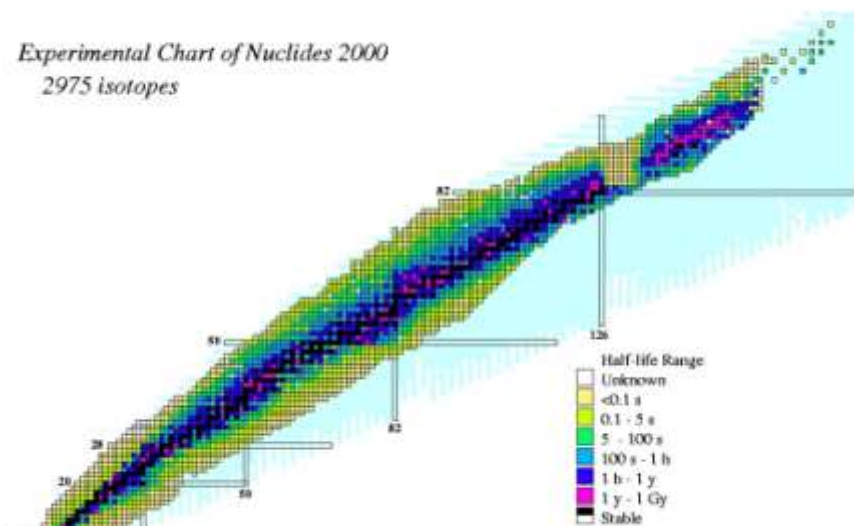


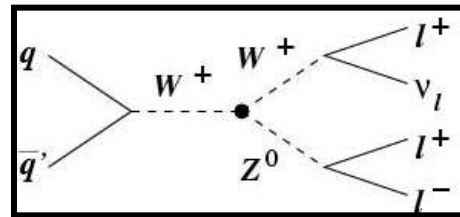
Experimental Chart of Nuclides 2000
2975 isotopes



The future of experimental nuclear and particle physics in Zagreb/RBI

Tome Antičić

Head of Division of Experimental Physics
Rudjer Boskovic Institute



RBI overview

RBI is the largest Croatian multidisciplinary research centre

20 000 m² area

TOTAL = 867 EMPLOYEES

542 RESEARCH STAFF (344 WITH PhD) +
325 SUPPORT AND TECHNICAL STAFF



Theoretical Physics

Molecular Biology

Experimental Physics

Molecular Medicine

Material Physics

Marine Research

Electronics

Marine & Environmental

Physical Chemistry

Laser and Atomic Research

**Organic Chemistry and
Biochemistry**

Material Chemistry



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Theoretical Physics

Molecular Biology

Experimental Physics

70 staff:

- 41 PhDs, including 5 foreign postdocs
- 19 grad students
- 10 technicians

Material Physics

Marine Research

Electronics

Marine & Environmental

Physical Chemistry

Laser and Atomic Research

Organic Chemistry and
Biochemistry

Material Chemistry



Scientific activities of DEP

Particle physics

cosmology

Nuclear physics

astrophysics

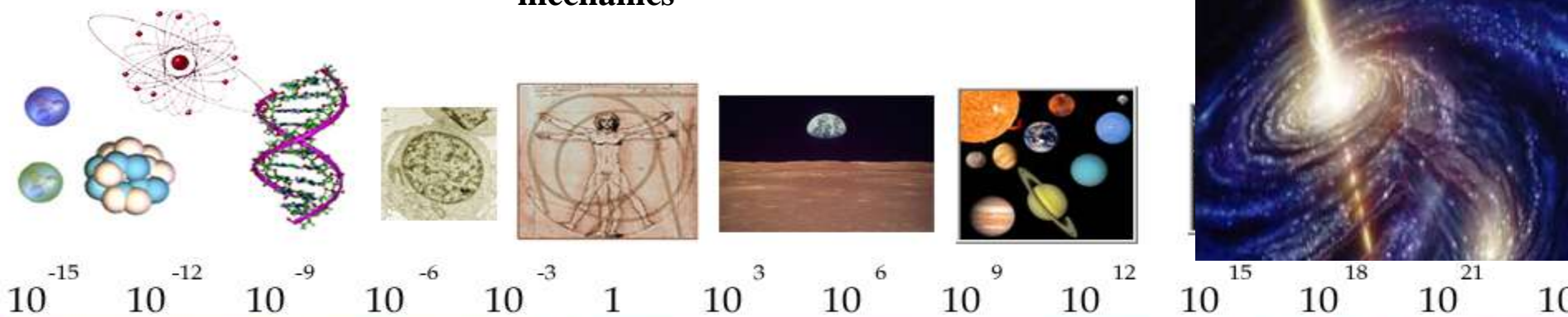
Solid state physics

astronomy

Chemistry-biology

geophysics

mechanics



fm pm nm μ m mm m km Mm Gm Tm Pm Em



10^{-15} m = 0,000 000 000 000 001 m

Scientific activities of DEP

Particle physics

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Solid state physics

Chemistry-biology

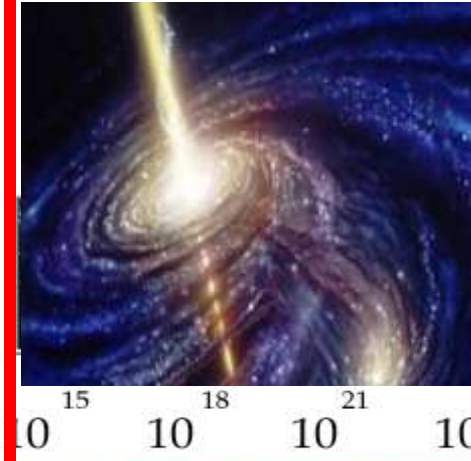
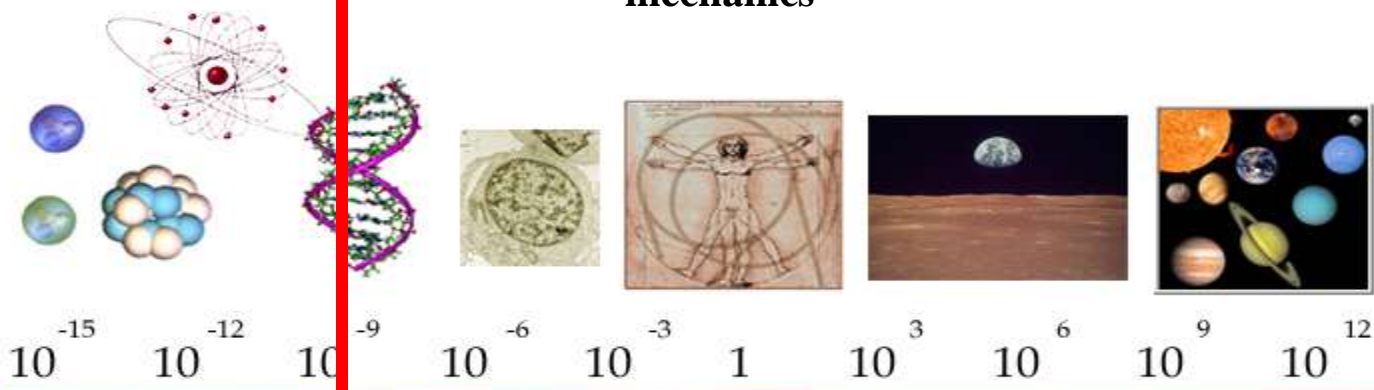
mechanics

geophysics

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fm pm nm μ m mm m km Mm Gm Tm Pm Em

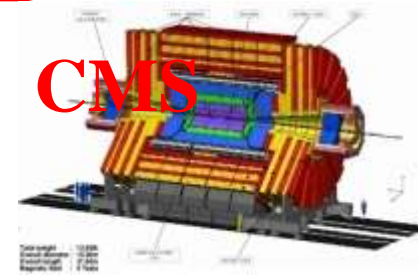


$10^{-15} \text{ m} = 0,000\ 000\ 000\ 000\ 001 \text{ m}$

Scientific activities II

Particle and astroparticle physics

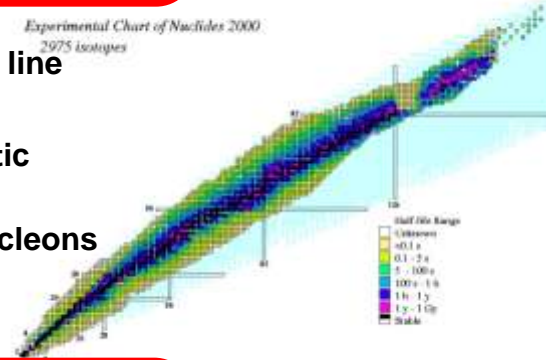
- Heavy boson production (CMS)
- Strangeness production/QGP in pp, pA, and AA collisions (NA61, ALICE)
- Matter/antimatter symmetry (Crystall Ball)
- Axions (CAST)
- Neutrinos (OPERA)
- Structure and evolution of universe, galaxies, black holes, stars, dark matter (MAGIC, Pierre Auger)



Nuclear physics

- The structure of light and medium mass nuclei away from the nuclear stability line
- The reaction mechanisms of deformed light and medium mass nuclei
- The properties of extremely hot and dense nuclear matter studied via relativistic collisions
- The influence of nuclear medium on properties of elementary particles and nucleons
- The study of nuclear reactions relevant for nucleosynthesis

Experimental Chart of Nuclides 2000
2075 isotopes

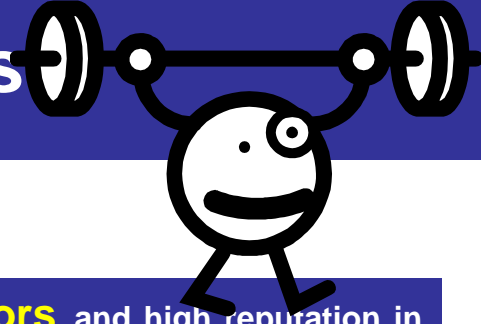


On-site low energy nuclear and applied physics

- Basic and targetted research on interaction of ion beams with matter, related interdisciplinary research and applications, in close relation with the use of the local Tandem accelerator facility
- Carbon dating
- Mine and bomb detection through nuclear methods
- Charged and photon detector testing and development



strengths and opportunities

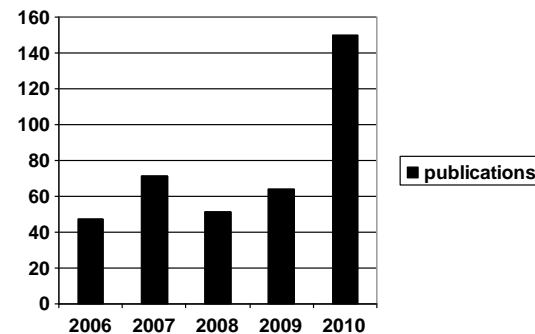


- world class research/ **established network of international collaborators** and high reputation in international scientific community
- wide spectrum of research topics with **overlapping equipment, knowledge and experience**
- excellent personal and scientific contacts among many members
- researchers very skilled at applying for and running competitive international projects – the **best** fundamental scientific unit in Croatia for this
- DEP **VERY international** by Croatian and RBI standards (5 foreign postdocs, majority of DEP staff and students has very extensive international experience)
- several top experimental researchers have desire for applicative work and close cooperation with industry

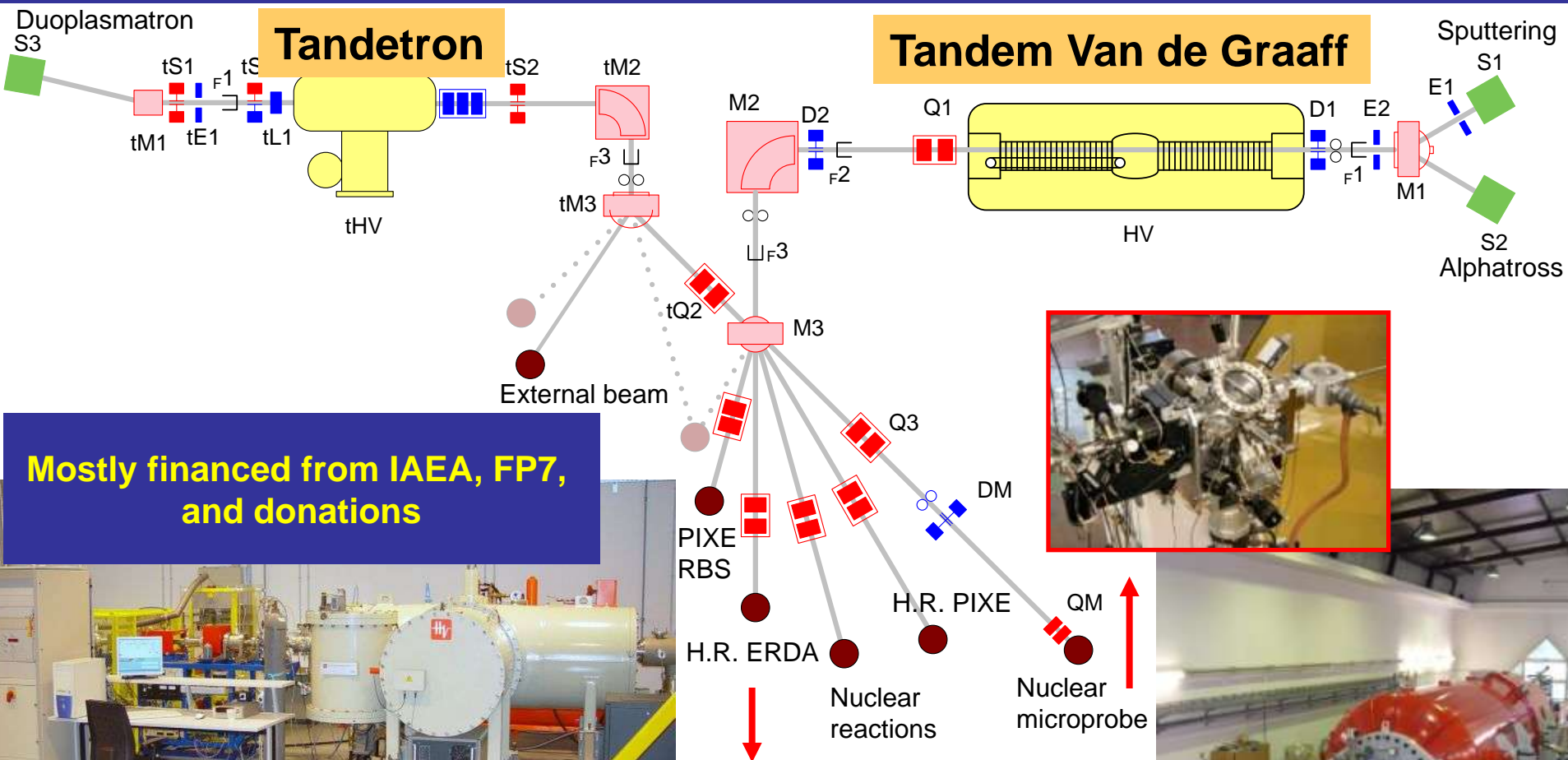
DEP is now at a cusp, through its current FP7 and other international projects, to **VERY significantly increase its local experimental capabilities** and international experimental contribution

About 10%
of staff at
RBI

About 25% of RBI
publications, with
increasing trend



Local accelerator complex



Mostly financed from IAEA, FP7, and donations

Largest experimental complex in Croatia



Very successful getting external projects and finances

•FP7 , IAEA, industry and many other external sources of funding...

MZOS

FP/IAEA/industry ...

Does not include salaries

~350 000 €

2009

~500 000 €

Very successful getting external projects and finances

•FP7 , IAEA, industry and many other external sources of funding...

MZOS

FP/IAEA/industry ...

Does not include salaries

~350 000 €

2009

~500 000 €

TIME

~300 000 €

2011

~1 000 000 €



Current FP7 projects



Acronym	Full project name	Type	No.	Euro
UNCOSS	Underwater coastal sea surveyor	Cooperation / Security	9	404 000
HadronPhysics2	Study of strongly interacting matter	Capacities / Infrastructures	46	11 000
SPIRIT	Support for public and industrial research using ion beam technology	Capacities / Infrastructures	11	214 000
SOWAEUMED	Network in soli waste nad water treatment between Europe and Mediterranean countries	Capacities / Research potential	6	75 000
CLUNA	Clustering phenomena in nuclear physics: strengthening the Zagreb-Catania-Birmingham partnership	Capacities / Research potential	4*	291 000
Particle Detectors	Upgraded facility for developemnt of silicon and diamond particle detetctor systems	Capacities / Research potential	1*	1 320 000
ENSAR	European nuclear science and applications research	Capacities / Infrastructures	28	50 000

7 out of 10 running RBI FP7 projects

Many more planned (+ IPA, IAEA,...)

TOT:2 650 000 €

International facilities used



International facilities used

France
Caen
Strasbourg
Subatech

Italy
Catania
Legnaro
Opera-Gran
Sasso

Germany
GSI
MAMI-Meinz

Switzerland(CERN)
CMS
NA49/NA61
ALICE
CAST

Belgium
Louvain-la-Neuve

Holland
GVI Groeningen

USA
Brookhaven
Oak Ridge

Canary Islands
Magic
Observatory

Australia
Canberra

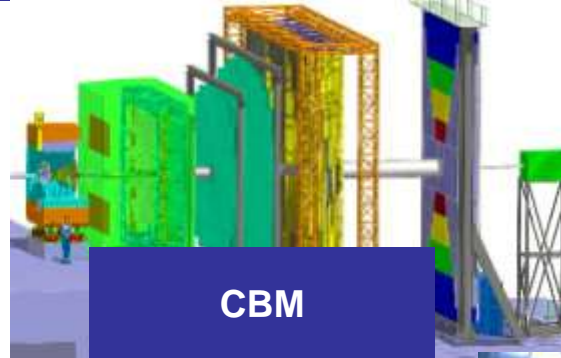
Argentina
Pierre Auger
Observatory



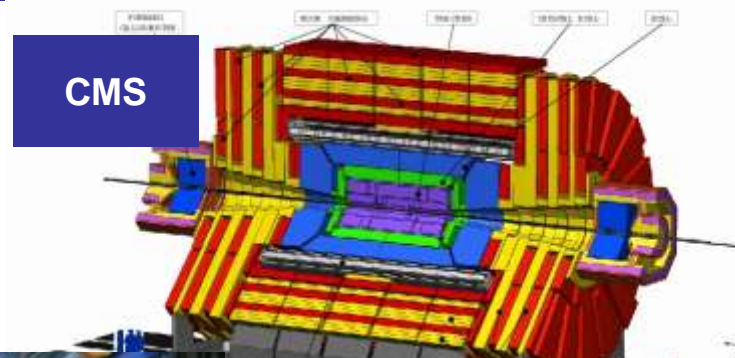
International facilities used II



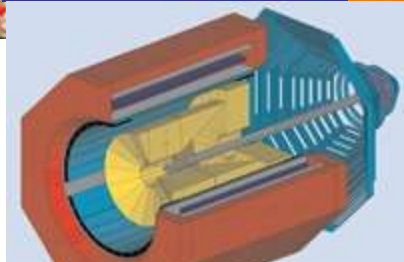
Crystall Ball



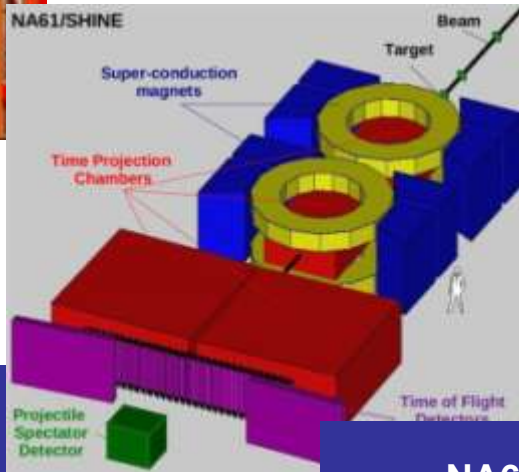
CBM



CMS



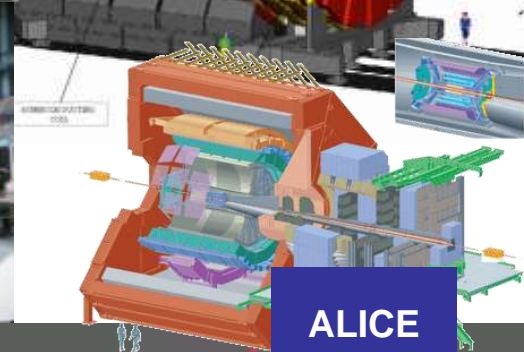
FOPi



NA61



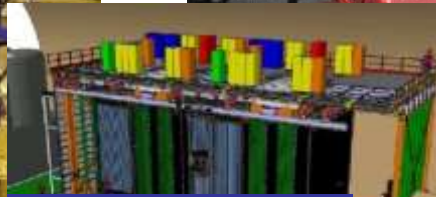
GANIL



ALICE



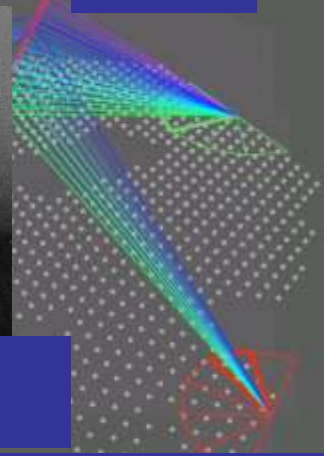
CAST



OPERA



MAGIC



Pierre Auger

Cooperation with international institutions



Cooperation with international institutions



All rosy?

some weaknesses and threats



some weaknesses and threats



Completely out of IEP control/ but trying to pressure MZOS and RBI to change this

- Insufficient total number of scientific staff
- **Extremely** insufficient number of young researchers, technicians, and PhD students (senior to student ratio is 2:1, good institutes have this more in the ballpark of 1:2 ...)
- Too small national R&D projects and amounts with scattered funds and focus

some weaknesses and threats



Completely out of IEP control/ but trying to pressure MZOS and RBI to change this

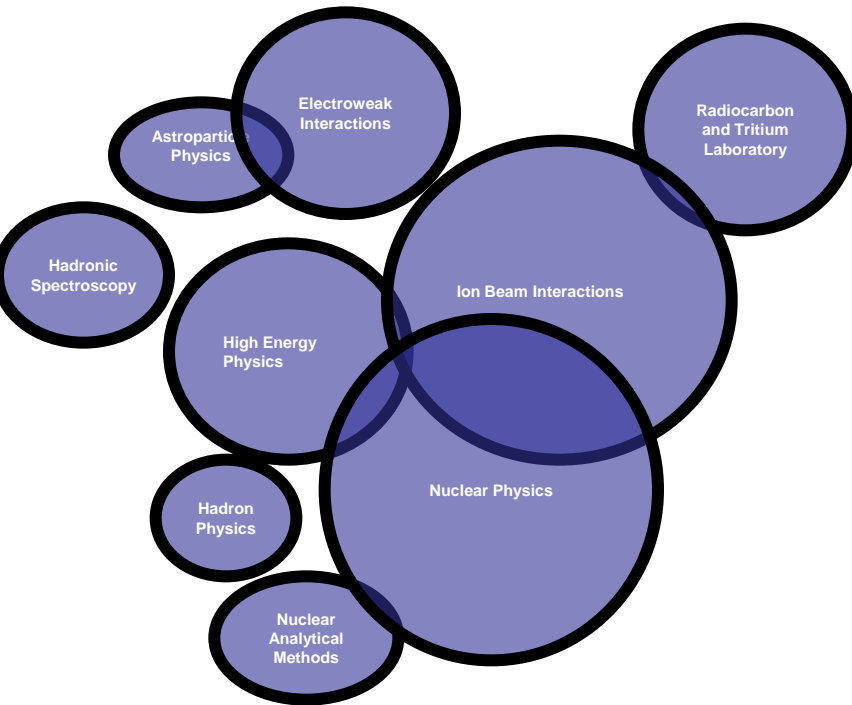
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At least partially under DEP control

- **lack** of on-site the state-of-the-art detector system research equipment
- **insufficient coordination** of technical staff activities, preventing synergetic effort in solving technical problems
- **research groups too small** for a more prominent contribution in large collaborations

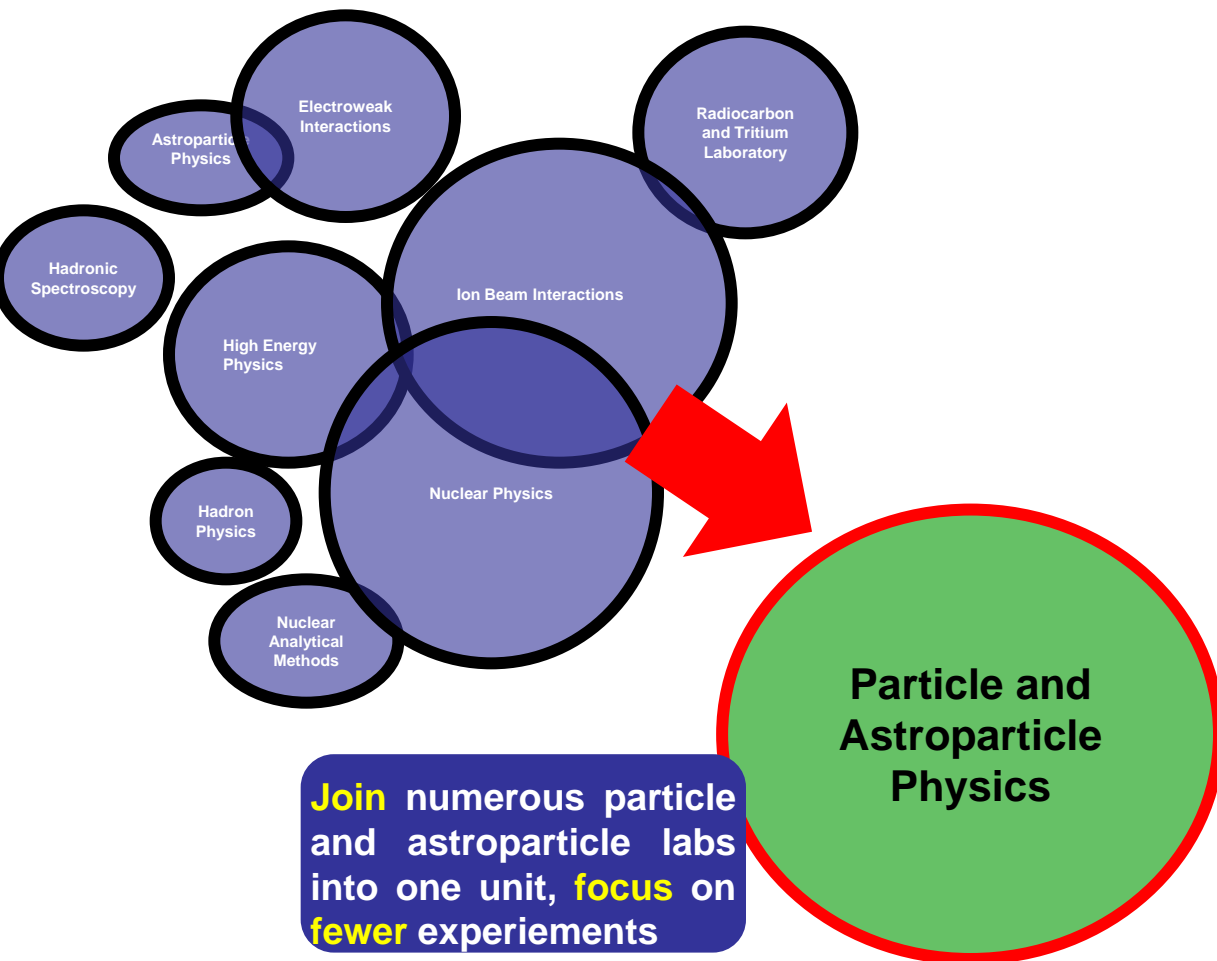
Pre-evaluation – main recommendations

**Denegri
Pocanic
Prokopec
Senjanovic**



Pre-evaluation – main recommendations

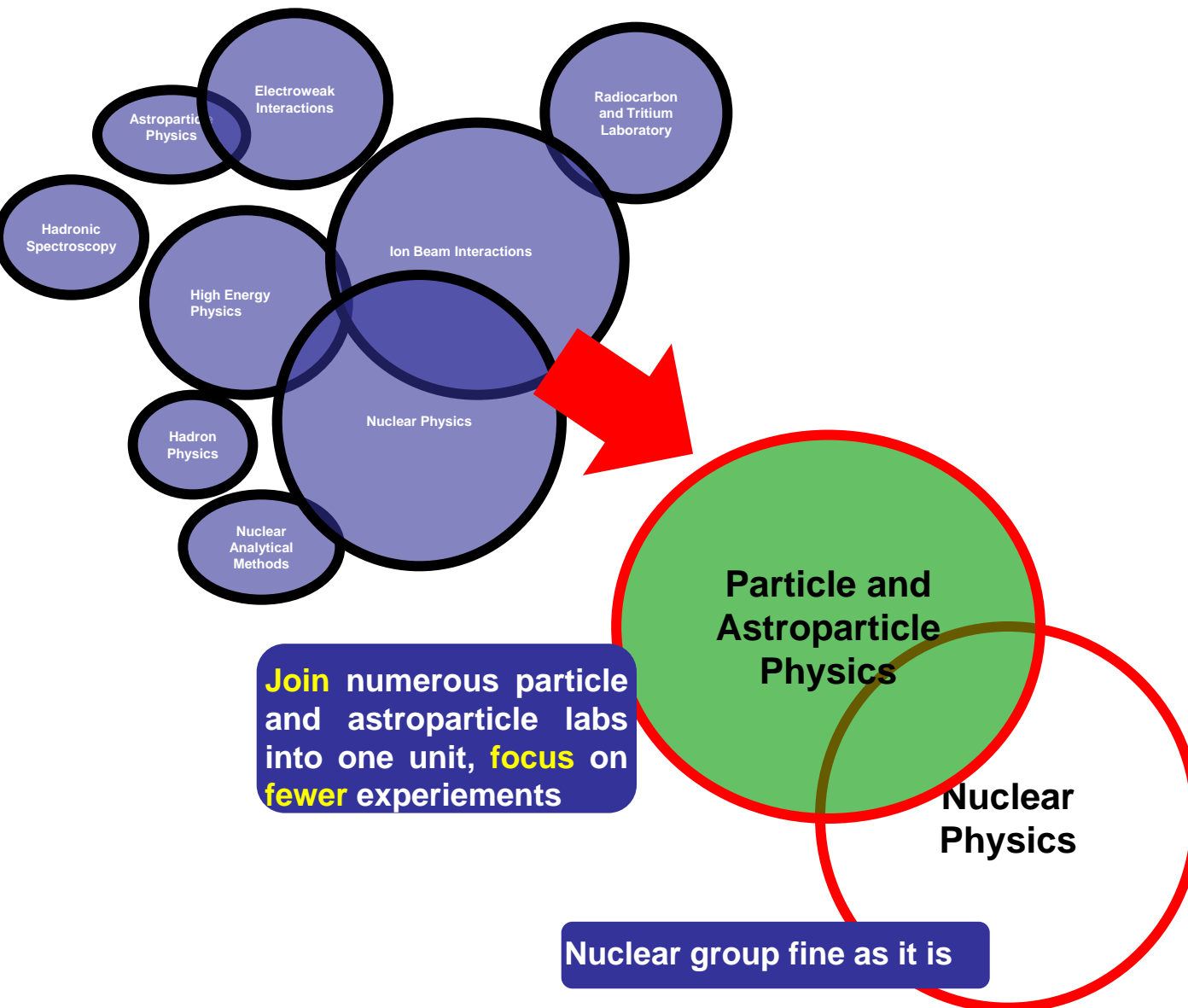
Denegri
Pocanic
Prokopec
Senjanovic



Join numerous particle and astroparticle labs into one unit, **focus** on **fewer** experiments

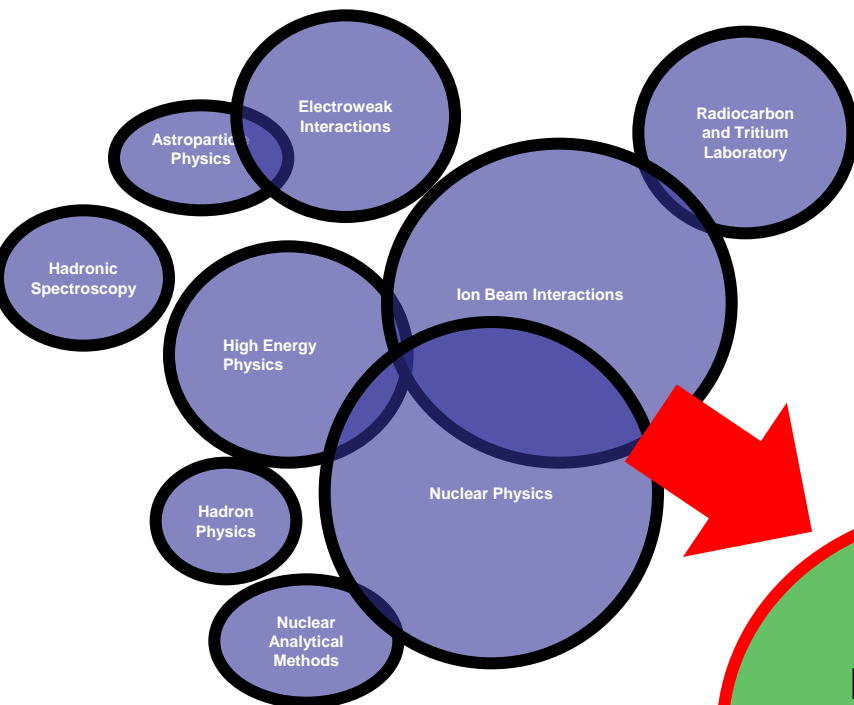
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Pre-evaluation – main recommendations

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Ion beam group does an excellent job, good to make related labs even closer to it

Join numerous particle and astroparticle labs into one unit, **focus** on **fewer** experiments

Particle and Astroparticle Physics

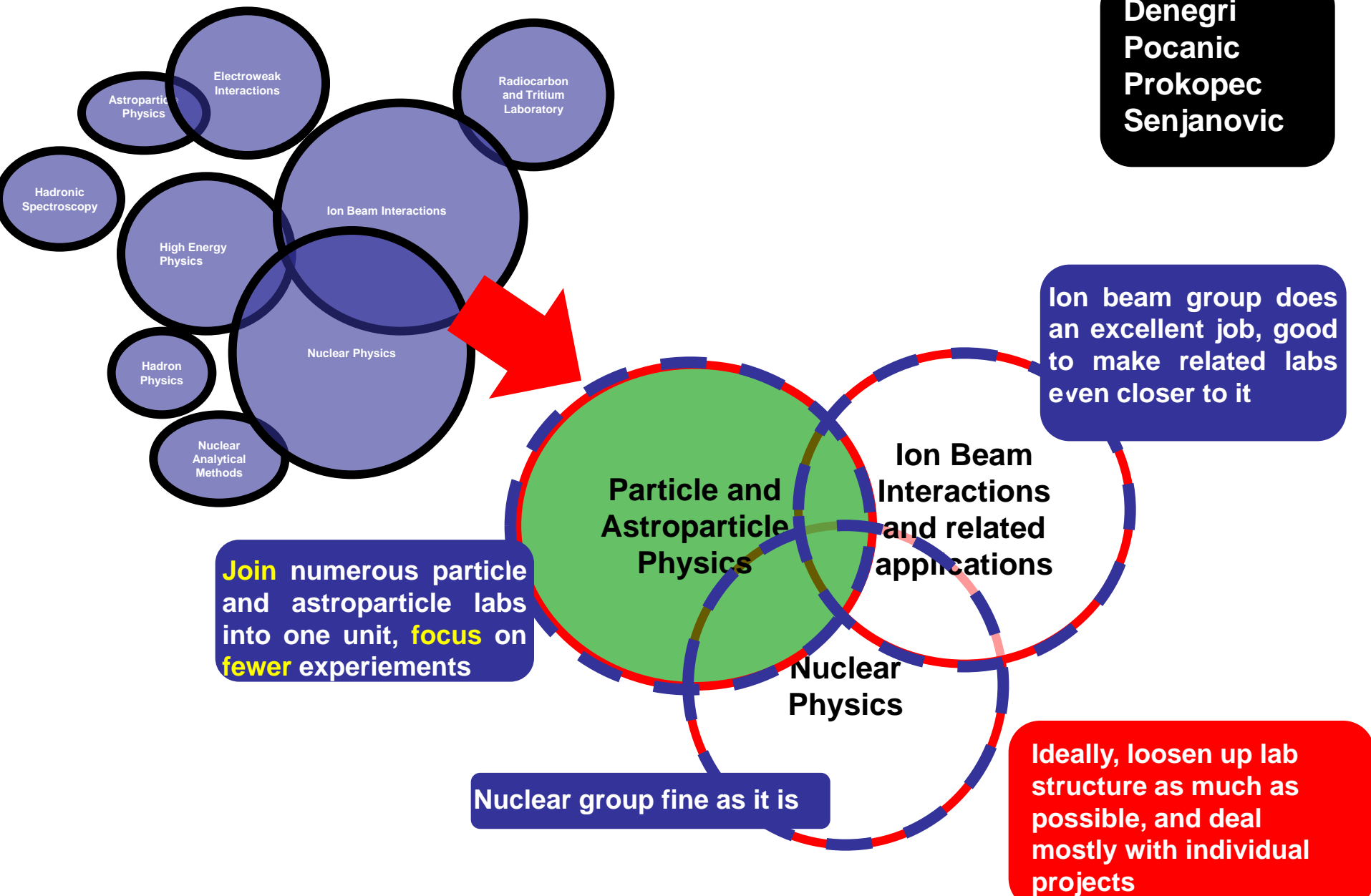
Ion Beam Interactions and related applications

Nuclear Physics

Nuclear group fine as it is

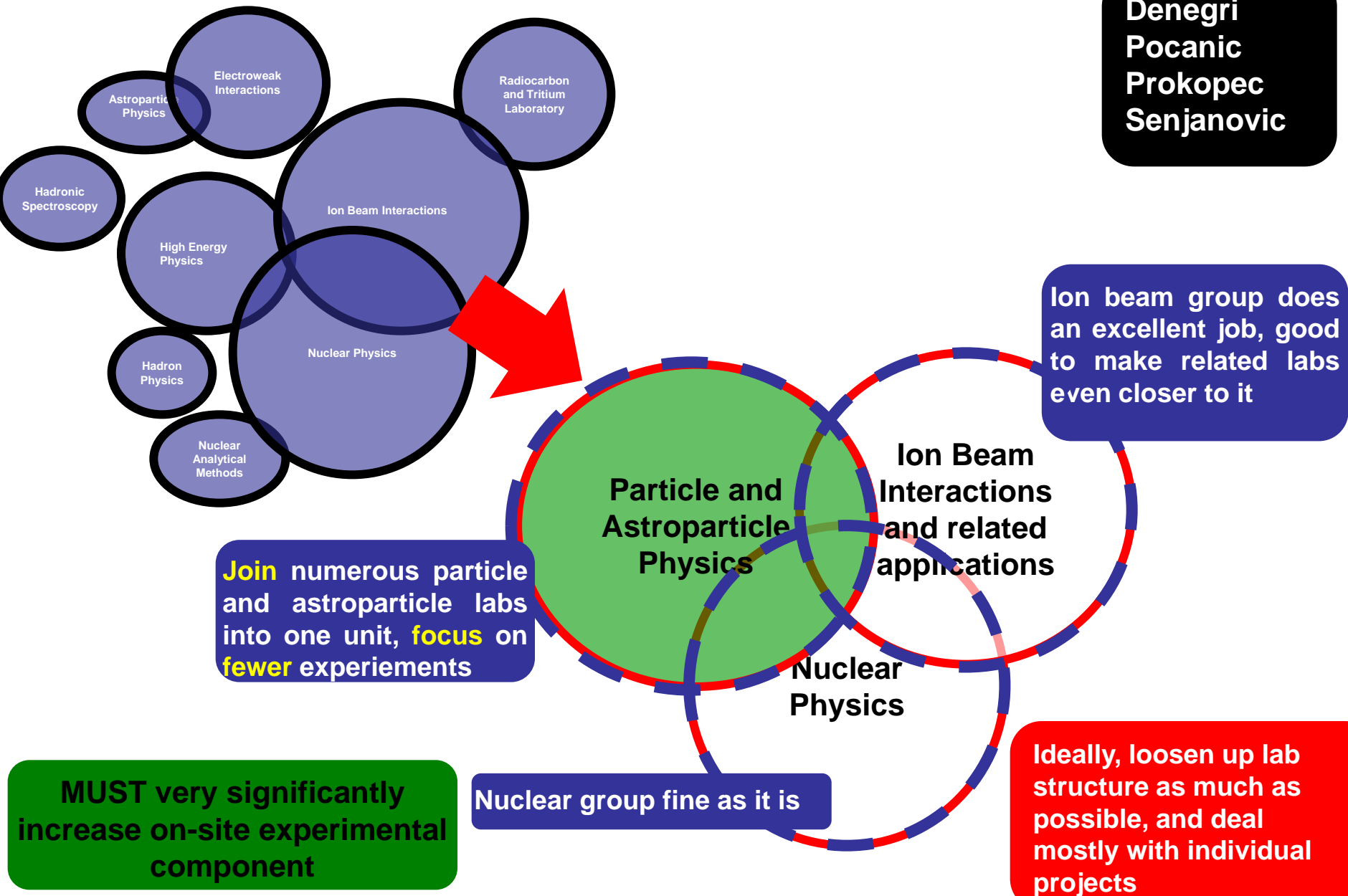
Pre-evaluation – main recommendations

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Pre-evaluation – main recommendations

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Mission of DEP

To address the weaknesses

- Focus effort on the existing **strongest** scientific and experimental projects, and gradually **defocus from the weaker ones**
- Pool **scientific** and **experimental** resources across laboratories and projects to improve the **on-site experimental contributions** to international experiments
- Encourage the top young scientists to pursue independent research
- Focus on **external funding** and cooperation with industry
- Prepare doctoral students for successful careers in both academia **and industry**

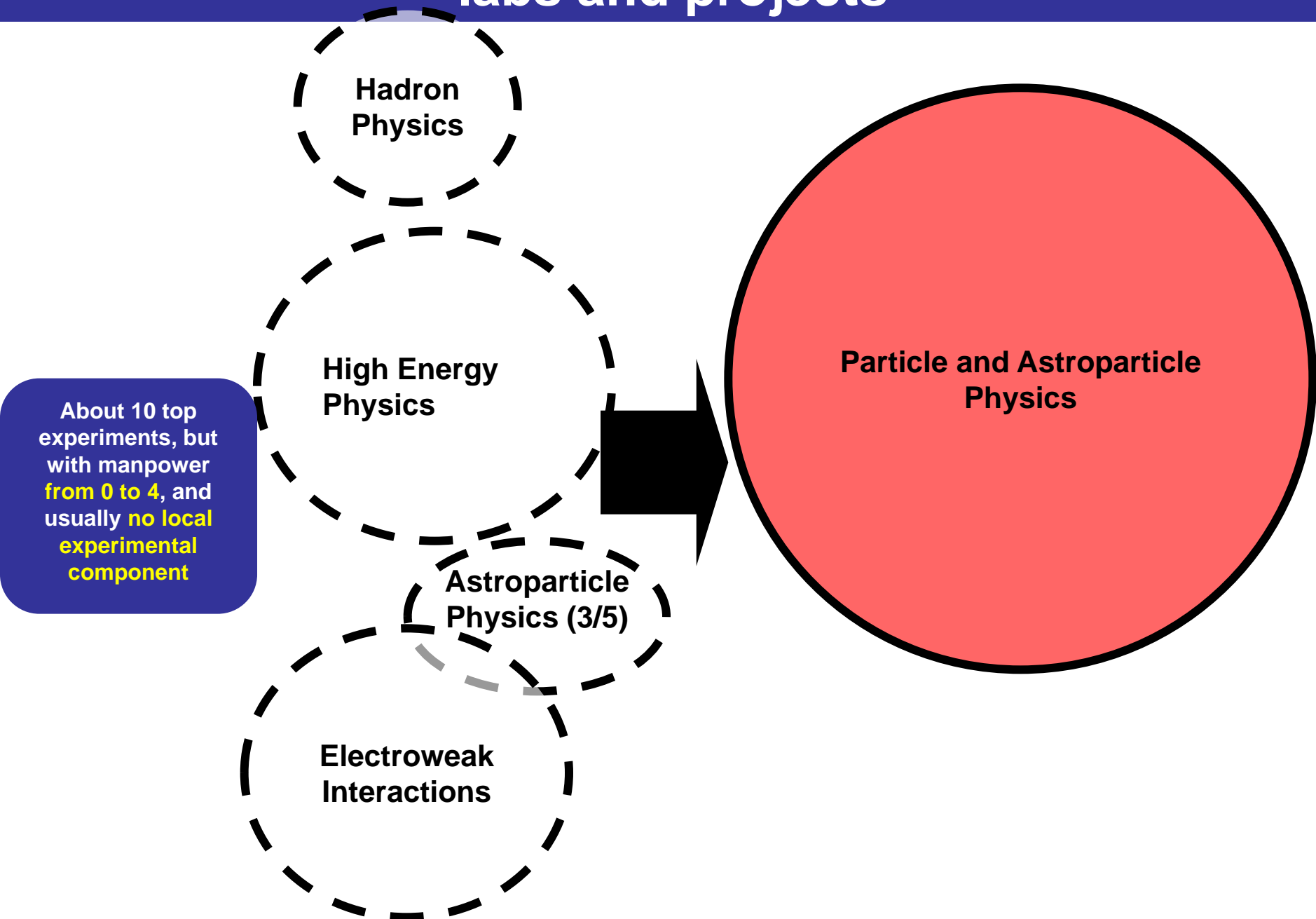
Make DEP the central experimental hub for all Croatian nuclear and particle physics groups in Zagreb, Split, Rijeka, ...

- Equipment accessible
- Staff cooperating

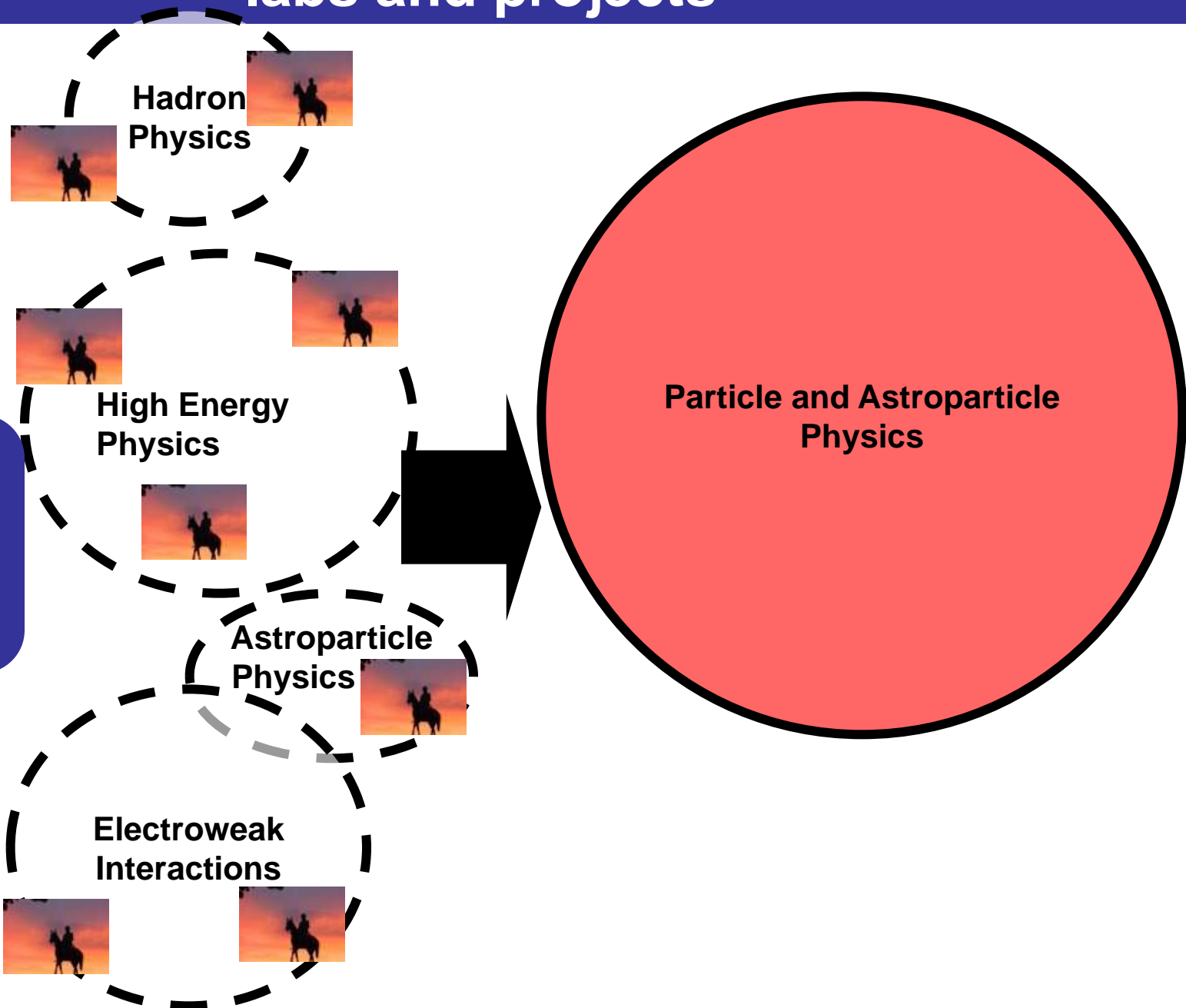
Many concrete steps taken to follow this, with very tangible results



Merging the many small particle and astroparticle labs and projects

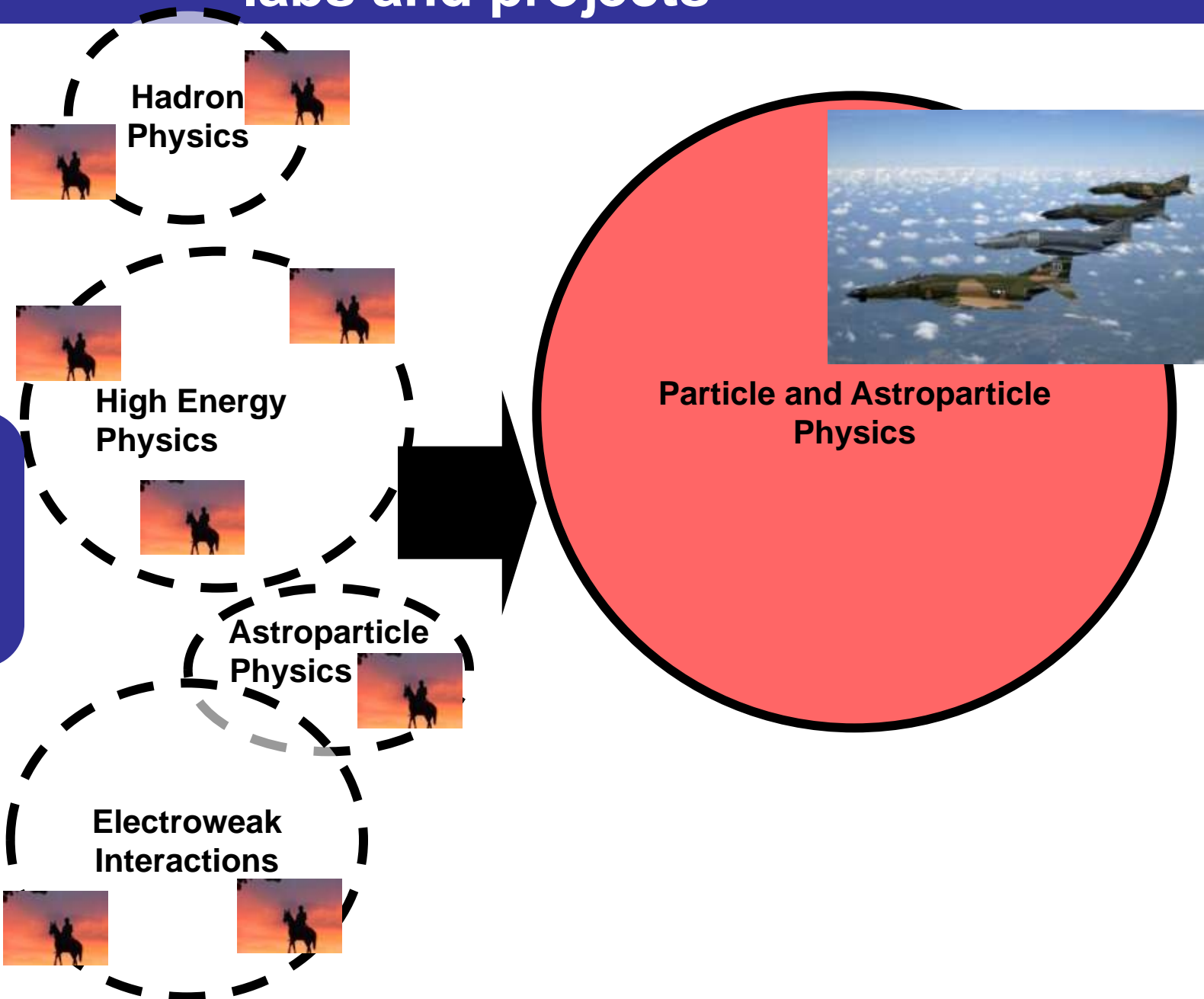


Merging the many small particle and astroparticle labs and projects



About 10 top experiments, but with manpower from 0 to 4, and usually no local experimental component

Merging the many small particle and astroparticle labs and projects



About 10 top experiments, but with manpower from 0 to 4, and usually no local experimental component

Hadron Physics

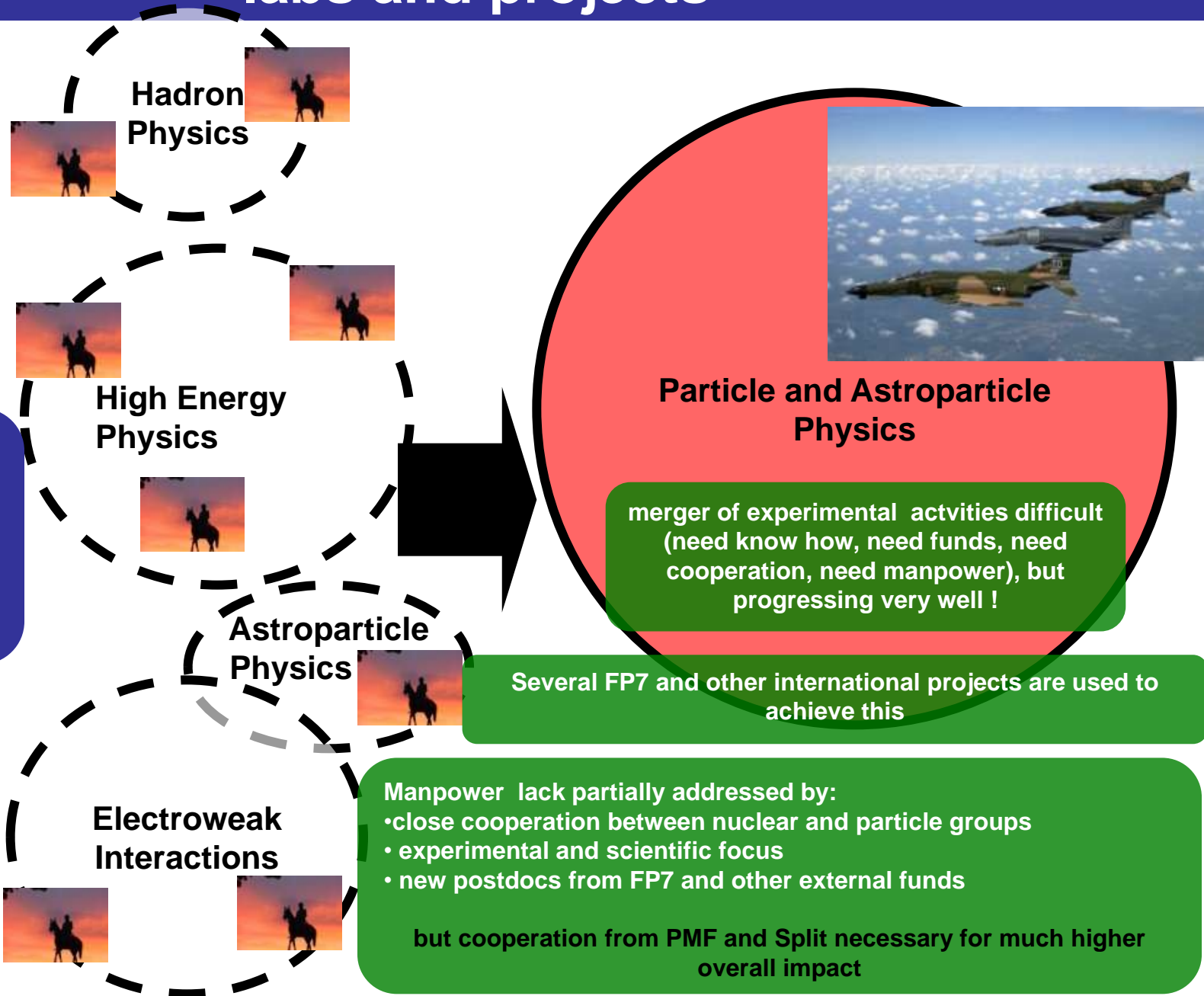
High Energy Physics

Astroparticle Physics

Electroweak Interactions

Particle and Astroparticle Physics

Merging the many small particle and astroparticle labs and projects



Purchasing of new silicon strip and pixel testing setup – CMS, NA61, (ALICE ?), CAST, CBM, local nuclear experiments...

Several FP7 projects + new SCOPES project with PSI Zurich for CMS + more projects planned

Windows LabView controlled
All device through GPIB cable.

HV/Ammeter
Keithley 6487

Windows
LabView

LCR Meter
Agilent 4263B

Switch system
Keithley 7002

Microscope

Dark Box

Probe stage

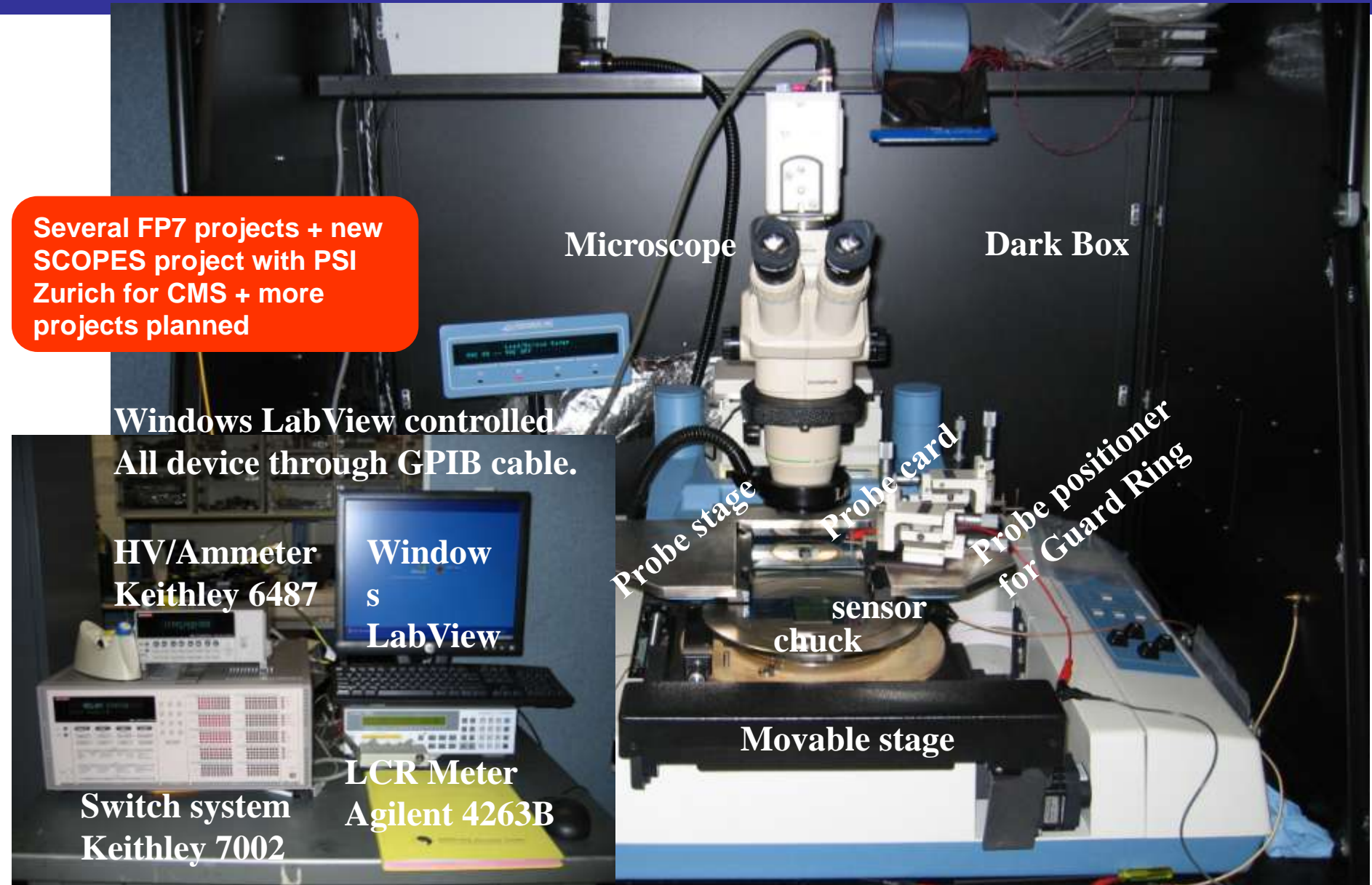
Probe card

Probe positioner
for Guard Ring

sensor
chuck

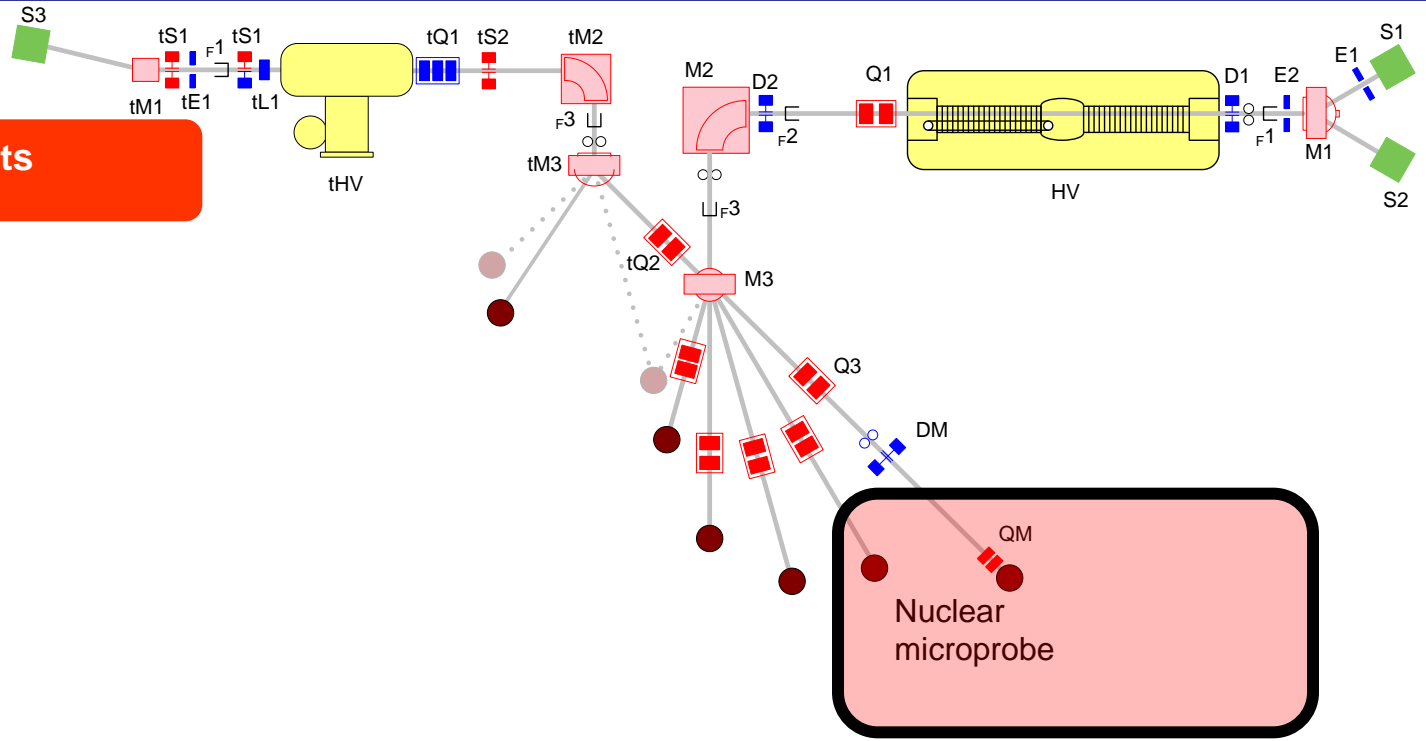
Movable stage

Probe station

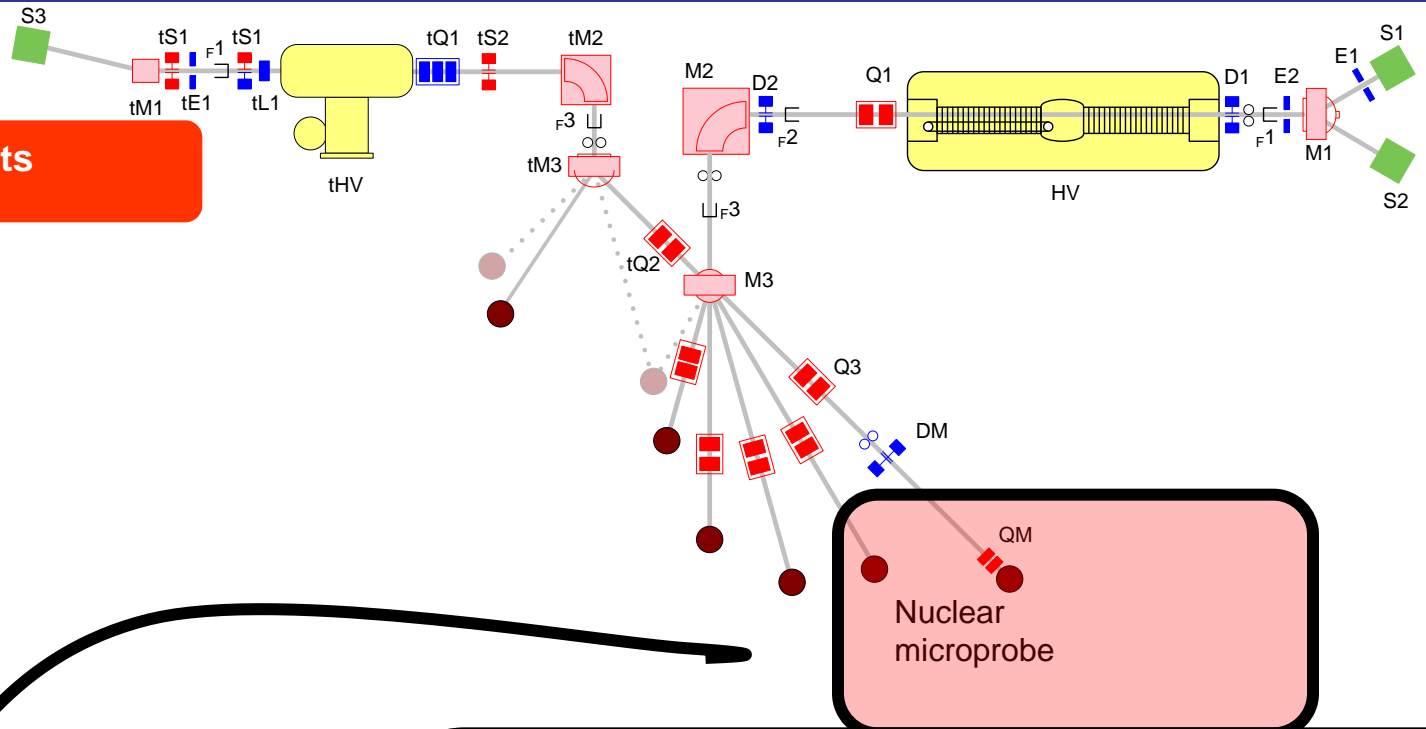


Unique beam testing facility for silicon and diamond detectors in development

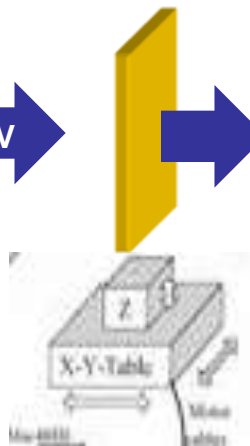
Several FP7 projects



Unique beam testing facility for silicon and diamond detectors in development



10 micron proton beam 10 MeV

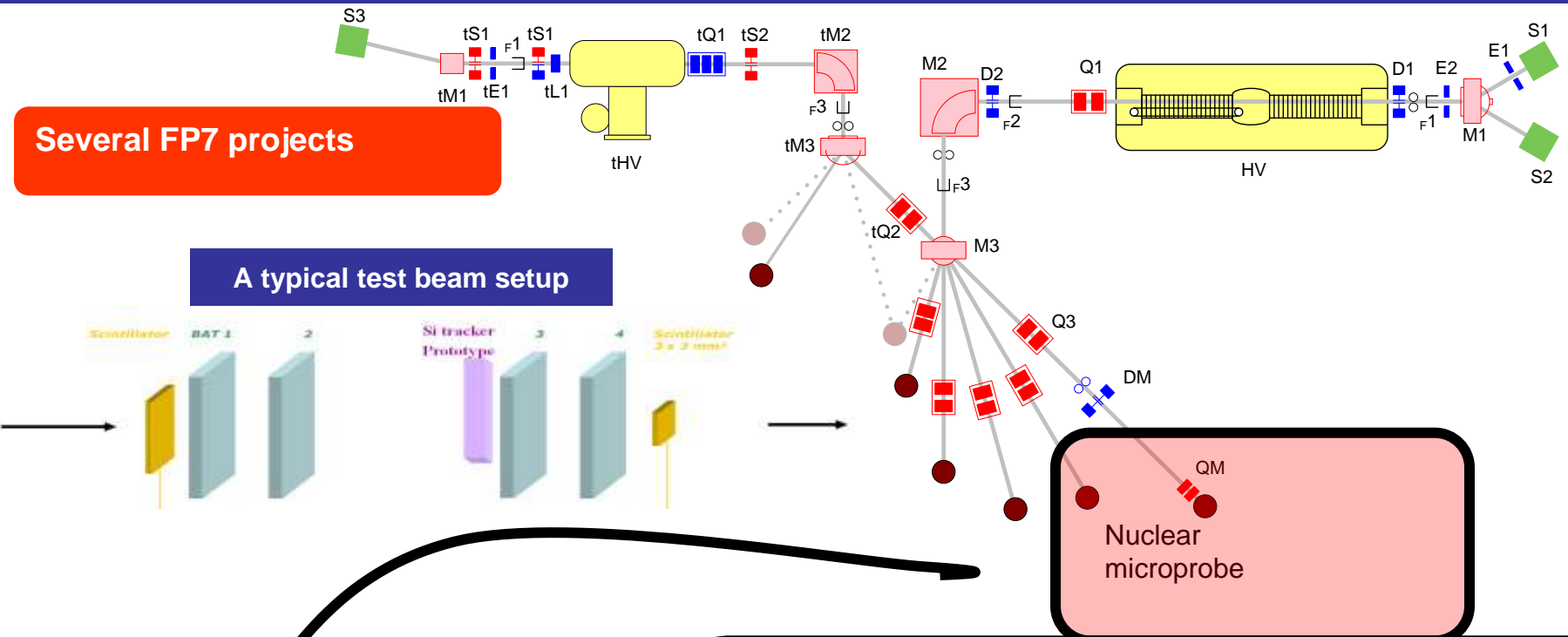


- 10 micron accuracy good enough for most position accuracy tests
- 10 MeV just enough to penetrate 300 microns of Silicon
- Table moves a few mm in x,y and z direction for precise position determination using actual beam
- Partial replacement for complex, expensive, and time consuming test beams in large accelerator complexes, using precise tracking telescopes (needed to get accurate position)

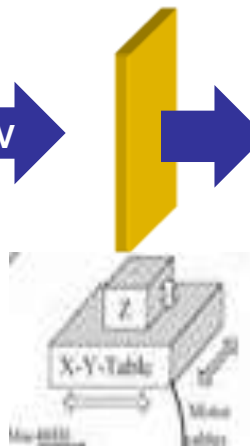
Unique beam testing facility for silicon and diamond detectors in development

Several FP7 projects

A typical test beam setup



10 micron proton beam 10 MeV

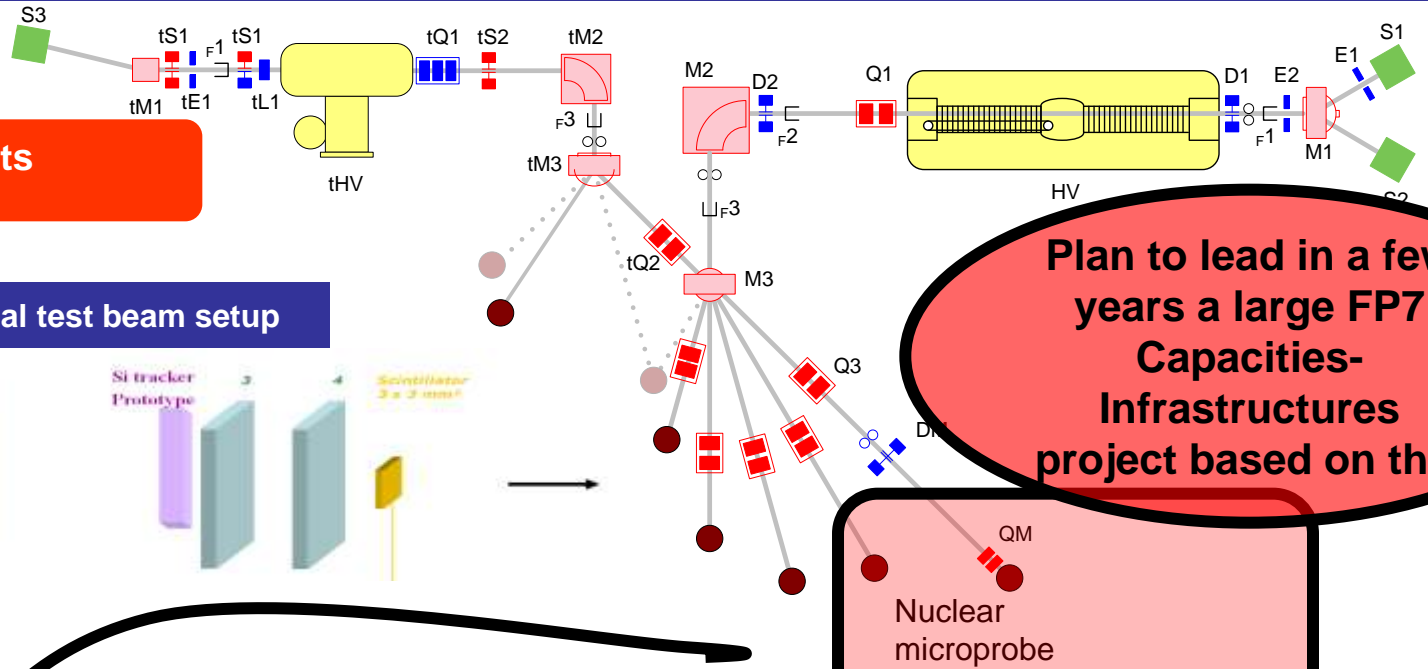


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Unique beam testing facility for silicon and diamond detectors in development

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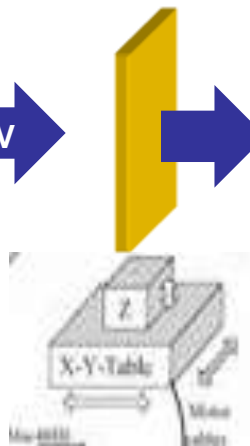
A typical test beam setup



Plan to lead in a few years a large FP7 Capacities-Infrastructures project based on this

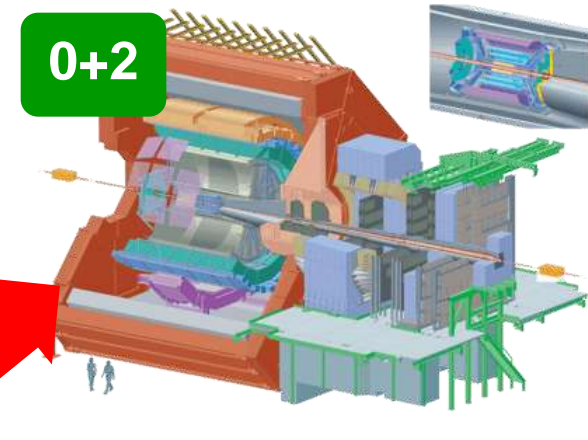
Nuclear microprobe

10 micron proton beam 10 MeV

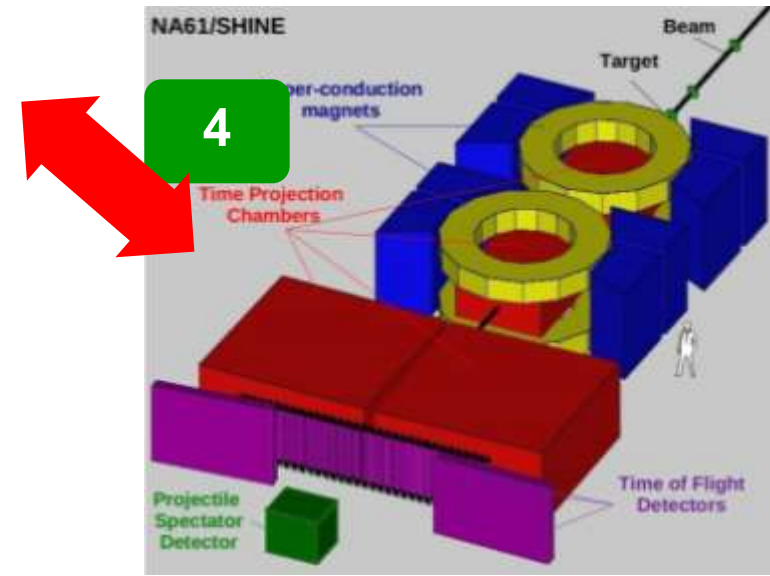
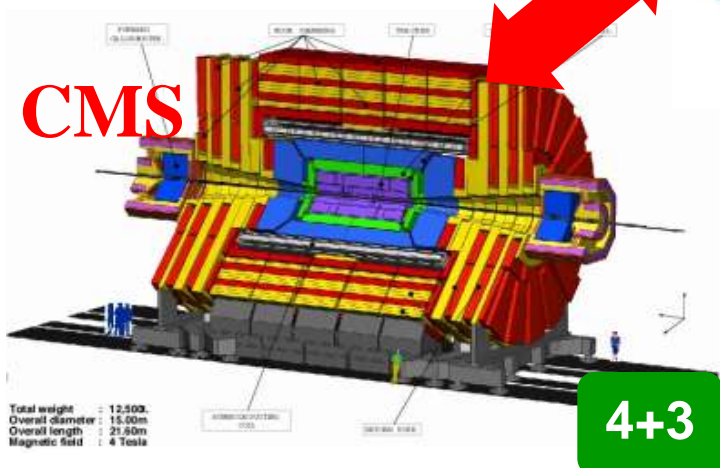
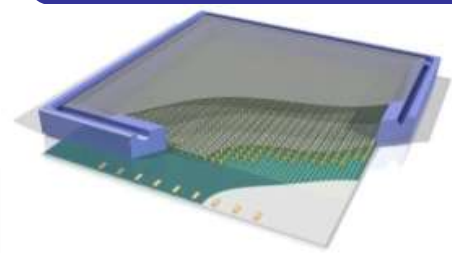


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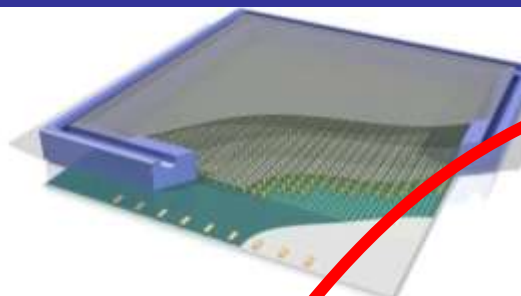
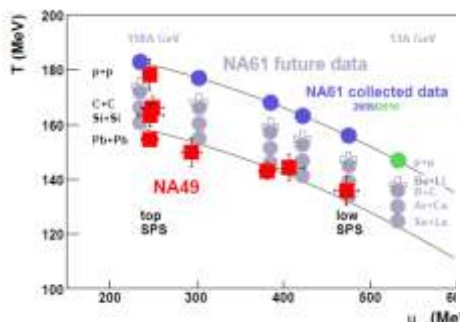
Focusing effort across DEF and Croatia around experimental techniques



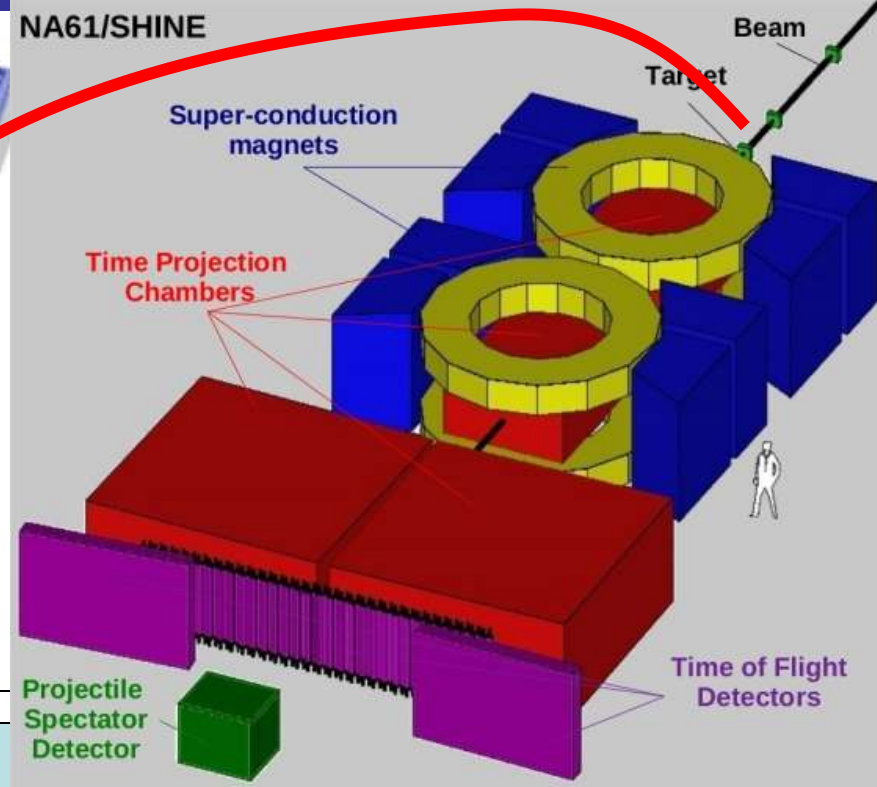
Silicon Pixel (silicon and gas active body)



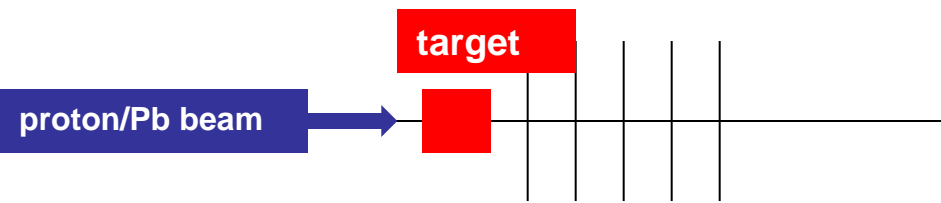
Plans: NA61 experimental upgrade – will be biggest experimental effort of Croatia at CERN



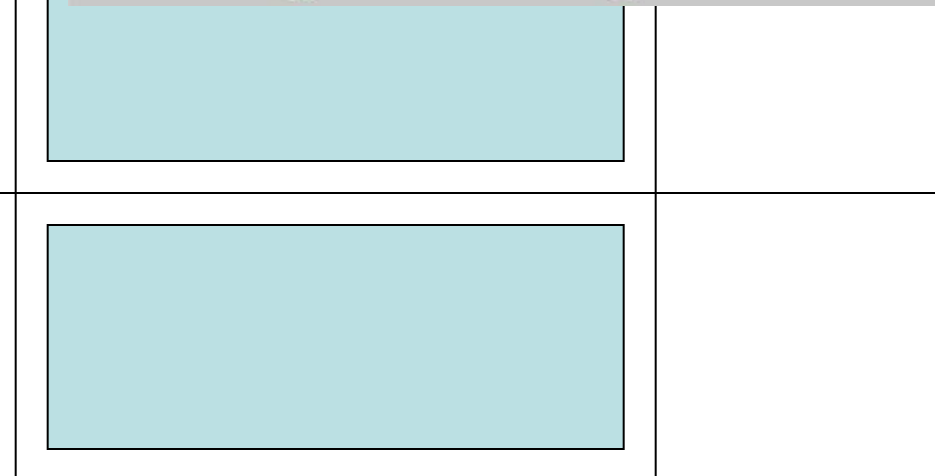
Gas (1mm) on Slimmed Silicon Pixels



Design, simulation, assembly, readout, testing, all will be done or coordinated by DEP
...



- 5 GOSSIP planes planned
- Region with very high number of tracks



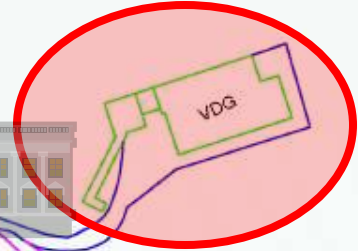
Structural funds – 2013



Structural funds – 2013

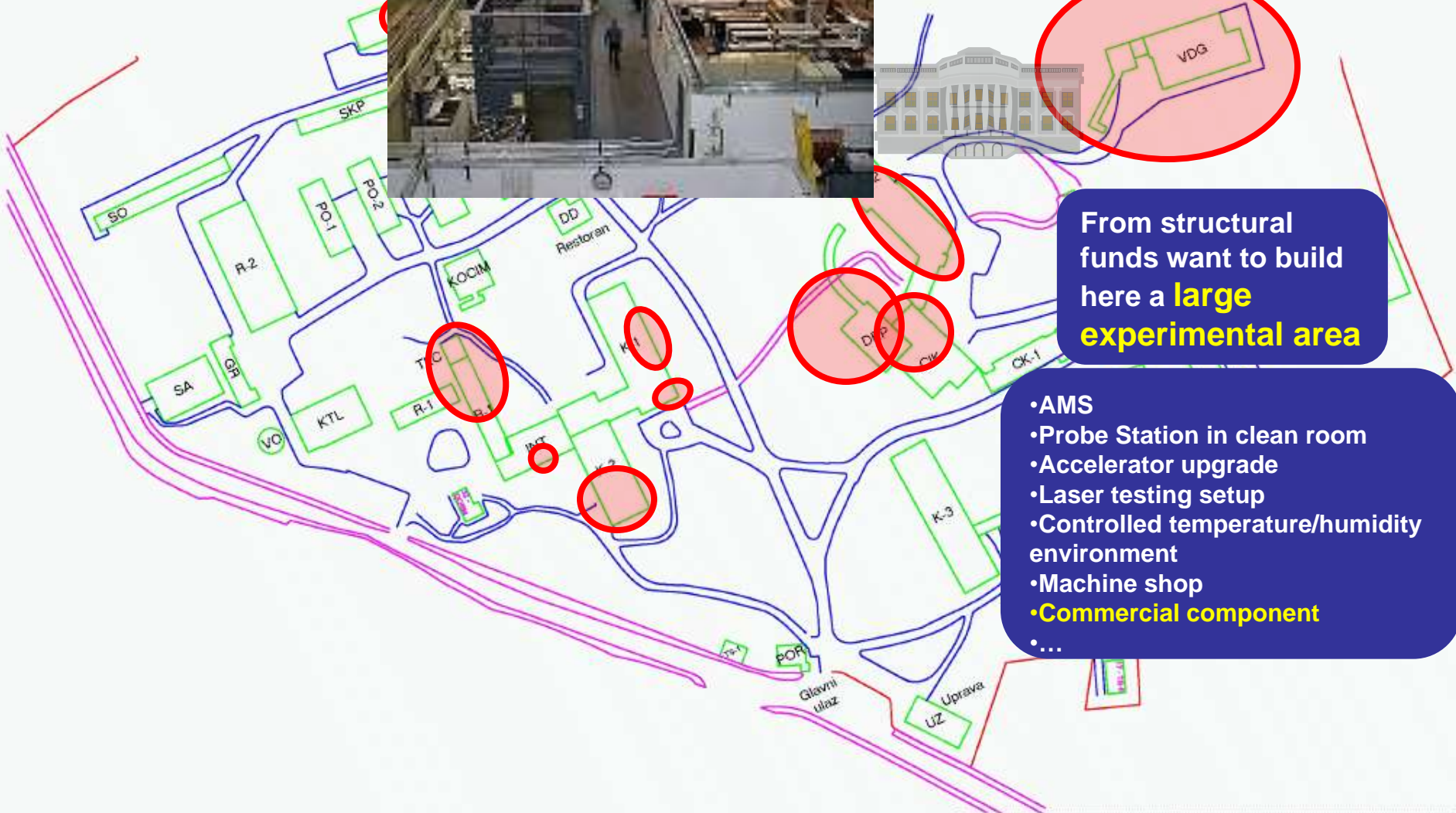


Structura



From structural funds want to build here a **large experimental area**

- AMS
- Probe Station in clean room
- Accelerator upgrade
- Laser testing setup
- Controlled temperature/humidity environment
- Machine shop
- Commercial component**
- ...



Structura

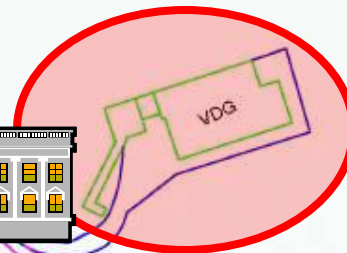


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Great opportunity for Croatian experimental nuclear and particle physics that **MUST NOT** be missed. DEP has the **necessary basis** (existing equipment, projects, know-how) to be able to get and run a **10-20 million Euro** investment. Should be jointly done and used by **DEP, PMF, Split, IFS**

Structura



The Croatian nuclear and particle physics groups are one of the very few Croatian scientific groups that would know what to do with tens of millions of Euros -> **MUST** use that

From structural funds want to build here a **large experimental area**

- AMS
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Great opportunity for Croatian experimental nuclear and particle physics that **MUST NOT** be missed. DEP has the **necessary basis** (existing equipment, projects, know-how) to be able to get and run a **10-20 million Euro** investment. Should be jointly done and used by **DEP, PMF, Split, IFS**

Conclusion

There is an excellent basis for an even brighter future for experimental nuclear and particle physics in Croatia (in many ways the best performing science group in Croatia)



Should make every effort to use the present opportunities and capitalize on current strengths

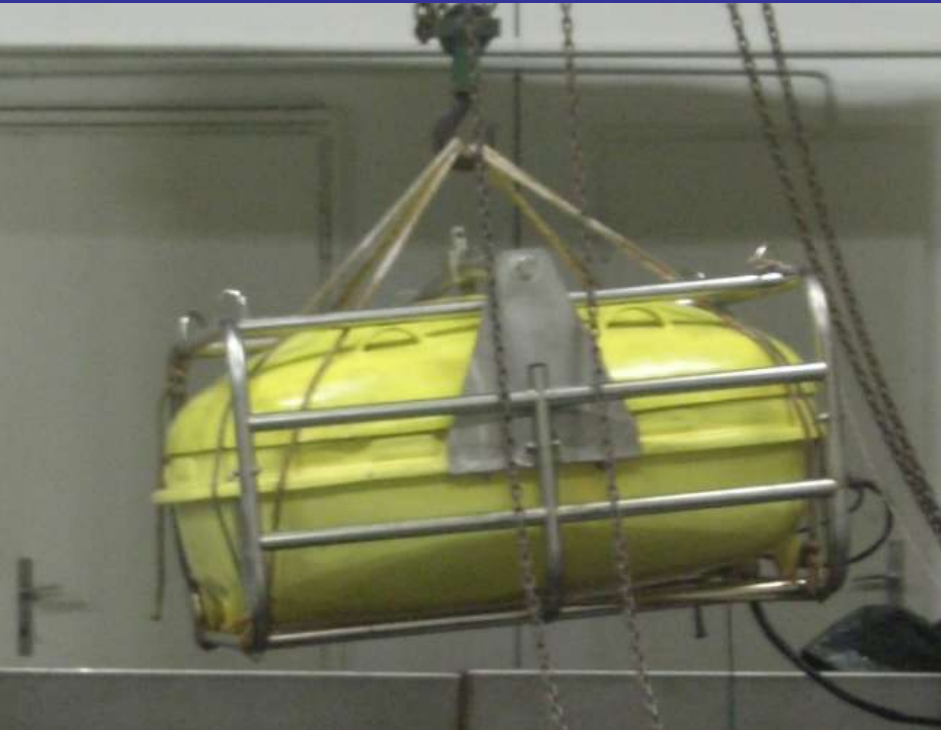


But this opportunity will be at least partially wasted if Ministry of Science/RBI does not modify its priorities...

Pressuring them at every opportunity 😊

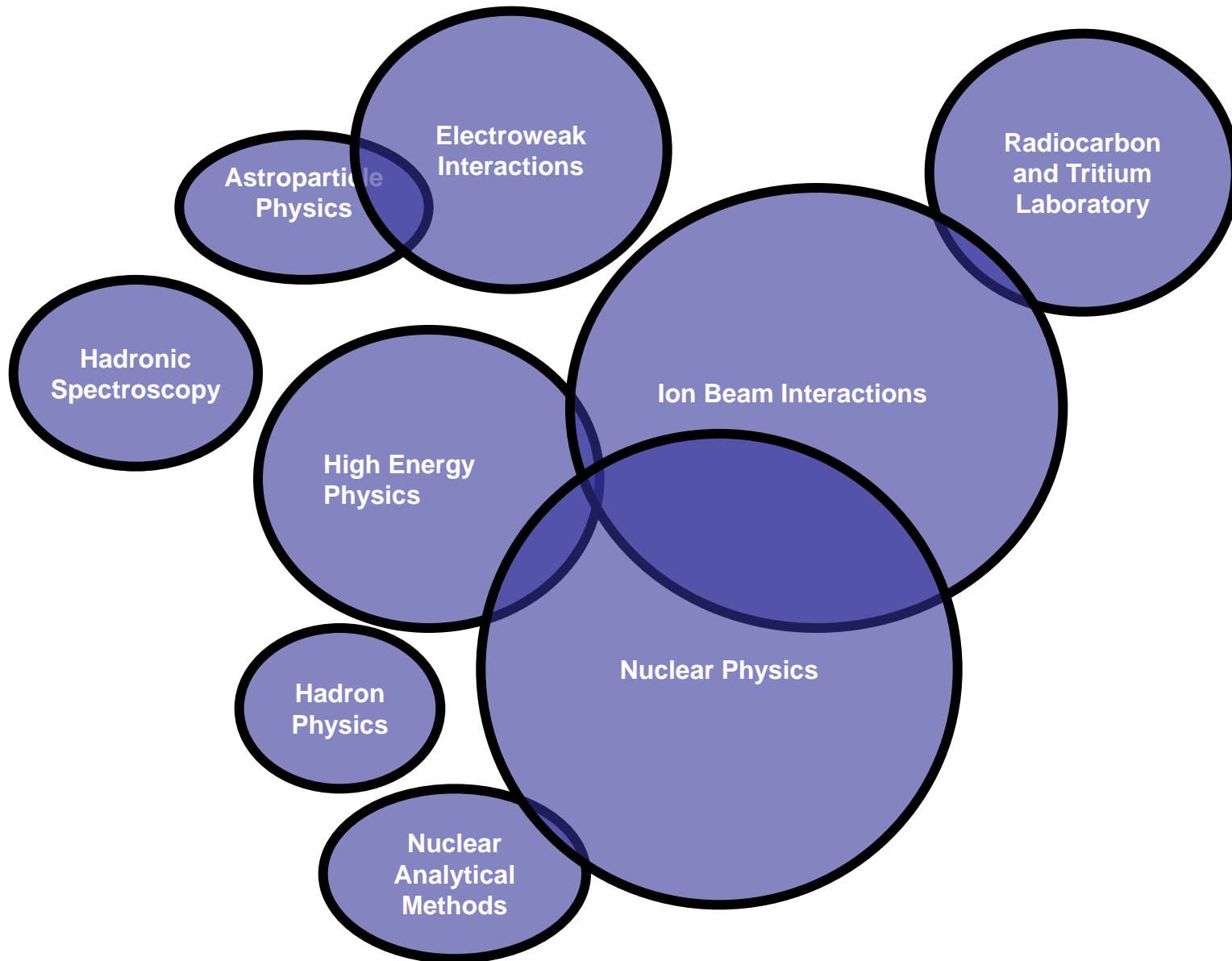


Application example: Detection of explosives at the bottom of sea



- Internal neutron source
- Detect gamma ray response (different for explosives, chemicals, background), and find underground old bombs and dangerous chemicals
- A lot of activities planned – remote controlled, more versatile and precise detection of different materials...
- HUGE commercial potential

Current situation within IEP



Oak Ridge, USA
Canberra, Australija

EUROPEAN NUPECC

• **Large Scale Facility**

Jyvaskyla, Finska

• LLN, Belgija

CERN-Isolde, Svicarska

• GSI, Njemacka

• Legnaro - Padova, Italija

• GANIL, Francuska

KVI, Nizozemska

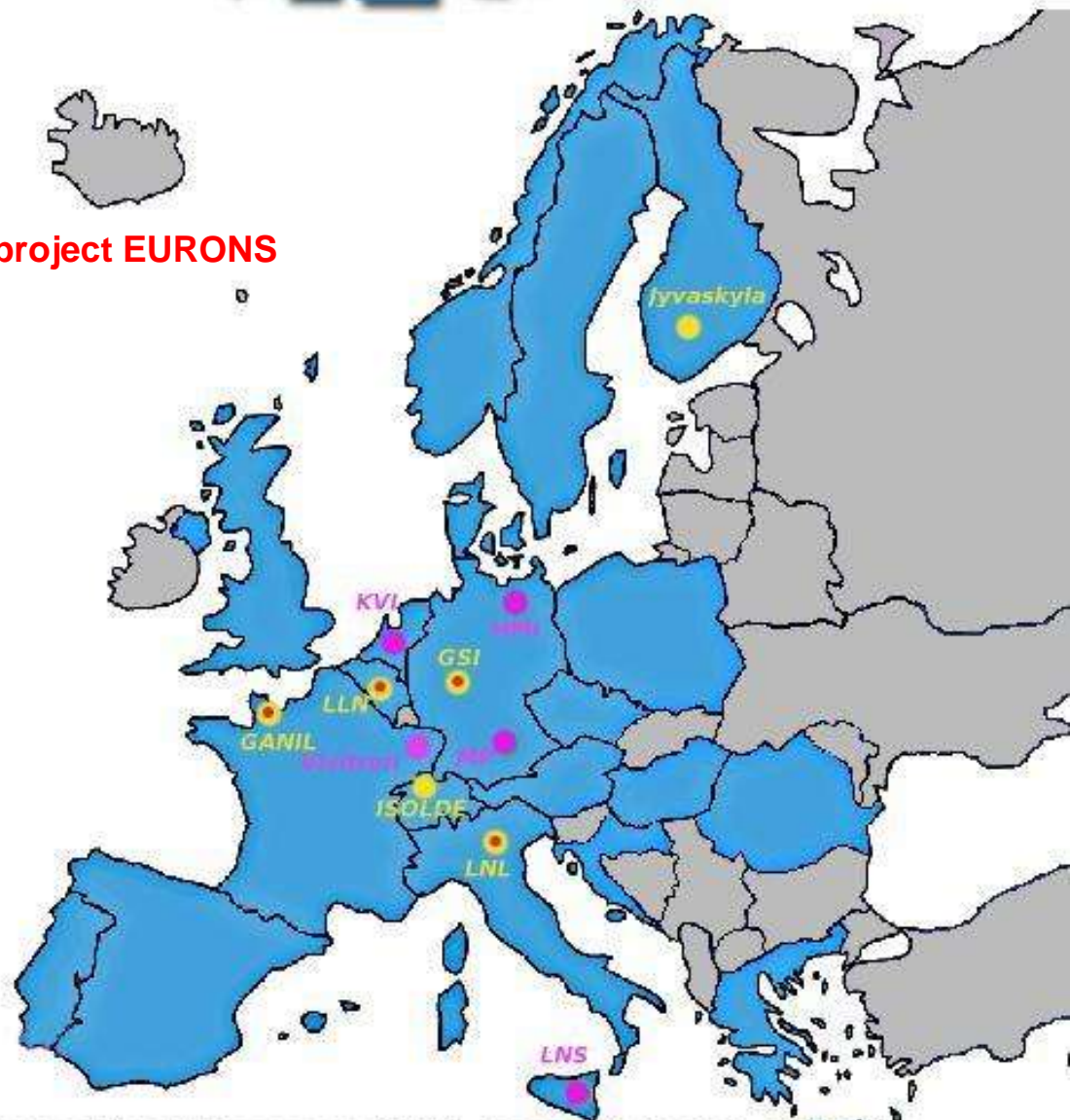
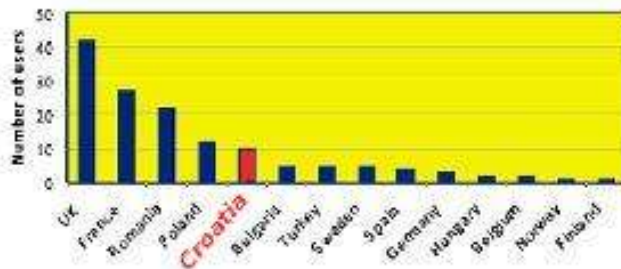
LNS, Catania, Italija

HMI, Berlin, Njemacka

MP, Munchen, Njemacka

(Vivitron, Strasbourg, Francuska)

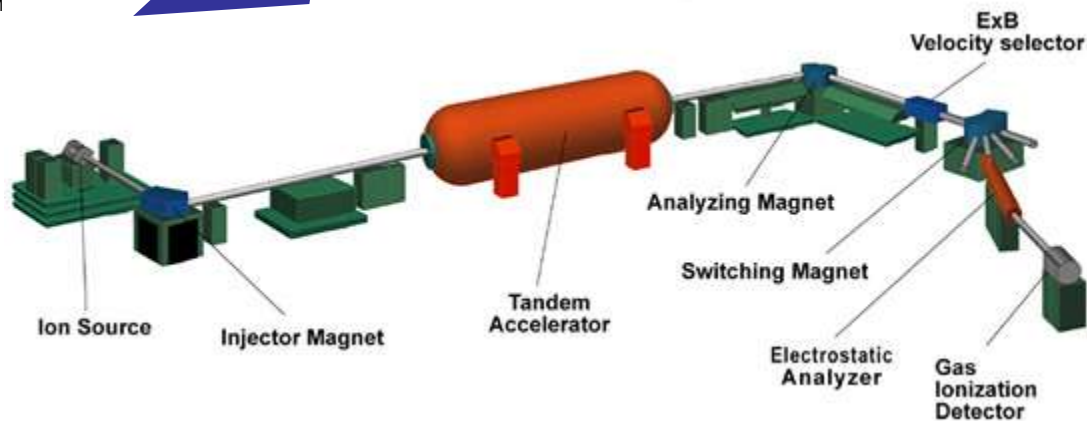
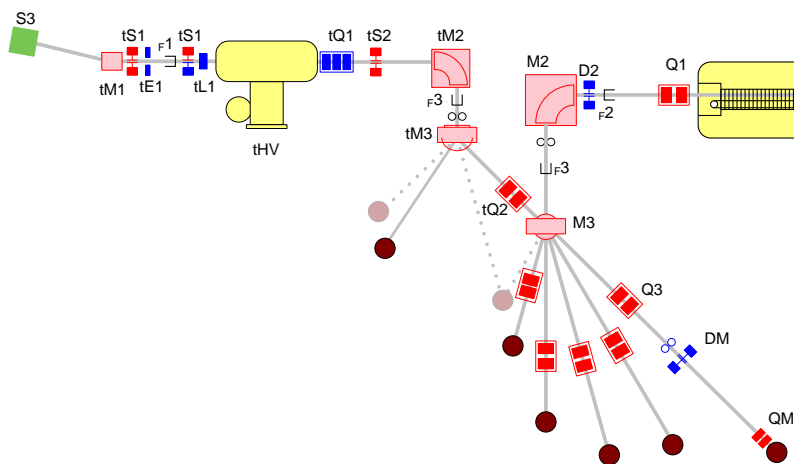
FP6 I3 project EURONS



EURONS (RII3-CT-2004-506065) Networking, Transnational Access and Joint Research Project Activities

Plans: Accelerator mass spectrometry

purchase a modern state-of-the-art compact radiocarbon AMS system and install in the IEP Van de Graaff accelerator facility operated by the Laboratory for ion Beam interactions.



Neutron generator

