RICH1 MAGNETIC SHIELDING

An overview of the LHCb RICH1 magnetic shielding design.

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IOP Dublin 2005

LHCb Detector in Cross Section

1. **Detector Overview**
2. **Magnetic Requirement**
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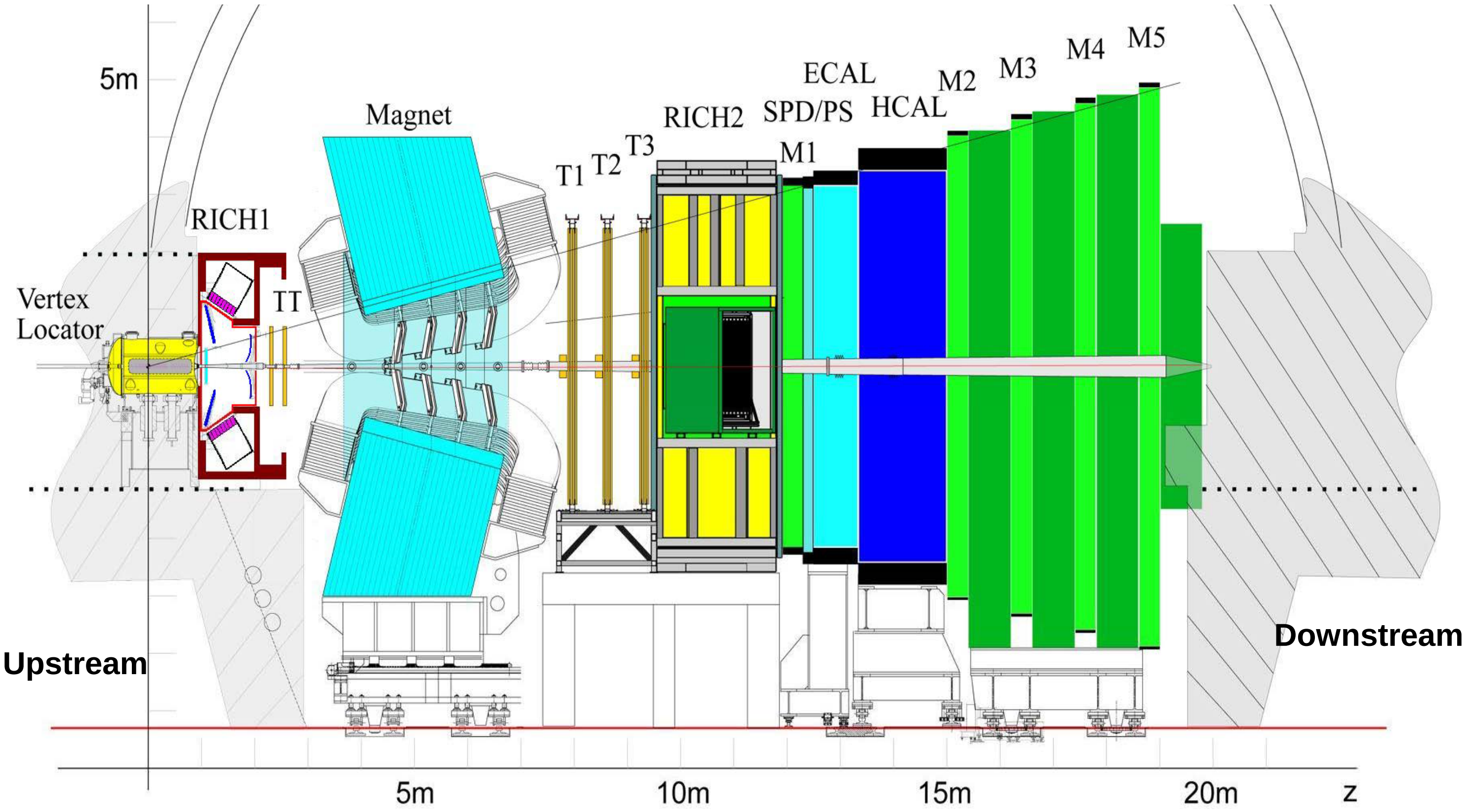
4. **Simulation tools**
5. **Shield Components**
6. **Field Measurement**

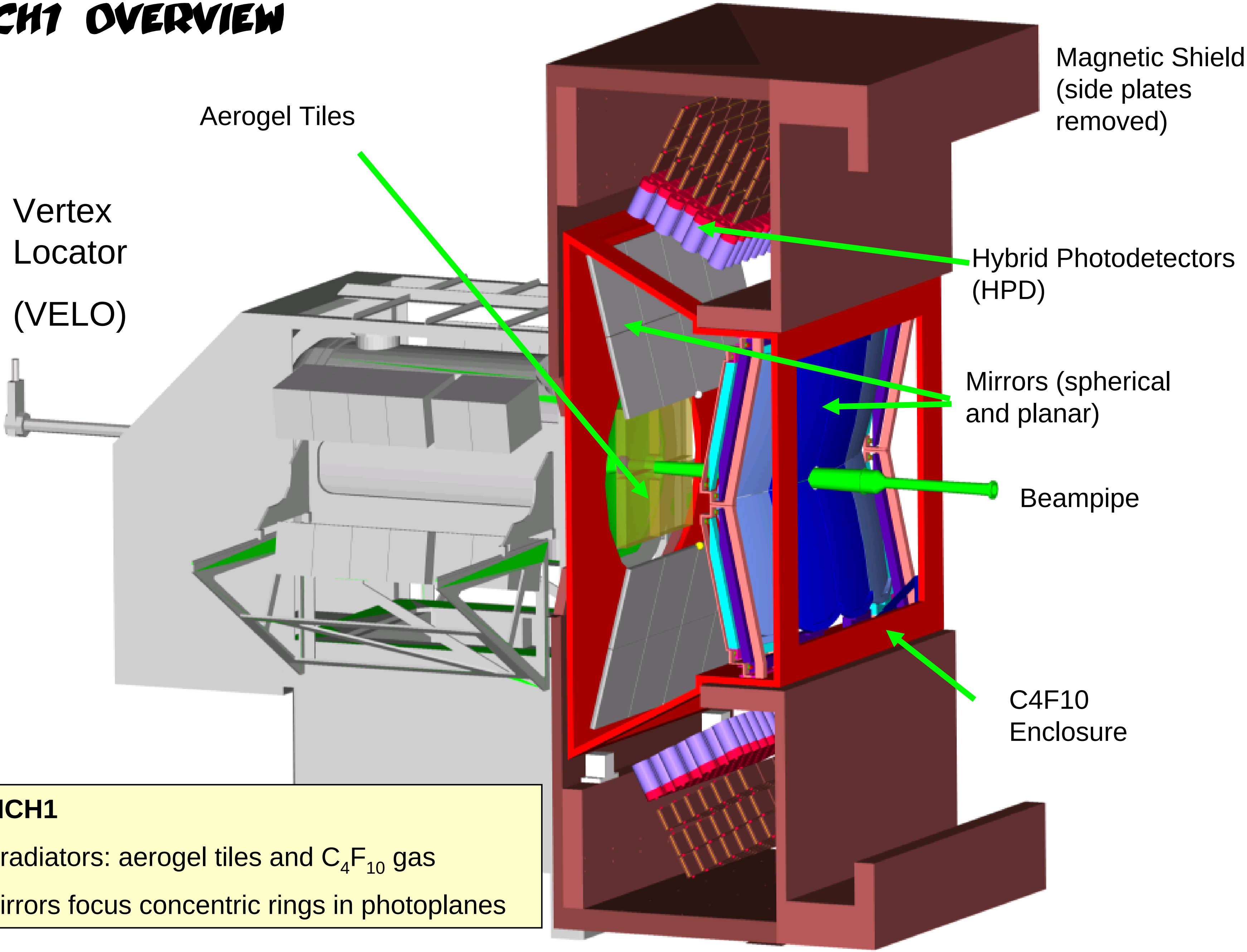


LHCb - a single arm spectrometer to perform B physics measurements at LHC

RICH System - Two ring imaging Cherenkov detectors, providing high quality PID

RICH1 - Covers momentum range 1GeV/c to 60Gev/c

RICH1 OVERVIEW



RICH1

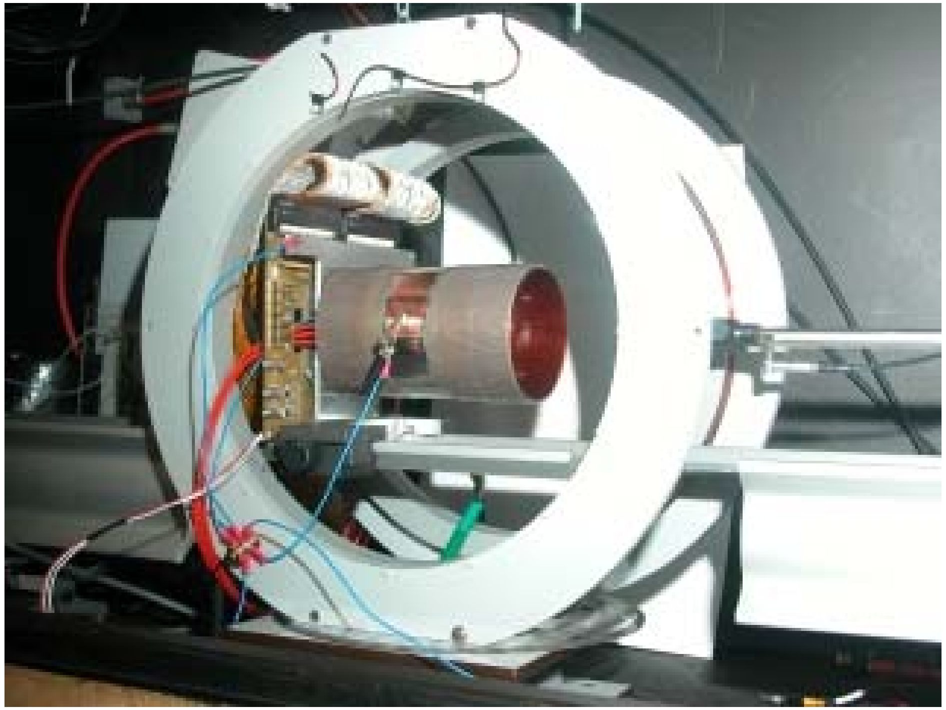
2 radiators: aerogel tiles and C_4F_{10} gas

Mirrors focus concentric rings in photoplanes

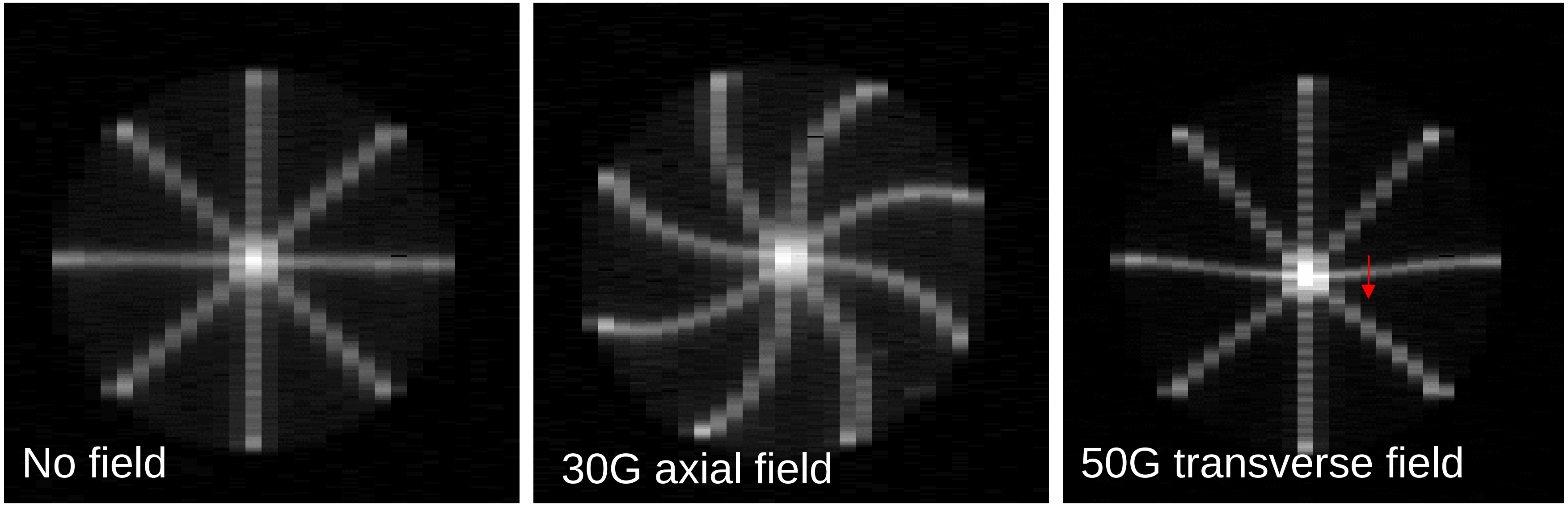
Hybrid Photodetectors in a Magnetic Field

Hybrid Photodetectors (HPDs)

- Single photon sensitive
- Low noise
- Pixel detectors 1000 channels
- Vulnerable to magnetic field over 30G



Results for an HPD in a mumetal shield



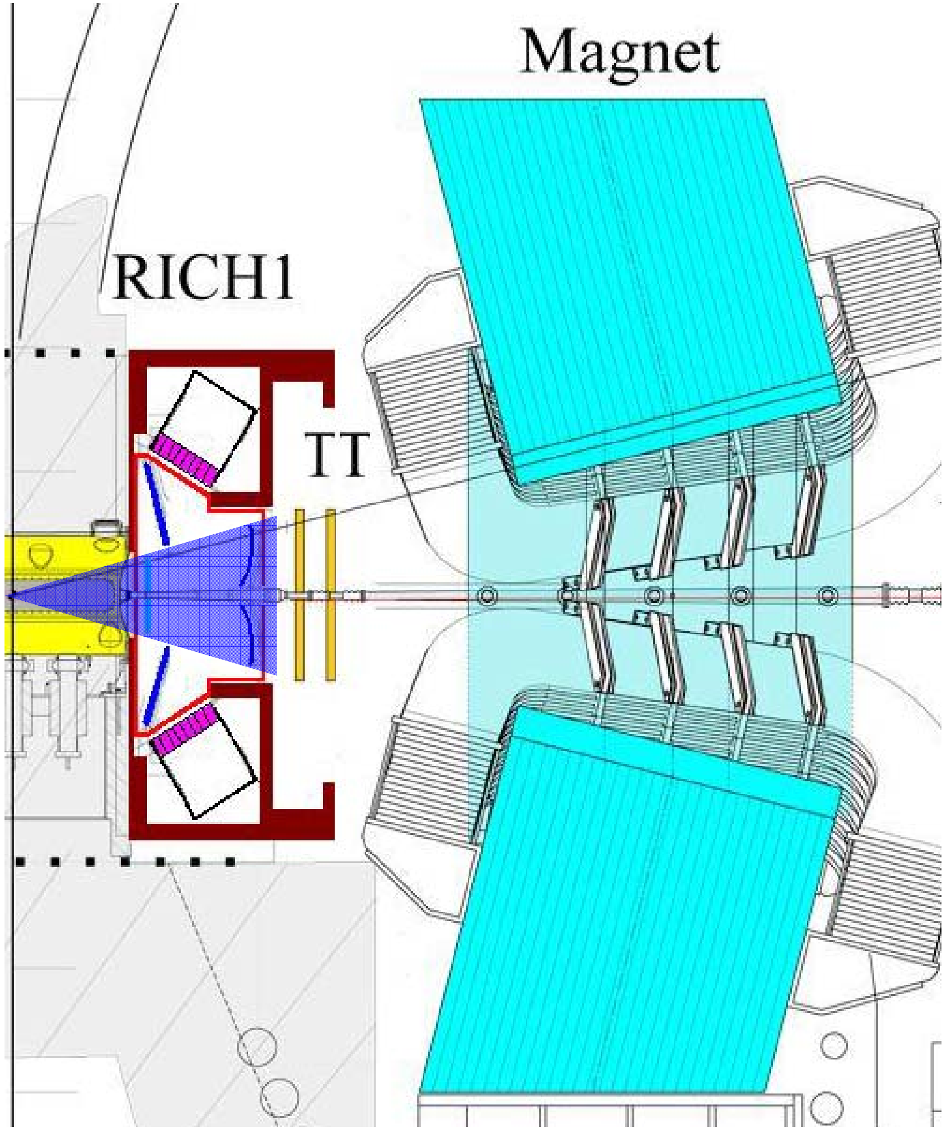
Magnetic Field in the RICH1 Region

RICH1 Shield - magnetic requirements

Shielding HPDs – Field in HPD region reduced from 600G to 25G

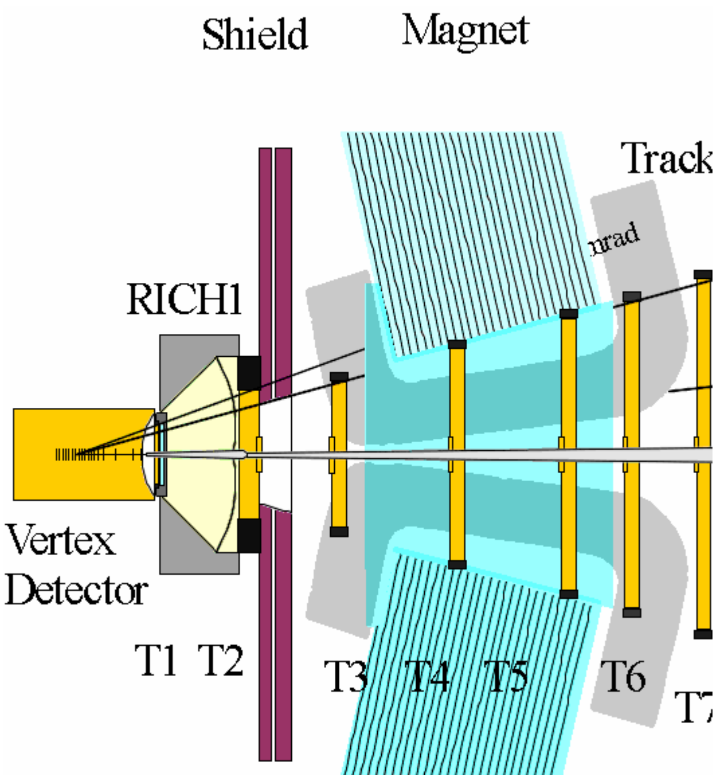
Trigger – Field integral for Trigger Tracker(TT) increased from 110kGcm to 150kGcm

(Trigger integral measured along beamline from interaction point to TT)

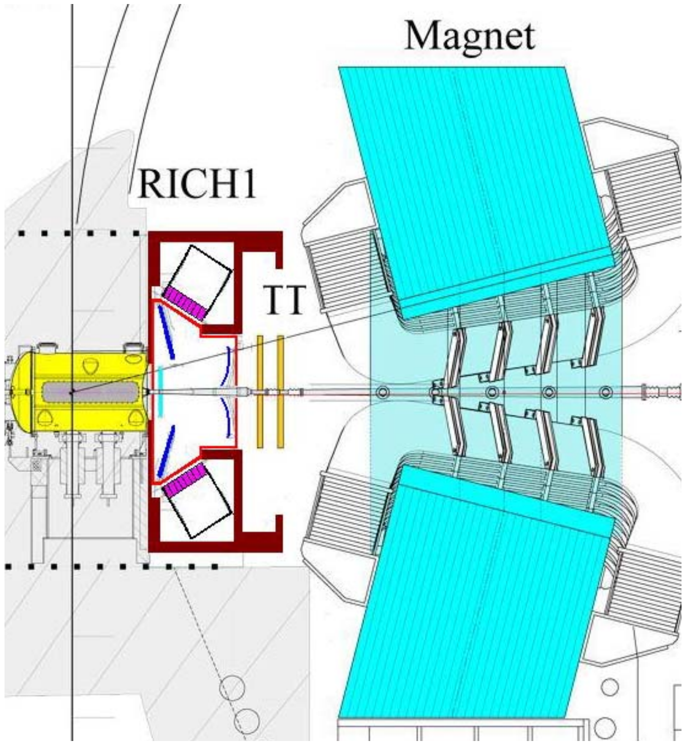


Why wasn't it designed earlier?

- The LHCb "light" redesign to reduce material in acceptance
- Tracking stations removed
- Increased field required for remaining tracker (TT) so shielding plate removed
- Field too high for HPD operation so RICH1 Shielding introduced
- RICH1 Shield used to increase TT field further

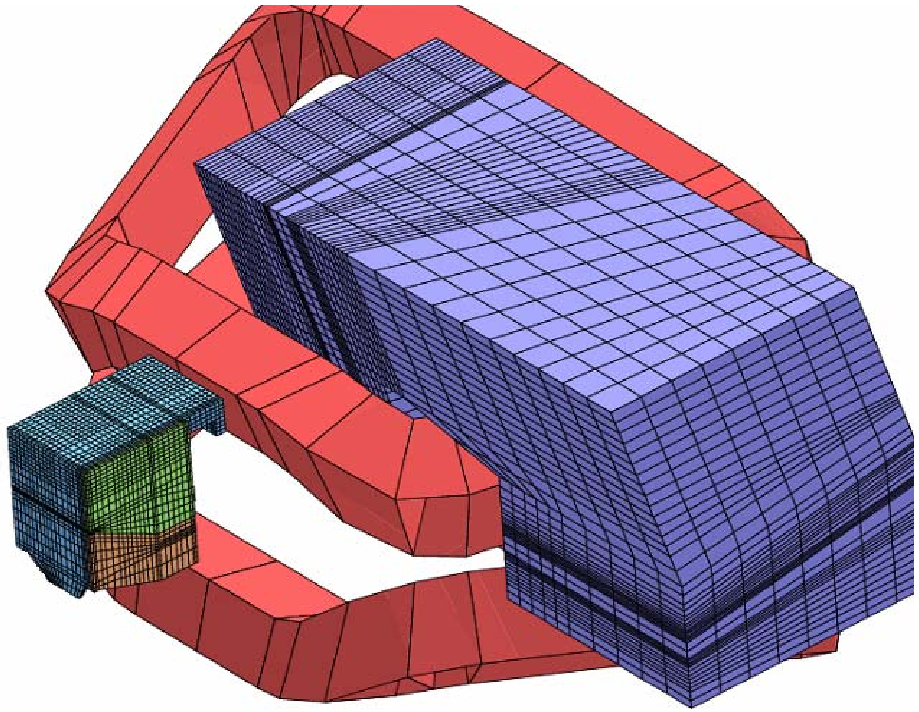


"Light" Redesign

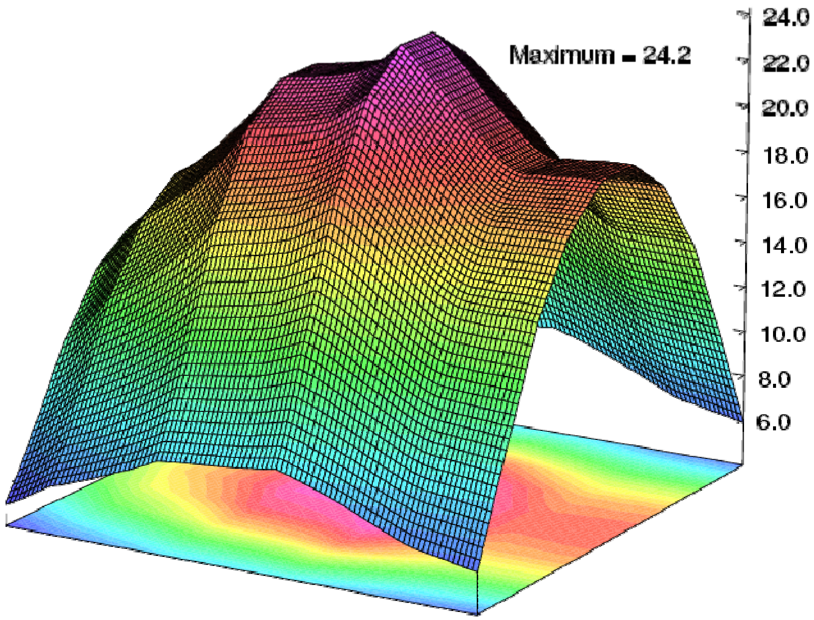


Simulation tools used

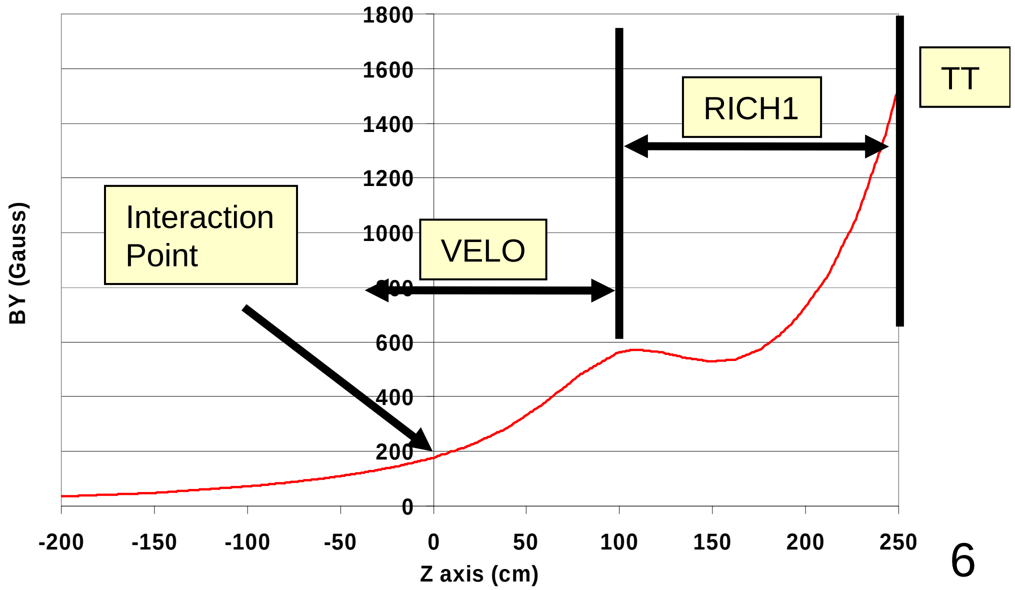
- Opera3d Finite Element package used to model magnetic behaviour
- Magnet and RICH1 shield modelled as a system
- Each geometric change required several models to establish a trend
- Two indicators were used to measure the designs:



B-Max - The maximum field in the HPD plane



B-Trig -The integral field along the beamline to the TT



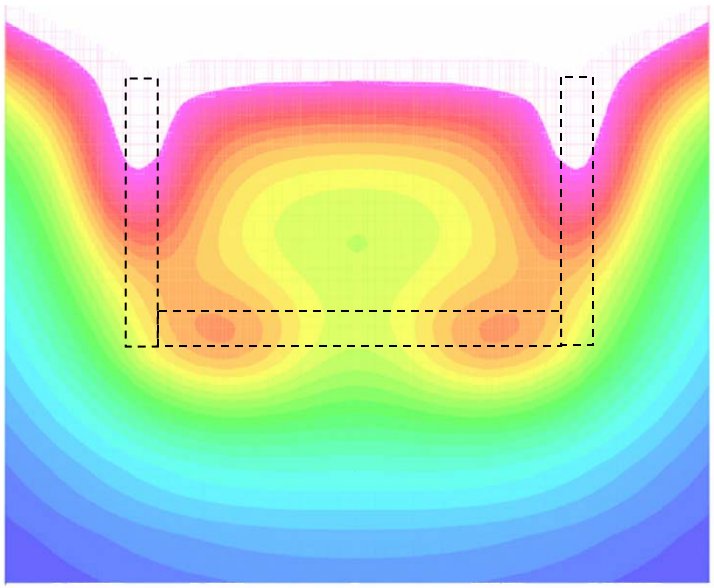
Magnetic Operation

Field is drawn in from magnet region by magnetic block

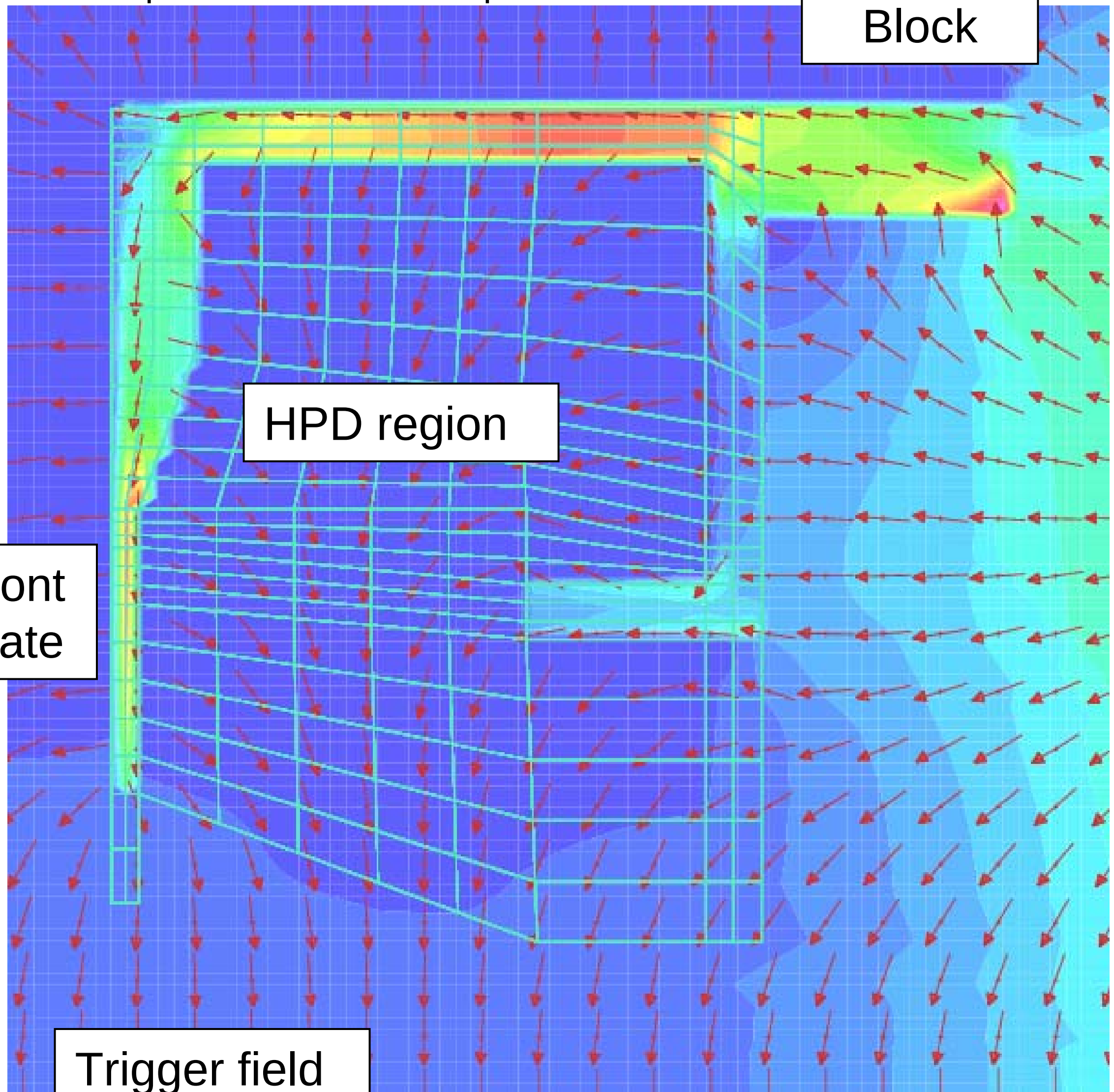
Passed along top plate away from HPD region

Then channelled to front plate and down to Trigger field region

Front plate and Magnetic Block geometry have most dramatic effect on shield performance



FEA output - cross section top half of shield



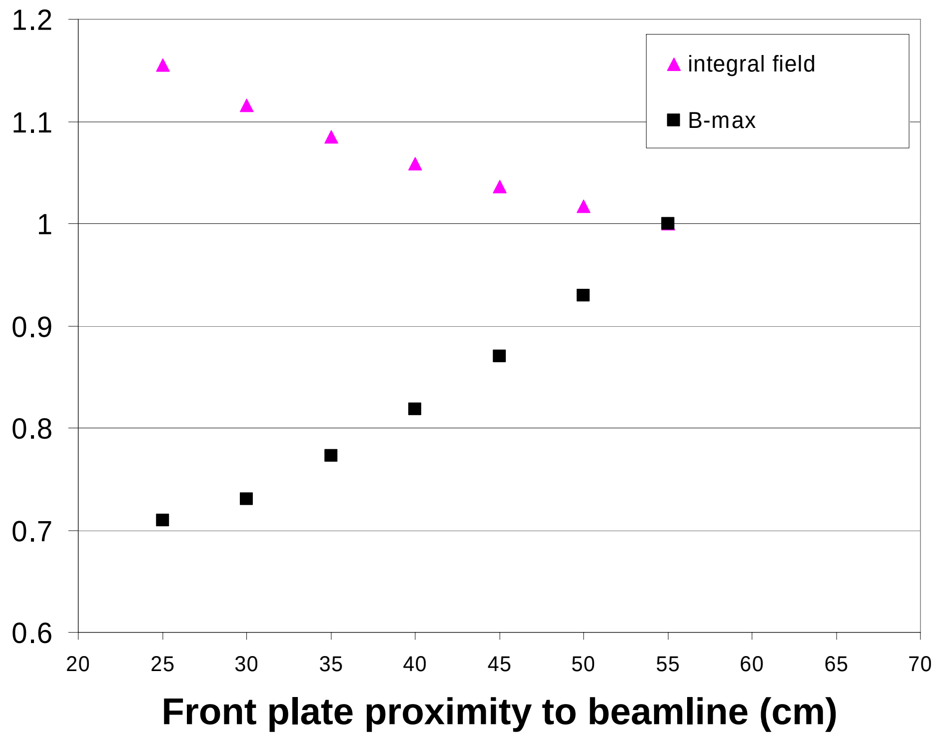
FRONT PLATE

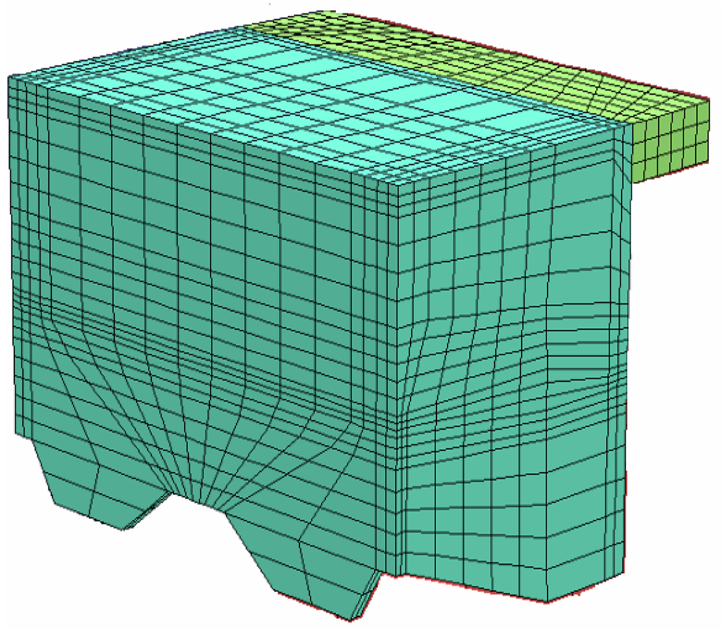
As front plate approaches beamline B-max decreases and B-trig Increases

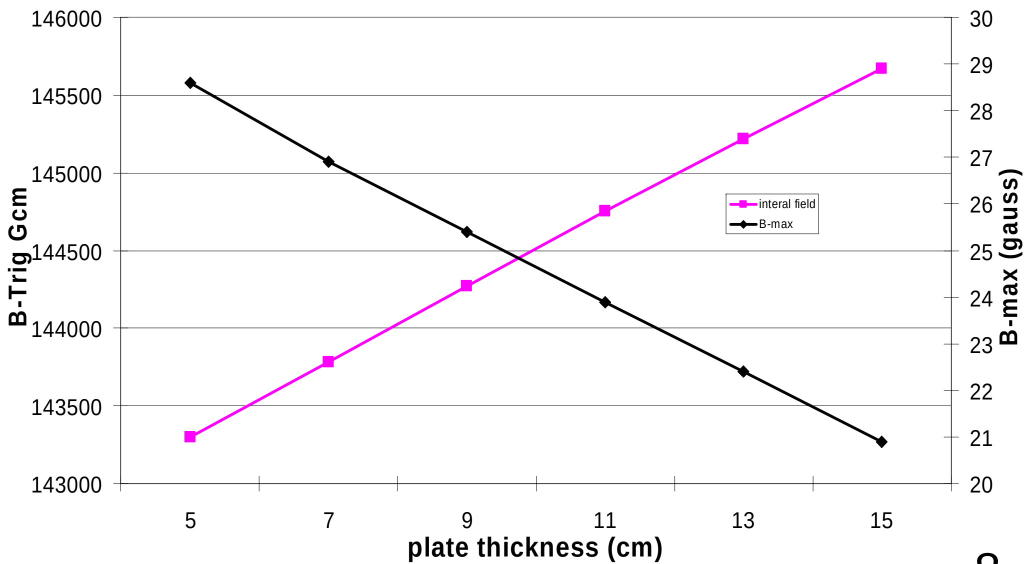
Approach limited by exit window of the vertex locator

'Teeth' used to gain extra shielding

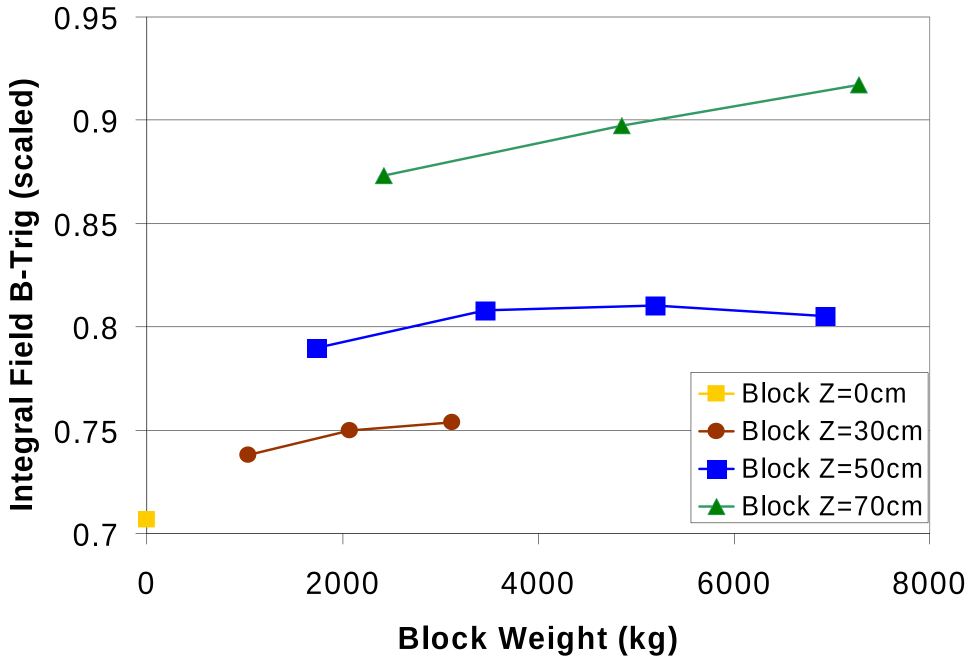
Thickening front plate reduces field leaking to HPD region so extra internal block added







Magnetic Block



Block proximity to magnet has strongest effect on B-Trig

Weight/size is a lesser consideration

Constrained by position of magnet and weight of block

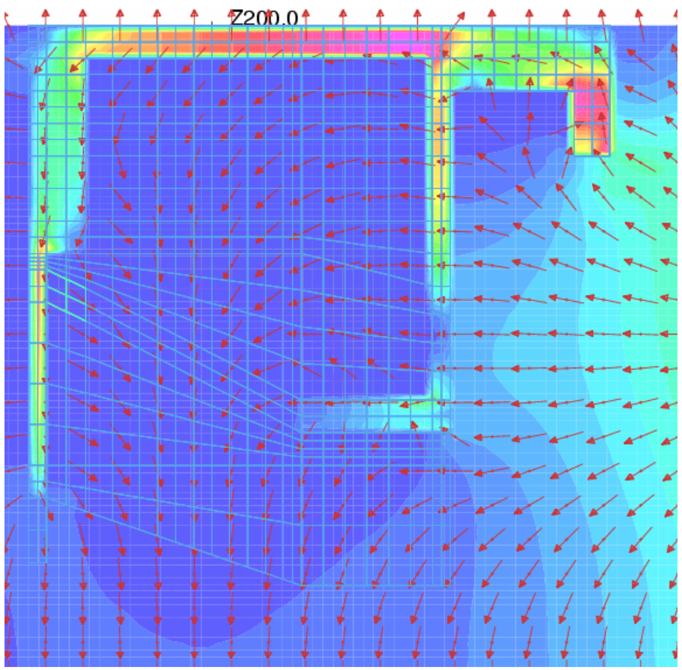
Very large parameter space

Size/shape/position/angle simulated

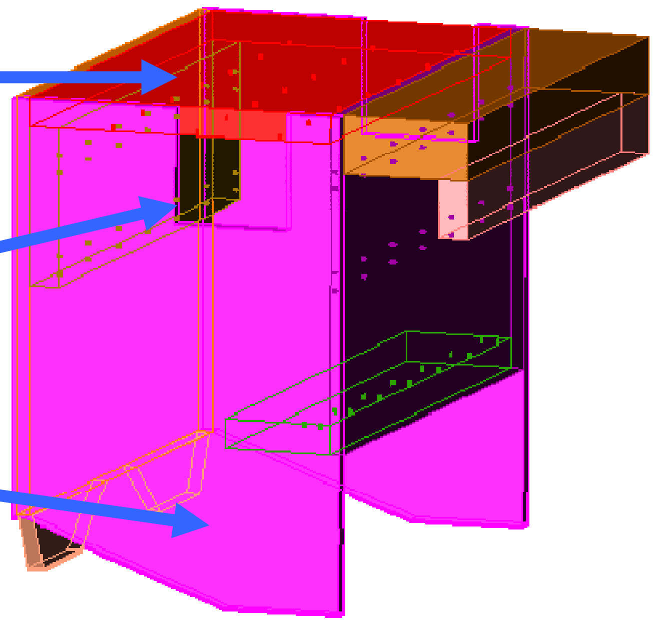
B-Max sensitive to position of block

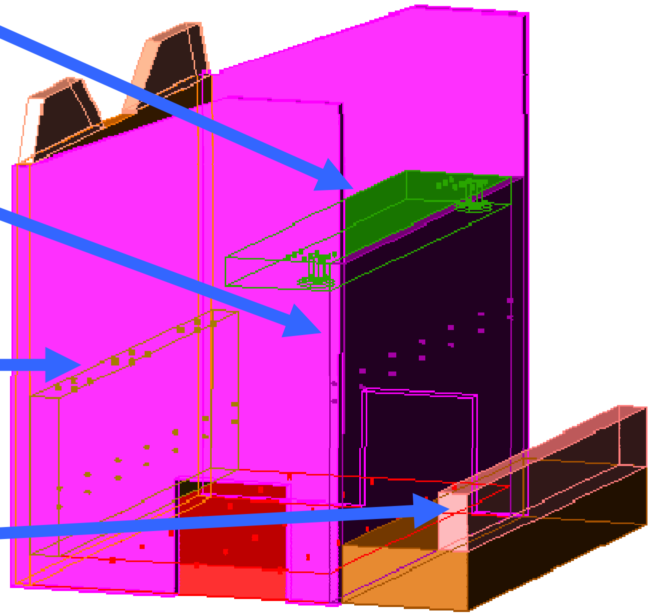
Back plate easily saturated

Extension added to boost field



OTHER SHIELD PARTS





•Top Plate - 10cm thick, any thinner and saturation occurs, no benefit from being thicker

•Cable Slot - a 30cm by 30 cm slot was modelled on each side to allow cable and cooling access to the HPD unit. Designed so that the side plates can be lifted away with minimum danger to cabling.

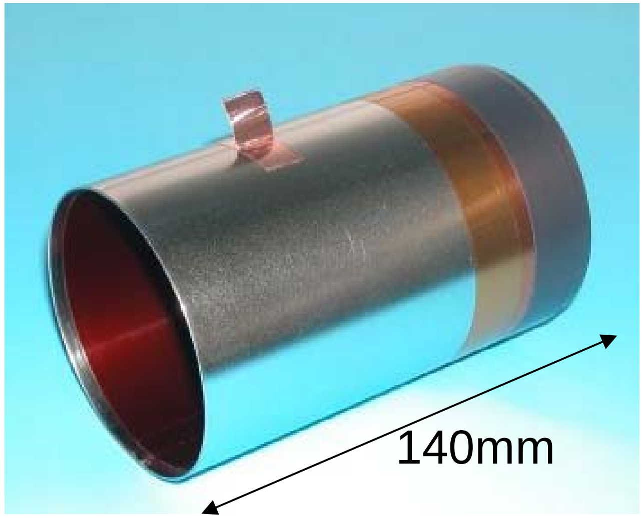
•Side Plates – 5cm thick. Necessary but less sensitive small changes then other pieces, there is a possible problem with saturation, which has been modelled and has a contingency solution.

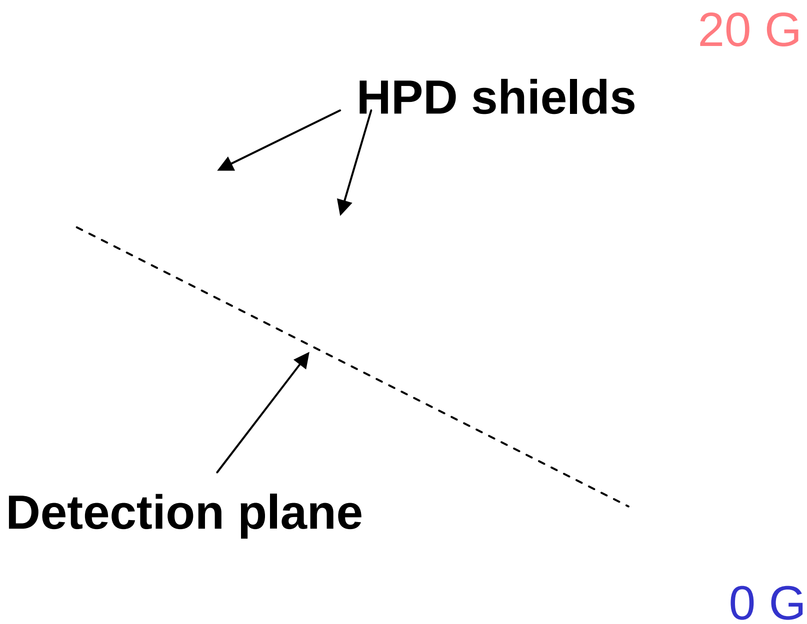
•Shelf – 10cm thick, length is VERY critical to the HPD shielding and must not obstruct Cherenkov photon path.

•Downstream Plate – 5cm thick, channels stray field from the magnet away from HPD's, being thicker has no effect

•Internal Block – 10cm thick, it acts as a thickener for the front plate where there is space available, helping the trigger field.

•Block Extension – 10cm thick. This was added to minimise field loss when the top of the shield was raised to accommodate the HPD electronics chain.


140mm


20 G
HPD shields
Detection plane
0 G

Field measurements in LHCb cavern

In December 2004 the LHCb magnet was powered for the first time.

Measurements of field in RICH1 area taken without the shield in place.

Position	Measured field (G)	Modelled field (G)
Trigger region	360	273
HPD region	340	307

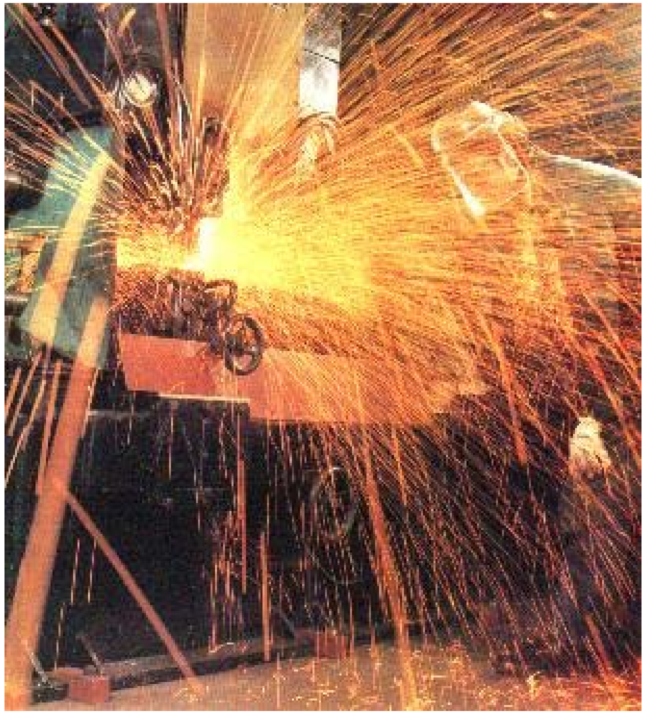
These provide an indication of the accuracy of the FEA, suggesting that model is underestimating

The current model predicts that B-Trig is 138kGcm and B-Max is 26.0G

Higher field will take shield very close to target value for trigger and should still allow good HPD operation

Definitive answer in May when shield performance will be measured

The shield is being constructed at the moment



In Summary

All design decisions of the shield are compromises between trigger, shielding and mechanical constraints

150 different models and 3 months of runtime on the CERN parc cluster were required to finalise a magnetic design that satisfies the mechanical requirements.

The RICH1 shield is in production and is expected to fulfil its magnetic requirements.

The magnetic performance is to be verified using the LHCb Magnet in May

Its been a long process involving a lot of work by many people. Notably: Steve Jolly, Trevor Savidge, Marcello Losasso, Mitesh Patel, Gianluca Aglieri Rinella and Tito Bellunato. Many thanks to them all.