EIC Detector Workshop
JLab : 4-5/June/2010

HERMES: Forward RICH Detector

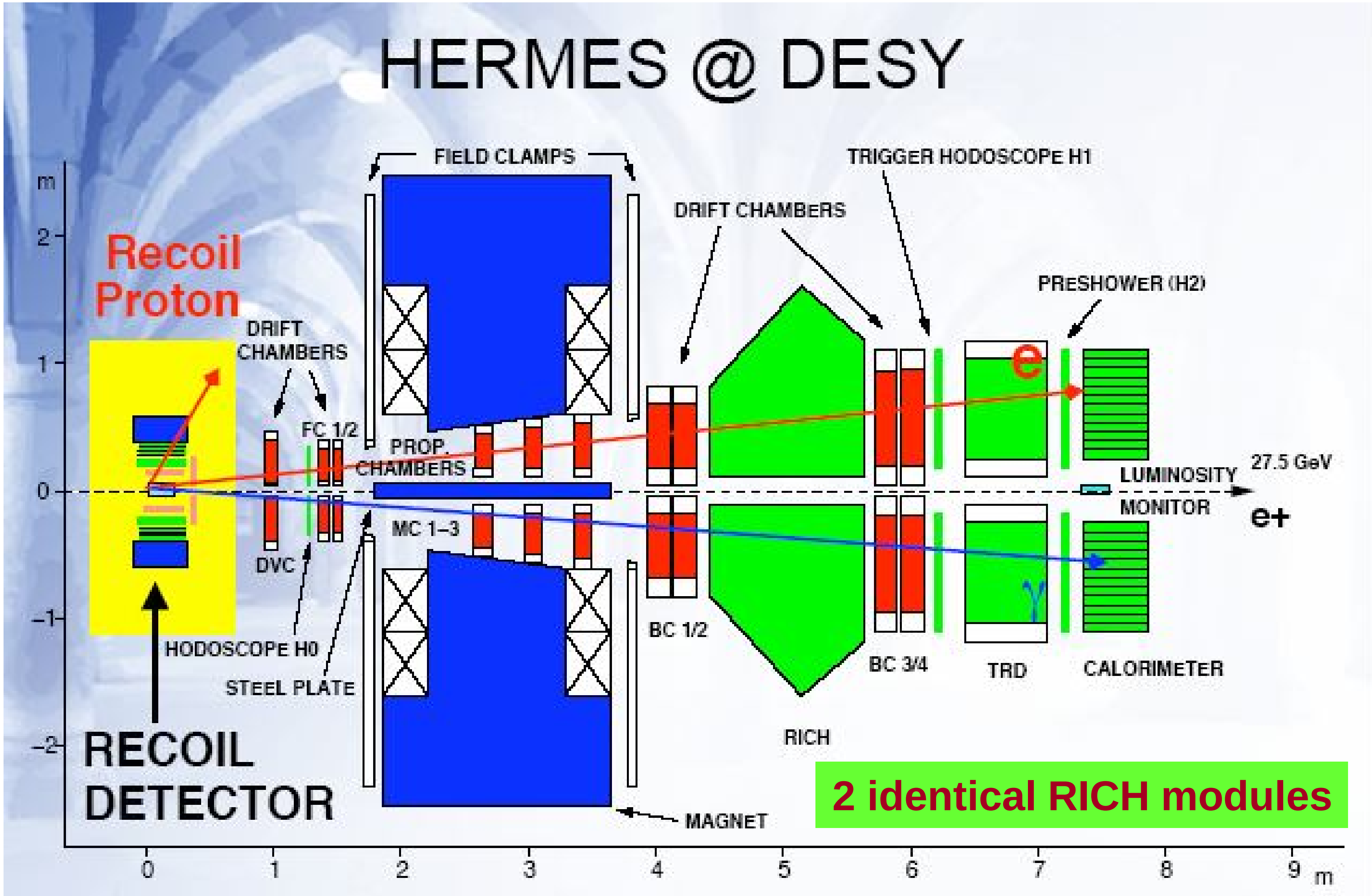
Evaristo Cisbani / INFN-Rome Sanità Group

Most of the slides from R. De Leo and D. Ryckbosch

- Overview
- Performances
- Inheritance
    - HERMES RICH in SBS HallA
    - Aerogel RICH in CLAS12

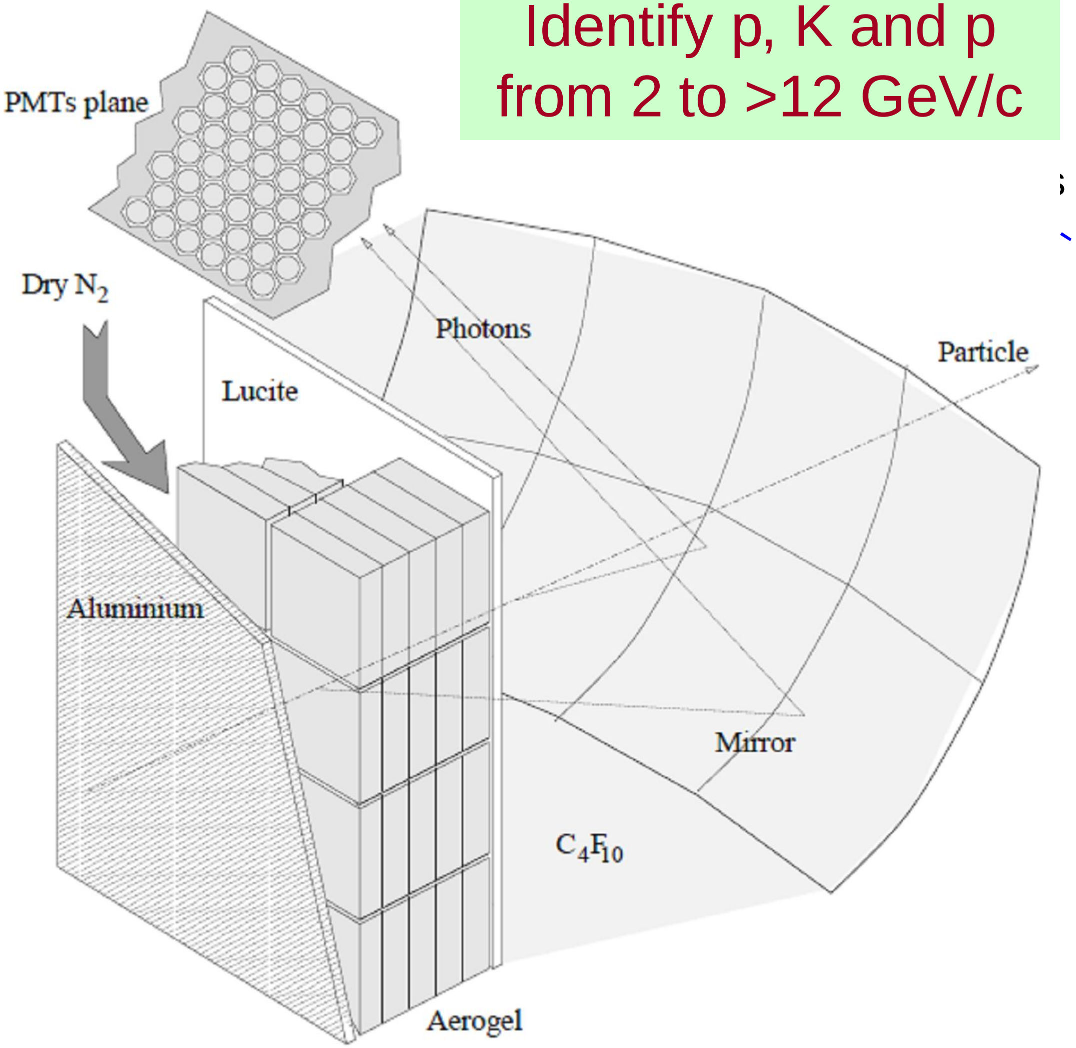
HERMES Experimental Setup

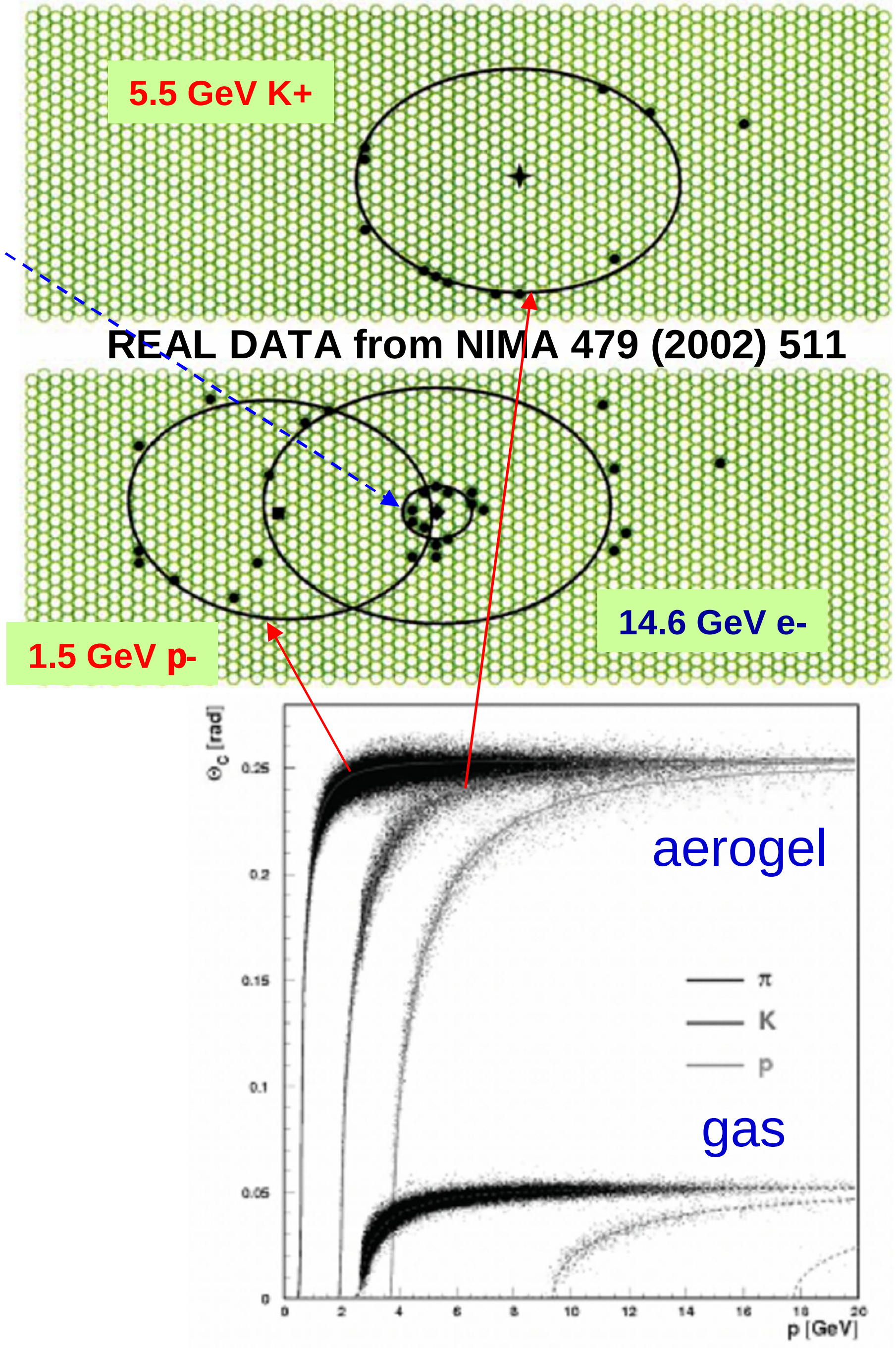
$e^{\uparrow}+N^{k}$ Þ $e' + h + X$ in DIS



Hadron PID: HERMES RICH

Identify p, K and p
from 2 to >12 GeV/c

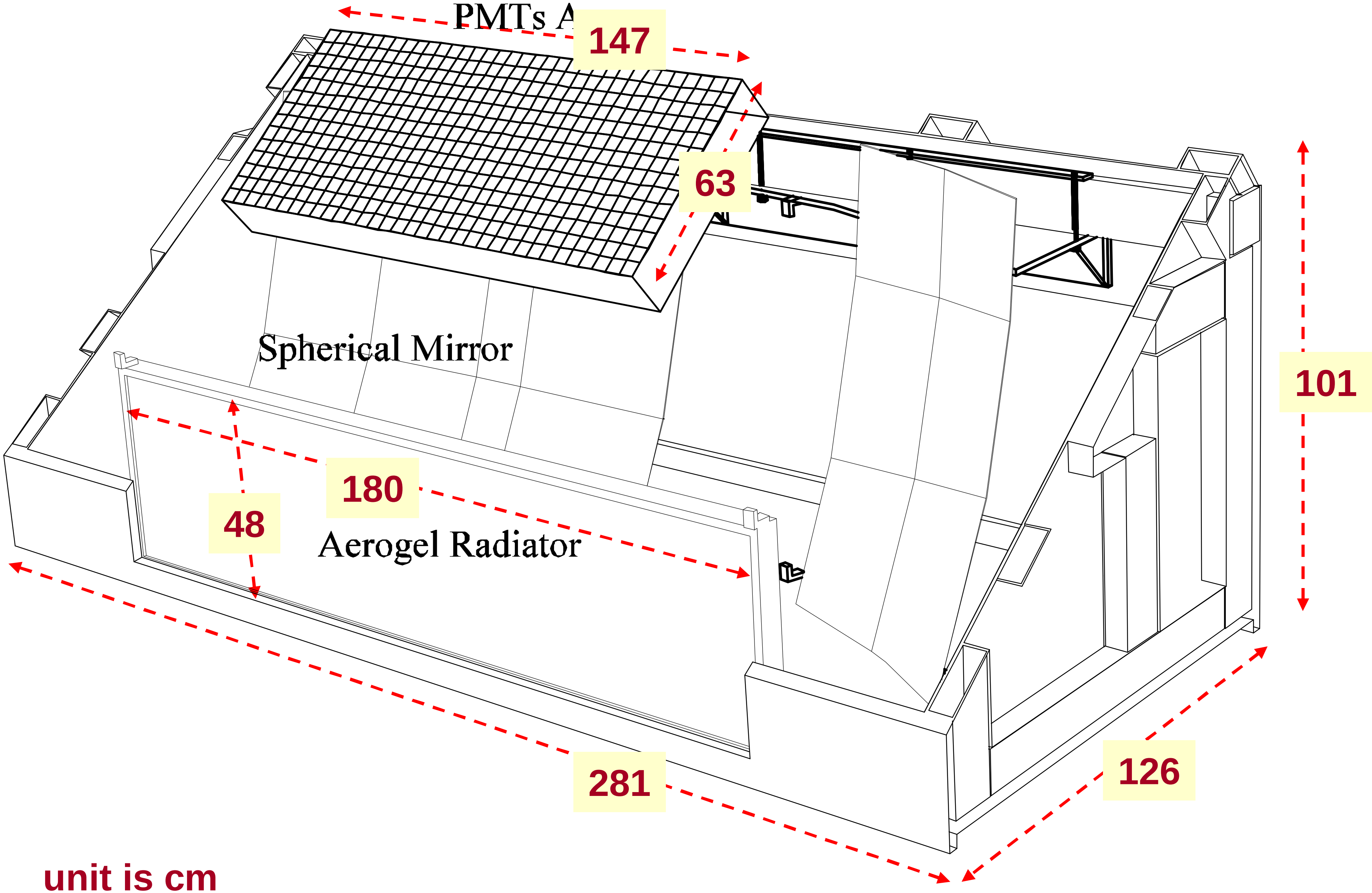




Two radiators: aerogel and gas
PMTs as photon detector
Focusing Optics

Reference: NIMA 479 (2002) 511-530

HERMES RICH module layout



unit is cm

Radiators

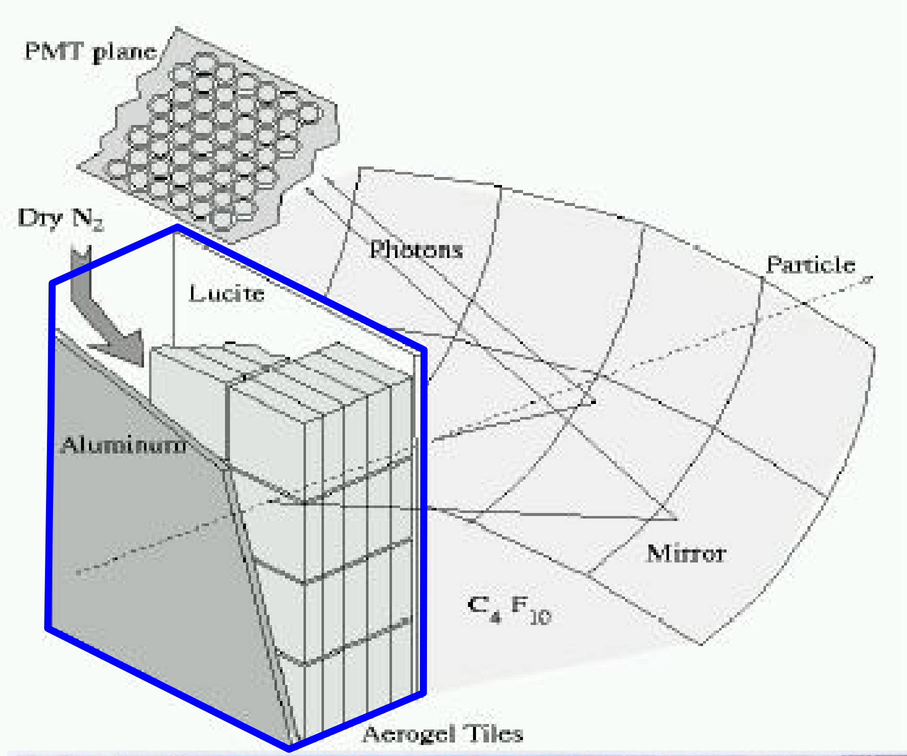
Aerogel

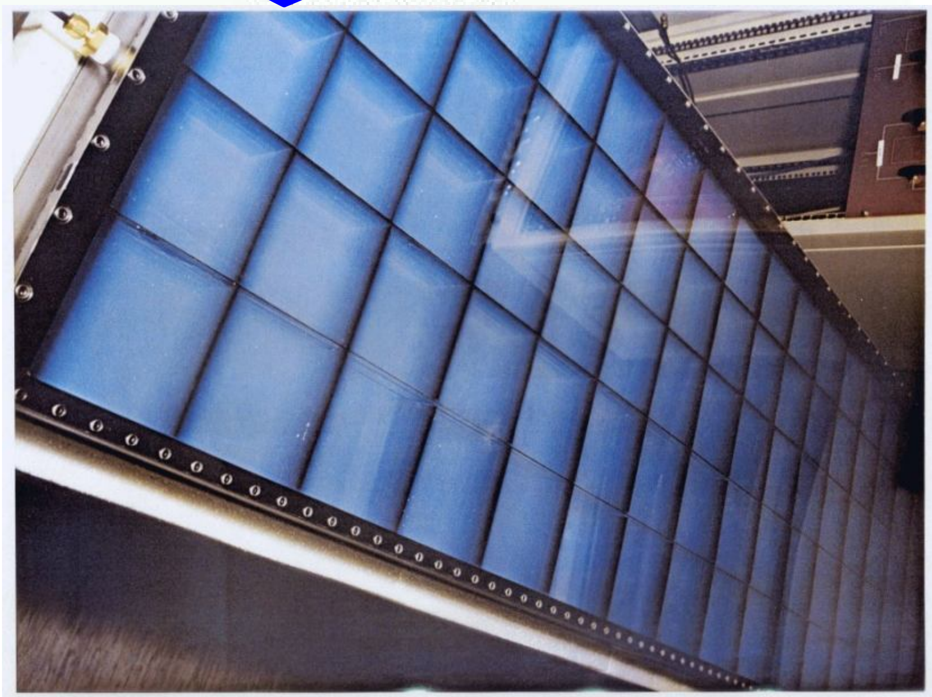
- Array of 425 tiles/half
- Stacks of 5 tiles
- Black tedlar foil around edges (Absorb otherwise randomly reflected photons)
- Lucite end window (cut photons with l<300 nm)
- Dry N_2 atmosphere

Refractive Index n(633 nm)=1.03

Scattering//Absorption Length
L (400 nm) = 2.3 cm

C_4F_{10} Gas at STP
n(633 nm)=1.00137

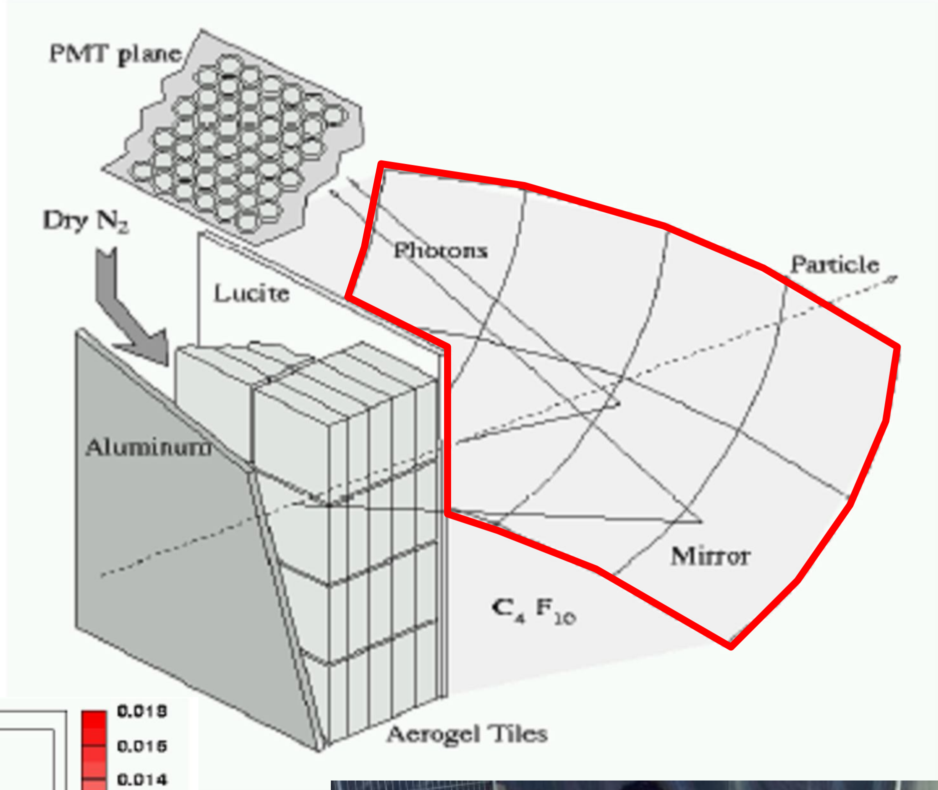


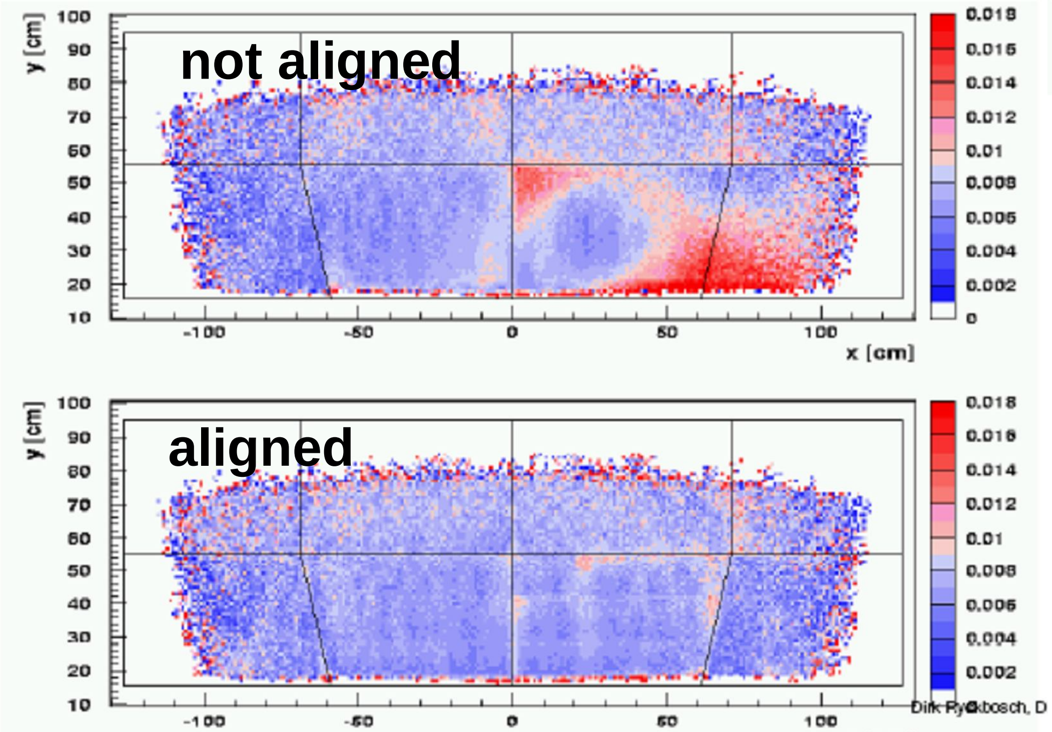


Mirror array

Optics

- Spherical array
- 4×2 mirror segments
- Focal length = 110 cm
- Graphite fibre composite

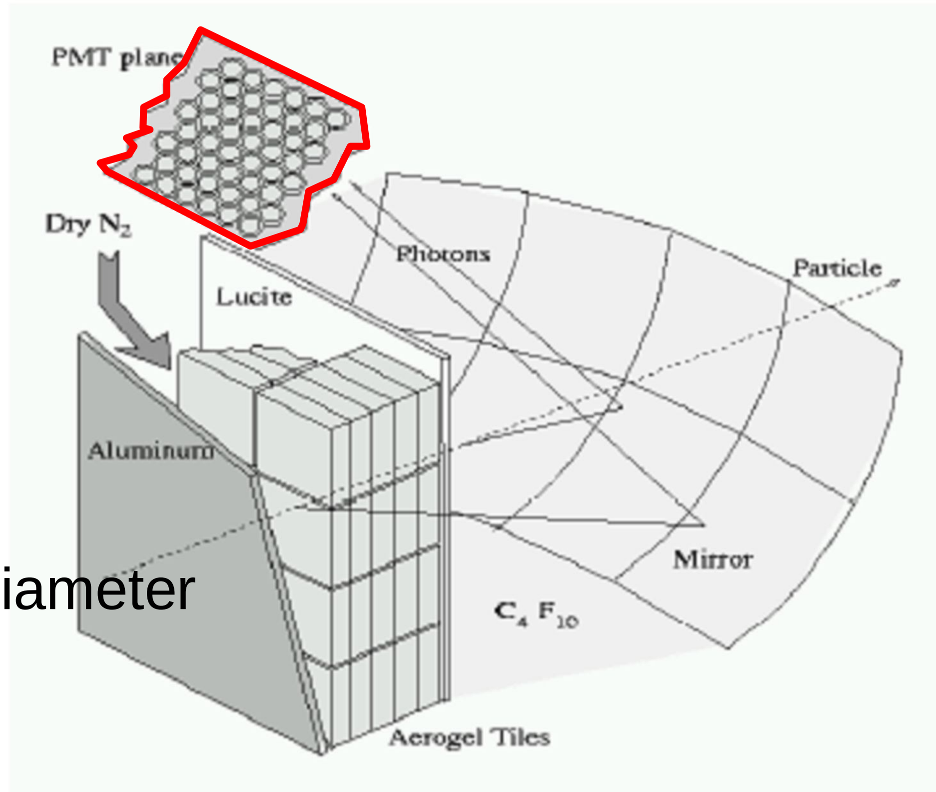




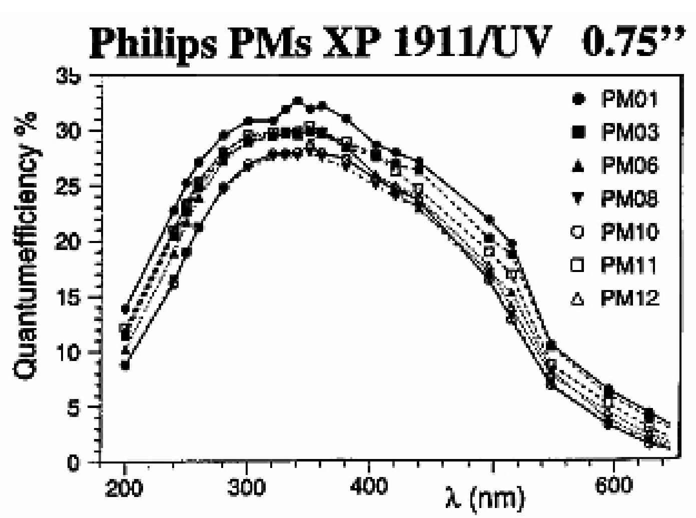
Dirk Ryckbosch, D

Photon Detector plane

- Based on SELEX design
- 1934 PMTs/half in hexagonal close-pack
- Philips XP1911/UV green enhanced ¾ inch diameter
- Soft steel matrix for magnetic shielding



+ single PMT 100 mm mMetal sheet wrap

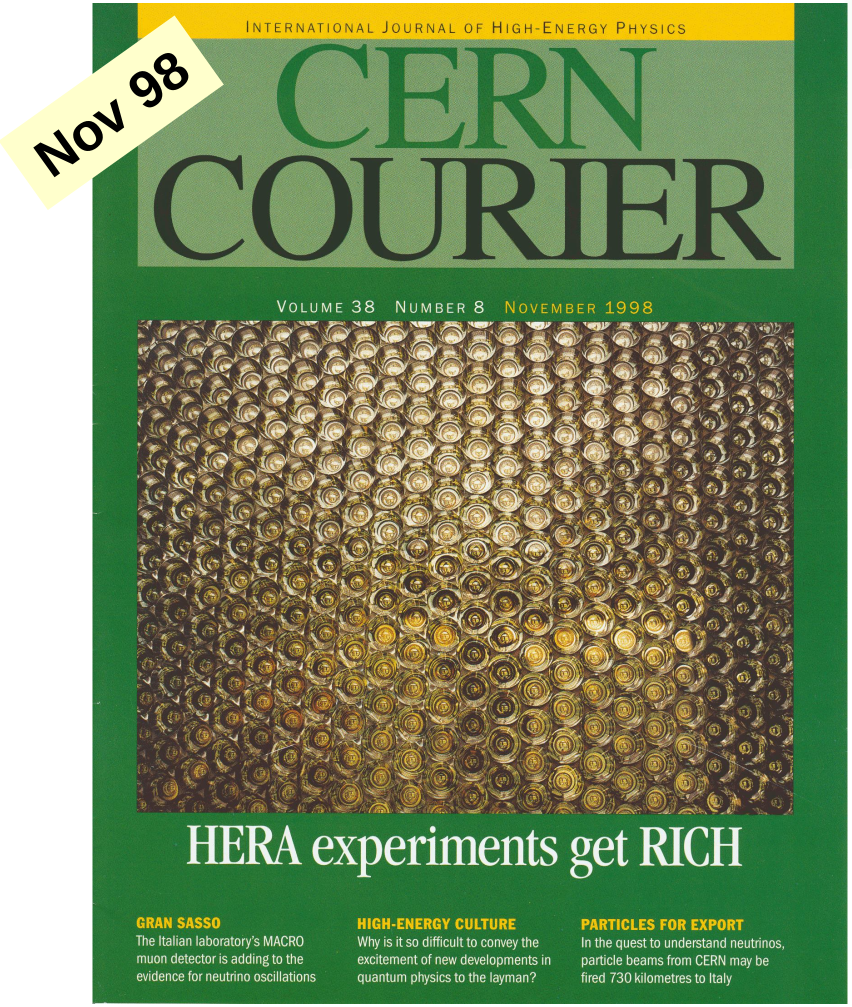


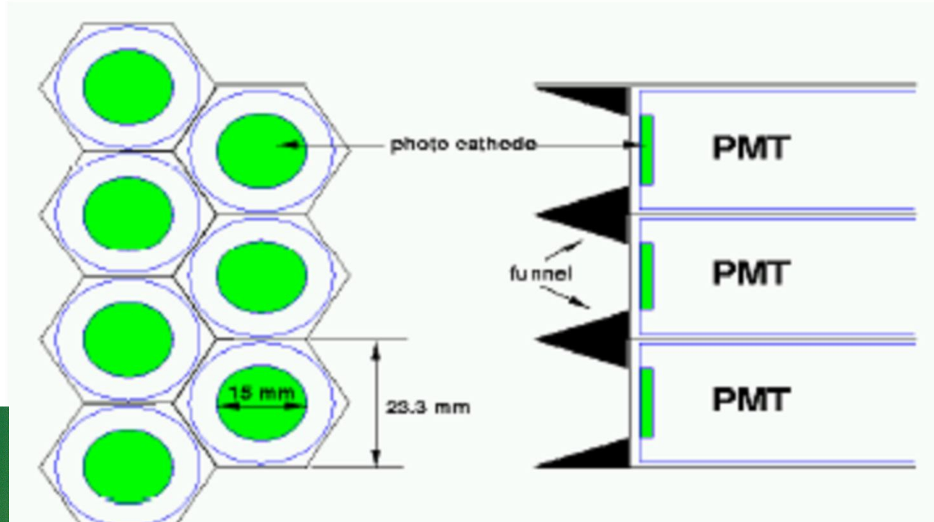
up to 90 G magnetic field

Size of the detector and diameter of the PMT defined by cost constraint

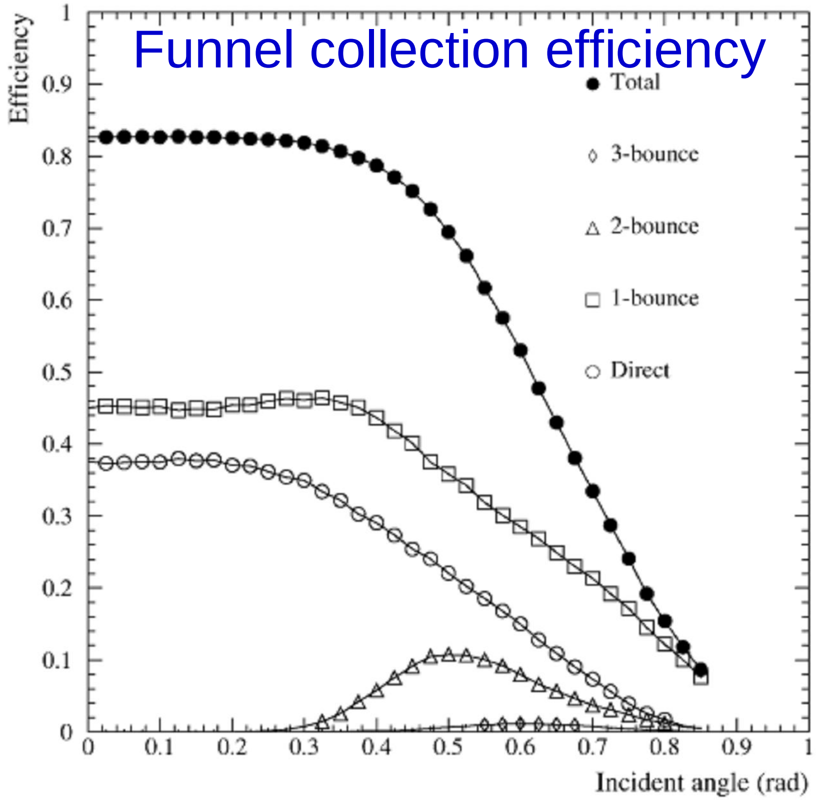
Light Collection

- Light collecting funnels to cover 92% of focal plane





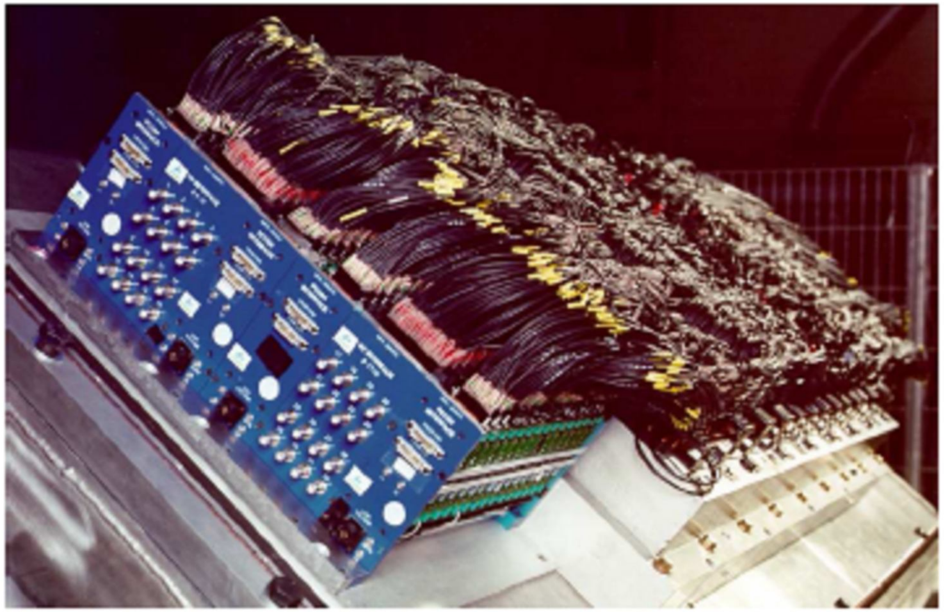
Dirk Ryckbosch – DESY07



Electronics

Read-out system

- PCOS4 system
  Like MCs
- Digital read-out
- Threshold = 0.1 p.e.

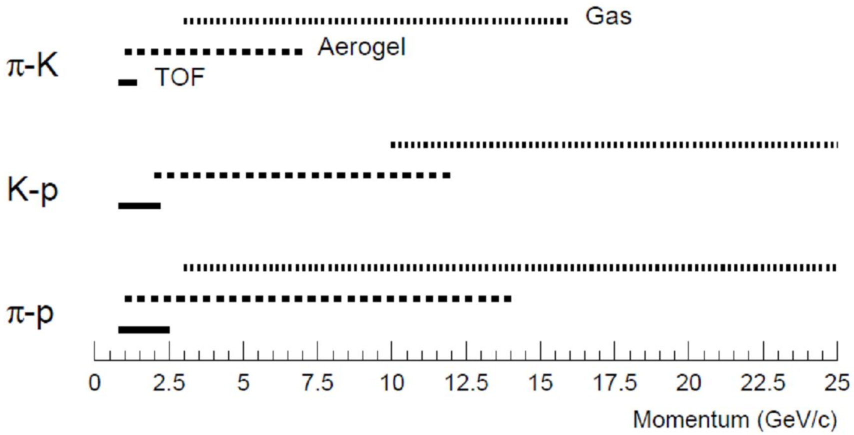


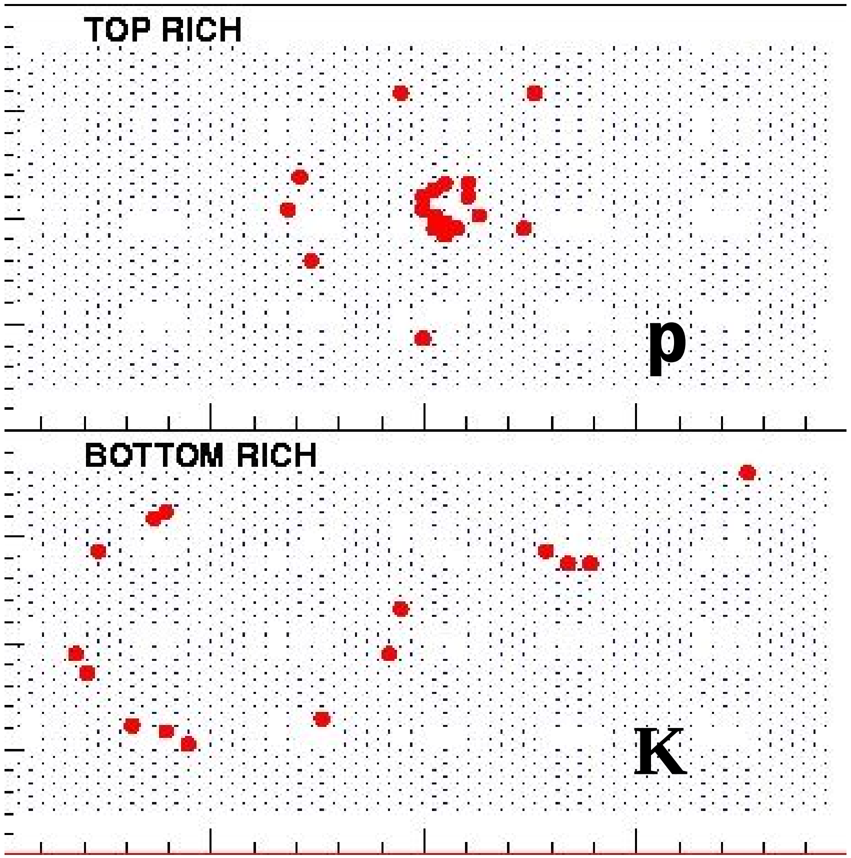
- VME based, 20 MHz bus from front-end to VME
- less than 30 ms to transfer data to VME
- able to keep data up to 800 ns (selectable) since trigger
- down to 50 ns gate width
- No time information

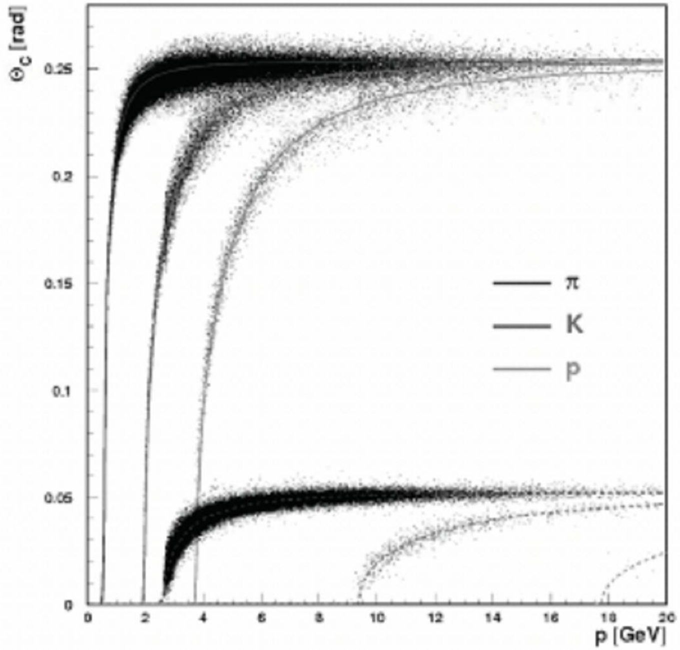
One RICH Module during installation

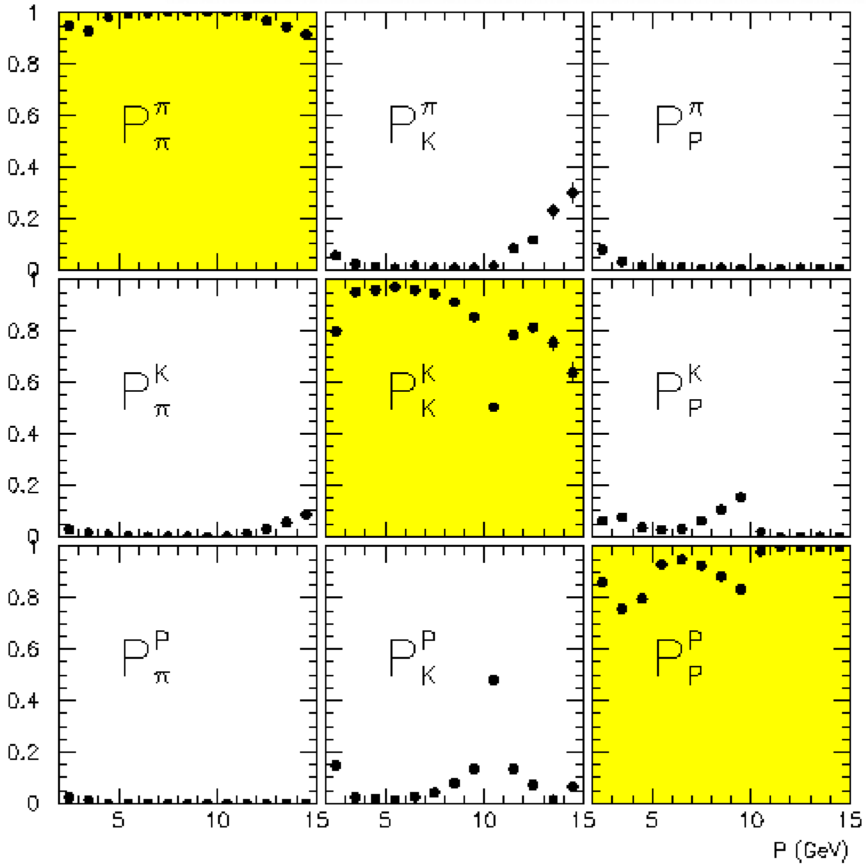
Dirk Ryckbosch, DESY, July 07 – p.20/22

Rings and identification probability matrix



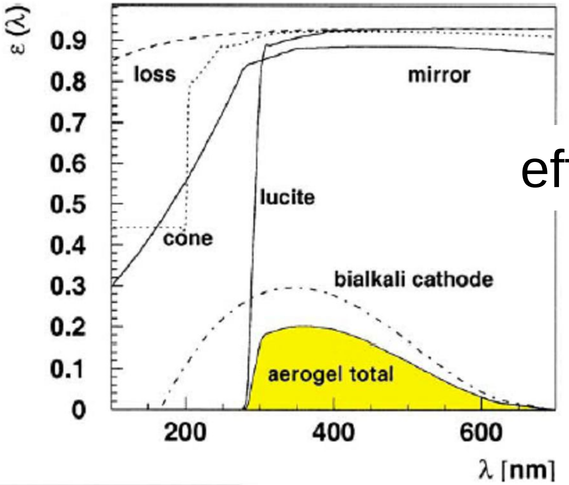




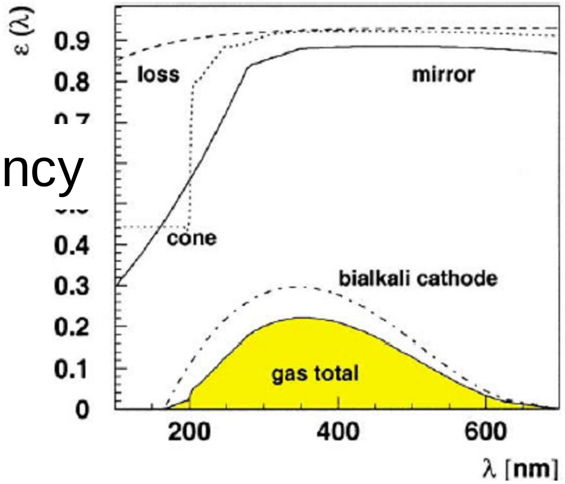


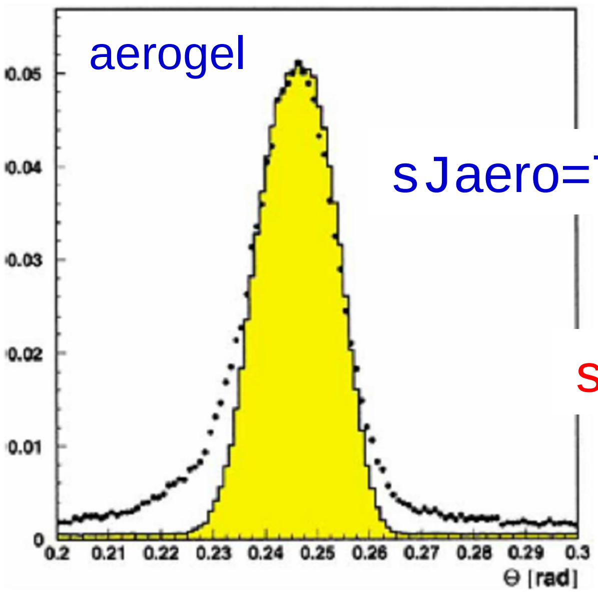
Reconstructed angle and number of photoelectrons

Rayleigh scattering ~l^{-4}



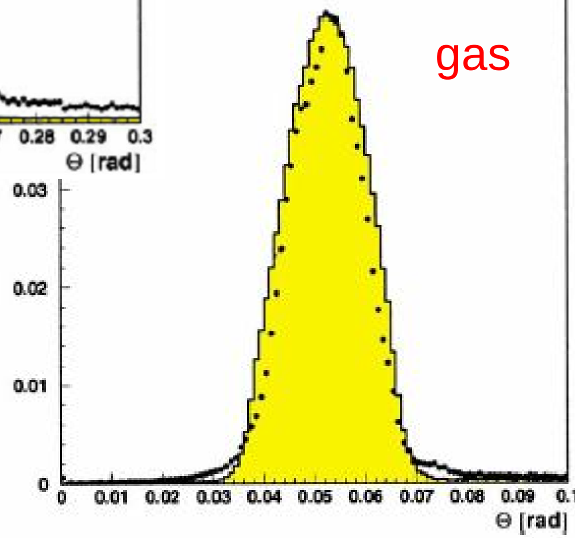
efficiency



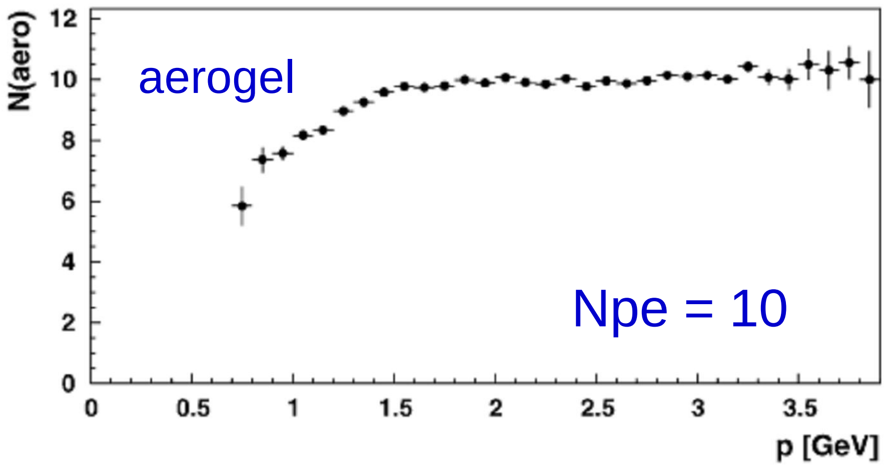


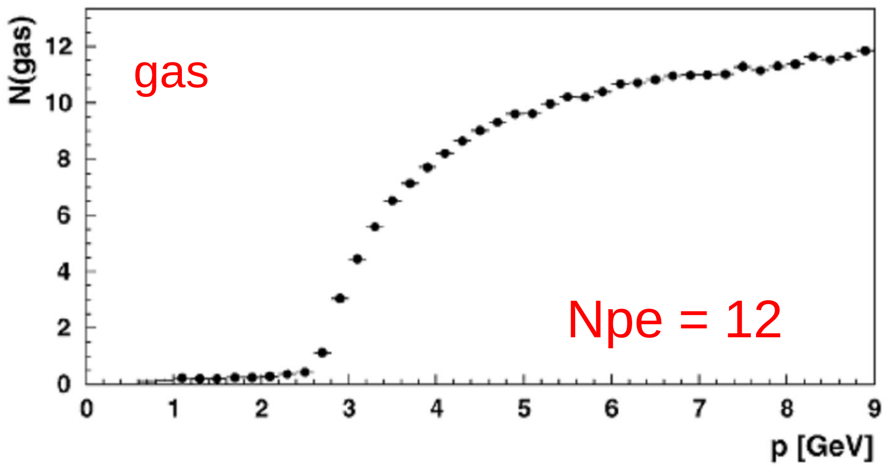
sJaero=7.6 mrad

sJgas=7.5 mrad



electrons



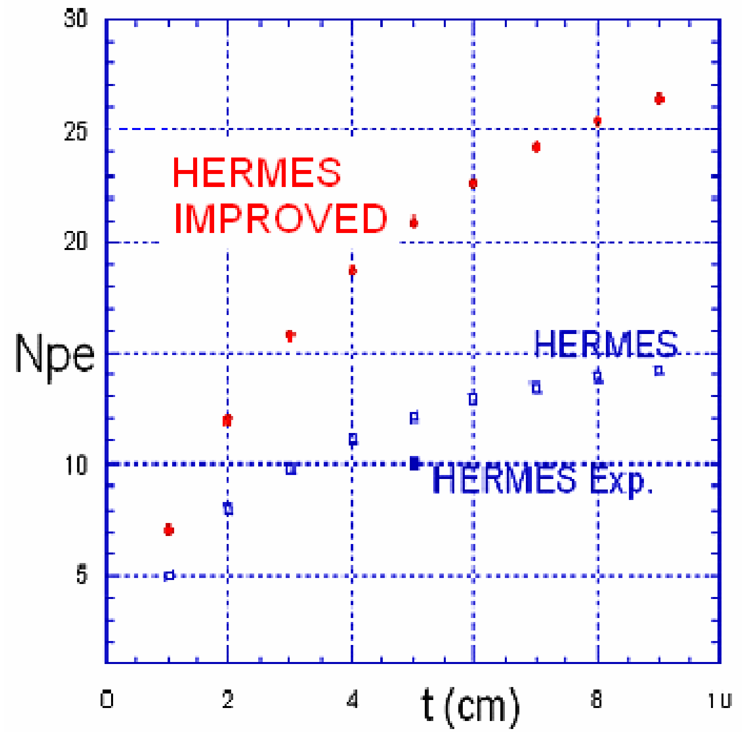


Exp. angle resolution (%)

	HERMES Aerogel	Today (estimated)
Pixel Size	2.3	0.7*
Mirror	0.6	0.5
Emission	0.7	0.6**
Disp. N	0.5	0.5
Chromatic	1.3	1.3
Forw. Scatt.	0.4	0.4
Surface	0.4	0.4
J_{Total}/pe	3.3	1.8
Npe	10	18**
J_{Total}/ring	**1**	**0.4**

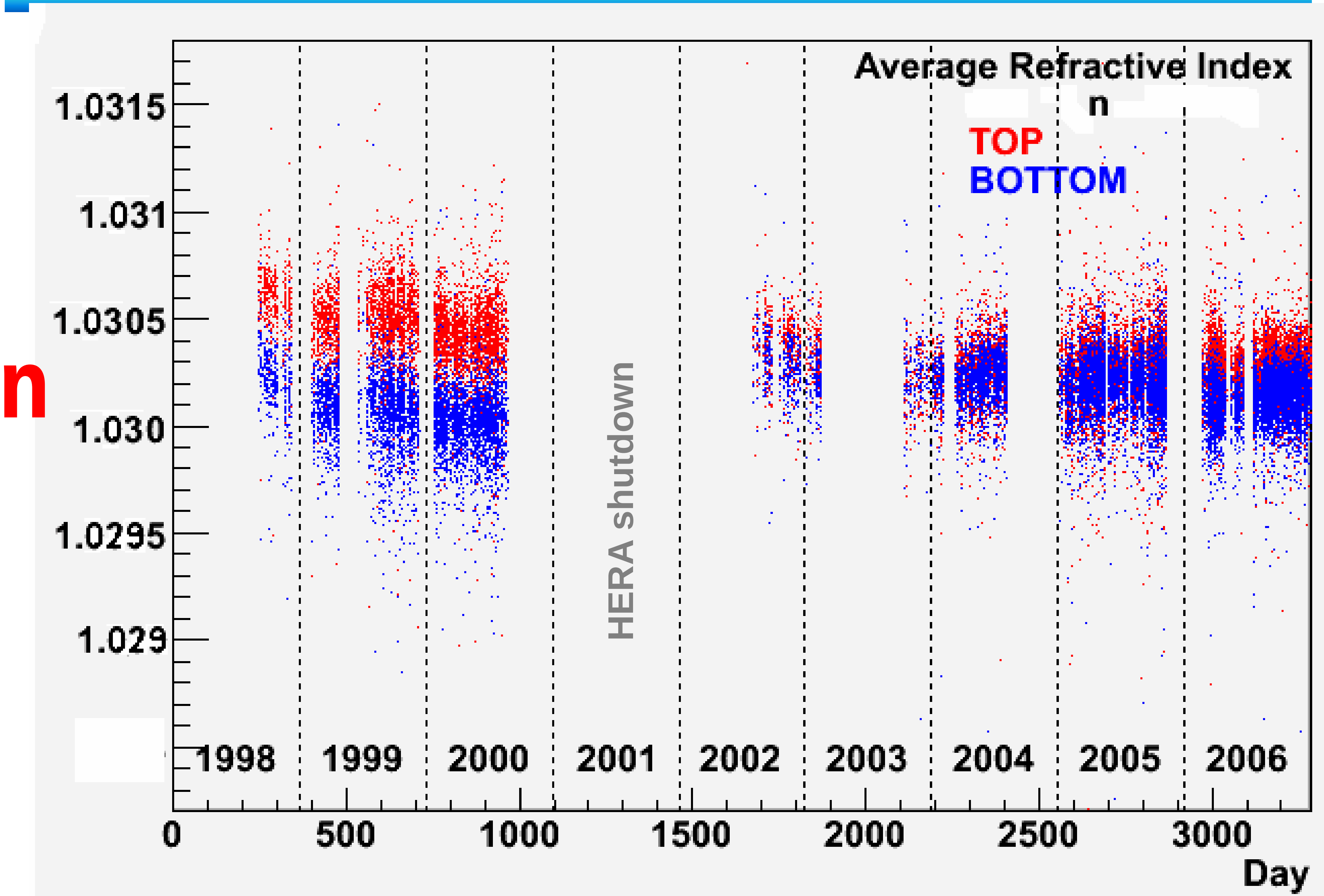
* Hamamtsu R7600

**Better aerogel transmittance, L(400 nm)~1 cm Þ reduced thickness (e.g. 4 cm)

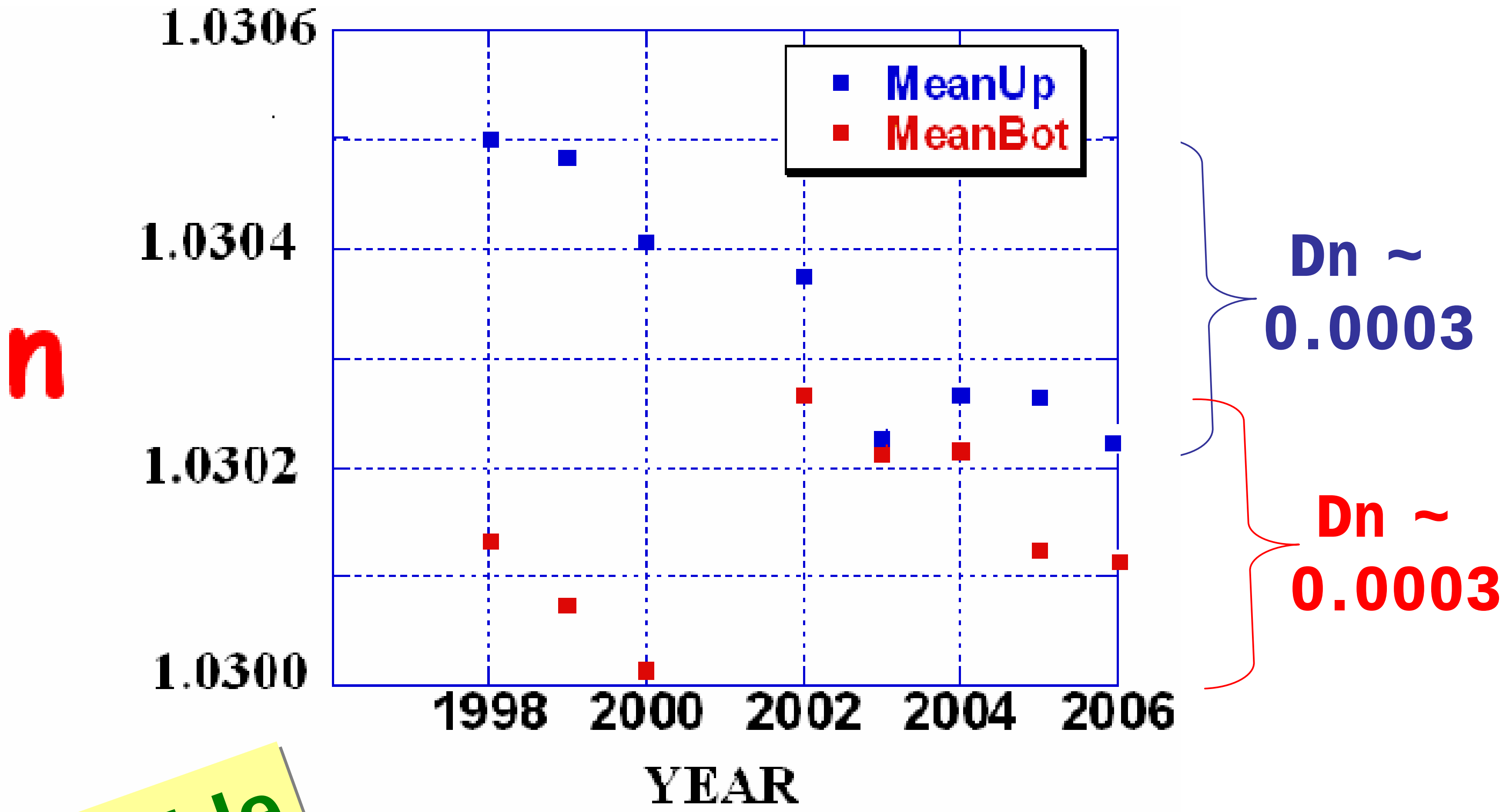


HERMES: Largest error from pixel size; by design (cost-performance tradeoff)

θ_C ring → n $(e^+ > 5\,GeV)$ plot vs day



average n (e^+>5GeV)



Very stable

Dn ≈ 3 *10^{-4} in 10 years!

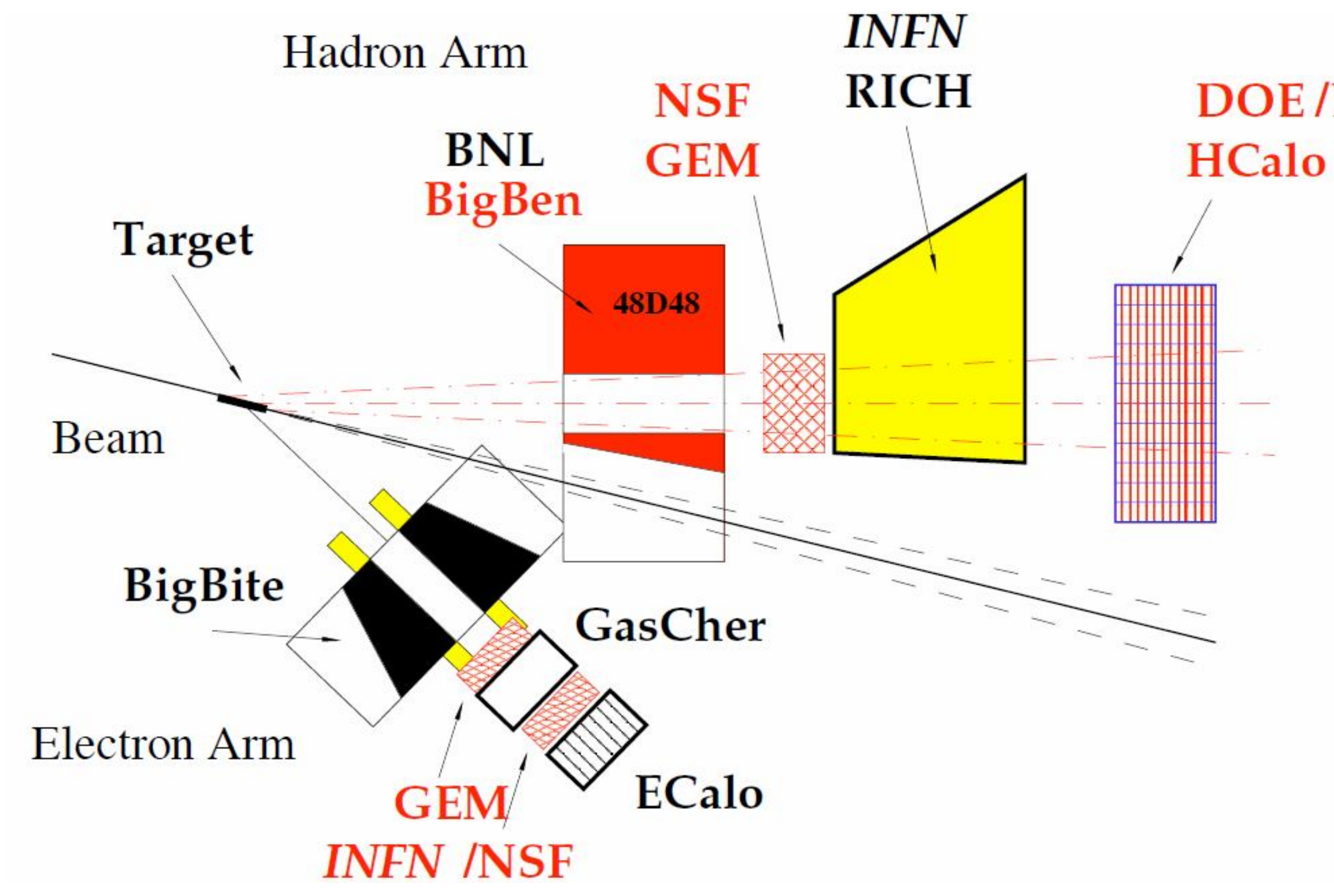
Dn ≈ 1*10^{-4} in the last 5 years!

one RICH module preserved @ UVa (thanks to G. Cates)

Now stored at UVa under safe/controlled conditions + additional wall of spare Aerogel from the other module.

SIDIS (Cond. appr. Exp.): Setup and parameters

$e+{}^{3}He^{\uparrow}\ \ e'+p(K)^{\pm}+X$



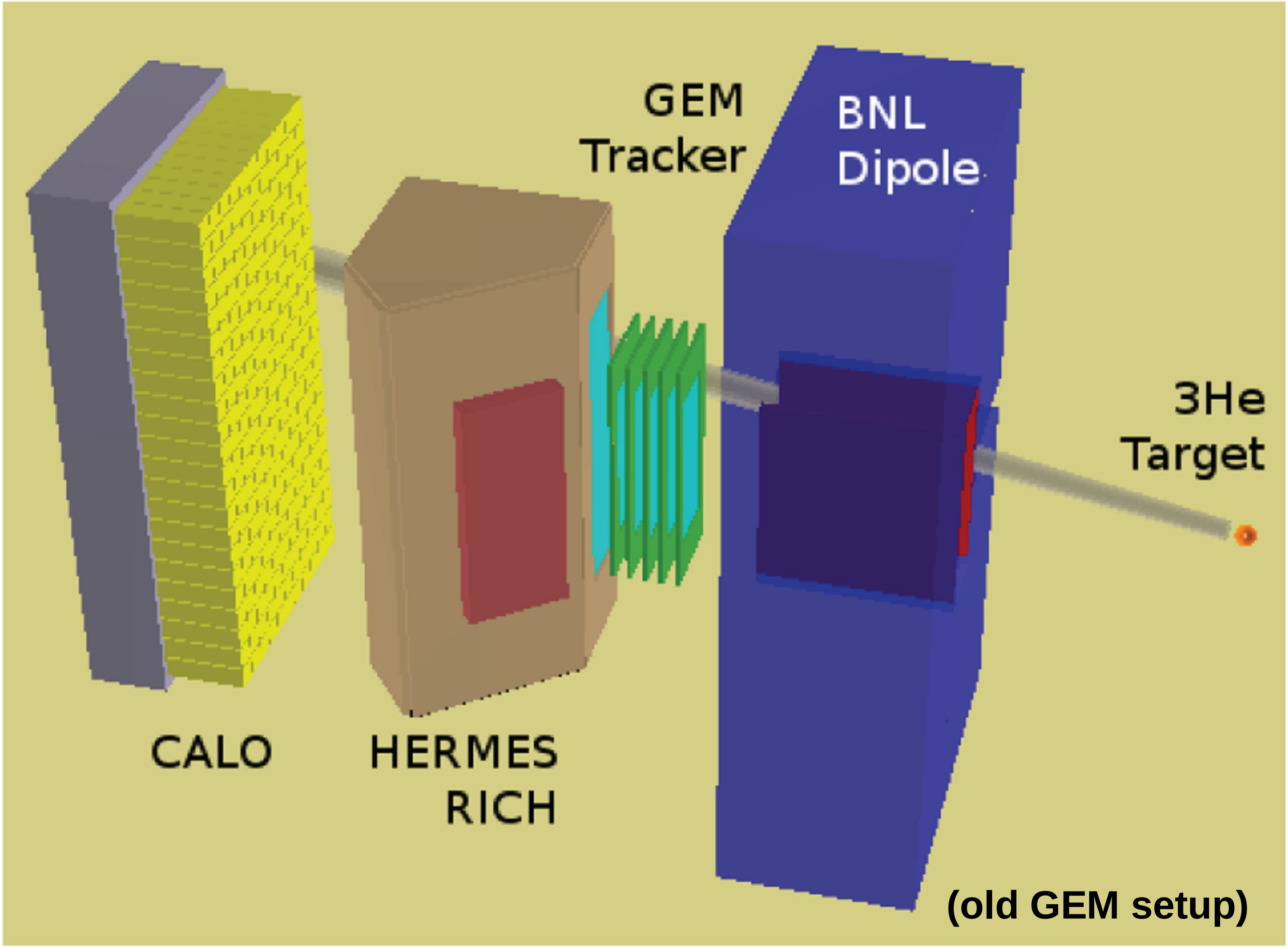
BB: e-arm at 30^{o}
W = 45 msr
GEM Tracker
Gas Cherenkov
Shower
Ü GMn/PR-09-019

SBS: h-arm at 14^{o}
W = 50 msr
GEM tracker
excellent PID / RICH
Hadron CALO

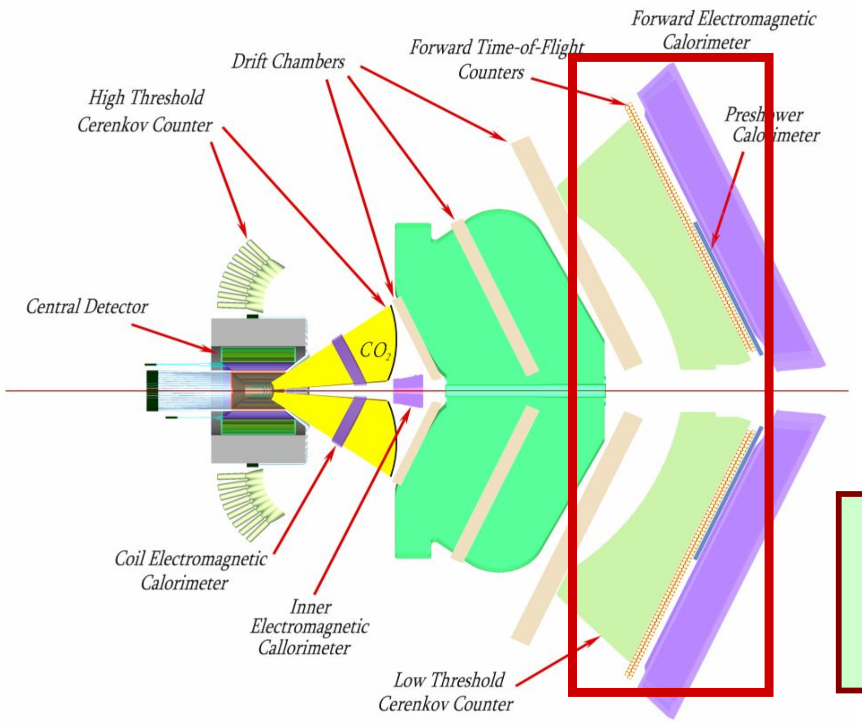
Beam: 50 mA, E=8.8 and 11 GeV (80% long. Pol.)
Target: 65% polarized 3He Ü GEn(2)/PR-09-016
ð Luminosity: 1.4 10^{37} cm^{-2}s^{-1}

Event rate: ~10^{4} HERMES
60 days of production
expected stat. accuracy:
10*better than HERMES on proton

HERMES RICH in SBS (SIDIS Exp.)



RICH detector in CLAS12

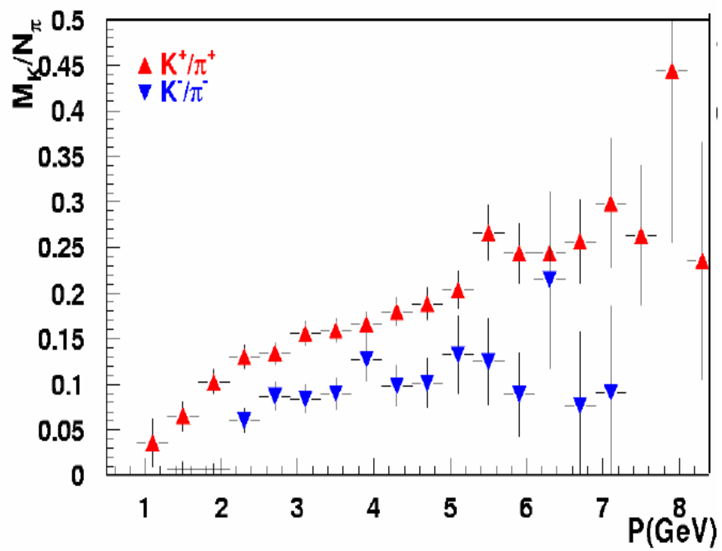


Main Requirements:

1. separation up to 8 GeV/c
2. from 5 to 40 degree polar angle
3. p/K rejection>100 (<1% p contamination)
4. minimize material budget

Substitute 2 LTCC sectors with a RICH detector
Possible option: aerogel + SiPM (with time correlation) RICH

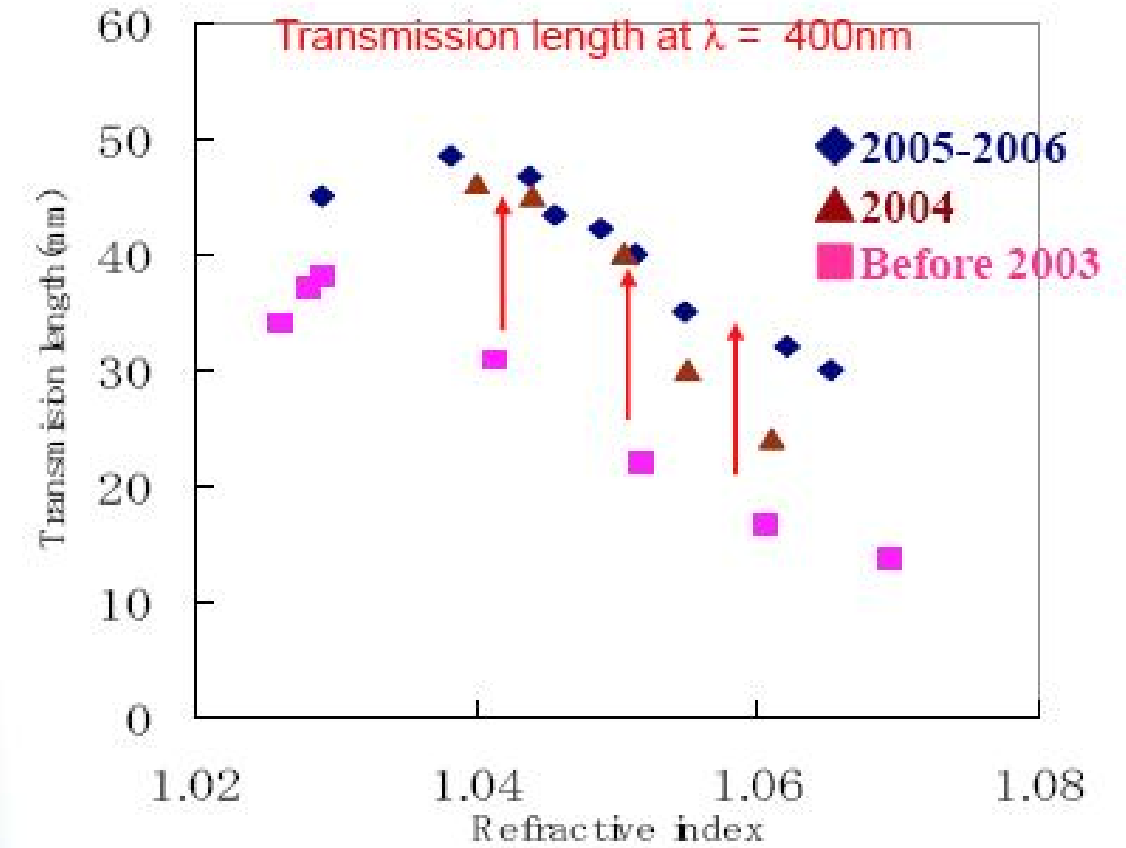
GeV/c	1	2	3	4	5	6	7	8	9	10
p/K	TOF	TOF								
			LTCC	LTCC	LTCC	LTCC	LTCC	LTCC		
						HTCC	HTCC	HTCC	HTCC	HTCC
p/p	TOF	TOF	TOF	TOF	TOF					
			LTCC	LTCC	LTCC	LTCC	LTCC	LTCC	LTCC	LTCC
						HTCC	HTCC	HTCC	HTCC	HTCC
K/p	TOF	TOF	TOF	TOF						
									LTCC	LTCC

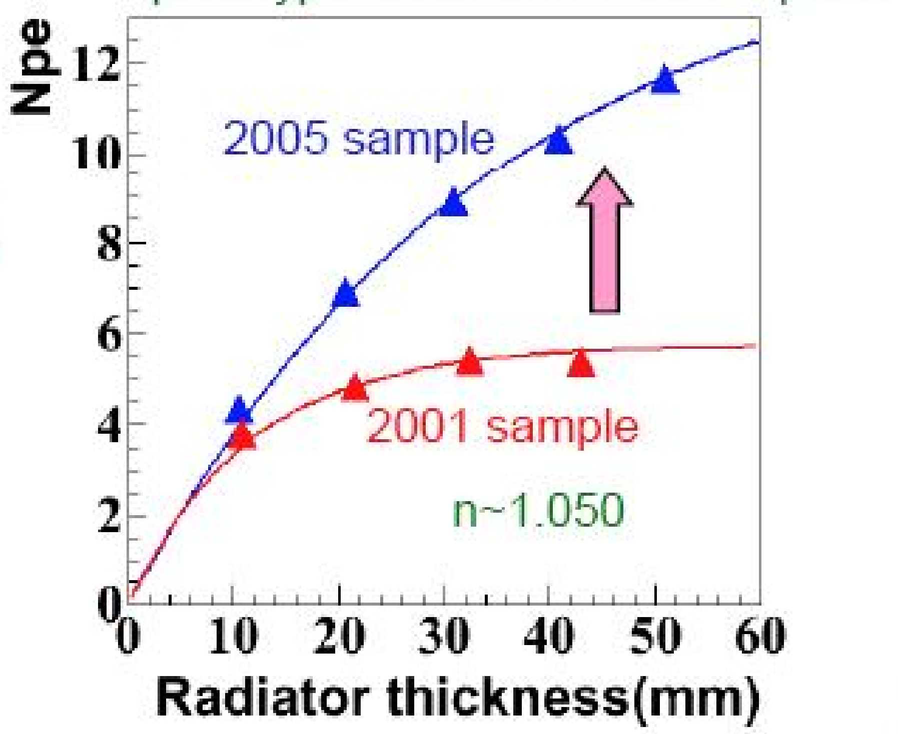


§ ratio K/p ~ 0.1-0.15

From. M. Contalbrigo

Aerogel characteristics improvements





2005 IEEE Nuclear Science Symposium Conference Record

M. Tabata et al.

Aerogel RICH with 2 x mirrors

Proximity between 5 and 10 degree

Mirrors acts at polar angle above 10 degree

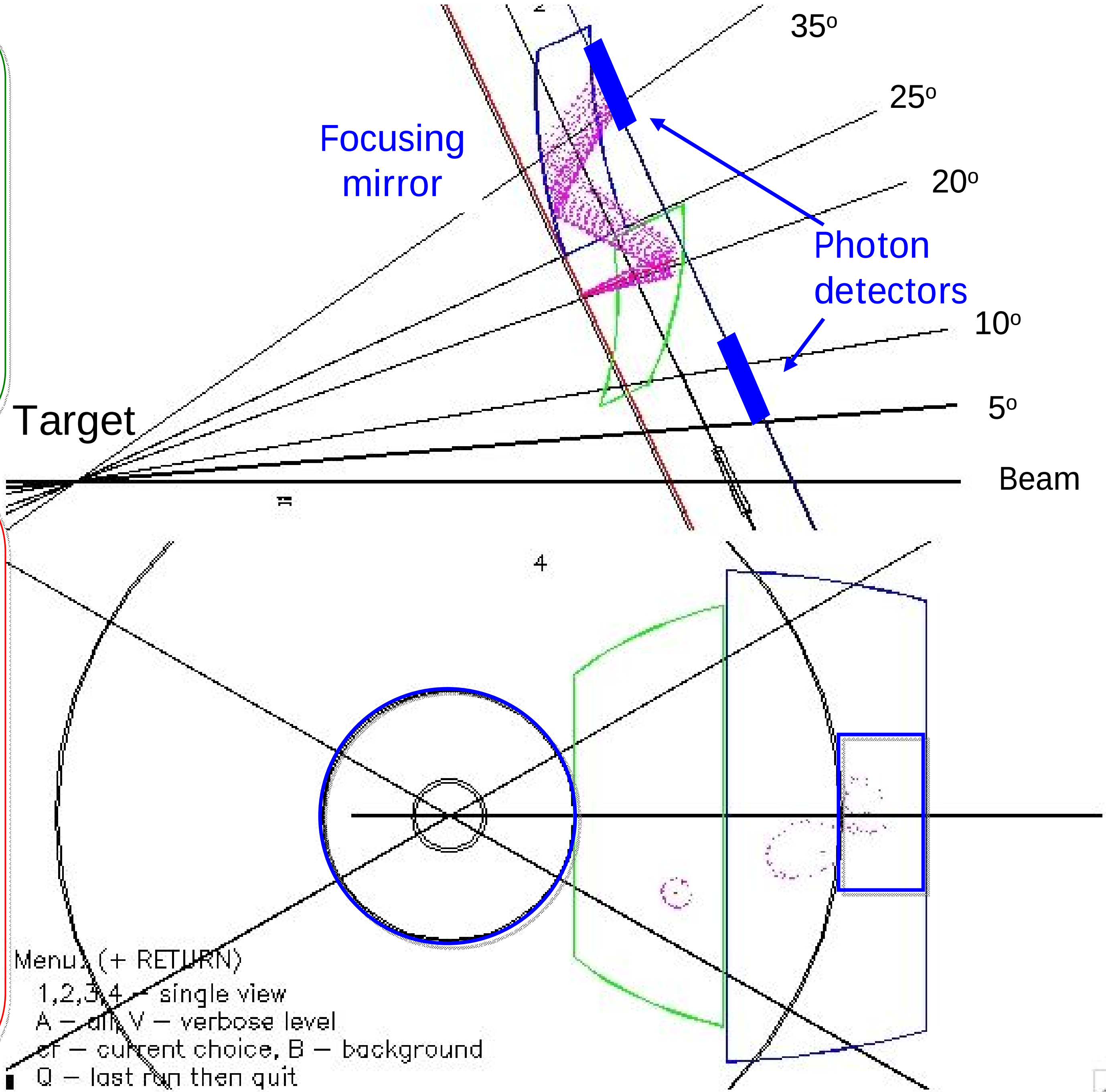
Doubled detector area

Focusing mirrors to reduce detector area to ~ 2 m^2/sec

Relax performance requests for the external half (lower p)

- Increase pad size
- Reduce channel number
- Standard PMTs

Similar to i.e. LHC-b !!!



From. M. Contalbrigo

Aerogel RICH with mirror & semi-reflective layer

Proximity up to 15 degree

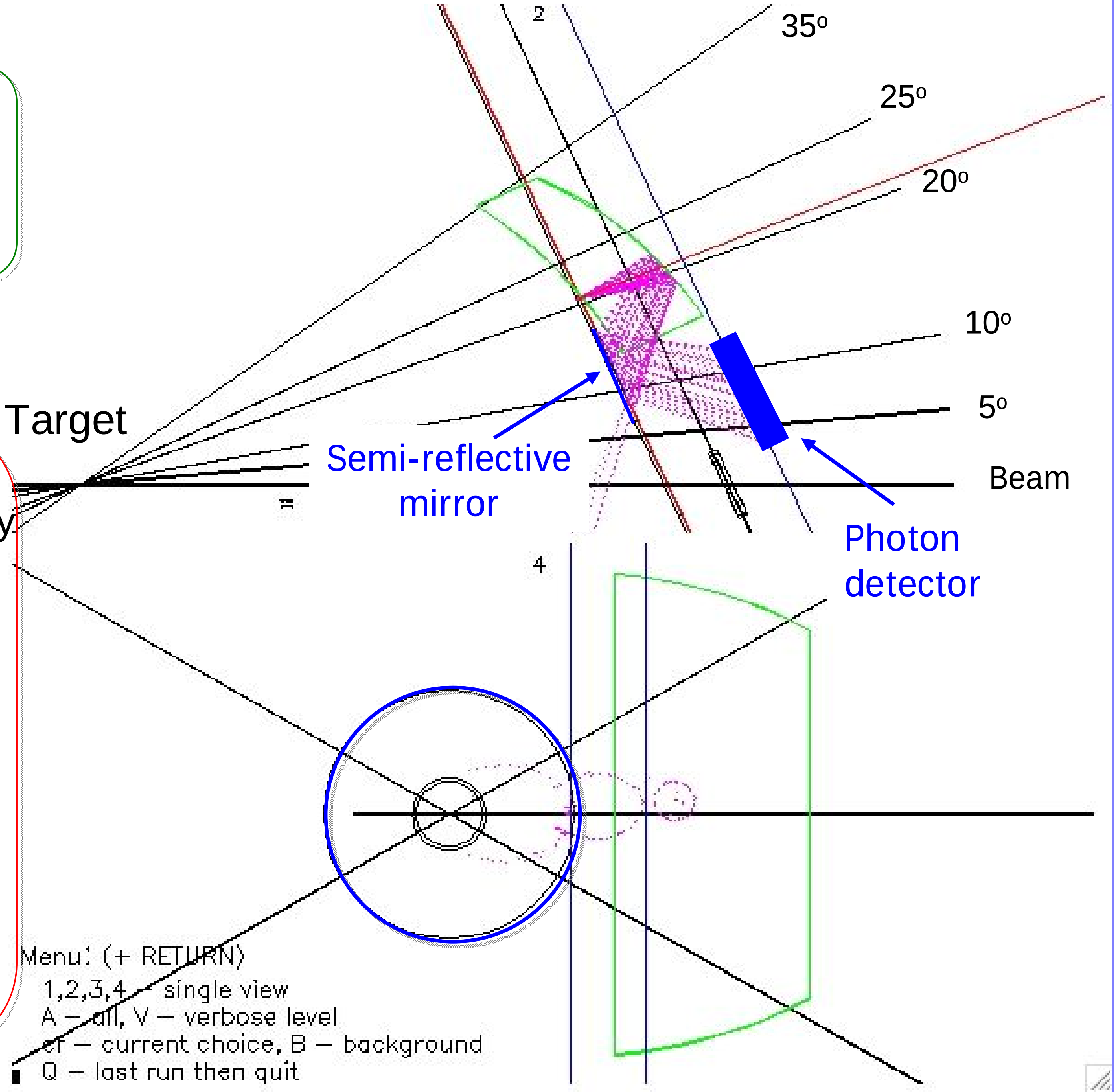
Mirror above 15 degree

High density of hits
check with track multiplicity

Too high absorption in aerogel
semi-reflective mirror

Reduced collection efficiency
(bi-alcali q.e. 25 %)
ultra bi-alcali q.e. 45 %
cost increases by 50 %

New concept !!!



From. M. Contalbrigo

Summary

- HERMES RICH designed and built in ~2 years
  - Configuration: Mirror Focusing, dual radiator, with PMT readout
  - First RICH using aerogel radiator in a real experiment
  - Very stable performance in 10 years
- HERMES RICH “inheritance”:
  - H-RICH for SIDIS physics in SBS/Hall A
  - CLAS12 p-K-p PID detector (work in progress!)
- Presently available improvements (at reasonable price):
  - Better aerogel (higher transmission and reduced scattering)
  - Smaller photon detectors: multianode PMTs, SiPM (with time information)
  - Improved mirrors

Recent RICH 2010 conference: http://rich2010.in2p3.fr/