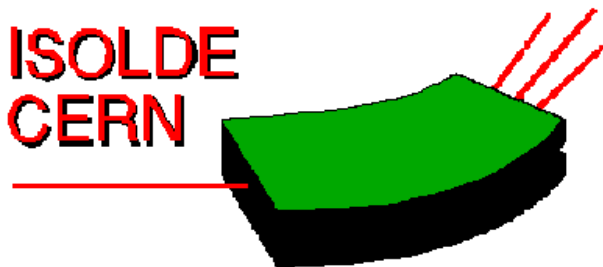




Physics with Post-Accelerated ISOL Beams: the HIE-ISOLDE Program

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*On leave from
IPN Orsay



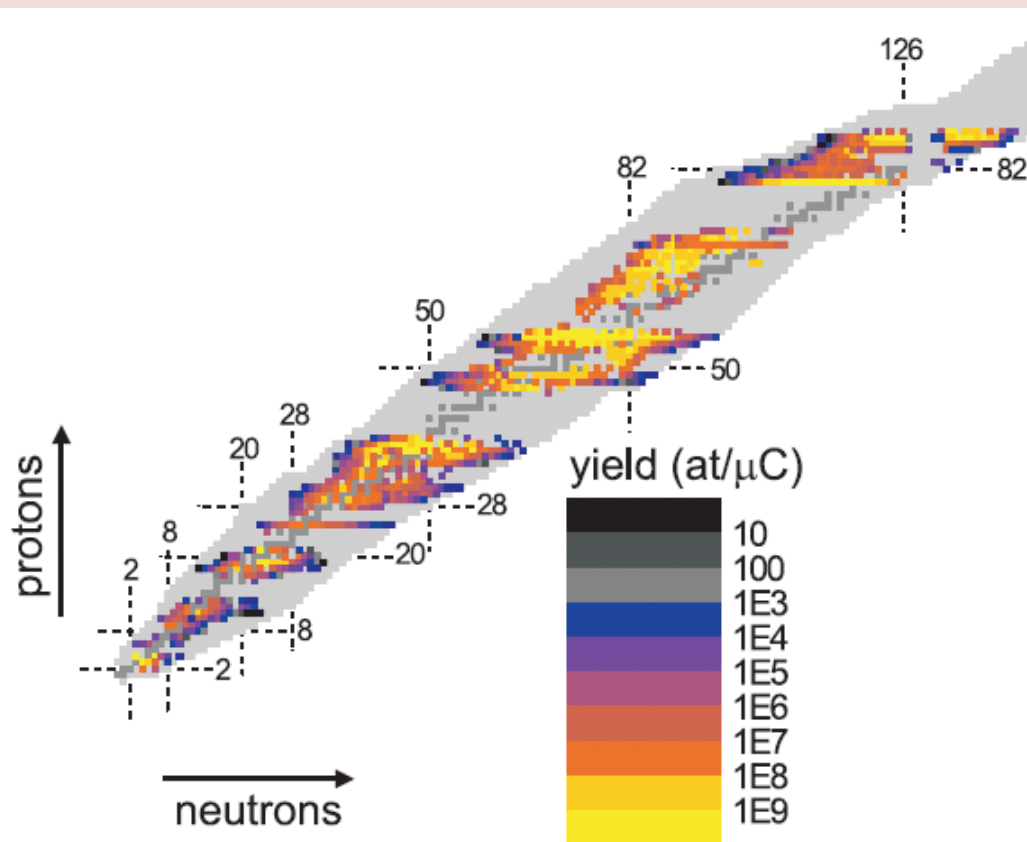
Outline

- The HIE-ISOLDE Project
- The LOI campaign
- Some examples of the future
Physics Program

ISOLDE today offers the largest range of available isotopes of any ISOL facility worldwide.

HIE-ISOLDE aims at increasing the energy of these RIB up to 10A MeV and their intensity by a factor 10

HIE-ISOLDE will play an important role in the network of ISOL facilities preparing EURISOL (with SPIRAL2 and SPES)



<http://isolde.web.cern.ch/ISOLDE/>

So far >600 radioactive isotopes of >60 elements

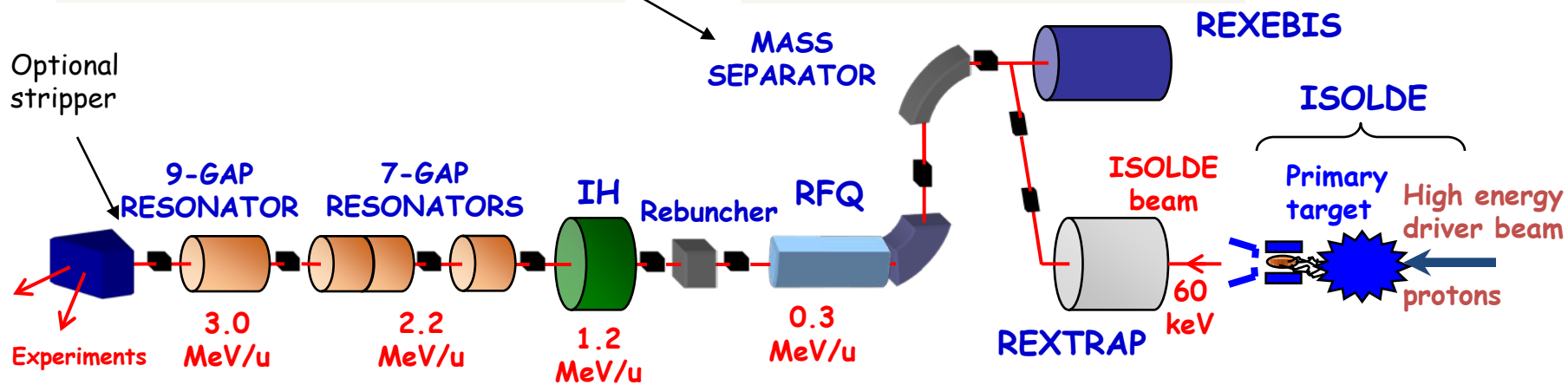
REX-ISOLDE OVERVIEW

Nier-spectrometer

- Select the correct A/q and separate the radioactive ions from the residual gases.
- A/q resolution ~ 150

EBIS

- Super conducting solenoid, 2 T
- Electron beam $< 0.4A$ 3-6 keV
- Breeding time 3 to >200 ms
- Total capacity $6 \cdot 10^{10}$ charges
- $A/q < 4.5$



Linac

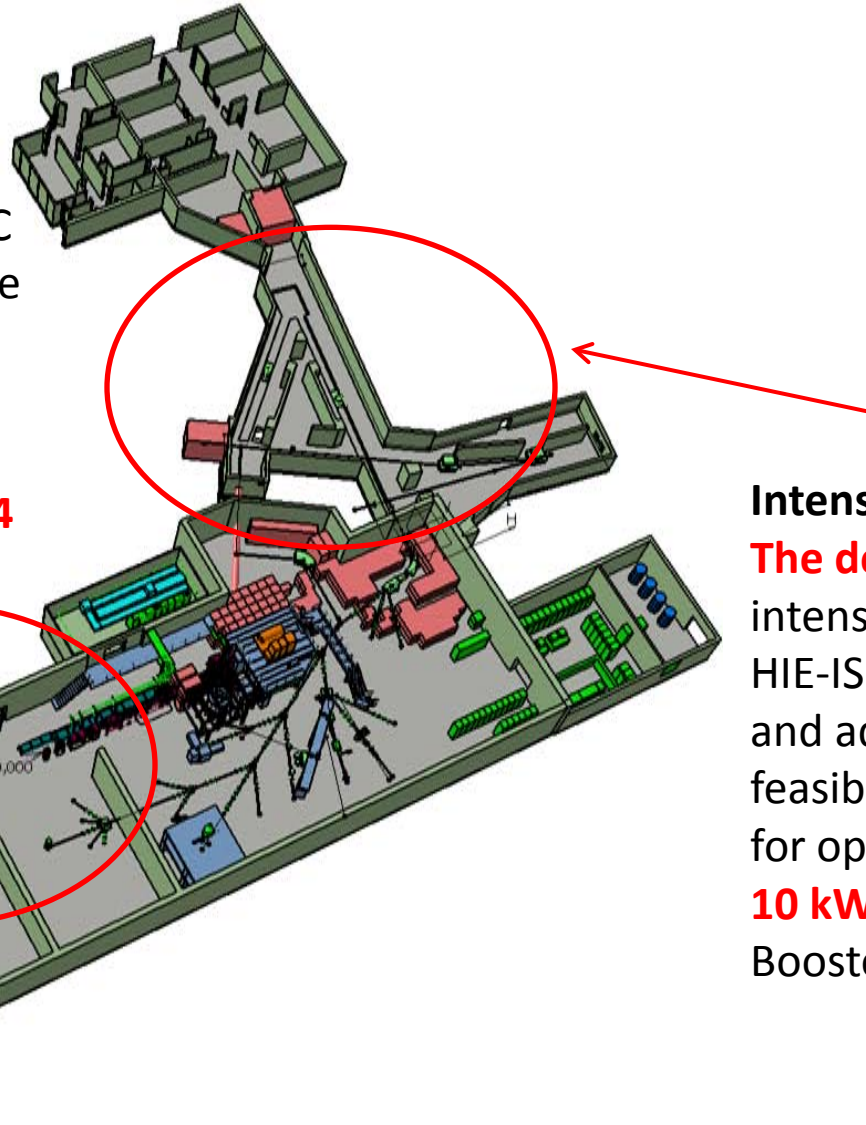
Length	11 m
Freq.	101MHz (202MHz for the 9GP)
Duty cycle	1ms 100Hz (10%)
Energy	300keV/u, 1.2-3MeV/u
A/q max.	4.5 (2.2MeV/u), 3.5 (3MeV/u)

REX-trap

- Cooling (10-20 ms)
- Buffer gas + RF
- (He), Li, ..., U
- 10^8 ions/pulse
- (Space charge effects $>10^5$)

Total efficiency : 1 -10 %

Scope of HIE-ISOLDE



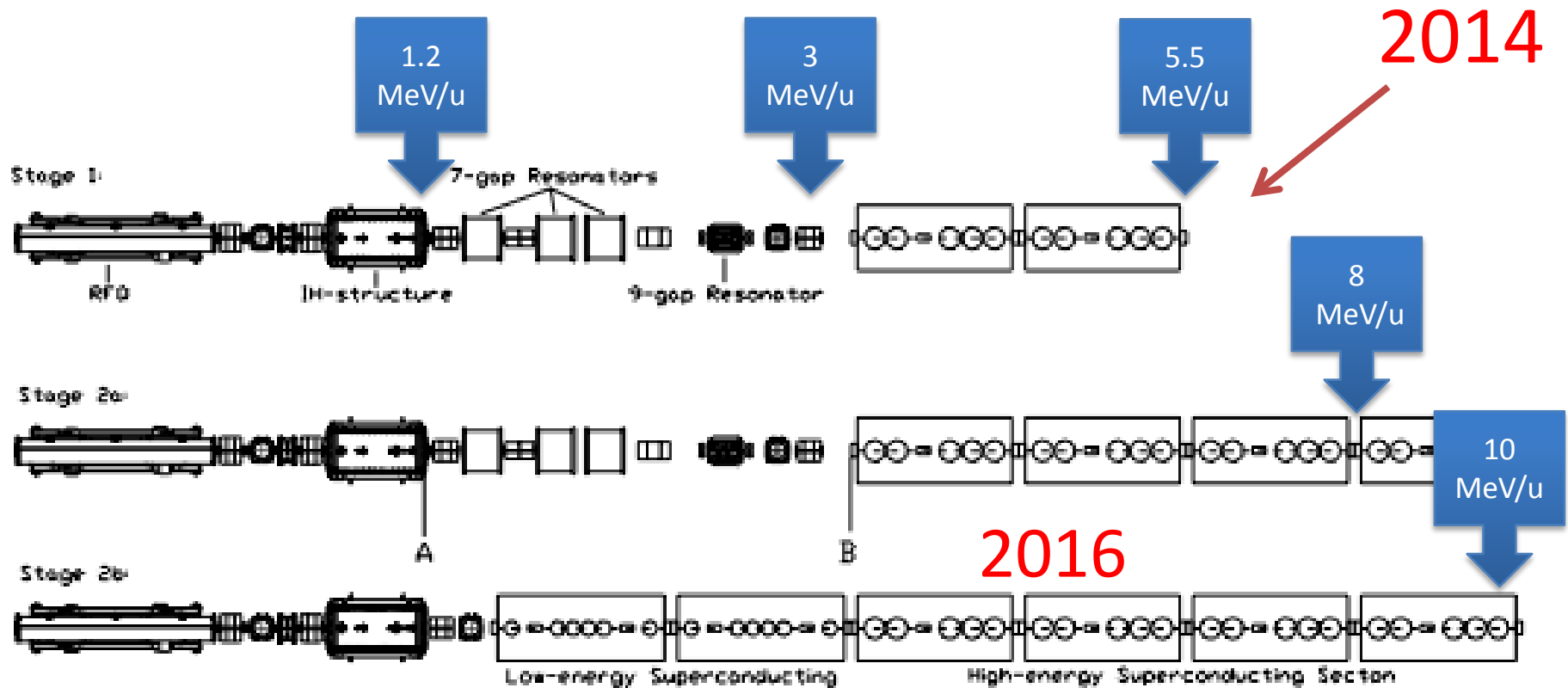
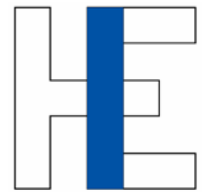
Energy Upgrade:

The HIE-ISOLDE project concentrates on the construction of the SC LINAC and associated infrastructure in order to upgrade the energy of the post-accelerated radioactive ion beams to **5.5 MeV/u in 2014** and **10 MeV/u by 2016**

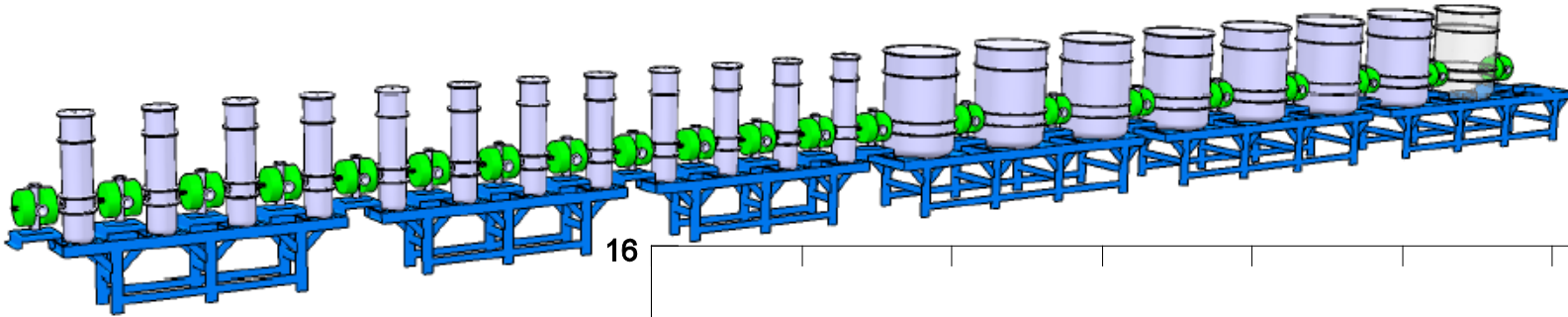
Intensity Upgrade:

The design study for the intensity upgrade, also part of HIE-ISOLDE, **starts in 2011**, and addresses the technical feasibility and cost estimate for operating the facility at **10 kW** once LINAC4 and PS Booster are online.

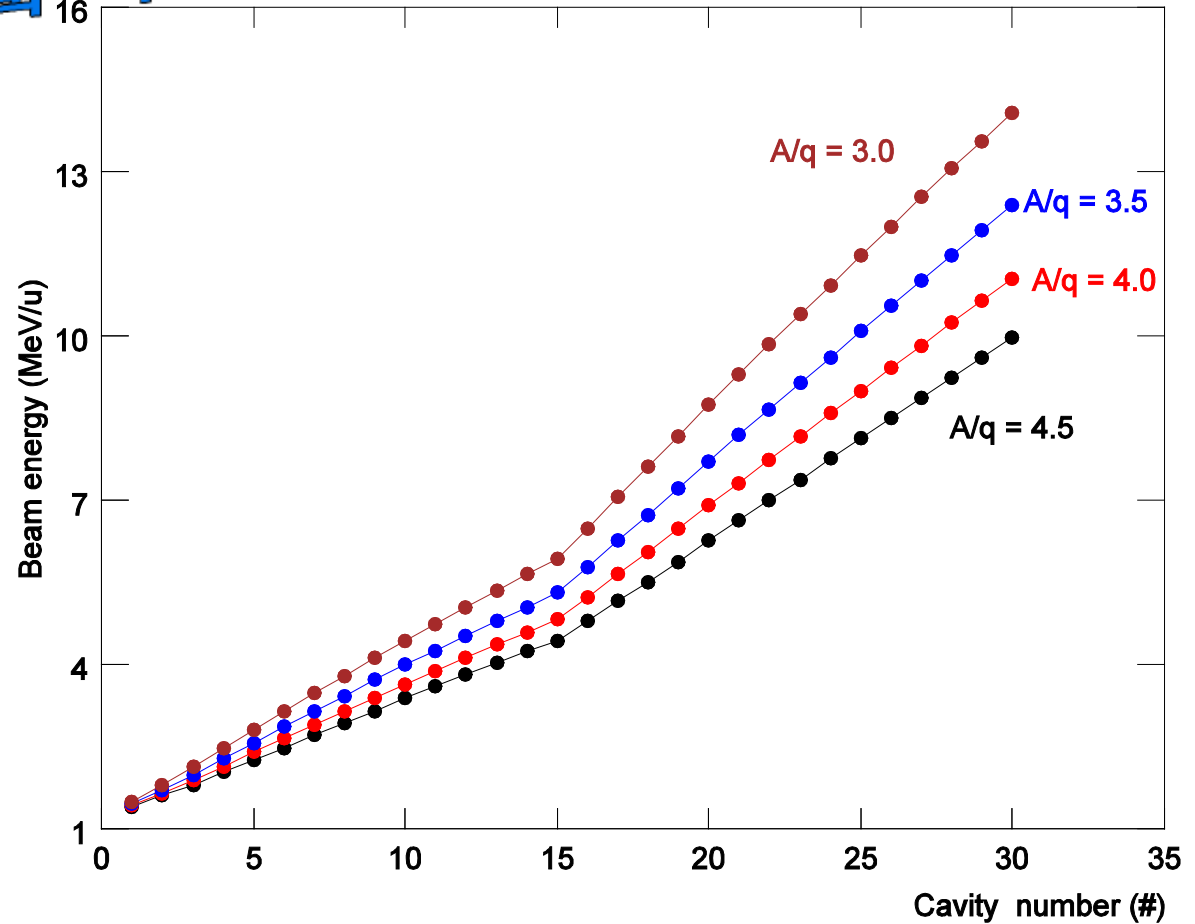
SC Linac Layout staged installation



SC linac



Max energy for
different A/q :



Overall Current Cost Estimate



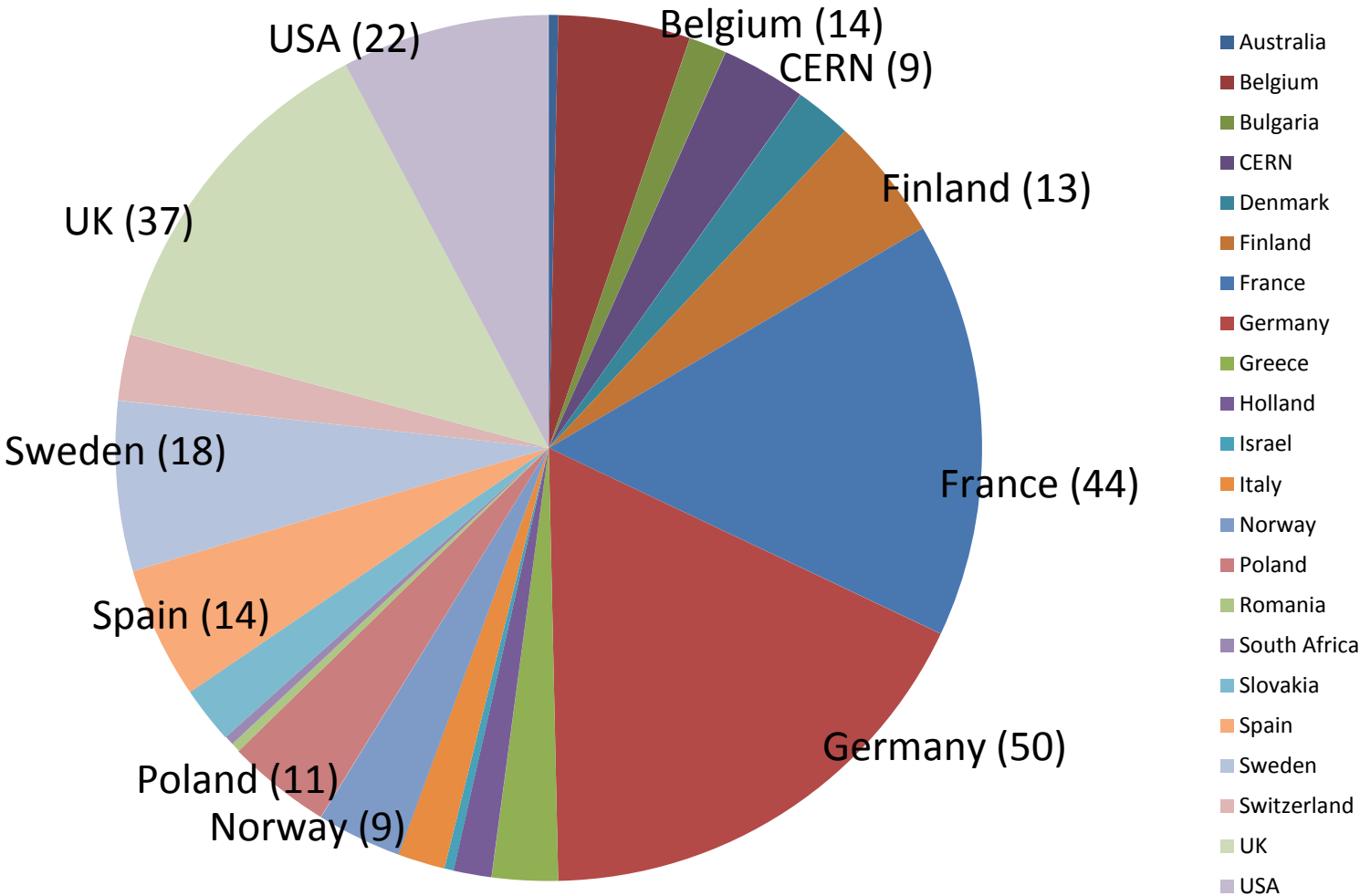
- The current total cost of HIE-ISOLDE is **39.3 MCHF materials** and **164 FTE** (90 Staff FTE+ 74 Fellows/Phd FTE)
- This includes the beam quality improvement and part of the linac design study & prototyping costs (**4.8 MCHF + 6 FTE**) that have already been spent, and necessary consolidation costs.
- Funding for the upgrade to 5.5A MeV is complete.
- 12.4 MCHF of external funding is still necessary to complete the project. Various negotiations and grant applications are ongoing,
- Staff is provided by CERN. Fellows/Phd will be funded by Marie Curie training network (CATHI) and ISOLDE Collaboration Funds

Call for Letters of Intent

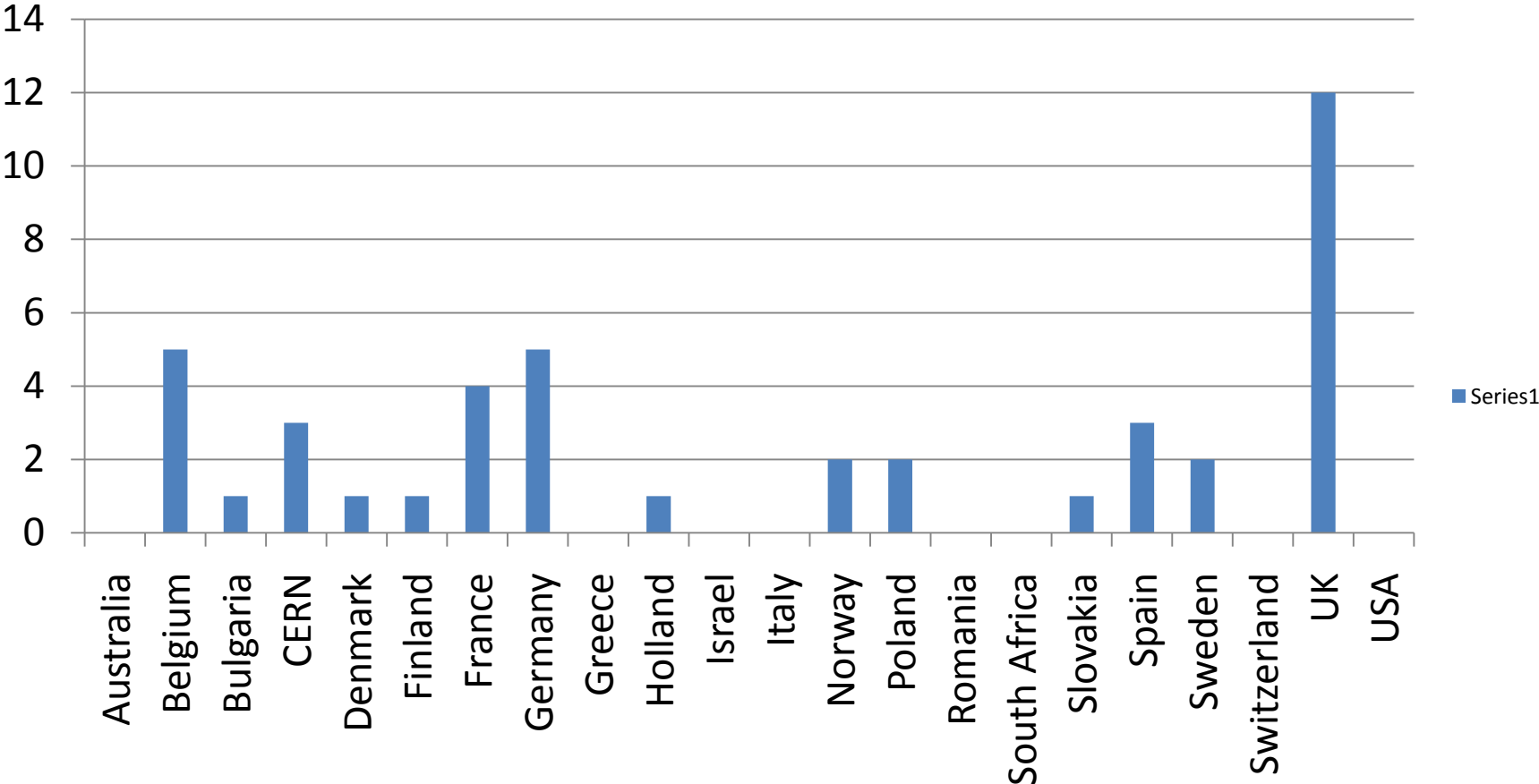
(deadline May 21)

- 34 Letters submitted
- 284 Participants from 76 Laboratories in 22 Countries
- 30 LOIs make use of the Energy and Intensity increases; 4 of the intensity upgrade only
- Major mechanisms are Coulex (13) and transfer(16); elastic scattering(3); fission(2)
- (3) letters concern masses and moments; (4) astrophysics and (5) major new instrumentation
- Major subjects: Nuclear shapes ; Shell evolution; Halo properties; Nuclear astrophysics

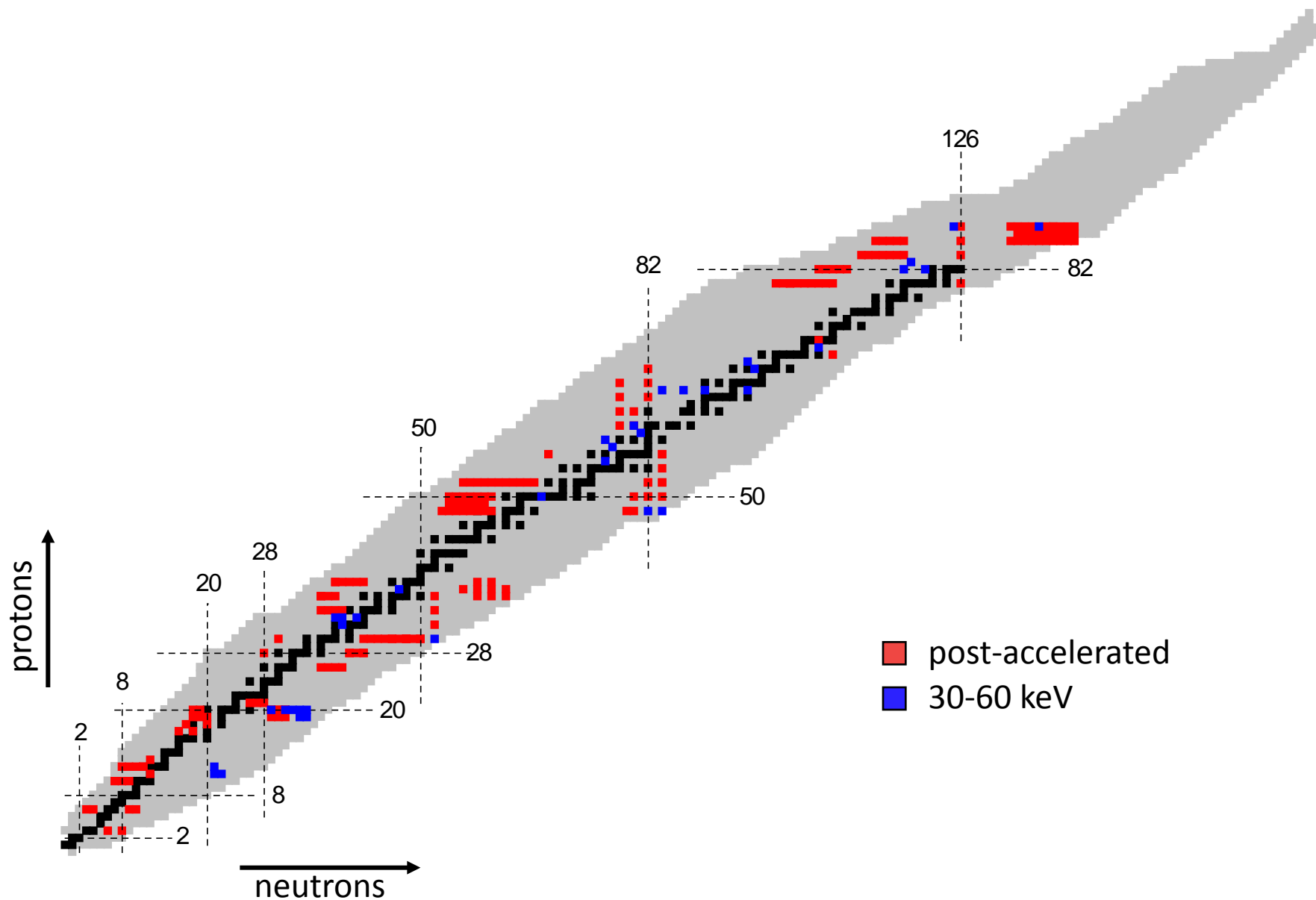
LOI participants by Country



LOI Spokespersons by Country

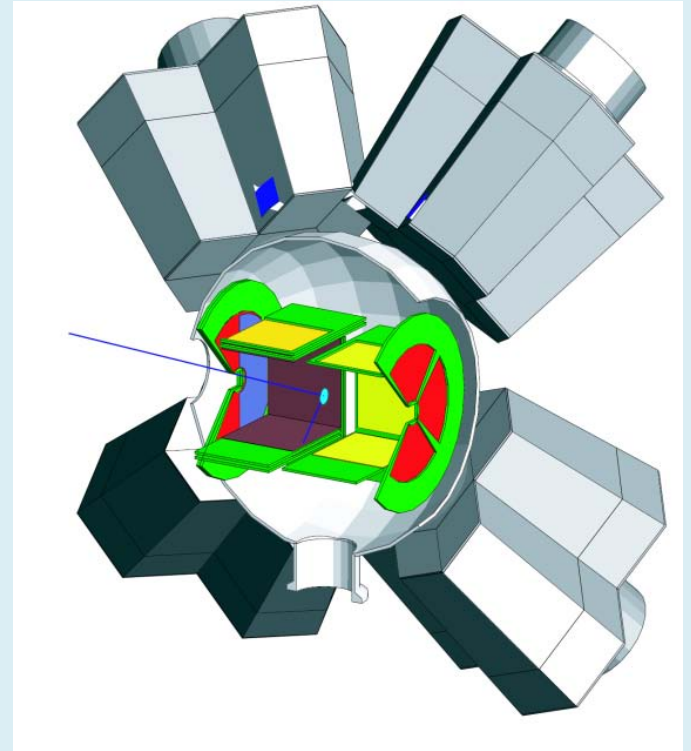


Radioactive isotopes requested in HIE-ISOLDE Letters of Intent



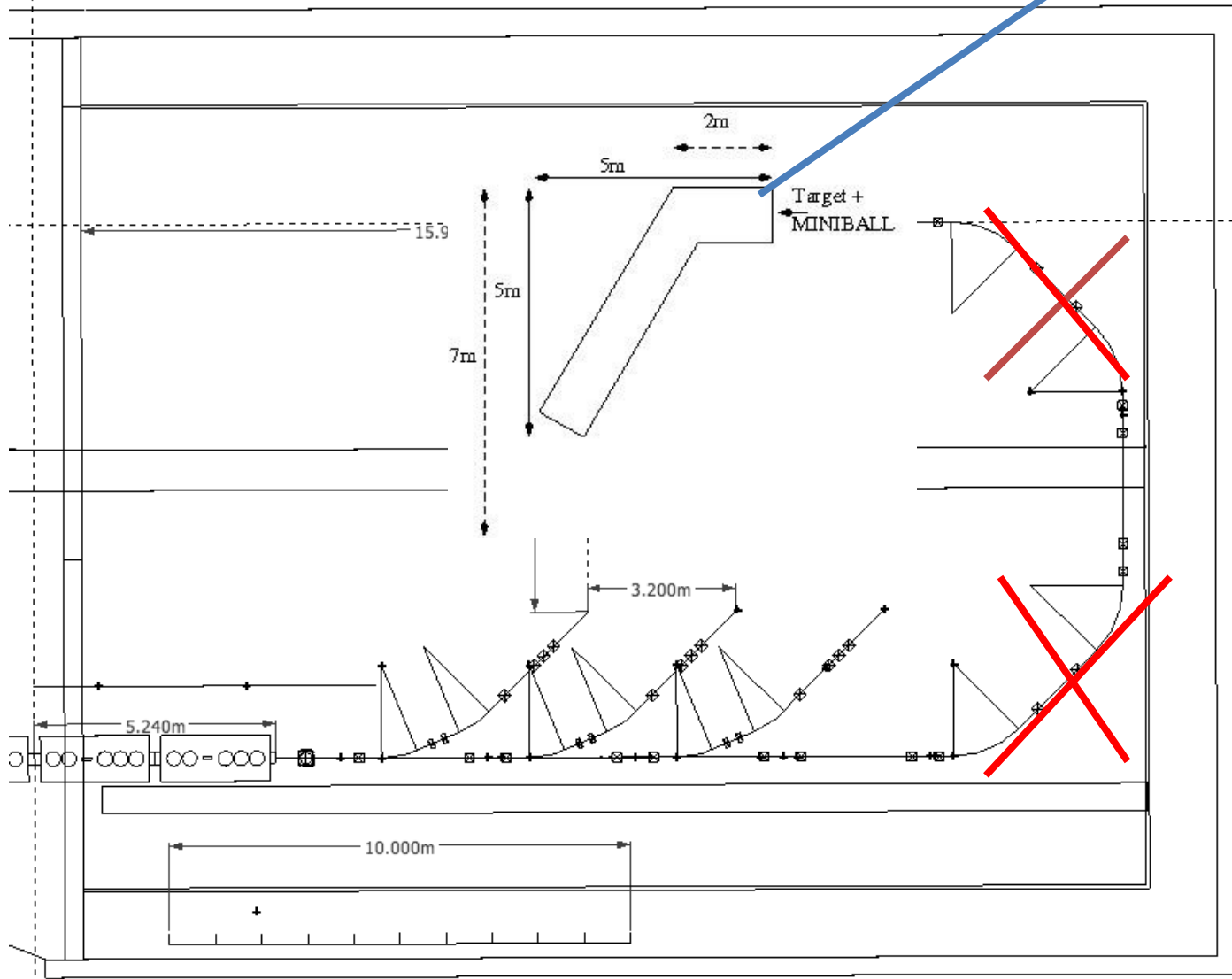
Detectors

- Main workhorse : MINIBALL + TREX
- Specific to HIE-ISOLDE: Magnetic spectrometer
- Other detectors :
 - MAYA/ACTAR
 - HELIOS
 - PARIS
 - GASPARD
 - Neutron detectors
- TSR (Heidelberg)?



Hall Layout (HEBT)

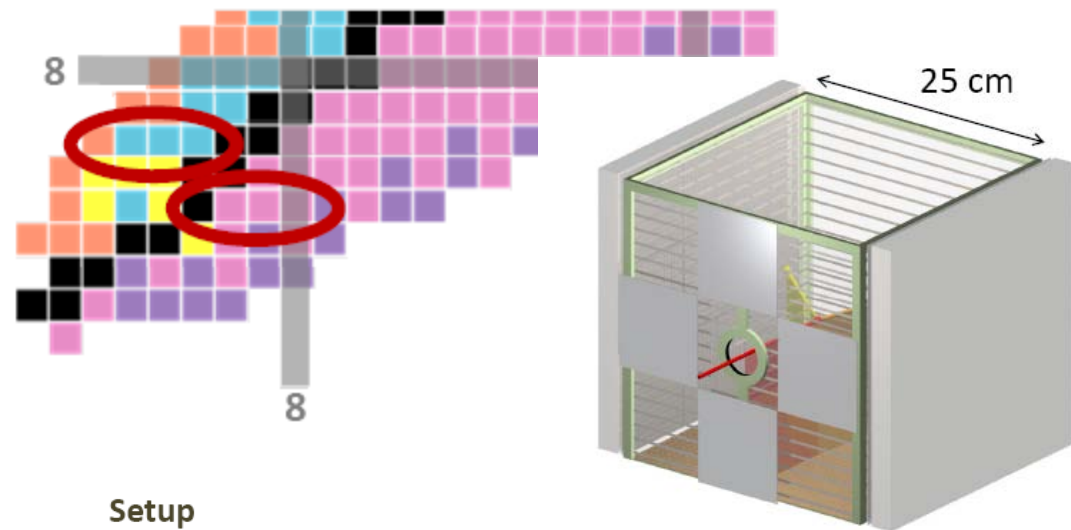
>2016



Reactions with an active target

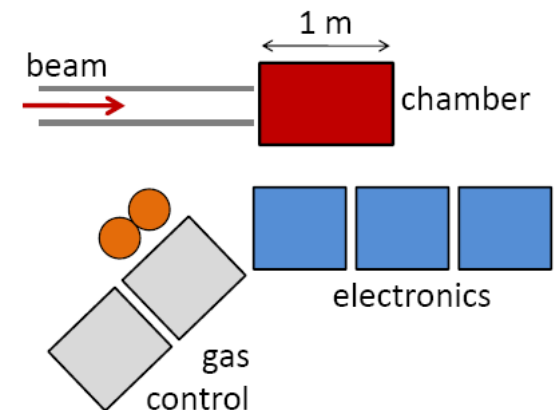
Light nuclei (nuclear structure, nuclear astrophysics)

- Transfer reactions
to access very exotic states
Example: ${}^9\text{C}(d,p){}^{10}\text{C}^*$
- Resonant reactions
Example: ${}^{12}\text{Be} + p$
- Keys:
Resolution (energy and spatial)
Efficiency



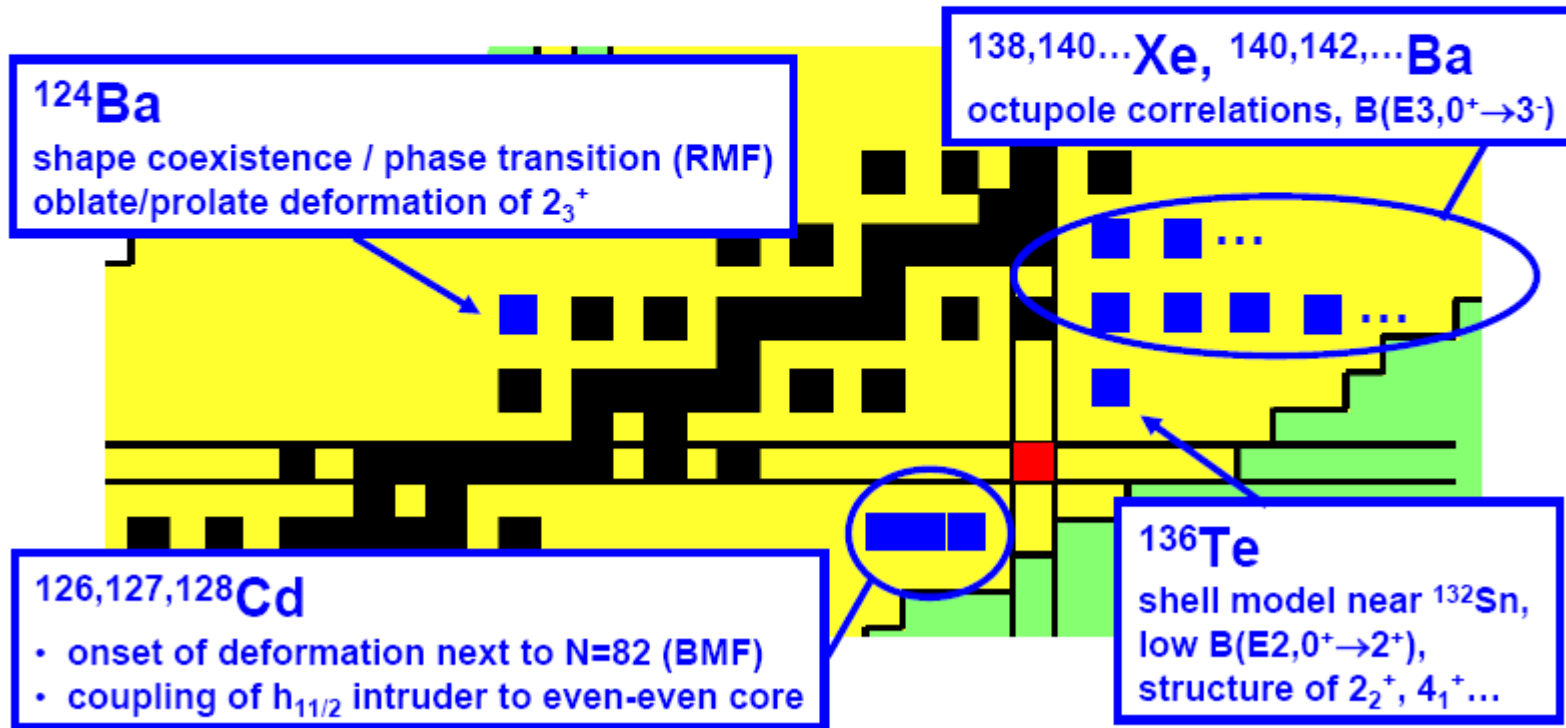
Setup

- Compact
- Portable!
- Includes services




Coulomb excitation Around ^{132}Sn

Higher energies at HIE-ISOLDE enable
... multiple Coulomb excitation
... population of high lying states, e.g. 3^- states (for ^{140}Xe : $10 \times \sigma$ @ REX)

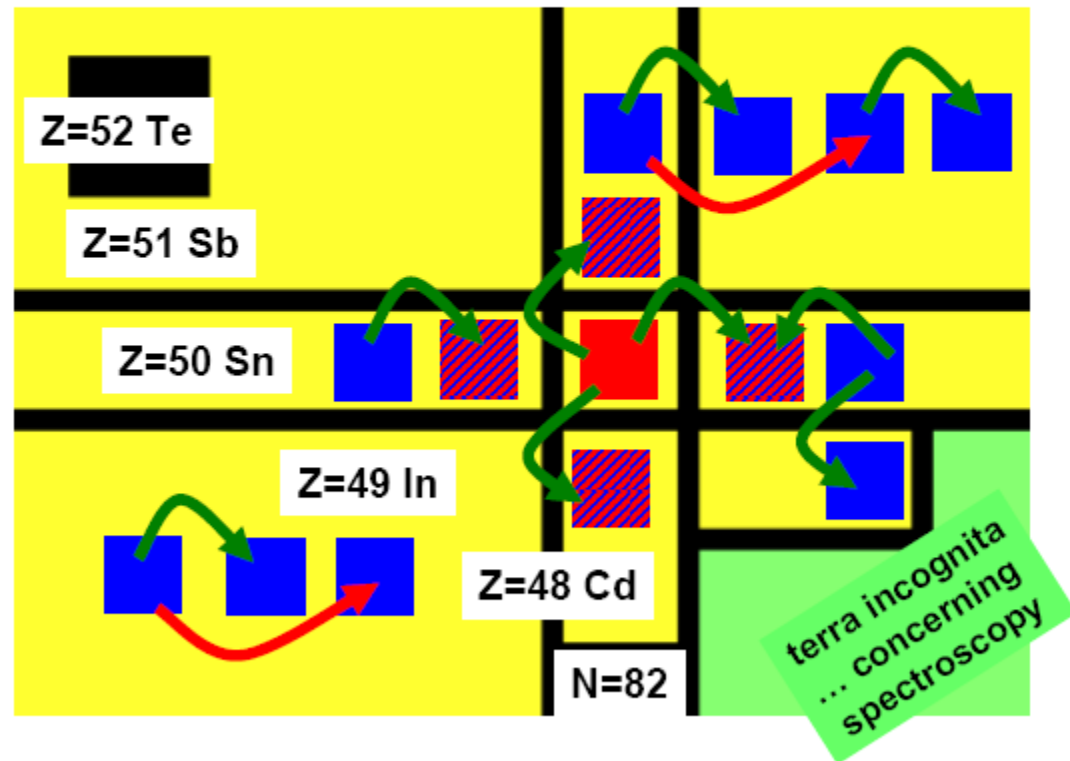


Nucleon transfer reactions Around ^{132}Sn

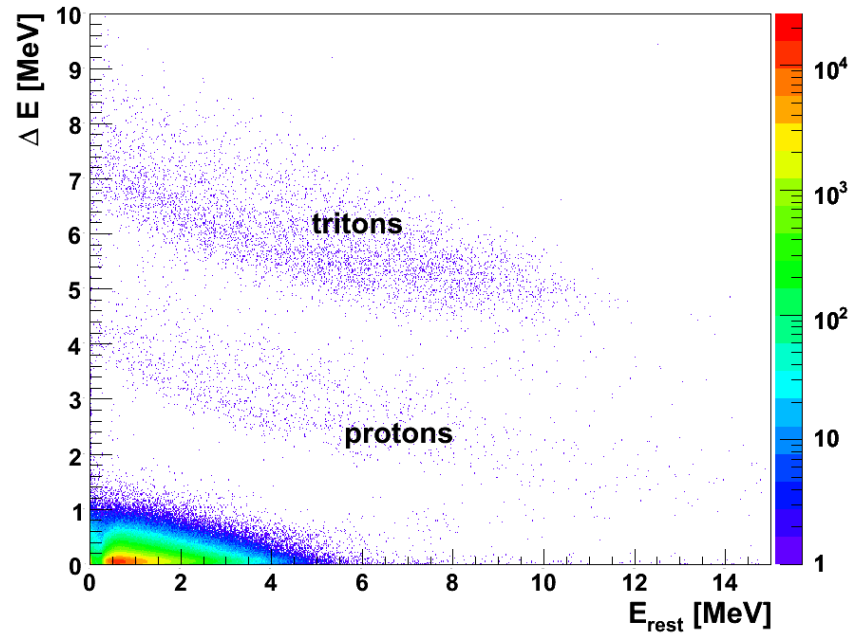
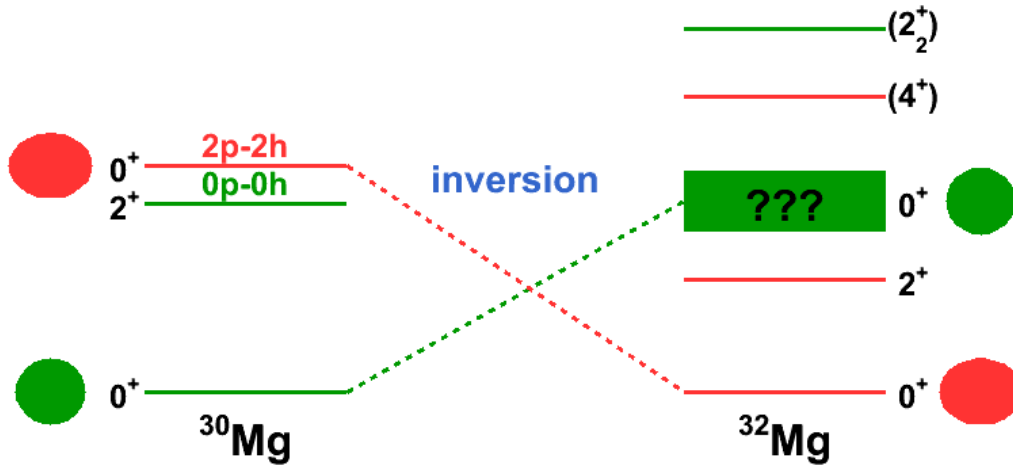
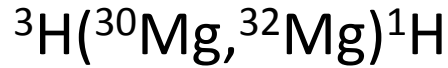
Higher energies at HIE-ISOLDE enable
... pronounced angular distributions \rightarrow orbital angular momentum transfer Δl

- „SM states“  :
 $^{132}\text{Sn} \pm$ particle/hole
... then extrapolation
- Spectroscopy of
 $Z < 50$ and $N > 82$ nuclei
- Weakening of s.o.
coupling
- $(d,p) \leftrightarrow (n,\gamma)$
- Pairing correlations

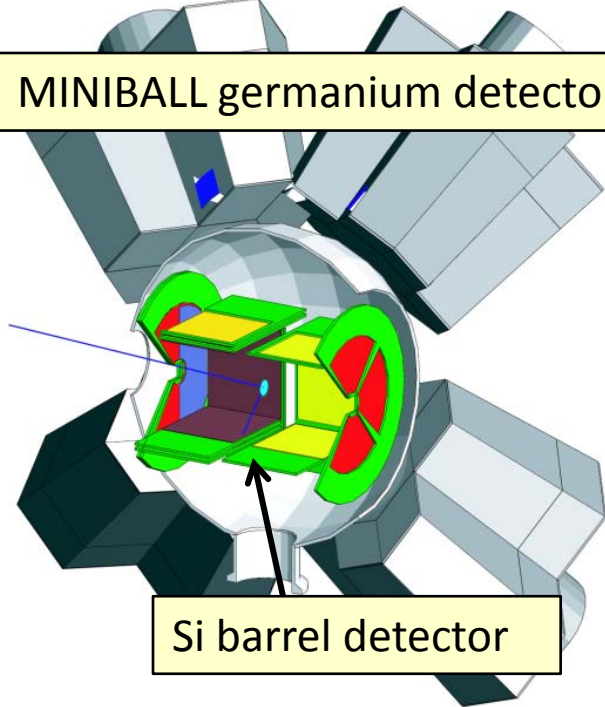
- Reactions:
 (d,p) , (t,p) ; $(^3\text{He},d)$, (t,α)
Q value matching \checkmark
- Main observables:
s.p. energies, Δl , SFs



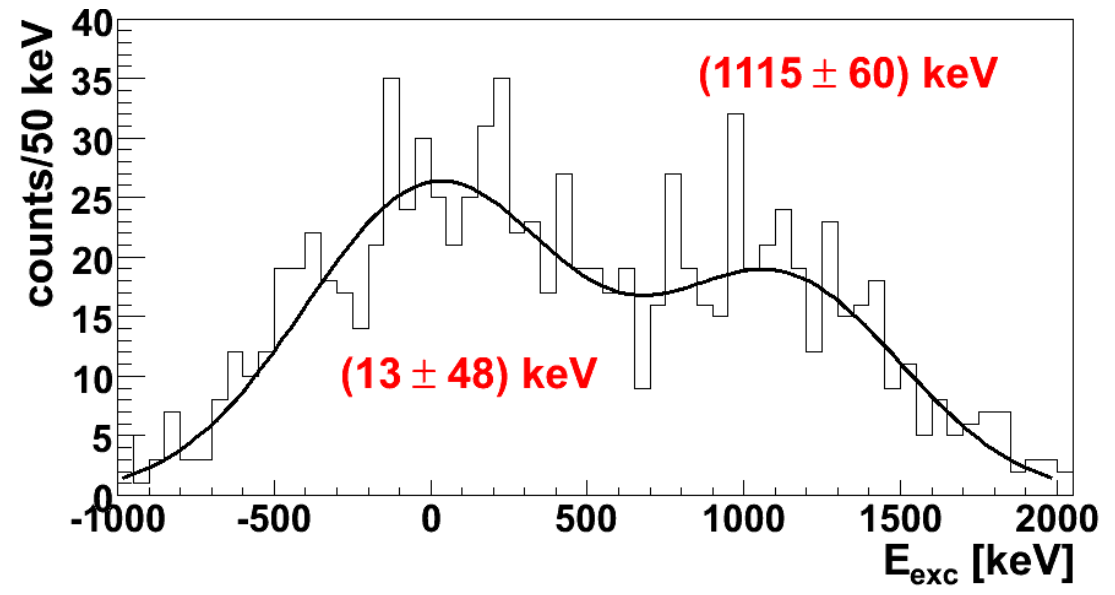
Two-neutron transfer reactions : radioactive beam onto a radioactive target



MINIBALL germanium detector



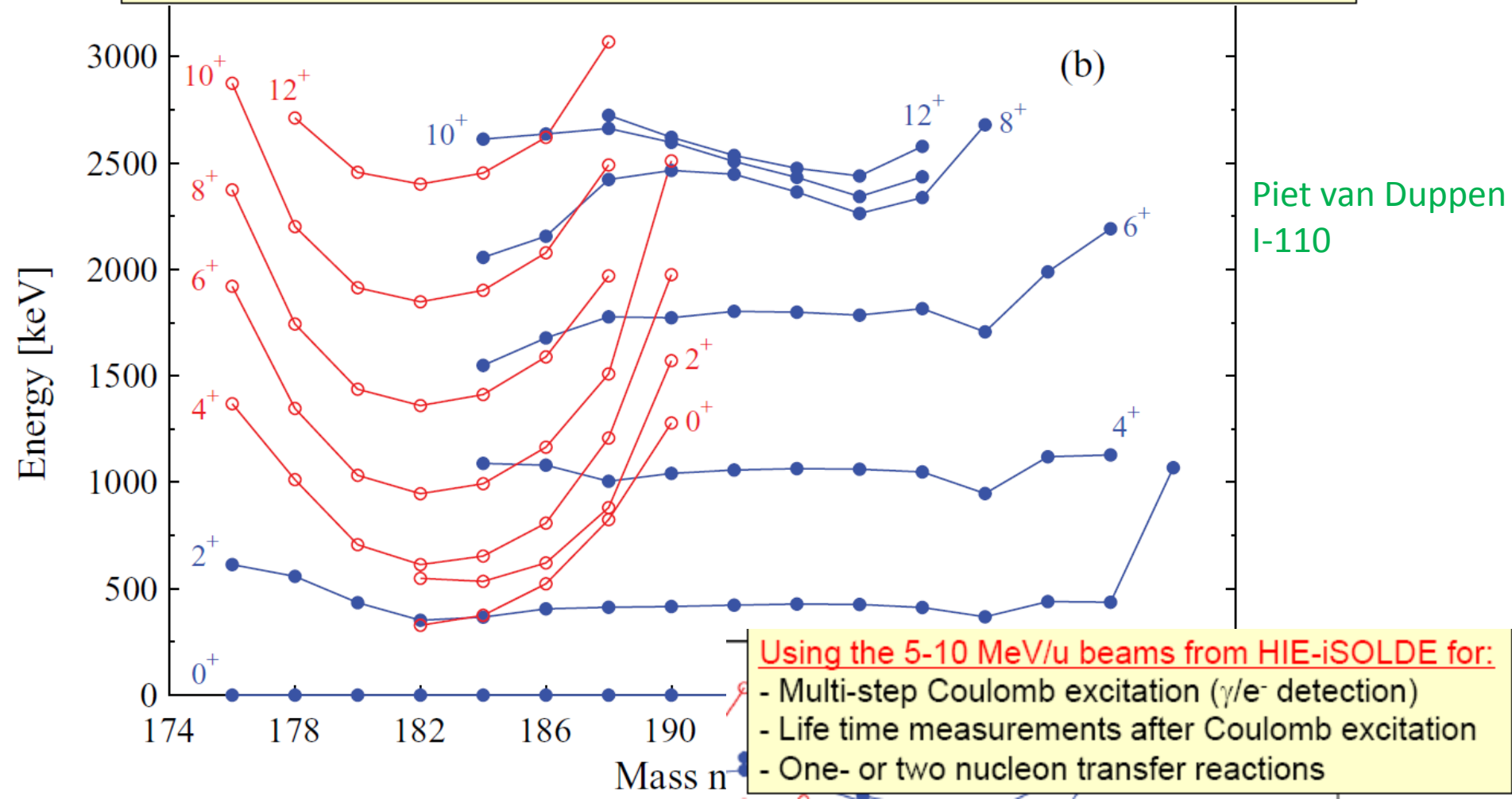
Si barrel detector



Shape coexistence in the neutron-deficient region around Z=82

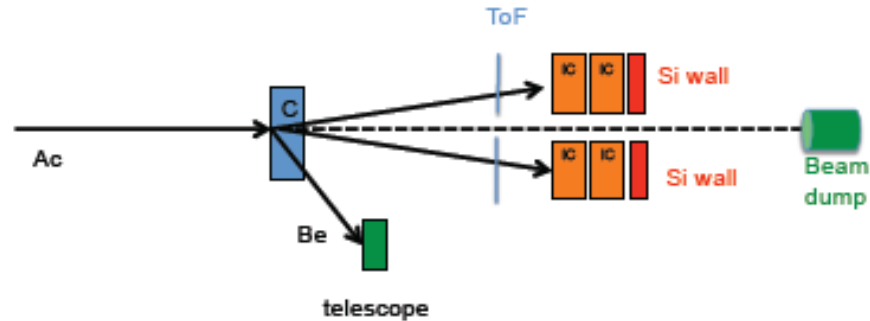
Aim of the experimental campaign proposed in the present Lol:

- Determine transition matrix elements, the magnitude and sign of the deformation
- Study the mixing between different band members
- Investigate the role of the proton/neutron orbitals involved



HiE ISOLDE: an unique opportunity for fissionists

- 10 MeV/u actinide beams with $>10^6$ pps: $^{205-220}\text{Rn}$, $^{205-227}\text{Fr}$, $^{212-228}\text{Ra}$
- Possibility to extend to other actinides (^{232}Th , $^{235,238}\text{U}$, ...) T. Stora priv. comm.
- Simple set-up to measure precisely as a function of excitation energy
 - element yields,
 - TKE,
 - fission probability,



- Study shell effects and pairing effects in fission of unstable actinides
- Inverse kinematics gives access to complete fission distributions

Conclusions

- HIE ISOLDE will offer an unmatched variety of beams at energies of 5.5A MeV (2014) and 10A MeV (2016)
- 34 LOIs have been submitted promising a rich Physics program. (I have noticed some overlap with SPES which will have to be coordinated)
- It will be efficient to share detectors between HIE-ISOLDE, SPES and SPIRAL2.
- These 3 facilities will pave the way towards EURISOL if the community coordinates its efforts.