HiLumi HL-LHC PROJECT

TE-VSC contribution to WP4: Vacuum aspects & procurement status

EDMS 2954141

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13th HL-LHC Collaboration Meeting, Vancouver, Canada, 25-28th September 2023

CERN

https://indico.cern.ch/event/1293138/overview

Outline

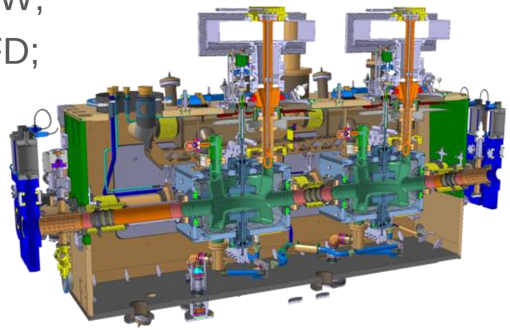
1. Overview
2. Status of the series production
3. Layout

1. Overview

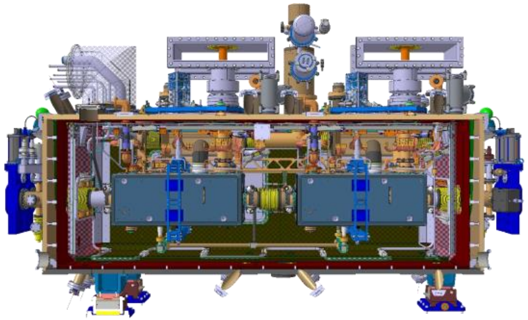
TE-VSC to WP4 contributions

- What is planned to be installed:
  - SPS – LSS6 : 1 X RFD – LHC type cryomodule (EYETS 2023/2024);
  - LHC – LSS1 (L+R) : 4 (2 + 2) DQW cryomodules;
  - LHC – LSS5 (L+R) : 4 (2 + 2) RFD cryomodules;

- What is planned for production: 10 CC cryomodules
  - SPS – LSS6 : 1 RFD (spare RFD);
  - LHC:
    - 5 (4 + 1 spare) DQW;
    - 5 (4 + 1 spare) RFD;

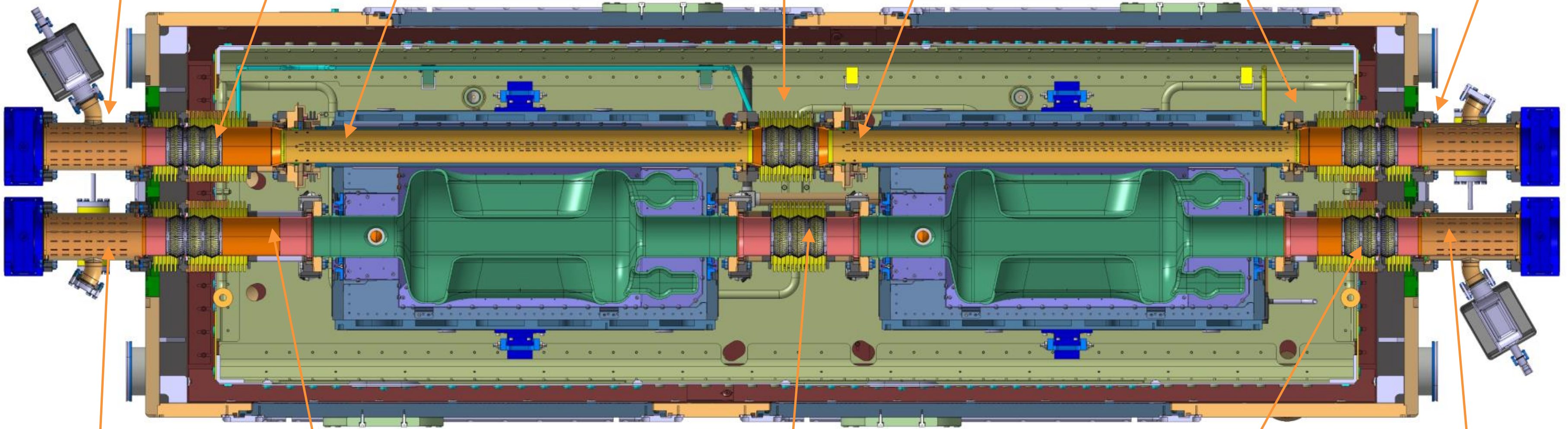


UK-CERN DQW CMs



Canada-CERN RFD CMs

TE-VSC to WP4 contributions



Courtesy of WP4

2. Status

Beam screens in non-crabbed line

Ongoing production

Item	Needed	Spare	Produced	Comments
Beam screen	20	2	29	14 DQW, 15 RFD, 4 DQW aC coated 2 RFD aC delivered to UK
BS Bellows	20	2	9	63 bellows delivered by Q4 2023 (more spares for the bellows) 2 delivered to UK

RFD beam screens in CERN storage

RFD type is1019 mm long, DQW type is 800 mm long

Plug-In-Modules & cold to warm transitions

Ongoing production

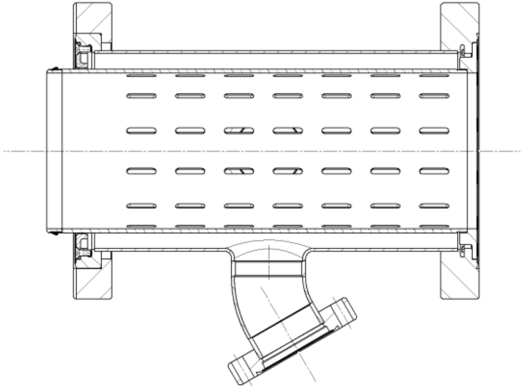
Item	Needed	Spare	Produced	Comments
PIM & cold to warm transitions	60	6	21	63 bellows delivered by Q4 2023 (more spares for the bellows) 6 assemblies for RFD delivered to UK

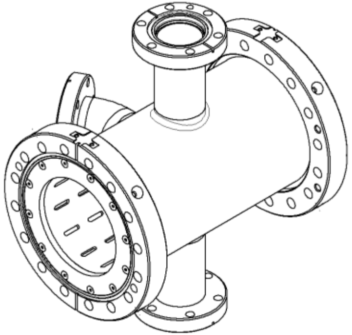
PIMs and cold to warm transitions production

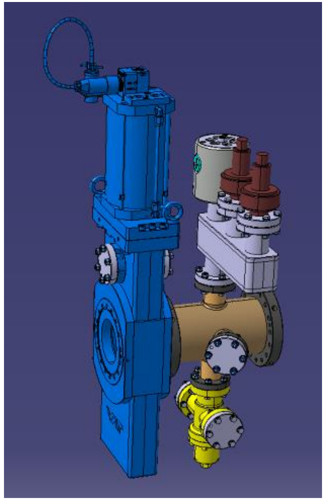
Extremity vacuum chambers

Production completed

Item	Needed	Spare	Produced	Comments
Ext. Vac. Ch	40	4	44	4 for RFD delivered to UK







DN80 Sector valves

Procurement completed

Item	Needed	Spare	Produced	Comments
Sector valves	40	4	44	4 for RFD delivered to UK 5 for RFD delivered to TRIUMF

Sector valves in CERN stores

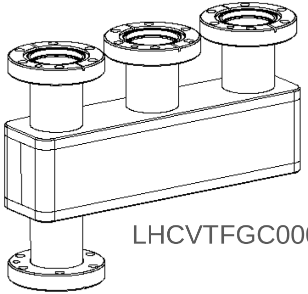
Sector valves at TRIUMF

Standard equipment

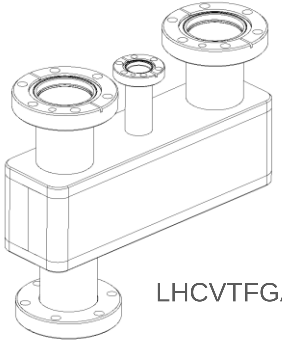
Production / procurement completed

Item	Needed	Spare	Received	Comments
Vacuum Manifold (VGP, VGR, VVR, VV)	40	2	42 21 (LHCVTFGC0001) 21 (LHCVTFGA0001)	4 delivered to UK

Vacuum manifold in CERN stores



LHCVTFGC0001



LHCVTFGA0001

Other/Standard Equipment's:

- Rupture disks
- Ion pumps
- Gauges
- Roughing valves
- Vacuum transition

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All ordered/Received

Project & quality management

- TE-VSC WP4 contributions EDMS node:
  - TE-VSC production Plan
  - Spending Profile
  - Long Term Planning (WP4 planning)
  - List of Assets
  - Monthly reports

TE-VSC Contribution to WP4 definition

EDMS NO.	REV.	VALIDITY
1754567	2.3	IN WORK

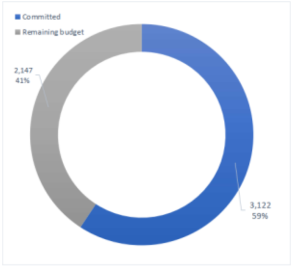
WP4: CRAB CAVITIES & RF

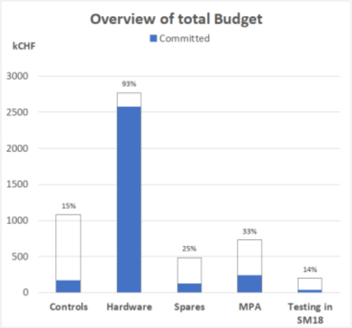
SUMMARY OF TE-VSC CONTRIBUTION TO WP4

Abstract

This document summarises the TE-VSC involvement in WP4.
It describes the activities, schedule, resources, and the related documentation.
This document was updated following several meetings between WP4, WP12 and HL-LHC management stakeholders.
The cost for this TE-VSC contribution is within the CtC of the WP4.

3. Overview of Total Budget





Total Budget	5,269
Committed	3,122
Remaining budget	2,147

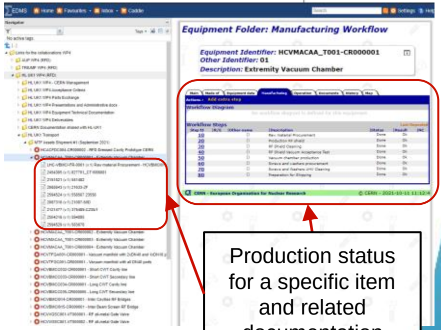
TE-VSC Budget follow-up

2. TE-VSC Production Status

Point: (Multiple Items)

Total Quantity Category	Sub-Category	Status2 Completed	In progress	Total	Total Progress
Beam vacuum	Rupture disk	22		22	100%
	Vacuum manifold	22		22	100%
	Beam Screen	29		29	100%
	Diamond bellow collars	2	18	20	10%
	Extension tube + Pinch off DN40		10	10	0%
	PIMS bellows	12	54	66	18%
	Extrusion chamber for roughing valve		10	10	0%
	Sector valve (VVGSC) DN80	44		44	100%
	Tee CF40x3	11		11	100%
	Tee CF40x2 with lateral DN16	11		11	100%
	Ion pump VPISA006 20 l/s DN35CF	4	18	22	18%
	Penning VGPB CF40	12	54	66	18%
	Pirani VGRA CF16	4	18	22	18%
	Roughing Angle valve VVFMD003 DN40	4	18	22	18%
	Flange DN40 (STDVFUHV0005)	10		10	100%
	Flange DN63 (STDVFUHV0007)	10		10	100%
	Flange QCF100 (STDVFCON0050)	20		20	100%
	Support for the roughing pipe		10	10	0%
	Extremity vacuum chamber/end module	44		44	100%
Insulation vacuum	Spring relief valve	1	10	11	9%
	Gauge grouping isolation valve	1	10	11	9%
	Membrane gauge	1	10	11	9%
	Pumping fixed groups_TMP	1	8	9	11%
	Pumping fixed groups_Isolation valve	1	8	9	11%
	Pumping fixed groups_Block multivalve	1	8	9	11%
	Pumping fixed groups_Primary valve	1	8	9	11%
	Roughing Angle valve VVFMD003 DN40	1	10	11	9%
	Pirani KF16	1	10	11	9%
	Penning KF40	1	10	11	9%
Intertanks	bellows in between vacuum lines		8	8	0%
	Intertank support		4	4	0%
	Penning VGPB CF40	4		4	100%
	Pirani VGRA CF16	4		4	100%
	Roughing Angle valve VVFMD003 DN40	8		8	100%
	Ion pump VPIAN002	8		8	100%
	NEG pump VPNCA D400 CF35	8		8	100%
	Vacuum Module (Bellows + instrumented VC)		8	8	0%
Total		303	322	625	48%

TE-VSC Production follow-up

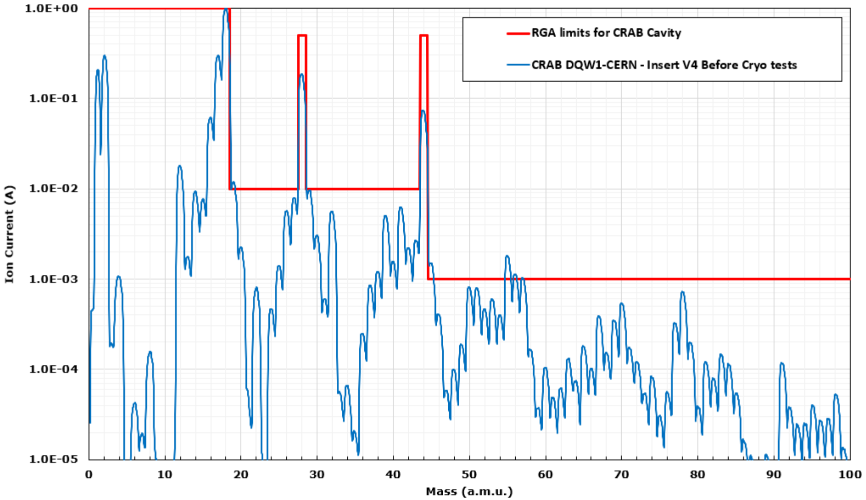


Production status for a specific item and related documentation

TE-VSC MTF

Vacuum acceptance tests

- Residual gas composition.
  - The RGA scan must be normalized to the highest peaks (H_2 or H_2O) and the RGA is considered non-conform if one of the following levels is not respected (EDMS 2779658)
    - Highest gas not being H_2 or H_2O;
    - Mass of 40 (argon) > mass 39: indication presence of air;
    - Light hydrocarbon (27,29,35,37,39,41): at least 100 times lower the maximum peak;
    - Masses > 50: at least 1000 times lower the maximum peak;
    - Presence of mass 4 (He).

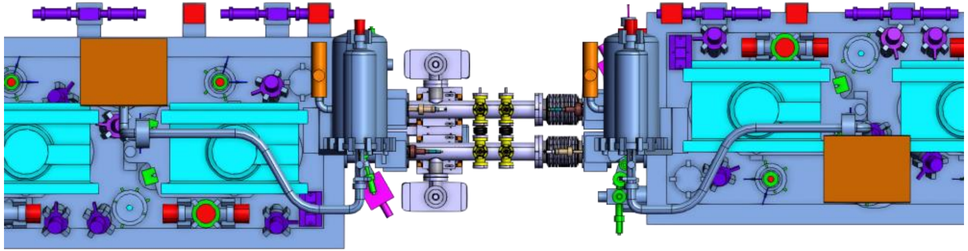


3. Layout

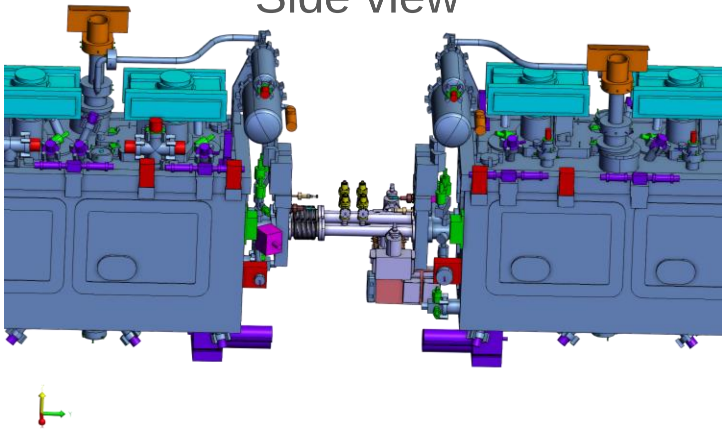
Inter-crab vacuum sector: integration

- Inter-tanks cryomodules design is at his final step
- Layout already in Optic LS3 V1.7 of Layout Data Base
- Engineering report will circulate soon for a final approval at the project level:
  - EDMS 2045739

Top view

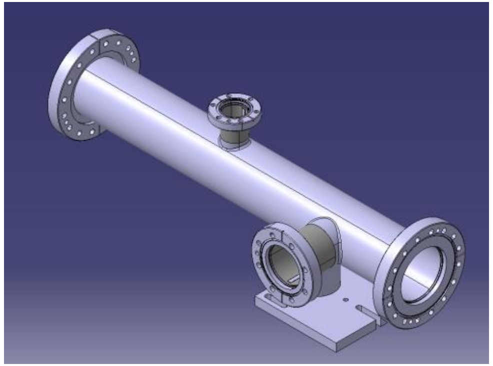


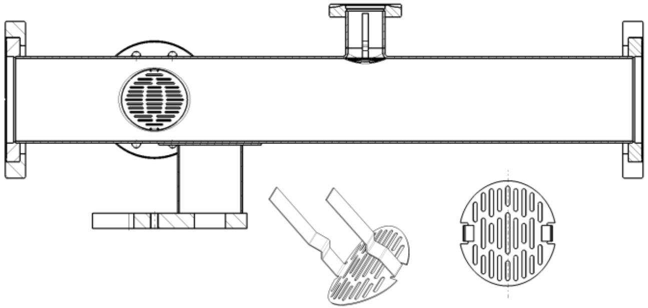
Side view



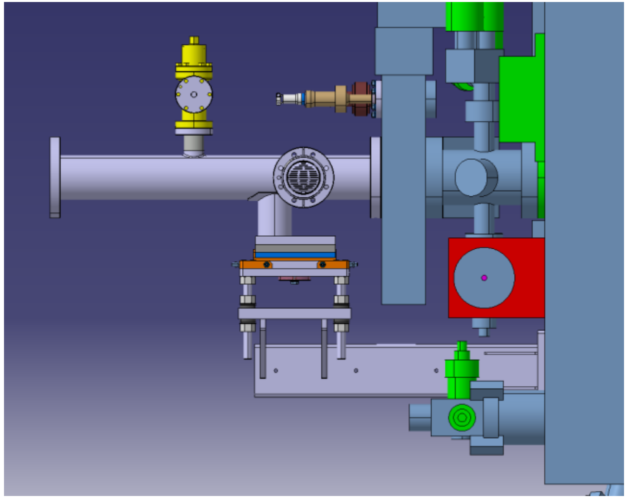
Optics v1.7

inter-crab vacuum sector: components



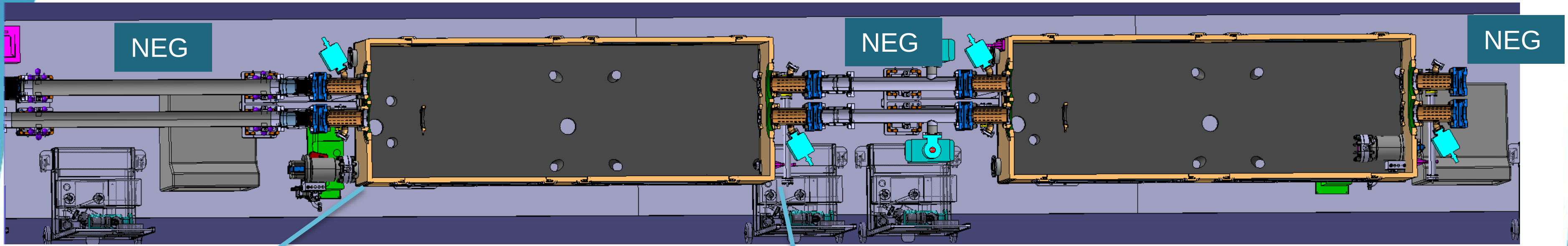


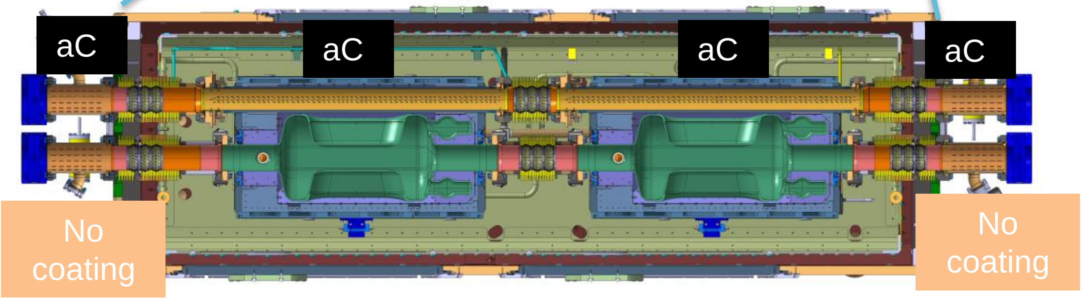
- Stainless steel vacuum fired
- Copper Pated, NEG coated
- Special RF shield for pumping and valves ports



- Compact and easy installation or intervention
- Support integrated in the CRAB vessel (EDMS 2899757)

Electron cloud mitigation

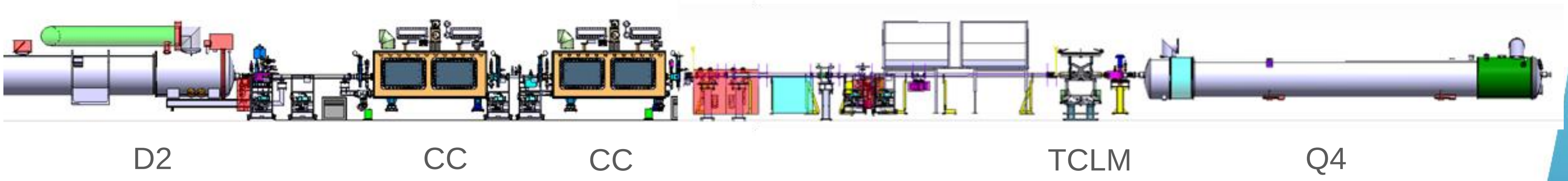




- Crab cavities are not expected to contribute to the e-cloud: EDMS 2663141

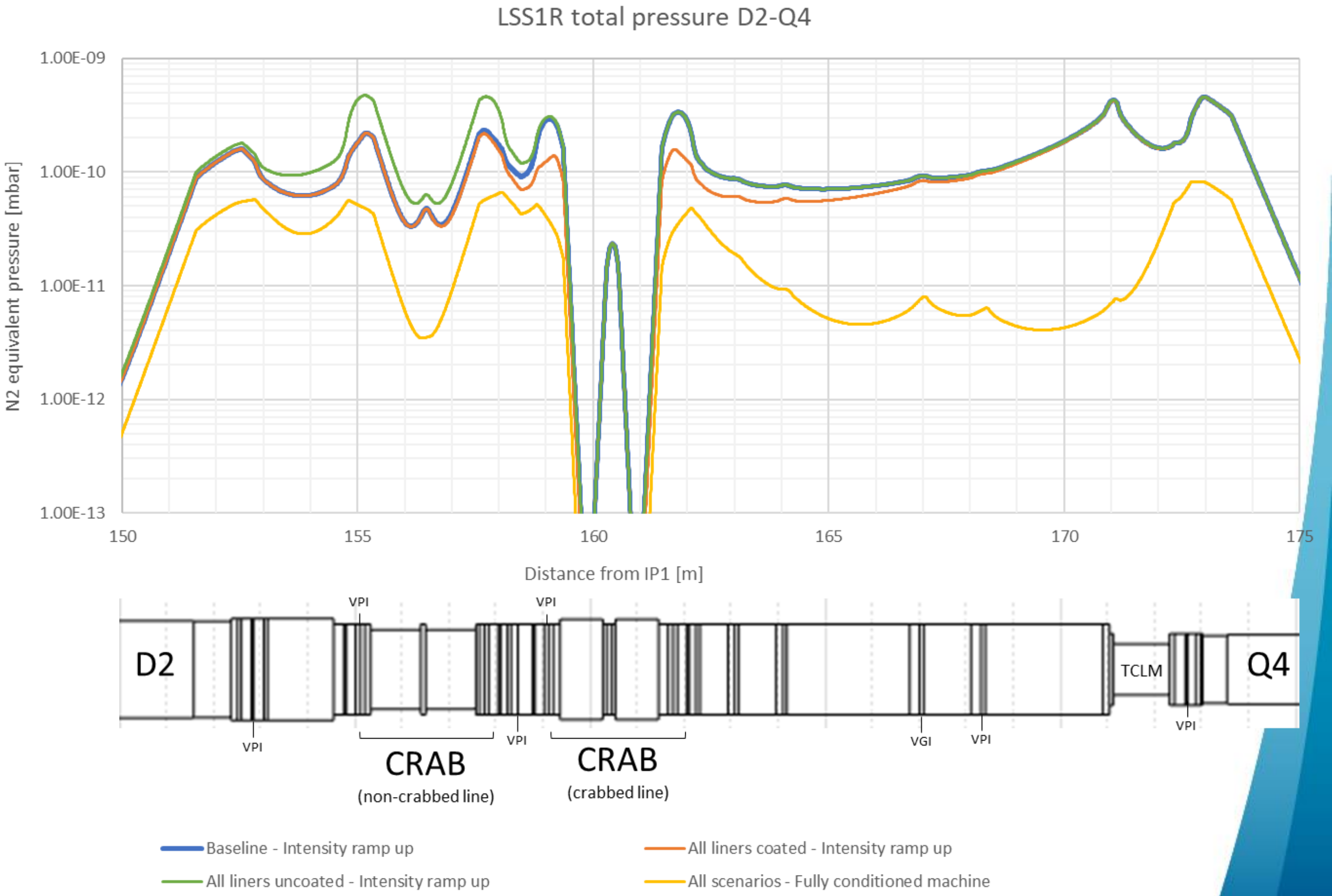
Pressure profile in D2-Q4

- Simulations of the blue beam (B1) in LSS1R as a worst-case scenario:
  - LSS1: shorter inter-cavity sector
  - Outgoing beam from IP having more SR radiation from the D2 dipole
- Three configurations investigated:
  - All extremity vacuum chambers uncoated
  - Baseline: aC coating on the extremity vacuum chambers of the non-crabbed line only
  - All extremity vacuum chambers aC coated



Pressure profile in D2-Q4

- Beam parameters:
  - Energy: 7 TeV
  - Intensity: 1.08A per beam (2748 bunches, 2.2×10^{11}ppb)
- Baseline:
  - P@NCL = 2 10^{-10} mbar
  - P@CL = 3 10^{-10} mbar
- All aC coated:
  - P@NCL = 2 10^{-10} mbar
  - P@CL = 1.5 10^{-10} mbar
- Full conditioned machine:
  - P@NCL = 4 10^{-11} mbar
  - P@CL = 4 10^{-11} mbar

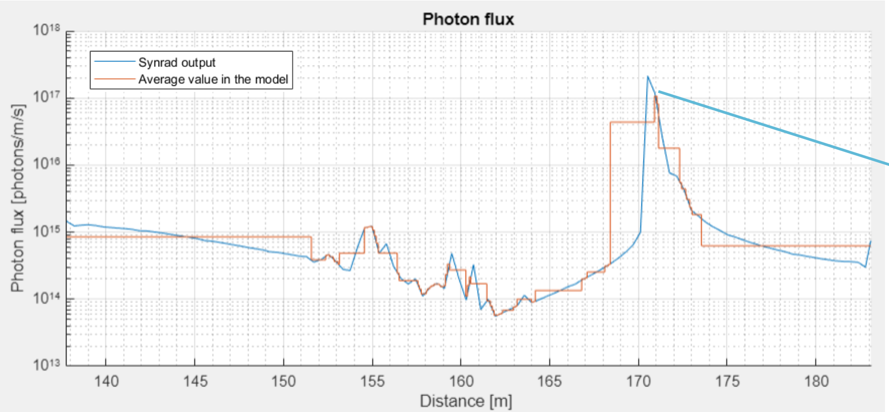


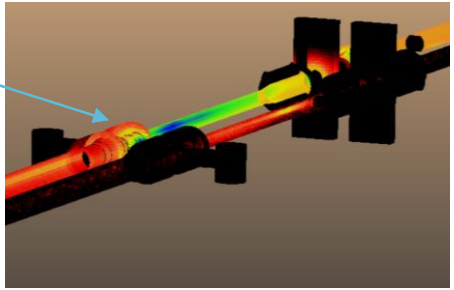
Thank you for your attention

Many thanks to all contributors

Inputs for simulation scenarios

Intensity ramp up scenario	Fully conditioned machine scenario
Electron flux only on uncoated parts: $2 \times 10^{15} \frac{e^-}{m\,s}$	No e^- flux (SEY < ecloud threshold)
ESD yields conditioned by a factor 10 (after scrubbing run)	No ESD
Synchrotron radiation imported from Synrad+	Synchrotron radiation imported from Synrad+
PSD yields of materials as received	PSD yields conditioned (dose ≈10^{23} photons/m)
Beam parameters: • Energy: 7 TeV • Intensity: ≈1.08A per beam (2748 bunches, 2.2×10^{11}ppb)	Beam parameters: • Energy: 7 TeV • Intensity: ≈1.08A per beam (2748 bunches, 2.2×10^{11}ppb)

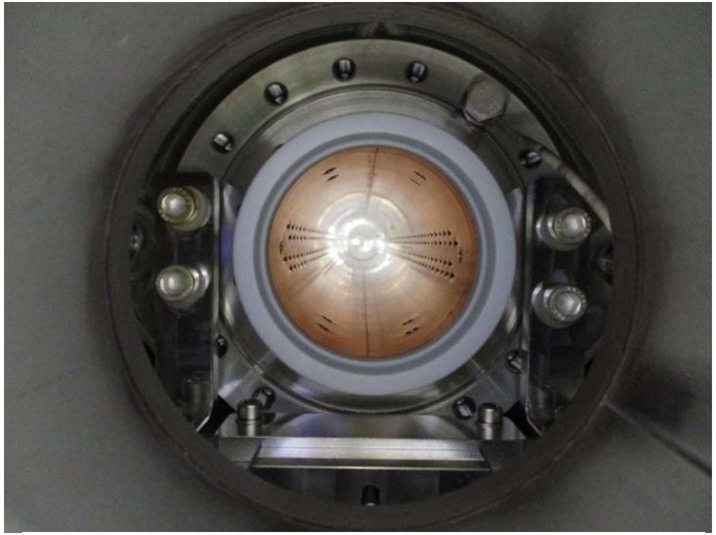


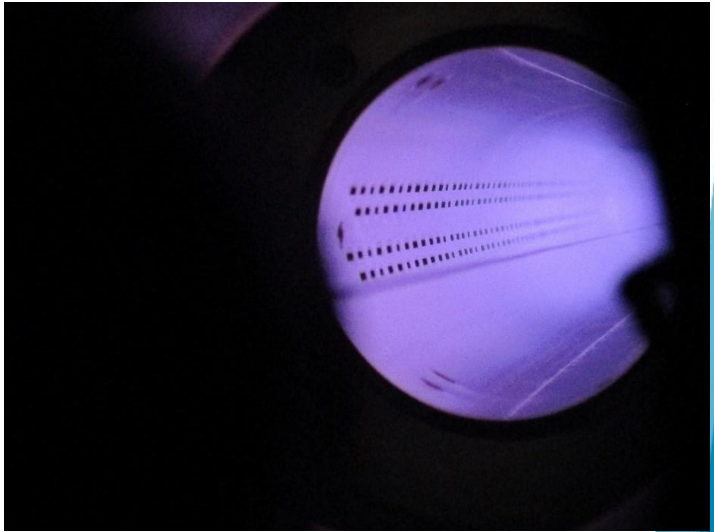


a-C coating for beam screen: Argon cleaning

- Argon glow discharge surface preparation step before a-C coating
  - Remove the native oxide layer
  - Then build a new oxide layer with dry air to avoid presence of copper hydroxides, detrimental for the adhesion.

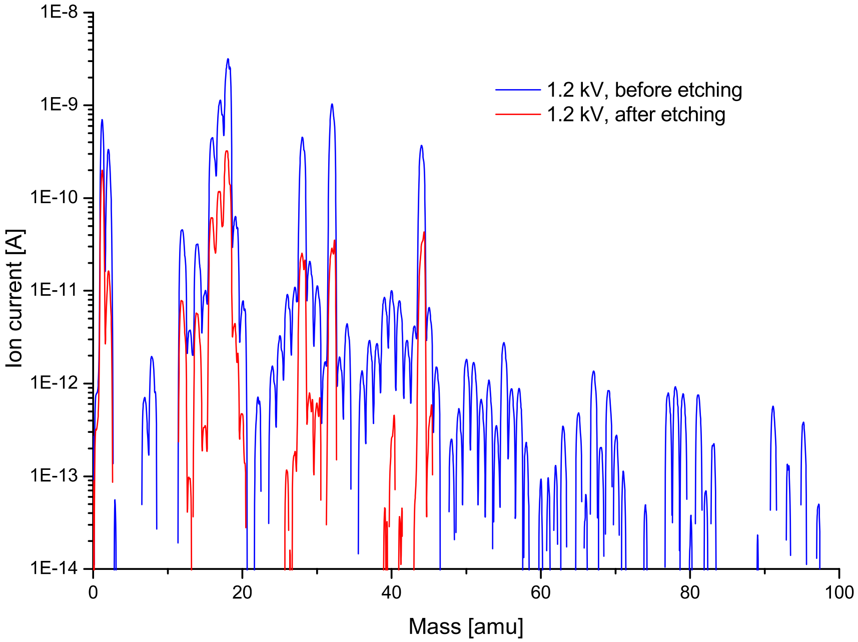

Beam screen


Insertion on special support system


Plasma cleaning process

Plasma cleaning of cold bore

- Plasma cleaning of the cold bore using O2 glow discharge.
  - Generation of a plasma inside the cold bore, using a Ti wire in the centre of the cold bore as anode and grounding the cold bore, that acts as a cathode.
  - O radicals and O ions are formed and clean the cold bore surface.
  - The O ions acquire an energy of ~200 eV and cause some sputtering of the cold bore.
  - The cleaning effect is clearly seen by comparing the spectra before and after cleaning. (the cold bore was dirty)



- ONGOING:
  - Finalization of a plasma cleaning process using a “remote plasma source”: the plasma is generated in a source and then injected in the cold bore -> The main advantages are the lower energy of the ions (~50 eV, practically no sputtering), and the simplicity (do not require the assembly of an anode; easier to operate).