# An exercise on optimisation

Henri Videau
LLR Ecole polytechnique
CNRS/IN2P3

We try to find an optimum aspect ratio for the TPC/ECal

We can consider different models with different R and Z (half barrel length)

But we want to find
the best measurement for charged tracks and photons
for our money not per se.

We will consider that the area of the ECal front is an adequate estimator of the price.
It is for the ECal, probably quite well also for the HCal
for the yoke, as the flux varies it is not very true

we could fix $BR^2$,
compute the field for each R and enter it in the formula
but fixing $BR^2$ in a large domain is not very realistic

# Angular dependency of δp

a track of momentum p (reasonnably high) and polar angle θ

$p_\perp = p \sin\theta \quad \delta p_\perp = a\, p_\perp^2$ with $a \propto L^{-2.5} \quad \delta p = \dfrac{\delta p_\perp}{\sin\theta}$ we forget about the error on θ

putting $x = \cos\theta$

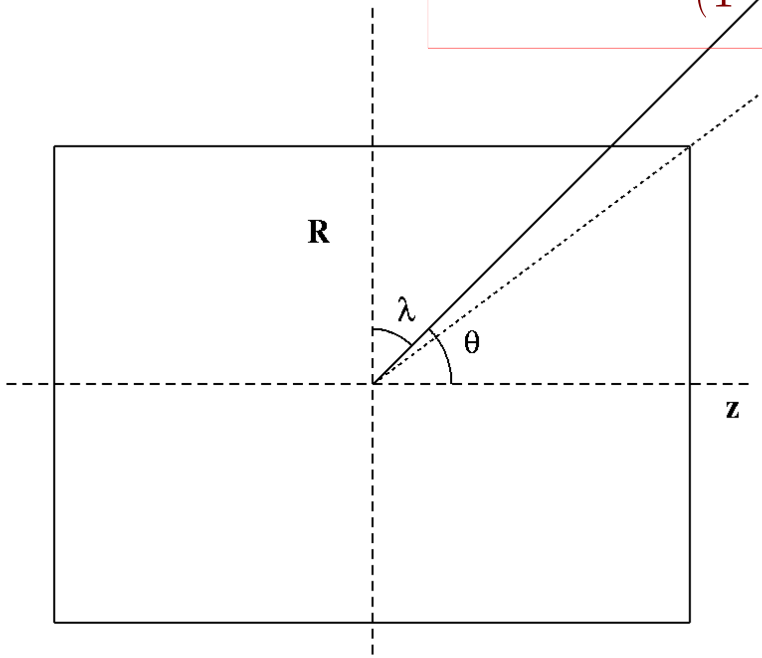
$$\delta p \propto L^{-2.5}\, p^2 \sin^2\theta / \sin\theta = L^{-2.5}\, p^2 (1-x^2)^{1/2}$$

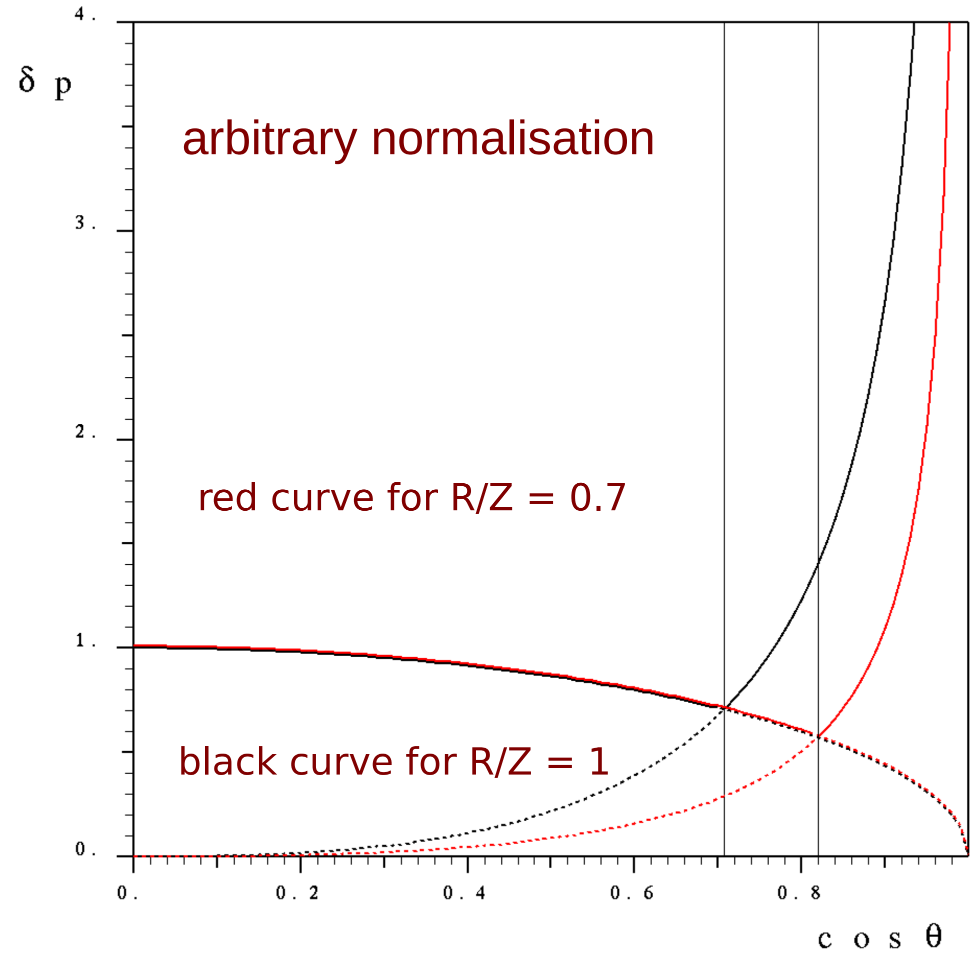
Barrel L = R

End cap L = Z tgθ

$$\delta p \propto R^{-2.5}\, p^2 (1-x^2)^{1/2}$$

$$\delta p \propto Z^{-2.5}\, p^2 \frac{x^{2.5}}{(1-x^2)^{0.75}}$$




function 1. x q-
function 1. x q- -1.5 ** x 2.5 ** * R/Z 2.5 ** *

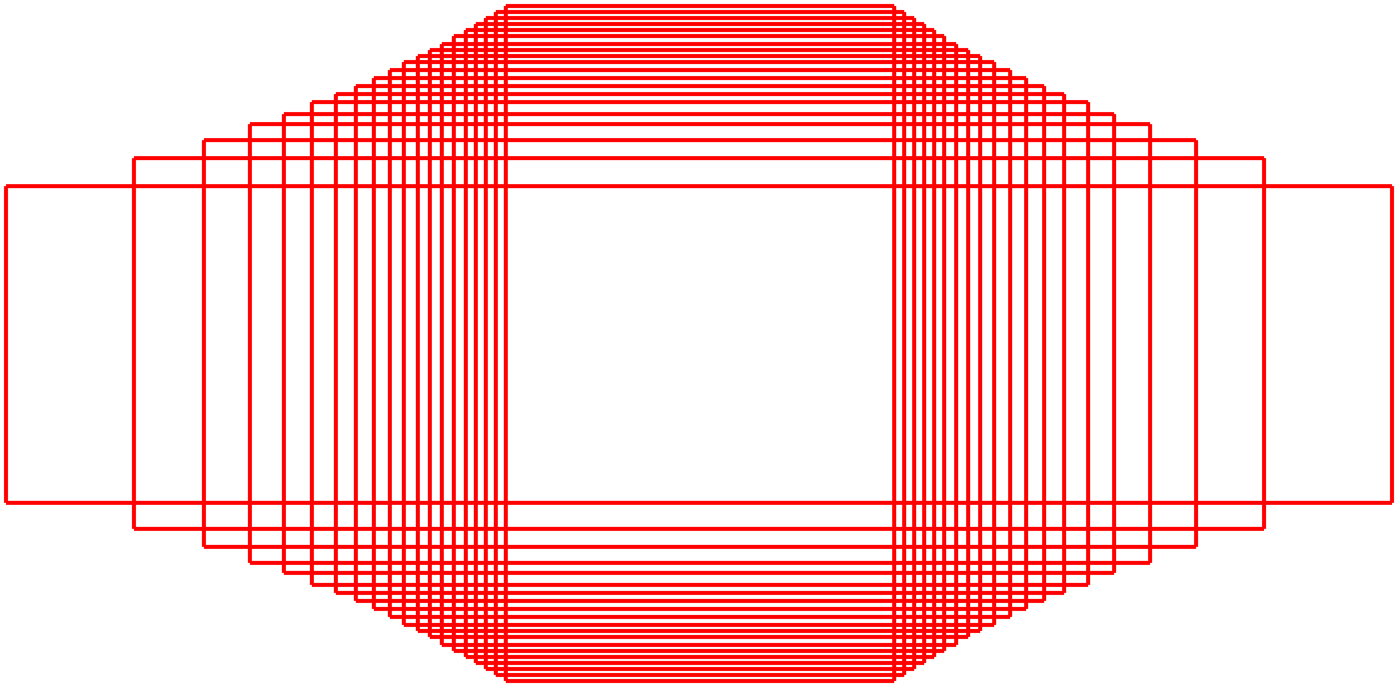
We consider the following exercise:

Taking the area as a constant (we chose 60m$^2$ not far from what we envisage) what is the best aspect ratio for the tracker ?
That depends on the physical angular track distribution.
Even though most of interesting physics is more picked than that we can consider a (1 + cos$^2$ θ) distribution corresponding to Z or γ → 2 fermions.

Calling R the radius and Z half the length $A = 2\pi R\, 2Z + 2\pi R^2$
the area A is around 60m$^2$
the aspect ratio $\alpha = \frac{R}{Z}$
the angle of the corner $\theta_0$ $\tan\theta_0 = \frac{R}{Z}$ $\cos\theta_0 = \frac{Z}{\sqrt{Z^2+R^2}}$
take for parameters A and cos $\theta_0$ $\alpha = \sqrt{\frac{1}{\cos^2\theta_0} - 1}$

$$Z = \sqrt{\frac{A}{2\pi\alpha(2+\alpha)}} \qquad R = \sqrt{\frac{A\alpha}{2\pi(2+\alpha)}}$$

We integrate then from 0 to cos$\theta_0$ with the barrel formula and from cos$\theta_0$ to 0.99 (low end of the TPC) with the end cap formula.
That provides, weighted in (1 + cos$^2$ θ), a mean δp.



These are the different aspect ratios I considered.
There is no use to go for a flat disk or a long tube.

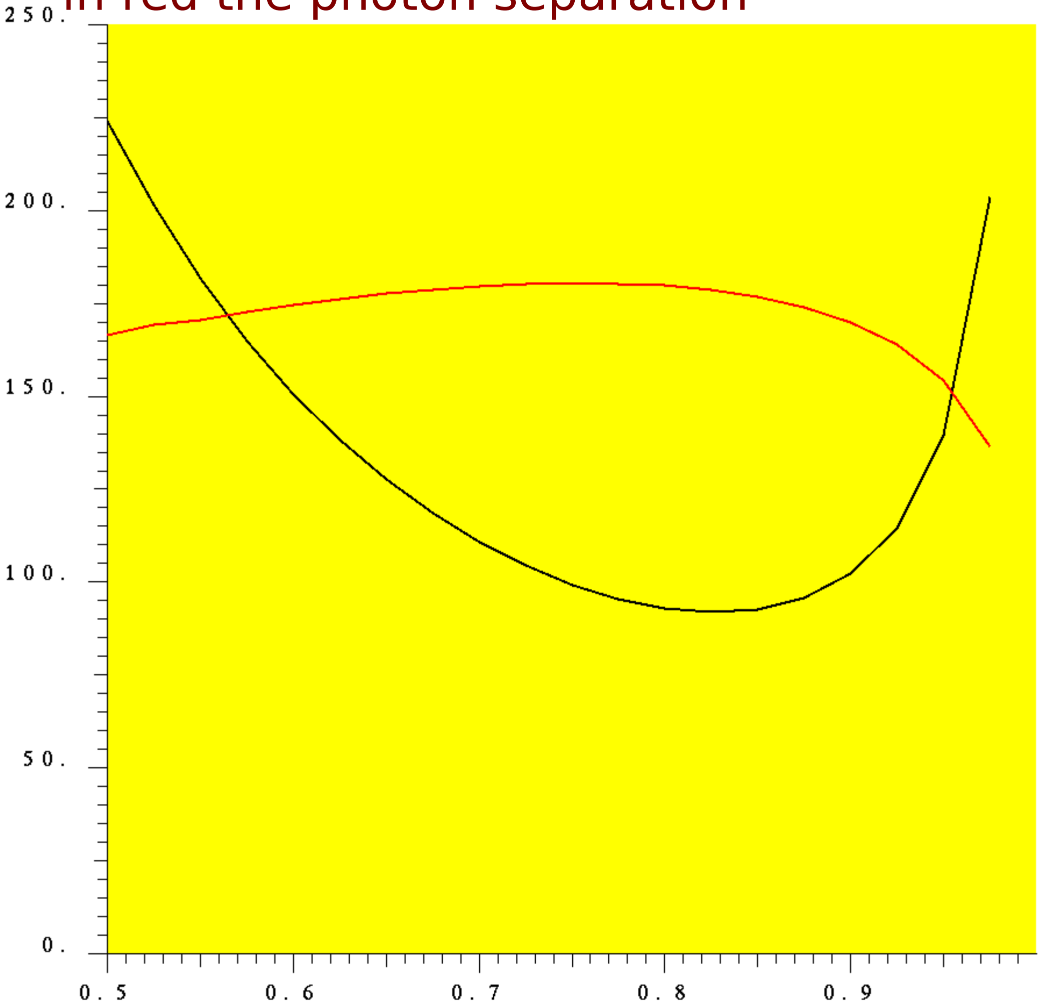
For the photons, it is more tricky
but simpler:

as the energy resolution
does not change much with angle
with the effect of the two thicknesses

the idea is to use as test variable
the distance between photons
at the entrance of the Ecal
(the farther the better)
for a fixed angular separation.

What we observe here is mostly
the effect of the angular distribution.
The conclusion is rather tivial
that we should not go for a narrow tube.

in black $\delta p$
in red the photon separation




$\cos\theta_0$

# Conclusion

using the area of the Ecal entrance as an estimator of the cost
deciding then on a given area, here $60m^2$,
considering a track/photon distribution in $1+\cos^2\theta$
the aspect ratio is varied and
the mean quality of the tracking as well as
the photon separation measured.
The optimum for tracks is found to be $\cos\theta=0.825$ or Z=2.28 R=1.56
The optimum for photons is found to be $\cos\theta=0.775$ or Z=2.04 R=1.66
but is rather shallow.

Recall that the proposed design uses Z=2.35, R~1.5
If we want, for an optimum tracking,
to obtain Z=2.35 then A=64 and R=1.6 QED
Quod erat demonstrandum

It is not that far from the optimum for the chosen criterion