Status report on Development and Characterization of New Material and Coatings for e-cloud mitigation @ LNF.

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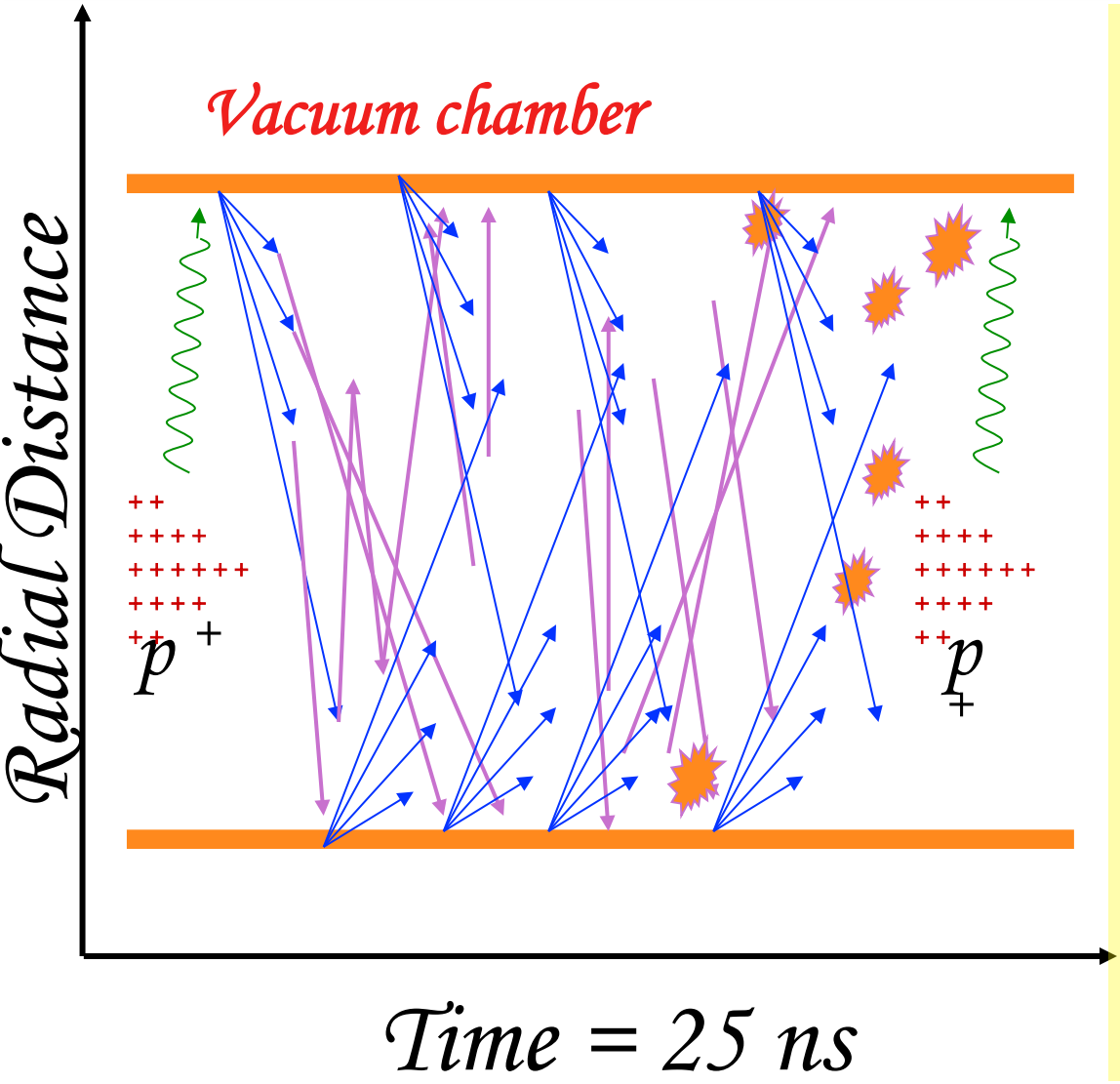
For the NTA-IMCA and Nuvola-GrV collaboration

- *The electron cloud problem.*
- *Material Science Laboratory @ LNF : some results.*
- *Conclusion and open questions.*

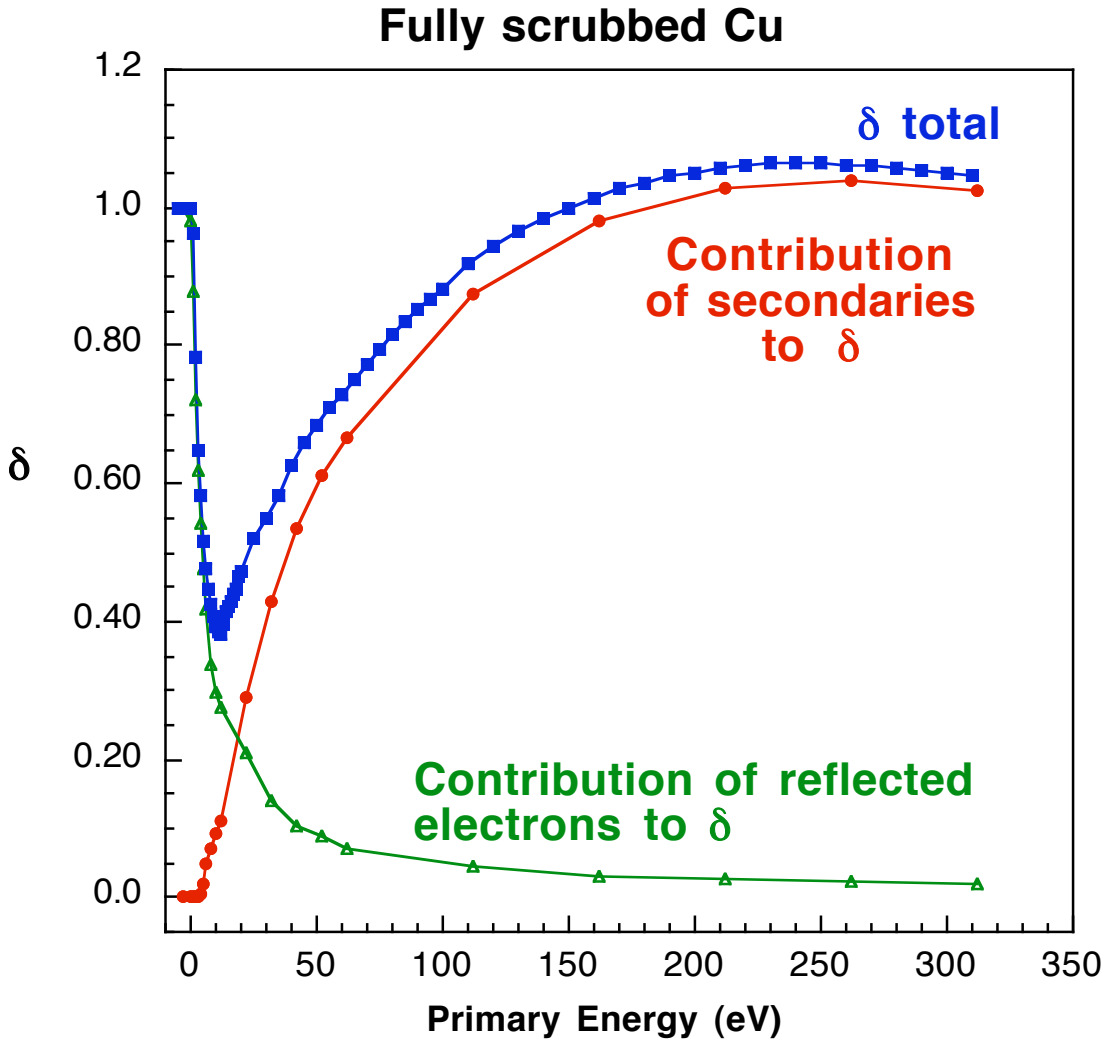
The "e-cloud" phenomenon (in pils)



The accelerated particle beam produces SR and/or e^- that, by hitting the accelerator's walls generate photo-e^- or secondary-e^-.

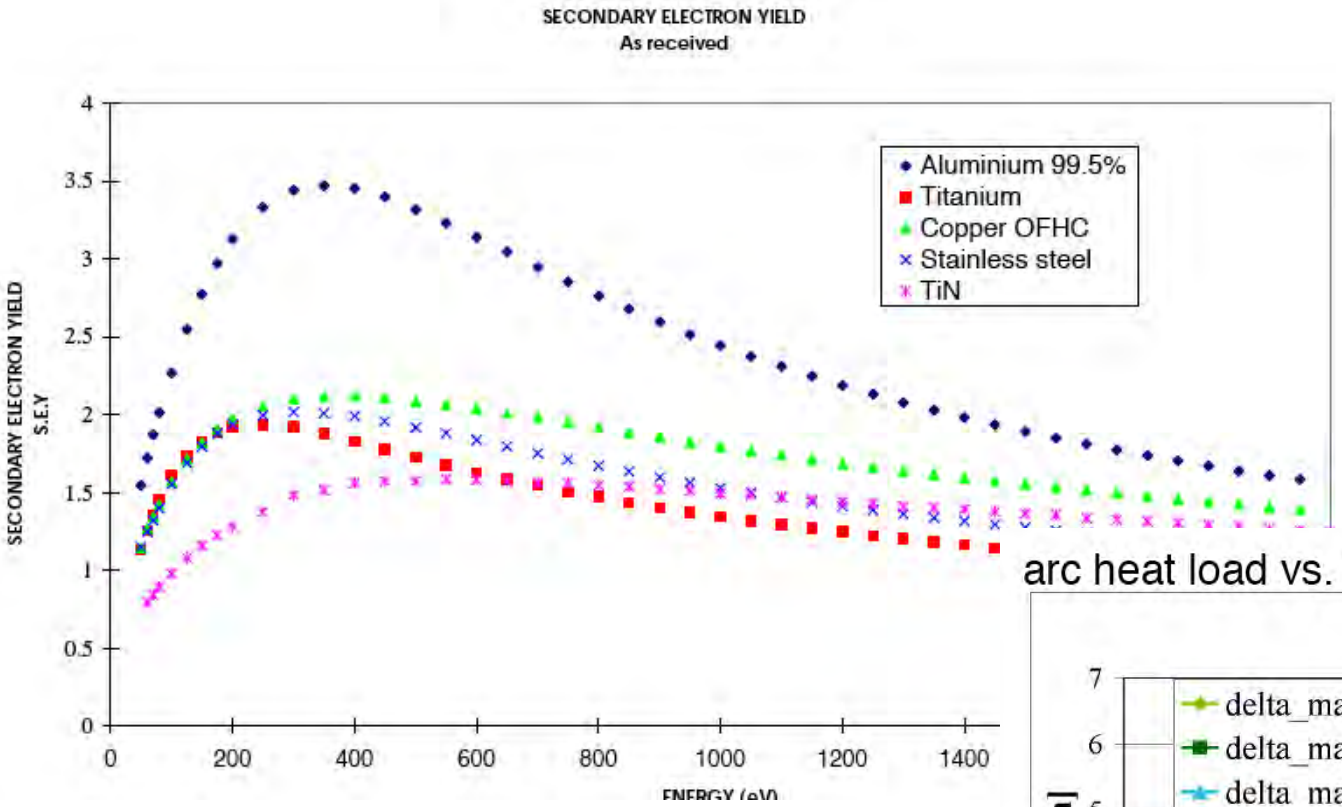
Such e^- can interact with the beam (most efficiently for positive beams) and multiply, inducing additional heat load on the walls, gas desorption and may cause severe detrimental effects on machine performance.

One of the most relevant parameter for e-cloud studies is: S.E.Y. (or δ)



I.e.: the number of electrons created after bombardment of a single electron.

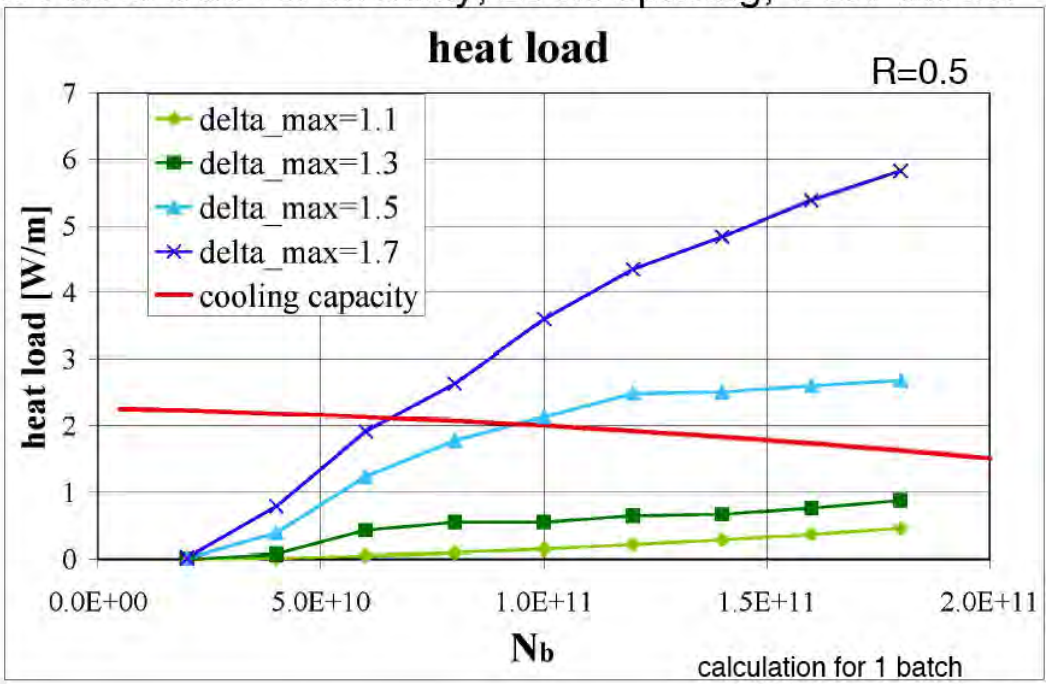
R. Cimino, et al., Phys. Rev. Lett. 93 (2004) 014801



Measure of Secondary e⁻ YIELD

…. And its impact to simulations (see calculation for LHC).

arc heat load vs. intensity, 25 ns spacing, 'best' model



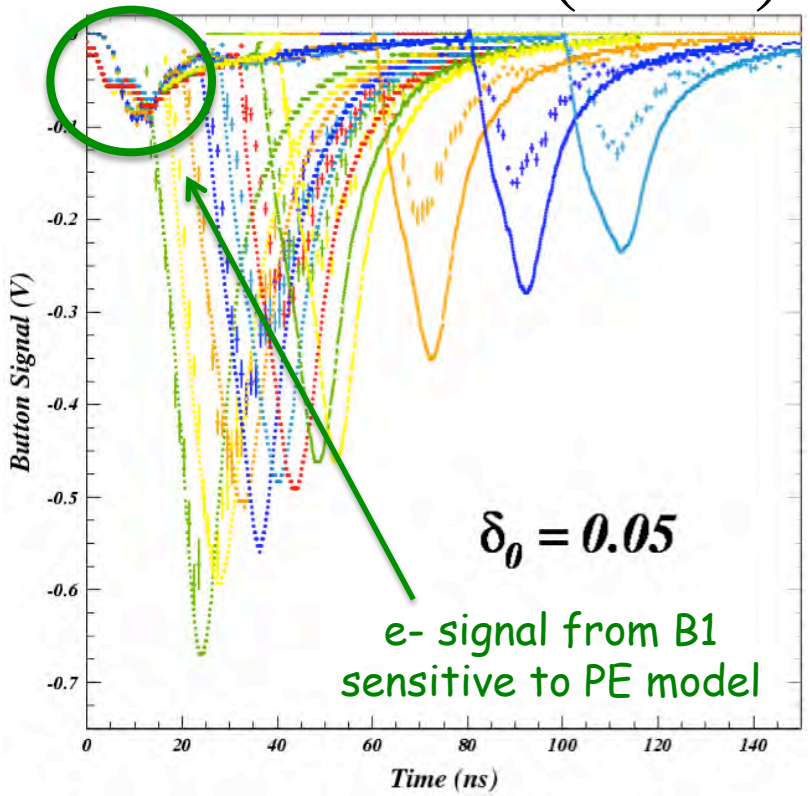
heat load for quadrupoles higher in 2nd batch; still to be clarified

Most of the existing and planned accelerator machines base the reaching of their design parameters to the capability of obtaining walls with a SEY ~1.2 or below to mitigate e-cloud driven multipacting!

K. Omi (KEK preprint 2005-100 (2006)) calculate $\rho\ [m^3] = 1 \times 10^{11}$ *as acceptable limit for the electron density in Super KEKB to avoid single bunch instability. This not only gives an even more stringent value for SEY (<1.1 for SuperB, see:Th. Demma) but call for a detailed knowledge on photon reflectivity and photo-yield on industrial materials.*

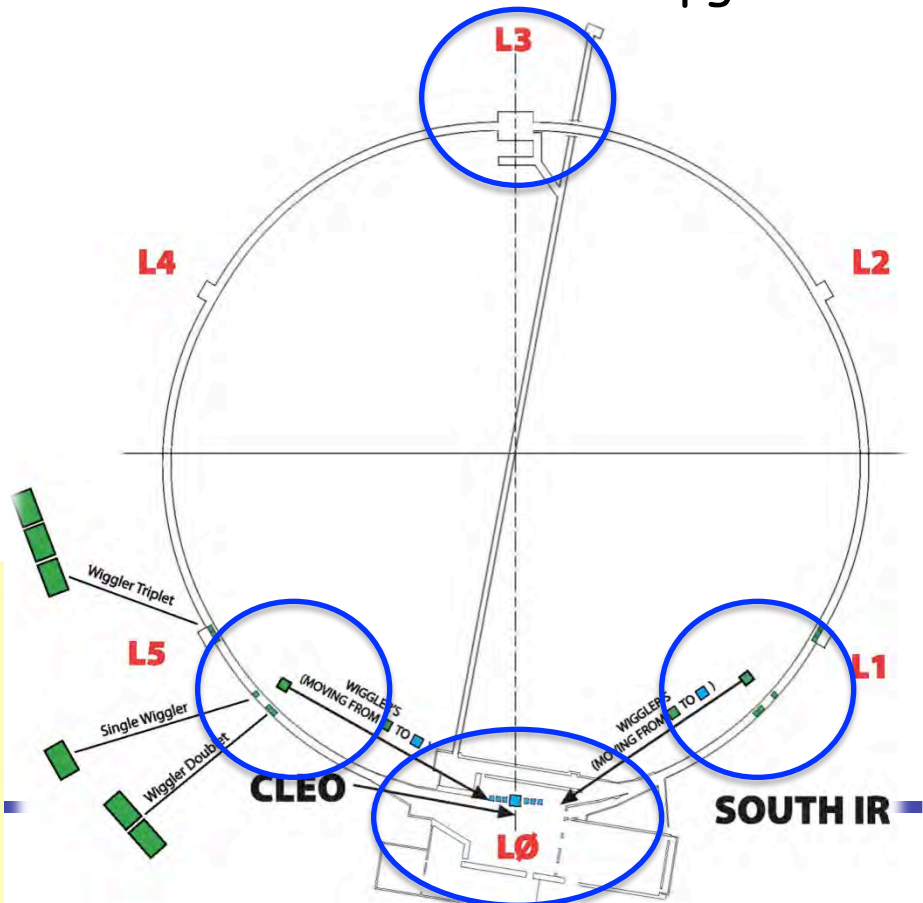
ECLOUD Modeling of CESRTA Shielded Pickup Pulse Shapes: Photoelectrons

Time-Resolved (SPU)



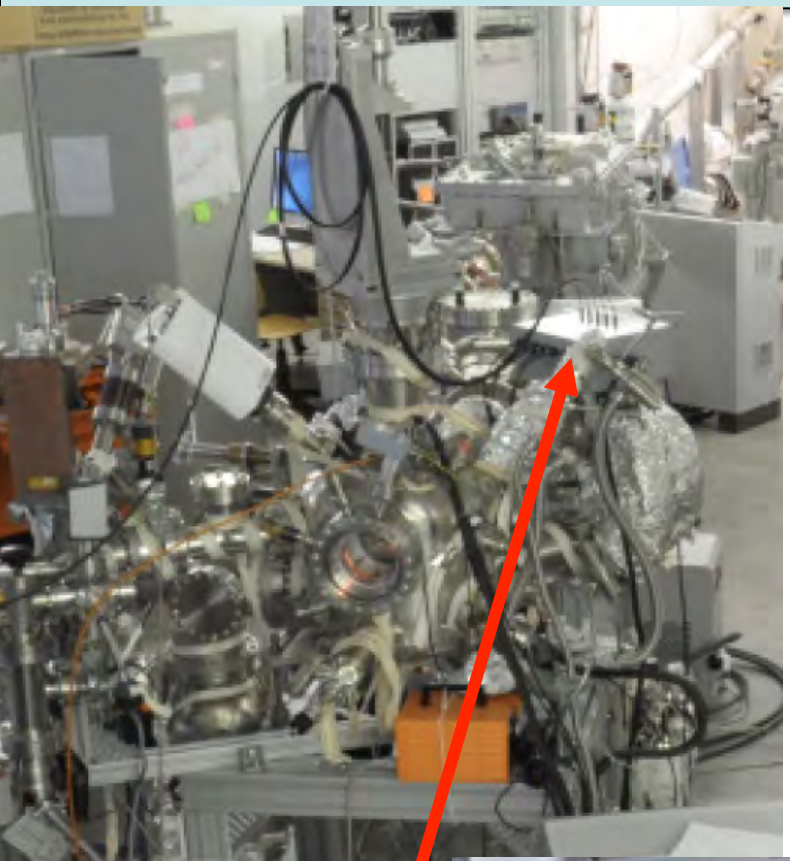
JAC et al, IPAC11, WEPC135, *Recent Developments ...*

- Damping Wiggler Straight for ultra low emittance operation
- 4 EC experimental regions
- Beam and EC instrumentation upgrades



Better photon reflection and transport model needed for simulations and data analysis. Time-resolved measurements indicate that we also need to have a better PE spectrum (fitting of RFA data also requires this)

LNF XUV Beam Lines @ DAΦNE



An international collaborative effort is ongoing to study photon reflectivity, SEY and PEY before and after e^- and ph. scrubbing on the same sample. This can be also studied at DAFNE SR beamlines.

XUV-H (60-1000)

V. TULLIO 2009

Potential remedies for e-cloud mitigation:

Surface Scrubbing (or conditioning)	⇨	-Efficiency (time & final SEY)…
Geometrical modifications	⇨	Impedance. Machining costs.
Intrinsically low SEY material	⇨	Stability and material choice…
Electrodes in the lattice.	⇨	If possible… (see talk) (Impedance, costs.)
External solenoid field.	⇨	Not always possible…

Activity of the LNF Material Science Laboratory:

Our Laboratory is becoming a reference Lab for material science analysis and tests of relevance for e-cloud studies.

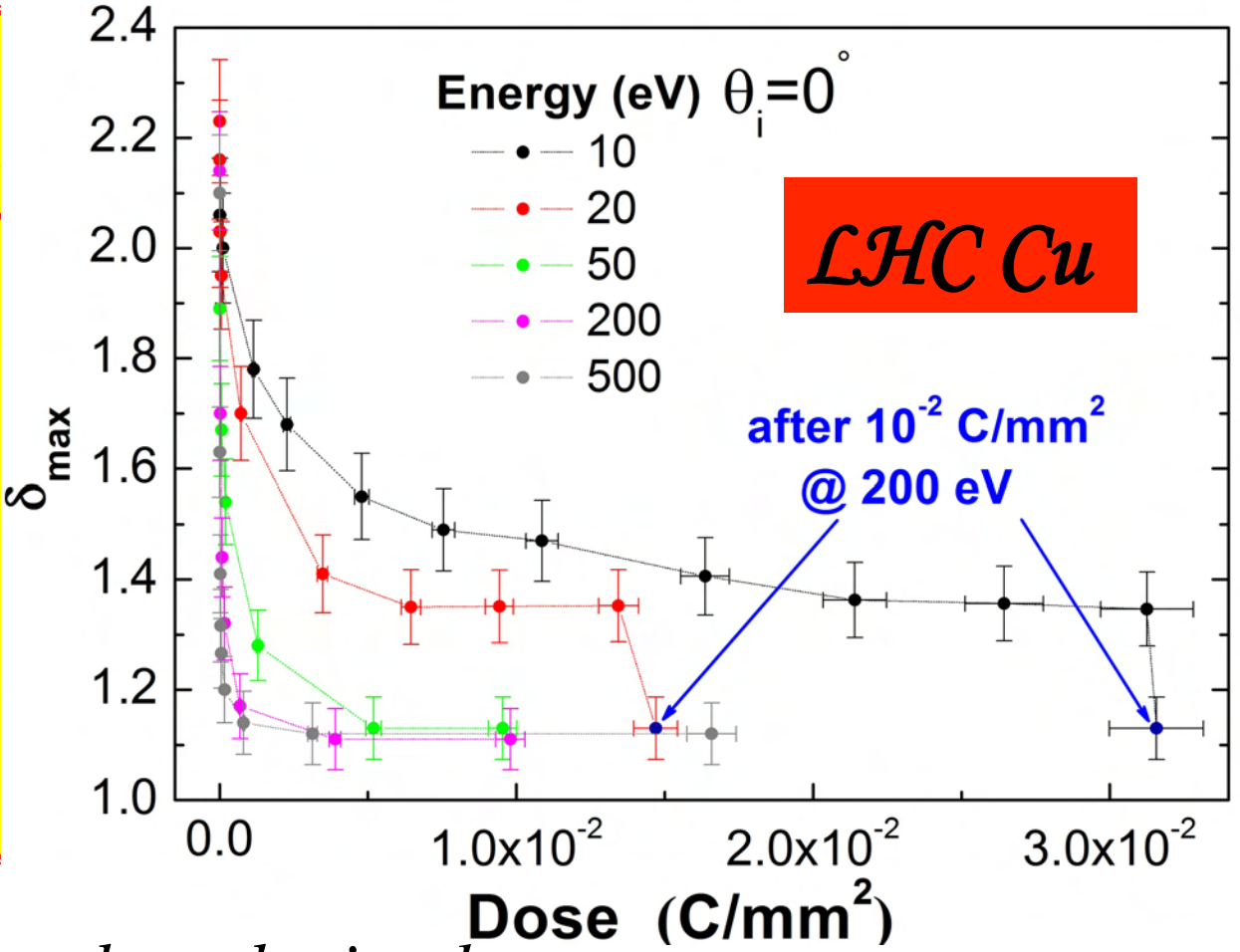
We are studying (in collaboration with the respective institutes):

- **CERN- LHC (Dipole chamber) Cu Samples**
- CERN – SPS a-C Coatings
- **Al from DAFNE and PETRA 3 (DESY)**
- Stainless Steal (from RICH, Brookhaven)
- **TiN "test" samples produced at LNF** and from PEP
- NEGs ……

… and we are learning a lot on the scrubbing process!!!

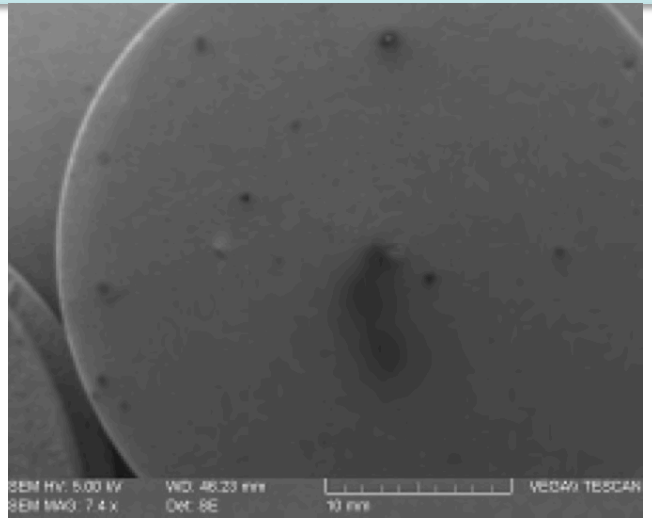
The Beam "scrubbing" effect is the ability of a surface to reduce its SEY after e^- bombardment. It depends on e^- energy!

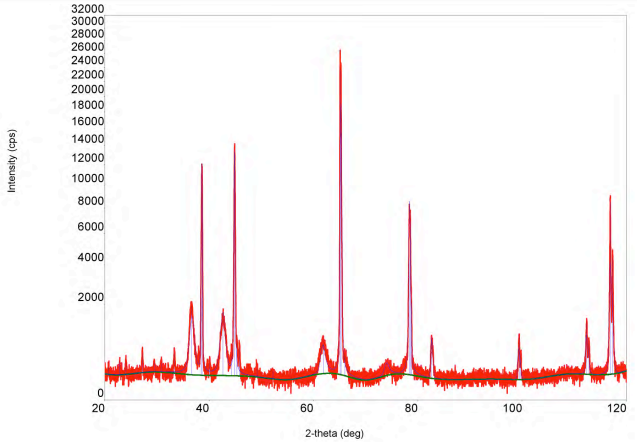
from LHC PR 472 (Aug. 2001): "...Although the phenomenon of conditioning has been obtained reproducibly on many samples, the exact mechanism leading to this effect is not properly understood. This is of course not a comfortable situation as the LHC operation at nominal intensities relies on this effect..."



R. Cimino et al, to be submitted.

TiN (done by S. Bini & the LNF Vacuum Group).

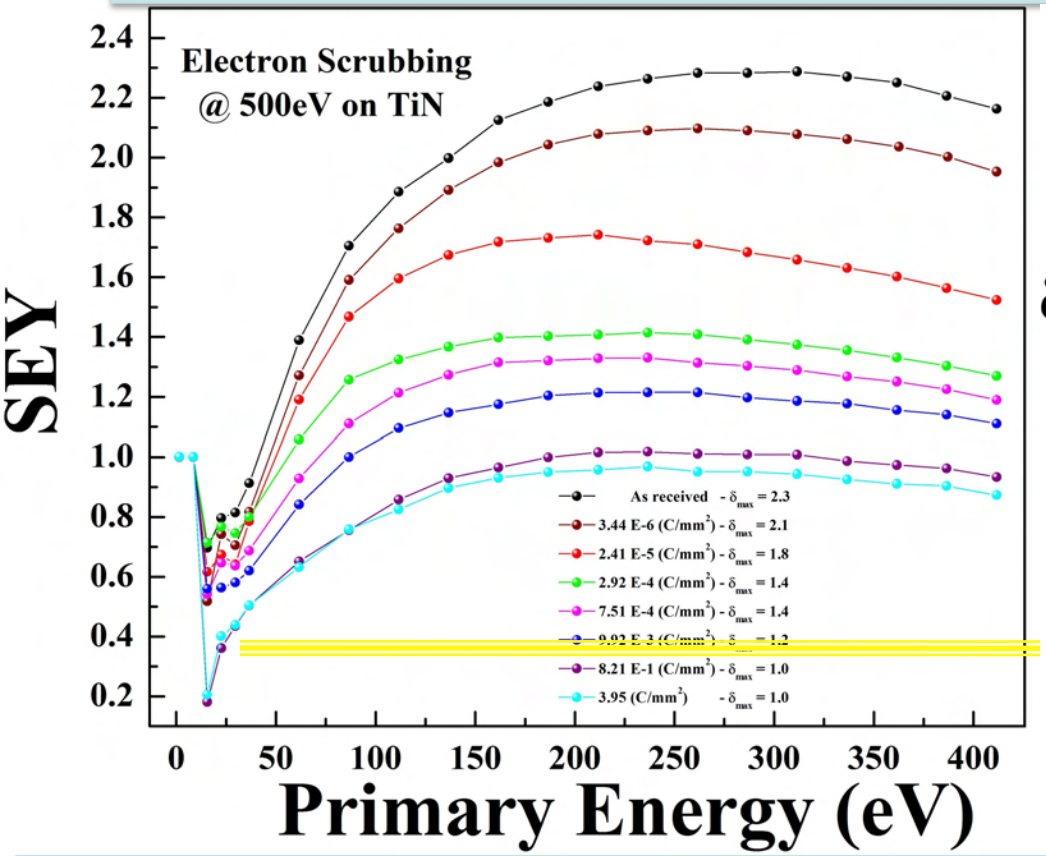


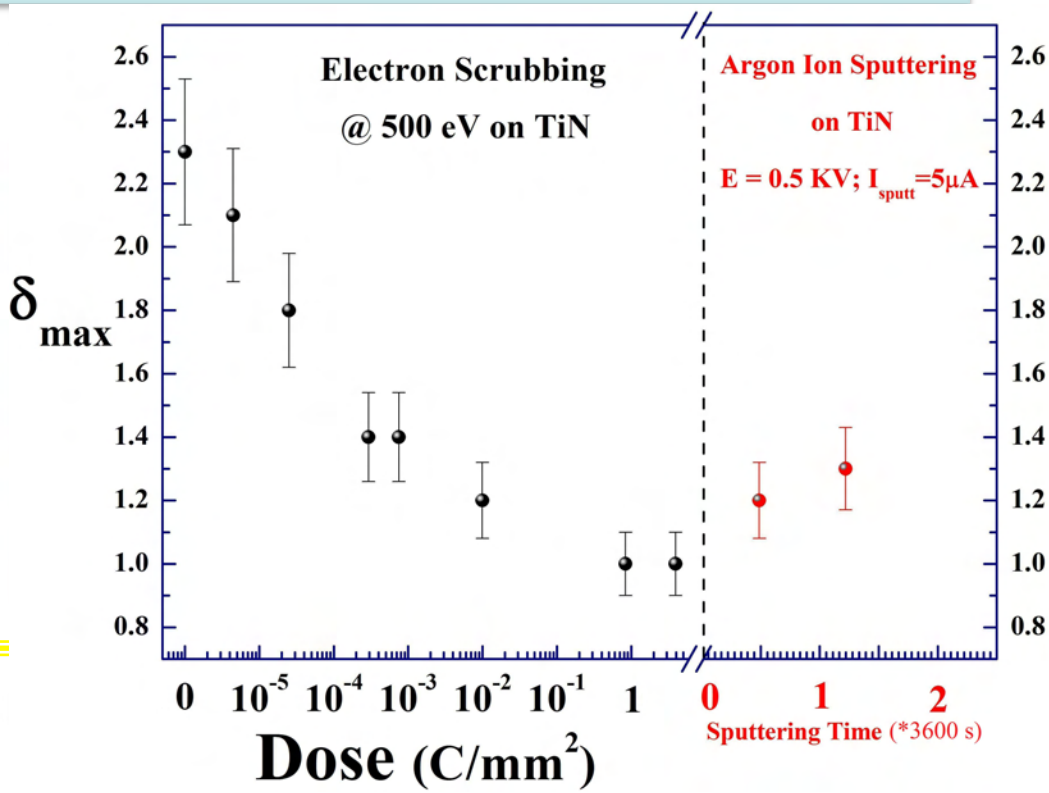


Nanocrystalline TiN thin films has been deposited on aluminum substrates by RF-magnetron sputtering. The "good" quality of the film in terms of microstructural morphology and texture was characterized by SEM and FE SEM and by X – Ray Diffraction.

*D.R. Grosso et al. in preparation

On such TiN we measured SEY vs. electron Dose and….

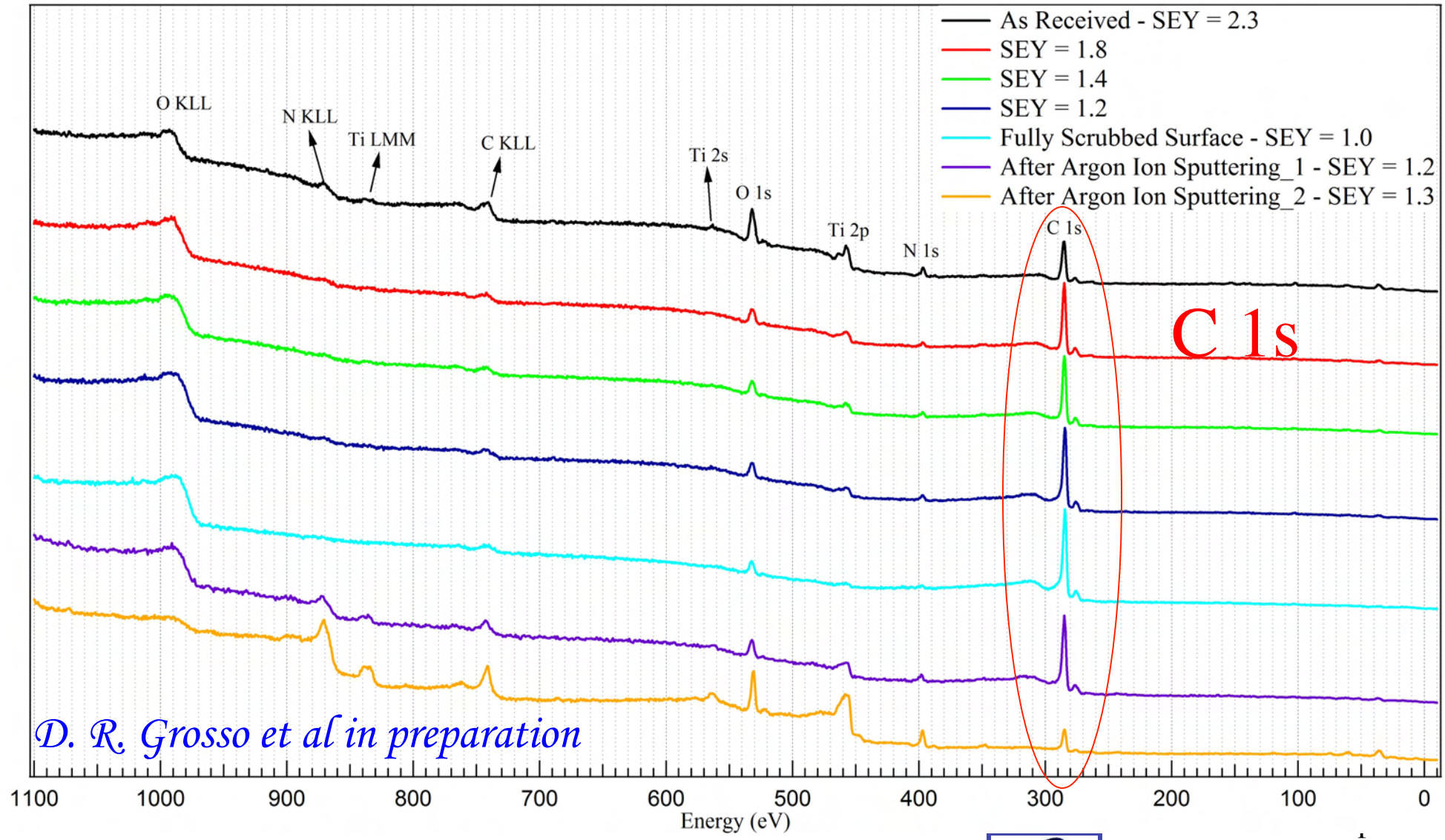




TiN (at least "our") needs scrubbing: then it reaches δ_{max} *~ 1, which is the value quoted at KEK*

D. R. Grosso et al in preparation

We measured XPS vs. e⁻ Dose and Ion sputtering and..



D. R. Grosso et al in preparation

PHYSICAL REVIEW B VOLUME 54, NUMBER 11 15 SEPTEMBER 1996-I

Separation of the sp^3 and sp^2 components in the C 1s photoemission spectra of amorphous carbon films

Javier Díaz,* Guido Paolicelli,† Salvador Ferrer, and Fabio Comin
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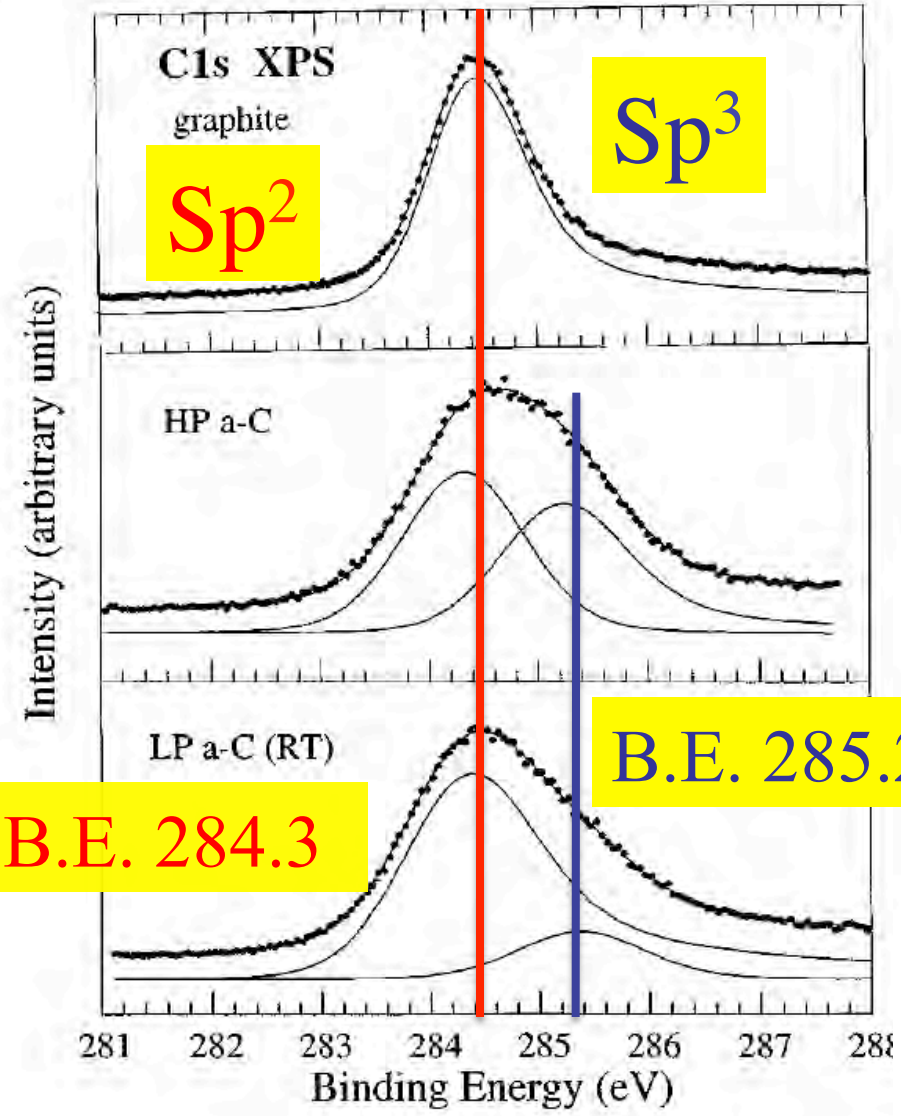
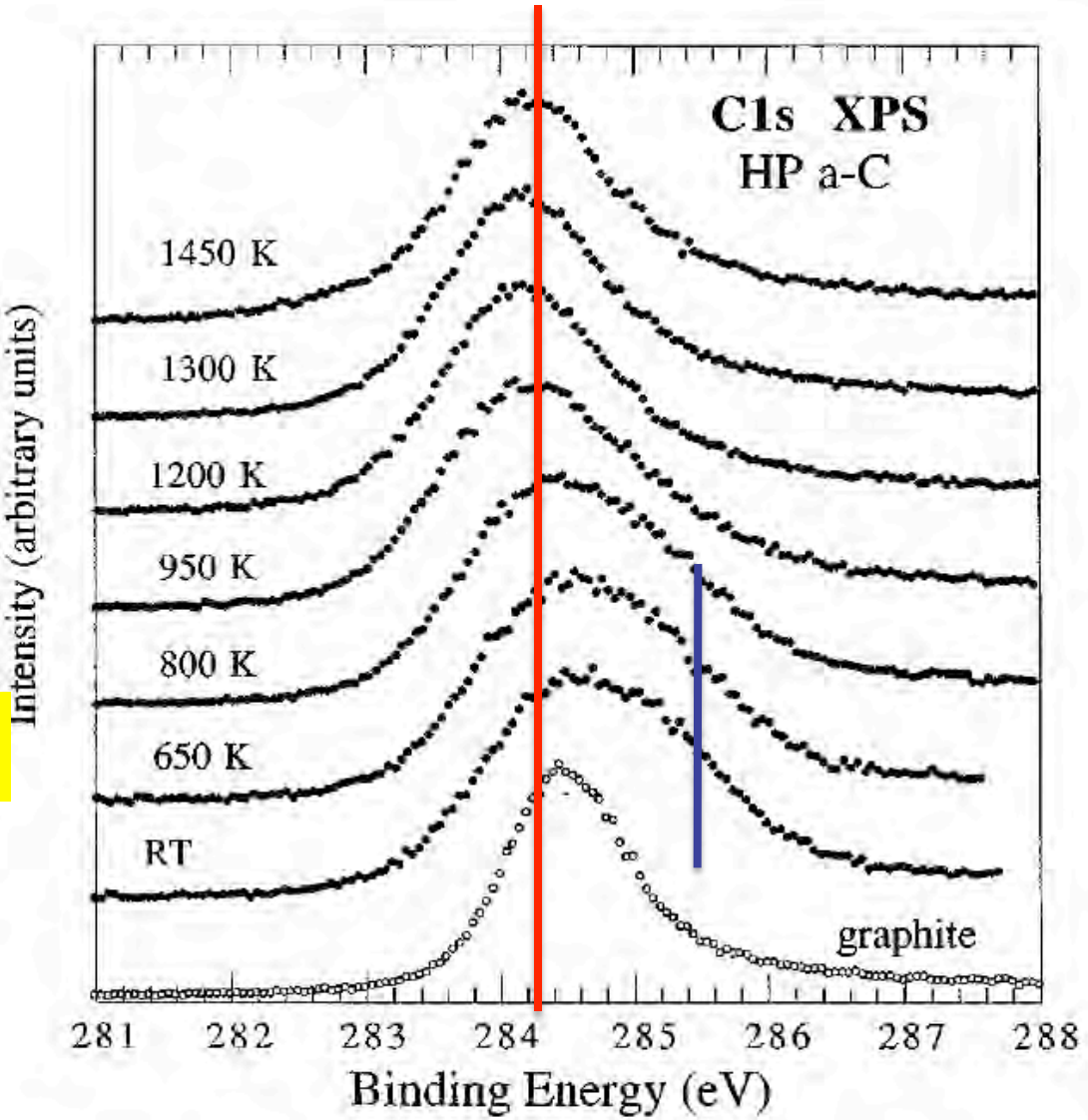
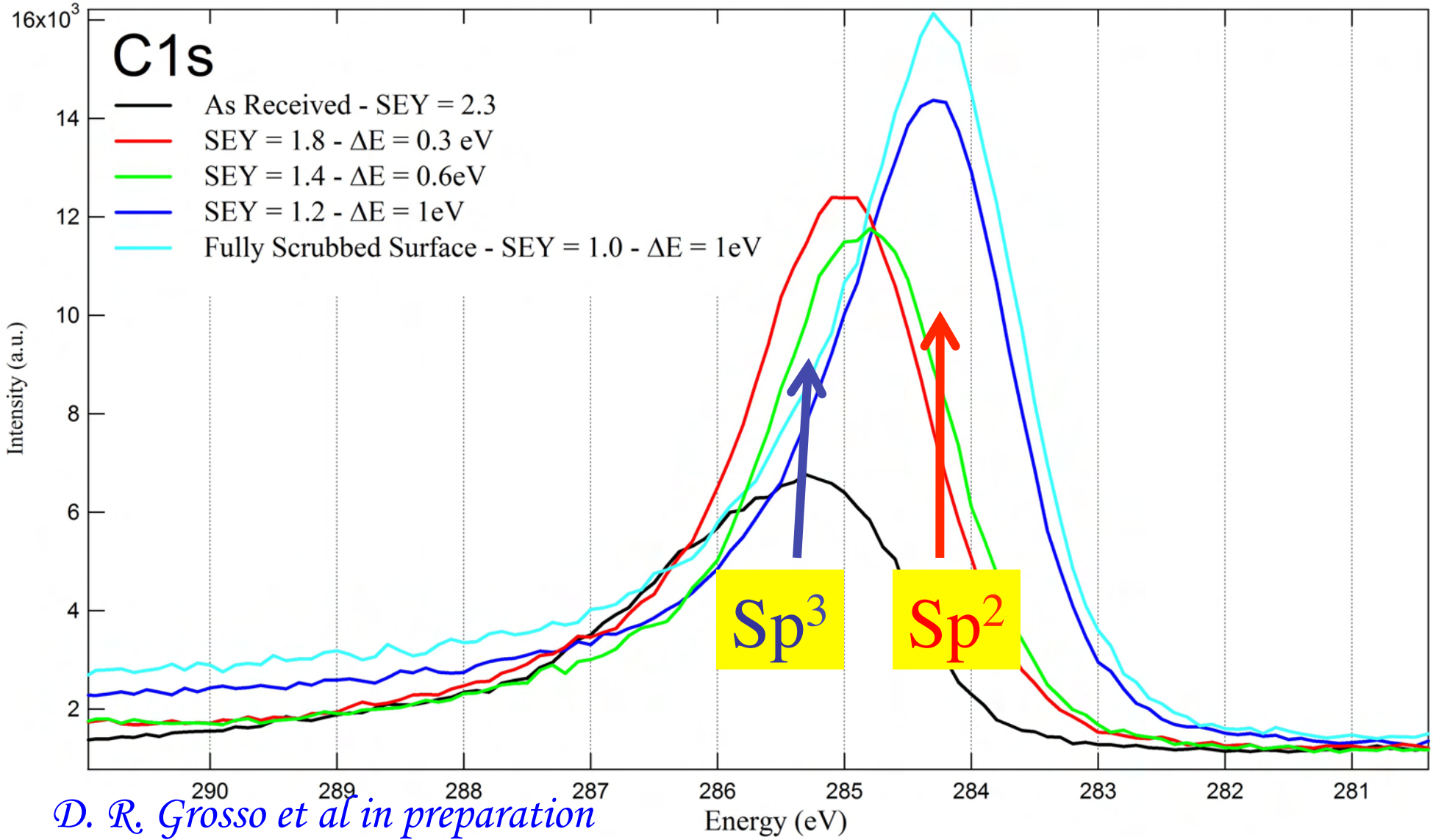
(Received 2 June 1995; revised manuscript received 18 December 1995)





In TiN (Cu, SS but not Al!) the SEY reduction is accompanied by C-sp² formation indicating a graphitization of the sample.



D. R. Grosso et al in preparation

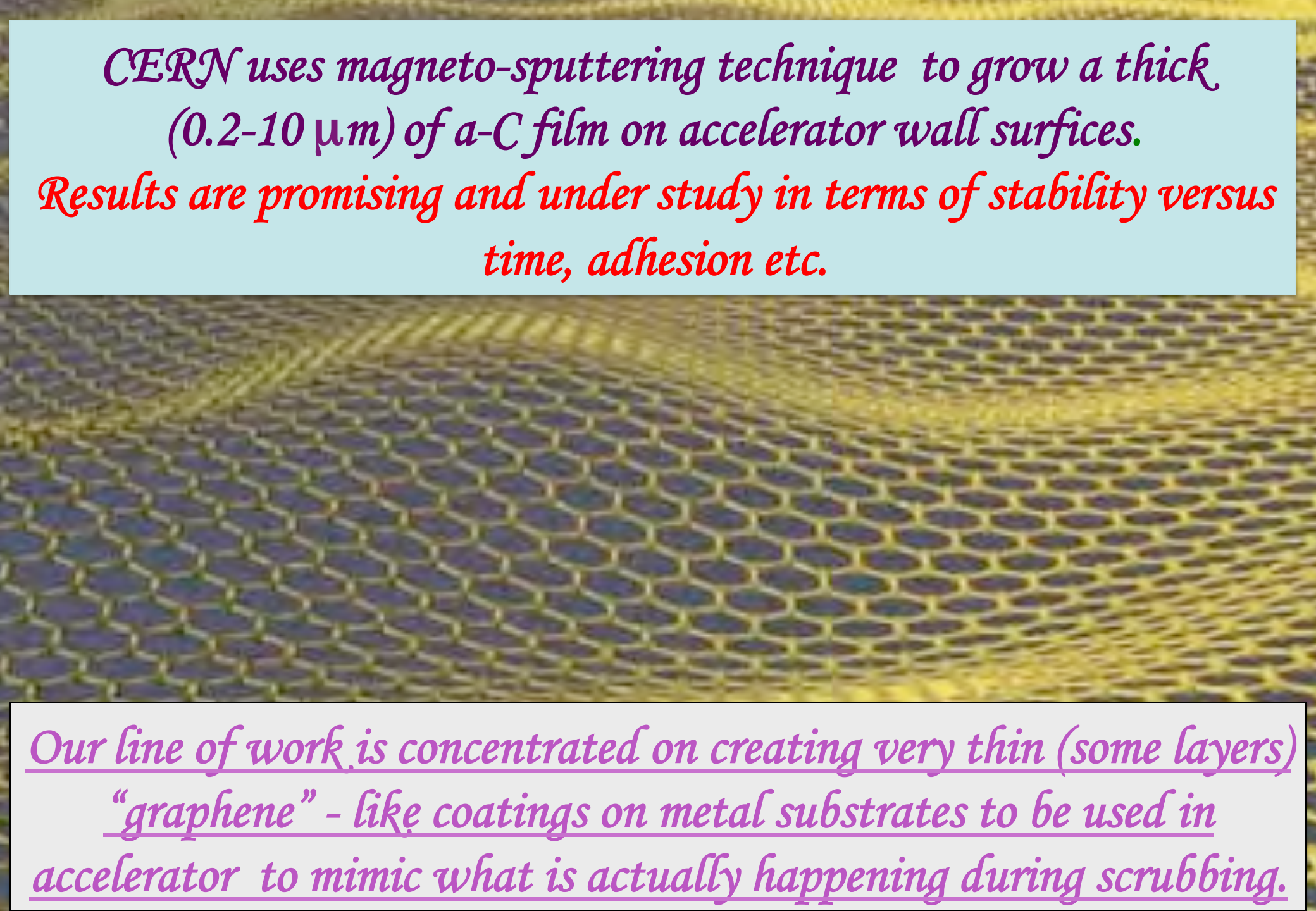
What did we learn so far?

Al, is very reactive, ageing etc. produce Oxides with very high SEY! (If used should be coated)

From Surface Analysis we learn that when C on the surface forms an sp^2 layer, then scrubbing is efficient and the δ_{max} goes below 1.2!!

Graphitization is an essential (and quite general, but Al) ingredient in SEY reduction!

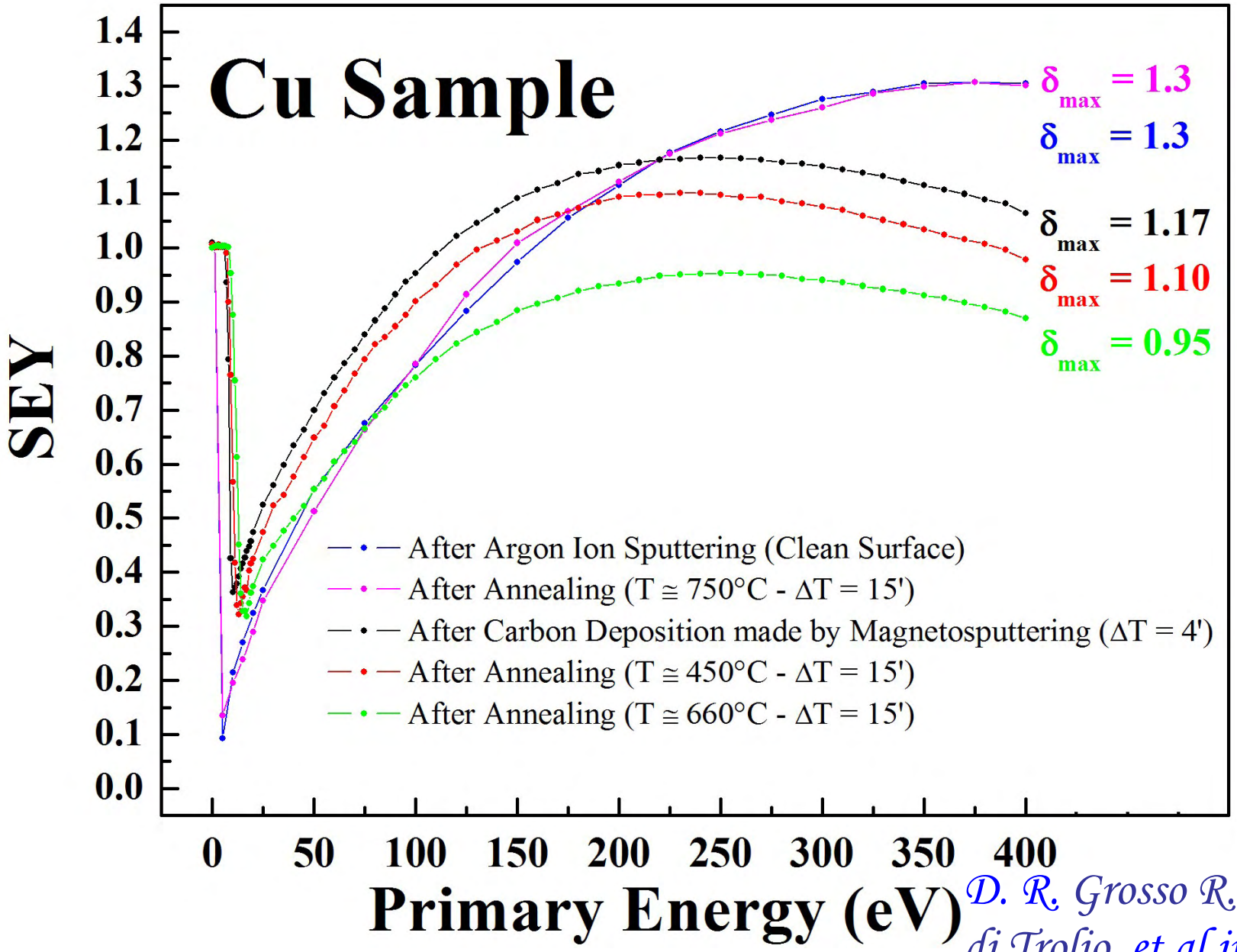
Is there an alternative way to graphitize samples in order to have low SEY surfaces? Can we deposit stable carbon or graphite coatings ?



CERN uses magneto-sputtering technique to grow a thick (0.2-10 μm) of a-C film on accelerator wall surfices.

Results are promising and under study in terms of stability versus time, adhesion etc.

Our line of work is concentrated on creating very thin (some layers) "graphene" - like coatings on metal substrates to be used in accelerator to mimic what is actually happening during scrubbing.



D. R. Grosso R. Larciprete, A. di Trolio et al in preparation

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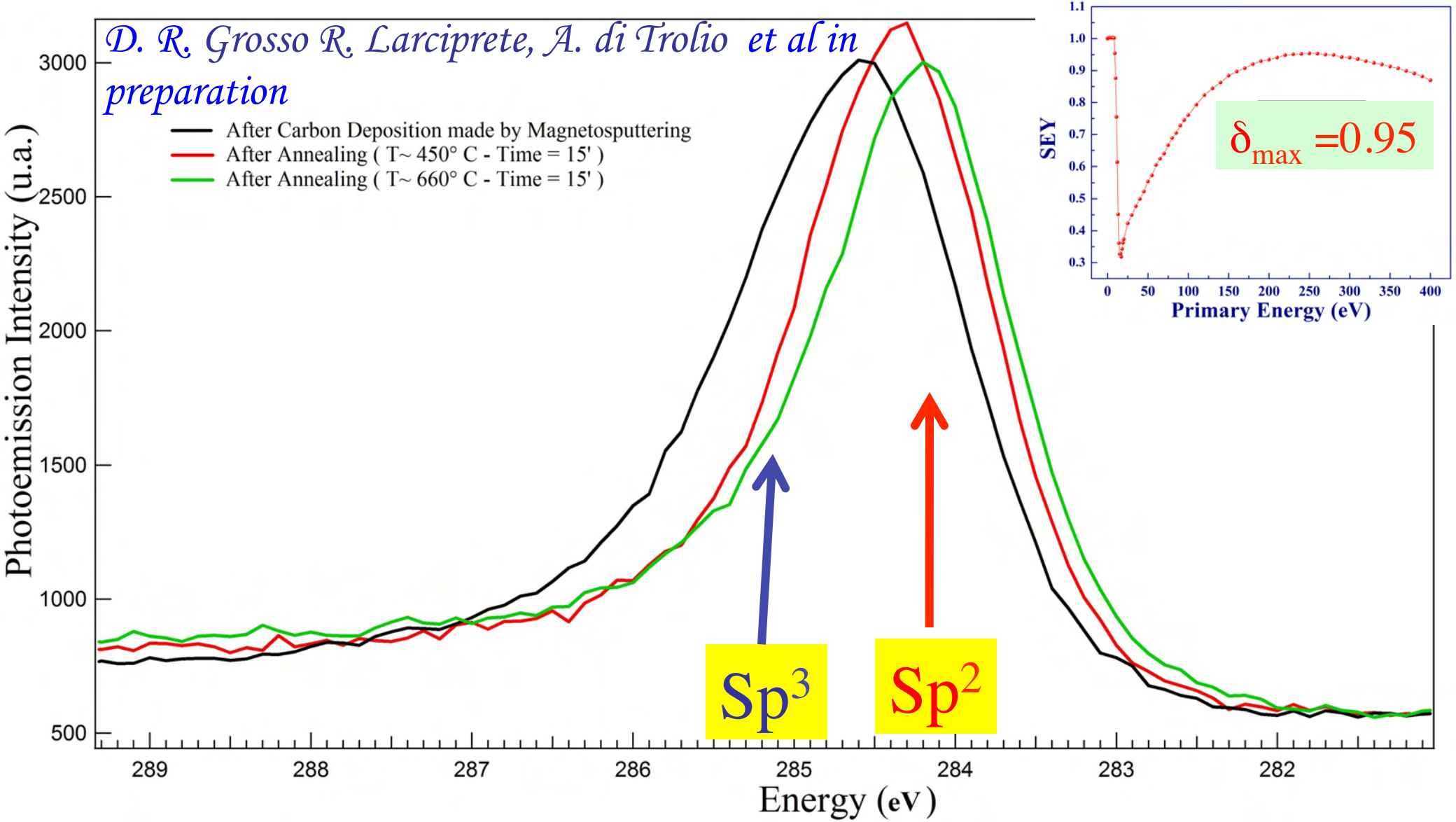

It confirms that the best Graphene/Graphite layer we grow the lowest the SEY is !

Not only we start to understand what is actually happening during SEY reduction, but also using it to develop conceptually new material and coatings.

Results are promising and suggest that this could be the right research direction!

Other accurate studies are necessary to optimize growth parameters, to test the performance of material in terms of stability vs time, adhesion, cost effectiveness etc..
We need to be able to produce these material in large scale for accelerators…… A lot of work!!!

Acknowledgments:

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ECLOUD'12

La Biodola, Isola d'Elba, Italy

http://www.hotelhermitage.it/

from 5 to 8 June 2012

topics: SEY models, e-cloud build & e-cloud effects in accelerators & space applications, beam induced multipactoring, surface properties, mitigation measures, microwave diagnostics, … electron clouds at LHC, FAIR, SuperB, KEKB, SuperKEKB, SPS, PS, ILC, CLIC, CesrTA, FNAL, RHIC, ESA satellites, …

more information at:

http://www.lnf.infn.it/conference/ecloud12/

contacts: Roberto Cimino, Frank Zimmermann

in memory of Francesco Ruggiero