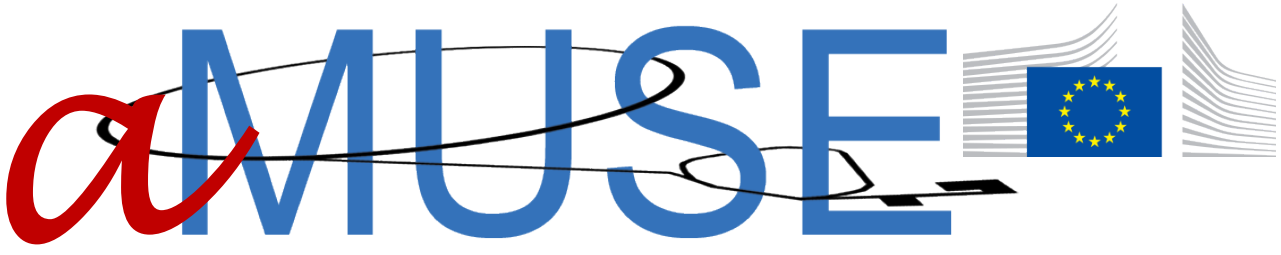


aMUSE overview

S. Giovannella (INFN LNF)

aMUSE Project Coordinator

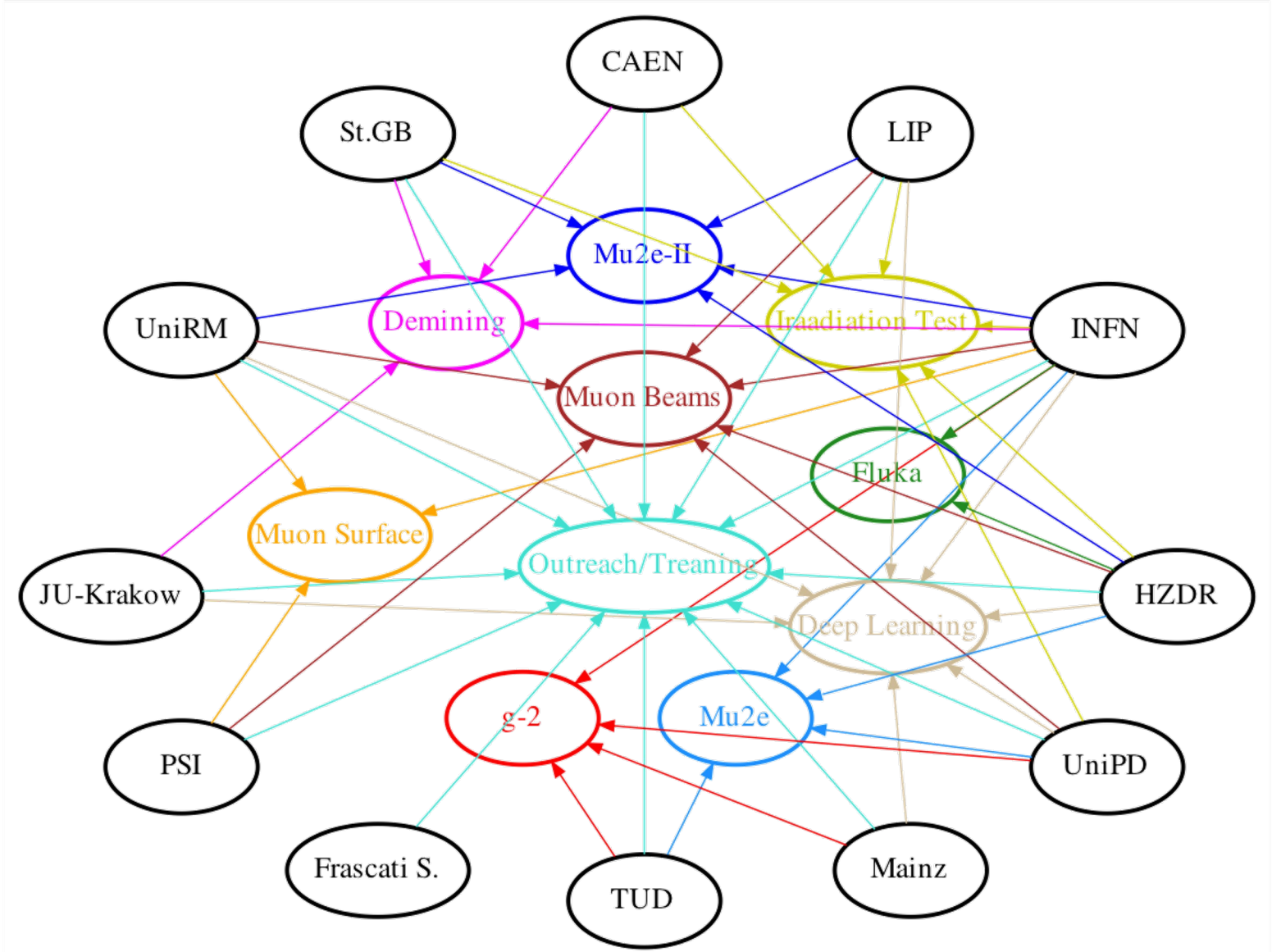
The aMUSE Project

- ✗ H2020 Research and Innovation Staff Exchange program (MSCA-RISE-2020)
- ✗ Extension of a previously funded RISE (MUSE, 2016-2019): **advanced MUSE**
- ✗ EU participants from 6 different countries:
  - ➢ 4 research institutes [**HZDR** (DE), **INFN** (IT), **LIP** (PT), **PSI** (CH)]
  - ➢ 5 universities [**JGU** (DE), **JU** (PL), **Padova** (IT), **Sapienza** (IT), **TUD** (DE)]
  - ➢ 2 companies [**CAEN** (IT), **St.Gobain→Luxium** (FR)]
  - ➢ 1 outreach organization [**Frascati Scienza** (IT)]
- ✗ Three US hosting institutes:
  - ➢ Fermilab (FNAL), Batavia, Illinois
  - ➢ Brookhaven National Laboratory (BNL), Upton, New York
  - ➢ Stanford Linac Accelerator Center (SLAC), Menlo Park, California
- ✗ ~ 80 researchers involved, total number of secondments: 413 person-months
- ✗ Timeline: **1 Jan 2022 ⇨ 31 Dec 2025**

Scientific Program

- Muon Campus Experiments at Fermilab: Muon (g-2) and Mu2e
  - Muon (g-2): emc & magnetic field calibration, data taking, ω_a measurement
  - Mu2e: emc commissioning & calibration, beam normalization, first data studies
  - Theoretical studies
- CLFV exploiting the high intensity beam @ PIP-II accelerator complex
  - Mu2e-II: R&D for detectors, beamline and shielding simulation
  - Feasibility study for muon decay searches with a high rate μ^+ beam from Mu2e beamline
- Development of muon beams
  - Muon beams cooling at different energies
  - Feasibility study of a high energy muon collider: beam IR optimization, radiation hazards, detector R&D
- Fundamental particle physics R&D applications to other fields:
  - Irradiation damages studies
  - Hazardous substance identification for mine-clearance and counter-terrorism
  - Laser-plasma characterization

aMUSE at a glance



aMUSE impact objectives

- ✗ Establish new collaborations among European groups participating in the project
- ✗ Increase our presence and visibility in the hosting institutes, strengthening the already existing partnership with the labs
- ✗ Exploit the existing European infrastructures to create a network of radiation hardness tests and characterization of detector components
- ✗ Transfer of knowledge among partners, exploiting specific competences of aMUSE participants
- ✗ Promote inter-sectoral collaborations among research and industry
- ✗ Use EU funds to increase
  - ✓ training, skill development of personnel
  - ✓ dissemination activities
  - ✓ science communication

Project Organization

aMUSE activities are organized in seven Work Packages (WP):

WP1	WP2	WP3	WP4	WP5	WP6	WP7
Muon Campus Experiments	Muon Campus Upgrade	Muon Beams	Software tools	Communication & outreach	Transfer of knowledge	Management
INFN	UniRM	UniPD	LIP	FS	HZDR	INFN

- WP1: Muon (g-2) and Mu2e experiments, theory developments
- WP2: R&D for Mu2e-II and feasibility studies for CLFV from muon decays at PIP-II
- WP3: R&D studies for muon collider and cooling of low energy muon beams
- WP4 connects specific expertise developed in WPs 1-3 into one synergic activity among all network participants
- WP5 coordinates communication & outreach activities of all participating institutes
- WP6: training and application of fundamental research to other fields
- WP7 coordinates and supervises activities across all the WPs

A convener for each WP from "Lead Beneficiary", co-conveners selected among researchers with experience in the field

Management

Project Coordinator: responsible for the day-to-day management and coordination of the aMUSE project and is the contact person with the Research Executive Agency of the European Commission

A **management support team** assists the project coordinator in financial and administration matters and in the development of the web site

Two boards for running the project:

✗ **MANAGEMENT BOARD** (meets each 4 months)

- Decision-making body, general guidelines
- One member for each partner + the coordinator (chair)

✗ **SCIENTIFIC BOARD** (meets each 3 months)

- Coordination of the network scientific activities
- WP conveners and co-conveners

Gender / Impact / Transfer of Knowledge advisors to maximize knowledge sharing, visibility and equal opportunity

Sharing information

Several communication channels to distribute information among participants:

- ✗ Specific mailing lists ensure the distribution of information among participants, both for scientific and administrative activities
- ✗ aMUSE website: http://amuse.lnf.infn.it/
  - private section to share documents and information among participants
    - minutes and slides of each aMUSE meeting (MB/SB included) available to all participants
  - section for the general public to maximize the visibility of the project
- ✗ Periodic reports (6 months)
- ✗ General Meetings (one per year)

Web site: http://amuse.lnf.infn.it

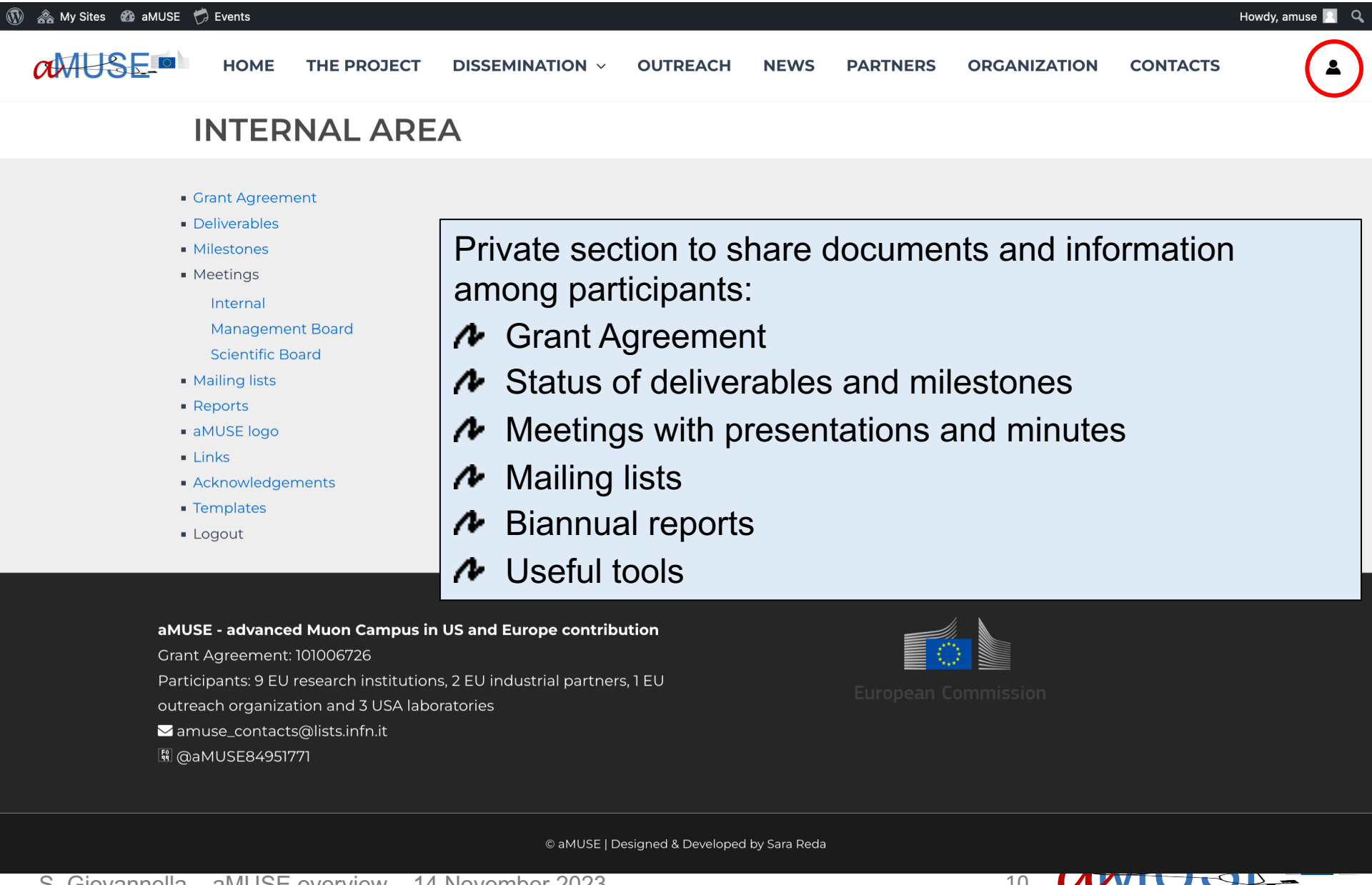
Public section for the general public to maximize the visibility of the project:

- General information on the project and its organization
- Dissemination and outreach events being kept updated on the web site with talks/posters/seminars, publications, communication and outreach events

industries participating to the search for New Physics in the muon sector and to the design of a new generation muon accelerators in high-profile US laboratories (Fermilab, BNL, SLAC).

The project involves the two Fermilab Muon Campus Experiments:

Web site: http://amuse.lnf.infn.it



WP6: Transfer of knowledge

✗ **Objectives**: coordination of the activities dedicated to the training of research and industry personnel to achieve a substantial ToK among participants and to increase the quality of the research and the competitiveness of the partners. The final goal is to provide the trained personnel with enough capabilities to become independent in their new competences

✗ **Tasks**: (6.1) research-industry ToK; (6.2) High Precision Crystal applications; (6.3) laser plasma detectors; (6.4) training

✗ **Activities**:

- **Irradiation program** involving research and industry aMUSE partners (HZDR, INFN, CAEN, LUXIUM)
- R&D on **High Precision Crystals** for scientific applications and remote detection and identification of hazardous substances (JU, INFN, LUXIUM, CAEN)
- Detectors for **laser plasma characterization** (HZDR, INFN, SLAC)
- **Training courses**: aMUSE General Meetings + others (ALL)

GM Training session
6 June 2023

09:00 **From Machine Learning to Differentiable Programming**
- Giles Chatham Strong

09:45 **Development of LGAD Sensors at FBK**
- Matteo Centis Vignali (Fondazione Bruno Kessler)

11:00 **Multichannel Digital Readout Strategies for Next-Generation Physics Experiments**
- Yuri Venturini (CAEN)

11:45 **Mu2e laboratory: Quality Control of SiPM, FEE readout**

Other networking activities

Besides the tasks listed in WP6, the activities planned in the aMUSE project are conceived to create new research collaborations and reinforce the already existing ones:

- **Detector R&D**
  - The design of the CAPRHI detector involves detector experts (INFN), radiation transport simulation (HZDR) and crystal producers (LUXIUM)
  - Distinctive skills in detector and simulation (INFN, UniRM, PSI) will be gathered together for the conceptual design of new challenging tracking detectors for cLFV experiments
  - Detector expertise in WPs 1-2 is transferred to research groups working on the design and optimization of detectors for high energy muon beams

Proposal for MuCol calo: prototyped and tested (CRILIN)

- **Muon beam studies**

  aMUSE created, for the first time, a network between European and US communities

- **Machine learning**

  expertise in advanced Machine Learning algorithms (HZDR, LIP) will be transferred for data analysis and detector reconstruction algorithms (INFN, UniRM, JU, JGU)

- **Monte Carlo simulation**

  simulation of the interaction and transport of particles and nuclei in matter (HZDR, INFN) is applied to shielding and radiation protection in HEP experiments, and simulation of beamlines (UniPD, UniRM, LIP, PSI)

- **Communication and Outreach**

  All partners will profit of the high competences of Frascati Scienza on spreading the scientific culture

Training

Secondments give a unique opportunity to aMUSE participants in improving their individual skills and career perspectives enhancing:

- work in high-level environment in international laboratories, with research activities at the cutting-edge of technology
- involvement in different activities, from design to prototyping, construction and commissioning phases
- opportunities to come in contact with colleagues from other institutions

aMUSE provided also the opportunity to:

- increase attendance of schools for PhD students and postdocs
- attend training courses (management, science communication, language…)

} 20 events listed

We have also organized specific training courses during General Meetings on specific advanced topics from research development in HEP or industry

aMUSE impact on MuCol community

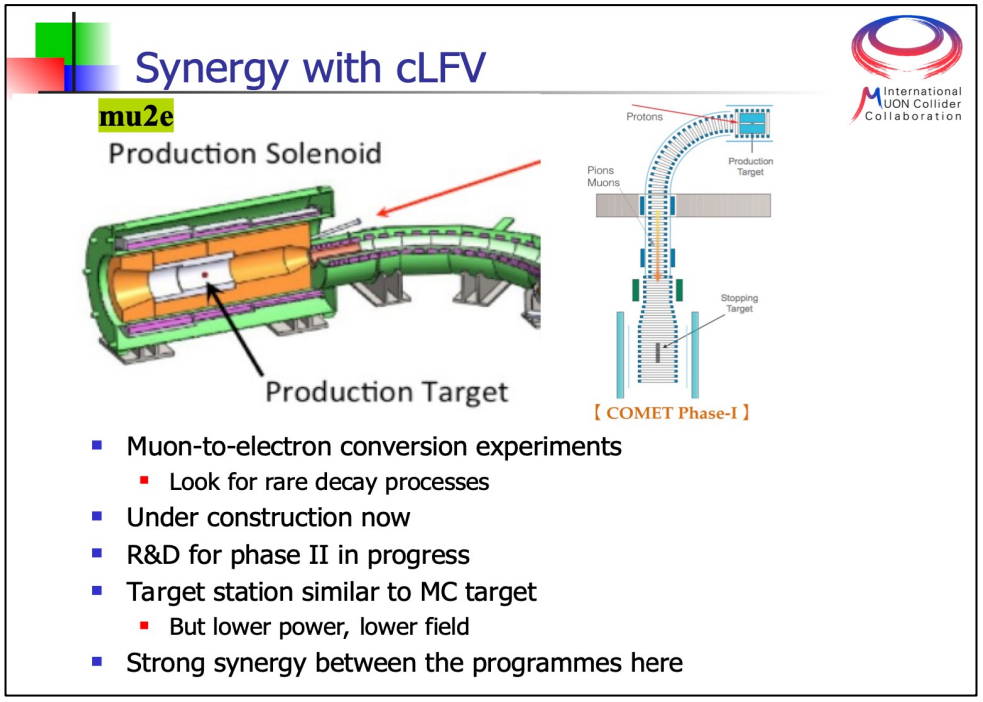
- aMUSE established for the first time an EU-US collaboration for the the study of muon beam technologies that could be exploited for the design of new high intensity and high energy frontier muon collider exploiting:
  - FNAL and BNL longstanding experience on muon beam technologies
  - EU expertise on the development of software tools to study the effects of the beam-induced background on the physics reach and on detector R&D
- After the aMUSE start-up, the International Muon Collider Collaboration (IMCC) was established also thanks to the aMUSE researchers, that are now part of the panels and working groups leading this effort
- Secondments to US also facilitated the participation of aMUSE researchers to the conclusive meeting of the Particle Physics Community planning exercise (aka Snowmass), contributing to the preparation of the summary document that provided input to the next US Particle Physics Project Prioritization Panel (P5)

International MUON Collider Collaboration

http://muoncollider.web.cern.ch

Unexpected synergies

- ✗ Mu2e talk at the 2022 IMCC first annual meeting, CERN, 11-14 October 2022
- ✗ Half day event: “Discussion of shared targetry needs between MuCol and Mu2e”, 31 January 2023
- ✗ C. Rogers, “Muon collider demonstrator project and CERN muon facility”, Muon4Future Workshop, Venice, 29-31 May 2023



Role of Secondments

RISE projects funds 'secondments', i.e. temporary transfers among project institutes:

- ➢ EU ➡ non-EU hosting institutes
- ➢ research ↔ industry within Europe
  (but different EU countries)

EU financing rule:
- 4600 € for a 30-day secondment
- 1/30*4600 € for every extra day

Eligible staff seconded under RISE project:

- ✗ **ESR**: in the first 4 years of the research careers and not be awarded a PhD degree
- ✗ **ER**: PhD or at least 4 years or full-time equivalent research experience
- ✗ **TECH**: technical staff directly involved in research and innovation activities
- ✗ **NO master thesis students**

Eligible secondments under RISE projects:

- ✗ A secondment receives funds if it lasts at least 30 days in the same host institute
- ✗ Secondments can be split in different travels along the 4 years of the project
- ✗ The same researcher can travel to different host institutes
- ✗ Contribution to 30-day secondments MUST be at least 2100 €/month

Summary

- ✗ First 2 years of the project completed, aMUSE active until Dec. 2025
- ✗ Despite some delays in few specific items, aMUSE activities are progressing well:
  - several achievements on the scientific side
  - despite the slow start-up due to pandemic, a reasonable fraction of planned secondments started
  - milestones on track, some delays on longer term activities
  - no showstopper to complete deliverables
  - very active networking and transfer of knowledge among different institutions
  - a lot of dissemination and outreach events

All INFN personnel and associated staff can easily profit of the aMUSE funds for travels among participating institutes

aMUSE irradiation network

- Existing European (and US) infrastructures used to carry on an irradiation program among aMUSE participants (HZDR, INFN, CAEN, LUXIUM), aiming to test radiation hardness and characterize detector components of the Mu2e, Mu2e-II detectors

- Already exploited in the previous RISE project, MUSE

- The ELBE accelerator complex at HZDR provides both high dose neutron flux (pELBE) and high-intensity Bremmstrahlung radiation (gELBE)

  - Several irradiation campaigns (neutrons, protons, photons) already performed @ ENEA/CNAO (Italy) and Fermilab, UCDavis (US) for the characterization of digital electronics for Mu2e

  - Two irradiation beam time approved @ ELBE for the second half of 2023:

    - Radiation hardness of scintillating crystals @ gELBE for the technology choice of the Mu2e-II calorimeter
    - Precise characterization of the neutron source for next round of irradiation campaigns