RF: review of the limitations in moving the components under vacuum and cold

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Review of HL-LHC Alignment and Internal Metrology, 26th August 2019

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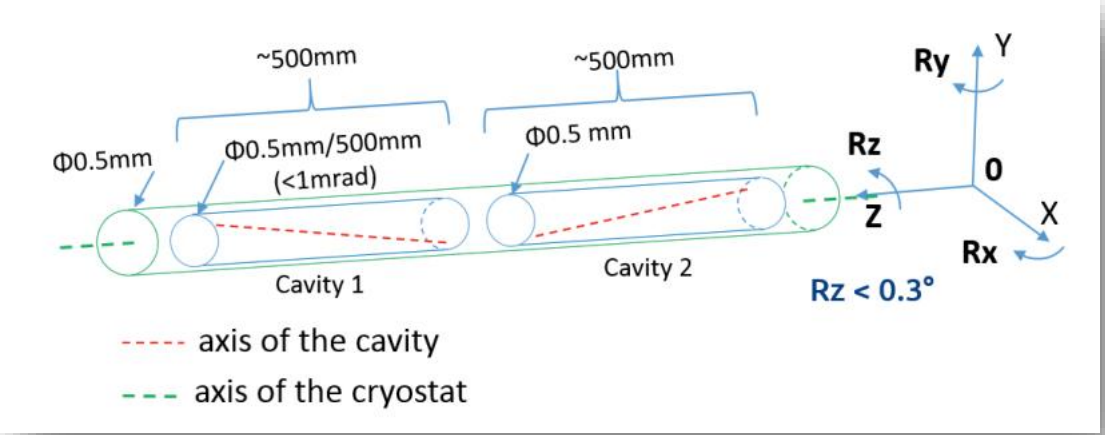
- Specification: Internal alignment
- Specification: FRAS
- Constraints from FRAS on CC cryomodule interfaces
  - RF waveguides
  - Cryogenic connection to jumpers
  - Intermodule vacuum modules
  - Longitudinal RF beam phase pick-up (APWL)

Specification: internal alignment

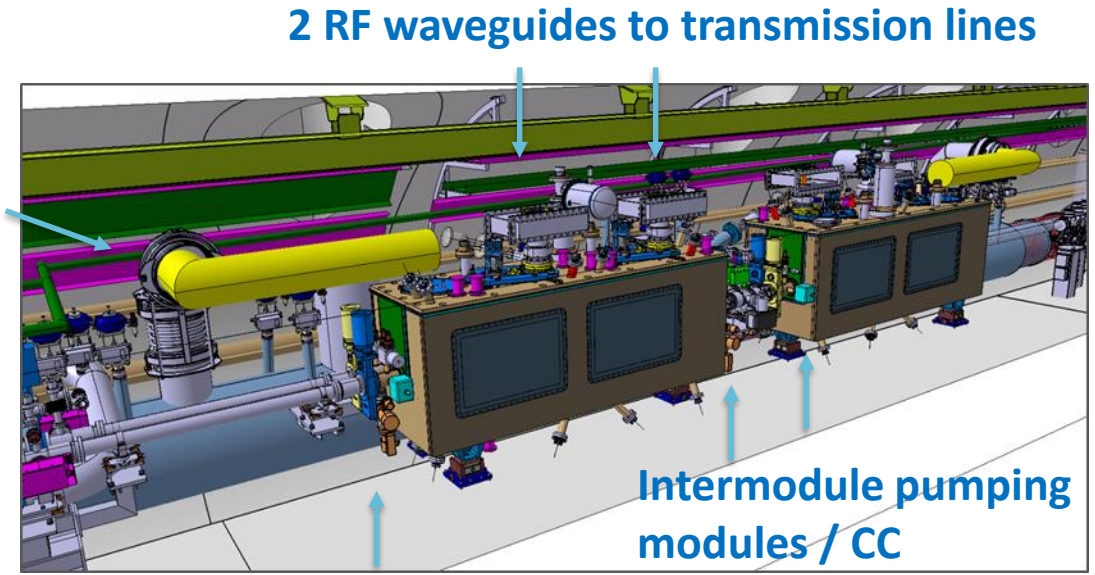


- Cavity rotation in X-Y plane < 0.3° =5.2mrad per cavity (R_z);
- Cavity yaw Ry and pitch Rx w.r.t. the cryostat axis < 1 mrad=0.057°;
- Transverse displacement of the cavities w.r.t. each other inside cryomodule:
  - Intra-cavity alignment in transverse plane w.r.t. the cryostat axis < 0.5mm;

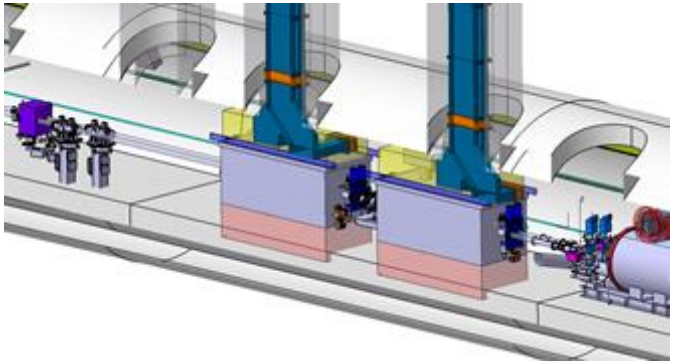
TDR HiLumi

Specification: Full Remote Alignment

- Rigid alignment of all components as a block from Q1 to Q5 within ±2.5mm
- Independent movement of all individual equipment within connecting bellow's stroke.



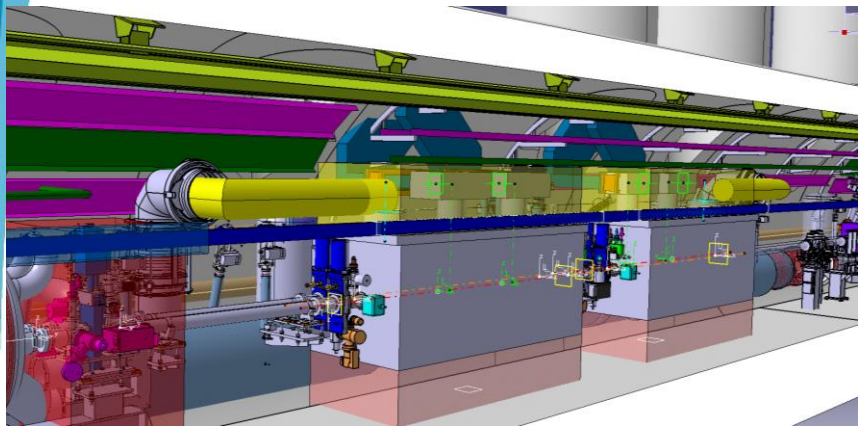
Constraints for interfaces: RF waveguides

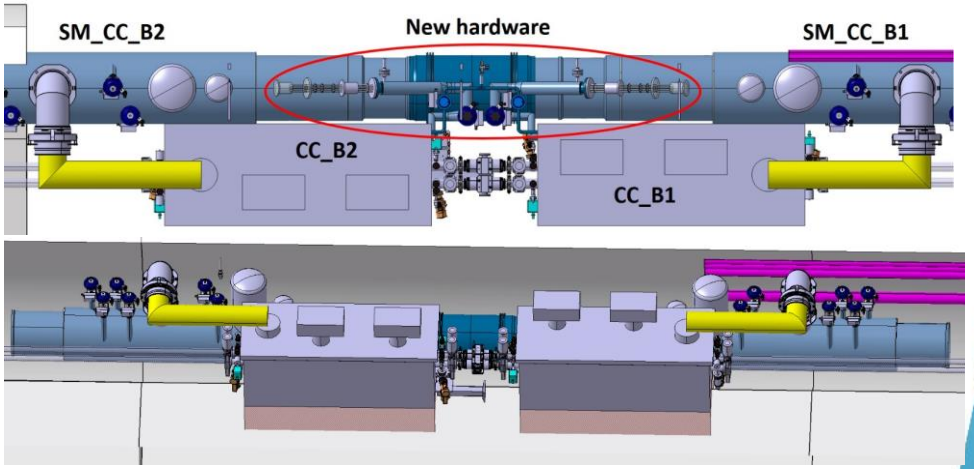


Re-alignment movement tolerance (square bellows): ± 1 mm in ver/hor (waveguide axis)
Today's view: To accommodate more, 1h access BE-RF-PM to free waveguide is required
Lab tests will be performed to verify up to ± 2.5mm.
No continuous monitoring of mutual position, only permanent target for alignment check in LS and YETS

Constraints for Interfaces: Cryogenics

Cryo equipment aligned at installation.
Large flexibility of connection, no constraint after installation within the FRAS specification





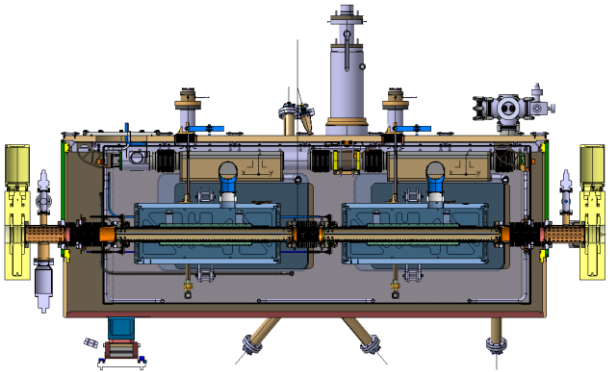
Courtesy P.Fessia / Integration team / K.Brodzinski

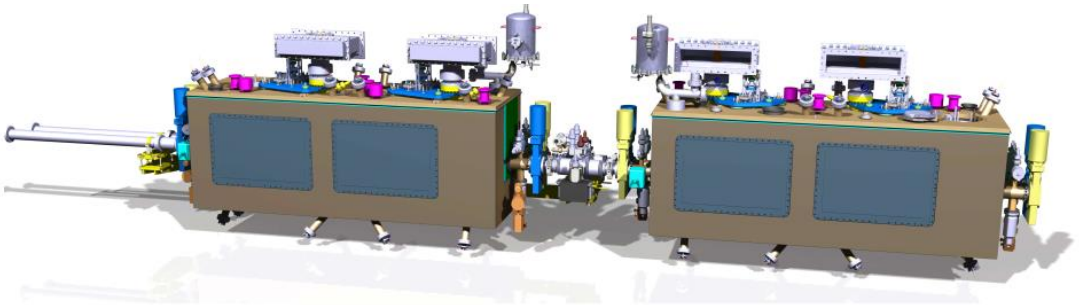
See S.Claudet , this review

Constraints for Interfaces: Intermodule alignment

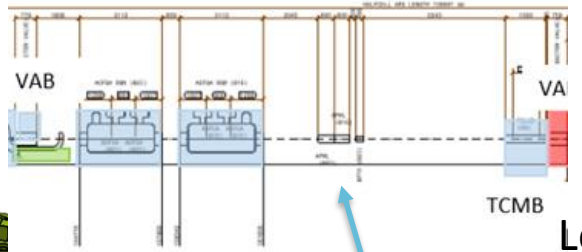
See G.Riddone, this review

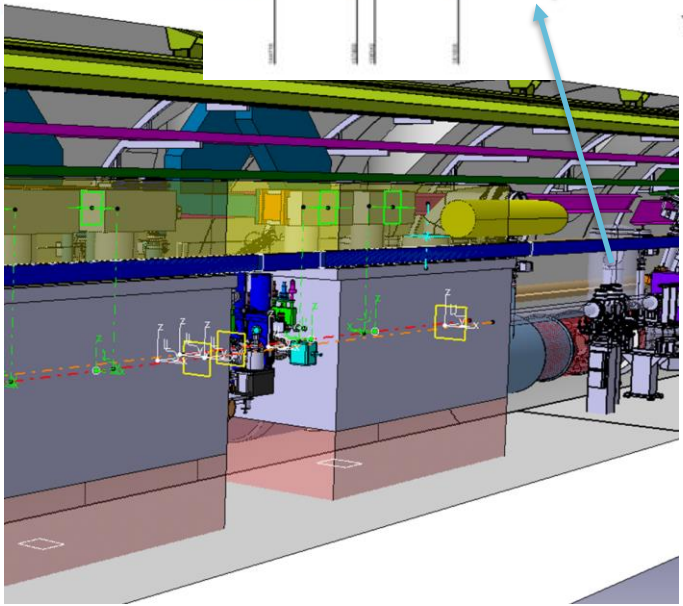
Determined by aperture and related reduction by mechanical tolerances (flange/ valve mechanical tolerances)
Crab cavity ϕ 84mm, adjacent drift tube aperture is determined by beam screen aperture and related tolerances. Verification in progress for compatibility with FRAS.





Constraints for interfaces: RF beam pick-up





Alignment during YETS/TS
Remote alignment
Static component: no alignment after the initial alignment

Longitudinal RF pick up for beam phase reference: transverse reference tolerance is above ±2.5mm

- Installed on individual platform, supported from the tunnel floor
- Aligned transversally at installation
- Supporting platform allows for transverse adjustment.

Permanent targets
Manual alignment in LSs

Information and figures from R.Calaga, O.Capatina, E.G. Mugica, T.Capelli, E.Montesinos, P.Fessia, H.Mainaud, M.Sosin, K.Brodzinski, Integration team, and many more

Project interfaces and knowledge transfer

	SPS		HL-LHC	
Type	DQW	RFD	DQW	RFD
Cavities from	CERN	CERN	RI (CERN contract)	ZANON (US-AUP contract)
Cryomodule from	CERN	UK (under UK1)	1 x CERN (first) 4 x UK (under UK2)	5 x TRIUMF

Strategy is in place for knowledge transfer to collaborating institutes, for FSI installation (FSI CERN's supply) and conventional and clean room alignment procedures during cryomodule assembly.
Alignment re-check at CERN during SM18 tests.