



High Intensity Upgrade of North Area's ECN3

M. Brugger (BE-EA) & M. Fraser (SY-ABT-BTP) on behalf of the PBC ECN3 Beam Delivery Task Force

Proposed Future Activities in the ECN3 beamline – 113th Plenary ECFA Meeting

CERN, Geneva, Switzerland
17th November 2023

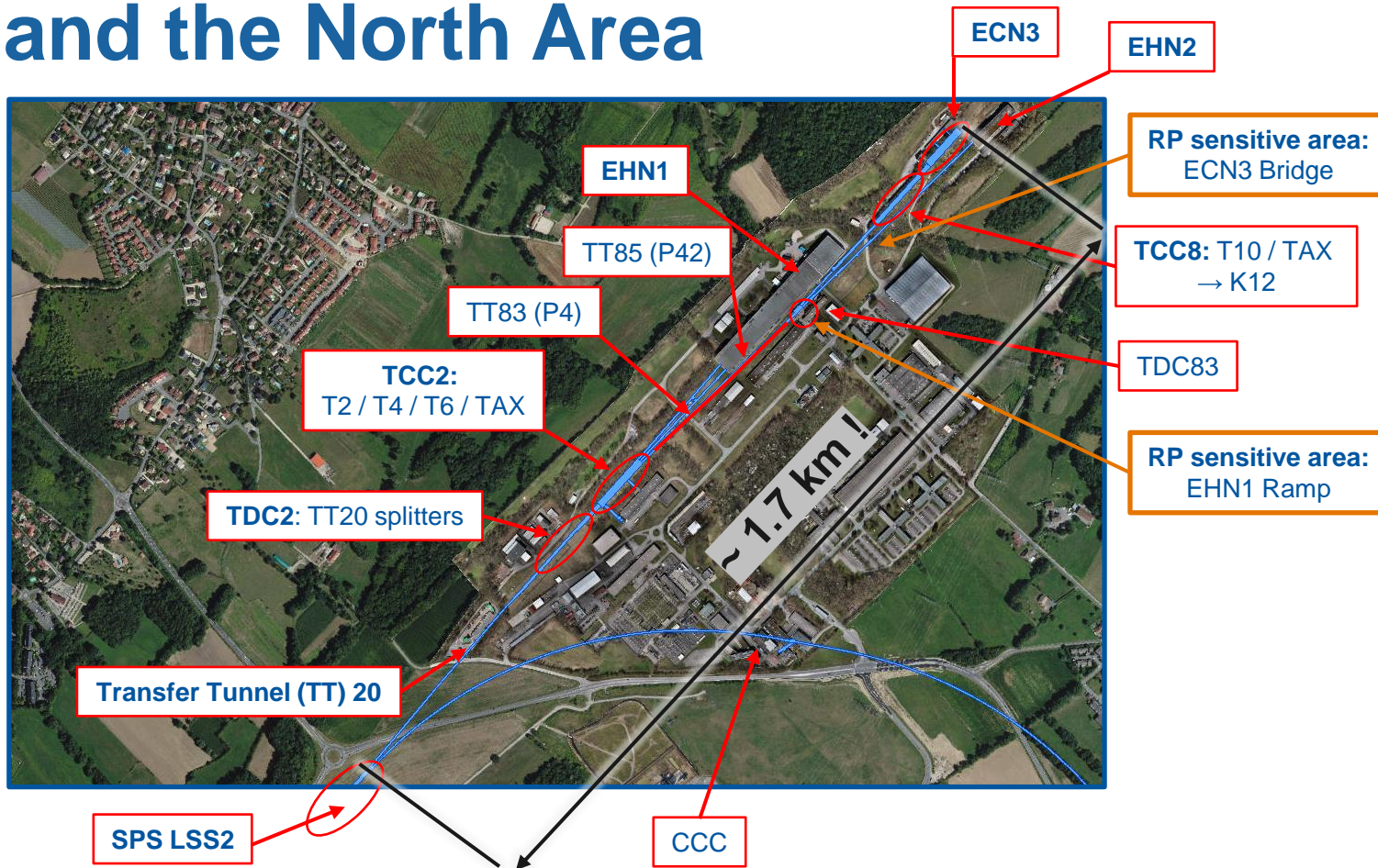
Talk outline

- **PBC Beam Delivery Task Force: mandate and conclusions**
- **Brief summary of relevant technical details**
- **Where are we today?**
- **Implementation schedule**
- **Summary & next steps**

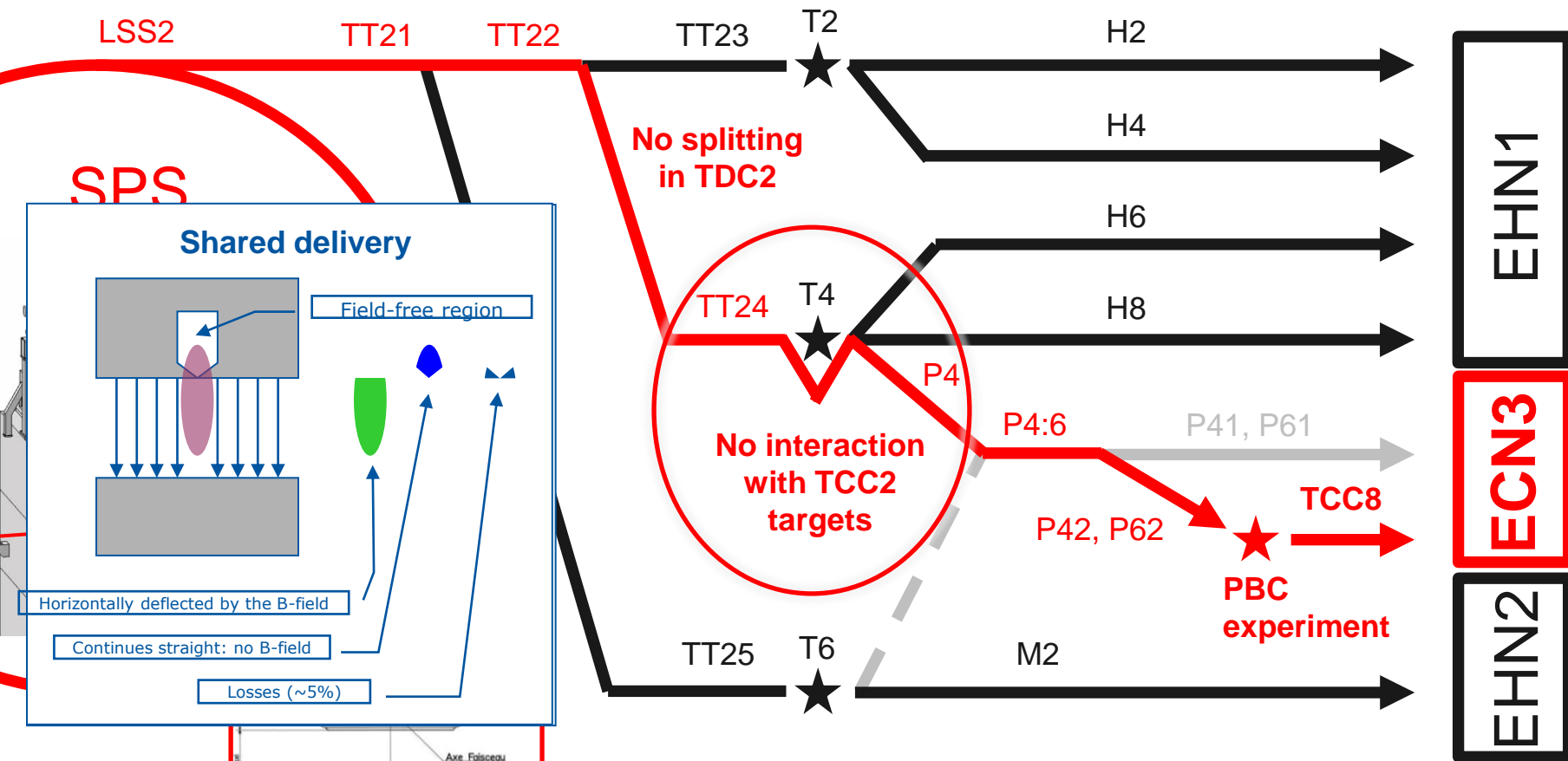
PBC ECN3 Beam Delivery Task Force

- **Mandated to:**
 - Determine **realistic beam line / infrastructure options** for an **intensity increase towards ECN3** for physics exploitation in Run4
- **Beam delivery investigations independent of PBC experiment LOI**
- **Deliverables:**
 - **NA-CONS project Cost, Scope & Schedule Review:** aligned with ECN3 upgrade proposal
 - **PBC ECN3 Beam Delivery Task Force final report:** CERN-PBC-REPORT-2023-001
 - **IEFC (LHC Injectors and Experimental Facilities Committee):** preliminary cost envelope for upgrade endorsed by all CERN groups EDMS #2825627
 - **MTP exercise in 2023:** strong physics motivation from SPSC, clear message of feasibility with cost estimates and a timeline endorsed by the Accelerator & Technology Sector
 - **Input to PBC Study Group report *Post-LS3 Experimental Options in ECN3*** document recently delivered to SPSC CERN-PBC-REPORT-2023-003

ECN3 and the North Area



ECN3 Dedicated Beam Delivery Scenario

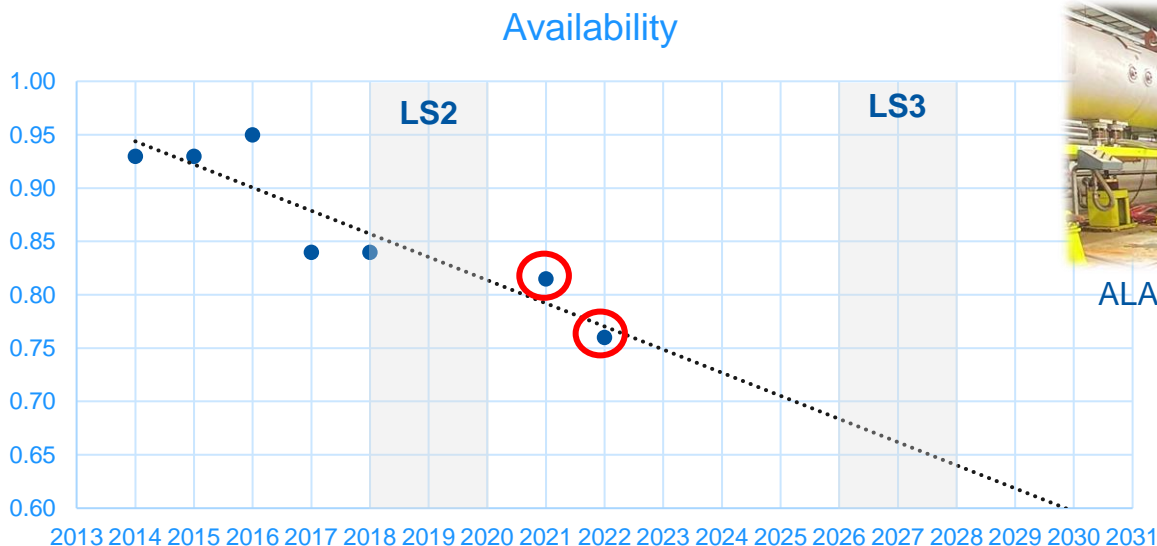


Beam Delivery TF Conclusions

- **A new high intensity facility in ECN3 is feasible for operation in Run4**
 - Over an order of magnitude increase in spill and yearly integrated intensity in ECN3
- **ECN3 upgrade is compatible with the NA-CONSolidation project:**
 - Critical NA-CONS items identified for action in Long Shutdown 3 (NA-CONS Phase 1)
 - NA-CONS project scope and implementation schedule optimised
 - Upgrade work in TCC8/ECN3 can be completed in Run4 without impact on NA operation
- **A dedicated ECN3 cycle is the preferred beam delivery scenario with a vertical magnetic bump to bypass TCC2 target systems:**
 - Satisfies requirements of all PBC LOIs submitted to SPSC without increasing dose rates
 - **Reduces scope of work in TDC2 and TCC2 during LS3:** NA ready for start-up post-LS3
- **Cost & resource estimate (inc. M4P) ~ 64 MCHF from today to 2031:**
 - 14 MCHF for high intensity beam delivery to ECN3
 - 50 MCHF for TCC8/ECN3 facility with peak spending expected 2028 - 2031

Critical NA-CONS project items in LS3

- The North Area and future upgrade plans depend on the reliability and availability of the aged equipment and infrastructure in TDC2 and TCC2:
 - A prioritized list of critical items based on recent operational experience have been strongly recommended for consolidation in LS3 to secure the reliability of a new facility in ECN3



ALARA improvements,
critical spares

Leaks: water, vacuum,
cabling/piping rerouting



Proton sharing to ECN3

• Assumptions:

- 80% availability, realistic SC & SPS RMS power limits
- Proton sharing computed to max. TCC2 POT: SFTPRO with 4.2×10^{13} ppp and with 4.8 s FT

• Dedicated ECN3 mode:

- **POT/y compatible with all PBC LOIs:** for both short and long spills (1.2 s & 4.8 s FT cycles)

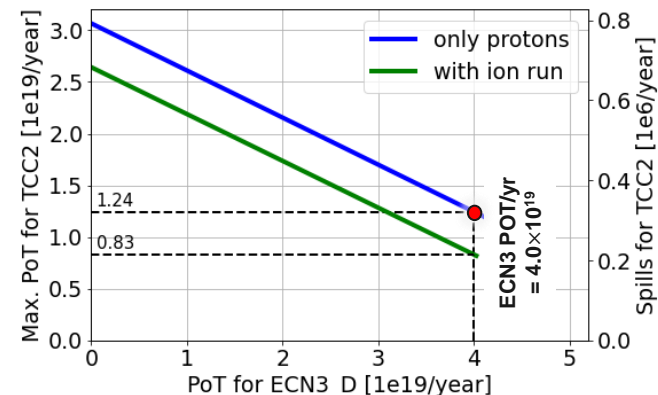
• Shared ECN3 mode:

- Assuming TCC2 – TCC8 transmission of 75 – 92%
- $1.6 - 2.1 \times 10^{13}$ ppp on T4 target needed to deliver requested 1.2×10^{19} POT to ECN3 (without ion run)
- **Pushing the limits existing TCC2 HW and RP constraints**

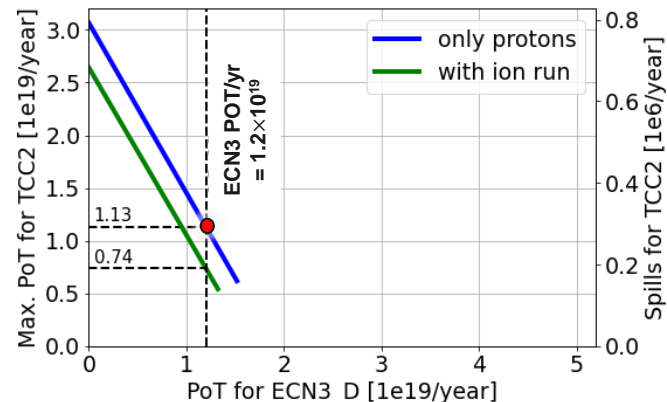
• Impact on other NA users:

- Longer 9.6 s FT are being investigated for TCC2 to help rate limited NA users whilst maximising POT

1.2 s FT dedicated ECN3 cycles:



4.8 s FT dedicated ECN3 cycles:



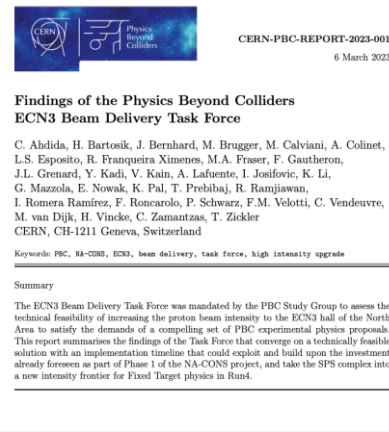
Technical challenges

Beam Delivery

- Extraction beam loss, TT20 and P42 transfer line optics
- TCC2 T4 target vertical by-pass: installed & tested in 2023
- TCC2 → P42 transmission
- RP limitations in P42 from TCC2 to TCC8
- Magnet and power converters
- Beam intercepting devices: TDC2 (collimator TCSC), TCC2 (T4 / TAX)

TCC8/ECN3:

- Requirements for new target system and experimental infrastructure, and alignment with NACONS project scope and schedule



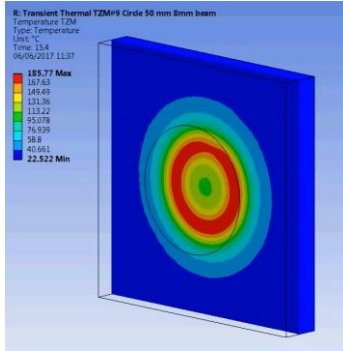
Key technical findings

- **Upgrades of NA primary transfer lines required:**
 - Additional **beam instrumentation**, T4 target bypass (**vertical bump**), **aperture bottlenecks removed**, **P42 realignment**, **P42 transfer line dump**
 - **Beam transfer of high intensity will be compatible with RP requirements:** areas with insufficient shielding identified and compatible solutions proposed
 - **Proton flux calibration of beam instrumentation** for direct transmission measurements
 - **Magnetic measurements** of spare quadrupoles to improve transfer line optics model
- **New target complex in TCC8 is a requirement for all PBC LOIs:**
 - High-power target system (> 100 kW average beam power) respecting today's RP legislation & best practices
- **Decoupling of TCC8/ECN3 from the rest of the North Area is possible:**
 - Allows implementation work to carry on in parallel to NA operation of EHN1/EHN2 after LS3, e.g. for test beams etc.
- **Limited civil engineering required in TCC8 and ECN3**

Target Complex in TCC8

- Both BDF/SHiP & HIKE/SHADOWS require high power target systems to be installed in the TCC8 area impacting technical infrastructure
- Remote handling is an intrinsic part of design and construction process
- Maintenance scenarios and unforeseen operations anticipated as much as possible: limited team for the maintenance of all CERN targets and beam dump areas (CERN objective: max individual dose 3 mSv/y)
- Ventilation and dehumidification systems are mandatory to prevent corrosion (which could end to contamination and operational problems)
- Activation of soil and groundwater contamination must be well controlled and should minimise environmental impact: geohydrological survey underway
- **A new Target Complex is the dominant cost of the HI-ECN3 upgrade**

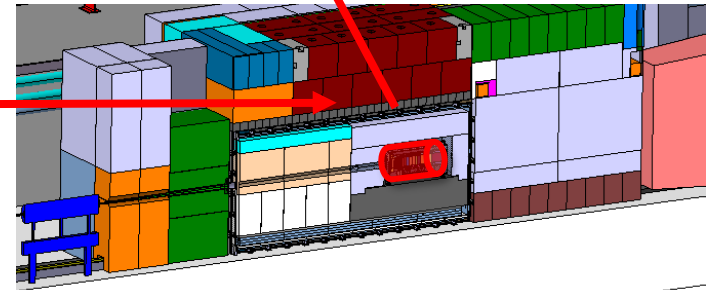
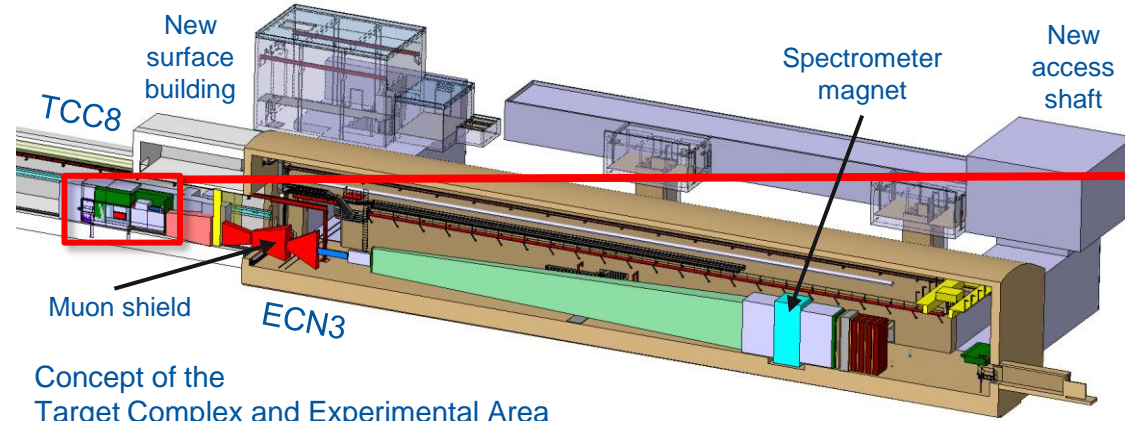
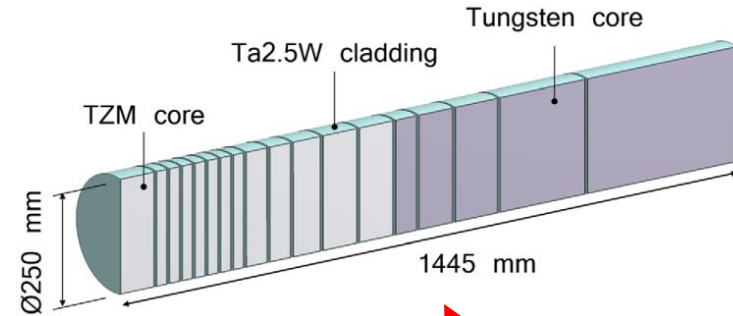
Target Complex: BDF/SHiP



BDF Target

- 13x claddded TZM Blocks
- 5x claddded W Blocks

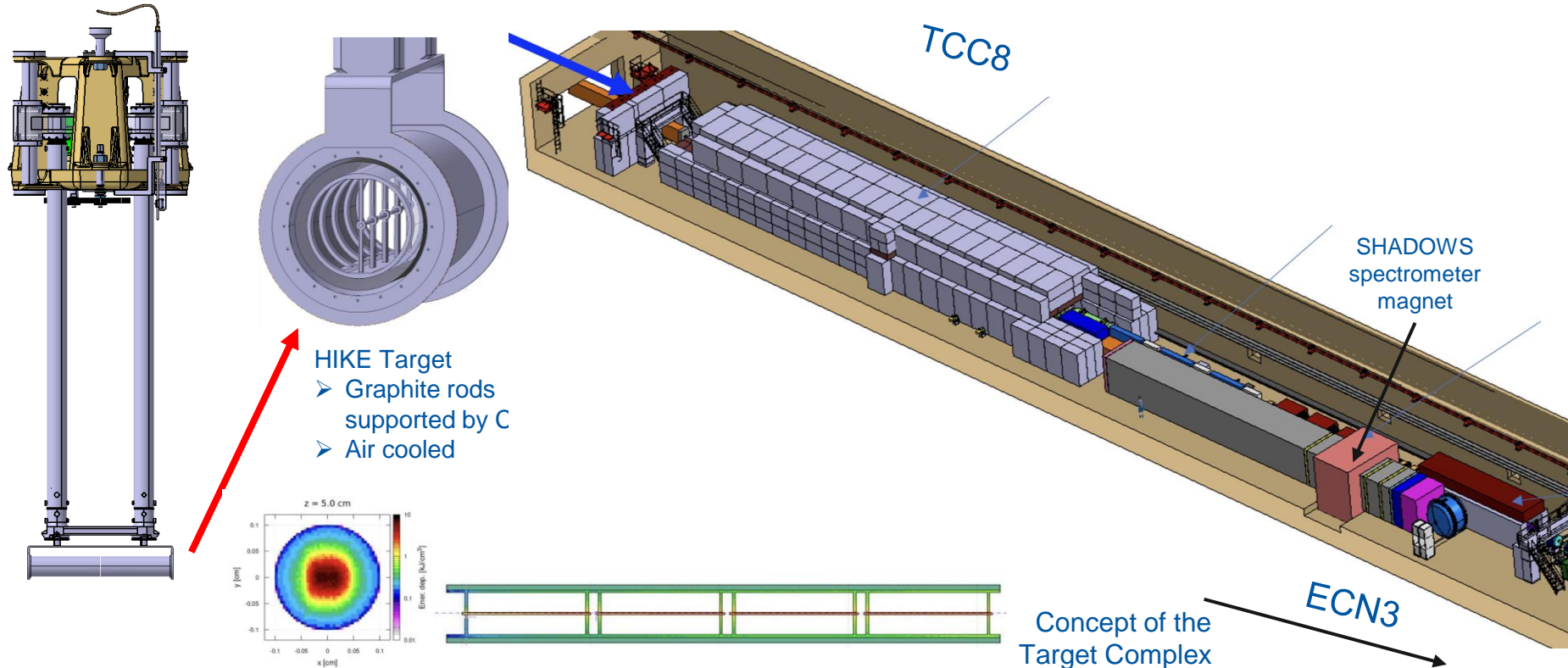
Beam “diluted” by magnets on the target



Vacuum vessel with longitudinal target handling with trolley

Concept of the Target Complex and Experimental Area

Target Complex: HIKE/SHADOWS

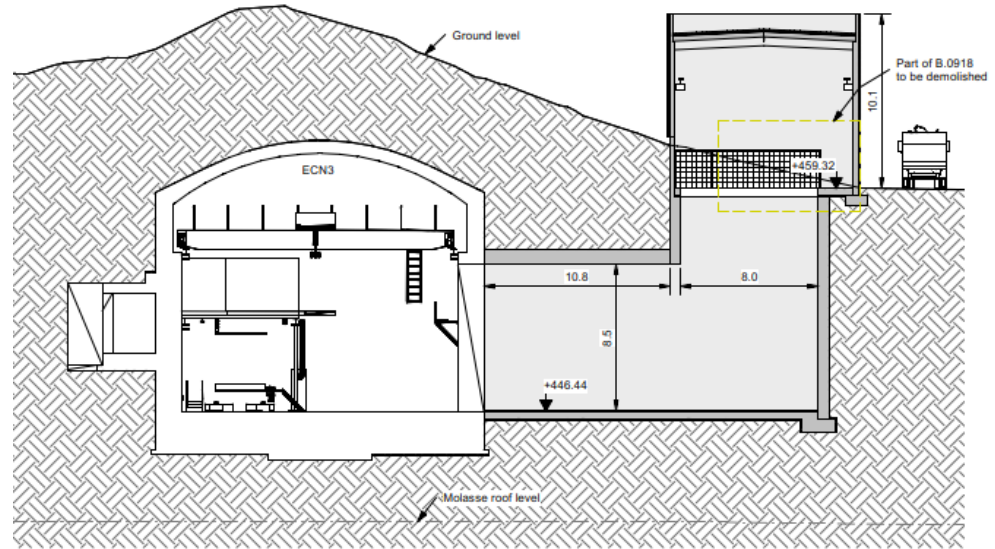
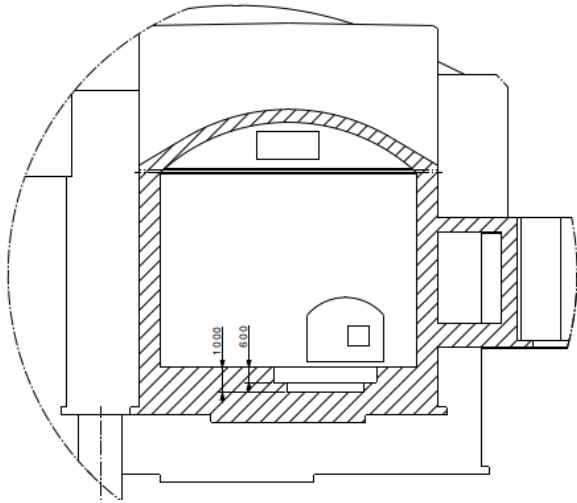


Civil Engineering Study



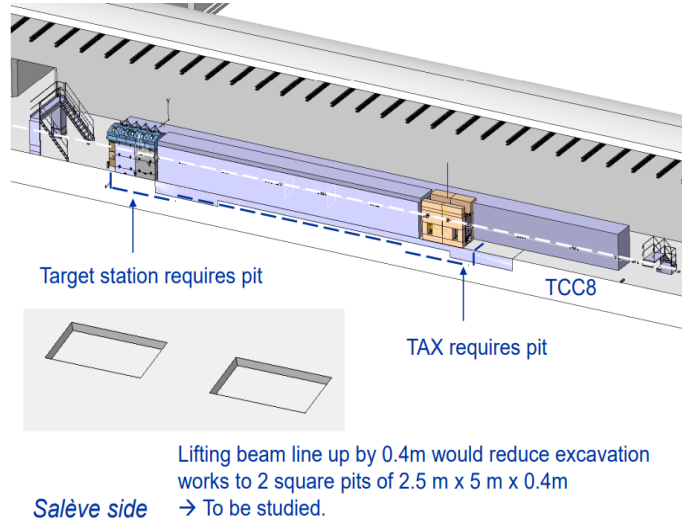
- Study carried out by an external consultant:
- Objective of the study:
 - Evaluate the feasibility of the proposed design and to assess the impact on the existing infrastructure
 - Identify and evaluate design and construction options
 - Create a preliminary cost estimate
- Synaxis AG, “CERN Preveessin Beam Dump Facility ECN3 & TCC8 - Report of Preliminary Study,” Lausanne, Switzerland, Tech. Rep. EDMS #2815529, 2023. [Online]. Available: <https://edms.cern.ch/document/2815529>

Civil Engineering Study: BDF/SHiP

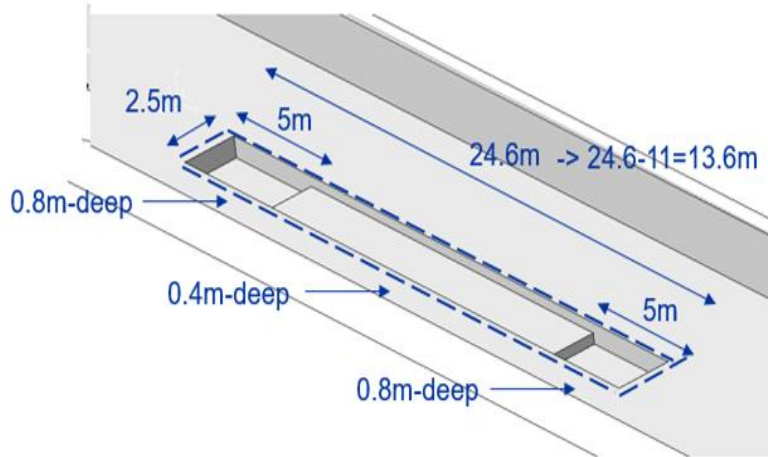


- Civil Engineering works in TCC8 (excavation and creation of the confined area) = 1.2 MCHF
- New shaft and access building = 4.5 MCHF
- Service Building for Target Complex (500 m²) = 3.1 MCHF

Civil Engineering Study: HIKE/SHADOWS



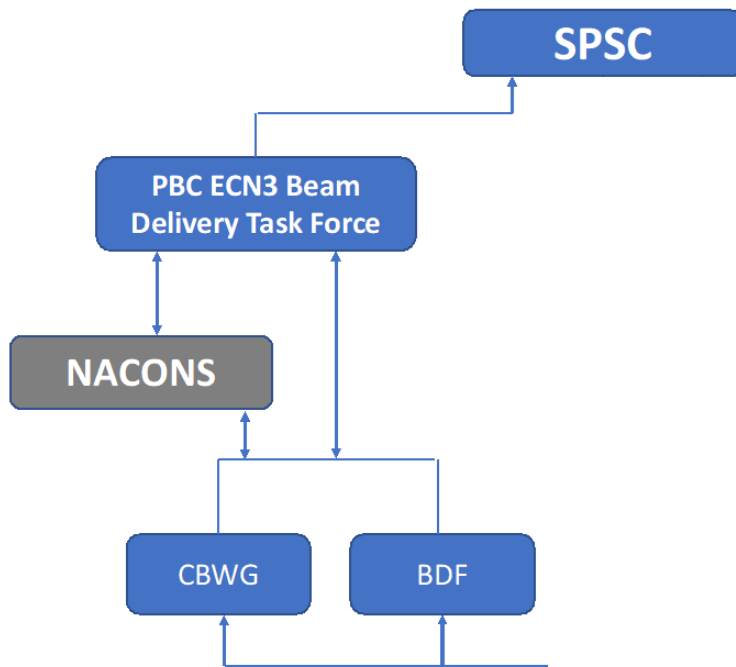
Potential excavation works in TCC8 cavern



- Civil Engineering works in TCC8 (excavation and creation of the confined area) = 1.2 MCHF
- Dimension of the pit 2.8m x 12m x 1m deep, under SHADOWS detector = 0.6 MCHF
- Service Building for Target Complex (500 m²) = 3.1 MCHF

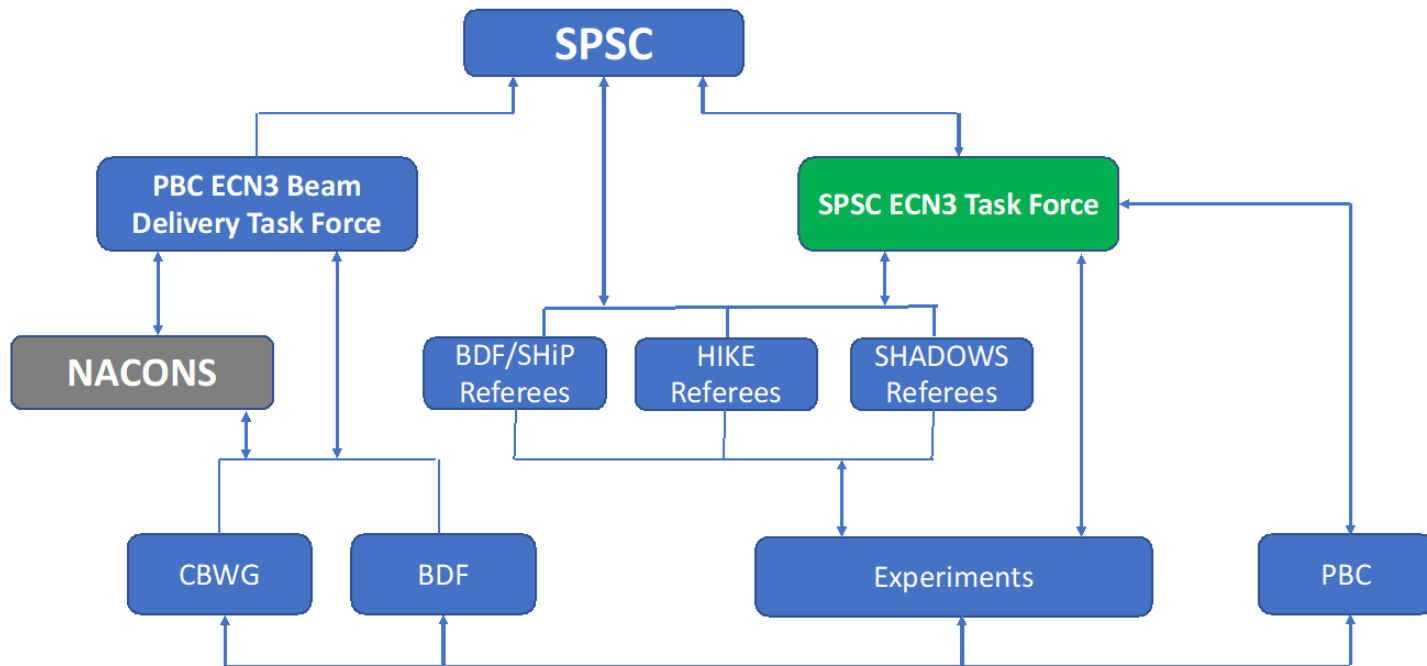
Where are we today? (i)

Research Board (March 2023)



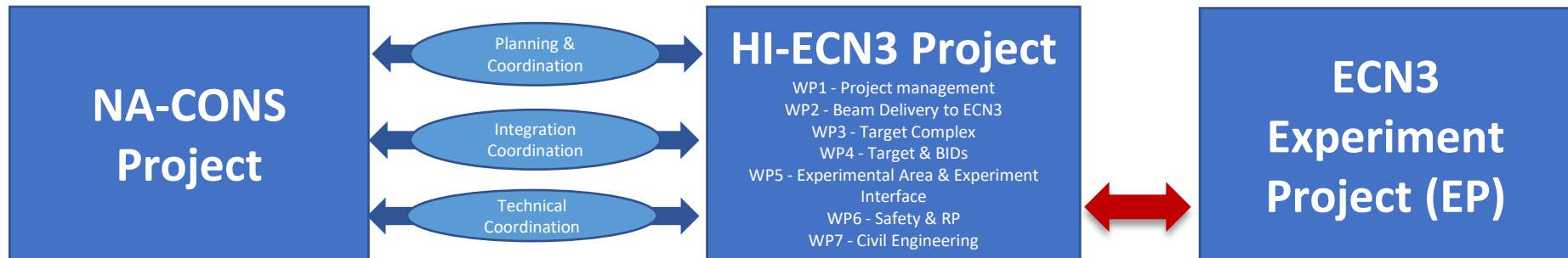
Where are we today? (ii)

Research Board (December 2023)



Where are we today? (iii)

- We came out of the MTP 2023 exercise in a position to move the study forward into a TDR phase:
 - Decision of the DG [11/04/2023]: *'Allocate 2.5 MCHF for 2023 and 2024 for the preliminary works, waiting for the project to be officially approved.'*
 - TDR budget approved by the CERN Council at the June 2023 meeting
- Transitioning to a project **ECN3 High Intensity Study (TDR phase)**:
 - Nominated as PL (EDMS #2921486) in August and have been requested to setup the project structure should the project be approved:



Implementation schedule (i)

Length of LS3 being discussed:
Critical to have test beam time for
experiment detector R&D

Research Board Experiment to be Approved (December 2023)

ECN3 High Intensity - Indicative Schedule & Constraints														
Machine/Facility/Experiments	Comments	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
LHC	priority on available resources esp. (EL, CV, HE, BI, STI, etc.)				LS3			Commissioning				LS4		
SPS					LS3							LS4		
EHN1+2 NA-CONS (baseline)	BA80 and general Infr. Focus	Preparation & YETS			LS3 Deployment			Commissioning + Operation				LS4		
ECN3 HI TT20/TCC2/TDC2/TTs	critical equipment & services (limited work in TCC2)	Implementation Phase			Installation (LS3)			Commissioning				LS4		
ECN3 HI TCC8 Target Complex	HL-LHC + NA-CONS overlapping resources/schedule	Engineering Design Phase			Final Opt. & PRR	Preparation, Dismantling	Procurement / Assembly	Procurement/ Installation	Installation/ Commissioning			LS4		
HIKE Experiment	Modifications and upgrades of detectors as required	Proposal	TDR	PRR	Upgrades and Installation			Detector Commissioning		Det./Beam Comm. (tbc)		LS4		
SHIP Experiment	Approval on critical path for TDR phase to be launched/financed	Proposal	TDR	TDR	TDR/PRR	Production / ECN3 Dismantling	Construction	Installation/Commissioning				LS4		
SHADOWS Experiment		Proposal	TDR	TDR	PRR	Production/ Area preparation	Construction /Installation	Installation/Commissioning				LS4		

- **2023 - 2025:** HI beam delivery engineering phase approved
- **2023 - 2028:** NA-CONS LS3 related preparation and implementation phase
- **2024 - 2031:** TCC8/ECN3 facility-specific TDR & implementation phase

Summary and next steps

- **HI-ECN3 Study Project to be launched imminently with a demanding schedule, but profiting with synergy to NA-CONS project**
- **An experiment-specific decision is needed from the CERN Research Board before the end of 2023 to start experiment-specific TDR in 2024**
- **TDR phase for TCC8/ECN3 facility to work in close synergy with the experiment, aiming for completion by end 2025**
- **ATS counts on a strong collaboration with EP to guarantee we move through the TDR phase of TCC8/ECN3 facility efficiently (& vice versa!)**
- **Attaining SPS North Area test-beam time in 2028 is important**

Acknowledgements

Thanks to everyone who supported the PBC Beam Delivery Task Force team effort, including the equipment and service groups

Scientific Secretary: Rebecca Ramjiawan (PBC Fellow, SY/ABT-BTP)

Core-team representatives:

- **NA-CONS:** Y. Kadi (PL), R. Folch (Engineering), T. Zickler (Technical Systems), F. Gautheron
- **TT20/P42 beam studies:** Y. Dutheil, R. Ramjiawan, F. Velotti (SY/ABT)
- **TCC2/P42 and impact on secondary beam studies:** J. Bernhard, M. van Dijk (BE/EA)
- **BIDs:** M. Calviani, F. Sanchez-Galan, L. Esposito, J-L. Grenard, (SY/STI, BE/EA)
- **Radiation Protection:** C. Ahdida, E. Nowak, H. Vincke (HSE/RP)

Experts:

- G. Arduini (PBC), V. Kain, K. Li (BE/OP), P. Schwarz (TE/MS), F. Roncarolo, C. Zamantzas (EABIWG, SY/BI), H. Bartosik, T. Prebibaj (PBC ACWG, BE/ABP), I. Josifovic (SY/EPC), C. Pasquino (TE/VSC), L. Krzempek, (BE/EA), P. Bestmann & C. Vendeuvre (BE/GM), D. Lafarge (EN/HE), F. Galleazzi + M. Lazzaroni (EN/ACE), A. Colinet, I. Romera Ramirez (TE/MPE), Y. Body, S. Deleval (EN/CV), E. Cano Gonzalez (EN/EL), K. Pal (SCE/DOD-FS), R. Franquiera Ximenes, G. Mazzola, A. Romero, C. Sharp, N. Solieri (SY/STI)

Thank you for your attention

Questions...?



Mandate as PL...



Mandate

Date: 31 July 2023

To: Matthew Fraser, SY-ABT

From: Mike Lamont, Director for Accelerators and Technology

CC: ATS Management Board and deputies, ATS Group Leaders, Manfred Kramer, Mar Capeans

EDMS ref.: 2921486

Subject: **Nomination as Project Leader of ECN3 High Intensity Study**

Dear Matthew,

I am happy to nominate you as Project Leader of the ECN3 High Intensity Study. This following recent approval of the study by Council. Please find below your mandate.

Thank you very much for all the work that you have already performed to facilitate approval of the study and for accepting this important role.

On behalf of the ATS management team, I would like to wish you every success going forward.

With best regards,

Mike

Mike

Mandate for Project Leader of ECN3 High Intensity Study

The proposed ECN3 High Intensity (HI) facility will provide unique capabilities for delivering high-intensity, high energy beam for fixed target physics. The funding for the initial Technical Design Report (TDR) phase of the beam delivery and facility study was approved by Council in September 2023 Council following recommendation by the Research Board. A decision on the specific experimental implementation and overall approval is expected in late 2023 or early 2024.

The overall feasibility has already been investigated and documented by the ECN3 Task Force, with the following working assumptions:

- ECN3 beam delivery via T4 target with magnetic bump bypass
- Dedicated HI mode with no splitting in TDC2 or impact on TCC2 targets
- Readiness in Run 4 with no impact on EHN1 and EHN2 NA operation post-LS3
- New target complex for TCC8 using ALARA principles for operation, maintenance and decommissioning
- Use of new target complex service building for additional power converters (instead of BA82)
- Recovering iron shielding blocks from CNGS hadron absorber, TT7 neutrino facility dump and Opera

The formation of an HI-ECN3 Project Team to deliver the facility TDR is requested by the ATS Director. The Project Leader's mandate is to define and implement the project structure and team, finalise the technical studies and present the coherent upgrade proposal (including timeline and resource and budget needs) in the form of the TDR.

It is important to note the close links to NACONS, and the imperative to minimise the extra work for the technical teams - this needs to be a guiding principle of the organisation, including the common coordination with NACONS.

The following items will form the basis for the deliverables for the TDR phase, which for the ATS aspects needs to be completed by the beginning of LS3. This list includes a number of decisions already needed in 2023.

- Technical specifications and engineering studies of equipment and infrastructure systems for high intensity beam delivery
- Agreement with CERN groups to recruit GRADs by November 2023, along with required STAFF resources for their supervision
- Manage HW expenditure linked to some aspects of beam delivery and infrastructure in parallel to TDR phase
- Define the detailed implementation schedule
- Construct efficient project interface and workflow to NACONS
- Finalise cost and resource estimates and profiles (update of EDMS #2825627)
- Perform ECN3 hydrological study
- Proposal for ECN3 bridge and EHN1 ramp RP shielding
- Oversee 2023 and 2024 beam tests

Mandate as PL...

Mandate for Project Leader of ECN3 High Intensity Study

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- **Form a Project Team for HI-ECN3:**
 - Project structure and team to be created with synergy to NA-CONS at its heart
 - Discussions started with CERN groups
 - Management have reacted positively and supportively, with resources starting to materialise
 - EN-ACE will support Coordination for NA-CONS & HI-ECN3
- **ECN3 Beam Delivery Task Force:**
 - Continues in earnest until project structure is established
- **Deliver a TDR by end 2025:**
 - Timeline with resource and budget needs
 - We are already on the critical path to launch civil engineering in 2027 (~ 2 years of civil works)
- **Asked to report back to ATSMB on 13th October 2023**
 - Aim to *kick-off* the project shortly afterwards