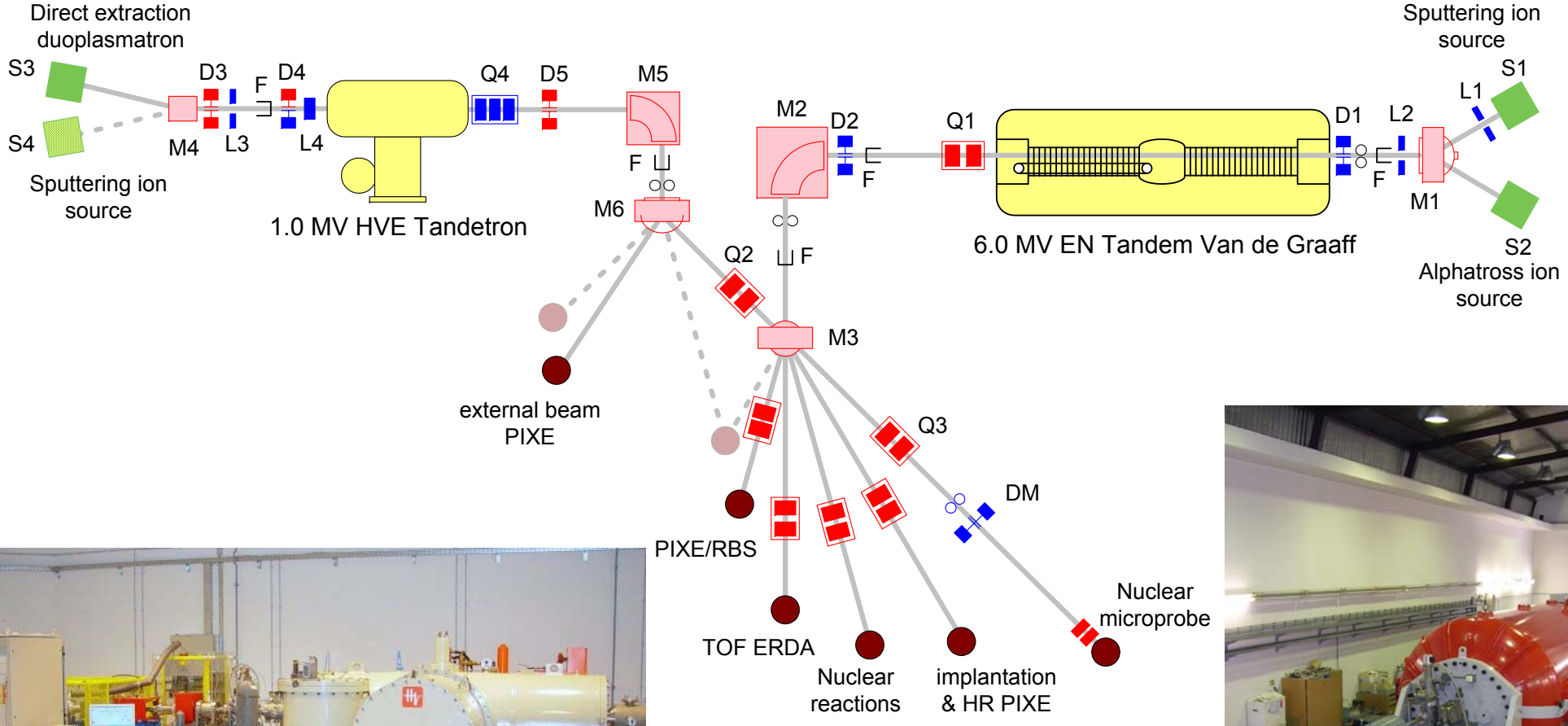
Accelerator facilities - Ruđer Bošković Institute, Zagreb, Croatia

Milko Jaksic, Neven Soic

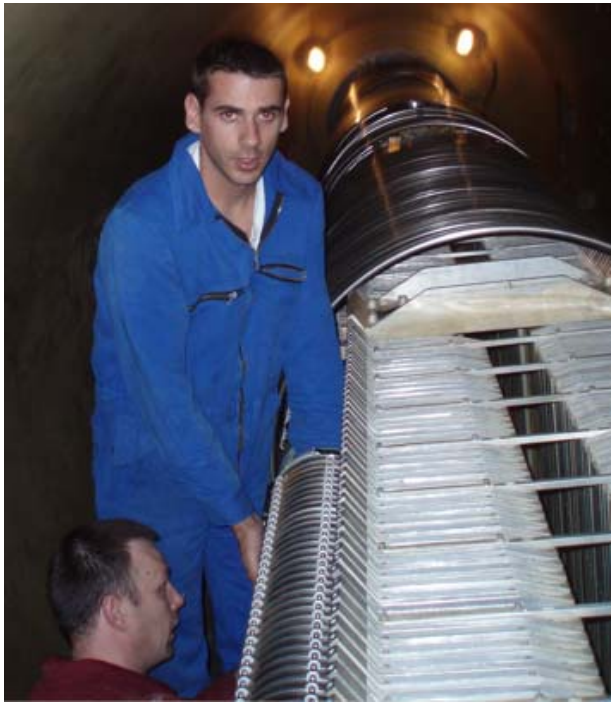
- Our capabilities (accelerator, sources, beamlines,...)
- Research activities (projects, users, int. collaborations,...)
- Staff and funding
- Proposals, needs, future

1. Facilities (accelerators, beamlines)



6.0 MV tandem

2006 - Change of 6.0 MV tandem accelerator tubes
2007 - IAEA TC project – new sputtering ion source
2007-2009 - EU INCO – new vacuum system, etc.



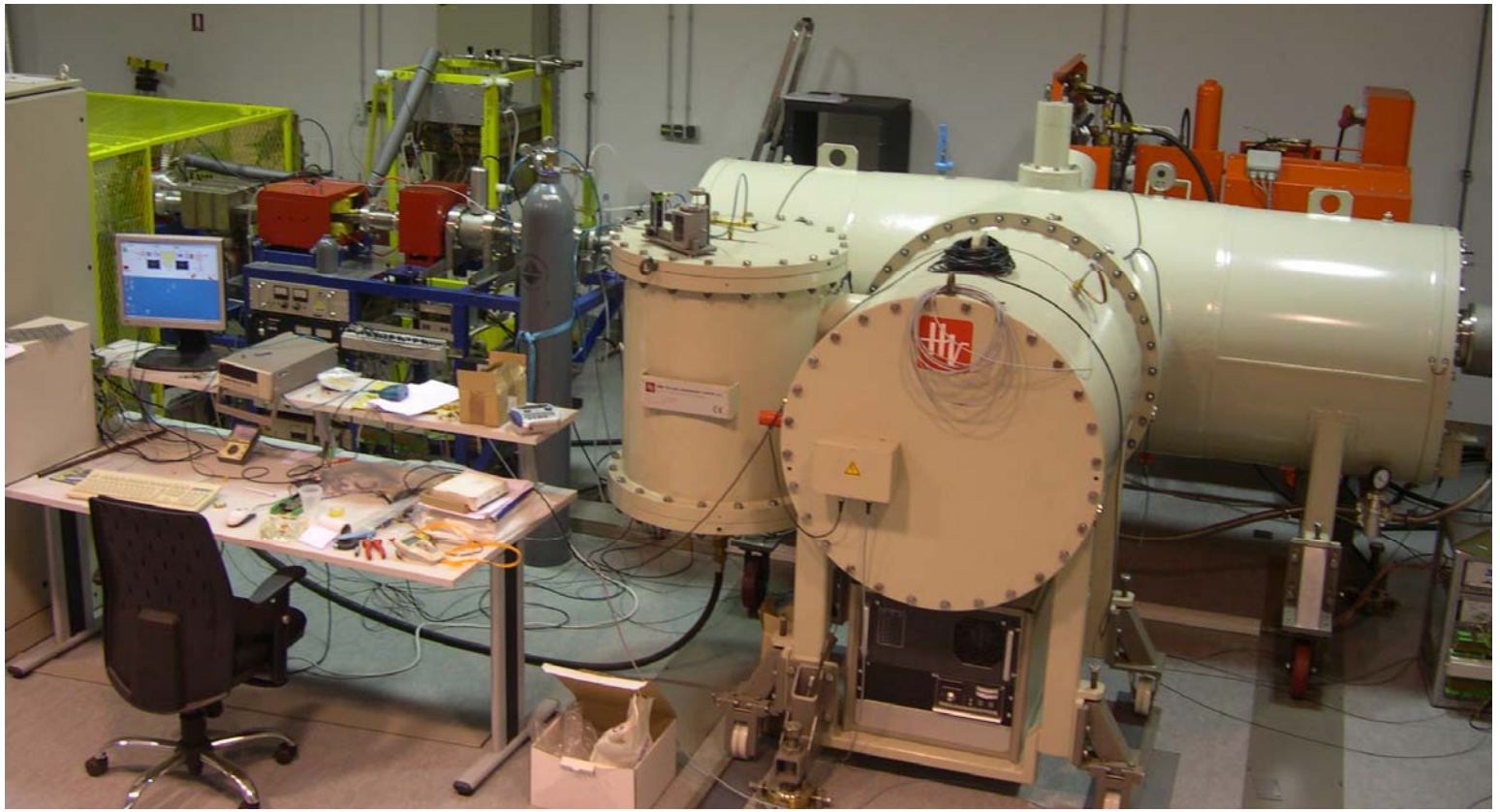
Ion sources of tandem accelerators

- Tandetron up to 1.0 MV
  - Duoplasmatron (p, O)
  - Sputtering (to be moved from EN tandem)

Voltages 0.1 to 1.0 MV

Ions / max. currents (μA)

H	30
D	15
^{16}O	0.5-1.0



EN tandem up to 6.0 MV

- Alphatross NEC
- Sputtering - homemade,

/ to be exchanged (in 2007) by new NEC

Voltages 0.4 to 6.0 MV

<u>Sputtering source</u>

Ions / source currents (μA)

H	10
D	1
^{6}Li	0.5
^{7}Li	1.0
^{10,11}B	1.0
C ,O	20
F, Si	20
Cl, I	20

<u>Alphatross source</u>

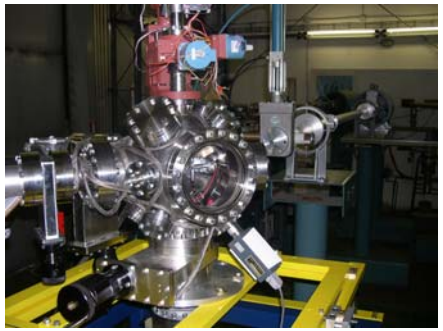
Ions / source currents (μA)

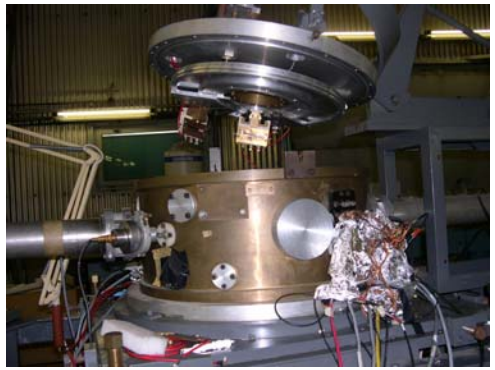
H	1
D	0.5
^{3}He	0.5
^{4}He	1.0

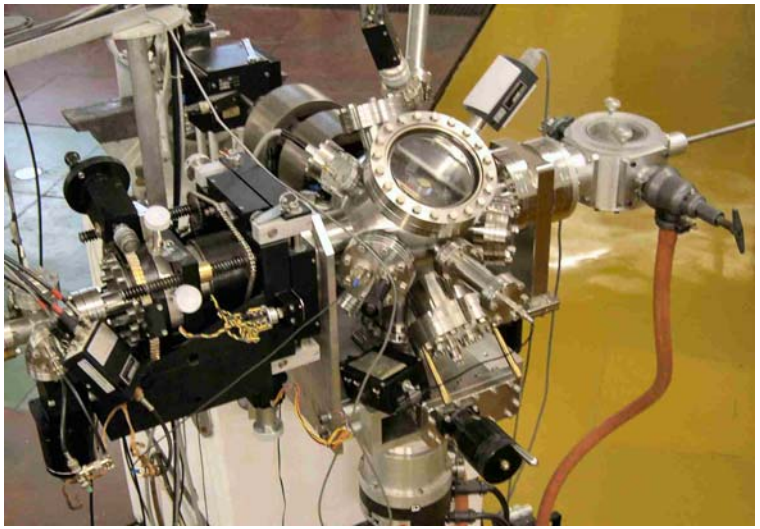
• Experimental beam lines

- Existing beam lines of EN Tandem accelerator

1. IAEA beam line - routine PIXE/RBS
2. TOF ERDA
3. Nuclear reactions chamber
4. High resolution PIXE / ion implant.
5. Nuclear microprobe

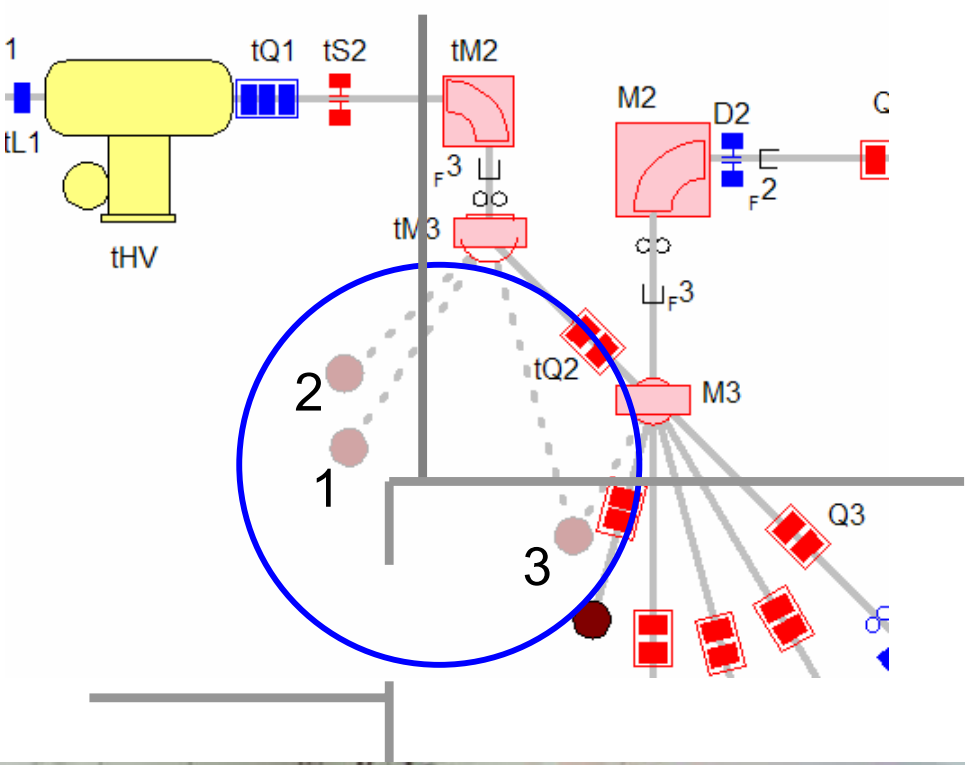






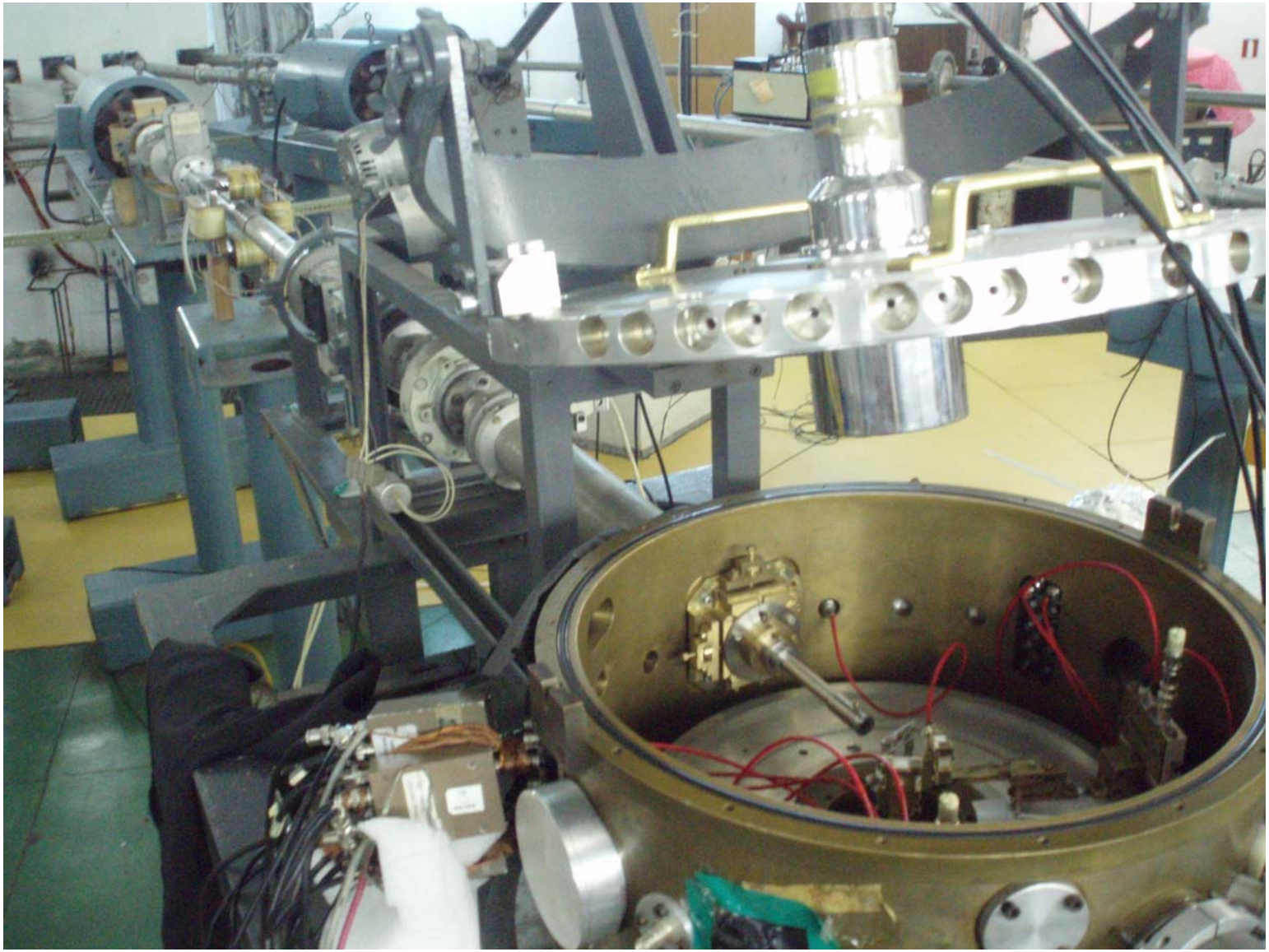
- Tandetron beam lines

1. External beam for cultural heritage objects (August 2006)
2. New beam line for chamber testing (January 2007)
3. Two beams chamber for materials modification (end of 2007)

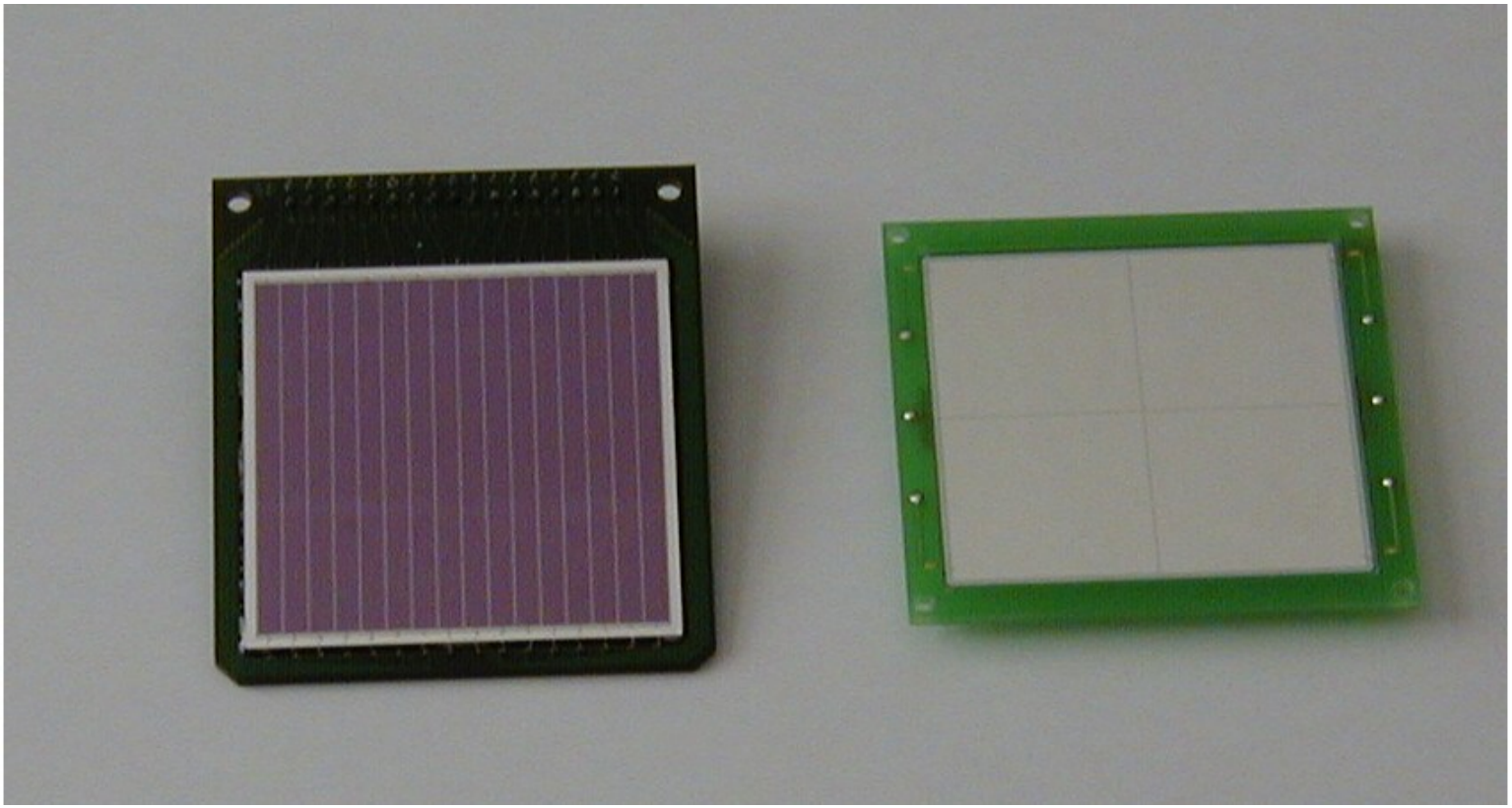


• Reaction measurements beam line

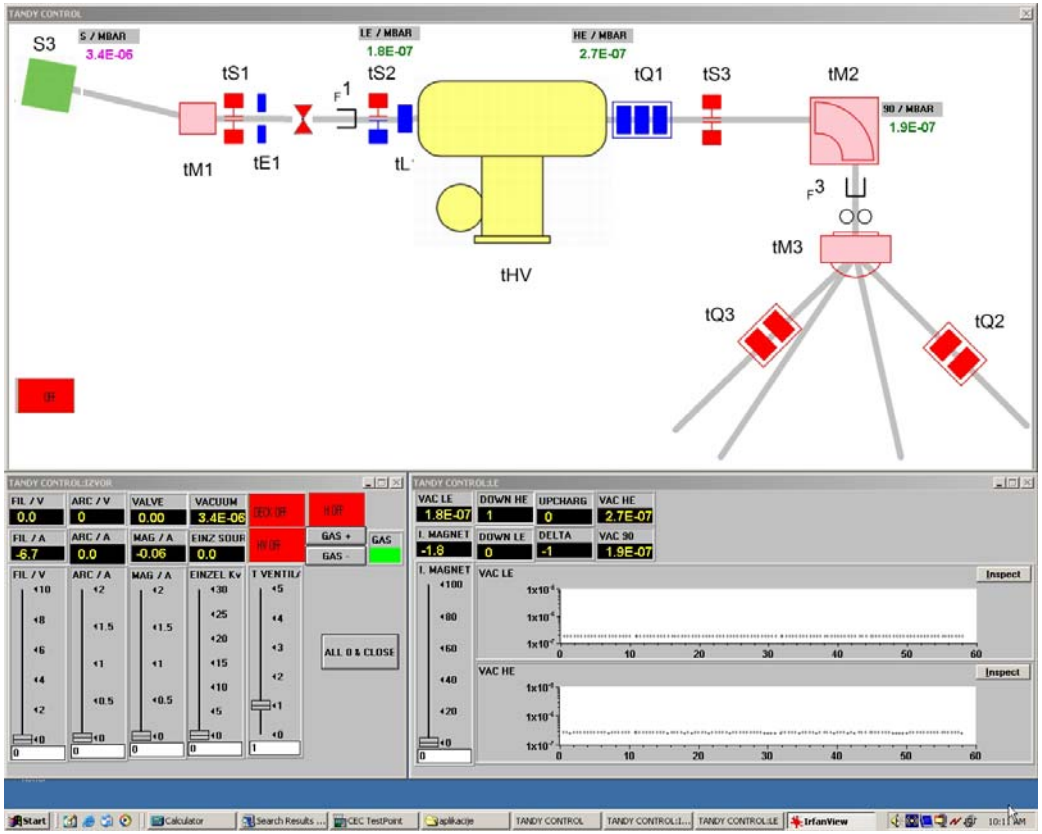
Universal scattering chamber – 50 cm diameter



- Charged particles multi-detector system consisting of very thin surface barrier silicon detectors (14 – 20 μm) and position sensitive silicon detectors with associated electronics and data acquisition system
- Highly segmented charged particles multi-detector system consisting of large (5 x 5 cm^2) thin (50 μm) silicon detectors and strip silicon detectors with associated electronics and VME data acquisition system



Computer control – ACCEL6 for EN Tandem Van de Graaff and ACCEL1 for Tandetron accelerator

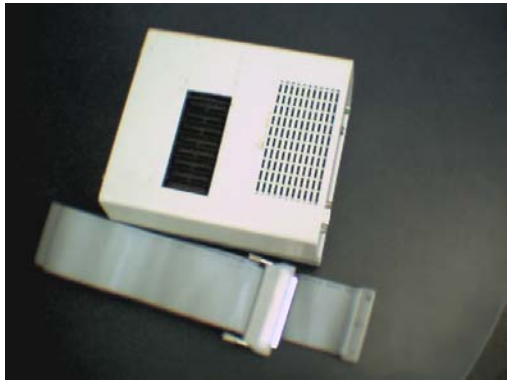


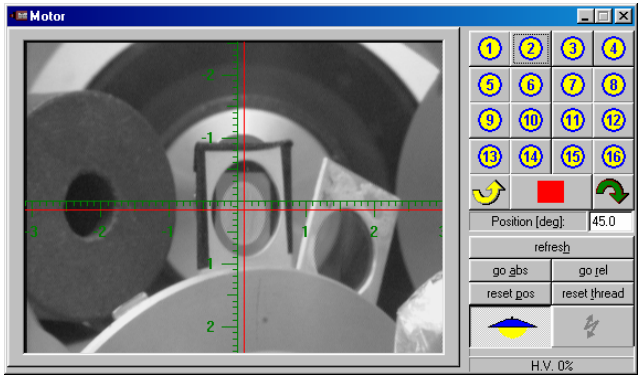
Natko Skukan – IRB
Dejan Đurđenić - Dilogic

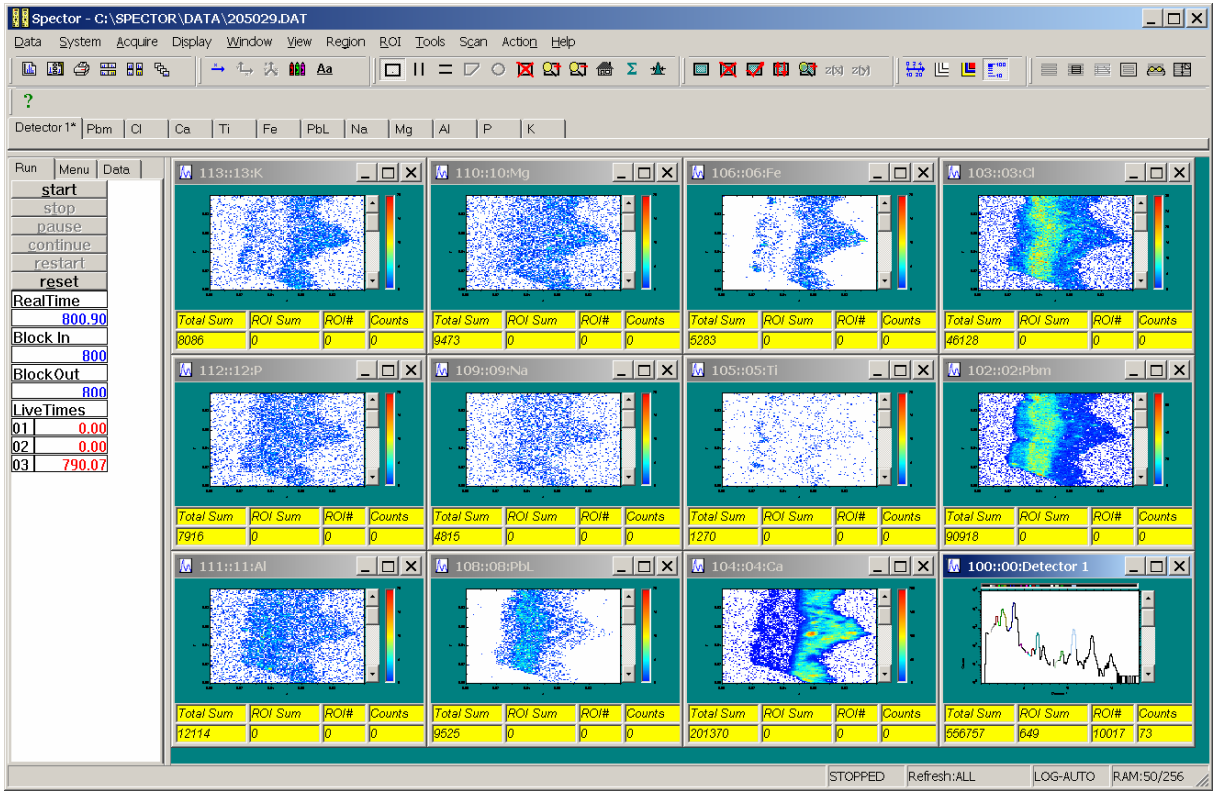
- 16 bit AD/DA modules (8 AD, 8DA) (controls for ion sources, accelerator and beam optics system)
- 8 digital inputs, 8 digital outputs
- Controls are based on TESTPOINT

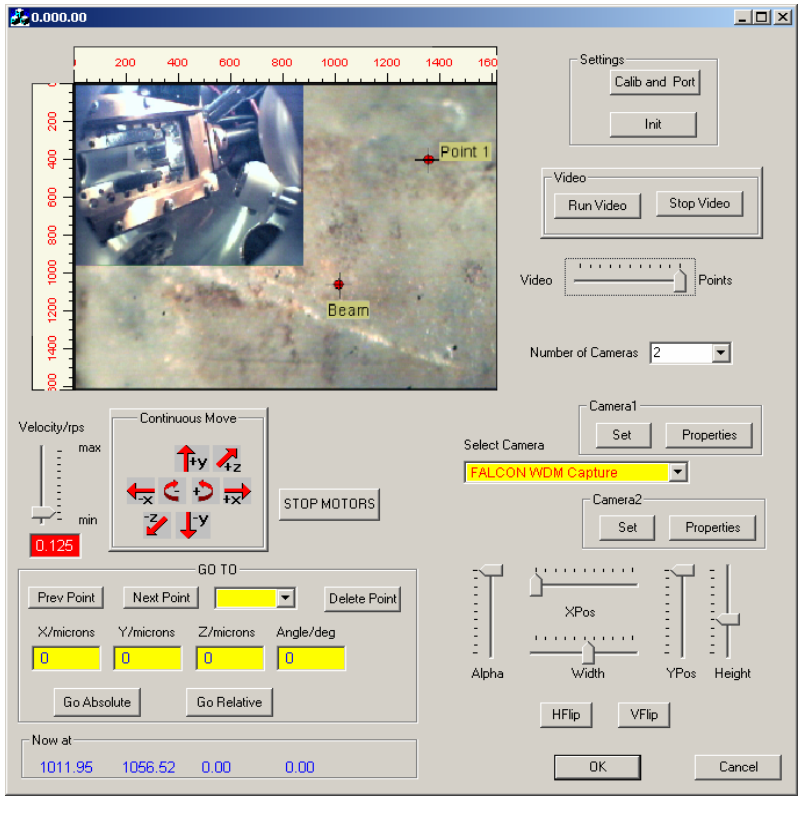
Capabilities:
Remote control (from remote computers)
Reads beam optics parameters from previous experiments
Calculates changes of parameters for change of energy and/or ion
Security interlock system

SPECTOR – Data acquisition (now with digital pulse processing) target positioning / beam scanning software / remote operation

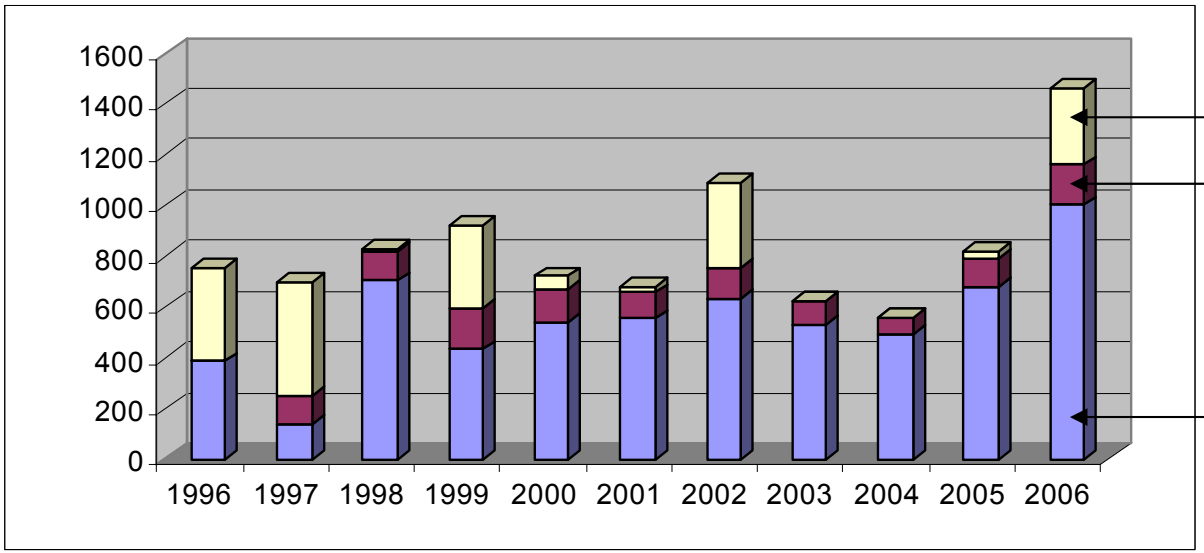








2. Research activities (users and projects, int. collaborations,...)



Working days in 2006	Ion beam interactions	Nuclear physics	Others	Int. Collab.	Analysis services	Mainte nance	TOTAL
6 MV VDG	42	25	5	7	-	40	**119**
1 MV TDT	50	-	10	14	11	17	**221**
Total	92	25	15	21	11	57	**340**

Laboratory for ion beams - activities

Basic Research

- Inner shell ionization, chemical effects, data base
- Elastic scattering data base (p, He beams) for ion beam analysis

Material science applications

- Charge transport in semiconductors
- Development and application of of depth profiling techniques (ERDA)
- Ion microprobe modification of materials (ion tracks, damage structuring, implantation)

Other applications

- Cultural heritage μPIXE analysis
- Technological projects (cement, glass, solar cells)
- Analytical services and irrradiation services

Nuclear physics activities

- **Existing equipment** allows for measurements of excitation functions and angular distributions for nuclear reactions as well as coincident detection of the two or more reaction products (charged particles and possibly γ-rays)
- Used for studies of the structure of nuclei and studies of the nuclear reactions itself
- Nuclear structure: properties of the nuclei levels: excitation energy, width, spin, decay mode, partial widths; clustering phenomena …
- Nuclear reactions: single-nucleon and multi-nucleon transfer reactions, fusion (formation of a composite system), cross section measurements at the low beam energy for nuclear astrophysics …
- **Past experiments:** 8 complex experiments and more than 10 short measurements for studies of these topics using beams of p, d, ^{3}He, ^{4}He, ^{6}Li, ^{7}Li, ^{12}C and ^{16}O
- **Future experiments:** may easily extend range of beam species (^{9}Be, ^{10}B, ^{11}B, ^{13}C, ^{14}C, ^{18}O etc) and beam energy range (terminal voltage from 0.3 to 6.0 MV)

3. Staff and funding (users and projects, int. collaborations,...)

Funding

- Ministry of science
  - Upgrades (2002-2004), including building - 300 kEu
  - accelerator maintenance (30 kEu/year)
  - users projects (10-20 kEu/year)
- IAEA projects (2002-2007) – Tandetron, sputtering ion source (total investment – 500 kEu)
- EU- INCO (2007-2009) – various upgrades (vacuum system, terminal pump, new beamline,...) - equipment – 150 kEu

Staff

- LIBI (100%)
  - 3 technicians (1 overqualified, 1 operator, 1 workshop)
    - 2 new operators needed
  - 5 scientists
  - 3 doctoral students
- LNR
  - 1 technician (neutron generator)
  - 3-4 scientists

International collaborations

- LIBI
  - IAEA beam line (20 working days/year)
  - Uni. Torino (several days)
  - Others (Debrecen, IAEA projects)
- LNR
  - Joint experiments with Catania
  - Others (University of Birmingham, University of Huelva,...)

4. Proposals, needs, future...

Our expectations from joint project

- Upgrades (beam line for nuclear physics)
- New positions (operators, doctoral students)
- Incerased funding (operation costs)
- Sharing our 'state of the art'
- Increasing local position as important scientific infrastructure

General expectations

- All – preferential use of existing capabilities in network!
- Minimize investments that are competing