

Complications

Forte amplification sur les fils \rightarrow charge d'espace du nuage d'ions lents \rightarrow distorsions

\rightarrow opération en "gating grid". Perturbation sur électronique, moins de gain sur la chambre et plus de gain demandé aux amplis.

Effets $E \times B$ au voisinage des fils (gradient de champ) et discontinuités de champ bords de cages et secteurs

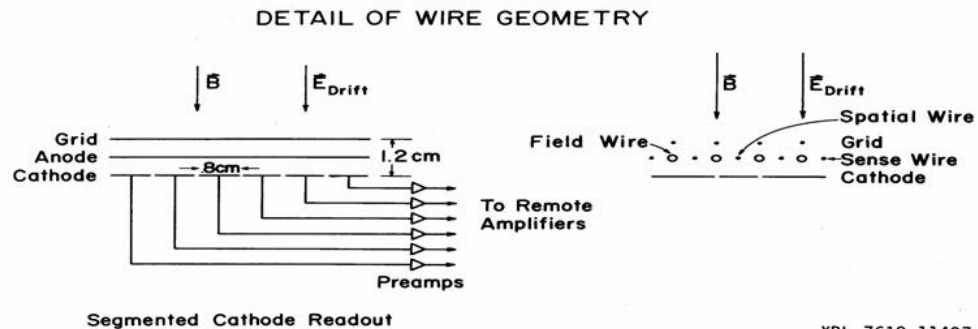


Fig. IIIA.9

“gating grid”

Appliquer $V_g \pm \Delta V$ sur grille de gate

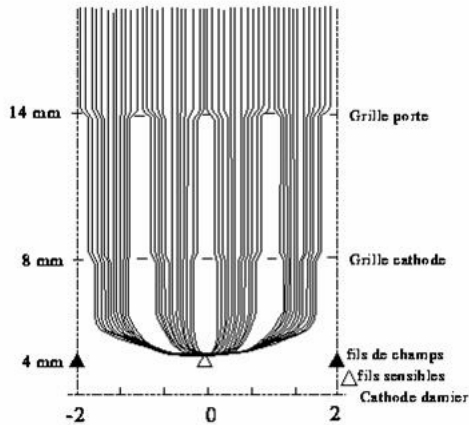
$\Delta V_g = 100V$ dynamique ou 30 V statique

- TPC gate fermée + ouverture après trigger L1 OK

Perte début trace + perturbation électronique

- Ouverture permanente + fermeture après L1 NO

- Générateur pulse + et - très symétriques !



Géométrie des grilles des secteurs et lignes du champ électrique

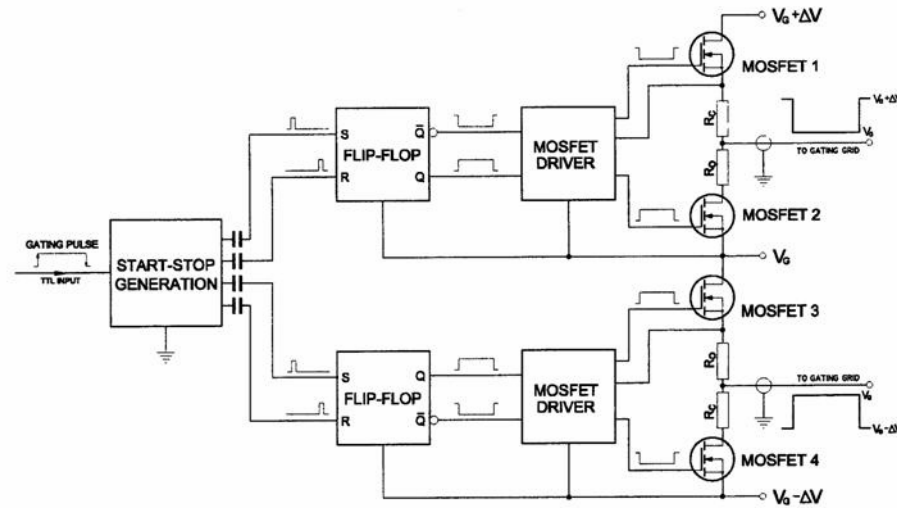
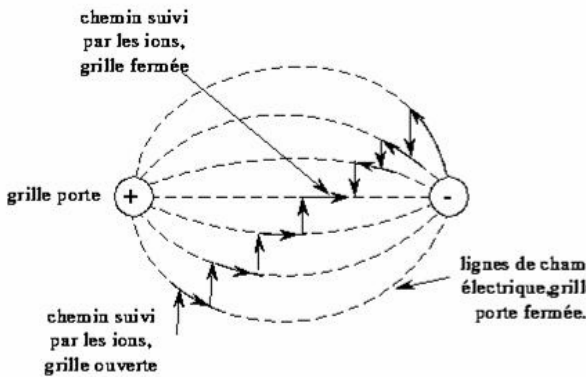


Figure 4.39: Block diagram of the gating pulser.

TPC PEP4 Conclusions

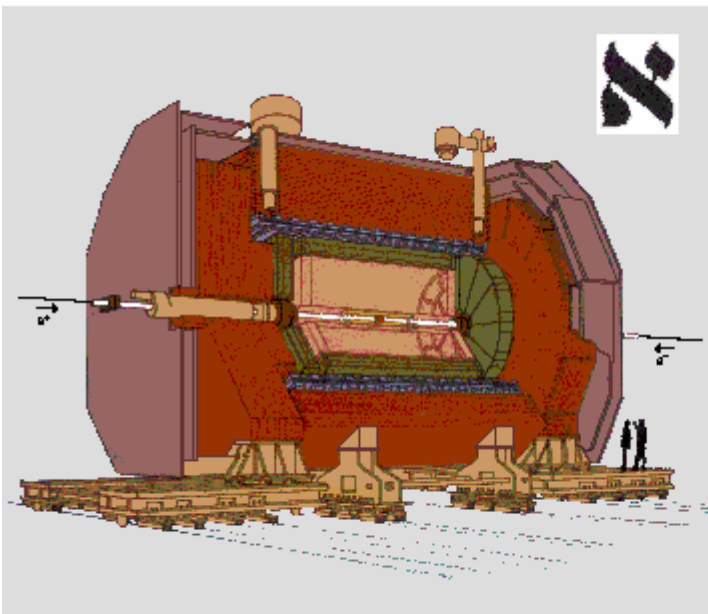
- A établi l'idée et les principes de base + validation

LA TPC C'EST POSSIBLE!

- Sera l'inspiratrice des TPC de LEP
- A montré la possibilité d'utiliser un chaîne de préamplis-amplis à haut gain et faible bruit.
- Devant les difficultés d'utilisation a poussé la recherche sur les FADC
- dE/dx optimiste

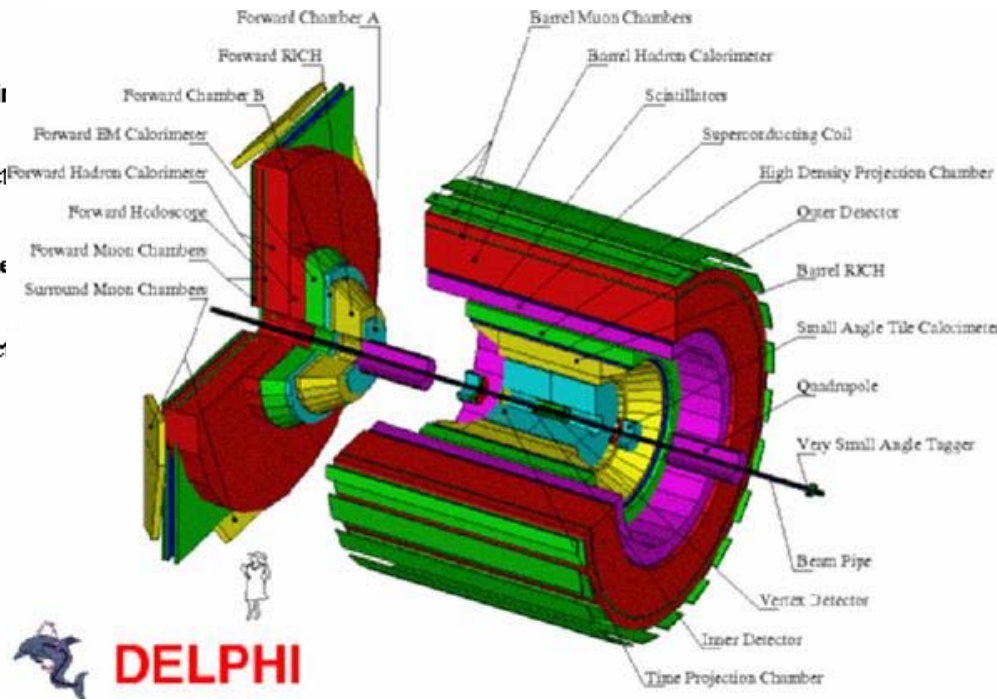
Les TPC à LEP

Aleph (1983-1989-2000) Delphi



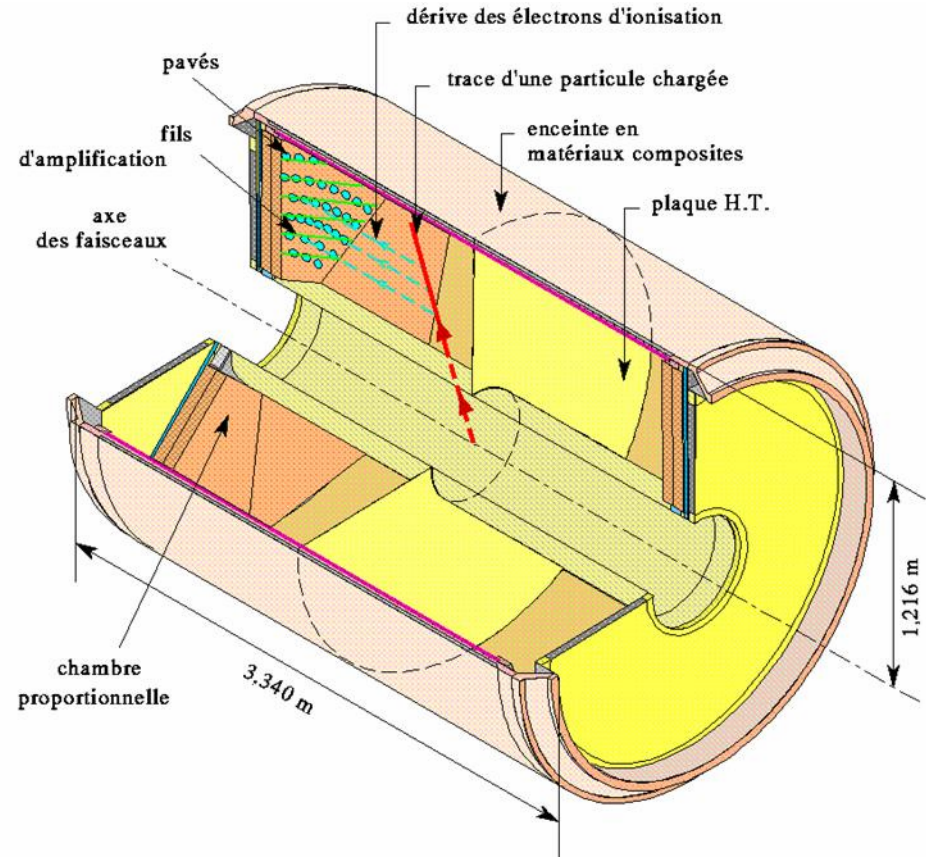
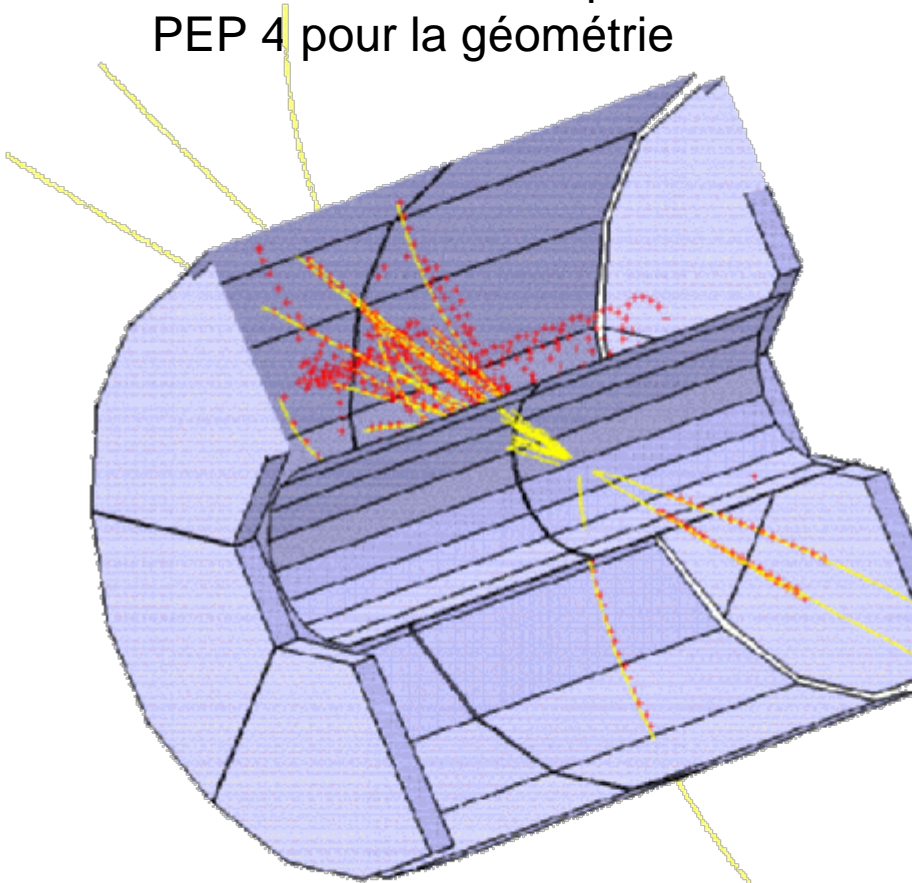
The ALEPH Detector

- Vertex Detector
- Inner Tracking Chamber
- Time Projection Chamber
- Electromagnetic Calorimeter
- Superconducting Magnet Coil
- Hadron Calorimeter
- Muon Chambers
- Luminosity Monitors



TPC Delphi

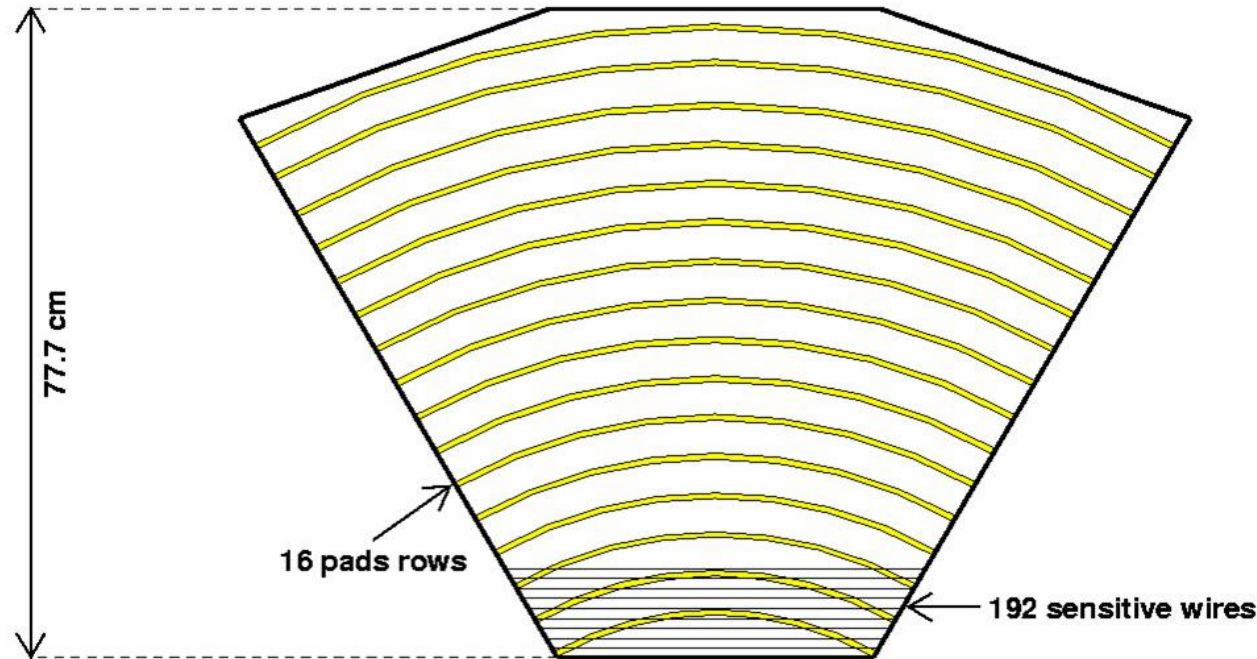
Très directement inspirée de PEP 4 pour la géométrie



TPC Delphi: caractéristiques

$P = 1$ atm Ar-CH₄ 80/20
2 x 1.34 m, r 0.325-1.16m
2 x 12 sectors

Résolutions:
R- ϕ = 180-280 μm
Z \sim 0.9 mm
Sep. 2 traces = 1.5 cm



12 x 1680 pads, 12 x 192 fils \rightarrow 22464 canaux

TPC Delphi:secteurs et cage HT



Cage externe

Plaque HT

Secteur(pads)

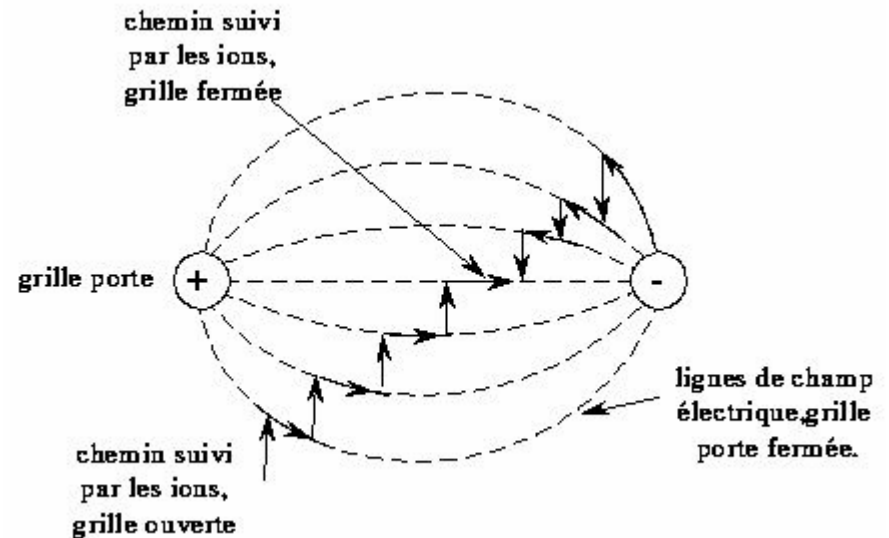
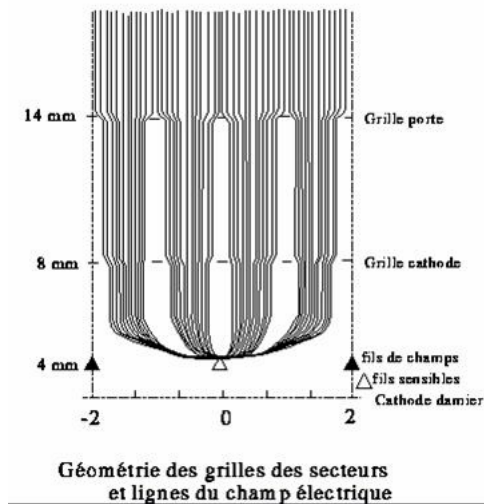
Resistances HT

Cage interne



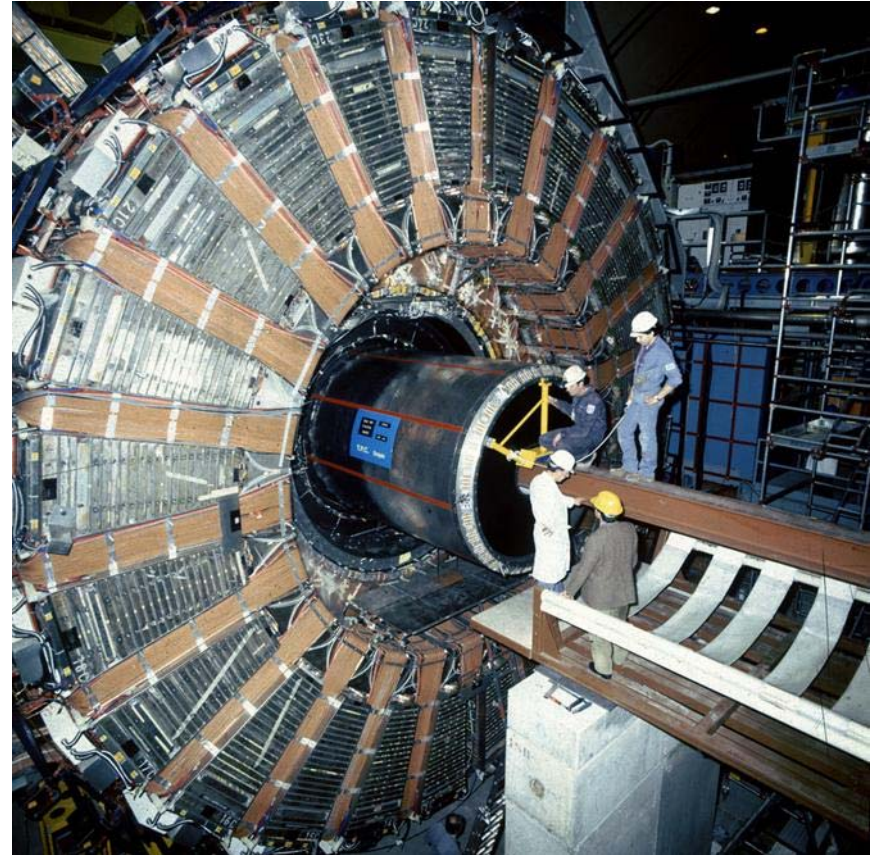
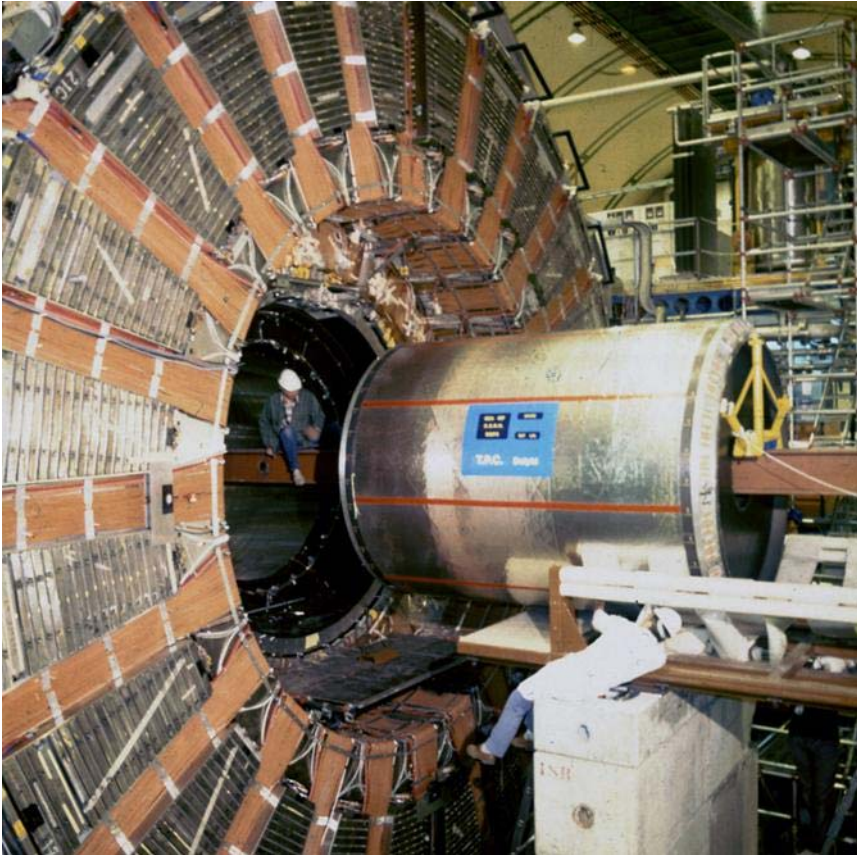
TPC Delphi: champs électriques et grilles

$E = 150 \text{ V/cm}$, $HT \sim 20 \text{ KV}$



Gate pulsée ou statique

TPC Delphi



TPC Delphi: chaîne électronique

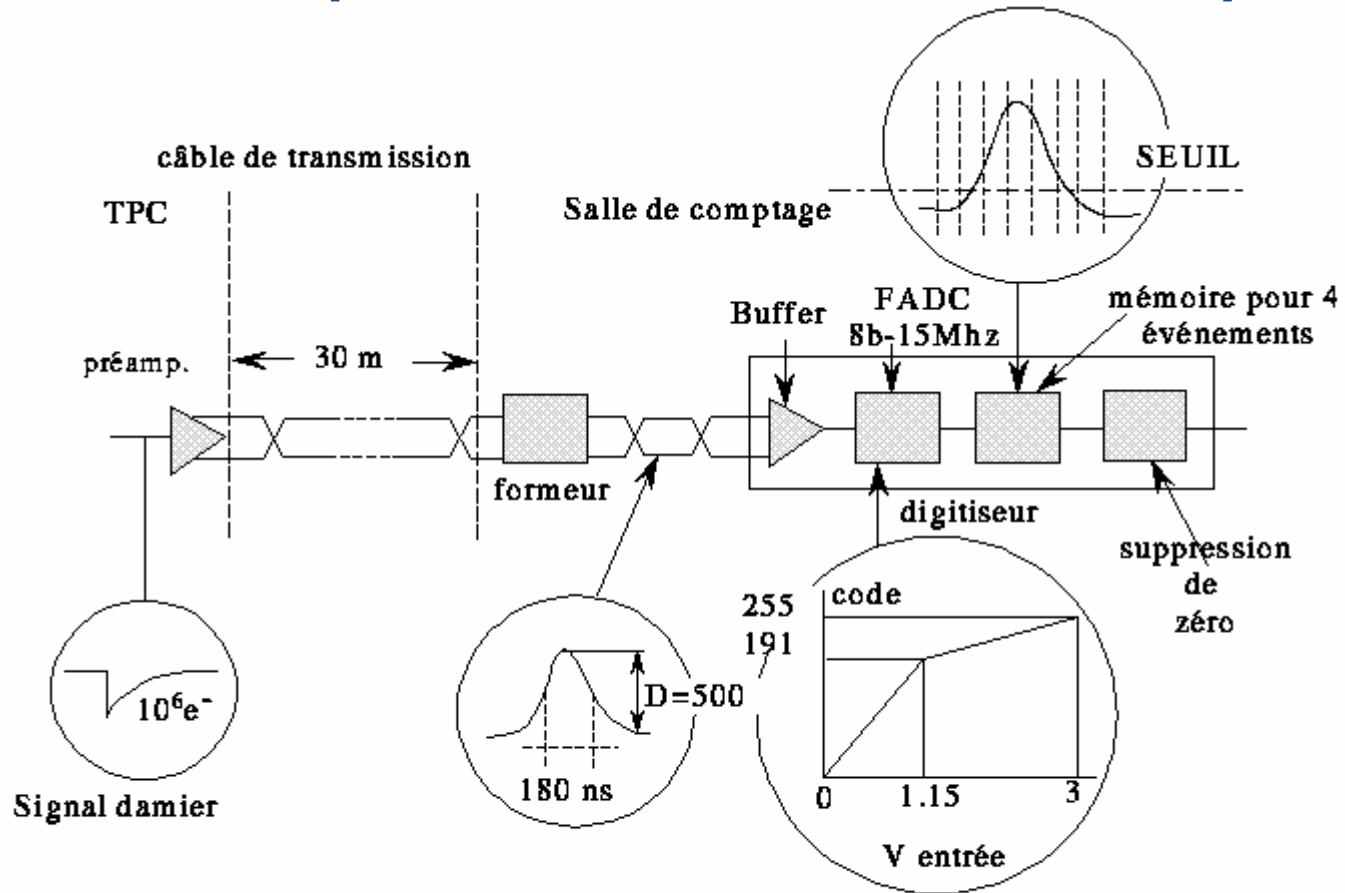
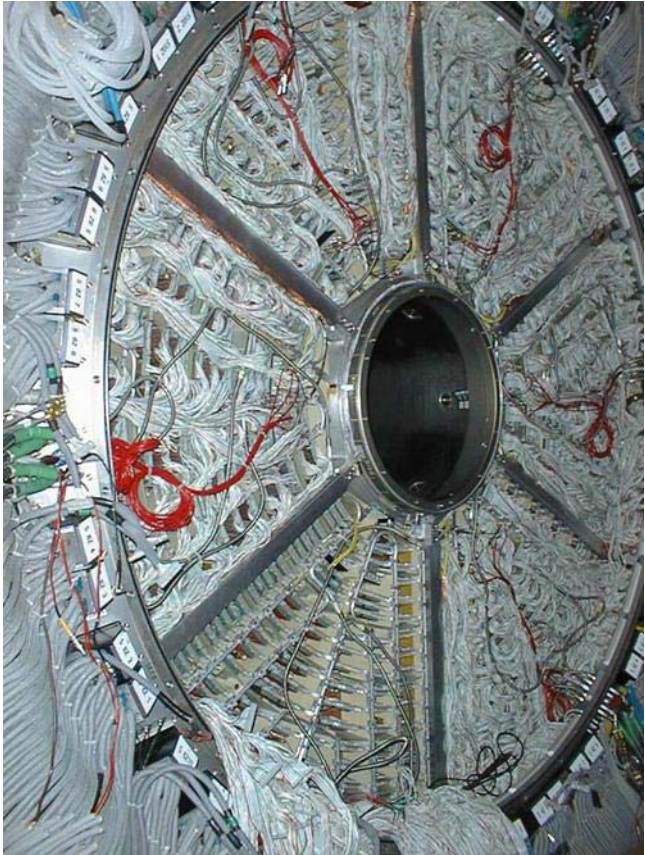


Schéma de la chaîne électronique

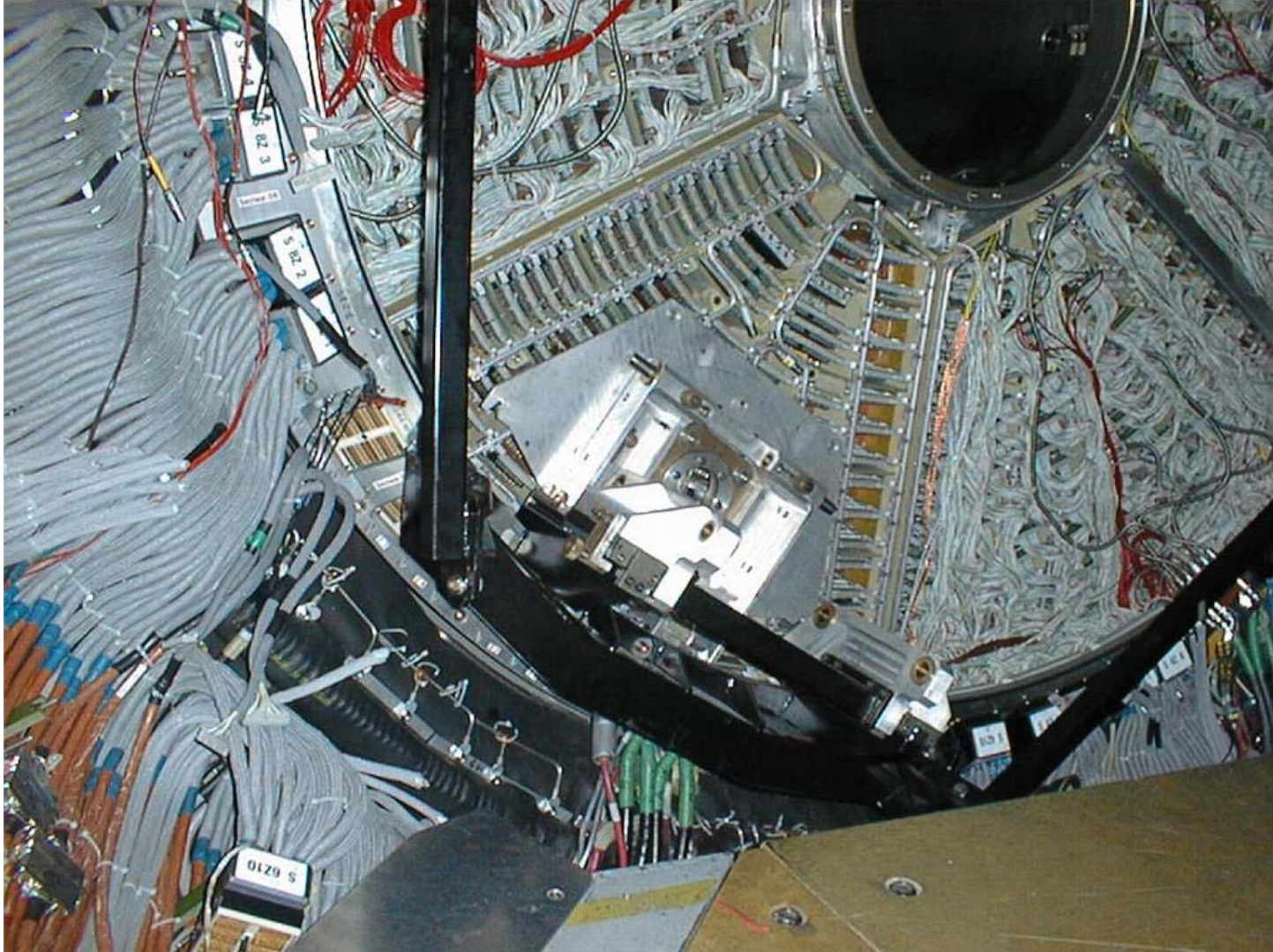
TPC Delphi



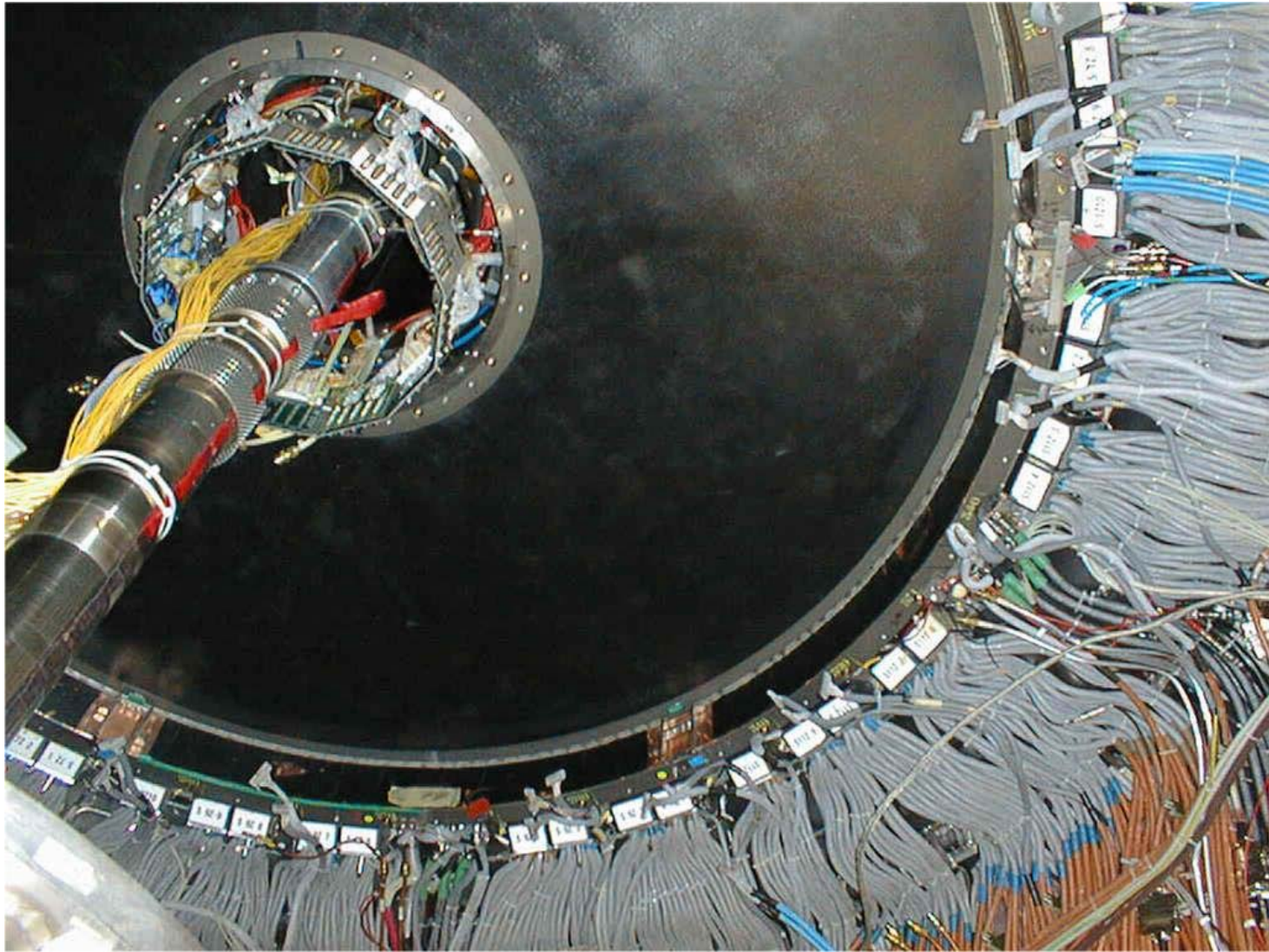
TPC Delphi



TPC Delphi



TPC Delphi



TPC Delphi:préamplis et amplis

Préampli: BF 992 MOS-FET

Hybride: pole zéro + émetteur de ligne

Dissipation 42 mW

16 hybrides/carte (alu + refroid. tuyau eau)

Ampli-Shaper: 2 sections ampli-filtre actif

Shaping 170 ns FWHM

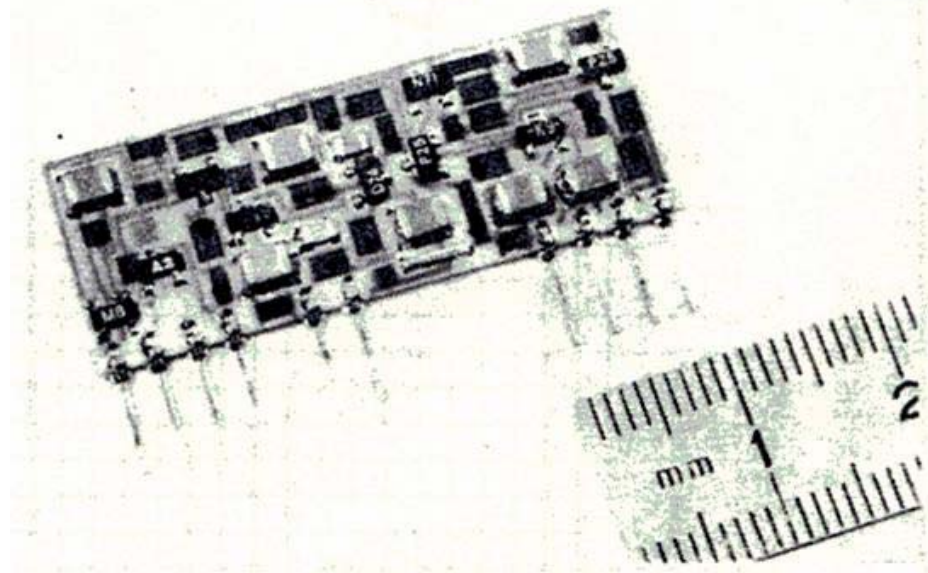
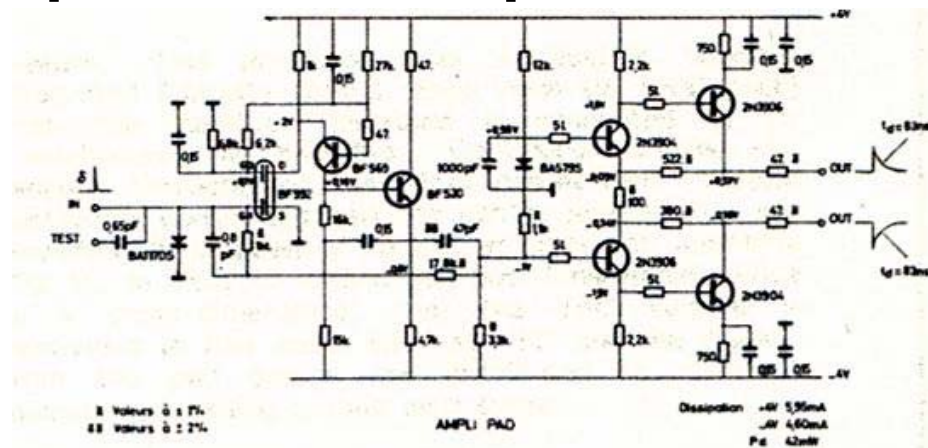
Receveur de ligne sym. 2 x 60 W

Controle de gain (sw) steps < 1%

32 hybrides/carte FB

Discris pour trigger (fils)

Bruit pads 500 e- sur 5 pF, fils ~1000 e-
à 20 pF



TPC Delphi:digitiseurs

Buffer d'entrée dif. Thomson LM318

8-bit FADC Thomson EF 8308 15 MHz

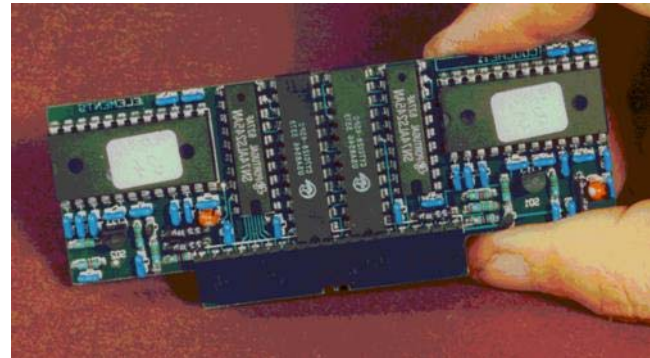
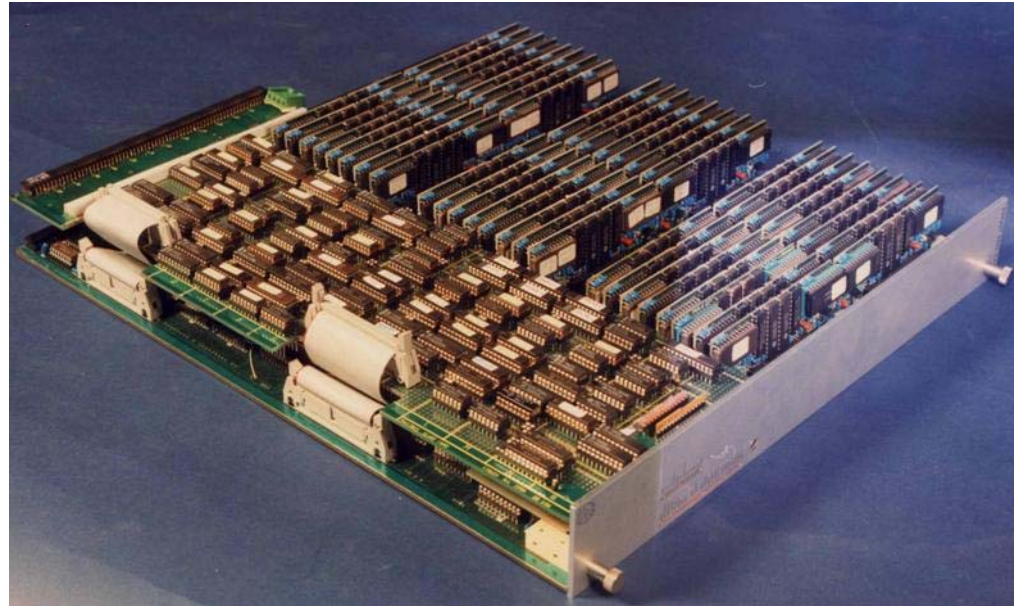
Caract. Bilinéaire, pas de 6.0 mV de 0 à 191 et 29.7 mV de 192 à 255.

Input max 3V, dynamique 500.

+/- 1 LSB intégrale et 0.7 LSB dif.

Mémoire en 4 pages de 512 bytes pour 4 événements de 511 tranches de temps (70 ns)

48 x 2 canaux par 3 U FB + carte ZS



TPC Delphi: digitisation & relecture

Digitisation: le FADC tourne en permanence. A chaque BCO (50KHz) le résultat est écrit dans une page mémoire au moins durant $2\mu\text{s}$ (attente trigger niveau I), puis soit l'événement est rejeté la plupart du temps et le pointeur mémoire est remis à 0, soit est gardé (1 KHz max) et l'écriture se poursuit pendant toute la durée de la dérive, 511 tranches de temps = $35\mu\text{s}$ pour une horloge à 14.67MHz. Ecriture en // dans toutes les 96 voies d'un digitiseur.

Zéro suppression et formatage: c'est le processus concurrent permis si le FADC n'écrit pas dans sa mémoire. Relecture de la mémoire, « clustering » en temps (tranches de temps adjacentes qui dépassent un seuil), fabrication d'une table de pointeurs (fixe) et formatage des clusters. Relecture en série des 96 voies, 1 seul ZS (automate HW) pour 96 voies de digitiseur. Info ZS dans mémoire de 2Kbyte/digitiseur.

Les digitiseurs de plusieurs châssis FB (FB clusters) sont lus par des processeurs de châssis (Fastbus Intersegment Processor FIP, MC68020). Taches principales: démarrage ZS si place mémoire, relecture mémoire de ZS et formatage, monitoring, calibration, clusterisation pour trigger niveau III (soft).

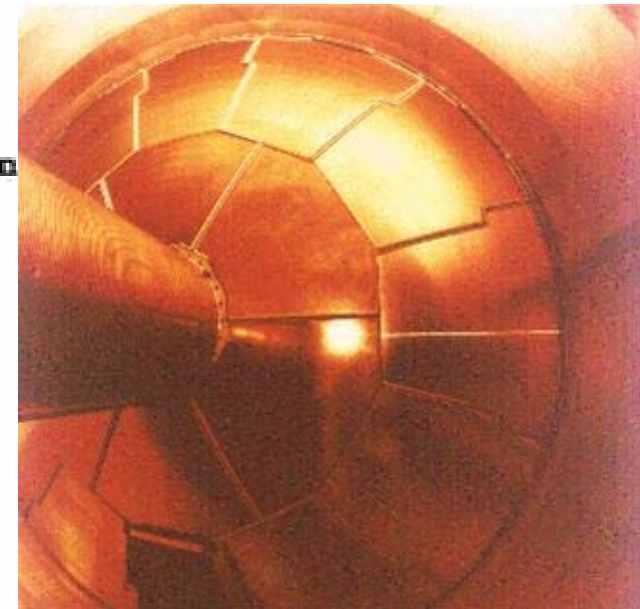
TPC Aleph

1 The Time Projection Chamber (TPC)

Description: Cylindrical drift volume with central electrode and planar wire chambers at the two ends. Electrons from ionization drift to the endplates along the electric field of 11 kV/m. Their charge is recorded by a system of proportional wires which are capacitively coupled to cathode readout pads. Each endcap has 6 inner sectors (type K) and 12 outer sectors (types M and W). Sectors have concentric rows of pads for 3 dimensional coordinate measurement ($r\phi$ from pad position, z from drift time). Wires across the sectors are used for dE/dx measurements. Each sector is equipped with special trigger padrows.

Gas: $ArCH_4$ (91 % : 9%) at atmospheric pressure.

Dimension:	Radius:	$R_{outer} = 1.8$ m	$R_{inner} = 0.31$ m
	Overall length	4.7 m	
	Drift length	2 x 2.2 m	
	Weight	3.6 t (with cables)	
	Gas volume	$43m^3$	
	Radiation length:	inner fieldcage	$0.023 X_0$
		outer fieldcage	$0.048 X_0$
		endplate	$0.35 X_0$



TPC Aleph

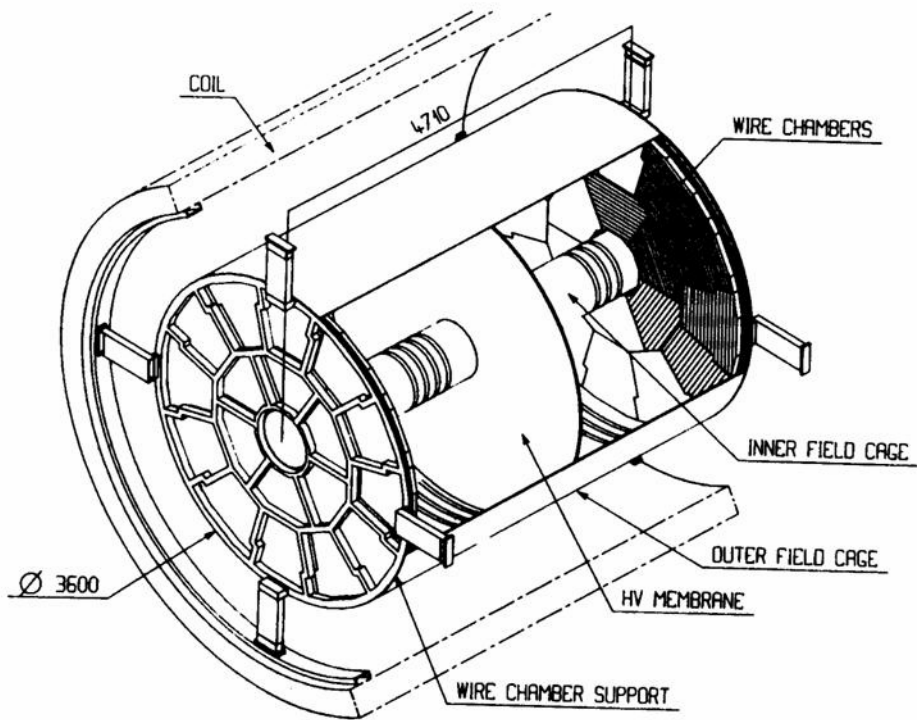


Fig. V.1 TPC overall view.

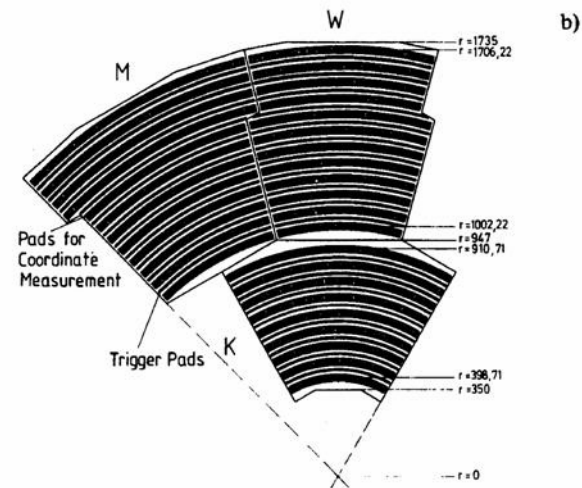
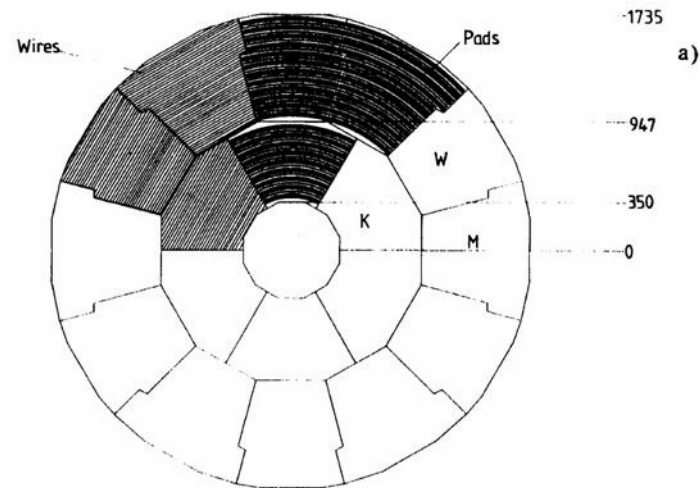


Fig. V.14 a) Overall geometry of the TPC end-plate.
b) A more detailed view of M, W, and K sectors.

TPC Aleph

Sectors:	R_{min}	R_{max}	No. padrows	No. trig. padrows	No. wires
Type K	38 cm	91cm	9	8	148
Type W _M	100 cm	170cm	12	11	196

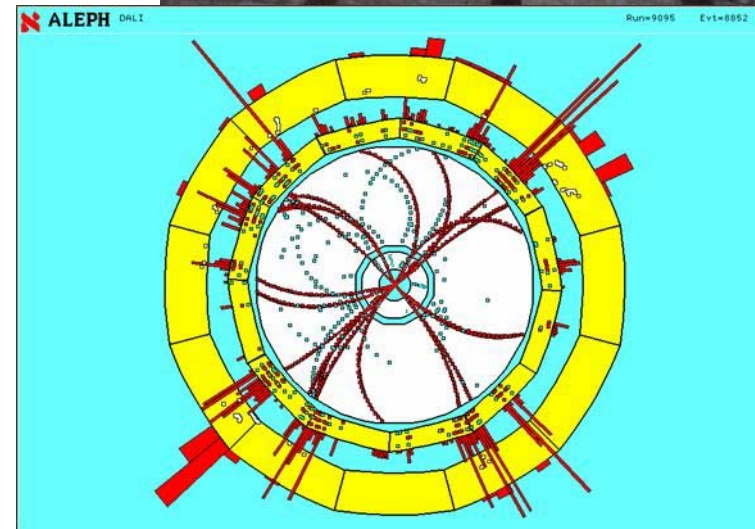
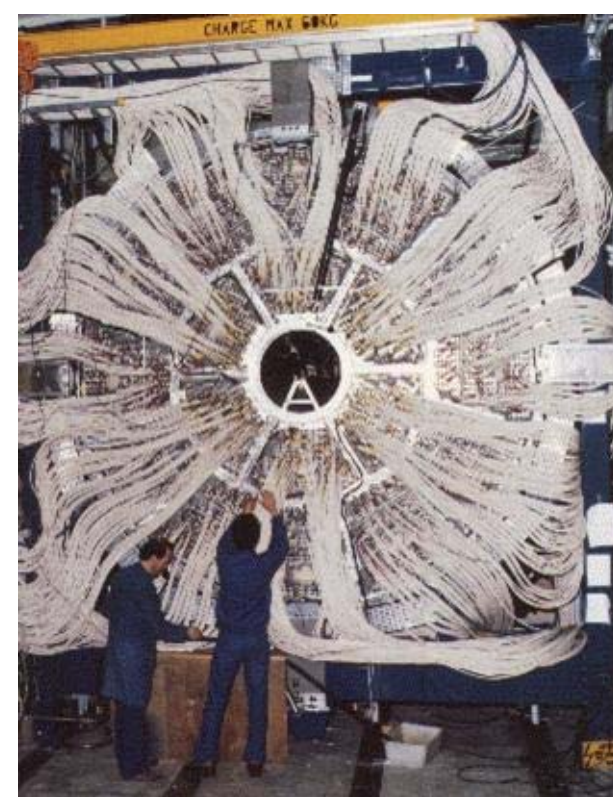
Pad size	$6.2 \times 30 \mu m^2$
Pitch in r- ϕ	6.7 mm
Triggerpad size	$6.8 \text{ mm} \times 15^\circ$
Sense wire spacing	4 mm
Sense wire diameter	20 μm
Field wire diameter	127 μm
Diameter of other wires	76 μm
Central electrode thickness	25 μm

<u>Gas Properties:</u>	Drift velocity	5.2cm/ μs
	Longitudinal diffusion	$4 \text{ mm}/\sqrt{m}$ per single electron.
	Transverse diffusion (B=1.5kG)	$0.8 \text{ mm}/\sqrt{m}$ per single electron.
	Specific ionization for min. i. p. (incau)	90 electrons/cm

Readout:

	pads	wires	total
Channels	2×20502	2×3168	47340
TPDs	660	108	768
TPI's	36	36	72

<u>Performance:</u>	r ϕ spatial resolution	180 μm at 0° pad crossing angle
	z spatial resolution	1.2 mm (wires) with "small" z dependence 0.8 mm (pads) at $\theta = 90^\circ$
	Momentum resolution	$\Delta p/p^2 =$ TPC only: $1.2 \times 10^{-3} (\text{GeV}/c)^{-1}$ at 45 GeV ITC + TPC: $0.8 \times 10^{-3} (\text{GeV}/c)^{-1}$ at 45 GeV
	dE/dx resolution	4.5% for Bhabha electrons



TPC Aleph: électronique

Préampli intégration de charge

25 e- primaires = 1 MIP → 15 mV

= 1/4 du range dynamique FADC

Bruit 600 e-. 50 000 preamp

Shaper: receveur diff + pole zero

+ 2 filtres 1 MIP → 0.5 V peak sortie

shaper

Largeur pulse 230 ns FWHM

Ampli & shapers hybrides

FADC: Thomson 8 bit

(comme Delphi)

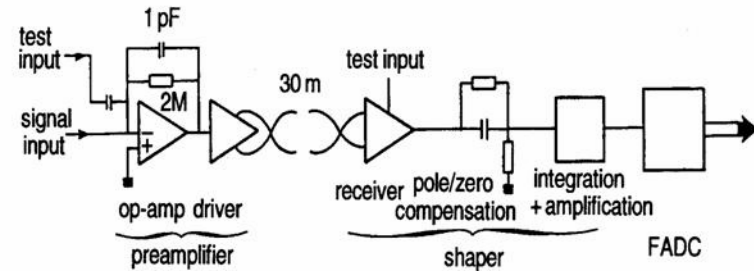


Fig. V.22 Functional diagram of the analog electronics chain.

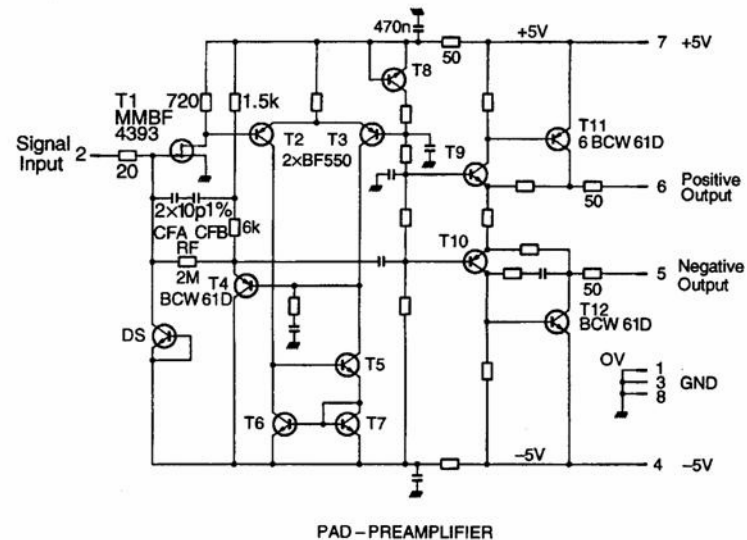


Fig. V.23 Circuit diagram of the pad amplifier.

TPC Aleph

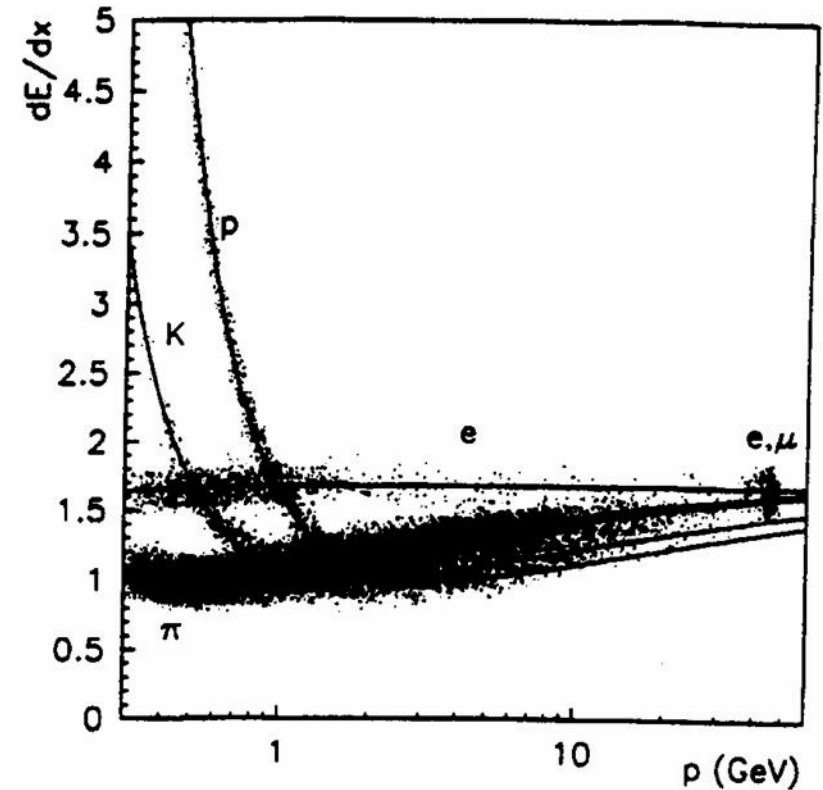
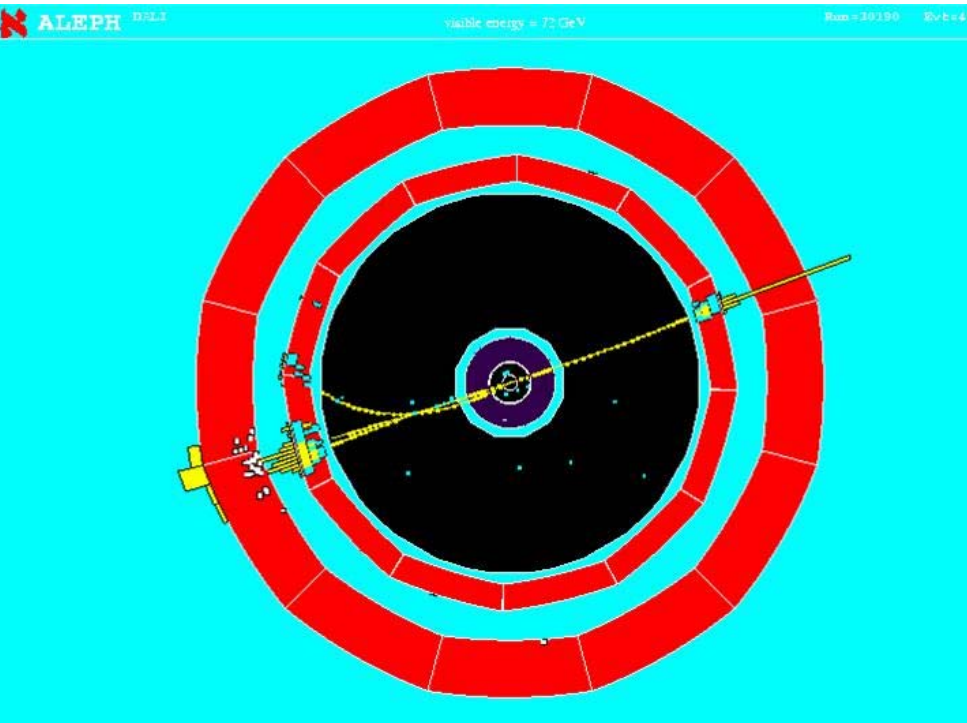


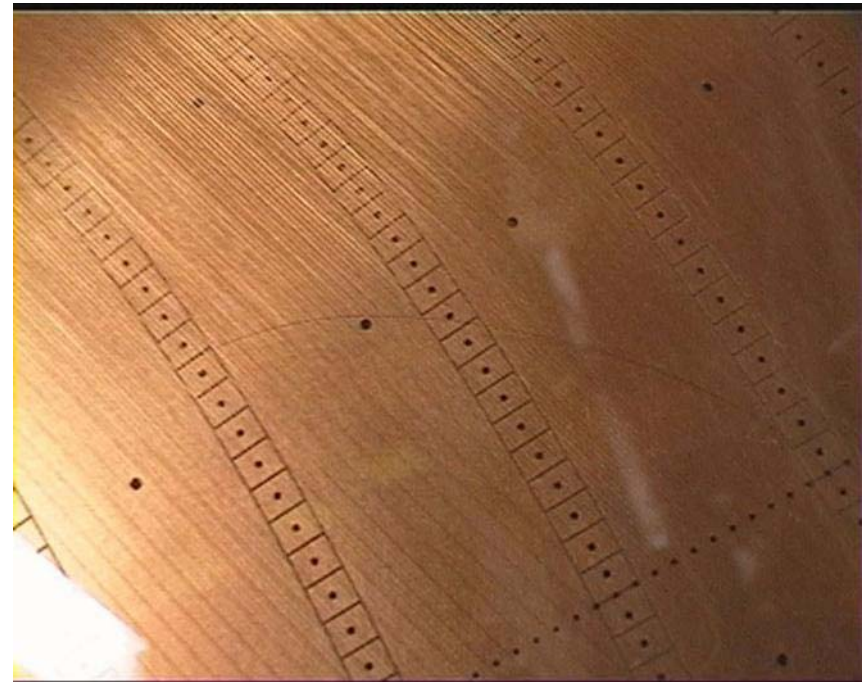
Fig. V.73 The measured dE/dx versus particle momentum for a sample of about 40,000 tracks. Each track was required to have at least 150 dE/dx measurements. The fitted parametrization is overplotted for electrons, muons, pions, kaons, and protons.

Les TPC à LEP: conclusion

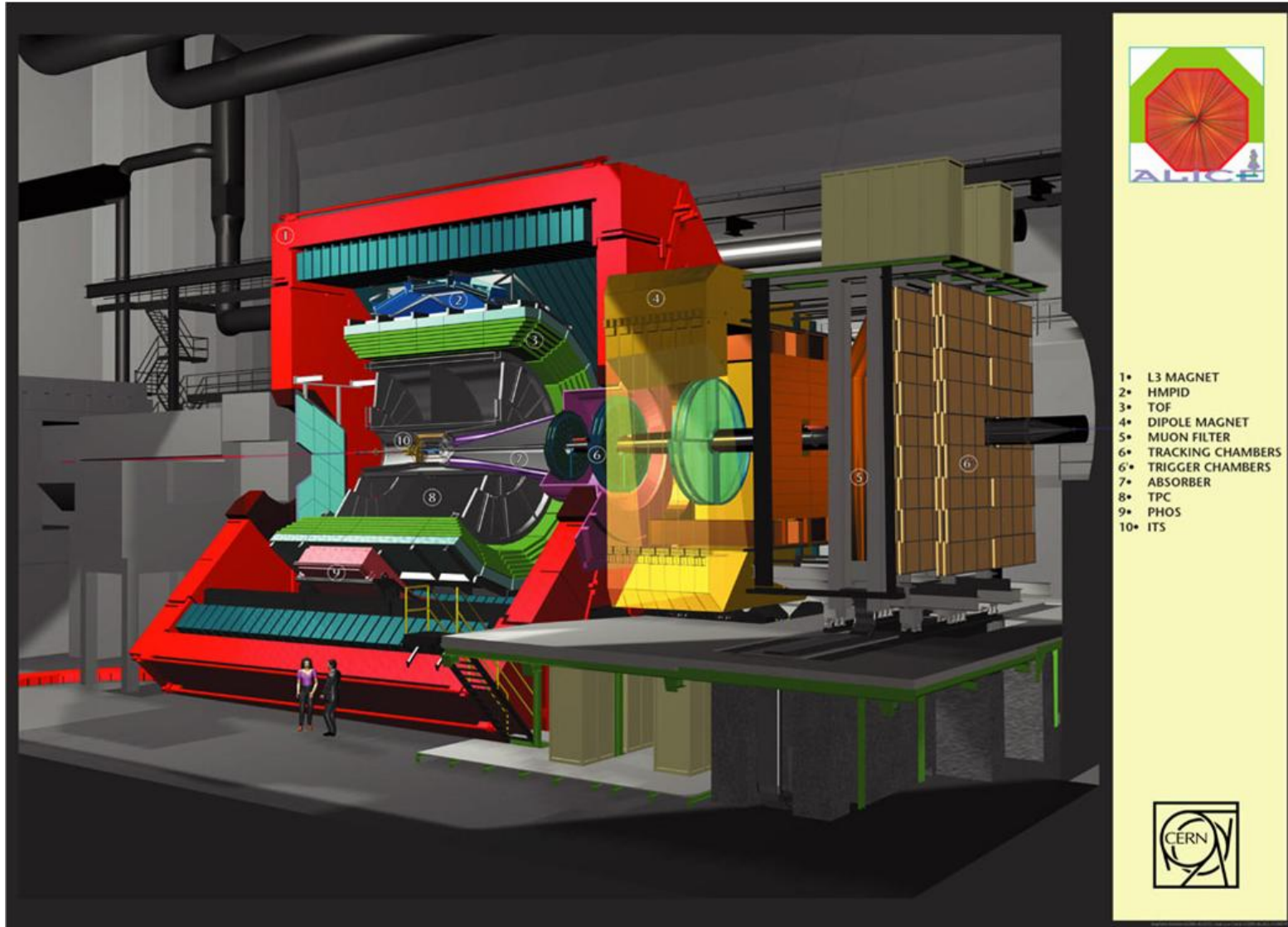
Lep a été la machine idéale pour exploiter tout le potentiel des TPC:

- Utilisation optimale des “longues dérives”. BC @ 50KHz
- Peu de bruit de fond...
- Evénements physiques!
- Electronique/taille optimale
- Electronique « solide »
- Investissement rentabilisé (89→2000)

1 fil casse apres 10
ans...



Les TPC après le LEP



Expériences ions lourds cible fixe

Ions lourds CERN Hall Nord SPS:

- NA35 (1990):, TPC 125 x 240 x 112 cm³, hors champ magnétique... Comptage de traces droites

- NA45 CERES

- NA49 (1995)

BEVALAC Berkeley: EOS (1992-93)

PS CERN: HARP expérience programme neutrino (2001-2002)

Expériences ions lourds collisionneurs

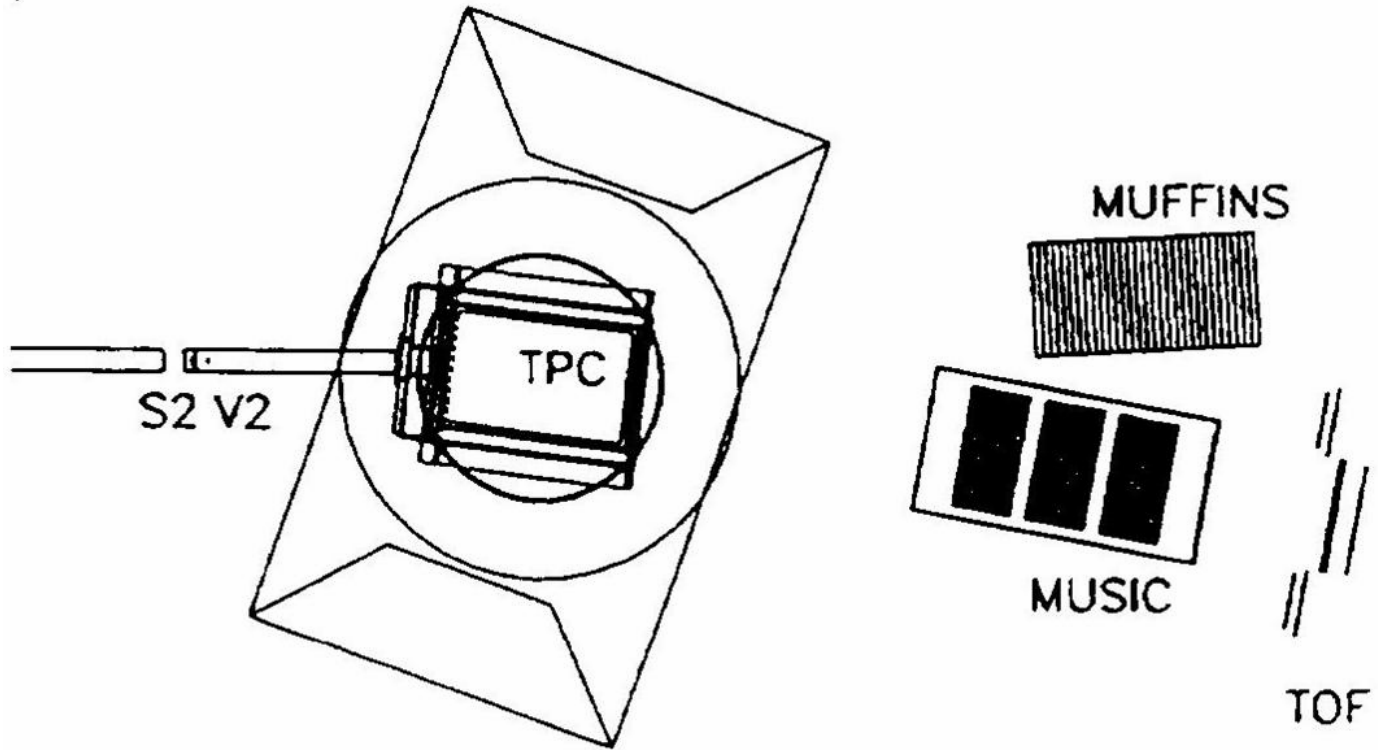
STAR à RHIC (Brookhaven-USA) (2001)

Alice au LHC CERN

Electronique:Filière LBL

EOS → NA49 → STAR

TPC EOS



TPC EOS

HISS TPC Characteristics	
Pad Plane Area	1.5m × 1.0m
Number of Pads	15360 (120 × 128)
Pad Size	12mm × 8mm
Drift Distance	75 cm
Time Sampling Freq.	10 MHz
Signal Shaping Time	250 ns
Electronic Noise	700 e
Gas Gain	3000
Gas Composition	90%Ar + 10%CH ₄
Pressure	1 Atmosphere
B Field	13 kG
E Field	120 V/cm
Drift Velocity	5cm/μs
Event Rate	10-80 events/ 1 sec spill
dE/dx range	Z = 1-8, Λ, π, p, d, t, He, Li - O
Two Track Resolution	2.5cm
Multiplicity Limit	≈ 200

TPC EOS:Electronique

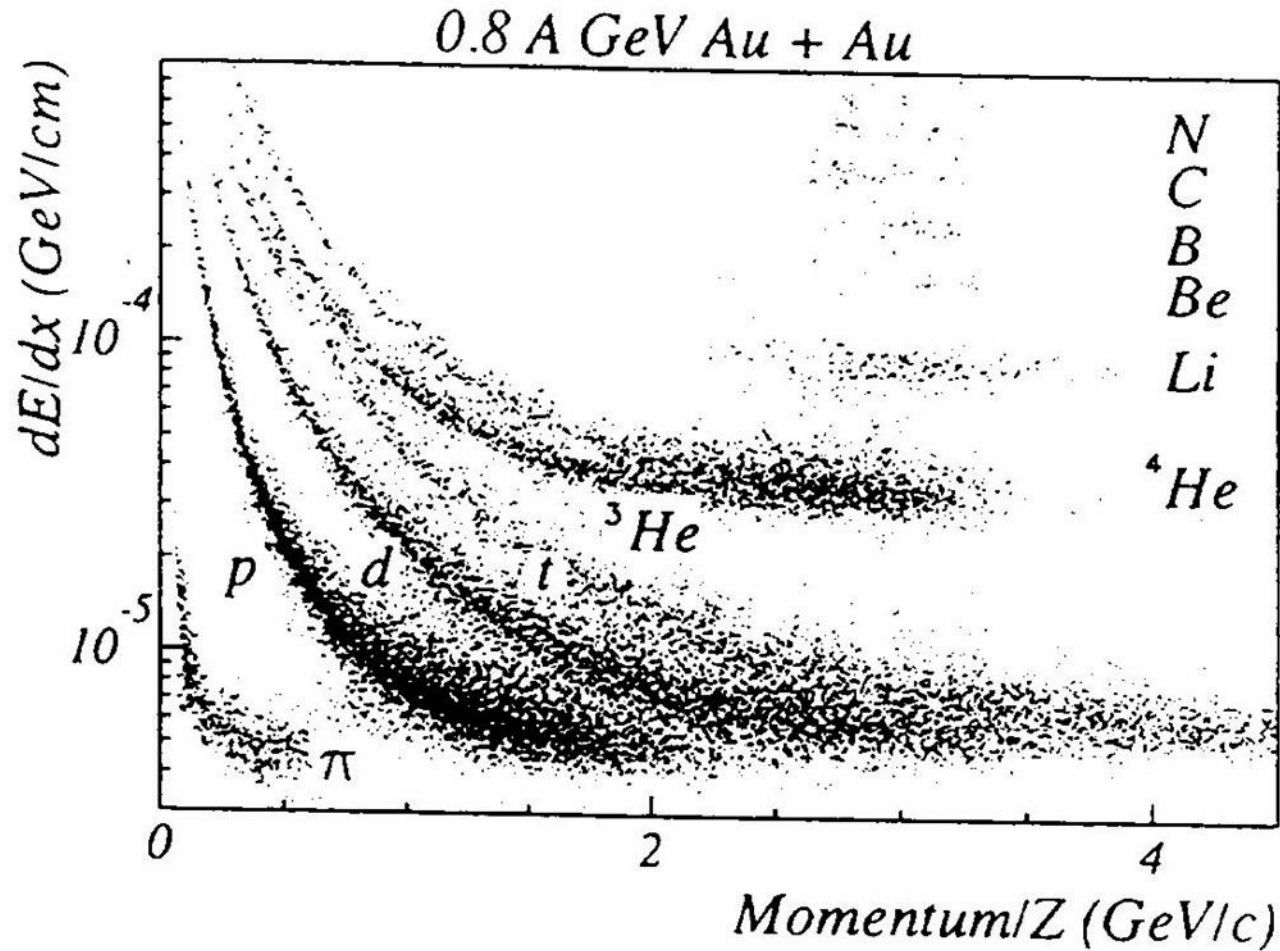
15360 pads à lire

Electronique à 700 e-

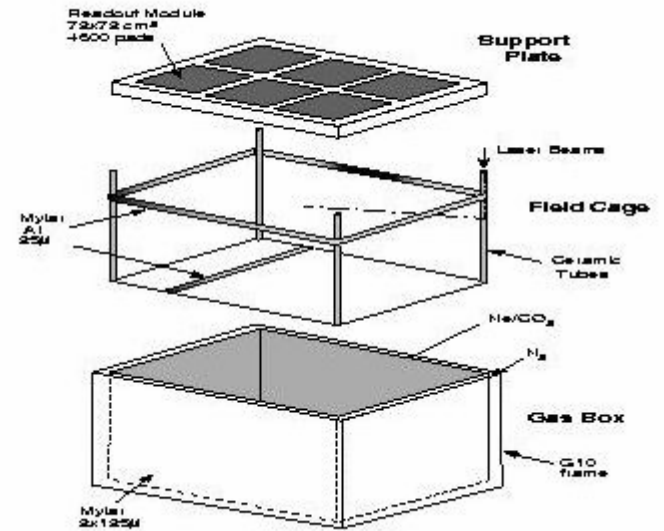
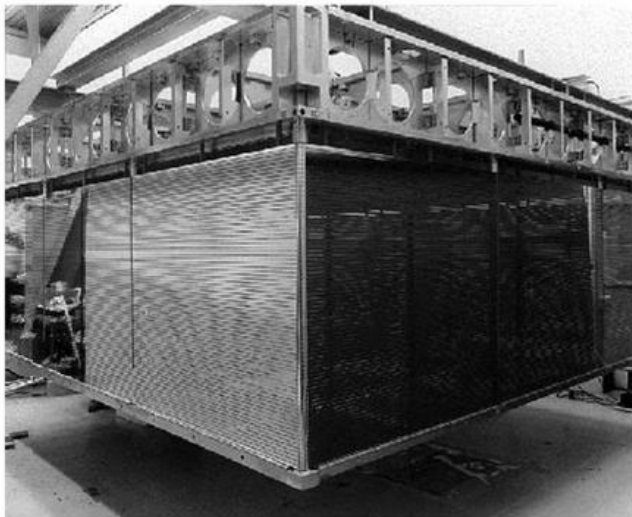
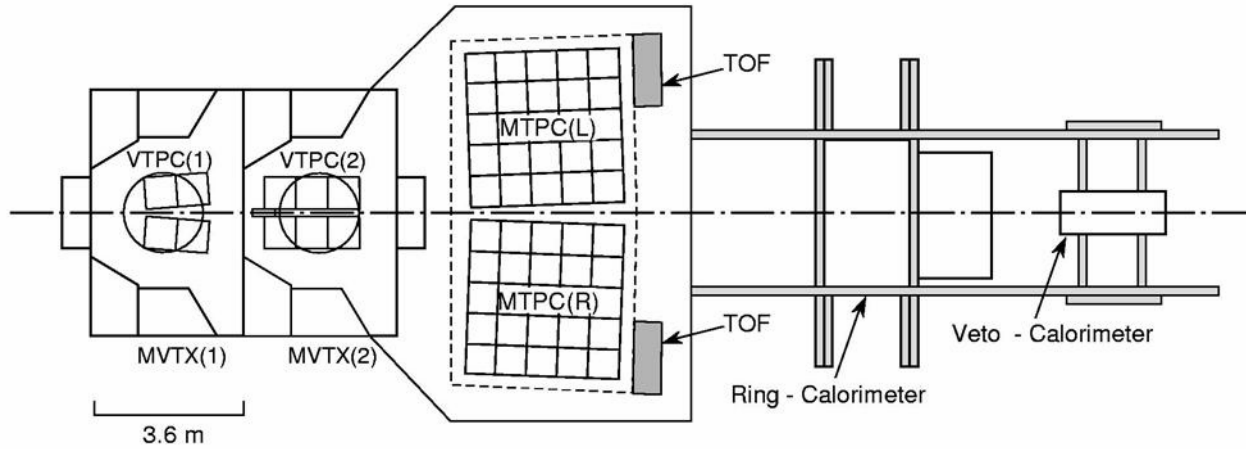
→ grande gamme dynamique, haute densité, bas prix

- 4 canaux préamp. CMOS intégré
- Ampli shaper « surface mount » techno
- 16 canaux SCA (switched capacitor array) 10 MHz input
- ADC commercial

TPC EOS: dE/dx pads



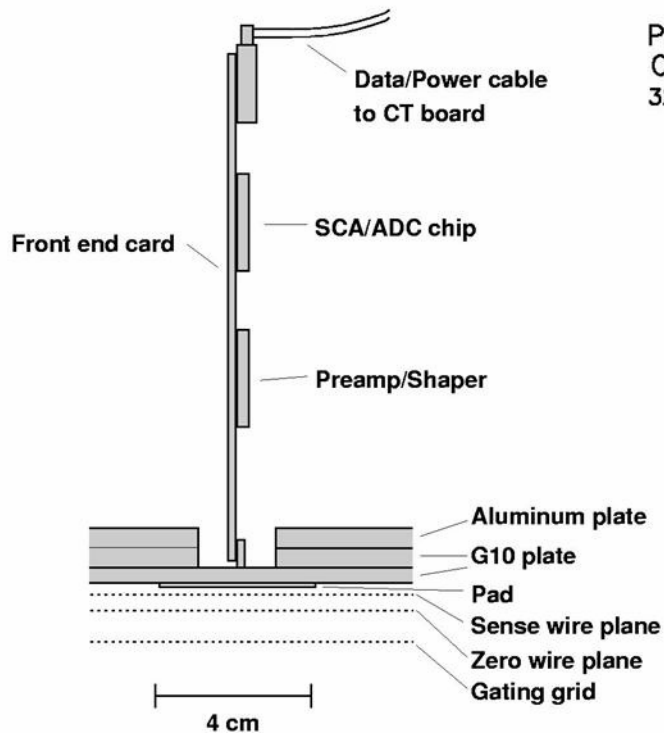
TPC NA 49



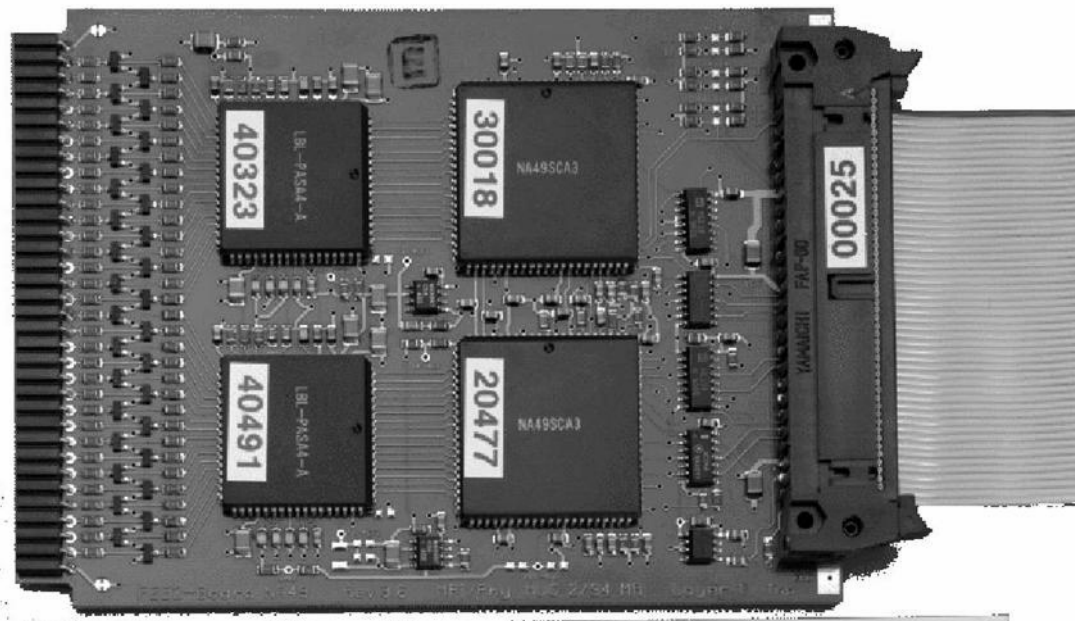
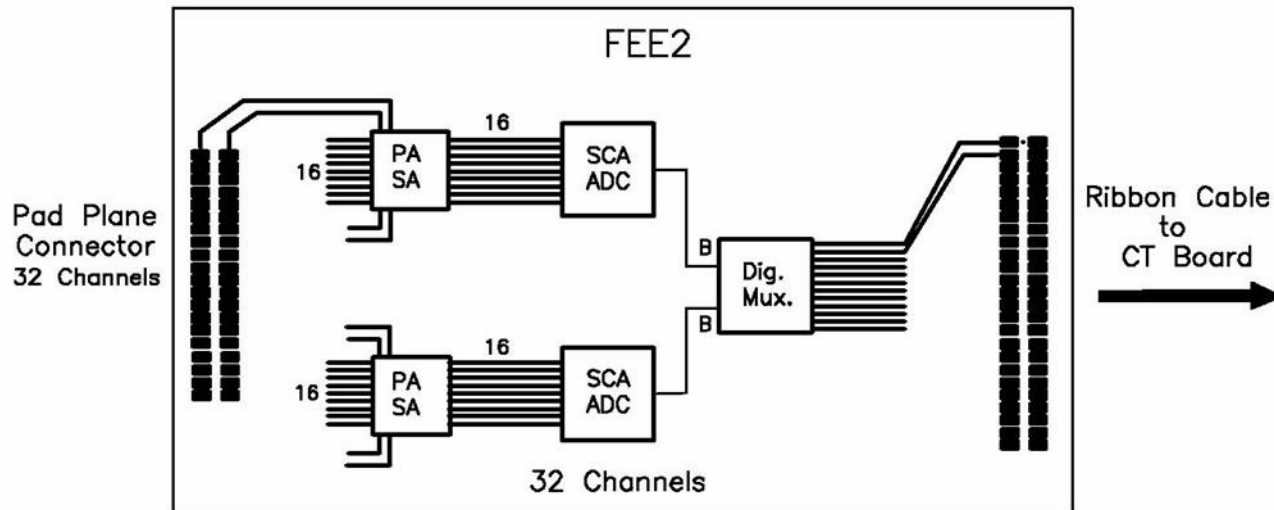
TPC NA 49:taille et nombres de canaux

TPC:	VTPCs		MTPCs	
Length:	260 cm		384 cm	
Width:	200 cm		384 cm	
Height:	72 cm		129 cm	
Drift distance:	69 cm		115 cm	
Drift voltage:	13 kV		16.5 kV	
Gas mixture:	Ne/CO ₂		Ar/CH ₄ /CO ₂	
Gas composition:	91/9		91/4.5/4.5	
	VTPC1:	VTPC2:	HR:	SR:
Sectors per TPC:	6	6	5	20
Pad-rows per sector:	24	24	18	18
Pads per pad-row:	192	192	192	128
Number of pads/sector:	4,608	4,608	3,456	2,304
Pad width:	3.0 mm	3.0 mm	3.13 mm	4.95 mm
Pad length	16 mm/28 mm	28 mm	39 mm	39 mm
Gap sense-wire/pad-plane:	3 mm	2 mm	2 mm	3 mm
Number of pads per TPC:	27,648		63,360	
Total number of pads:	182,016			

TPC NA49:Front End

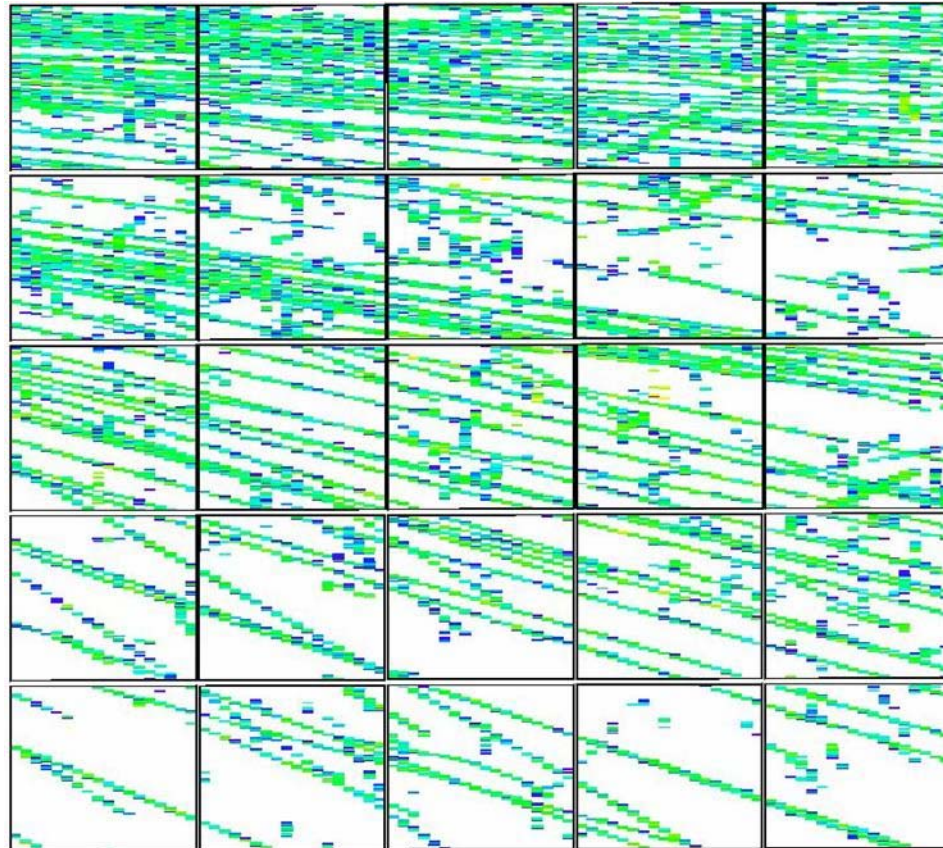


2 Watts / board



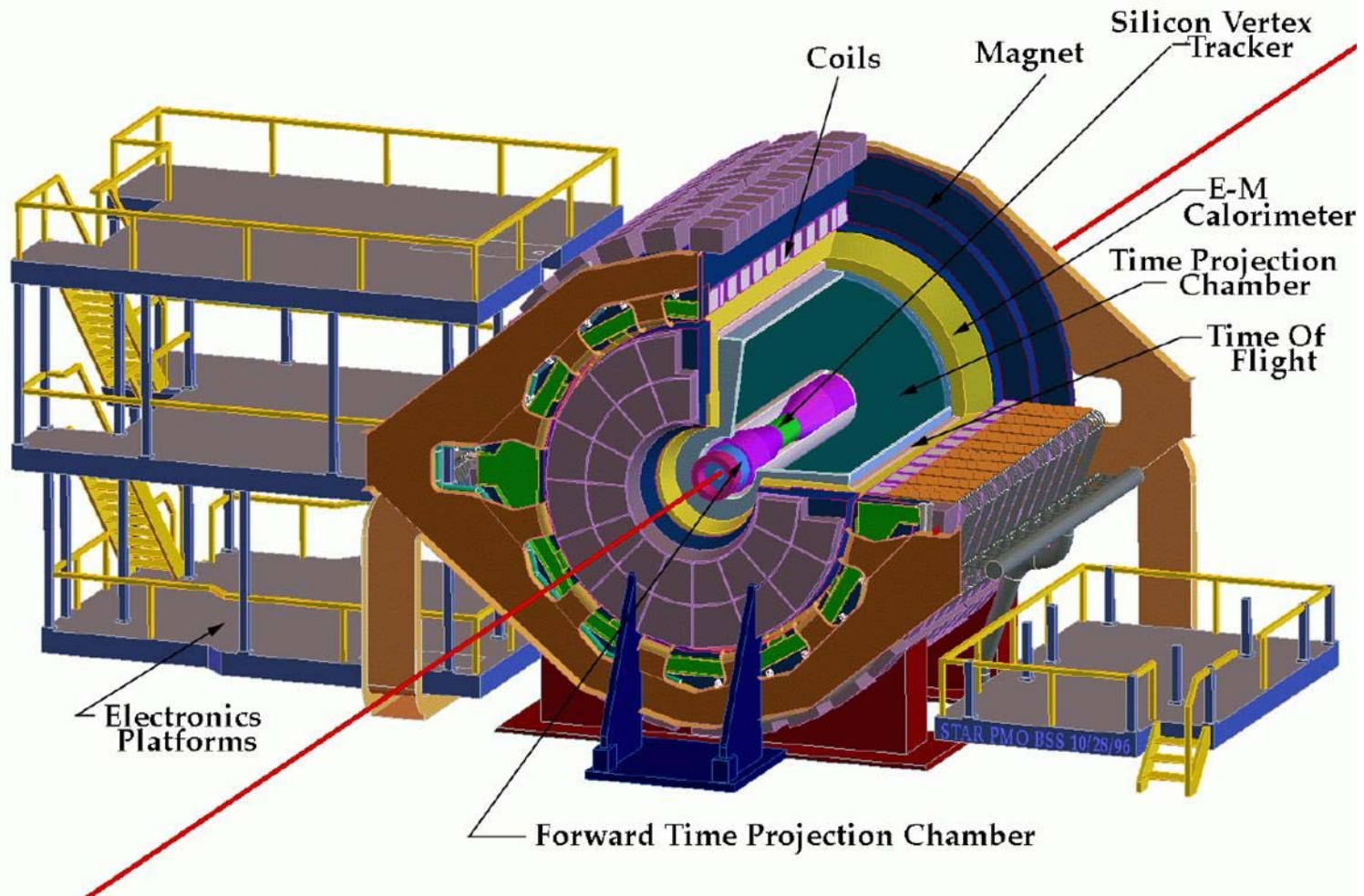
TPC NA49: Données brutes

Beam →



MTPCR

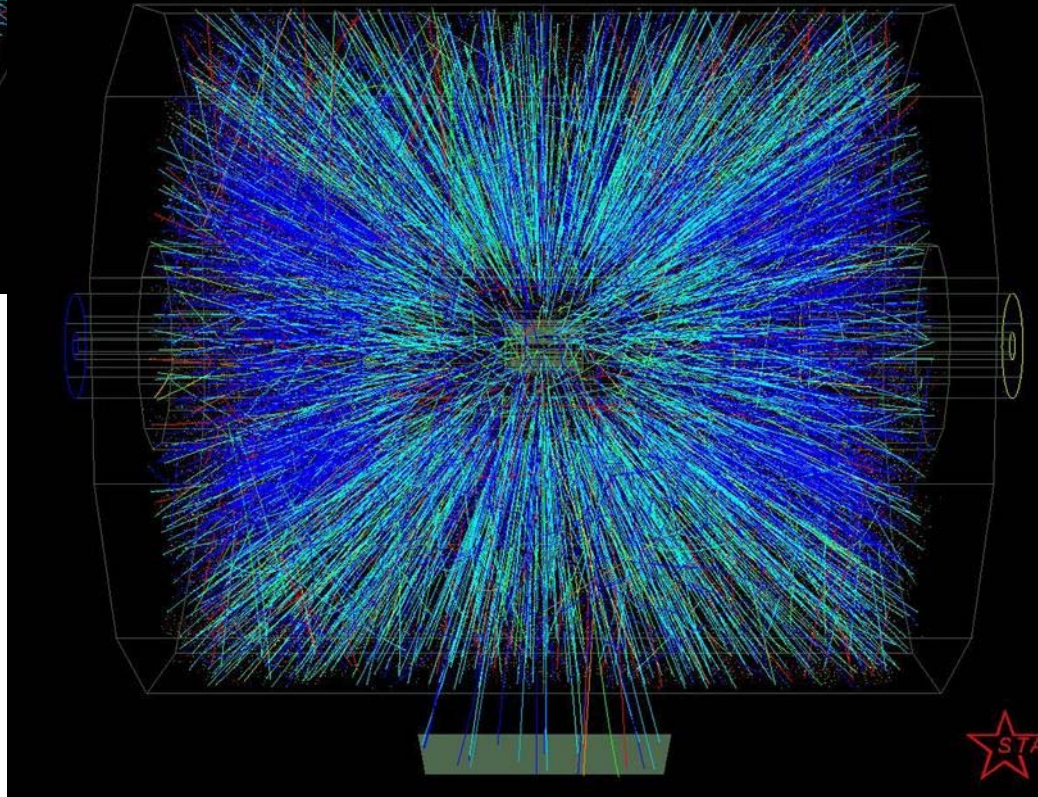
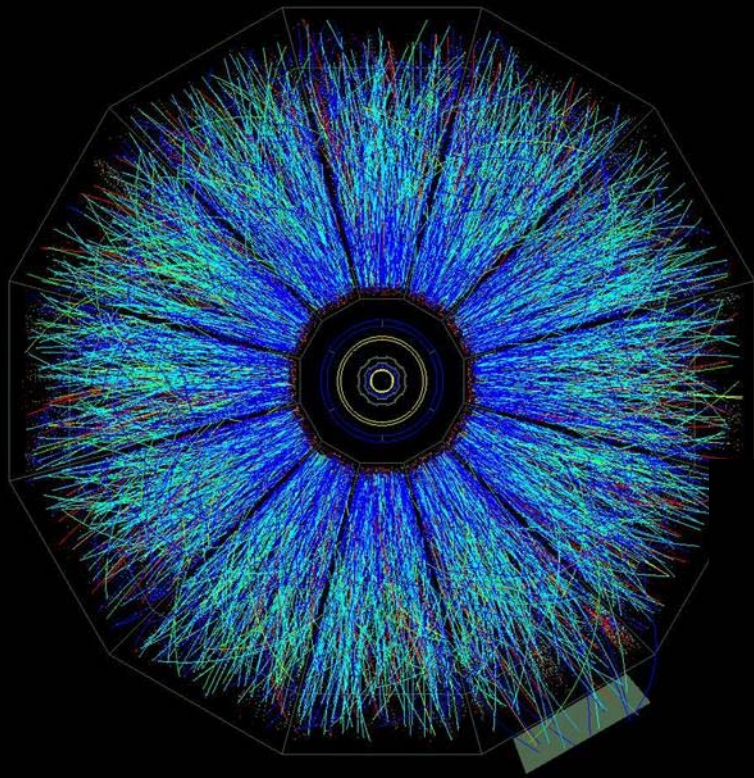
STAR Detector



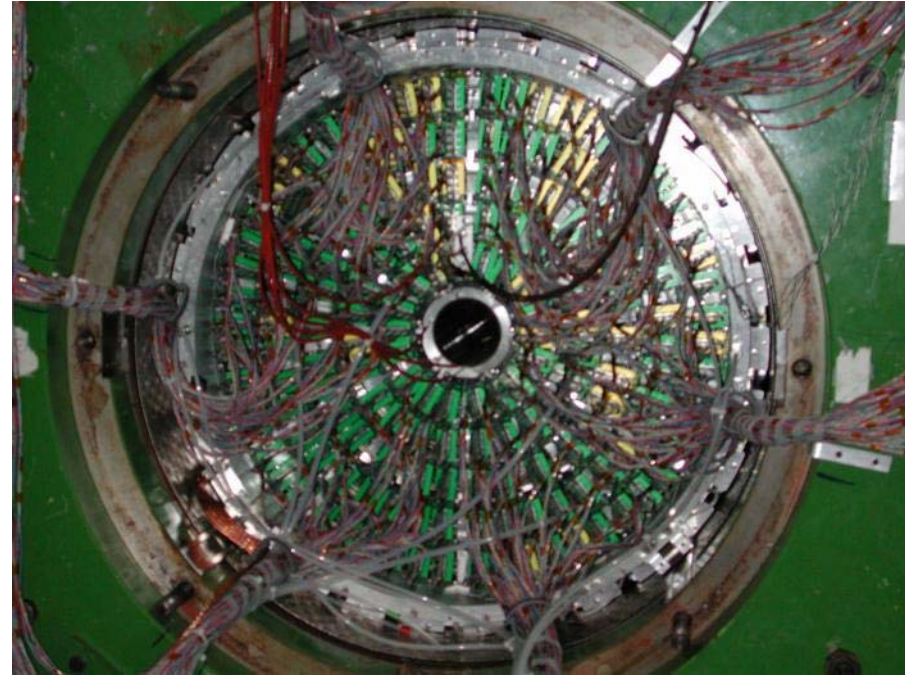
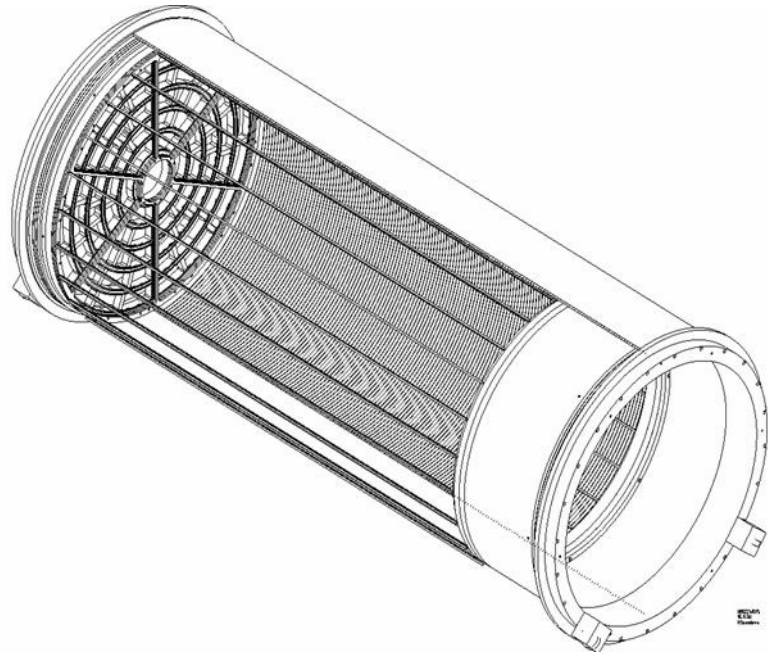
TPC STAR

- $L = 4\text{m}$, $0.5\text{m} < R < 2\text{m}$
- $B = 5\text{ kG}$
- 136 600 pads en 45 rangées /endcap
- Electronique similaire à NA49
- $S/N = 20:1$, range dynamique 10 bit, shaping 180 ns FWHM, digitization @6.3 ou 13.8 MHz

TPC STAR Golden Events



HARP



~ OK en juillet 2001

HARP:Electronique

Analog FE: preamp/shaper
CALICE3(SMB302A)Alcatel

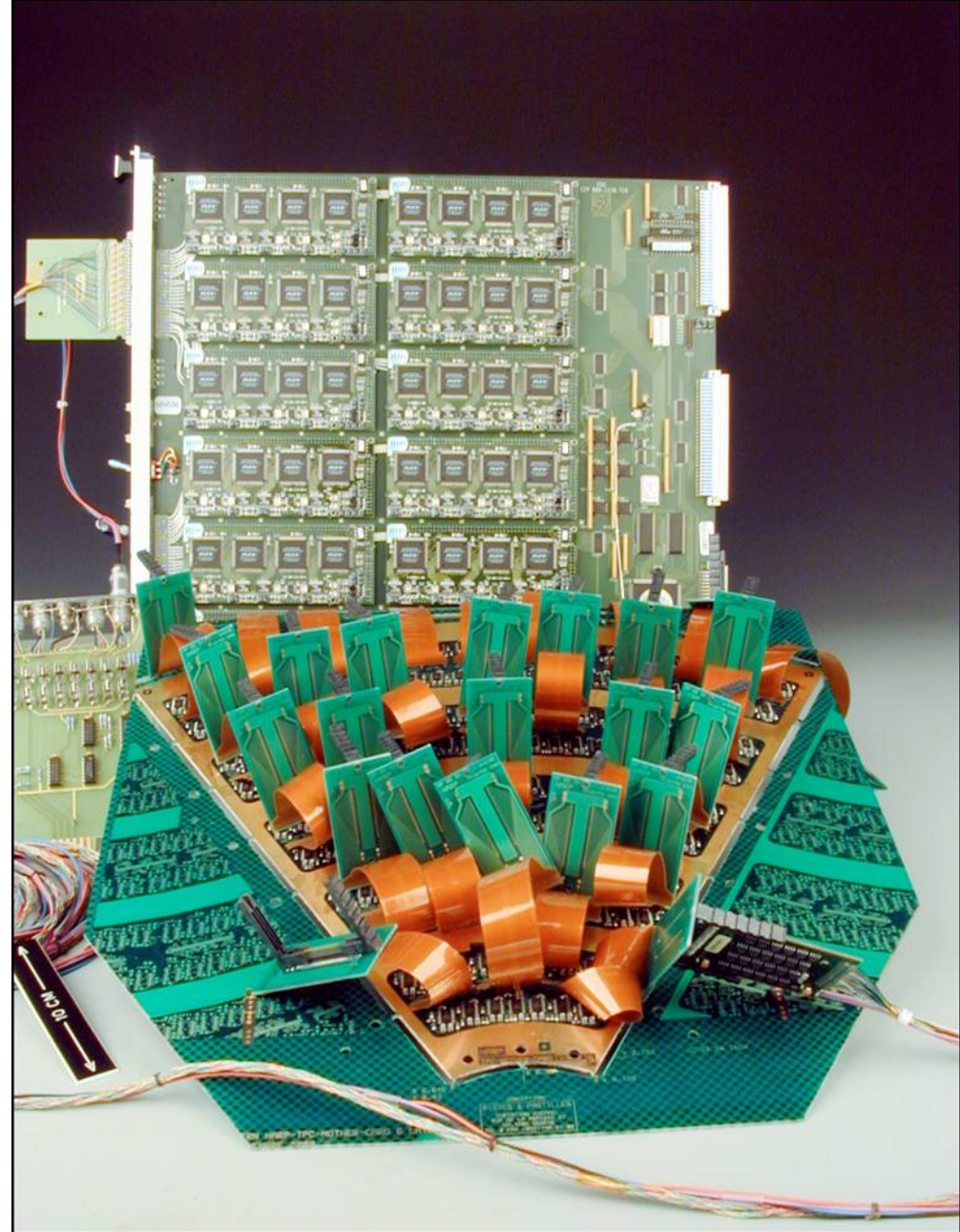
Low impedance current preamplifier /
shaper / baseline restorer.

Four channel per die.

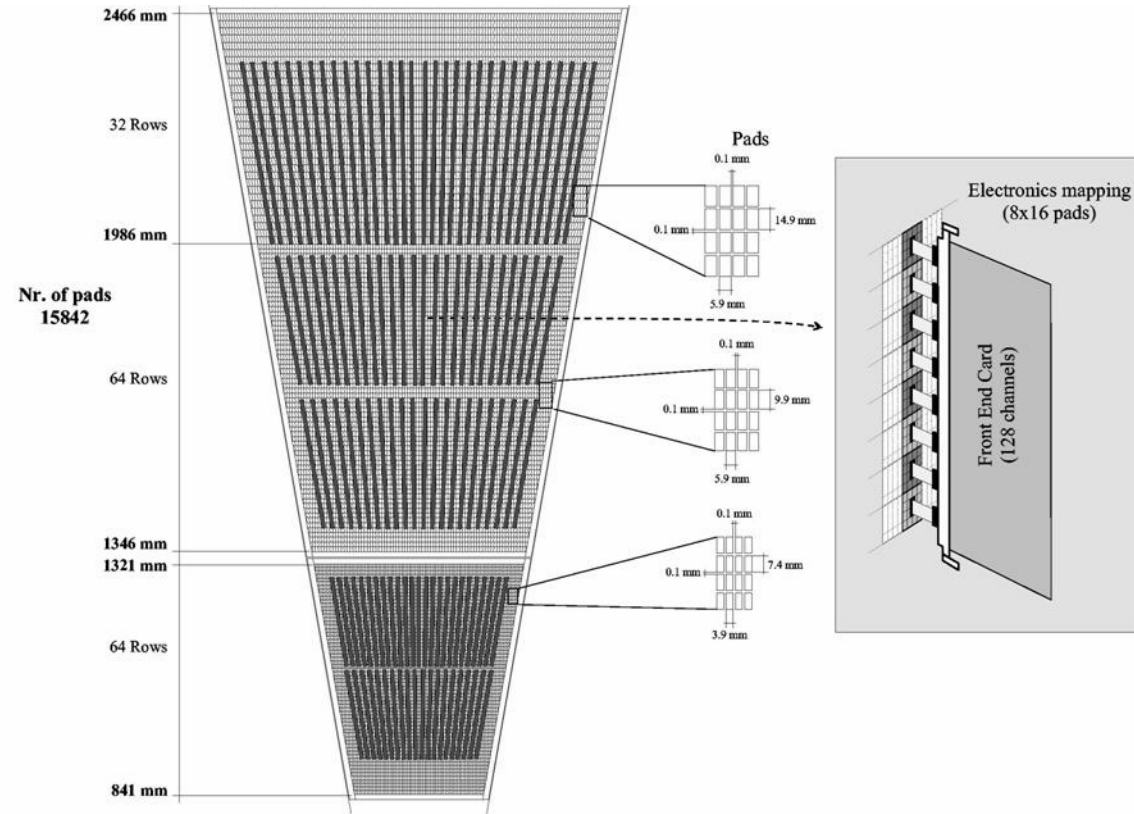
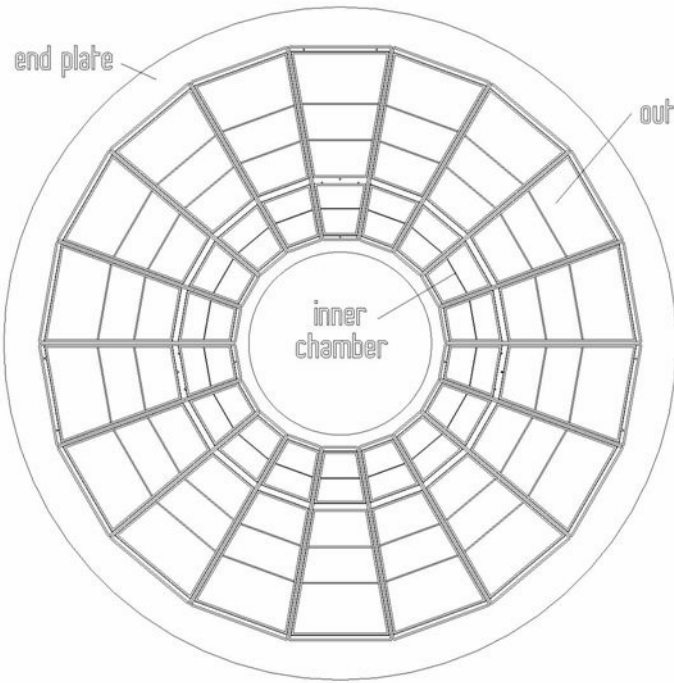
Design in a fast complementary bipolar
process form INTERSIL

Digital: CERES (modifie) FEDC

ALTRO



TPC ALICE



TPC ALICE

Table 5.1: Front-end electronics requirements.

Parameter	Value
Number of channels	570 132
Signal-to-noise ratio (MIP)	30 : 1
Dynamic range	900 : 1
Noise (ENC)	1000 e
Conversion gain	12 mV/fC
Crosstalk	< 0.3%
Shaping time	about 200 ns
Sampling rate	5.66(-7.69) MHz
Tail correction after 1 μ s	0.1%
Bandwidth to DAQ/Level-3	8.4 GByte/s
Maximum dead time	10%
Power consumption	< 100 mW/channel

Futur pour les TPC ?

- NLC ??
- Autres Machines ?
- Ions lourds → OK
- Associer longue dérive + nouvelles techno ?
 - Silicium Micro-strips
 - Autres ?

Détecteurs de traces gazeux

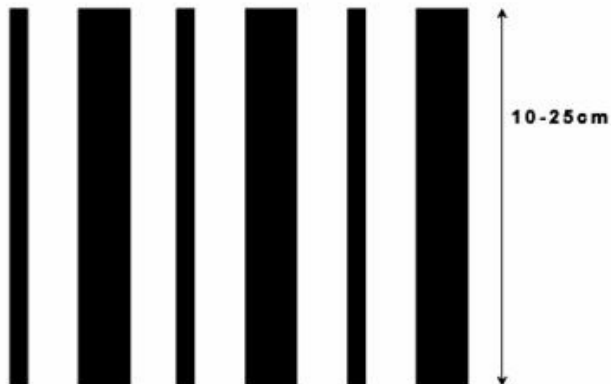
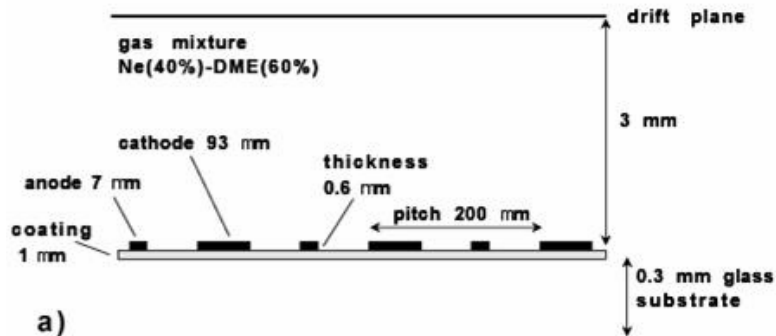
- Détecteurs pour hauts flux
 - MSGC
 - GEM
 - Micromegas
- Détecteurs muons LHC
 - CMS: DT, RPC, CSC
 - Atlas: TGC
 - LHCb: MWPC, GEM

MSGC

- Début des années 90
- Comment faire des détecteurs de trace supportant les très hauts flux? Tracker LHC
- Grande segmentation, petites chambres, petites cellules (200 μm), collection de charge rapide
- Silicium trop cher (et trop petit)
- Chambres classique \rightarrow 1 mm de pas de fil mini. Précision & tolérances mécanique
- Adapter des techniques de micro électronique pour un compteur à gaz sur un substrat moins cher...
- \rightarrow MSGC sur substrat de verre (spécial) avec amplification gazeuse

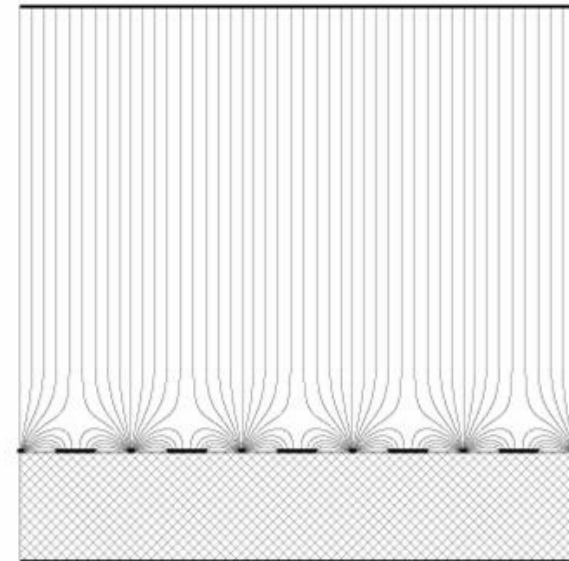
MSGC

Principe



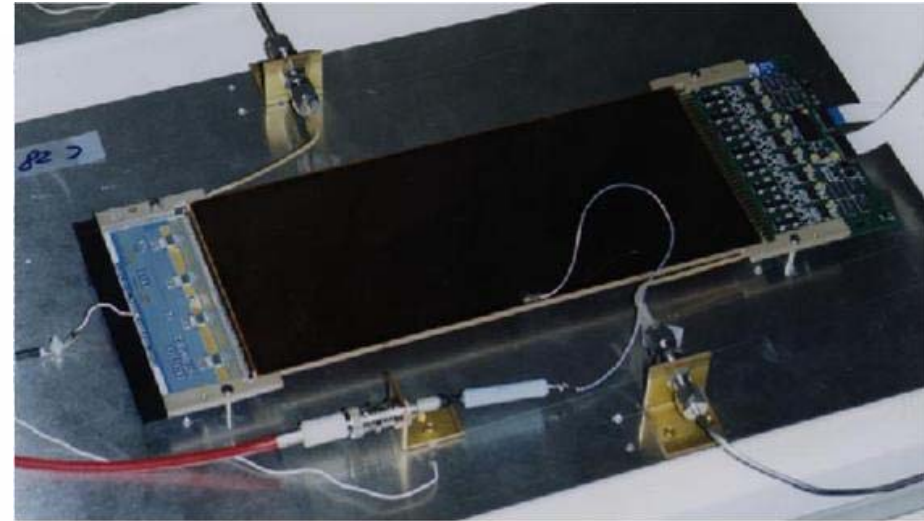
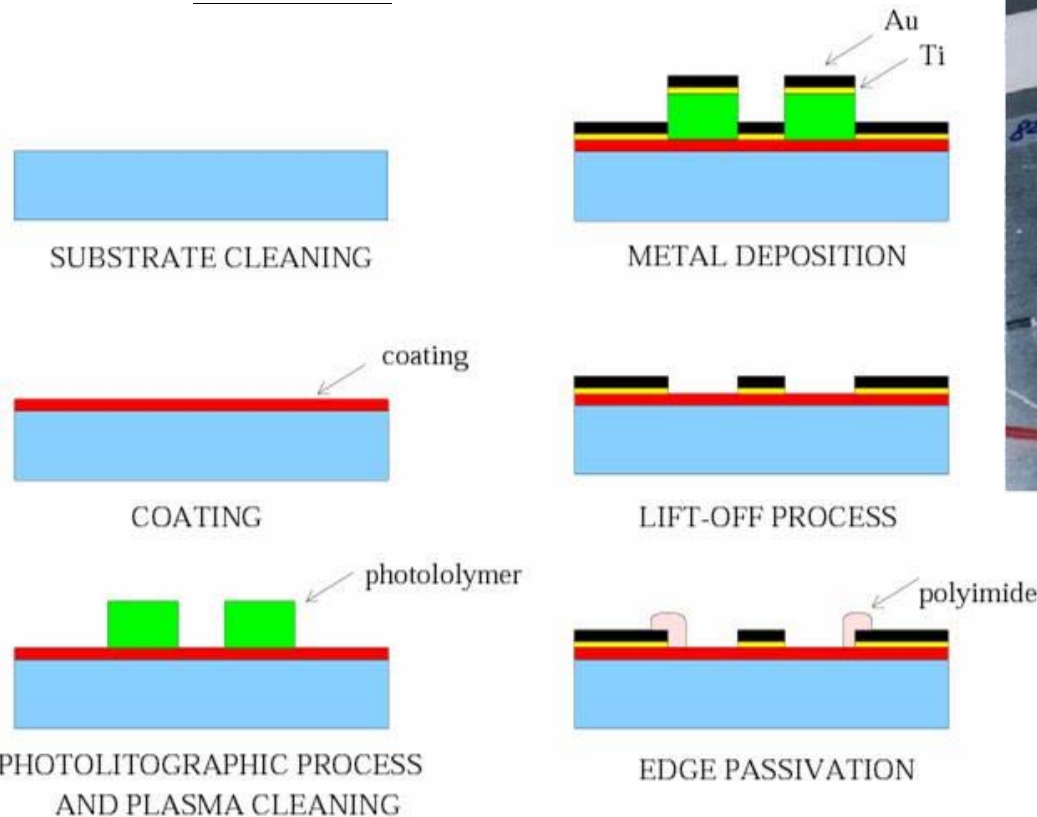
R. Bellazzini

Champ électrique

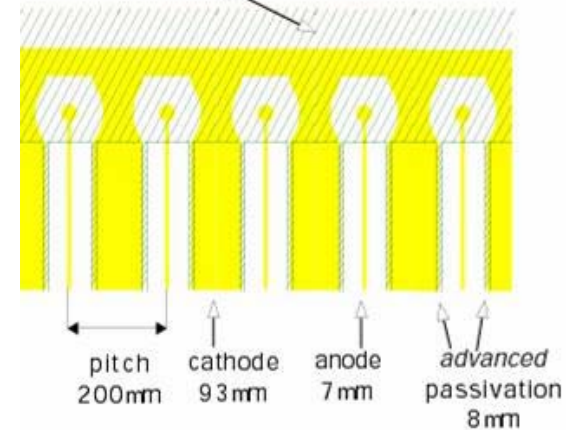


MSGC technique de fabrication

Lift off



standard polyimide passivation bar over the MSGC edge



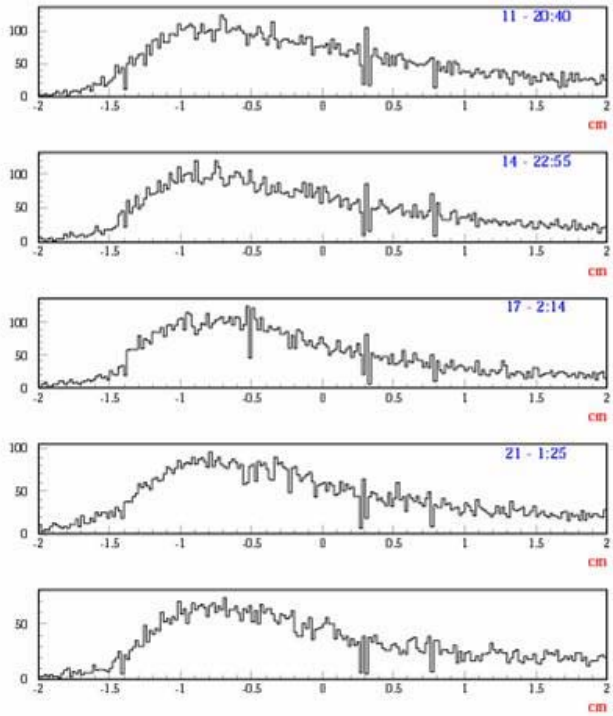
Passivation

MSGC

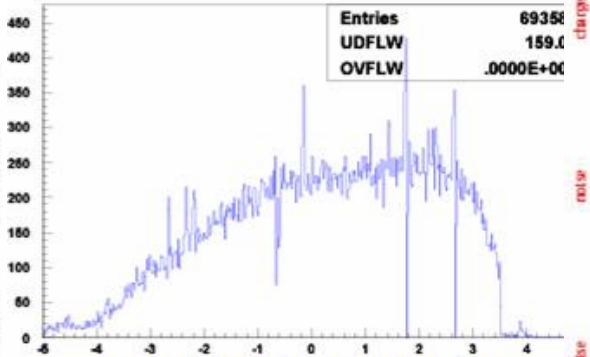
Etudes & tests extrêmement poussés sur

- Type de substrat (verres spéciaux)
 - Matériaux rad hard
 - Gaz
 - Vieillissement
 - Faisceaux intenses
- ➔ ~ OK

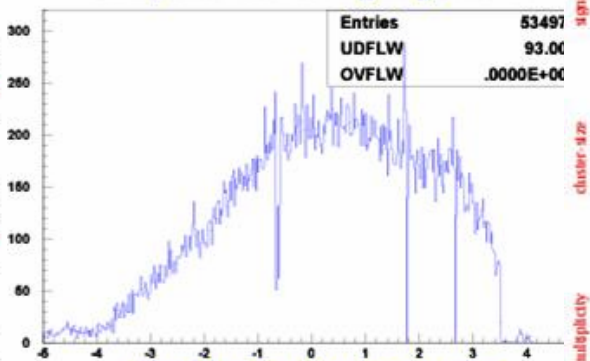
Mais finalement solution abandonnée...



PSI test beam

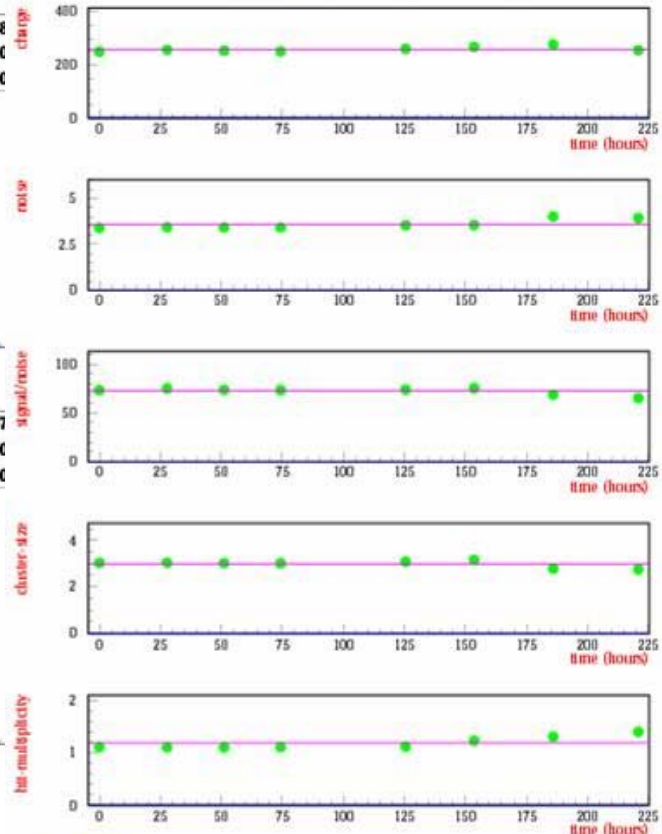


Beam profile in det. P10 - Beginning of the run



Beam profile in det. P10 - End of the run

Stability for chamber Pisa 1



11/4 - 20:40

21/4 - 1:40

MSGC

