EUROPEAN UNION

GOVERNMENT OF ROMANIA

Structural Instruments 2007-2013

Sectoral Operational Programme
„Increase of Economic Competitiveness”
“Investments for Your Future”

Extreme Light Infrastructure – Nuclear Physics (ELI-NP)

Project co-financed by the European Regional Development Fund

Nuclear Physics Studies at ELI-NP

Dimiter L. Balabanski

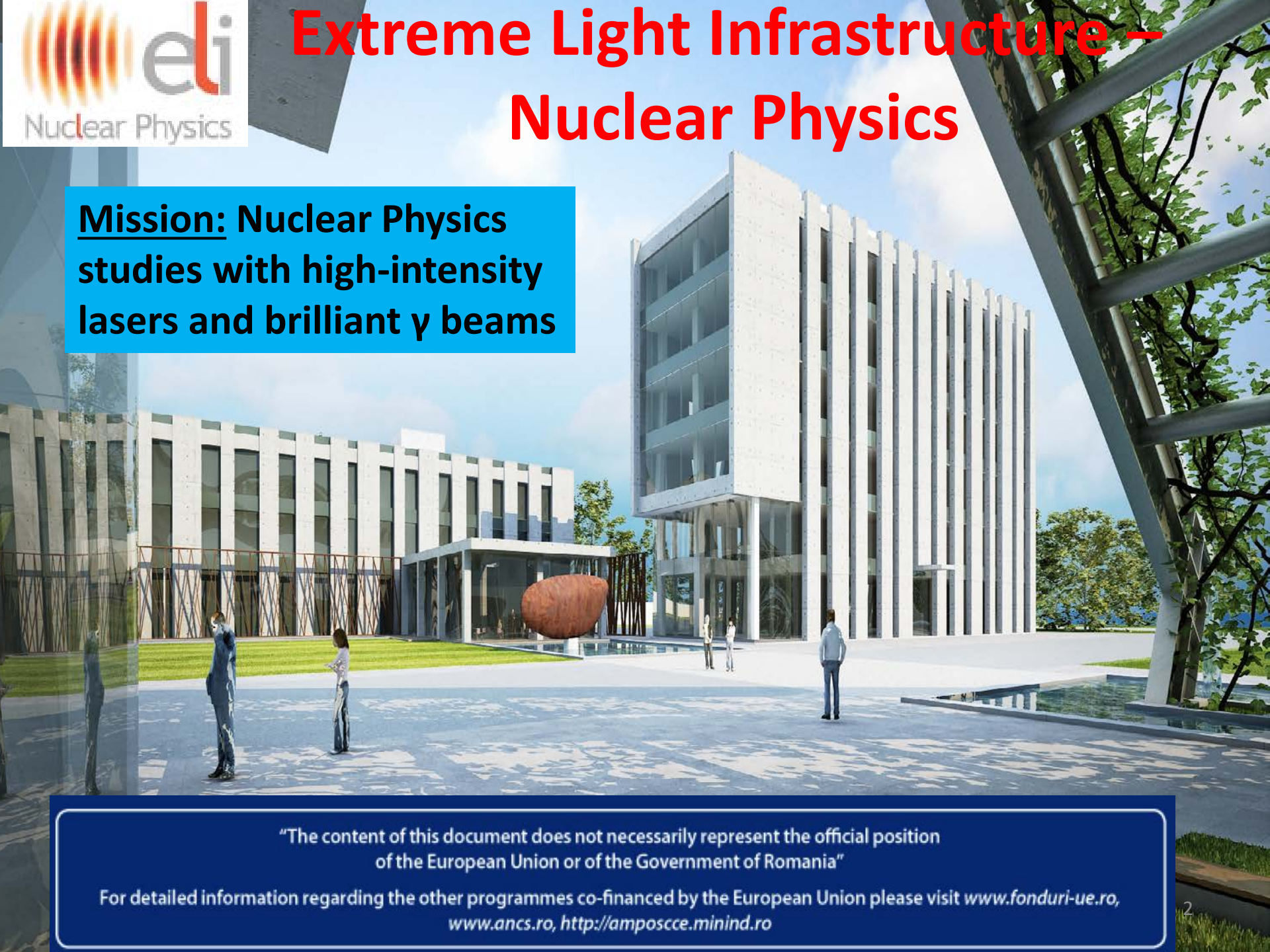
SDANCA15, Sofia
Oct. 08th-10th, 2015

Nuclear Physics

IFIN-HH

Extreme Light Infrastructure – Nuclear Physics

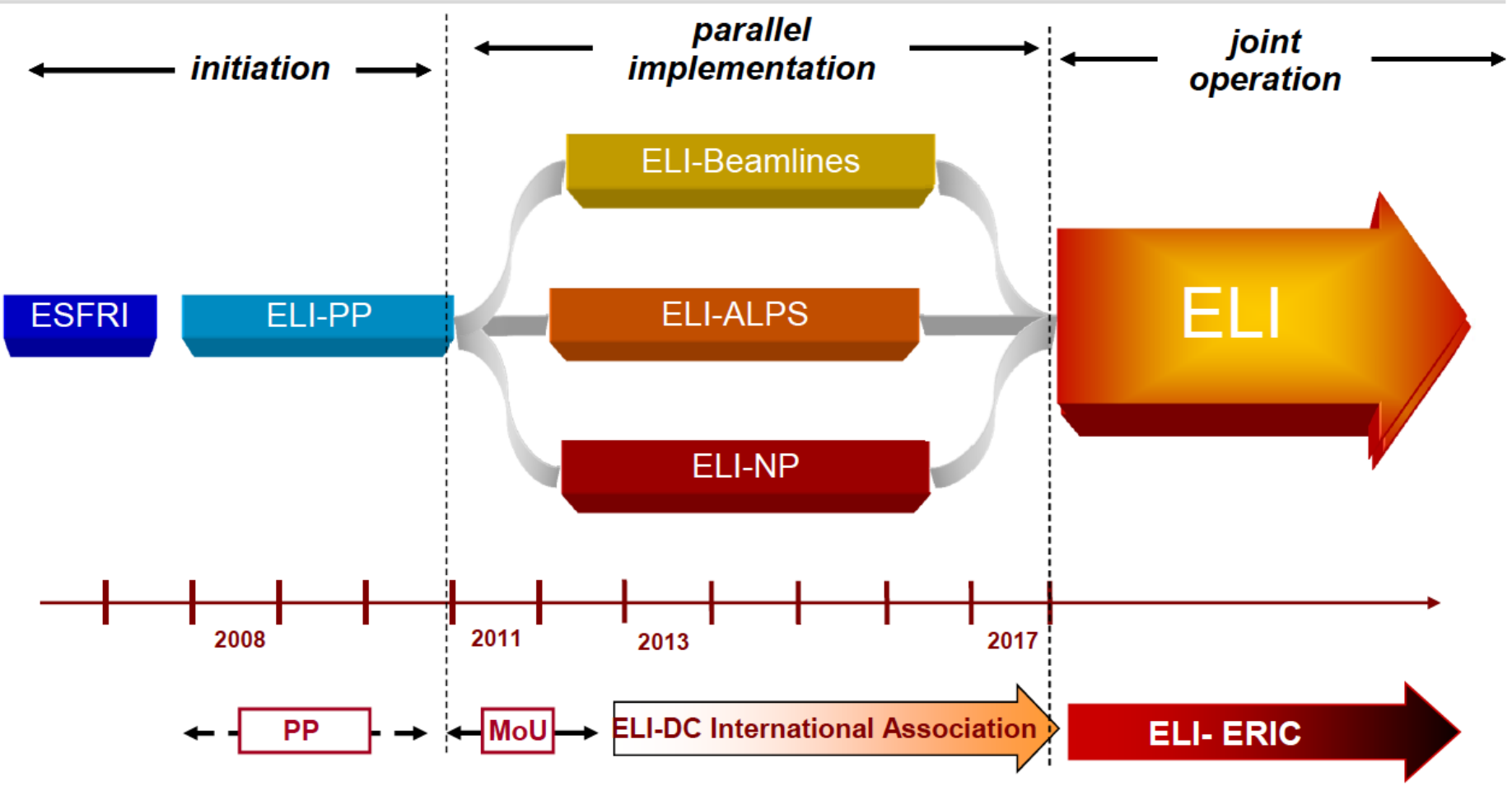
Mission: Nuclear Physics studies with high-intensity lasers and brilliant γ beams



"The content of this document does not necessarily represent the official position of the European Union or of the Government of Romania"

For detailed information regarding the other programmes co-financed by the European Union please visit *www.fonduri-ue.ro, www.ancs.ro, http://amposcce.minind.ro*

ELI Road Map

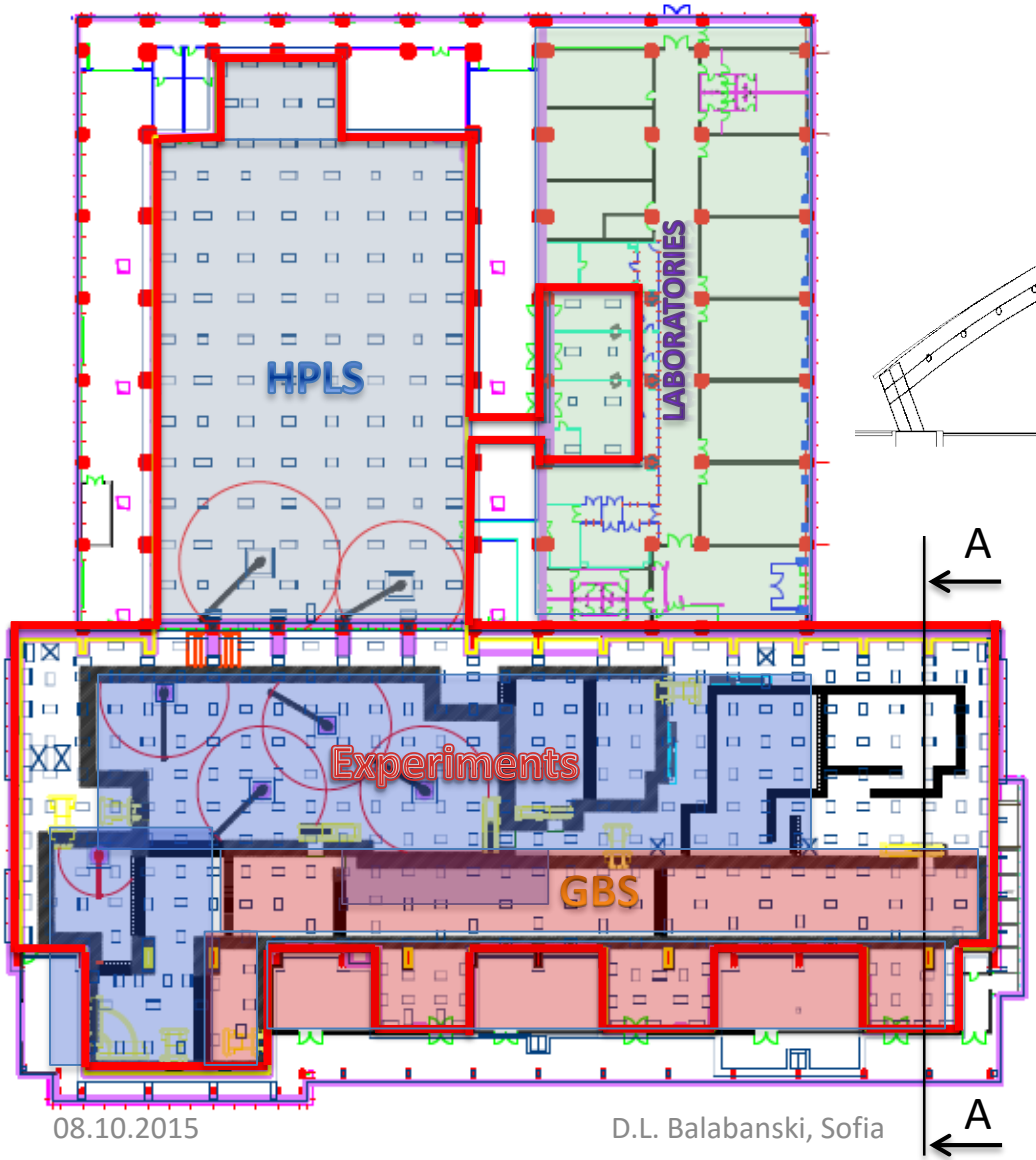


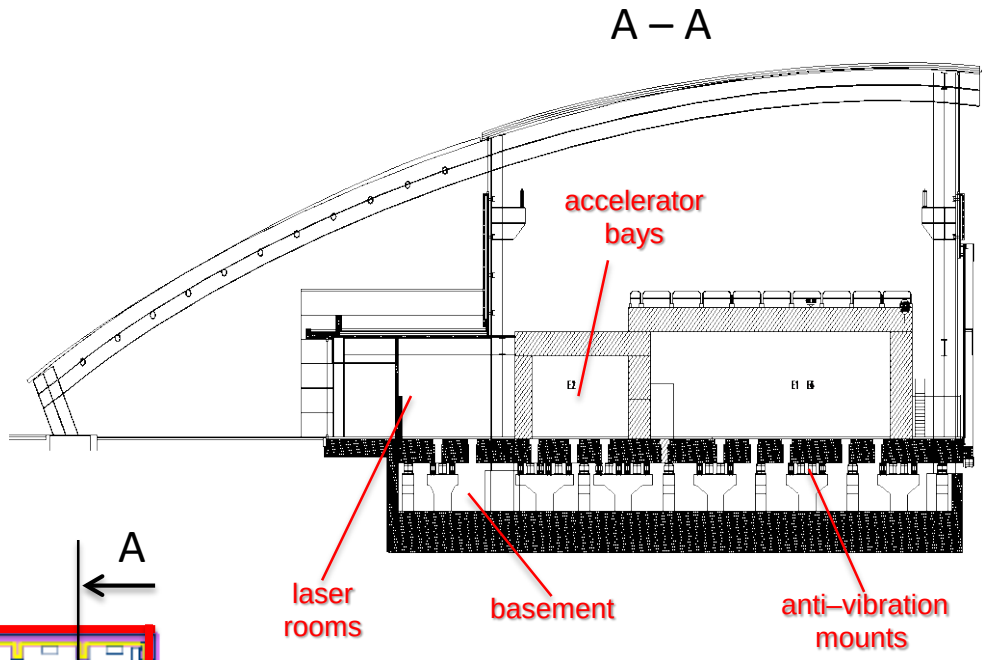
W. Sandner, ELI DC

June 7th, 2013

Buildings – one contractor, 33000 m^2 total

ELI–NP Building Structure





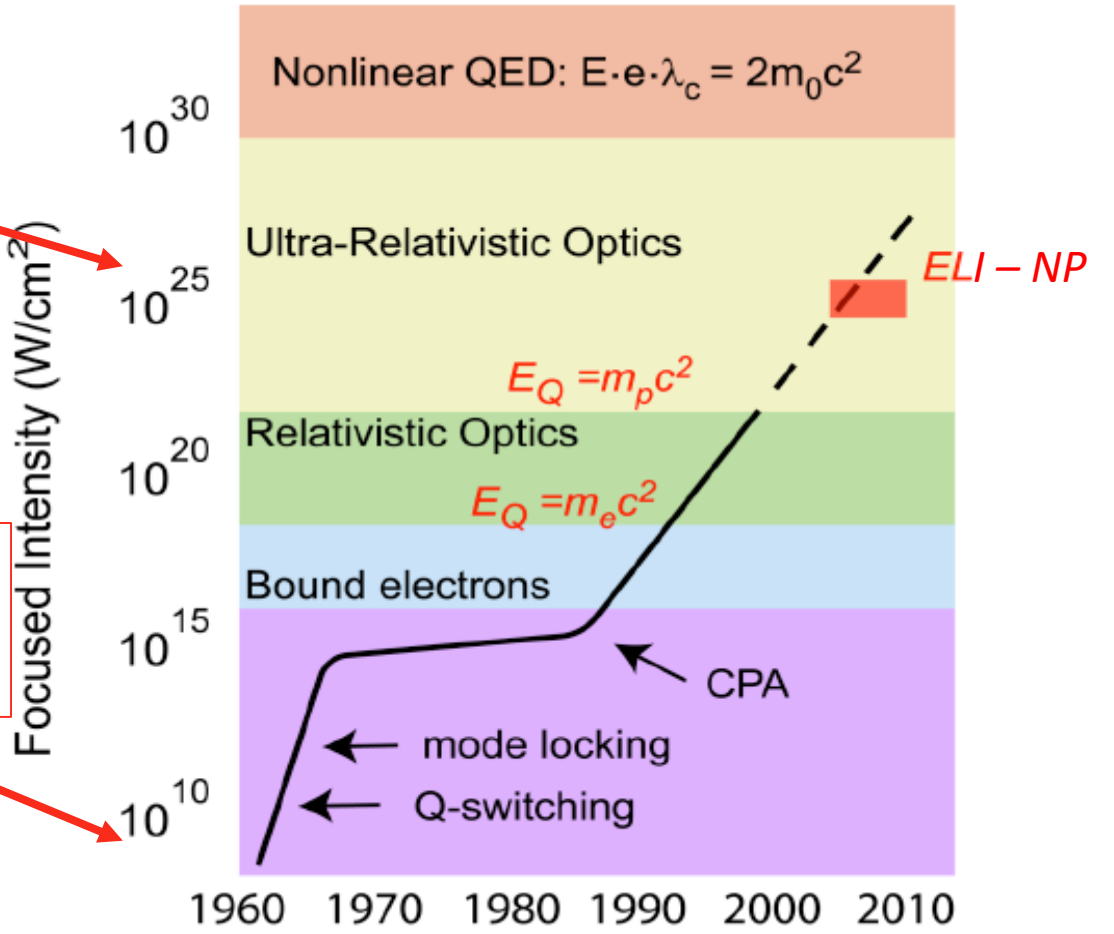
Platform supported on dampers

Extreme Light Infrastructure (ELI)

Gerard Mourou 1985: Chirped Pulse Amplification (CPA)

Strickland, Mourou, Opt. Commun. 56, 219 (1985)

10^{26} W ~ Sun's total power on 1 cm^2



10^{23} W/cm^2

10^9 W ~ power of an nuclear reactor on 1 cm^2

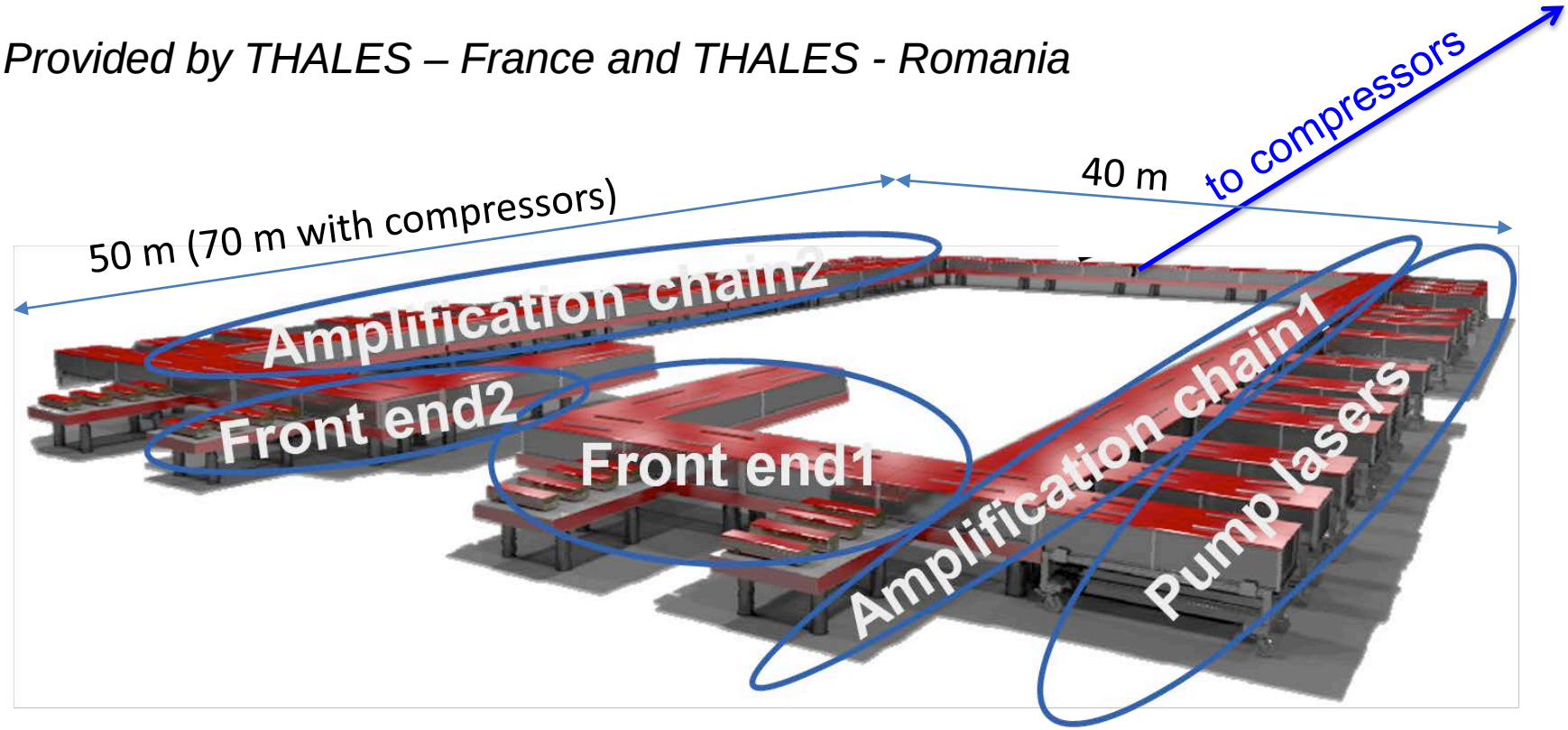
ELI–NP HPLS

2 HPLS up to 10 PW – 6 output lines

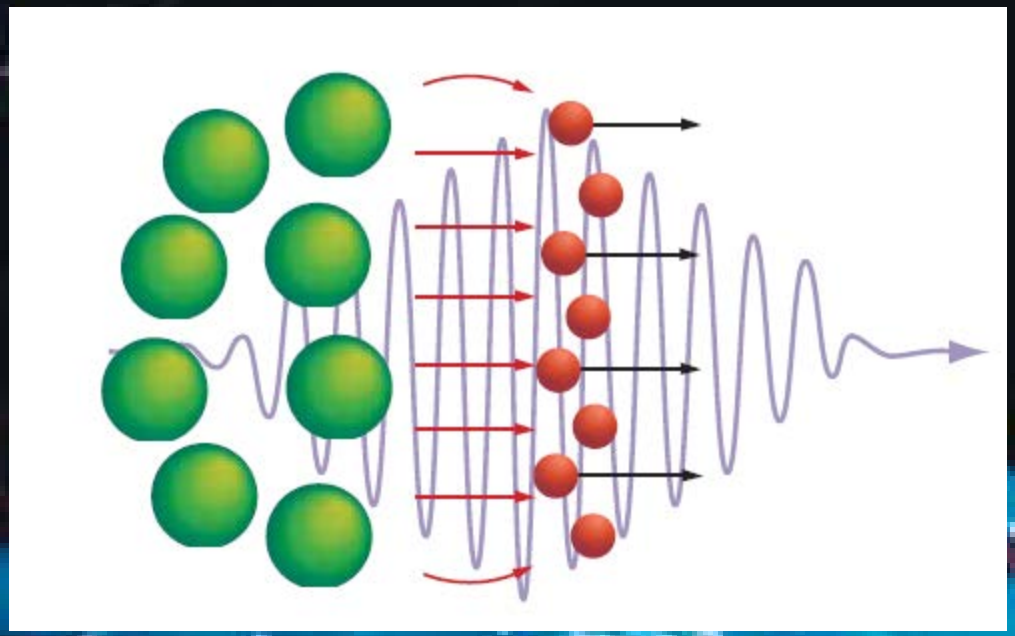
2 x 0.1 PW 10 Hz
2 x 1 PW 1 Hz
2 x 10 PW 0.1 Hz

at present the most powerful lasers are 1 PW,
e.g. CETAL at Magurele (commissioned in 2015)

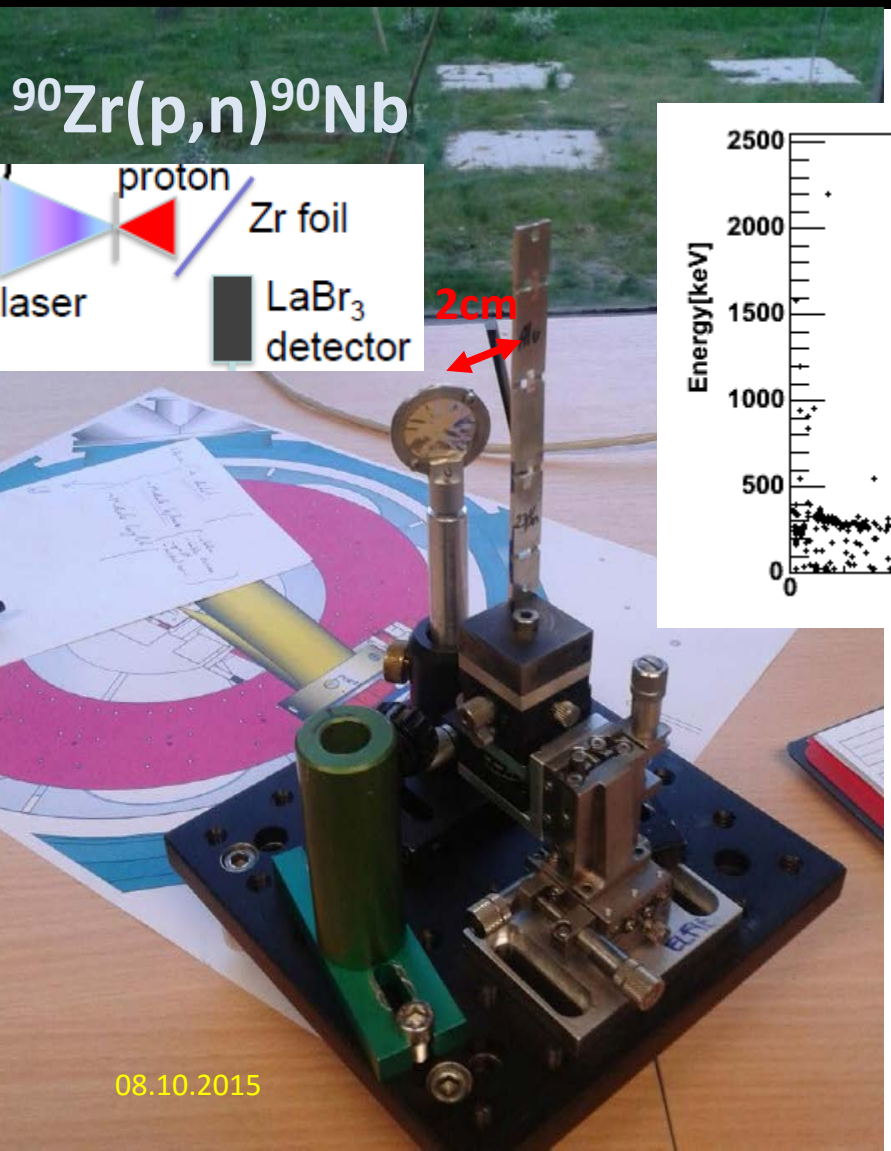
Provided by THALES – France and THALES - Romania



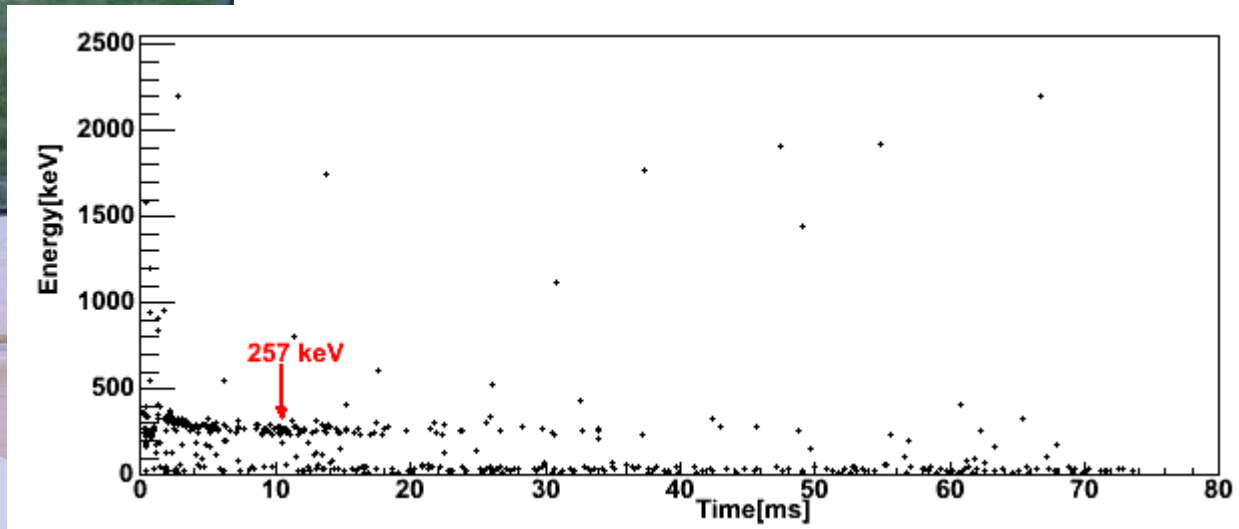
Electrons and ions accelerated at solid state densities 10^{24}e cm^{-3} **never reached before**

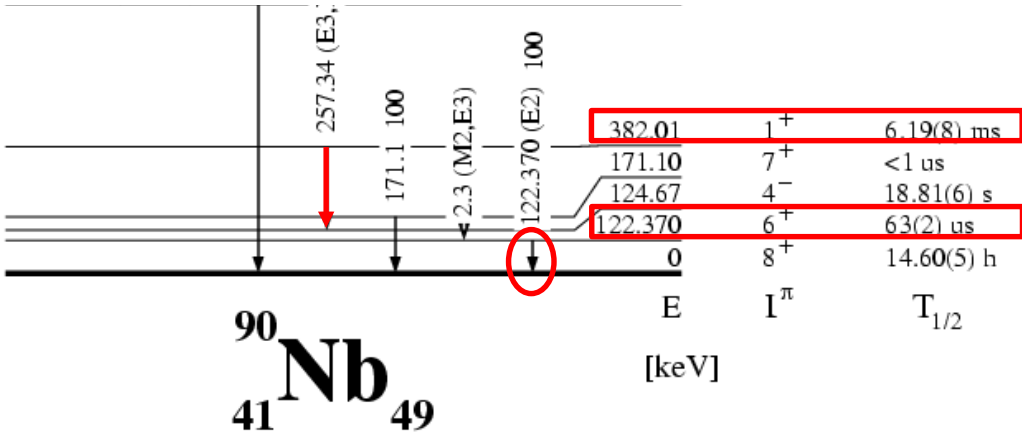


Nuclear isomer spectroscopy

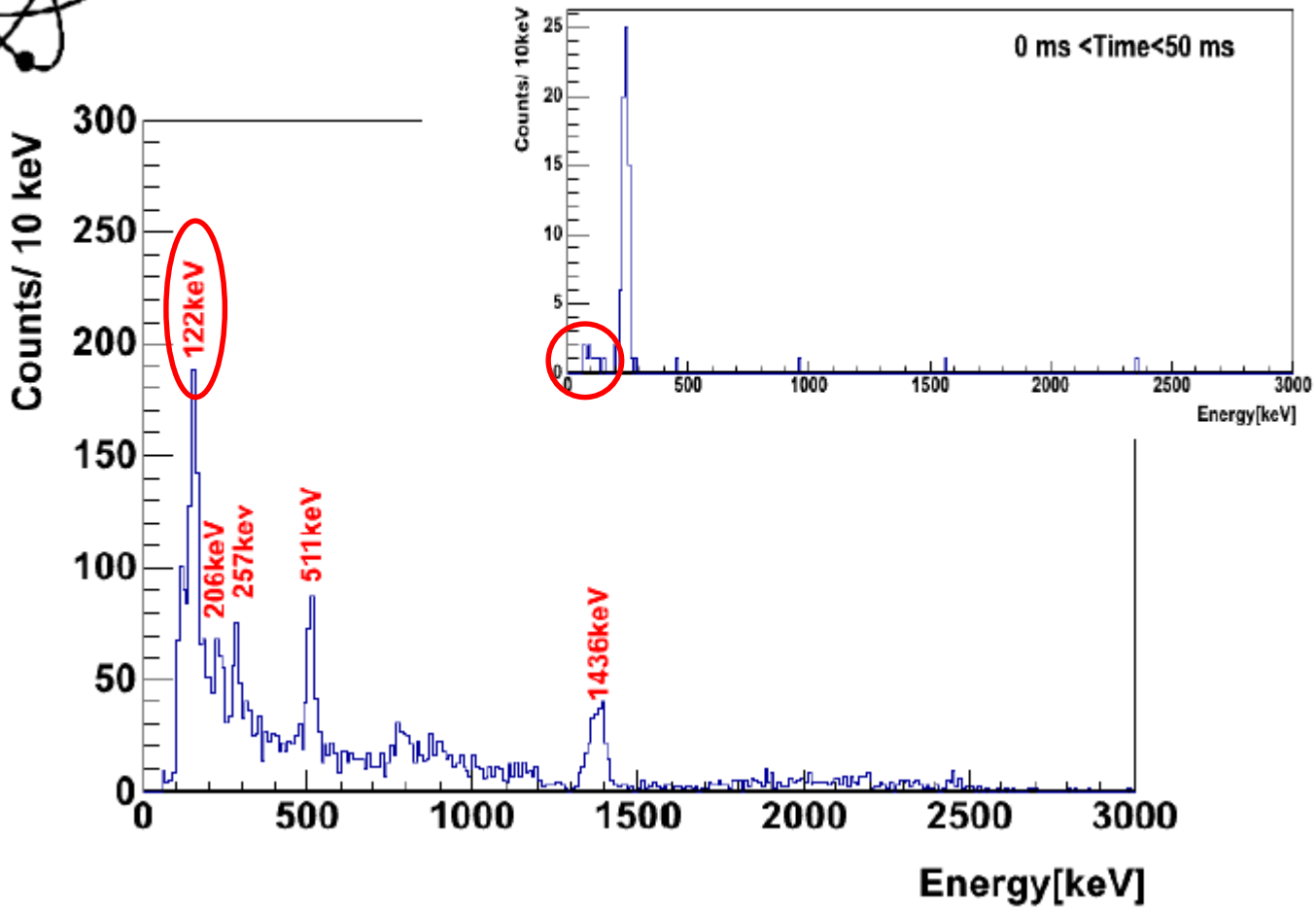


experiment of Florin Negoita @ LULI





γ-ray spectra



courtesy Florin Negoita

Nuclear Physics

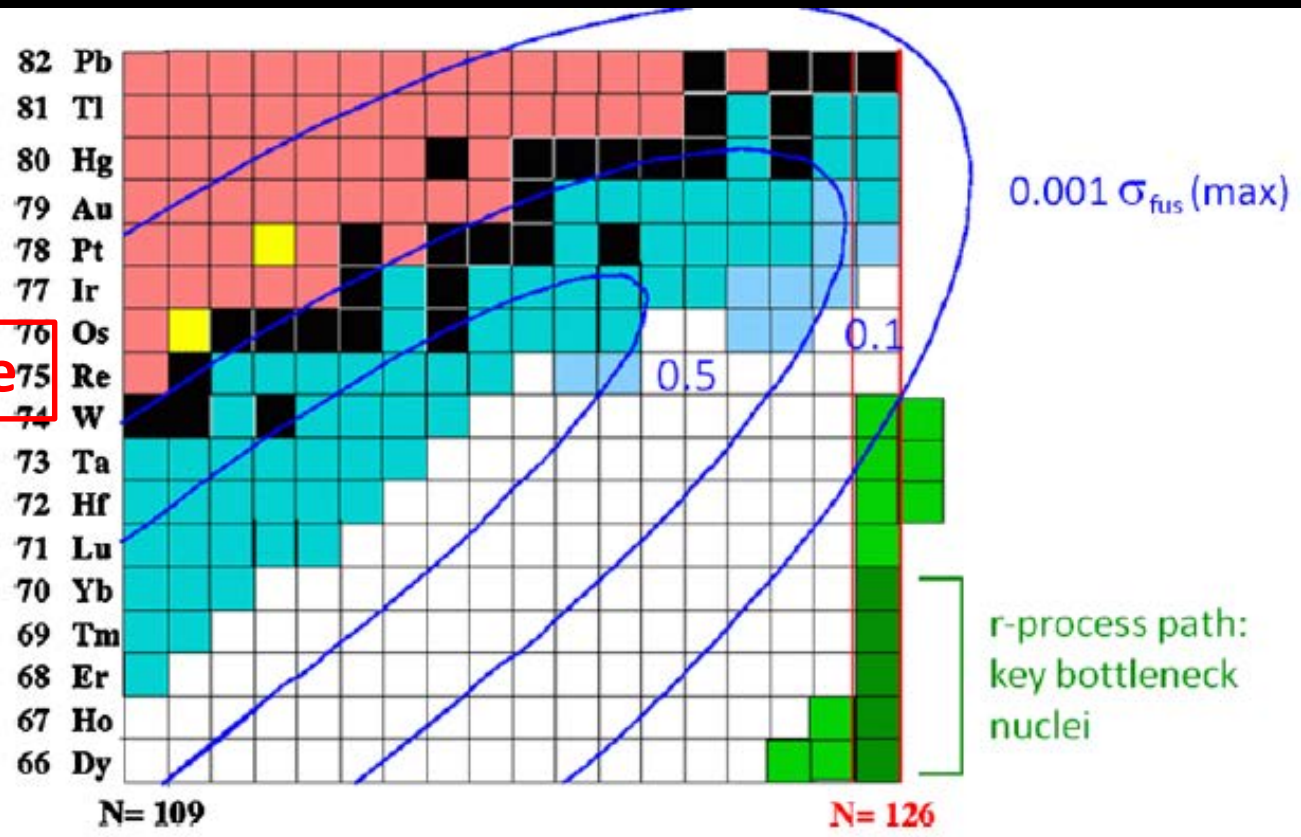
Las

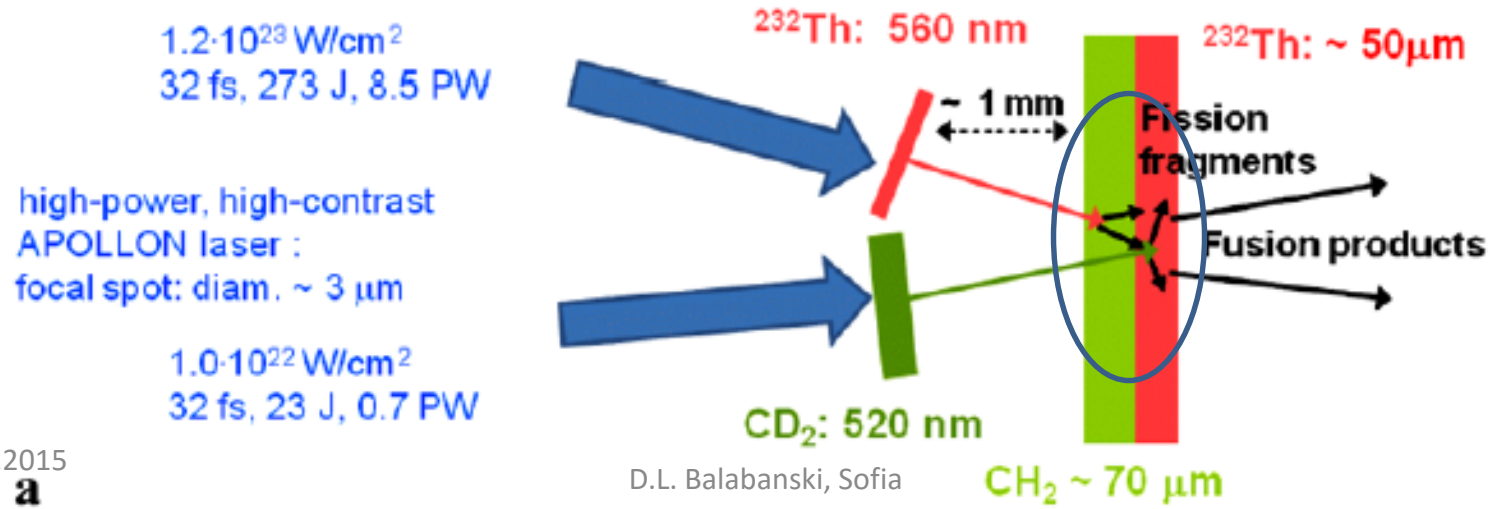
Appl Phys B (2011) 103: 471–484
DOI 10.1007/s00340-010-4261-x

$F_L + F_L \rightarrow \langle {}^{A}Z \rangle \approx {}^{192}Re$

Introducing the fis
a laser-accelerated
towards the $N = 1$

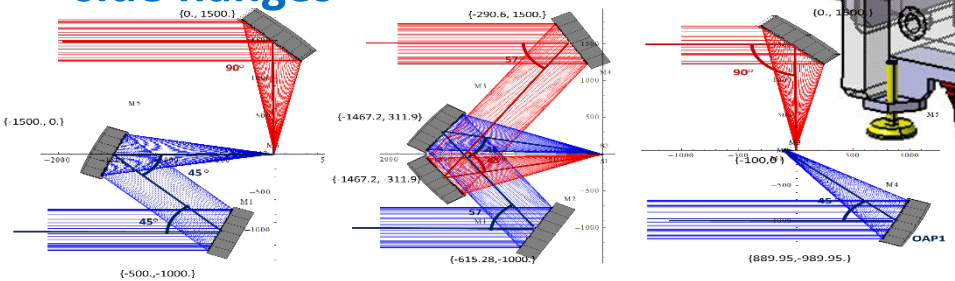
D. Habs · P.G. Thirolf · M. Gr
A. Henig · D. Kiefer · W. Ma ·

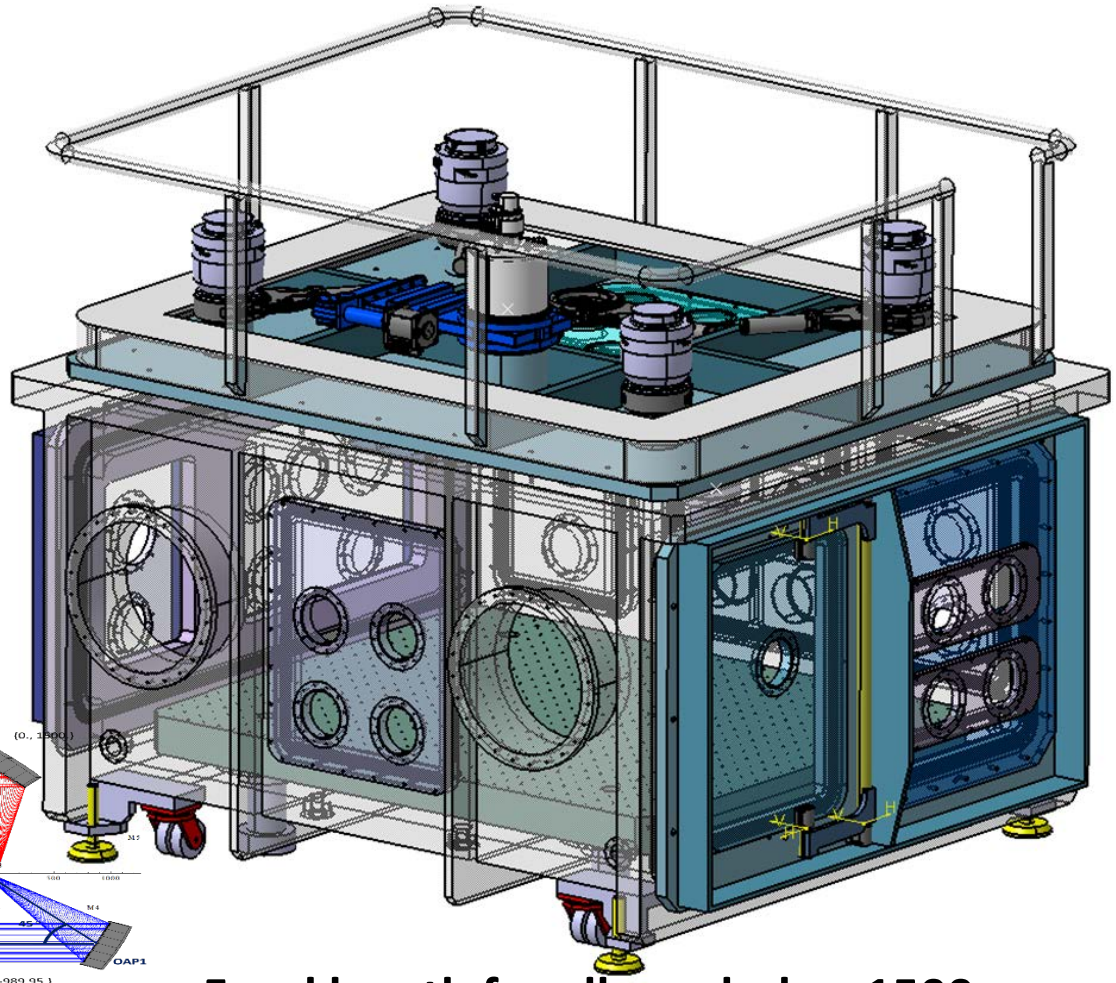




E1 Interaction Chamber (under construction)

- Shape: Rectangular
- Material: aluminium
- Volume: $3 \times 4 \times 2$ (=24) m^3
- Vacuum:
  10^{-6} mbar (empty chamber)
- Pump-down to
  $5x10^{-6}$ mbar: 45 min.
- Multiple flanges and ports
- Isolation of optical table
- Removable roof and
  side flanges



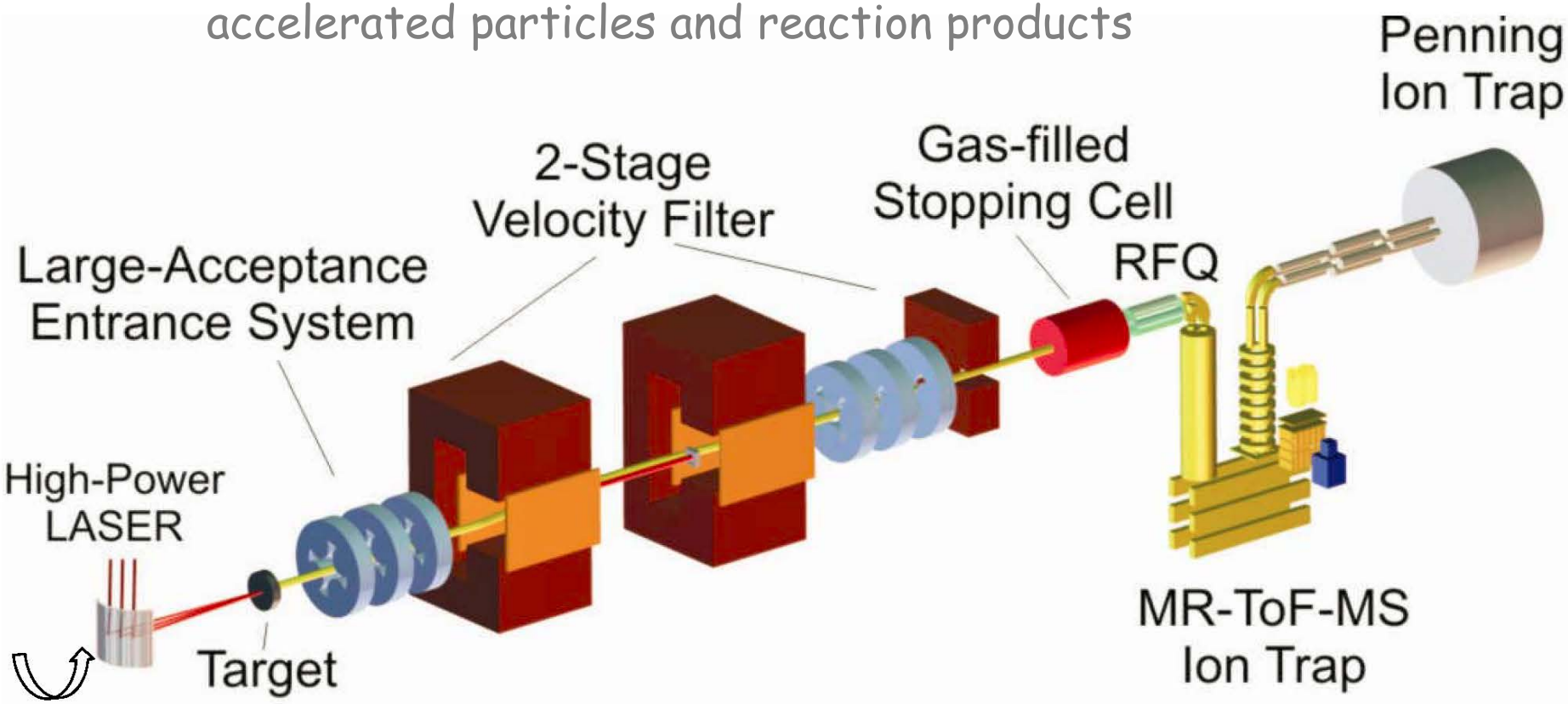


Focal length for all parabolas: 1500 mm

- Access on top for target exchange system
- Internal crane for heavy equipment (mirrors) manipulation
- Door for access inside through a cleanroom attached to the chamber
  (not shown)

In-flight separator for the ELI-NP laser-driven studies

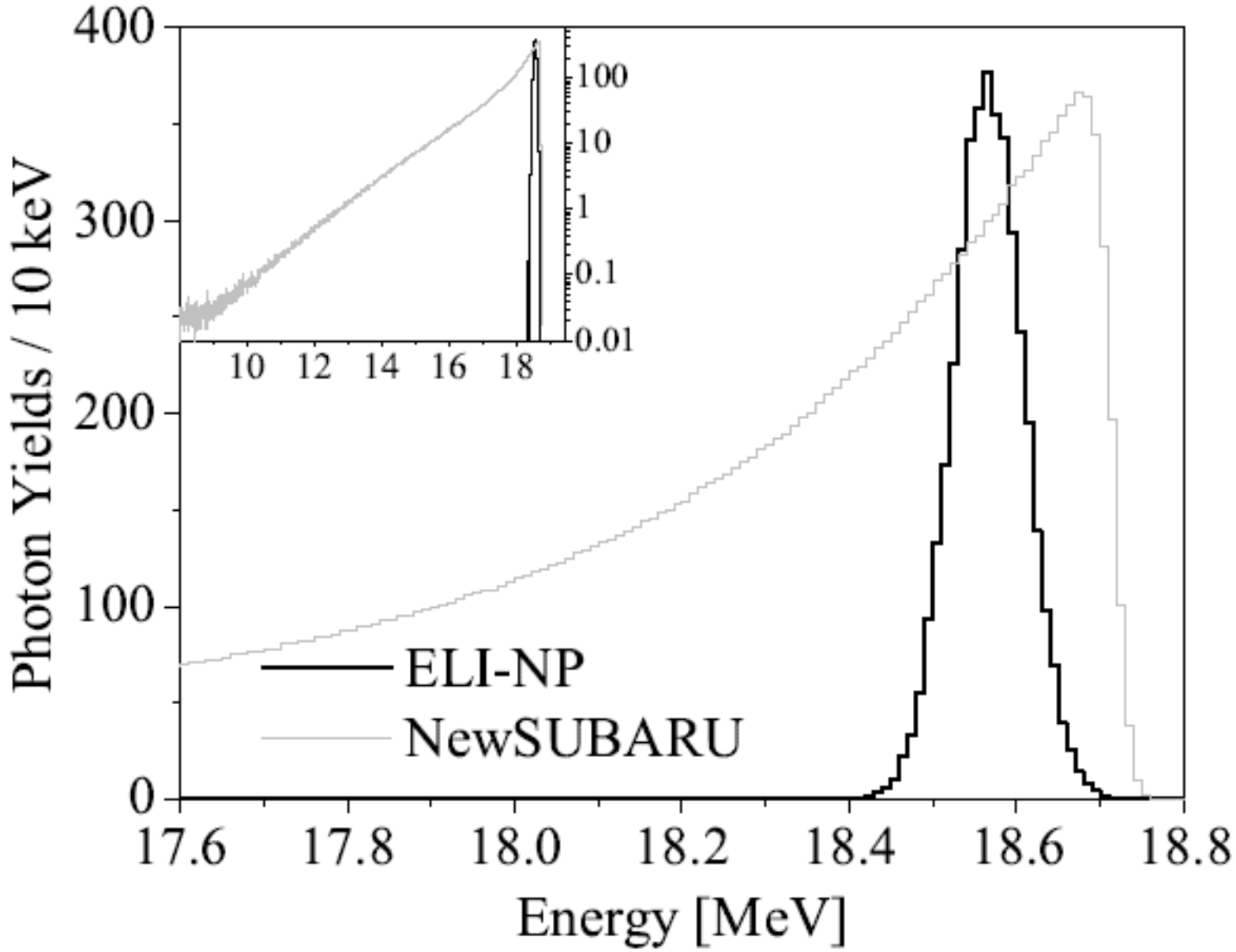
concept proposed by H. Geissel (GSI/U Giessen)
for separation of nuclei of interest from all other
accelerated particles and reaction products



Measuring basic properties of N~126 nuclei: **masses**
lifetimes
decay modes

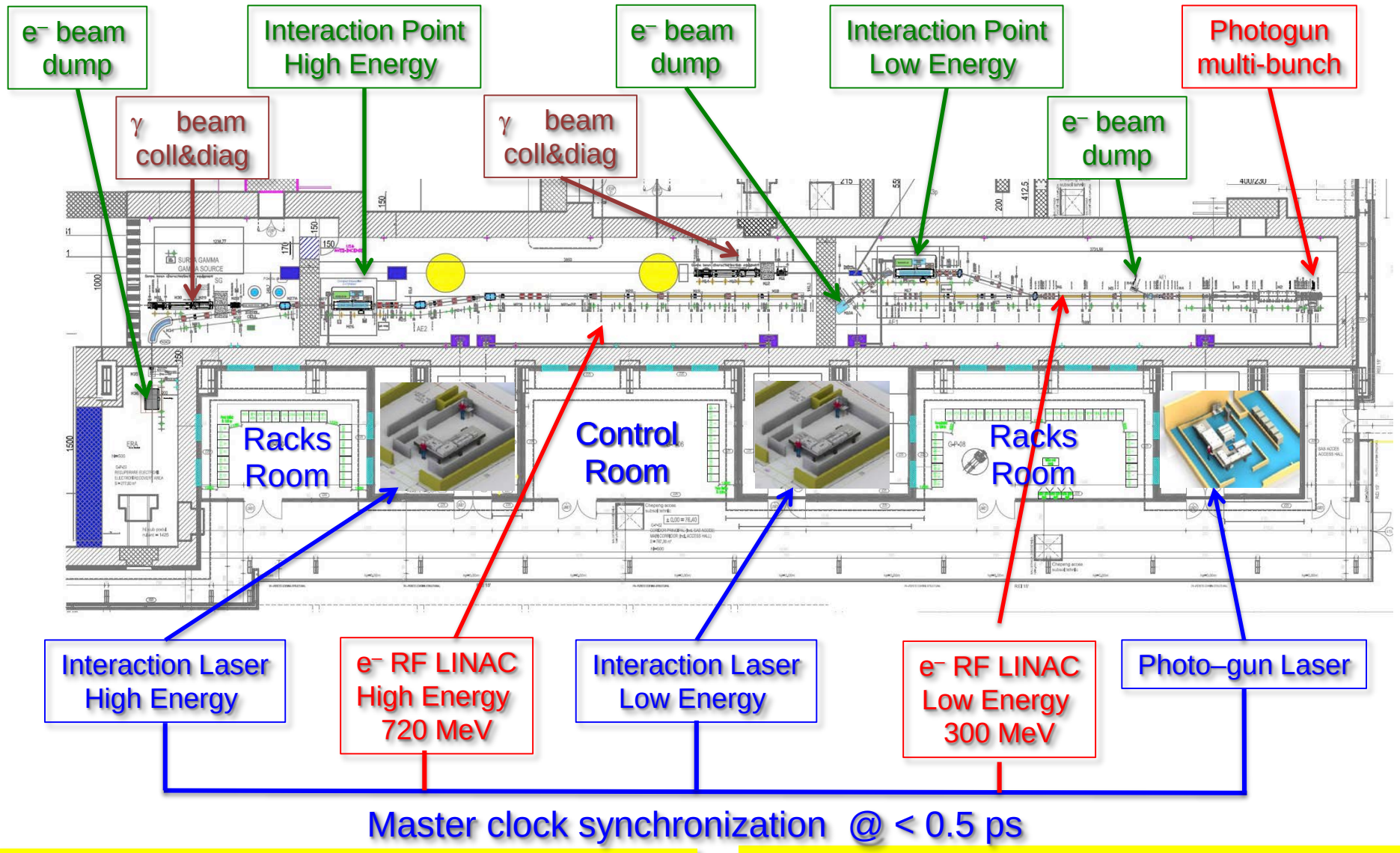
ELI-NP Gamma Beam System (GBS)

$$E_\gamma = 2\gamma_e^2 \cdot \frac{E_e}{1+}$$



Narrow

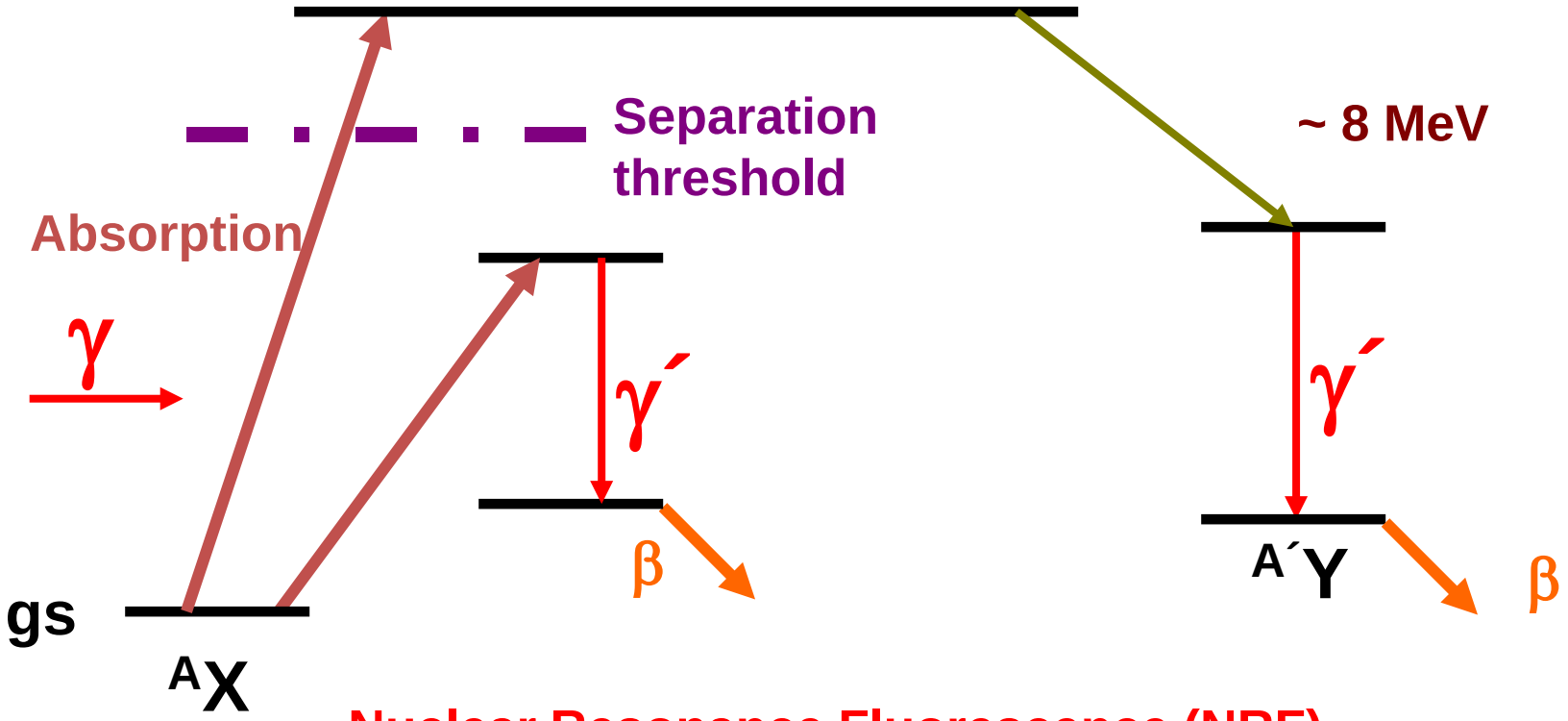
Gamma Beam System – Layout



The Electron LINAC

Factory Acceptance Tests – C–Band structure + Modulator

Photonuclear Reactions



Nuclear Resonance Fluorescence (NRF)

Photoactivation

Photodesintegration (-activation)

Photofission

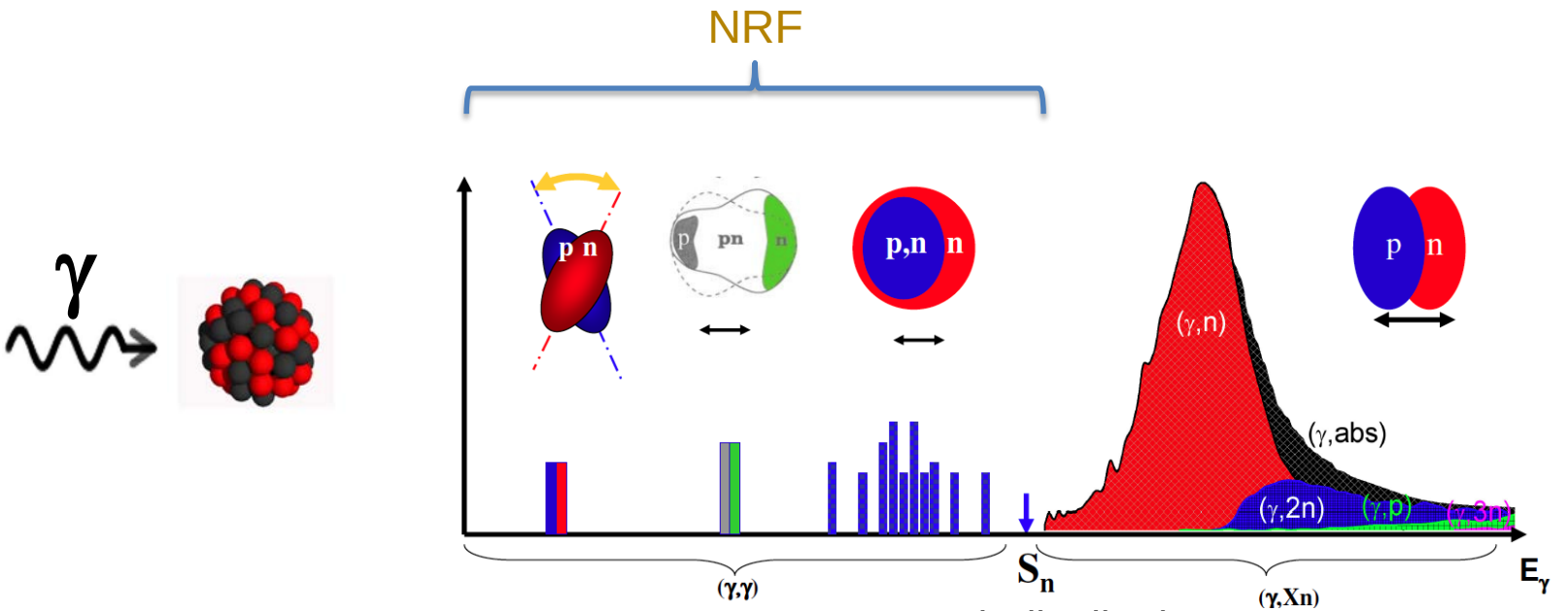
Nuclear Photonics

Electromagnetic dipole response of nuclei

Nuclear structure
- Modes of excitation below the GDR

Impact on nucleosynthesis
- Gamow window for photo–induced reactions in explosive stellar events

Understanding exotic nuclei
- E1 strength will be shifted to lower energies in neutron rich system

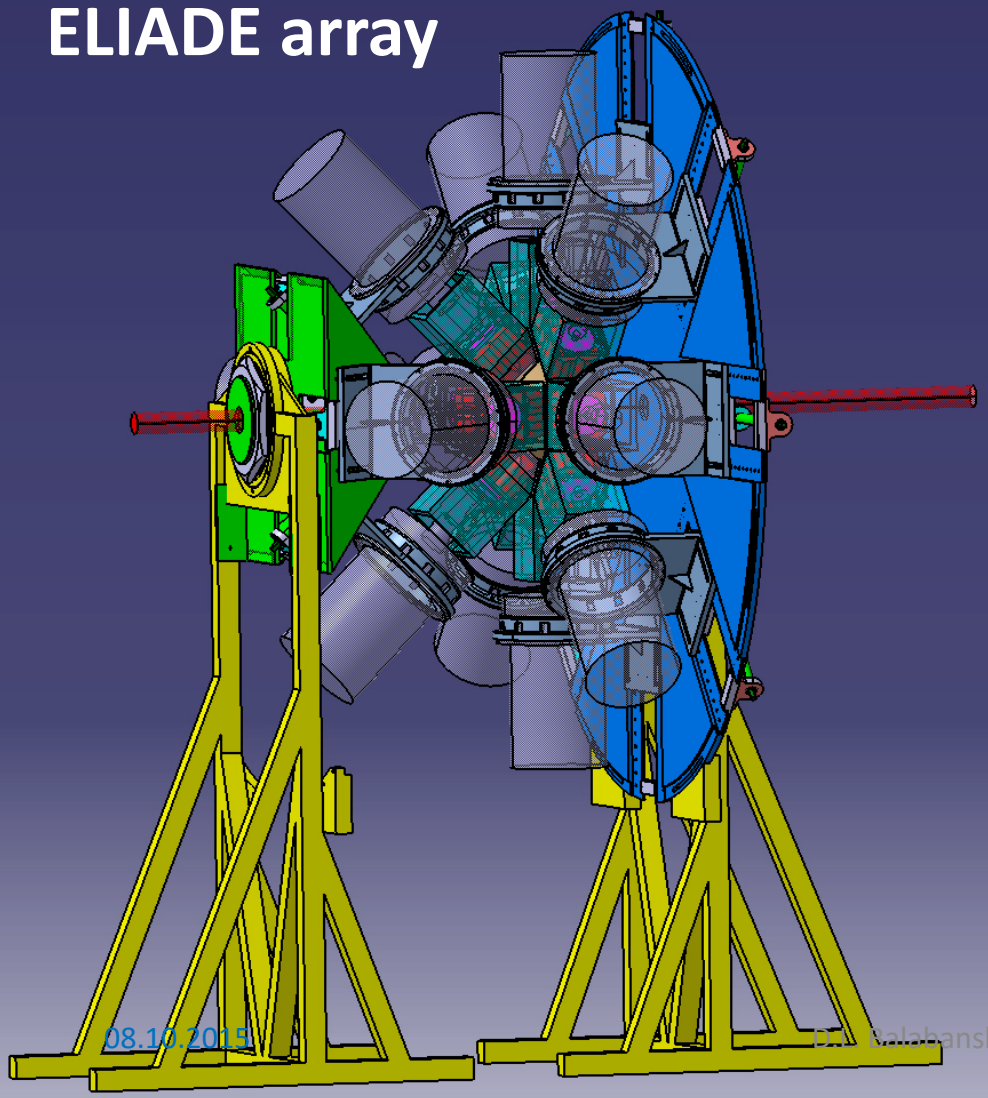


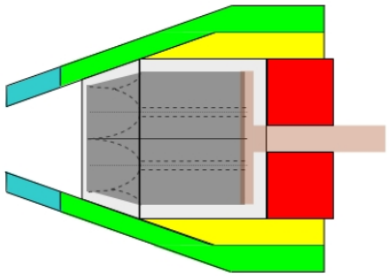
E1 strength distribution

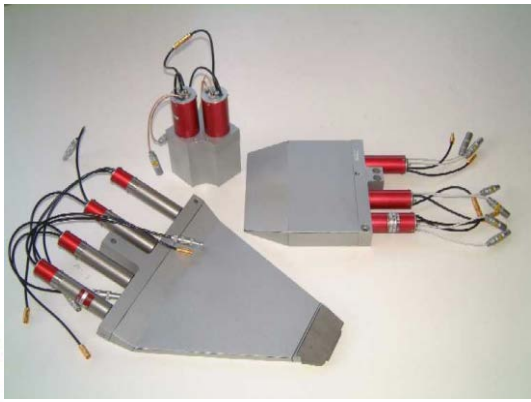
γ-ray spectroscopy

delivery of 4 Tigress-type Clovers and electronics is underway

ELIADE array



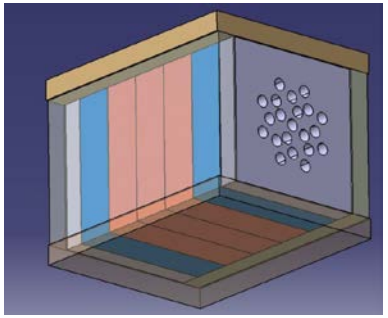




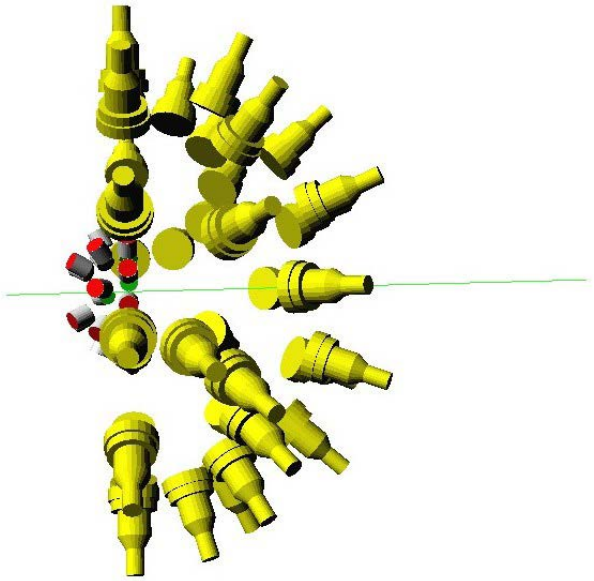
Calin A. Ur

Physics above the neutron threshold

30 ^{3}He, 15 $LaBr_3$, 15 $CeBr_3$, 20 NE213 detectors and electronics



- Studies of GDR and PDR decay
- Studies of spin-flip M1 resonances
- (γ, n) cross section measurements, *e.g.* p process related measurements:
  - the $^{138}La(\gamma,n)\,^{137}La$ reaction,
  - the $^{180m}Ta(\gamma,n)^{179}Ta$ reaction.



Instrumentation:

(i) $LaBr_3$(Ce) array,

(ii) Fast-neutron detector array

(iii) NE213 liquid scintillator array

Nuclear Astrophysics

tender for 20 DSSD Si detectors is open

- Molecular states and symmetries in light nuclei
- The $^{16}O(\gamma,\alpha)^{12}C$ reaction
- The $^{24}Mg(\gamma,\alpha)^{20}Ne$ reaction
- The $^{22}Ne(\gamma,\alpha)^{18}O$ reaction
- The $^{19}F(\gamma,p)^{18}O$ reaction
- The $^{21}Ne(\gamma,\alpha)^{17}O$ reaction

$$\omega_A \frac{\sigma_A(X,\gamma)}{\lambda_\alpha^2} = \omega_B \frac{\sigma_B(\gamma,X)}{\lambda_\beta^2}$$

Day One experiment:

The ^{7}Li cosmological problem

ELI-NP will be the ideal cite to study the

$^{7}Li(\gamma, \alpha)^{3}H$ reaction

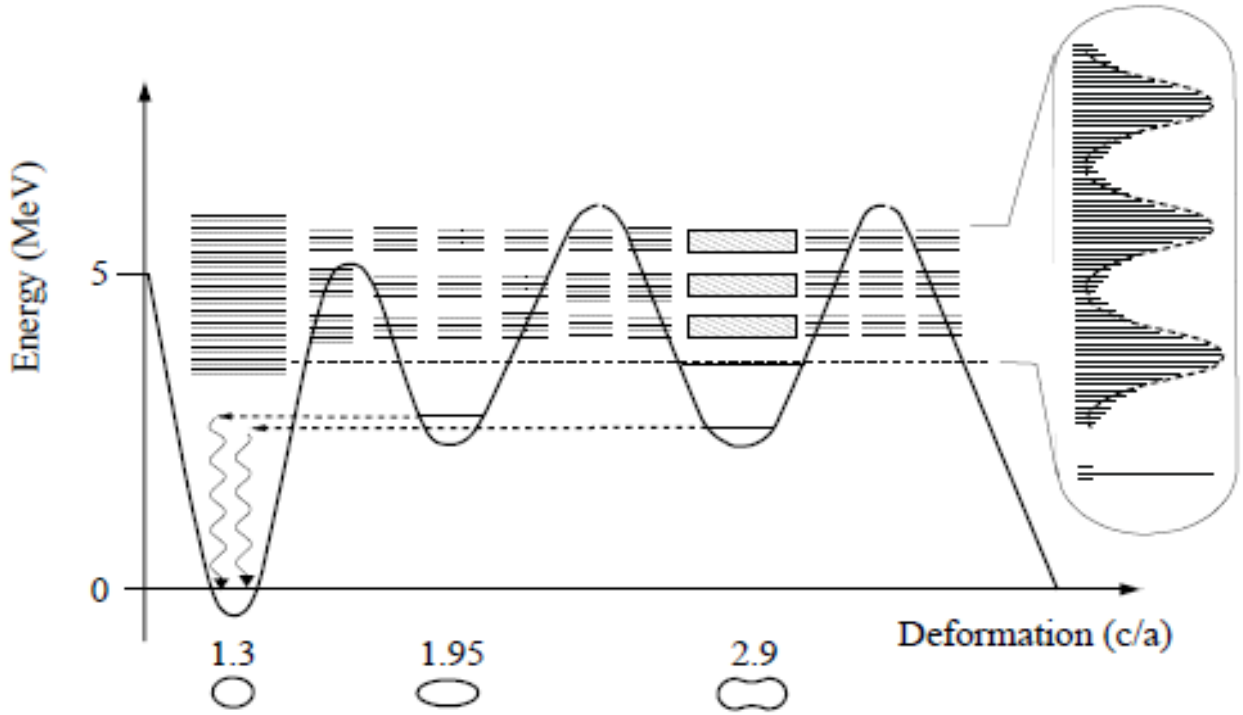
Nuclear Physics

Photofission

tenders for 5 BICs, 8 Si DSSD, THGEM array, electronics and support infrastructure are open or in preparation

1. Studies in the 2nd and 3rd minimum of the fission barrier: transmission resonances
2. Rare fission modes: ternary fission
3. Structure of neutron-rich nuclei: the rare-earth neutron-rich deformed region

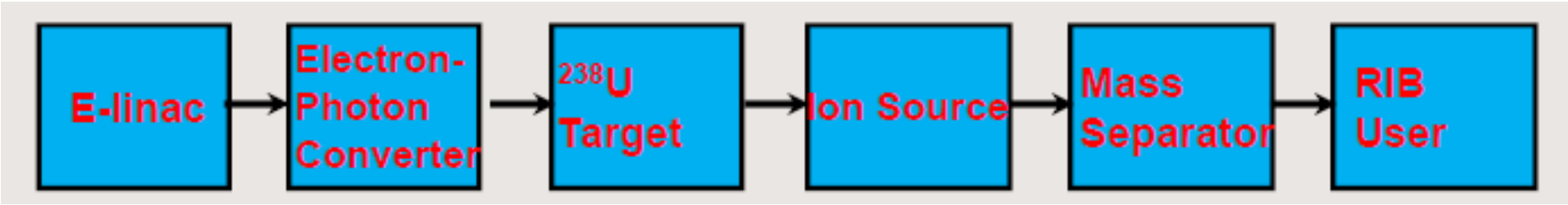
Studies of the 2nd and 3rd minimum



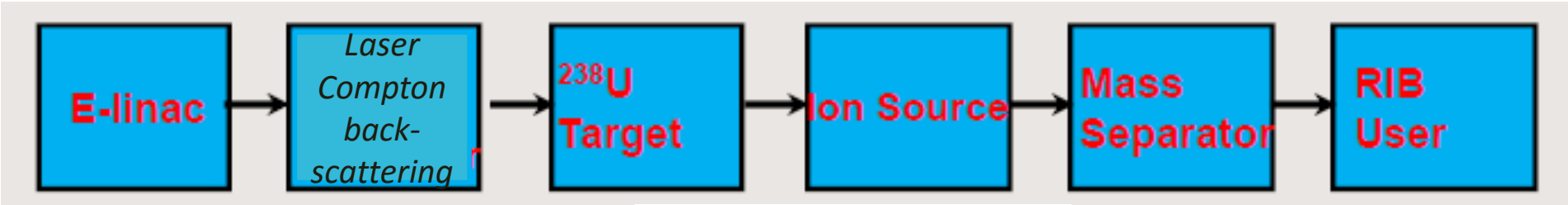
schematical description of the occurrence of transmission resonances

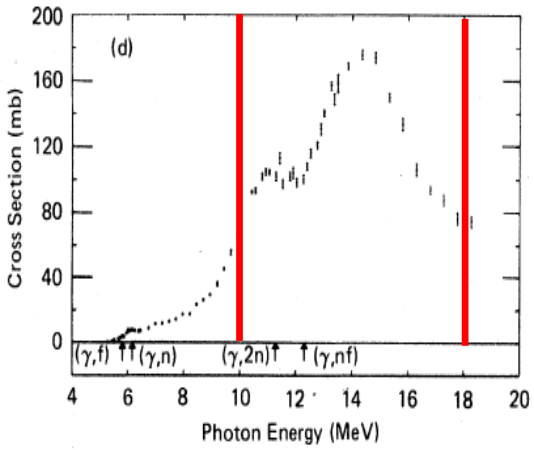
P.G. Thirolf et al., EPJ Web of Conferences 38, 08001 (2012)

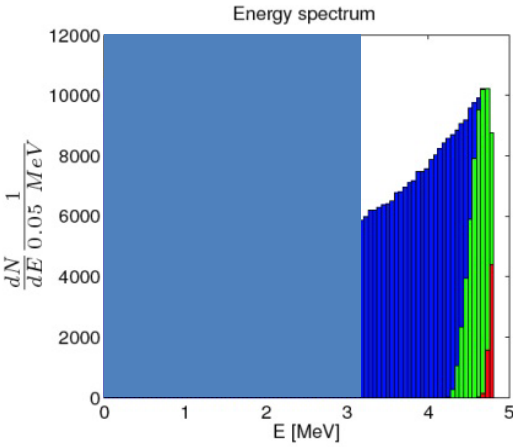
ALTO, ARIEL, etc.



ELI-NP



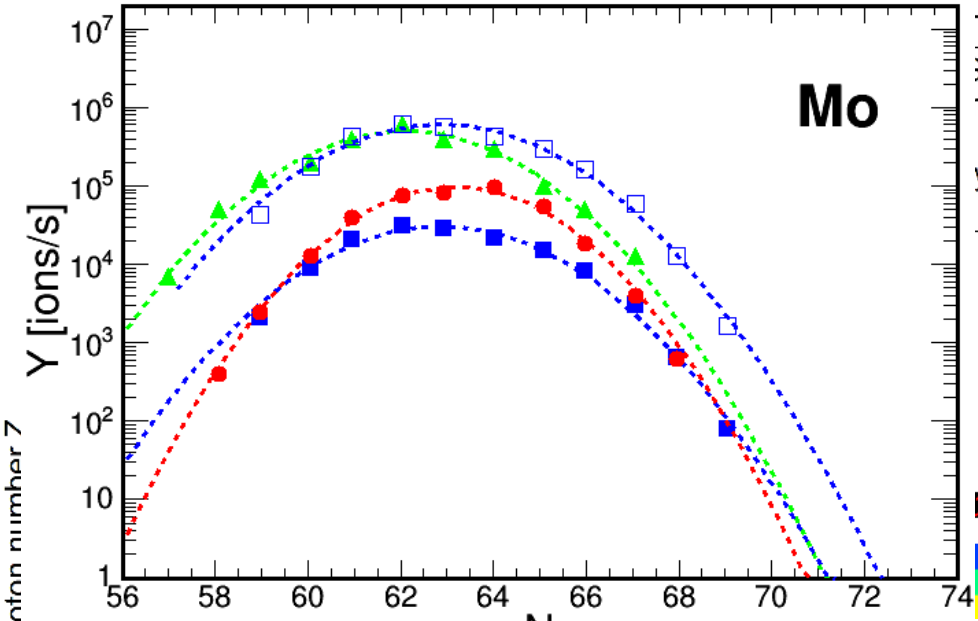


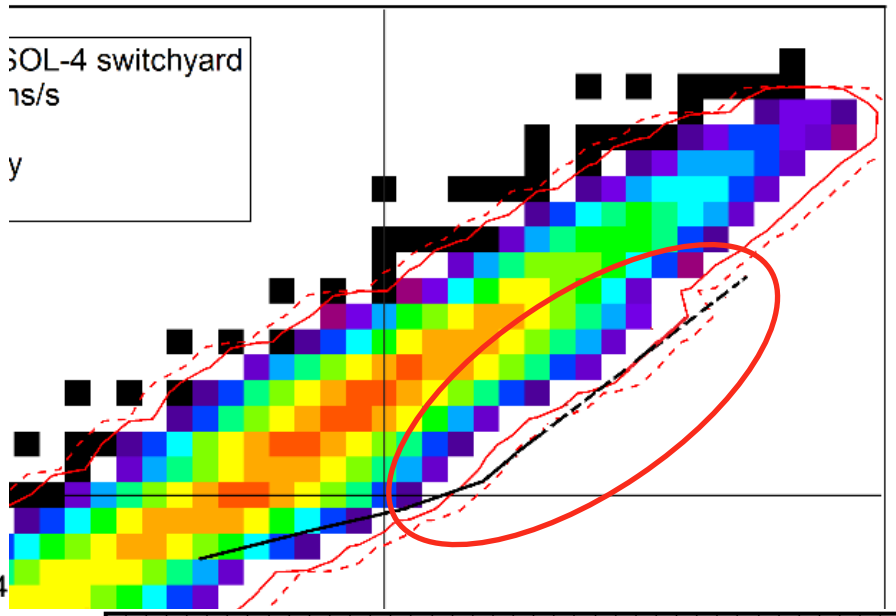


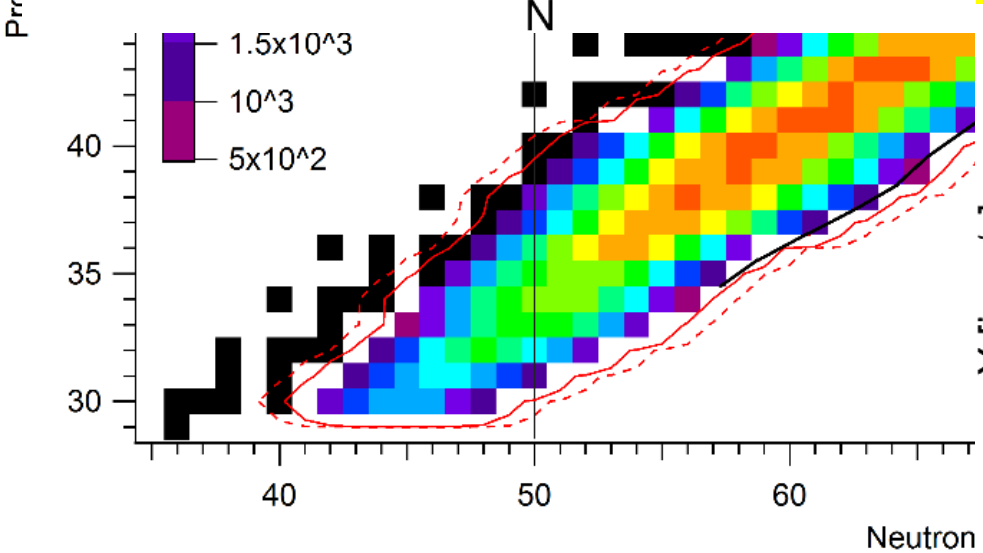
γ–beam spectrum at the IP (without collimator)

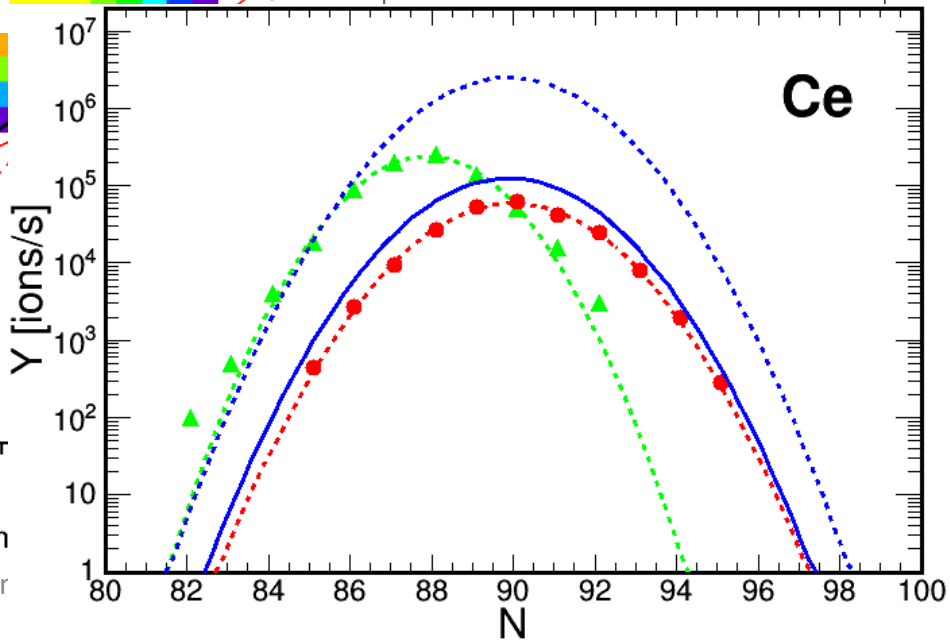
~ 10^{11} γ/s

Fragment Yields at the IGISOL-4 facility at JYFL





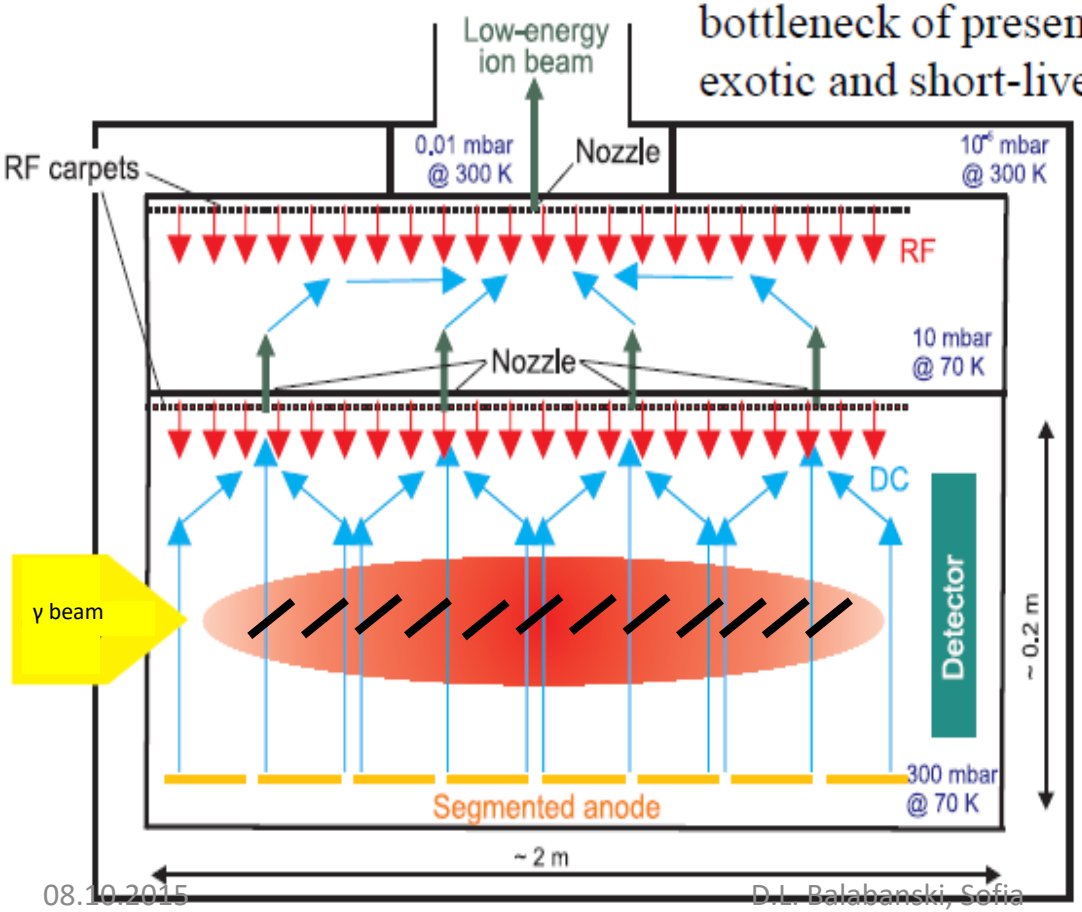




ELI-NP Cryogenic Stopping Cell

50% efficiency,
5 ms extraction time
at a rate of ~ 10^7 ions/s

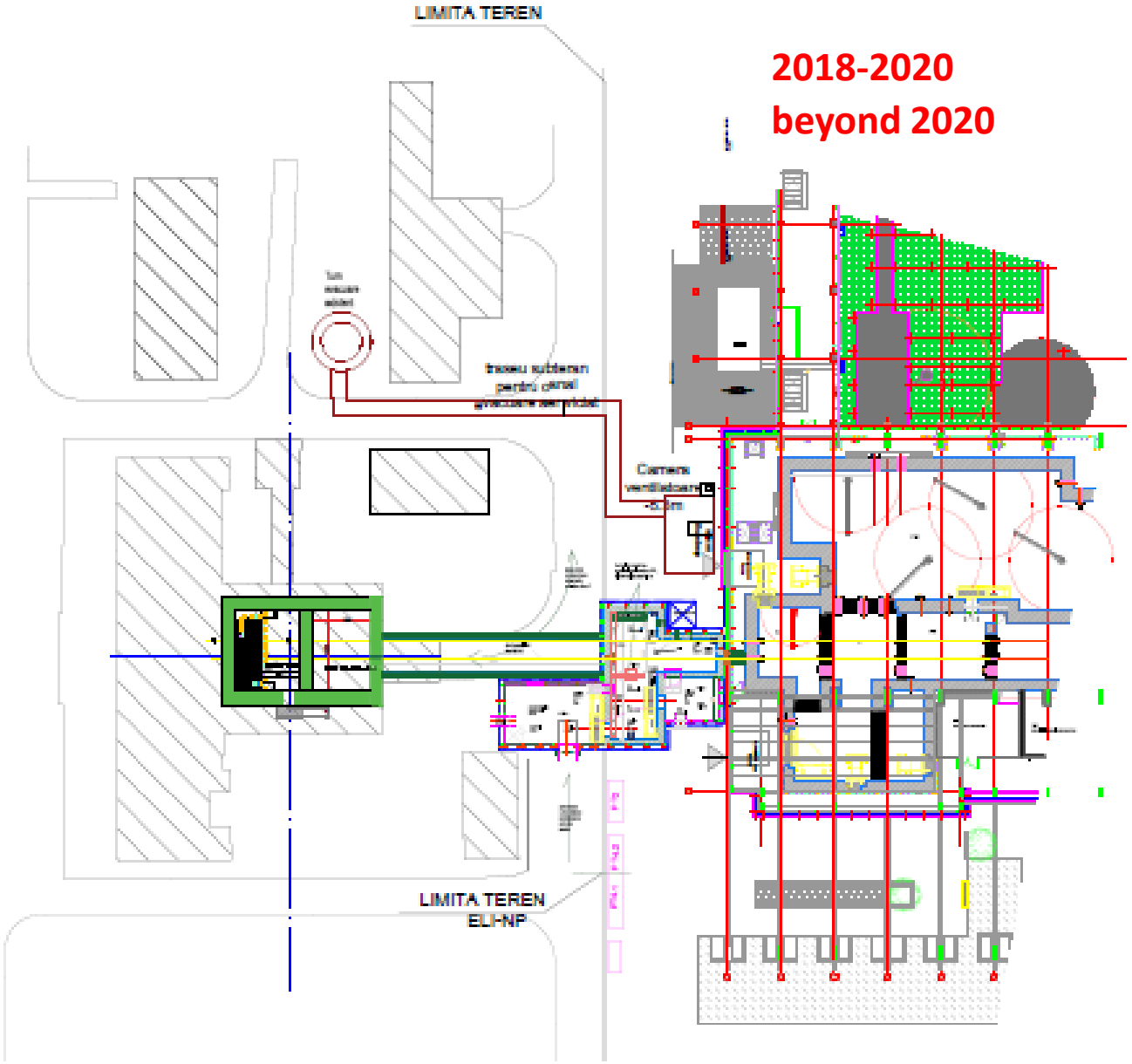
nuclei. Ion survival and extraction effciencies of better than 50% are expected. The extraction time of the ions will be about 5 ms, shorted by a factor of 5 compared to the present CSC. The novel CSC will thus remove the performance bottleneck of present stopping cells and give access to very exotic and short-lived nuclei available at the Super-FRS.



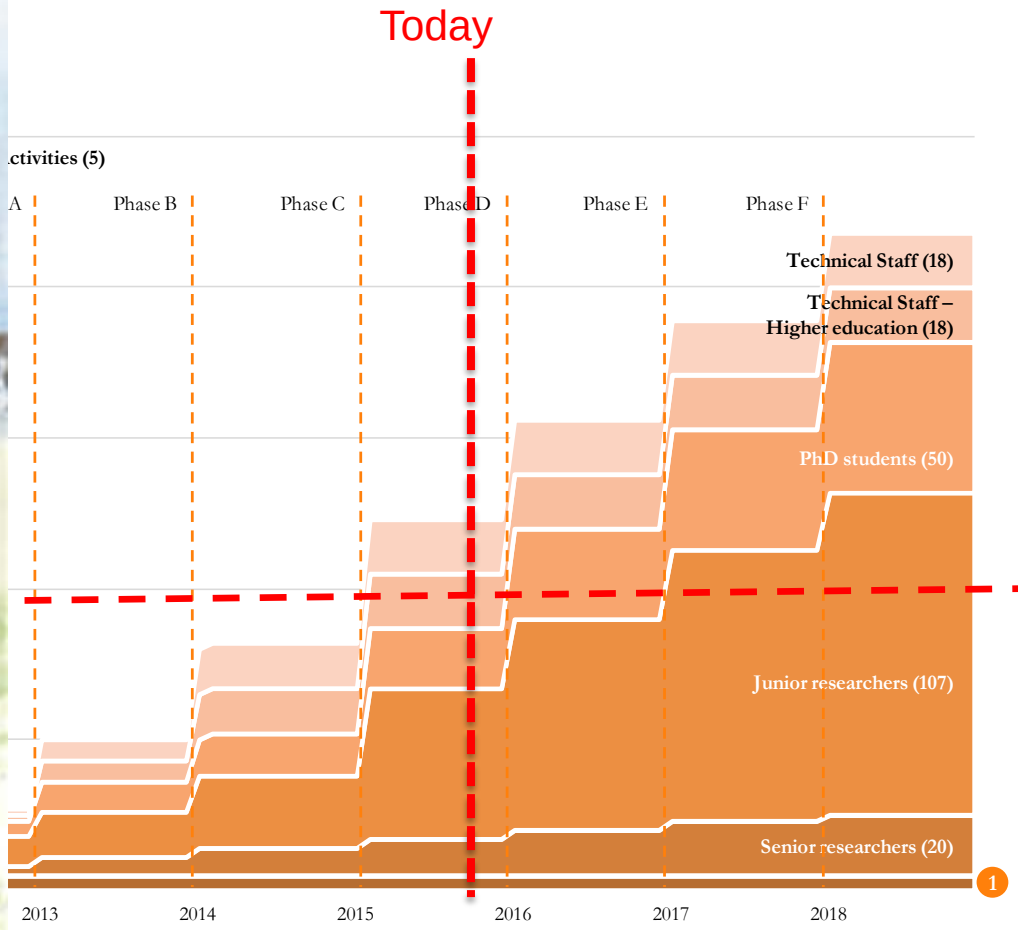
technical design
at GSI, Darmstadt

He gas @ 70 K
pressure 300 mb and 10 mb
> 100 V/sm DC field
RF carpet

Next phases of ELI-NP



Resources



http://www.eli-np.ro/jobs.php

Summary

- The laser-driven and gamma-beam science program at ELI-NP address key problems of present-day research.
- ELI-NP provides beyond-state-of-the-art gamma beams in terms of intensity, monochromaticity and polarizability, as well as intense laser pulses at much higher frequencies compared to existing facilities, which define experiments that cannot be done anywhere else.
- The facility will push ahead laser-driven research and photonuclear physics and their applications.

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"Investments for Your Future!"

IFIN-HH

Extreme Light Infrastructure - Nuclear Physics (ELI-NP) - Phase I

eli Nuclear Physics

www.eli-np.ro

Project co-financed by the European Regional Development Fund

Thank you!