

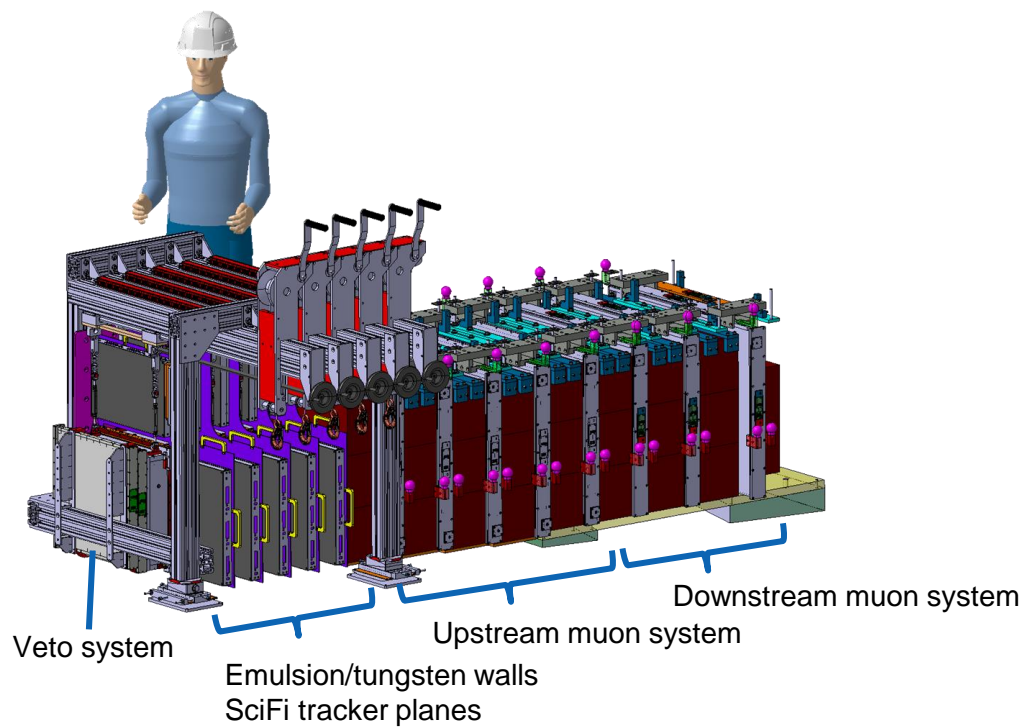
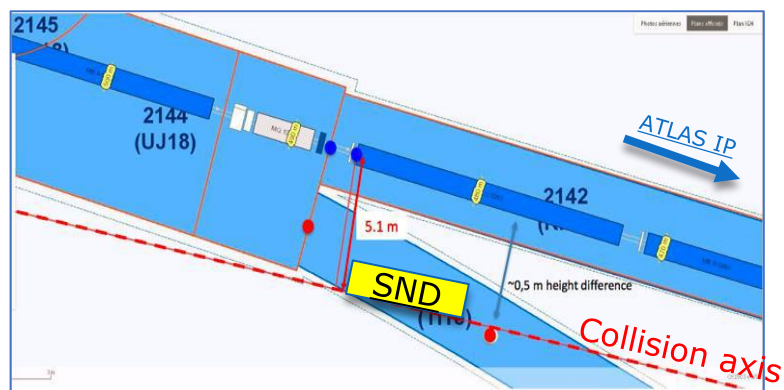
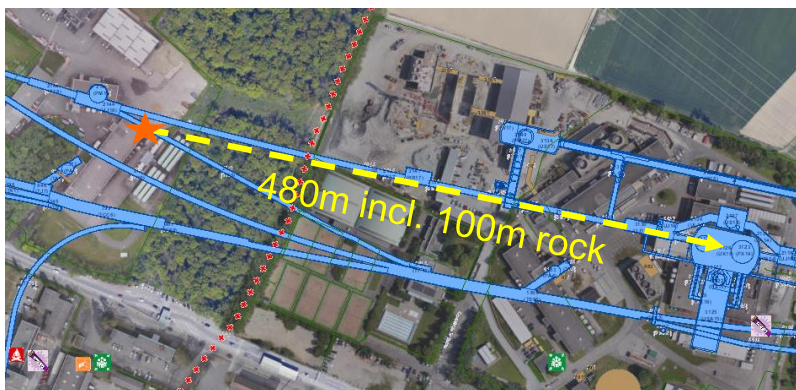


SND@LHC status report, 16 November

SND@LHC Collaboration

Last LHCC report (1 June - 30 August)

A enormous thanks to everyone involved from EN-HE-PO, TE-MPE-EP, BE-EA-AS, EN-EL-FC, EN-EL-EWS, EN-CV, BE-GM-ASG, EP-AGS-SI, Neutrino platform, HSE, TE-RAS-GLO, LHC coordination and operation



Collaboration:

- MoU for M&O agreed on in collaboration, out for signature by FAs
- 50% of M&O budget for 2022 already secured



Collaboration:

180 members
24 institutes in 13 countries
and CERN

- Physics Coordinator elected: A. Di Crescenzo
- Editorial Board elected: E. Graverini, M. Guler, E. van Herwijnen
- Experiment stimulating theorists: Neutral Exotica at FASERv and SND@LHC ([arxiv:2109.13962.pdf](https://arxiv.org/abs/2109.13962))
- JINST joint issue on the LHC and experiment upgrades for Run3. To be published early 2022

Conference talks

Conference	Date
NuCo2021	28-30 Jul 2021
ICNFP2021	23 Aug-2 Sep 2021
TAUP2021	26 Aug – 3 Sep
PANIC2021	5 – 10 Sep 2021
NUFACT2021	5 – 11 Sep 2021
TAU2021	27 Sep – 1 Oct
Blois2021	17-22 Oct 2021
LLP	9 – 12 Nov 2021
ComHEP21	29 Nov – 3 Dec 2021
Lake Louise	20 – 25 Feb 2022

Overall experiment status



Preparation of experimental area and infrastructure 98% ready for LHC cool-down in September

- ◉ All detector chambers constructed (13 October)
- ◉ September – October: Focus on surface commissioning and test beams
- ◉ Detector installation started as scheduled on Monday November 1

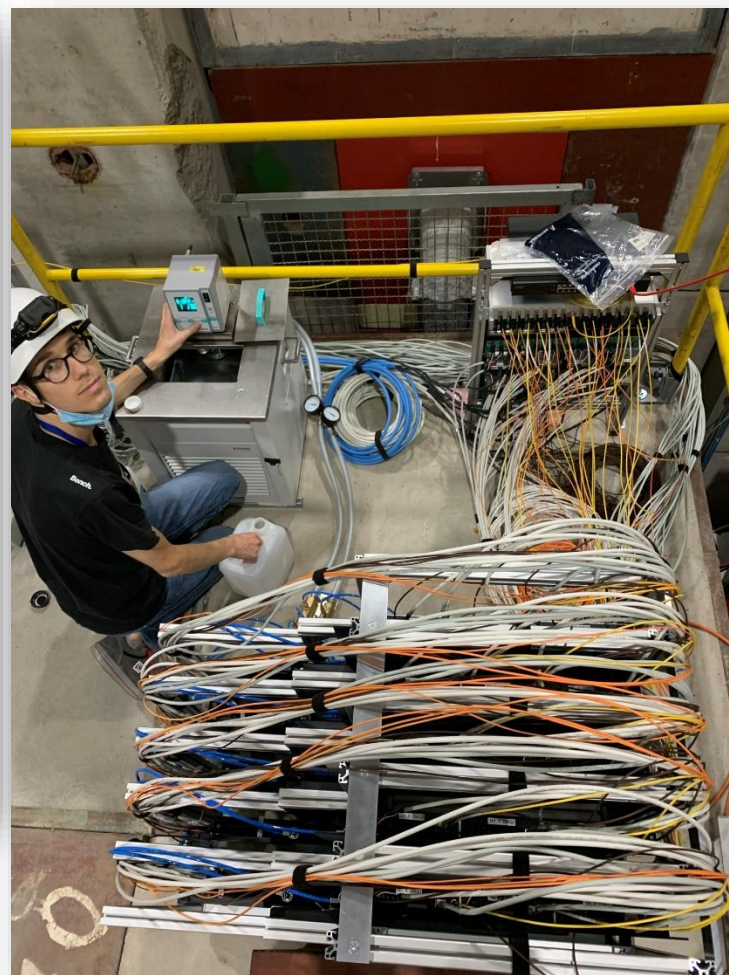


- ◉ Allocated budgets for construction are being made available in time
 - Project remains within available budgets, no cost overrun in sight
- ◉ Tight but sufficient availability of manpower for construction, surface commissioning and installation

Surface commissioning in H6

Intense activity September – October

Limited space on platform reproducing well experience to come in TI18 installation



Thanks for superb support from North Area beam line teams!

Surface commissioning

All systems installed!

- Target on the reproduced 2.5dgr slope

SciFi tracker

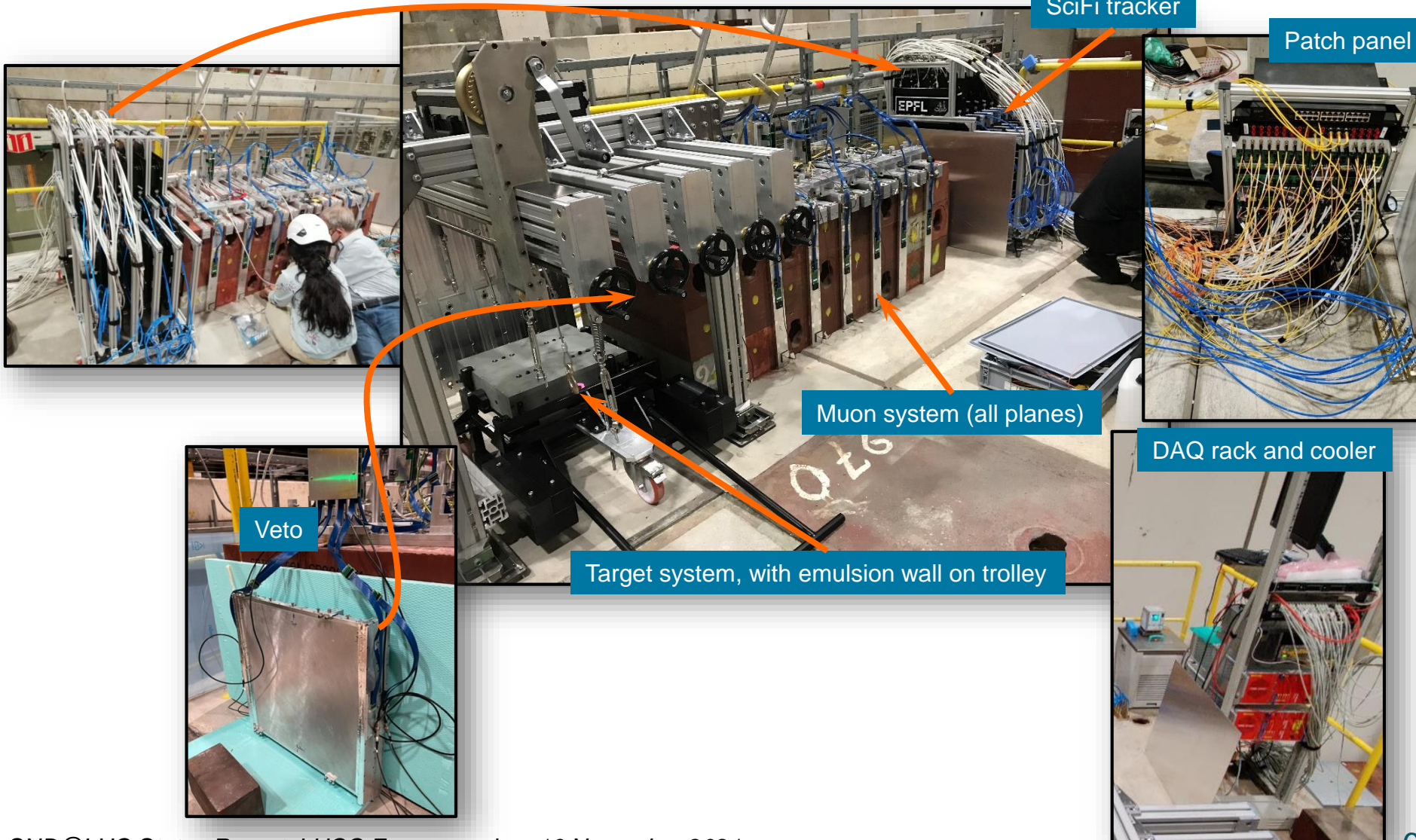
Patch panel

Muon system (all planes)

DAQ rack and cooler

Veto

Target system, with emulsion wall on trolley



Surface commissioning - mechanical tests

Target system

- Successfully installed on reproduced 2.5^{dgr} slope
- Successful load test with tungsten-filled emulsion wall, attended by HSE
- Test of mounting SciFi to emulsion wall
 - Some small adjustment of the fast-lock system
 - Mounting and unmounting is easy but surface must be clean to prevent damage to SciFi light tightness cover
- First compatibility test for Veto, all OK, later tested with final mechanics in TI18 (see later)

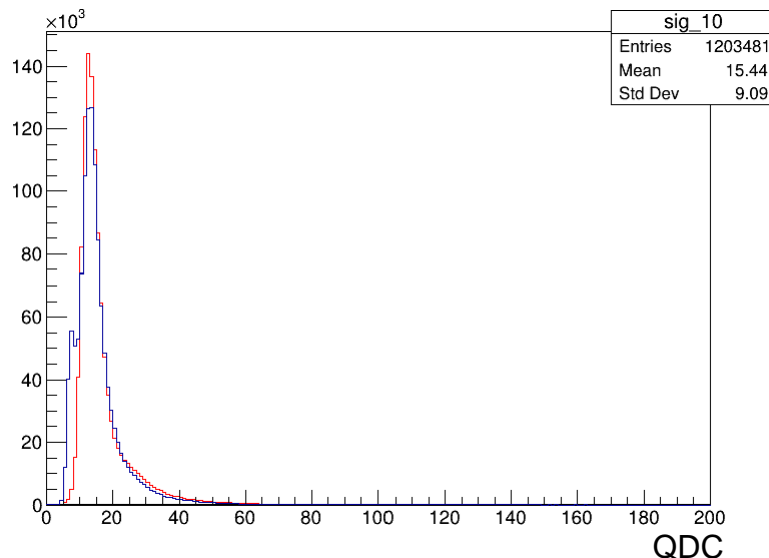
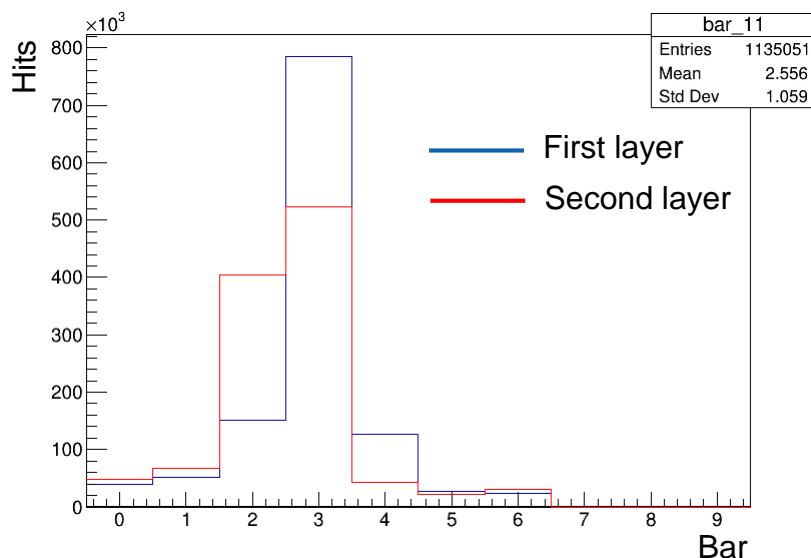


More than 120h runs of data with muon beam, ~22h with SciFi, veto and muon system

- Another 50h stability test with DAQ

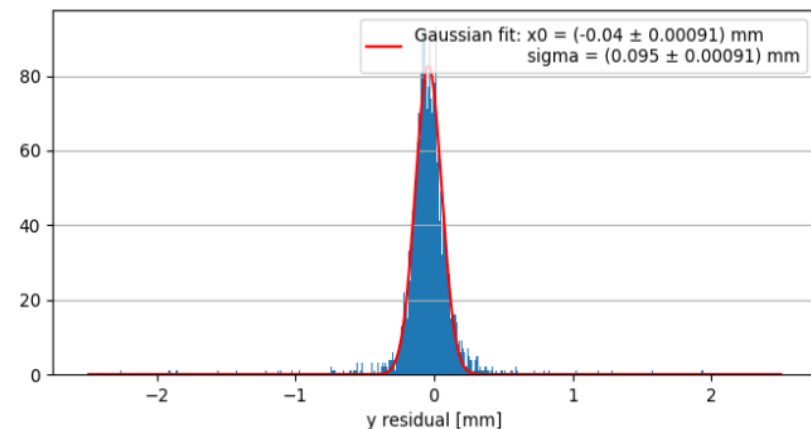
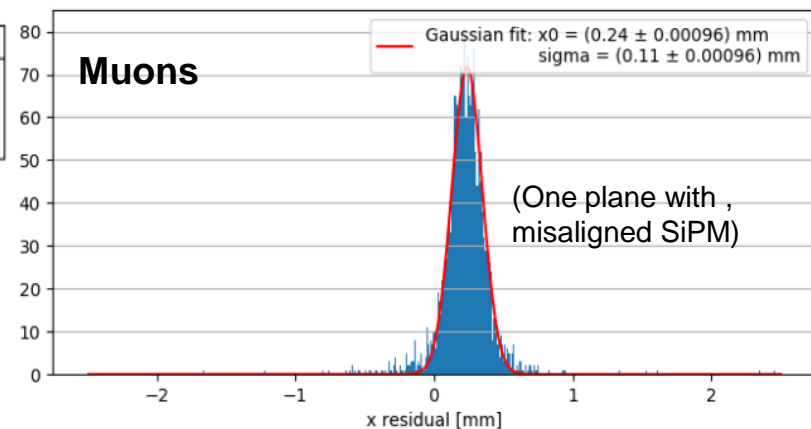
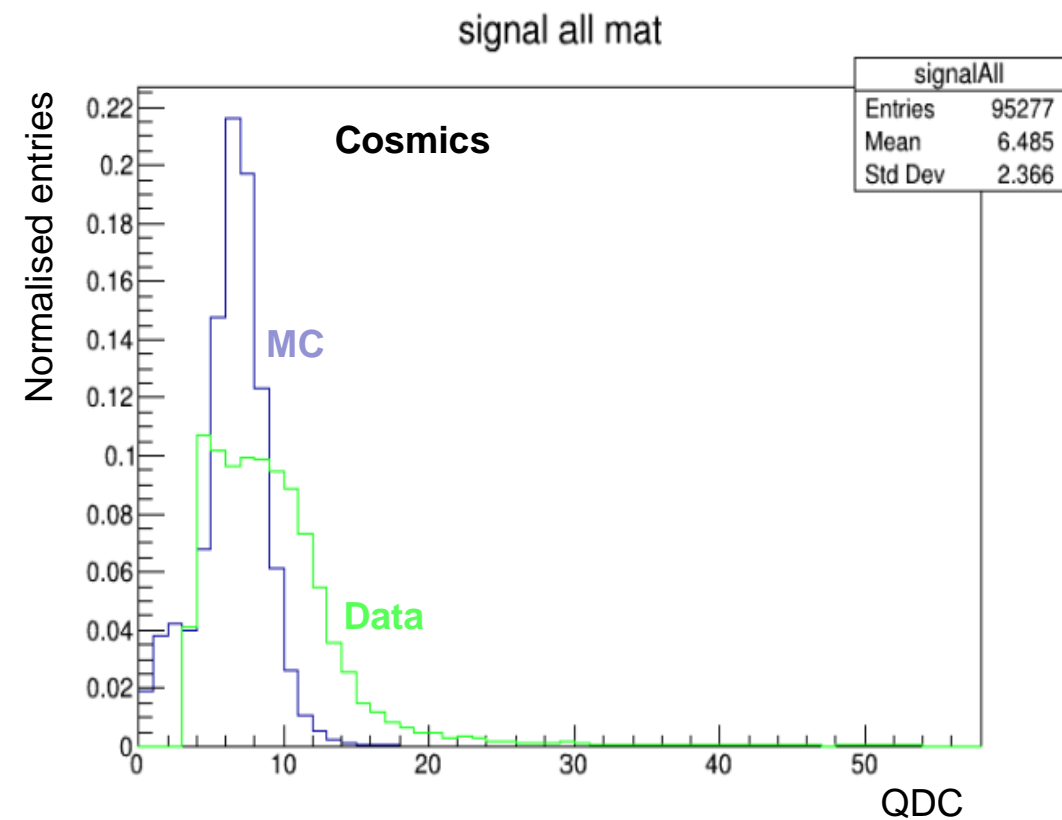
→ DAQ software has been demonstrated to show good stability with the whole system

Veto system



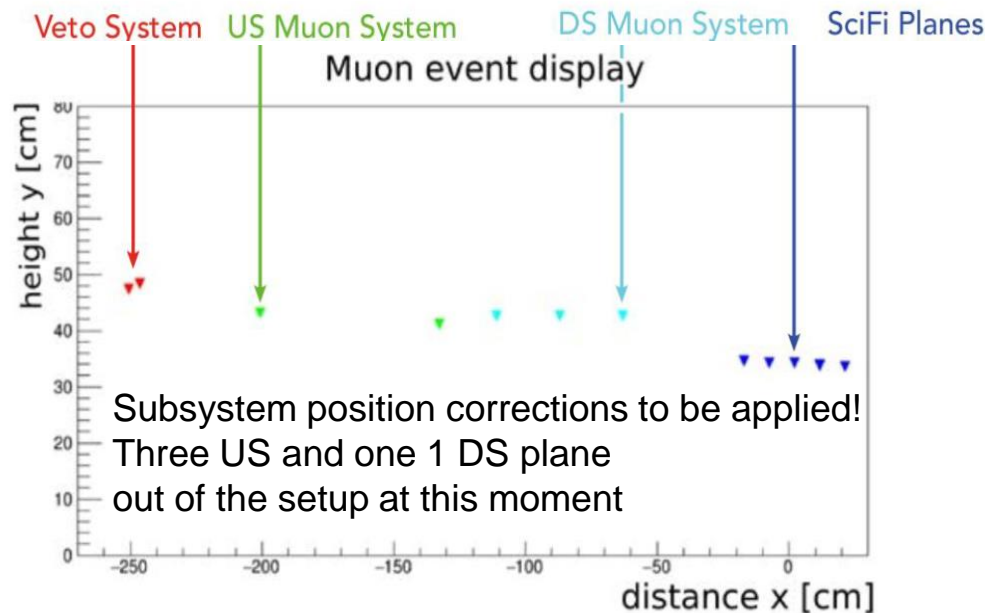
SciFi target tracker

- Very uniform response across all mats, MC tuning to be done, well aligned



PRELIMINARY

Surface commissioning in H6 – data taking



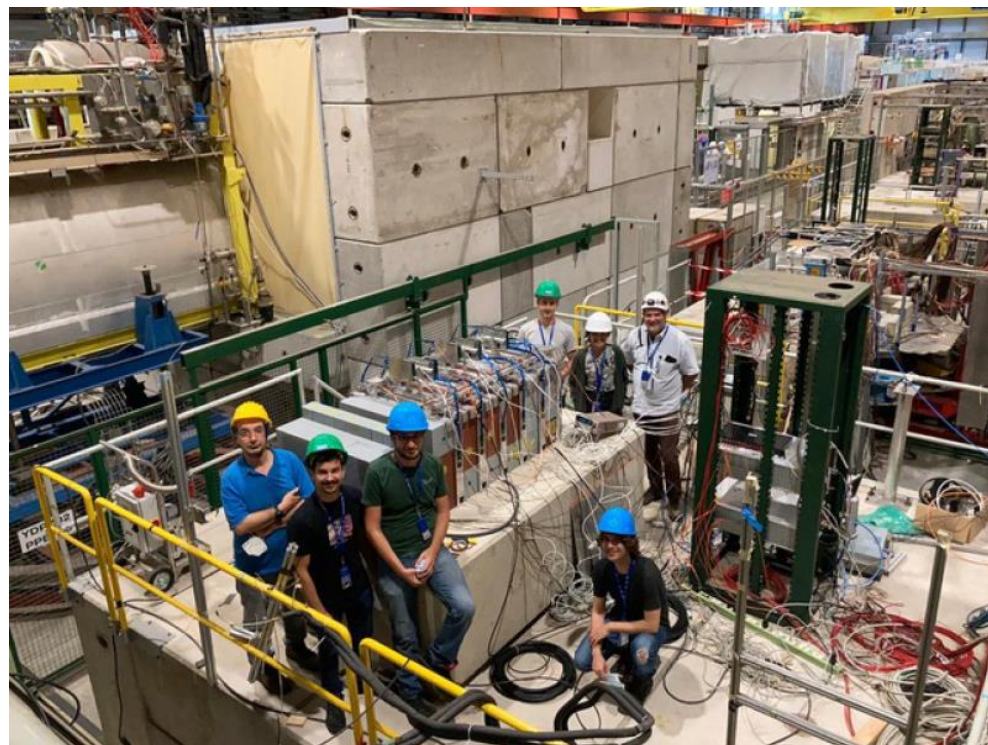
Some issues uncovered

- SciFi target tracker: developed an increase in bias current for some SciFi SiPMs
 - Problem with one board identified, has been repaired at EPFL
 - ➔ 2 SiPM assemblies replaced – tested OK again
- Muon system: issue with the PCBs were revealed after return to H6 from 2nd H8 test beam
 - ➔ A few boards showed problems with either no bias current, no signals, problem configuring, noise leading to poor calibration of channels
 - ➔ Partly solved (see dedicated slide)

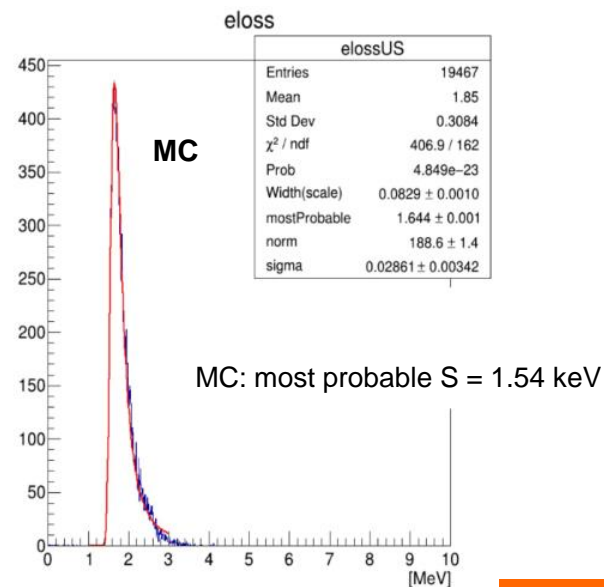
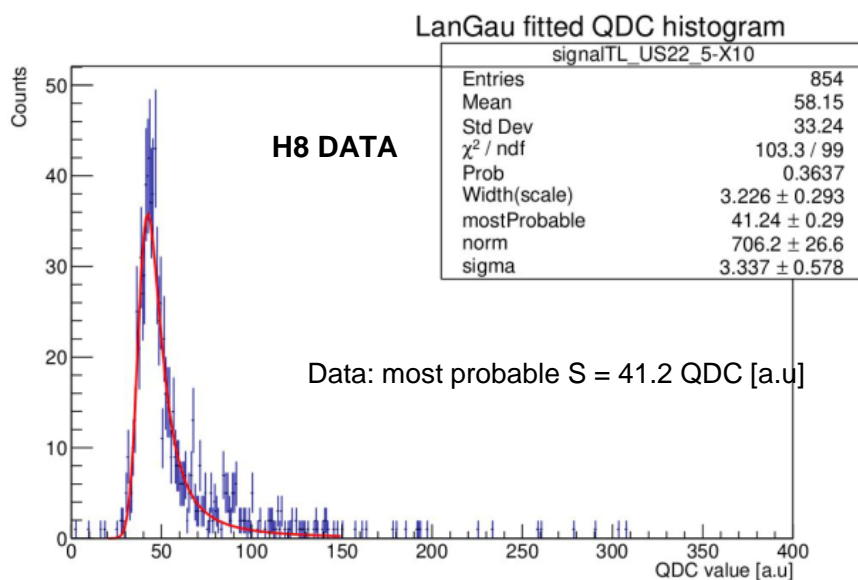


Test beam in H8 with muon system

- ◉ Thanks for LHCC's support on getting second period of test beam!
 - First test Sep 1st-5th made difficult by late PCBs and partial delivery of DAQ cables → Missed the chance to get the 300 GeV data
 - Desynchronisation during the run at 100,180 GeV
- ➔ Successful second run on Oct 1-6 at H8 for energy calibration with 140, 180, 240 and 300 GeV pions
 - Two downstream stations were included as well



- Particular attention on grounding, noise level in H8 was even better than in H6
- First glance at the signal, attenuation, efficiency, spatial and time resolution, saturation effects, MC tuning

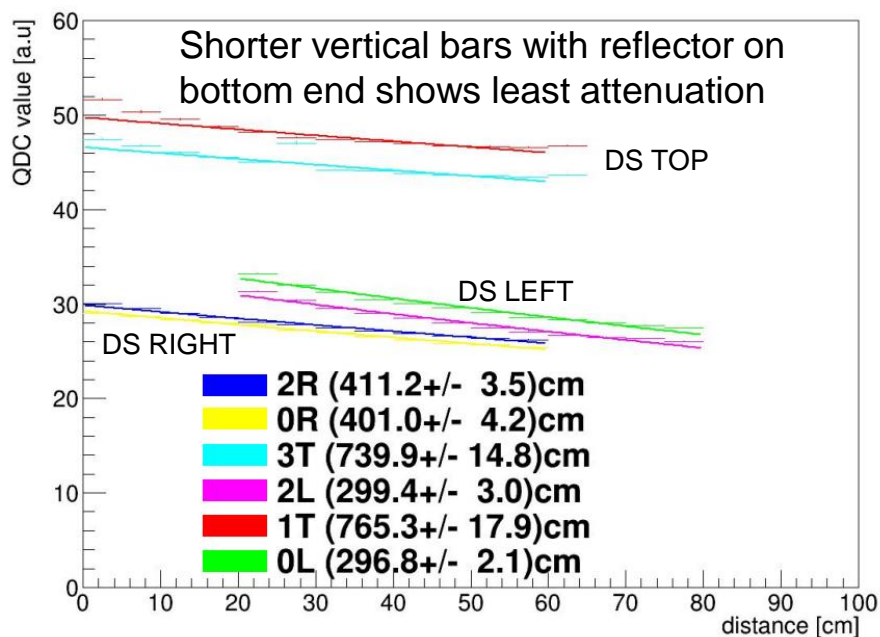


- Conversion factor 1 QDC = 0.04 keV
- Data distribution broader → too conservative attenuation length and no electronic noise in MC
- MC tuning

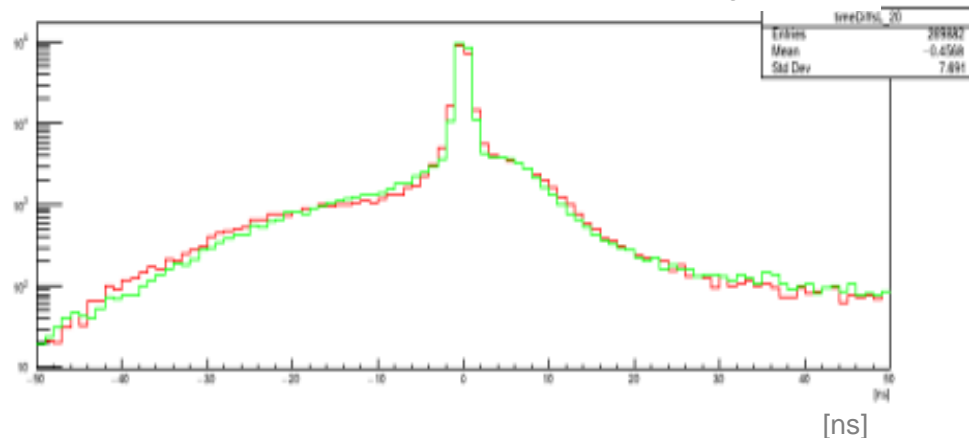
PRELIMINARY

- Attenuation in DS system with $1 \times 1 \text{ cm}^2$ bars much less than initially thought

Downstream signal dependence on distance



US1 difference mean time for left and right side



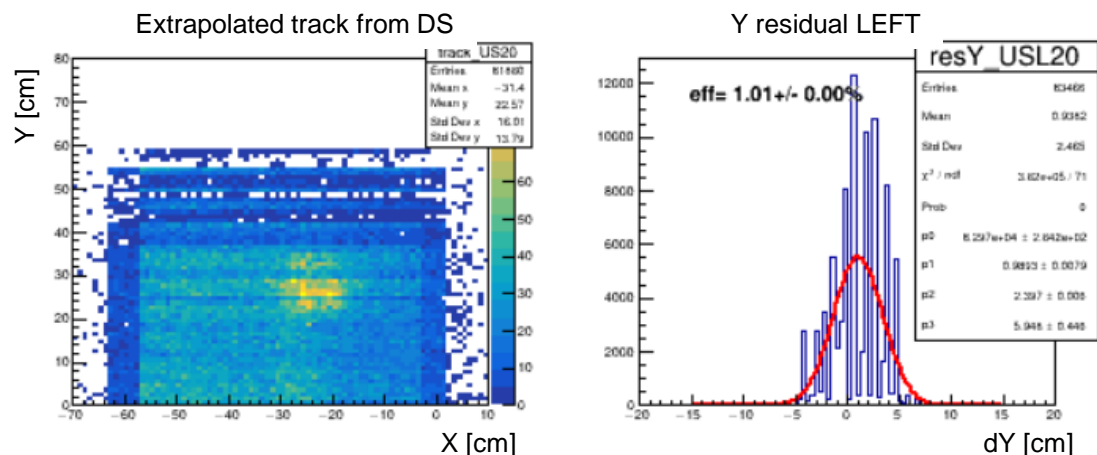
Gives already time resolution US1: ~ 0.7 ns

PRELIMINARY

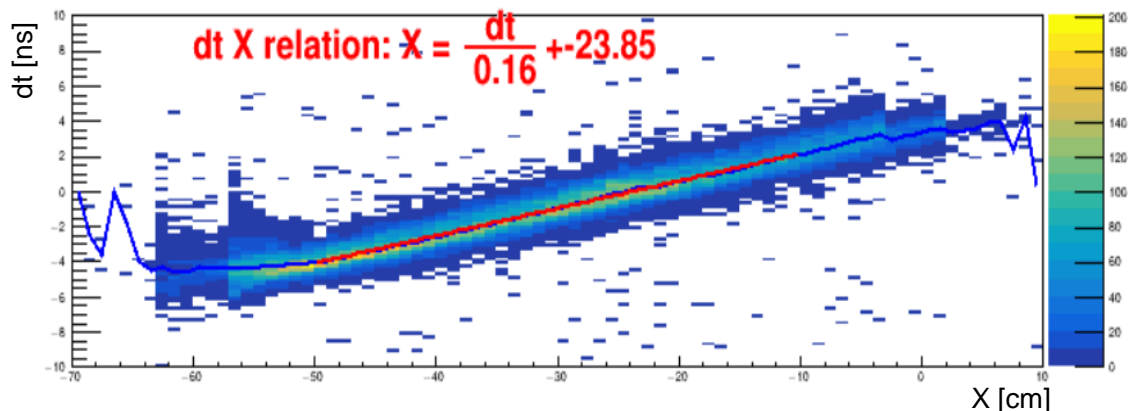
Test beam in H8 with muon system

- Vertical residuals from Kalman fitted tracks from DS muon system

US1



- Extrapolated track X position vs mean time difference between left and right side
 - Estimation of position resolution $\sigma_t \sim 0.55\text{ns} \rightarrow \sigma_x \sim 0.55/0.16\text{cm} = 3.7\text{cm}$



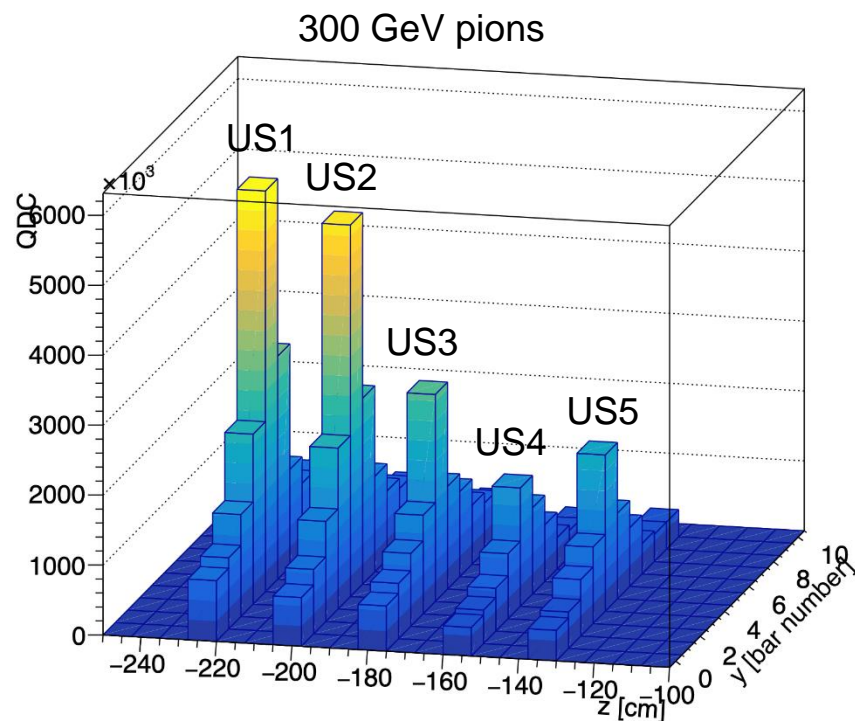
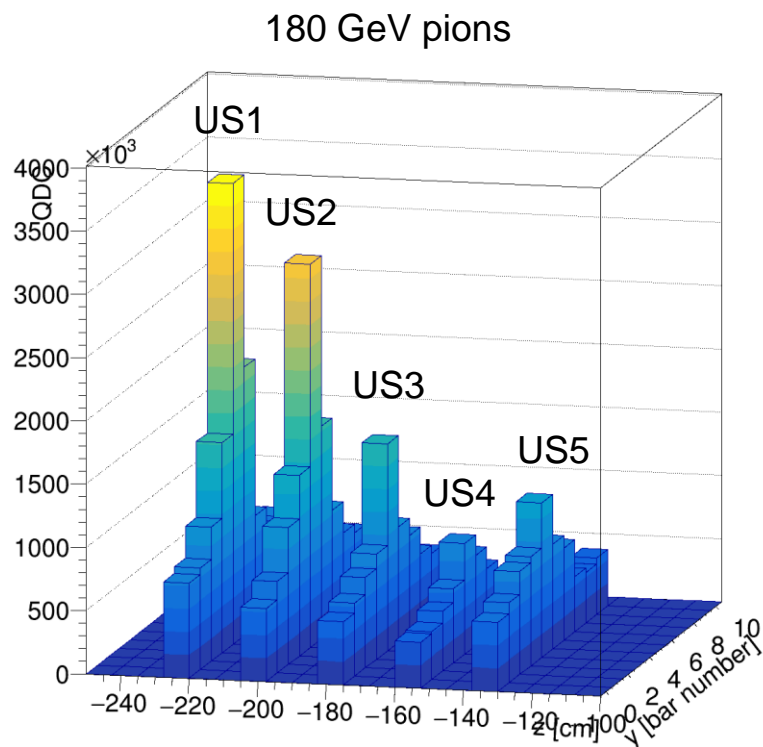
- Same exercise in DS gives $\sigma_x \sim 2.1\text{cm}$ which may be used to resolve ambiguities

PRELIMINARY

Test beam in H8 with muon system



- A first look at hadronic showers

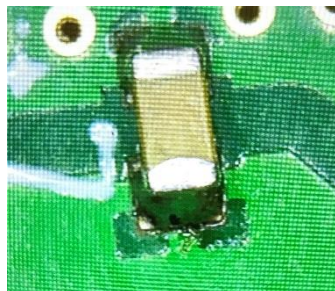
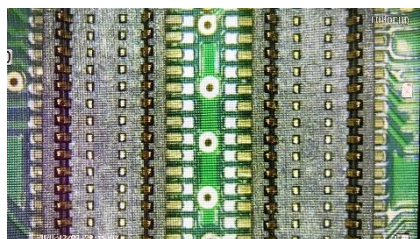


The lower signal in US4 comes from a poor connection to the TOFPET in this run

PRELIMINARY

Muon system issue

- Problems uncovered in H6 related to problems in component mounting
 - Some components show signs of cold soldering and poor placements on US PCBs
 - Insufficient solder flow on LEMO connectors for bias voltage
 - Hirose connectors misaligned – stress and connection problems with interposer/TOFPET board
- ➔ Attempt to repair boards in CERN SMD workshop – very difficult, one successful
- ➔ Now only 2 PCBs out of 24 still have serious issues
- ➔ Low on spares



- Plan to launch production of new boards
 - Lead time for new SiPMs now 4.5 - 5 months (!)
 - ➔ Spare PCBs only ready by April at the earliest
- Focus on systematic testing/repair of individual planes in temporary storage in Neutrino Platform
- ➔ Installation in TI18 as foreseen from w.48



Tests with emulsion

- 60 Slavich emulsion films were used for the light leak test of the wall box
- After development all emulsion films turned out to be dark grey, i.e. overexposed to light
- Prompt reaction of colleagues from MISiS and Lebedev allowed to quickly collect important information to identify the reason of the problem
 - Specific batch was damaged during transport between Moscow-Geneva.
 - Conclusion: exposed to high-dose luggage scan X-ray on checked baggage

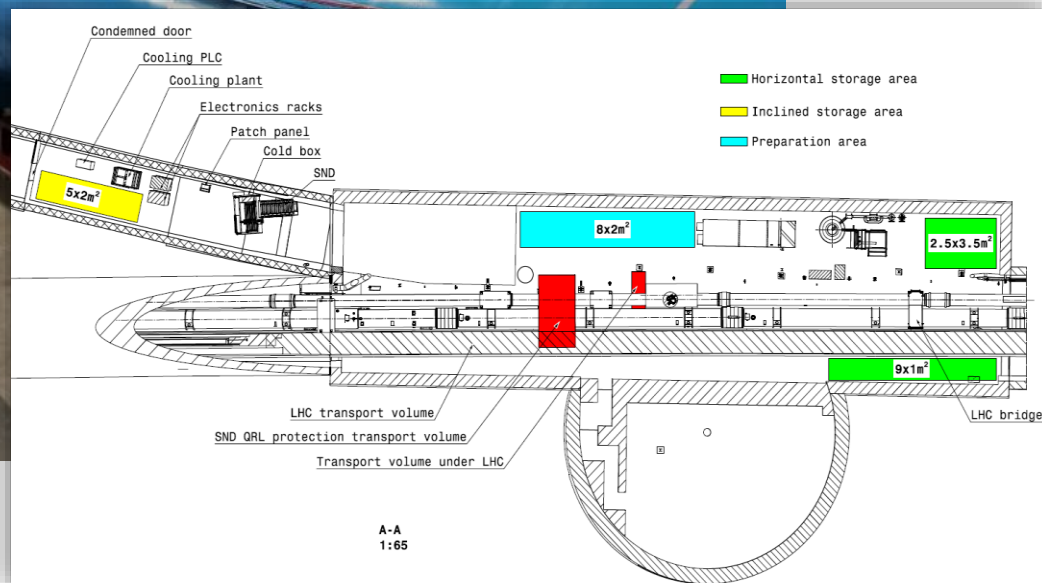
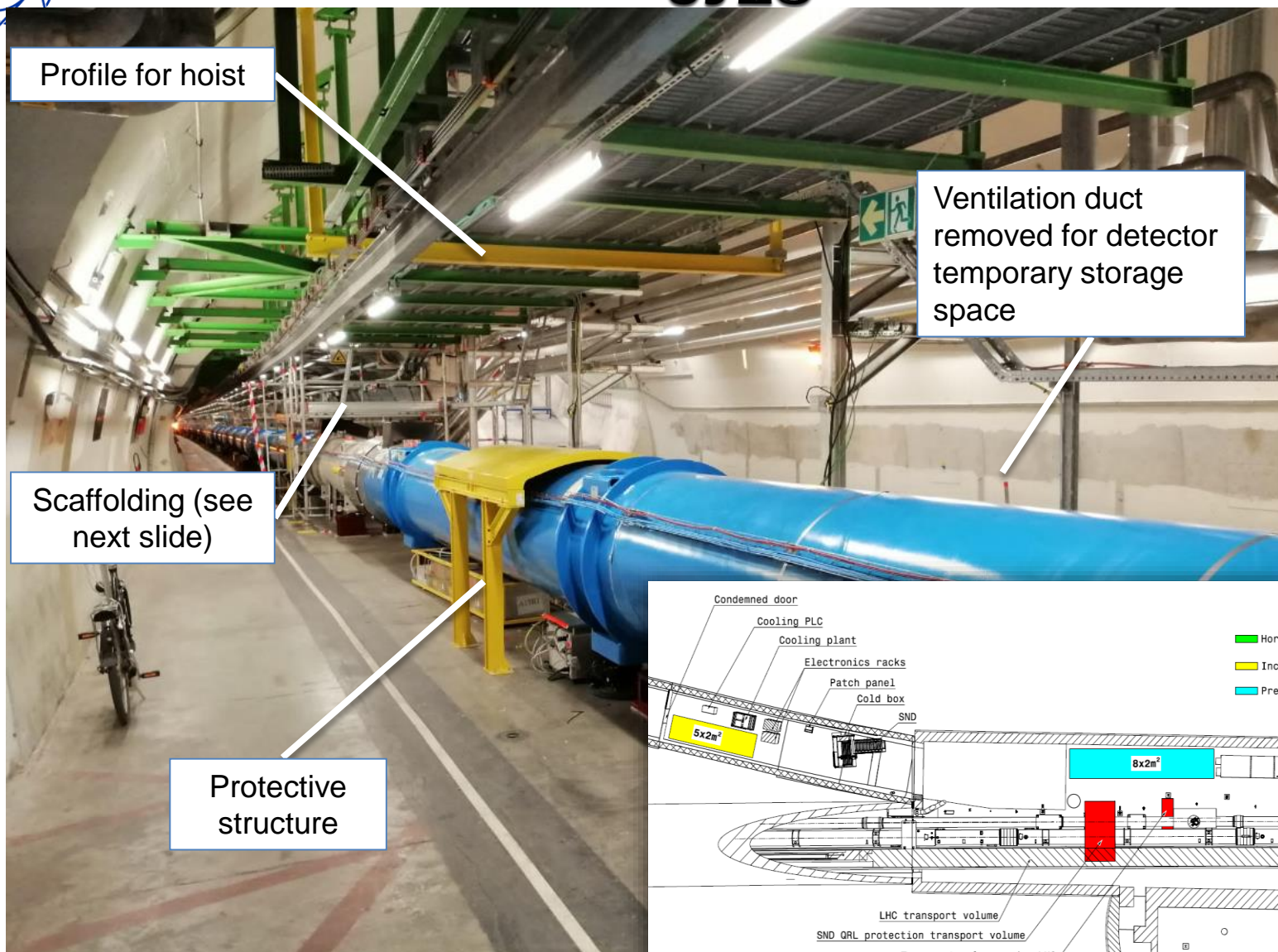
➔ Never happened before! Procedure for delivery as scientific material being worked out

◉ Emulsion production and wall commissioning

- Production of the new emulsion batch completed at Slavich
- Quality check with optical microscope at Lebedev performed
- In delivery from Moscow now
- Commissioning of wall box with tungsten plates and emulsions foreseen during coming week.

◉ Low-level fail safe temperature, humidity and smoke detection system with interlock to power supplies being developed for installation within cold box

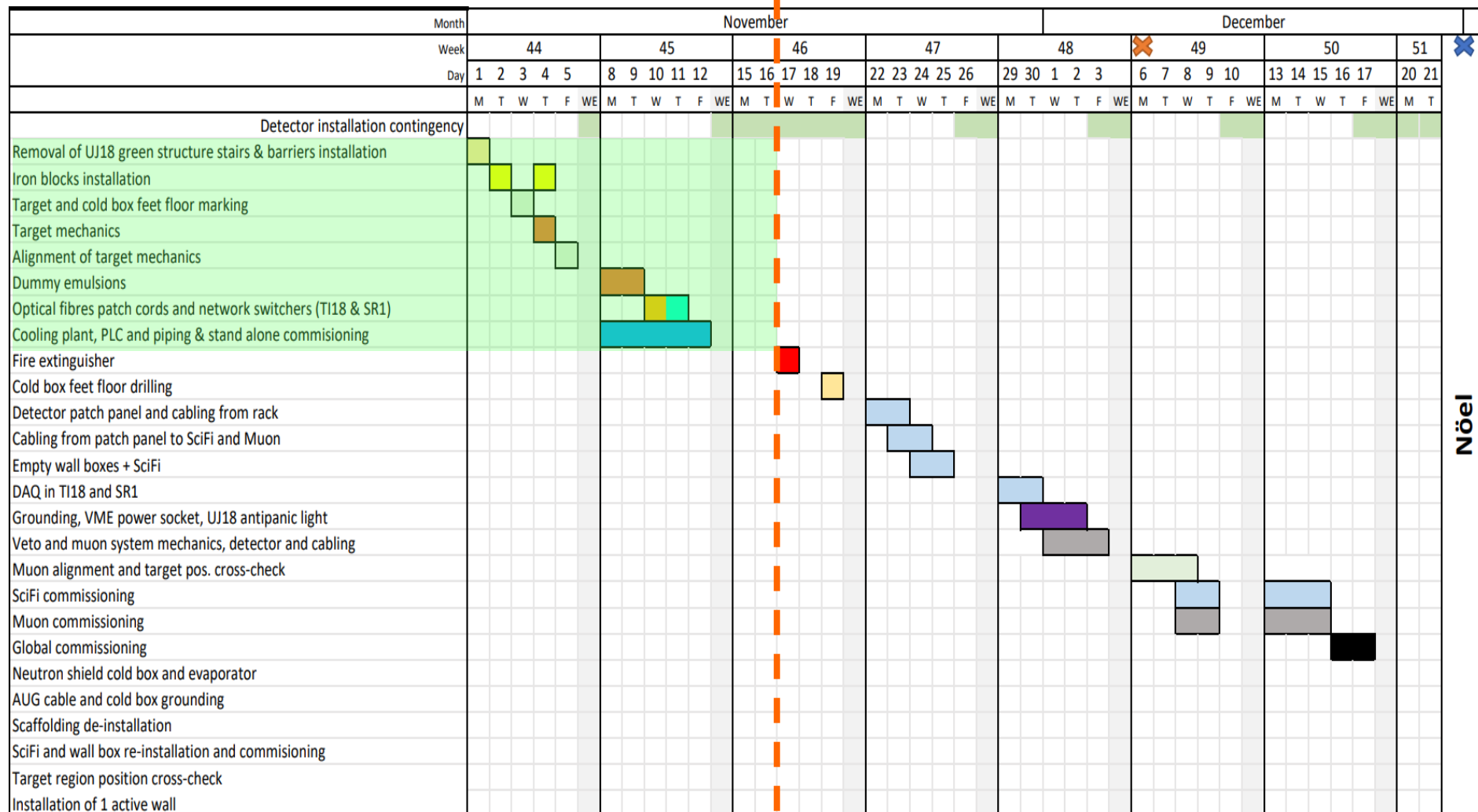
- ◉ Change in hardware architecture
 - TTC VME crate moved to surface rack in SR1
 - Monitoring sensors for cold box directly on ethernet
 - ➔ No more need for control PC in TI18
- ◉ Multithreaded event builder and data client with improved max data rate capacity
- ◉ Online servers ordered
- ◉ Work in progress
 - Logging and alarms
 - Luminosity from ATLAS
 - Run control and monitoring interfaces
 - Communication with LHC
 - Control room to be equipped
 - Data quality monitoring
- ◉ Software framework in place for reading raw data, producing histograms, etc
 - Detector geometry for H6 and TI18
 - Work on tuning digitization in MC and more advanced reconstruction techniques ongoing
- ◉ Emulsion data challenge under discussion
 - processing, distribution, scanning, data access



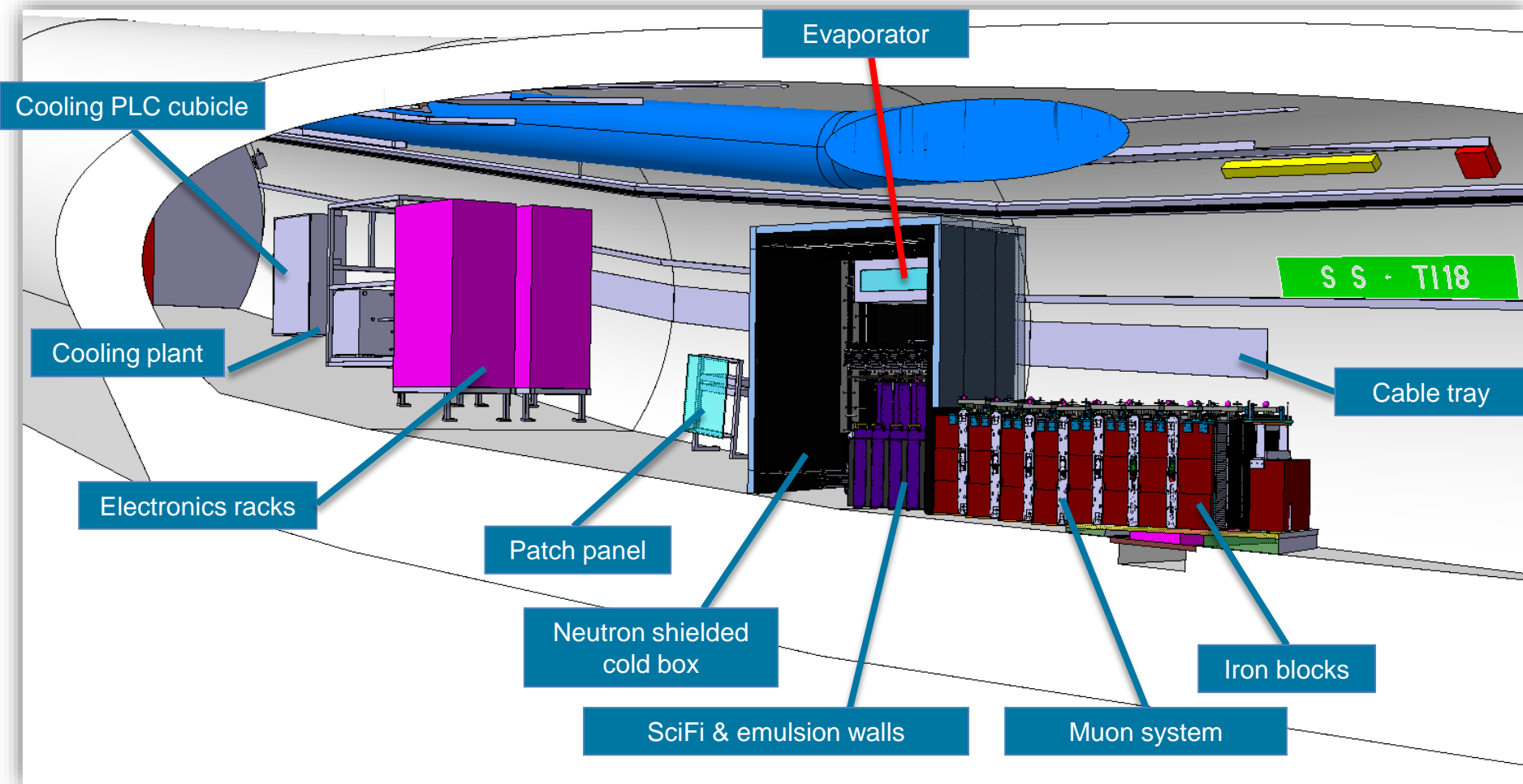
Detector construction schedule

- Surface commissioning, test beam and start of detector installation
- Up to now following schedule on the day!

Today




Nöel



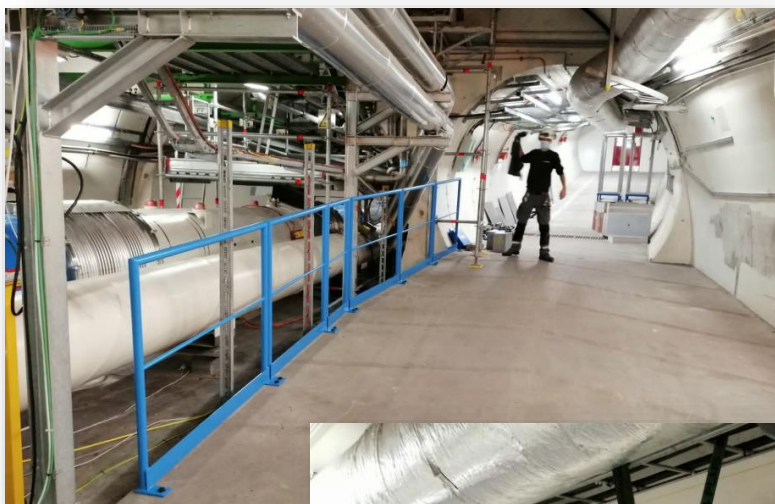
Special thanks to P. Santos Dias for coordinating installation

- ECR approved by LMC on November 3

CERN CH-1211 Geneva 23 Switzerland		EDMS NO. 2646034	REV. 0.1	VALIDITY DRAFT
 LHC		REFERENCE LHC-X1FP-EC-0007		
Date: 2021-10-15				
ENGINEERING CHANGE REQUEST SND Detector Installation and Commissioning				
BRIEF DESCRIPTION OF THE PROPOSED CHANGE(S): SND (LHC Scattering and Neutrino Detector) is designed to take data in Run 3 and is to be located at the downstream end of TI18. All works related to the preparation of the components transport, the experimental area and the infrastructure have been performed [1] [2]. This document describes the detector installation and commissioning that will be carried out from November 2021 up to February 2022.				
DOCUMENT PREPARED BY: P. Santos Diaz, BE-EA R. Jacobsson, EP-LBD	DOCUMENT TO BE CHECKED BY: V. Algoet, M. Andreini, M.Barberan, M. Bernardini, N. Bellegarde, O. Beltramello, S-M. Benmehdi, J. Blanc, M. Bonnet, K. Brodzinski, M. Brugger, D. Calcoen, G. Canale, S. Cherault, C. Colloca, M. Collignon, J-P. Corso, O. Crespo Lopez, D. Delikaris, L. Di Giulio, E. Duret Bourgoz, J-F. Fuchs, C. Gaignant, R. Garcia Alia, G. Girardot, J-L. Grenard, A. Infantino, R. Jones, D. Letant-Delrieux, Y. Maurer, M. Krupa, A. Pascal, L. Pereira, J. Perez Espinos, O. Pirotte, J. Rodriguez, I. Ruehl, M. Solfaroli, M. Souayah, R. Steerenberg, C. Vendeuvre, J Wenninger		DOCUMENT TO BE APPROVED BY: M. Lamont (on behalf of LMC) F. Sanchez Galan (on behalf of TREX)	
DOCUMENT SENT FOR INFORMATION TO: O. Beltramello, ATS groups leaders, SND Technical Board				
SUMMARY OF THE ACTIONS TO BE UNDERTAKEN: The detector installation consists of the following main activities: <ul style="list-style-type: none"> Transport of the cooling plant and detector components (SciFi, emulsion target, muon system and neutron shielded cold box) in several steps. Installation work in TI18 to set up the SND detector and cooling plant throughout November and December 2021. Powering, grounding and commissioning of the detector components and cooling plant in December 2021 and January 2022. Installation of one active neutrino target emulsion wall in a single work shift before the closure of the LHC experimental caverns in February 2022. 				
Note: When approved, an Engineering Change Request becomes an Engineering Change Order. This document is uncontrolled when printed. Check the EDMS to verify that this is the correct version before use.				

Detector construction

- Week 44: Iron blocks installation, cooling plant and target structure transport



Detector construction



- Week 44: Target assembly and positioning and grouting of feet with survey team



Detector construction

- Week 44-45: Test of emulsion wall trolley and emulsion wall



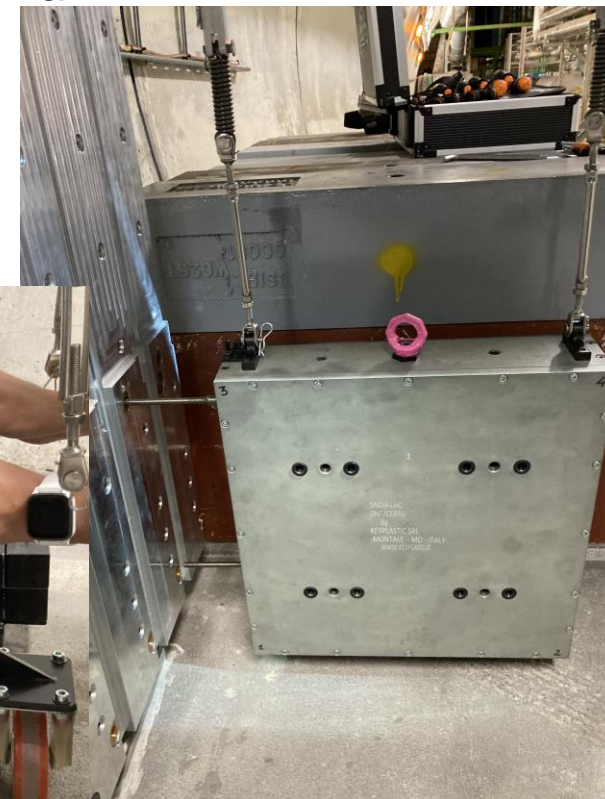
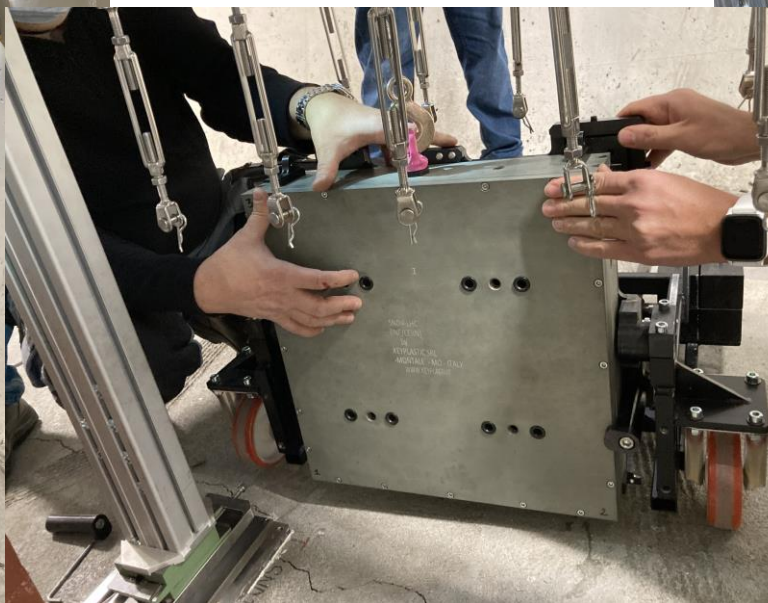
Detector construction

- Week 44-45: Test of emulsion wall trolley and emulsion wall



Detector construction

- Week 44-45: Test of emulsion wall trolley and emulsion wall

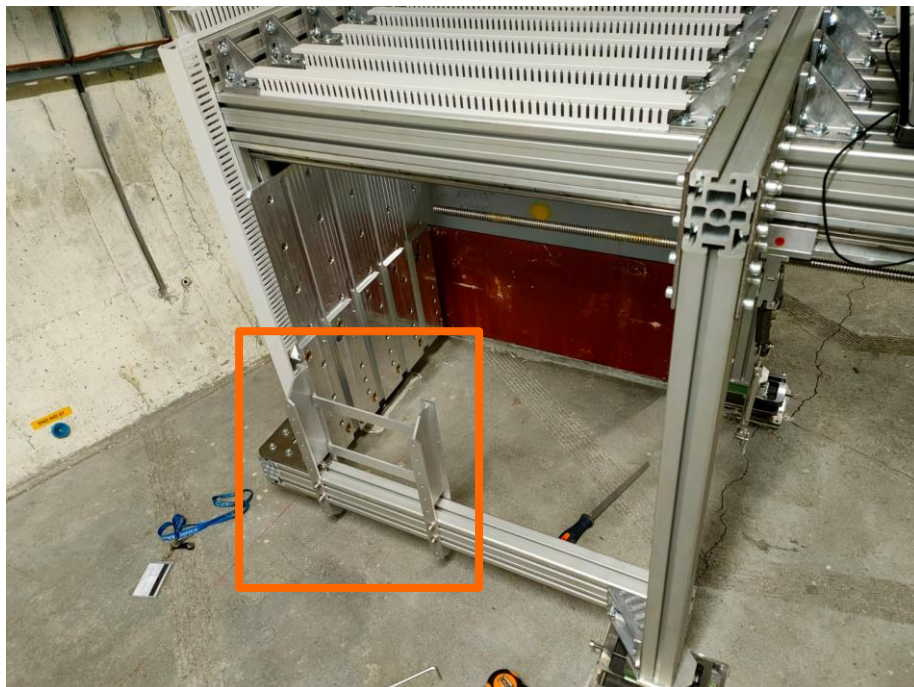


- Wall box production

- Wall boxes production at the final stage
- Delivery of first 5 wall boxes at CERN foreseen between Nov 18th-24th
- Transportation of 5 empty wall boxes to T118 and installation with SciFi

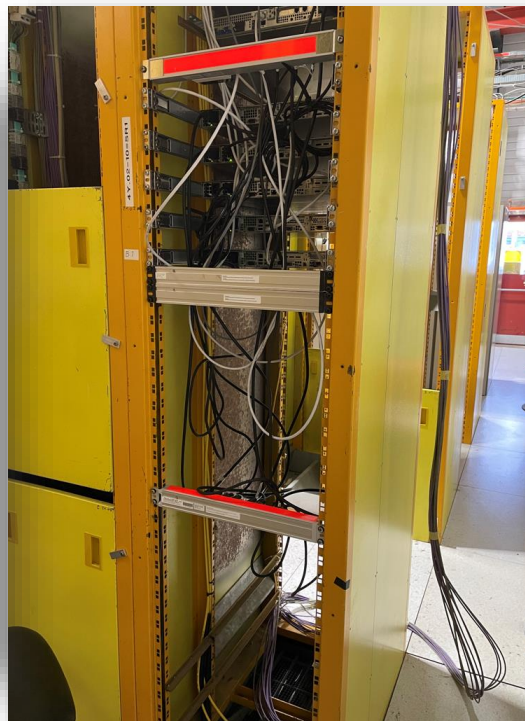
Week 45:

- ◉ Test with Veto support mechanics in TI18 on installed target system
 - Some small modifications needed to pieces holding planes together
- ◉ Cooling plant installation and stand-alone commissioning

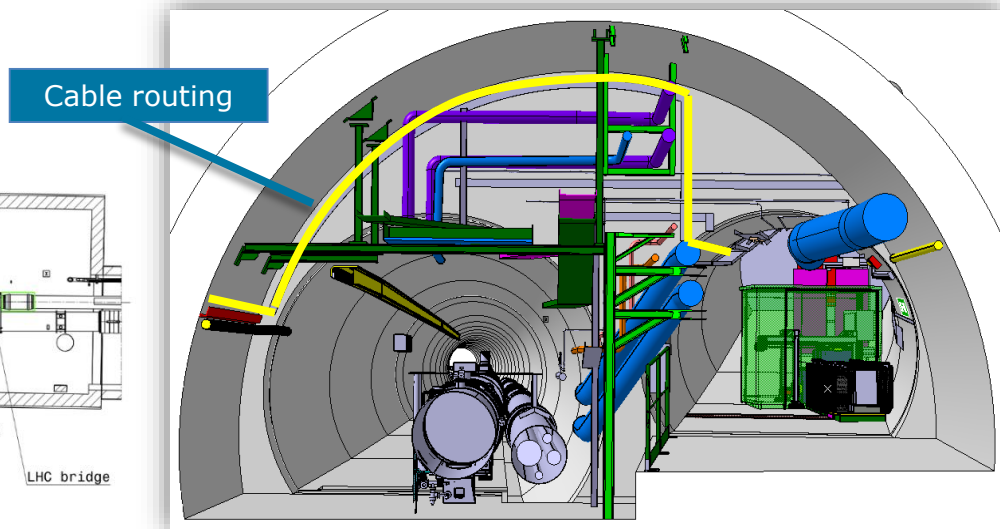
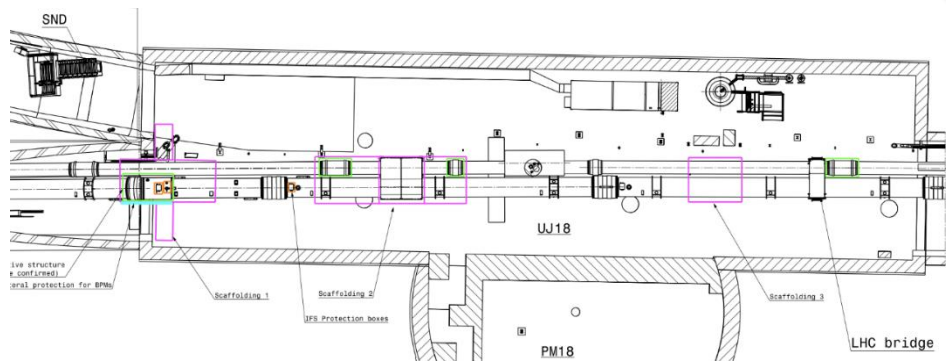


Detector construction

- ◉ Cold box feet positioning
- ◉ SR1 online system rack for FASER and SND@LHC
 - IT infrastructure foreseen to be operational this week



- ◉ Installed AUG cable non-conform
 - ➔ Cable ordered by EN/EL but will arrive only January (was scheduled for November)
 - ➔ Agreed with cryo, RP, operation and coordination that scaffolding on the left of UJ18 will remain for replacement of cable. Acceptable to deinstall scaffolding with machine at 4.5K since additional protections of bellows, instrumentation and feedthroughs will remain in place. Exceptional Authorisation Request submitted for removal of scaffolding in December
- ➔ Two AUGs available within acceptable distance on machine side and AULs in rack sufficient for installation and commissioning activities



- ◉ Cold box update:

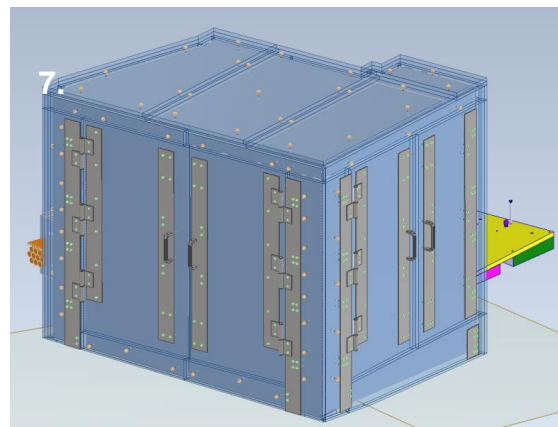
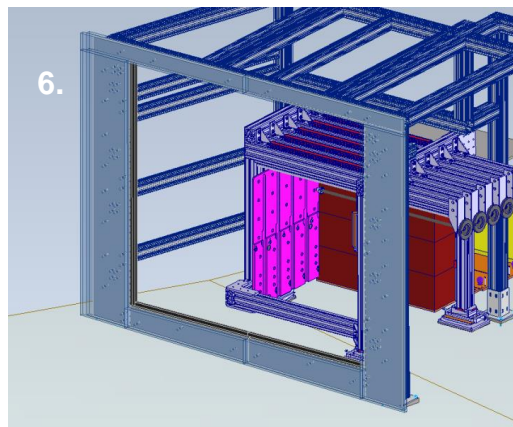
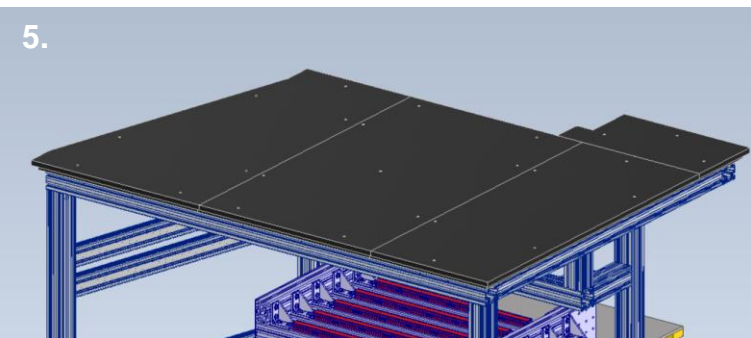
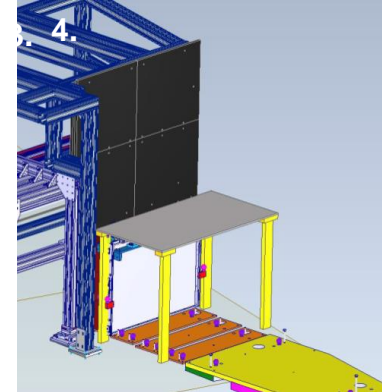
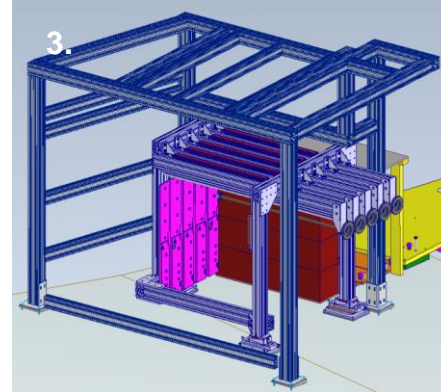
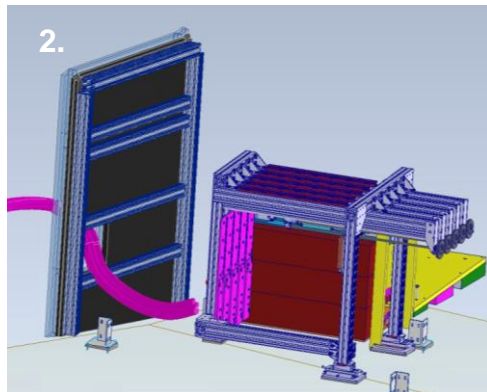
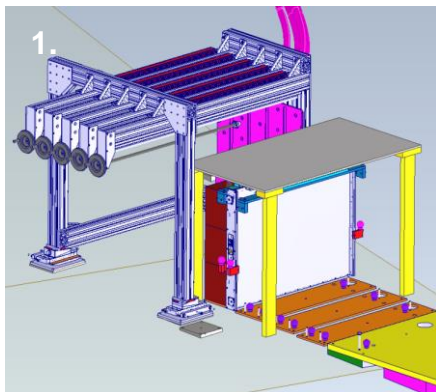
- Aluminium profiles for frame and fasteners arrived at CERN.
- Acrylic panels arrived at CERN yesterday and borated polyethylene schedule to arrive end of November
 - Significant delays on this material
- Order for hinges launched.
- Glue and spacers identified from EDH store.

- Aluminium profile drawings are ready
 - ➔ Machining will start this week
 - ➔ EHN1 assembly will start next week

Cold box/neutron shield

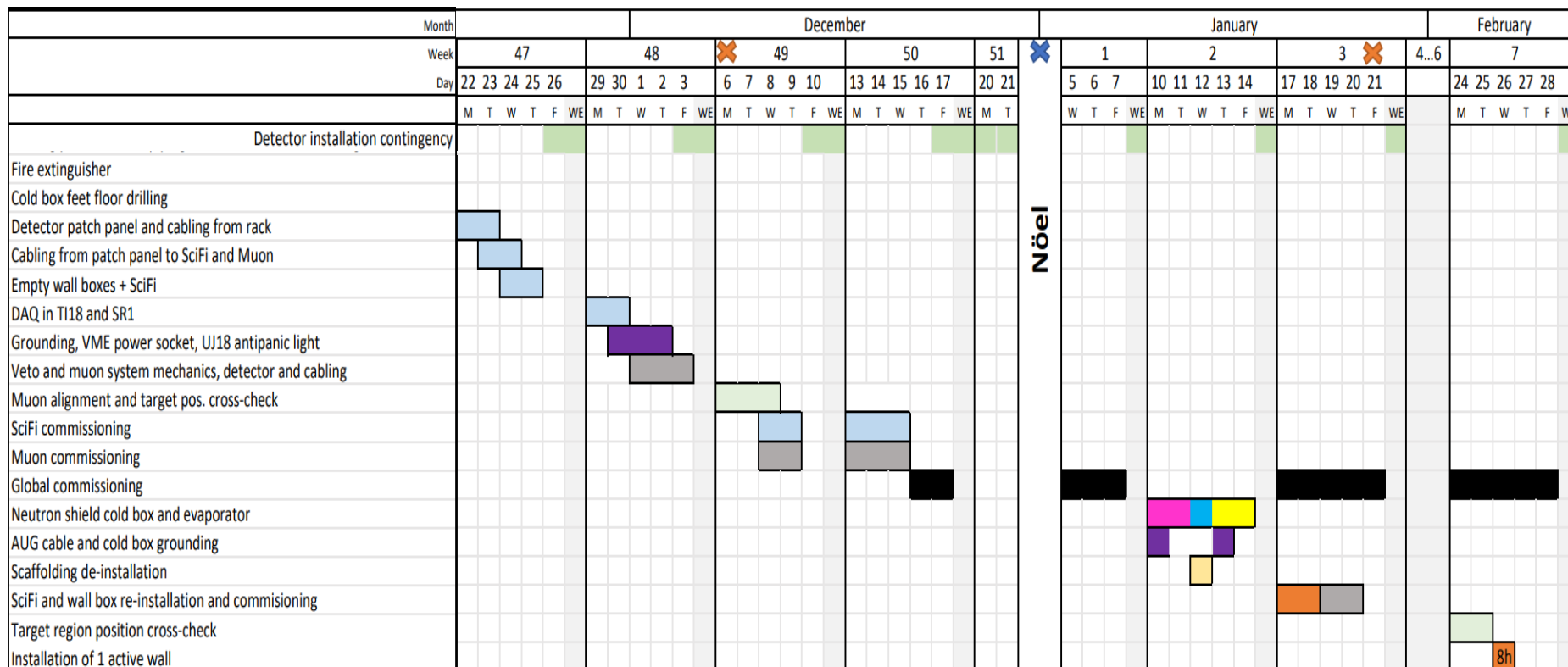
Re-scheduled installation

- ◉ Initially planned before detector installation and cabling, now after
- ◉ Detailed execution planned prepared together with EN-HE-PO and EN-CV and reviewed at Technical Board last week
 - Removal of SciFi and emulsion walls as in an emulsion replacement
 - Protection of cables
 - Protective table over entire muon system



Updated work plan

- Cold-box (initially foreseen for week 46) shifted to January with little impact on overall schedule



➔ With updated machine schedule taking into account Sector 23 intervention we would like to request three additional weeks of continuous access to TI18

- ◉ Two dedicated SRM++ course (Self-Rescue Mask + detector installation safety) held for SND installation workers
 - 2574542 v.1 "SND@LHC - **Launch Safety Discussion**" by MARCO ANDREINI in status: Released
 - 2574585 v.1 "SND@LHC - **Project Safety Requirements**" by MARCO ANDREINI in status: Released
 - Pressure test, mechanical and electrical inspection
 - 2651919 v.1 "**Structural analysis of the main support structure for "SND@LHC" experiment target**" by S. Buontempo in status: Released
 - 2652344 v.1 "**Safety Request Form - SND@LHC- Acceptance of the structural assessment report for the target hanging structure**" by MARCO ANDREINI in status: Released
 - **Derogation for non-compliant IS41 material** (neutron shield, SciFi, emulsion, and scintillating bars) with mitigations discussed and submitted
 - 2631966 v.1 "**Exceptional Authorisation: SND Project Activities at 1.9K**", by DELPHINE LETANT_DELRIEUX in status Released (AUG cable installation and removal of scaffolding)
 - 2650049 v.1 "**HSE-RP studies and activities linked to SND installation, operation and maintenance**", by L.Elle, A. infantino, M. Maietta in status: Draft
- ◉ In preparation
 - Emulsion wall replacement procedure, including operation manual for trolley (photos)
 - Emulsion facility work procedure

- ◉ Thanks for excellent support from Letiza Di Giulio, Marco Andreini, J. Gulley

- Radioprotection studies draft EDMS 2650049 (L. Elie, A. Infantino, M. Maietta, HSE)

Residual dose rates in T118 after 1h of beam stop at nominal Run 3 operation

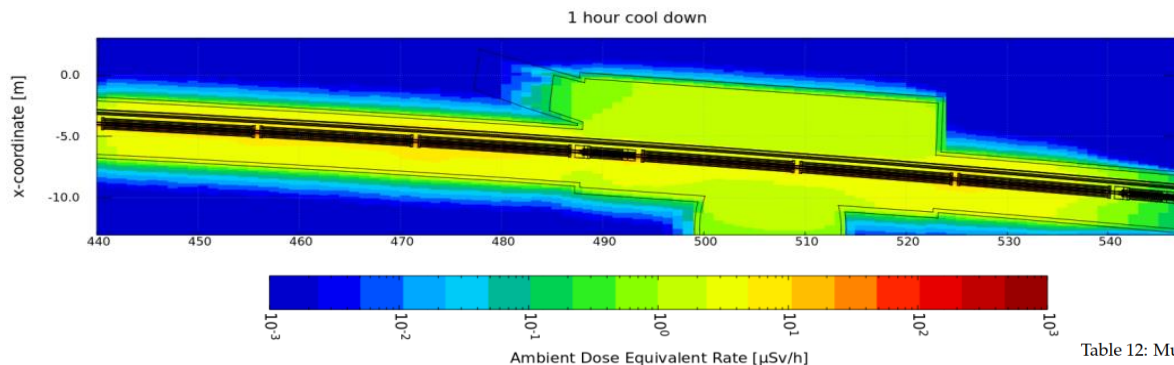


Table 12: Multiple of LL in the emulsion film only, using particle spectra scored in in the emulsion region (1). The material used in ActiWiz is reported in the table.

EMULSION	2 hours	1 day	1 week	2 weeks
Gas-density H_2/m^3	LL \pm %	LL \pm %	LL \pm %	LL \pm %
1.00E+15	7.83E-03 \pm 15.66%	6.95E-03 \pm 17.57%	5.34E-03 \pm 22.41%	5.12E-03 \pm 22.93%
2.25E+13	1.76E-04 \pm 15.66%	1.56E-04 \pm 17.57%	1.20E-04 \pm 22.41%	1.15E-04 \pm 22.93%
2.25E+12	1.96E-05 \pm 15.66%	1.74E-05 \pm 17.57%	1.34E-05 \pm 22.41%	1.28E-05 \pm 22.93%

Table 13: Multiple of LL in the emulsion film only, using particle spectra scored in in the emulsion region (5). The material used in ActiWiz is reported in the table.

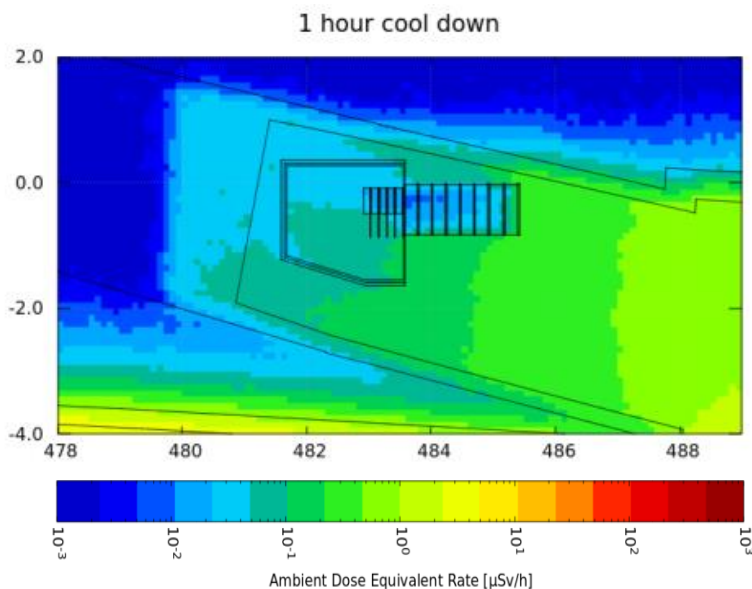
EMULSION	2 hours	1 day	1 week	2 weeks
Gas-density H_2/m^3	LL \pm %	LL \pm %	LL \pm %	LL \pm %
1.00E+15	6.06E-03 \pm 18.95%	5.41E-03 \pm 21.12%	4.23E-03 \pm 26.52%	4.06E-03 \pm 27.06%
2.25E+13	1.36E-04 \pm 18.95%	1.22E-04 \pm 21.12%	9.51E-05 \pm 26.52%	9.14E-05 \pm 27.06%
2.25E+12	1.51E-05 \pm 18.95%	1.35E-05 \pm 21.12%	1.06E-05 \pm 26.52%	1.02E-05 \pm 27.06%

Table 14: Multiple of LL in the W-plate, using particle spectra scored in in the emulsion region (1). The material used in ActiWiz is reported in the table.

W-PLATE	2 hours	1 day	1 week	2 weeks
Gas-density H_2/m^3	LL \pm %	LL \pm %	LL \pm %	LL \pm %
1.00E+15	1.18E-02 \pm 3.38%	8.59E-03 \pm 2.57%	5.29E-03 \pm 1.49%	4.93E-03 \pm 1.52%
2.25E+13	2.65E-04 \pm 3.38%	1.93E-04 \pm 2.57%	1.19E-04 \pm 1.49%	1.11E-04 \pm 1.52%
2.25E+12	2.94E-05 \pm 3.38%	2.15E-05 \pm 2.57%	1.32E-05 \pm 1.49%	1.23E-05 \pm 1.52%

Table 15: Multiple of LL in the W-plate, using particle spectra scored in in the emulsion region (5). The material used in ActiWiz is reported in the table.

W-PLATE	2 hours	1 day	1 week	2 weeks
Gas-density H_2/m^3	LL \pm %	LL \pm %	LL \pm %	LL \pm %
1.00E+15	7.64E-03 \pm 4.05%	5.45E-03 \pm 3.16%	3.14E-03 \pm 1.97%	2.92E-03 \pm 2.02%
2.25E+13	1.72E-04 \pm 4.05%	1.23E-04 \pm 3.16%	7.07E-05 \pm 1.97%	6.58E-05 \pm 2.02%
2.25E+12	1.91E-05 \pm 4.05%	1.36E-05 \pm 3.16%	7.85E-06 \pm 1.97%	7.31E-06 \pm 2.02%



Emulsion wall replacement

- ◉ Conclusion: With regard to activation, no value predicted higher than clearance limit (LL), even with the conservative residual gas-density in the machine of $10^{15} \text{ H}_2 \text{ m}^{-3}$.
- ◉ Intervention procedure should still have preliminary Work and Dose planning and any material leaving zone should be checked by RP
- ◉ LSS walkthrough dose estimated to be 10-20 μSv for short term access (~2h from beam stop with nominal Run 3 conditions)
 - Conservative assumption based on RP surveys (TS 2017) and FLUKA simulations
- ◉ Discussion and coordination of emulsion replacement and use of emulsion facility together with FASER ν planned as soon as LHC schedule is updated

Development procedure outlined in detail

CHEMICAL TREATMENT PER EACH RUN

- 1200 films (44m²)
- 4 development processes
- 14 days

ONE DEVELOPMENT PROCESS:

- 10 chains x 30 films = 300 films (11 m²)
- chains can be parallelised (groups of three)
- Three days/process

WEEK 1	DAY 1	CHEMICALS PREPARATION
	DAY 2	PROCESS 1: CHAINS 1-6
	DAY 3	PROCESS 1: CHAINS 7-10
	DAY 4	DISPOSAL & CHEMICALS PREPARATION
	DAY 5	PROCESS 2: CHAINS 1-6
	DAY 6	PROCESS 2: CHAINS 7-10
	DAY 7	DISPOSAL & CHEMICALS PREPARATION
WEEK 2	DAY 1	PROCESS 3: CHAINS 1-6
	DAY 2	PROCESS 3: CHAINS 7-10
	DAY 3	DISPOSAL & CHEMICALS PREPARATION
	DAY 4	PROCESS 4: CHAINS 1-6
	DAY 5	PROCESS 4: CHAINS 7-10
	DAY 6	DISPOSAL
	DAY 7	



Emulsion production and scanning



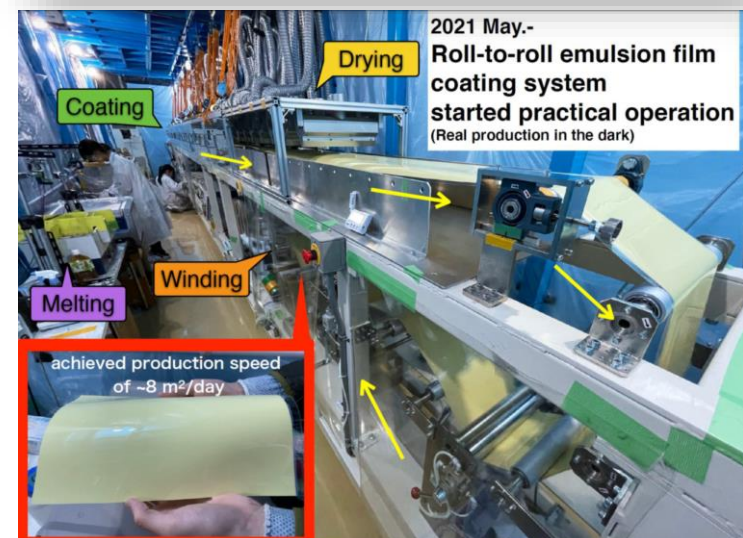
Slavich emulsion facility upgrades

- 2021: 2 rooms with 80 manual pouring tables up to 20x25cm²
- 2022: industrial emulsion synthesis and aiming for automated emulsion pouring line in a clean room for 300 m²/year



Nagoya emulsion facility upgrades

- 2021 upgrade: 7-8 m² / day
- 20m² (out of 44 or 88 m²) foreseen to contribute in 2022
- Committed to contribute with 100m² during Run 3



Scanning microscopes under upgrade Berlin, MISiS, Naples, Zurich, CERN

Plan for 2022



- ◉ Plan during LHC beam commissioning is to have one wall equipped with emulsion
 - Additional bricks outside of target, both inside and outside of cold box in strategic positions to measure neutron background
 - ➔ Requires alternative dark room for preparation of active wall (IdeaSquare?)
 - ➔ Access to T118 during single 8h shift as late as possible (previous schedule week 7)

- ◉ Focus on background measurements (comparison with simulation) and first ν with 1/5 emulsion and electronic detectors:
 - Rate of passing through muons
 - Muon deep-inelastic scattering
 - Muon bremsstrahlung
 - High-energy neutron flux
 - Neutrino flavour, NC versus CC to prepare for the NC/CC ratio
 - Electron/muon neutrino identification with data from the electronic detectors only (Veto, SciFi target tracker, muon system) ➔ Fast lane for analysis.
 - ➔ SND@LHC can do the first (robust) observation of electron/muon neutrinos from a collider by this method
 - Important tool while waiting for emulsion to be scanned/analysed

- ◉ New schedule from LHC essential to discuss replacement strategy
 - One or two emulsion replacements

Plan for 2022 and beyond

- ◉ 18 weeks of operation in previous schedule
 - Shift schedule for detector operation, emulsion wall assembly, emulsion wall replacement, film development, scanning under preparation
- ◉ Preparation to secure operation for extension of Run 3 (financial) ongoing
- ◉ Test beam in 2022
 - Interest from collaboration to go into test beam in first week of November
 - ➔ Perform a potentially more accurate hadronic energy calibration and SciFi R&D