7th PISA MEETING
F. COSTANTINI
PISA UNIV. & INFN

THE NA48 LIQUID KRYPTON CALORIMETER

FIRST OPERATION RESULTS

NA48 COLLABORATION

CAGLIARI - CAMBRIDGE - CERN - DUBNA - EDIMBURGH
FERRARA - FIRENZE - MAINZ - ORSAY - PERUGIA - PISA
SIEGEN - SACLAY - TORINO - VIENNA - WARSAW

OUTLINE

- PHYSICS REQUIREMENTS ON THE CALORIMETER
- CALORIMETER STRUCTURE & F. END ELECTRONICS
- PRELIMINARY PERFORMANCES COMPARED TO THE PROTOTYPE ONES:

ENERGY, POSITION, TIME RESOLUTIONS

PHYSICS AIM

- THE NA48 EXP.T IS DESIGNED TO MEASURE THE DIRECT $\not{CP}$ OBSERVABLE R:

$$Re(\varepsilon'/\varepsilon) = \frac{1}{6}(1-R) \leftarrow R = \frac{\Gamma(K_L \to \pi^0\pi^0)}{\Gamma(K_S \to \pi^0\pi^0)} \cdot \frac{\Gamma(K_S \to \pi^+\pi^-)}{\Gamma(K_L \to \pi^+\pi^-)}$$

- A 10^{-3} DEVIATION FROM UNITY IN DOUBLE RATIO R DETERMINES A $\sim 2 \cdot 10^{-4}$ VARIATION ON $Re(\varepsilon'/\varepsilon)$

- THE MAIN REQUIREMENTS FOR THE E.M. CALORIMETER USED TO RECONSTRUCT $K \to \pi^0\pi^0 \to 4\gamma$ DECAYS ARE:

  - $\sigma(E)/E \sim 1\%$ @ 10 GeV + CONSTANT TERM $\lesssim 0.5\%$
  - POSITION RESOLUTION ~ 1 mm IN X, Y
  - TIME RESOLUTION $\lesssim 0.5$ ns FOR K_S IDENTIFIC.
  - SINGLE RATE CAPABILITY ~ 1 MHz TO ACHIEVE THE REQUIRED STATISTICS OF 10^6 $K_L \to \pi^0\pi^0$
  - TRANSVERSE SCALE ACCURACY OF 0.1/1000 mm TO CONTROL SYSTEMATICS ERROR FROM ENERGY SCALE DIFFERENCE BTW $\pi^0\pi^0$ AND $\pi^+\pi^-$ DECAYS.

- THE PHOTON RANGE OF INTEREST IS $\sim 5 \div 100$ GeV

REQUIREMENTS ON CALORIMETER:
ENERGY AND POSITION RESOLUTIONS

- THE K DECAY VERTEX POSITION ALONG THE BEAM LINES $K \to 2\pi^0 \to 4\gamma$ IS MEASURED BY THE 4 SHOWER ENERGIES AND POSITIONS IN THE CALORIMETER

$$\rightarrow \quad Z_{VTX} = \frac{1}{m_K} \left\{ \sum_{i,j<i}' E_i E_j \left[(x_i - x_j)^2 + (y_i - y_j)^2 \right] \right\}^{1/2}$$

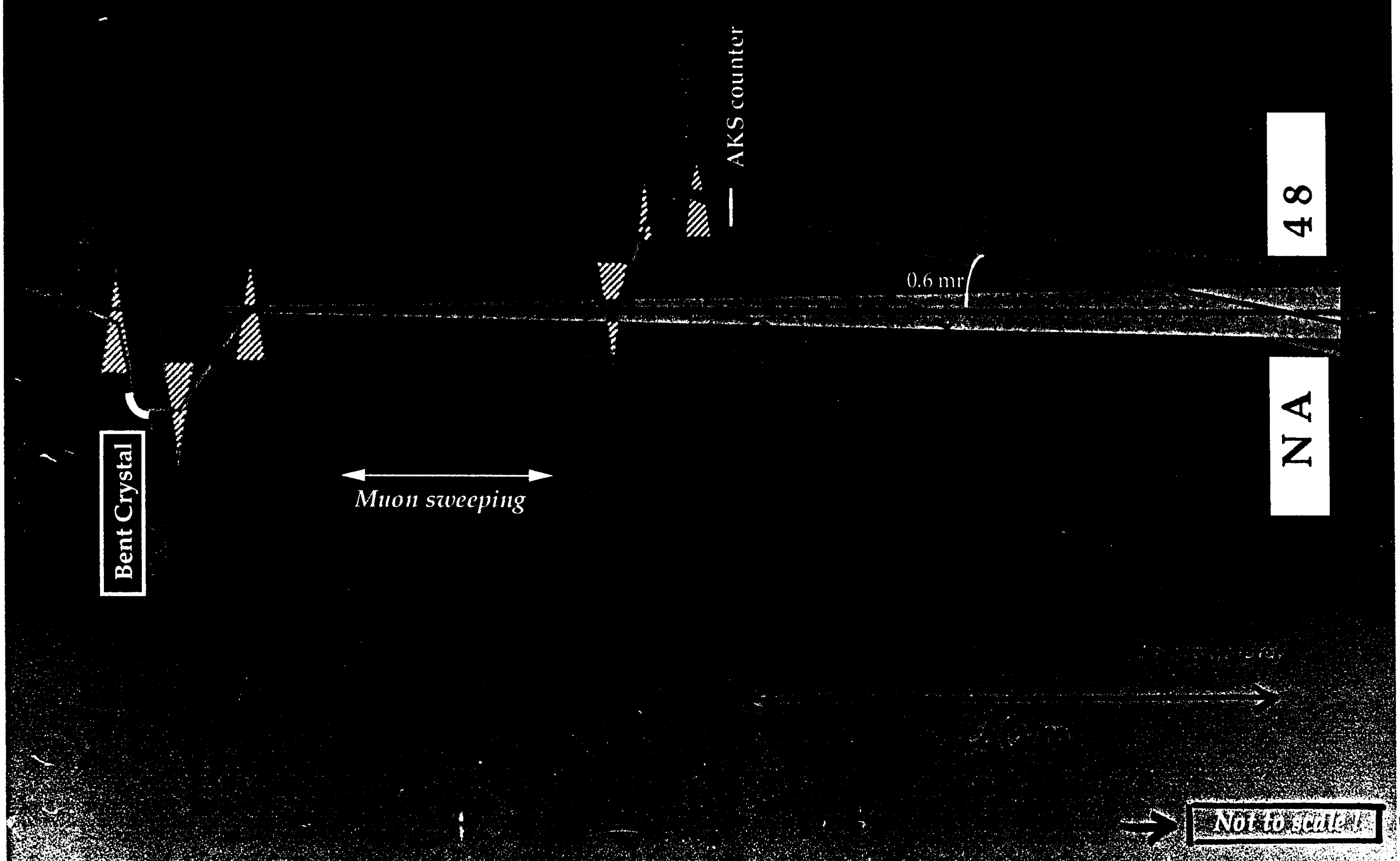
- THE ENERGY AND POSITION RESOLUTIONS (AND THEIR UNIFORMITY!) ALL OVER THE WHOLE CALORIMETER SURFACE DETERMINE THE ERROR ON Z_V
- AN ERROR OF $\Delta Z_V / Z_V \simeq 2 \cdot 10^{-4}$ PRODUCES AN ERROR ON $\Delta \varepsilon' / \varepsilon \simeq 10^{-4}$

  (FIDUCIAL REGION ON Z_V : 110 m ± 6)

- A GOOD ENERGY RESOLUTION MINIMIZES ALSO THE BACKGROUND $K_L \to 3\pi^0$ CONTRIBUTION (WHEN ONLY 4 γ'S ARE DETECTED) TO THE $K_L \to 2\pi^0$ SIGNAL.

  (3-rd MOST IMPORTANT SOURCE OF ERROR)

THE SIMULTANEOUS K_L AND K_S BEAMS



2) REQUIREMENTS ON CALORIMETER: THE TIME RESOLUTION

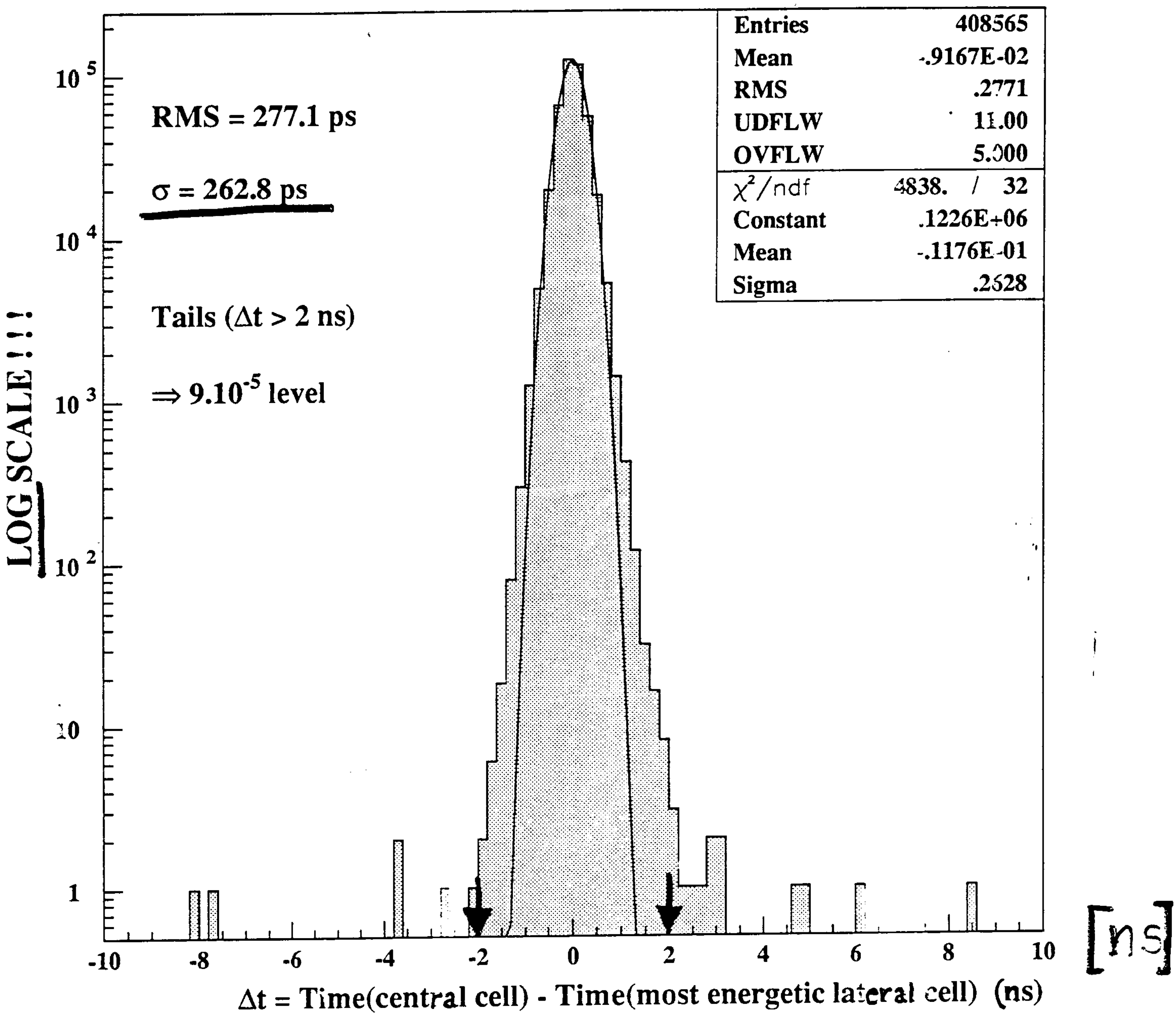
- THE TIMING INFORMATION FROM THE CALORIMETER PROVIDES, IN CONJUNCTION WITH THE TIMING FROM THE K_S TAGGER, THE WAY TO TELL A K_S NEUTRAL DECAY FROM A K_L ONE.

- A GOOD CALORIMETER TIME RESOLUTION IS THEREFORE VITAL FOR THE EXPERIMENT

- A $\sigma(t)$ OF 260 ps HAS BEEN OBTAINED FOR 50 GeV electrons IN 1996 (SEE Sabine CRÉPÉ TALK) OVER THE CALORIMETER CENTRAL REGION EQUIPPED WITH SINGLE CELL FADC READ-OUT i.e. 384 channels

(Sabine Crépé)

LKr calorimeter time resolution (50 GeV e⁻)

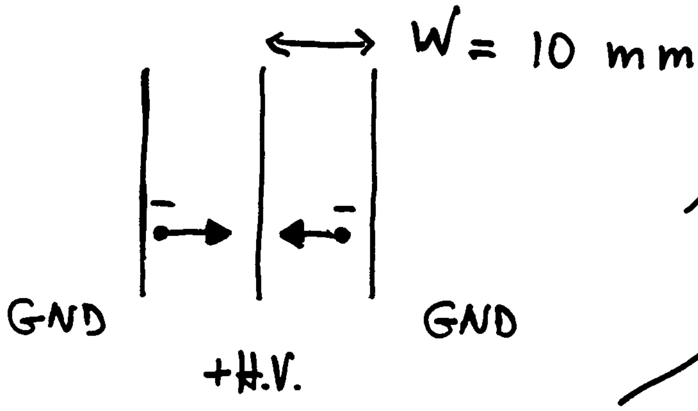


THE CALORIMETER STRUCTURE

- A TOWER STRUCTURE IS OBTAINED BY ~ 13 500 CELLS $(2 \times 2\ cm^2) \times 120\ cm$ (~ $26 X_0$ DEPTH)

→ A SINGLE CELL GETS AT MOST ~ 50 % OF SHOWER

- EACH CELL IS FORMED BY TWO EXTERNAL GROUNDED RIBBONS AND BY A CENTRAL ONE AT +H.V.



$$i(t) = i_0 \left(1 - \frac{t}{T_D}\right) e^{-t/\tau}$$

↑ if LKr life-time $\tau \gg T_D$ this can be neglected.

In '96 $\tau \gtrsim 40\ \mu s$ $T_D = 3{,}7\ \mu s$ (1,5 KV)

- INITIAL CURRENT READ-OUT METHOD

$$i_0 = Q_{ION.} \frac{V_{DRIFT}}{Width}$$

$Q_{ION.}$ → $\propto$ ENERGY

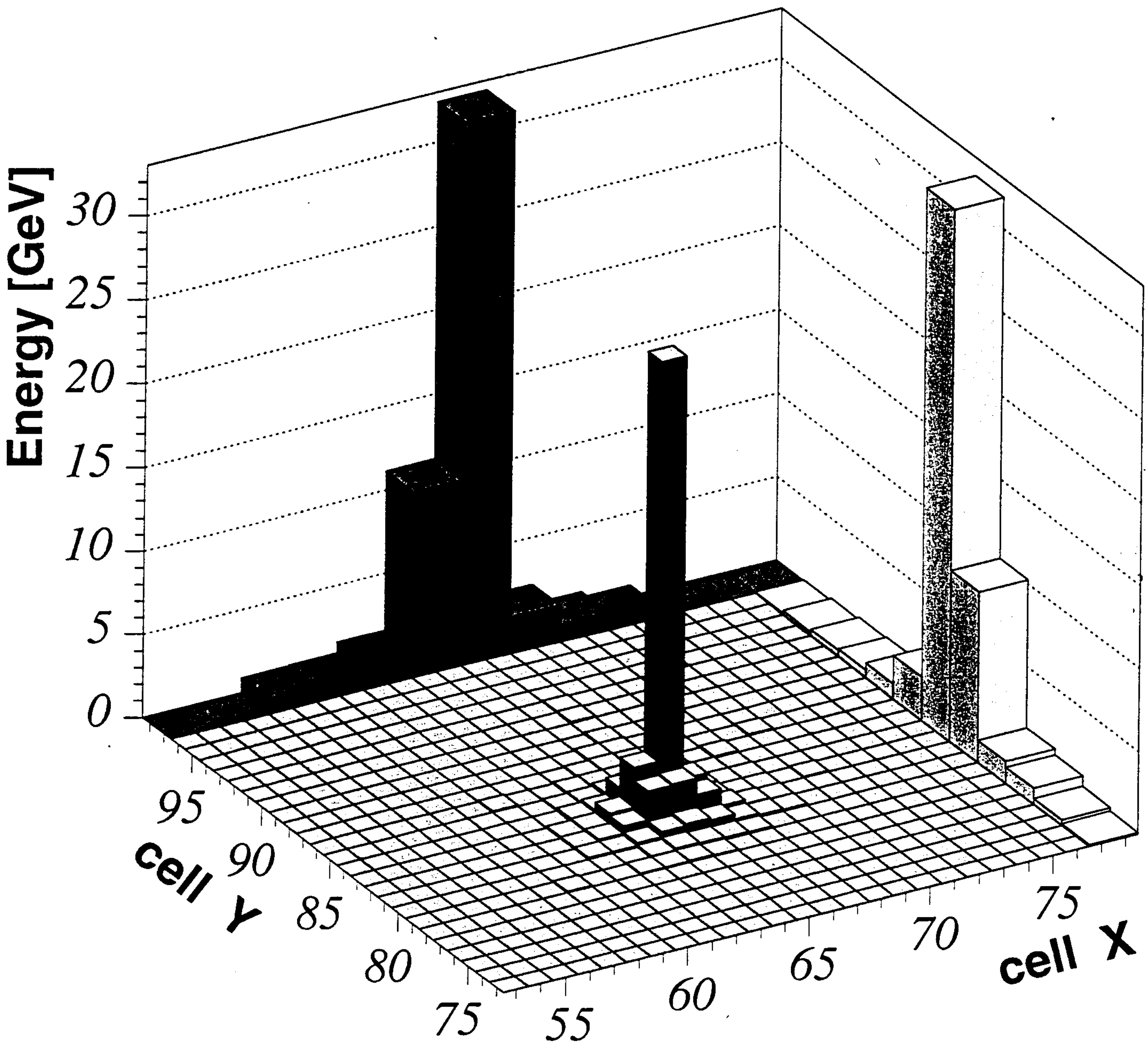
Width ← ~ 50 μm/10 mm Geometrical accuracy

V_{DRIFT} ← LKr Uniformity (space & time)

(e.g. $\Delta V_{DRIFT} / \Delta T \sim -0{,}9\ \% / K$)

NA48 LKr

50 GeV e^-



- X AND Y PROJECTIONS (FACTOR 2 LESS GRANULARITY) ARE USED FOR TRIGGERING ON K NEUTRAL DECAYS

(See I. MIKULEC)

THE CALORIMETER STRUCTURE (CONT.)

- TO COPE WITH THE STRINGENT REQUIR.TS ON CELL WIDTH UNIFORMITY (~ 0.5%) RIBBON POSITIONS ARE FIXED BY A SET OF 5

→ SPACER PLATES. THEY ARE PLACED EVERY 20 cm

- SPACERS ARE DISPLACED GIVING A ± 50 mrad

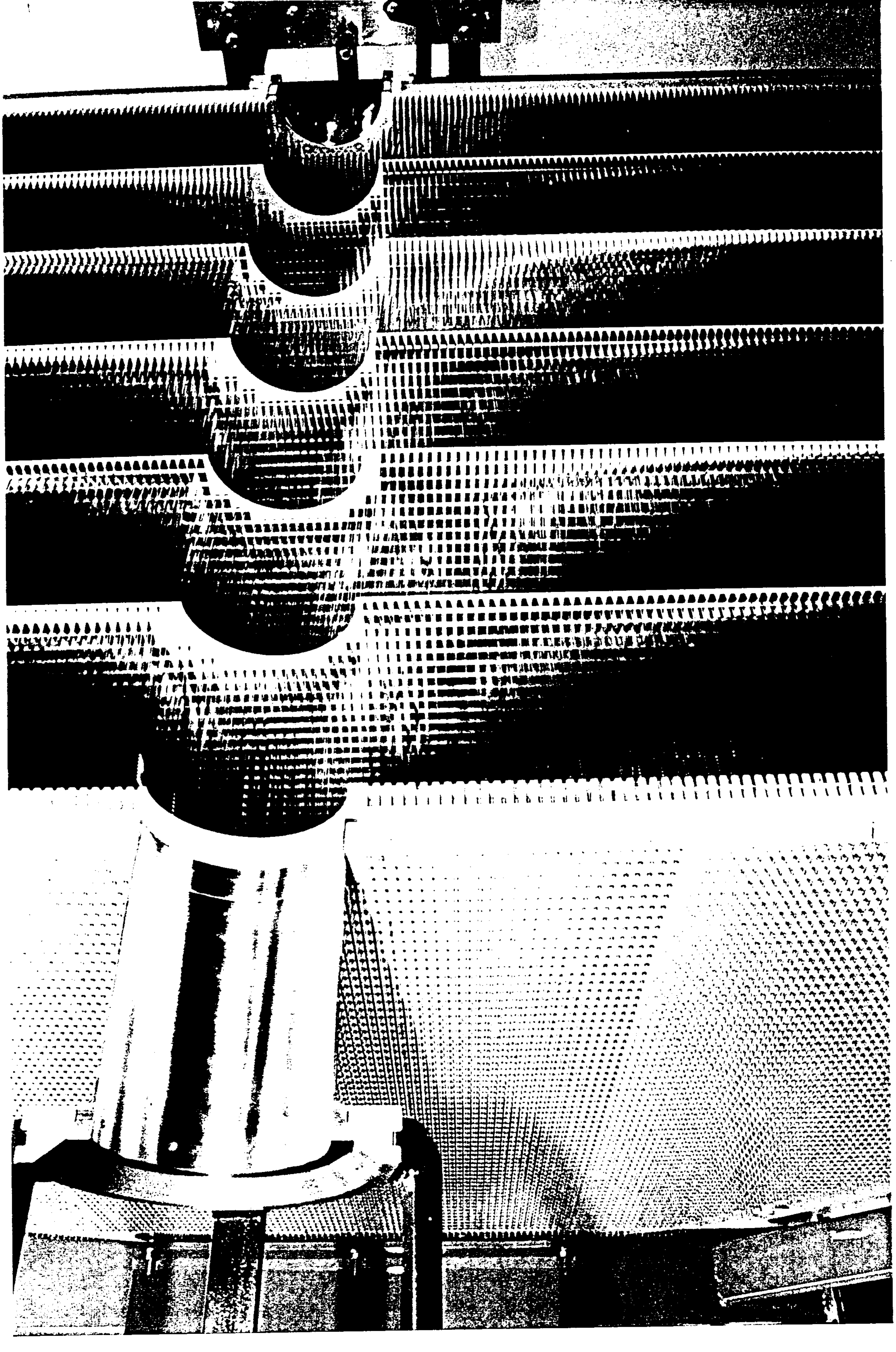
→ LONGITUDINAL 'ZIG-ZAG' TO THE RIBBONS.

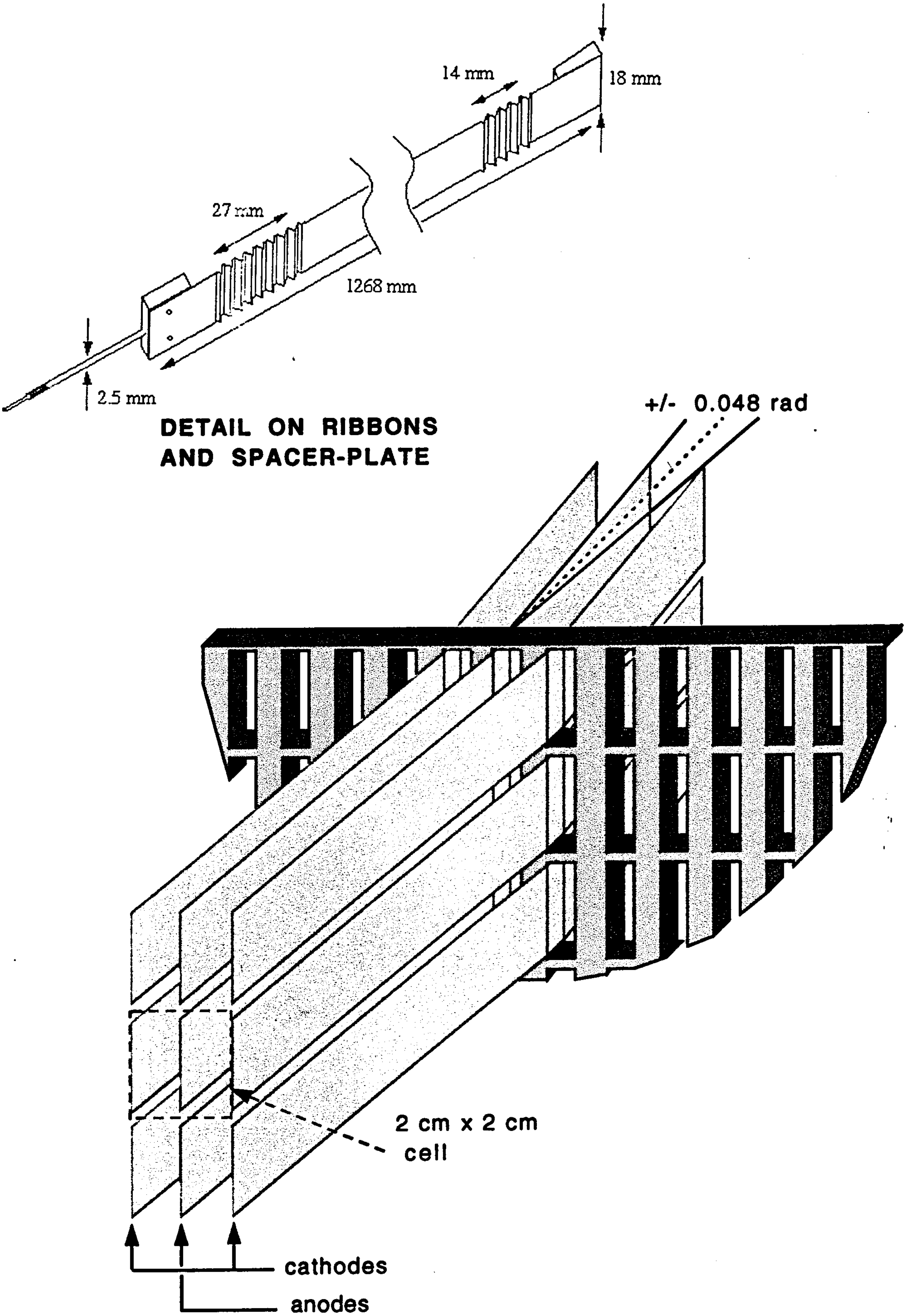
- THIS ACCORDEON SHAPE REDUCES TO ~ ± 0.5%

→ A SMALL DROP IN RESPONSE UNIFORMITY ACROSS THE CELL, WHEN THE SHOWER CORE HITS THE CENTRAL ANODE RIBBON

- A PROJECTIVE GEOMETRY POINTING TO ~ 110 m UPSTREAM, IS OBTAINED LINEARLY INCREASING THE CELL TRANSVERSE SIZE (IN X AND Y) FROM THE FRONT PLATE, ADDING UP TO + 1.1%.

- THE SHOWER RESPONSE UNIFORMITY BOTH ON THE IMPACT POINT RADIUS AND ON THE DEPTH OF SHOWER MAXIMUM, IS IMPROVED IN THIS WAY.

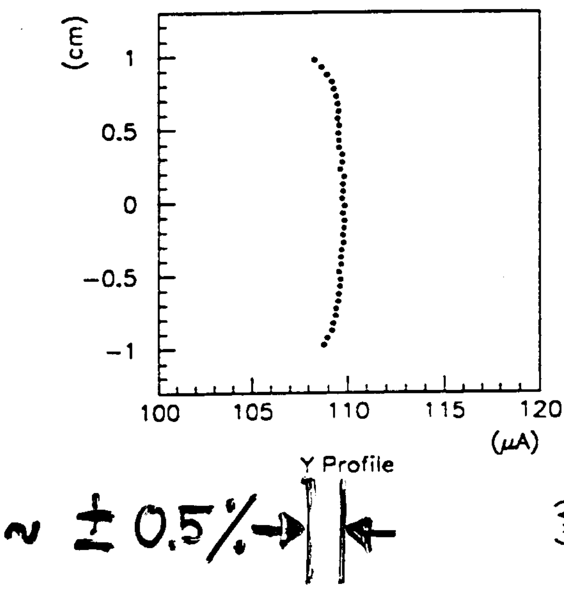




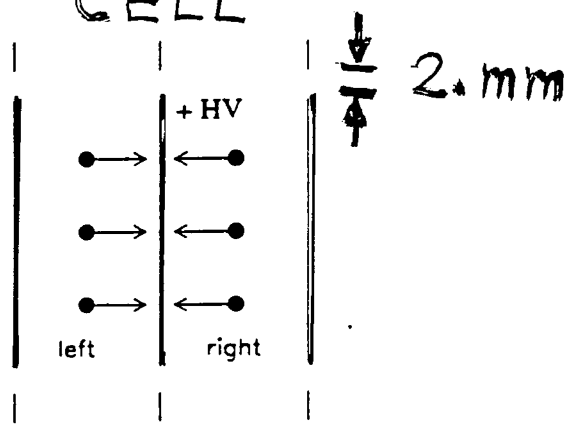
DETAIL ON RIBBONS AND SPACER-PLATE

• UNIFORMITY INSIDE CELLS

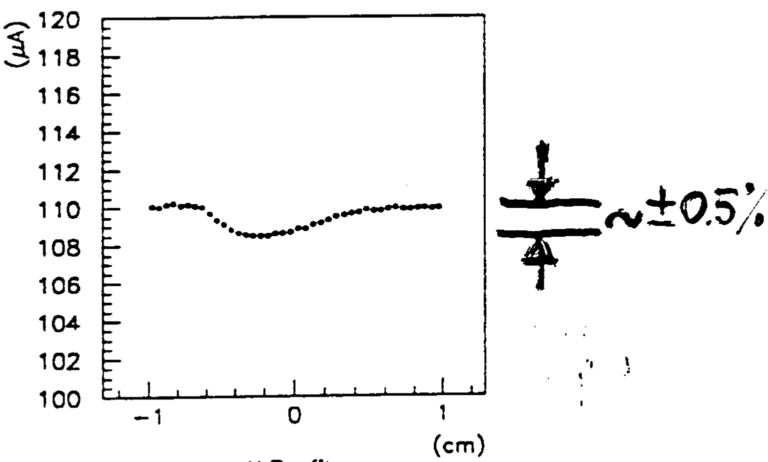
Y PROFILE



CELL

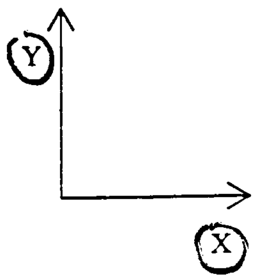


the read out cell



X Profile

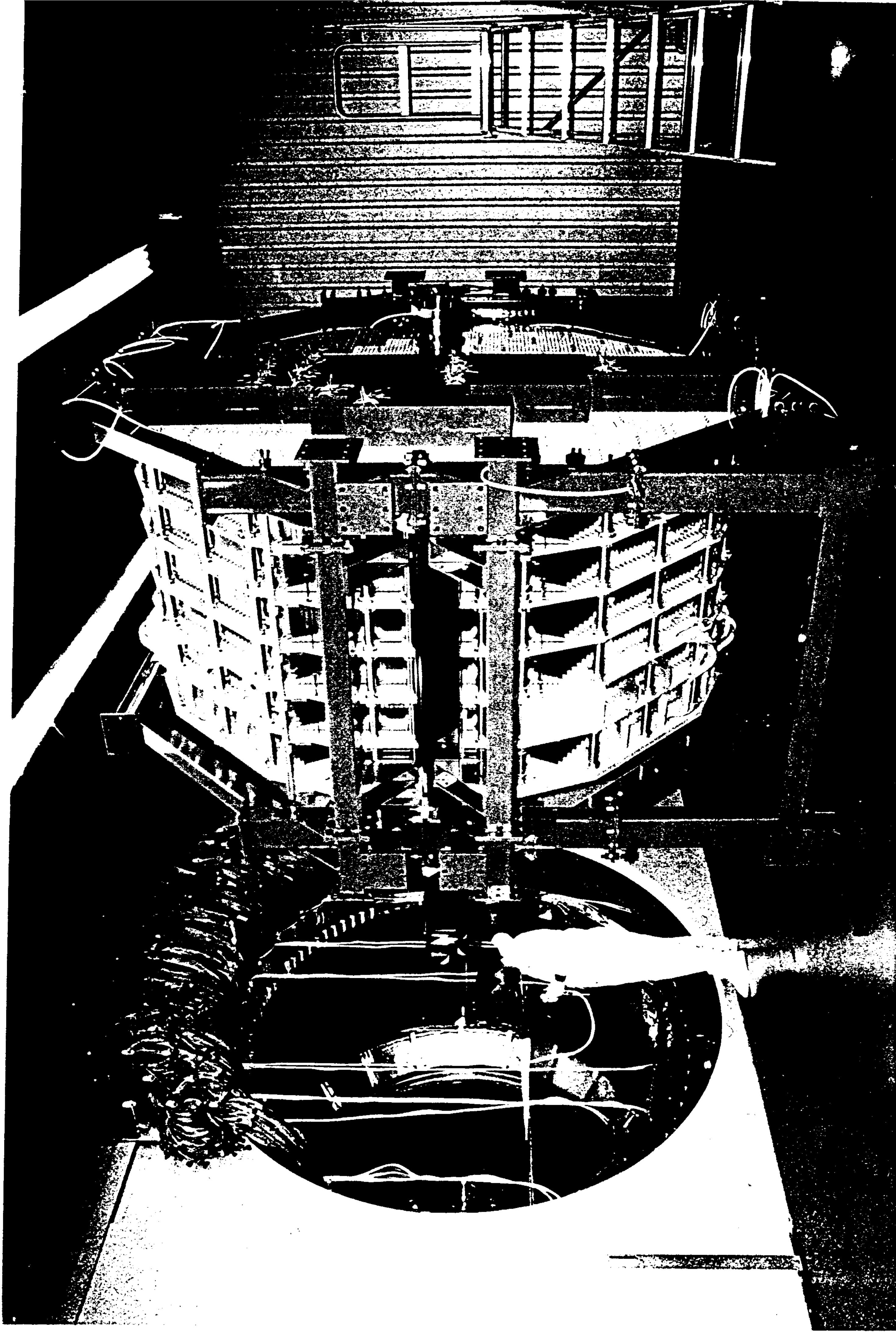
X PROFILE



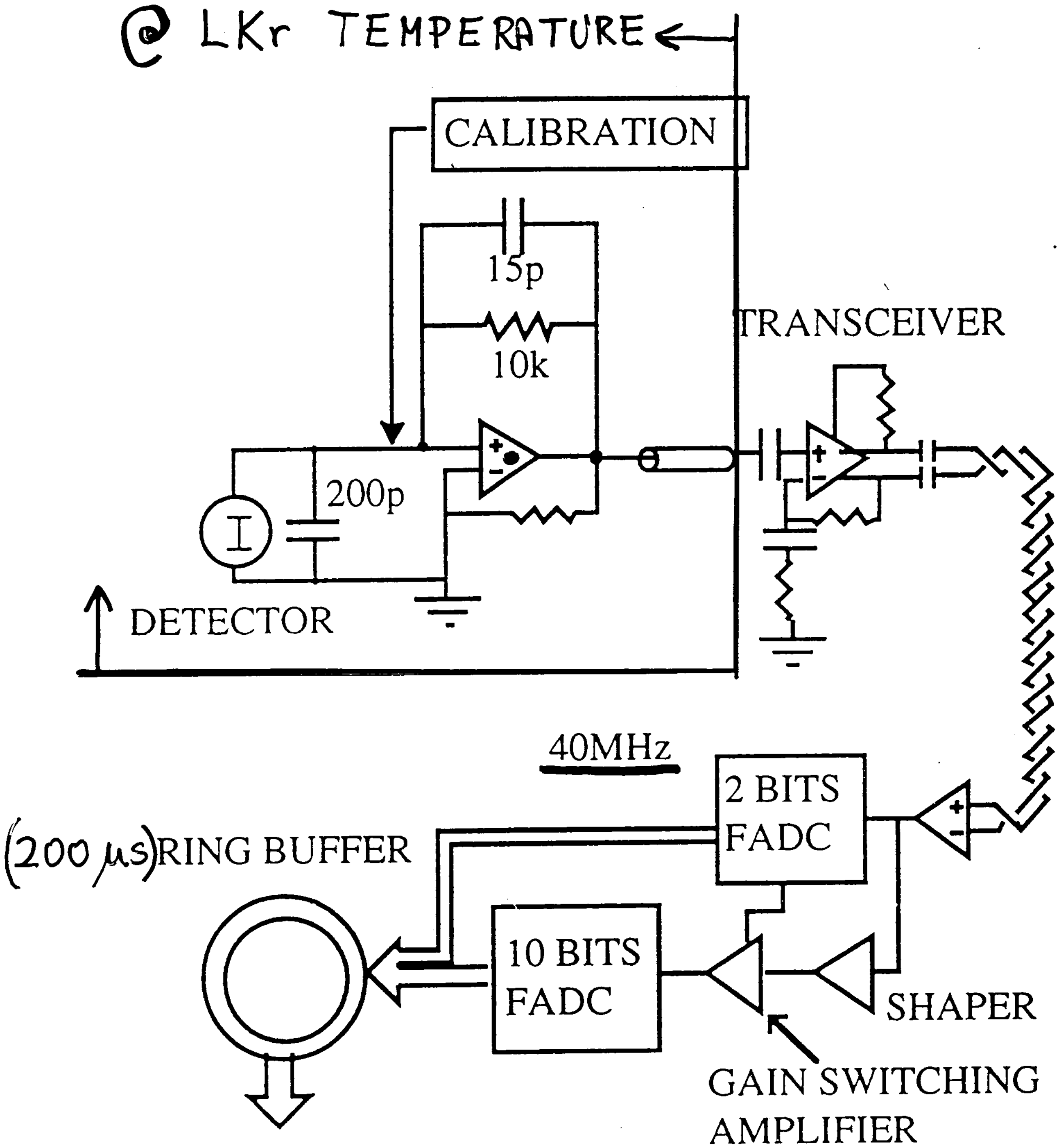
• UNIFORMITY CORRECTIONS ARE <u>IDENTICAL</u> FOR ALL CELLS.

THE FRONT END ELECTRONICS

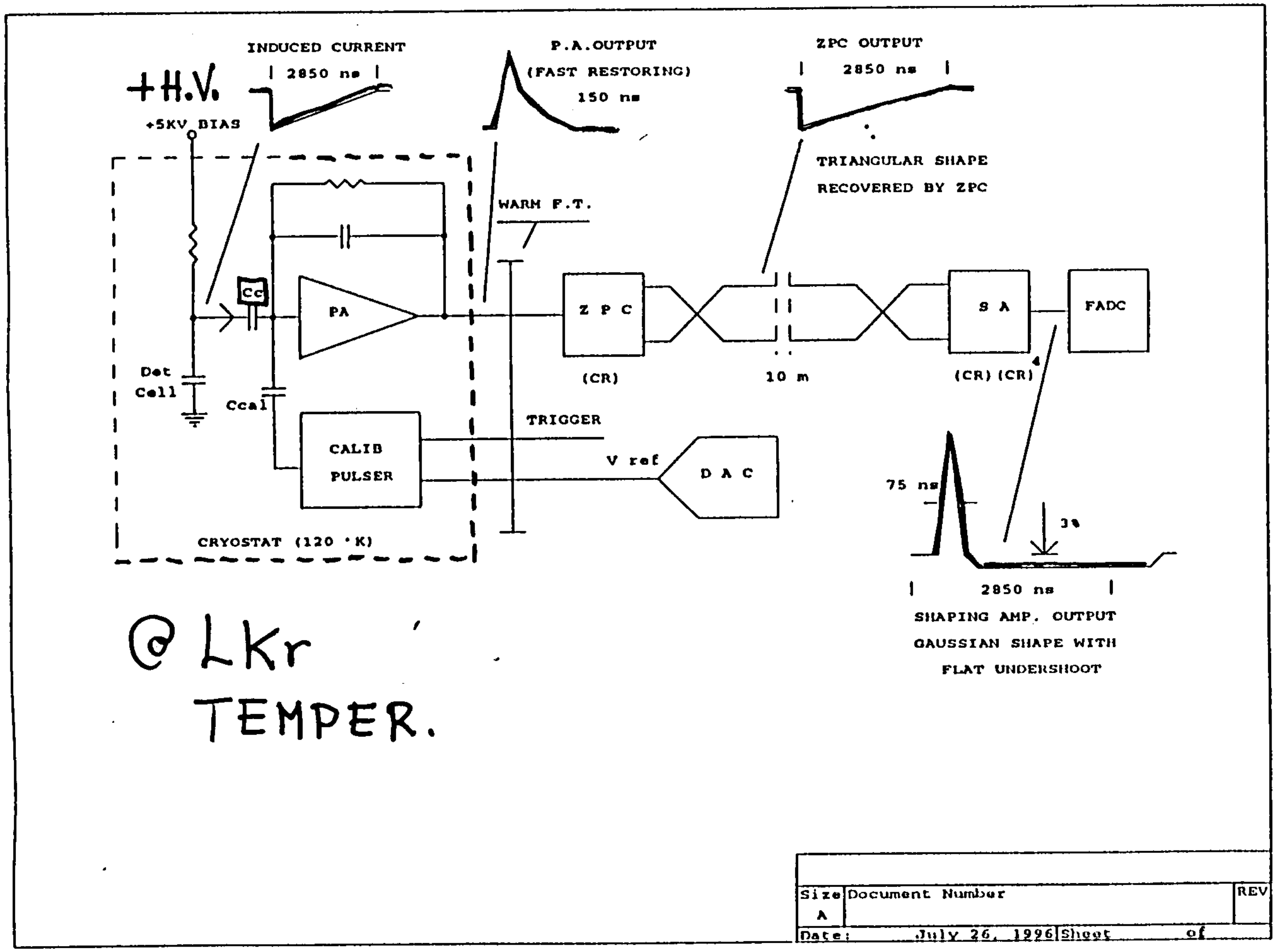
- THE PREAMPS AND THE CALIBRATION SYSTEM ELECTRONICS ARE PLUGGED ON THE BACK → END OF RIBBONS, INSIDE THE LKr TO:
  - MINIMIZE THE NOISE (Si JFET's ARE CLOSE TO THEIR MINIMUM NOISE FIGURE @ LKr T = 120 K)
    - EN. EQUIV. NOISE FROM 4 MeV → 8 MeV (@ 5 KV) WITH SHAP. TIME 120 ns → 70 ns
  - EXPLOIT LKr BATH AS THERMOSTAT TO STABILIZE IN TEMPERATURE THE ABOUT 2000 PULSER GEN. OF THE CALIBR. SYSTEM
- CALIBRATION PULSES ARE PRODUCED LOCALLY TO AVOID DISTORSION OR CROSS-TALKS DUE TO TRANSMISSION OVER LONG LINES
- THE CALIBRATION SYSTEM IS IMPLEMENTED ON AN 18 LAYER MOTHER BOARD WHICH ALSO DISTRIBUTES THE P.S. TO 64 PREAMP CARDS
- THE PRECISION AND THE STABILITY OF THE CALIB. SYSTEM SHOULD ALLOW TO CONTROL THE RESPONSE UNIFORMITY OF THE ~ 13500 CH. TO BETTER THAN 0,5 % (THE FINAL CHECK IS NOW POSSIBLE WITH ALL FADC's INSTALLED)



ELECTRONICS CHAIN



- PREAMP BNL-RADEKA TYPE
  (CHARGE INTEGRATING, Si JFET)

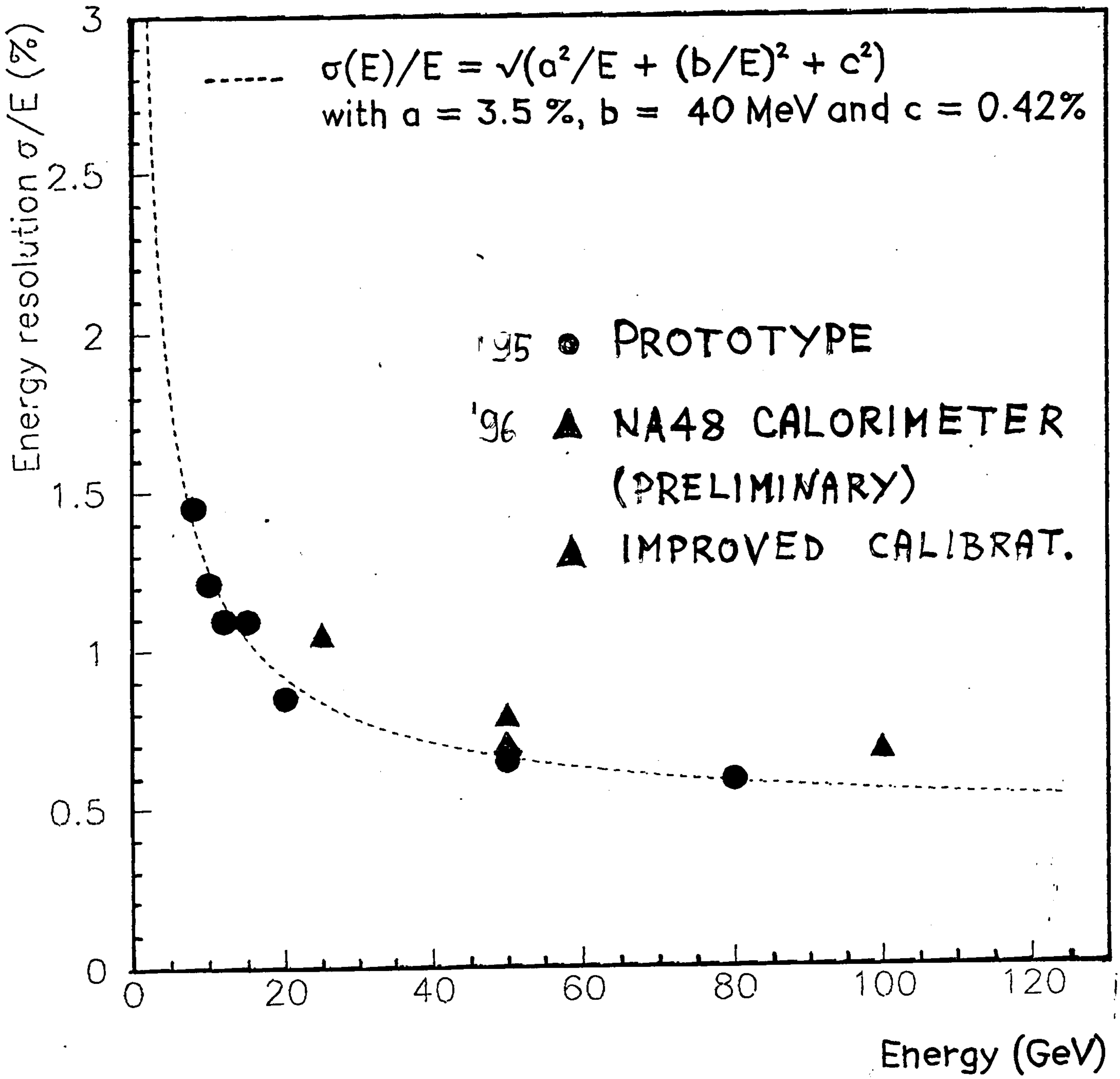


☐ H.V. DECOUPLING CAPACITOR

- PROBLEM: A FEW CAP'S ARE DISCHARGING @ $\gtrsim$ 2KV
- LIKELY WE'LL REPLACE ALL CAPACITORS DURING WINTER SHUT DOWN
- THE MAIN EFFECT IS A ~0.2 % CORRECTION DUE TO SPACE CHARGE EFFECT
- THIS CORRECTION HAS TO BE APPLIED AT NOMINAL INTENSITY(*), IN THE 2-nd HALF OF 2.4 s SPS SPILL

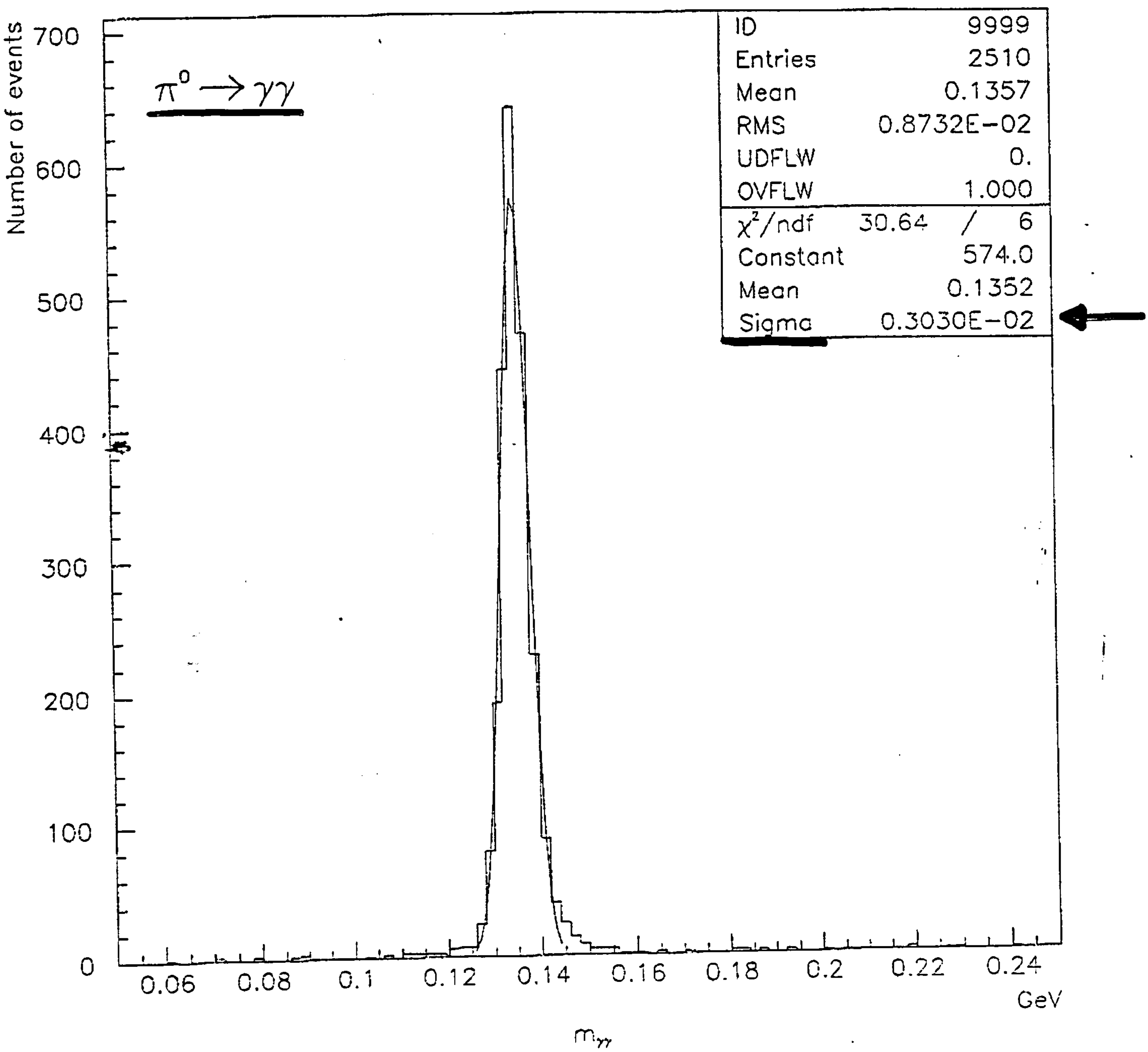
(*) 1.4 10^6 K DECAYS IN'S. DET.

NA48 PRELIMINARY



	▲ CALO '96	● PROTOT.
H.V. (kV)	1.5	5.0
SH. TIME (ns)	70	120
ELECTR.	FADC	ADC
PHASE CORR.	NO	YES

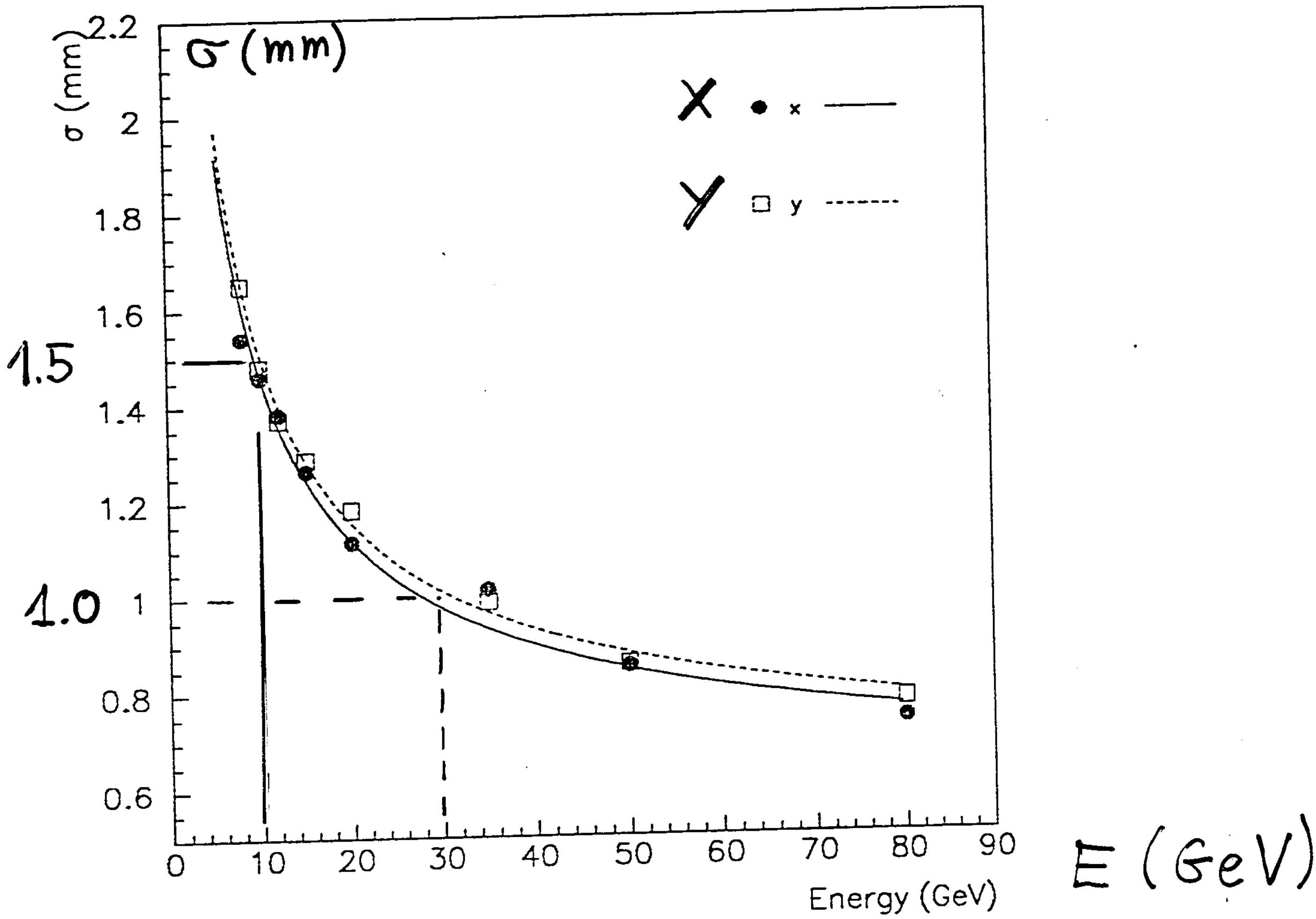
NA48 PRELIMINARY



- 96 DATA OBTAINED GROUPING 16 CELLS (2×8)
- IN THIS YEAR DATA CELLS ARE INDIVIDUALLY READ
- EXPECTED RESOLUTION ~ 1 MeV

NA48 LKr CALORIMETER

POSITION RESOLUTION



$$\sigma_x \simeq \sigma_y = (4.2/\sqrt{E} + 0.6) \text{ mm}$$

- PRELIMINARY RESULTS OF CALORIMETER ~ MATCH PROTOTYPE ONES.

THE PREAMPLIFIER PROTECTION SYSTEM DURING H.V. ↗ CONDITIONING

- THE SYSTEM AIM IS TO PREVENT PREAMPS. FROM BEING DAMAGED BY POSSIBLE H.V. DISCHARGES BTW. RIBBONS DURING THE INITIAL H.V. RAMP-UP AND CONDITIONING

- IN THE 'CLOSED' POSITION OF THIS SWITCHING SYSTEM ALL PREAMPS INPUTS ARE SIMULTANEOUSLY GROUNDED BY SETS OF LONG METALLIC SPRING CONTACTS.

- TESTS HAD SHOWN THAT CONTINOUS H.V. DISCHARGES UP TO 7 KV 'SIMULATED' IN THE RIBBON STRUCTURE
  LEAVE PREAMPS UNAFFECTED.

- THE SWITCHING MECHANICAL ACTION INSIDE THE CRYOSTAT, IS OBTAINED BY A SET OF 64 BELLOW PAIRS DRIVEN BY A GAS CONTROLLED SYSTEM PLACED OUTSIDE THE CRYOSTAT

CONCLUSIONS

- PRELIMINARY RESULTS ON '96 DATA ~ MATCH PROTOTYPE ONES

ENERGY $\sigma(E)/E = \frac{3.5\%}{\sqrt{E}} + \frac{0.04}{E} + 0.4\%$

POSITION $\sigma_x \simeq \sigma_y = \frac{4.2}{\sqrt{E}} + 0.6$ mm

TIME $\sigma_T = \frac{0.6}{\sqrt{E}} + \frac{1.7}{E} + 0.2$ ns

- FINAL RESULTS FROM '97 DATA WITH INDIVIDUAL CELL READ-OUT
('96 DATA TAKEN READING OVER THE ENTIRE CALORIMETER GROUPS OF 16 CELLS 2×8)

- H.V. PROTECTION SYSTEM WORKS WELL