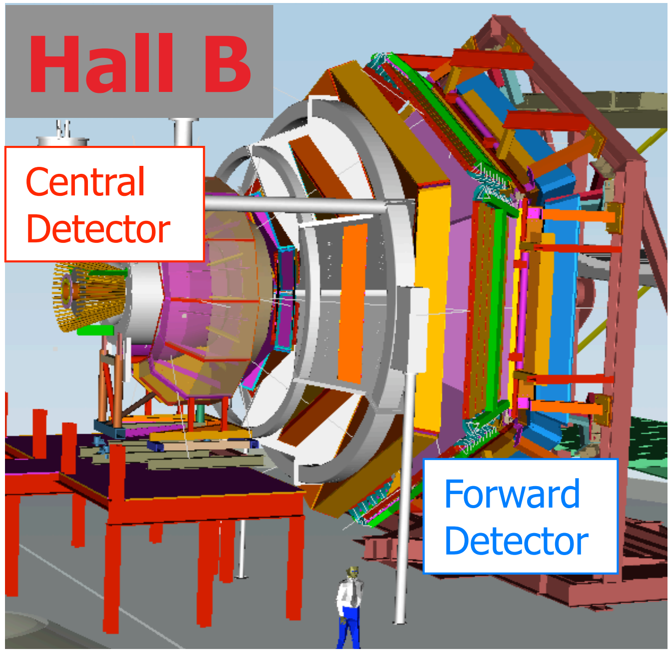
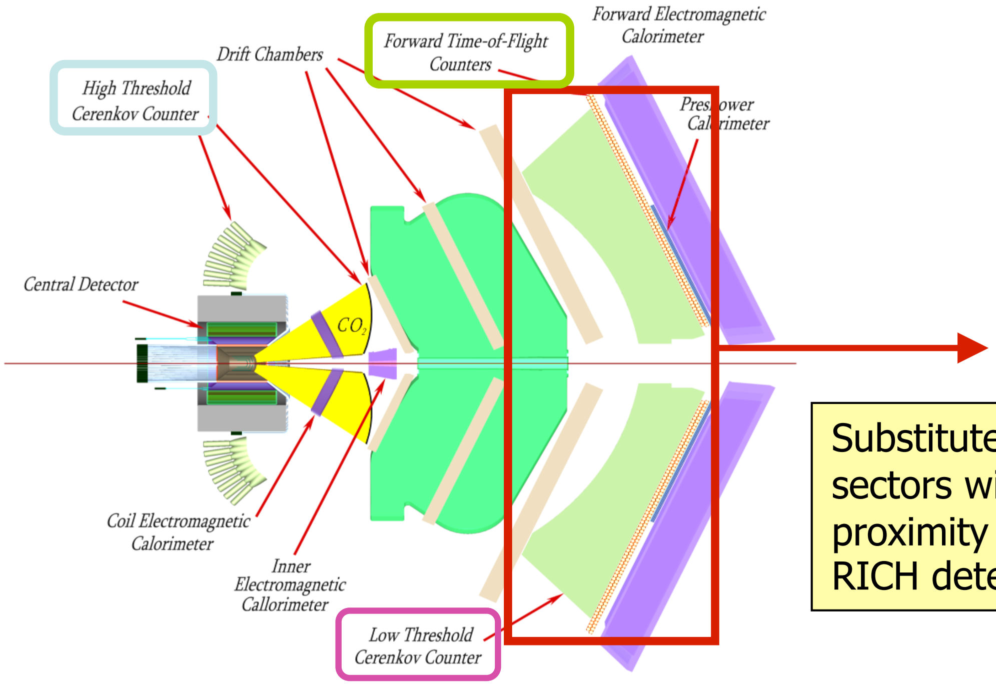
RICH simulation for CLAS12

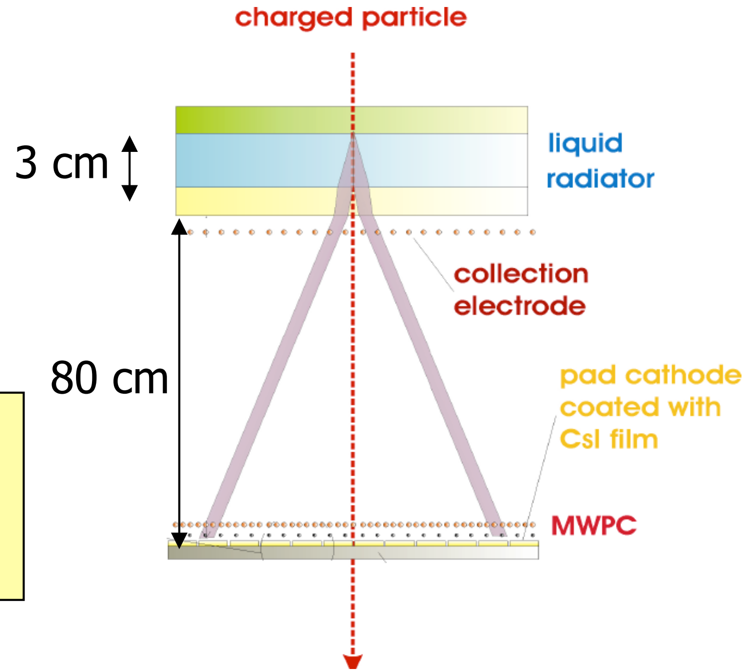


Contalbrigo Marco
Luciano Pappalardo
INFN Ferrara

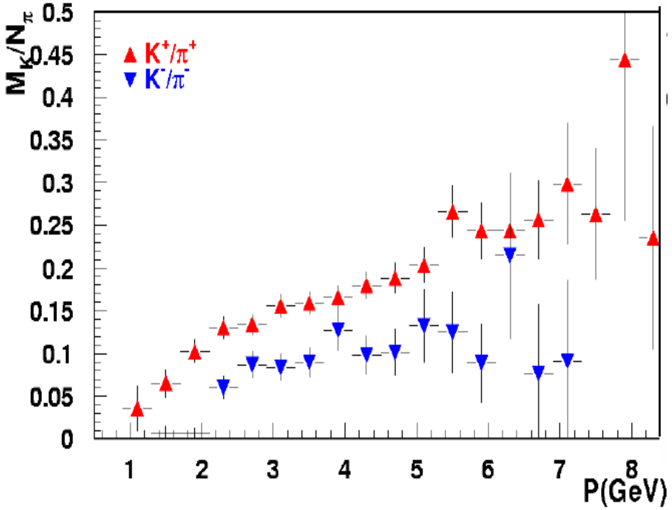
RICH detector



Substitute LTCC sectors with a proximity focusing RICH detector

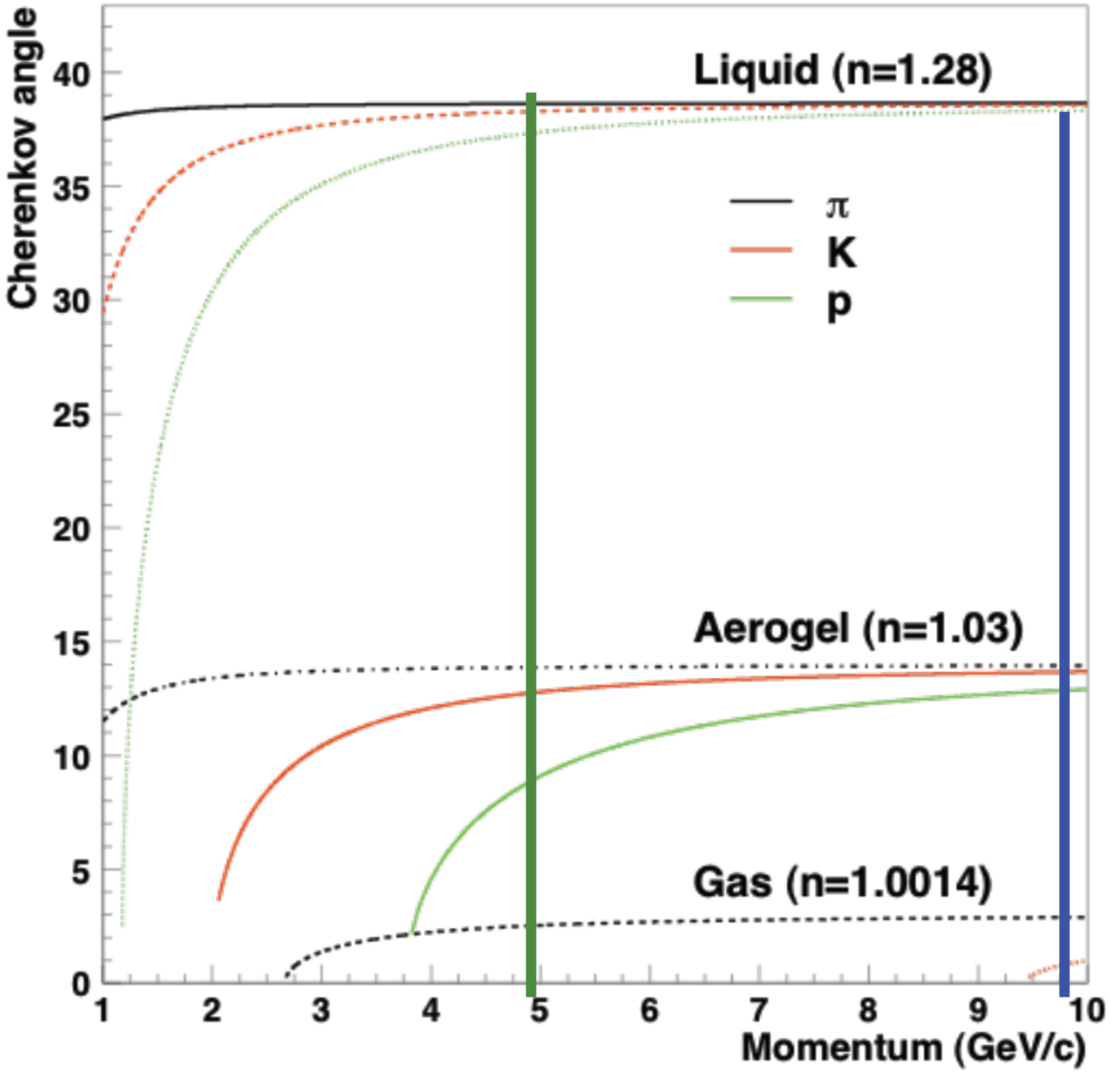


GeV/c		1	2	3	4	5	6	7	8	9	10
π/K	TOF	TOF	TOF								
	LTCC			LTCC	LTCC	LTCC	LTCC	LTCC	LTCC		
	HTCC						HTCC	HTCC	HTCC	HTCC	HTCC
π/p	TOF	TOF	TOF	TOF	TOF	TOF					
	LTCC			LTCC	LTCC	LTCC	LTCC	LTCC	LTCC	LTCC	LTCC
	HTCC						HTCC	HTCC	HTCC	HTCC	HTCC
K/p	TOF	TOF	TOF	TOF	TOF						
	LTCC									LTCC	LTCC



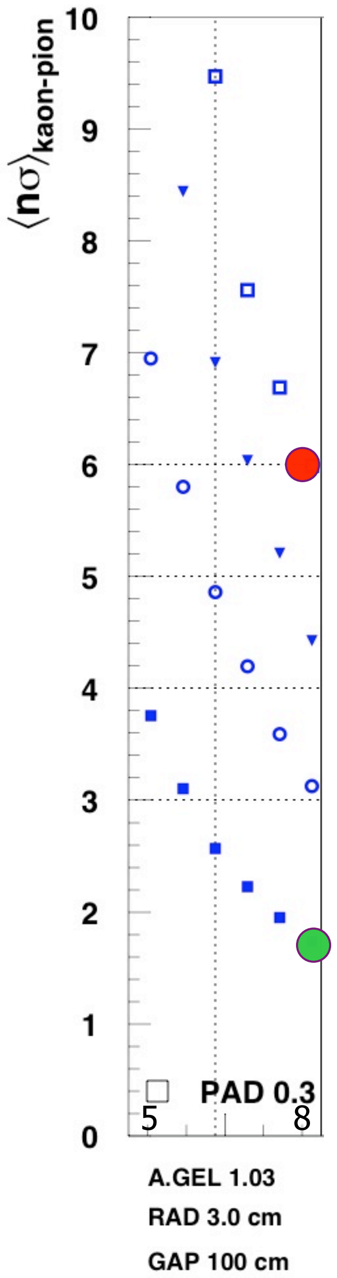
- ratio K/π ~ 0.1-0.15

The Aerogel option



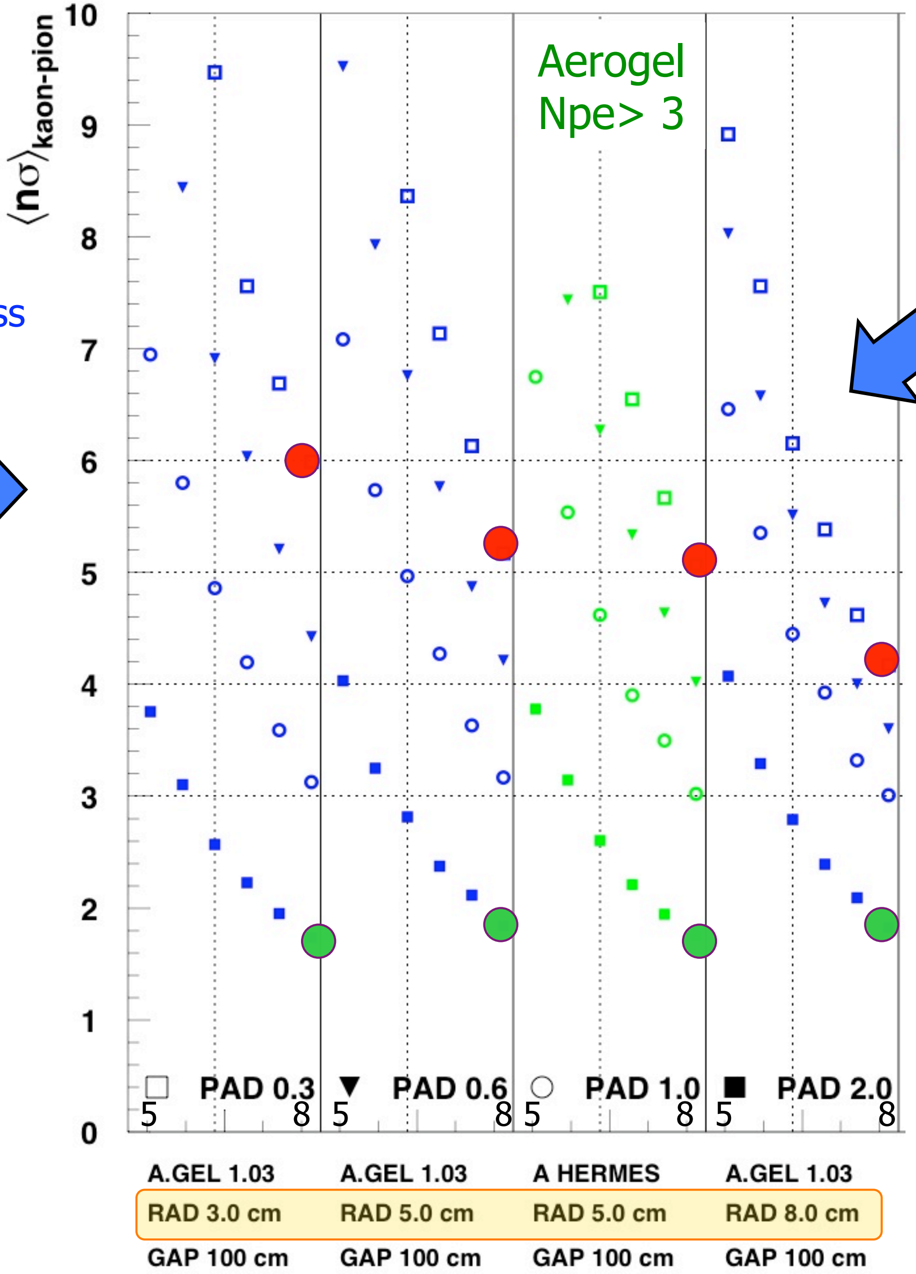
Less photons
Larger angle separation

Mean πk separation (5-8 GeV)



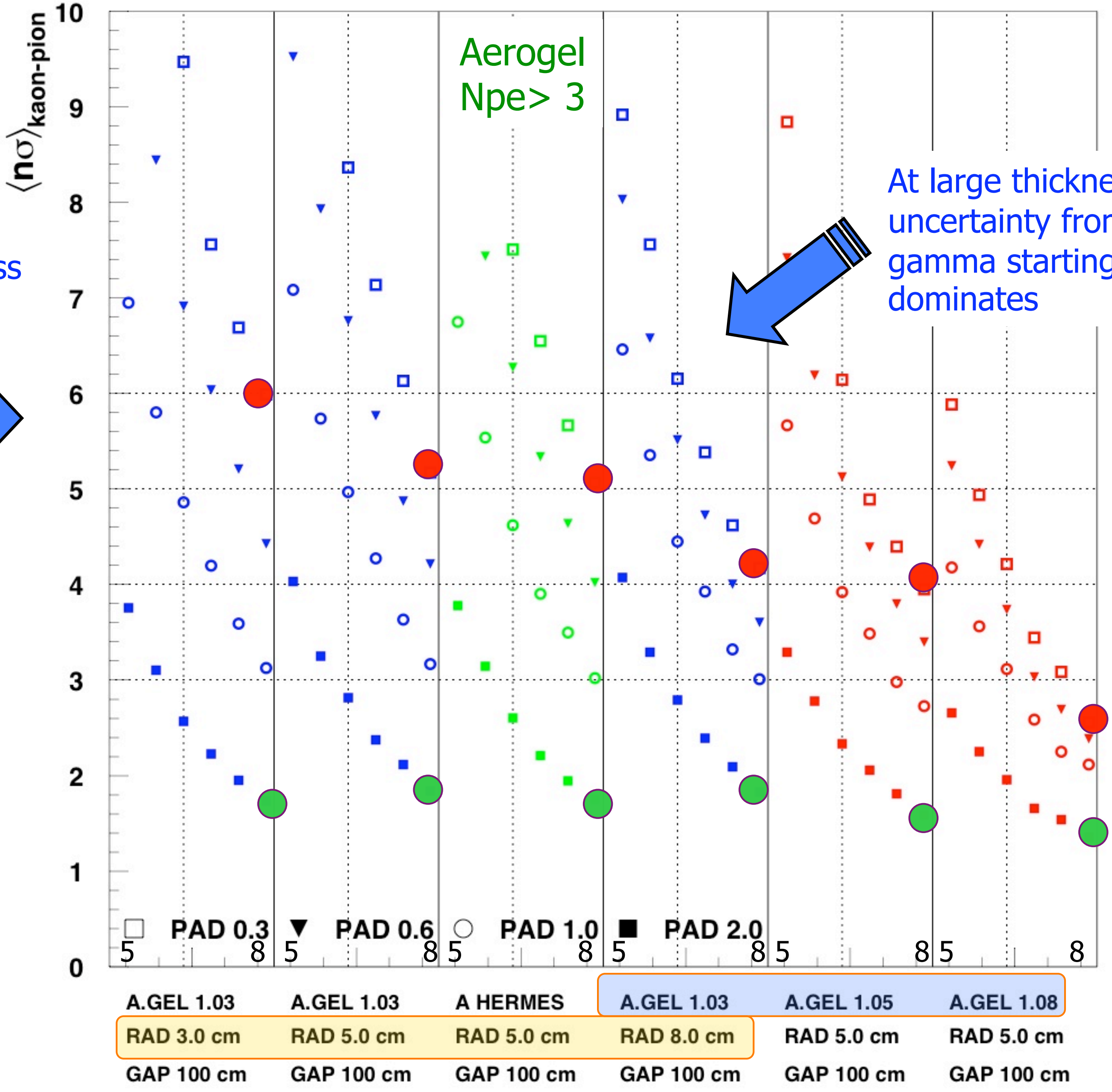
Mean πk separation (5-8 GeV)

Reducing thickness improves small pad response



At large thickness uncertainty from gamma starting point dominates

Mean πk separation (5-8 GeV)



Reducing thickness improves small pad response

At large thickness uncertainty from gamma starting point dominates

Increasing n reduces angle difference

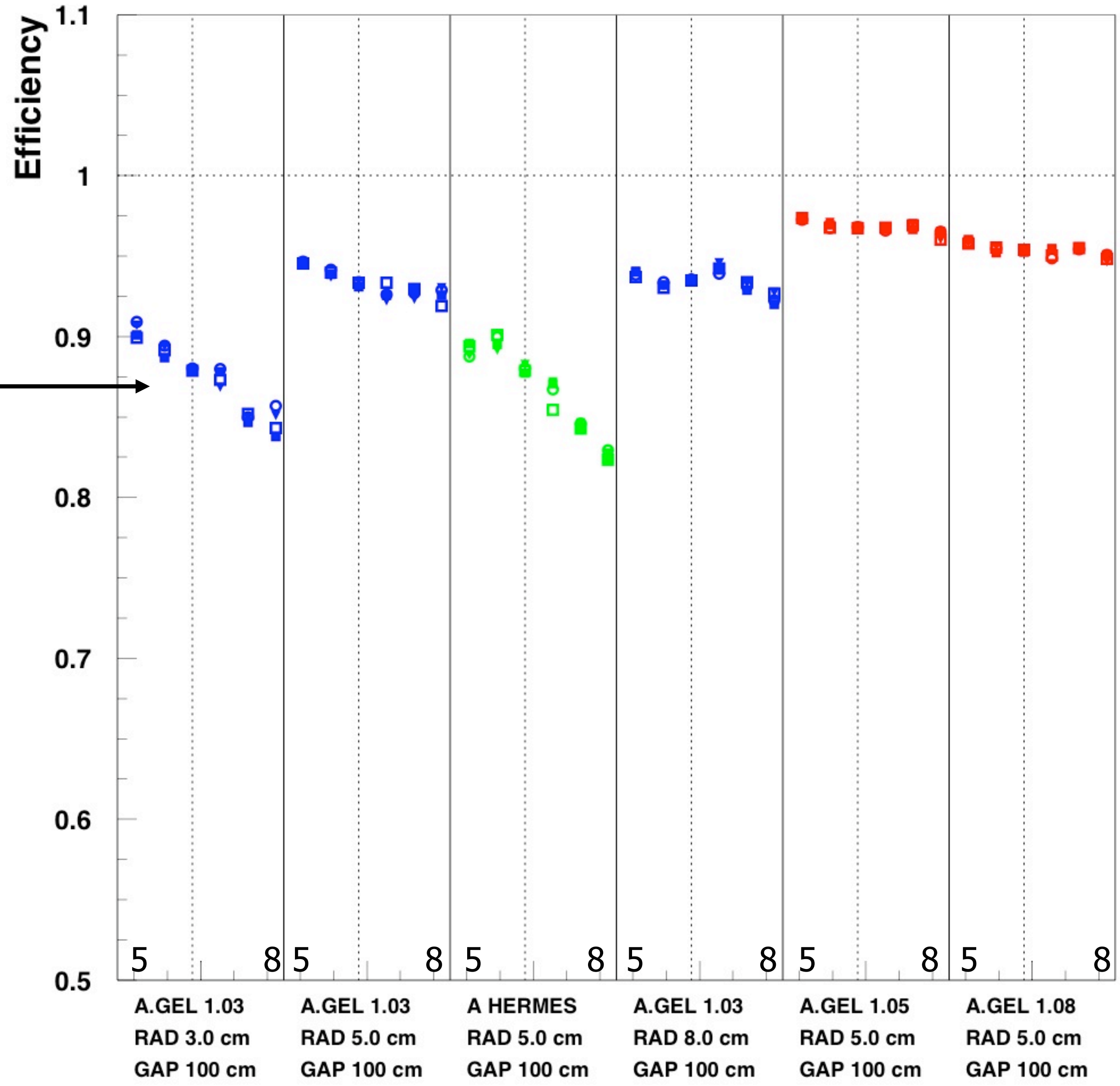
ID efficiency (5-8 GeV)

ID eff. ~ **85-90%** in the most promising configuration:

n_Aerogel =1.03

rad. thickness: 3 cm

gap: 100 cm



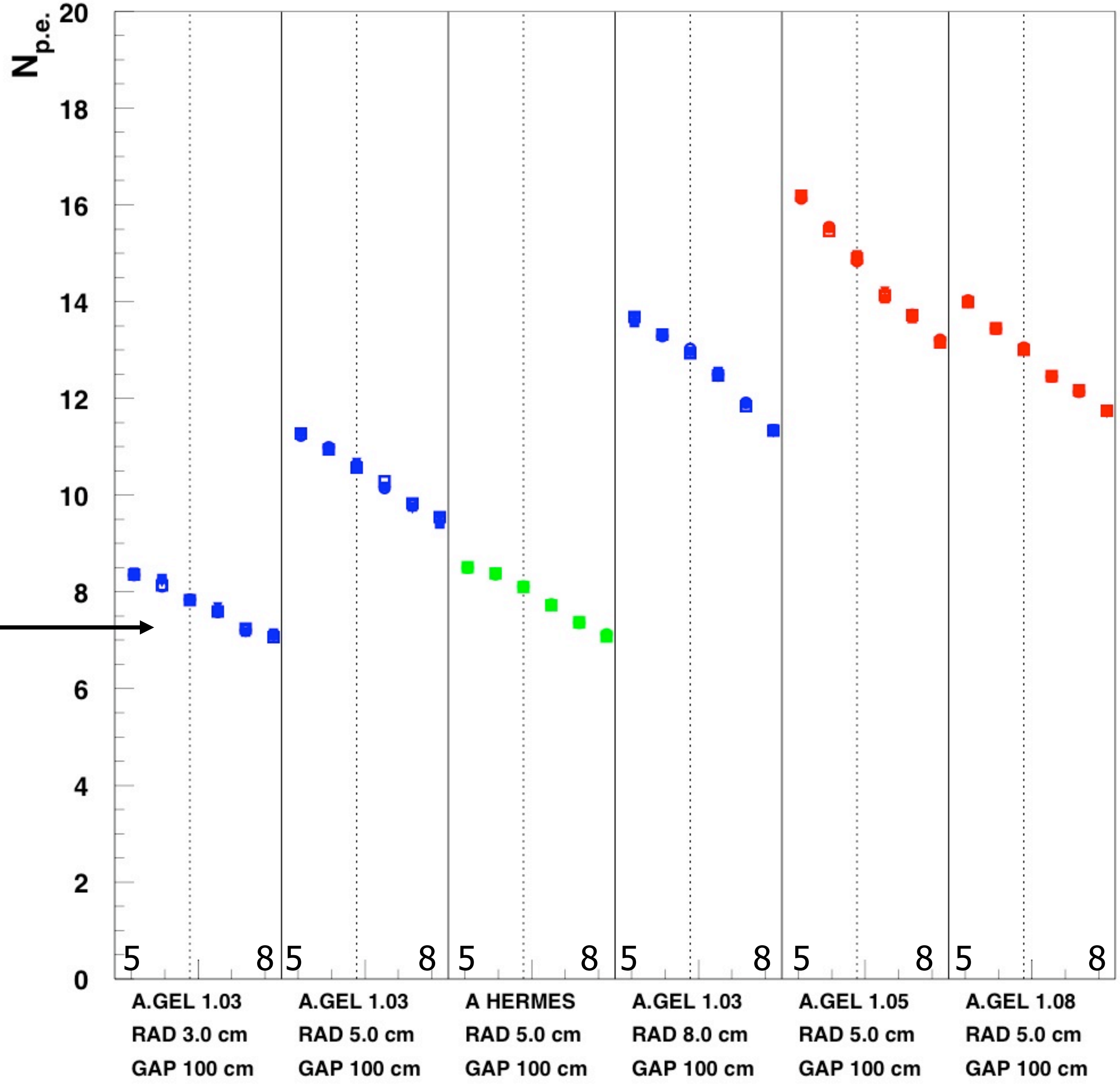
Mean p.e. number (5-8 GeV)

7-8 photo-electrons the most promising configuration:

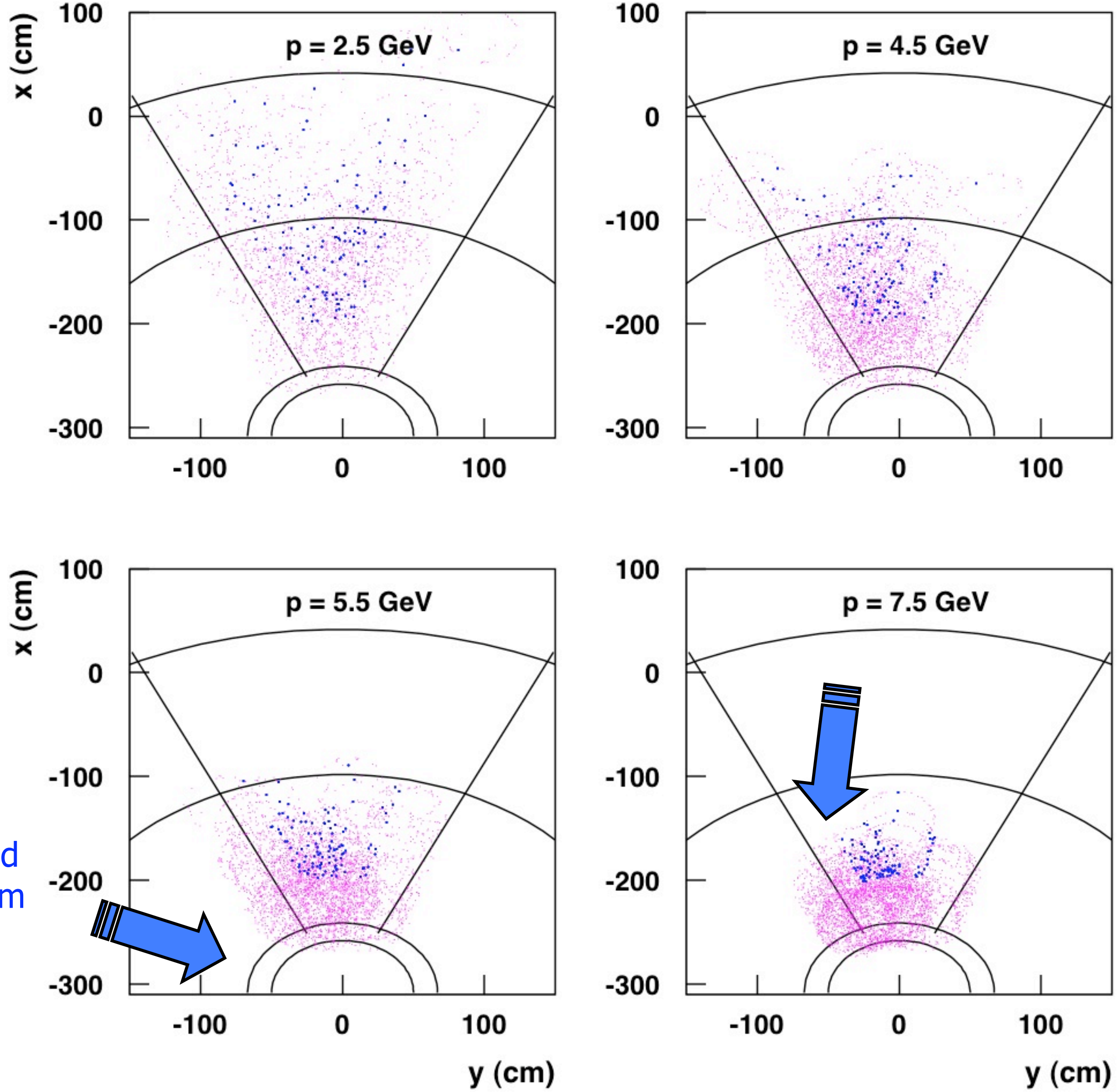
n_Aerogel =1.03

rad. thickness: 3 cm

gap: 100 cm



Gamma hits with Aerogel



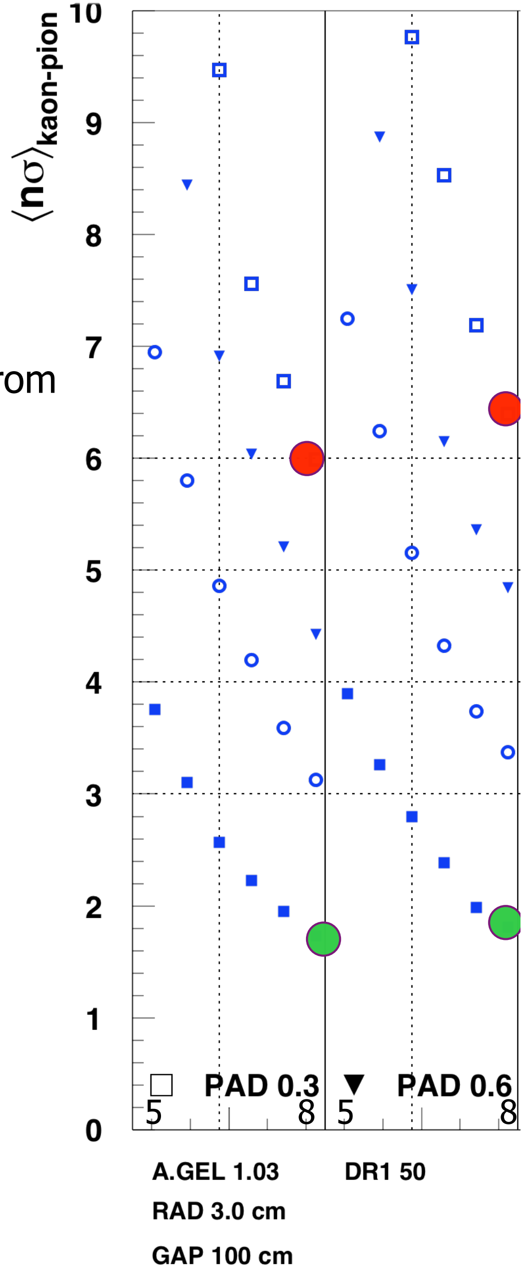
Full ring catched if down to 50 cm from beam line

Asymmetric illuminiation (due to 5 T solenoid) suggests better to use multi sectors

Mean πk separation (5-8 GeV)

Geometry costraints:

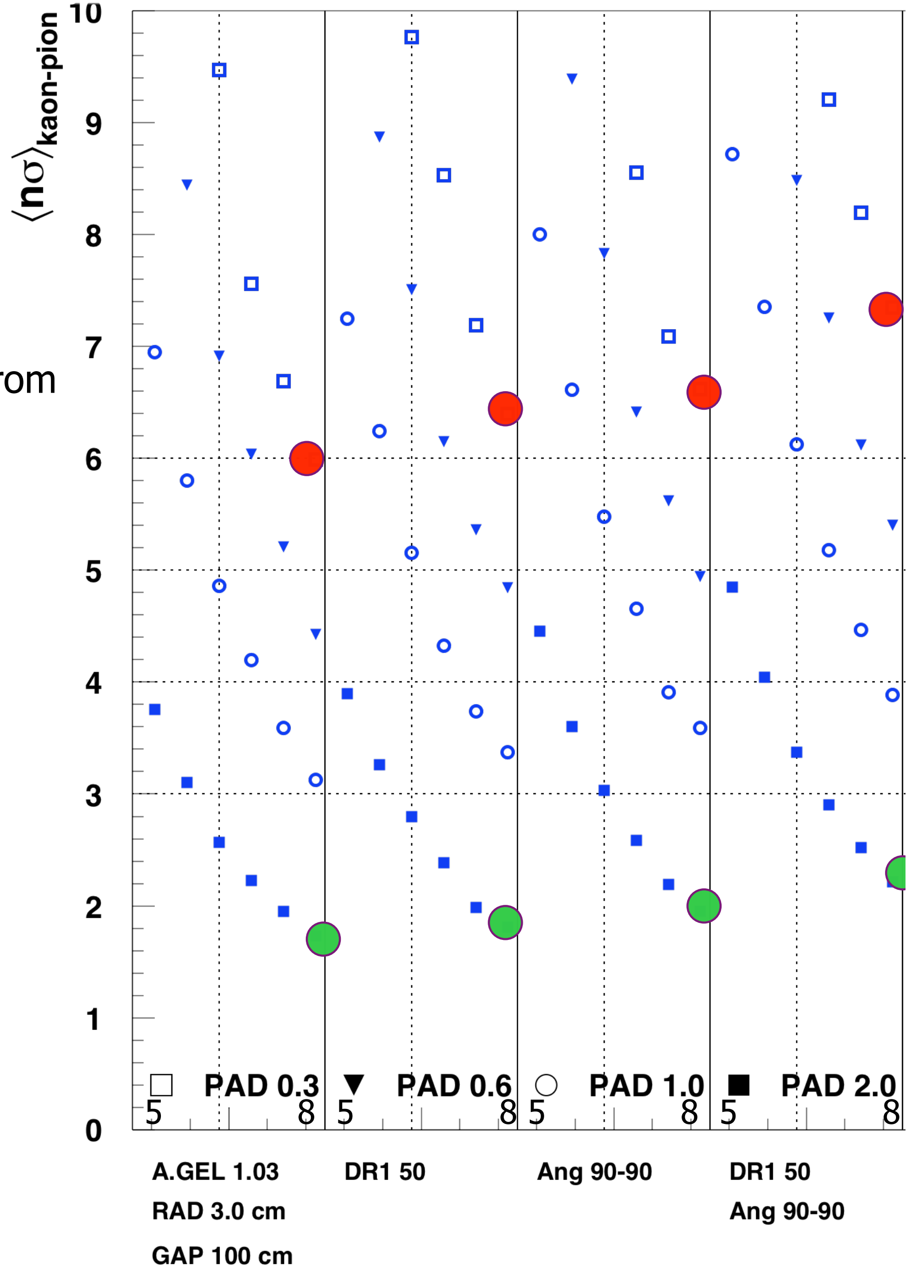
- minimum radius down to 50 cm from beam line



Mean πk separation (5-8 GeV)

Geometry costraints:

• minimum radius down to 50 cm from beam line



Mean πk separation (5-8 GeV)

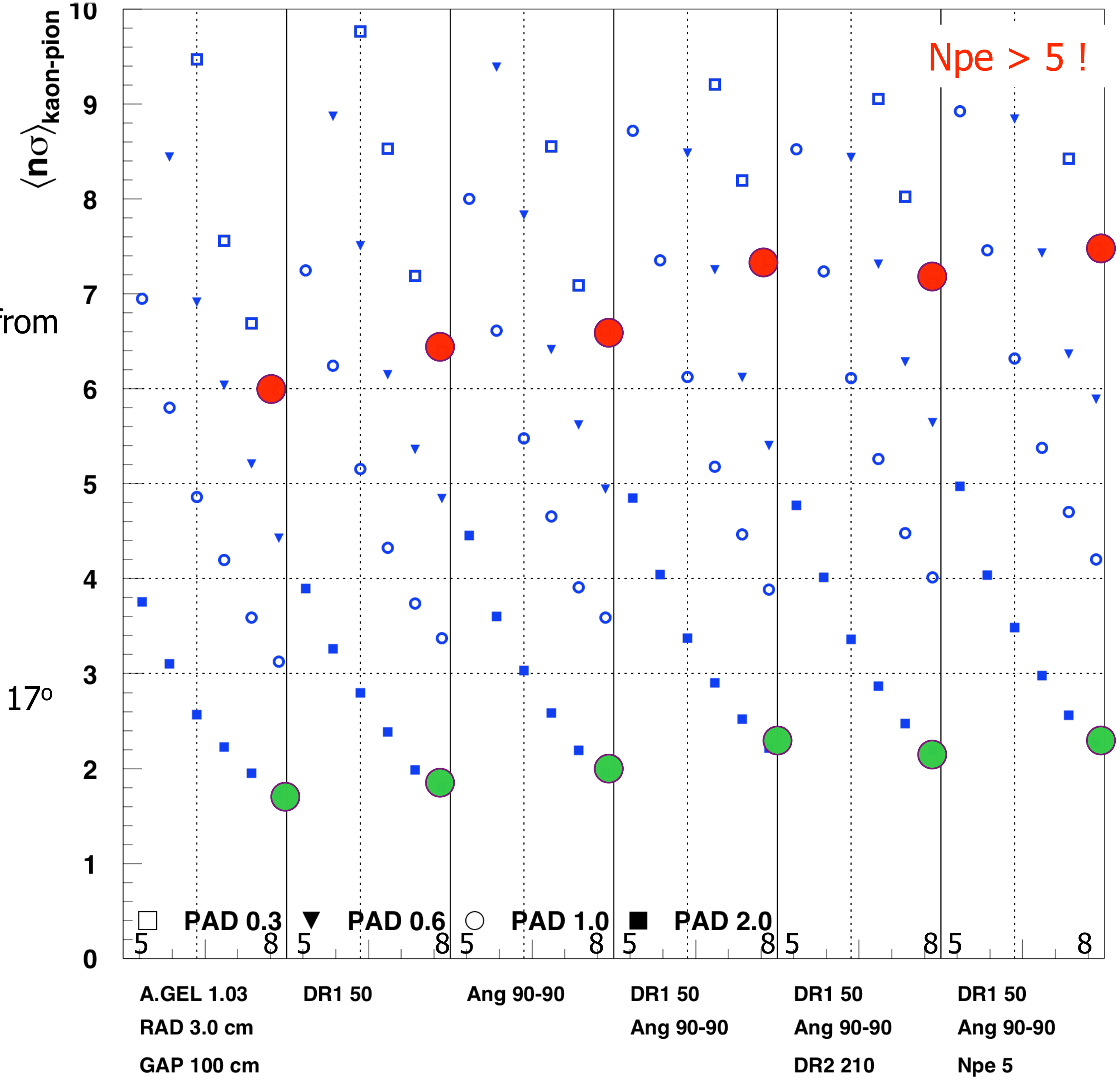
Geometry costraints:

• minimum radius down to 50 cm from beam line

Weak sensitivity on:

• reduction of active area down to 17°

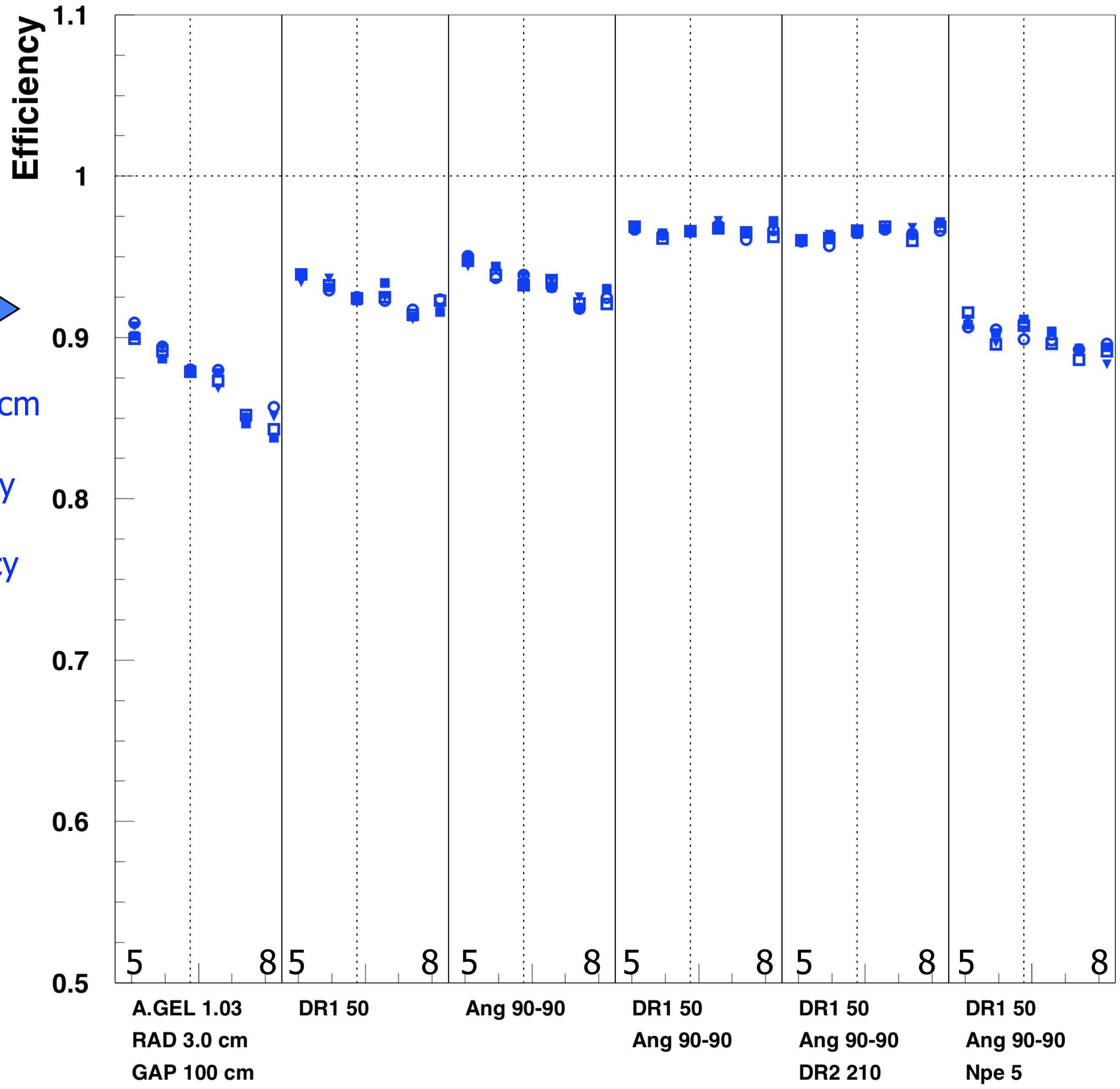
• minimum N p.e. (from 3 to 5)



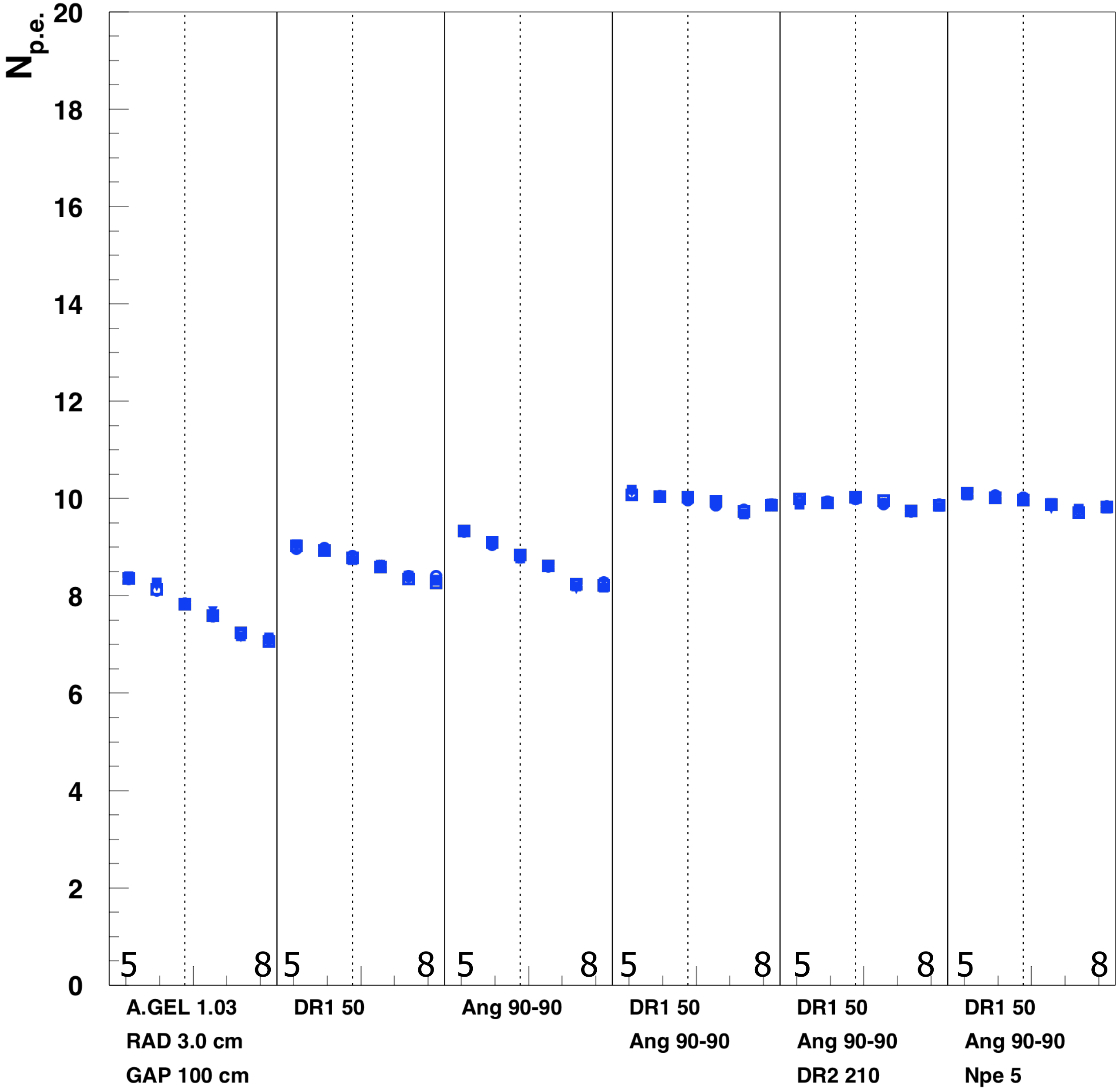
ID efficiency (5-8 GeV)

Going down to 50 cm
&
Left-right symmetry

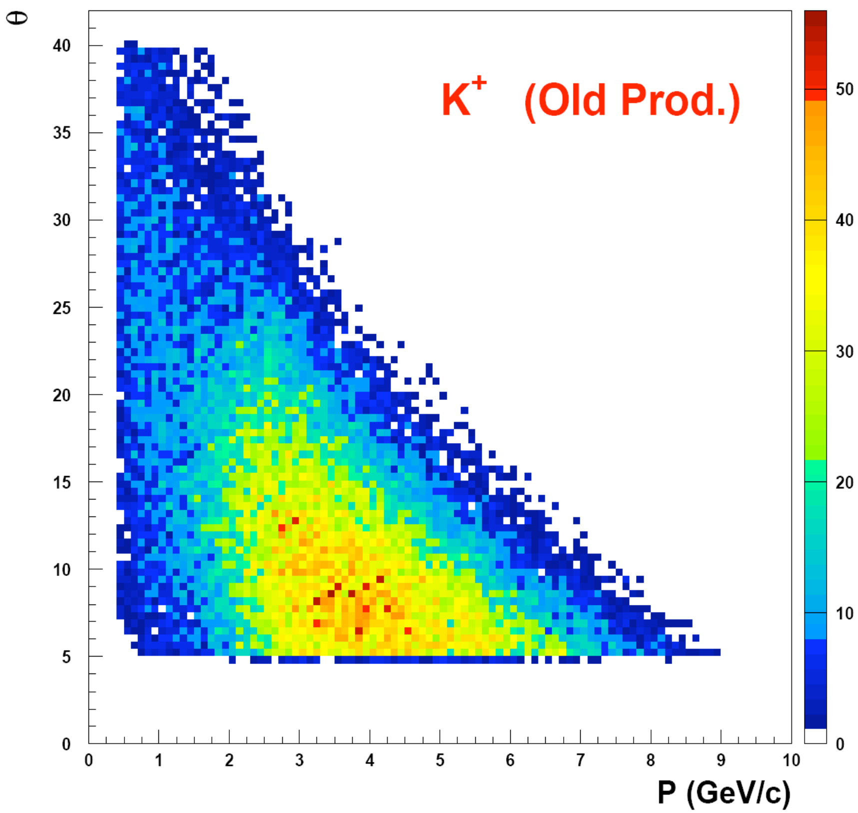
increases efficiency



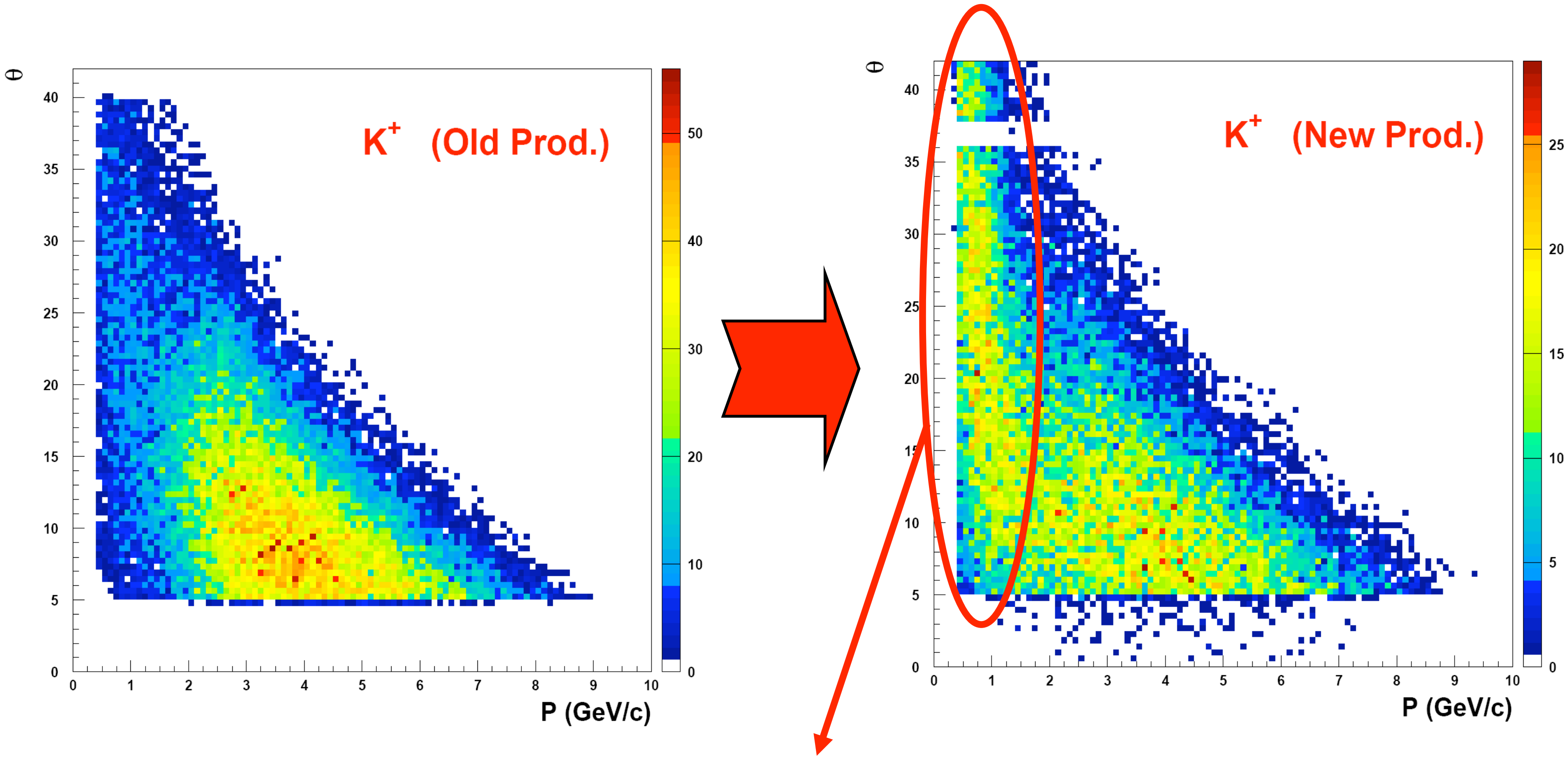
Mean p.e. number (5-8 GeV)



A first glimpse into the new productions (with toroid)

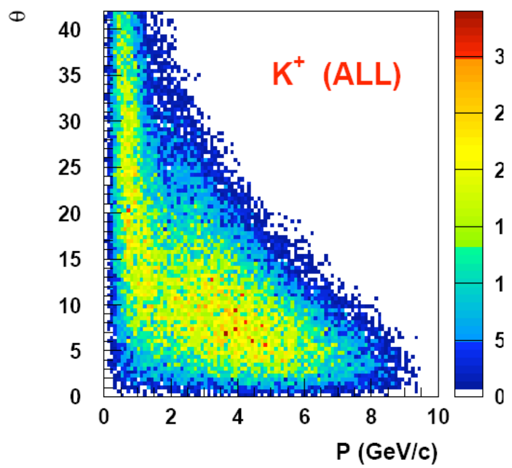


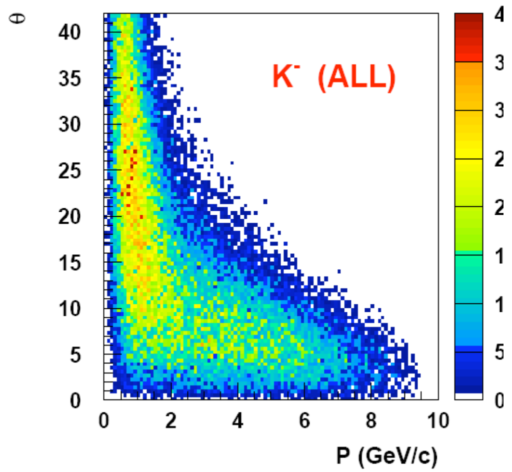
A first glimpse into the new productions (with toroid)



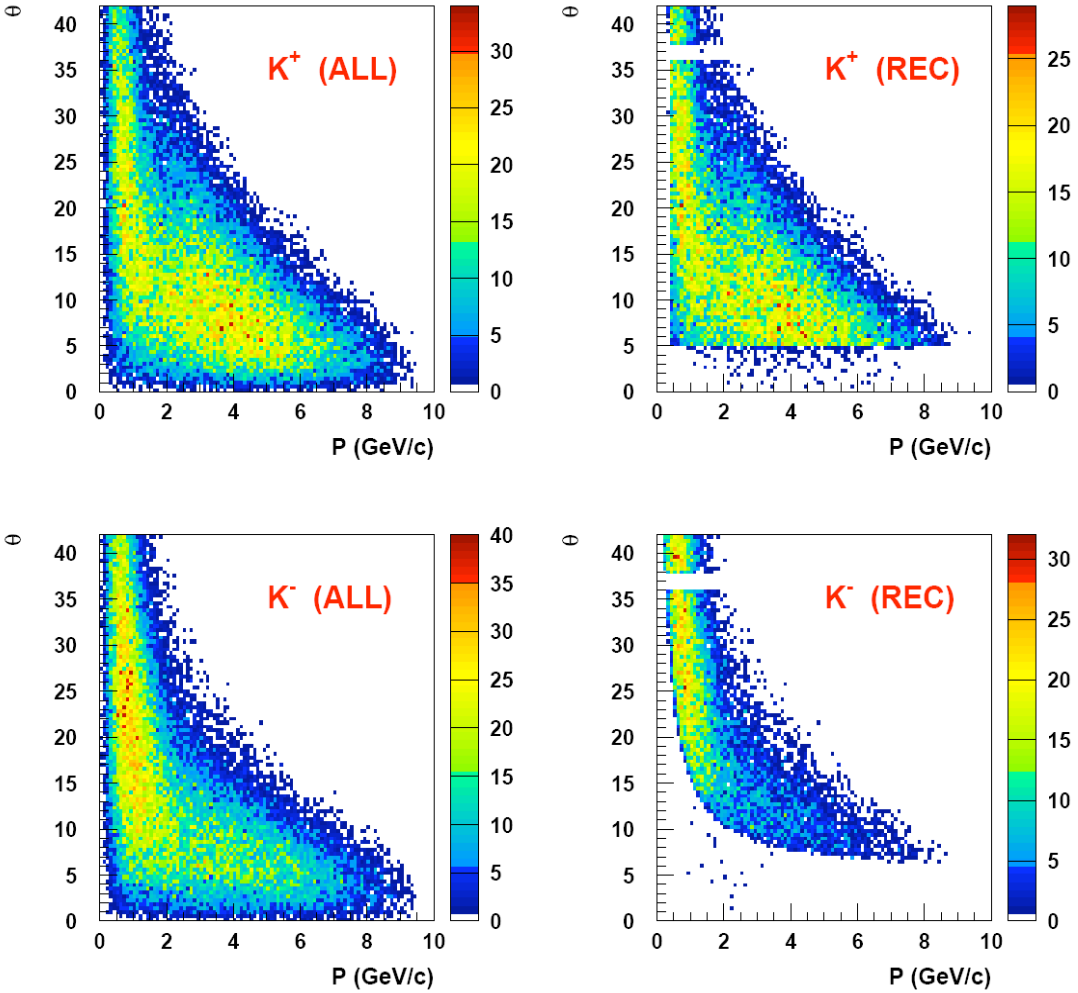
Enhancement of tracks with low momentum $(P < 2\,\mathrm{GeV})$

A first glimpse into the new productions (with toroid)





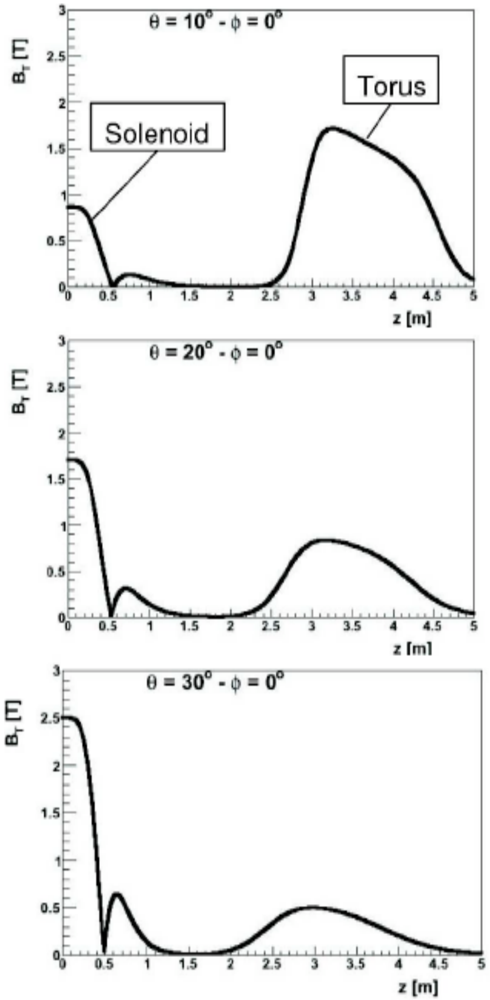
A first glimpse into the new productions (with toroid)



Charge effects clearly visible in kinematic plane!

Simulating the torus effect by grepping info from CLAS12 Technical Design Report

- Center of torus field obtained from linear interpolation of data in fig. 1.1 (pag 110)

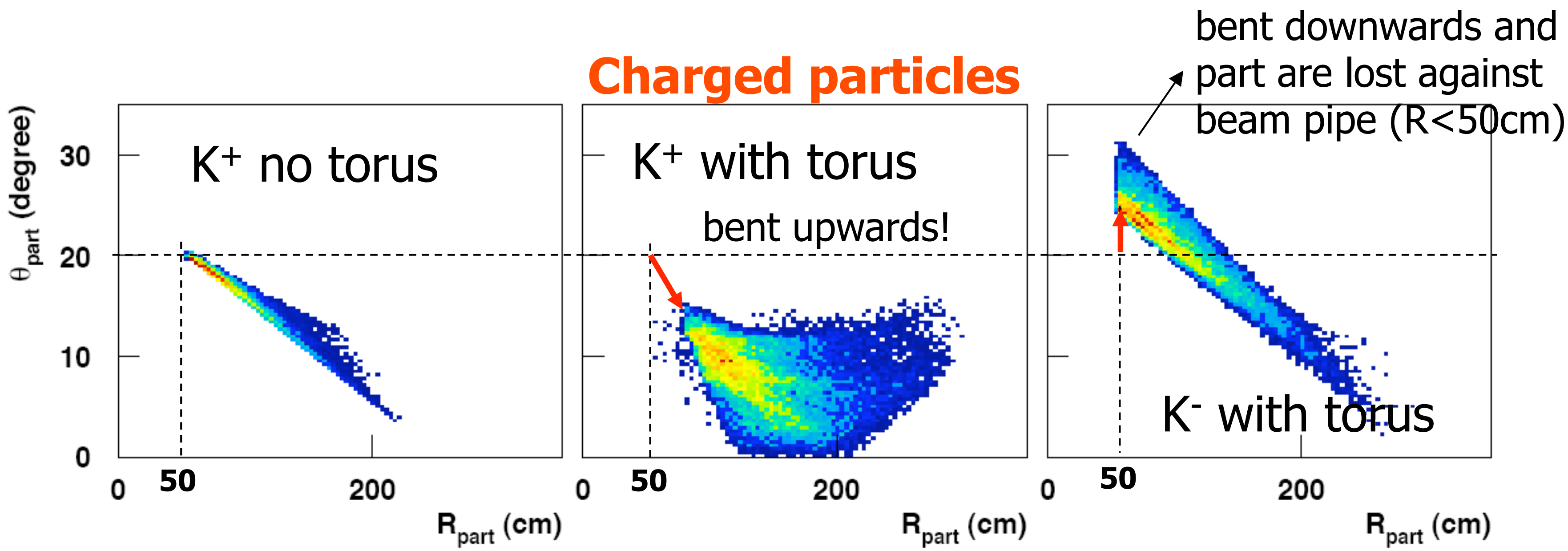


- Integrated field from exponential interpolation of data in tab 1.1 (pag 113)

Conductor	NbTi
Configuration, overall dimensions	Six trapezoidal sections
Radial thickness	294 mm
No. of double pancakes in section	1
No. of turns in double pancake	$2\times140 = 280$
Conductor length (one section)	2.43 km
Conductor length (torus)	14.56 km
Torus inductance	3.12 H
Conductor current	3150 A
Amp-turns (one section)	0.882 mA
Amp-turns (torus)	5.3 mA
Stored energy (torus)	15.5 MJ
Max. field (at the winding)	4.6 T
$\int Bdl\ (\theta{=}40^\circ)$	0.517 Tm
$\int Bdl\ (\theta{=}5^\circ)$	3.32 Tm
$\int Bdl\ (\theta{=}20^\circ)$	1.43 Tm

Table 1.1: Parameters of the torus reference winding.

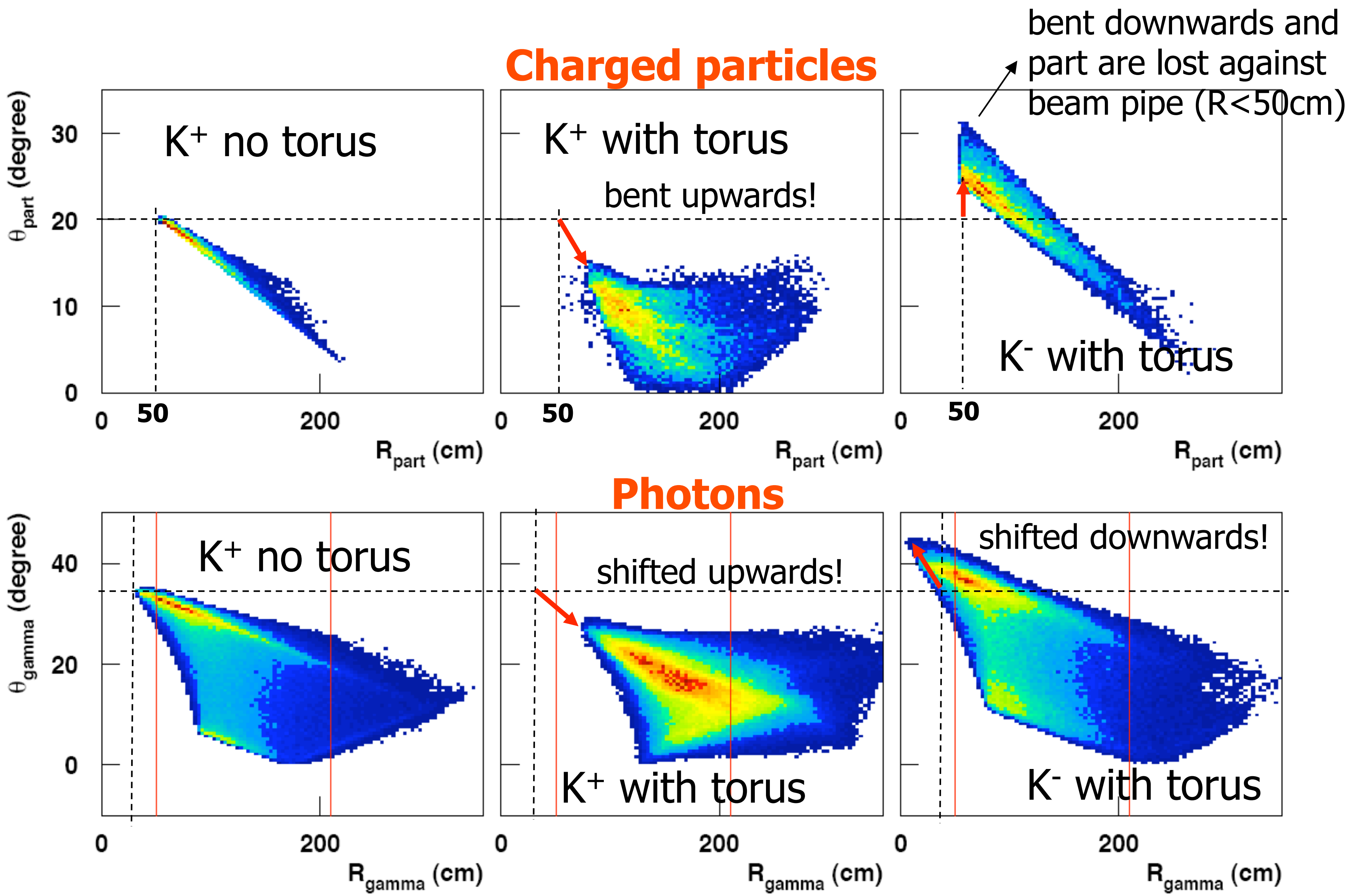
A first glimpse into the new productions (with toroid)



R = radial distance from beam

θ = w.r.t. direction normal to RICH

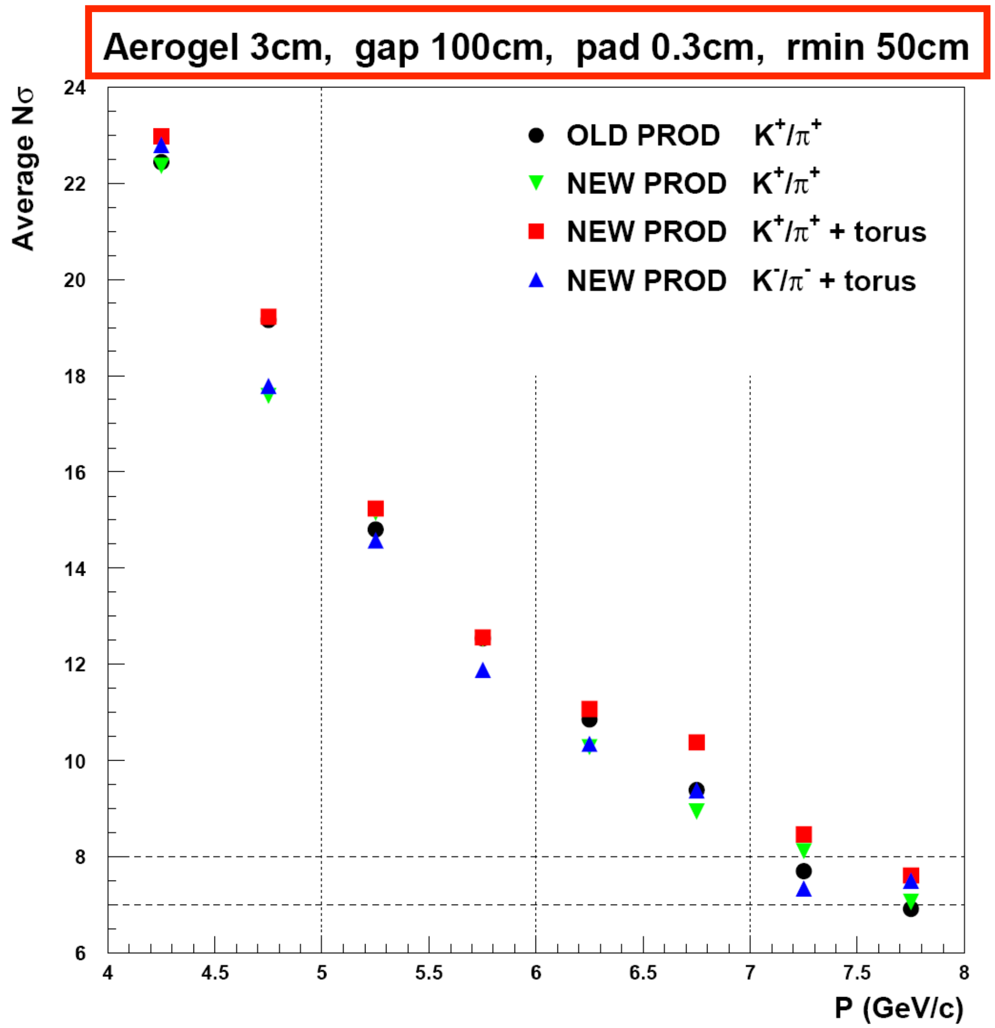
A first glimpse into the new productions (with toroid)



R = radial distance from beam

θ = w.r.t. direction normal to RICH

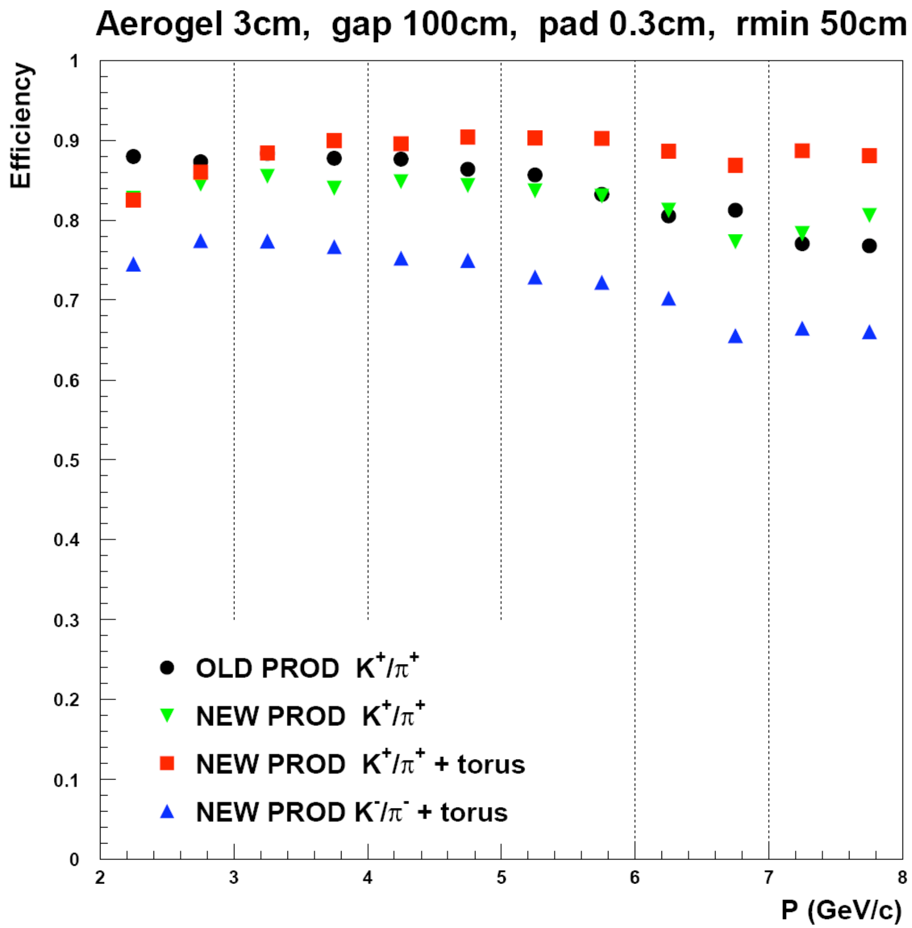
A first glimpse into the new productions (with toroid)

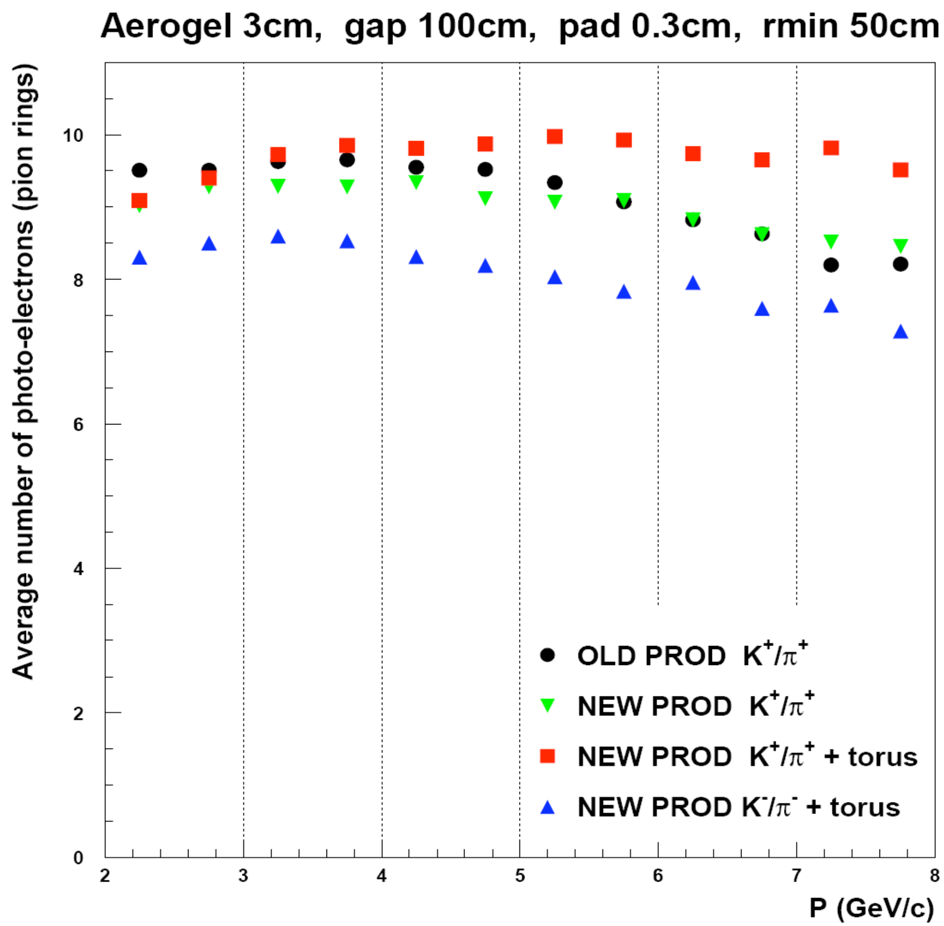


First results for the "standard" configuration:

- pi/K separation barely affected by the toroid
- pi/K separation weakly dependent on hadron charge

A first glimpse into the new productions (with toroid)





Conclusions (1st part)

Aerogel provides a very good pion/kaon separation up to 8 GeV/c

- **Performances were found to improve for:**
  - small photo-detector pads (~ 0.3 cm)
  - small radiator thickness (~ 3 cm)
  - relatively small refraction index (~ 1.03)
  - minimum radius down to 50 cm from beam pipe
  - all sectors covered

- **Similar pion/kaons separation w/wo toroid and weak sensitivity to particle charge**

⇨ Move to Geant 4 for refined studies

- **Main problems:**

  1. Interference with TOF detector
  2. High costs due to small pad size & large photo-detector area

⇨ Need to minimize detector area & material budget

Interference with TOF: preliminary studies

The idea: simulate the material budget of the photon-detector with a dummy material wall placed at the end of the GAP

Main features:

- **material: alluminum, copper or tungsten** (to test various densities)
- **pattern: 8x8 matrix of 0.6 cm squared cells surrounded by 2 mm dead area** (total area is a square of 52 mm side to resemble the H8500 modules with 0.6 cm pad)
- **thickness of the cells is random within [0, 2cm]** (to randomize material budget)
- **z position of the cell is varied randomly within 8 cm from the end of the GAP** (to randomize material position)

Interference with TOF: preliminary studies

Time-of-flight differences due to multiple scattering in the wall

A realistic scenario:

- particle momenta of [2.0, 2.5] GeV
- 1m GAP
- random wall width [0, 2.0] cm
- random wall position (within 8 cm, close to GAP end)
- tracks with original generated angles

Interference with TOF: preliminary studies

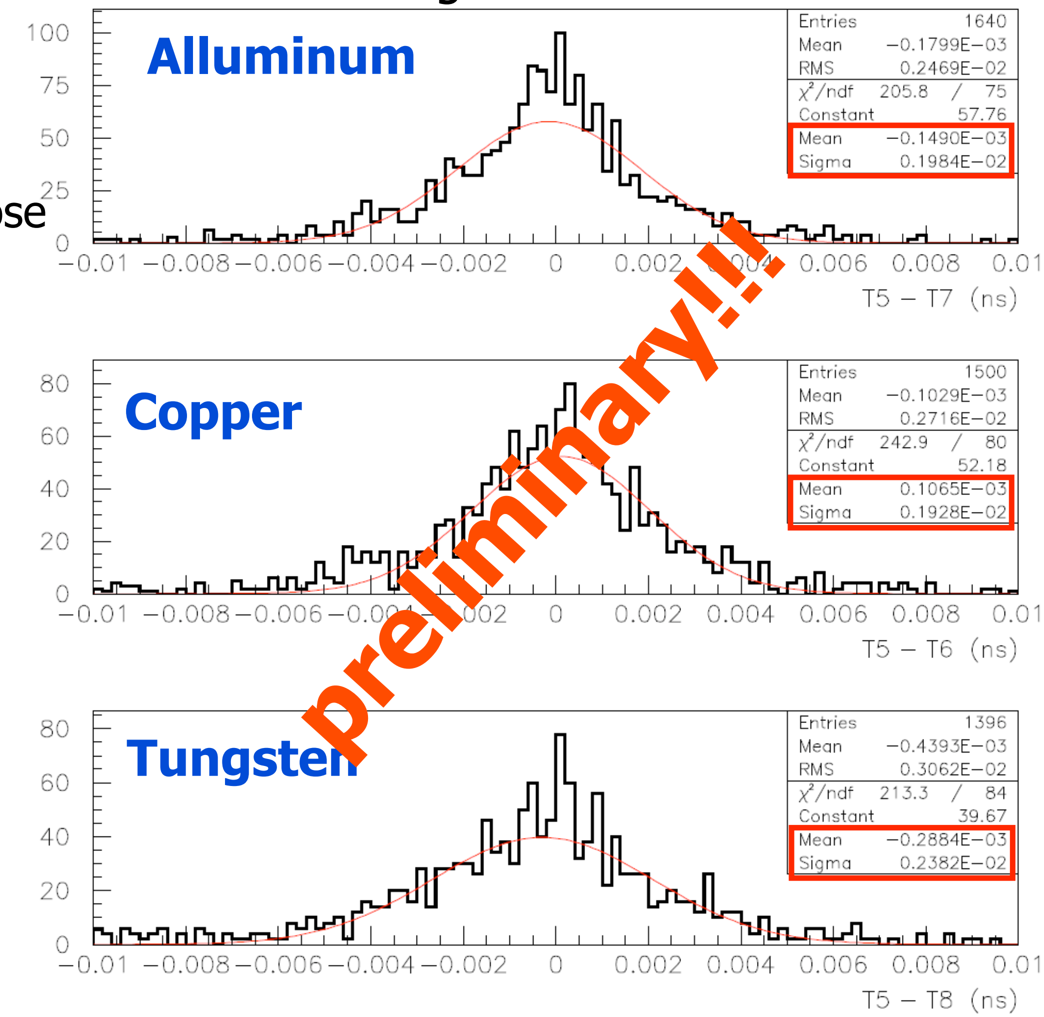
Time-of-flight differences due to multiple scattering in the wall

A realistic scenario:

- particle momenta of [2.0, 2.5] GeV
- 1m GAP
- random wall width [0, 2.0] cm
- random wall position (within 8 cm, close to GAP end)
- tracks with original generated angles

- **negligible effect !!**

Time-of-flight differences in ns



Interference with TOF: preliminary studies

Time-of-flight differences due to multiple scattering in the wall

A "artificially worst case" scenario:

- very low particle momentum (~ 500 MeV) and maximal wall width (2 cm) to maximize effects of multiple scattering
- 4m GAP and wall close to radiator, to magnify to effect of multiple scattering
- tracks at fixed angle (25 degrees)

Interference with TOF: preliminary studies

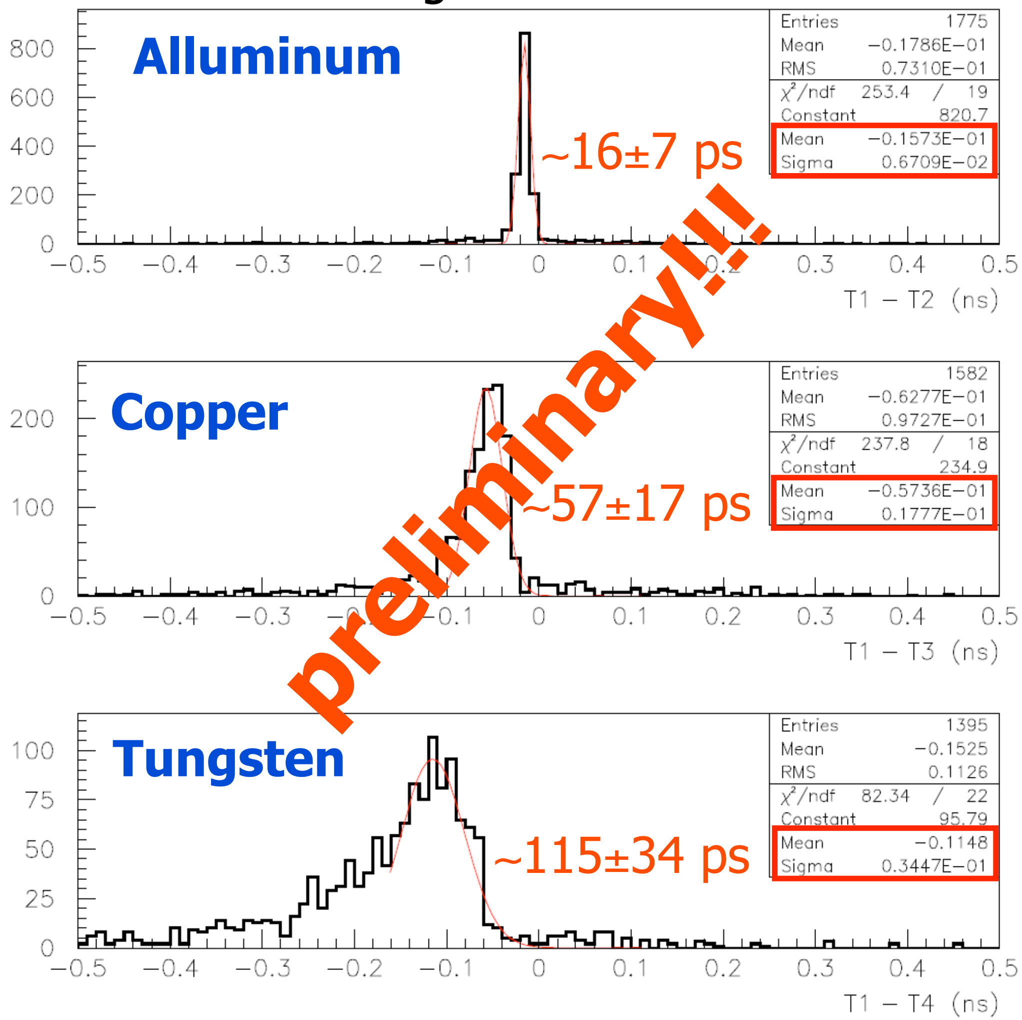
Time-of-flight differences due to multiple scattering in the wall

An "artificially worst case" scenario:

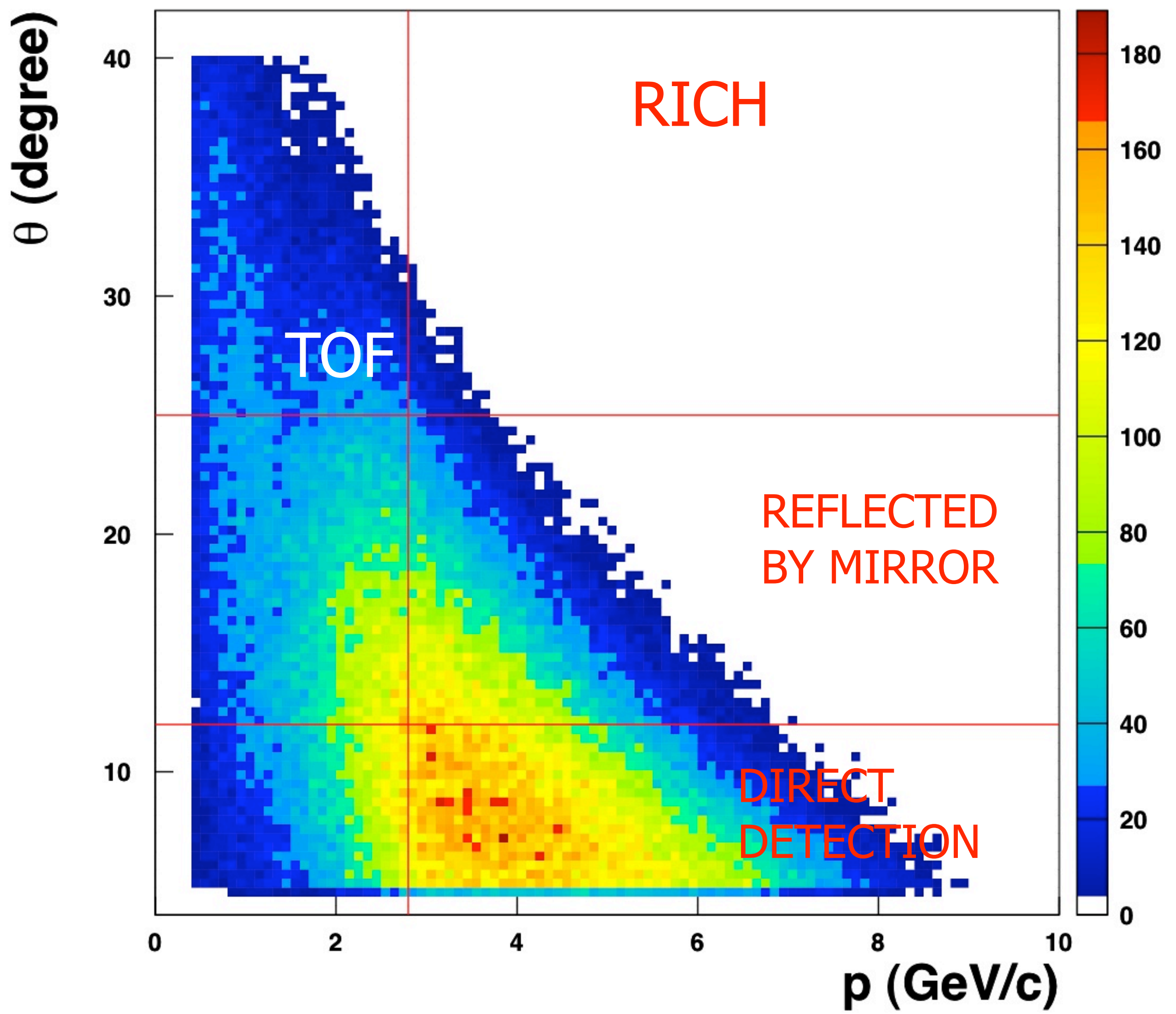
- very low particle momentum (~ 500 MeV) and maximal wall width (2 cm) to maximize effects of multiple scattering
- 4m GAP and wall close to radiator, to magnify to effect of multiple scattering
- tracks at fixed angle and normal to the RICH surface (25 degrees)

- **effects within TOF detector resolution**

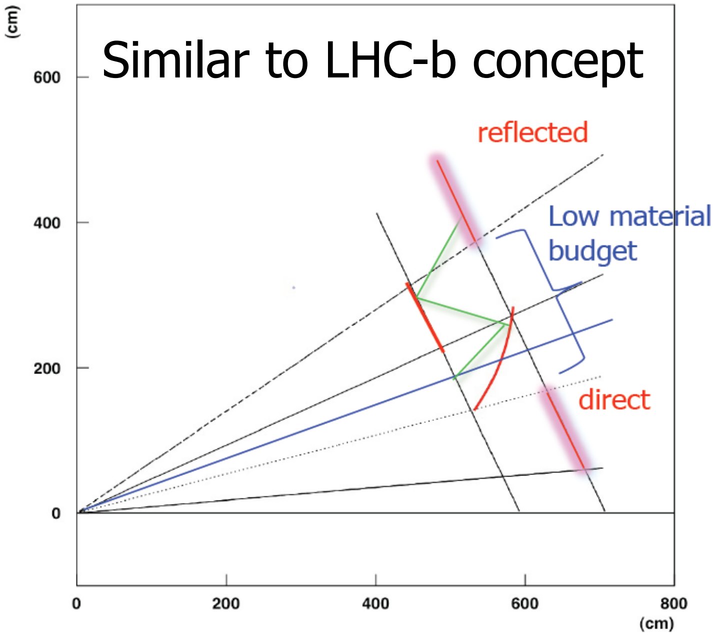
Time-of-flight differences in ns



The mirror option to limit detector area (old production)



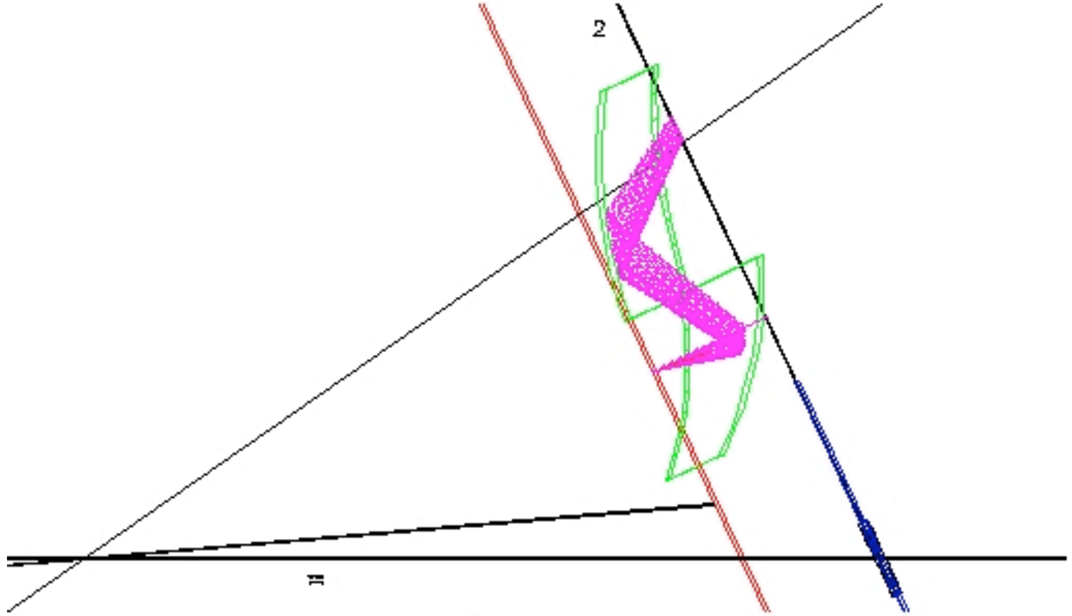
The mirror option: reflection outside

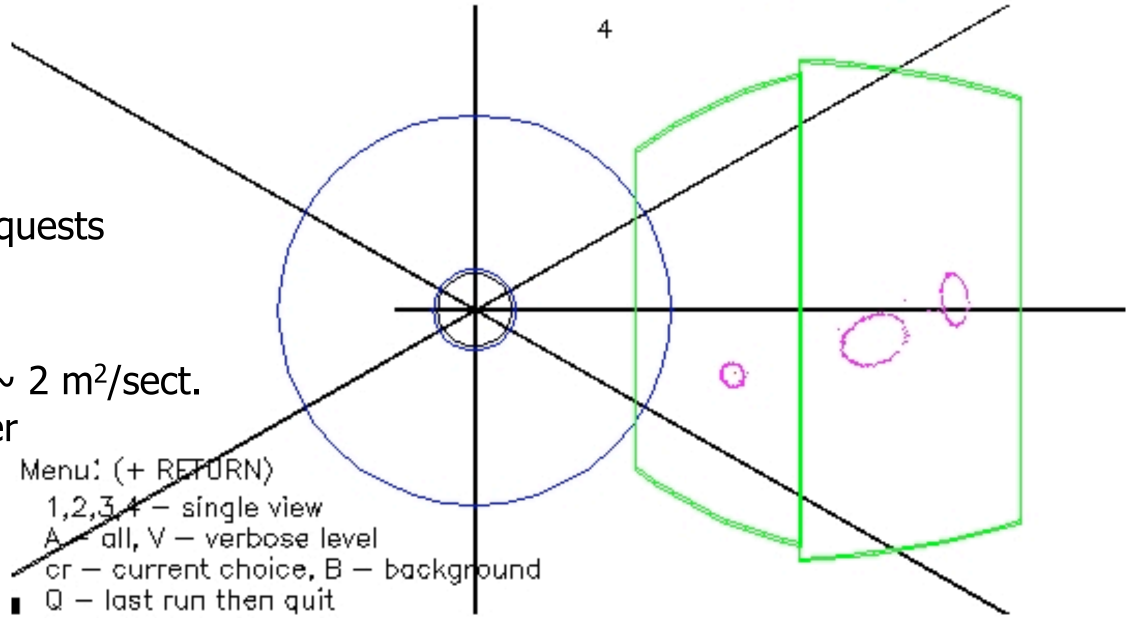


Direct:
high momentum → high performance

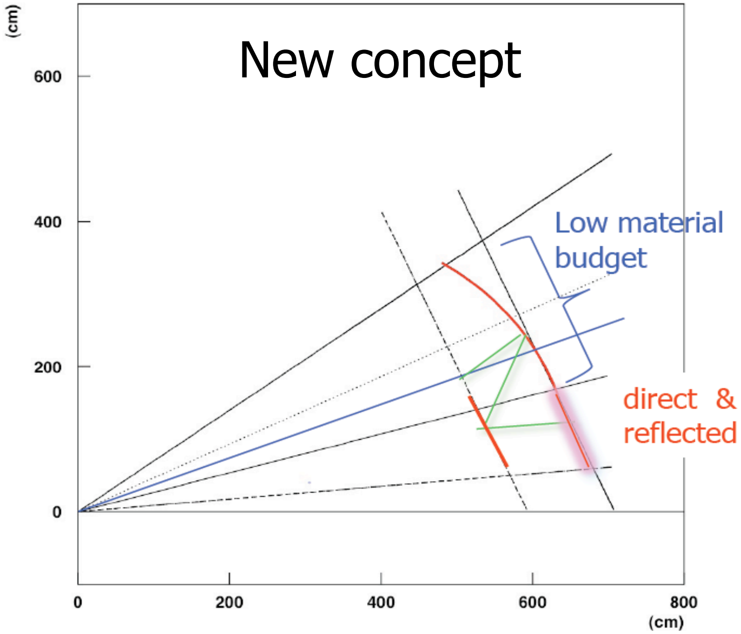
Reflected:
lower momentum → relax performance requests

- Minimize interference with TOF
- Focusing mirrors to reduce detector area to ~ 2 m^2/sect.
- Increase pad size → Reduce channel number

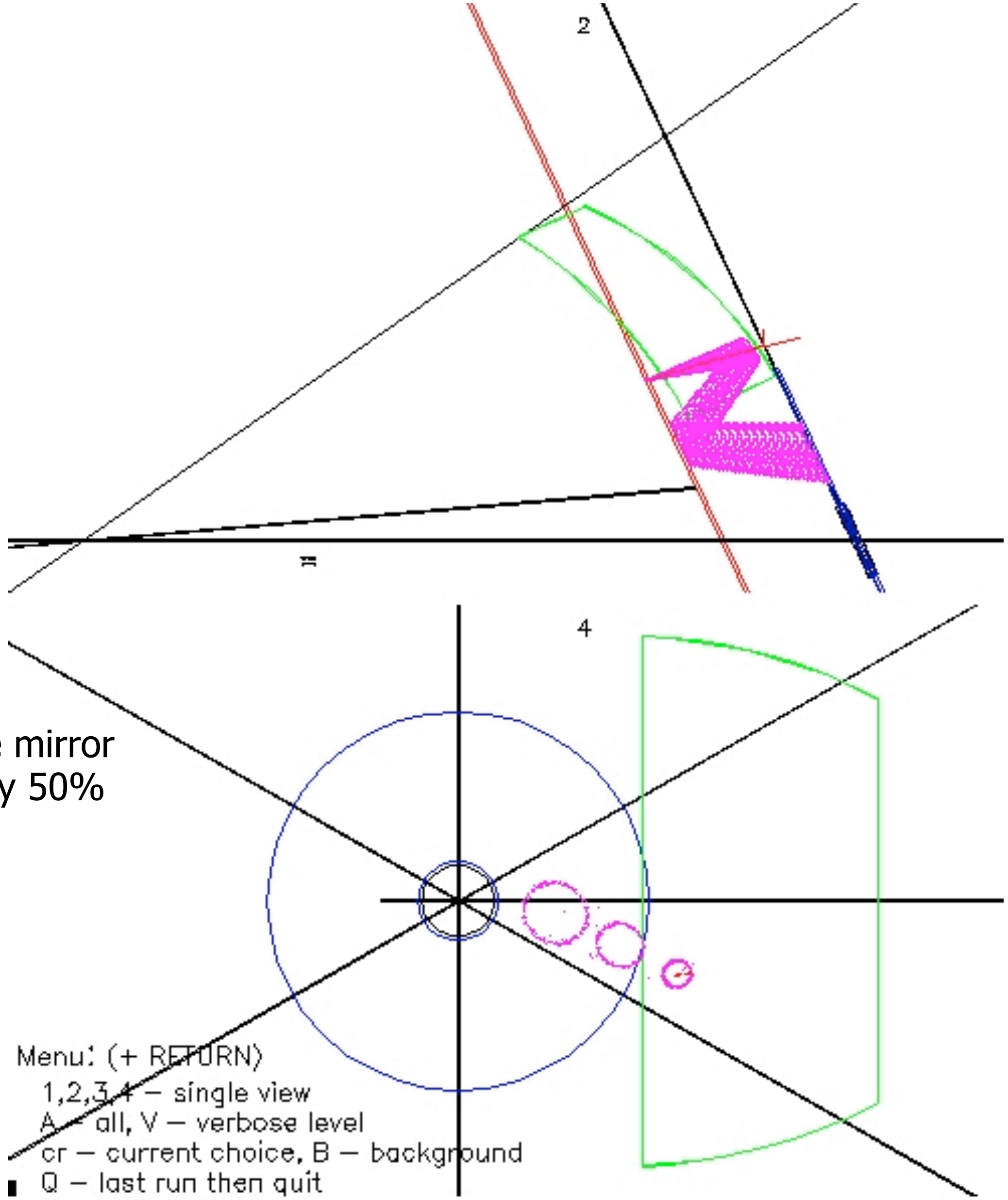




The mirror option: reflection inside



- Minimize interference with TOF
- Detector area down to ~ 1 m^2/sect.
- Too high absorption in aerogel → semi-reflective mirror
- Reduced collection efficiency → costs increase by 50%



Conclusions (2nd part)

- **Interference with TOF**

  - preliminary studies show negligible effects on TOF detector performances due to multiple scattering on photon-detector material (material wall)

  - effects of secondary particles emission need to be examined

- **Reduction of detector area**

  - two different mirror configurations were examined

  - need to repeat studies with the new productions (with toroid)

- **Future developments needed for more refined studies**

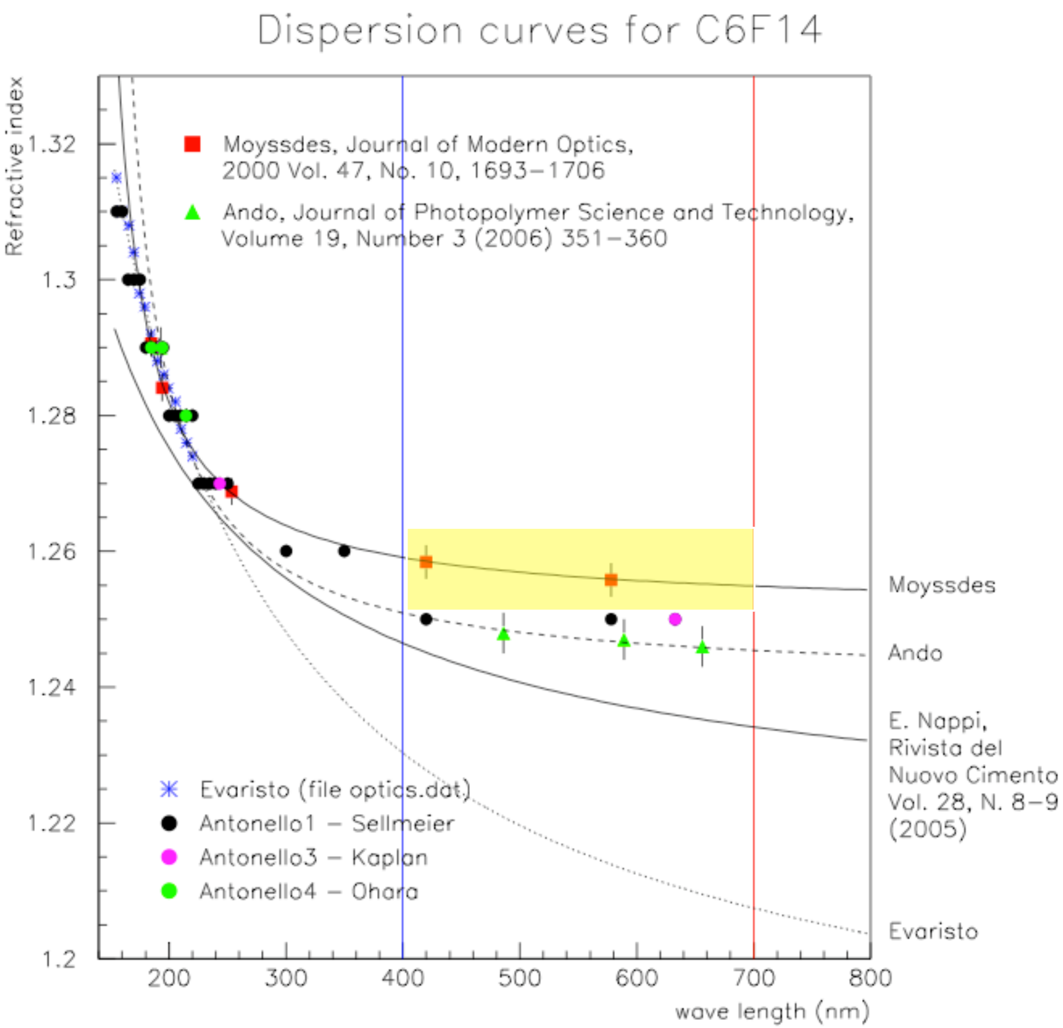
  - use of GEANT4 and implementation within the JLAB12 simulation framework

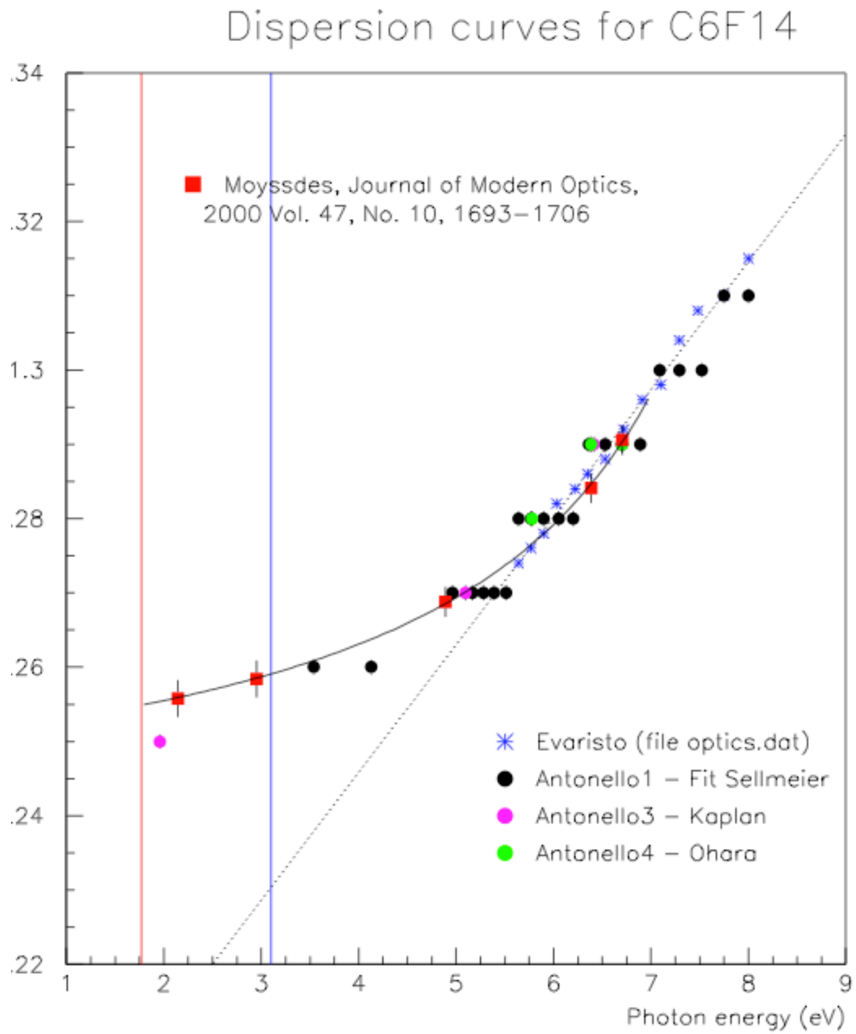
  - reconstruction of multi-tracks events

  - optimization of mirror geometry

Backup slides

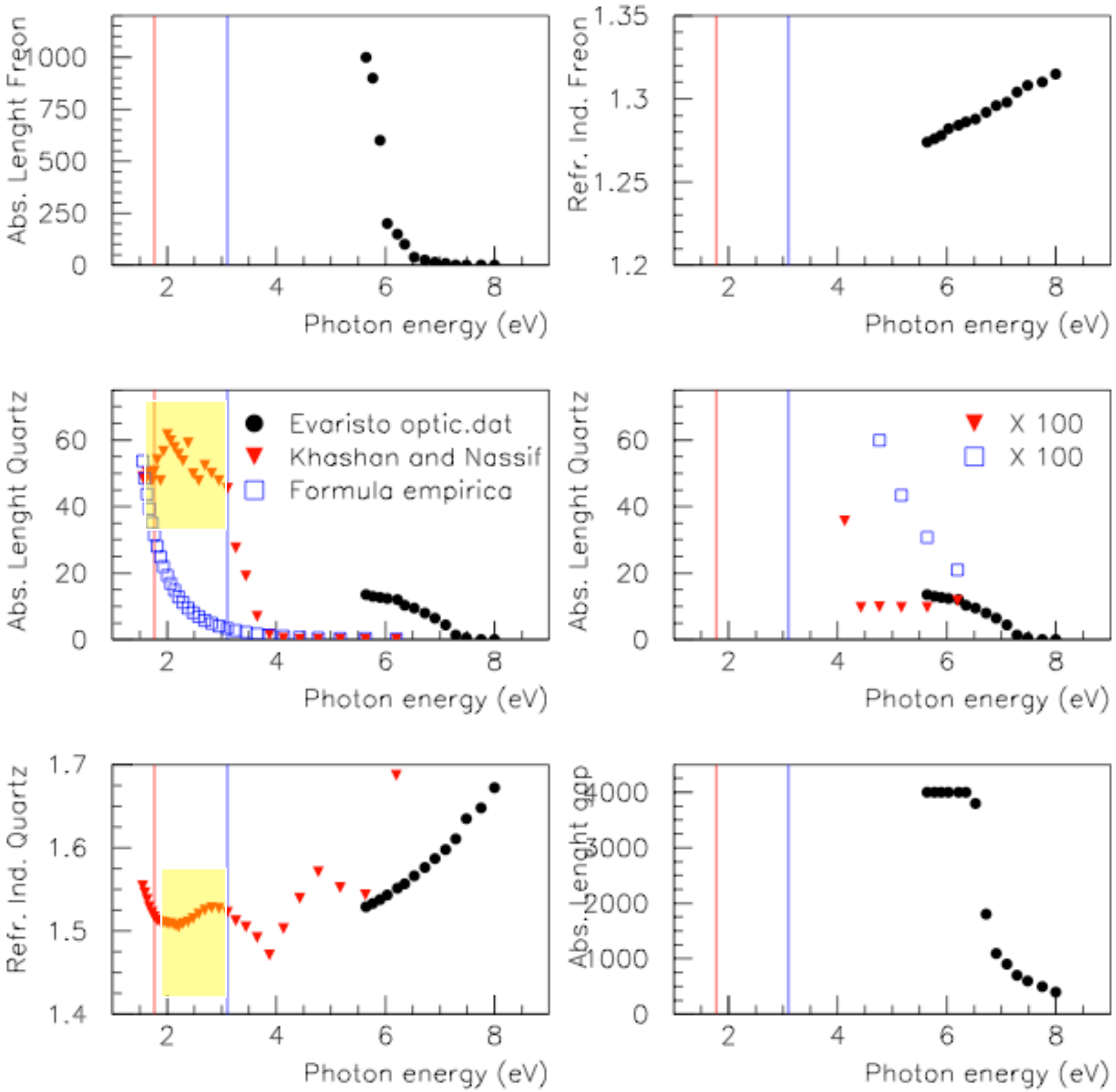
Refraction index: freon





Simulation based on most conservative n (Moyssdes)

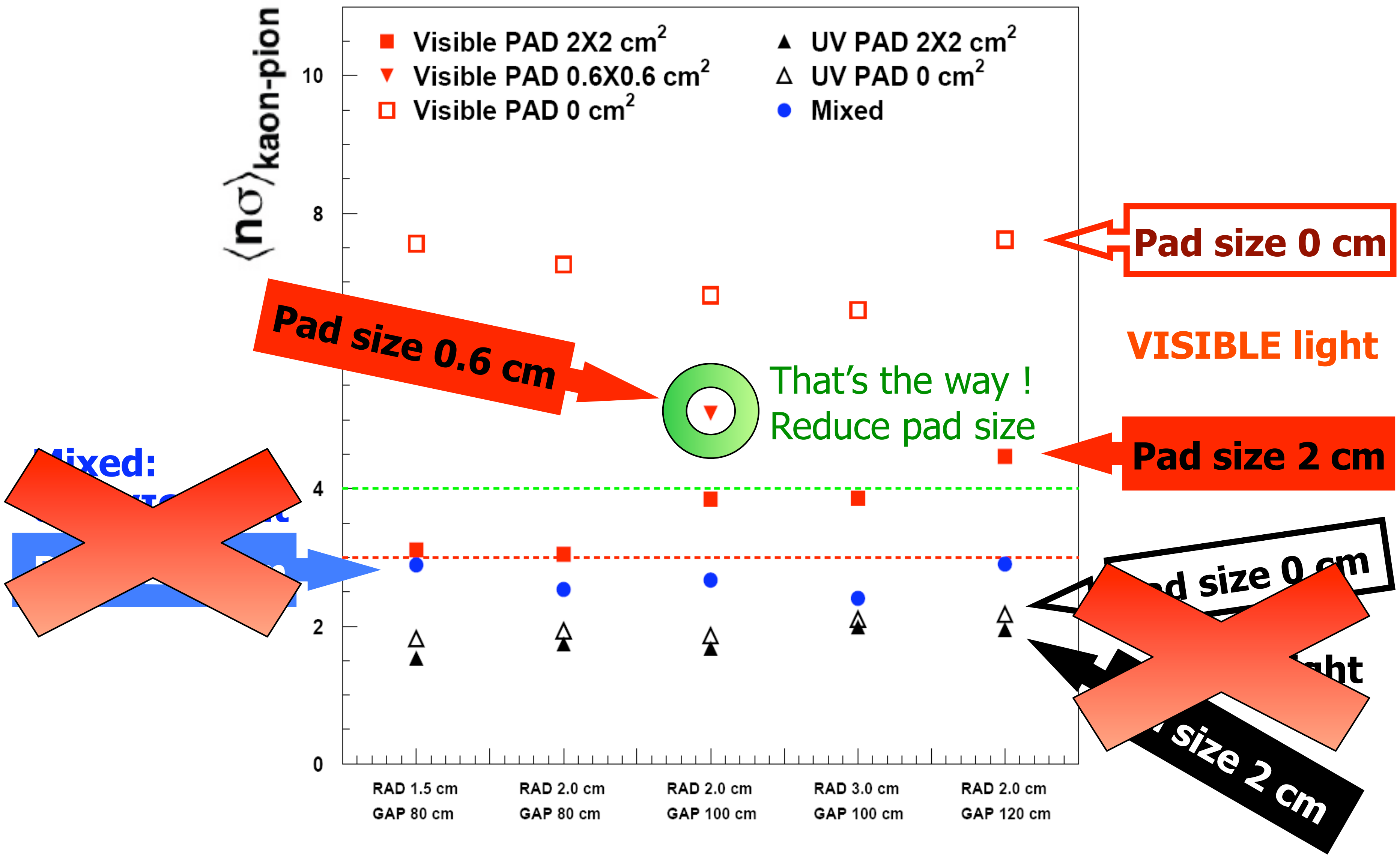
Refraction index: quartz



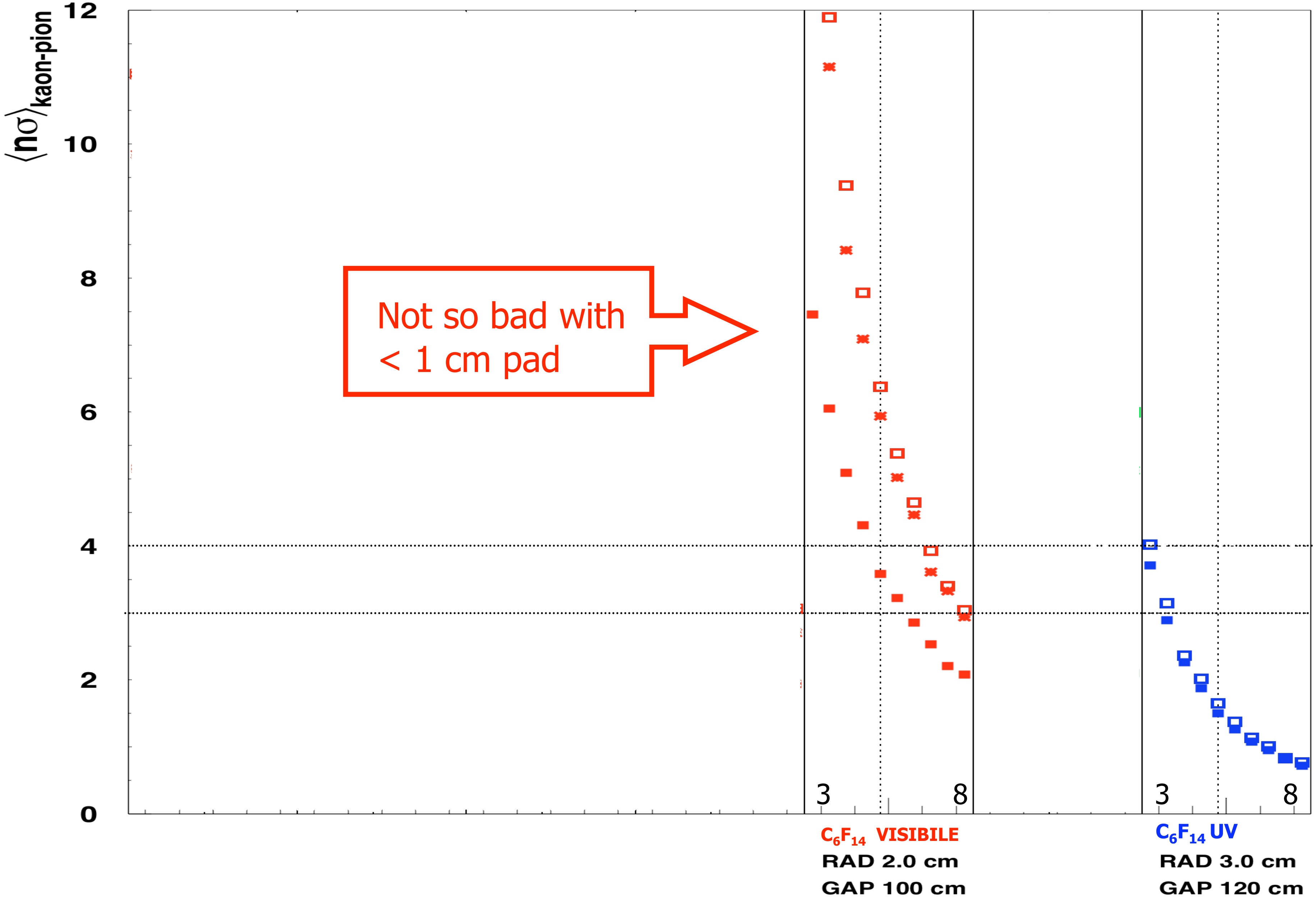
Quartz absorption length and refraction index from
Khashan and Nassif, Optic communications 188 (2001) 129

Mean πk separation (4.5-5 GeV)

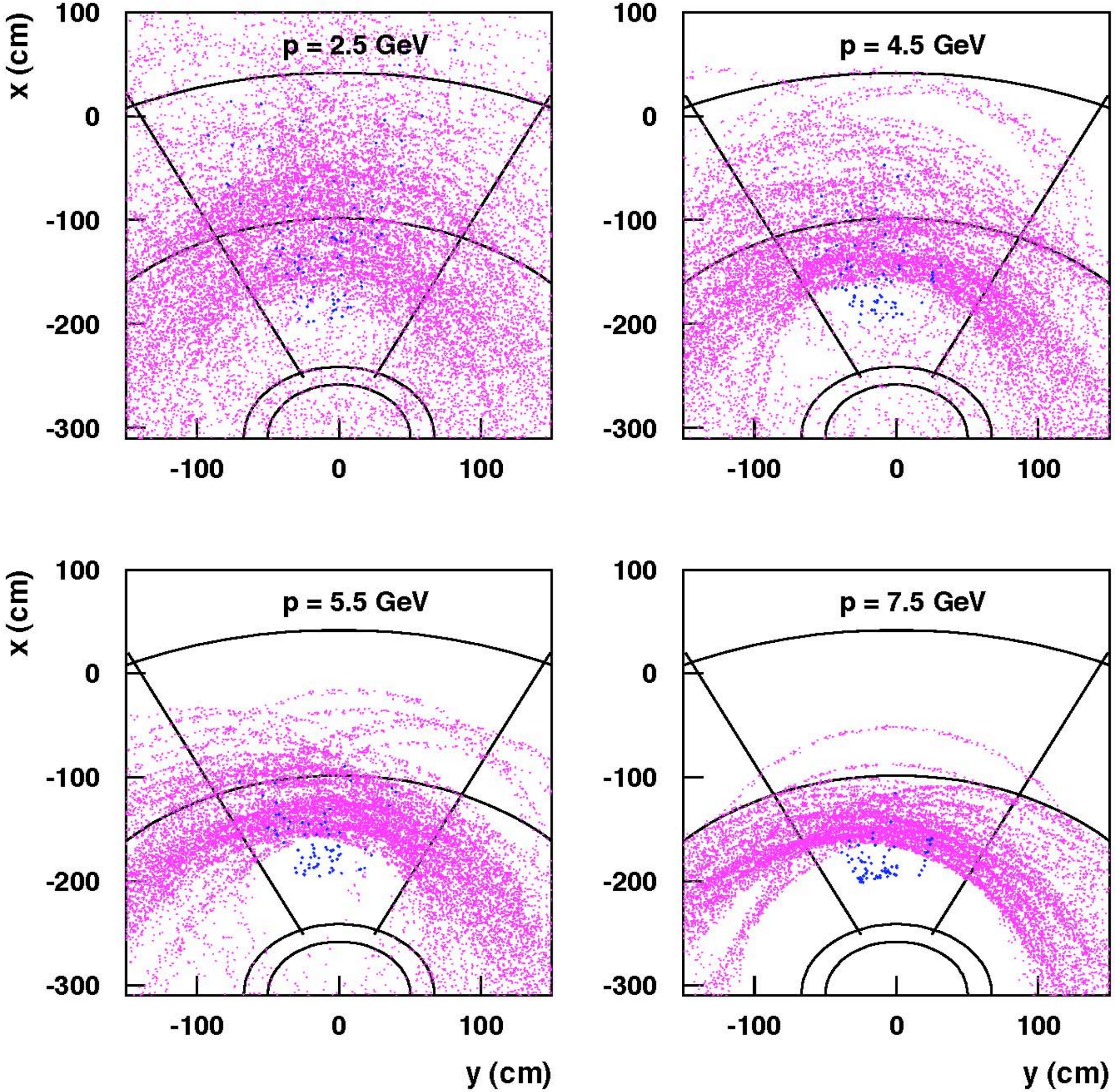
Liquid C_6F_{14} (freon) radiator



Mean πk separation (3-8 GeV)



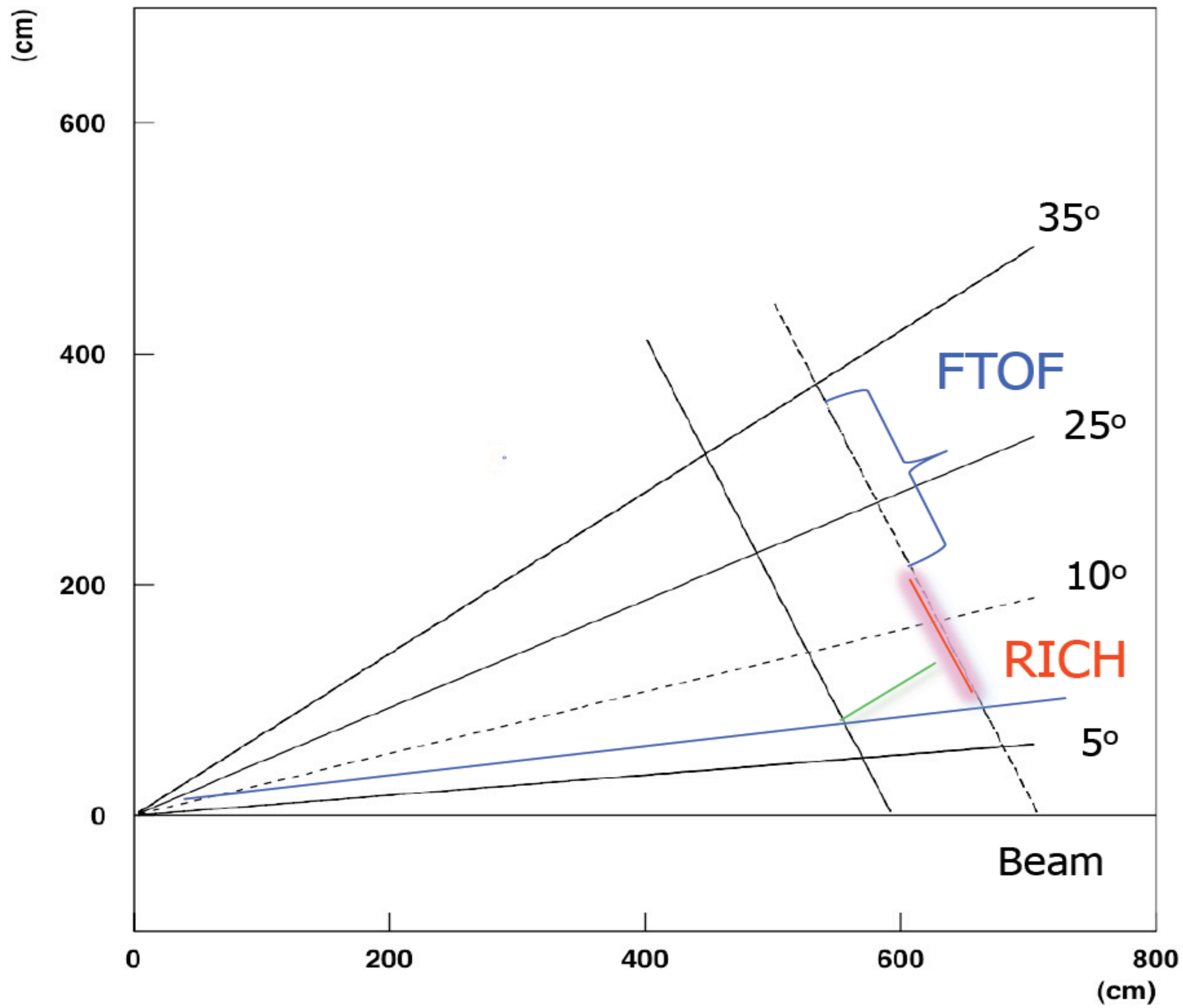
Gamma hits with C_6F_{14}



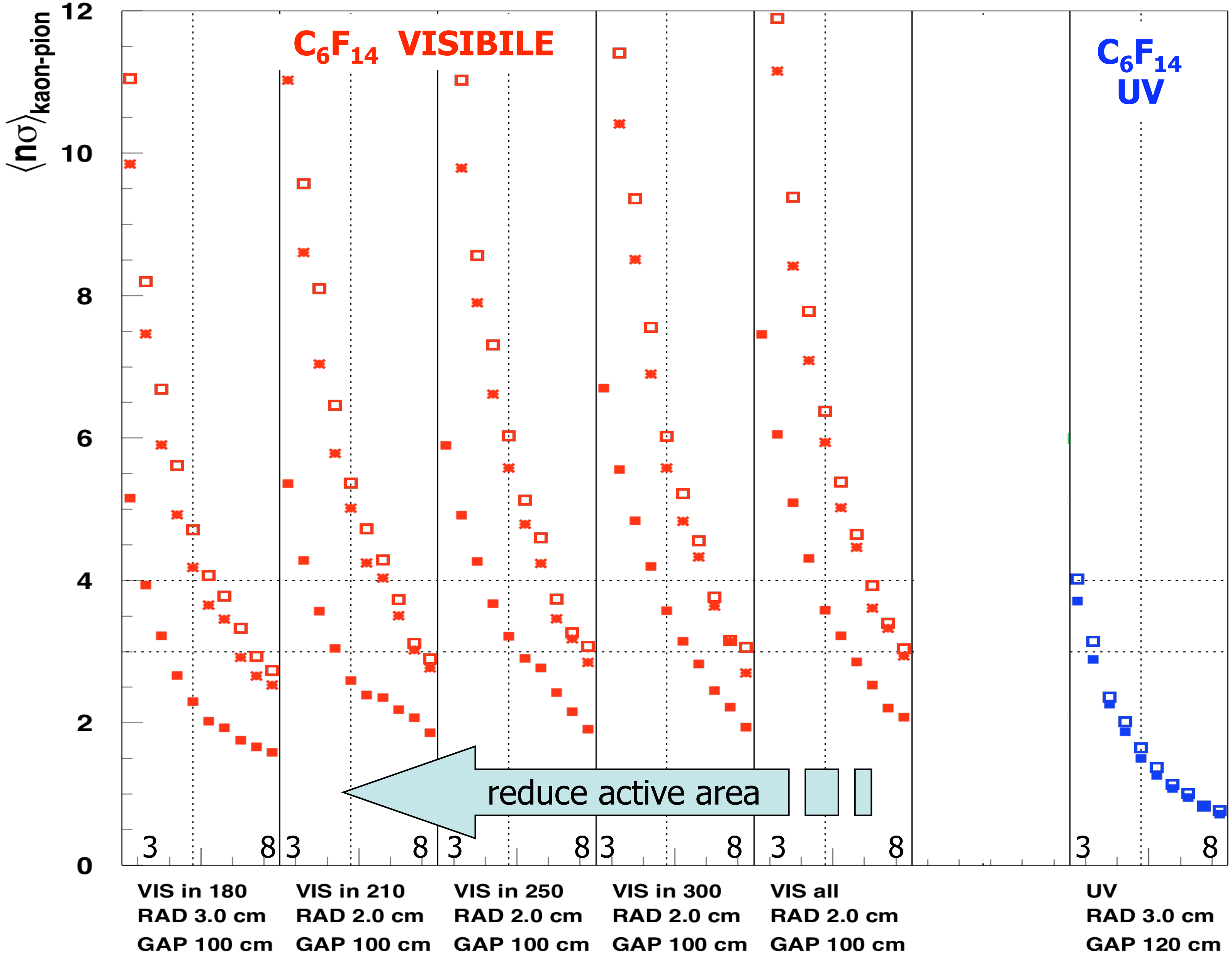
Try to reduce active area

The proximity focus option

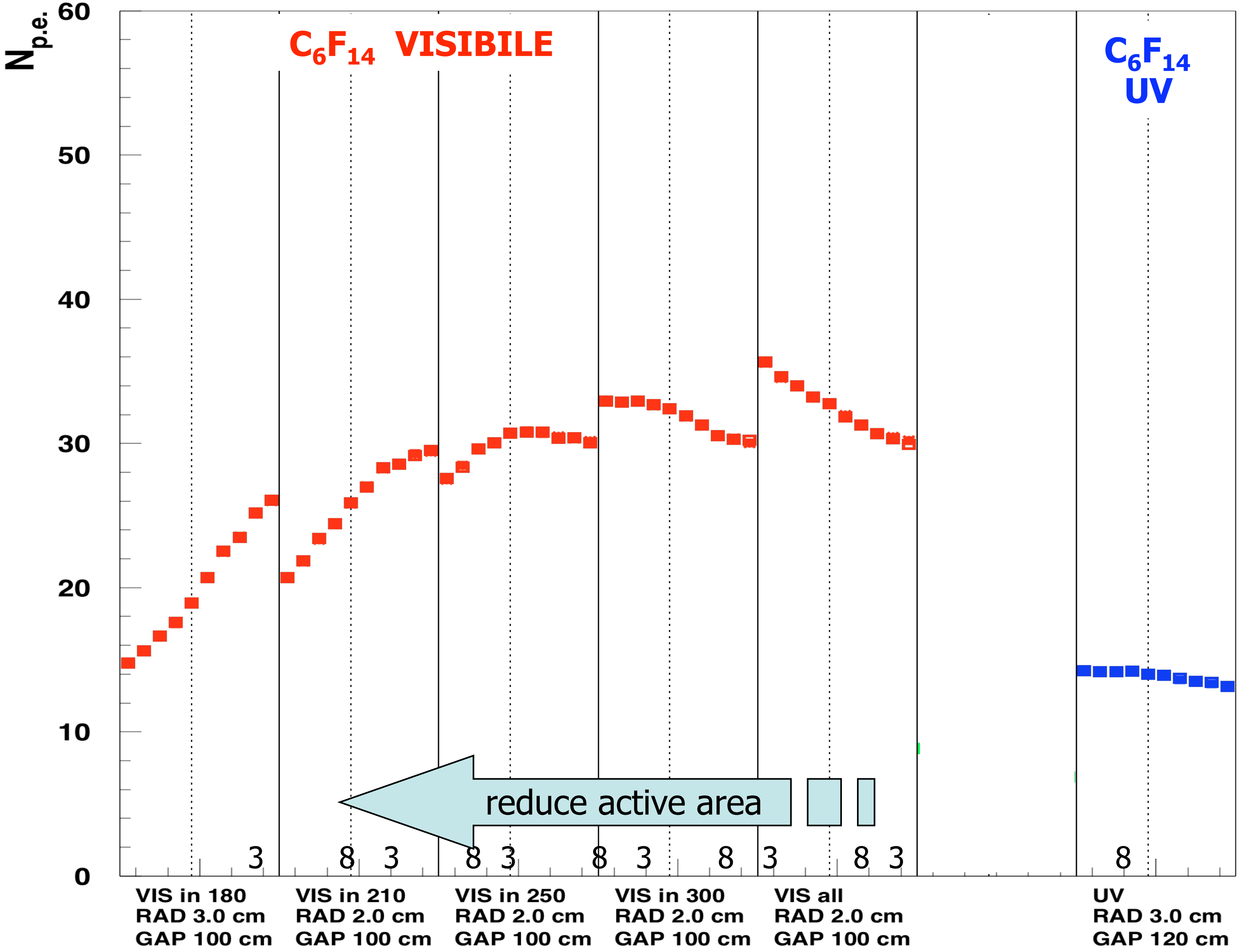
Direct measurement in a restricted area



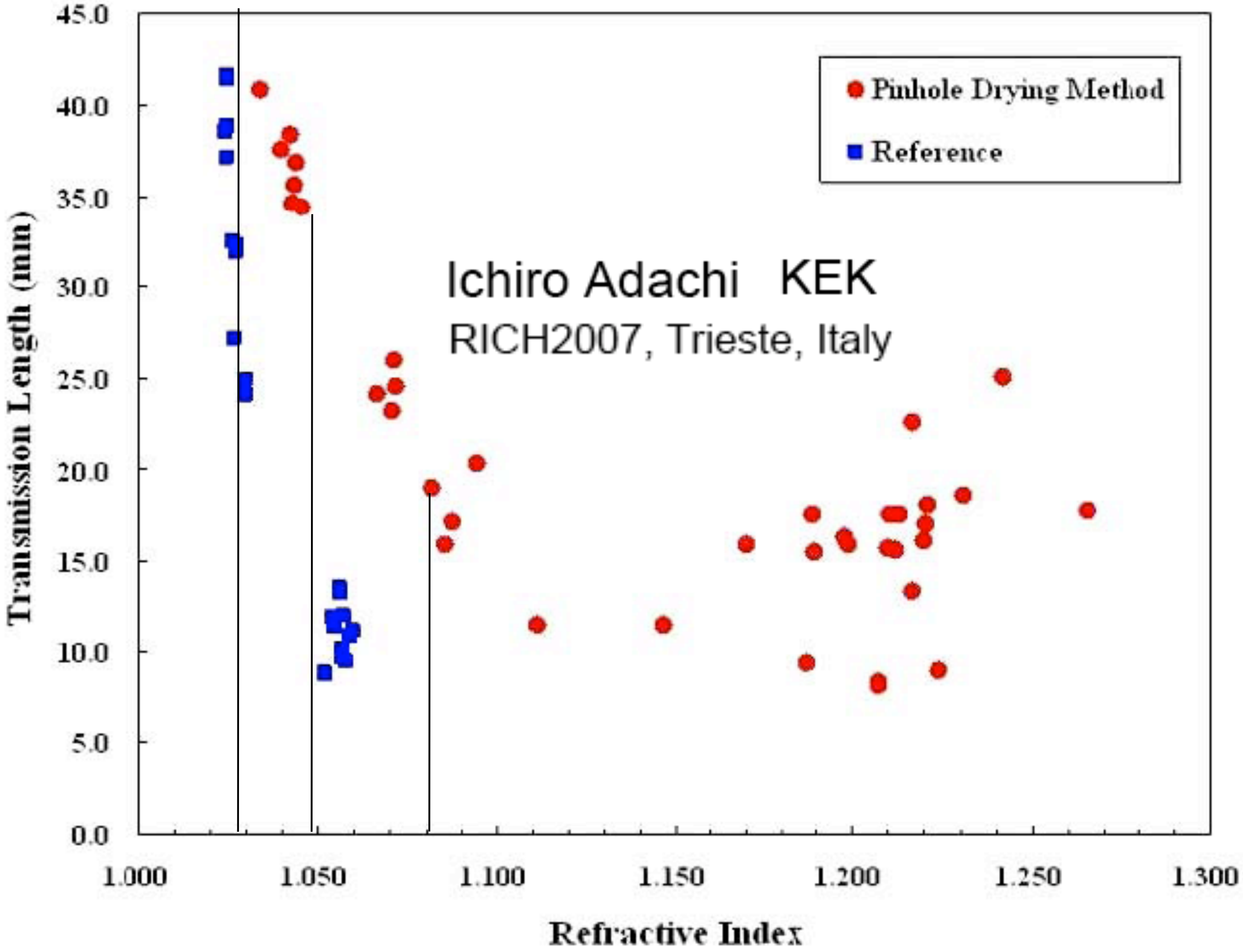
Mean πk separation (3-8 GeV)



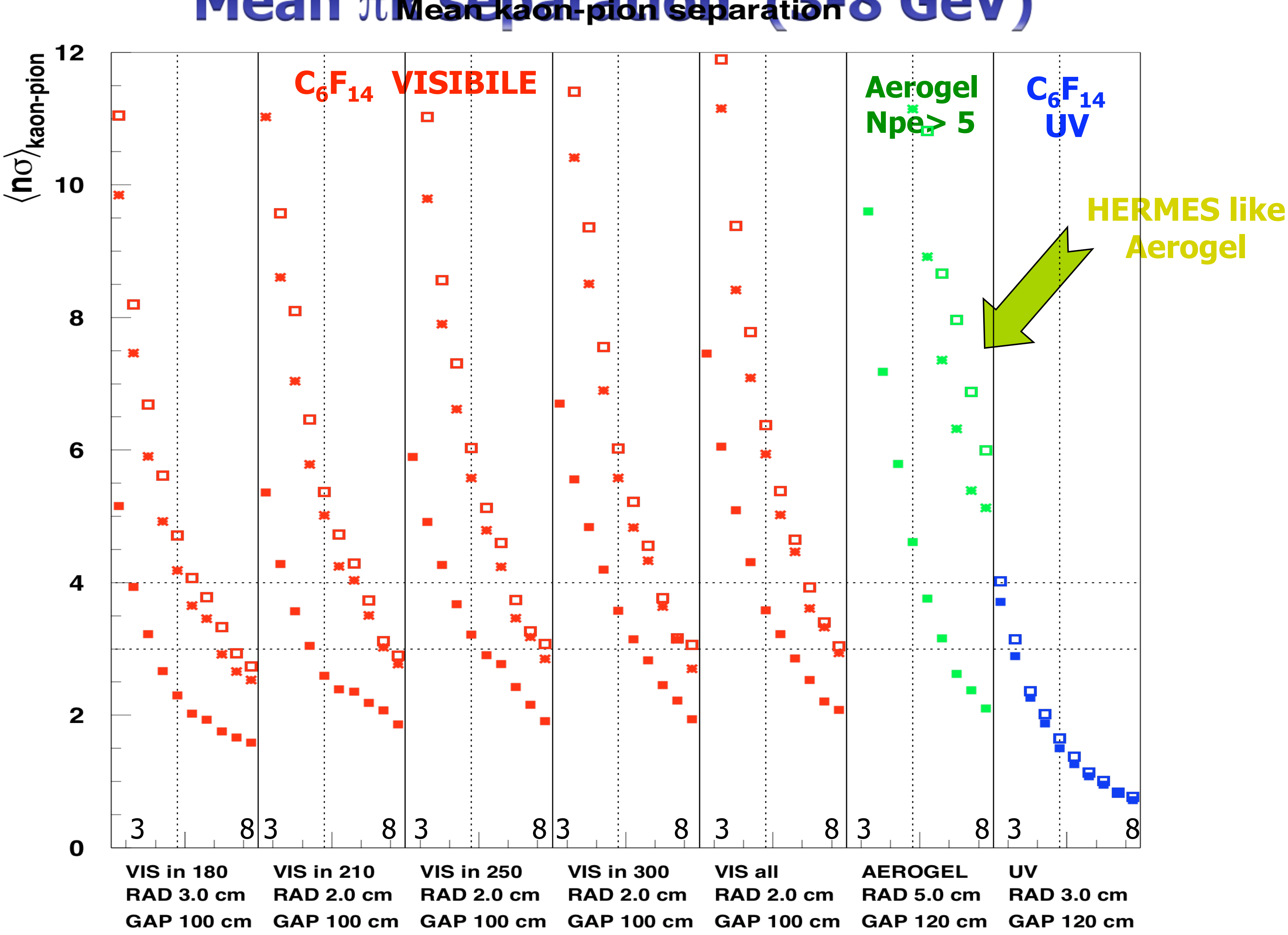
Mean p.e. number (3-8 GeV)



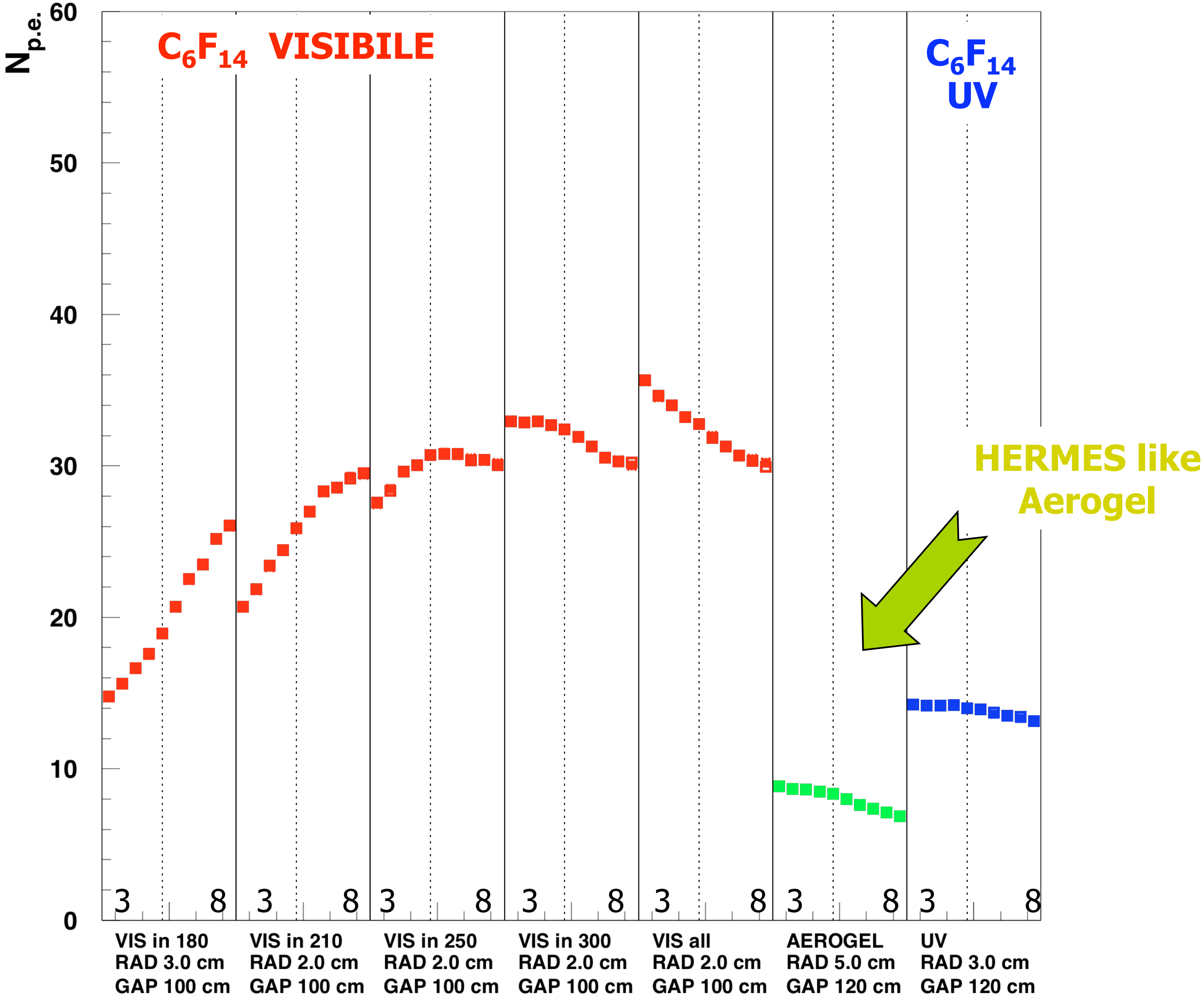
The Aerogel option



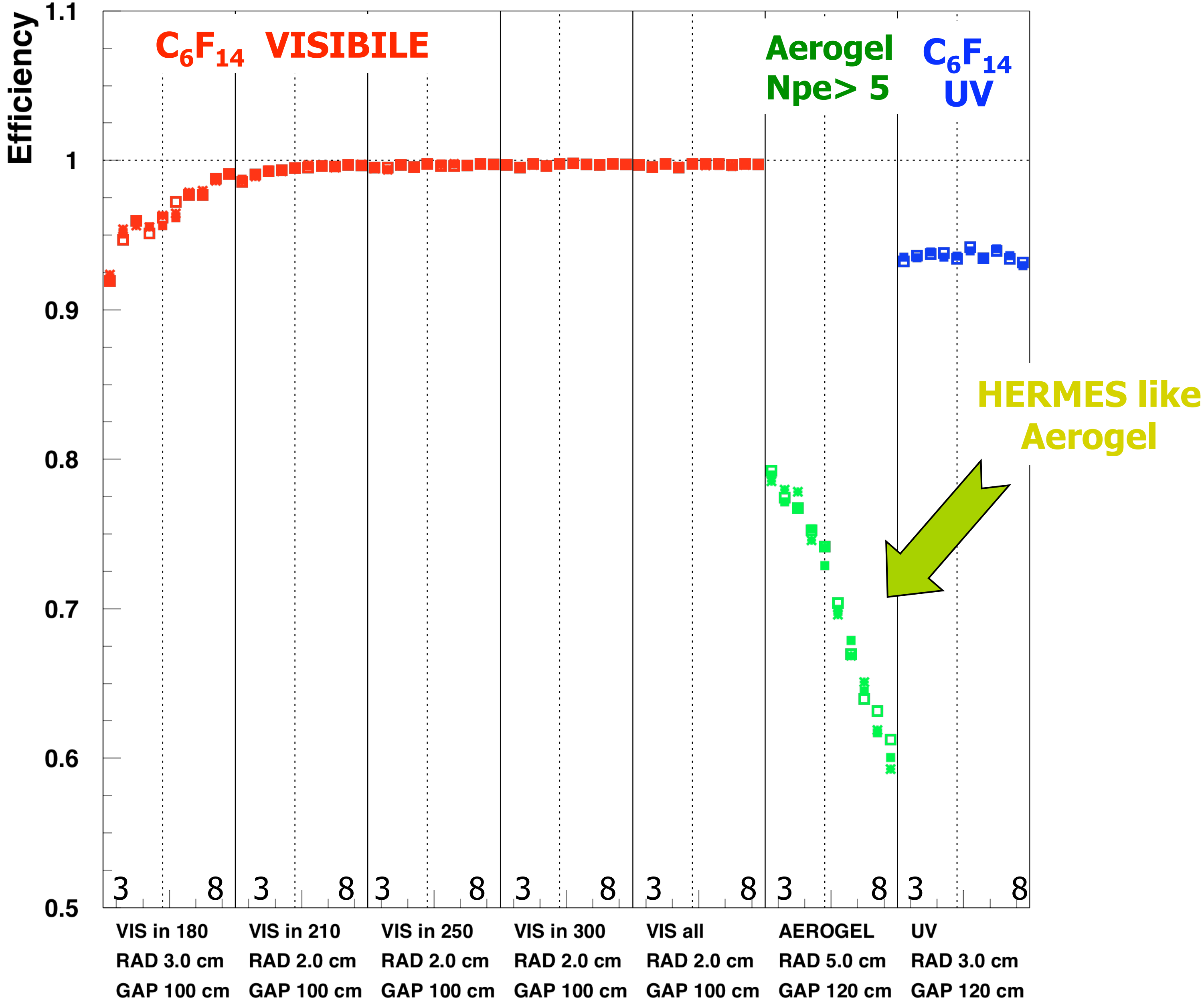
Mean πk separation (3-8 GeV)



Mean p.e. number (3-8 GeV)

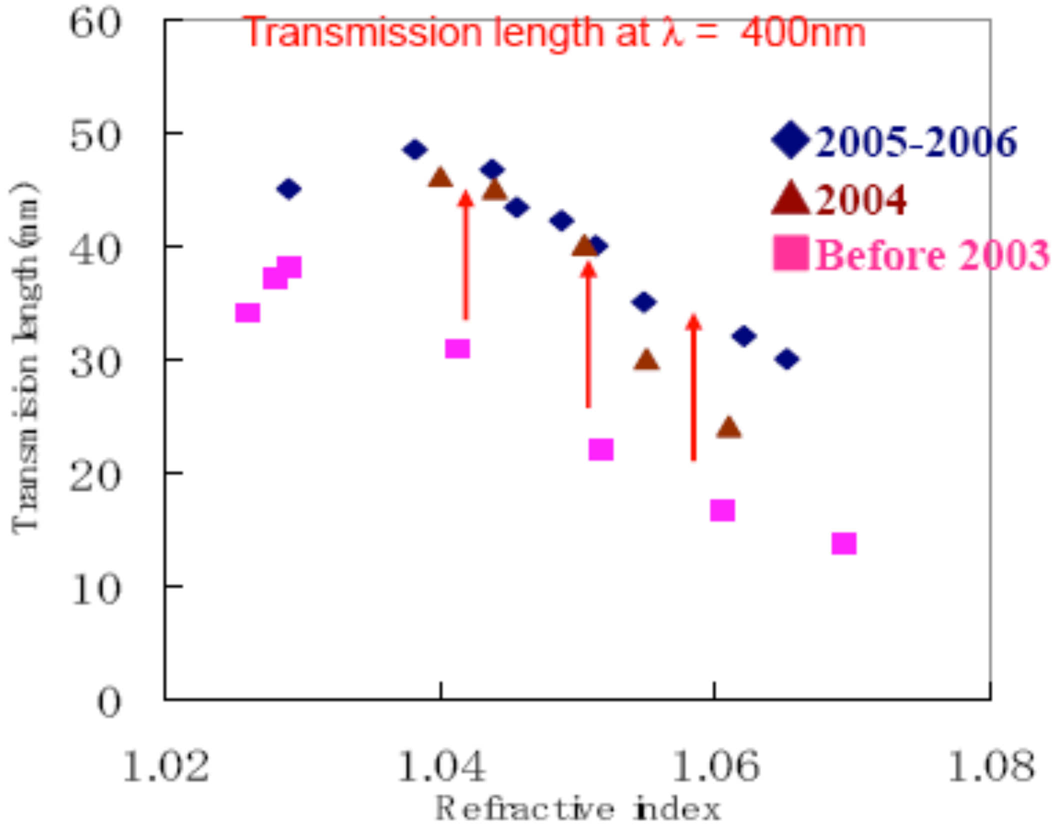


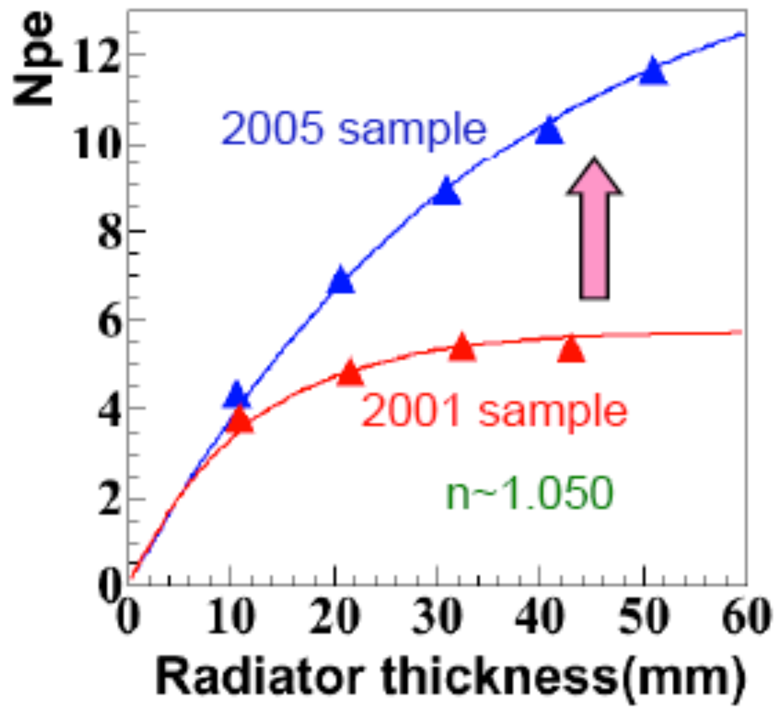
ID efficiency (3-8 GeV)



The Aerogel option

Trasmission length is undergoing significantly improvements





2005 IEEE Nuclear Science Symposium Conference Record

M. Tabata et al.

Mean πk separation (5-8 GeV)