TDR threads & project timeline for the Target WP, WP3 BDF/HI-ECN3

Target & Target Complex Initial Concept Review (ICR)

Rui Franqueira Ximenes, M.Calviani, T.Griesemer, A.Francia, M.Parkin, Jean-Louis Grenard, D.Grenier, C.Mucher, L.Esposito, G.Mazzola (SY-STI), L. Gentini, S.Sgobba, A.Fontenla (EN-MME), M. di Castro, J.Lendaro (BE-CEM), R.Jacobsson (EP), M. Fraser (SY-ABT), C. Ahdida (HSE-RP), + HI-ECN3 team et al.

29/04/2024

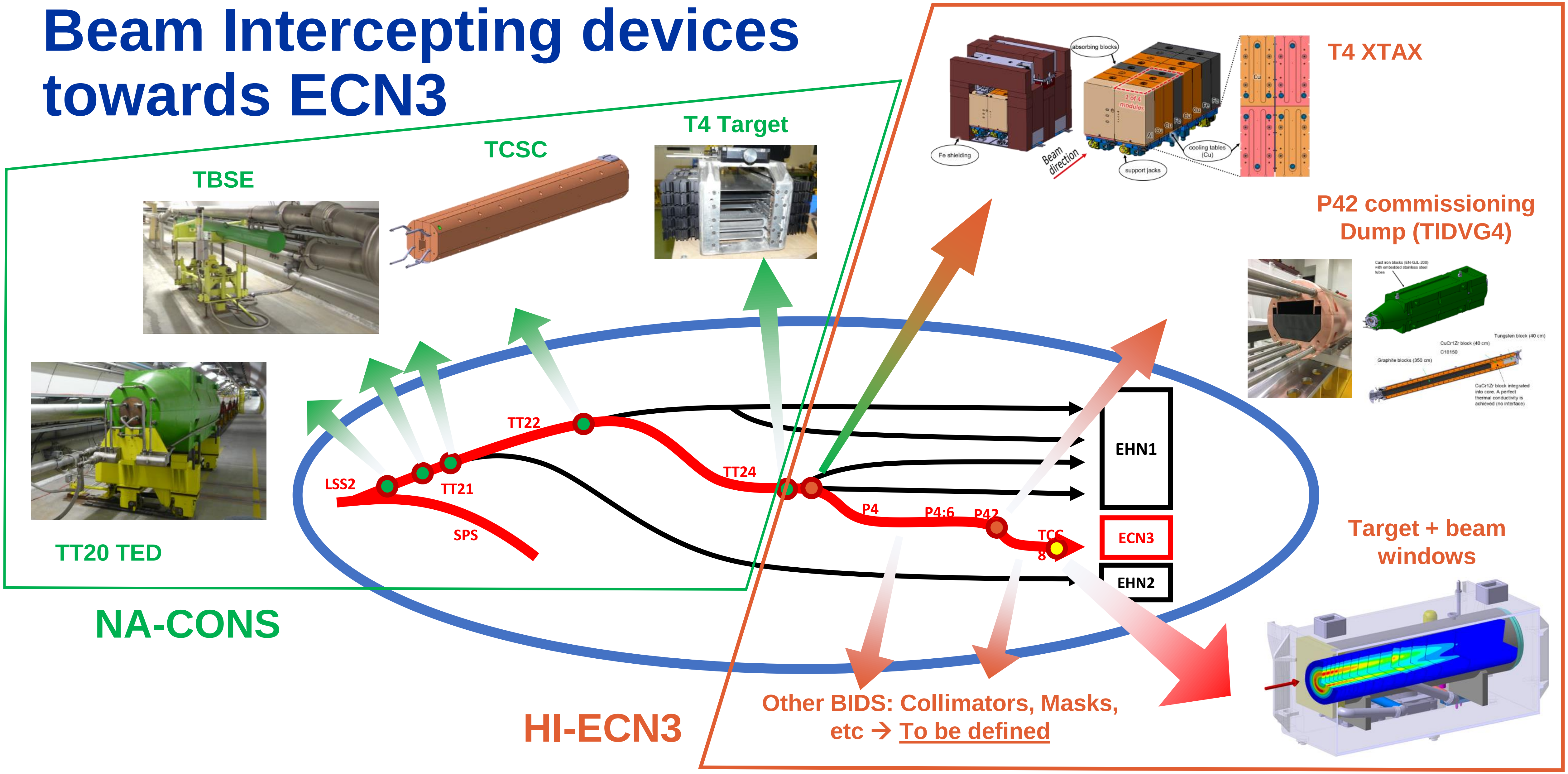
Target system

- Scope of the studies
- Motivation for TDR studies & key developments to be pursued
- Planning snapshot
- Main deliverables
- Conclusions (addressing Matt’s questions)

WP3 – Target & BIDs: Scope

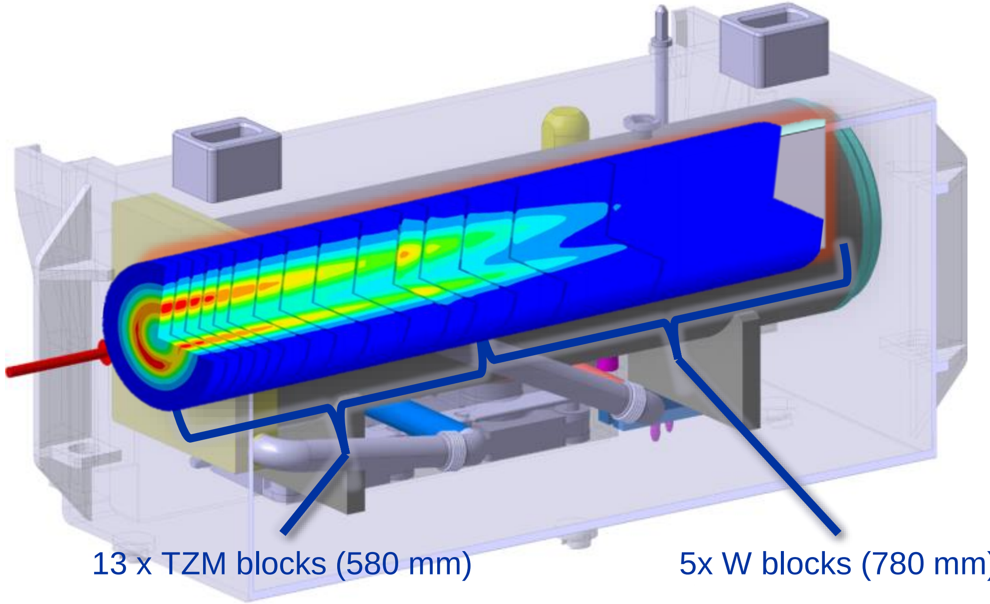
- The WP is **responsible for the design, engineering, procurement and installation for all beam intercepting devices** related to the HI-ECN3 Project.
- This includes **transfer lines BIDs from TCC2 XTAX to TCC8** (P42 dump, collimators, scrapers and absorbers as required) as well as **target/dump for BDF/SHiP**.
- The WP include all **necessary R&D** required to fulfil the function of the target.
- The WP **liaise with the other WPs** for the delivery of certain services and components. As well as with technical groups/experts
- And looking at **collaborations/synergies with external laboratories & communities**.

Beam Intercepting devices towards ECN3

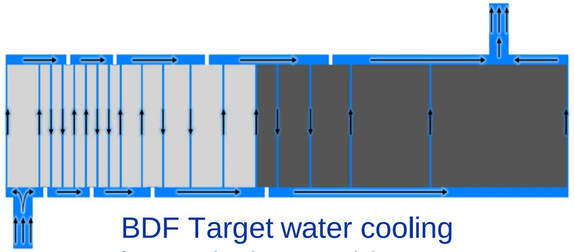


WP3 – Target & BIDs: The background & missing bits (→ Why we need a TDR for the Target & BIDs?)

The baseline



Design of a high power production target for the beam dump facility at CERN: https://doi.org/10.1103/PhysRevAccelBeams.22.113001



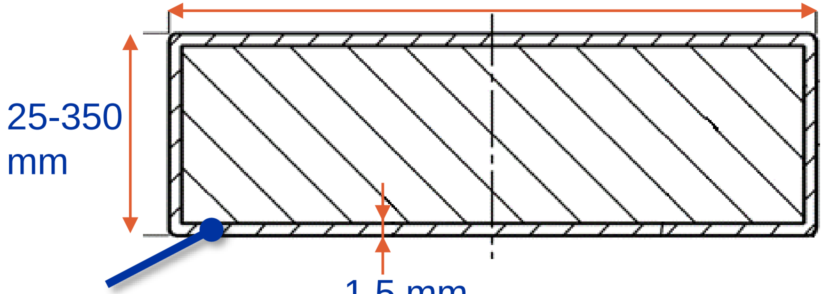
BDF Target water cooling layout (20bar, 5m/s)

Target will become an extremely radioactive device!
~100 Sv/h after few hours of cool-down

Baseline beam parameters of the BDF Target operation. https://doi.org/10.23731/CYRM-2020-002

Proton momentum (GeV/c)	400
Beam intensity (p^+/cycle)	4×10^{13}
Cycle length (s)	7.2
Spill duration (s)	1.0
Beam dilution pattern	Circular
Beam sweep frequency (turns/s)	4
Dilution circle radius (mm)	50
Beam sigma (H, V) (mm)	(8, 8)
Average beam power (kW)	356
Average beam power deposited in target (kW)	305
Average beam power during spill (MW)	2.3

~ 4.0×10^{19} p^+/y

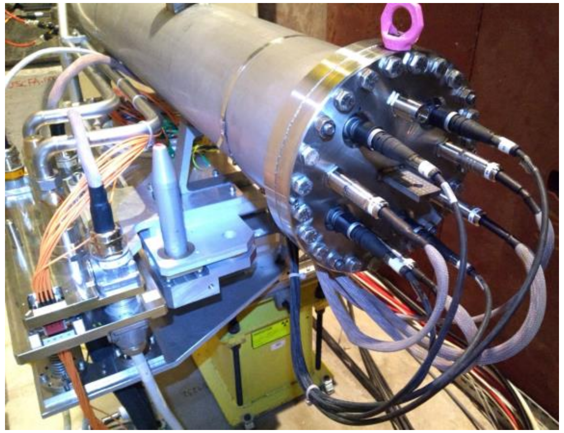


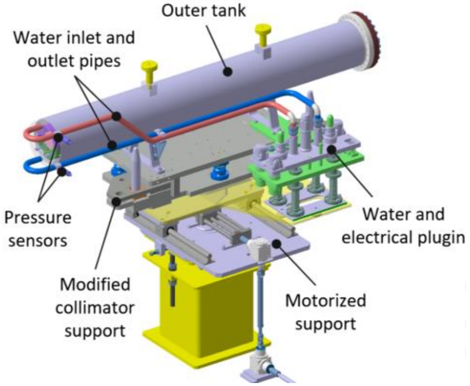
Application of hot isostatic pressing (HIP) technology to diffusion bond refractory metals for proton beam targets and absorbers at CERN: https://doi.org/10.1002/mdp2.101

WP3 – Target & BIDs: The background & missing bits (→ Why we need a TDR for the Target & BIDs?)

The 2018 prototype & PIE

Beam impact tests of a prototype target for the beam dump facility at CERN: Experimental setup and preliminary analysis of the online results: *https://doi.org/10.1103/PhysRevAccelBeams.22.123001*





- Built a SX test-bench in T6/TCC2
- Gained manufacturing experience on a Ta2.5W-cladded baseline target
- Operational experience
- Validated engineering studies
- Via PIE* (2020-2022), validated HIPing technology with these materials & identified material aspects to be addresses during TDR

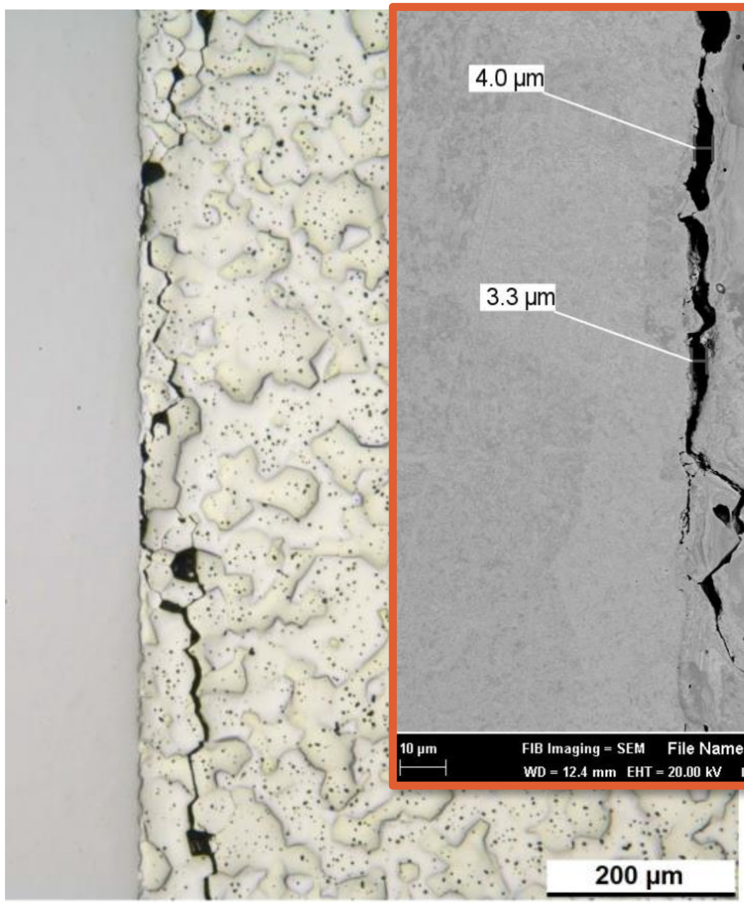
*paper in the pipeline

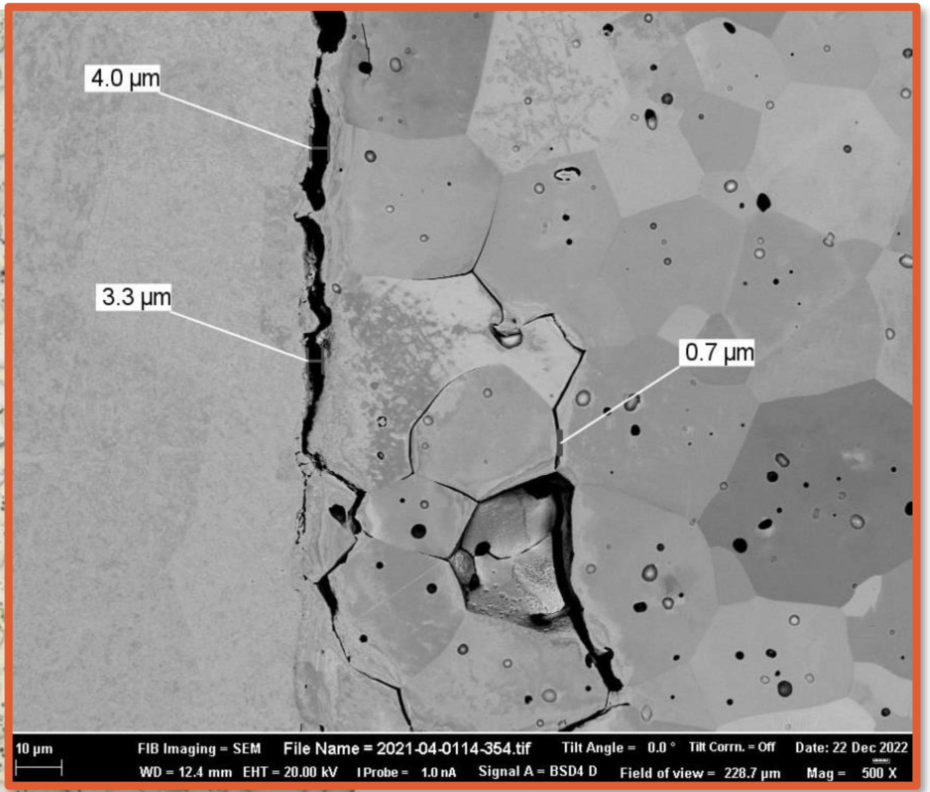
(some) Missing threads → TDR studies

- Most of the shower develops on TZM and not on W → core could be further optimized for physics
- Water in-beam promotes formation of radicals → safety concerns should be addressed
- Target system missing full definition & design → detailed system design & engineering to be done
- However, stress relaxation of the cladding is expected with first pulses. → Residual stress shall be fully understood & quantified
- Large safety margin on W (even if operating at low temperature (brittle)) → Margin for Target core optimization
- Critical element/material is Ta2.5W cladding. → Need for QA plan
- Possibility of LOCA poses a critical safety risk
  - → Address LOCA in detail
  - → look for alternative claddings
- Very high radiation doses → ALARA driven design and detailed waste disposal considerations to be analysed
- Radiation damage & gas production → effect on target materials mechanical properties to be well understood and quantified
- SX test-bench built & available in T6/TCC2 → Unique opportunity to test with beam (2025) alternative claddings & designs
- PIE (2020-2022), final check of baseline target design. → identified design & material aspects to be improved, particularly W material

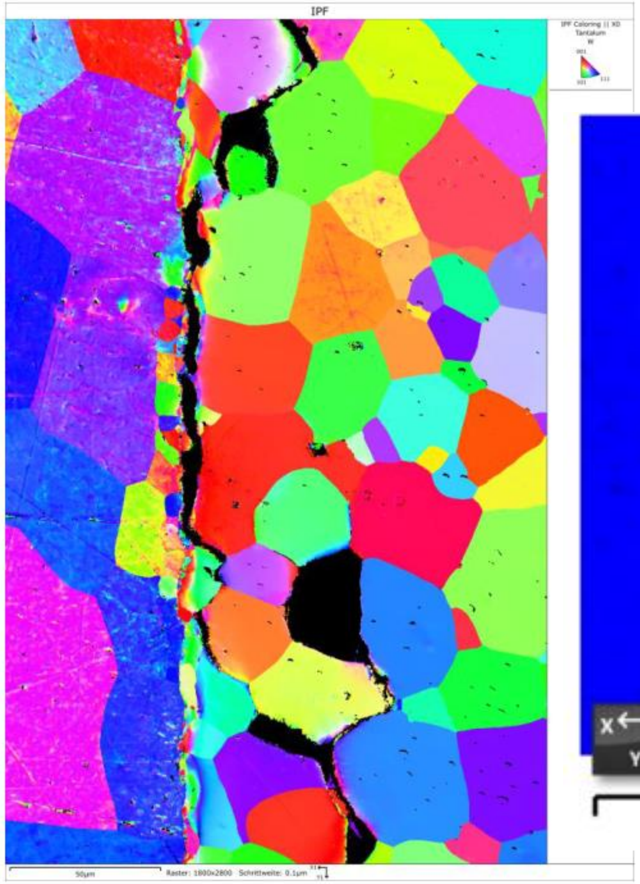
WP3 – Target & BIDs: The background & missing bits (→ Why we need a TDR for the Target & BIDs?)

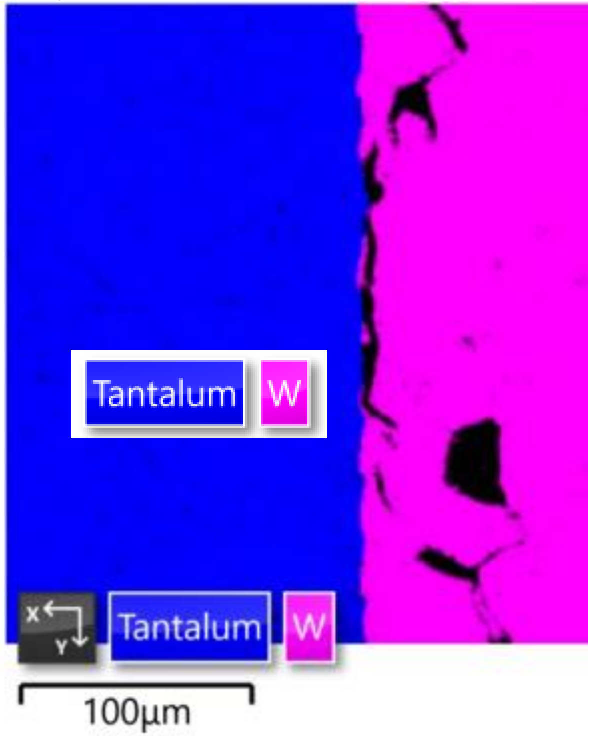
The issue → The Tungsten QA





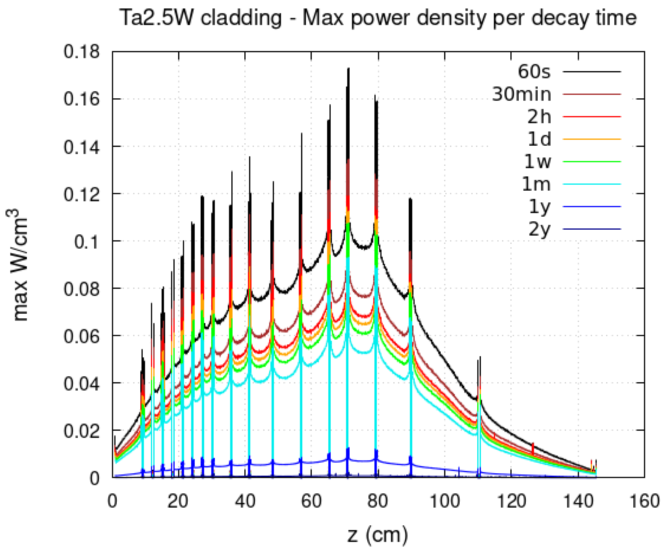
Crack 3

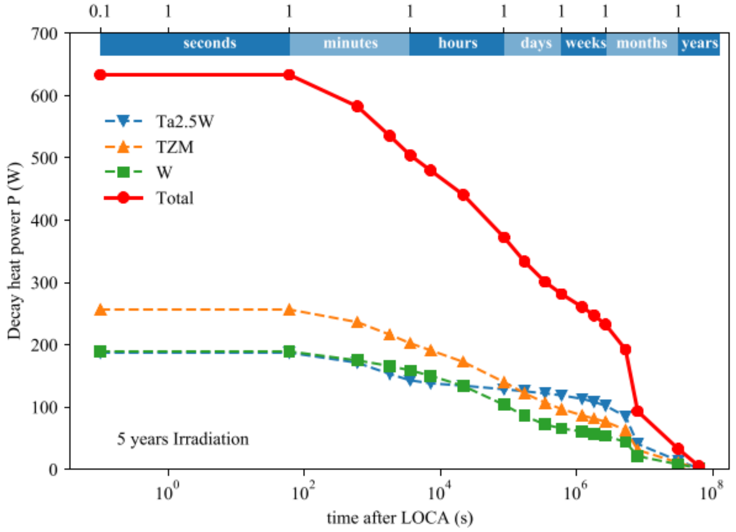




WP3 – Target & BIDs: The background & missing bits (→ Why we need a TDR for the Target & BIDs?)

The issue → The decay heat & LOCA



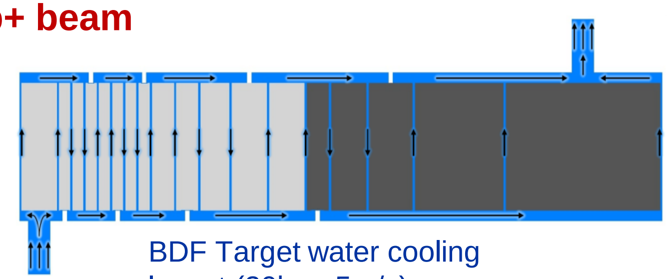


→ Already being partially addressed with Nb-alloys cladding R&D

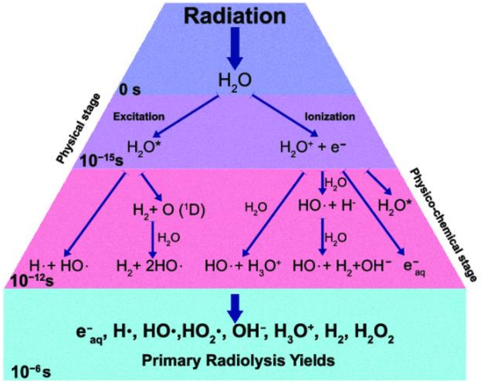
WP3 – Target & BIDs: The background & missing bits (→ Why we need a TDR for the Target & BIDs?)

The issue → Water, radiolysis, production of radicals, explosion

400GeV/c p+ beam
$4x10^{19}$ POT



BDF Target water cooling layout (20bar, 5m/s)



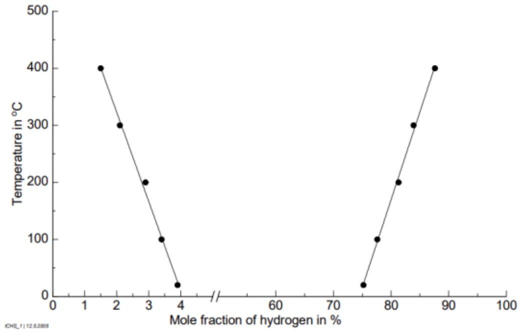


Figure 1. Influence of the temperature on the explosion limits of hydrogen-air mixtures, measured at atmospheric pressure according to DIN 51649 [8]

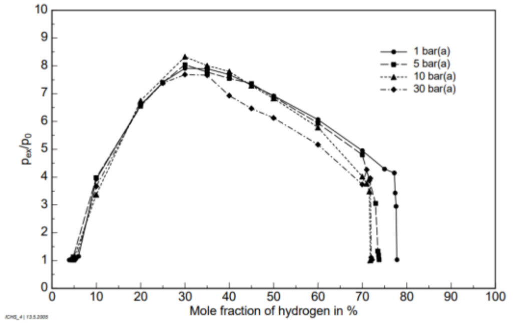


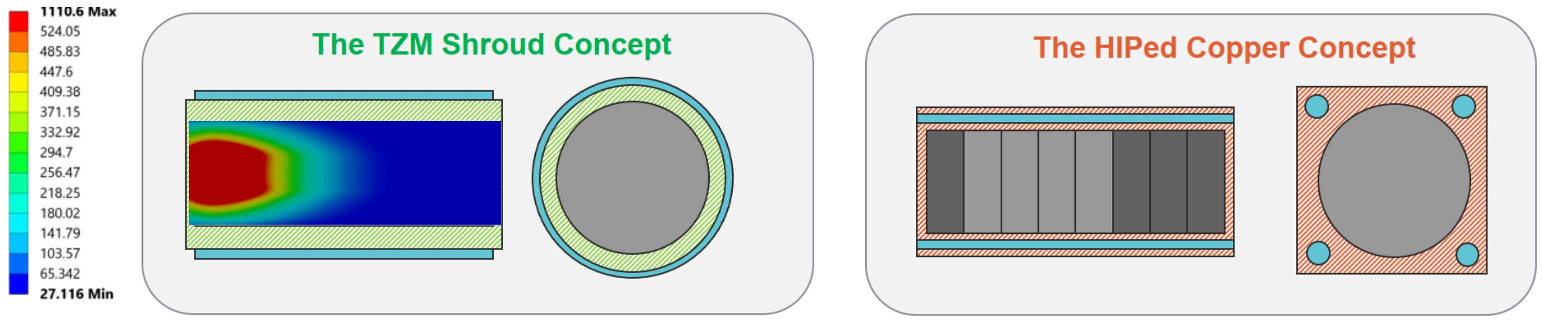
Figure 4. Explosion pressures of hydrogen-air mixtures at 20 °C and different initial pressures [11]

WP3 – Target & BIDs: The background & missing bits (→ Why we need a TDR for the Target & BIDs?)

The interest → Potential for target physics optimization while mitigating operational concerns

- Reduce the amount radiolysis-produced free hydrogen gas (ATEX)
- Reduce activation of the water and of the target (less Ta)
- Reduce decay heat (less Ta)
- Reduce sources of possible contamination of the water with W spallation products (stronger and thicker layer between core and cooling (via an external shroud) as opposed to a thin cladding)
- Increase, possibly, physics performance.
- Shorter target will simplify waste packaging and disposal

Challenging endeavour requiring extensive engineering studies, manufacturing trials and beam test validation during TDR



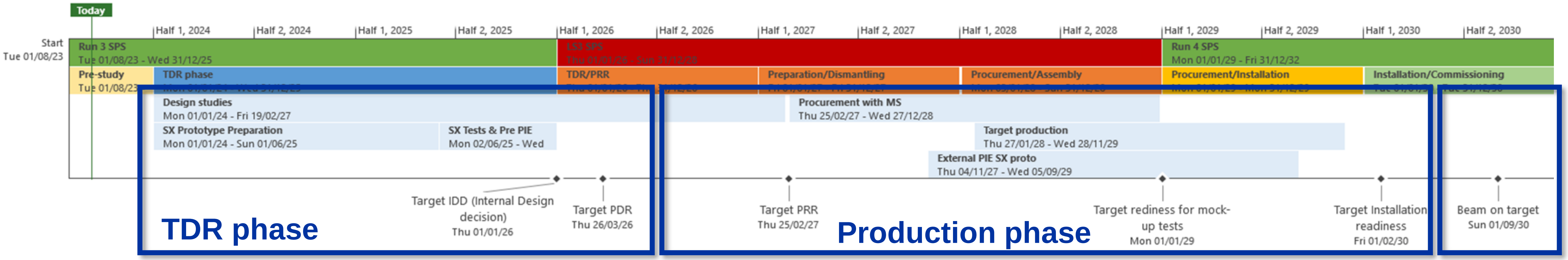
WP3 – Target & BIDs: The background & missing bits (→ Why we need a TDR for the Target & BIDs?)

✓ **<u>We start with a solid background from PBC studies. Yet, many things still to be addressed:</u>**

- ❑ Address safety aspects such as LOCA, radiolysis & retrofit it into the target design → need for alternative design studies & their validation with a prototype w/beam → <u>Only opportunity will be 2025</u>
- ❑ Need to detail the mechanical design of the Target, instrumentation & integration
- ❑ In depth Target physics optimization & review beam delivery/sweep optimization on target
- ❑ Define the manufacturing technology specification & material QA (taking the PIE lessons learnt) necessary to go ahead with procurement in a Production phase
- ❑ Identify the other required BIDs. Design and engineer them.
- ❑ → **Overall, getting ready for a project/production phase**

→ More technical details at the Initial Concept review on the 29th of April ←

WP3 – Target & BIDs: Planning (key dates)



Commissioning & operation

<u>TDR phase (main activities)</u> – (2024-mid 2026)

1) Target (& BIDs) conceptual design followed by detailed design
2) Prototype(s) Target Design, construction and beam tests
3) Material studies, R&D and Procurement

<u>Production phase</u> – (2026 – 2030)

1) Detailed Design phase
2) Procurement & production of components and systems
3) Tests/dry-run, installation activities
4) Material tests/PIEs

WP3 – Target & BIDs: Main deliverables (TDR&PRD) 1/2

- **Design and build** a physics optimized **350kW high-Z core Target**, thus comprising technical design, engineering, energy deposition studies, manufacturing (**BDF/SHiP experiment)**
- **Ensure,** together with EP, the **Target fulfills SHiP requirements**
- **Design and build** the required **BIDs for the HI ECN3 delivery (P42 dump, collimators, masks, etc),** thus comprising technical design, engineering, energy deposition studies, manufacturing
- **Identify, assess & mitigate** in the design **safety** and **radiological concerns**.
- Pursue extensive **design, materials and manufacturing R&D** with refractory metals and joining technologies (EBW and HIPing) to fulfill the engineering requirements
- **Define and execute the procurement** of refractory metals, INCONEL, CuCrZr and other special materials, as well as all other BIDs components.
- Define, design and integrate the **target/BIDs instrumentation**
- Include **remote handling** features adapted for an extremely highly radioactive environment

WP3 – Target & BIDs: Main deliverables (TDR&PRD) 2/2

- Define and design the require **services** (cooling, power, etc)
- **Build and execute prototype tests with beam** at the **SX testbench** and possibly HiRadMat, and execute the required post-irradiation inspections/tests.
- Execute the required **final target/BIDs tests, dry-runs, installation and commissioning with beam**.
- **Liaise with WP2** of beam delivery for **beam delivery and beam dilution studies**
- **Liaise with WP4** of Target complex for **HW interfaces and integration**
- **Liaise with WP5** of safety & RP to execute the required **radiation protection and waste disposal studies** and optimize BIDs accordingly
- **Liaise with WP8** for energy deposition & radiation effects studies
- **In synergies with NA-CONS ensure the reliable upgrade of P4 XTAX in TCC2**
- **Liaise with external partners** (ISIS, ORNL) for synergies with spallation sources and high-power target facilities.

Conclusions

Baseline: what is our baseline today ? Can we converge on a baseline design before LS3 to guarantee reliable & safe operation in 2030 ?

- **CDR++ (slightly improved design) baseline still valid today**
  - ➢PIE results showed sound cladding bonding
  - ➢LOCA accident may be not as critical as expected
  - ➢QA of core materials is at reach within timeline
- **We know what are the critical items. We know how to quantify them. Mitigation strategies can be defined on time. Challenge is fully validating them in operational conditions**

Conclusions

Baseline R&D: what are the most important problems to solve & test with beam before LS3 ? Scope? Can we converge on a prioritized list of activities with decision points on a timeline?

- **Physics performance:** what can we optimize further, is it worth it ?
- **Reliability:** validation with beam before LS3 is necessary / alternative labs for beam time during LS3 ?
- **Safety:** can we improve the choice of cladding material (LOCA) and reduce free radicals in cooling water ?

- **Priority is on the mitigation of safety constrains while keeping present physics performance.**
- **Physics improvement is possible and will be pursued. It can be important (full W vs CDR). But won't be the driving motivation for alternative designs. And will be only adopted if improvement is meaningful for SHiP.**
- **Beam test post-2025 outside CERN is potentially possible. However, the effort saving in re-using T6 SX test-bench, even under a tight timeline, is likely more attractive than trying to replicate SPS beam test conditions elsewhere, despite gaining some extra time on project schedule.**
- **Cladding alternatives exist, only require validation with beam.**
- **Radicals' production in water is more challenging to address without changing baseline design. Besides alternative core design, one could invest on defining a sound control system at the CS.**

Conclusions

Longer term R&D:

- **Strategy for upgradeability:** can we stage development to focus on safe/reliable operation at 4×10^{13} ppp but leav the door open to installing an upgraded target for ultimate SPS performance closer to 7×10^{13} ppp in ~ Run 5 ? … imagine a FIP signal is observed in Run 4 !

- **Yes. But services and target complex will need to be prepared for the upgrade already in LS3**
- **We will need to briefly address it (not necessarily changing the design) to understand what it means for the selected target design**

home.cern

WP3 – Target & BIDs: Why are you invited?

WP3 core team	**Target and BIDs Design & engineering, Prototype Target Beam test**	**Rui Franqueira XIMENES, Mike PARKIN+Tina GRIESEMER+Alvaro FRANCIA, Marco CALVIANI + STI-TCD**
	Detailed design & Production	**Luca GENTINI**
	XTAX upgrade	**Miguel SANTOS**
	Energy deposition & radiation effects	**Luigi ESPOSITO, Giuseppe MAZZOLA**
	Material R&D	**Stefano SGOBBA, Ana Teresa PEREZ FONTENLA**
	Target Instrumentation	**Mario DI CASTRO, Jerome LENDARO**
	Experiment Requirements	**Richard JACOBSSON**

WP3 – Target & BIDs: Why are you invited?

WP3 – Target & Beam Intercepting Devices
Rui XIMENES

- Target Design & Engineering **Rui XIMENES**
- BIDs Design & Engineering **Rui XIMENES**
- XTAX Upgrade **Miguel SANTOS**
- Experiment Requirements **Richard JACOBSSON**
- Energy Deposition & Radiation Effects **Luigi ESPOSITO**
- Detailled Design & Production **Luca GENTINI**
- Target Instrumentation **Jerome LENDARO**
- Material R&D **Stefano SGOBBA**
- Prototype Target Beam Test **Rui XIMENES**

BE-CEM	Robotics / tooling	Luca BUONOCORE
BE-CEM	Control Infrastructure	Ioan KOZSAR
BE-EA	Integration (ICEA)	Michael LAZZARONI
BE-EA	Secondary Beam Line	Dipanwita Banerjee
BE-EA	Configuration Management	Giulia ROMAGNOLI
BE-EA	P42 Vacuum	Miguel SANTOS
BE-GM	Primary Area Survey	Camille VENDEUVRE
BE-OP	SPS	Kevin LI
BE-OP	SPS	James RIDEWOOD
EN-ACE	WP1 & WP7 (management, services, planning)	Fernando PEDROSA, Ixone VAQUERO
EN-CV	Cooling & Ventilation	Roberto BOZZI / Francesco DRAGONI, Nikola ZARIC
EN-HE	Handling Engineering	Roberto RINALDESI, Cristina DURÁN GUTIÉRREZ
HSE-RP	WP6 (Radiation Protection)	Claudia AHDIDA, Olin PINTO, Francesca LUONI
HSE-RP	Radioactive Waste Management	Renaud CHAROUSSET
SY-ABT	WP2 (Beam delivery)	Francesco VELOTTI, Aleksandr GORN
SY-BI	Beam Instrumentation (Profile /Spill)	Federico RONCAROLO
SY-STI	WP4 (Target Complex)	Jean-Louis GRENARD
SY-STI	R2E	Ruben ALIA
TE-MSC	Magnets	Philip SCHWARZ
TE-VSC	Primary Beam Line Vacuum	Anthony HARRISON
TE-MPE	Machine Protection	Antoine COLINET
SY-STI	Project Safety Officer	Melania AVERNA

+ Matthew Fraser (Project Leader)

WP3 – Target & BIDs: (TDR)

Main activities & responsibilities

Commissioning & operation

<u>TDR phase (main activities)</u> – (2024-mid 2026)

1) Target (& BIDs) conceptual design followed by detailed design
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WP3 – Target & BIDs: (TDR)
Main activities & responsibilities

TDR phase (main activities) – (2024-mid 2026)

1) **Target (& BIDs) conceptual design followed by detailed design**
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TDR phase

1) Target (& HI BIDs) conceptual design followed by detailed design

- Conceptual design studies and BIDs engineering (Production Target, windows, P42 Dump, other BIDs) → **WP3 | SY-STI**
- Energy deposition studies, radiation damage, radiolysis estimation → **WP3 | SY-STI**
- Beam delivery studies & optimization, functional specification → **WP2 | F.Velotti, A.Gorn**
- Radiation protection studies (design handling & shielding considerations) → **WP6 | C.Ahdida, O.Pinto F.Luoni & WP4 J.Grenard**
- Waste disposal studies (for design optimization and disposal considerations) → **WP6 | R.Charousset, P.Bertreix & WP4**
- Detailed mechanical design and engineering of Target's and BIDs → **WP3 | L.Gentini**
- Design integration of alignment/survey features → **WP7 | C. Vendeuvre**
- Definition and prototyping of instrumentation and controls → **WP3 | J.Lendaro, M.di Castro, I.Kozsar + M. Guinchard**
- Cooling Station requirements and design/dimensioning → **WP7 | R.Bozzi, F.Dragoni, N.Zaric + WP6 + WP4**
- Design integration of handling features → **WP4 & WP7 | J.Grenard, R.Rinaldesi, C.Gutiérrez**
- Design integration of vacuum components (vacuum, beam windows, tests) → **WP2 | M.Santos**
- Physics optimization studies → **WP3 + EP (liaison with Experiment), R. Jacobsson**
- Design/interfaces integration studies with Target Complex WP → **WP3 + WP4**

WP3 – Target & BIDs: (TDR)
Main activities & responsibilities

TDR phase (main activities) – **(2024-mid 2026)**
1) Target (& BIDs) conceptual design followed by detailed design
2) **Prototype(s) Target Design, construction and beam tests**
3) Material studies, R&D and Procurement

TDR phase

2) Prototype(s) Target Design, construction and beam tests

- Conceptual design studies and engineering → **WP3 | SY-STI**
- Energy deposition studies → **WP3 | SY-STI**
- Beam delivery studies → **WP2 | BE-OP, K.Li, J,Ridewood**
- Radiation protection studies (for design handling considerations) → **WP6** | **C. Ahdida, Y. Pira**
- Waste disposal studies (for design optimization and disposal considerations) → **WP6 | G. Dumont**
- Detailed mechanical design and engineering of Prototype → **WP3 | L.Gentini + SY-STI-TCD**
- Design integration of alignment/survey features → **WP7 | BE-GM, C.Vendeuvre,**
- Definition of instrumentation and controls → **WP3 | BE-CEM, J. Lendaro, EN-MME, M. Guinchard**
- Cooling Station operation → **WP7 | EN-CV-SPS**
- Design integration of handling features → **WP7 | EN-HE, R. Rinaldesi**
- Robotic support → **BE-CEM, L.Buonocore**
- Beam tests in TCC2 → **WP3 | STI-TCD, BE-OP, K.Li, J,Ridewood, BE-EA**

WP3 – Target & BIDs: (TDR)
Main activities & responsibilities

TDR phase (main activities) – (2024-mid 2026)

1) Target (& BIDs) conceptual design followed by detailed design
2) Prototype(s) Target Design, construction and beam tests
3) **Material studies, R&D and Procurement**

TDR phase

3) Material studies, R&D and Procurement

- Material specifications and definition of manufacturing procedures → **WP3 | EN-MME-MM, S. Sgobba, A. Fontenla + SY-STI-TCD**
- Material testing/characterization → **WP3 | EN-MME-EDM, EN-MME-MM, S. Sgobba**
- Strategy and Procurement of core materials (Refractories, graphite, CuCrZr, etc) → **WP3 | SY-STI-TCD, FHR-IPT-PI**
- Collaboration with external partners (e.g., neutron spallation sources ISIS, ORNL) → **WP3 | SY-STI-TCD, M. Calviani**

WP3 – Target & BIDs: (TDR)
Main activities & responsibilities

TDR phase (main activities) – (2024-mid 2026)

1) Target (& BIDs) conceptual design followed by detailed design
2) Prototype(s) Target Design, construction and beam tests
3) Material studies, R&D and Procurement

TDR phase

- General support
  - Configuration management (assets, nomenclature, documentation, etc) → **G.Romagnoli**
  - BIDs layout integration → via **ICEA, M.Lazzaroni + WP4, J.Grenard in the Target Complex**
  - Services, planning, liaison with NA-CONS → **F.Pedrosa, I.Vaquero + P.Schwarz**
  - Beam instrumentation for the proto beam tests & BIDs / Target (via WP2) → **WP2 + SY-BI, F.Roncarolo, S.Burger**
  - R2E studies (out of Target complex) related with BIDs (as required) → **R.Garcia Alia**
  - Primary beam line vacuum (if any & related with prototype tests) → **A. Harrison**
  - BID's machine protection aspects, BIS implementation → **A. Colinet + J.Lendaro**
  - General safety aspects, EIS, etc → **M.Averna**
  - Secondary beam lines support (via WP2) → **WP2 + D. Banerjee**

MTP Spending profile

				TDR				Implementation phase				
				Design studies			Procurement / MS					
				SY Proto design & tests & pre-PIE				Production		Install/Comm issioning		
M / P Category	**Description**	**Start Date**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**Total**
M+P	**Target TDR phase (WP3)**		0	110	220	220						**660**
P	TDR preparation (FLUKA inc. R2E)	01/01/2025			110	110	110					330
P	TDR preparation (Target & Facility)	01/01/2024		110	110	110						330
	Target TDR phase M (WP3)		0	230	470	0	0	0	0	0	0	700
Material	Beam test Prototype design			60								60
Material	Beam test Prototype core production			20	300							320
Material	Beam test Prototype assembly production			50	50							100
Material	Beam test Prototype Target instrumentation				10							10
Material	Beam test other (adaptations plugin, tools, etc)				10							10
Material	Prototype of robust target alternatives			50	50							100
Material	Final Target & interfaces pre-design			50	50							100
M+P	**Target assembly and annexe equipment (WP3)**					530	980	1015	2255	1210	110	**6100**
Material	Target & interfaces design					100	100	100	100	100		500
Material	Target core materials						50	50	1200	800		2100
Material	Target costruction & assembly						100	45[illegible]	650	200		1400
Material	R&D on refractory metals					300	200					500
Material	Beam test prototype PIE					20	225					245
P	Other M/P						85	8[illegible]	85			255
P	Target P for STI						110	22[illegible]	220	110	110	770
P	Target P for MMEstudies					110	110	11[illegible]				330
M+P	**Target Instrumentation package (WP3)**					0	85	16[illegible]	355	0	0	**600**
Material	Target instrumentation							5[illegible]	100			150
Material	He-vessel instrumentation (WP4)							1[illegible]	80			95
Material	Shielding instrumentation (WP4)							1[illegible]	90			100
P	Target Instrumentation package (P)						85	8[illegible]	85			255
M+P	**Beam window(s) and sector valve (WP3)**					25	125	15[illegible]	100	0	0	**400**
Material	Beam window for vacuum interface design					25	25					50
Material	Beam window production						50	100	100			250
Material	Beam window interfaces (WP4)						50	50				100
M+P	**Passive mask (WP3)**					0	20	20	260	0	0	**300**
P	Design & integration studies (P)						20	20	20			60
Material	Passive mask production								240			240
M+P	**P42 Dump (WP3)**			20	180	0	0	0	0	0	0	**200**
Material	Design & integration studies			20	30							50
Material	TIDVG4 adaptation & shielding				150							150

Budget WP3

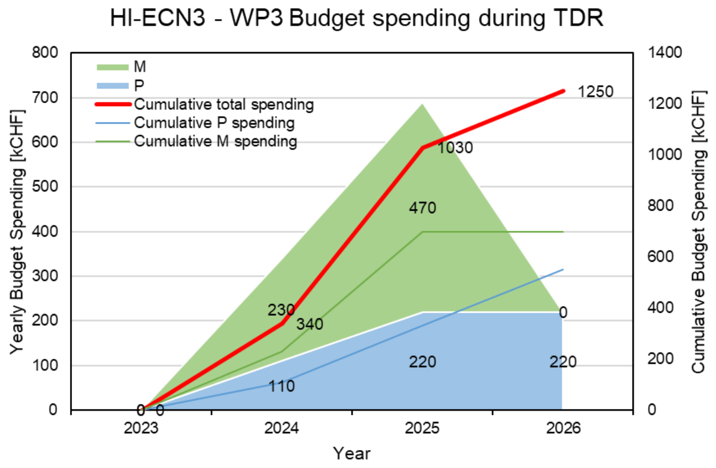
700kCHF (Target TDR)

200kCHF (BIDs TDR)

660kCHF (GRAD TDR++)

7400kCHF (Post-TDR)

TDR spending profile



M / P Category	Description	Start Date	2023	2024	2025	2026
M+P	**Target TDR phase (WP3)**		0	110	220	220
P	TDR preparation (FLUKA inc. R2E)	01/01/2025			110	110
P	TDR preparation (Target & Facility)	01/01/2024		110	110	110
	Target TDR phase M (WP3)		0	230	470	0
Material	Beam test Prototype design			60		
Material	Beam test Prototype core production			20	300	
Material	Beam test Prototype assembly production			50	50	
Material	Beam test Prototype Target instrumentation				10	
Material	Beam test other (adaptations plugin, tools, etc)				10	
Material	Prototype of robust target alternatives			50	50	
Material	Final Target & interfaces pre-design			50	50	
M+P	**P42 Dump (WP3)**			20	180	
Material	Design & integration studies			20	30	
Material	TIDVG4 adaptation & shielding				150	

Project WBS v0.1

Matt's slides at 345^{th} IEFC

WP1 – Project Management
Matthew FRASER

- Planning, Scheduling & Coord. – **Fernando PEDROSA**
- Budget & Resources – **Sylvie PRODON**
- Procurement
- Project Office – **Matthew FRASER**
- Technical Coordination – **Matthew FRASER**
- Configuration & Quality Management – **Giulia ROMAGNOLI**
- Installation
- Commissioning

WP2 – Beam Extraction, Transfer and Delivery
Francesco VELOTTI
Deputy: **Laurie NEVAY**

- Extraction – **Pablo ARRUTIA**
- Primary Beam Line – **Laurie NEVAY / Francesco VELOTTI**
- Magnets – **Philip SCHWARTZ**
- Power Converters – **Ivan JOSIFOVIC**
- Vacuum Upgrade – **Miguel SANTOS**
- Instrumentation
- Machine Protection – **Antoine COLINET**
- Operational Controls & Tools – **Kevin LI**
- Beamline Shielding Improvements – **Laurie NEVAY**
- Experiment Requirements – **Richard JACOBSSON**

WP3 – Target & Beam Intercepting Devices
Rui XIMENES

- Target Design & Engineering – **Rui XIMENES**
- BIDs Design & Engineering – **Rui XIMENES**
- XTAX Upgrade – **Miguel SANTOS**
- Experiment Requirements – **Richard JACOBSSON**
- Energy Deposition & Radiation Effects – **Luigi ESPOSITO**
- Detailled Design & Production – **Luca GENTINI**
- Target Instrumentation – **Jerome LENDARO**
- Material R&D – **Stefano SGOBBA**
- Prototype Target Beam Test – **Rui XIMENES**

WP4 – Target Complex
Jean-Louis GRENARD

- Target Complex Design & Engineering – **Jean-Louis GRENARD**
- TC & Surface Building Integration – **Jean-Louis GRENARD**
- Containment Systems – **Jean-Louis GRENARD**
- Service Cell Systems – **Jean-Louis GRENARD**
- Robotic Systems – **Luca BUONOCORE**
- Remote Handling Systems – **Roberto RINALDESI**
- Radioactive Components Storage & Disposal – **Jean-Louis GRENARD**
- Radiation to Electronics – **Ruben ALIA**
- Accelerator Interfaces – **Jean-Louis GRENARD**
- Magnetised Hadron Stopper

WP5 – Exp. Area, Interface & Integration
Francois BUTIN

- Expt Area Design & Engineering – **Francois BUTIN**
- Global Integration (inc. Exp. Area Integration) – **Francois BUTIN**
- TCC8/ECN3 Dismantling – **Nicolas QUINQUIS / Francois BUTIN**
- Shielding Proecurement & Recovery – **Michael LAZZARONI**
- Experiment Interfaces – **Richard JACOBSSON**
- Accelerator Interfaces – **Francois BUTIN**
- Experiment Installation – **Francois BUTIN / Richard JACOBSSON**
- Experiment Requirements – **Richard JACOBSSON**

WP6 – Radiation Protection & Safety
Claudia AHDIDA

- Safety Files – **Melania AVERNA**
- Radiation Protection – **Claudia AHDIDA**
- Radioactive Waste Management – **Renaud CHAROUSSET**
- Fire Safety – **Oriol RIOS**
- Access & Safety Systems – **Tomaz LADZINSKI / Anna SUWALSKA**
- Occupational Safety – **Simon MARSH**

WP7 – Infrastructure, Services & Civil Eng.
Fernando PEDROSA

- NA-CONS Synergism – **Fernando PEDROSA**
- Civil Engineering – **John OSBORNE**
- Gas Distribution – **Davide JAILLET**
- Cooling & Ventilation – **Roberto BOZZI**
- Electrical & Fiber Infrastructure – **Eva CANO GONZALEZ**
- Cryogenics
- Survey & Alignment – **Camille VENDEUVRE**
- Handling Systems & Operational Support – **Roberto RINALDESI**
- Telecom & Network