

# SHADOWS-LNF: 2023 Status Report

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## 1 Status of the SHADOWS project

The year 2023 has been fully dedicated to the preparation of the SHADOWS Technical Proposal. The Technical Proposal has been submitted to the SPS Committee in August 2023 and is a 220 pages long document publicly accessible at the following location: <http://cds.cern.ch/record/2878470/files/SPSC-P-367.pdf> The LNF group has taken the responsibility of the chapter related to the Muon System. G. Lanfranchi, as interim-spokesperson of the project, is the main Editor of the Proposal.

Between August and October 2023 the SPSC has done an in-depth review of the project. The decision about the approval of the project, initially foreseen to be taken during the CERN Research Board of 6 December 2023, has been postponed to March 2024, in order to allow the CERN Directorate to integrate the scientific review with informations related to resources and funding. A full document related to resources has been submitted to the CERN Management on February 16th.

The Technical Proposal, has been signed by about 80 people coming from the following institutions:

1. INFN, Sezione di Napoli, Napoli, Italy
2. Ruprecht-Karls-Universität Heidelberg, Heidelberg, Germany
3. INFN, Sezione di Ferrara, Ferrara, Italy
4. INFN Laboratori Nazionali di Frascati, Frascati (Rome), Italy
5. INFN, Sezione di Roma III, Roma, Italy
6. Johannes Gutenberg Universität Mainz, Mainz, Germany
7. INFN, Sezione di Bologna, Bologna, Italy
8. CERN, European Organization for Nuclear Research, CH-1211 Geneva 23, Switzerland
9. Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany
10. PARTREC and University of Groningen, Groningen, The Netherland
11. University of Freiburg, Freiburg, Germany
12. Charles University, Prague, Czech Republic
13. Royal Holloway, University of London, UK
14. INFN, Sezione di Roma1, Roma, Italy
15. University of Bologna, Bologna, Italy
16. University of Lancaster, Lancaster, UK

The main institutions and national labs that have contributed to the design of the detector and will contribute to the construction of the experiment if approved, are listed in Table 1. The groups from LNF, together with Bologna and Ferrara, will take care of designing and building the SHADOWS muon system.

Table 1: Main institutions (universities and national labs) contributing to the design and construction of the experiment .

<b>Item</b>	<b>Technology</b>	<b>Interested groups</b>
MIB system	magnetized iron blocks	CERN
Upstream Veto	Micromegas	INFN-Rome3, INFN-Naples
Decay Volume	He-based	INFN-Ferrara
Dipole Magnet	warm	CERN
Tracker	Straws	University of Heidelberg
Timing Layer	scintillating bars	University of Freiburg
ECAL	StripCal	Mainz cluster of excellence Karlsruhe Institute of Technology
Muon	scintillating tiles	INFN-Laboratori Nazionali Frascati INFN-Ferrara, INFN-Bologna
Software		INFN-Rome 1, Prague
TDAQ		CERN
NaNu		University of Bonn

In 2023, the LNF, Ferrara and Bologna INFN groups have built and operated two full-scale muon system modules that have been used for the measurement of the muon flux in ECN3 in June 2023 (Figure 1). These modules have been funded in 2023 by INFN and by AIDA-Innova European Grant (Task 8.3.2, Large scale scintillator detectors) for a total of o(30) kEuros (material) + 1.0 PhD-equivalent (25 kEuros). In addition to the PhD funded by AIDA-Innova, 2 electronic engineers, 3 technicians, and o(5) staff physicists have been involved in the construction and test of the prototypes.

The measurement of the muon flux in the ECN3 area has allowed the SHADOWS collaboration to validate the Monte Carlo simulations necessary for a proper estimate of the muon background.

## 2 Outlook

The future of SHADOWS depends upon the approval, that will be known in March 2024. In case of positive outcome the timeline of project is shown in Figure 2. If approved, we plan to prepare a Technical Design Report (TDR) by mid of 2026 and undergo through a Production Readiness Review (PRR) by the end of 2026. This would allow a timely start of the construction in 2027, which could last until mid-2029, followed by one year of installation/commissioning in 2029-2030. The first pilot run could be performed already by the end of 2030 or the beginning of 2031. Then we expect height years of data taking when the beam will be operated 50% of the time in kaon mode (for HIKE phase I) and 50% of the time in beam-dump mode (for HIKE and SHADOWS), interleaved by long shutdown periods that will be used to consolidate the setup.

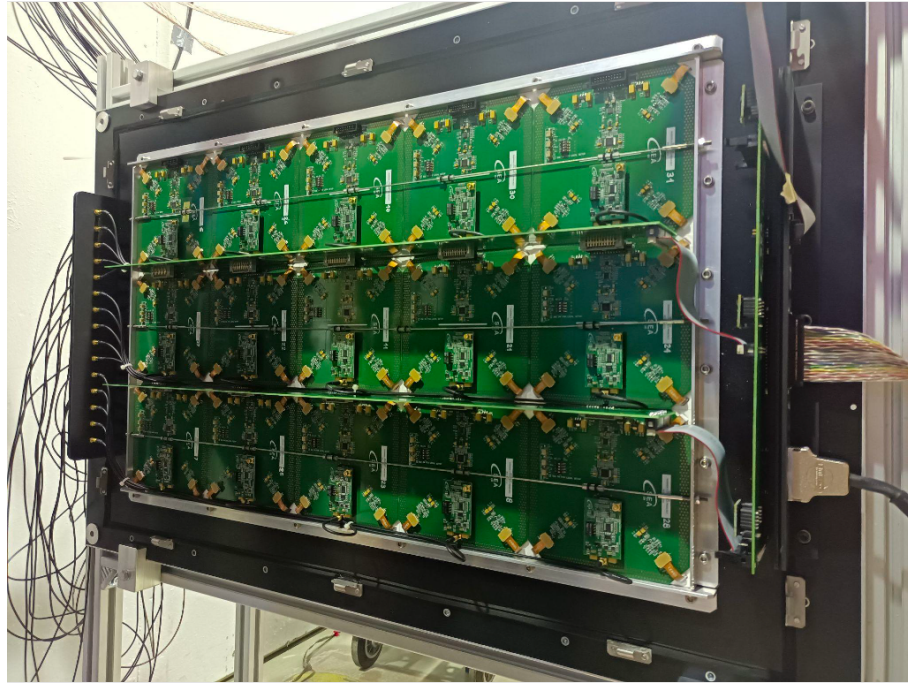


Figure 1: One of the two full-size modules of the muon system.

2023	2024	2025	2026	2027	2028	2029	2030	2031
NA62 Run			LS3	LS3	LS3	ECN3/HI Installation/ commissioning	ECN3/HI Installation/ commissioning	ECN3/HI run
Proposal	TDR	TDR	TDR/PRR	Production	Production	Production/ Installation	Installation/ Pilot Run	SHADOWS run
2032	2033	2034	2035	2036	2037	2038	2039	2040
ECN3/HI run	LS4	ECN3/HI Run					LS5	
SHADOWS run	consolidation	SHADOWS run	SHADOWS run	SHADOWS run	SHADOWS run	SHADOWS run	consolidation	SHADOWS run

Figure 2: SHADOWS schedule.

### 3 SHADOWS-related Talks given by LNF people

- Dark Matter 2023, 29.5-1.6, Santander (Spain), <https://indico.ifca.es/event/2675/> *Search for Dark Matter at accelerators*, invited talk.
- Cosmic Wisper Kick-off workshop, 22-24 February 2023, Laboratori Nazionali di Frascati, Rome, Italia <https://agenda.infn.it/event/33570/>, *The search for feebly interacting particles and the Physics Beyond Colliders activity at CERN*, invited talk.
- 113th ECFA Plenary session, 16-17 November, Main Auditorium, CERN, <https://indico.cern.ch/event/1220533/>, *The SHADOWS project at CERN*.
- INFN, Commissione Scientifica Nazionale 1, 14-15 November, *The SHADOWS project at CERN*.
- 150th meeting of the SPSC, Open session, 5-6 September, <https://indico.cern.ch/event/1303571/>, *Status of the SHADOWS experiment*.

### 4 SHADOWS-related Workshops/Conferences/Schools organized by LNF people

- *FIPs in the ALPs, School on Feebly-Interacting Particles*, Les Houches (France), 14-19 May 2023. G. Lanfranchi is in the Organizing Committee and one of the Lecturers.

### 5 SHADOWS-related publications in 2023

- The SHADOWS Collaboration, *SHADOWS Technical Proposal*, CERN-SPSC-2023-029 ; SPSC-P-367.
- C. Ahdida *et al.* *Post-LS3 Experimental Options in ECN3*, e-Print: 2310.07726 [hep-ex]
- F. Stummer *et al.* *Conceptual design of the magnetised iron block system for the SHADOWS experiment*. J.Phys.Conf.Ser. 2687 (2024) 2, 022030 (contribution to IPAC 2023).
- C. Antel *et al.*, *Feebly Interacting Particles: FIPs 2022 workshop report*, Eur.Phys.J.C 83 (2023) 1122, arXiv:2305.01715.