STATUS OF DILEPTON MEASUREMENTS WITH CERES

DARIUSZ MIŚKOWIEC, GSI DARMSTADT

HIRSCHEGG, JANUARY 2000

1. INTRO
2. CERES RESULTS 1990 – 1996
3. UPGRADE
4. OUTLOOK

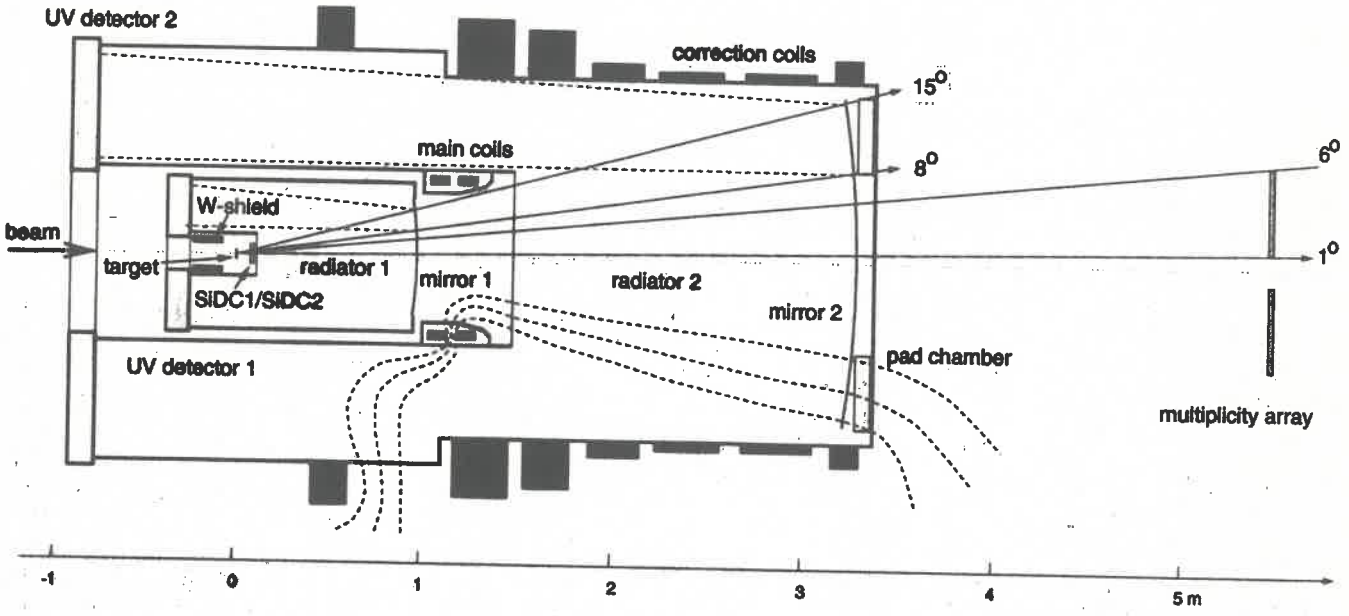
SOURCES OF e^+e^- PAIRS

- $q\bar{q} \to \gamma^* \to e^+e^-$ DRELL-YAN
  $qg \to q\gamma^* \to qe^+e^-$
  $q\bar{q} \to g\gamma^* \to ge^+e^-$
- $\varsigma, \omega, \phi, J/\psi, \Upsilon \to e^+e^-$ VECTOR MESONS
- $\pi\pi \to e^+e^-$ PION ANNIHILATION
- $q\bar{q} \to \gamma^* \to e^+e^-$ THERMAL RADIATION FROM QGP
- $\pi^0, \eta, \eta' \to e^+e^-\gamma$ DALITZ DECAY
  $\omega \to e^+e^-\pi^0$
- $D \to e^+X$ OPEN CHARM, SEMILEPTONIC DECAY
  $\bar{D} \to e^-X$
- $\gamma X \to e^+e^-X$ CONVERSION

CERES HISTORY

1990	INSTALLATION	
1991	COMPLETED	
1992	200 GeV/u S+Au	4M CENTRAL + 3M PAIRS
1993	450 GeV p+Be	10 M PAIRS
	" p+Au	3M PAIRS
1995	160 GeV/u Pb+Au	10 M CENTRAL
1996	" "	60 M CENTRAL
1997	TPC CONSTRUCTION	
1998	TPC INSTAL. + TESTS	
1999	40 GeV/u Pb+Au	10 M CENTRAL
2000	160 GeV/u Pb+Au	

CERES setup in 1996



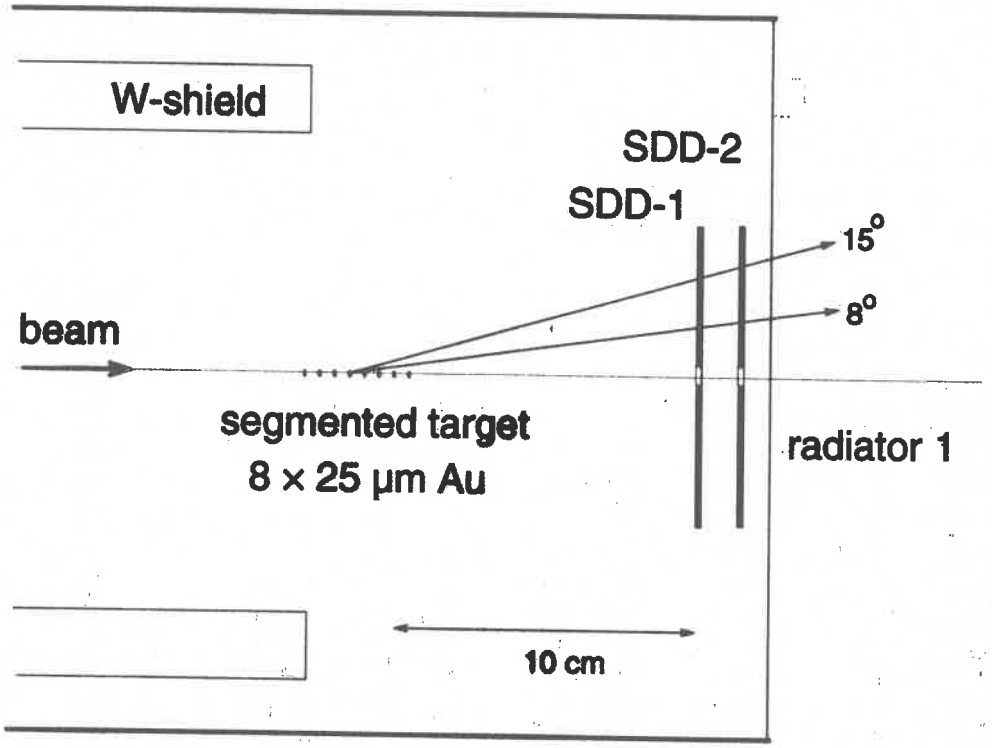
Main features:

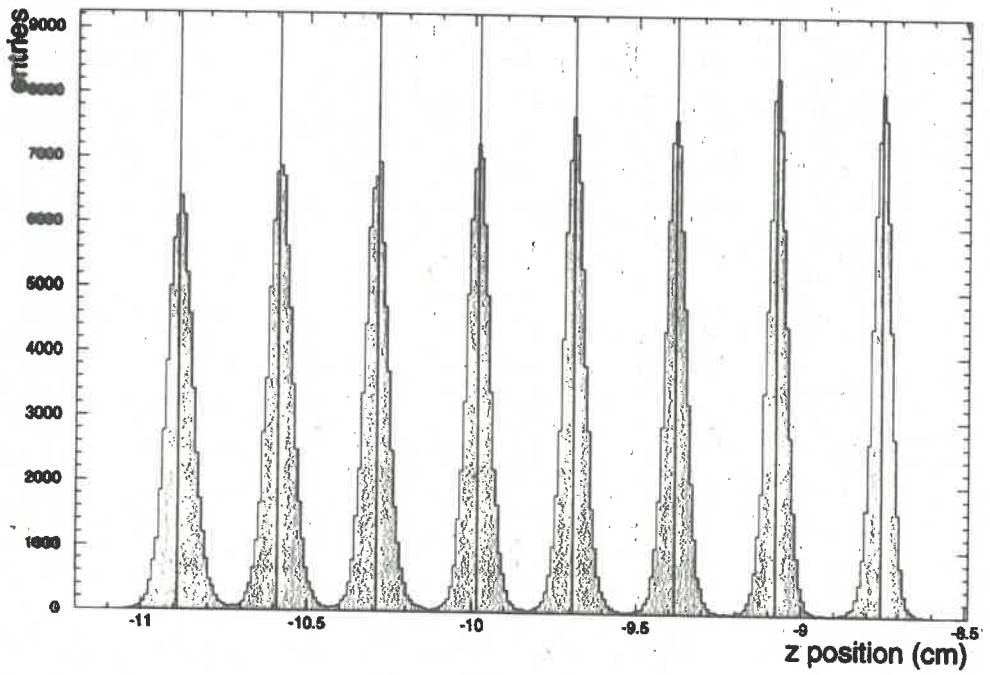
- cylindrical symmetry; $2.7 > \eta > 2.1$
- radial magnetic field, ll to traj. within RICH2
- UV detectors upstream of target
- pair conversion minimized

Detectors:

- SDD1, SDD2 (charged particles)
  vertex, centrality, rejection of close pairs
- RICH1, RICH2 (electrons)
  electron id, momentum measurement
- PADC (charged particles)
  tracking

CERES target area





CERES'96 PARAMETERS

TARGET: Be WIRE ϕ1.2 × 30 7.4% INTER. 0.8% X_0
29 Au DISCS ϕ0.6 × 0.05 2.9 SPACING 23% INTER. 1.1% X_0
8 Au DISKS ϕ0.6 × 0.025 2.8 SPACING

MATERIAL IN PATH: 1-2% X_0

RICH: CH_4 (METHAN) AT 1 at. AS RADIATOR. $\gamma_{thr} = 32$. FOR π THIS MEANS 4.5 GeV, i.e. ~2% ABOVE. RICH1 MIRROR 1MM C. RICH2 MIRROR 6 MM GLASS. 12 PHOTONS PER RING. 1 MRAD RESOLUTION PER PHOTON. 92% EFFICIENCY PER PHOTON. UV DETECTORS UPSTREAM OF TARGET. UV DETECTOR GAS He + 6% CH_4 (QUENCHER) + TMAE (PHOTOSENSITIVE AGENT). KEPT AT 50°C SO TMAE SATURATED VAPOUR. TWO PPAC + 1 MWPC STAGES. GAIN $2-4 \cdot 10^5$. EXPONENTIAL PHOTON AMPLITUDE DISTRIBUTION. HIT DISTRIBUTED OVER 5-10 PADS. 50000 PADS EACH DETECTOR.

MAGNET: SUPERCONDUCTING DOUBLE SOLENOID + WARM CORRECTION COILS.

MDC: ADDED IN 95, 3.3 m FROM TARGET, $2.0 < \eta < 2.7$

MULT. WALL: 24 SCINTILLATORS, $2.9 < \eta < 4.8$, FOR TRIGGER.

SDD: RADIAL DRIFT OUTWARD. MAX ~ 3cm. 360 SIGNAL ANODES. DRIFT FIELD 500V/cm. POSITION RESOLUTION ~ 20μm.

TAPS: 6 m FROM TARGET. $3.0 < \eta < 4.0$. 378 BaF_2 WITH 12 X_0.

CERES Pb ANALYSIS SCHEME

TRACK QUALITY CUTS

- MATCHING BETWEEN DETECTORS
- RING RADIUS - π REJECTION
- RING QUALITY

PHYSICS CUTS

- dE/dx - CONVERSIONS REJECTION
- CLOSE PAIRS - CONVERSIONS AND DALITZ REJECTION

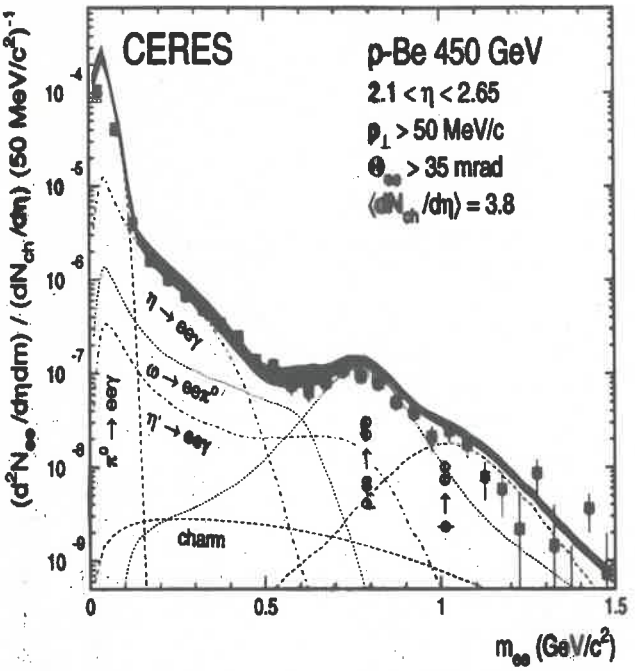
PAIRING

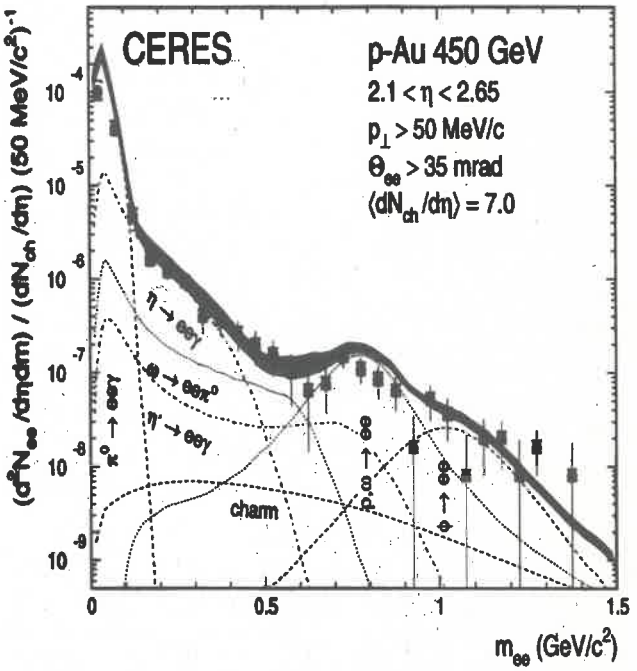
$$\frac{dN}{dM_{+-}} \;/\; \frac{dN}{dM_{++}} \;/\; \frac{dN}{dM_{--}}$$

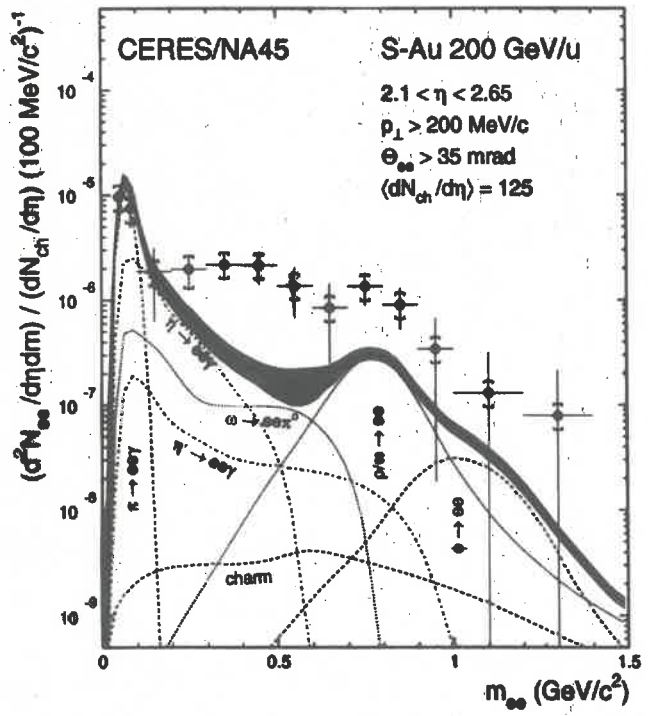
SUBTRACTION OF COMB. BACKGROUND

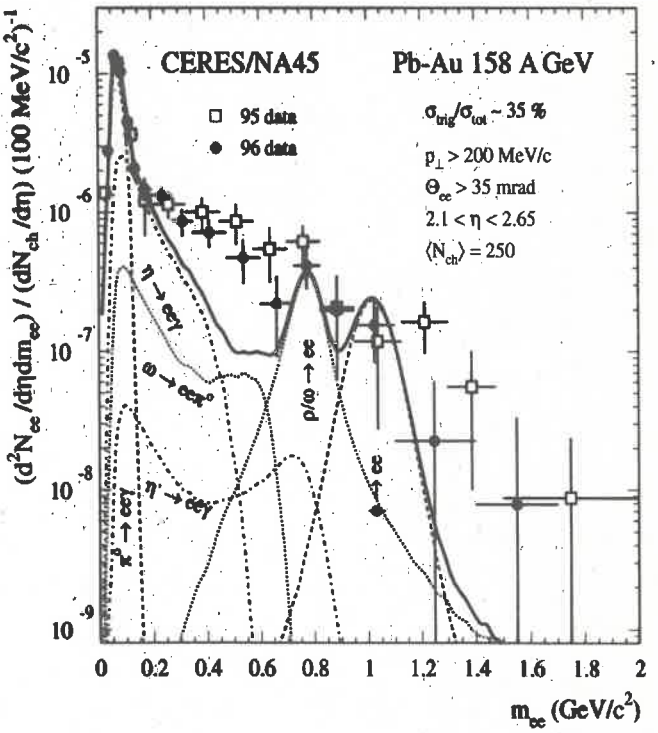
$$\frac{dN}{dM_{+-}} - 2\sqrt{\frac{dN}{dM_{++}} \cdot \frac{dN}{dM_{--}}}$$

CERES results









0.2 GeV < m_{ee} < 1.5 GeV excess 0.25 GeV < m_{ee} < 0.7 GeV

$5.0 \pm 0.7 \pm 2.0$

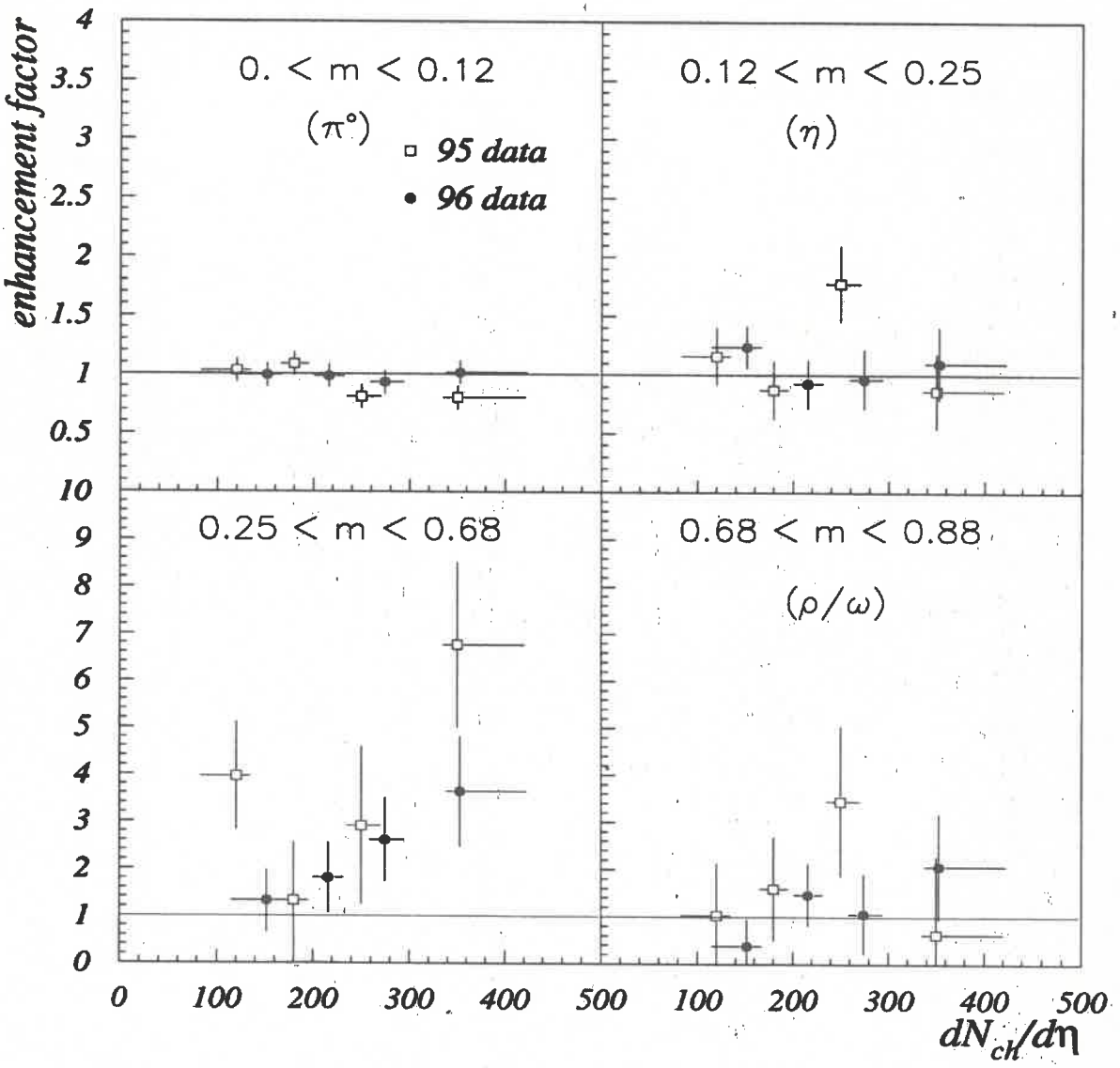
$4.9 \pm 1.1 \pm 1.0$ (95)

$3.3 \pm 0.7 \pm 0.7$ (96)

Centrality dependence

BJÖRN LENKEIT, QM99

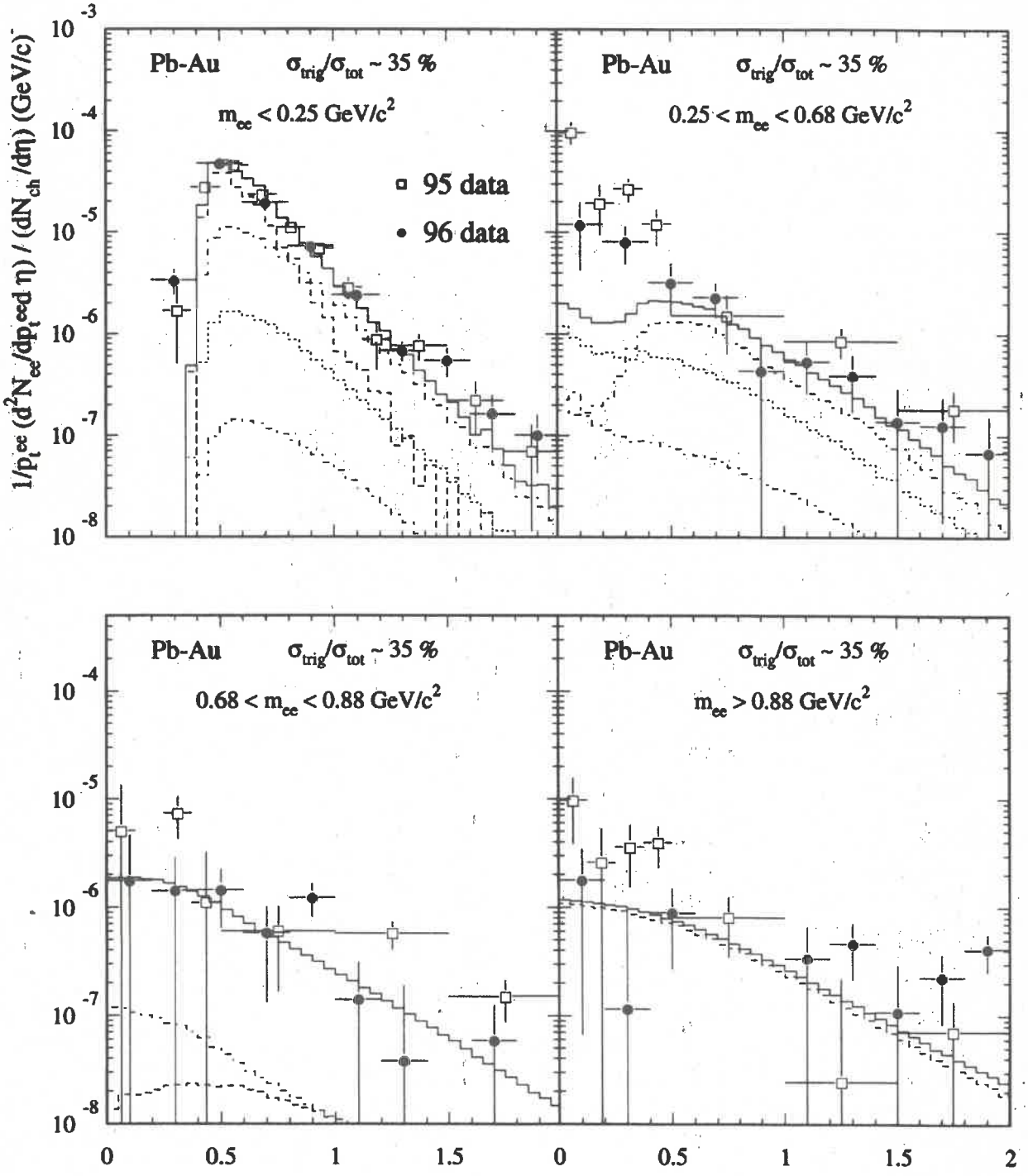
enhancement factor = $N^{e^+e^-}$ / $N^{e^+e^-}$ (hadronic sources)



increase of pair yield stronger than linear with multiplicity in the mass range between $2 \cdot m_\pi$ and the ρ/ω peak

e^+e^- pair $p_\perp$-spectra

BJÖRN LENKEIT, QM 99



enhancement most pronounced at low pair $p_\perp$

GENESIS

	σ/σ_{π^0}	decays
π^0	1.00	$\pi^0 \to \gamma e^+e^-$
η	0.053	$\eta \to \gamma e^+e^-$
η'	0.009	$\eta' \to \gamma e^+e^-$
ψ	0.0033	$\psi \to e^+e^-$
ς	0.065	$\varsigma \to e^+e^-$
ω	0.065	$\omega \to \pi^0 e^+e^-$, $\omega \to e^+e^-$

$$\frac{dN}{dp_\perp} \sim A\, e^{-B m_\perp} + C \frac{\left(1 - \frac{2m_\perp}{29.1}\right)^{7.9}}{\left(1 + m_\perp^2\right)^4}$$

$$\frac{dN}{dy} \sim \cosh^{-2}\left(\frac{0.75}{\sigma}(y - y_0)\right) \quad , \quad \sigma = \sqrt{\log(\gamma_{BEAM})} \cdot \frac{y_{max}}{y_{max}^{\pi^0}}$$

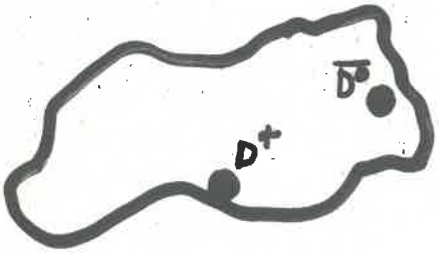
NEW

- CHARM ADDED
- ς SHAPE IMPROVED
- REWRITTEN IN C++ (ORIG. IN F90)
- DECAYS BY JETSET
- THERMAL PARTICLE YIELDS

HOW IT HAPPENS:

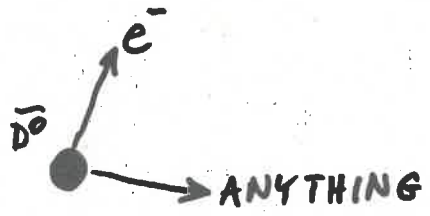
10^{-1} IN CENTRAL Pb+Pb @ 160GeV

10^{-4} IN MIN. BIAS p+p

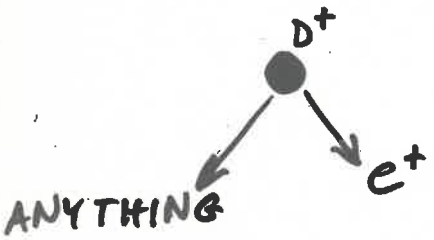


D^+	$c\bar{d}$
D^0	$c\bar{u}$
D_s^+	$c\bar{s}$
Λ_c^+	udc

$c\tau \sim 0.2$ mm



7%



17%

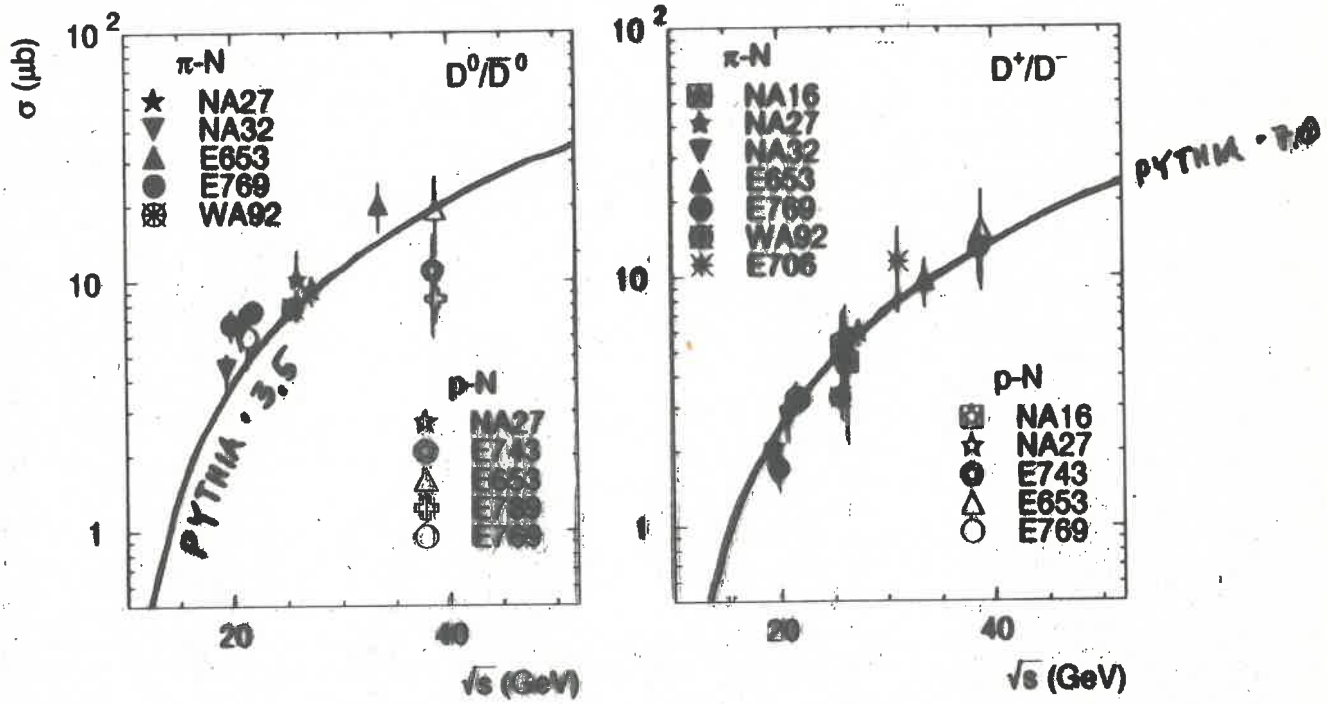
DILEPTONS FROM OPEN CHARM CALCULATION

- $c\bar{c}$ PRODUCTION BY PYTHIA
- HADRONIZATION, DECAY BY JETSET
- SCALE FROM PP TO Pb+Au
- CERES FILTER

P. BRAUN-MUNZINGER, D. MIŚKOWIEC, A. DREES, C. LOURENÇO
EUR. PHYS. J. C1 (1998) 123-130.

D production with proton and pion beams

DATA: COMPILATION BY C. LOURENÇO PYTHIA 5.710 JETSET 7.405



AGREEMENT:

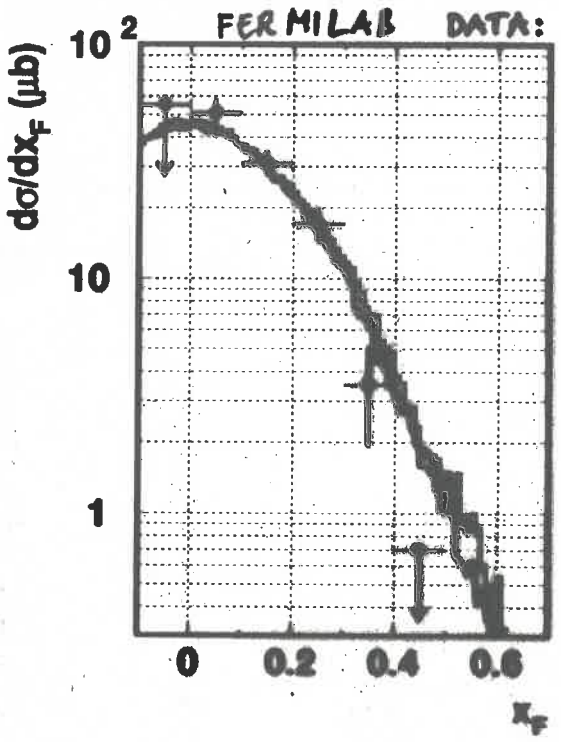
D- YIELD, K=5.0

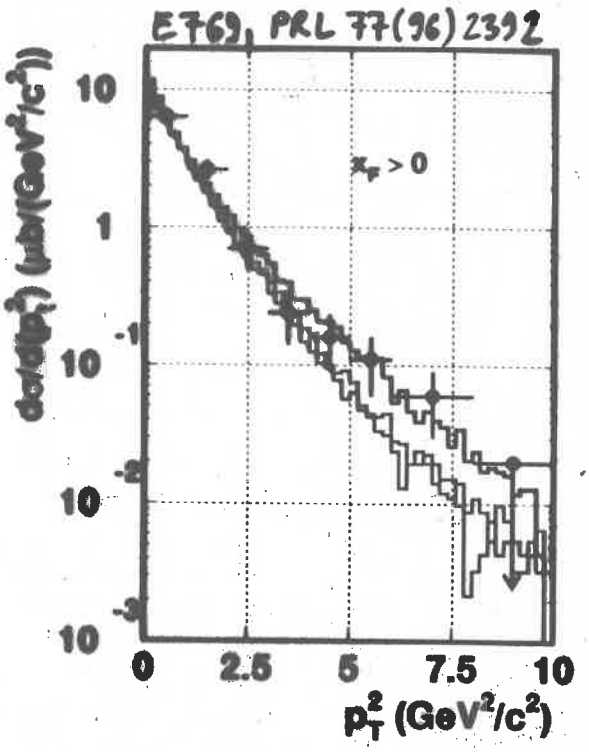
$\sqrt{s}$ DEPENDENCE

DISAGREEMENT:

D^+/D^0 RATIO

D production in p-p at 250 GeV





——— $\langle k_T^2 \rangle = 2$ GeV^2/c^2

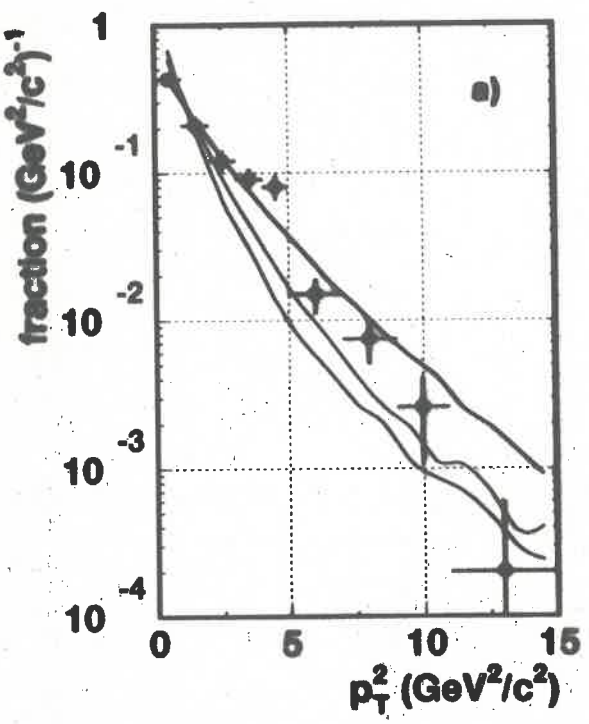
——— $\langle k_T^2 \rangle = 1$ GeV^2/c^2

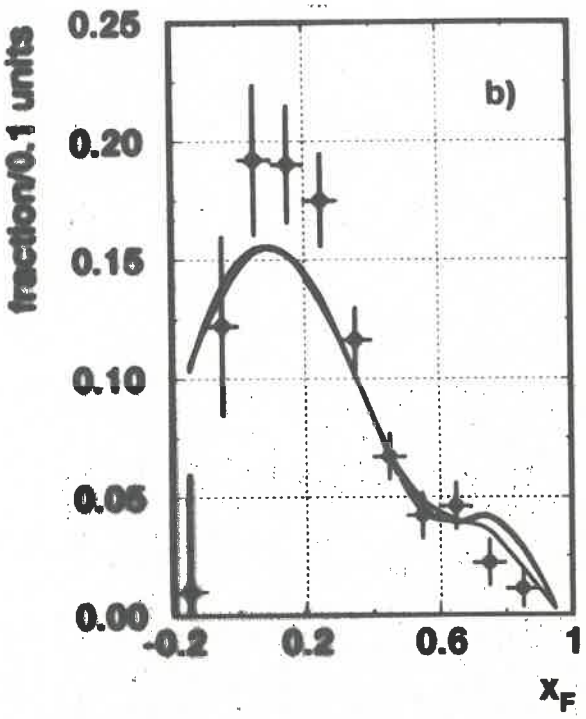
——— $\langle k_T^2 \rangle = 0.64$ GeV^2/c^2

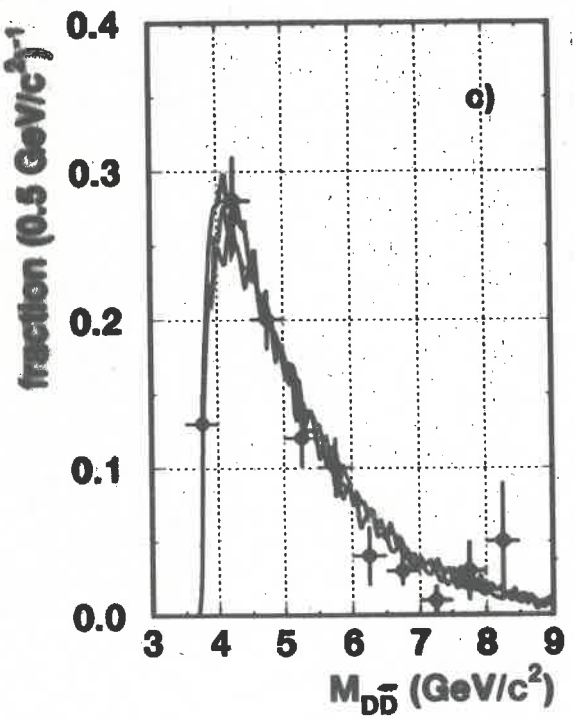
$\langle k_T^2 \rangle^{1/2}$ – WIDTH OF PRIMORDIAL $k_\perp$ DISTRIB. INSIDE HADRON, DEFAULT $\langle k_T^2 \rangle = 0.2$

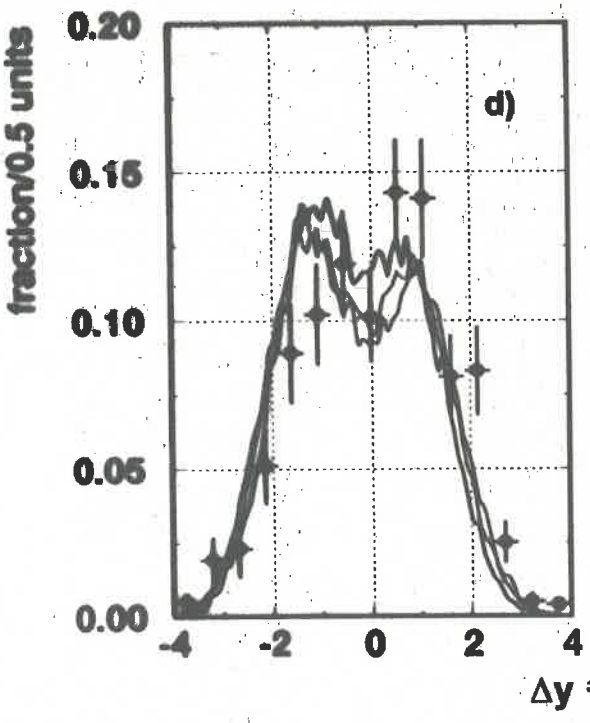
D-$\overline{D}$ pair production in π^--Cu at 360 GeV

WA92 DATA, CERN-PPE/96-180.









PYTHIA PARAMETERS

PYTHIA 5.710

JETSET 7.405

STRUCTURE FUNCTION MRS G

$M_c = 1.35$ GeV/c^2

$K = 5.0$

$\langle k_T^2 \rangle = 1$ GeV^2/c^2

pp TO pA SCALING

$\sigma \sim A^{\alpha}$, $\alpha = 1.02 \pm 0.05$ (E789)

$\alpha = 1.00 \pm 0.07$ (E769)

pp TO AB SCALING

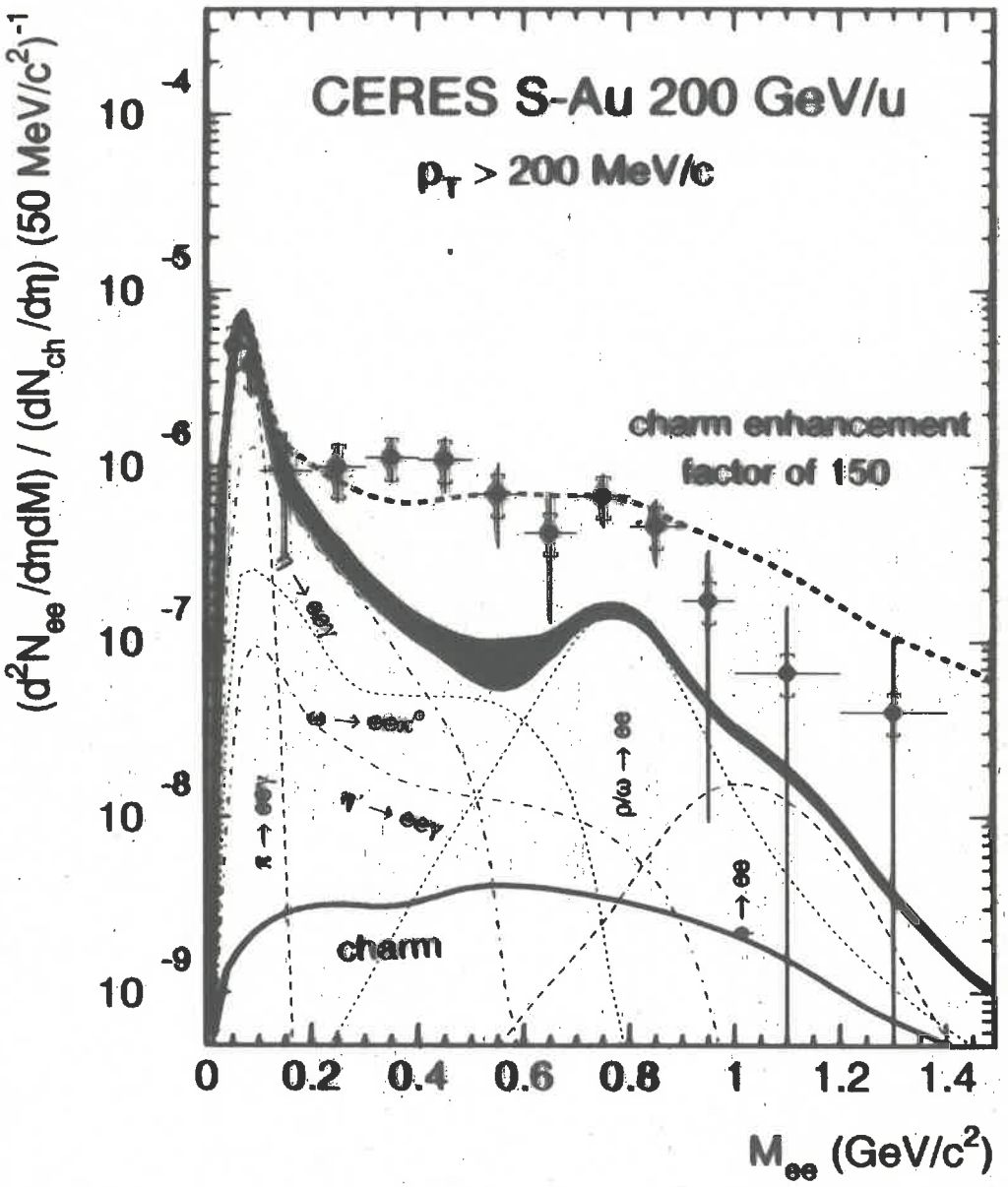
(ESCOLA, NUCL. PHYS. B323(89)37)

$$T_{AB}(\vec{b}) := \int d^2 r_T \int dz_A \, \rho_A(\vec{r}_T + \vec{b}, z_A) \int dz_B \, \rho_B(\vec{r}_T, z_B)$$

$$\sigma_{AB} = \underbrace{\int_0^{b_{max}} 2\pi b \, db \cdot T_{AB}(b)}_{A \cdot B} \cdot \sigma_{pp}$$

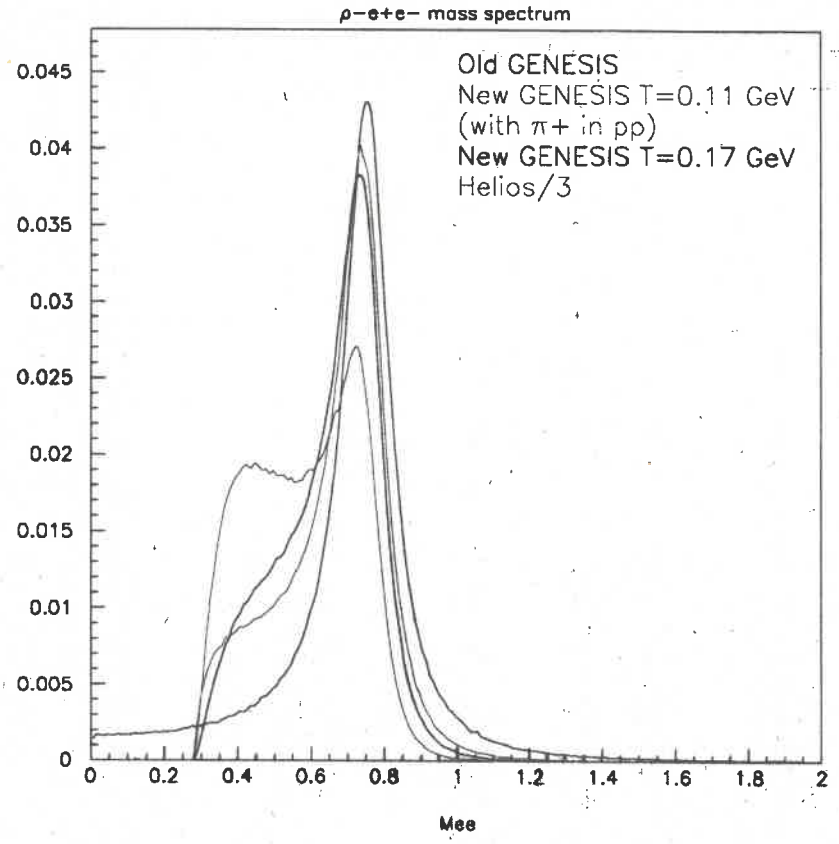
$$N_{AB} = \underbrace{\frac{\int_0^{b_{cut}} 2\pi b \, db \cdot T_{AB}(b)}{\pi b_{cut}^2}}_{28 \text{ mb}^{-1} \text{ FOR Pb+Pb } 5\% \text{ CENTRAL}} \cdot \sigma_{pp}$$

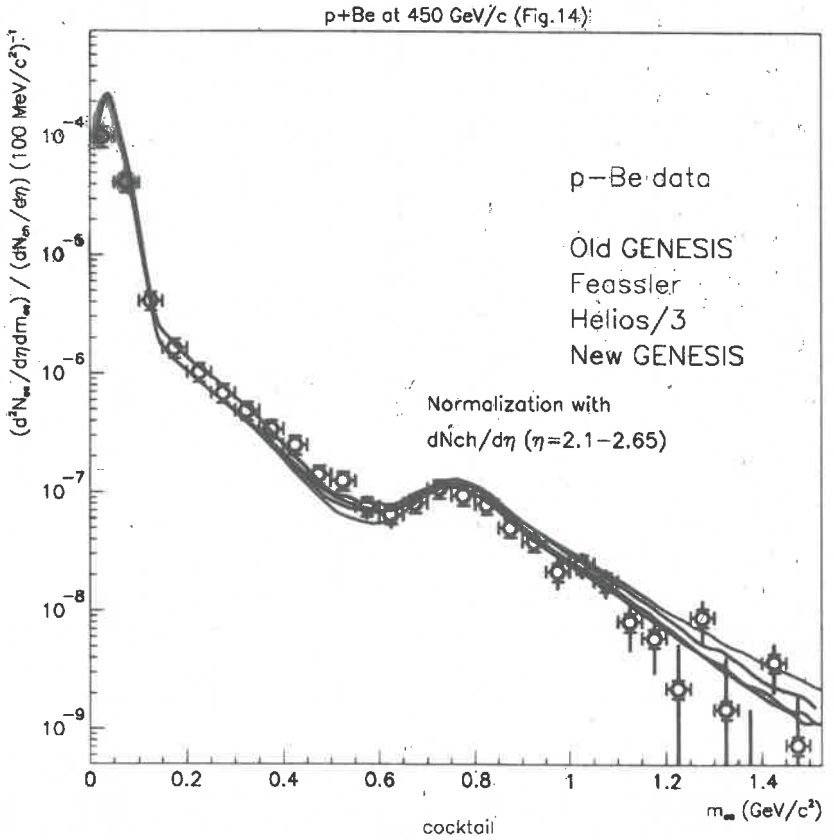
CERES dilepton excess - not from charm



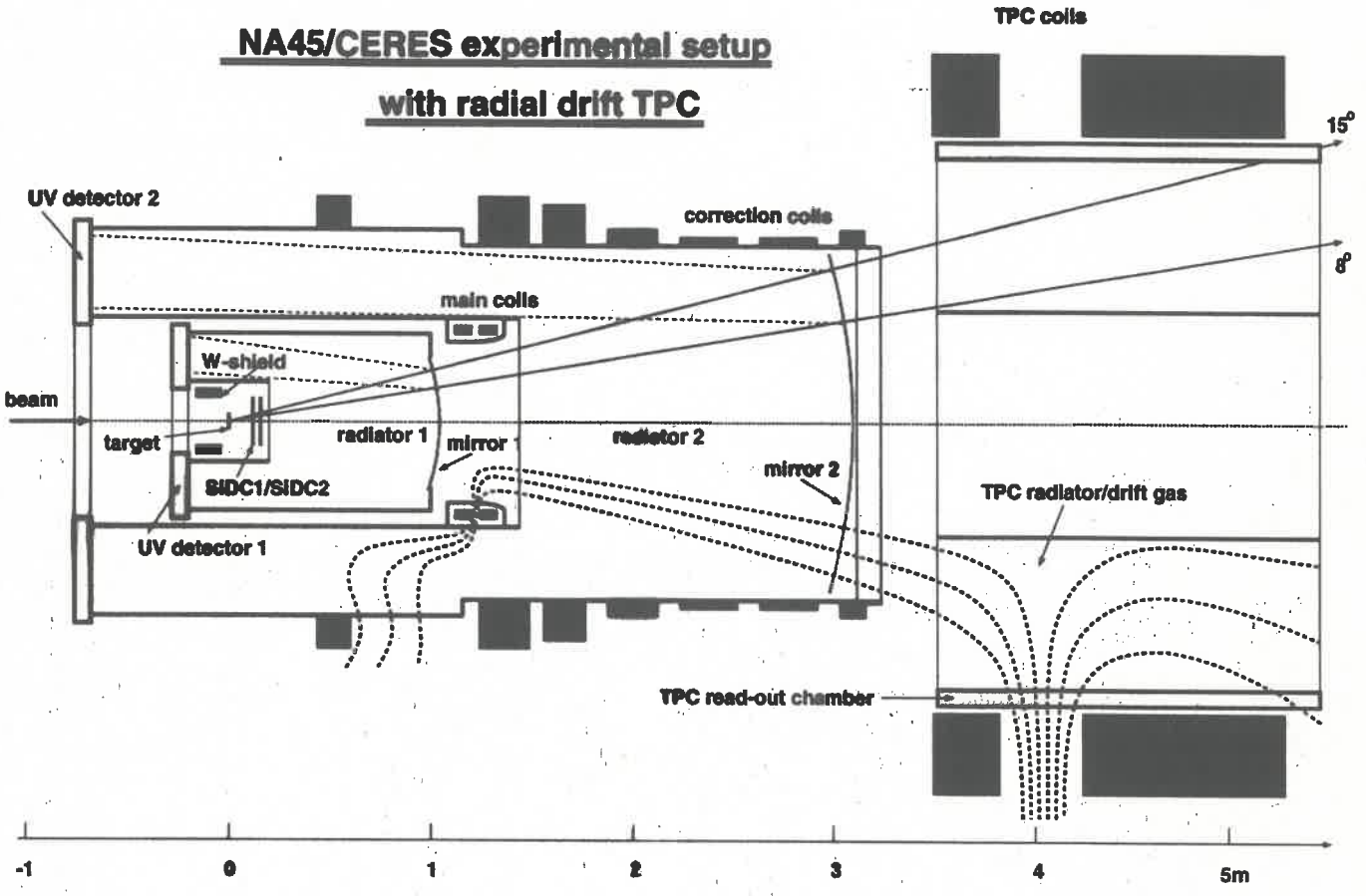
polishing GENESIS

HIRO SAKO





CERES setup in 1998



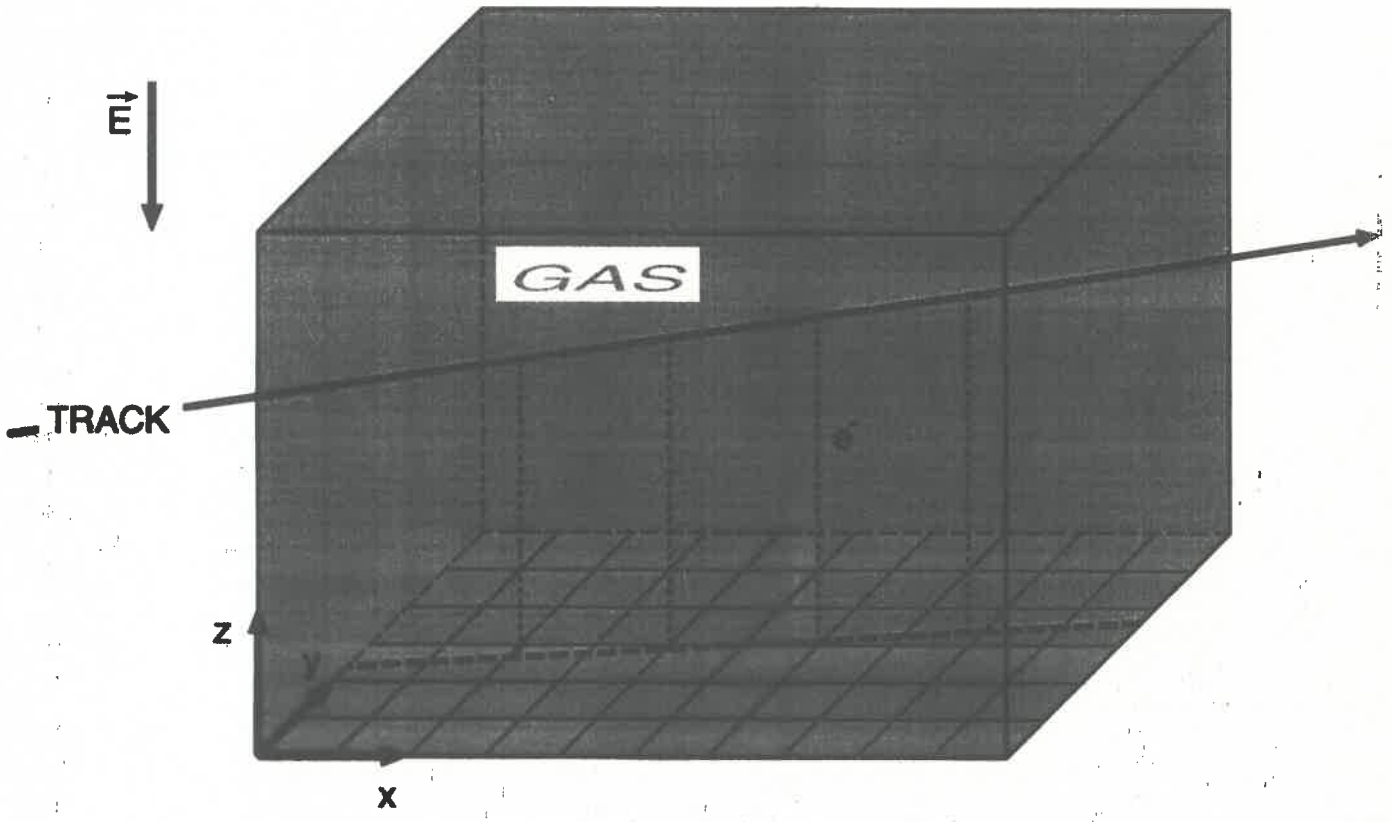
Upgrade:

- TPC (+ magnet, slow control, laser etc.)
- new DAQ and trigger
- new pid/tracking philosophy
- new people

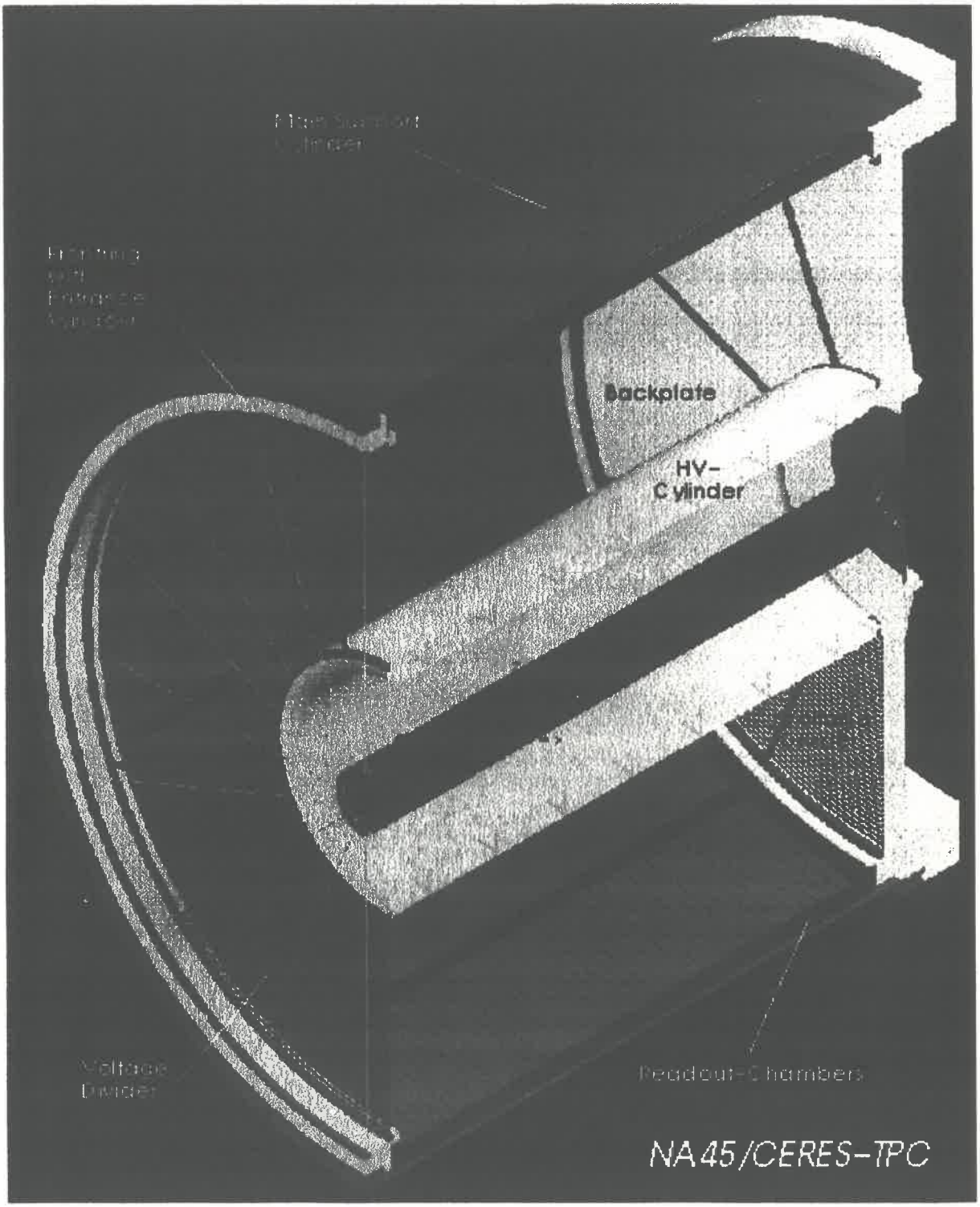
Gain:

- better mass resolution (2% at ω mass)
- better rejection of close pairs

Time Projection Chamber - principle

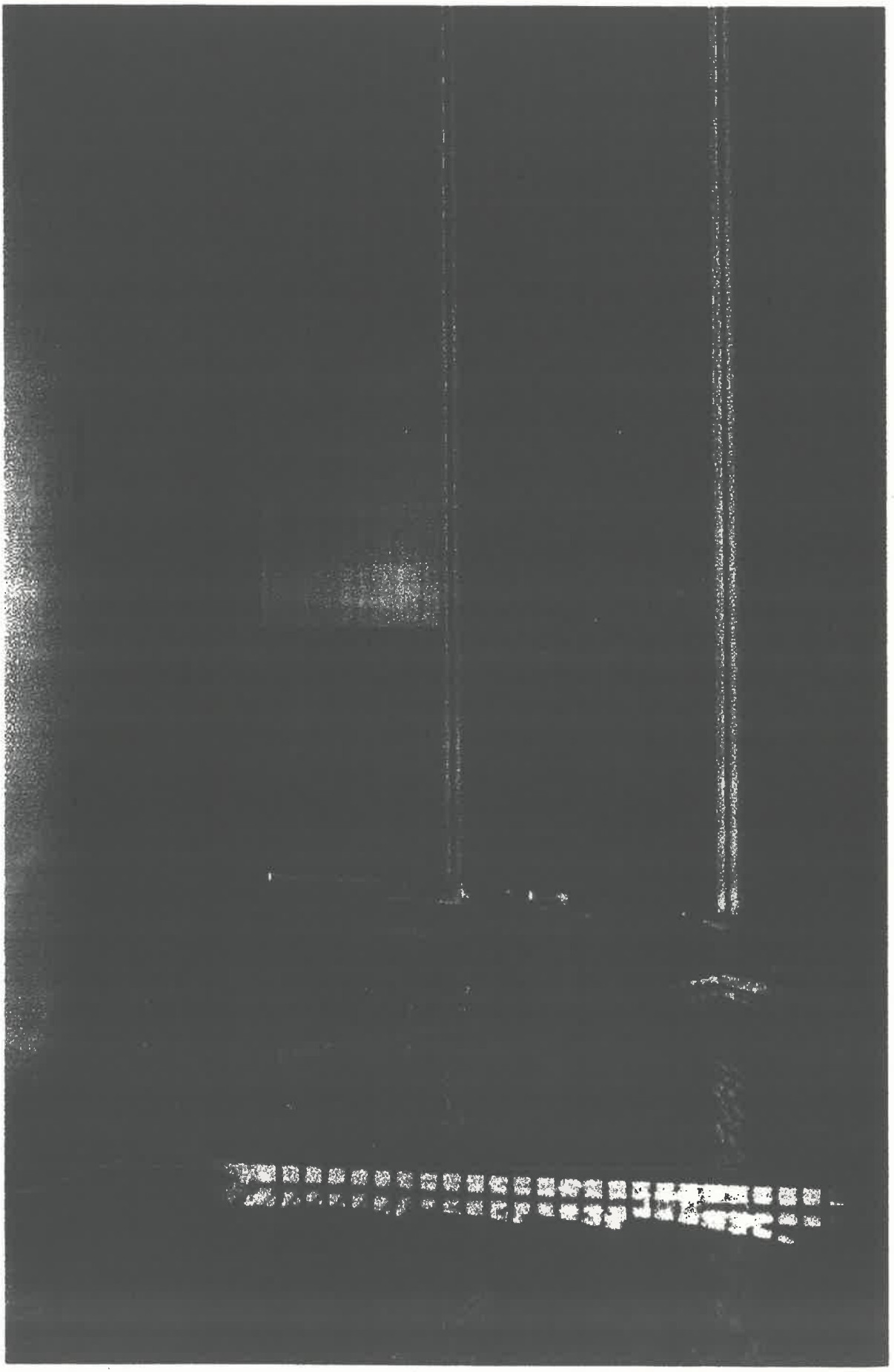


CERES TPC

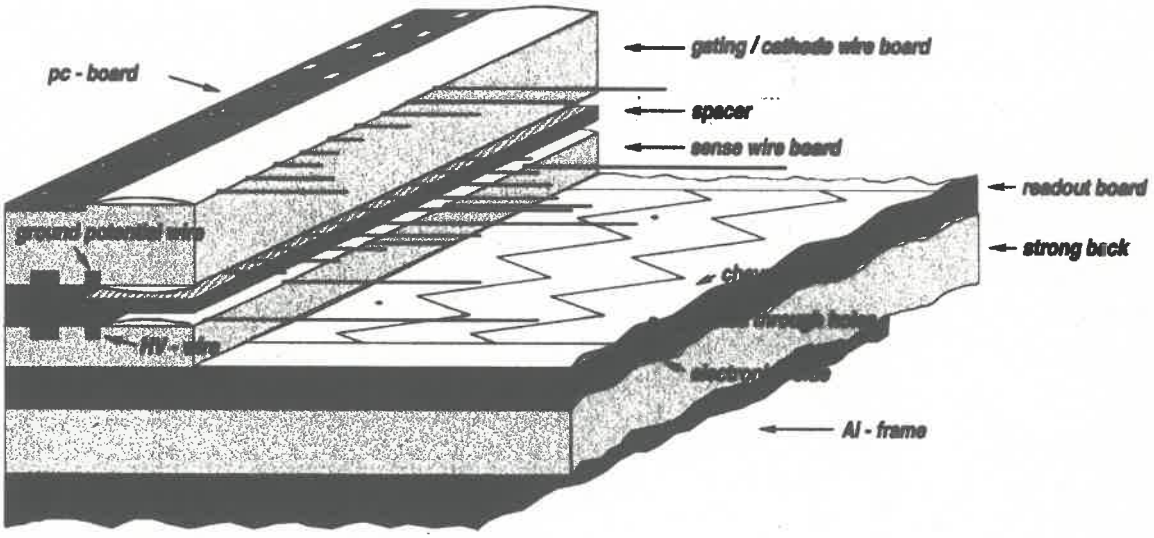


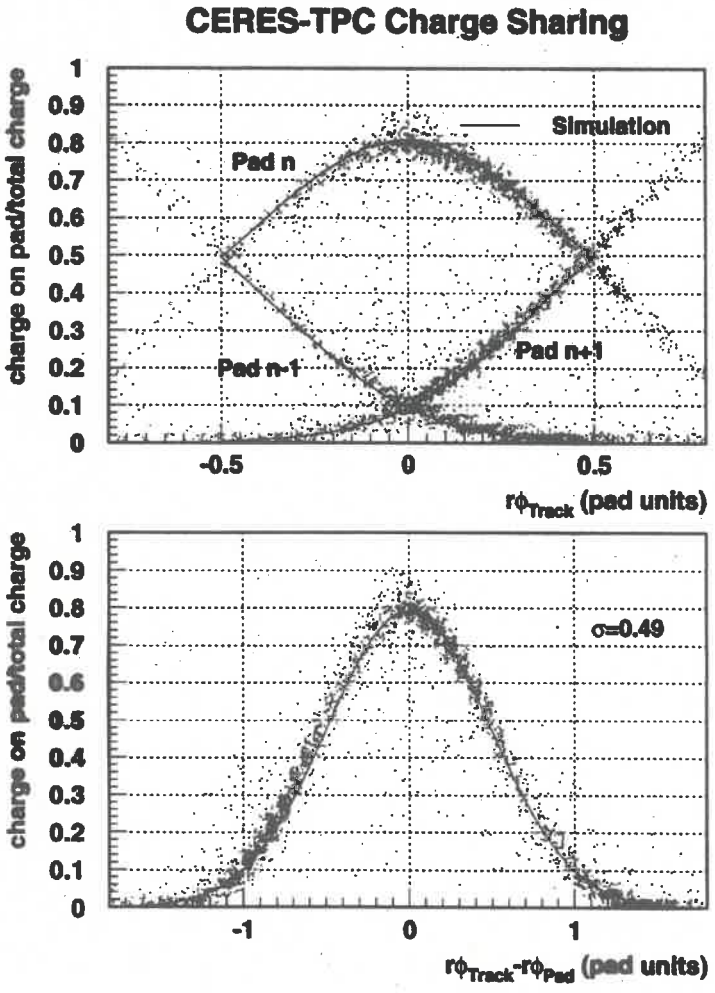
- cylindrical shape Φ 2.6 m x 2.0 m
- gas Ne:CO_2 (80:20)
- radial field $E \sim 1/r$ with E=0.2-0.6 kV/cm
- radial drift with v=0.7-2.4 cm/μs

CERES TPC



TPC readout



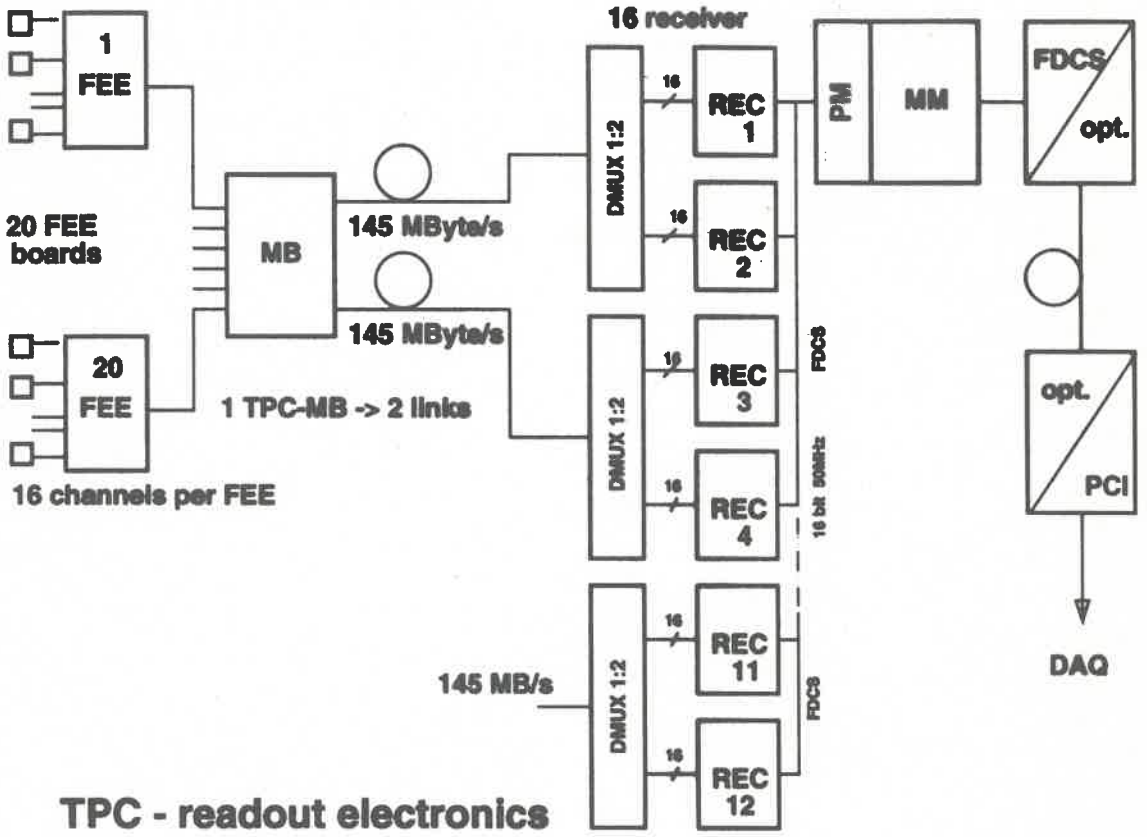


$r\Delta\phi$=0.25-0.40 mm
(design 0.27 mm)

TPC laser

ANA MARIN

TPC readout scheme



TPC - readout electronics

⇒On the TPC: 48 Mother Boards × 20 FEE boards

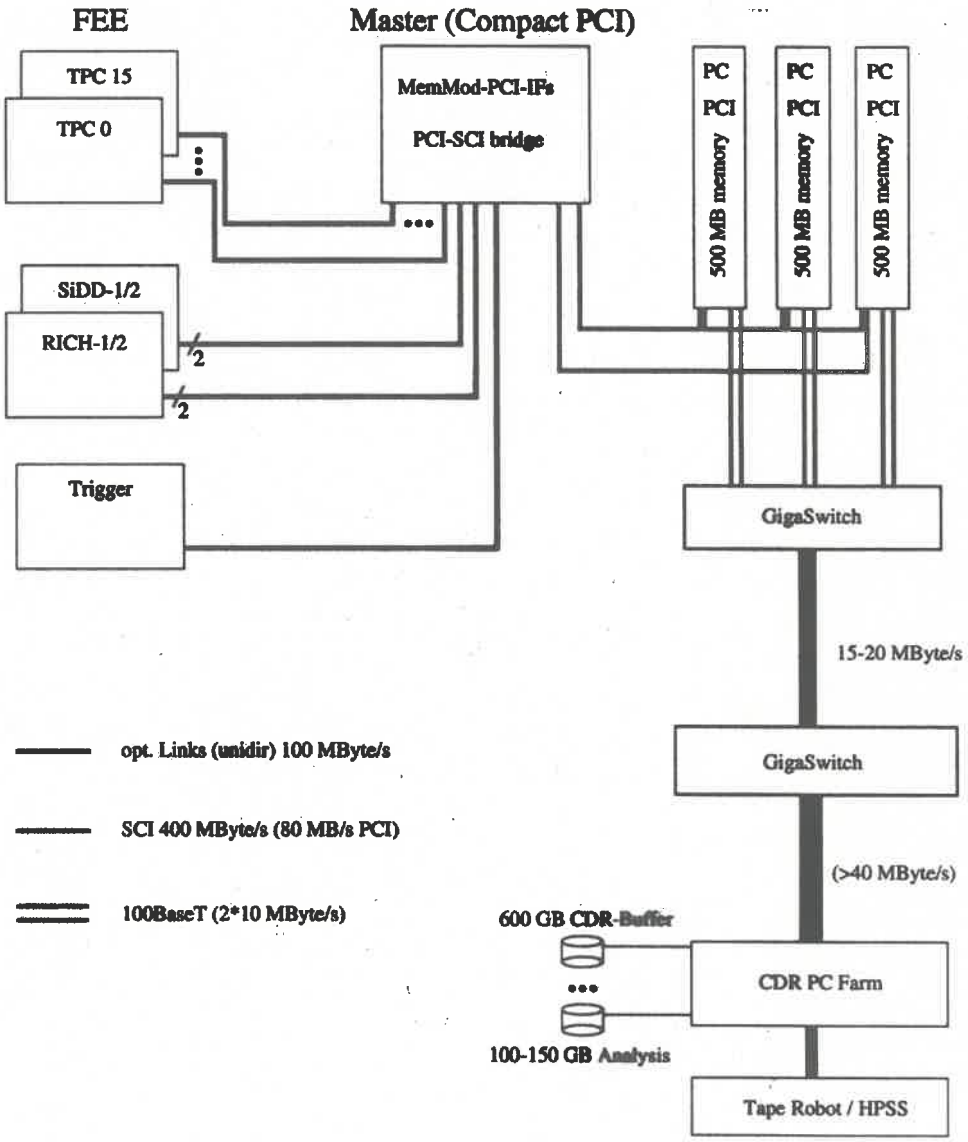
⇒Data transmission via optical links to the receivers

⇒Zero suppresion and Huffman-encoding on the receivers (400 KB/event)

500-1000 events/spill (7 seconds) at the SPS

ANA MARIN

CERES Data acquisition

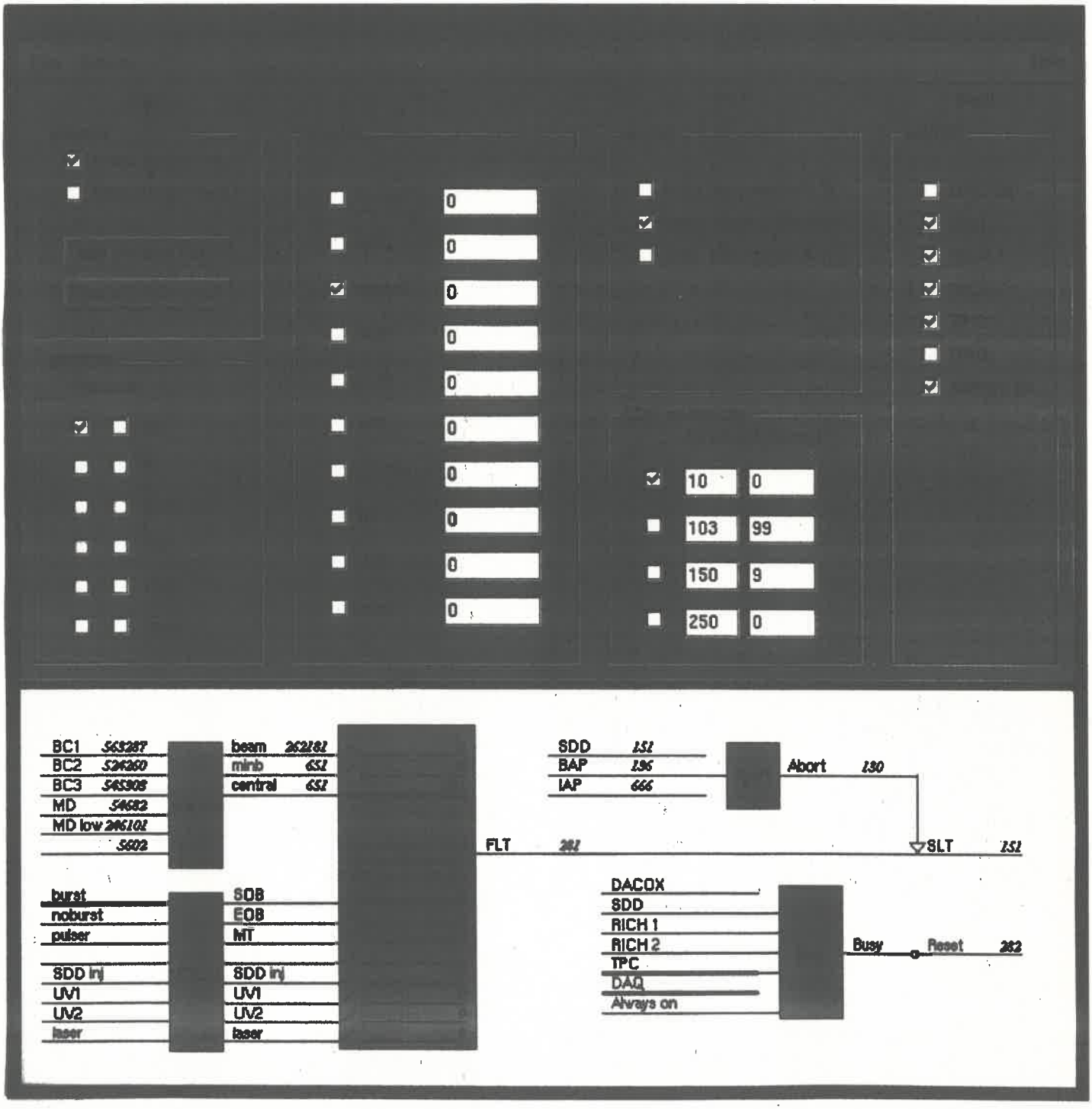


⇒Event built in Compact PCI

⇒Event sent via Gigabit-ethernet to CDR

new trigger implementation 1998

- hardware in VME; logic arrays CAEN V495
- software:
  server in VME (250 line in C),
  client in linux PC (6500 lines in C++/ROOT)



CERES RUN 1999

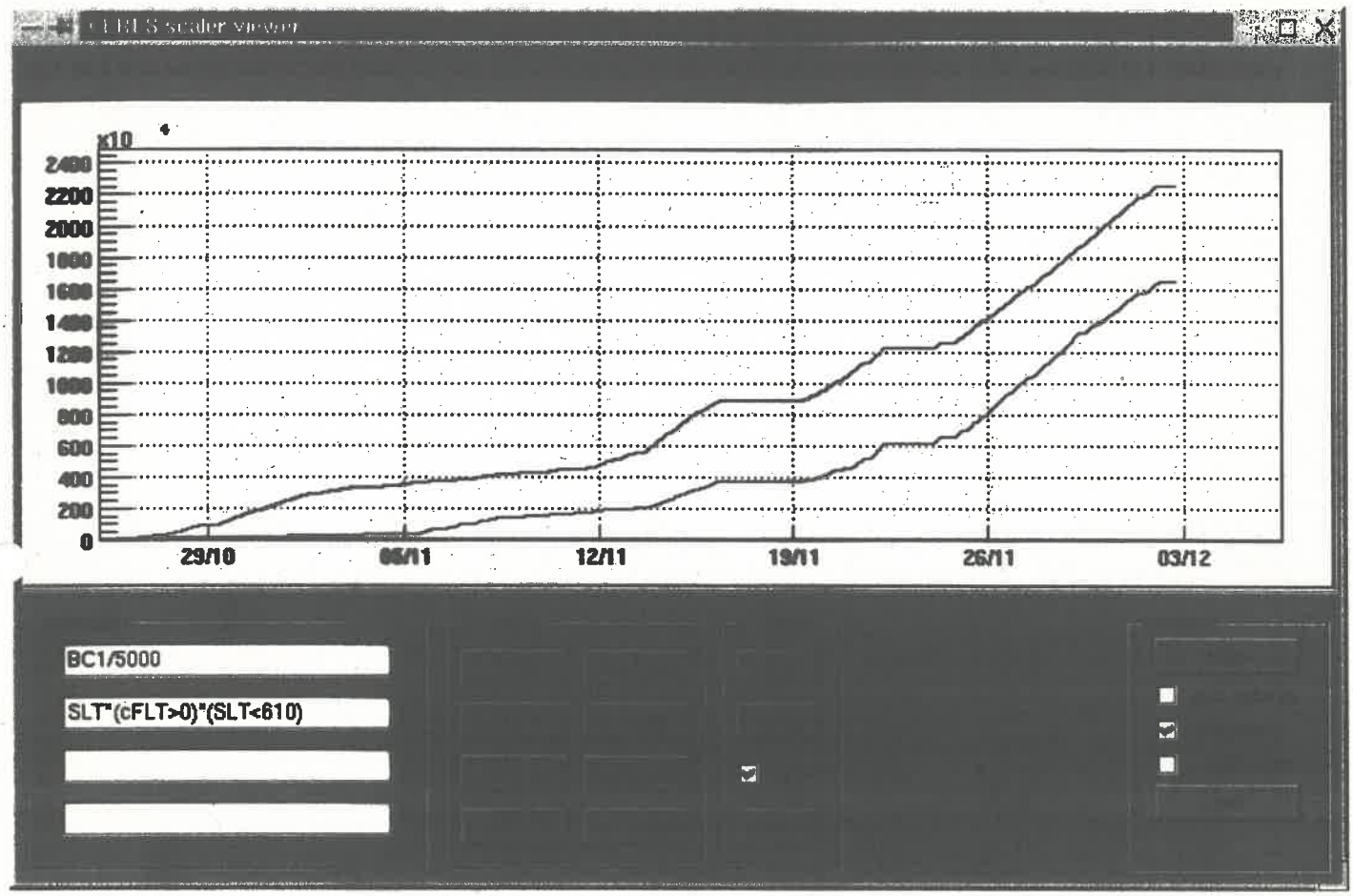
40 GeV/NUCLEON Pb + Au

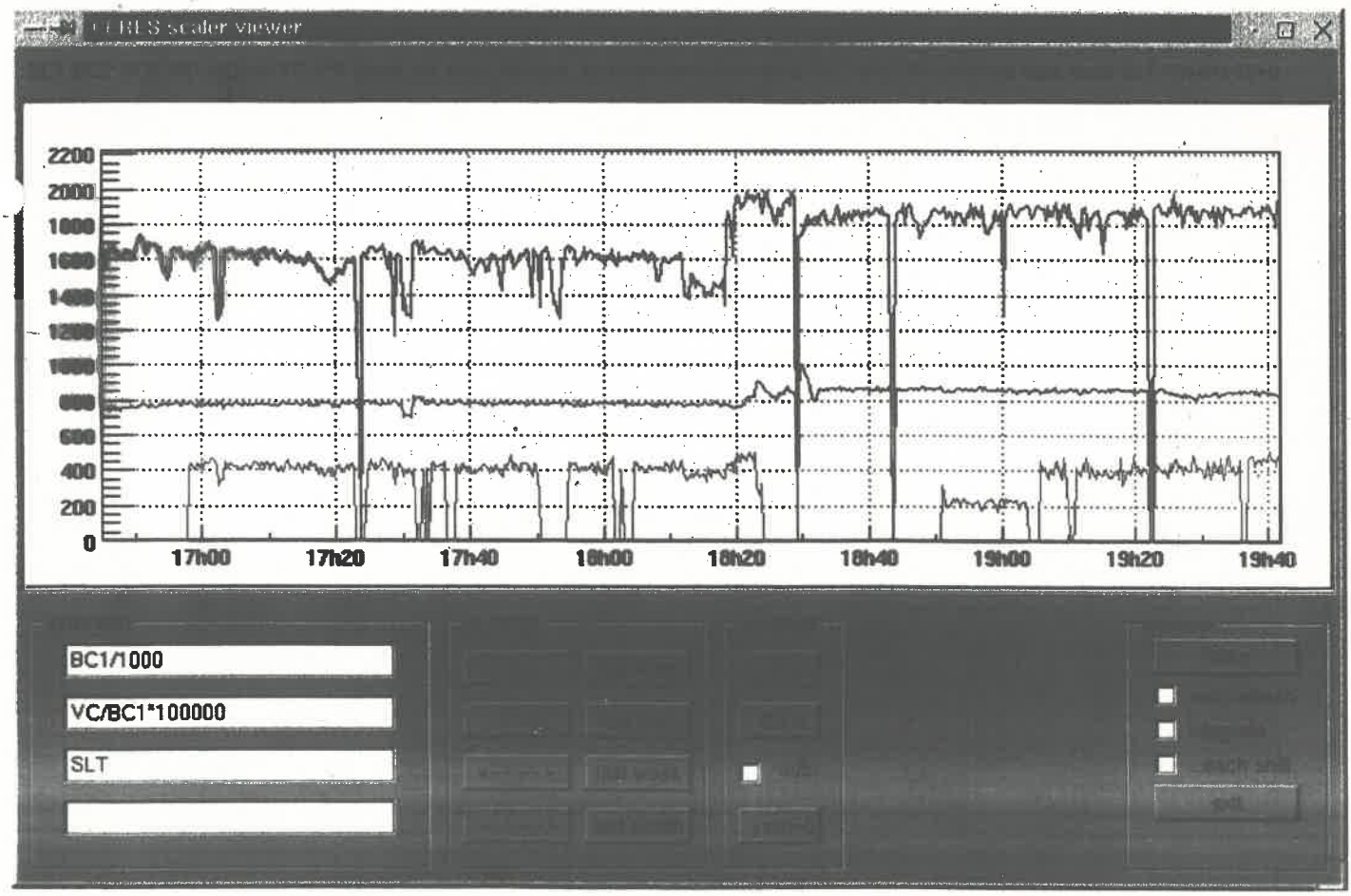
(SEMI) CENTRAL TRIGGER

- INITIAL PROBLEMS WITH NEW DAQ/READOUT
- ONE CHAMBER (1/16 TPC) MISSING IN READOUT
- DEAD PADS AND BOARDS
- BEAM DIAMETER > TARGET DIAMETER

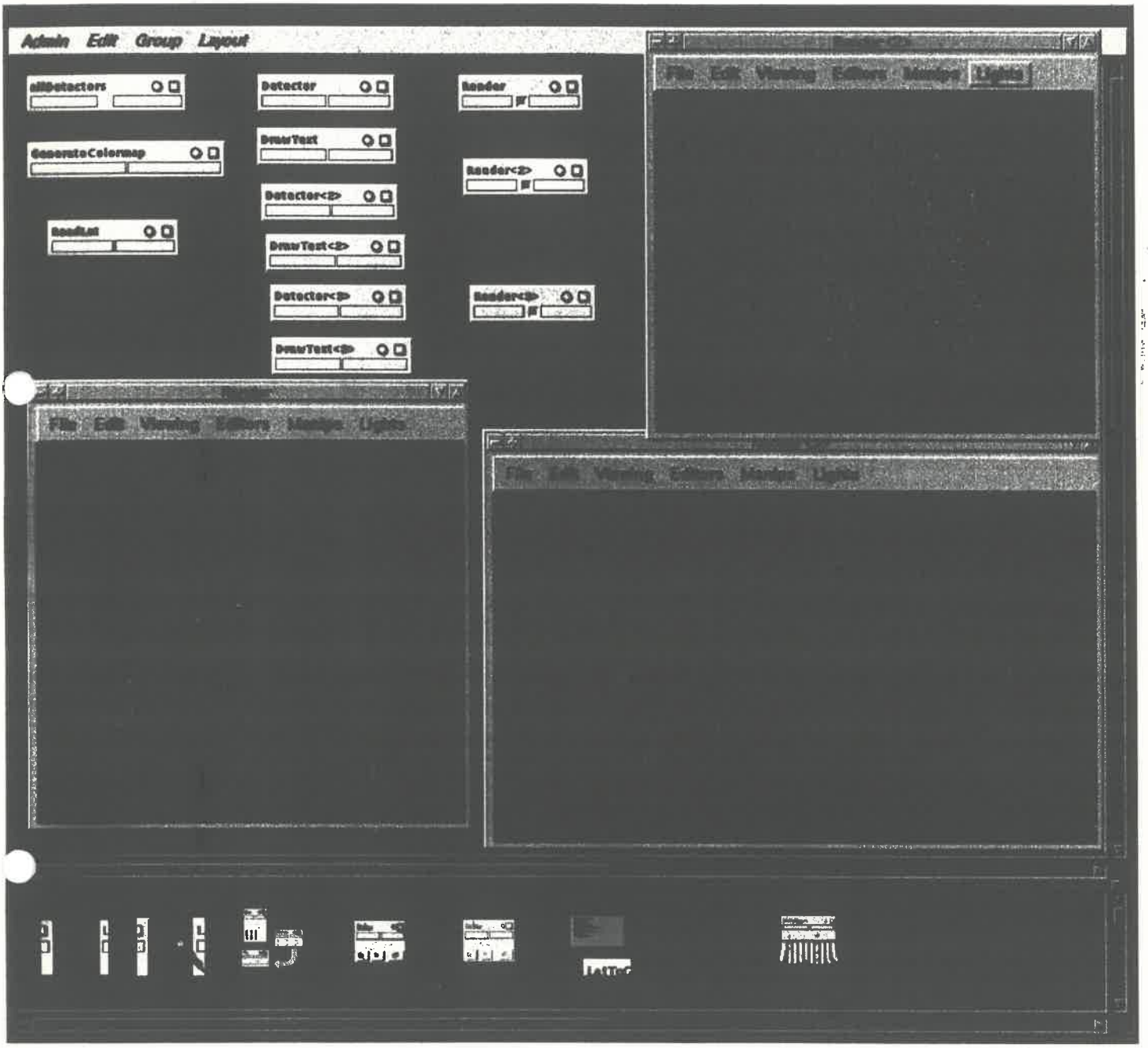
- ALL DETECTORS WORKING AND STABLE
- FINALLY 600 EVENTS/BURST
- TOTAL 10 M EVENTS ON TAPE

scaler monitoring in 1999





HEP explorer event display



SUMMARY

... OF CERES ACTIVITIES 1997-1999

TPC MECHANICS (B. WINDELBAND)
TPC MAGNET (P. GLAESSEL)
TPC FIELD CAGE (C. GARABATOS, A. SHARMA)
TPC GAS + TEMPERATURE (A. MARIN)
TPC READOUT CHAMBERS (H. APPELSHÄUSER, W. SCHMITZ)
TPC READOUT ELECTRONICS (M. RICHTER, W. SEIPP)
DAQ (A. PFEIFFER)
LASER SYSTEM (D.M.)
ANALYSIS SOFTWARE (A. MARIN, S. ESUMI, T. WIENOLD)
TRIGGER (D.M.)
TESTS AND CALIBRATIONS (ALL)

TPC PROJECT MANAGMENT H. WESSELS
TWO STROKE DRIVING FORCE T.S., PBM

ANALYSIS OF 40 GeV RUN — ALL

SUMMARY OF THIS TALK

- EXCESS STILL THERE
- COCKTAIL IMPROVED
- UPGRADE DONE
- 40 GeV/NUCLEON Pb+Au ON TAPE
- 160 GeV/NUCLEON Pb+Au FALL 2000