BEAM SCREEN SURFACE CHARACTERISATION FOR HIGH ENERGY BEAMS: TEST RESULTS AT FRASCATI.

R. Cimino, M. Angelucci, L. Spallino, E. La Francesca[1], A. Liedl and R. Larciprete[2]

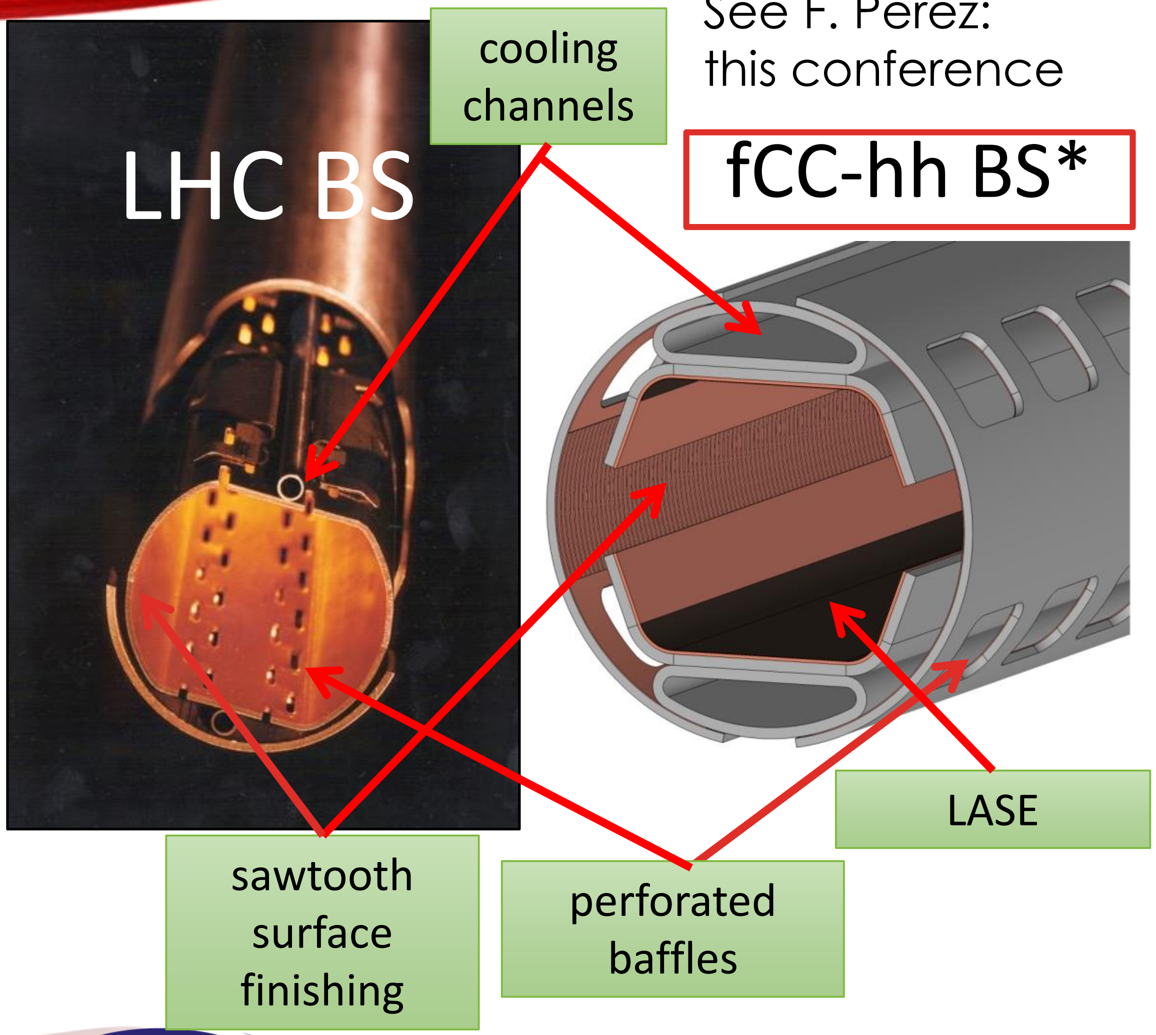
LNF-INFN Frascati (Rome) , Italy.

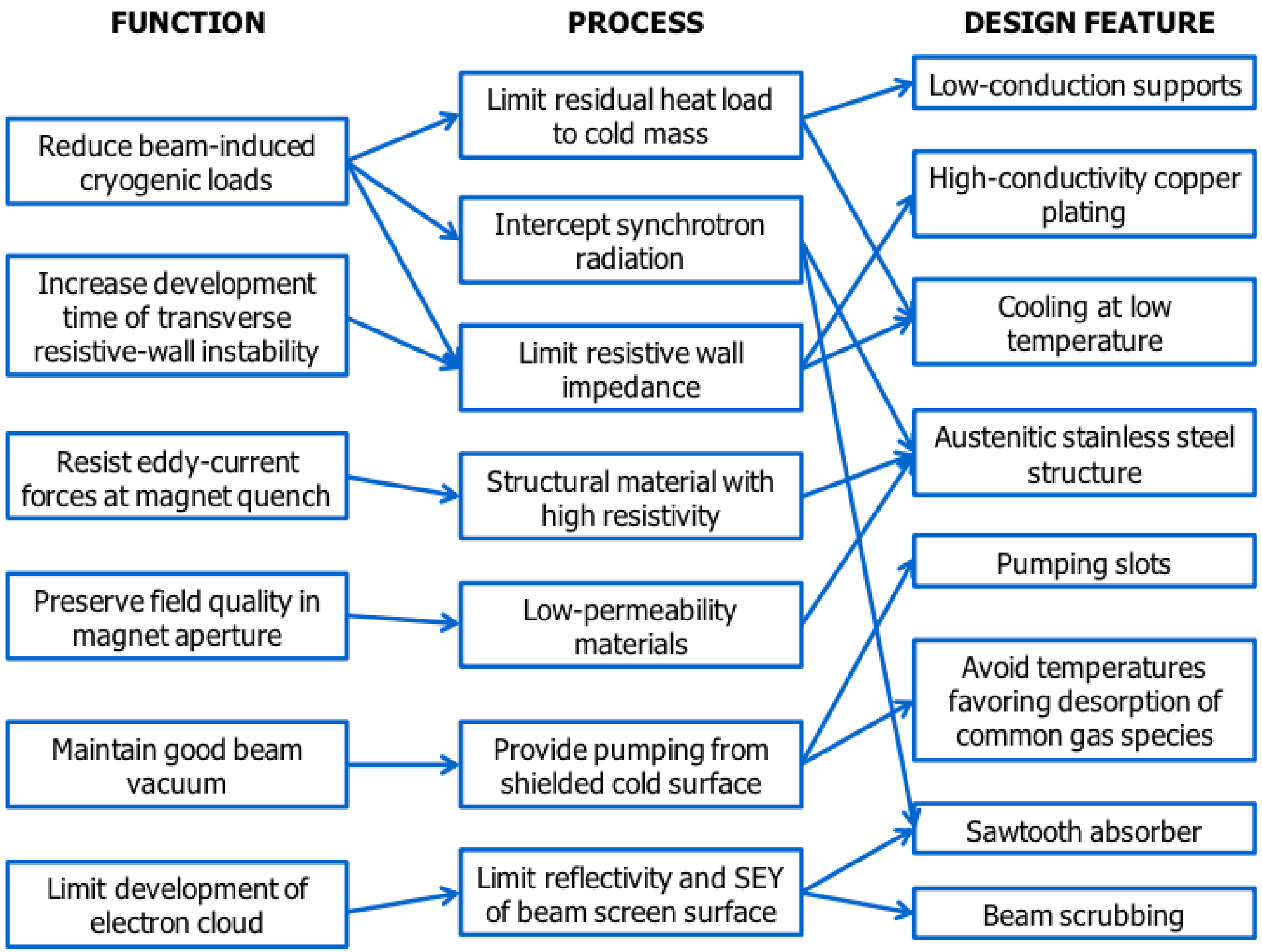
1) Also at: University of Rome “La Sapienza” – Rome, Italy

2) Also at: CNR-ISC, Rome, Italy

BEAM SCREEN

See F. Perez: this conference

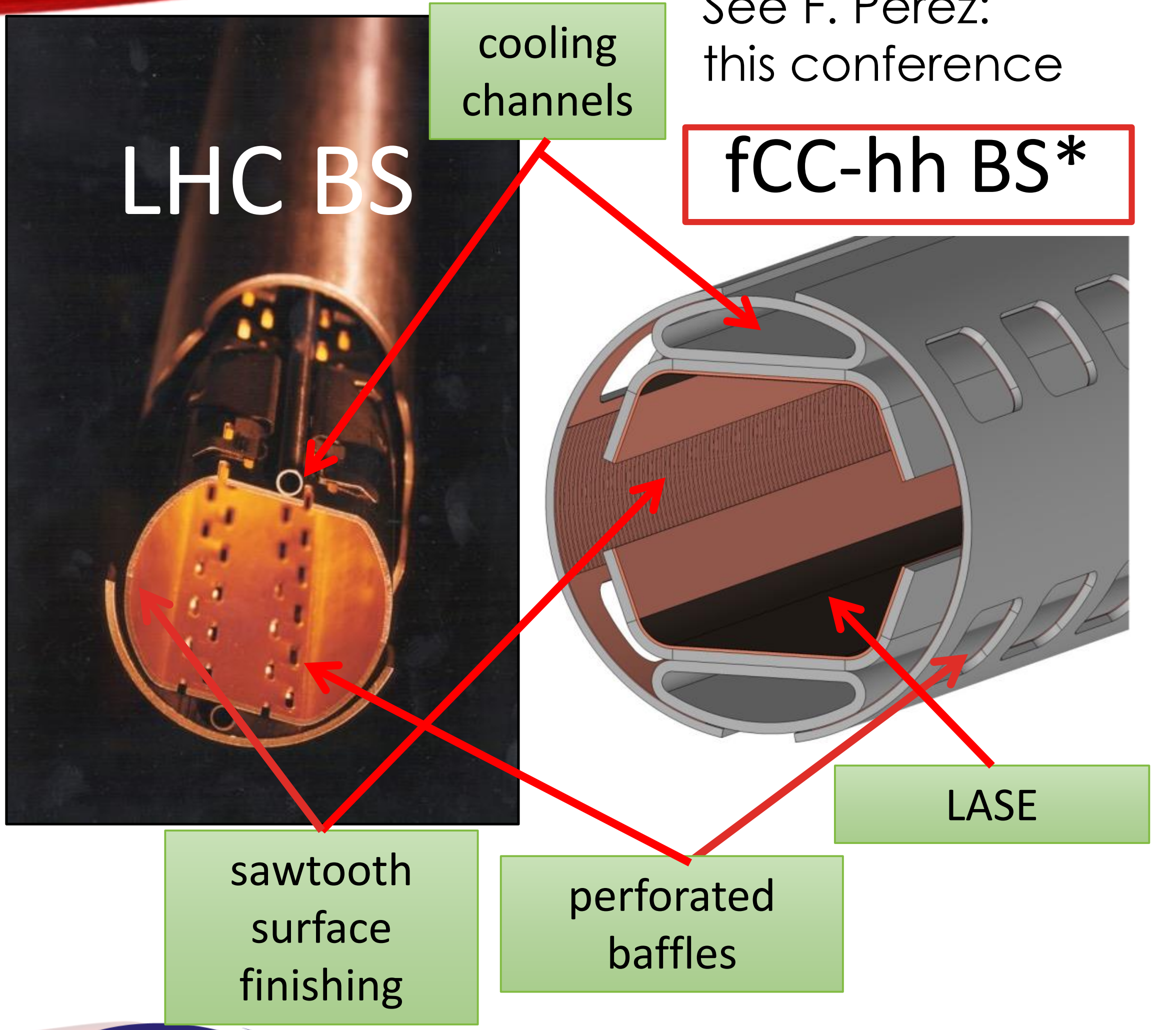


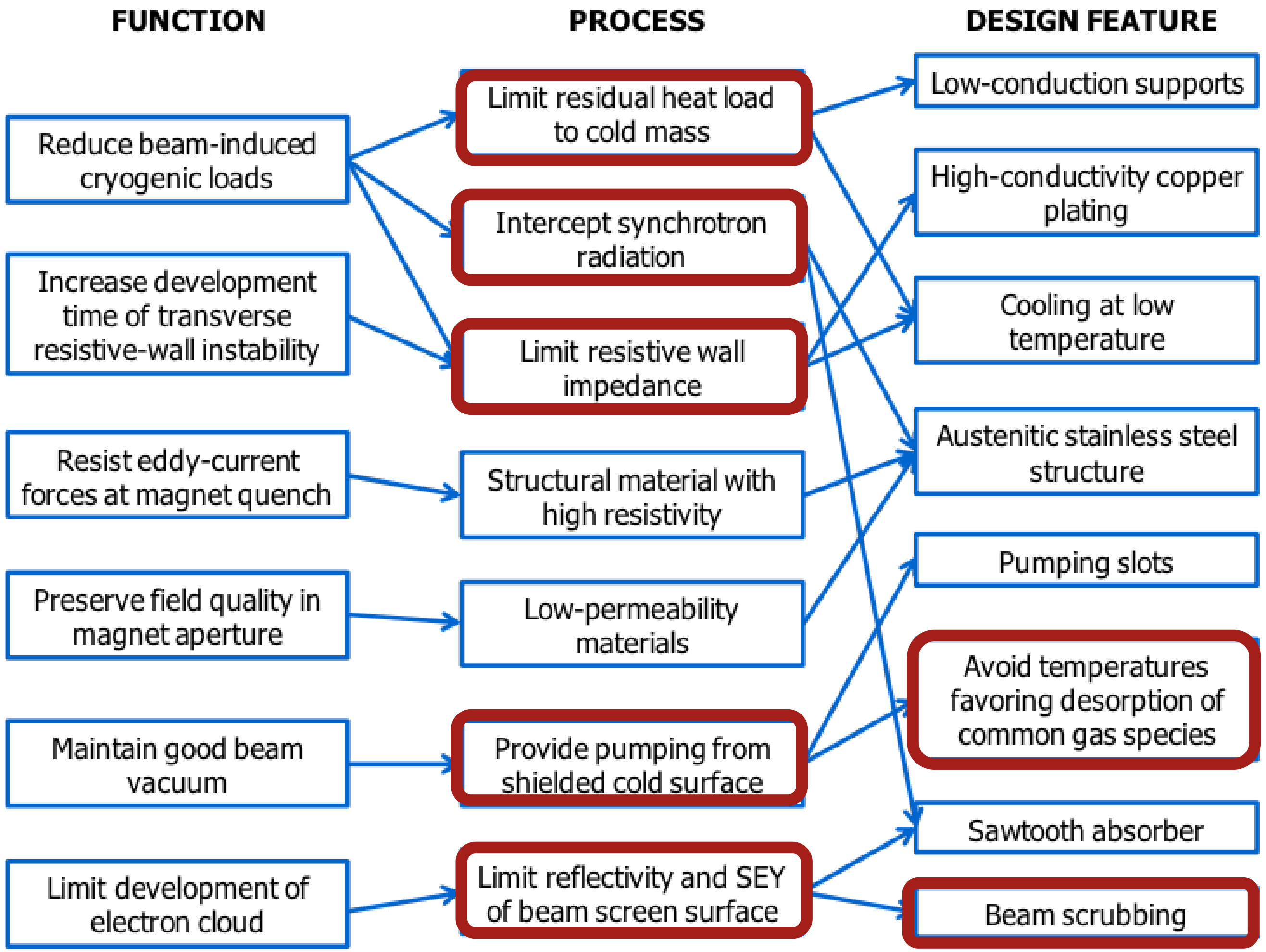


From: "Cryogenic Beam Screens for High-Energy Particle Accelerators"
By: V. Baglin et al CERN-ATS-2013-006 -

BEAM SCREEN SURFACE

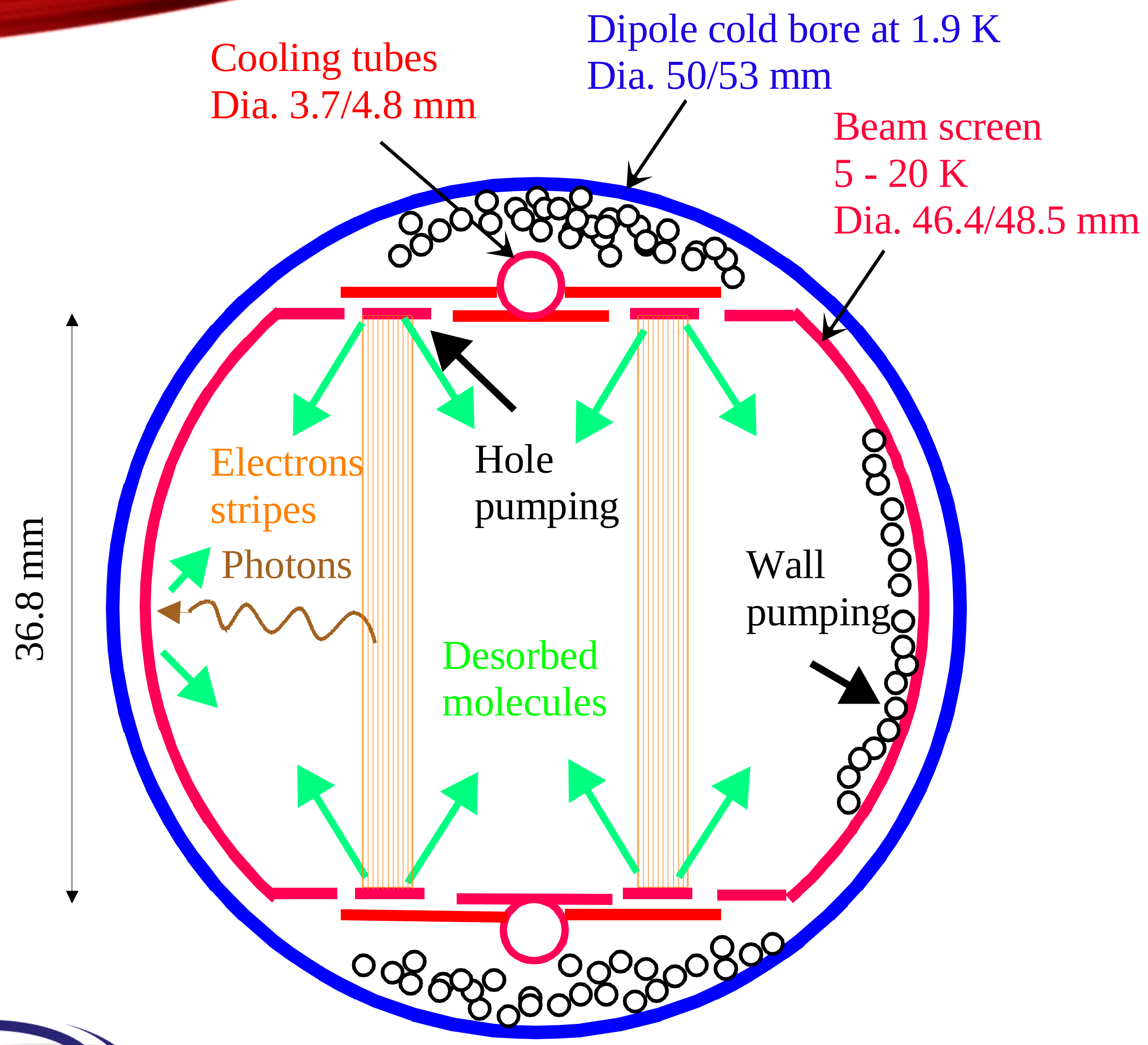
See F. Perez:
this conference





From: "Cryogenic Beam Screens for High-Energy Particle Accelerators"
By: V. Baglin et al CERN-ATS-2013-006 -

BEAM SCREEN INTERACT WITH:



- Residual Gas
- Photons
- Electrons
- (Ions)

BEAM SCREEN /RESIDUAL GAS

Working Pressure $<10^{-11}$ ⟷ BS Temperature Range

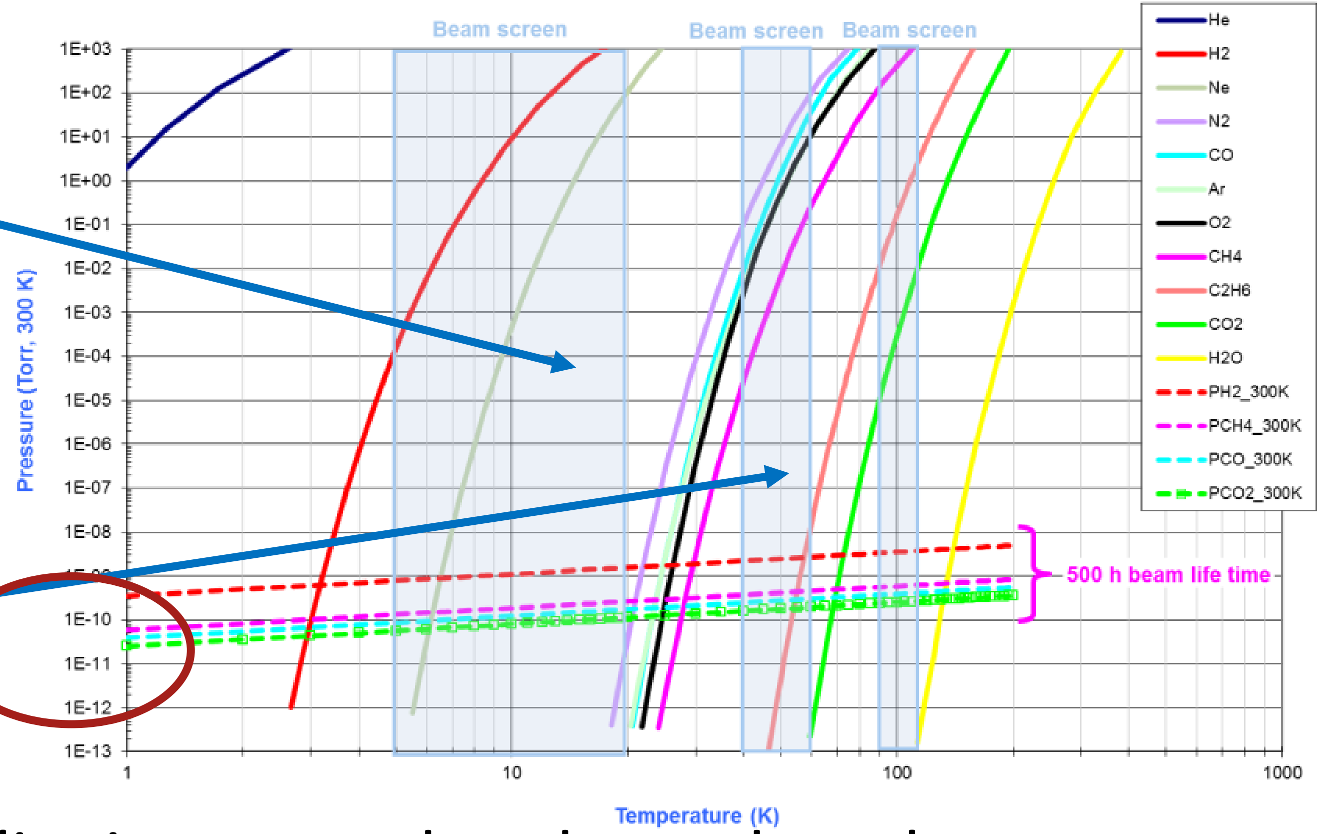
Saturated vapour pressure from Honig and Hook (1960) (C2H6 Thibault *et al.*)

LHC

SR Power = 0.13 W/m

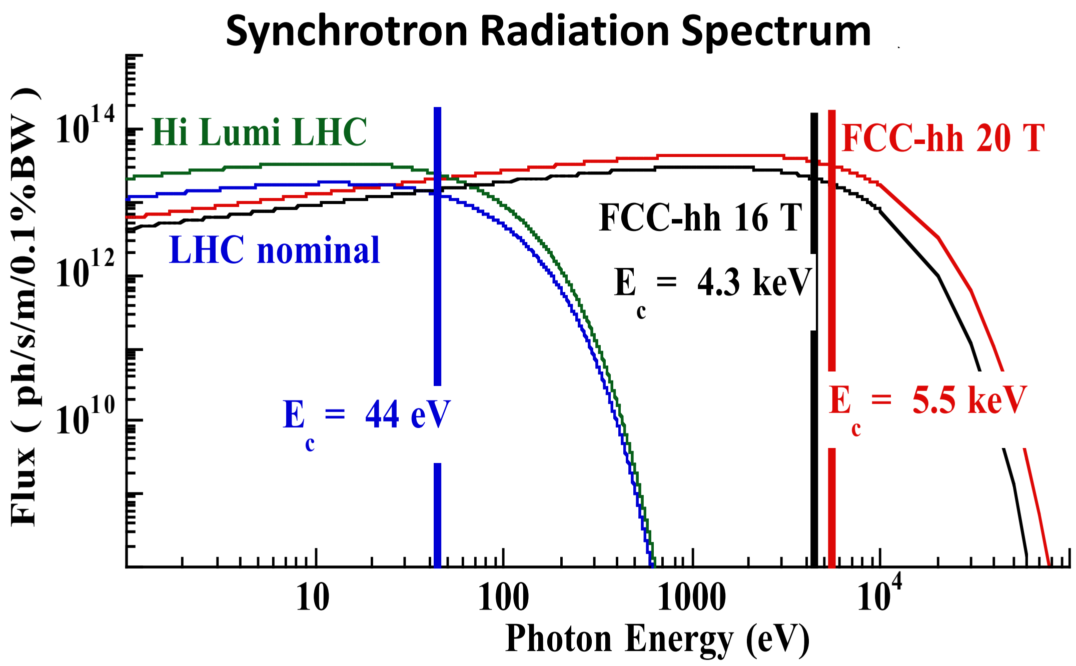
FCC

SR Power = 40 W/m



Vacuum stability is assumed to depend on the nature of adsorbed gas not on substrate type.

BEAM SCREEN / PHOTONS



Version 1.0 (2014-02-11)	LHC	HL-LHC	FHC-hh
SR power per ring [MW]	0.0036	0.0073	2.4 (2.9)
Arc SR heat load [W/m/aperture]	0.17	0.33	28.4 (44.3)
Critical photon energy [keV]	0.044		4.3 (5.5)

Photons induce:

- Heat load
- Photo electrons and related instabilities
- Photo induced desorption

To be studied (vs. time):

- Reflectivity (where photons interact with BS)
- Photo Yield (Number of photo-el produced)
- Photo induced desorption

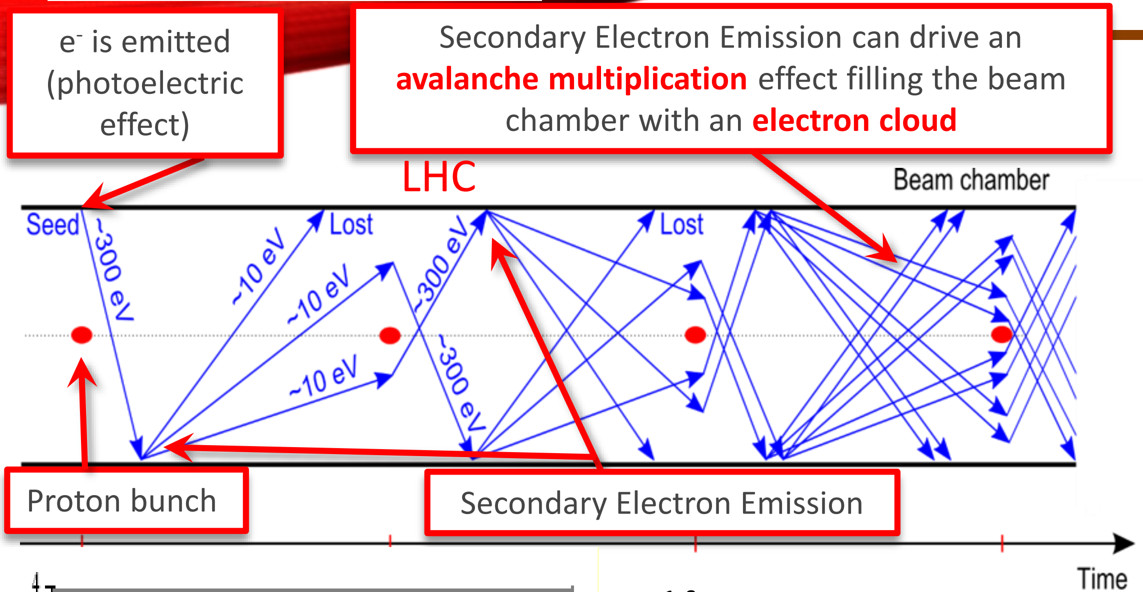
Essential features:

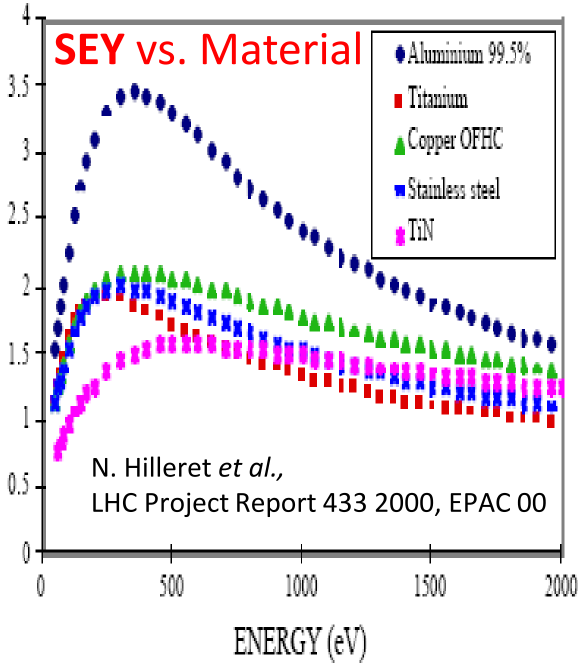
- Photon energy
- Very grazing geometry (@LHC: 0.28° ; @ FCC-hh 0.08°)

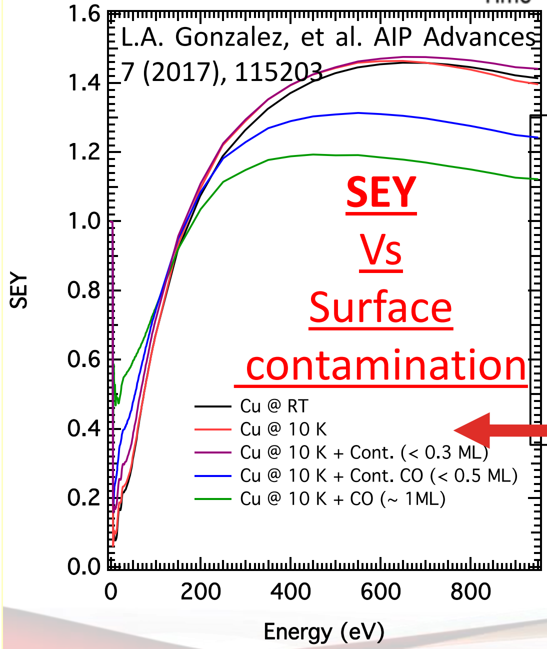
Of moderate/partial importance:

- Representative surfaces (unbaked, untreated, at operating temperature, etc.)

BEAM SCREEN / ELECTRONS







Electrons induce:

- Heat load
- Secondary electrons and related instabilities (e⁻cloud)
- Photo induced desorption

To be studied (Vs. time):

- SEY
- Electron induced desorption
- Surface chemistry

R. Cimino and T. Demma "Electron cloud in Accelerators" Int. J. Mod. Phys. A 29 (2014) 1430023

Essential features:

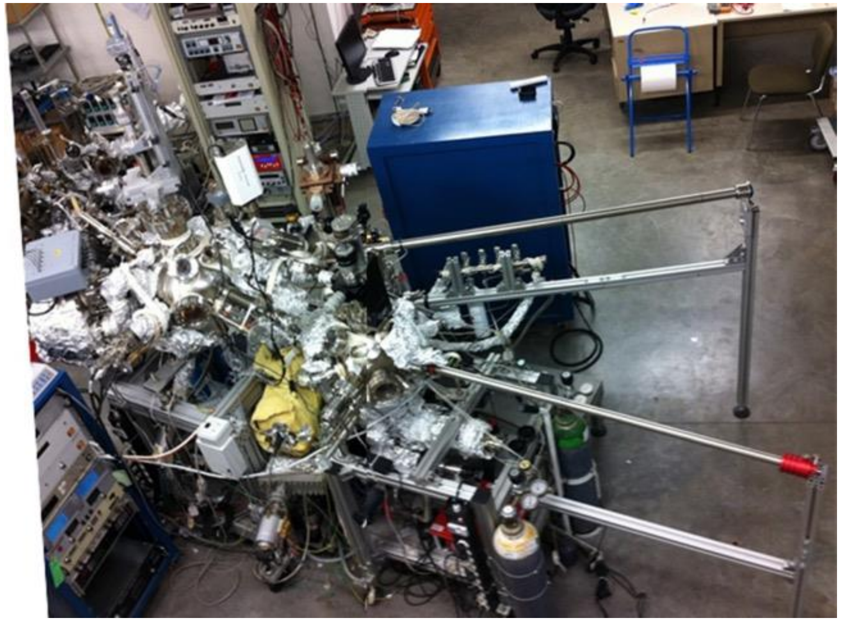
- (primary and secondary) Electron energy variation
- Representative surfaces (unbaked, untreated, at operating temperature (Low T), etc.

Of moderate/partial importance:

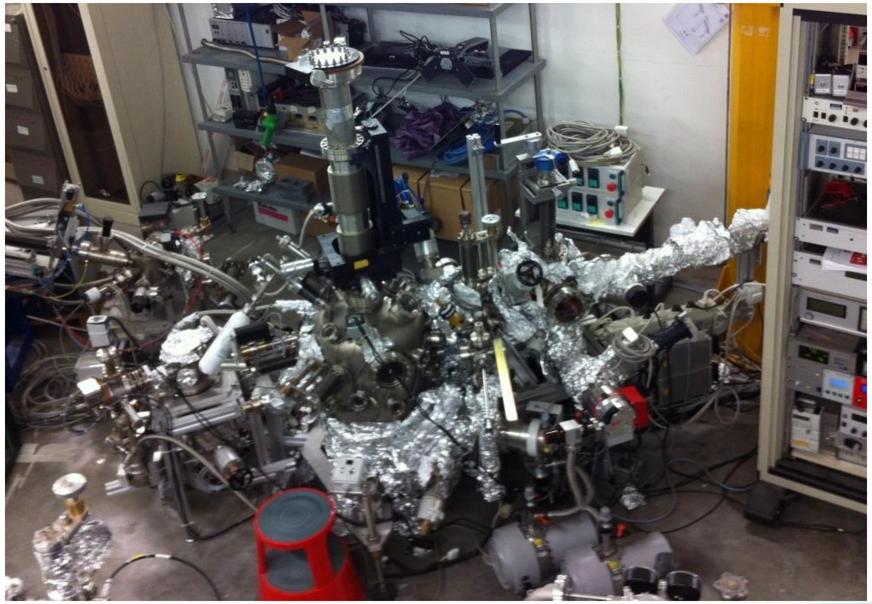
- Close to Normal incidence geometry

STRATEGY AT LNF

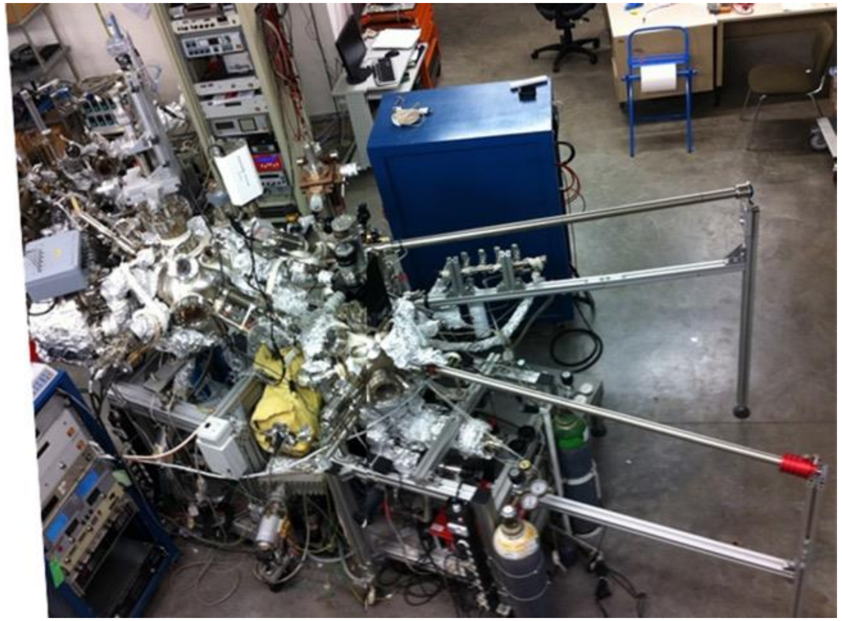
two Ultra high vacuum systems



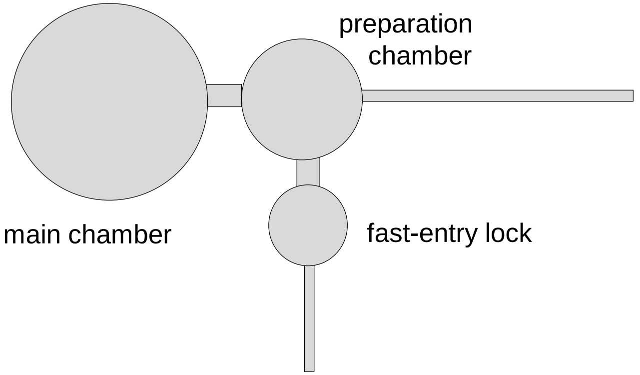
MiCA

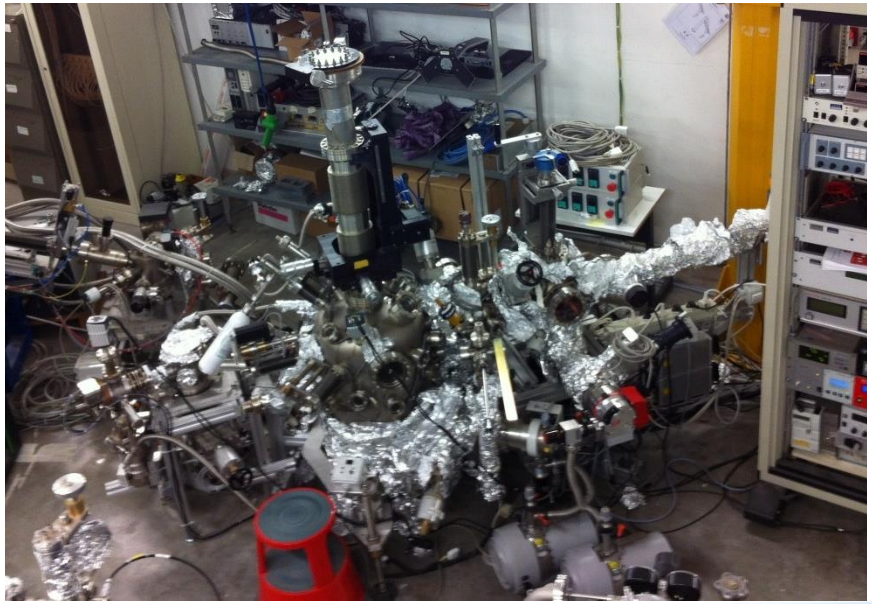


STRATEGY AT LNF



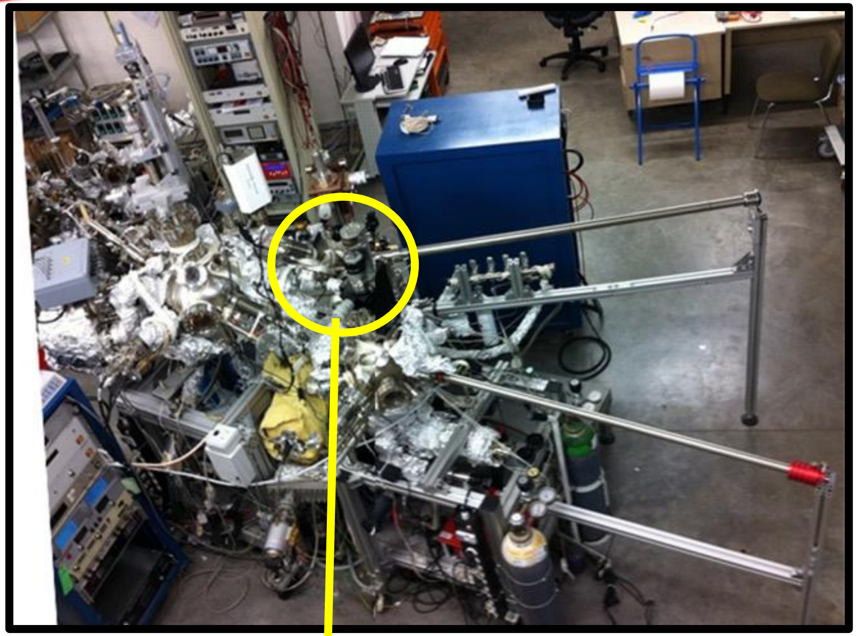
two Ultra high vacuum systems



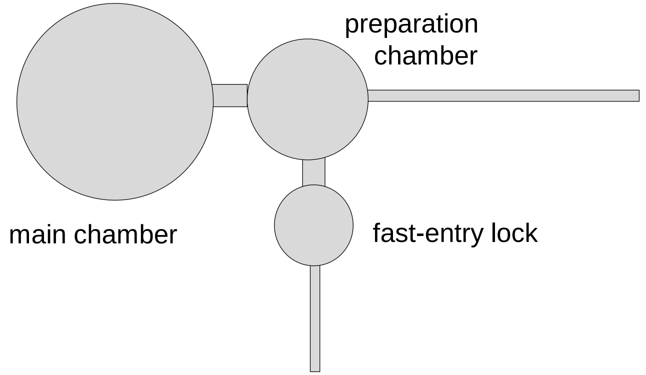


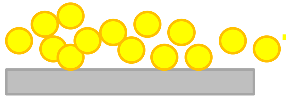
- We are able to insert as received samples (**no bake-out** or anything) from atmosphere to UHV ($<10^{-10}$ mbar)

STRATEGY AT LNF



two Ultra high vacuum systems

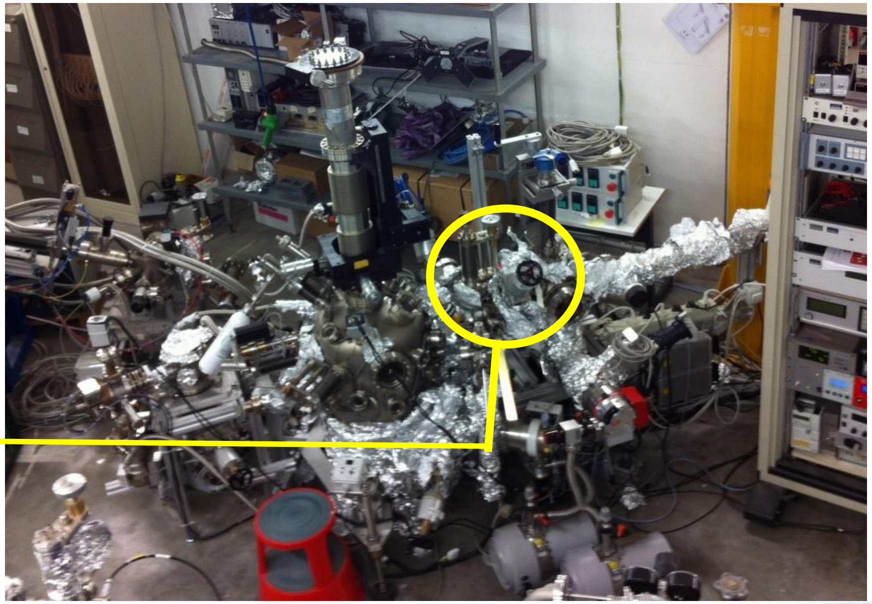




“Ad hoc” surface preparation:

- Sputtering
- Heating
- Controlled deposition

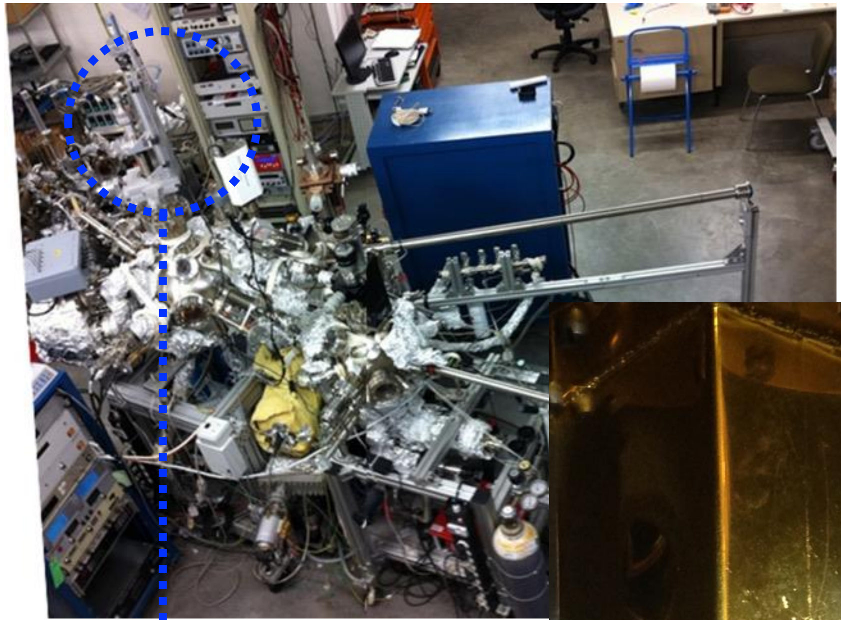
“in situ” coating

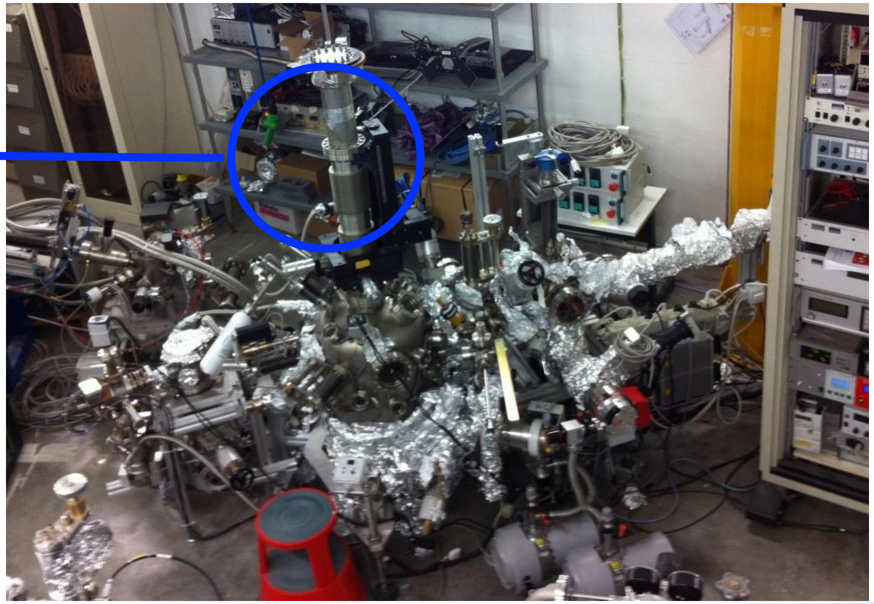


STRATEGY AT LNF

two Ultra high vacuum systems

- LNF-cryogenic manipulator
- sample at 15-300 K
- Gas dosing on cold surfaces



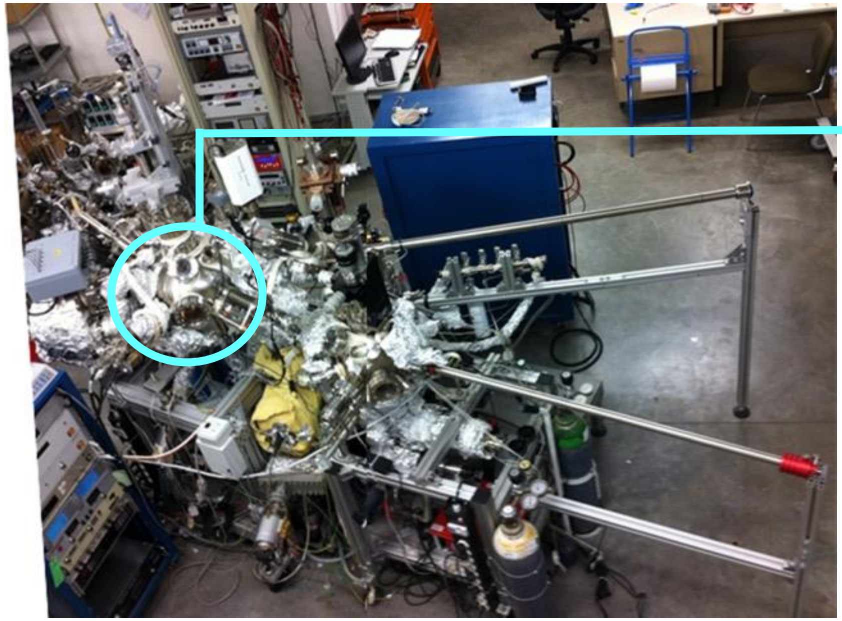


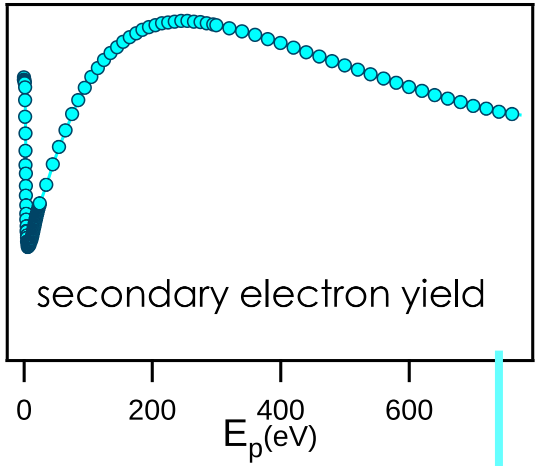
IN CONSTRUCTION

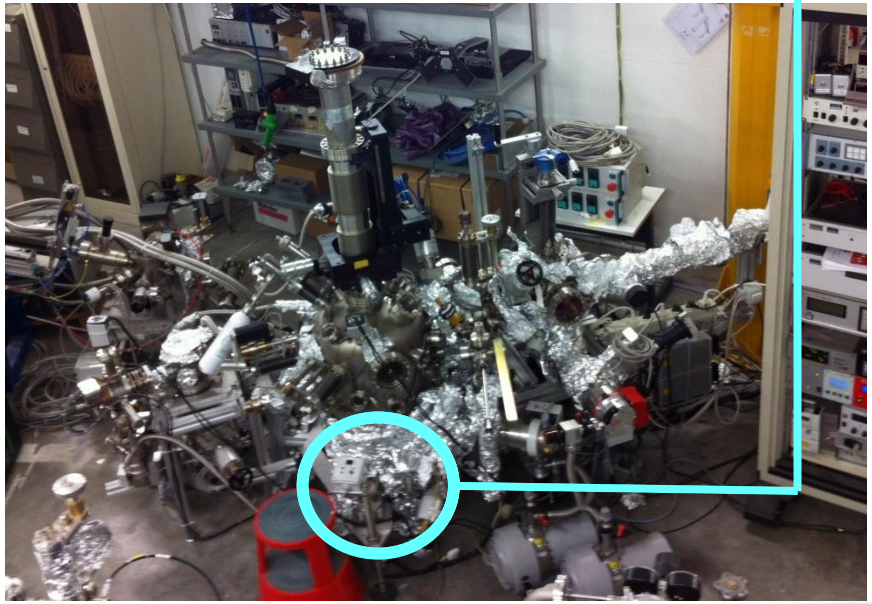
MiCA

STRATEGY AT LNF

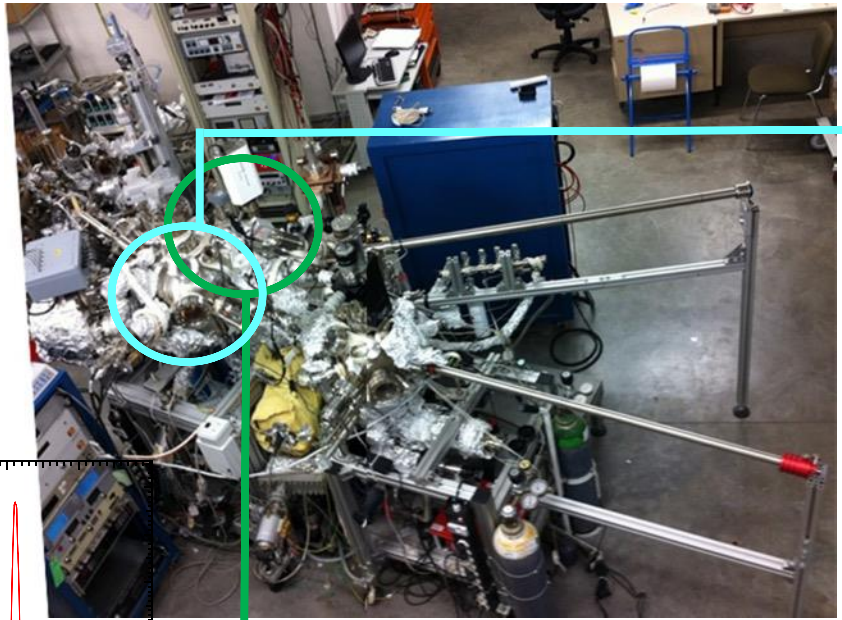
Equipment :
Electron gun, Faraday cup



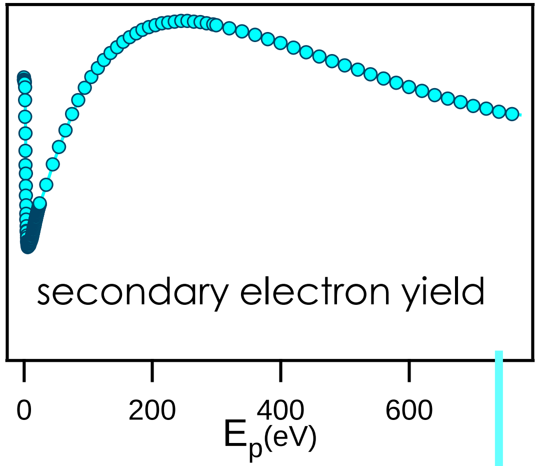


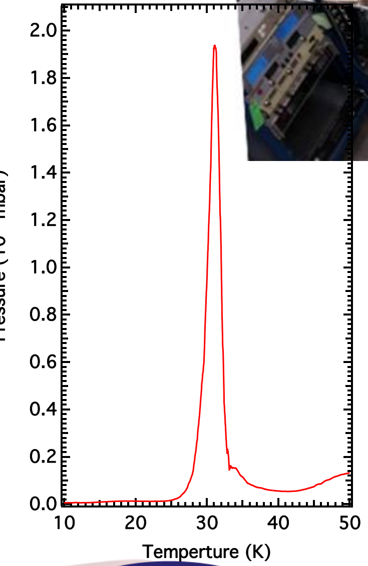


STRATEGY AT LNF



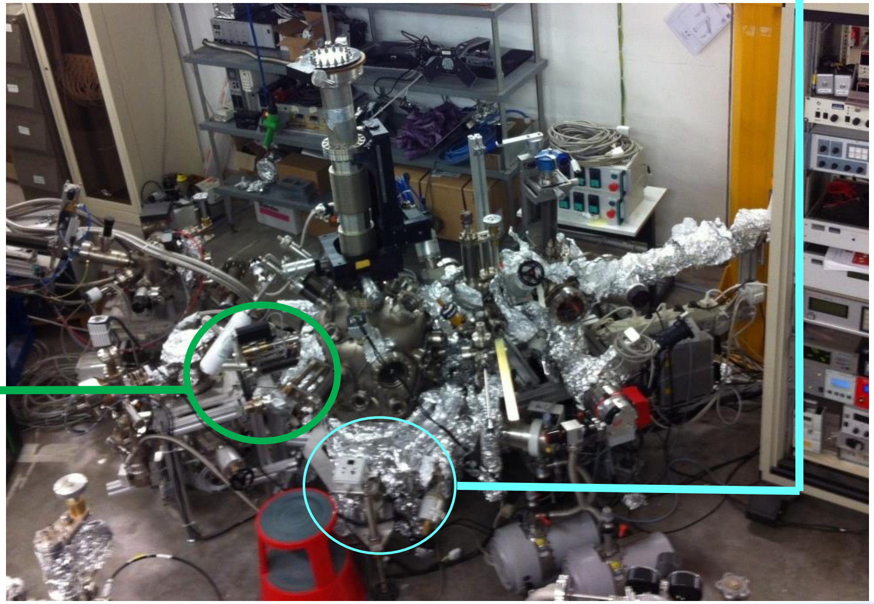
Equipment :
Electron gun, Faraday cup



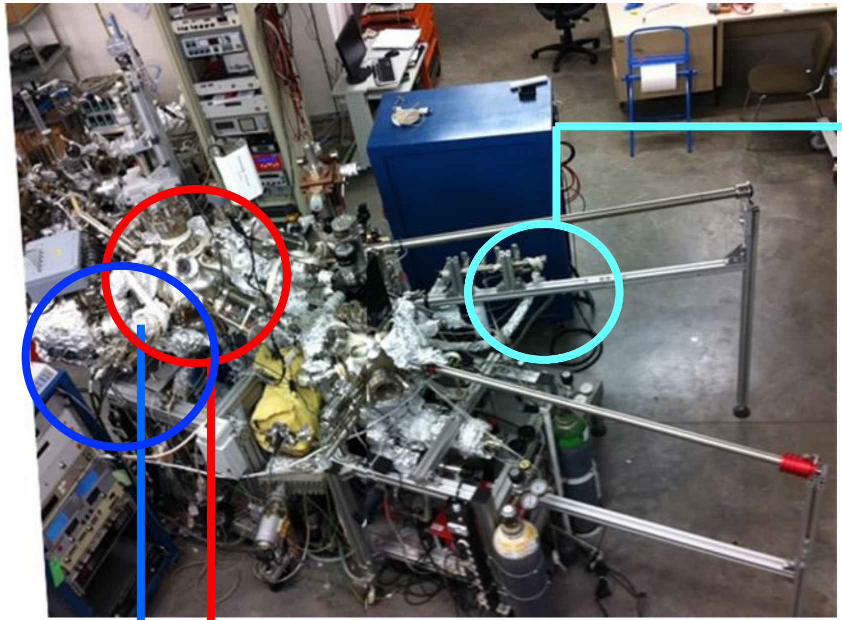


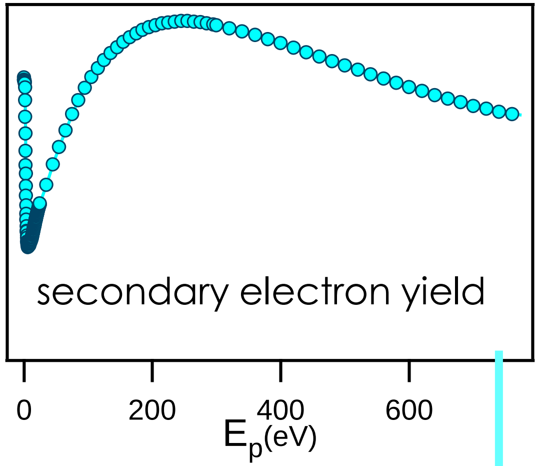
Measure Temperature Programmed Desorption with Mass Spectrometer

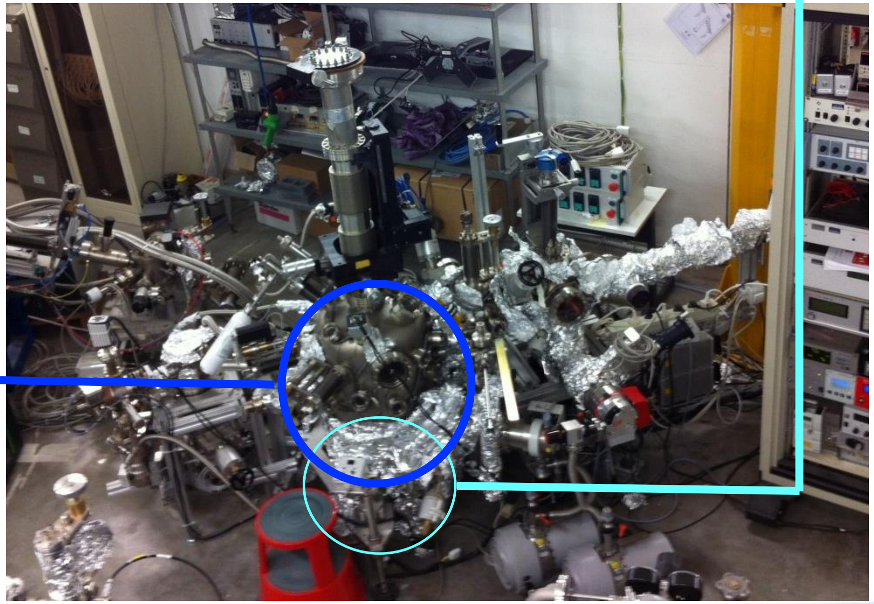
Equipment : QMS
Hiden HAL 101 Pic

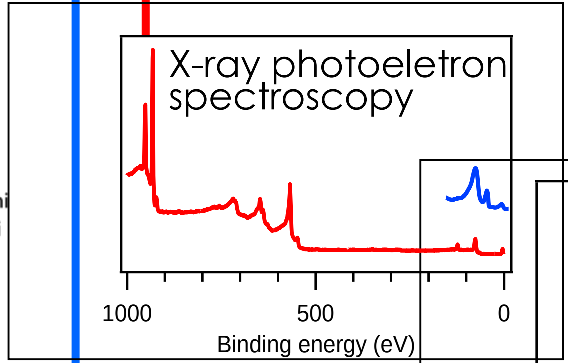


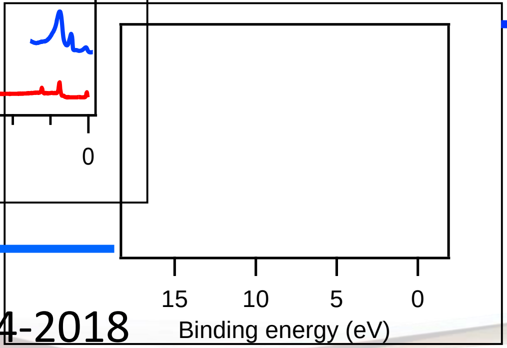
STRATEGY AT LNF







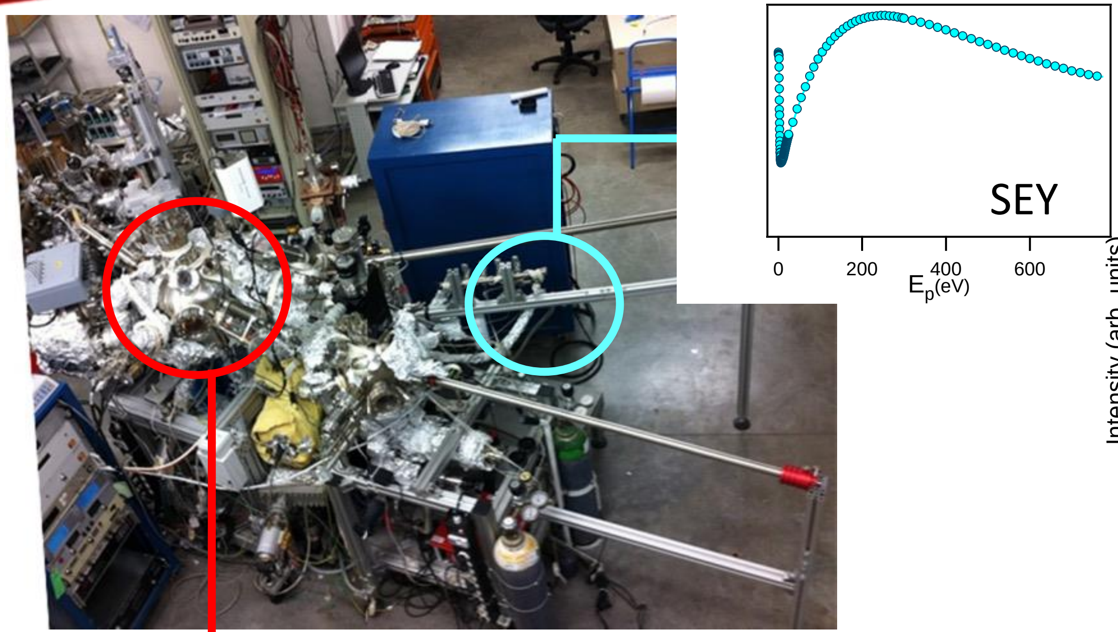




Collaboration with

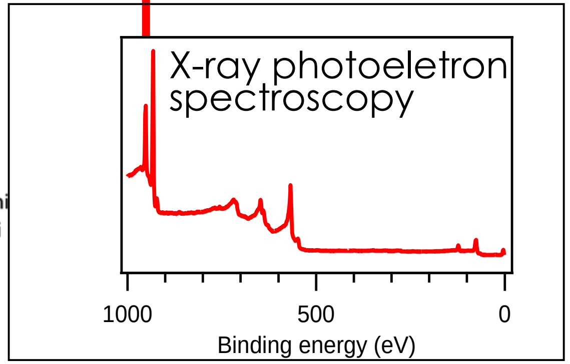
istituto dei sistemi complessi

STRATEGY AT LNF



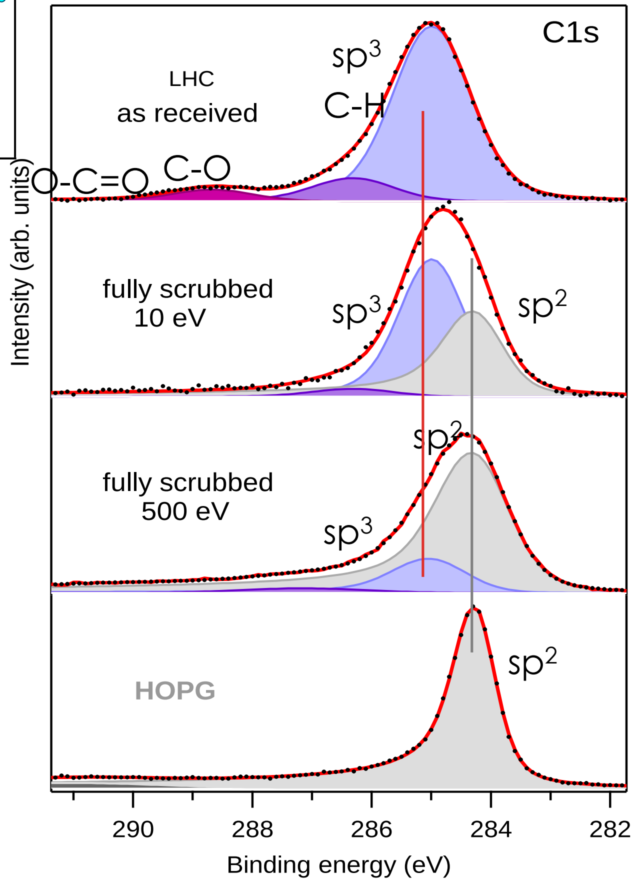
Collaboration with

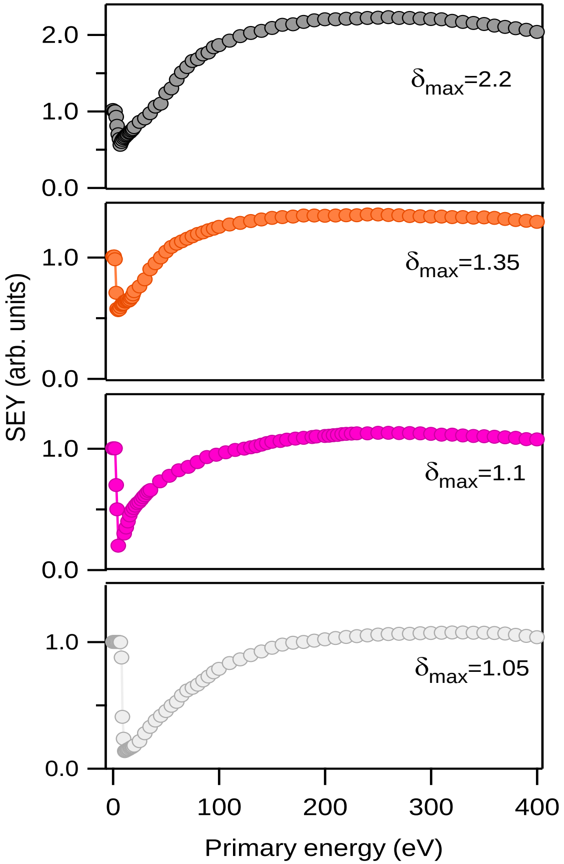
istituto dei sistemi complessi



UV photoeletron spectroscopy

Unveil the nature of " e^- scrubbing" at LHC

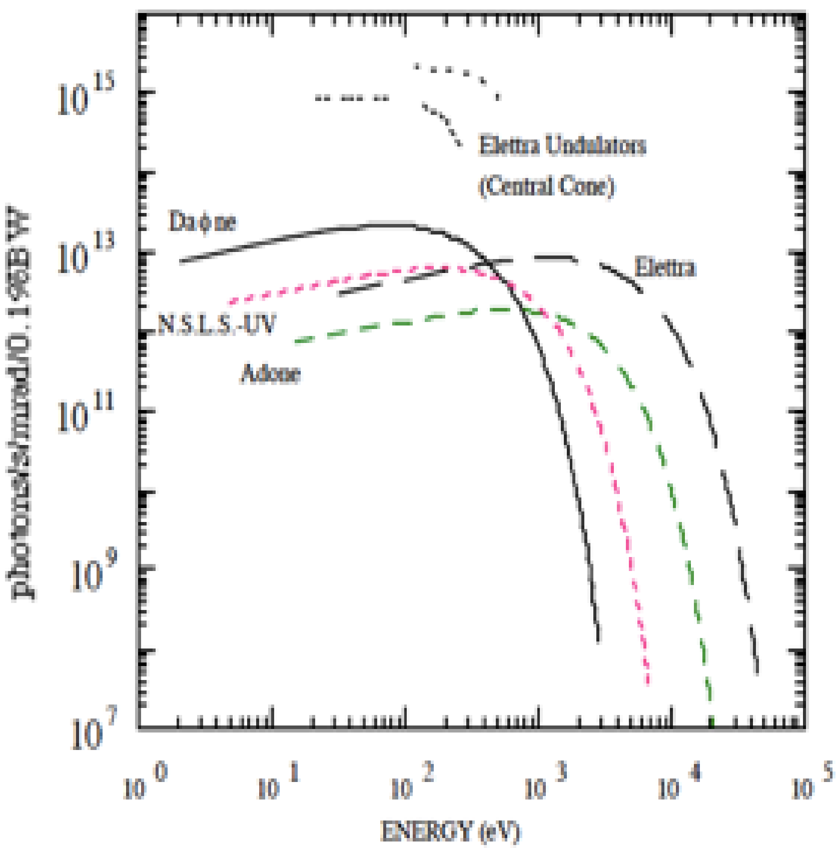




R. Cimino et al. PRL **109 064801 (2012)**

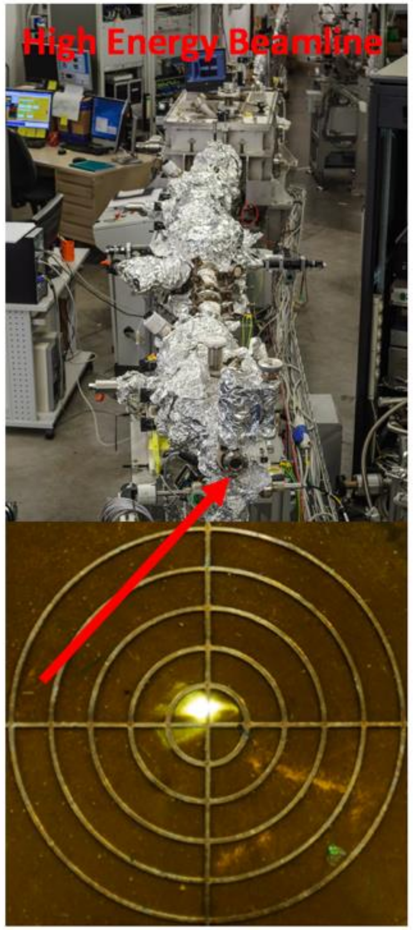
STRATEGY AT LNF

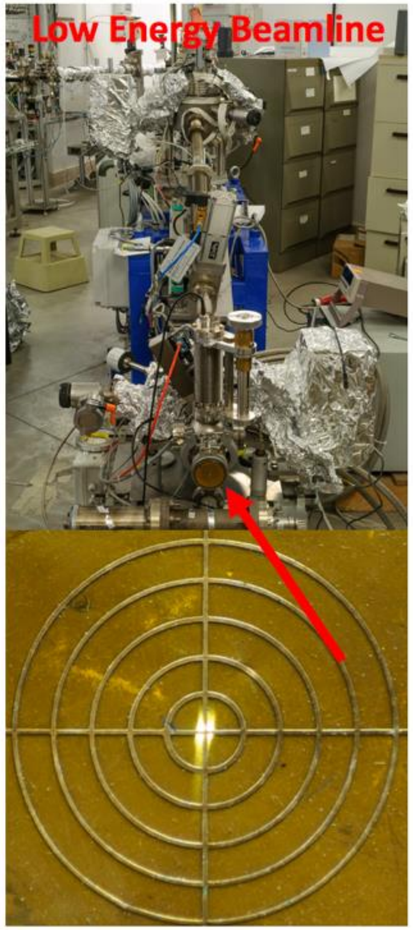
DAΦNE Bending magnet (same as HE-LHC)



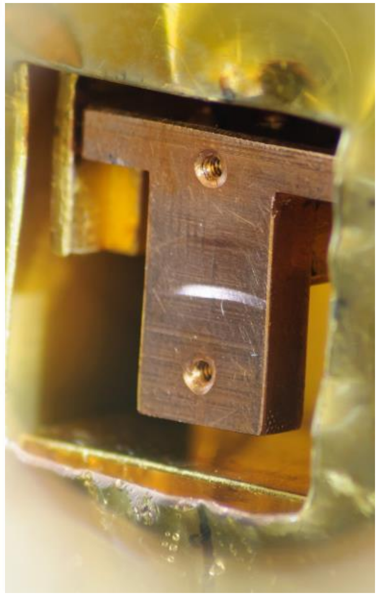
Synchrotron Beam-lines

White light
>50 μA
on sample





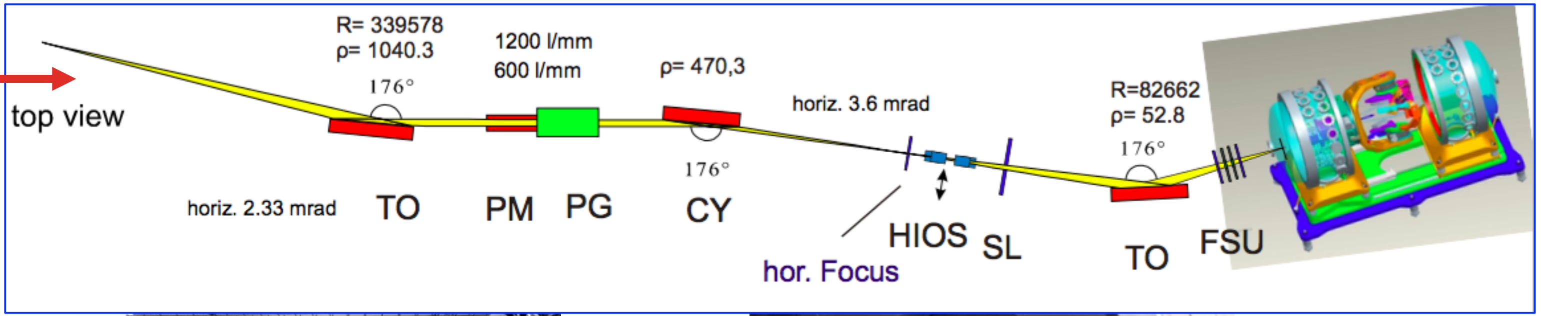
White light
~ 1 μA
on sample
(to be optimized)



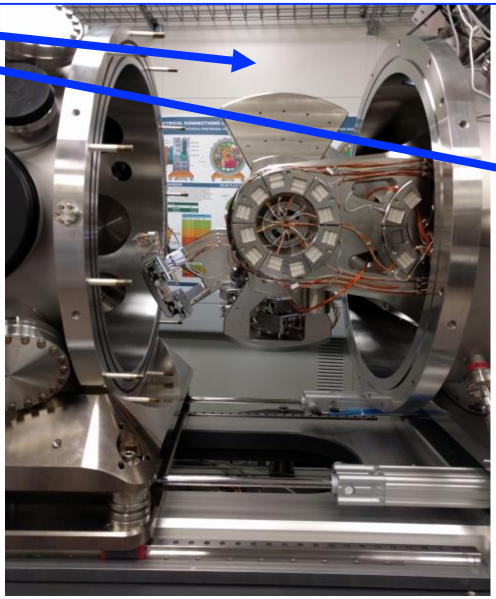
STRATEGY AT LNF

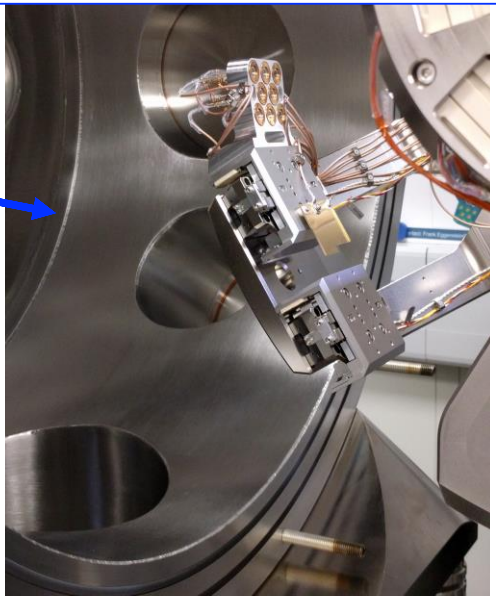
When resources are not available we use external facilities:

BESSY-II optic beamline and reflectometer for grazing incidence study



HZB Helmholtz Zentrum Berlin





Grazing incidence reflectometry and Photon Yield

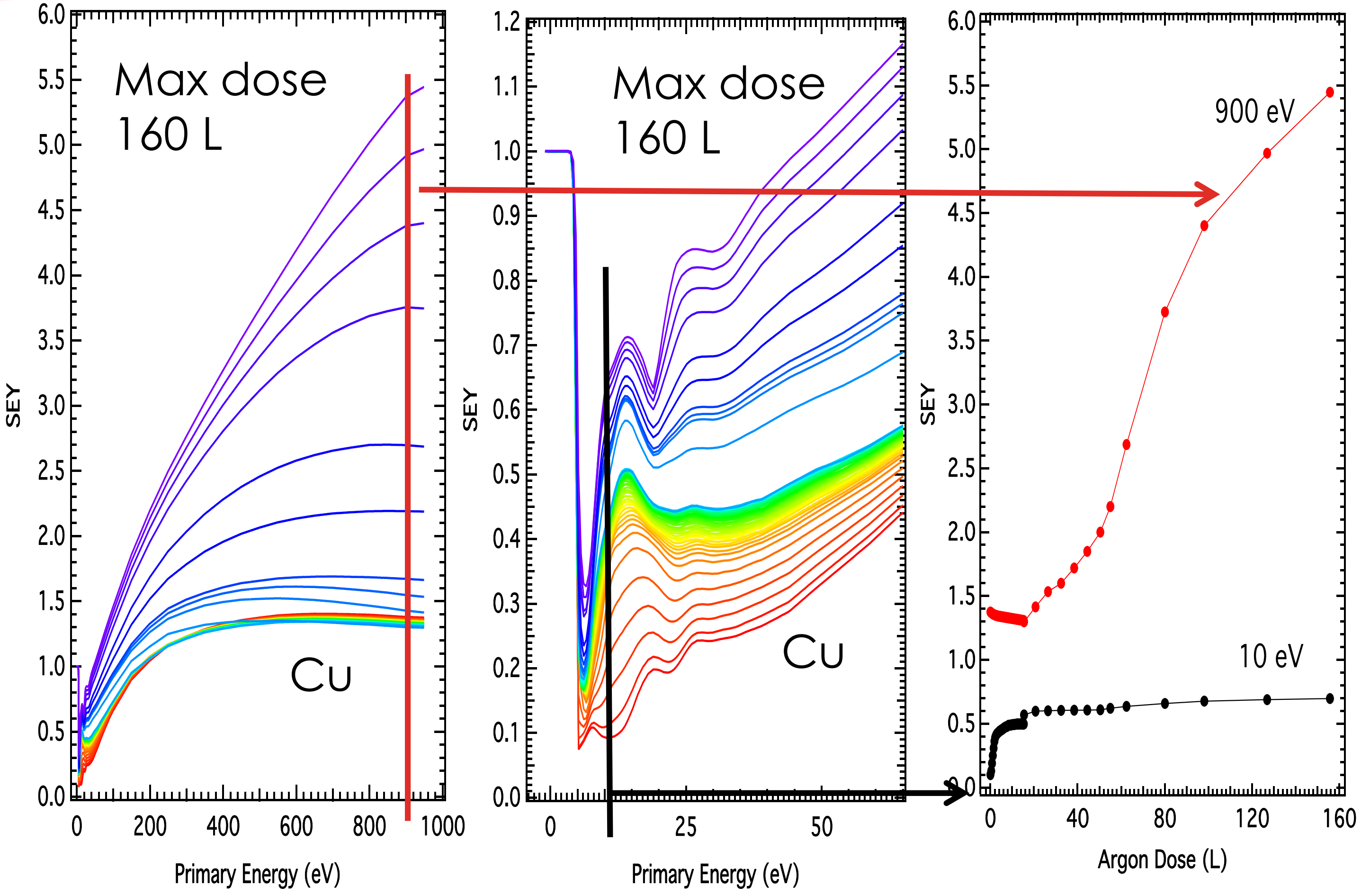
A.A.Sokolov,et al,Proc.of SPIE92060J-1-13(2014)

SELECTED RESULTS:

- SEY (in the entire energy range) at Low temperatures
- Electron induced desorption
- Thermal desorption to test thermal stability
- Photon Reflectivity and Photo Yield at grazing incidence.
- Photo stimulated desorption, photon scrubbing.

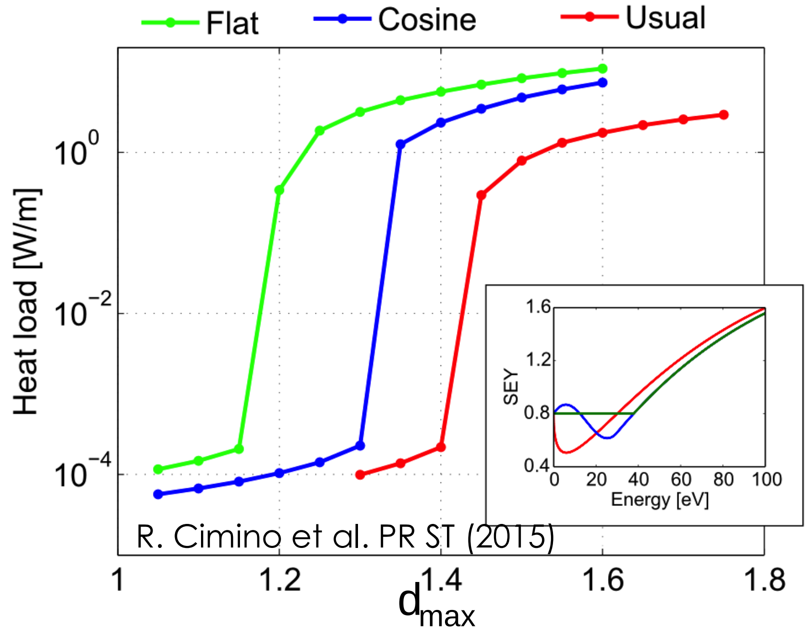
SEY at Low temperatures

Test system: Argon adsorption on Low temperature Clean polycrystalline Cu

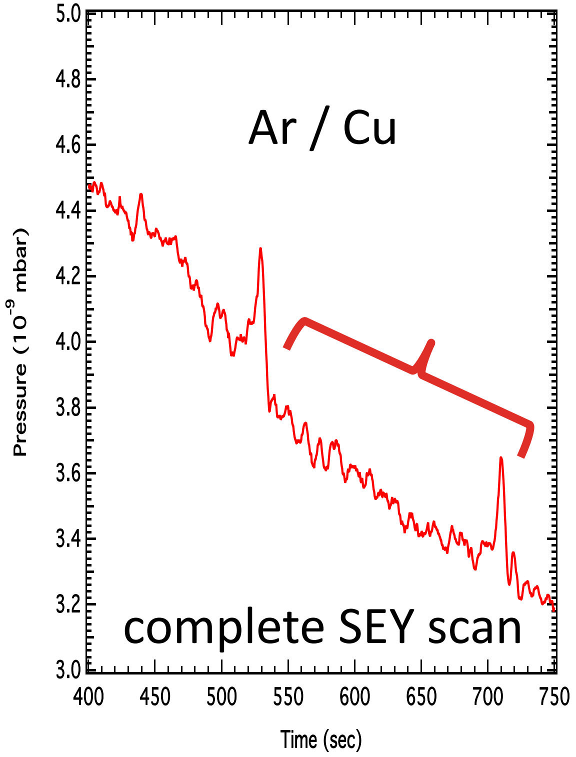


M. Angelucci to be publ.

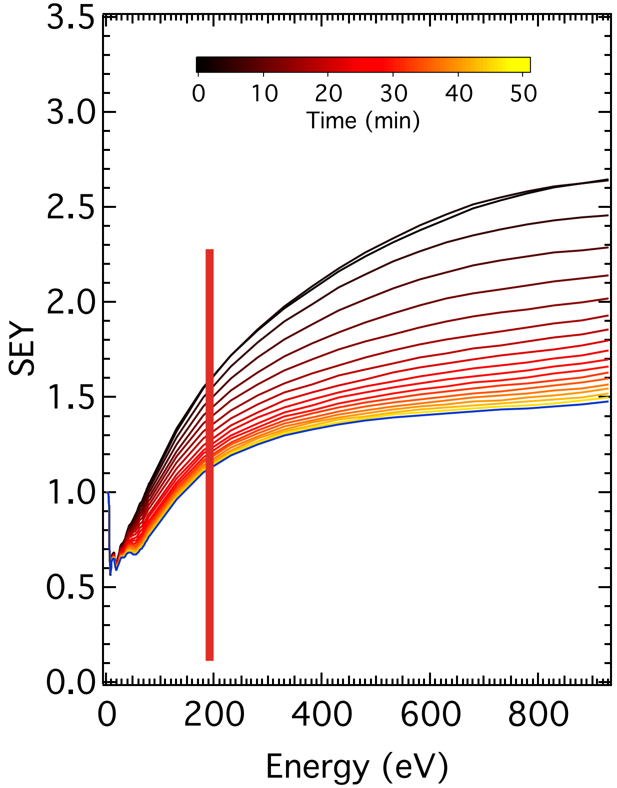
- SEY is ideal to follow gas adsorption
- SEY changes with adsorbed gas
- ➔ contaminants will affect SEY!
- **Low energy SEY changes at very low coverages!**



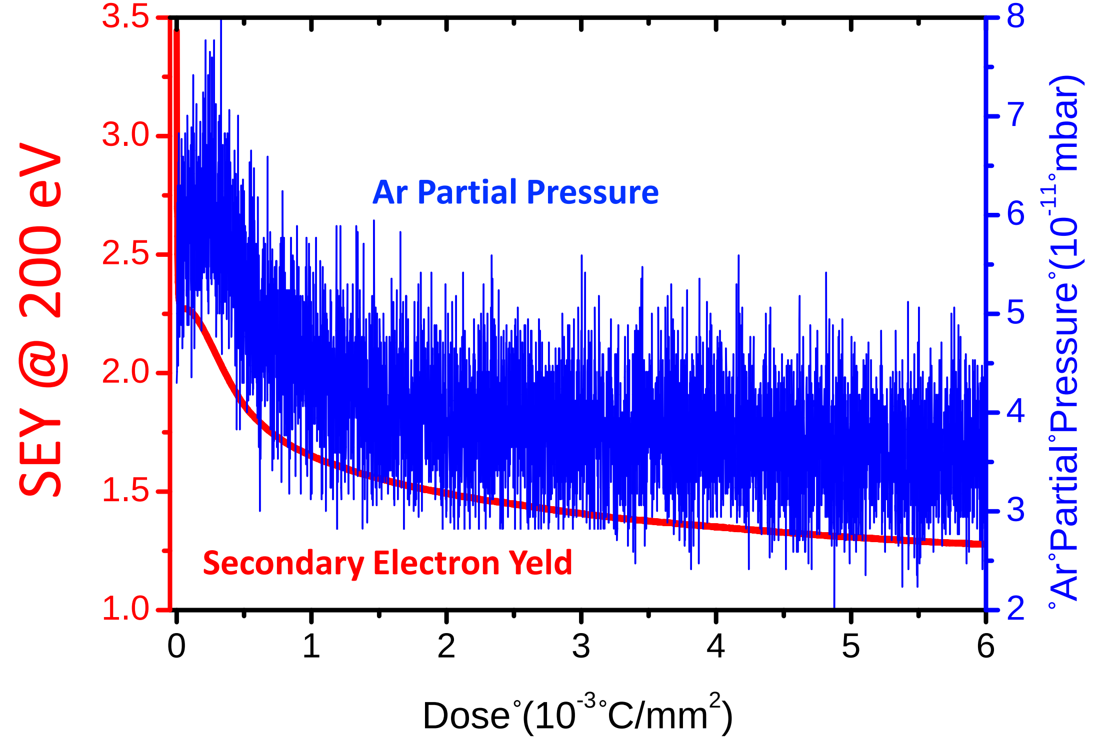
Electron induced desorption



Continuous SEY scans



Continuous irradiation @ 200 eV

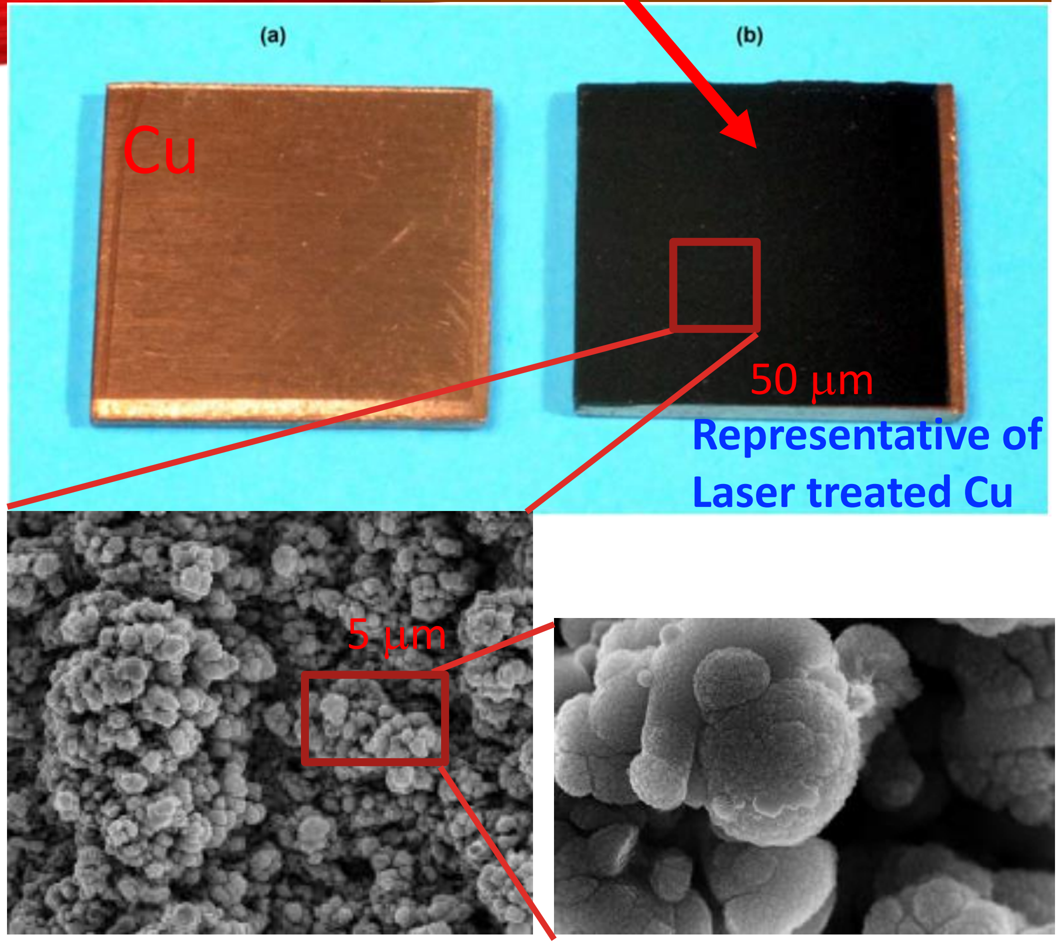


- Study Electron Stimulated Desorption with **Mass spectrometer**

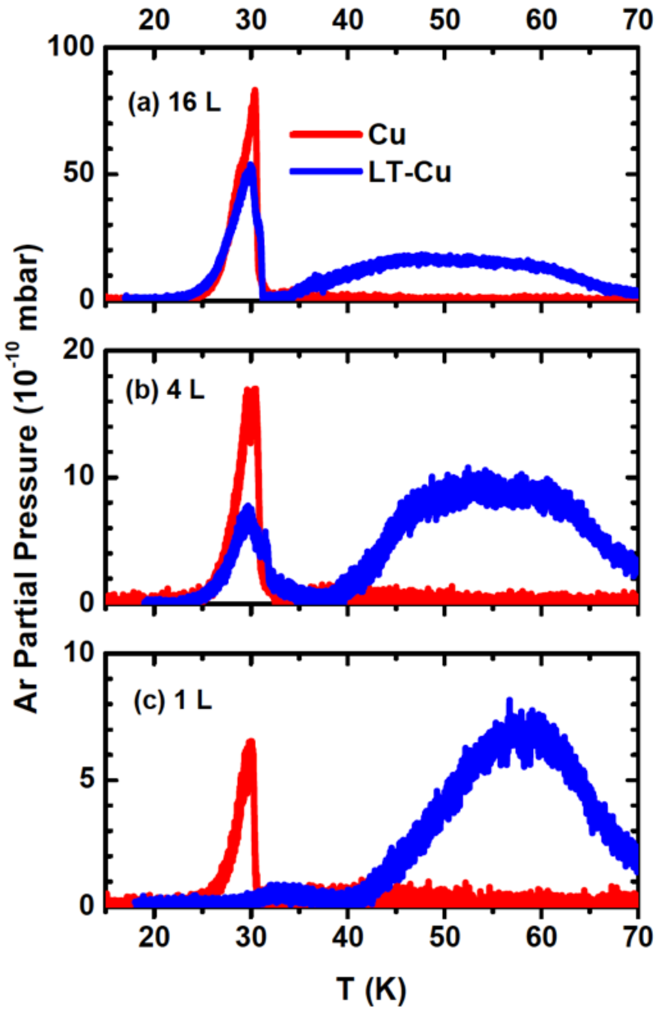
- SEY at 930 decreases with el. dose
- SEY at 10 eV remains constant

SEY and mass spectrometry: ideal to study el. Stimulated desorption

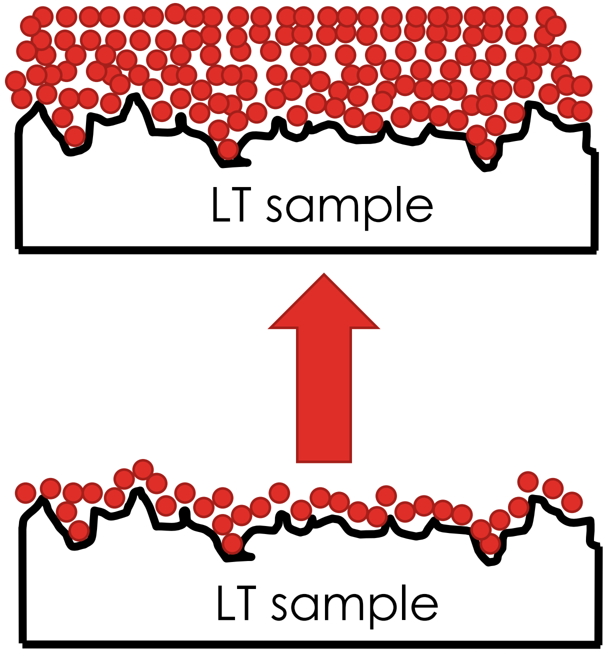
Thermal desorption



R. Valizadeh et al.: Applied Surface Science 404 (2017) p. 370



At higher coverages the desorption is dominated by usual Ar/Ar Van-der-Waals interaction



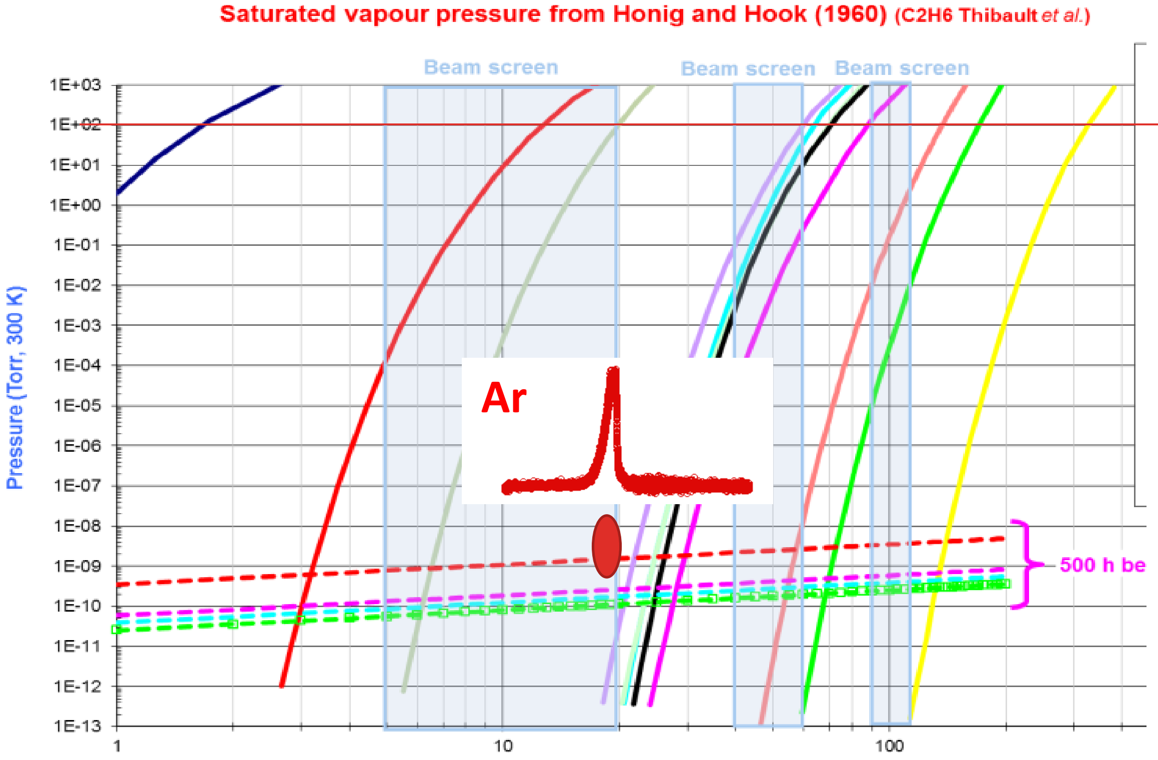
At low coverages the desorption is dominated by Ar/LASE interaction

See Poster 259: Study of Vacuum Stability and Desorption processes at low Temperature for various FCC-hh candidate Materials

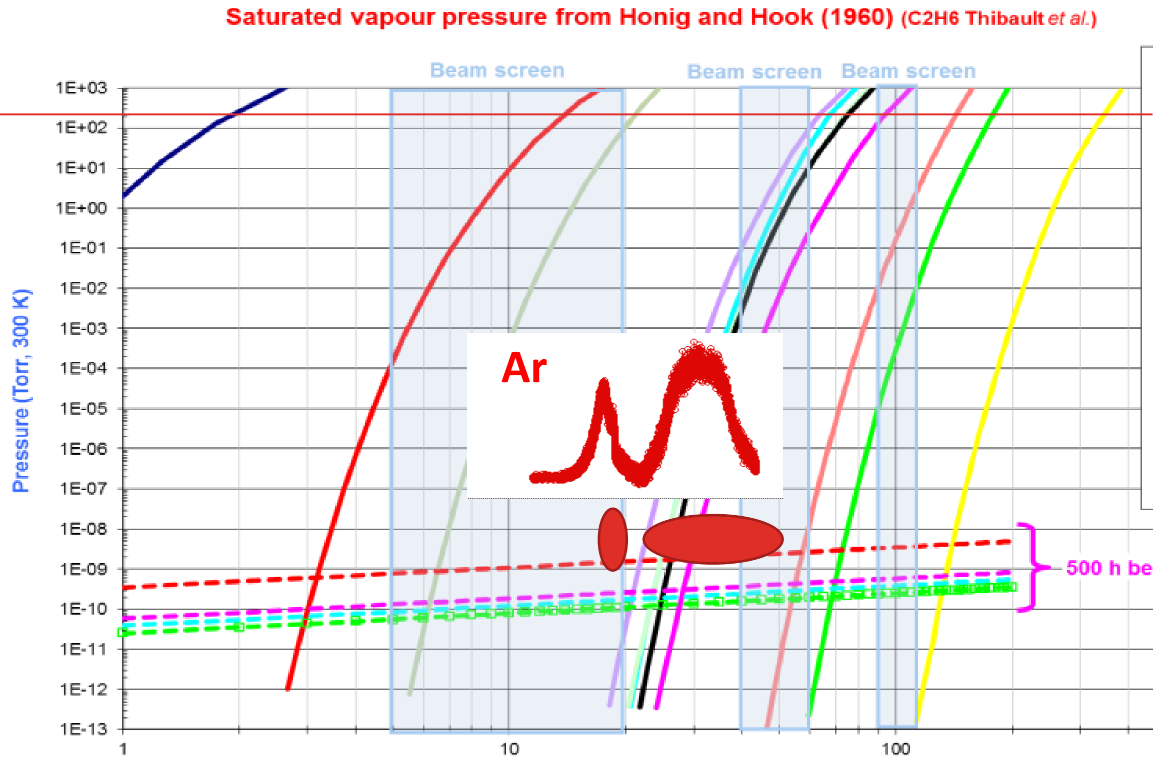
By Luisa Spallino et al

Implications for thermal stability

For ices dominated by Ar-Ar Van-der-Waals bond strength, Ar desorbs as expected T ~ 25-30 K.



For ices dominated by Ar-LASE, Ar desorbs both at T ~ 25-30 K and in a much wider range



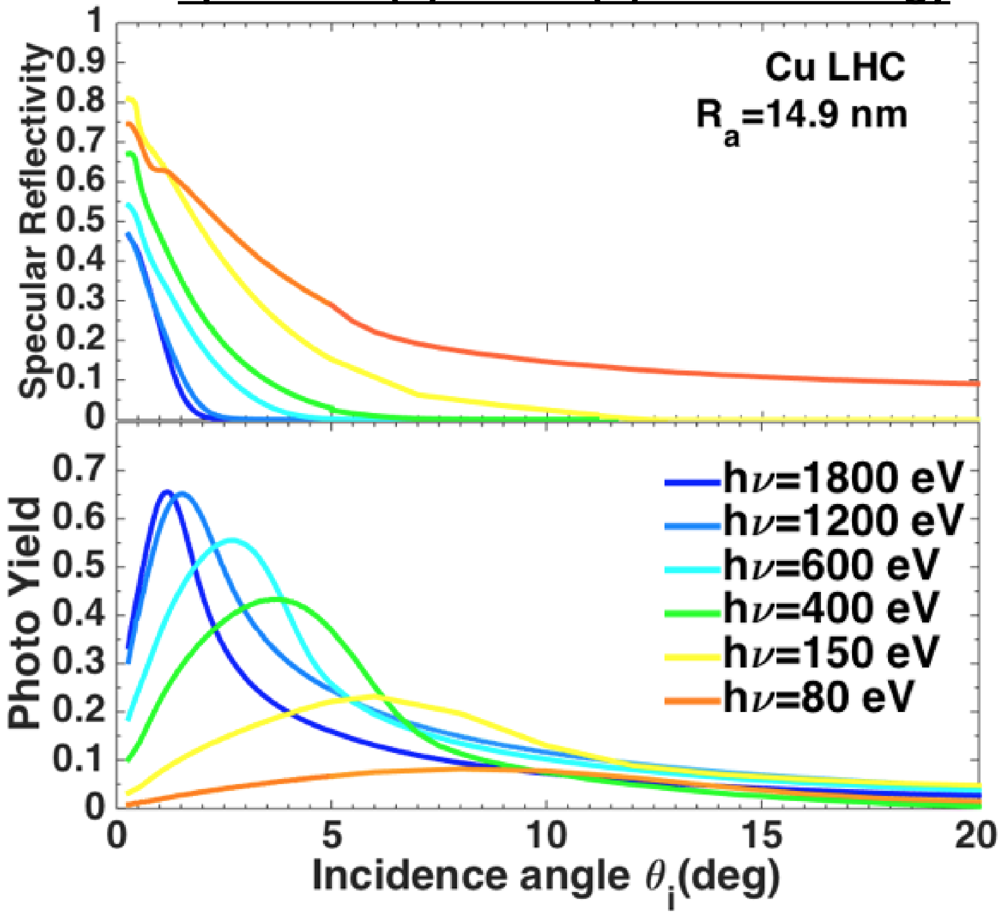
WARNING: If confirmed, the use of highly porous materials at LT must be considered with great care!

See Poster 259: Study of Vacuum Stability and Desorption processes at low Temperature for various FCC-hh candidate Materials
By Luisa Spallino et al

@ **Bessy II** "optic beamline".

Photon Reflectivity and Photo Yield at grazing incidence.

Specular R(θ) and PY(θ) at fixed energy



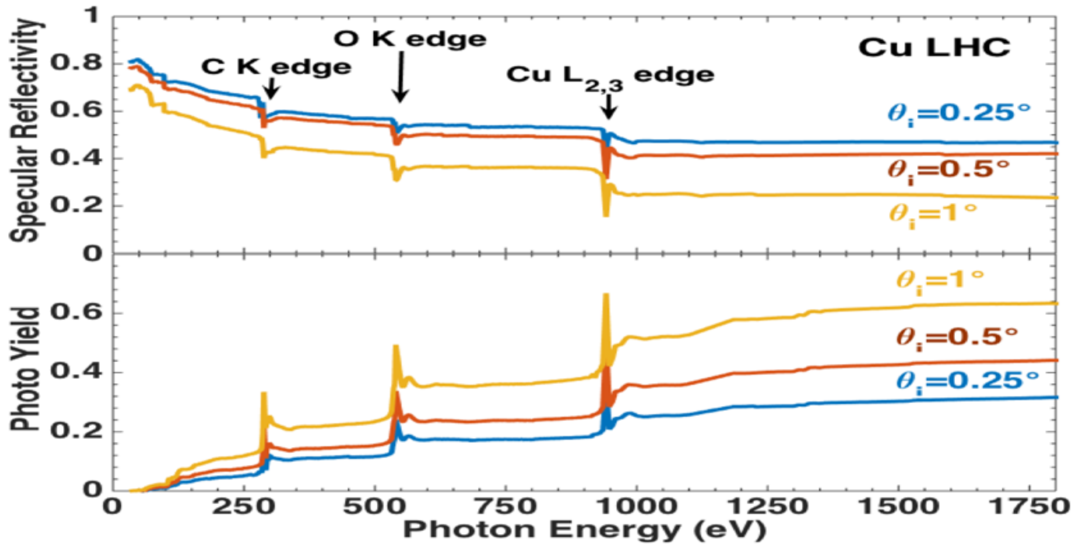
Analysis of **R(θ)** and **PY(θ)** highlights the importance of measuring at as close as possible operating conditions.

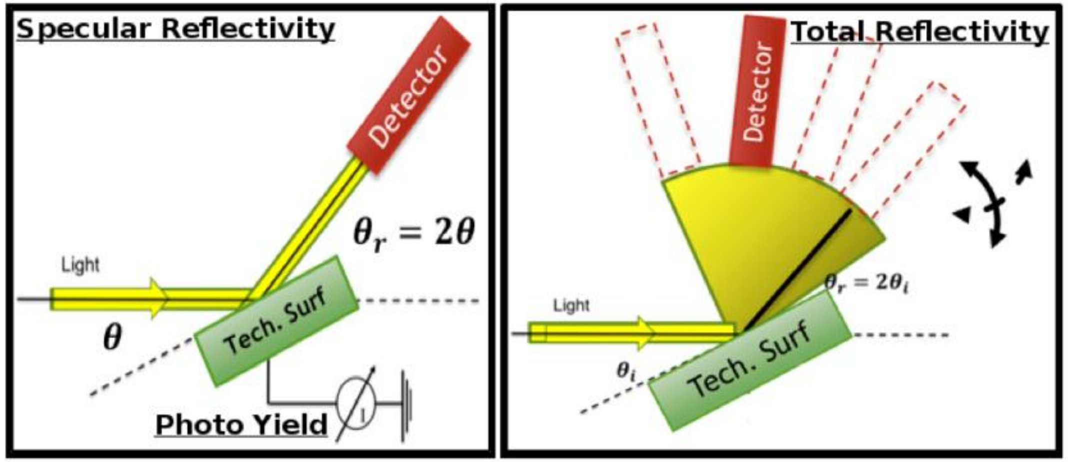
- **R(θ)** for flat surfaces is higher for smaller incidence angles and for lower energies.
- **PY(θ)** results from two competing effects:
  - It increases with θ_i due to an enhanced photo absorption (reduced R).
  - It decreases with θ_i due to a deeper radiation penetration and low electron mean free path.

See Poster 258: Study of Reflectivity and Photo Yield on FCC-hh proposed beam screen surfaces
By Eliana La Francesca et al

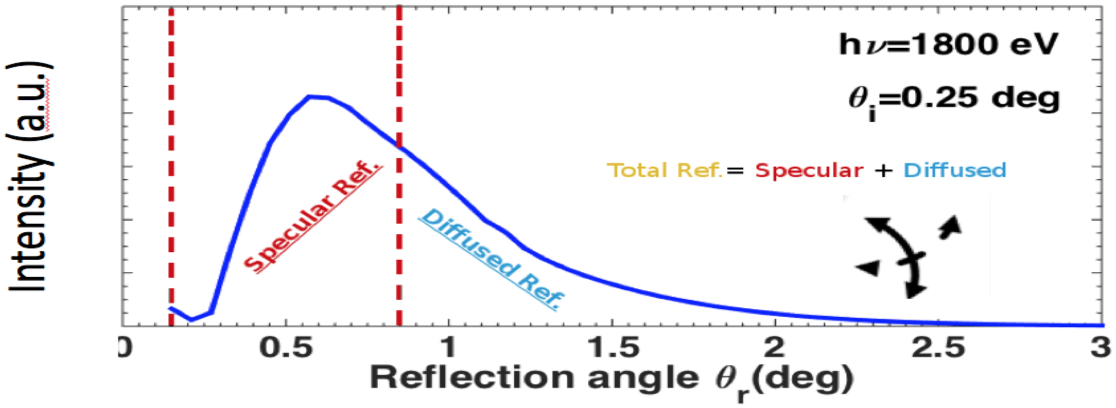
@ Bessy II "optic beamline".

Photon Reflectivity and Photo Yield @ grazing incidence.





- Ultimate Synchrotron Radiation metrology is very useful to our studies
- Importance to work at very grazing angles
- Importance of measuring Specular as well as total Reflectivity
- Morphologically modified structures, need to be experimentally studied: their simulated optical properties need experimental validation. (see poster)



See Poster 258: Study of Reflectivity and Photo Yield on FCC-hh proposed beam screen surfaces

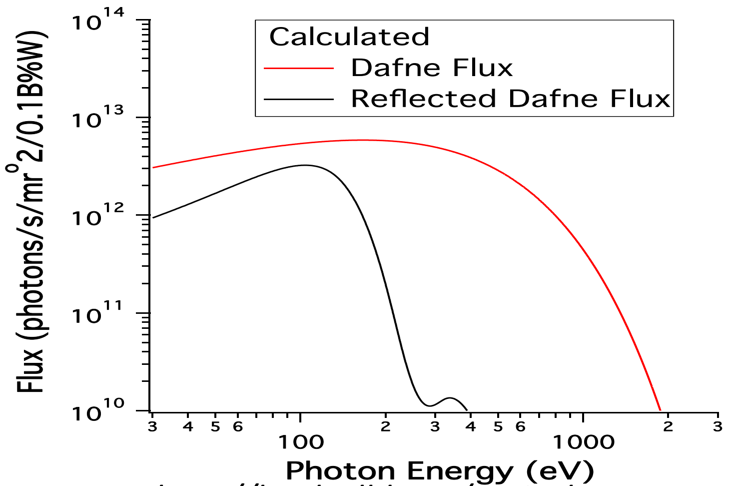
By Eliana La Francesca et al

Back at LNF: DAΦNE-L

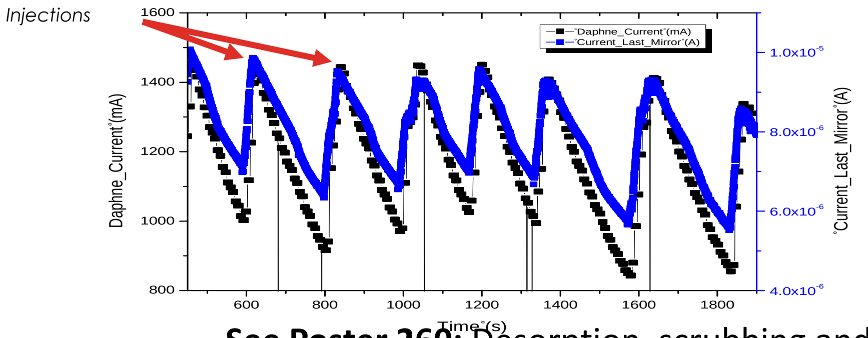
Photo stimulated desorption, photon scrubbing

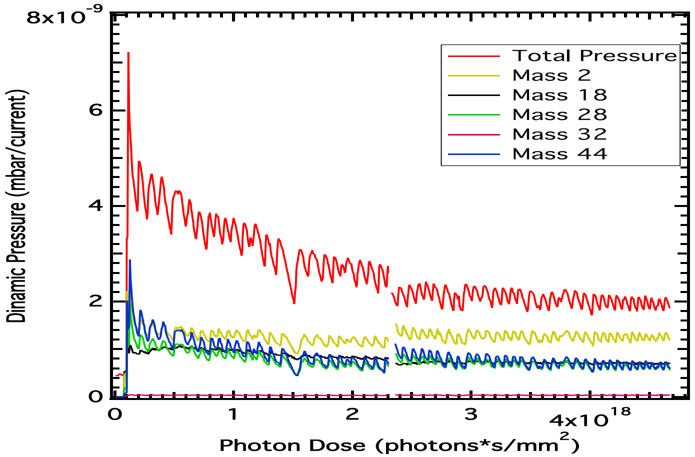
Preliminary *Results* of photo-stimulated desorption on Cu-LHC sample

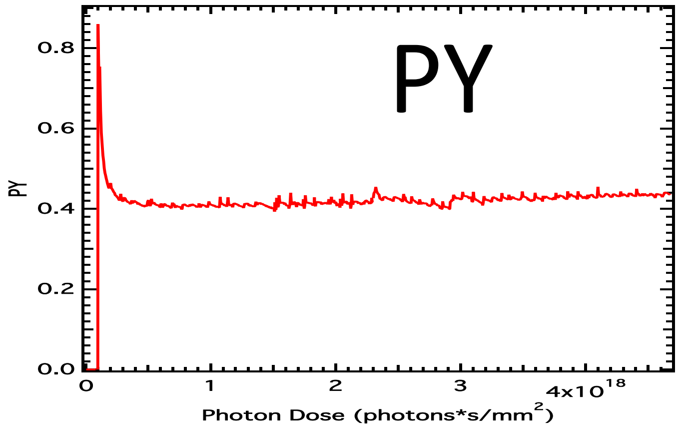
SR Wight light flux at Source and after beamline reflections/focussing

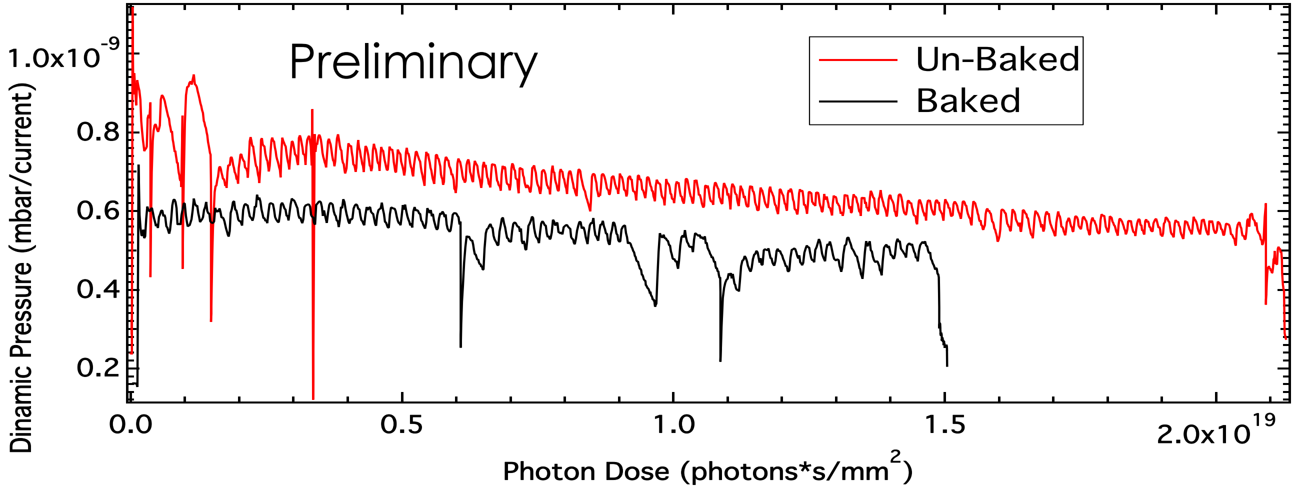


http://henke.lbl.gov/optical_constants/









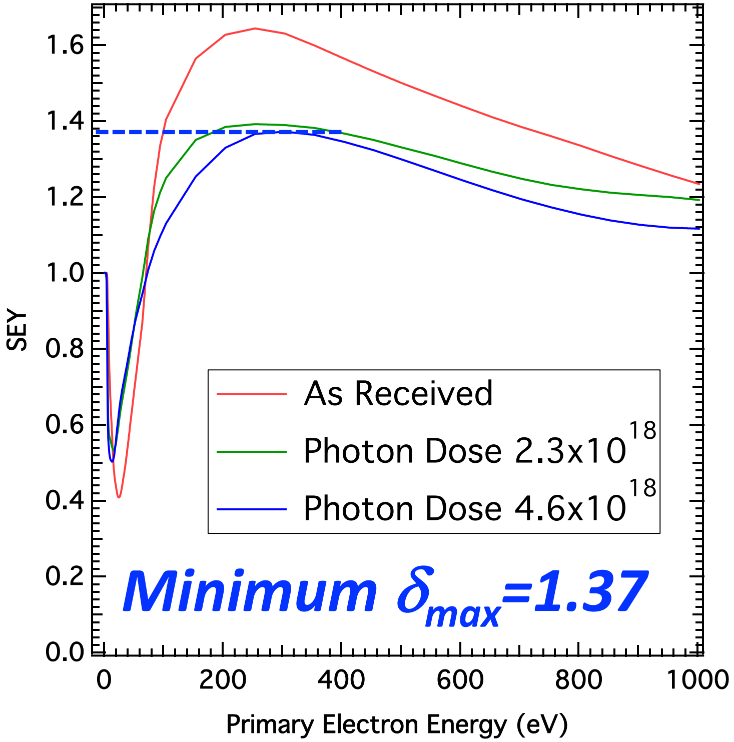
See Poster 260: Desorption, scrubbing and surface modifications during Synchrotron Radiation light irradiation of accelerator walls.

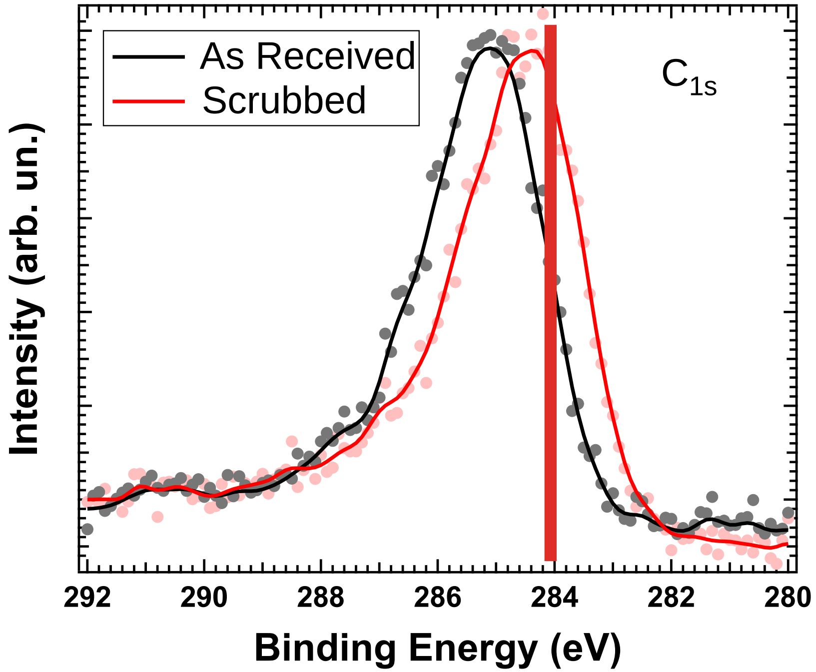
By Marco Angelucci et al

Back at LNF: DAΦNE-L

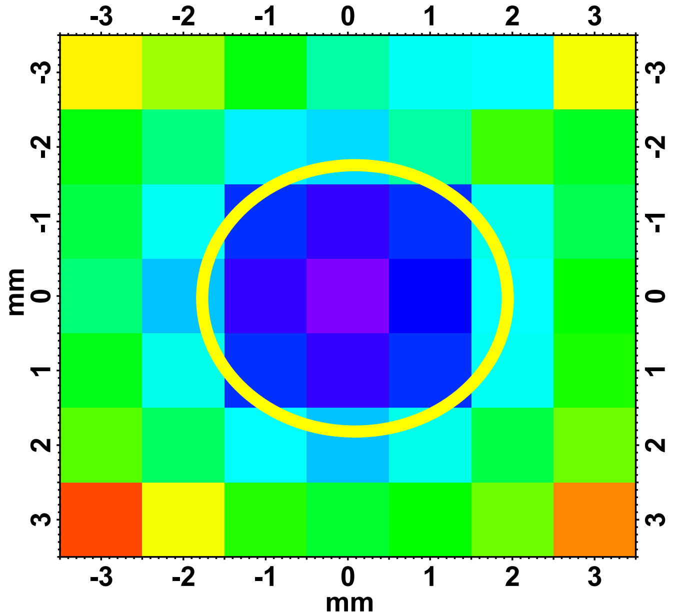
Photo stimulated desorption, photon scrubbing

Follow: DESORPTION, PY, SEY, SURFACE CHEMISTRY MODIFICATION CONTEMPORARILY!





Photon-scrubbing effects



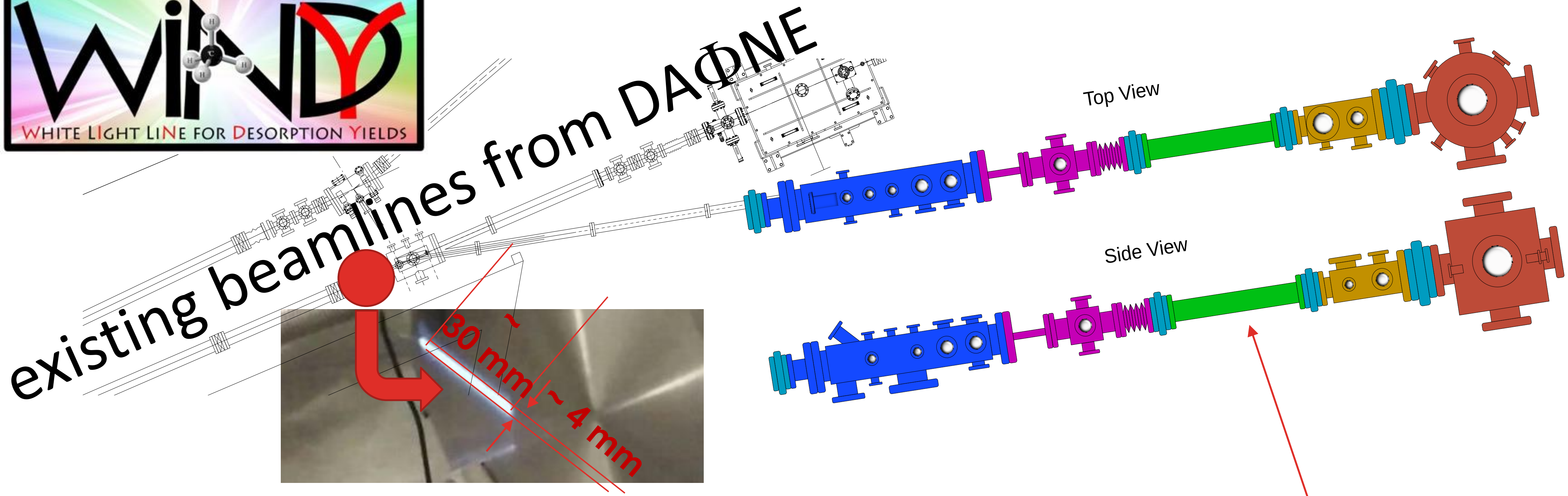
Unique opportunity to see photon scrubbing:
- Same as electron scrubbing?
- Does it influence SEY and electron scrubbing?
- Etc. etc.

See Poster 260: Desorption, scrubbing and surface modifications during Synchrotron Radiation light irradiation of accelerator walls.

By Marco Angelucci et al

Photo stimulated desorption: Real samples.

WHITE LIGHT LINE FOR DESORPTION YIELDS



The goal (within a collaborative effort with CERN*) is to have a "White light" irradiation test facility to study desorption properties on long and real beam-pipes and to correlate such results with the one obtained on small samples

*KE3724/TE/HL-LHC-Addendum No.4 to Agreement TKN3083

CONCLUSIONS

- A multi- technique material science approach is the key for a successful R&D
- Working at as "close as possible" operation condition is essential to be predictive
- LNF is now running and implementing a "unique" facility.
- SR is a key feature: we hope that it will last long @ DAΦNE!

THE TEAM AT LNF ...

GOES COLD!

E. La Francesca **R. Cimino** **R. Larciprete**

M. Angelucci, **A. Liedl** **L. Spallino**

Acknowledgements

L. Gonzalez, Mario Commisso, Theo Demma, Davide Remo Grosso, Dafne-L and Dafne Accelerator group @ INFN-LNF.

V. Baglin, I. Belafont, P, Chiggiato, R. Kersevan, M. Jimenez, G. Iadarola, G. Rumolo, M. Taborelli, F. Zimmermann etc… *CERN, Geneva, Switzerland*

Franz Schäfers, M. G. Sertsu, F. Siewert A. Sokolow
Institute for Nanometre Optics and Technology (INT) Berlin

Acknowledgements

L. Gonzalez, Mario Commisso, Theo Demma, Davide Remo Grosso, Dafne-L and Dafne Accelerator group @ INFN-LNF.

V. Baglin, I. Belafont, P, Chiggiato, R. Kersevan, M. Jimenez, G. Iadarola, G. Rumolo, M. Taborelli, F. Zimmermann etc… *CERN, Geneva, Switzerland*

Franz Schäfers, M. G. Sertsu, F. Siewert A. Sokolow
Institute for Nanometre Optics and Technology (INT) Berlin

And all the e⁻ cloud community

which

will reconvene in: "Isola D'Elba"

From 2 to 7 June 2018