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The FP420 R&D Project

LOI to LHCC signed by 29 institutes from 11 countries - more in the process of joining

The aim of FP420 is to install high precision silicon tracking and fast timing detectors close to the beams at 420m from ATLAS and / or CMS

FP420 is basically a spectrometer using LHC magnets to bend protons with small momentum loss out of the beam (moveable silicon tracker ~ 8m long)

"The LHCC acknowledges the scientific merit of the FP420 physics program and the interest in its exploring its feasibility." - LHCC

"The panel believed that this offers a unique opportunity to extend the potential of the LHC and has the potential to give a high scientific return." - UK PPRP (PPARC)

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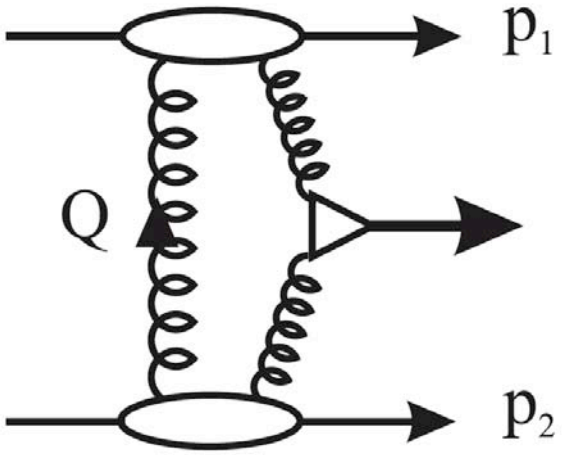
The FP420 R&D Project



Motivation from KMR calculations (e.g. hep-ph 0111078)

- Selection rules mean that central system is (to a good approx) 0^{++}
- If you see a new particle produced exclusively with proton tags you know its quantum numbers
- CP violation in the Higgs sector shows up directly as azimuthal asymmetries
- Proton tagging may be the discovery channel in certain regions of the MSSM
- Tagging the protons means excellent mass resolution (~ GeV) irrespective of the decay products of the central system

At low luminosity (~ 30 fb^{-1}) we can :

- Establish the quantum numbers of SM Higgs
- Be the discovery channel in certain regions of the MSSM
- Make high precision measurements of $\gamma\gamma \rightarrow WW$ / ZZ couplings
- Host of interesting QCD measurements ($0.002 < x_{IP} < 0.015$)

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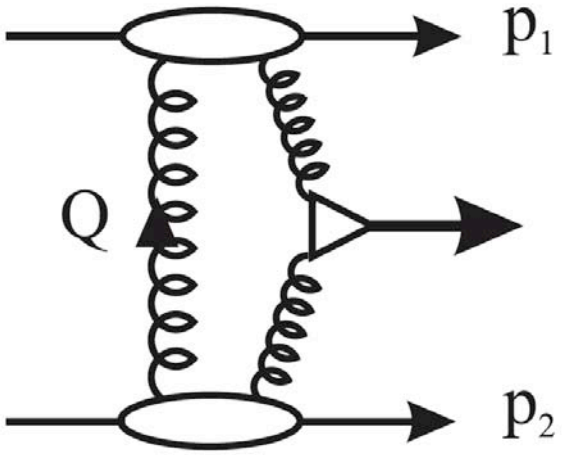

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In addition, at higher luminosity (~ 100 fb^{-1}) we can :

- Discover exotic bound states such as gluinoballs
- Make direct observation of CP violation in some SUSY Higgs scenarios
- Disentangle wide range of SUSY scenarios, including nearly degenerate Higgs sectors

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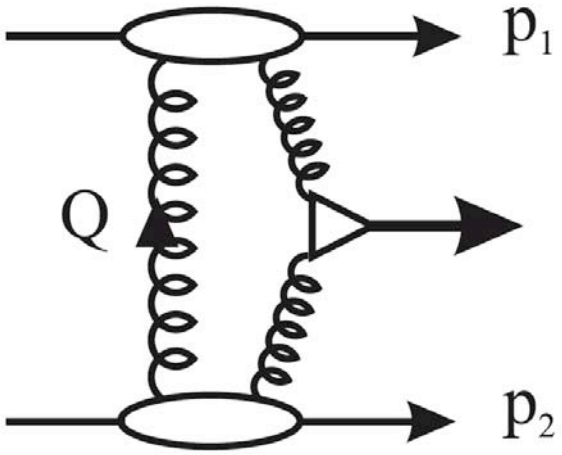
The FP420 R&D Project



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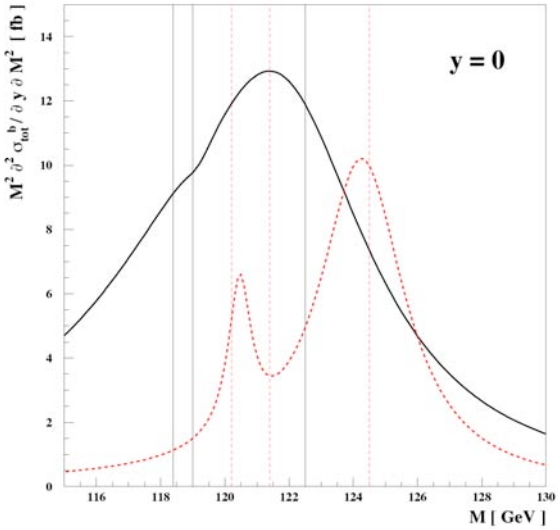
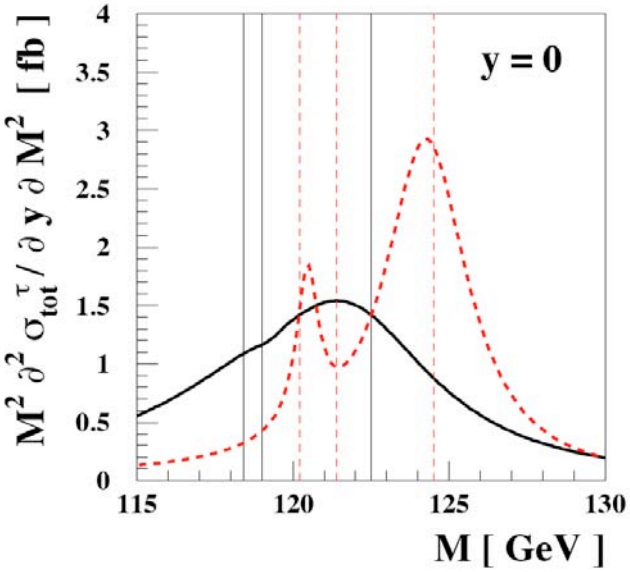
FP420 turns the LHC into a glue-glue (and $\gamma\gamma$) collider where you know the beam energy of the gluons to ~ 2 GeV.

CP violation in the Higgs Sector

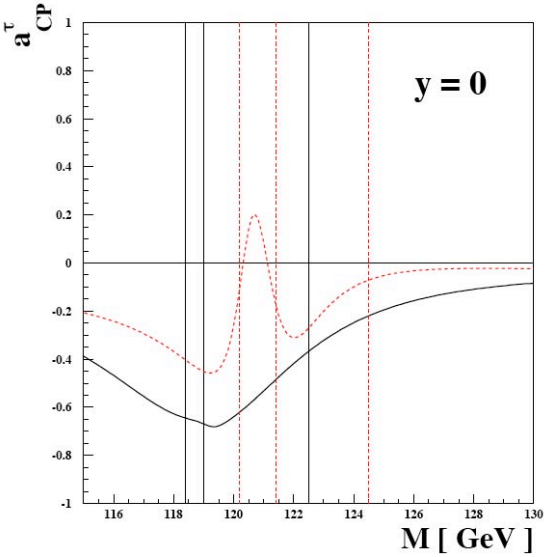
bb decay



ττ decay



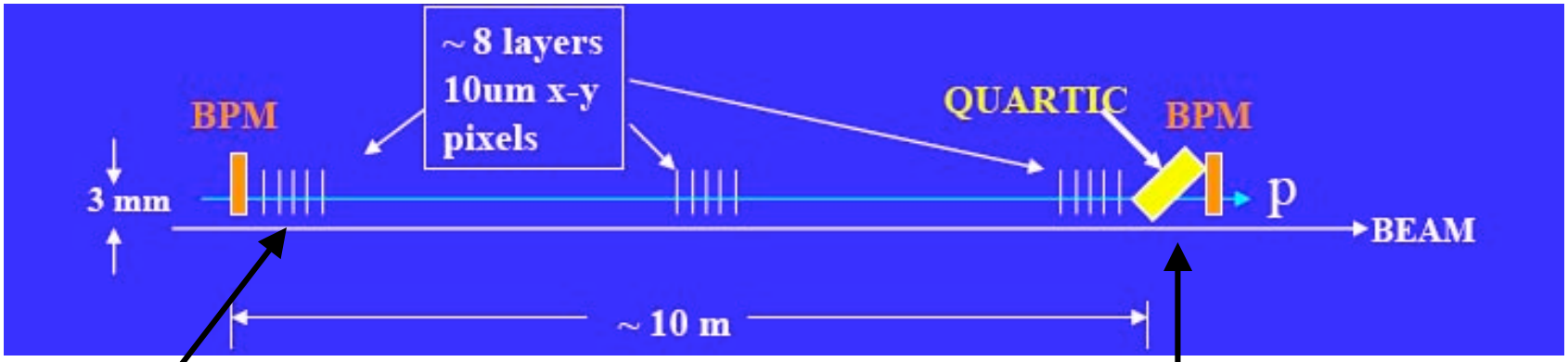
ττ decay



This example shows that exclusive double diffraction may offer unique possibilities for exploring Higgs physics in ways that would be difficult or even impossible in inclusive Higgs production. In particular, we have shown that exclusive double diffraction constitutes an efficient CP and lineshape analyzer of the resonant Higgs-boson dynamics in multi-Higgs models. In the specific case of CP-violating MSSM Higgs physics discussed here, which is potentially of great importance for electroweak baryogenesis, diffractive production may be the most promising probe at the LHC.

J. Ellis et al hep-ph/0502251

FP420 Schematic Outline

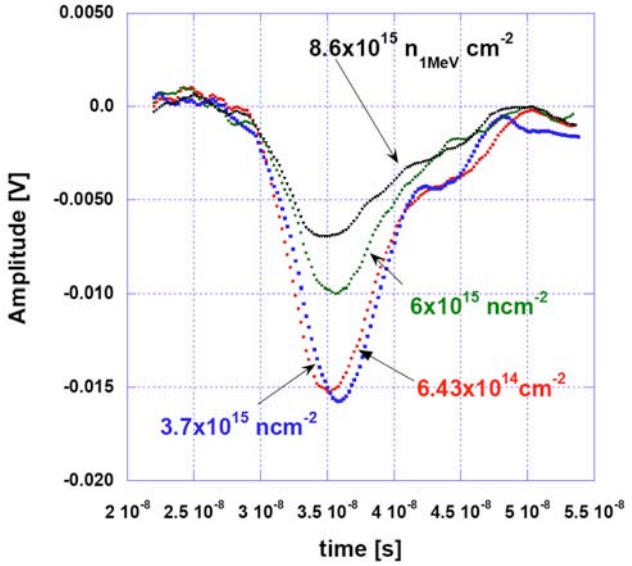


3D edgeless silicon (Brunel, Stanford, Hawaii)

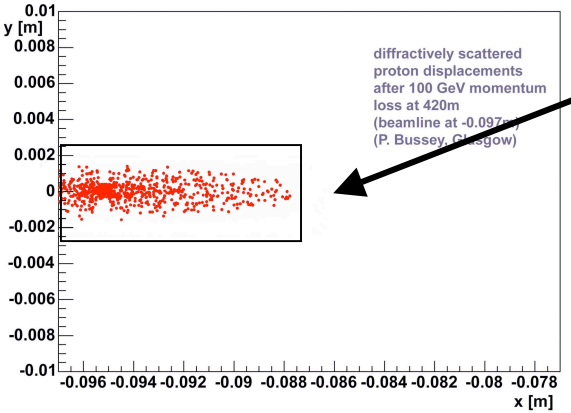
Fast timing < 20ps (FNAL, UTA, Alberta, Louvain)

$\sigma_{TOF}(z) \approx 4.2 \rightarrow 2.1$ mm

cf σ_z(interactions) ≈ 52 mm



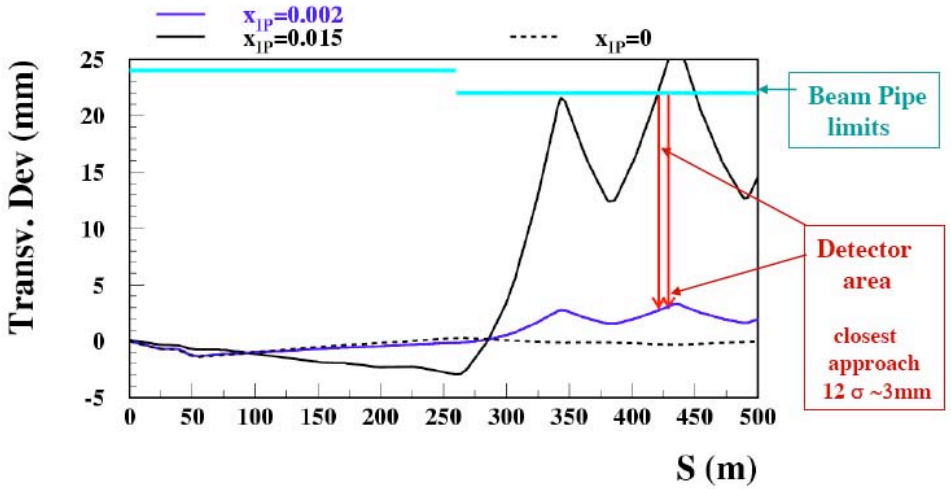
5 years at 10^{35} cm^{-2} s^{-1}

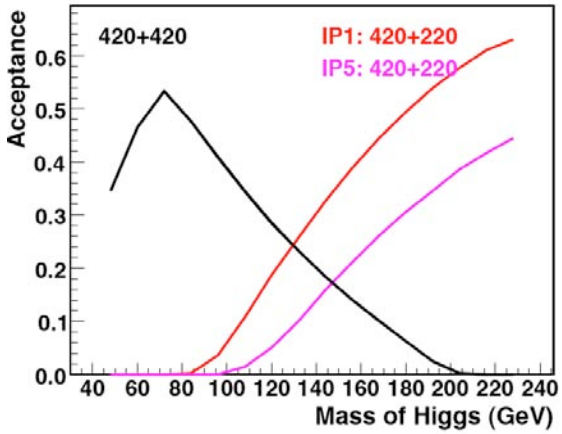


6mm x 24mm (7.2 x 8 mm^2 sensors)

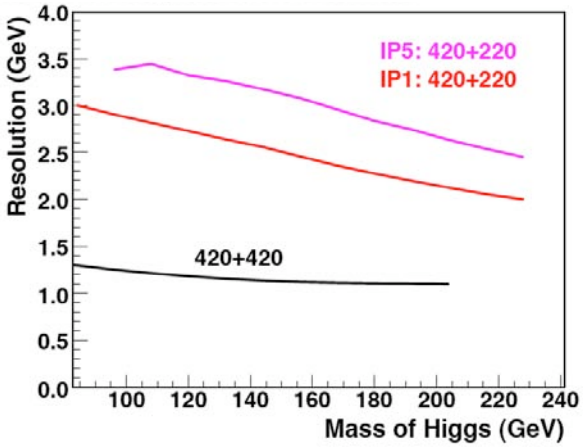
Hybrids (Manchester / MSSL)

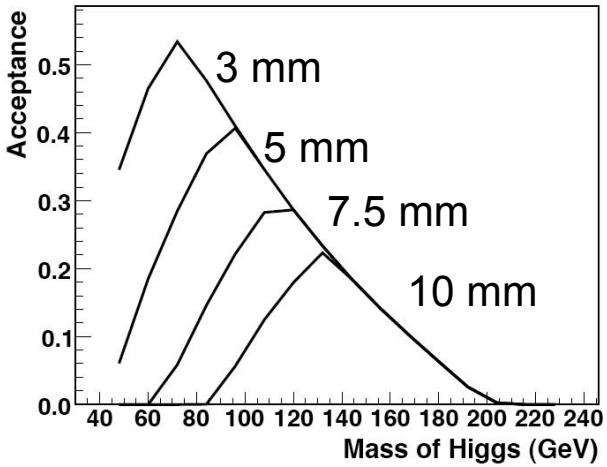
FP420 Acceptance and Resolution

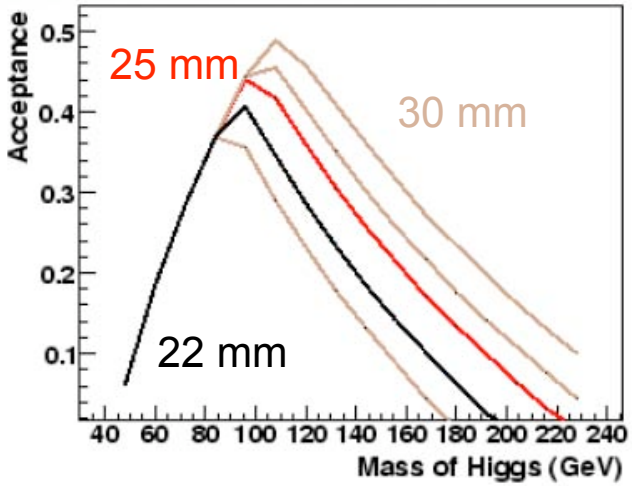




3 mm + 3 mm







MB apertures

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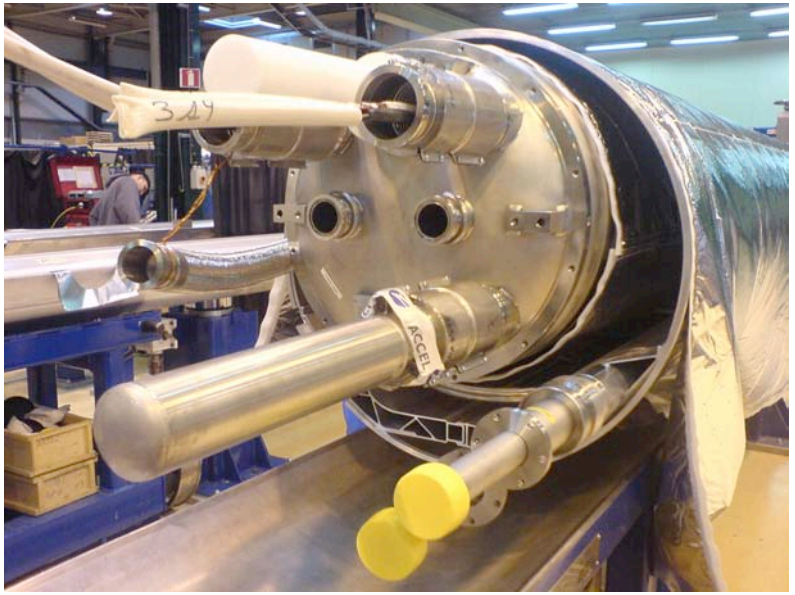
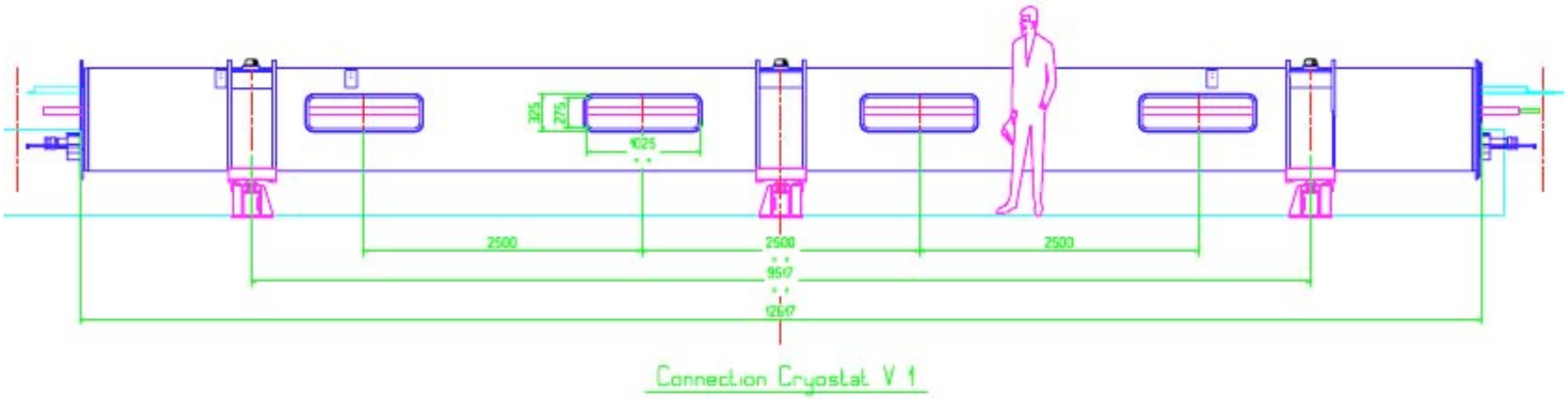
The 420m region at the LHC





Cockcroft Institute + CERN + Torino

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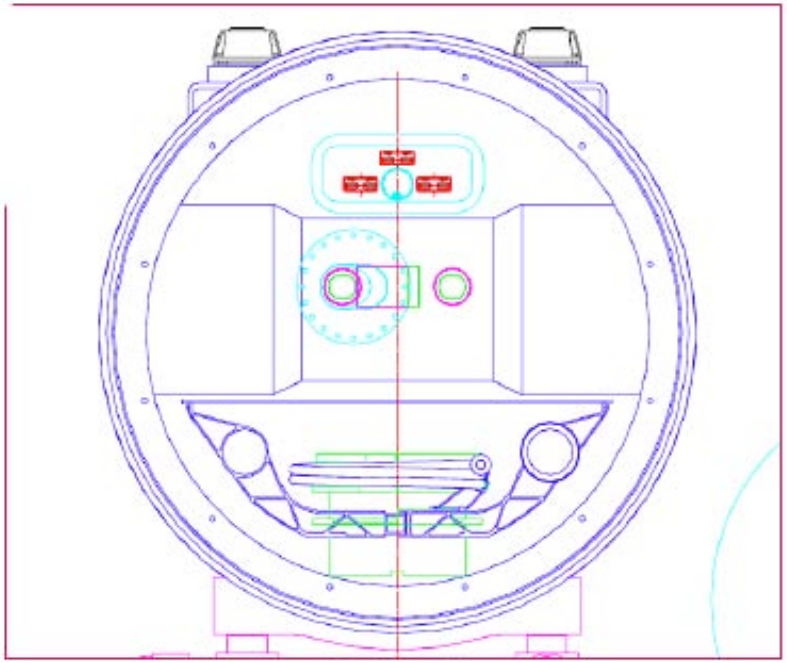
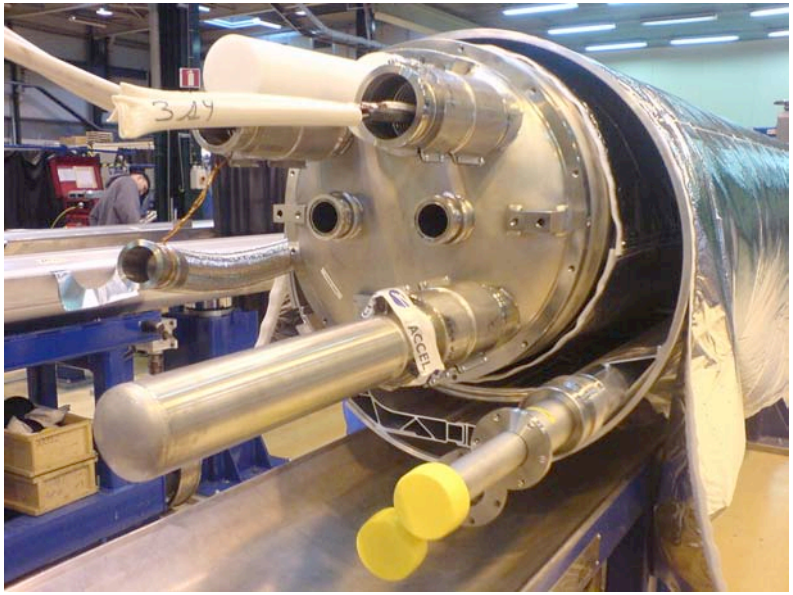
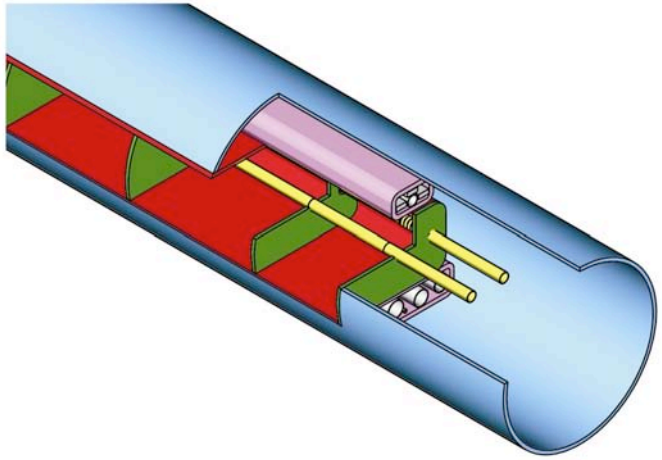
The 420m region at the LHC







Design underway with cryo-design effort from Cockcroft Institute (UK) + CERN design office funding (UK) and collaboration with CERN AT/CRI group (+ design effort from Torino)

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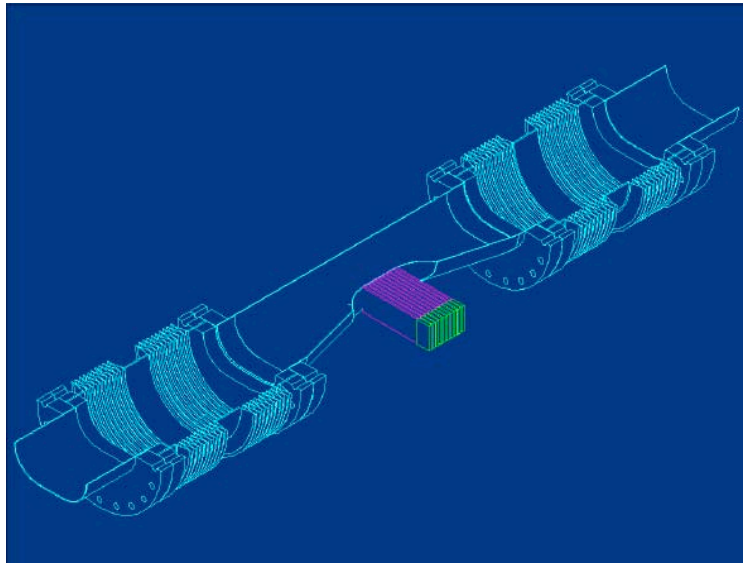
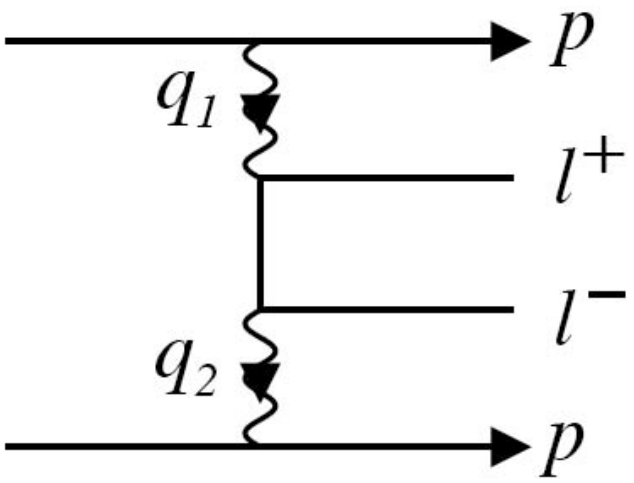
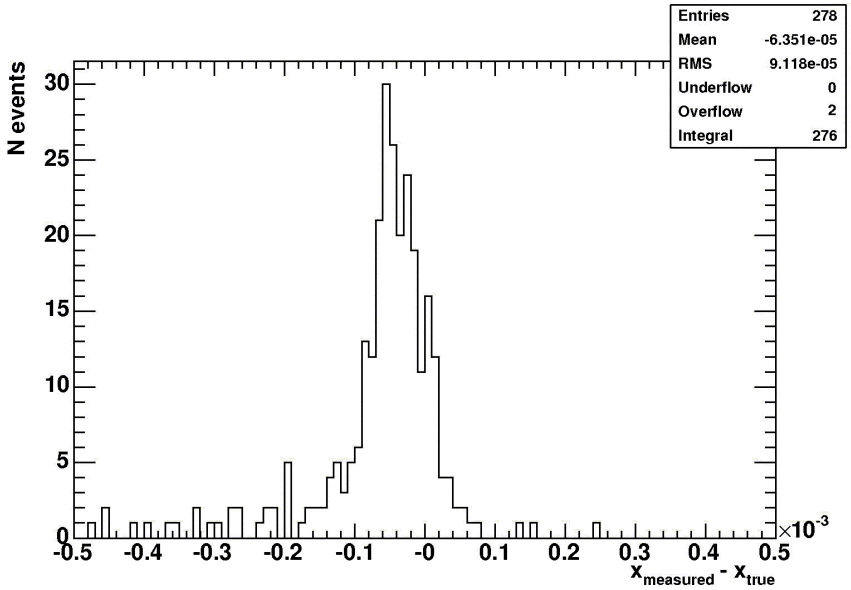
Movement Mechanism Designs



Louvain + Torino + Helsinki

FP420 alignment

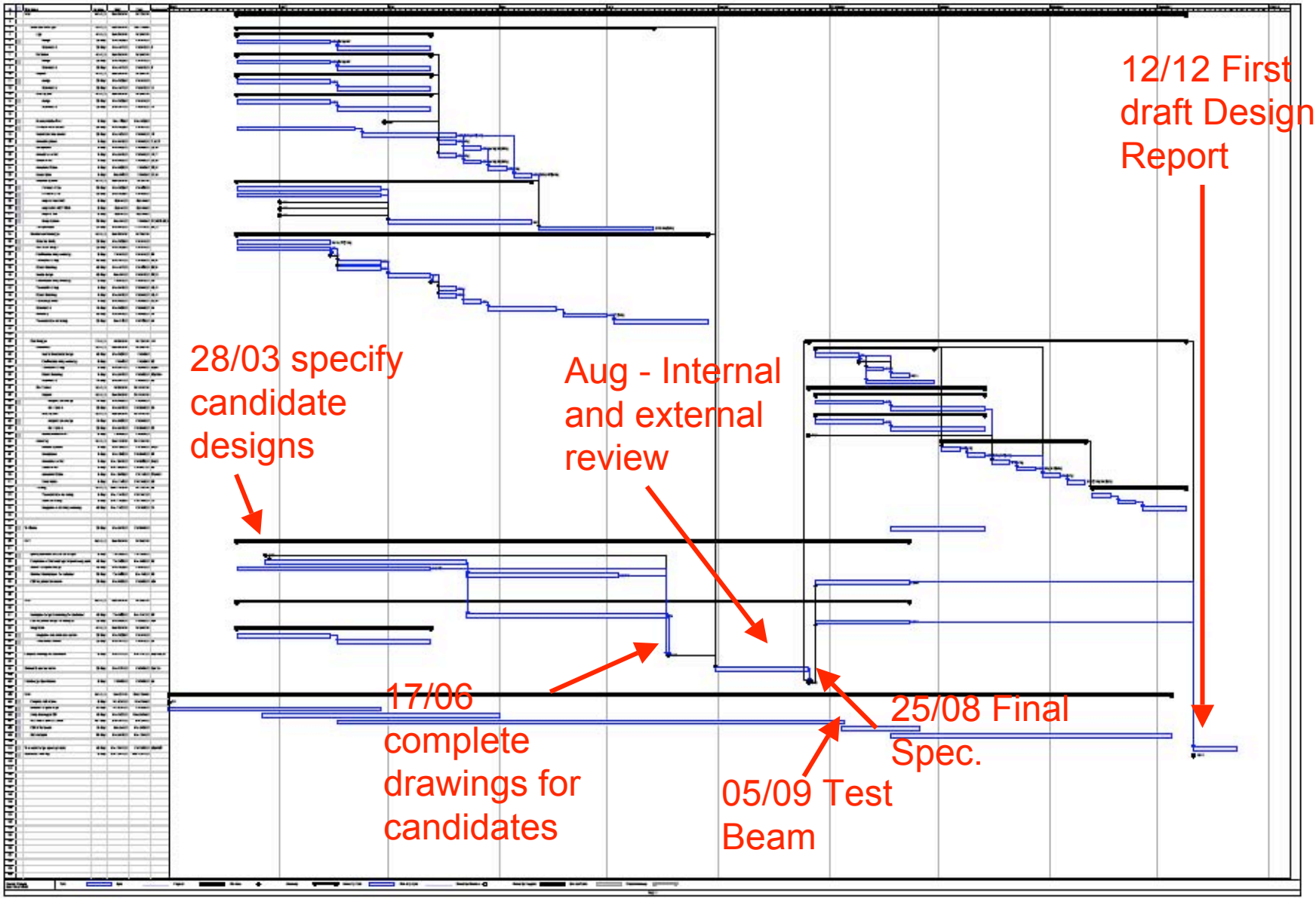




- @ 1 x 10^{33} cm^{-2} s^{-1} expect ~ 100 $\mu^+\mu^-$ events / fill with standard trigger thresholds
- Simulations (Louvain) indicate precision is better than necessary (theoretical limit is LHC beam energy uncertainty , σ_0 = 0.77 GeV ~ 50 microns)

(also $\gamma\gamma WW$, $M_{\gamma\gamma} > 300$ GeV, $\sigma \sim 100$ fb -> very high sensitivity to anomalous quartic couplings)

FP420 Key Milestones



FP420 Collaboration

FP420 : An R&D Proposal to Investigate the Feasibility of Installing Proton Tagging Detectors in the 420m Region at LHC

M. G. Albrow[1], T. Anthonis[2], M. Arneodo[3], R. Barlow[2,4], W. Beaumont[5], A. Brandt[6], P. Bussey[7], C. Buttar[7], M. Capua[8], J. E. Cole[9], B. E. Cox[2,*], E. A. De Wolf[5], C. DaVia[10], A. DeRoeck[11,*], J. Freeman[1], J. R. Forshaw[2], P. Grafstrom[11,+], J. Gronberg[12], M. Grothe[13] , G. P. Heath[9], V. Hedberg[14,+], B. W. Kennedy[15], C. Kenney[16], H. Kowalski[17], V. A. Khoze[18], Y. Liu[5], F. K. Loebinger[2], J. Lamsa[19], A. Mastroberardino[8], O. Militaru[5], D. M. Newbold[9,15], R. Orava[19], K. Osterberg[19], V. O'Shea[7], S. Parker[20], J. Pinfold[21], P. Petroff[22], K. Piotrzkowski[23], J. Rohlf[24], M. G. Ryskin[16], G. Snow[25], A. Sobol[25], A. Solano[12], M. Tasevsky[26], M. Rijssenbeek[27], L. Rurua[5], M. Ruspa[3], D. H. Saxon[7], W. J. Stirling[16], E. Tassi[8], P. Van Mechelen[5], S. J. Watts[10]

1. FNAL
2. The University of Manchester
3. University of Eastern Piedmont, Novara and INFN-Turin
4. The Cockcroft Institute
5. University of Antwerpen
6. University of Texas at Arlington
7. The University of Glasgow
8. The University of Calabria and INFN
9. Bristol University
10. Brunel University
11. CERN
12. Lawrence Livermore National Laboratory
13. University of Turin and INFN-Turin
14. University of Lund
15. Rutherford Appleton Laboratory
16. Molecular Biology Consortium
17. DESY
18. Institute for Particle Physics Phenomenology, Durham University
19. Helsinki Institute of Physics and University of Helsinki
20. University of Hawaii
21. University of Alberta
22. LAL Orsay
23. UC Louvain
24. Boston University
25. University of Nebraska
26. Institute of Physics, Academy of Sciences of the Czech Republic
27. Stony Brook University

We are at present reviewing FP420 membership, there are jobs still to be done.

Contacts :

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Albert.deroeck@cern.ch (CMS)

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FP420 Summary

• We have built a strong international collaboration with the manpower and expertise to deliver forward proton tagging at high luminosity to the LHC

•FP420 adds real discovery potential to ATLAS / CMS.

• 12 month R&D study fully funded from UK (and elsewhere) (~1000K CHF)

• Funding bids and significant manpower from Belgium, Italy, Germany, Finland, US, Canada

• Agreed list of key R&D areas (with CERN) to address machine safety issues and physics goals.

• Technical design by Feb 2007 (Manchester 2006) and (if successful) TDRs to LHCC from ATLAS / CMS spring 2007.

• First opportunity for installation is autumn 2008, dependent on LHC schedule.

• Physics returns potentially huge