Scattering and Neutrino Detector at the LHC

Recent Results from SND@LHC

Les Rencontres de Noirmoutier

1st-5th June, 2026 | Noirmoutier, France

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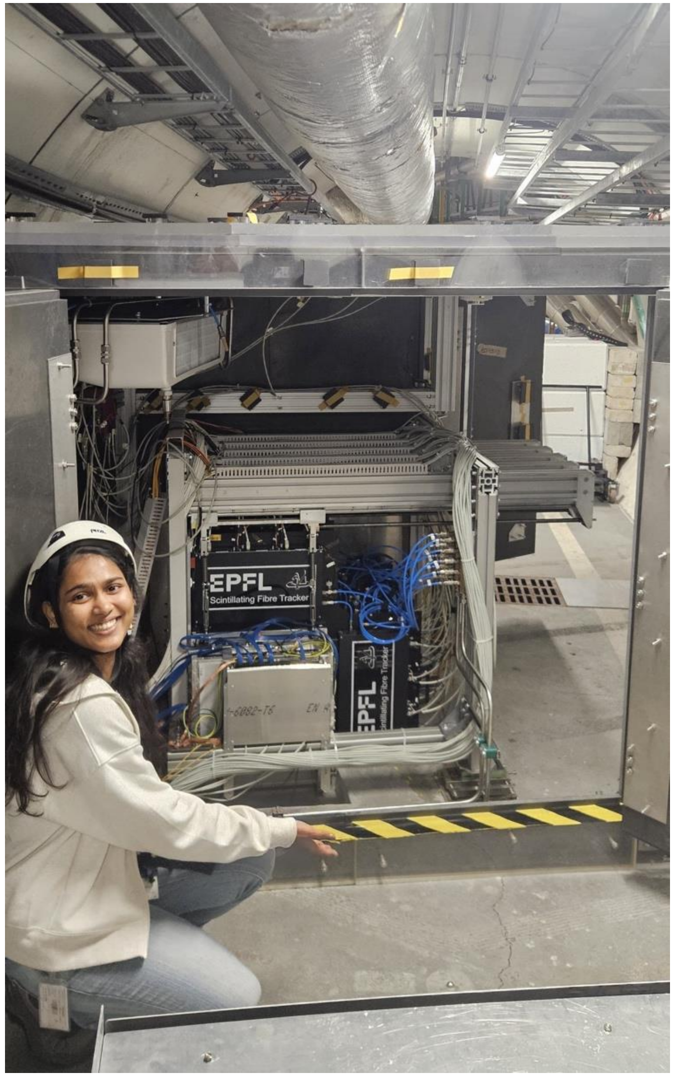
On behalf of the SND@LHC Collaboration

Outline

- Introduction
  - Neutrinos at the LHC
  - Physics Goals /Detector Design / Calibration / Data Collection
- Physics Results:
  - Muon Studies
  - Neutrino Measurements
- HL-LHC Upgrade



Neutrinos at the Large Hadron Collider

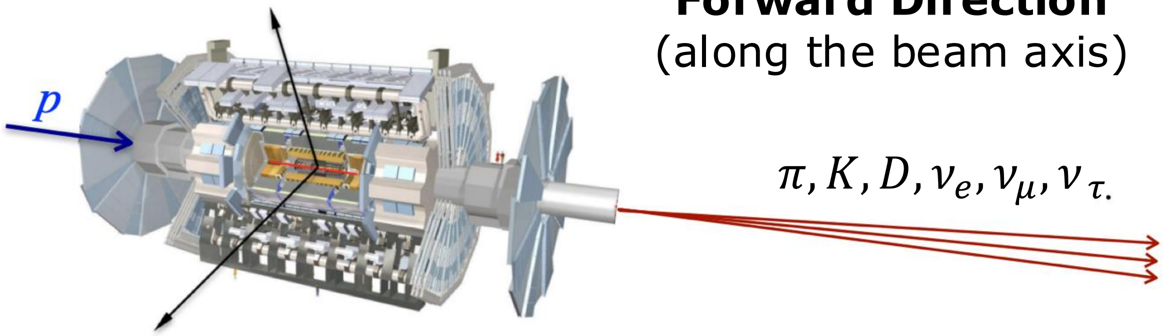
LHC pp collisions ($\mathbf{pp} \rightarrow \boldsymbol{\nu_X}\ \mathbf{X}$)

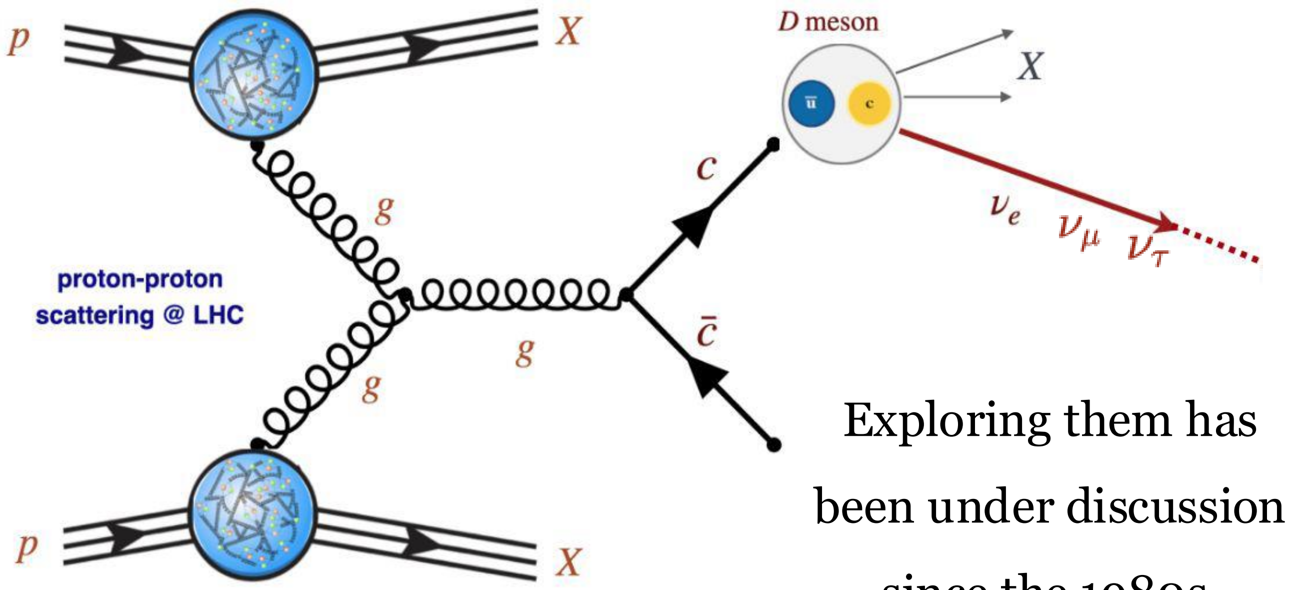
Large neutrino flux

unexplored energy range $[10^2 - 10^3]$ GeV

ATLAS@LHC

Forward Direction
(along the beam axis)





- LHC detectors are well instrumented in the central detector region.
- A lot of interesting physics is being missed in the forward region.

Exploring them has been under discussion since the 1980s.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J. Phys. G: Nucl. Part. Phys. **47** (2020) 125004 (18pp)
https://doi.org/10.1088/1361-6471/aba7ad

Further studies on the physics potential of an experiment using LHC neutrinos


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J. Phys. G: Nucl. Part. Phys. **46** (2019) 115008 (19pp)
https://://doi.org/10.1088/1361-6471/ab3f7c

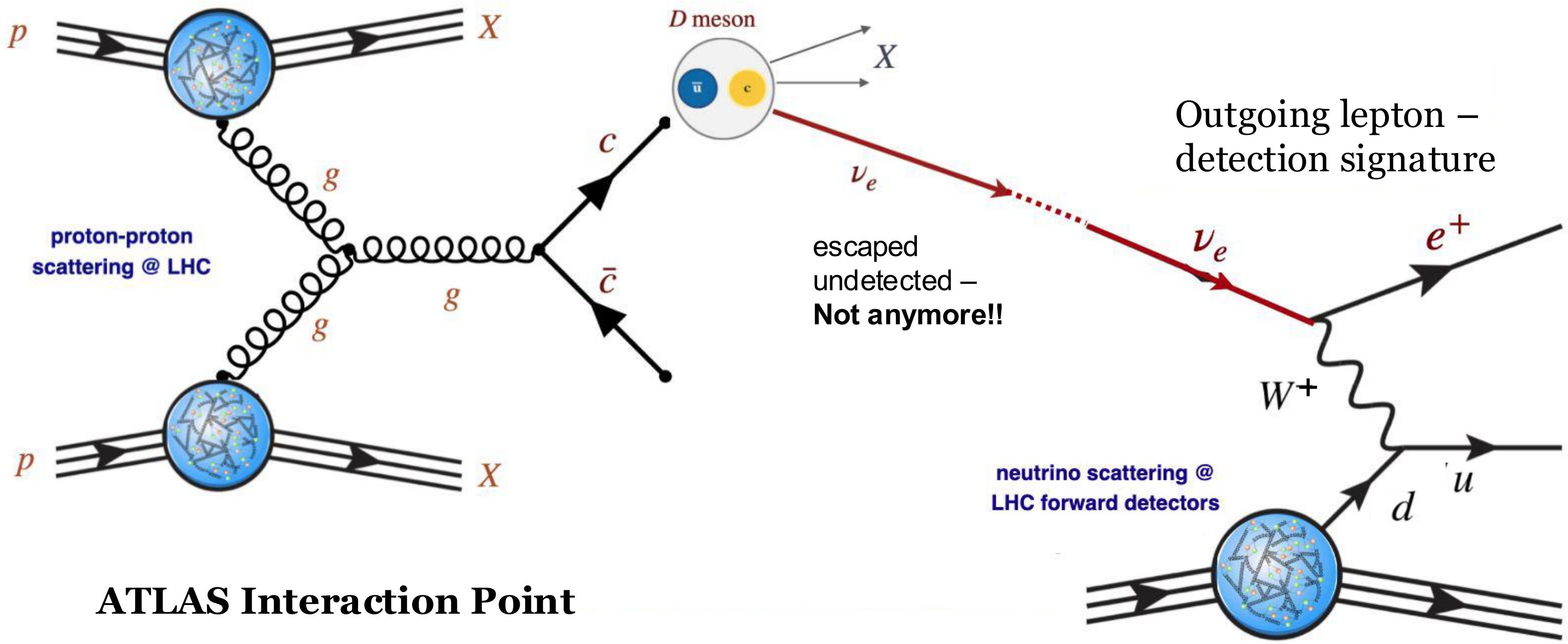
Physics potential of an experiment using LHC neutrinos

Adapted from Juan Rojo's CERN TH seminar

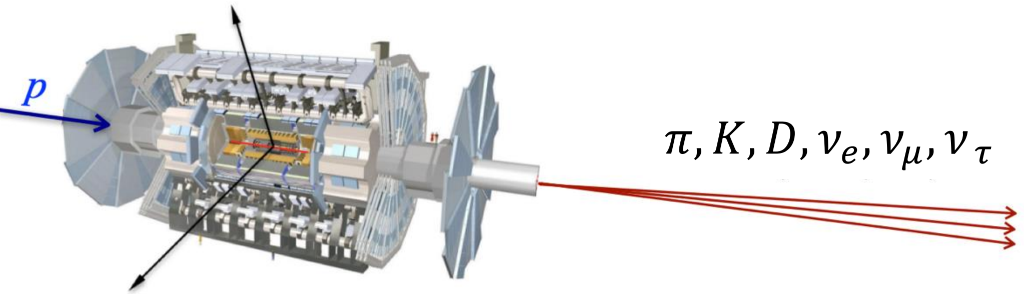
Neutrinos at the Large Hadron Collider

Small-scale neutrino detectors can achieve this!

Weak decay of hadrons



ATLAS Interaction Point



In LHC Run 3: FASERν and **SND@LHC** **Observed the first LHC ν s**

Adapted from Juan Rojo's CERN TH seminar

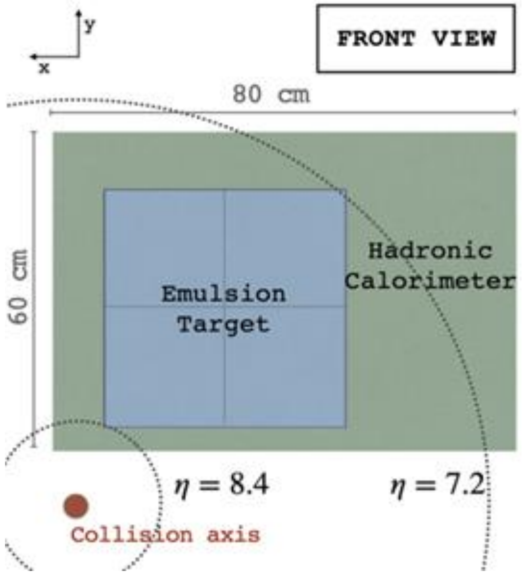
Scattering and Neutrino Detector at the LHC

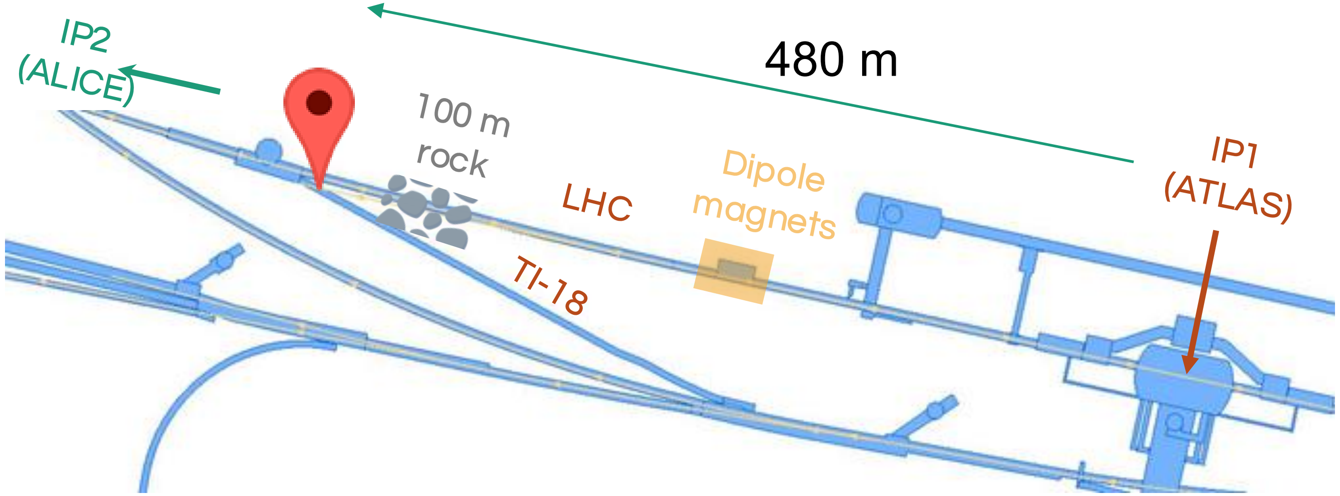
Operating since 2022
(LHC Run 3)

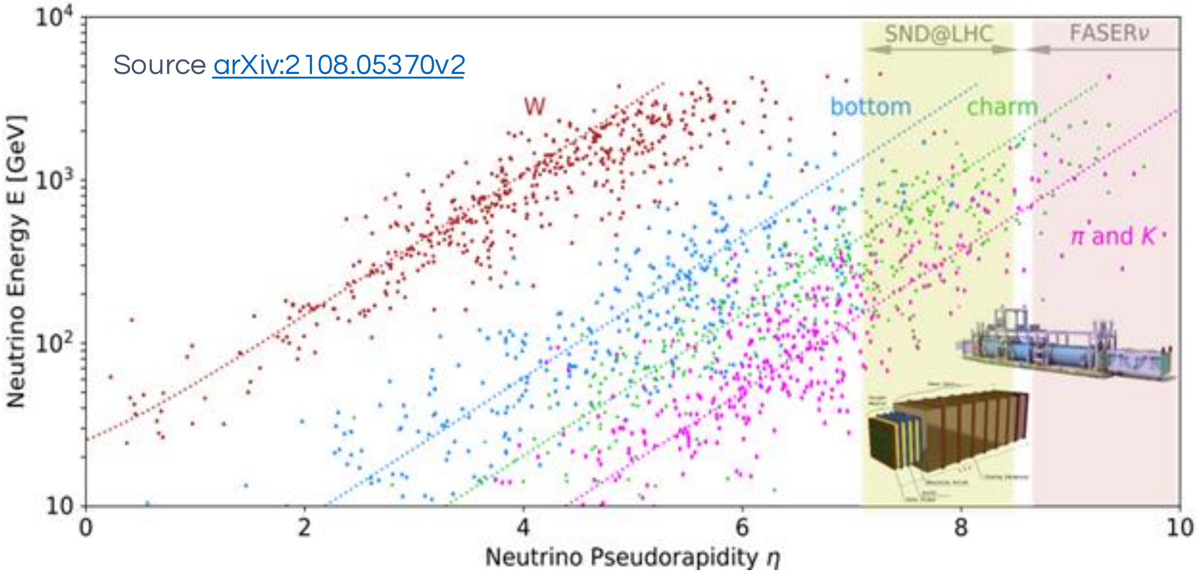
In the TI18 tunnel (former SPS to LEP transfer line)
480 m downstream ATLAS.
Shielded by:

- ~100m rock
- LHC magnets deflect charged particles.

Angular acceptance **7.2 <η< 8.4**, where ν_e flux mainly comes from charm parents.



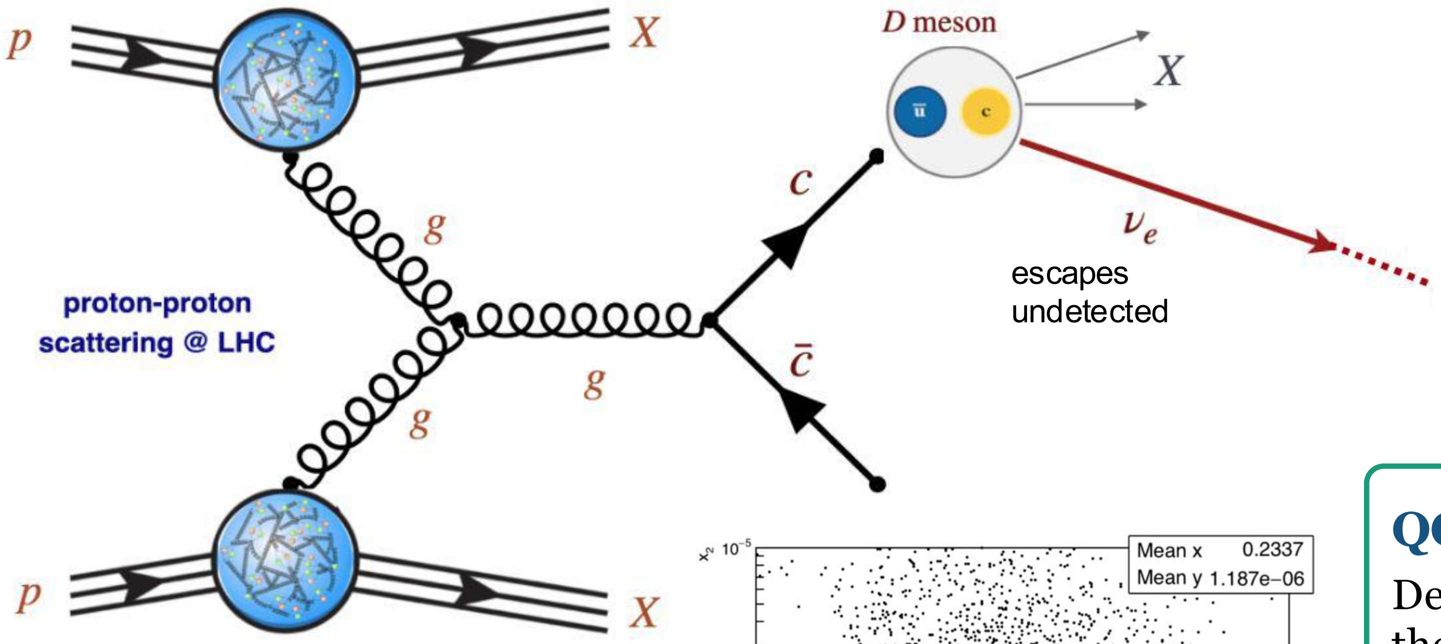




SND@LHC Physics Goals

LHC *pp* collisions (**pp** → $\boldsymbol{\nu_X}$ **X**)

Large neutrino flux - in the **forward region**



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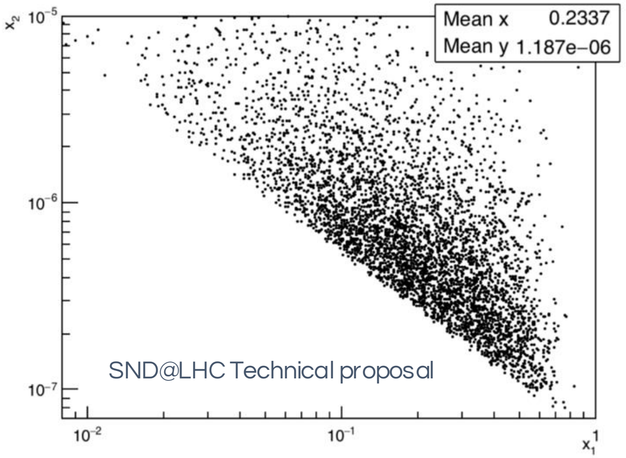
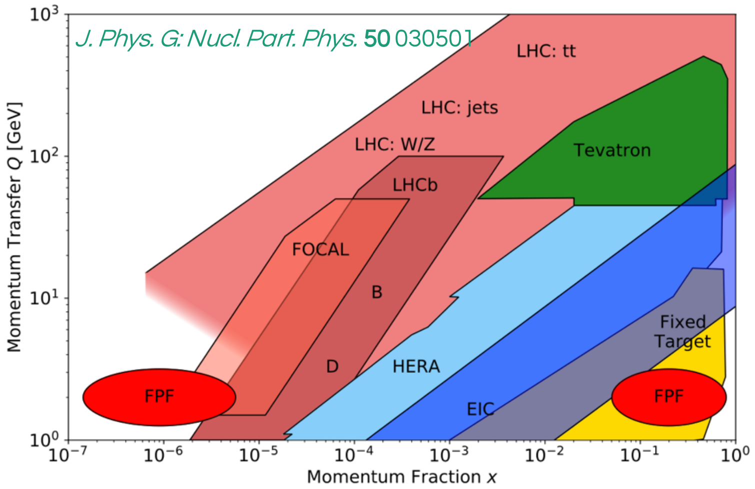




QCD physics

Decays of **charm** hadrons contribute significantly to the neutrino flux in SND@LHC.

⇒ **Measure forward charm production with ν_es.**

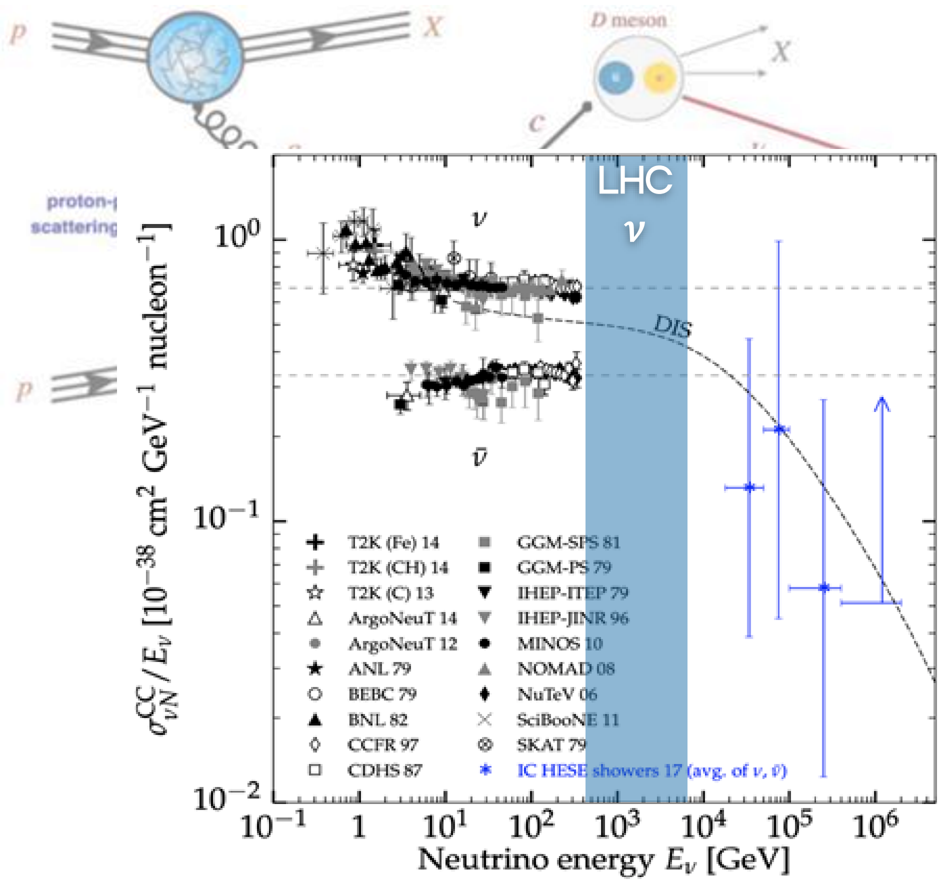
Implication for future colliders & astrophysics.

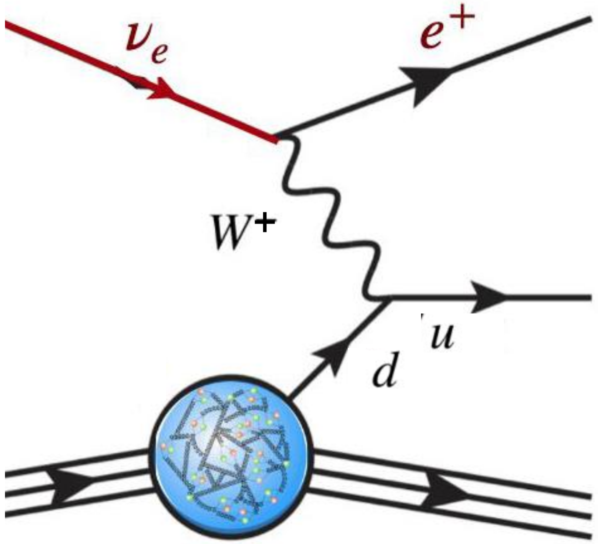
SND@LHC Physics Goals

Bridge the gap between accelerator neutrinos and high-energy neutrino telescopes.

Neutrino interactions

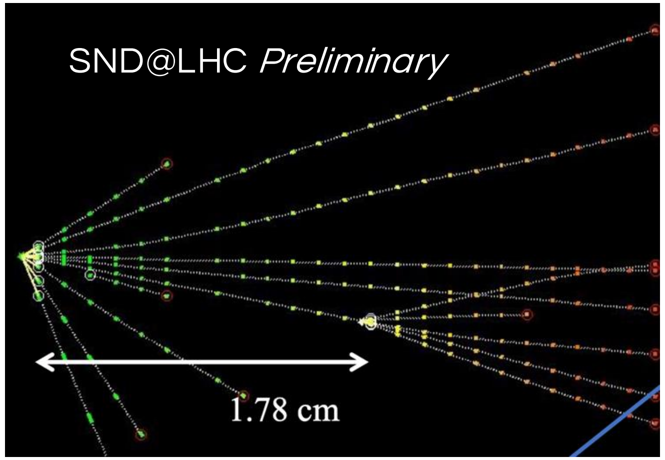
- **Measure ν interactions in the ~TeV energy range.**
- **Large yield of ν_τ will likely double existing data.**
  - About 20 events observed by DONuT and OPERA.
  - 7 astrophysical ν_τ candidates observed by IceCube.





Expected neutrino interactions in Run3, 310 fb^{-1}:

Flavour	DIS-CC	DIS-NC
$\nu_\mu + \bar{\nu}_\mu$	1575	508
$\nu_e + \bar{\nu}_e$	484	161
$\nu_\tau + \bar{\nu}_\tau$	37	19
Tot	2096	688



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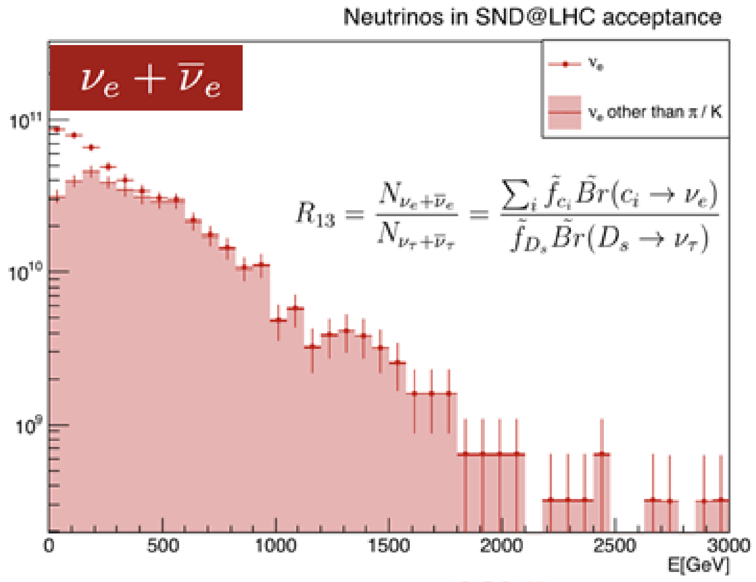
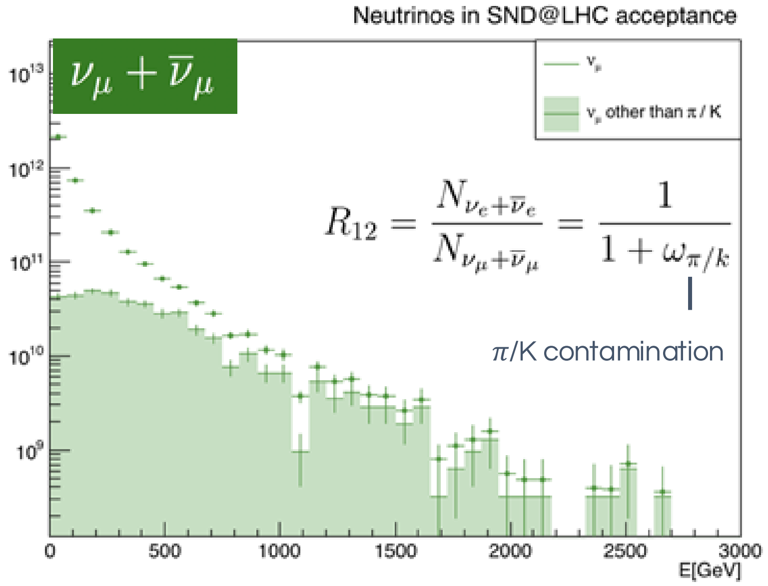
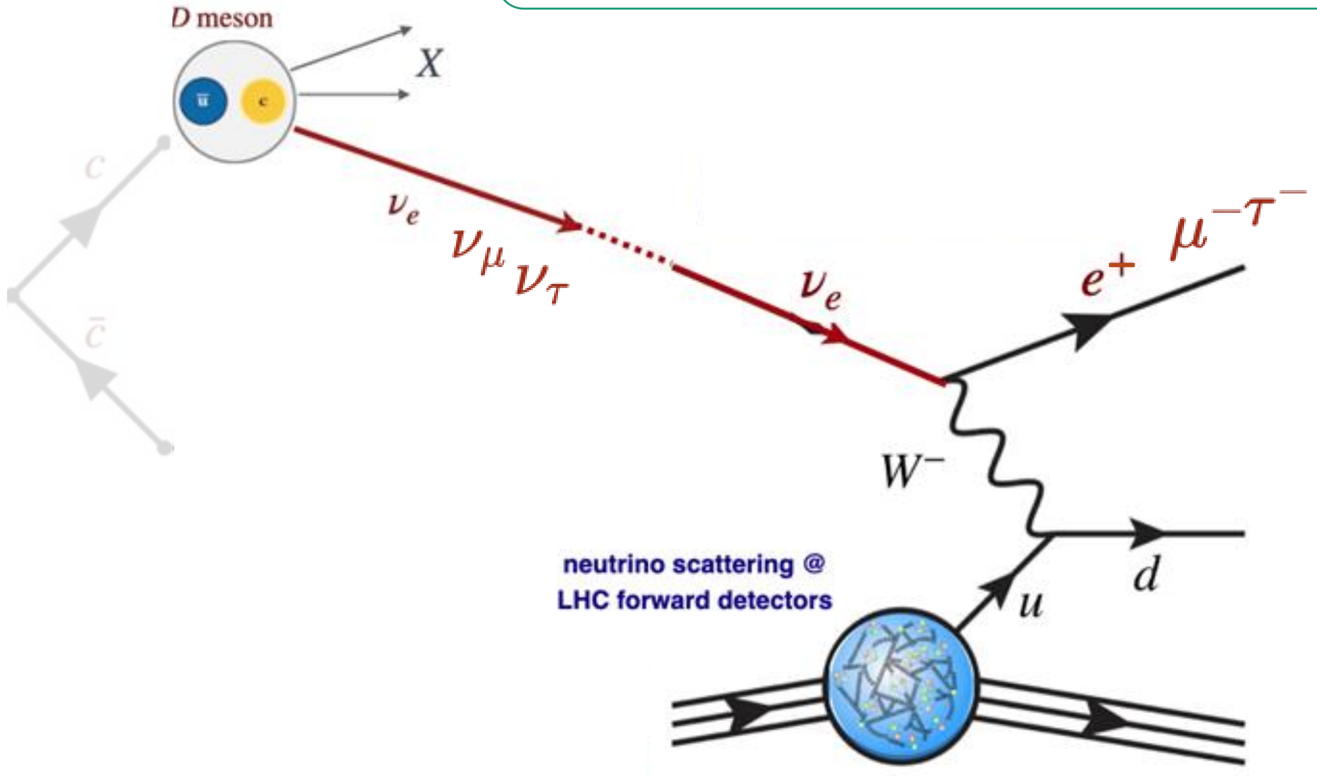
SND@LHC Physics Goals



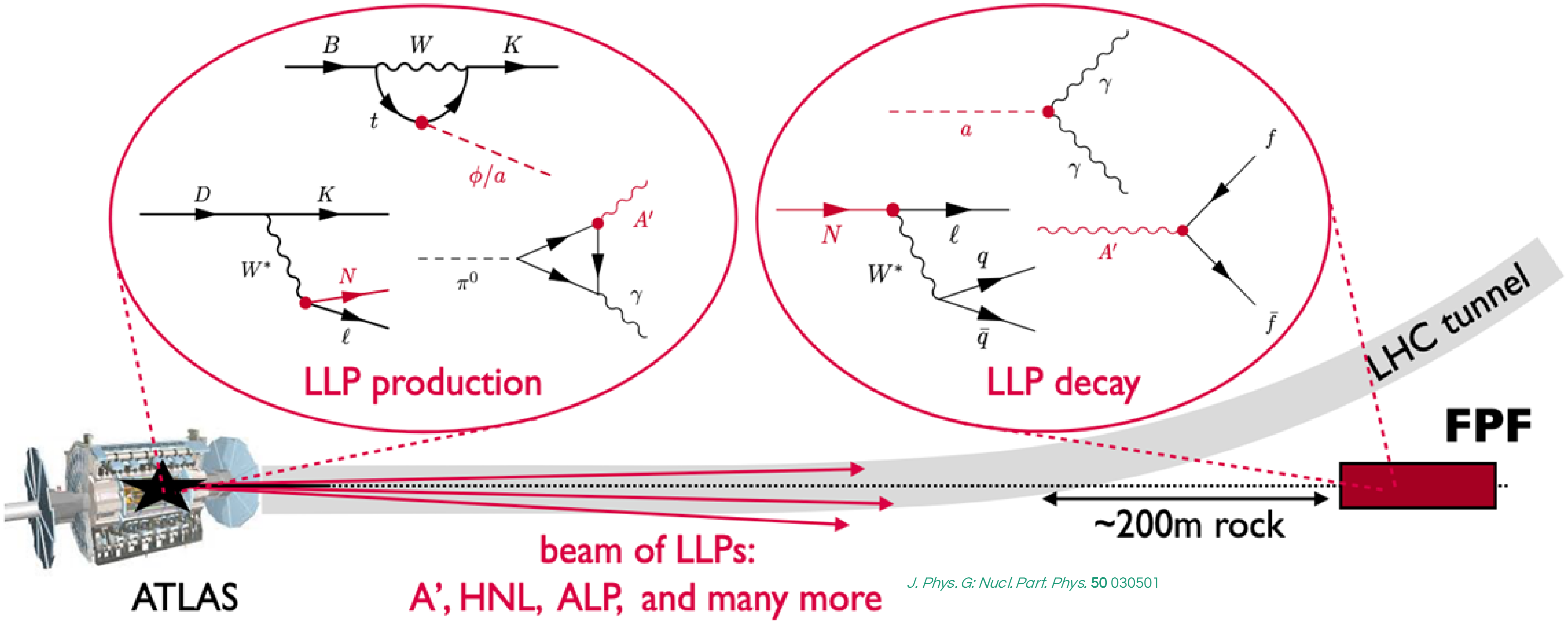


Flavour Tests

- Detection of all **three types of neutrinos** allows for tests of **lepton flavour universality**.



SND@LHC Physics Goals



J. Phys. G: Nucl. Part. Phys. 50 030501

+ scattering signatures

Beyond the Standard Model

- Search for new, feebly interacting, Long-lived particles (LLP) **decaying** within the detector or **scattering** off the target.

Detector Design

Veto system

2 (2022 – 2023) → 3 (2024 -) 1 cm thick scintillator planes.
- **Tag penetrating muons.** *JINST* **20** P07011

Compact hybrid detector with triggerless data acquisition. **2024 JINST 19 P05067**

Target, Vertex Detector & ECal

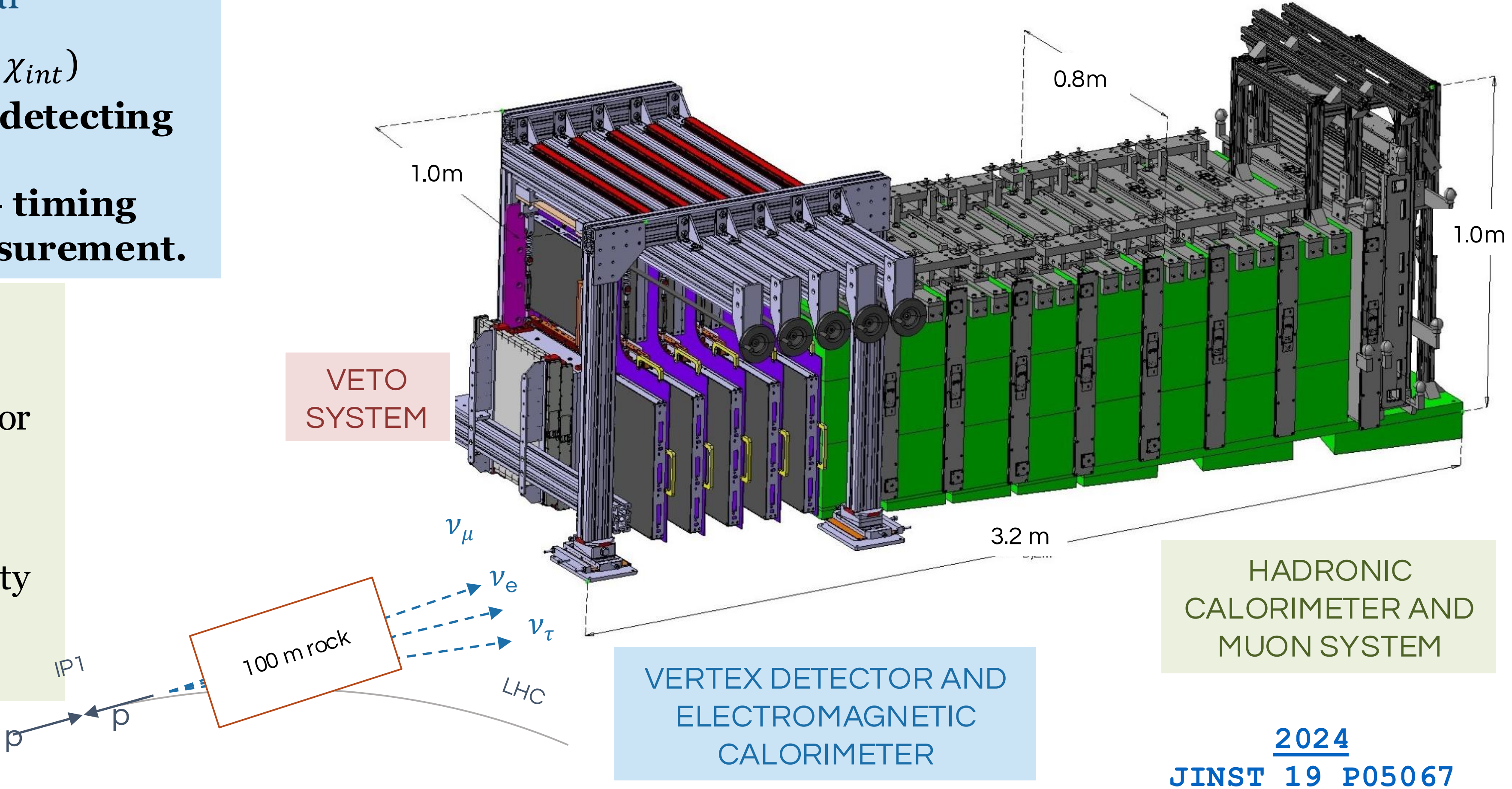
830 kg tungsten target. (84 X_0, 3 χ_{int})

Five walls x 59 emulsion layers – **detecting neutrino interaction.**
+ Five scintillating fibre stations - **timing information and energy measurement.**

Muon system & HCal

Eight 20 cm Fe blocks + scintillator planes. - **fast time resolution and energy measurement.**

Last 3 planes have finer granularity - **to track muons**.
2025 - Drift Tubes installed.

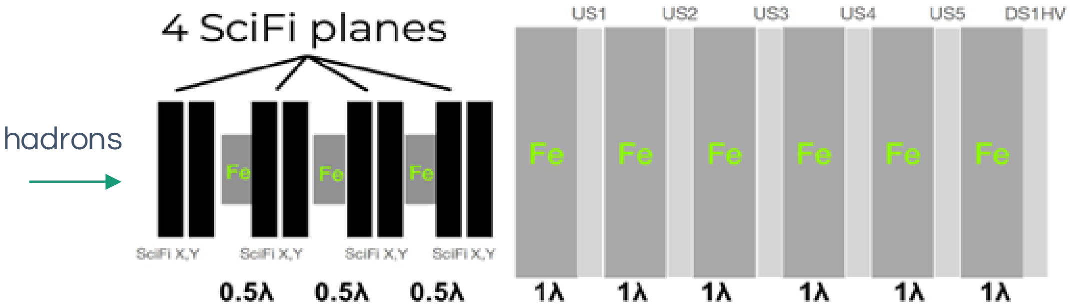


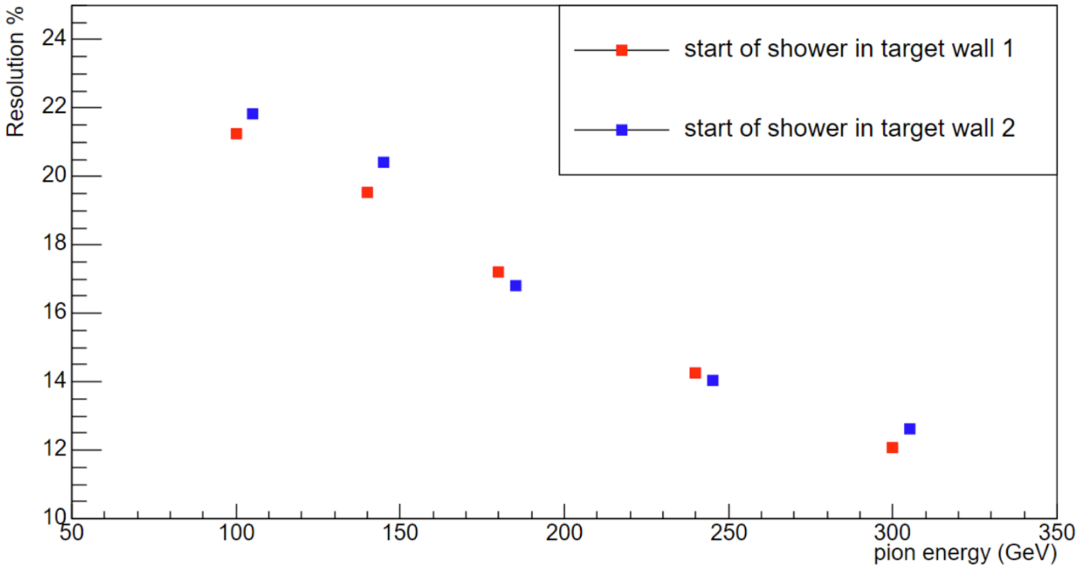
2024 JINST 19 P05067

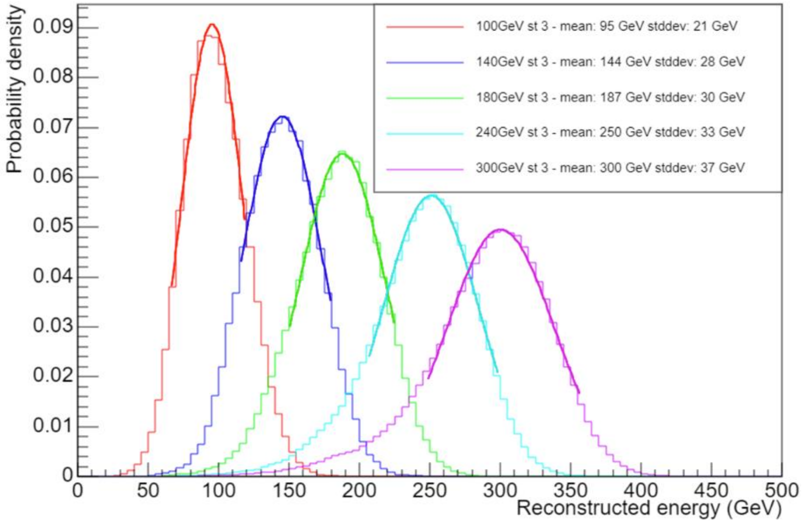
Energy Calibration with Testbeam Data

- Very successful hadron testbeam data taking campaign in August 2023.
- Exact replica of the hadron calorimeter.
- Downsized mockup of the target
  - Energy deposited in target contributes significantly.
- Calibrated calorimeter response. [JINST 20 P10039]

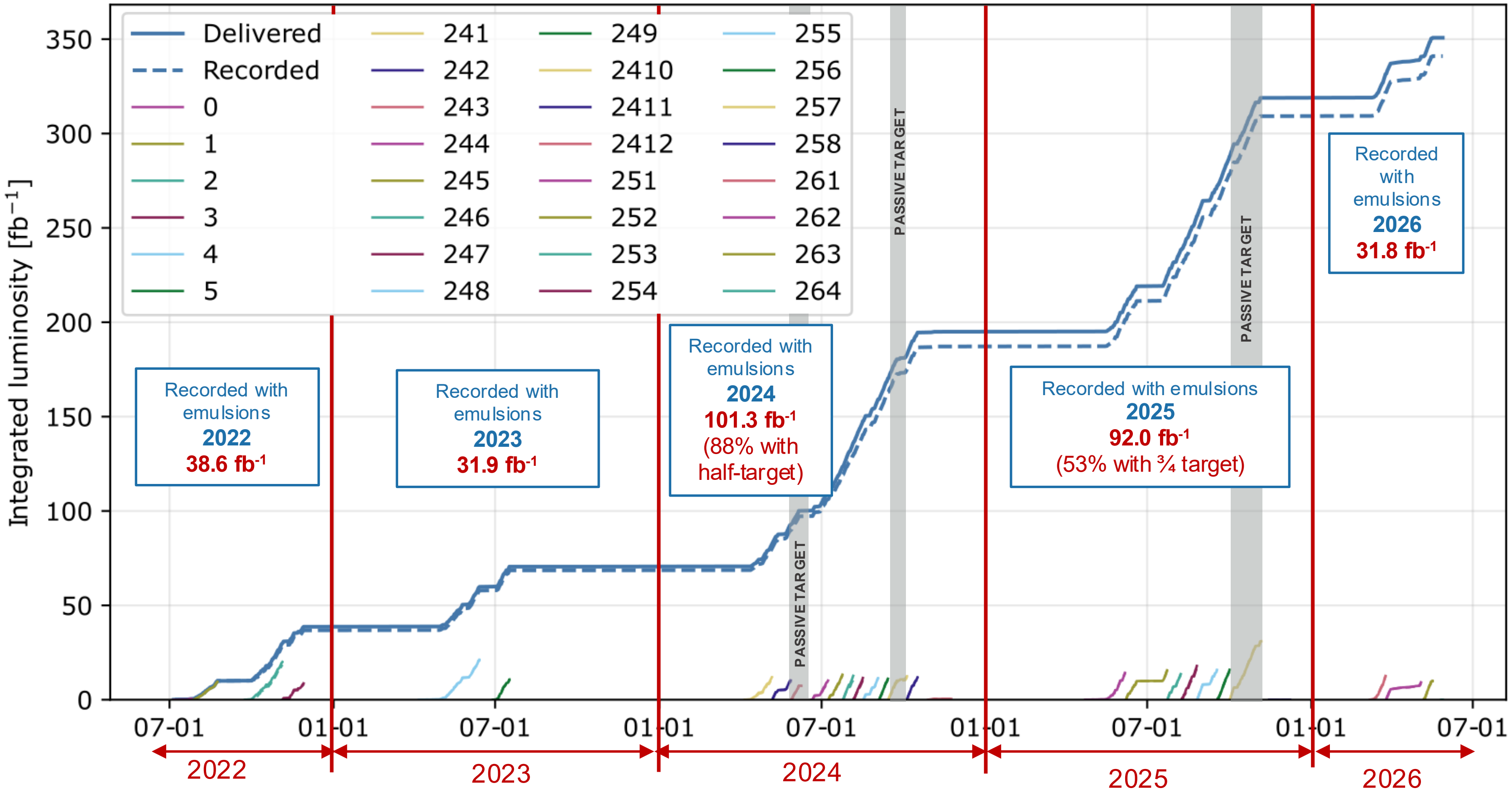
Hadrons
($\pi^{\pm}$ 100, 140, 180, 240, 300 GeV)



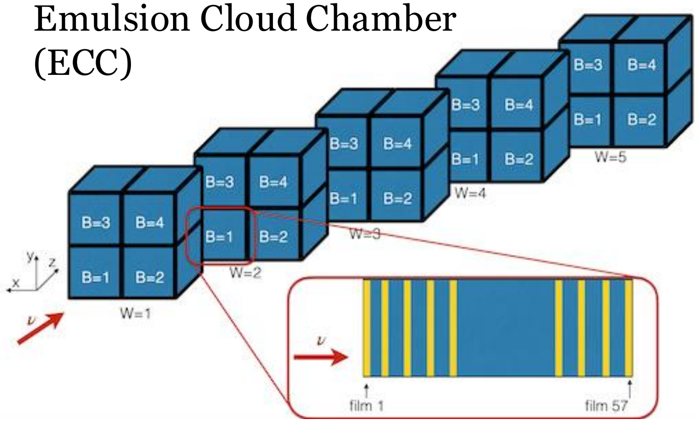




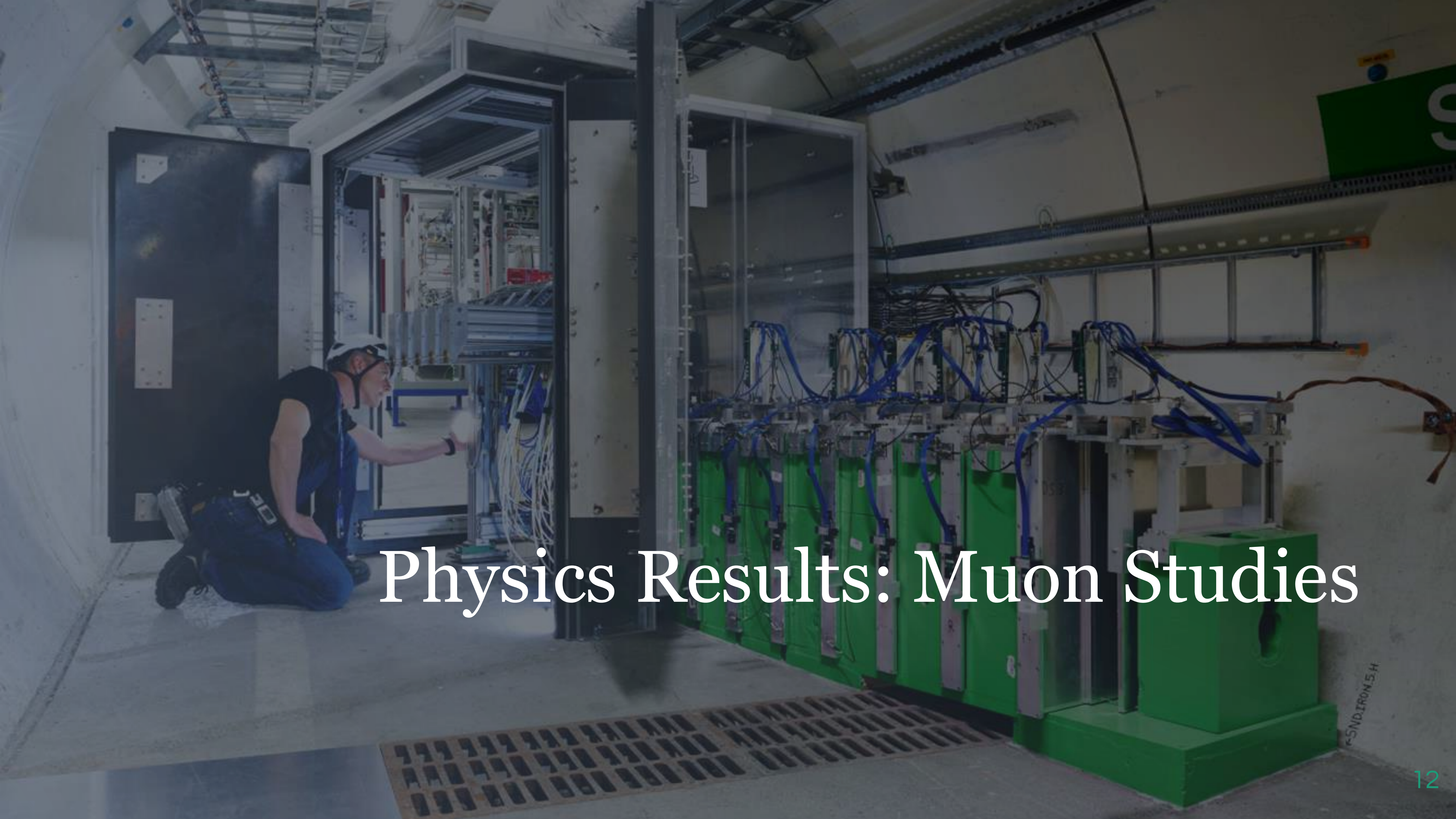
SND@LHC Data



Emulsion Cloud Chamber (ECC)



- Electronic detector uptime: 97% (~ 300 fb^{-1})
- The target construction allows for adaptation to LHC configurations.
- Percent of total luminosity recorded with emulsions: 83%
- ECC: Keep track density < **$4x10^5$** tracks/cm^2



Physics Results: Muon Studies

Muon Flux Studies

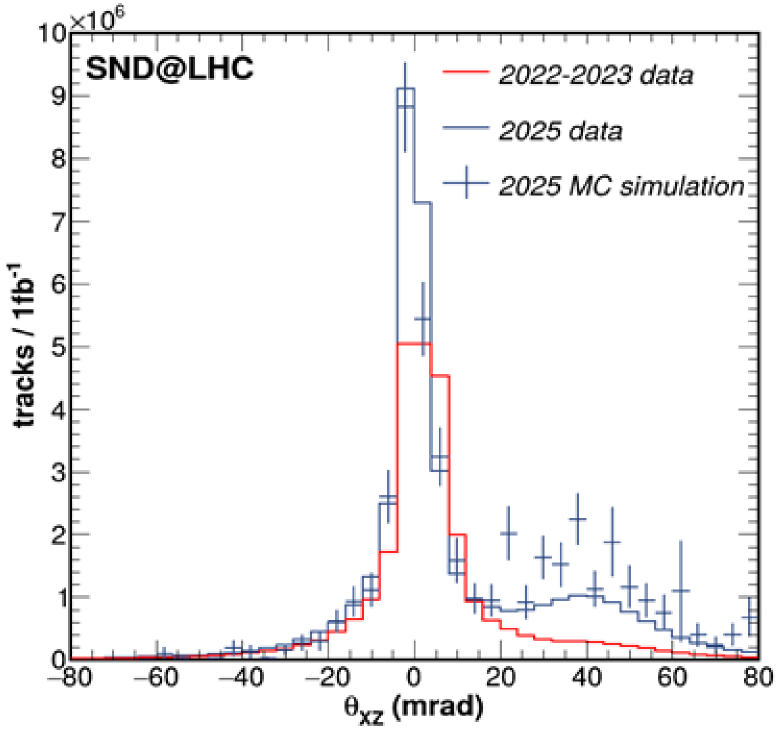
- Muons are the primary background for neutrino interaction searches.
- The muon flux is dependent on LHC configuration (e.g. crossing angle).
- Published 2022 muon rates: Eur. Phys. J. C (2024) **84**: 90
- 2023-2025 muon rates for ***pp*** and ***heavy-ion*** runs: arXiv:2602.23412, submitted to EPJC.

pp runs

2023 Data: $\Phi_\mu = (1.90 \pm 0.04) \times 10^{-2}\ \mathrm{nb/cm^2}$
2024 Data: $\Phi_\mu = (3.74 \pm 0.06) \times 10^{-2}\ \mathrm{nb/cm^2}$
2025 Data: $\Phi_\mu = (2.48 \pm 0.04) \times 10^{-2}\ \mathrm{nb/cm^2}$

PbPb runs

2023 Data: $\Phi_\mu = (3.13 \pm 0.11) \times 10^{4}\ \mathrm{nb/cm^2}$
2024 Data: $\Phi_\mu = (5.54 \pm 0.17) \times 10^{4}\ \mathrm{nb/cm^2}$
2025 Data: $\Phi_\mu = (3.60 \pm 0.13) \times 10^{4}\ \mathrm{nb/cm^2}$

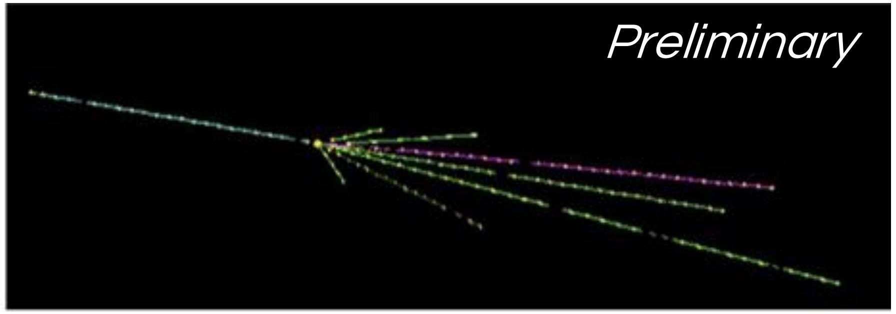


- Muon origins and data/LHC FLUKA simulation comparisons for the Run-3 proton runs in close collaboration with the CERN SY-STI team. arXiv:2603.21878

Muon DIS Search with Emulsion

- Selection based on topological and kinematic variables

Muon DIS event candidate



Preliminary

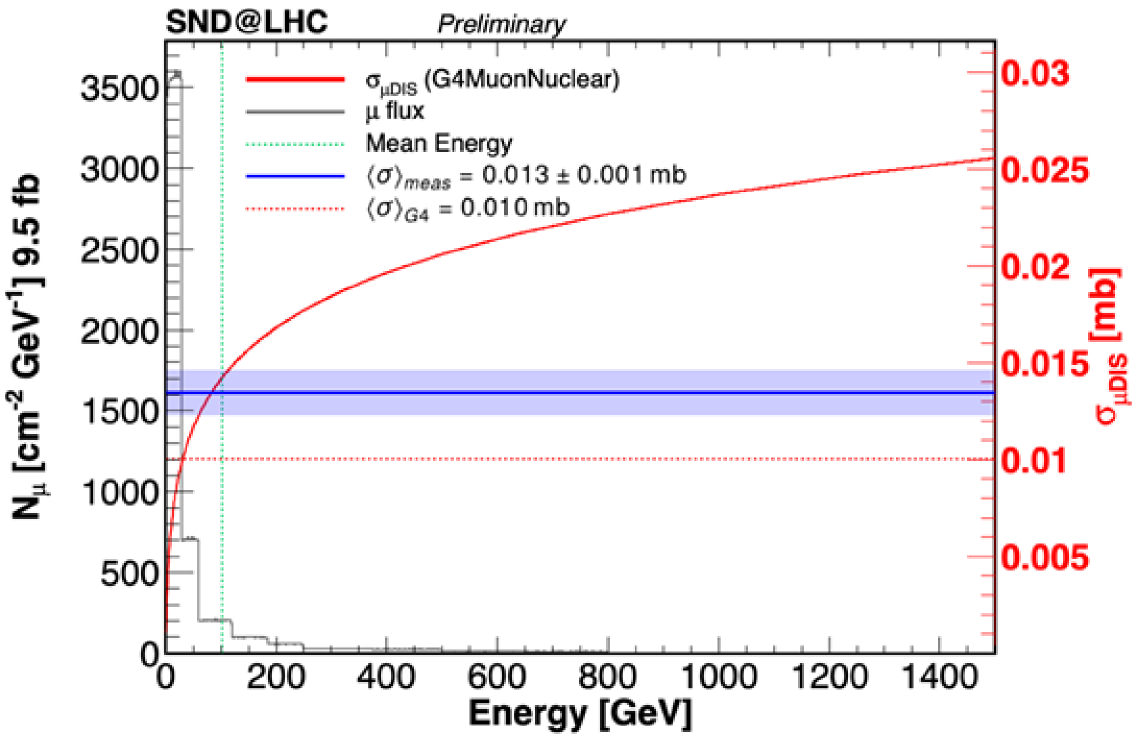
Number of events expected in 1 brick x 9.5 fb^{-1}: 225 ± 14

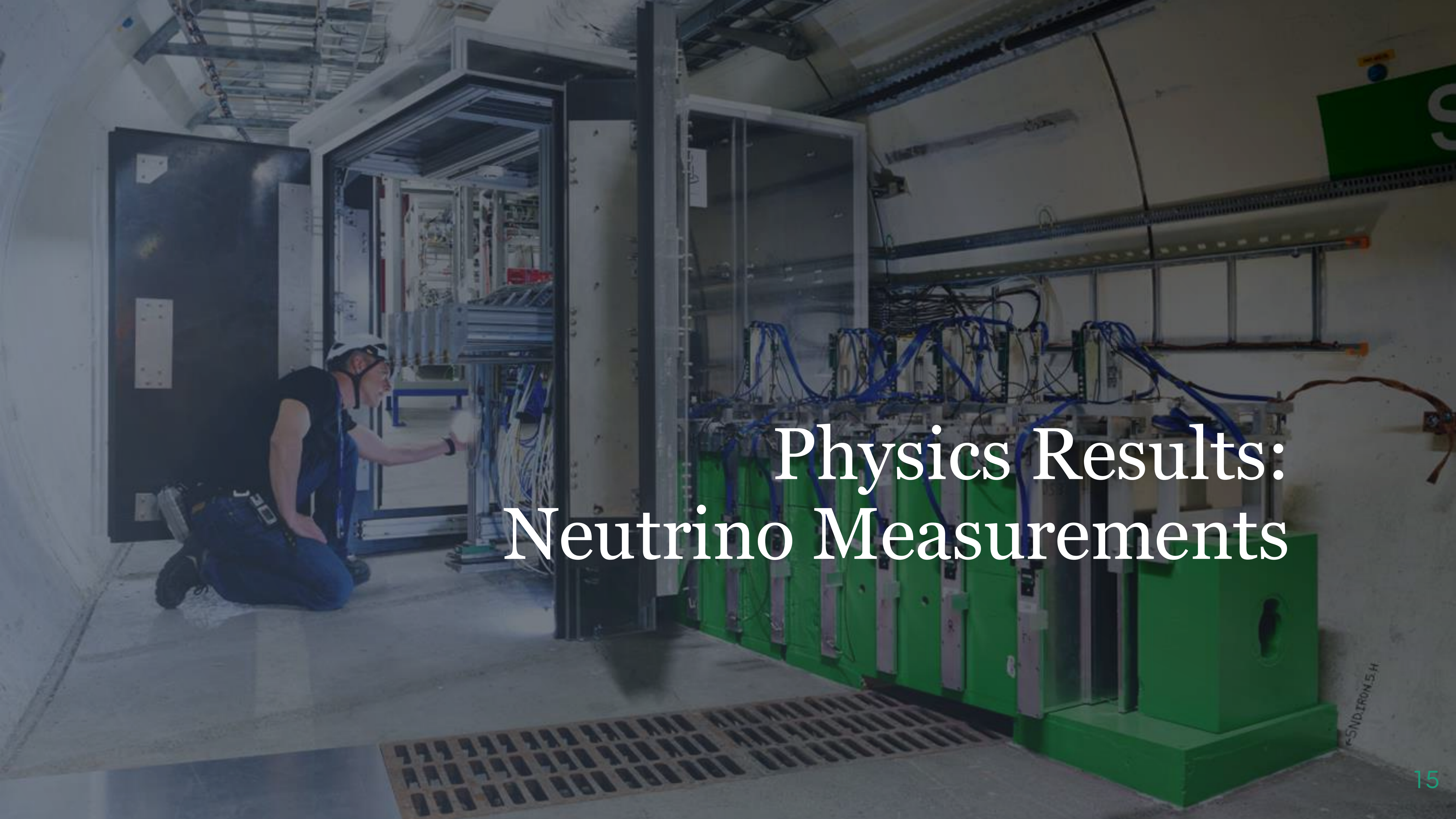
- **Signal: 210 ± 13**
- **Background: 15 ± 4**
  - Passing muons: 10 ± 3
  - Hadronic re-interactions: 5 ± 2

Number of events observed: 288

Muon DIS cross-section:

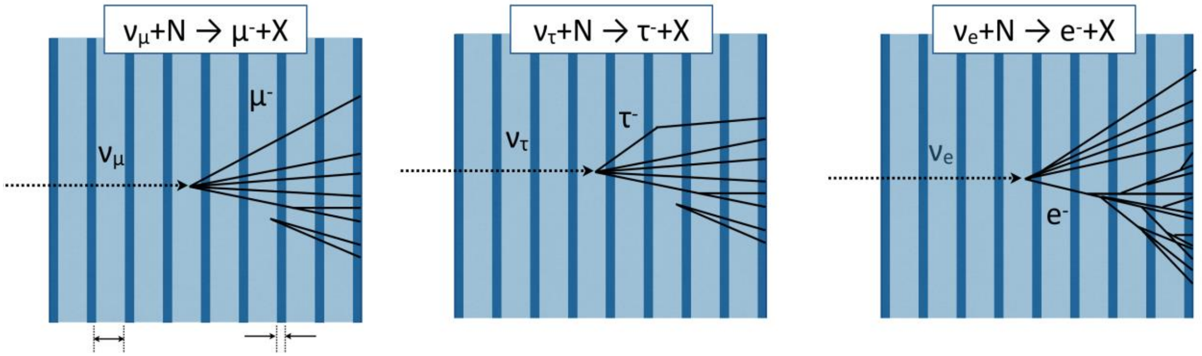
- **Expected: 0.010 mb**
- **Measured: 0.013 ± 0.001 mb**

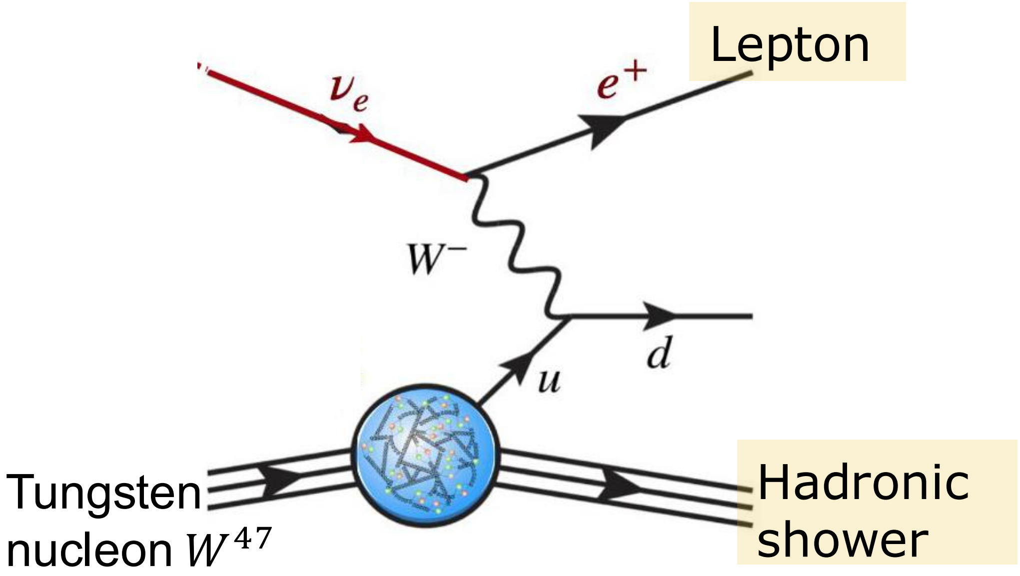




Physics Results: Neutrino Measurements

Neutrino Detection at SND@LHC

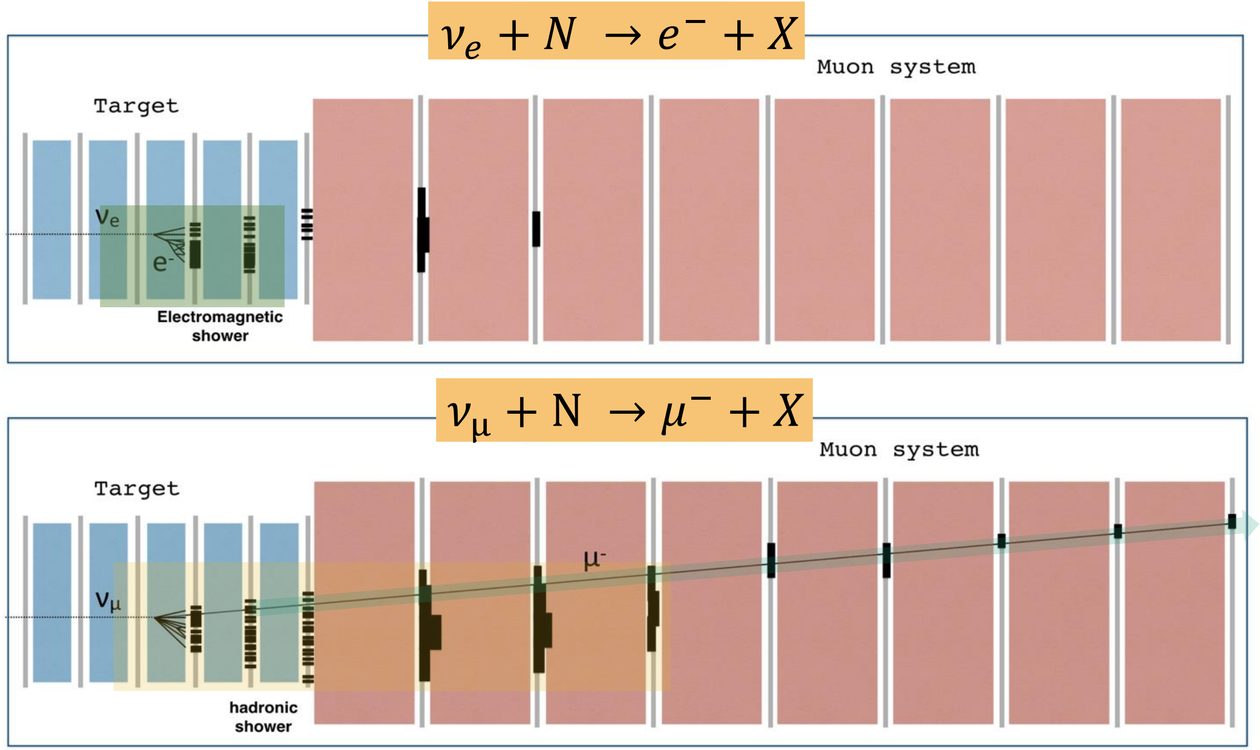




Charged Current (CC) interaction

Each of the ν CC interaction is identified by the signature left by the outgoing lepton in the detector.

Muons – clean tracks, Electron – Electromagnetic Showers, Tau – secondary vertex



Electromagnetic shower

Hadronic shower

ν_μ with Electronic Detectors (2022-23 Data)

- Phys. Rev. Lett. 131 analysis (8 ν_μ 6.8 σ - only 2022 data)
- **Updated** with 2022-23 (68.fb^{-1})
  - Event Selection:
    - Extended acceptance from 7.5 to 18%
    - Time-filtering of signals; MC Event Building
  - Background expectation: side-entering background
  - Signal expectation: EPOSLHC+POWHEG as baseline

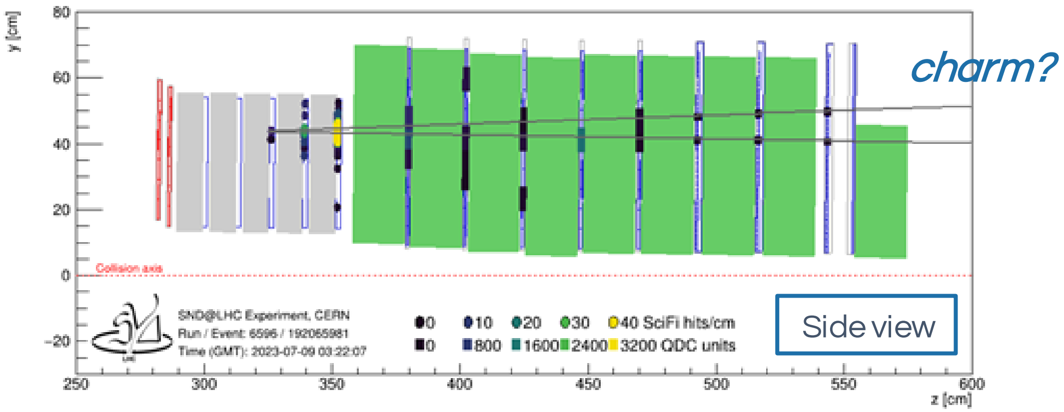
Preliminary

Number of events expected in 68.6 fb^{-1}

- **Signal: 24^{+10}_{-9} (prod) $^{+2}_{-8}$ (sel)**
- **Background: 5.0 ± 1.1**
  - Entering muons: 4.7 ± 1.1
  - Neutral hadrons: 0.3 ± 0.1

Number of events observed: 31

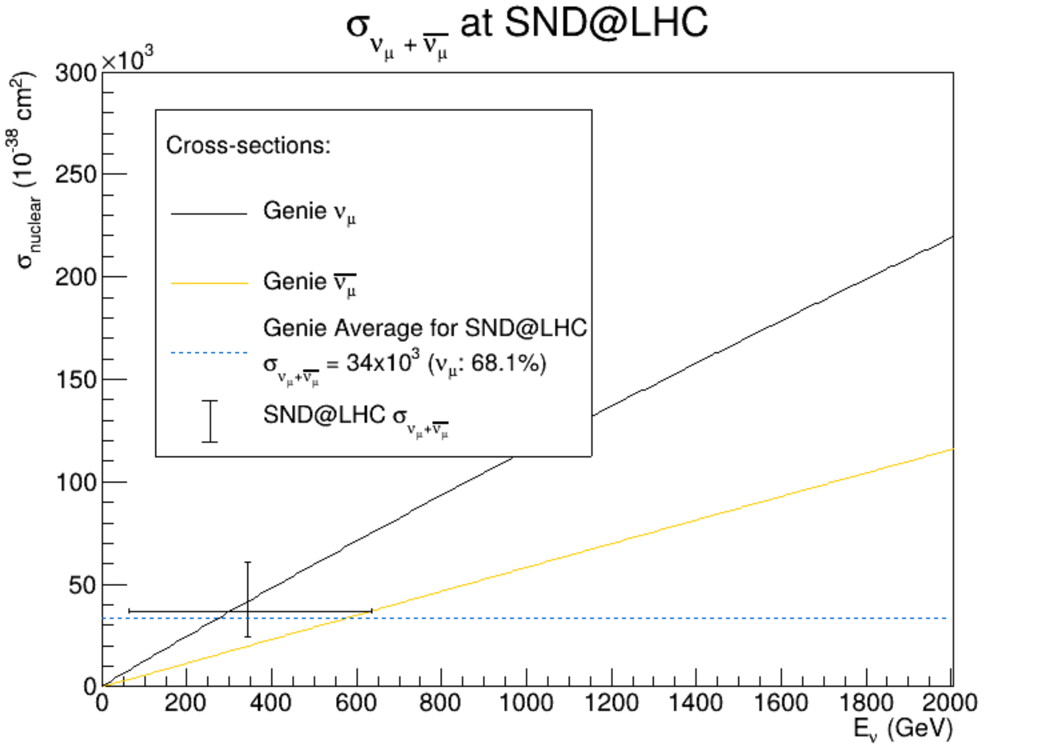
selected ν interaction with 2 muons in final state



Preliminary

The nuclear cross section averaging the (anti)neutrino energies:

- **Expected: 34 x10^{-35} cm²**
- **Measured: 37^{+24}_{-12} x 10^{-35} cm²**

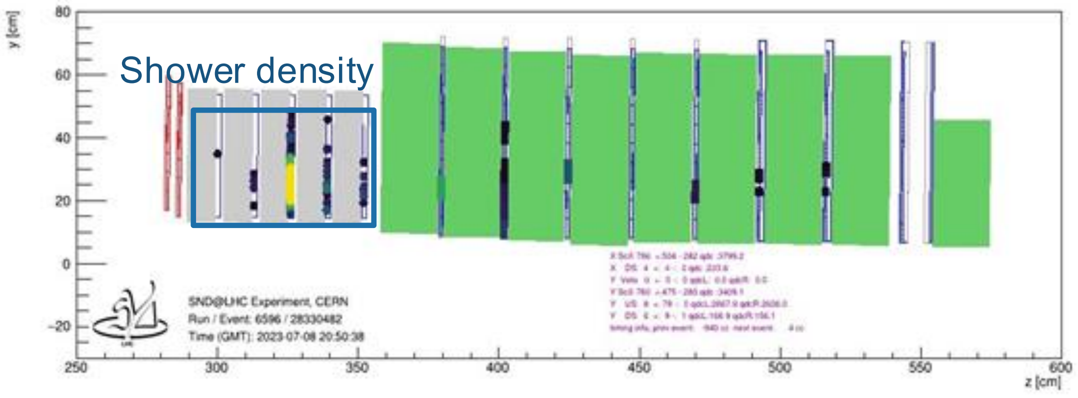


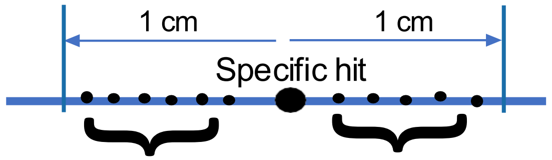
Signal Discriminator (0μ & ν_e CC obs.)

Sum of Hit Density Weights

Topological Signal Discriminator – characterizing the **shower density**.

- **More effective than simpler metrics** like the number of Sci-Fi hits.
- Separate dense EM showers from sparser hadronic showers.





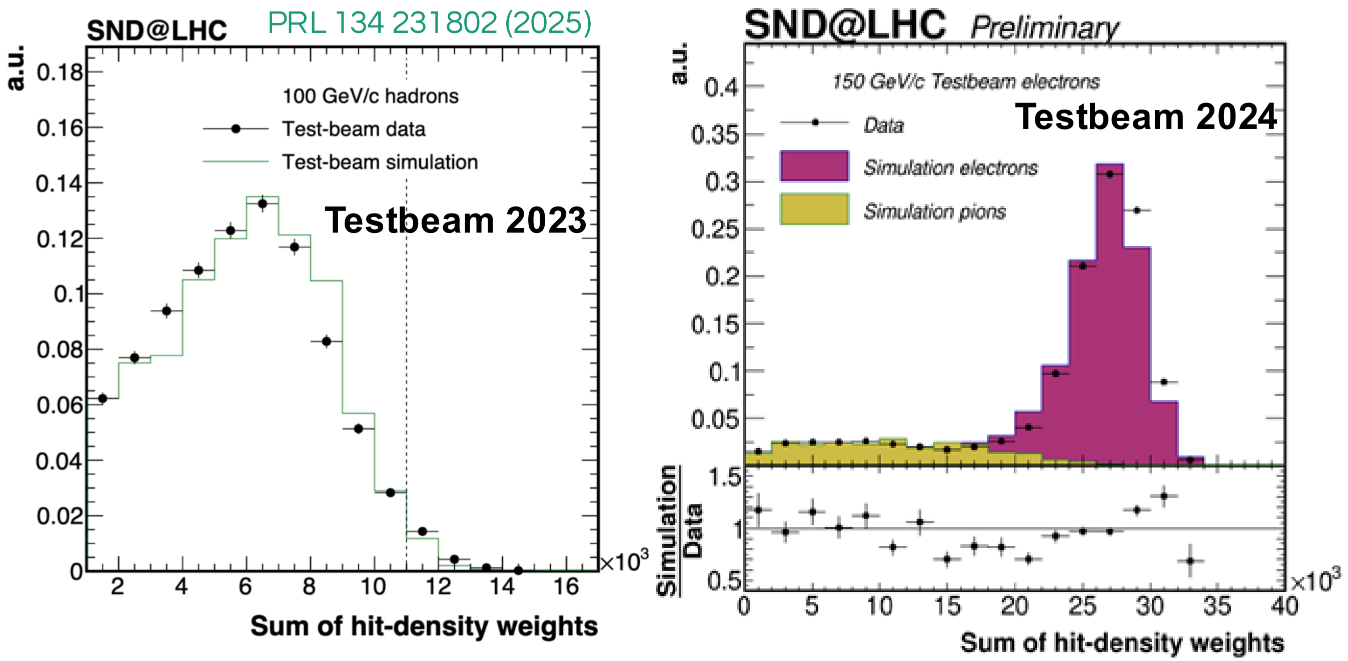
Validated by:

Testbeam 2023 (Signal selection for **0μ observation**)

- 100 GeV/c hadrons have a low sum of hit-density weights.

Testbeam 2024 (Binned Likelihood fit - **ν_e CC observation**)

- 150 GeV/c electrons → high sum of hit-density weights, separating well from hadrons of the same energy.



0μ Events with Electronic Detectors (2022-23 Data)

Signal: ν_eCC and NC interactions
Identification :
Large detector activity, no reconstructable muon,
Topological signal discriminator:
Summed of hit density weights >11000

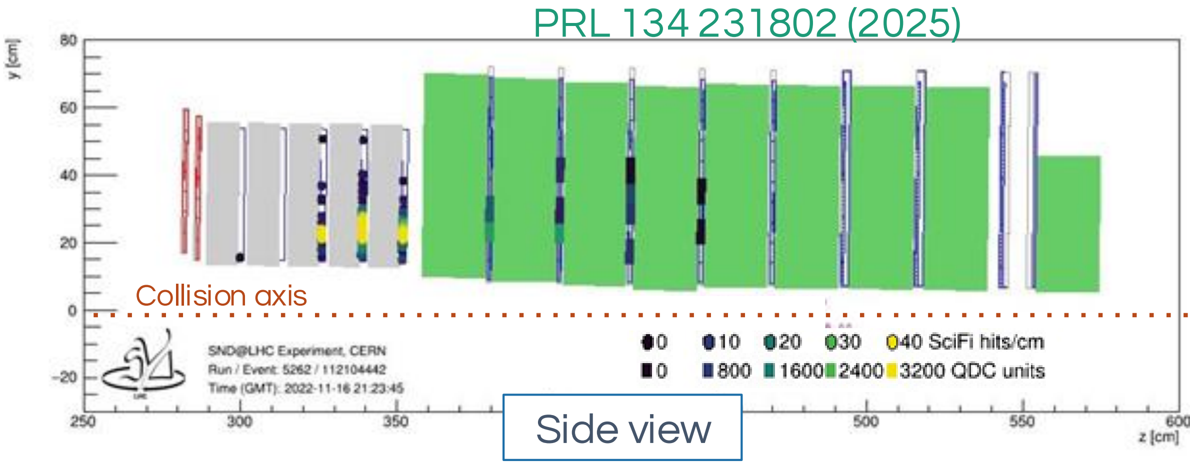
Backgrounds: neutral hadrons (**0.01** events), neutrino background(**0.30** events)

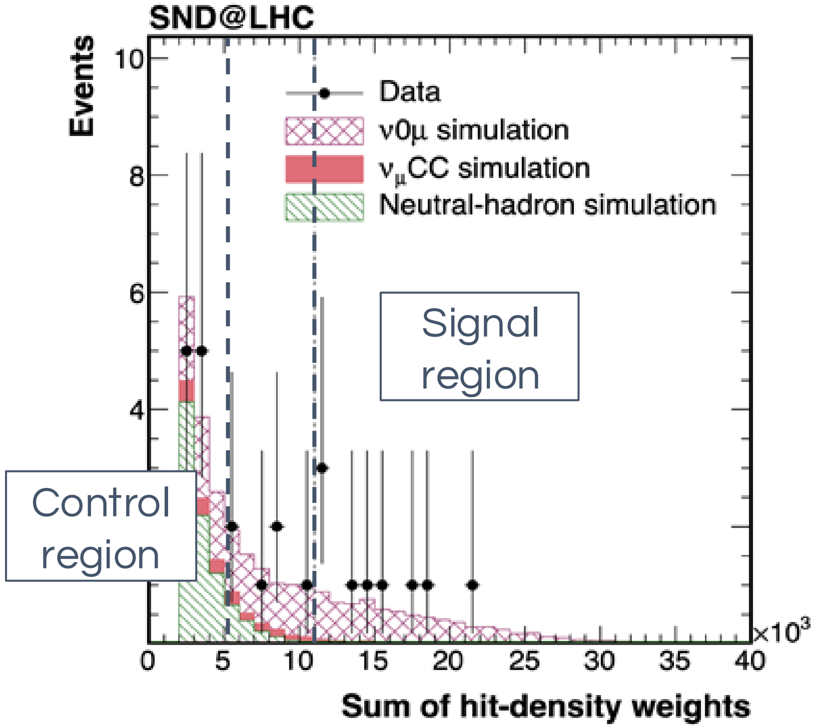
0μ observation significance

- Total expected background: **0.32 ± 0.06 events**
- Expected signal: **7.2 events**
  - 4.9 ν_eCC, 2.2 NC, 0.1 ν_τCC
- Expected significance: **5.5 σ**

Number of events observed: 9
Observation significance: 6.4 σ

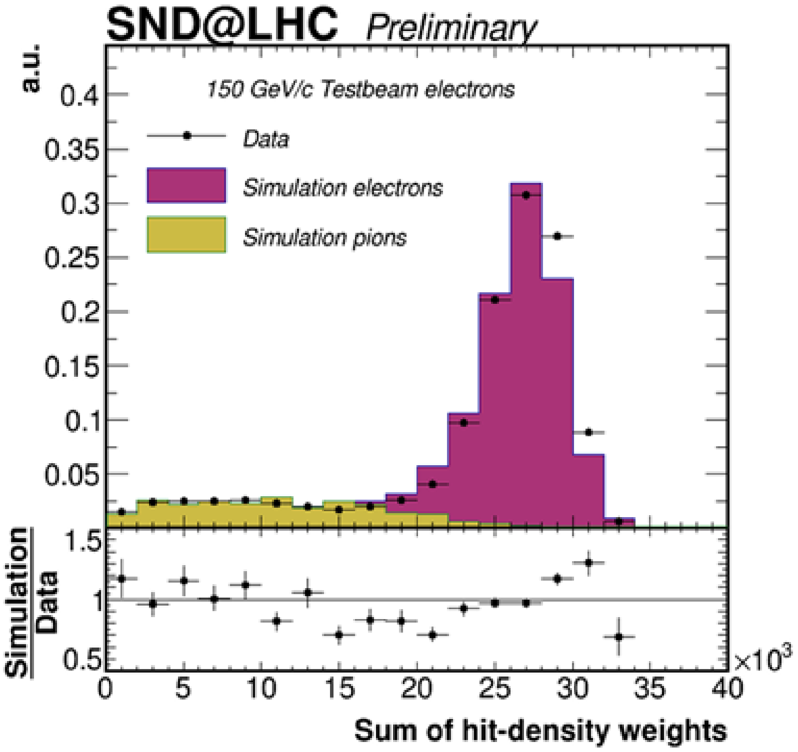
PRL 134 231802 (2025)

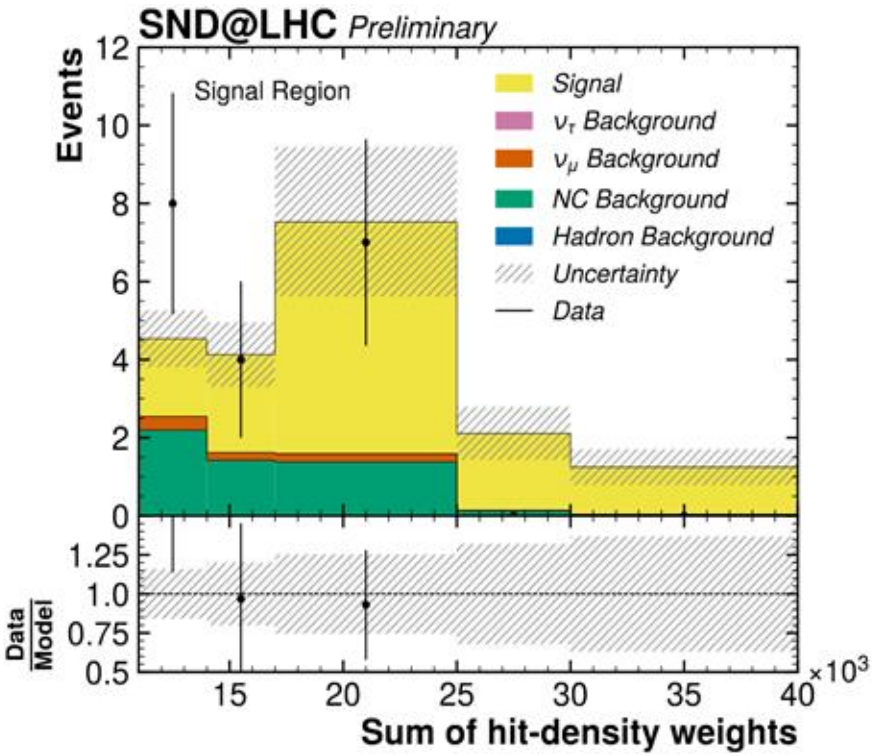




ν_eCC with Electronic Detectors (2022-24 Data)

- Binned likelihood analysis on the summed hit density weights in the target, and a count-based check.



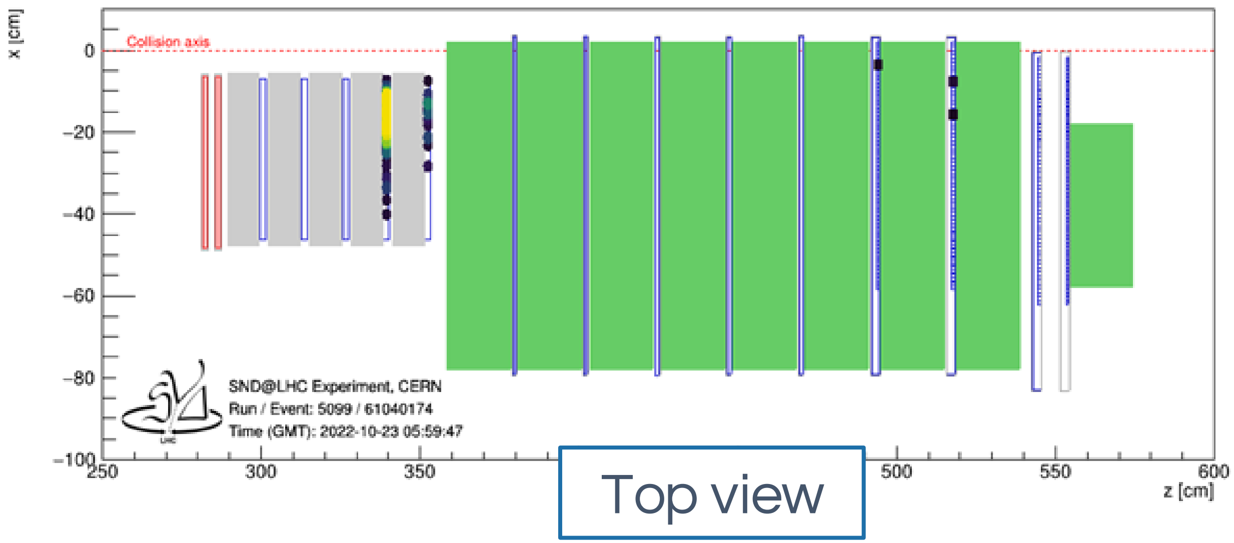


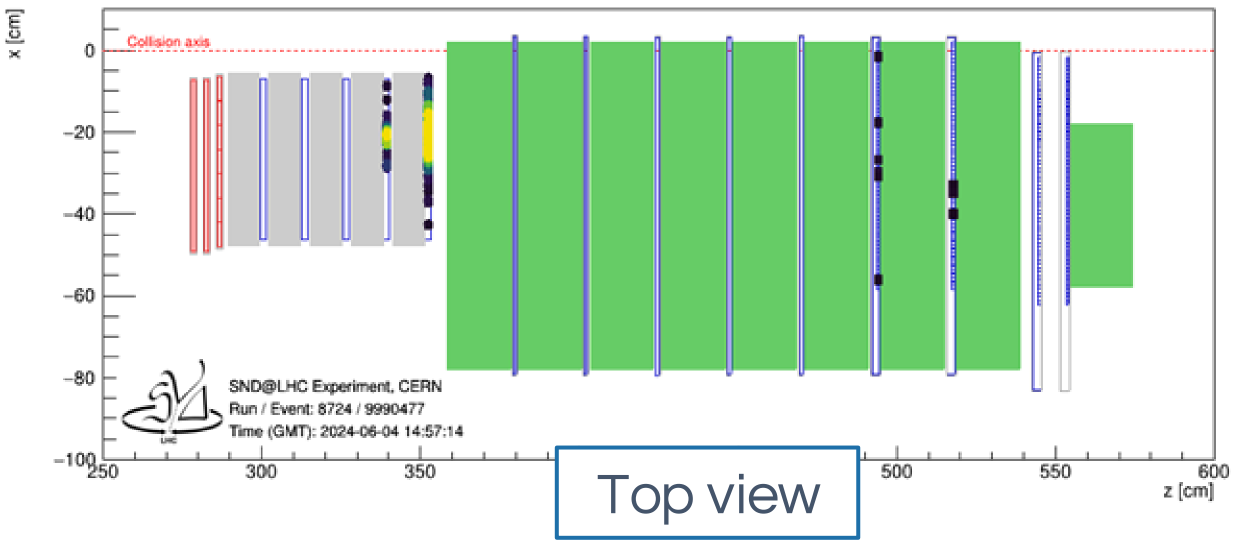
Preliminary

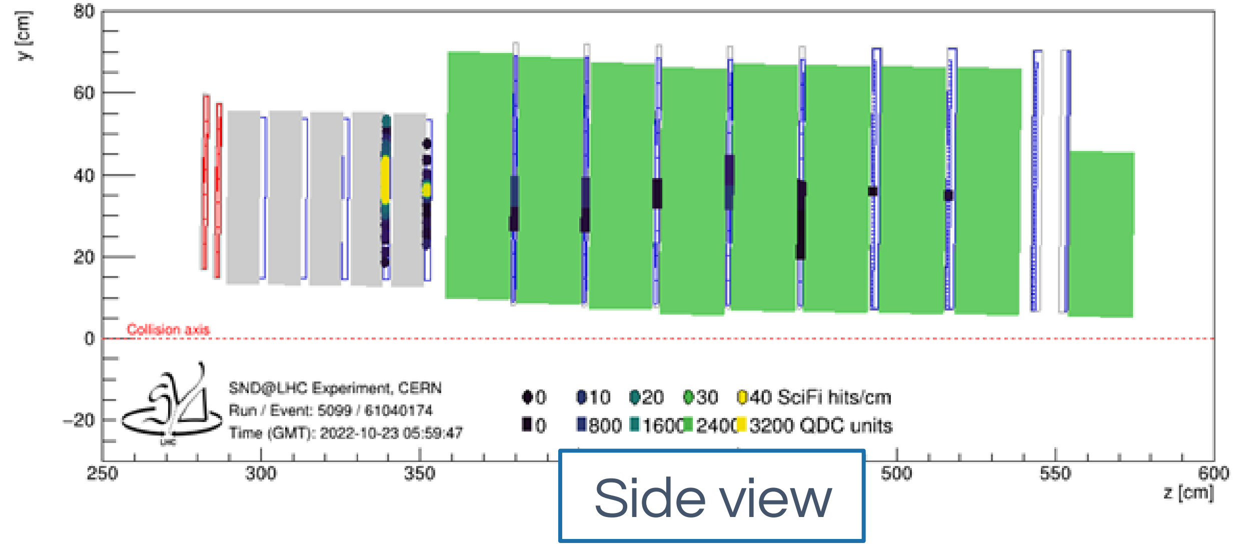
Expected events in 2022-2024,
68.6 +102.0 fb^{-1}**: 19±5**
*excluding 12fb^{-1} of 2024 due to SciFi connection issue
Signal: 13±5
Background: 6±1
Observed events: 19
= 9(2022-2023) + 10(2024)
Significance for the binned(unbinned) data, using DPMJET as baseline:
Expected: 4.5σ (3.8σ for ν_e CC in 0μ sample)
Observed: 2.7σ (3.6σ)

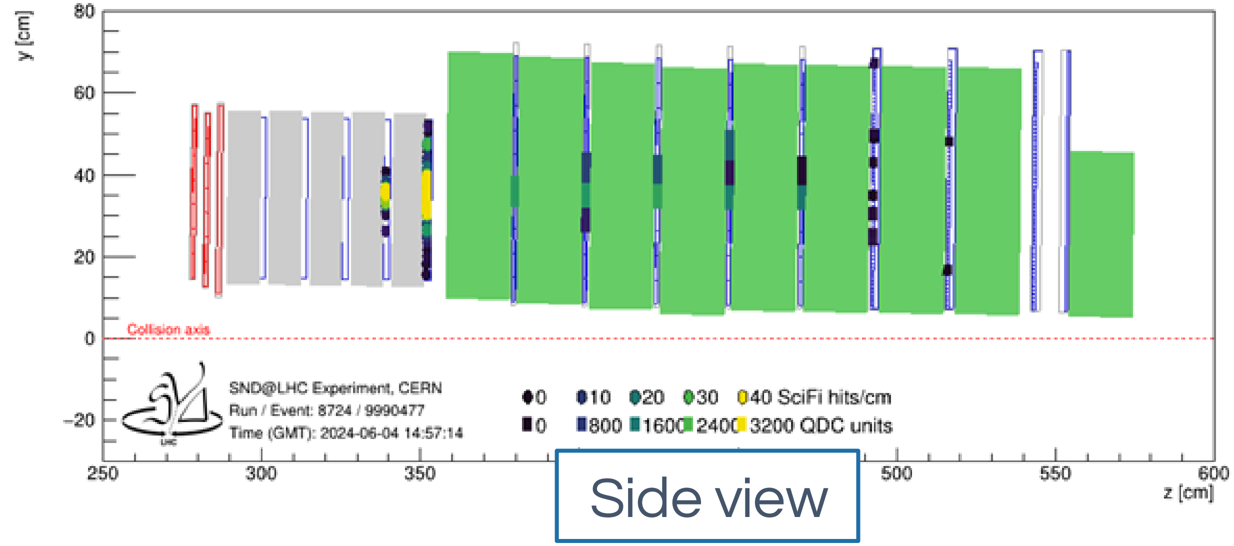
- Clear evidence of ν_e component in the electronic detector data.
- Investigating why the simulation does not accurately predict the shape of the hit density distribution.
- On the physics model side: EPOSLHC(light)+POWHEG(heavy hadrons) were also tested.
  - **4.2 σ (3.8 σ) expected significance**
  - **2.6 σ (3.7 σ) observed**

ν_eCC Event Candidates







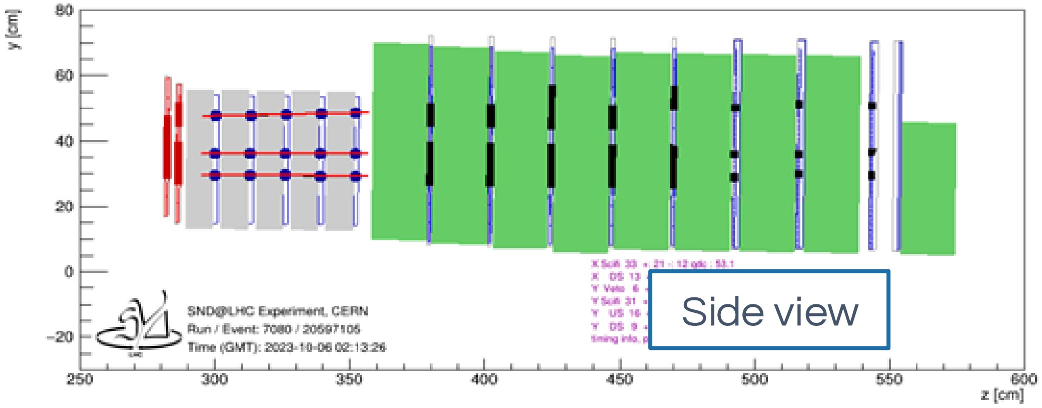


Interesting Ongoing Analyses

Muon trident process

- SND@LHC is sensitive to muon trident interaction in the upstream rock.

$$\mu^{\pm} + N \rightarrow \mu^{+}\mu^{-}\mu^{\pm} + N$$

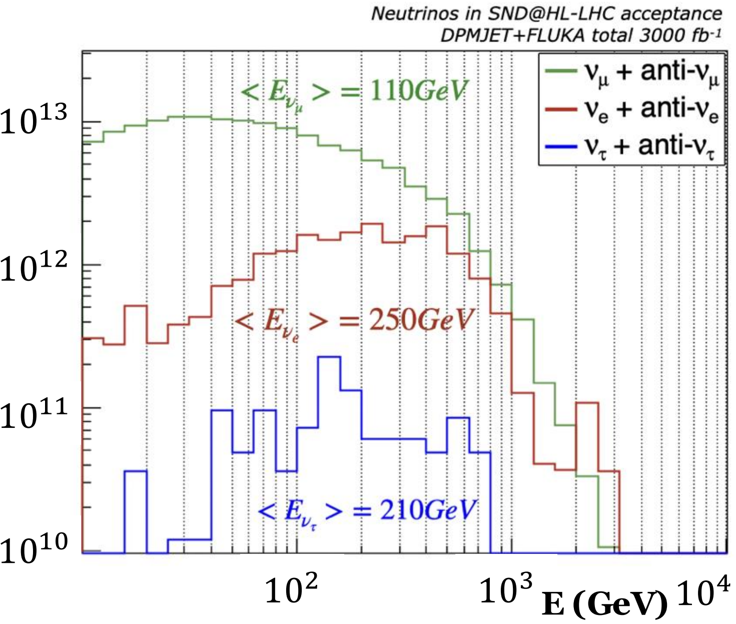


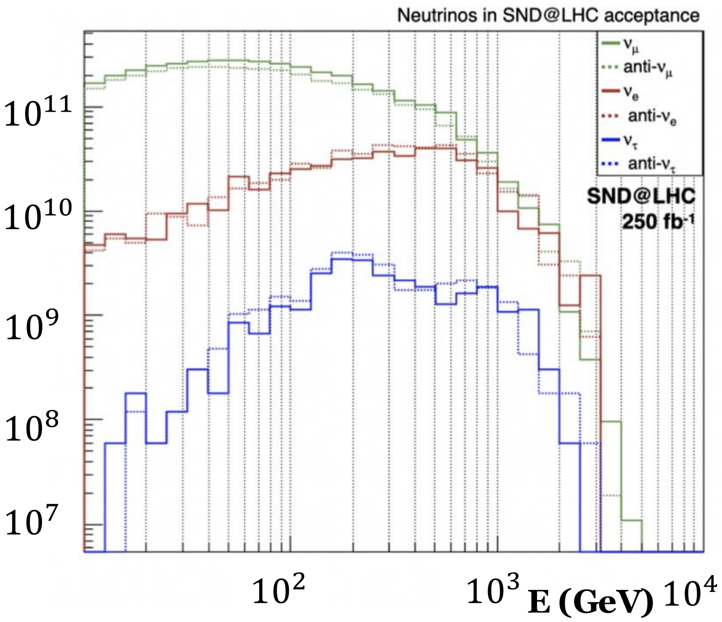
- Choice of generator has a potentially large impact on the efficiency correction.
  - Considering both Geant4 and MESMER
  - Currently evaluating our efficiency with MESMER

ν_τ magnetic moment

- Signal: ν_τ - electron scattering
- Signature: single EM shower, no hadronic activity
- *Preliminary* neutrino background prediction: 0.22 events
- Assuming no events are observed in 309.3 fb^{-1}, the expected *preliminary* sensitivity is 3.68 x 10^{-6} μ_B
- Extrapolating to HL-LHC and assuming same efficiency as DONuT expect 2.9 x $10^{-7}\mu_B$

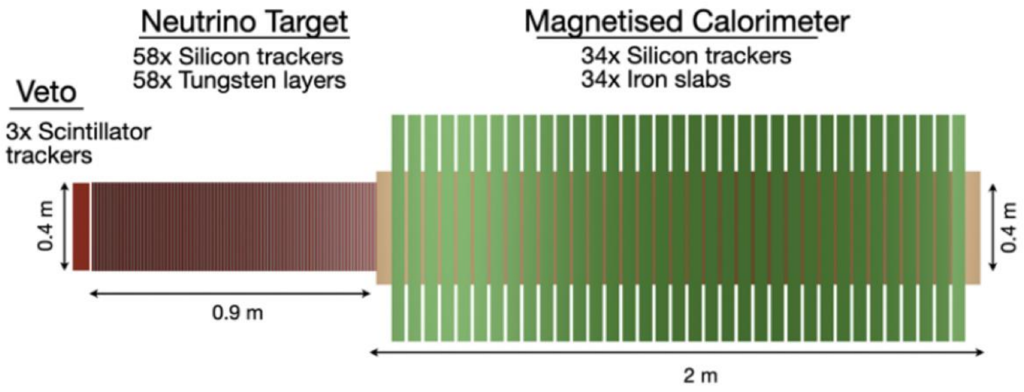
Extend neutrino physics measurements at the TeV scale with the increased statistics offered by HL-LHC.





Measurement	Uncertainty Stat.	Uncertainty Sys.	Uncertainty Stat.	Uncertainty Sys.
Gluon PDF ($x < 10^{-5}$)	5%	35%	2%	5%
ν_e/ν_τ ratio for LFU test	30%	22%	6%	10%
ν_e/ν_μ ratio for LFU test	10%	10%	2%	5%
Charm-tagged ν_e/ν_μ ratio for LFU test	-	-	10%	< 5%
ν_μ and $\overline{\nu}_\mu$ cross-section	-	-	1%	5%

Approved in June 2025, TP Run4 SND@LHC

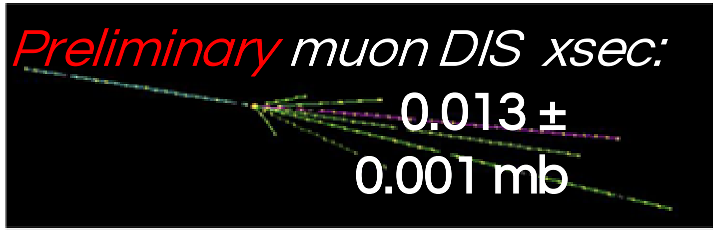


- Upgrade performance: arXiv:2602.21881
- Vertex detector - CMS TOB silicon strips detector
  - 30 µm expected resolution
  - First cosmic rays with prototype.
- Magnetised calorimeter → discriminate neutrinos from anti-neutrinos.

1st Testbeam of the prototype – completed. Analysis ongoing.

Summary and Outlook

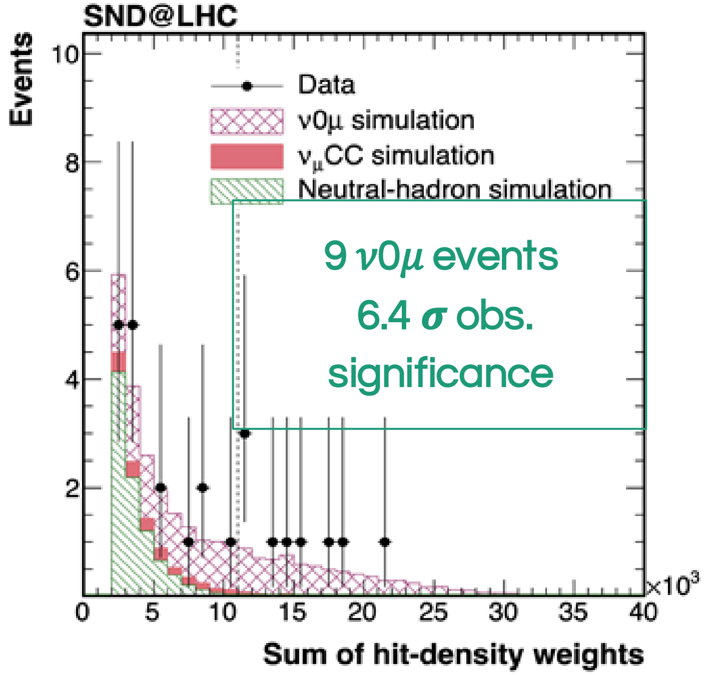
- SND@LHC measures neutrinos in the forward region of pp collisions.
- Recorded 330 fb^{-1} of 2022-2026 data, **97 % detector uptime.**
- Run3 muon flux measurement in agreement with LHC FLUKA prediction.



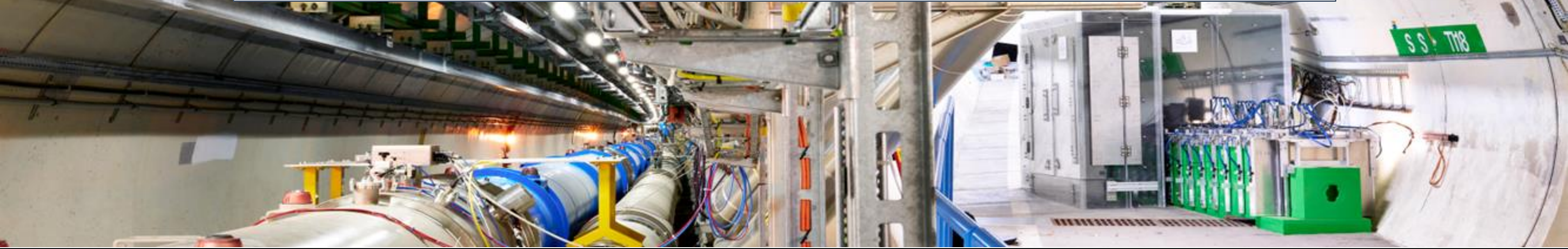
Preliminary

ν_μ nuclear xsec: 37^{+24}_{-12} x 10^{-35} cm^2

- Reported **evidence of ν_e CC** in electronic detectors.
- Muon trident and sensitivity to BSM underway, including 2024-2025 data.
- First Testbeam completed for the Run4 prototype –analysis ongoing!



Many thanks to the LHC team for the excellent machine performance!



Thank you

Supplementary Slides

Experiment Timeline

Scattering and Neutrino Detector at the LHC

Letter of Intent

August 2020

TECHNICAL PROPOSAL

SND@LHC

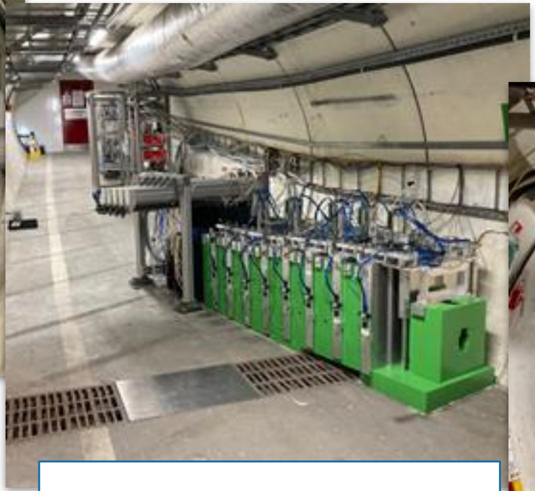
January 2021

CERN approves new LHC experiment

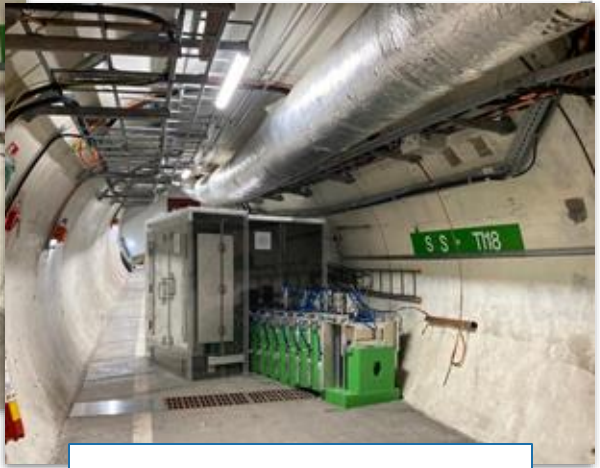
SND@LHC, or Scattering and Neutrino Detector at the LHC, will be the facility's ninth experiment

March 2021

September 2021

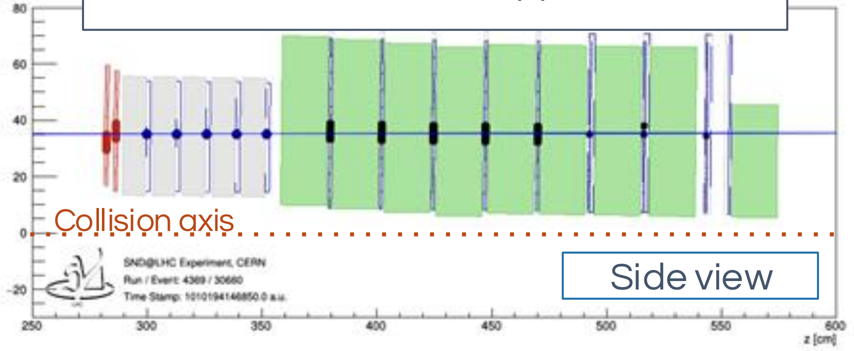


December 2021



March 2022

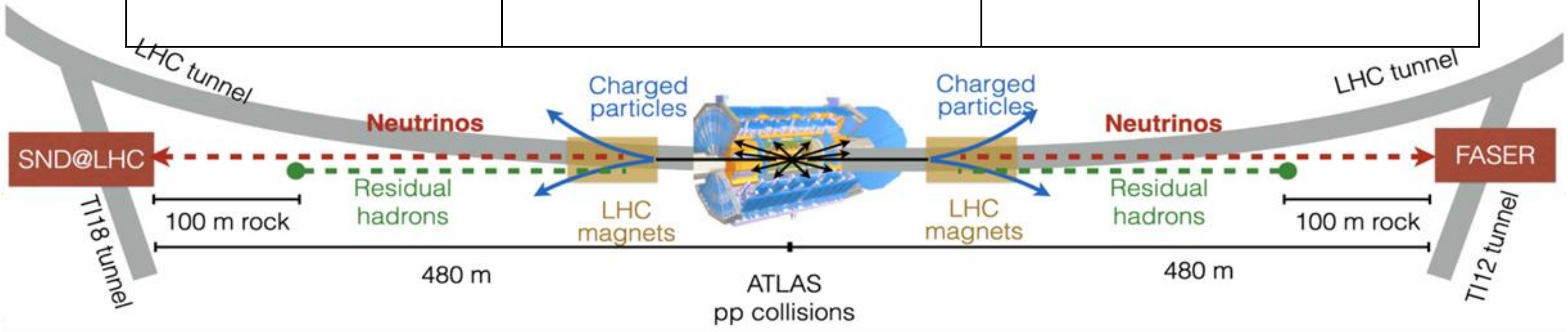
Muon from 13.6 TeV pp collision



July 2022

Complementarity with FASER

	SND@LHC	FASER
Location	**Off-axis:** $7.2 < \eta < 8.4$ Enhances **charm** parentage	**On-axis:** $\eta > 9.2$ Enhances **statistics**
Target	**800 kg** of tungsten	**1100 kg** of tungsten
Detector technology	**Emulsion vertex detector,** electromagnetic and hadronic **calorimeters**	**Emulsion vertex detector** and **spectrometer**



SND@LHC Physics Goals

Neutrino interactions

- Measure ***ν* interactions** in unexplored ~TeV energy range.
- Large yield of ν_τ will likely double existing data.
    - About 20 events observed by DONuT and OPERA.
    - 7 astrophysical ν_τ candidates observed by IceCube.

QCD

- Decays of **charm** hadrons contribute significantly to the neutrino flux in SND@LHC.

⇒ Measure **forward charm production** with ν_es.

⇒ Constrain gluon PDF at very small x.

Flavour

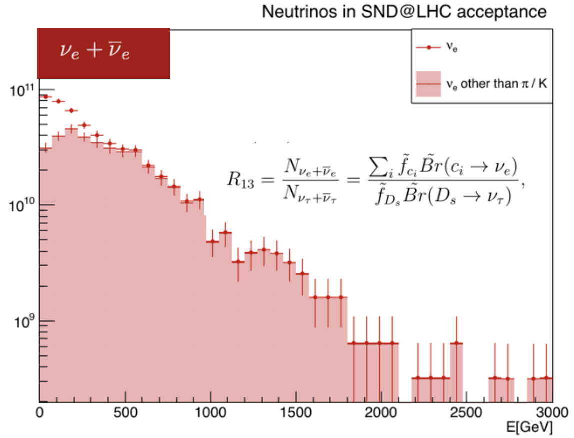
- Detection of all **three types of neutrinos** allows for tests of **lepton flavour universality**.
    - Charm parentage leads to partial cancelation of flux uncertainties.

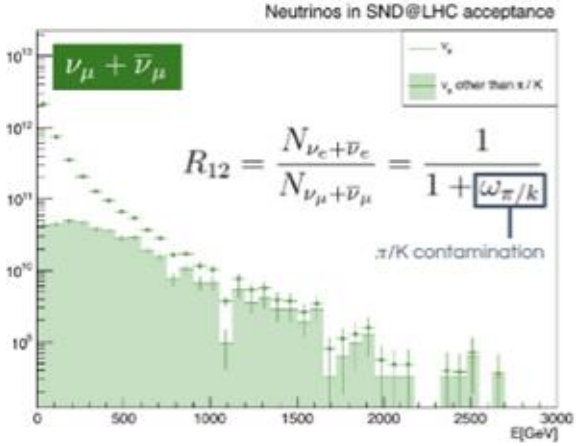
Beyond the Standard Model

- Search for **new**, feebly interacting, **particles decaying** within the detector or **scattering** off the target.

Expected neutrino interactions in Run3, 310 fb^{-1}:

Flavour	DIS-CC	DIS-NC
$\nu_\mu + \bar{\nu}_\mu$	1575	508
$\nu_e + \bar{\nu}_e$	484	161
$\nu_\tau + \bar{\nu}_\tau$	37	19
Tot	2096	688

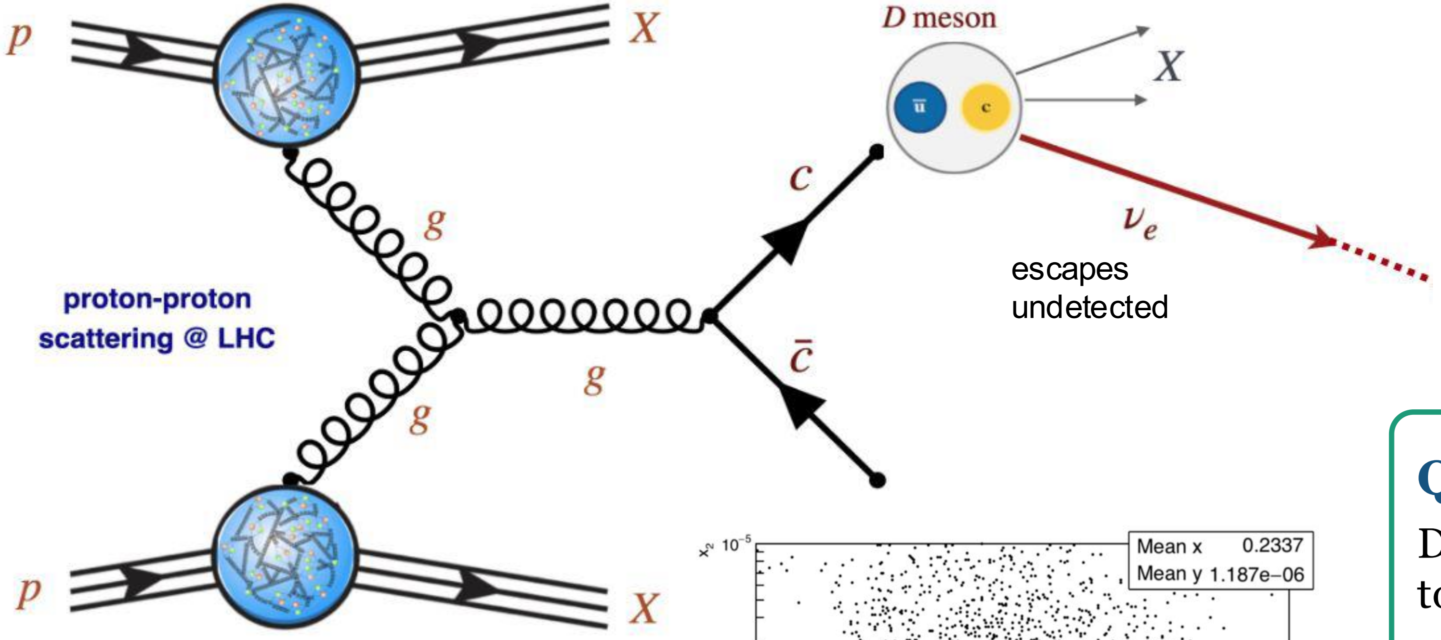


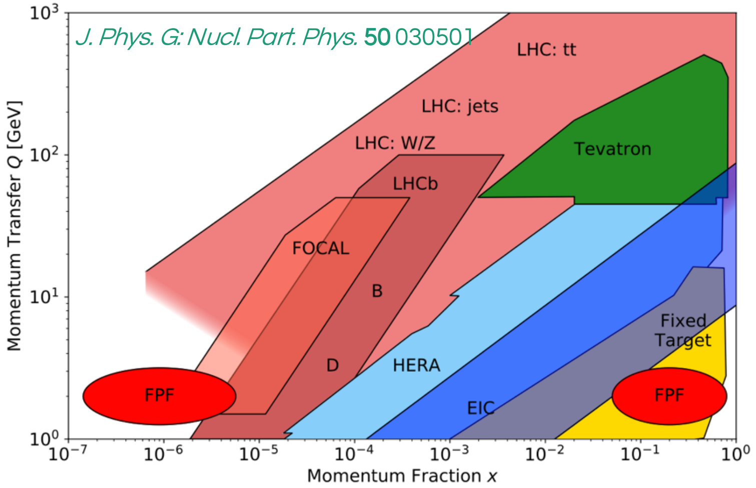


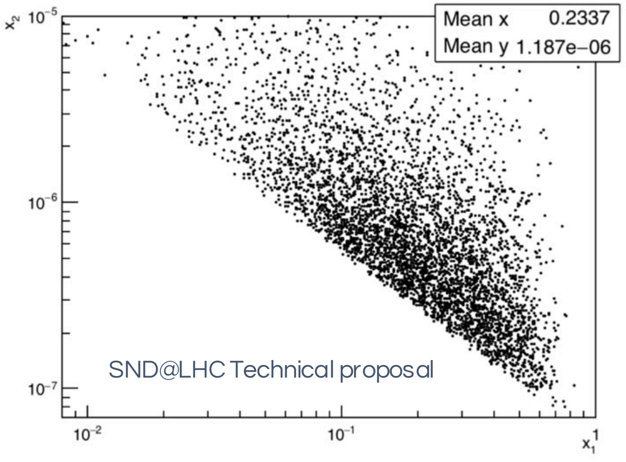
Quantum Chromodynamics

LHC *pp* collisions (**pp** → ν_X **X**)

Large neutrino flux - in the **forward region**







QCD physics

Decays of **charm** hadrons contribute significantly to the neutrino flux in SND@LHC.

⇒ Measure **forward charm production** with ν_es.

⇒ Constrain gluon PDF at very small x [~10^{-6}]

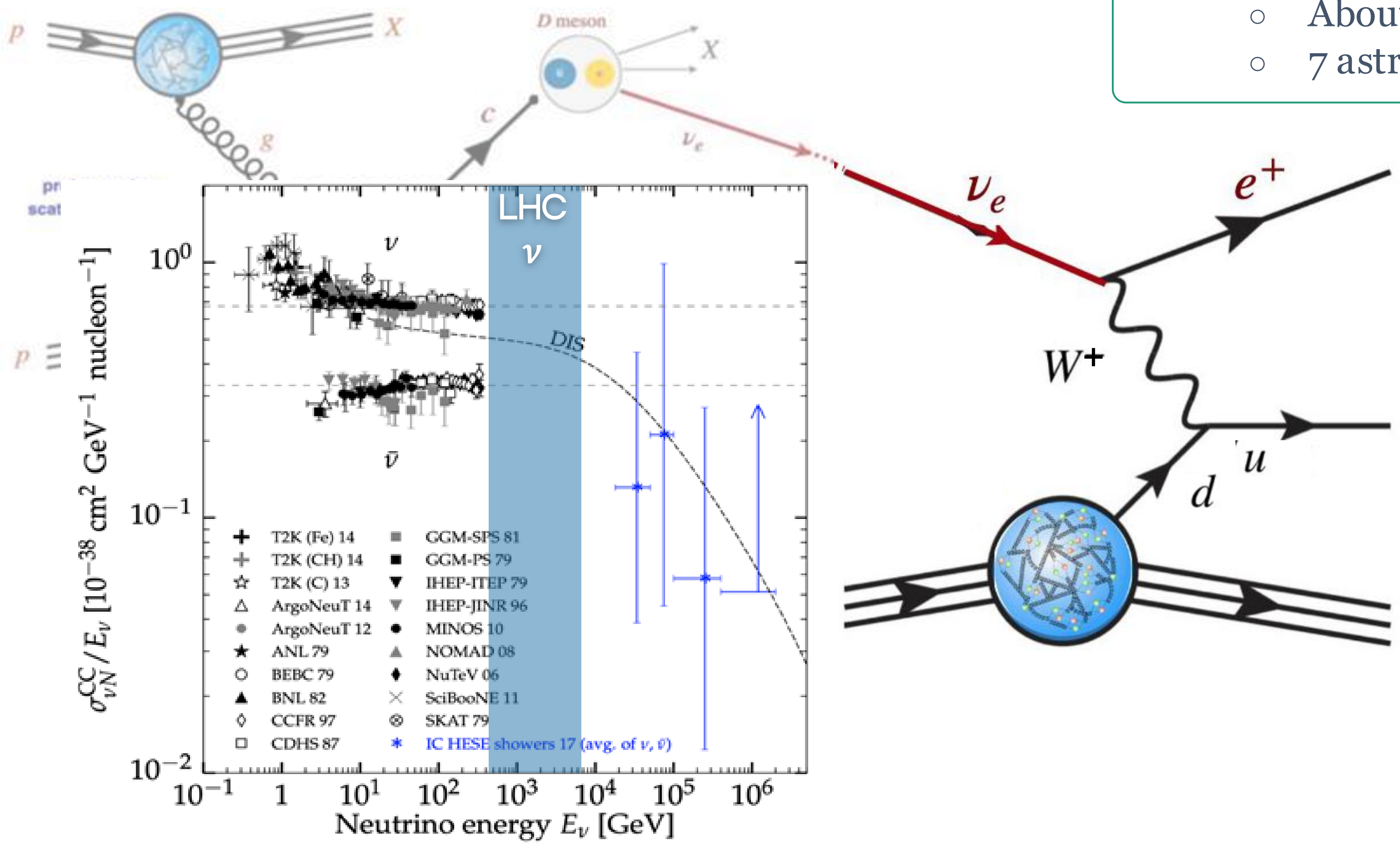
Implication for future colliders & astrophysics.

Adapted from Juan Rojo's CERN TH seminar

Neutrino Interactions

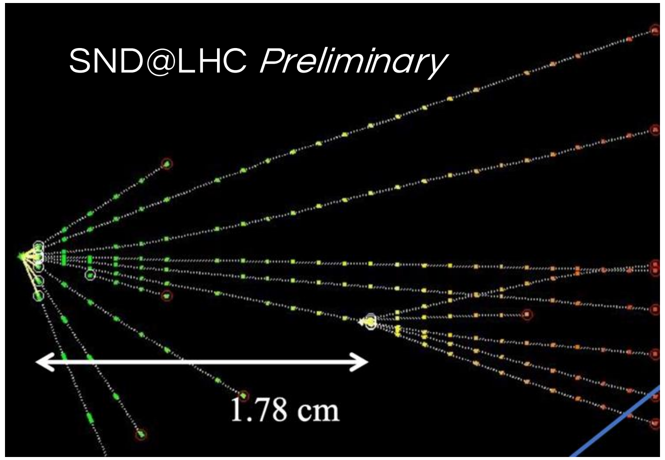
Neutrino interactions

- Measure ν **interactions** in the ~TeV energy range.
- Large yield of ν_τ will likely double existing data.
  - About 20 events observed by DONuT and OPERA.
  - 7 astrophysical ν_τ candidates observed by IceCube.



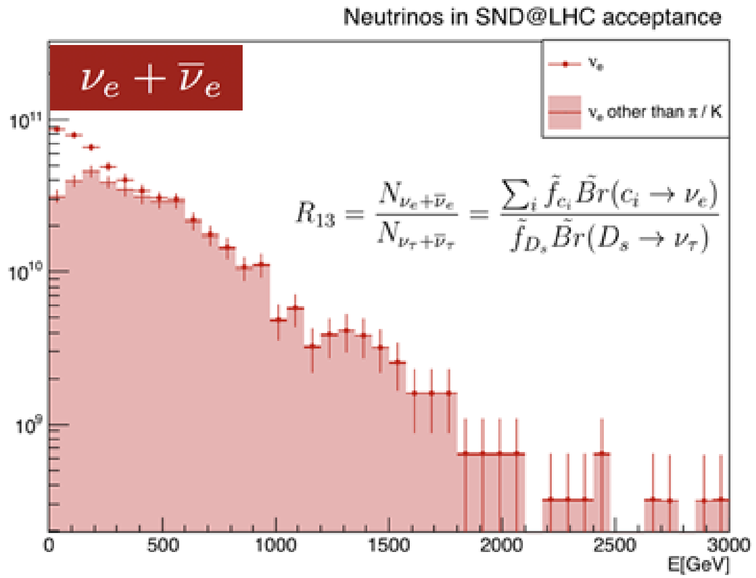
250 fb^{-1}

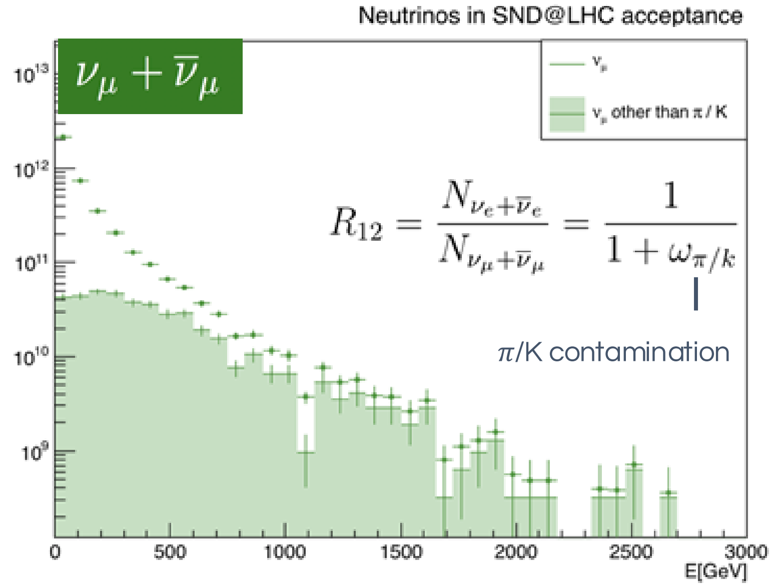
Flavour	Neutrinos in acceptance ⟨E⟩ [GeV]	Yield	CC neutrino interactions ⟨E⟩ [GeV]	Yield	NC neutrino interactions ⟨E⟩ [GeV]	Yield
ν_μ	130	3.0×10^{12}	452	910	480	270
$\bar{\nu}_\mu$	133	2.6×10^{12}	485	360	480	140
ν_e	339	3.4×10^{11}	760	250	720	80
$\bar{\nu}_e$	363	3.8×10^{11}	680	140	720	50
ν_τ	415	2.4×10^{10}	740	20	740	10
$\bar{\nu}_\tau$	380	2.7×10^{10}	740	10	740	5
TOT		4.0×10^{12}		1690		555



Adapted from Juan Rojo's CERN TH seminar

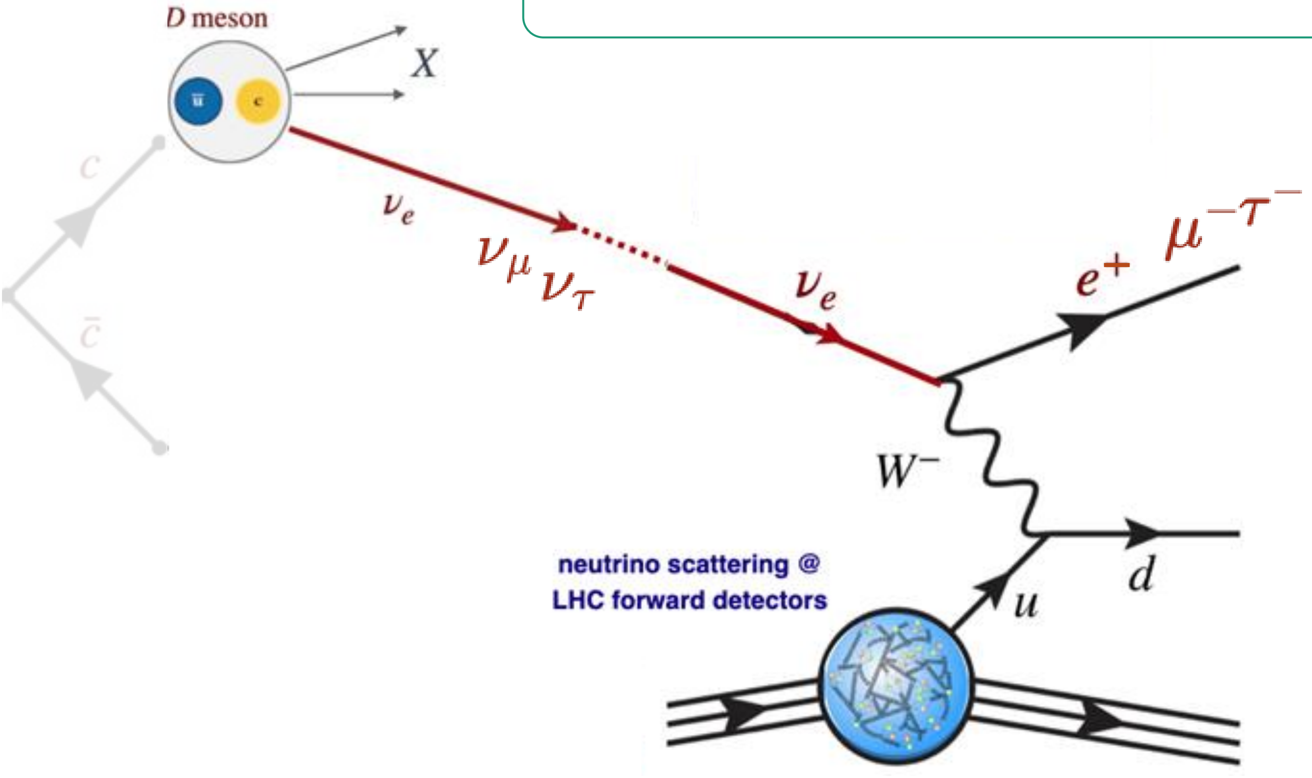
Lepton Flavour Universality Tests



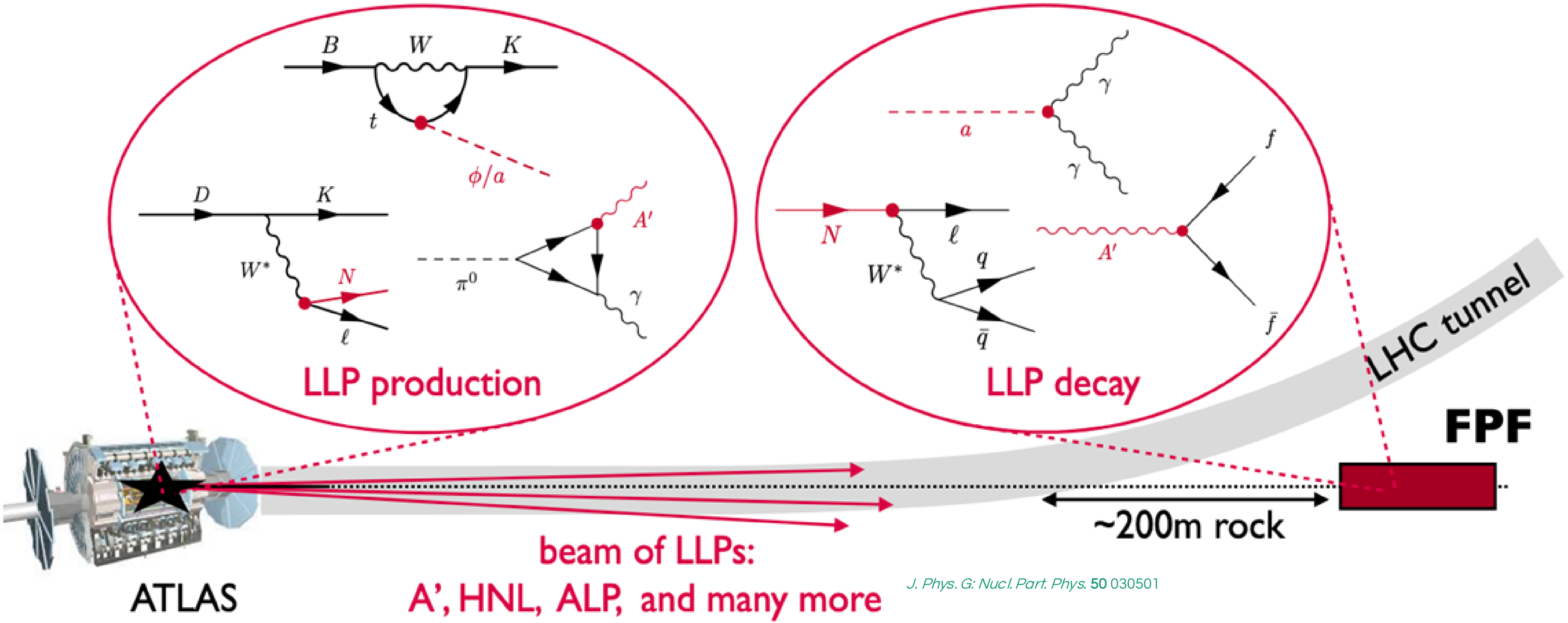


Flavour Tests

- Detection of all **three types of neutrinos** allows for tests of **lepton flavour universality**.
    - Charm parentage leads to partial cancellation of flux uncertainties



Beyond Standard Model



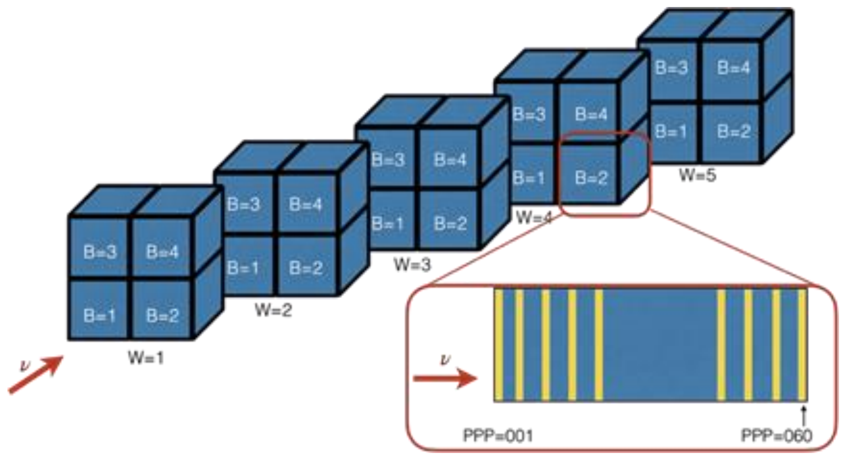
J. Phys. G: Nucl. Part. Phys. **50** 030501

+ scattering signatures

Beyond the Standard Model

- Search for new, feebly interacting, Long-lived particles (LLP) **decaying** within the detector or **scattering** off the target.

Detector Subsystems



5 Target walls to be installed

Target wall

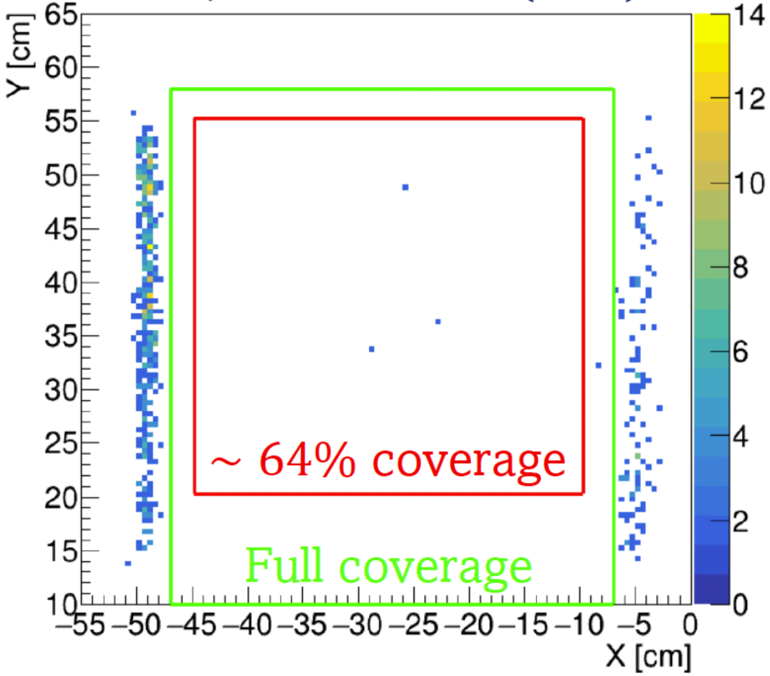
Target wall installation

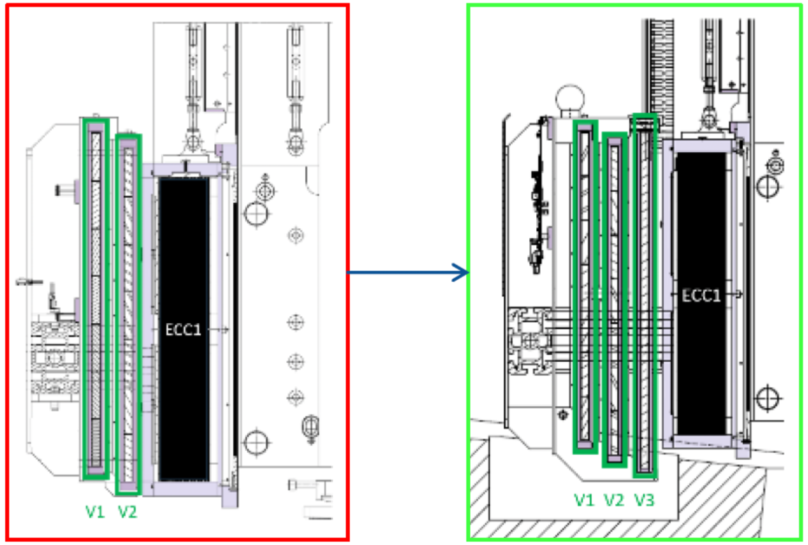
Upgrades: 3rd Veto Plane

3rd veto plane

- Lowered the whole system and added a 3rd veto plane with **vertical bars** to minimize inefficiency due to spatial and temporal coincidences.

JINST 20 P07011 (2025)





2022/23 veto

Upgraded veto

- **Before**: $(7.8 \pm 2.8) \times 10^{-8}$ inefficiency with ~ **64% target** area coverage.
- **After**: $(4.9 \pm 1.9) \times 10^{-9}$ inefficiency with **full target** area coverage.

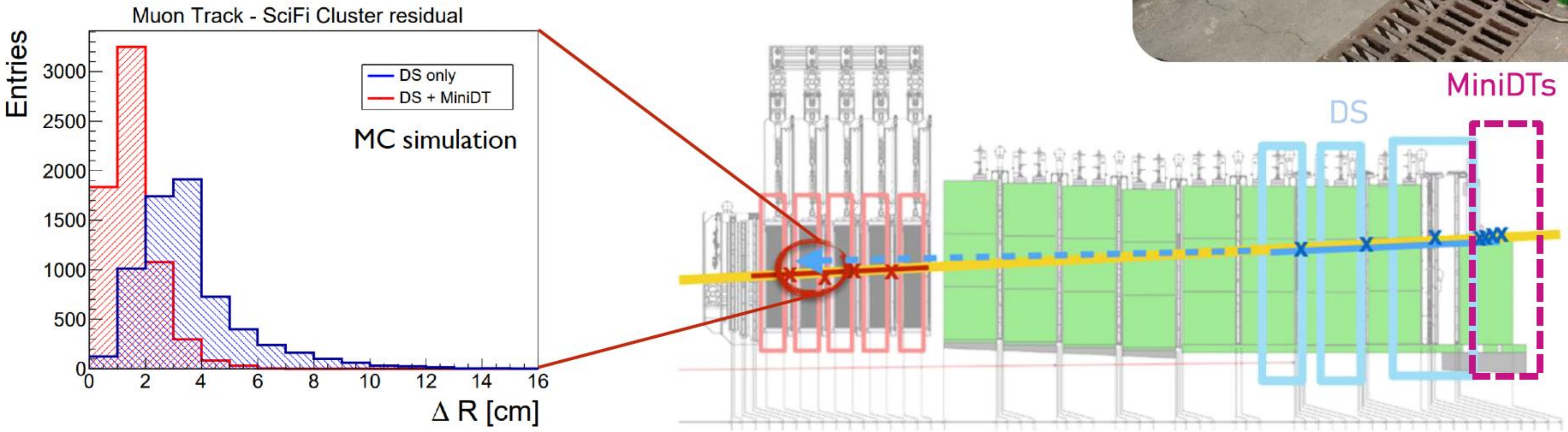
6

Filippo Mei, University of Bologna and INFN Bologna 10/4/2026

Upgrades: MiniDTs

MiniDTs

- Small replica of CMS drift tubes.
- **μ tracking** is fundamental for operation and ν_μ analysis.
- DS (1 cm wide bars) + MiniDT (250 μm resolution) **improves resolution** on μ impact parameter by a factor of 2 (**3 cm → 1.5 cm**).



7

Filippo Mei, University of Bologna and INFN Bologna

10/4/2026

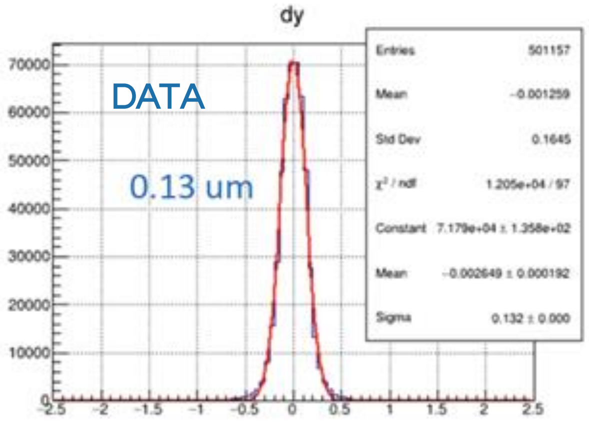
Momentum Measurement via MS in Emulsion

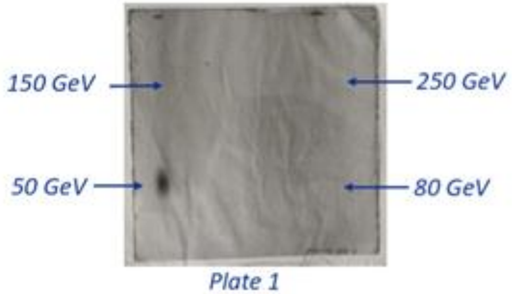
Test beam exposure in October 2025

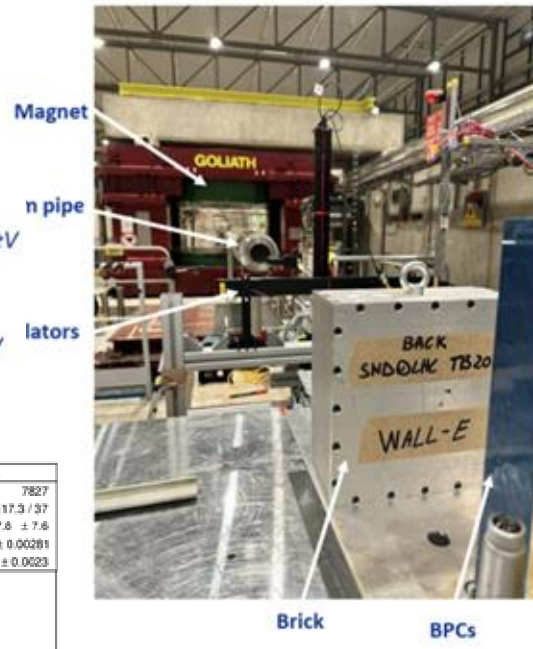
- H4 beam line in North Area
- Muon energies: 50, 80, 150, 250 GeV/c
- Scintillators + beam monitor

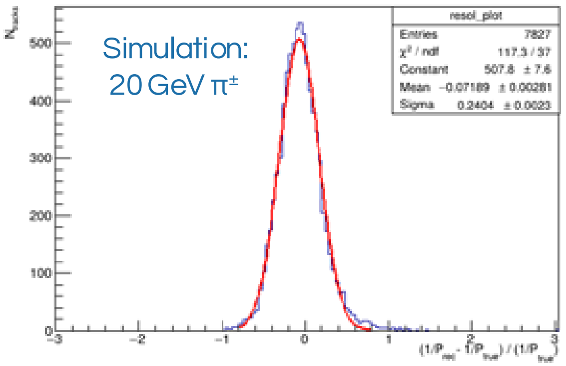
Preliminary results

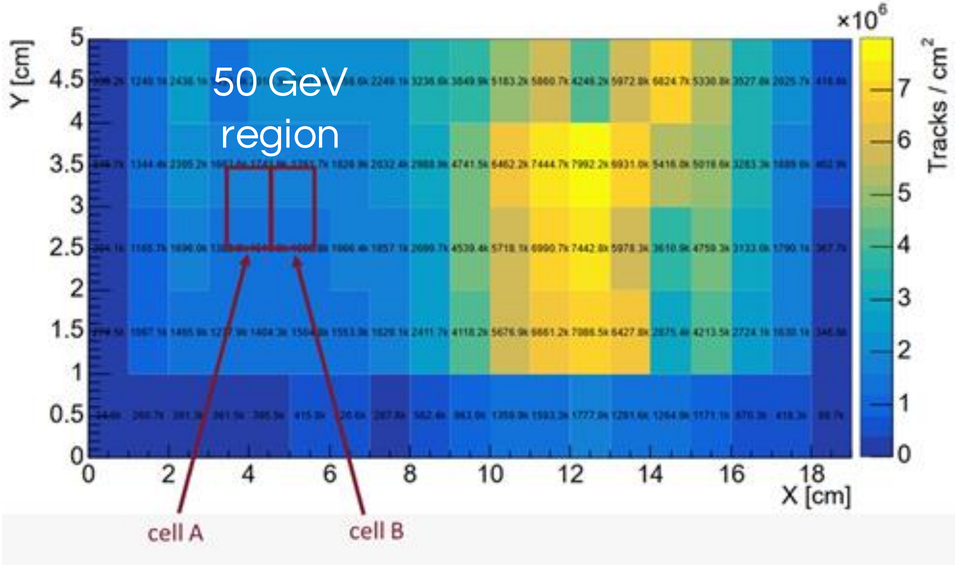
- Huge EM component in the halo
- Tracks at small angle associate to the 50 GeV/c beam (50% pions, 50% muons)

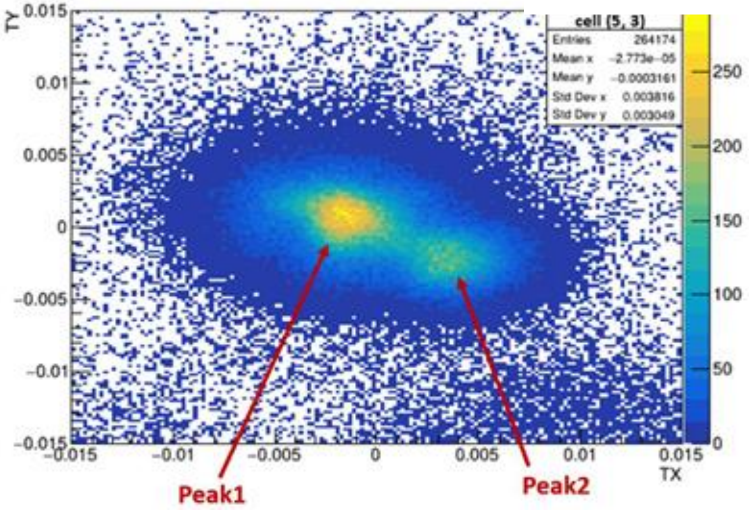


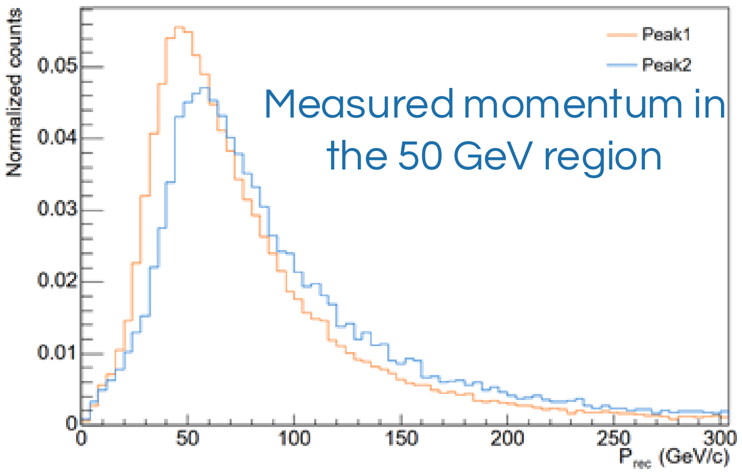












SND@LHC Backgrounds

2023

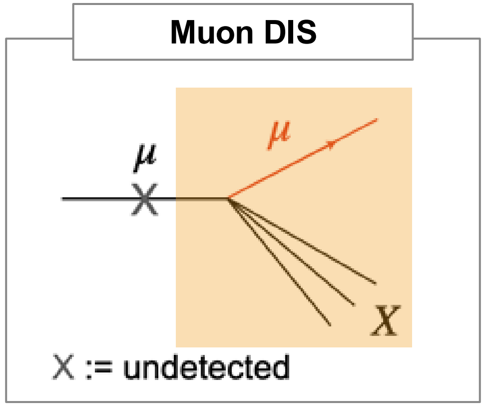
Phys. Rev. Lett. 131, 031802

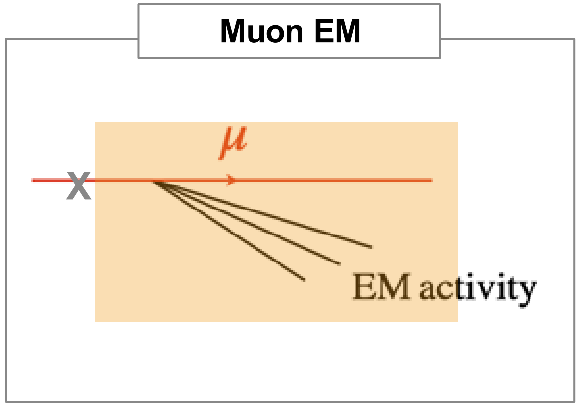
Entering muons

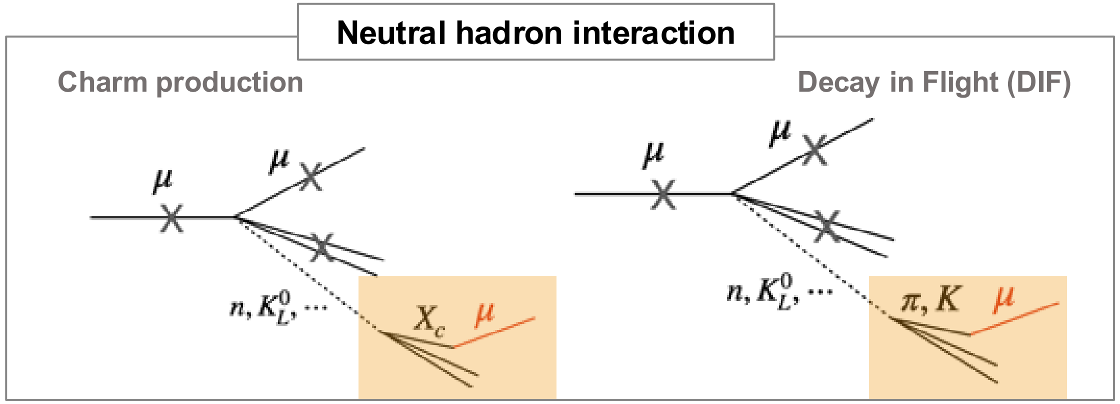
- Incoming muon track may be missed due to detector inefficiency.
- Shower induced by DIS or EM activity.
- Number of muons in acceptance: 5×10^8
  SNDLHC-NOTE-2023-001
- Detector inefficiency: 5×10^{-12}
  - Two veto and two scintillating fibre planes.
- **Negligible** background with tight fiducial volume.

Neutral hadrons

- Neutral hadrons are produced in muon DIS in materials upstream of the detector.
- Muon from pion decay-in-flight or charm production.
- Expect a total of **$(8.6 \pm 3.8) \times 10^{-2}$** background events due to neutral hadrons.







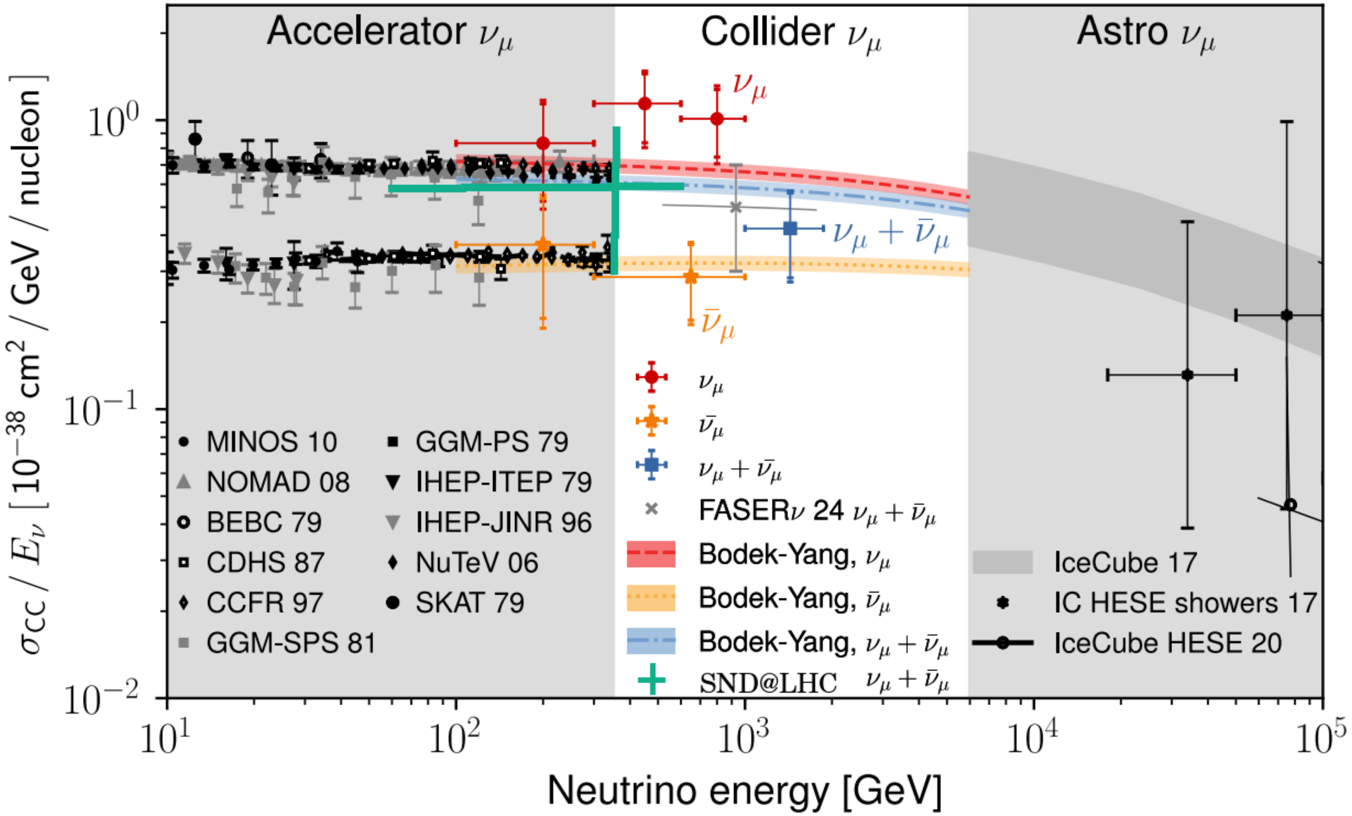
:= within SND@LHC acceptance

ν_μ Cross-Section Literature Review (2022-23 Data)

- Signal expectation updated with EPOSLHC+POWHEG as baseline.
  - DPMJET and SIBYLL - uncertainty on light hadron flux.
  - POWHEG scale variations - uncertainty on heavy flavour flux.

Preliminary

Adapted from Phys. Rev. Lett. 134, 211801



Preliminary

The nuclear cross section averaging the (anti)neutrino energies:
- **Expected: 34×10^{-35} cm^2**
- **Measured: $37^{+24}_{-12} \times 10^{-35}$ cm^2**

ν_μ Cross-Section Measurement (2022-23 Data)

Flux prediction by EPOS-LHC

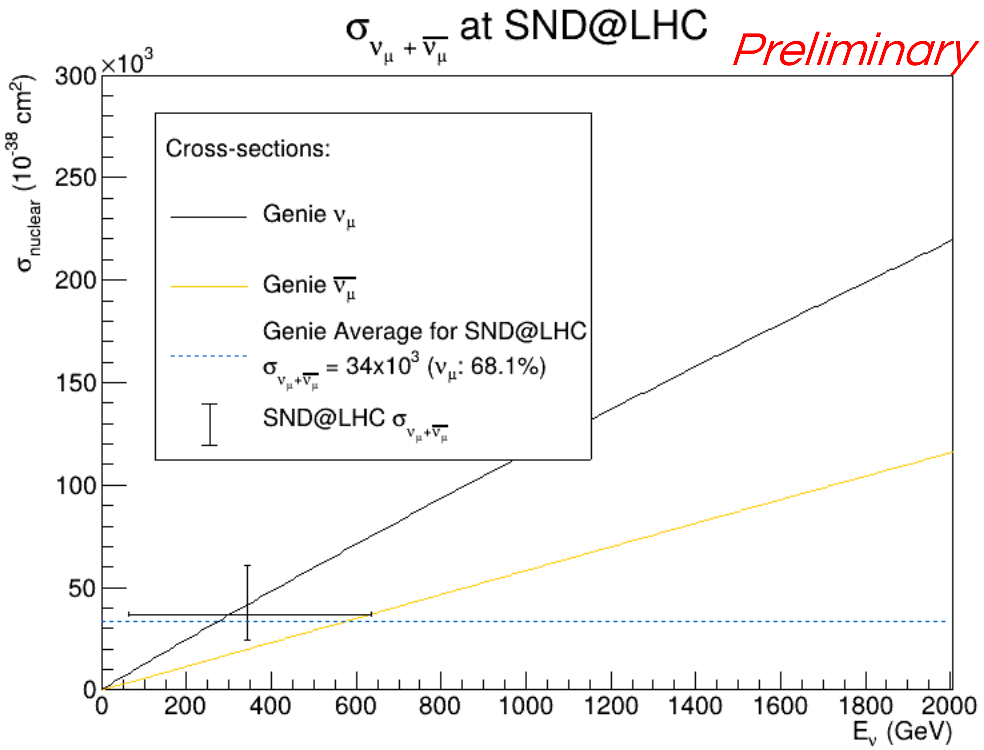
Average energy: 343 GeV

([64,635] GeV -15.87% - 84.14% interval)

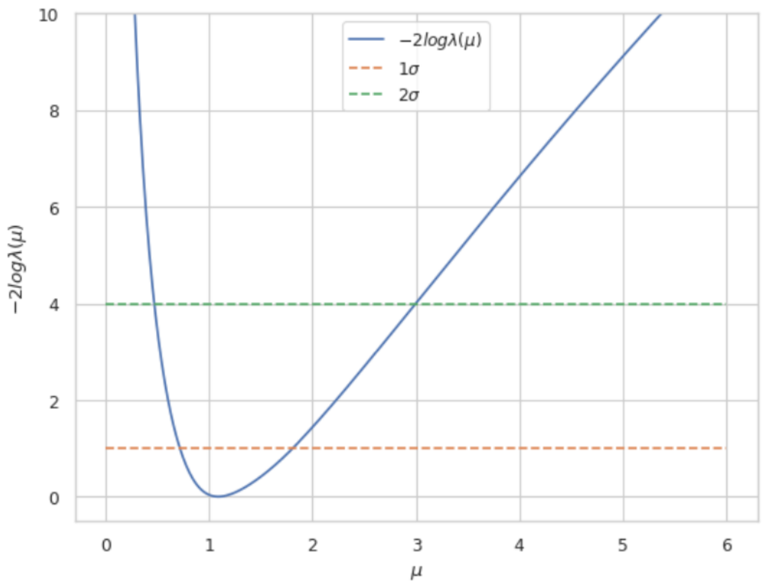
Median energy: 208 GeV

ν_μ Fraction: 68.1%

Preliminary



Preliminary



Log likelihood fit of signal parameter μ

$$\hat{\mu} = 1.09^{+0.72}_{-0.37}$$

Preliminary

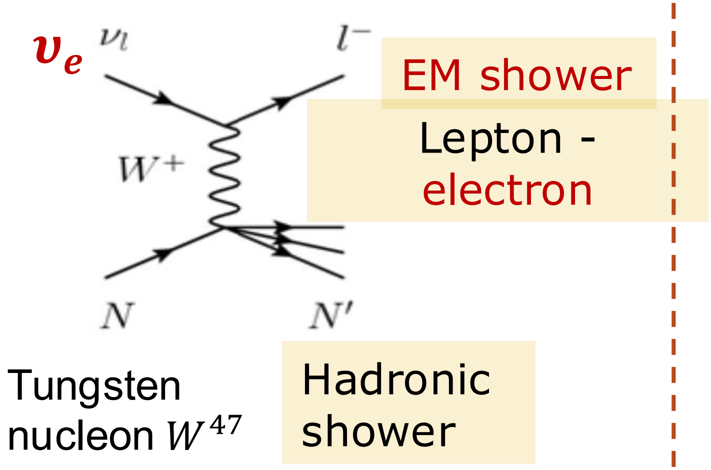
The nuclear cross section averaging the (anti)neutrino energies:

Expected: 34 x 10^{-35} cm^2

Measured: 37^{+24}_{-12} x 10^{-35} cm^2

Identification of ν_e cc using Electronic Detectors

- **Identify the Signal ($\nu_e CC$) :**
  - Outgoing electron → **EM shower**
- From **Backgrounds** :
  - **NC Interaction**: Neutrino carries away energy; only hadronic shower remains.
  - **Neutral hadrons** : Can mimic signal signature in later interactions



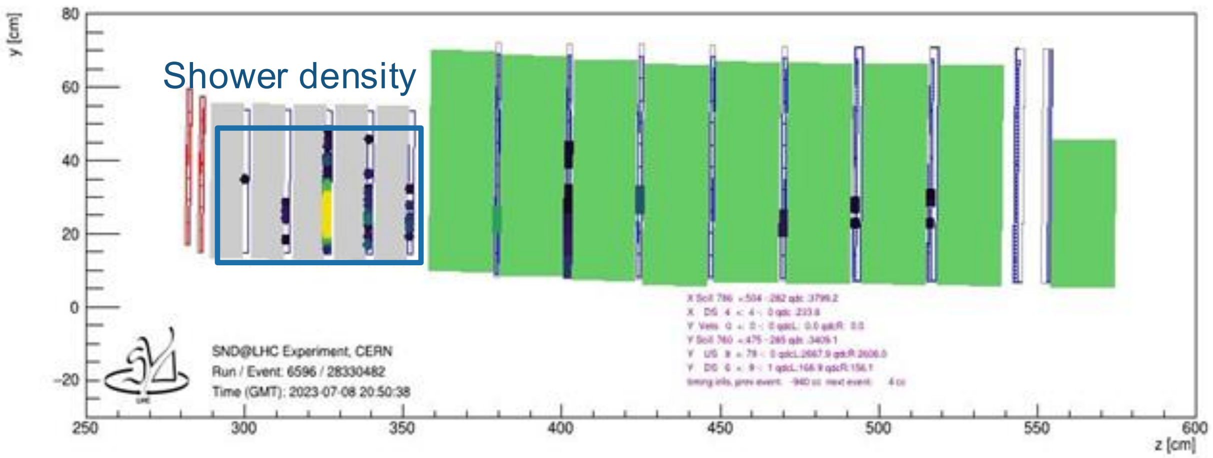
$\nu_e + N \rightarrow e^- + X$ **(CC)**

Topological Signal Selection

Devise discriminating variables to characterize showers based on topological and calorimetric information such as – shower spread, total signal hits, density of hits in SciFi plane.

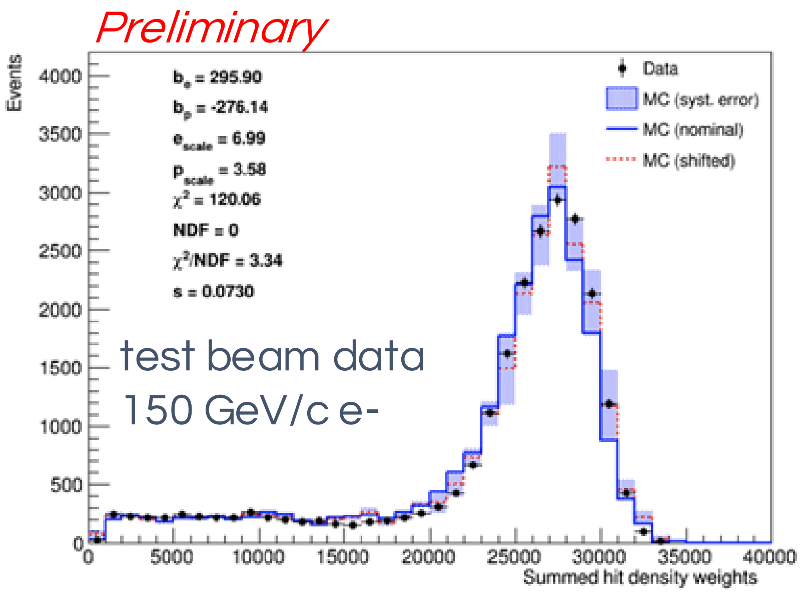
"Best $\nu_e CC$ /(NC/Hadron) Discriminator" (so far):

- **Summed hit density weights** in the most active SciFi station.
- Key idea : EM showers more dense than hadronic showers

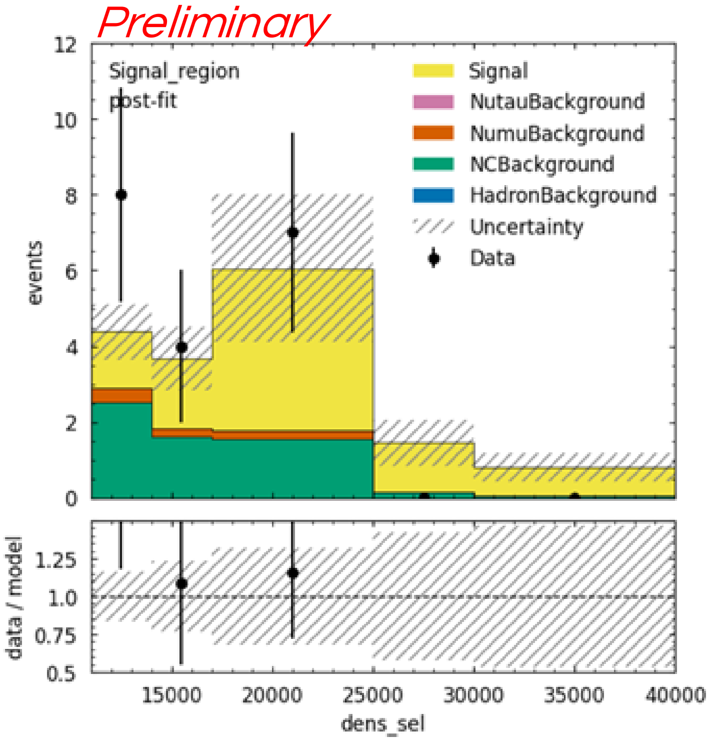


ν_eCC with Electronic Detectors (2022-24 Data)

- Binned likelihood analysis on the summed hit density weights in target, and a count based check



Shape Systematics using distribution for different energies of e- & π^- (from testbeam)



Preliminary

Expected events in 2022-2024, 68.6 +102.0 fb^{-1}: 19±5

*excluding 12fb-1 of 2024 due to SciFi connection issue

Signal: 13±5

Background: 6±1

Observed events: 19

= 9(2022-2023) + 10(2024)

Significance for the binned(unbinned) data, using DPMJET as baseline:

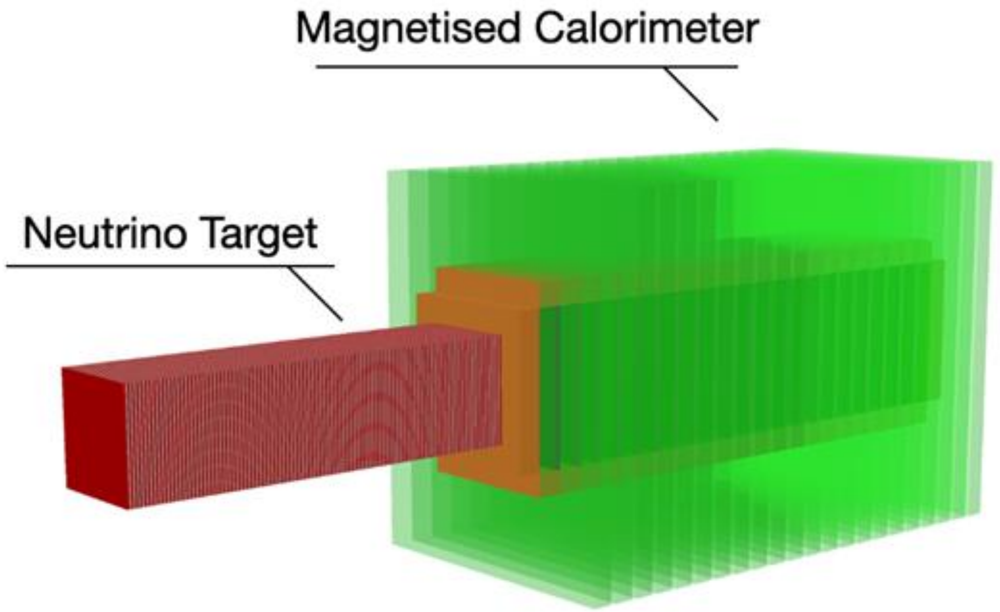
Expected: 4.5σ (3.8σ for ν_e CC in 0μ sample)

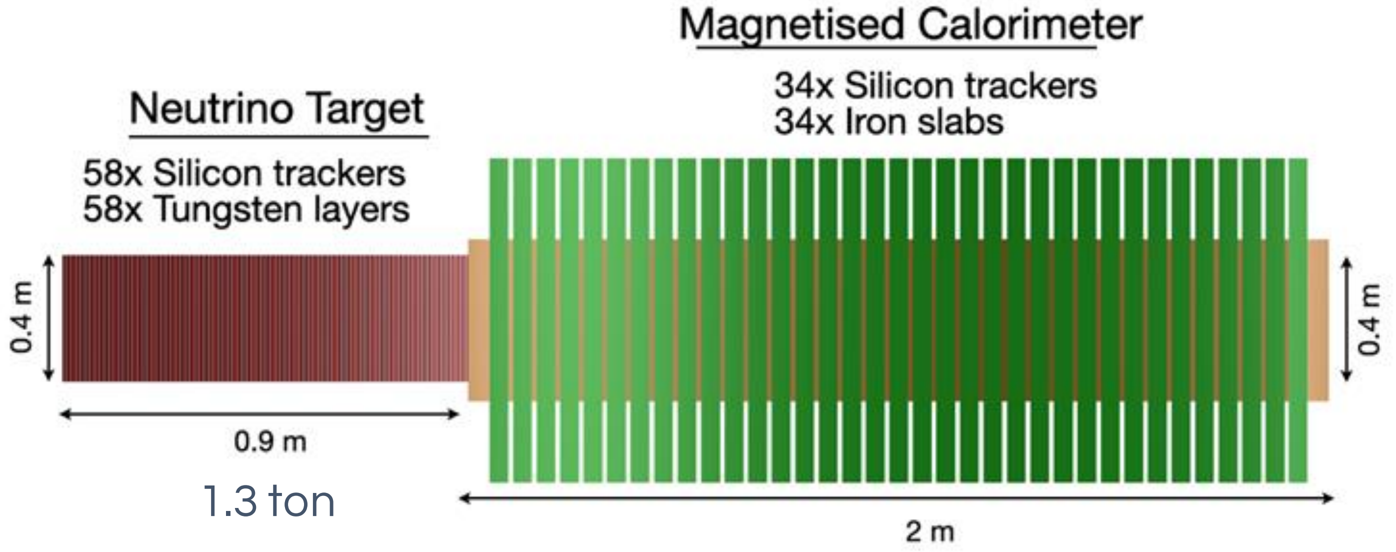
Observed: 2.7σ (3.6σ)

- Clear evidence of ν_e component in the electronic detector data
- Investigating the reason simulation does not predict the shape of the hit density distribution well enough
- Alternating the baseline signal model with EPOSLHC(light)+POWHEG(heavy hadrons):
  - **4.2 σ (3.8 σ) expected significance ([6.42, 5.66, 4.83, 3.93, 2.96], [5.55, 4.82, 4.02, 3.13, 2.17])**
  - **2.6 σ (3.7 σ) observed**

SND@LHC Upgrade

- The experiment will use silicon-strip instrumentation in place of emulsions.
  - Emulsions quickly get overexposed after LHC upgrade.
  - The first time Si technology will be used to detect neutrinos!
- The calorimeter will be magnetised for muon momentum and charge measurement.



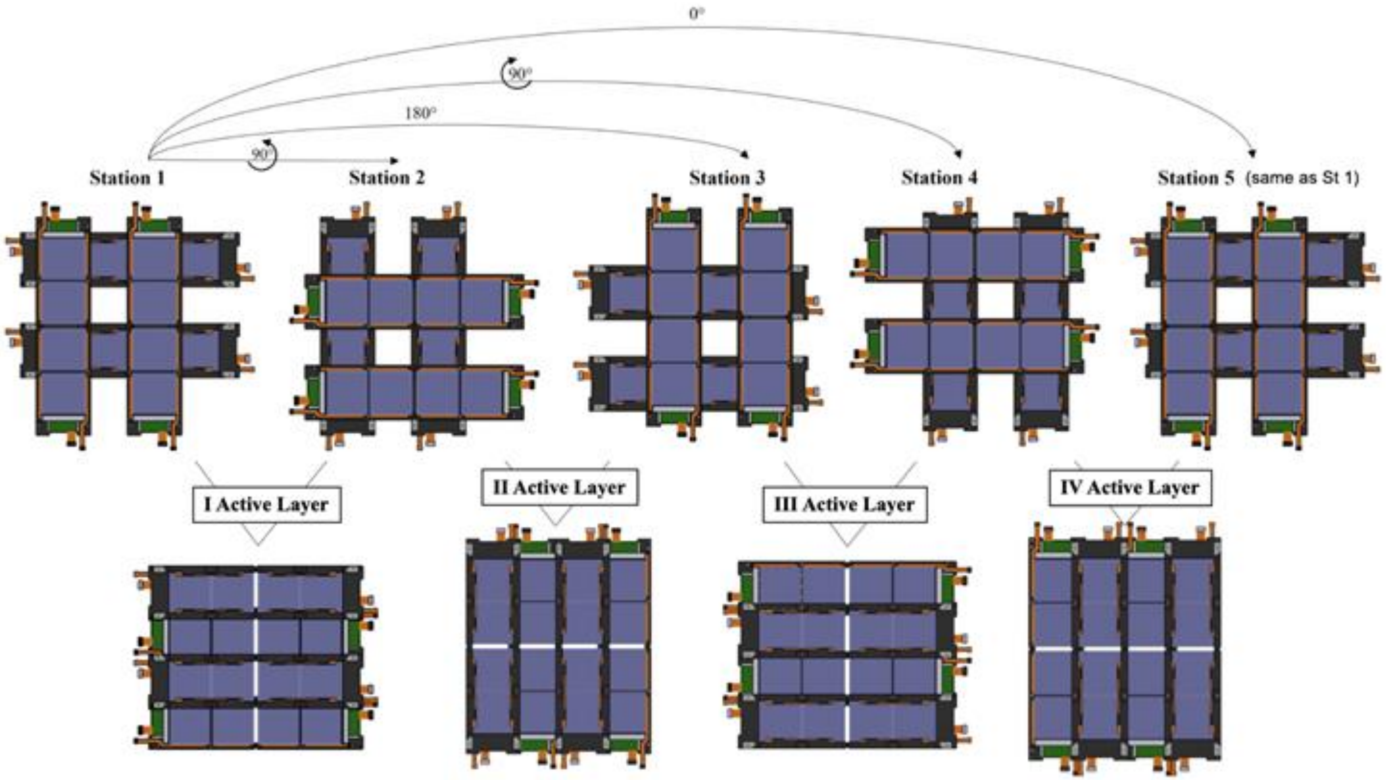


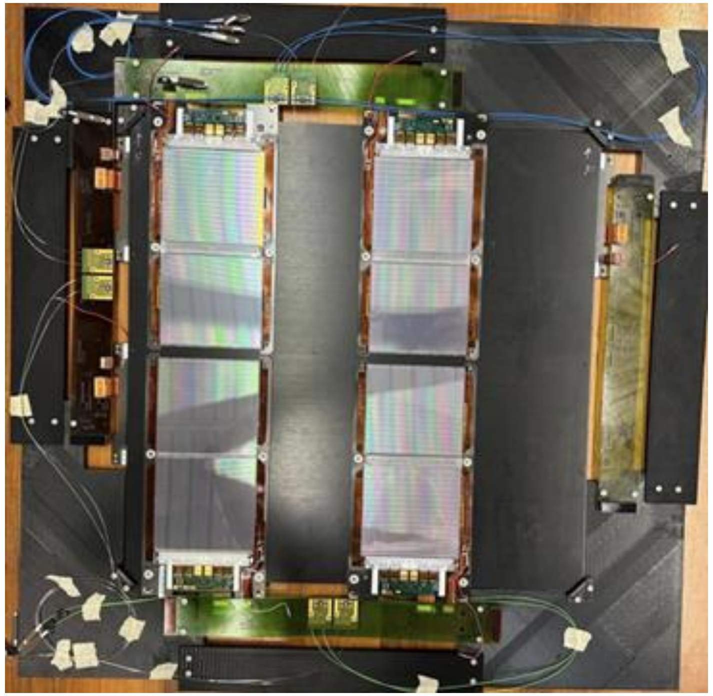
1.3 ton

CERN-LHCC-2024-014

SND@LHC Upgrade: Silicon Strip Detectors

- Detector modules inherited from the CMS outer barrel tracker.
- Eight modules per plane. 1680 modules available.
- 122 micron strip pitch.



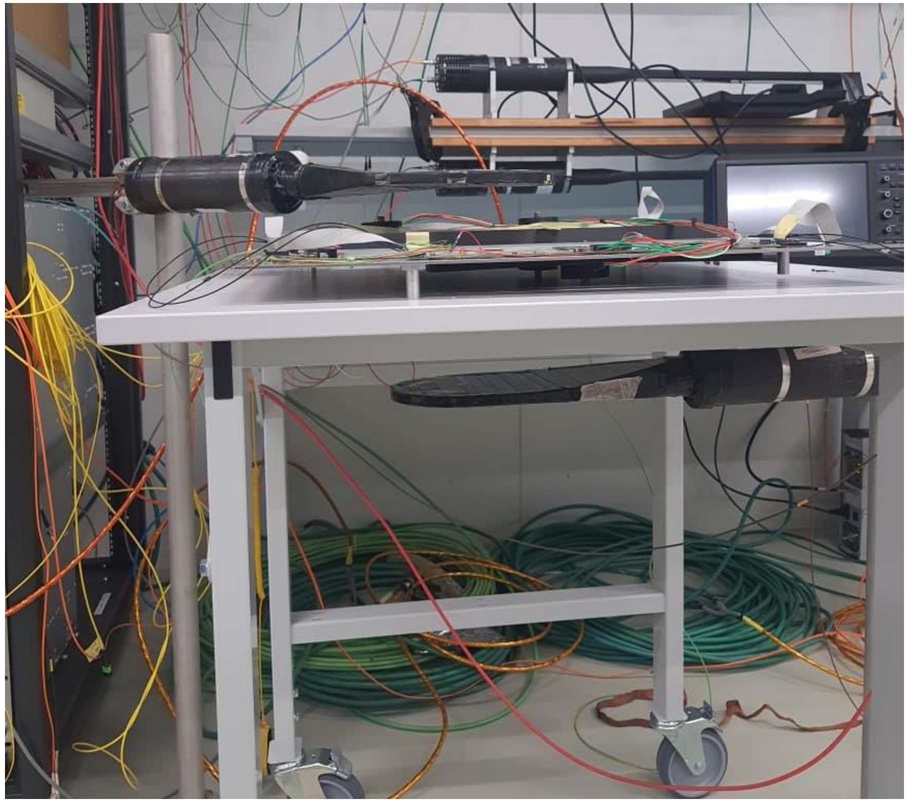


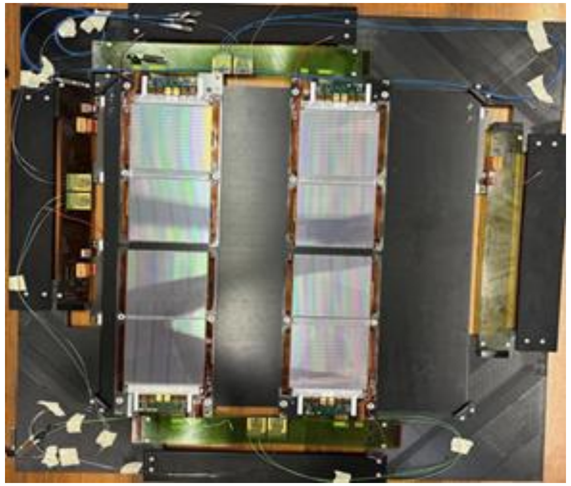
CERN-LHCC-2024-014

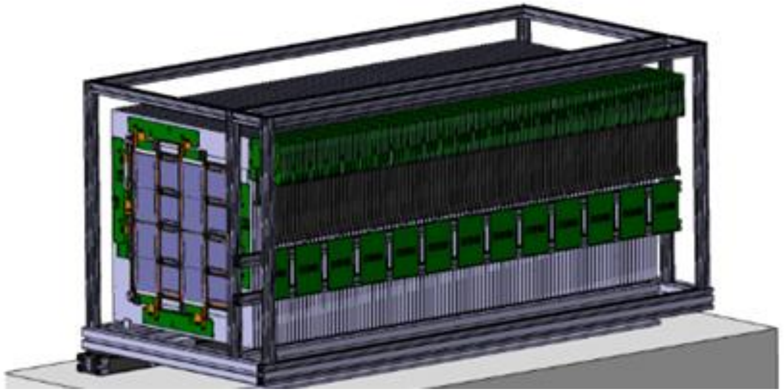
SND@LHC Upgrade: Silicon Strip Detector

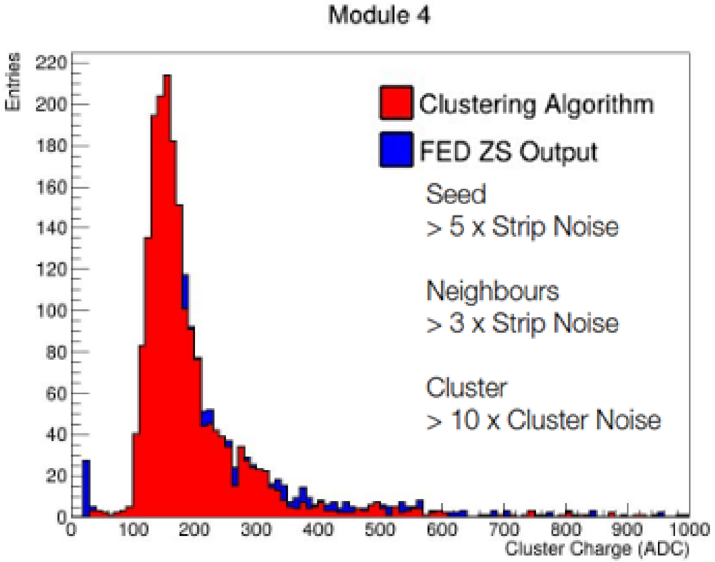
Performance: First Cosmic testing

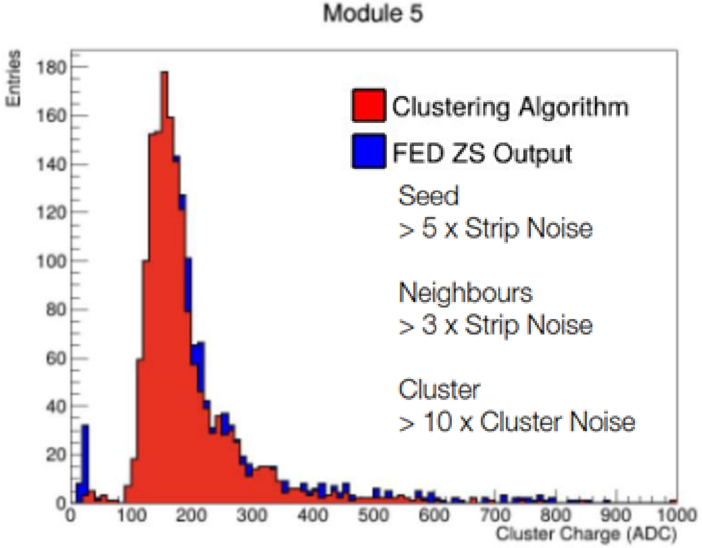
16x16cm^2 scintillators for testing cosmic rays placed above Si strip modules 4 and 5



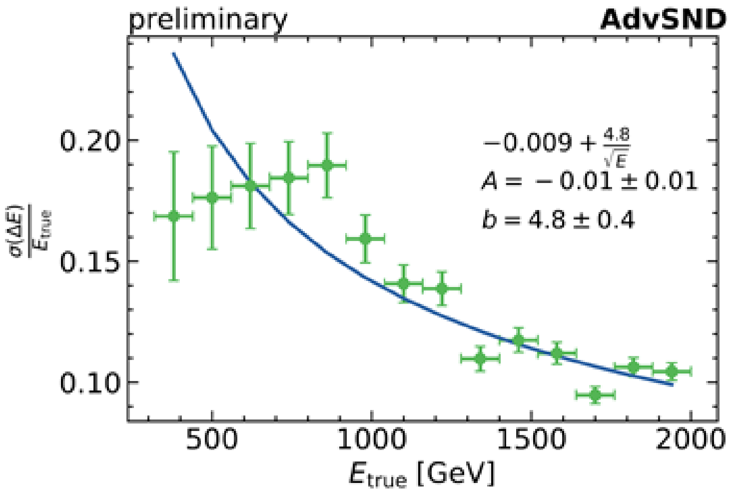


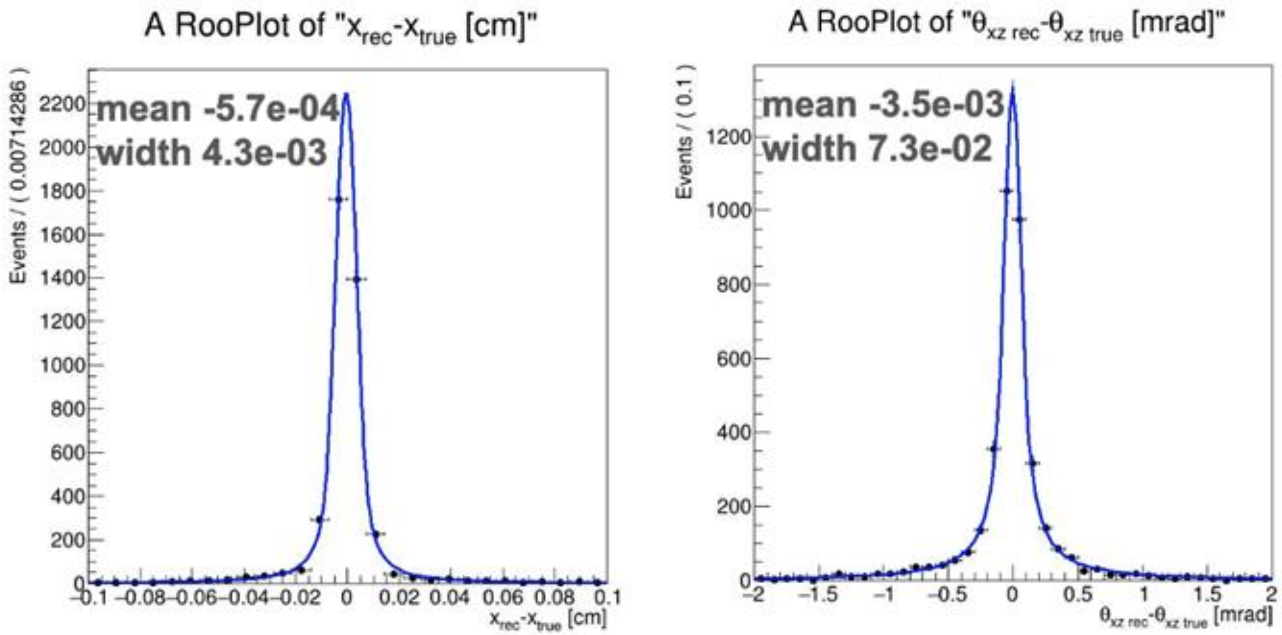






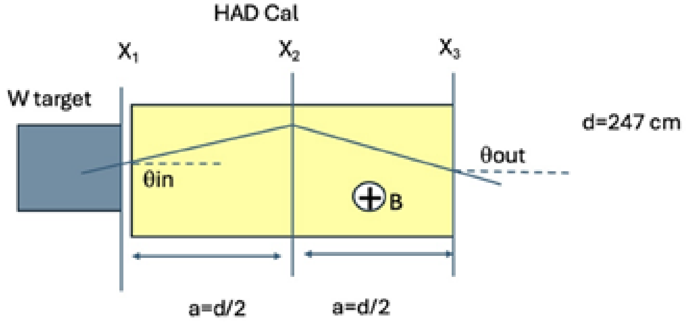
SND@LHC Upgrade :Expected detector performance

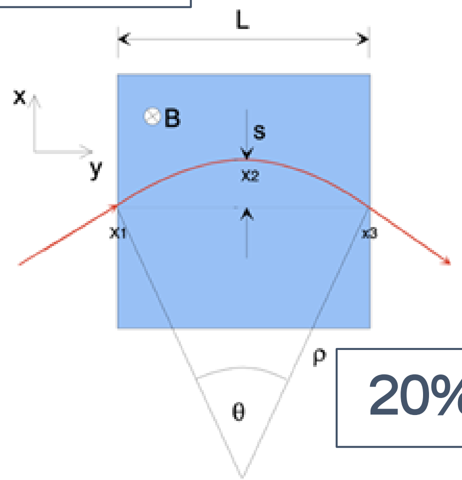




10 – 20% Hadron energy resolution

40 micron and 0.1 mrad tracking





$$s = \rho\left(1 - \cos\frac{\theta}{2}\right) \simeq \rho\frac{\theta^2}{8} = 0.3\frac{BL^2}{8p}$$

$$\frac{\Delta p}{p} = \frac{\Delta s}{s} = \sqrt{\frac{3}{2}}\frac{8p\sigma_x}{0.3BL^2}$$

20% Muon momentum resolution at 1 TeV

1.7 T over 1.7 m

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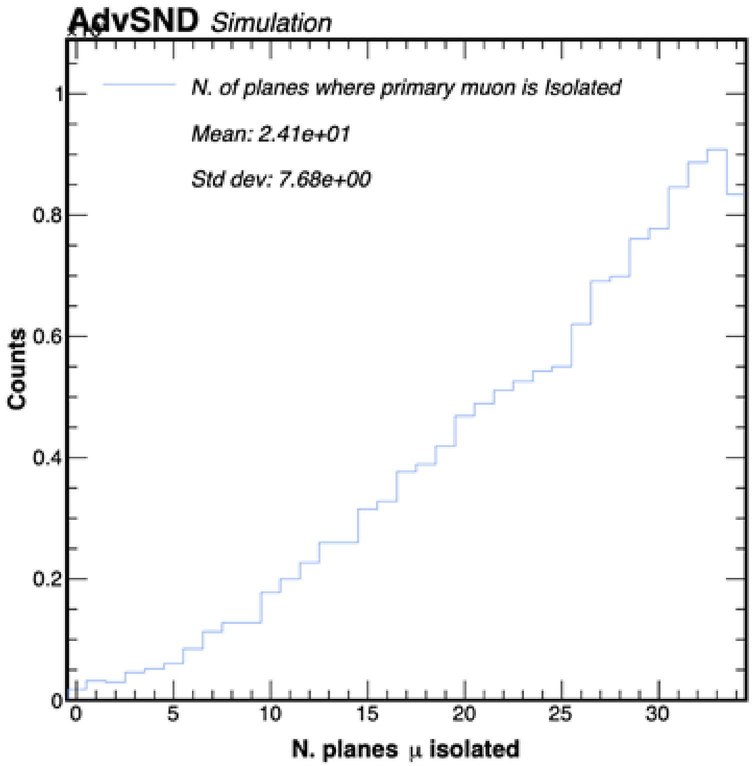
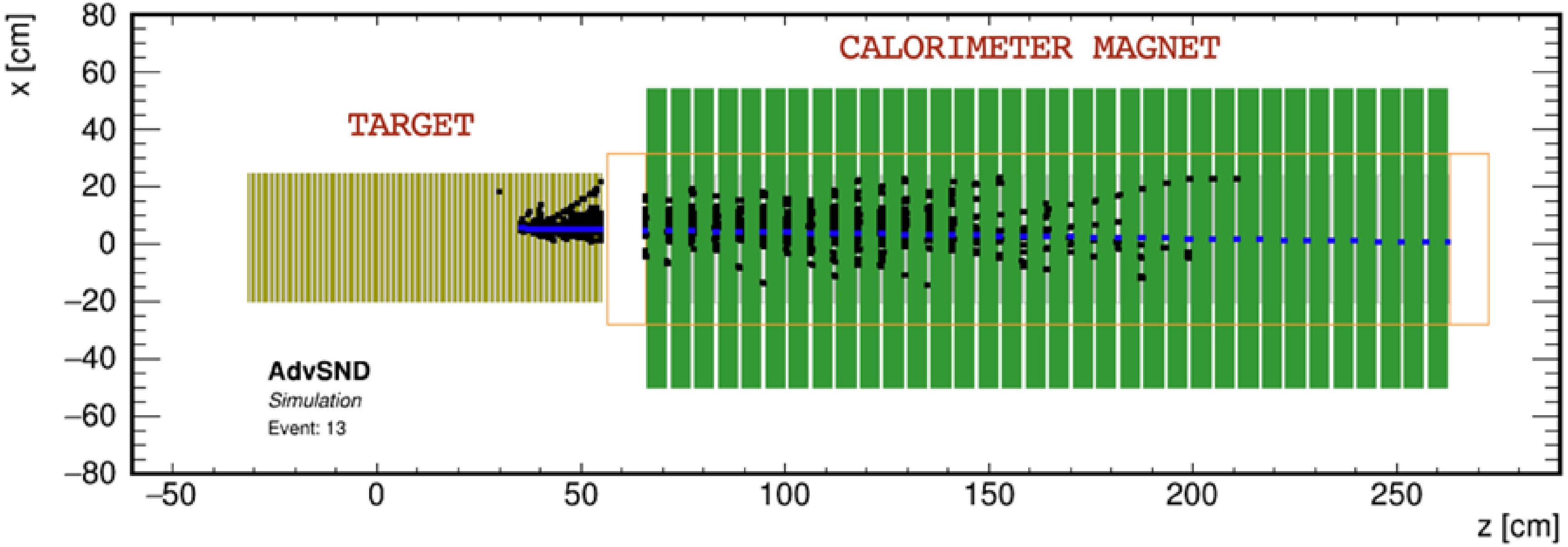
SND@LHC Upgrade :Muon neutrino identification





Muon geometrical acceptance is around 72%

Muon hits are isolated in 24 planes on average

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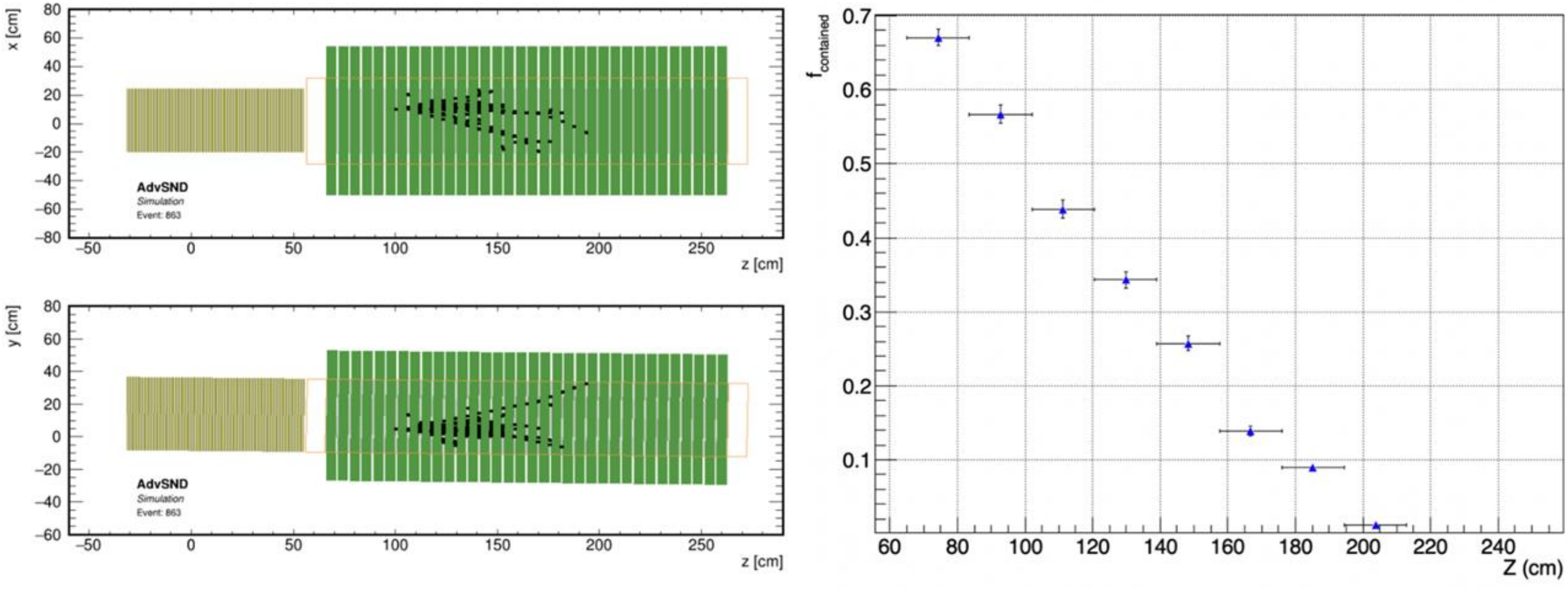
SND@LHC Upgrade : Interactions in the HCal

- About 25% of electron neutrino interactions in the HCal are contained.
  - Additional 30% in statistics compared to interactions only in the target.



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