Beampipe design

F.Raffaelli

Framework for Geant4 Interaction Region simulation

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1) Beampipe design

F.Raffaelli

Some figures of merit

Power dissipation	1 KW
Beam Pipe Radius	O(1 cm)
T Inlet	8 C
T MAX raise	3 C
Water speed	< 5m/s
Negative pressure	

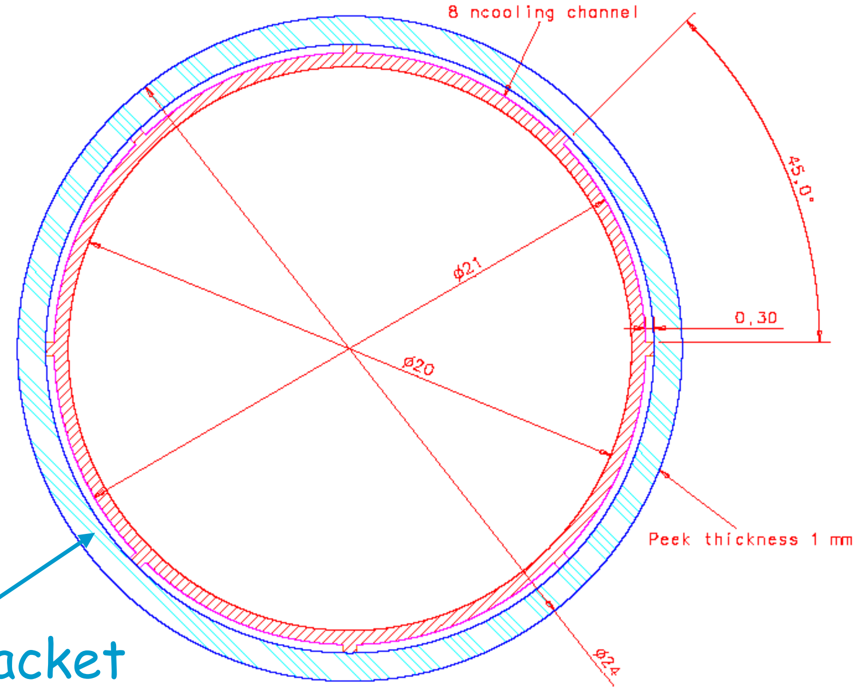
A possible design

Pipe Inner Radius 1 cm

"Uniform" Water Jacket
(8 flat channels)

Single channel area = 2.35 mm^2
Channel width = 300 um

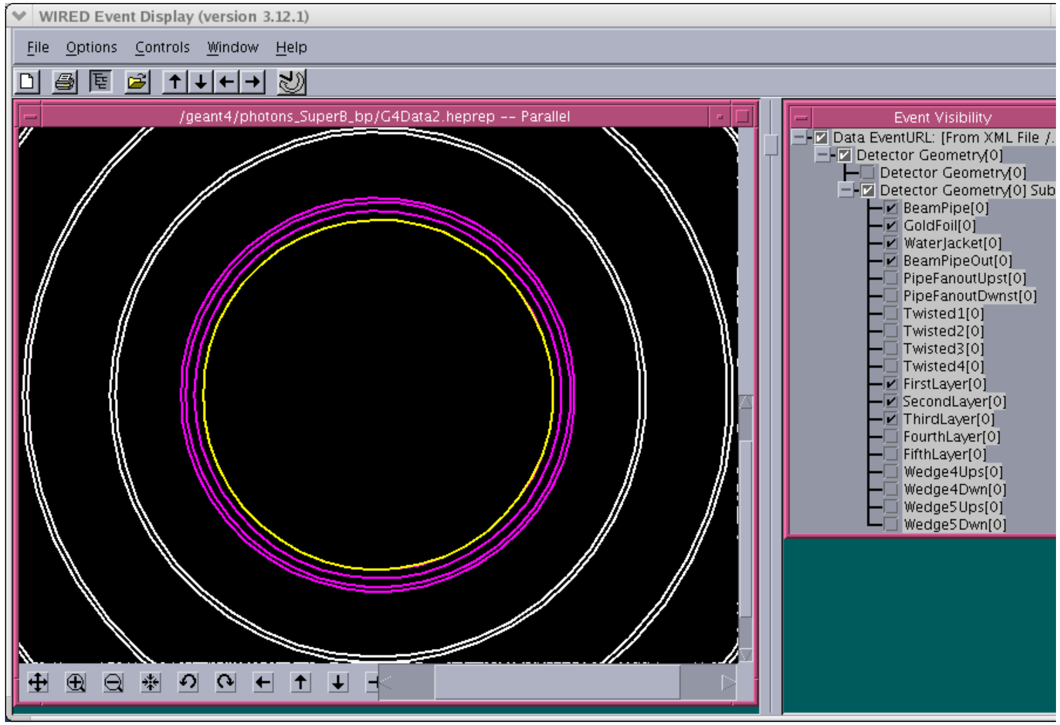
To dissipate 1KW with water specific heat and thermal conductivity



Peek (plastic) jacket

Flow: 4.2 m/s (OK)

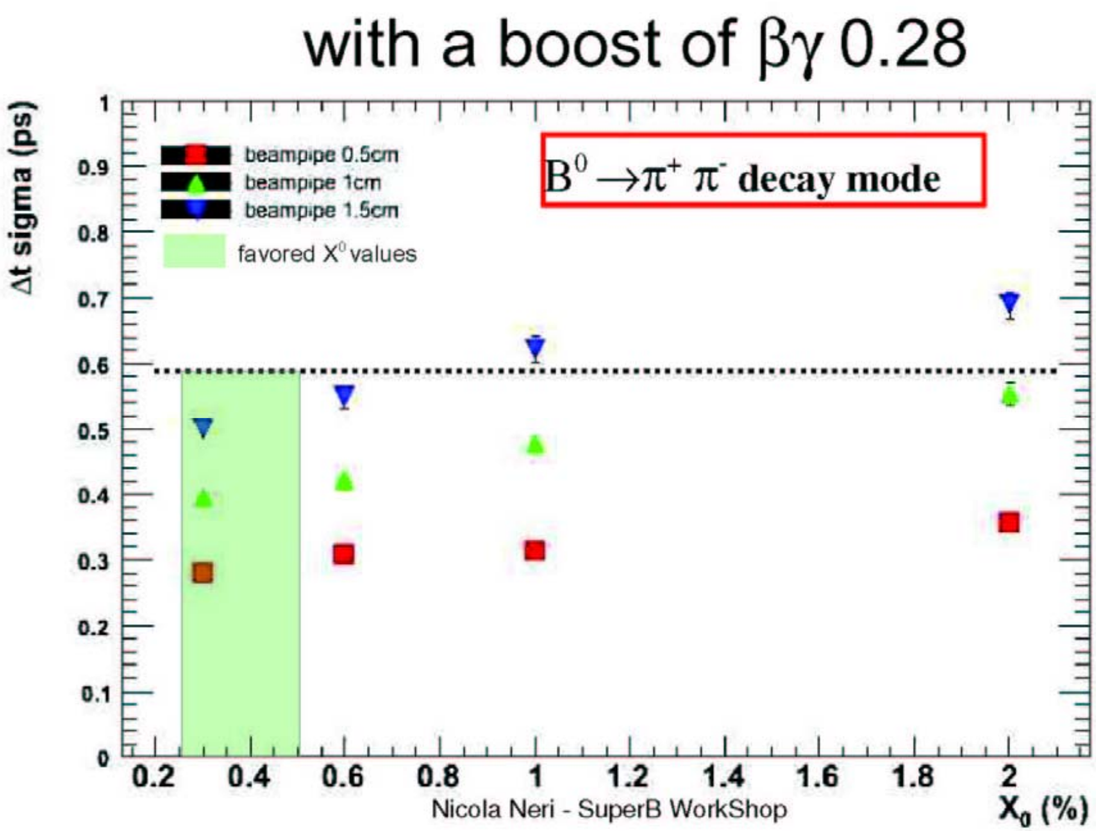
Requires channel 1-side coating
to prevent erosion
(7um Ni and/or BerylCoatD)



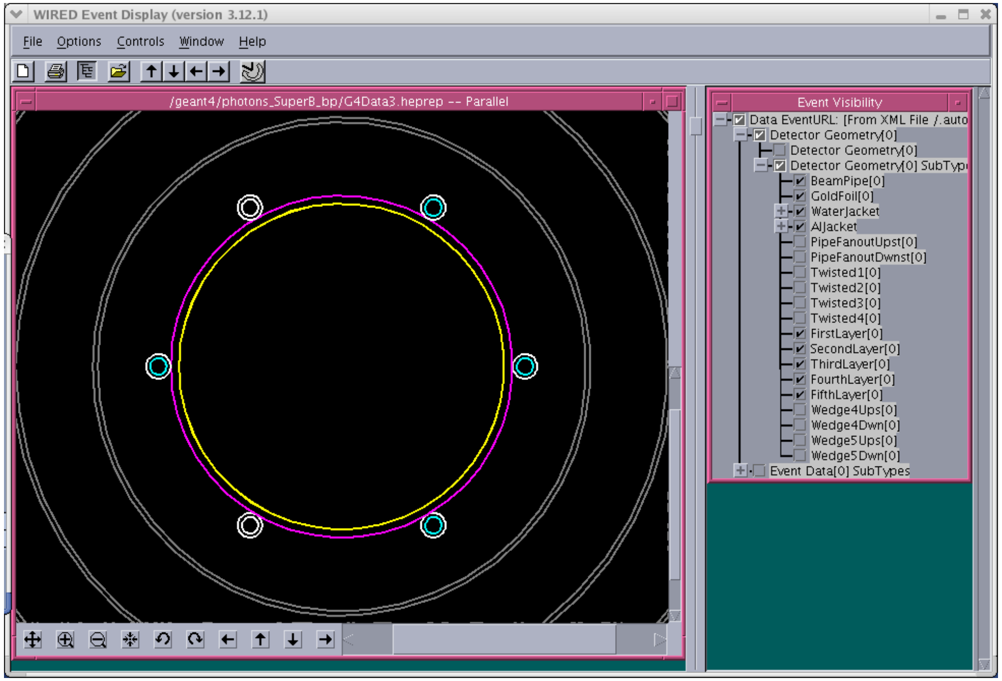
Gold foil	4 um		0.121 % X0
Berillium	300 um		0.085 %
Peek layer	500 um		0.142 %
Water	300 um		0.083 %
Ni coating	7 um		0.050 %
		Total	0.481 % X0

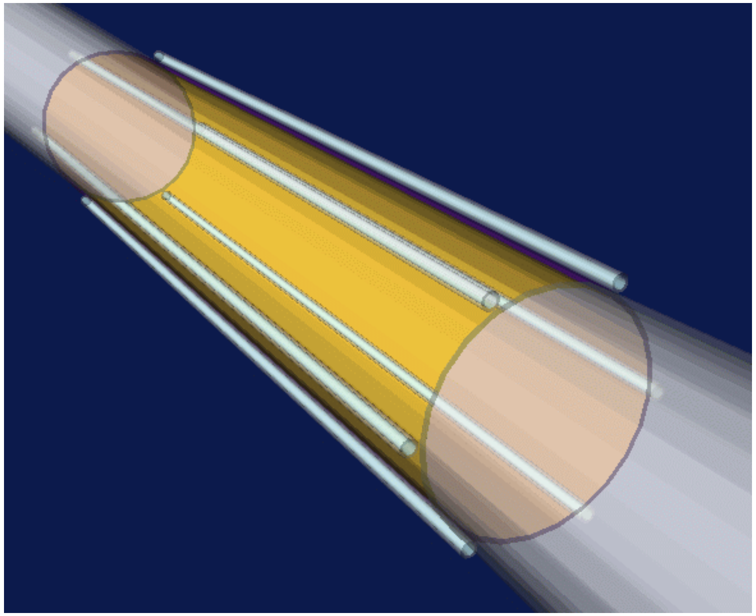
For comparison:

BaBar:	R= 27.9 mm (32mm Layer1)	SuperB	R=10 mm
Total material	1.1% X0		0.48% X0



Alternative design





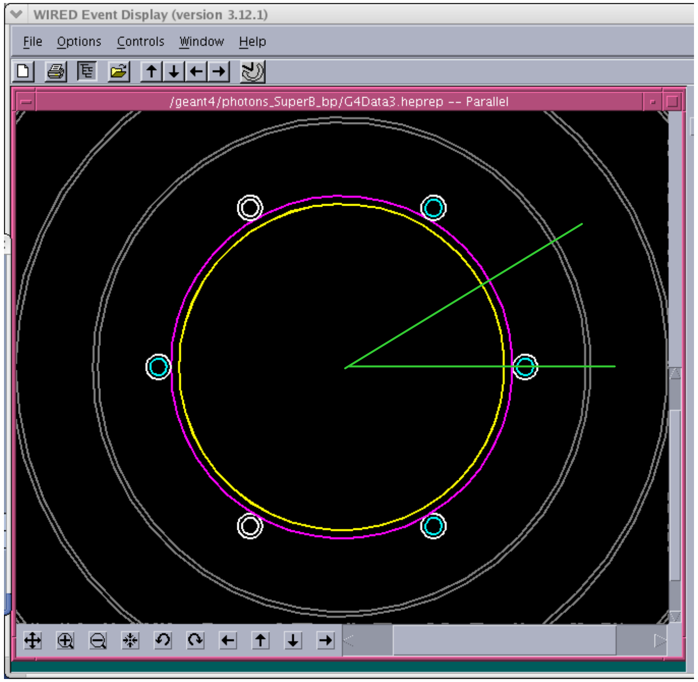
6-8 external lines

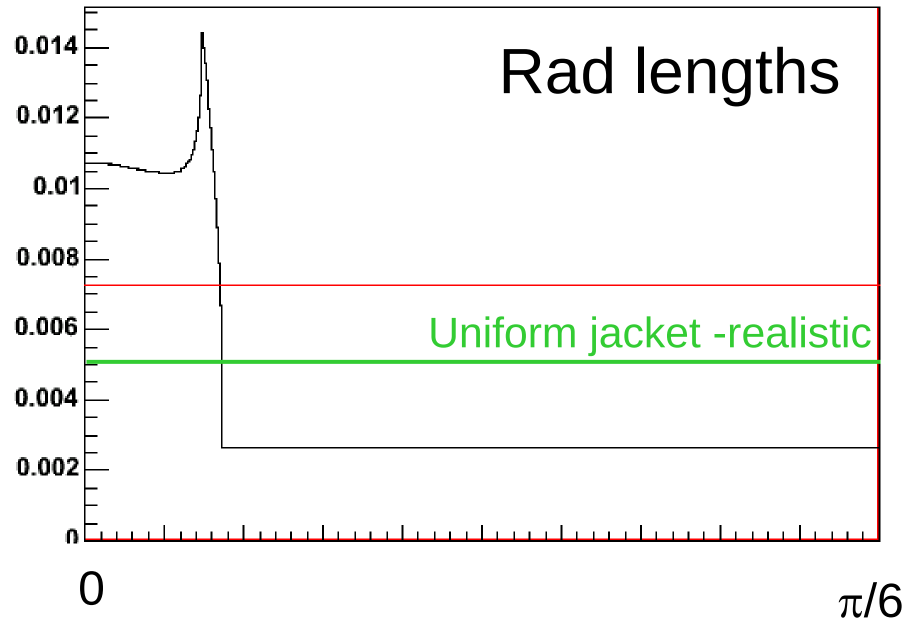
Reduced material (no water jacket)

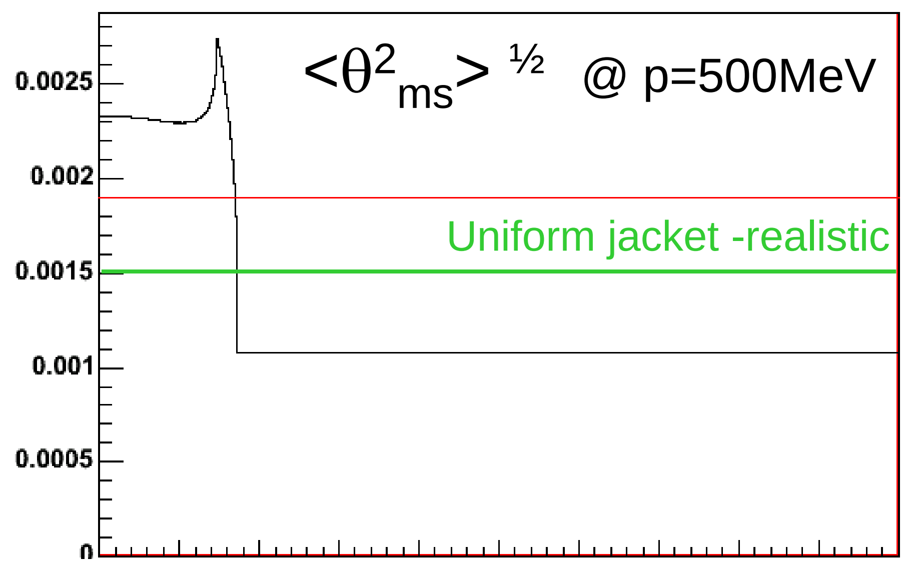
No coating, gold foil only

Non-homogeneous temperature distribution

Non-homogeneous material thickness







R beam-pipe = 1cm

500 um Be + 4 um Au

R lines = 1mm

Thickness Al = 150um

Badly non-uniform

Status:

the beam pipe thickness and radius are obviously crucial for performance

We think we can reach 1-1.5 cm of radius with a thickness of (0.5 - 0.75) % X0

A different design could provide an even lower average thickness, at the expense of a strong non-uniformity.

For this reason is presently not one of the favoured scenarios, but nevertheless needs to be further investigated and improved

Update with the Geant4 simulation framework

Already in production:

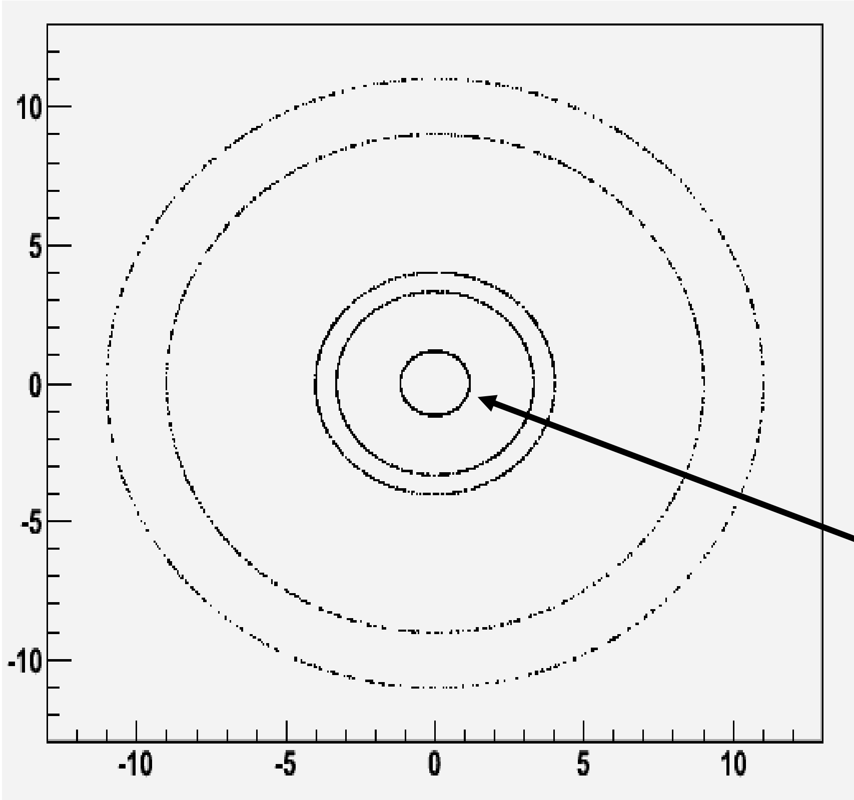
- γ production (Beamsstrahlung) from Guinea Pig
- pairs production in beam-beam

Still at the design phase:

- radiative BhaBhas interaction in the downstream region of the pipe
- bremmstrahlung in the incoming beams

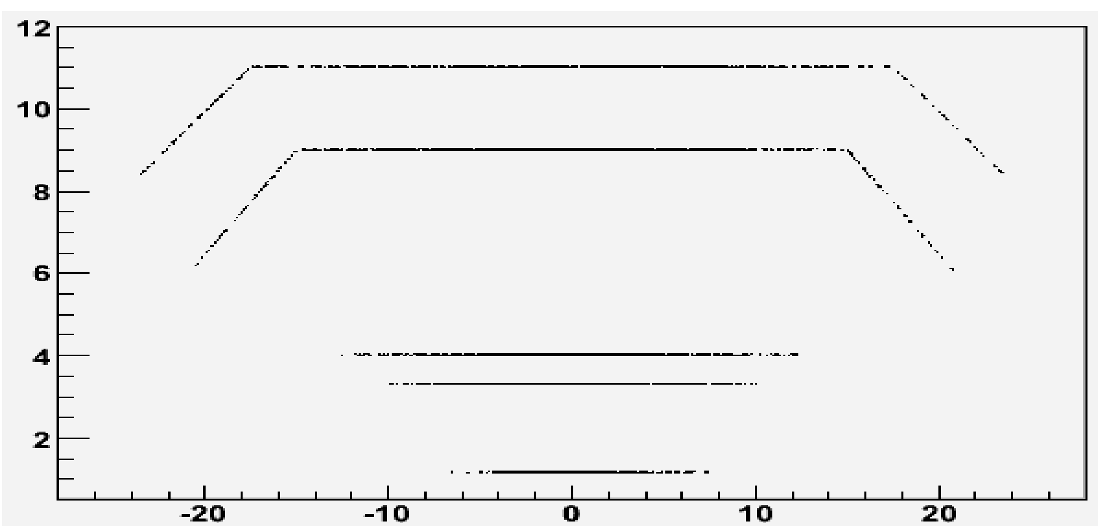
these two are extremely important but have been postponed since require a detailed layout of the IR

Detector layout

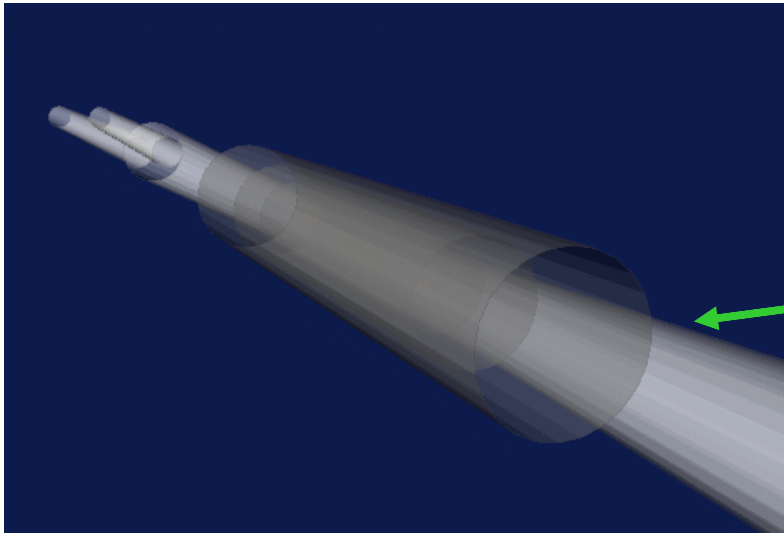


5 silicon layers
(SVT-like design)

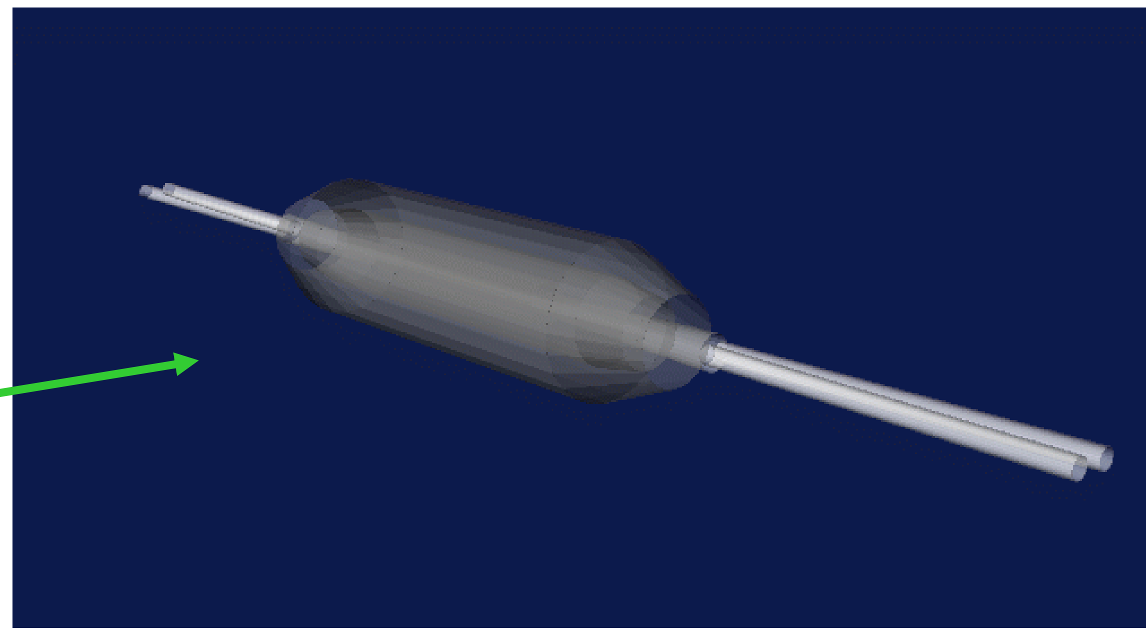
Layer1 at R=1 cm



This mockup is used to determine occupancy due to the backgrounds



3 inner layers

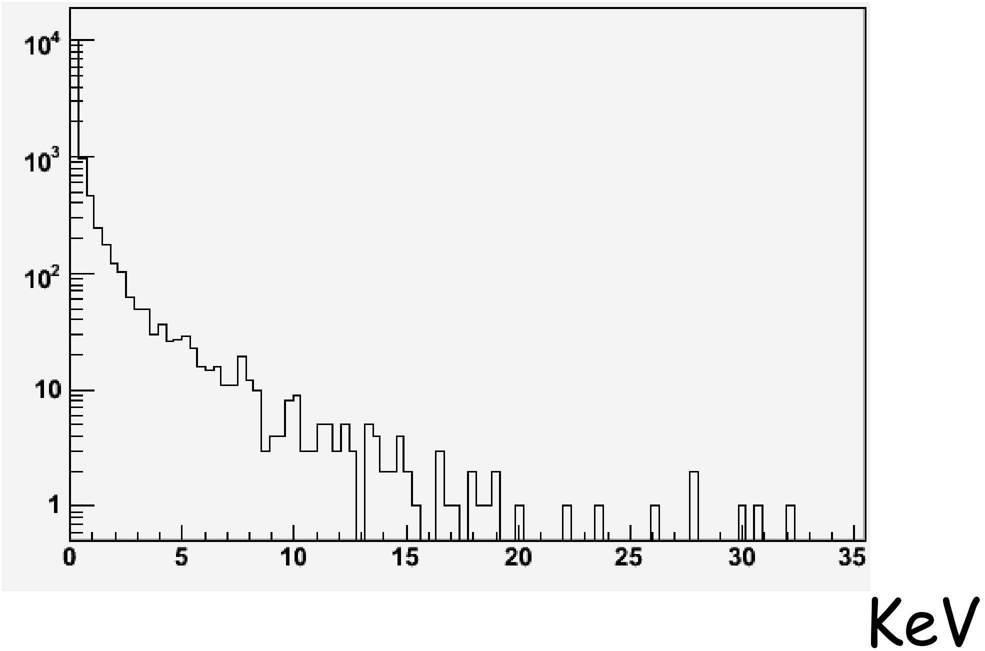


2 outer layers
(SVT-like, wedges,
just example)

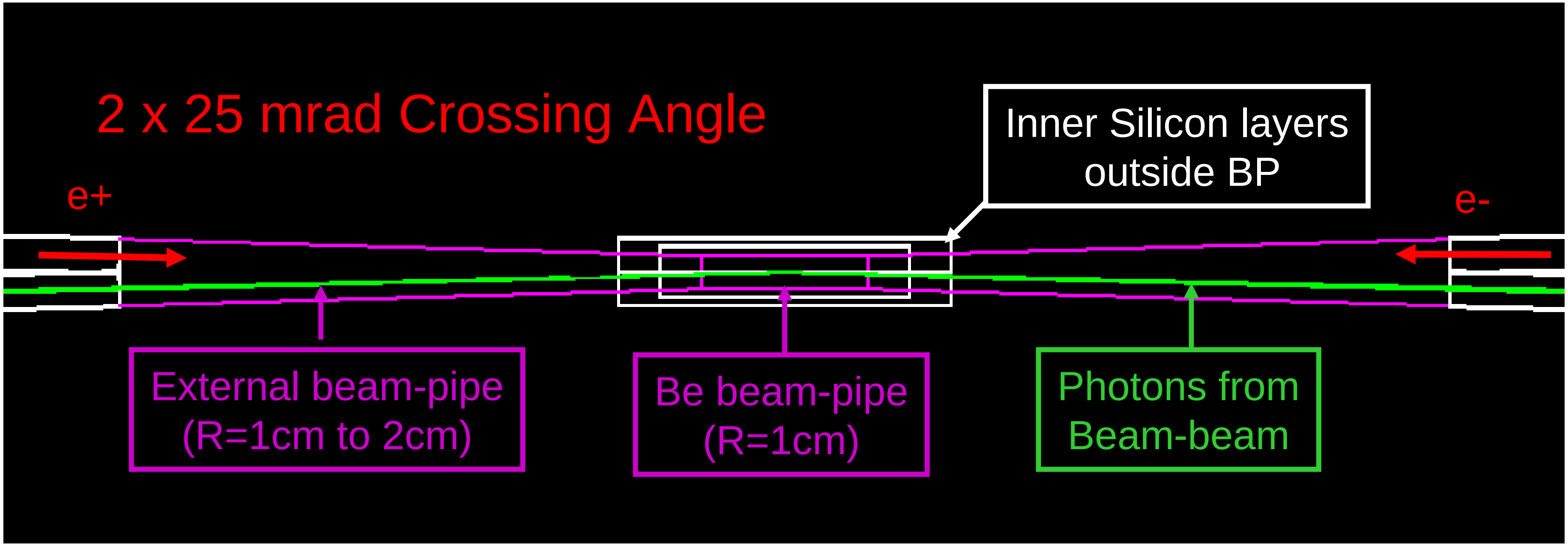
1) Beamsstrahlung photon production

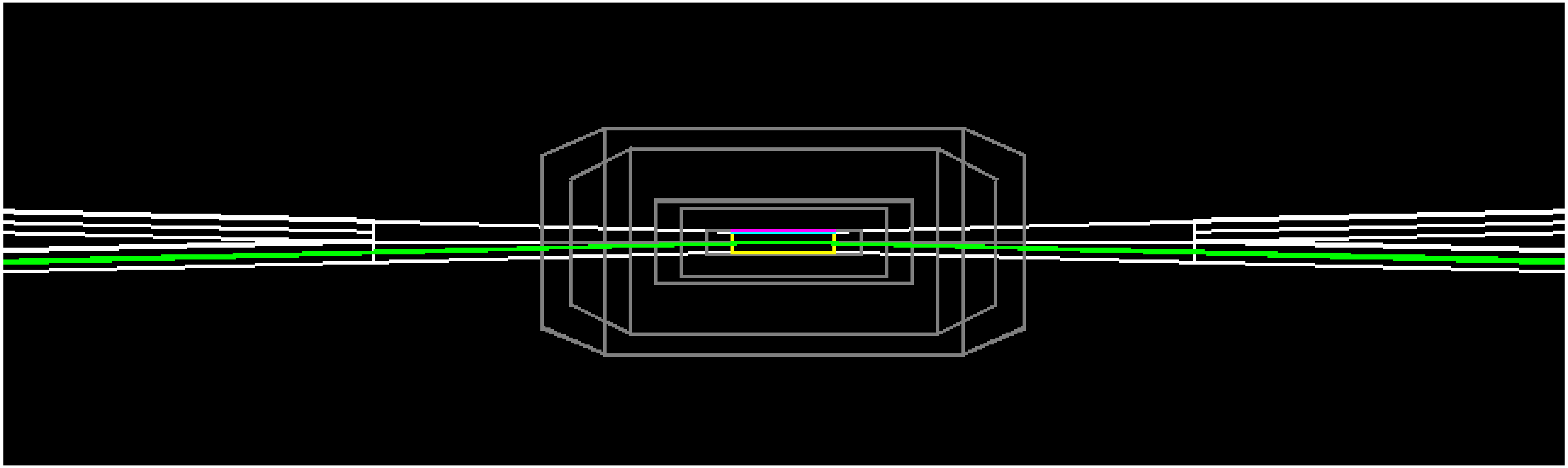
Simulation with Guinea-Pig of γ production in the beam-beam interaction. A list of photon energy & directions is obtained. The photon list is fed to Geant4 simulation

~20000 photons produced per bunch crossing, with energy < 20 Kev

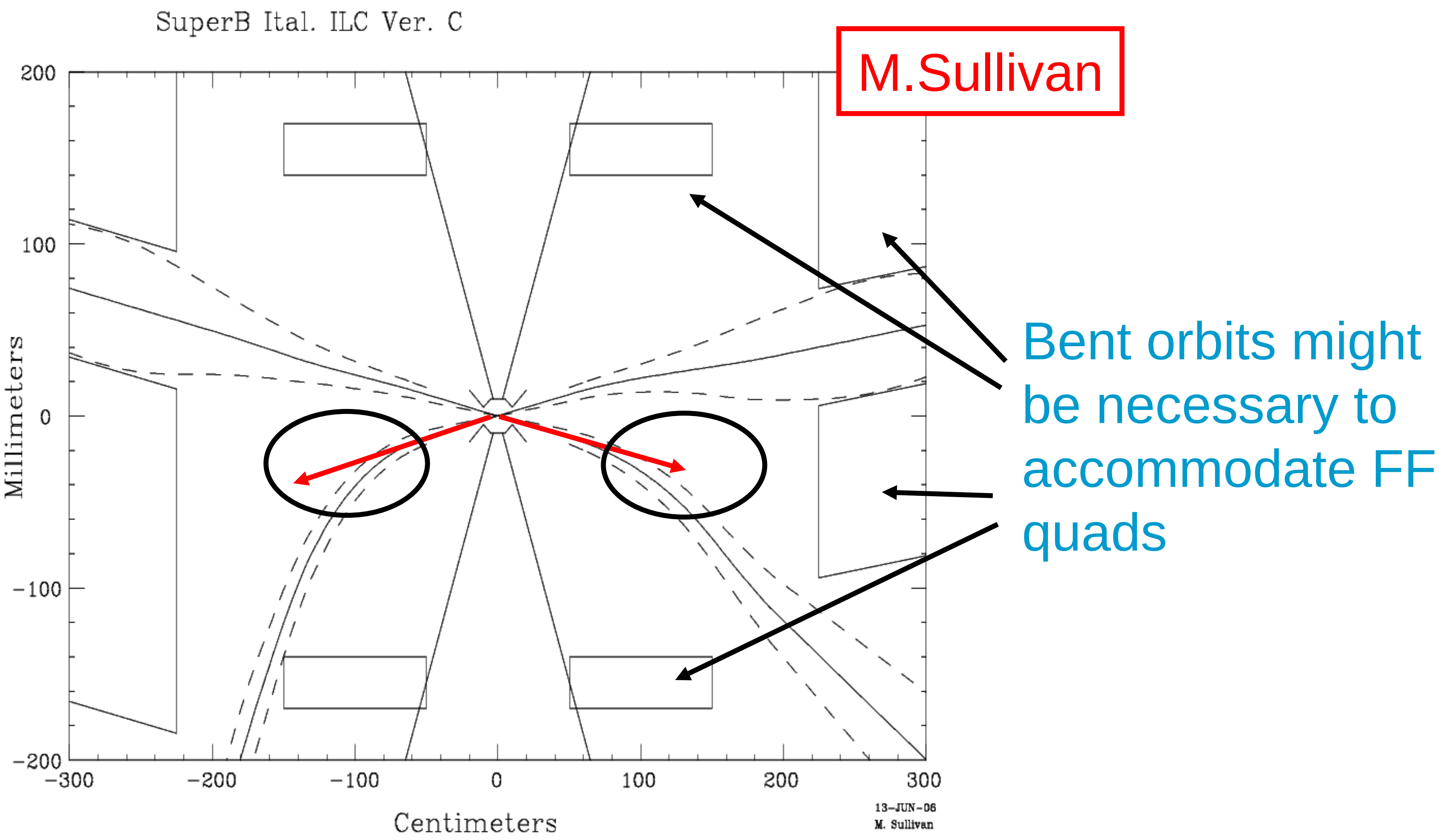


They are focused around the downstream beams…


2 x 25 mrad Crossing Angle
Inner Silicon layers outside BP
e+
e-
External beam-pipe (R=1cm to 2cm)
Be beam-pipe (R=1cm)
Photons from Beam-beam

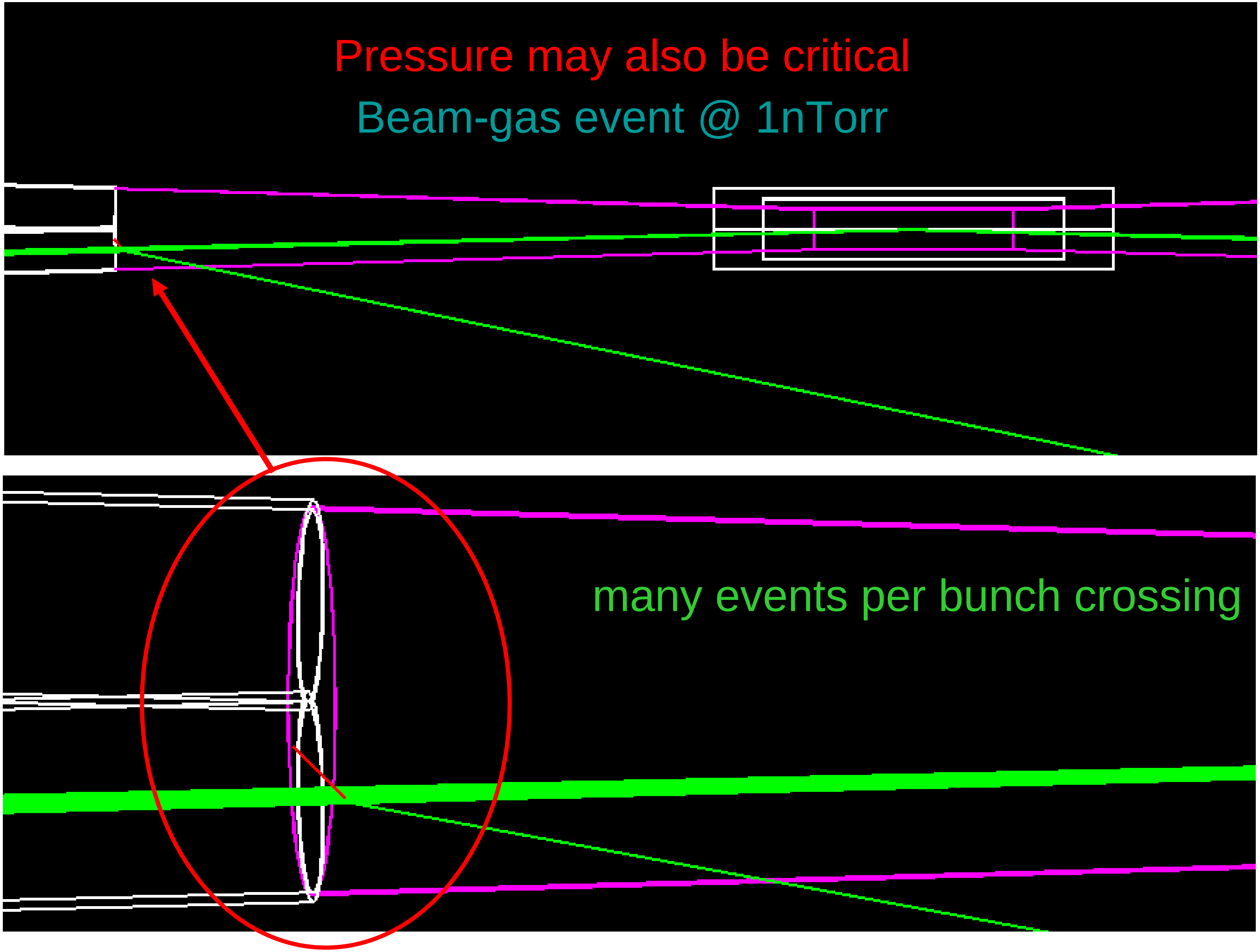


… but …



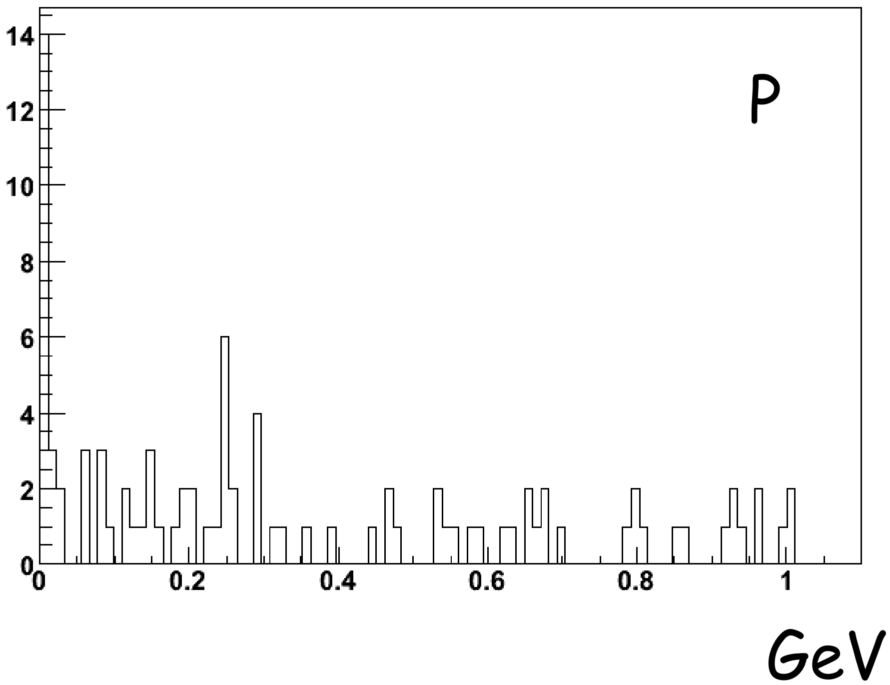
It becomes a problem with bent orbits

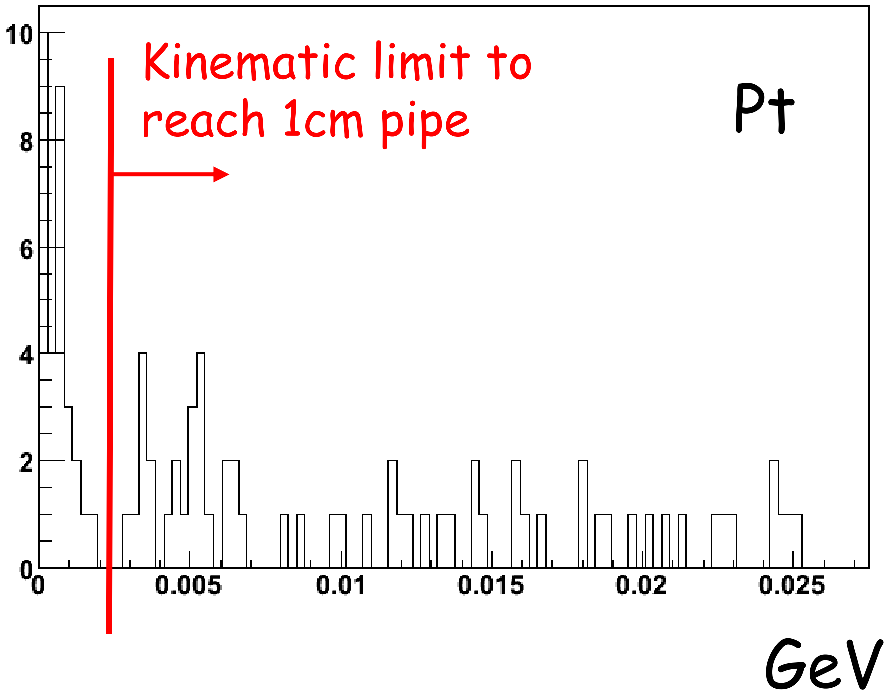
The downstream region will need to be modeled carefully


Pressure may also be critical
Beam-gas event @ 1nTorr
many events per bunch crossing

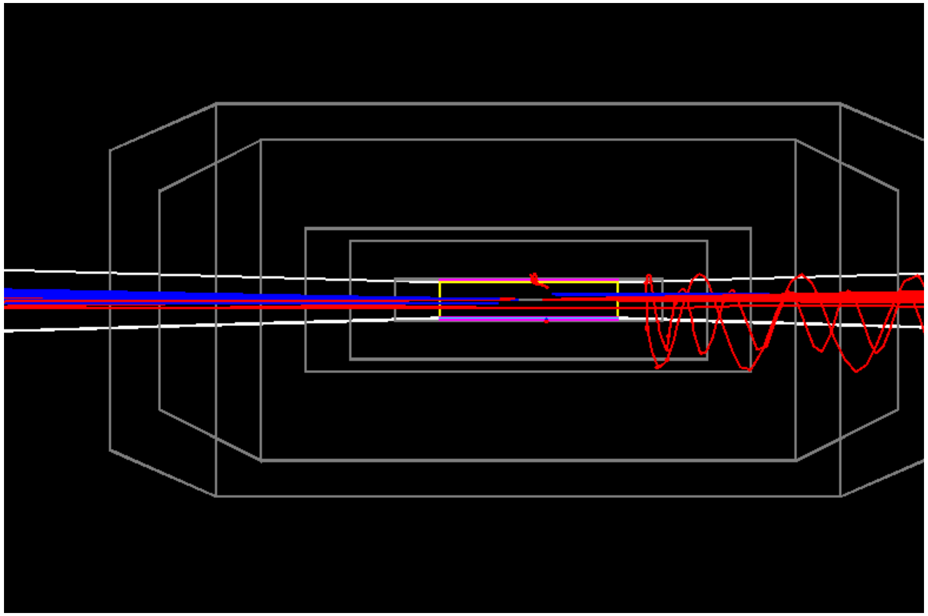
2) Beamsstrahlung pairs production

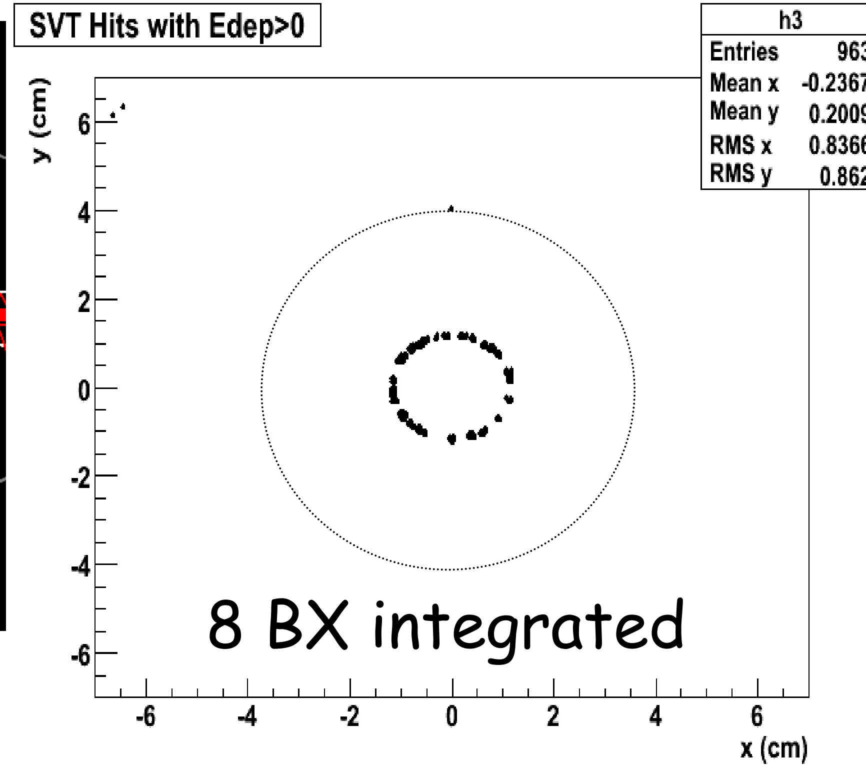
Simulation with Guinea-Pig of pairs production in the beam-beam interaction. A list of e+, e- tracks is obtained and fed to the Geant4 simulation

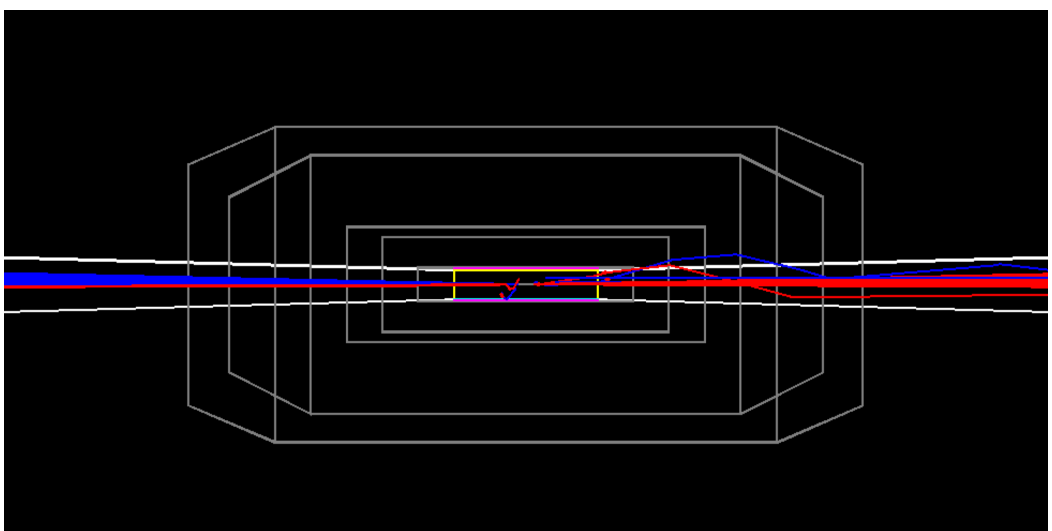




~90 tracks produced per bunch crossing, with Pt < 25-30 Mev







In layer1

O(1.4 hits/BX)

In layer1

O(1.4 hits/BX)

Bx = 600 MHz
Area = 62.8 cm^2

O(14 MHz/cm^2)

Pitch = 50um x 50um
= 4 10^4 channels/cm^2

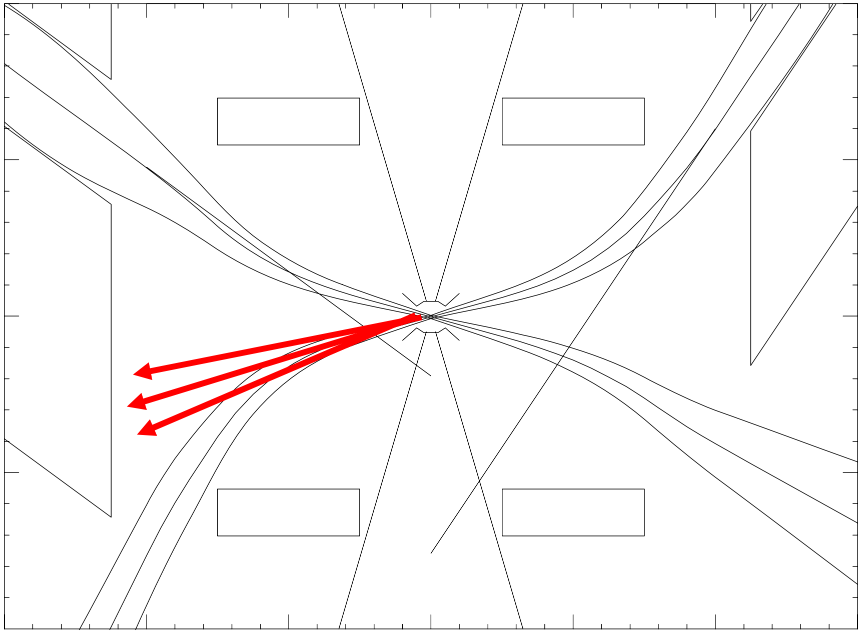
O(350 Hz/chann)

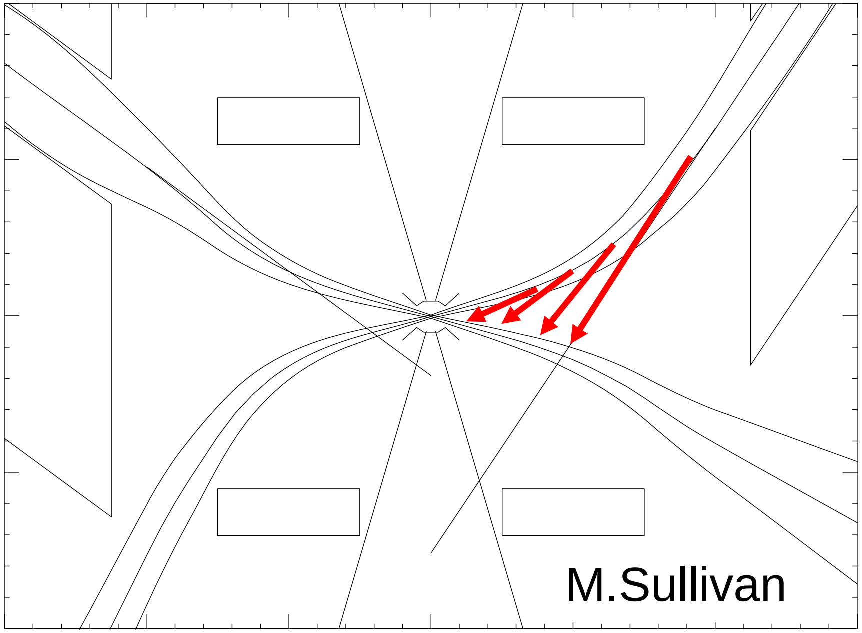
Readout window = 1us

$\boxed{\text{Occupancy}=3.5\ 10^{-4}}$

To do next:

evaluation of radiative BhaBha effects on the detector
evaluation of incoming bremmsstrahlung





These studies need a more defined layout interaction region