Progress of NUSTAR Instrumentation

J. Gerl

GSI Darmstadt, Germany

NUSTAR Annual Meeting

GSI Darmstadt

27.2.2013

NUSTAR - The Project

DESPEC γ-, β-, α-, p-, n-decay spectroscopy

ELISE elastic, inelastic, and quasi-free e^--A scattering

EXL light-ion scattering reactions in invere kinematics

HISPEC in-beam γ spectroscopy at low and intermediate energy

ILIMA masses and lifetimes of nuclei in ground and isomeric states

LASPEC Laser spectroscopy

MATS in-trap mass measurements and decay studies

R3B kinematically complete reactions at high beam energy

Super FRS RIB production, identification and spectroscopy

The Approach

Complementary measurements leading to consistent answers

The Collaboration

> 800 scientists

146 institutes

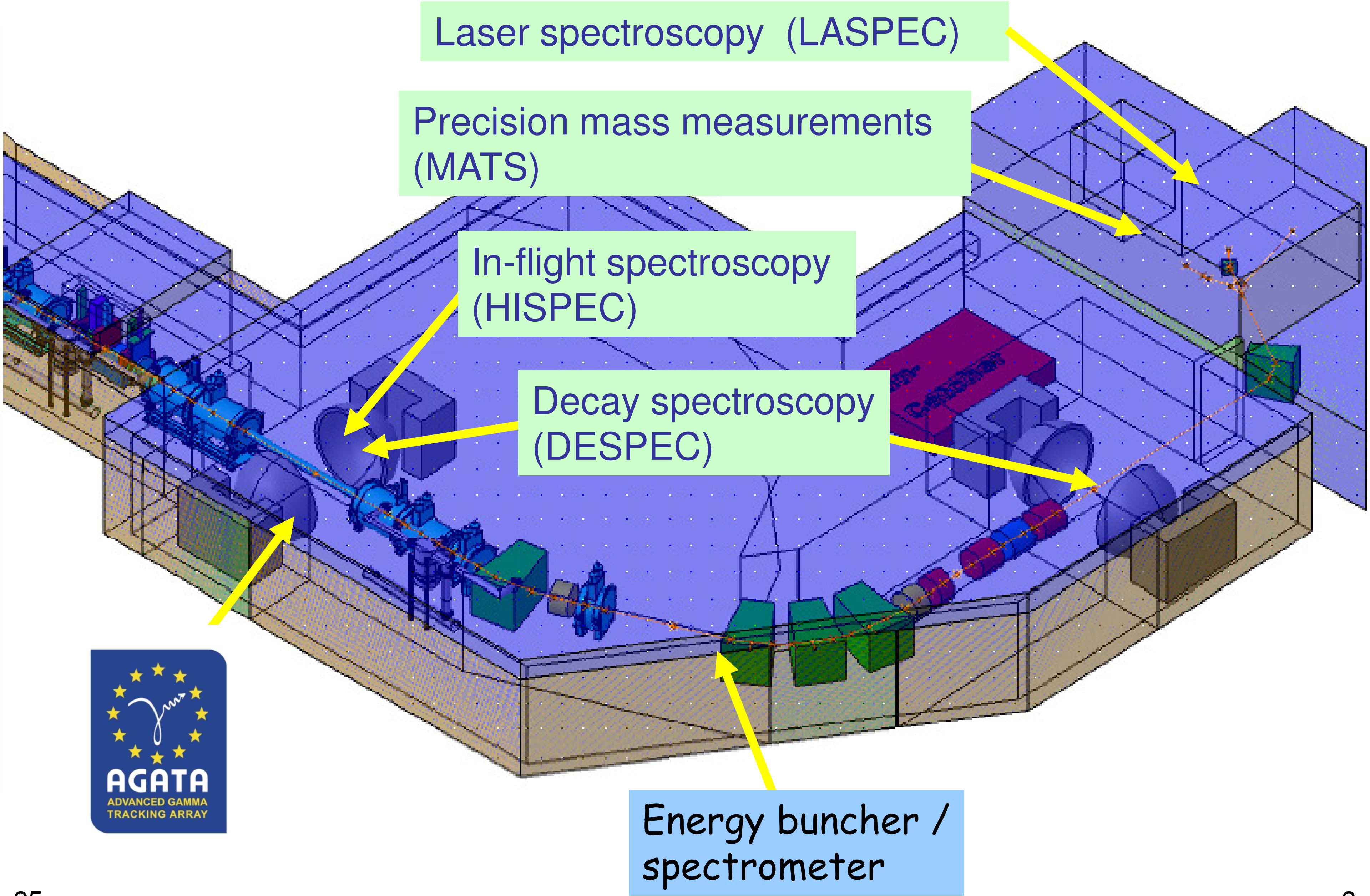
38 countries

The Investment

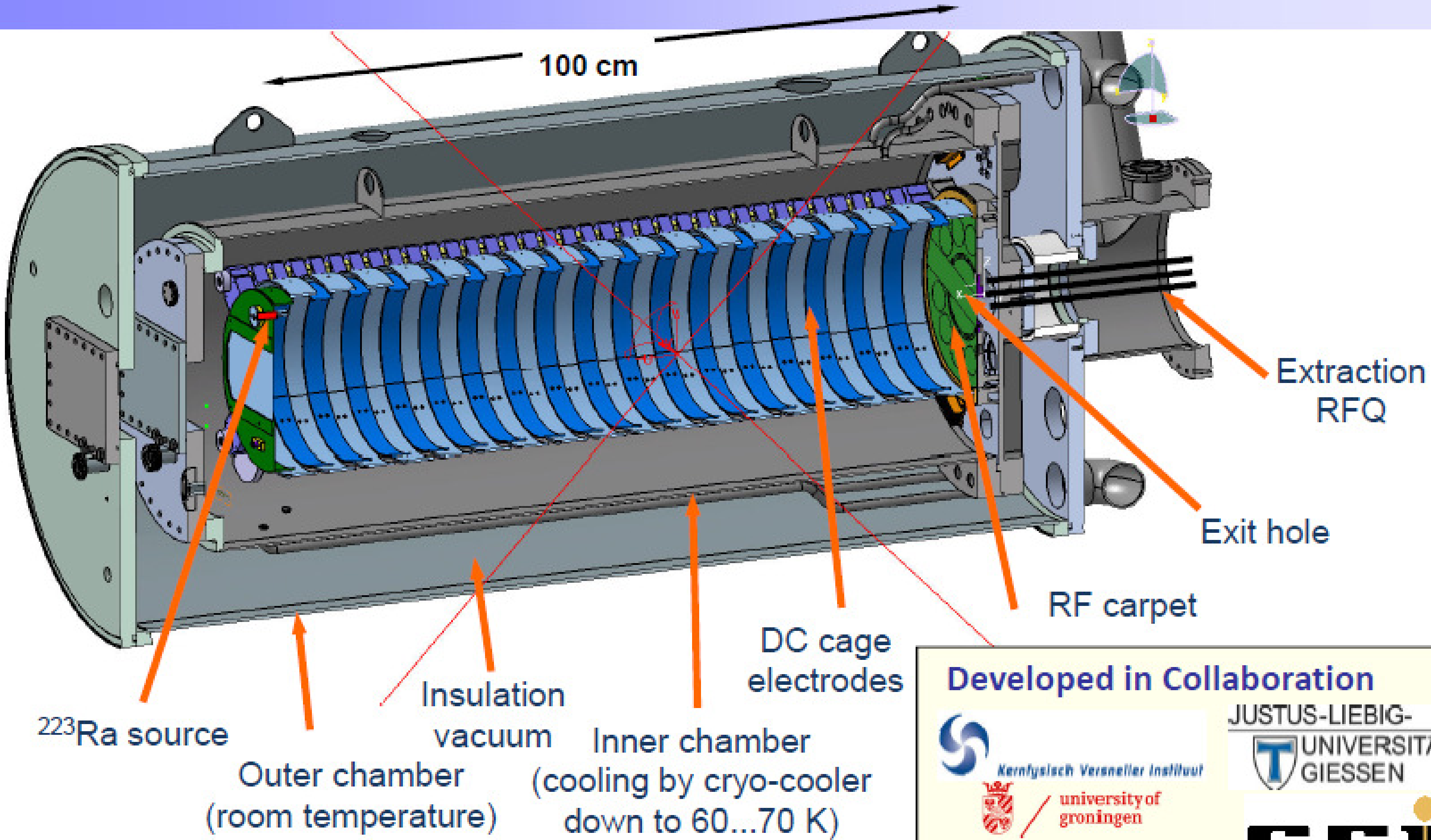
82 M€ Super FRS

73 M€ Experiments

Experiments with slowed and stopped beams



The cryogenic stopping cell for the LEB



Developed in Collaboration

Kernfysisch Versneller Instituut

university of groningen

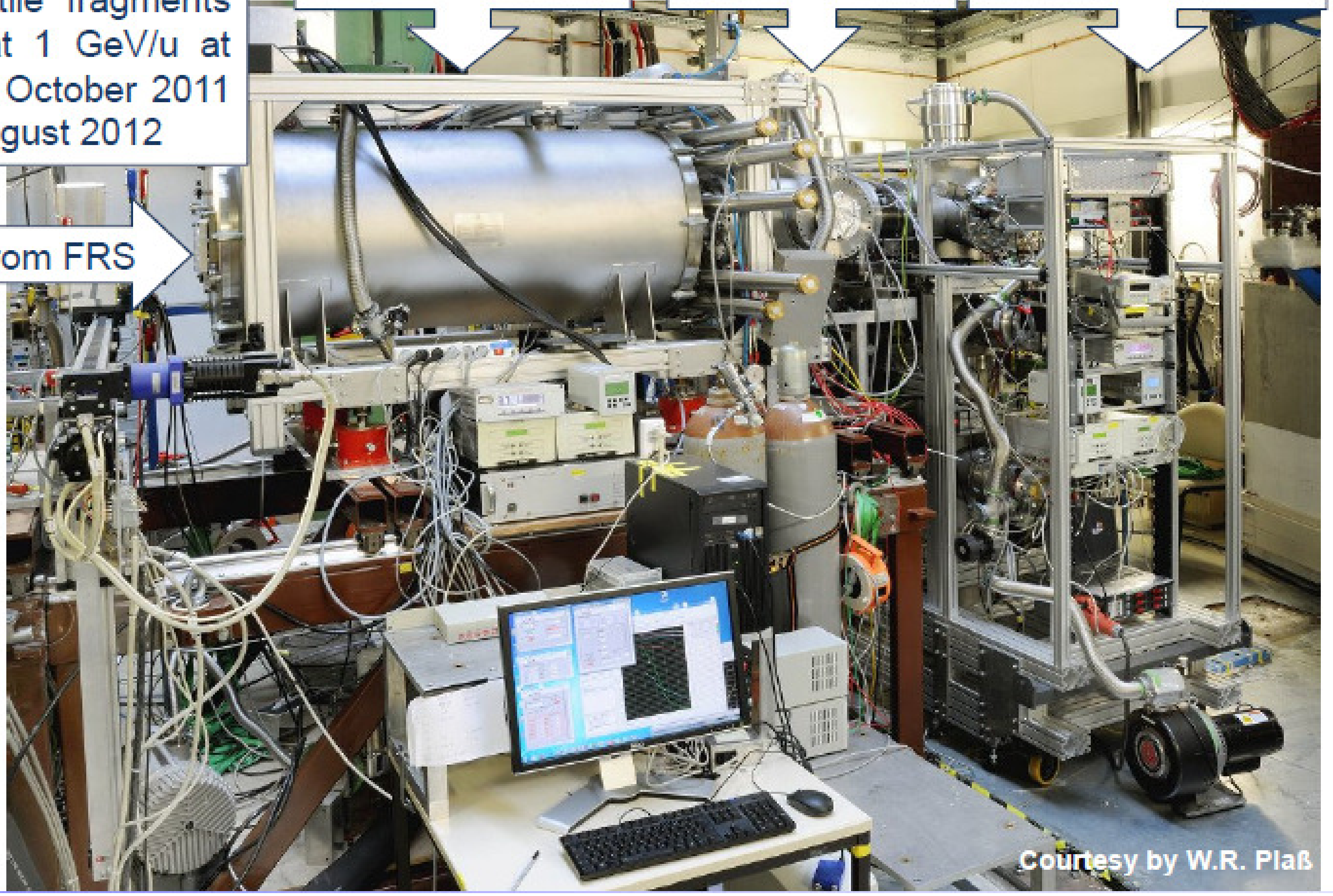
JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

GSI

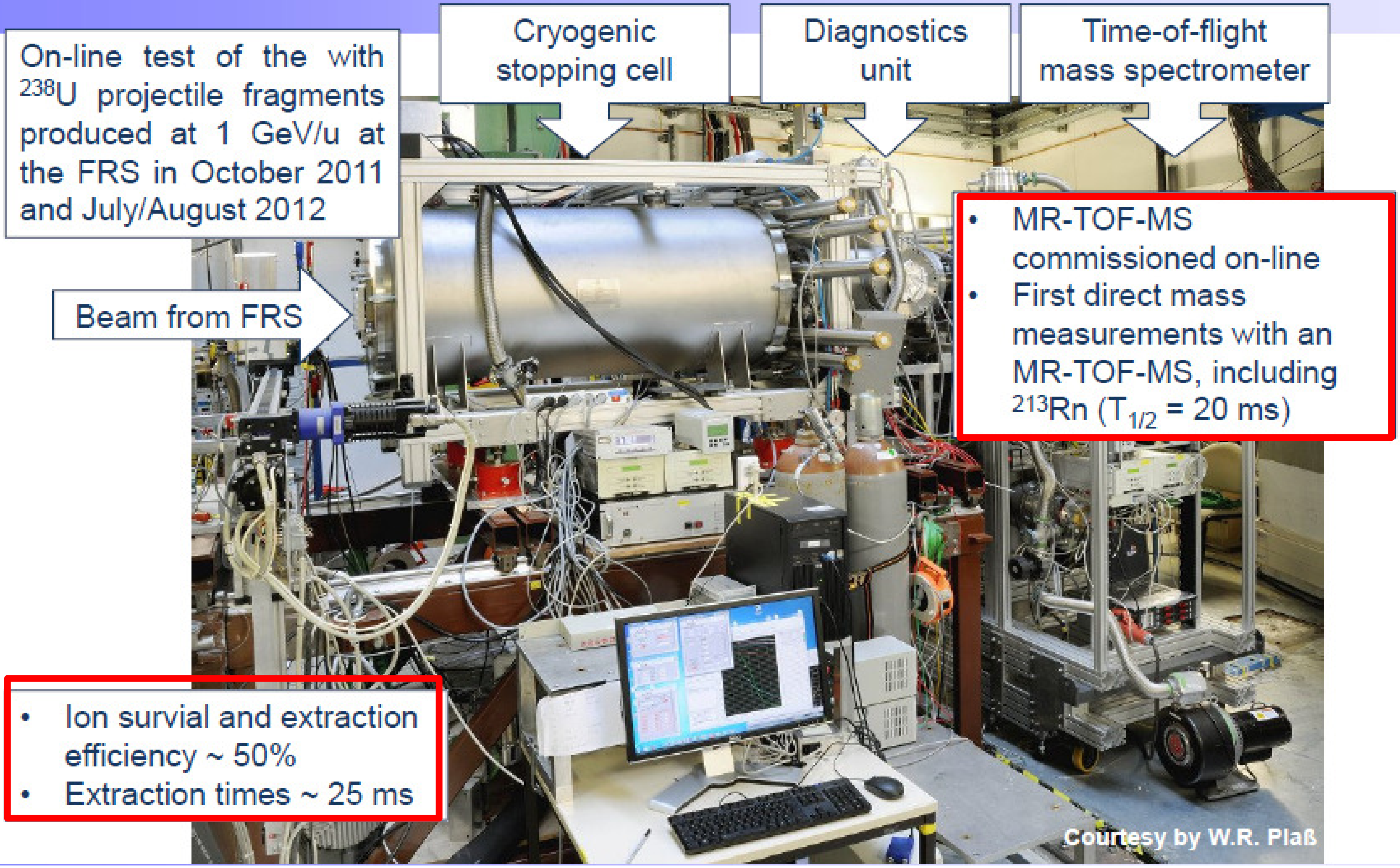
M. Ranjan et al., Europhys. Lett. 96 (2011) 52001
M. P. Reiter, Master Thesis, Justus-Liebig-Universität Gießen (2011)

Experimental setup at the FRS (GSI)

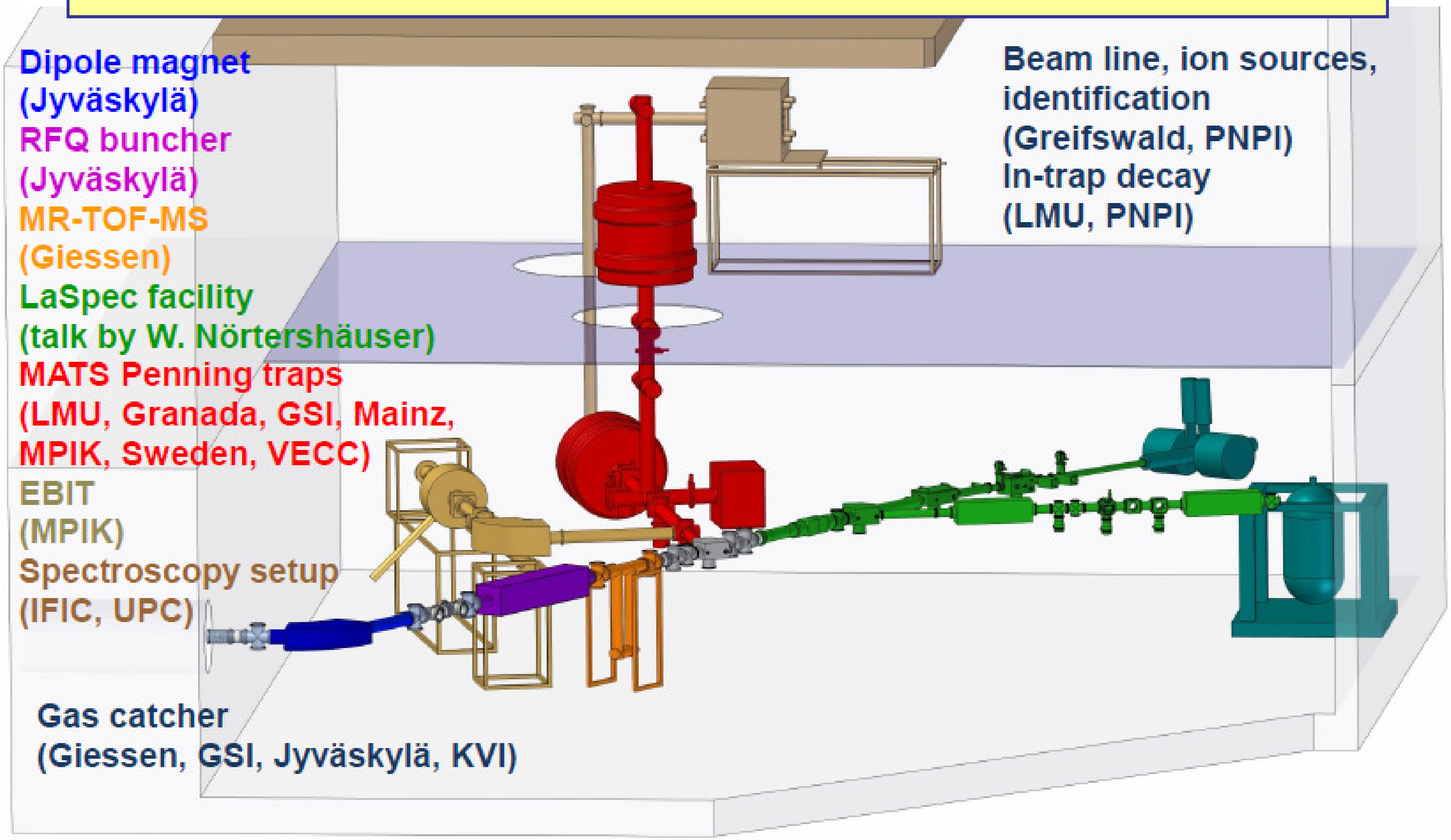
On-line test of the with ^{238}U projectile fragments produced at 1 GeV/u at the FRS in October 2011 and July/August 2012



Experimental setup at the FRS (GSI)



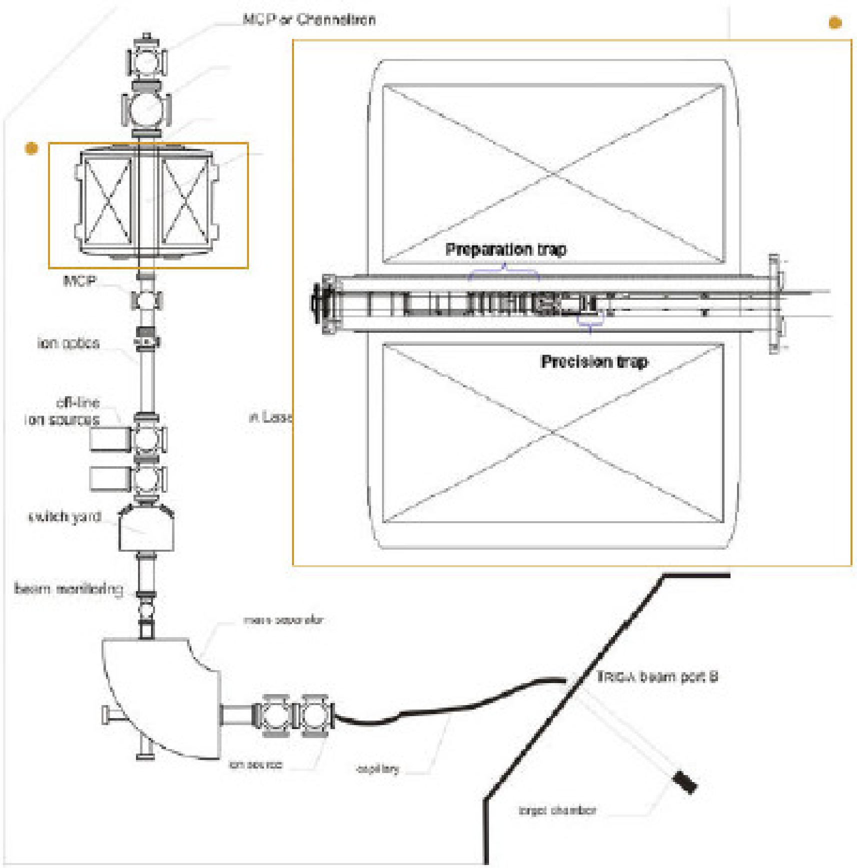
MATS at the LEB



Requires LEB Cave!!!

25

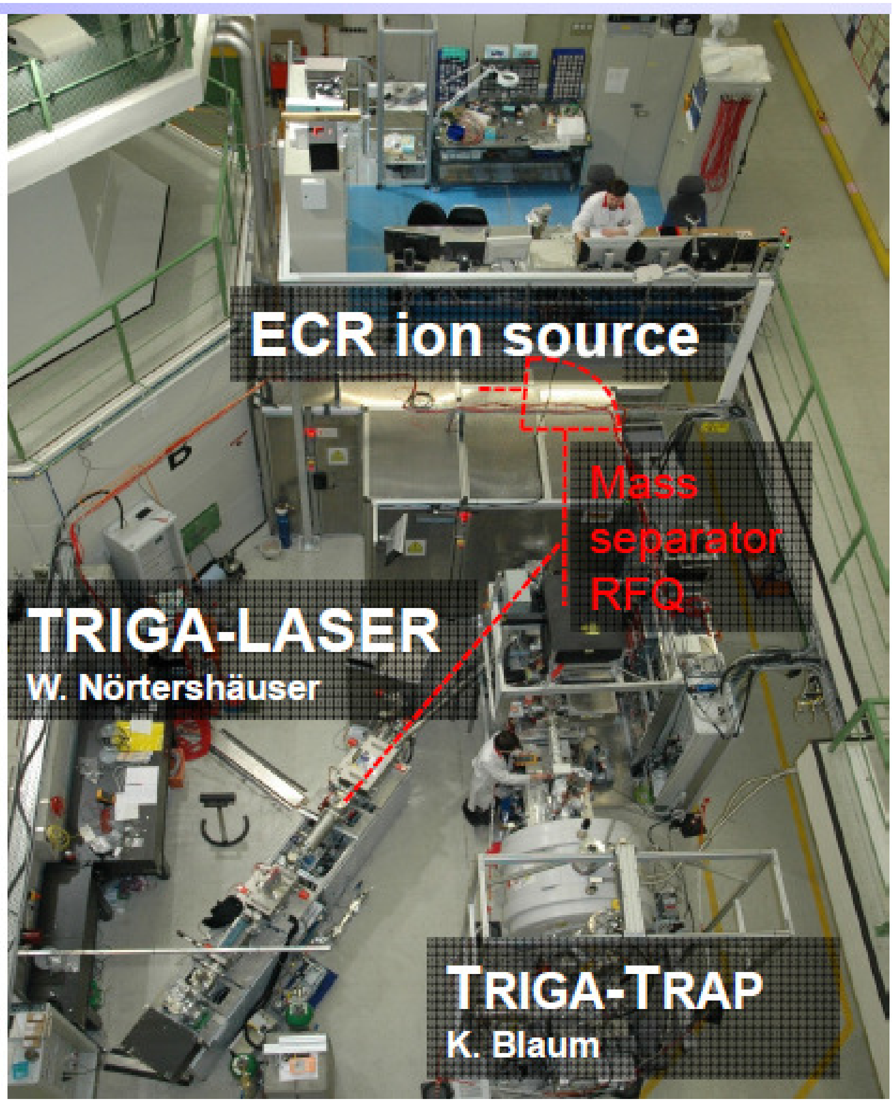
The Penning-trap system TRIGA-TRAP



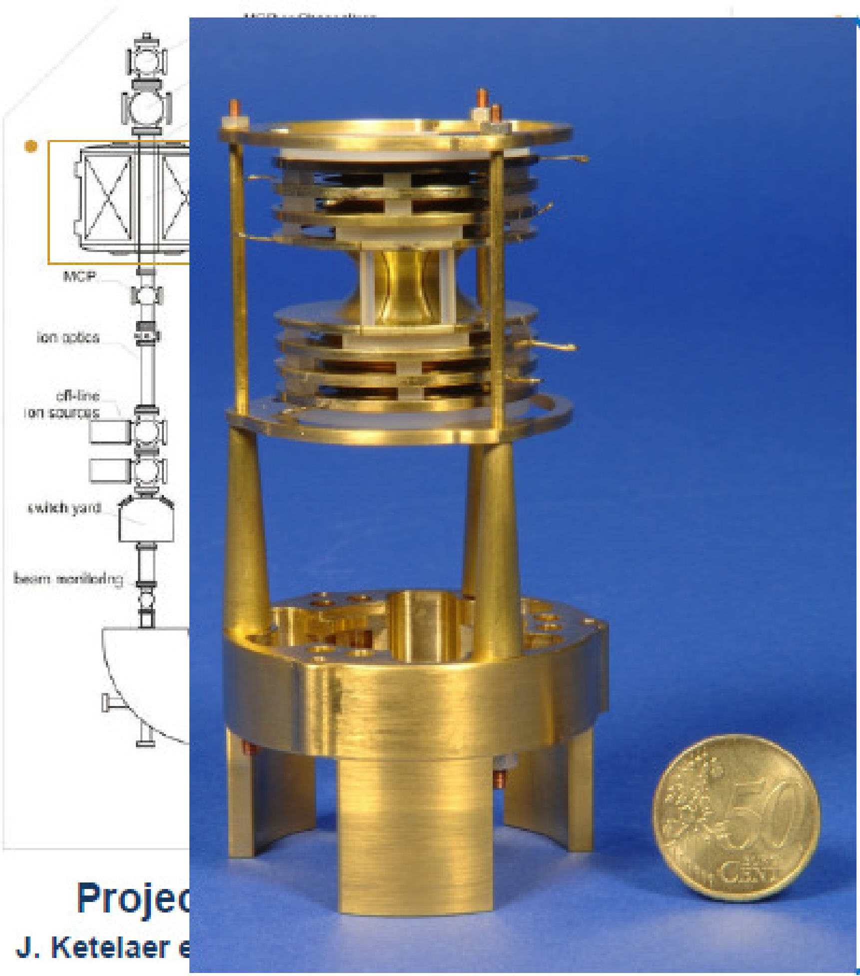
Project start @ TRIGA (Mainz): 01/08

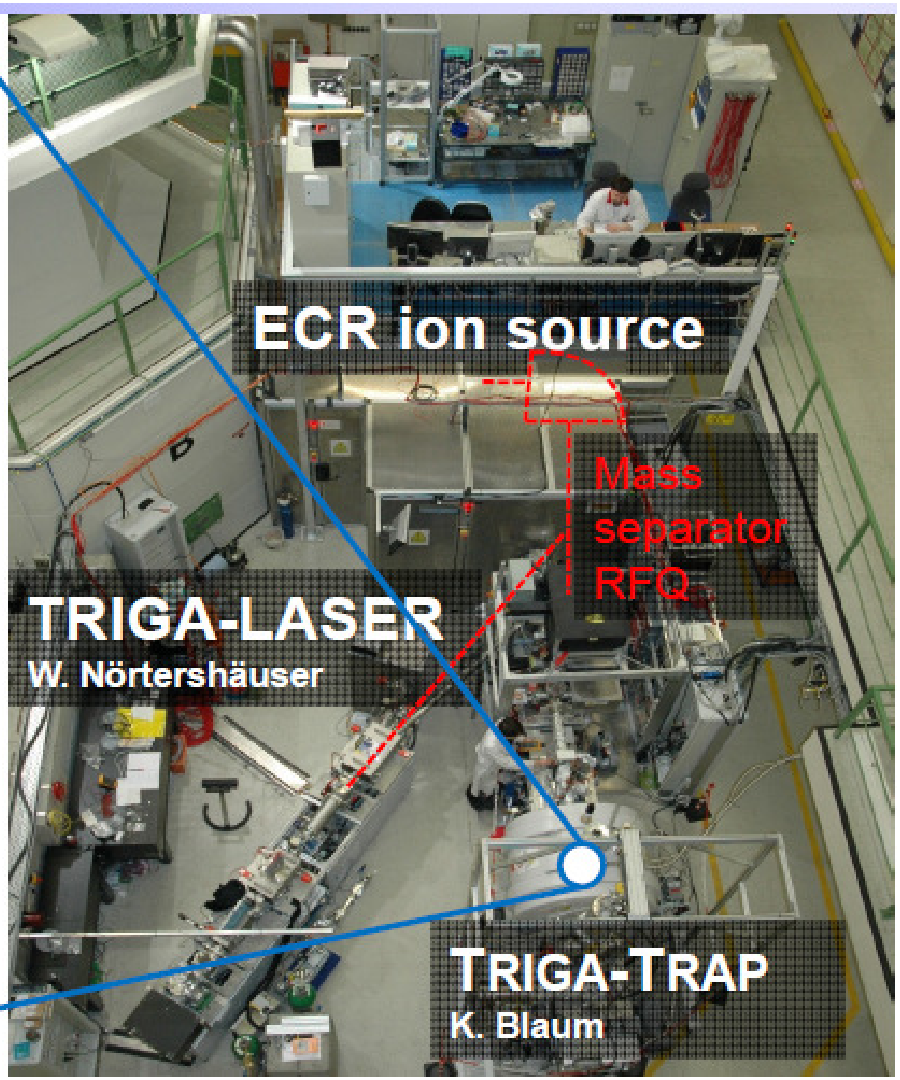
J. Ketelaer *et al.*, Nucl. Instrum. Methods A 594, 162 (2008)

Start data taking: 05/09



The Penning-trap system TRIGA-TRAP

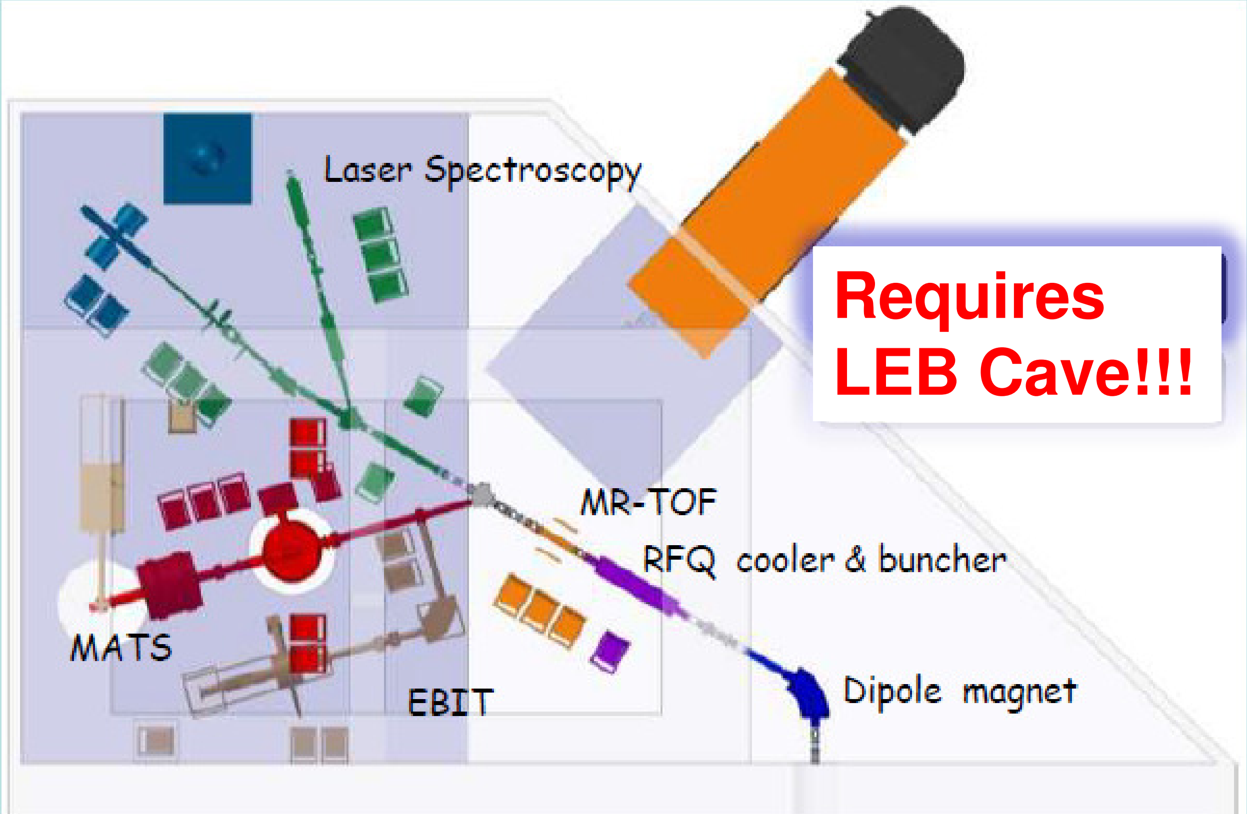




Start data taking: 05/09

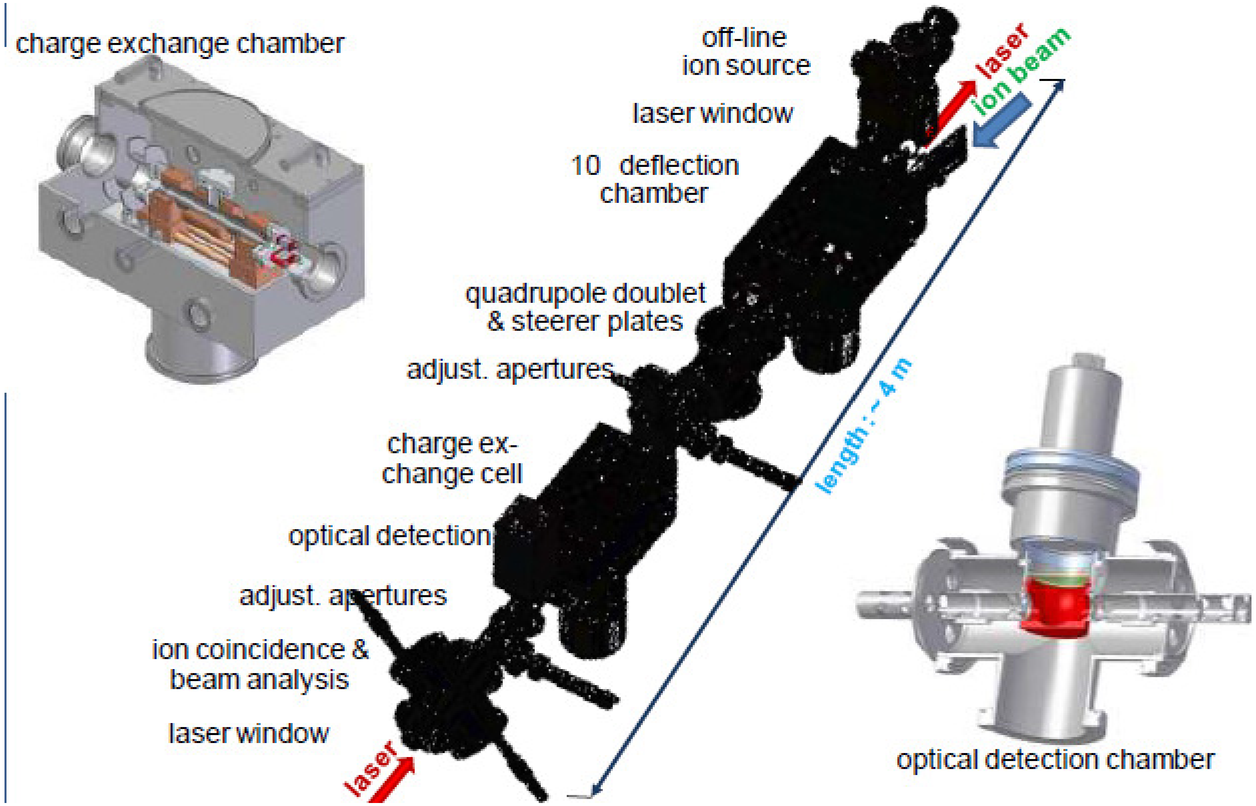
Many important physics rersults obtained already!

LASPEC at the LEB



for more information see:
Technical Design Report of MATS & LaSpec:
D. Rodriguez, EPJ Special Topics 183 (2010) 1-123

LASPEC Beamline available



Beamline completed

Off-line comissioning

Charge exchange cell comparison

Optical detection region improve-ments ongoing

New tools for ion beam analysis under development

On-line comissioning awaiting

Foreseen instrumentation for Spectroscopy

HISPEC

-LYCCA *heavy ion calorimeter with ToF capability*

-AGATA *gamma spectrometer*

-HYDE *light particle array*

-NEDA *Neutron detector array*

-EDAQ *dedicated electronics and DAQ based on several branches*

DESPEC

-AIDA *active implantation device*

-MONSTER *neutron ToF array*

-BELEN *neutron detecion array*

-DTAS *Decay Total Absorption Spectrometer*

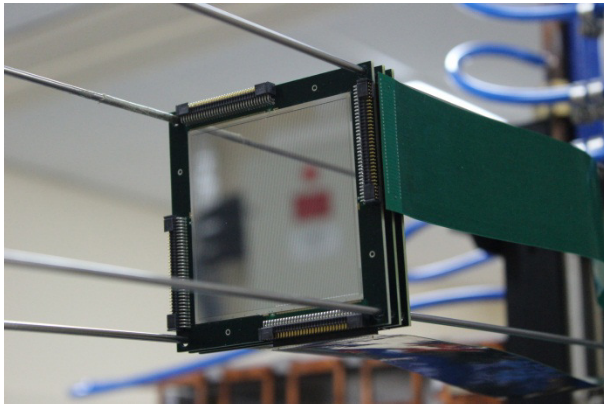
-DESPEC Ge Array *gamma spectrometer*

-FATIMA *Fast timing array*

-EDAQ *dedicated electronics and DAQ based on several branches*

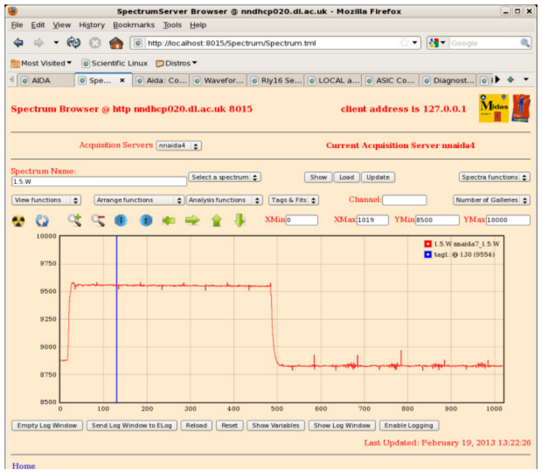
AIDA -Advanced Implantation Detector Array

Detector:
multi-plane Si DSSD array
wafer thickness 1mm
8cm x 8cm (128x128 strips) *or*
24cm x 8cm (384x128 strips)



TDR long ago...

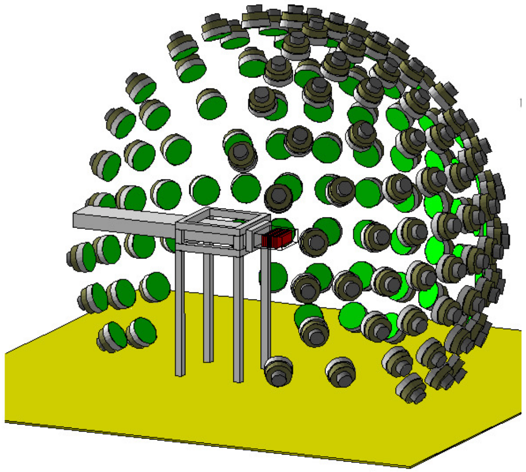
Instrumentation:
ASIC
low noise (<12keV FWHM), low threshold (0.25% FSR)
20GeV FSR *plus* (20MeV FSR *or* 1GeV FSR)
fast overload recovery (~µs)
spectroscopy performance
time-stamping



advanced EDAQ

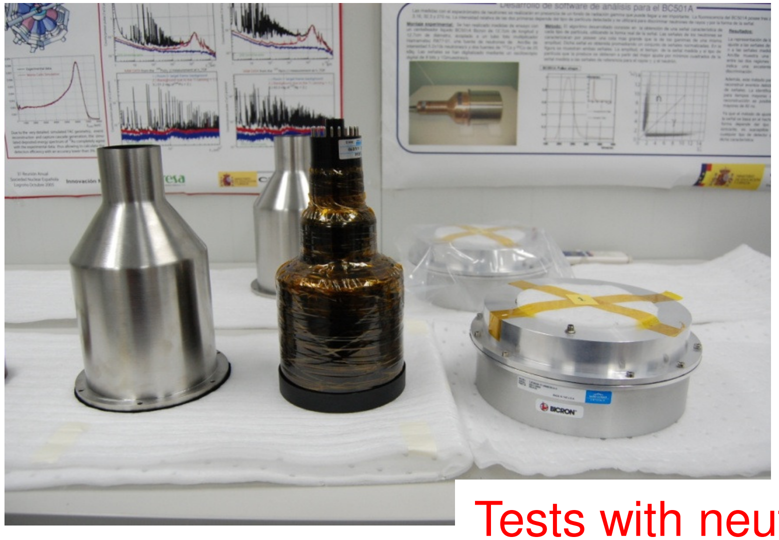
The DESPEC MOdular Neutron SpectromeTER

MONSTER will be used to determine the energy spectra and emission probabilities of β delayed neutrons with high resolution.



200 detectors, 10cm radius		ΔE/E @ 1 MeV	
TOF distance (m)	Geometric efficiency	1ns	4ns
2	12.5%	3.5%	6.0%
3	5.6%	2.5%	4.2%

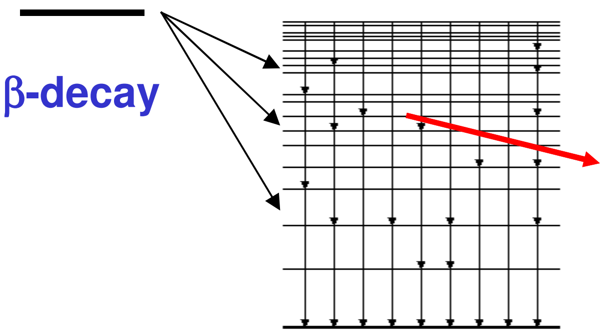
Initial quality problems solved 30 detectors delivered to CIEMAT



Prototype development for own production at VECC Kolkata ongoing.

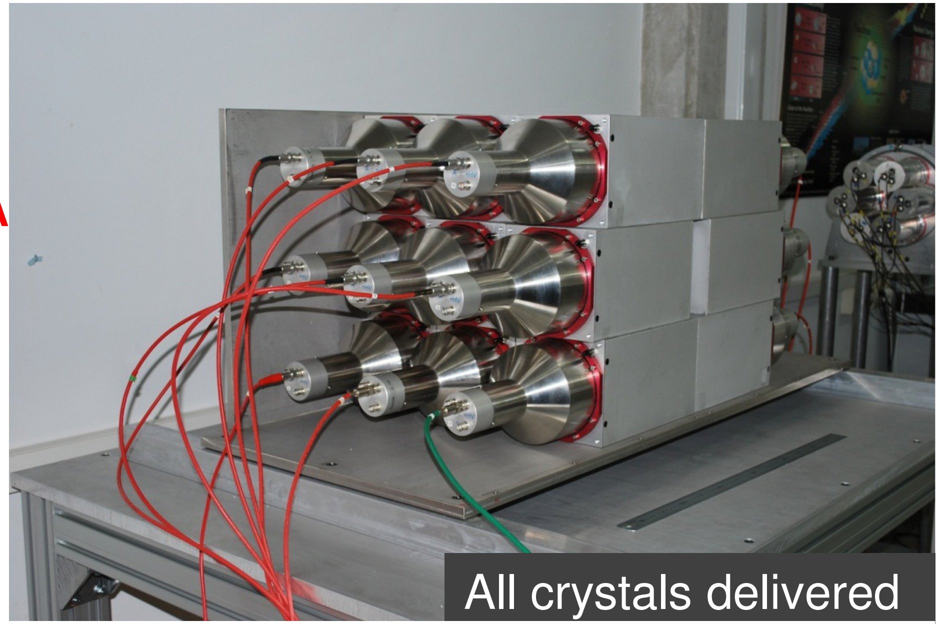
Tests with neutron performed successfully at Bruyeres Le Chatel

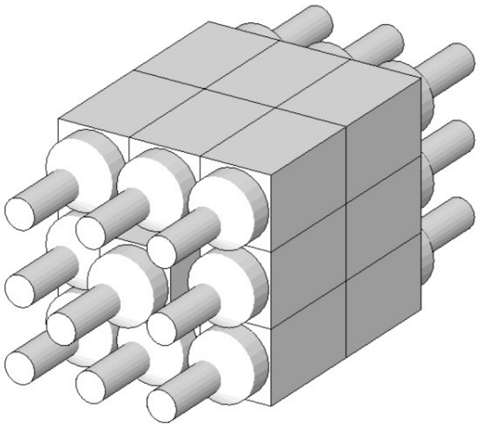
Decay Total Absorption Spectrometer (DTAS)



Designed to be coupled to AIDA implantation detector

Information on the multiplicity of the gamma cascade

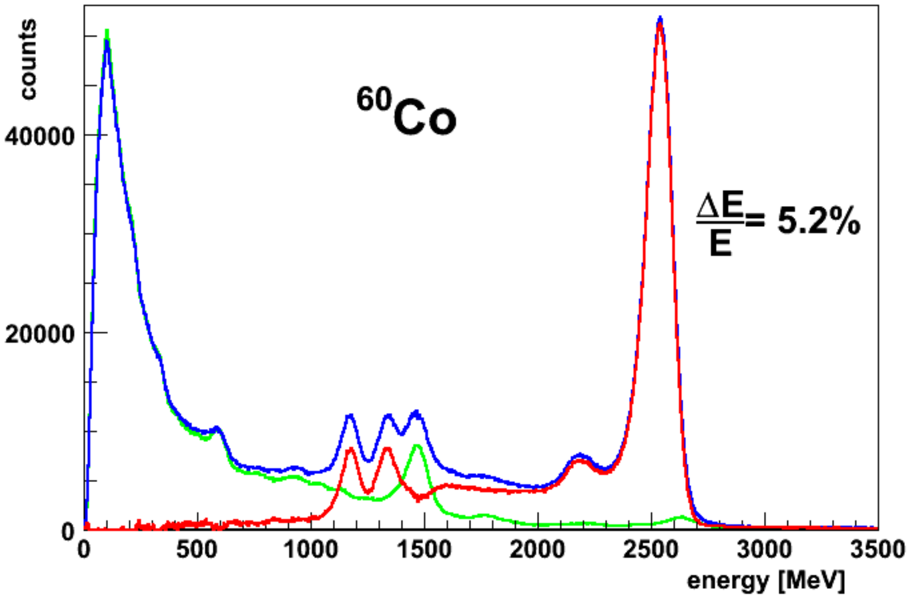




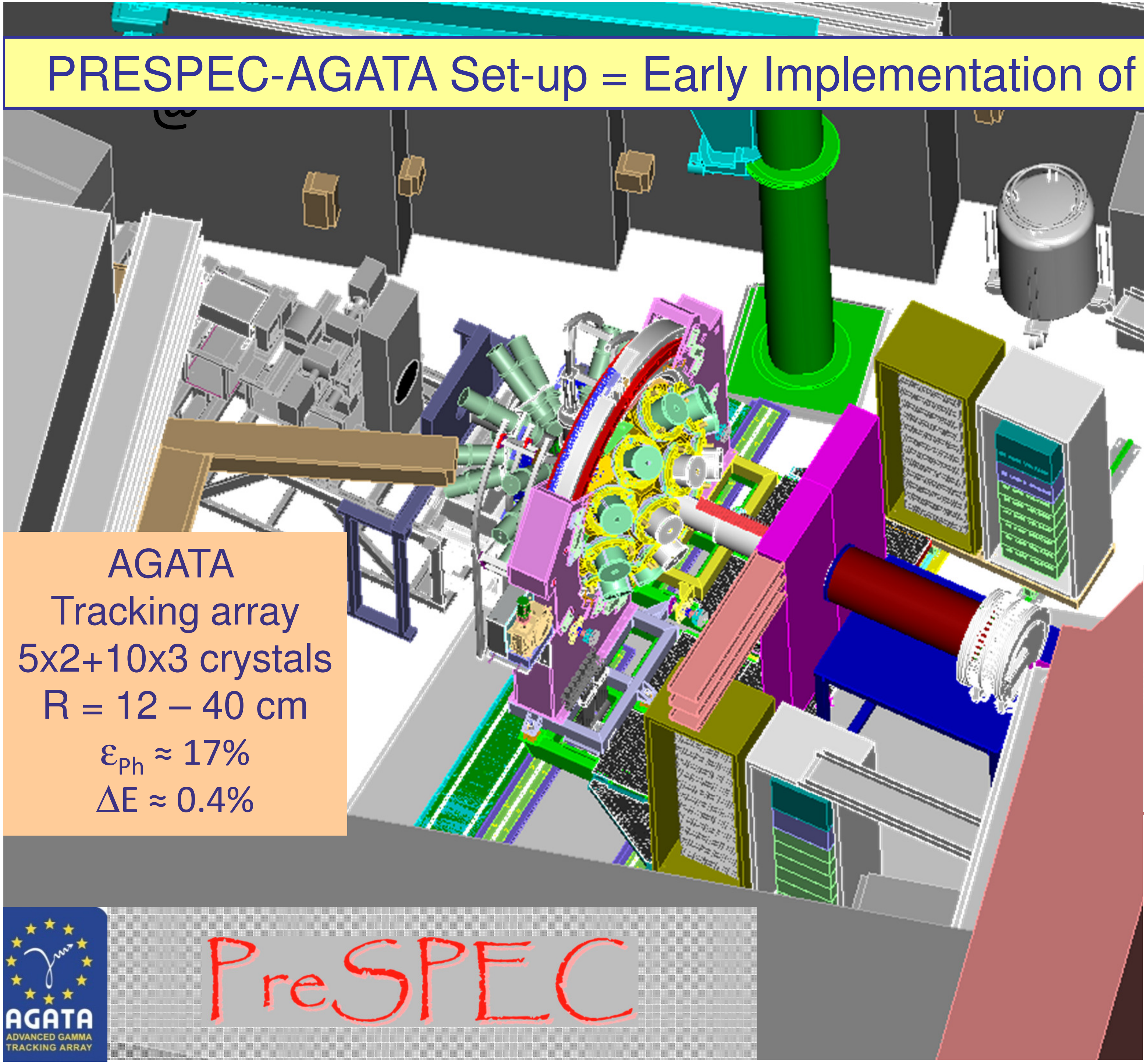
TDR submitted in 2012 and accepted!

16 × NaI(Tl) crystals:

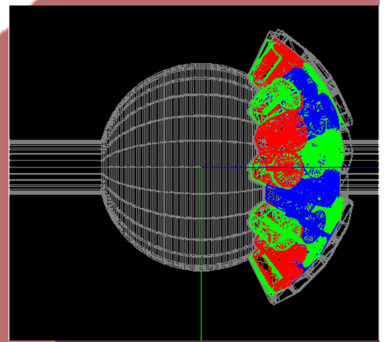
- $15\times15\times25$ cm^3
- Minimum dead-material
- 5" PMT: ETL9390

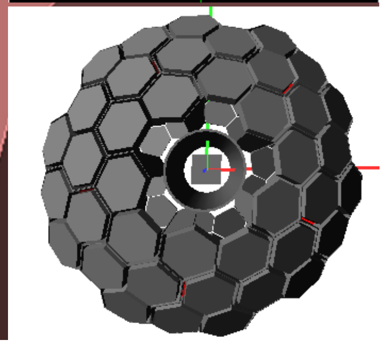


PRESPEC-AGATA Set-up = Early Implementation of HISPEC



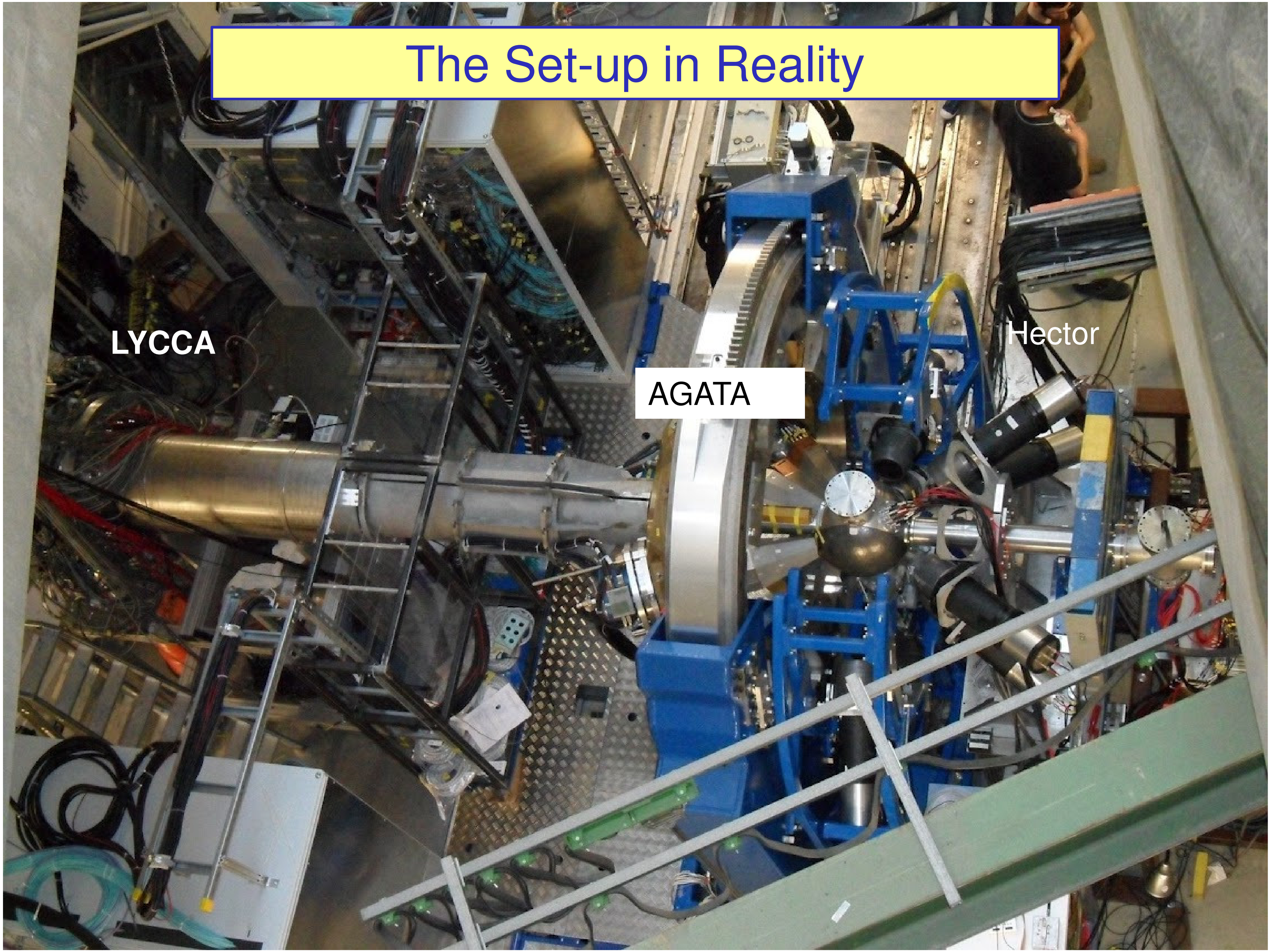
AGATA
Tracking array
5x2+10x3 crystals
R = 12 – 40 cm
$\varepsilon_{Ph} \approx 17\%$
$\Delta E \approx 0.4\%$



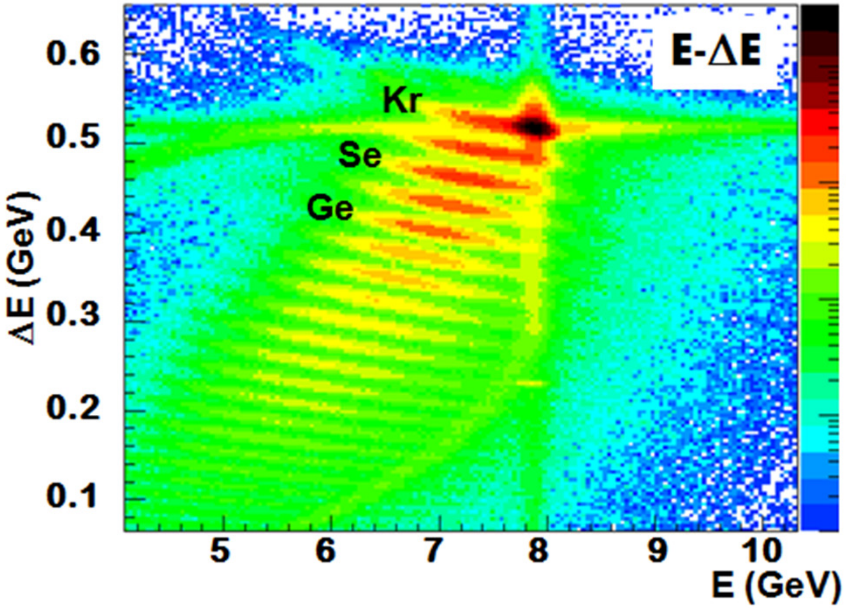


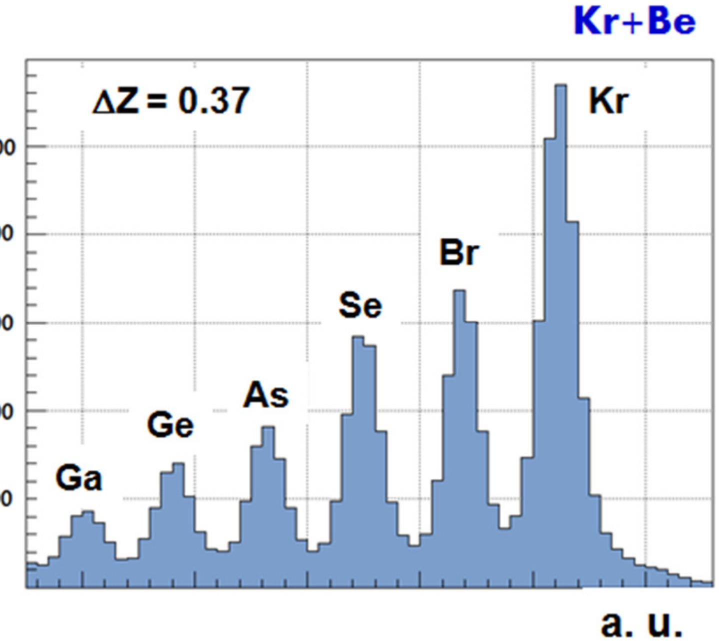
PreSPEC

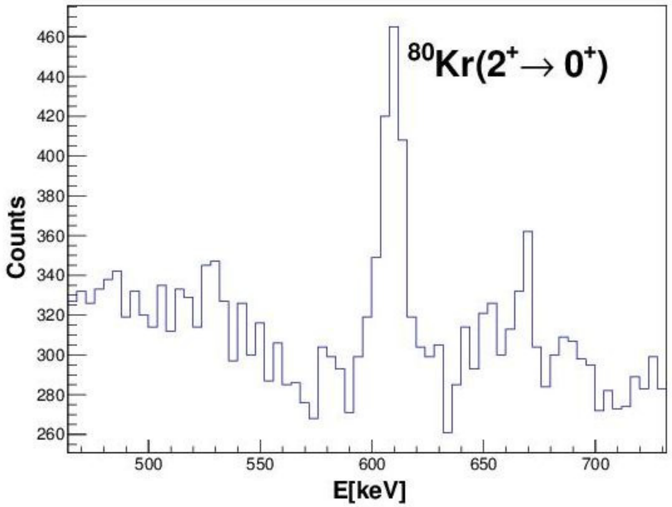
The Set-up in Reality



Successful Commissioning

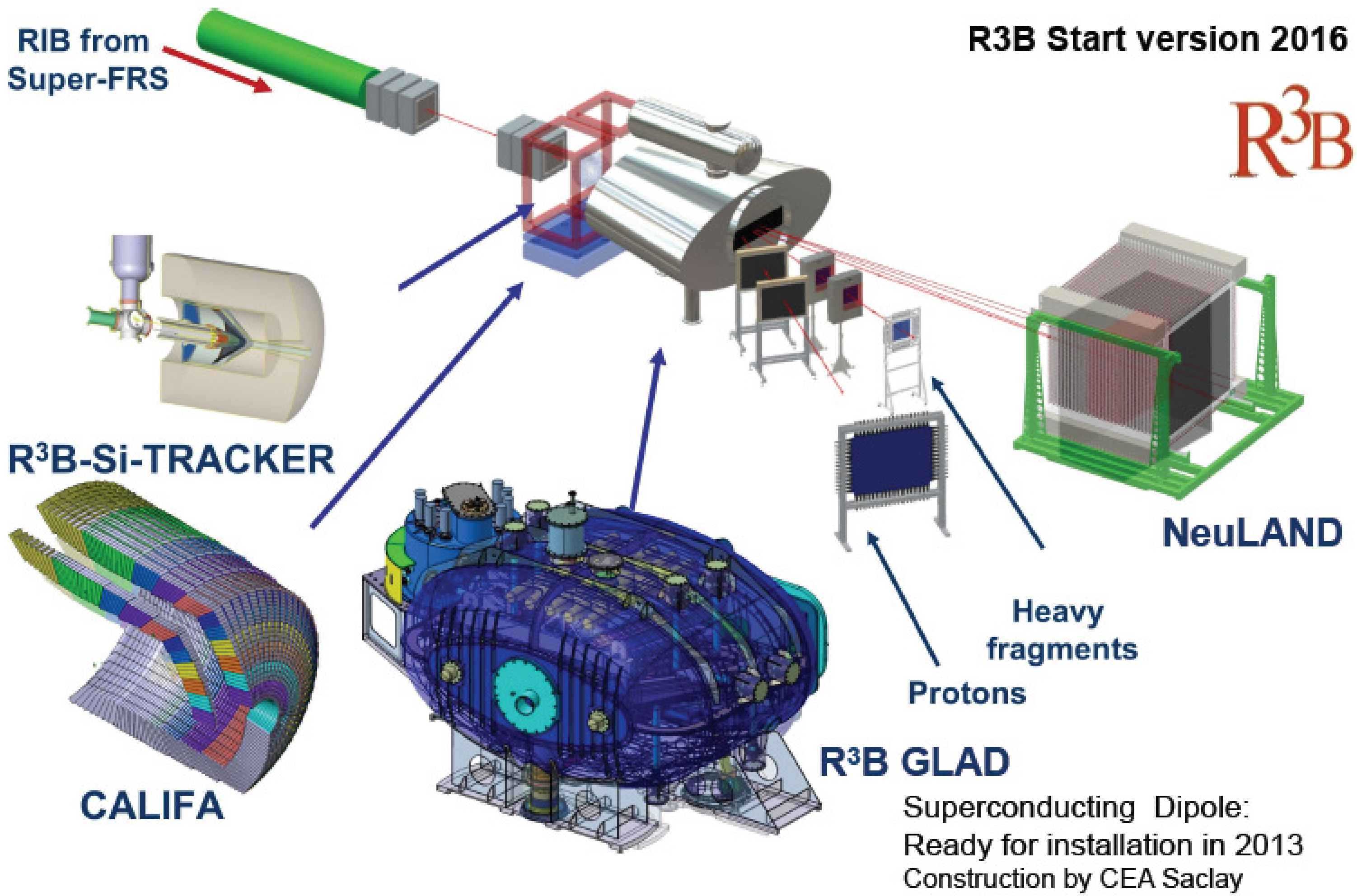




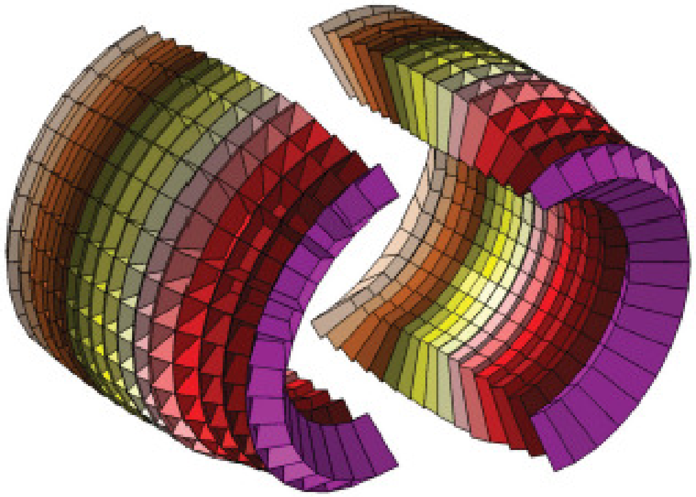


Experiments performed from 27.9. to 21.11.
Coulomb excitation around ^{208}Pb
Fine structure in Pygmy resonance
Coulex on isomeric state in ^{52}Fe
Lifetimes in heavy Zr-Mo isotopes

R3B at the HEB



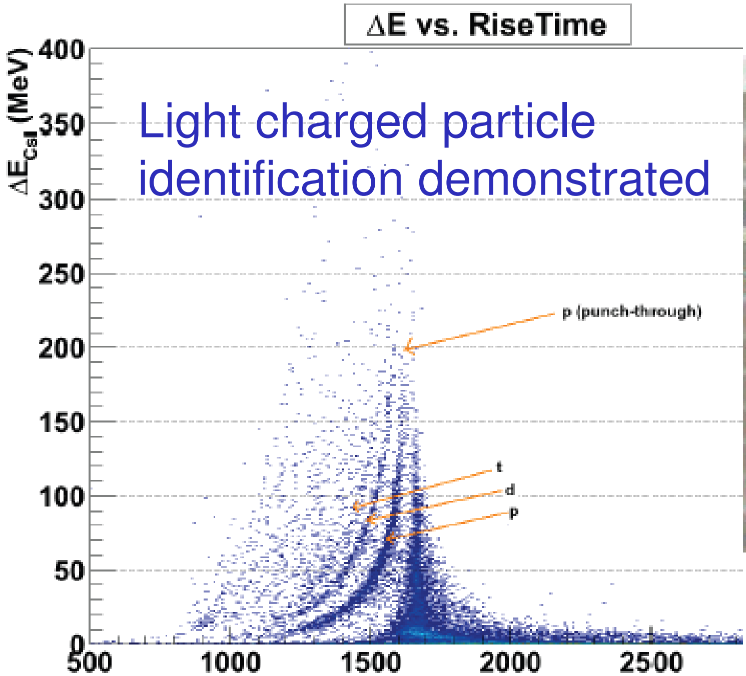
CALIFA



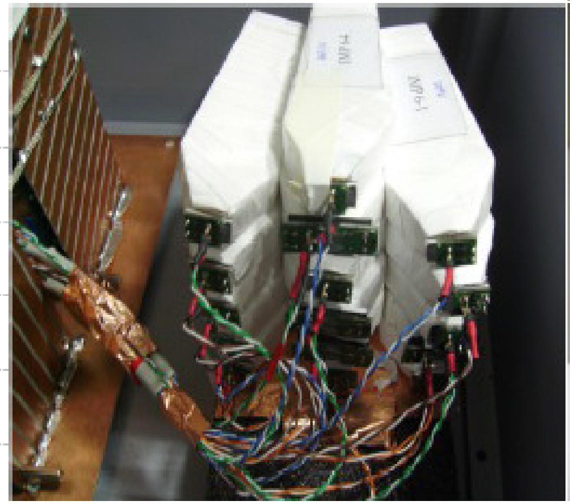
TDR submitted in 2012 and accepted!

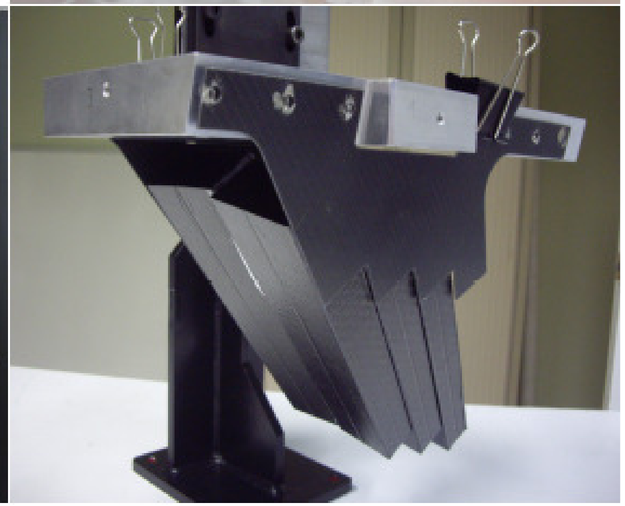
9.

Barrel design ready,
Prototype
successfully tested

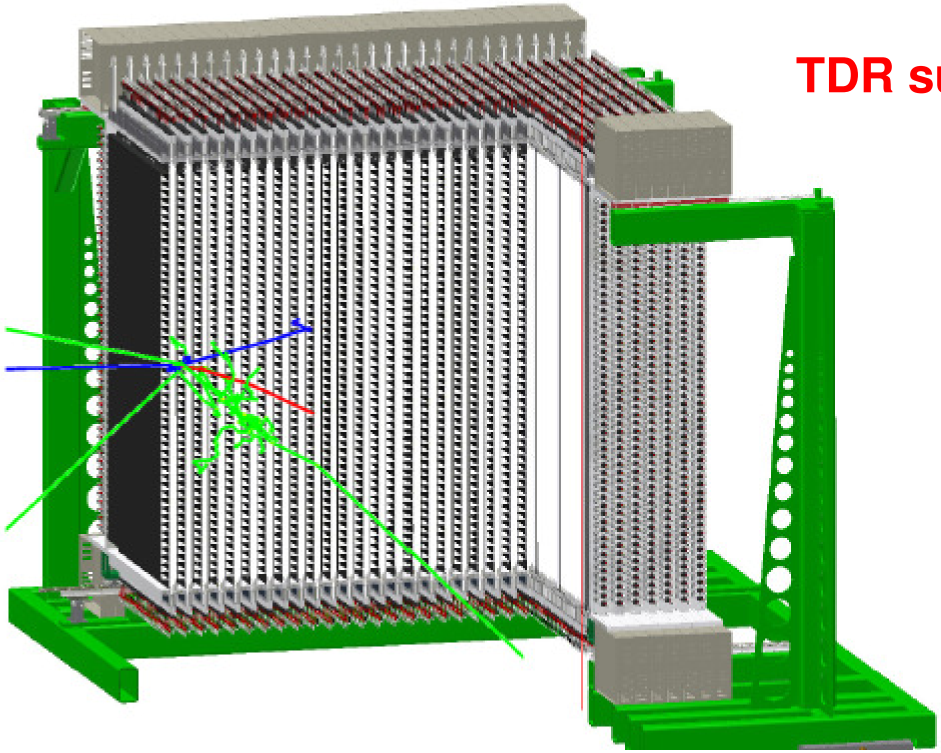


Light charged particle
identification demonstrated





NeuLAND



TDR submitted in 2012 and accepted!

20% version in construction
for in-beam run in 2014

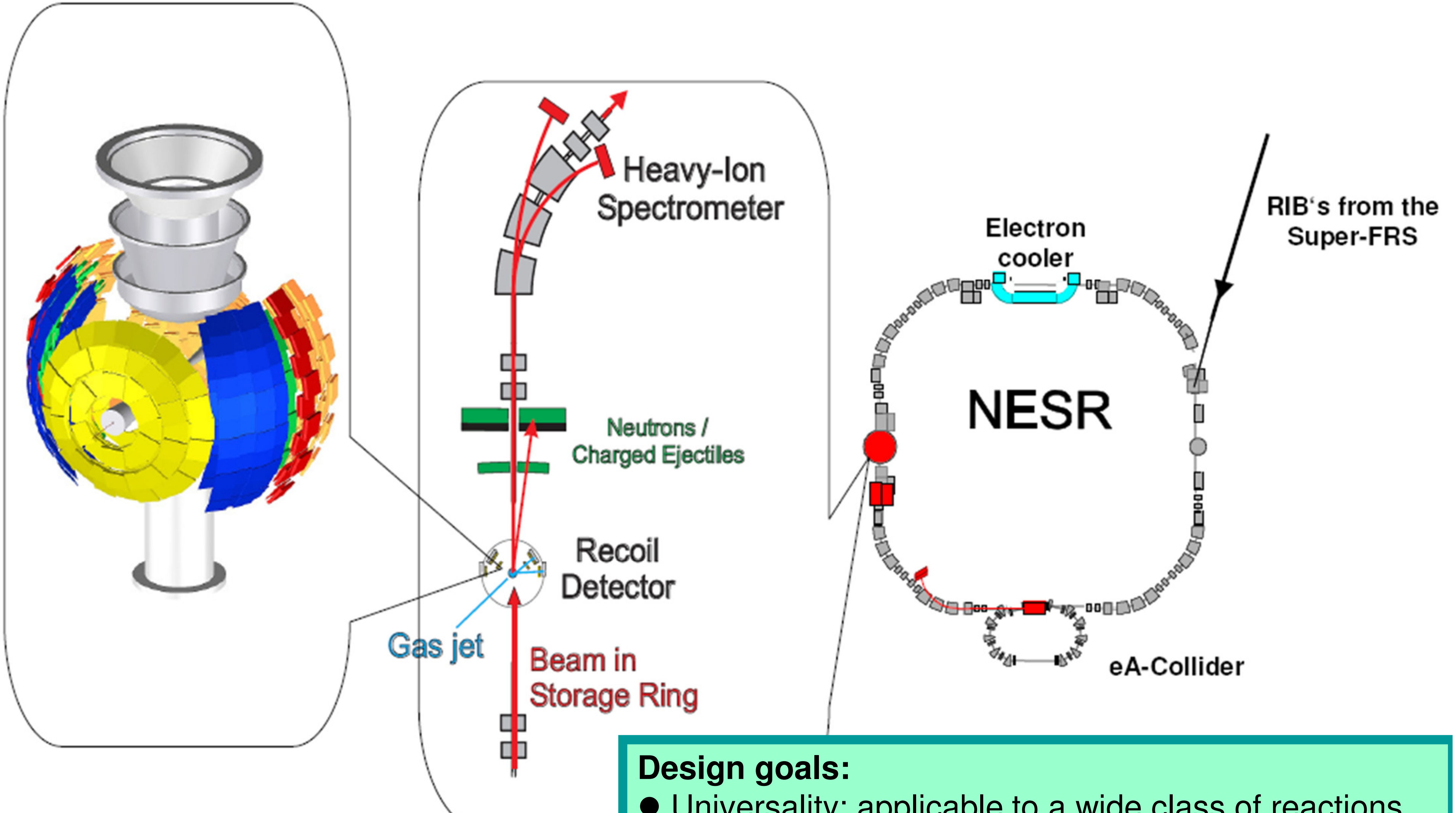
excellent multi-neutron capability

	%	200 MeV generated 1n	2n	3n	4n	5n
detected	1n	**88**	31	6	1	0
	2n	2	**62**	37	10	2
	3n	0	5	**49**	38	14
	4n	0	0	8	**48**	54
	5n	0	0	0	3	**26**
	6n	0	0	0	0	3

	%	600 MeV generated 1n	2n	3n	4n	5n
detected	1n	**92**	22	2	0	0
	2n	2	**71**	32	7	1
	3n	0	6	**55**	32	9
	4n	0	0	10	**57**	50
	5n	0	1	1	4	**35**
	6n	0	0	0	0	5

	%	1000 MeV generated 1n	2n	3n	4n	5n
detected	1n	**89**	12	1	0	0
	2n	7	**78**	23	3	0
	3n	0	8	**63**	26	5
	4n	0	0	12	**63**	40
	5n	0	0	0	7	**46**
	6n	0	0	0	0	8

Details of the EXL setup



Detection systems for:

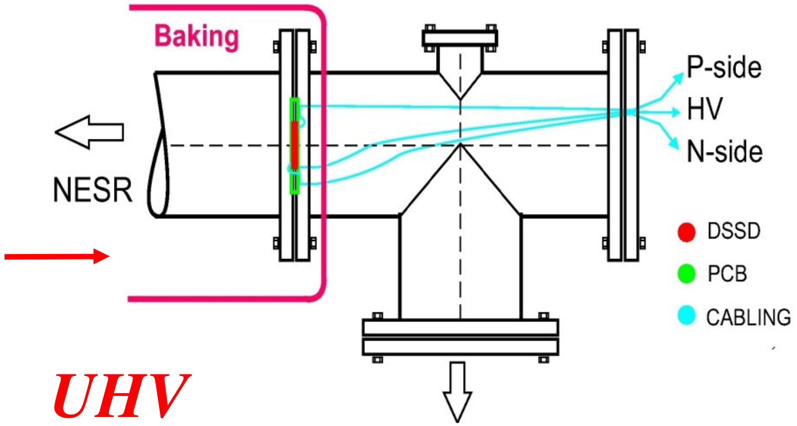
- Target recoils and gammas (p,α,n,γ)
- Forward ejectiles (p,n)
- Beam-like heavy ions

Design goals:

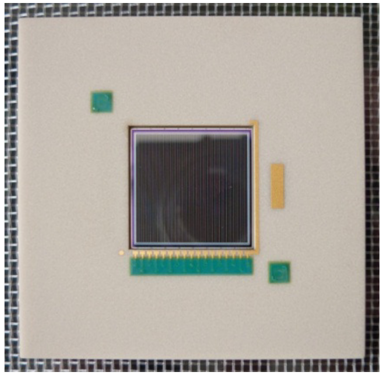
- Universality: applicable to a wide class of reactions
- Good energy and angular resolution
- Large solid angle acceptance
- Specially dedicated for low q measurements with high luminosity (> 10^{28} cm^{-2} s^{-1})

Vacuum solution with DSSDs

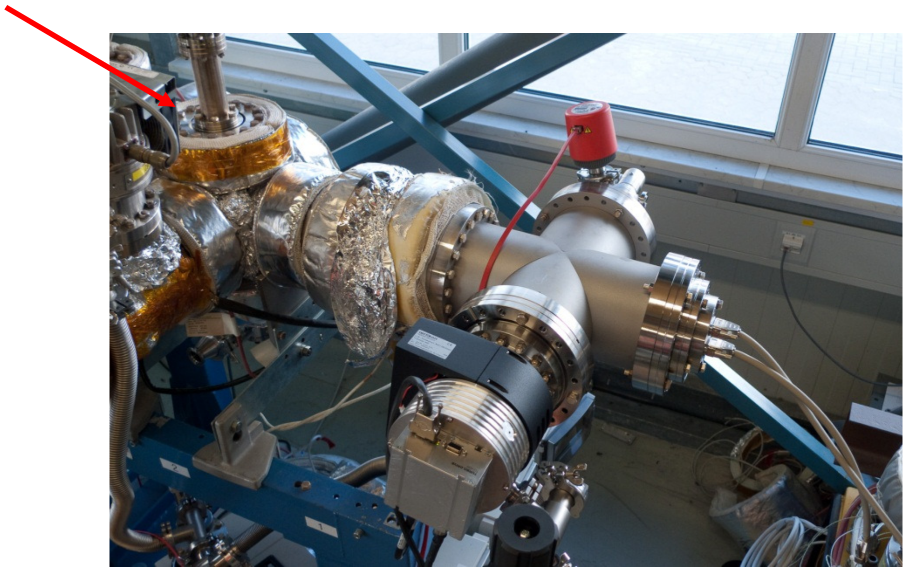
[courtesy : B. Streicher (KVI/GSI) and M. Mutterer (GSI)]

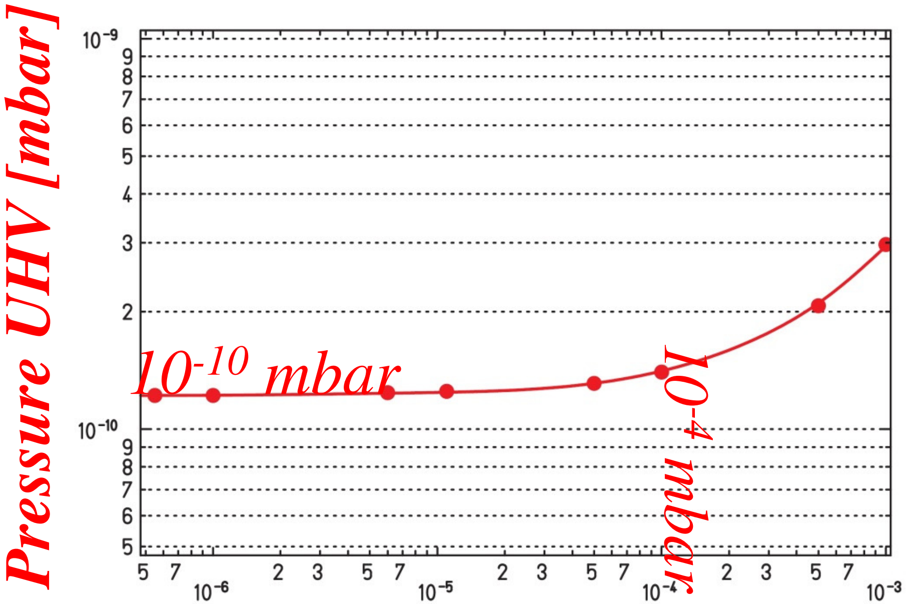


p-side (21x21 mm^2) DSSD
64x64 strips
AlN PCB (ceramic – UHV)
good heat conductivity
< 5μm roughness after polishing



UHV

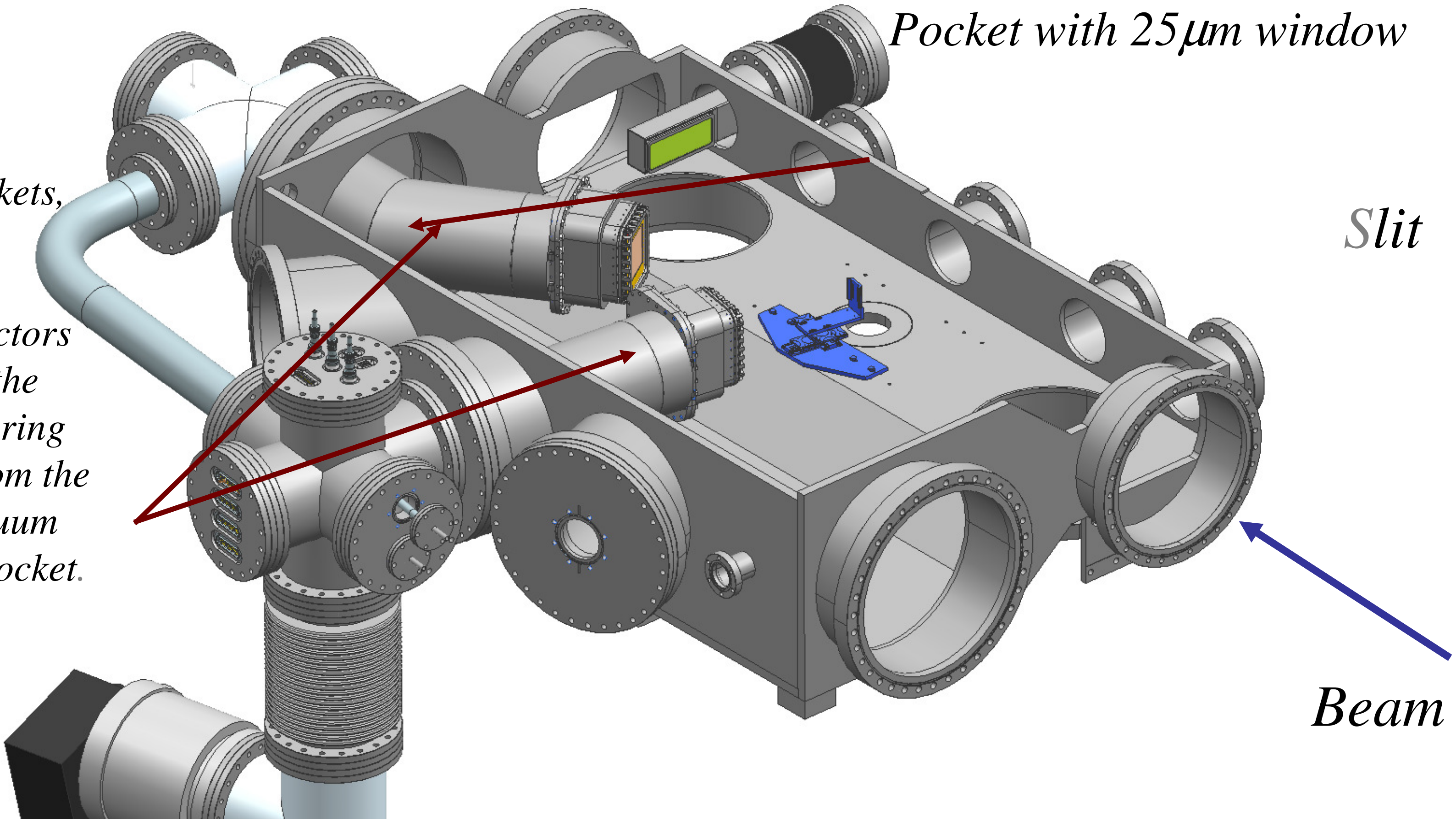




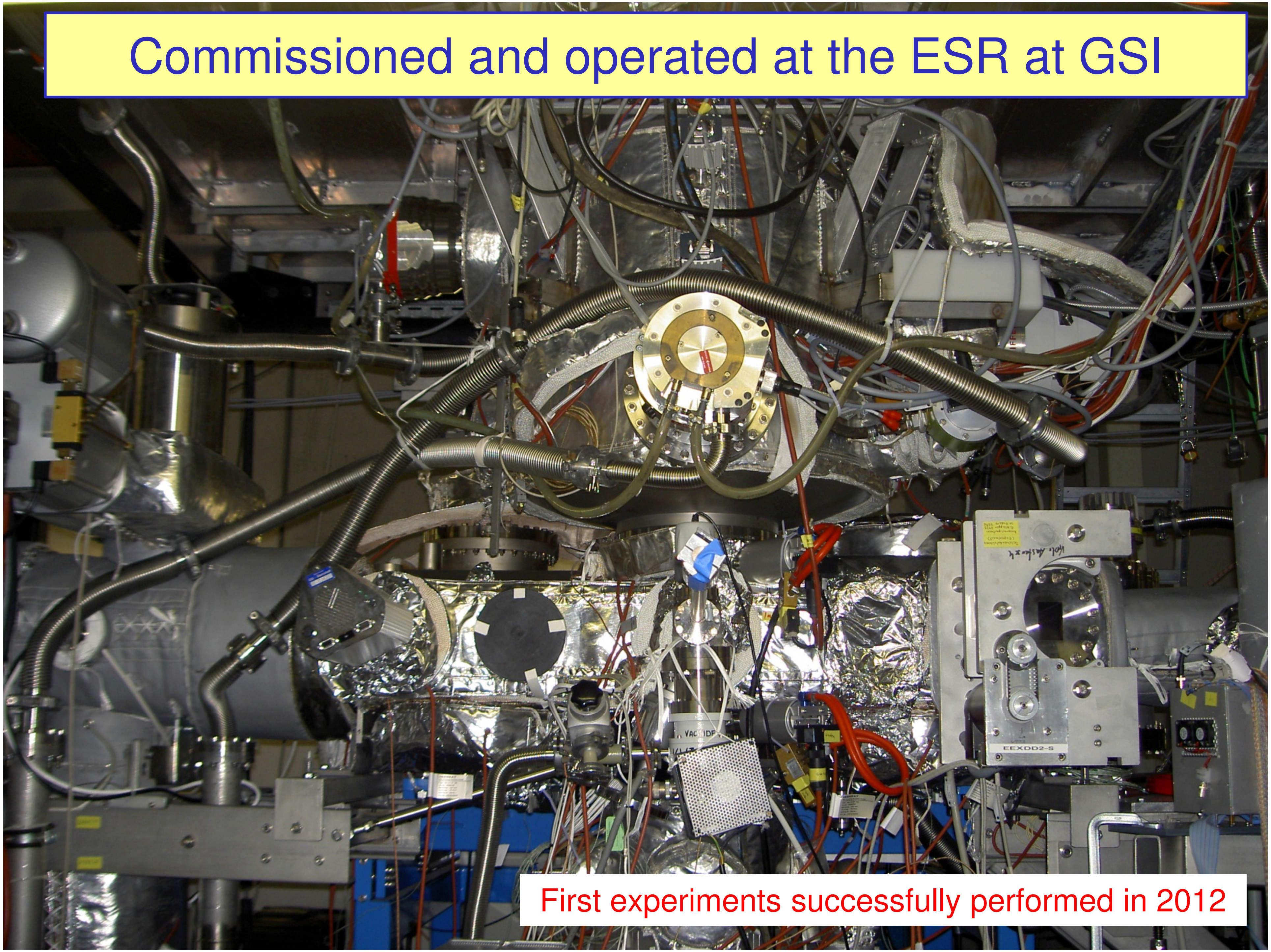
Streicher et al., NIM A 654 (2011) 604

Mechanical engineering

Special pockets, whose front face are silicon detectors separating the UHV in the ring chamber from the normal vacuum inside the pocket.



Commissioned and operated at the ESR at GSI



First experiments successfully performed in 2012

Conclusions

- Most sub-system designs are ready
- Many prototypes exist
- Early implementations of major sub-systems are being tested
- First sub-systems are completed in their final version
- Some sub-systems are already being exploited for experiments
- Commissioning and physics campaigns provide valuable information
- Experimental methods and analysis algorithms are steadily improving

Most NUSTAR experiments are able to perform day-one experiments within one or two years.

Test and commssioning at GSI as host laboratory is a critical issue

Funding of fully completed sub-systems in most cases not yet secured

NUSTAR EDAQ and common infrastructure needs to be tackled now

NUSTAR Instrumentation is in a very good shape