



Work Package 4

New mechanical integration methods

November 20th, 2013



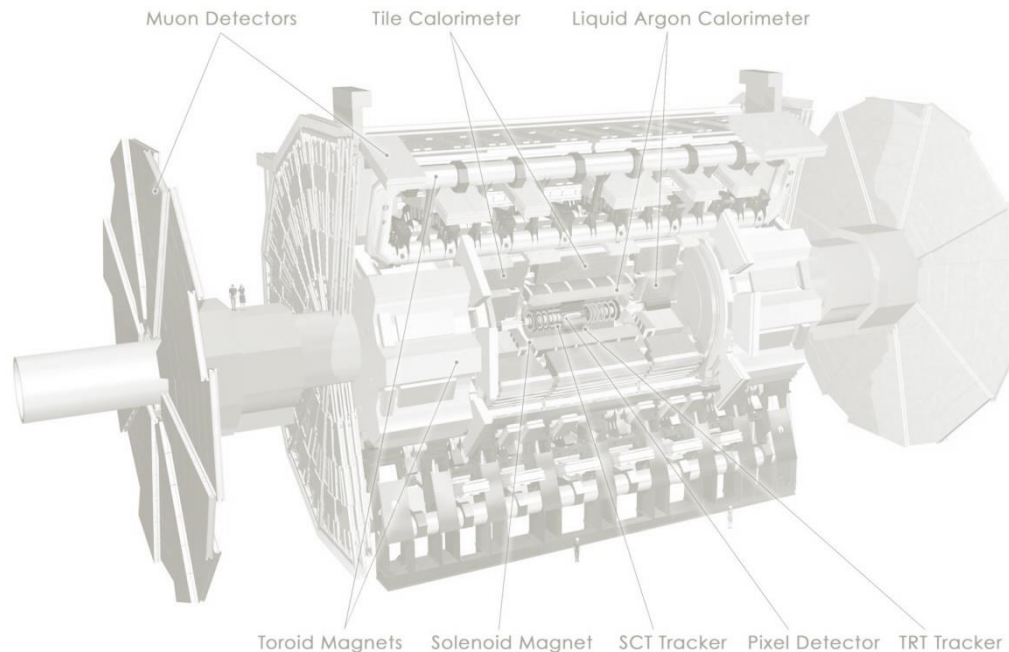
UNIVERSITÉ
DE GENÈVE



Franck CADOUX (on behalf of Nigel HESSEY)



- ***What does WP4 stand for (reminder)?***
- ***Status report on deliverables (Nikhef, Wuppertal, UniGe)***
- ***Outlooks for the next 2 years and synergies between ESR?***

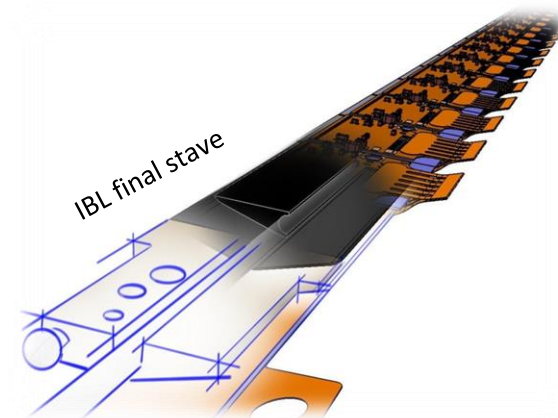


The main tasks to be covered...

- Radiation length to be lowered down to the...minimum!
Optimization in weight, not only for supports (*stave* for instance)
Material selection (CFRP, Carbon foam, glues, grease...), processes, and design
- As a ultimate goal... Integration of the cooling system into the “support” (common philosophy in the Inner Tracker)
Design pushed to the limit to take into account CTE mismatch... and keep the thermo mechanical stability
- As shown yesterday, Qualification is mandatory for very high radiation doses (and for 10 years survival)
Maintain the thermo mechanical properties after irradiation (Testing)
- Tools for engineering management (large project such as Upgrade Phase2)
CAD exchanges using Smart team (or EDMS) at CERN (up to date MODELS)



Bi tube stave (first IBL design...)



The Partners, Group Leaders and positions...

- NIKHEF:
 - Nigel HESSEY as group leader
 - ESR7 (Koral) has started in mid February 2013 (*CFRP structure and integrated cooling for PETAL*)
 - ESR9 (Afroditi) has started beginning of January 2013 (*focus on CO2 cooling system applied to the PETAL, perfect correlation with ESR7*)

- WUPPERTAL:
 - Peter MATTIG and Karl-Walter GLITZA
 - ESR8 (Mukundan) has started beginning of January 2013 (*CFRP cooling pipes & mechanics... obvious links with NIKHEF group and others, focus on material characterization*)

The Partners, Group Leaders and positions... (Cont.)

- GENEVA UNIVERSITY:
 - Giuseppe IACOBUCCI
 - ER1 (Augusto) has started beginning of February 2013 (*IBL integration team, testing, FEA and CAD... works with S.Michal on the updating of the IBL overall CAD model*)
- Composite Design (Industrial partner):
 - Mr FAVRE / Mr BURQUI
 - Secondments & training in CFRP processing (based on prepreg)... to be more involved in the next 2 years...



For cigars ...!

Griffin's cigars box

For aerospace experiments!



L-BAND SAR
Sandwich pannel (1100 X 1000) CFRP — Alu. honeycomb — CFRP

For Sauber_Mercedes (Formula 1)



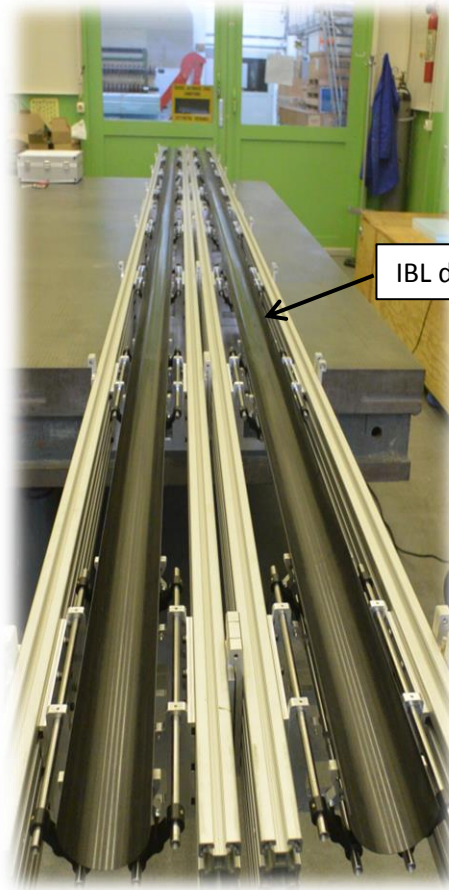
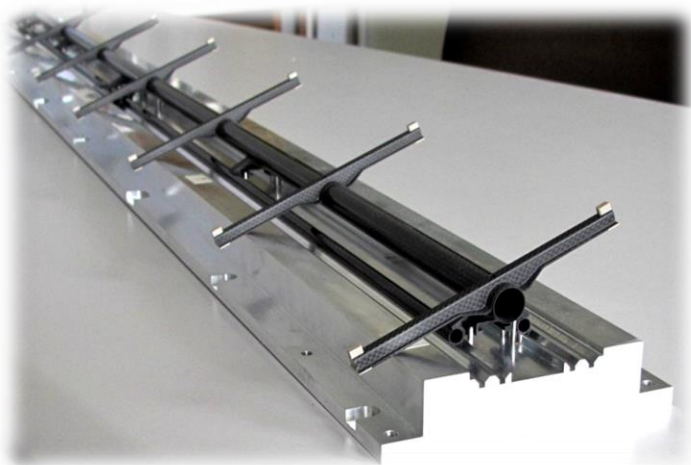
Formula 1
Watter bottle

WP4: New mechanical integration methods within ATLAS Inner Tracker

The Partners, Group Leaders and positions... (Cont.)

- Composite Design (Industrial partner):
Over the last 2-3 years on IBL (and even earlier in ATLAS and others!), they produced quite a lot of pieces... see below.

In the Upgrade
phase 2 context
(super module for
strips)



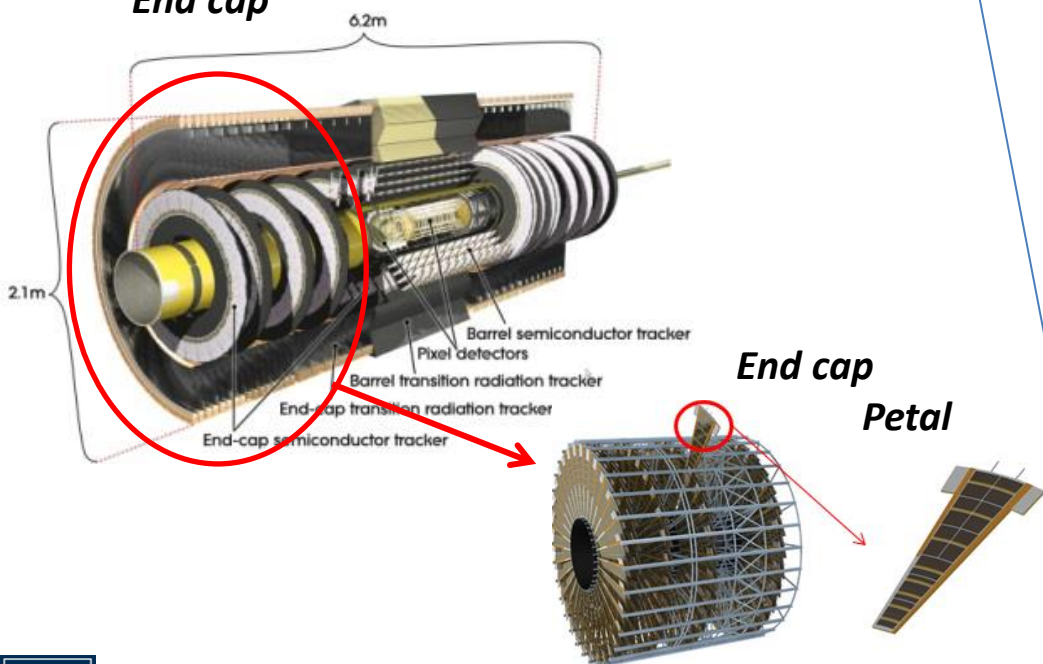
IBL dummy IST



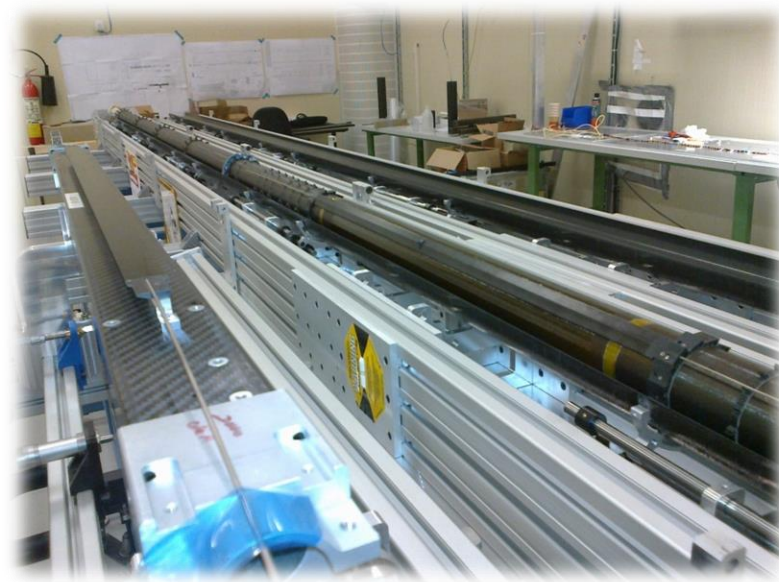
No limit...!

Status report on deliverables & Milestones

End cap



IBL integration



WP4: Status report on deliverables and Milestones



ESR7& ESR9 combined in one common goal... ***Koral and Afroditi***

- Cooling studies (ESR9)

Optimize the cooling design for future particle detectors (applied to the PETAL)...


- Mechanical studies (ESR7)

Optimize the mechanical performances of support structures under high radiation environment (applied to the PETAL)... and including the cooling design (ESR9)

WP4: Status report on deliverables and Milestones

ESR7

Prototyping Samples

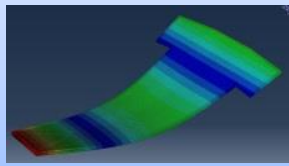


Lab scale Experiments

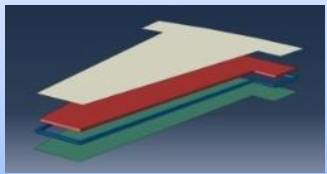
- Modal analysis
- 3 & 4 point bend test

Milestone 1

Adapting FEA model to satisfy lab scale results



Computer based model (FEA) of Petal



Milestone 2

Optimization of model to satisfy design criteria

- Stiffness vs. Thickness Opt.
- Carbon-fiber tests
- Carbon Foam tests
- Glue-Facesheet interface

Manufacturing specimens

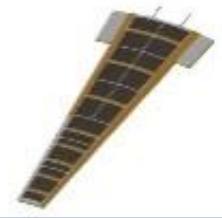
- Radiation hardness test
- Quality assurance for manufacturing standards

End-Cap Space-Frame FEA modeling

- Geometric modifications
- Joint tests

Milestone 3

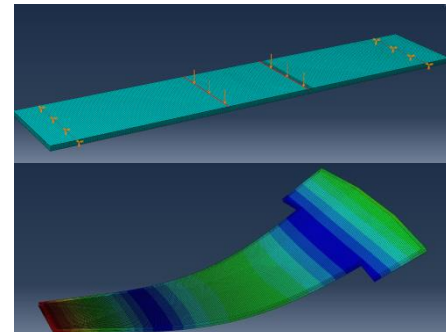
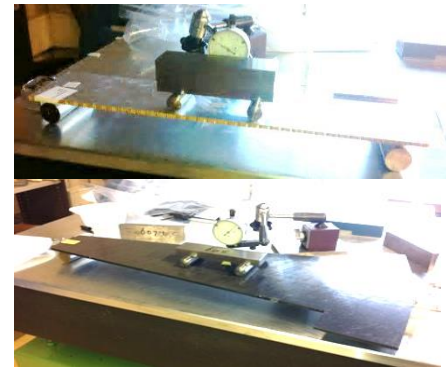
Final Concept Design



Milestones achieved by **Koral** up to now...

ESR7

- Two different petal prototypes made at NIKHEF with different facesheet lay-ups.
- Analytic methods has been developed.
- Bending tests were performed on petal prototypes and samples...
- ...leading to the FEA model validation (correlation with lab measurements)



Main objectives to be fulfilled by *Afroditi*

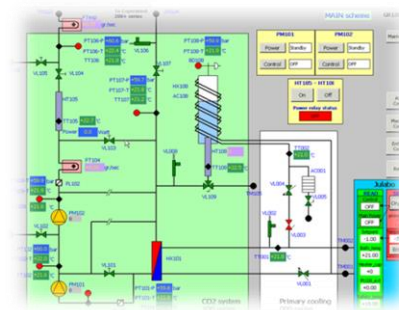
- Implementation of CO2 cooling designs in light weight CFRP structures
- FEA including the definition of thermal properties (heat transfer coeff, thermal expansion and orthotropic conductivities)... links with ESR8??
- FEA validation with prototypes...not an easy task!
- When OK, use the FEA to optimize the design of future trackers

Deliverables and Milestones achieved by *Afroditi*

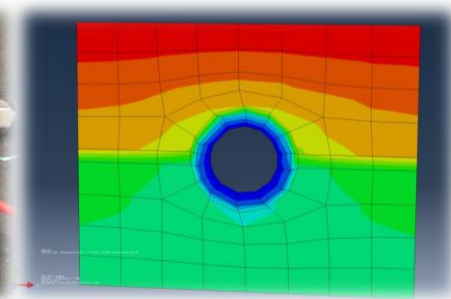
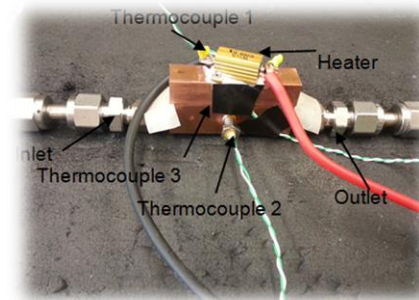
- Prototype of PETAL including: *heaters, dummy wafers, connector frame...*



- **CO2 Test set up** is being prepared to measure the cooling performances of a PETAL proto



- ...in order to validate the thermal FEA of the prototype (pre tests on simple parts)



WP4: Status report on deliverables and Milestones

ESR8 in Wuppertal University... **Mukundan**

CFRP cooling pipe and mechanics (of general interest among IBL, PETAL... and others)

Research and qualification of high-pressure CFRP pipes



Improving the transverse thermal conductivity of CFRP



Thermo Mechanical FEA of CFRP (micro structure models)

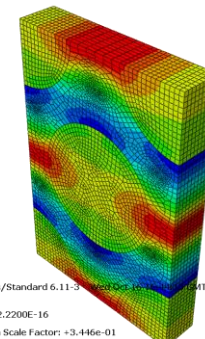
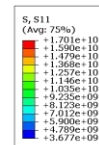
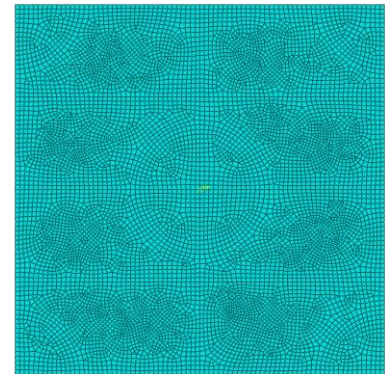
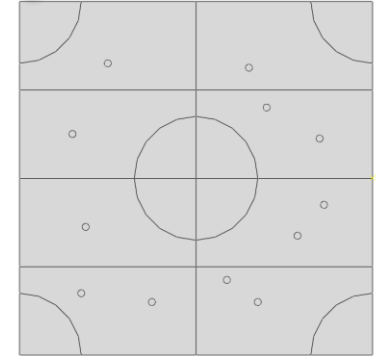
Milestones achieved by **Mukundan** up to now...

- Using a CFRP UD face plate... including some nano fillers and some perturbations... an FEM is generated in a microstructure scale...
- ...leading to a first FEA which predicts the Elastic properties of the material (could be used in a macroscopic scale)
Experimental tests are ongoing (along with thermal simulations)

Face Plate
0° UniDirectional



Python script to generate microstructure



Y
Z X
ODB: Job-3DRVE.odb Abaqus/Standard 6.11-3 02/02/2013
Step: Step-CL2
Increment: 1; Step Time = 2.2200E-16
Primary Var: S, S11
Deformed Var: U Deformation Scale Factor: +3.446e-01

ER1 in University of Geneva... **Augusto**

IBL Integration

Testing, FEA, CAD drawings ...including the updating of the IBL overall model

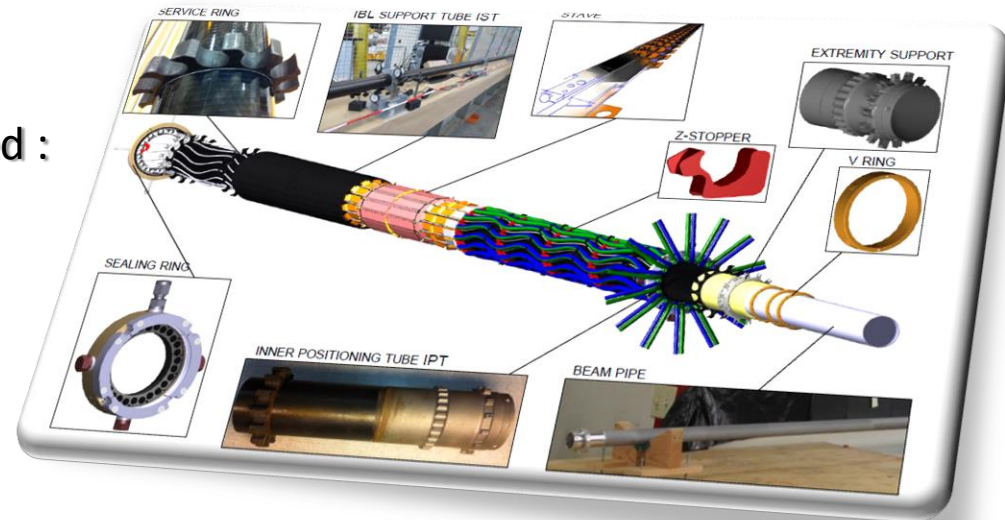
As part of the engineering team... the range is large!

- Material and Design optimization (Catia V5)
- Structural and thermal analyses (FEA on Abaqus)
- Experimental tests (IBL thermal mock up)
- Design of components, and their integrations (IBL loading stand)
- Integration techniques (IPT, type 1 services...)

WP4: Status report on deliverables and Milestones

Milestones and Deliverables achieved by **Augusto** up to now...

- The overall CAD model of IBL is released :
IPT, Beam Pipe, Stave, Services, ...
everything stored in CERN Smart Team
(including tools, jigs)



- IBL thermal Mockup is completed...
Led to the validation of Beam pipe
aerogel removal (Stave area, critical
part)...and services extra length!
FEA validation still to be done (CFD in
Abaqus)!



ESR9

- Optimize the PETAL design in terms of radiation length (based on validated FEA... combined effort with ESR7)
- Material study ... links with **ESR8??**
- Bi-phase cooling studies (CO₂)
- Measure pressure drop along small tubes (CO₂)
- Study convective heat loads in the Endcap (CFD and measurement?)...links with ER1?

ESR7

- Optimization on Validated FEA PETAL Model (further weight reduction)
- Research on specific field in CFRP (cracks propagation, honeycomb)
- Overall FEA on the End cap frame (structure) to estimate the PETAL stability and assembly techniques (*Composite Design?*)

ESR8

- Experimental tests on samples to validate the FEA predictions (mechanics and thermo mechanics)
- Provide the thermo mechanical characteristics of CFRP layup (various kind of fibers, fillers...?)
- Participate in the global effort with ESR7,9 and ER1? Spread info?

ER1

- Complete the IBL integration (around April 2014)
- Complete the FEA on the IBL fluid dynamics (IBL Mock up)
- Start new developments for the Upgrade phase 2 (PIXEL, overall structures?)...in collaboration with others ESR?

We clearly see some obvious links between ESR/ER (micro and macro structures, CFRP material, cooling,... skills on Abaqus and Catia V5). TBD