New SR beam line at BINP for photo-desorption and photo-electron emission investigations. Experimental program for HiLumi. Options for future experiments

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- **Measurements made at BINP for LHC cold beam vacuum**
- **Electron Clouds mitigation at Inner Triplets**
- **Parameters of SR beam line and experimental set-up at BINP**
- **Experimental program for HiLumi**
- **Options for future investigation**
  - PEE at high magnetic field
  - NEG coating for cold beam pipe

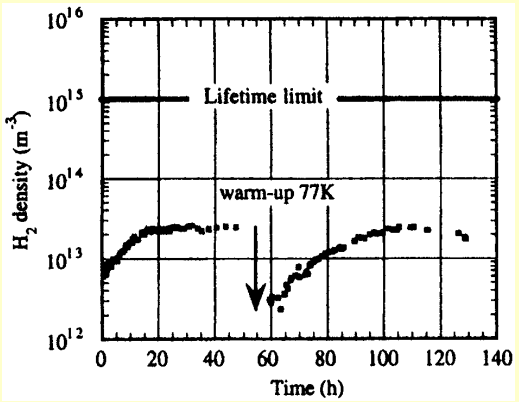
CERN-BINP COLLABORATION in frame of LHC project

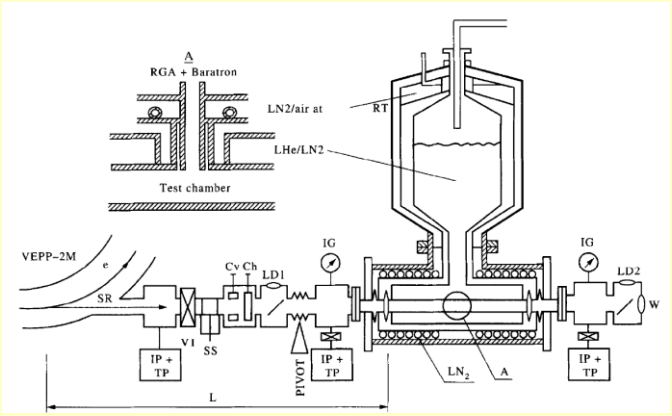
STUDIES OF PHOTODESORPTION PROCESSES IN PROTOTYPES OF LHC VACUUM SYSTEM

PERIOD: 1996–2002

1. BASIC RESULT:

   IT WAS SHOWN THAT THE DYNAMIC PRESSURE UNDER DESORPTION CONDITION AT SR ACTION IN LHC DID NOT EXCEED THE DESIGN VALUES.



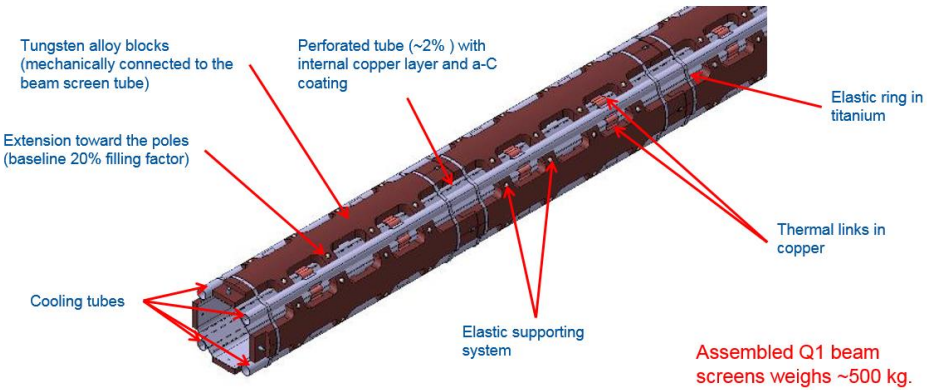


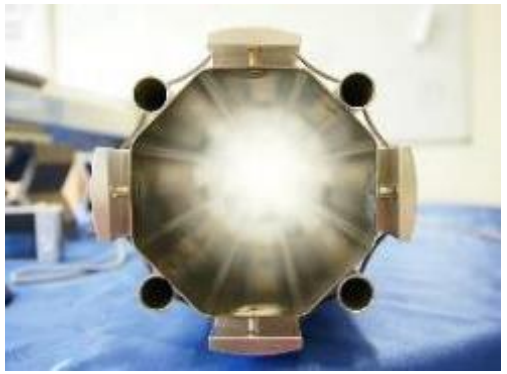
2. SEVERAL KEY PARAMETERS NECESSARY FOR THE DESIGN OF LHC VACUUM SYSTEM WERE DETERMINED.

HL-LHC Shielded Beam Screen

• Around the experiments, the final focussing quadrupoles need to be shielded against the collision debris produced at the interaction point.

- Tungsten alloy (Inermet) to intercept the debris produced at the IP
- 100-200 nm thick a-C coated onto 80 μm copper co-laminated beam screen
- Operating temperature : 40 – 60 K (base line under review) with the cold bore at 1.9 K
- Length ~ 10 m, weight ~ 500 kg , transparency for pumping ~ 2 %



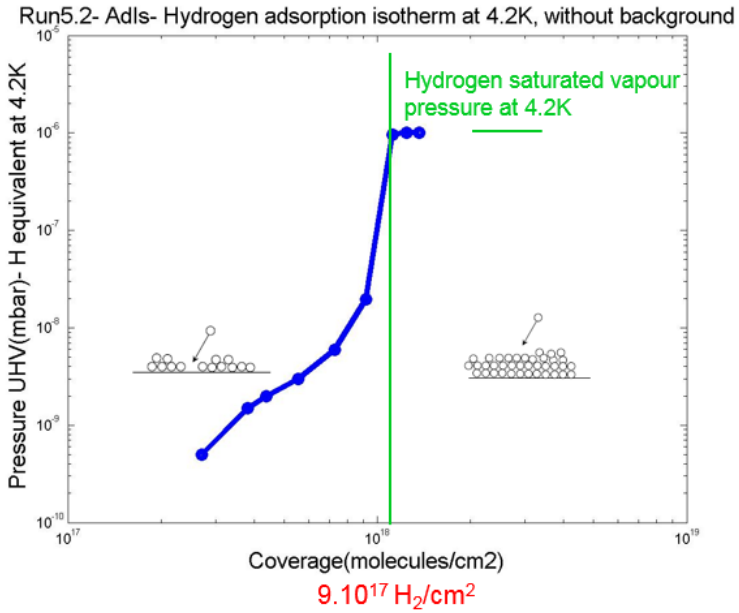


Courtesy C. Garion TE-VSC

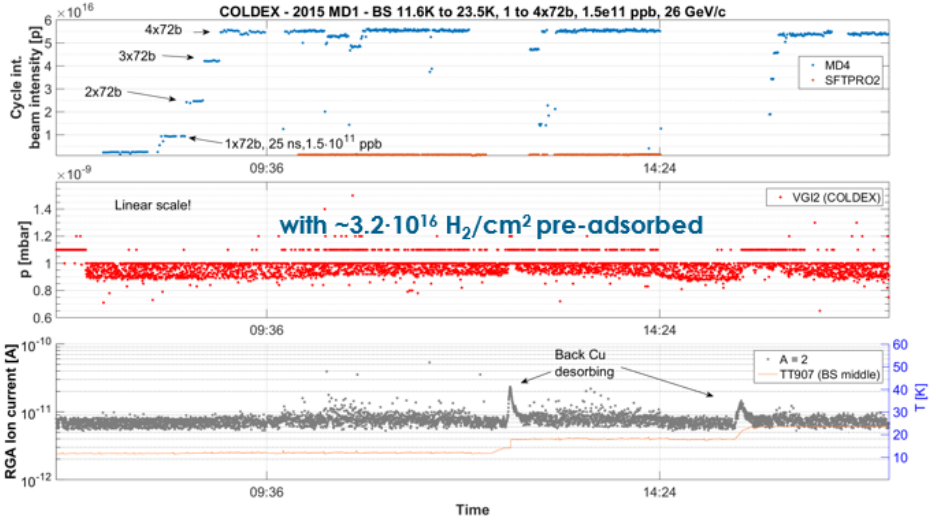
- Heat load: 15-25 W/m

a-C coating at Cryogenic Temperature

- a-C coating has been proposed to mitigate electron multipacting to reduce the heat load on the beam screen and the background to the experiments.
- The coating is currently under evaluation at cryogenic temperature with and without LHC type protons beams.



Courtesy A-L. Lamure TE-VSC



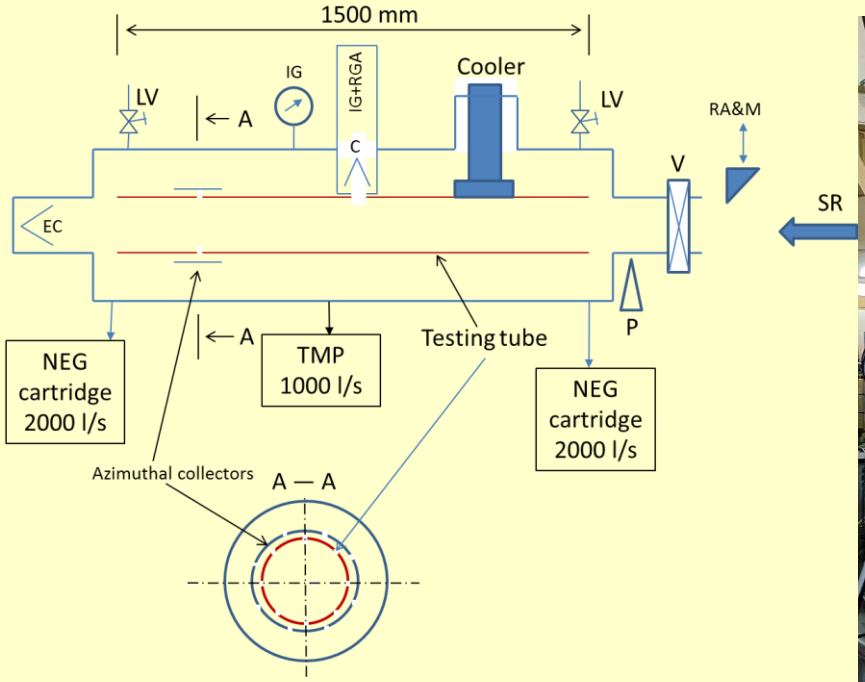
R. Salemme *et al.* IPAC 2016

- The coating is porous
- Capacity ~ 100 x Cu

- No pressure increase larger than 10^{-9} mbar nor heat load larger than 0.1 W/m due electron cloud are observed

Collaboration R&D CERN – BINP (Addendum P110/A2)

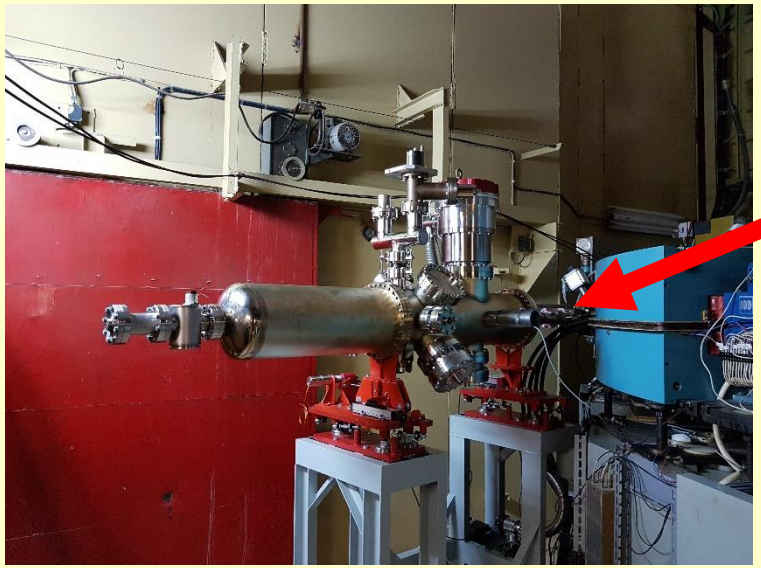
In the framework of the HL-LHC project, the vacuum performance of new surface material needs to be studied in details. In particular, amorphous carbon (a-C) coating is proposed as an anti-multipactor surface with the objective to minimize the heat load deposed on the shielded beam screen and the background to the experiment due to proton scattering onto the residual gas. Since the protons in the HL-LHC Inner Triplets generates SR with ~ 10 eV critical energy and ~ 10^{16} ph/m/s flux, it is therefore of great importance to study the impact of such photons on a-C coating held at room and cryogenic temperature and compare the results against present LHC material.



The experimental set-up is installing on BEP SR beam line at BINP

SR beam line at BINP for vacuum investigations

VEPP-2000 linked to new Injection complex



BEP after reconstruction. Maximum energy increased up to 1 GeV at circumference 22m. Max dipole field 2.6 T.

SR Beam Line and Experimental set-up is ready for commissioning

Planning:

- Experiments at RT: 01.2018 – 04.2018
- Experiments at cryogenic temperature: autumn 2018

Parameter	min	nominal	max
E [MeV]	200	300	900
Beam current [A]	0.5	0.5	0.5
Banding magnet radii [mm]		1280	
SR critical energy [eV]	14	47	1260
SR flux [ph/mrad/s]	1.1E15	1.8E16	5.6E16
SR power [W/mrad]	0.009	0.045	3.6
SR vertical divergence [mrad] at Ec	2.5	1.7	0.56

BEP and SR parameters for incoming experiments

Experimental program in frame of Collaboration R&D CERN – BINP (Addendum P110/A2)

- quantitative photon stimulated gas desorption by a calibrated residual gas analyzer (RGA);
- photo-electron yield; forward reflectivity in SR power and photon flux units; azimuthal distribution of photoelectrons and azimuthal distribution of diffusely scattered photons.

These measurements will be done for two CERN supplied samples: uncoated and a-C coated OFE-Cu tubes.

The experimental program and system parameters will be the same for both samples and consist of:

- an accumulated photon dose > 10^{23} ph/m, a SR incident angle of 13 mrad, a SR critical energy in accumulated photon dose mode is in the range 40 ÷ 50 eV, a scanning over SR critical energy at 100, 200, 400, 800, 1300, 1700 eV at selected doses of 10^{21}, 10^{22}, 10^{23} ph/m, a total number of azimuthal collectors of 10.

BINP will repeat the measurements in the temperature range 60 ÷ 300 K for exchangeable Cu tube samples perforated with holes in order to simulate a distributed pumping

Experimental set-up

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BEP and SR parameters for incoming experiments

Options for future investigation

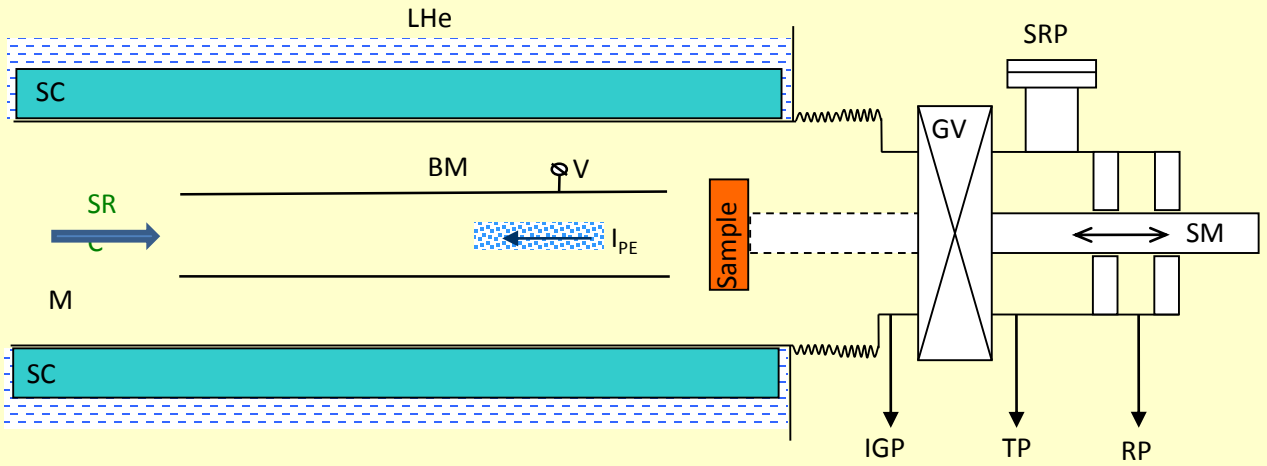
Future possible experiments on the BEP SR Beam Line

- **Photoelectron emission (PEE) from cold surface in presence of strong magnetic field (up to 10T)**
- SEE *in situ*
- XPS (Auger) *in situ (surface element analysis)*
- *Ion desorption under SR*
- RF stimulated electron cloud build-up in presence SR – experimental simulation phenomena in LHC arc beam pipe
- **Behavior of NEG coating at Low temperatures**

Options for future investigation

PEE from cold surface in presence of strong magnetic field

Main question:
does PEE depend on magnetic field at cryogenic temperatures?



Experimental set-up for PEE measurements
Based on the new SR beam line and 14T SC solenoid of VEPP2000

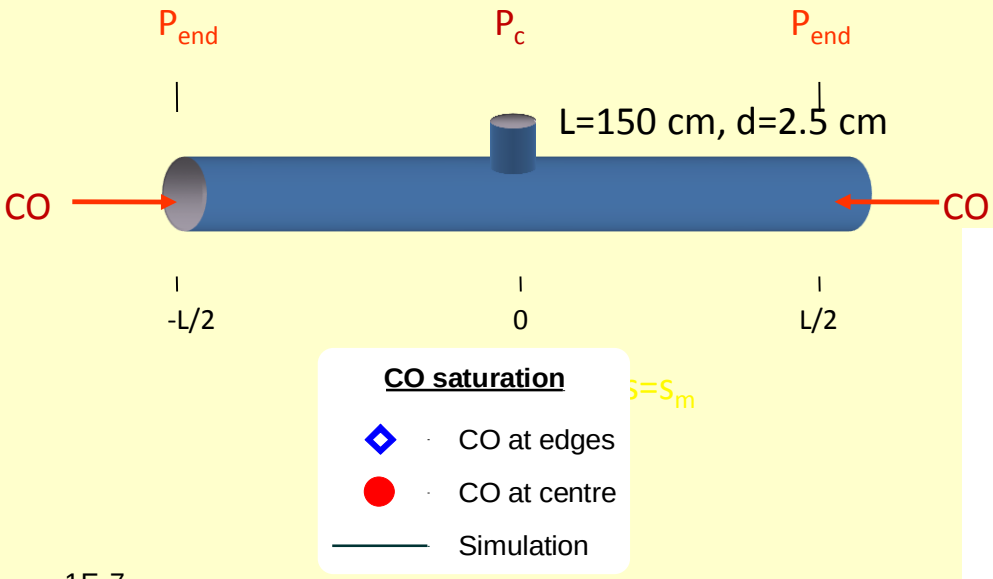
"SR" – Synchrotron Radiation, "SC" – superconducting solenoid, "C" – thermo-cathode, "BM" – beam monitor, "V" – potential of BM, "LHe" – liquid helium, "GV" – all metal gate valve, "TP" – turbo-molecular pumps, "RP" – rough pump, "SRP" – sample replacement port, "SM" – sample manipulator with double Wilson seal.

Measurement options:

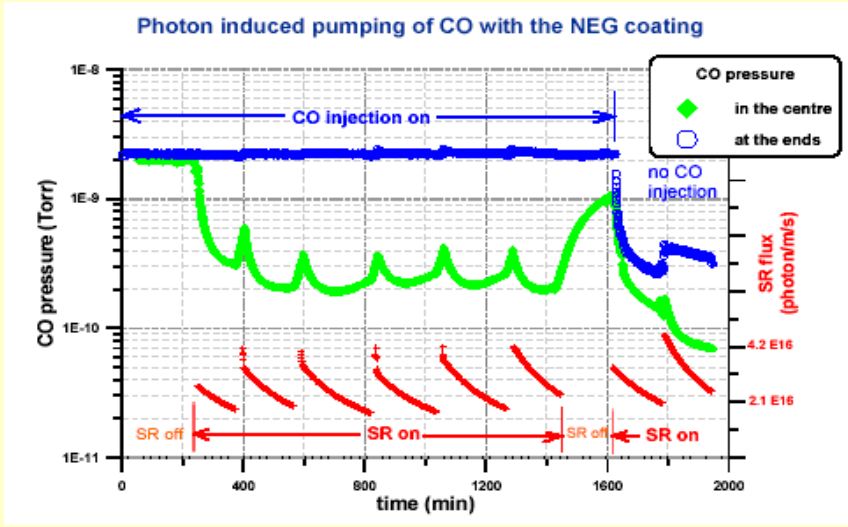
- PEY in strong magnetic field (up to 10 Tesla). DC and time resolution modes.
- TOF measurements of energy distribution of photoelectrons. Pulse repetition 73,3 ns

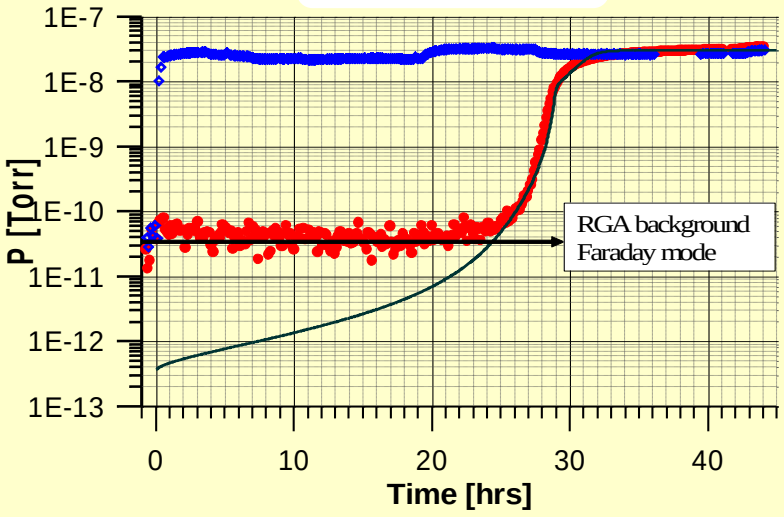
Options for future investigation
NEG coating

BINP



Experiment with saturated NEG





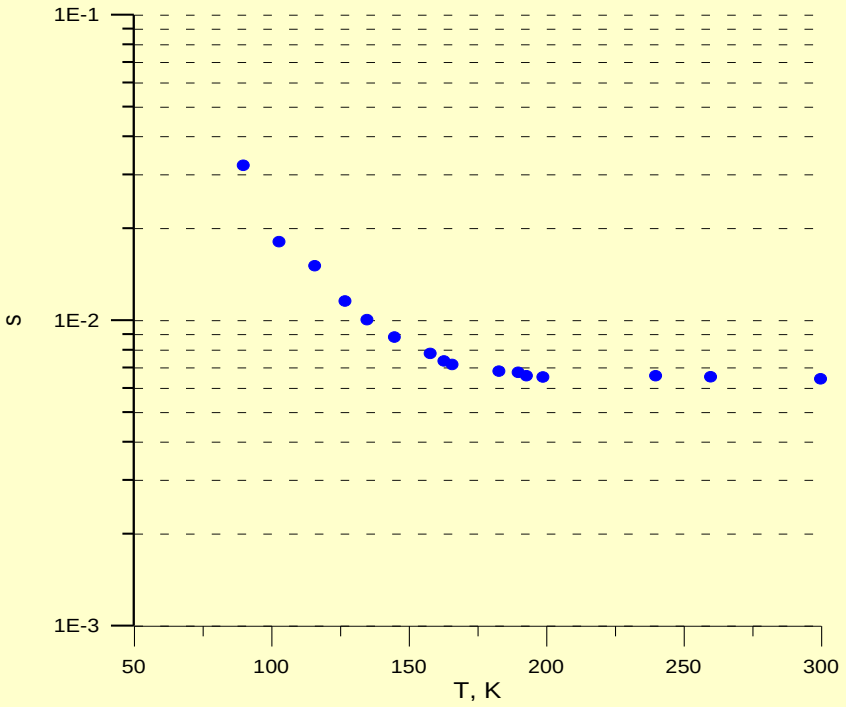
SR stimulates diffusion of molecules into NEG film!

– prolongation of lifetime (sorbtion capacity)!

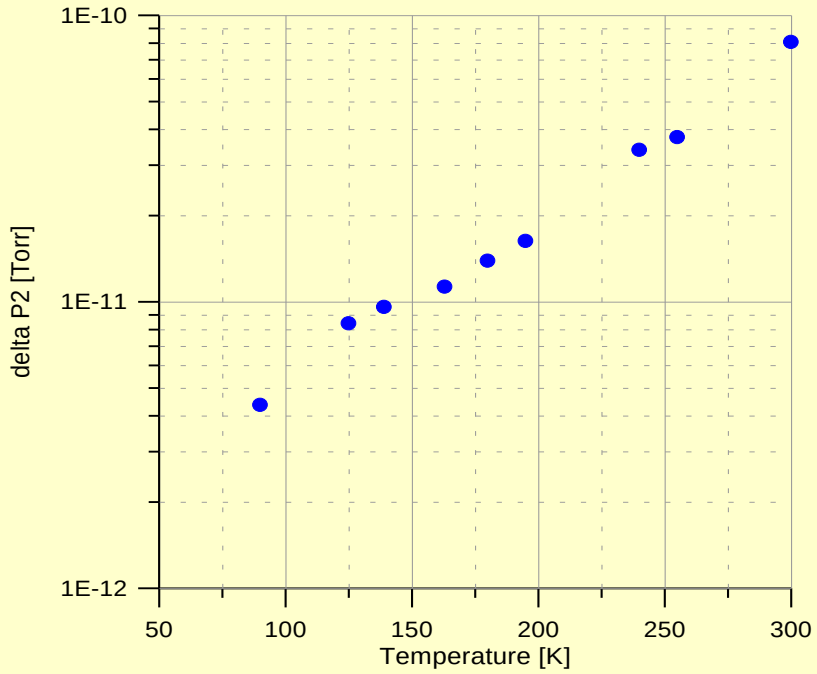
- No re-cycling!

Options for future investigation

NEG at low temperature



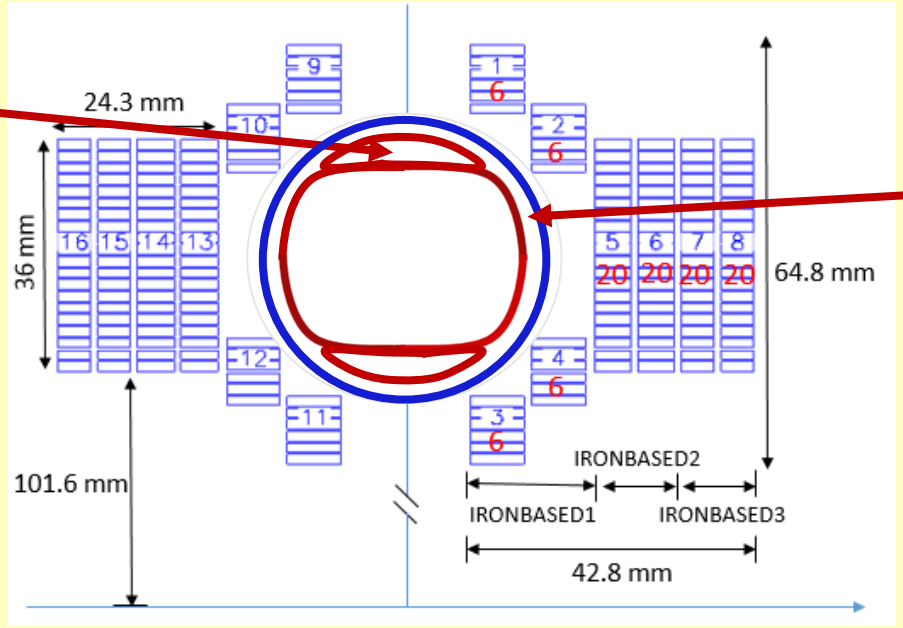
H_2 sticking probability versus temperature



H_2 dynamic pressure rise at presence of SR flux $4 \cdot 10^{16}$ ph/s versus temperature

Proposal for SPPC arc beam pipe with CB at T>4K

Main idea: separation of the beam pipe vacuum from CB



Mandatory:

- **NEG coating for pumping and EC mitigation (activated NEG has low SEY)**
- **Heater and thermo-insulation (needs less than 1mm gap) between beam pipe and CB (to do NEG activation at 220 C)**
- **Cooling: LN_2 (undercooled, 10 atmosphere(?))**

Main advantages:

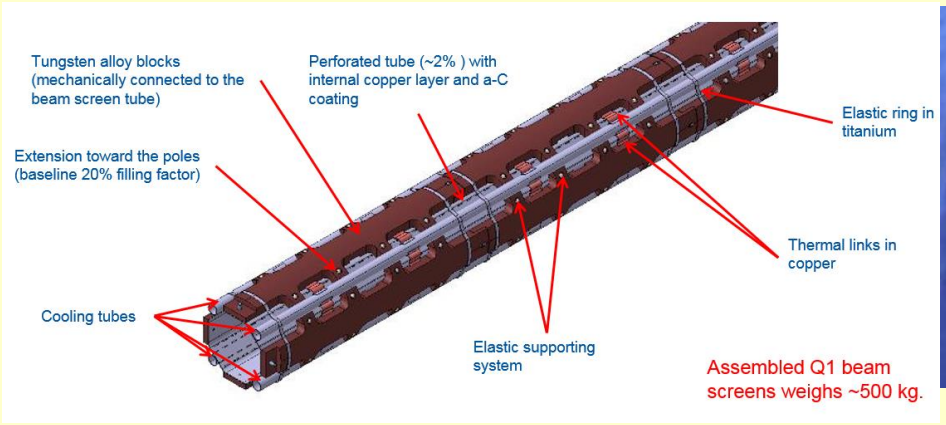
- no connections between He vessels/pipes and beam vacuum

- CB temperature does not matter

- The use maximum horizontal aperture. No re-cycling - a conditioning is NOT necessary!

Options for future investigation
NEG coating for beam pipe vacuum insulation from CB

Could it be interested for HL-LHC inner Triplets? Or in other places?



The advantages could be:

- **No-recycling, No conditioning**
- **Design simplification**
- **Better shielding against debris**

Disadvantage:

Needs activation at 200 ^{o}C

Conclusion

- **The New SR Beam Line and Experimental set-up is ready for commissioning**

Planning of experiments for HiLumi:

- **Experiments at RT: 01.2018 – 04.2018**
- **Experiments at cryogenic temperature: autumn 2018**

- **A set of proposed investigations with the use the new SR beam line are under consideration**

- **The idea of NEG coating application for insulating beam vacuum from CB is still in life**

Thanks for your attention