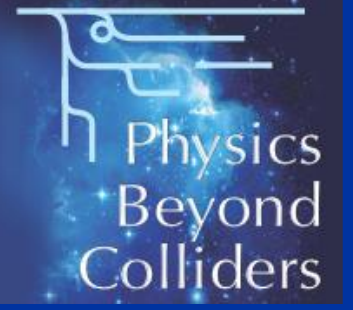
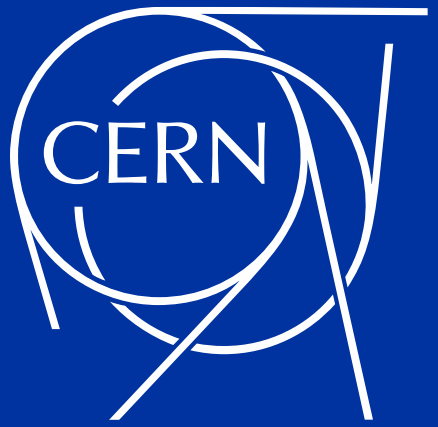




Conventional Beams Working Group ECN3 Report

Johannes Bernhard for the CBWG ECN3 Working Group

07.11.2022

CBWG Mandate

ONVENTIONAL BEAMS

The working group analyses the **requirements** and **provides support for the experiments** attributed to the working group, including **design of secondary beam lines** and **integration** in the existing SPS and PS experimental areas, in view of the submission of the **proposals** to the relevant committees. Similar support will be also provided for the study on novel neutrino beam lines. The working group evaluates **the feasibility, compatibility, infrastructure needs, approximate costs and resource requirements** from CERN and collects all this information for the PBC-A&T Committee.

The following experiments are followed by the PBC: NA64μ/h, NA60+, **HIKE (Phase1/K^+, Phase 2/ K_L, Phase 3/KLEVER), SHADOWS,** AMBER (RF-separated beams), ENUBET and NuTAG. Representatives from experiments already followed-up by the SPSC using the same areas and/or requiring shared physics studies will be part of the working group.

Structure

ONVENTIONAL BEAMS

CONVENTIONAL BEAMS WORKING GROUP

Conveners: M. Brugger, J. Bernhard
Expert Advisor: L. Gatignon
PBC physics representatives, experts, and SPSC referees on demand

CBWG-EHN1

Convener: M. van Dijk

- NA60+
- NA61 upgrades
- NA64 high intensity & hadrons

CBWG-EHN2

Convener: D. Banerjee

- AMBER (muon & RF-sep. beams)
- MUonE
- NA64 muons

CBWG-ECN3

Convener: J. Bernhard

- HIKE (K^+, BD, K_L, KLEVER)
- SHADOWS

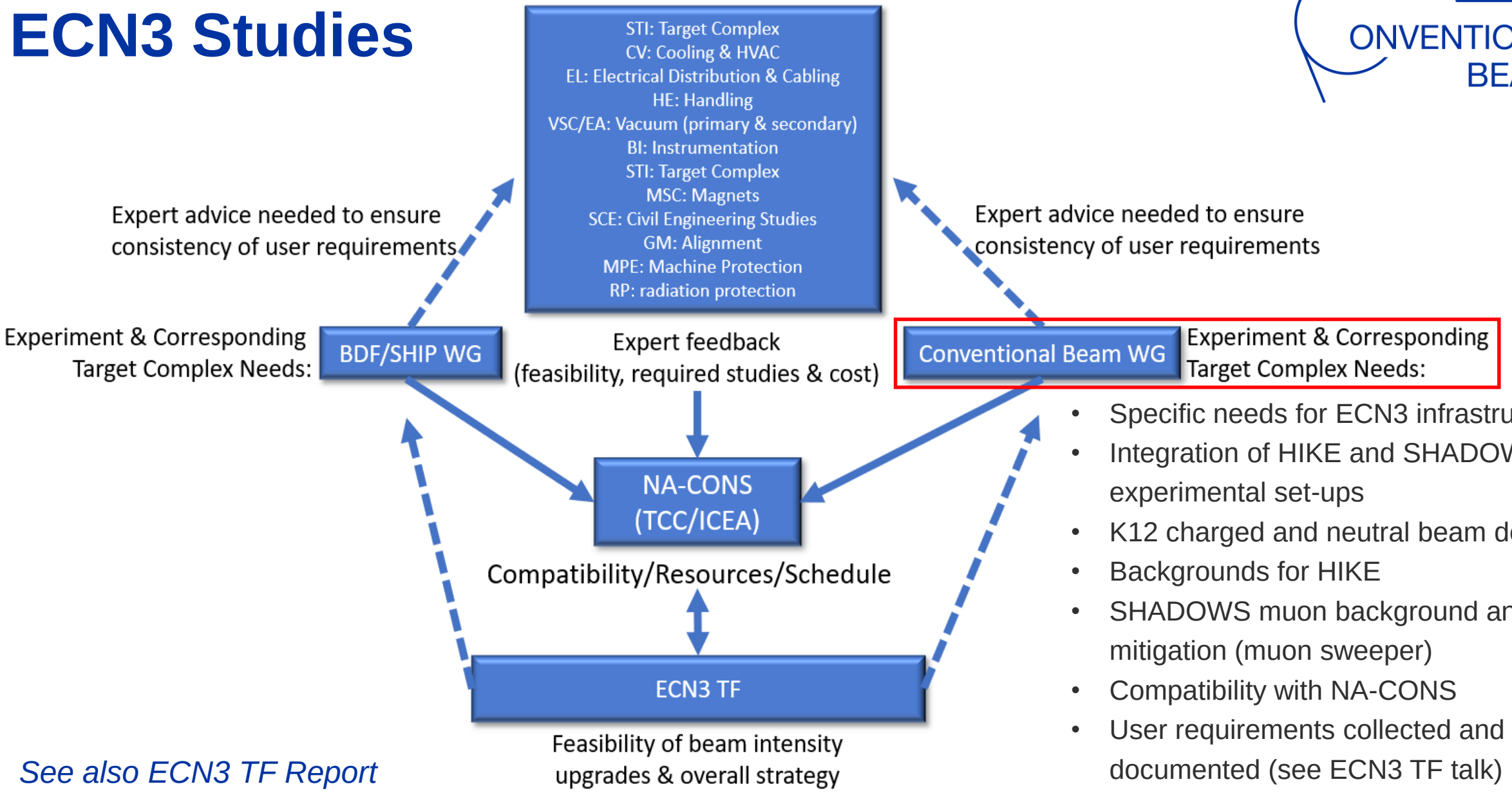
CBWG-NB

Convener: N. Charitonidis

- ENUBET
- NuTAG
- NA61 low energy beams

- Key contributions by fellows and PhD students: A. Baratto Roldan, G.L. D'Alessandro, L. Dyks, E. Nowak, F. Metzger, R. Murphy, and F. Stummer.

ECN3 Studies



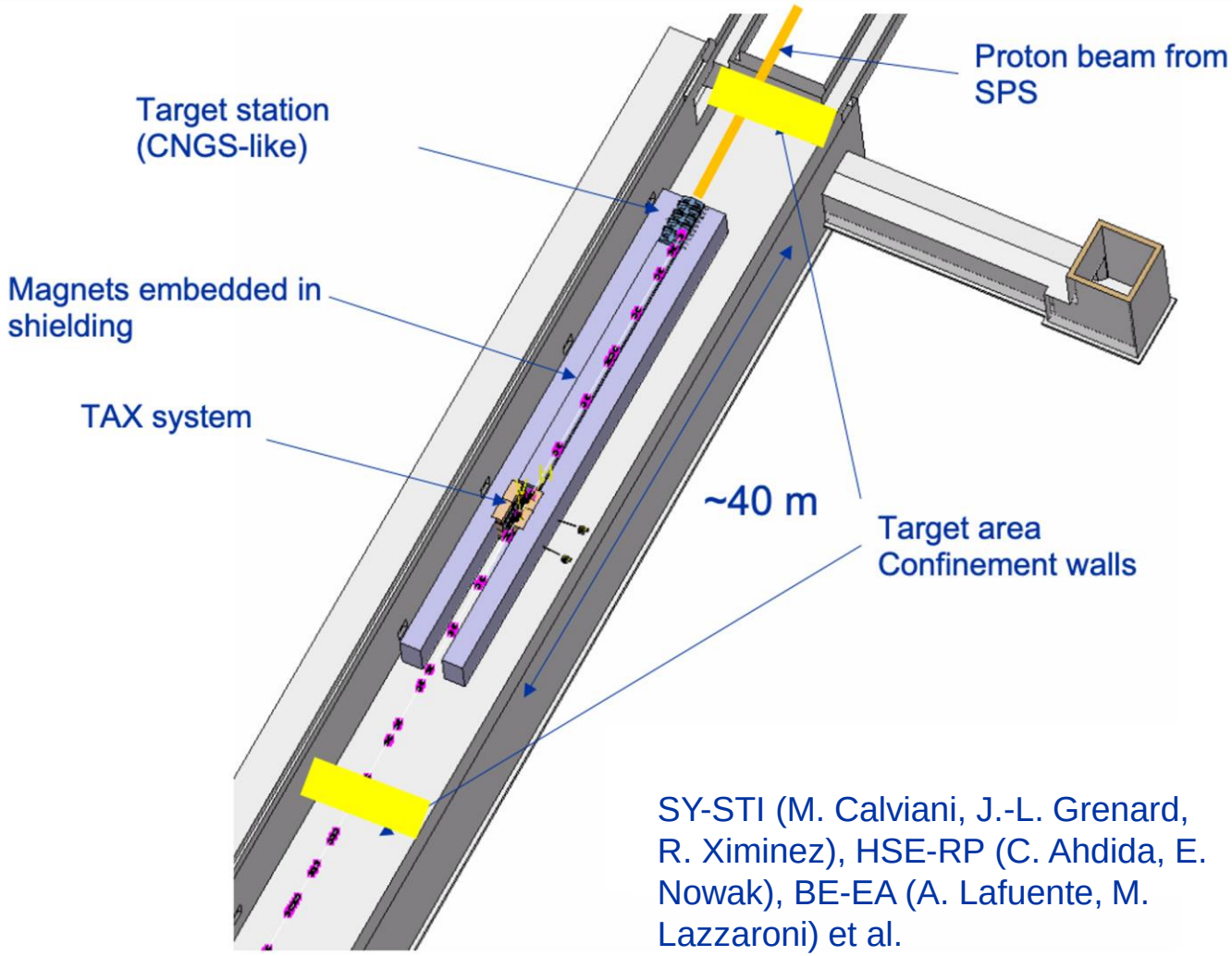
- Specific needs for ECN3 infrastructure
- Integration of HIKE and SHADOWS experimental set-ups
- K12 charged and neutral beam design
- Backgrounds for HIKE
- SHADOWS muon background and mitigation (muon sweeper)
- Compatibility with NA-CONS
- User requirements collected and documented (see ECN3 TF talk)

See also ECN3 TF Report

Target and TAX Complex in TCC8

ONVENTIONAL BEAMS

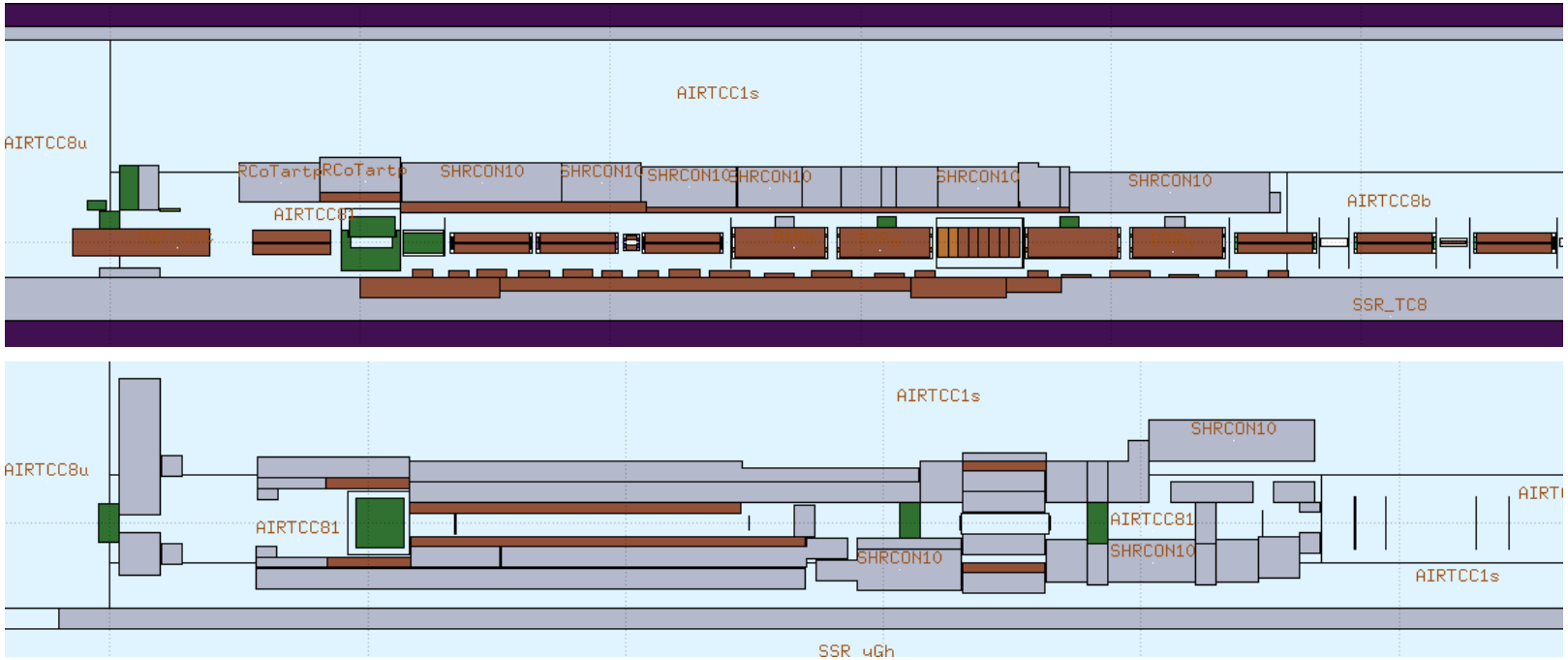
- Initial studies for the limitations of the T10 target and K12 TAX have been completed during the last PBC study phase and show the need of a new design for both elements for high intensity operation.
- Detailed studies have started in the second PBC phase, including radiation protection requirements and for handling and operation.
- There is the necessity of a new target-TAX complex, which is compatible with RP needs and best practices of maintenance and operation, in synergy with and based on the ECN3 TF studies.



SY-STI (M. Calviani, J.-L. Grenard, R. Ximinez), HSE-RP (C. Ahdida, E. Nowak), BE-EA (A. Lafuente, M. Lazzaroni) et al.

Radiation Protection

- FLUKA studies show high **prompt dose rates** in the target and TAX locations in TCC8.
- Very high **residual dose rates** have been found for the current target complex in the accessible area of TCC8 with higher intensities: up to 3 mSv/h next to the shielded target station and 1 mSv/h next to the shielded TAX after one day of cooldown → need of improved shielding.



Preliminary shielding as proposed by HSE-RP

TCC8 Side View

TCC8 Top View

HSE-RP (C. Ahdida, E. Nowak)

Radiation Protection

ONVENTIONAL BEAMS

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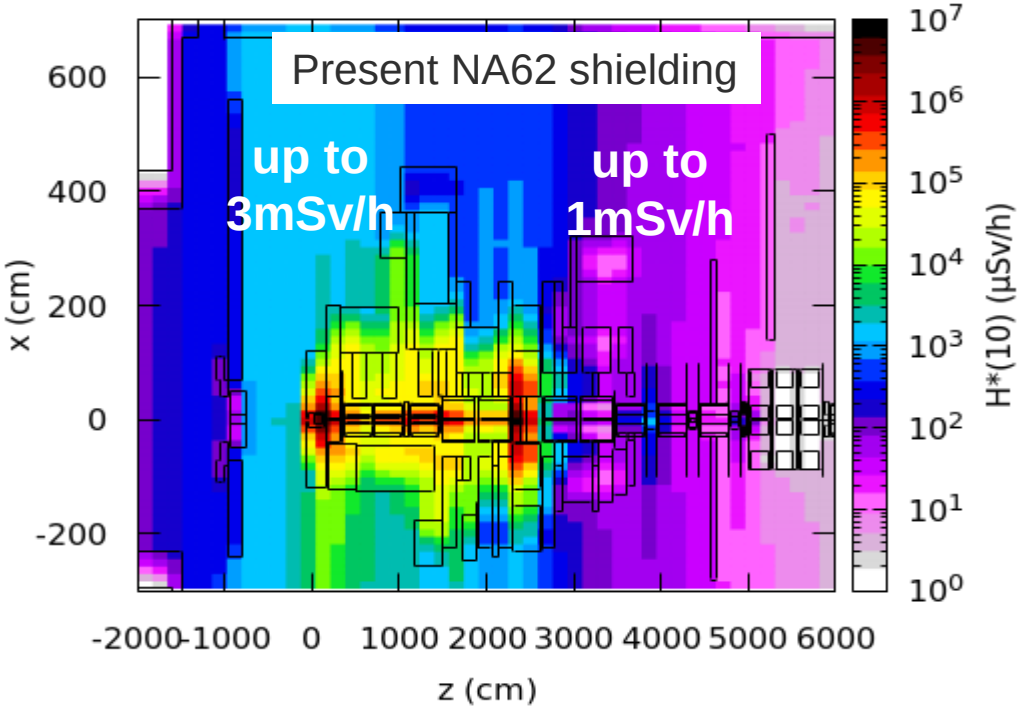
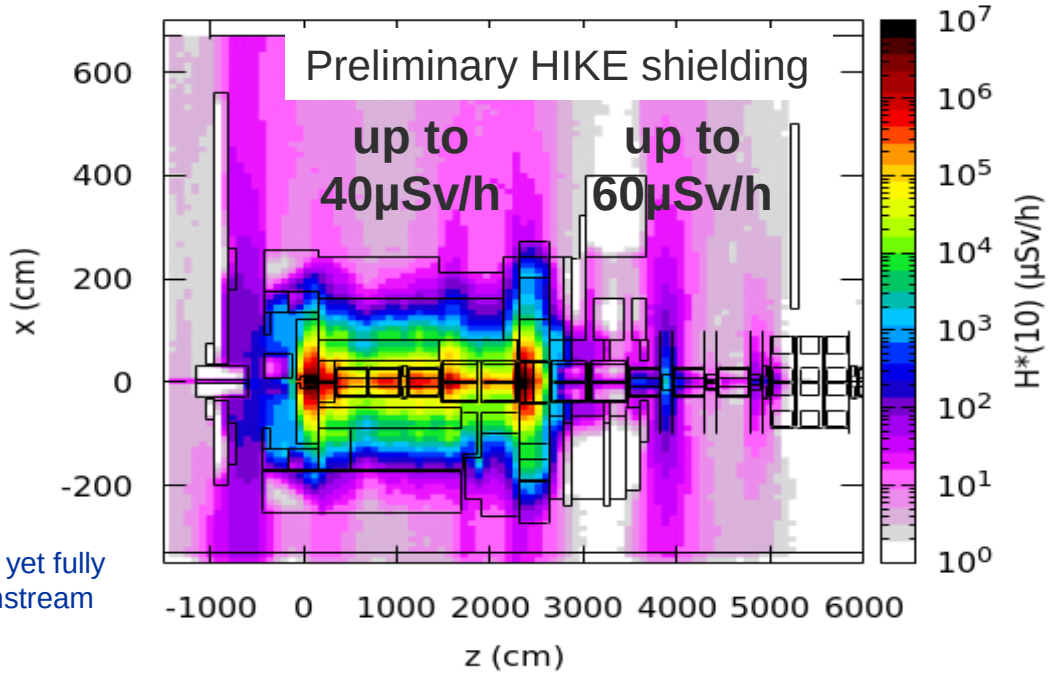


Reduction of about 75 times in the target region



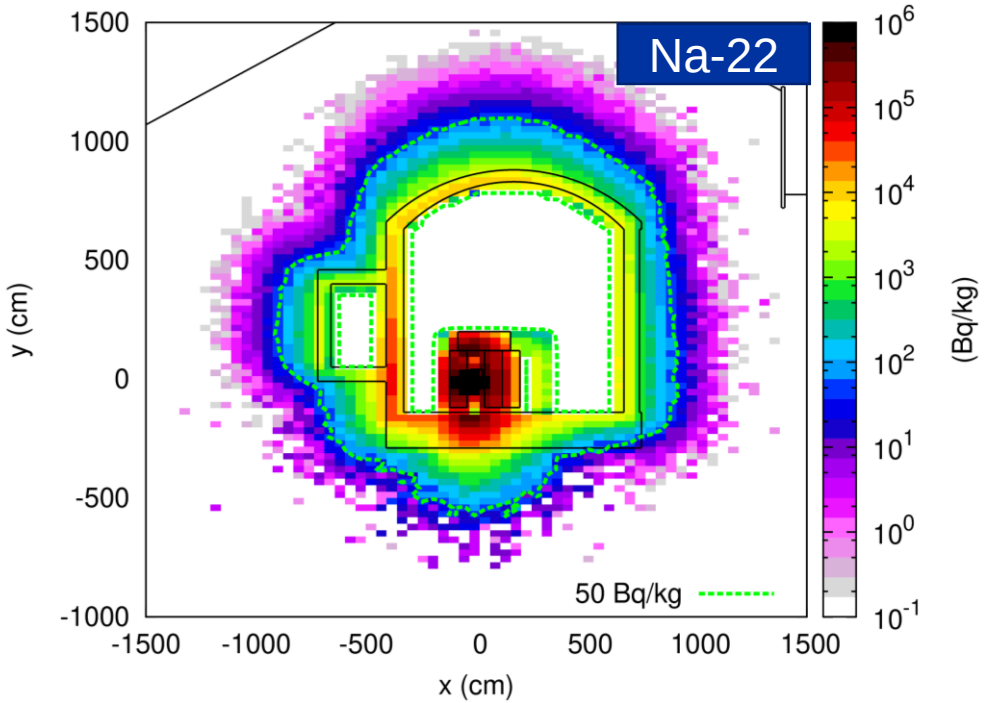
Note: shielding design is not yet fully optimized in the region downstream of the TAX for SHADOWS

HSE-RP (C. Ahdida, E. Nowak)

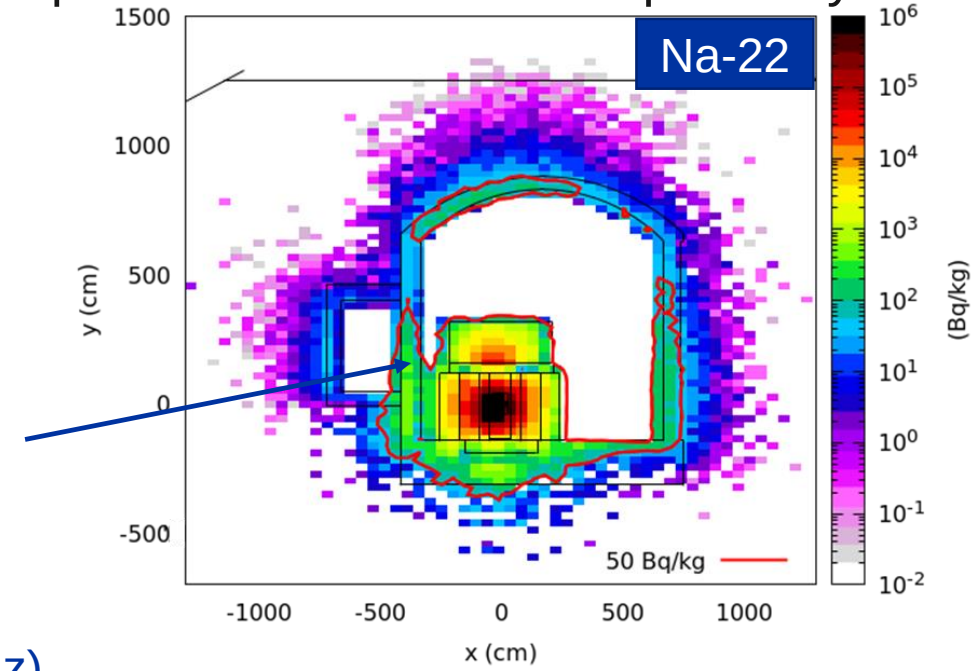
Radiation Protection

ONVENTIONAL BEAMS

- A soil activation study evaluates ground water contamination risks and implies the potential need for further ground shielding (i.e. civil engineering), even with relaxed limits of the overall radio-nuclide built-up during operation of the facility of ^{3}H: 1000 Bq/kg (CENF/BDF CDS: 10 Bq/kg) and ^{22}Na: 50 Bq/kg (CENF/BDF CDS: 2 Bq/kg).
- A dedicated hydrogeological study at ECN3 would allow to predict these limits more precisely.



Additional concrete shielding foreseen on Jura side



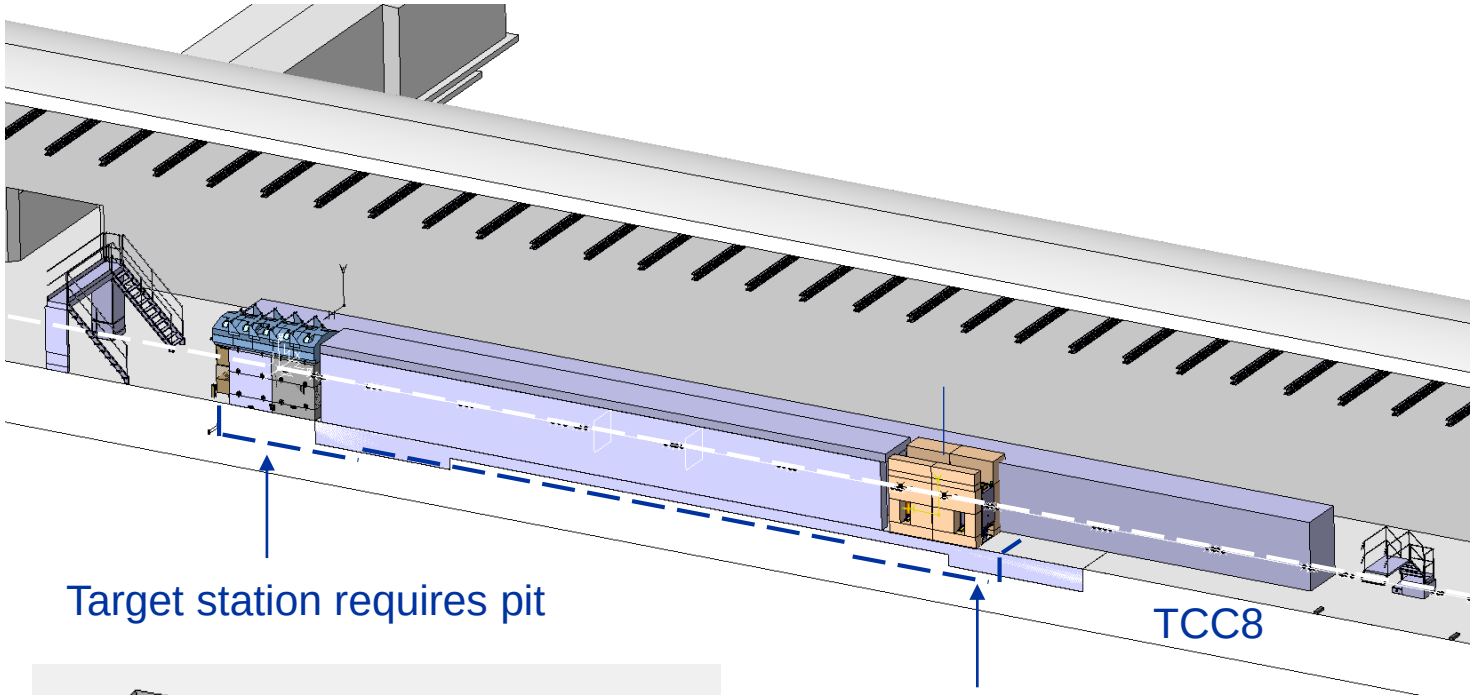
Target area (6 m in z)

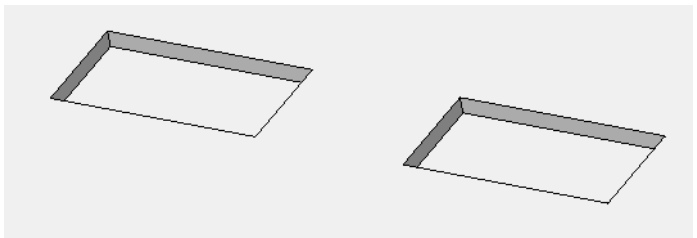
HSE-RP (C. Ahdida, E. Nowak)

Target Complex Civil Engineering

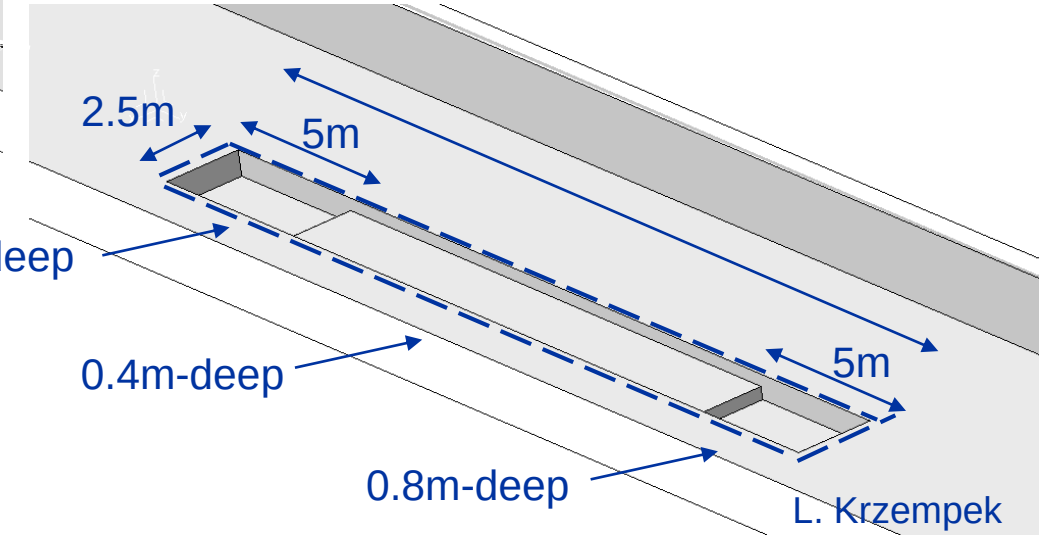
ONVENTIONAL BEAMS

Jura side





Potential excavation works in TCC8 cavern
For target / TAX complex

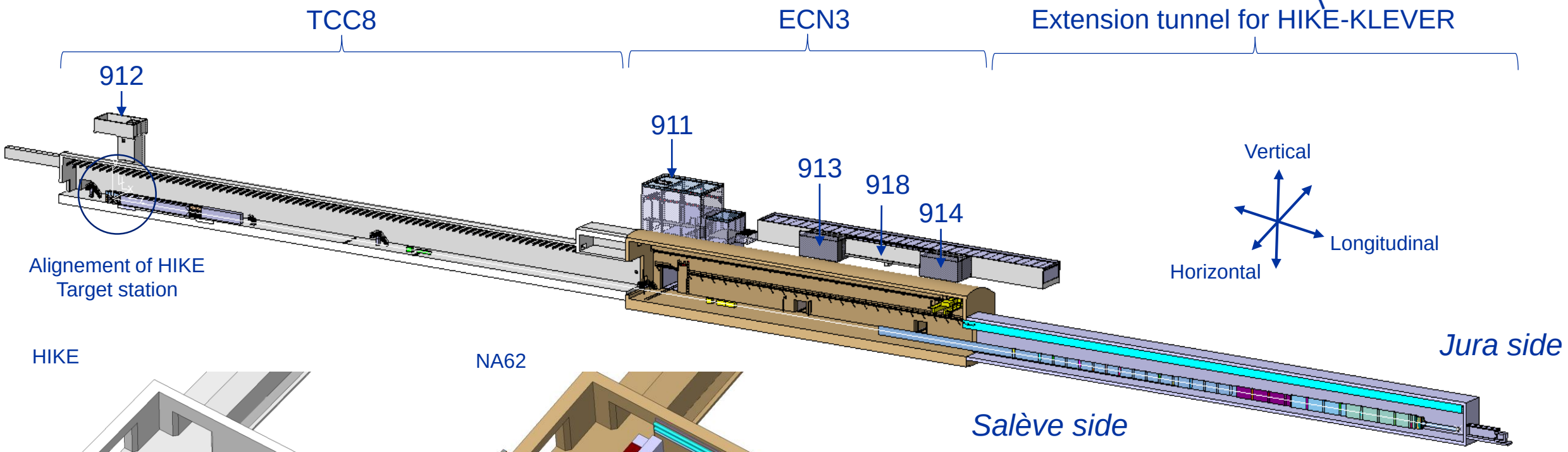


Salève side

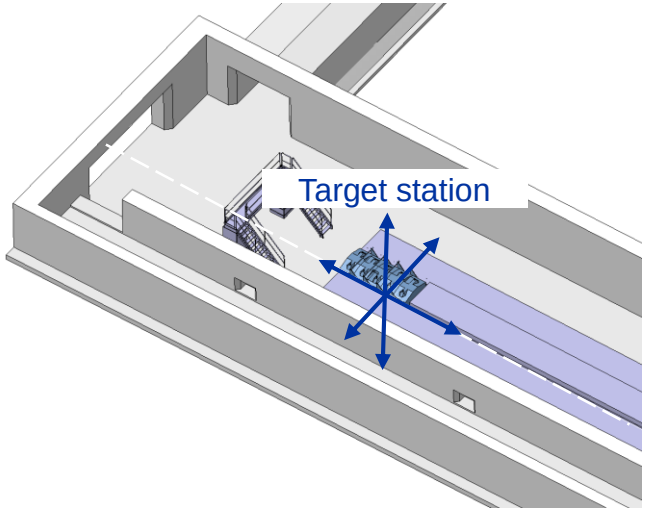
Lifting beam line up by 0.4m would reduce excavation works to 2 square pits of 2.5 m x 5 m x 0.4m
→ To be studied.

HIKE-KLEVER Integration

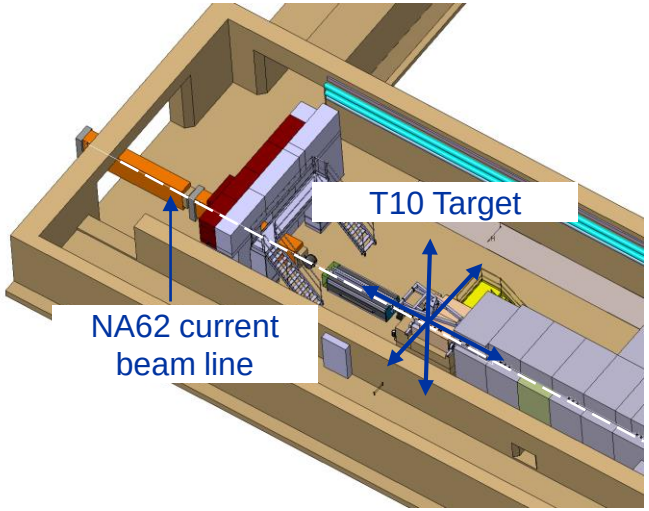
ONVENTIONAL BEAMS



HIKE



NA62



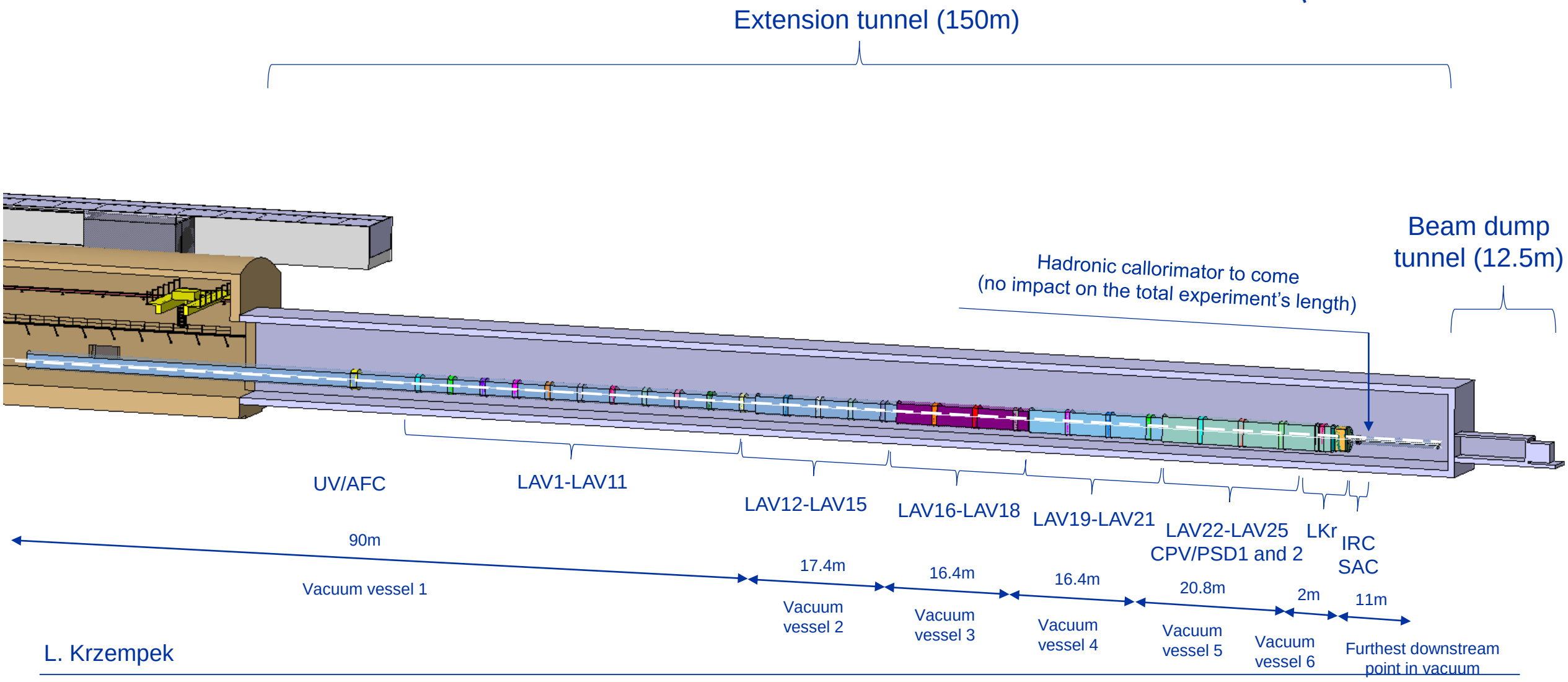
HIKE-KLEVER is aligned:

- Longitudinally wrt T10 Target
- Horizontally wrt current NA62 beam line
- Vertically wrt current NA62 beam line

L. Krzempek

HIKE-KLEVER Integration

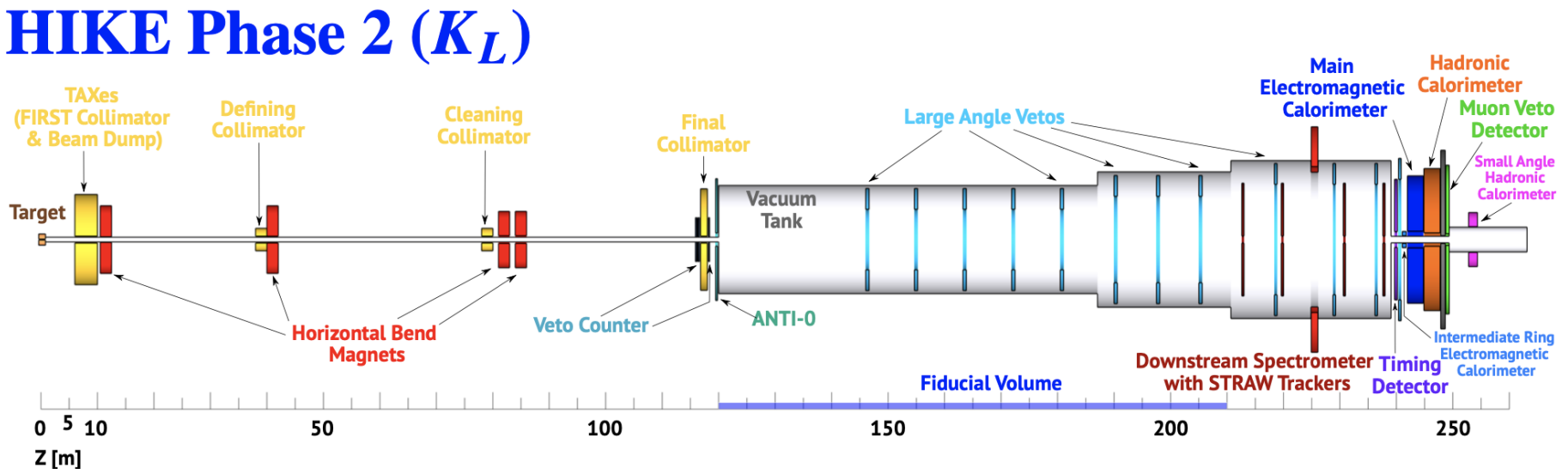
ONVENTIONAL BEAMS



L. Krzempek

HIKE Phase 2

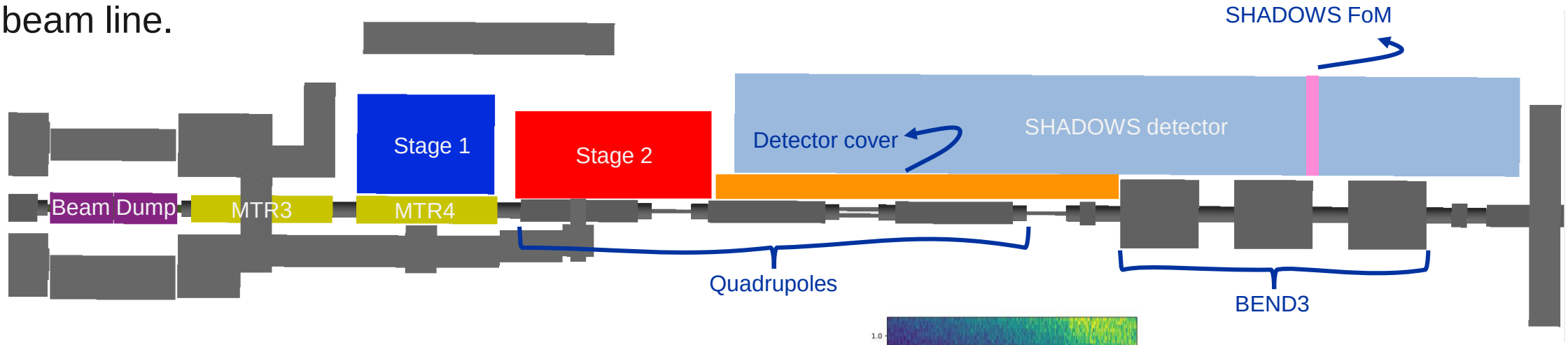
- A recent addition to the studies is the HIKE Phase 2 set-up, aimed at multi-purpose measurements with high-intensity neutral beams and tracking in the HIKE spectrometer.
- Based on the original HIKE-KLEVER beam design, a 120 m-long beam line with 0.4 mrad acceptance is proposed with minimal changes to the HIKE set-up.
- First ideas have been discussed and a first design will be started next, to be included in the next update of the CBWG report.

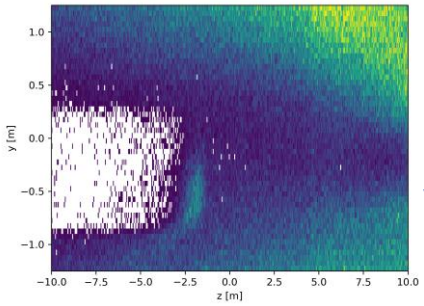


C. Lazzeroni et al.

SHADOWS

- The original idea of a two-stage muon shield has been further developed. Several iterations on position of the magnets have been completed, leading to an overall reduction of the muon background by a factor 10.
- In a next step, a passive detector cover has been added to shield against stray muons from the beam line.





Muons entering the side of the SHADOWS acceptance

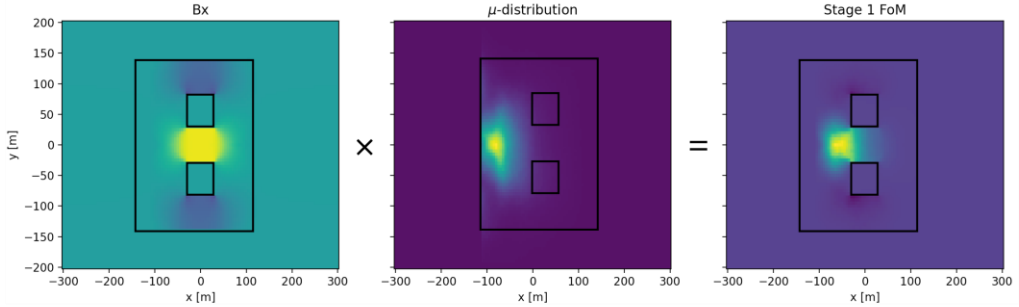
F. Stummer

SHADOWS

ONVENTIONAL BEAMS

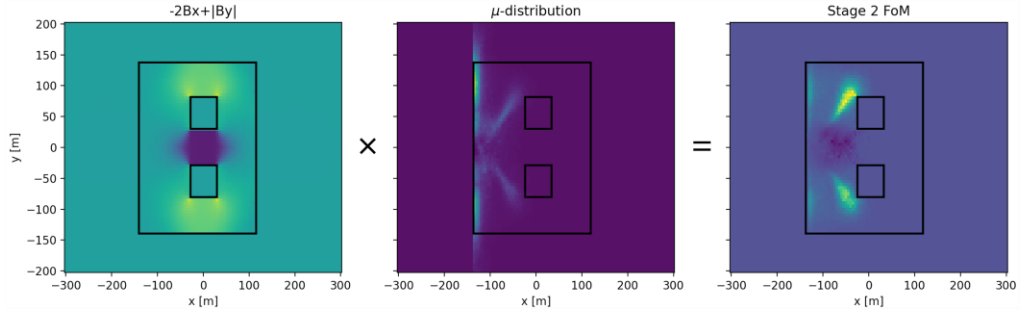
- A Figure of Merit (FoM) has been constructed, including the initial muon distributions as well as the preferred deflection and maximum field of the two stages.
- Then, a set of 20000 different magnet designs has been generated with field calculations in FEMM, varying the most important magnet parameters.

Stage 1

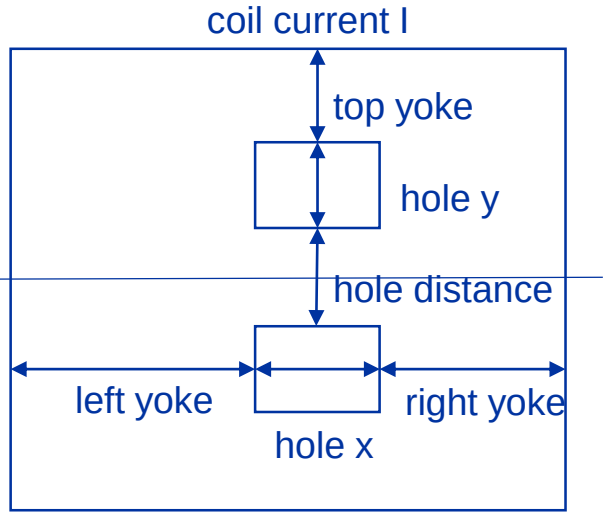


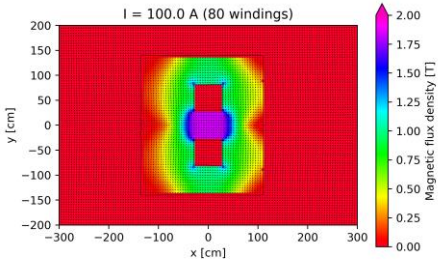
$$\longrightarrow FoM = \sum_{bins} Stage\ 1\ FoM$$

Stage 2



$$\longrightarrow FoM = \sum_{bins} Stage\ 2\ FoM$$

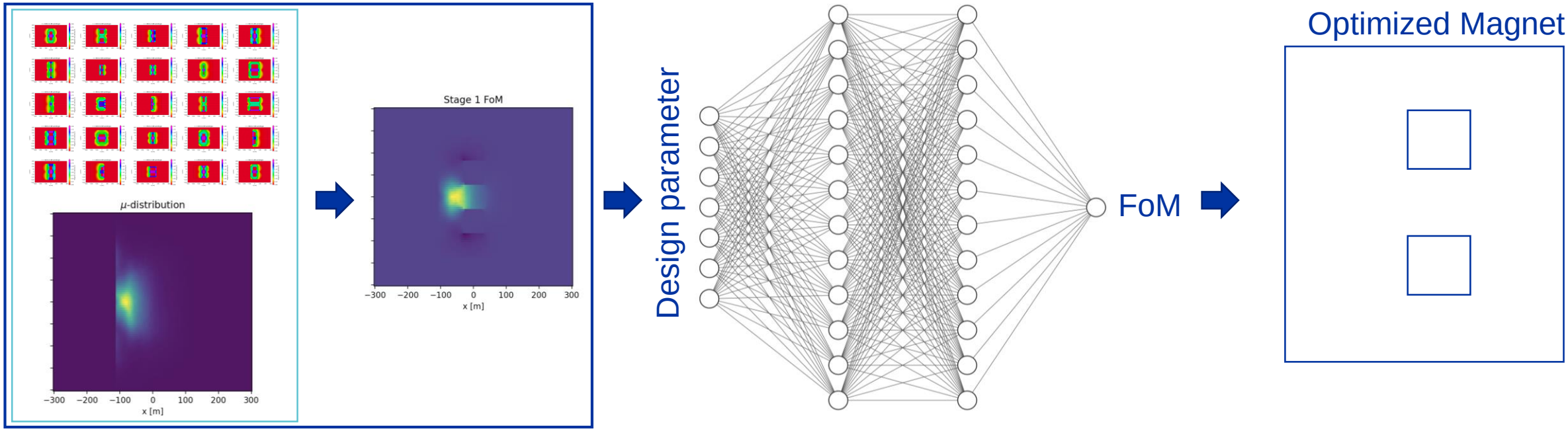




F. Stummer, T. Zickler

SHADOWS

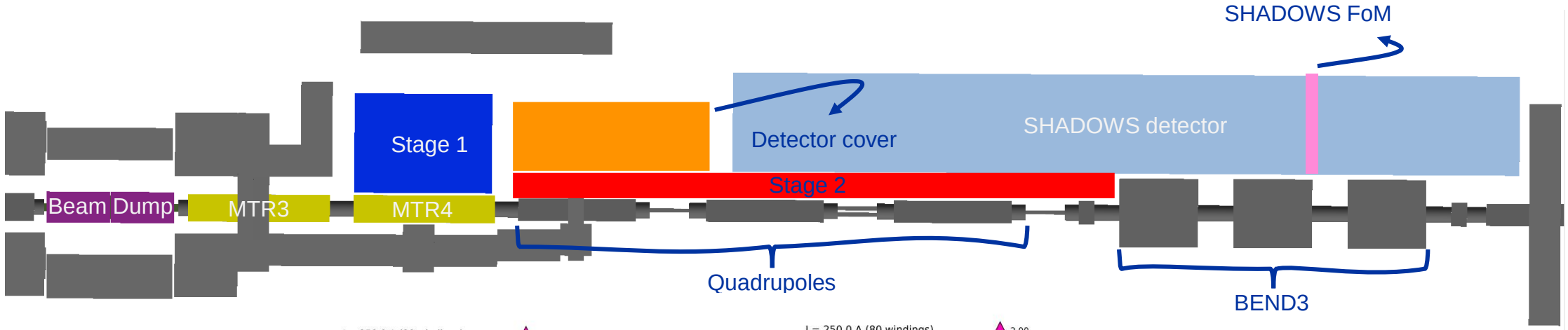
- A deep neural network (DNN) was then trained with the FoM of the 20000 generated samples,
- The 100 designs giving the best FoM have then been modified by the DNN for further design optimisation.
- The procedure then has been iterated several times for stage 1 and stage 2.



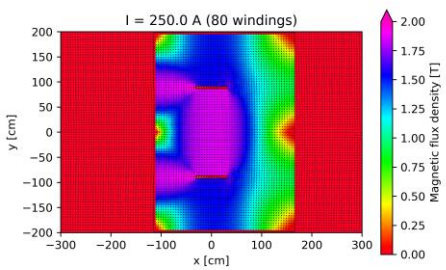
F. Stummer

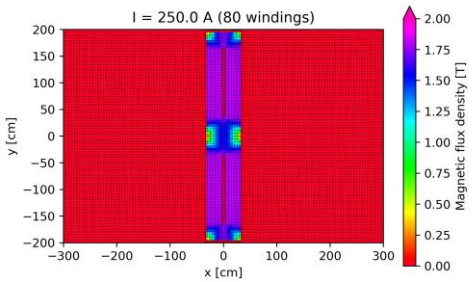
SHADOWS

- A deep neural network (DNN) was then trained with the FoM of the 20000 generated samples,
- The 100 designs giving the best FoM have then been modified by the DNN for further design optimisation of this conceptual study.
- The procedure then has been iterated several times for stage 1 and stage 2.



Stage 1 Magnet



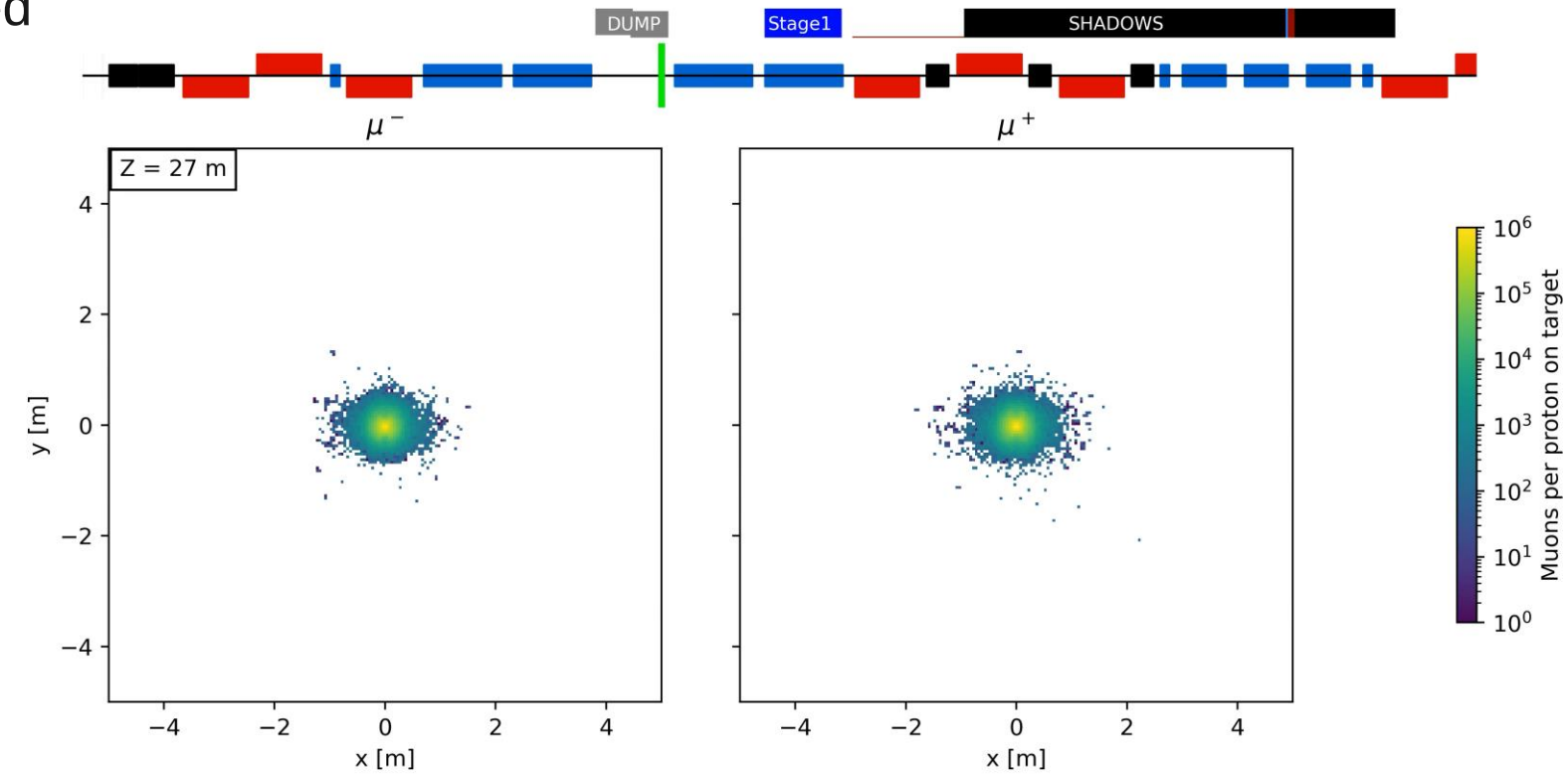


Stage 2 Magnet

F. Stummer

SHADOWS

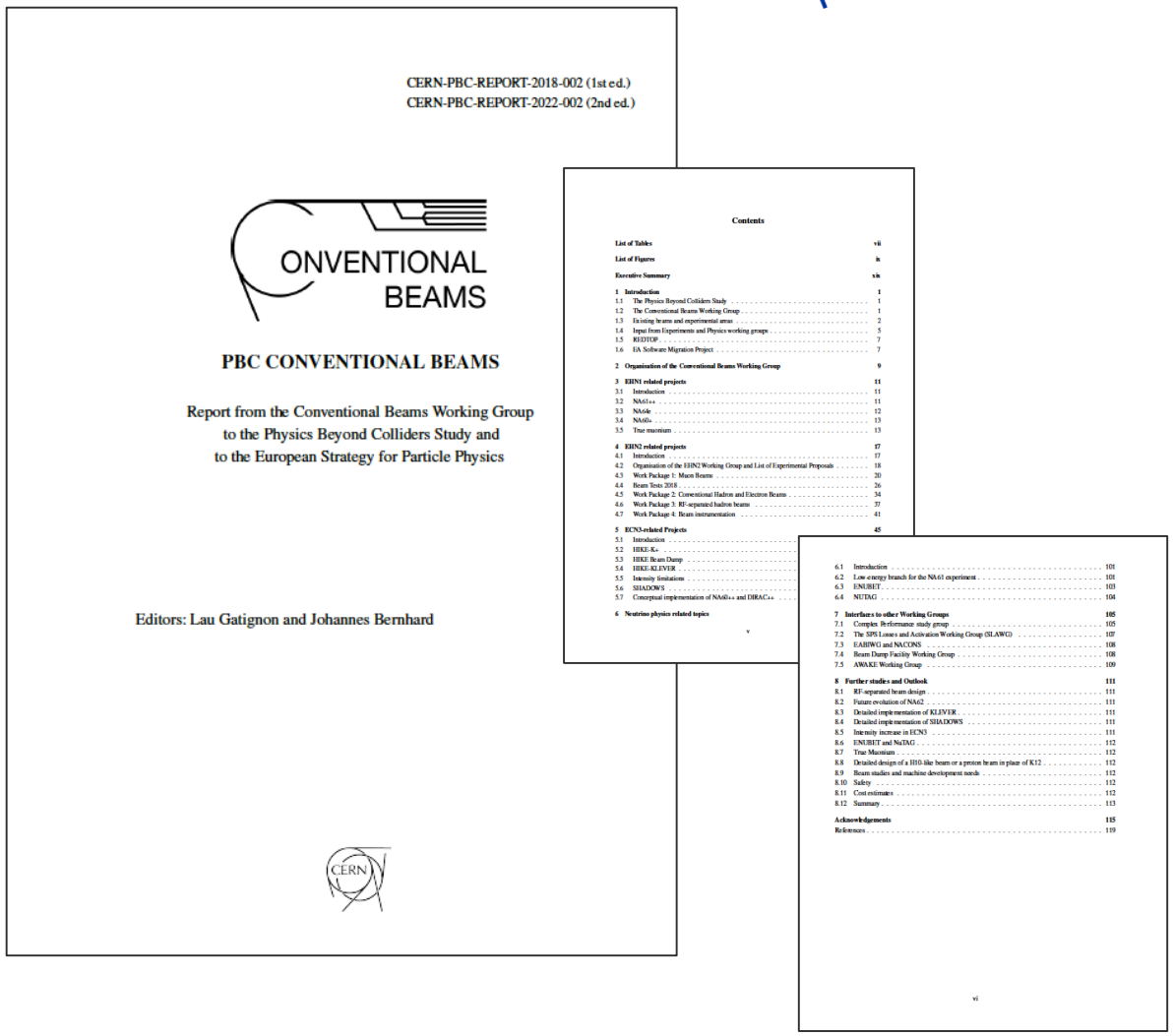
- The new design proposal reduces the muon background for SHADOWS by a factor of 157 without impact on the HIKE muon rates.
- Mechanical stability and other engineering aspects will be included in further optimisations. Integration, handling, required services etc are not yet studied and will be tackled next.



F. Stummer

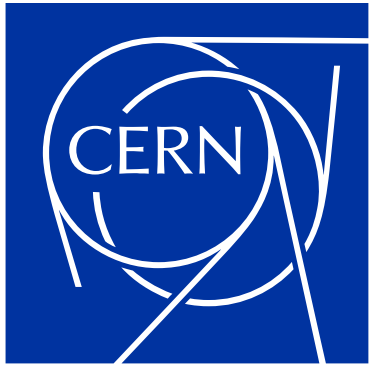
Updated Report

- The PBC CBWG Report has been updated to reflect studies done during LS2 and included some update on the first measurements with new beam configurations.
- The current second edition is a snapshot and will be updated further with the upcoming findings for ECN3 and the other CBWG subgroups.
- For traceability, the original report is still available as CERN-PBC-REPORT-2018-002 while the new version is called CERN-PBC-REPORT-2022-002 (same CDS link).
- The next edition will be published as a Yellow Report.



Summary

- The ECN3 subgroup of the Conventional Beams Working Group has successfully integrated the new ideas for **HIKE** and **SHADOWS**.
- While the current **focus is on the beam delivery** for higher intensities via the **ECN3 Task Force**, substantial progress was made for the radiation protection and integration aspects of HIKE.
- The next priority is the **optimised design of the target/TAX complex in TCC8** that is compatible with the North Area Consolidation Project, all three phases of HIKE, SHADOWS data taking, radiation protection needs and operational, handling and maintenance aspects.
- The new idea of a short K_L beam as **HIKE Phase 2** will be studied and a new beam design will be proposed. For **HIKE-KLEVER**, the studied **extension of ECN3** offers the possibility to include further collimation stages, subject to further investigations.
- A new **muon sweeping system** has been designed for **SHADOWS** that significantly reduces the muon background.
- The next important steps will be a mechanical design for the SHADOWS muon sweeping magnets, the integration of the full **SHADOWS** setup, the evaluation of **R2E** for the SHADOWS frontend electronics, and several **infrastructure aspects** such as access to the experimental area. Integration of an optional neutrino detector downstream of SHADOWS will be started soon.



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