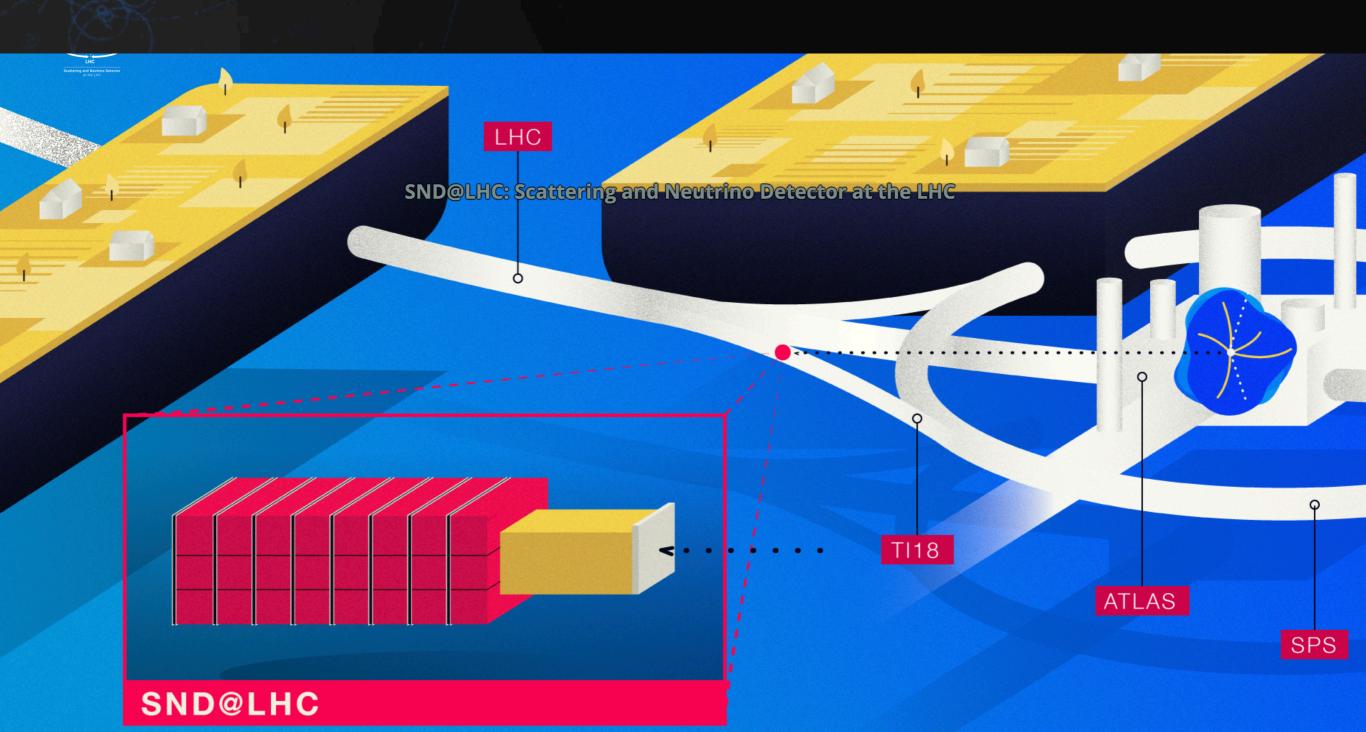
Jornadas científicas LIP PARTÍCULAS & TECNOLOGIA

SHIP&SND@LHC

N.Leonardo (LIP), nuno@cern.ch

Coimbra, 8.7.2022





The SHiP & SND@LHC Group at LIP

A.Blanco, P.Bordalo, P.Fonte, N.Leonardo, L.Lopes, S.Ramos, J.Saraiva, G.Soares Interns: A.Branco, P.Figueiredo, F.Safara, H.Santos, R.Santos, R.N.Santos

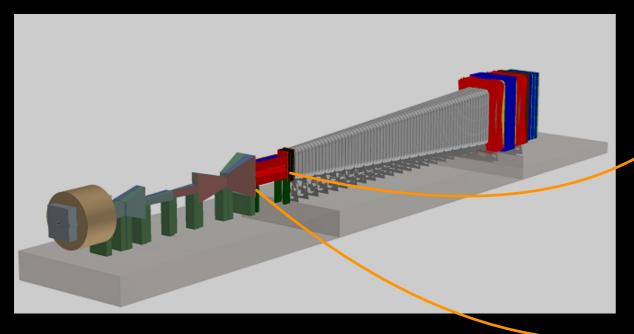




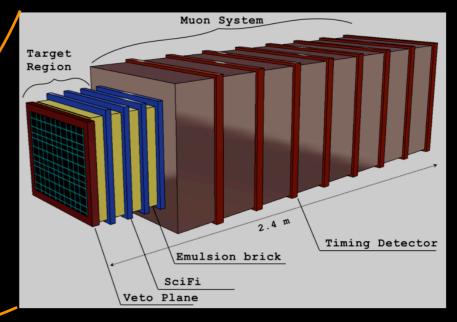


CERN/FIS-INS/0028/2021





to LHC

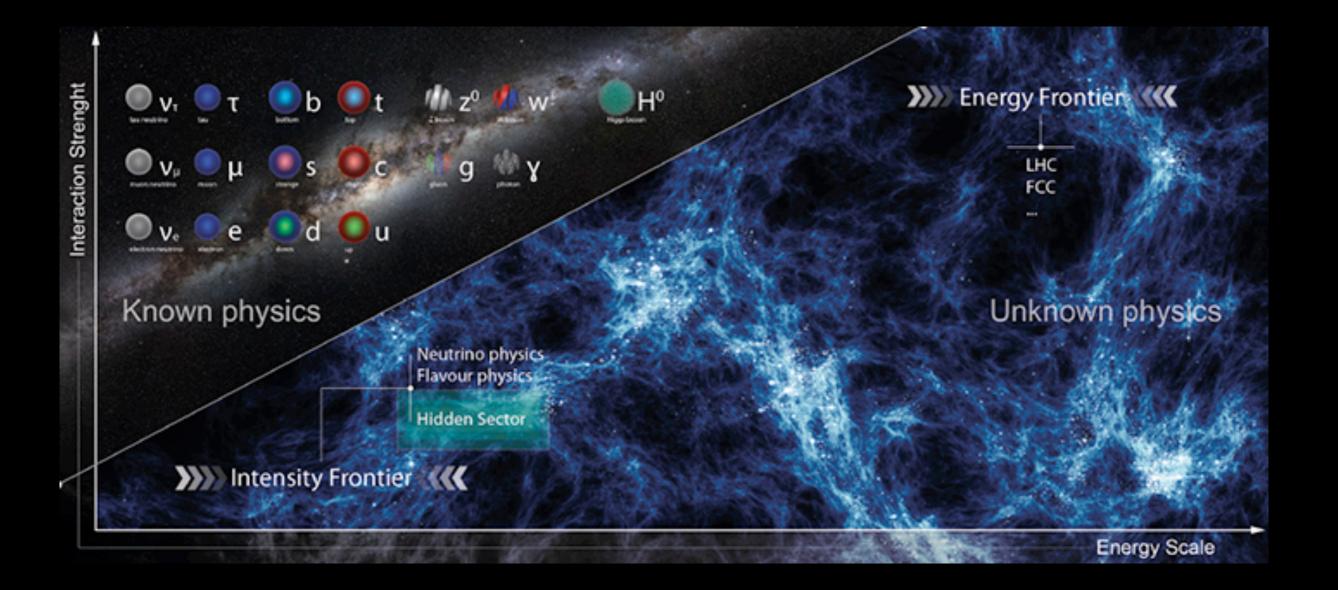


SHiP

- Next-generation experiment
- LIP involved in Timing + Veto detectors
- TDR phase delayed after ESPPU'2020
- Due to BDF cost, despite leading sensitivity
- Redesigned for new location at SPS
- Reduce cost, keep physics potential
- Decision before next ESPPU

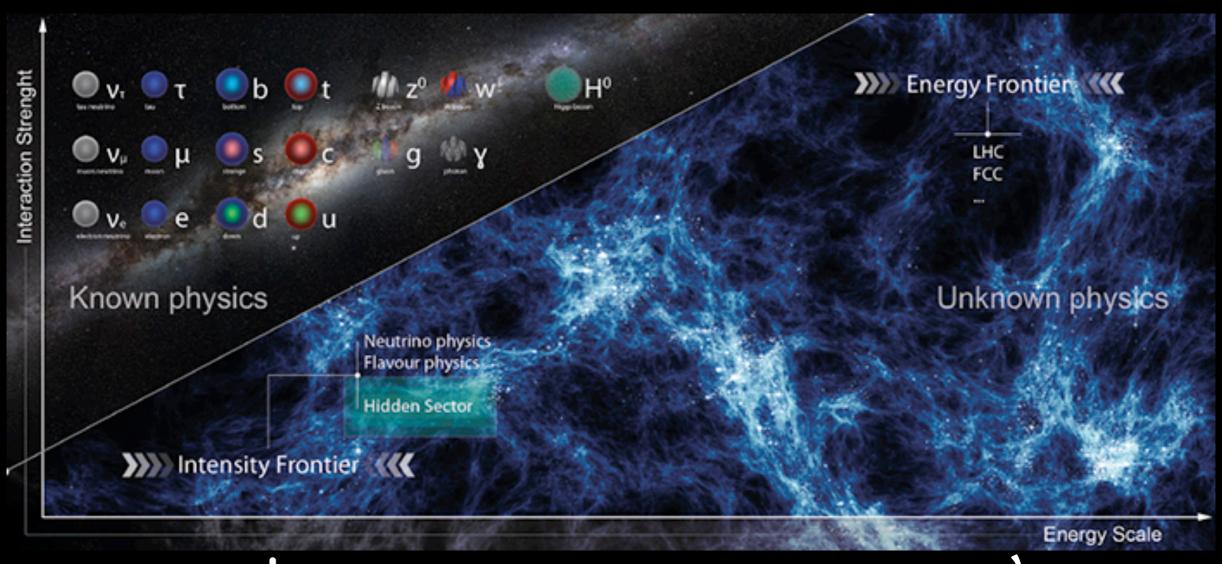
SND@LHC

- The most recent LHC experiment
- Approved & constructed in 2021
- LIP is a founding member
- LIP involved in Muon system
- Detector design and construction
- Full detector commissioning ongoing
- Experiment installed in time for Run3



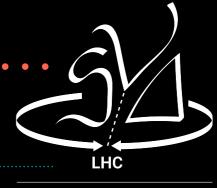
Goals

Explore the intensity frontier of particle physicsContribute novel detector systems **Extend the LHC physics reach**



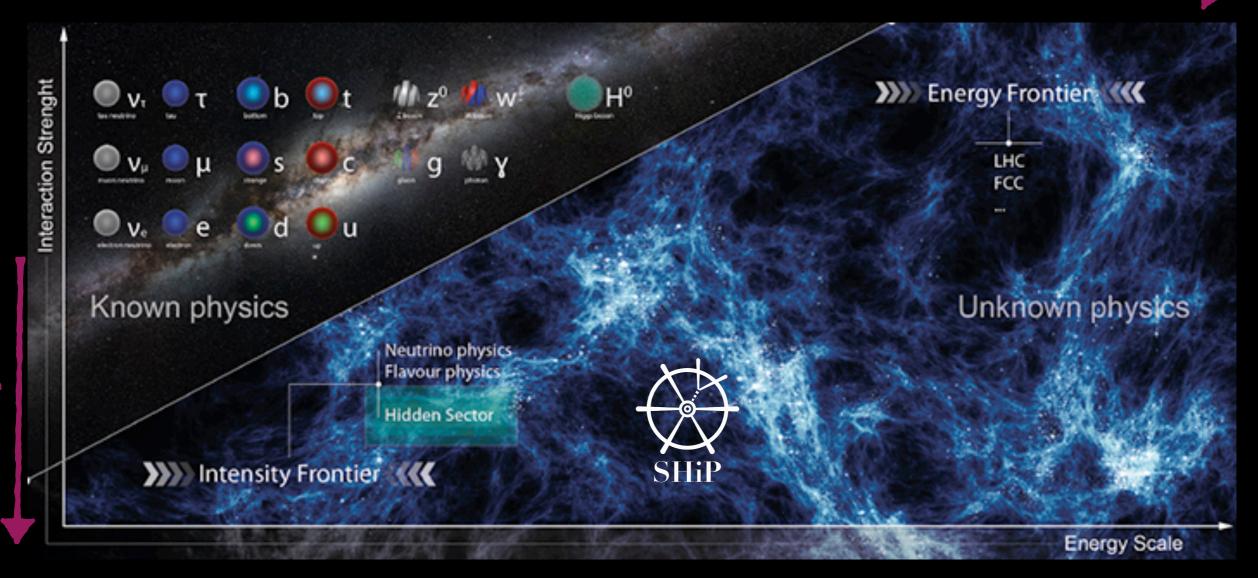


Neutrinos · · ·
Flavour
Hidden Particles



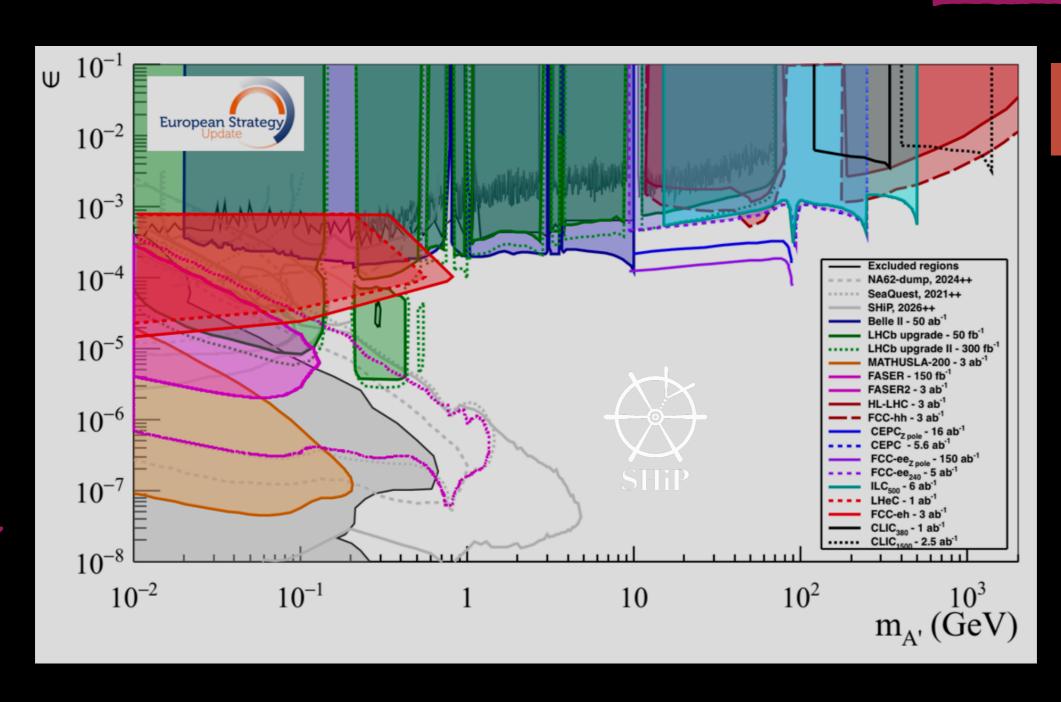
Scattering and Neutrino Detector at the LHC

energy frontier



Search for Feebly Interacting Particles

energy frontier



LHC FCC

SHIP — Search for Hidden Particles



larget/Hadron absorbel

RPC detector prototype tested at CERN and FAIR





Timing Detector - MRPC's

Muon Shield

Hidden sector particle

Scattering and

Decay product Straw Trackers

Nuon ID

Decay Spectrometer with particle ID

Photon Track (ECAL)



Neutrino detector

Optimization of the Selection of Hidden Particles in the SHiP Experiment

Guilherme Machado Santos Soares

CERN-THESIS-2021-038

Search for dark matter and supersymmetry using machine learning at SHiP

Francisco Safara^{1,a} and Raúl Santos^{2,b}

¹ Faculdade de Ciências da Universidade de Lisboa, Lisboa, Portugal

² Instituto Superior Técnico, Lisboa, Portugal

Project supervisors: N. Leonardo, G. Soares

LIP-STUDENTS-20-17

October 2020

Abstract. SHiP is an In actions, low masses and of the *hidden sector* of particles, specifically da and tested several mach taining a high signal effi regression and classifica

Keywords: Hidden Sec

Distinguishing Hidden Sector Particles with Machine Learning at SHIP

Henrique Santos^{1,a} and André Branco^{1,b}

¹ Instituto Superior Técnico, Lisboa, Portugal

Project supervisors: N. Leonardo, G. Soares

October 2021

Abstract.

Given the plausible existence of new physics particles and interactions, the SHiP experiment at CERN aims to explore the Intensity Frontier in search for the so called Hidden Sector particles with exceedingly feeble couplings and thus distinctively rare decays. Three theoretical particles are studied consisting of Dark Photons(DP), Heavy Neutral Leptons(HNL) and Neutralinos. Using previously Monte Carlo simulated data sets in conjunction with sundry machine learning methods it is possible to classify those three different hypothetical particles from several decays (into Pion-muon and Muon-muon pairs) yielded from the input information culminating in efficiencies over 74% for all results and over 99% for the foremost ones.

Keywords: Hidden Sector, Dark Photons, Heavy Neutral Leptons, Neutralinos, Deep Neural Networks, Inten-

Literature

Group strongly involved in preparation of SHIP



SHiP Experiment

COMPREHENSIVE DESIGN STUDY REPORT

SHiP Collaboration

Abstract

Following the completion of the Comprehensive Design Study of the SHiP detector, this document summarises the status of the physics and the detector and outlines a three-year design and development plan towards Technical Design Reports. The document concludes with an overall road map and updated costs for the detector R&D and construction. With the submission and review of this document, together with the SHiP Progress Report [1] and the Beam Dump Facility Yellow Report [2], the SHiP Collaboration is ready to proceed with the preparation of Technical Design Reports, pending approval.

Keywords

CERN-SPSC-2019-049 / SPSC-SR-263

SHiP, Comprehensive Design Study, SPS, CERN

https://cds.cern.ch/record/2704147/

Journal of Instrumentation

The SHiP timing detector based on MRPC

A. Blanco¹, F. Clemencio², P. Fonte^{1,3}, C. Franco¹, N. Leonardo¹, L. Lopes¹, C. Loureiro⁴, J. Saraiva¹ and G. Soares¹

Published 14 October 2020 • © 2020 IOP Publishing Ltd and Sissa Medialab

Journal of Instrumentation, Volume 15, October 2020

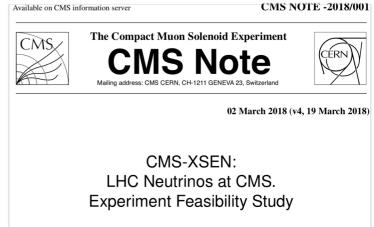
XV Workshop on Resistive Plate Chambers and Related Detectors (RPC2020)

Citation A. Blanco et al 2020 JINST 15 C10017

Proposals for neutrino physics at the LHC have a long history



https://www.sciencedirect.com/science/article/abs/pii/055032139390427Q



OPEN ACCESS

IOP Publishing

J. Phys. G: Nucl. Part. Phys. 46 (2019) 115008 (19pp)

Journal of Physics G: Nuclear and Particle Physics

S. Buontempo^a, G.M. Dallavalle^b, G. De Lellis^c, D. Lazic^d, F.L. Navarria^e

https://doi.org/10.1088/1361-6471/ab3f7c

Physics potential of an experiment using LHC neutrinos

TECHNICAL PROPOSAL

SND@LHC

Scattering and Neutrino Detector at the LHC

SND@LHC Collaboration

Abstract

SND@LHC is a proposed, compact and stand-alone experiment to perform measurements with neutrinos produced at the LHC in an hitherto unexplored pseudo-rapidity region of $7.2 < \eta <$ 8.6, complementary to all the other experiments at the LHC. The experiment is to be located 480 m downstream of IP1 in the unused TI18 tunnel. The first phase aims at operating the detector throughout LHC Run 3 to collect a total integrated luminosity of 150 fb-

Following the review of the Letter of Intent [1], submitted in August 2020, LHCC recommended the collaboration to proceed with the preparation of a Technical Proposal (TP),

Memorandum of Understanding

for Construction of the Scattering and Neutrino Detector at LHC (SND@LHC Experiment)

and

The EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH, "CERN", an Intergovernmental Organization having its seat at Geneva, Switzerland,

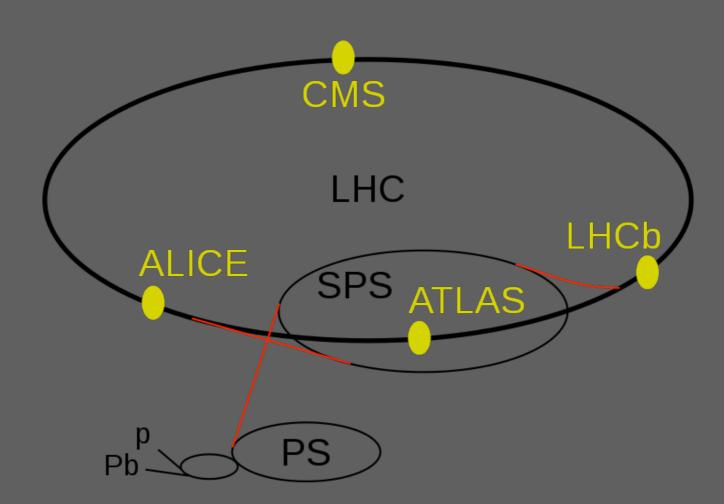
SND@LHC Collaboration

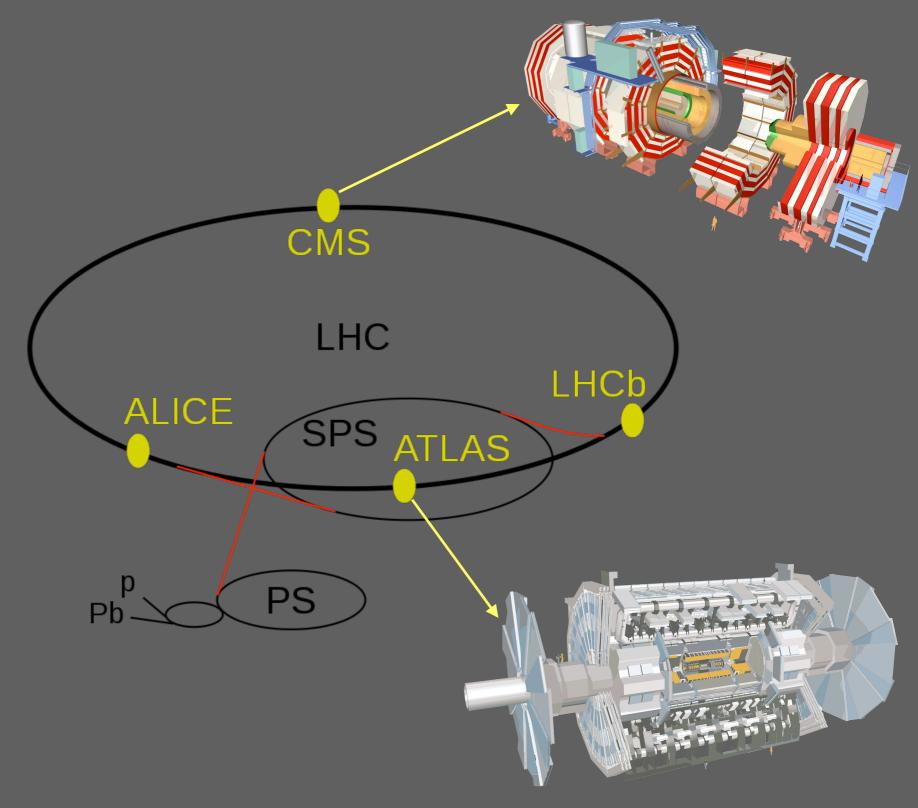
on the one hand

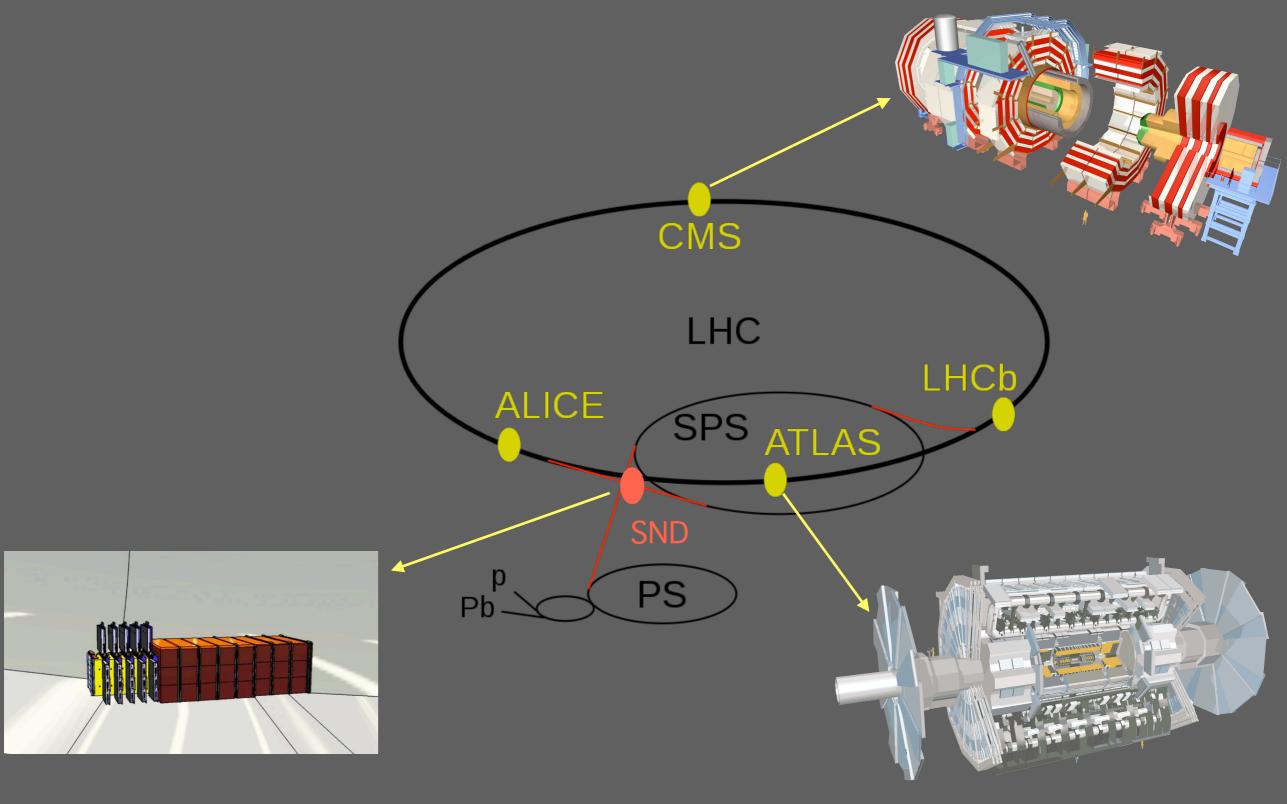
the Collaborating Institutions/Funding Agencies of the SND@LHC Collaboration

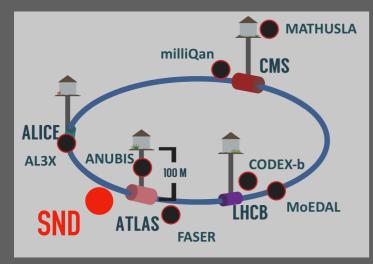
on the other hand.

CERN-MoU-2021-034

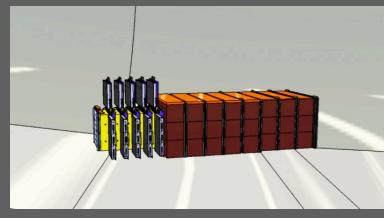


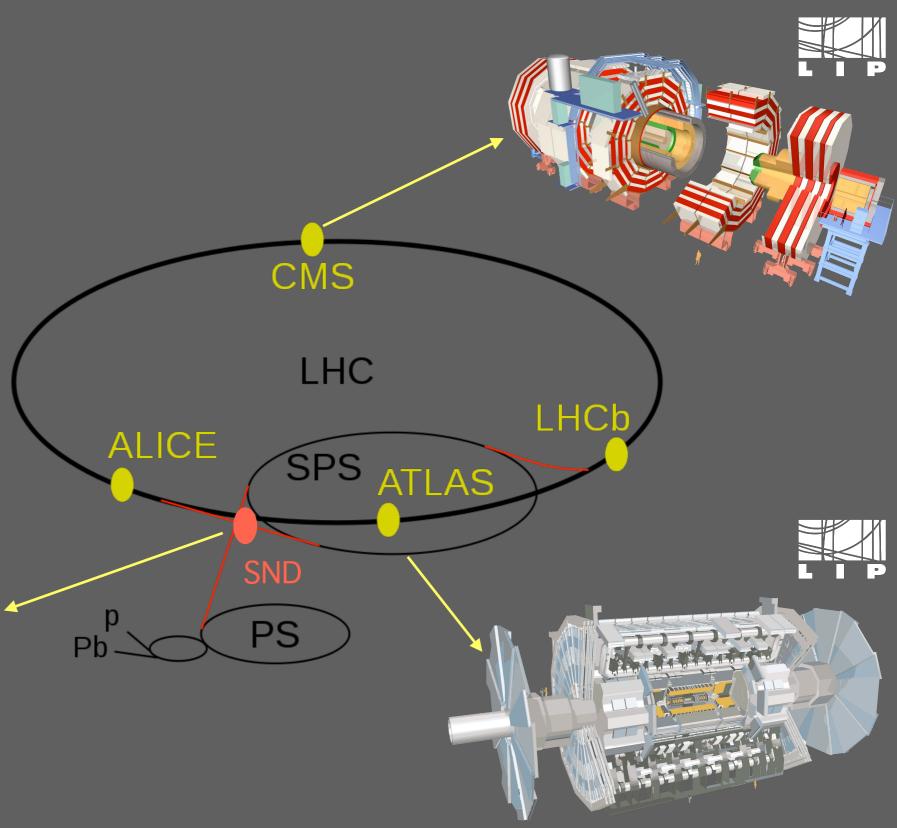








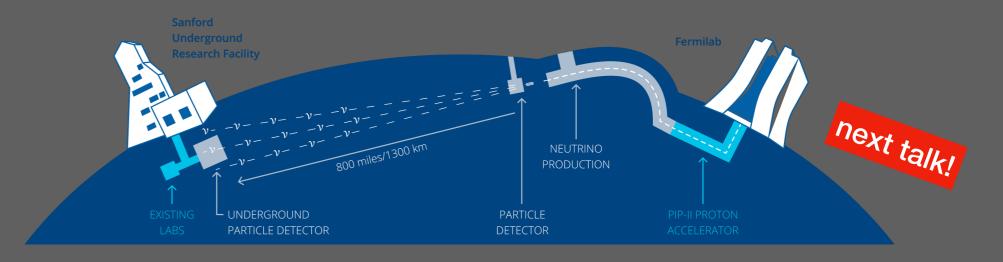




Neutrinos, at the LHC?

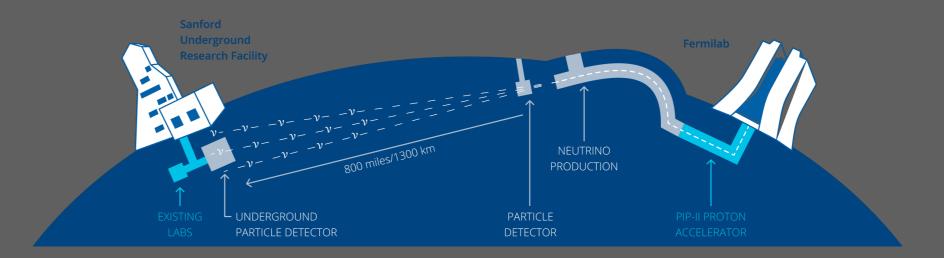
Neutrinos, at the LHC?

@ long
baseline



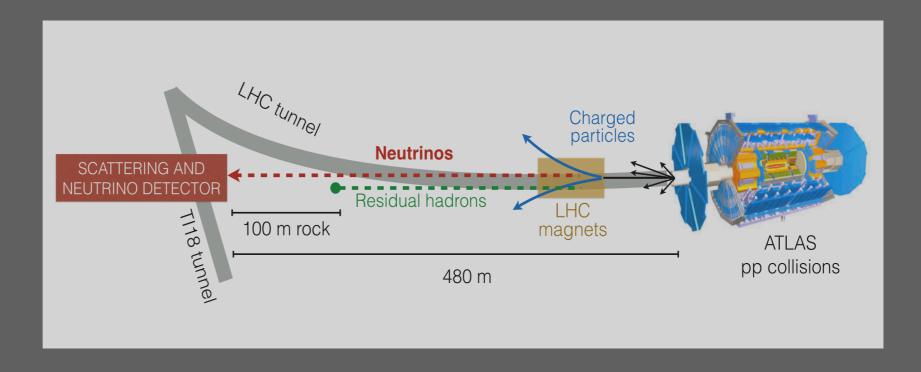
Neutrinos, at the LHC?

@ long
baseline



complementary

@ particle
collider!



Detector installation

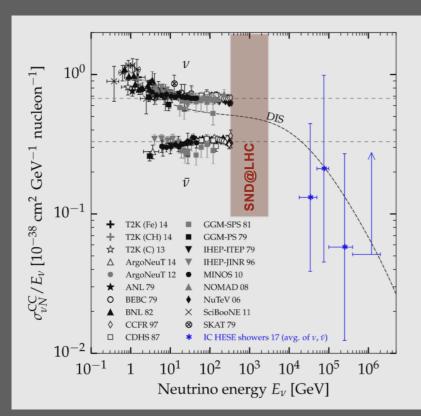


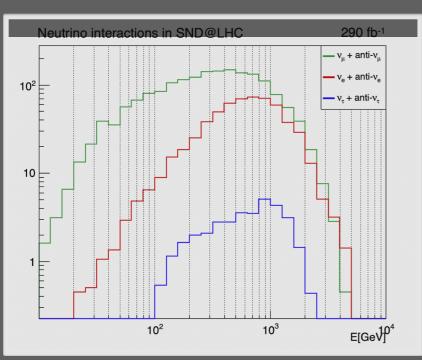






Neutrinos et al with SND@LHC



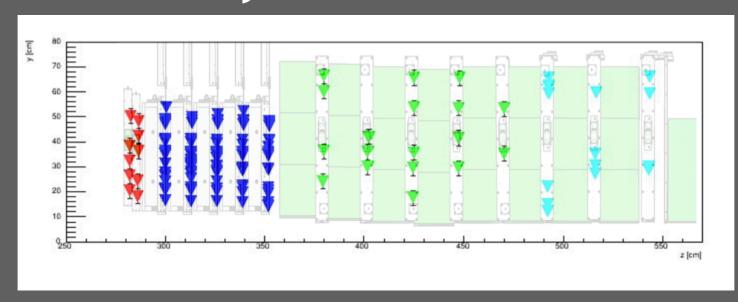


- high v energies (large vN cross-section)
- large v flux (forward region, 7.2<η<8.4)
- all V flavours (from heavy quark decays)

SND @ LHC physics goals:

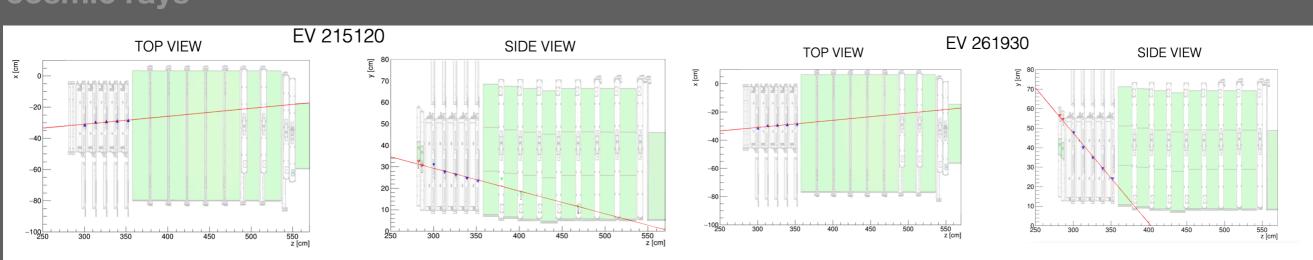
- observe first collider neutrinos
- measure backgrounds
- measure pp→vX cross sections
- heavy flavour production in pp collisions
- probe lepton flavour universality (LFU)
- measure least known SM particle $(\mathbf{V}_{\mathsf{T}})$
- direct search for new particles (FIPs)

First events, from cosmics & LHC





cosmic rays

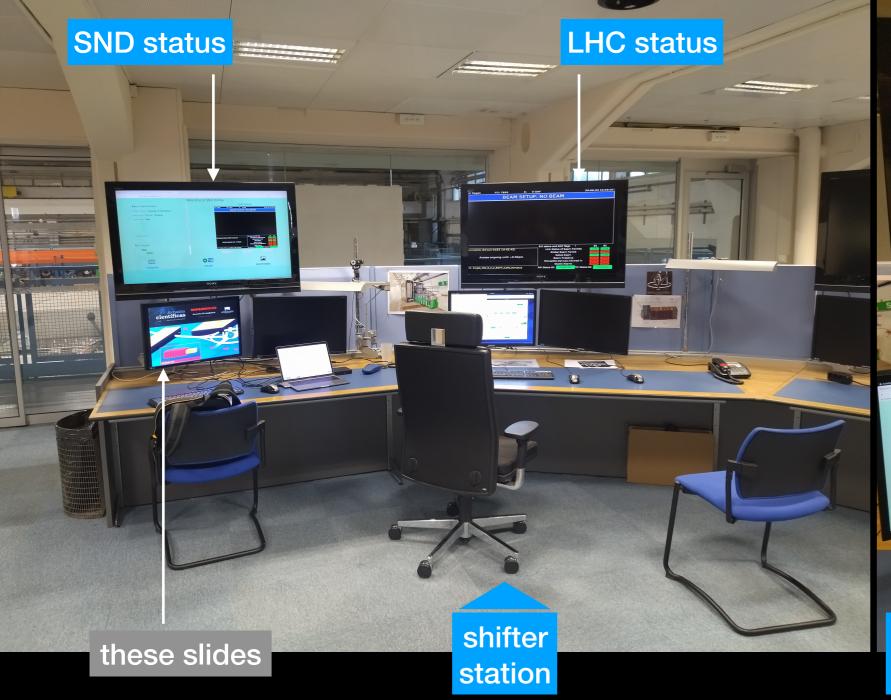


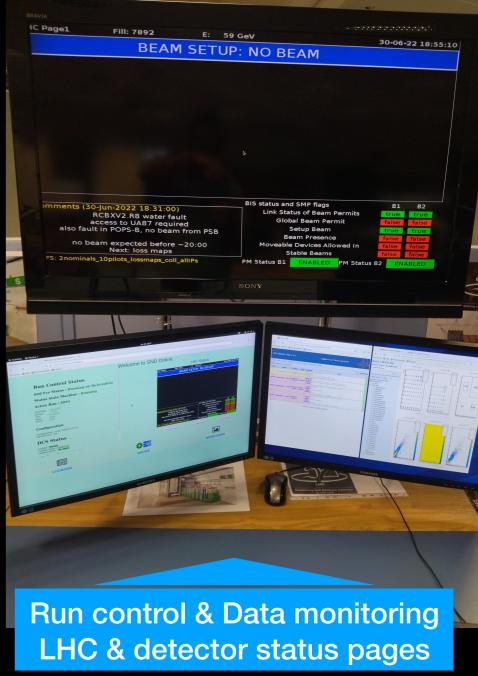
Control Room @CERN

LHC Run 3 data taking just started

I've set it up last week — in time for start of stable data taking. Installed in a section of the CMS Center in CERN's Meyrin site.

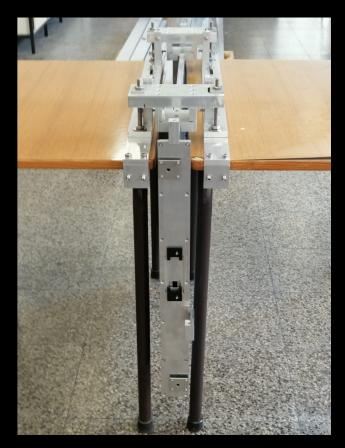
Team members actively involved in data taking & shifts at CERN.





Building the Muon System

- Detector assembly: July October 2021
- Frames produced by LIP in Coimbra



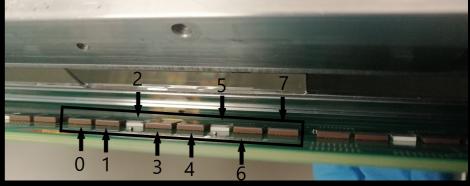




G.Soares

Building the Muon System





Test Beams at H8 (SPS)

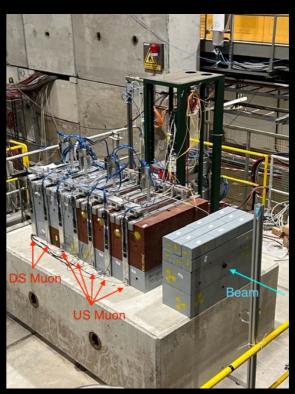
1. 1 - 5 September:

1st Time detector was turned on No useful data for commissioning

2. 29 September - 6 October:

Pion beams
4 different energies
Varied luminosity
Different FEE calibrations
Most data currently used for commissioning



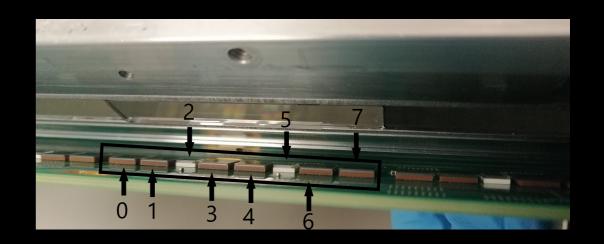


Timing Calibration

— bad SiPM timing coincidence

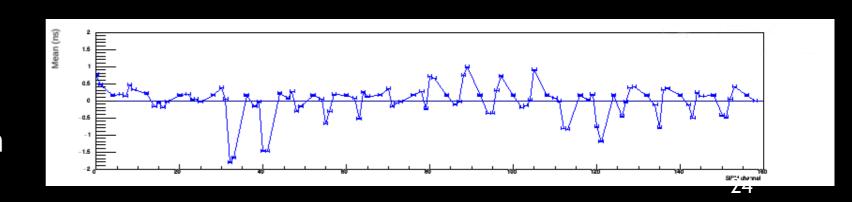
Goals:

- Check timing difference distributions
- Infer corrections
- Define easily repeatable and automated process that can be applied retroactively and to Run 3 data



Process:

- Fit distributions
- Find the mean
- Refine fitting criteria
- Get accurate description
- Correct channels

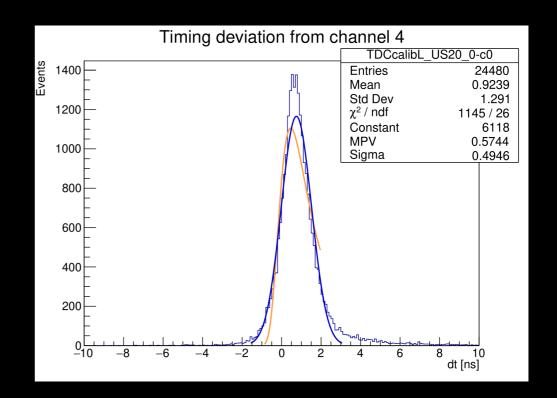


Timing Calibration

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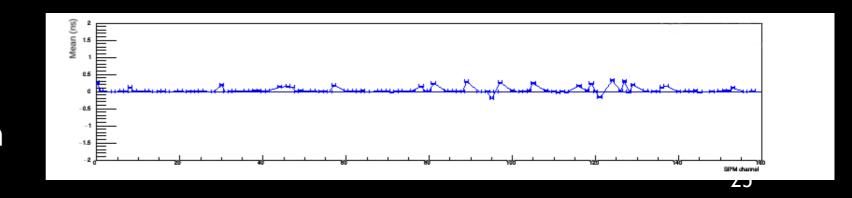
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Process:

- Fit distributions
- Find the mean
- Refine fitting criteria
- Get accurate description
- Correct channels



Summary

- SND@LHC is a novel experiment at the LHC
- aim at measuring neutrinos at LHC and search for BSM physics
- approved, constructed, installed in 2021 just started taking data
- LIP involved in construction, commissioning, data taking and analysis
- SHiP proposed as a next-generation experiment
- large sensitivity in search for feebly interacting particles
- LIP involved in detector design, prototype, analysis sensitivity
- FIPs are enjoying explosion of interest in the community
- era of neutrino exploration at the LHC is starting