Ion Beam Analysis Today and Tomorrow

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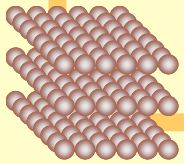
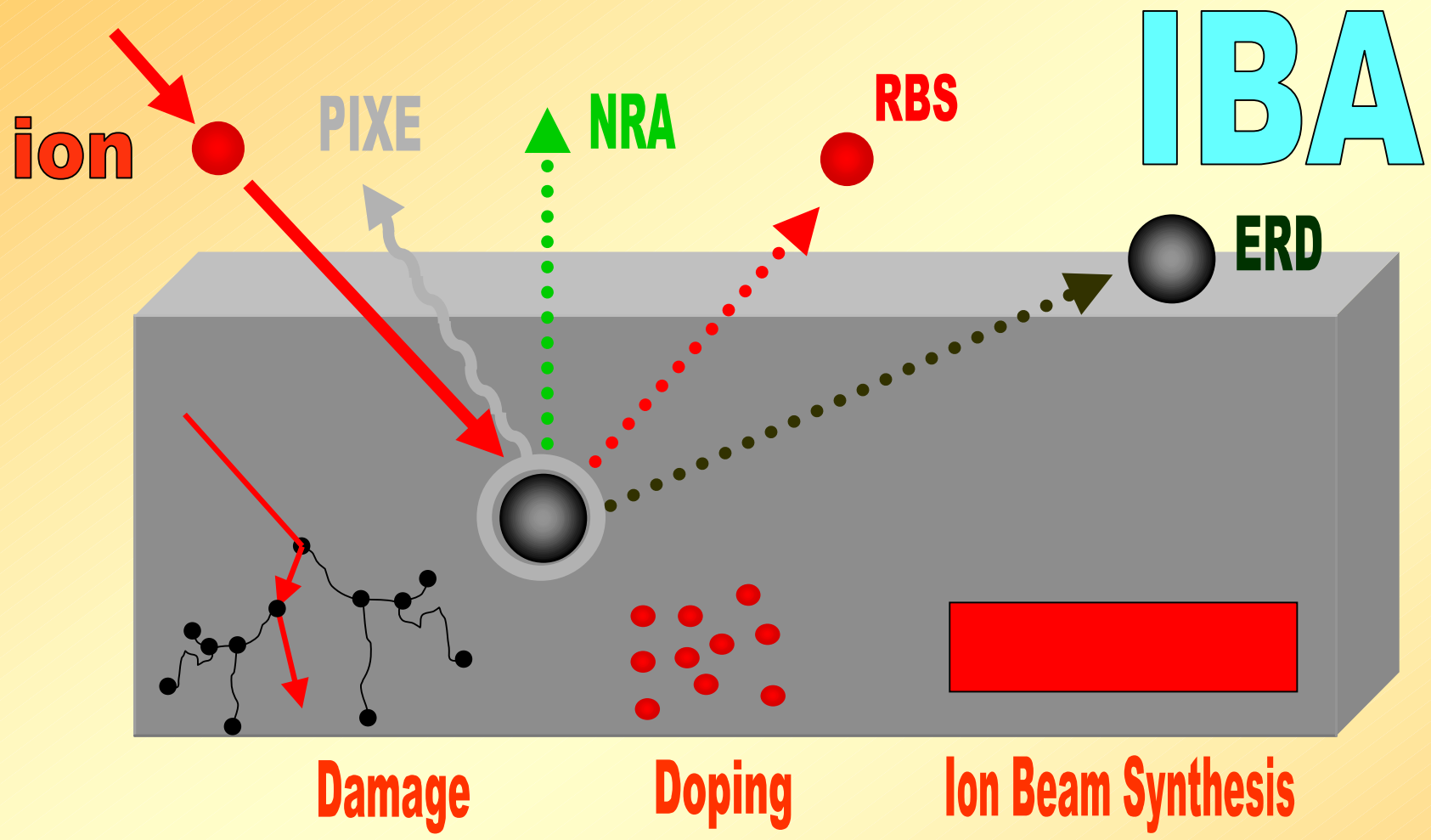
Research Institute for Particle and Nuclear Physics, Budapest



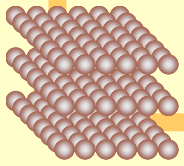
20+5 min



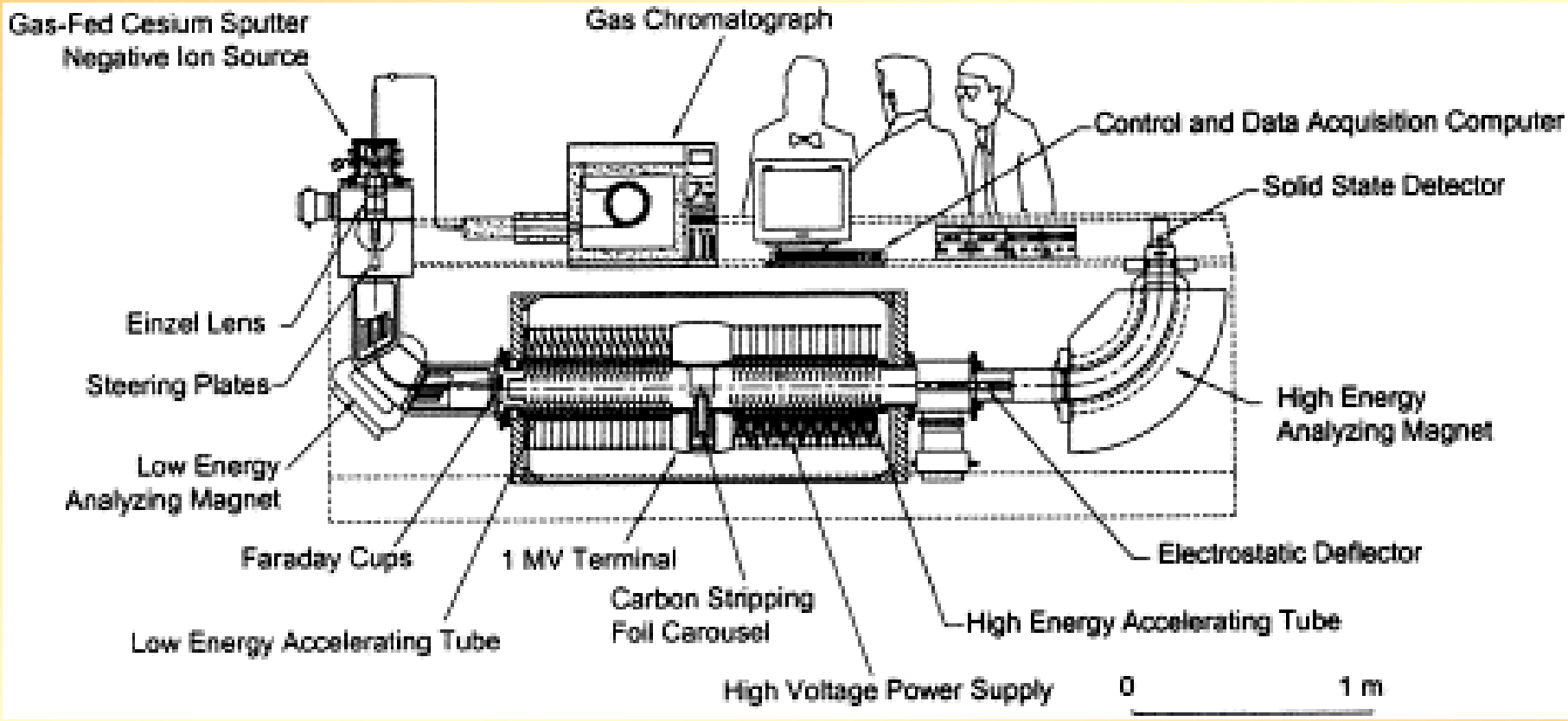
Ion Implantation

The incident beam

- **Accelerators**
  - **Used ones (5 MeV VdG, …)**
  - **Smaller and cheaper (200 keV FIB, …)**
  - **Special designs (3 MeV Tandem)**
- **Radioactive sources (planetary research)**
- **Beam size**
  - **Normal (1x1 mm^2)**
  - **Microbeam (1x1 μm^2)**

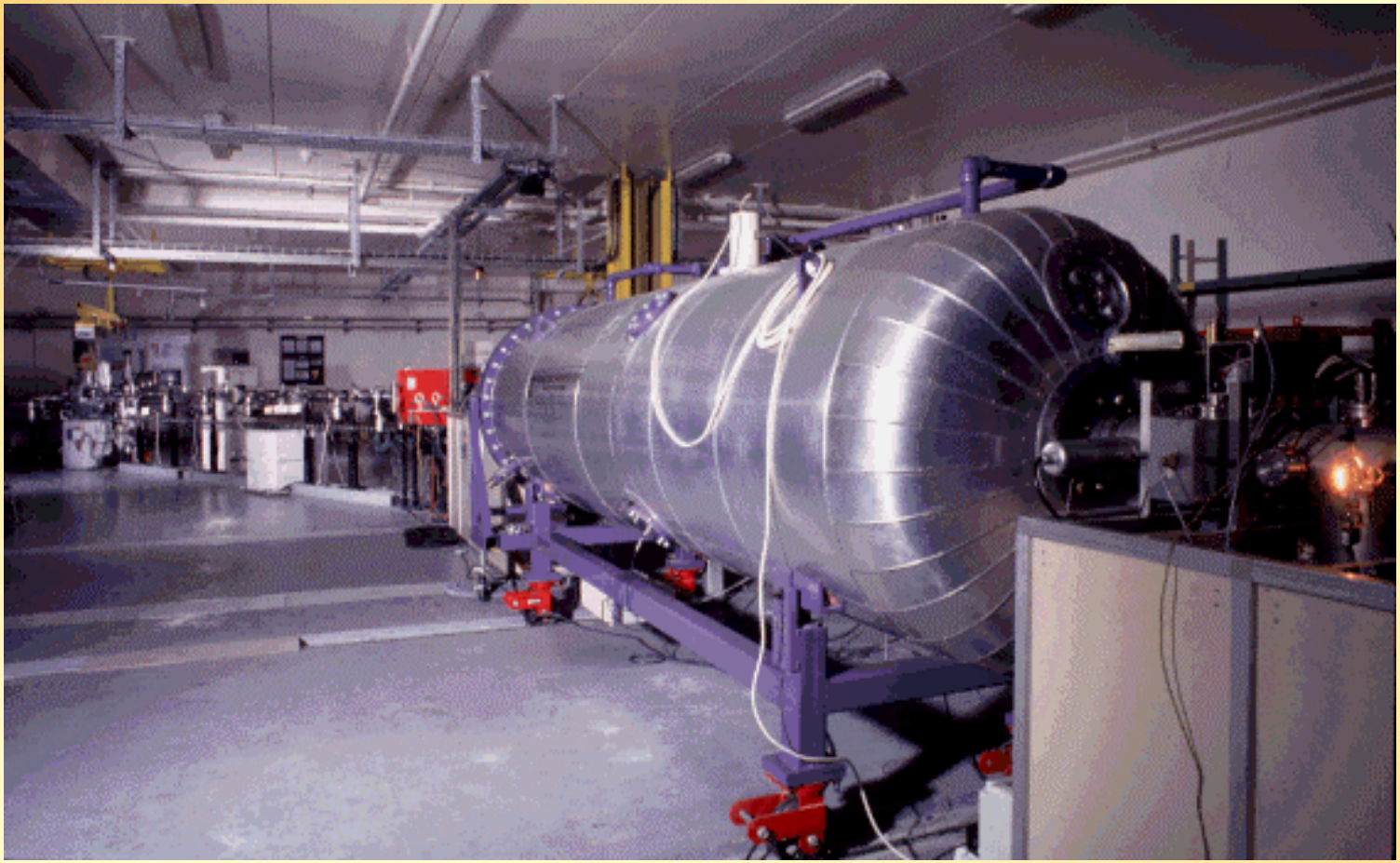


5 MeV Van de Graaff Accelerator (EG-2R) at RIPNP, Budapest



1MeV tandem at Cambridge (GC–AMS)

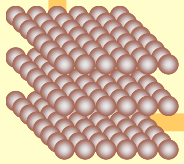
B. J. Hughey, Nucl. Instr. Meth. B 172 (2000) 40.



2MeV Tandem at Louvre Paris (AGLAE)

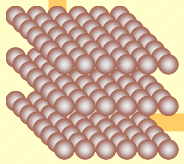
http://www.culture.gouv.fr/culture/conservation/fr/methodes/aglae.htm

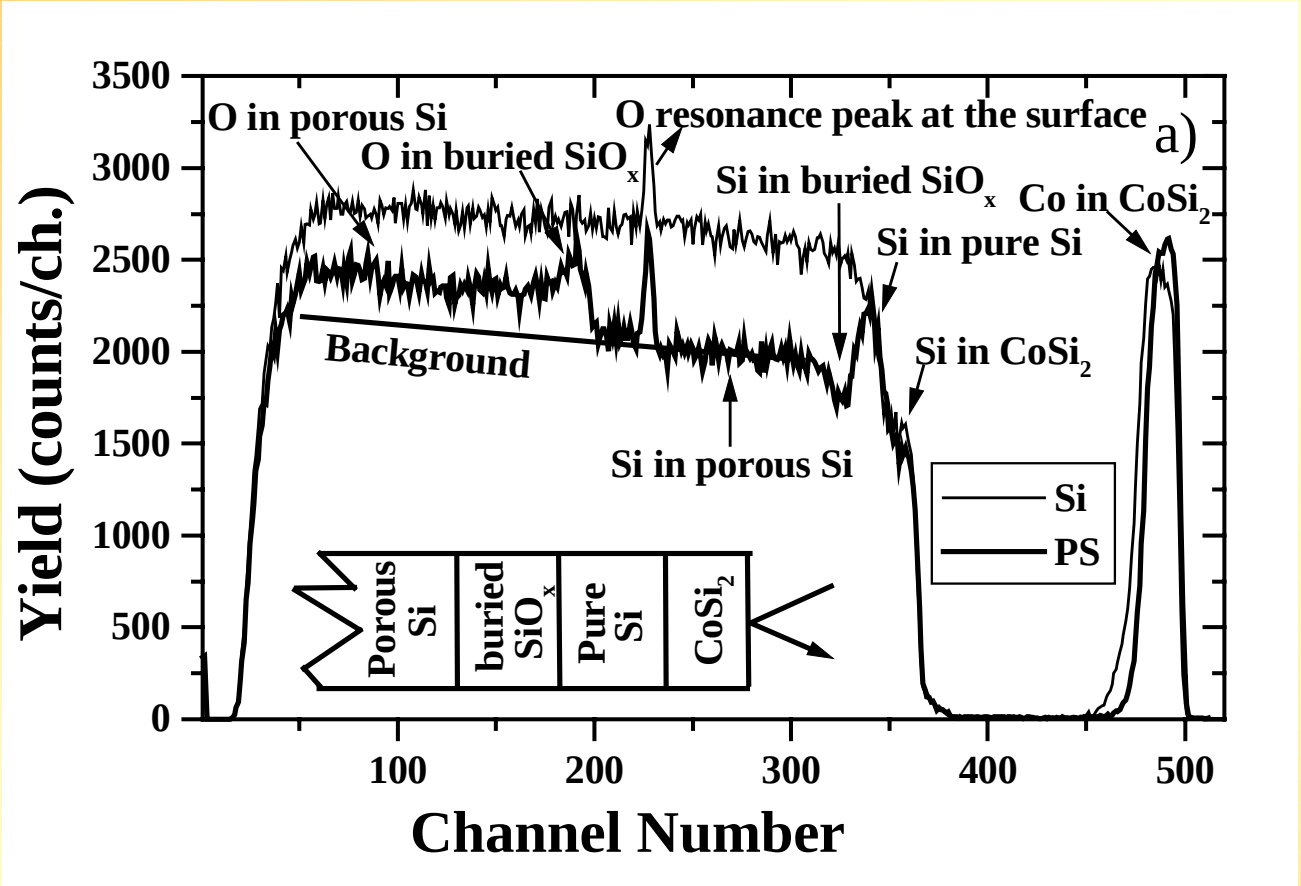
RBS



Main parameters

- **Elements** → **heavier than the ion**
  Isotopes → **for light elements**
- **Depth of analysis** → **few 100nm (few μm)**
- **Depth resolution** → **few 10nm (few Å)**
- **Sensitivity** → **few at% (light) - few 100 ppm (heavy)**

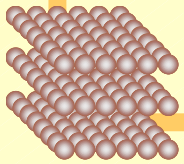




RBS spectra (3.045 MeV ^{4}He) of Co implanted Si and a porous Si.

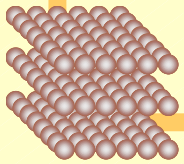
A.R.Ramos, Nucl. Instr. Meth. B 178 (2001) 283.

ERD



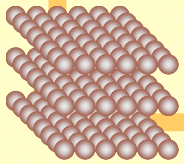
Suppressing the scattered ions

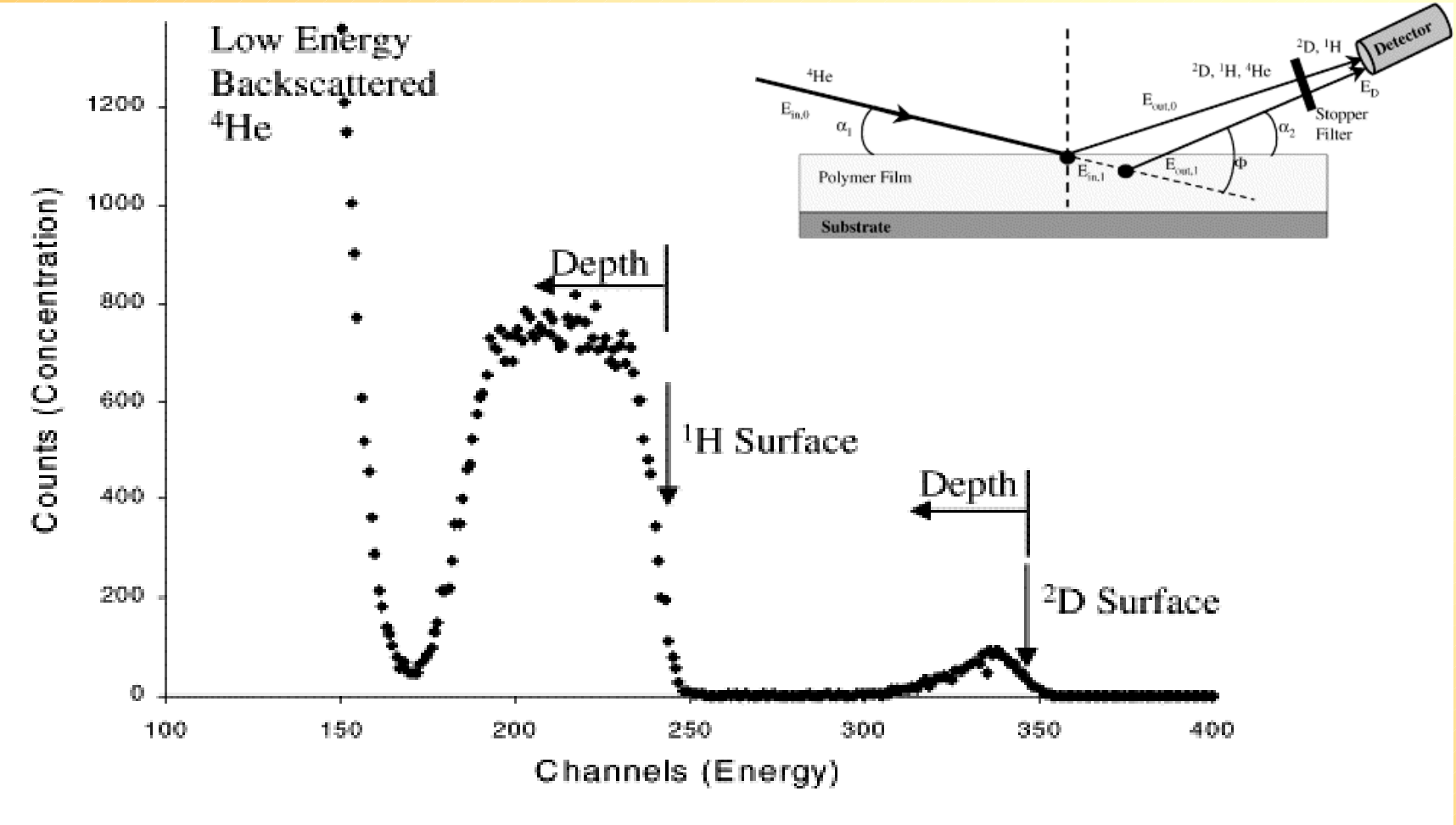
- Absorber foil
- Kinematics
- Coincidence
- Element identification (ΔE-E, TOF-E, ExB…)
- …



Main parameters

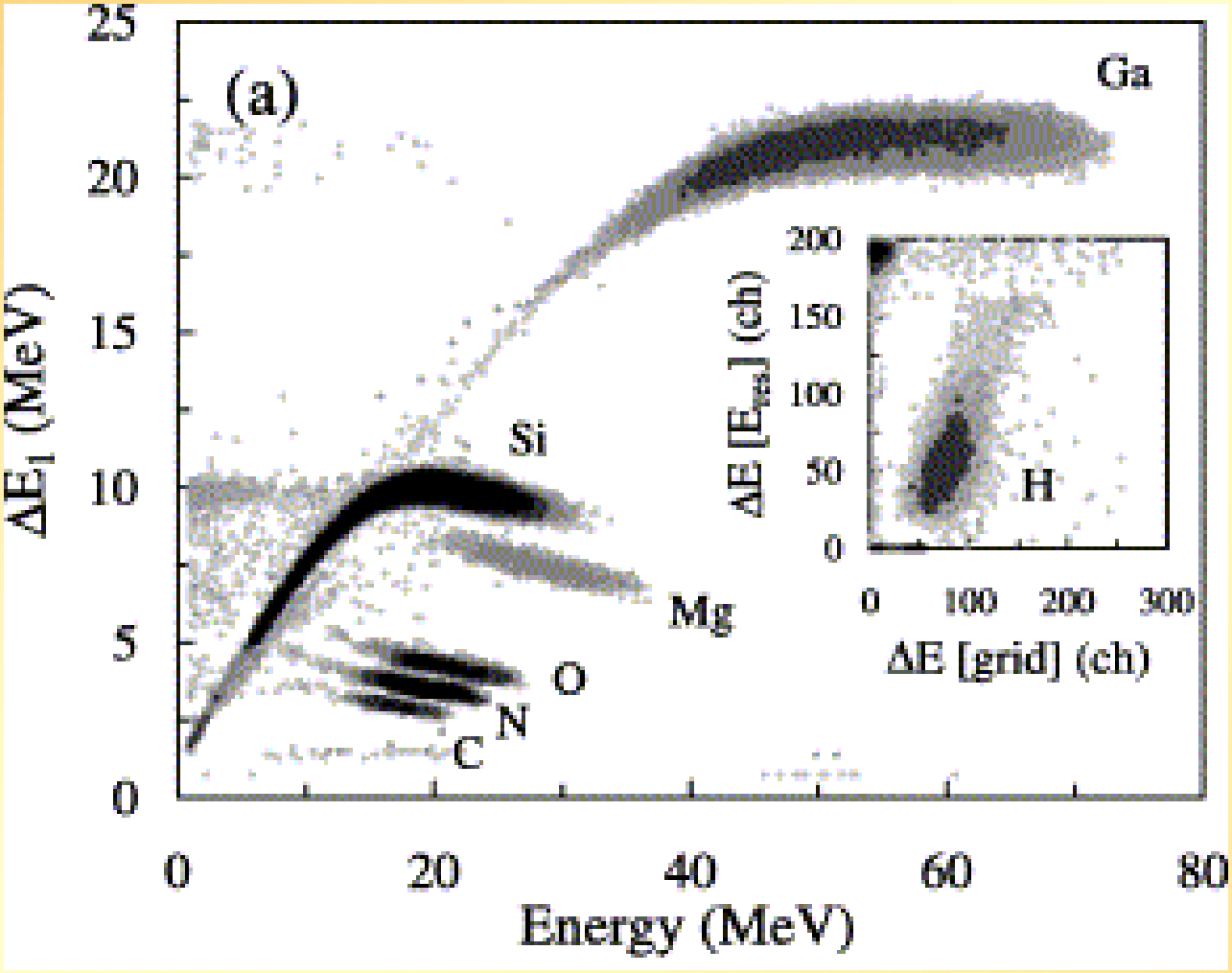
- **Elements** → **Lighter than the ion**
Isotopes → **for light elements**
- **Depth of analysis** → **few 100nm**
- **Depth resolution** → **few 10nm (few nm)**
- **Sensitivity** → **few 0.1% (few ppm)**





ERD spectrum from a thin, 200 Å, deuterated polystyrene film

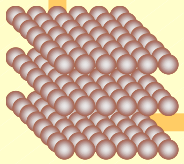
J. Russel, Mat. Sci. Eng. R 38 (2002) 107.



2D ERD spectra from a GaN film with impurities (200 MeV Au ions, ΔE-E gas detector)

H. Timmers, Nucl. Instr. Meth. B 190 (2002) 393.

NRA



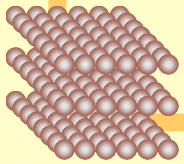
Suppressing the scattered ions

- **Ions (p, d, α, …)**

  Positive Q value, filter foil

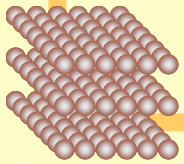
- **n or γ**

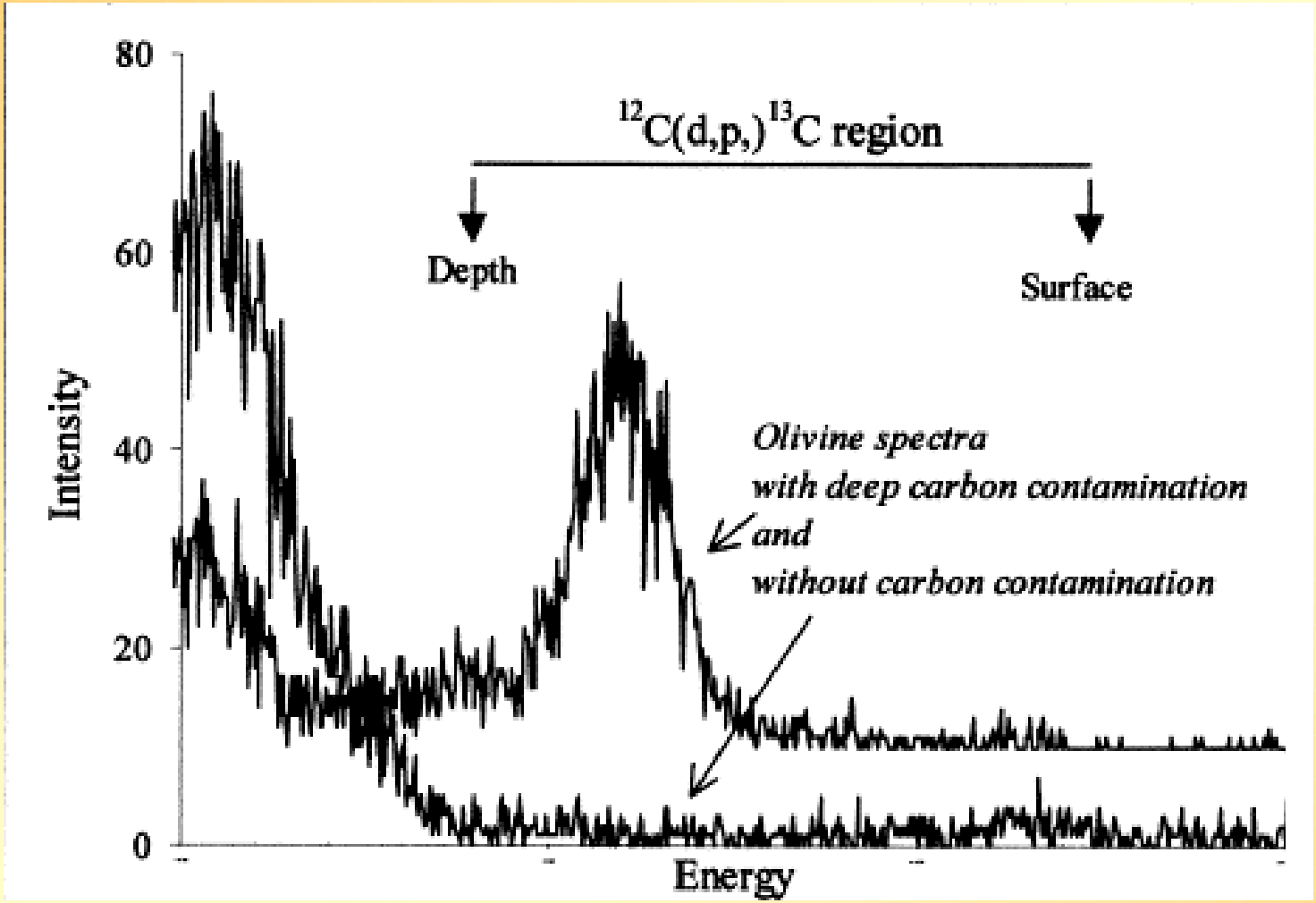
  Special detectors



Main parameters

- **Elements** → **specific**
  Isotopes → **specific**
- **Depth of analysis** → **few 10nm - few μm**
- **Depth resolution** → **few nm - few μm -**
- **Sensitivity** → **few ppm**

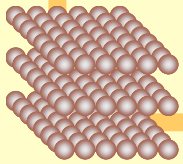




$^{12}C(d,p)^{13}C$ NRA spectra of olivine with 1000 ppm C content (1.45 MeV d, 9 μm Al filter foil)

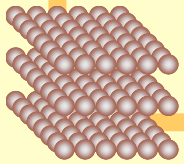
M.E.Varela, Geochimica et Cosmochimica Acta 64 (2000) 3433

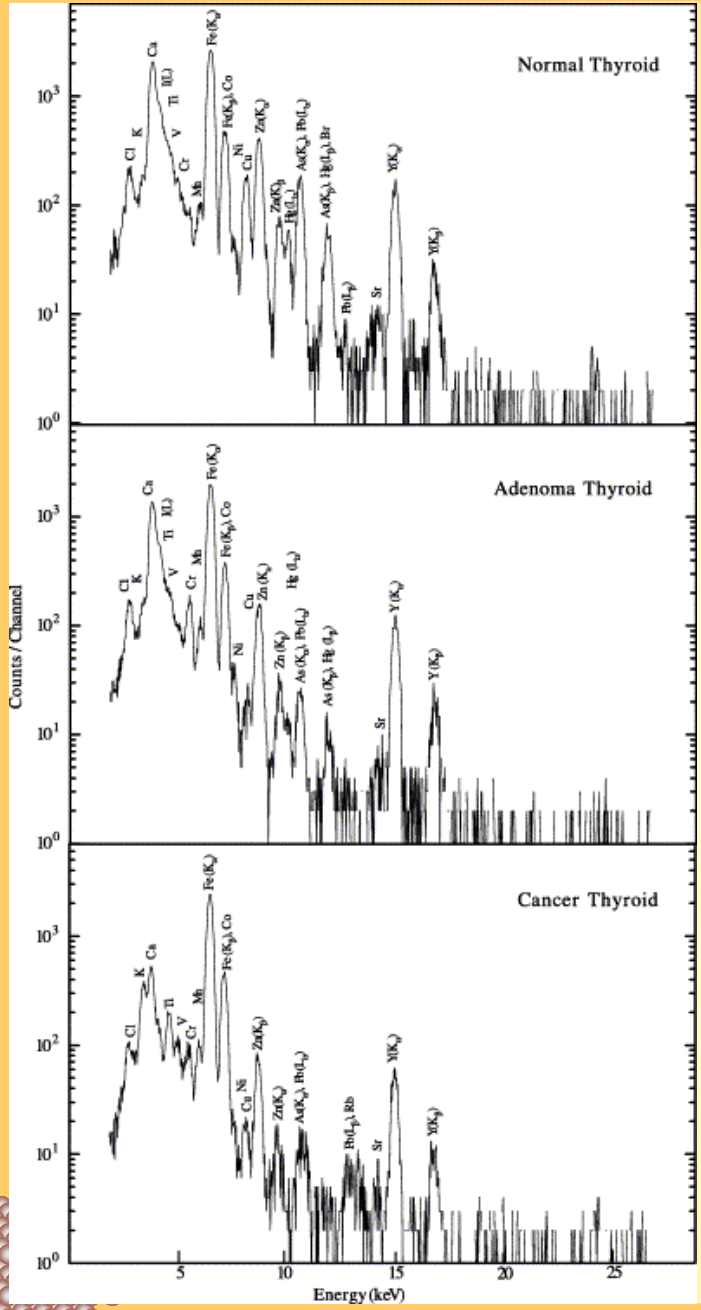
PIXE



Main parameters

- **Elements** → **heavier**
  Isotopes → **no**
- **Depth of analysis** → **few μm**
- **Depth resolution** → **no**
- **Sensitivity** → **few % - few 10 ppm**



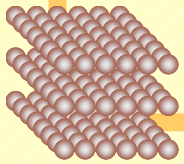


PIXE spectra taken from tissues of thyroid

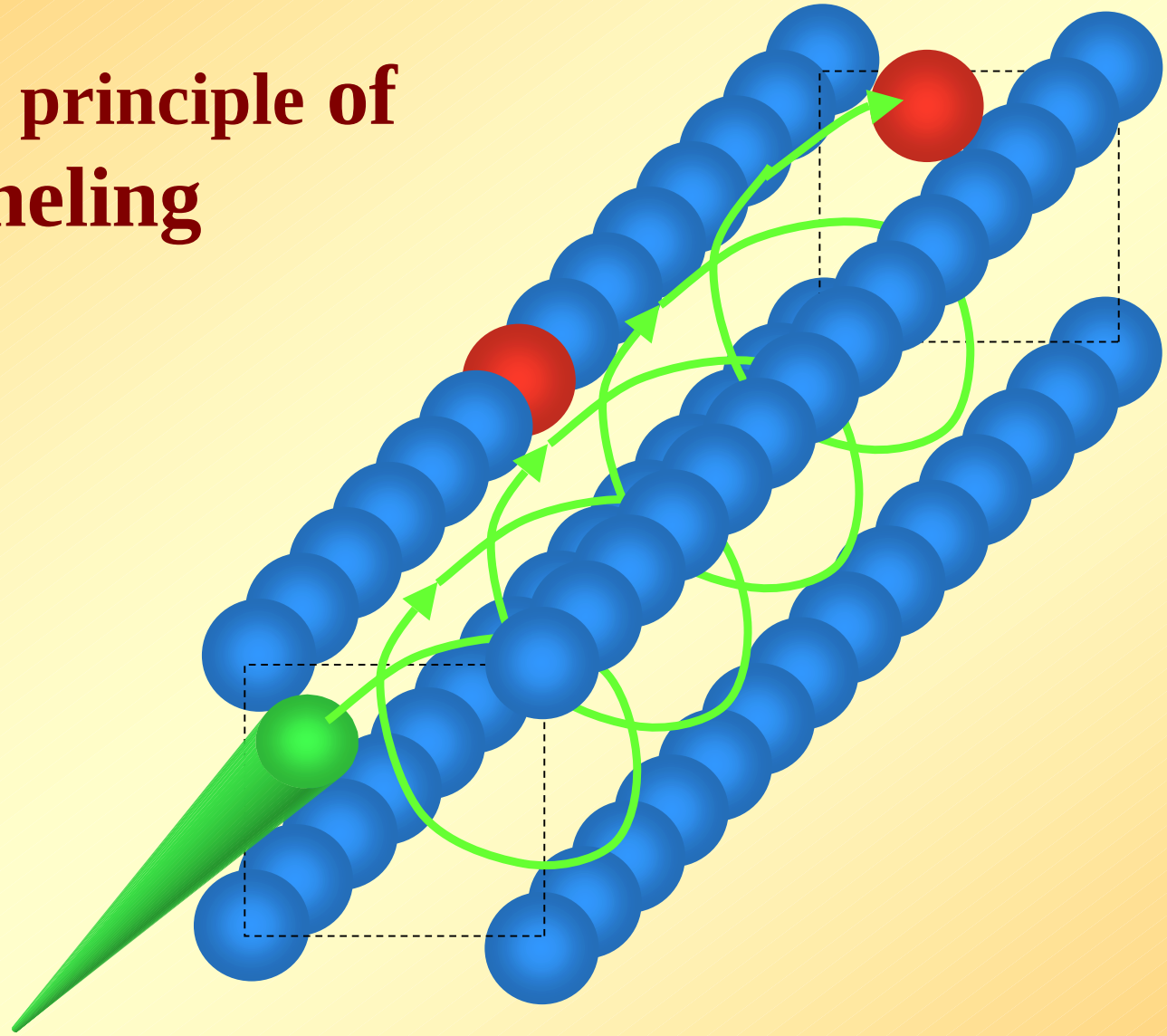
Normal
Adenoma
Cancer

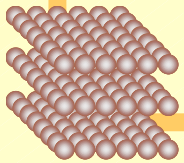
S.B. Reddy, Nucl. Instr. Meth. B in print

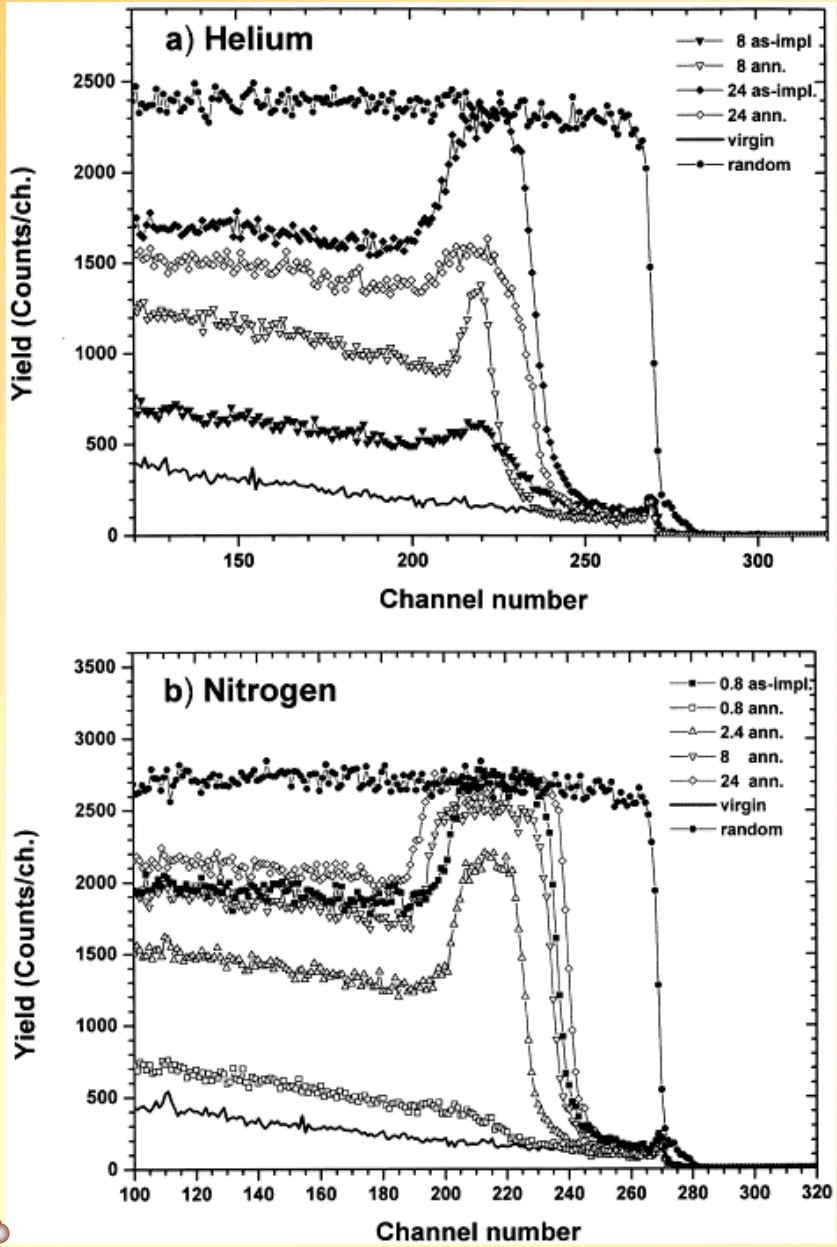
Channeling



Basic principle of channeling



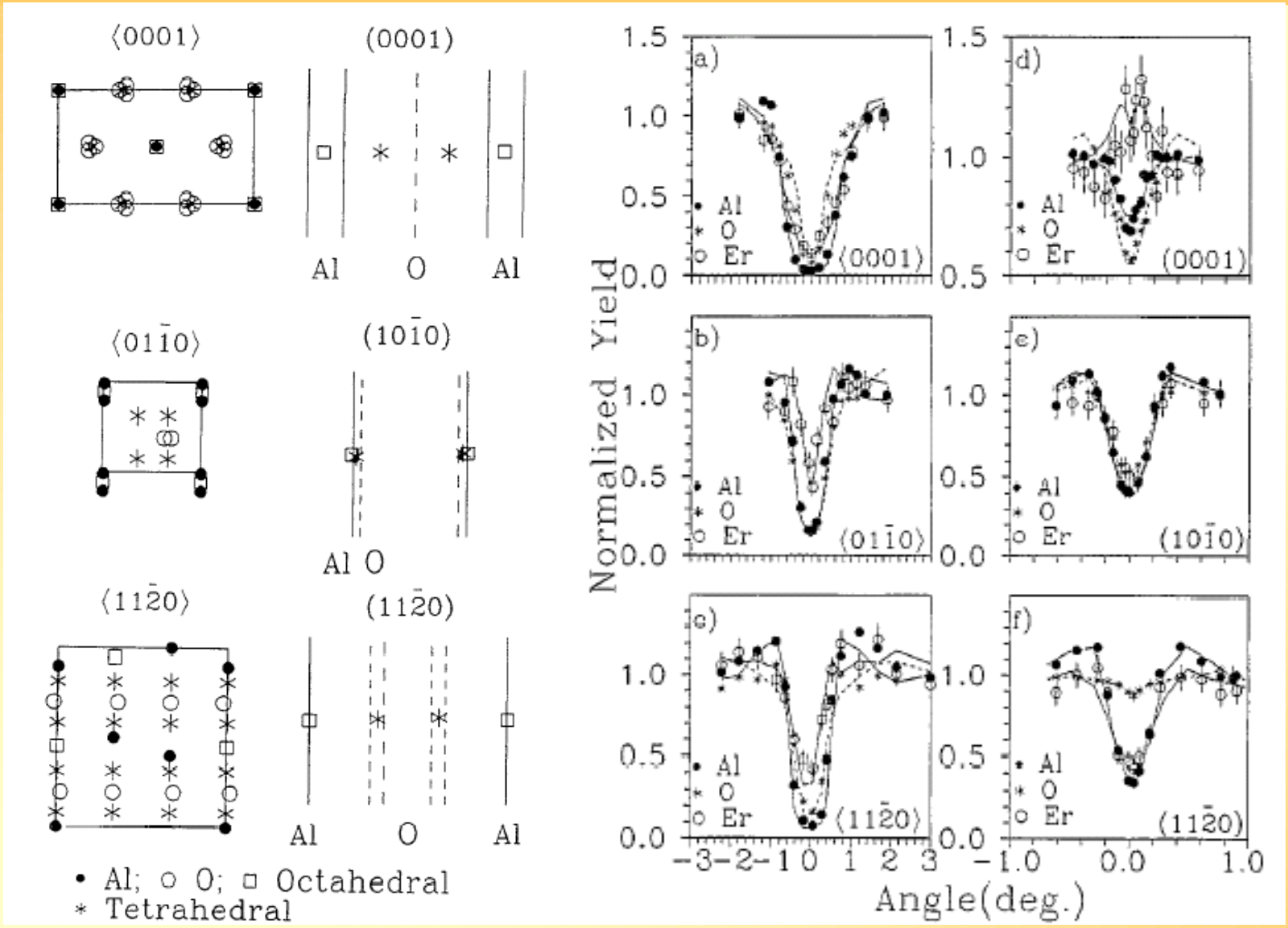




Channeling RBS spectra of He and N-implanted and annealed Si. Virgin and random spectra are also included.

(10^{16} ion/cm^2 units)

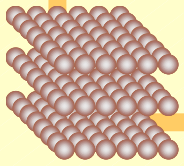
A. Manuaba, Nucl. Instr. Meth. B (2001) 63

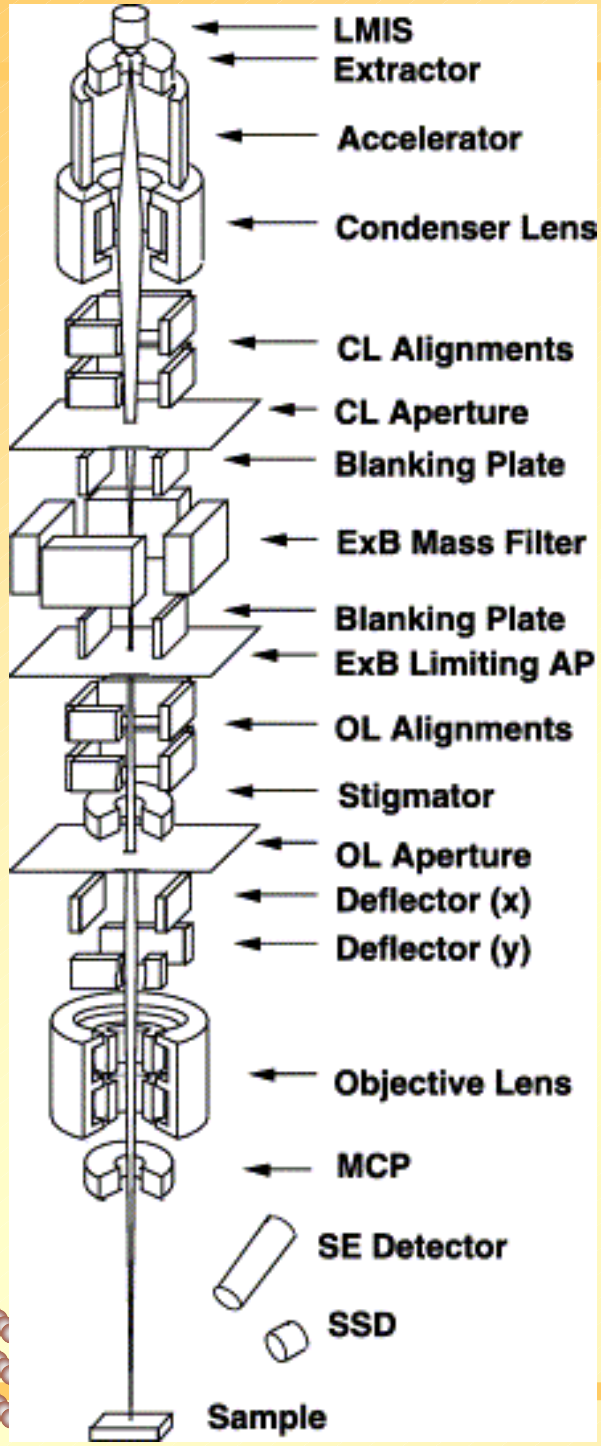


Lattice localization of Er in sapphire by RBS/channeling

E. Alves, Nucl. Instr. Meth. B 106 (1995) 429

Microprobe



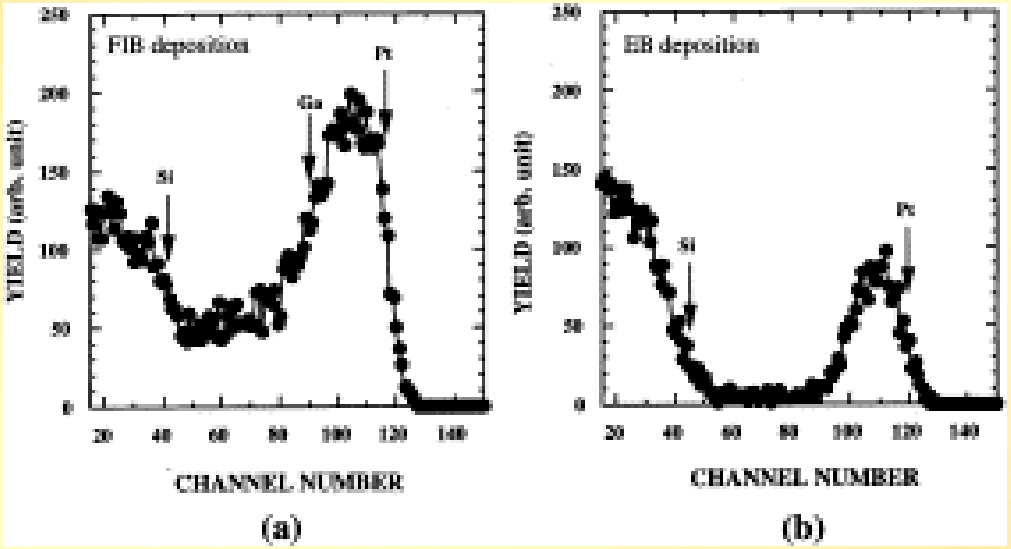


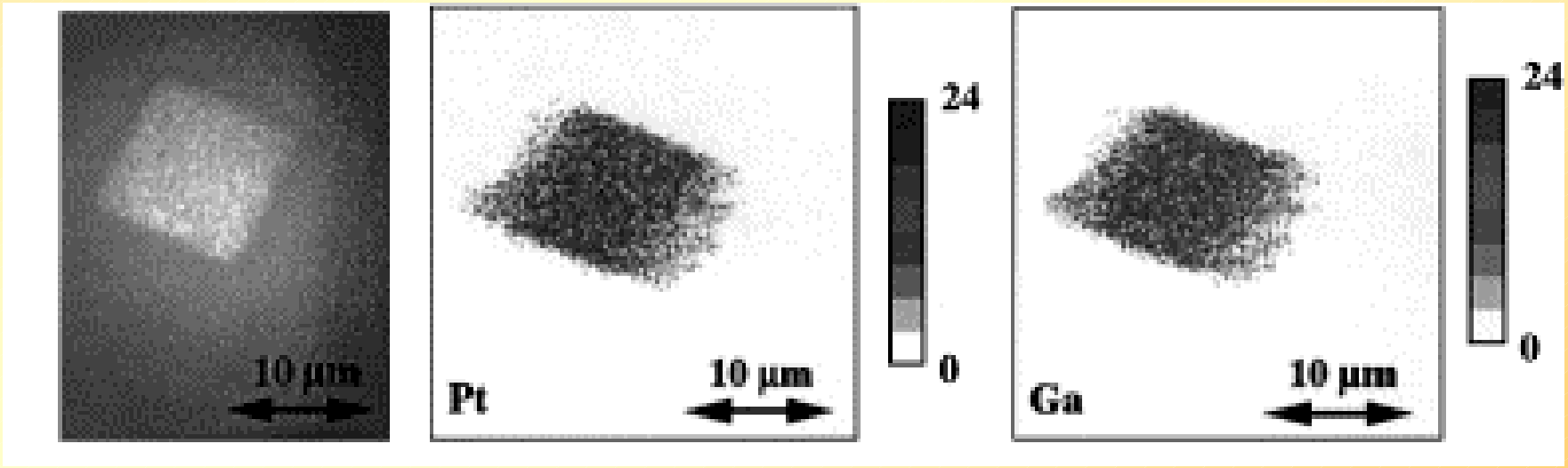
Schematic diagram of the 200 kV FIB microprobe at Osaka University. 80 nm lateral resolution, Si, Be Au ions.

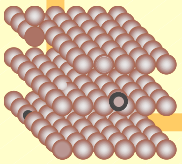
J. Tajima, Nucl. Instr. Meth. B 181 (2001) 44.

Secondary electron and RBS mapping images by the FIB microprobe.

300 keV Be^{2+}







Y.K. Park, Nucl. Instr. Meth. B 158 (1999) 487.

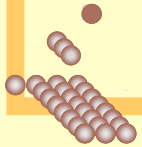
Future

New accelerators for IBA

- Cheaper and smaller accelerators for routine applications
- Larger used machines (HI-ERDA)
- Better microprobes
- Transportable IBA?

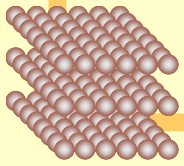
Unique features

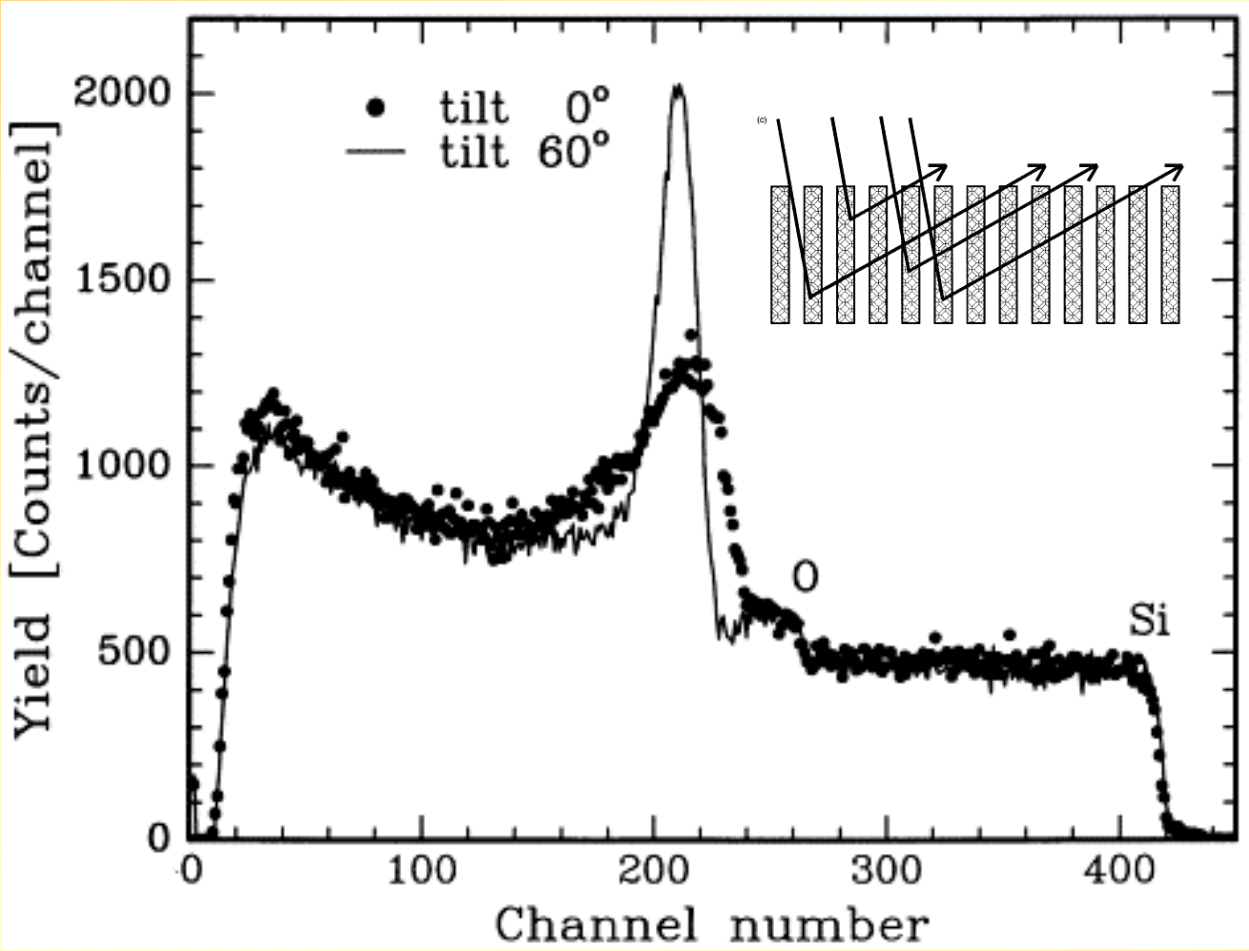
- Channeling for damage profiling and lattice localization
- H depth profiling
- Atomic depth resolution
- Extreme sensitivity



New methods appear

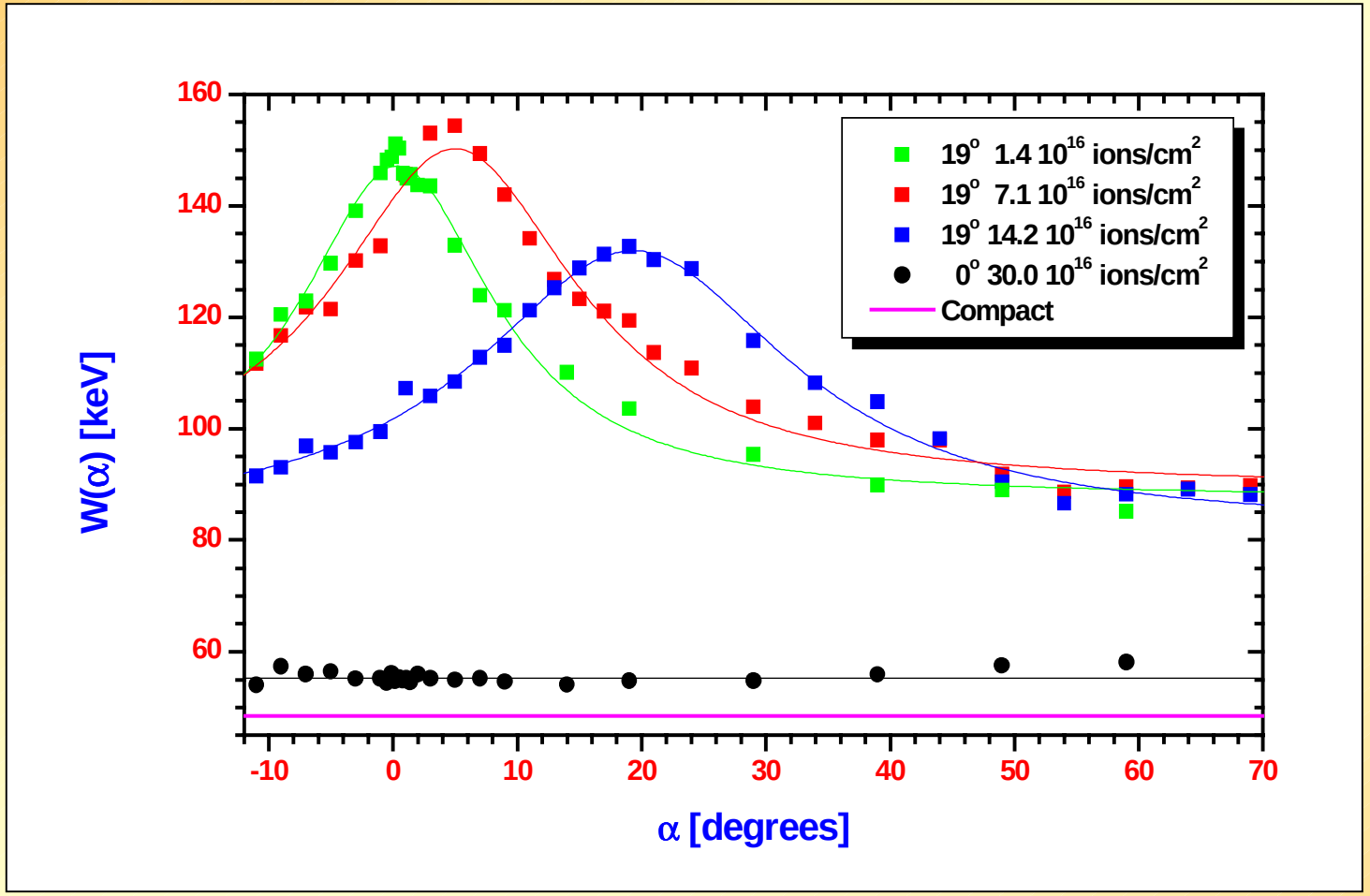
- **Pore structure determination by resonance method**
- **Combination of TOF-RBS and TOF-SIMS by a nanoprobe**
- **…**





R-BS spectra on columnar porous Si (3045+100 keV $^{4}He^{+}$). The peak is due to $^{16}O(\alpha,\alpha)$ resonance. At tilt 0° the beam is parallel to the pores.

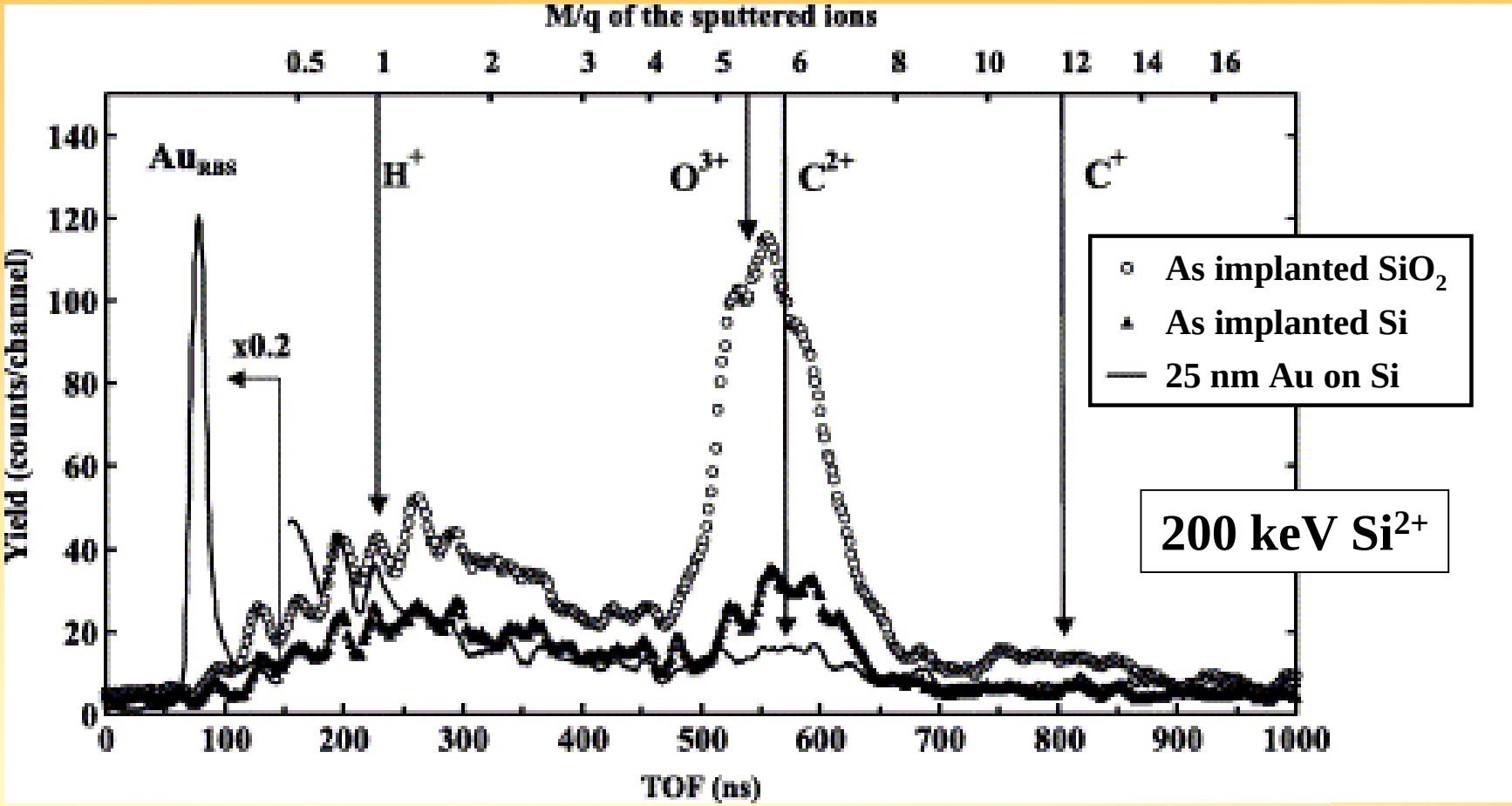
F. Pászti, Vacuum. 50 (1998) 451.



Half-width of the resonance peak for samples implanted at various tilts and fluencies.

Solid lines are fitted Lorentzian curves.

F. Pászti, Nucl. Instr. Meth. B 161-163 (2000) 963.



TOF spectra by the 200keV FIB. H, O, C peaks are due to secondary ions accelerated by the 1.8 kV detector bias of the MCP (TOF-SIMS).

K. Iwasaki, Nucl. Instr. Meth. B 190 (2002) 296.