Laboratório Nacional de Luz Síncrotron

Sirius Vacuum System

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On behalf of the LNLS Vacuum Group

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Outline

- General requirements
- Storage ring
  - Design concept
    - Chamber materials
    - Pumping
  - Vacuum chamber layout
  - Cleaning process and NEG coating
  - Installation and Bake-out
- Summary

General requirements

- **Fit to compact lattice and small aperture magnets:**
  - Tight manufacturing tolerances: **average clearance with magnets < 0.5 mm**
- Average vacuum **< 1 x 10^{-9} mbar** (CO eq.) in order to guarantee a beam lifetime **> 5 hours (at 500 mA)**
- Impedance/HOM issues:
  - **Keep down** the beam impedance and HOM power
  - No steps inside the chambers, i.e. welds, flanges, etc.
  - Transitions must be carefully studied by EM simulation
- No radiation hitting uncooled surfaces
- Quick vacuum recovery, either after start-up or after any venting to the atmosphere pressure
- Finally, the vacuum system must be reliable and cost-effective

Storage ring:
Design concept - chamber materials

Copper

Material	Thermal expansion coefficient [1/C°]	Electrical conductivity [%IACS]	Thermal conductivity [W/m.K]	Young Modulus load [GPa]	Yield Strength [MPa]
Copper OF w/ silver (UNS C107)	17.7	100	388	115	250

Stainless steel:

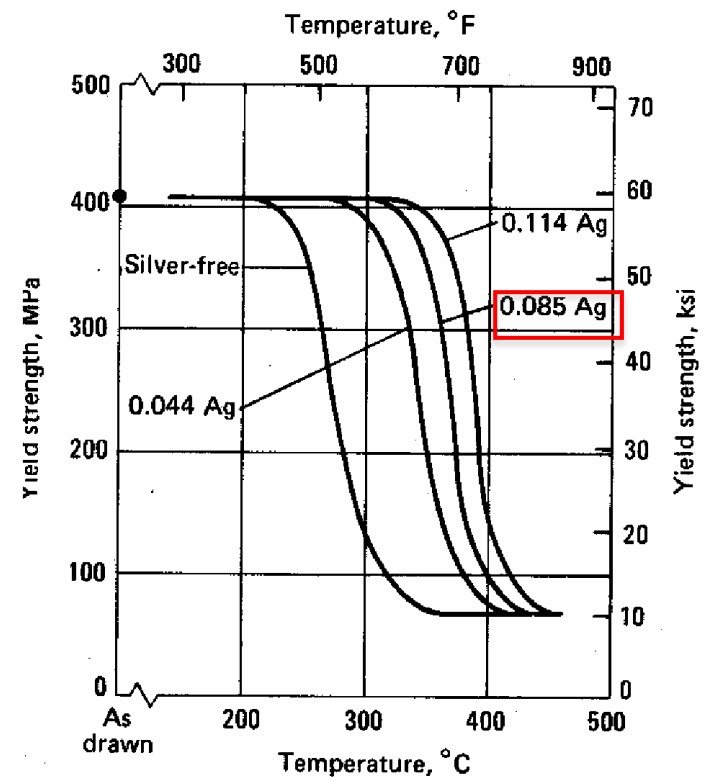
- Flanges
- Pumping ports

Alumina:

- Small sectors for fast orbit correctors

OBS: electron beam will not face the stainless steel or alumina parts

Effect of Silver on copper



Storage ring:
Design concept - pumping

Pumping philosophy:

- Extensively use of **NEG coating** - chambers will be full NEG coated:
  - Chambers in electron beam path (except RF-cavities, bellows, valves and BPMs);
  - Pumping ports.
- Small **ion pumps** will be used to pump gases not pumped by the NEG coating (hydrocarbons and noble gases);

A license agreement between CERN and LNLS has been signed – NEG thin film technology transfer

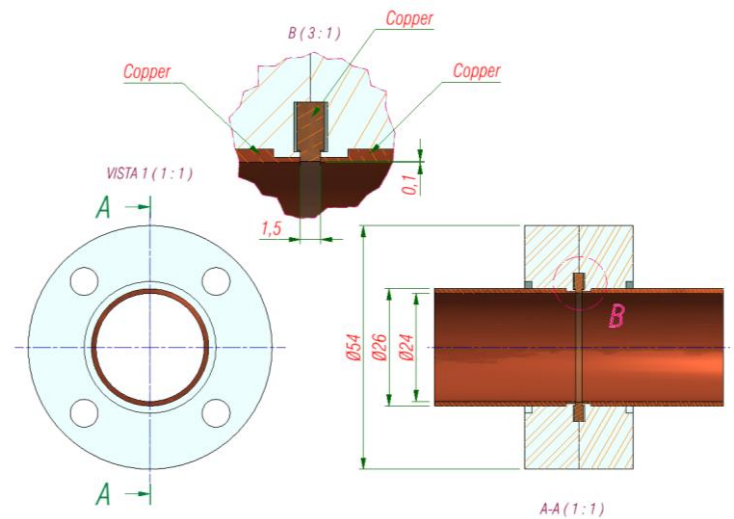
OBS.: NEG coating is a well established technology, used in many places: **LHC** (more than 6 km of chambers); **Soleil** (56% of the chambers); proposed for **MAX-IV** (all chambers of the storage ring); and many other places (ID's and other chambers).

Storage ring:
Vacuum chamber layout

One arc (1/20 of the machine)

Modified KEK MO-type flange (circular and non-circular):

- No gap
- No step
- Smooth inner surface



- 16 vacuum chambers

- 10 BPMs

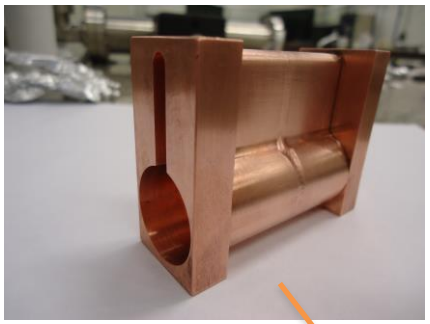
- 3 Pumping stations

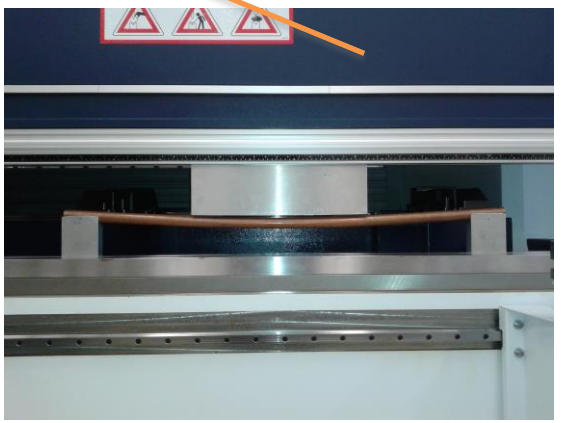
- 12 Bellows

Storage ring:
Vacuum chamber layout

Main manufacturing processes to be used:

- Machining
- Wire cutting (EDM)
- High temperature brazing
- Copper TIG welding
- Low temperature brazing
- Precise bending
- Copper cleaning/etching
- NEG coating





Needs careful handle between processes to maintain the tight tolerances!

Storage ring:
Cleaning process and NEG coating

Manufacturing developments: final **cleaning**

- **Based on recirculation system with a peristaltic pump:**
  - 6 chambers cleaned each time;
  - Less acid volumes needed
  - Better cleaning efficiency
  - Only copper is exposed to the cleaning solutions

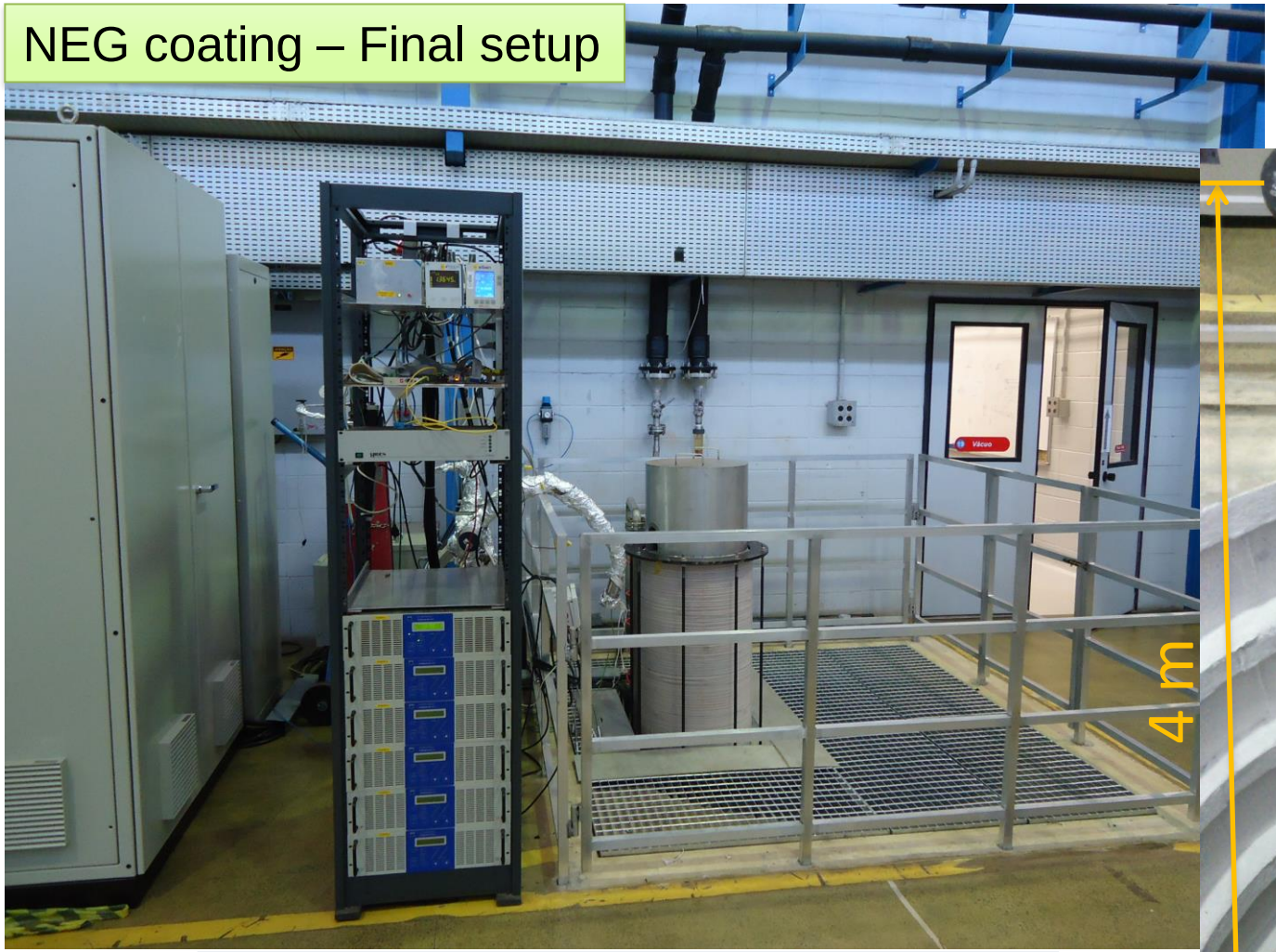
  - **Cleaning Procedure under study:**
    - ✓ Degreasing with alkaline detergent
    - ✓ 10% ammonium persulfate – etch about 50 µm (remove extrusion defects)
    - ✓ 0.5% sulfamic acid + 4% hydrogen peroxide (remove persulfate residues)
    - ✓ 5% ammonium citrate (passivation)
    - ✓ Water rinsing

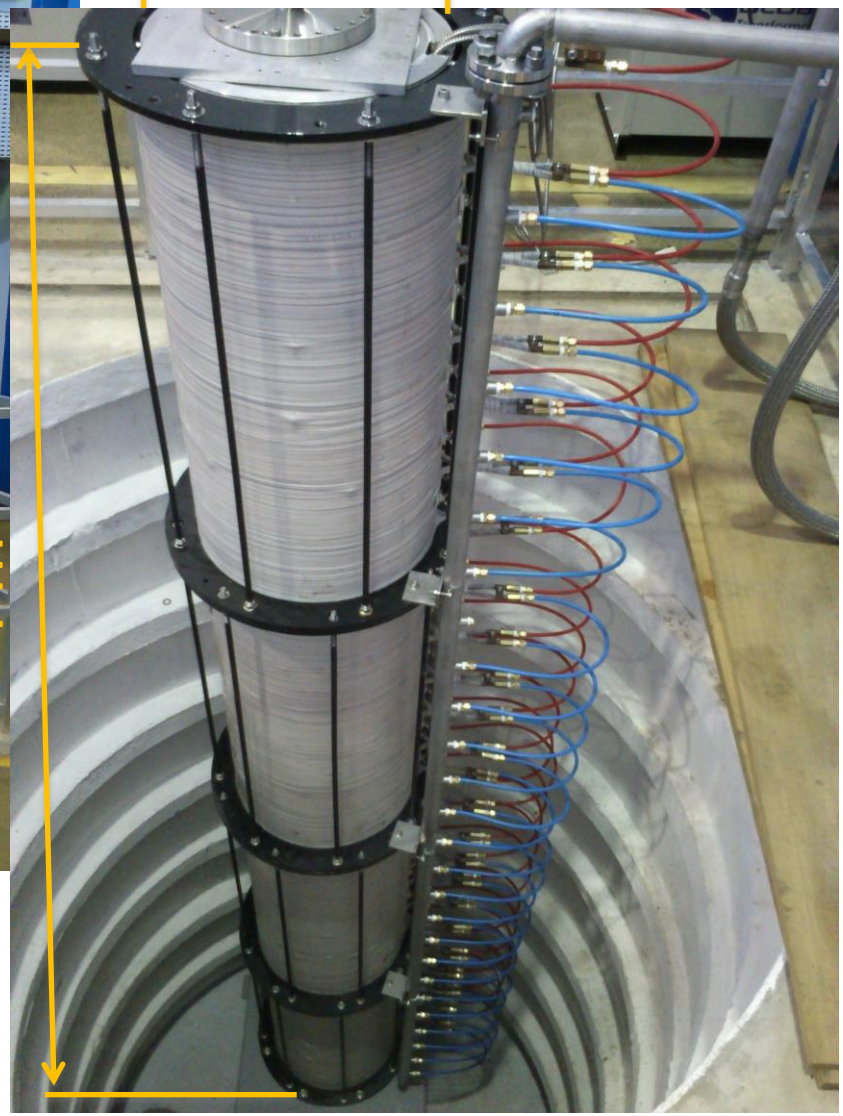
Built cleaning facility

Cleaning OFS copper is very tricky!

Storage ring:
Cleaning process and **NEG coating**

NEG coating – Final setup





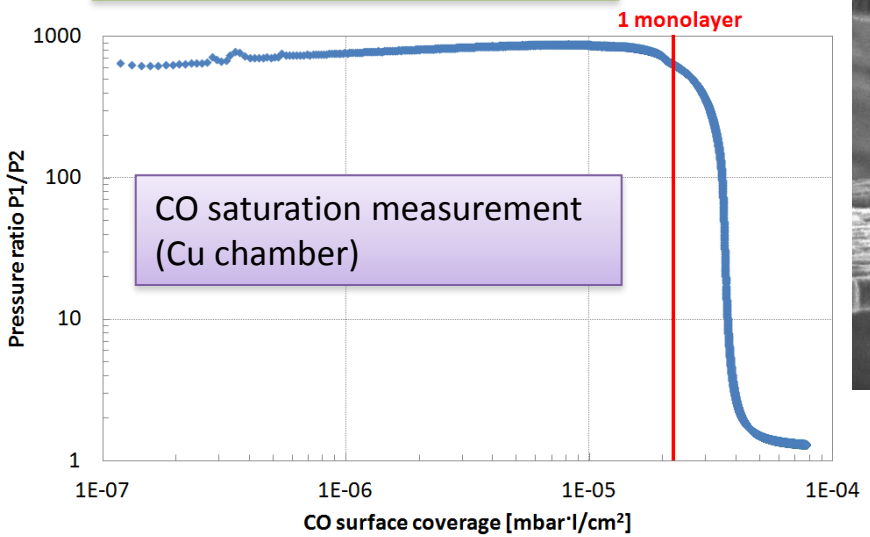
Main characteristics:

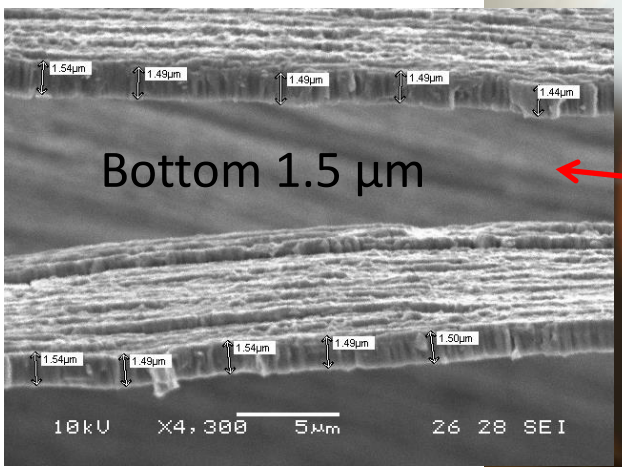
- Deposition up to 3.2 m long
- 6 straight chambers each run
- Individual control of each chamber
- Bake-out system integrated to the solenoids
- Automatic control of the whole deposition run

Storage ring:
Cleaning process and **NEG coating**

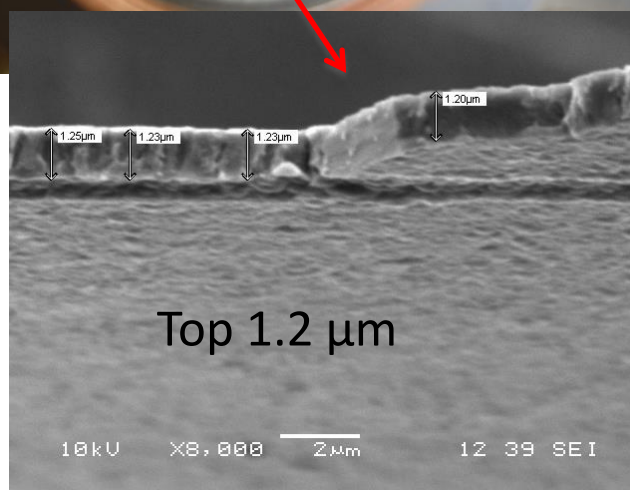
Manufacturing developments: **NEG coating**

Tests – main results





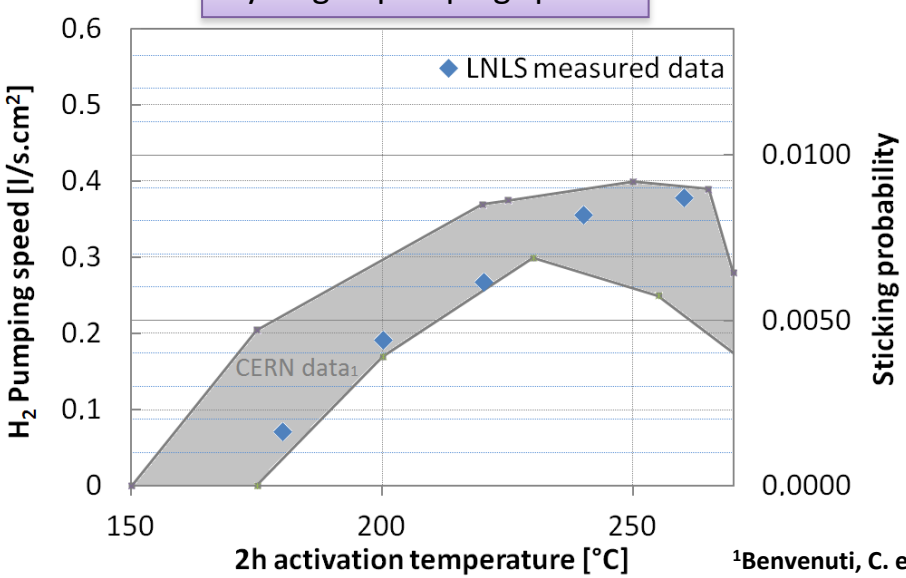
No peel-off – 10 cycles of activation (250 ° C)



Actual stage:

- Coatings with good adhesion and pumping performance were achieved for:
  - Straight and bent chambers

Hydrogen pumping speed



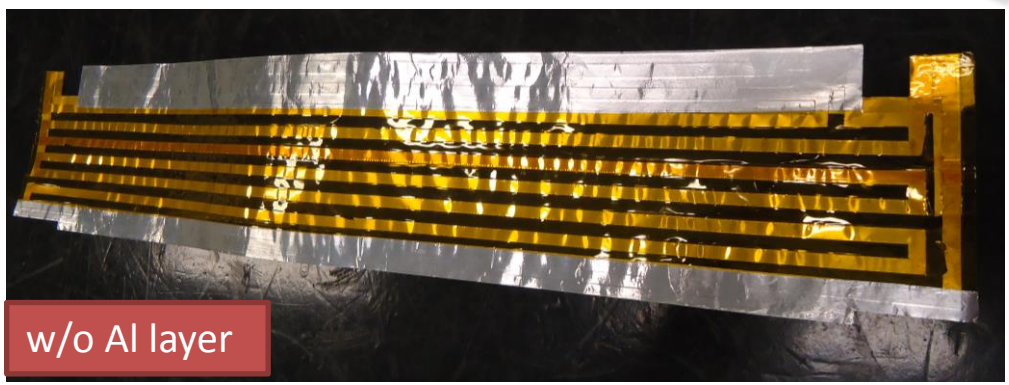
[1]Benvenuti, C. et al. JVST A19 (2001) p. 2925-2930

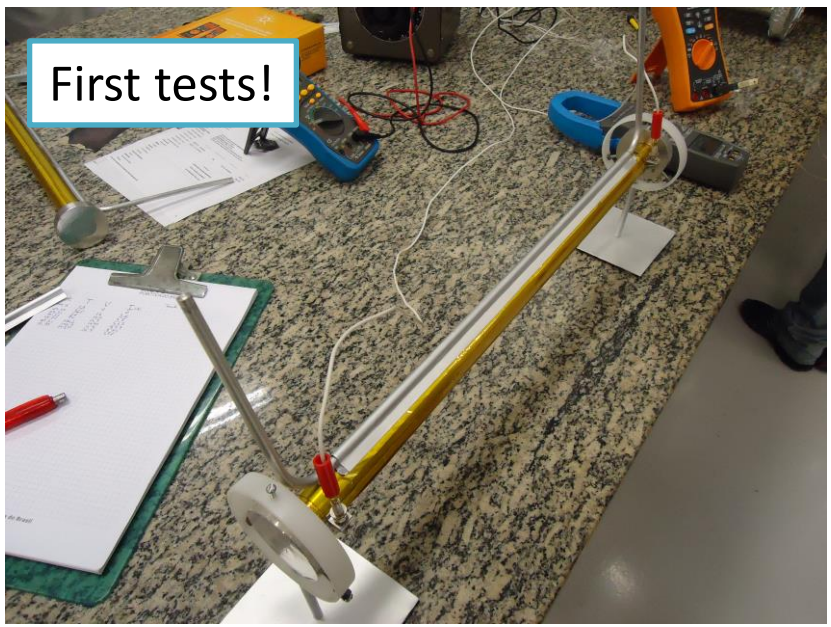
Still need to be developed:

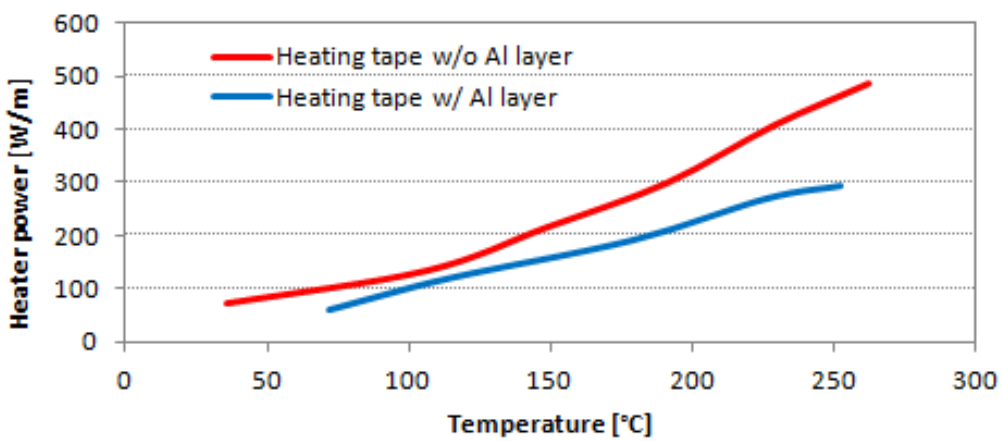
- Coat small gap sectors (photon beam extraction)
- Complex geometry chambers, i.e. pumping stations

Storage ring:
Installation and Bake-out

1. After NEG coating, the chambers will be filled with N_2 and stored
2. *In-situ* assembling the chambers with half of the magnets in place
3. Make all electrical and hydraulic connections
4. Close magnets
5. *In-situ* bake-out for NEG activation (200 ^{o}C @ 24h):
   - An thin polyimide heating tape will be used:
     - Thickness < 0.4 mm
     - Max. tested temperature 250 ^{o}C







Summary

- The chamber's material must be carefully chosen, because its cleaning process, **prior to NEG coating,** can be very tricky;
- The design of the chambers must take into account the different manufacturing processes and their sequence:
    - Cleaning process and NEG coating **must be feasible** for the designed components, i.e. small gaps, complex geometries, different materials, etc.
    - **Pay attention** to EDM process, because it can leave surface contaminats (not compatible with UHV and NEG coating) that comes from the wire;
- The number of needed bellows and the design of some components **are impacted** by the decision of **in-situ** or **ex-situ NEG activation**.
- All NEG films should be **visually inspected**, it is not so accurate and should be done by **trained people**. Endoscopes can be used to help in the visual inspection, but care must be taken not to contaminate or damage the film.