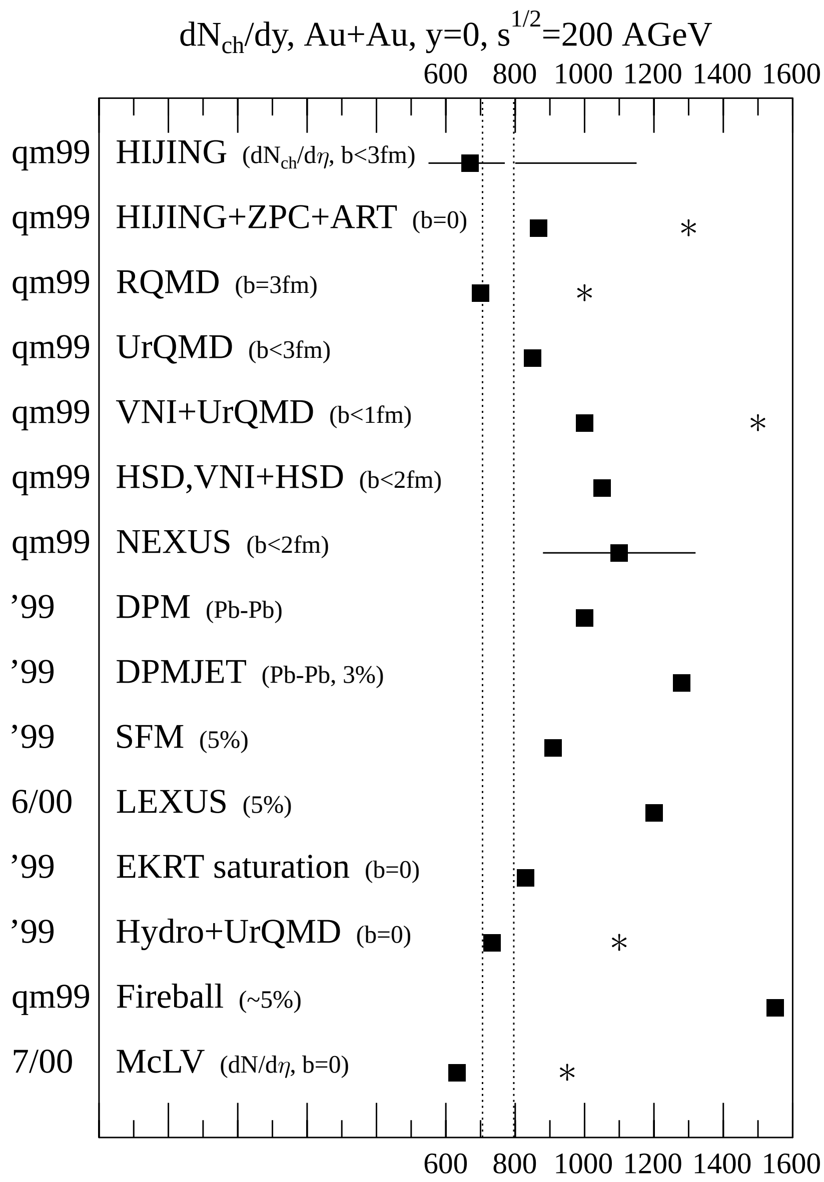
Charged Particle Multiplicity at Mid-Rapidity in Au-Au Collisions at RHIC

David Silvermyr
Div. of Cosmic and Subatomic Physics
Lund University

Outline

- Predictions for $dN_{ch}/d\eta$ at mid-rapidity
- Detectors used in this analysis
- Multiplicity analysis @ 130 GeV
- Energy scaling of charged particle multiplicities, from AGS to RHIC
- Multiplicity results @ 200 GeV, predictions for LHC.

dN$_{ch}$/dy Predictions



Charged particle multiplicity at midrapidity is an essential global variable for characterizing high-energy heavy-ion collisions.

Before data-taking the range in predictions was large..

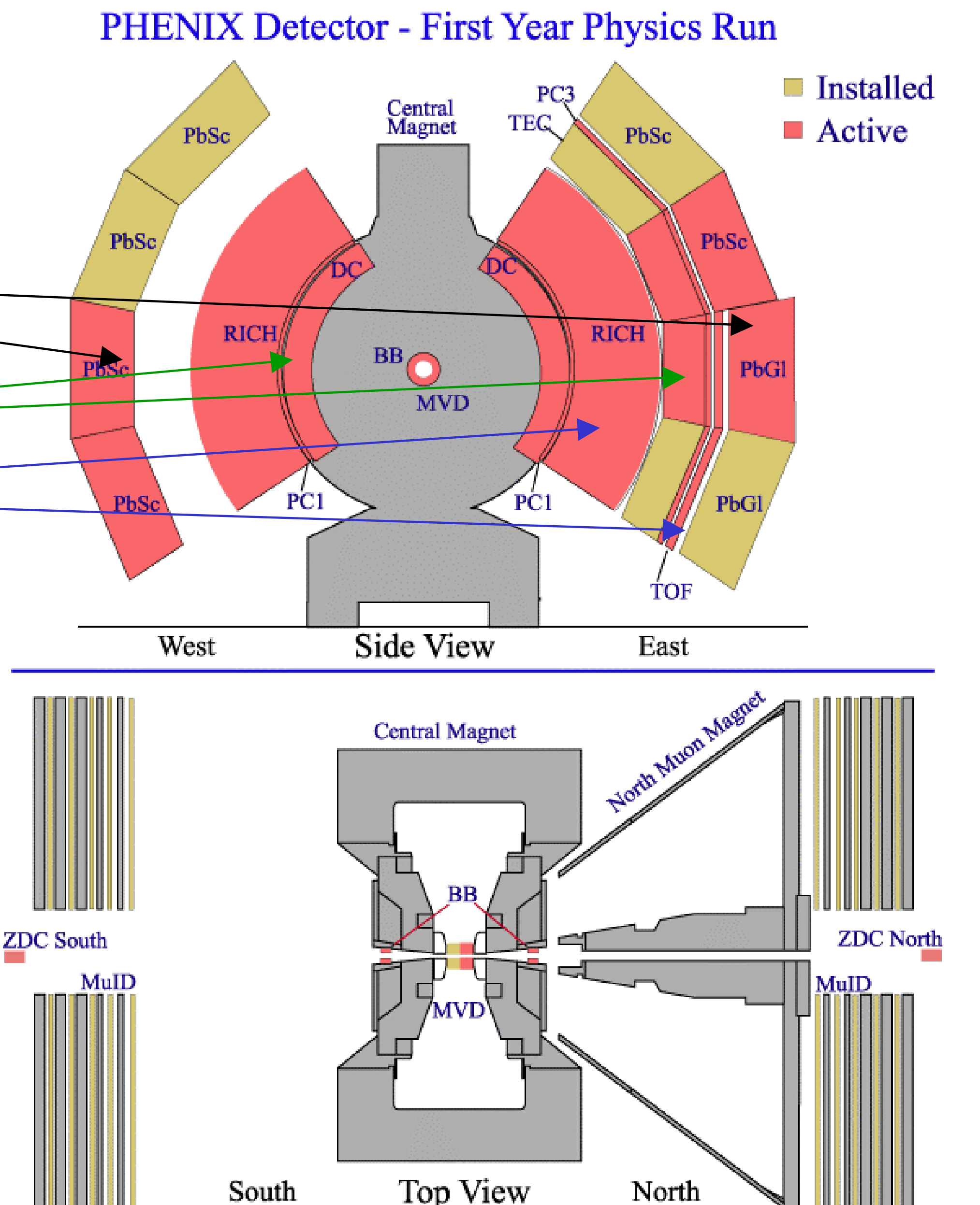
Year 2000 Configuration

Calorimetry -
Pb-glass, Pb-scint.

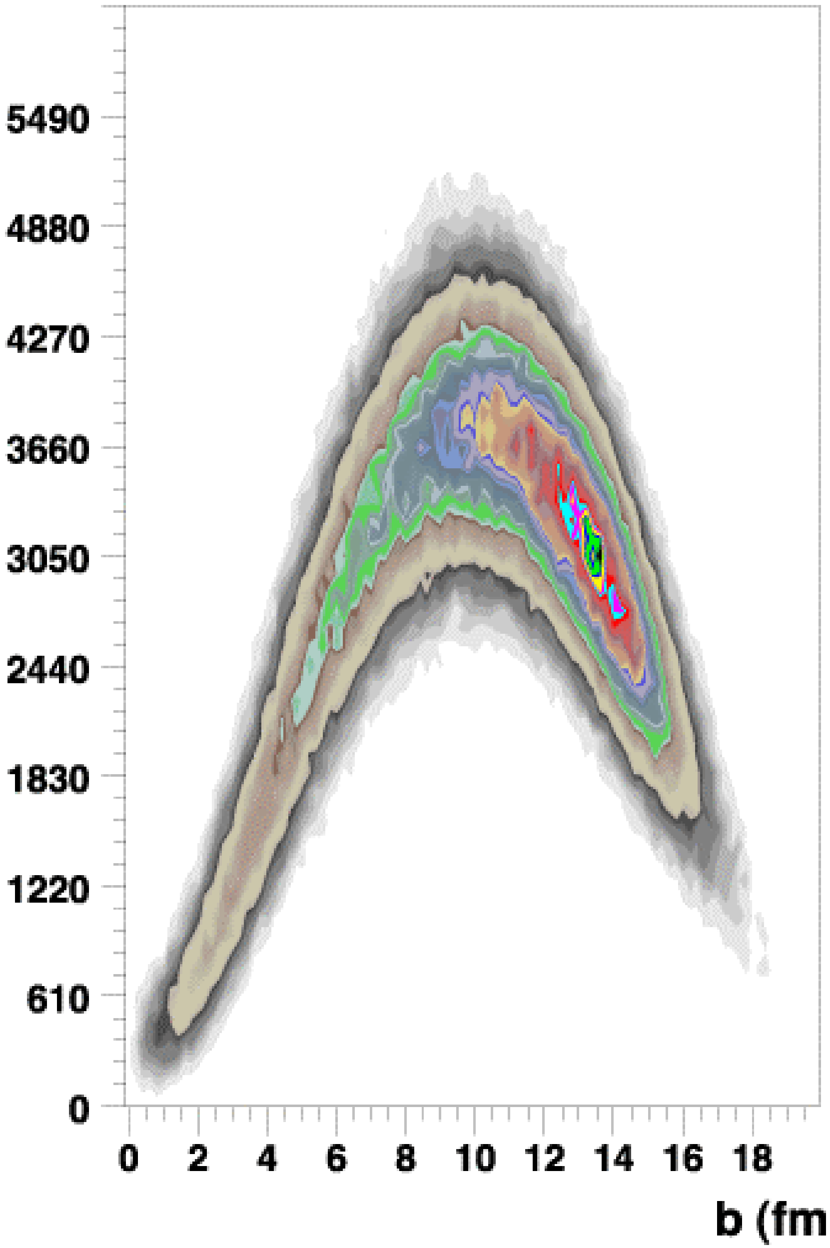
Tracking
Drift, Pad, Time Exp.

PID - RICH, TOF

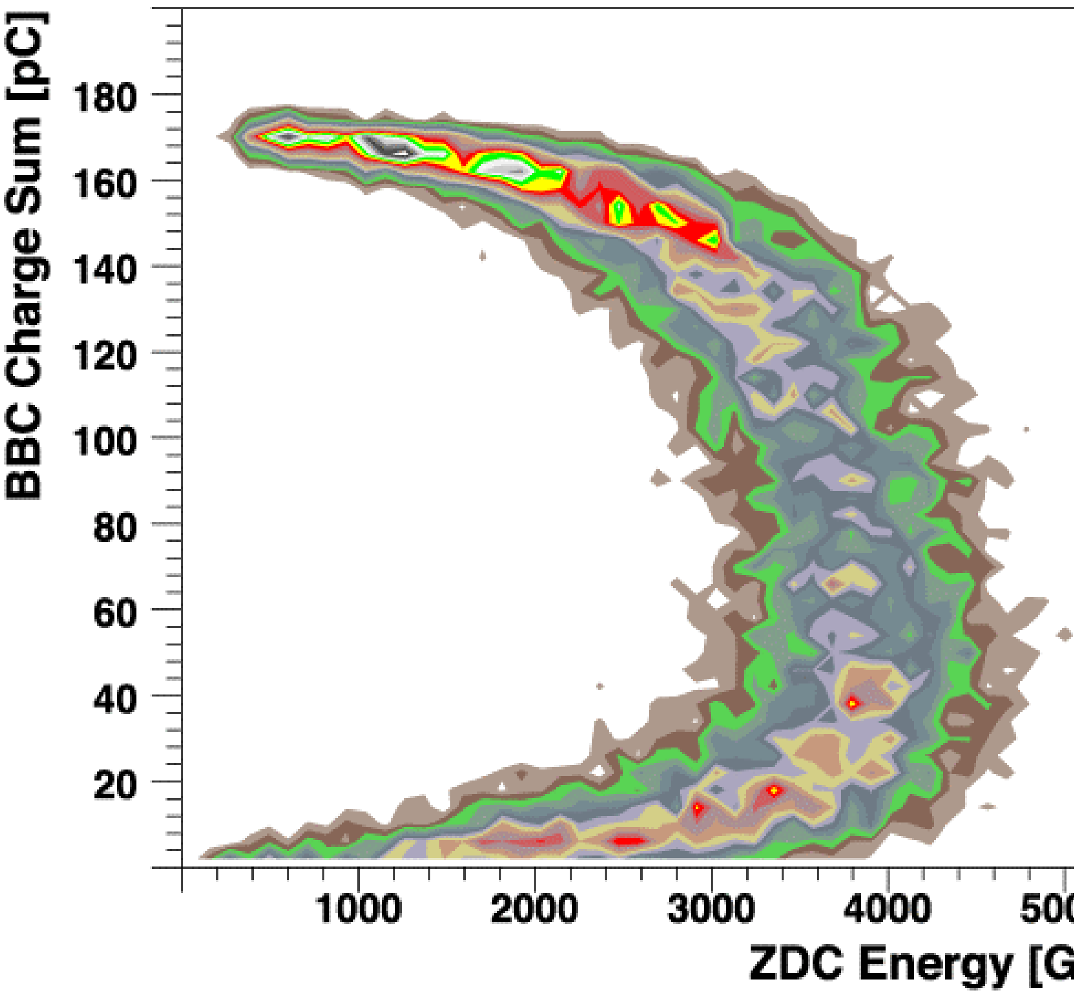
Global - MVD, Beam-Beam, Zero-Deg.



rigger



Glauber model reproduces ZDC spectrum reasonably, which gives a possibility to estimate # of participant nucleons.



he Pad Chambers in PHENIX

Three layers: **PC1**, **PC2** and **PC3**.
rovide 3D coord. for charged tracks
n field-free

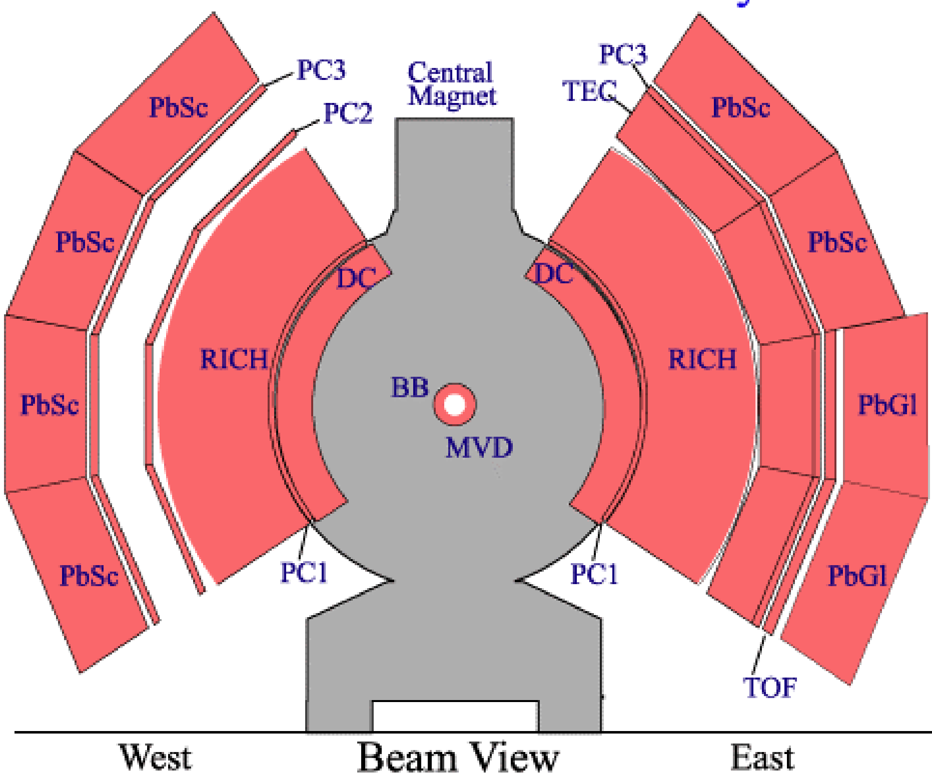
Ensure reliable pattern recognition
n the high-multiplicity environment.

MWPC with a total of 172 800
es/No readout channels.

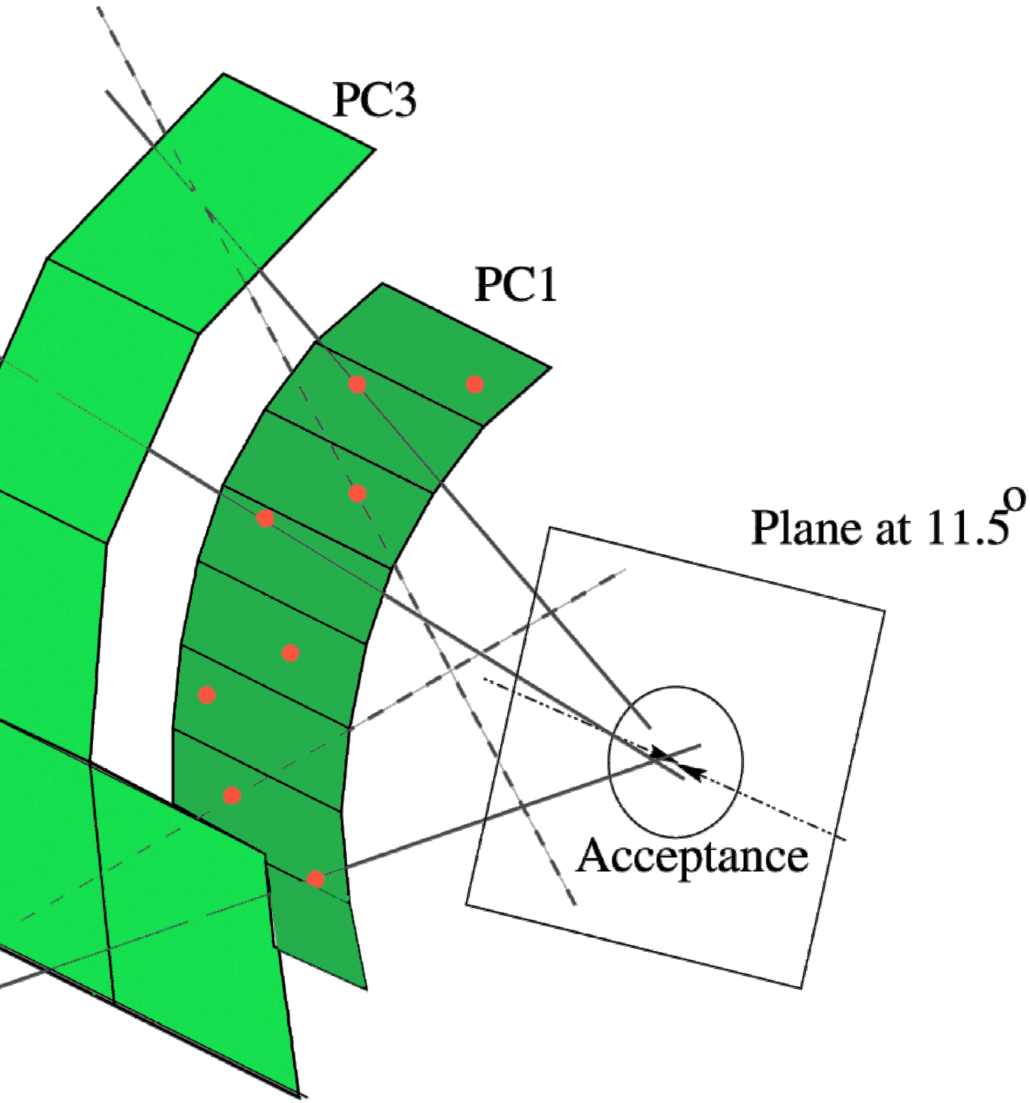
88 m^2 total active detector area.

BNL - Lund University - McGill University -
ORNL - Stony Brook - Vanderbilt University -
Weizmann Institute

PHENIX Detector - Second Year Physics Run



Hit Matching Procedure



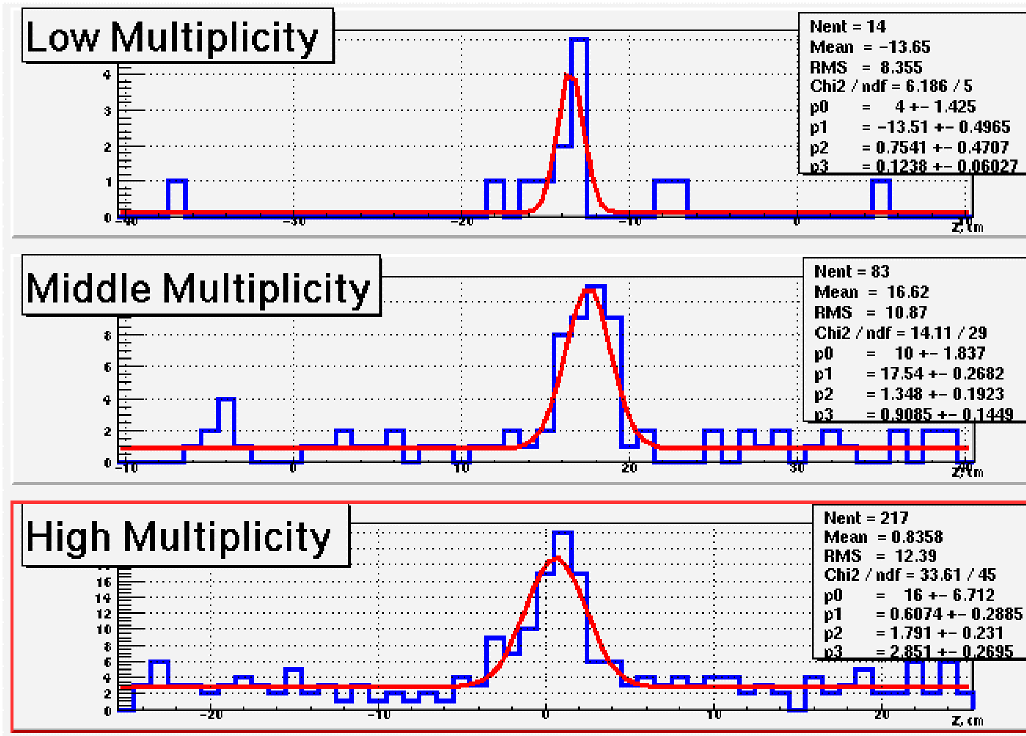
The analysis presented here was performed with field off runs only and using PC1 and PC3 in the East arm. (For year-2: also West arm)

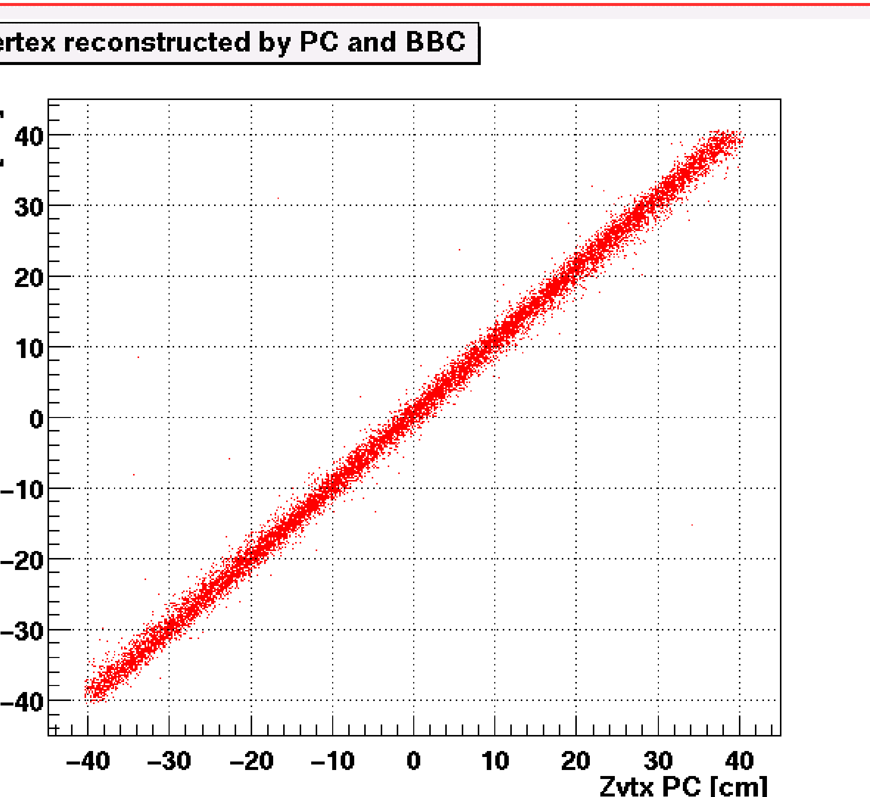
The background contribution is determined by a mixed event technique of exchanging each PC1 sector with its neighbour.

Vertex reconstruction is done by PC/BBC.

Vertex Reconstruction

he vertex position is determined by
- Combining all PC1 and PC3 hits to lines
- Project the lines to the plane and save all within an appropriate X and Y window.
- Calculate the peak position of the Z distribution.

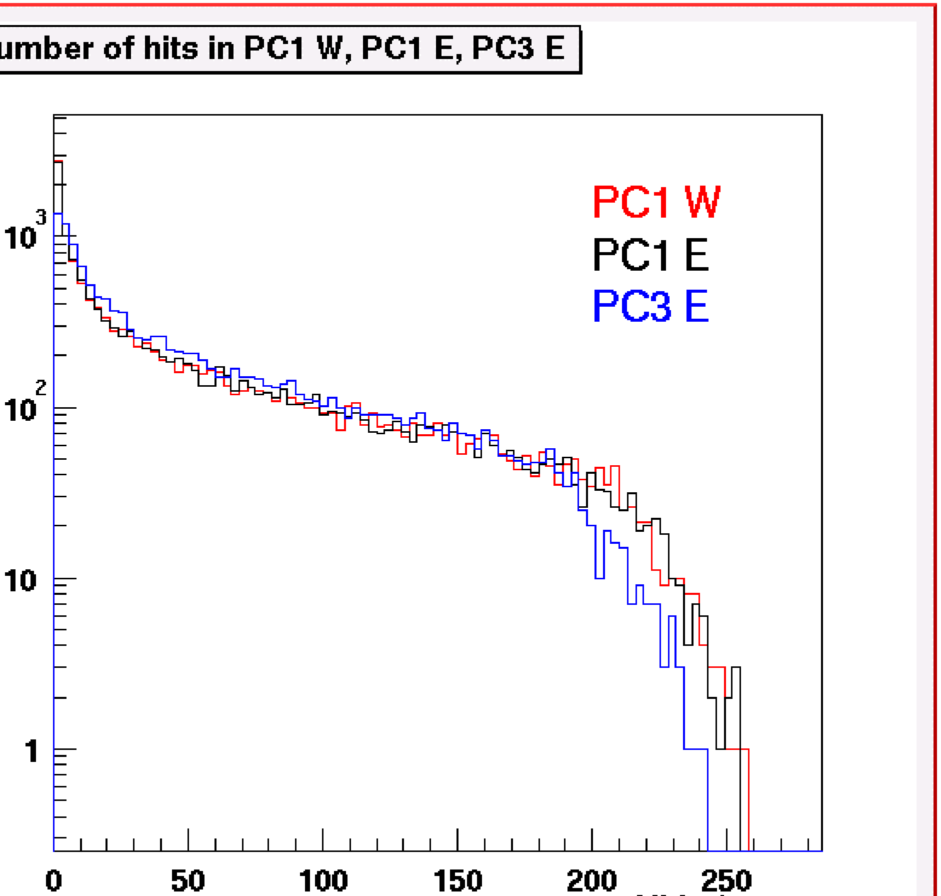


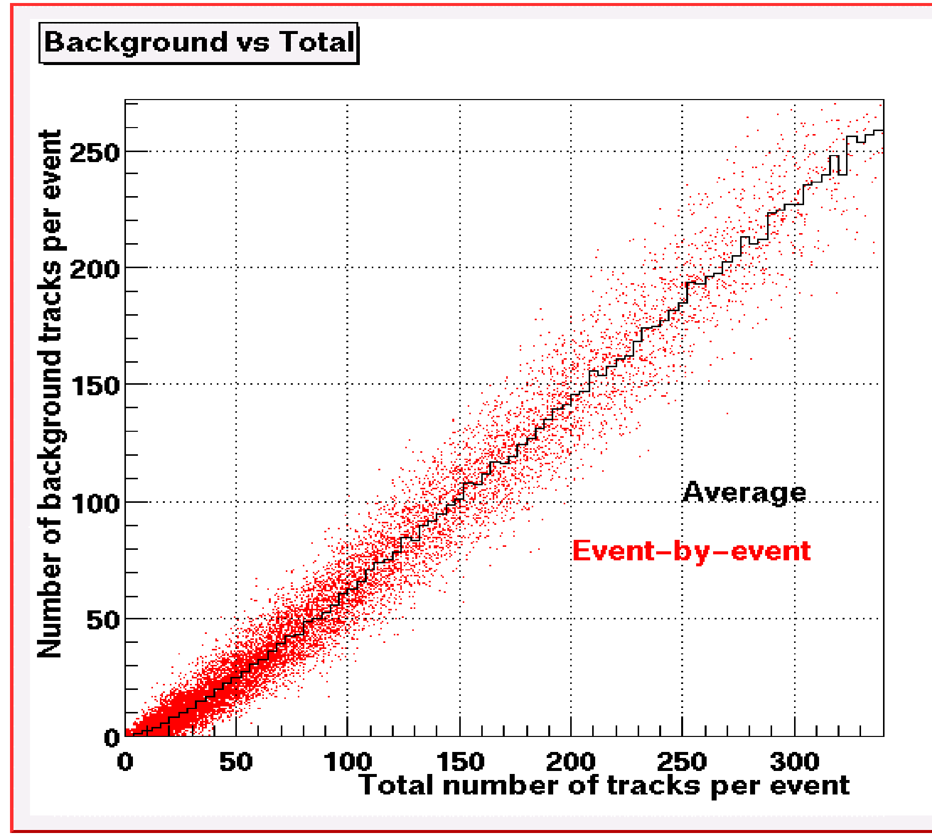


The vertices found by PC and BBC agree nicely. By repeating the procedure with a tighter cut placed around the found vertex, one can estimate the number of tracks in the collision.

Raw Multiplicity Distributions

The number of hits in PC1 W, PC1 E and PC3 E are very similar. Differences from the expected are due to less geometrical active area coverage in PC3.



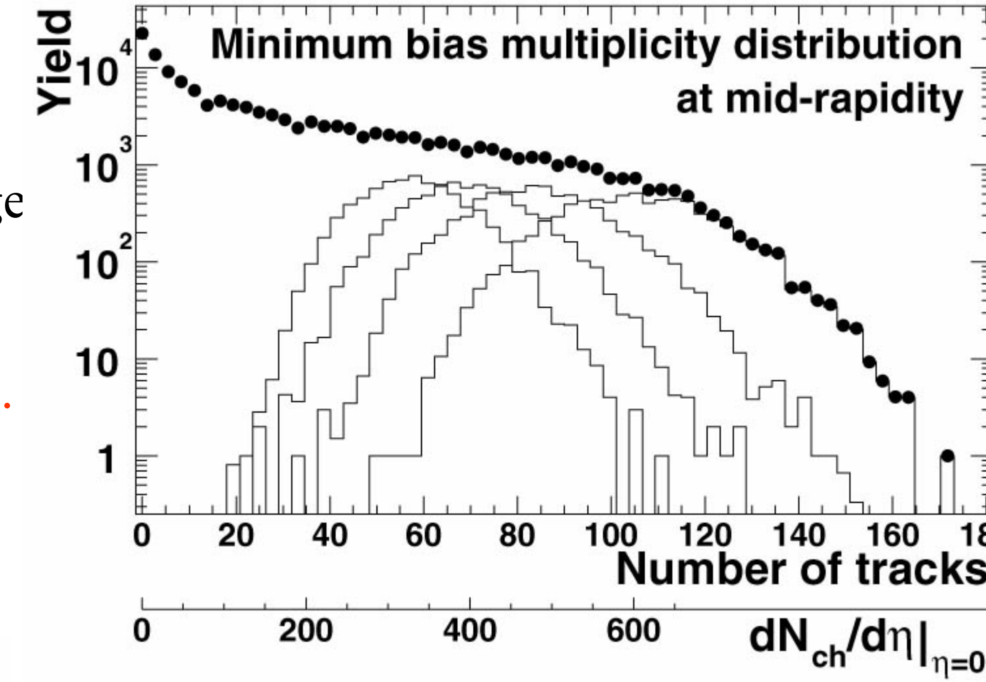


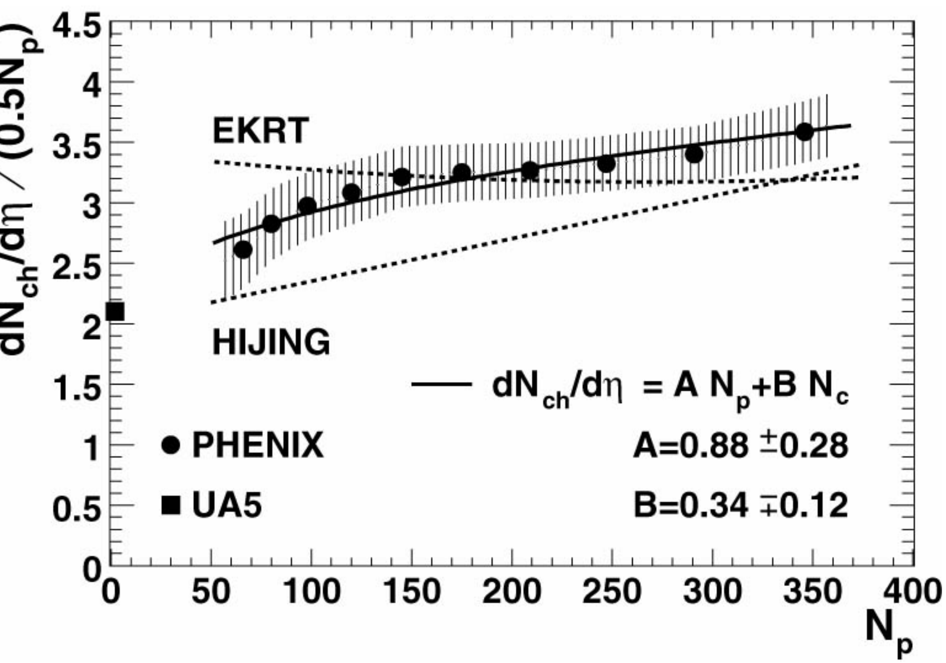
The number of background tracks dependence on the total number of tracks agree with expectations from first principles.

Multiplicity distribution @ 130 GeV

Distribution has been scaled by the known correction factors, to correspond to a coverage of ± 0.5 in η and 2π in φ.

Width of high N_{ch} roll-off is a function of e.g. finite aperture.





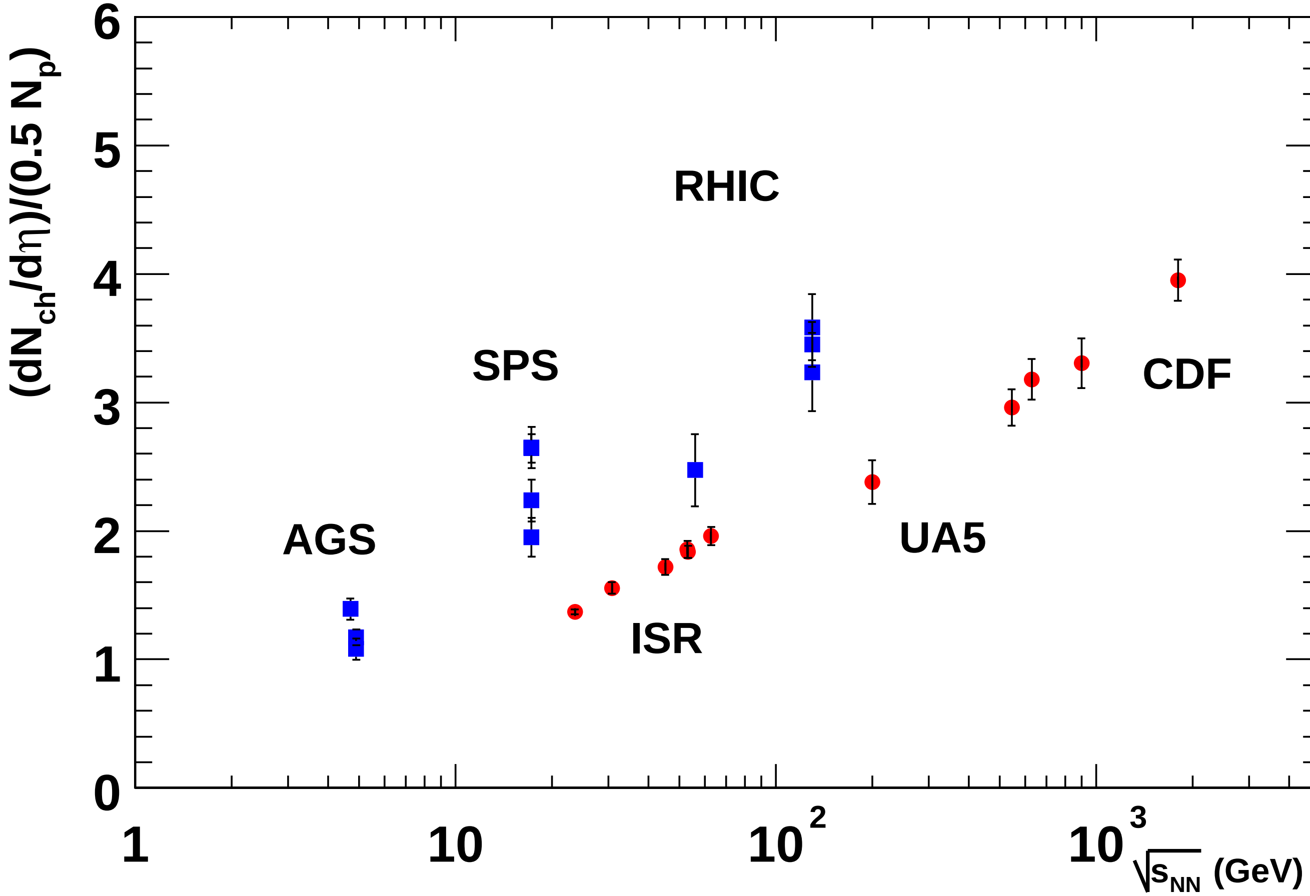
First results on centrality dependence of charged particle multiplicity at RHIC energies.

Energy Scaling of $dN_{ch}/d\eta$: pp and AA

Collection of data points from pp and AA experiments.

AA Fixed-target:
$dN_{ch}/d\eta$ approx. equal to dN_{ch}/dy

AA Collider:
$dN_{ch}/d\eta$ not equal to dN_{ch}/dy

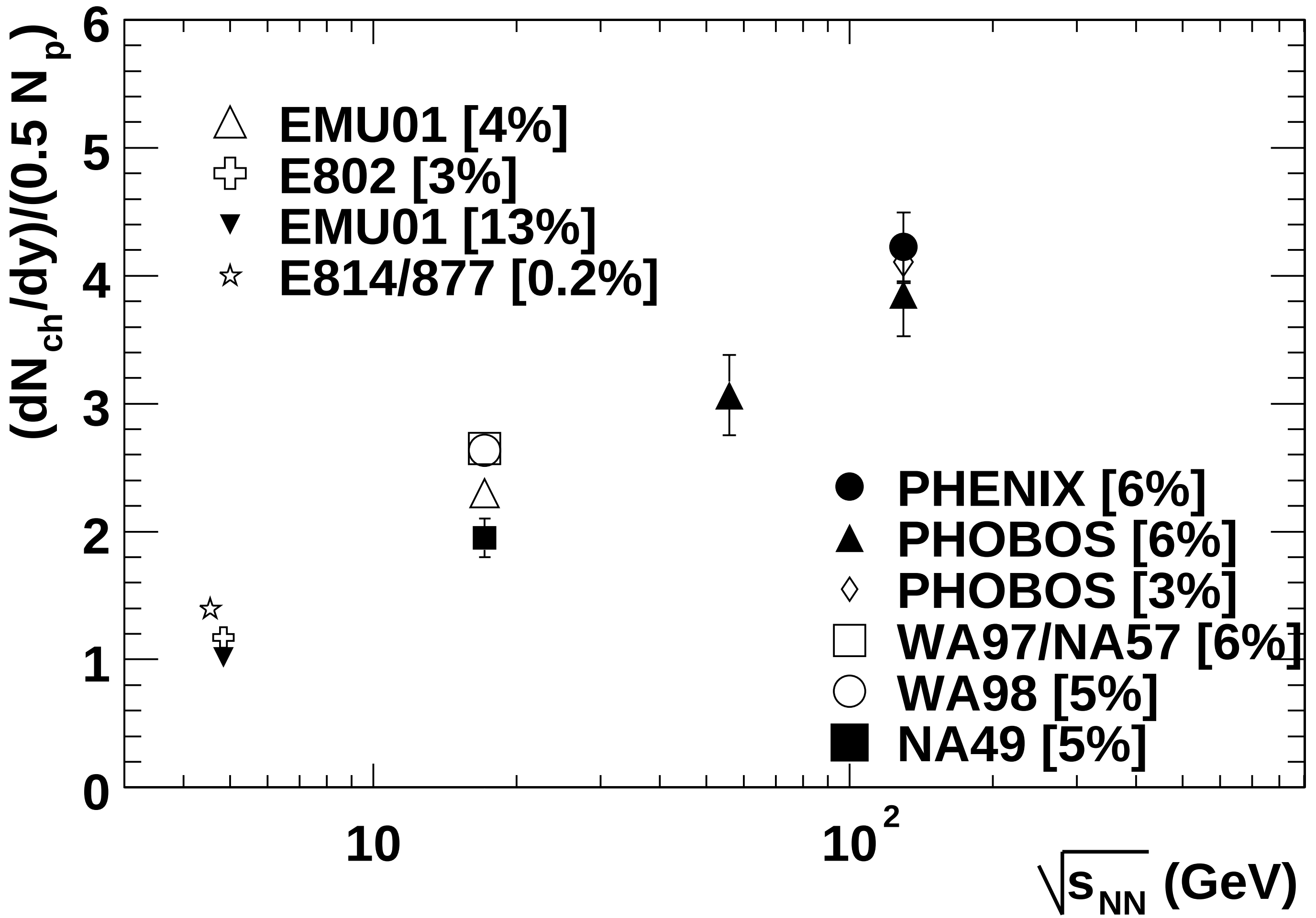


Energy Scaling of dN_{ch}/dy: AA

AA points only. Collider data scaled to correspond to dNch/dy.

Scale-factor (model-dependent):
1.24 @ 56 GeV
1.19 @ 130 GeV

Note the large spread between points at SPS.

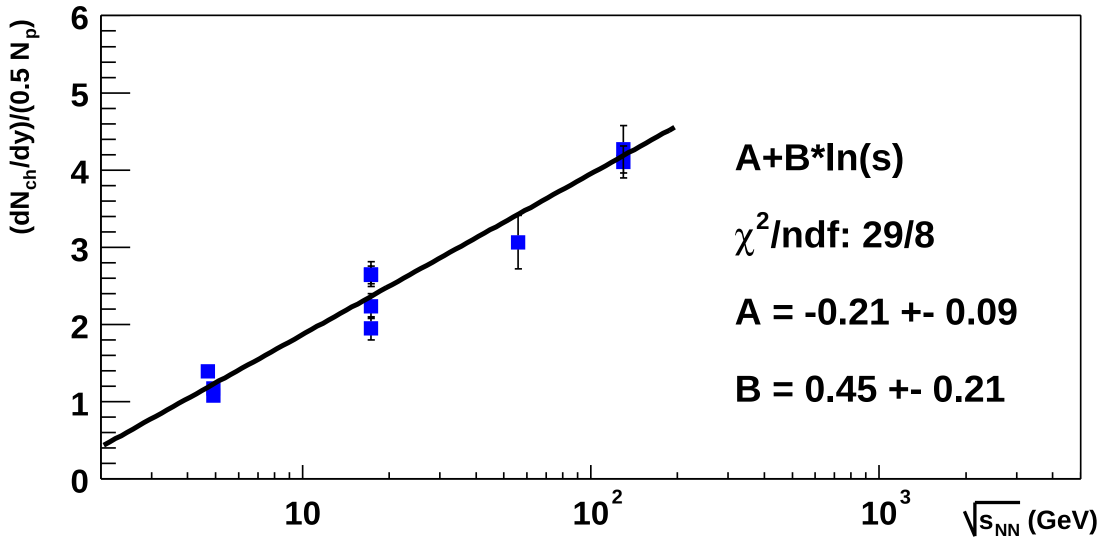


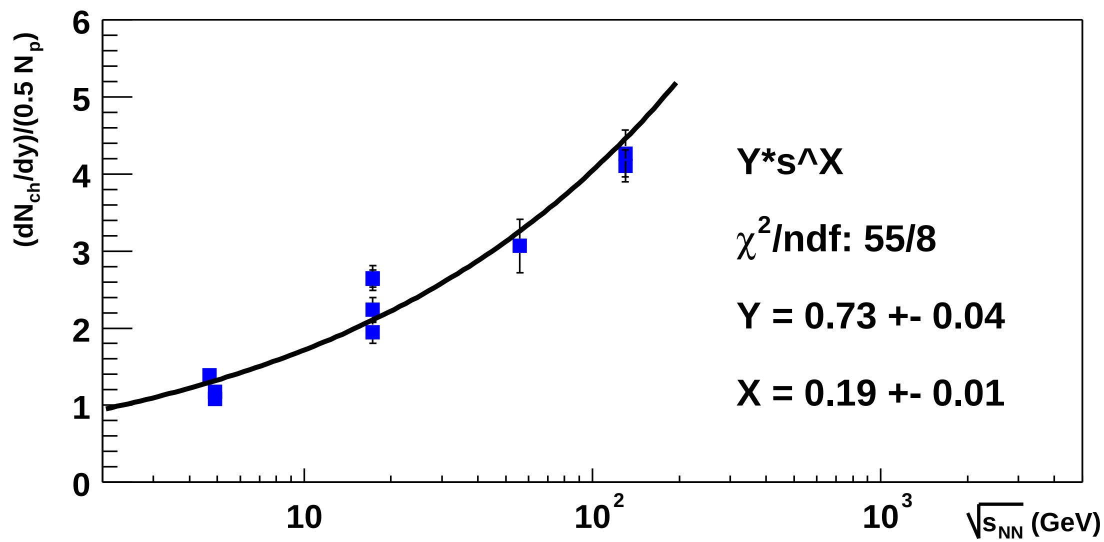
lNch/dy Fits: AA

wo simple functional forms:

og: A+B*ln(s)

ow: Y*s^X



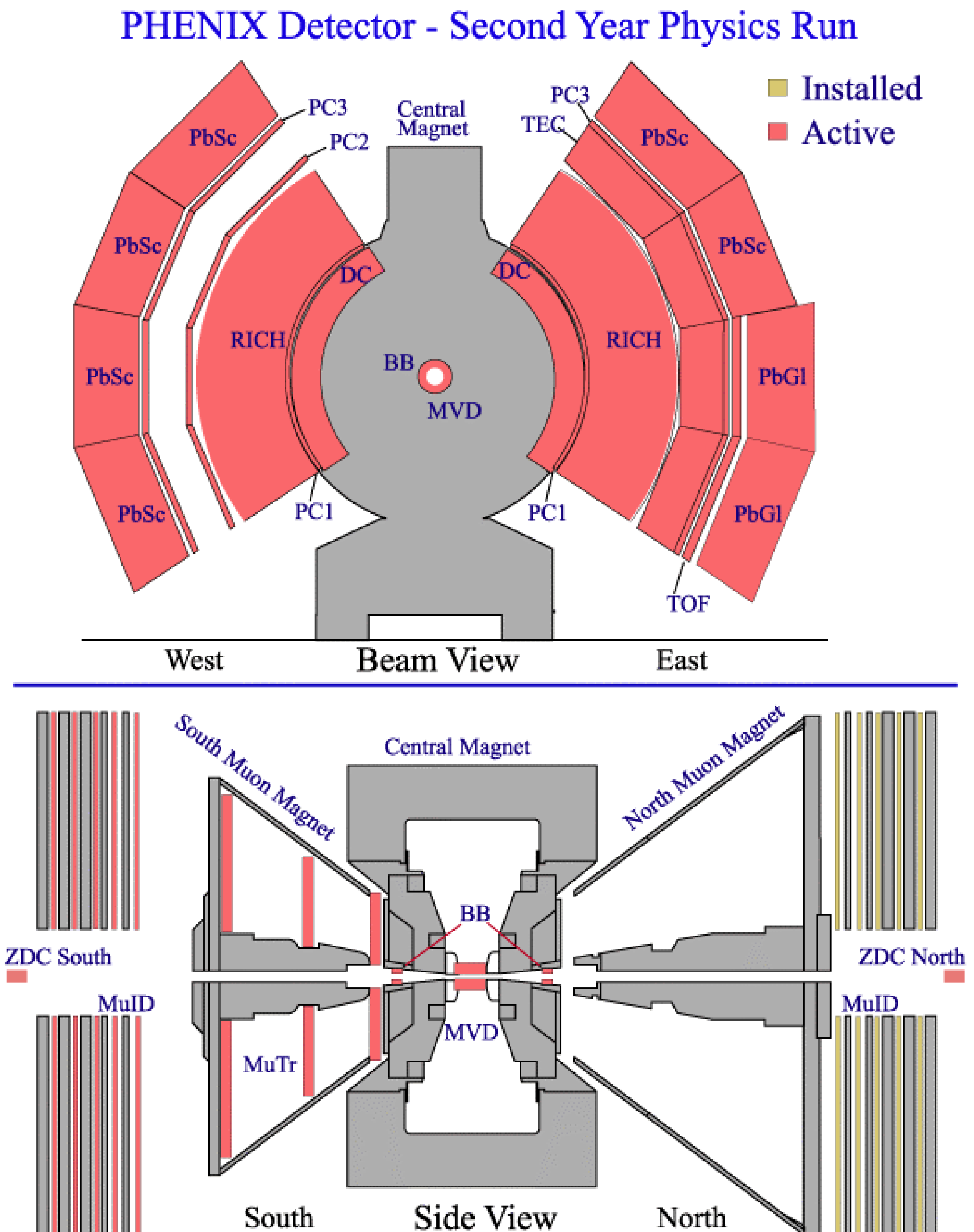


oth describe data reasonably
vell.

00 GeV is next..

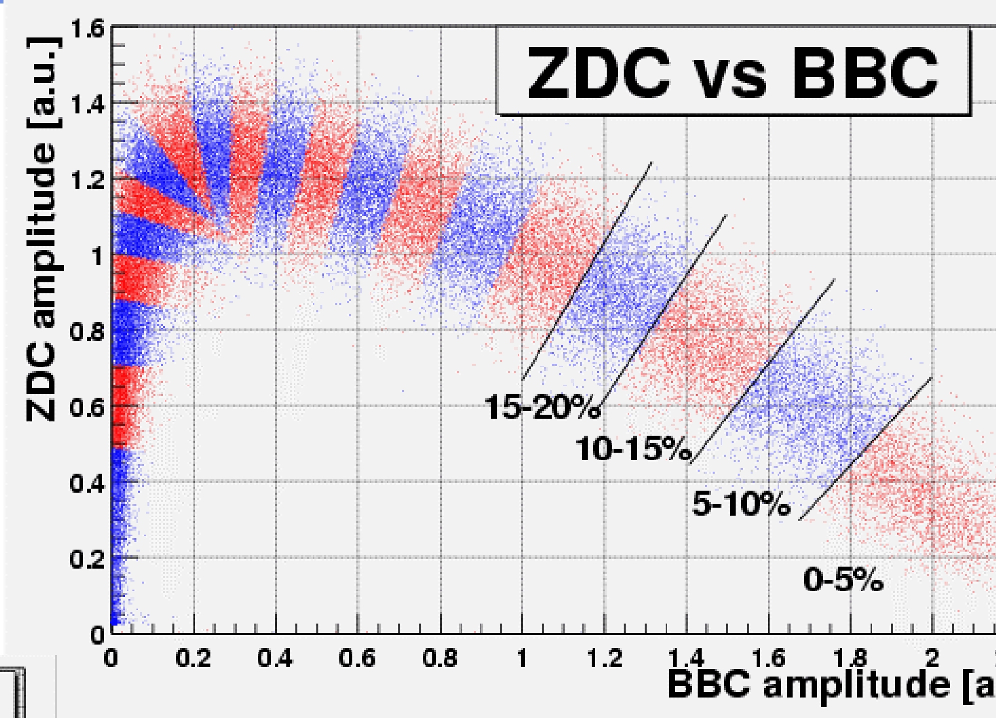
Year 2001 Configuration

* EMCal coverage extended
* South Muon Arm added
* PC2 and PC3 West added

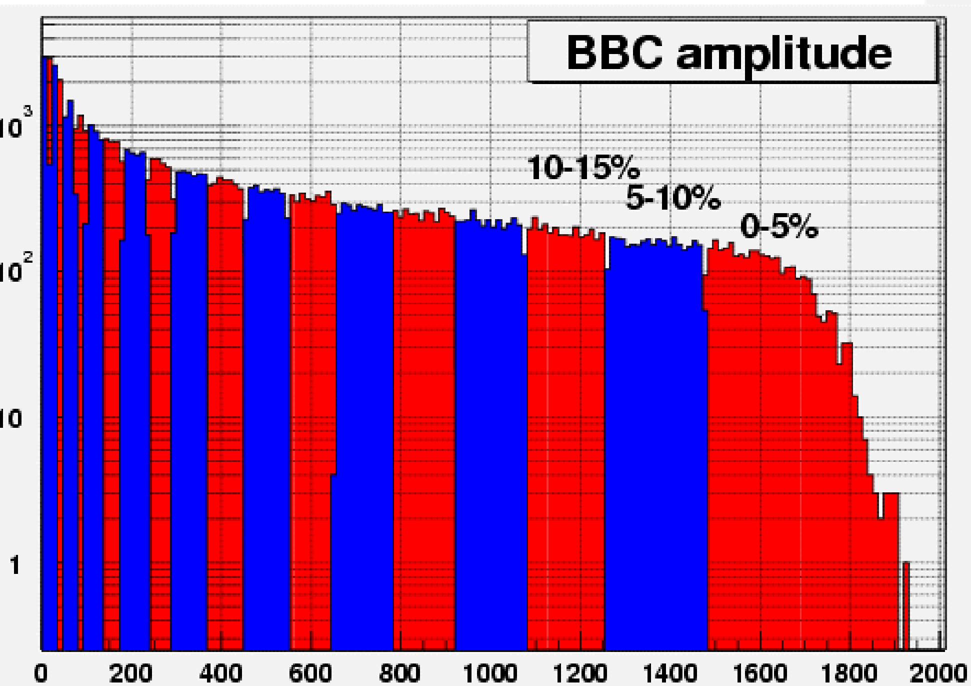


Centrality determination: Year 2001

- Two dimensional cut in the same way as first year analysis.



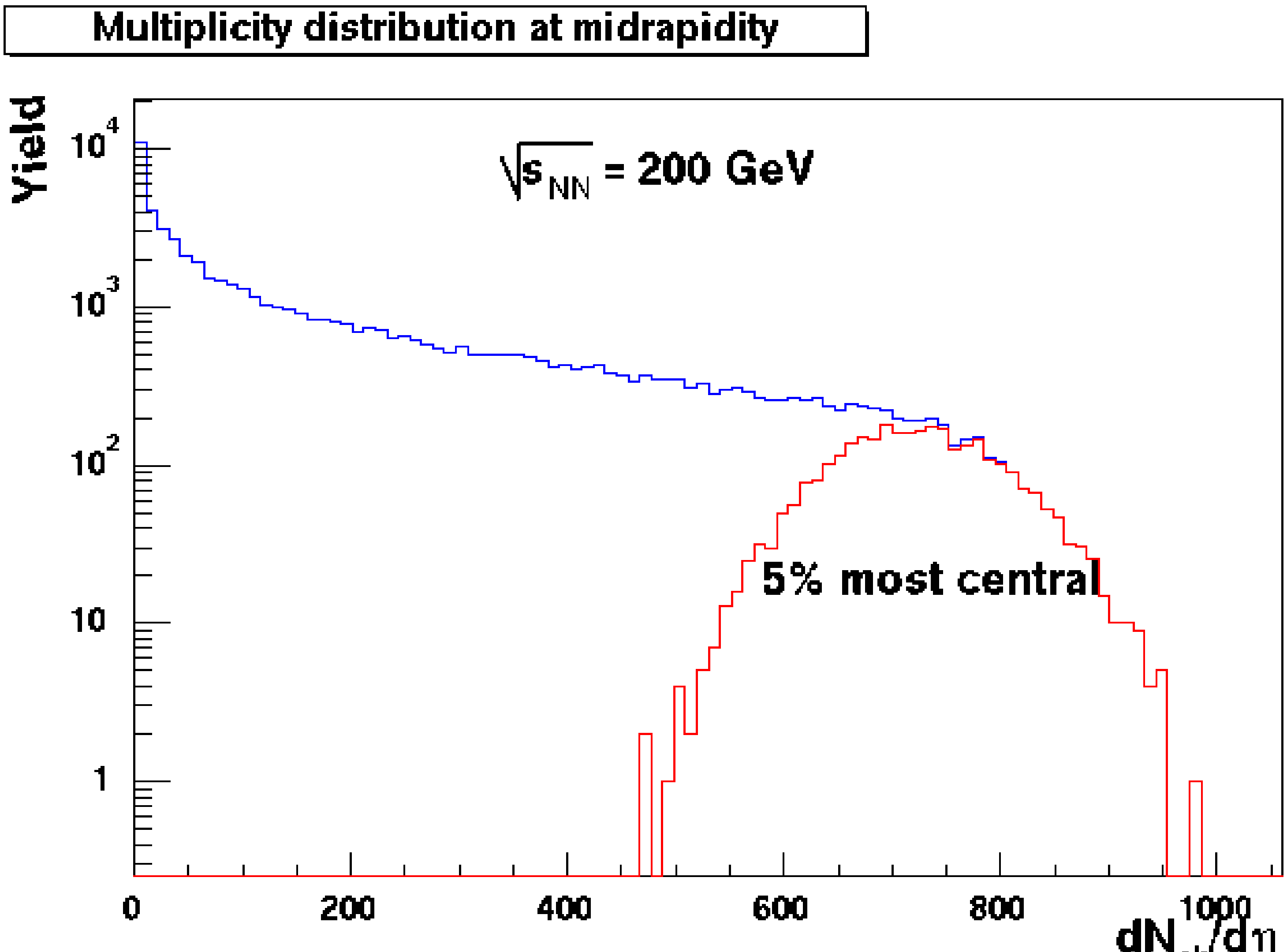
- Can also do one-dimensional cut.



Both methods are in good agreement for centrality < 60 % (most central).

Multiplicity distribution @ 200 GeV

For the 5 % most central collisions, an increase of 1.15 ± 0.04, relative to 130 GeV in $dN_{ch}/d\eta$ per participant pair is observed.



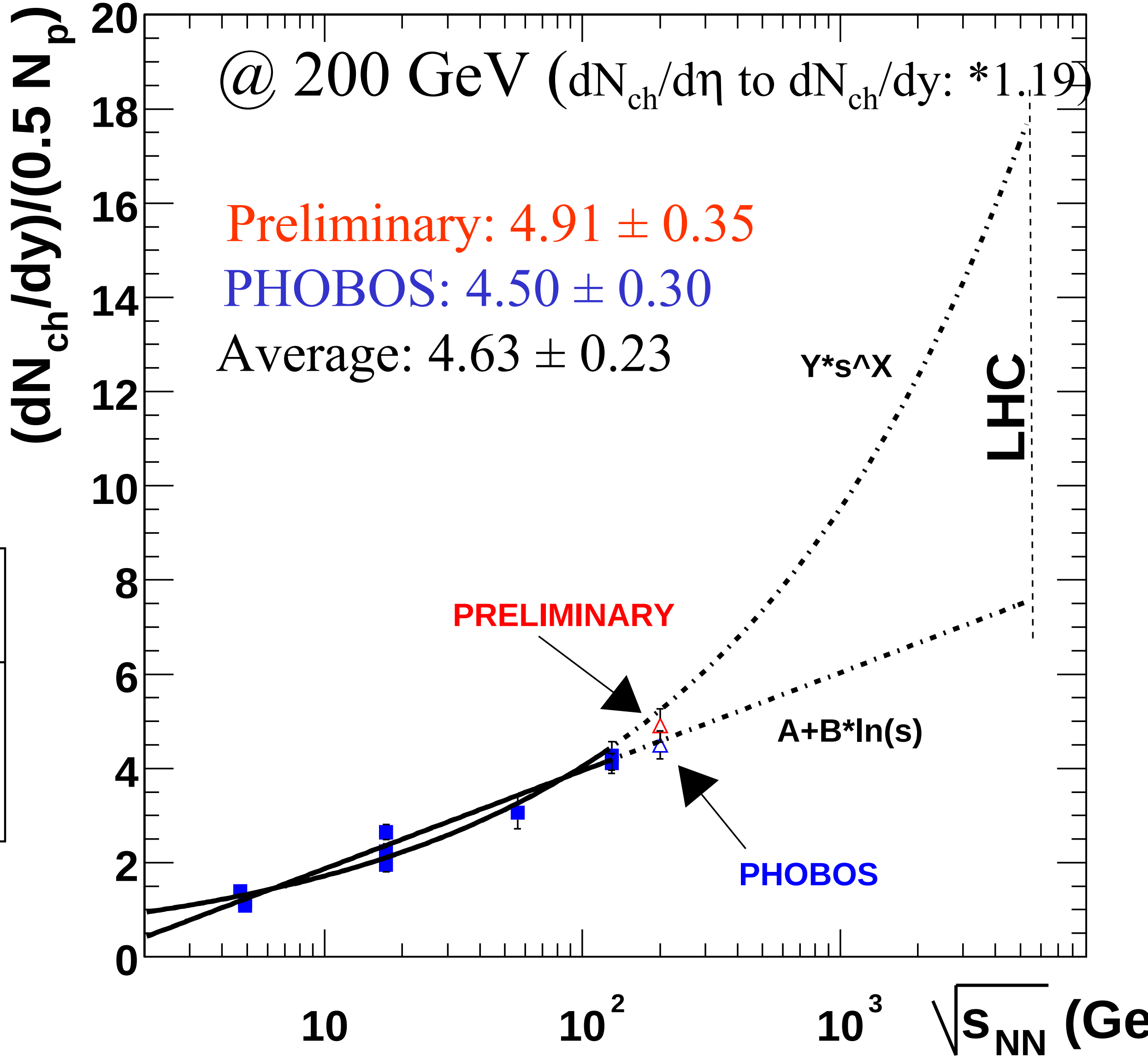
Extrapolations to 200 GeV and LHC

Predictions @ 200 GeV from data up to 130:

Log: A+B*ln(s): 4.58
Pow: Y*s^X: 5.23

At LHC:

Fit	dN_{ch}/dy	N_{ch}
Log	1 400	13 000
Pow	3 400	30 000



N_{ch} obtained assuming that the shape is invariant in y/y_{max}

Summary

- $dN_{ch}/d\eta$ analysis at mid-rapidity performed for 200 GeV and 130 GeV.
- Increase in $dN_{ch}/d\eta$ per participant pair from 130 to 200 GeV of a factor 1.15 ± 0.04
- Logarithmic scaling with s_{NN} for dN_{ch}/dy per participant pair describes the data up to 200 GeV.

  If the scaling holds to LHC energies, dN_{ch}/dy at mid-rapidity will be about 1400 and the total charged particle multiplicity about 13000.

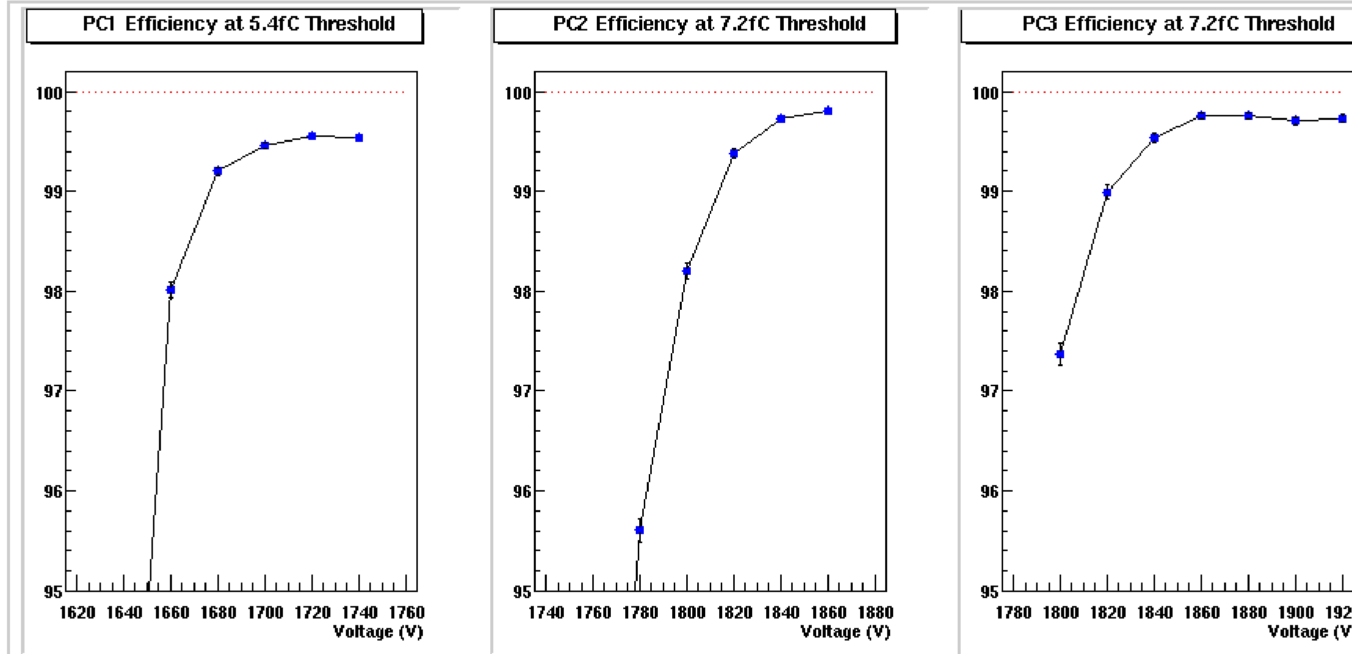
H ENIX

ty of São Paulo, São Paulo, Brazil
ia Sinica, Taipei 11529, China
stitute of Atomic Energy (CIAE), Beijing, P. R. China
oire de Physique Corpusculaire (LPC), Universite de Clermont-Ferrand, 63170
, Clermont-Ferrand, France
CEA Saclay, Bat. 703, F-91191, Gif-sur-Yvette, France
ay, Universite Paris Sud, CNRS-IN2P3, BP1, F-91406, Orsay, France
Palaiseau, Ecole Polytechnique, CNRS-IN2P3, Route de Saclay, F-91128,
u, France
CH, Ecole des Mines at Nantes, F-44307 Nantes, France
ty of Muenster, Muenster, Germany
Hindu University,Banaras, India
Atomic Research Centre (BARC),Bombay, India
nn Institute, Rehovot, Israel
or Nuclear Study (CNS-Tokyo), University of Tokyo, Tanashi, Tokyo 188, Japan
na University, Higashi-Hiroshima 739, Japan
titute for High Energy Physics,Tsukuba, Japan
niversity, Kyoto, Japan
ci Institute of Applied Science, Nagasaki-shi, Nagasaki, Japan
nstitute for Physical and Chemical Research, Hirosawa, Wako, Japan
ty of Tokyo, Bunkyo-ku, Tokyo 113, Japan
nstitute of Technology, Ohokayama, Meguro, Tokyo, Japan
ty of Tsukuba, Tsukuba, Japan

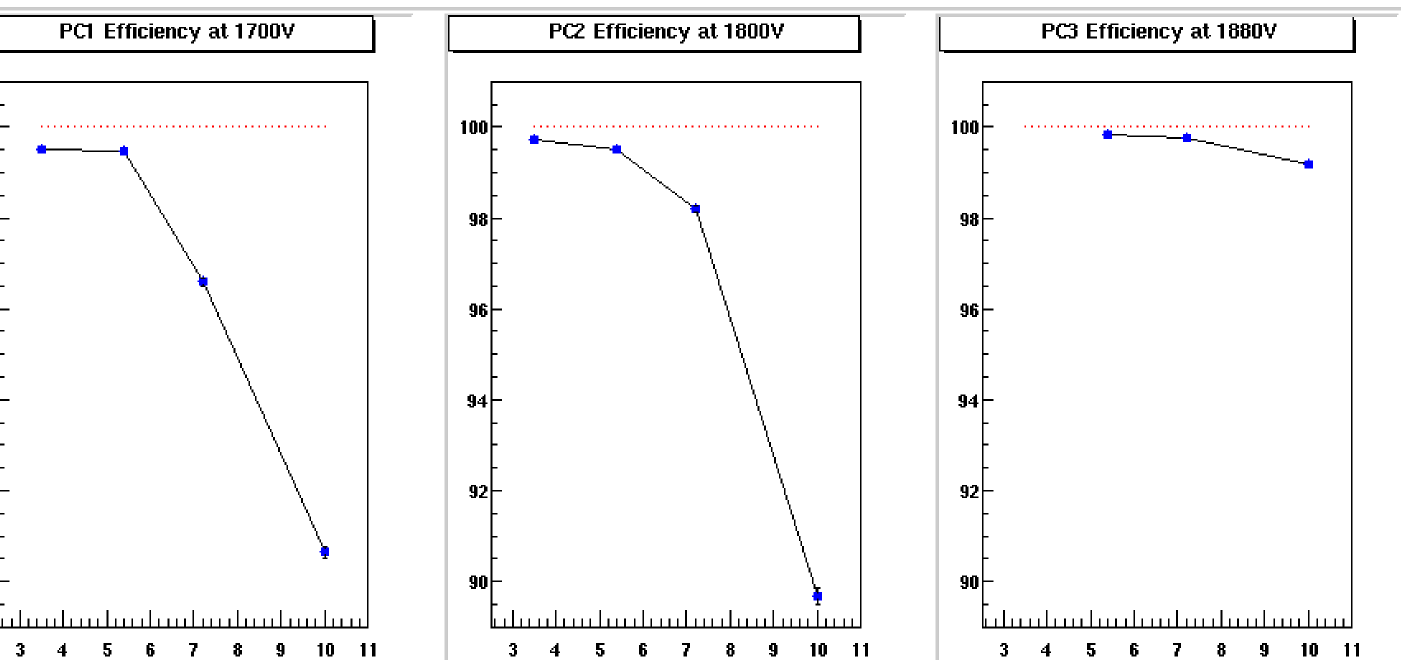
Cyclotron Application Laboratory, KAERI, Seoul, South Korea
Kangnung National University, Kangnung 210-702, South Korea
Korea University, Seoul, 136-701, Korea
Myong Ji University, Yongin City 449-728, Korea
System Electronics Laboratory, Seoul National University, Seoul, Sout
Yonsei University, Seoul 120-749, KOREA
Institute of High Energy Physics (IHEP-Protvino or Serpukhov), Protov
Joint Institute for Nuclear Research (JINR-Dubna), Dubna, Russia
Kurchatov Institute, Moscow, Russia
PNPI: St. Petersburg Nuclear Physics Institute, Gatchina, Leningrad, Ru
Lund University, Lund, Sweden
Abilene Christian University, Abilene, Texas, USA
Brookhaven National Laboratory (BNL), Upton, NY 11973
University of California - Riverside (UCR), Riverside, CA 92521, USA
Columbia University, Nevis Laboratories, Irvington, NY 10533, USA
Florida State University (FSU), Tallahassee, FL 32306, USA
Georgia State University (GSU), Atlanta, GA, 30303, USA
Iowa State University (ISU) and Ames Laboratory, Ames, IA 50011, USA
LANL: Los Alamos National Laboratory, Los Alamos, NM 87545, USA
LLNL: Lawrence Livermore National Laboratory, Livermore, CA 94550
University of New Mexico, Albuquerque, New Mexico, USA
New Mexico State University, Las Cruces, New Mexico, USA
Department of Chemistry, State University of New York at Stony Broo

Efficiency Studies

Efficiency as a function of HV



Efficiency as a function of threshold



Efficiency is better than 99.5 %.

Binominal Broadening

Suppose there are N particles in every event in $|\eta| < 1$, full azimuth.

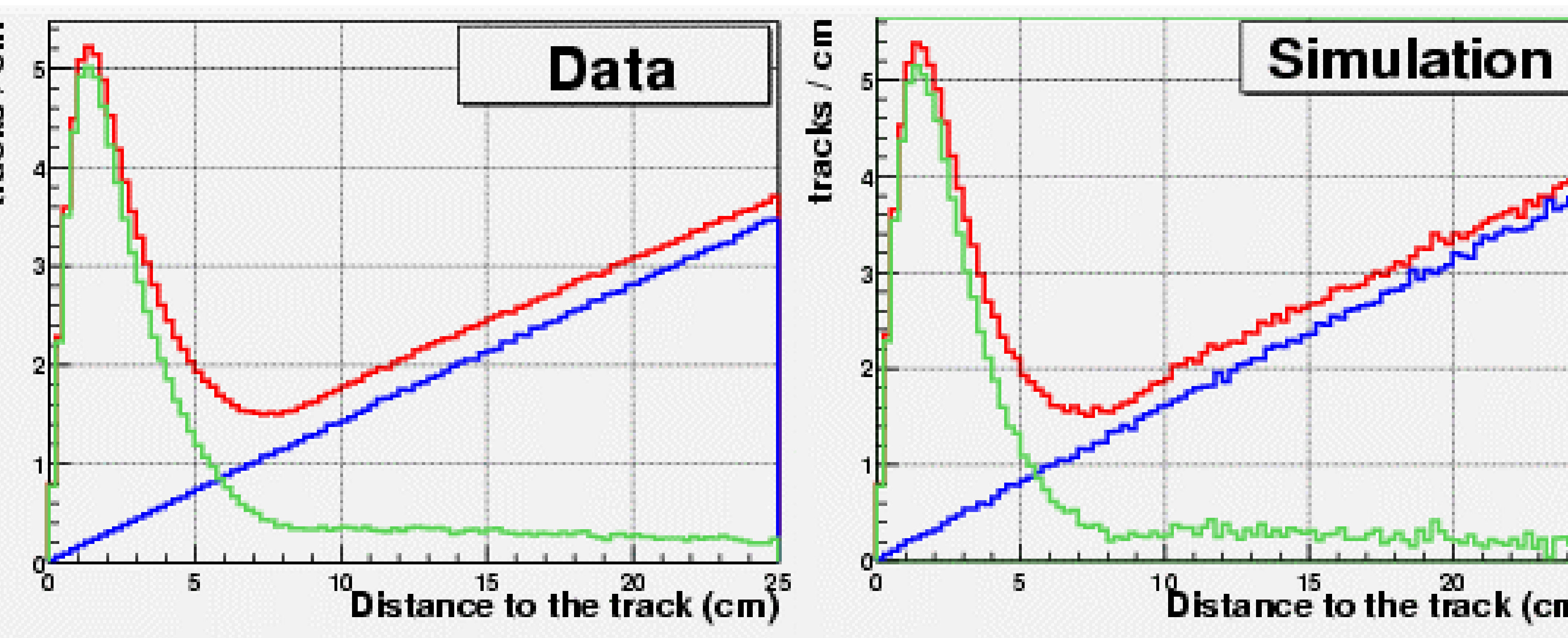
Our acceptance covers a fraction p ($0 < p < 1$) of this interval.

On average, we thus see $n = N*p$ in our acceptance, but not in every event. Our variance in
is given by $\sigma^2 = N*p*(1-p)$

Thus when rescaling to the full acceptance we get
$N \pm 1/p*(N*p*(1-p))^{1/2}$
i.e. a broadening..

PC 1/3 analysis: track selection

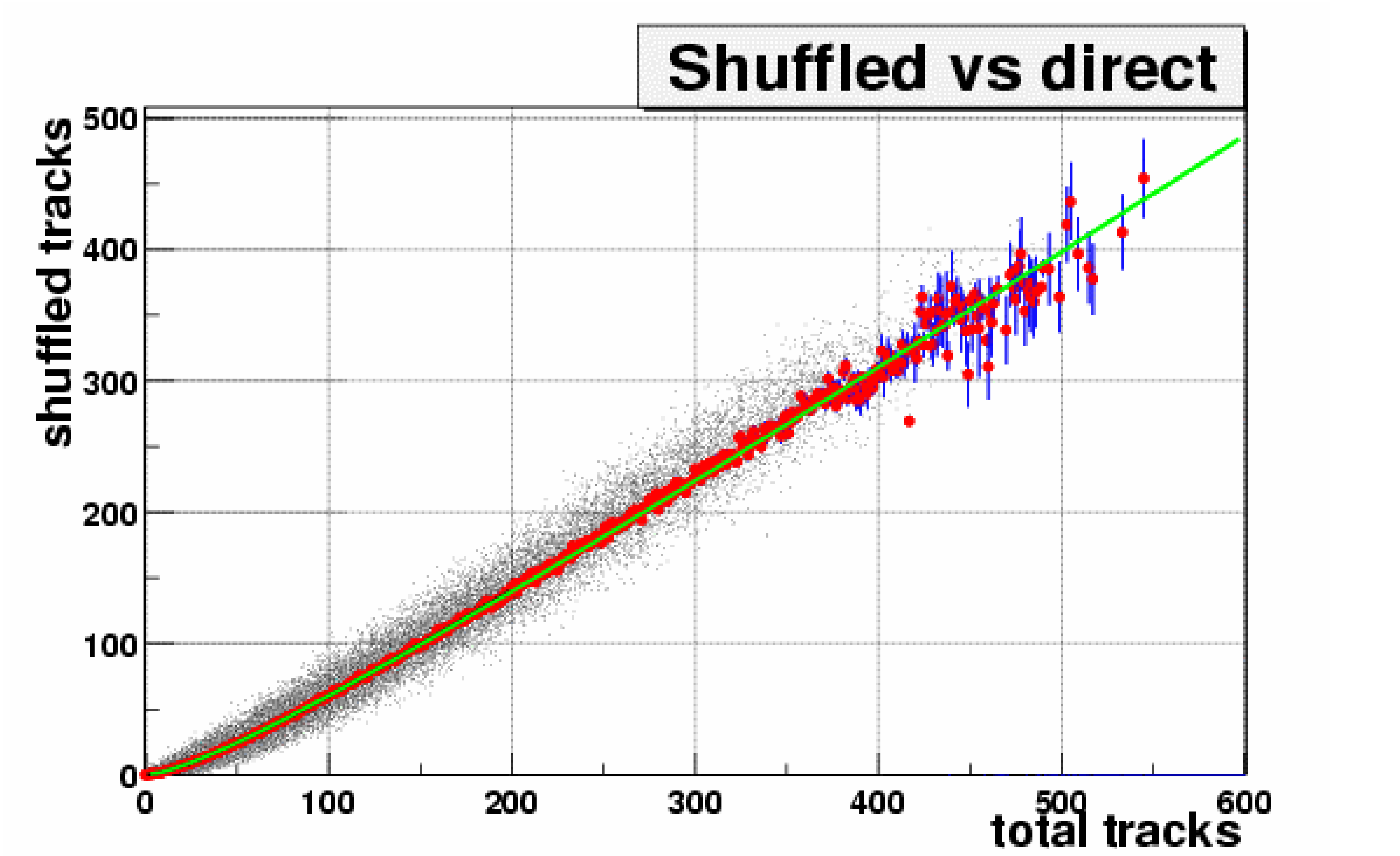
- The same type of the analysis as in year-1
- Hit combinatorics of PC1 and PC3 in B=0
- 25 cm acceptance window cut



PC 1/3 analysis: background subtraction

Subtraction of the average background on event by event basis

The DHR correction 3.6% (mixed events has more tracks than accidentals in the direct event) implemented at this stage.



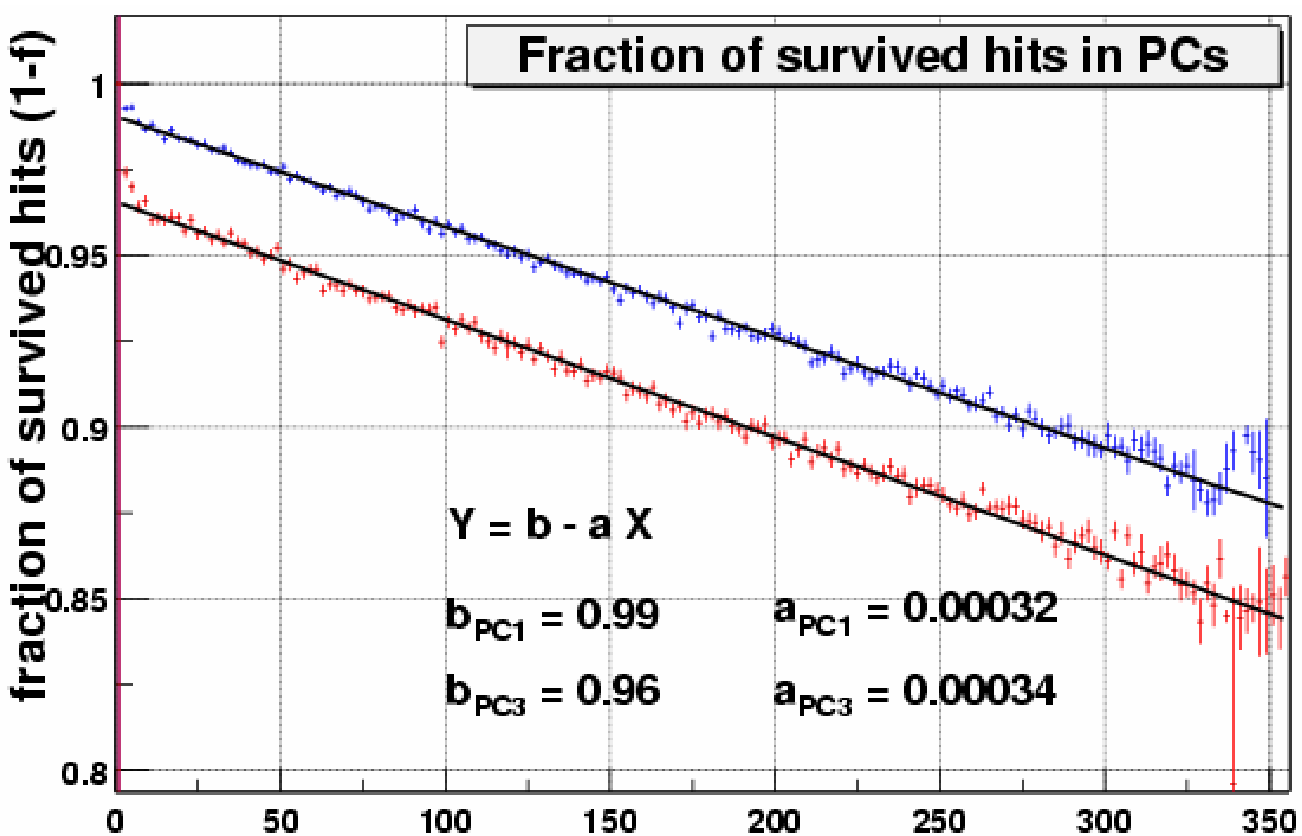
PC 1/3 analysis: DHR correction

DHR correction done proportional to the hits lost in PC1 and PC3 is done in the same way as in Year-1

fraction of survived hits: $$f = \frac{(N-1)}{2} \times \frac{\pi R^2}{S}$$

number of survived hits: $$N' = N - \frac{N(N-1)}{2} \times \frac{\pi R^2}{S}$$

calculated slope: 0.00036



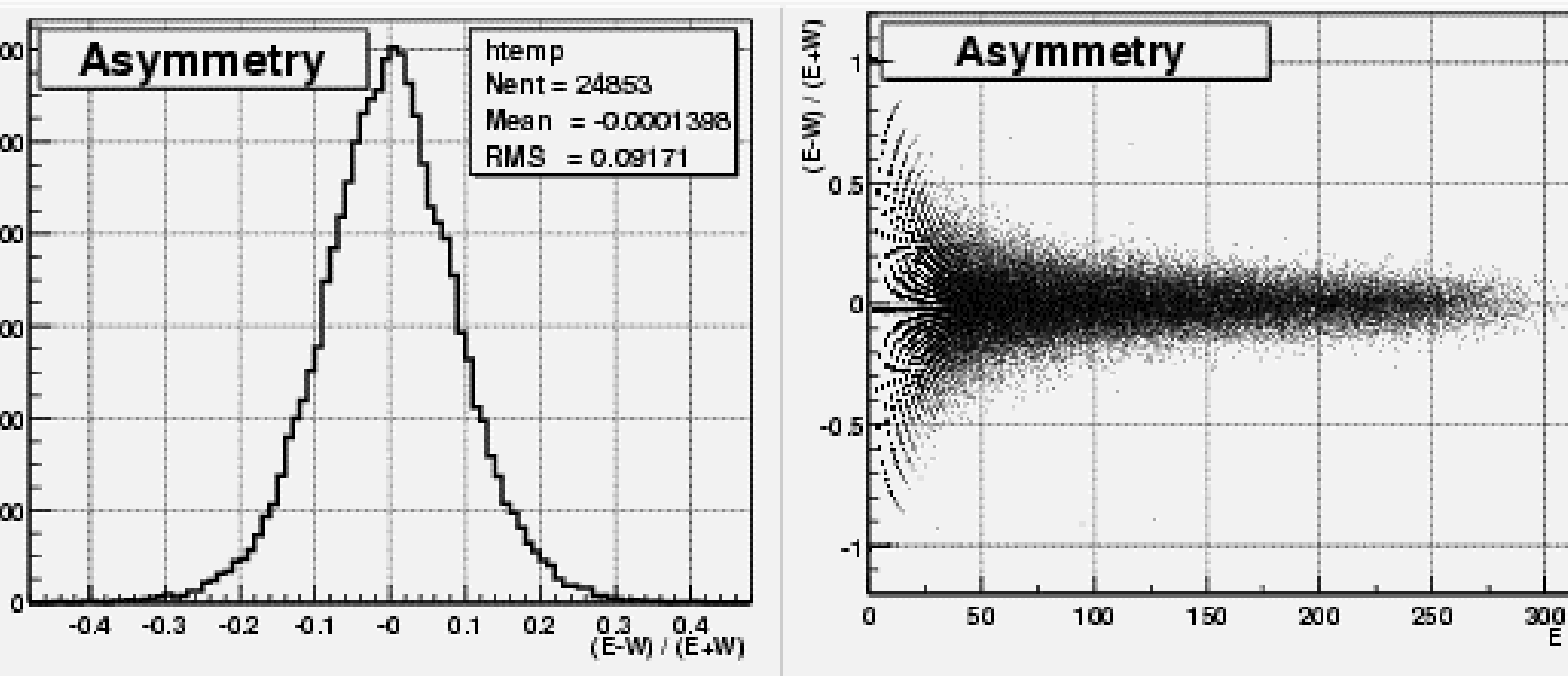
PC 1/3 analysis: scaling correction

aling correction factors

Layer	PC1 East	PC1 West	PC3 East	PC3 West
Inactive ROCs	0.9%±0.2%	0.5%±0.2%	6%±1.0%	0.7%±0.2%
Inactive TGLs	0.6%±0.2%		0.3%±0.2%	
Dead area by construction	1.5%		6.6%	
Inefficiency	0.6%+0.5%		0.3%+0.5%	
Tracks outside R acceptance	4.1% ±1.5%			
In-flight particle decays	1.8%±4.0%			

PC 1/3 analysis: results comparison

East and West arm multiplicities rec. independently
- are in a very good agreement



Scaling factors: feed-down correction

Origin	PISA	HIJING
$\pi^+\pi^-$	21.72	26.99
p^+p^-	1.16	1.19
K^+K^-	1.16	2.45
e^+e^-	0.02	0.03
Others $(\Sigma^\pm, \bar{\Sigma}^\pm, \Xi^\pm \ldots)$	0.29	0.22
Charged	24.36	**30.89**
π^0	0.88	15.13
γ	0.07	3.01
$n, \bar{n}$	0.07	1.19
K^o_L	0.10	1.20
K^o_S	1.66	1.19
Others $(\Lambda, \Xi^o, \Sigma^o \ldots)$	0.44	0.40
Neutral	3.21	22.12
Total	**27.57**	53.01
Total corrected	**30.33**	

Feed - down correction can be derived based on the known particle ratios from Year-1

PHENIX is very "sensitive" to strange component of the event.

This would not affect the Y2/Y1 ratio, but may change absolute value.