Combination of Scanning Probe Microscope and X-rays for Detection of Electrons

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Scientific Cases

Nano system

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Topological information

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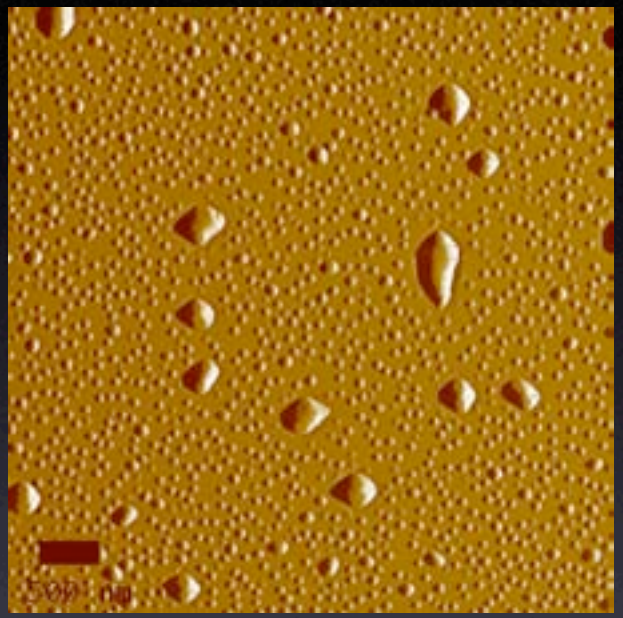
Chemical information
Electronic information

Force interaction
Nano-manipulation

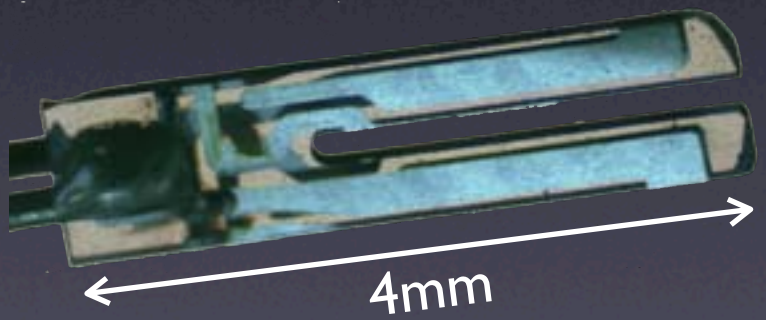
X-rays needed



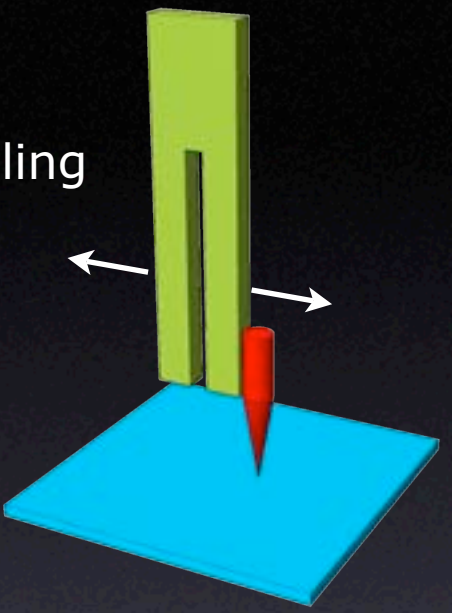
Tip surface distance control

Tuning Forks:
Piezo-electric
Q Higher than 10 000 without any tip
Allow very small amplitudes < 1nm
No laser

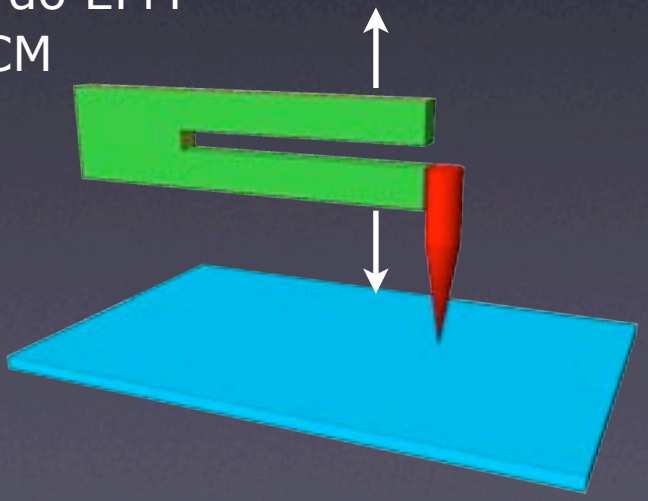
A tip must be glued



a. Parallel
- Weak capacitive coupling
- Possibility to do SCM
- No possibility of EFM

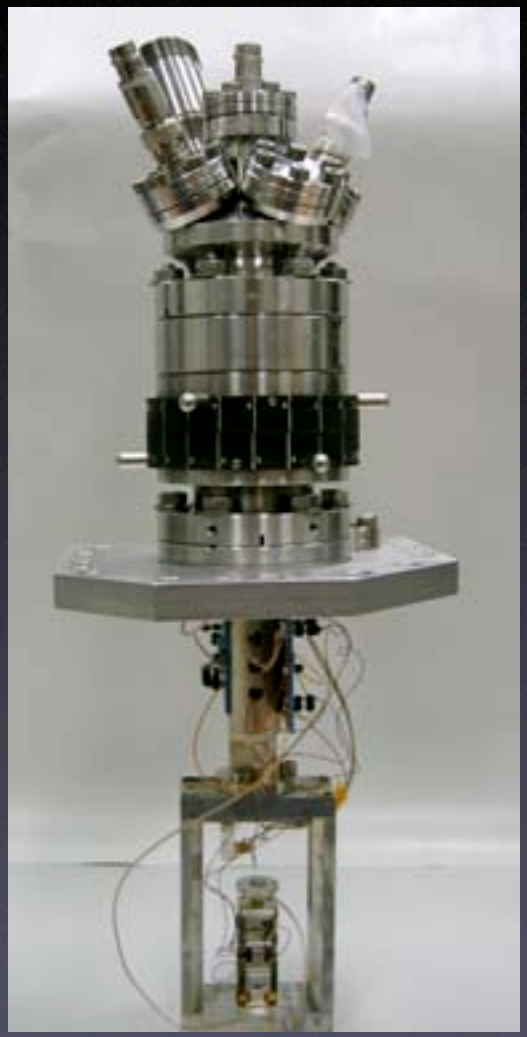


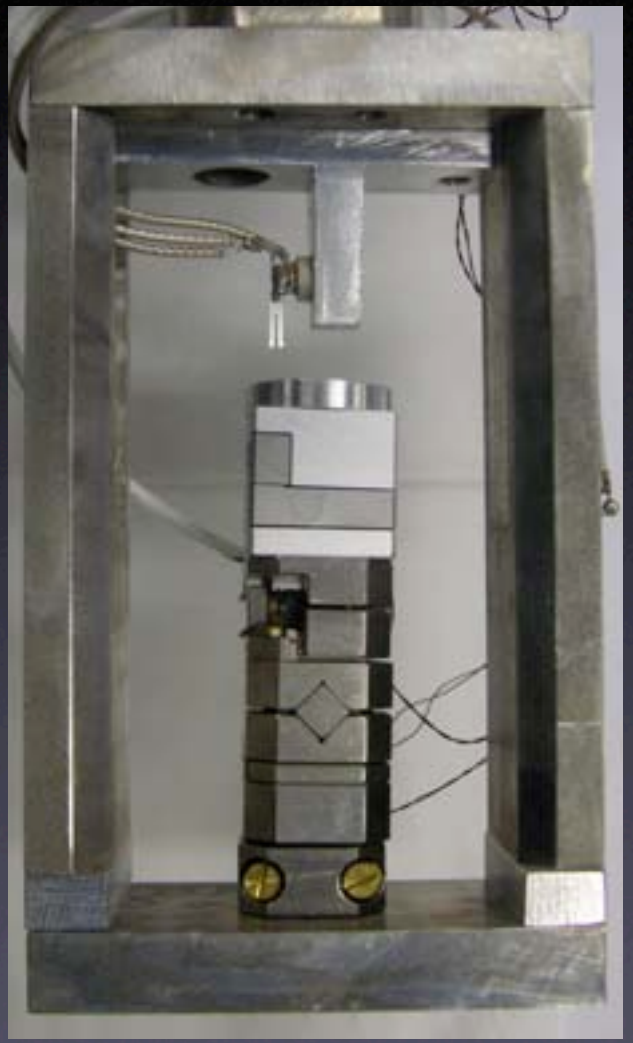
b. Perpendicular
- Good capacitive coupling
- Possibility to do EFM
- As well as SCM



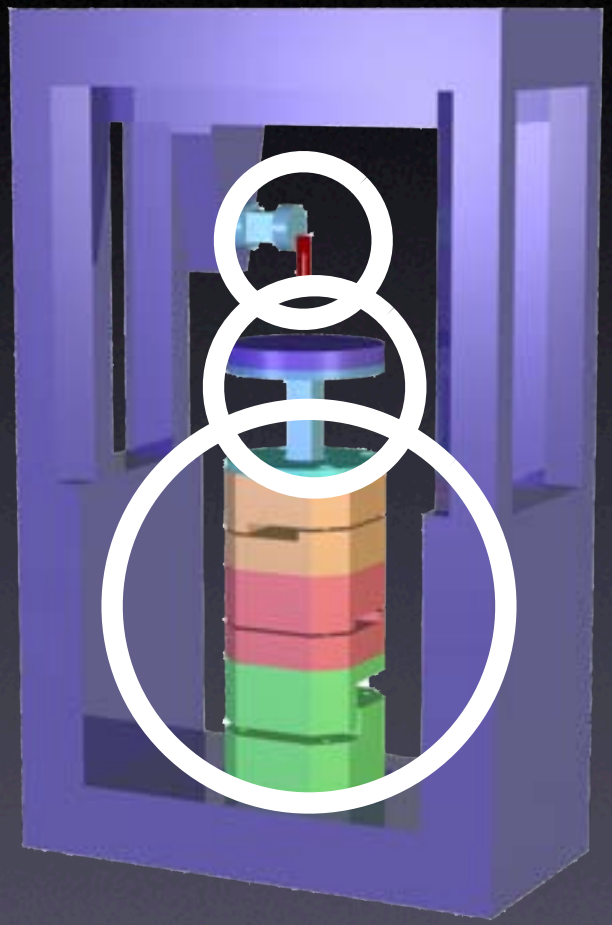
Distance regulation:
frequency shift - PLL regulation+PID

Setup





Microscope

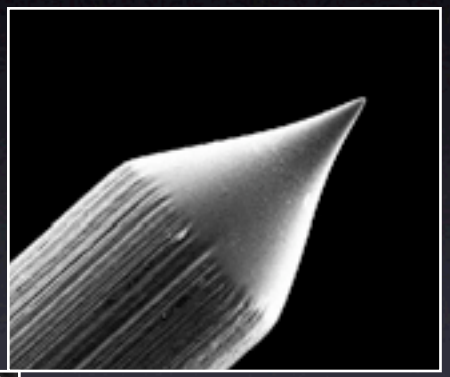


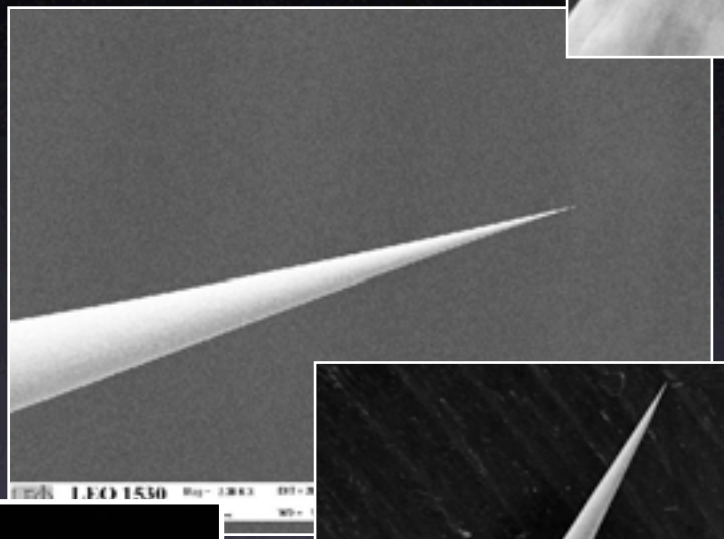
Tuning Forks system

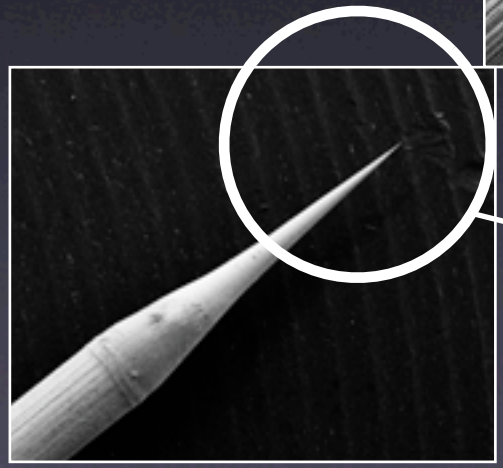
XYZ direction fine movement
(Travel:9μm, Res: 0.02nm)

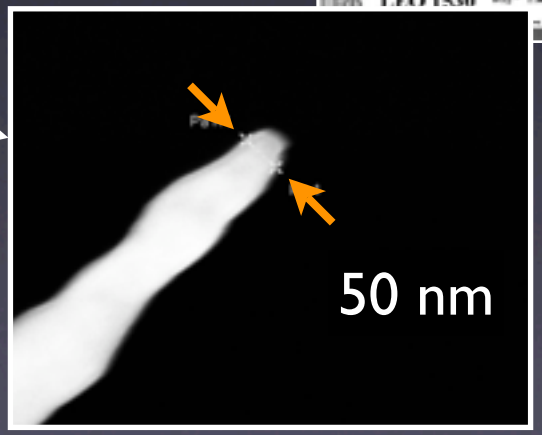
XYZ direction coarse approach
Attocube Systems
(Travel:4mm, Res: 25nm)

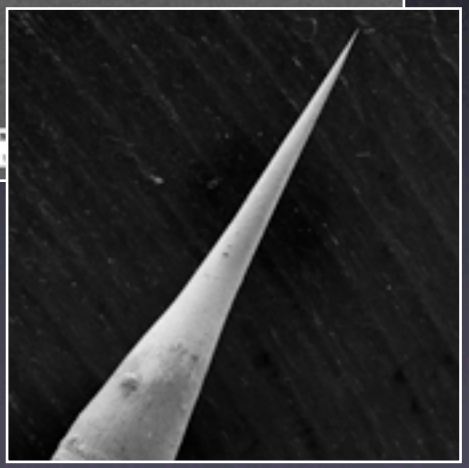
Metallic Tips









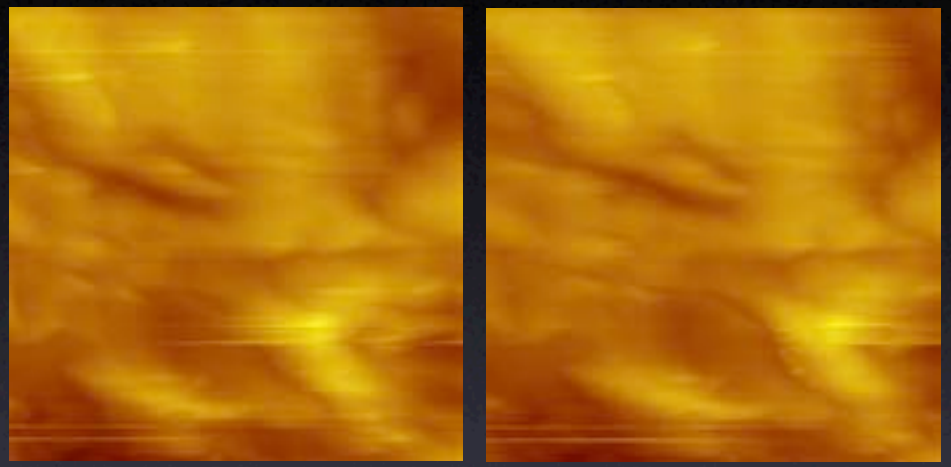


NaOH chemical etched

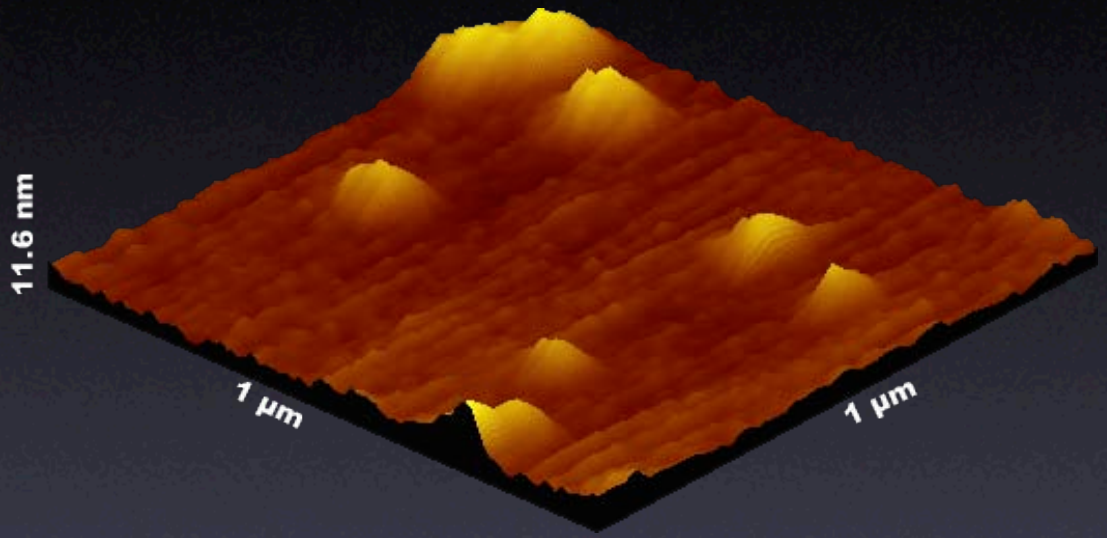
Curvature radius: 10-100nm

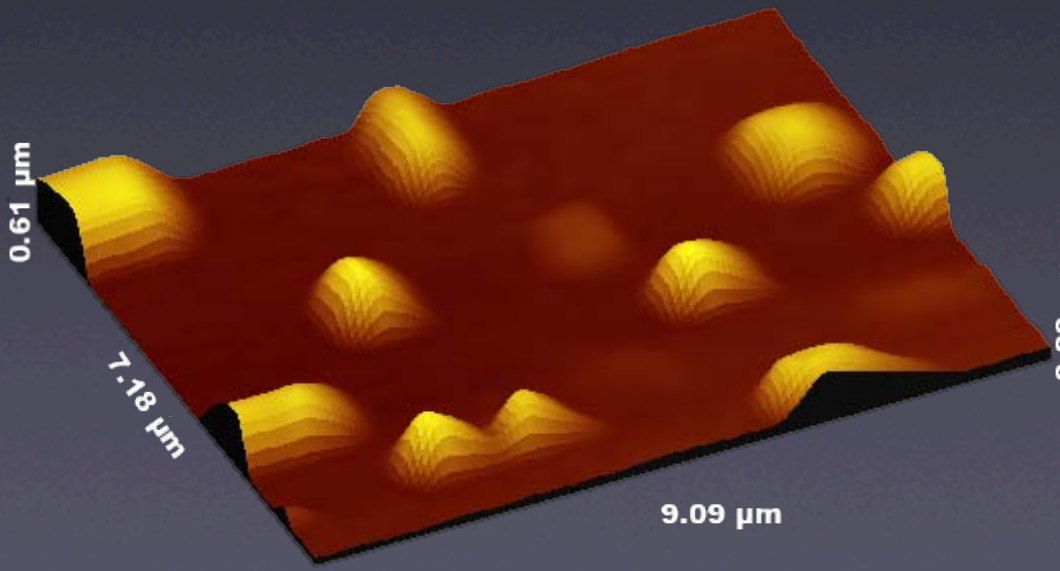
Images Capabilities

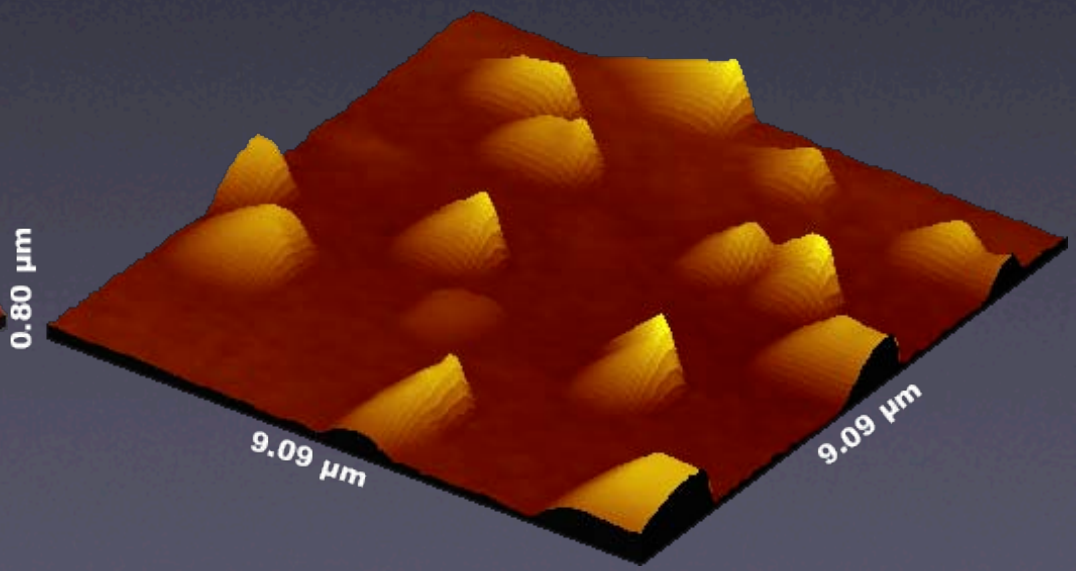
STM Images



AFM Images







Experiment I

Goal:
Photoelectron detection.
Detection chain validation.
Simulation - experience comparison

Method:
Faraday cup design.
Lock-in detection.

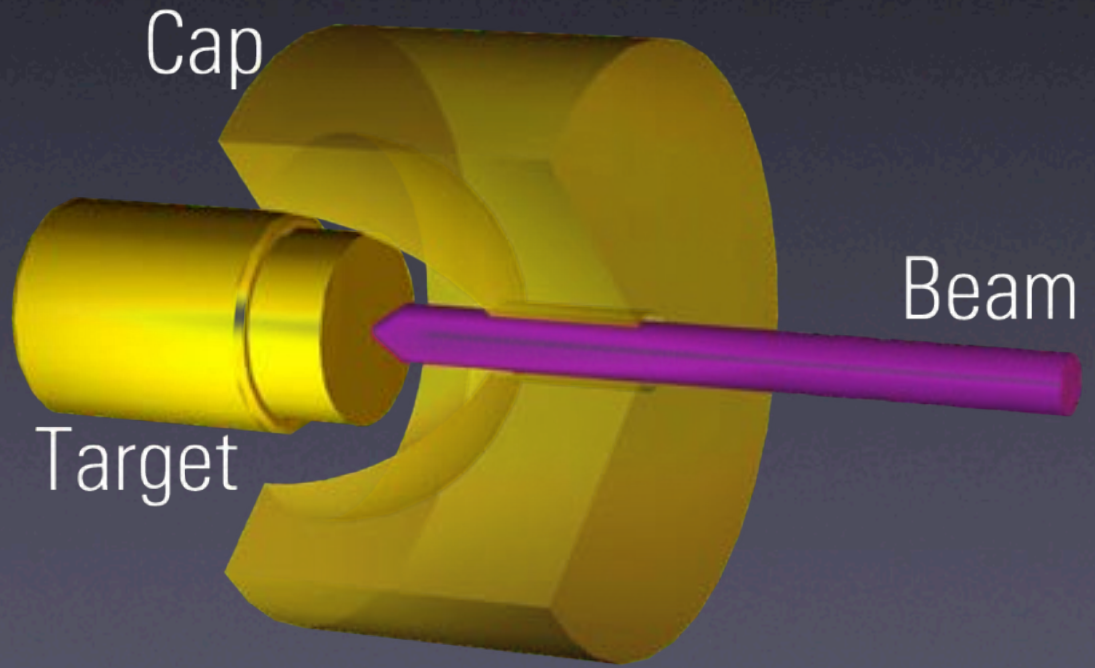
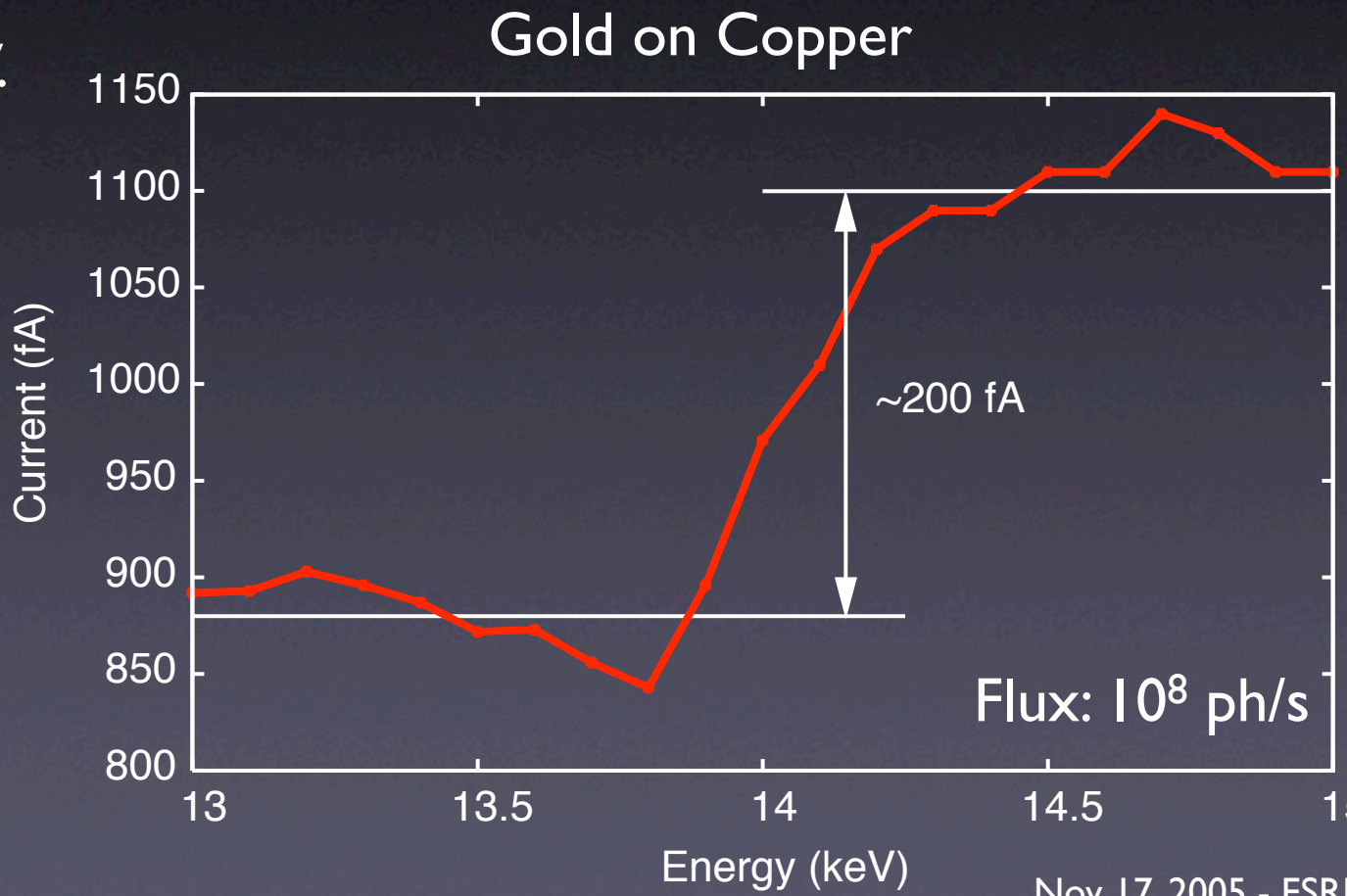


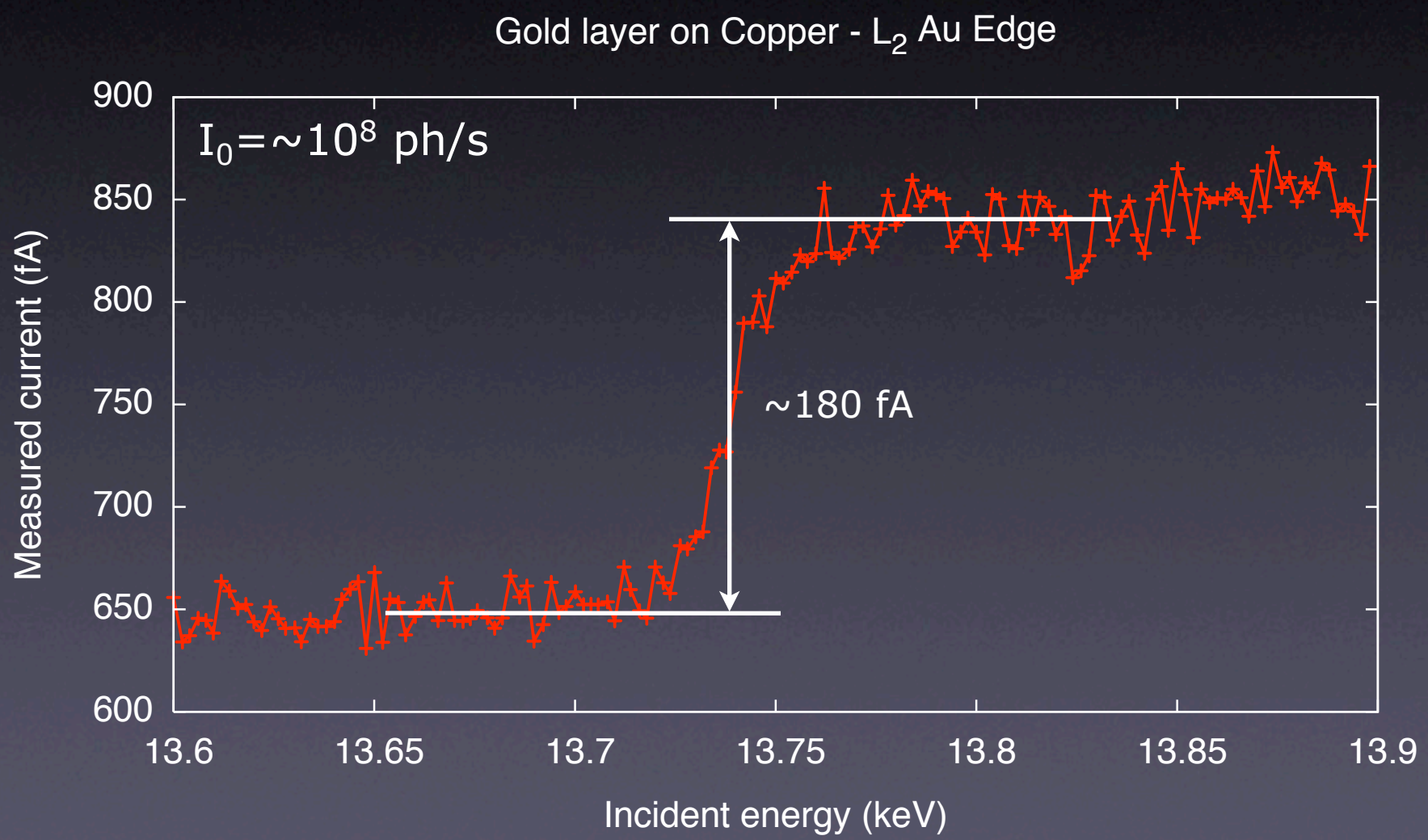
Photo-Electron Yield simulation

- Monte Carlo codes: EGS4 and Penelope
  Limitation: do not follow the slow electrons
  EGS4 >1keV
  Penelope >100eV.

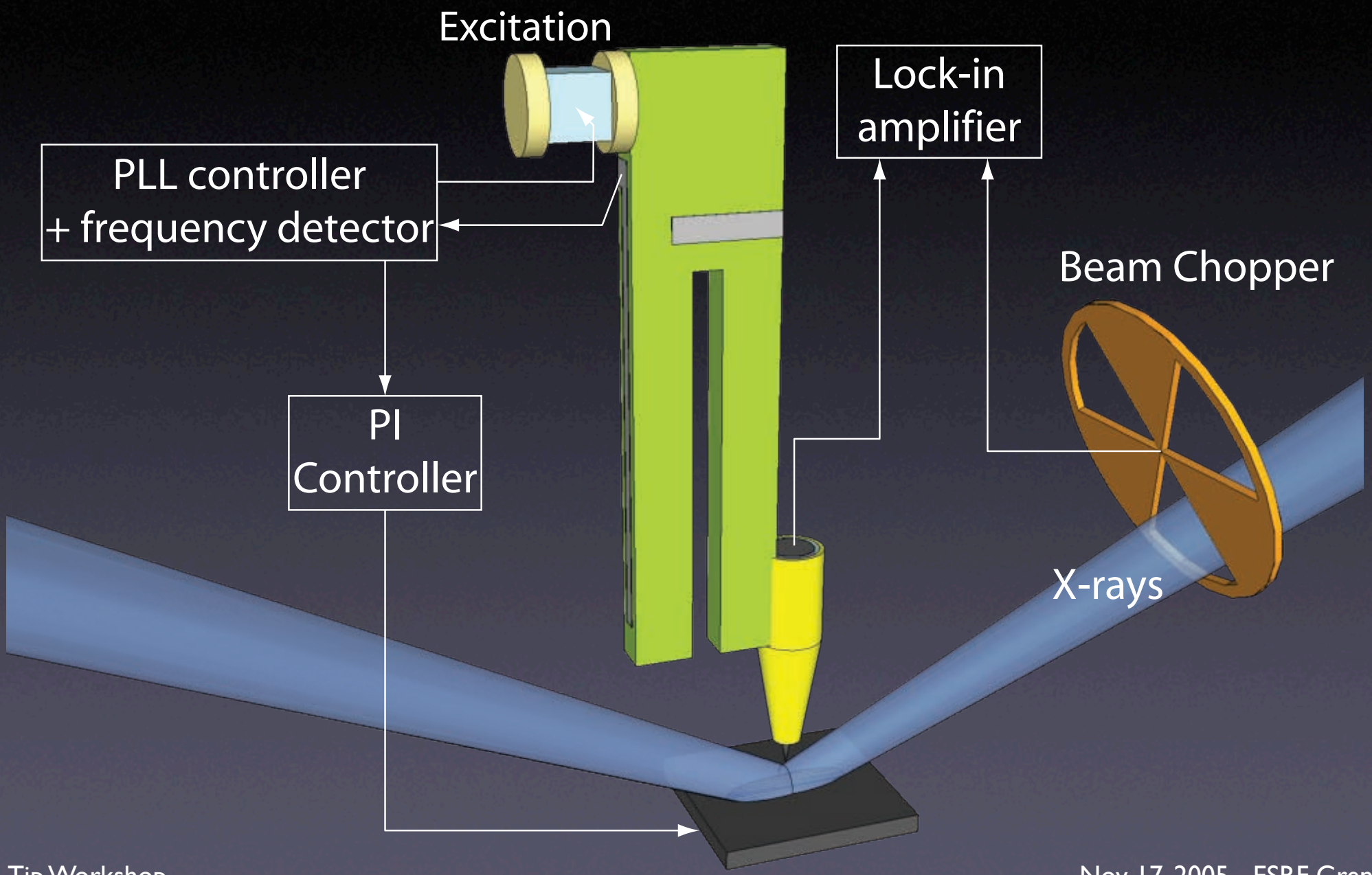


Experiment Results

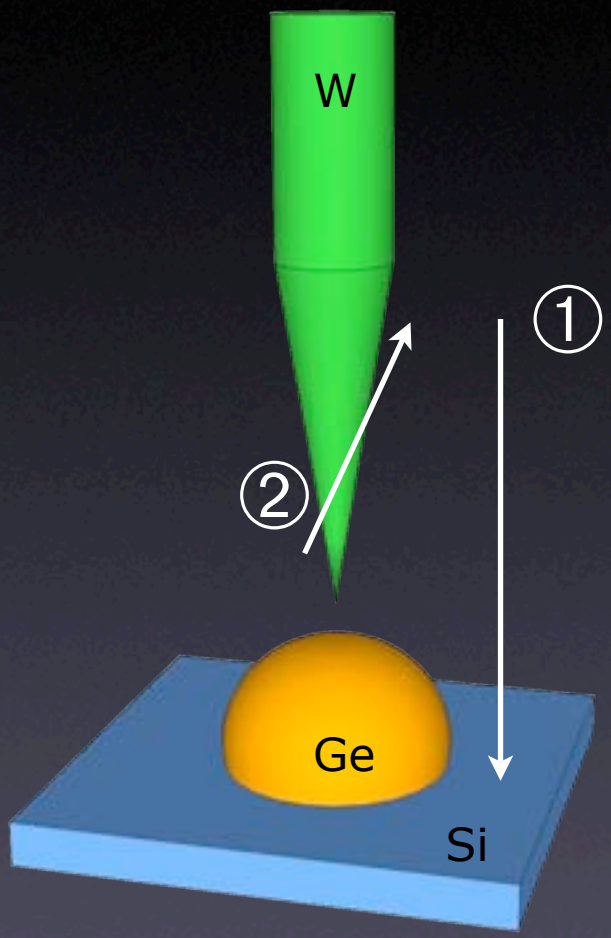
Experiment parameters:
Monochromatic Beam (1x3 µm)
BM05 - I_0=10^8 ph/s - E=13.7 keV (L_2 edge of Au)

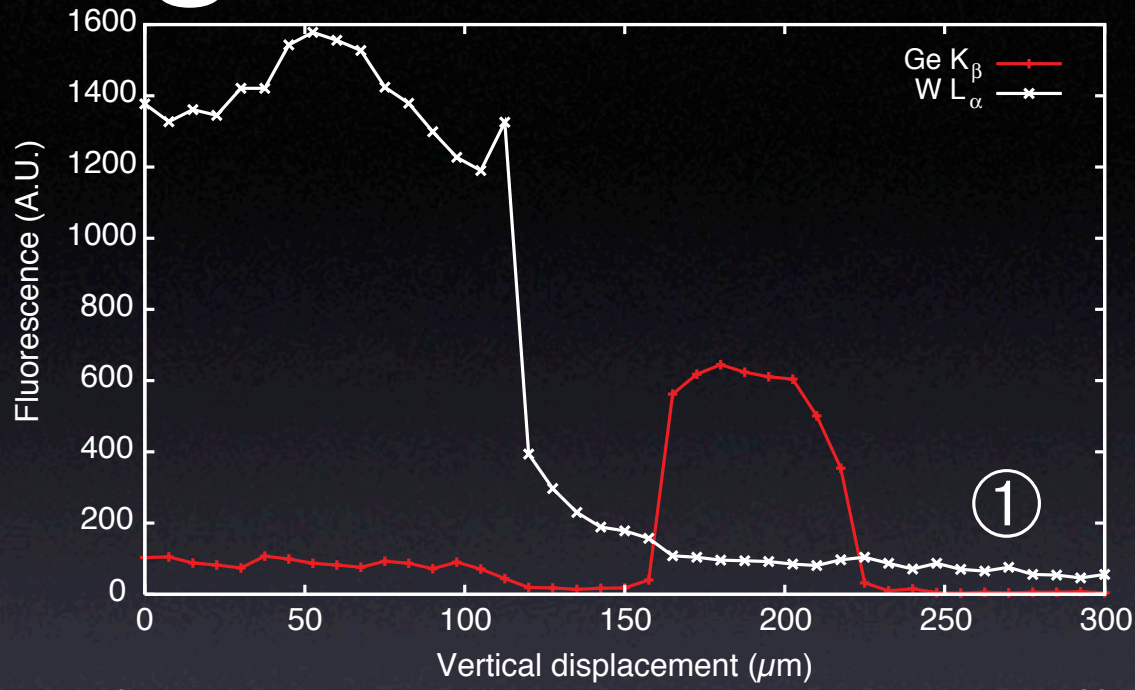


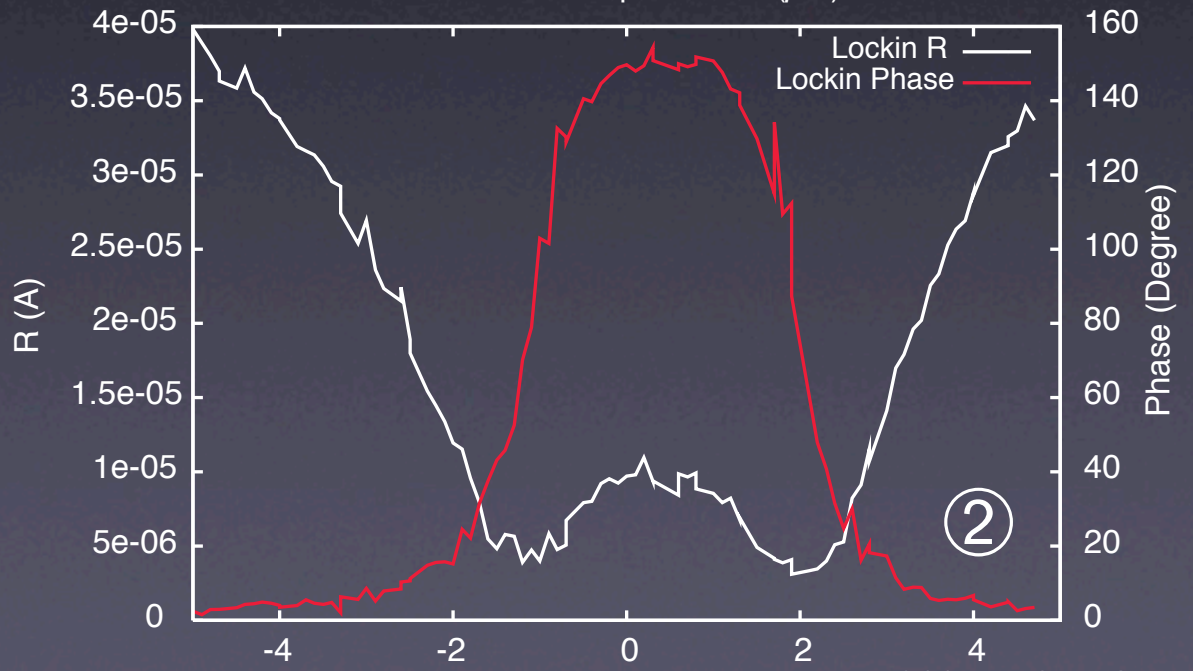
Experiment II



Tip Alignment







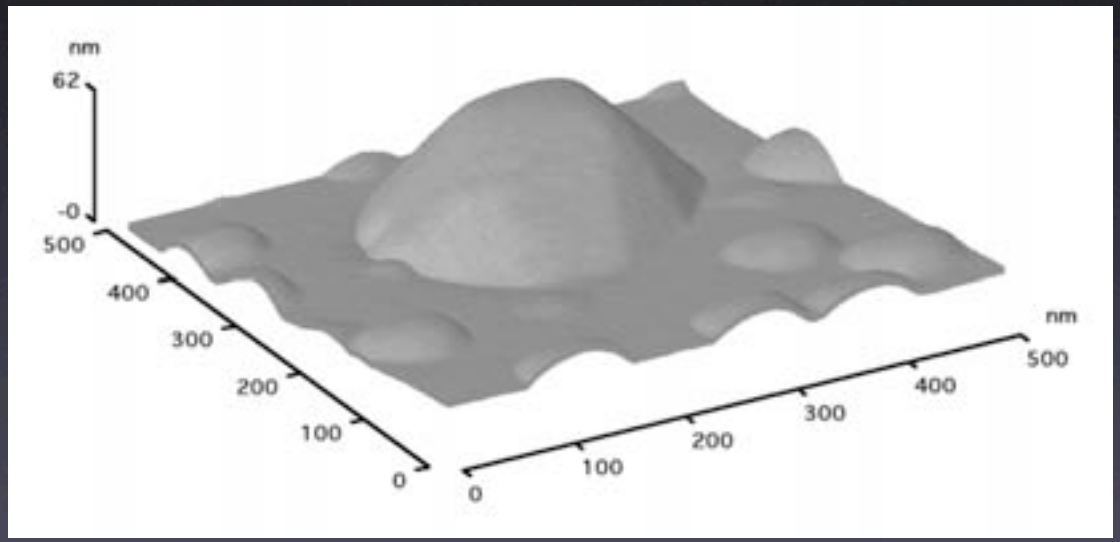
Ge K_β: 9.88 keV W L_α: 8.39 keV

Experiment Parameters

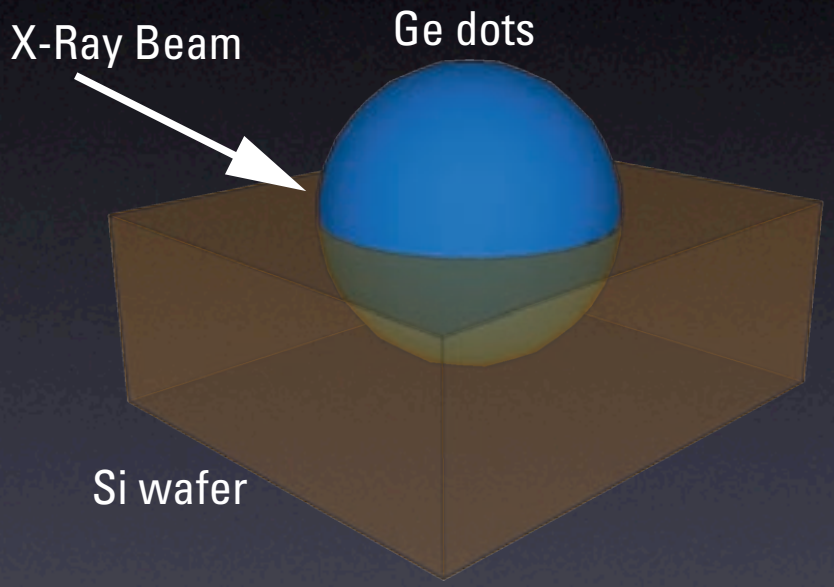
Setup:
ID22 Beamline ESRF
Focusing device: Kirk-Patrick Baez.

Beam characteristic:
Monochromatic Beam
Size: 2x3 μm^2
Incidence angle: ~5º
$I_0=6.10^{11}$ ph/s
E=11.1 keV (K edge of Ge)
Sample-Tip distance: ~10nm

Ge dots on Si



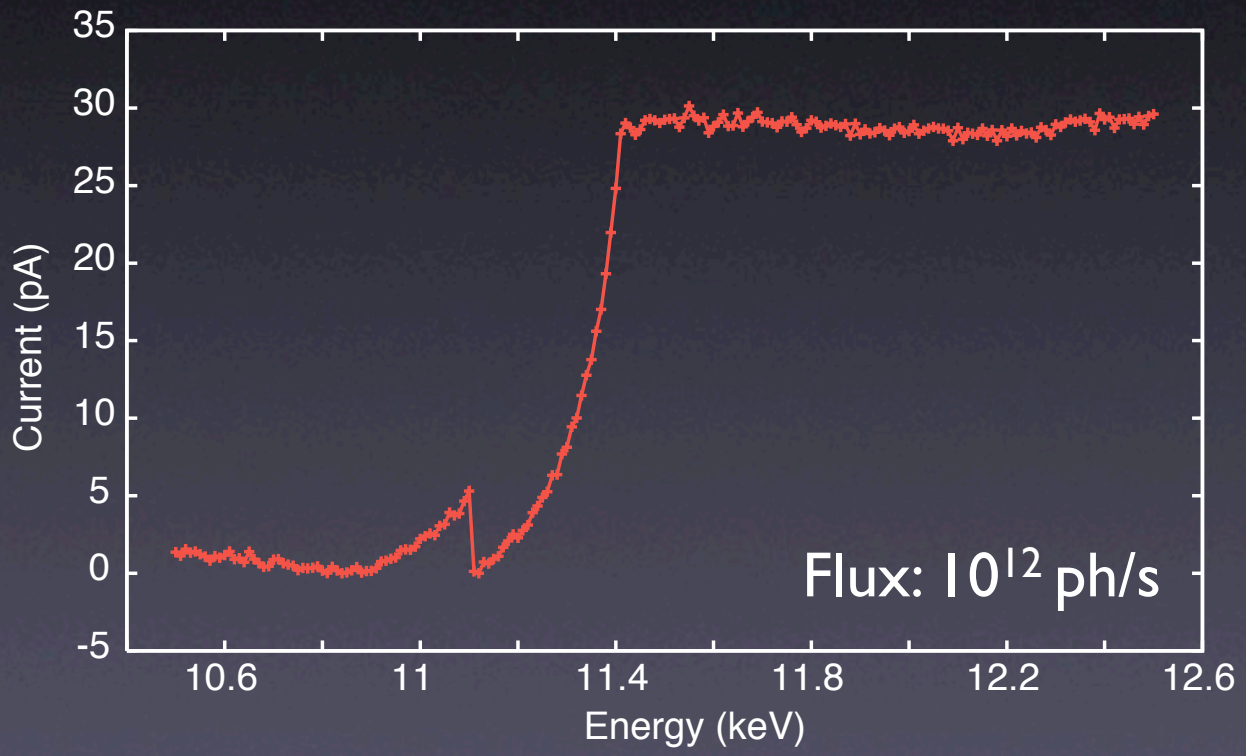
Simulation



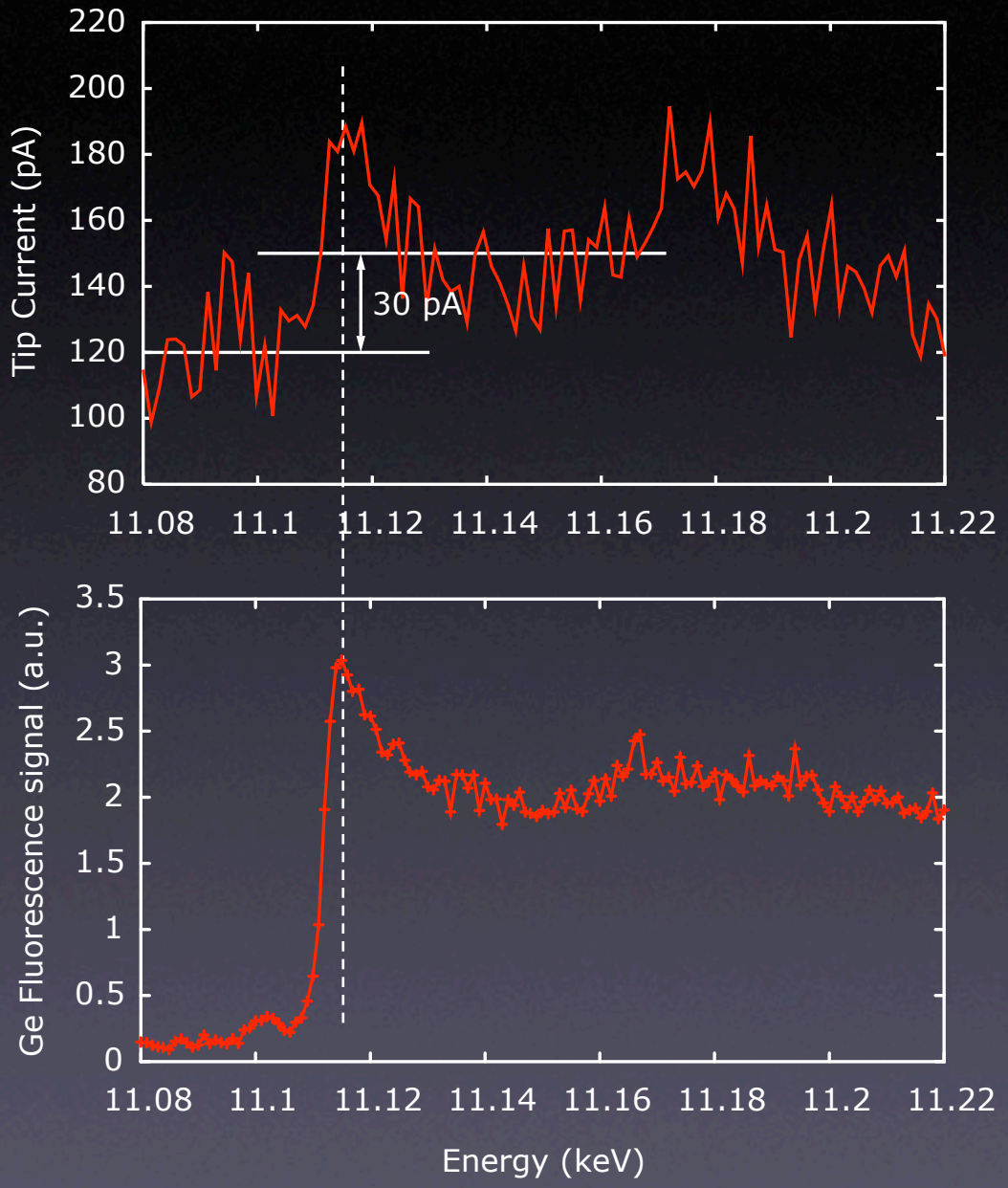
Ge dot R=36nm
Si layer l=10μm

Ge Dot on Si wafer

Code: EGS4



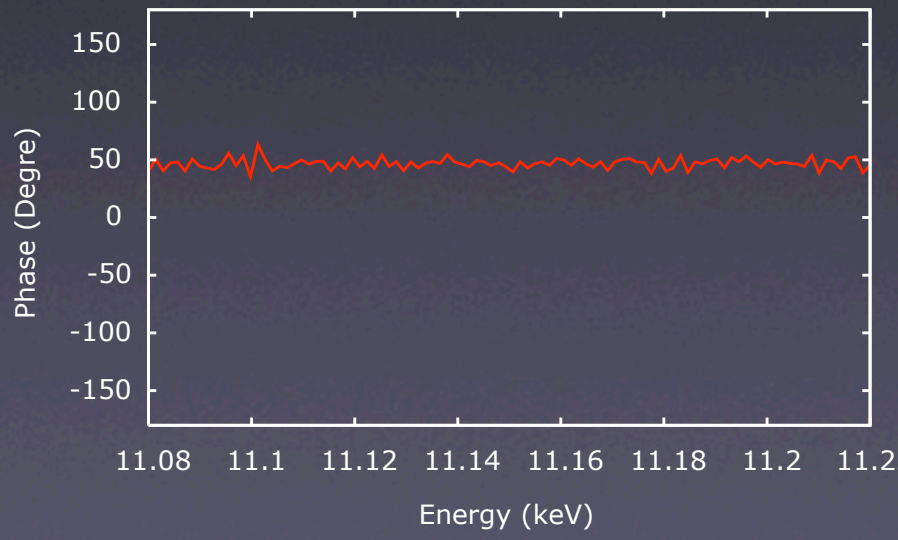
XANES



Simulation with EGS4 for Ge dots on Si: I_{jump}=28pA

AFM (sample/tip) regulation: 10 nm during the measure

Noise Level: few fA

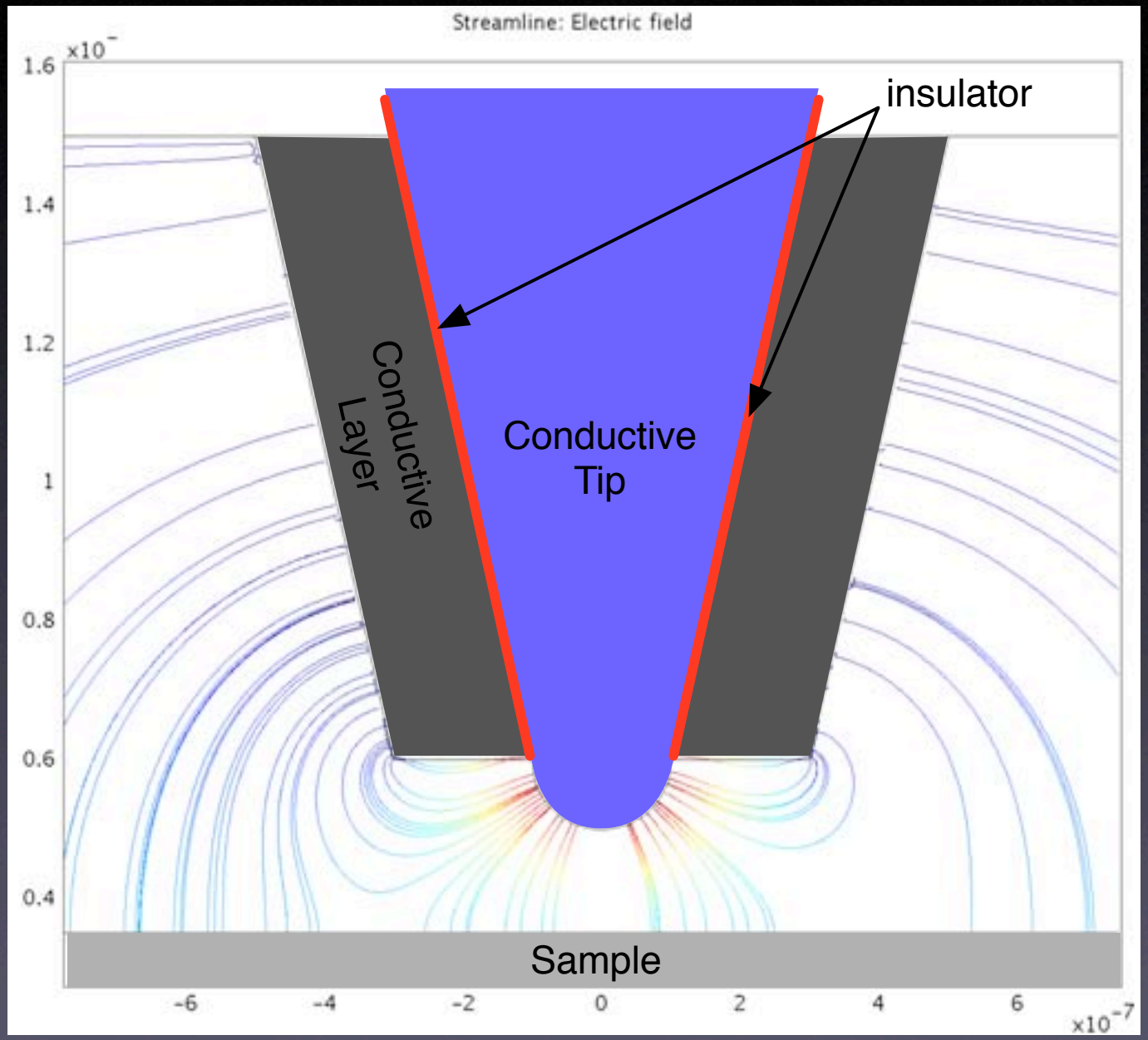


Conclusion

- A home built microscope compatible with X-rays synchrotron instrumentation.
- AFM-STM Imaging Capabilities
- We shows sensitivity to photo-excited electrons.

What Next

Coaxial Tips Why ?



Coaxial Tips development

Tungsten Wire (250µm),
Chemical Etched.

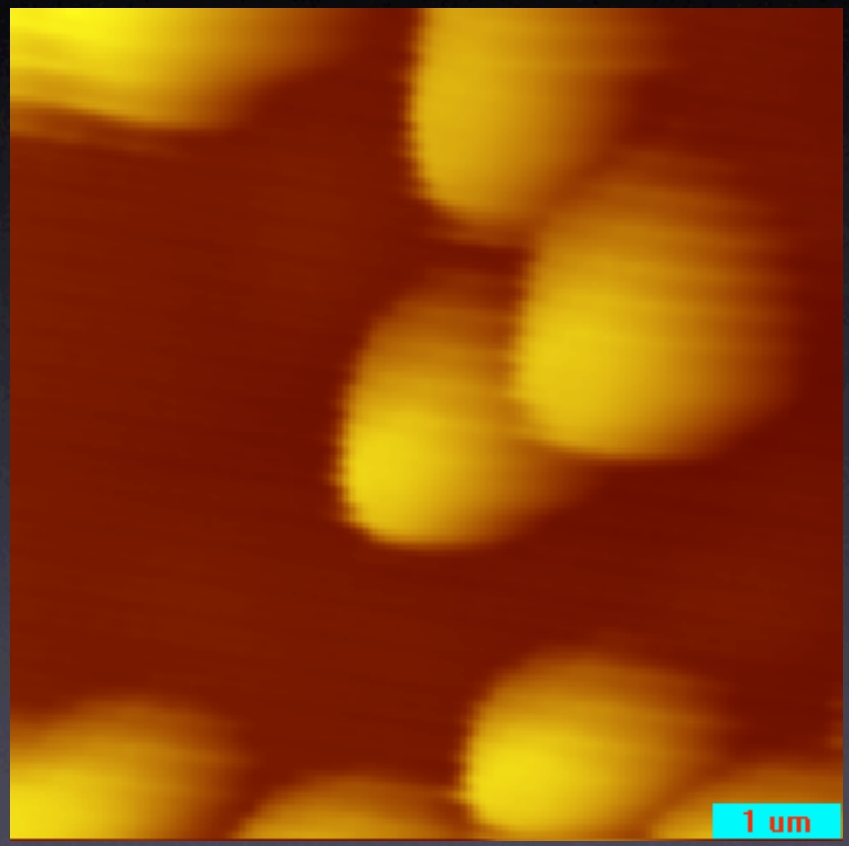
Parylene film (~1000Å)

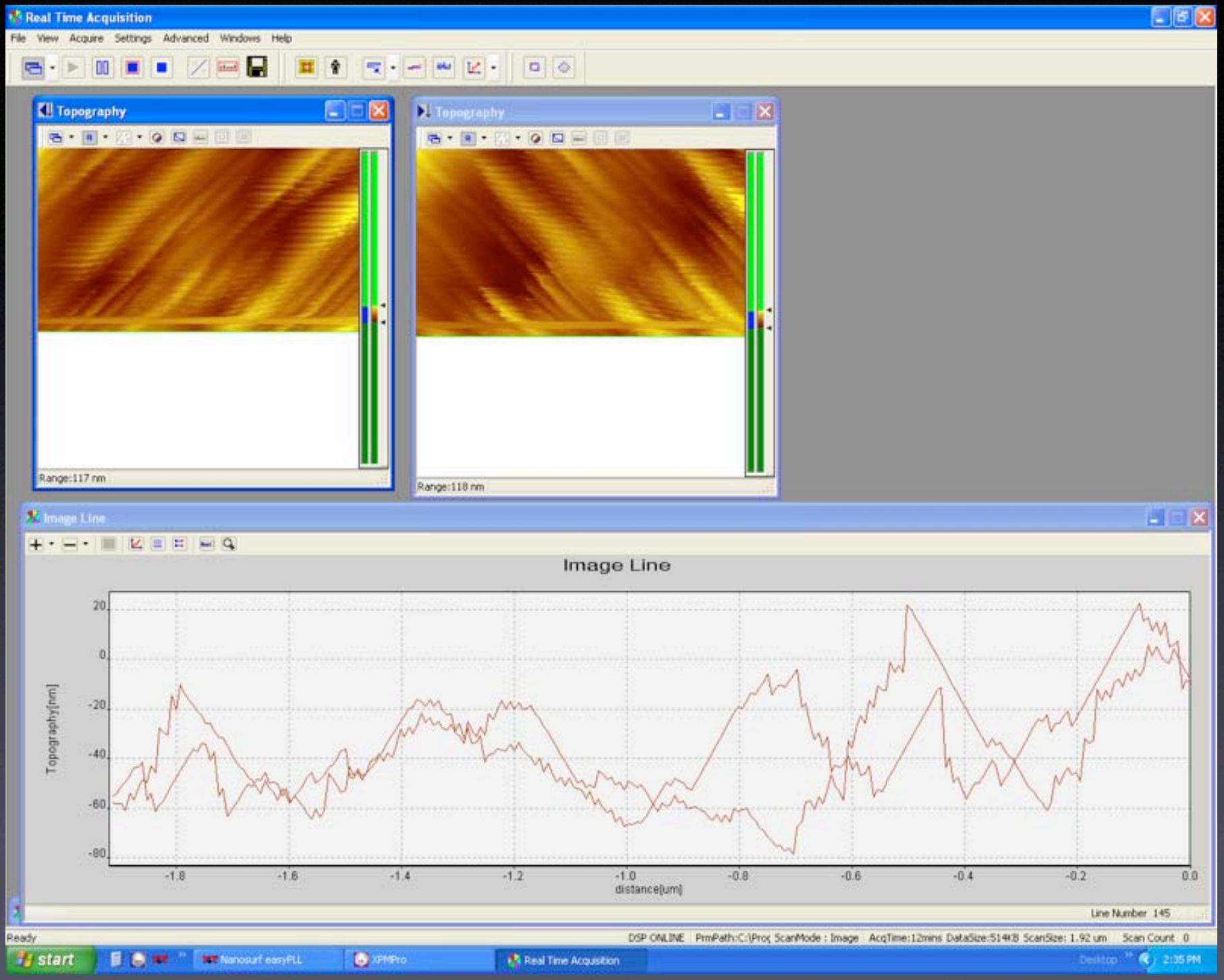
Gold layer (~1000Å)

End opening (FIB)

Other development

- Implementation on beamline
  - Imaging capability.
  - → Resolution: 50 nm.
- Noise problem:
  - Mechanical noise (Pump, ...)
  - Electronic Noise.
- Collaboration with ID1




Real Time Acquisition
File View Acquire Settings Advanced Windows Help
Topography
Range:117 nm
Topography
Range:118 nm
Image Line
Image Line
Topography[nm]
distance[um]
Line Number 145
Ready
DSP ONLINE PrmPath:C:\Proj ScanMode : Image AcqTime:12mins DataSize:514KB ScanSize: 1.92 um Scan Count 0
start
Nanosurf easyPLL
XPMPro
Real Time Acquisition

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