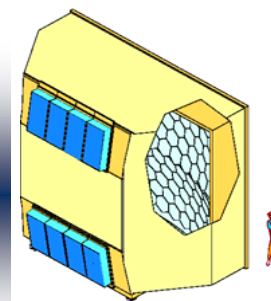




STATO E CARATTERIZZAZIONE DEL RICH-1 DI COMPASS



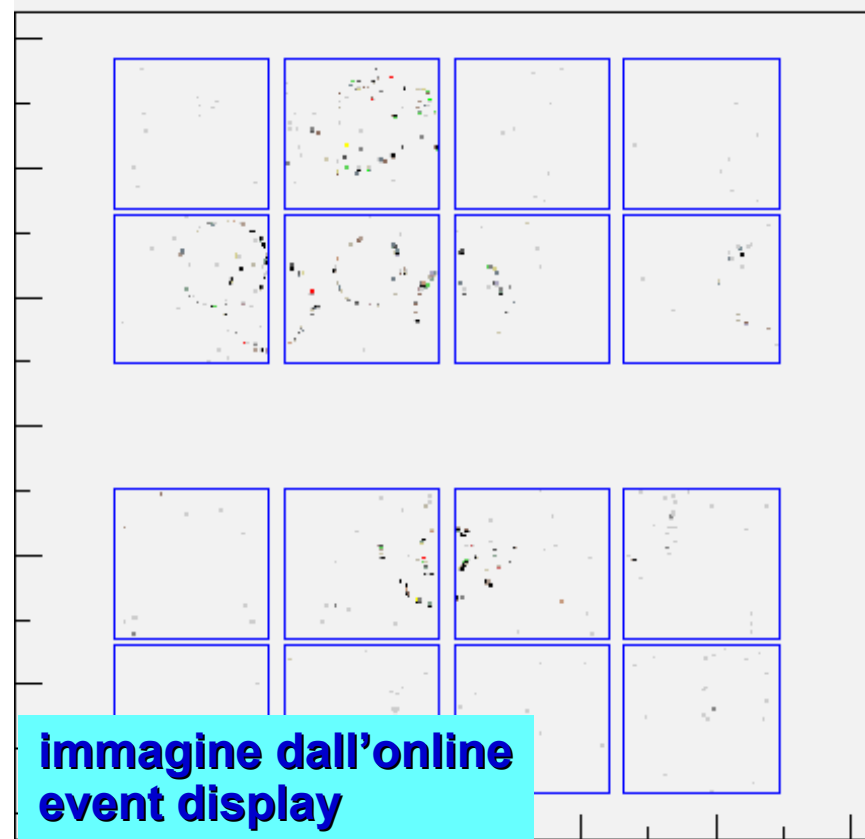
S. Dalla Torre
INFN – TRIESTE
(per il gruppo COMPASS RICH)

ISTITUTI:

- Torino, INFN e Università'
- Trieste, INFN e Università'
- Bielefeld, Università', contributo sistema gas
- CERN, supporto tecnico

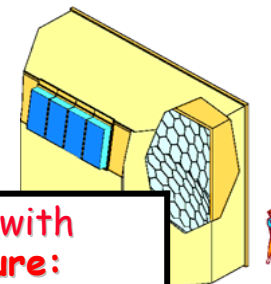
argomenti scelti:

- perché parlare di RICH
- il RICH-1 in COMPASS
- le principali caratteristiche del hardware
- le prestazioni del rivelatore





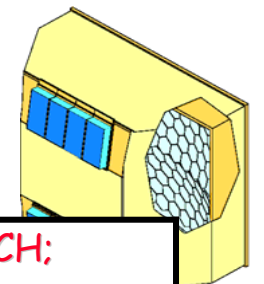
VITALITA' DEI RICH 1/2



Physics Topic	Examples: Exciting Issues (2004)	Some Experiments with RICH; Active/ Future: (and without RICH)
Heavy Flavor Physics	<ul style="list-style-type: none"> • Confronting the Standard Model: Precision Measurements of CP Violation in B Sector; • Are there experimental hints of New Physics? 	BaBar(SLAC), BELLE(KEK), CLEO-III(Cornell), CKM, SELEX, BTeV (Fermilab) LHCb (CERN); Super B-Factory (SLAC/KEK?)
Hadron Structure	<ul style="list-style-type: none"> • Do Pentaquarks exist? • Do other exotic hadrons exist? • What is quark content of new states? E.g., $D_{sJ}[2317]$; $D_{sJ}[2460]$; $D_{sJ}[2632]$(SELEX); X(3872) 	Many of the Heavy Flavor Experiments above; HERMES(DESY); COMPASS(CERN); (SELEX(Fermilab)) GSI: PANDA, CBM HALL-A (JLAB)
Neutrino Physics	<ul style="list-style-type: none"> • First Confirmed Physics Beyond SM • Are neutrinos Dirac or Majorana? • What is the mass hierarchy? • Neutrino Astrophysics 	Super Kamiokande; SNO(Sudbury); Lake Baikal; Ice Cube(South Pole); Antares(Mediterranean); NESTOR (Greece)



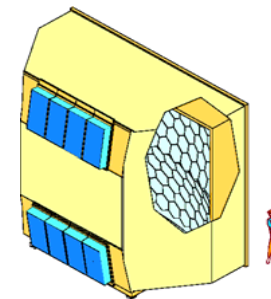
VITALITA' DEI RICH 2/2



Physics Topic	Examples: Exciting Issues (2004)	Some Experiments with RICH: Active/ Future: (and without RICH)
Quark Matter at High Density (Heavy Ions)	Discovery of Quark-Gluon Plasma	HADES(GSI) PHENIX(RHIC) STAR(RHIC) ALICE (CERN)
High Energy Frontier	Discovery! • Higgs?; • Supersymmetry?	CDF/DO(Fermilab) LHC/ILC
Astro-particle physics	• Ultra High Energy Cosmic Rays; • Very High Energy Gamma Rays;	<u>Discussed at this conference</u> AMS-02(Space) Auger (Argentina) HESS (Namibia): Puebla TUNKA (Siberia) Mexico/Chalcataya Magic (la Palma)



COMPASS



studio della fisica adronica

Con fascio di muoni *

- Contributo gluonico allo spin dei nucleoni $\Delta G/G$
- Le funzioni di distribuzione di spin trasverso $\Delta_T q(x)$
- la separazione in flavour delle distribuzioni di densita' polarizzate dei quark $\Delta q(x)$
- la fisica delle Λ
- la produzione difrattiva di VM

* Data collected

Con fasci adronici

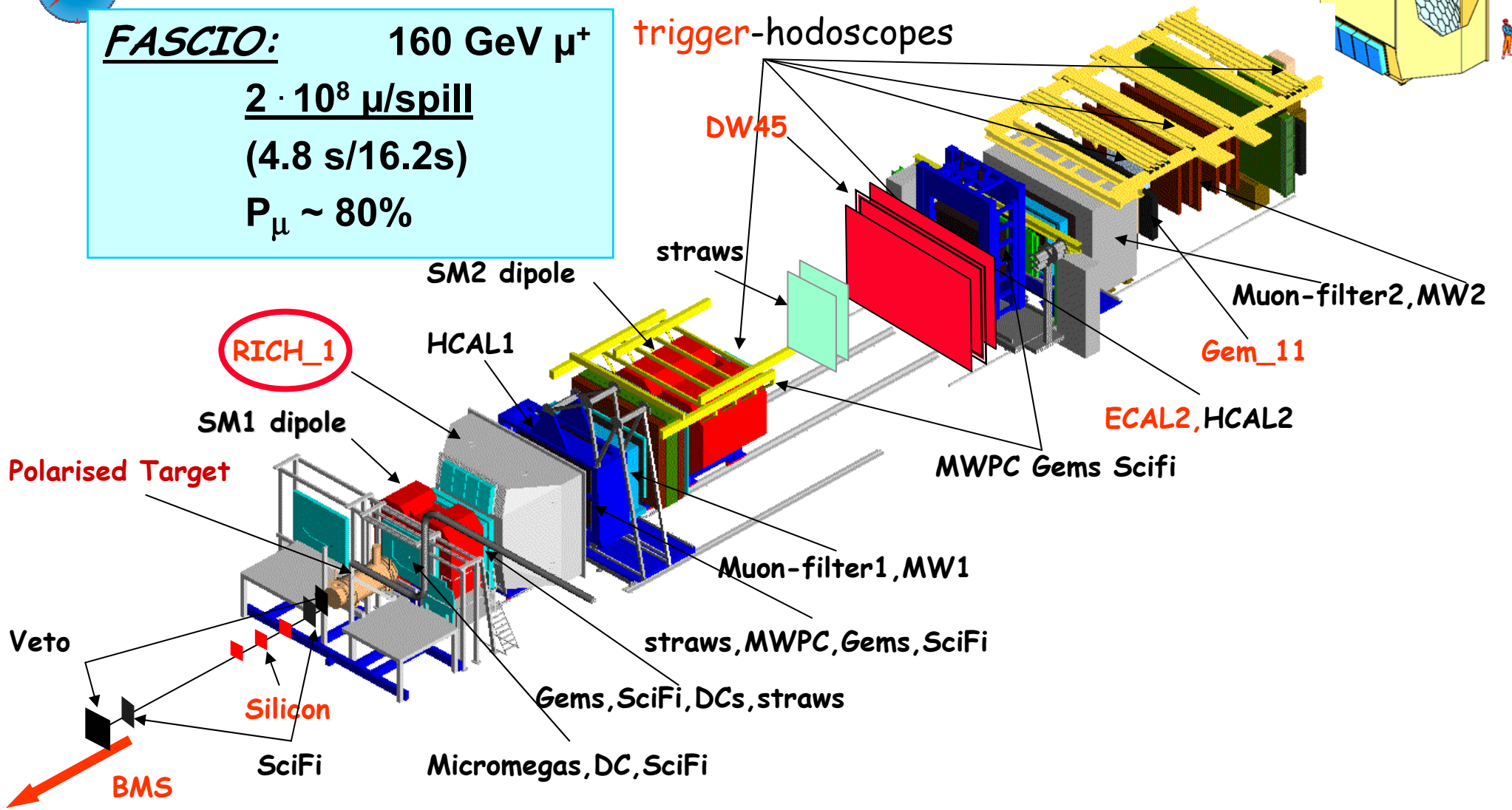
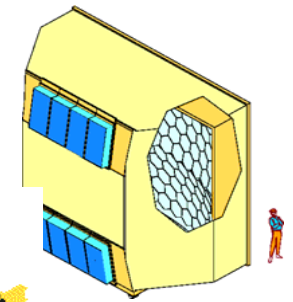
- Reazioni Primakoff *
- Polarizzabilita' del π e del K
- Glueball e ibridi
- Mesoni e barioni con charm
- Decadimenti semi-leptonici
- Barioni doppiamente charmati

LO SPETTROMETRO COMPASS



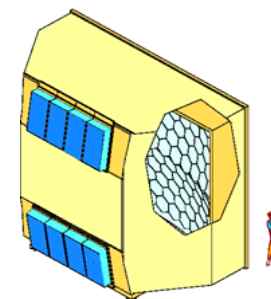
FASCIO: 160 GeV μ^+
 $2 \cdot 10^8 \mu/\text{spill}$
 (4.8 s/16.2s)
 $P_\mu \sim 80\%$

trigger-hodoscopes





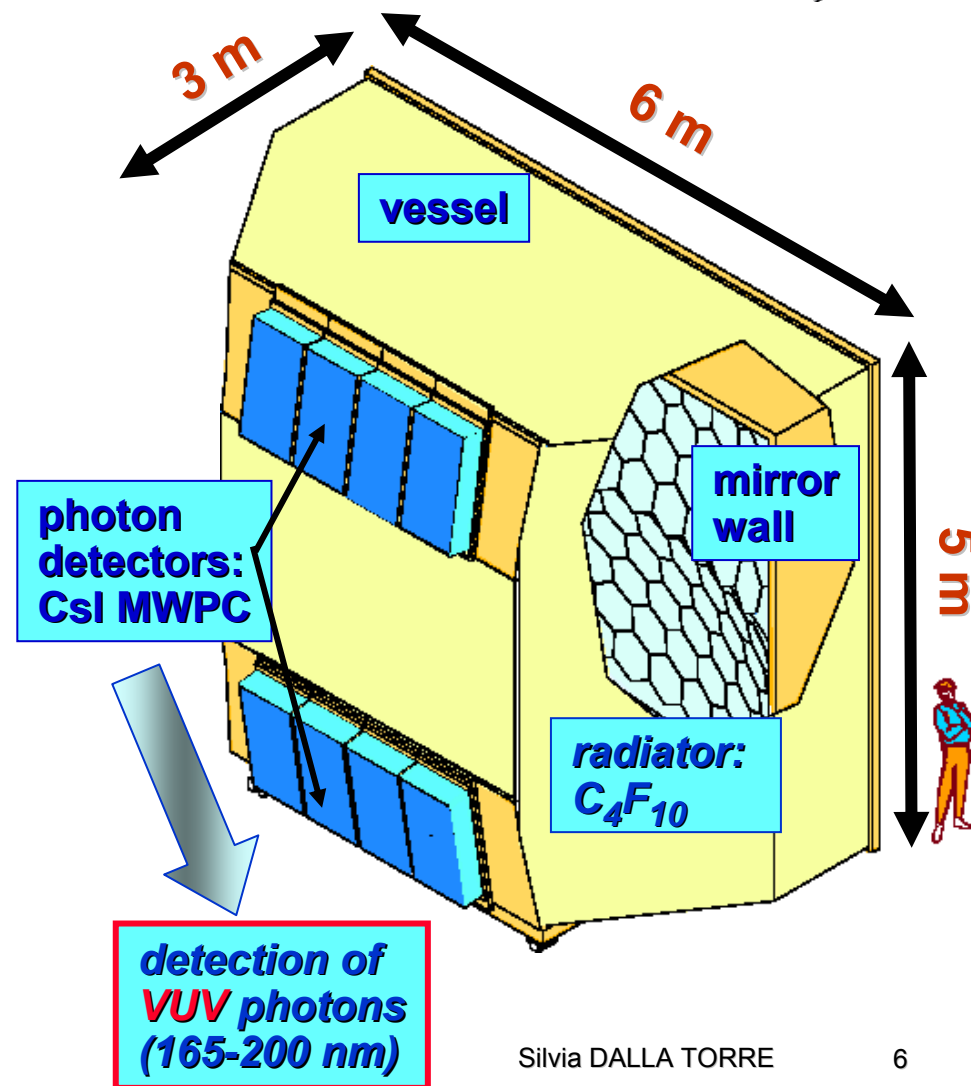
COMPASS RICH-1 - IL DISEGNO



DAI PARAMETRI DELL'ESPERIMENTO:

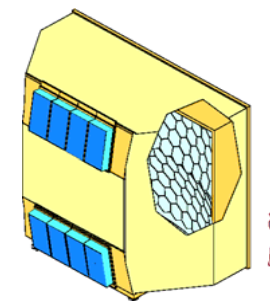
- h-PID fino a $p > 50 \text{ GeV}/c$
- grande accettazione(= grandi dimensioni trasverse):
 - H: 500 mrad
 - V: 400 mrad
- capacita' di sostenere
 - rate di trigger fino a 10^5 Hz
 - rate di fascio fino a 10^8 Hz
- materiale minimizzato

+ progetto del 1996





PHOTON DETECTION



rivelatori di fotoni:

5.3 m² MWPC

(8 camere) con

fotocatodi a CsI

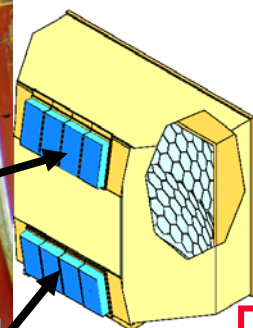
read-out:

**84,000 canali
analogici**

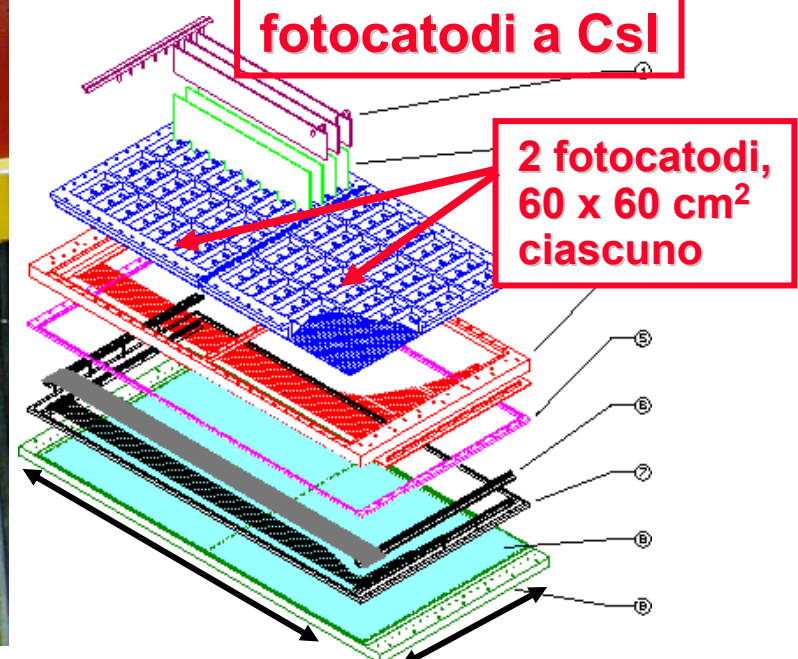
**con intelligenza
locale estesa**



**il piu' esteso
sistema di
fotorivelatori a
CsI in operazione**



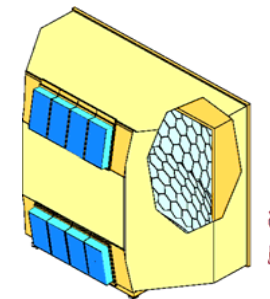
**MWPC con
fotocatodi a CsI**



**2 fotocatodi,
60 x 60 cm²
ciascuno**



MWPC CON FOTOCATODI DI GRANDI DIMENSIONI, L'ESPERIENZA COMPASS



stoccaggio dei catodi



Csl: igroscopico, l'acqua attacca la QE
catodi mai esposti all'aria
(max 50 ppm O₂, normalmente: 10 ppm)



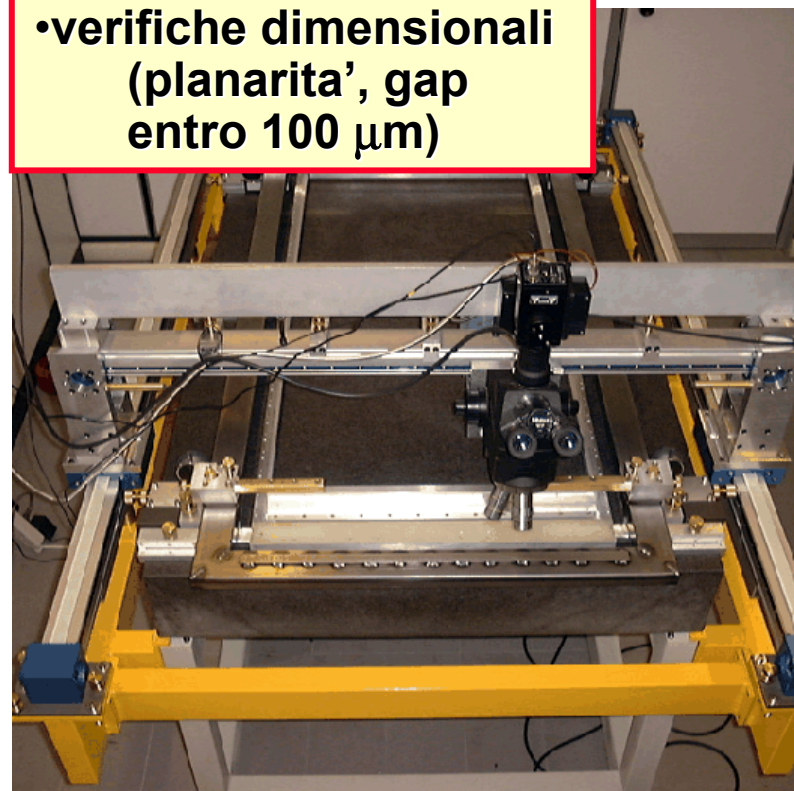
montaggio dei fotocatodi in camera a guanti

Tavolo rettificato con movimento x,y e microscopio per

- saldare i fili anodici
- verifiche dimensionali (planarita', gap entro 100 μm)

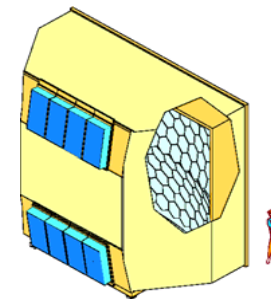


trasporto dei fotocatodi





COMPORTAMENTO DEI FOTORIVELATORI



instabilita' elettriche dei fotorivelatori in ambiente radioattivo (*),

TEMPI DI RECUPERO LUNGI ! (~ 1 d)

instabilita' legate a piccoli difetti locali

superate con :

- controllo parametri geometrici
- ispezione filo (al microscopio)
- validazione al GIF

2001 - 2/8 camere stabili

2002 - 5/8 camere stabili

2003, 2004 – segmentando la HV:

97% della superficie camere stabile

→ stabili fino a ~2000 V → $\epsilon_{\text{fotoel}} = 65-70\%$ (85% ai test beam)

(*) nel fascio di μ :

flusso di MIP : $\sim 5 \times 10^5 / \text{s} / \text{m}^2$

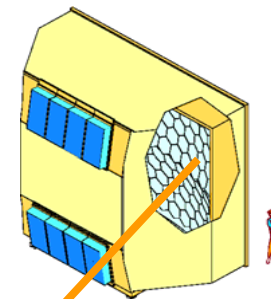
flusso di fotoni : fino a $3 \times 10^5 / \text{s} / \text{cm}^2$

**filo difettoso,
diametro 20 μm**

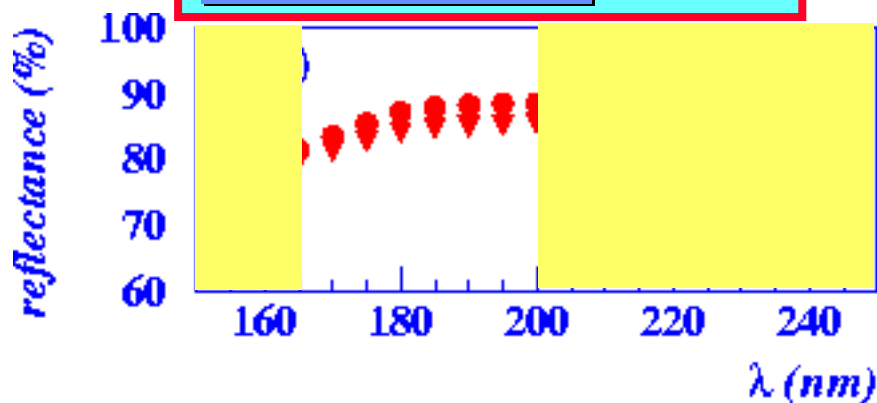




IL SISTEMA DEGLI SPECCHI

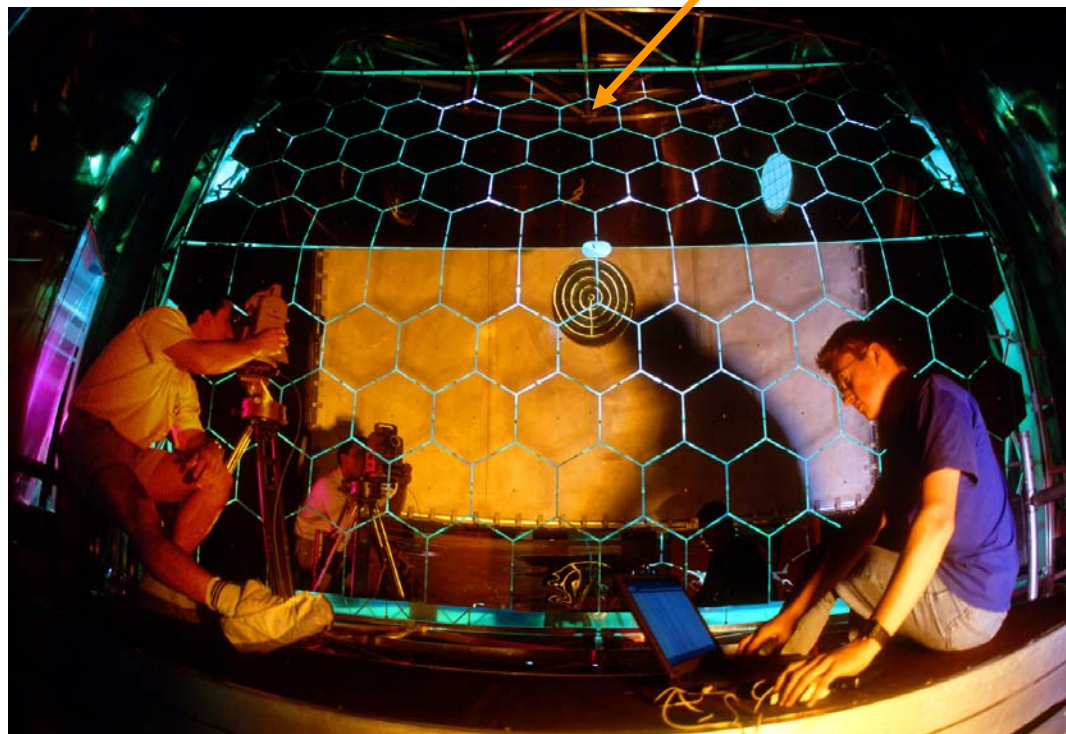
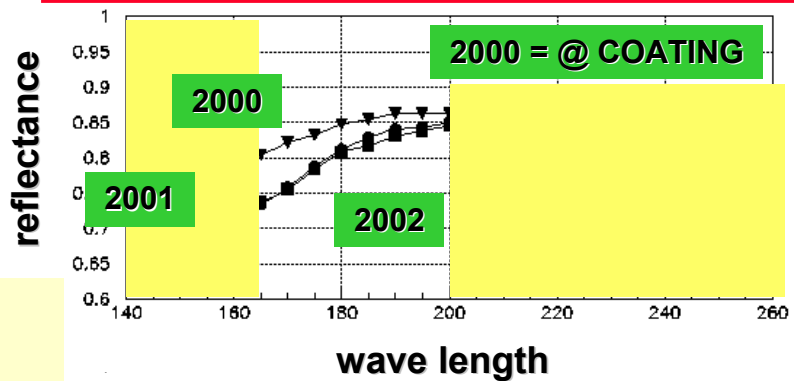


media sui 126 specchi,
alla produzione



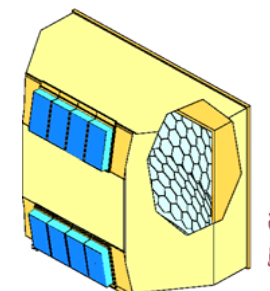
'la parete specchi VUV',
21 m², 116 elementi
raggio: 6.6 m

riflettanza stabile nel tempo





LA MECCANICA DEL MIRROR WALL: COME ESSERE LEGGERI, RIGIDI E REGOLABILI



la parete durante
l'assemblaggio

l'elemento della
struttura modulare

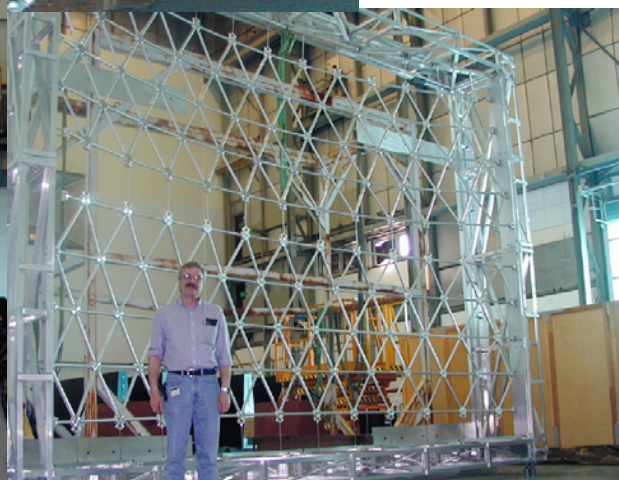
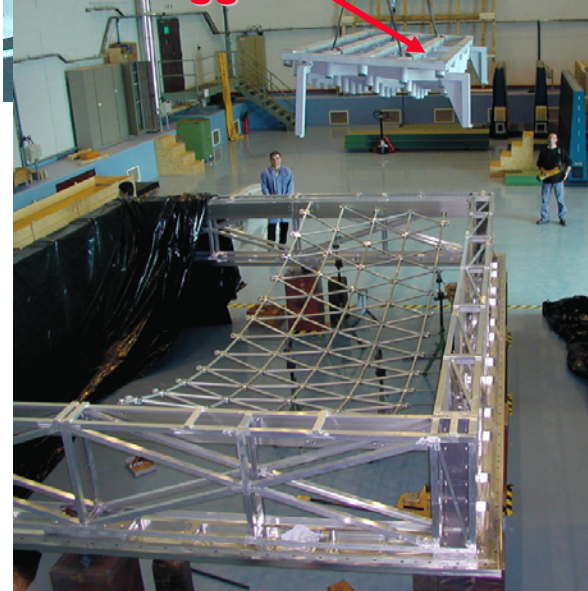
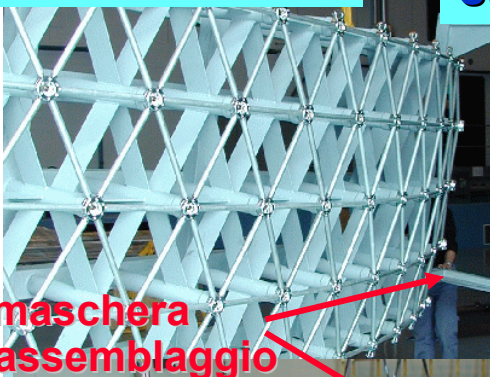
SPESSORE

meccanica: $2.5 \% X_0$
specchi $\sim 5.5 \% X_0$

STABILITA':

Dopo una deformazione
iniziale di ~ 1 mrad,
stabile: 0.1 mrad su ~ 3.5 y

la maschera
di assemblaggio



la struttura meccanica
della parete assemblata



supporti
individuali

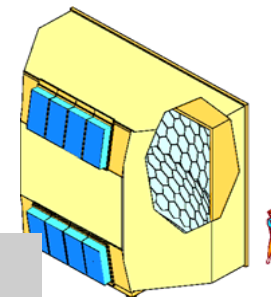
mirror rear side



regolazione per
l'allineamento
angolare,
2 movimenti
ortogonali
(ris. < 0.1 mrad)

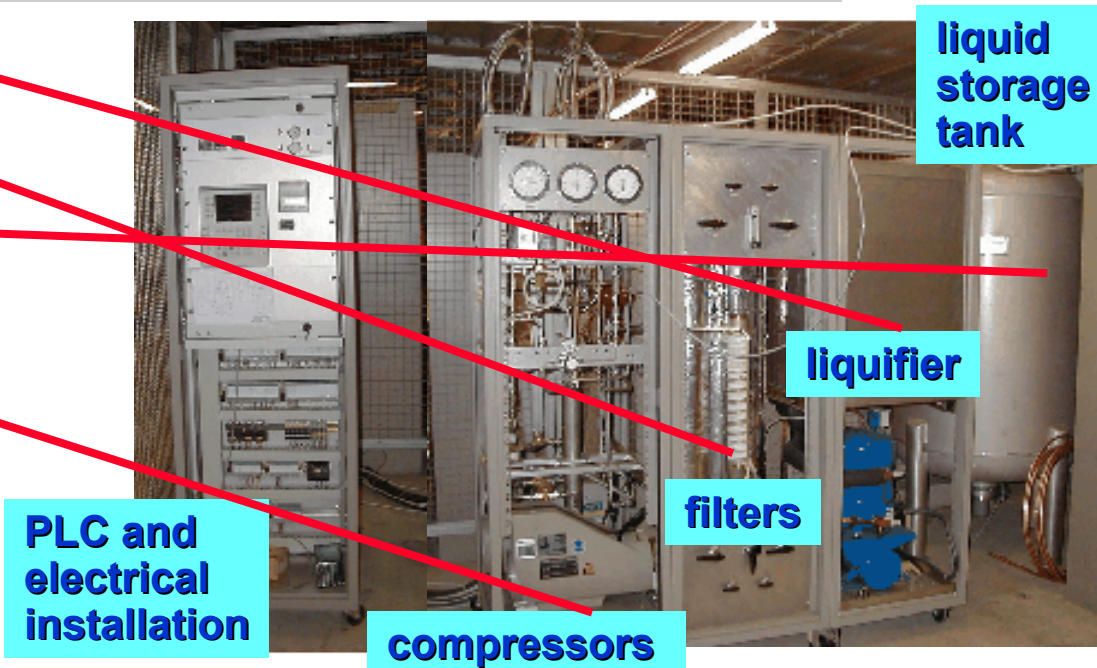
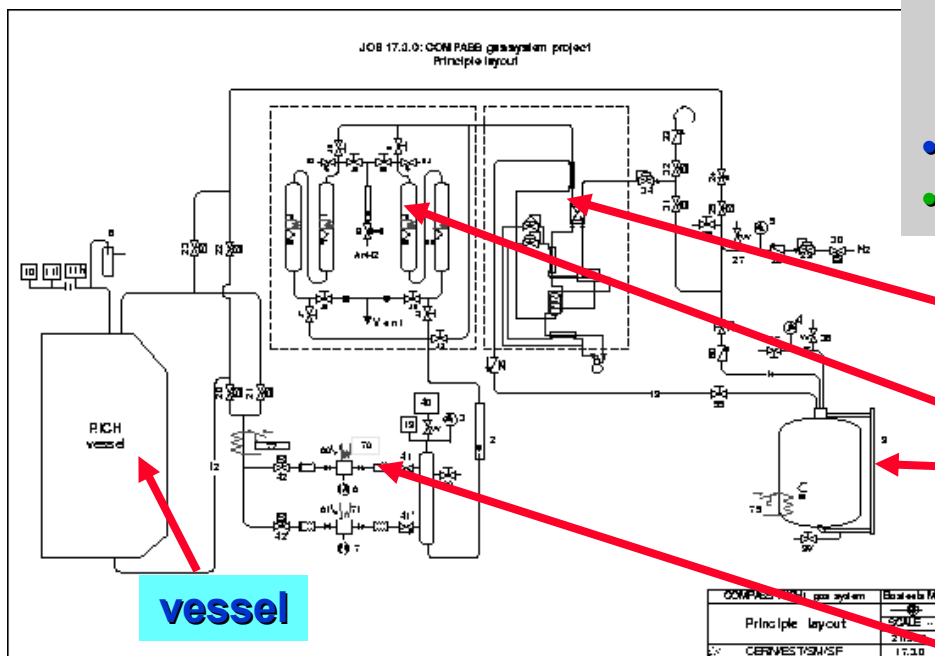


IL SISTEMA DEL GAS RADIATORE C₄F₁₀



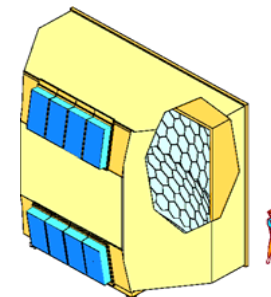
funzioni:

- P relativa costante (+/- 0.1 mbar) per limitare ΔP su
 - finestre del serbatoio
 - Lastre di quarzo
 - beam pipe contenente He
- filtraggio del gas (rimozione H₂O, O₂)
- riempimento/recupero C₄F₁₀





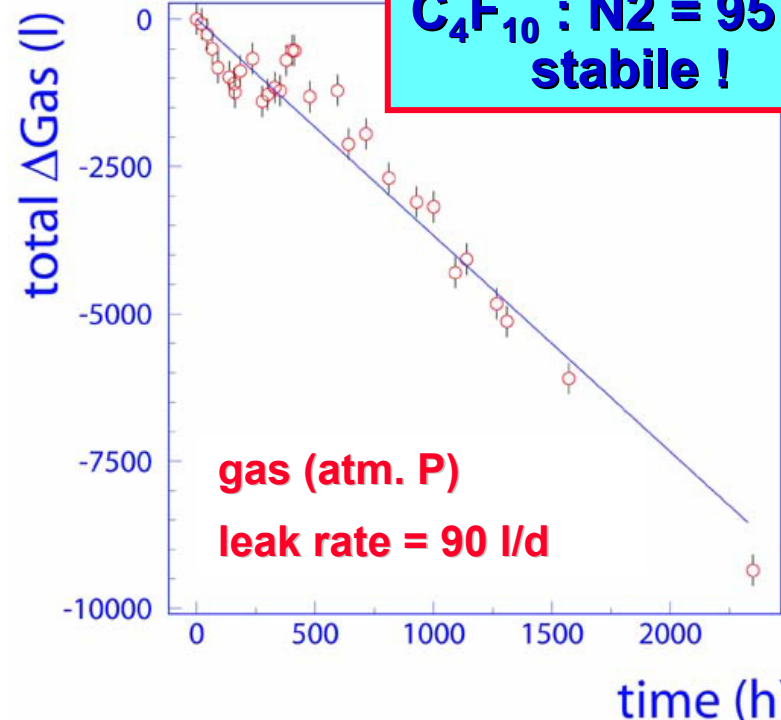
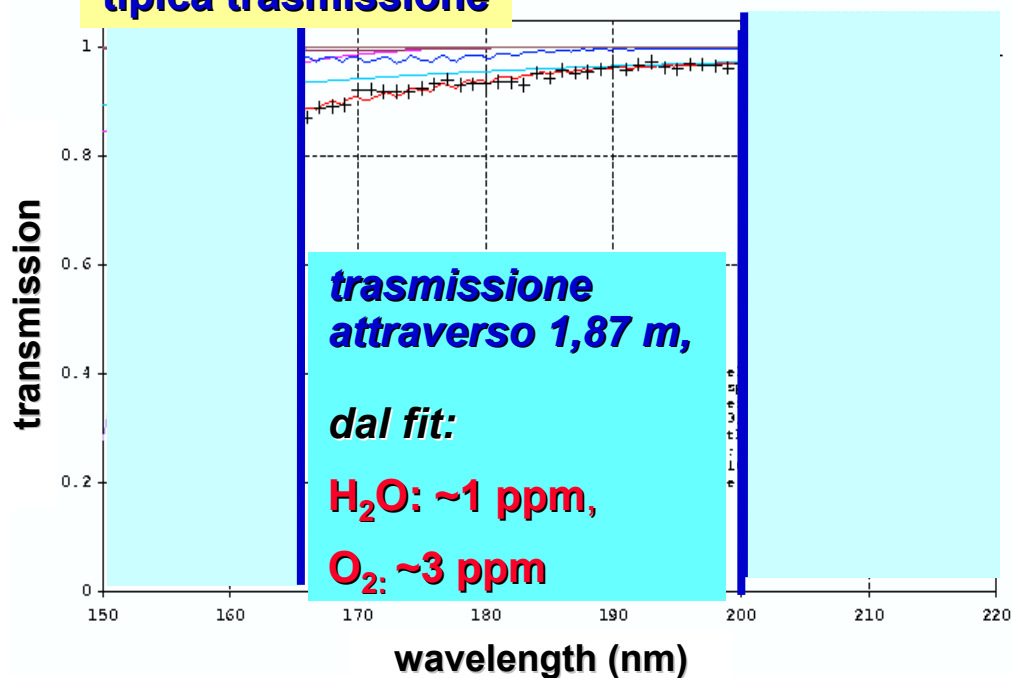
PRESTAZIONI



- ottima trasparenza,
meglio dei parametri di progetto
- filtri on-line a funzioni separate:
 - catalizzatore Cu, ~ 40°C per O₂
 - filtro molecolare 5A, ~ 10°C per H₂O

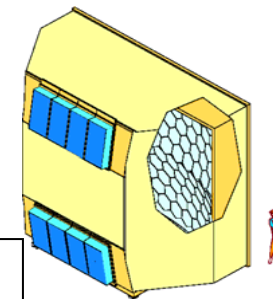
- perdite ridottissime:
- volume del serbatoio 85 m³
- lunghezza orale o-ring : ~ 100 m

tipica trasmissione

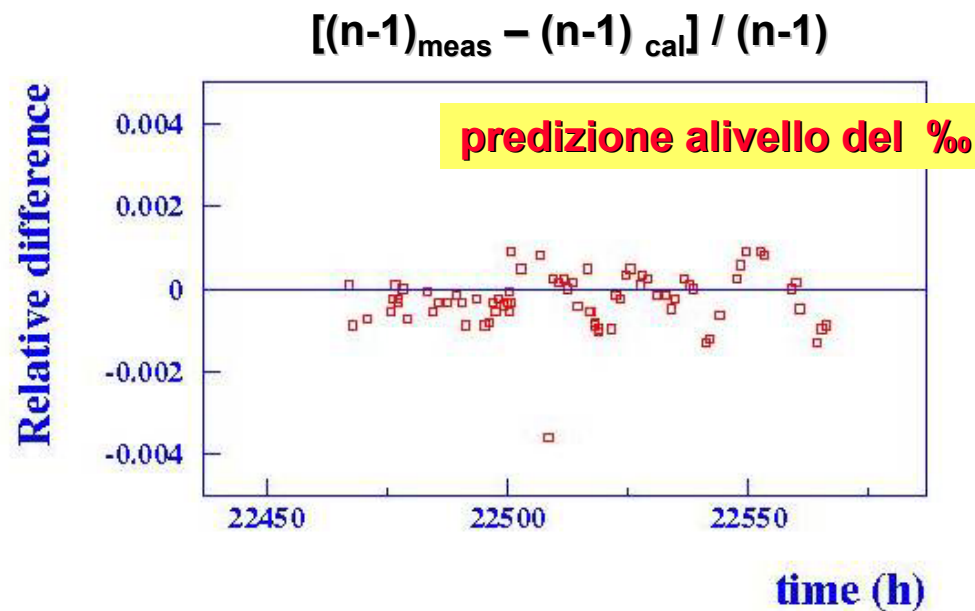
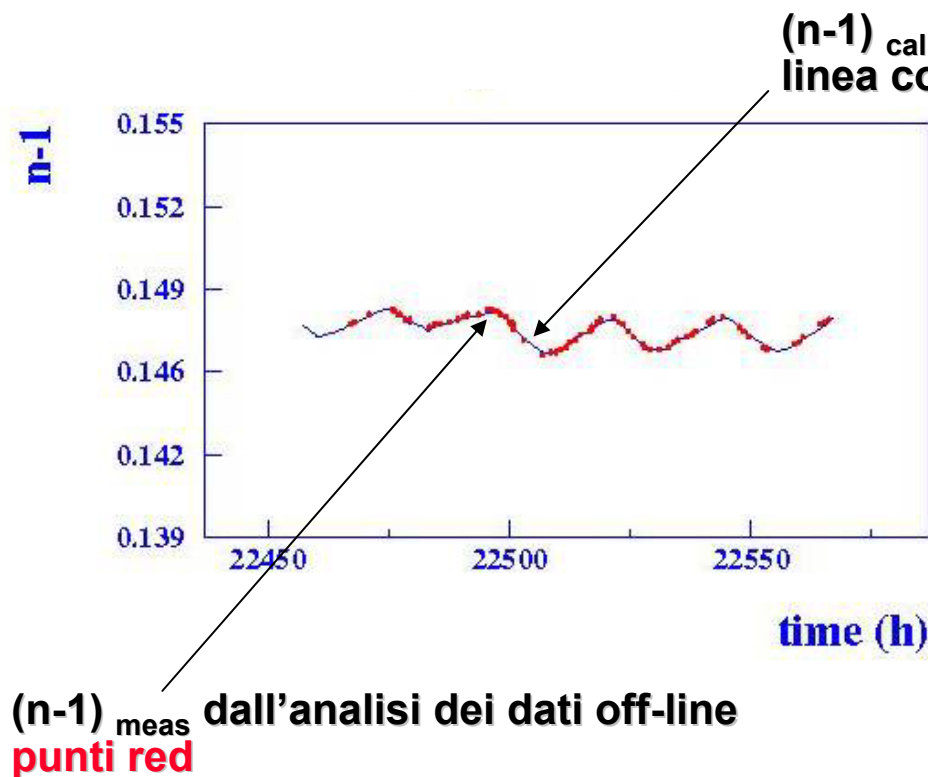




LA PREDIZIONE ON-LINE DI (n-1)

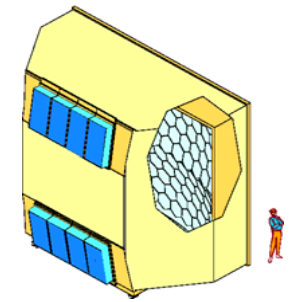


PER PERMETTERE LA PROCESSATURA QUASI ON-LINE DEI DATI:
UNA NECESSITA' PER COMPASS, IN FATTI = 3 TB/day

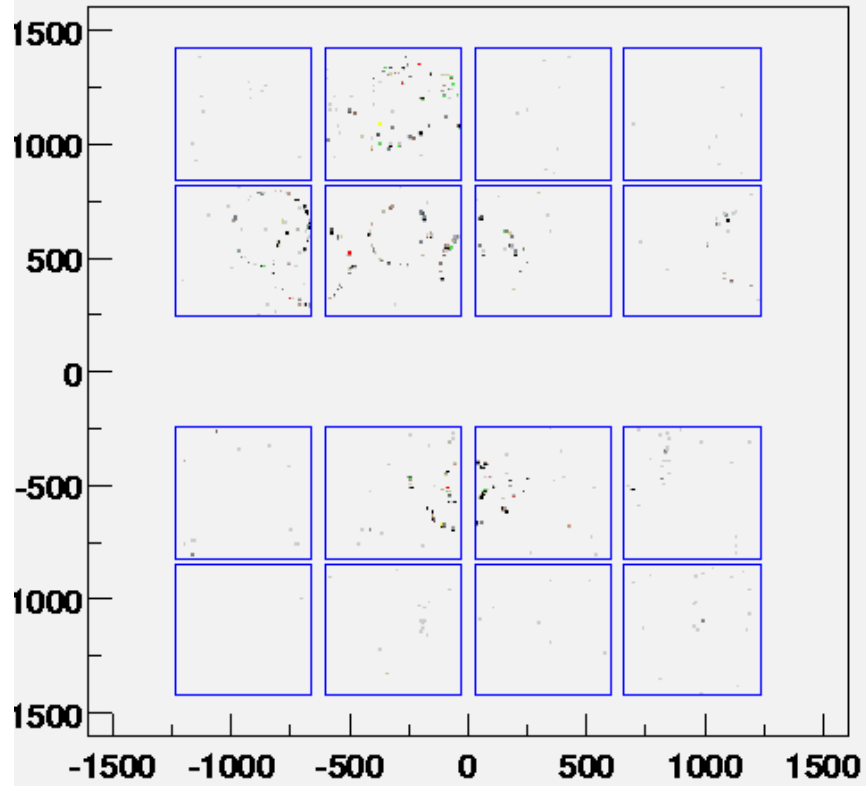




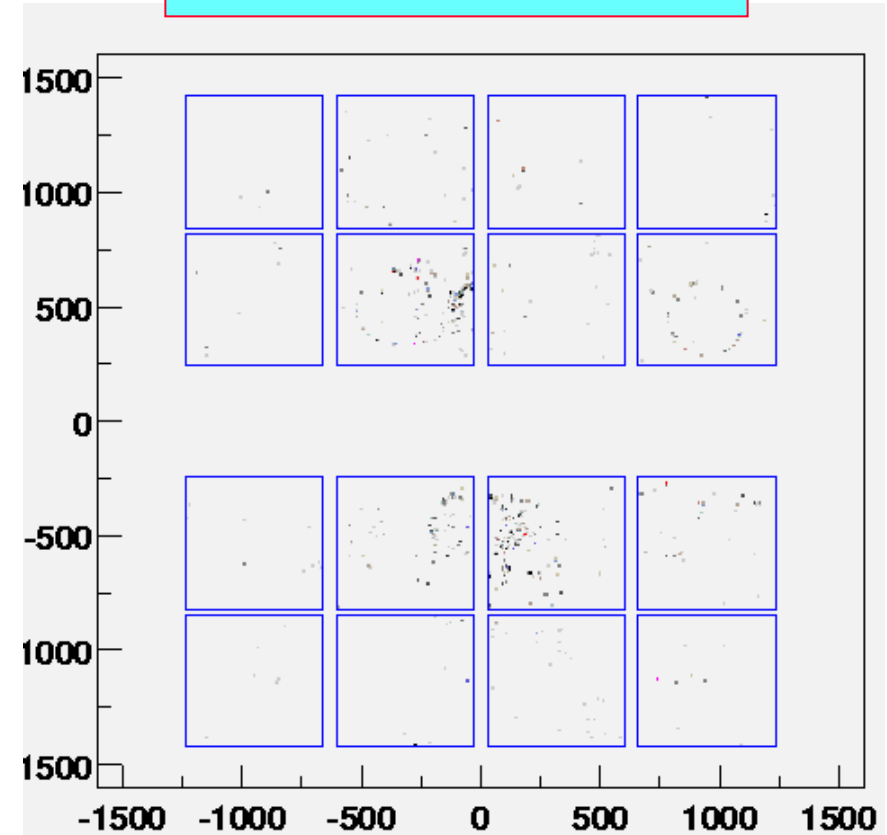
L' INFORMAZIONE BRUTA



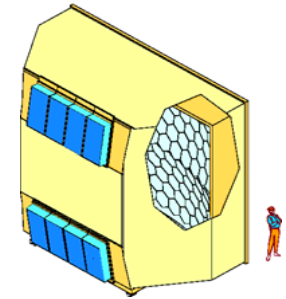
un evento, run di calibrazione
a bassa intensita': $10^7/\text{sec}$



un evento, run standard ad
Intensita' nominale: $4 \times 10^7/\text{sec}$

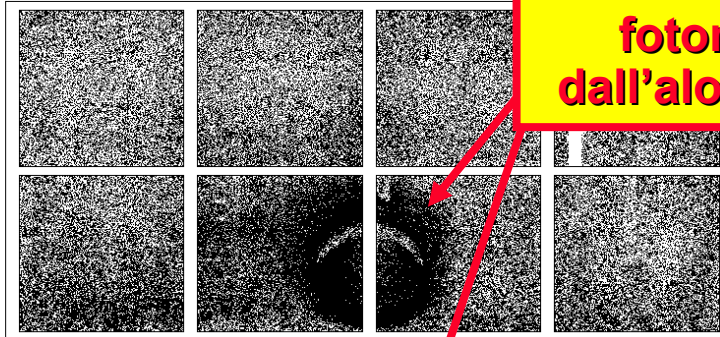


LA REGIONE CENTRALE DEL RICH-1



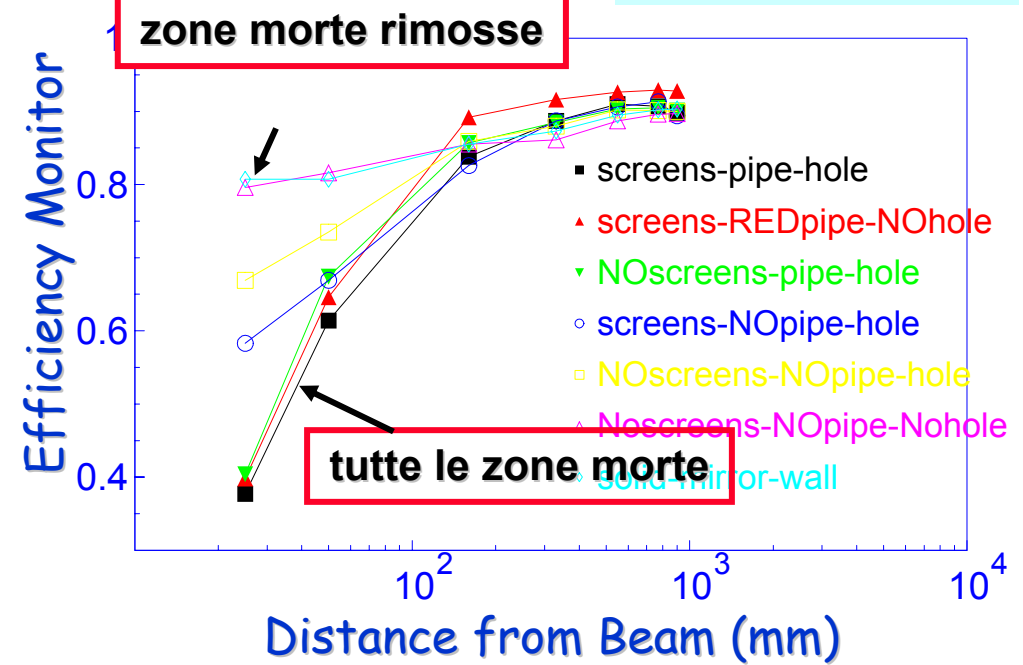
- 2 effetti combinati:
- l'alone el fascio
 - le zone morte centrali

plot cumulativo di eventi



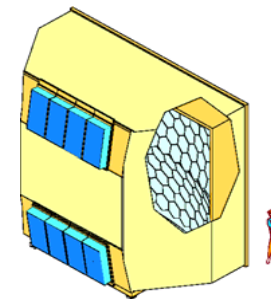
fotoni generati dall'alone del fascio

efficienza PID da Monte Carlo geometrico



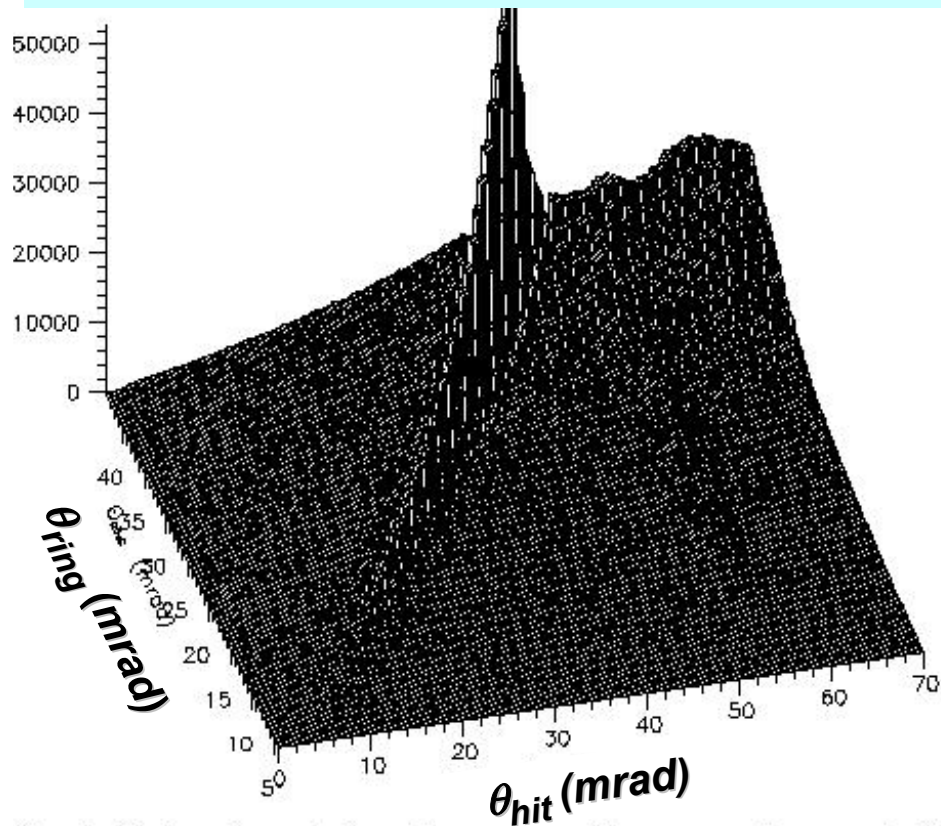


LE PRESTAZIONI PER "FOTONI SINGOLI"

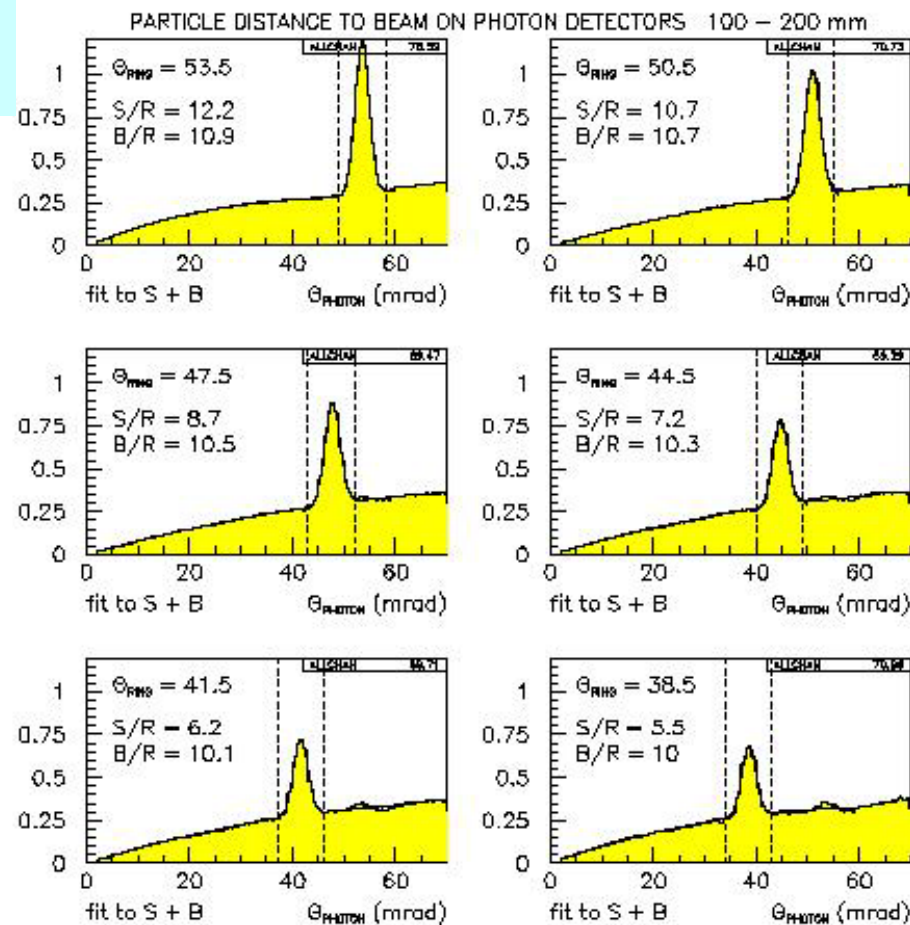


particelle selezionate secondo l'angolo polare e producendo bande in θ_{ring} \rightarrow informazione su :

- **risoluzione**
- **numero di fotoni rivelati**
- **fondo**

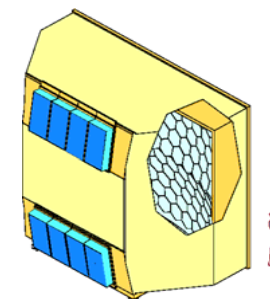


esempio

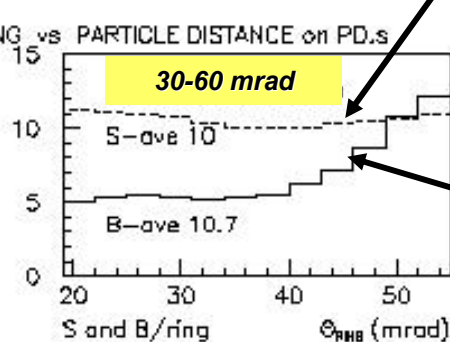
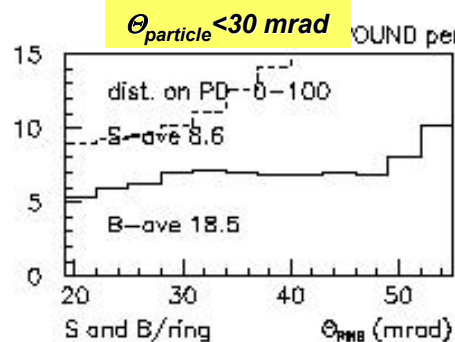




NUMERO DI FOTONI

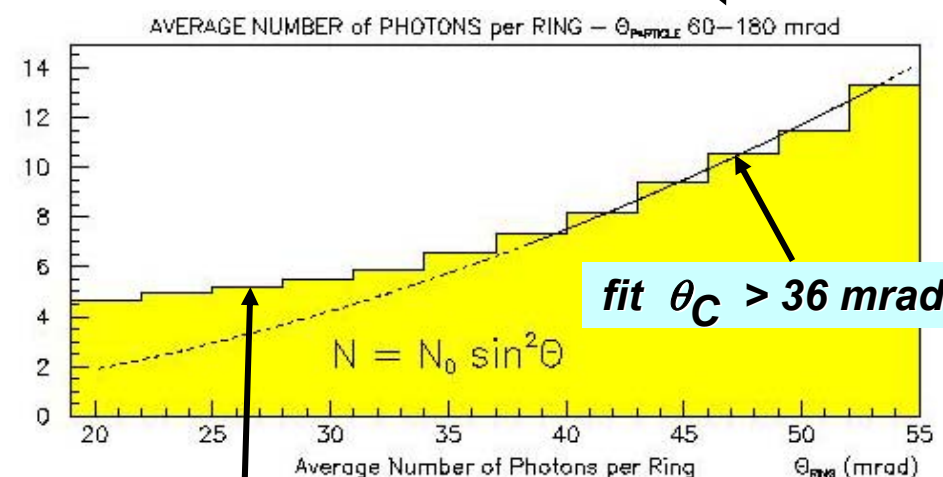
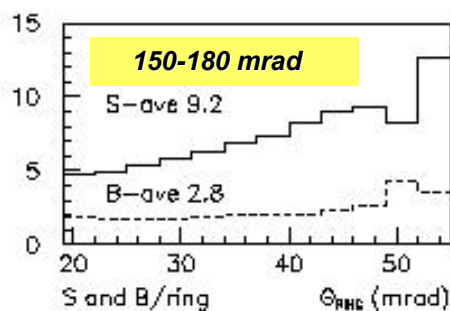
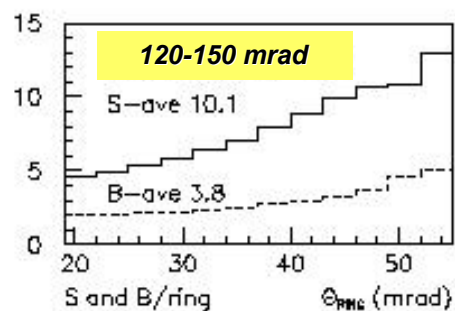
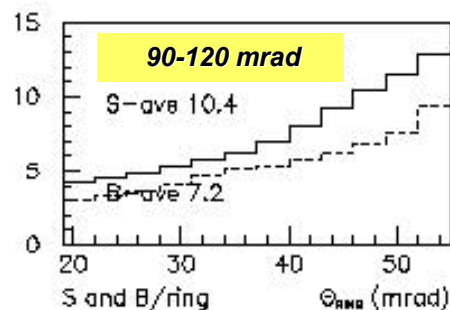
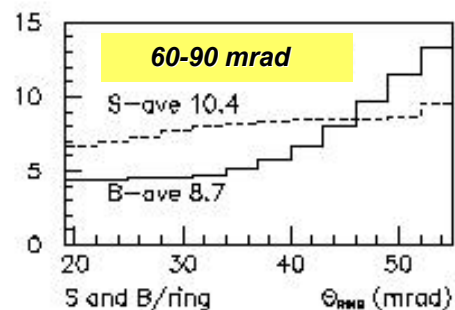


FONDO nella regione dell'anello



N. FOTONI

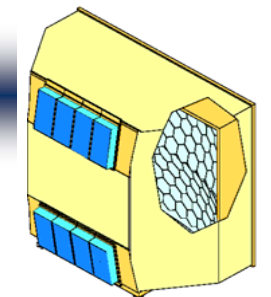
$\theta_{particella} > 60 \text{ mrad}$



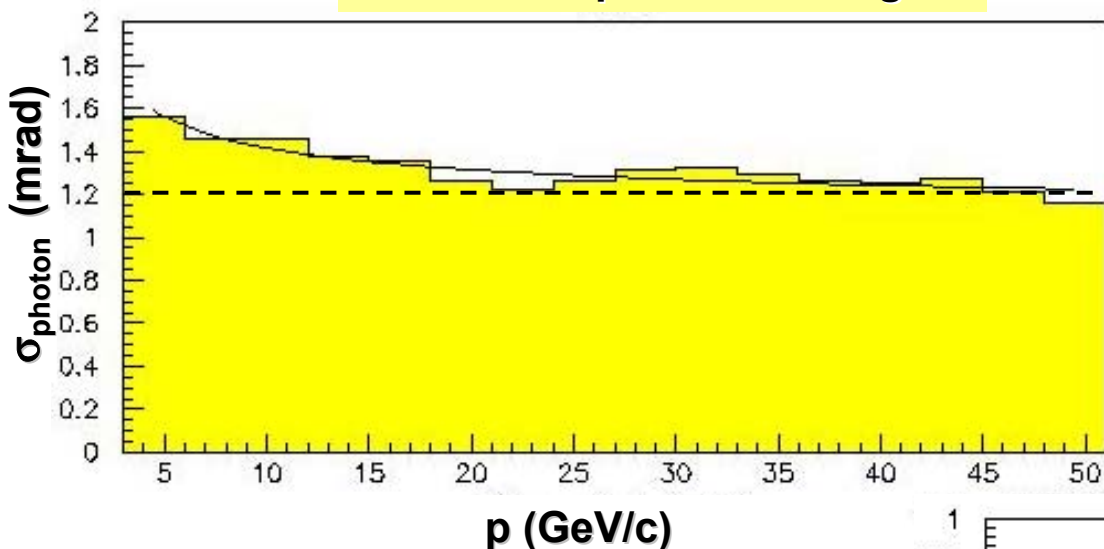
anelli con < 5 fotoni non ricostruiti



RISOLUZIONE

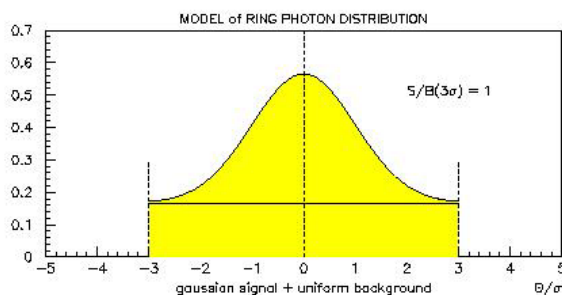
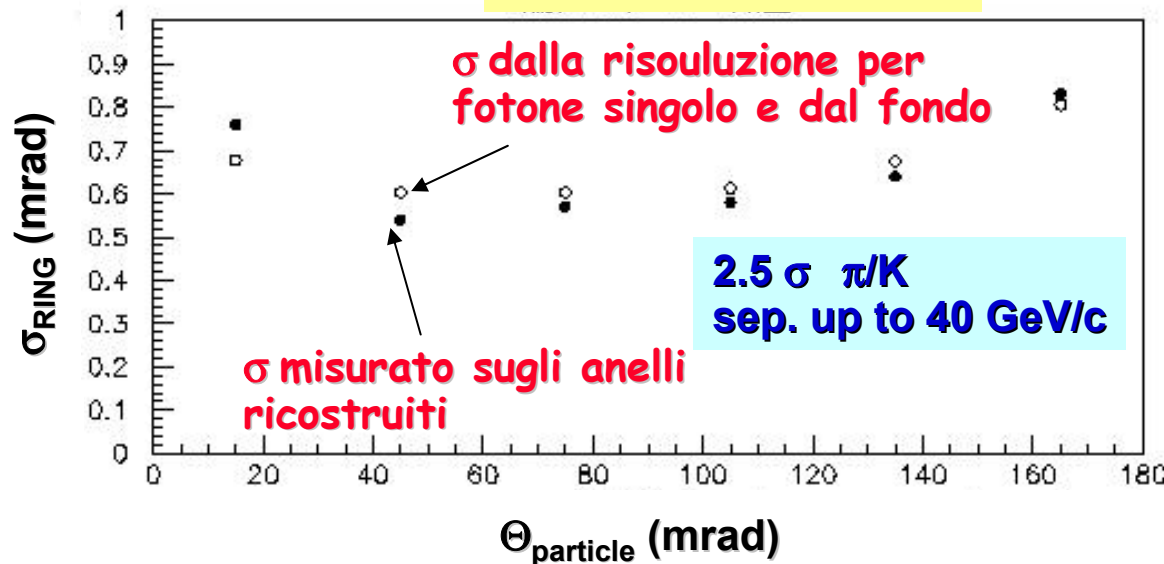


risoluzione per fotone singolo



confronto della **risoluzione da anello** direttamente **misurata** (anelli ricostruiti) e **calcolata dalla risoluzione per fotone singolo**: in ottimo accordo → **IL RIVELATORE E' COMPLETAMENTE CAPITO**

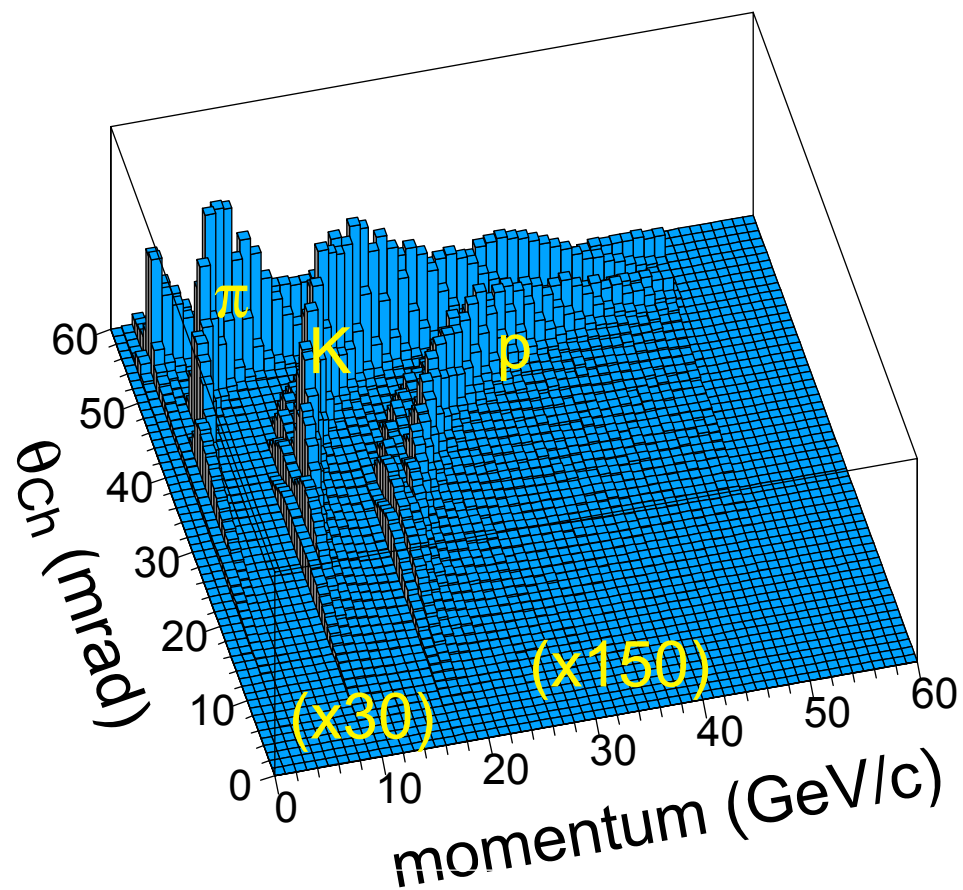
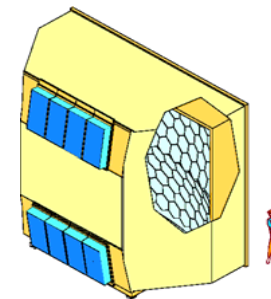
risoluzione dall'anello



$$\sigma_{\Theta \text{ RING}}^2 = \frac{(1 + 3 \frac{B}{S})}{(1 + \frac{B}{S})} \frac{\sigma_{\Theta \text{ PHOTON}}^2}{S}$$

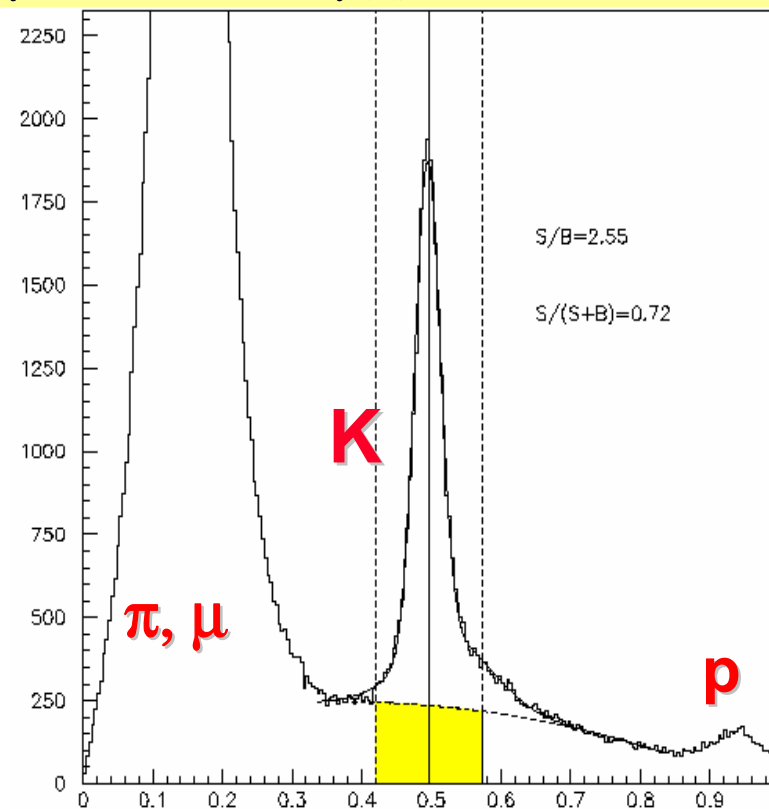


L'IDENTIFICAZIONE



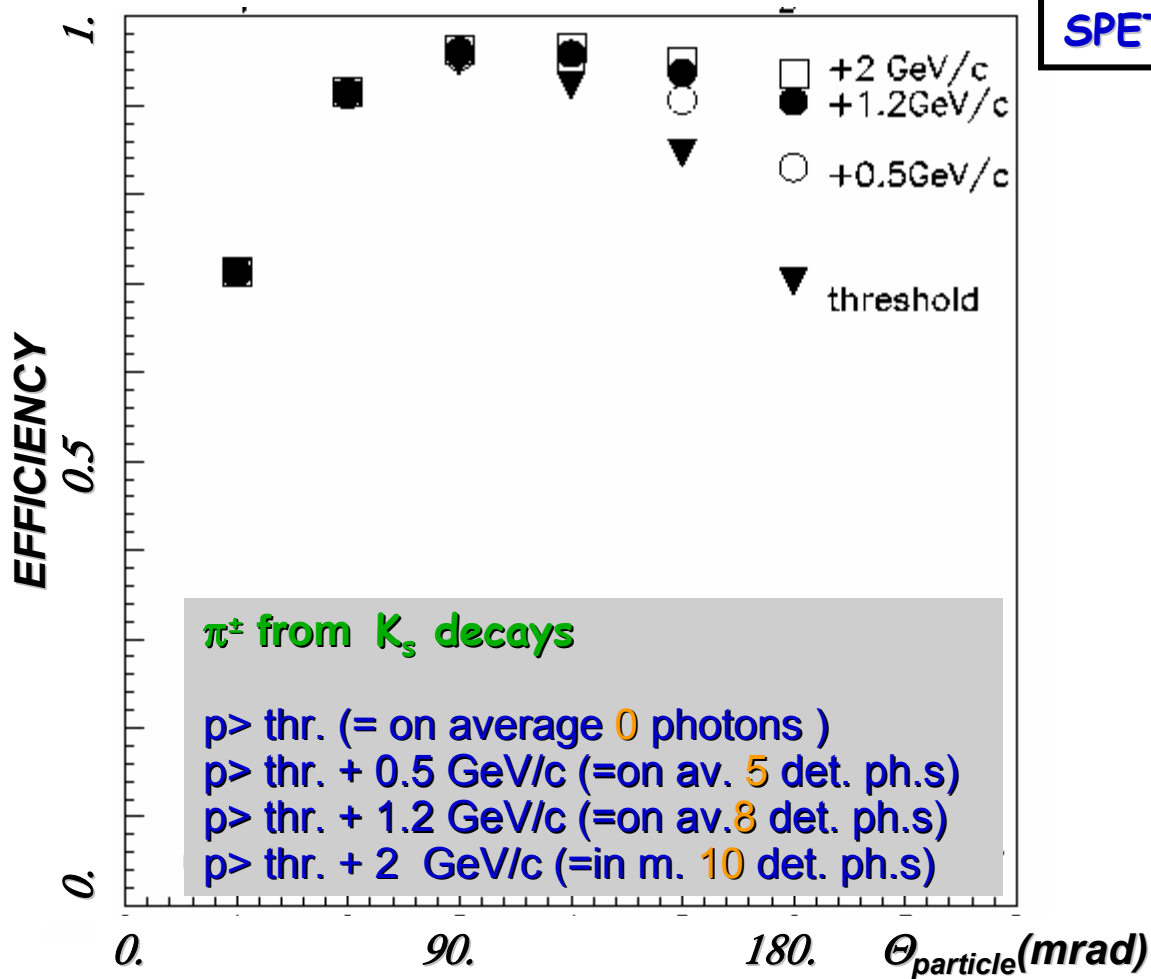
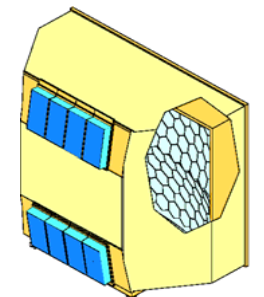
$$\theta_{particle} > 25 \text{ mrad}$$

$$p \text{ (GeV/c)} > p_{thr}(K) + 2 \text{ GeV/c}$$

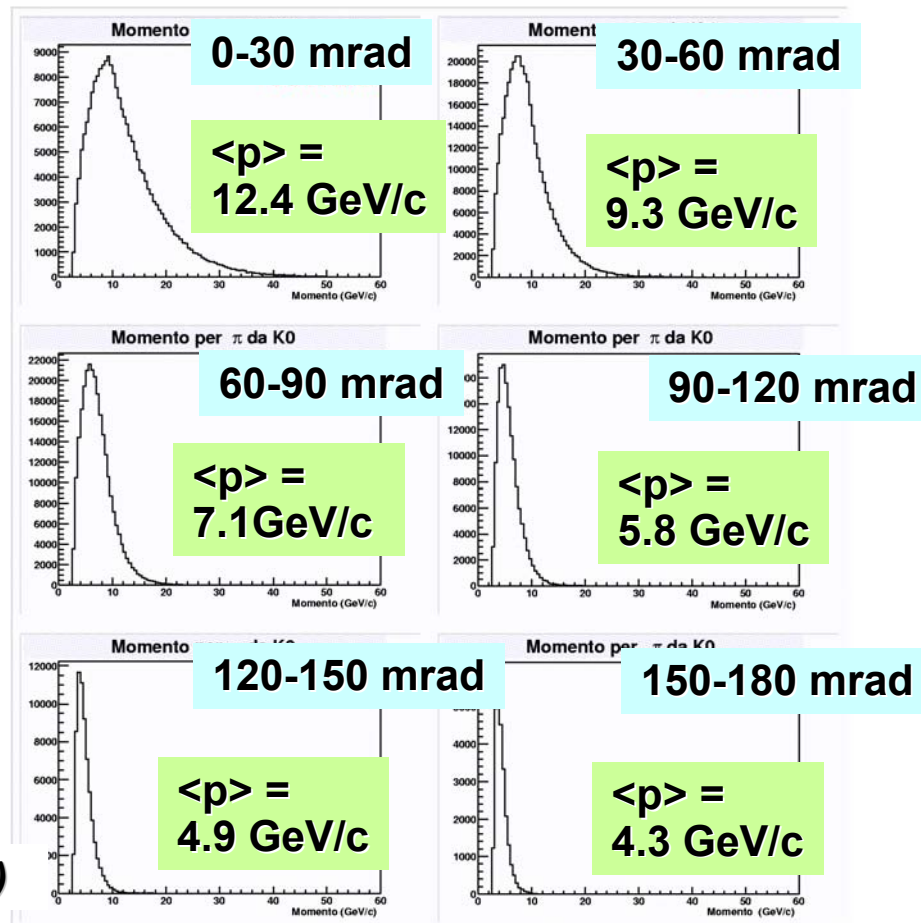




L' EFFICIENZA DI IDENTIFICAZIONE

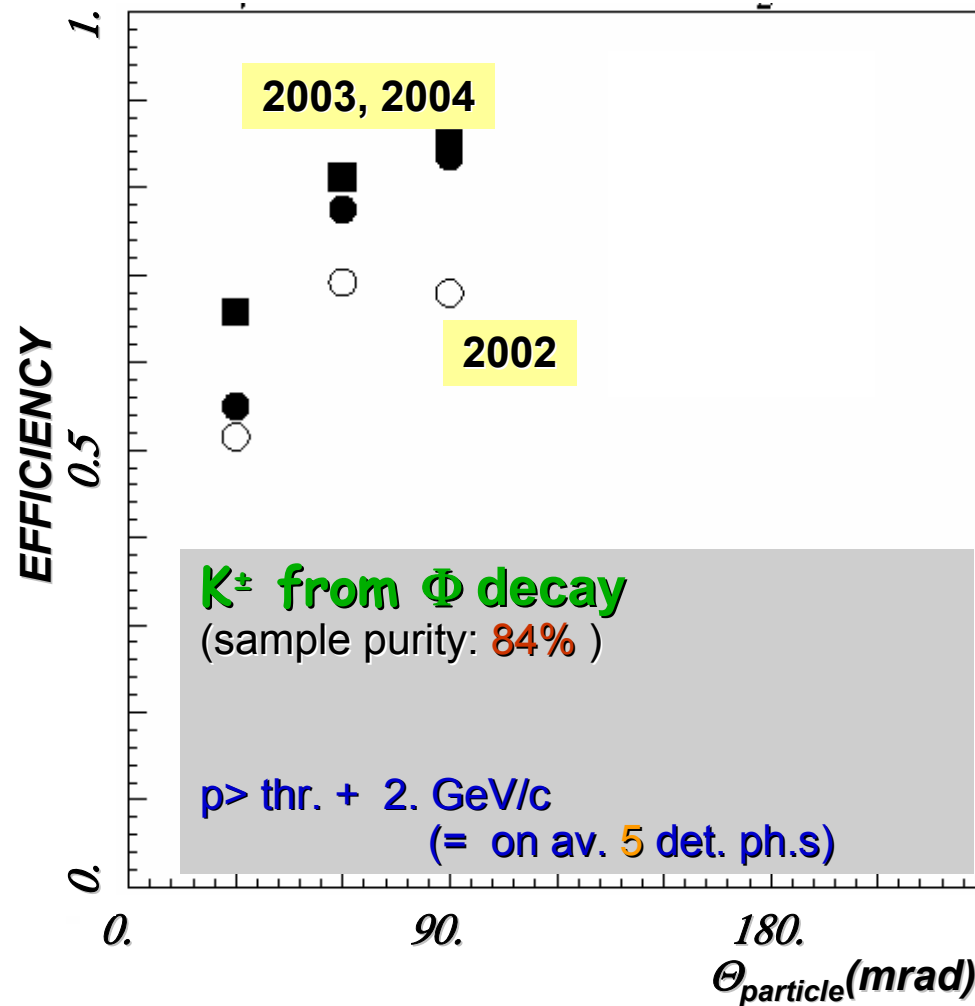
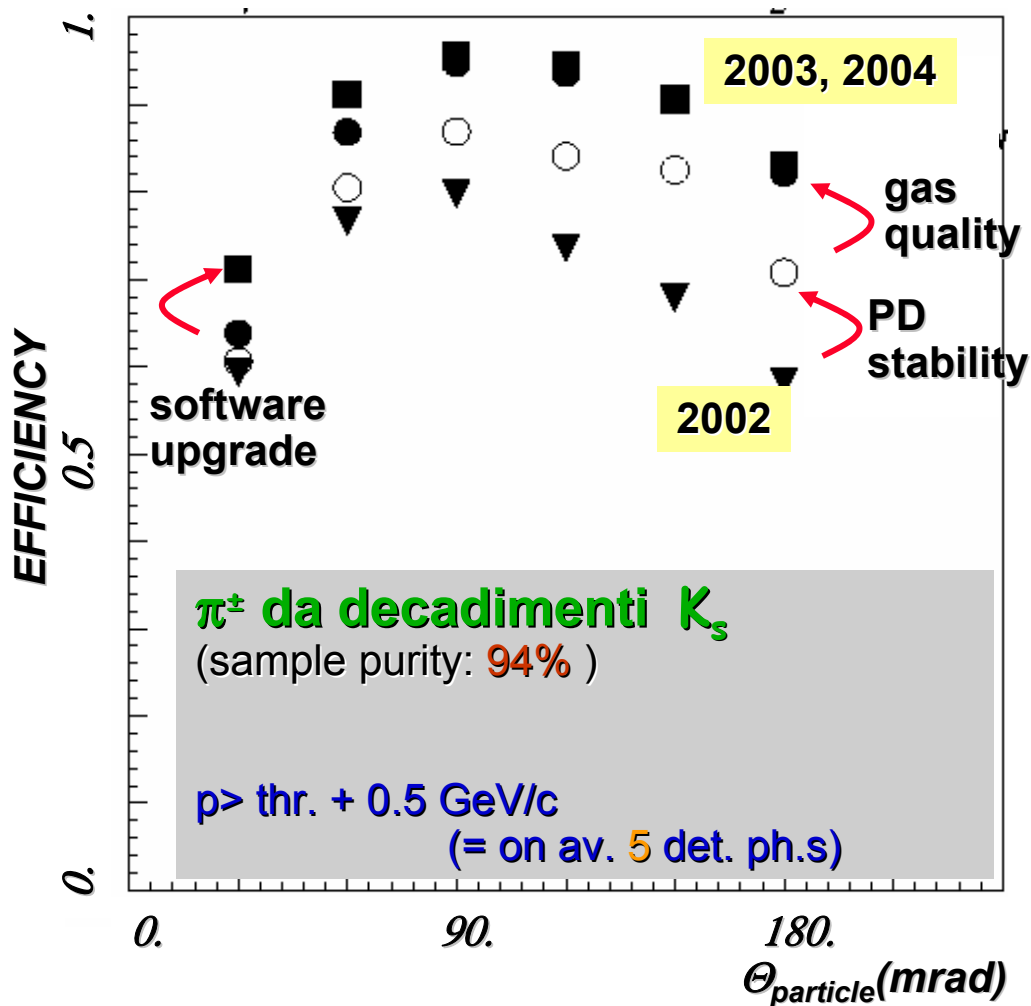
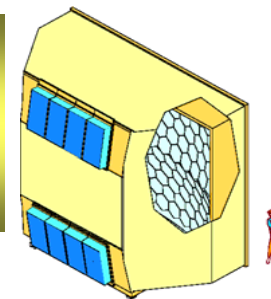


SPETTRI DI MOMENTO IN BIN DI $\theta_{particle}$





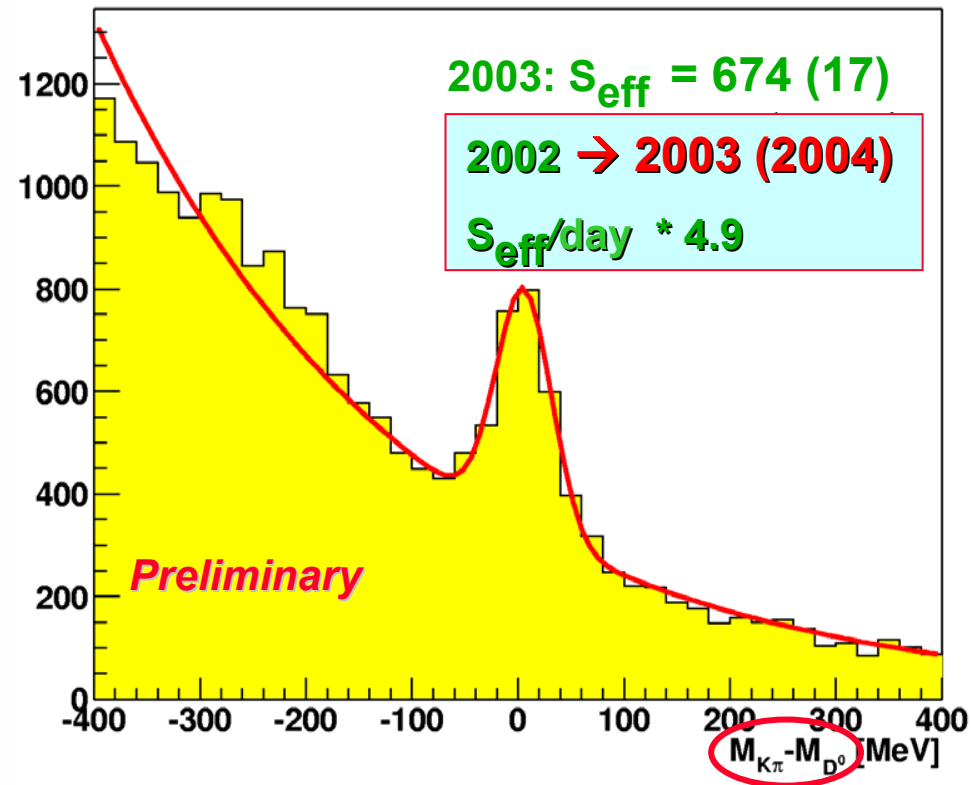
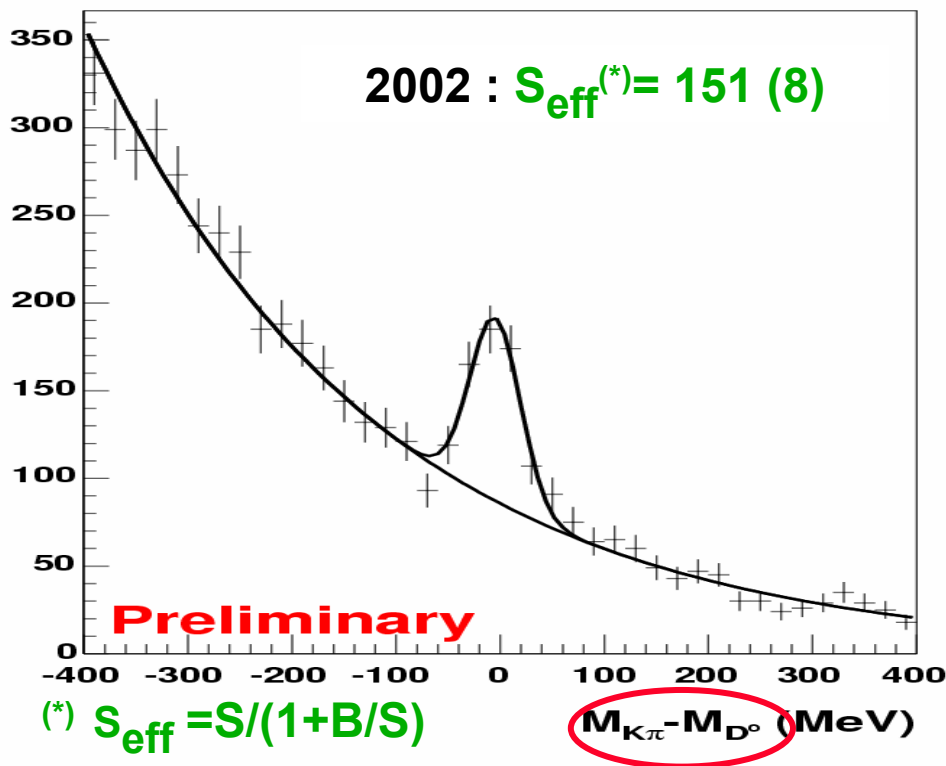
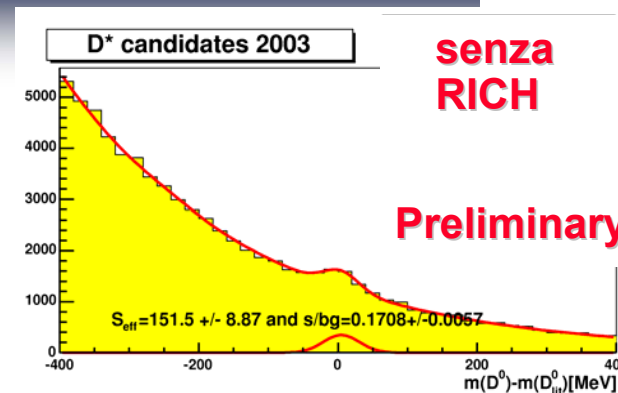
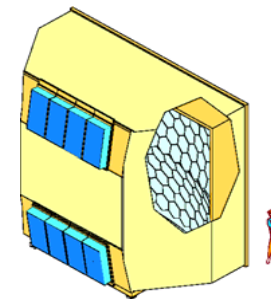
L'EFFICIENZA DI PID, LA CURVA DI APPRENDIMENTO



IL RICH-1 nella FISICA DI COMPASS

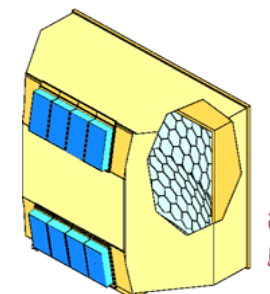


Un esempio notevole:
 $\Delta G/G$ da open charm, il segnale
 $\rightarrow D^0$ & \bar{D}^0 senza rivelatore
 microvertice

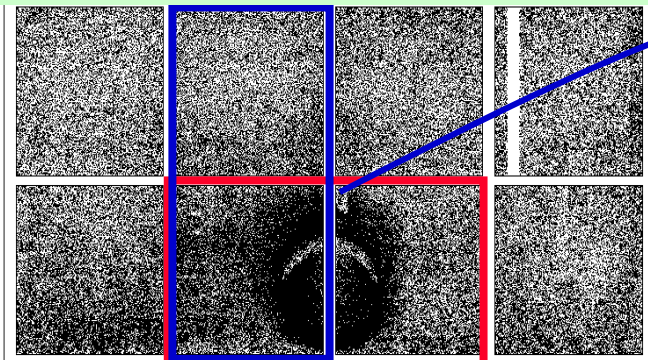




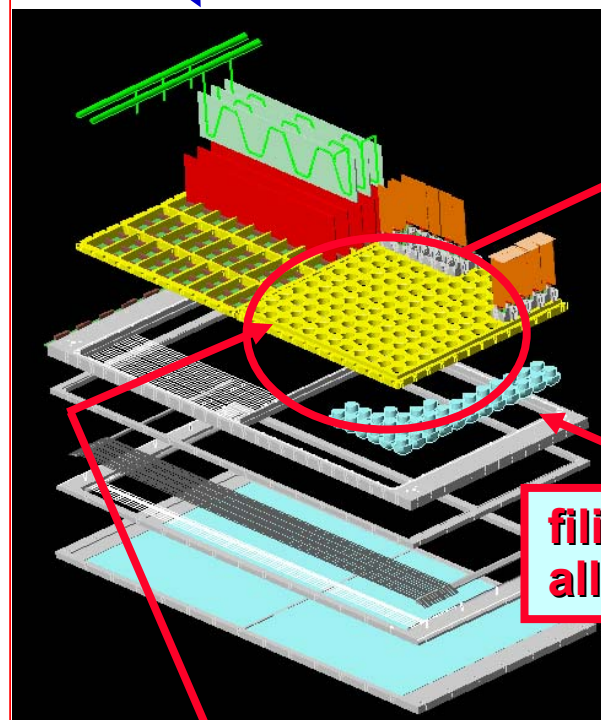
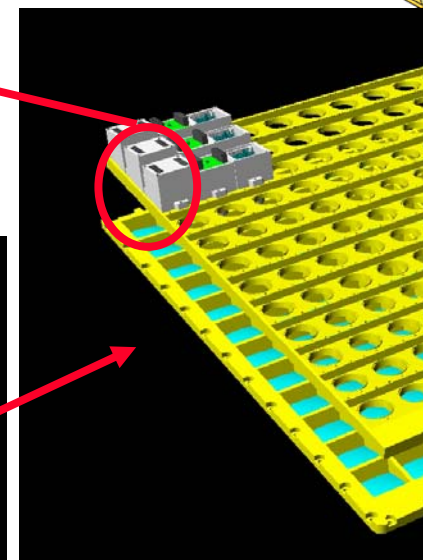
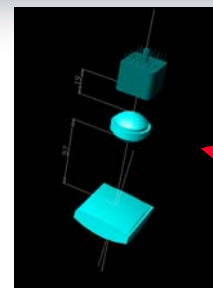
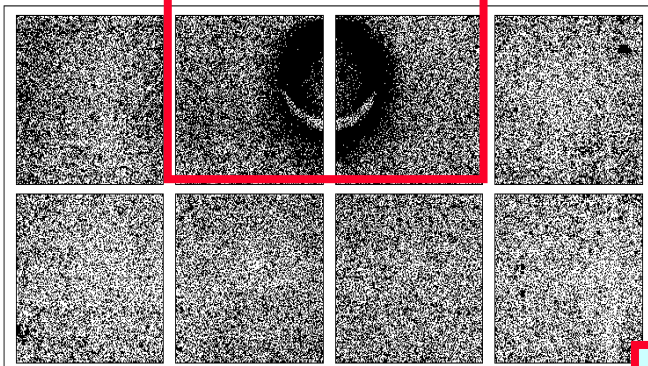
UNO SGUARDO AL FUTURO L'UP-GRADE DEL RICH-1 CON MAPMT



rivelatori di fotoni nella regione centrale:
MAPMT (HAMAMATSU R7600-M16-03)



Lower Chambers

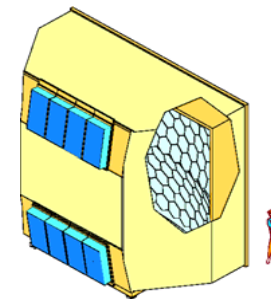


**filì anodici rimossi davant
alle lenti: non c'e' campo E**

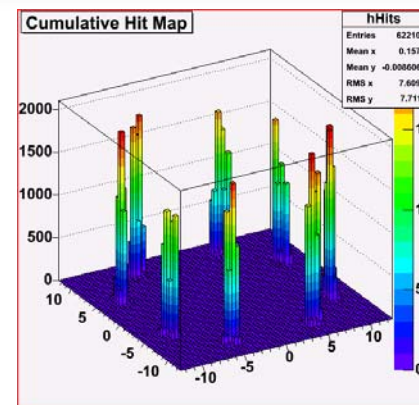
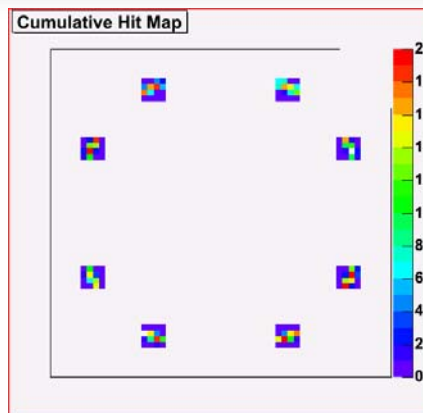
catodo rimpiazzato da un pannello di MAPMT e lenti



MAPMT & FOTONI SINGOLI

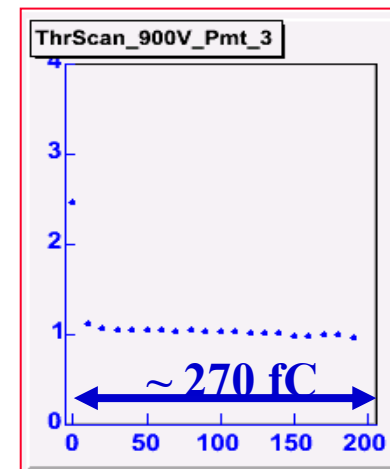
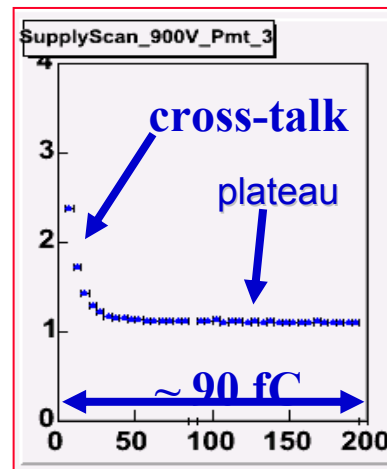
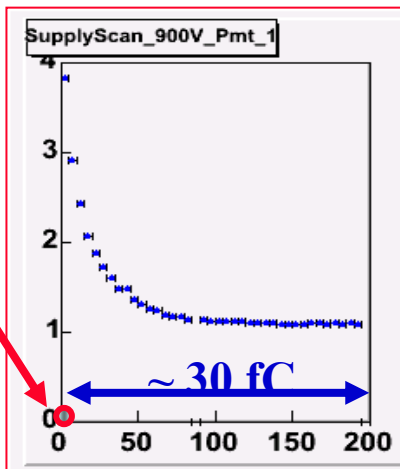


plot cumulativi:
gli anelli in linea



plot:
hit multiplicity / event
vs threshold setting,
arbitrary units

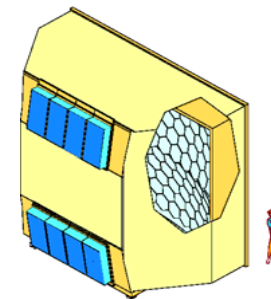
noise,
PM off



Si identifica chiaramente una **regione completamente piatta** (nessuna perdita di fotoni), **adeguata per il settaggio non critico della soglia**, fra la **regione del cross-talk** (a basse soglie) e la **regione dove inizia la perdita di fotoni** (visibile nel terzo plot)



CONCLUDENDO



- **Il RICH-1 di COMPASS e' pienamente operativo**
 - ha raggiunto il plateau delle prestazioni nel 2003
- **Il RICH-1**
 - progettato a meta' degli anni 90
 - parametri di disegno severi concernenti
 - le dimensioni trasversali
 - le rate (beam, trigger)
 - RICH VUV di grandi dimensioni con radiatore gassoso
- **si sono riscontrate limitazioni nell' operare fotocatodi a CsI di grandi dimensioni in ambiente radioattivo**
- **la risoluzione di fotone singolo e' soddisfacente e vicina al valore di disegno**
- **la risoluzione per anello e' limitata dal fondo fisico e dal numero di fotoni rivelati**
 - permette separazione a livello di 2.5σ di π / K fino a $40 \text{ GeV}/c$
- **il rivelatore e' centrale per la fisica di COMPASS (esempio: $\Delta G/G$)**