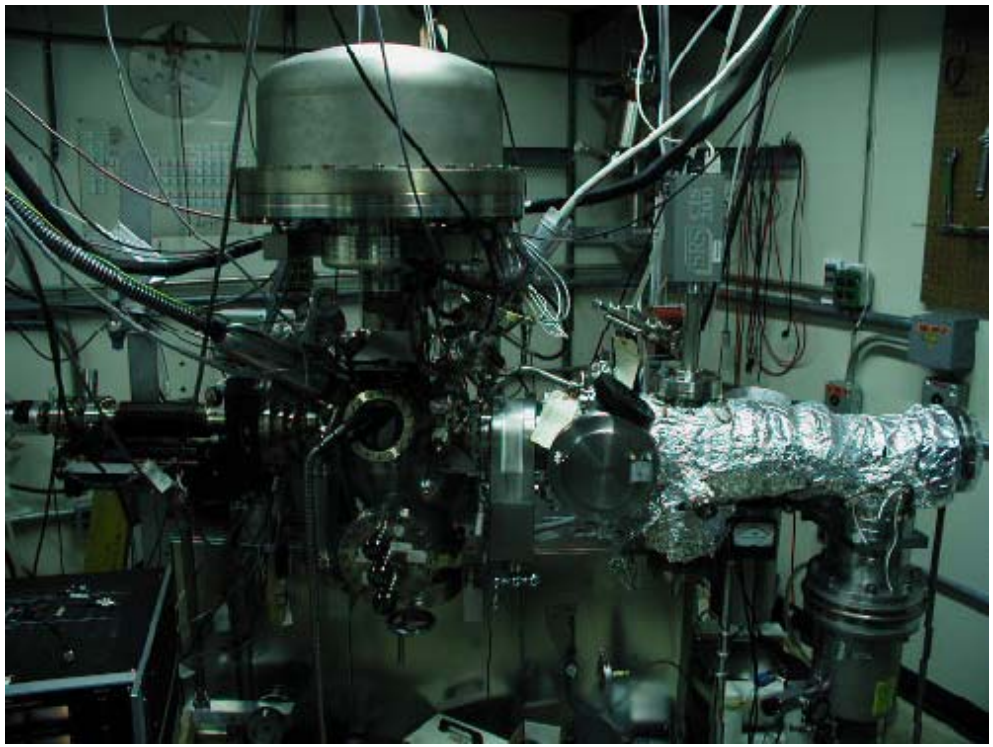
2003-2008 Summary of SEY measurement at SLAC

F. Le Pimpec (PSI)
on behalf of my SLAC Colleagues

CERN, 20-21/11/2008

Surface Science Lab



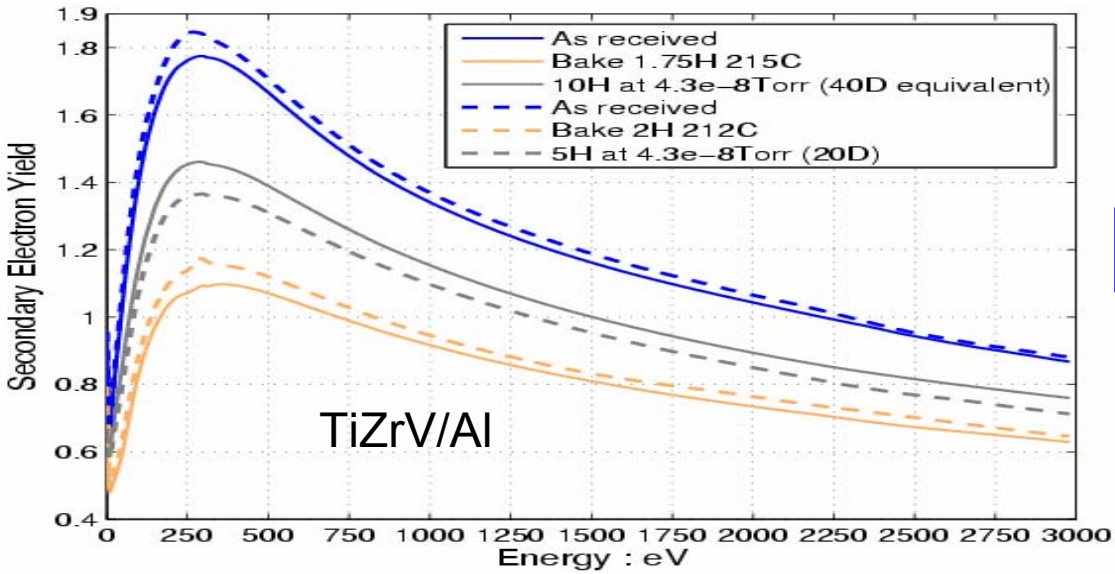
1. Analysis chamber
2. Load lock chamber
3. Sample plate entry
4. Sample transfer plate
5. Rack and pinion travel
6. Sample plate stage
7. XYZ θ Omniax^{TM} manipulator
8. Sample on XYZ θ
9. Electrostatic energy analyzer
10. X-ray source
11. SEY/SEM electron gun
12. Microfocus ion gun
13. Sputter ion gun
14. To pressure gauges and RGA
15. To vacuum pumps
16. Gate valve

Illuminated Areas by the 130 eV conditioning electron (0.8 cm^2) and 250 eV ion (5 cm^2) gun.

Sample Diameter 2.54 cm

An almost unique UHV device XPS-AES-XRF-SEY-QE

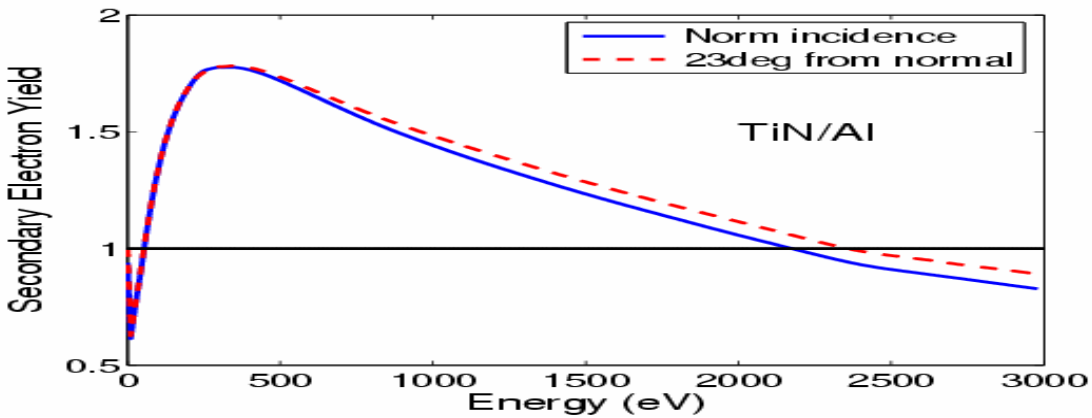
Heating and angle dependence



So far we haven't found a material with an as received δ_{max} below 1.5

As Received = air exposed

As received TiZrV getters have a δ_{max} varying between 1.7 and 2 (not exhaustive…)



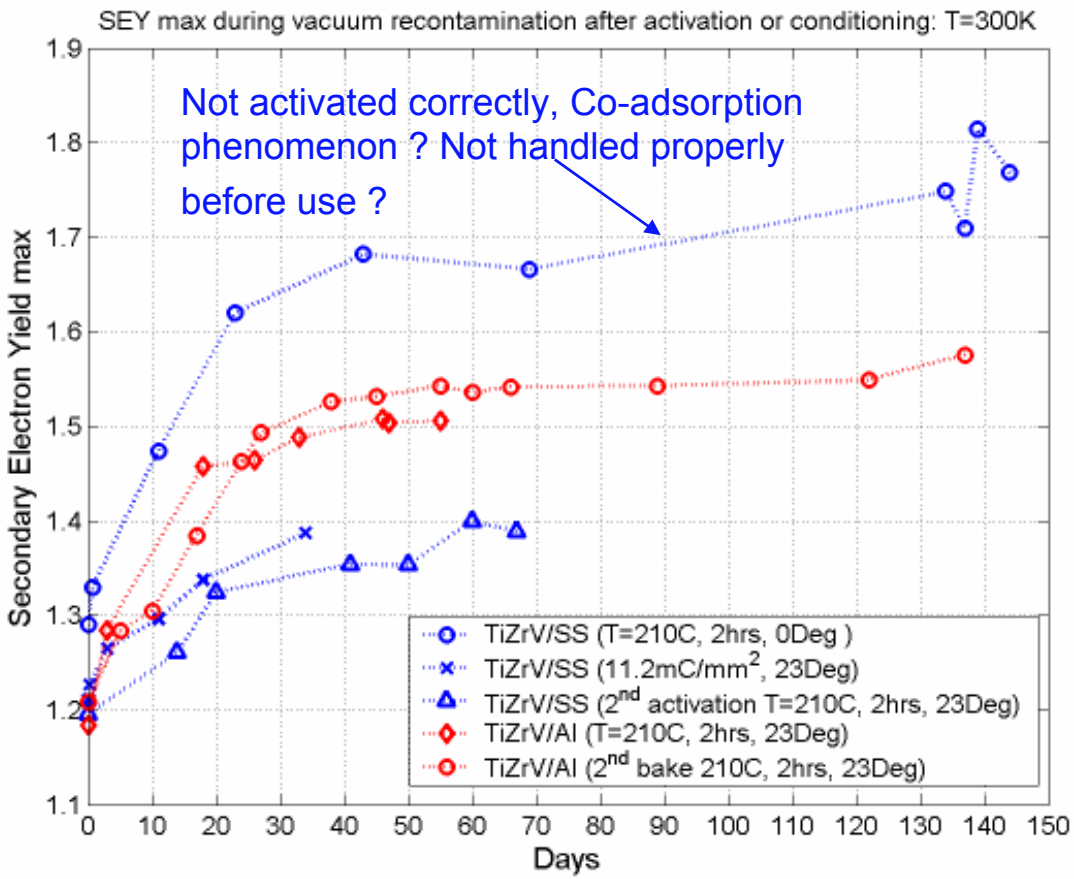
As received TiN samples have an as received δ_{max} varying between 1.6 and 2.4

CERN and C based film δ_{max} < 1.5 - Problem : you must convince your colleagues that it is OK to test in-situ

We must play tricks : heating, particles bombardment, roughness change …

Vacuum recontamination

TiZrV NEG activation at 210 °C for 2 hours brings $\delta_{max} \leq 1.2$
Not much difference is observed for TiN or TiCN, when heated to 150°C - 170°C, compare to the as received state.



<P> in the system 5 10^{-10} Torr (hydrogen dominated spectrum)
Previous slide, <P> ~ 4 10^{-8} Torr (water dominated spectrum)

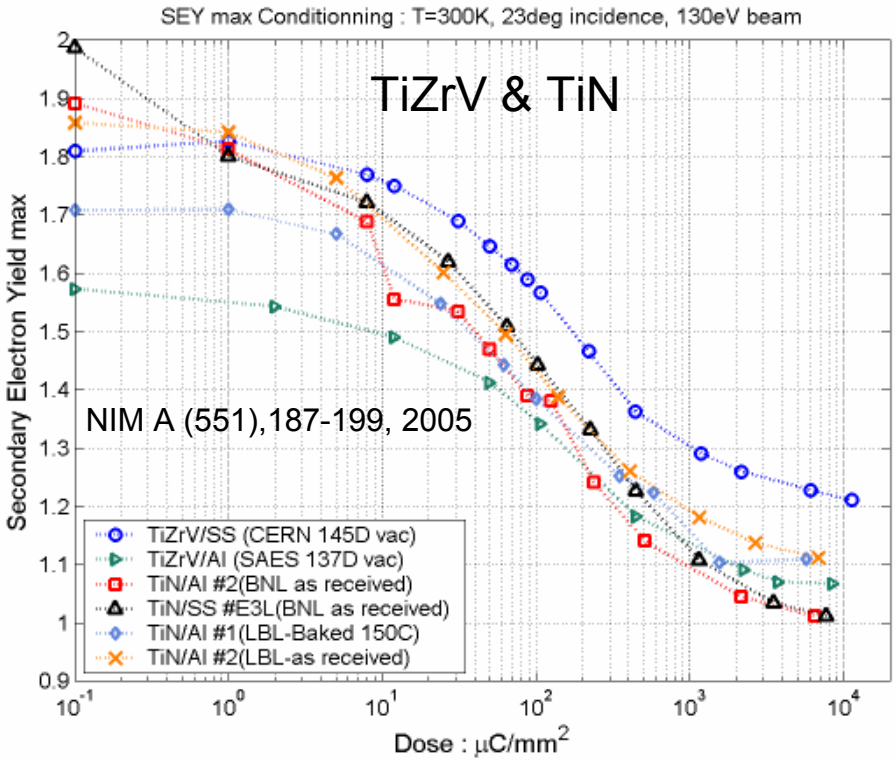
Depending on the NEG composition and its roughness, the saturation level,
$1.4 \leq \delta_{max} < 1.6$

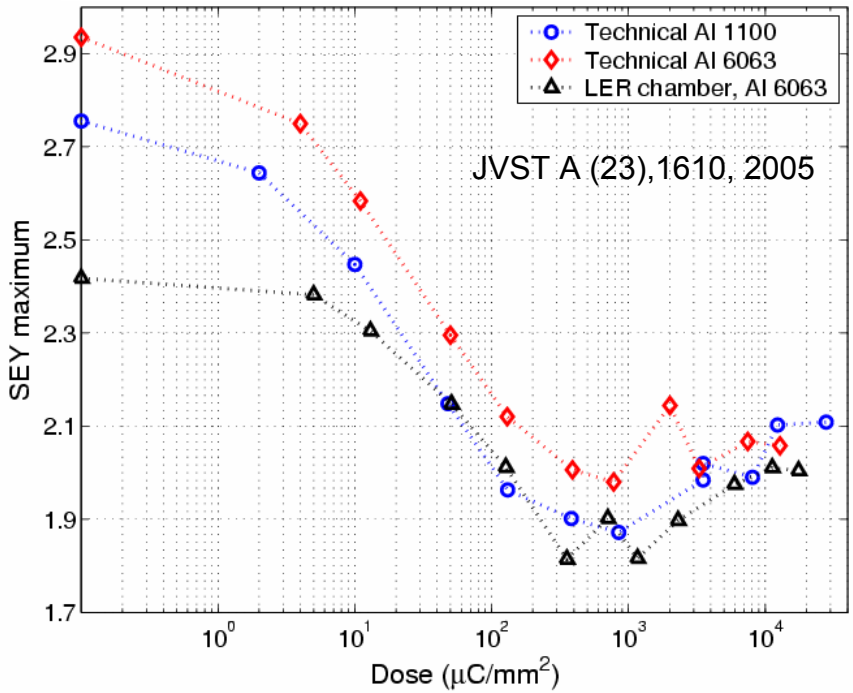
Dosing with a single species bring a limit to $\delta_{max} < 1.35$ (CERN)

NIM A (551),187-199, 2005

Electron cloud conditioning

Electrons from the e-cloud can condition surfaces.
Hopefully in a reasonable time scale !



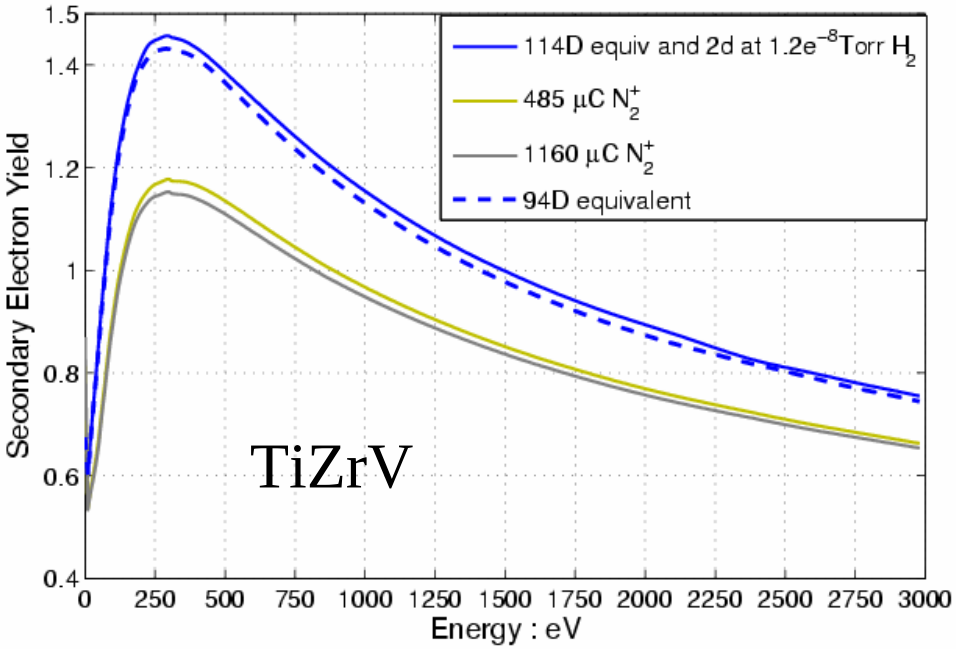


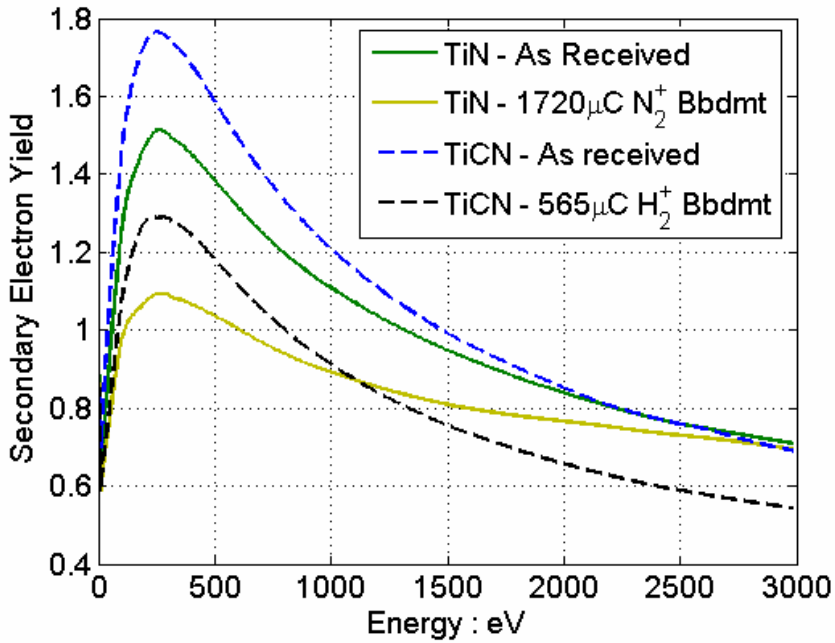
However, as the e-cloud disappears the conditioning dies off !

But we get steady help from the SR (CERN and KEK results) and some extra help from residual gas ions kicked to the wall

Shift in Al 2p - C 1s observed. XPS show changes from pure Al to Al oxide

TiN -TiCN - TiZrV : 250 eV ion conditioning





Thin Film	Particle	δ_{max}	$Energy_{max}$	Dose $\mu C/mm^2$
TiZrV/SS(CERN)	e^-	1.21	300	11233
TiZrV/Al (SAES)	e^-	1.07	370	8425
TiN/Al (LBL)	e^-	1.11	290	6829
TiN/Al (BNL)	e^-	1.01	380	6529
TiN/SS (BNL)	e^-	1.01	290	7720
TiCN/Al	H_2	1.29	280	1.11
TiN/Al	N_2	1.09	260	3.39
TiZrV/Al	N_2	1.15	300	2.29

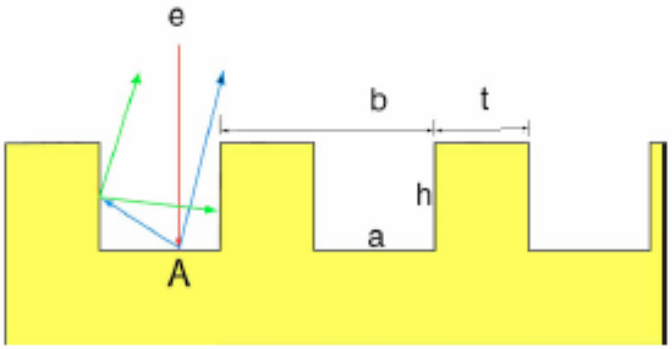
130 eV electrons

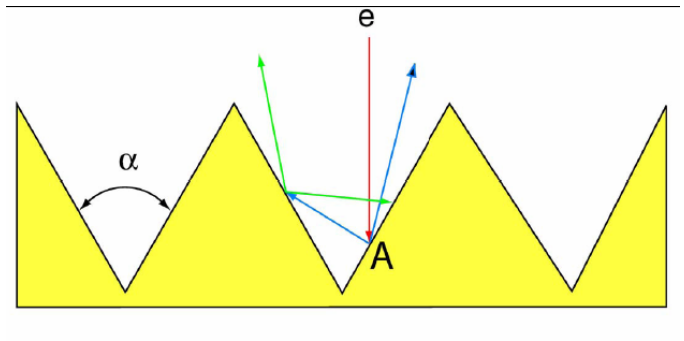
250 eV ions

What about CO?

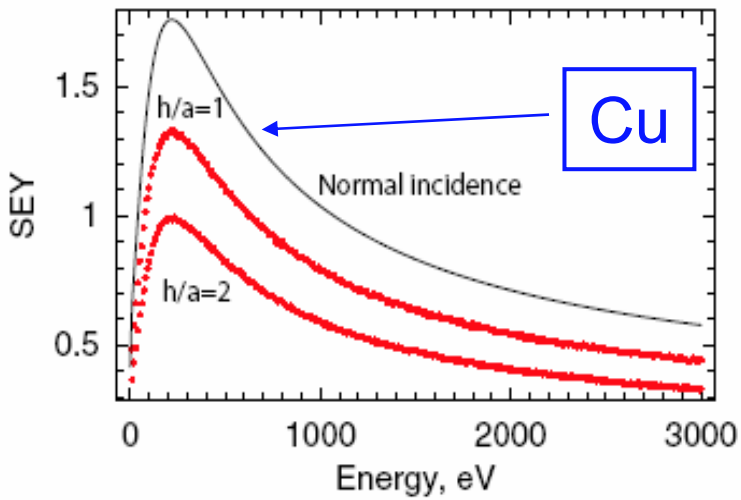
NIM A (564),44-50, 2006

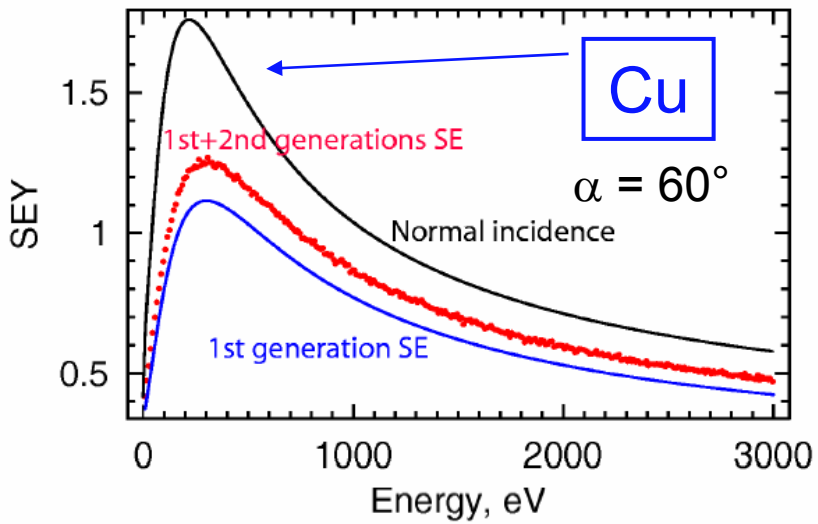
Artificial roughness





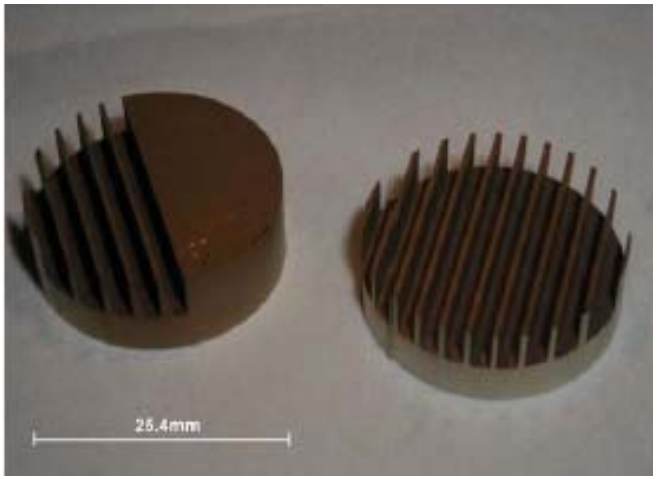
Simulation



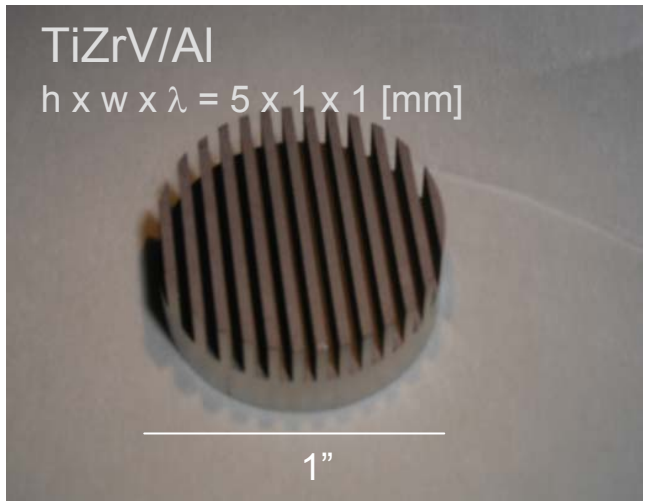


JAP 104,104904, 2008

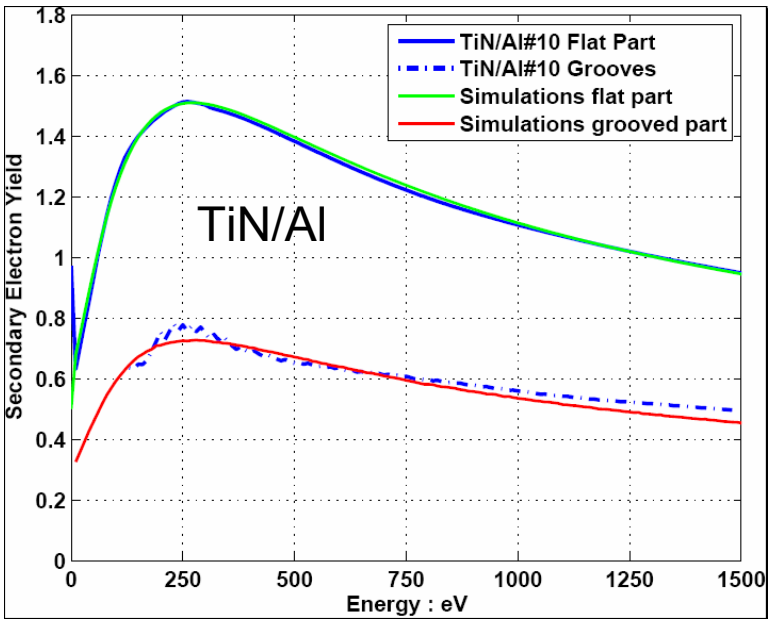
Artificial roughness & coatings

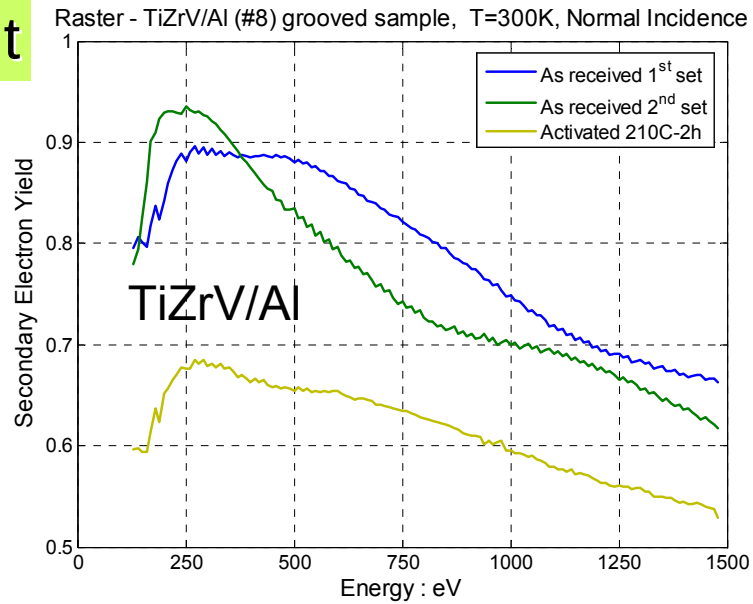


Accepted for publication in J. App.Phys.



SEY experiment





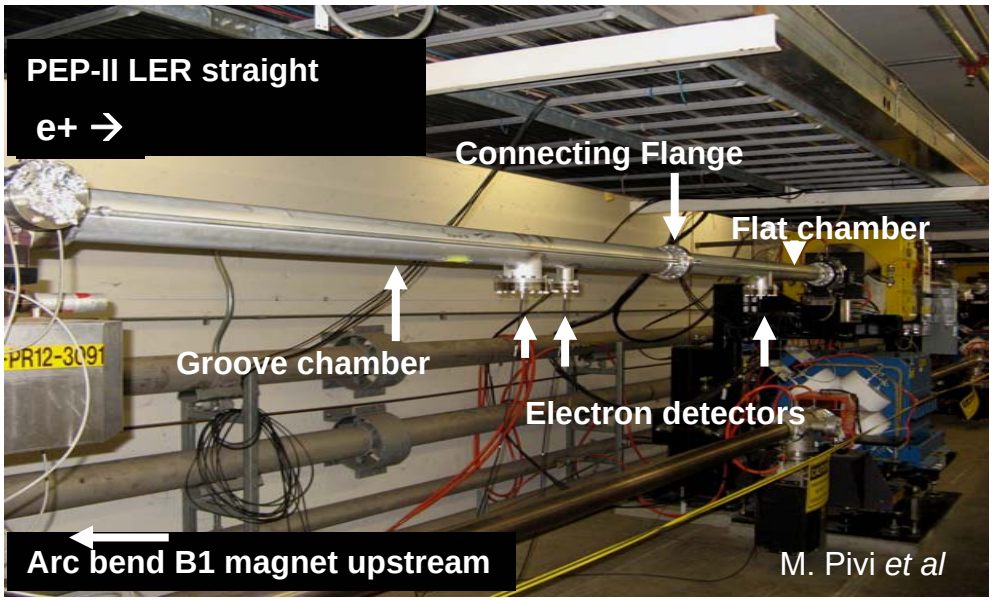
Accelerator vs lab experiment

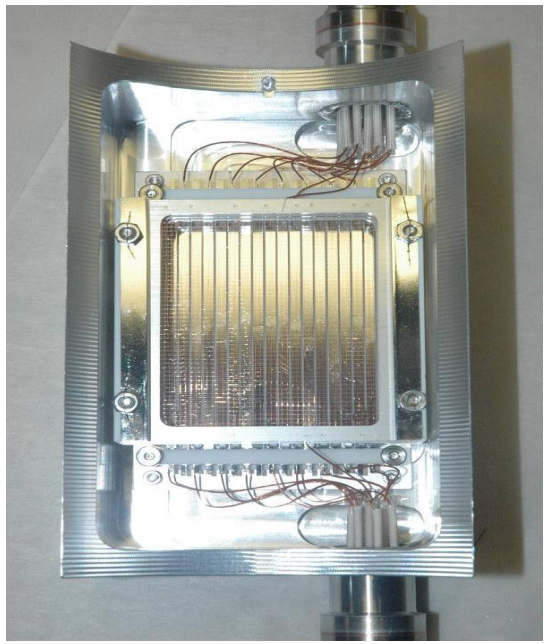
SR, ions and electrons do produce electrons & increase the pressure (PSD, ESD, ISD). In the other hand they cleanup the surface and lower the SEY over time. Thence, surfaces in an accelerator environment might not behave or condition as in the lab.

Nevertheless, we did expect that lab and accelerator test would agree !!

In-situ machine studies

Most of the major laboratory (ANL, BNL, CERN, KEK, LLNL, SLAC) are measuring the EC and the distribution in energy of the electron – usually use of a special RFA device (See ILCDR08 – Cornell University)



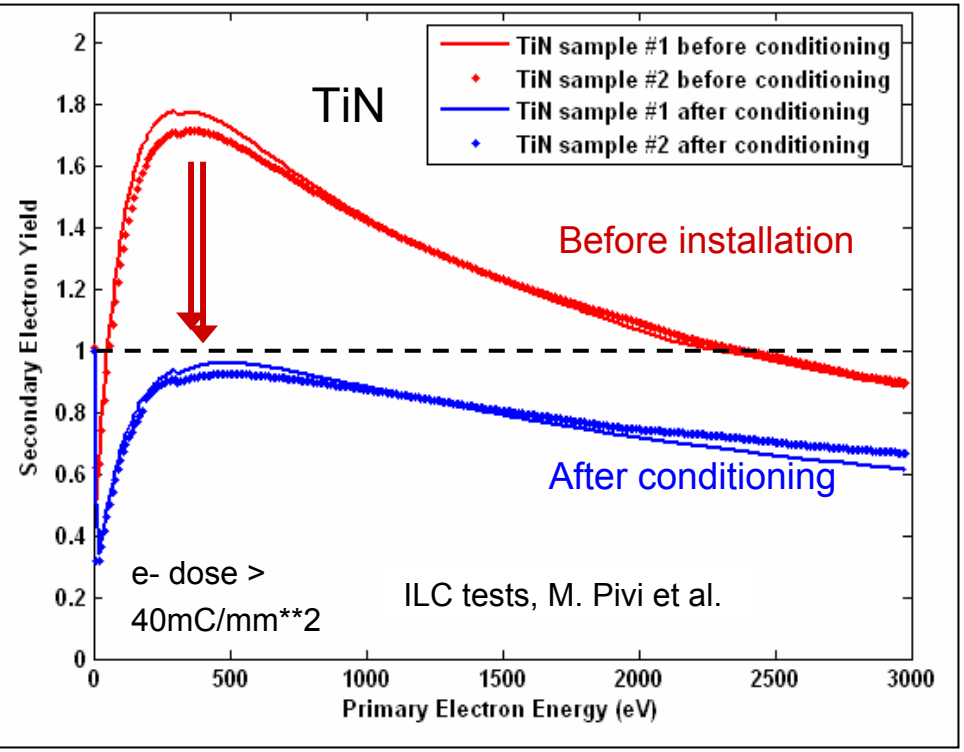


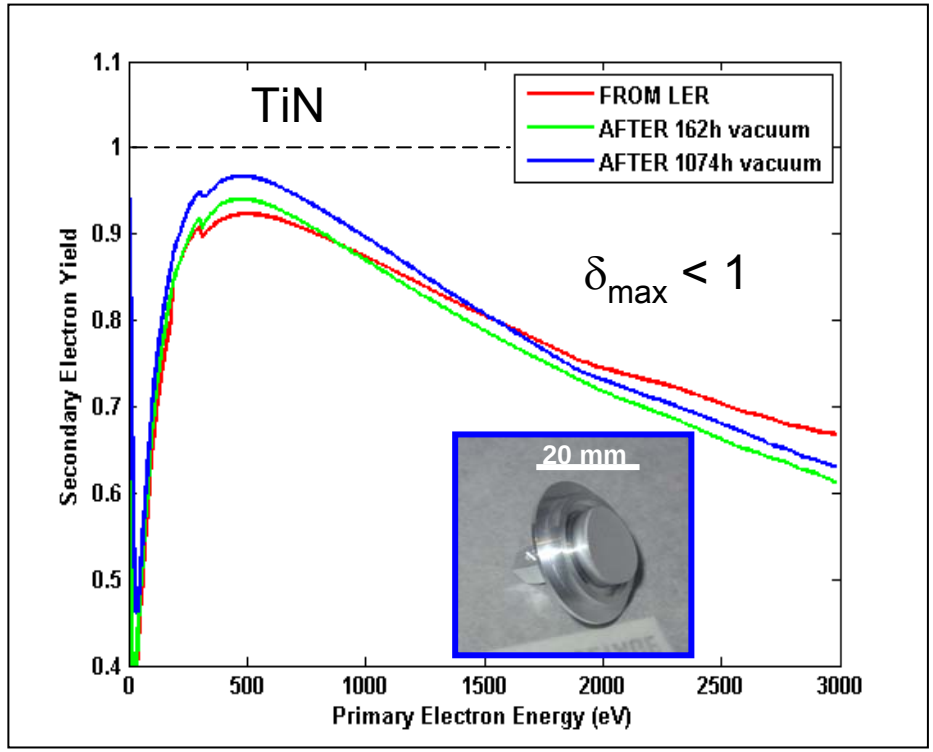
M. Pivi, R. Kirby et *al*

e^- detectors in dipole: measure e^- Horizontal distribution & energy

Now samples and even full length UHV chamber are exposed to accelerator operation. NEG coating was found to not only suppress EC but SEY results were in agreement with what was measured in lab (see A. Rossi ecloud'04)

Conditioning in PEP-II : LER



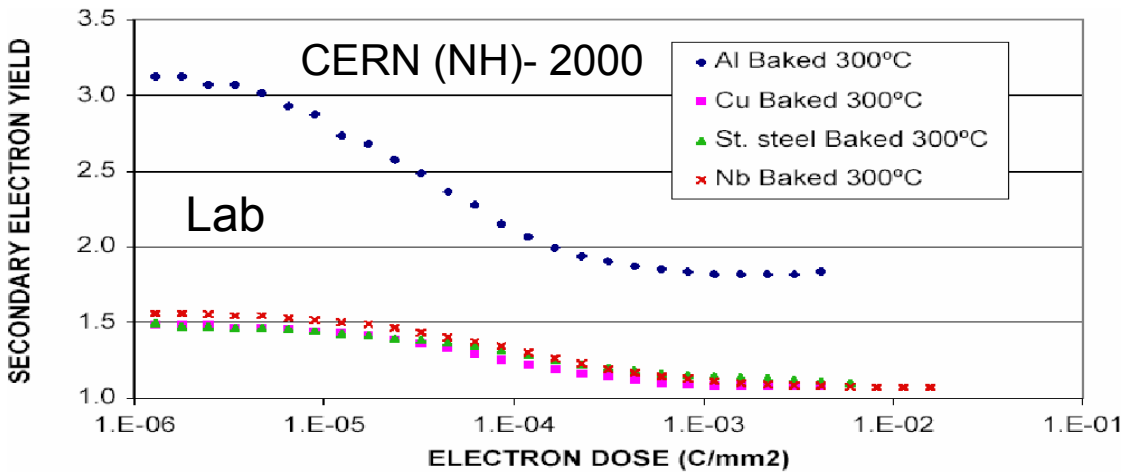


TiN samples measured before and after 2-months conditioning in the beam line.
Samples inserted respectively in the plane of the synchrotron radiation fan (0º position) and out (45º).

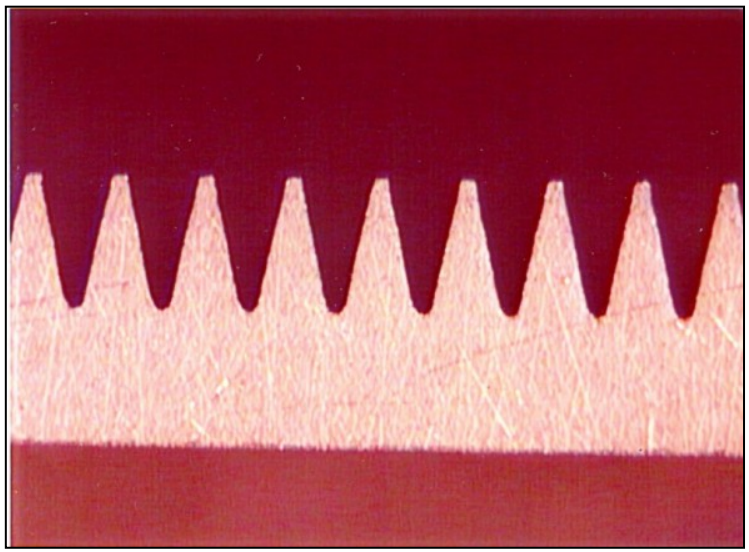
TiN surface then left standing-by in vacuum: SEY < 1 even after 1000 hours.
Recontamination effects are small for TiN after conditioning in PEP-II.

Samples' conditioning in the accelerator beam line

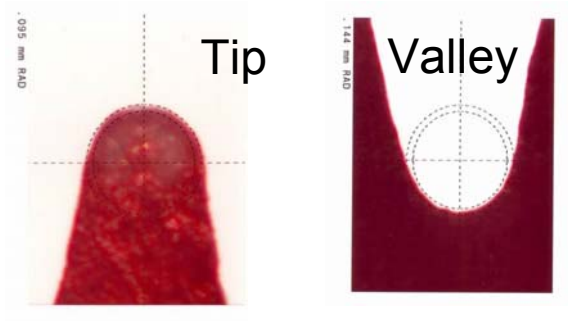
SLAC - PEP II	SEY_{max} before installation	SEY_{max} after conditioning
TiN/Al	1.7	0.95
TiZrV	1.33	1.05
Al	3.5	2.4
StSt	1.85	1.26
Cu	1.8	1.22

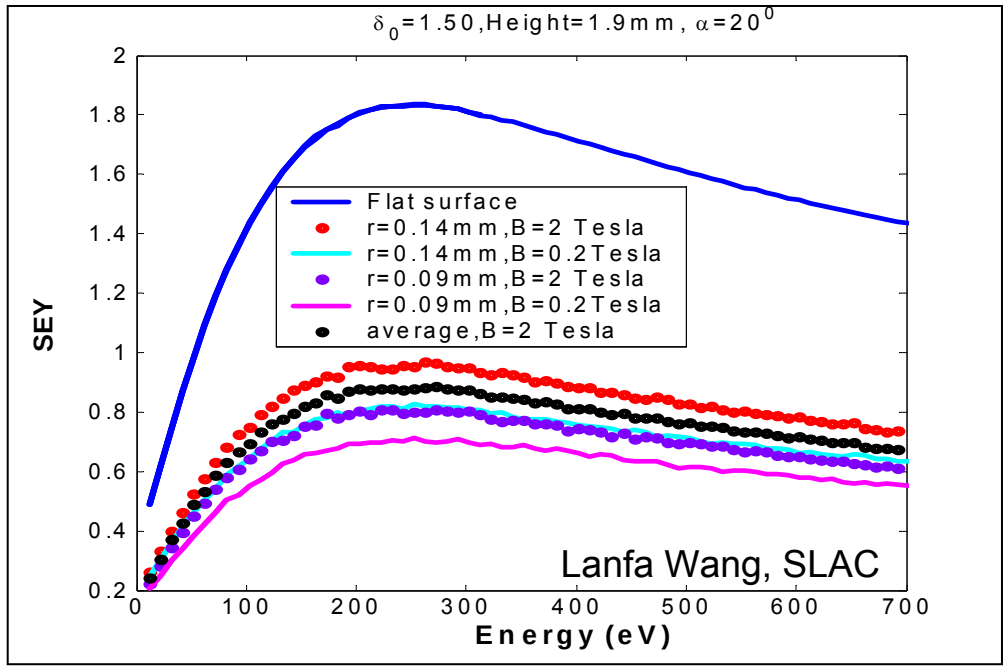


Grooved insertions : SPS tests



Courtesy M. Pivi



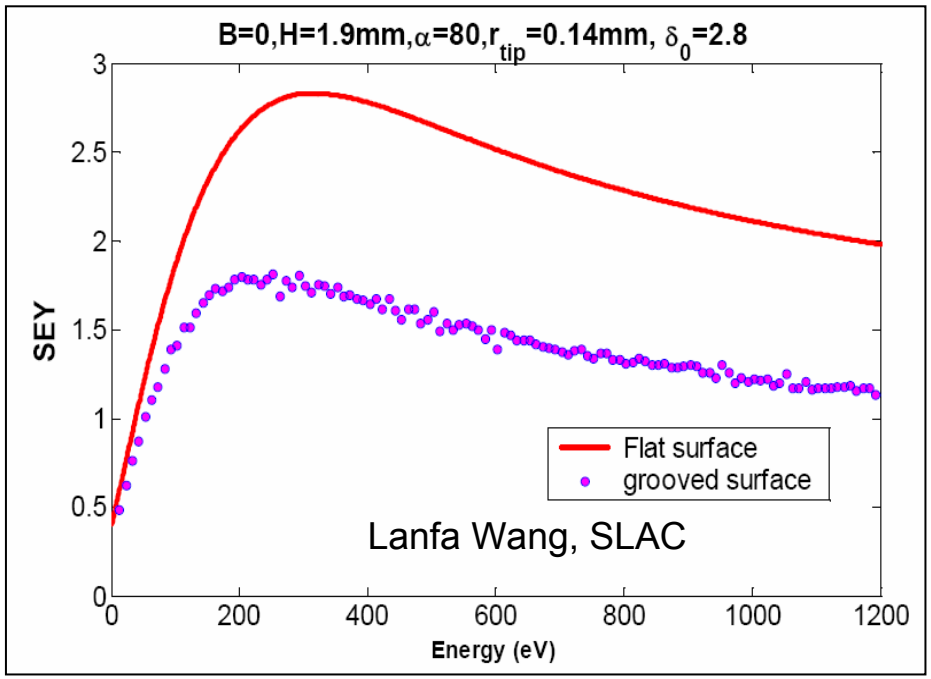


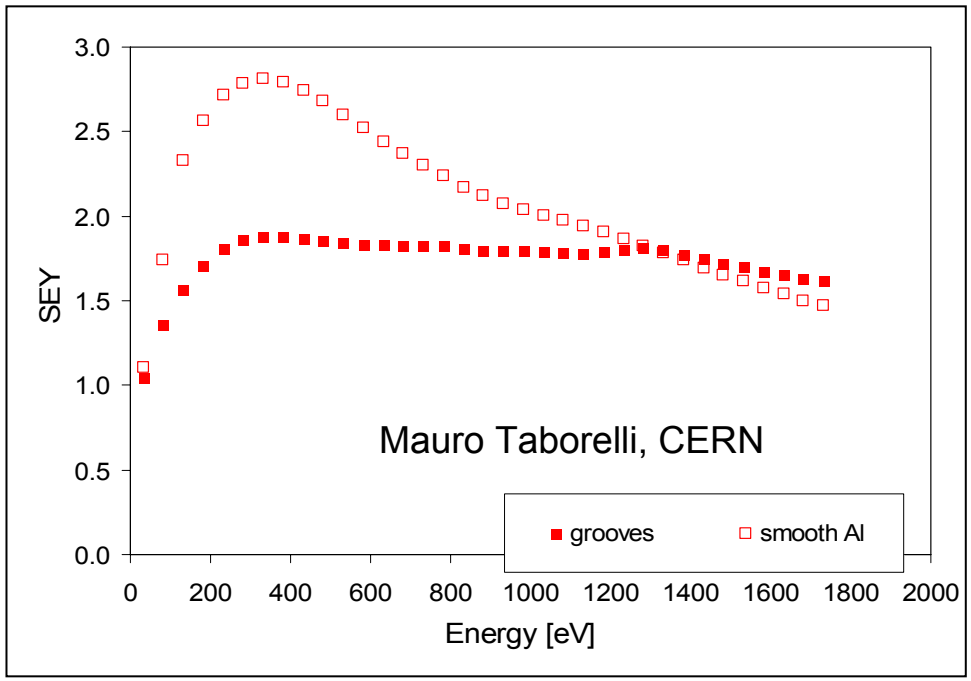
Collaboration SLAC / CERN:

- **2 mm Aluminum+Coating triangular grooves (pictures above). Simulated SEY below 1 in magnetic field. →**
- **Under development: reduced 1mm deep grooved insertion. To increase vacuum chamber aperture.**

Groove Insertion

Measured SEY of the aluminum groove insertion before TiN coating.





Simulated SEY for the 2mm aluminum groove in a field free B=0.

Measured SEY in field free for the 2mm aluminum groove insertion. Note: the e-beam might be less well focused above 1200eV than below (M. Taborelli).

Collaboration

- KEK-B:
  - Provide groove insertions for experiment at KEK-B
  - Compare grooved and flat TiN coated surfaces, and clearing electrodes.

- CesrTA:
  - Redeploy all experiments ECLOUD1,2,3 (plus grooved chamber in dipole).

- Project-X:
  - Re-deploy ECLOUD1 (SEY Station) to Fermilab (after CesrTA)

M. Pivi in ILCDR08 workshop @ Cornell

Summary & Future

- NEG, TiN and TiCN are successfully conditioned by low energy electrons and ions, bringing $\delta_{max} \leq 1.2$
- NEG : Vacuum residual gas exposure gives higher δ_{max} than fast saturation even by H_2O, cf Scheurlein CERN ($\delta_{max} \leq 1.4$)
- Artificially rough surfaces do reduce the SEY - Coating further reduce δ_{max} - Simulation and experiment agrees very well !
- SEY results in LAB and in PEP-II are concordant. SEY PEP-II results concordant with KEK-B
- **SMS group has been disbanded : XPS/SEY machine has been moved to SSRL (access for more SEY ?!)**
- **PEP2 is terminated : All in-situ experiment are moved to CESR-TA Frequent trips to Cornell …**
- **Key collaboration with other labs (national and international) to develop complementary mitigation techniques**

SLAC

R. Kirby, F. King, M. Pivi, G. Collet, L. Wang,
T. Raubenheimer, N. Phinney, G. Stupakov,
not forgetting the PEP 2 people

LBNL & BNL

A. Wolski, D. Lee, P. He