NATIONAL INSTITUTE FOR RESEARCH AND DEVELOPMENT IN ELECTRICAL ENGINEERING ICPE-CA
Splaiul Unirii 313, District 3, Bucharest - 030138
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Three success achievements of National Institute for R & D in Electrical Engineering in the field of energy systems and smart cities & communities.

3RD UNI-SET Energy Clustering Event, UPB, Bucharest, Romania, 21-23 November 2016

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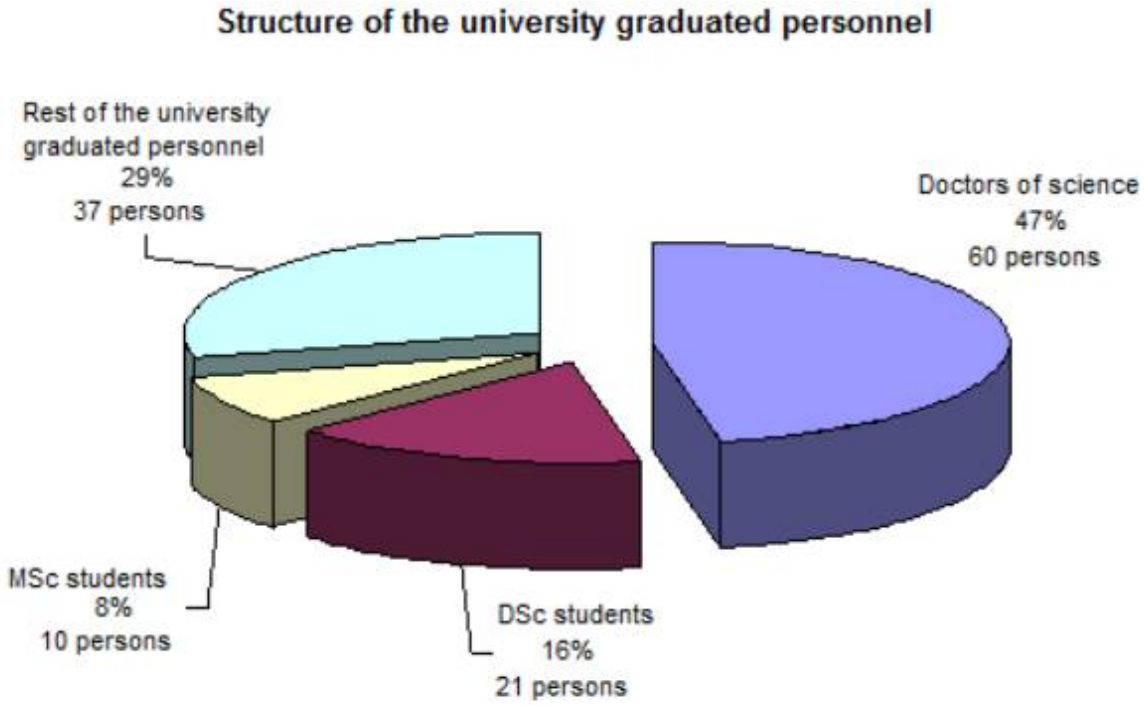
0. Overview of INCDIE ICPE-CA

Main activities

- **Fundamental and applicative research** in the field of electrical engineering;
- **Technical assistance and consultancy** in the field of electrical engineering;
- **Information, documentation and personnel training** in the field of electrical engineering;
- **Technology transfer.**



Areas of Research and Development

- ***Advanced Materials:*** functional / multifunctional, crystalline and nanostructured materials and composites;
- ***Renewable energy and energy efficiency*** (wind energy, solar energy, fuel cells, biogas, hydro-energy, hydrogen storage): ***conversion, saving and recovery of energy*** ;
- ***Micro-Electromechanical technologies and systems*** (nonconventional electrical engineering) .

Likewise, ***ICPE-CA provides technical assistance, supply of scientific and technological services*** to companies and to any beneficiaries which are interested ***in testing laboratories***:

- ***Lab. of Characterization and Testing of Electrical Materials and Products;***
- ***Lab. of Electromagnetic Compatibility;***
- ***Lab. of Evaluation of Thermal Behavior of Products and Materials by Thermal Analysis;***
- ***Lab. of Testing for Micro and Nano-Electromechanics***.


Satu Mare
MARAMUREŞ
Carei
SATU MARE
Dorohoi
BOTOŞANI
Rădăuţi
Suceava
Botoşani
Fălticeni
SUCEAVA
IAŞI
Vatra Dornei
Iaşi
Paşcani
Zalău
Oradea
SĂLAJ
Dej
Bistriţa
Gherla
CLUJ
BIHOR
Roman
Piatra Neamţ
Salonta
Reghin
Vaslui
Huşi
Cluj-Napoca
Gheorgheni
BACĂU
Turda
Târgu Mureş
Moineşti
Bacău
VASLUI
Câmpia Turzii
HARGHITA
ARAD
MUREŞ
Miercurea-Ciuc
Comăneşti
ALBA
Aiud
Bârlad
Arad
Târnăveni
Odorheiu S
Adjud
Mureş
Blaj
Alba Iulia
Brad
Sebeş
Deva
Timişoara
Hunedoara
Orăştie
SIBIU
BRAŞOV
COVASNA
VRANCEA
Tecuci
Sibiu
GALAŢI
HUNEDOARA
Braşov
Focşani
Lugoj
TIMIŞ
Galaţi
Caransebeş
Petroşani
Râmnicu Sărat
ARGEŞ
Brăila
Reşiţa
PRAHOVA
BUZĂU
Tulcea
Câmpulung
Rîmnicu Vîlcea
CARAŞ-SEVERIN
Buzău
BRĂILA
Tirgu Jiu
TULCEA
GORJ
VÂLCEA
Târgovişte
Ploieşti
Moldova Nouă
Motru
Orşova
Piteşti
Drăgăşani
DÎMBOVIŢA
IALOMIŢA
Filiaşi
Slatina
MEHEDINŢI
Craiova
Bucharest
Cernavodă
OLT
Feteşti
TELEORMAN
Călăraşi
Constanţa
D O L J
Roşiori de Vede
GIURGIU
Băileşti
Alexandria
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1. Common Strategy for Public Transport on Road and River in Călăraşi - Silistra Area

developed on the project :

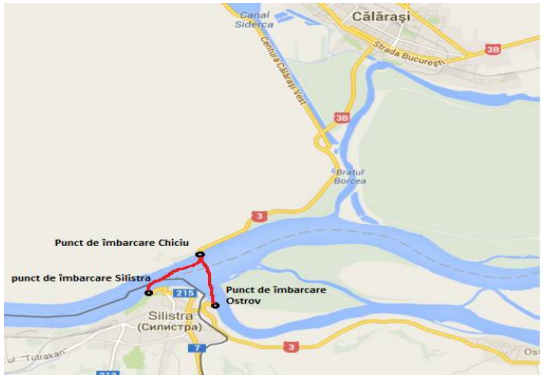
CLEAN ACCESS IN CALARASI - SILISTRA CROSS-BORDER AREA - CLEEA"

under the framework of

ROMANIA - BULGARIA
Cross Border Cooperation Programme
Common borders. Common solutions.

Dr. Sergiu Nicolaie

The project implemented a sustainable transport system based on **two modern concepts**:
(1) Access within urban and residential areas with zero emission of CO2 vehicles.
(2) Promotion and implementation of energy efficiency and renewable energy sources in Romania – Bulgaria cross border area (Calarasi – Silistra).



*The transport system have **2 components (road & river).***
(a) The River Transport System component (**demonstrative)** is considered to be proper not only for ***accessibility between the urban areas***, but also for ***accessibility in protected areas*** that is specific on Danube River.
Thus, we see a **huge potential for the development of ecological tourism in these areas**, which can lead to a new economic developments.

The demonstrative River Transport System have 2 modules (one for Calarasi and one for Silistra). Each module is composed by an electric boat who will be energetically supplied with solar power and wind power.

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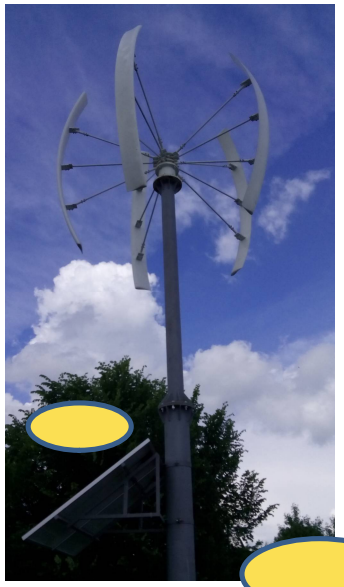
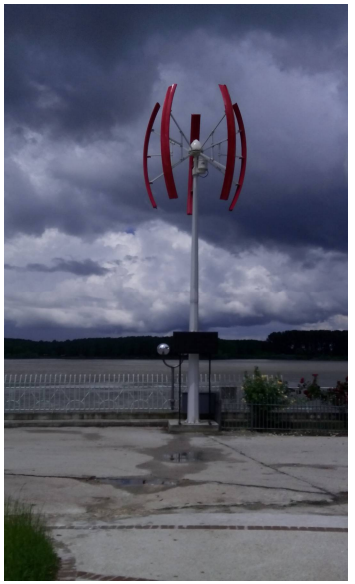




Type: OPEN;
Roof with PV panels
Length: 6,5 m;
Width: 2,5 m
Seats: 8 (7 + 1 driver)

The main characteristics of the ecological boat (Calarasi)

4 x

Total power of 1000 W

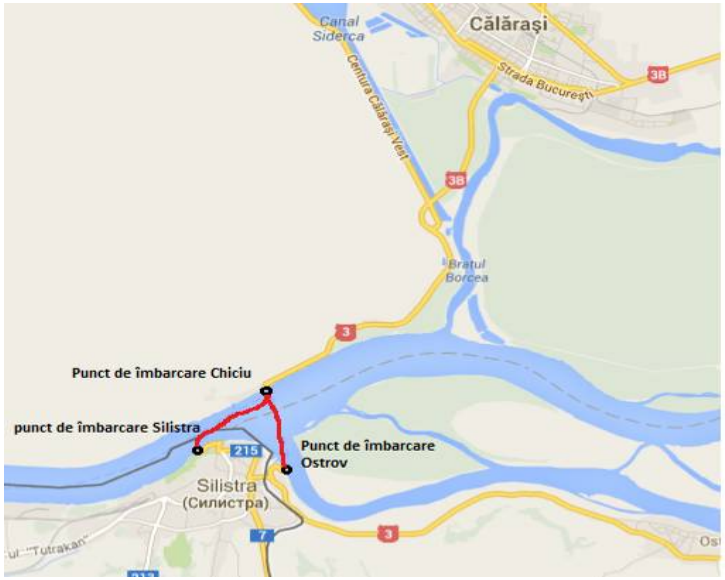
4 x

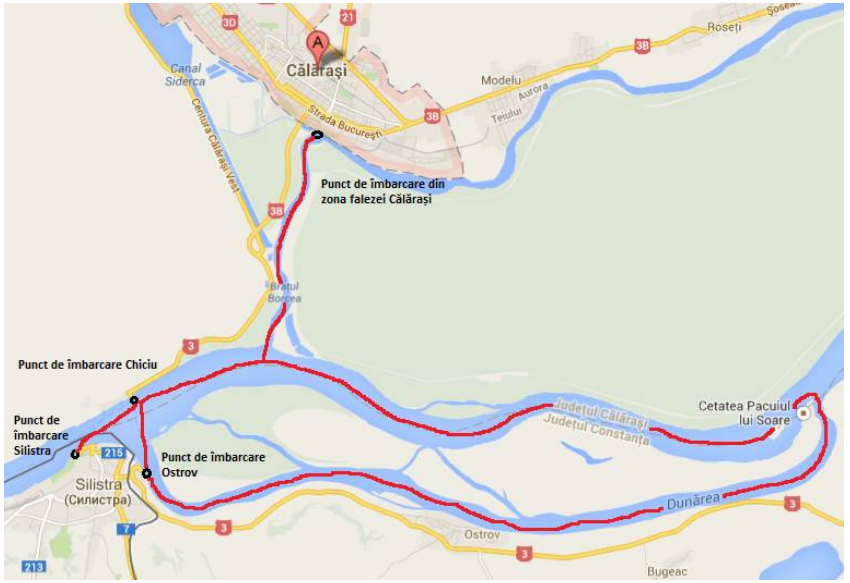
Li-Ion

Main propulsion system (5 kW)

Backup propulsion system

<u>Route I</u> for passenger transport
(cross-border Chiciu – Silistra – distance 2 km) **<u>Route II</u> for touristic rides** (~ 2 x 25 km)





(b) The of terrestrial transport System in Calarasi – Silistra cross border area component

During this project, it was achieved a ***Road Transport Plan for Calarasi and Silistra municipalities***.

This plan was prepared in order to ***replace in Calarasi and Silistra municipalities the current buses that use classic fuels, with electric buses***.

The both Municipal Transport Plans from Calarasi and Silistra was sized based on a local road traffic study, taken into account the current transportation structure of the two municipalities.

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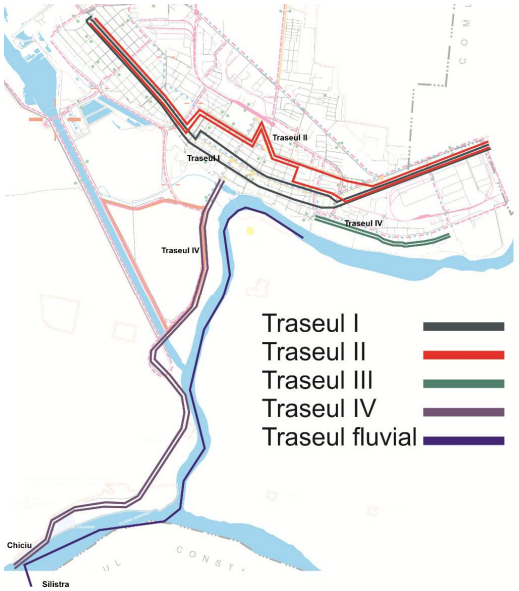
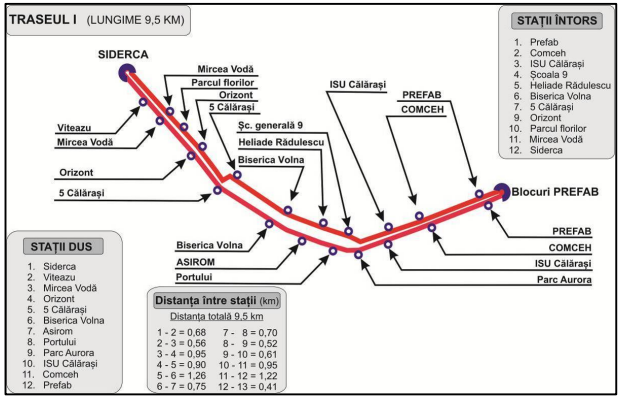
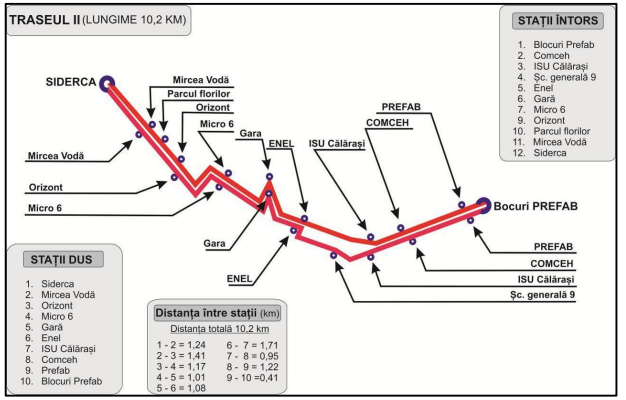
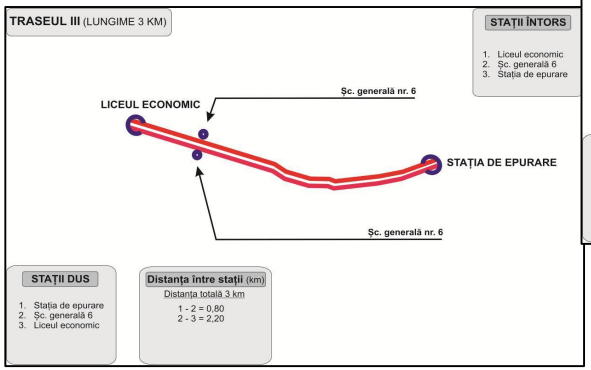
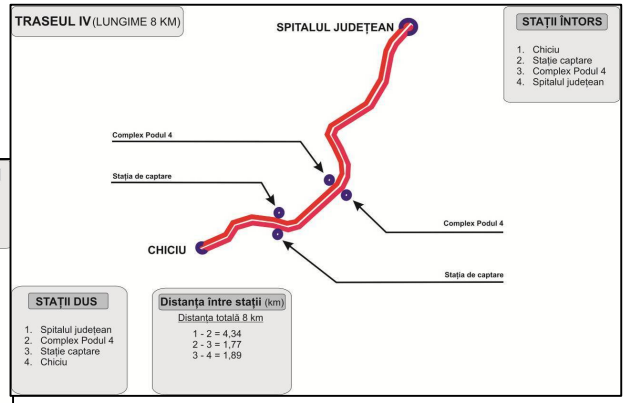
In Calarasi Municipality ***there are four routes*** that is made urban passenger road transport.
In Silistra Municipality ***there are two routes,*** urban exclusive inside

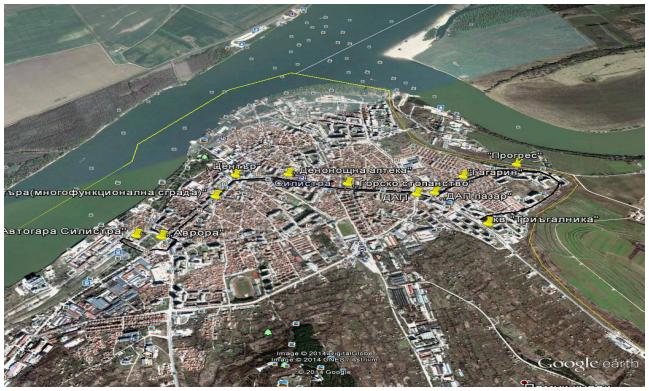












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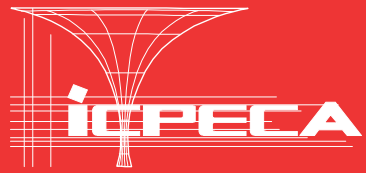

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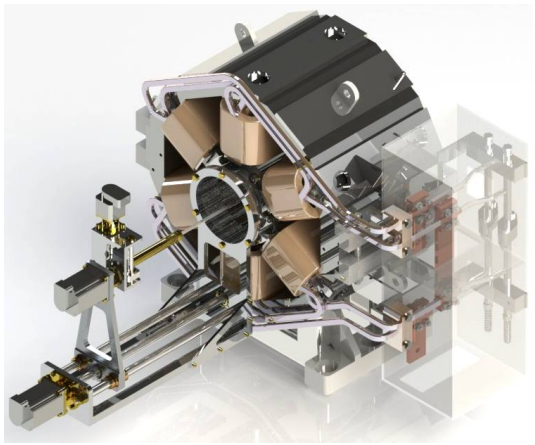
2. NORMAL CONDUCTING MAGNETS AND POWER CONVERTERS FOR FAIR – ICPE-CA PARTICIPATION TO THE IN-KIND CONTRIBUTION OF ROMANIA



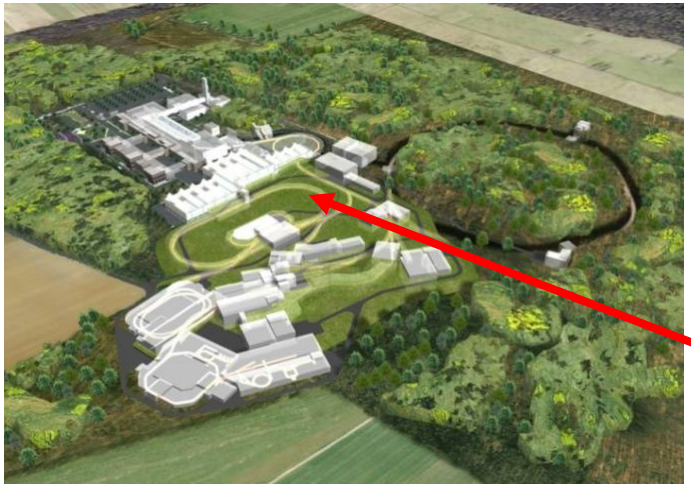
Dr. Ionel Chiriță

3RD UNI-SET Energy Clustering Event, UPB, Bucharest, Romania, 21-23 November 2016

- FAIR, the "Facility for Antiproton and Ion Research" is an integrated system of particle accelerators which will provide high energy and high intensity beams of ions from antiprotons to uranium particle, which will be set up in Darmstadt, Germany.

The existing GSI plus the future FAIR

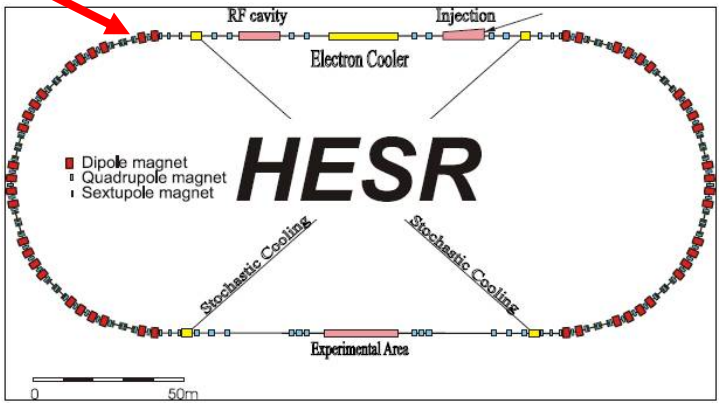
- On 4 October 2010, in Wiesbaden, nine countries, including Romania, signed the international agreement on the construction of the accelerator facility FAIR. The other eight countries are: Germany, Finland, France, India, Poland, Russia, Slovenia and Sweden.



High Energy Storage Ring

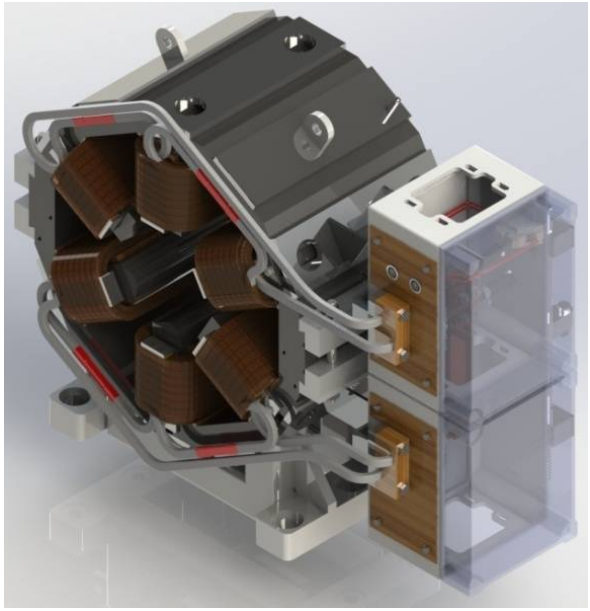
- Since 2007 ICPE-CA was adopted in the HESR consortium, created to develop the High Energy Storage Ring, important part of the FAIR project.

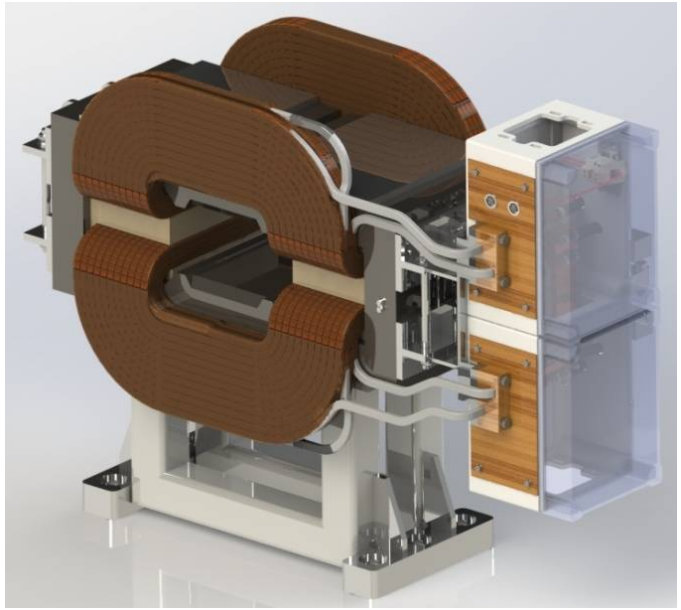
- With a circumference of 574 m the HESR is dedicated to Strong Interaction studies with antiprotons in the momentum range from 1.5 to 15 GeV/c.

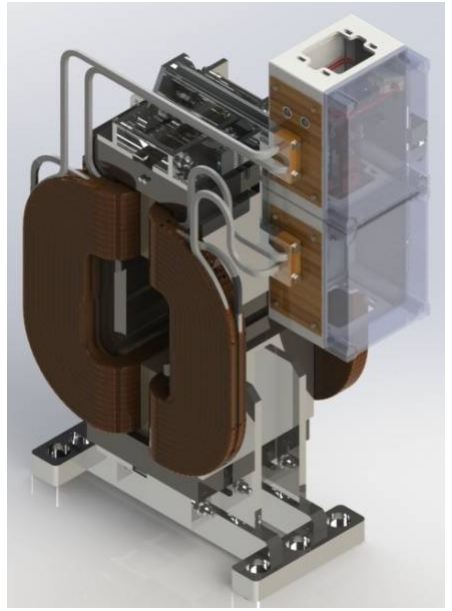


- The contribution of Romania to the FAIR project is coordinated by the Ministry of National Education, which also acts as the Romanian Shareholder within FAIR GmbH and it has three components:
  - ~5.4 mil. €€ in-kind contribution, consisting of equipments that will be integrated in various subprojects of FAIR;
  - ~4.0 mil. €€ consisting contribution by the participation of romanian scientists to the experiments that will be performed after the commissioning of FAIR accelerators;
  - ~2.5 mil. €€ cash contribution.
- The largest part of the in-kind Romanian contribution will be provided by INCDIE ICPE-CA, the total value of this contribution rising to allmost ~4.0 mil. €.

- ICPE-CA will deliver to FAIR GmbH following equipments:
- Sextupole Magnets - 66 pieces;
- Horizontal Steerer Magnets – 27 pieces;
- Vertical Steerer Magnets – 26 pieces;







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Magnets characteristics

Parameter	Sextupole Magnet	Steerer Magnet
Sextupole strength (max d^2B/dx^2)	45 T/m^2	-
Max deflection angle	-	2 mrad at p_{max}
Aperture (diameter)	140 mm	100 mm
Magnetic length	300 mm	300 mm
Iron yoke length	270 mm	270 mm
Iron yoke width	450 mm	580 mm
Iron yoke height	450 mm	450 mm
Number of coils	6	2
Windings / coil	15	44
Layers / coil	2	4
Windings / layer	7.5	11
Conductor dimensions	10.6 x7 mm^2	10.6 x7 mm^2
Cooling bore	4 mm	4 mm
Copper crossection	60.77 mm^2	60.77 mm^2
Length of conductor / coil	~ 12 m	~ 72 m
Current	290 A	304.1 A
Current density	4.77 A/mm^2	5 A/mm^2
Total mass	~ 220 kg	~ 350 kg
Voltage (DC)	6.12 V	12.84 V
Resistance	21.12 mΩ	42.2 mΩ
Inductivity	3.4 mH	0.28 mH
Power (DC)	1.8 kW	3.9 kW
Water flowrate	~ 0.86 l/min	~ 1.81 l/min
Pressure drop Δp	~ 1.14 bar	~ 5.21 bar

- The prototype of the sextupol magnet was realized in collaboration with our sub-contractor SC ELECTROMAGNETICA SA Bucharest. After ICPE-CA finalize the assembling and testing of the prototype, the sextupole magnet was exibit at the Hanover 2011 fair. From the fair the sextupole was delivered to FZJ where it has undergone a thoroughly testing by the german specialists.

- The prototype of the steerer magnet was also realized in collaboration with SC ELECTROMAGNETICA SA Bucharest. He was assembled and tested by ICPE-CA and then was exibit at the TIB 2011 fair.

- **ICPE-CA will deliver also to FAIR 82 pieces of power converters.**

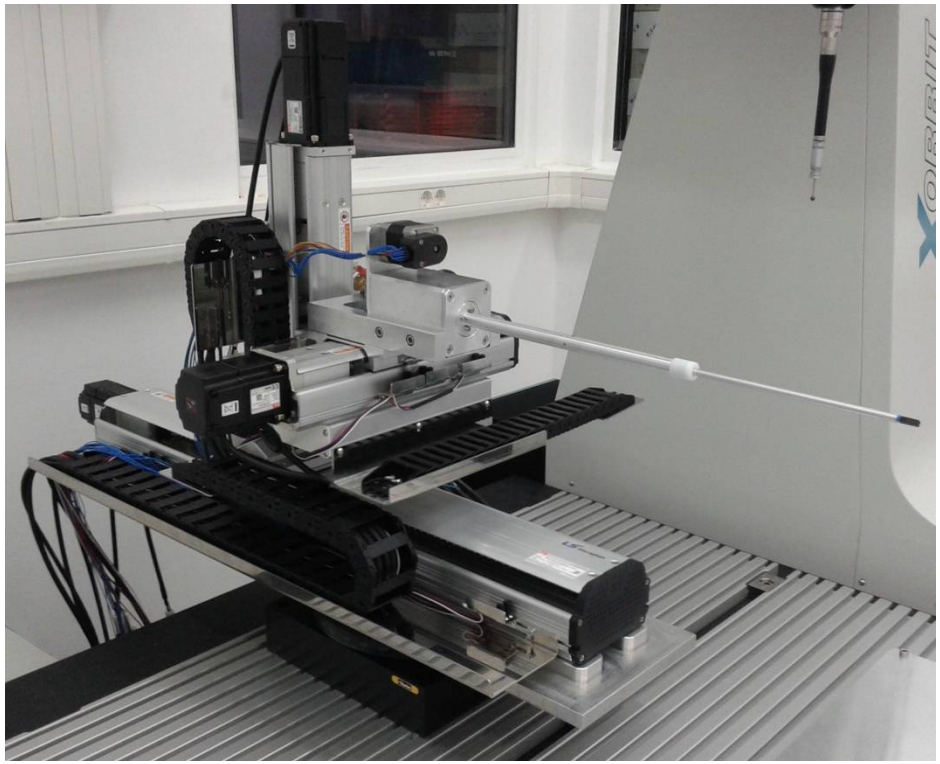
The characteristics of the power converters are:

- **Input: 400 V, 3 phases, 50 Hz;**
- **Output voltage: +/-45 V;**
- **Output current: 0...350 A;**
- **Current slew rate: 20 A/s;**
- **Statically and dynamical accuracy: $10^{-4} \cdot I_{max}$;**




Final assembling location

XOrbit 87-1500 Next Generation Coordinate Measuring Machine from WENZEL Prazision GmbH



Hall probe measuring system

Rotating coils measuring system

- **The results of the carried out and foreseen activities for the FAIR project opens new direction to involve for ICPE-CA:**
  - **ELI Project - Extreme Light Infrastructure, it's a project for which ICPE-CA allready expresed the firm intention to involve since the preparatory phase, especialy in the research, manufacturing and testing of the normal and superconducting magnets.**
  - **ICPE-CA intend to involve in projects for the construction of hadrontherapy facilities that can be located in hospitals or in other special centers.**
  - **Past and present collaborations with famous research centers in the field of nuclear physics, like CERN and JINR Dubna, will allow the participation of the ICPE-CA researchers in projects similar to the FAIR project.**
  - **ICPE-CA can also become a potential supplier for the existing research facilities in the field of nuclear particles, ICPE-CA allready beeing on the list of CERN suppliers.**

Particle accelerators are not only powerful tools for discovery science, but also essential tools in industry, medicine, and security. Recent advances in particle accelerator technology have the potential to benefit many energy and environmental applications, such as:

- **Treating potable water, waste water and sludge;**
- **Removing pollutants from stack gases;**
- **Treating medical waste;**
- **Conducting environmental remediation of hydrocarbon contaminated soil and conversion of fossil fuels;**
- **Treating asphalt to improve wear resistance;**
- **Increasing the capacity of wind generators;**
- **Enhancing the magnetic separation of material streams;**
- **Increasing the efficiency of electrical power transmission.**

A beam of particles is a very useful tool.

A beam of the right particles with the right energy at the right intensity can shrink a tumor, produce cleaner energy, spot suspicious cargo, make a better radial tire, clean up dirty drinking water, map a protein, study a nuclear explosion, design a new drug, make a heat-resistant automotive cable, diagnose a disease, reduce nuclear waste, detect an art forgery, implant ions in a semiconductor, prospect for oil, date an archaeological find, package a Thanksgiving turkey or discover the secrets of the universe.

"Accelerators for America's Future", US Department of Energy, 2010

National Institute for Research and Development in Electrical Engineering ICPE-CA

(Superconductivity and Cryogenics Applications in Electrical Engineering Laboratory)

3. Superconducting coils and magnets for nuclear Physics Applications

Research Projects:

- "Nucleu" Program 2012-2015, theme 5102/2012
- International Collaborations with Joint Institute for Nuclear Research – Dubna, Russia, 2014-2016.

Dr. Ion Dobrin

Program "NUCLEU" 2012-2015

Research projects:

1. Development of superconducting magnets for particle accelerators (design, realization and testing):
   - dipole superfferic magnet (NbTi), 2012
   - dipole HTS split magnet (3T), 2014
   - quadrupolar HTS magnet, 2013
   - superconducting coils for particle accelerators (NbTi), 2015.

COLLABORATIONS BETWEEN JINR AND ICPE-CA (Applied Superconductivity Laboratory), IN 2015

Grant:

- "*Realization of the devices for the execution of the superconducting coils for corrector magnets of the NICA booster accelerator* "

JINR Laboratory: Veksler and Baldwin Laboratory of High Energy Physics (VBLHEP)
Finalisation: 2015

Objectives: Execution of the tooling necessary for NbTi superconducting coils execution in both planar and cylindrical shapes.

Outlook: Could be developped and improved according to future needs and involvments.

COLLABORATIONS BETWEEN JINR AND ICPE-CA (Applied Superconductivity Laboratory), IN 2015

PROJECT:

- No. 08626319/1420986-74 "Design of the superconducting magnet (cooled by a closed cycle cryocooler) from the IBR-2M REACTOR "

JINR Laboratory: Frank Laboratory for Neutron Physics

Finalisation: 2015

Objectives:

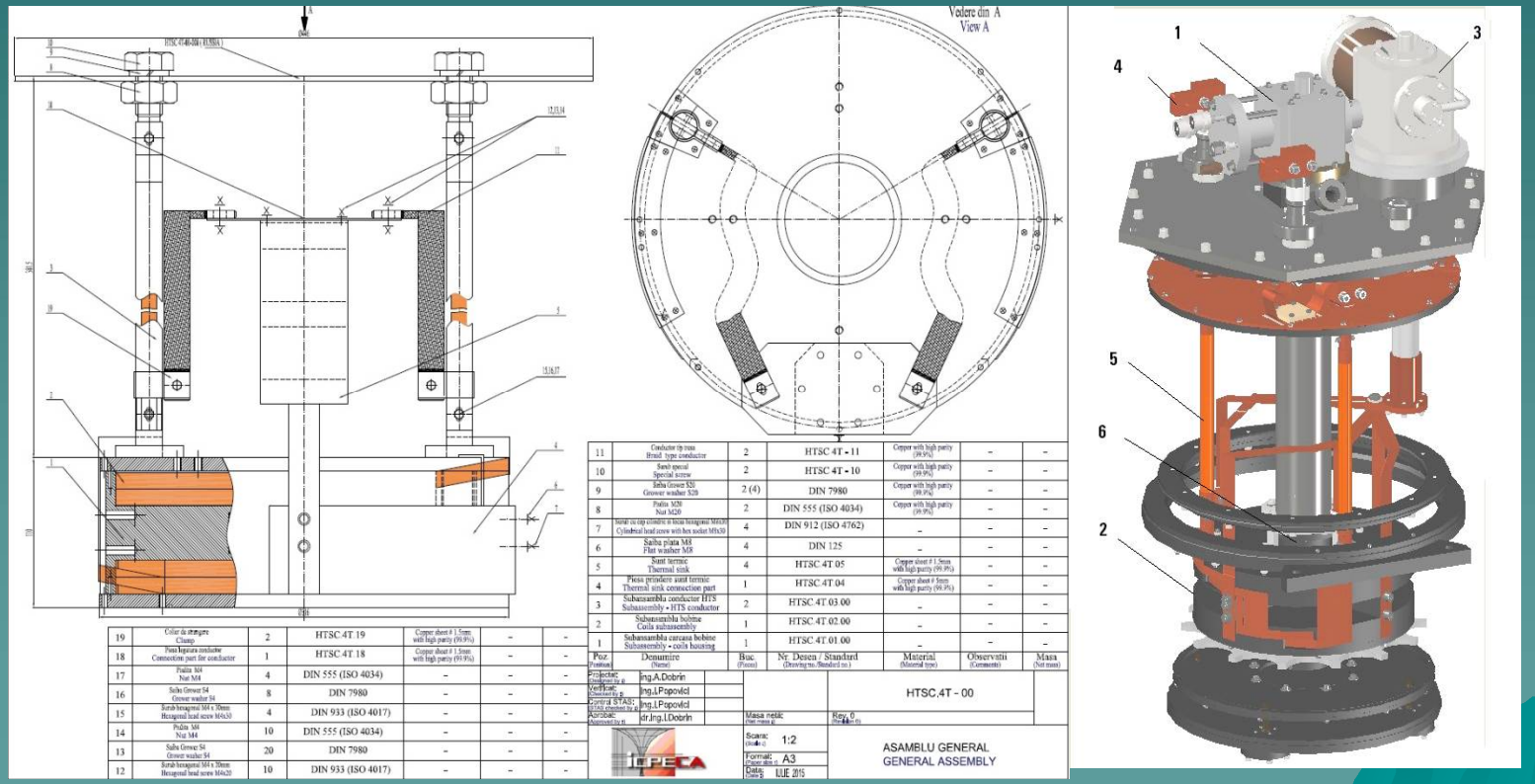
- Design of a Superconducting Magnet for High Magnetic Field Generation:
  - 4T maximum magnetic field in the central region;
  - high uniformity (10-3) magnetic field in central region;
  - room temperature (300K) n-beam access;
  - room temperature probe access.
  - the use of the High Temperature Superconductors (HTS) for coils construction.
  - use of cryogen free cooling of the coils (cryocolers)

Results: - Design of the HTS superconducting coils (magnet) and design of the quench protection circuit

Outlook: The works will continue with the execution and testing of the HTS magnet in the next period: 2016

COLLABORATIONS BETWEEN JINR AND ICPE-CA (Applied Superconductivity Laboratory), IN 2015

Results: Design and execution of the 4T HTS magnet



Poz. Position	Denumire Name	Buc. Pieces	Nr. Desen / Standard Drawing no./Standard no.	Material Material type	Observatii Comments	Masa Unit mass
19	Colier de strangere Clamp	2	HTSC.4T.19	Copper sheet # 1.5mm with high purity (99.9%)	-	-
18	Piesa legatura conductor Connection part for conductor	1	HTSC.4T.18	Copper sheet # 1.5mm with high purity (99.9%)	-	-
17	Piulita M4 Nut M4	4	DIN 555 (ISO 4034)	-	-	-
16	Saiba Grower S4 Grower washer S4	8	DIN 7980	-	-	-
15	Surub hexagonal M4 x 70mm Hexagonal head screw M4x30	4	DIN 933 (ISO 4017)	-	-	-
14	Piulita M4 Nut M4	10	DIN 555 (ISO 4034)	-	-	-
13	Saiba Grower S4 Grower washer S4	20	DIN 7980	-	-	-
12	Surub hexagonal M4 x 70mm Hexagonal head screw M4x20	10	DIN 933 (ISO 4017)	-	-	-
11	Conductor tip truss Braid type conductor	2	HTSC 4T - 11	Copper with high purity (99.9%)	-	-
10	Surub special Special screw	2	HTSC 4T - 10	Copper with high purity (99.9%)	-	-
9	Saiba Grower S20 Grower washer S20	2 (4)	DIN 7980	Copper with high purity (99.9%)	-	-
8	Piulita M20 Nut M20	2	DIN 555 (ISO 4034)	Copper with high purity (99.9%)	-	-
7	Surub cu cap cilindric si hexag hexagonal M4x30 Cylindrical head screw with hex socket M5x30	4	DIN 912 (ISO 4762)	-	-	-
6	Saiba plata M8 Flat washer M8	4	DIN 125	-	-	-
5	Sant termic Thermal sink	4	HTSC 4T 05	Copper sheet # 1.5mm with high purity (99.9%)	-	-
4	Piesa prindere sant termic Thermal sink connection part	1	HTSC 4T 04	Copper sheet # 5mm with high purity (99.9%)	-	-
3	Subansamblu conductor HTS Subassembly - HTS conductor	2	HTSC 4T 03.00	-	-	-
2	Subansamblu bobina Coils subassembly	1	HTSC 4T 02.00	-	-	-
1	Subansamblu carcasa bobine Subassembly - coils housing	1	HTSC 4T 01.00	-	-	-

Proiectat: ing.A.Dobrin
Verificat: ing.I.Popovici
Control STAS: ing.I.Popovici
Aprobat: dr.ing.I.Dobrin

HTSC.4T - 00

Masa neta: Rev. 0

Scara: 1:2
Format: A3
Data: IULIE 2015

ASAMBLU GENERAL
GENERAL ASSEMBLY

1. Cryocooler I
2. Superconducting Coils
3. Cryocooler II
4. Copper current leads
5. HTS current leads
6. Sample

COLLABORATIONS BETWEEN JINR AND ICPE-CA (Applied Superconductivity Laboratory), IN 2015

Project:

- No. 08626319/142010155-74 "NbTi Superconducting Coils execution in planar shape for NICA booster corrector magnets "

JINR Laboratory: Veksler and Baldwin Laboratory of High Energy Physics (VBLHEP)

Finalization: 2015

Objectives: Execution of the Superconducting Coils for NICA corrector magnets of booster accelerator.

Results: Execution of: Dipole coils – 4 sets
Quadrupolar coils – 4 sets
Sextupolar coils – 4 sets

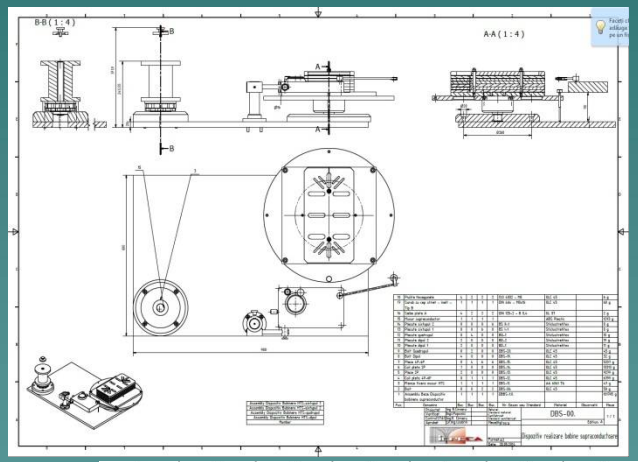
Outlook: Development of multipole corrector magnets assembly in final shape.

COLLABORATIONS BETWEEN JINR AND ICPE-CA (Applied Superconductivity Laboratory), IN 2015

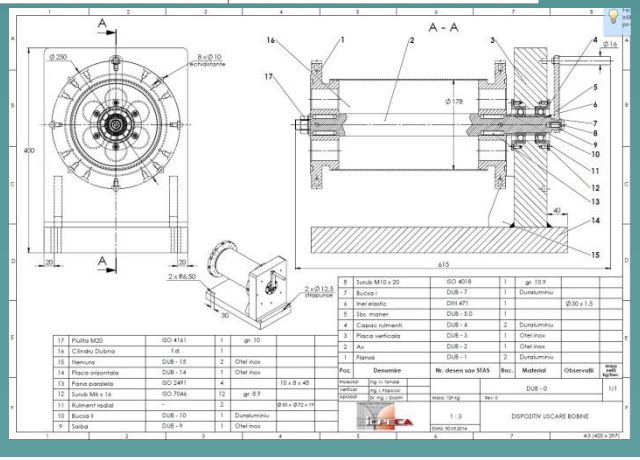
Results: I. Devices for prototype coils execution

DESIGN

EXECUTION



Planar shape



Cylindrical shape

COLLABORATIONS BETWEEN JINR AND ICPE-CA (Applied Superconductivity Laboratory), IN 2015

Results: II. Prototype Coils execution

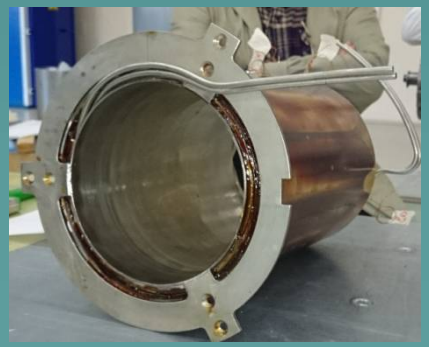
a. Planar shape

Dipole coils

Quadrupolar coils

Sextupolar coils

b. Cylindrical shape



2016 AGIR AWARD : 1st prize for "Superconducting Coils Realization, Destinated to Particle Accelerator Magnets "

ASOCIAŢIA GENERALĂ A INGINERILOR DIN ROMÂNIA

PREMIUL AGIR
2015

În domeniul "Inginerie electrică"

Se acordă

INSTITUTULUI NAȚIONAL DE CERCETARE-DEZVOLTARE PENTRU INGINERIE ELECTRICĂ - INCDIE ICPE - CA

pentru lucrarea: ***Bobine supraconductoare pentru electromagneți supraconductori utilizați în acceleratoare de particule.***

16.09.2016

Preşedinte,
Mihai MIHĂIŢĂ

FUTURE DEVELOPMENTS

- Projects for superconducting coils execution in planar & cylindrical shape for booster and collider NICA accelerator, Dubna, Russia.
- Projects for superconducting dipole magnets for ELI – NP project (experimental setups).
- Projects for higher magnetic field generation using HTS materials (10-25 T) in cooperation with JINR- Dubna
- Projects for Superconducting Solenoids used in particle accelerators