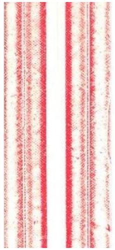
An explanation on what we need for the collaring process

F. Savary on behalf of WP11

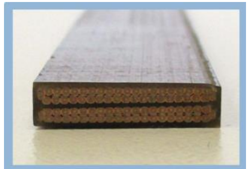
11T Dipole Task Force Meeting Nr 8 – CERN 180/1-N51 – 2018-02-21

Allowable stress on cable

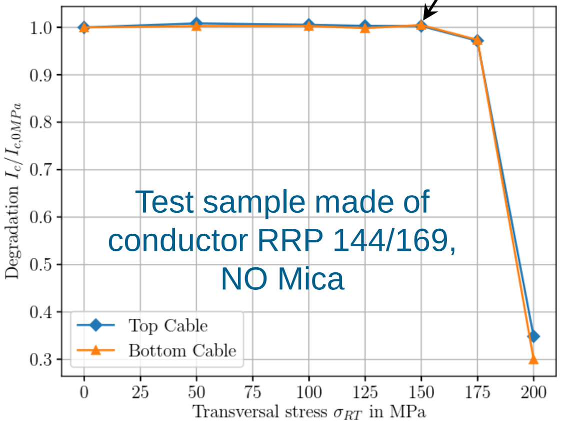
- **Irreversible degradation** on final cable with final insulation scheme
- **3 types of samples**
  - No MICA
  - MICA 25 mm wide
  - MICA 31 mm wide



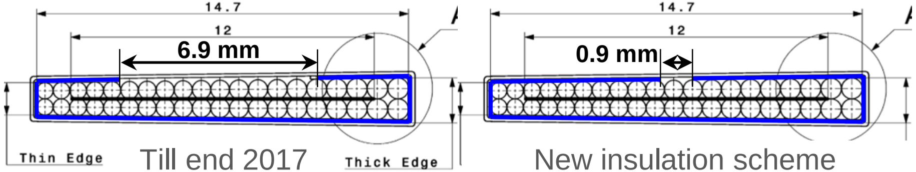
$\sigma_{allowable}$
Local



Specimen cross section (15.6 x 3.8) mm²



- **Role of MICA, as stress concentrator**



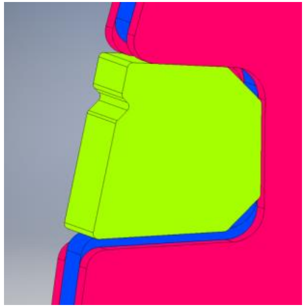
- **Optimization of Fiber Glass braiding parameters to reduce thickness of insulation**

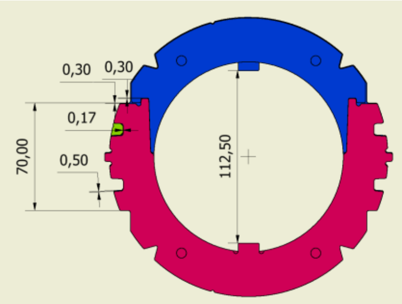
Parameter	All coils till end 2017	New models & Series production
Cable width, mm	14.7	14.7
Cable thickness, mm	1.25	1.25
Mica width, mm	25	**31**
Gap, mm	6.9	0.9
Gap/cable width, %	50	6
Gap/cable thickness, --	5.5	0.7
Insulation thickness @ 5 MPa	135	**100**

Courtesy P. Ebermann, J. Fleiter, F. Wolf

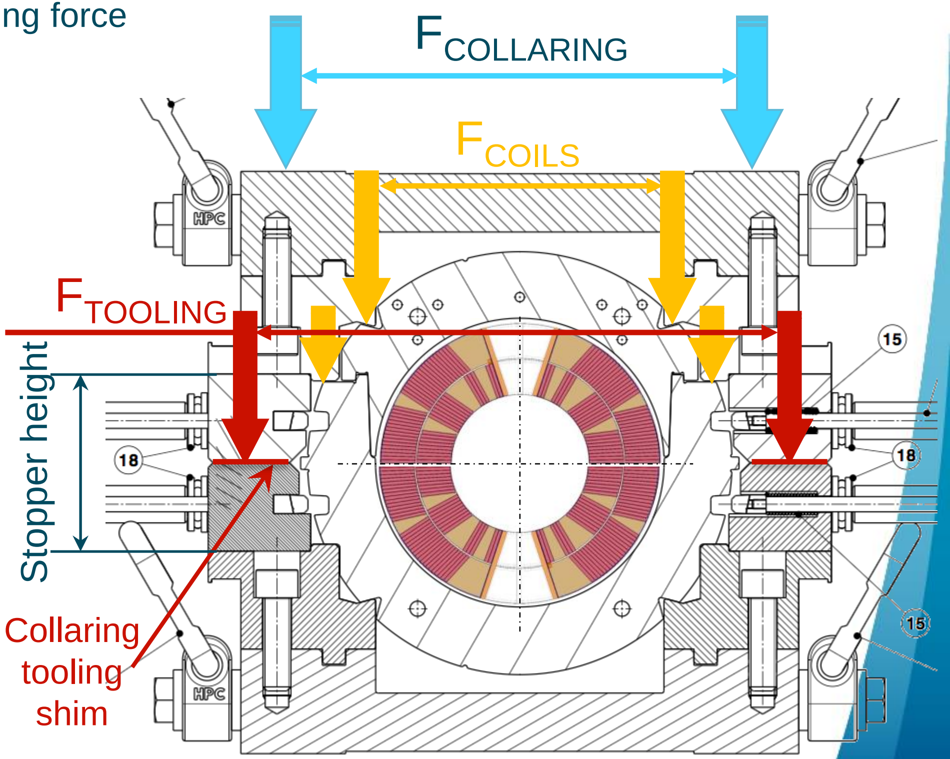
Collaring

- Stopper height, or collaring tooling shim, and $F_{COLLARING}$ such that:
  - Keys can be inserted successfully at minimum collaring force
  - Coil stress at full collaring force < allowable stress (w.r.t. irreversible degradation)
  - Spring back as small as possible



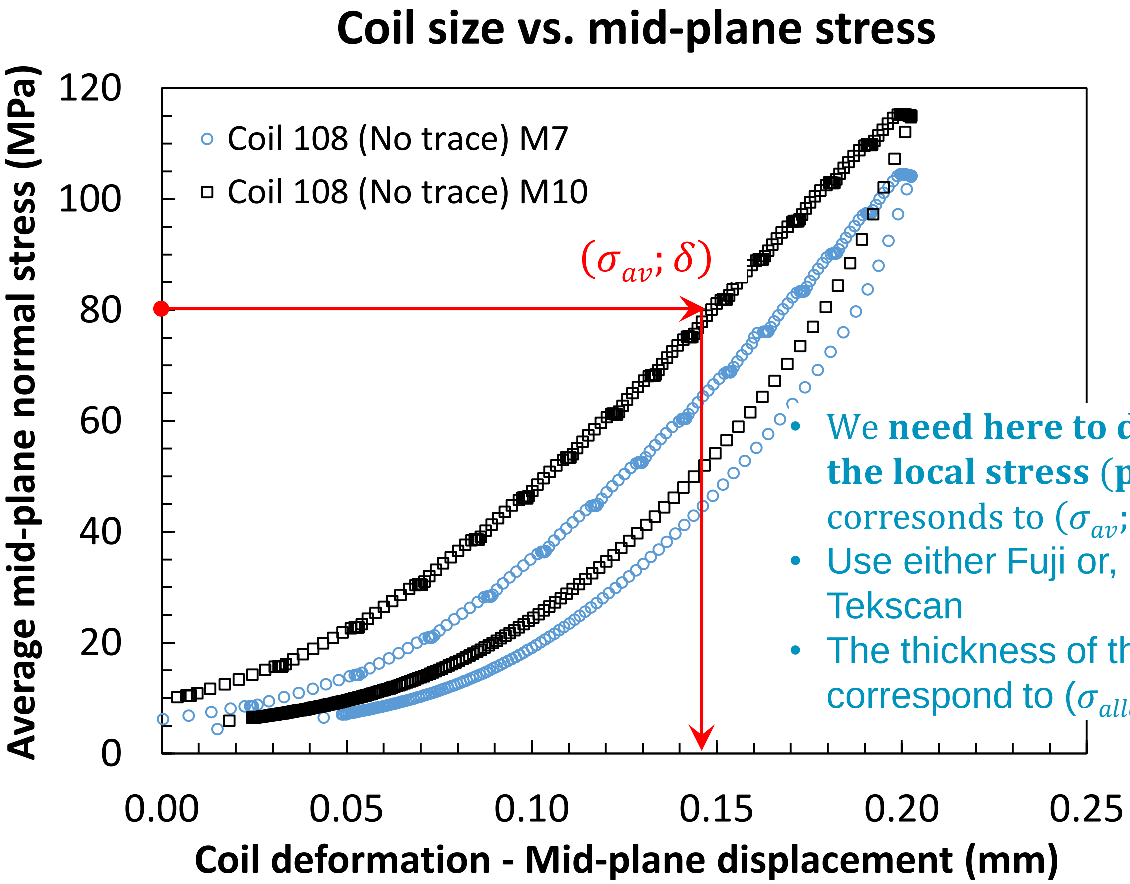


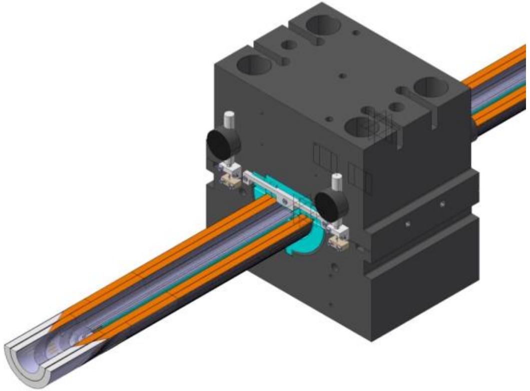
$$F_{COLLARING} = F_{COILS} + F_{TOOLING}$$



How do we use the E-modulus measurements to control the collaring process?

E-modulus measurements on full coil X-section



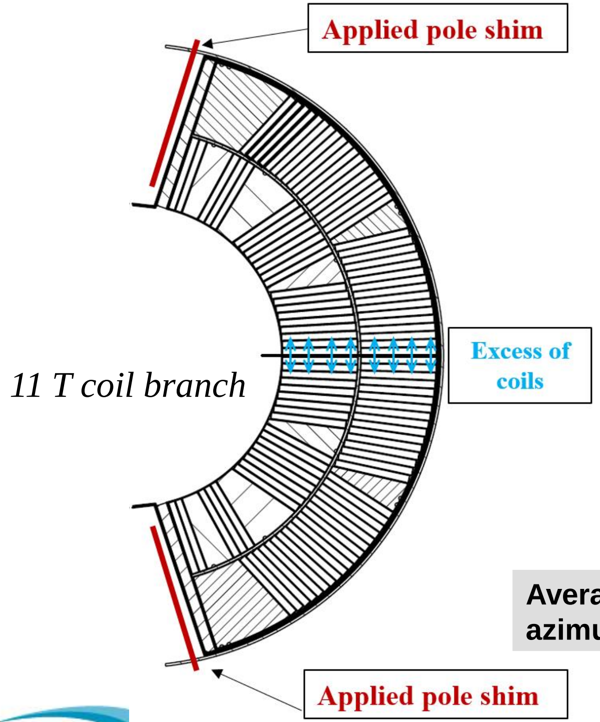


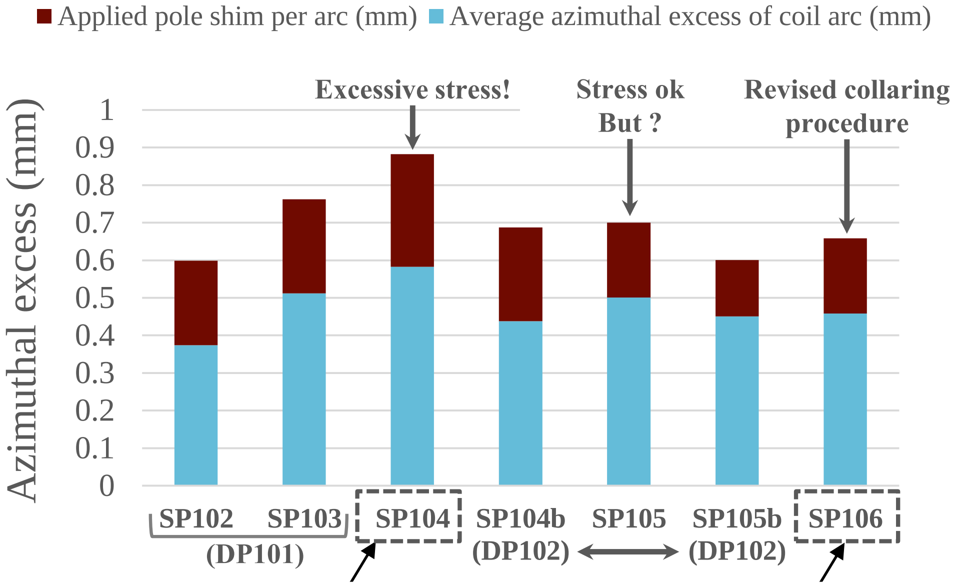
- We **need here to determine the local stress (peak)**, which corresonds to $(\sigma_{av}; \delta)$
- Use either Fuji or, better, Tekscan
- The thickness of the shim shall correspond to ($\sigma_{allowable}$ - *margin*)

Courtesy J.L. Rudeiros Fernandez, S. Ferradas

Shimming of magnet models

- The pre-stress depends on the sum of the **azimuthal oversize of the coils with the thickness of the pole shims** (… and also on the mechanical properties of the coil)

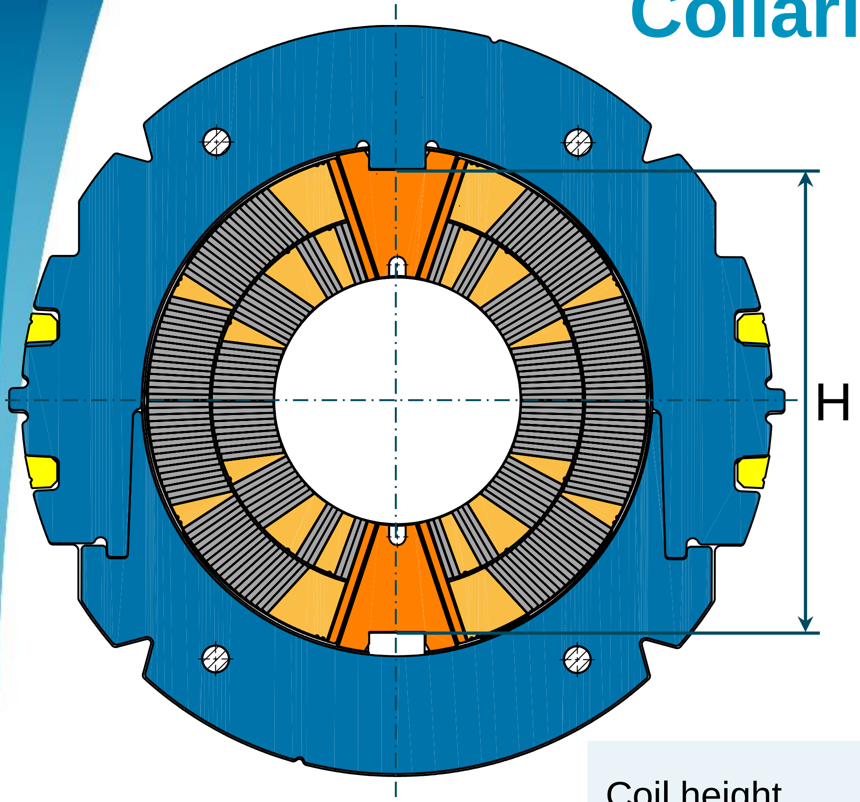


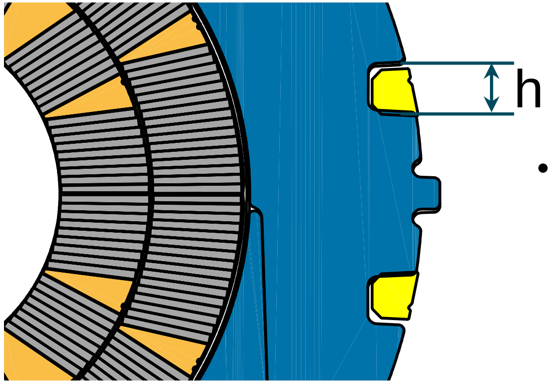


Average inner layer azimuthal stresses @ 12 T	SP104		SP106	
	Midplane turn	-147 MPa	Midplane turn	-127 MPa
	Pole turn	-29 MPa	Pole turn	-7 MPa

Courtesy C. Löffler, E. Nilsson

Collaring mock-up





- Determine Excess, i.e. shim, such that local stress at mid-plane stays below allowable for the largest coil, first in the E-modulus press, and then in the collaring mock-up
- Check that, for the smallest coil, stress level is still reasonable (not too low), first in the E-modulus press, and then in the collaring mock-up

	Step 1	Step 2	Step 3	Step 4
	No coil No load Keys inserted	Coil No load No key	Coil Collaring load Keys inserted	Coil Collared Keys inserted
Coil height	H	H + Excess	H	H + Spring back
Key slot height	h	h + Excess	h	≈ h
Key to slot Gap	G	G - Excess	G	≈ G

HiLumi HL-LHC PROJECT

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In production

- **Shimming plan based on collaring mock-up made of coil segments cut from coil 118**, not anymore on FEM analysis
- Variations of E-modulus acceptable, if margin on allowable stress is sufficient (or can be made sufficient)
- **Variations of coil size at rest** (no compression) **can be compensated, if needed**, by changing the thickness of the shim determined by E-modulus measurements and mock-up tests
- **Collaring process controlled in displacement** (not in load / pressure, and there is no mechanical instrumentation), and **collaring cavity shall be closed**