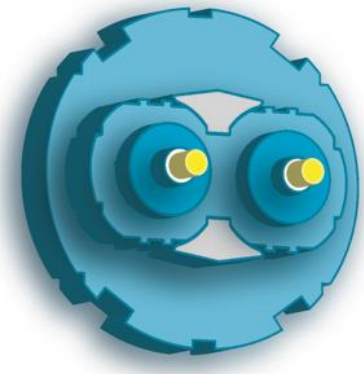


High Luminosity LHC

Vacuum interfaces and crab cavities (SPS/LHC)

V. Baglin (TE-VSC)
on behalf of WP12

4th Joint HiLumi LHC-LARP Annual Meeting
KEK – 17-21 November 2014

The HiLumi LHC Design Study is included in the High Luminosity LHC project and is partly funded by the European Commission within the Framework Programme 7 Capacities Specific Programme, Grant Agreement 284404.

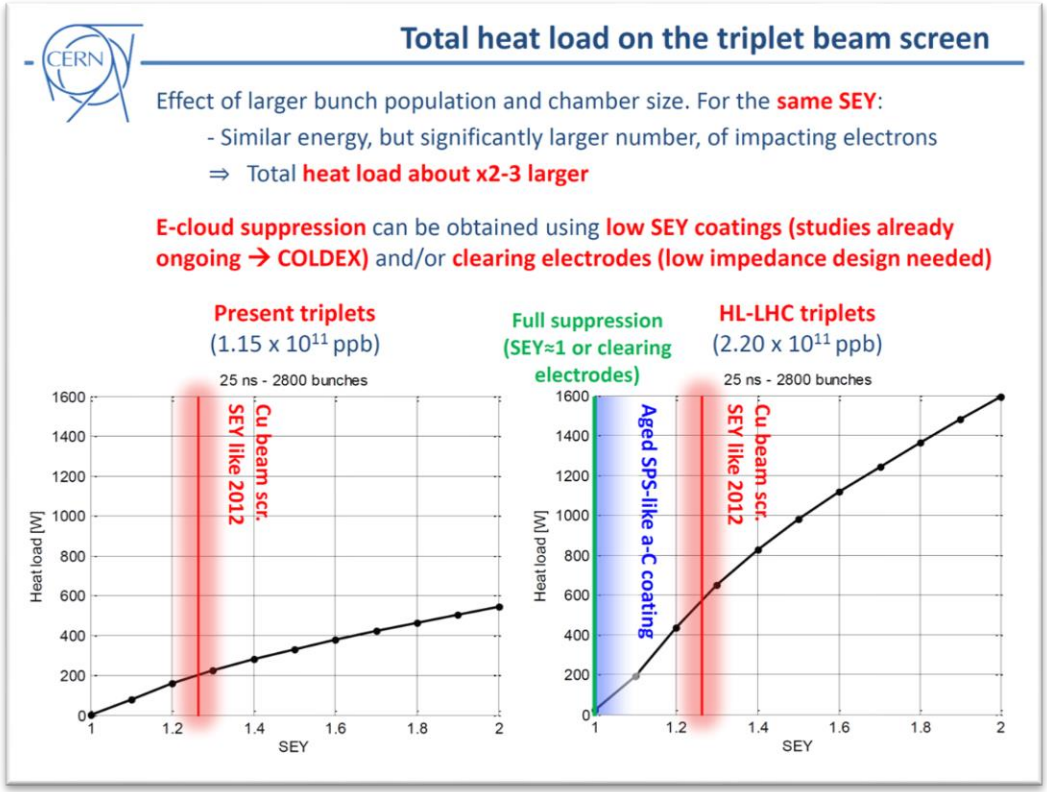
Outline

1. COLDEX in SPS
2. Crab cavities in SPS
3. Crab cavities in LHC
4. Conclusion

1. COLDEX in SPS

Motivation: HL-LHC Inner Triplets

- Extrapolation for the HL-LHC of Run 1 observations predicts large heat load due to electron cloud on the beam screen of the inner triplets
- This increase of heat load will be accompanied by increase of background to the experiments
- To reduce the heat load to ~ 200 W on the beam screen, amorphous carbon (a-C) coating is proposed (SEY~ 1.1)
- This base line must be validated at cryogenic temperature with LHC type beams

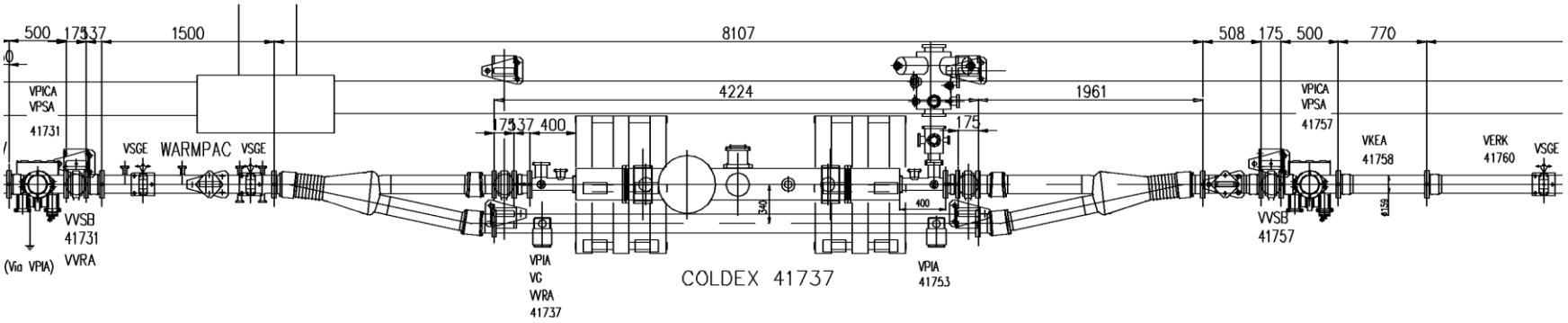


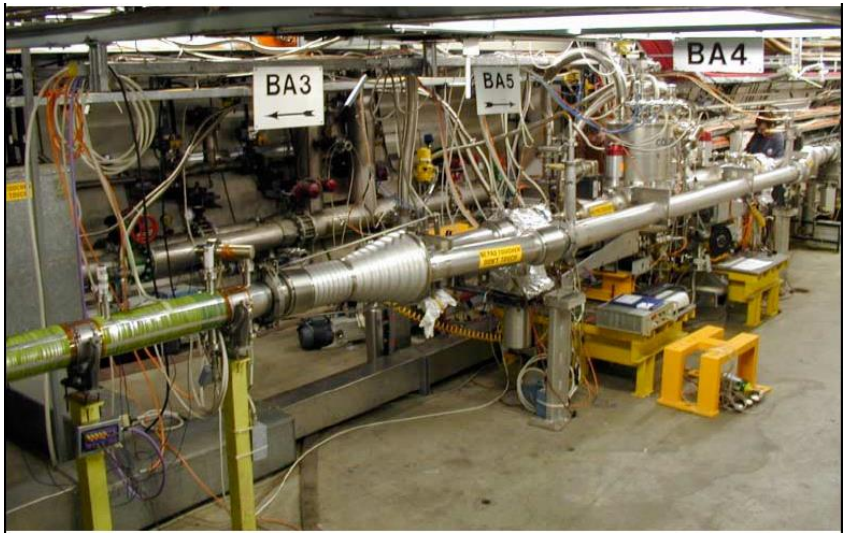
G. Iadarola, G. Rumolo
3rd Joint HiLumi LHC-LARP Annual Meeting, Daresbury
11-15/01/2013

What is COLDEX ?

COLD (Bore) **EX**(periment) – installed at CERN-SPS (BA4)

Mimics the LHC cold bore and beam screen section, for electron cloud studies





- Mitigate the electron cloud build-up with amorphous carbon coating
- Operate in the BS in the 40 to 60 K temperature range
- Reduce background to experiments

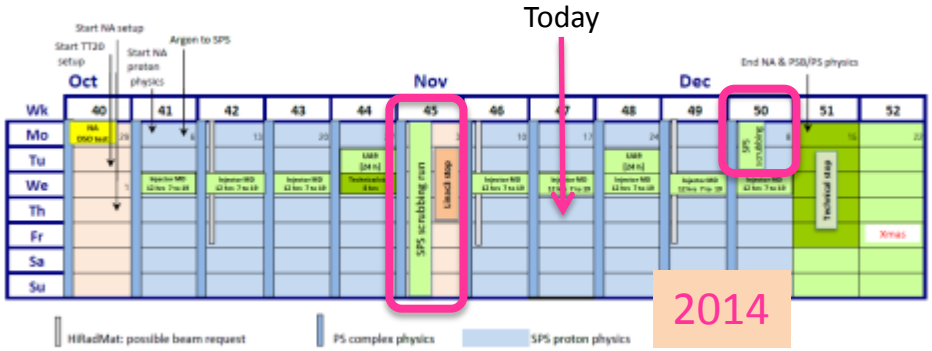
- Refurbishment of COLDEX : strong support and commitment of many CERN groups: TE-CRG, BE-OP, BE-ABP, TE-EPC, EN-ICE

COLDEX Scientific Objectives

- Accumulate beam time with:
  - a-C coating on Cu (HL-LHC inner triplets & matching section)
- Studies with LHC type beams of:
  - Pressure increase
  - Gas composition
  - Heat load
  - Electron flux
- Study multipacting triggering vs:
  - BS temperature
  - Beam structure and bunch intensity
- Study the impact of BS temperature:
  - 5-20 K for HL-LHC matching section
  - 40-60 K for HL-LHC inner triplets
- Studies of operational impact of:
  - Gas pre-condensation, H_2, CH_4, H_2O, CO and CO_2: simulates long term operation and impact of quenches
  - Temperature oscillations / excursion

Current schedule

- Study long term behaviour during “scrubbing runs”:
  - 9 days in 2014 + 7 days in 2015 ➔ 15 days with a-C copper coated beam screen



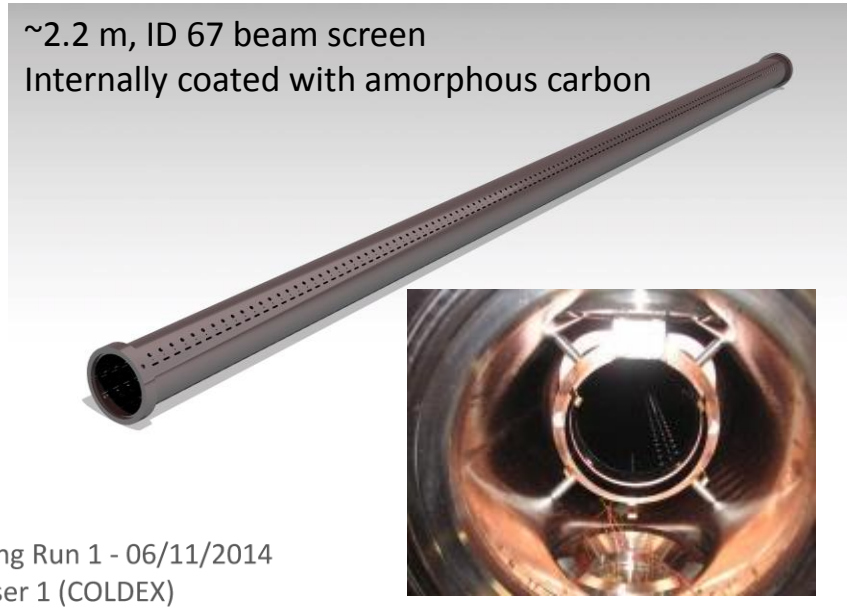
- Specific studies during “Injector Complex MD block”: 1 shift of 8 h
  - None in 2014 + some blocks (5 ?) ➔ still to be defined in 2015

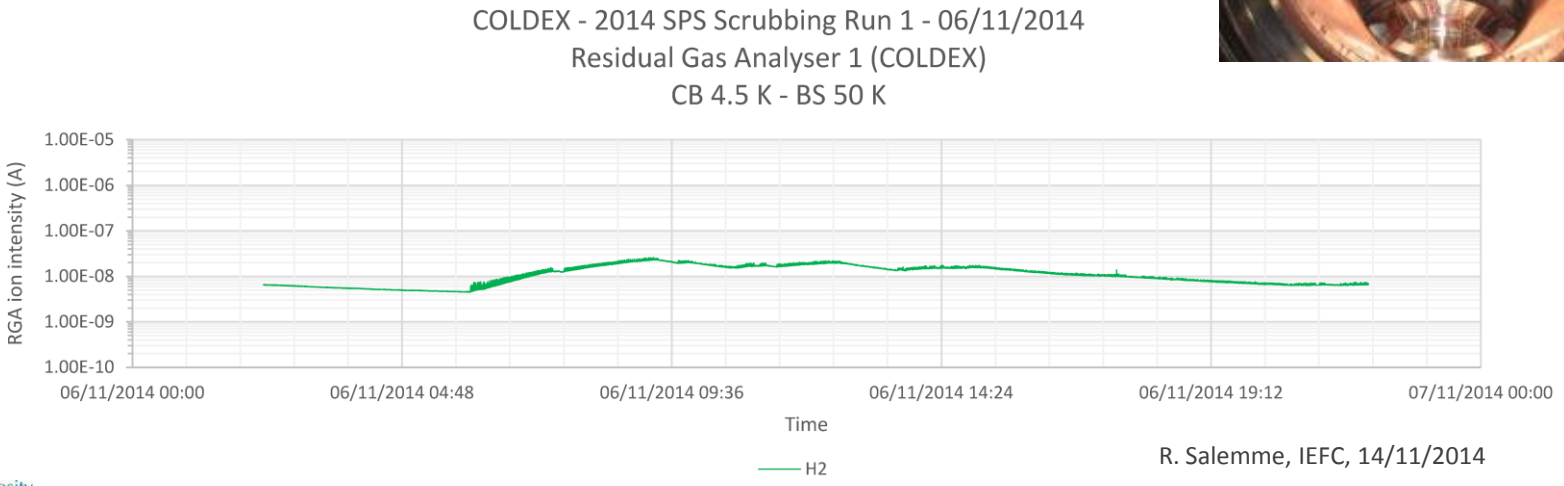
- Remark: COLDEX needs to be moved in/out so not compatible with floating injector MD where LHC beam has priority

Preliminary results

- a-C beam screen held at 50 K, 5 k then 10 K while cold bore ~ 4K

- LHC type beams circulating in SPS (3-9/11/2014):
  - Heat load < 1 W/m
  - Pressure rise < 5 10^{-9} mbar
  - Main gas is H_2





R. Salemme, IEFC, 14/11/2014

2. Crab Cavities in SPS

Current Schedule (tbc)

- The SPS crab cavity tests bench is proposed to be installed in BA4
- The schedule was revised for this meeting and needs to be approved (A . Macpherson private communication, 14/11/2014)
- Preparatory work in 2015-2016 YETS
- Installation of crab infrastructure to start by December 2016 (EYETS) :
  - RF power installation
  - Supporting table
  - New cryogenic cooling system at 2 K
  - New vacuum bypass (Jan 2017)
- COLDEX could operate during 2015, 2016 (tbc)

A. Macpherson, 17/10/2014

Impact of Schedule

- This implies:
  - Dec 2016, removal of COLDEX (in a non destructive way): Time estimate ~ 1 week
  - Installation of a new vacuum system to accommodate the crab cavity test bench

- Potential impact on the COLDEX scientific program (HL-LHC and also FCC)

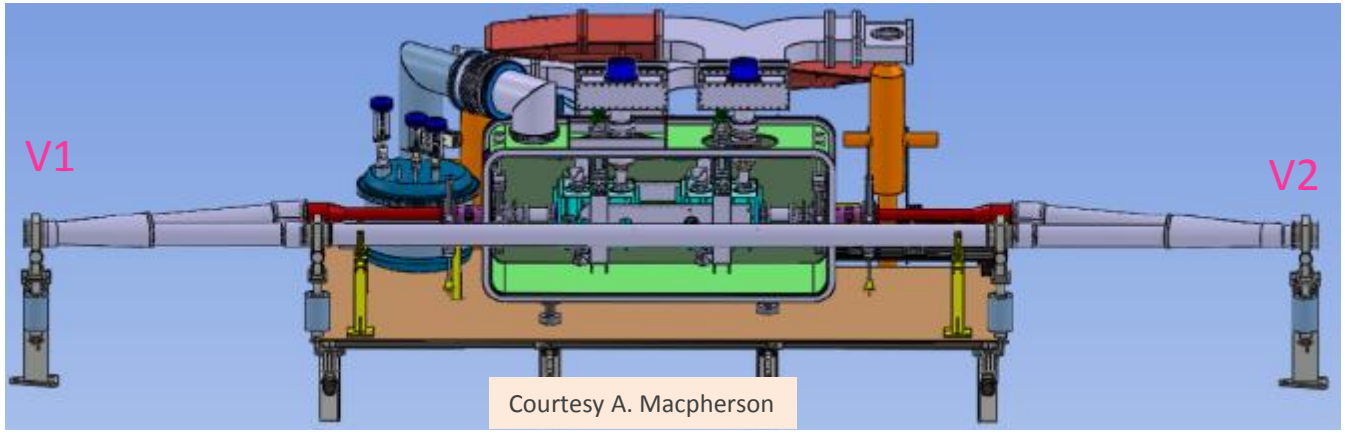
- The location of the SPS crab cavity test bench in BA4 was driven by the presence of a cryogenic system (4.2 K) and the presence of a bypass system, but, following studies, both systems have to be replaced by new ones.

  ➔ Other location might be envisaged *e.g.* BA5 which is very similar to BA4

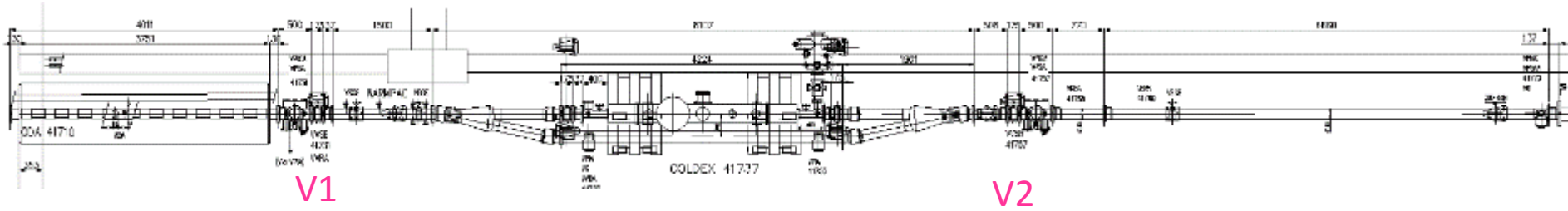
  ➔ This would open the possibility for CERN to possess TWO beam test stations operating at cryogenic temperature: an advantage for HL-LHC but also FCC

Layout

- Operating pressure ~ 10^{-10} mbar with beams: a detailed computational analysis is needed
- Similarly to LHC, NEG coated vacuum chambers between V1 and V2 (except CC module !)
  - Differential pumping system between V1/V2 and module
  - If needed, a-C coating or solenoids could be implemented elsewhere



Courtesy A. Macpherson



- A new layout must be defined by June 2015 to complete the design of the "Y" chamber and start the procurement of components

SM18 preparation

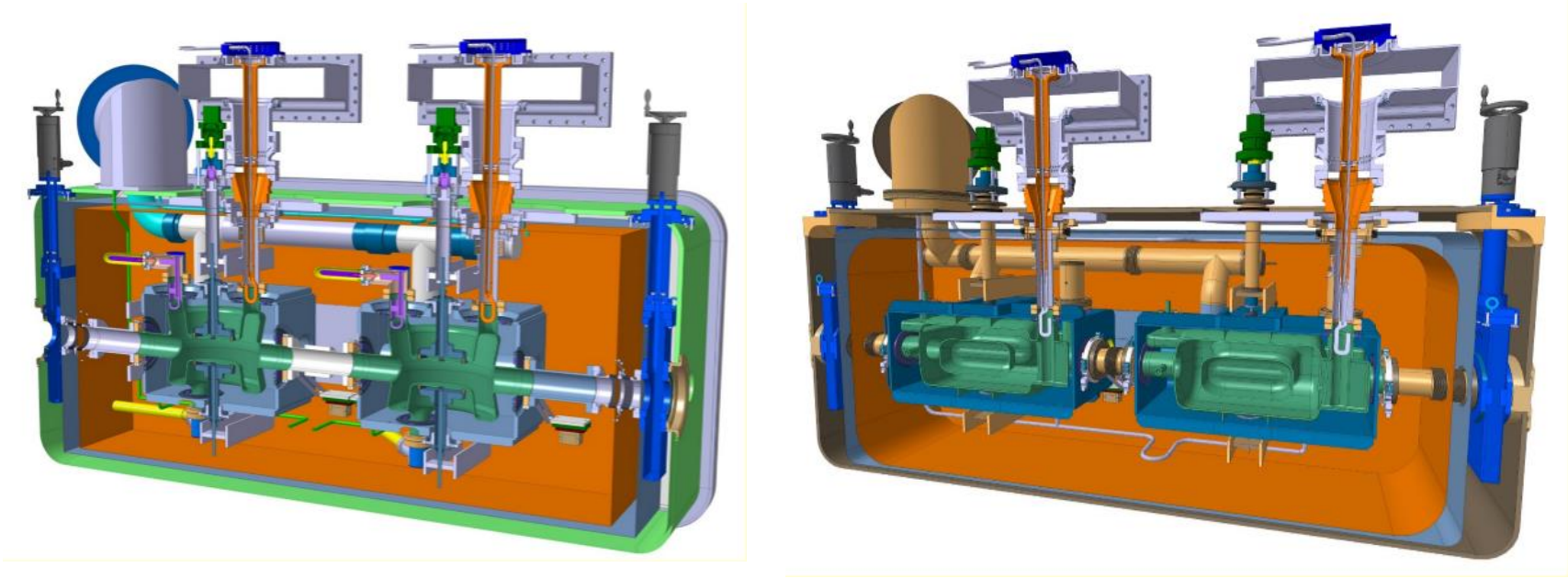
- Vertical test bench for cavities to be refurbish by March 2015
  - Industrial support
  - Material defined (mobile pumping group, bakeout, RGA)
  - Quoted launched
  - Budget defined

- Horizontal test bench located in bunker for modules needs to be operational for 2016

3. Crab Cavities in HL-LHC

Crab Cavities

- Operating pressure ~ 10^{-10} mbar with beams
- 2 designs with bulk Nb operating at 2 K
- Vacuum instrumentation on the modules is under definition
- Drawings and leak detection procedures needs to be validated by VSC



Cryomodules for the DQW (left) and RFD (right) cavities respectively

Courtesy R. Calaga, O. Capatina

Crab Cavities

- Bulk Nb treatment is well defined (EDMS 1389669):
  - 150 micron chemical etching, 600 deg heat treatment, 10-20 micron chemical etching, high pressure water rinsing and finally a 120 deg bake

- Impact of the electron cloud in the CC modules must be evaluated:
  - Nb cavity itself
  - Inter-cavity tube
  - Module cold warm transition

} Samples needed for qualification

1.1 < Nb film SEY < 1.7

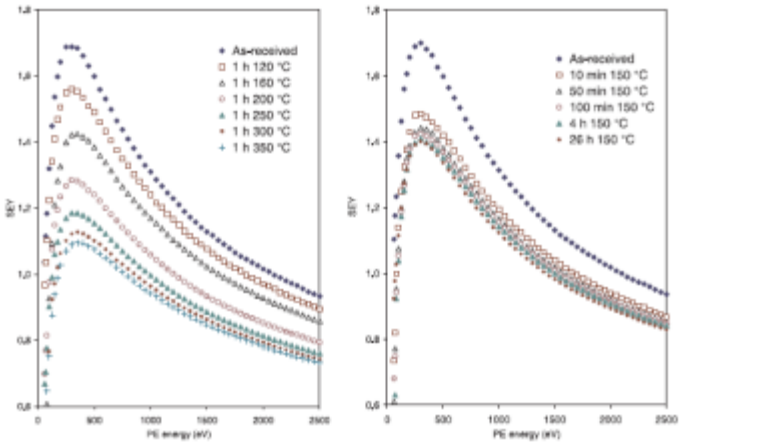
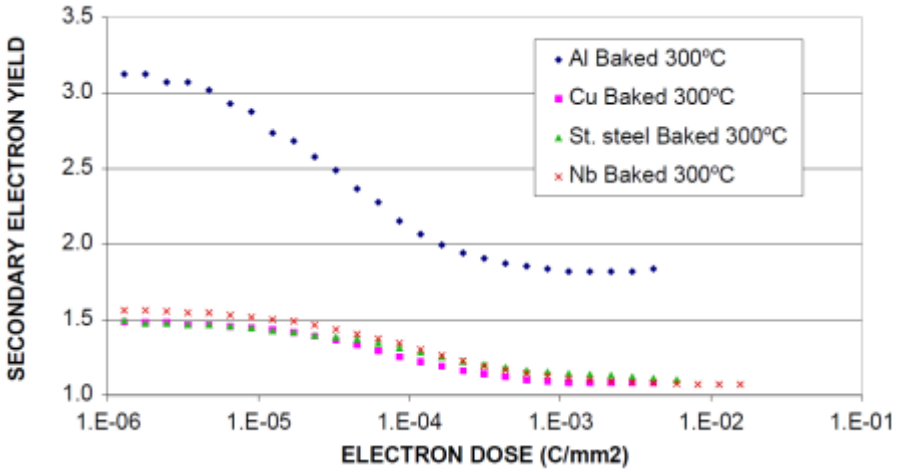


FIGURE 2 SEY vs PE energy of a Nb thin film as a function of heating temperature at 1 h heating time (*left plot*) and as a function of heating time at 150 °C (*right plot*)

N. Hilleret *et al.*, Appl. Phys. A 79, 1085-1091 (2003)

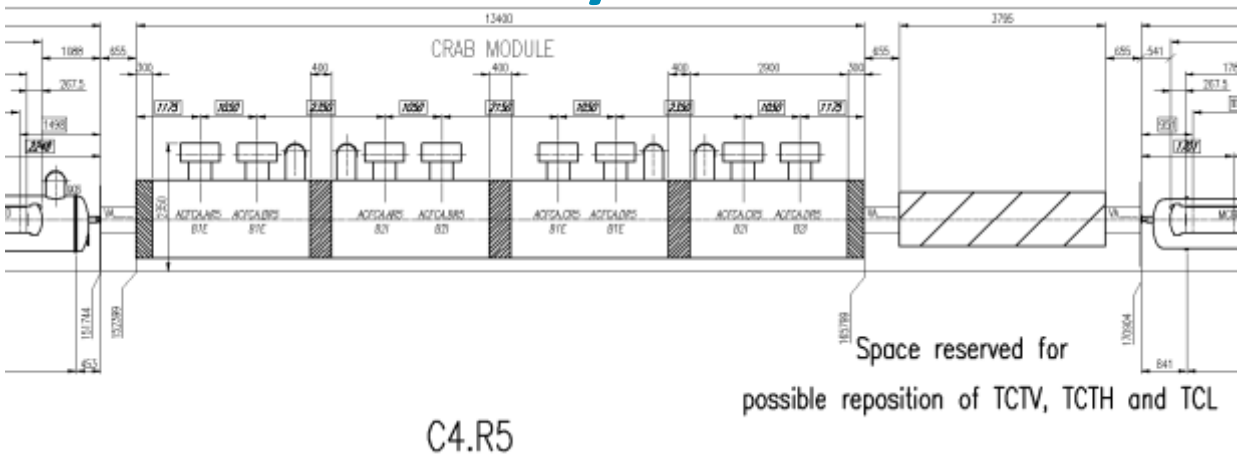
Electron conditioning



N. Hilleret *et al.* EPAC 2000, Vienna, Austria

Layout –D2-Q4

side view



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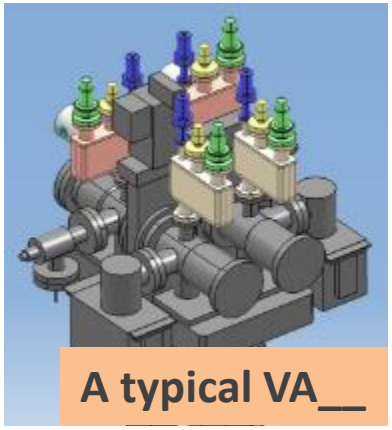
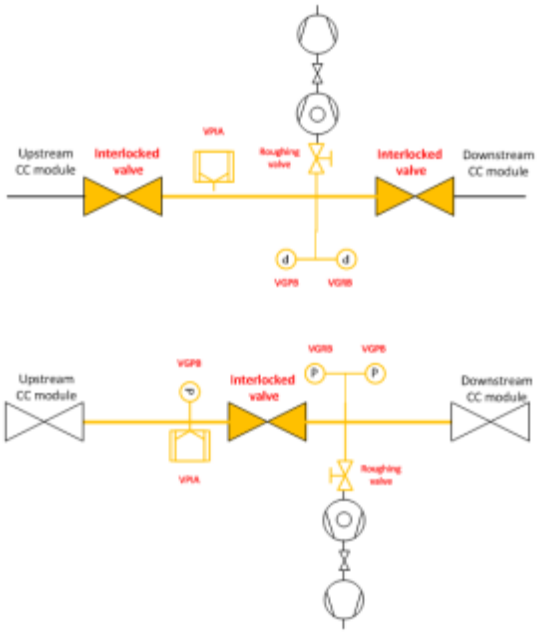


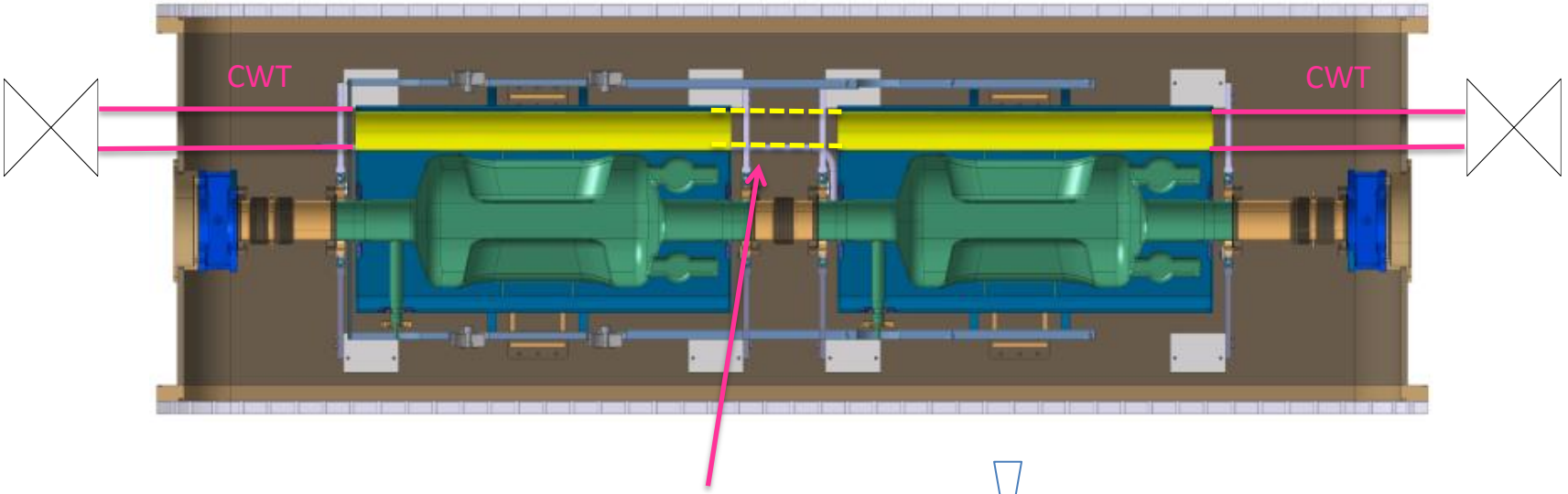
- Room temperature (except CC modules): bakeable and NEG coated
- 4 Sectorised CC modules:
  - Standard sectorisation valves (VA__), length 655 mm, at extremity
  - Specific sectorisation assembly, length 400, between modules. To be defined & designed. 2 beam line:
    - 2 roughing valve
    - 3 sector valve (beam interlocked)
    - 3 penning gauges + 2 ion pump + 2 pirani gauges



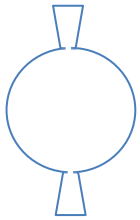
Layout –D2-Q4: 2nd beam pipe

- The 2nd beam pipe is held at 2 K and has cold warm transition (CWT) !
- Current material is Nb, diameter limited by space

- In LHC, maximum length without beam screen is < 1 m (to be revised for HL-LHC)
- Detailed studies are needed to comply with vacuum stability and pressure level



A beam screen between
2 cryogenic pipes ?

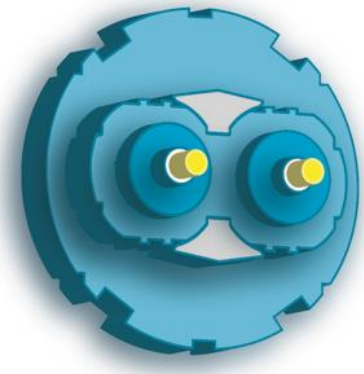


A beam pipe with
Antechamber ?

4. Conclusions

Conclusions

- COLDEX has started data taking to validate WP12 a-C coating base line:
  - should operate in 2015 and 2016
- SPS layout with crab cavities needs to be validated by mid-2015 to complete design and start procurement of components
- Crab cavity vacuum layout in HL-LHC is under definition
- Dedicated studies are needed to:
  - understand the impact of electron cloud
  - design the 2nd beam pipe of the module



High Luminosity LHC

Thank you for your attention

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