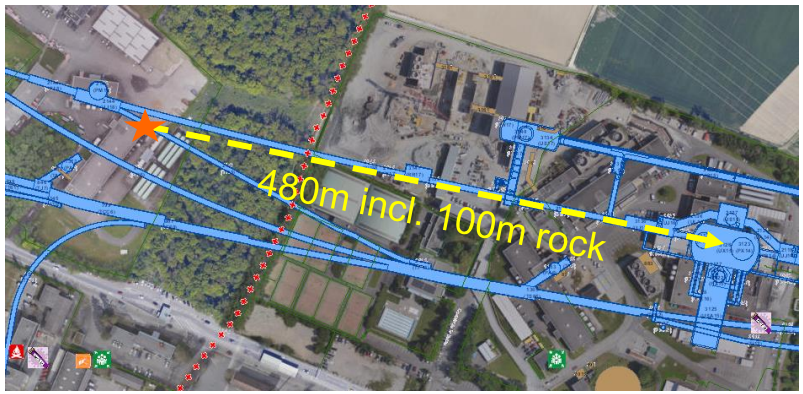
SND@LHC status report, 16 November

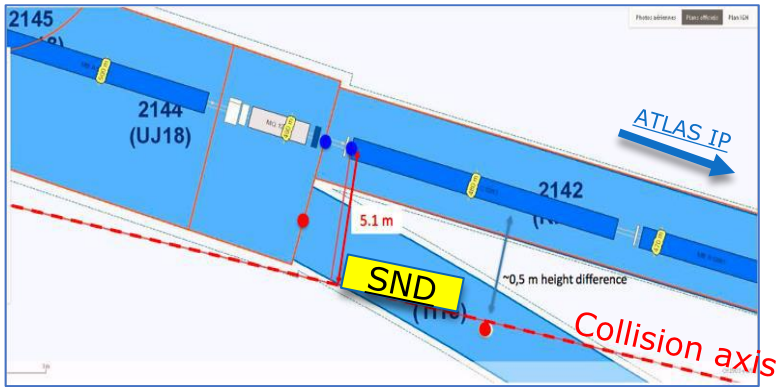
SND@LHC Collaboration

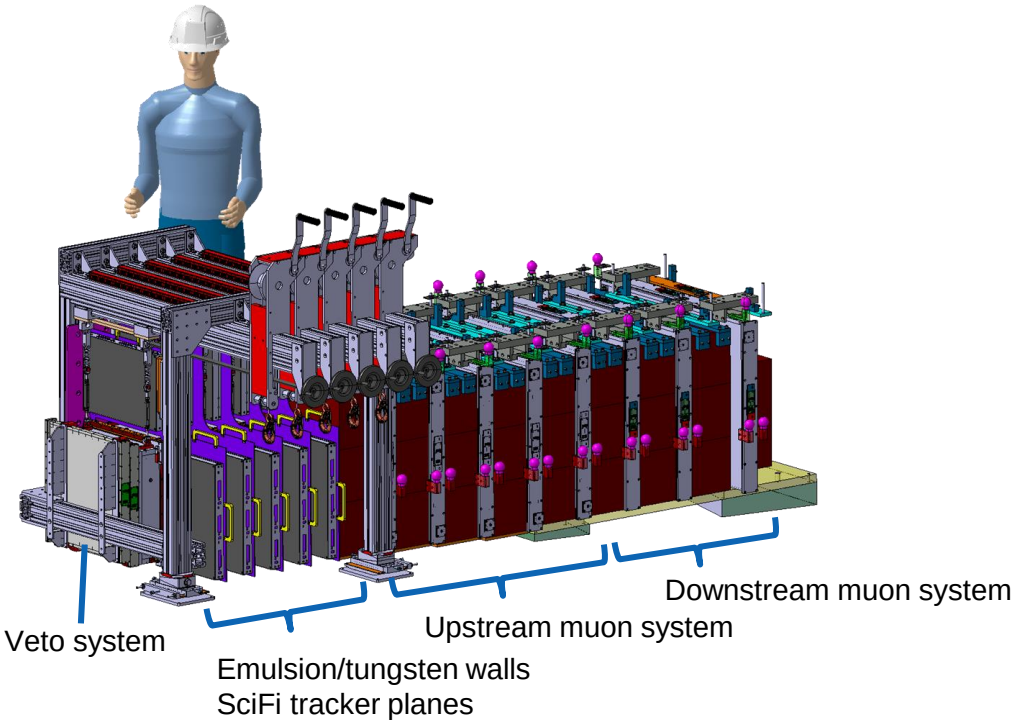
Last LHCC report (1 June - 30 August)

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, ATLAS Technical Coordination

Refresher


480m incl. 100m rock


2145
2144
(UJ18)
ATLAS IP
2142
5.1 m
SND
~0,5 m height difference
Collision axis


Veto system
Emulsion/tungsten walls
SciFi tracker planes
Upstream muon system
Downstream muon system

General news

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

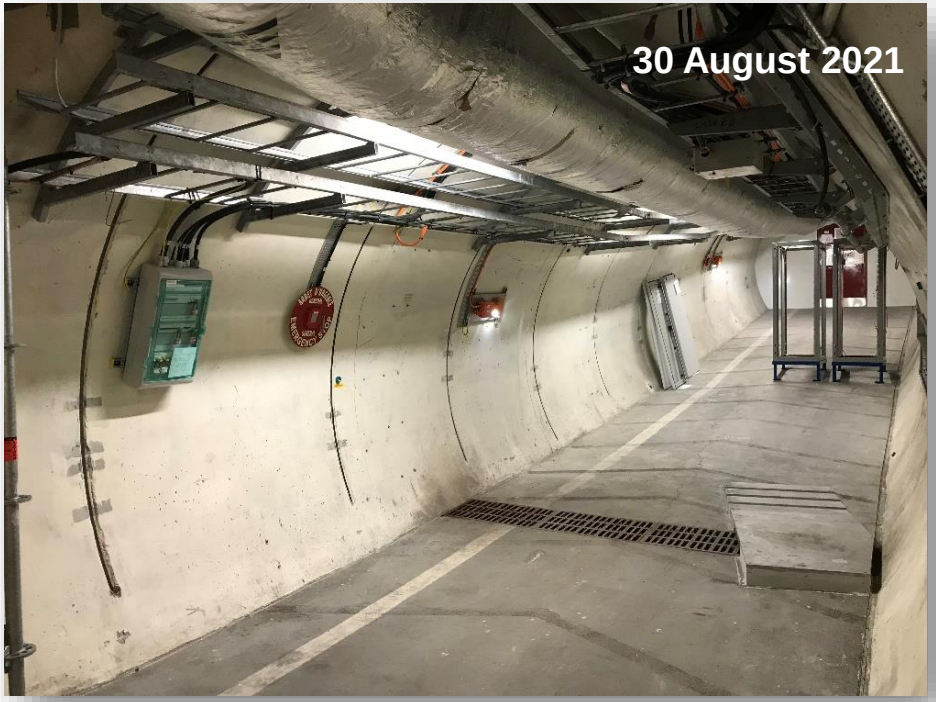
- Physics Coordinator elected: A. Di Crescenzo
- Editorial Board elected: E. Graverini, M. Guler, E. van Herwijnen
- Experiment stimulating theorists: Neutral Exotica at FASERv and SND@LHC (arxiv:2109.13962.pdf)
- JINST joint issue on the LHC and experiment upgrades for Run3. To be published early 2022
- 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 commission and test beams
- Detector installation started as scheduled on Monday November 1

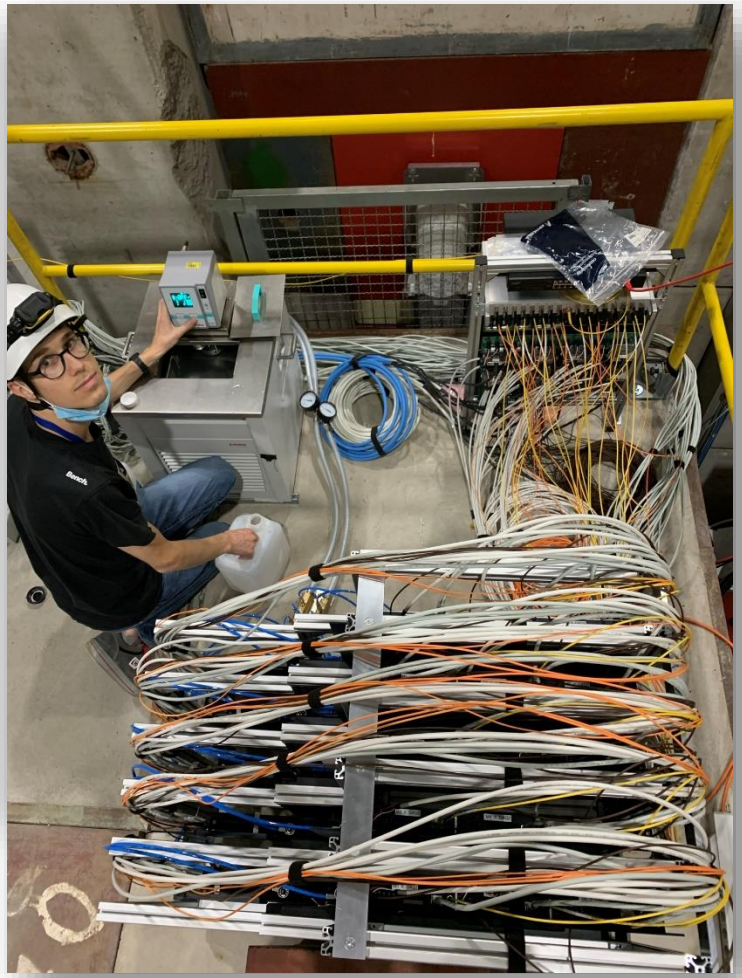


- Allocated budgets for construction are being made available in time
  - Project remains within available budgets, no cost overrun in sight
- Tight but sufficient availability of manpower for construction, surface commissioning and installation

Surface commissioning in H6

Intense activity September – October

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

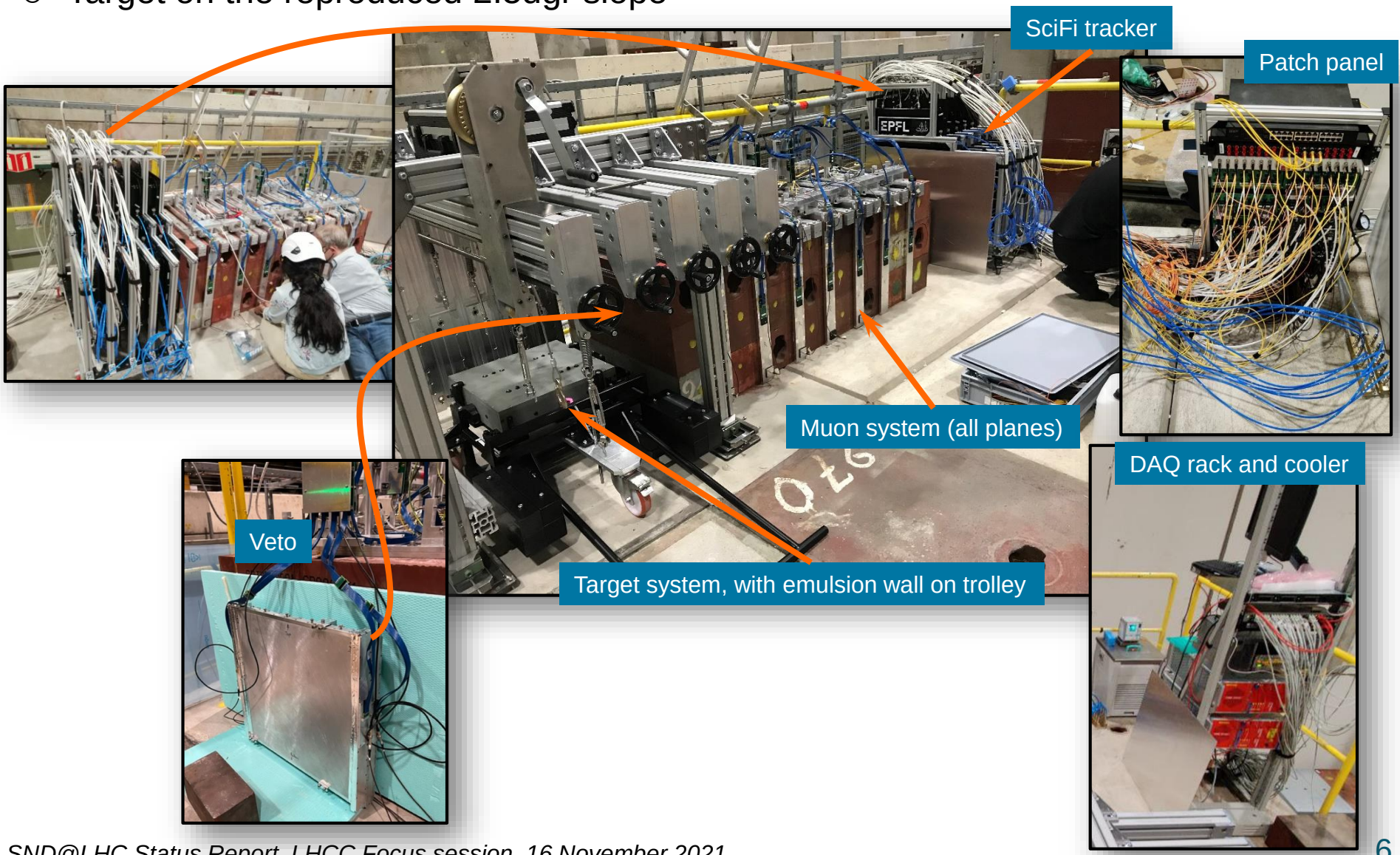


Thanks for superb support from North Area beam line teams!

Surface commissioning

All systems installed!

- Target on the reproduced 2.5dgr slope



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)

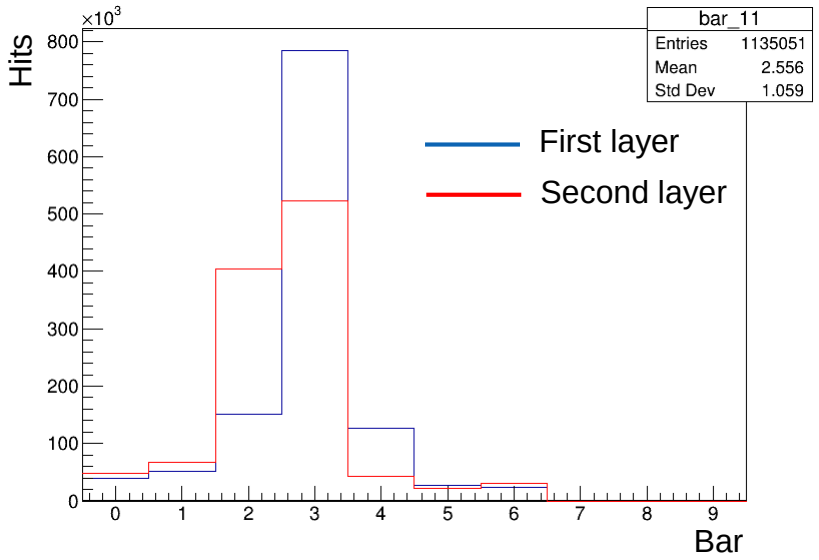
Surface commissioning in H6 – data taking

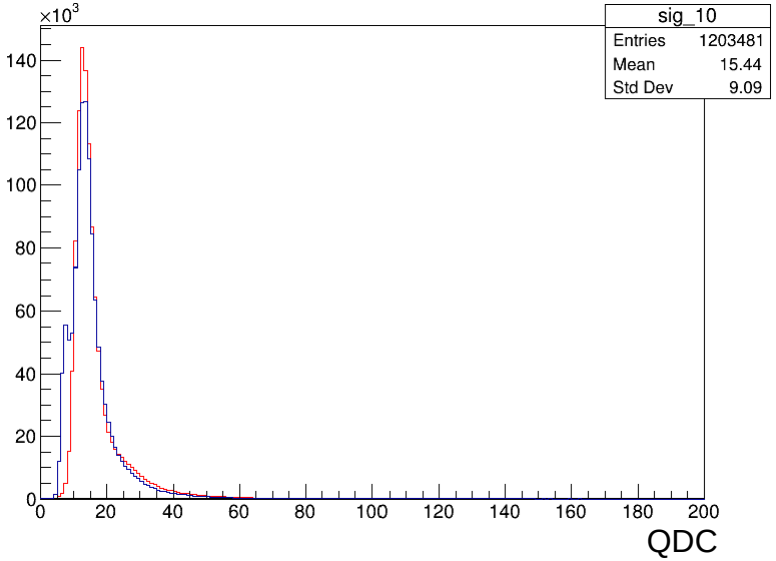
More than 120h runs of data with muon beam, ~22h with SciFi, veto and muon system

- Total 1.2 TB…
- Another 50h stability test with DAQ

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

Veto system



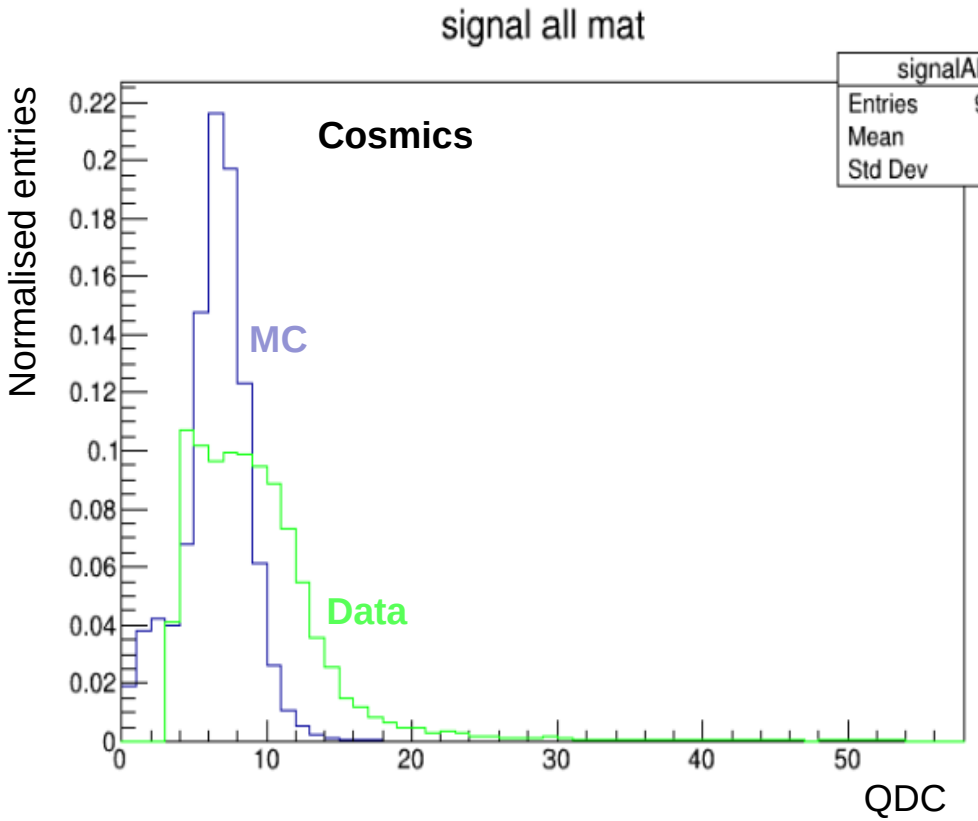


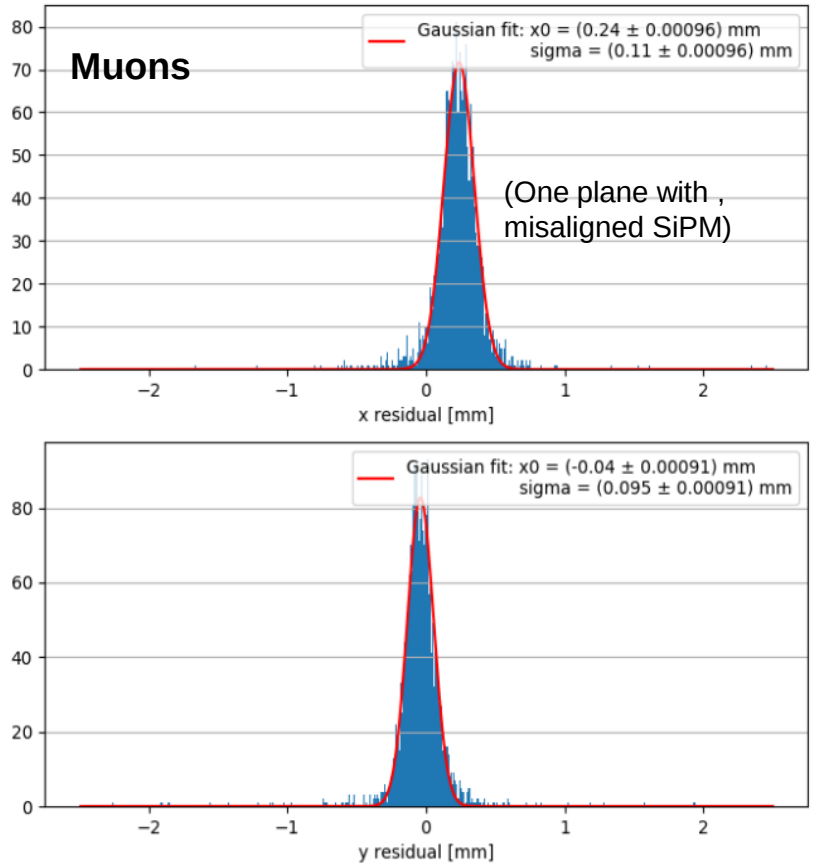
PRELIMINARY

Surface commissioning in H6 – data taking

SciFi target tracker

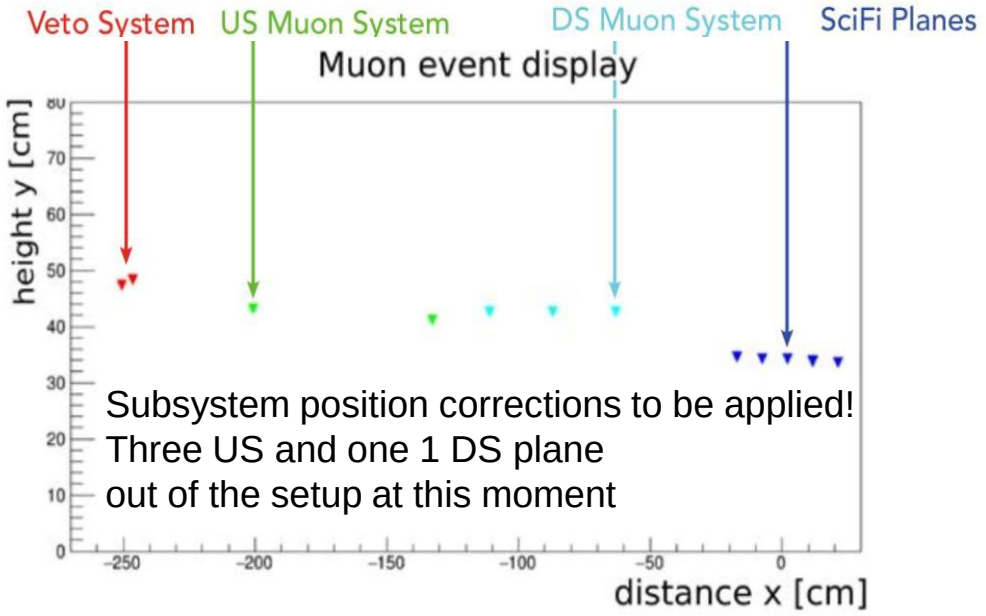
- Very uniform response across all mats, MC tuning to be done, well aligned





PRELIMINARY

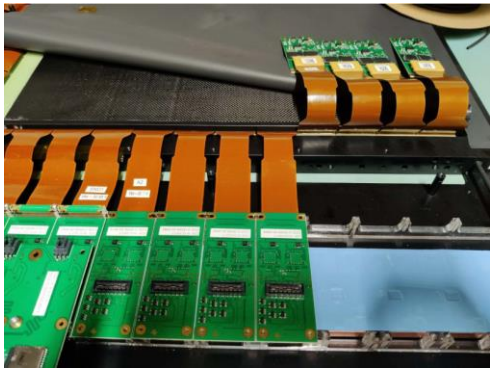
Surface commissioning in H6 – data taking



<u>Some issues uncovered</u>

- 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

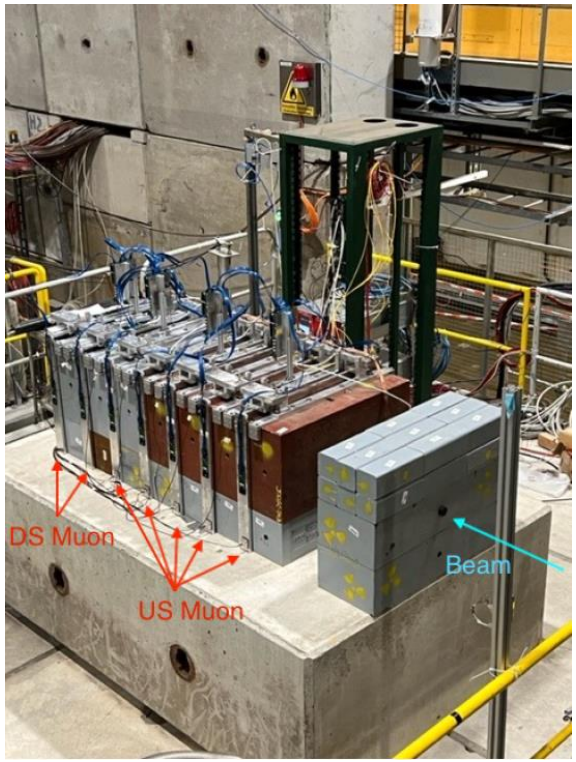
  ➔ Partly solved (see dedicated slide)

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
  - Desychronisation during the run at 100,180 GeV

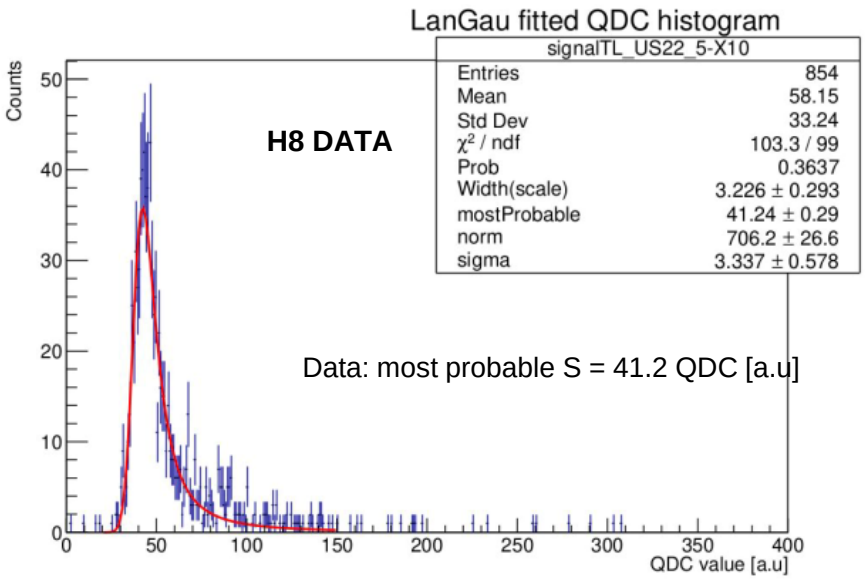
➔ Successful second run on Oct 1-6 at H8 for energy calibration with 140, 180, 240 and 300 GeV pions

- Two downstream stations were included as well

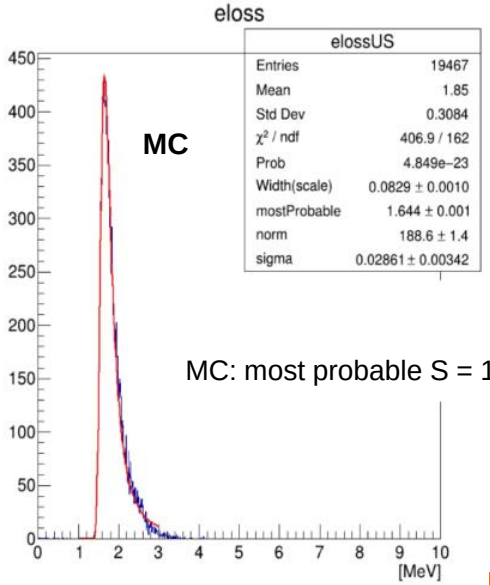


Test beam in H8 with muon system

- 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



Data: most probable S = 41.2 QDC [a.u]



MC: most probable S = 1.54 keV

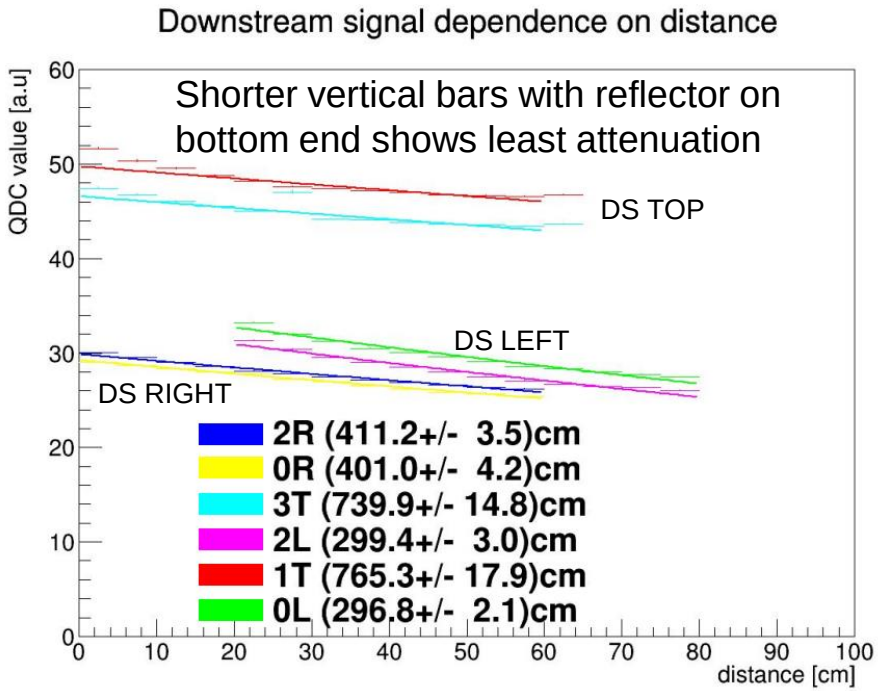
PRELIMINARY

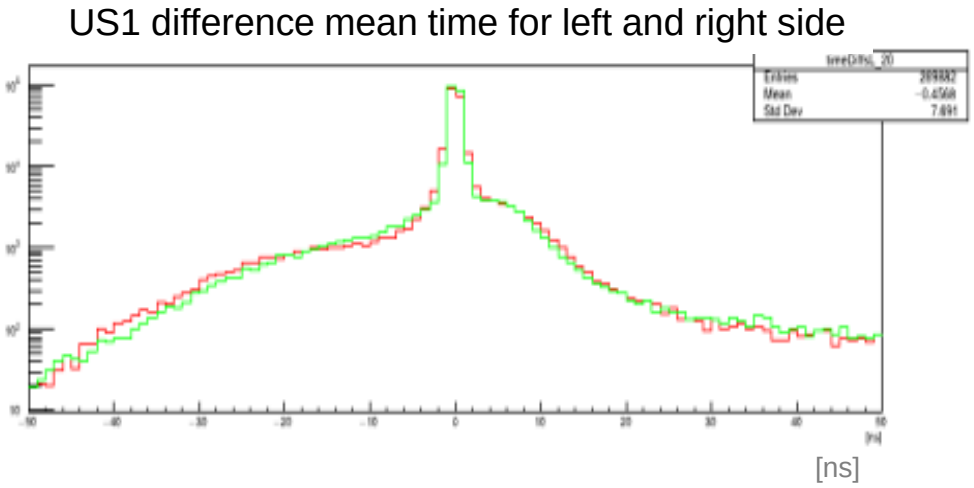
- Conversion factor 1 QDC = 0.04 keV
- Data distribution broader ➔ too conservative attenuation length and no electronic noise in MC

➔ MC tuning

Test beam in H8 with muon system

- Attenuation in DS system with 1x1cm^2 bars much less than initially thought





Distribution dominated by noise in tails, core gives already time resolution US1: ~0.7 ns

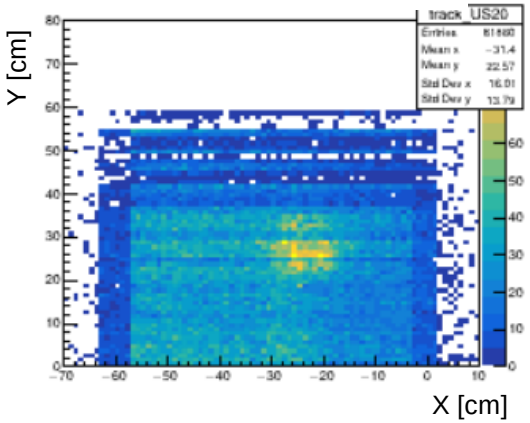
PRELIMINARY

Test beam in H8 with muon system

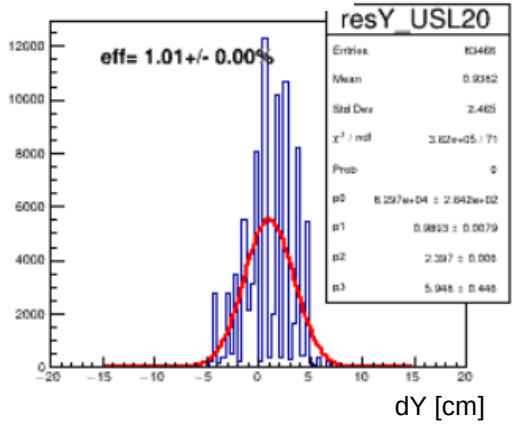
- Vertical “residuals” (extrapolation error and bar width) from Kalman fitted tracks from DS muon system

US1

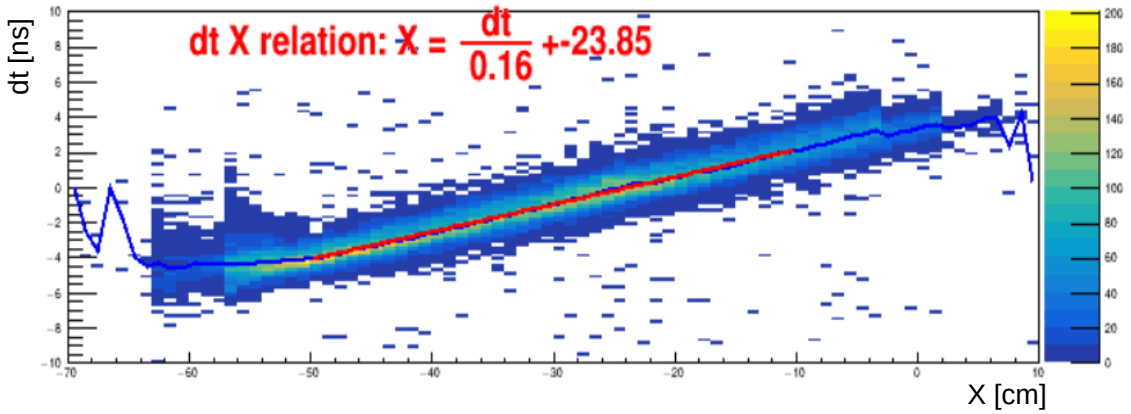
Extrapolated track from DS



Y residual LEFT



- Extrapolated track X position vs mean time difference between left and right side
  - Estimation of position resolution from spread σ_t ~0.55ns
    - ➔ σ_x~0.55/0.16cm = 3.7cm



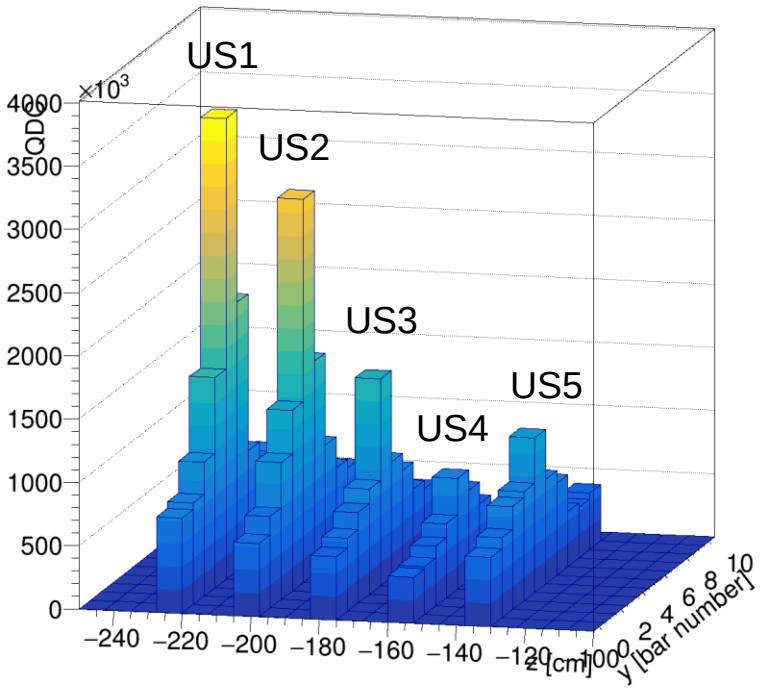
- Same exercise in DS gives σ_x~ 2.1cm which may be used to resolve ambiguities

PRELIMINARY

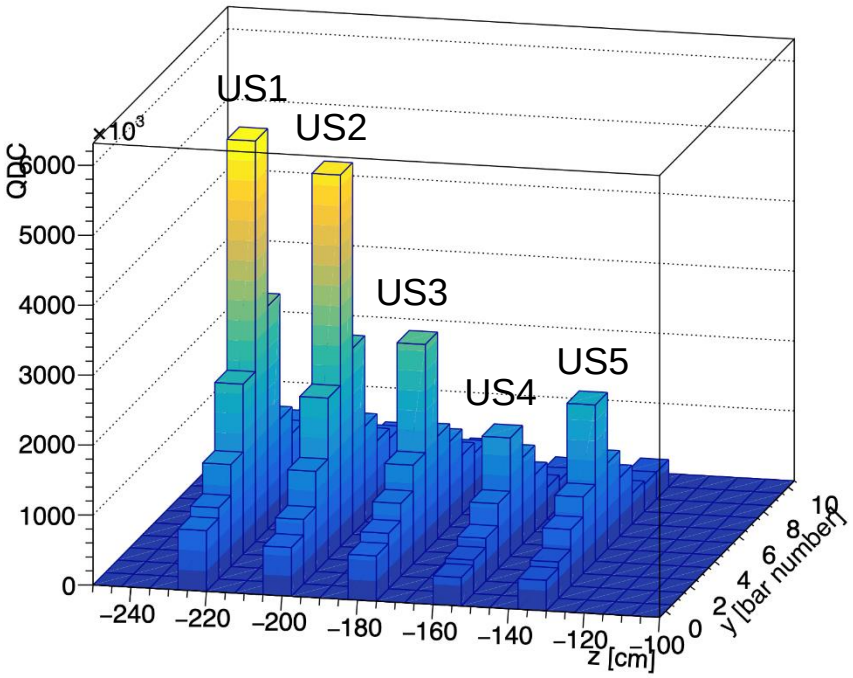
Test beam in H8 with muon system

- A first look at hadronic showers

180 GeV pions



300 GeV pions

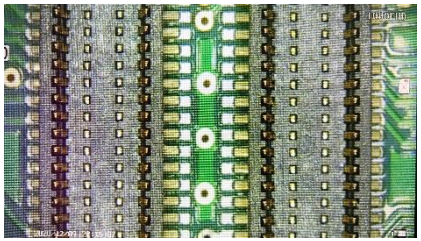
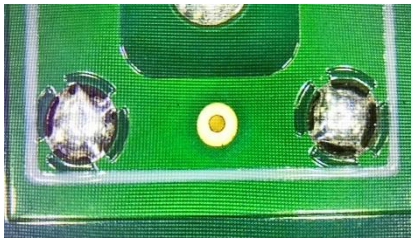
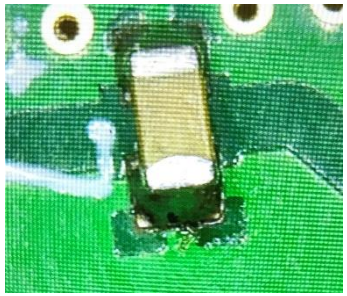
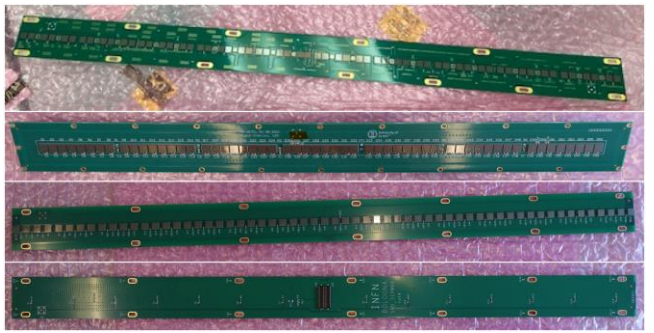


The lower signal in US4 comes from a poor connection to the TOFPET in these runs

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

Emulsion

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

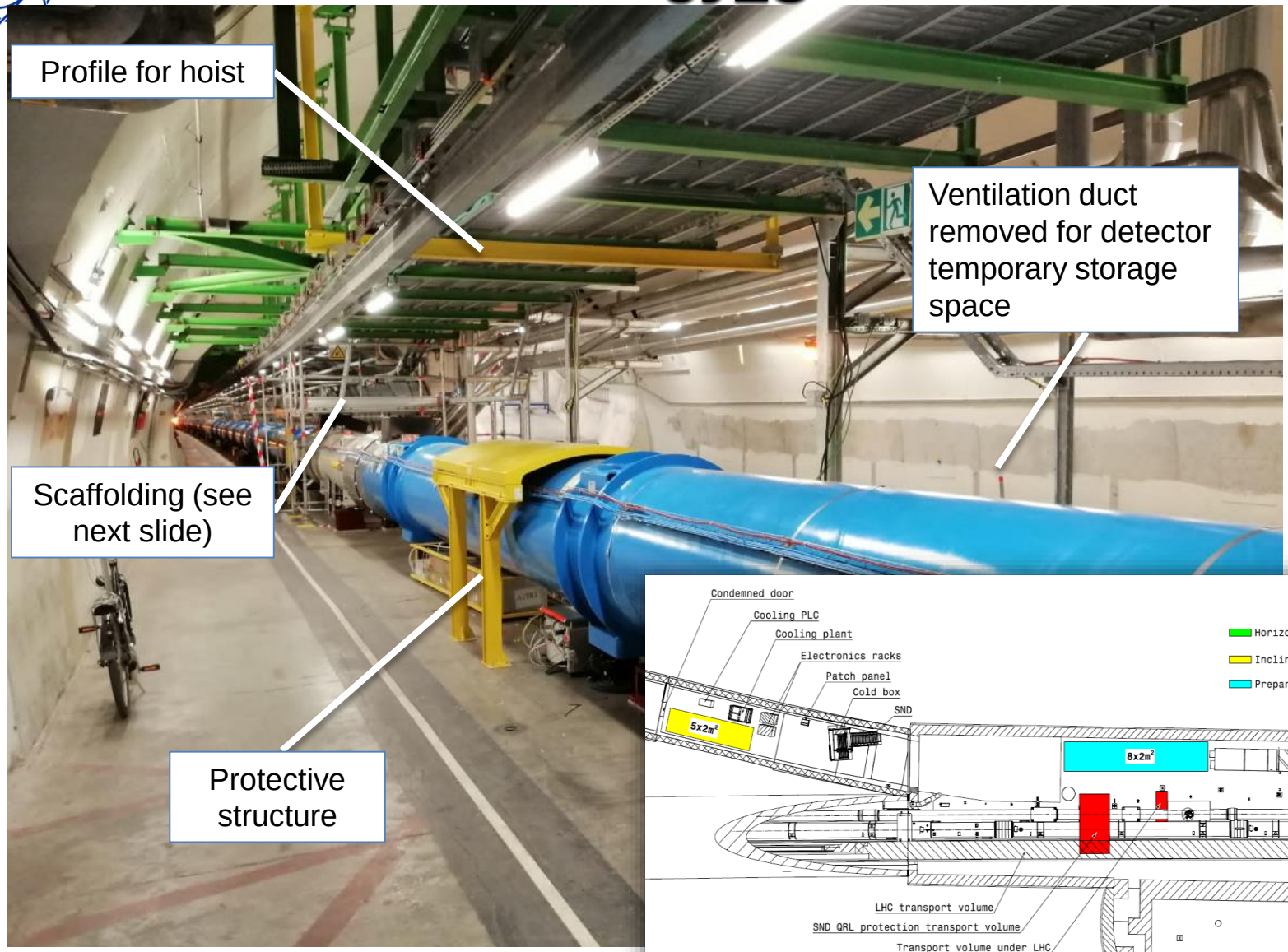
- Emulsion production and wall commissioning
  - Production of the new emulsion batch completed at Slavich
  - Quality check with optical micrsocope at Lebedev performed
  - In delivery from Moscow now
  - Commissioning of wall box with tungsten plates and emulsions foreseen during coming week.

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

DAQ and software

- 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

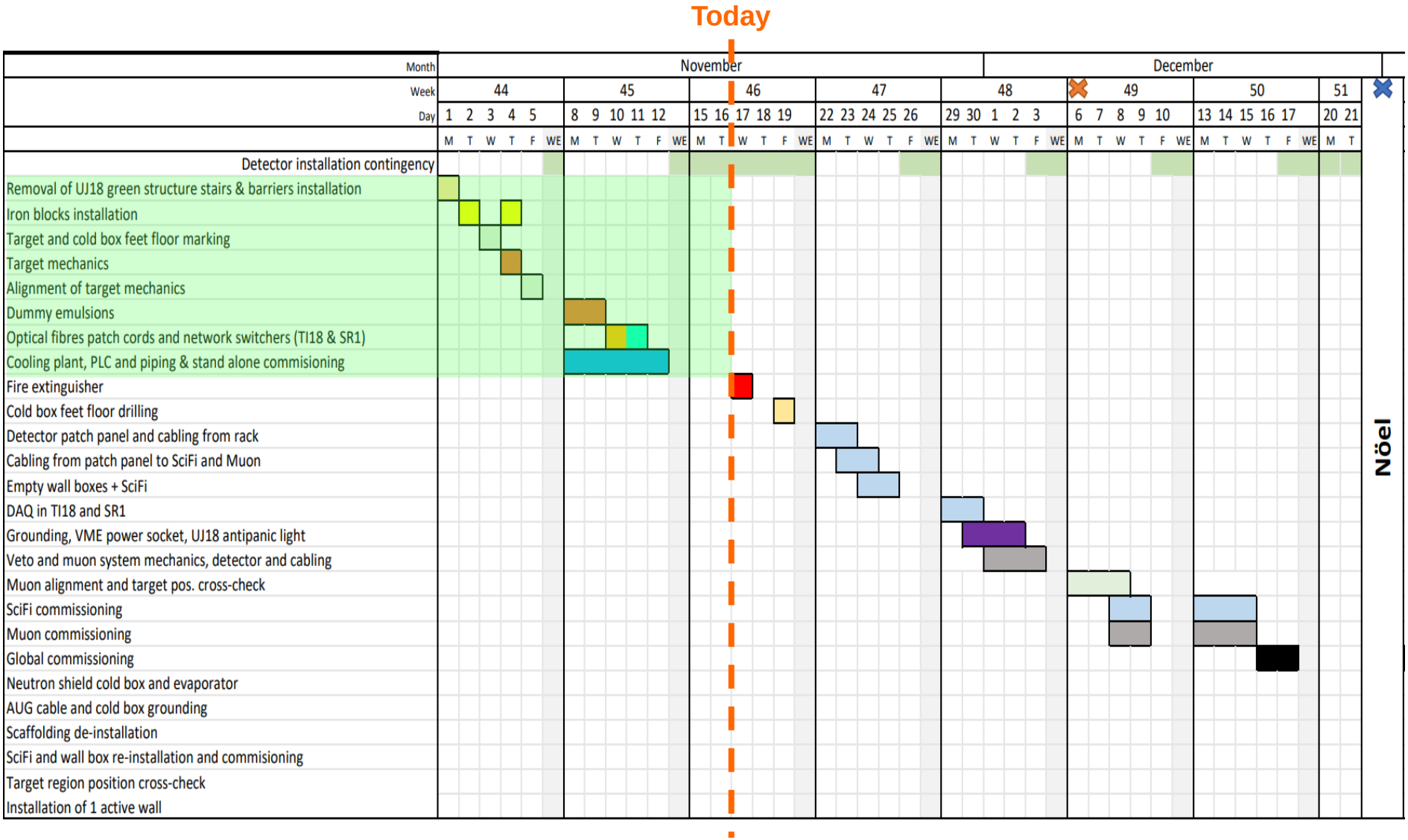
UJ18


Profile for hoist
Ventilation duct removed for detector temporary storage space
Scaffolding (see next slide)
Protective structure

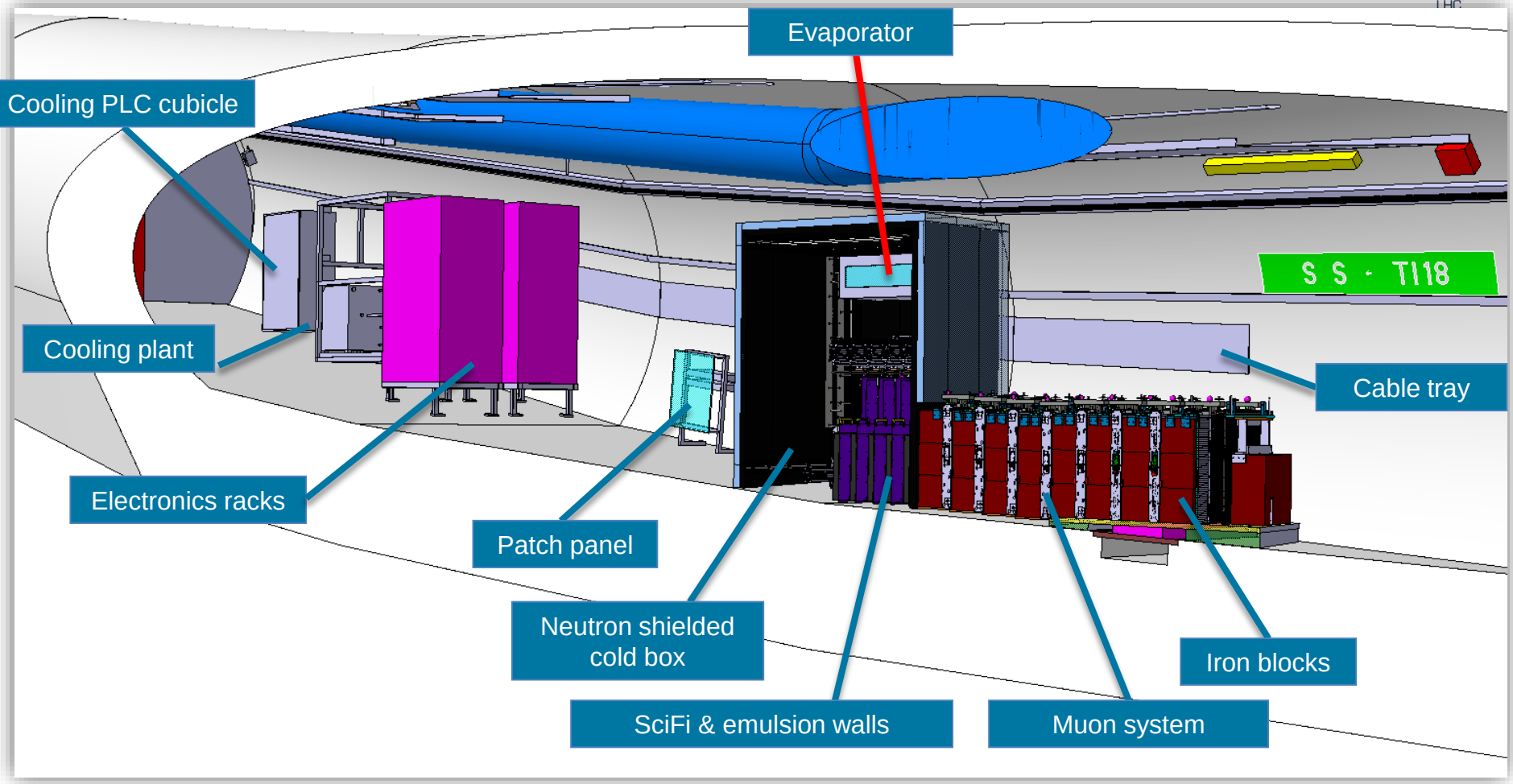
Condemned door
Cooling PLC
Cooling plant
Electronics racks
Patch panel
Cold box
SND
5x2m²
8x2m²
2.5x3.5m²
9x1m²
Horizontal storage area
Inclined storage area
Preparation area
LHC transport volume
SND QRL protection transport volume
Transport volume under LHC
LHC bridge
A-A
1:65

Detector construction schedule

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



Detector installation

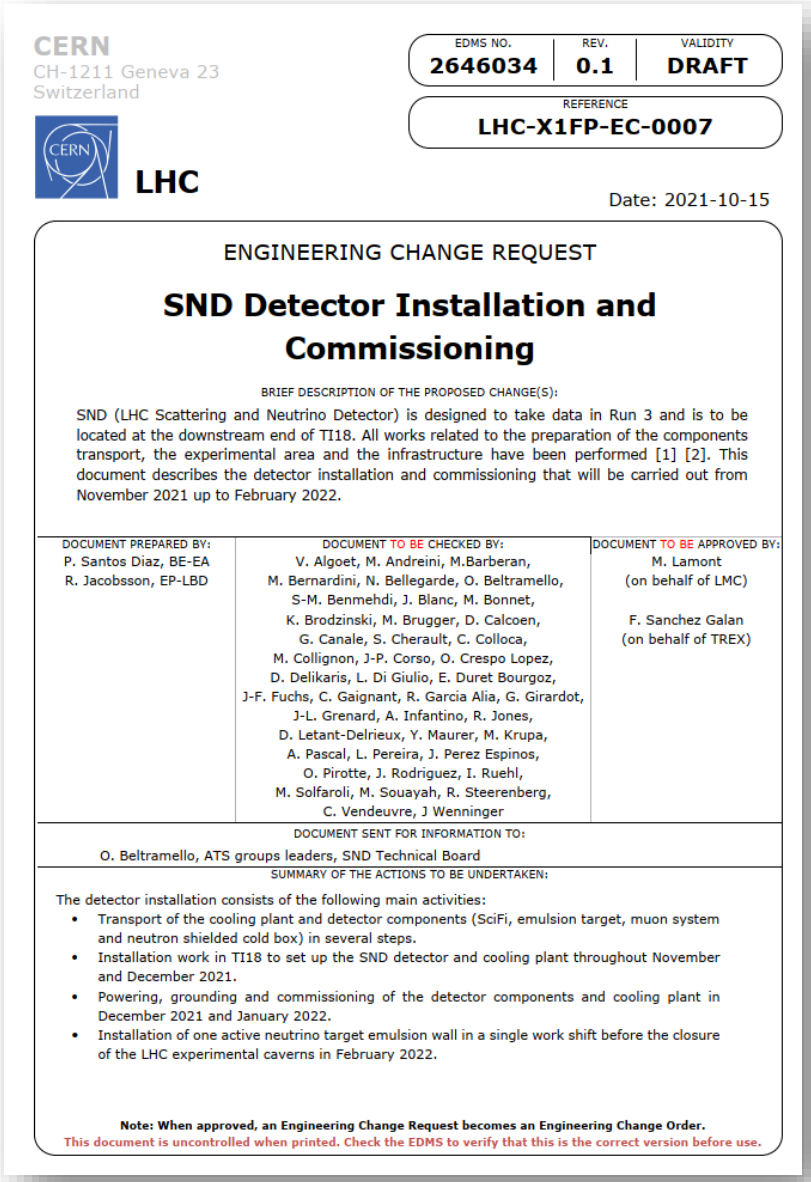


Special thanks to P. Santos Diaz for excellent coordination of installation

Great thanks to J. Brina for support over at IP1

Detector installation

- ECR approved by LMC on November 3



CERN
CH-1211 Geneva 23
Switzerland

LHC

EDMS NO.	REV.	VALIDITY
2646034	0.1	DRAFT

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:	DOCUMENT TO BE CHECKED BY:	DOCUMENT TO BE APPROVED BY:
P. Santos Diaz, BE-EA R. Jacobsson, EP-LBD	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	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:

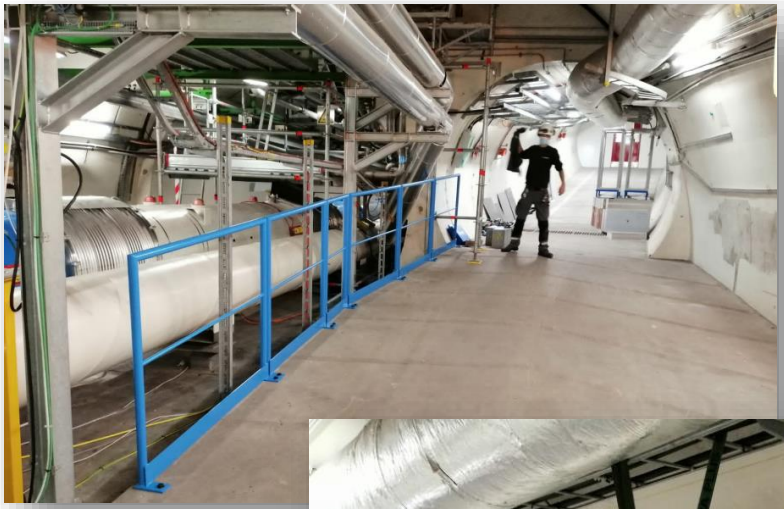
- Transport of the cooling plant and detector components (SciFi, emulsion target, muon system and neutron shielded cold box) in several steps.
- Installation work in TI18 to set up the SND detector and cooling plant throughout November and December 2021.
- Powering, grounding and commissioning of the 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

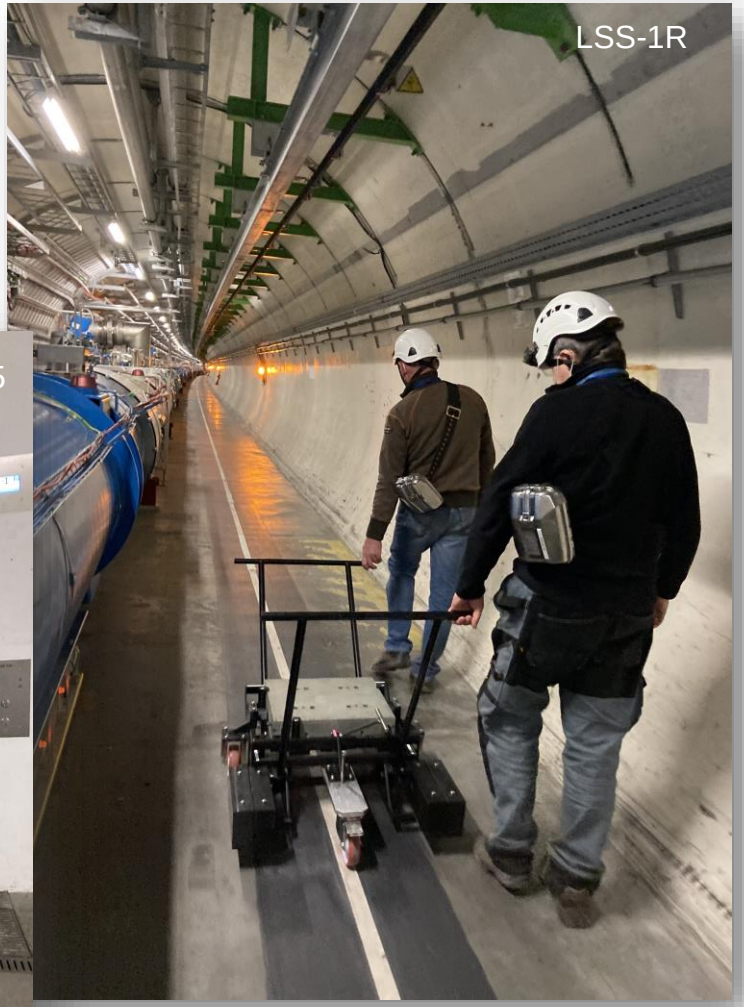


Detector construction

- 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

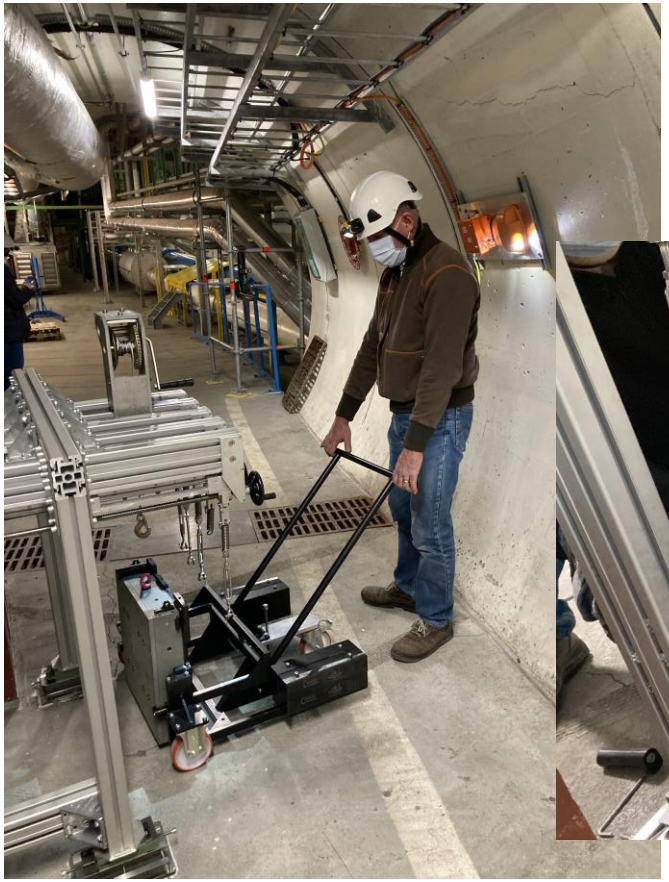


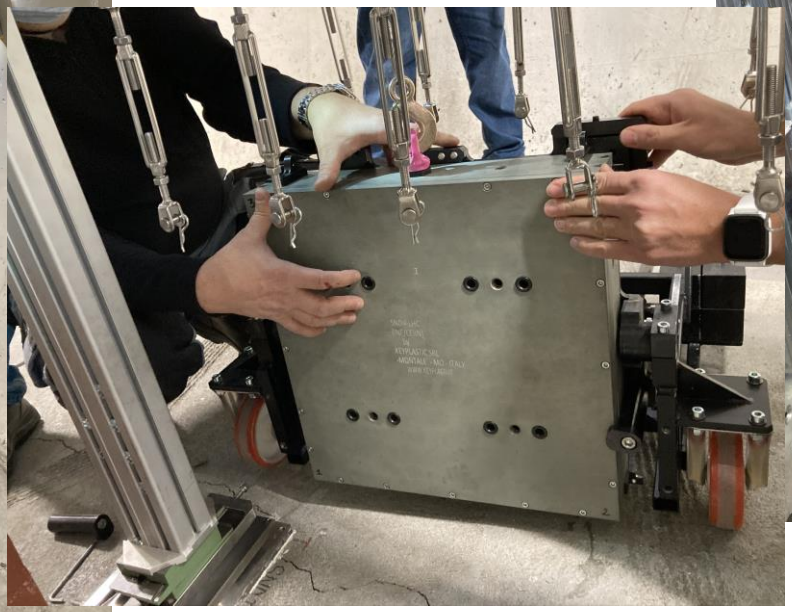
Detector construction

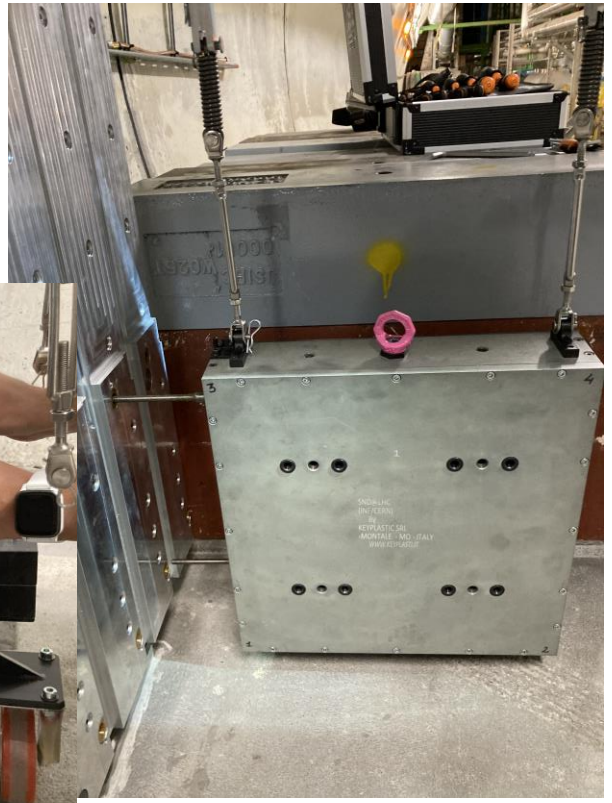
- Week 44-45: Test of emulsion wall trolley and emulsion wall

Detector construction

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





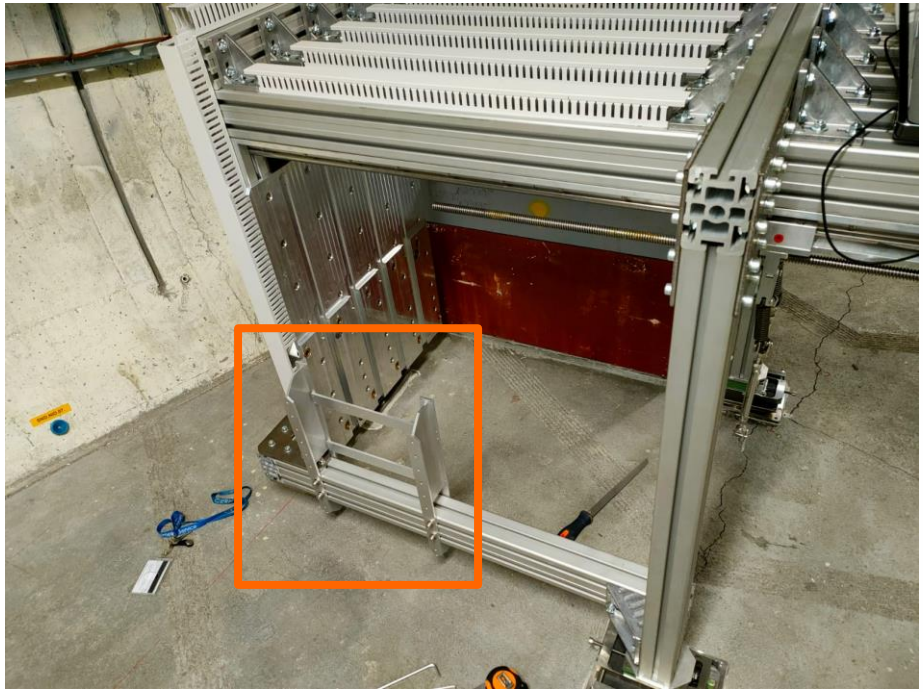


- Wall box production
  - Wall boxes production at the final stage
  - Delivery of first 5 wall boxes at CERN foreseen between Nov 18th-24th
  - Transportation of 5 empty wall boxes to TI18 and installation with SciFi

Detector construction

Week 45:

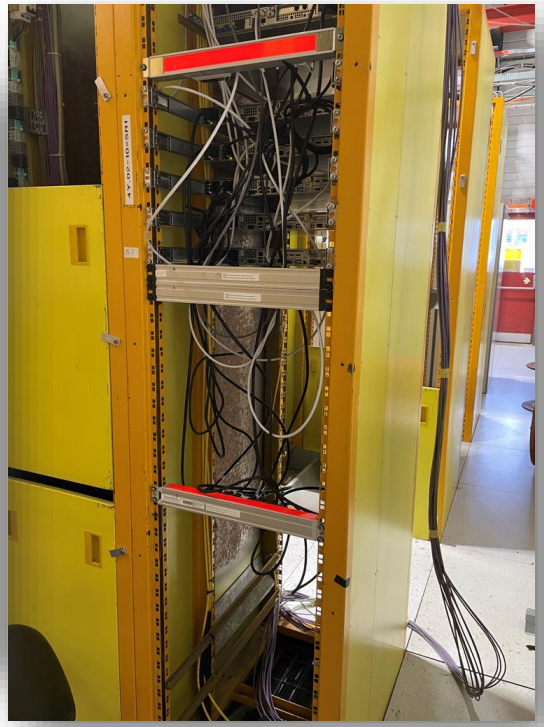
- Test with Veto support mechanics in TI18 on installed target system
  - Some small modifications needed to pieces holding planes together
- Cooling plant installation and stand-alone commissioning



Detector construction

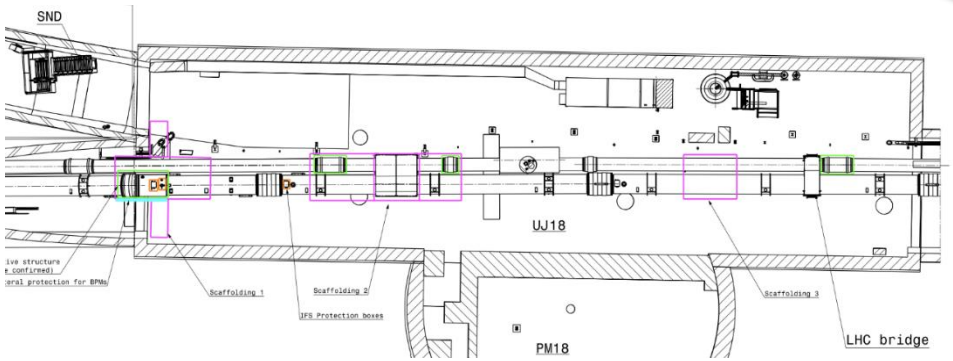
Week 45:

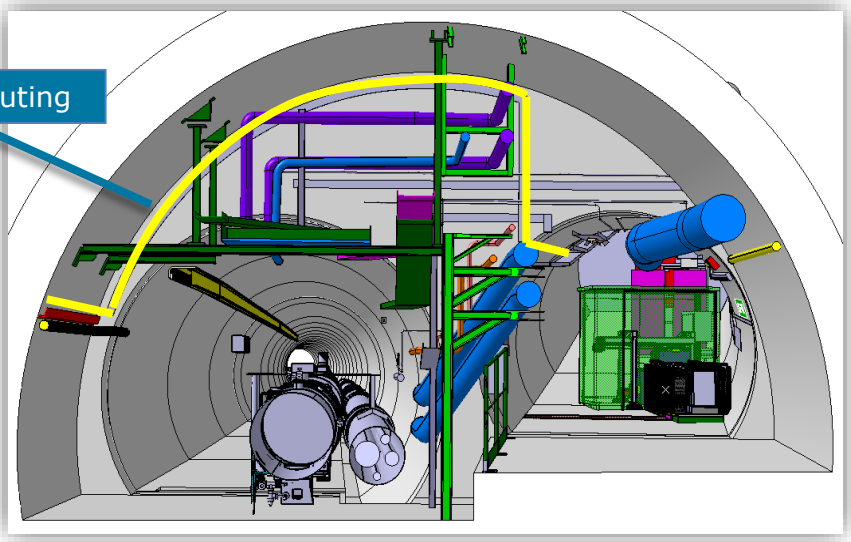
- Cold box feet positioning
- SR1 online system rack for FASER and SND@LHC
  - IT infrastructure foreseen to be operational this week



Outstanding infrastructure item

- 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/neutron shield

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

  - Aluminium profile drawings are ready

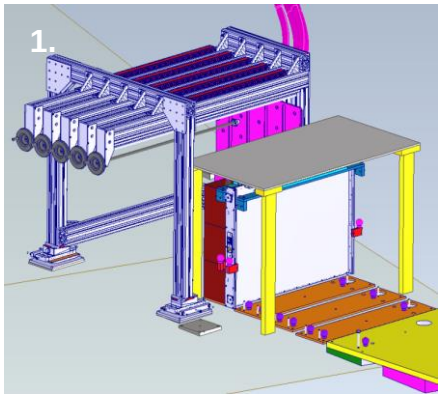
    ➔Machining will start this week

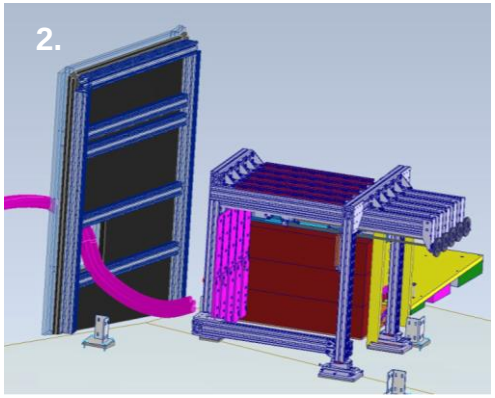
    ➔EHN1 assembly will start next week

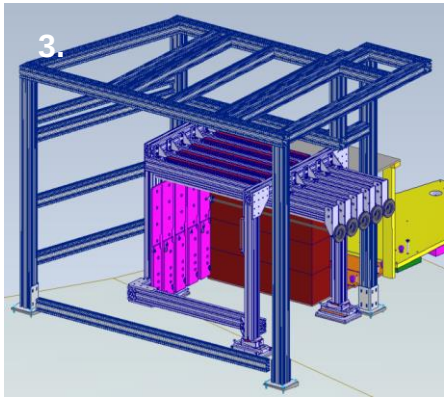
Cold box/neutron shield

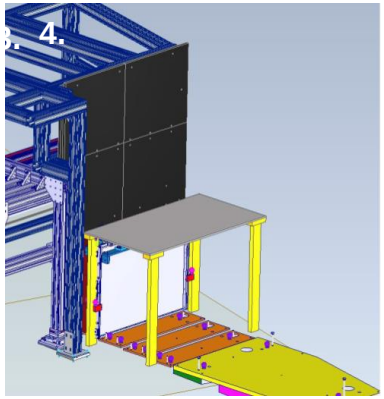
Re-scheduled installation

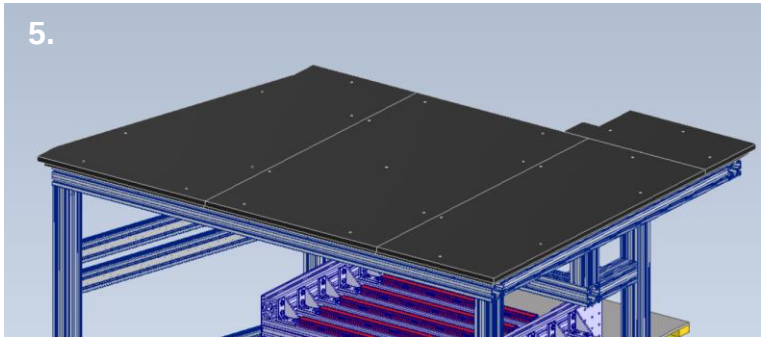
- Initially planned before detector installation and cabling, now after
- Detailed execution planned prepared together with EN-HE-PO and EN-CV and reviewed at Technical Board last week
  - Removal of SciFi and emulsion walls as in an emulsion replacement
  - Protection of cables
  - Protective table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

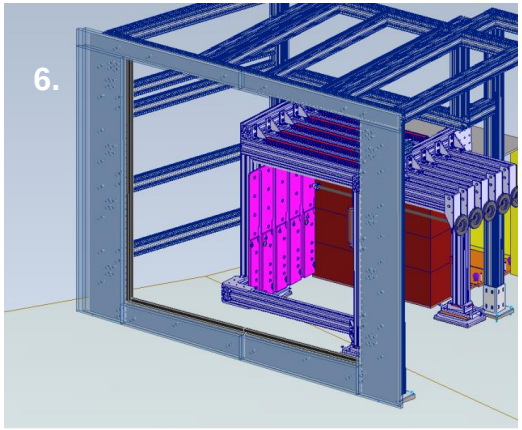


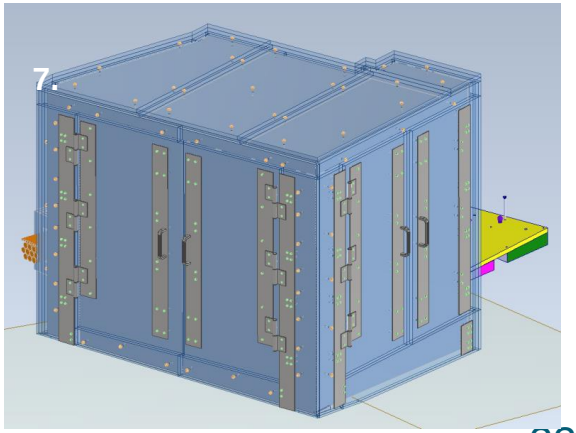






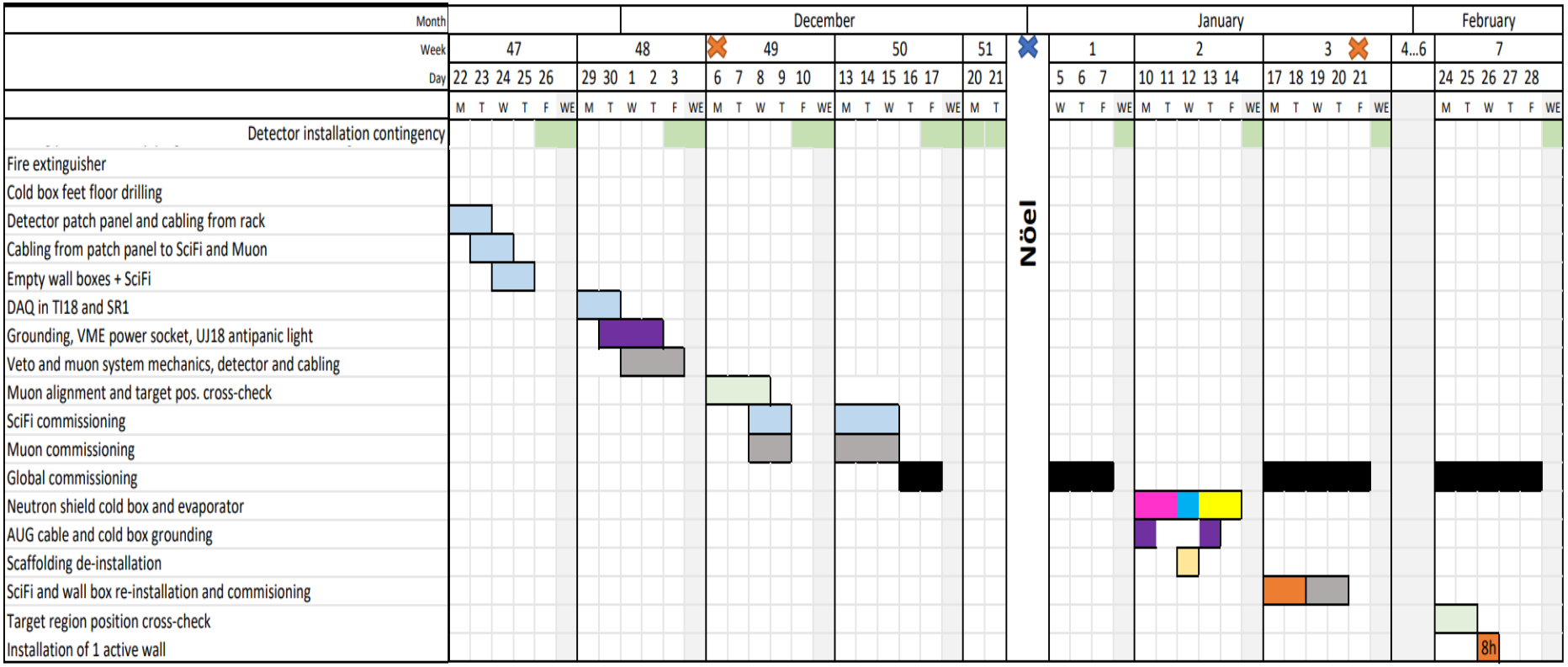






Updated work plan

- 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

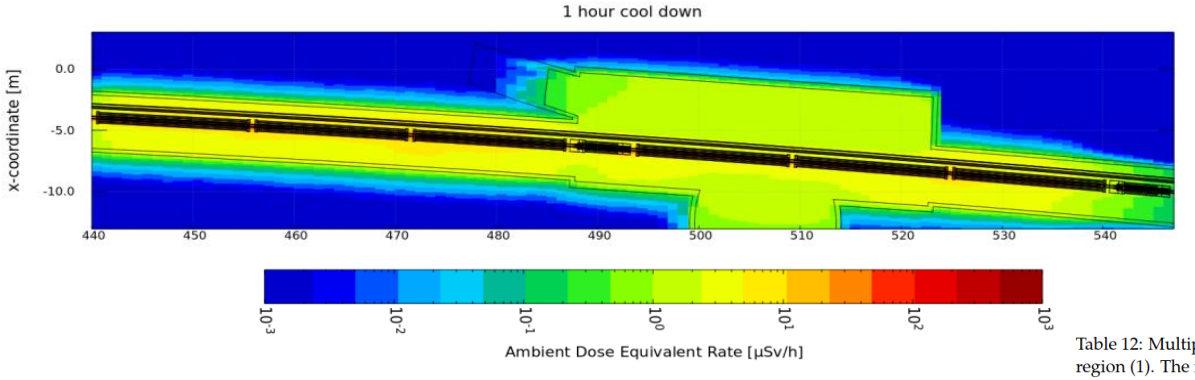
Safety

- 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.Elie, 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

Emulsion wall replacements

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

Residual dose rates in TI18 after 1h of beam stop at nominal Run 3 operation



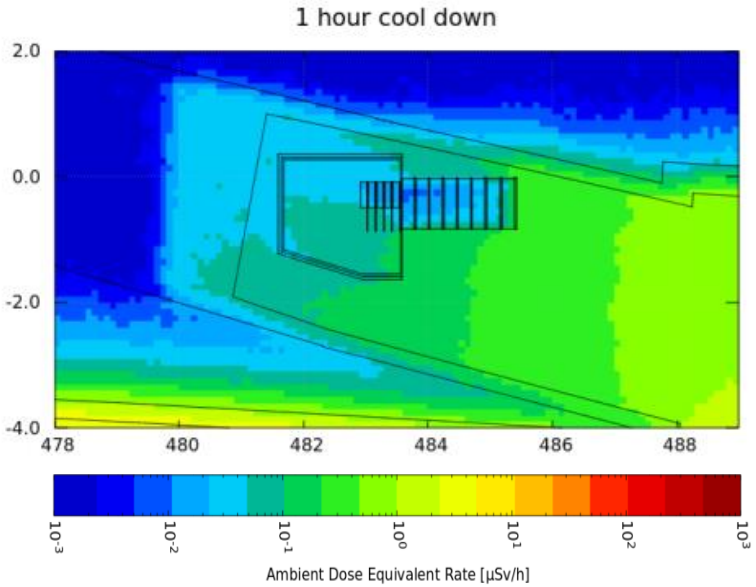


Table 12: Multiple of LL in the emulsion film only, using particle spectra scored in in the emulsion region (1). The material used in ActiWiz is reported in the table.

EMULSION	2 hours			1 day			1 week			2 weeks		
Gas-density H_2/m^3	LL	±	%	LL	±	%	LL	±	%	LL	±	%
1.00E+15	7.83E-03	±	15.66%	6.95E-03	±	17.57%	5.34E-03	±	22.41%	5.12E-03	±	22.93%
2.25E+13	1.76E-04	±	15.66%	1.56E-04	±	17.57%	1.20E-04	±	22.41%	1.15E-04	±	22.93%
2.25E+12	1.96E-05	±	15.66%	1.74E-05	±	17.57%	1.34E-05	±	22.41%	1.28E-05	±	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	±	%	LL	±	%	LL	±	%	LL	±	%
1.00E+15	6.06E-03	±	18.95%	5.41E-03	±	21.12%	4.23E-03	±	26.52%	4.06E-03	±	27.06%
2.25E+13	1.36E-04	±	18.95%	1.22E-04	±	21.12%	9.51E-05	±	26.52%	9.14E-05	±	27.06%
2.25E+12	1.51E-05	±	18.95%	1.35E-05	±	21.12%	1.06E-05	±	26.52%	1.02E-05	±	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	±	%	LL	±	%	LL	±	%	LL	±	%
1.00E+15	1.18E-02	±	3.38%	8.59E-03	±	2.57%	5.29E-03	±	1.49%	4.93E-03	±	1.52%
2.25E+13	2.65E-04	±	3.38%	1.93E-04	±	2.57%	1.19E-04	±	1.49%	1.11E-04	±	1.52%
2.25E+12	2.94E-05	±	3.38%	2.15E-05	±	2.57%	1.32E-05	±	1.49%	1.23E-05	±	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	±	%	LL	±	%	LL	±	%	LL	±	%
1.00E+15	7.64E-03	±	4.05%	5.45E-03	±	3.16%	3.14E-03	±	1.97%	2.92E-03	±	2.02%
2.25E+13	1.72E-04	±	4.05%	1.23E-04	±	3.16%	7.07E-05	±	1.97%	6.58E-05	±	2.02%
2.25E+12	1.91E-05	±	4.05%	1.36E-05	±	3.16%	7.85E-06	±	1.97%	7.31E-06	±	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} H_2 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 FASERν planned as soon as LHC schedule is updated

Emulsion facility (SND specific)

- Development procedure outlined in detail

CHEMICAL TREATMENT PER EACH RUN
- 1200 films (44m^2)
- 4 development processes
- 14 days

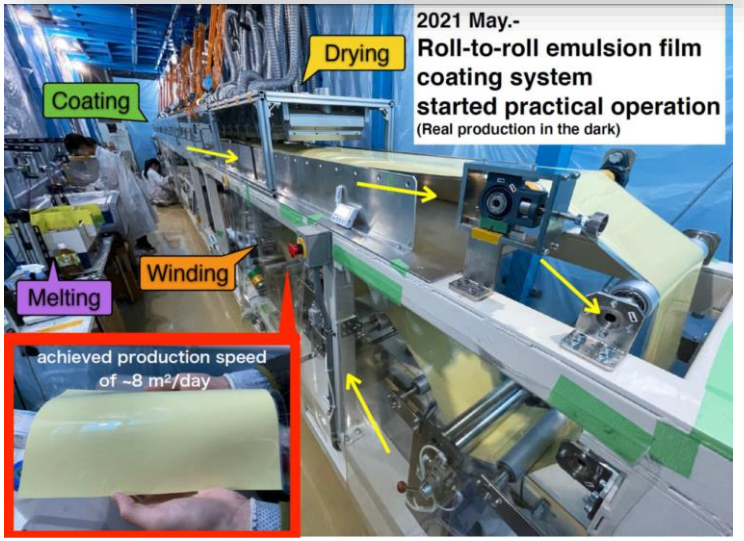
WEEK 1	DAY 1	CHEMICALS PREPARATION
	DAY 2	PROCESS 1: CHAINS 1-6
	DAY 3	PROCESS 1: CHAINS 7-10
	DAY 4	DISPOSAL & CHEMICALS PREPARATION
	DAY 5	PROCESS 2: CHAINS 1-6
	DAY 6	PROCESS 2: CHAINS 7-10
	DAY 7	DISPOSAL & CHEMICALS PREPARATION
WEEK 2	DAY 1	PROCESS 3: CHAINS 1-6
	DAY 2	PROCESS 3: CHAINS 7-10
	DAY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

ONE DEVELOPMENT PROCESS:
- 10 chains x 30 films = 300 fims (11 m^2)
- chains can be parallelised (groups of three)
- Three days/process

Emulsion production and scanning

- Slavich emulsion facility upgrades
  - 2021: 2 rooms with 80 manual pouring tables up to 20x25cm^2
  - 2022: industrial emulsion synthesis and aiming for automated emulsion pouring line in a clean room for 300 m^2/year

- Nagoya emulsion facility upgrades
  - 2021 upgrade: 7-8 m^2 / day
  - 20m^2 (out of 44 or 88 m^2) foreseen to contribute in 2022
  - Committed to contribute with 100m^2 during Run 3



- Scanning microscopes under upgrade Bologna, 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 TI18 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