

# Rudjer Boskovic Institute (RBI) – largest Croatian institute MULTIDISCIPLINARY science institute

**130,000 m<sup>2</sup>** area  
**82** research laboratories  
**11** research divisions

**850 EMPLOYEES**  
**OVER 450 PhDs**

**Tome Antičić**  
director

5% of Croatian  
researchers

~ 60% of Croatian  
Horizon 2020

20% of Croatian  
publications

50% of top 20%  
publications

PHYSICS



THEORETICAL PHYSICS

MATERIAL PHYSICS

EXPERIMENTAL  
PHYSICS

CHEMISTRY



MATERIAL  
CHEMISTRY

ORGANIC CHEM. &  
BIOCHEMISTRY

PHYSICAL CHEM.

NMR

LIFE SCIENCES



MOLECULAR  
MEDICINE

MOLECULAR  
BIOLOGY

ENVIRONMENT



SEA & ENVIROMENT

CENTAR FOR SEA  
RESEARCH

COMPUTER  
SCIENCE



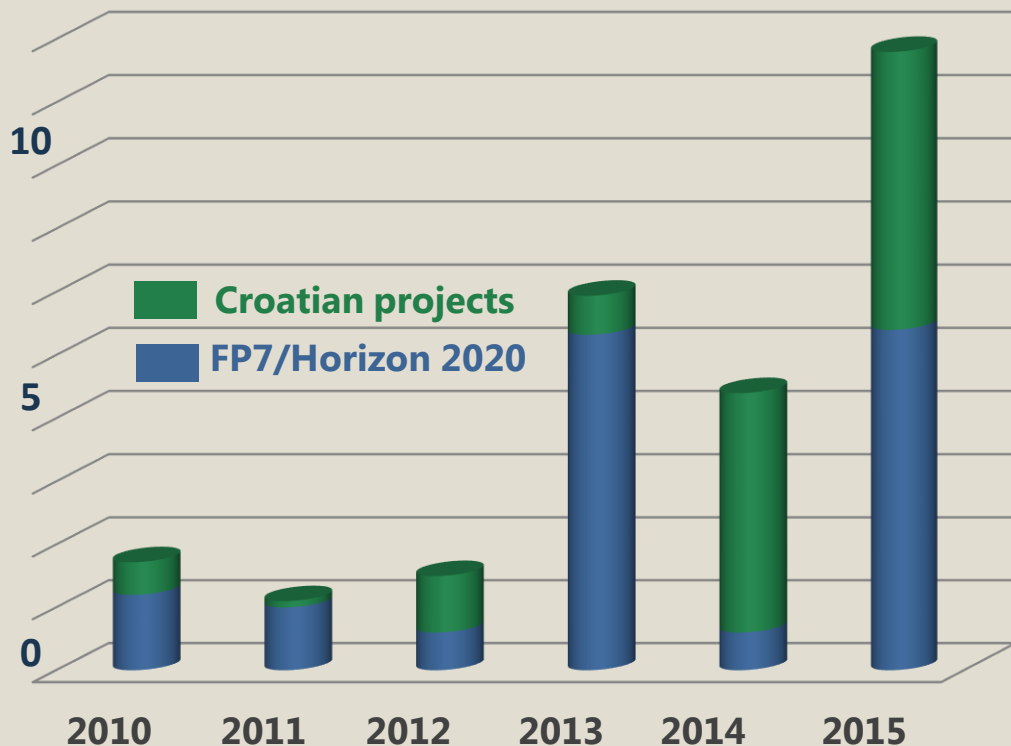
ELECTRONICS

**Excellent science**

**Strong involvement in higher education**

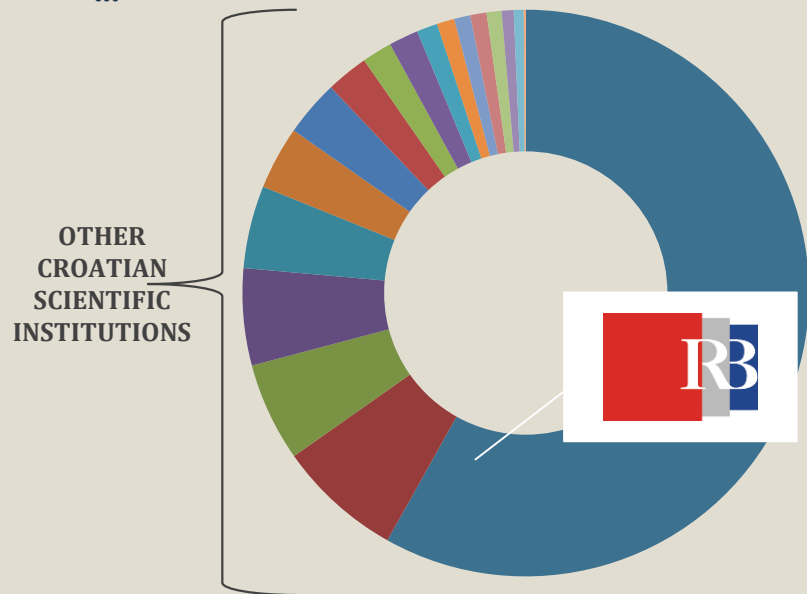
**Leading contribution to the growth of the  
national economy**

# RBI- CRO LEADER IN INTERNATIONAL PROJECTS



NEW PROJECTS, MILLIONS OF EUROS

- 2 ERCs (out of 4 in Croatia), both within past two years, both returnees
- 2 CENTRES OF EXCELLENCE ( 1 out of 1 in material sciences, 1 out of 2 in biotech, key partner in 1 in ICT)
- ...



PERCENTAGE OF HORIZON2020 FUNDING

# OPEN SCIENTIFIC INFRASTRUCTURAL PLATFORM FOR INNOVATIVE APPLICATIONS IN THE ECONOMY AND SOCIETY: O-ZIP

**60 million Euro**



- RH Operational Programme 2014-2020
- Smart Specialisation Strategy

**BIOMEDICINE**

**ENVIRONMENT AND  
SEA**

**ADVANCED MATERIALS**

**ICT**

**BEGINNING 2018**



Satellite DNA  
Evolutionary genetics  
Cell biology and biophysics  
Microbiology  
Plant biology  
Neuroscience

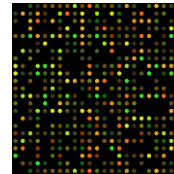
Protein dynamics  
Experimental therapy  
Oxidative stress  
Mitochondrial bioenergetics  
Virology and bacteriology  
Hereditary cancer  
Personalized medicine  
Epigenomics  
Genomics



**NewSpindleForce/Iva Tolic:** A new class of microtubules in the spindle exerting forces on kinetochores



FP7 (largest in Croatia): **Enhancement of the Innovation Potential in SEE through new Molecular Solutions in Research and Development – InnoMol** - investigation of relevant diseases such as cancer



# Chemistry

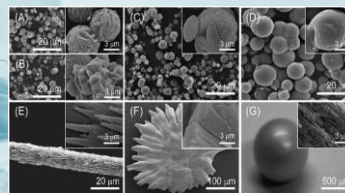
Organic chemistry and biochemistry  
Biomimetic chemistry  
Supramolecular chemistry  
Biomolecular interactions  
Stereoselective catalysis  
Protein biochemistry



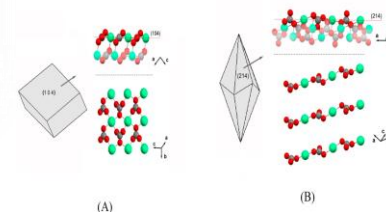
**MEMBRANES ACT/Ana Suncana Smith:**  
Biological Membranes in Action: A Unified Approach to Complexation, Scaffolding and Active Transport



Solid state chemistry  
Precipitation processes  
Radiation chemistry  
New material synthesis  
Functional materials



Mass spectrometry  
Computational biosciences  
Surface chemistry  
Mechanochemical synthesis  
Chemical and biological crystallography  
NMR



## Information Communication

Cloud computing

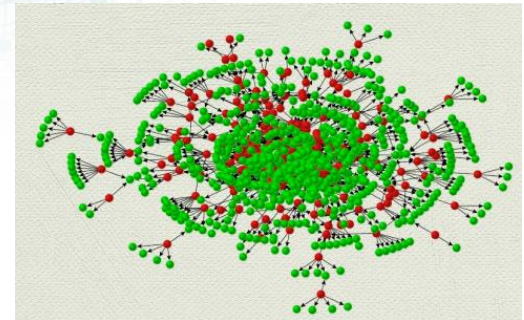
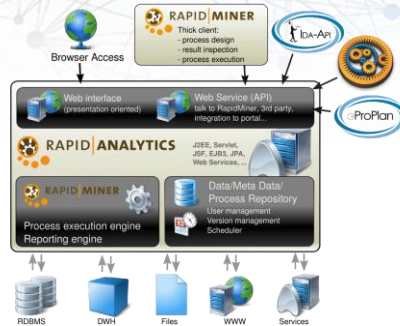
Optoelectronics and visualisation

Bioinformatics

Machine learning

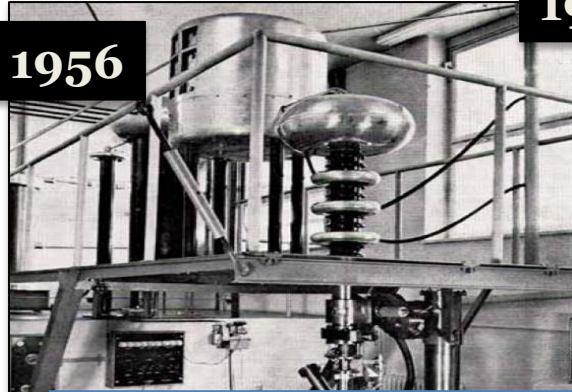
Stochastic signals

- FP7: e-Laboratory for Collaborative Interdisciplinary Research in Data Mining and Data Intensive Sciences - Enlarged European Union - e-LICO
- FP7 : Foundational Research on MULTIllevel comPLEX networks and systems
- FP7 : Learning from Massive, Incompletely annotated, and Structured Data
- H2020: Integrating Distributed Data Infrastructures for Global Exploitation
- H2020: Supercomputing Expertise for Small and Medium Enterprise Network
- Key part of **Center of excellence** for Big Data



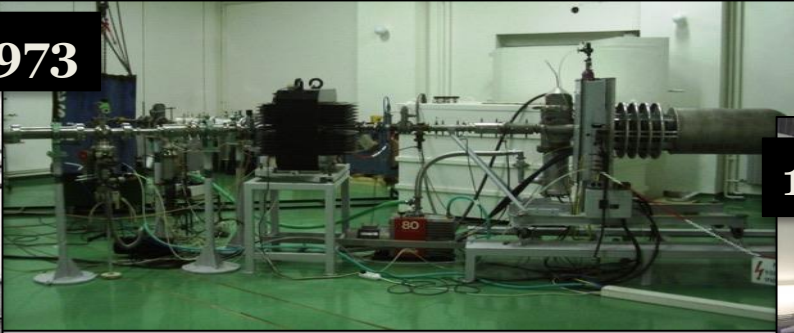


# RBI & accelerators:



1956

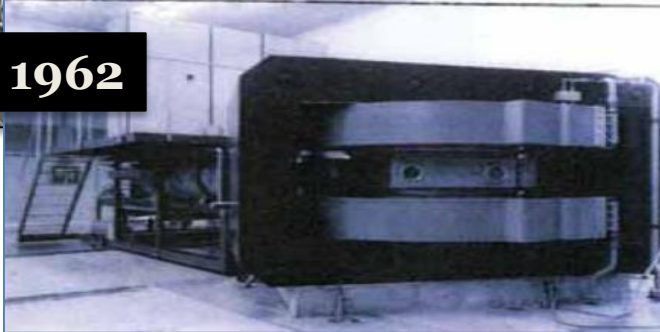
1973



1987



1962



2009



2005





# RBI ACCELERATOR CENTER TODAY

PIXE/RBS



In-air PIXE



Dual-beam irradiation

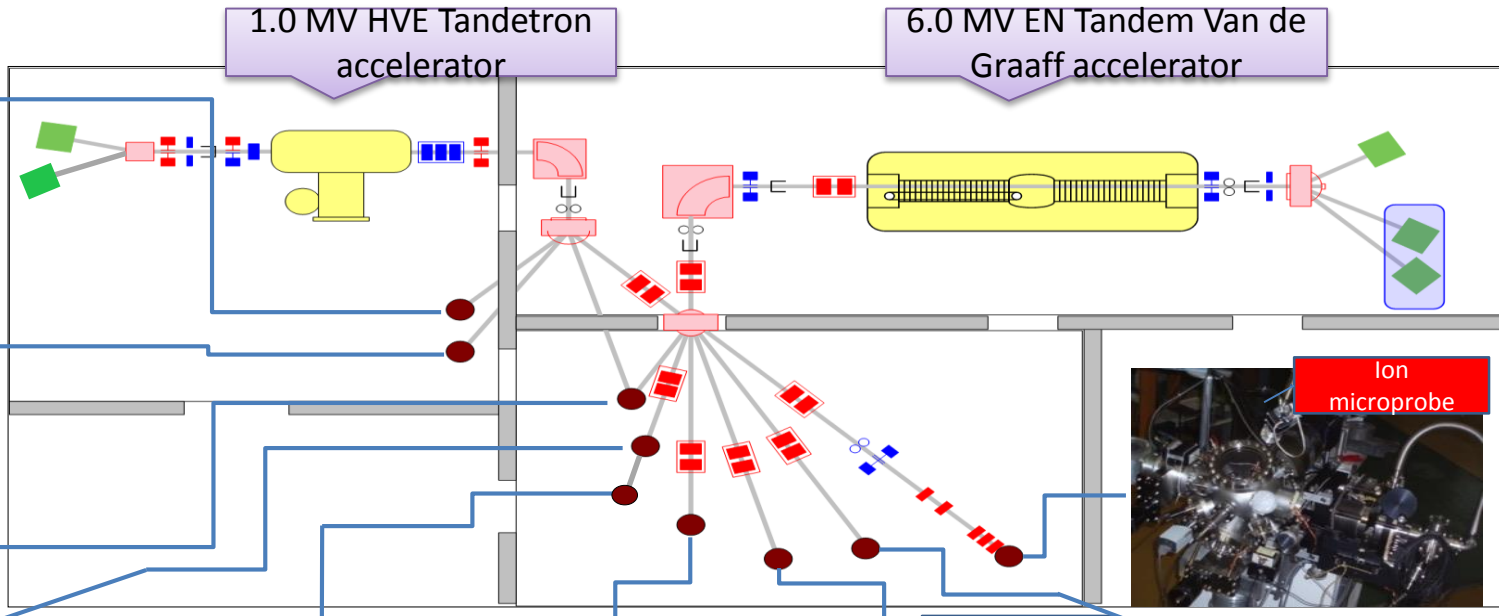


IAEA beam line

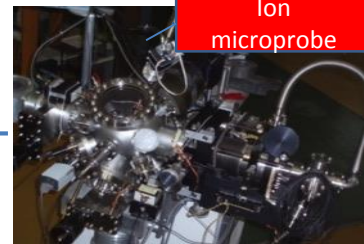


1.0 MV HVE Tandem accelerator

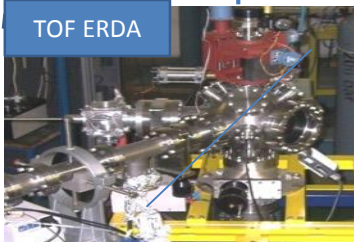
6.0 MV EN Tandem Van de Graaff accelerator



Ion microprobe



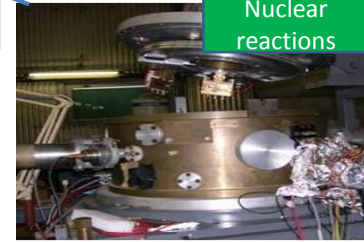
TOF ERDA



PIXE crystal spectrometer



Nuclear reactions



Detector testing



## Current major RBI Accelerator related projects

### Nuclear physics

Particle Physics/CERN

Astroparticle physics

Condensed matter

Thin films

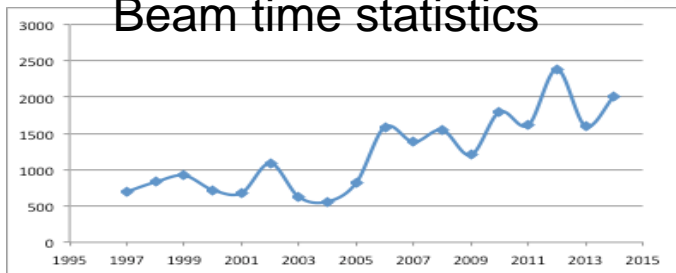
Sensors

Photonics and optics

Ion beam physics

- H2020 ERA Chair: **Particle and Radiation Detectors, Sensors and Electronics**
- **IAEA TC projects**
- **EuroFusion**
- H2020: **AIDA - Advanced European Infrastructures for Detectors at Accelerators**
- **C-ERIC – EU Research Infrastructure open for external basic and applied users in the fields of Materials, Biomaterials and Nanotechnology**
- **Center of excellence** for advanced materials and sensors

### Beam time statistics



First (and only) EU TNA  
(transnational access) provider  
in Croatia

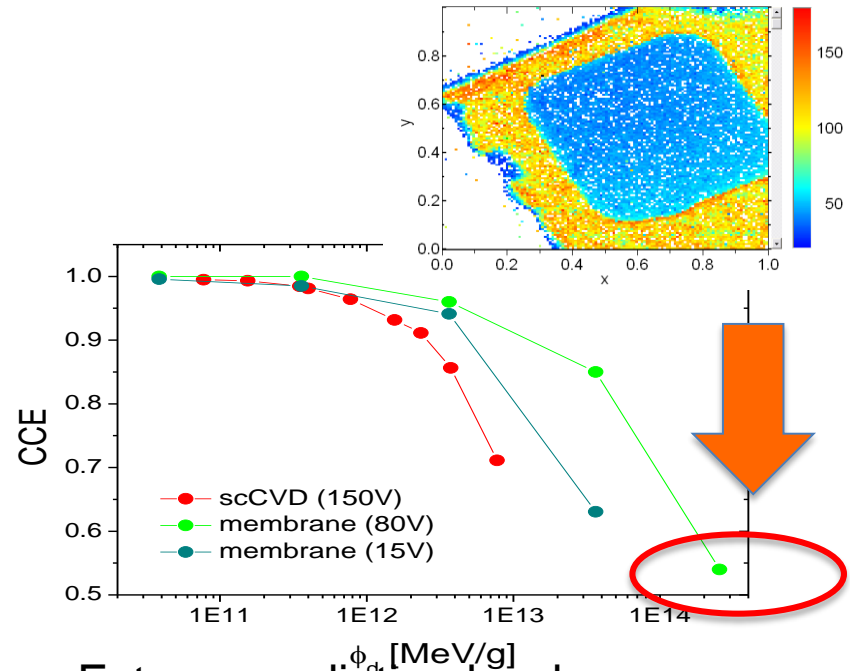
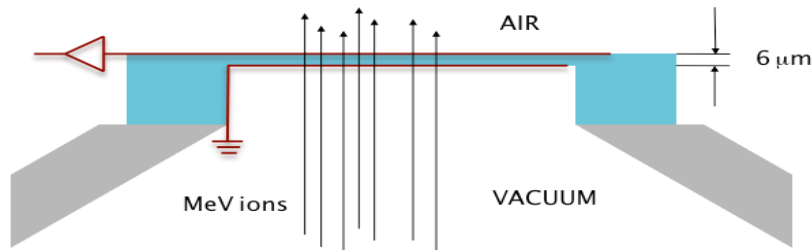
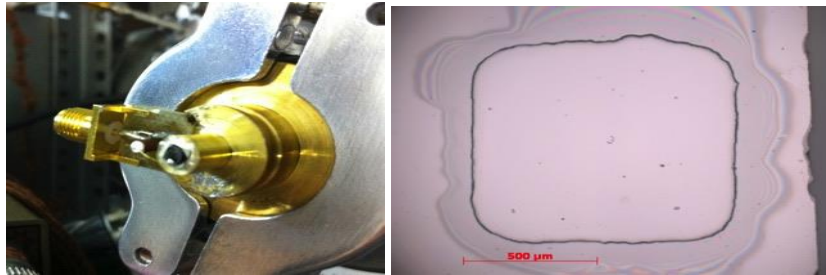
# State of the art techniques

## Example: Diamond membrane detector

First in the world (with JAEA Takasaki i CEA Saclay)

Diamond membrane 6  $\mu\text{m}$  thick dual role:

- a) Vacuum window;
- b) Charged particle detector

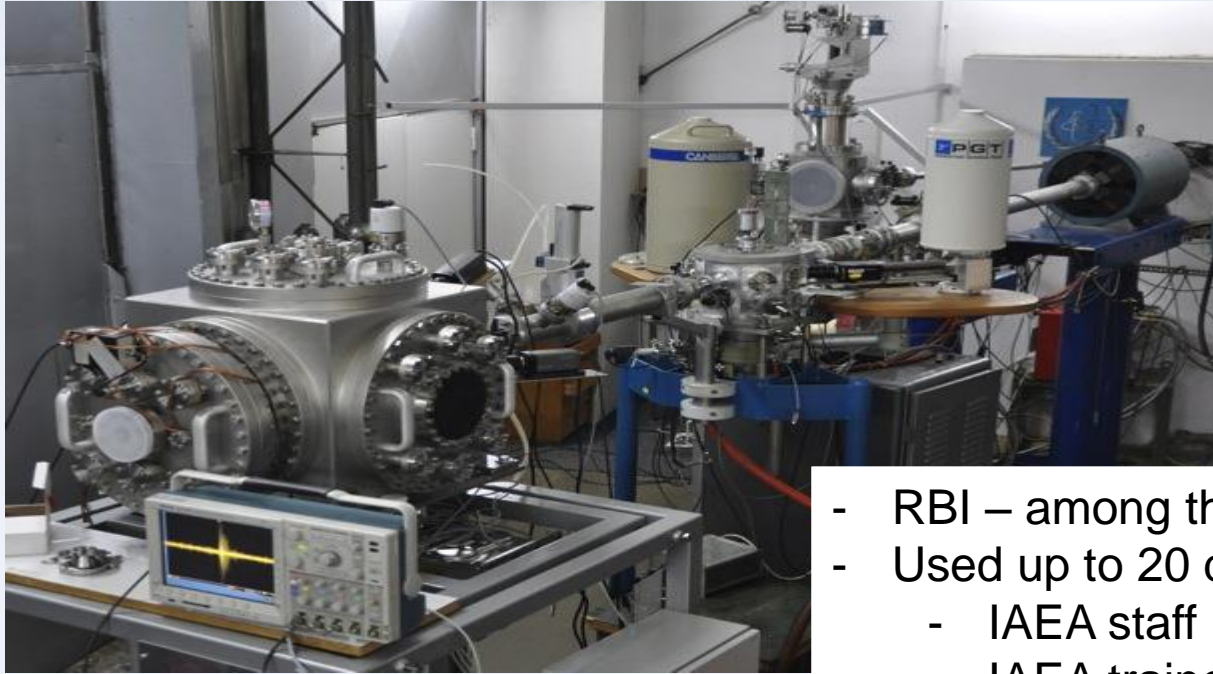


Extreme radiation hardness  
- eq.  $10^{16} \text{ cm}^{-2}$  1 MeV neutrons !!



# IAEA BEAM LINE AGREEMENT

Since 1996.



- RBI – among the closest facilities to Vienna
- Used up to 20 days/year by:
  - IAEA staff (different projects)
  - IAEA trainees (TC projects)
  - Training courses
- Exploring other possibilities

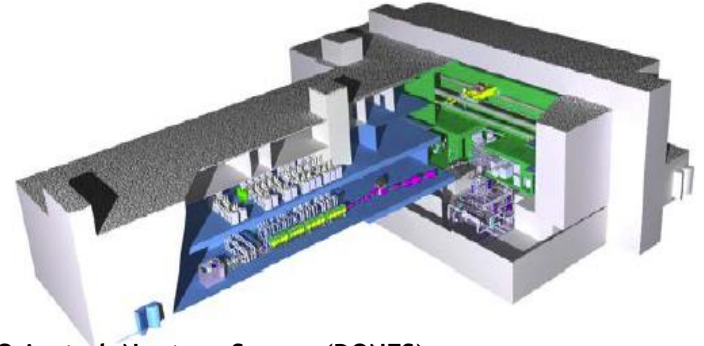
# The amazing future??

- H2020 ERA Chair:
- H2020 Twinning:
- IAEA TC projects
- EuroFusion
- H2020: AIDA
- C-ERIC
- Center of excellence
- O-ZIP
- ...

**These activities  
could, among other,  
make RBI an  
important factor for**



## DONES



DEMO Oriented Neutron Source (DONES)

Accelerator - neutron source for modification and testing of materials for DEMO, the planned successor to ITER fusion reactor (under construction)

EU investment  $\approx$  400 M €

Estimated start of construction : 2016.

**Open possibility for DONES to be located in Croatia!**  
(negotiations under way for 200-300 million Euros to come from Croatian structural funds)



**RBI PLAN/VISION: WITHIN 10-20 YERAS  
BECOME A TOP 100 SCIENTIFIC INSTITUTION IN  
THE WORLD, AND REGIONAL LEADER IN MAIN  
RBI ACTIVITIES**

**Structural investments/funds**

**Sustained focus on excellence  
and project success**

**Strong focus on cooperation  
with the industry**

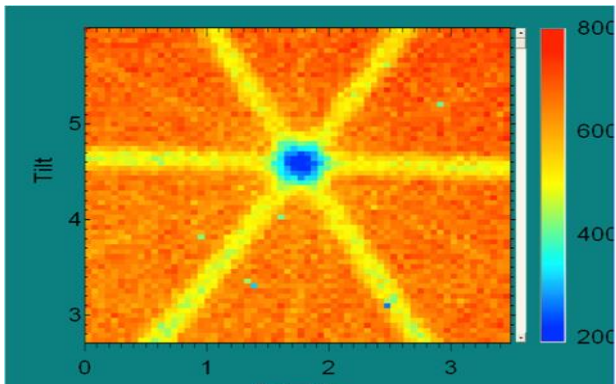
**Brain gain**

**Strategic scientific and industrial  
partners outside Croatia**

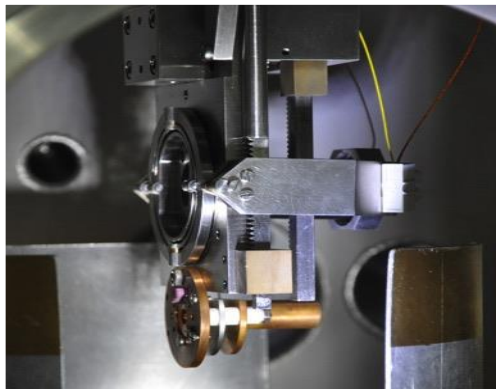


# State of the art techniques

## Example: Dual beam irradiation



Simulation of neutron irradiation



Ion from 6.0 MV tandem

Ion from 1.0 MV tandem

# Success not accidental

## NEW rules

STATUTE

ORGANISATION

HIRING AND  
ADVANCEMENT

OPEN ACCESS – SPACE  
AND EQUIPMENT

RESTRUCTURING OF  
LABORATORIES AND  
DEPARTMENTS

## STRUCTURAL FUNDS

### FOCUS ON HORIZON2020 AND SIMILAR

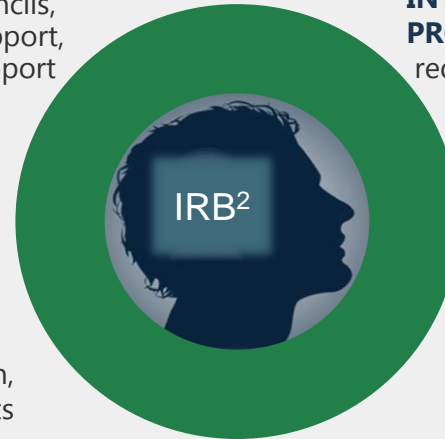
membership in dep. councils,  
financial support,  
project support

### COOPERATION WITH INDUSTRY

Patents,  
membership in dep. councils

flexible organisation,  
dependent on international projects

term limits,  
parallel function number limits



### INTERNATIONAL PROJECTS

requirement for key positions

### INTERNATIONAL EXCELLENCE AND POSTDOCTORAL EXPERIENCE

requirement for hiring and  
career advancement

Financial and logistical  
help for returnees

open infrastructure,  
flexibility of space

# HUGE STEP FORWARD FROM COMMON PRACTICE IN CROATIA

# Environment

Biological Effects of Metals

Chemistry of traces

Marine and water systems

Environmental Modelling

Organic Compounds

Environmental geochemistry

Aquaculture and Aquatic Organisms

Marine biochemistry and atmosphere

Molecular ecotoxicology

Radioecology

Marine processes

Marine ecotoxicology

Marine microbial ecology

Benthos

Marine biotechnology

Evolutionary ecology

Biotechnology in aquaculture

- **Center of excellence** for bioprospecting of the sea





# Ion beam applications



## ION BEAM ANALYSIS



### Ion implantation:

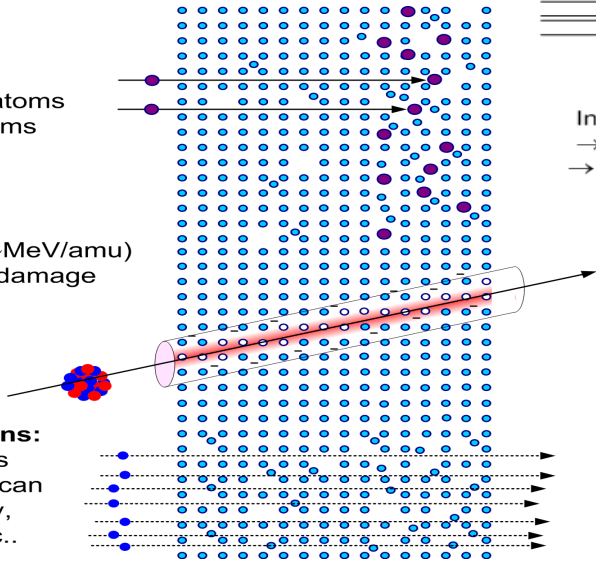
- a) Injection of foreign atoms
- b) Displacement of atoms

### Single ion tracks:

Fast and heavy ions (~MeV/amu) create latent tracks of damage used as a template in nanostructuring

### Irradiation with protons:

Produce homogeneous radiation damage that can be used for lithography, defect engineering, etc..



Elastic scattering of incoming ion  
→ Rutherford backscattering spectrometry - RBS

Inner shell ionization  
→ emission of x-ray  
→ PIXE spectroscopy

Nuclear reaction → emission of reaction product (particle; gamma ray) → PIGE and NRA techniques

Energy loss of incoming ions → Scanning transmission ion microscopy - STIM

Elastic scattering → recoil of target nuclei → ERDA depth profiling technique



## MATERIALS MODIFICATION