Graphite and C-C materials for UHV applications

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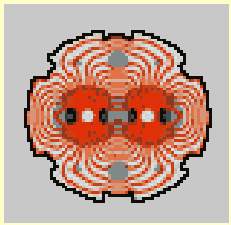
Prepared by J.M. JIMENEZ

AT/VAC/SL Section



Main topics

- **What did we learn from past experiences ?**
- **Static outgassing of the Graphite R7500[1] and C-C 1501G[2]**
- **Thermal outgassing**
  - Dependence of the outgassing on the operating temperature
  - High temperature outgassing stimulated by e-bombardment
- **Conclusions and Recommendations**

[1]Carbone Lorraine, [2]SGL Carbon Group

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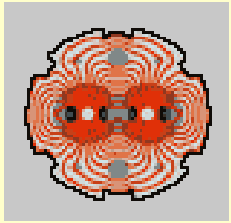


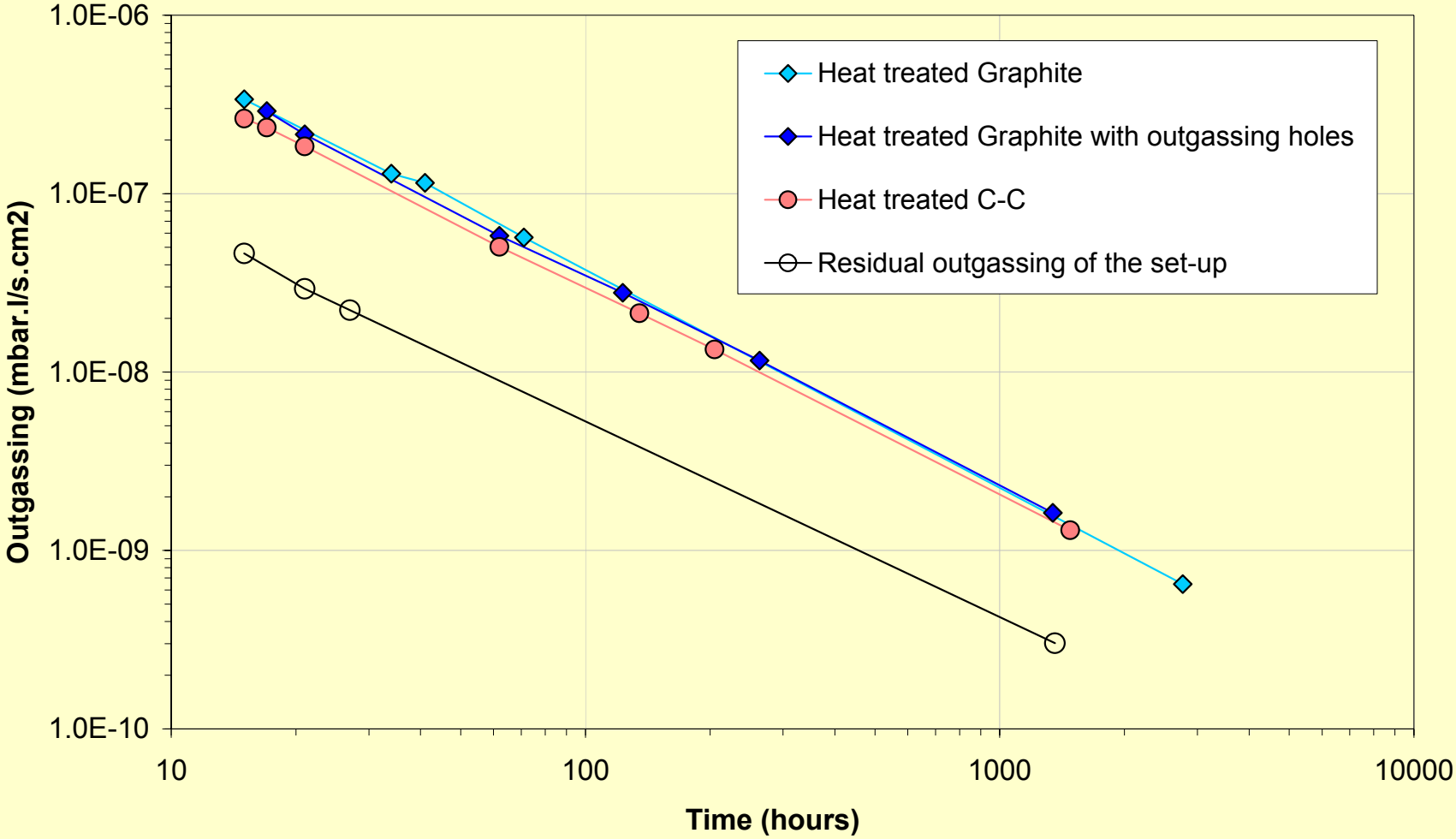
What did we learn ?
(TIDVG, TPSG, Lab measurements)

- Testing the real material (composition and dimensions) is essential
  - ⇨ Factor 10 between the materials tested
- Heat treatment in a clean vacuum or high temperature bake out help
  - ⇨ Factor 10 in performances (pumping time)
- "Exotic" treatments could decrease performances
  - ⇨ Factor 6 introduced by a PVD Ti coating (2 μm)
- Bake out > 300°C improve performances
  - ⇨ Factor 10 in performances (pumping time)
- CH species are only pumped by ion pumps
  - ⇨ Can not rely on NEG or Ti sublimations
- Design is essential (outgassing channels, direct bake out)

…….after installation, it is tooooo late !

Static Outgassing before bakeout

- after a heat treatment at 1000°C during 2 hours -



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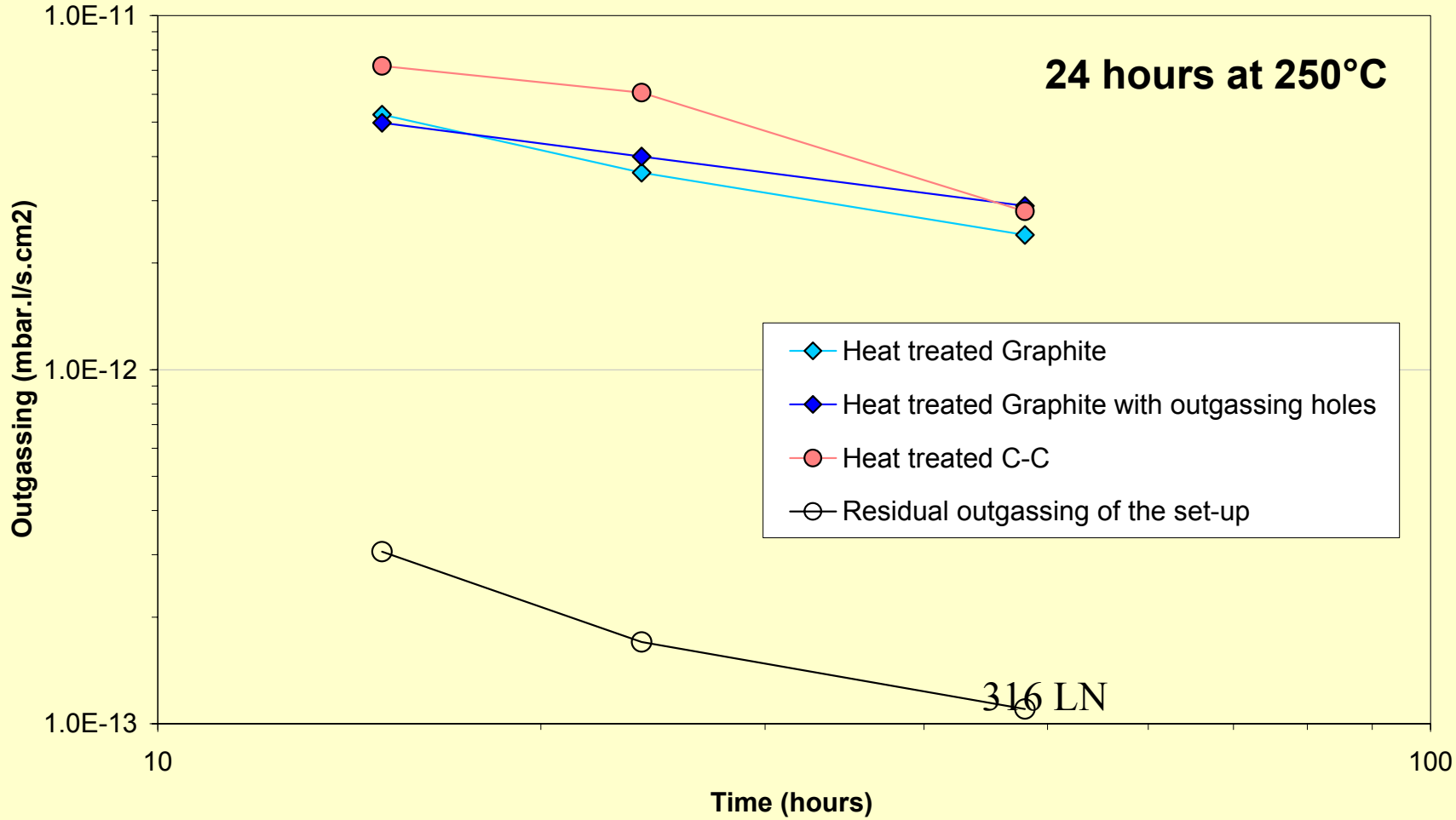
Static Outgassing after bakeout

- after a heat treatment at 1000°C during 2 hours -



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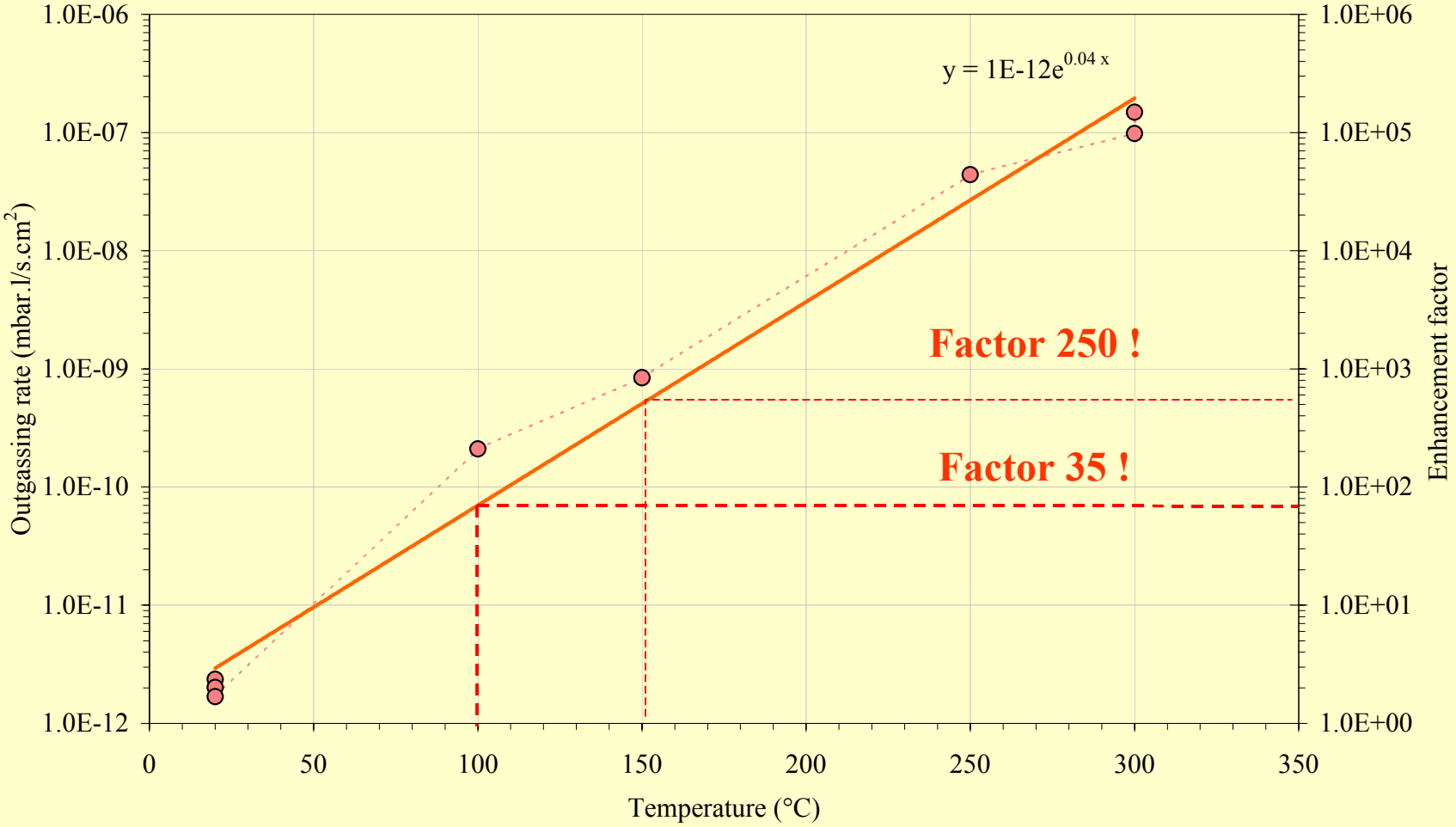
Thermal outgassing expected if running above RT

Graphite R7500



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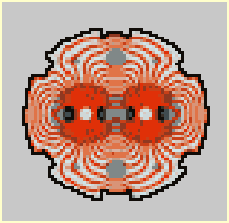
Outgassing stimulated by e^- bombardment



Sample: 14 cm^2
Heating power: 175 W (2.5 keV, 70 mA)
Bombardment duration: 3 min.
Temperature reached: 1050°C
Effective pumping speed: 40 l/s

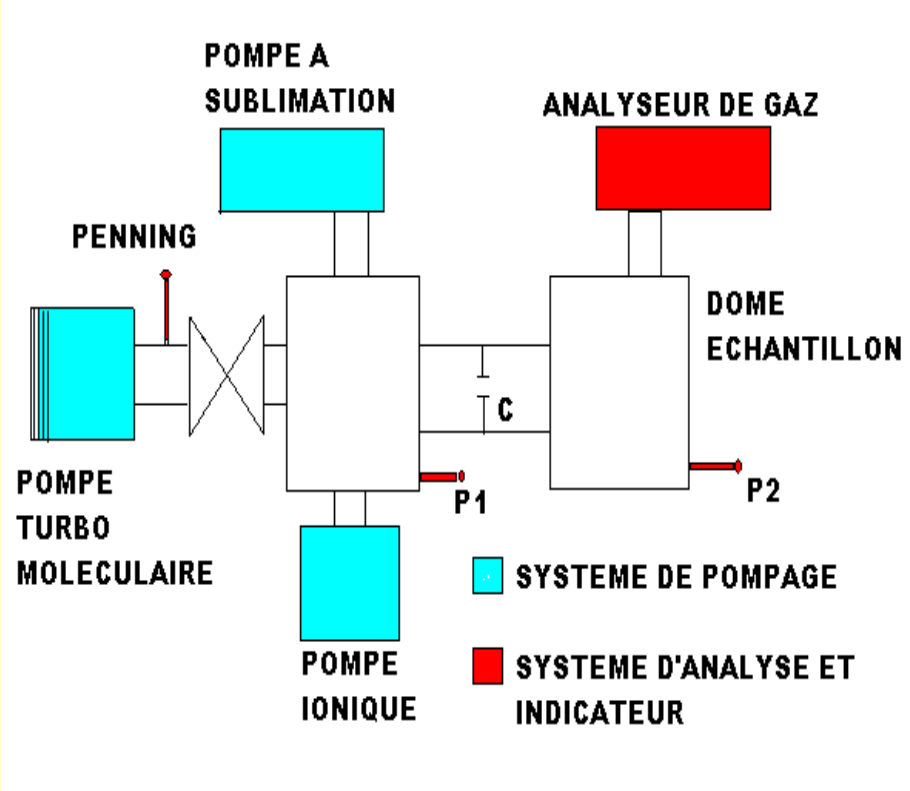
☞ Pressure rise by 4 orders of magnitude

Gas analysis after 1 hour

	At 1050°C	After 1 h RT
H_2O		30 %
H_2	30 %	23 %
CH_4		15 %
CO	40 %	12 %

☞ Higher ionization cross section for CH_4 and CO

Schematic view of the set-up



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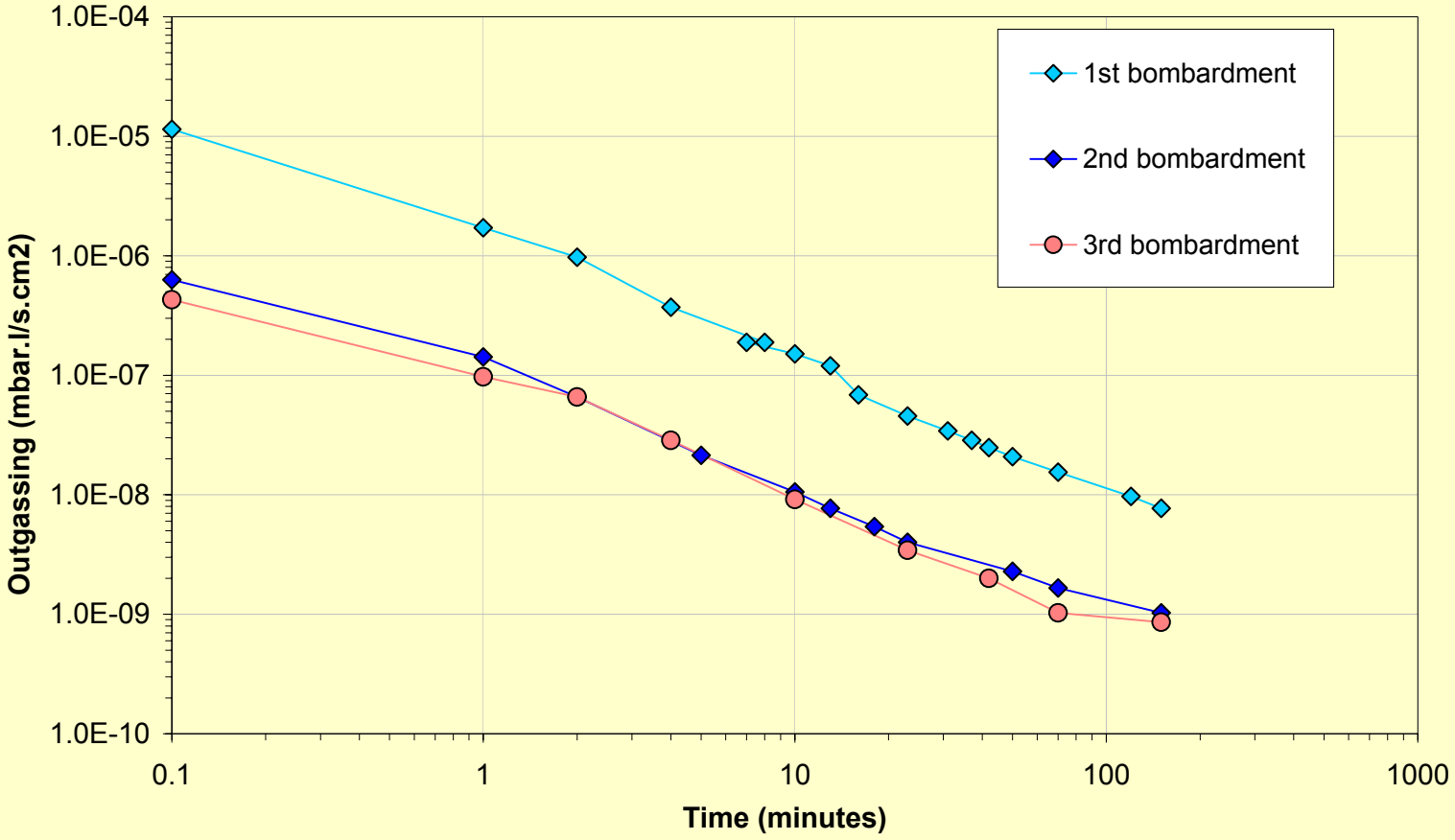
Outgassing stimulated by e^- bombardment

Outgassing recovery after heating

Case of the C-C



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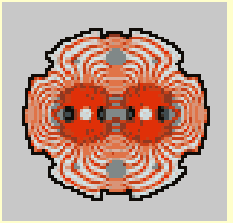
CONCLUSIONS



- Heat treatment under vacuum at 1000°C during 2 h
  - ☞ Absolutely required, gain: 2 orders of magnitude
- Static outgassing rate
  - Before bake-out: 5.0×10^{-10} mbar.l/s.cm^2
  - After bake-out: 3.0×10^{-12} mbar.l/s.cm^2
  - ☞ Acceptable for the LHC after the in-situ bake-out (250°C min. – 24 h)
- Gas composition at 1050°C
  - ☞ CH_4 and CO are a problem ⇨ high ionisation cross section
- Recovery after heating
  - 4 orders of magnitude increase at 1050 °C
  - 3 orders of magnitude recovery after 1h½
  - ☞ Compatible with the refilling of the LHC

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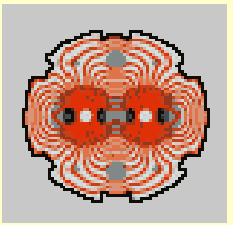
Conclusions and Recommendations



- **LHC is an UHV system**
  - ⇨ **bake out at 300°C required**
- **Control of the outgassing rates by an optimisation of the :**
  - ⇨ **material and heat treatment under vacuum**
  - ⇨ **shape design**
  - ⇨ **component heating (heat loads) ⇨ Design an efficient cooling (avoid vacuum brasing in the water circuit)**

Gas densities in the LHC LSS close to the experiments will be a problem due to the higher ionisation cross section of CH species and to the limited pumping speed for CH species which are only pumped by ion pumps, not by NEG nor by the titanium sublimation pumps.

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