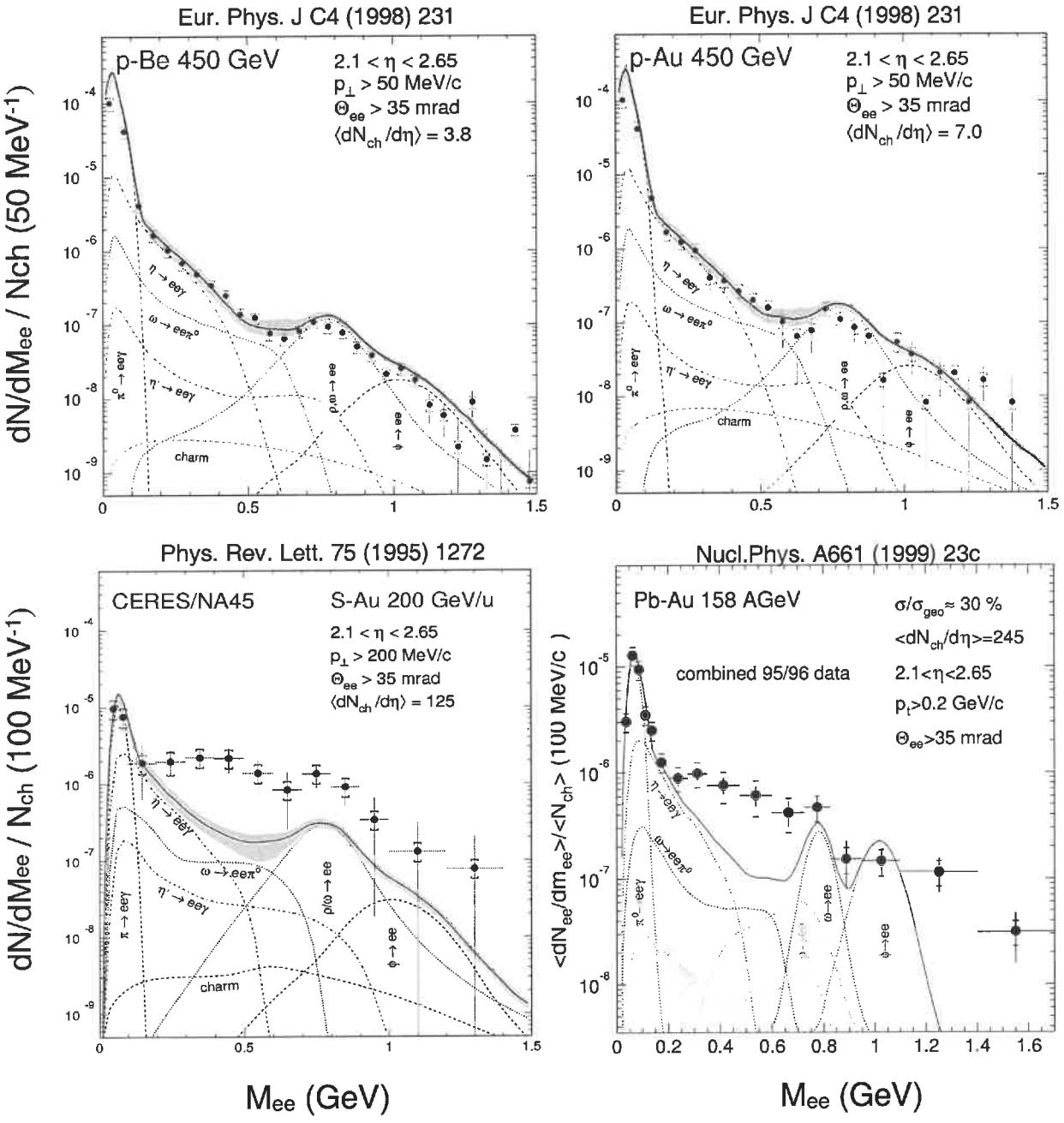
Addendum 2 to Proposal SPSC-P-P280

Study of Electron Pair and Hadron Production with In and Pb Beams

D. Miśkowiec, GSI Darmstadt
November 2002

- introduction
- present status of CERES
- proposed running in 2003
- summary

CERES results 92-96



→ excess of e^+e^- pairs in heavy ion collisions

CERES running in 2003

Origin of the excess pairs

- absent in p+A, present in A+A
- M_{ee} range 0.2-1.0 GeV/c^2
- low pt
- proportional to charged-particle-multiplicity squared

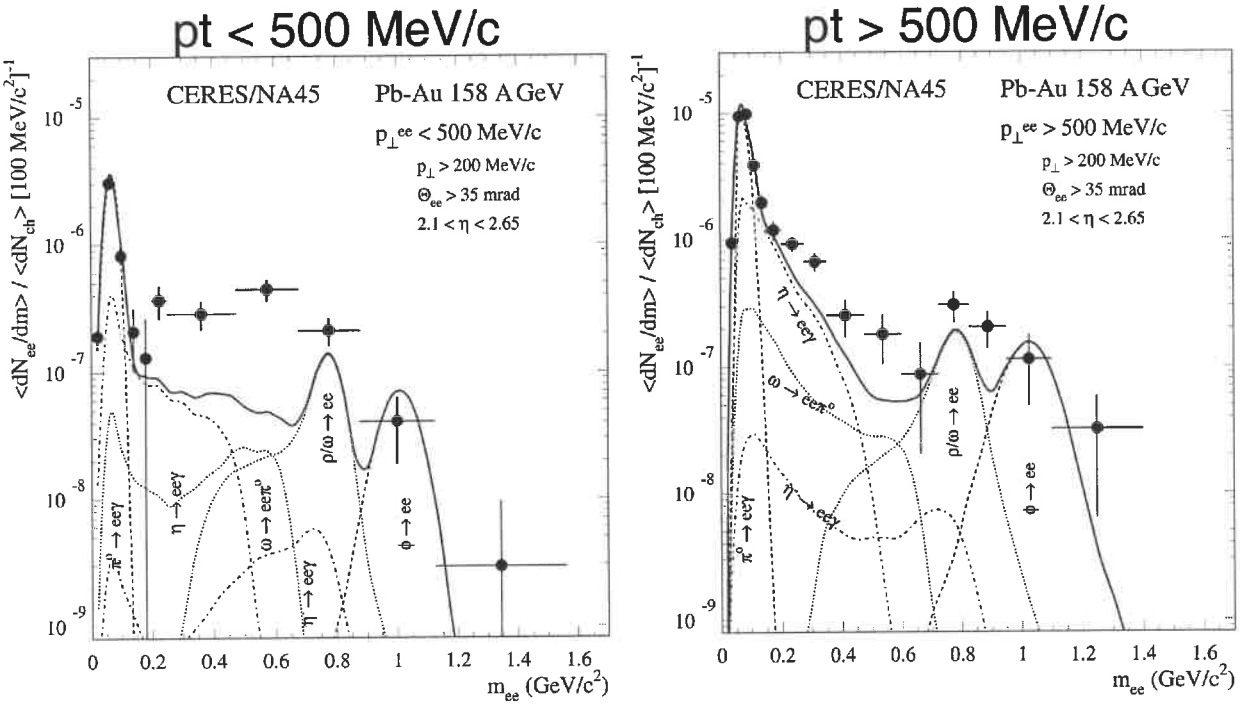
consistent with

$\pi + \pi \rightarrow \rho \rightarrow e^+ e^-$

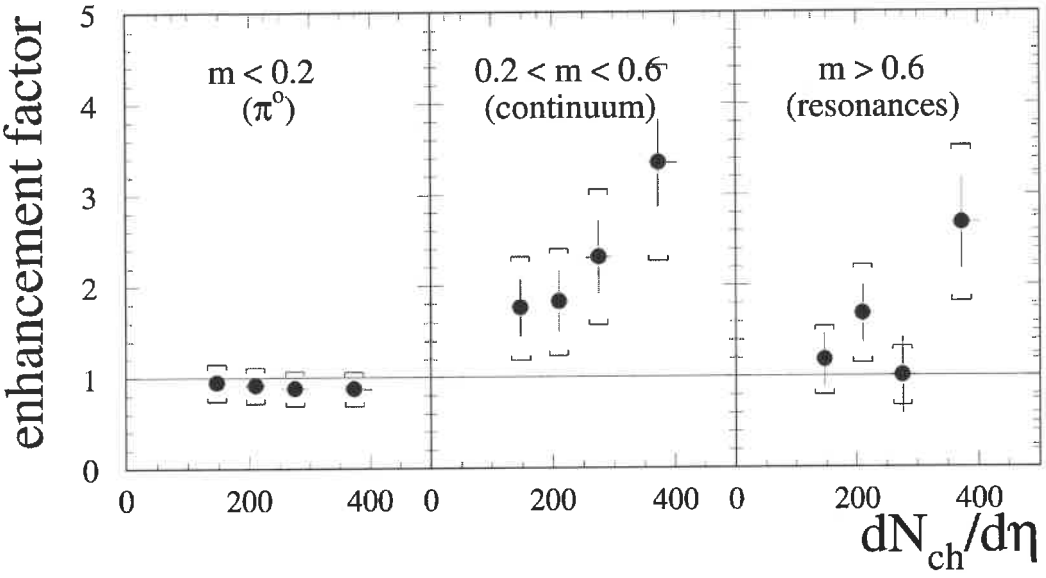
qqbar $\rightarrow \gamma^* \rightarrow e^+ e^-$

CERES running in 2003

Excess pairs have low pt...



... and scale with N_{ch}^2



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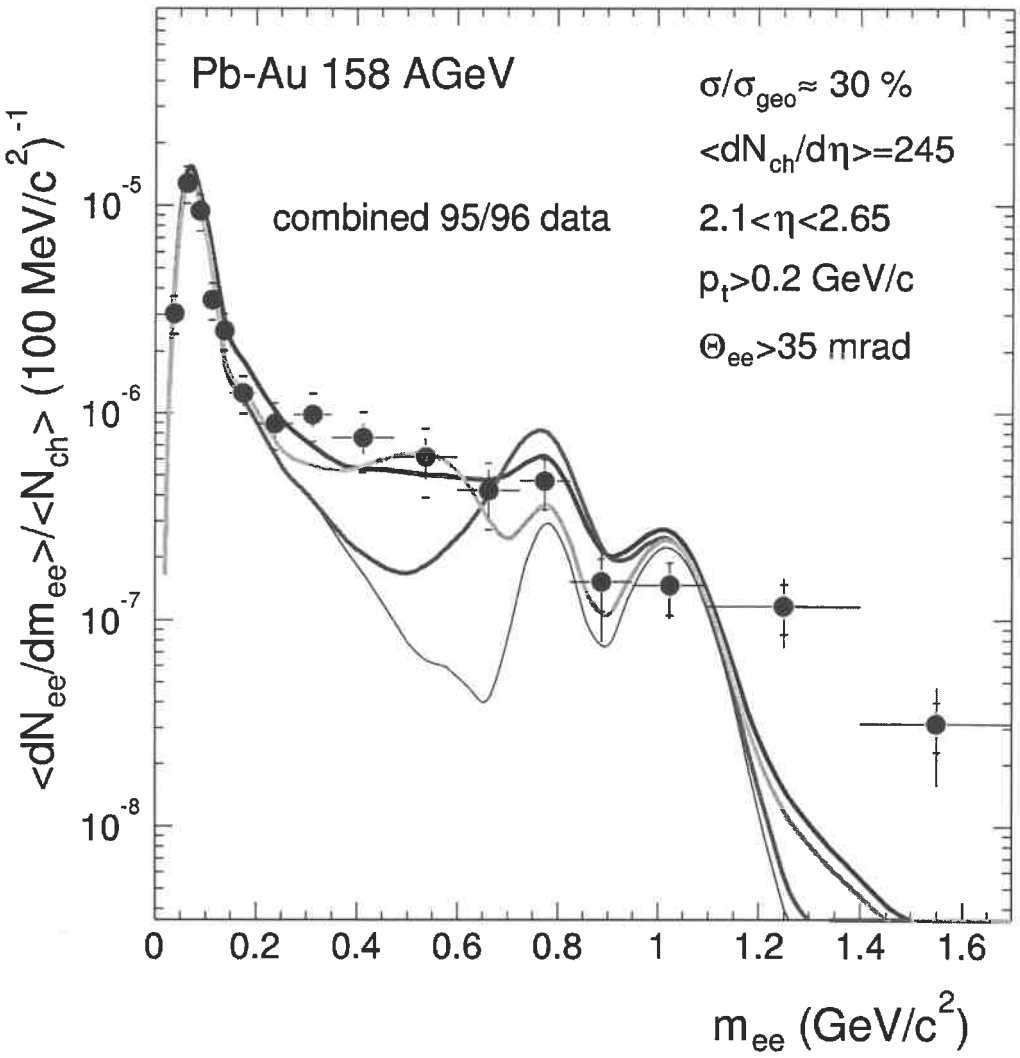
Theoretical description



no rho

vacuum rho

dropping rho mass (Brown-Rho)

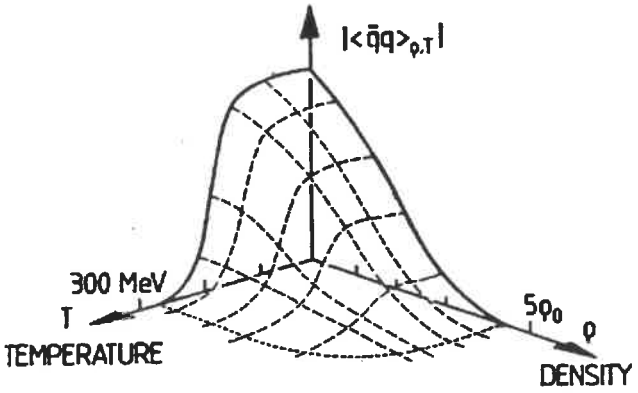
in-medium rho (Rapp-Wambach)

CERES running in 2003

Brown-Rho approach

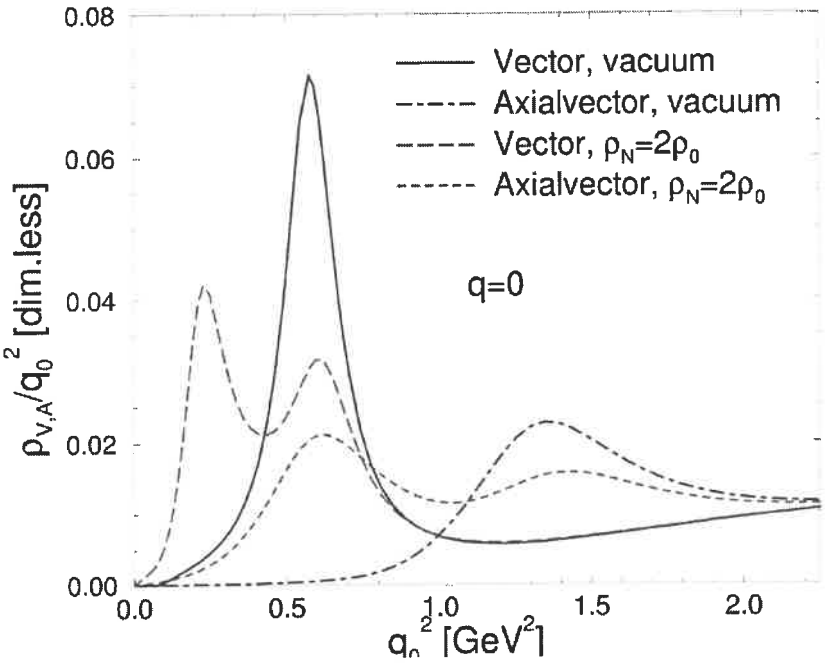
PRL 66(91)2720, Phys.Rep. 363(2002)85

$$\frac{m_\rho^*}{m_\rho^0} = \frac{\langle \bar{q}q \rangle^*}{\langle \bar{q}q \rangle^0}$$



Rapp-Wambach approach

Adv. Nucl. Phys. 25(2000)1



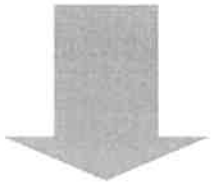
CERES running in 2003

Is rho-modification interesting?

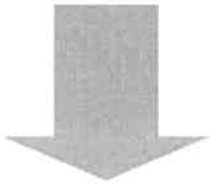
At high density and/or temperature
chiral condensate disappears

$\rightarrow$ meson masses change

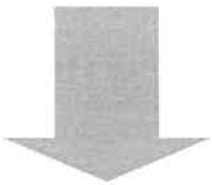
quarks interact with chiral condensate



constituent mass of quarks



mass of hadrons



mass of macroscopic objects

CERES running in 2003

CERES upgrade 97-98

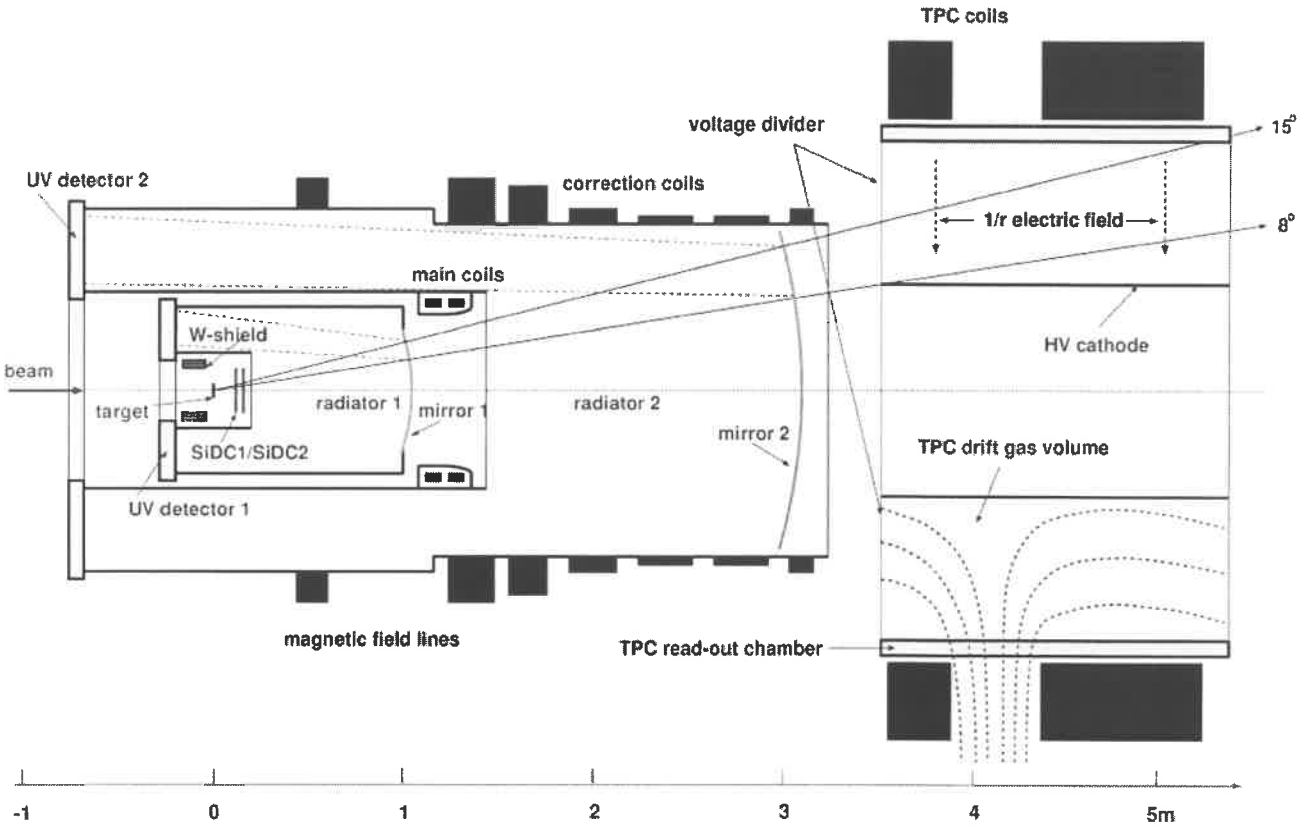
goal:

- improve the invariant mass resolution
- improve electron PID

way:

- replace PADC with a TPC,
  decouple momentum measurement from PID

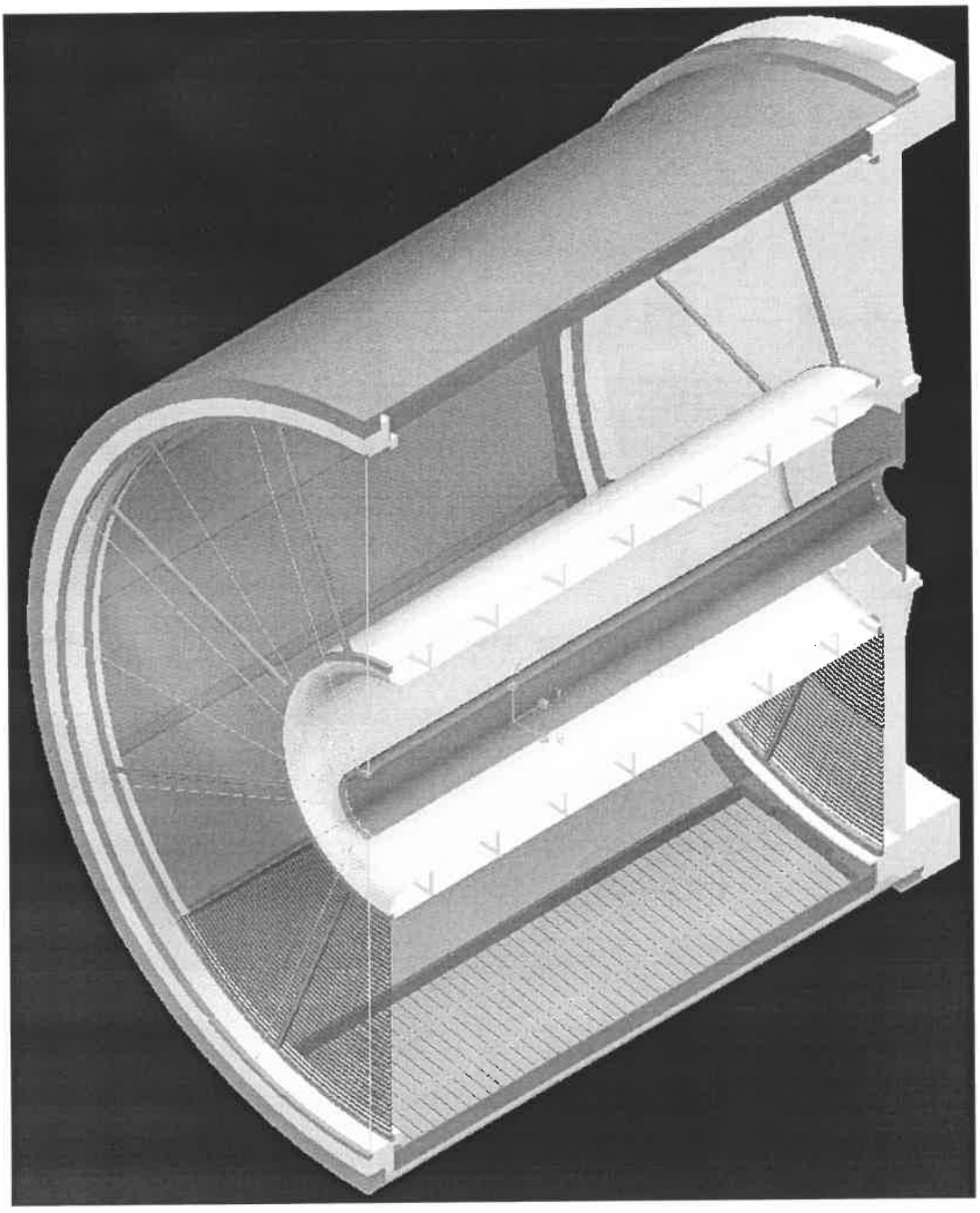
Upgraded CERES setup



SD's: angle | RICH's: electron PID | TPC: momentum, dE/dx

- better mass resolution (2% at ω mass)
- better electron PID
- hadron measurement

CERES TPC



- cylinder Φ 2.6 m x 2 m
- gas Ne:CO_2 (80:20)
- radial E-field E_R~1/r with E=200-600 V/cm
- radial drift with v=0.7-2.4 cm/μs

CERES running in 2003

Upgraded CERES Pb+Au results

1997	upgrade	
1998	upgrade	
1999	40 GeV Pb+Au	10M central 185 open pairs TPC readout pbs
2000	80 GeV Pb+Au 160 GeV Pb+Au	1M central 30M central

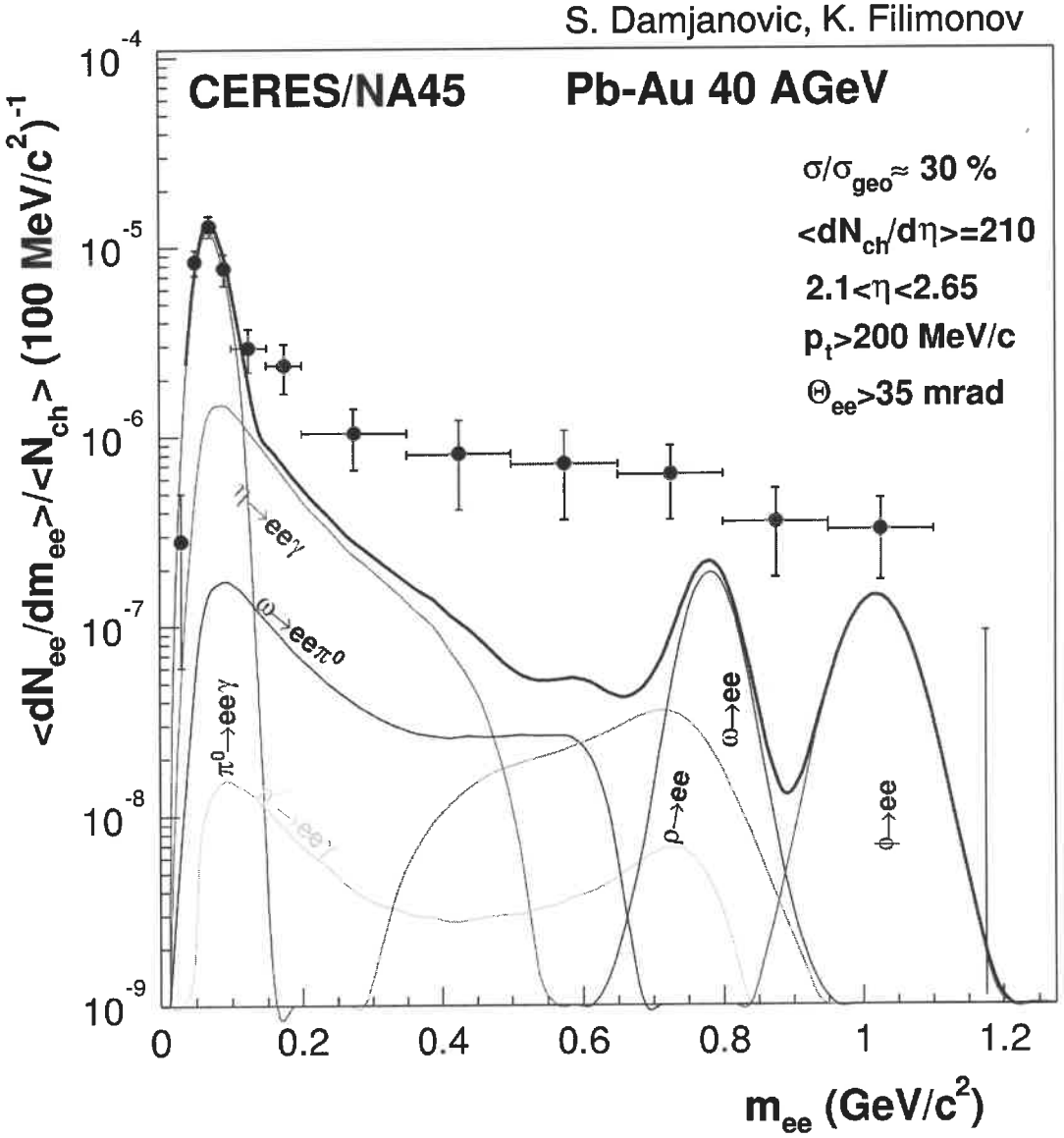
- 40 GeV e^+e^-
- 40 GeV hadron spectra
- 40 GeV lambda
- 40,80,158 GeV two-pion HBT
- 40,80,158 GeV elliptic flow
- 40,80,158 GeV event by event fluctuations
- 158 GeV e^+e^-

CERES running in 2003

Electron pairs from Pb+Au at 40 GeV per nucleon, 1999 run

nucl-ex/0209024, submitted to PRL

S. Damjanovic, K. Filimonov

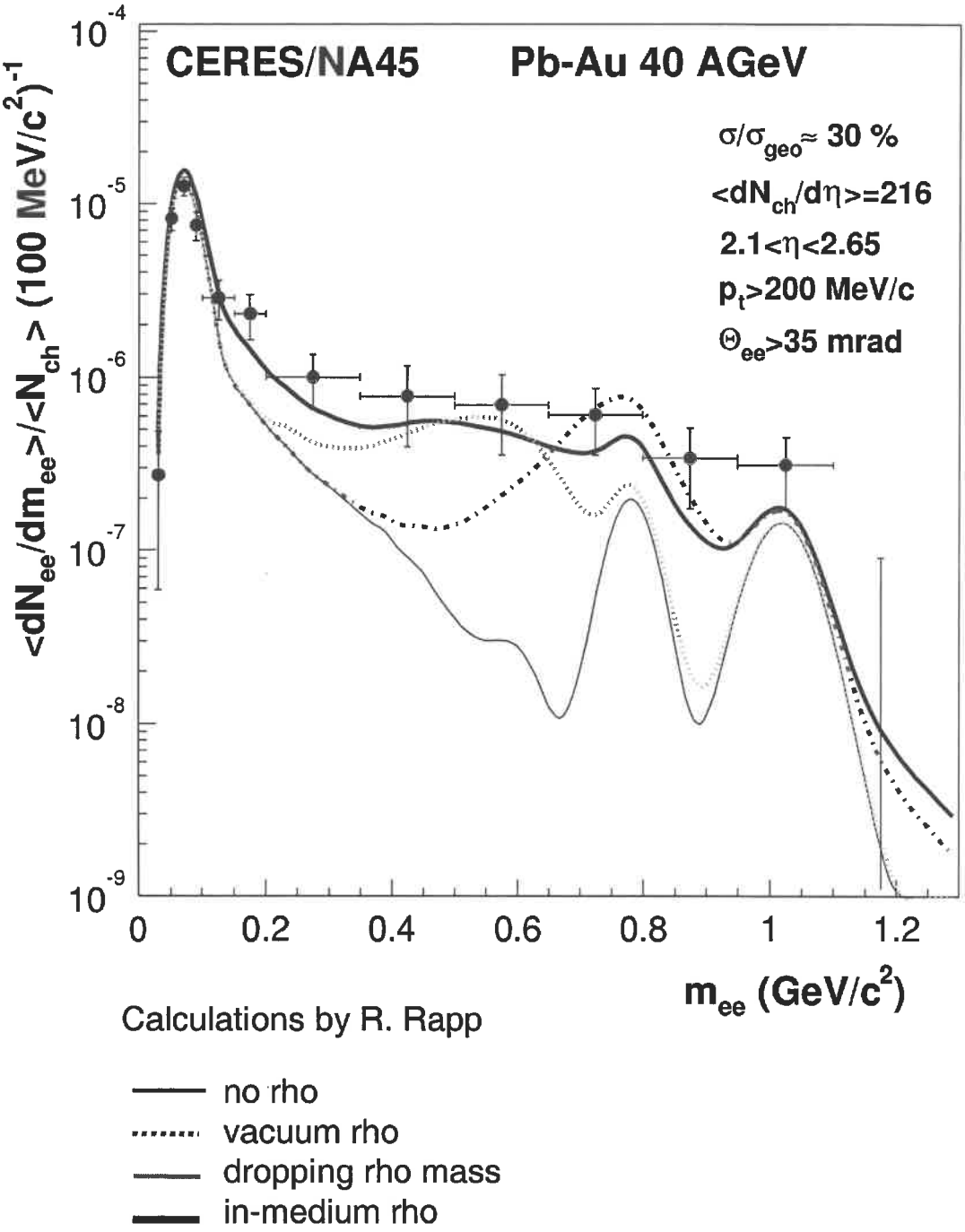


185 pairs with M>0.2 GeV/c^2

dp/p = 4.2 %

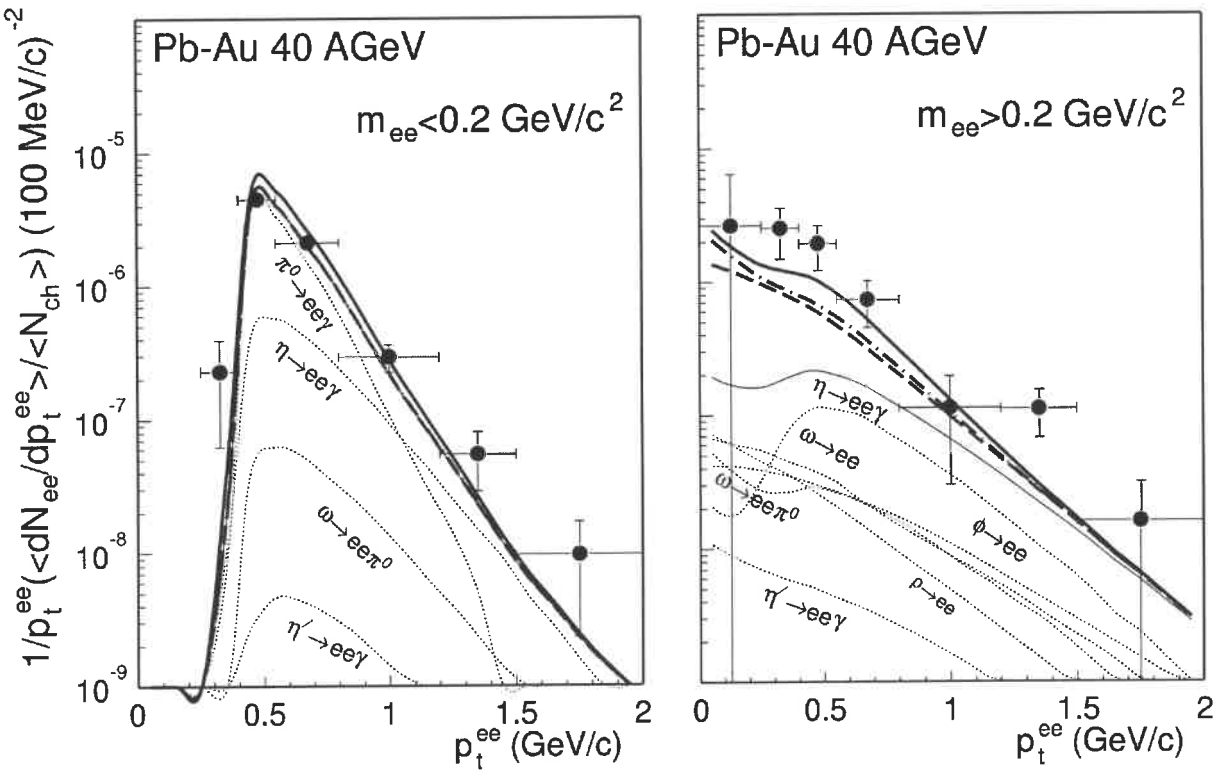
CERES running in 2003

Electron pairs from Pb+Au at 40 GeV per nucleon, calculation



CERES running in 2003

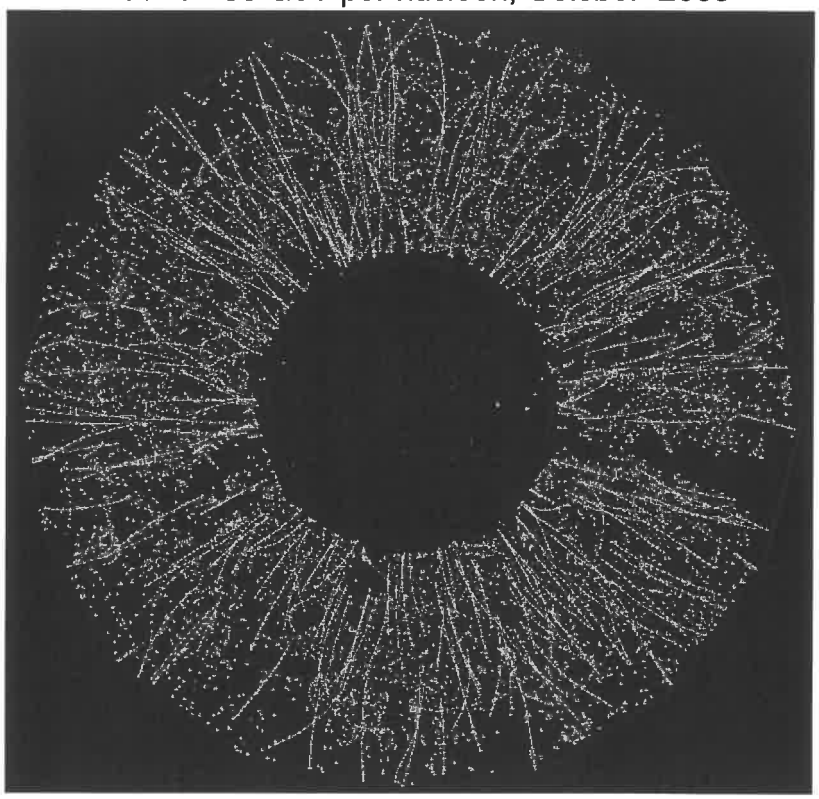
Pb+Au at 40 GeV per nucleon, pt-dependence of mass spectrum



CERES running in 2003

Understanding the TPC

Pb+Au 158 GeV per nucleon, October 2000

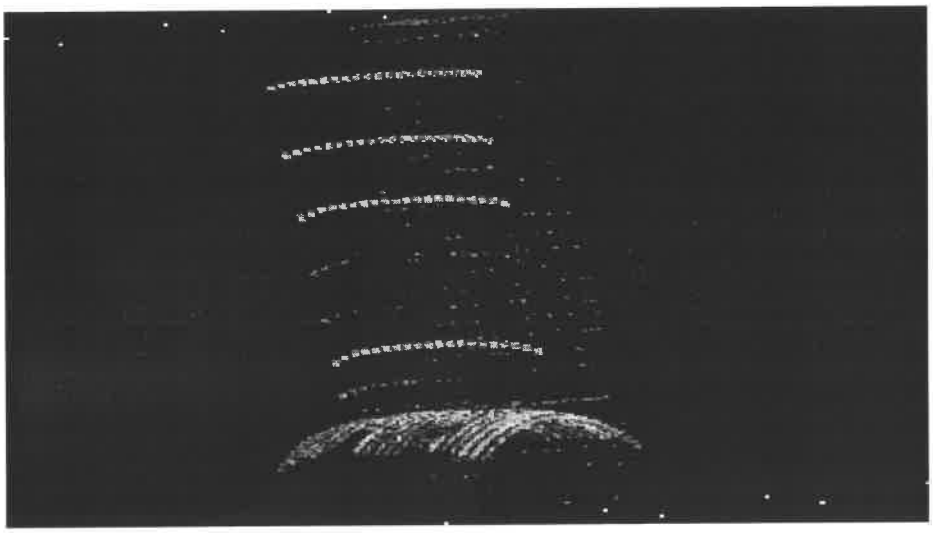


- detailed calculation of E-field
- detailed calculation of B-field
- drift velocity calibration
- chamber geometry calibration
- pad gain calibration
- pad non-linearity calibration
- new hit finding algorithm
- improved tracking algorithm

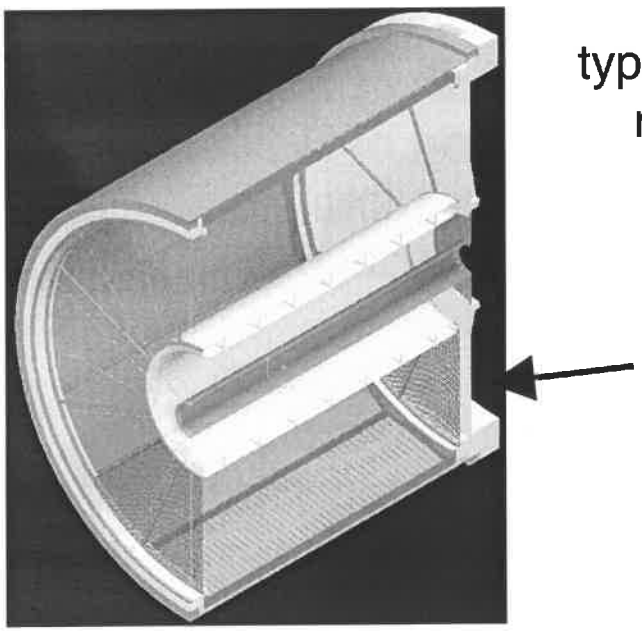
CERES running in 2003

TPC electric field

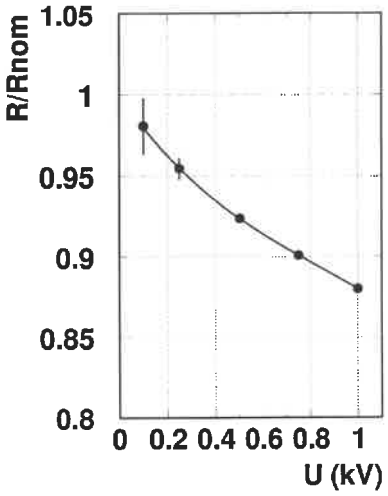
reconstructed laser tracks were curved:



explanation: bad resistors in the chain

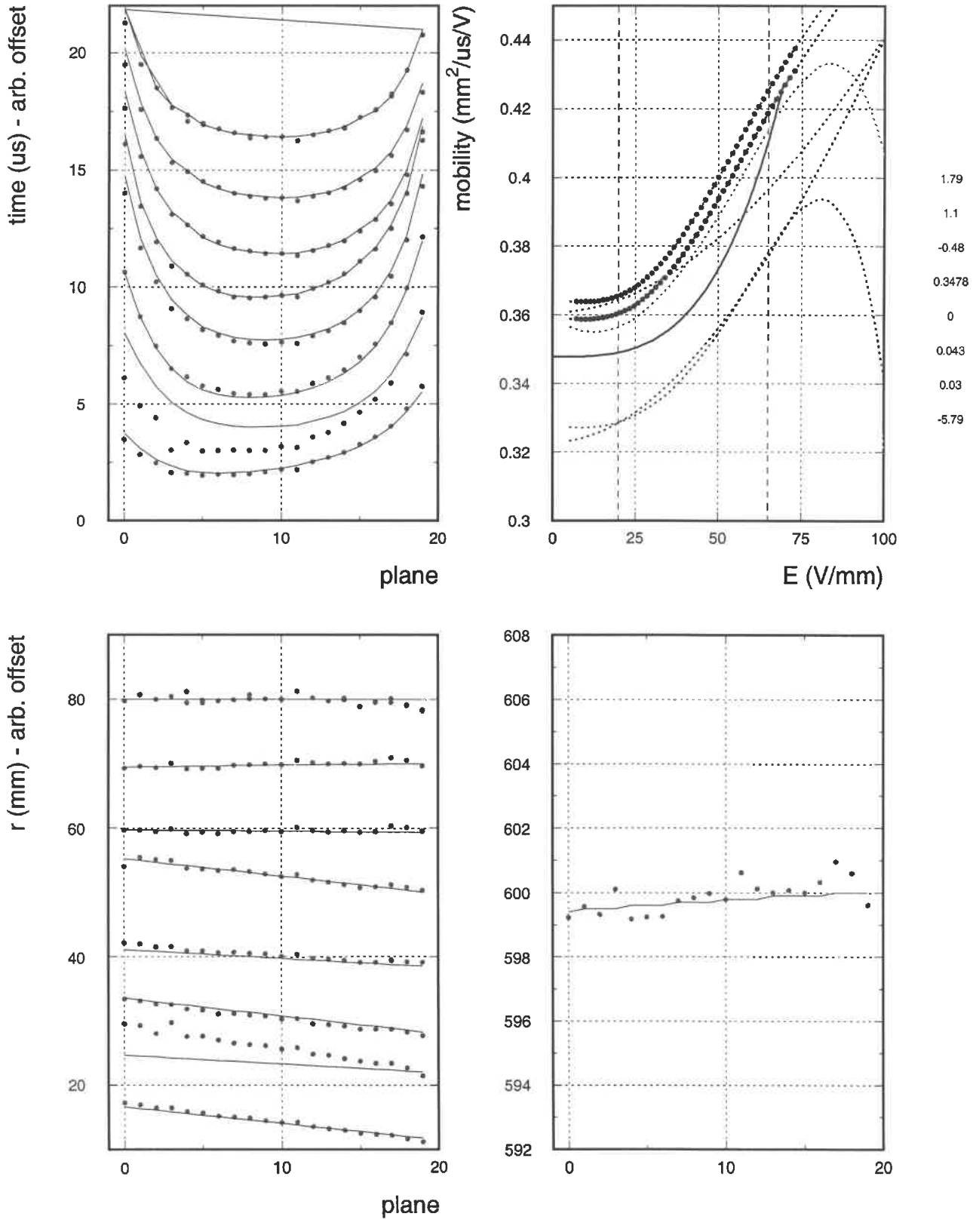


typical behavior of a carbon resistor (CERN stock):



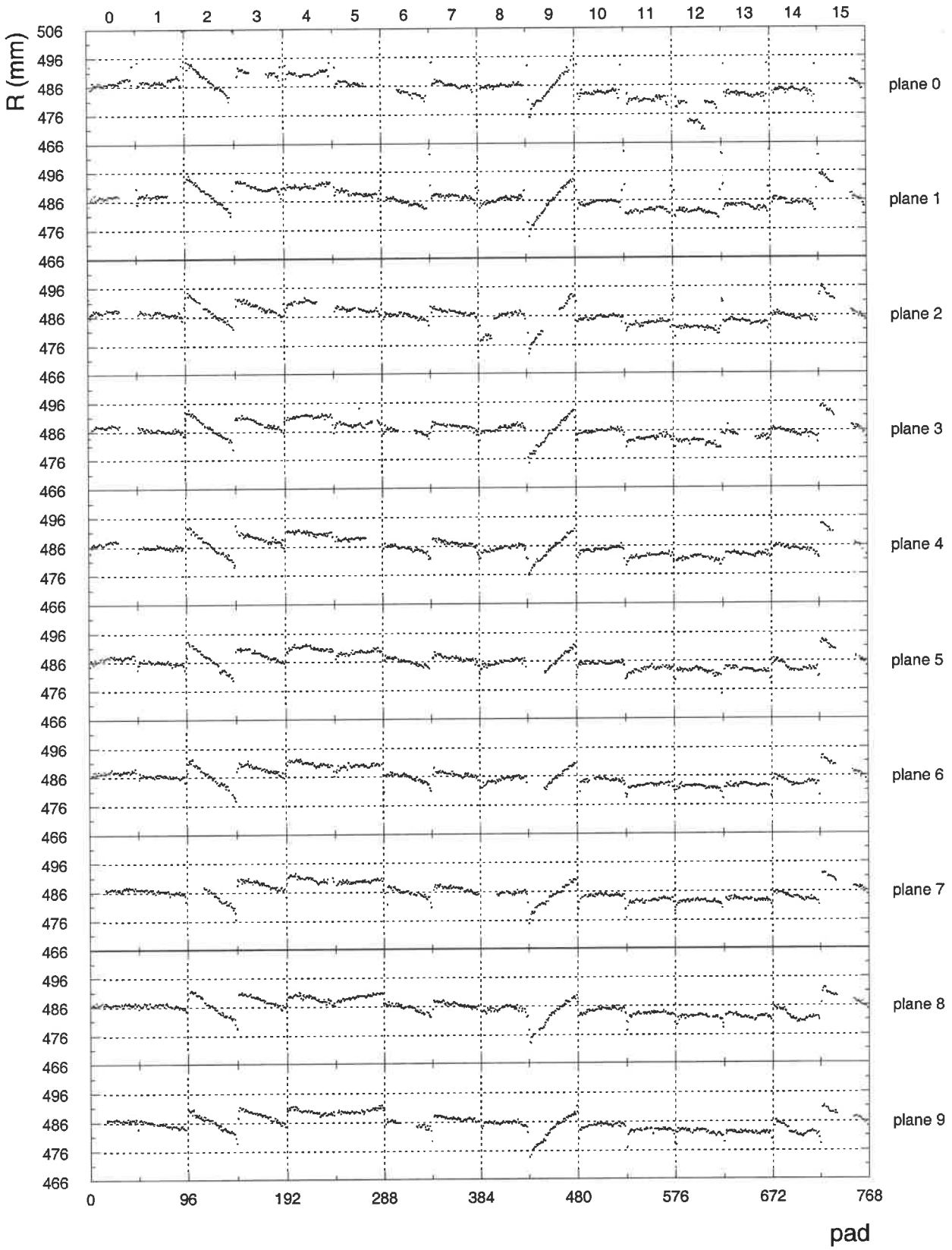
2002/04/10 10.18

Drift velocity determination from laser data



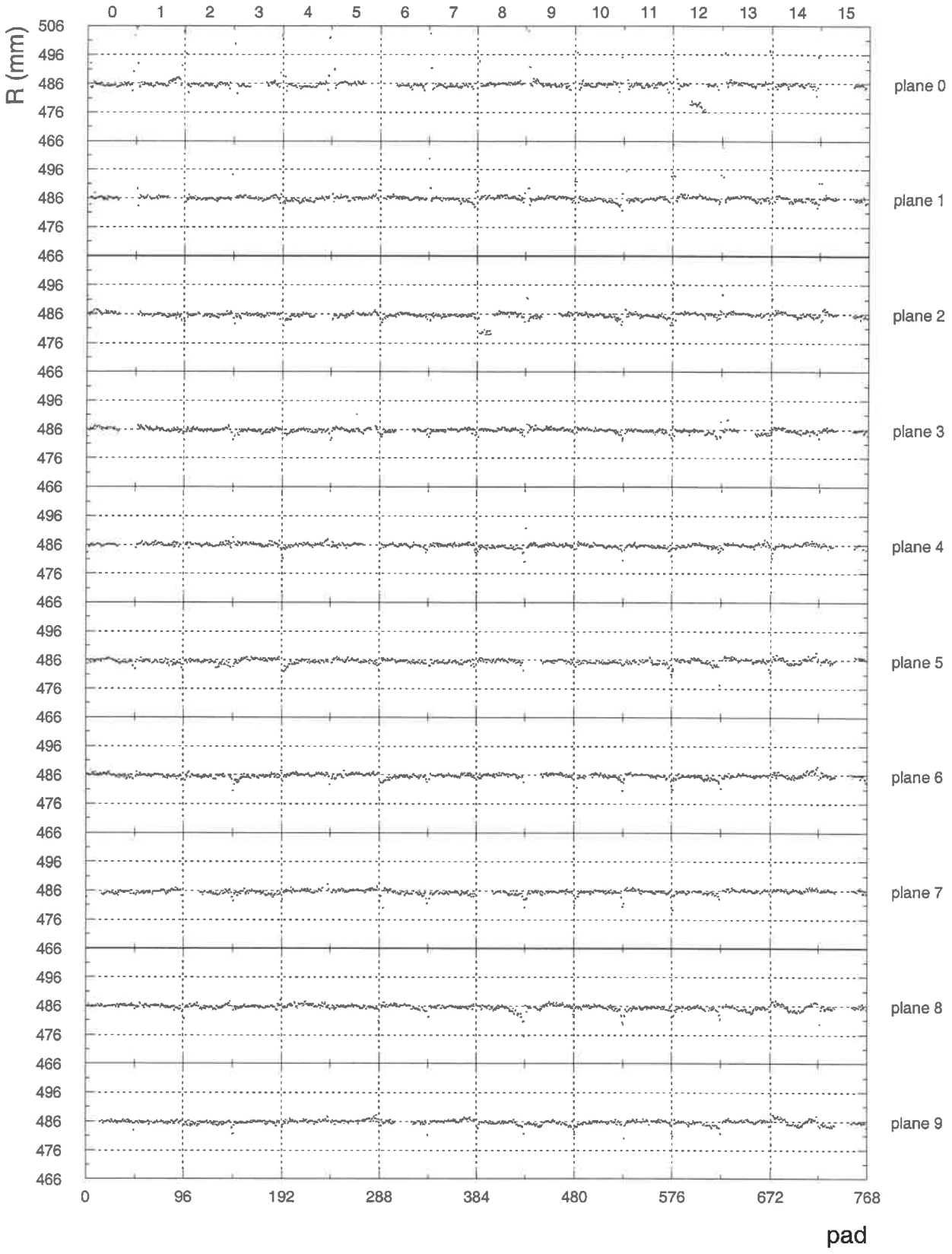
CERES running in 2003

2002/04/17 09.14



CERES running in 2003

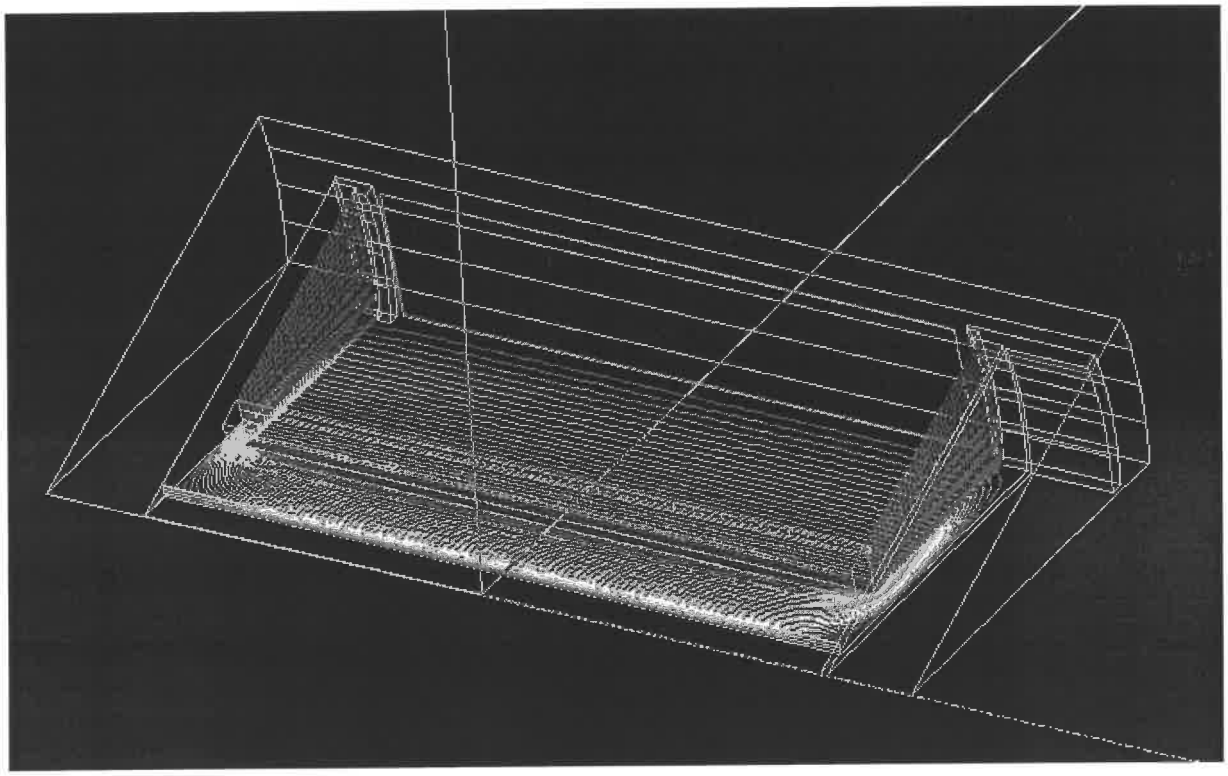
2002/04/17 09.07



CERES running in 2003

Electric field calculation

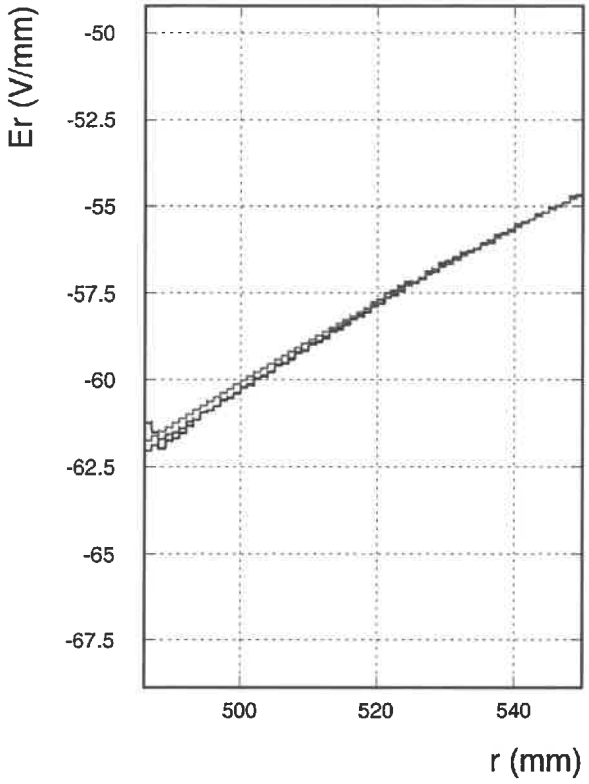
Maxwell package at CERN



CERES running in 2003

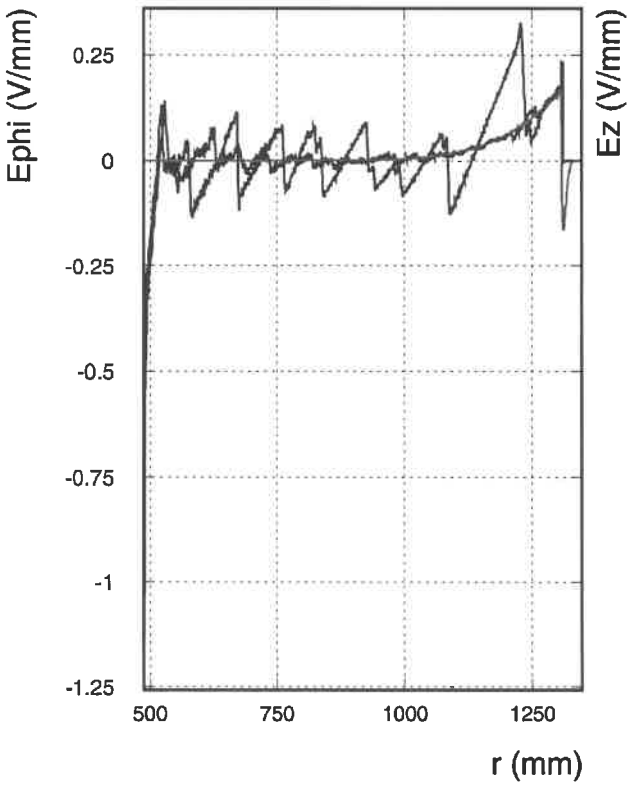
2002/03/25 12.19

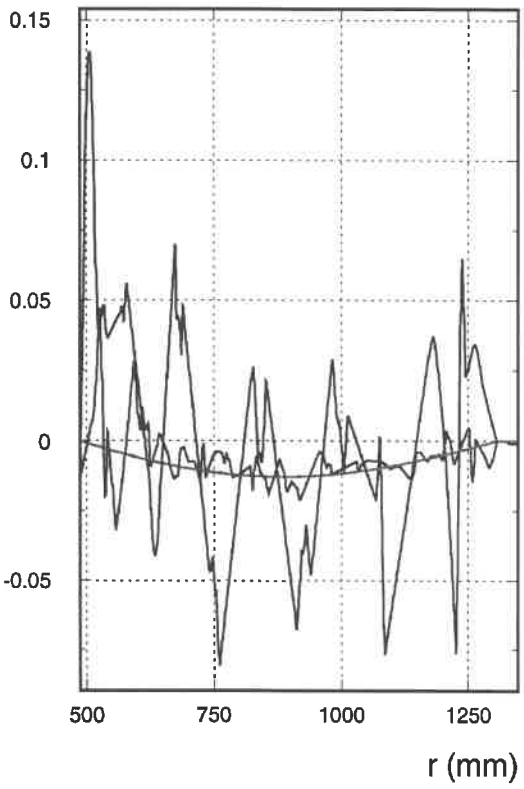
Bumps with maxwell and mymax at phi=0.25, z=50



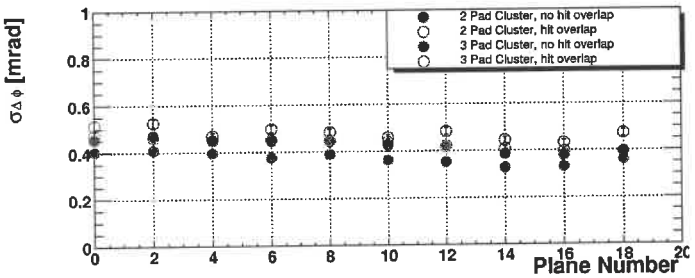
black- (31) maxwell auto mesh
blue - (54) maxwell manual mesh
red - (64) mymax

typical execution time:
maxwell 140 CPUh
mymax 14 CPUh



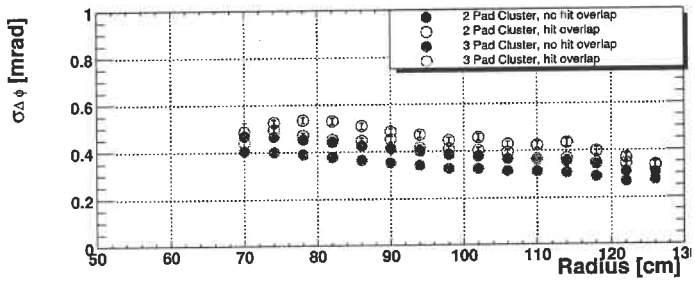


Present position resolution



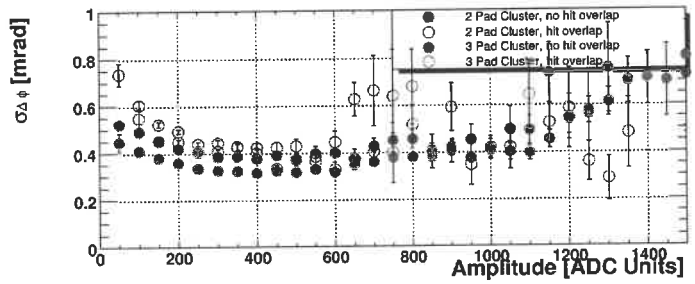
Radius = 100 cm

Ampl = 300-350



Plane = 14-15

Ampl = 300-350

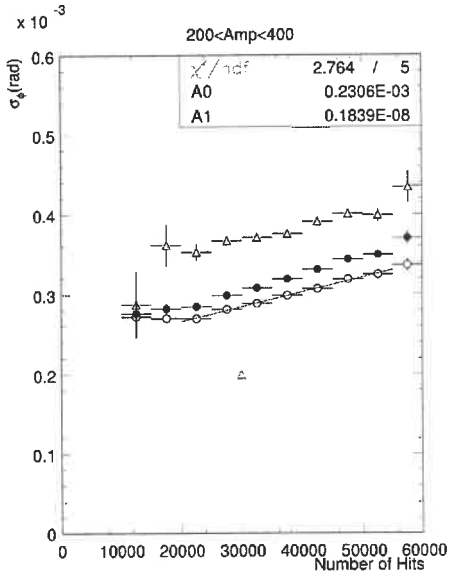


Radius = 100 cm

Plane = 14-15

hit multiplicity: 24-26 k; typical central: 20-50 k

typical amplitude for electrons: 270-350

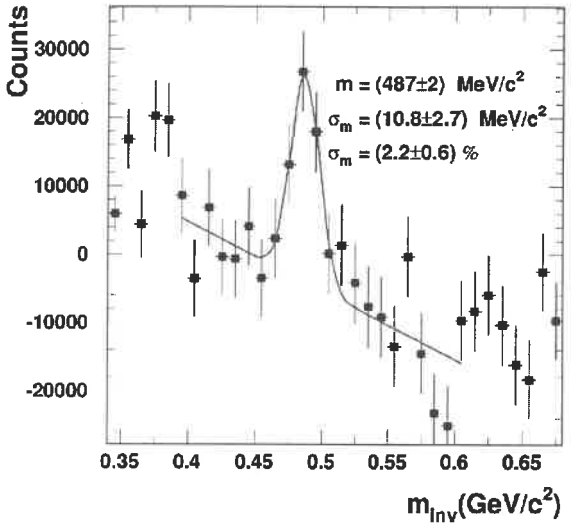


→ similar to the local resolution with B=0

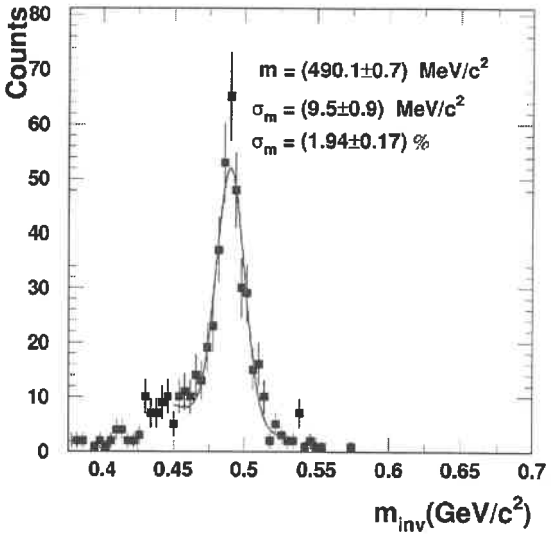
CERES running in 2003

Present momentum resolution

Pb+Au in 2000, 590 k events

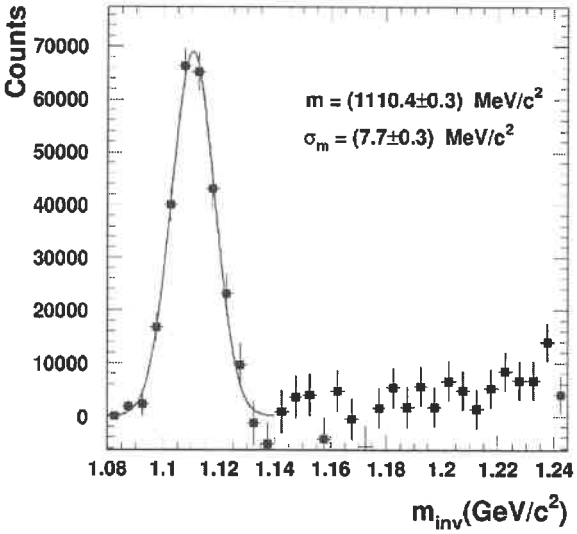


Monte Carlo

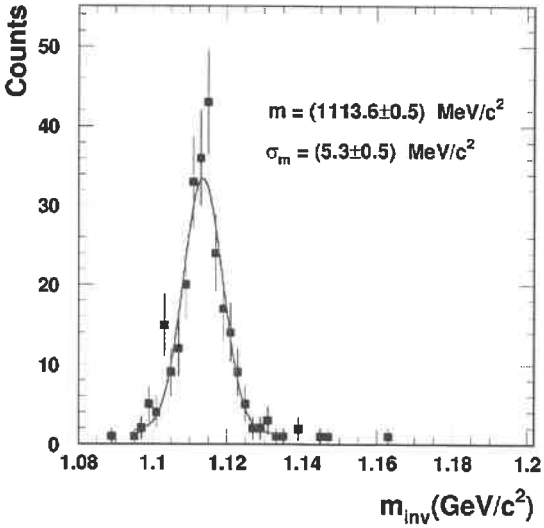


K^0_S

Pb+Au in 2000, 930 k events



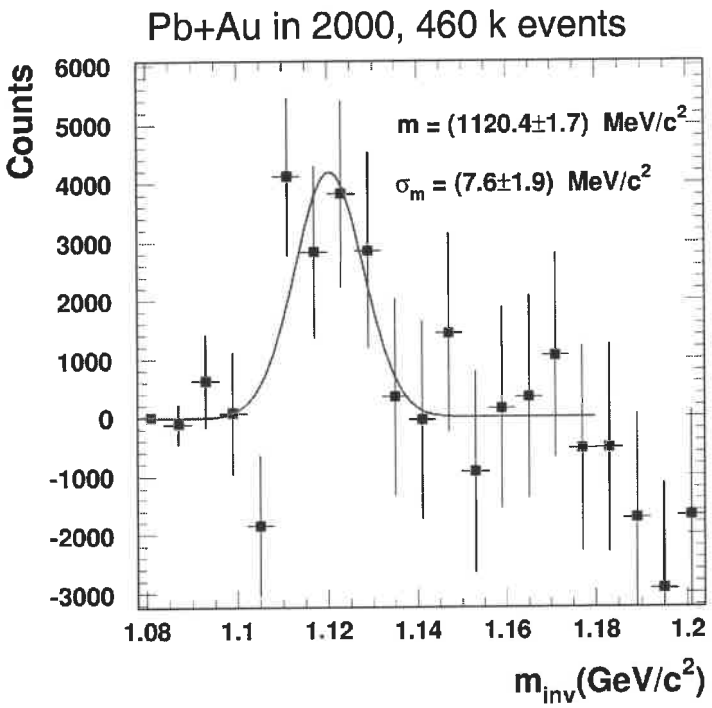
Monte Carlo



Λ

Compare to the widths in 1999: lambda 12.6 MeV, K0 21.7 MeV

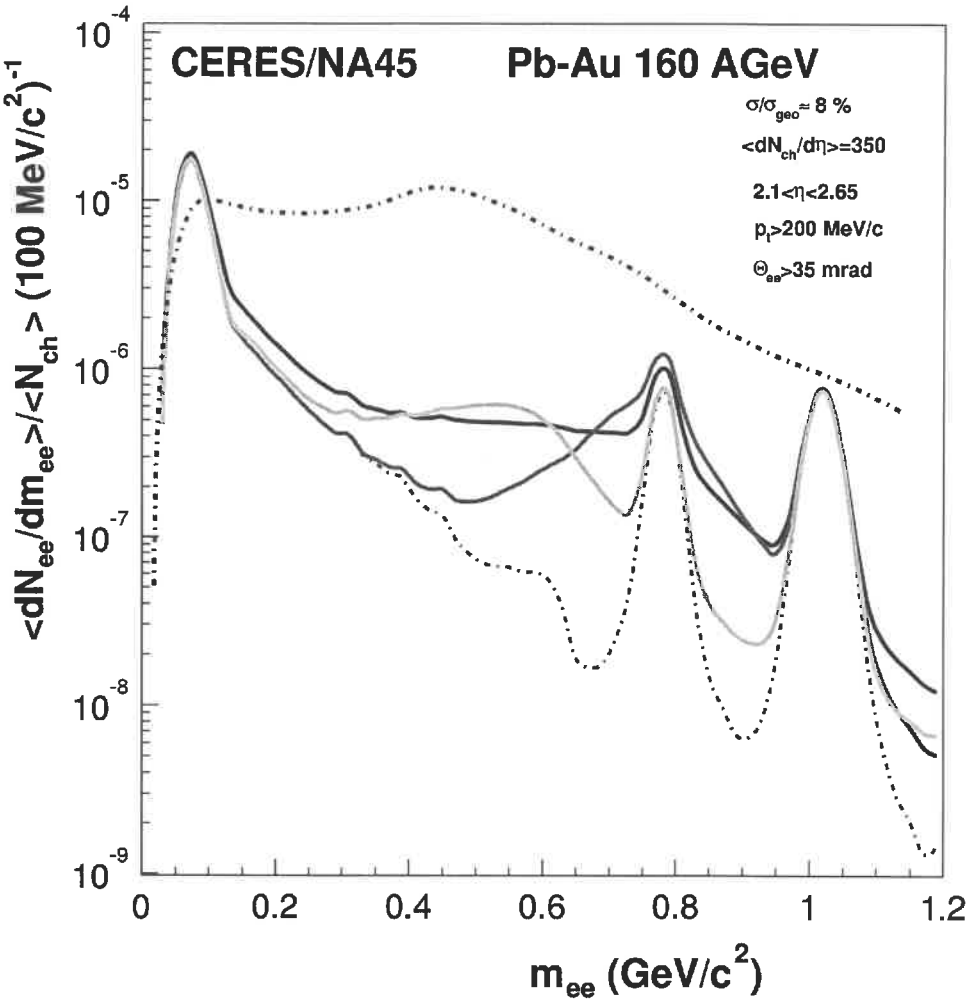
CERES running in 2003



$\overline{\Lambda}$

CERES running in 2003

Mass resolution expected in the 2000 data



→ ω can be distinguished from ρ

CERES running in 2003

e^+e^- pair yields

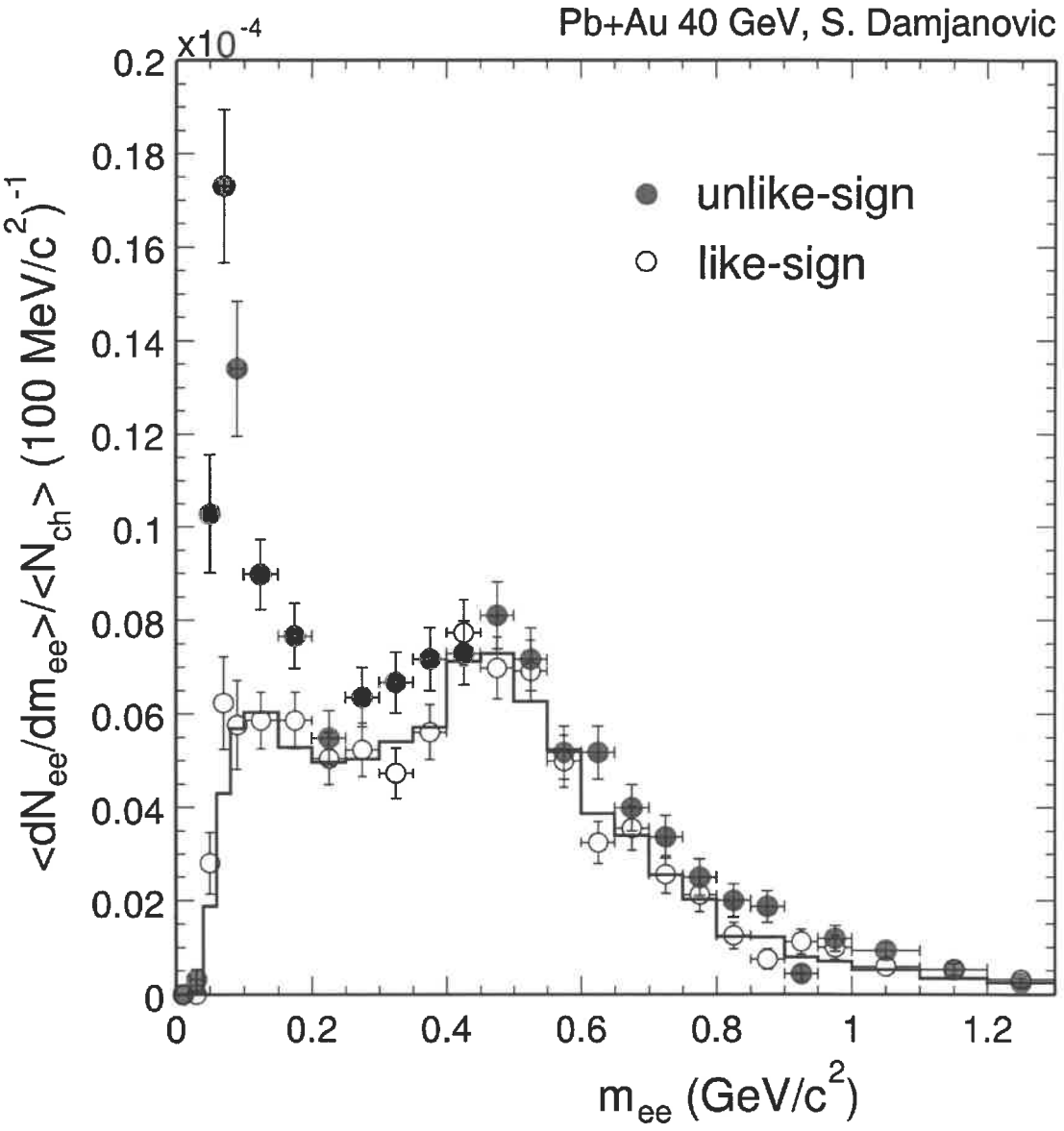
	S+Au 200 1992	Pb+Au 158 1995/96	Pb+Au 40 1999	Pb+Au158 2000
events	6 M	51 M	8 M	32 M
centrality	0.08	0.30	0.25	0.08
signal pairs	445	2666	184	5300*
B/S	4.3	11	6	8.5*
eff. pairs (S_{eff})	46	113	14	290*
stat. error	15%	9.4%	27%	6%

signal pairs: pairs with M>0.2 GeV/c^2

S_{eff} definition: $\frac{1}{\sqrt{S_{eff}}} = \frac{\Delta S}{S}$ $\qquad S_{eff} = \frac{S}{1+2B/S}$

CERES running in 2003

unlike-like subtraction



CERES running in 2003

Can we do better in 2003? Yes!

- lower mulitplicities in In+Ag

→ improved S/B, doubled event rate

- technological progress in networking

→ double event rate

- CERES upgrade was succesful, and the TPC calibration is nearly completed

→ improved momentum resolution and electron identification

Dielectron physics goals

In+Ag at 170 GeV per nucleon

→ A-dependence (by comparing to Pb+Au)

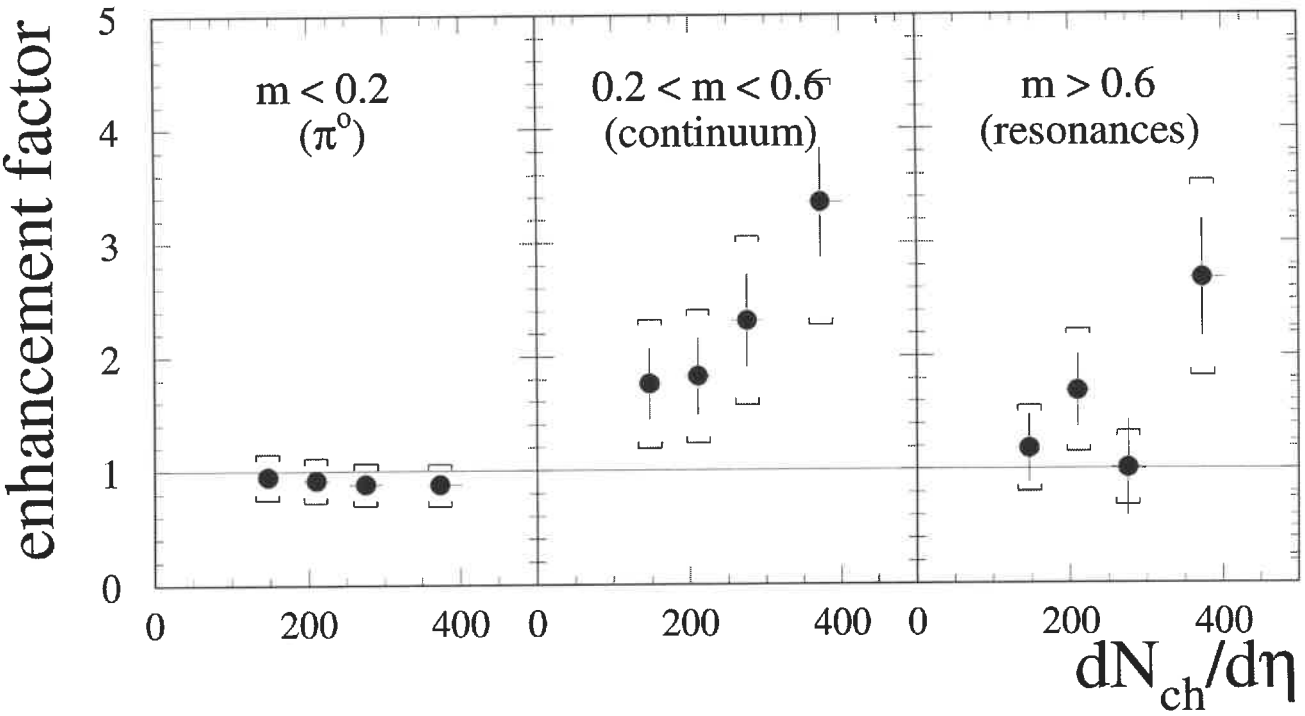
→ N_{ch}-dependence

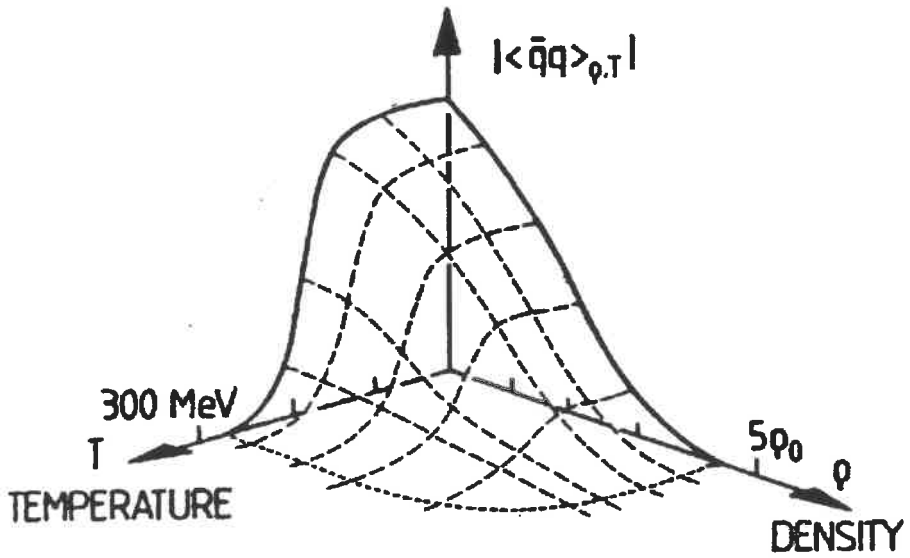
→ serious test of theoretical descriptions

Pb+Au at 25 GeV per nucleon

→ role of temperature and baryon density

CERES running in 2003





CERES running in 2003

Estimate of event rates

37 days of In+Ag at 170 GeV per nucleon

10 days of Pb+Au at 25 GeV per nucleon

	Pb+Au 158 2000	In+Ag 170 2003	In+Ag 25 2003	Pb+Au 25 2003
centrality	0.08	0.30	0.30	0.30
$dN_{ch}/d\eta$	355	138	88	160
triggers per burst	620	2400	4300	3200
events per burst	400	1200	2300	1300
net days	30	34	8	8
running efficiency	0.60	0.75	0.75	0.75
total events	32 M	140 M	54 M	31 M
open pair efficiency	0.13	0.24	0.27	0.23
total open pairs	5300	11700	3200	2800
B/S	8.5	4.7	3.0	5.4
statistical error	6%	3%	5%	6%

Hadron physics goals

Pb+Au at 25 GeV per nucleon

Fill the gap in beam energy systematics and search for the "softest point" (Hung and Shuryak, PRL 75 (1995) 4003).

Signatures:

1) increased duration
2) reduced elliptic flow
3) enhanced fluctuations
4) enhanced strangeness

Accessed, respectively, via:

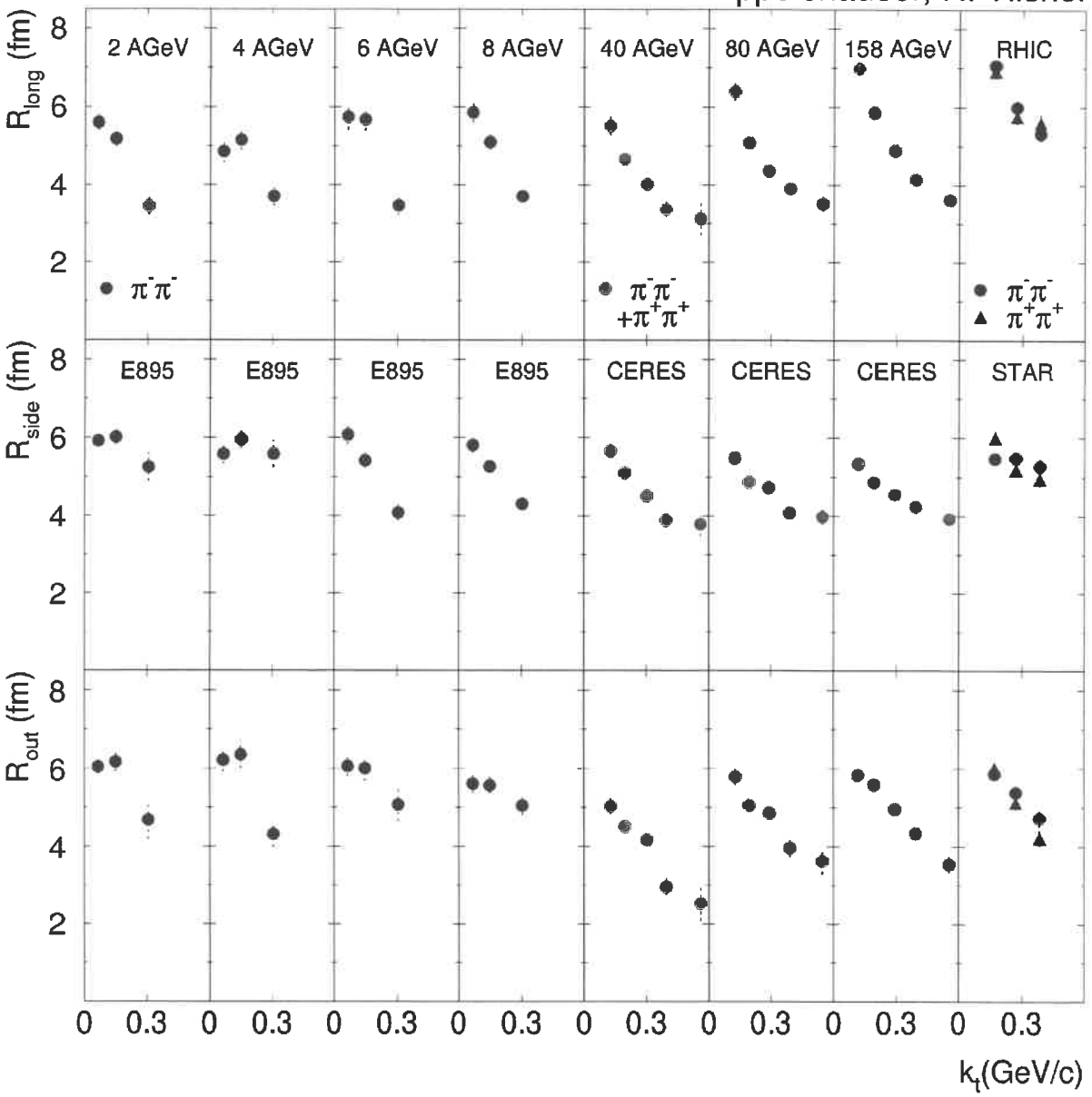
1) two-particle correlations
2) v_2 for charged particles
3) <pt> and charge fluctuations
4) lambda and kaon measurement

CERES running in 2003

Two-pion HBT in Pb+Au at 40,80,158 GeV per nucleon

nucl-ex/0207005, submitted to Nucl. Phys. A

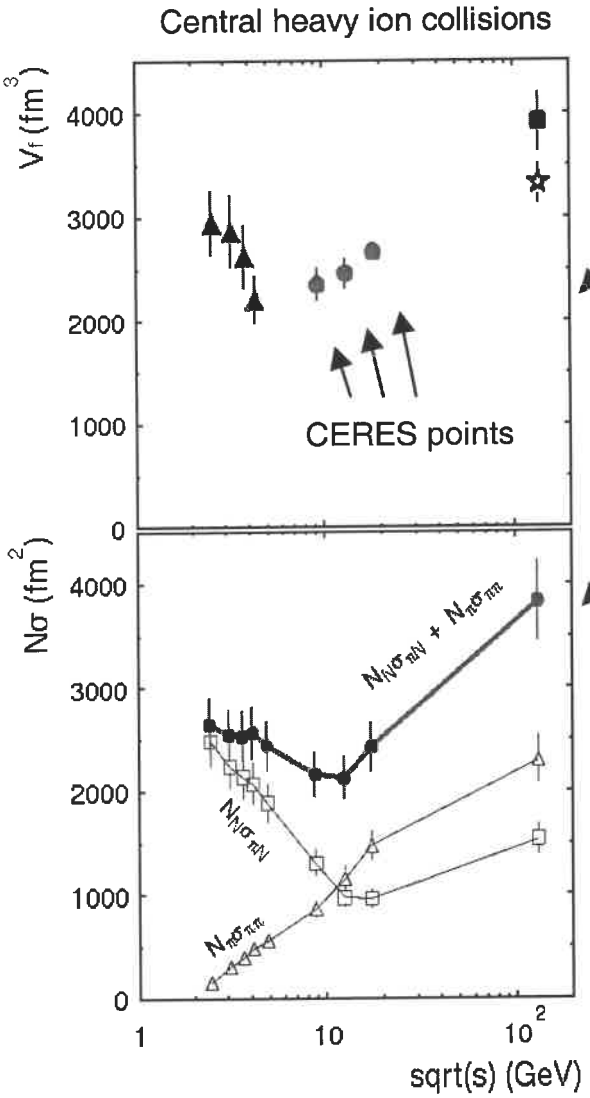
H. Appelshäuser, H. Tilsner



CERES running in 2003

New freeze-out criterium deduced from two-pion HBT analysis

nucl-ex 0207008, submitted to Phys.Rev.Lett.



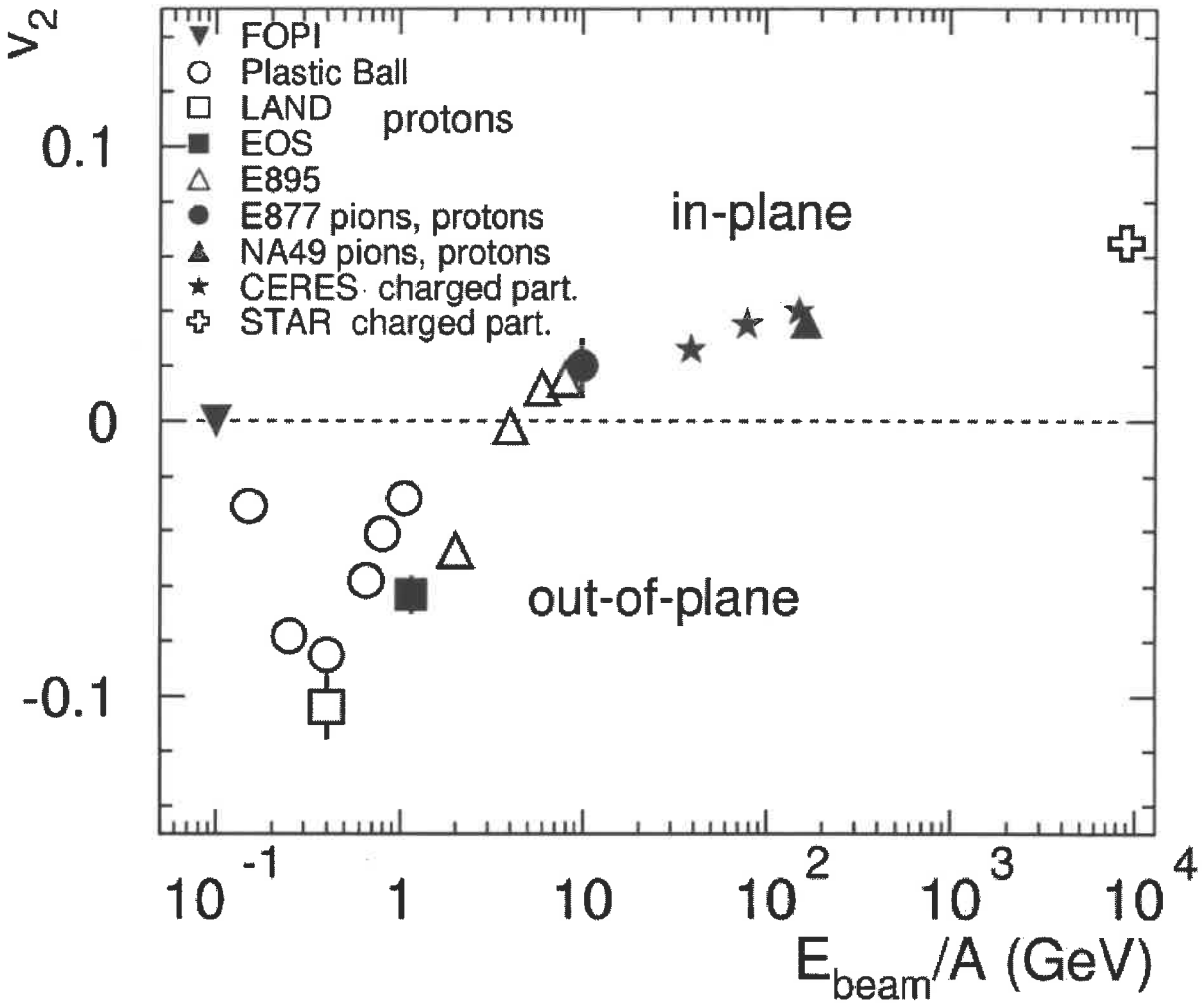
Freeze-out volume
$V_f = (2\pi)^{3/2} R_{long} R_{side}^2$
has a minimum at a beam energy of 10-40 GeV per nucleon

Particle multiplicity times mean hadron-hadron cross-section Nσ has a similar beam energy dependence

$V_f / N\sigma = \lambda_f = 1$ fm
independent of beam energy

Freeze-out
-- not at a fixed spatial density
-- not at a fixed phase-space density
-- not when mean free path ≈ R
but
when mean free path ≈ 1 fm

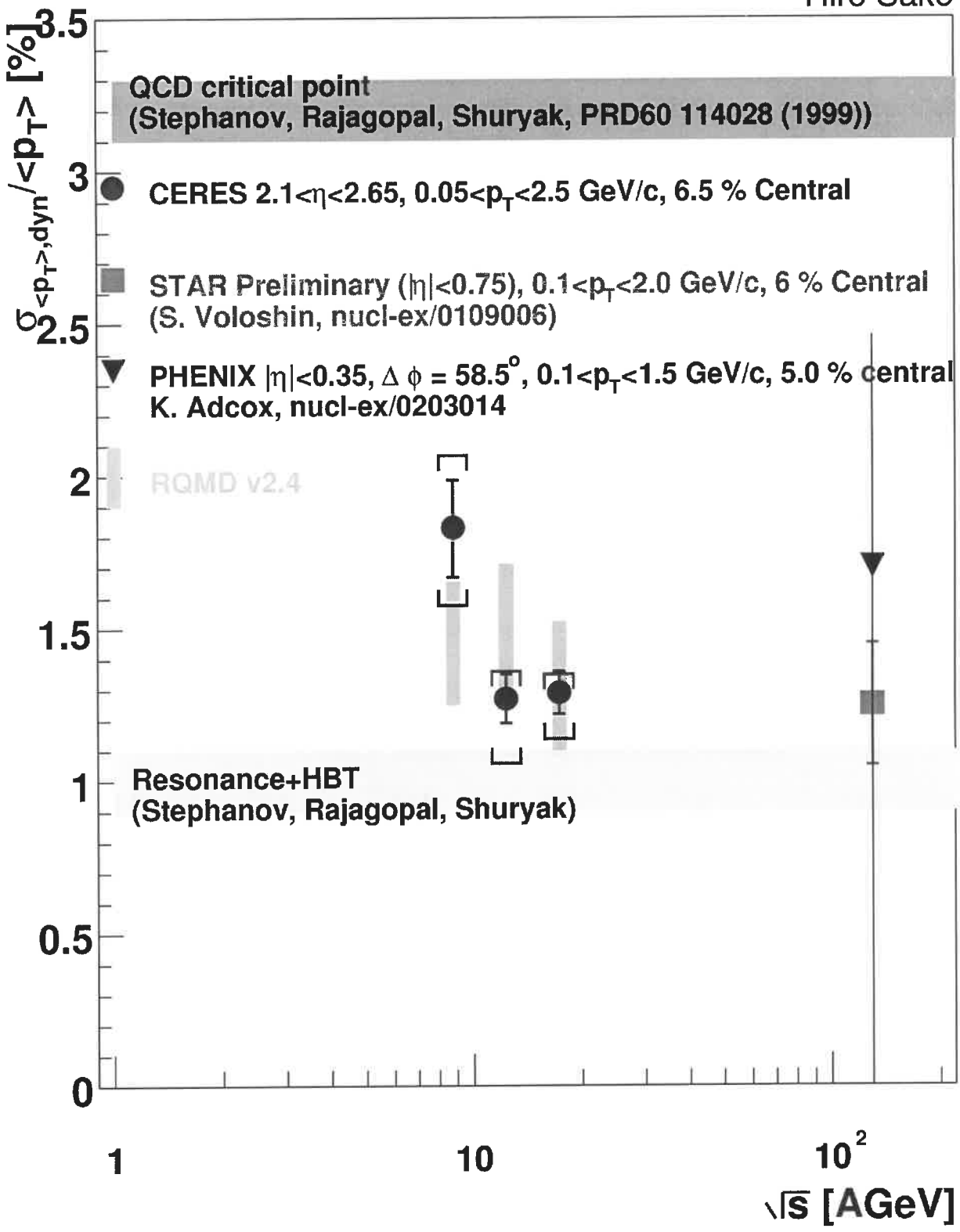
Elliptic flow systematics



CERES running in 2003

mean-pt fluctuations

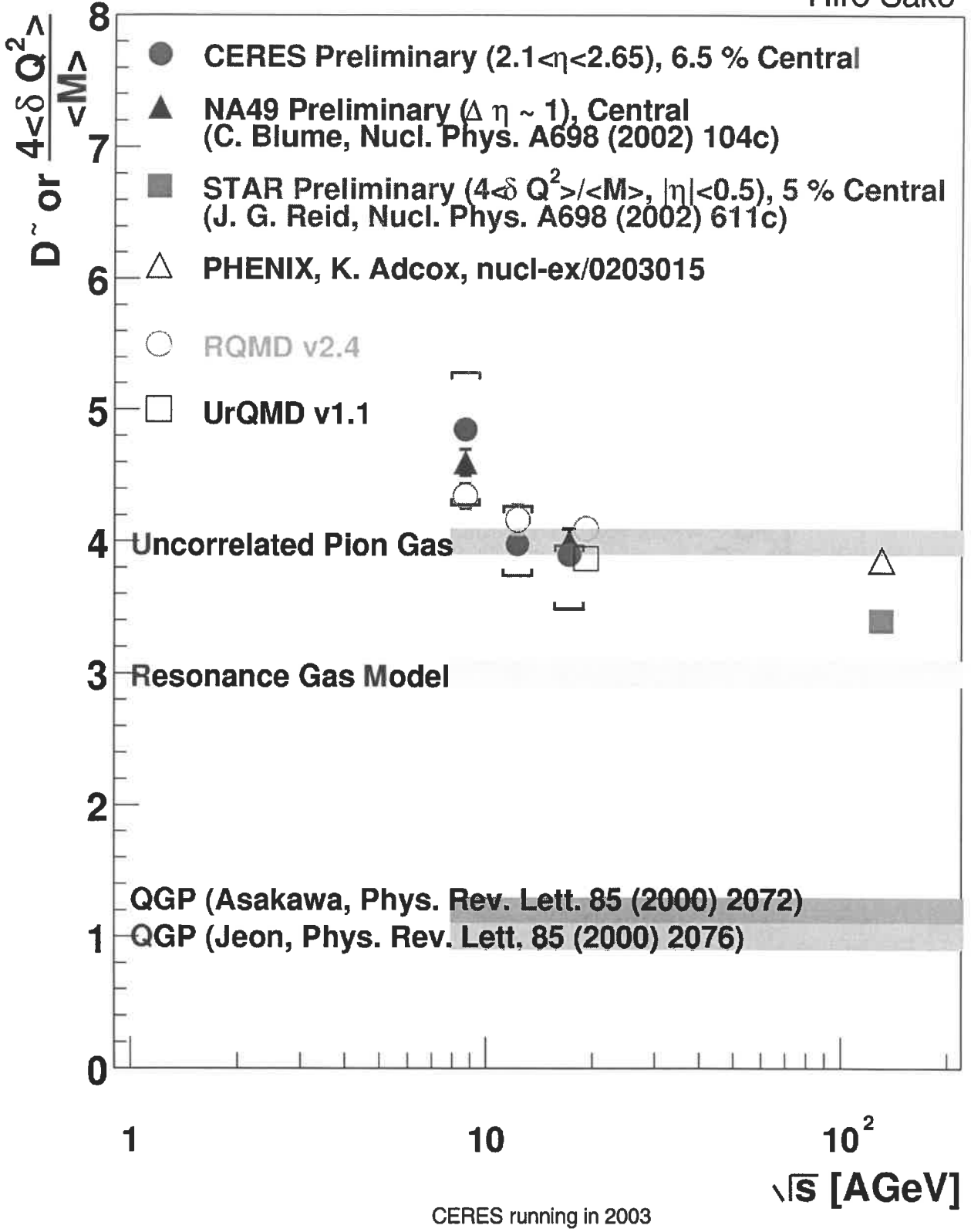
Hiro Sako



CERES running in 2003

Charge fluctuations

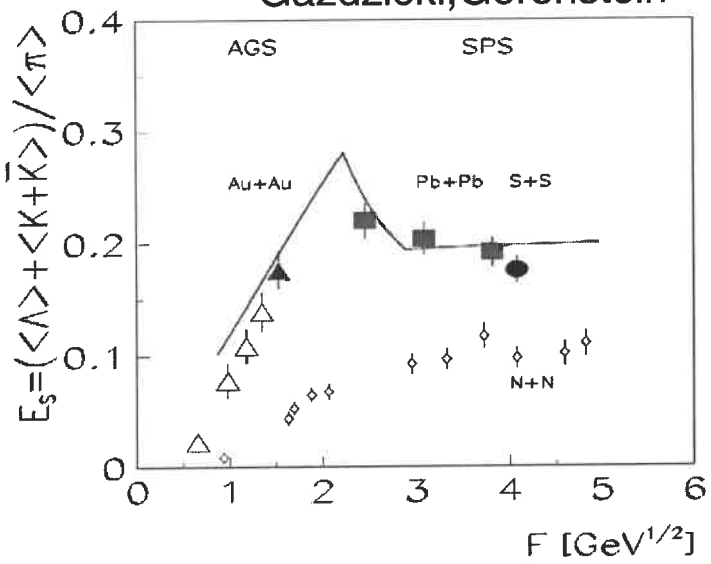
Hiro Sako



CERES running in 2003

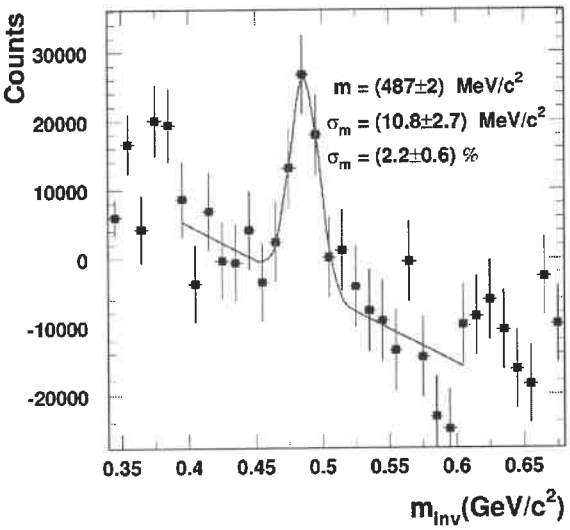
lambda and kaon measurements

Gazdzicki,Gorenstein



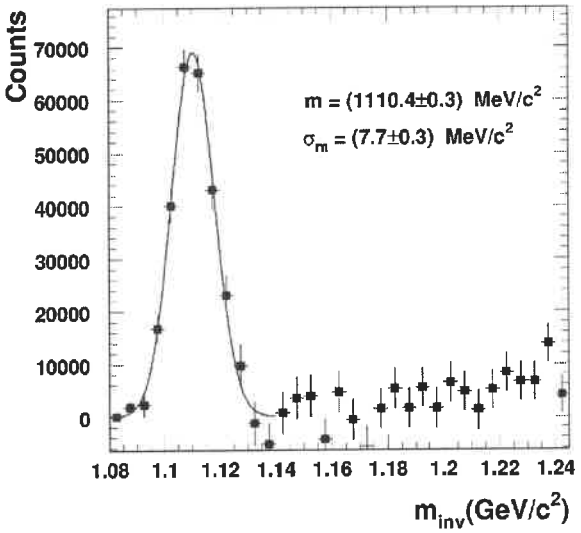
K^0_S

Pb+Au in 2000, 590 k events



Λ

Pb+Au in 2000, 930 k events



CERES running in 2003

Estimate of the effort

experiment preparation

C_4F_{10} for beam Cherenkov for 25 GeV

new targets

new receiver PCs

RICH gas safety inspection

TPC magnet inspection

CERN

– powering H8 beamline (1.3 MW)

– powering TPC magnet (2 MW)

– VME crates and MXI interfaces from pool

– CDR routine support for storing data

– ED support in emergencies

–TPC gas, RICH gas, TMAE, data storage

(covered by CERES)

Summary

- in 2003 we request
  - 37 days of high energy In beam
  - 10 days of 25 GeV Pb beam
- strong improvement of accuracy of dilepton measurements is within the reach
- high statistics hadron measurement in the probably most exciting beam energy range can be easily done

CERES team for the 2003 run

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