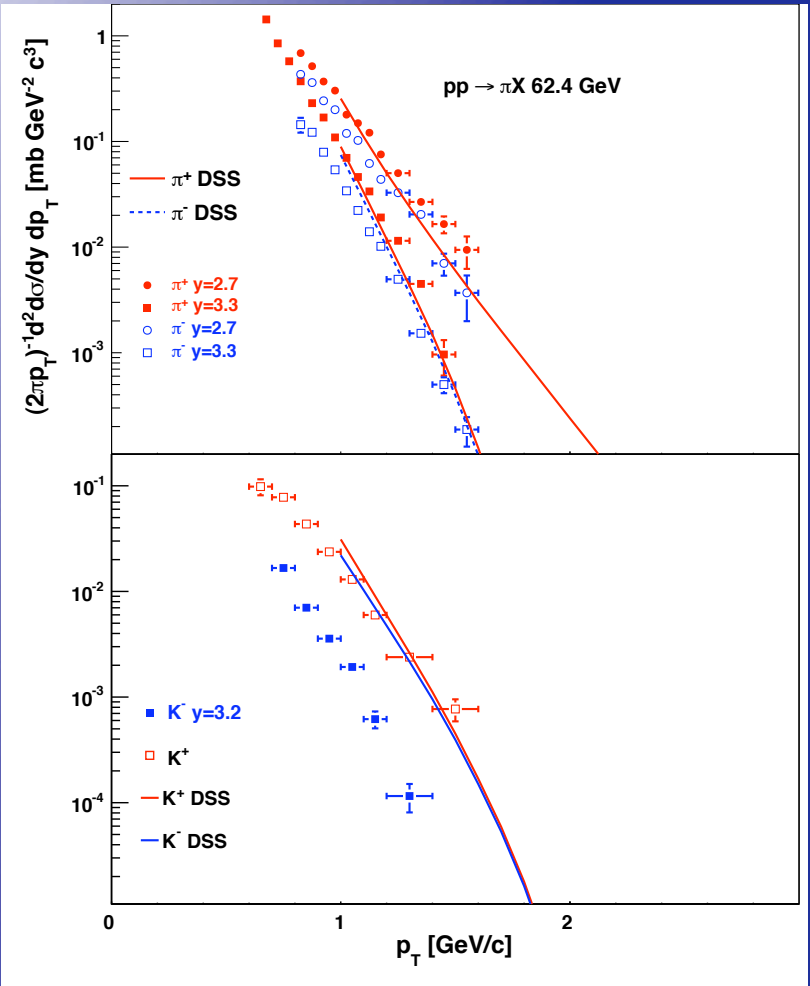
p+p 62 GeV



pQCD can describe magnitude at forward rapidities at lower energies

π^+ reasonable well described in magnitude

π^- ~ π^+ in disagreements with data.

The 62.4 GeV, magnitude of pion and Kaon production for the favored (π^+, and K+) also seems ok. The expected difference due to valence quark dominance i.e. difference between π^+, π^- and K+/K- is not observed. Failure in description of Dp(Z) at large z for DSS

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Take away message

- Large systematic data set is now available.
- Net proton rapidity distribution exhibits longitudinal scaling. Comparison from sqrt(s) 17 to 200 shows NO apparent new physics. Similar observations has come from ALICE using pbar/p ratios from ISR to LHC energies in pp.
- Comparisons to PYTHIA shows that min bias/ UE is not well described for most current tunes.
- NLO pQCD works for large rapidity range at 200 GeV, while flavor separation at lower energy fails in DSS fragmentation function.
- These studies are nearing completion and will be ready for publication soon.

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BACKUP
and Surplus slides

Collaboration

I.Arsene[7], I.G. Bearden[6], D. Beavis[1], S. Bekele[6] , C. Besliu[9], B. Budick[5],
H. Bøggild[6] , C. Chasman[1], C. H. Christensen[6], P. Christiansen[6], H.Dalsgaard, R.Debbe[1],
J. J. Gaardhøje[6], K. Hagel[7], H. Ito[10], A. Jipa[9], J. I. Jordre[9], E.B. Johnson[10],
C.E.Jørgensen[6], R. Karabowicz[3], N. Katryńska[3], E. J. Kim[4], T.M.Larsen[11], J. H. Lee[1],
Y. K. Lee[4], S.Lindal[11], G. Løvhøjden[2], Z. Majka[3], M. Murray[10], J. Natowitz[7], B.S.Nielsen[6],
C.Nygaard, D. Ouerdane[6],
D.Pald, R.Planeta[3], F. Rami[2], C. Ristea[6], O. Ristea[9], D. Röhrich[8],
S. J. Sanders[10], R.A.Sheetz[1], P. Staszel[3],
T.S. Tveter[11], F.Videbæk[1], R. Wada[7], H. Yang[6], Z. Yin[8], I. S. Zgura[9] ,V.Zhukova

[1]Brookhaven National Laboratory, USA,
[2]Institut Pluridisciplinaire Hubert Curien , Strasbourg, France
[3]Jagiellonian University, Cracow, Poland,
[6]Niels Bohr Institute, University of Copenhagen, Denmark
[7]Texas A&M University, College Station. USA, [8]University of Bergen, Norway
[9]University of Bucharest, Romania, [10]University of Kansas, Lawrence,USA
[11] University of Oslo Norway

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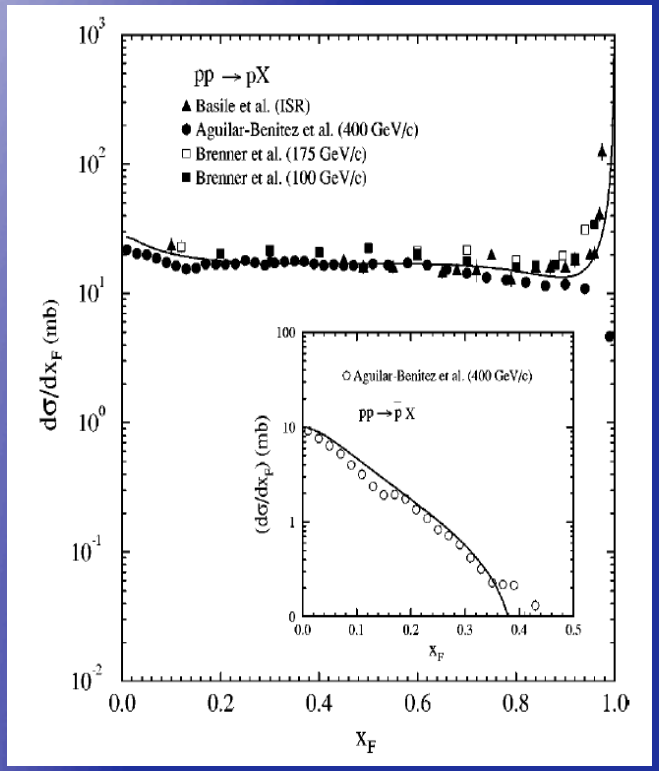
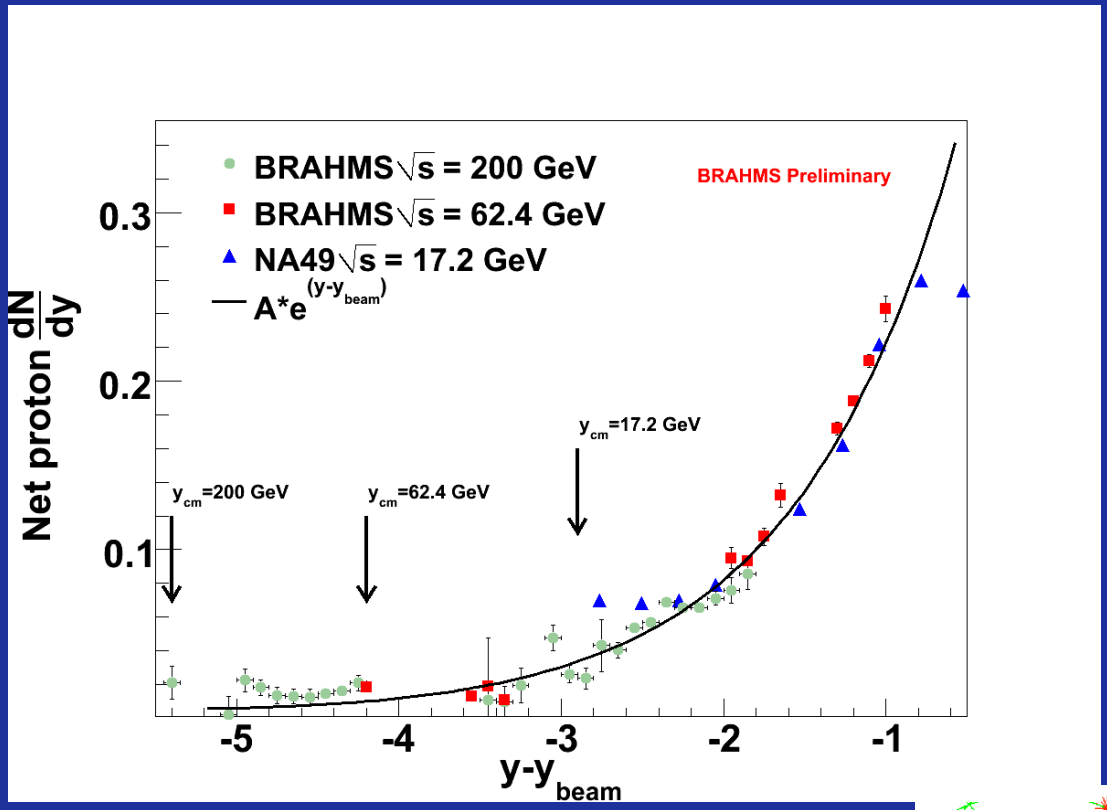
Scaling in pp

- pp collision at lower energies exhibits a feature where dN/dx~c with an integral of ~0.6-0.7
- This implies for constant $<m_T>$ vs. rapidity that dN/dy~ exp(-y)
- The present data confirms this behavior at 200 GeV





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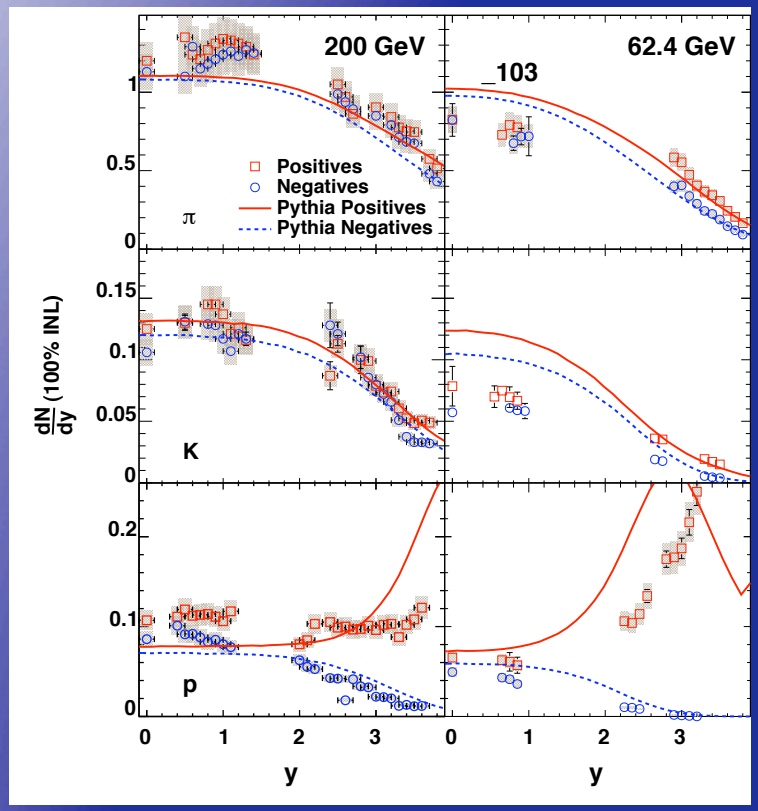
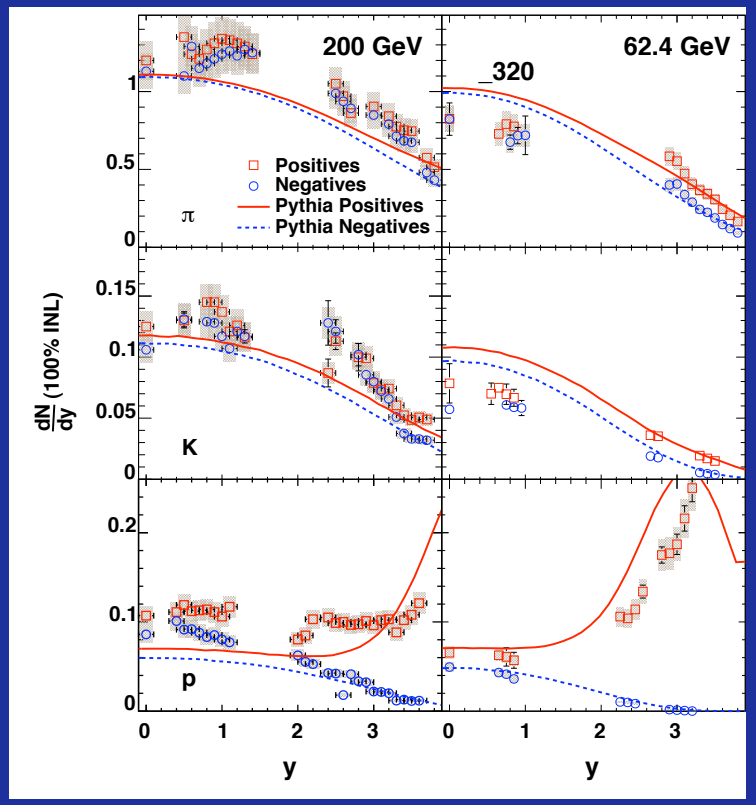
Pythia dN/dy comp.





BRAHMS

Peter Skands Pythia Tunes

Peter's Pythia Plots

February 2009 © P. Z. Skands

Navigate these pages by using the menu to the left. More plots will be added, as new tunes become available, and as the available data increases. The default for each topic is a comparison of a small number of tunes to available data (or just to each other if no data exists), but look for links at the top of each page for comparisons with more models.

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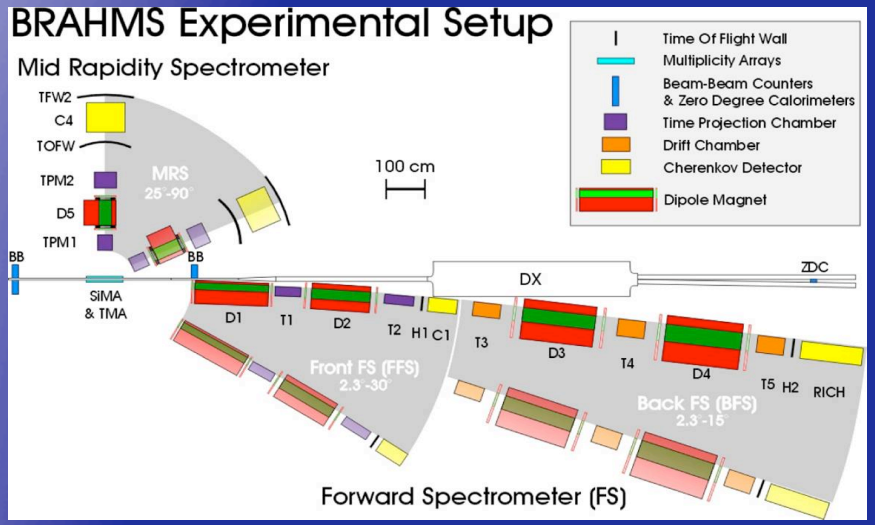
- http://home.fnal.gov/~skands/leshouches-plots/

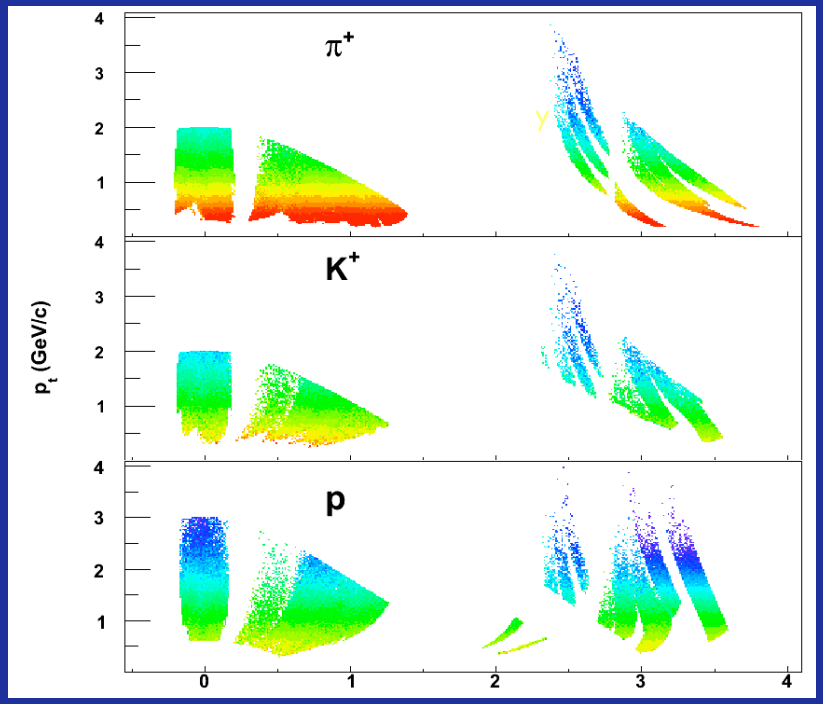
- *Conventional Spectrometers*
  - *Small solid angle, moveable*
  - *High resolution momentum determination*
  - *Excellent PID using TOF and RICH*

BRAHMS at RHIC completed in 2006

Heavy Ion Au+Au,Cu+Cu,d+Au, p+p 200, 62.4 GeV

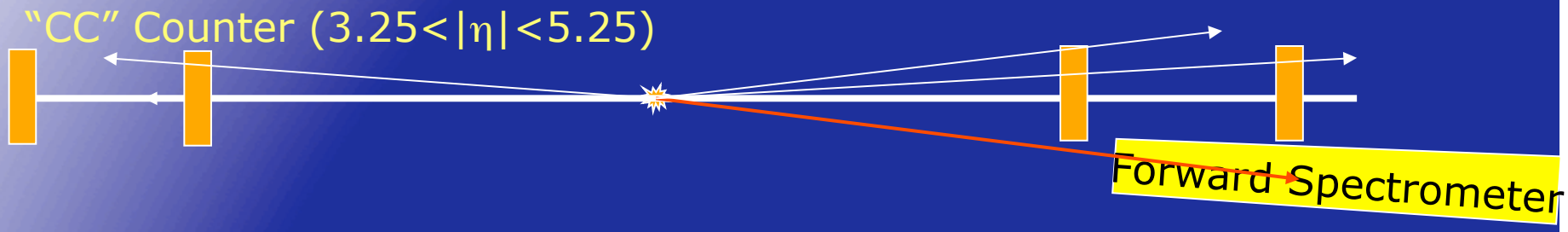
Transverse spin physics p+p 62.4 200 GeV





BRAHMS

Event Characterizations pp: Inelastic and NSD events



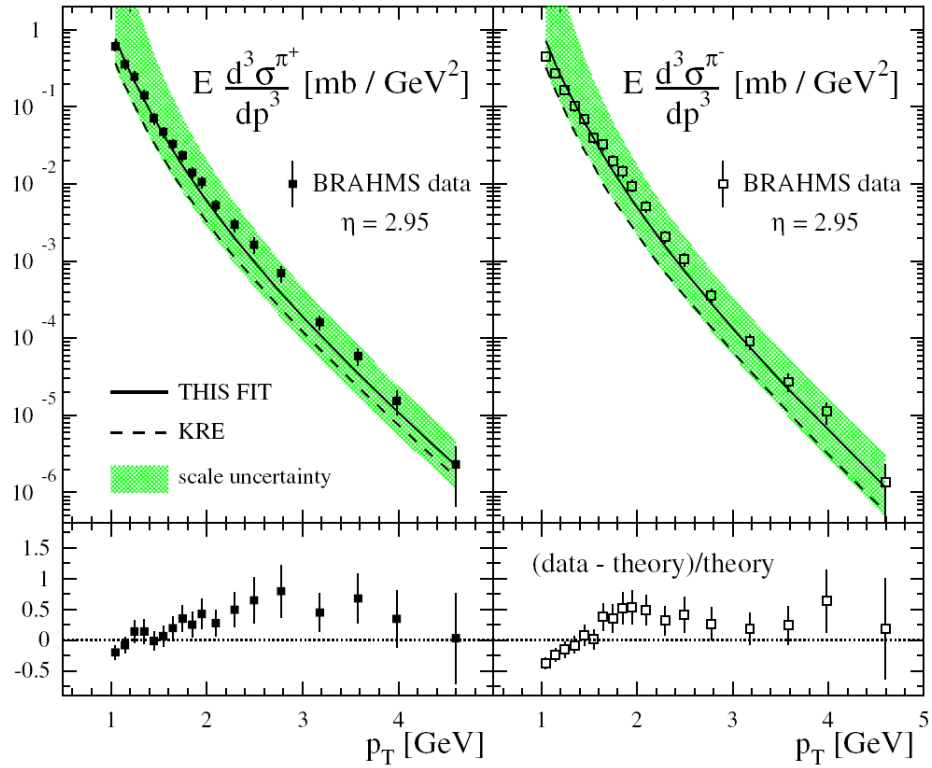
- Inelastic trigger requires a vertex reconstructed by "CC" counters (Cherenkov radiators) .CC events are a subset of NSD event class.
- Normalization done via Vernier scan
- σ_{CC} = 27 mb (200 GeV), 13 mb (62.4) GeV
- Spectrometer Events were triggered, and do not require CC coincidence.
- Ratio of events with and w/o CC is determined at both energies.

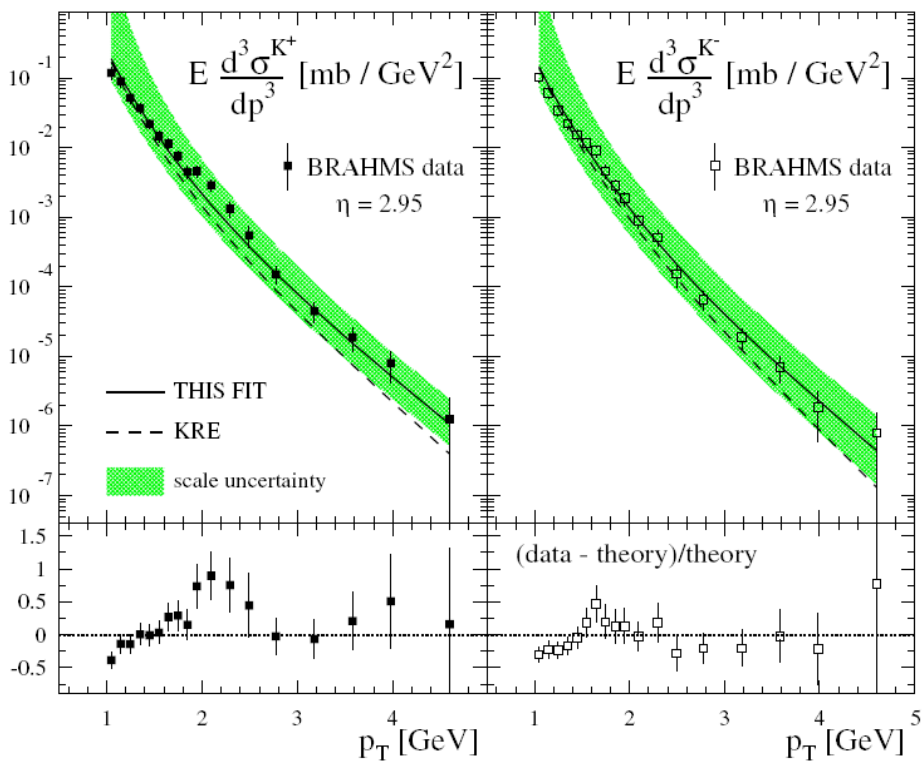
BRAHMS

Global fits to data including BRAHMS large rapidity data

DSS, PRD **75,** 114010 (2007)

Brahms data: PRL 98, 252001 (2007)





Recently deFlorian, Sassot and Stratman performed a global fit including new data from Brahms at high rapidity. PRD **75,** 114010 (2007)

- Charged separated fragmentation functions
- Fragmentation functions significantly constrained compared to previous "state of the art" when adding RHIC data into fits.

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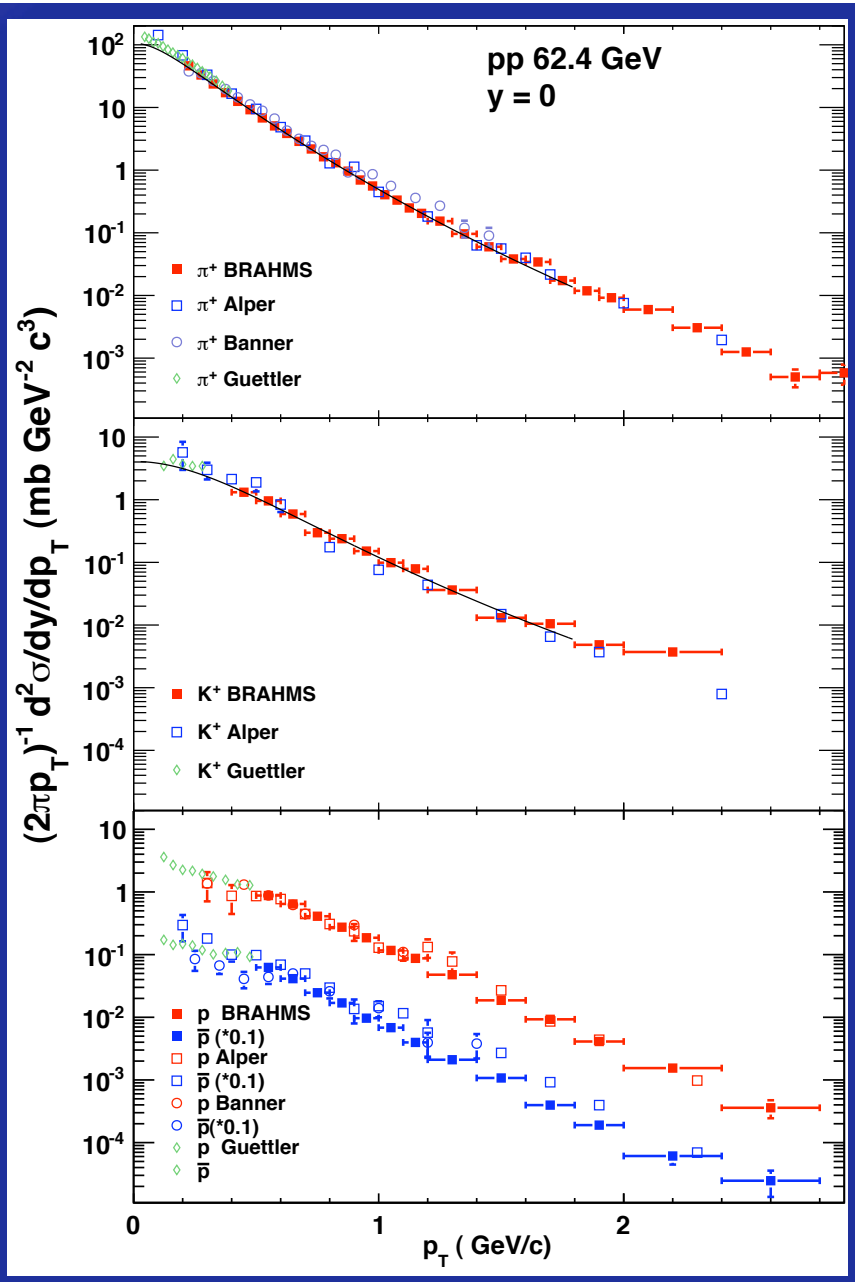
Comparisons to ISR at 62.4 GeV y~0



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Parameter	Type	S0A-Pro	P-0	P-HARD	P-SOFT	P-3	P-NOCR	P-X	P-6
MSTP(51)	PDF	7	7	7	7	7	7	20650	10042
MSTP(52)	PDF	1	1	1	1	1	1	2	2
MSTP(64)	ISR	2	3	3	2	3	3	3	3
PARP(64)	ISR	1.0	1.0	0.25	2.0	1.0	1.0	2.0	1.0
MSTP(67)	ISR	2	2	2	2	2	2	2	2
PARP(67)	ISR	4.0	1.0	4.0	0.5	1.0	1.0	1.0	1.0
MSTP(70)	ISR	2	2	0	1	0	2	2	2
PARP(62)	ISR	-	-	1.25	-	1.25	-	-	-
PARP(81)	ISR	-	-	-	1.5	-	-	-	-
MSTP(72)	ISR	0	1	1	0	2	1	1	1
PARP(71)	FSR	4.0	2.0	4.0	1.0	2.0	2.0	2.0	2.0
PARJ(81)	FSR	0.257	0.257	0.3	0.2	0.257	0.257	0.257	0.257
PARJ(82)	FSR	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
MSTP(81)	UE	21	21	21	21	21	21	21	21
PARP(82)	UE	1.85	2.0	2.3	1.9	2.2	1.95	2.2	1.95
PARP(89)	UE	1800	1800	1800	1800	1800	1800	1800	1800
PARP(90)	UE	0.25	0.26	0.30	0.24	0.32	0.24	0.23	0.22
MSTP(82)	UE	5	5	5	5	5	5	5	5
PARP(83)	UE	1.6	1.7	1.7	1.5	1.7	1.8	1.7	1.7
MSTP(88)	BR	0	0	0	0	0	0	0	0
PARP(79)	BR	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
PARP(80)	BR	0.01	0.05	0.01	0.05	0.03	0.01	0.05	0.05
MSTP(91)	BR	1	1	1	1	1	1	1	1
PARP(91)	BR	2.0	2.0	1.0	2.0	1.5	2.0	2.0	2.0
PARP(93)	BR	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
MSTP(95)	CR	6	6	6	6	6	6	6	6
PARP(78)	CR	0.2	0.33	0.37	0.15	0.35	0.0	0.33	0.33
PARP(77)	CR	0.0	0.9	0.4	0.5	0.6	0.0	0.9	0.9
MSTJ(11)	HAD	5	5	5	5	5	5	5	5
PARJ(21)	HAD	0.313	0.313	0.34	0.28	0.313	0.313	0.313	0.313
PARJ(41)	HAD	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49
PARJ(4		PS, Proceedings of the Perugia MPI Workshop 2008						1.2	1.2
PARJ(46)	HAD	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
PARJ(47)	HAD	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

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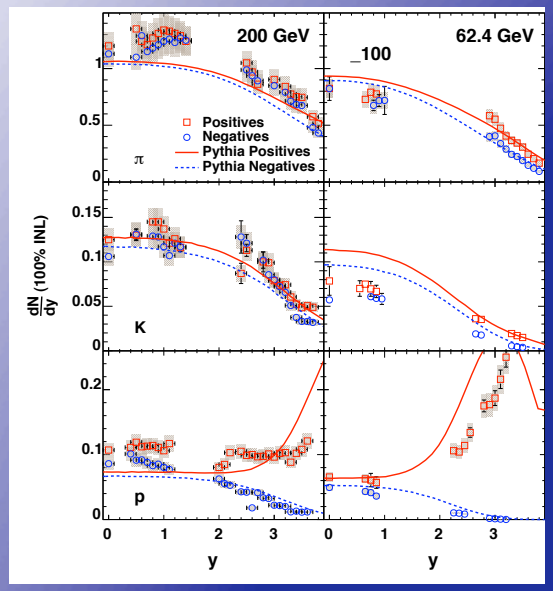
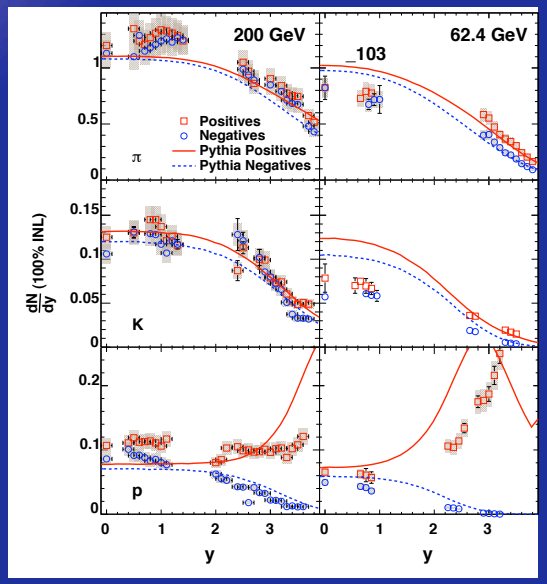
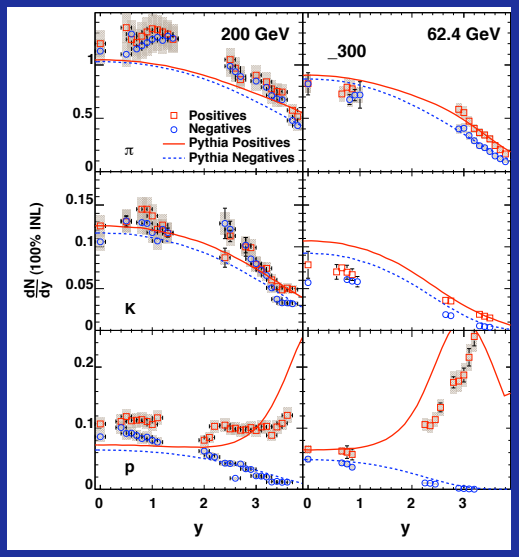
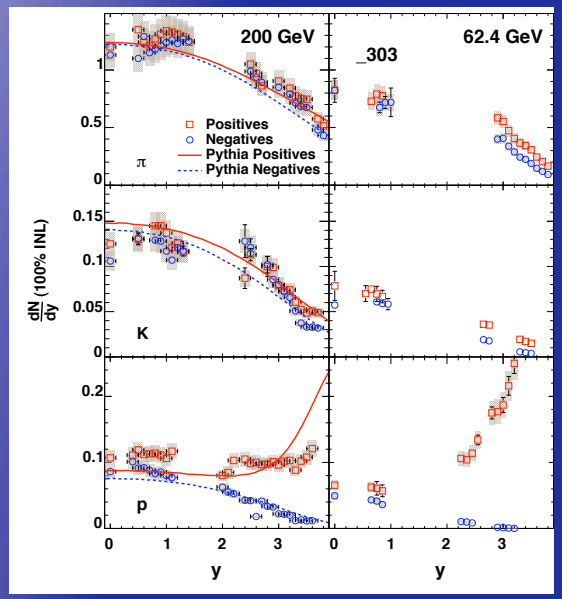
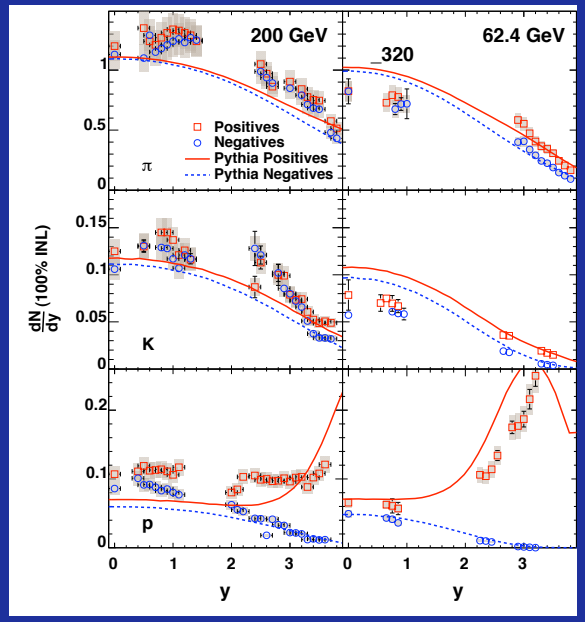
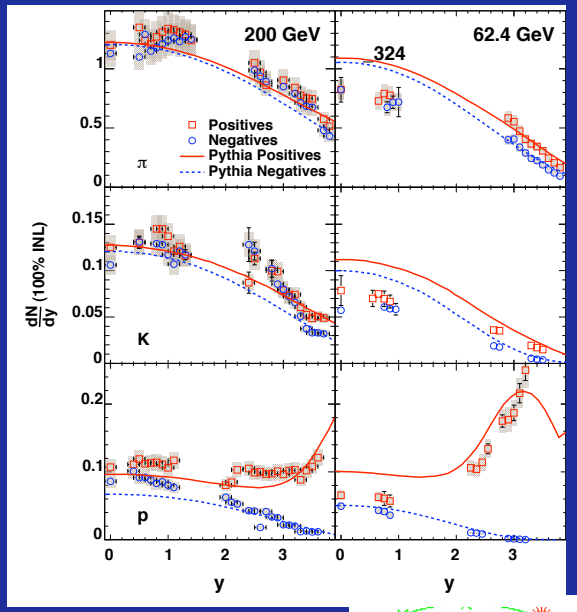

200 GeV
_100
62.4 GeV
Positives
Negatives
Pythia Positives
Pythia Negatives
π
K
p
dN/dy (100% INL)
y


200 GeV
_103
62.4 GeV
Positives
Negatives
Pythia Positives
Pythia Negatives
π
K
p
dN/dy (100% INL)
y


200 GeV
_300
62.4 GeV
Positives
Negatives
Pythia Positives
Pythia Negatives
π
K
p
dN/dy (100% INL)
y


200 GeV
_303
62.4 GeV
Positives
Negatives
Pythia Positives
Pythia Negatives
π
K
p
dN/dy (100% INL)
y


200 GeV
_320
62.4 GeV
Positives
Negatives
Pythia Positives
Pythia Negatives
π
K
p
dN/dy (100% INL)
y


200 GeV
324
62.4 GeV
Positives
Negatives
Pythia Positives
Pythia Negatives
π
K
p
dN/dy (100% INL)
y

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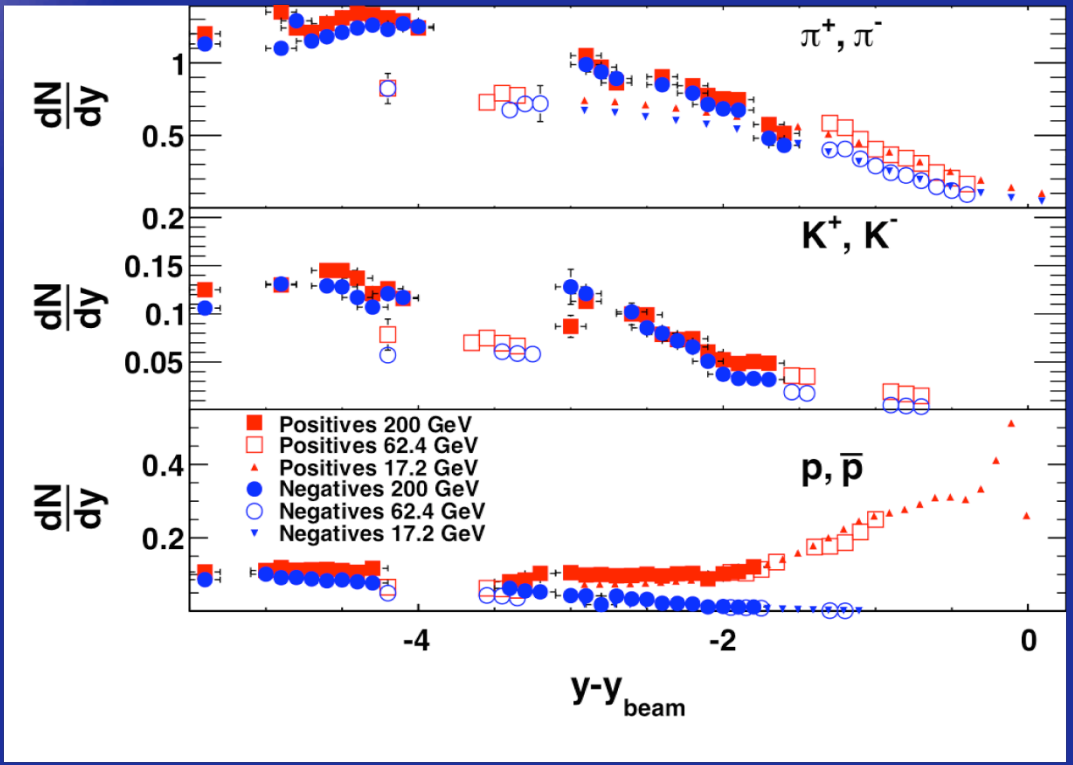
Longitudinal Scaling

- Our 62.4 and 200 GeV data together with NA49 from 17.2 GeV (pi,p) allows to explore the idea of longitudinal scaling $y'=y-y_{beam}$



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Another view on this

Convert Net-p to Net-baryon distribution, assuming

$$\frac{dN_{B-\bar{B}}}{dy} = \frac{dN_{p-\bar{p},meas}}{dy}\,\frac{n_p + n_n + n_\Lambda}{n_p + c_1 n_\Lambda}$$

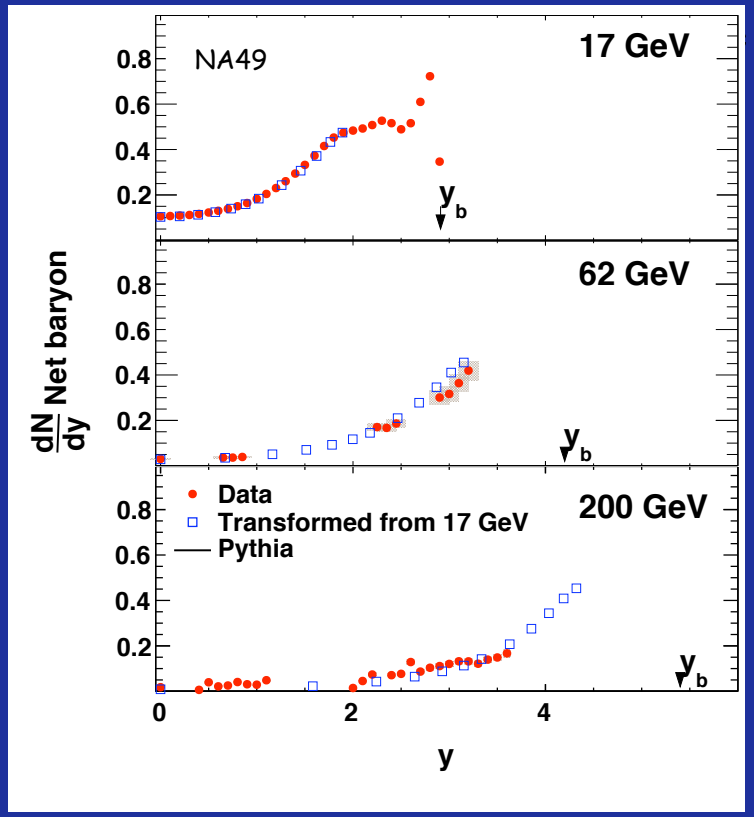
NA49 has very precise Net-proton distribution vs y,xfF.

Assume dn/dx is same at higher enegies.Convert dn/dx at 62 and 200 to dn/dy

Compare to BRAHMS Data.

The re is no indication of change in net-baryoan distributions

in p+p p to 200 GeV (junctions,…)



Pythia Summary

- Tunes commonly used to describe Tevatron and by now mid-rapidity 200 GeV data have been investigated. Note that these data are min bias, and not underlying event (UE) data.
- No tunes describes the dn/dy and pt-spectra of pi,K, and proton, p-bar
- The tunes related to 'best' CDF-RHIC does a fair job on the pion, and kaon (flavour separation) and pt dep at 200 GeV.
- The energy dependence down to 62.4 fails to describe the pion, kaon yield (too weak dependence)
- Some tunes clearly gives a too small pion yield at 200. tunes derived from CDF A in general does better
- ALL tunes fails badly in describing dn/dy for net protons, or alternative dN/dx. Such information has generally not been part of considering min bias events.

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Comments on pQCD

- There has always been doubts to what degree pQCD can describe forward rapidities at lower energies (ISR,RHIC)
- 200 GeV seems well with flavor separation, with new DSS FF for π and K.
- The 62.4 GeV, magnitude of pion and Kaon production for the favored (π^+, and K+) also seems ok. The expected difference due to valence quark dominance i.e. difference between π^+, π^- and K+/K- is not observed. Failure in description of Dp(Z) at large z for DSS

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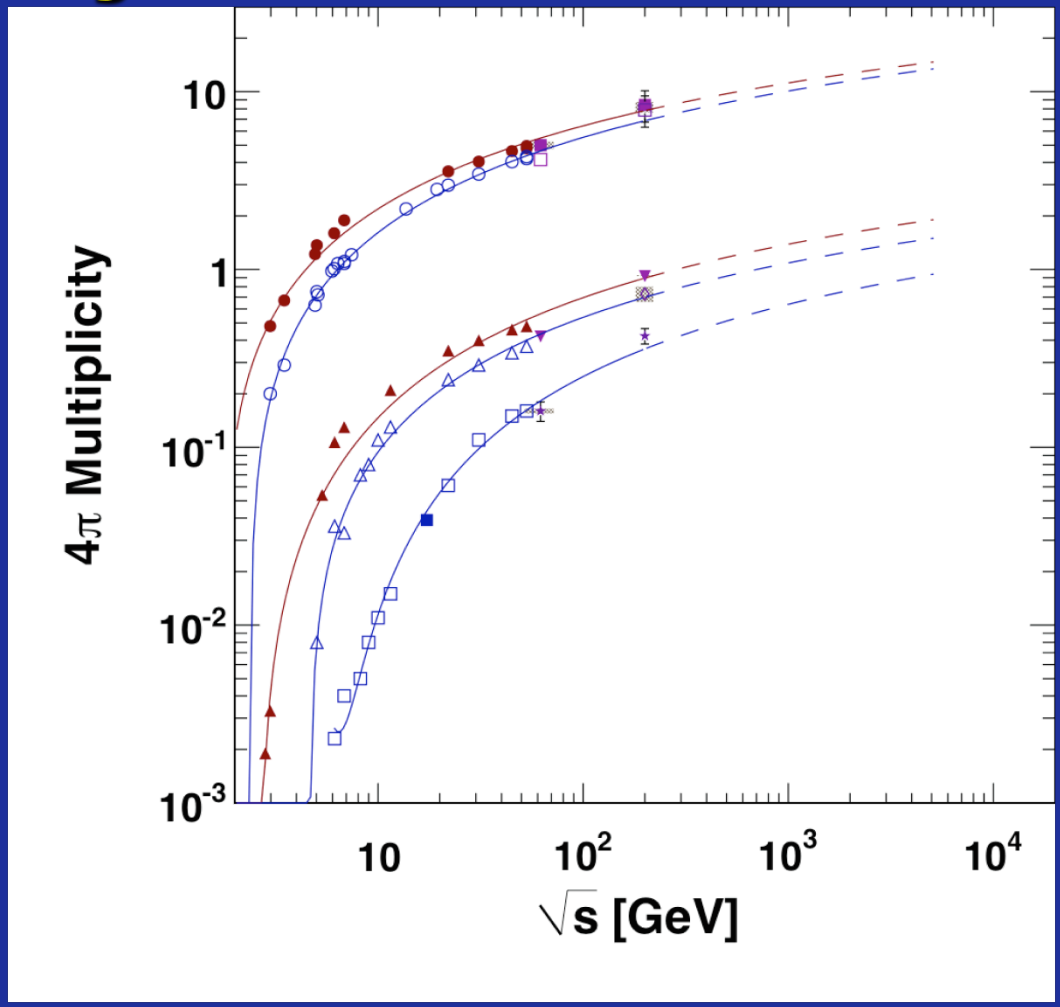
4pi yields

BRAHMS 200 GeV data allows to extrapolate to 4pi yields assuming Gaussian distributions.



M.Antinucci, Lett.Nuovo Cimento 6,121

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