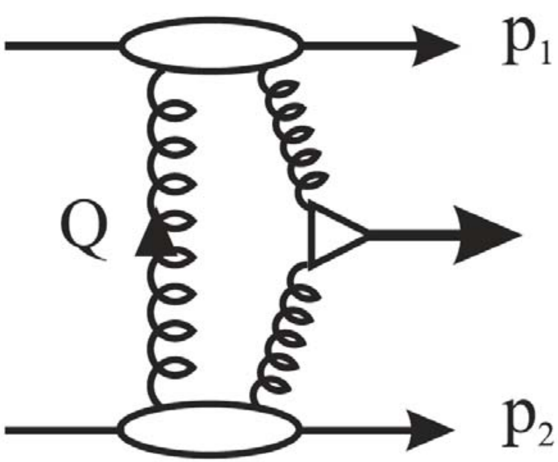
Status of FP420

Steve Watts – on behalf of FP420



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
- 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

1. Can we detect outgoing protons in interesting range of momentum loss ?
2. Can we use these protons to enhance the discovery potential of ATLAS and CMS ?

FP420 R&D Funding (ATLAS & CMS) :

"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)

R&D now fully funded : £500k from UK (Silicon, detector stations, beam pipe + LHC optics and cryostat design), $100k from US (QUARTIC, Andrew Brandt/UTA), €100 Belgium (+Italy / Finland) (mechanics)

FP420 R&D Collaboration

- Spokespersons : Brian Cox (Manchester, ATLAS) and Albert DeRoeck (CERN,CMS)
- Technical Co-ordinator : Cinzia DaVia (Manchester)

Collaboration : FNAL, The University of Manchester, University of Eastern Piedmont, Novara and INFN-Turin, The Cockcroft Institute, University of Antwerpen, University of Texas at Arlington, The University of Glasgow, University of Calabria and INFN-Cosenza, CERN, Lawrence Livermore National Laboratory, University of Turin and INFN-Turin, University of Lund, Rutherford Appleton Laboratory, Molecular Biology Consortium, Institute for Particle Physics Phenomenology, Durham University, DESY, Helsinki Institute of Physics and University of Helsinki, UC Louvain, University of Hawaii, LAL Orsay, University of Alberta, Stony Brook University, Boston University, University of Nebraska, Institute of Physics, Academy of Sciences of the Czech Republic, Brookhaven National Laboratory, University College London, Cambridge University

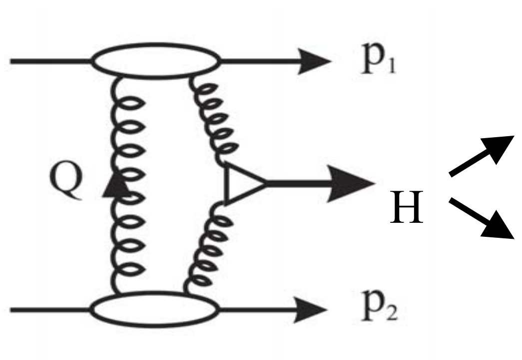
Note also Roman Pots at 220 m from IP1 and IP5 - TOTEM and FP220. Combined 220/420 systems have improved acceptance. Need to upgrade 220m systems to operate at full LHC luminosity.

NOTE……………

Thanks to Brian Cox, Cinzia DaVia for many of the slides.

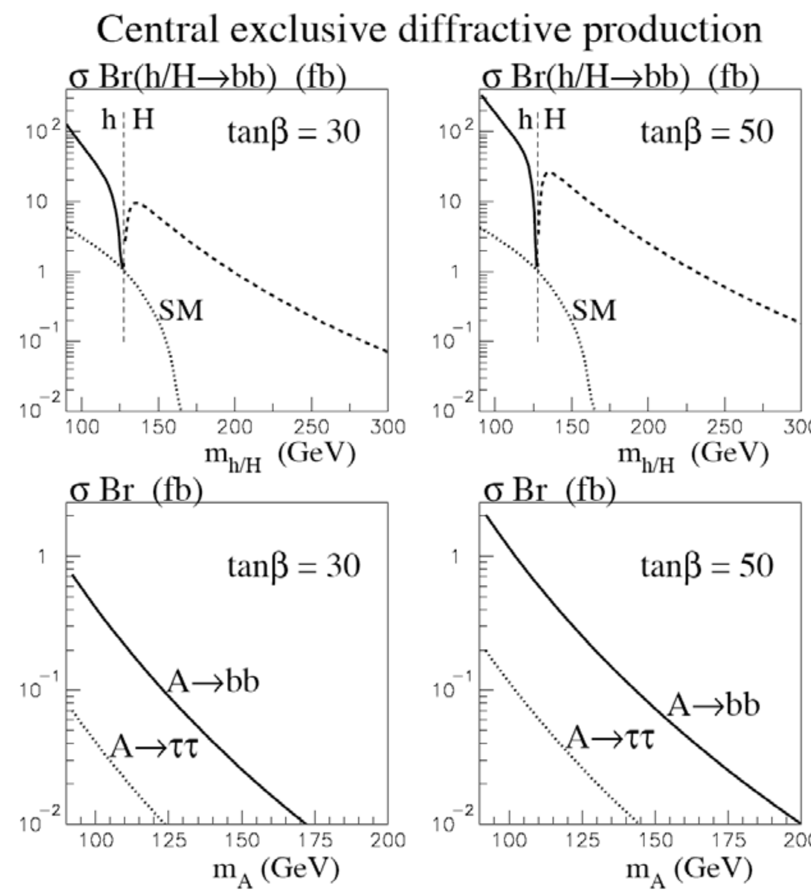
Group contributions noted on relevant slides

Prime Motivation : Higgs Production



0++ Selection rule

QCD Background ~ $\frac{m_b^2}{E_T^2}\frac{\alpha_S^2}{M_{b\bar{b}}^2 E_T^2}$



Higgs Quantum Numbers / mass resolution

WW* : M_H = 120 GeV $\sigma = 0.4$ fb

M_H = 140 GeV $\sigma = 1$ fb

M_H = 200 GeV $\sigma = 0.5$ fb

M_H = 140 GeV : 5 (10) signal (1 (2) "gold platted" dl), very small backgrounds in 30 fb^{-1}

B.E. Cox. et al, Eur. Phys. J. C 45, 401-407 (2006)

M_A = 130 GeV, tan β = 50

M_h = 124 GeV : 71 signal in 30 fb^{-1}

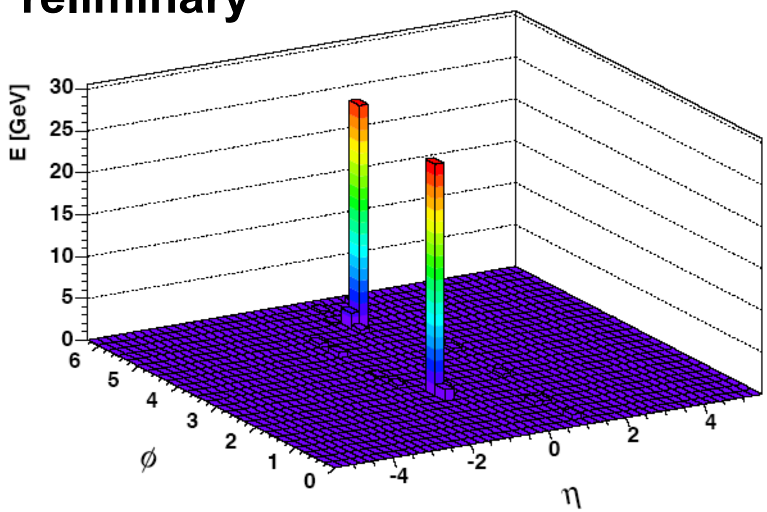
M_H = 135 GeV : 124 signal in 30 fb^{-1}

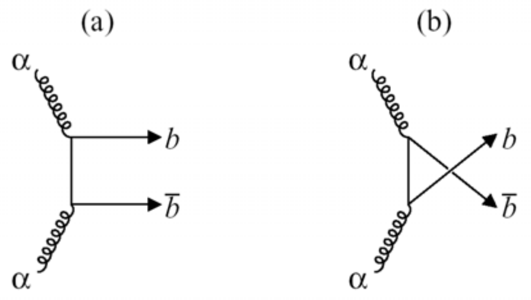
M_A = 130 GeV : 1 signal in 30 fb^{-1}

A. B. Kaidalov. et al, Eur.Phys.J. C33 (2004) 261-271

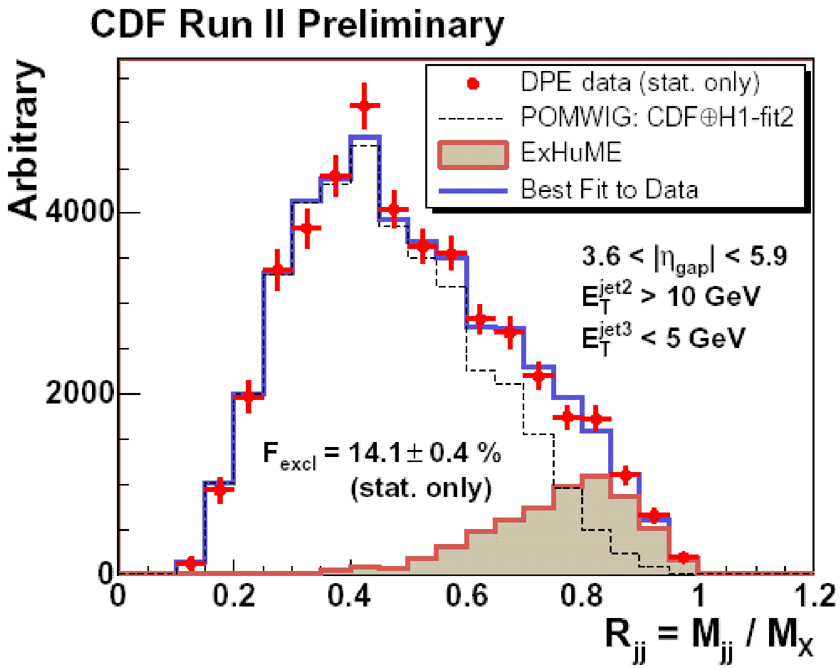
Evidence for Exclusive Production at Tevatron

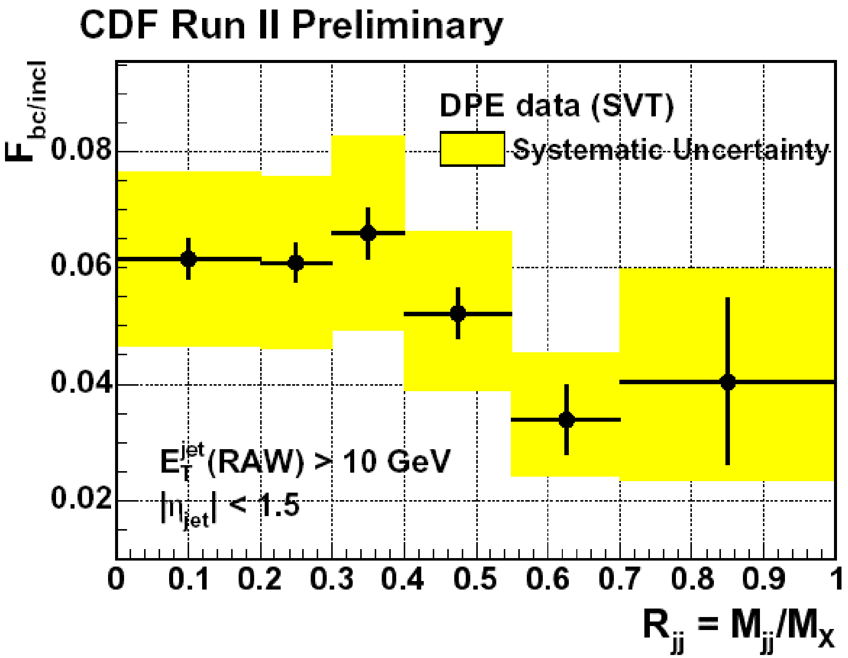
D0 Preliminary





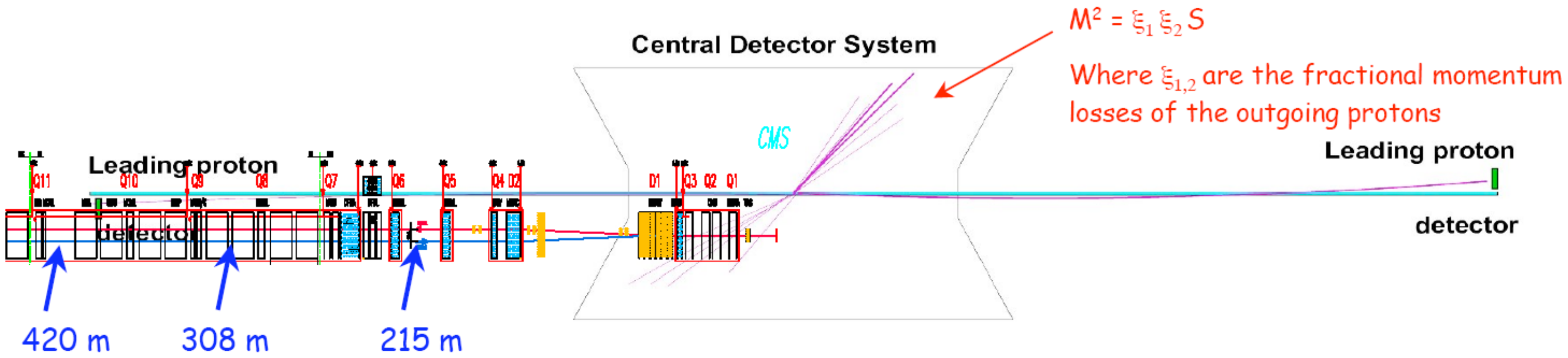
J_Z=0 -> for colour singlet bbar production, the born level contributions of a) and b) cancel in the limit m_b -> 0

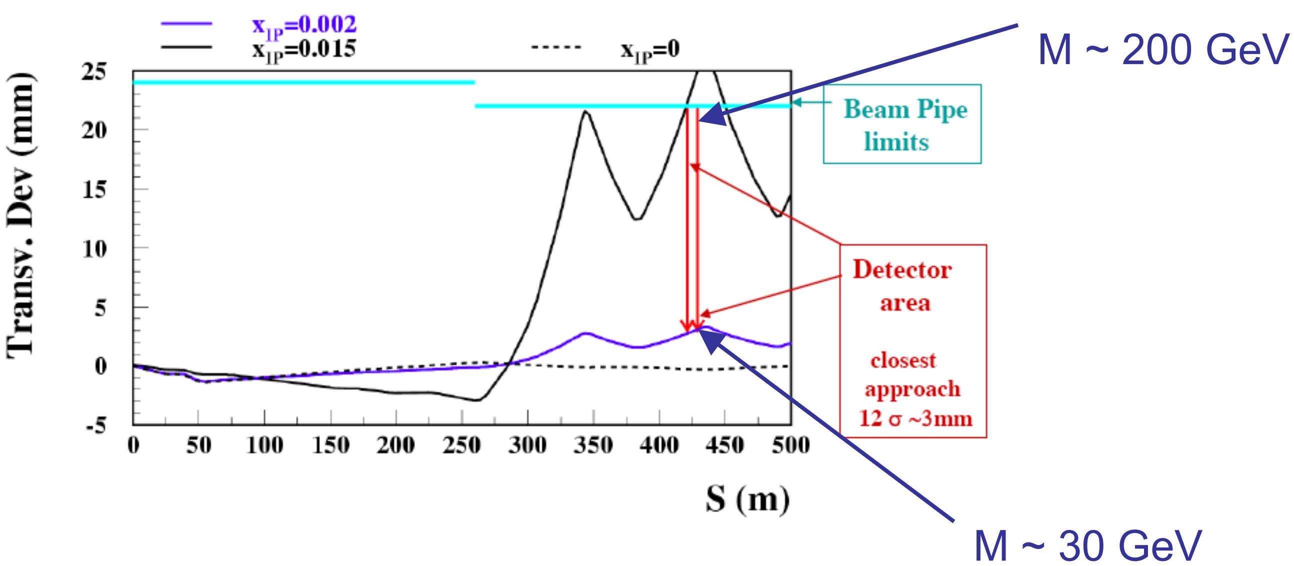




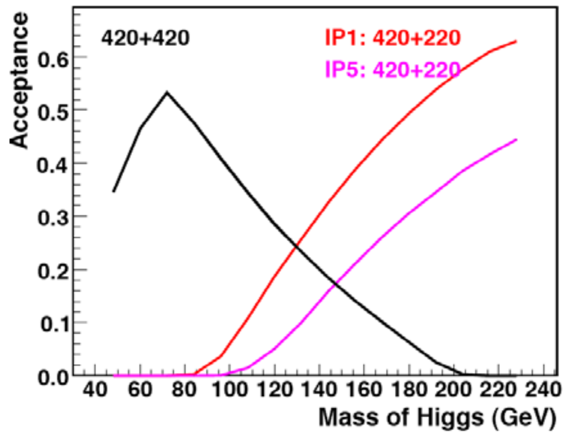
Schematic Outline

Spectrometer using LHC magnets to bend protons with small momentum loss out of the beam

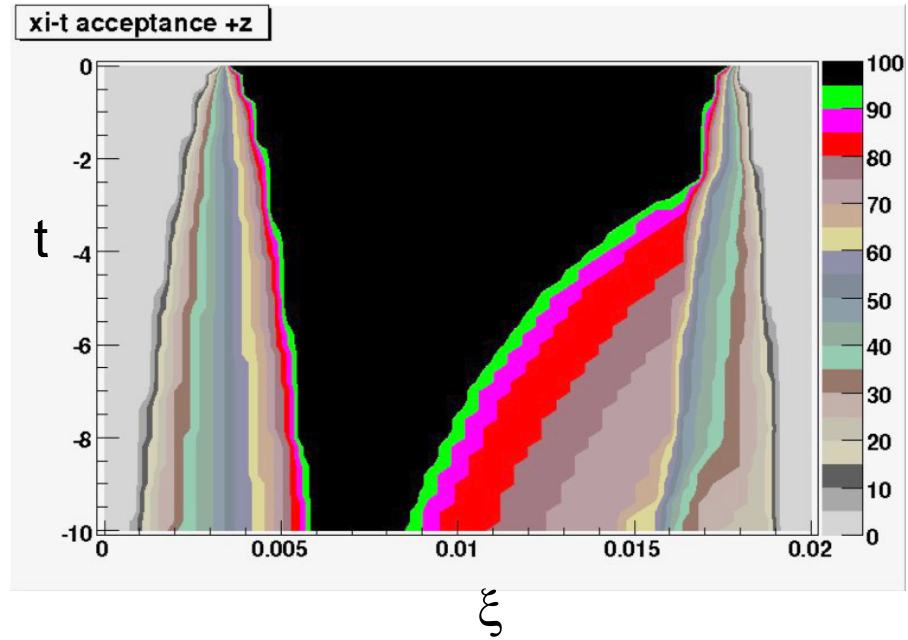


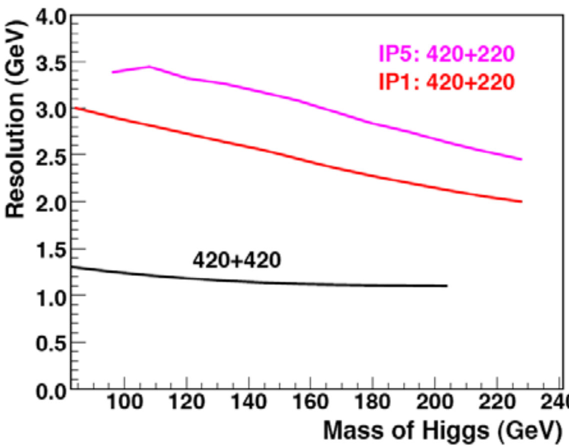


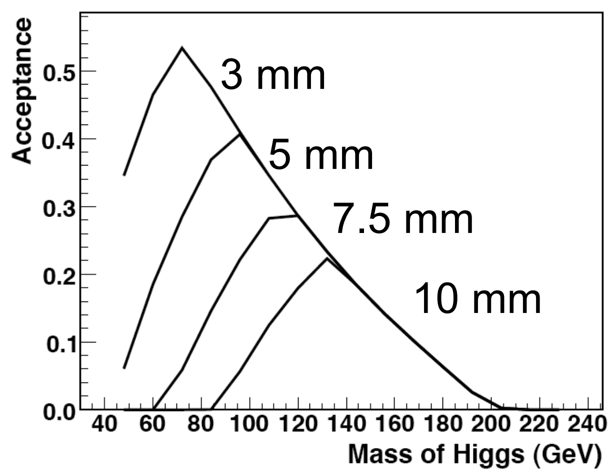
Acceptance and Resolution

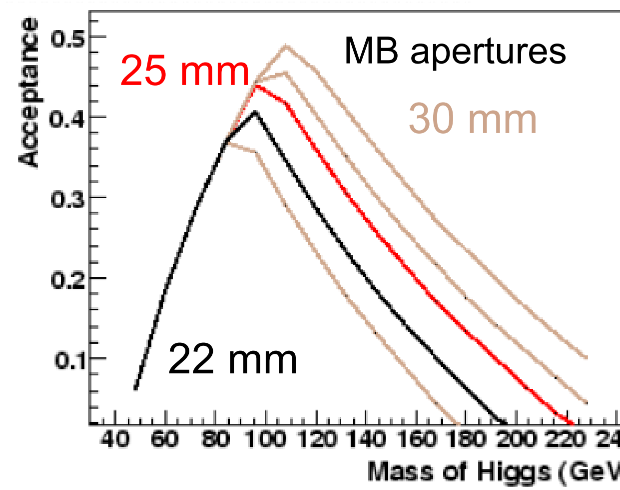


3 mm + 3 mm



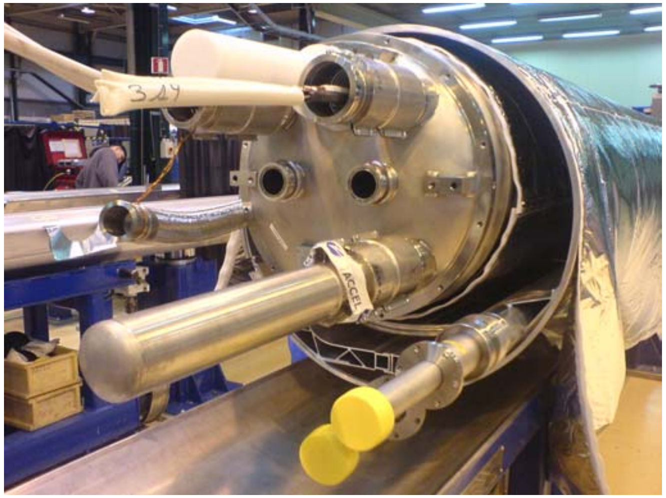


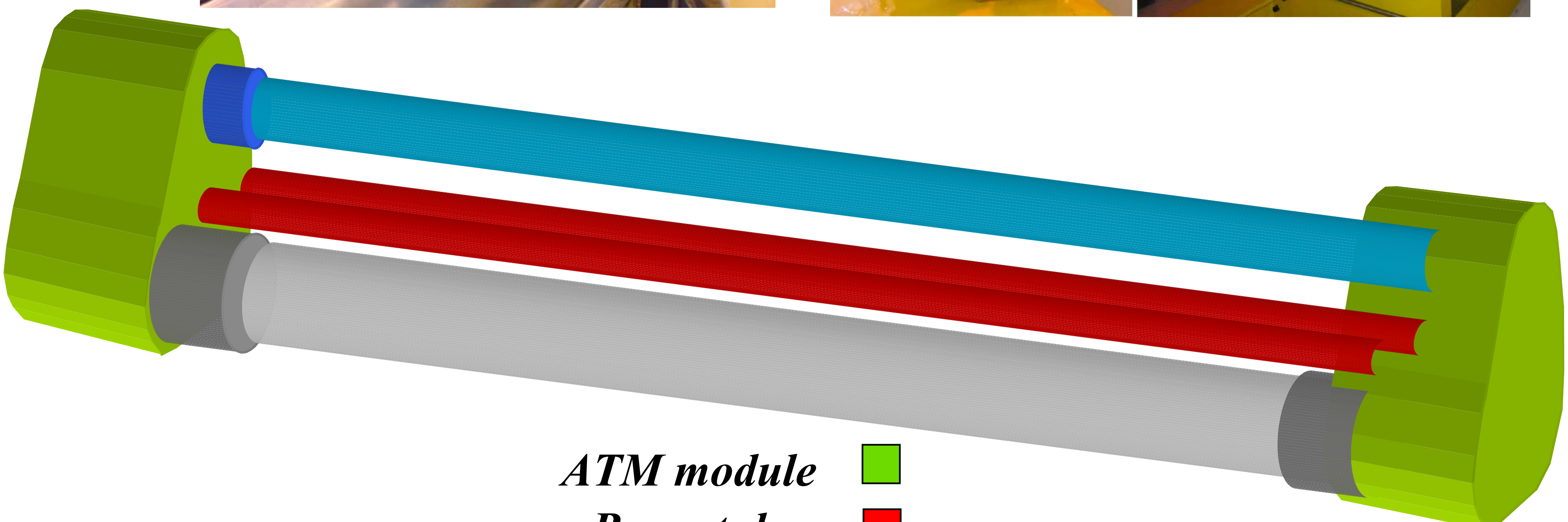




Plots : P. Bussey / W. Plano using ExHuME / FPTrack / FPTrack++

FP420 Connection Cryostat





ATM module

Beam tubes

Line X vacuum vessel

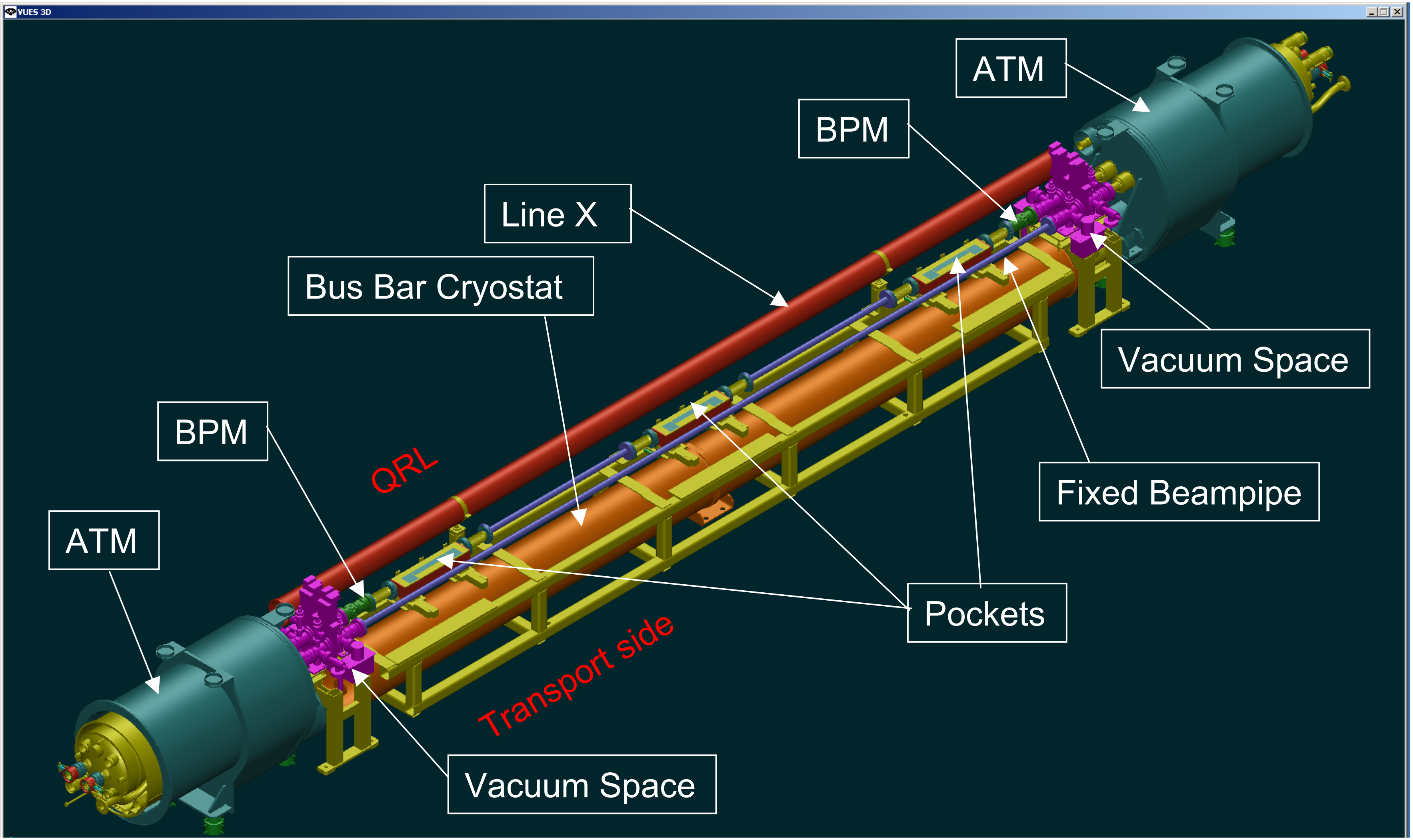
Connection Module

T. Colombet (At-Mcs)

T. Renaglia,

R. Folch

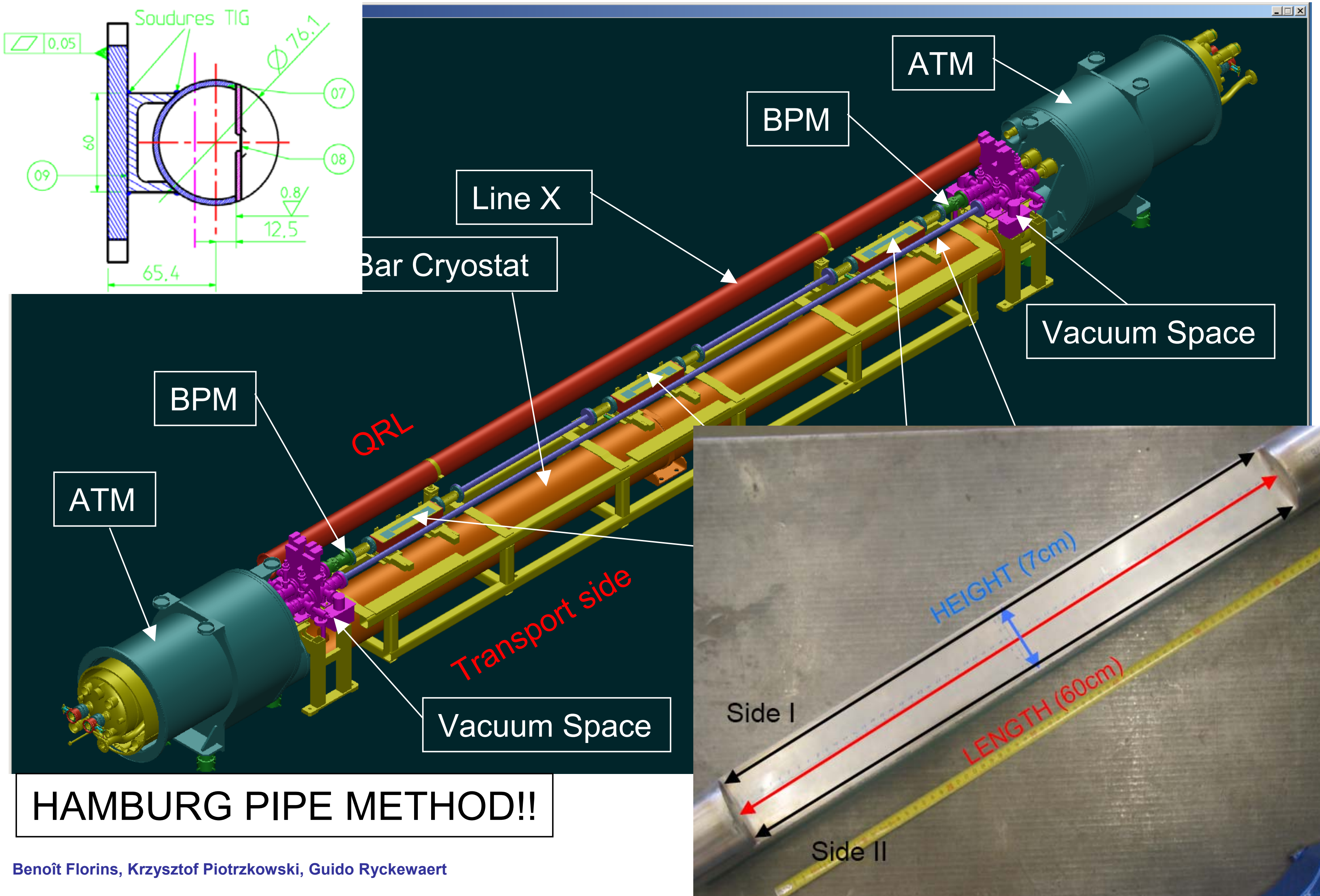
Integration of the moving beampipe and detectors



Benoît Florins, Krzysztof Piotrzkowski, Guido Ryckewaert

CRC
Louvain-la-Neuve

Integration of the moving beampipe and detectors

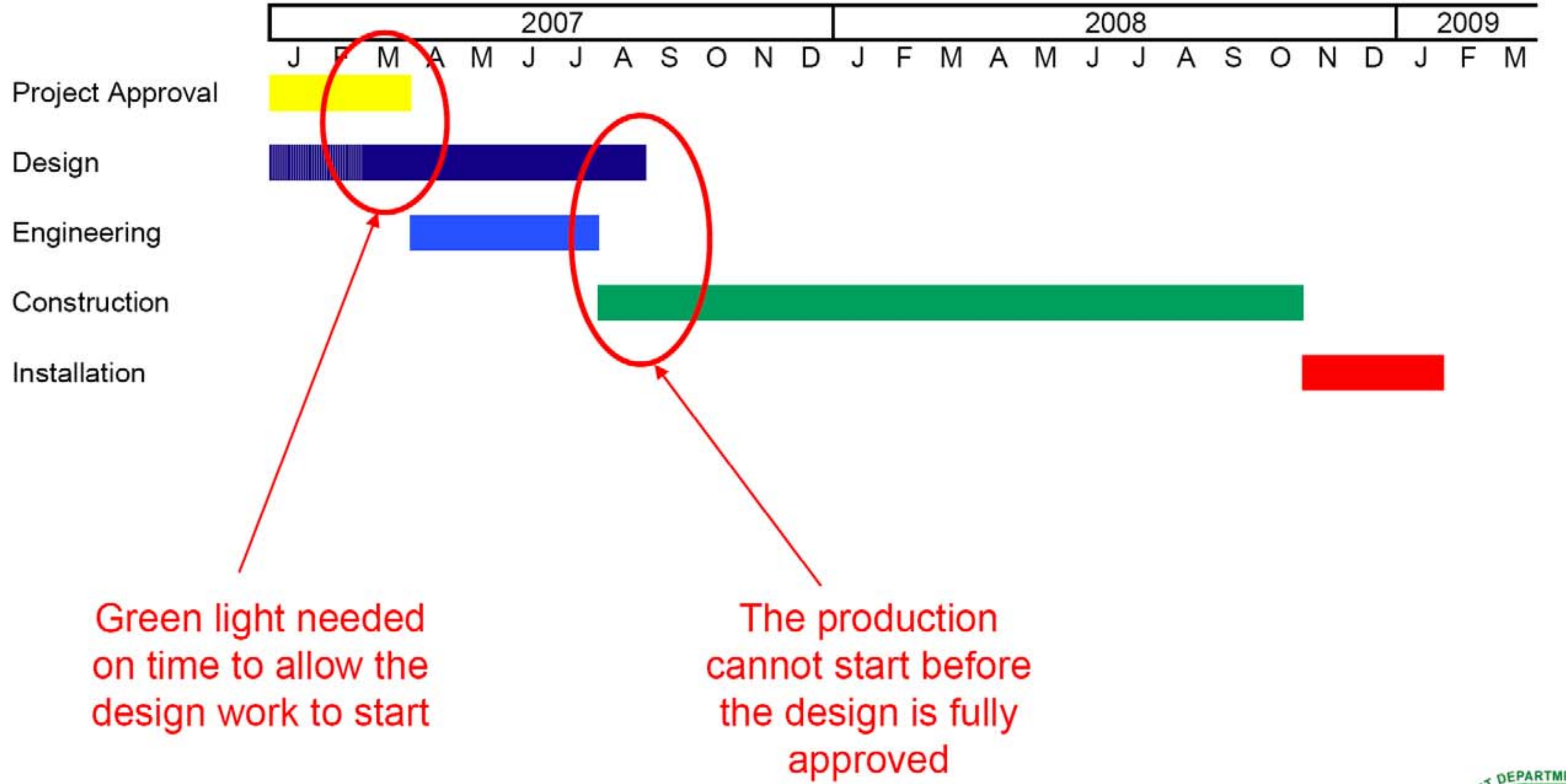


HAMBURG PIPE METHOD!!

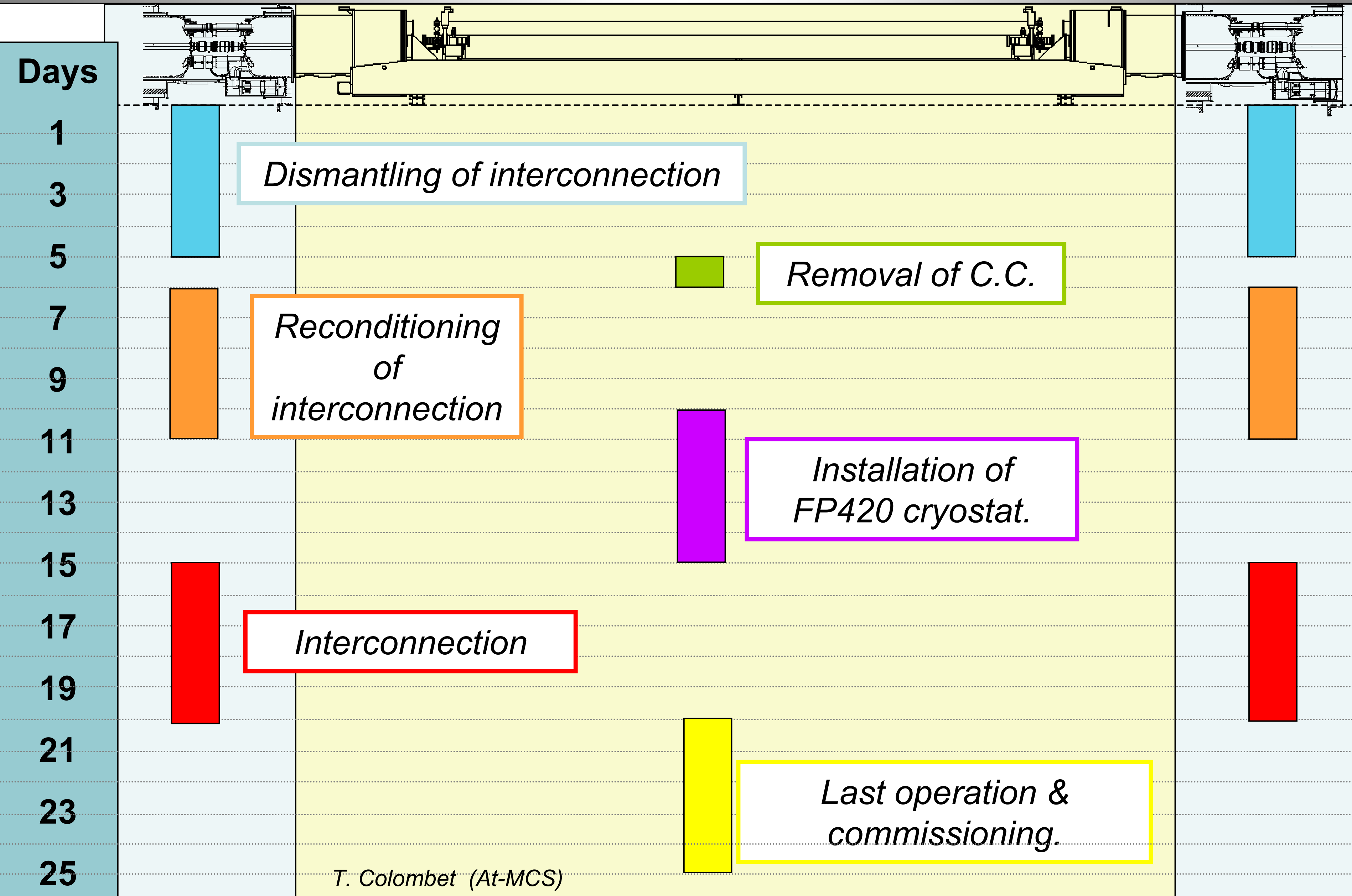
Benoît Florins, Krzysztof Piotrzkowski, Guido Ryckewaert

FP420 Connection Cryostat

Schedule projection attempt



Preliminary planning of interconnection:



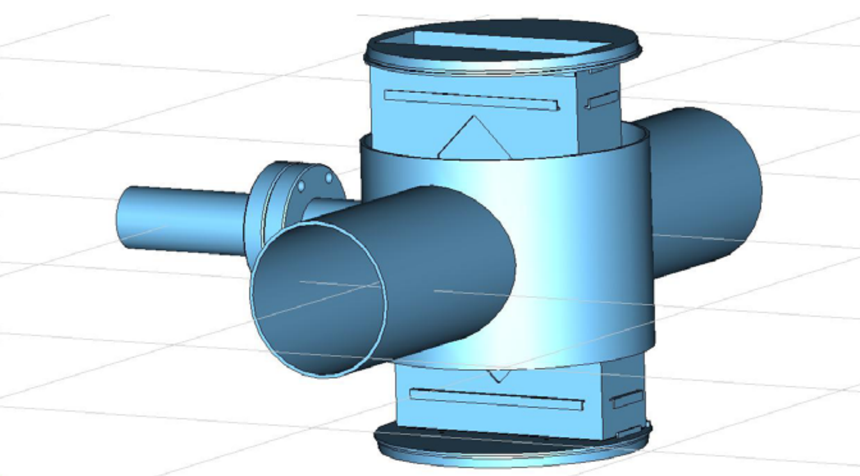
T. Colombet (At-MCS)

RF and Impedance tests

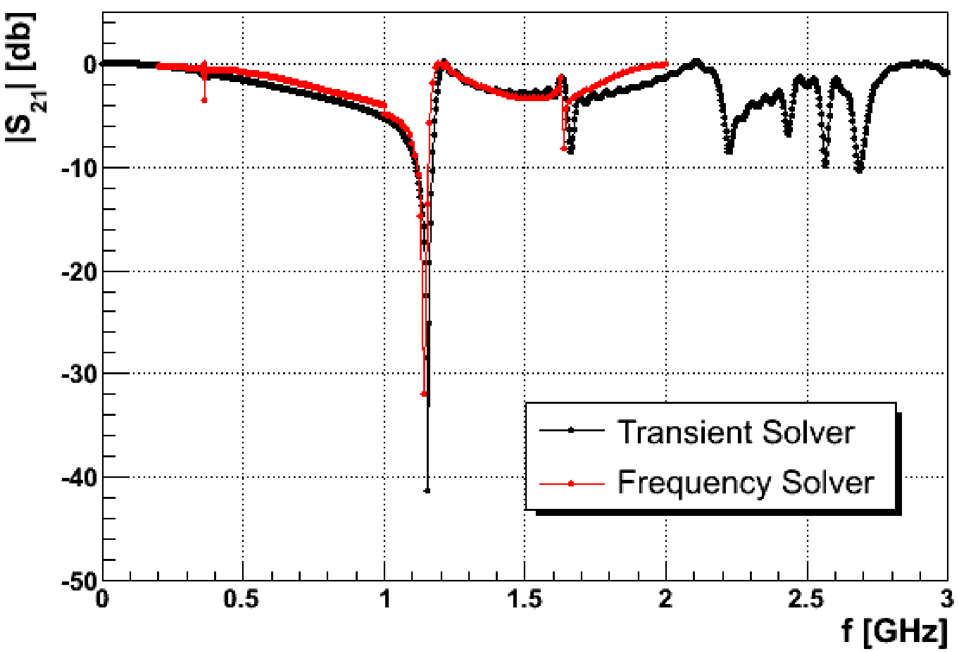
- Numerical simulations - in progress
  - Longitudinal and transverse impedance
  - Fields distribution
  - Energy exchange with pot materials

- Laboratory measurements - to be organized according to prototype production
  - Longitudinal and transverse impedance - benchmark of simulations
  - Pick-up signal at detector electronics level -very difficult to simulate

ATLAS Luminosity Pot



Simulations with CST Microwave Studio   130μm, 10σ



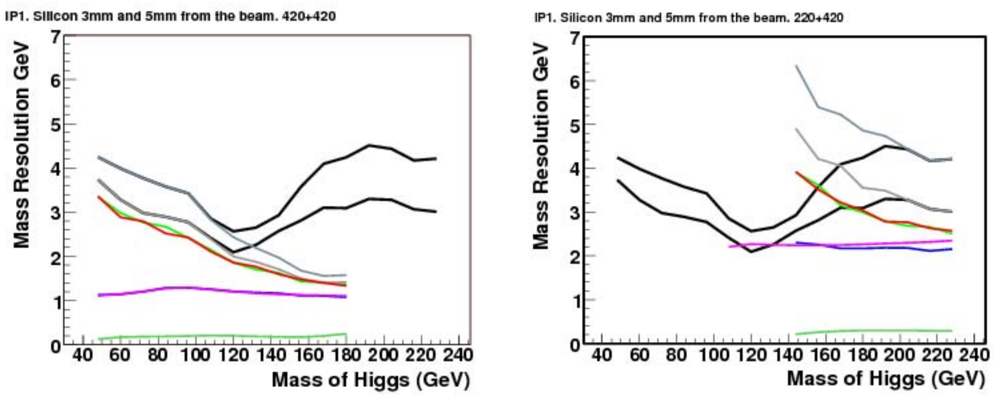
F. Roncarolo

FP420 TRACKING - REQUIREMENTS

- **MUST GET CLOSE TO THE BEAM**
- **EDGELESS DETECTOR**
- **VERY RADIATION HARD – have to operate at full luminosity**
- **FAST**

Few micron precision in each detector and

system angular precision of around 1 μrad



Lower to Higher curves…

No smear

Primary proton mom. (0.77GeV)

10 micron beam spot

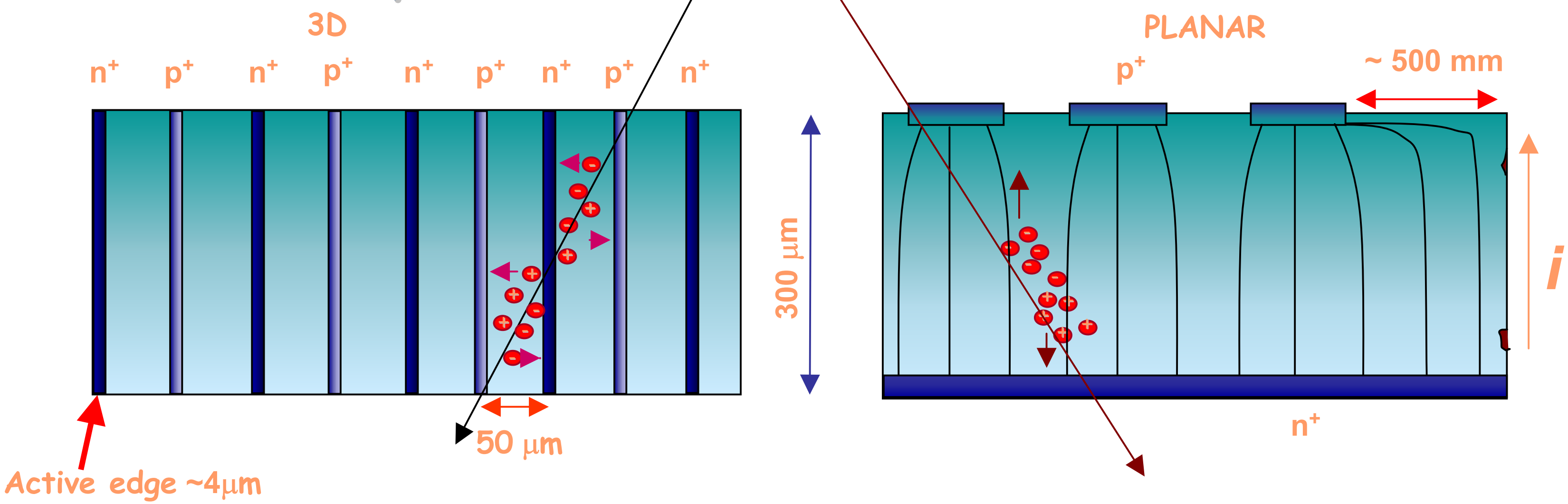
1 and 2 μrad smear in tracking

Figure 6: Mass resolutions obtainable in ATLAS for the 220 m region and for the 420 m region. For explanation, see text

P. Bussey

3D Silicon Detector Development

3D versus planar



Manchester/Stanford/MBC

3DC Collaboration

Transfer to Industry in

progress – SINTEF

Also support from Bonn/LBL/Prague

Note: 3D ATLAS R&D Collaboration forming

	3D	planar
V_{dep}	< 5-10 V	50-70 V
Q_{1mip}	24000e⁻	24000e⁻
C	40-80fF	50-200fF

Yield + Large area : FP420/Atlas pixel

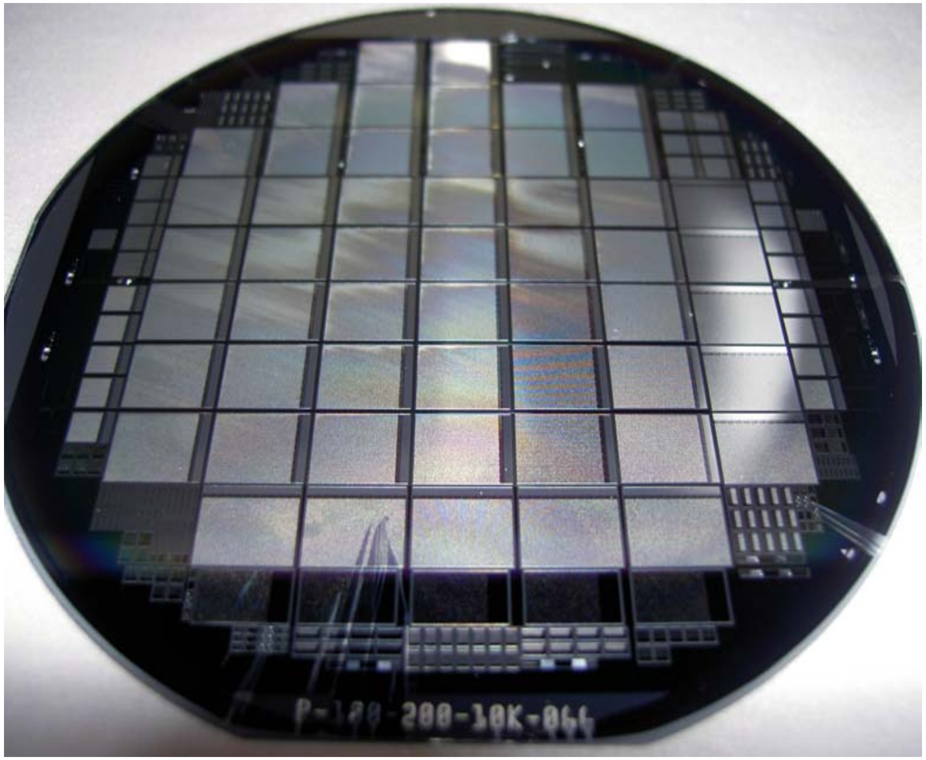
Pixel size

DIMENSIONS	RO SIGNAL	Technology	BUFFER/speed
50x400 μm^2 7.2x8mm^2	binary and time over threshold	0.25 μm IBM CMOS6SF	2 - 6.4μs 40 MHz

Atlas chip picture from Bekerle Vertex03

- -32 3E ATLAS Single Chips
- -6 4E ATLAS Single Chips
- -6 2E ATLAS Single Chips
- -Quarter Size ATLAS Chips
- -ATLAS Test Structures
- -Other structures

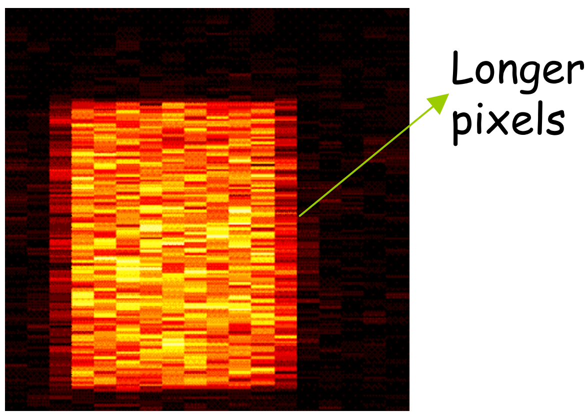
Thickness <250 μm>
p-type substrate 12kΩcm



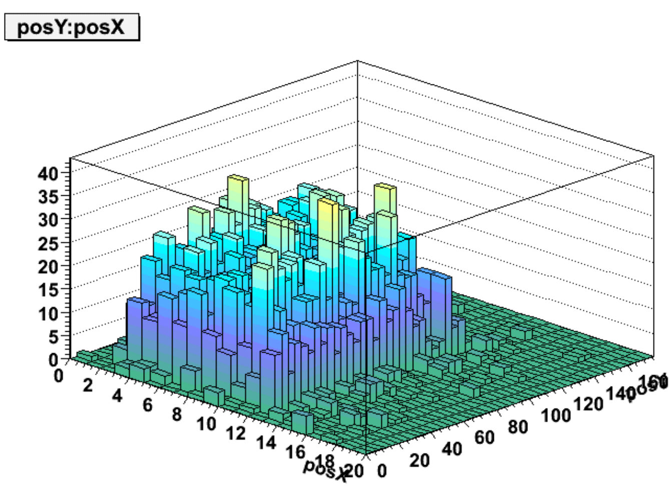
10 wafers completed : Yield on one wafer ~80%

3D-2E-A preliminary

V_{bias}=30V Threshold=4000e^-

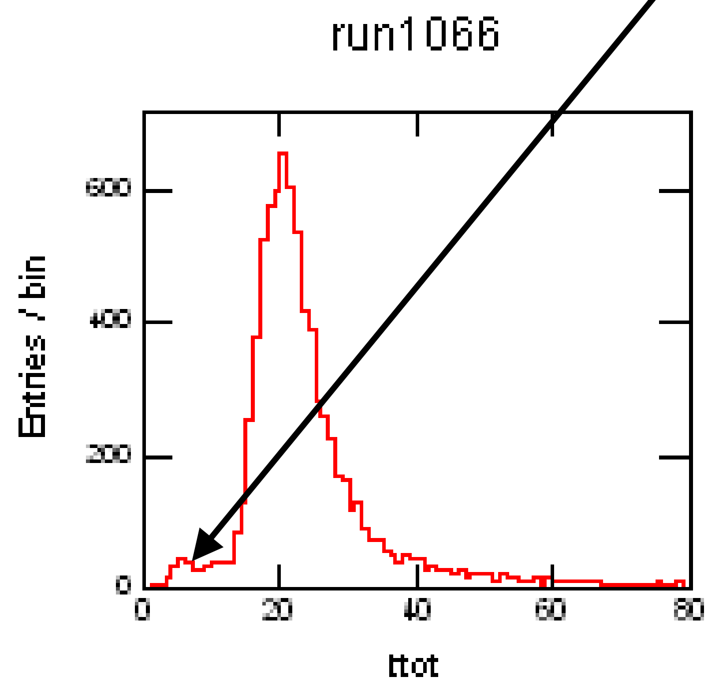


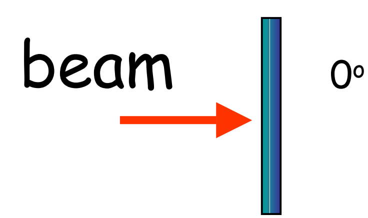
hitmap with the 12x12 mm² trigger



hitmap with the 3x3 mm² trigger

Track through electrode ?

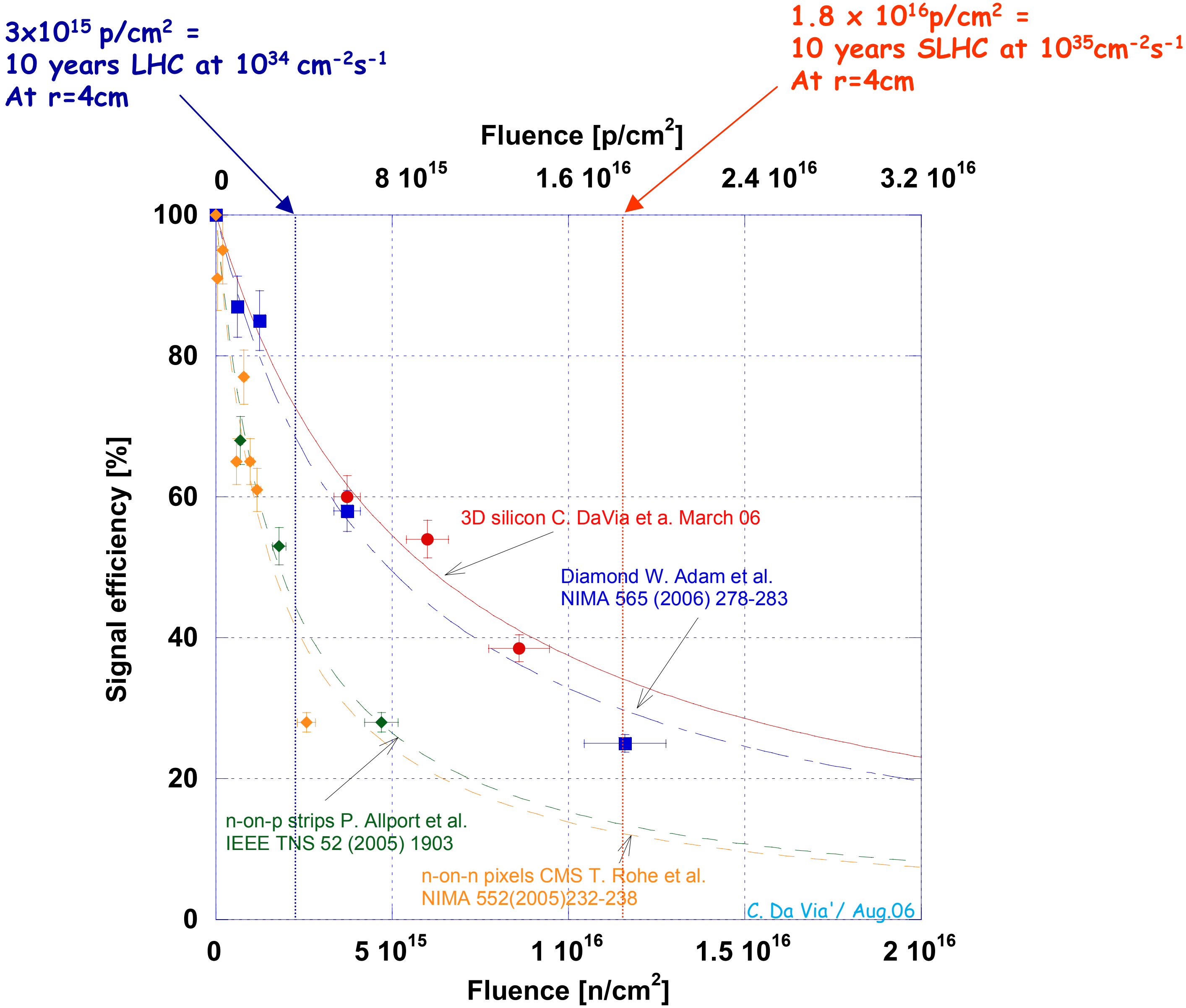


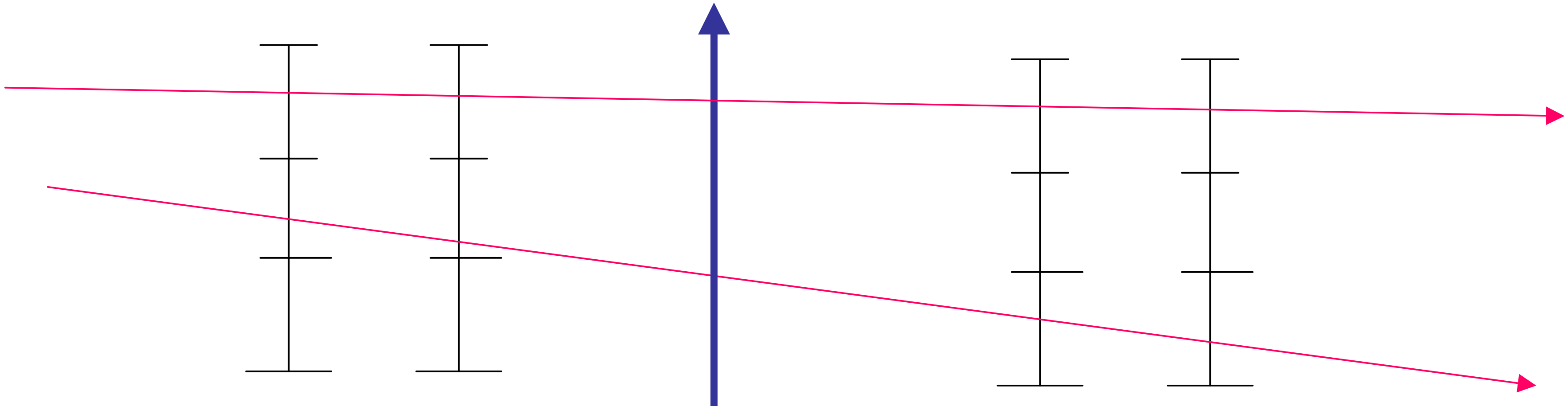


3D Group + Bonn + LBL

Radiation Hardness

Cinzia DaVia – Hiroshima Conf. 2006





Choose a reference point mid-point between two stations

Minimises the error

$\Delta x = \sigma/\mathrm{sqrt}(N)$ $\delta\theta = \delta x . z_{ref}$

BUT only if points are uncorrelated.

This is not true as the tracks have small angle

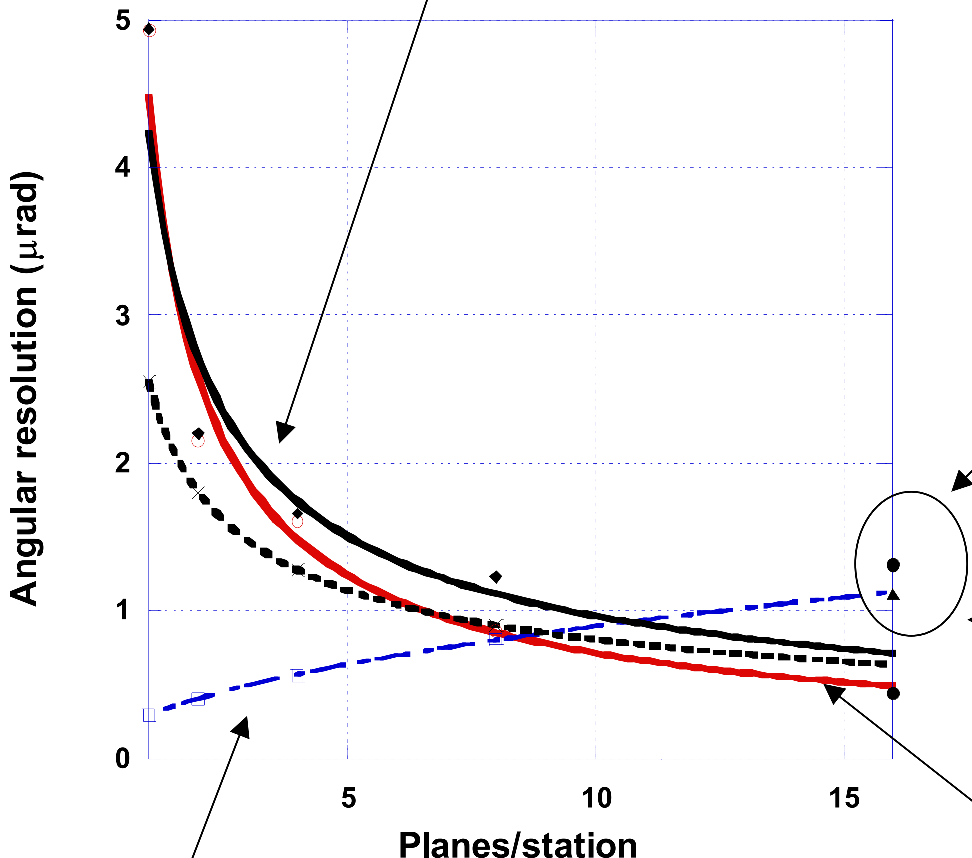
Can improve matters by offsetting alternate layers by 0.5 of the pitch.

Pitch + Multiple Scattering

"Shifted" Tracker

Note: 0.7% Xo per plane

16 plane/station tracker
Is NOT better



Design Goal

Multiple scattering only

Pitch only

Also confirmed by

Alexander Zhokin

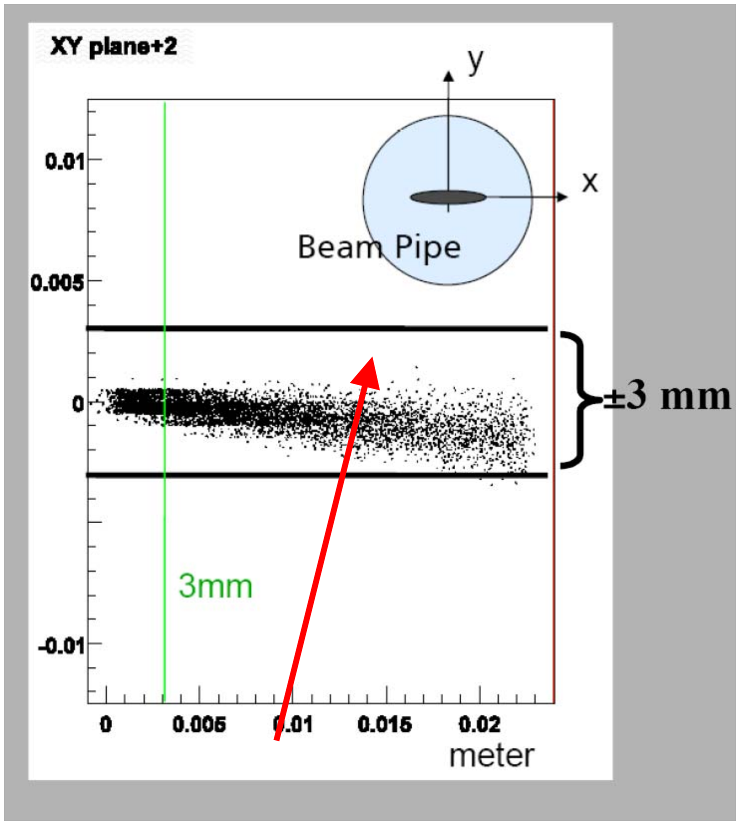
GEANT calculations.

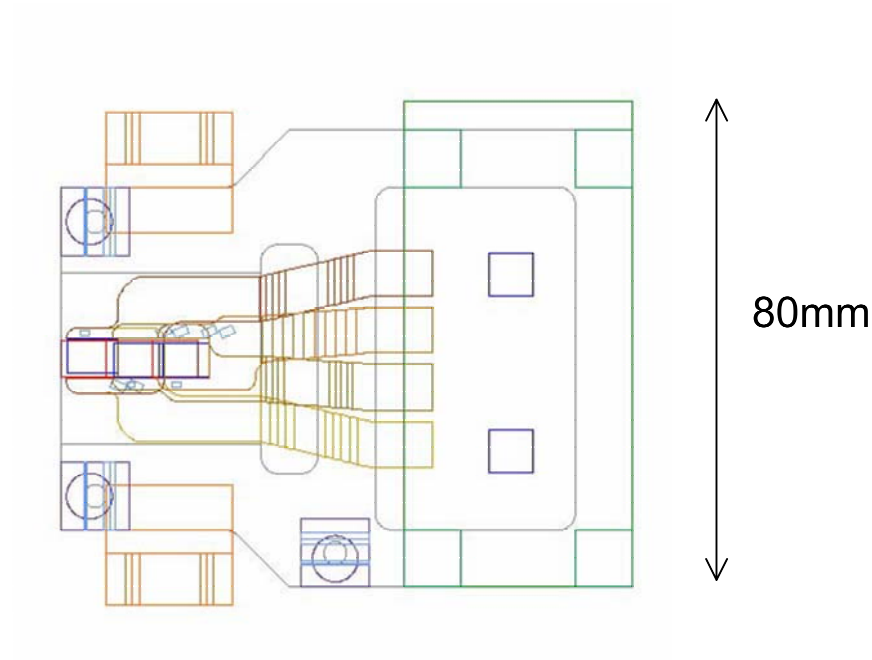
Multiple scattering takes over after 8-10 planes/station
Do not forget about secondary interactions – 0.2% per layer

MANCHESTER 1824

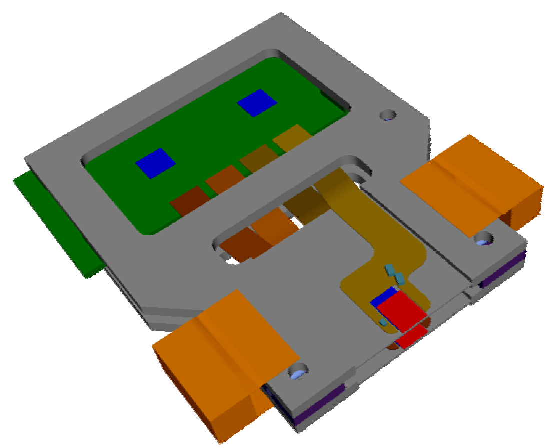
The University of Manchester

FP420 Silicon Detector Stations

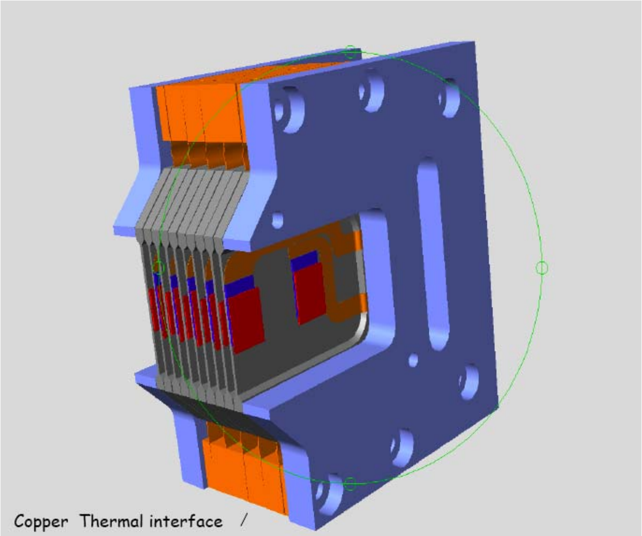


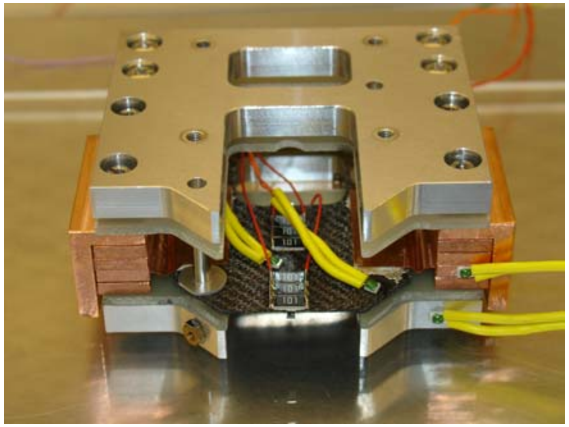


7.2 mm x 24mm (7.2 x 8 mm^2 sensors)



FP420 Silicon Detector Stations

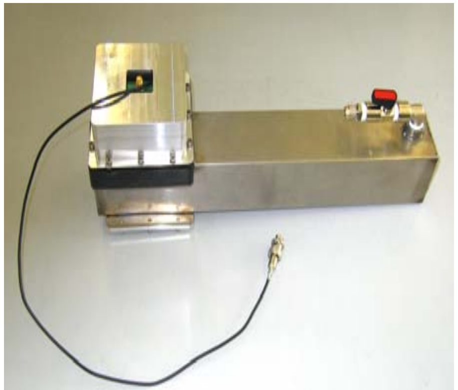




TEST BEAM AT CERN IN SEPTEMBER 2007

UTA / Alberta / FNAL / Louvain

FP420 Fast timing Detectors

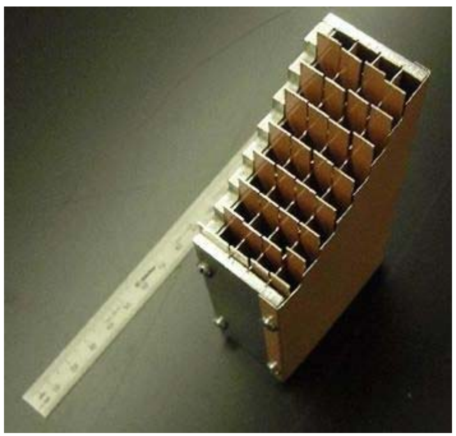


Why ? Pileup Background Rejection

E.g., Two protons from SD interactions, and two b-jets from another

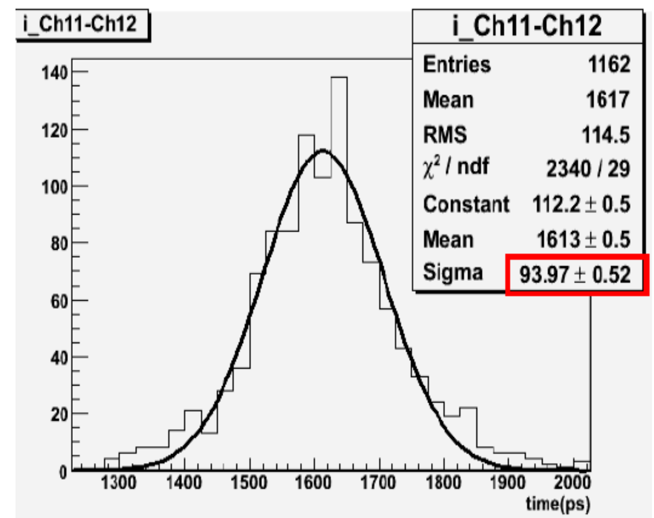
How? Compare z-vertex for SVX with TOF

10 psec -> x40 rejection



Expect 30ps with new electronics in March testbeam

T958 (FNAL)

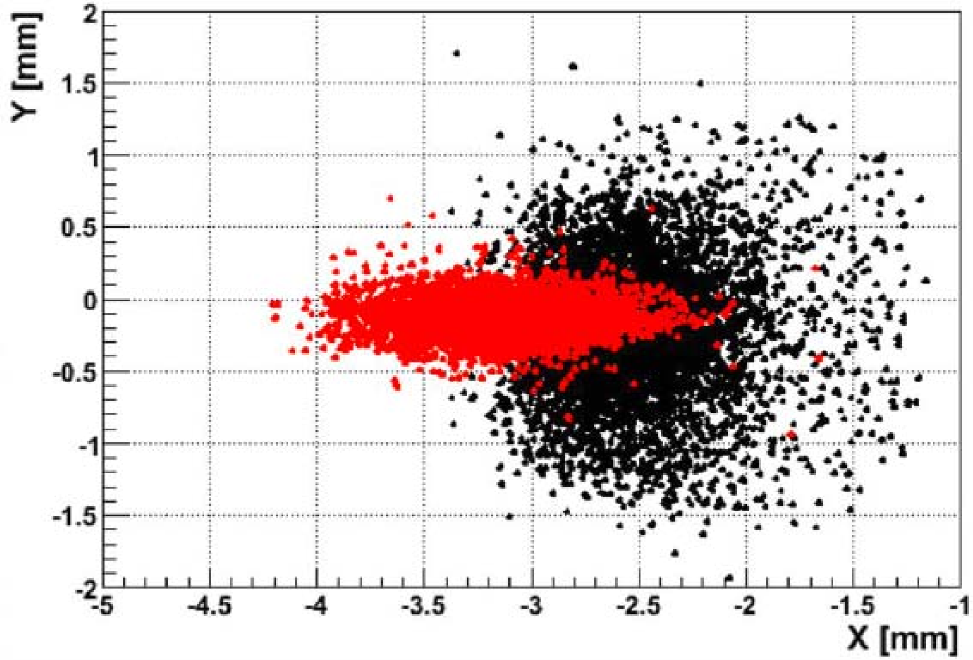


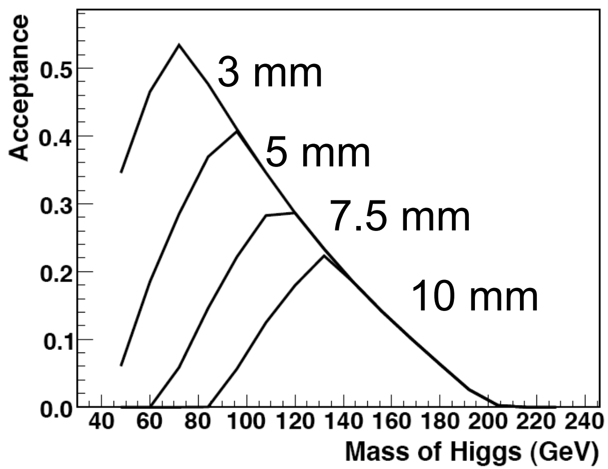
- 1% events at LHC have diffractive proton track in FP420
- @ 2 x 10^{33} $cm^{-2}s^{-1}$, 7 interactions / bunch crossing
- -> 30% of FP420 events have an additional track
- Matching mass and rapidity of central system removes large fraction of these
- Of the remaining, 97.4% rejected by fast timing detectors with 10ps timing resolution (2.1 mm)

I Baishev, F. Roncarolo, K. Potter

Machine Induced Backgrounds I

- 20000 momentum cleaning events at IR3 collimators
- Track emerging off-momentum halo protons
- Count hits at FP420 location in x,x',y,y',dp/p until when all protons are absorbed at collimators or other aperture limits (NOT FP420)
- I'll show plots for FP420 IP5





I Baishev, F. Roncarolo, K. Potter

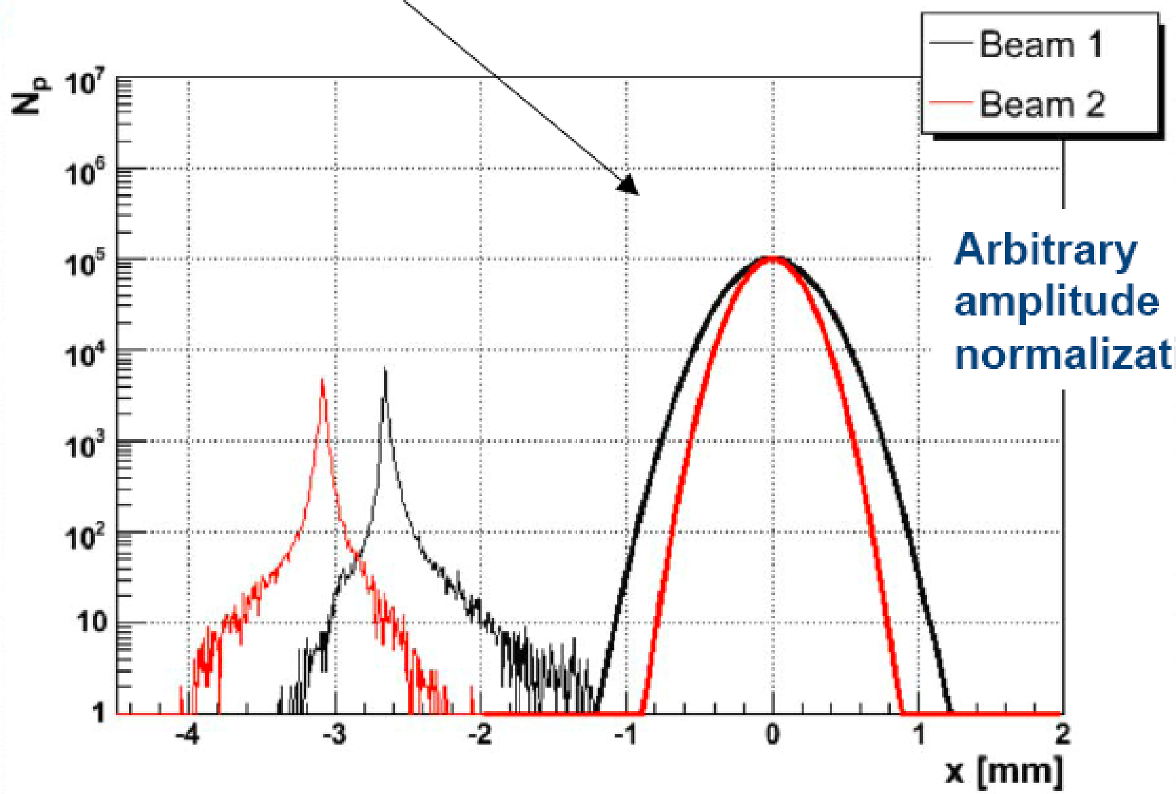
Machine Induced Backgrounds II

Hor beam profiles with nominal optics and momentum spread

Physical beam sizes:

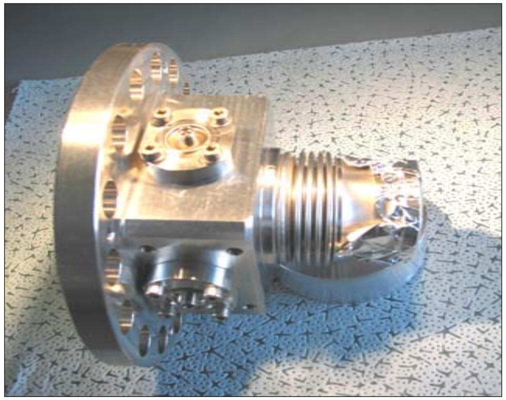
Sigma1=250um

Sigma2=180

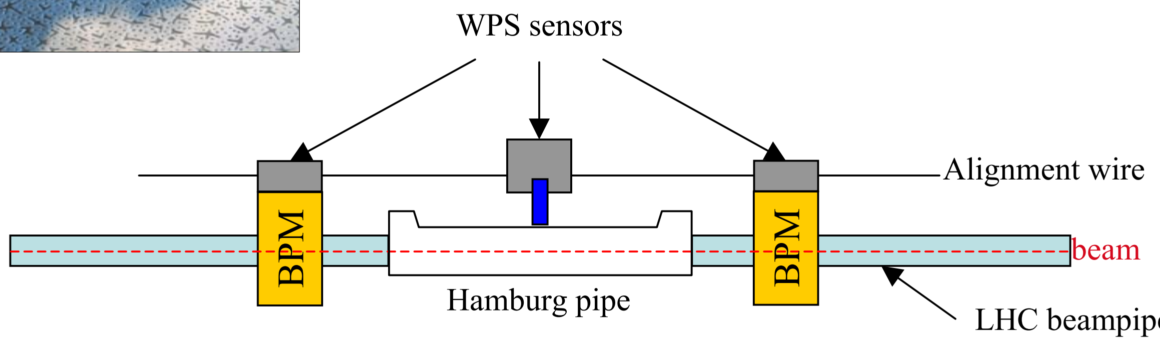


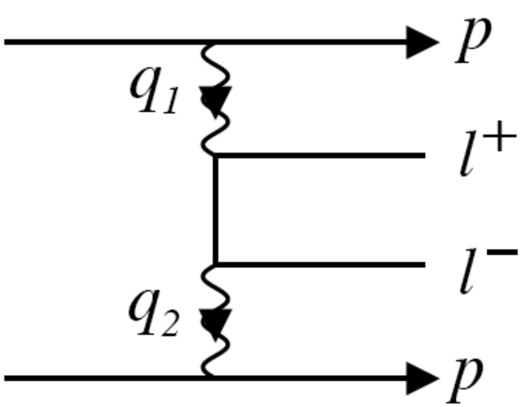
Arbitrary amplitude normalization

FP420 Alignment



CLIC BPMs + wire positioning system : aim for 10 microns relative to beam





@ 10^{33} $cm^{-2}s^{-1}$ with standard ATLAS triggers, have ~ 30 di-muon events / fill in FP420 acceptance

See also P. Bussey Talk – Manchester Dec 06

Thanks to Lars Soby, Rhodri Jones, Helene Mainaud-Durand, Andreas Herty and Robert Boudot

Forward Physics Timetable

• FP420 is currently an R&D collaboration between ATLAS, CMS and non-affiliated groups.

• In addition, there is a strong, complementary program to upgrade the 220m region with horizontal pots at ATLAS, which adds significant value to 420m program

• Proposal to ATLAS for a sub-detector upgrade in Spring / Summer this year for 420m and 220m upgrades

• If accepted by ATLAS (and / or CMS), this would lead to TDR from experiment to LHCC in summer 2007

• The FP420 design phase is fully funded, and will be completed in summer 2007

• If funding is secured by Autumn 2007, cryostats (built by TS-MME) and baseline detectors could be ready for installation in Autumn 2008

• FP220 220m detectors ready for installation in Autumn 2009

• 220m and 420m tagging detectors have the potential to add significantly to the discovery reach of ATLAS and CMS for modest cost, particularly in certain regions of MSSM parameter space

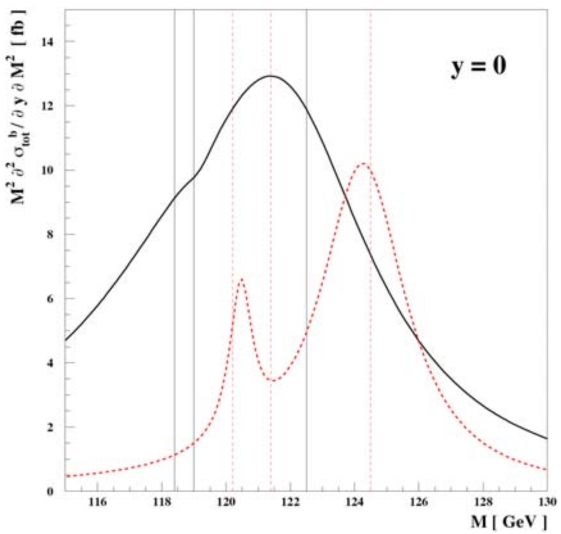
• There is a rich QCD and electroweak physics program in parallel with discovery physics

EXTRA SLIDES

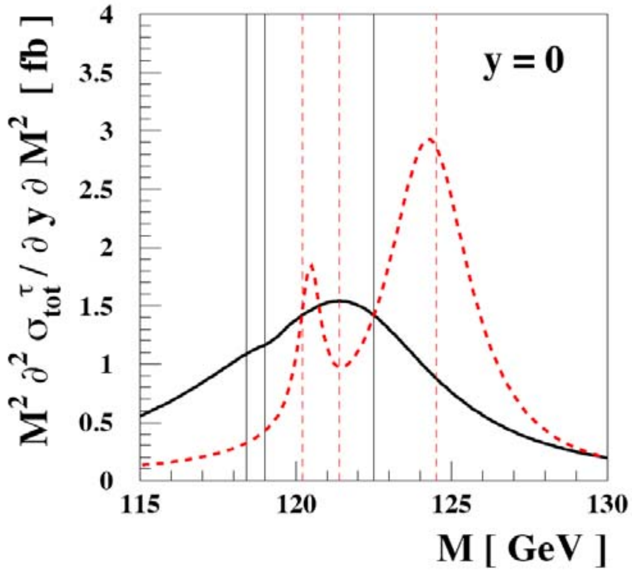
CP violation in the Higgs Sector

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

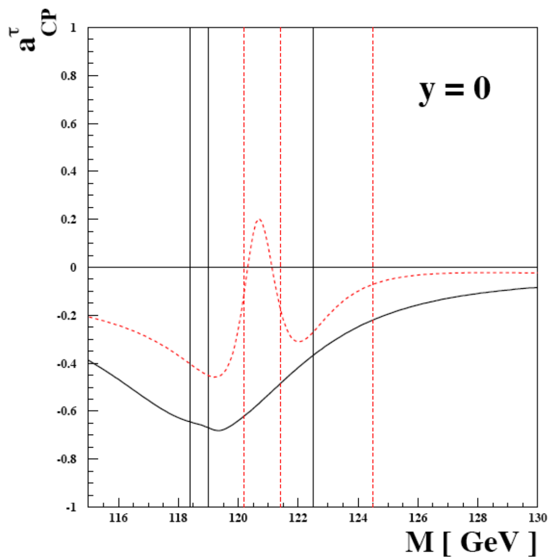
bb decay



ττ decay



ττ decay

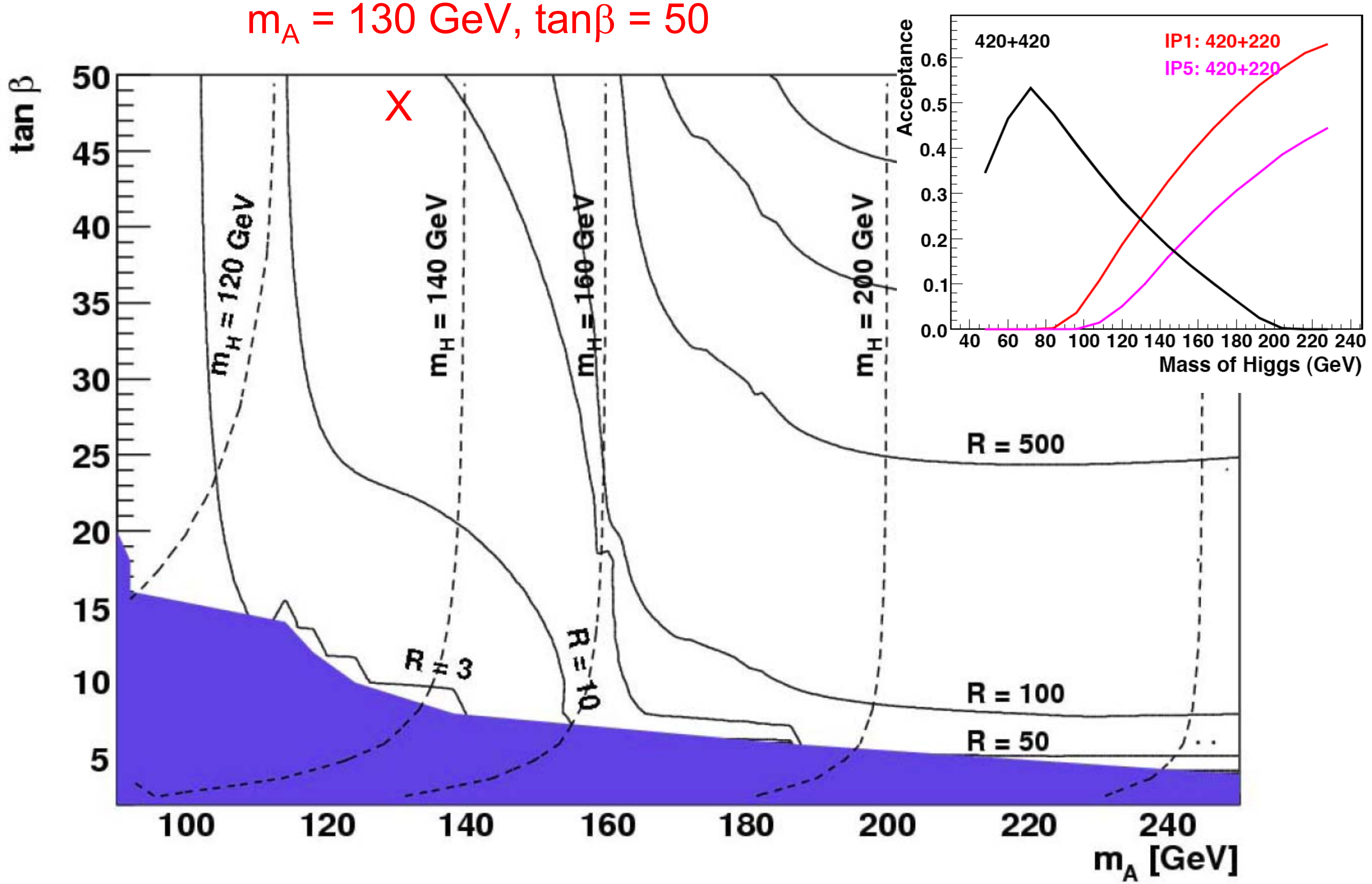


This example shows that exclusive double diffraction may offer unique possibilities for exploring Higgs physics in ways that would be difficult or even impossible in inclusive Higgs production. In particular, we have shown that exclusive double diffraction constitutes an efficient CP and lineshape analyzer 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

Detailed Analysis of Benchmark MSSM Scenario @ 420m

m_A = 130 GeV, $\tan\beta$ = 50



Plot from Marek Tasevsky

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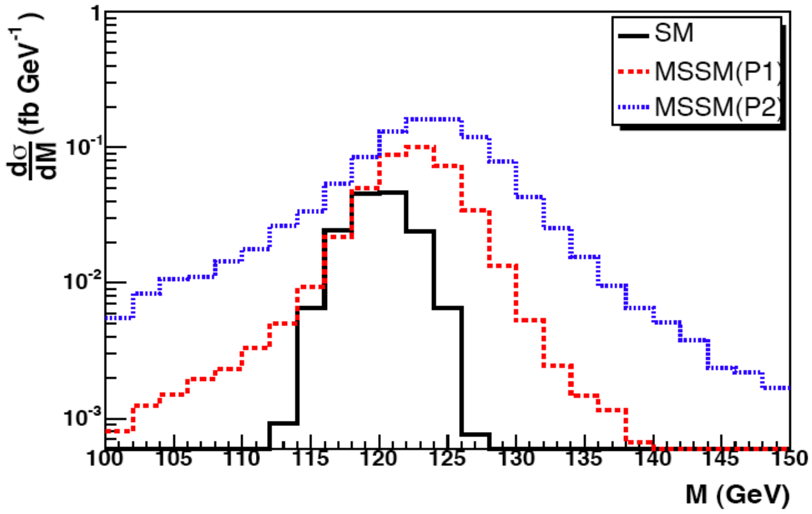
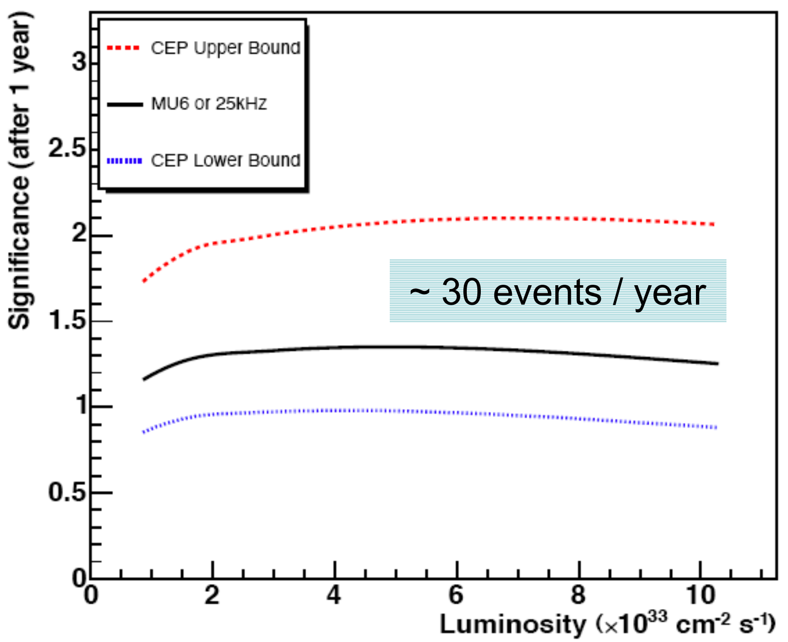


Assume Max 20 Hz L2 rate for FP420

Available triggers are di-jets and muons

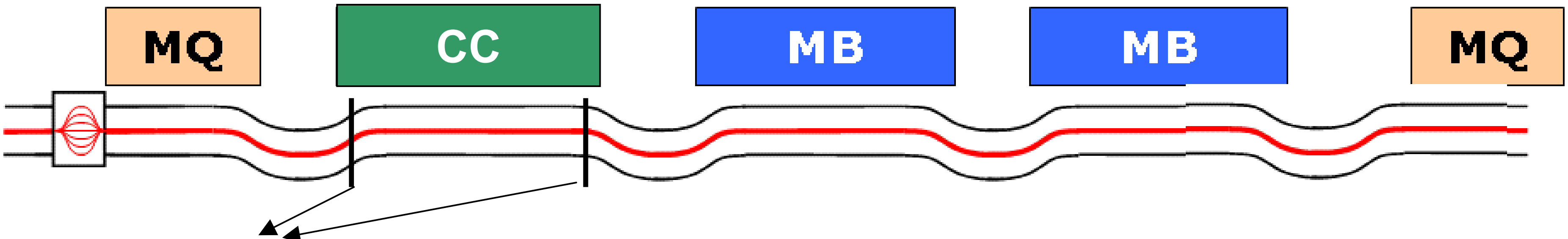
Luminosity ($\times 10^{33}$)	Non-diffractive reduction by FP420 without QUARTIC	with QUARTIC
1	2.7×10^{-4}	6.8×10^{-6}
3	5.8×10^{-3}	1.5×10^{-4}
5	1.8×10^{-2}	4.6×10^{-4}
10	8.1×10^{-2}	2×10^{-3}

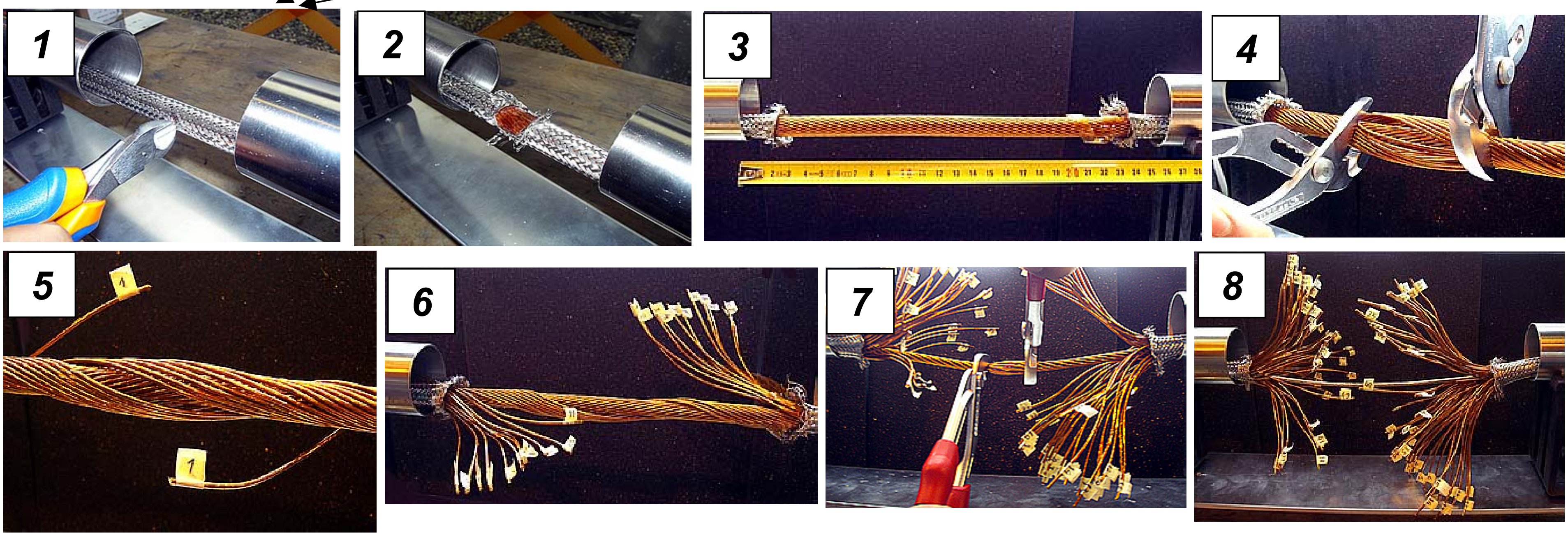


Acceptance increase by factor of 2 with 220m pots, plus trigger efficiency improvement. Mass resolution decrease not so important for MSSM.

Dismantling of interconnections :

Line N dismantling :





T. Colombet (At-MCS)

2 peoples	12 hours + previous (4 hours) = 2 days