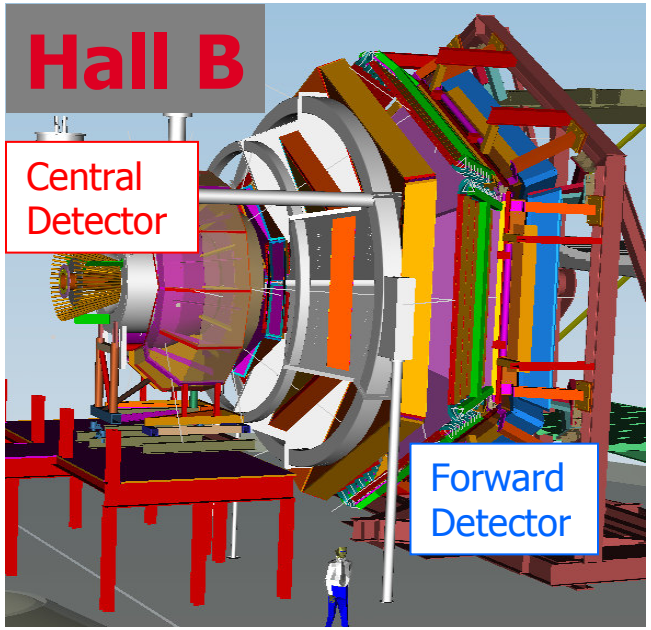
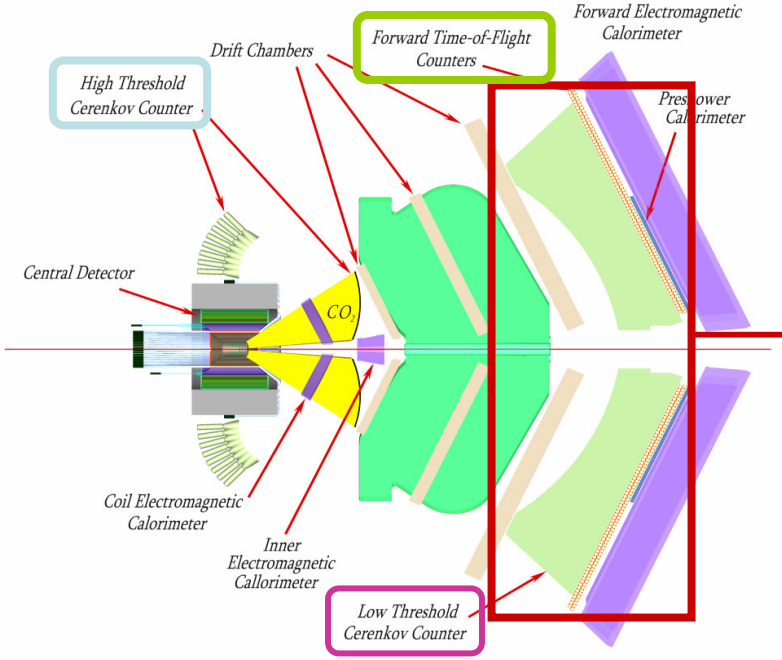
RICH simulation for CLAS12

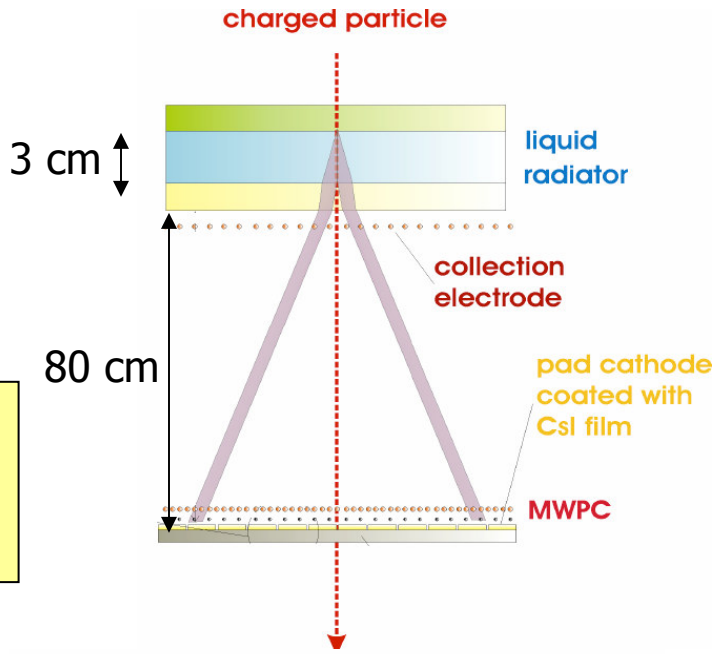


Contalbrigo Marco
INFN Ferrara
Luciano Pappalardo
INFN Ferrara

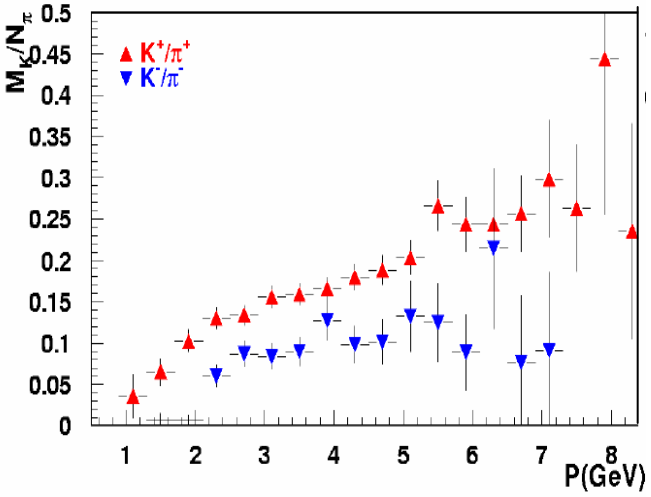
RICH detector



Substitute 2 LTCC sectors with a proximity focusing RICH detector



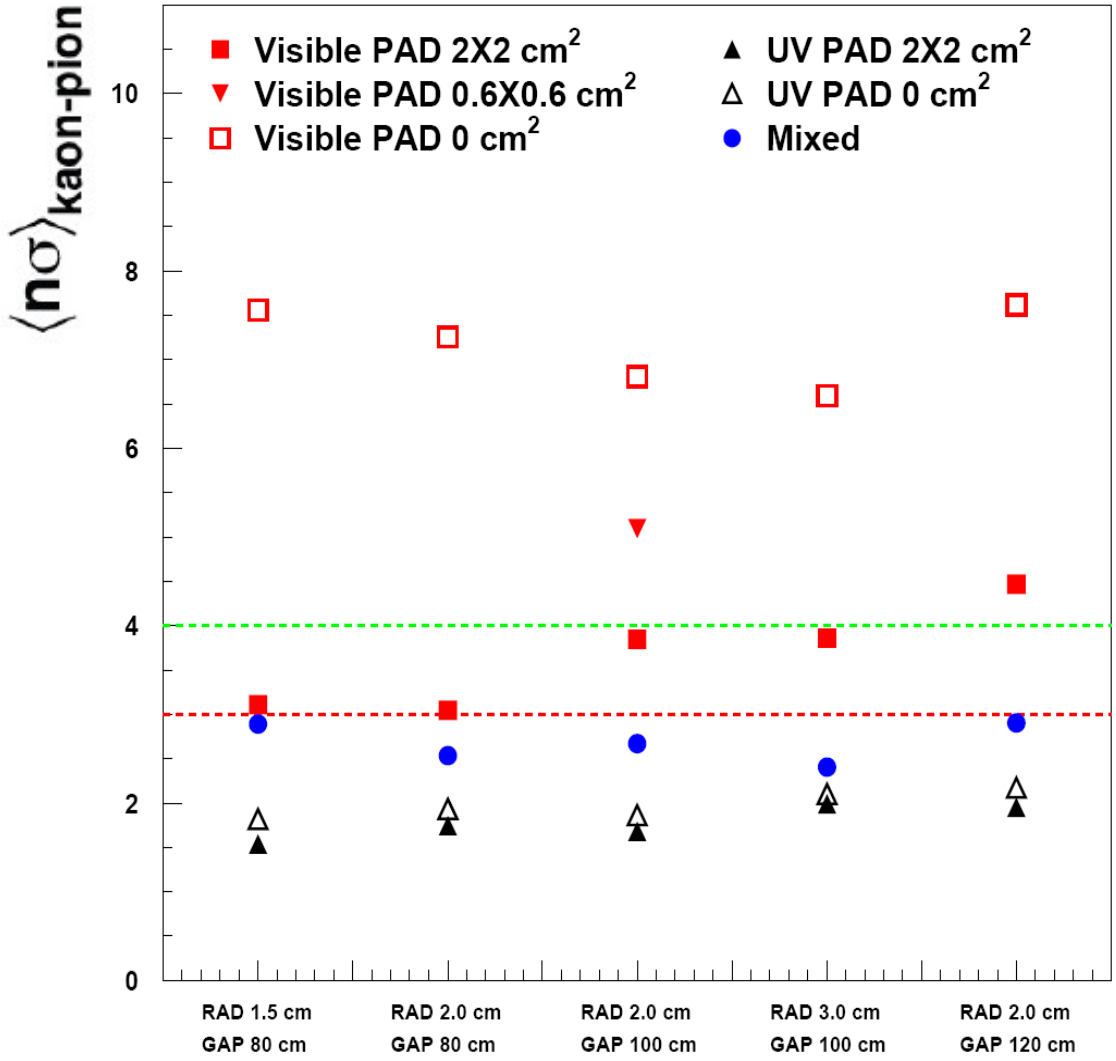
GeV/c	1	2	3	4	5	6	7	8	9	10
π/K	TOF		LTCC			HTCC				
π/p	TOF						LTCC			
						HTCC				
K/p	TOF								LTCC	



- ratio K/π ~ 0.1-0.15

Mean πk separation (4.5-5 GeV)

Liquid C_6F_{14} (freon) radiator



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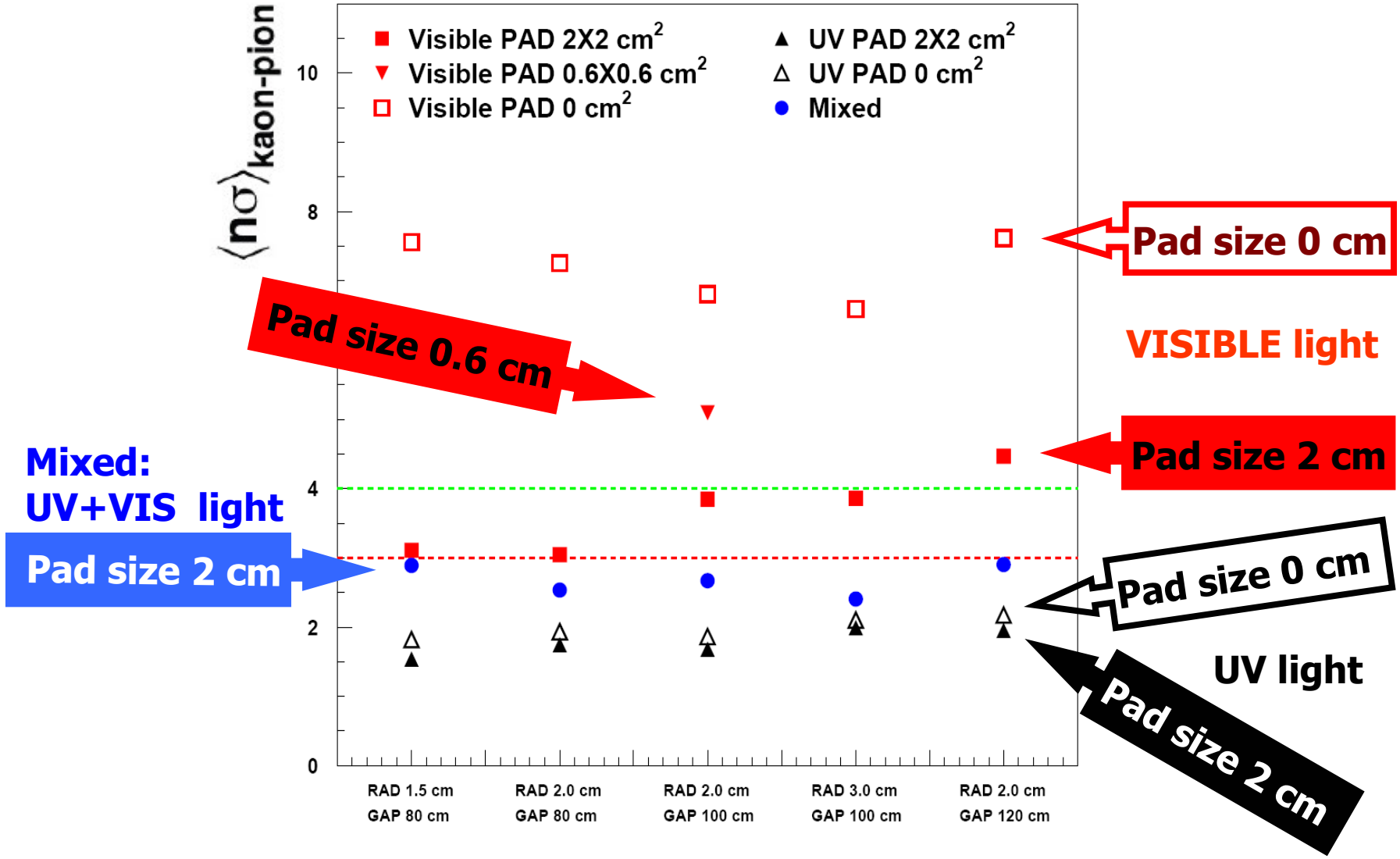

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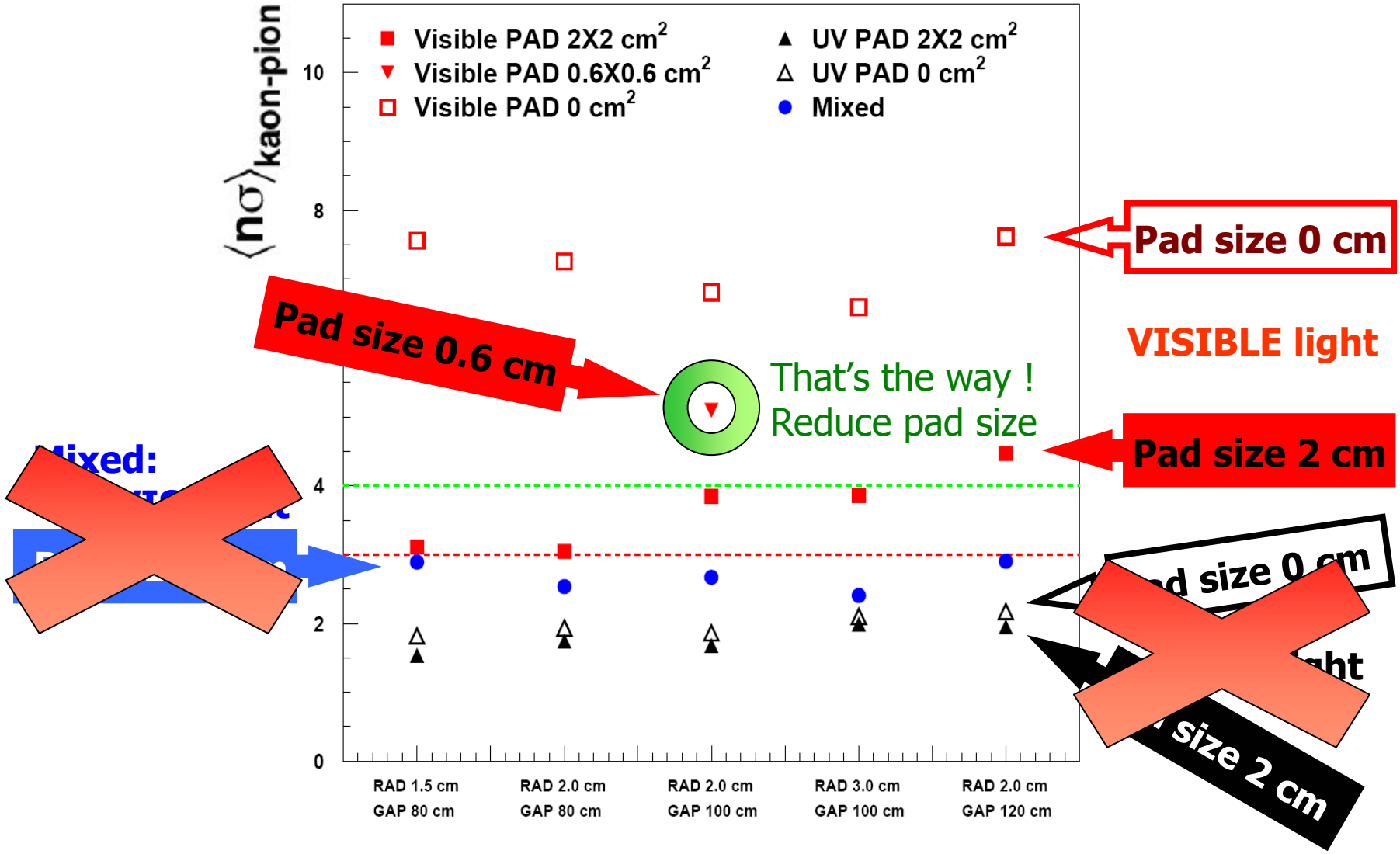
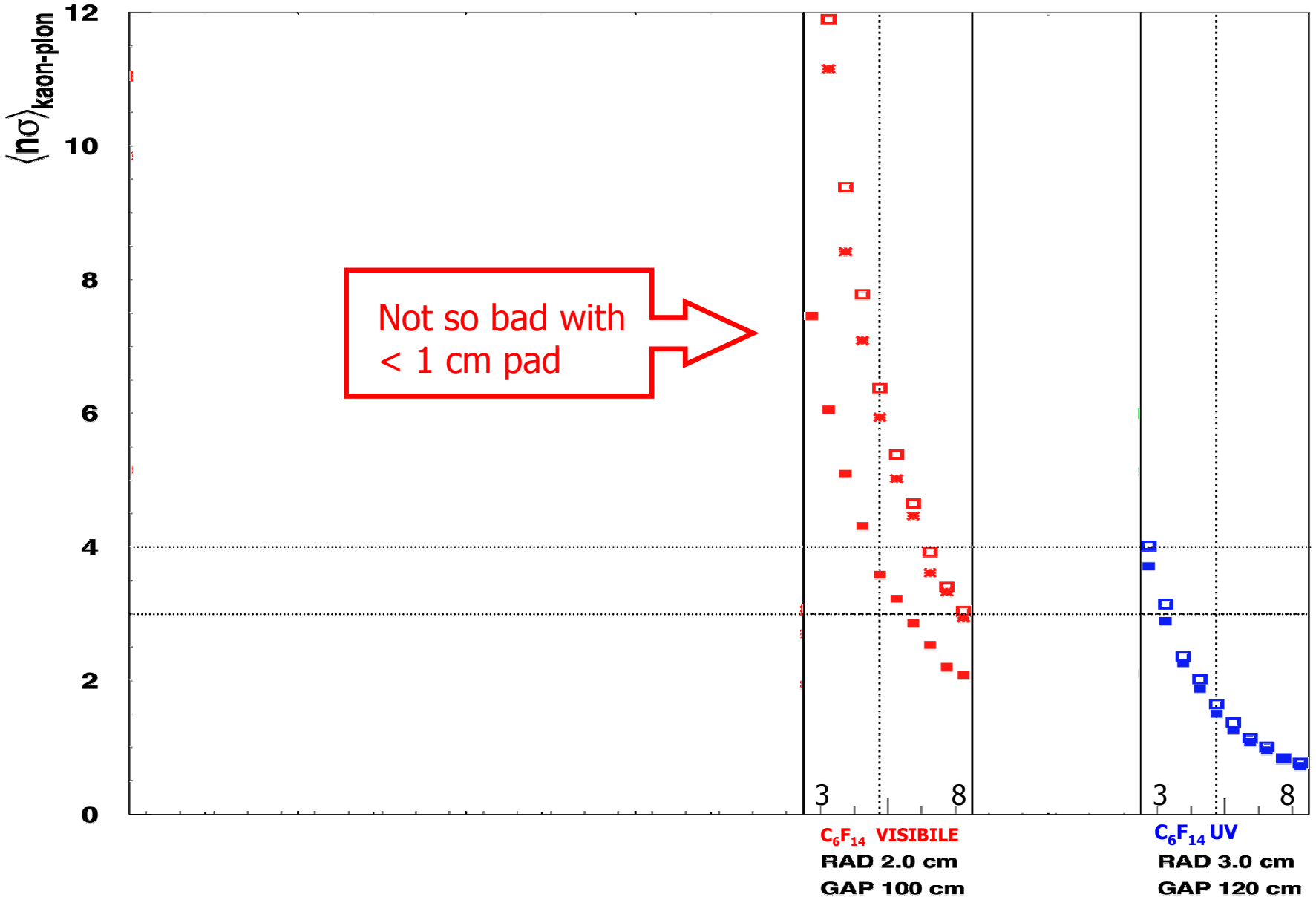
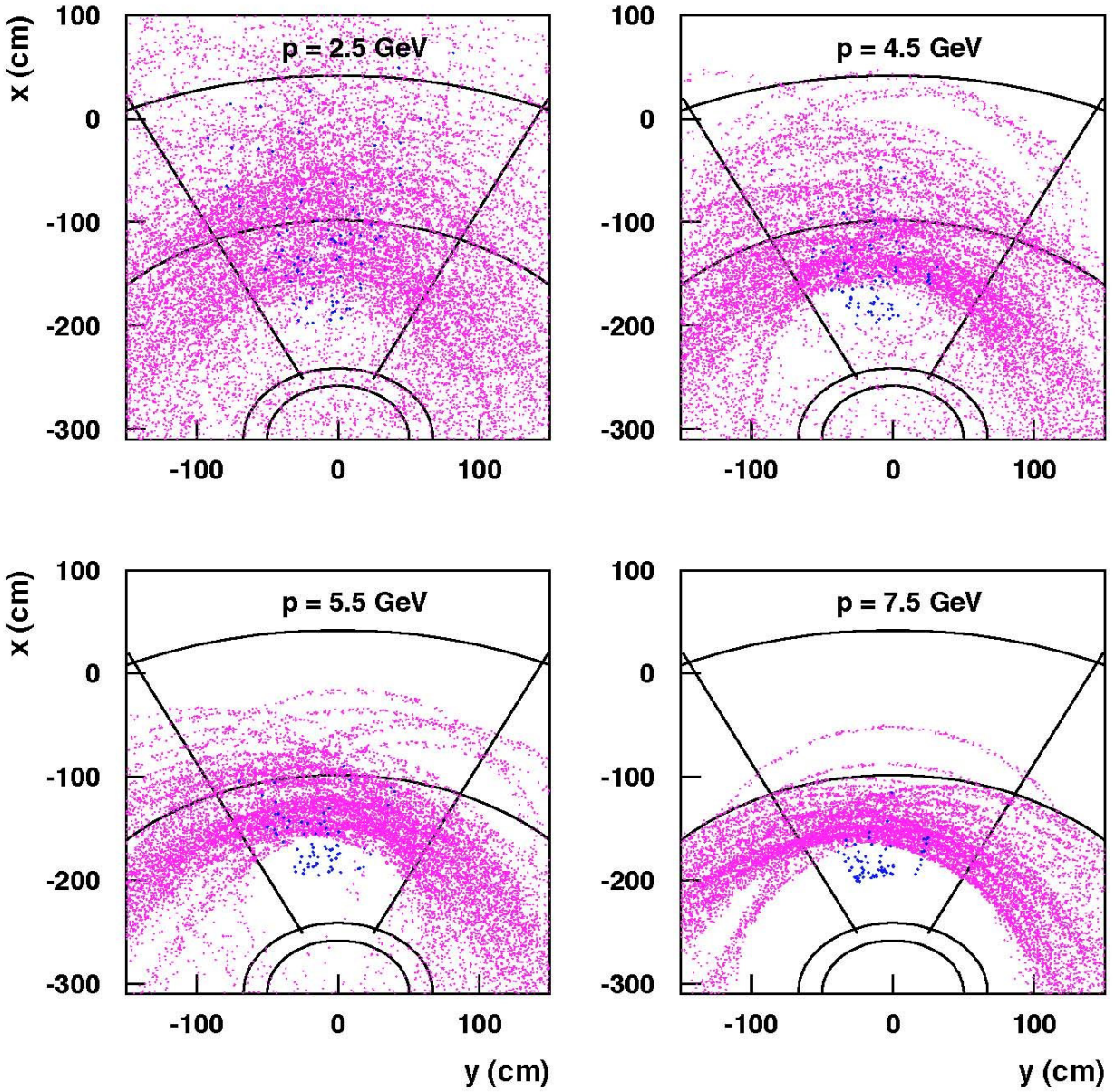


Mean πk separation (3-8 GeV)



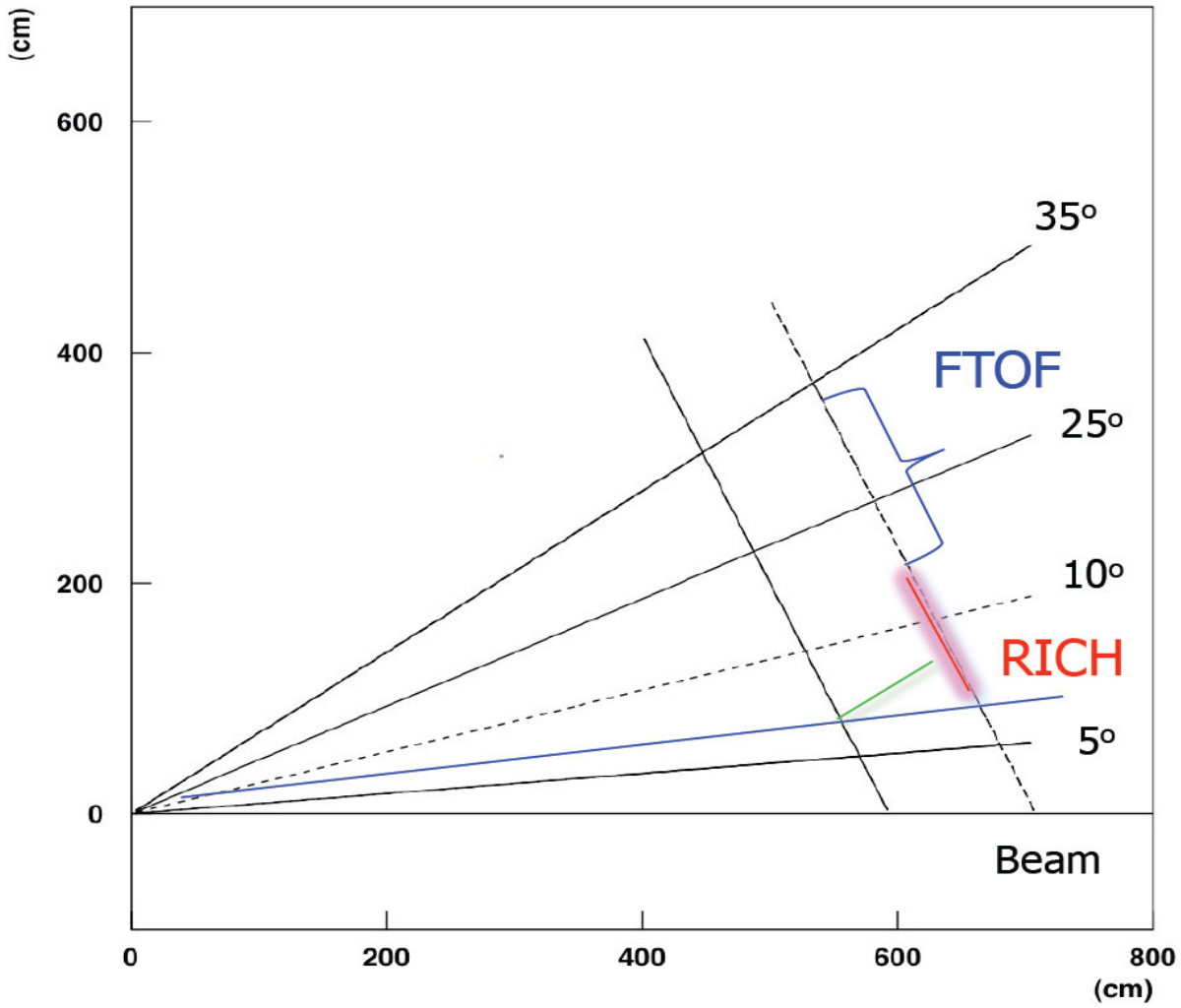
Gamma hits with C_6F_{14}



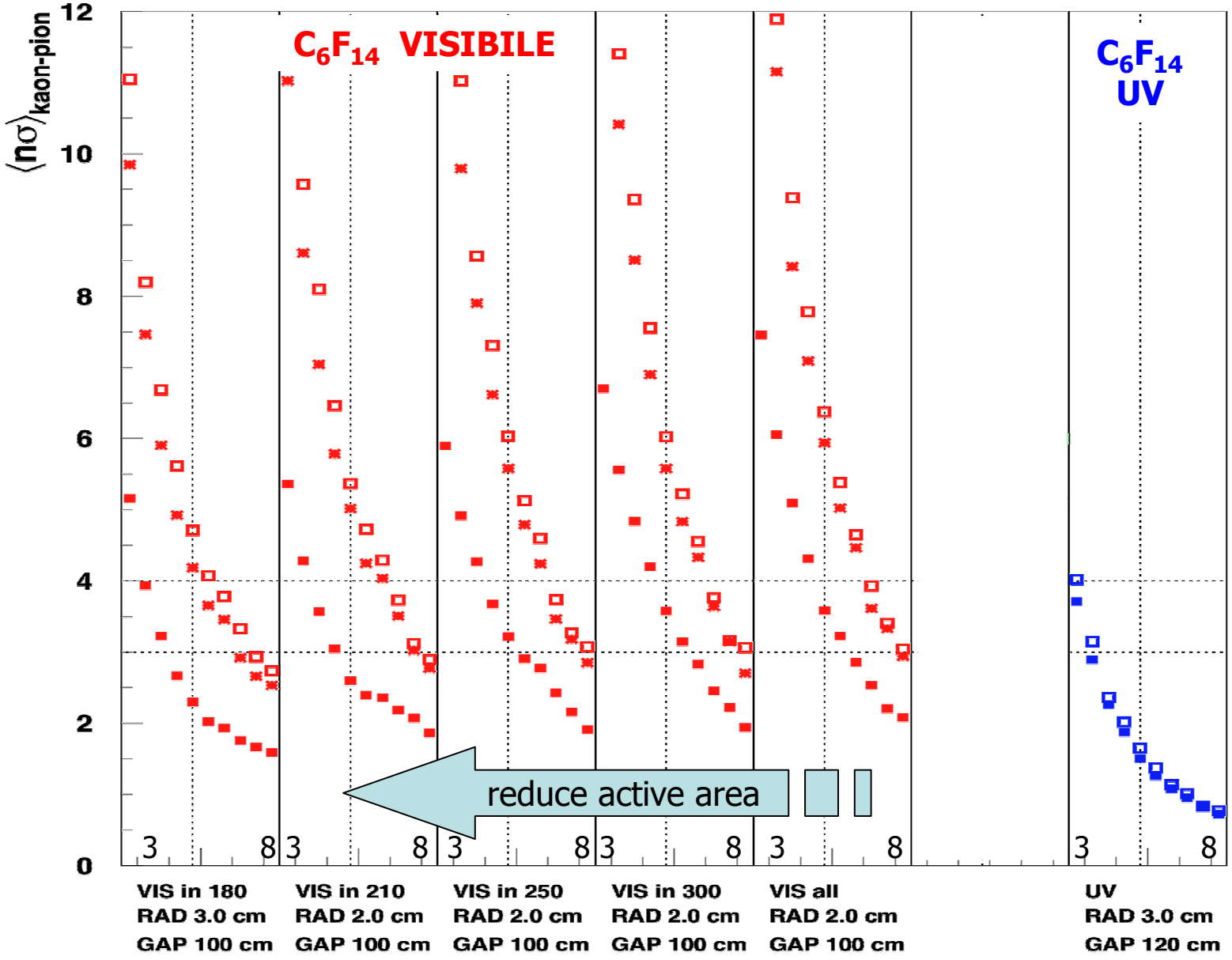
Try to reduce active area

The proximity focus option

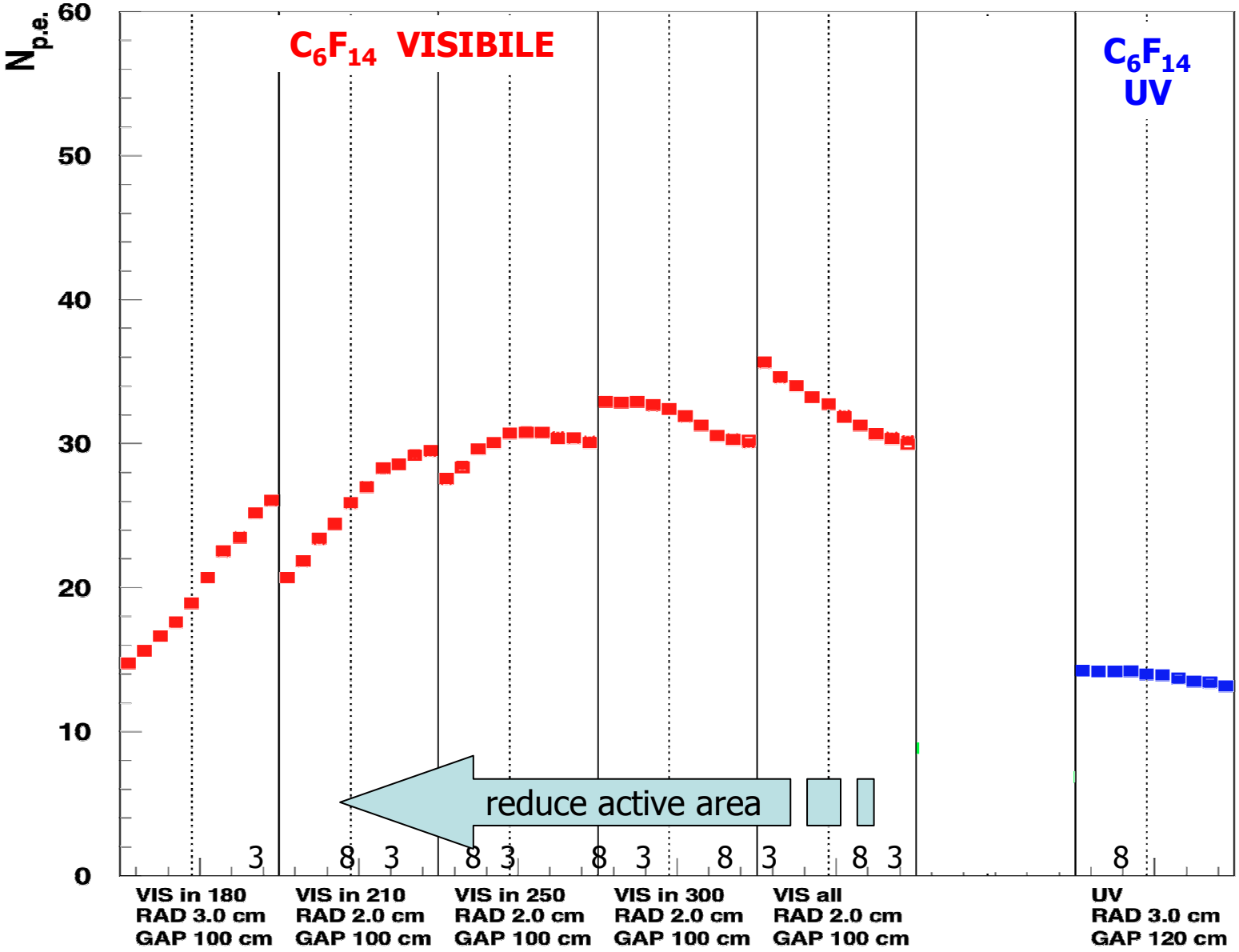
Direct measurement in a restricted area



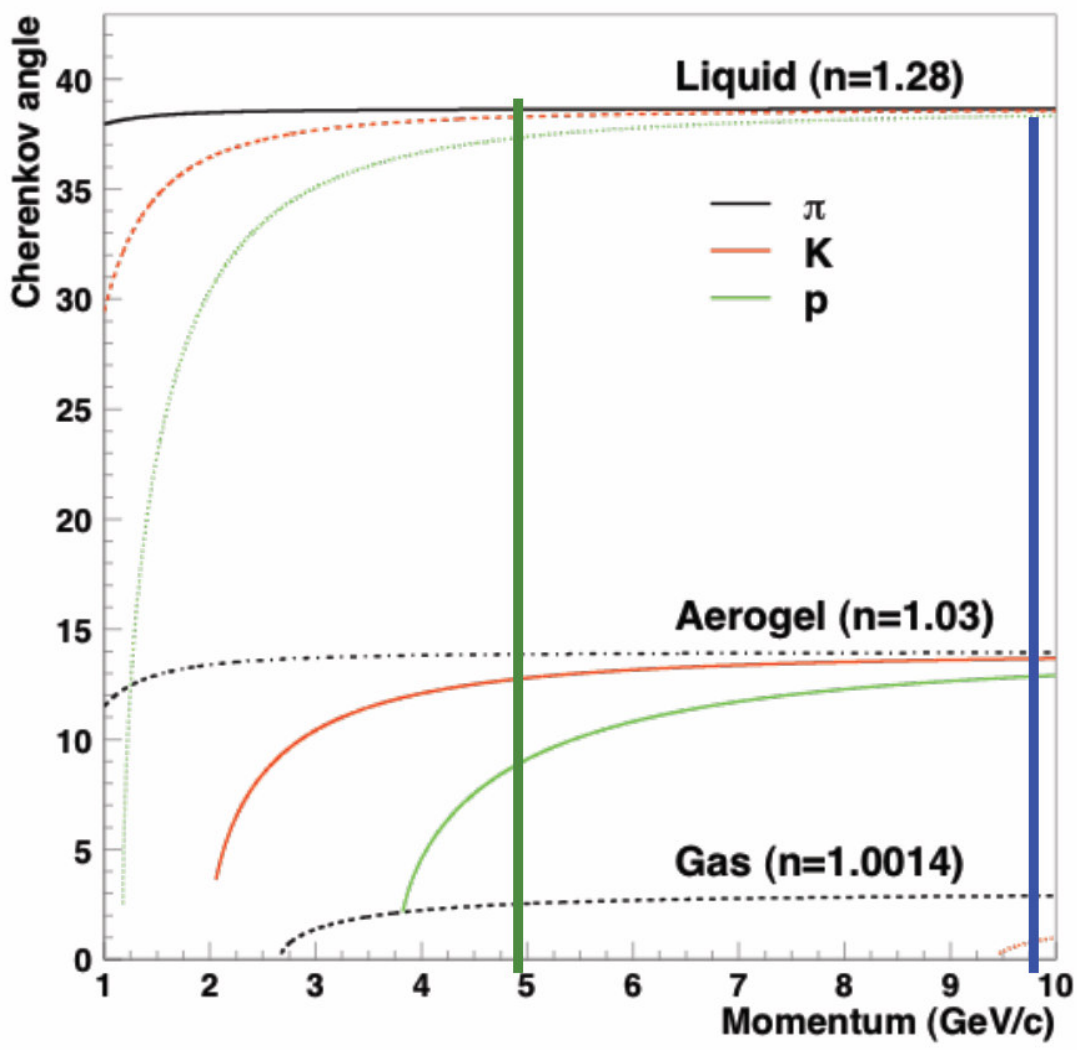
Mean πk separation (3-8 GeV)



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

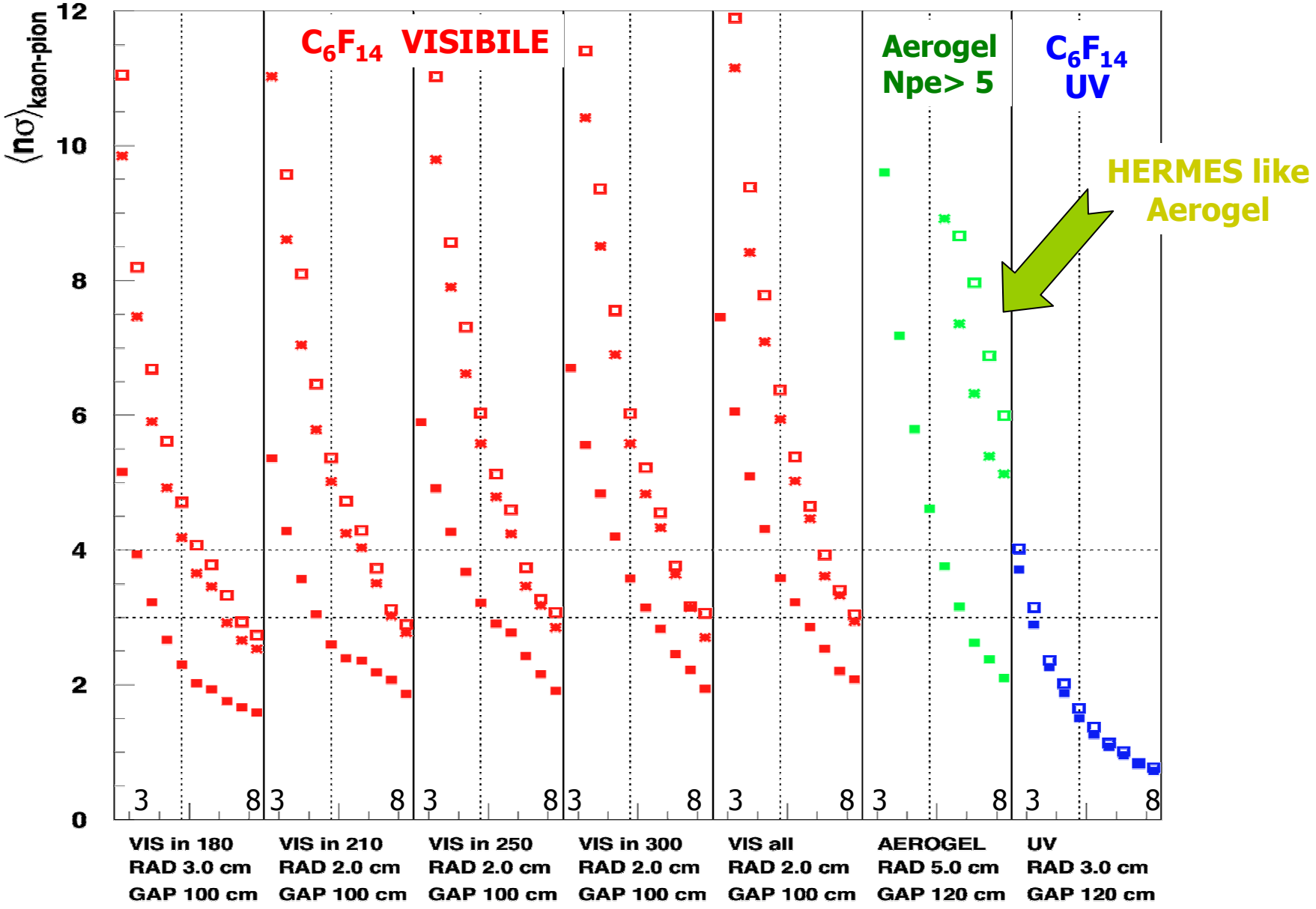


The Aerogel option

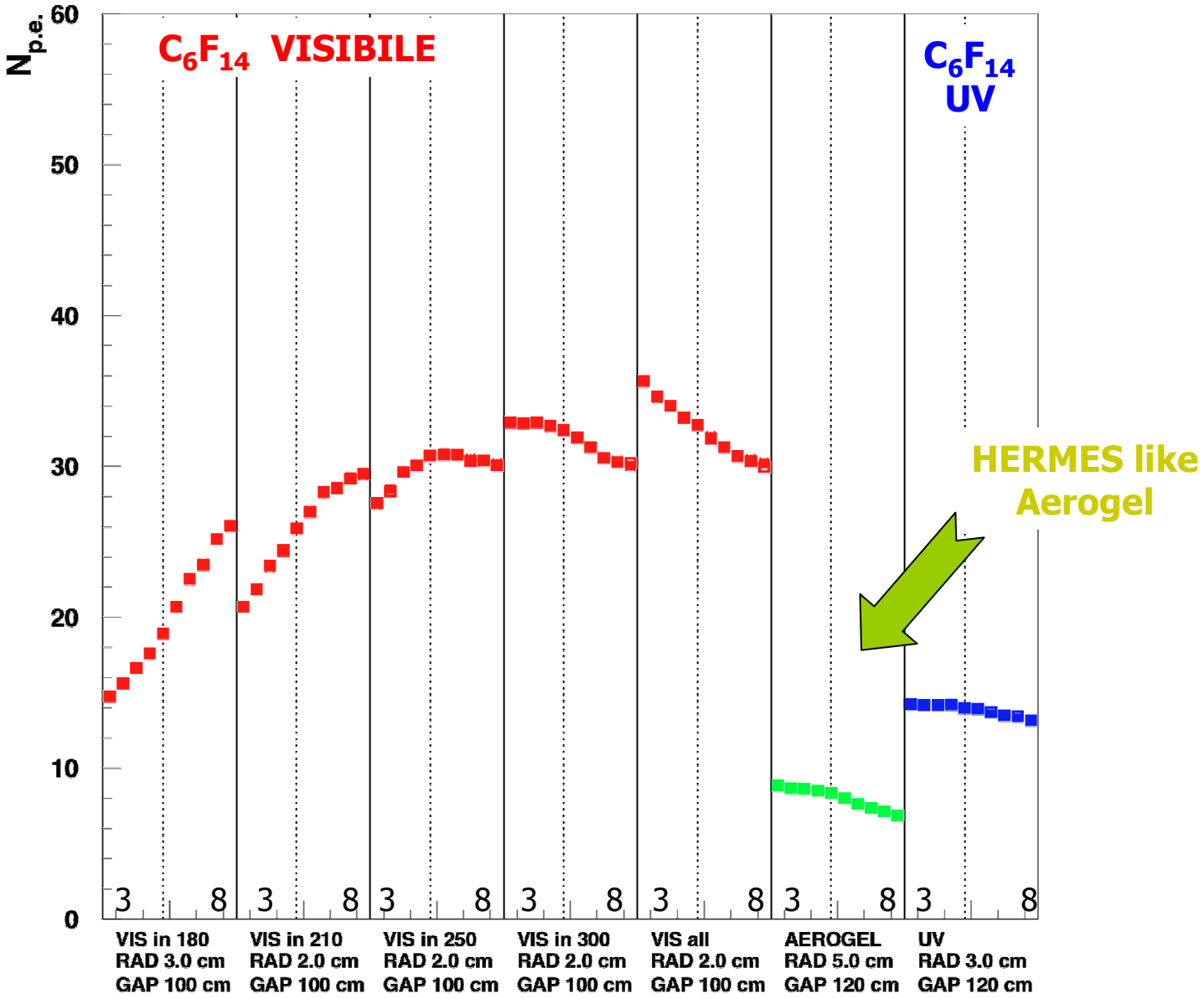


Less photons
Larger angle separation

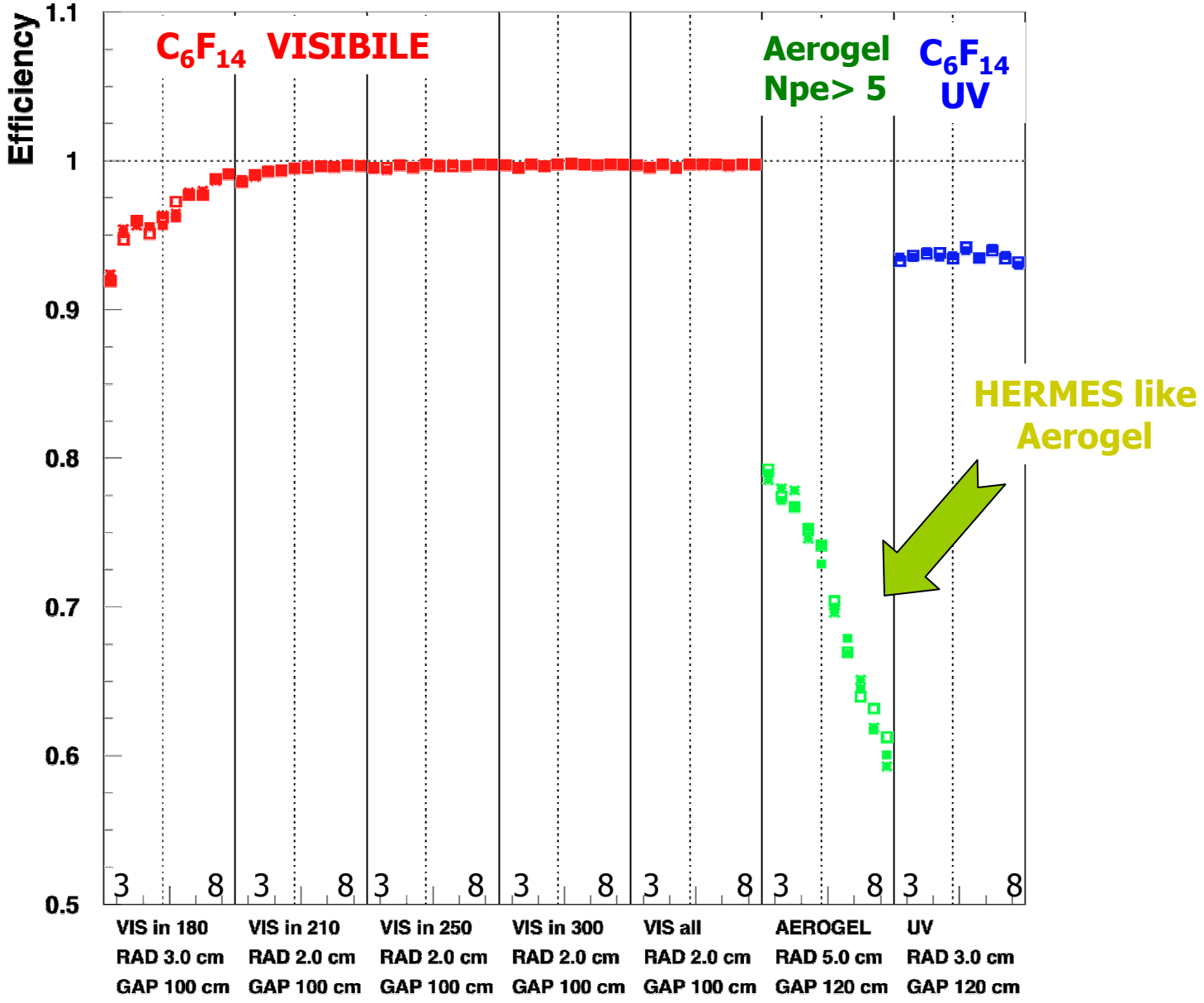
Mean πk separation (3-8 GeV)



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

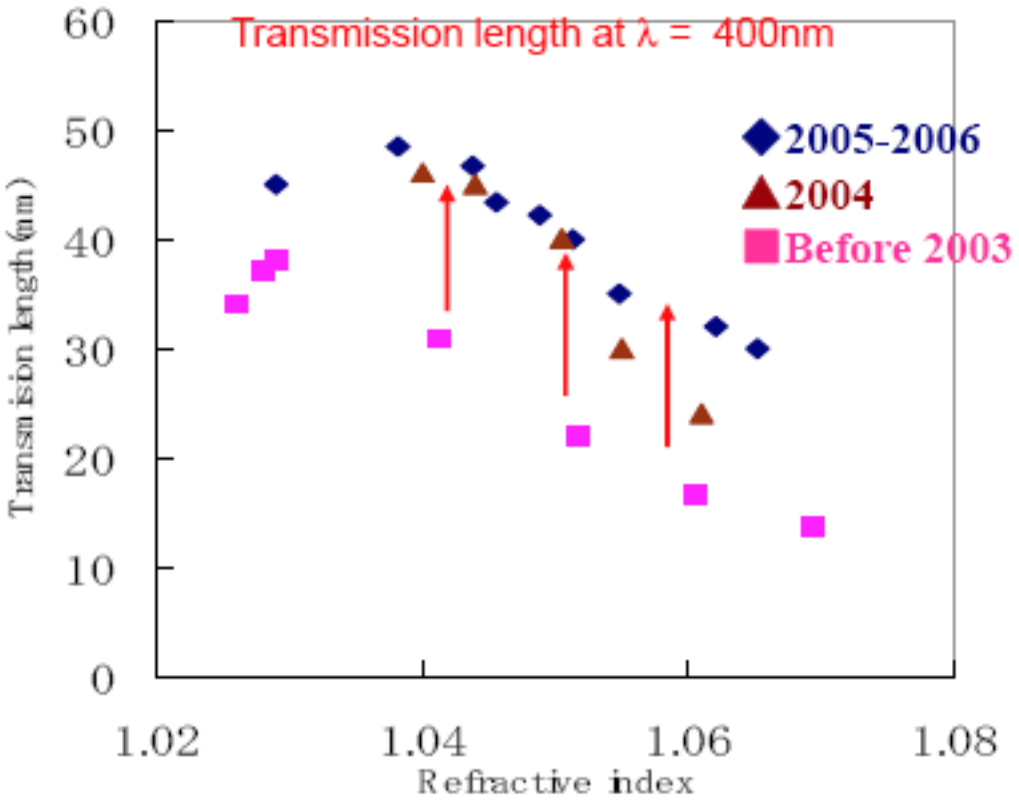


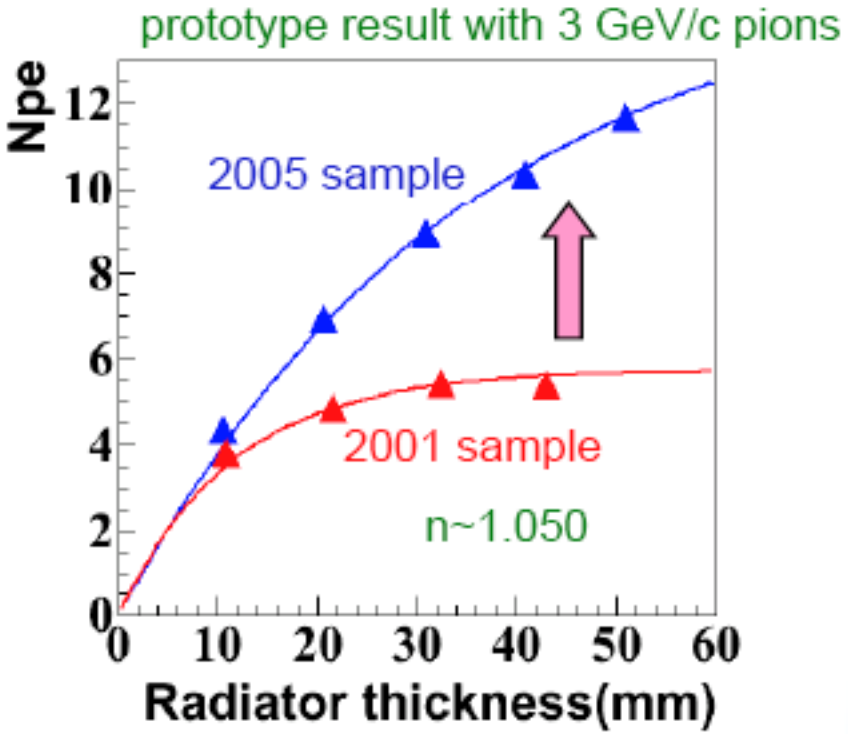
ID efficiency (3-8 GeV)



The Aerogel option

Trasmission length is undergoing significantly improvements





photon yield is not limited by radiator transparency up to ~50mm

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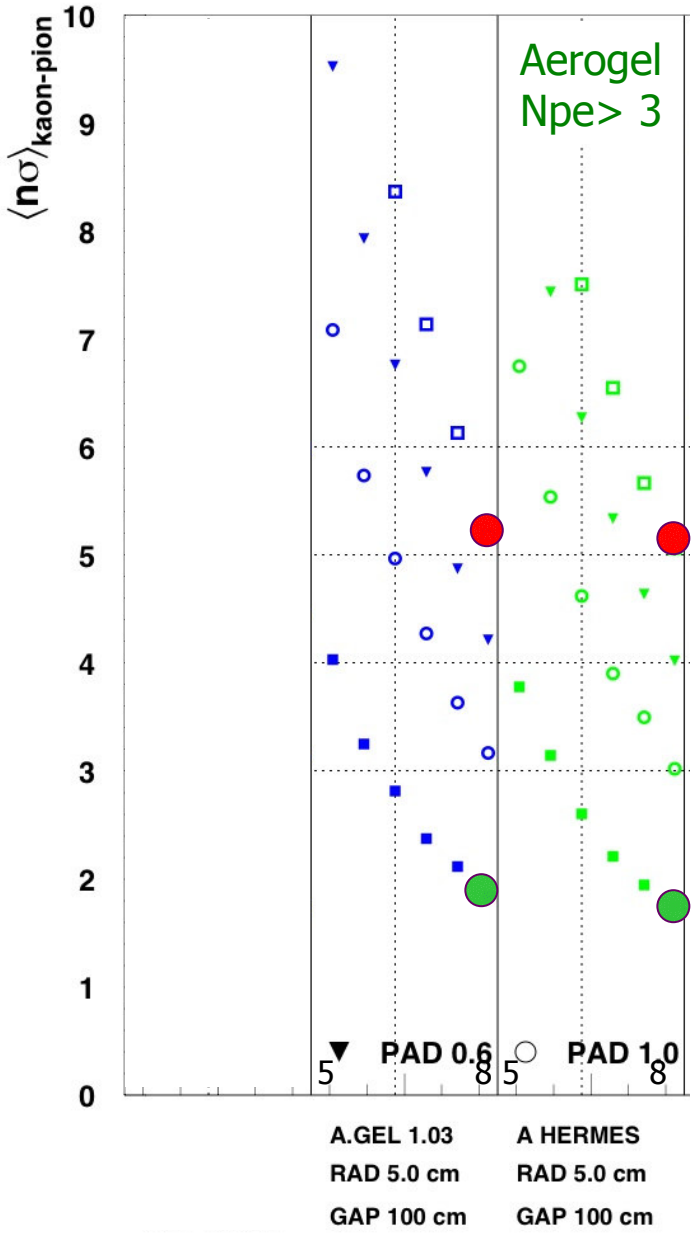
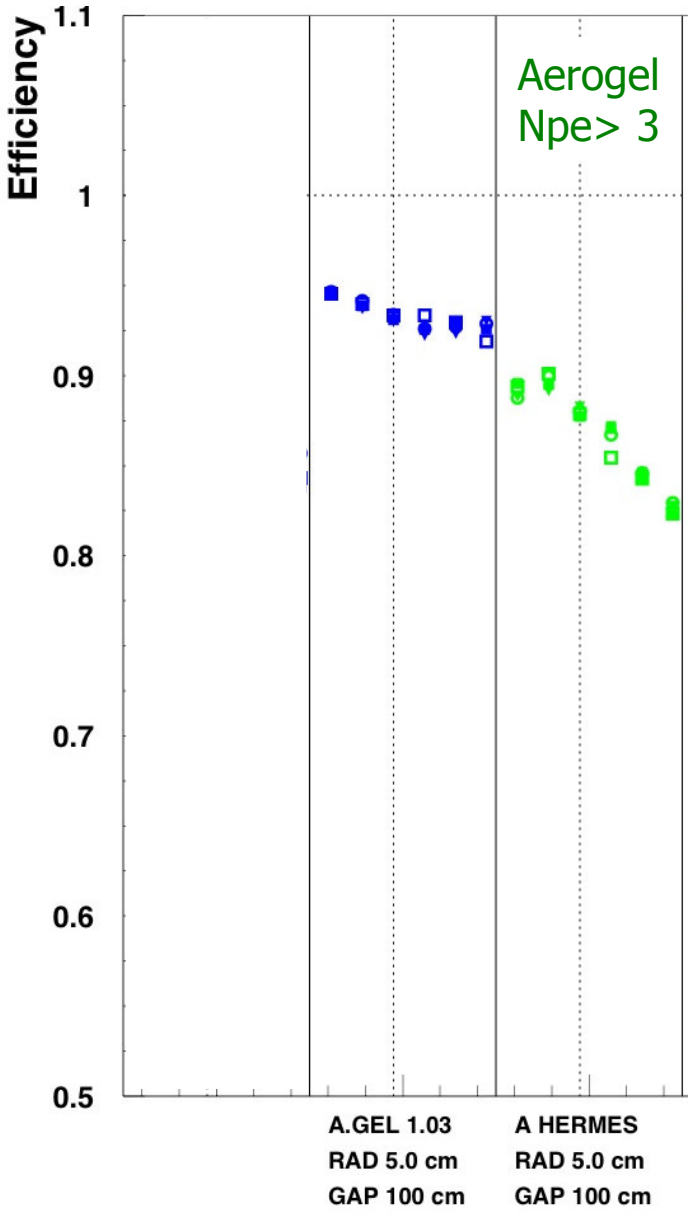
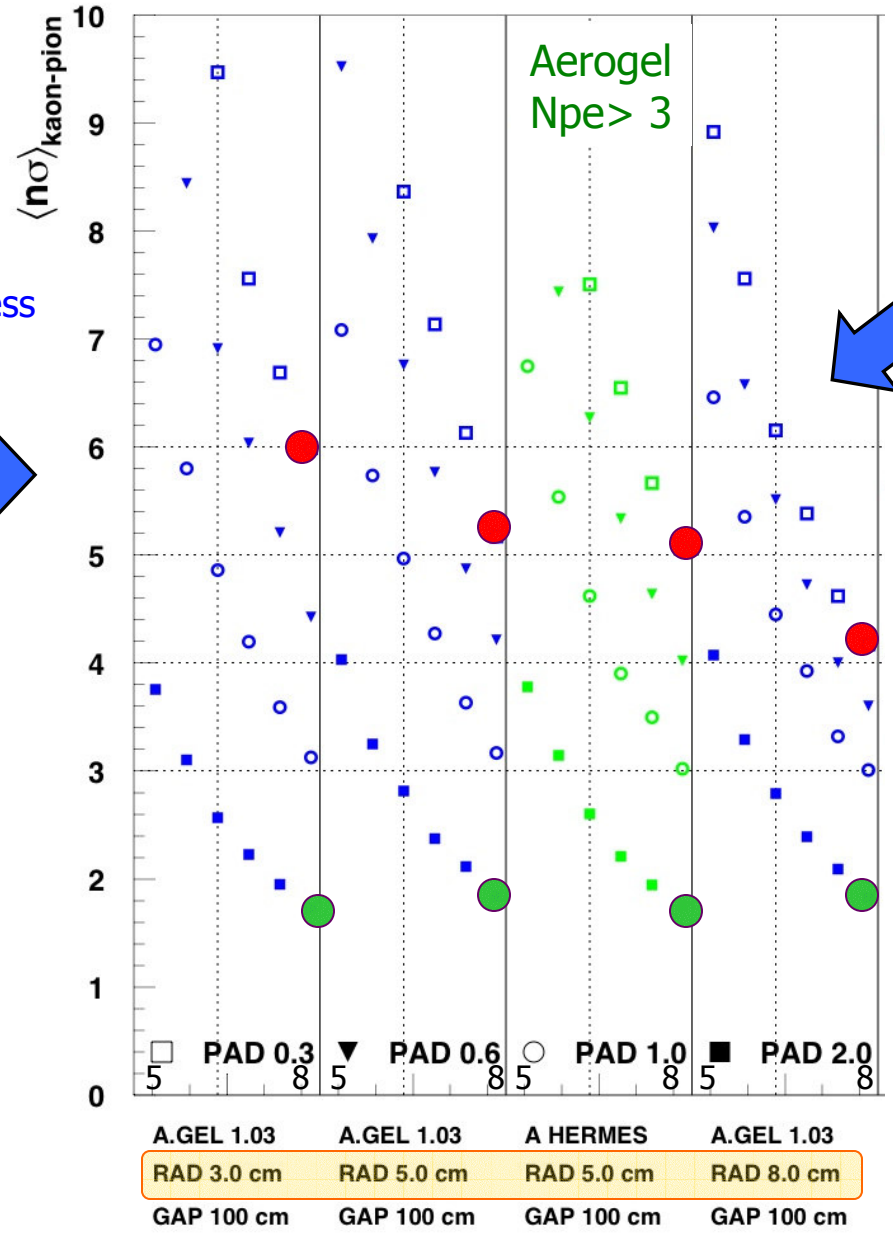
M. Tabata et al.

Mean πk separation (5-8 GeV)





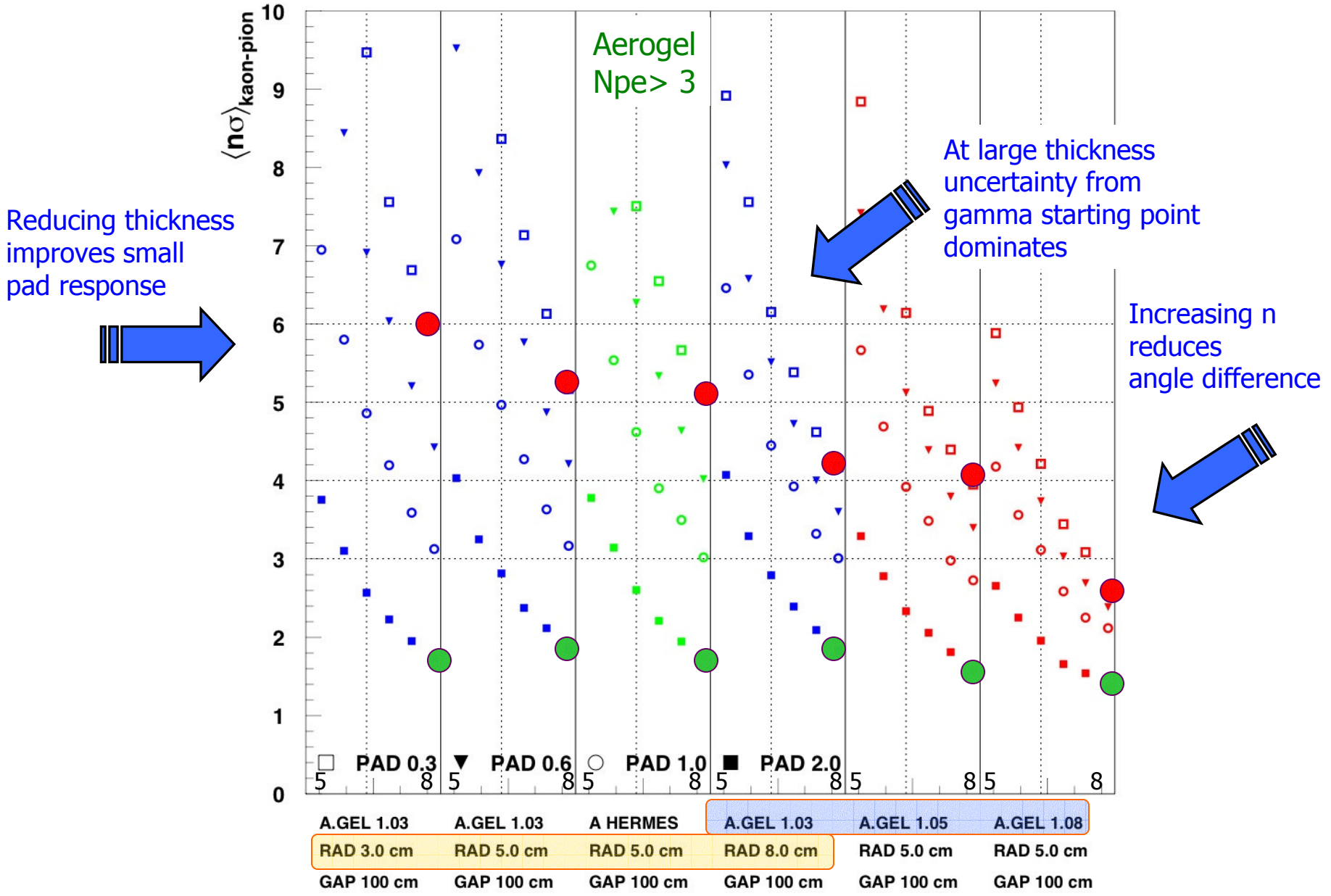
Mean πk separation (5-8 GeV)



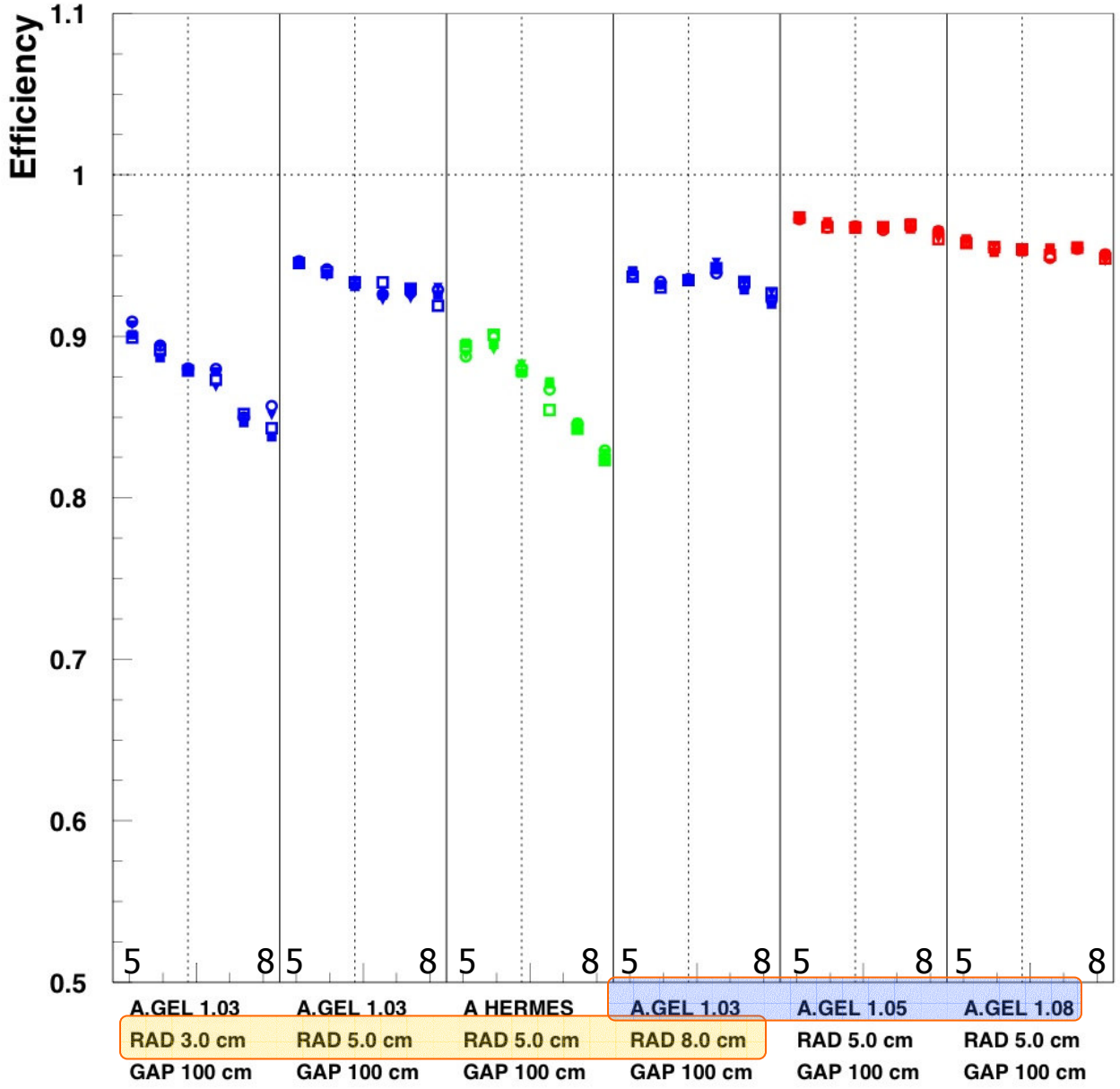
Reducing thickness improves small pad response

At large thickness uncertainty from gamma starting point dominates

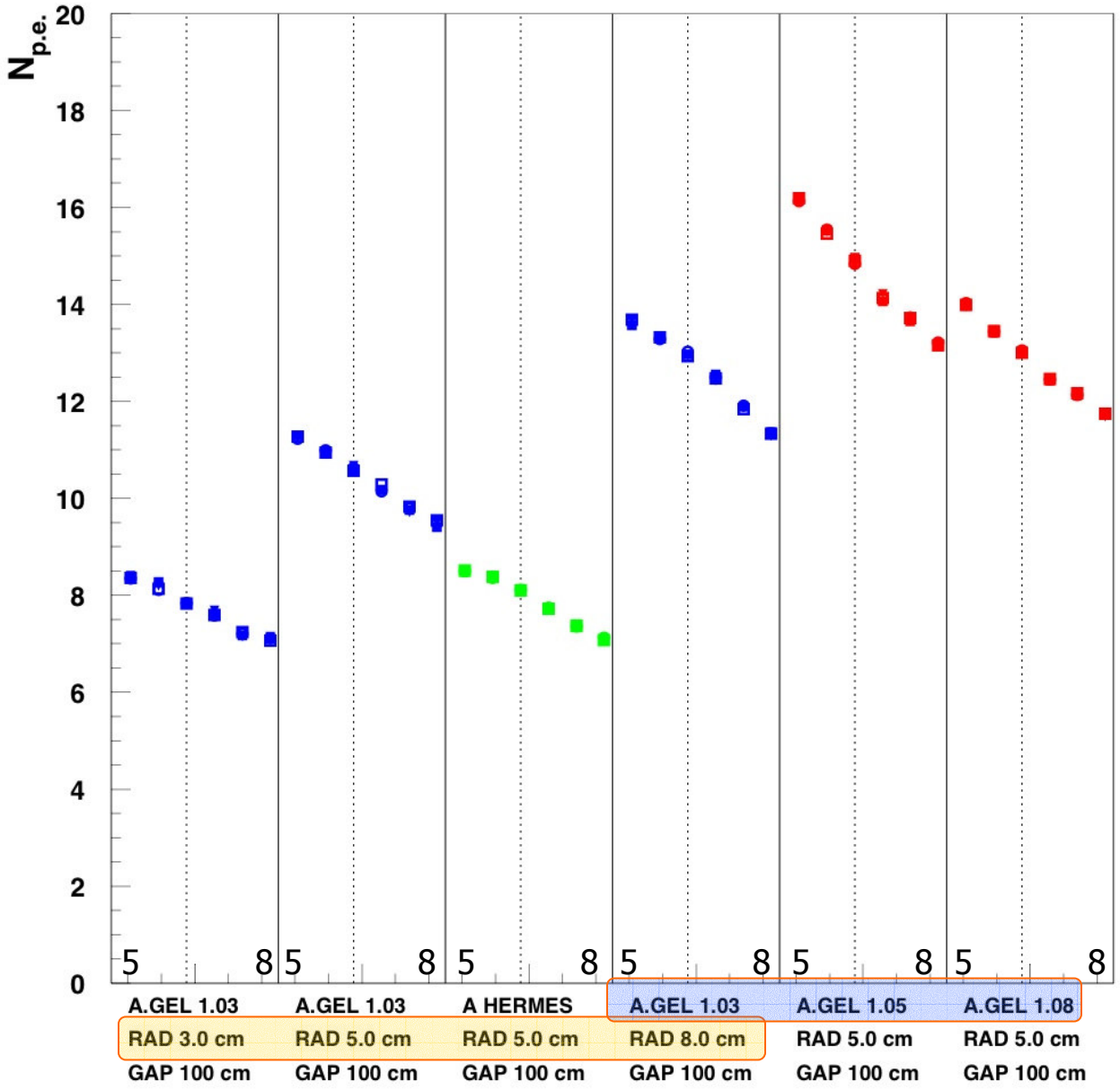
Mean πk separation (5-8 GeV)



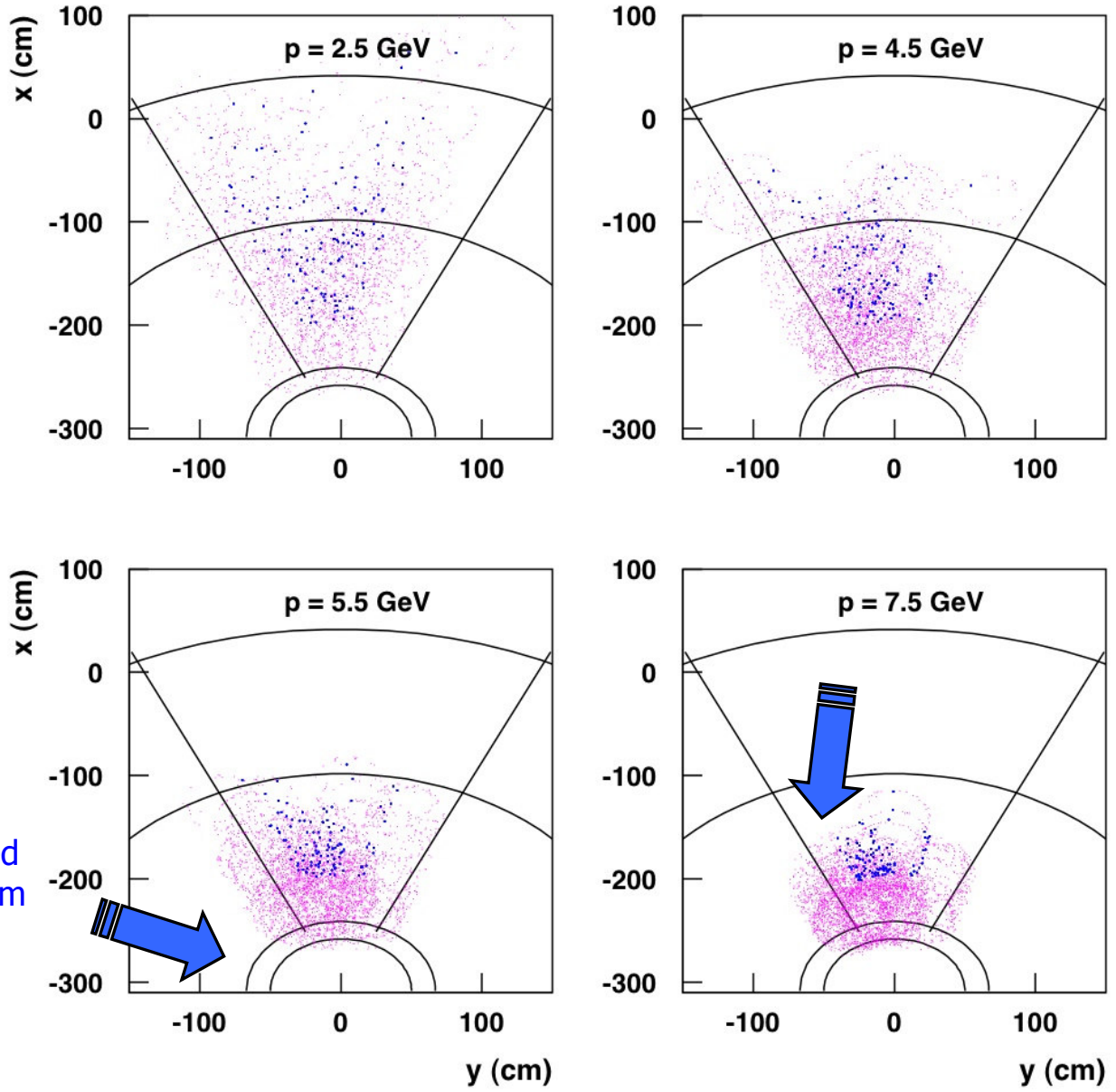
ID efficiency (5-8 GeV)



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



Gamma hits with Aerogel



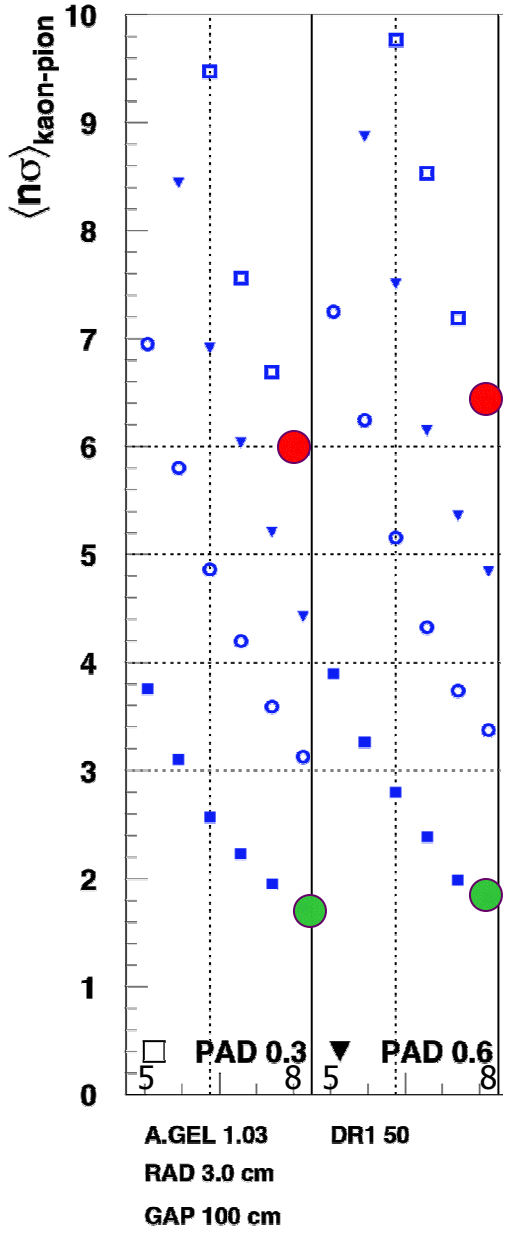
Full ring catched if down to 50 cm from beam line

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

Mean πk separation (5-8 GeV)

Geometry costraints:

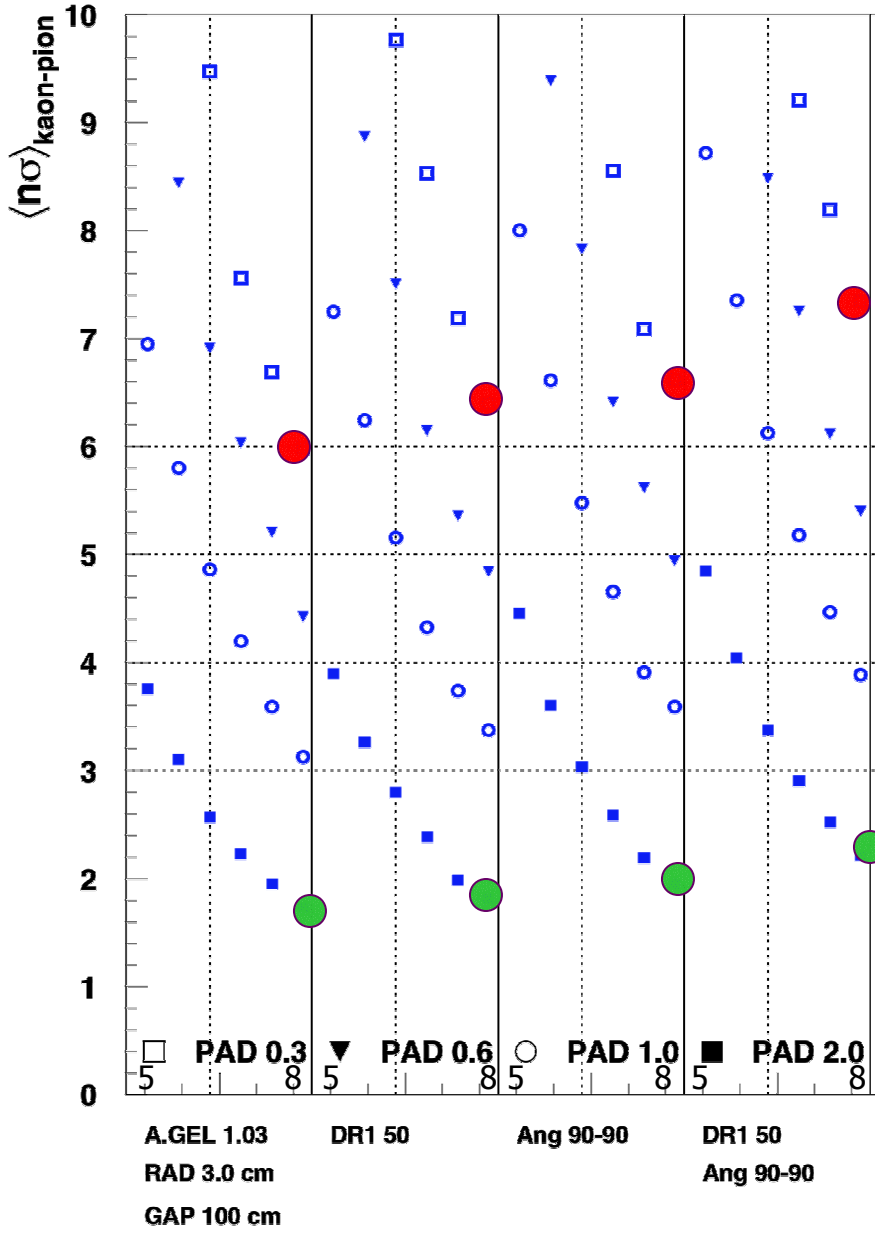
• minimum radius down to 50 cm from beam line



Mean πk separation (5-8 GeV)

Geometry costraints:

- minimum radius down to 50 cm from beam line
- increase number of sectors



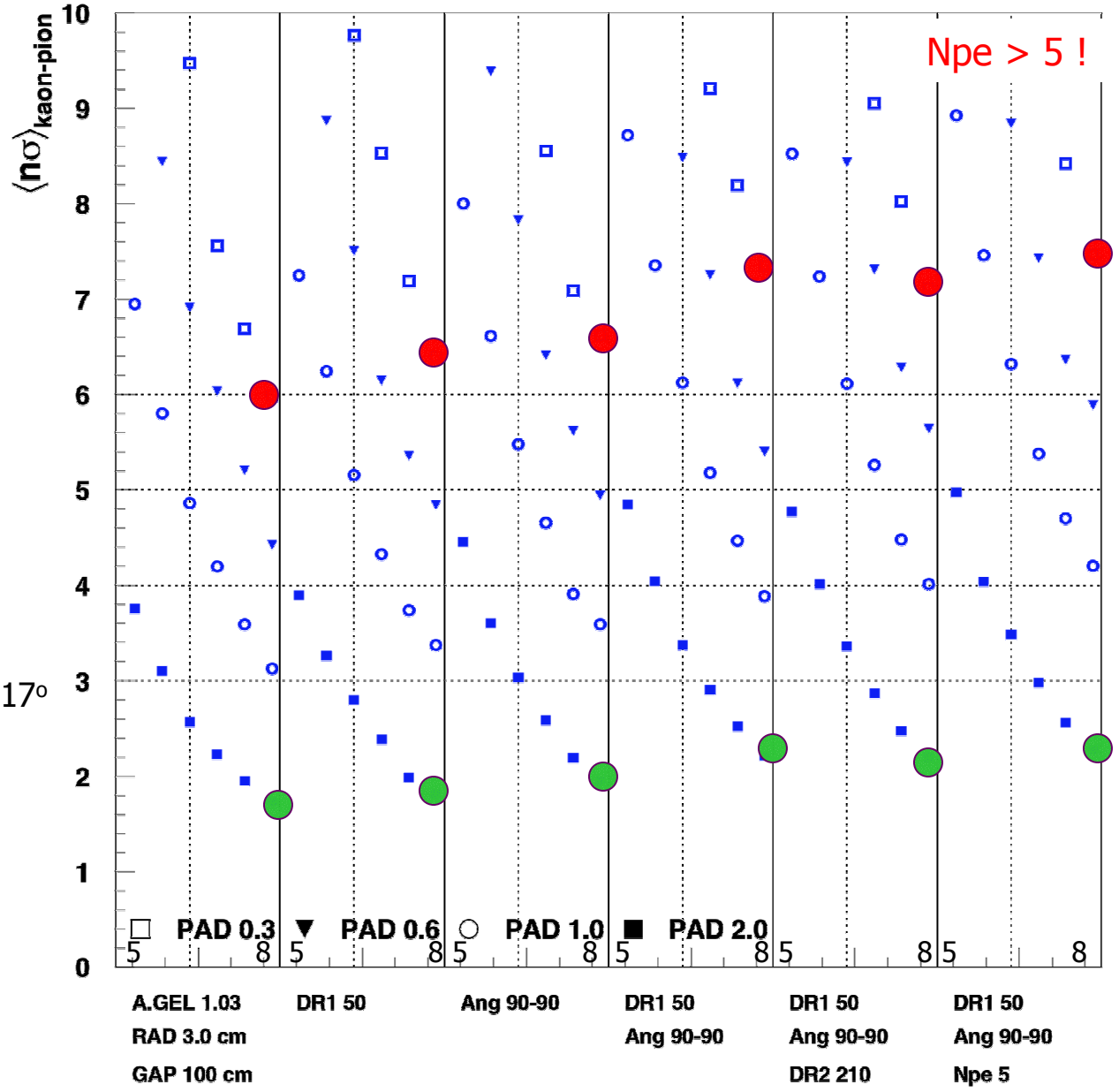
Mean πk separation (5-8 GeV)

Geometry costraints:

- minimum radius down to 50 cm from beam line
- increase number of sectors

Weak sensitivity on:

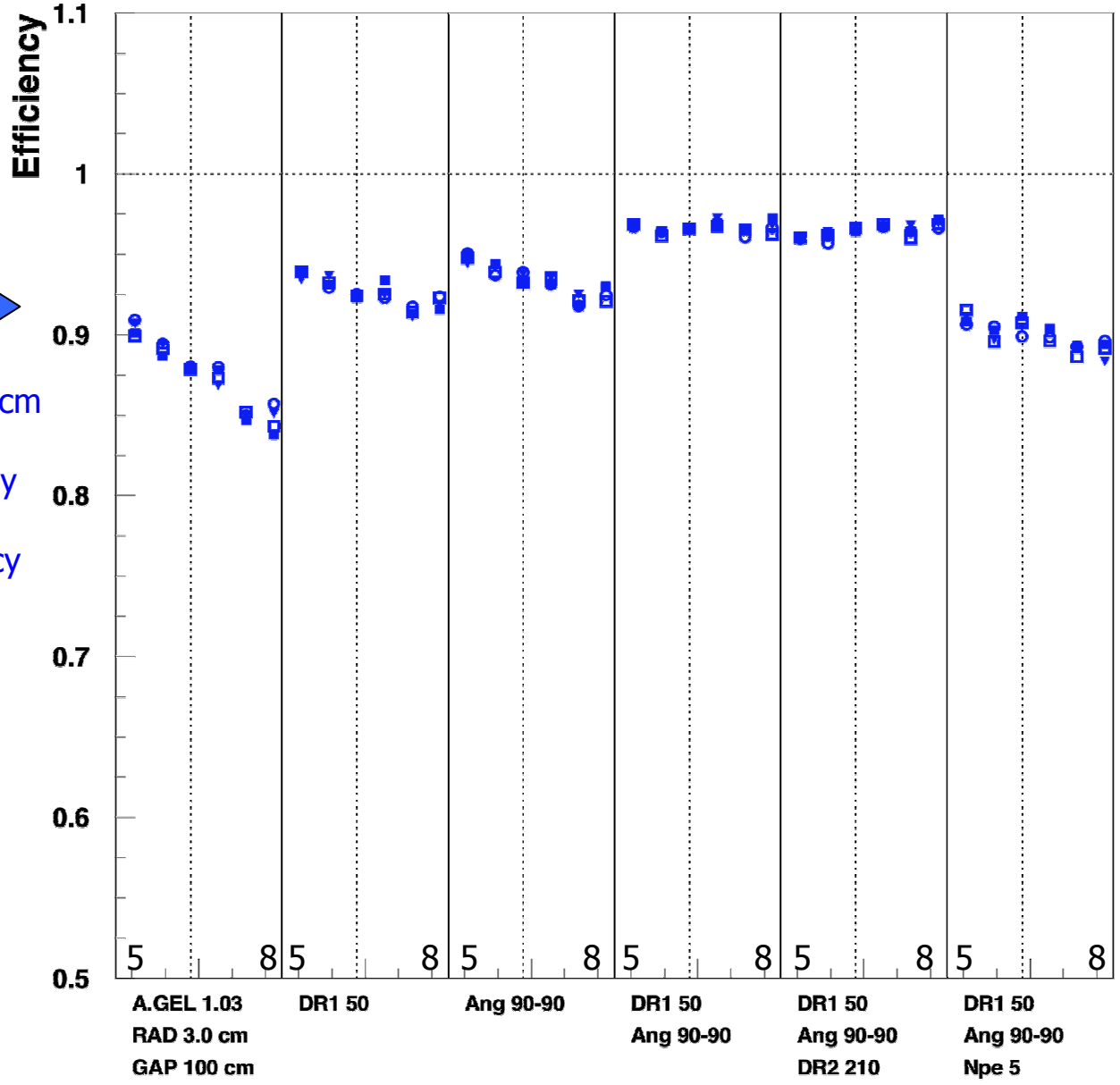
- reduction of active area down to 17°
- minimum N p.e. (from 3 to 5)



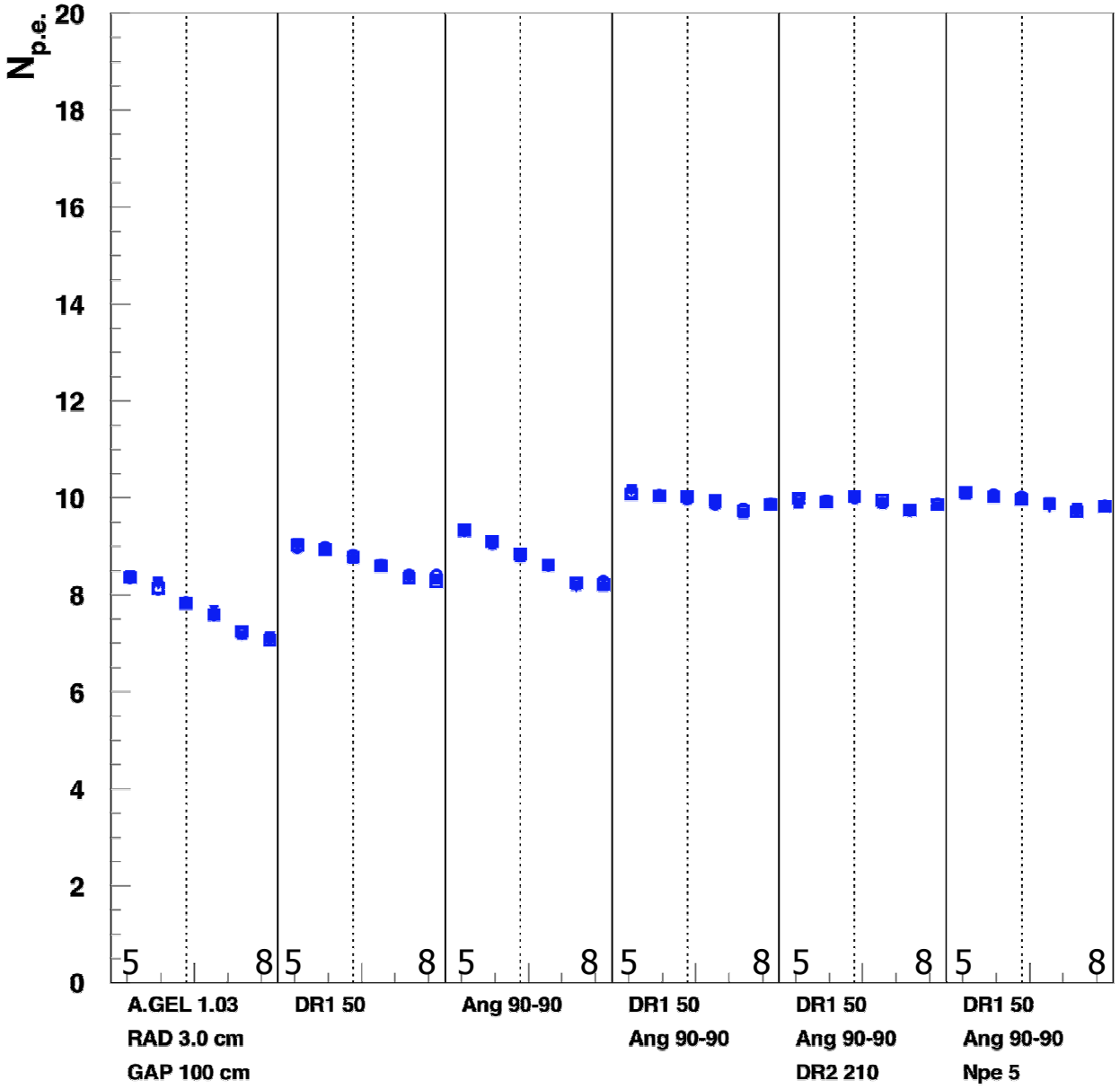
ID efficiency (5-8 GeV)

Going down to 50 cm
&
Left-right symmetry

increases efficiency



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



Executive summary

RICH with Aerogel
matches the required performances

High costs due to:

Large surface

Expensive detectors for visible light

Small pad size required

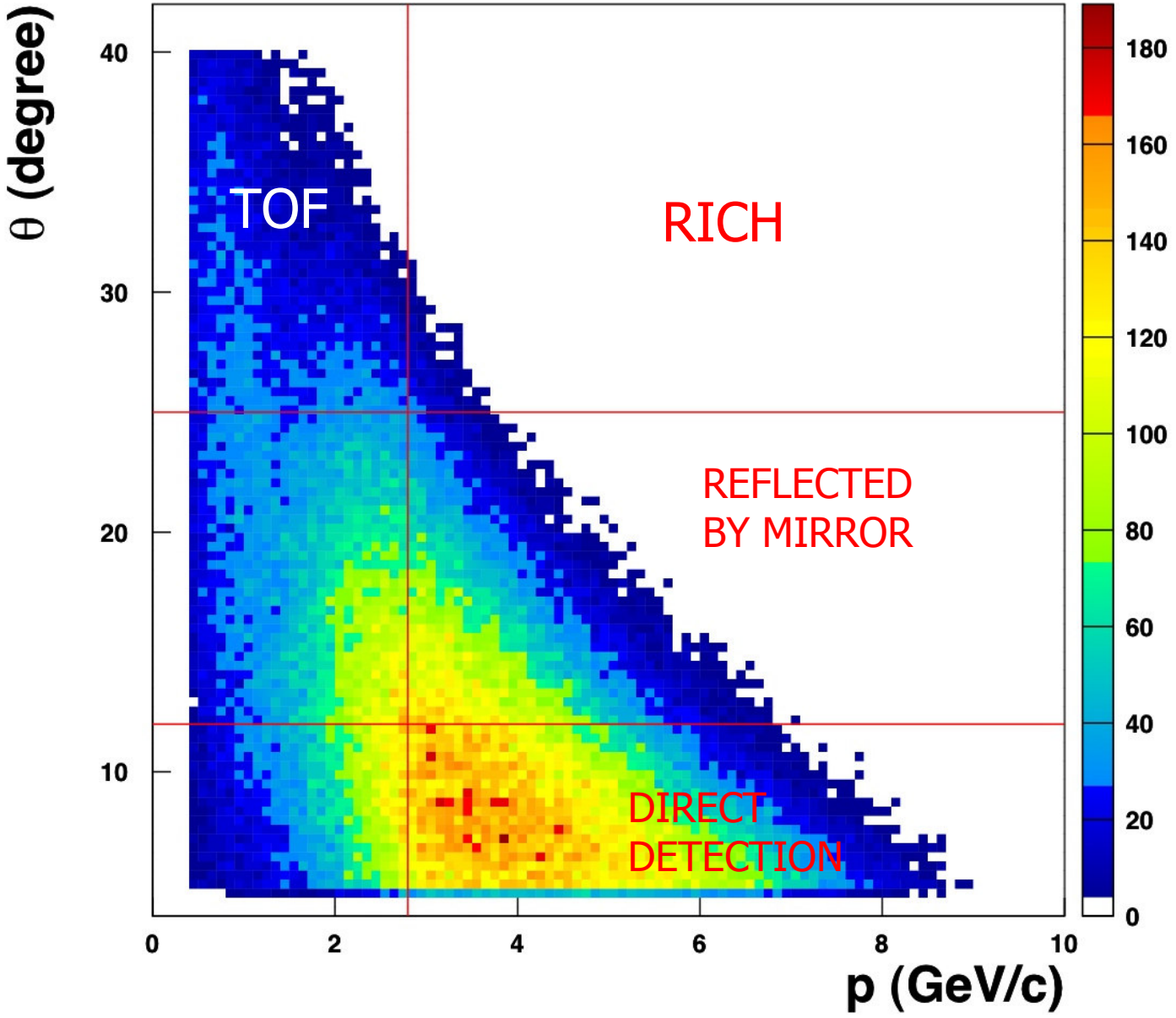
Interference with TOF:

Material budget → preliminary studies!

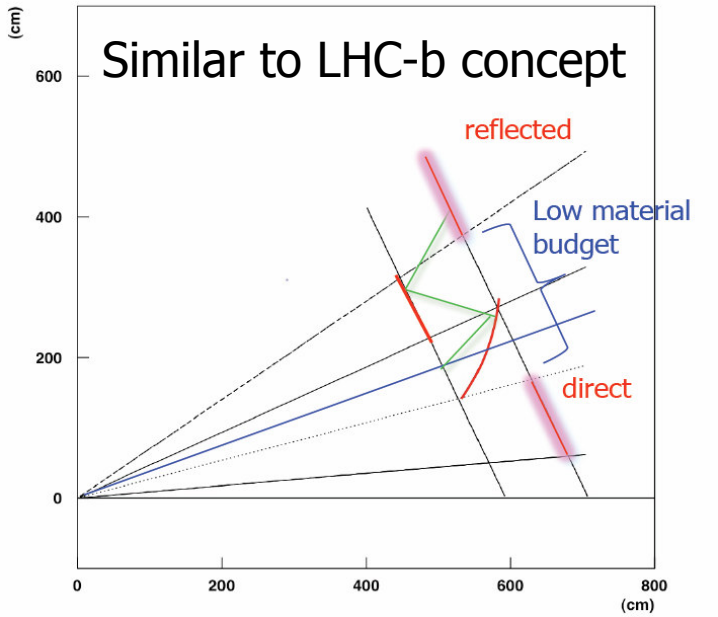
→ **Need to minimize: detector area & material budget:**

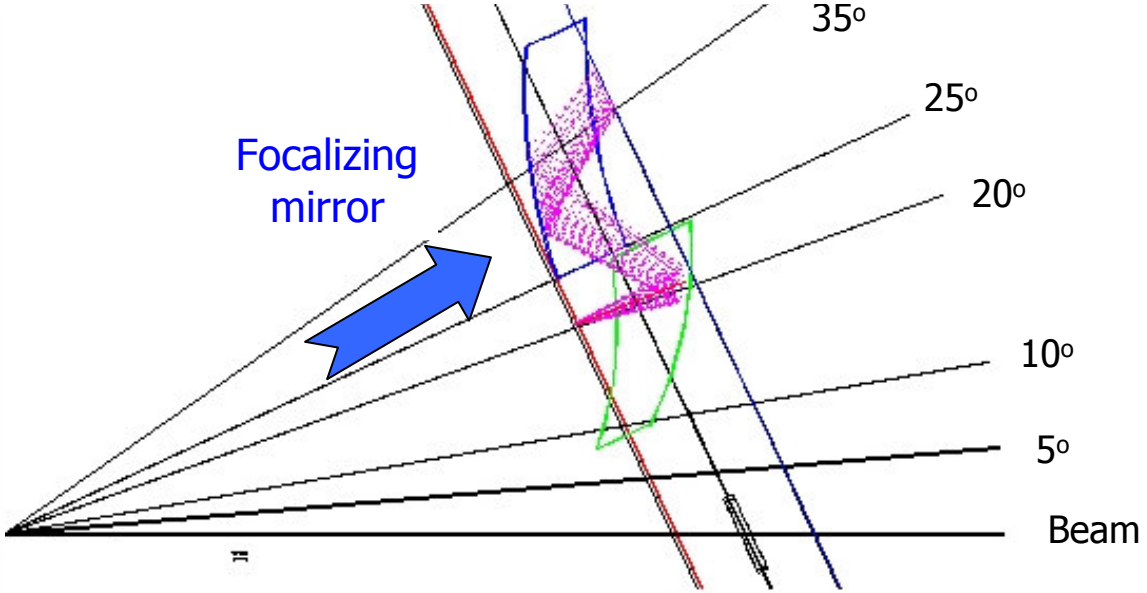
Mirror option

Kinematics


θ (degree)
40
30
20
10
0
2
4
6
8
10
p (GeV/c)
TOF
RICH
REFLECTED
BY MIRROR
DIRECT
DETECTION
180
160
140
120
100
80
60
40
20
0

The mirror option: reflection outside

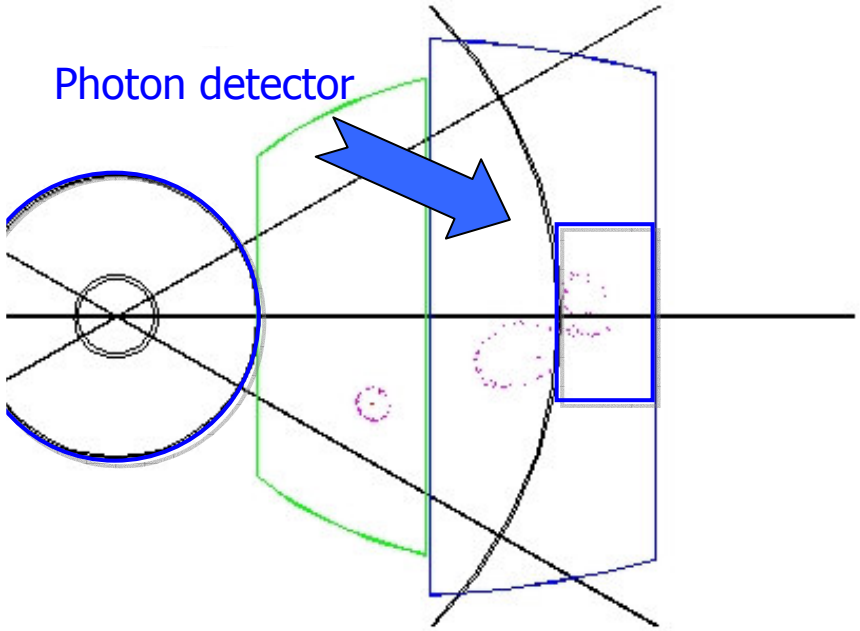




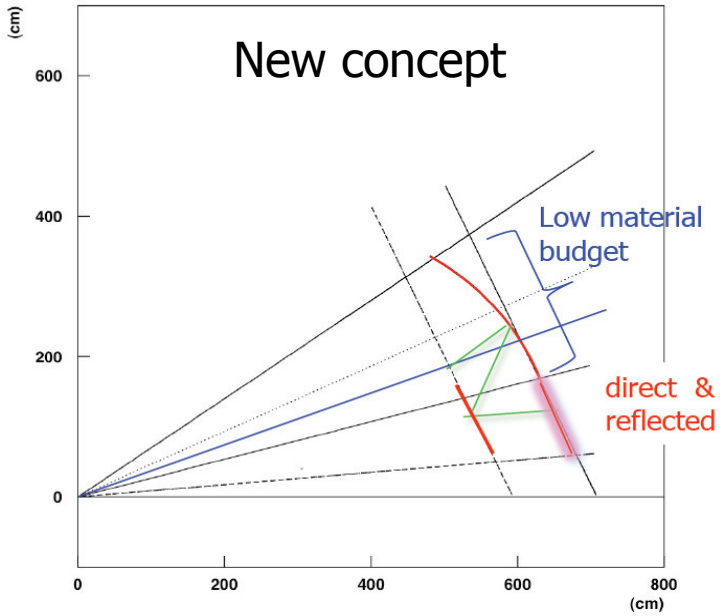
Direct:
high momentum ⟶ high performance

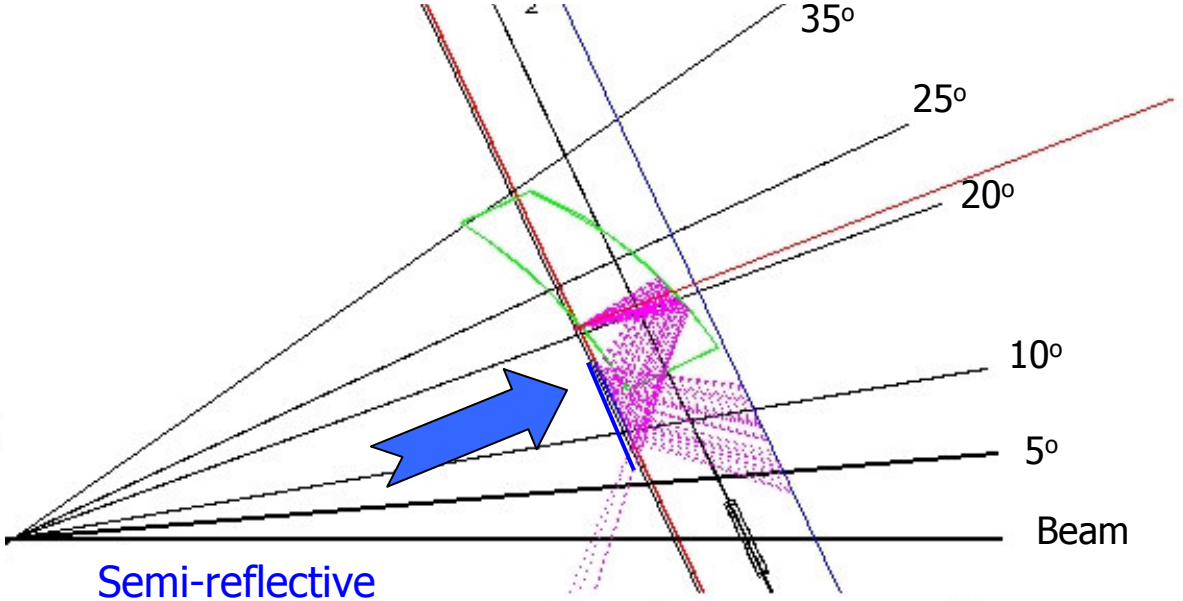
Reflected:
lower momentum ⟶ relax performance requests

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

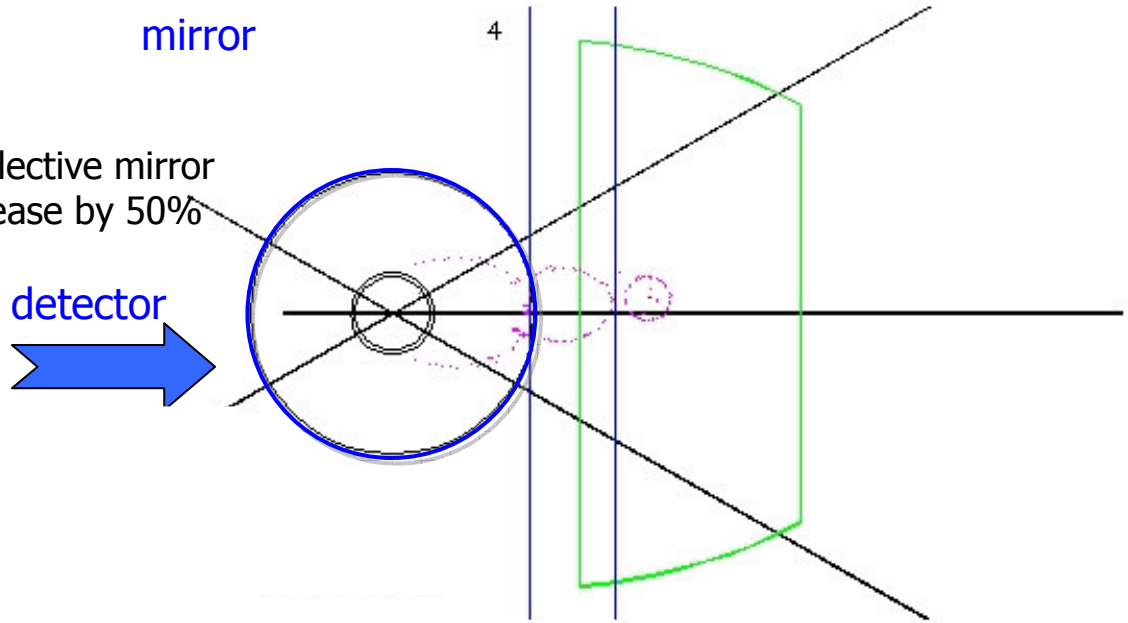


The mirror option: reflection inside





- 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%



Interference with TOF: preliminary stiudies

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

Main features:

- material: alluminum, copper or tungsten
- pattern: matrix of 8x0.6 cm squared cells (each cell is 52 mm wide with 4 mm of dead area to resemble the **H8500 modules with 0.6 cm pad**)
- width of the cells is random within [0, 2cm]
- position of the wall is varied randomly within 8 cm close to the end of the GAP

Interference with TOF: preliminary stiudies

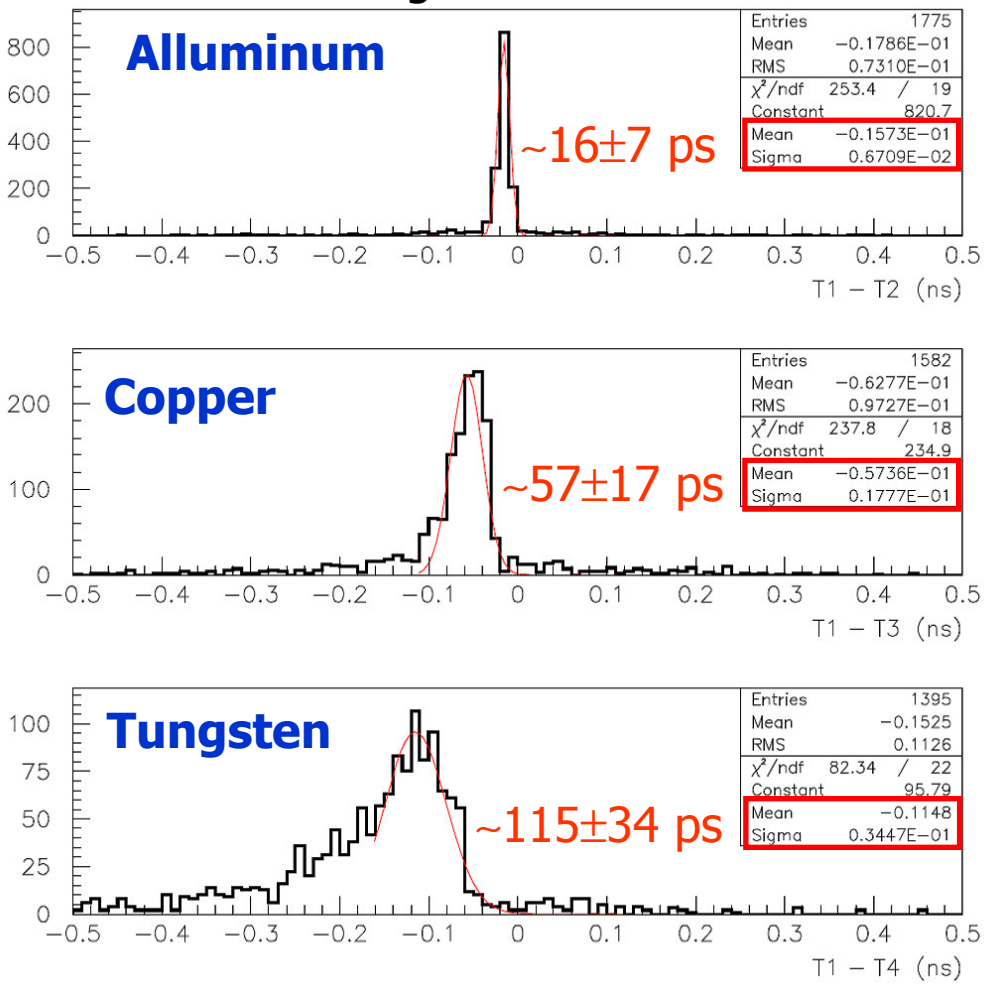
Time-of-flight differences due to multiple scattering in the wall

The 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)

- effects within TOF detector resolution

Time-of-flight differences in ns



Interference with TOF: preliminary stiudies

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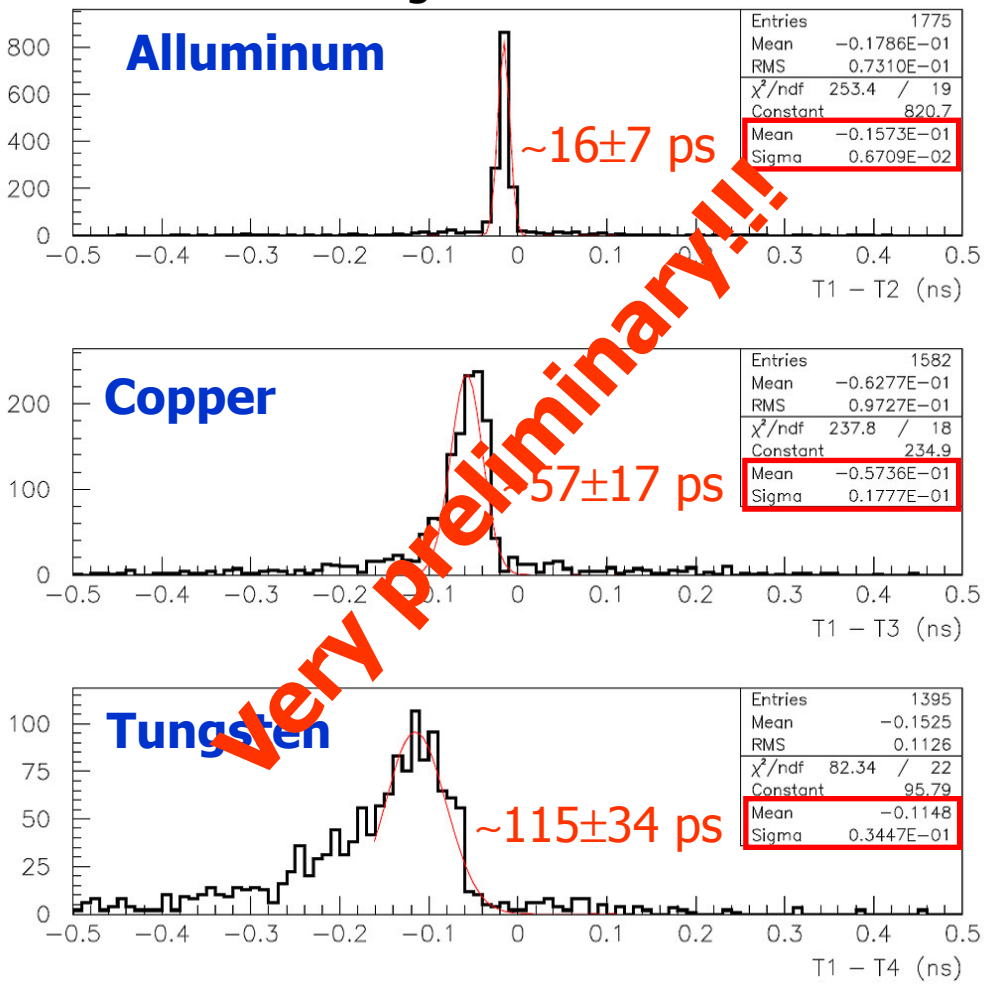


Interference with TOF: preliminary stiudies

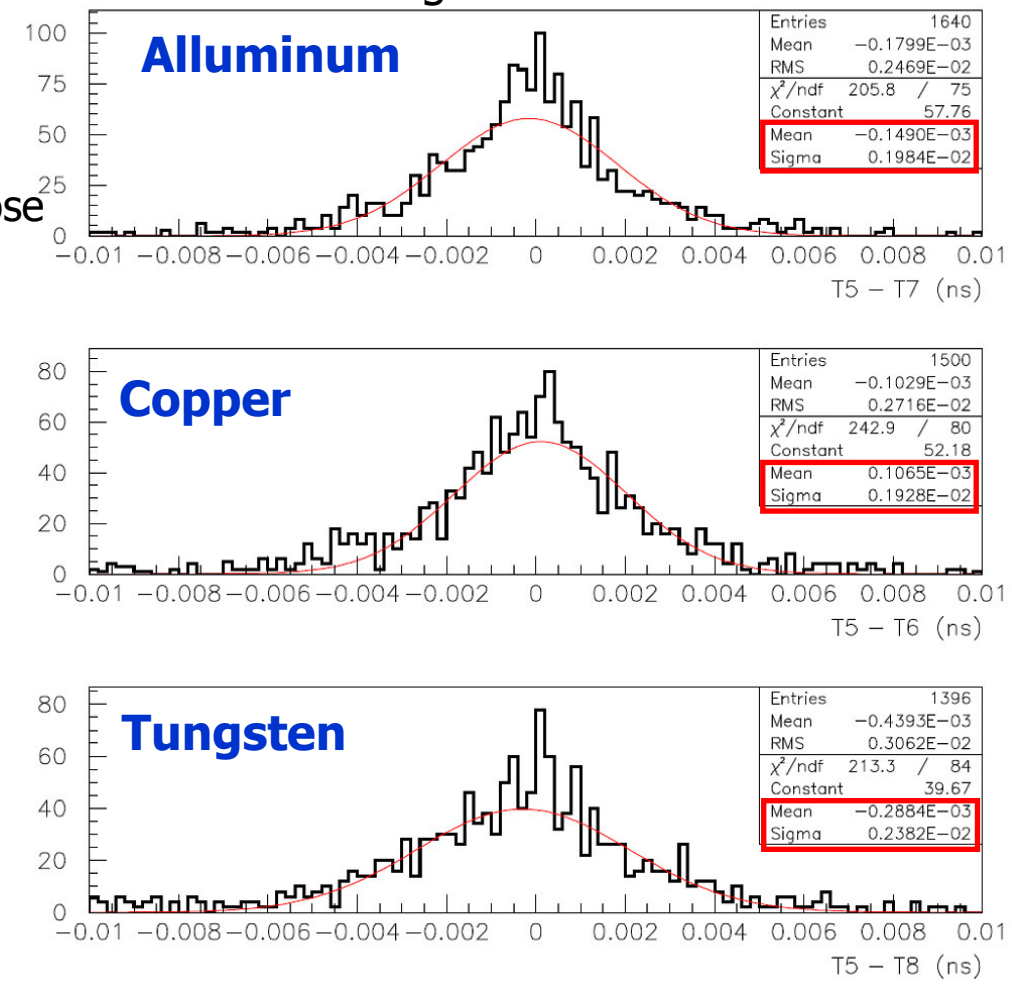
Time-of-flight differences due to multiple scattering in the wall

A more 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

- effects compatible with zero!!

Time-of-flight differences in ns



Interference with TOF: preliminary stiudies

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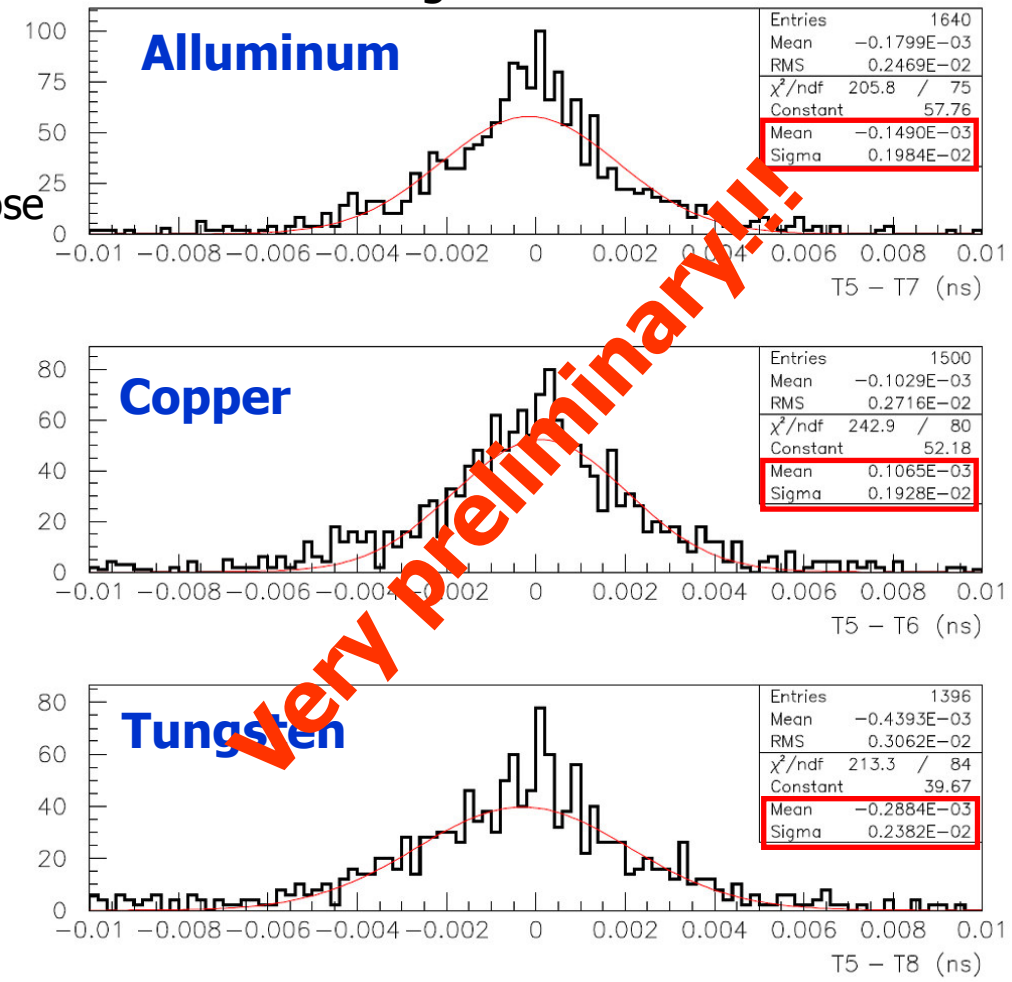
Time-of-flight differences in ns



Conclusions

RICH with Aerogel
matches the required performances

Working to:

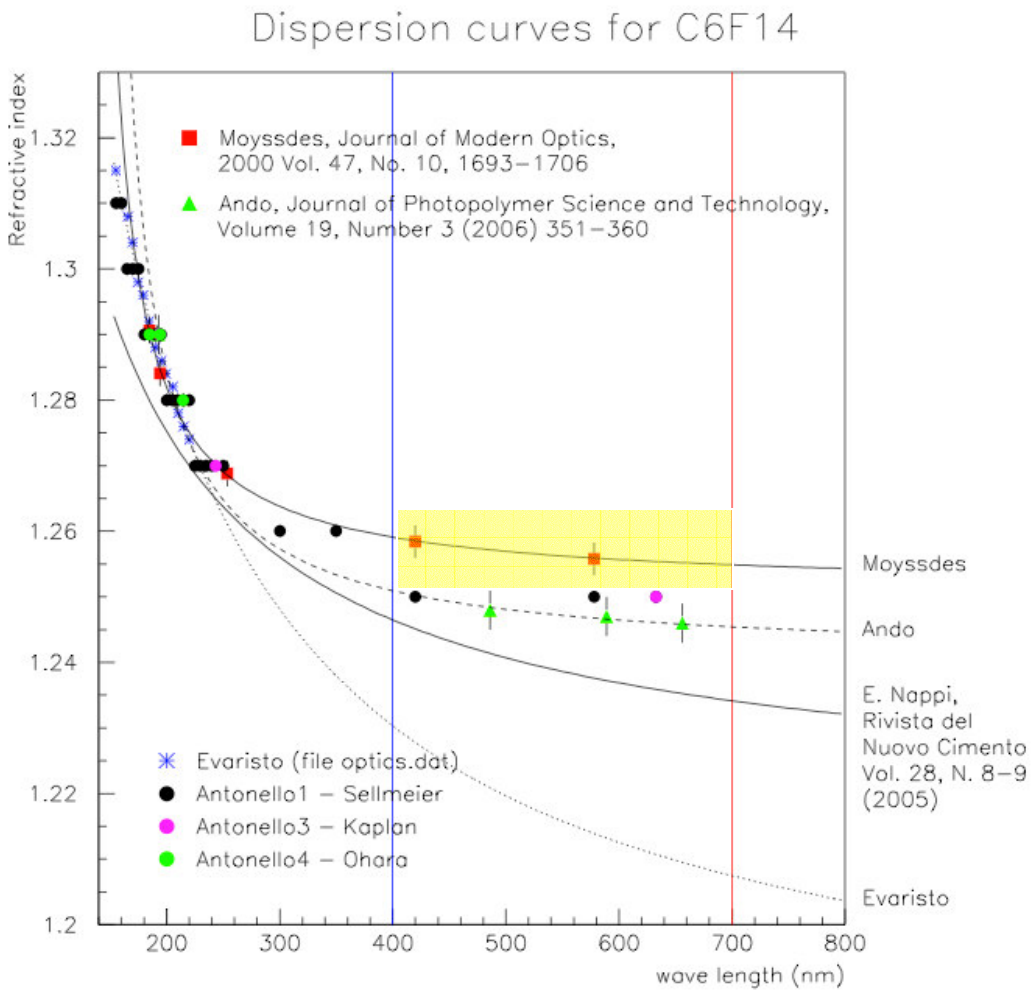
- minimize detector area
- minimize detector material ⟶ preliminary studies are promising!

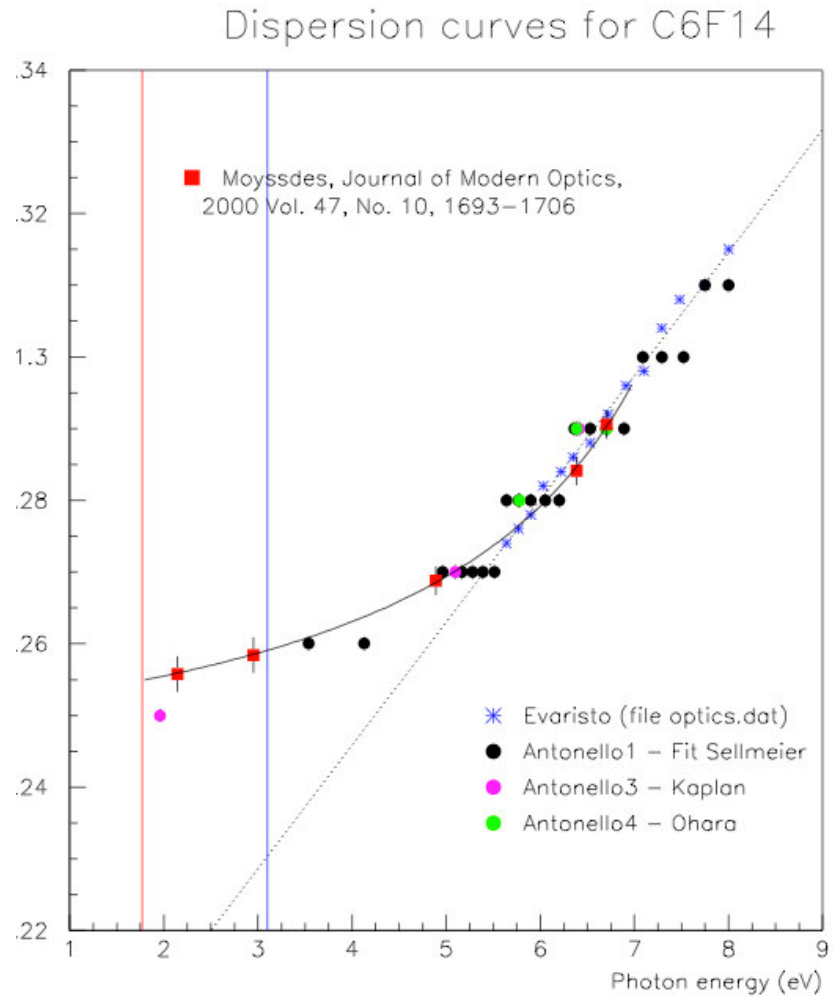
Ongoing:

Generalize reconstruction algorithm to treat:
- multiple track events
- mirrors

Optimize mirror geometry:
- minimize detector area
- minimize interference with TOF

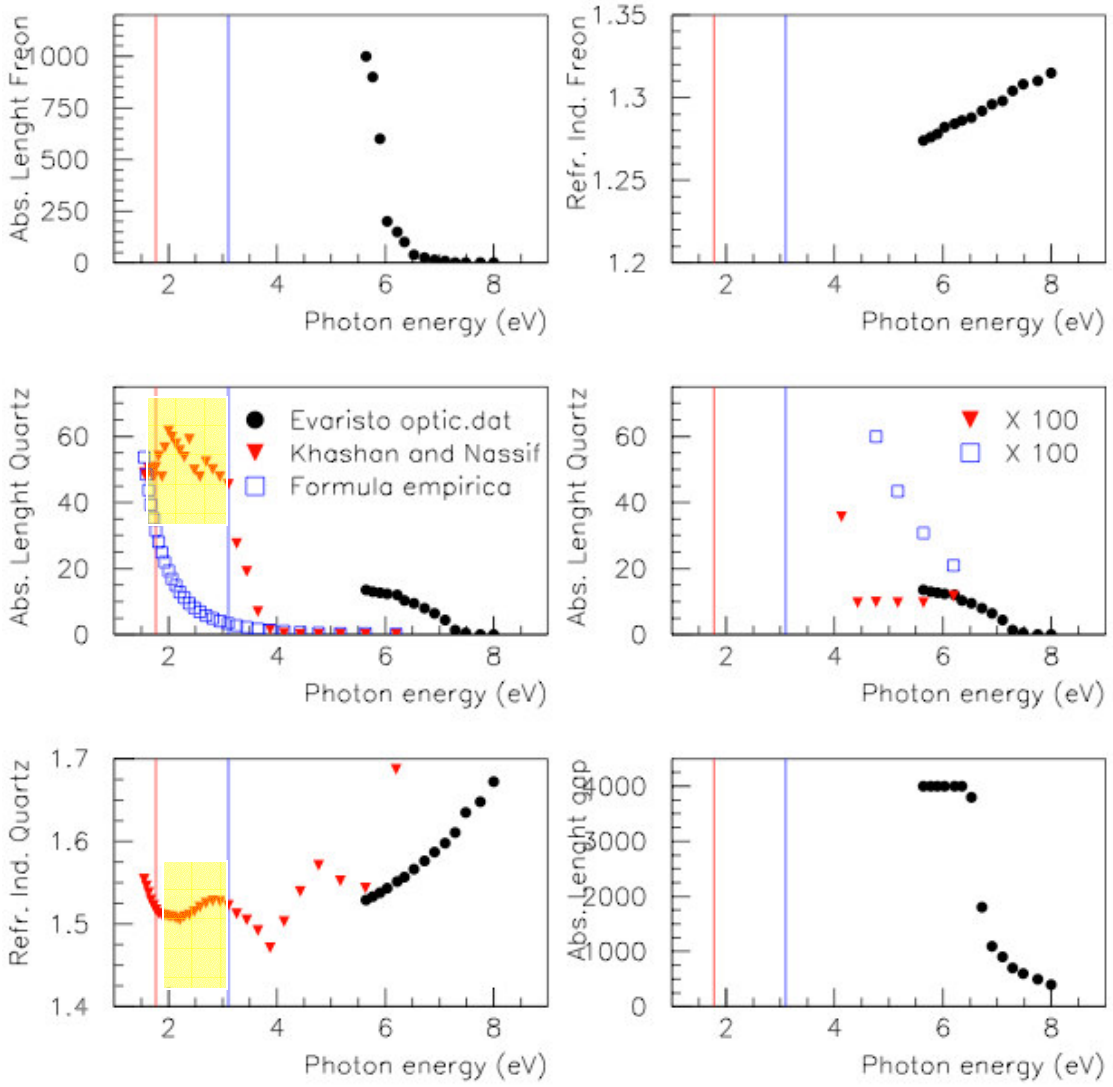
Refraction index: freon





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

The Aerogel option