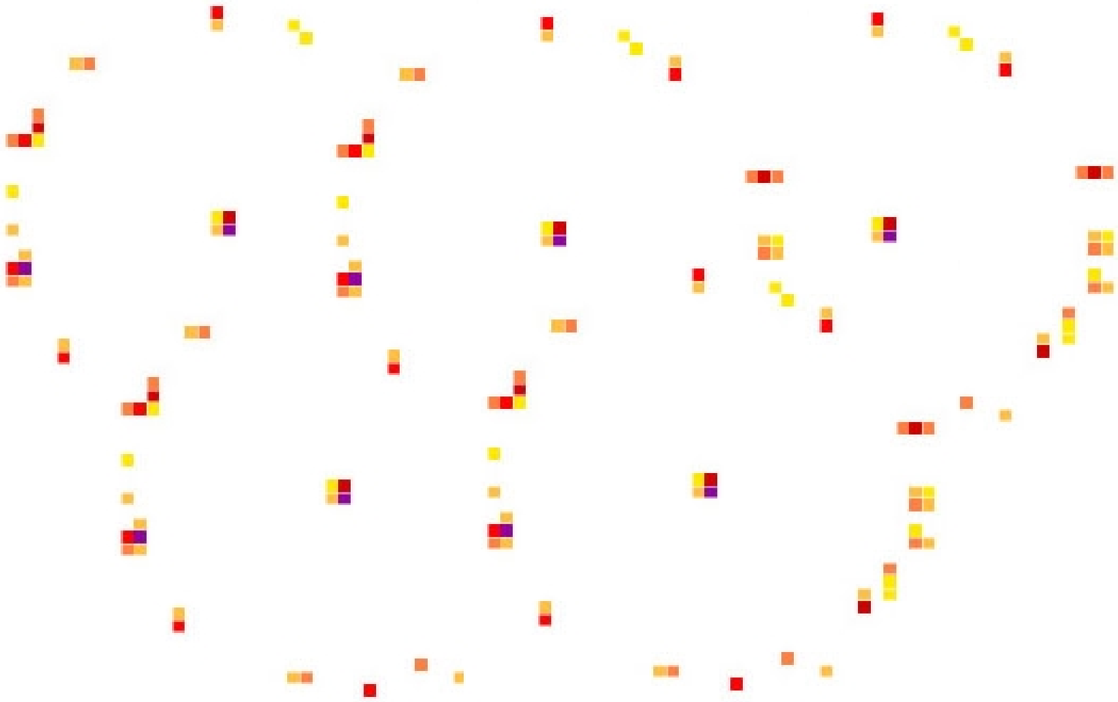
RING IMAGING CHERENKOV SYSTEMS BASED ON GASEOUS PHOTO-DETECTOR TRENDS AND LIMITS

F. PIUZ
CERN
Geneva, Switzerland



ATHENS 2004

A MEMORY…1977

CERN/EP/PHYS 76-60
J. Seguinot, T. Ypsilantis
NIM 142, 1977, 377

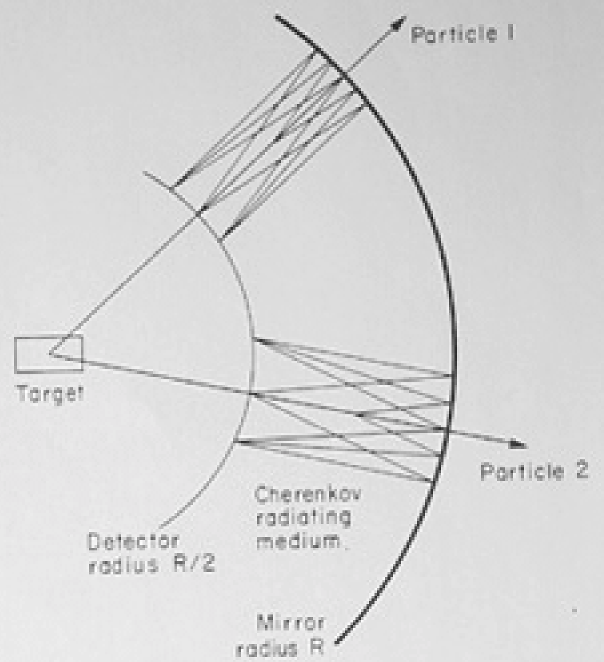


FIG. I

QUITE EFFICIENT FOR CRID AND DELPHI…
BUT A BIT TOO SLOW FOR
SOME OTHER USERS….

E. Barrelet et al
NIM 200, 1982, 219

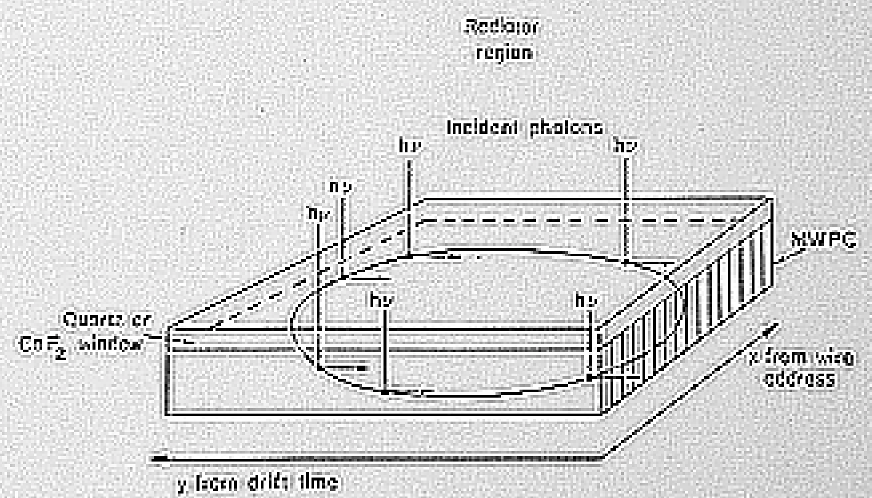


Fig. 2

The Fast RICH, "proximity focusing", layout

**IT HAS THE POTENTIAL TO SATISFY
MORE AMBITIOUS APPLICATIONS REQUESTING:**

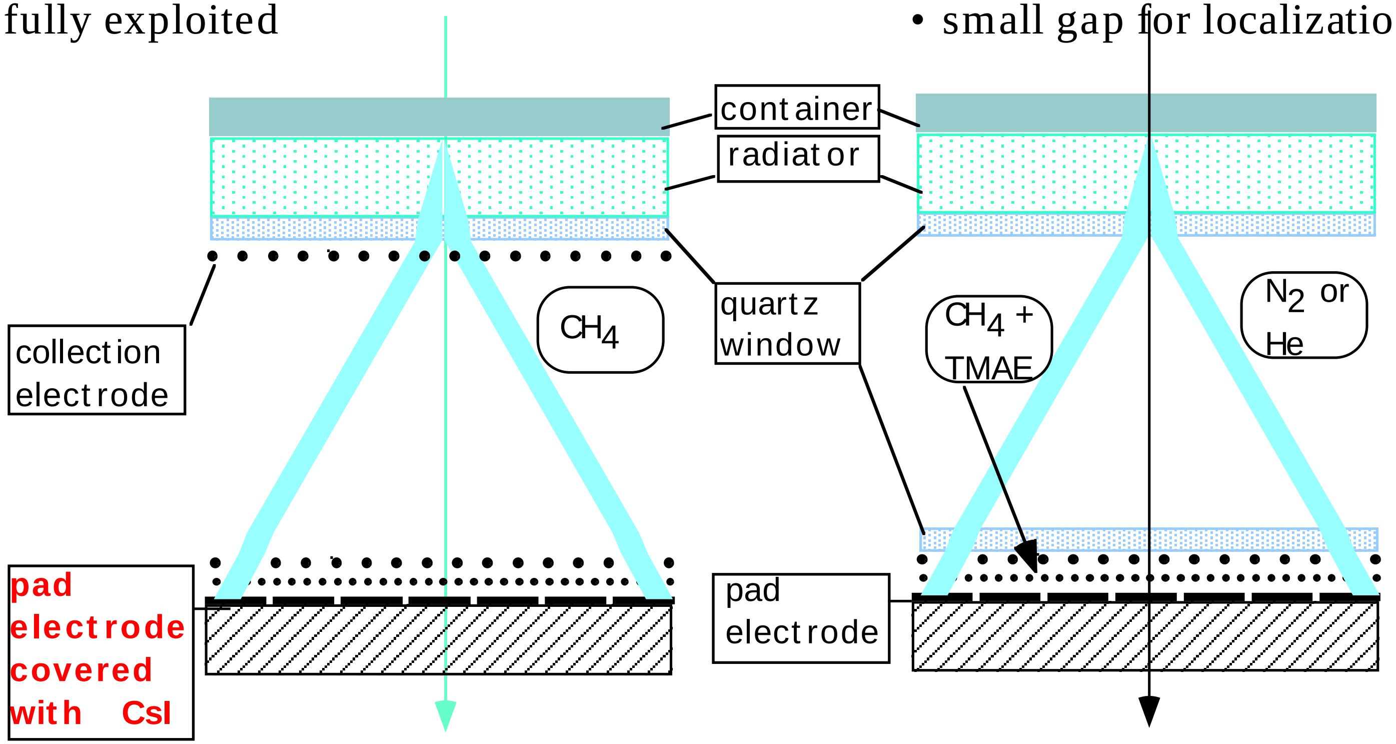
- **HIGHER RATES**
- **HIGHER MULTIPLICITIES** ==> **(LHC)**

SOLID PHOTOCATHODE

- CsI, CsBr,
- 2D photon feedback
- one containing window
- QE fully exploited

GASEOUS PHOTO CONVERTER

- TMAE, TEA
- 3D photon feedback
- 2 containing windows
- small gap for localization



SINCE 1998 EIN-GEDI

SEVERAL SYSTEMS HAVE BEEN BUILT AND ARE OPERATIONNAL

REVIEWING THEM TO COMPARE

- **MAIN COMPONENTS AND SOLUTIONS TO CRITICAL POINTS**
- **MAIN PRESENT PERFORMANCE**

QUESTIONS, PROBLEMS, LIMITS for next applications

detailed dedicated talks in this session

CLEO III	**Sh. Stone**
ALICE	**G. De Cataldo**
STAR-RICH	**G. Kunde**
HADES	**R. Gernhauser**
COMPASS	**A. Bressan**
J-LAB	**F. Garibaldi**

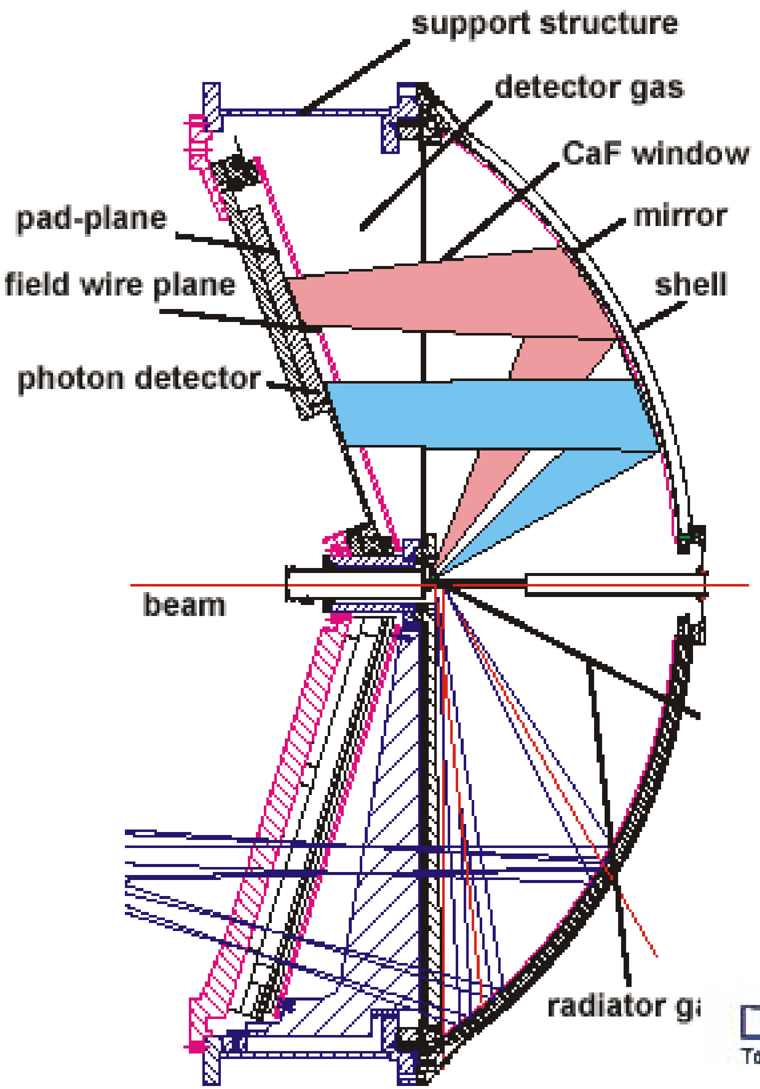
+ talks in sessions 7 and 8

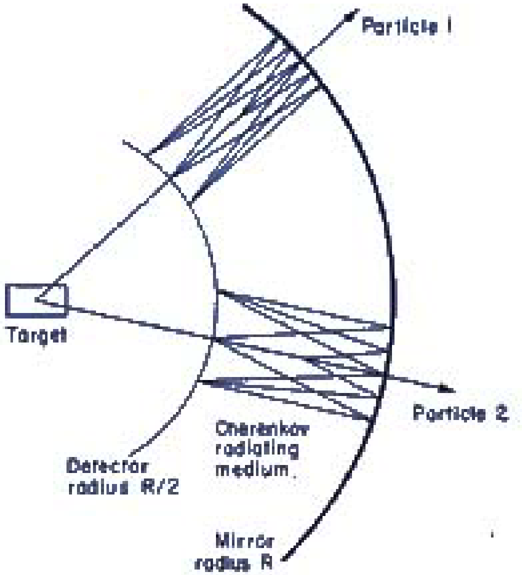
2d-GENERATION: "PIXELIZED" RICH SYSTEMS AT HEP EXPERIMENTS

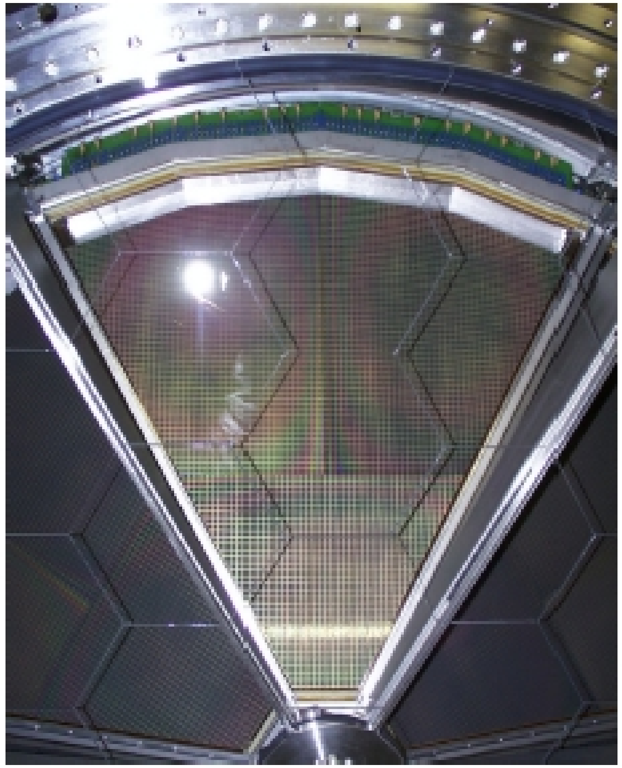
	PHOTO DETECTOR		RADIATOR		PARTICLE IDENTIFICATION				
Experiment	Photo converter	PC size[mm2] # of PCs total area	Medium	Thickness	Event	P.I.D	Momentum range [GeV/c]	Multiplicity Rate[s-1]	Status
CERES SPS	TMAE 40°C		CH4	0.9/1.8m	up to Au on target	e+/e-			ended
TIC NA44 SPS	TMAE 40°C		Isobutan gas	1 m	up to Pb on targets	π/K/p (+ToF)	3-8	up to 1 10E05 on target	ended
CLEO III CESR	TEA 15°C		LiF solid	12 mm	e+/e- coll.	π/K	2-3		running
TIC NA44 SPS	CsI	780 x 190 2 0.3 m2	Isobutan gas	1 m	up to Pb on targets	π/K/p (+ToF)	3-8	up to 1 10E05 on target	ended
HADES GSI	CsI	0.25 m2 6 1.5 m2	C4F10, gas	0.4 to 0.7m	π,p to U-Pb on target	e+/e-		10E03, trig 10E05, total	running
STAR-RICH RHIC	CsI	640 x 407 4 1 m2	C6F14 liq	10 mm	from pp- to Au-Au	π/K/p	1-3 π/K 2-5 p/p-	10/m2 10E03 centr 10E04 mibias	ended
COMPASS SPS	CsI	576 x 576 16 5.3 m2	C4F10, gas	3 m	pol.μ on pol. H2/D2 targ. + H-beam	π/K/p	up to 60	10E04 μ 10E05 hadr	running
HALL-1 J-LAB	CsI	640 X 407 3 0.7 m2	C6F14 liq	15 mm	FT	π/K	< 4	1-2/m2 up to 1 10E05	running
ALICE HMPID LHC-ION	CsI	640 X 407 42 11 m2	C6F14 liq	15 mm	from pp- to Pb-Pb	π/K/p	1-3 π/K 2-5 p/p-	50/m2 10E03 centr 10E04 mibias	prepar
PHENIX RHIC	CsI				from pp- to Au-Au	e+/e-			prepar

HADES RICH@ GSI

talk, this session
R. Gernhauser





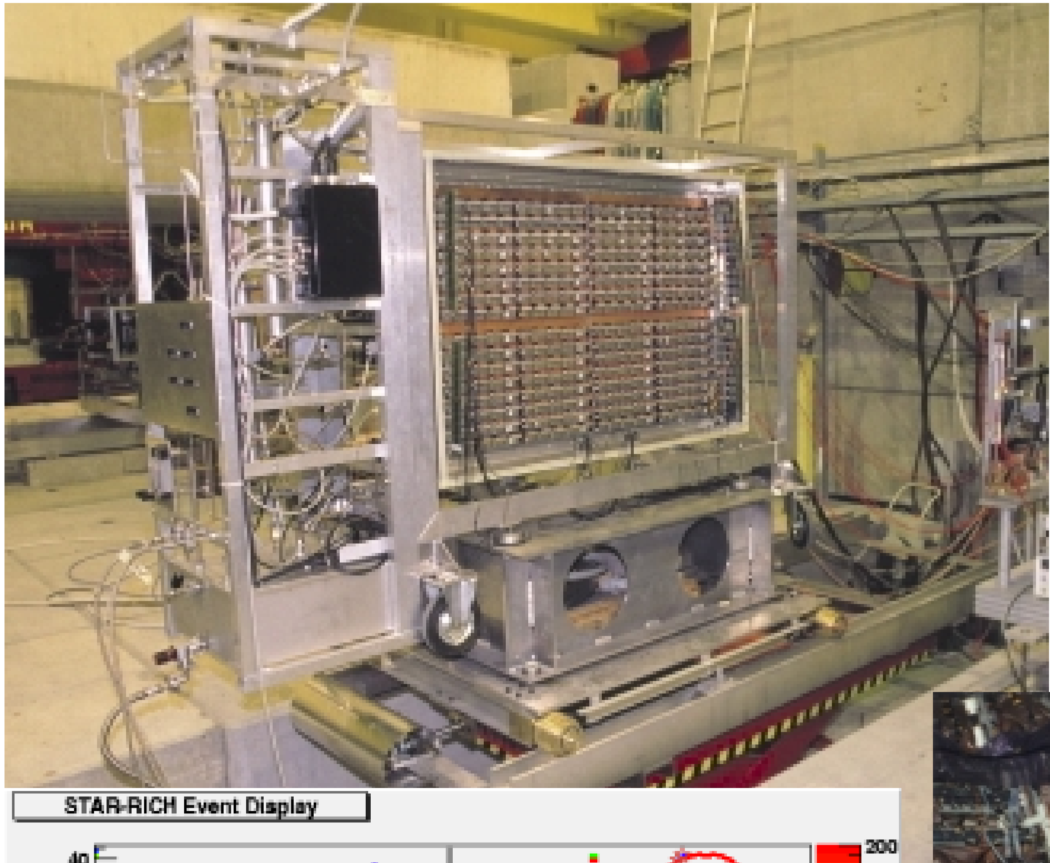


http://hades.ph.tum.de/rich

K. Zeitelhack et al NIM A433,1999,201

ALICE-HMPID

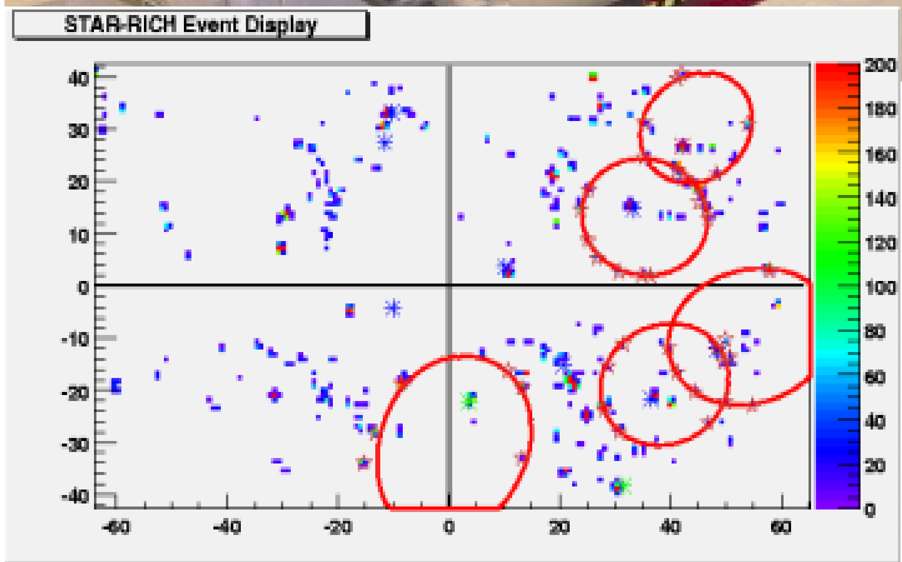
• “PROTO-2” AT SPS (1997)

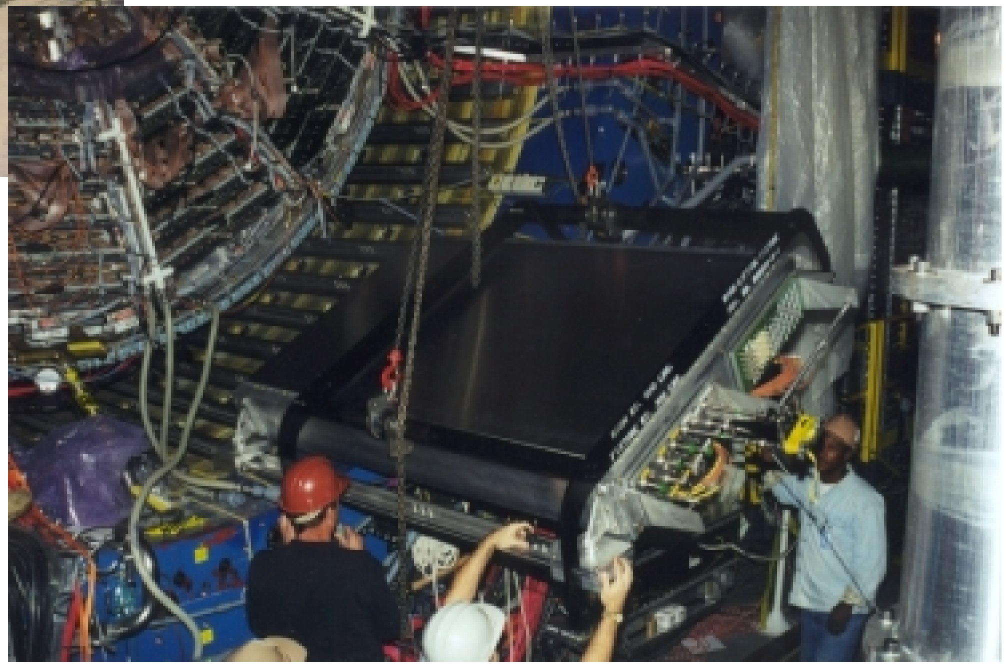


ALICE PROTO-2 INSTALLED IN THE STAR EXPERIMENT IN 1999

160 X 84 cm2 sensitive area

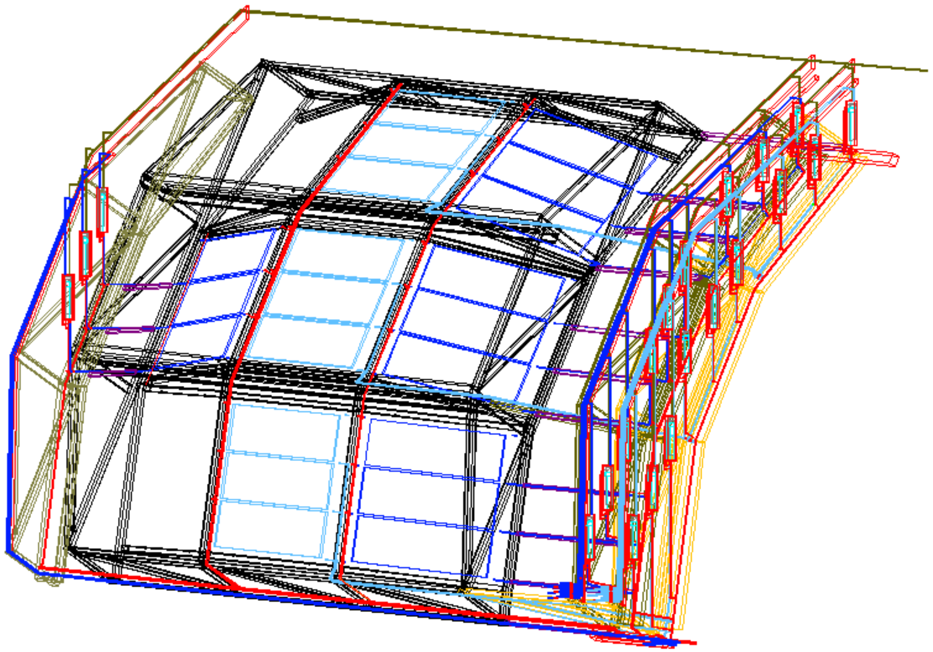
talk, this session
G.J. Kunde

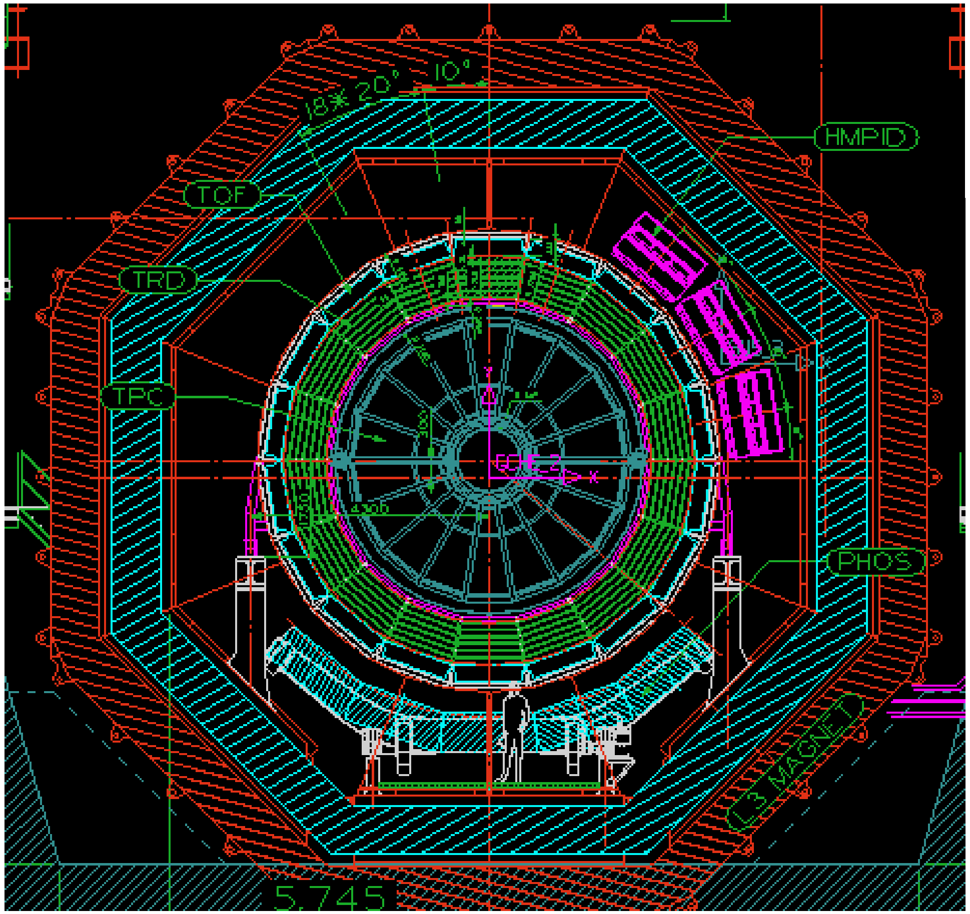




ALICE / HMPID @ LHC-ION

installation 2005-end
start 2006-7 ????

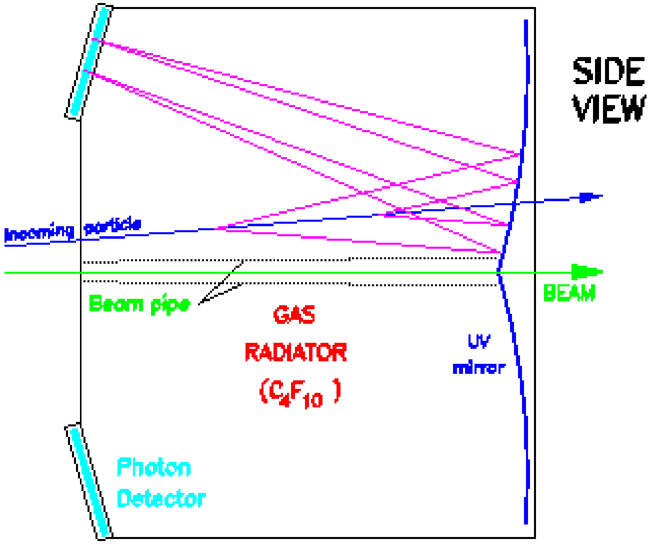


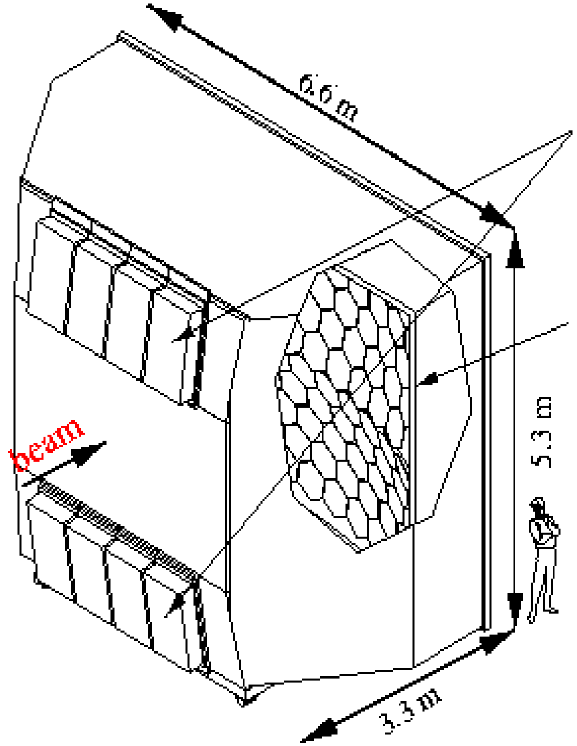


distance vertex-module = 4.9 m

talk, this session G. De Cataldo
Session 9, N. Di Bari

COMPASS @ CERN/SPS
RICH-1

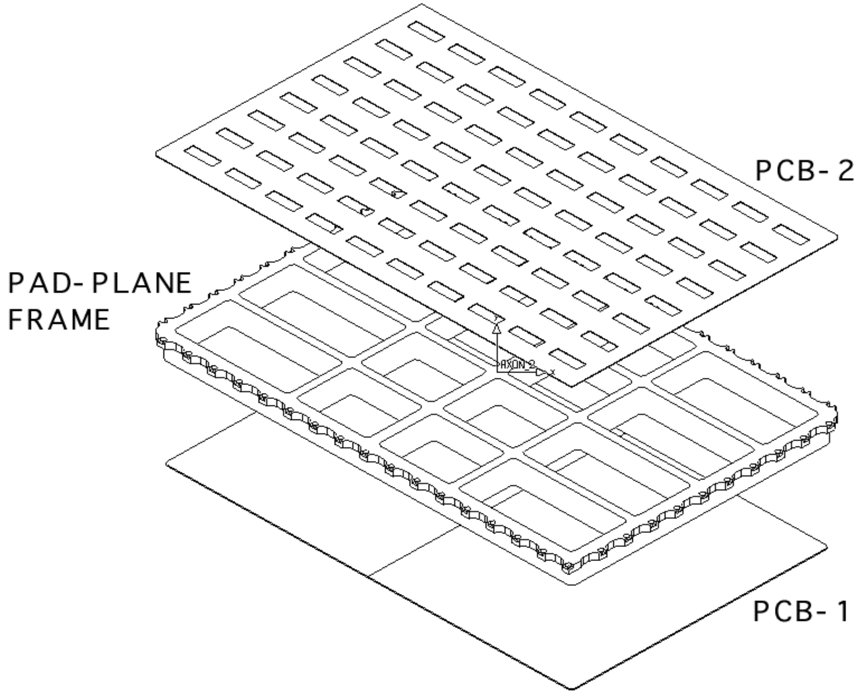


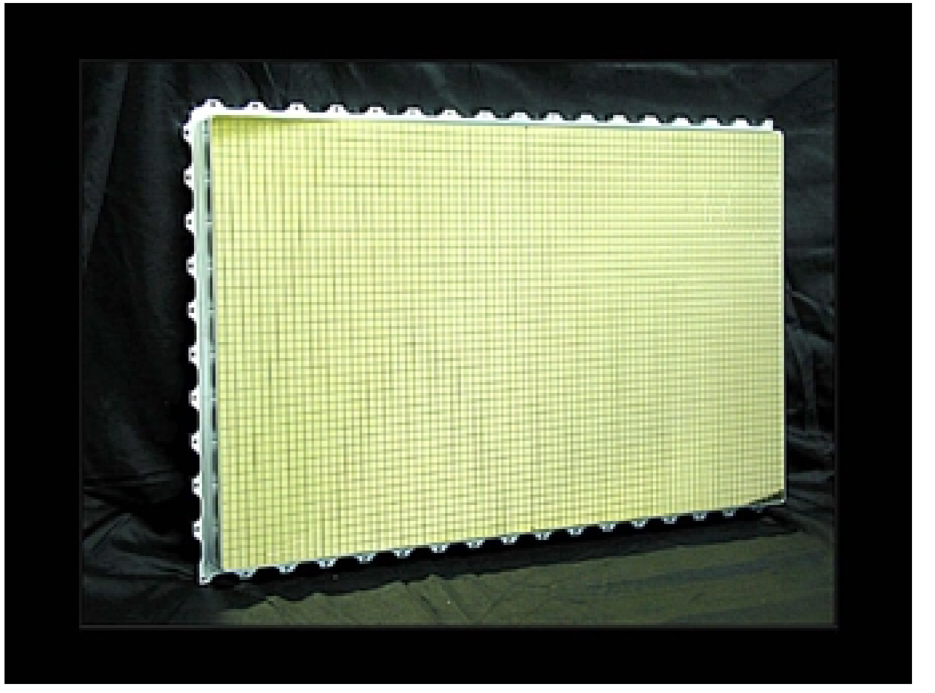


http://wwwcompass.cern.ch

S. Dalla Torre et al
NIM A461,2001,549

talk, this session A. Bressan
Session 7 S. Costa
Session 8 ML Crespo





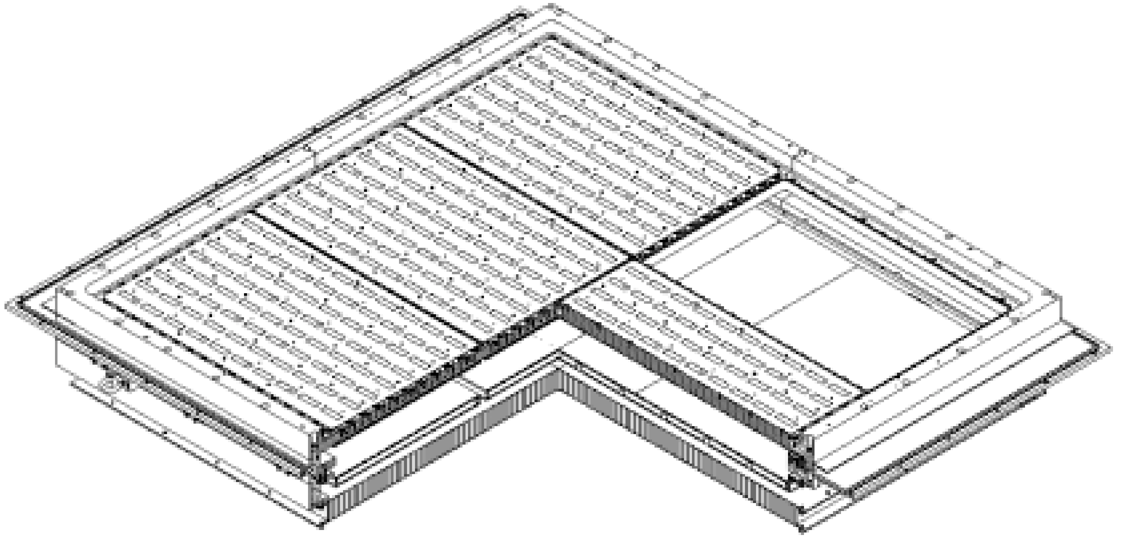


PHOTO-DETECTORS - TECHNICAL

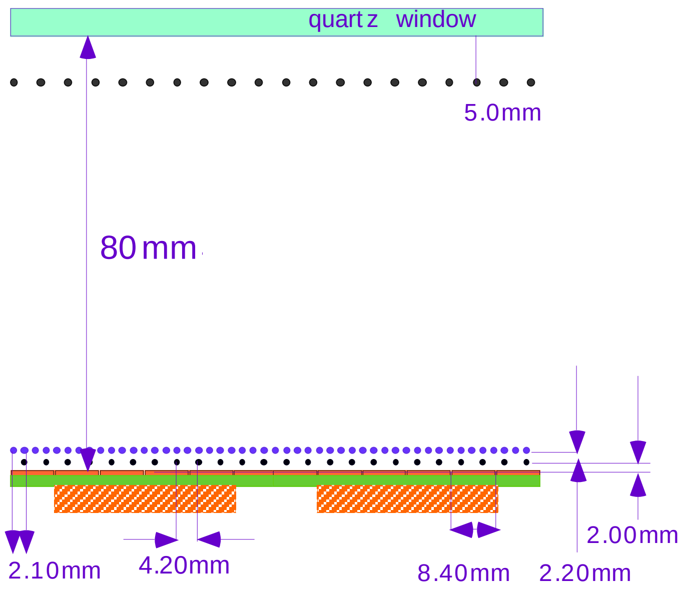
- **PAD PLANES AND PCBs**

planareity, surface state, cleaning
==>(A. Braem's talk Session 6)

- **CsI-PC MOUNTING**

no exposure to air during the tranfer from evaporation plant to the detector ("glove box")

PROTO-2 and ALICE / HMPID
StarRich F. Piuz et al NIM A433,1999, 222



HADES , R. Gernhauser et al
Imaging2000, Stockholm

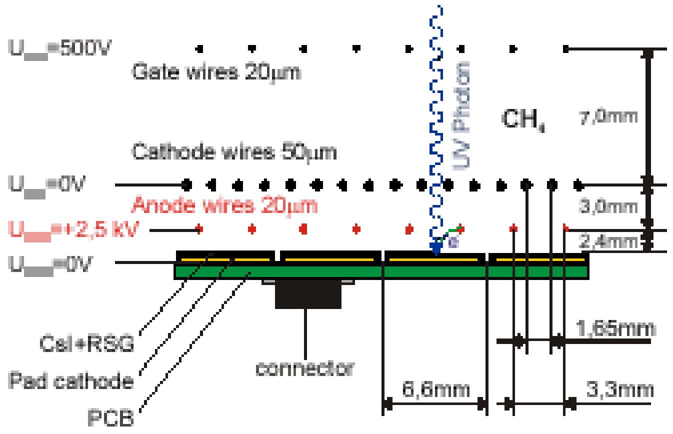
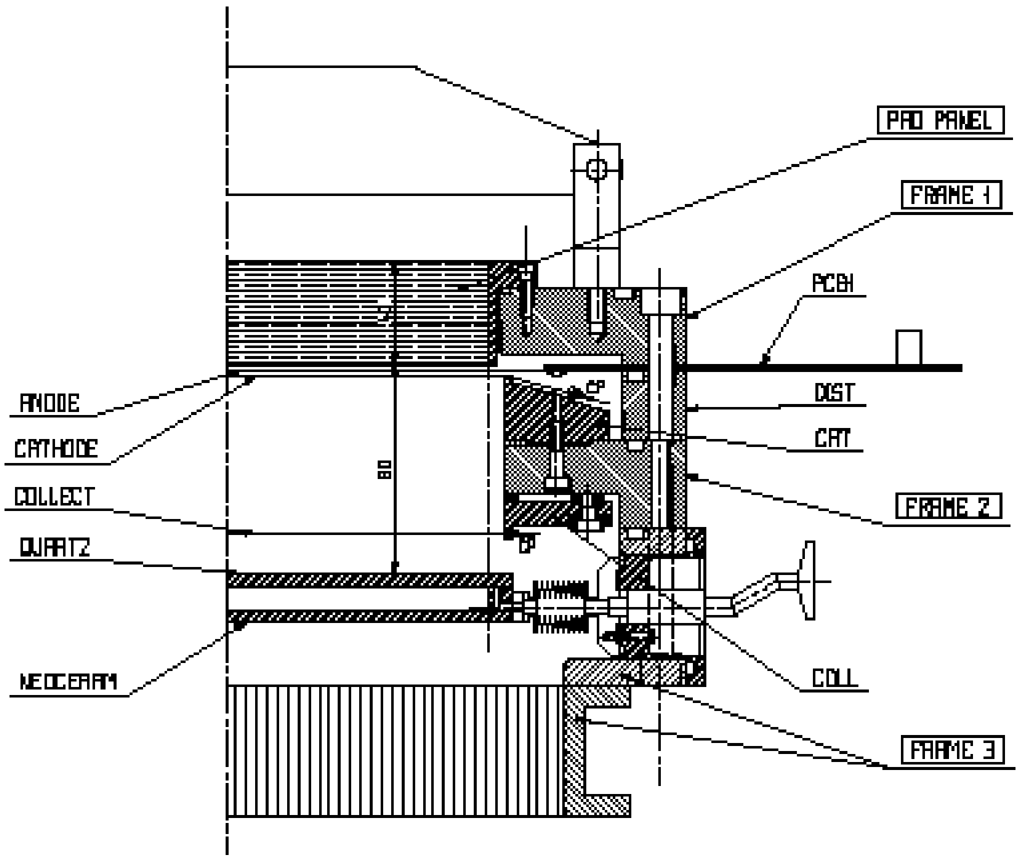


PHOTO-DETECTORS - TECHNICAL

- **design allowing the mounting of stacked frames, keeping high tolerances on gaps and planareity (order 50µm)**
- **windows mountings, tightness**



PHOTODETECTORS PARAMETERS: GEOMETRY, FEE, OPERATION

Experiment	Photo converter GAS	Anode pitch [mm]	Pad size [mm2]	Anode to pad [mm]	anode to cath. [mm]	cath. to coll. elect.	FEE chip	ECN [electr]	HV Gain	Pad occupancy
CERES SPS	TMAE 40ºC He, C2H6									
TIC NA44 SPS	TMAE 40ºC CH4	4	8.0x8.0	2	2	30	Gassiplex 1.5μ	1000		
CLEO III CESR	TEA15ºC CH4	2.5	8.0x7.5	1	4.5		VA_Rich	200		
TIC NA44 SPS	CsI CH4	4	8.0x8.0	2	2	30	Gassiplex 1.5μ	1000		
HADES GSI	CsI CH4	3.3	6.6x4.6 to 6.6x7.1	2.5	3	12	Gassiplex 1.5μ	1000		
STAR-RICH RHIC	CsI CH4	4.2	8.4x8.0	2	2.2	60	Gassiplex 1.5μ	1000		
COMPASS SPS	CsI CH4	4	8.0x8.0	2	2	11	Compass Gassiplex	1000		
HALL-1 J-LAB	CsI CH4	4.2	8.4x8.0	2	2.2		Gassiplex 1.5μ	1000		
ALICE HMPID LHC-ION	CsI CH4	4.2	8.4x8.0	2	2.2	60	Gassiplex 0.7μ	1000		
PHENIX RHIC	CsI									

ACTUAL PERFORMANCE AND LIMITS OF CsI-RICH, WITH PROX. FOCUSING GEOMETRY

FACTORS DRIVING THE PID PERFORMANCE

- CsI QUANTUM EFFICIENCY
- SINGLE ELECTRON DETECTION EFFICIENCY

LIMITS WILL ARISE FROM:

- INCREASING RATE OF EVENTS (FIXED TARGET EXPERIMENTS)

- INCREASING PAD OCCUPANCY (HIGH MULTIPLICITY EVENTS)

TWO MAIN PARAMETERS AT DISPOSAL

FEE SENSITIVITY or/and CHAMBER GAIN

FEEDBACK PHOTONS
AGEING

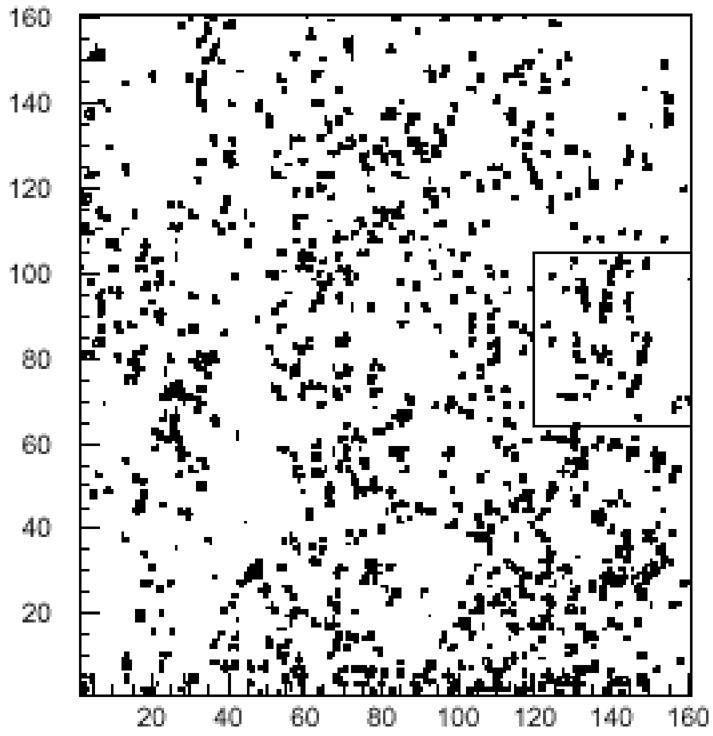
(**other ones: radiator photon yield, chamber geometry and anode/pad coupling, etc)**

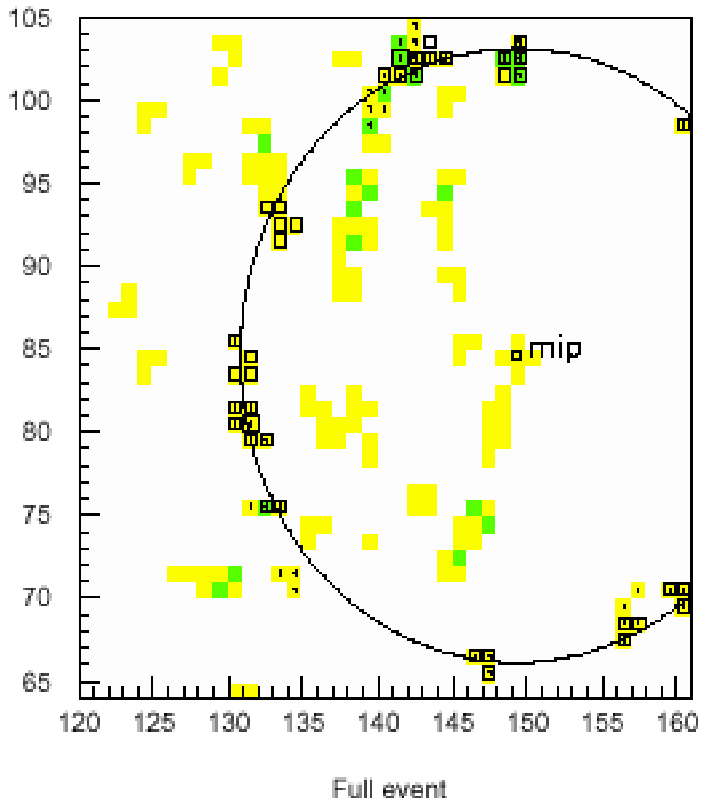
We shall discuss the performance and limitations of the CsI-based RICH under two experimental situations :

- **experiments where a high track multiplicity is expected (say >50 charged tracks/m2)**
- **experiments where the high rate of events is predominent**

TOWARDS HIGH MULTIPLICITIES….

- ALICE Pb-Pb central
- 50 tracks/ m2





TOWARDS HIGH TRACK MULTIPLICITY, OR HIGH LOCAL TRACK DENSITY:

mandatory for efficient pattern recognition with optimal angular resolution:

==> PAD OCCUPANCY

==> in order to keep it at a minimum ==> reduce parasitic photon feedback,

==> cluster size ==>**CHAMBER GAIN**

ALICE

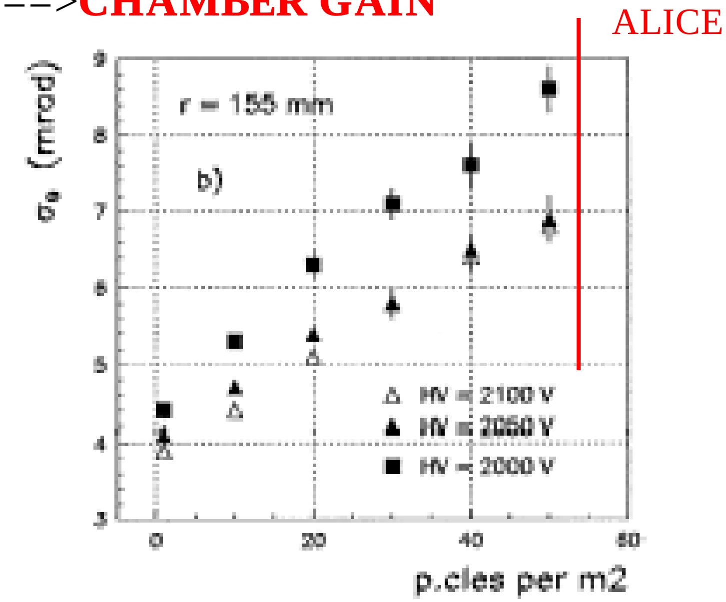
full Galice simulation

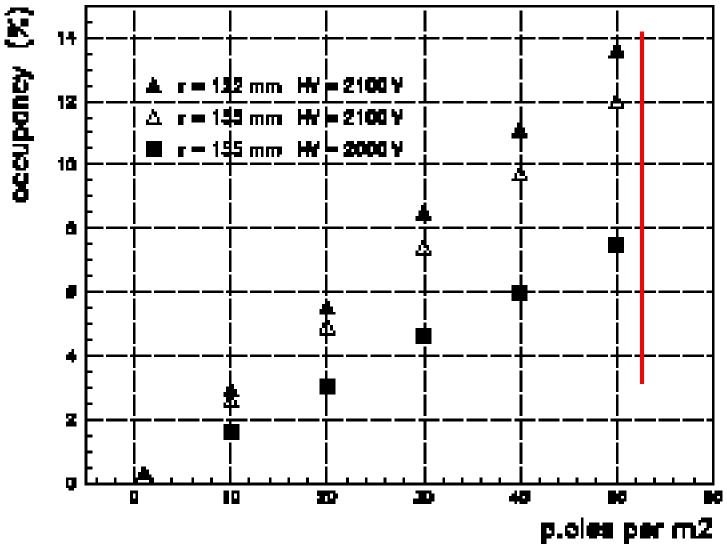
Pb-Pb, CoM energy: 5.5 TeV

Pseudo-rapidity range: -1< η < 1

dN/dy= 8000 charged tracks

per η-unit





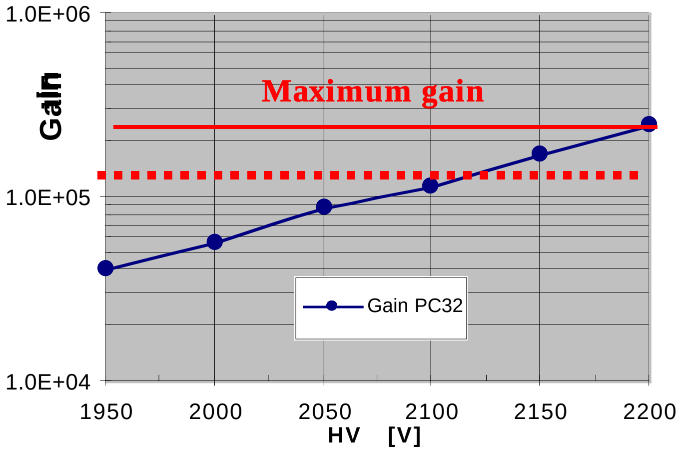
D. Elia et al, NIM A433,1999,262
D. Cozza et al NIM A482,2002,226

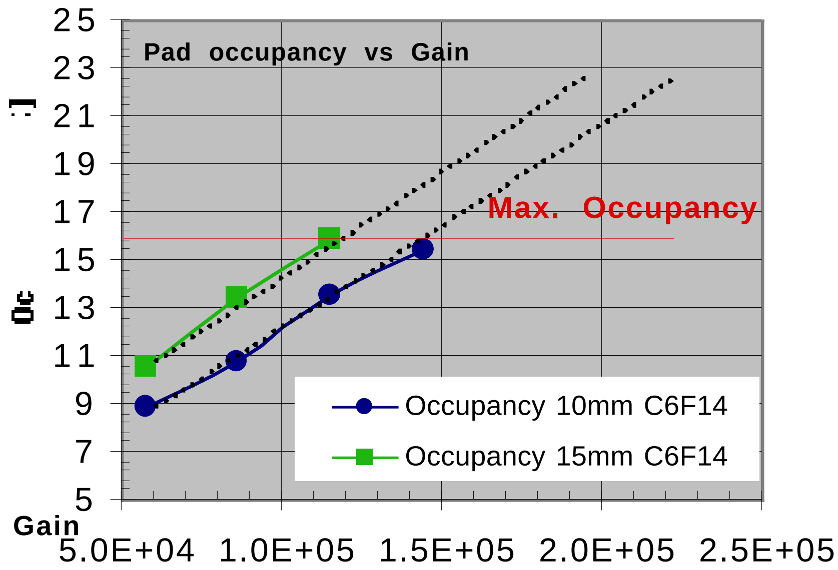
ALICE, Pb-Pb, central [Alice-HMPID TDR CERN/LHCC 98-19]

INFLUENCE OF THE CHAMBER GAIN AND EVENT MULTIPLICITY ON THE PAD OCCUPANCY

===> AFFECT CHERENKOV ANGULAR RESOLUTION

Alice Pb-Pb central event:
Pad occupancy versus Gain 20ADCch--> G= 5.7 10E04





N. Di Bari Session 9

IS IT POSSIBLE TO MINIMIZE THE YIELD OF FEEDBACK PHOTONS USING A SPECIFIC GAS MIXTURE ?

YIELD OF FEEDBACK PHOTONS IN CH4:

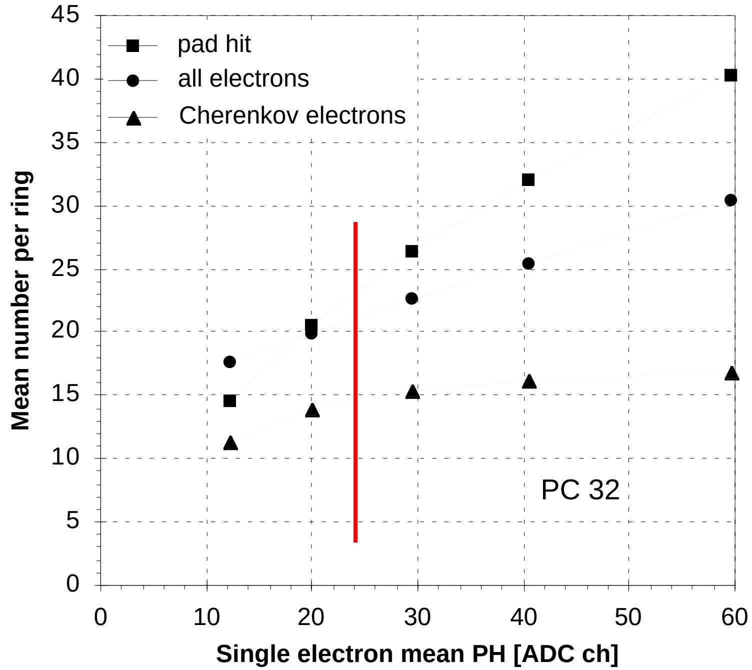
$$\text{RATIO} \quad \frac{\text{\# OF ELECTRONS in fid. zone}}{\text{\# OF CHERENKOV CLUSTERS}}$$

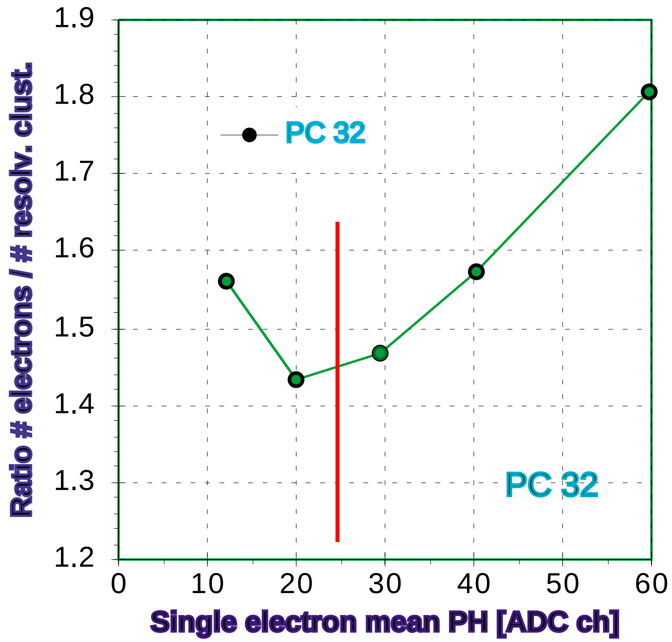
$$N_{feed.photo} = K \times Gain$$

K=> gas dependent

OPTIMAL GAIN FOR A MINIMUN YIELD OF FEEDBACK PHOTONS (CH4)

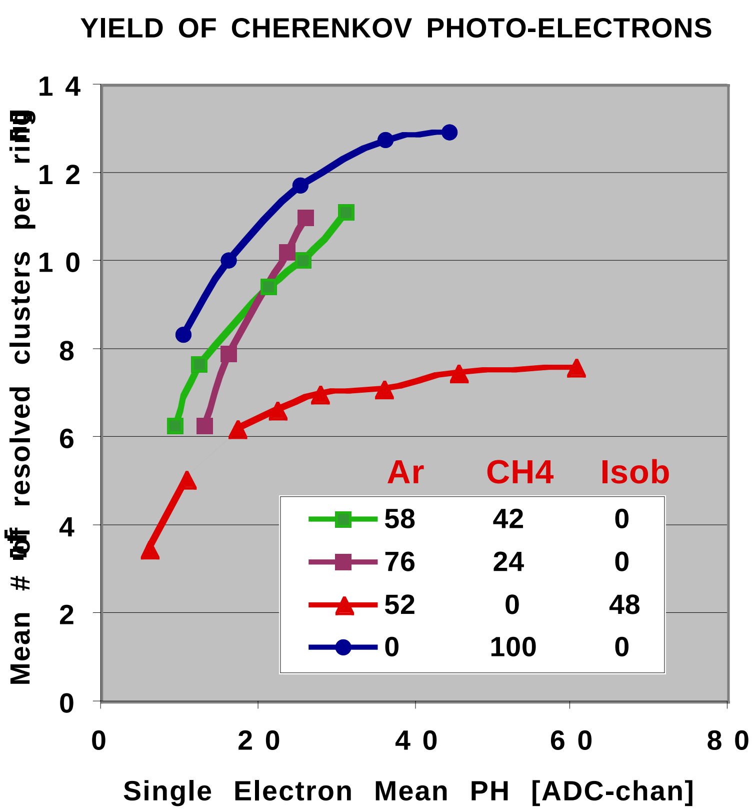
CH_4

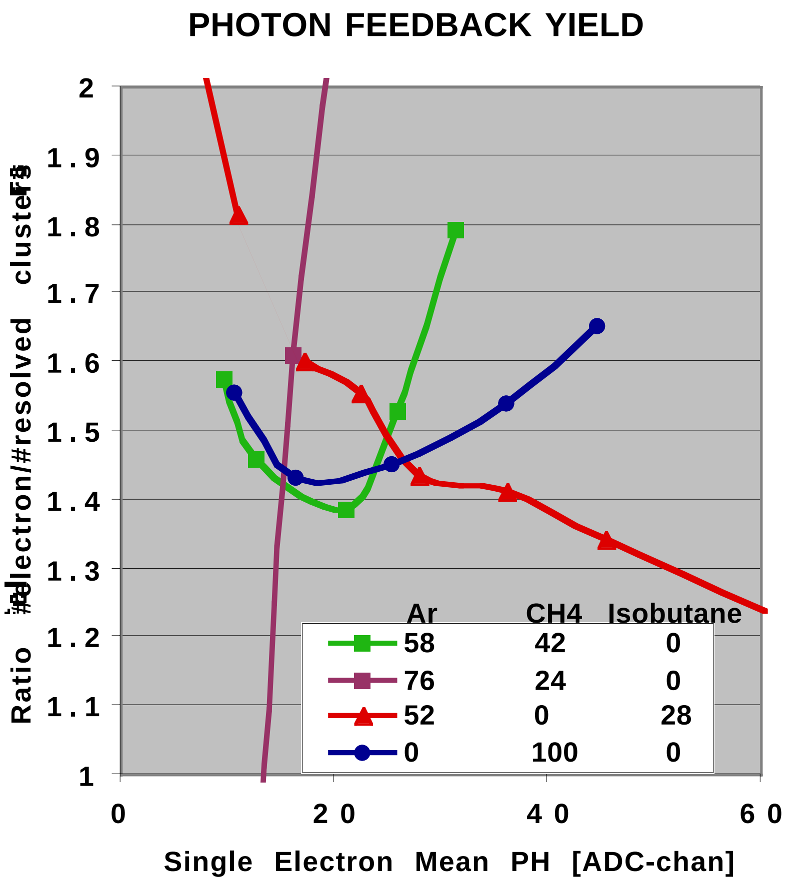




F. Piuz et al NIM A433,1999,178

USING NOBLE GASE- BASED GAS MIXTURE: DETRIMENTAL TO THE CsI QE





- Mixture of organic gases (CH4/Isobutan): better but still 10% loss in photoelectric yield

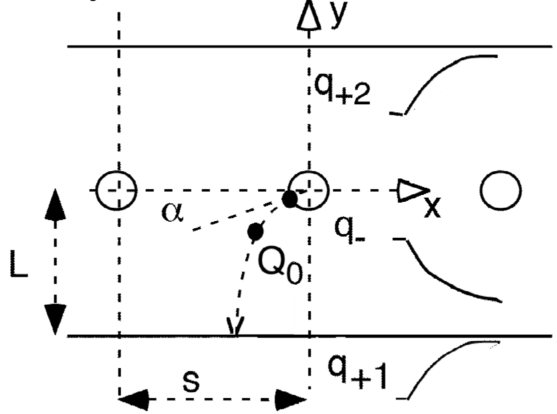
- If possible: increasing the radiator thickness as much as possible (ang. resolution!!) allows for a chamber gain reduction

TOWARDS INCREASED EVENT RATES:

How far with gain and how low with FEE sensitivity should one go to preserve Single electron efficiency

With:

- A_0, the mean of a single electron PH spectrum measured at **T_0=800ns**
- A_{th}, FEE thresh / 3sigma
- ECN= 0.17fC (1000el.)



MWPC geometry:
pitch=4mm, gap= 2mm
in CH4

1) Single electron detection efficiency and Gain at T_0

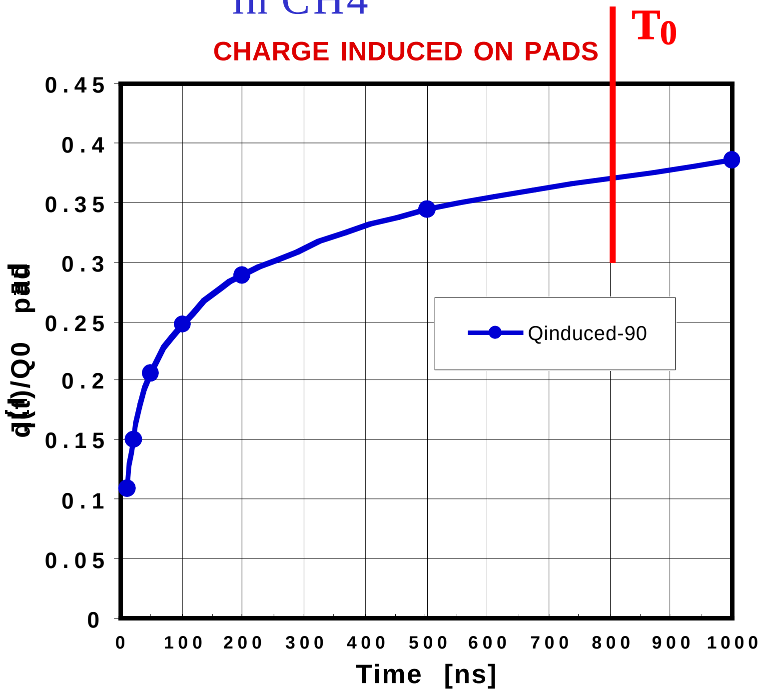
$$\mathrm{Eff.}(T_0) = \exp\left[-\frac{A_{th}}{A_0(T_0)}\right] \quad , \; G(T_0) = K.\,A_0.\,\frac{1}{q(T_0)/Q_0}$$

with K = 0.17fC / 1.6 10^{-4} fC

2) Single electron detection efficiency and Gain at T <T_0

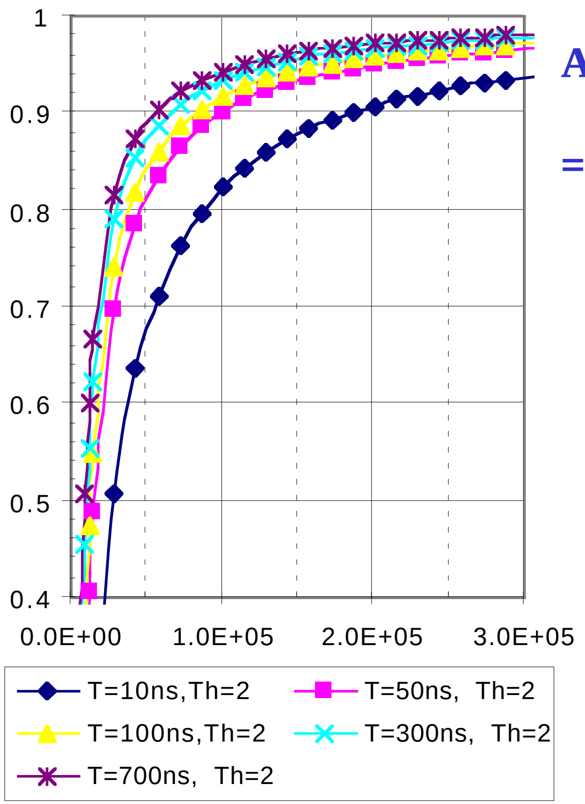
$$\mathrm{Eff.}(T) = \exp\left[-\frac{A_{th}}{A_0(T)}\right] \quad , \text{ with}$$

$$A_0(T) = A_0(T_0).\,\frac{q(T)/Q_0}{q(T_0)/Q_0}$$



AIMING TO Single Electron EFFICIENCY > 90%

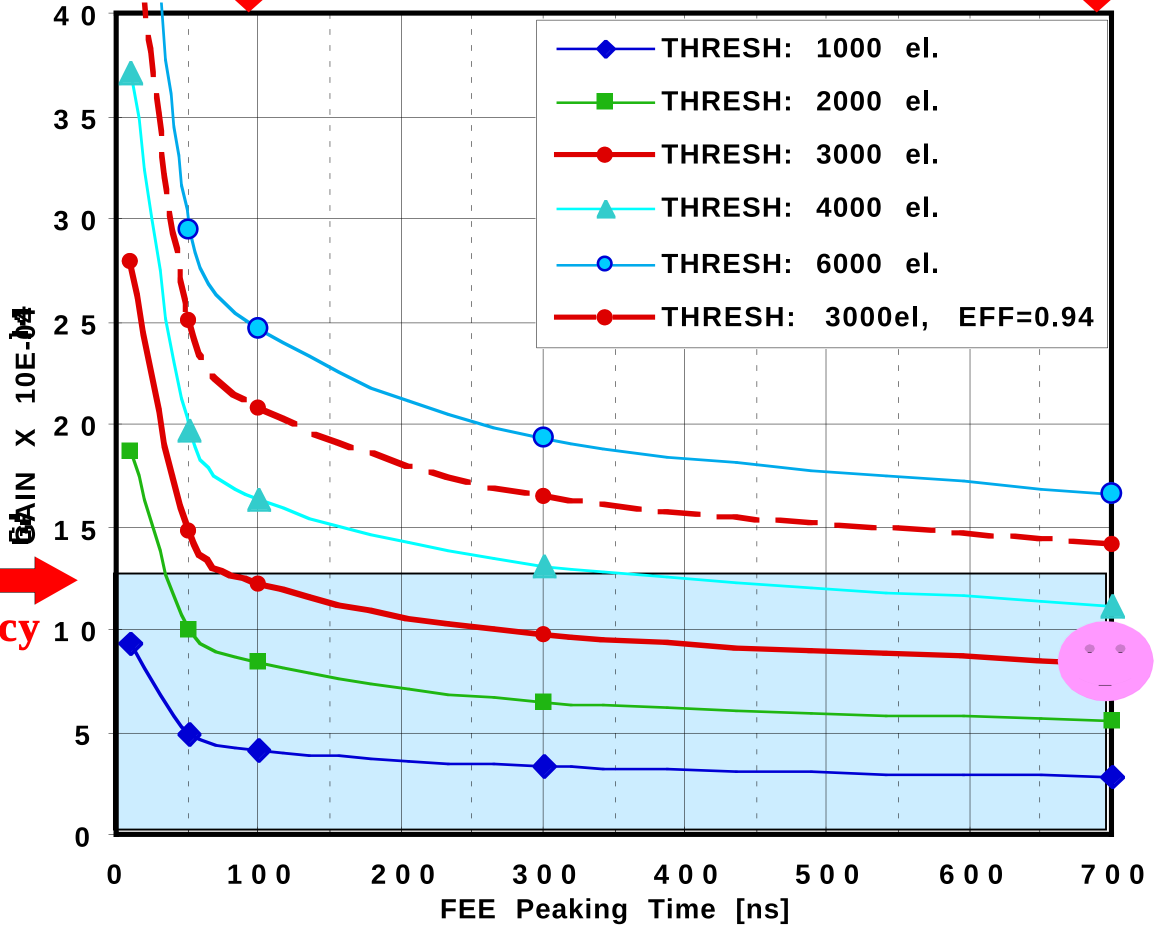
==> CHAMBER GAIN VS EVENT RATE AND FEE THRESHOLD



THRESH: 2000 el.

1MHz event rate

100kHz event rate



Max. gain for pad occupancy

CsI-PCs AGEING STUDIES: IRRADIATION A LIMITING PARAMETER

performed for many different applications and RICH-systems....

USING SMALL SAMPLES OF CsI-PC

few new papers since A. Breskin's review
NIM A371,1996,116:
H. Rabus et al NIM A438,1999,103
B. Singh et al NIM A454,2000,364
A.Tremsin et al NIM A442,2000,337

1- IRRADIATION BY INTENSE PHOTON FLUX

- more effective:
  - in vacuum
  - at long wave length

- **NOT EFFECTIVE IN RICH SYSTEMS   MUCH LOWER PHOTON FLUX**

1.2 10E12 ph/cm2,s @ 185nm
30nA/cm2, CH4 1atm

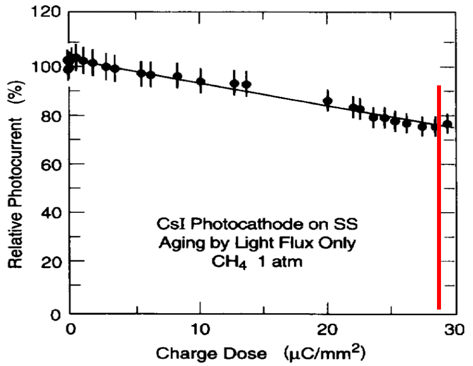
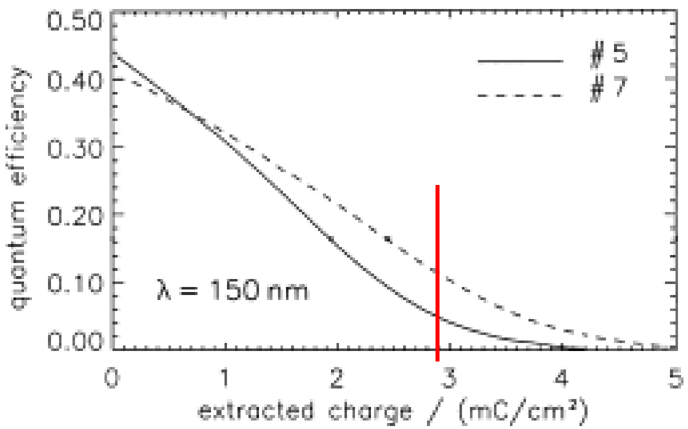


Fig. 15. The CsI photocathode ageing induced by light flux only (chamber had no gain) with CH_4 gas at 1 atm 500 nm CsI on polished stainless steel (ss) substrate.

J. Va'vra et al NIM A387, 1997,154

5.0 10E14 ph/cm2,s @ 150nm
300nA/cm2, vacuum



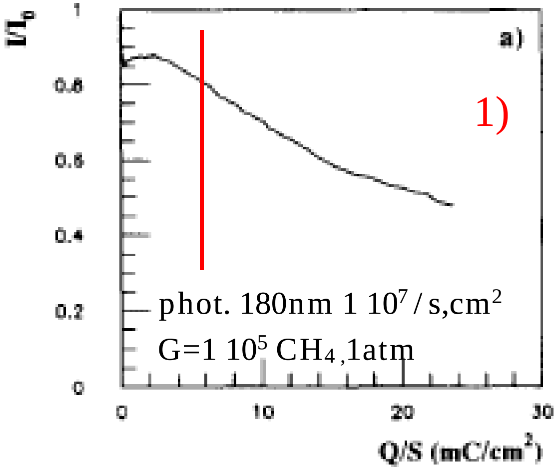
H. Rabus et al NIM A438,1999,103

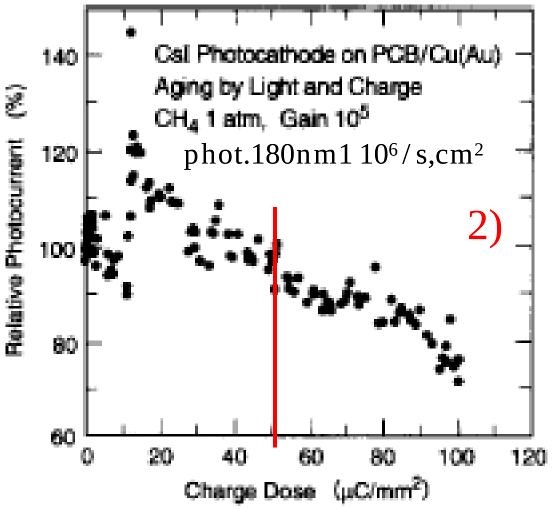
2-CsI SAMPLE EXPOSED TO PHOTON FLUX AND ION IMPACT (GAS 1atm+ GAIN)

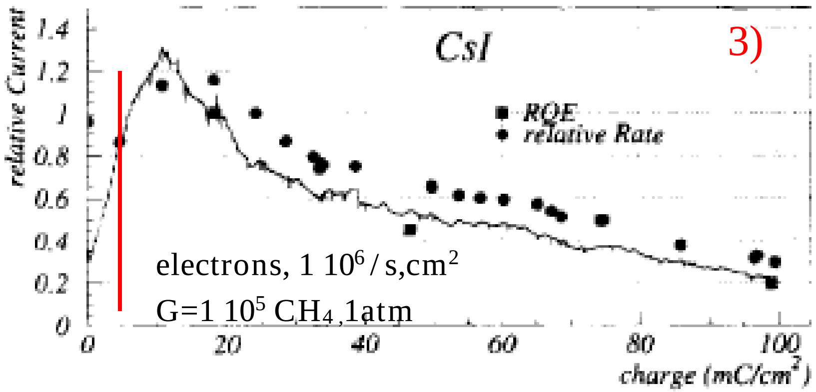
1)P. Krizan et al NIM A364,1995,243
2)J. Va'vra et al, NIM A387, 1997,154
3)P. Krizan et al NIM A387,1997,146
4)B. Singh et al NIM A454,2000,364

- current decay
- QE measurement (not shown)

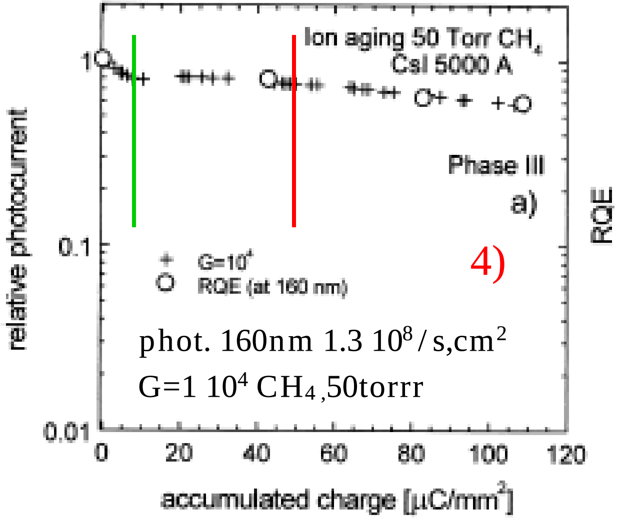
==> exposure to air to be avoided between the 2 steps

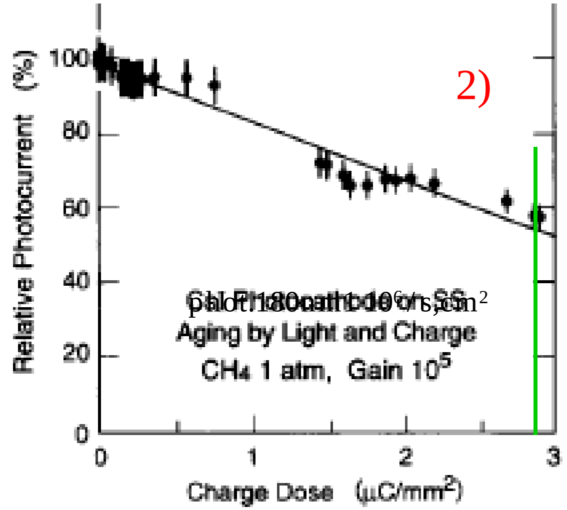






charging-up?





UNDERSTANDING? MODELING AGEING ?

Many physical processes involved:
- photoemission: surface effect for reflective PCs (50nm, layer=300nm)
- aging: bulk or surface effect, driven by photo conduction
- gaseous ion deposition at the surface, charging-up
- polarized surface

photon-ageing,no gain:

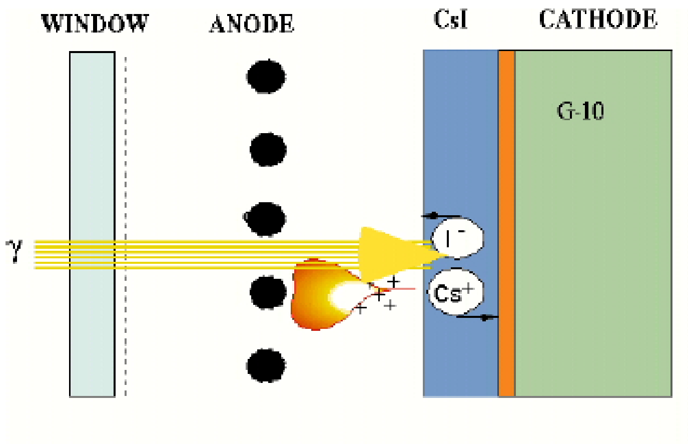
photolysis process==>**h√ + CsI --> Cs^+ +I+ e^- (cesiation)**

ageing with gain in gas

? • ion sputtering, ion induced dissociation

A^+ + CsI --> A + CsI^+ --> Cs^++I ==>(cesiation)

? • electrolysis driven by charging-up effect



Cesiation:
- Iodine is very resistive ρ = 1.3x109 Ohm.cm
- Cesium is very conductive ρ = 2x10-5 Ohm.cm
- Cesium has an higher work function than CsI==> kill QE

A.Breskin NIM A371,1996,116
J. Va'vra, SLAC_pub_9062

SUMMARY (small samples)
AGING UNDER GAS GAIN

Author	Photon flux # / cm2,s	Photon nm	Gain x 10E-04	Doze mC/cm2	Current decrease	QE decrease	detector	gaz pressure
Krizan 1)	1 10E+07	180.00	10.00	10.00	0.30	**0.40**	MWPC	CH4, 760
Va'vra 2)	1 10E+6	185.00	10.00	0.30	0.40		MWPC	CH4, 760
Chechik 2)	1 10E+6	185.00	10.00	10.00	0.20	**0.30**	MWPC	CH4, 760
Singh 3)	1.3 10E+8	160.00	1.00	4.30	0.20	**0.20**	PP	CH4, 50
Singh 3)	1.3 10E+8	160.00	1.00	8.30	0.40	**0.50**	PP	CH4, 50

COMMENTS: at evidence….delicate measurement….

MANDATORY:

- **extracted charge AND QE measurement in the same apparatus**
- **MWPC, 1atm, gas (CH4) to comply with HEP conditions**
- **parameters: Gain, flux dose rate effect?**

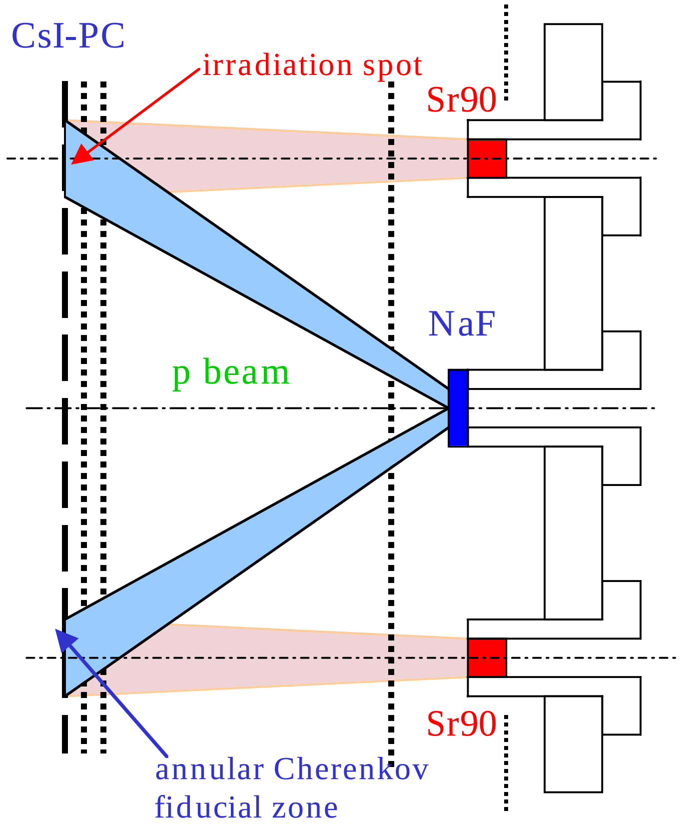
SET-UPs at disposal……so many…...:

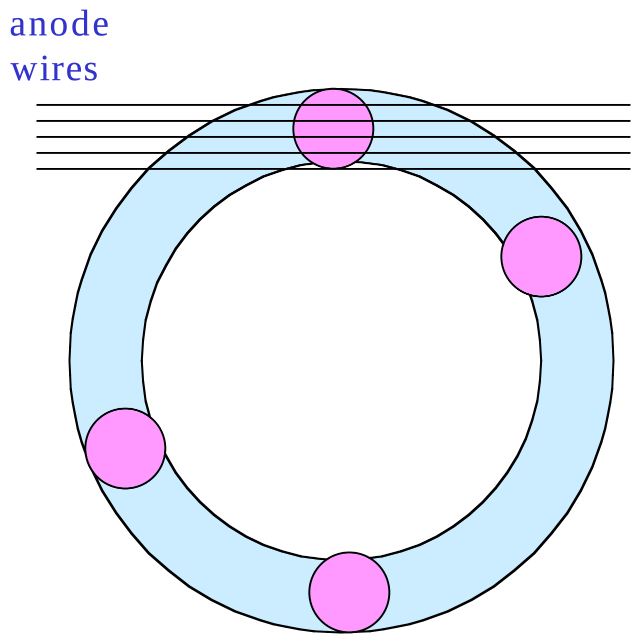
- Weizmann, CERN / ASSET, Bari / INFN, ISS Roma, Hades

FOR THE TIME BEING: ASSUME THAT A DOSE OF 5 mC/cm2 (50µC/mm2) INDUCES A QE DROP OF 20%
WILL BE TAKEN AS A MAXIMUM DOSE ALLOWED IN HEP ENVIRONMENT
(this pad doze is equivalent to draw 10nA / m of wire during 230 days)

AGEING EVALUATION "HEP dedicated"

- using the RICH / CsI-PCs module as of the experiment
- define a Cherenkov fiducial zone using NaF radiator / p beam
- monitor the CsI-QE by Cherenkov photon counting
- irradiate several spots overlapping the fiducial zone by means of Sr90 elecron sources
- irradiation dose obtained by anode current monitoring





IRRADIATION AT HEP EXPERIMENTS: STATUS and RESULTS

1- COLLIDER HIGH MULTIPLICITY

INTEGRATED DOSE AT THE ALICE EXPERIMENT

- FULL SIMULATION, Au/Au EVENTS

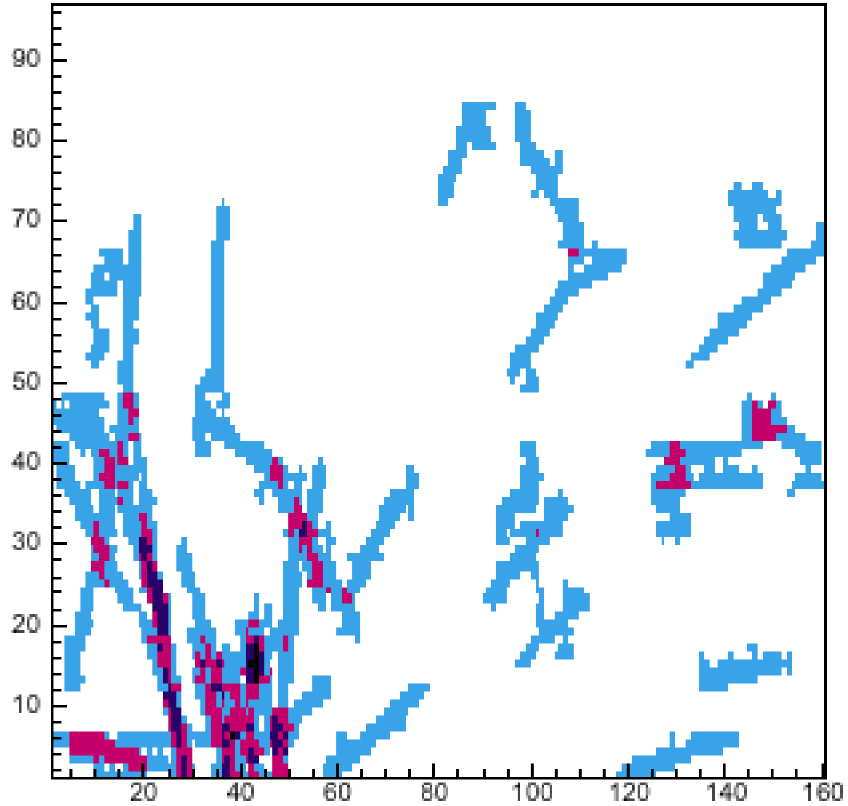
A0 [ADC ch.]	GAIN x1 10E-04	Ev. RATE [MHz]	DOZE [µC/day,mm2]	TOTAL DOZE [µC/day,mm2]
20.00	**5.70**	central: 0.001 minibias:0.01	central: 1.58 10E-03 minibias: 3.16 10E-03	**4.74 10E-03**
40.00	**11.50**	central: 0.001 mini bias: 0.01	central: 3.19 10E-03 minibias: 6.32 10E-03	**9.51 10E-03**

IF MAX. DOSE is 50 µC/mm2: ==>
5000 -10000 days of operation.. looks promising…...

MOST PROBABLE TROUBLE EXPECTED==>
heavily ionizing events (neutrons, reactions,etc..)

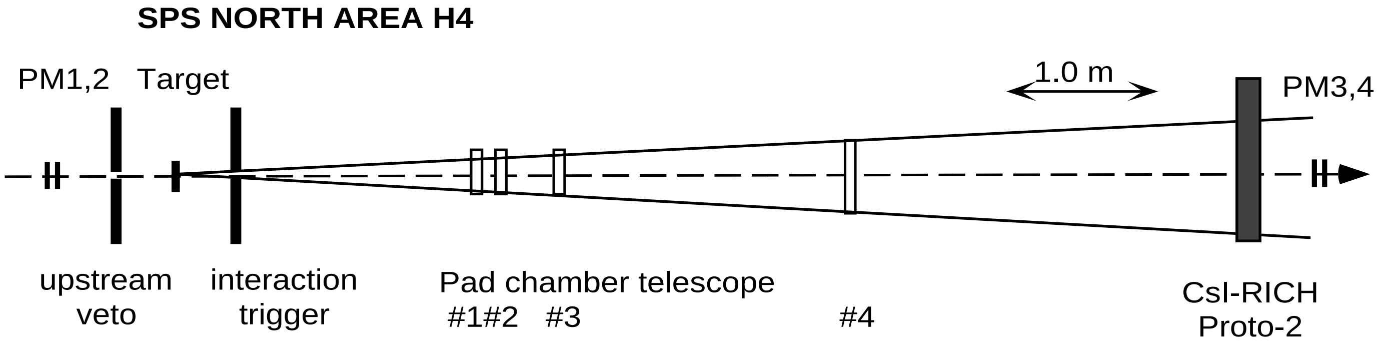
ALICE-PROTO-2 AT SPS (pion, 300GeV/c on Al target)

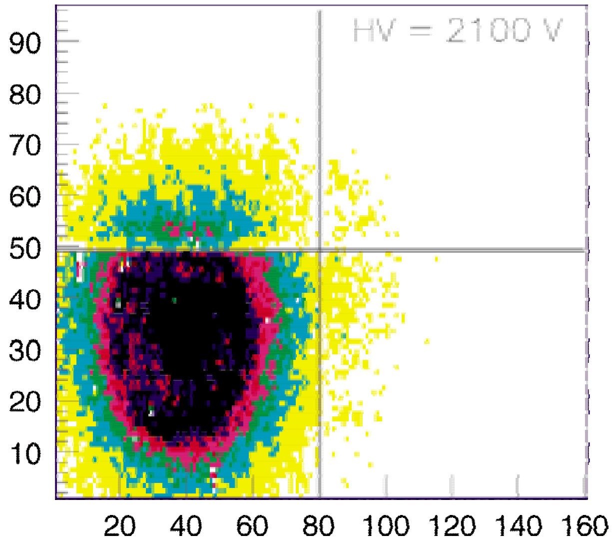
selected hadronic interactions in the chamber
(> 60 pads events
39 patterns out of 5000 events)

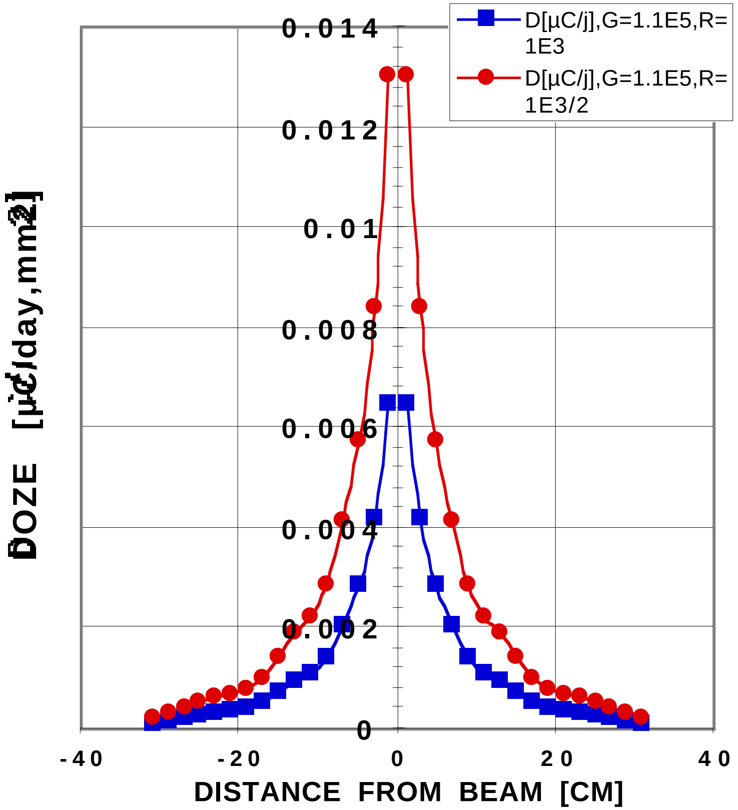


IRRADIATION OF ALICE-PROTO-2 AT THE SPS (1997)

Pion 300GeV/c, Beryllium target







ACCUMULATED DOSE IN THE SPS RUNS:

with targets: **0.5 µC/mm2**

with punctual beam **5-10 µC/mm2**

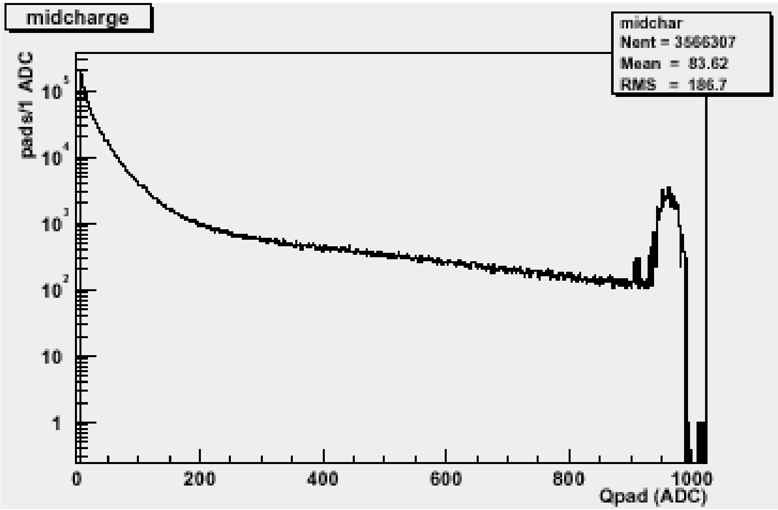
(spot area about 1 cm2)

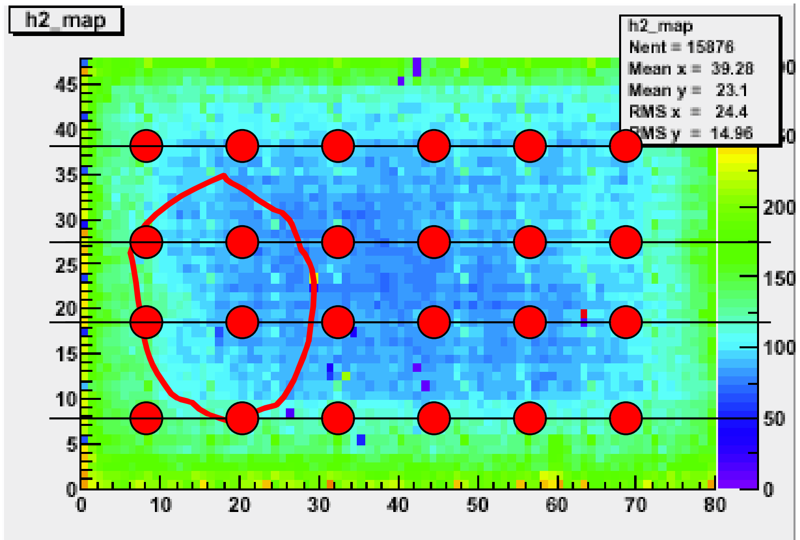
==> not visible on the Starrich maps)

STARRICH IRRADIATION

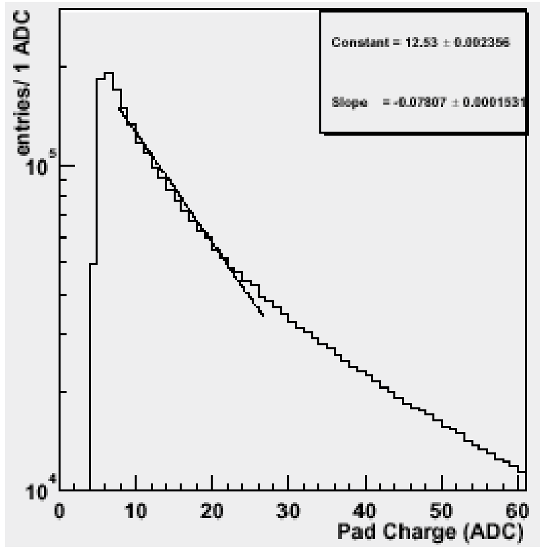
is it possible to see only single electron charge contribution ?

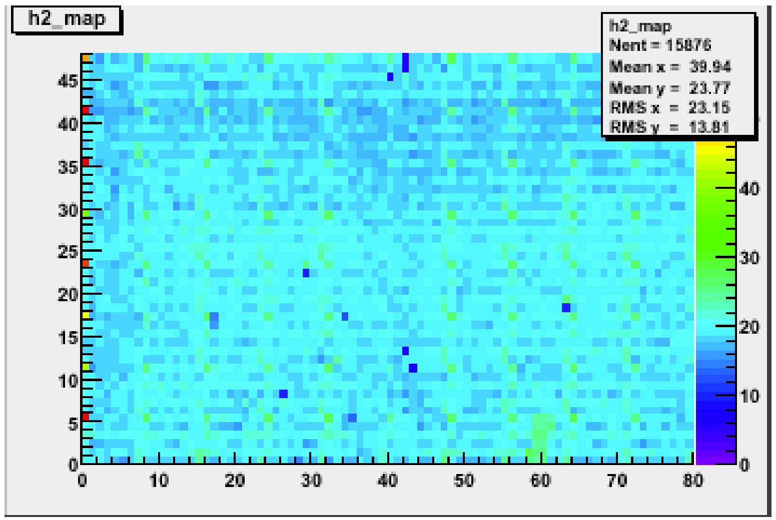
ALL TRACKS, NO PH-CUT
SINGLE PAD PH-SPECTRUM





SINGLE ELECTRONS
PH CUT AT <60ADC ch
SINGLE PAD PH SPECTRUM
A0 = 20 adc ch





INTEGRATED DOSE FROM FIXED TARGET EXPERIMENT:
Pion 300GeV/c, Beryllium target

HV [V]	GAIN x1 10E-04	Ev. RATE [MHz]	MAX. DOZE [µC/day,mm2]
2100	**11.50**	0.001	0.015
2100	11.5	**0.100**	**1.400**
2100	11.5	**1.000**	**14.000**

(HERA/B)-LIKE SITUATION

5 DAYS OF OPERATION…

ATTEND SESSIONS 1 AND 6…..

Imply a FEE with the following performance:
FEE: 1000 el. ECN Threshold
50ns Peaking time
allowing for:
GAIN 5.0 10E+04 and SE EFF. = 92%

HADES

- current drawn by one chamber (0.25m2): from 100 to **4000 nA**, duty cycle 50%

--> 0.035 to **1.4 µC/day,mm2**
critical value, but intermittent
--> next talk

COMPASS **--> next talk**

SUMMARY: PRESENT AND FUTURE

COLLIDERS (low rate in case of ions):

- **PAD OCCUPANCY IS LIMITING FACTOR, NOT AGING**
- IMPROVED FEE WOULD ALLOW HIGHER RATES

FIXED TARGET

- **AGING + RATE MORE CRITICAL**

max dose: 50 μC / mm2

Event rate [Mhz]	FEE Integrating time [ns]	Treshold [electrons]	H.V. [V]	Gain X 10E-04	SE efficiency	Pad occupancy [%]	Cherenkov ang. resol [mrad]	Irrad. dose [μC/d,mm2]	COMMENT
0.01	1200.00	2000.00	2000.00	5.70	0.90	10.50	8.50	5.0 10E-03	NO
0.01	1200.00	2000.00	2100.00	11.50	0.95	16.00	6.80	10.0 10E-03	OK
1.00	100.00	2000.00	2040.00	8.00	0.90	13.00	7.20	7.0 10E-03	OK
2.00	50.00	2000.00	2075.00	10.00	0.90	14.50	7.00	8.7 10E-03	OK
10.00	10.00	2000.00	2175.00	20.00	0.90	**25.00**		22 10E-03	NO
2.00	50.00	4000.00	2220.00	23.00	0.90	**> 25.00**			NO
10.00	10.00	4000.00	2320.00	37.00	0.90	**> 25.00**			NO
1.00	100.00	1000.00	2075.00	10.00	0.96	14.50	7.00	8.7 10E-03	OK
2.00	50.00	1000.00	2075.00	10.00	0.95	14.50		8.7 10E-03	OK
10.00	10.00	1000.00	2075.00	10.00	0.90	14.50	7.00	8.7 10E-03	OK

SITES	PRODUCTION (1999-2002)	
• **HADES PLANT**		>2m2 ?
• **CERN PLANT**		
ALICE (protos)	8	2m2
COMPASS (FINAL PCs)	16 + 8	8m2
J-LAB	1	0.3m2
		10m2
	===> 20 000 Ø1- inch phototubes….	
• **ISS ROMA** (now moved at J-LAB)		
J-lab	3	0.7m2

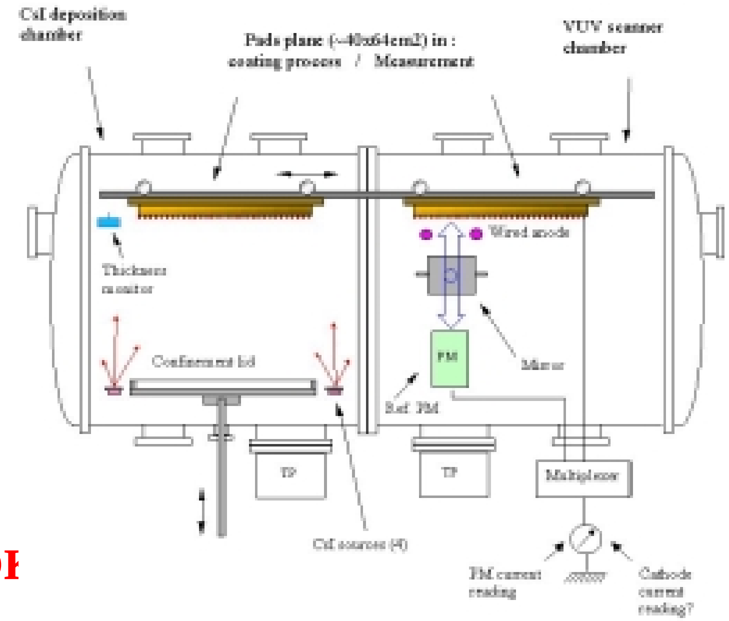
-CsI evaporation processing: A. Braem's talk, Session 6

- **kept unchanged at CERN**
- **CsI-control in situ, after evaporation**

-PCB substrate under careful examination

- **Au/Ni layers on copper-cladded PCB**
- **no visible influence on QE performance:**
  - **electrochemical/ chemical deposit**
  - **polishing**
- **1 nm Carbon layer found at the surface**
- **STRONG CHEMICAL CLEANING ESSENTIAL**

-WASHING OUT A BAD LAYER AND RE-EVAPORATE: OI



THE QE PERFORMANCE IS IMPROVING WITH TIME….

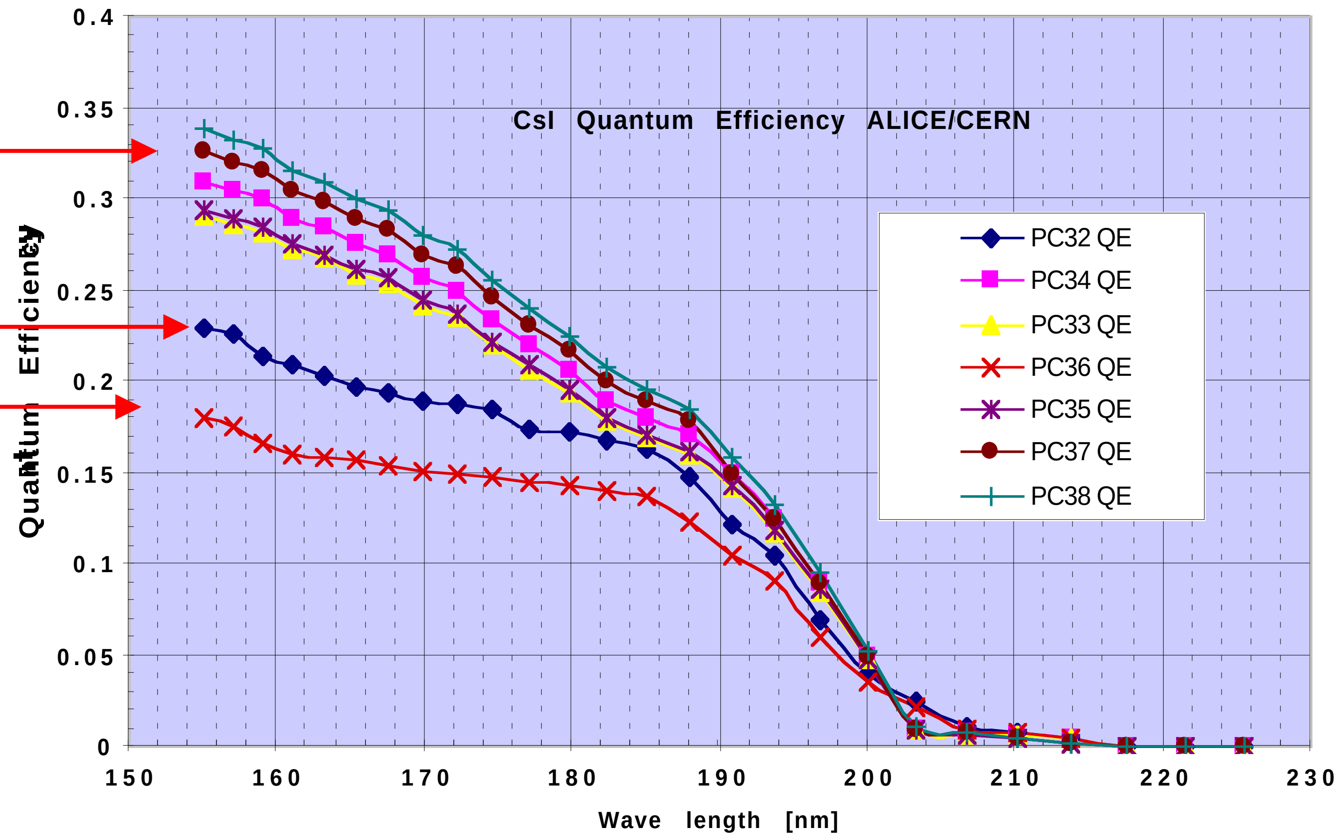
- THANKS TO **CAREFUL CONTROLS BEFORE AND DURING THE PROCESSING**
(TA1 and TA2 procedures, M. Davenport, D. Fraissard

- (from ALICE test beam measurements) **PARTICLE BEAM**
  - can also provide indirectly a differential QE curve with liquid radiator
  - single photon counting, close to HEP operation conditions
  - will allow "detector full caracterization" if TEST beam available….

2001-02 production

1997-8 best (proto-2)

bad guy…….



CsI-QE: PRESENT SITUATION WITHIN THE CORPORATION:

- **RICH SYSTEMS (large PCs)**

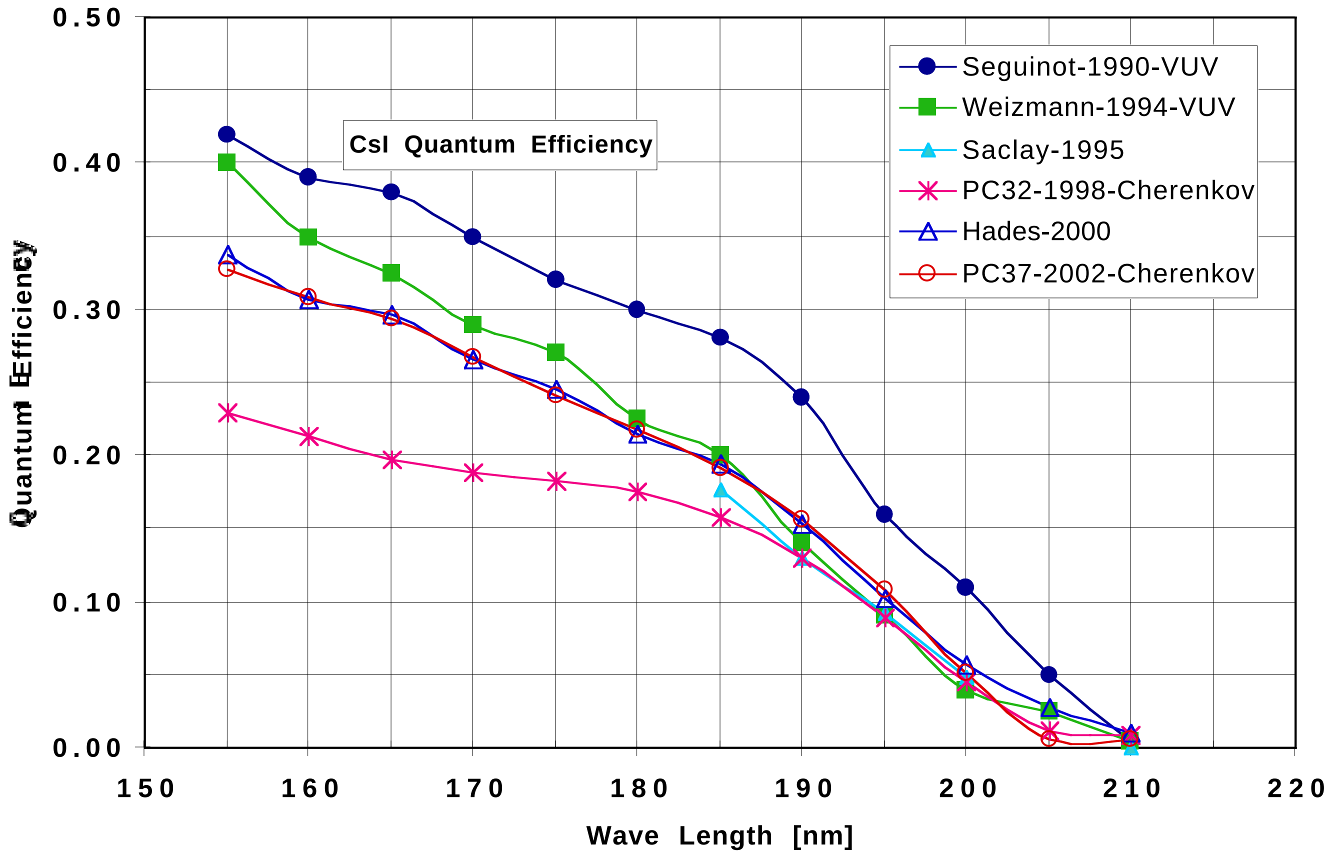
  - comparable performance between most recent published data of HADES and ALICE (despite of quite different CsI processing)
  - close to reference value from Weizmann 3) (small sample, VUV in vacuum)

- **STILL INFERIOR TO REFENCE VALUES** J.Seguinot 1)

  (small sample, VUV in vacuum)

1) J. Seguinot et al
NIM A297,1990,133

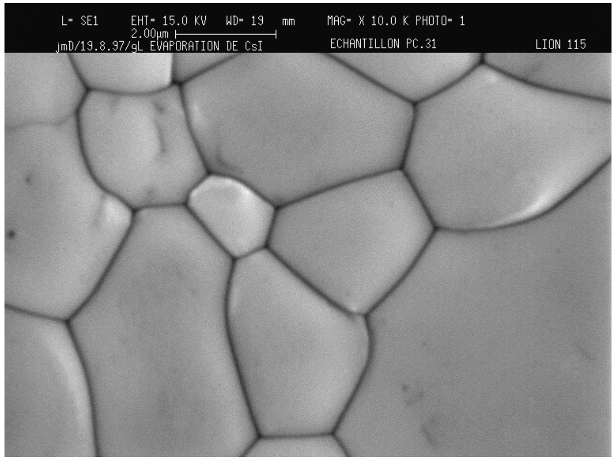
2) A. Breskin et al
NIM A343,1994,159

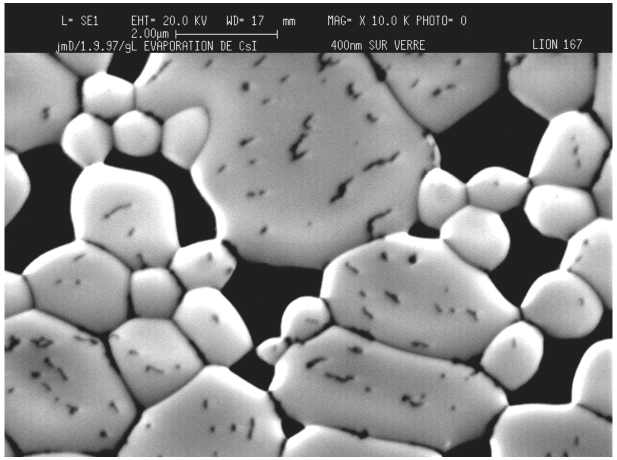


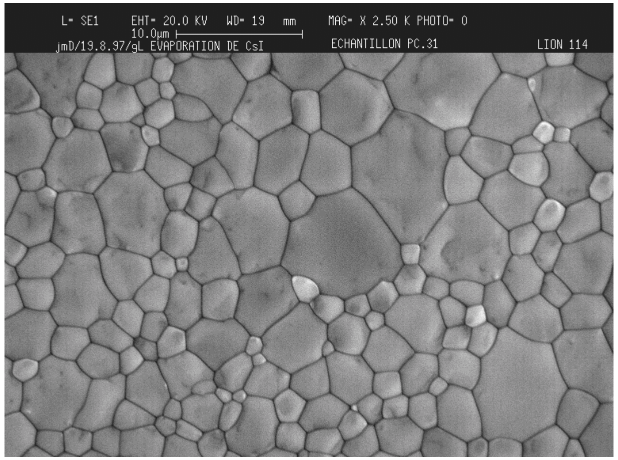
HOW DIFFERENT CAN BE THE SURFACE MORPHOLOGIES OF CsI-FILMS....

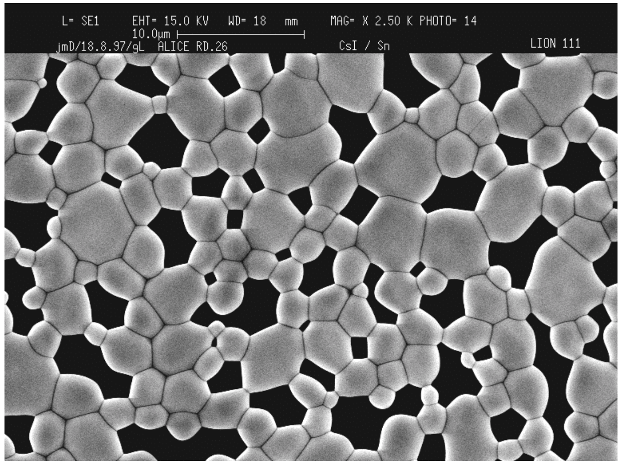
substrate: Au / Ni (CERN)

substrate: carbon / aquadag (HADES)









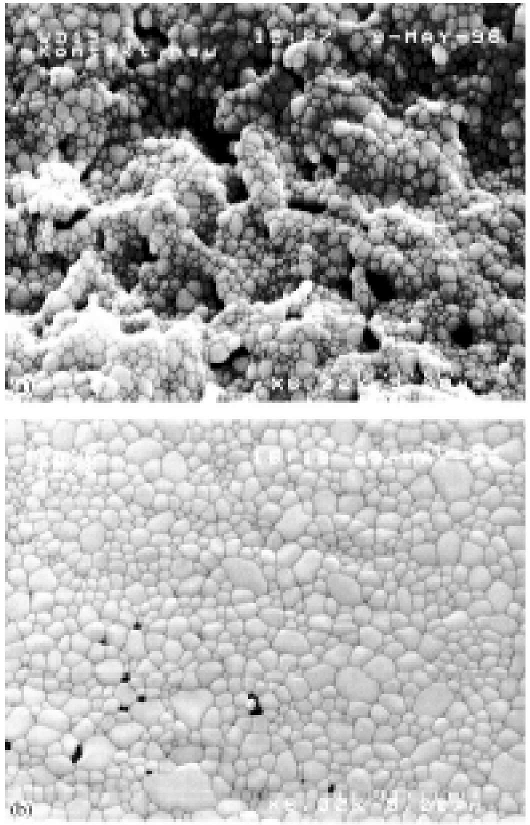


Fig. 2. Microstructure of CsI layers on an RSG-coated substrate (a) and on a polished stainless steel substrate (b). Pictures taken with a secondary electron microscope with a recording width of 20 µm.

12 µm hor. field
40 µm hor. field

J. Friese et al NIM A438, 1999.86

MORPHOLOGY AND STRUCTURAL TRANSFORMATION

• UNDER CHEMICAL CONTAMINENTS

Study of exposure to H_2O and O_2
(A. Di Mauro et al NIM A461,2001,584)

T. Boutboul et al NIM A438, 1999,409

• no visible QE degradation after:

- O_2 flow at 100000ppm /6 hours

- H_2O, (outgasing) up to 50 ppm, 17 hours stagnancy during transportation CERN--> BNL

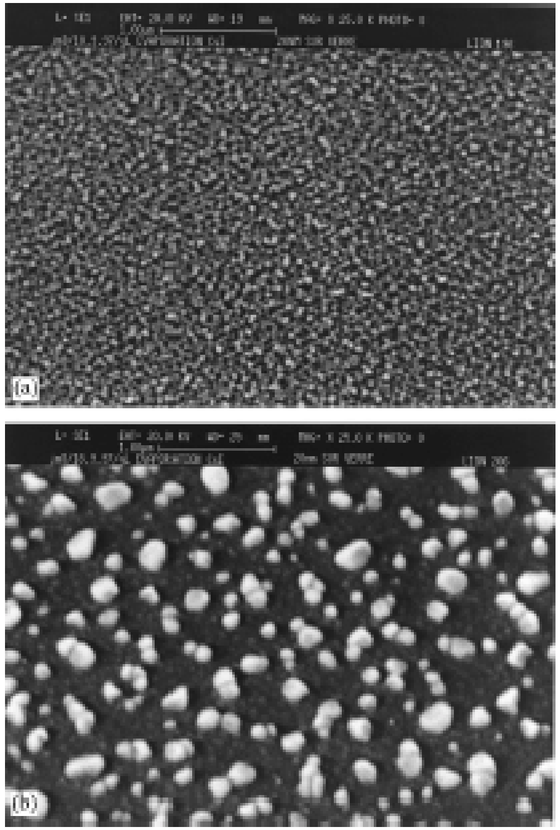


Fig. 7. An SEM view of a 20 nm thick CsI film deposited on a glass substrate coated with Au/Ni: (a) "as evaporated" and (b) after exposure to Ar at 82% relative humidity for 1 min. The full scale is 5 μm.

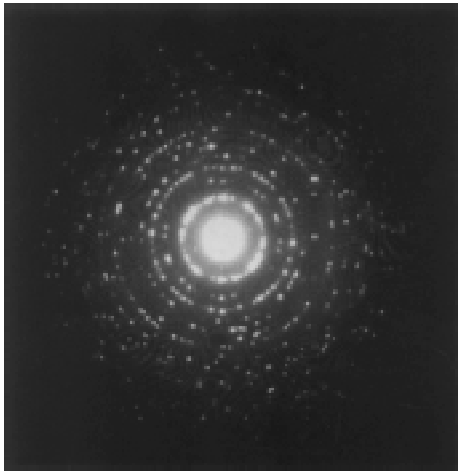


Fig. 2. The electron diffraction pattern obtained with an as-deposited CsI photocathode. The image demonstrates that the CsI film has a polycrystalline structure with grains randomly oriented within the film relative to the substrate.

A. Tremsin et al NIM A447,2000,614

STABILITY OF LARGE CsI-PCS AGAINST CHEMICAL CONTAMINENTS

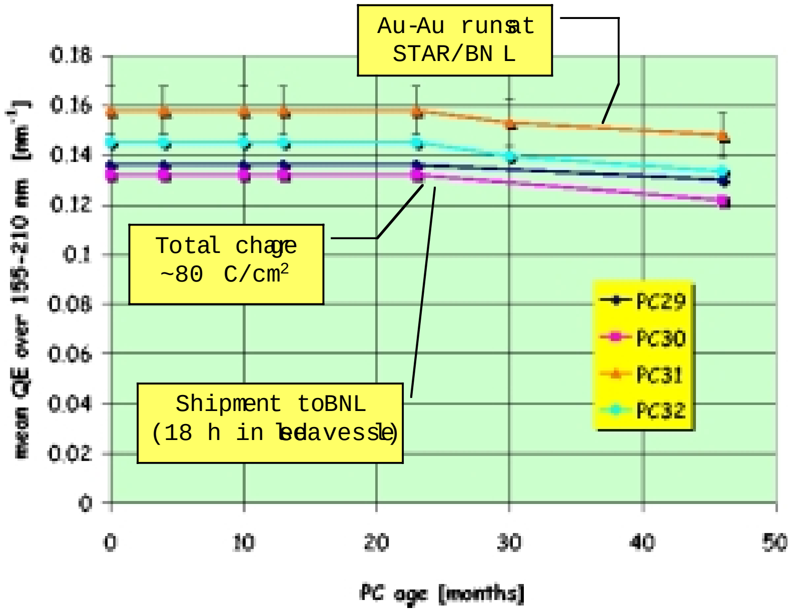
(OXYGEN AND MOISTURE)

PCs kept under permanent argon flow (10l/h) in a protective vessel

O_2 < 10 ppm

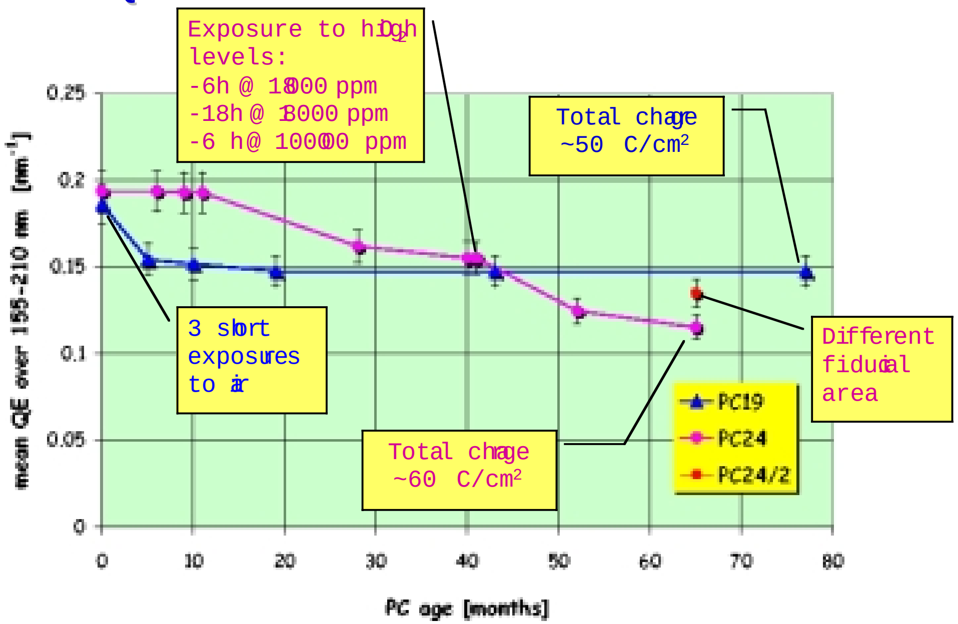
H_2O < 10ppm

QE HISTORY OF PC29-PC32



5 years, including 3 years at BNL

QE HISTORY OF PC19 AND PC24

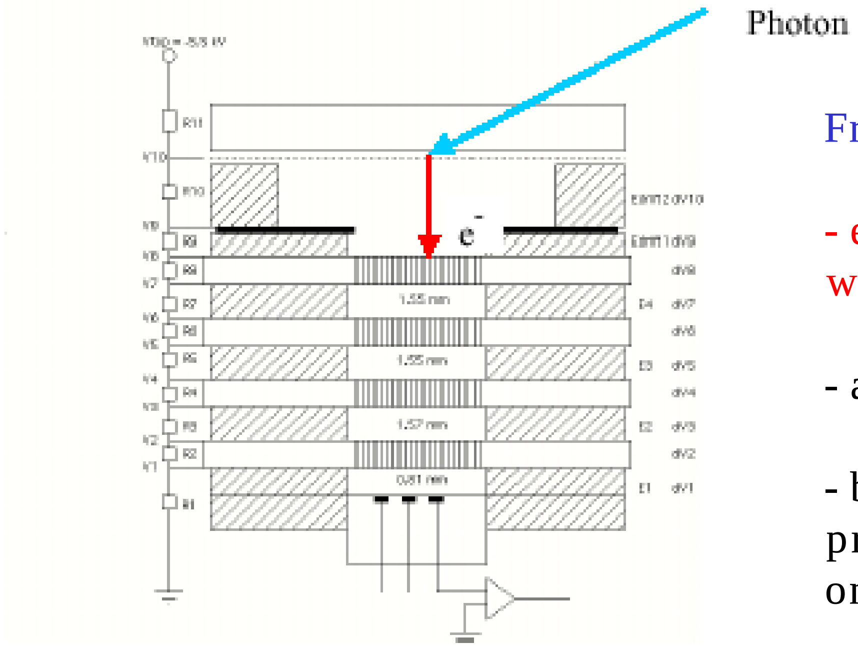


..7 years...600m3 argon….

3d-GENERATION: GEM-based PHOTO-DETECTORS

Quadruple-GEM Detector design

(J. Va'vra and A. Sharma, Vienna Instrumentation conference, February 2001)



From what we have seen, to be explored when:

- event rate >1MHz
with irradiation dose > 5mC / cm2

- anyhow, improved FEE mandatory

- before starting, check if the CsI PC-ageing problem is not transferred to a detector-ageing one, (I suspect ???)

CsI-PC decoupled from ionic impact ageing problem relaxed

warning:
- transmissive CsI-PC of lower QE
- if operated with He, Ar, CF4-based gas
==> strong reduction of CsI-QE

Applications:

- Hadron Blind device
(talk A. Koslov, Session 6)
- medical

2d GENERATION,PIXELIZED RICH, TIME FOR CONCLUSIONS

SINCE EIN-GEDDI ,1998: SEVERAL LARGE SYSTEMS IN OPERATION:
- CLEOIII, HADES, STAR-RICH, COMPASS

IN TERMS OF PRODUCTION/ASSEMBLY

- choice of photo-detector geometry adequat for mechanical assembly within tolerance
- quartz radiator of excellent VUV-transmission affordable
- production of large CsI-PC with good yield of reproducible high QE(exp. rate: 2 / week)
- CsI QE routinely at 170nm : 0.25-0.28 over areas of 1/4 m2
- CsI-PC transfer under inert gas protection: essential

IN TERMS OF PERFORMANCE- ACTUALLY

- using the present FEE (Gassiplex family), 0.8- 1.2 µs PT, 1000el.ECN, MPX-analog
  - SE efficiency at 90-94% at gain 0.5-1 x10E05
  - stable photo detector operation at rate 0.5 -1.0 10E05/s
- Cherenkov angular resolution matching the present PID requirements

AROUND ION-COLLIDER

- Cher. resolution degrades with pad occupancy (<15%)==> gain control
- irradiation dose small at LHC-ION rates
- watch gain against highly ionizing environment

AROUND FIXED TARGET EXPERIMENT:

- ageing becoming critical, usually running at higher event rate

CONCLUSIONS-2

GOING TO HIGHER RATES (FT AND COLLIDER)

- at evidence, FASTER, MORE SENSITIVE FEE
    - ECN AT ≤ 500 elec. AND P.T at 50ns

==> mandatory to reach the MHz range while preserving a convenient gain < 1-1.5 10E05

MANDATORY : AGEING STUDIES DEDICATED TO HEP SYSTEMS

- performed with detectors AS OF EXPERIENCE
- irradiation: only ionizing particles (MIP and α-like)
- QE evaluation by photon counting

- Dose rate effect, charging-up studies

RD, MODELLING :

- CsI film resistivity
- other substrates: C-based, CsI columnar growth
- photo emission, photo conductivity

I can't resist displaying this Jerry's slide
who has suffered, like me, the past 30 years
on these simple and cheap wire chambers....

J. Va'vra, October 2, 2001
Last few words of "wisdom".

. It is cheaper to spend money on electronics (better amplifiers, highly segmented HV power supplies with a low trip levels, etc.) than to rebuild the chambers.

. Run as low gas gain as physics allows.

. Run as low HV trip level as possible.
. Use clever software to search for any anomalous activity in the chamber.
. Use gas additives right from the beginning, do not wait when you detect a trouble.

J. VA'VRA at the AGEING CONFERENCE, HAMBURG, 2001