(4) Seek Office of High Energy Physics (OHEP) support for e-cloud research on HCX

Art Molvik & HCX and NDCX Groups

the Heavy-Ion Fusion Science Virtual National Laboratory (HIFS-VNL)

February 22, 2007

This work performed under the auspices of the U.S Department of Energy by University of California, Lawrence Livermore and Lawrence Berkeley National Laboratories under contracts No. W-7405-Eng-48 and DE-AC02-05CH11231.

UCRL-PRES-228123

Office of High Energy Physics (OHEP) support – two approaches

(A) International Linear Collider (ILC) support, bolstered by being formal collaborator on Cornell Electron Storage Ring Test Accelerator (CesrTA) proposal

(B) Proposal to OHEP Advanced Technology R&D for halo studies

(A) Formal collaborator on CesrTA – proposed testbed for ILC-Damping Rings

- Visited Cornell, 1/31-2/2/07 with 2 other e-cloud experts
- Discussed possible diagnostics for quantitative e-cloud measurements – Retarding field analyzer, grid-shielded electrode, and biased capacitively-coupled electrodes.
- Mark Palmer (ILC Coordinator at Cornell) commented favorably on these diagnostics and on VNL 3-D simulations during subsequent teleconference.

Funding will require a separate proposal from us – if CesrTA proposal funded. HCX support will require additional arguments.

(B) Proposal to OHEP Advanced Technology R&D for halo studies

- High brightness beams study group (Fall, 2006) identified halo formation as the highest priority issue – it is still not well understood or experimentally validated.
- 3-D self-consistent simulation, e- & gas diagnostics, and mitigation techniques developed to an unprecedented level in our e-cloud work.
- These new capabilities could push halo understanding to a new level.
- Proposal deadline Oct. 1, 2007.

Funding probable if American Competitiveness Initiative fully implemented; possible at moment with +$200M for Office of Science in FY07, +$300M in '08.

Backup slides

HIFS e-cloud effort

HCX Experiment

- Art Molvik
- Michel Kireeff Covo
- Frank Bieniosek
- Peter Seidl

NDCX Experiment

- Peter Seidl
- Joshua Coleman
- Prabir Roy
- Frank Bieniosek
- Art Molvik

Simulation

- Jean-Luc Vay
- Bill Sharp
- Ron Cohen
- Alex Friedman
- Dave Grote
- Steve Lund

Prioritization of high-brightness beam transport issues – near term [Fall 2006 High Brightness Study Group]

1. Halo formation
   a. Aperture beam at multiple (+)electrostatic quads (ESQ), then if necessary
   b. Replace quad magnets to smoothly continue ESQ lattice
   c. Study and improve ion injector
2. Reduce e-cloud induced beam degradation to negligible level (less halo, improved vacuum)
3. Reduce gas-cloud induced beam degradation to negligible level
4. Longitudinal dynamics (beam ends and emittance budget)
5. Negative ions to eliminate e-cloud issues, possibly lower emittance
6. Cause of Pulse Line Ion Accelerator (PLIA) break down
7. Suppressing electrons and gas in unneutralized drift compression, but with neutralized final focus
8. Time dependent focal spot from beam energy variation

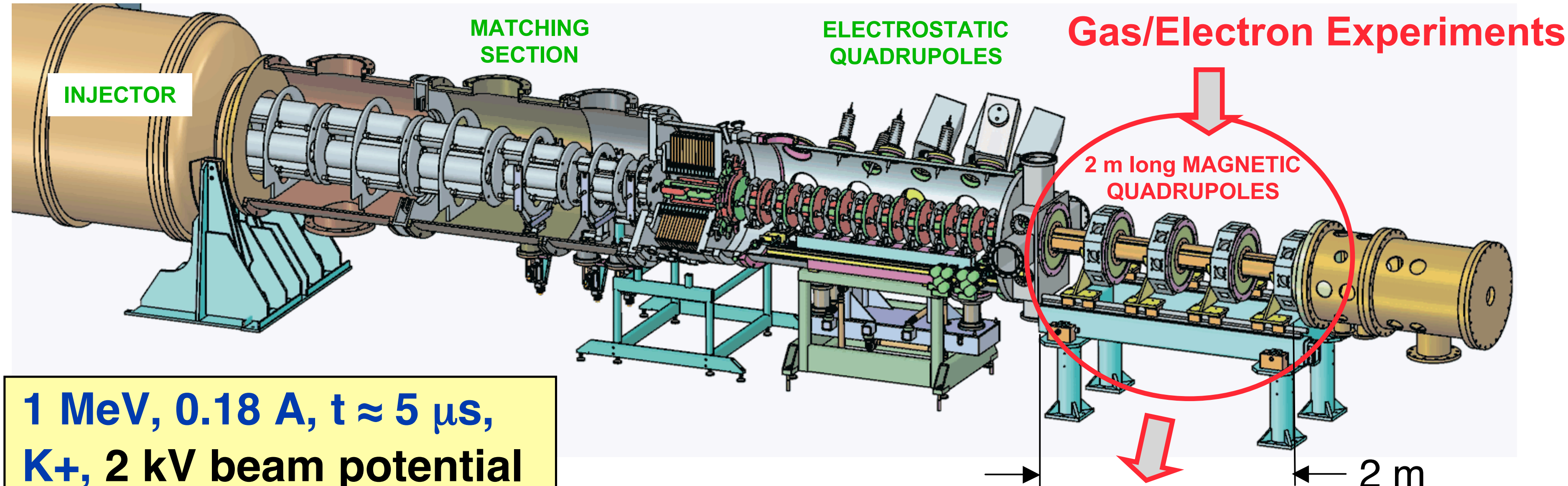
Prioritization of high-brightness beam transport issues – longer term

9. Multiple beam interactions in driver
10. Multiple beam interactions in chamber

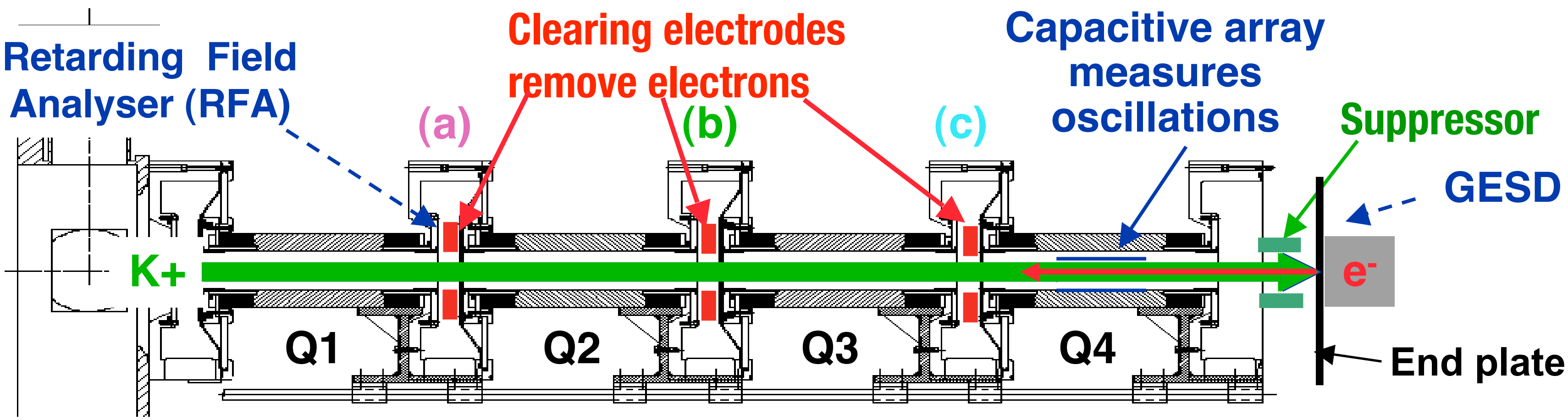
New capabilities for e-cloud & relevant to halo growth

- Reconstructed beam distributions
- Measured scaling of gas desorption coef. with ion angle & energy
- Measured & modeled scaling (ion angle & energy) of e- emission coef.
- Simulate transport of e- & gas and interactions with beam
- Multiple methods that increase code speed by orders of magnitude – 3-D self-consistent simulations feasible.
- Developed diagnostics to measure details of e- & gas within beam
- Simulations point way to "halo-free" injector, some exper. validation
- Demonstrated aperturing of beam with biased electrodes to control e-emission, but halo increased:
  - Due to ion reflection, desorbed gas interaction, …?
  - Mitigations: low-oxide metal, larger diameter to scrape less, closer to knife edge to reduce scattering, NEG coating(?), run hot, …

The High Current Experiment (HCX) is a small, flexible heavy-ion accelerator (at LBNL)



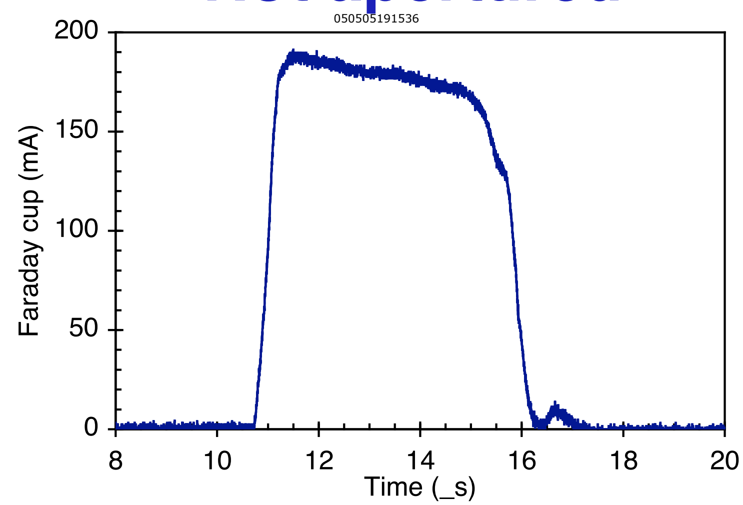
1 MeV, 0.18 A, t ≈ 5 μs,
K+, 2 kV beam potential

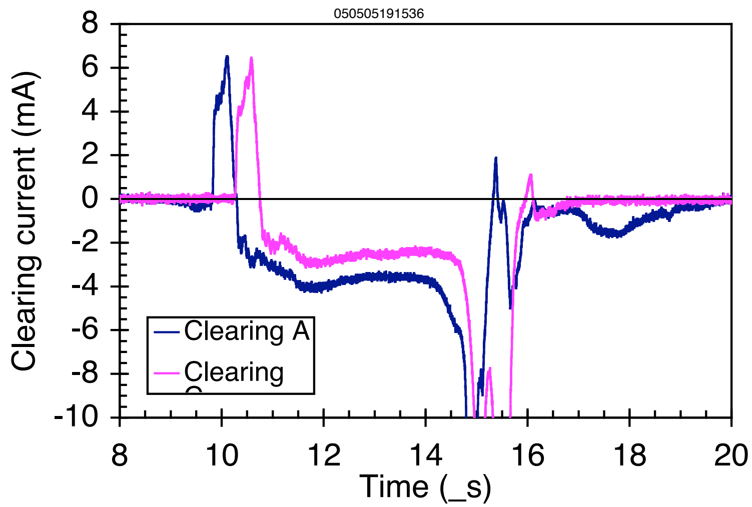


Quadrupole magnets Q1 - Q4 for beam transport

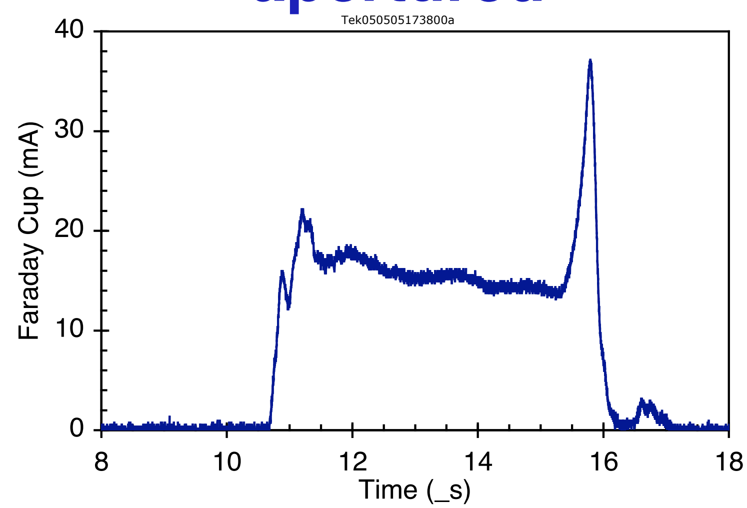
HCX clearing current ~constant without aperture, grows in time with aperture – ionization of gas desorption?

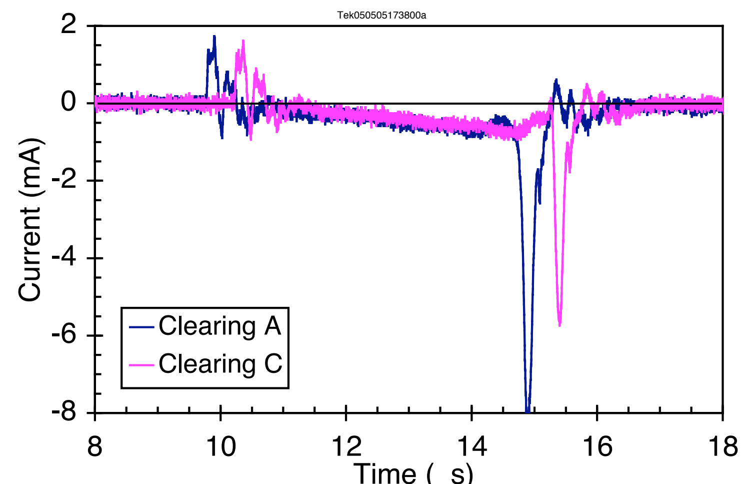
Not apertured



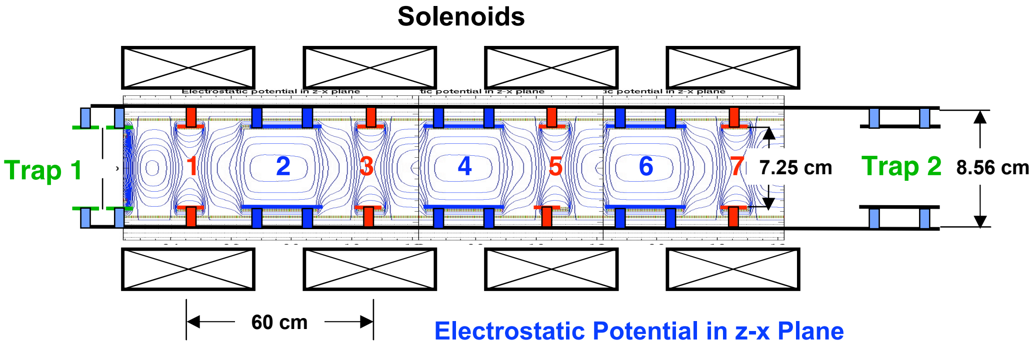


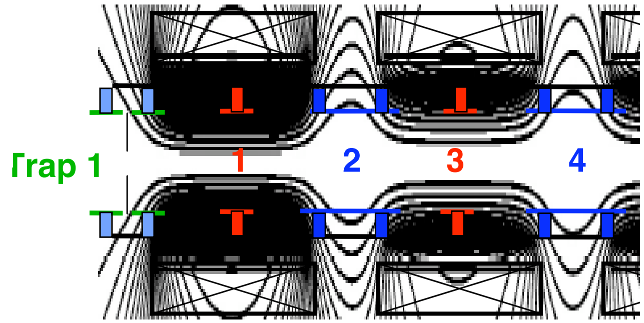
apertured



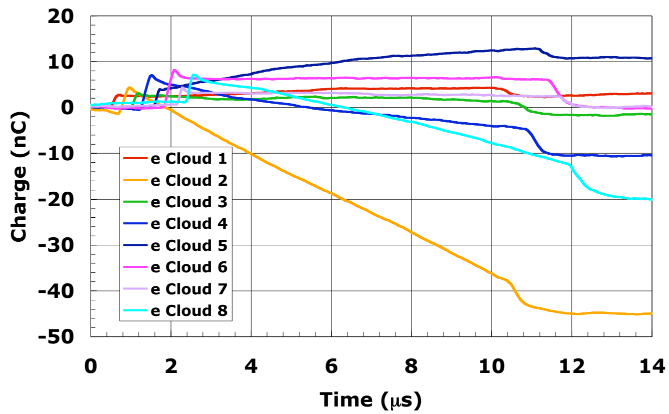


NDCX – e-Trap and aperture are the main sources of e-

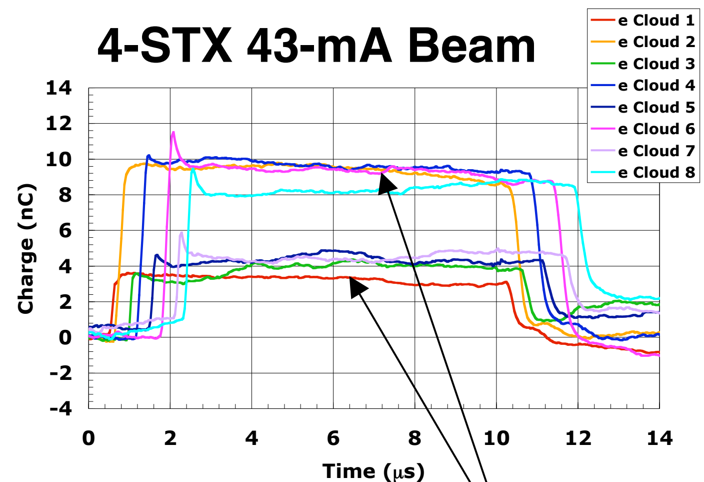




4-STX Apertured 26-mA Beam



4-STX 43-mA Beam

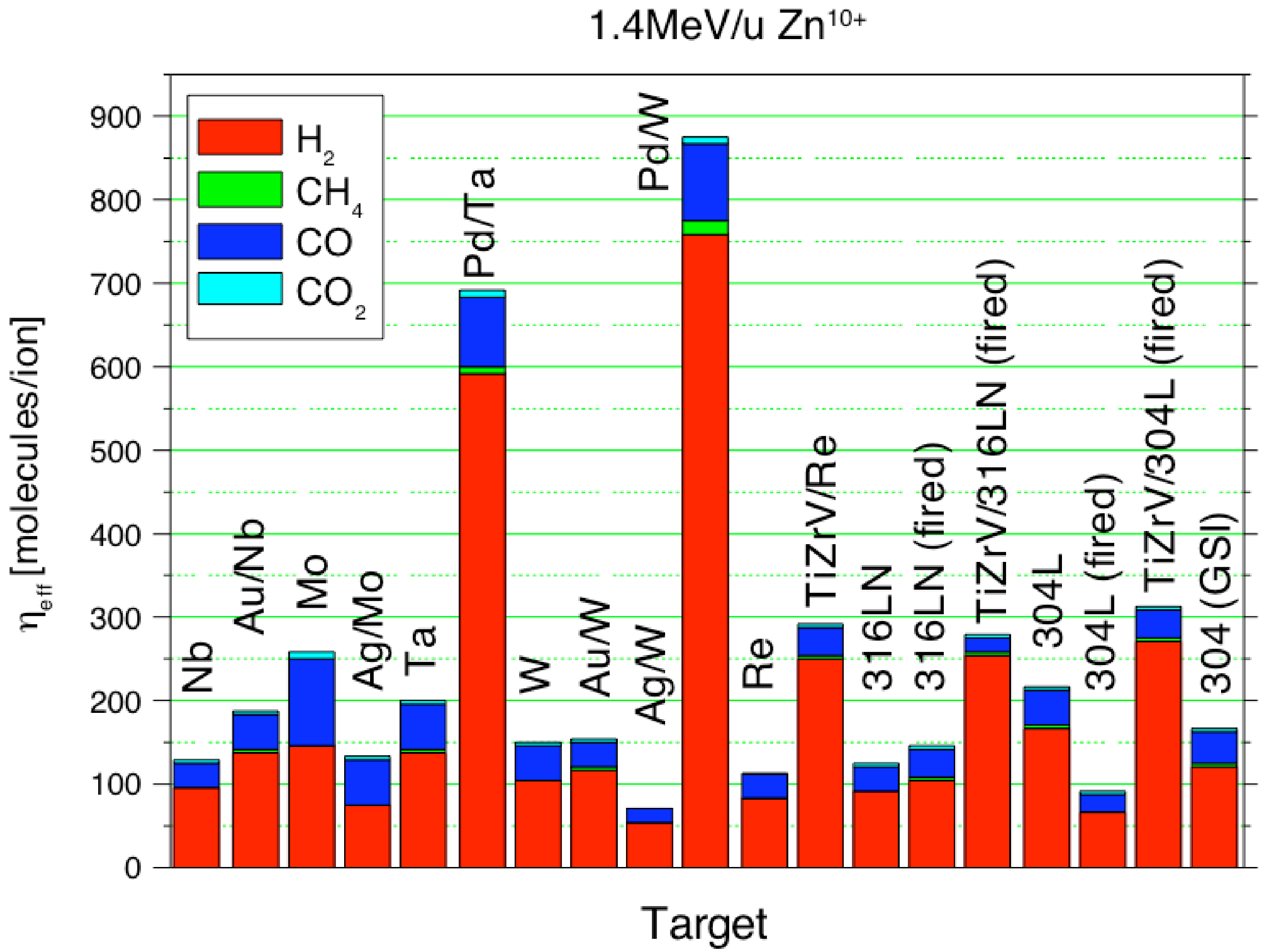


	43-mA beam	26-mA beam
Diagnostic	Charge (nC)	Charge (nC)
e Cloud 1	-0.51	1.39
e Cloud 2	-1.06	-41.08
e Cloud 3	0.35	-1.70
e Cloud 4	-0.94	-11.24
e Cloud 5	-0.06	9.00
e Cloud 6	-2.22	-1.50
e Cloud 7	-0.85	-1.37
e Cloud 8	-0.35	-18.69
Total Charge (nC)	6.33	85.97

Collected capacitive charge demonstrates dependence on electrode length

Magnetically connected to aperture/e-trap – 40x current

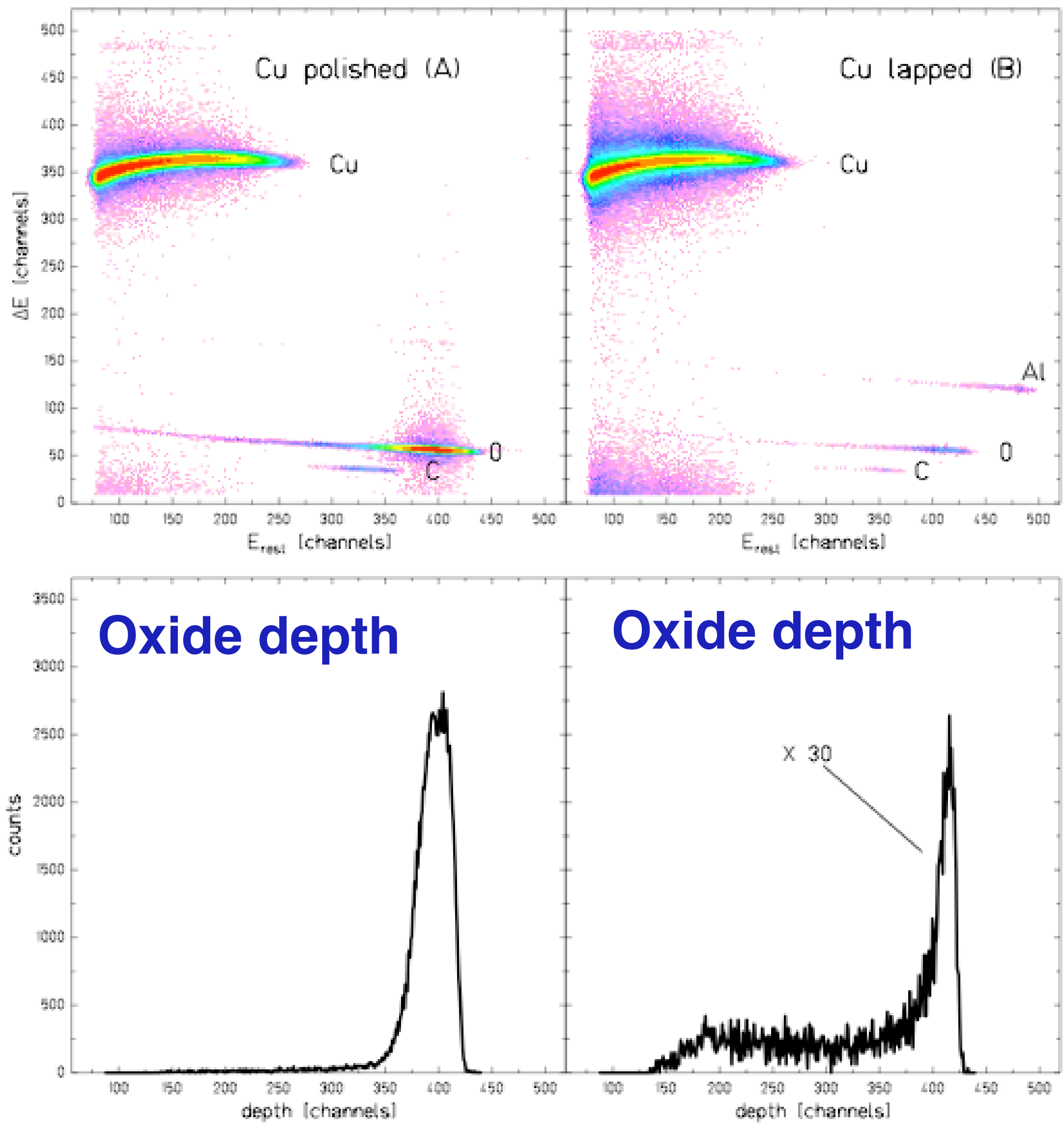
Desorption varies with material



Mainly desorbed gases are H_2 and CO.

targets provided by

Desorption increases with oxide layer



Left- Heavy oxide layer

- **Desorption 1500 ⇒ 80 after $3\text{x}10^{12}$ Xe^{21+} ions**

Right-Light oxide layer

- **Desorption 300 ⇒ 15**

Gold coated-[not shown]

- **Desorption 200 ⇒ ~20**