LHC Experimental Vacuum Upgrades: Status

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Introduction and Overview

- Last presentation to LHCC in November ’08
  - There were a growing number of requests for work for experimental beampipes, but no longer any structure for project approval financing, or follow-up
- Talk Overview
  - How the project has been organised
  - The current programme of work
    - Radius of phase I upgrade beampipes
    - Some examples of development of new technology
  - Resources for the project
  - Summary

Initial Steps

- LHC Experimental Beampipes (LEB) group
  - Set-up in Jan '09
  - Representation from all LHC experiments, plus machine groups
  - Reporting to experimental collaborations and accelerator LMC committee
  - INDICO site: http://indico.cern.ch/categoryDisplay.py?categId=2261
- LEB meetings
  - 2 'strategy' meetings to agree work programme and priorities
    - PRIORITY 1: Required radius of phase I upgrade beampipes
    - PRIORITY 2: Design and technology for the consolidation programme
  - 5 'technical' meetings to advance on the agreed programme

Work Programme

- Change requests come from 2 directions
  - Requests from the LHC experiments for modifications required for their consolidation and upgrade programmes
  - Changes to the layouts in the experiments due to the phase I machine (triplet) upgrade
- Three phase approach:
  - Consolidation of existing experimental beampipe geometries
    - Consolidate spares, replace under-performing components, reduce background
  - Phase I upgrades to experiments and machine
    - New PIXELS, new TAS absorbers and inner triplet in IR's 1 and 5
  - Phase II upgrade beampipes
    - New layouts, higher luminosity,
- Scheduling
  - Overview plan made up the end of 2013
    - NOTE: Even Phase I projects will continue beyond 2013
  - Requirements beyond 2013, in particular for phase II upgrades are not yet clear

Agreed Work Programme and Requested Timeline

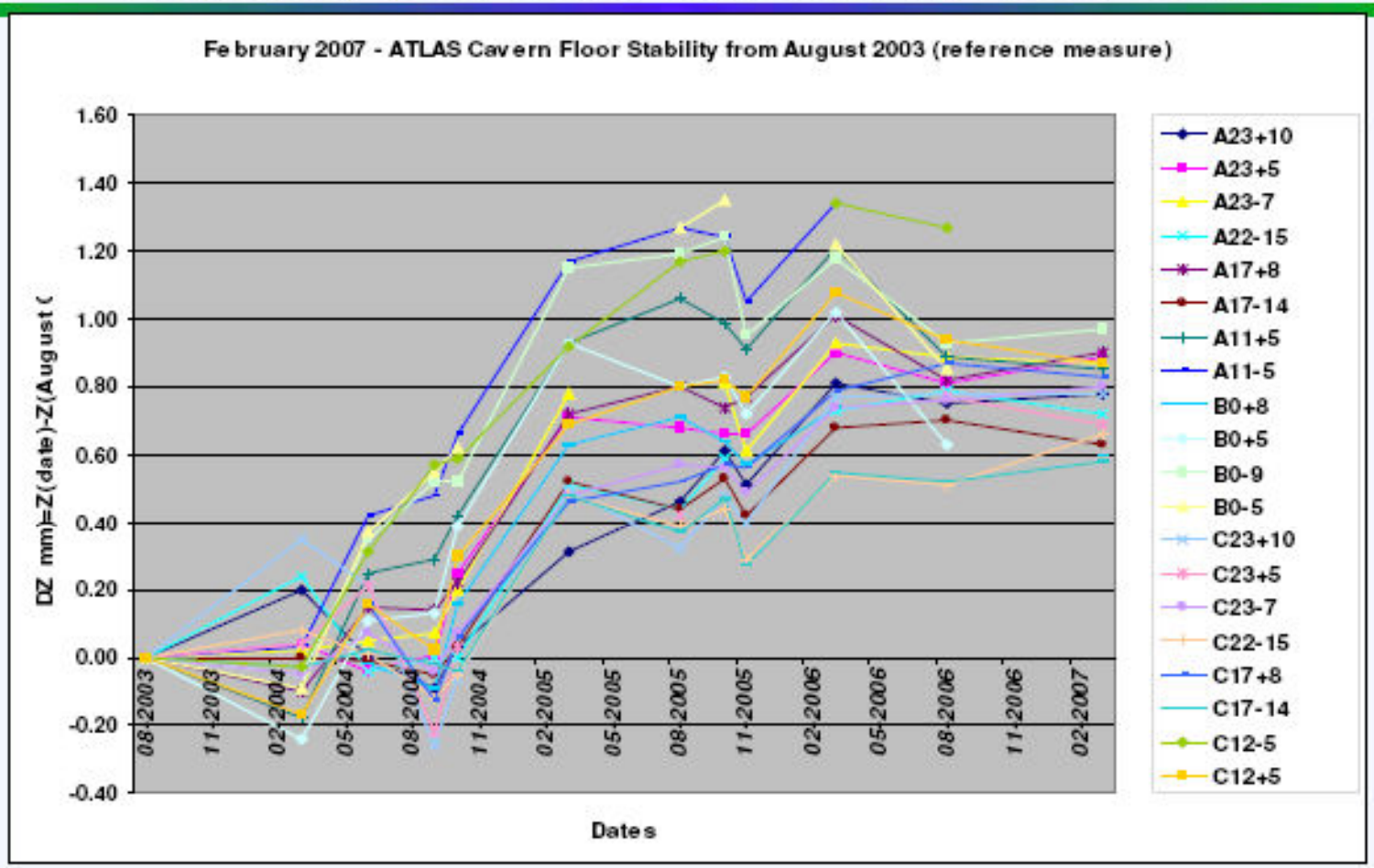
	2009	2010	2011	2012	2013
Consolidation phase					
Development of Aluminium bellows and ion pump body					
ATLAS new VA chambers in aluminium					
ATLAS new VT chambers in aluminium					
CMS Reserve end cap pipe					
LHCb UX85/3 replacement chamber					
LHCb Optimisation of UX85/2 and UX85/3 supports					
LHCb Spare aluminium bellows					
LHCb replacement VELO box					
LHCb: Add bakeout equipment on UX85/3 RICH2 section					
Common spare components for ATLAS, ALICE and CMS beryllium					
Phase I upgrade					
Definition of minimum beampipe radius for phase I chambers					
Impact of collimation schemes on layout and infrastructure					
Models and tooling for DIMR/ALARA access at nominal luminosity					
ALICE new (smaller diameter) beryllium chamber					
ATLAS smaller diameter beryllium beampipe for IBL					
CMS new (smaller diameter) beryllium beampipe for 4-layer PIXEL					
ATLAS and CMS: replace TAS and forward chambers for IR upgrade					
CMS re-optimise and replace CT2 chambers					
420 m beam vacuum sectors for IR 1 and/or 5 (TBD)					
Phase II upgrade					
New materials for beampipes, supports and flanges					
New insertion layouts and radii for SLHC					
New (smaller diameter) central chambers for all experiments					
New (beryllium or other) VA, VT, VJ chambers for ATLAS					
Remote handling for experimental chambers					

NOTE: This schedule only covers the period upto 2013. Many of these projects will continue beyond this date

Radius of Phase I upgrade beampipes

- Smaller radius requested for phase I upgrade beampipes
  - Designs for ATLAS Insertable B-layer and CMS 4-layer PIXEL imply a smaller beampipe
- How to achieve this?
  - The physical beampipe radius is initially defined by beam stay-clear, alignment precision, construction tolerances and stability between re-alignments
  - Still no experience of operation with colliding beams, but..
  - LEB meeting reviewed all of these factors that were originally fixed in ~1999 to see what had been learned

Summary plot from Christian Lasseur et al



- Average movement was <~ 1 mm
- It has stopped moving since ~2006
- Pixel and VI measurements taken since then, so no correction needed

Central Beampipe Radius

	Current Design (mm)	Phase I (proposed) (mm)
Beam aperture (10σ)	14	14
Alignment	2.6	2.6
Construction and deflection	2.6	2.6
Stability during run, and between alignments	9.8	5.8
Physical radius of pipe	29	25

See comments on the next slide!

Current Situation for beampipe radius

- ‘Baseline’ established 28/5/09 in the LEB-WG
  - Considering: Phase I upgrade machine, 14 TeV collisions, high-luminosity (low-β) optics, in the region ± 3.5 m from the IP
  - 25 mm beampipe radius is compatible with aperture and mechanics
- There are some issues
  - Very high-β operation is not compatible with this radius for currently achievable emmitances
  - Existing radii of forward chambers (eg CMS CT-2 pipe) must be re-evaluated
- A number of open questions remain to validate this number
  - Machine protection (larger TAS with smaller beampipes)
  - Machine-induced background
  - Impedance and vacuum pressures (smaller radius pipes)
- To answer these questions, a specific proposal for the beampipe geometry is required

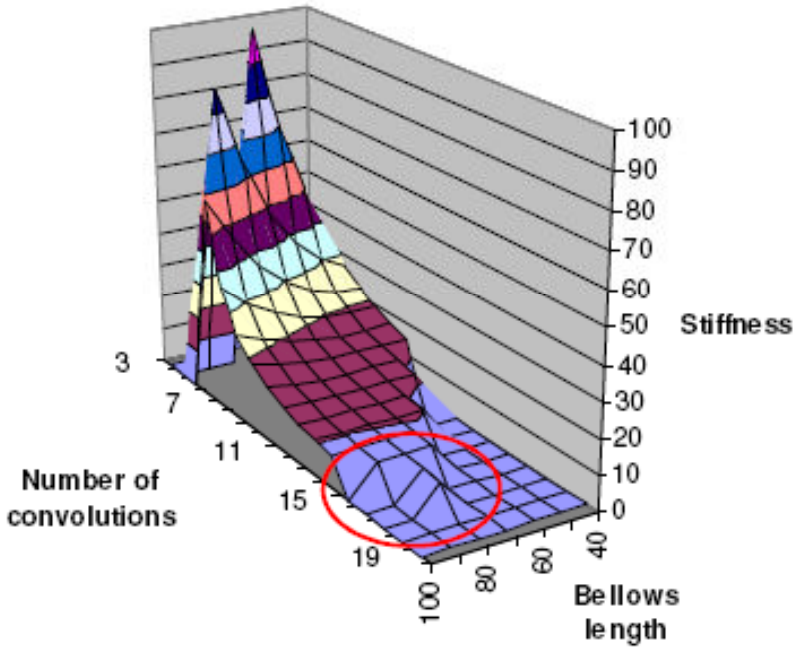
Beam Vacuum Technology Development

- Short-term development (Consolidation and Phase I upgrade programmes)
  - Targeted at reducing background from, and activation of beampipe materials
  - High-temperature aluminium alloys to replace stainless steel in ATLAS forward (VA, VT) chambers and ion pump bodies
  - Reliable aluminium bellows with large displacements for NEG-coated chambers
  - Re-optimisation of supports in LHCb detector acceptance
- Medium-term development (Phase II upgrade)
  - Targeted at resolving the major new issues posed by increased luminosity in ATLAS and CMS
  - New ‘ultra-transparent’ materials (alternatives or compliments to beryllium)
  - Remote or minimum-access flanges and equipment for highly activated areas

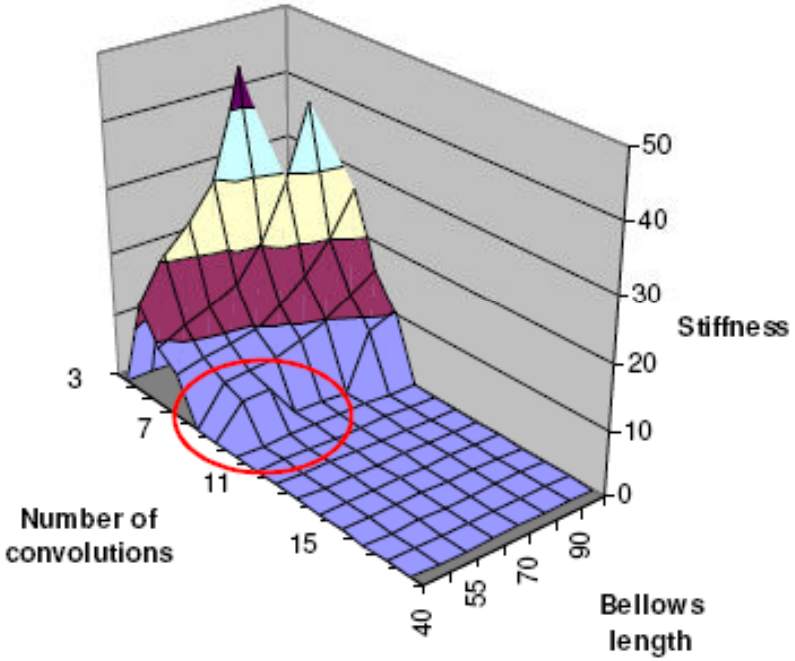
Design

Bellows parameters

Thickness 0.3 mm



Thickness 0.2 mm



Design has to be compatible with formability capacity

Other wish: if possible use the same tooling:

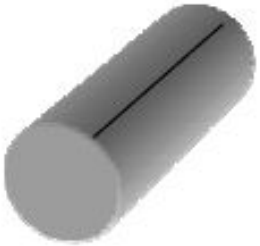
→0.3mm thick: 13 convolutions, bellows length: ~96mm, Inner diameter: 60 mm, outer diameter: 78.8mm

→0.2mm thick: 8 convolutions, bellows length: ~59mm, Inner diameter: 60 mm, outer diameter: 78.8mm

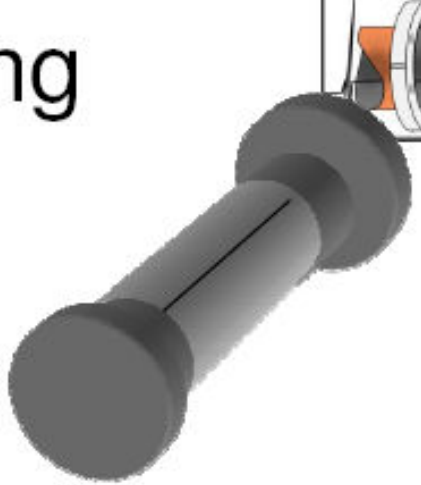
Bellows manufacturing

(courtesy of L. Prever Loiri, EN/MME)

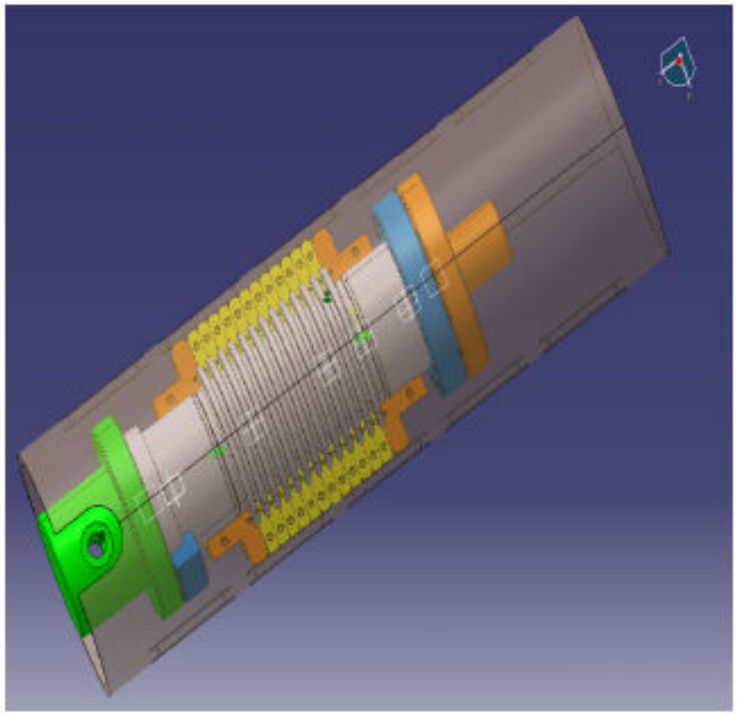
Aluminum foil



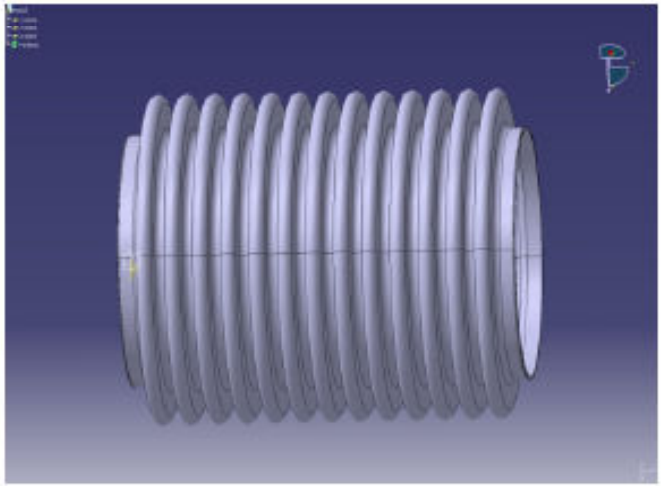
Rolled tube & longitudinal weld (EB)



Welds of the end fittings (EB)



Forming @150 C combining pressure and displacement loading

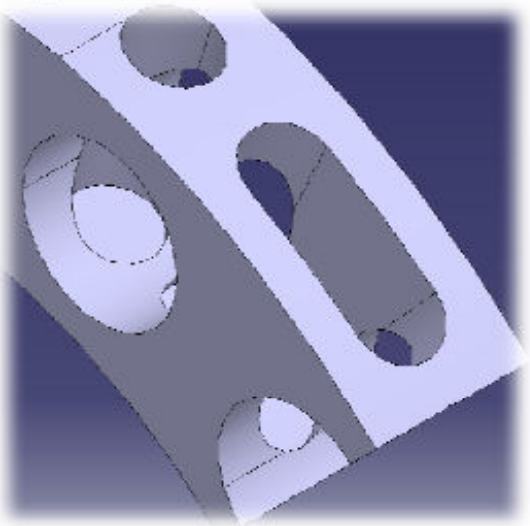


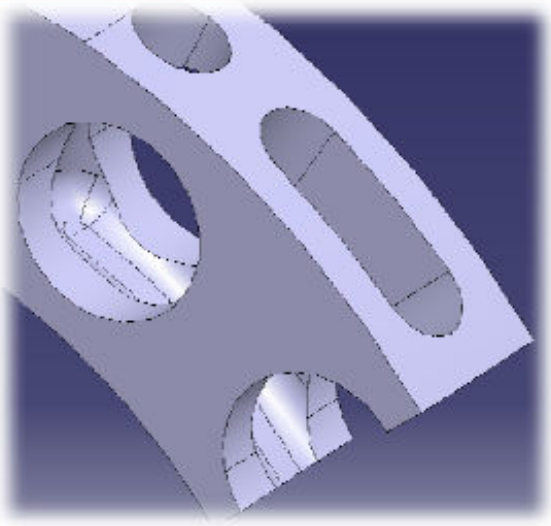
Cut of the end fittings

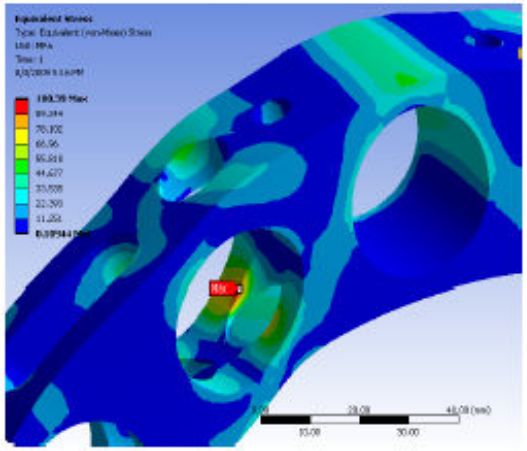
OPTIMIZATION OF A BEAM PIPE SUPPORT FOR LHCB

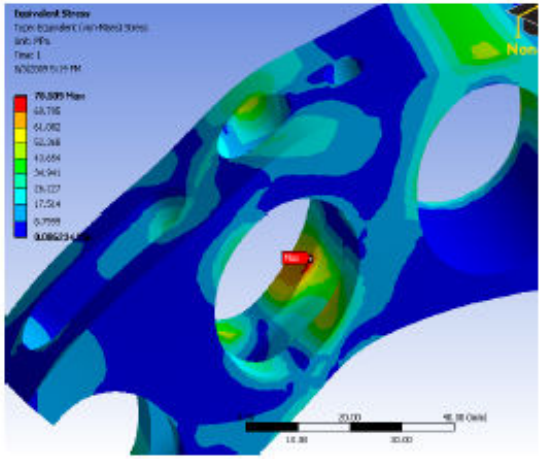
Frederic Tarnowski

The new design









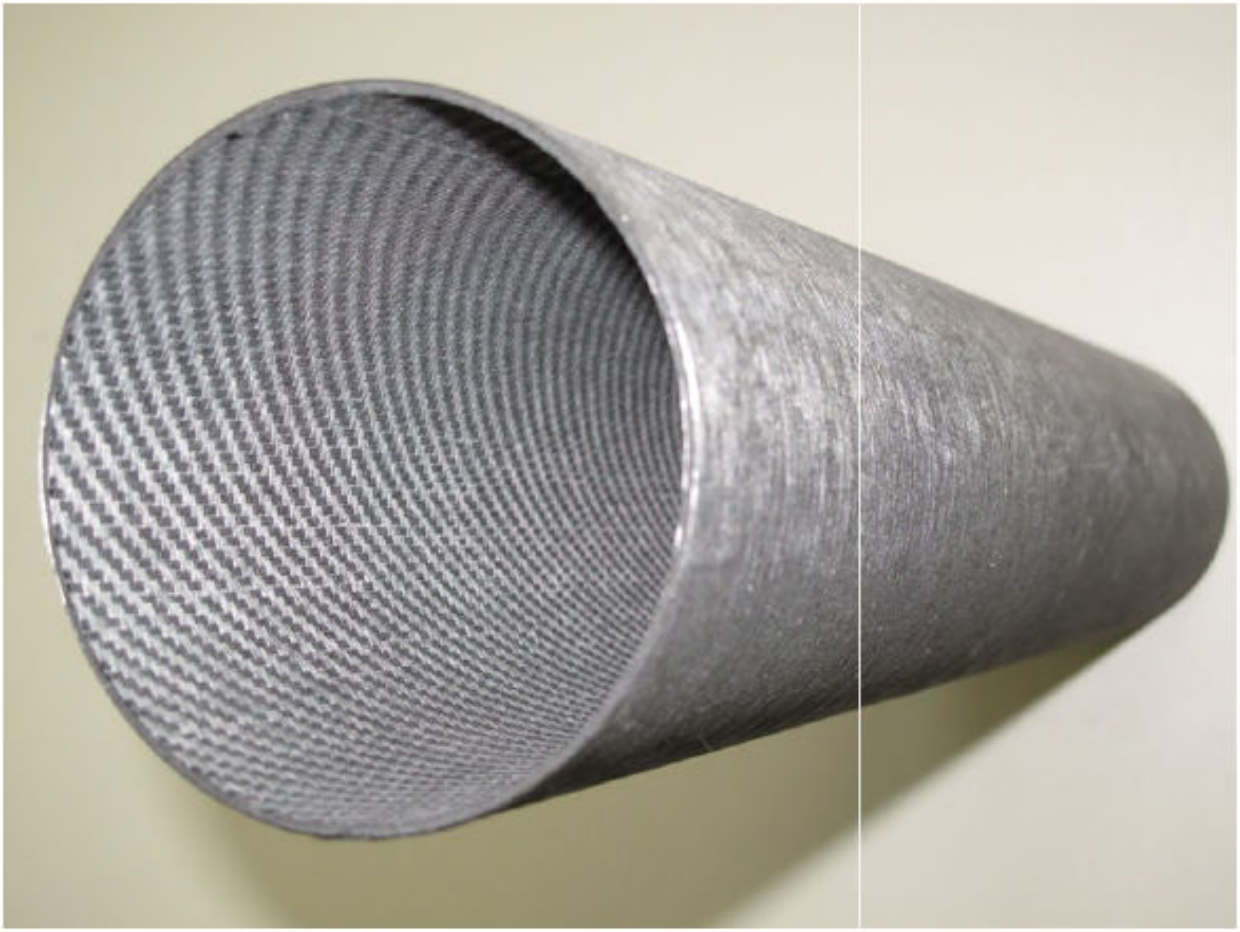
100 MPa

78.5 MPa

Stress reduced of 21% for the nominal load

(11% for the exceptional load)

Carbon-Carbon Tube for tests



SGL Carbon Production

Dia 100/104 mm

Cost: ~4000 CHF/m

LHC Experimental Beampipes (LEB) WG 30.07.09 G. Schneider TE/VSC

Resources for the Project

- Resource plan
  - An estimate has been made for personnel and material needed to complete the agreed work plan up to 2013 (~phase I), and agreed with the technical coordinators
- Staffing
  - Additional staff (1 Engineer and 1 senior technician) and visitors (1 fellow and 1 project associate) have been requested from CERN management for the duration of the project
  - Other staff and support will come from within the TE-VSC group
- Material
  - The materials estimate of 9.8 MCHF has been included in the TE department medium-term plan
- The current situation
  - Approval for both the new staff and material budget are still pending
  - These provisions will need to be extended when Phase II upgrade is approved

Summary

- Progress since the last LHCC Presentation (11/08)
  - A list of requests has been agreed with the LHC experiments
  - A project plan was produced based on this an submitted to the CERN management for resourcing
  - A working group was set-up (LHC Experimental Beampipes) and a baseline beampipe radius for the phase I upgrade agreed
- Ongoing activities
  - 10 of the 11 activities planned to be started in 2009 are already in progress
  - Progress has been slower than planned for several projects due to
    - Higher than expected workload in TE following the 3-4 incident
    - Delays in agreeing the approval of the project and associated resources
- Open issues
  - Experiments need to propose a beampipe geometry for validation of the upgrade beampipe radius
  - The resources for the project have not yet been allocated
    - We are working on ad-hoc financing and personnel