DRD1 WP9: Beyond High Energy Physics

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https://drd1.web.cern.ch/wp9

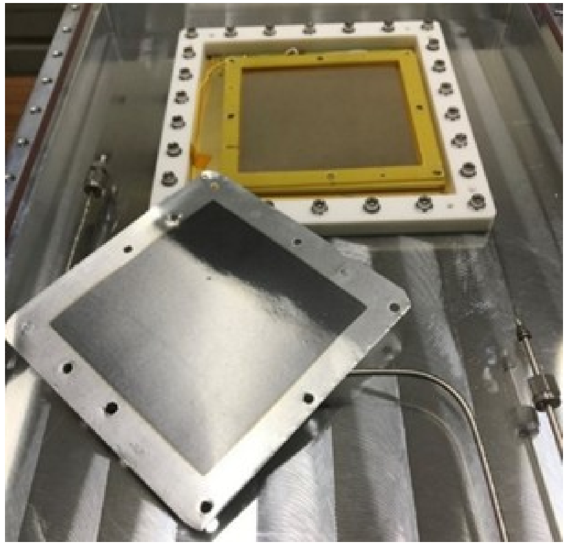
Beyond HEP: broad range of applications

- Aim is to **exploit achievements in frontier research**, transfer knowledge and technology to areas of high social and economic interest
- BHEP is more **cost-sensitive** than frontier research. It has **innovative** (secretive?) aspects, need for industrial production / construction techniques
- Detectors must work in **hostile environments**, run with low maintenance and be installed by non-experts, must be highly reliable

Scientific Projects

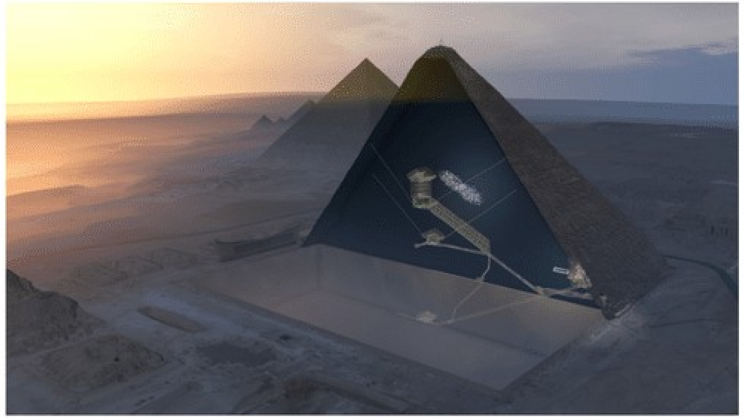
At the present status we identified three main projects, but should be **possible to include everything relevant to BHEP**. Most objectives are of joint interest!

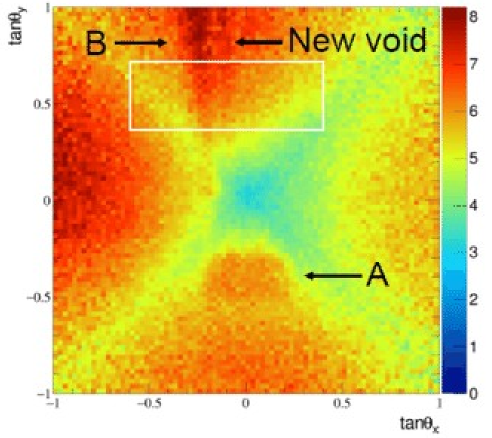
- Cosmic muon imaging (Dezső Varga)
- Medical Applications (Jona Bortfeldt)
- Neutron science (Gabriele Croci)

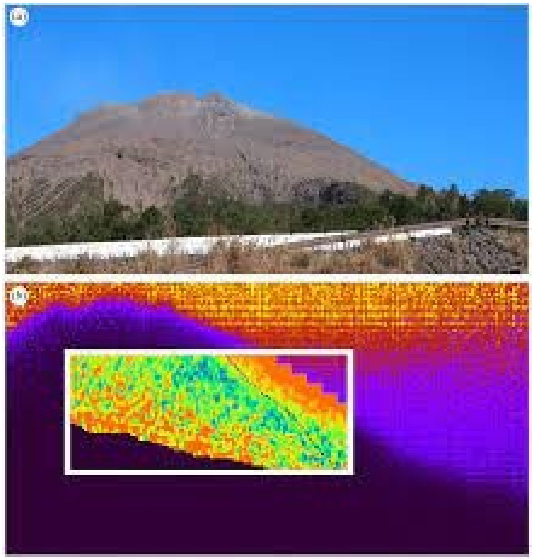


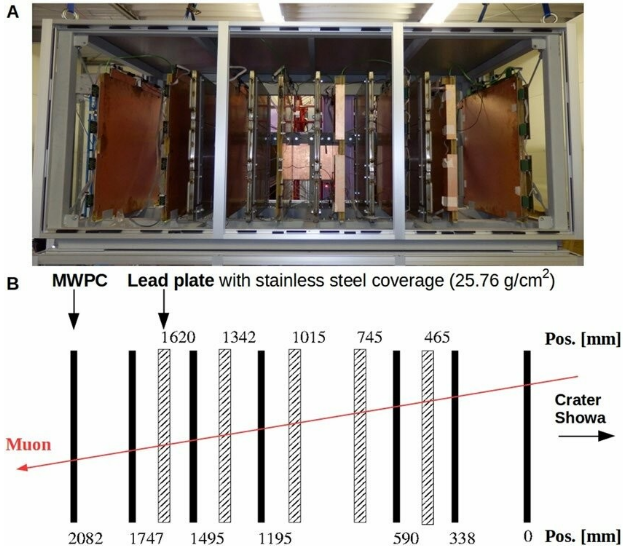
Cosmic muon imaging (muography) goals

- Developing research field, highly visible (ScanPyramids, volcanology) but also actually, socially and economically high impact
- Aim is to bring together knowledge, build collaborations, ensure information flow – many groups are new, knowledge scattered





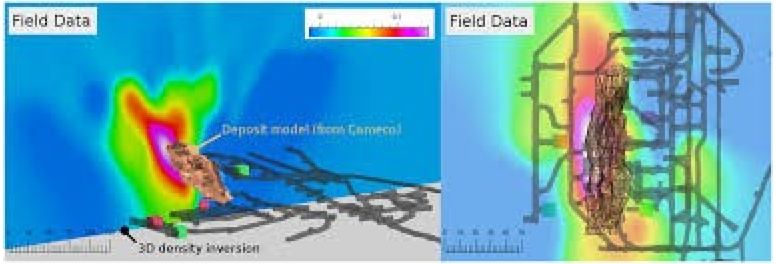




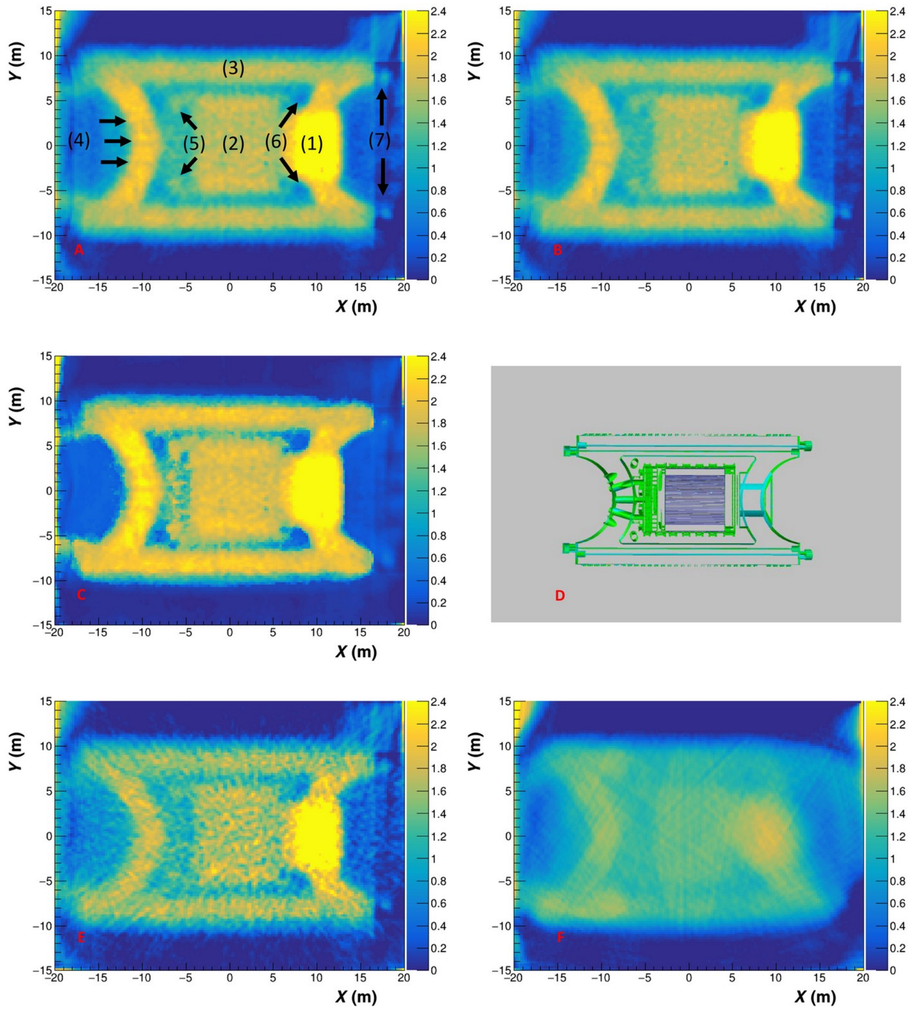
Participating Institutes: IRFU-CEA, LSBB, VUB/UGent, UCoimbra, UCL, Saha, NISER, Istinye U, INP Almaty, Wigner

Cosmic muon imaging (muography) goals

- Existing proof-of-concept measurements as basis
- Practical, field-proven, high TR-Level instruments. Should be lightweight, robust, low power, low maintenance
- Gaseous challenges: low (or no) gas consumption, low risk gases (eco-friendly, non-flammable, etc)



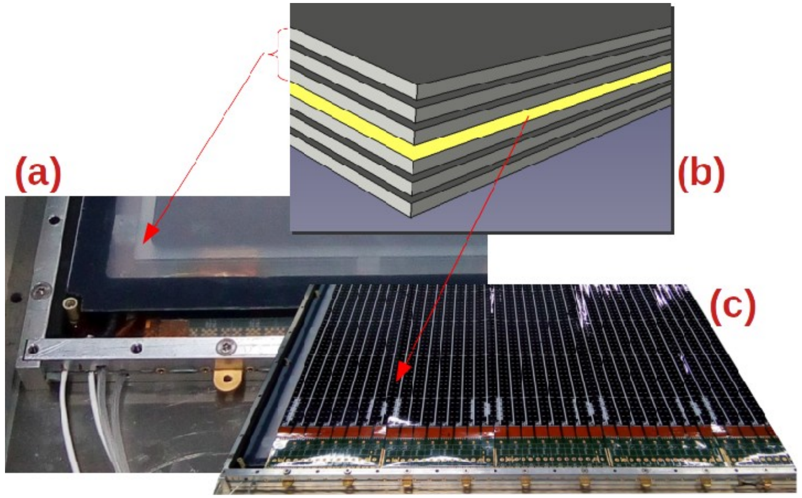
(Muon image with scintillator)



IRFU-CEA (Micromegas)

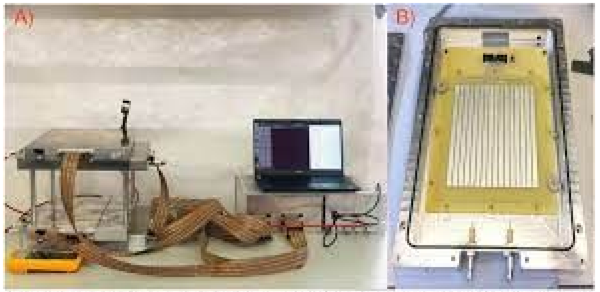
Muography – Tasks and Deliverables

- T1 (D1.1): **Cost efficient large size outdoor structures**
- Demonstration of outdoor-readiness of large size (>50cm) detectors, documentation of design features to reduce cost
- T2 (D1.2): **Extreme condition mechanical / thermal stability**
- Demonstration of applicability in limiting conditions (arctic to warm climate, low to high (>95%) humidity, vibrations, pressure changes). Compatibility with clinical environment and requirements
- T3 (D1.3): **Portability and low maintenance**
- Portability, scalability, modularity demonstration. Low to zero gas consumption operation. Documentation of solutions to reduce installation, maintenance needs



RPC: LIP Coimbra

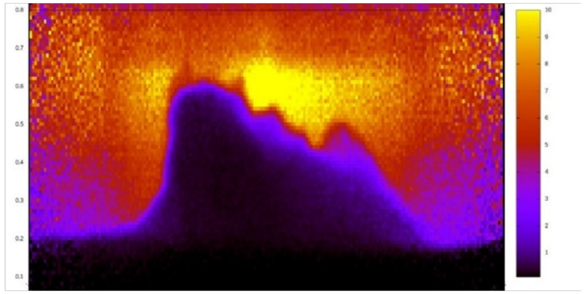
RPC: UCL



A) Muoscope set-up consisting of four glass RPC layers and DAQ. B) One of the RPCs inside its casing: consists of 16 sensitive strips, hosted in an air-tight aluminum box.

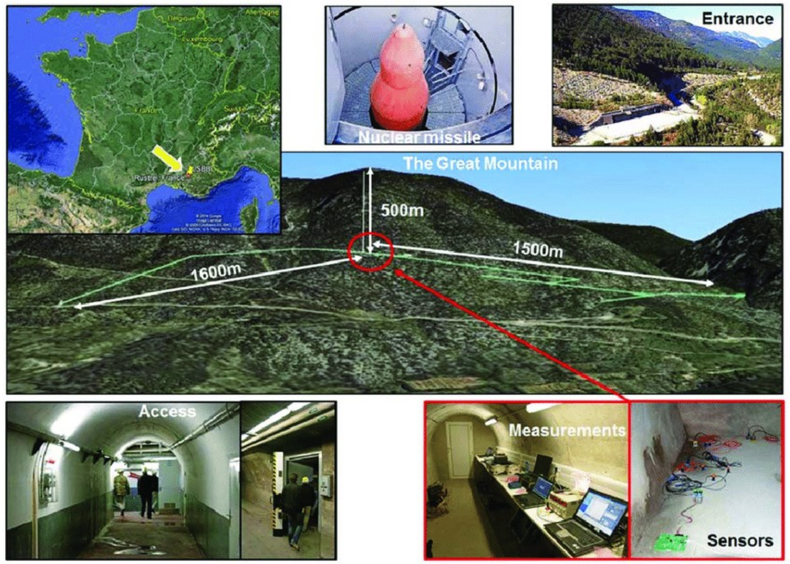
Muography – Tasks and Deliverables

- T4 (D1.4): **Cost efficient, low power, long life Front-End and DAQ**
- Demonstration of relevant electronics components, soluitons
- T5 (D1.5): **Detector configuraton optimization, simulations**
- Optimization and simulation algorithms, leading to efficient design, high predictive power on performance (resolution, background)
- T6 (D1.6): **Benchmarking infrastructures, performance evaluation**
- Characterization of benchmarking infrastructures (sites), joint definition of benchmarking parameters (resolution, efficiency, noise level, FoV, etc)



Wigner RCP

LSBB



Medical Applications goals

- **Join forces**: **collaborative** and **dedicated** gas detector **R&D** for medical applications and technology transfer into pre-clinics and clinics
- Cope with **requirements specific for clinical use**: fail-safety, operational stability, operation in non-laboratory environments, portability and cost
- Current drivers: radiation therapy, in-beam range monitoring, pre-clinical and clinical beam instrumentation (also at ultra-high dose rates), imaging

Medical Applications – Tasks and Deliverables

T7: Optical readout MPGDs for biomarker imaging and beam characterization in ion beam therapy

- Exploit production of light in electron avalanches in amplification gap to register energy deposition in the active area of the device. Gas gain easily adjustable → the same device sensitive to single particles and photons or to intense beams.
- Simulate, design and develop prototype detectors, suitable for individual gamma and charged particle detection as well as for ion beam characterization.

D7.1 Demonstration of the capability to measure sub-Becquerel activities (^{3}H and ^{14}C) in single cells with an optical readout Micromegas prototype.

D7.2 Development and characterization of an optical readout Micromegas device in pre-clinical and clinical particle beams.

Involved institutes: CEA Saclay, LMU, LIP

Medical Applications – Tasks and Deliverables

T8: Gaseous photon detectors for in-beam monitoring for ion beam therapy and imaging

- Improve ion beam therapy by in-beam range monitoring: Locate beam-induced tissue activation by positron emission tomography with 511keV-sensitive RPCs.
- Study gaseous photon detectors for use in other photon-based imaging modalities, such as imaging Positron Emission Tomography, SPECT, or for dosimetry applications.

D8. Assembly of a prototype for annihilation photon detection and study of its parameters on a dedicated experimental setup after MC simulation to determine optimum design parameters.

Involved institutes: Sofia, Johannesburg

Medical Applications – Tasks and Deliverables

T9: Beam monitors with high temporal resolution for ion beam therapy and space radiation simulation

- current gaseous beam monitors: position and intensity of raster scanned clinical ion beams
- temporal resolution to be increased by factor 100 for future more intense clinical beams, especially in ultra-high dose rate conditions, in breathing cycle-timed delivery, or for real-time beam monitoring for space radiation simulation
- add MPGD amplification structure to render chambers sensitive only to rapidly moving ionization electrons and increase sensitivity

D9.1 Report on the simulation, design and characterization of a prototype system with high temporal resolution for clinical beam monitoring with MHz temporal resolution and large dynamic range.

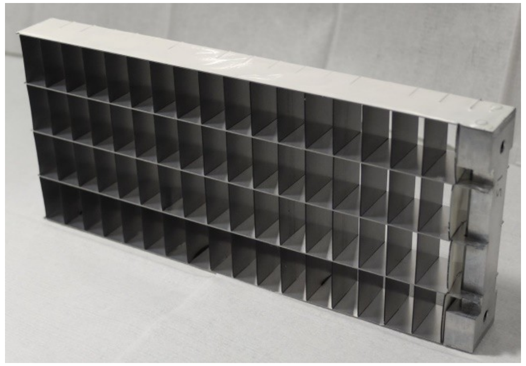
D9.2 Report on the design, characterization and optimization of a full-scale, low-material budget prototype for space radiation-like beam monitoring. Configurable for particles from carbon to uranium in a range from 100 MeV/u to 2 GeV/u, with spatial resolution better 0.5mm and fast feedback <10μs to the beam control system.

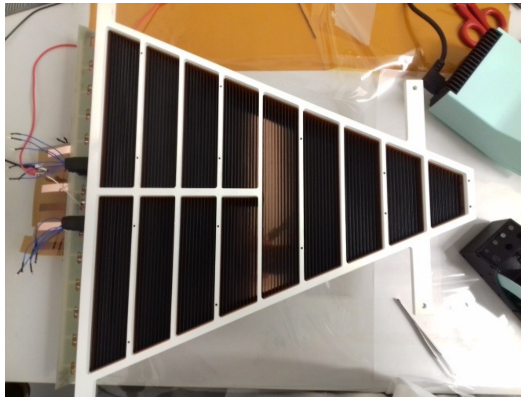
Involved institutes: LMU, MedAustron, GSI

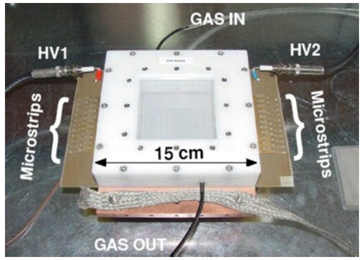
Neutron Science goals

- Development of high efficiency, high rate capability detectors to cope with high brillance neutron facilities (e.g ESS) w/o ^{3}He
- Development of large area and cost effective neutron converters coating (e.g 10B) laboratories
- Low-budget fast and thermal neutron beam monitors, beam profilers and beam loss monitors for safety applications
- Development of low background thermal epithermal and fast neutrons detectors
- Development of large area high granularity detectors
- Physics applications (e.g neutron differential cross section studies, fuel ion studies in fusion, ….)

In general: advance all neutron gaseous detector technologies to open new up applications







Neutron Science – Tasks and Deliverables

- **T10: Innovative neutron converter geometries** in combination with gaseous amplifying structures for high rate, efficient, low background detectors

  - Study and optimization of (2D or 3D) large area solid-state neutron converters (eg. based on B, Li, Gd, U-238, CH2)
  - Enhancement of solid-state converter geometries (especially 3D) to improve detector efficiency.
  - Study of the sensitivity taking into account the intrinsic resolution.
  - Evaluation of intrinsic background due to employed materials in the detectors and implementation of common strategies to limit it.

D10.1 Report on realization processes and characterization of 2D or 3D solid converters of different areas to determine chemical and physical properties.

D10.2 Report on efficiency measurements of different detectors realized by coupling solid state or gaseous converters to various amplification structures.

D10.3 Report on evaluation of intrinsic background due to employed materials in the detectors and on common strategies to limit it.

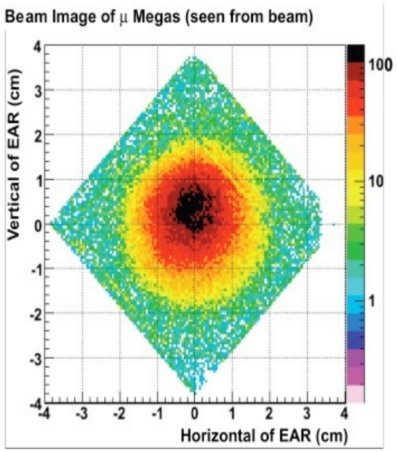
Involved institutes: UNIMIB, Bonn, LIP, AGH, Hamburg, Saclay, ESS

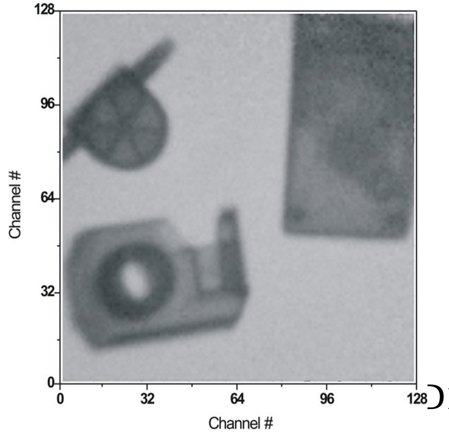
Neutron Science – Tasks and Deliverables

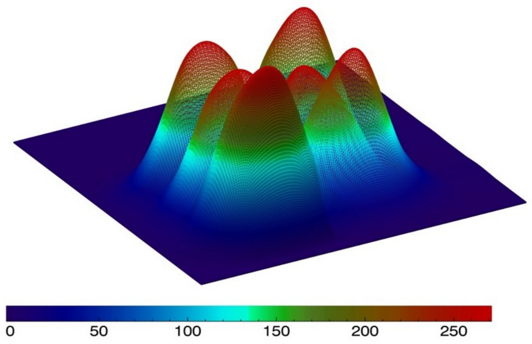
- T11: Spatial resolution, readout granularity and rate capability impact on neutron imaging and dosimetry
  - Enhance spatial resolution of neutron detectors by optimising readout granularity and develop readout solutions which can improve spatial resolution.
  - Evaluation of image-capability reconstruction for imaging applications, sensitivity and dosimetry in clinical environments

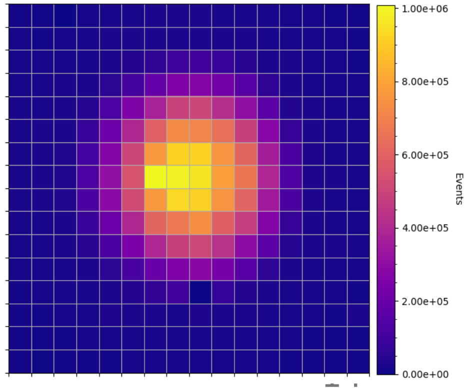
D11. Report on spatial resolution and image capability reconstruction with different detectors

Involved institutes: UNIMIB, Bonn, Hamburg, Saclay, ESS







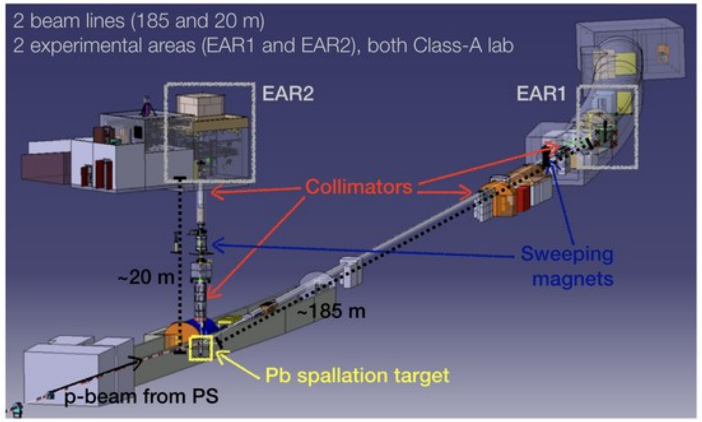


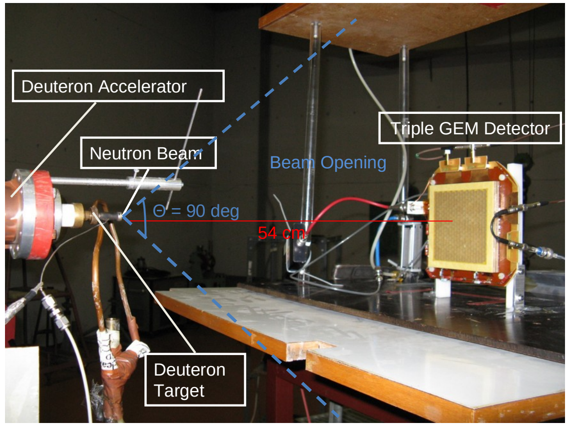
Neutron Science – Tasks and Deliverables

- T12: Study of Gamma Ray sensitivity and neutron discharge probability
  - Evaluation of gamma rays sensitivity of gaseous neutron detectors (gamma ray field associated with neutrons has an average energy of 1 MeV) by using high flux facilities like nTOF and GIF++ at CERN or other accelerator facilities (e.g clinical accelerators).
  - Detailed study of neutron induced discharge probability
  - Relevant also for beam monitors for clinical environments, especially at high dose rates or in high-gain single particle sensitive operation.

D12. Report on evaluation of gamma ray sensitivity and neutron discharge probability of different detectors subjected to high dose rate of gammas and neutrons

Involved institutes: UNIMIB, Bonn, Hamburg, Saclay, ESS





Next Steps

- Once established, WP9 was rapidly populated, many synergies identified – this is expected to continue as DRD1 is launched!
- Common activities expected to start soon, many started already
- Kick-off meeting with all WP9 members in February/March
  - Agree on organizational structure (if anything specific to WP9)
  - Agree on most efficient meeting schedule → also see discussion on Thursday
  - Present current status at each institute, discuss plans and agree on concrete joint efforts
- Continue populating **drd1-wp9 mailing list**: please send WP9 member names & addresses to WP9 coordinators
- Your topic or institute missing? contact WP9 coordinators!