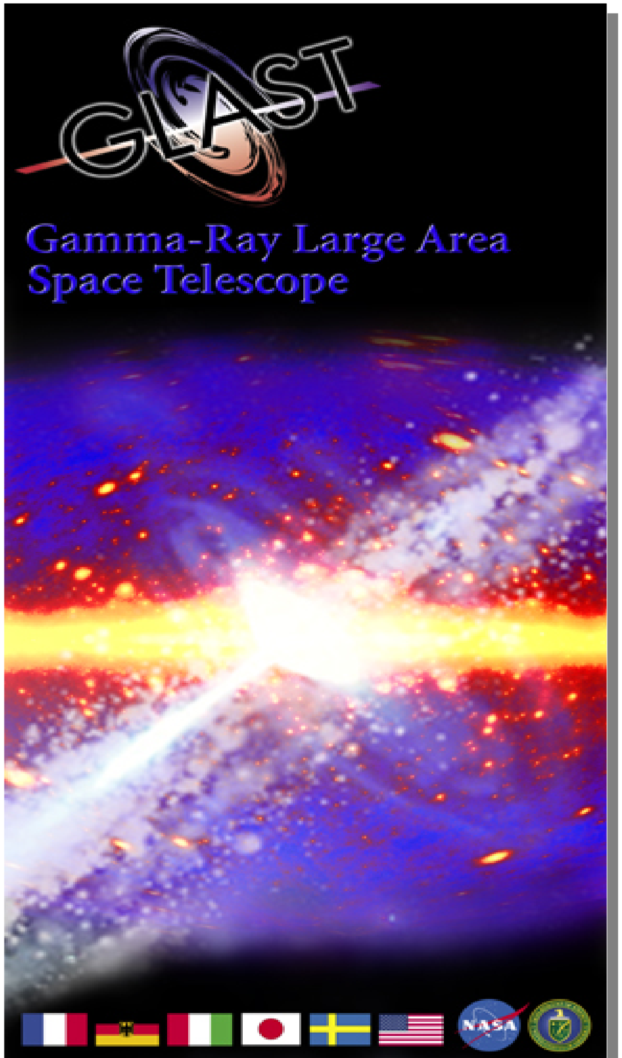

GLAST Program
Beam Test Workshop

The calibration strategy of the magnetic spectrometer

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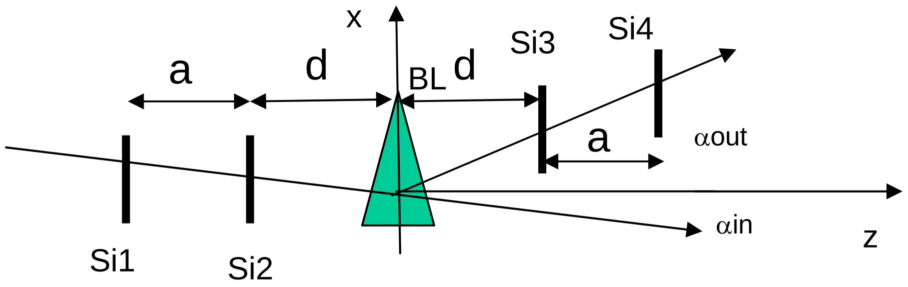
Definition of the spectrometer geometry



Simmetric spectrometer

$P = 0.3\ BL/[\sin(\alpha_{out}) - \sin(\alpha_{in})]$
$\tan(\alpha_{out}) = (X4-X3)/a$ 1)
$\tan(\alpha_{in}) = (X2-X1)/a$

In this work I try to choose the best BL, d and a parameters and to estimate the influence of the errors on the following parameters:

1. a
2. d
3. Xo1,Xo2,Xo3,Xo4
4. The parallelism of the strips to the vertical direction
5. The real value of the magnet bending power BL

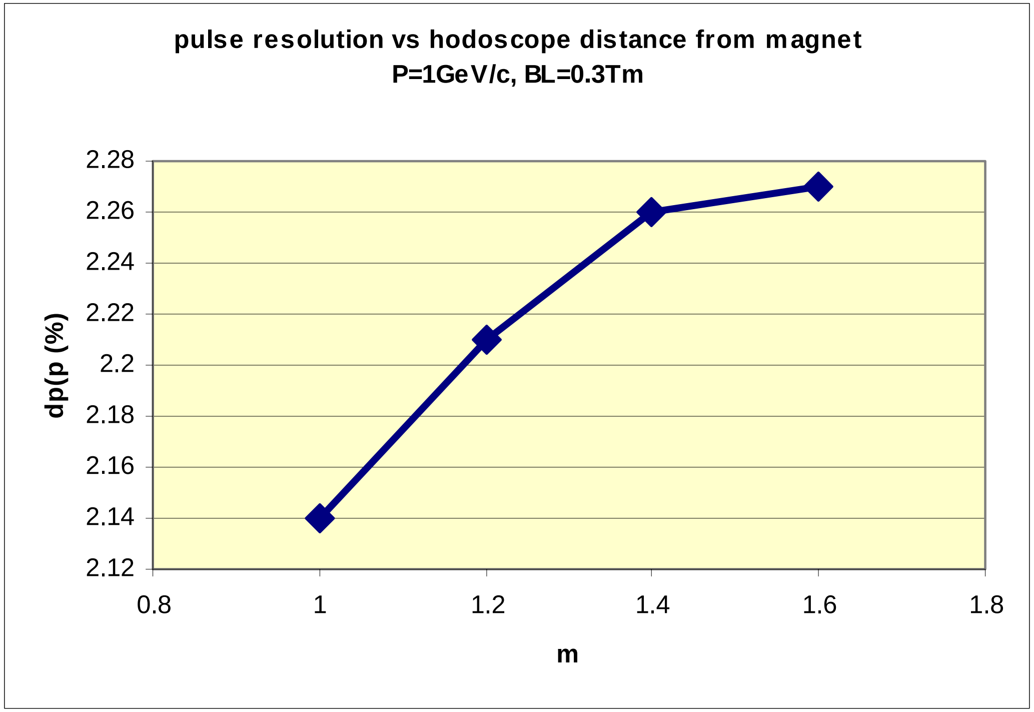
The multiple scattering has been evaluated with the parametric formulas

$\theta_{MS} = \mu/p = [0.0136 \times (x/Xo)^{1/2} \times (1+0.0038 \ln(x/Xo))]\ /p(GeV)$
$\Delta X_{MS} = \theta_{MS} \times L/\sqrt{3}$

Distance from the magnet axis *d*

The parametric Monte Carlo is in rough agreement with the analytical calculation by Bruel for hodoscopes arms >0.3m and with the experimental distributions obtained by the Agile group:
$\delta p/p = \mu/0.3BL(1+\cos\alpha_{out}) \sim 6.7 \cdot 10^{-3}/BL$

First exercise: $\delta p/p$ versus d

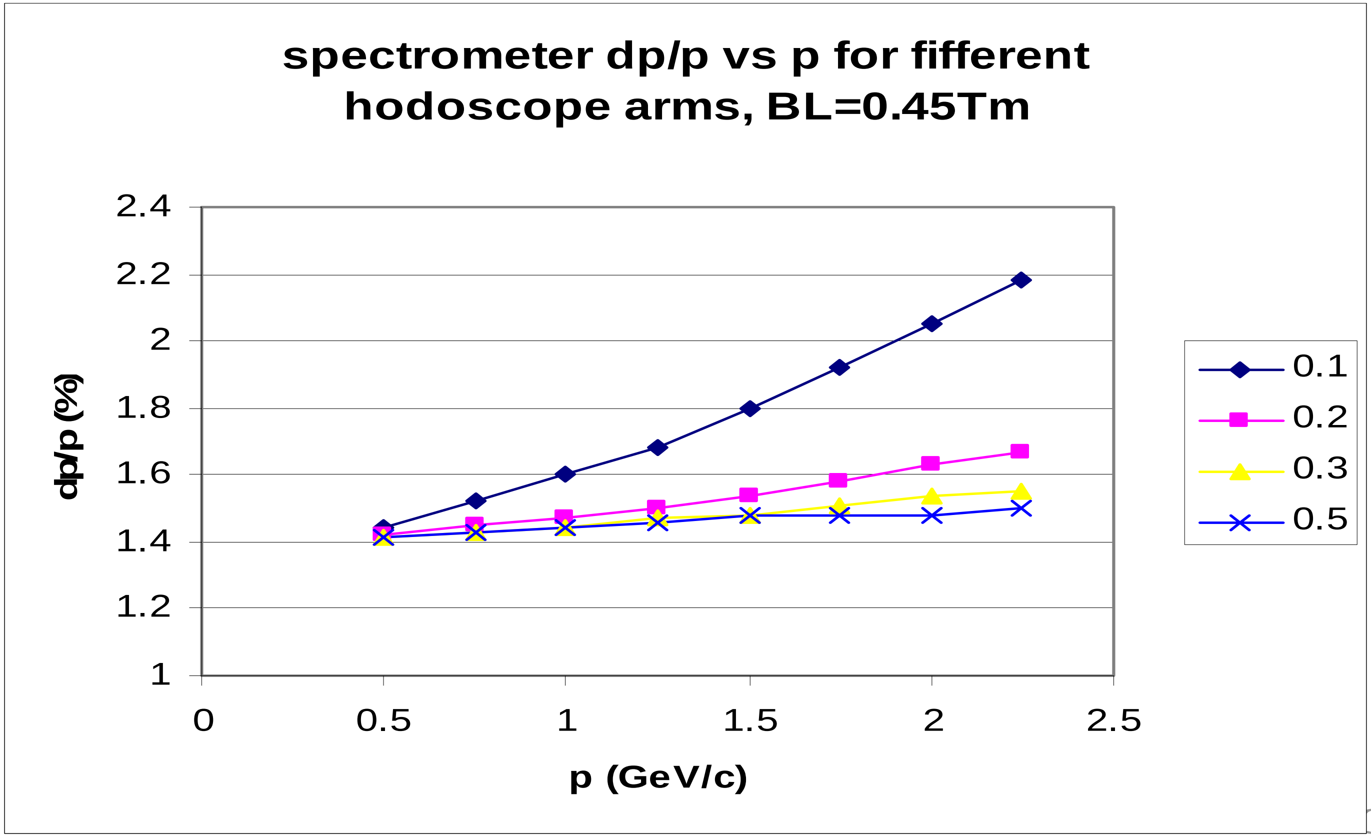


The momentum formula does not use the ***d*** parameter. A larger distance from the magnet increases the multiple scattering in air only:

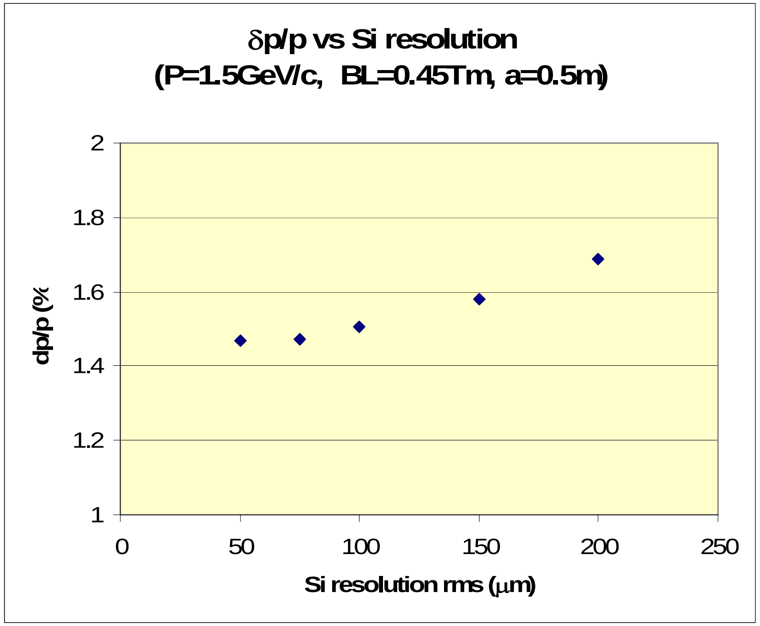
- **we have to place the Si hodoscopes close to the magnet**
- **we have to avoid scintillators in between the two hodoscopes**

Length of the hodoscope arm *a*

For a<0.3m there is a sensible contribution of the spatial resolution of the Si detectors. The momentum resolution is quite flat for a>0.3m. The hodoscope before the magnet will have an arm length ***a=[0.5,0.7]m***. The second hodoscope will have ***a=0.3m.*** This value is easier (we have not much space) and defines a larger acceptance angle.



Si spatial resolution and Si parallelism

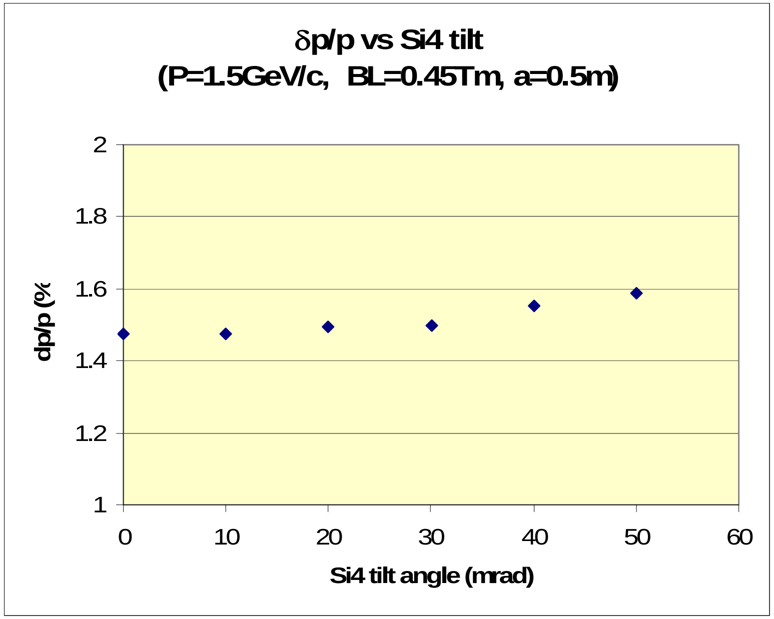


The foreseen Si rms is $241/\sqrt{12}=70\mu m$

The Si spatial resolution is one order of magnitude smaller than the multiple scattering.

If a Si detector is rotated by an angle $\theta \ll 1$, the true coordinate is $X_{true}=X_{meas}+\theta\times Y_{meas}$

The example shows the effetcs of a tilt of the last Si detector (beam height 10mm) 10mrad correspond to a parallelism error of about 1mm



BL, a, d, Si offset errors

The errors in the knowledge of these parameters generate systematic errors on P
What is the precision we need to know these parameters?

Two simple formulas

Suppose that we have an unknown offset of the Si detectors, so that what we measure is $X_{meas}=X+X_{off}$

We drive the beam on the hodoscopes with two momenta P_1 and P_2

$$X_{off4}-X_{off3}=X_{meas4}-X_{meas3}-0.3aBL/[p^2-(0.3BL)^2]^{½}$$

$$0.3aBL/[p_1^2-(0.3BL)^2]^{½} - 0.3aBL/[p_2^2-(0.3BL)^2]^{½} = (X_4(P_1)-X_4(P_2))/(a+d)$$

These two formulas allow to define BL and the relative shift of chamber 4 and 3 (chamber 1 and 2 are supposed to be aligned with the beam)

Magnetic spectrometer calibration

1. P=3GeV/C, BL=0Tm : alignment run of Si1, Si2 and CU.
2. P=3GeV/C, B=-0.1,-0.2,-0.3,-0.4,-0.45Tm: measurement of BL at different magnet currents.
3. P=0.5,1,2,3GeV/c, BL=-0.45Tm: measurement of $\delta P/P$
4. P=1.5GeV/c, BL=+0.45Tm, no dump. Alignment of Si3 and Si4
5. P=1.5GeV/c, BL=+0.45Tm, dump: study of the backsplash and of the losses of the dump

Use of the CU to define the spectroemeter parameters

We can operate the magnet with inverse polarity and we can see the beam directly over the CU.

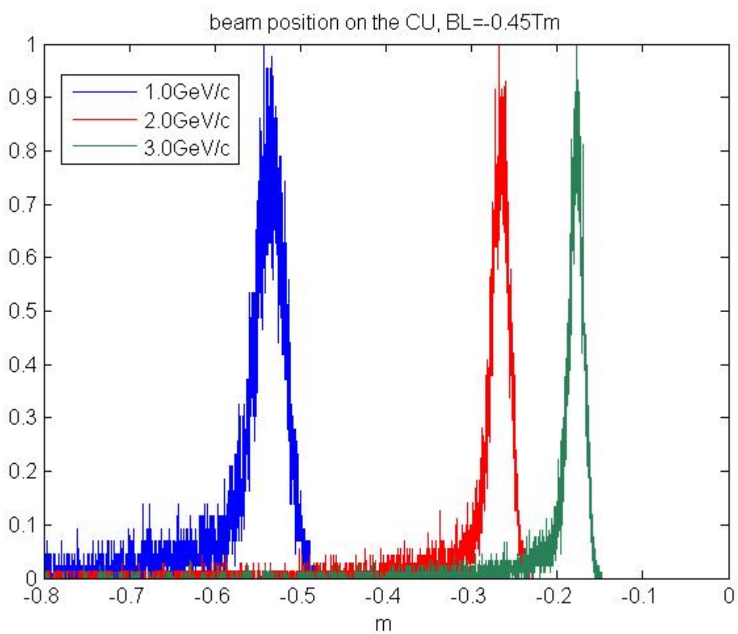
Using the relations:

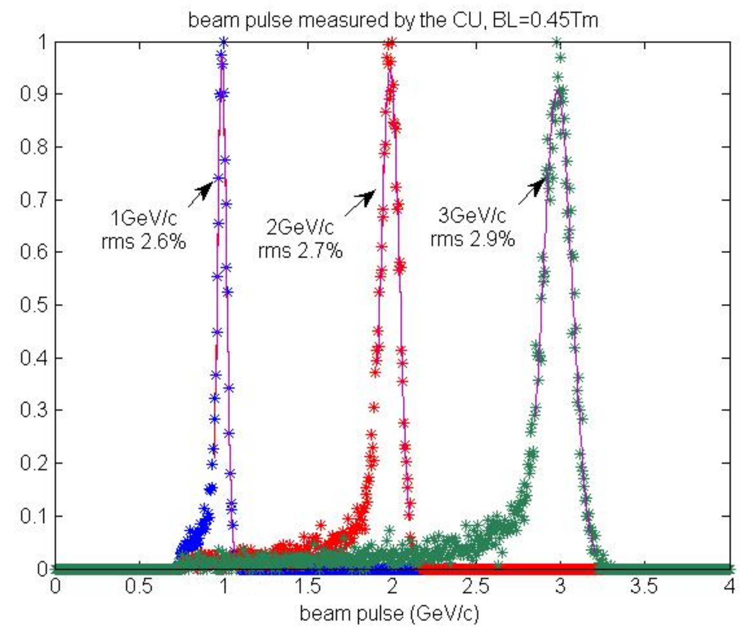
$\tan\alpha_{out} = X_{CU}/D_{CU}$ (with the approximation that the incoming and outgoing trajectories cross at the magnet axis)

$\sin\alpha_{out} - \sin\alpha_{in} = 0.3BL/P$

Where X_{CU} is the measured point by the CU and D_{CU} is the distance from the CU detection plane from the magnet axis

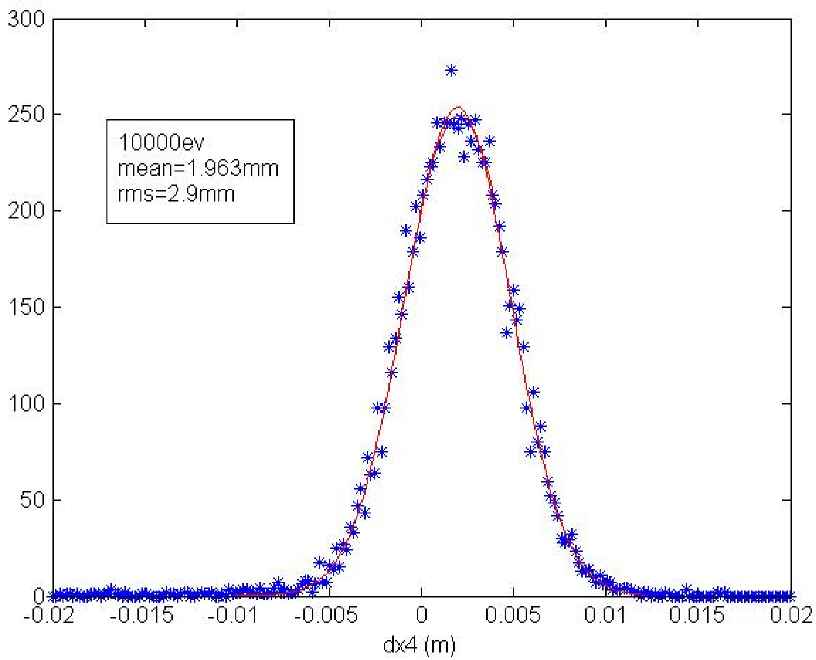
The MC plots show the CU response to 1,2,3 GeV/c beams with 2%$\delta p/p$

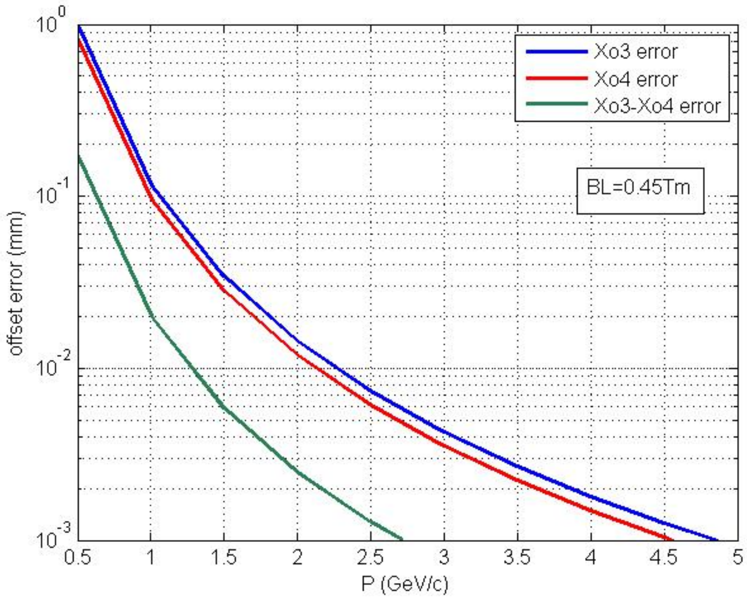




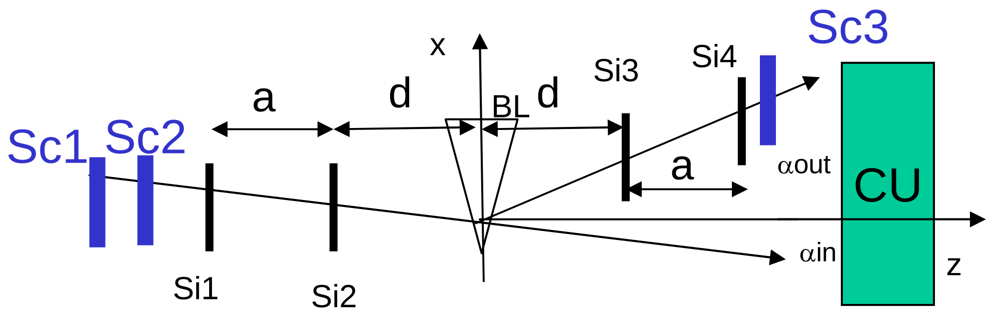
Hodoscope alignment

The hodoscope in front of the magnet can be aligned to the CU with a run at B=0
The bending power *-BL* can be measured with a current scan at fixed momentum.
The second hodoscope arm can be aligned sending the beam at 1.5GeV/c, BL=0.45Tm in absence of the beam dump.
I have simulated a 2mm shift of the Silicon 4. Using the approximate formula
$dX_4 = X_{Si4} – X_{CU} * Z_{SI4}/Z_{CU}$ (as shown in the 2° plot the error due to the approximation is negligible when $\tan\alpha_{out}$=(X4-X3)/a is computed)
The curve rms is 3mm, with 10^4 events the relative shift is measured with a 37μm error (27μm systematic)





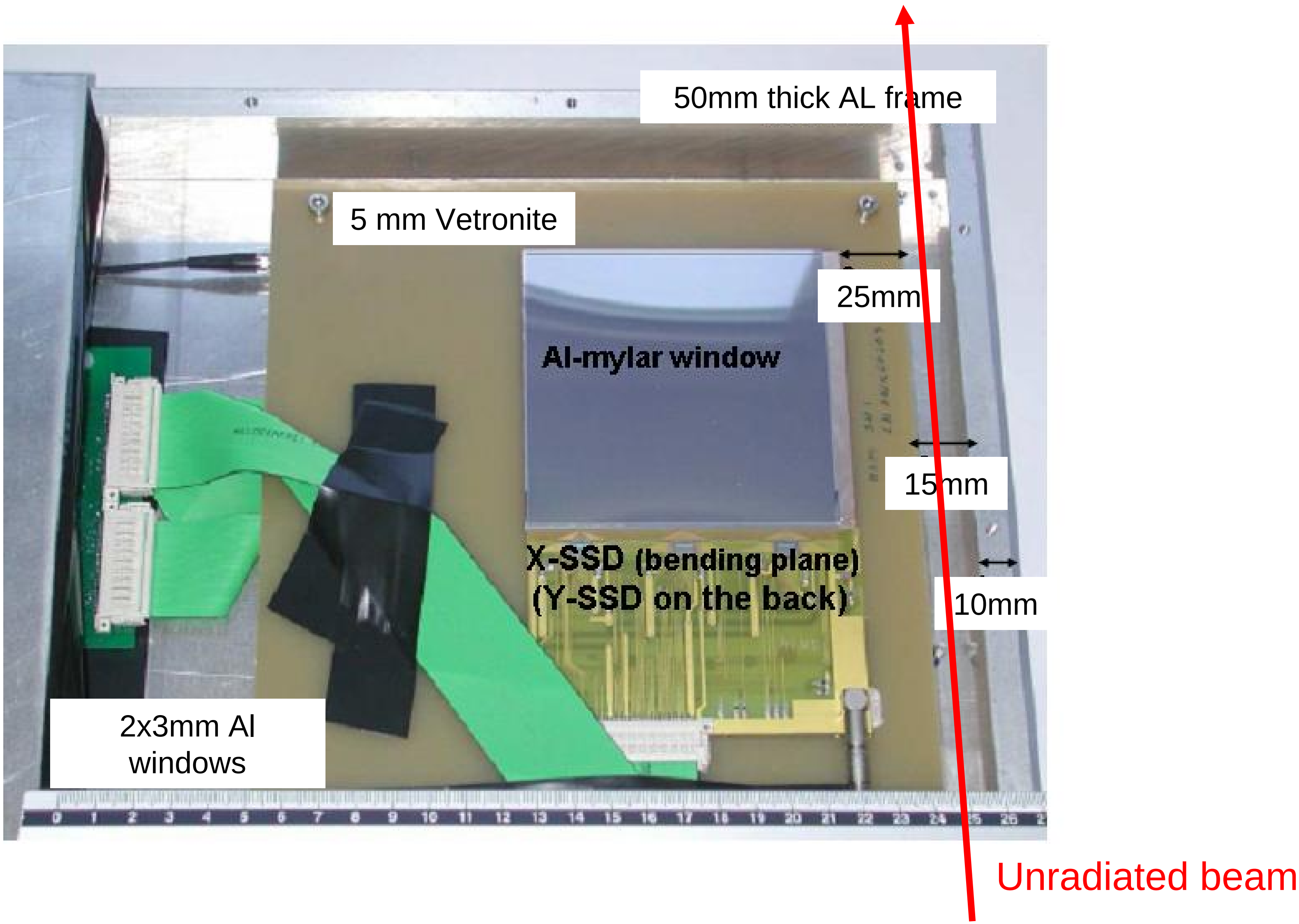
Calibration runs



Cherenkov always on

RUN n.	P GeV/c	BL Tm	Trigger	N ev. Per run	Conditions, scope
~20	3	0.	Sc1* Sc2	10^4	setup + relative alignment of Si1, Si2, CU, Sc1, Sc2
6	3	From 0 to -0.45	Sc1* Sc2	10^4	-BL absolute calibration
4	0.5,1, 2,3	-0.45	Sc1* Sc2	10^5	Δp/p measurement of the electron beam
~5	1.5	0.3	Sc1* Sc2* Sc3	10^4	Δp/p at 1.5GeV + Si3, Si4, Sc3 alignement
~3	1.5	0.3, 0.45	Sc1* Sc2* Sc3	10^4	Beam dump installation with the 1.5GeV/c beam hitting the edge of the 2° hodoscope arm

Mechanics of the SI detectors



Position of the SI detectors

The distance from the active area of the Si detector to the external edge of its aluminum frame is $F=50mm$.

The distance of the hodoscope after the magnet from the scintillators that define the beam is $L = 3m$.

Assuming a scintinillators dimension D = 10mm and a beam angular dispersion $\sigma_{\alpha}=1mrad$, the safe distance of the detector box from the beam to avoid interactions with the tagged gammas is

$$Xo = D/2+5\sigma_{\alpha}L+F = 70mm$$

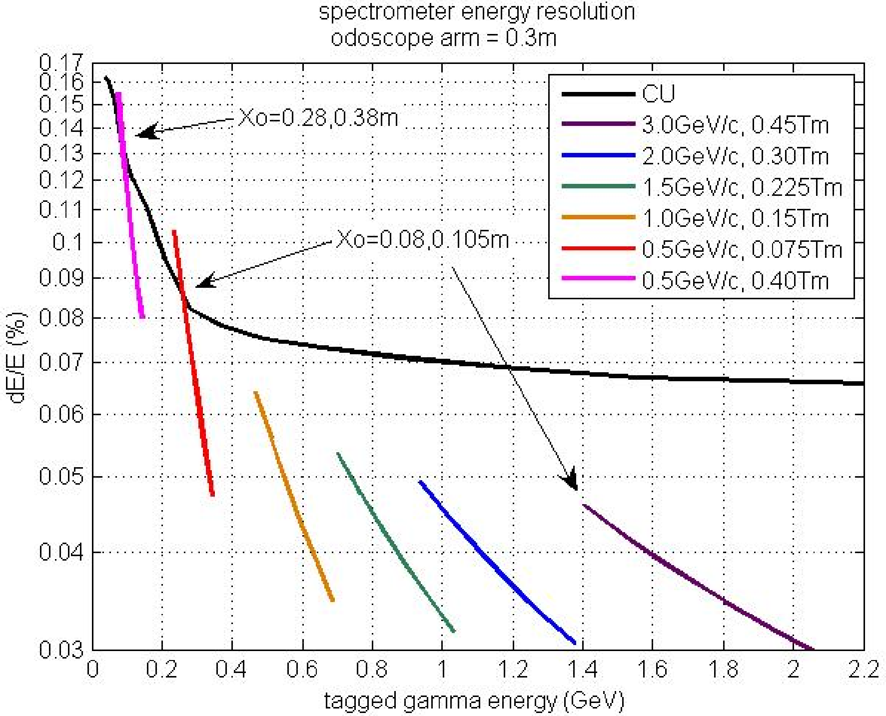
We add some space to take into account the possibility of few mrad misalignment of the different beams. Moreover the events very close to the beam have a very poor gamma energy resolution.

I have considered a distance of the Si3 detector from the beam axis

$$Xo3 = 80mm$$

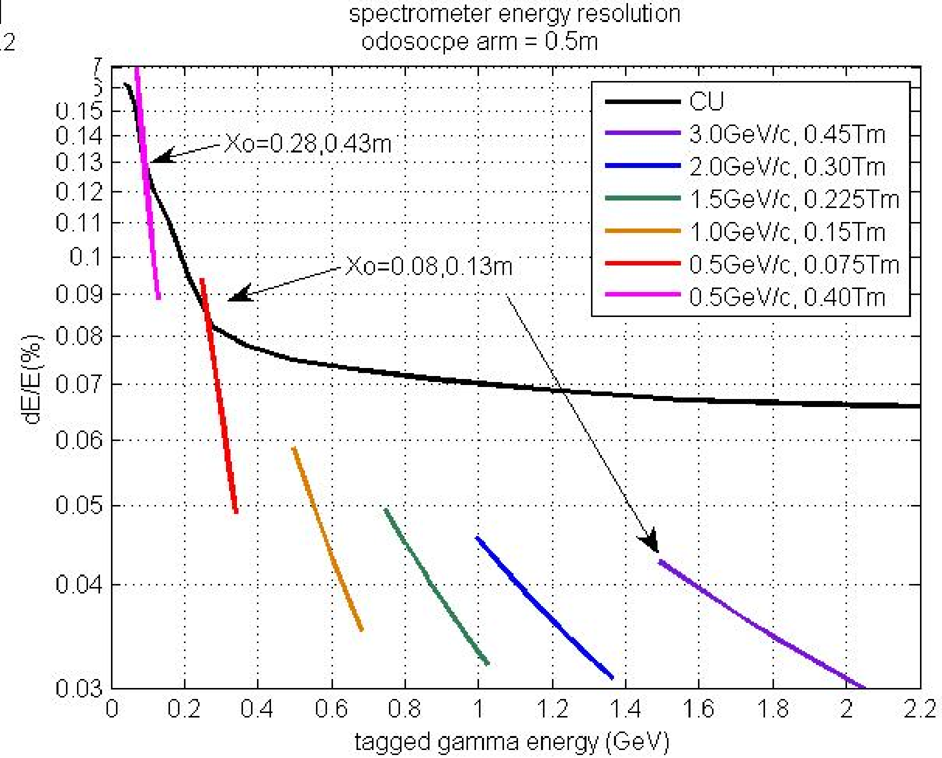
The optical bench has 25mm slots. It is better to choose

$$Xo4 – Xo3 = n\times25mm$$



Tagged gamma energy resolution

The curves show the gamma energy resolution assuming a fixed position of the hodoscope and scaling BL with the momentum. The momentum dispersion is 2%



Two different hodoscope arms are considered: 0.3m and 0.5m

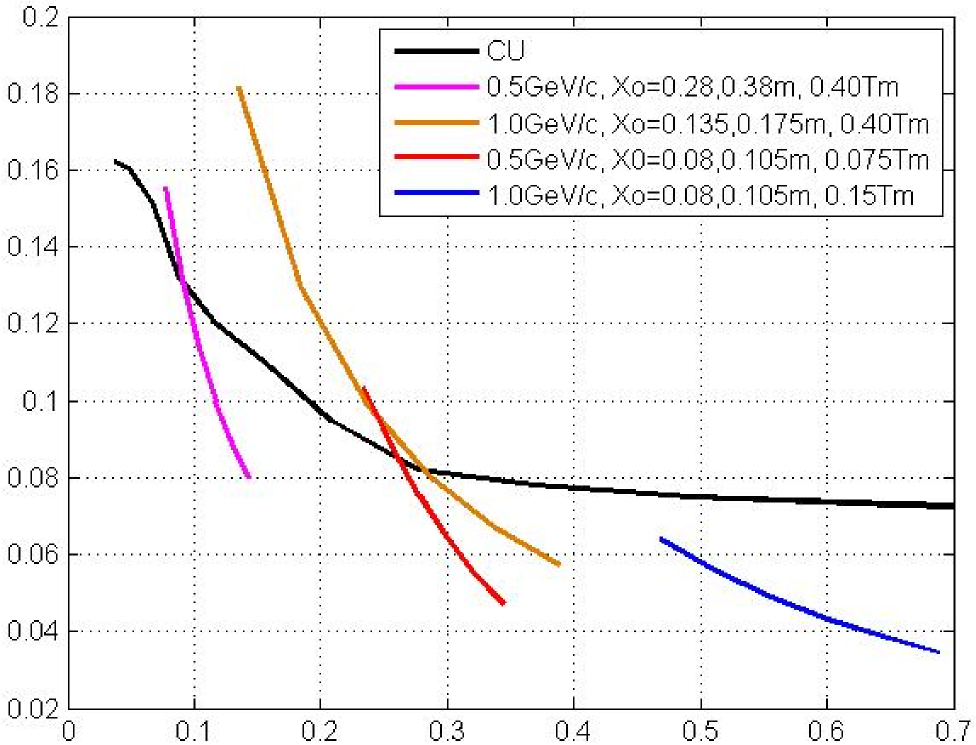
The energy resolution is the same.

With a lower arm the acceptance is larger and the performance at low energy is better.

The 0.3 arm matches better with the fixed 25mm steps of the optical bench

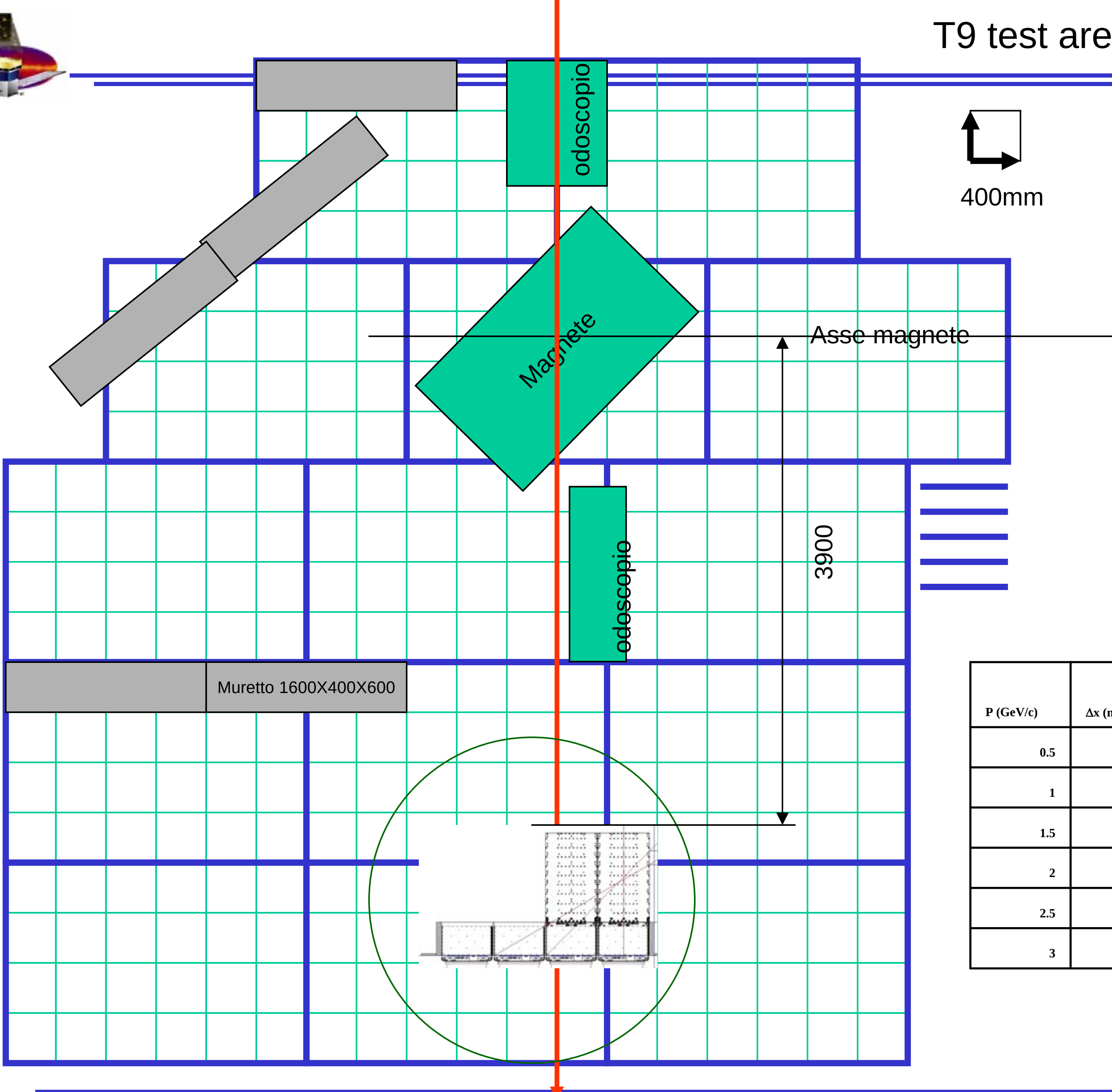
100MeV gamma case

With 1GeV beam we can tag photons in the 0.5-0.7 GeV range
Increasing BL and moving the Si detectors we can tag photons in the 0.12-0.4GeV range but with a bad energy resolution up to 0.3GeV.
Using a 0.5GeV beam we can cover the 0.22-0.32GeV energy range without changing the hodoscope geometry.
If we increase BL and we move the Si detectors, we can tag 100MeV photons



To reach the 100MeV energy we must use:
- 0.5GeV/c beam
- 0.40Tm
- New setup of the Si detectors
- 0.3 hodoscope arm allows a better acceptance matching

T9 test area



P (GeV/c)	Δx (mm)
0.5	1226
1	592
1.5	392
2	293
2.5	234
3	195

Rotated magnet BL=BL*√2