TOTEM	**I**_nelastic_ **D**_etector_	**Vacuum Chamber for Very Forward Physics**		
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Summary

The different requirements for the CMS/TOTEM vacuum chamber are investigated in order to define guidelines for the final shape in the region between 11mt and 18mt. Optimization can be done only when which kind of detector will be installed and a general purpose beam pipe for both total cross section physics and diffractive physics is very difficult to define. A comparison between slightly different solutions is given

1. Introduction

The very forward region is attracting for two main LHC physics programs:

a. *pp* Total Cross Section (σ_{tot})
b. Diffractive physics

Total cross section measurement requires special running conditions during the early stage of low luminosity phase of LHC and few days are sufficient to collect enough statistics. The detector has not to be radiation hard and doesn't need to be in the vacuum of the beam pipe since access to very small angles access is not mandatory.

Diffractive physics at LHC is more demanding since measurements are done during standard running at 40MHz at very small angles and under a high radiation level. Therefore the detector must be radiation hard and very close to the beam where a strong integration with the vacuum chamber is required.

The shape of the vacuum chamber starting from the bellow at 11mt has a big impact on the very forward detector located downstream between 15mt and 18mt, but since many concurrent requirements must be faced in this region, a general-purpose solution it is very difficult to achieve. Optimization can be done if guidelines on the nature of physical measurements and detectors are available.

2. *pp* Total Cross Section Guideline

Detectors have to measure the inelastic rate of *pp* collision with a fully inclusive trigger and the special running conditions [1] required for this measurement (β*=1100mt, $N_{bunches}$ = 36) allows collecting enough statistics in few days. Therefore a not radiation hard detector (Cathode Strip Chambers + Resistive Plate Chambers), fast to install, in the very early stage of LHC, is more then sufficient. T1 telescope, covering the eta range from 3 to 5, has been designed and integrated in CMS and the inner vacuum chamber optimized for both CMS and TOTEM. In order to get a good accuracy for σ_{tot}, the angular region covered must be as wide as possible. Looking at the layout of CMS, the only region where it is possible to install a second detector T2 is behind HF inside the Rotating Shielding, very close to beam pipe.

Rotating shielding can be designed in such a way that T2 can start at eta=5, but the HF calorimeter must kept open during this special running phase otherwise it would make a shadow on T2 up to eta= 5.33. Great attention must be given to the beam pipe design from eta=5, assuring a shape minimizing the background on T2.

In order to access small angles, a narrow cylindrical beam pipe between 15 and 18mt, would be a good compromise, but even if the material is not directly in front of T2 the background generated by the conversion of secondaries in the wall of the pipe would make the detector unusable.

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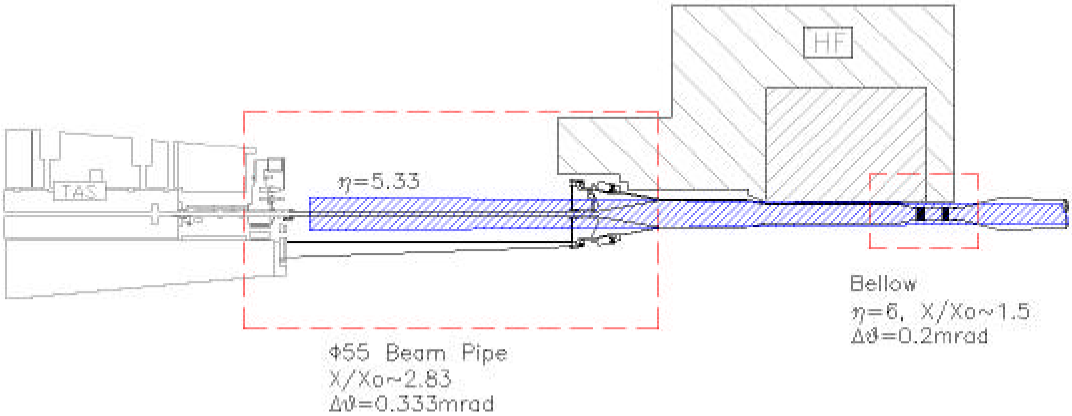
[1] TOTEM Technical Proposal http://totem.web.cern.ch/Totem/

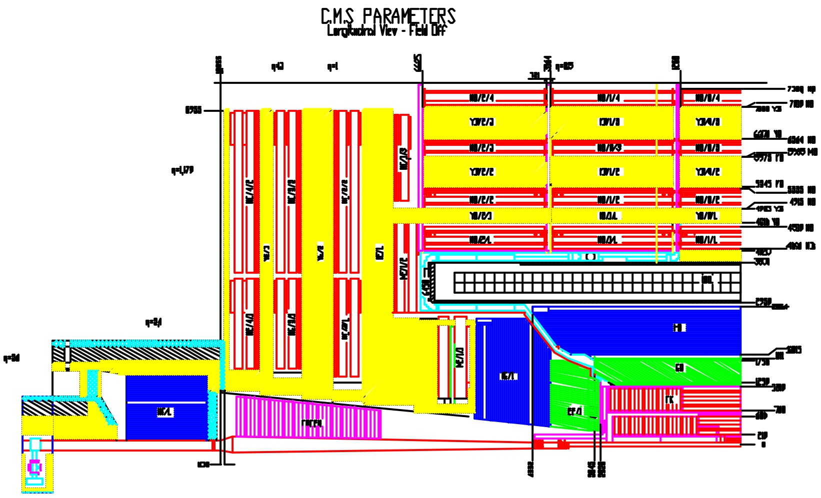


3. Diffractive physics Guidelines

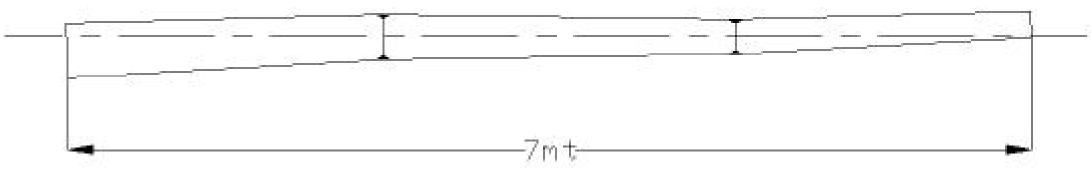
Diffractive physics measurements must be done contemporarily with CMS therefore with nominal LHC running conditions (β*=0.5mt, $N_{bunches}$ = 2835). The detector and the electronics must be radiation hard and access very small angles closest to the beam.
The Rotating Shielding, in which should be accommodated the detector, doesn't offer the same flexibility as for σ_{tot} special running, because it must assure a full shielding to the Muon Endcap. The HF calorimeter must be kept in running position. Therefore the optimization of the beam pipe concerns only the region starting at eta=5.33.

4. Inner Beam Pipe (from IP to 10.5mt)

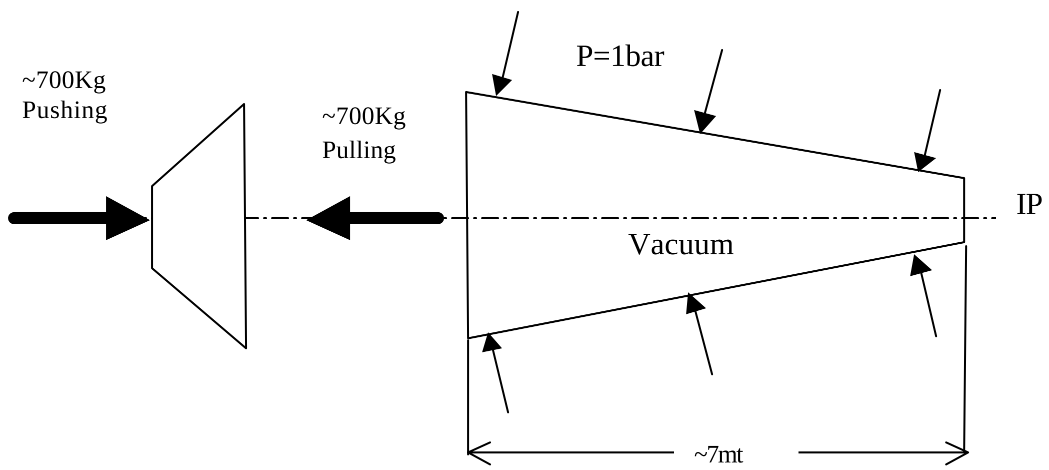
Vacuum chamber is an important source of radiation background for CMS/TOTEM therefore its shape has been optimized. (See CMS Note 2000/069). A conical shape pointing at vertex has shown significant advantages since, even if the amount of material transversed is big, it is concentrate in a very small solid angle. This has been the guideline to optimize the beam pipe for the inner part of CMS and TOTEM T1 Telescope, up to 10.5mt.



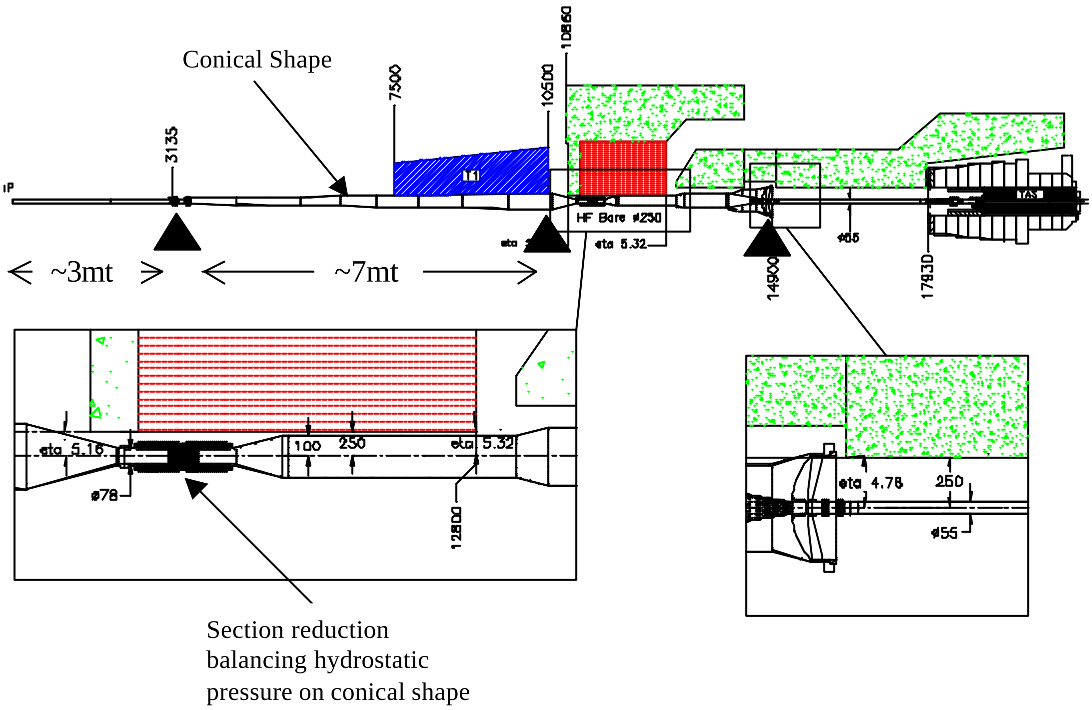
The vacuum chamber is a thin wall structure made of welded pieces. Therefore first drawback of a conical shape versus a cylindrical shape are manufacturing tolerances of the assembly are larger., especially for a 7mt assembly size.



When vacuum is done, the external atmospheric pressure loads the vacuum chamber with an unbalanced pulling force due to the horizontal component on the conical shape.



Unbalanced permanent loads could be very dangerous for the long-term integrity of the structure. A reduction of the diameter is required to balance the pulling of hydrostatic pressure.



5. Section reduction and Bellows at ~11mt

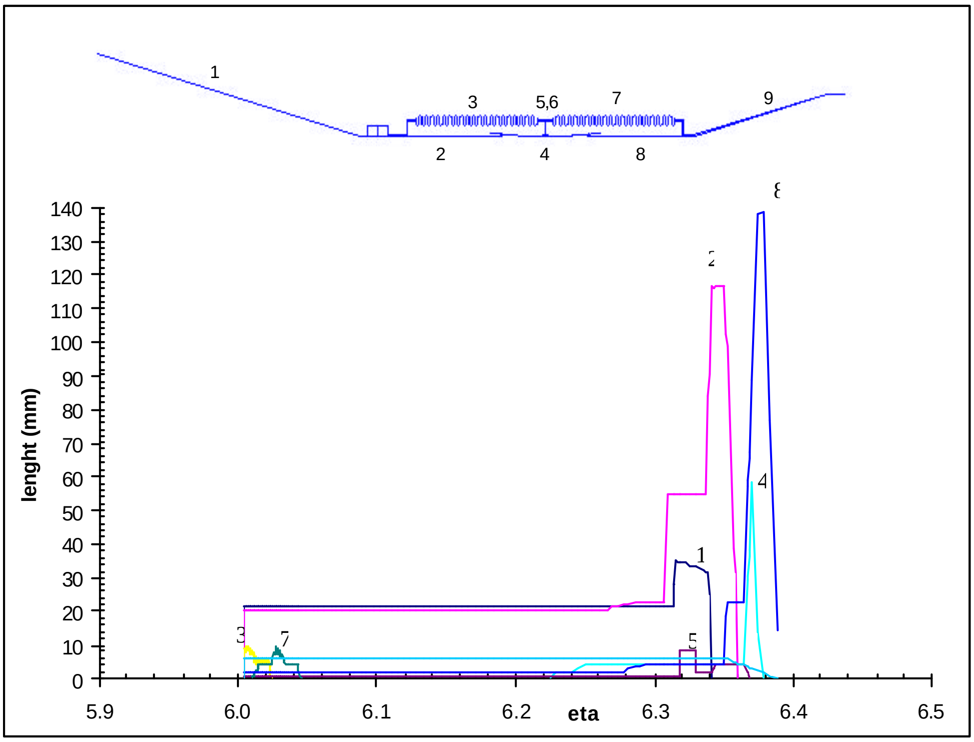
The vacuum chamber is supported at ~3mt by the CMS Tracker where an expansion joint bellow is placed in order to decouple the thermo elastic deformation induced during the bake out phase. A second support is given by the CMS end cap at ~10.5mt where a second expansion joint is placed to decouple the Endcap beam pipe from following part supported at ~15mt.

Section reduction and bellows happen at same location, being responsible of the presence of a big amount of material at eta~6 where the background generate by secondaries emitted from the vertex is very high

It has been calculated that the background generate in this point is not a major problem for HF calorimeter but it is a major drawbacks for any very forward detector placed downstream.

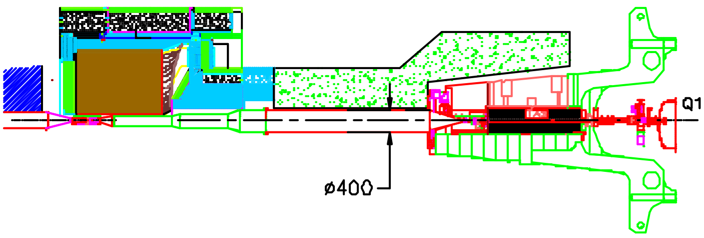
Any enlargement of the section at ~11mt impose major modification of the End cap beam pipe with consequent increase of background

The study of the amount of material located in this point has been done and it has been shown that real contribution to the background comes from all the cylindrical components required to tackle the RF problems, The real contribution of the bellows corrugation is negligible. The only real possibility is to keep under control the amount of material in the bellow, where mechanical, vacuum and RF constraints are present together.

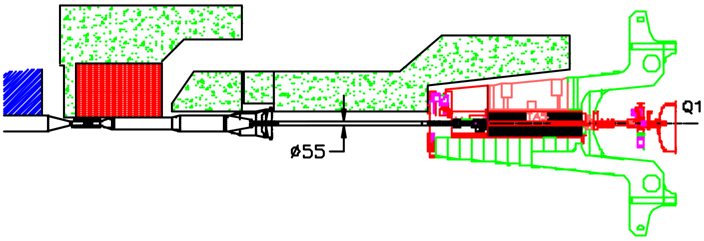


6. Vacuum Chamber between 11mt and 18mt

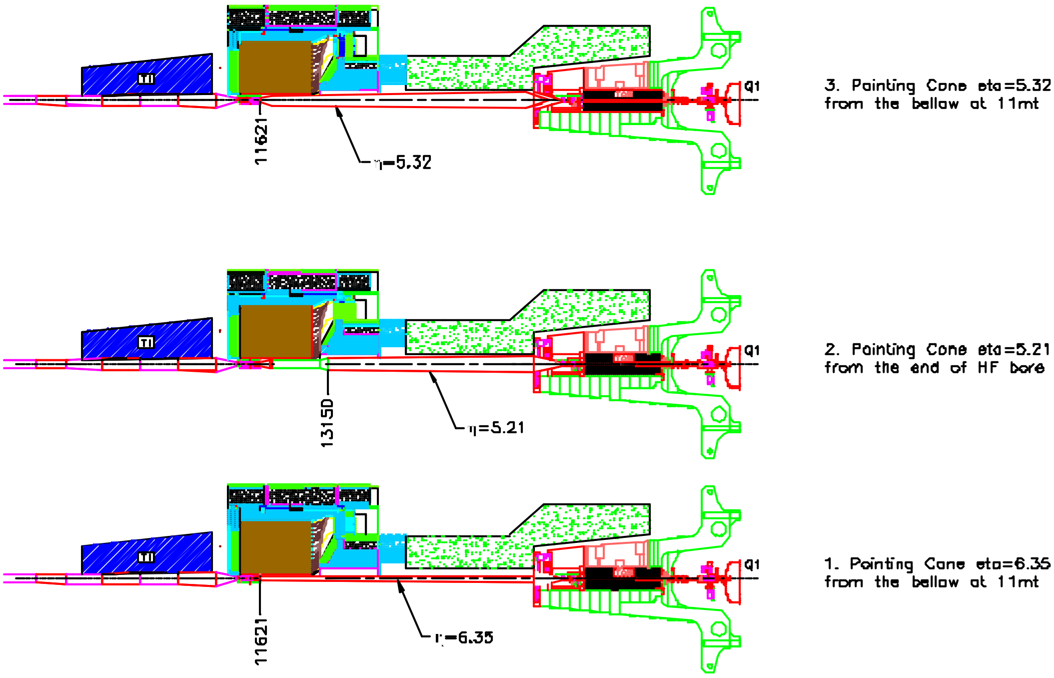
Two baselines are available for low luminosity and high luminosity. The amount of material is calculated and is compared to three possible alternatives.

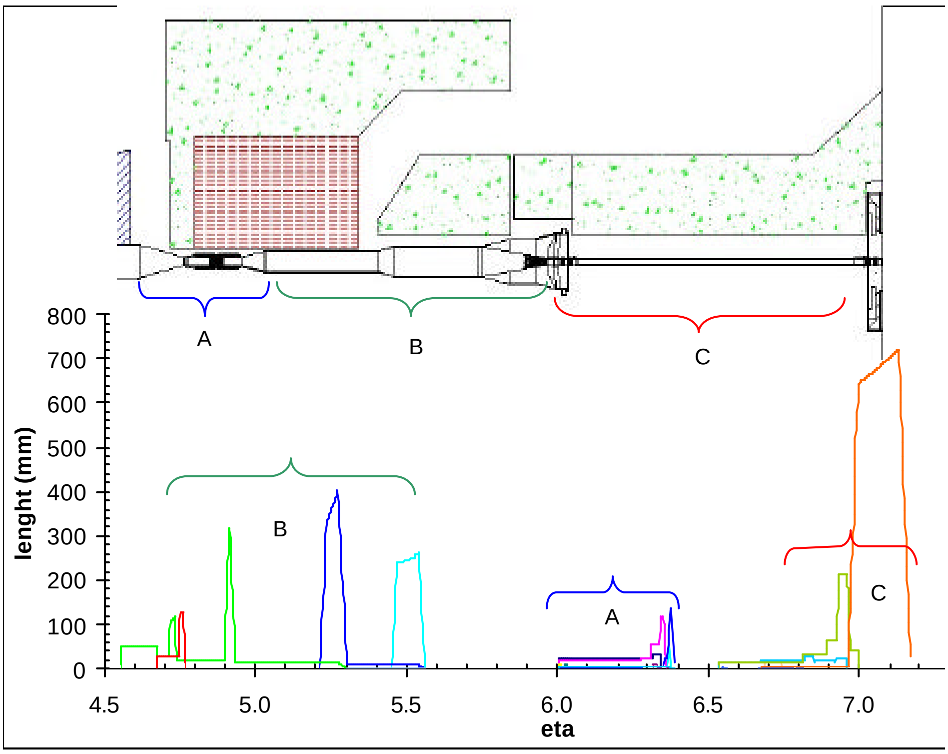


B. High Luminosity Baseline



A. Low Luminosity Baseline





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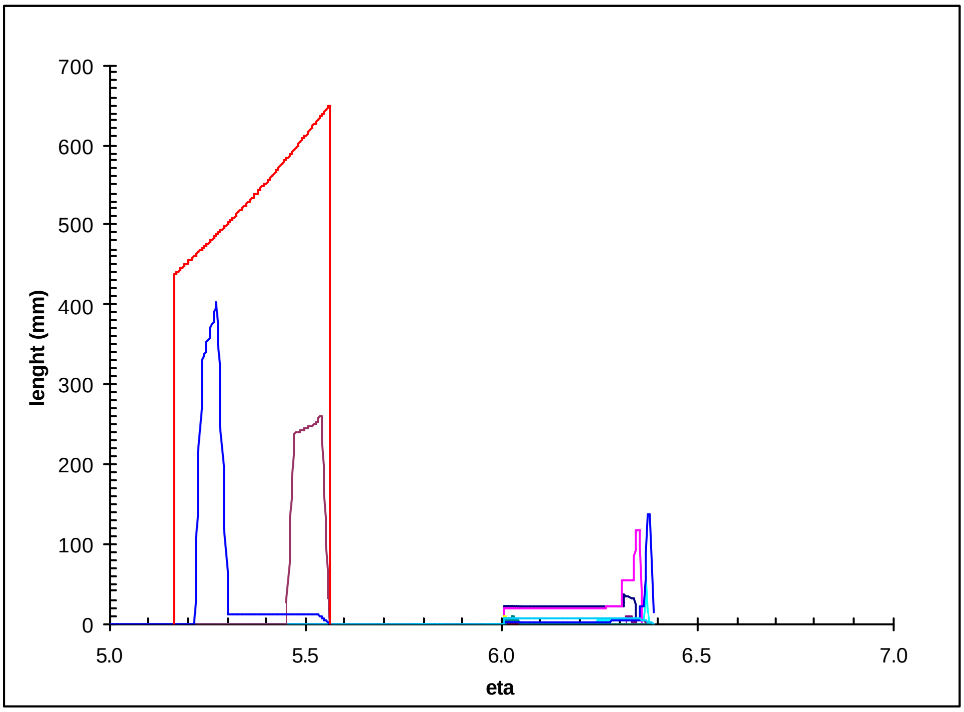
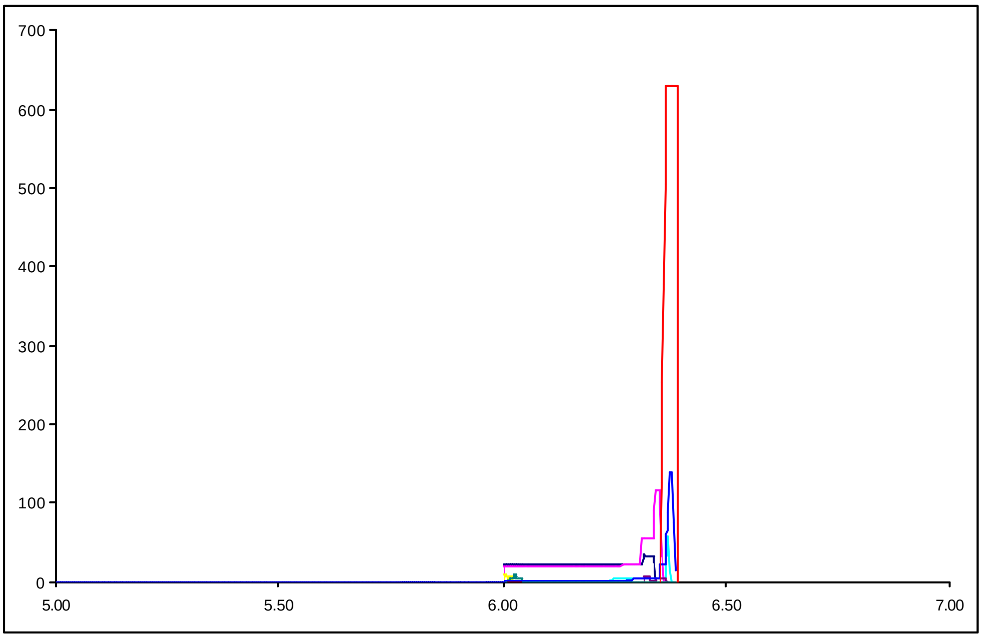
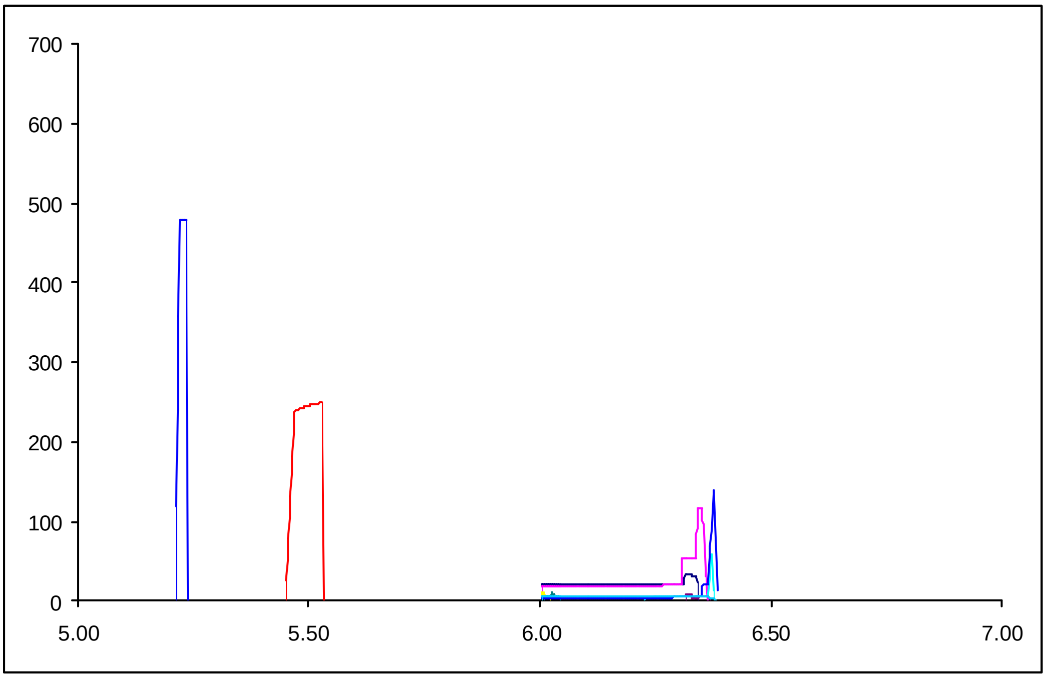


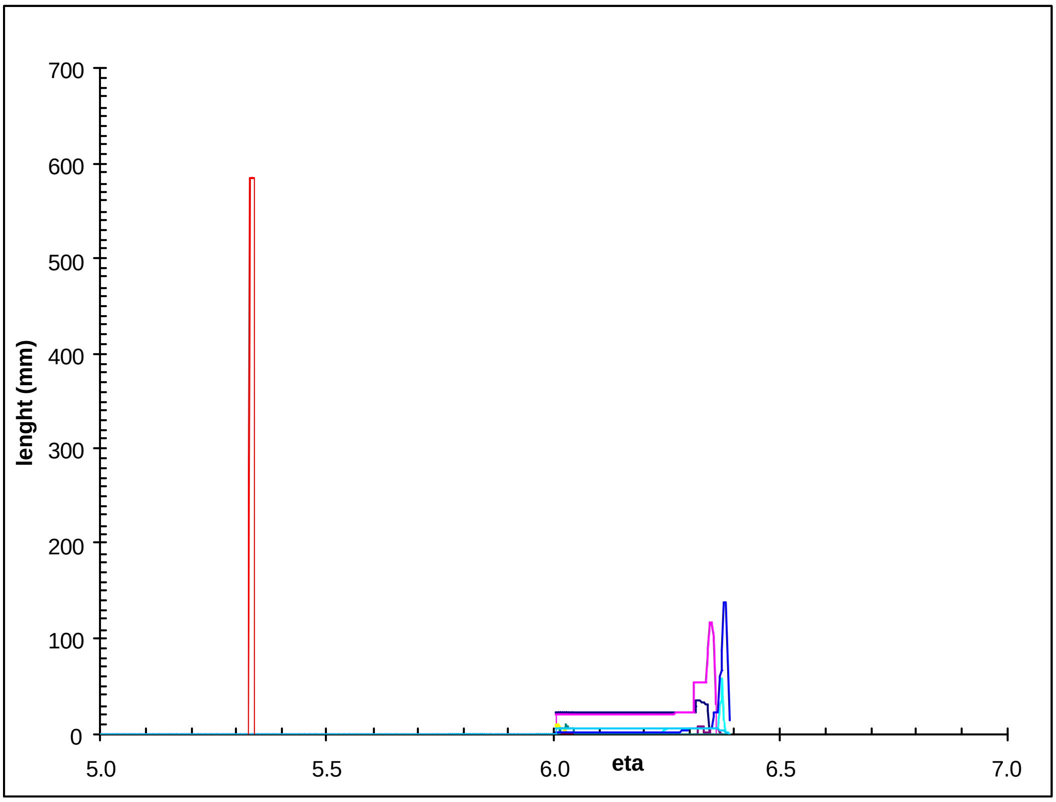
B. High Luminosity Baseline



1.Pointing Cone eta=6.35 from the bellow at 11mt



2. Pointing Cone eta=5.21 from the end of HF bore



3. Pointing Cone eta=5.32 from the end of the bellow at 11mt

Some considerations

- Secondaries emitted from primary 7+7 TeV *pp* collisions are cut off by HF beyond η 5.32, starting at z=12800 (HF it is an intrinsic shielding for etas>5.32)

- Energy Absorption breakdown (from CMS In 2000/51):

CMS Detector $-3< \eta <+3$	120 GeV per event
HF $3<\vert\eta\vert<5$	2 x 310 GeV per event
TAS $5<\vert\eta\vert<7$	2 x 2.3 TeV per event (equivalent to 2 x 250W)
TOTAL	5.34 TeV per event

Energy escaping in LHC ring 8.66 TeV

- At higher etas, the main sources of background are the HF, the bellow at 11mt and the cylindrical beam pipe in the HF. If the bellow problem is tackled, HF (X/Xo = 132) and the cylindrical beam pipe (X/Xo = 25) are still a relevant background source on T2 region (backscattering)
- The rotating shielding protect from the background of TAS