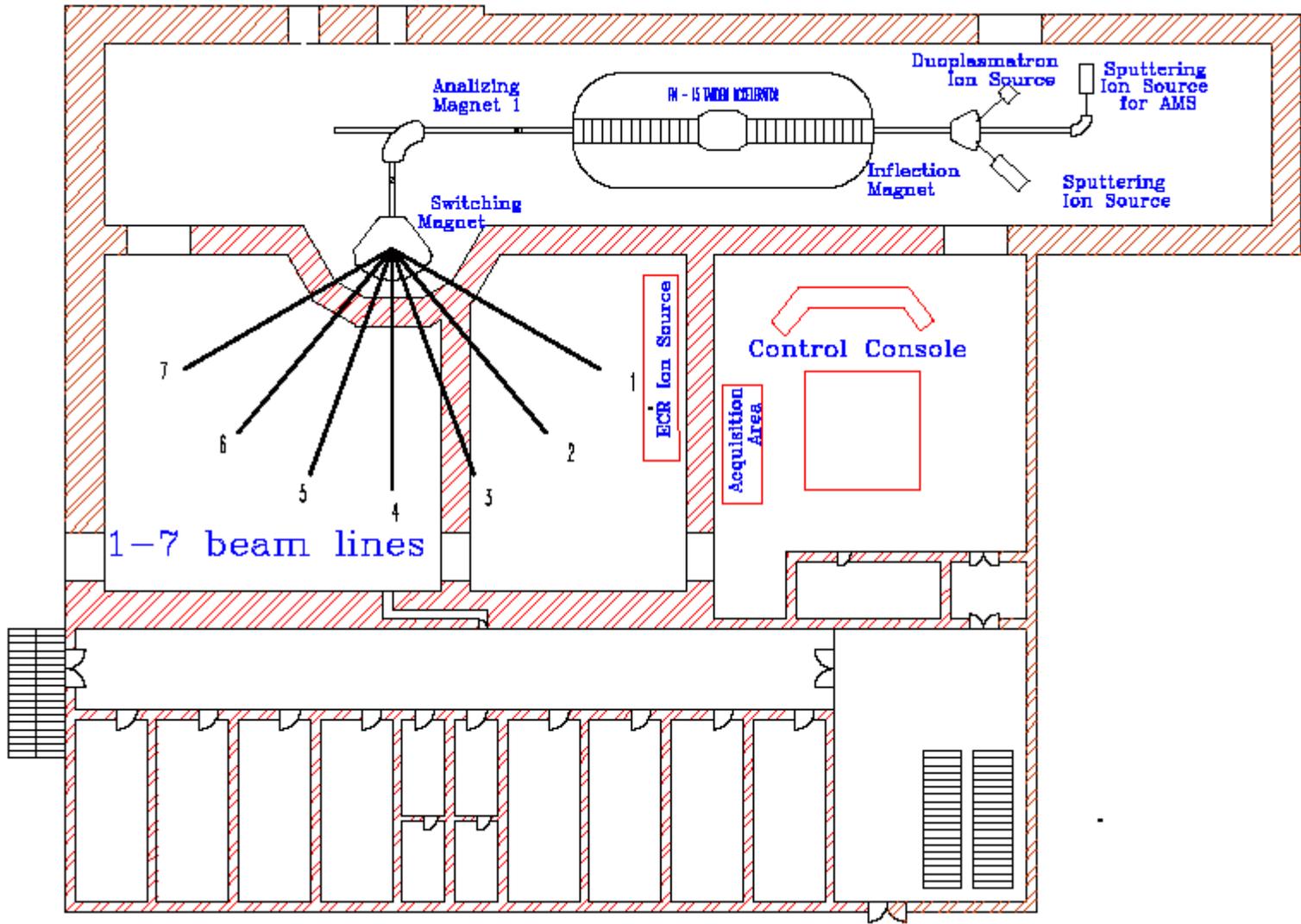


# Upgrade of the Bucharest FN Tandem Accelerator

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# Main milestones of the Bucharest FN tandem accelerator

- **1973** : Commissioning of the FN Tandem accelerator
- **1977** : A strong earthquake (7.2 Richter scale) induced the collapse of the tandem column
- **1979** : Upgrade to 9 MV of the tandem (5-10% SF6)
- **1983** : A second negative heavy ion injector (HICONEX 834) was installed
- **1986** : Another strong earthquake (6.9 Richter scale) damaged again the tandem column
- **1989 - 1990** : An original seismic protection system of the tandem accelerator tank was installed (see picture)
- **1990** : A new terminal voltage divider was installed
- **1991 – 2005** : About 3500 beam hours/year
- **2006 – 2009** : **Upgrade program of the Bucharest tandem accelerator**



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**The main original tandem equipment still in use in 2006 was in very poor condition due to physical and moral wear and some of the necessary spare parts were no longer available on the market.**

**Question:**

***Is it worth to invest in an old facility ?***

**Answer:**

***Yes, in certain conditions:***

- The main accelerator parts (column, tank, magnets, building) are in good condition***
- There is a scientific interest and a strategy for the future research with accelerated ion beams***

# MOTIVATIONS

## The Bucharest FN Tandem Accelerator :

- Is the only tandem accelerator of this type in Romania and even in S-E Europe
- Is an important facility for:
  - Atomic and some nuclear physics research
  - Applications (IBA, AMS)
  - Preparation of experiments for LSF
  - Education

# **UPGRADE PROGRAM**

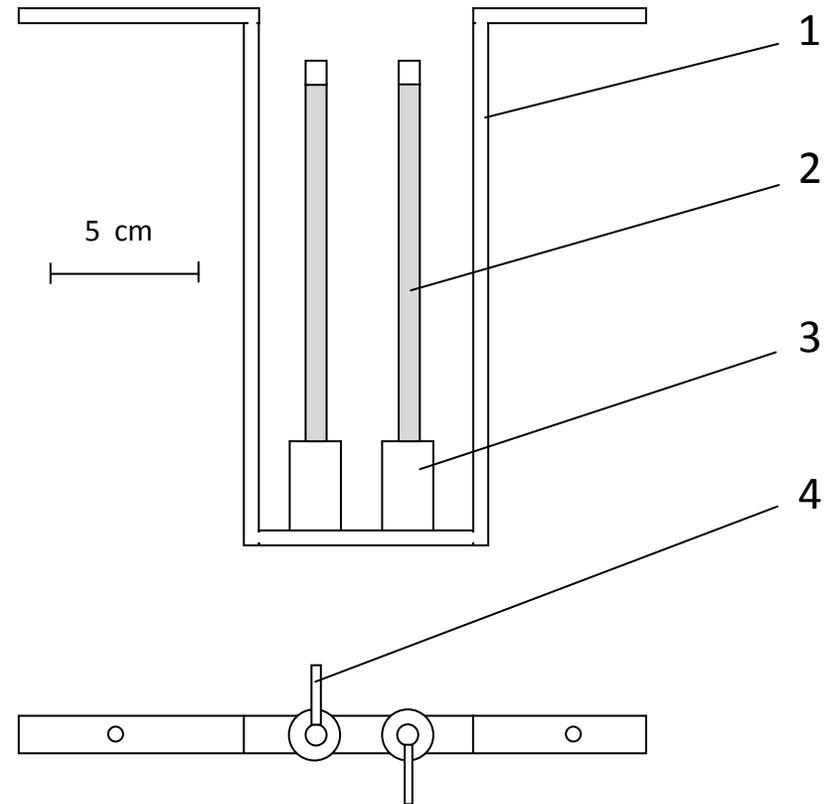
## **(2006 – 2009)**

- **Pelletron system installation**
- **New set of accelerator tubes**
- **Renewing of the tandem injector**
- **Millisecond beam pulsing**
- **Nanosecond beam pulsing**
- **Replacement of all electrical equipment**
- **Refurbish of the tandem vacuum system**
- **Improvement of auxiliary equipment**

# 1. Pelletron system installation



# Frames with 300 M $\Omega$ resistors



## **2. New set of accelerator tubes**

**The old set of accelerator tubes**  
*(st. steel electrodes, inclined field)*

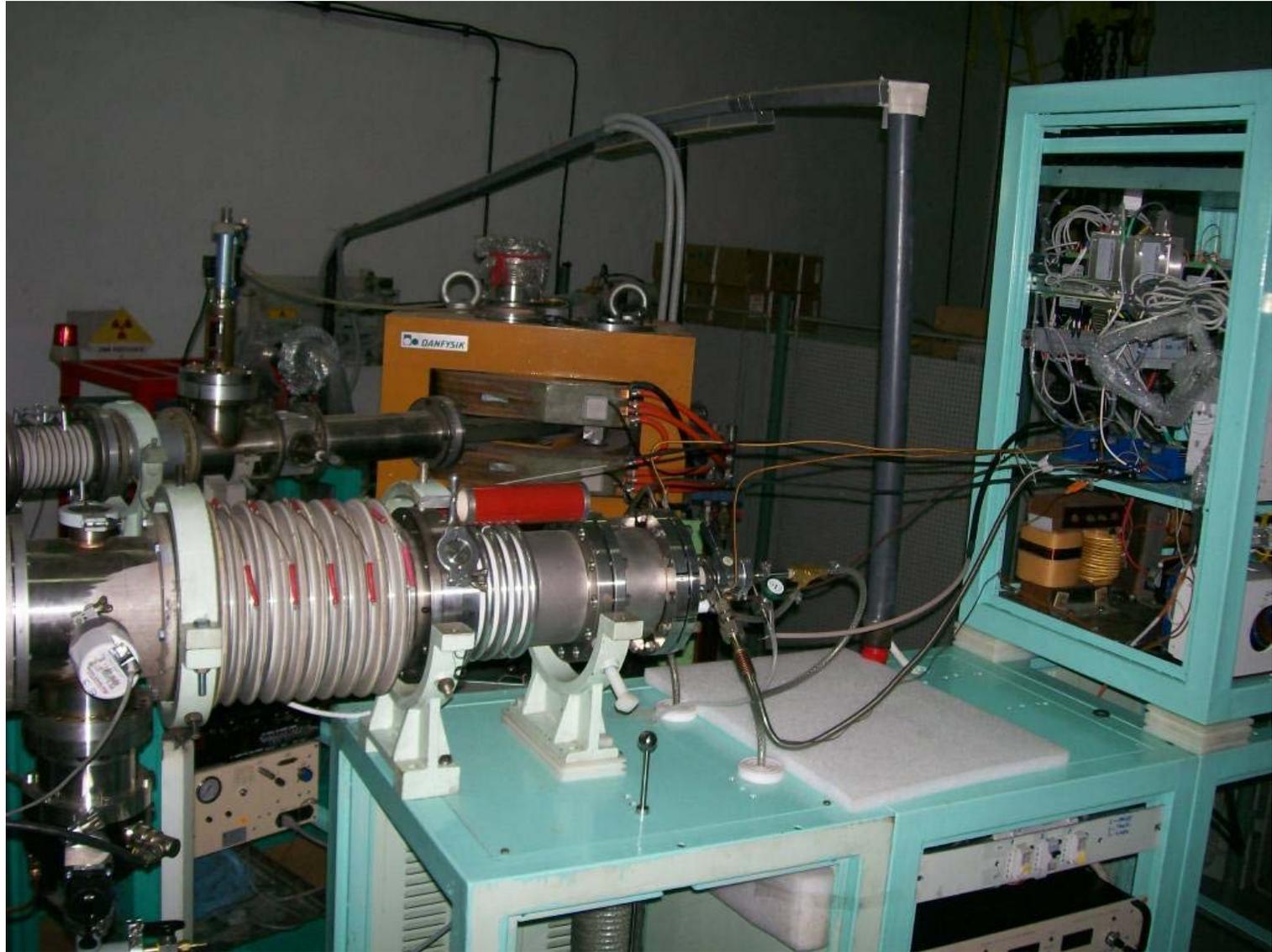


**A set of new accelerator tubes**  
*(titanium electrodes, spiral field)*

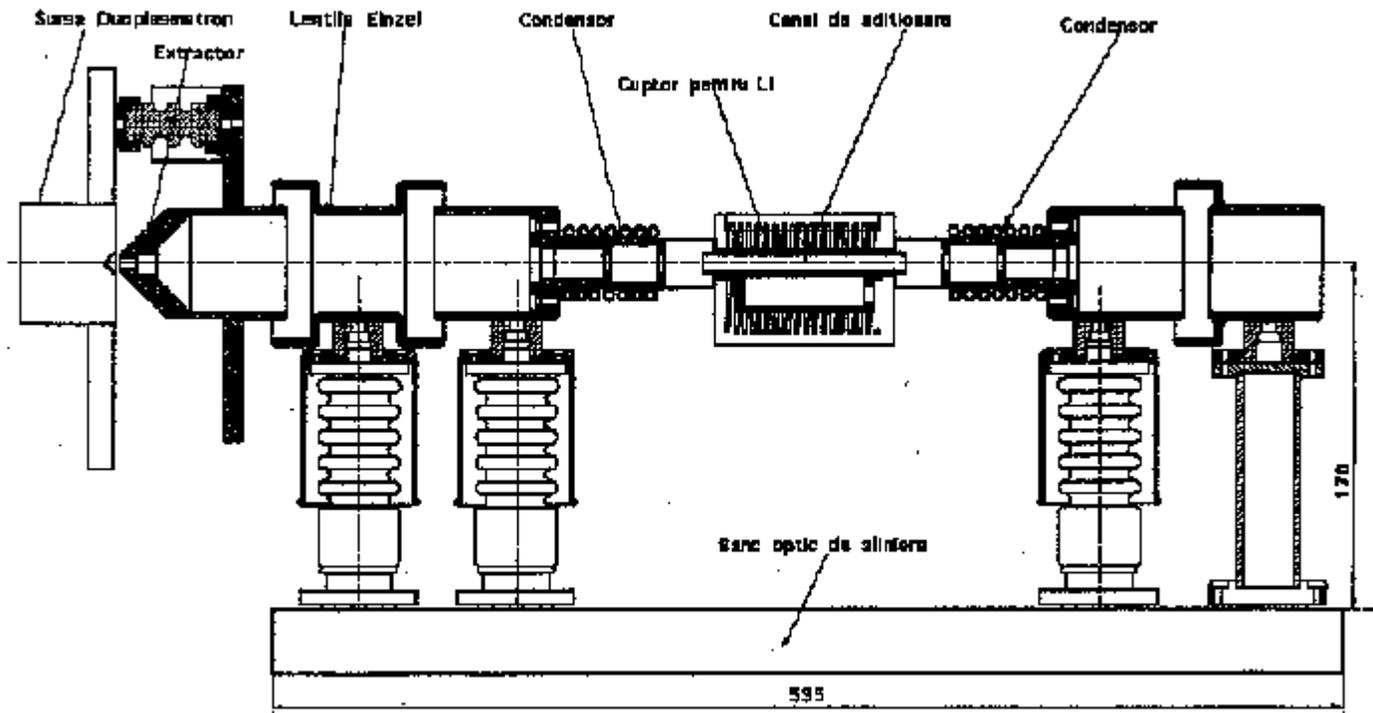
# **3. Renewing of the tandem injector of negative ions**

- a) New sputter negative ion source (SNICS II)**
- b) New helium negative ion source**
- c) New sputter ion source for AMS application (MC-SNICS II)**

## a. SNICS II sputter source installation



## b. He negative ion source



Sursa de Ioni negativi cu schimb de sarcina pe litiu.

S: 40%

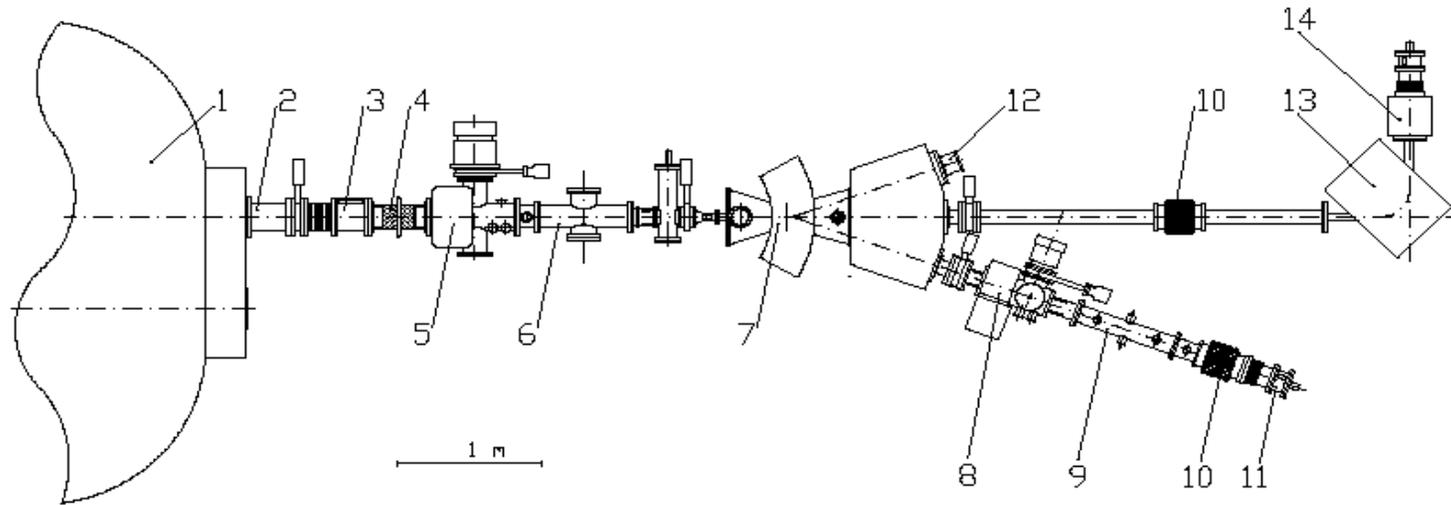
## 4. Millisecond pulsing system

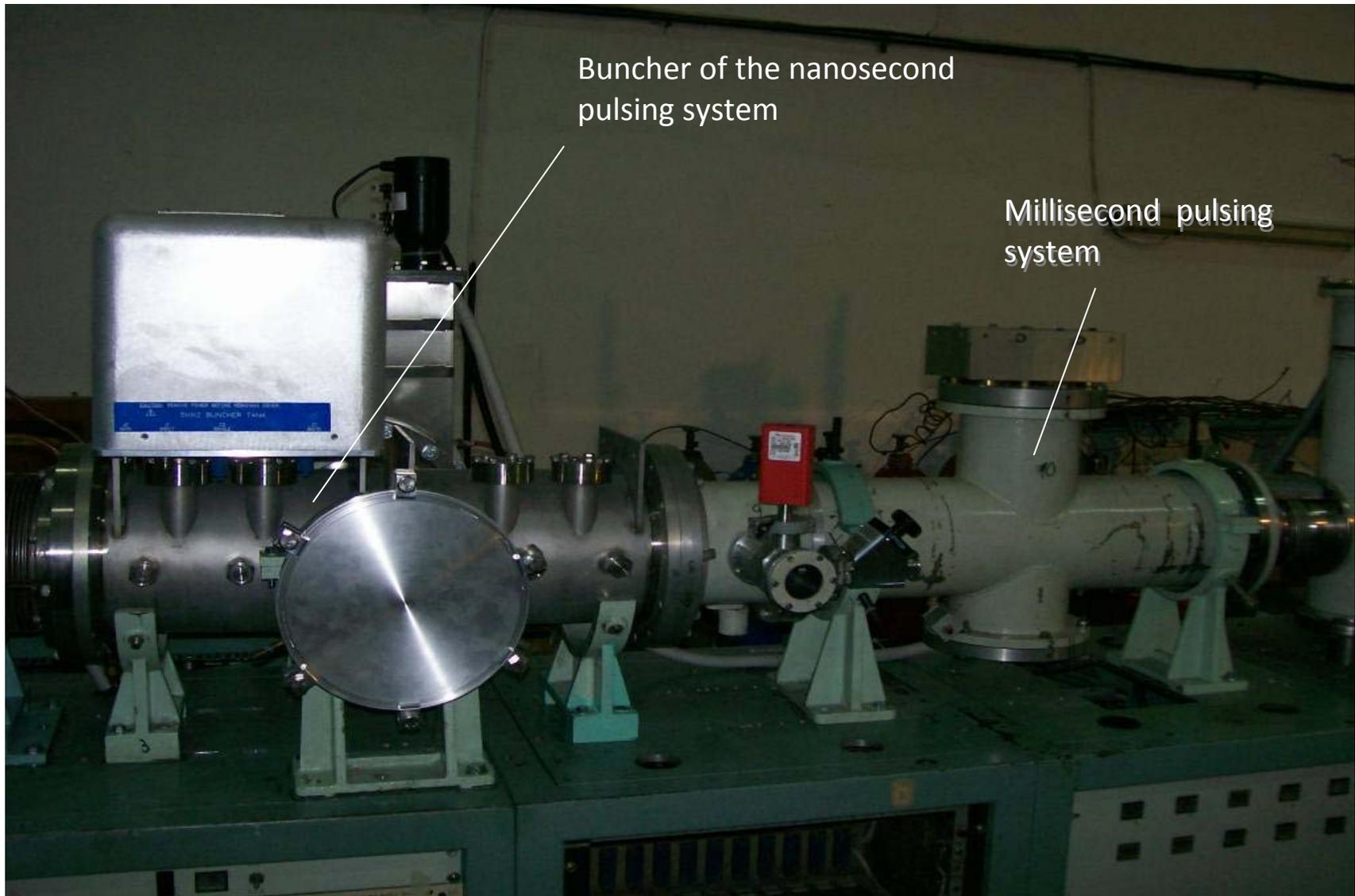
- Chopper system (two plates 500 mm long)
- Rectangular TTL-pulses
- Period:  $T = 5 \text{ ms} - 2 \times 10^4 \text{ s}$
- Amplitude: up to 1 kV
- Rise time:  $< 50 \text{ ns}$
- Pulse duration: 3% - 50% of T
- Home made

# 5. Nanosecond pulsing system

- Chopper + buncher
- Chopper pulse rate: 5 MHz, 1.25 MHz, 625 kHz, .... , 19.53 kHz
- Buncher: two tubes, match injected beams from mass 1 to over mass 40 u
- Pulse duration: 1-3 ns
- Packing efficiency: 25%
- Made by NEC (2009)

# The injector and LE line of the Bucharest tandem



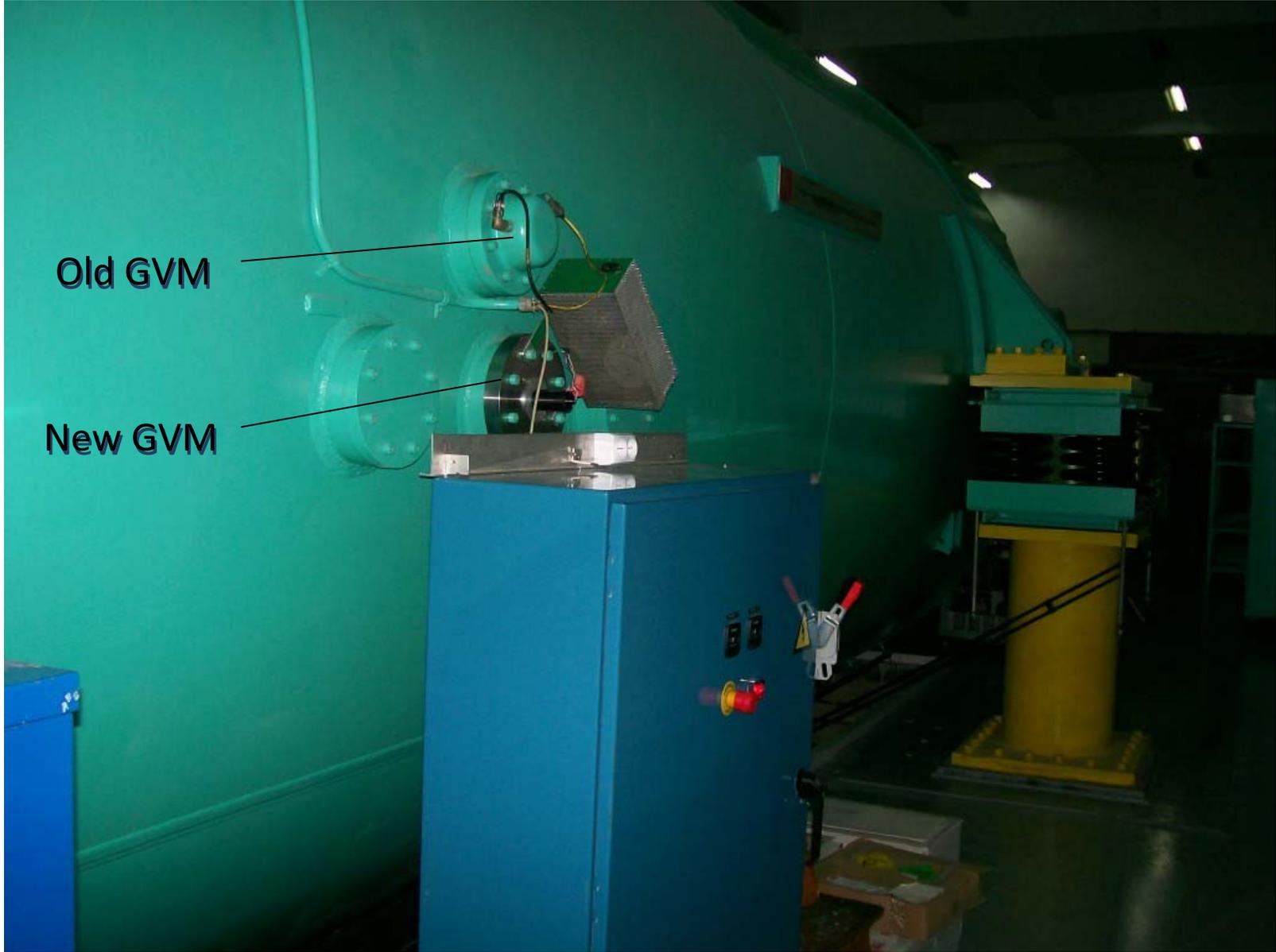


Buncher of the nanosecond pulsing system

Millisecond pulsing system

## 6. Replacement of all electric equipment

- ❖ **Power supplies** of low voltage for the *inflection magnet* (1 kW), *analyzing magnet* (12 kW) and *switching magnet* (20 kW) (DANFYSIK, Denmark)  
Long term current stability : 10 ppm
- ❖ **Power supplies** for two *magnetic quadrupole lenses*. (SORENSEN, USA)  
Long term current stability : 100 ppm
- ❖ **High voltage power supplies** for the *ion injectors* and for the *Einzel lens* on the LE ion beam line (GLASSMAN, USA)
- ❖ **Hall probe fluxmeter** for the inflection magnet (Group3, New Zealand)
- ❖ **RMN fluxmeter** for the analyzing magnet (METROLAB, Switzerland)
- ❖ **GVM** : a second GVM, terminal stability < 1 kV at 9 MV



Old GVM

New GVM

## **6. Refurbish of the vacuum system**

- **New turbomolecular and fore vacuum pumps**
- **New gate valves**
- **New vacuum measuring system**

## **6. Improvement of auxiliary equipment**

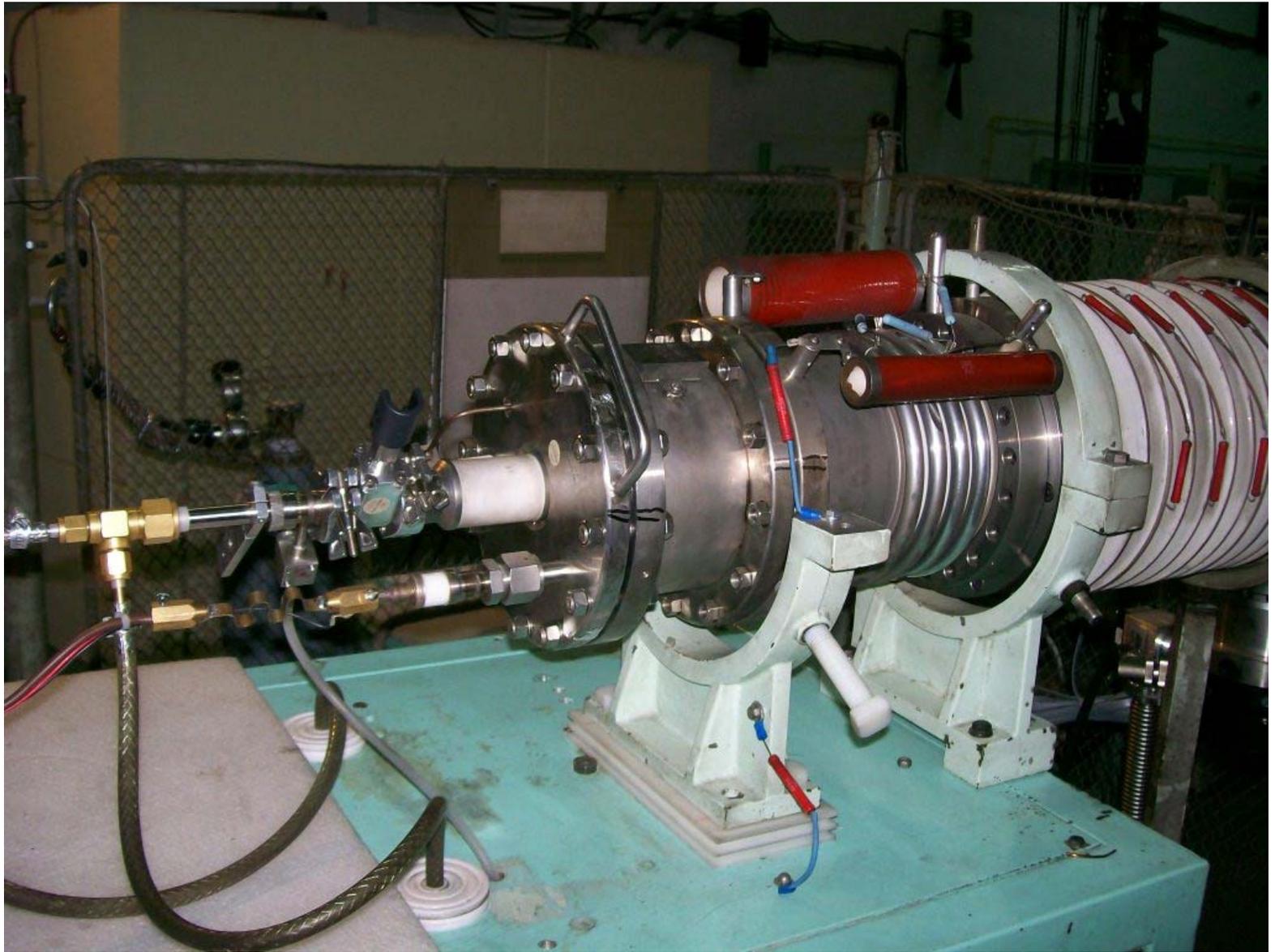
- **Installation of a high power (250 kVA) on-line, dual UPS (*Uninterruptible Power Supply*)**
- **Increase of the thermal capacity of the refrigeration system that cools down the distilled water**
- **Installation of new distilled water pumps and air compressors**

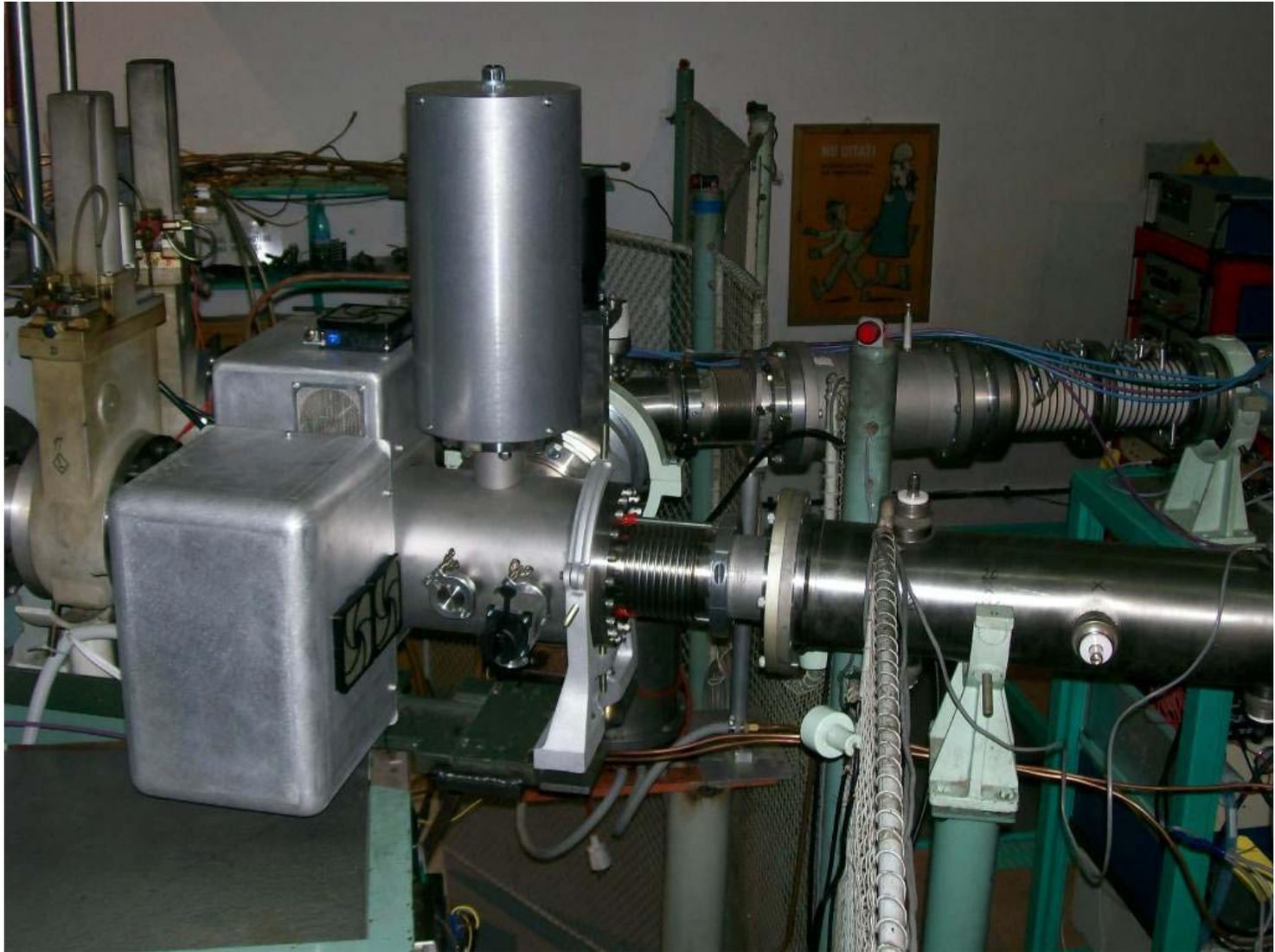
# CONCLUSIONS

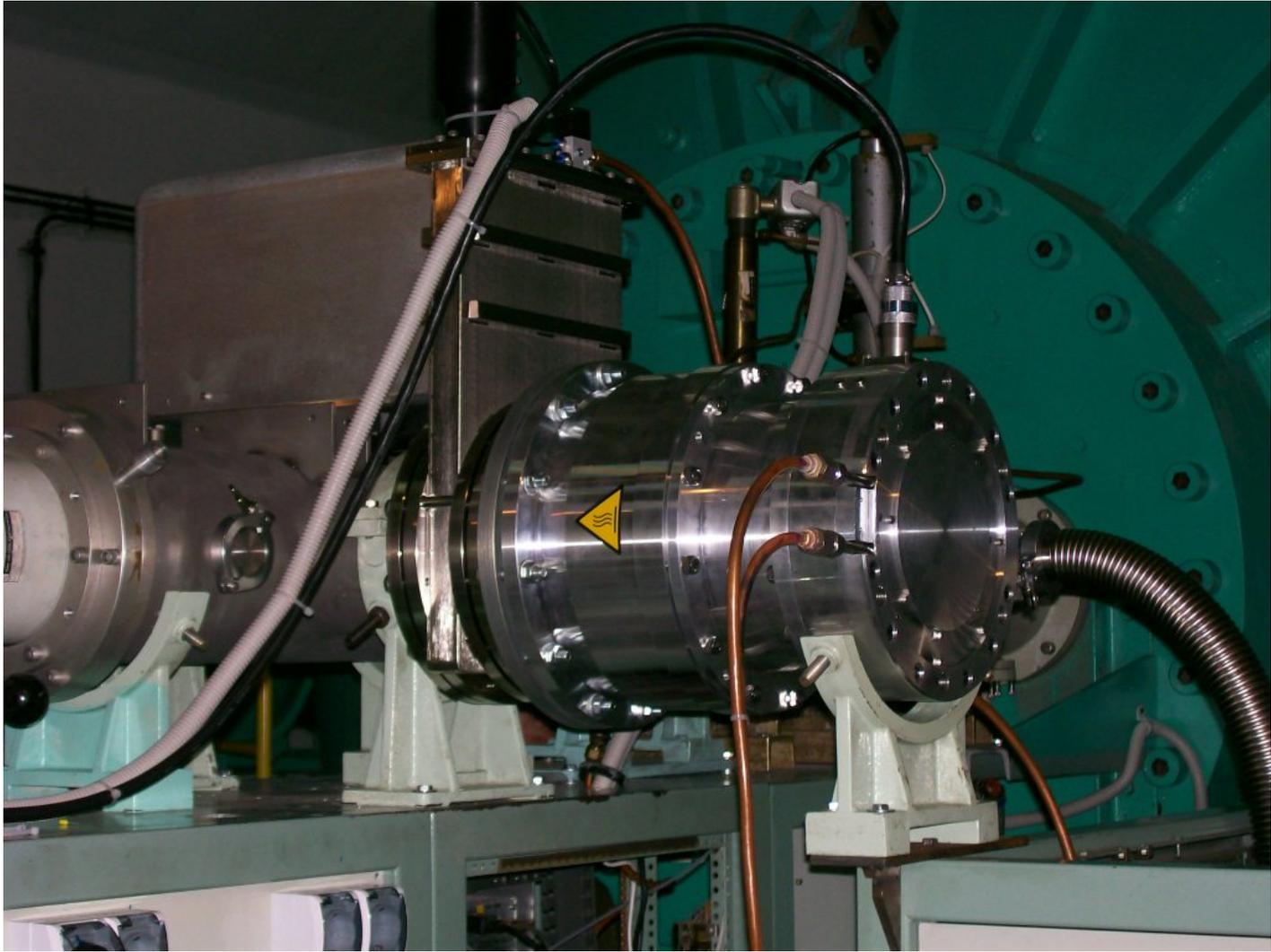
- 1.** The upgrade program of the Bucharest FN tandem accelerator, developed in the period 2006-2009, had as a main result the transformation of this 36 years old accelerator into *a modern, performing and reliable facility*
- 2.** The tandem delivers stable beams of a large range of ion species: *protons* (2 – 18 MeV), *helium* (3-27 MeV) and a broad range of *heavy ions* at energies up to 100 MeV
- 3.** The beam intensities range from *nA* to  $\mu$ A depending on the electron affinity of the elements
- 4.** The accelerated beam may be pulsed in the *millisecond* range and in the *nanosecond* range

***The performances of the upgraded Bucharest FN tandem accelerator combined with a strong scientific research program and with high level results open for this facility the prospect to become an active part of the European Infrastructure in Nuclear Physics.***

*THANK YOU*







# Research program

- ❖ **In-beam Gamma-ray Spectroscopy** using a small array of HPGe detectors, silicon detectors for charged particles and liquid scintillators for neutron detection.
- ❖ **Proton induced fission studies** on actinides using an array of 81 plastic scintillators for neutron detection to be installed.
- ❖ **Studies of nuclear isomery**, namely accurate measurements of the electromagnetic moments of excited isomeric states, using ns pulsed accelerated ion beams.
- ❖ **Atomic physics:** new studies of the inner shell vacancy production and sharing in heavy systems at intermediate ion energies.
- ❖ **New applications of IBA methods** using up-to-date experimental set-ups now under development.
- ❖ **In-house research** making use of the tandem accelerator ion beams for testing new detection systems and experimental methods for **large scale facilities**.