

# Extreme Light Infrastructure – Nuclear Physics (ELI-NP)



BMBF Verbund 05P2015



Darmstadt – Köln – München

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**Universität zu Köln**

# Extreme Light Infrastructure – a European project



## **ELI ATTOSECOND LIGHT PULSE SOURCE (ELI-ALPS) (SZEGED, HUNGARY)**

Ultrashort laser pulses with high repetition rate.  
Dynamic studies in the attosecond scale.



## **ELI-BEAMLINES (PRAGUE, CZECH REPUBLIC)**

Short-pulse secondary sources of particles and radiation.  
Biomedical, material, molecular sciences.



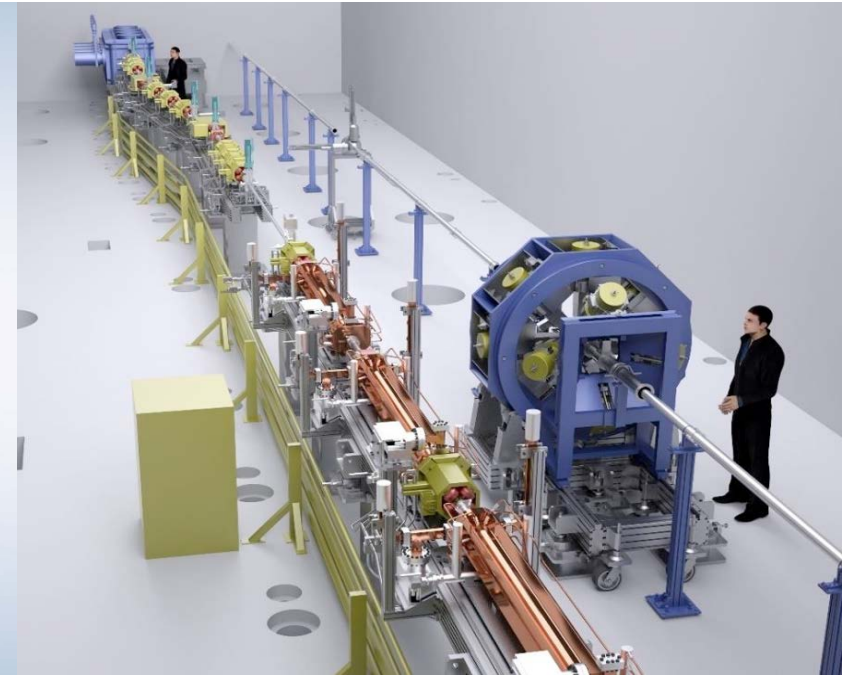
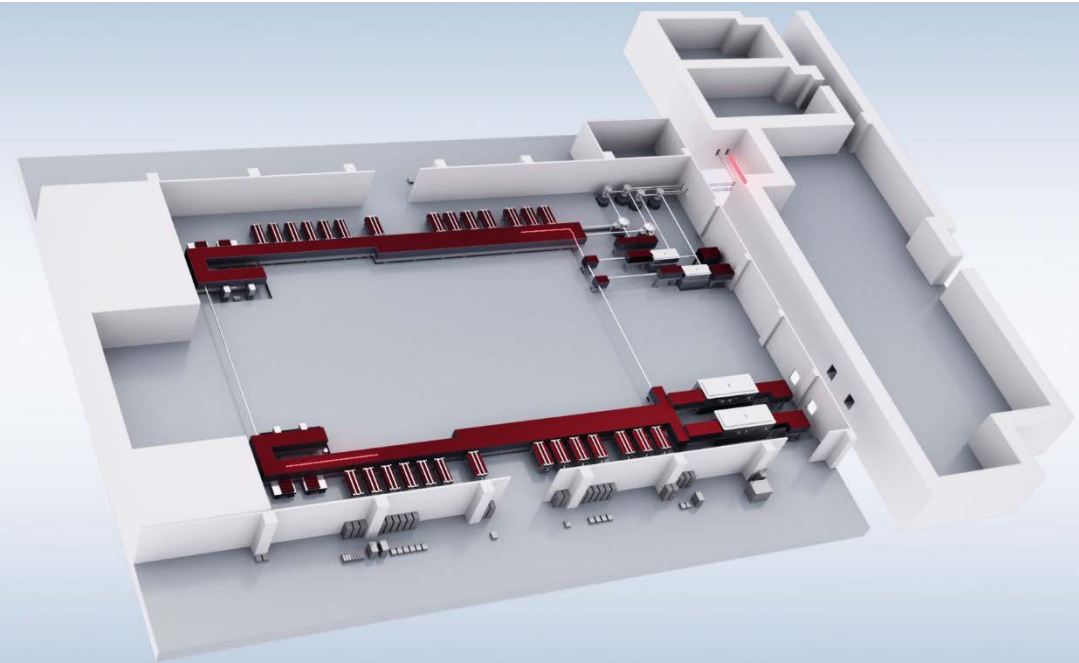
## **ELI NUCLEAR PHYSICS (ELI-NP) (BUCHAREST, ROMANIA)**

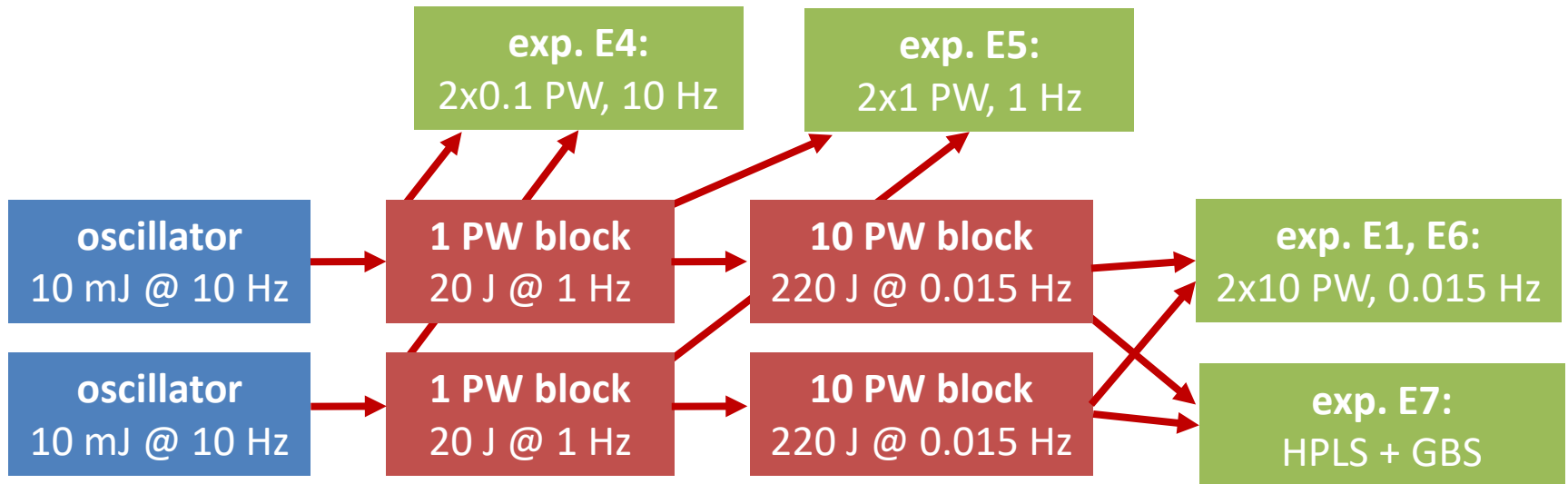
Ultrahigh-intensity lasers, intense MeV Gamma-beams.  
Laser-particle acceleration laser, photonuclear physics.

# Components of ELI-NP

- high power laser system **HPLS**, 2 x 10 PW maximum
- high intensity gamma beam system **GBS**,  
 $E_{\gamma} = 0.2-19.5$  MeV from laser-Compton backscattering
- eight experimental areas

Total investment: about 350 M€

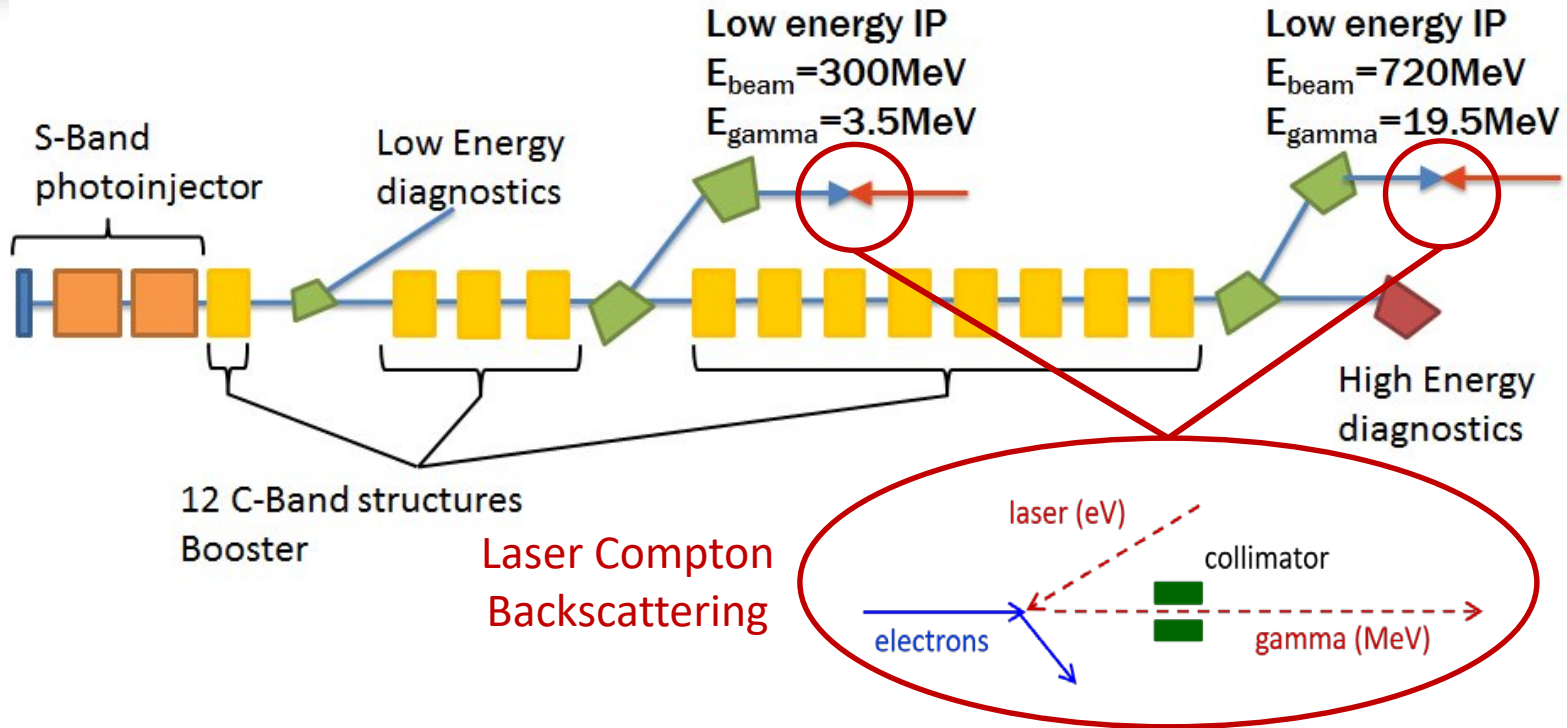




- intensities up to  $10^{23}$  W/cm<sup>2</sup>
- electric fields up to  $10^{15}$  V/m
- pulse duration < 50 fs

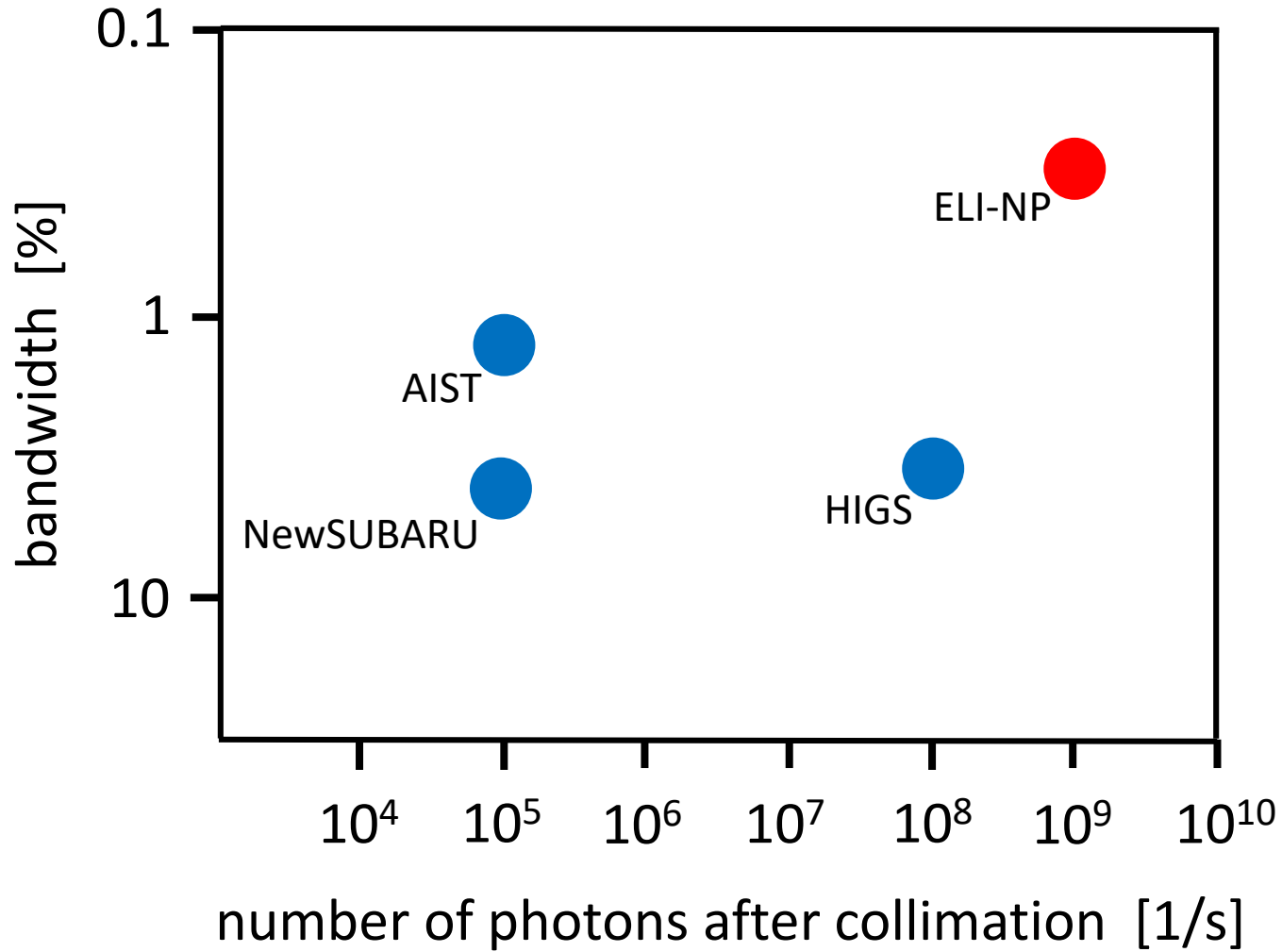


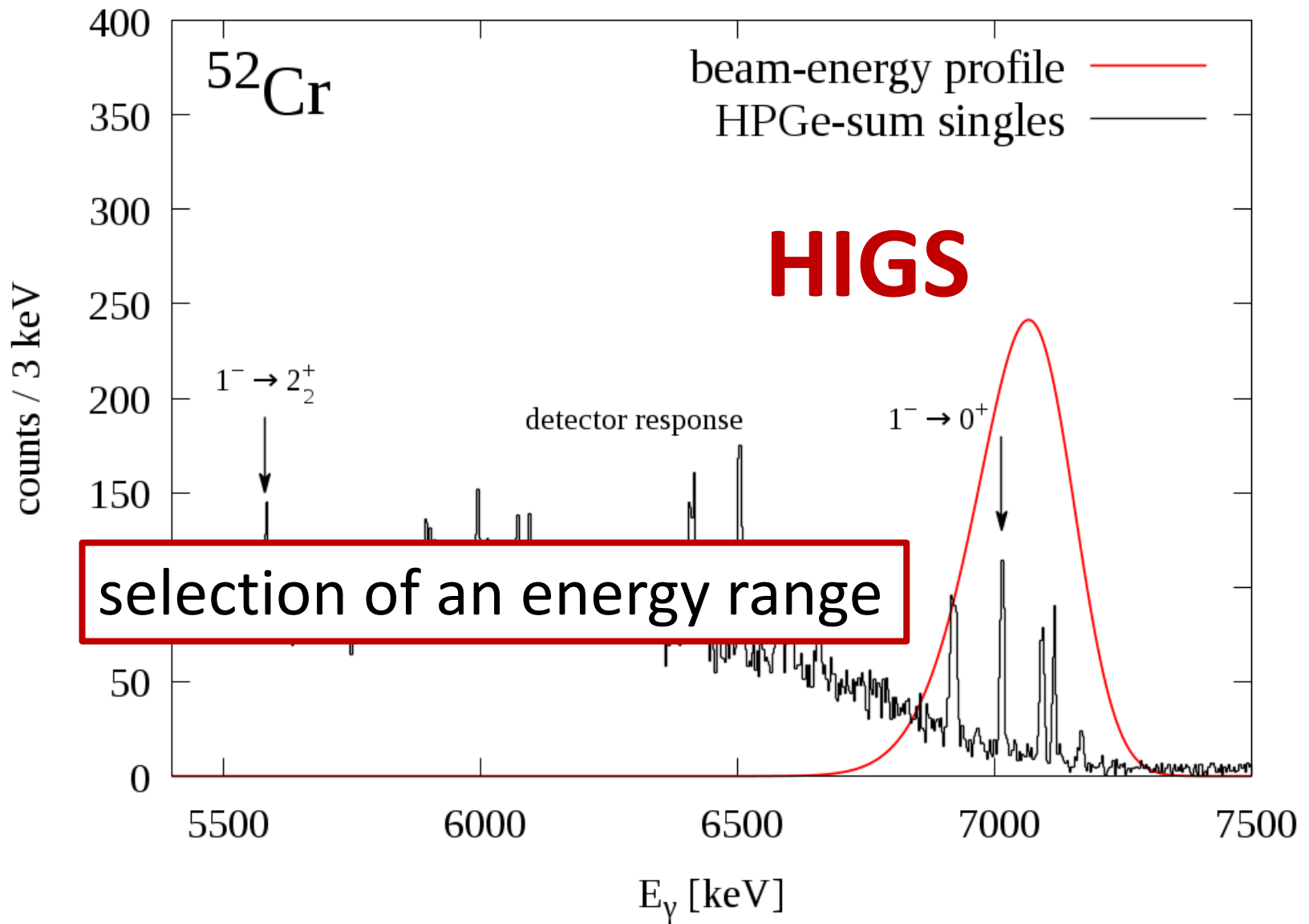
# Gamma Beam System - GBS

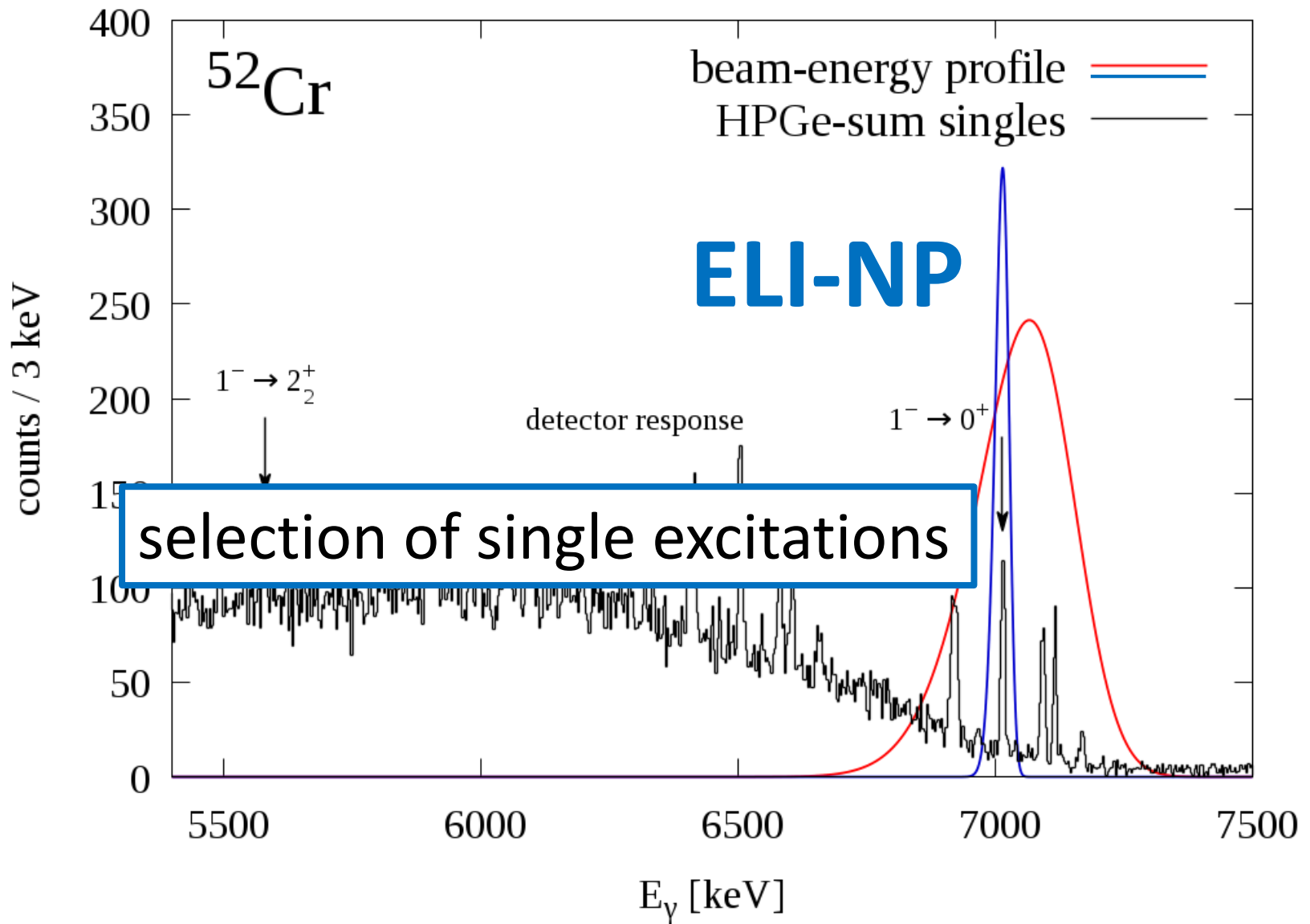


- variable energy (0.2-19.5 MeV)
- quasi-mononenergetic ( $\Delta E/E < 0.5\%$ )
- high-intensity ( $10^4$  photons/s/eV)
- completely polarized

**NUCLEAR  
PHOTONICS**









# Commissioning of ELI-NP

- Funds approved: September 2012
- Start of construction: June 2013
- Civil construction finished: June 2017



experimental hall

office building,  
guest house,  
restaurant



Oktober 2016

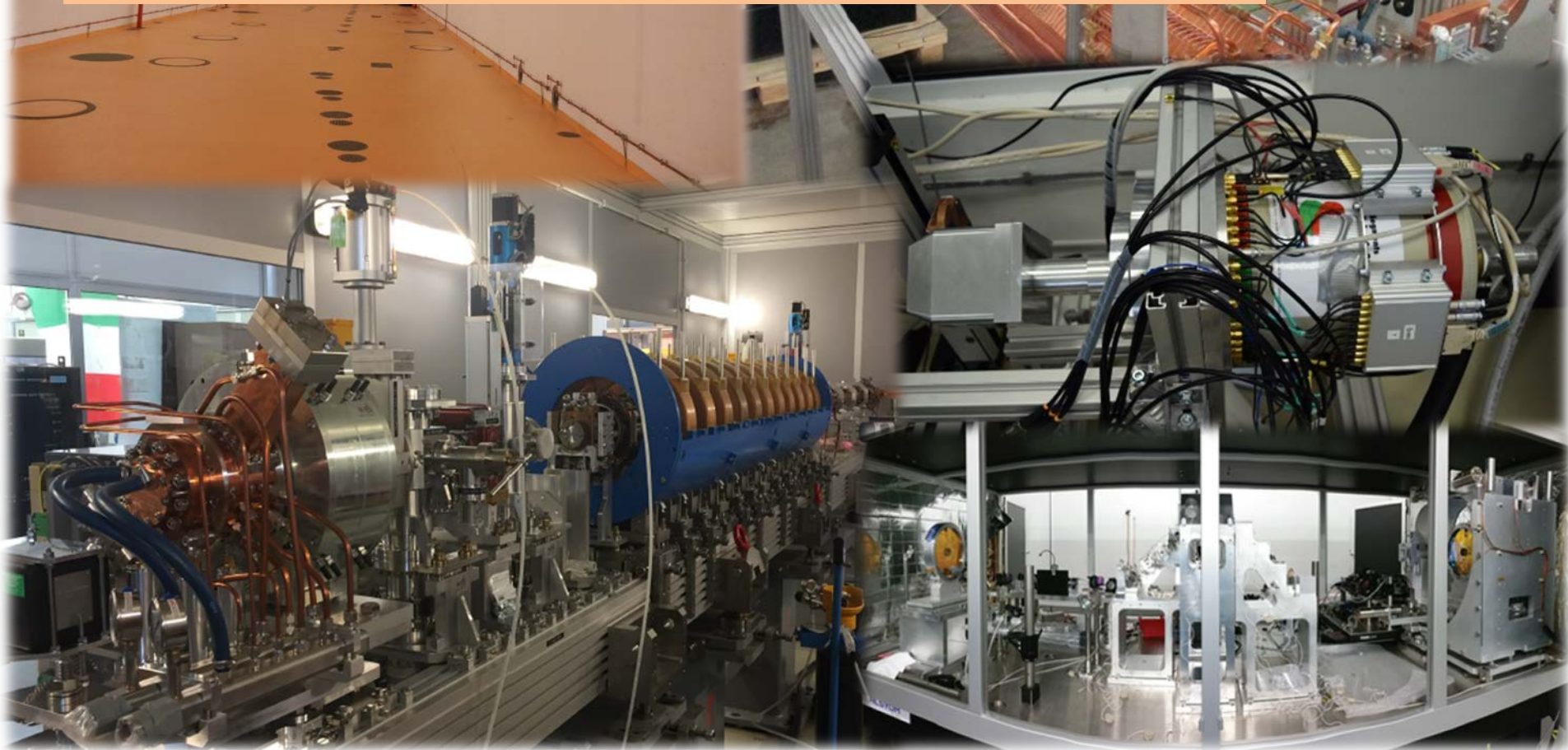
- most components in final position
- 4900 m<sup>2</sup> clean room operational
- 100 TW running since 10/2017
- 10 PW in 2019



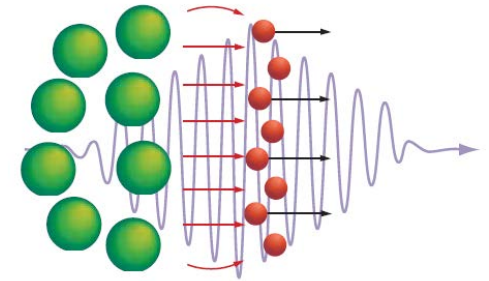
Oktober 2017



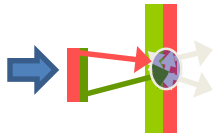
- all accelerator and laser parts tested before delivery
- re-assembling at ELI-NP started in 10/2017
- all experimental setups nearly finished
- first test beam 2018, full beam 2019



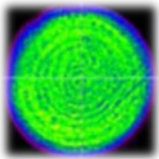
# High power laser-matter interaction



**How effective is ion acceleration  
by laser beams?**

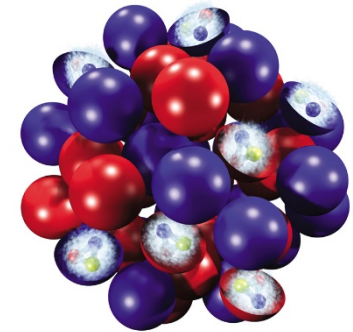


**The fission-fusion mechanism:  
A new way to extremely neutron-rich isotopes**

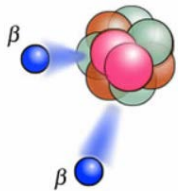


**Development of ultra-relativistic electron sources**

## Selective manipulation of excitations in atomic nuclei



**How do nuclear excitations violate parity?**

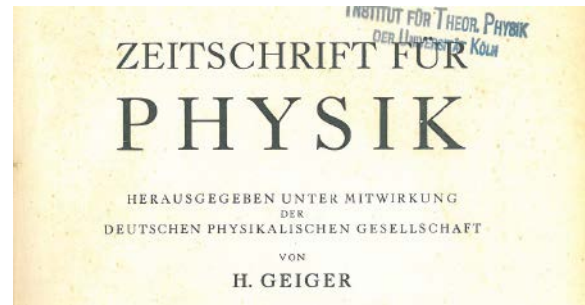
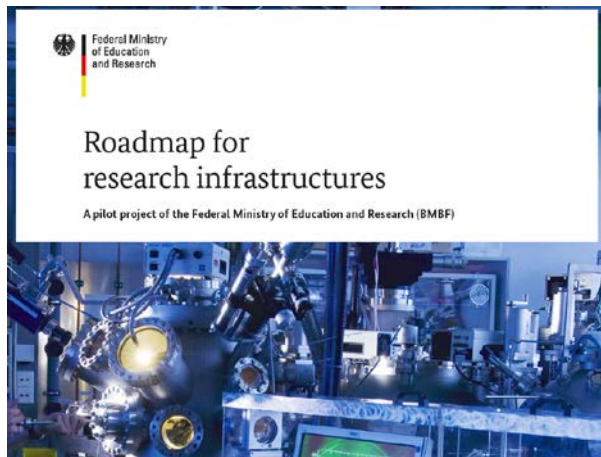


**Are there new boundary conditions to the neutrinoless double-beta decay?**



**What is the equation of state of nuclear matter and of neutron stars?**

- ELI-NP is on the roadmap of research infrastructures of the BMBF.
- Long history and expertise in photonuclear research in Germany.
- Strong involvement of German research groups from the very beginning of ELI-NP: Planning phase, white book.
- Major contributions (co-editing) to various TDRs.
- Membership in various committees: ISAB (4/10), ISAB-ELI-RO (2/5), Co-organization Nuclear Photonics 2016 and 2018
- BMBF network OP52015: ELI-NP supported since July 2015.



**Atomumwandlungen durch  $\gamma$ -Strahlen.**

Von **W. Bothe** und **W. Gentner** in Heidelberg.

Mit 3 Abbildungen. (Eingegangen am 15. Mai 1937.)





GBS 1 – photofission at the barrier



GBS 2 – pair spectrometer



GBS 3 – online diagnostics and activation experiments

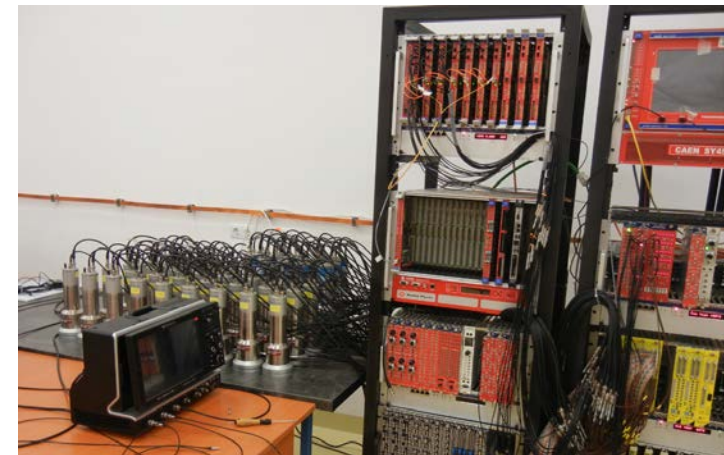
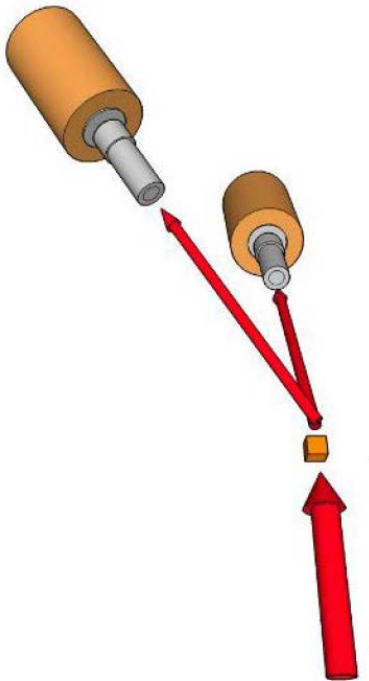


GBS 4 – NRF setup and day-one experiments



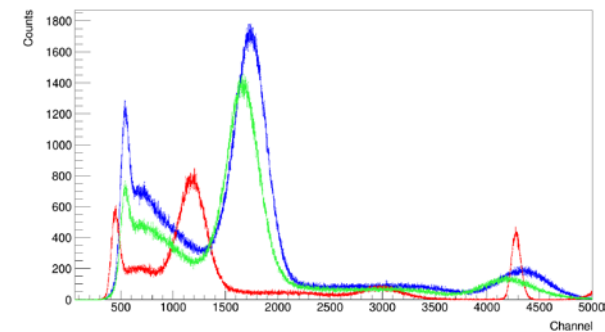
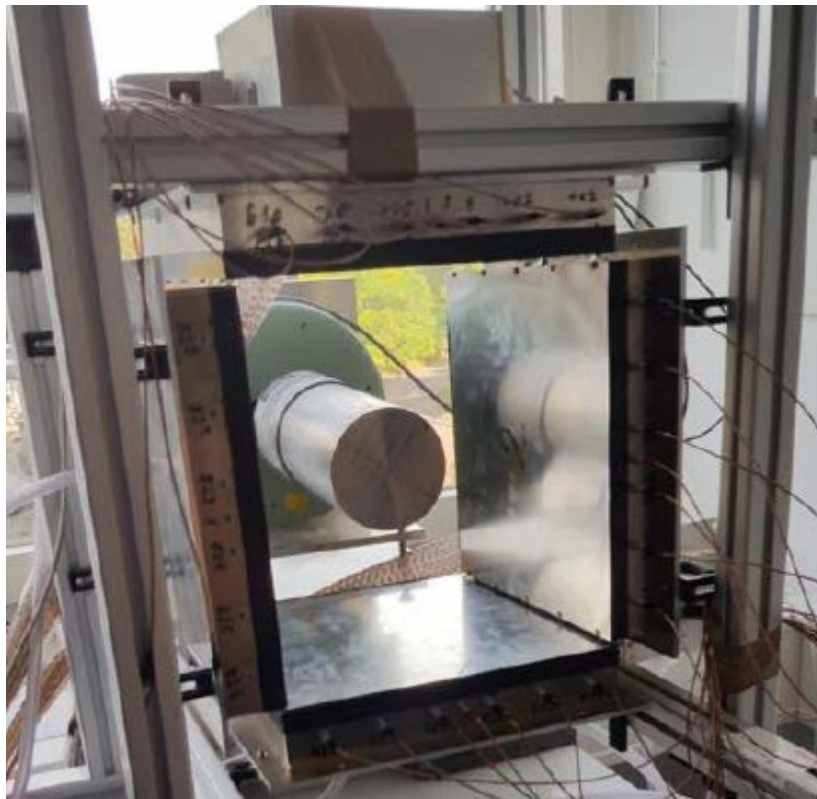
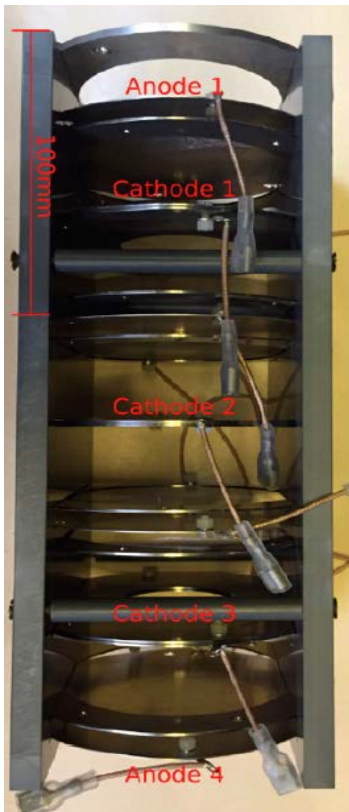
HPLS 1 – laser acceleration of heavy ions

- Compton-scattering based photon beam monitor
- Signal read out and transfer system for segmented Ge detectors
- Detector tests

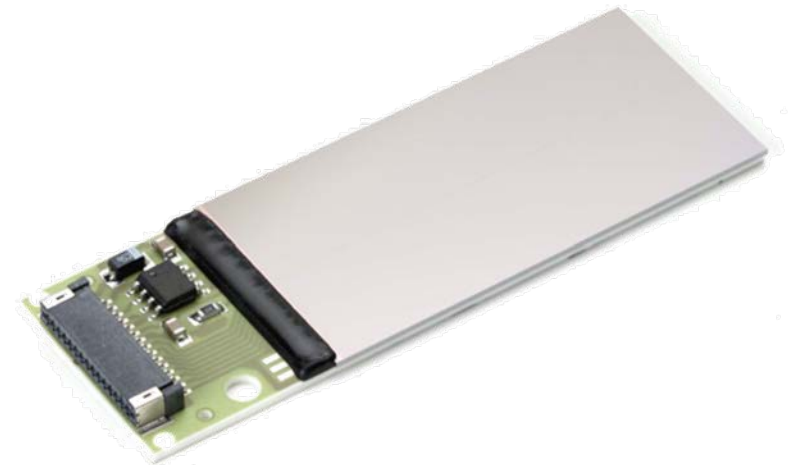
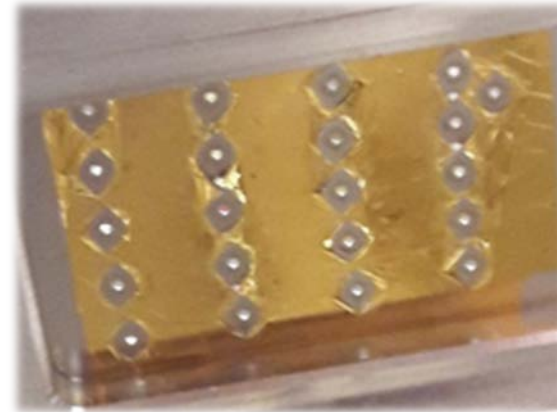


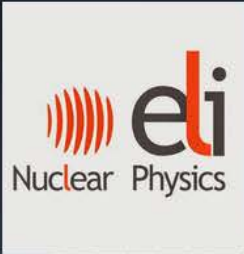


- Multi-cathode ionisation chamber for fission fragments
- Photodiode read-out (APD and SiPM) for szintillator crystals



- Target wheel and positioning system
- From non-electronic detection to CMOS pixel detectors





## BMBF-VERBUNDPROJEKT **ELI-NP**

Extreme Light Infrastructure - **Nuclear Physics**



### WAS IST ELI-NP?

Mit einem Investitionsvolumen von über 300 Millionen Euro wird die europäische Forschungsinfrastruktur ELI-NP in der Nähe von Rumänien aufgebaut. In weltweiter einzigartiger Weise sollen dort Laserstrahlen mit höchster Intensität und hochenergetische Photonenstrahlen mit bisher unerreichter Brillanz zur Verfügung stehen. Damit bieten sich völlig neue Möglichkeiten für die Grundlagenforschung in der Kern- und Astroteilchenphysik und für verschiedenste Anwendungen. Das BMBF fördert Arbeitsgruppen NP an drei deutschen Universitäten seit August 2015 im Rahmen Verbundprojekts GP2015.

© SBS GAMMA BEAM SYSTEM: Quasi-monochromatischer, hochenergetischer Laserstrahl mit unendlicher Energie bei  $\lambda = 0,2$  bis  $10,5$  MeV  
© HPLS - HIGH POWER LASER SYSTEM: Zum der aktuell weltweit im Laser mit je  $10$  PW maximaler Leistung und Intensitäten von bis zu  $10^{22}$  W/cm $^2$

### FORSCHERTEAM

- Prof. Dr. Andreas Zilges  
Universität zu Köln  
Vertikales Laserlabor
- Prof. Dr. Dr. h.c. Norbert Pietrala  
TU Darmstadt  
Projektleitung TUO
- PD Dr. Peter Thöniel  
LMU München  
Projektleitung LMU
- Prof. Dr. Axel Hülsmann  
TU Braunschweig  
Projektleitung TU Braunschweig

### FORSCHUNGSPROJEKTE

Die folgenden Projekte werden gefördert durch die BMBF im Rahmen des Verbundprojekts GP2015. Die Projekte sind:

- GBS 1
- GBS 2
- GBS 3
- GBS 4

© HPLS - HIGH POWER LASER SYSTEM: Zum der aktuell weltweit im Laser mit je  $10$  PW maximaler Leistung und Intensitäten von bis zu  $10^{22}$  W/cm $^2$

### ARCHIV - VORTRÄGE UND VERÖFFENTLICHUNGEN

ENGLISCHER PRÄSENTATION: "LASER DRIVEN PHOTONICS NEW HORIZONS AT ELI-NP"  
AUF DER INTERNATIONAL CONFERENCE ON EXTREME LIGHT '12 IN CROZEFINGRAN, NOVEMBER 2012

Andrea Eigen

Projektabschnitt	2018		2019				2020				2021	
	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2
GBS1: Aufbau Spaltkammer												
GBS1: Test mit Quelle und S-DALINAC												
GBS1: Erweiterung Multi-Anoden-Kammer												
GBS1: Entwicklung DAQ bei ELI-NP												
GBS1: Experimente an U- und Pt-Kernen												
GBS2: Aufbau Paarspektrometer												
GBS2: Experimente an der Schwelle												
GBS2: Pulsformanalyse ELIADE												
GBS2: Aufbau verzögerte Spektroskopie												
GBS2: Experimente verzögerte Spekt.												
GBS3: Aufbau Strahlmonitor												
GBS3: Experiment Ta-180												
GBS3: Experiment an T...												
GBS3: Weiterer...												
GBS3: F...												
...												
... Designparametern												
... Laserbeschl. Au-197												
... Charakterisierung Au-Ionenpulse												
HPSL1: Protoneninduzierte Spaltung												
HPSL1: Abbremsseffekte in Festkörperfolie												
HPSL1: Energieverlust in Plasmen												
HPSL2: Recherche und Simulation												
HPSL2: Test an Neutronenquellen												
HPSL2: Aufbau Neutronen-Strahlführung												
HPSL2: NRS an Kompositmaterial												
HPSL2: Probenherstellung												
	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2
	2018		2019				2020				2021	

ELI-NP will become fully operational during the next funding period