CERN (carbon) coating developments

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SEY of a-C coatings
Characterization
Aging
Conditioning

The SPS upgrade as motivation

The condition to avoid e-cloud in SPS dipoles with nominal LHC beam is (G.Rumolo et al.) the following:

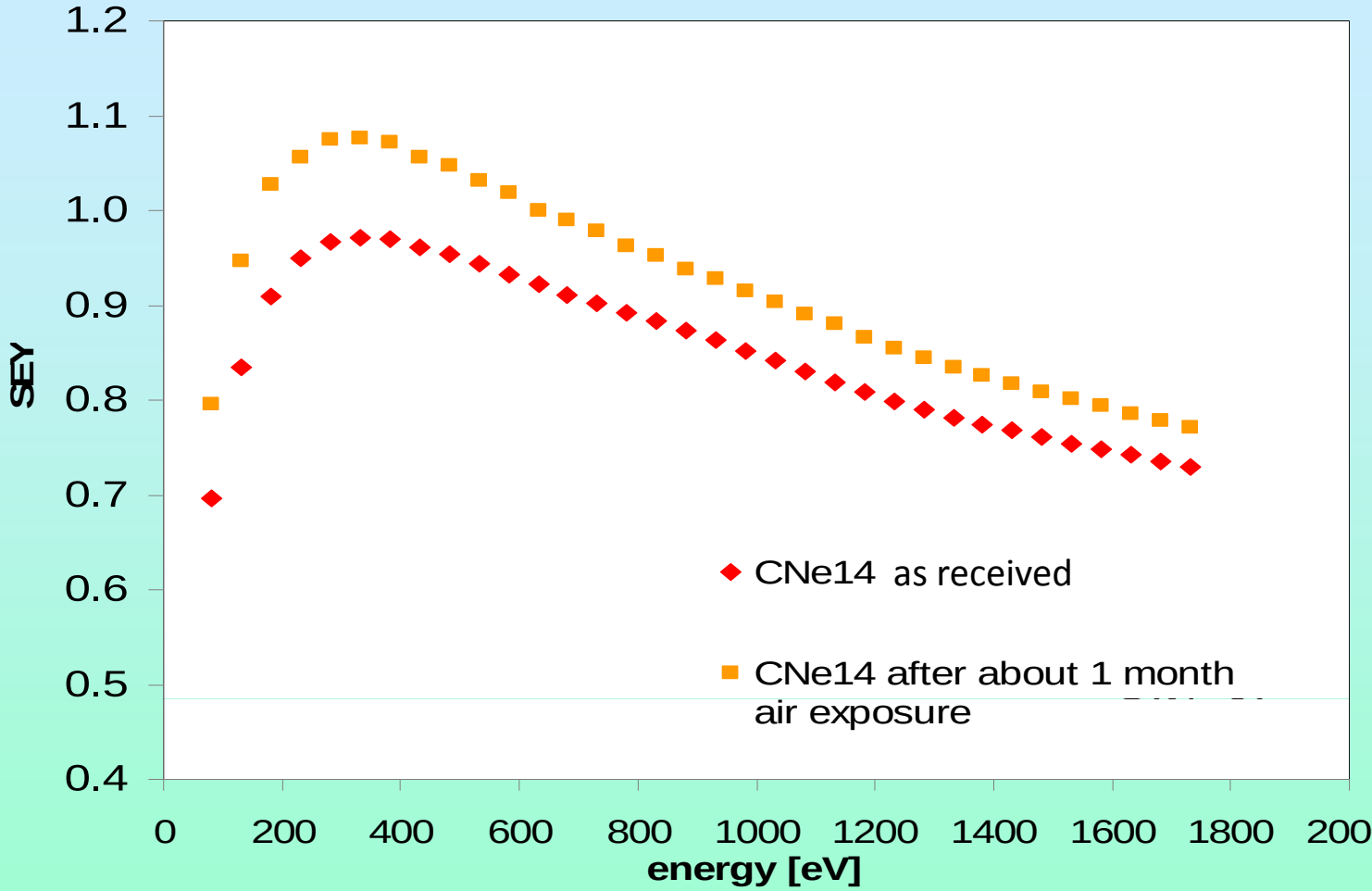
$$\delta_{max} < 1.3$$

-the vacuum pipe is not thermally isolated from the magnet coil and bake-out is excluded.
- parts of the machine can be vented for maintenance
- a solution implementing macroscopic roughness (grooves) in the present magnets would significantly reduce the aperture
-clearing electrodes are also an option (see presentation F.Caspers)

Find a surface treatment which can be implemented in the present magnets, does not require bake-out and is robust against air venting

More on this in**:** **http://paf-spsu.web.cern.ch/paf-spsu/default.htm** by the SPSU team chaired by E.Shaposhnikova (G.Arduini, F.Caspers, K.Cornelis, E.Metral, G.Rumolo. E.Shaposhnikova, F.Zimmermann, E.Mahner, B.Henrist, S.Calatroni, P.Chiggiato, M.Taborelli, C.Yin-Vallgren)

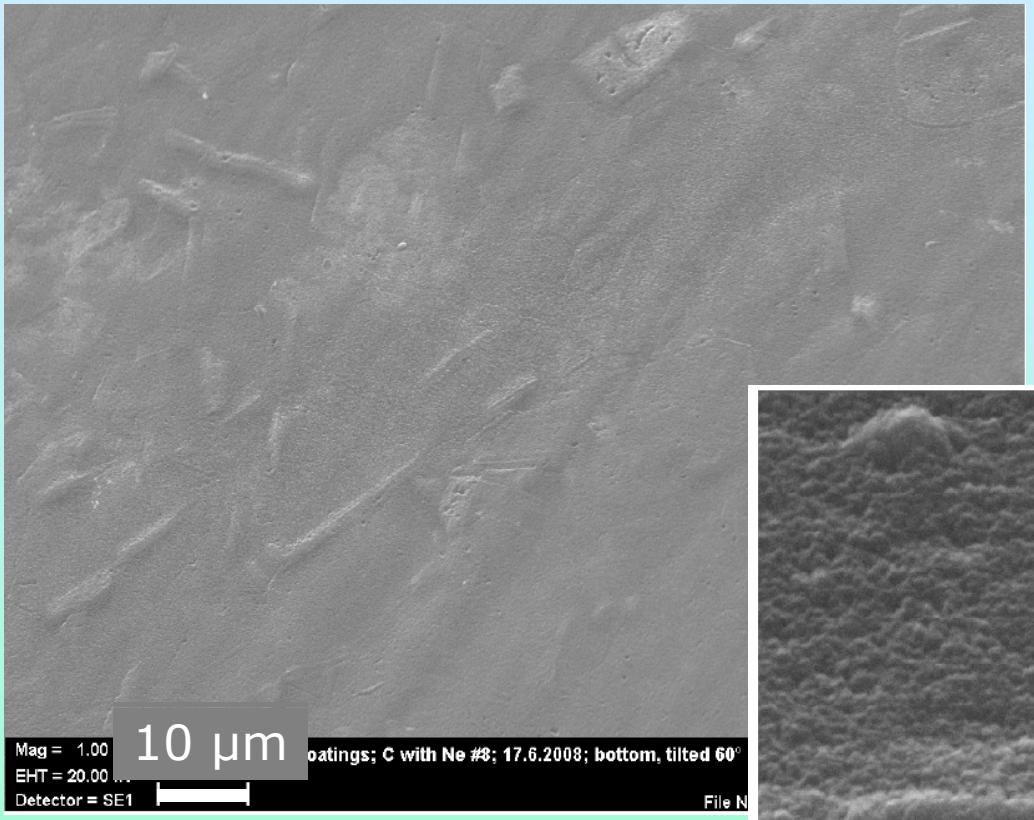
Amorphous carbon a-C coating:



Dose below 10^{-6} Clb/mm^2

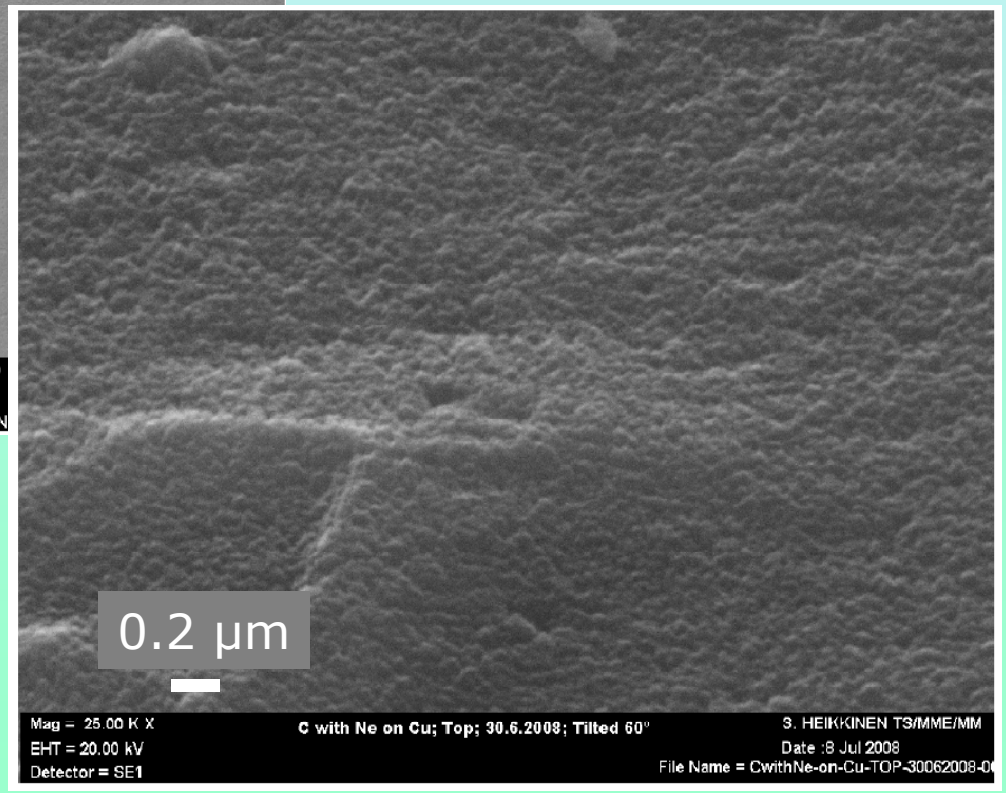
-a-C coating on copper deposited by magnetron sputtering (in Ne)
-as expected SEY does not depend on coating thickness in the range 30-1300 nm

SEM images of a-C(Ne)



Courtesy of S.Heikkinen

Good adhesion, no loose particles



Powder, dust and particles: not an issue

Two identical SS tubes measured in clean room TUBE + REF

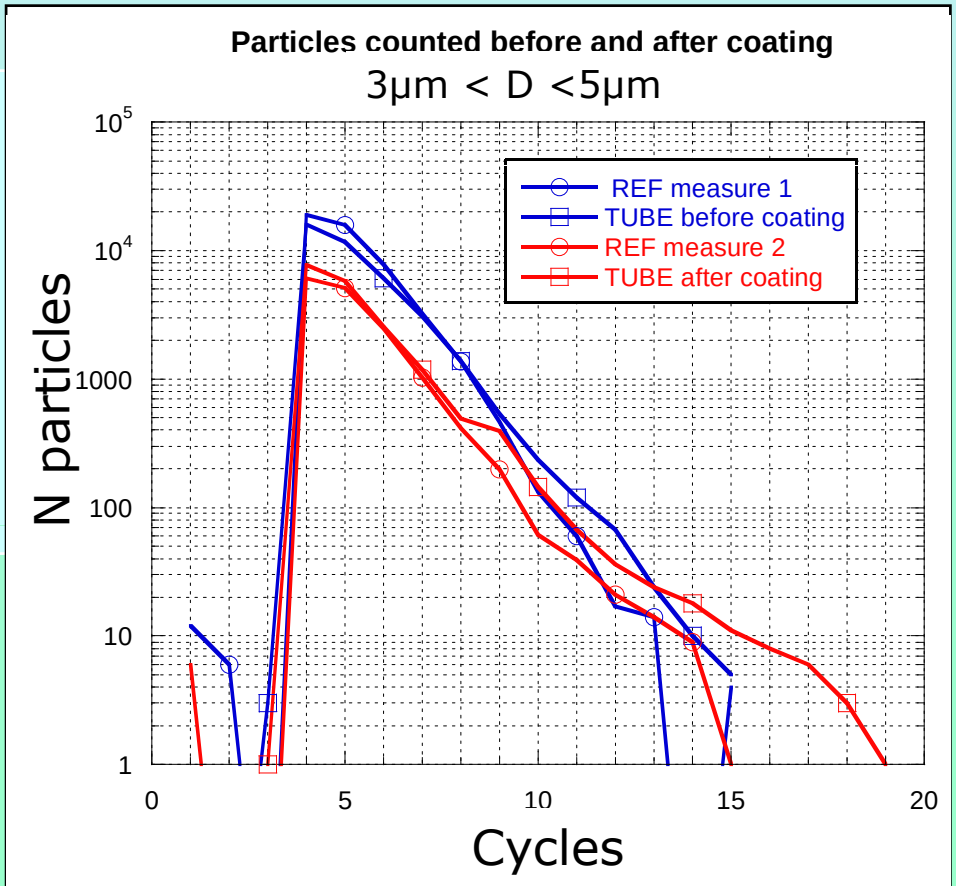
TUBE coated with carbon

REF remains in the coating lab. (closed with plastic covers)

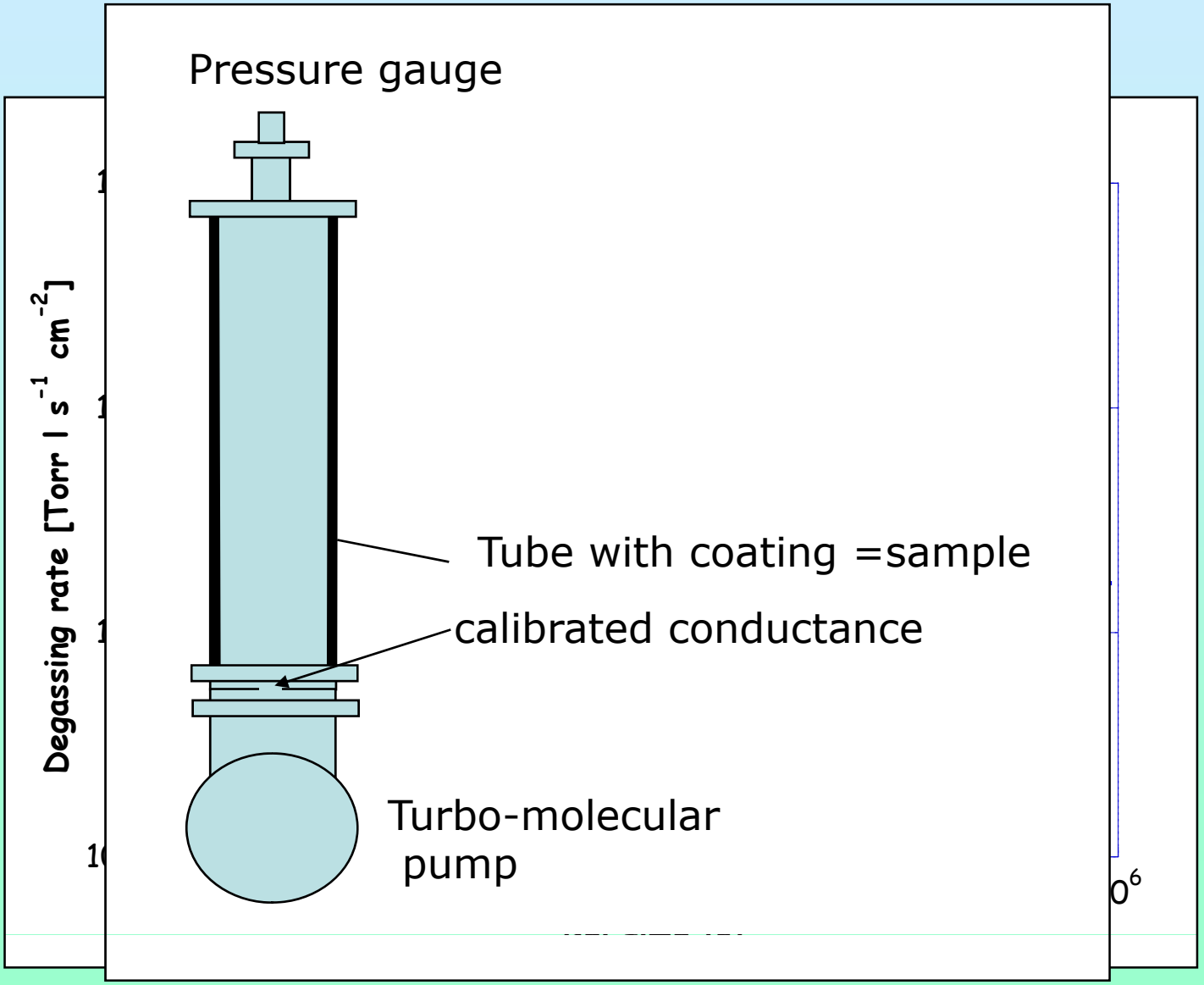
TUBE + REF measured again in the clean room

Measured with an optical particle counter

-Same result for size above 5 μm
-No increase after shaking and gentle hammering of the chamber
-No increase for a chamber left in air for months

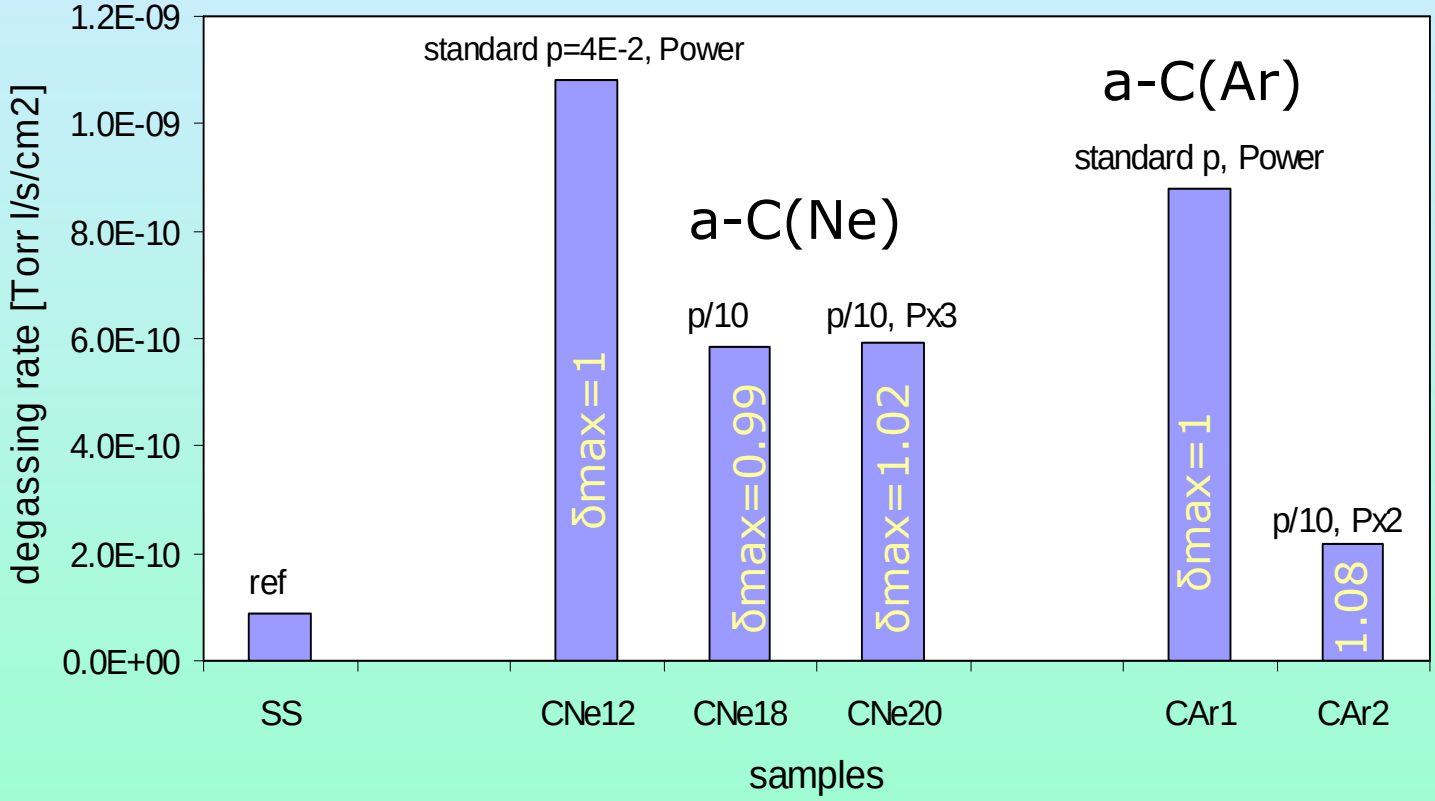


UHV compatibility: pumpdown curve



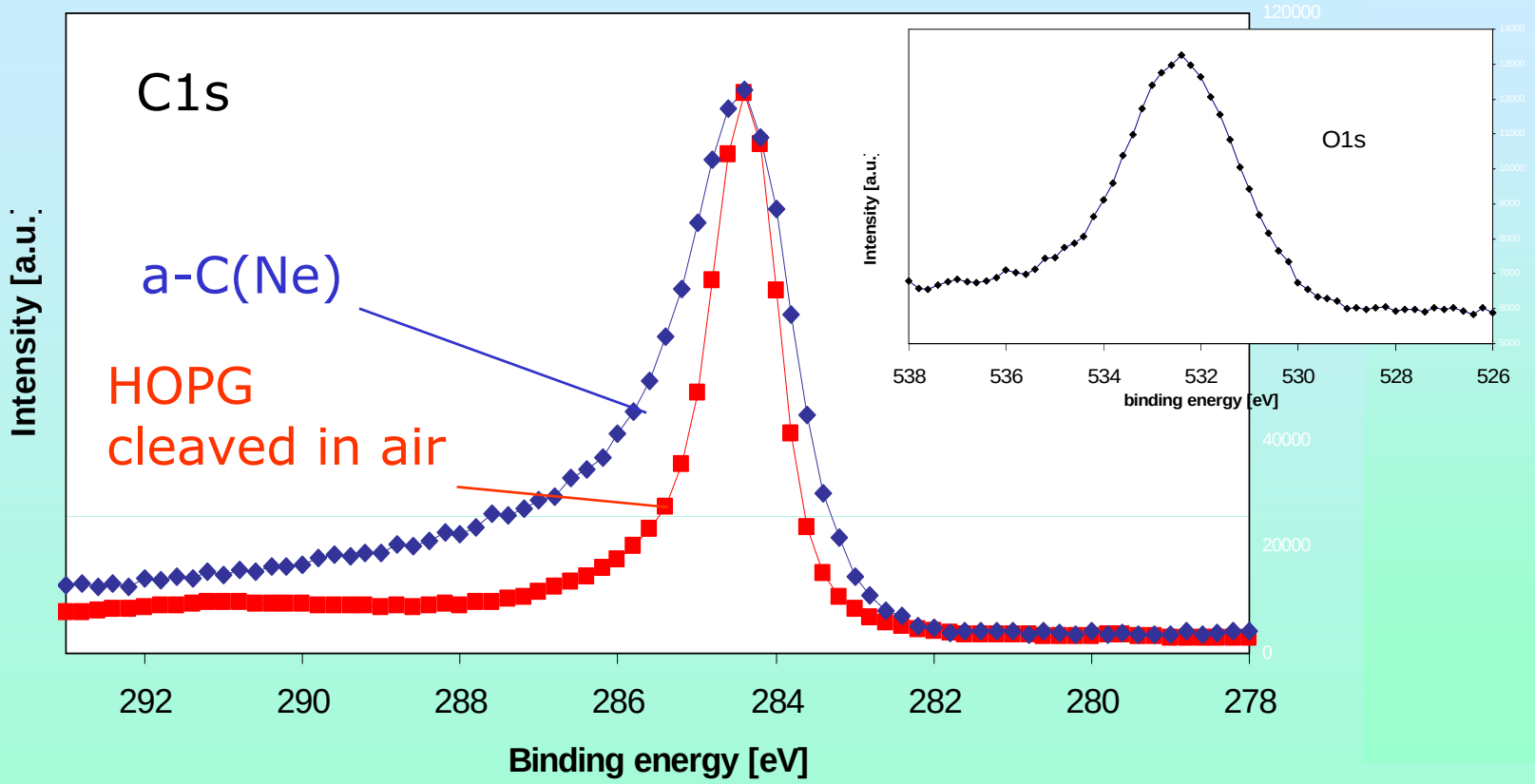
Degassing rate for different coatings

Measured after 1h air exposure and 10h pumping



-less porous at low pressure (less voids for faster ions F.Rossi, J.Appl. Phys. 75, 3121, 1994)? Effect of bombardment by higher energy neutrals?
-Ne degassing 7-20x10^{-13} Torr l/s/cm^2 (Ne content < 40ppm)

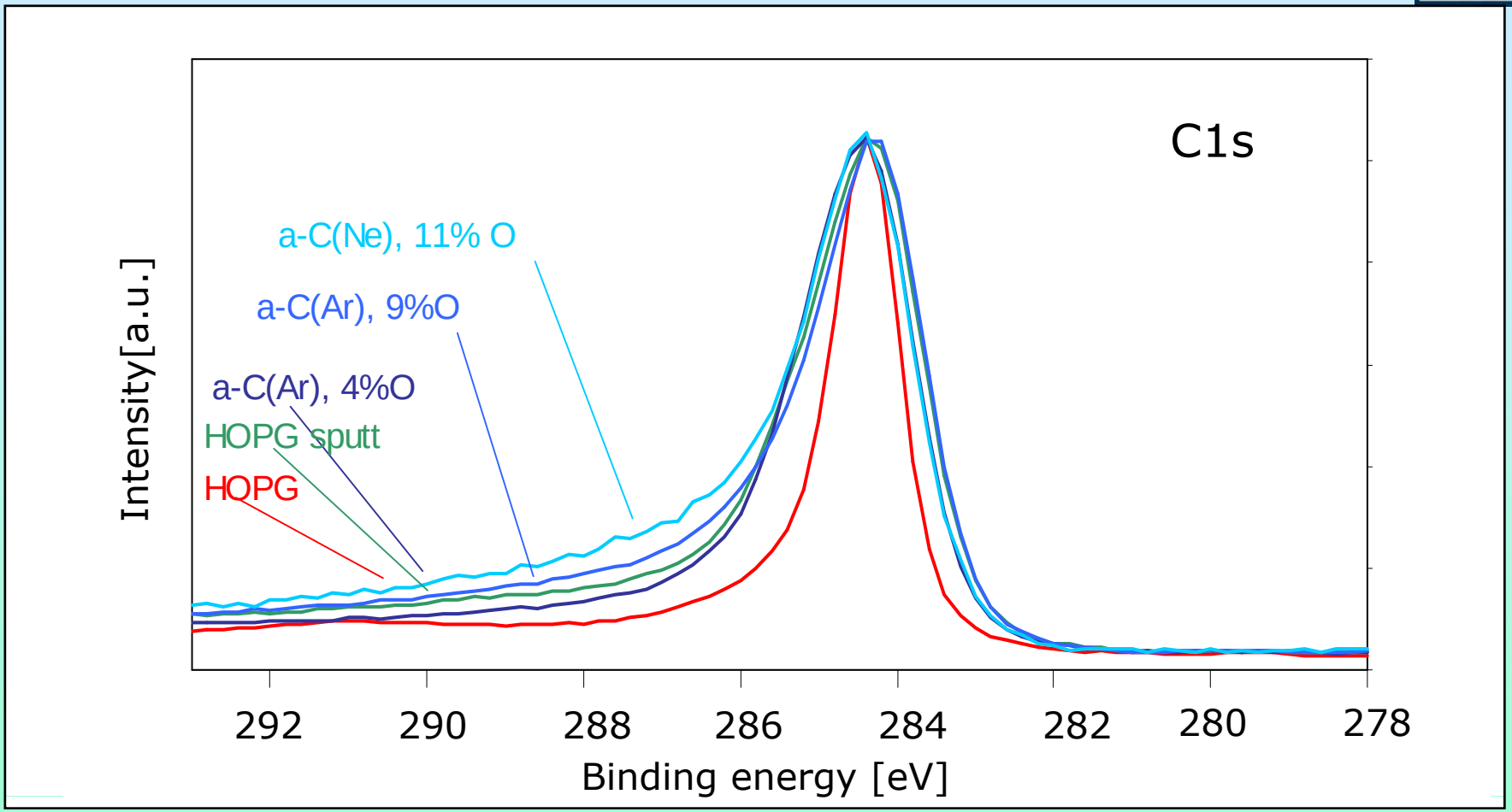
XPS: comparison with graphite



The C1s peak is wider than that of freshly cleaved graphite: due to the **oxygen** on the surface (8-10% typical) and chemical shift of C-O bonds or due to the more **disordered** structure and different C-C bond species?

No correlation between SEY and measured O; O% does not decrease by baking in situ 160C, 2h ➔ chemisorbed during air exposure

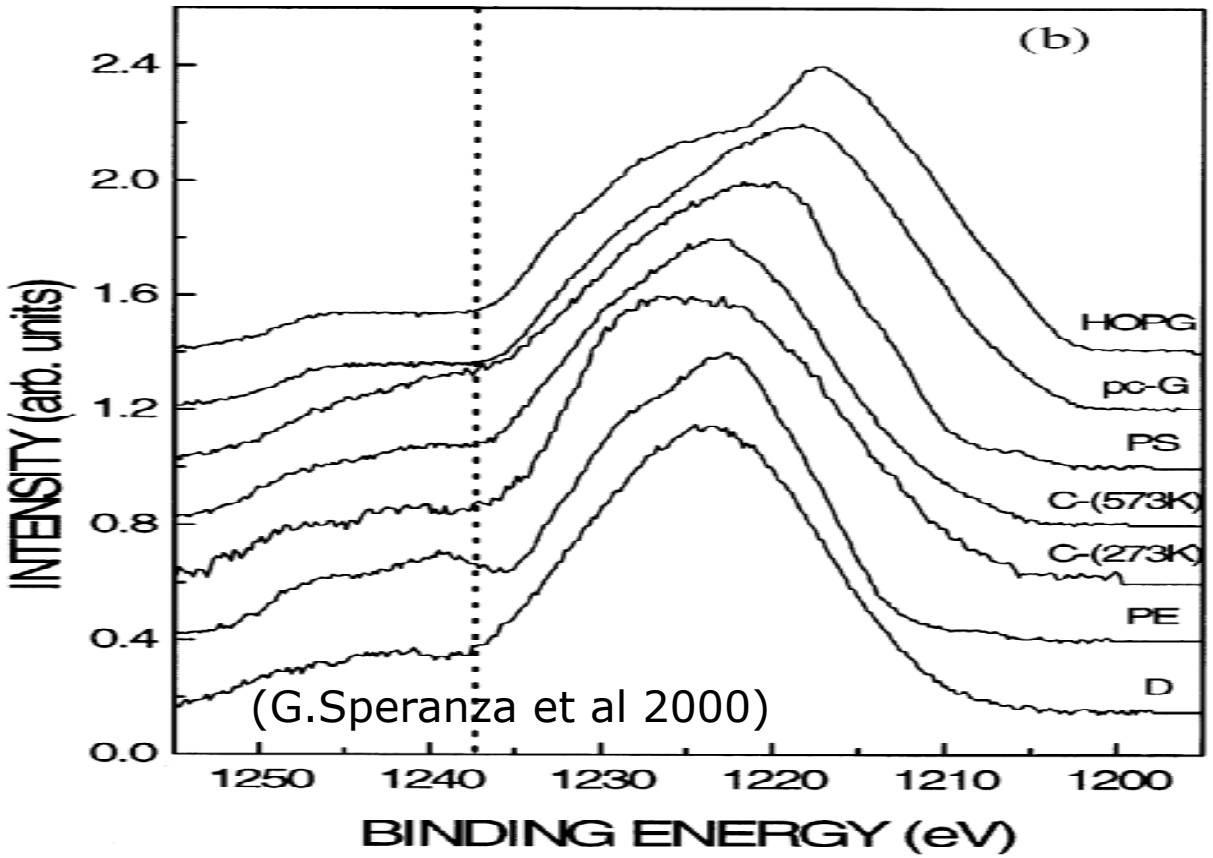
XPS: effect of Oxygen on C1s



-the intensity around 286.5-287 eV is due to C-O bonds and that at lower BE is mainly due to disorder

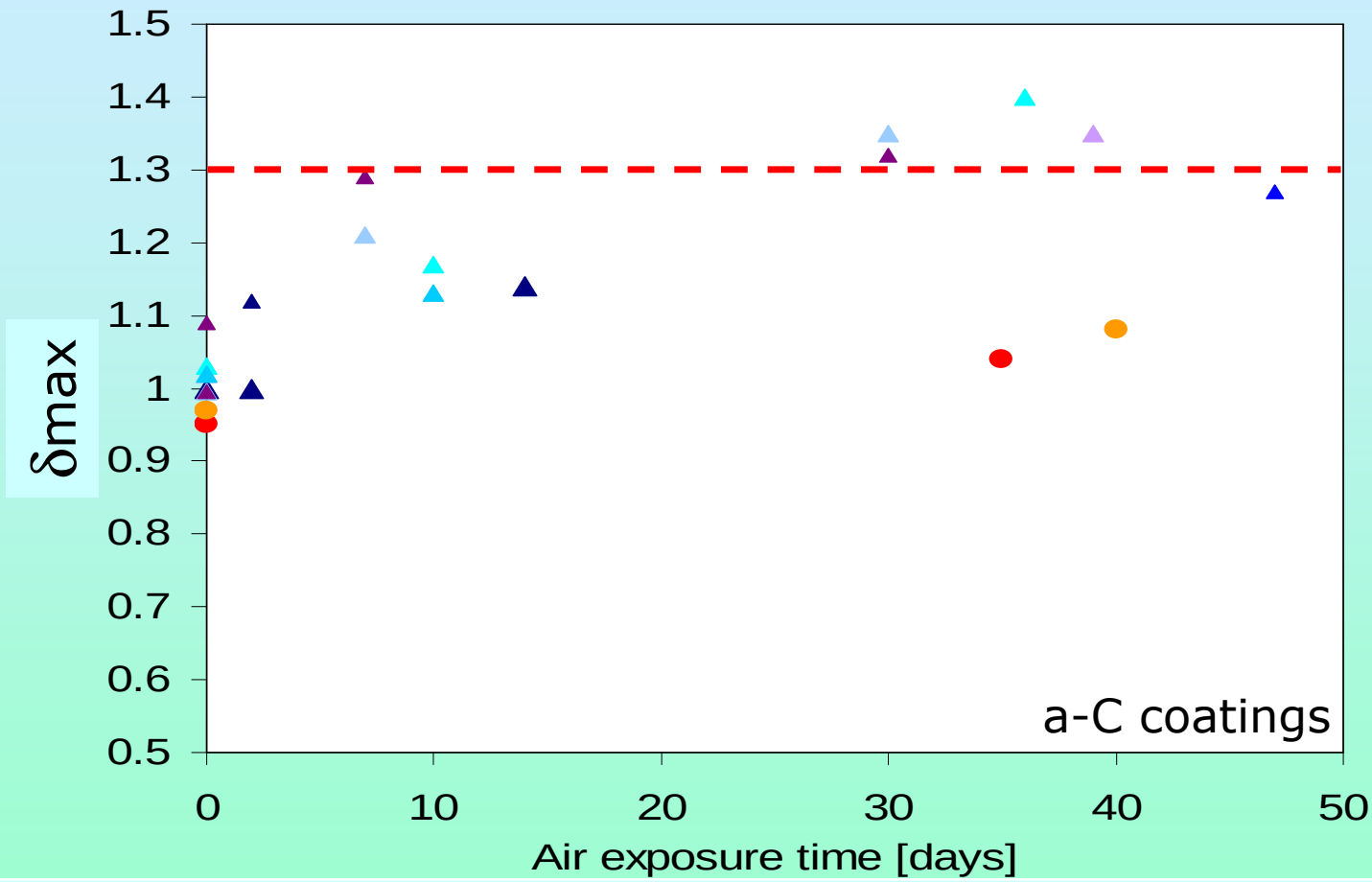
-assuming the disorder part is completely due to sp^3: 14%-32% sp^3 depending on fits (symmetric asymmetric) as upper limit for the coating with the 4% O (S.T.Jackson at al. 1995, R.Haerle et al. 2001)

XAES: Comparison with graphite



(G.Speranza et al 2000)

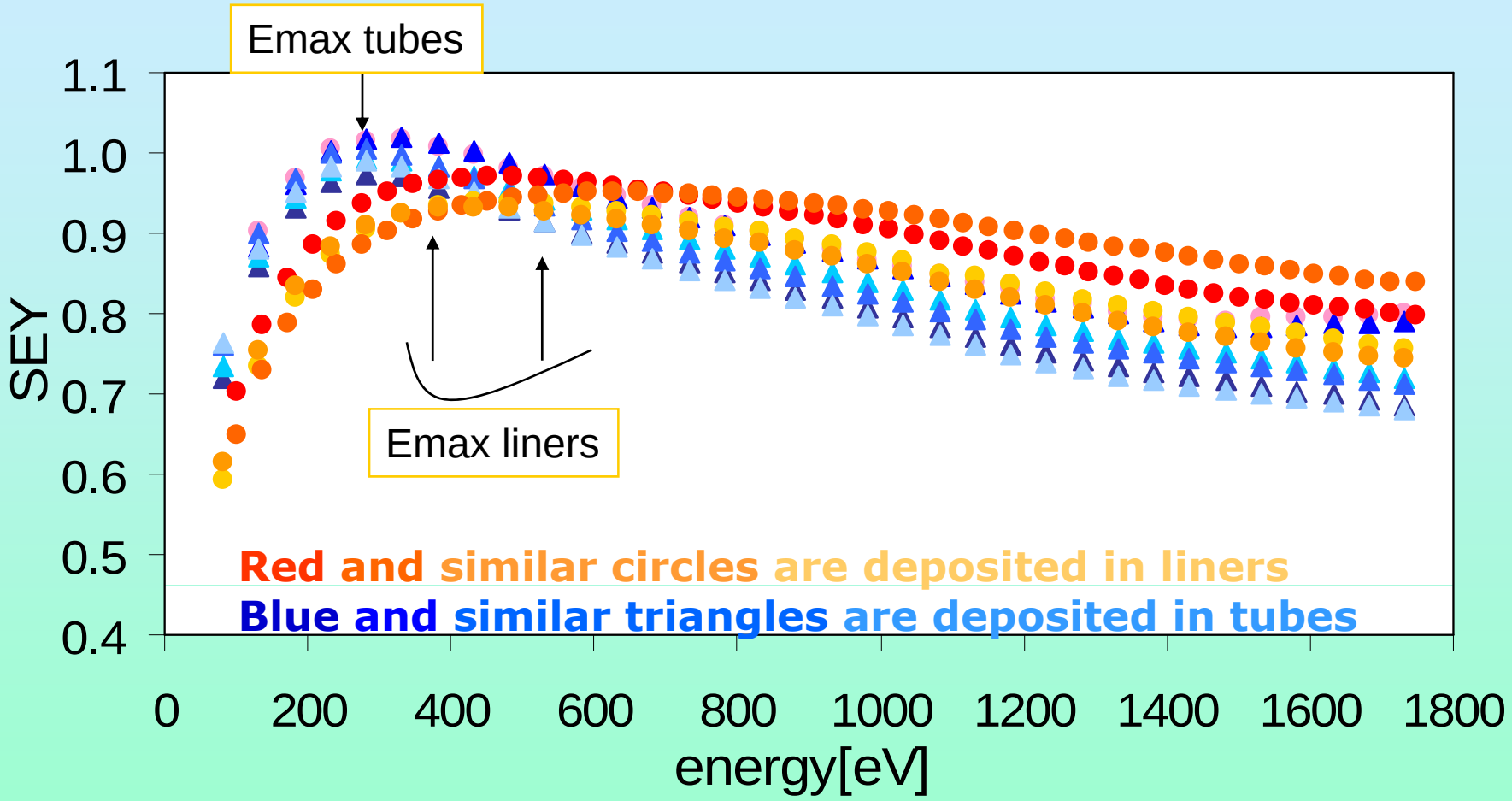
Aging as a function of air exposure time



No cumulated dose

-Maximum SEY is below 1.3 for air exposures up to some 20 days
-The best coatings have 1.1 after 40 days in air
-Maximum air exposure time for the application should be specified

SEY curve dependence on sputtering configuration

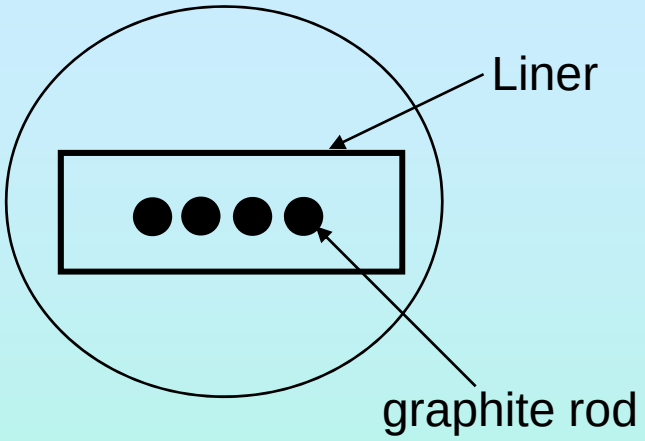


-different shape can be explained in some cases by nano-roughness
-possible differences in substrate T during deposition, distance cathode-substrate, angle of arrival on the substrate
-related to differences in aging during air exposure

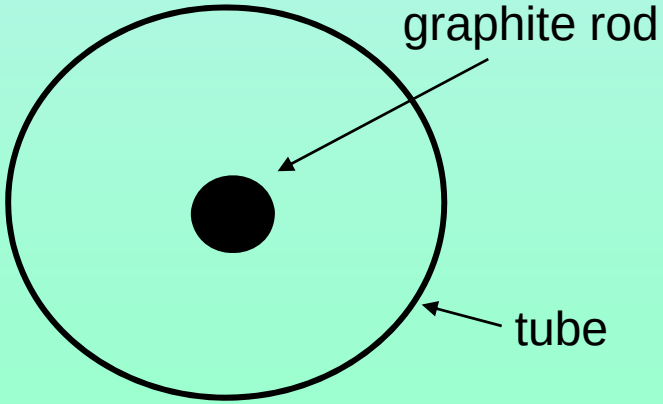
Magnetron sputtering configuration

Tube versus liner:

	Liner	Tube
T substrate	+	-
Energy of impinging atoms	+	-
Impact direction	many	normal
Observed roughness	+	-



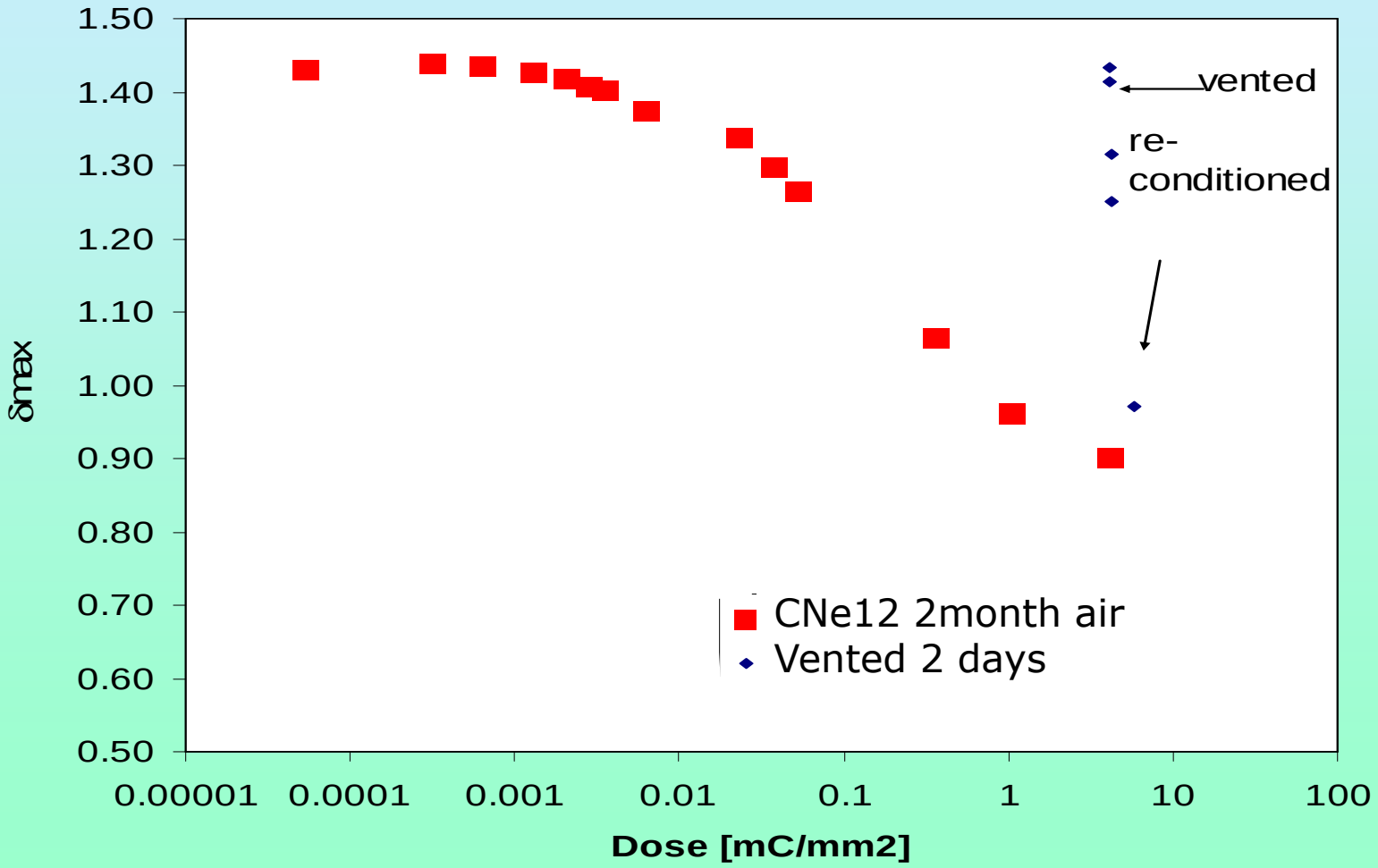
Liner configuration



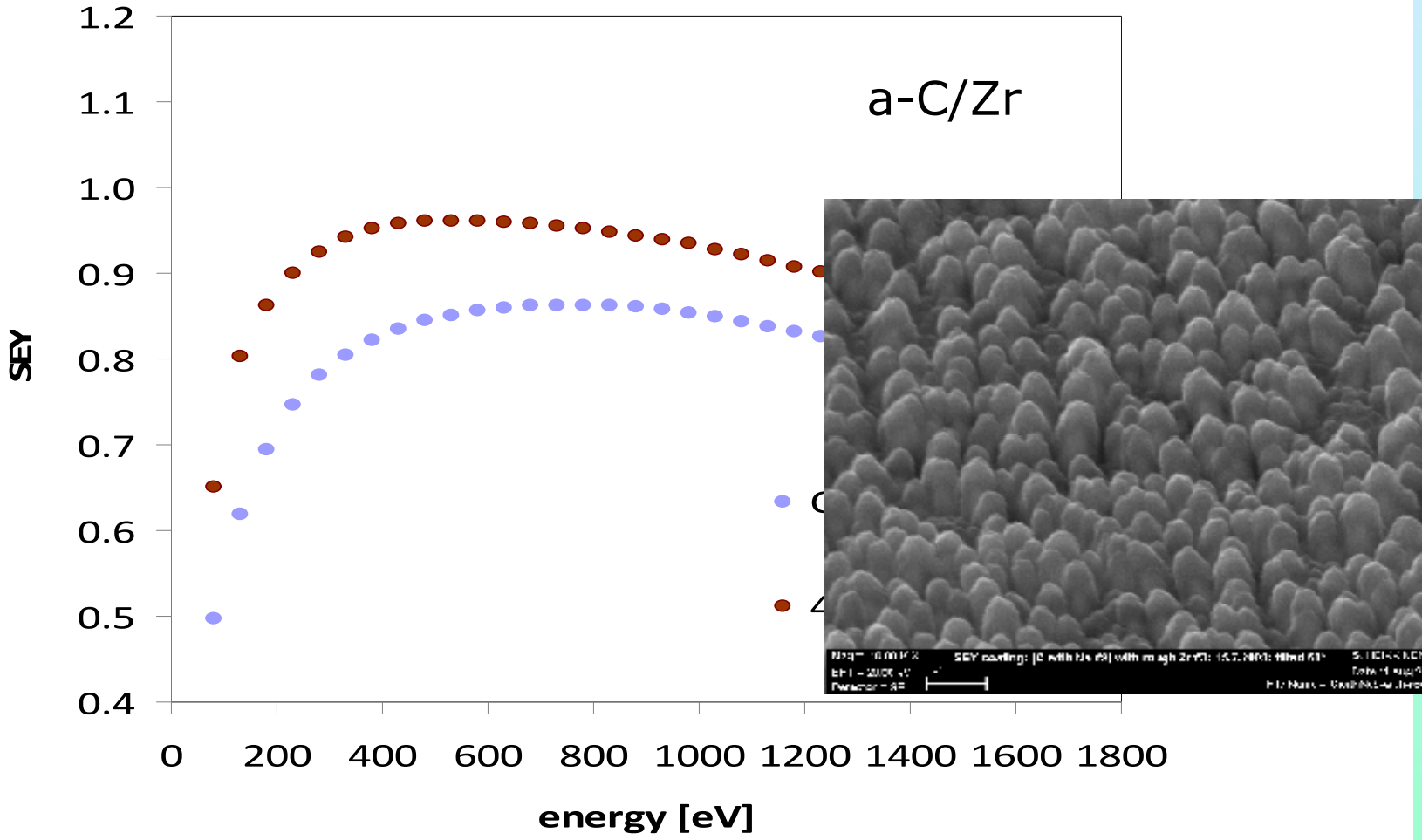
Tube configuration

Conditioning with electrons

Electrons at 500eV, **relative** SEY measured directly with the irradiation gun, at 500eV by polarizing the sample +/-45V

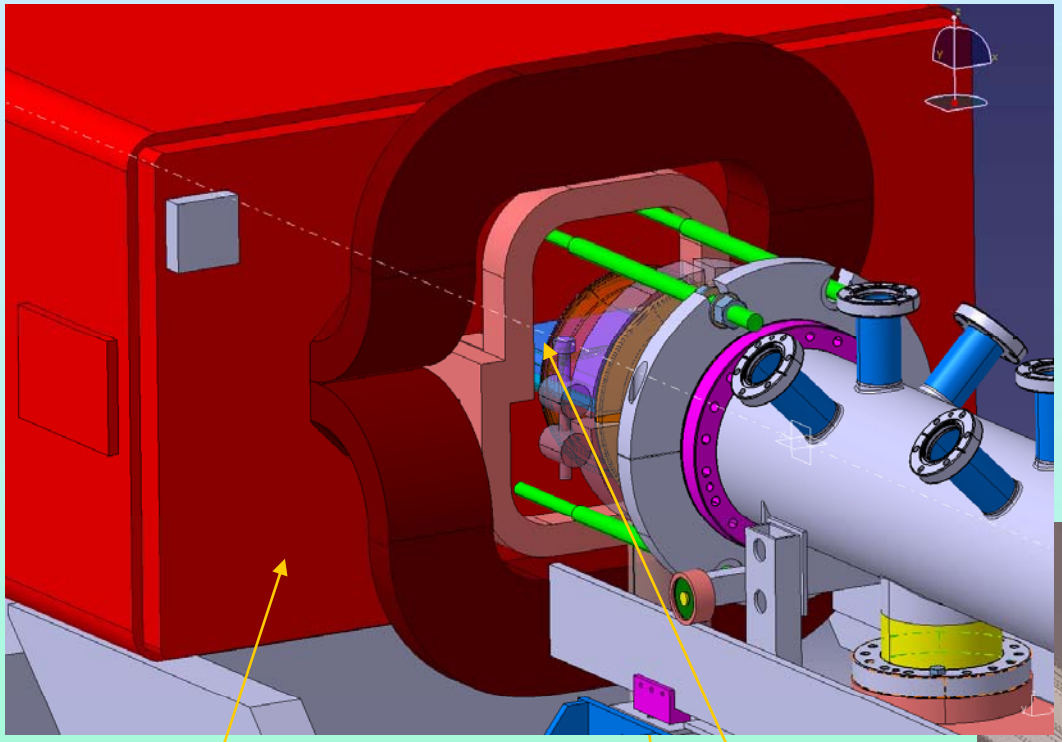


Improvement with a-C on rough coatings



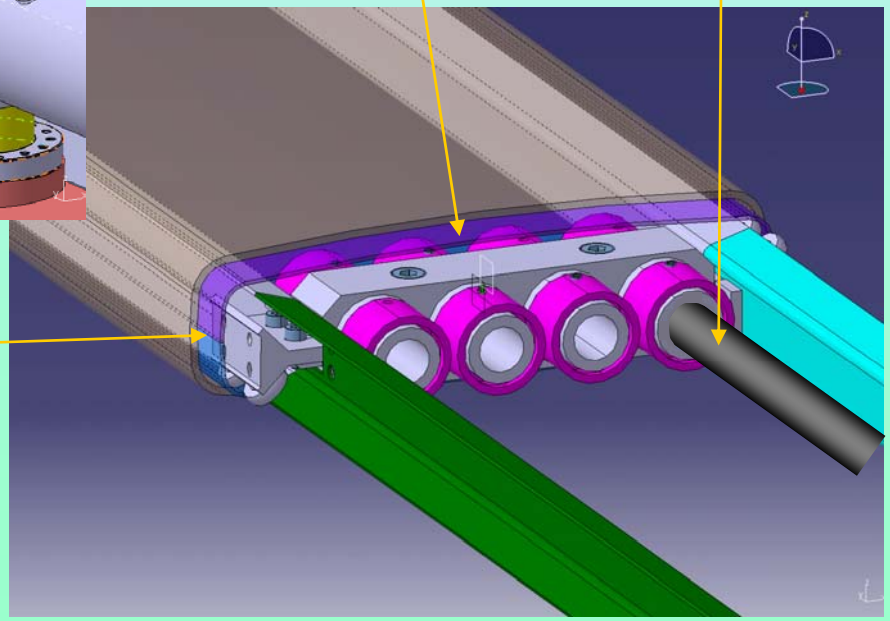
-advantage: low SEY, less sensitive to aging
-disadvantage: it requires 2 subsequent coatings

Preparation for SPS magnet prototype coating



graphite cathode

Liner to be coated

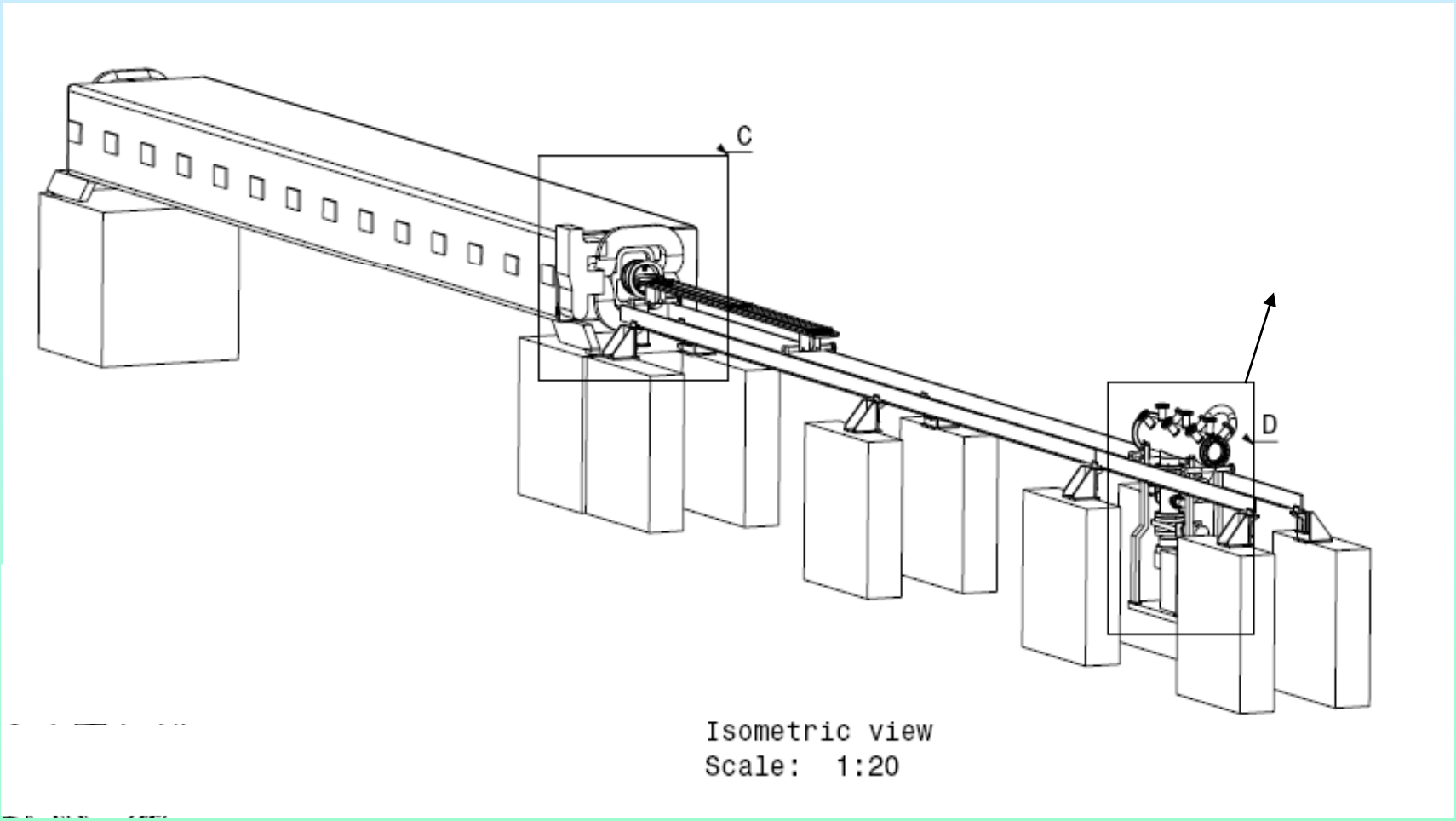


SPS dipole

vacuum chamber

Cathode insertion mechanism extraction

Progress on SPS prototype coating



Tentative schedule for coatings of magnets to be inserted during shutdown

Conclusions:

-the SEY of a-C remains below 1.3 for up to 2 weeks air exposure

-the optimization in terms of aging is still progressing

-Characterization with electron spectroscopy indicates more graphite-like than diamond-like character

-the degassing can be reduced to 5 and 2 times the value of StSt for C(Ne) and C(Ar) coatings, respectively

-Conditioning by electrons of samples exposed long time to air is similar to conditioning of air exposed metals, but comparable SEY are obtained with lower dose

-Characterization by PSD (coll. with ESRF), NRA (Uni Namur) are in progress and Raman spectroscopy (Cambridge University) is planned

-Tested in SPS: see presentation tomorrow of Ch.Yin-Vallgren

Many thanks to

I.Montero, L.Galan (Universidad Autonoma, Madrid, E)
R.Kersevan (ESRF Grenoble, F)
A.Ferrari (University of Cambridge, UK)
All SPSU team