LHC Collimators for Phase 1

Comparative Thermo-mechanical Analysis of Collimators

(Different materials and different energy distribution)

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Outline

- General Hypotheses
- The FEM full-scale model
- Temperature distribution
- FEM analysis
- Results

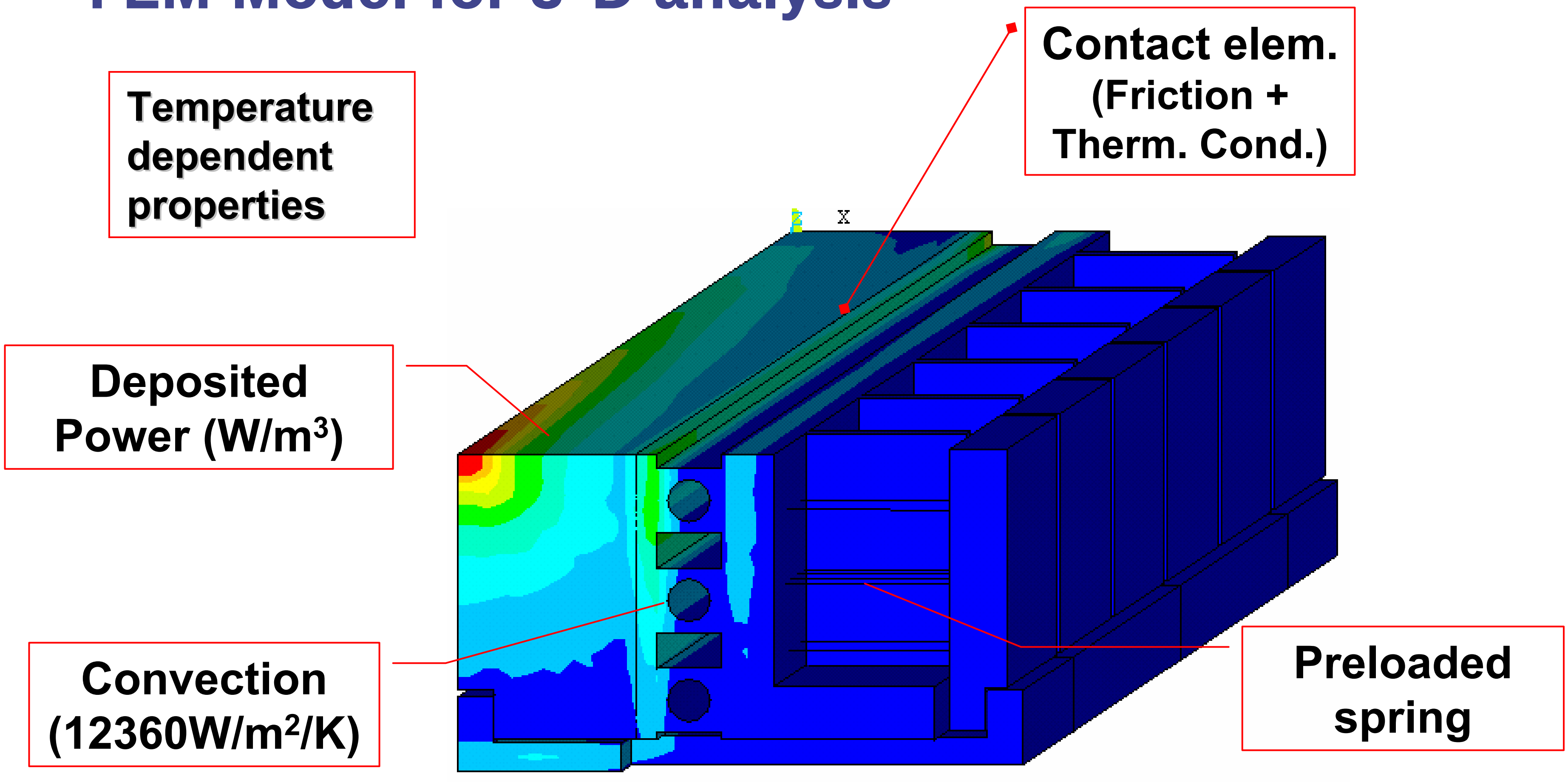
Thermo-mechanical Analysis

General Hypotheses

- Water inlet temperature: 27ºC
- Water flow rate (per pipe): 5l/min (2.95m/s)
- FLUKA Energy depositions:
  - Nominal Conditions 6.2kW at 0.8e11p/s
    V.V. 13.01.04 (symmetric) TCS.B2 from TCP3
  - Nominal Conditions (worst case equiv.) 4.5kW at 0.8e11p/s.
    V.V. Sept. 04 (non-symmetric) TCSG.A6.L1
- Spring preload (avg. pressure): 3 bar
- Materials:
  - AC150K 2-D C/C (properties as experimentally measured)
  - R4550 Isotropic Graphite (properties as experimentally measured)

Thermo-mechanical Analysis

FEM Model for 3-D analysis

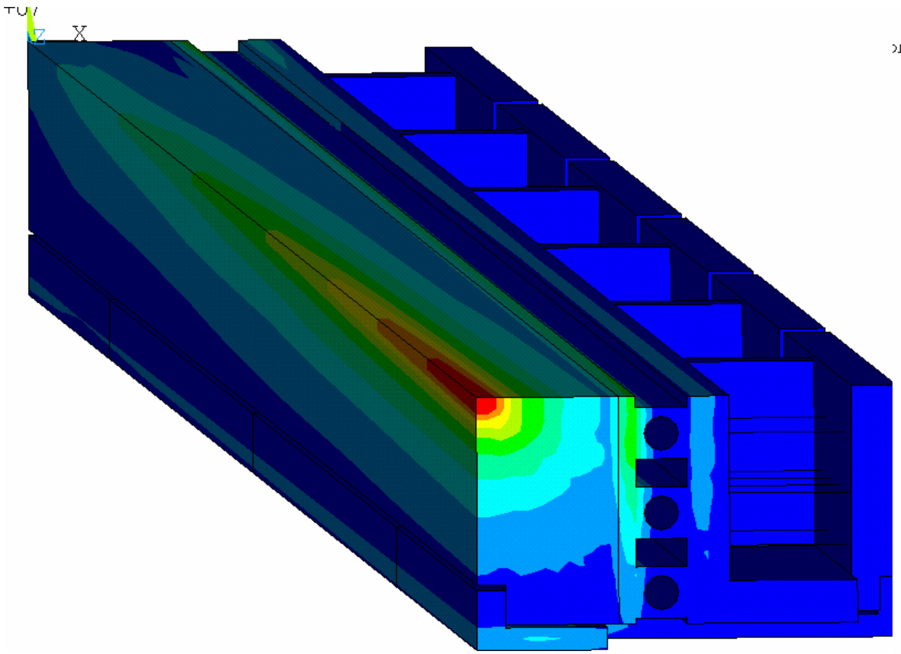


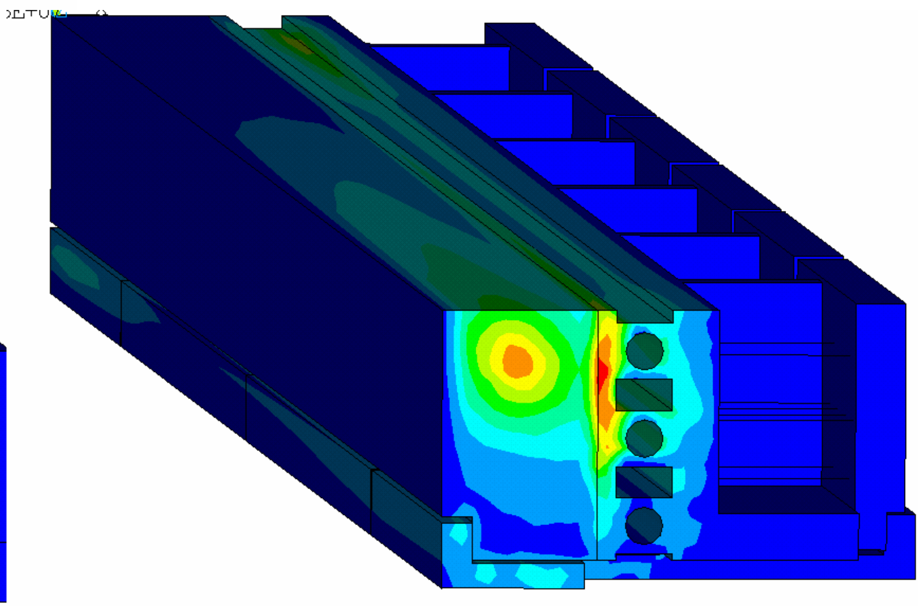
Thermo-mechanical Analysis

Nominal conditions: 0.8e11p/s 7TeV Steady-state

Symmetric Power Density Distribution

Unsymmetric Power Density Distribution





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Thermo-mechanical Analysis

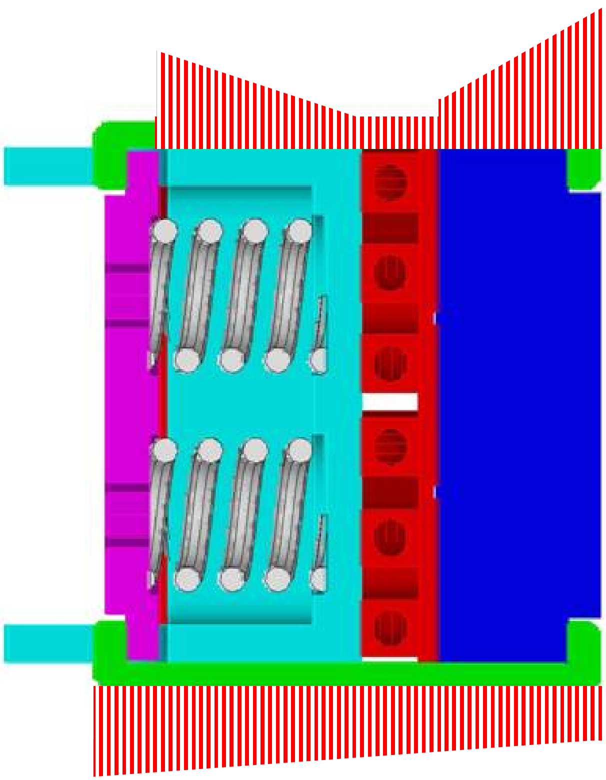
Mechanical properties of C/C and Graphite (excerpts)

	AC150K C/C 2D (z direction)	R4550 Graphite
CTE @ RT α [°K^-1]	-1.5e-6	4.3e-6
Young Modulus E [GPa]	76.84	11.5

Thermo-mechanical Analysis

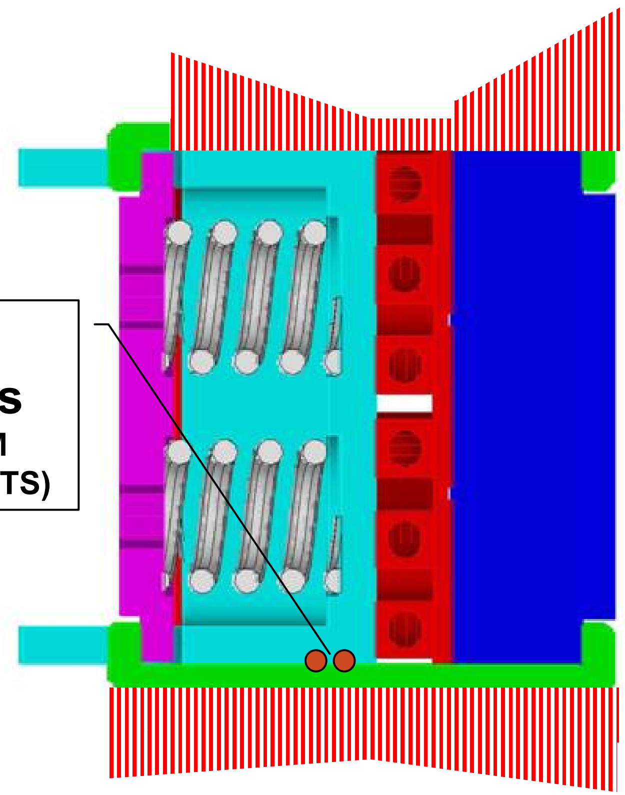
Temperature distribution with updated design

Previous set-up



Current Set-up with a new contact surface

Contact
C_bar – Clamps
(COPPER-BERILLIUM SPIRAL SHIELD GASKETS)



Thermo-mechanical Analysis

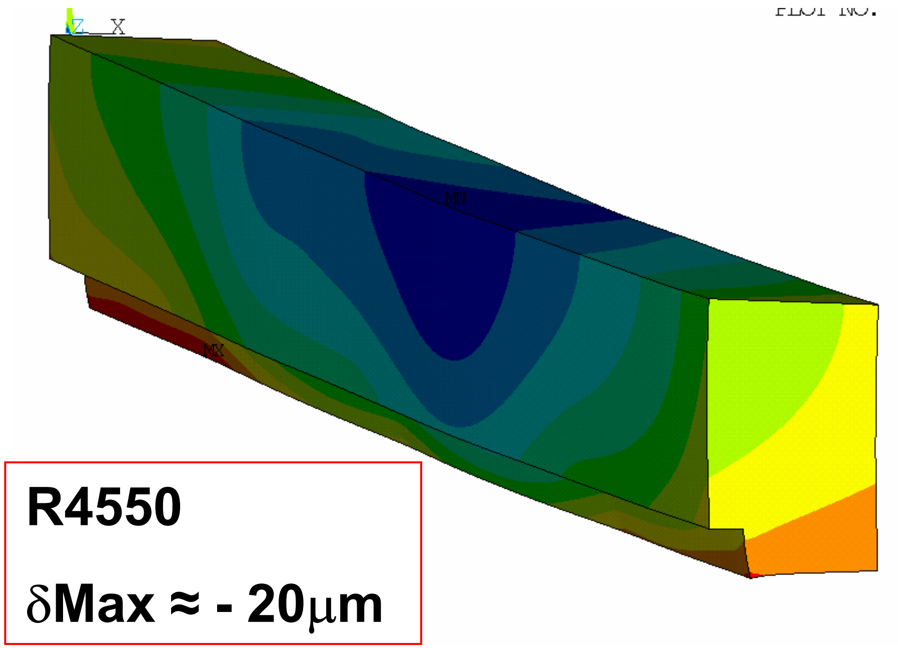
Thermal analysis
Nominal conditions: 0.8e11p/s 7TeV Steady-state

	AC150 C/C 2D	R4550 Graphite
Symmetric Power Density Distribution	48[°C]	52[°C]
Unsymmetrical Power Density Distribution	43[°C]	47 [°C]

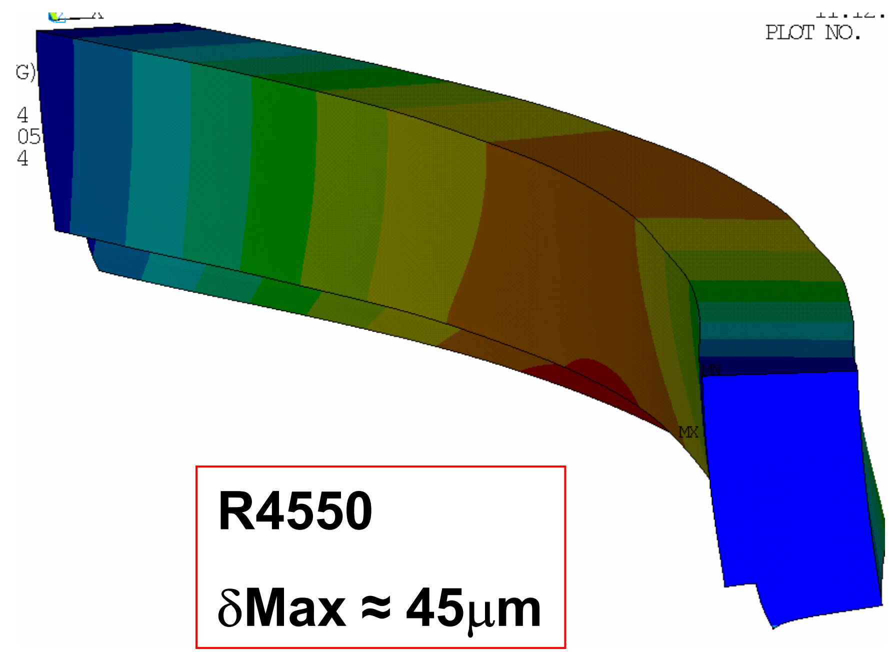
Thermo-mechanical Analysis

Displacement analysis – Isotropic graphite
Nominal conditions: 0.8e11p/s 7TeV Steady-state

Symmetric Power Density Distribution



Unsymmetric Power Density Distribution



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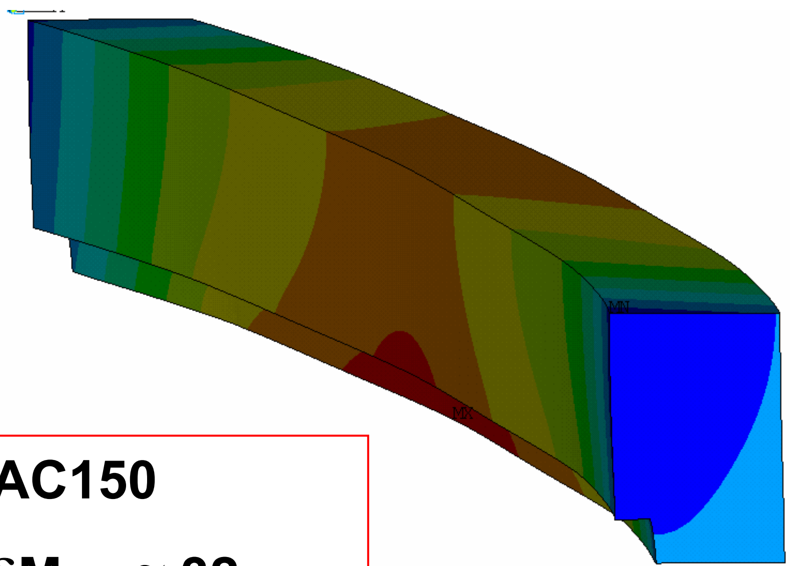
Thermo-mechanical Analysis

Displacement analysis – 2D C/C composite
Nominal conditions: 0.8e11p/s 7TeV Steady-state

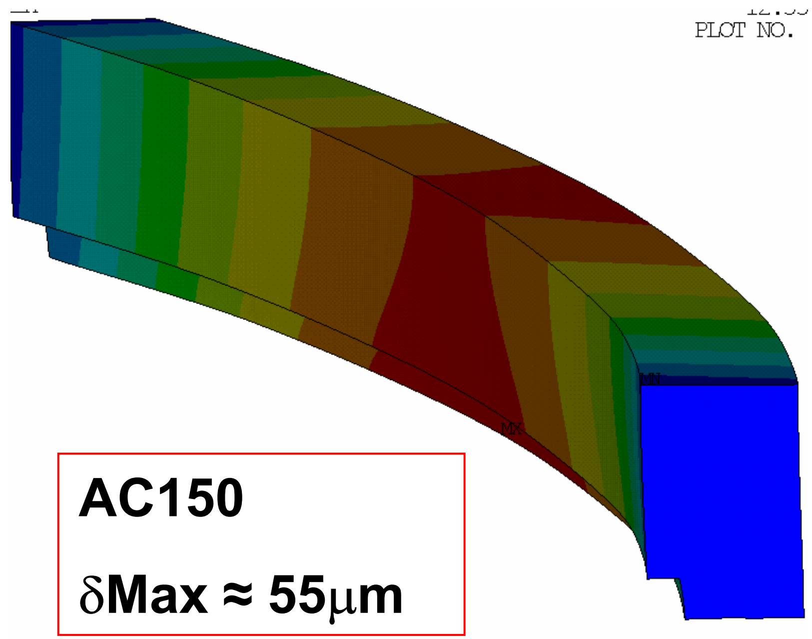
Symmetric Power Density Distribution



AC150

δMax ≈ 32μm

Unsymmetric Power Density Distribution



AC150

δMax ≈ 55μm

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Conclusions

- Both materials and both Fluka distributions give acceptable temperature values (springs not included)
- New Fluka distribution worsens maximum deflections for both materials in steady-state (8e10 p/s)
- 2D - C/C with negative CTE is better than graphite in terms of T distribution, but worse for displacements.
- Newly added contact surface improves significantly thermal deflections, making the system less sensible to jaw material and overall more stable
- Transient analysis ongoing …(possible problems with unsymmetric pwr distribution)