International MUON Collider Collaboration

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Muon Cooling Demonstrator: CERN implementation

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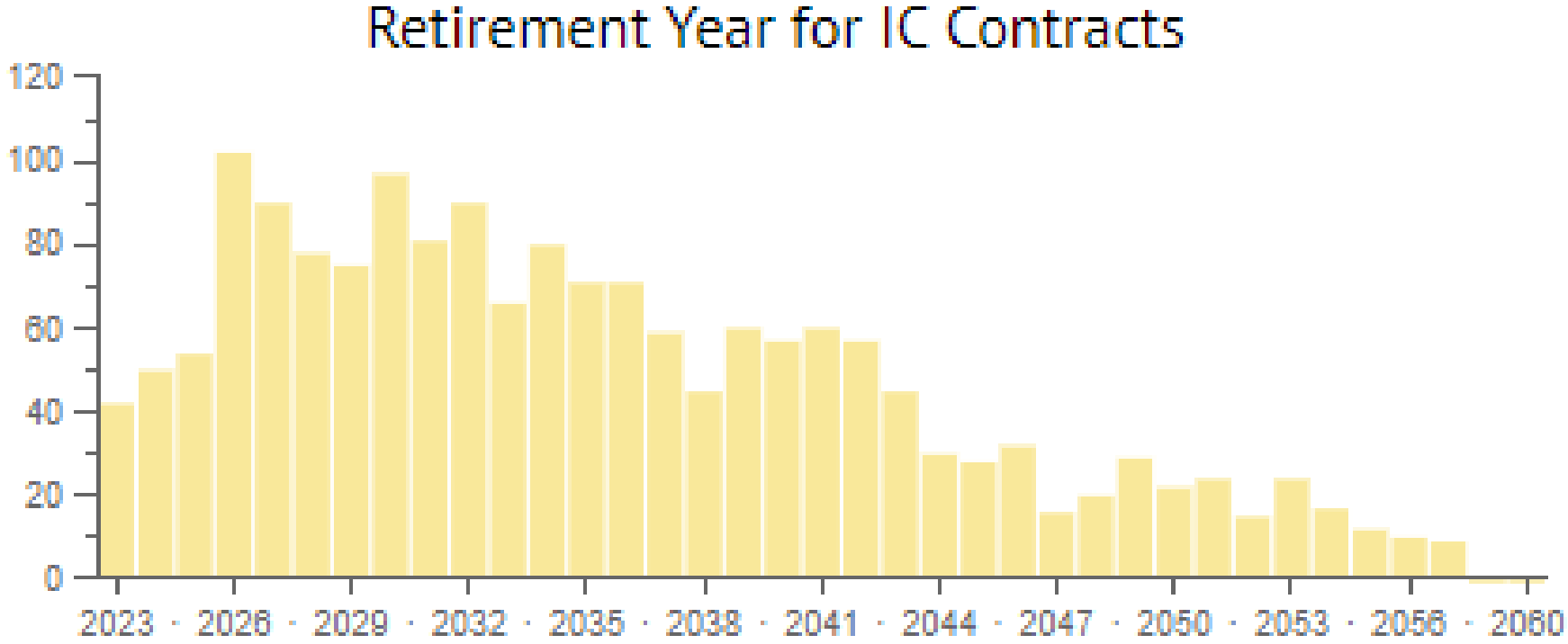
CERN

Funded by the European Union (EU). Views and opinions expressed are however those of the author only and do not necessarily reflect those of the EU or European Research Executive Agency (REA). Neither the EU nor the REA can be held responsible for them.

Outline

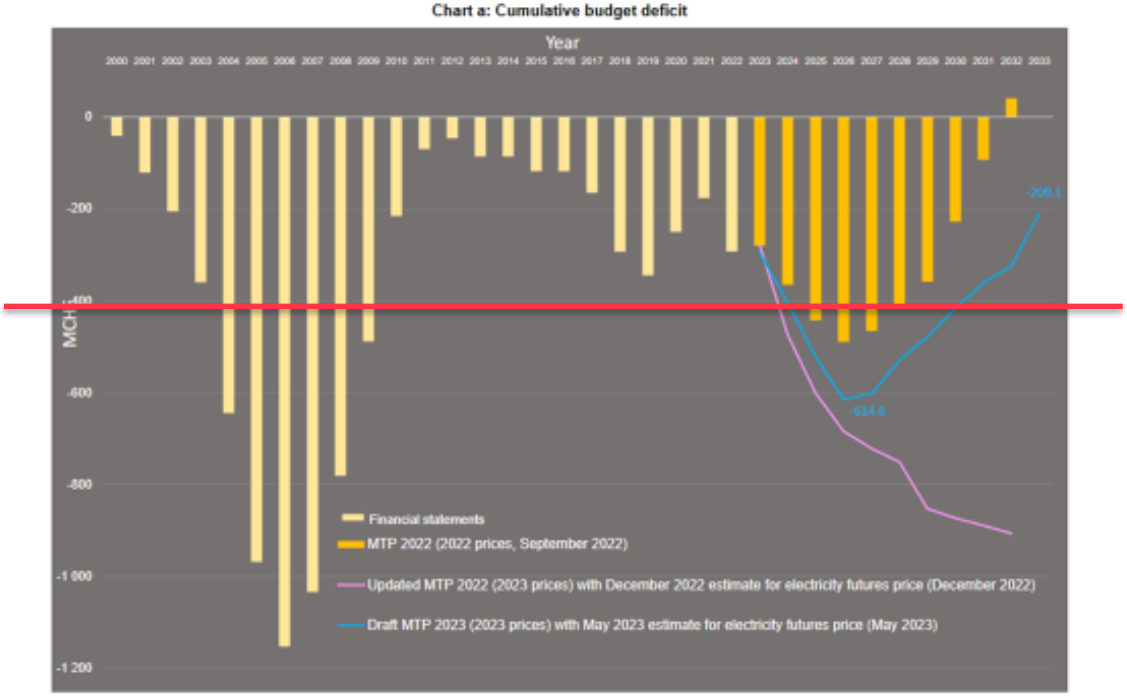
- The next 10÷15 years at CERN
- The two options
  - Low-Power (10 kW) site
  - High-Power (80 kW) site
- A possible roadmap
- Conclusions

Personnel evolution (Courtesy J. Purvis)



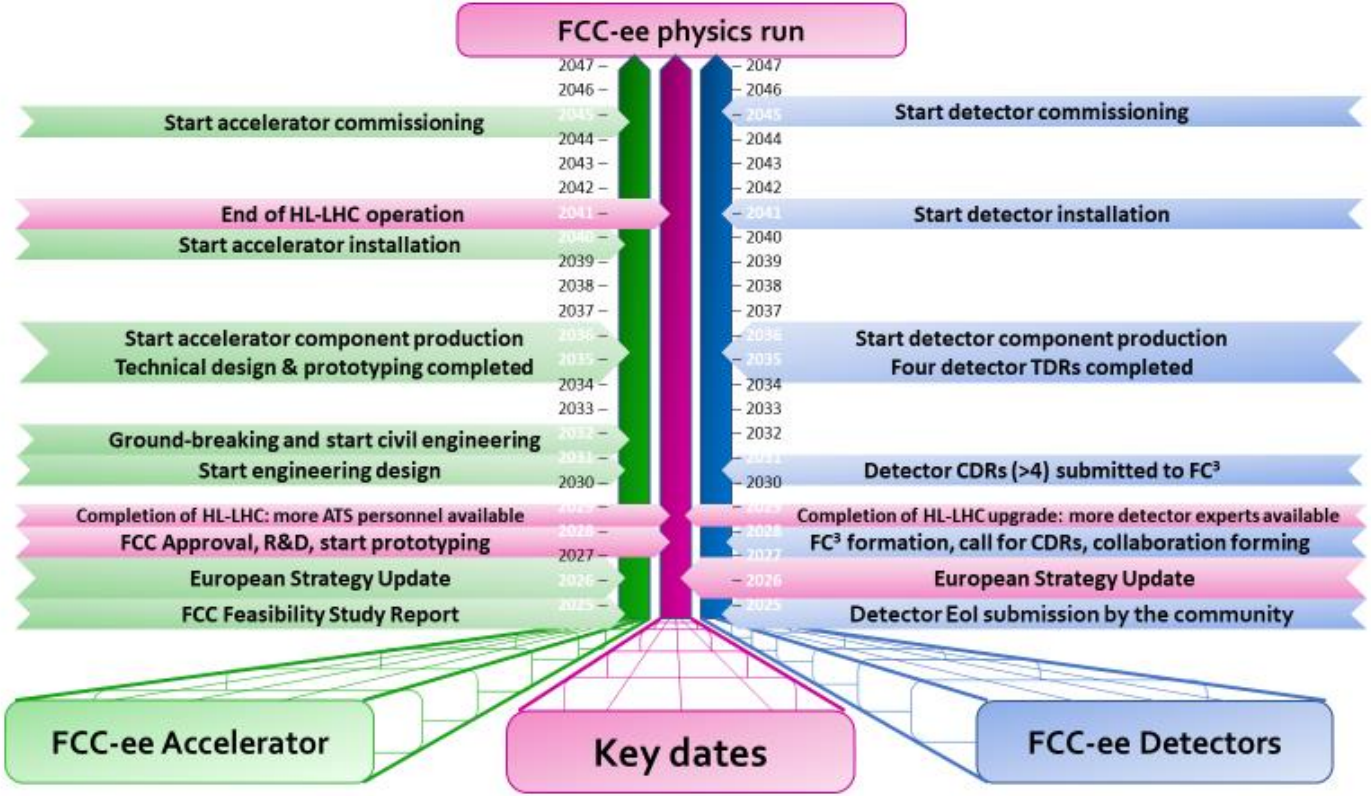
Long term financial planning at CERN (F. Sonnemann, FCC Week 23)

Financial planning and reporting cycle



Aim: to be close to zero in the beginning of the 2030ties such as to be able to afford starting the construction of the next large facility (i.e. post HL-LHC).

FCC-ee roadmap (M. Benedikt, FCC week 2023)

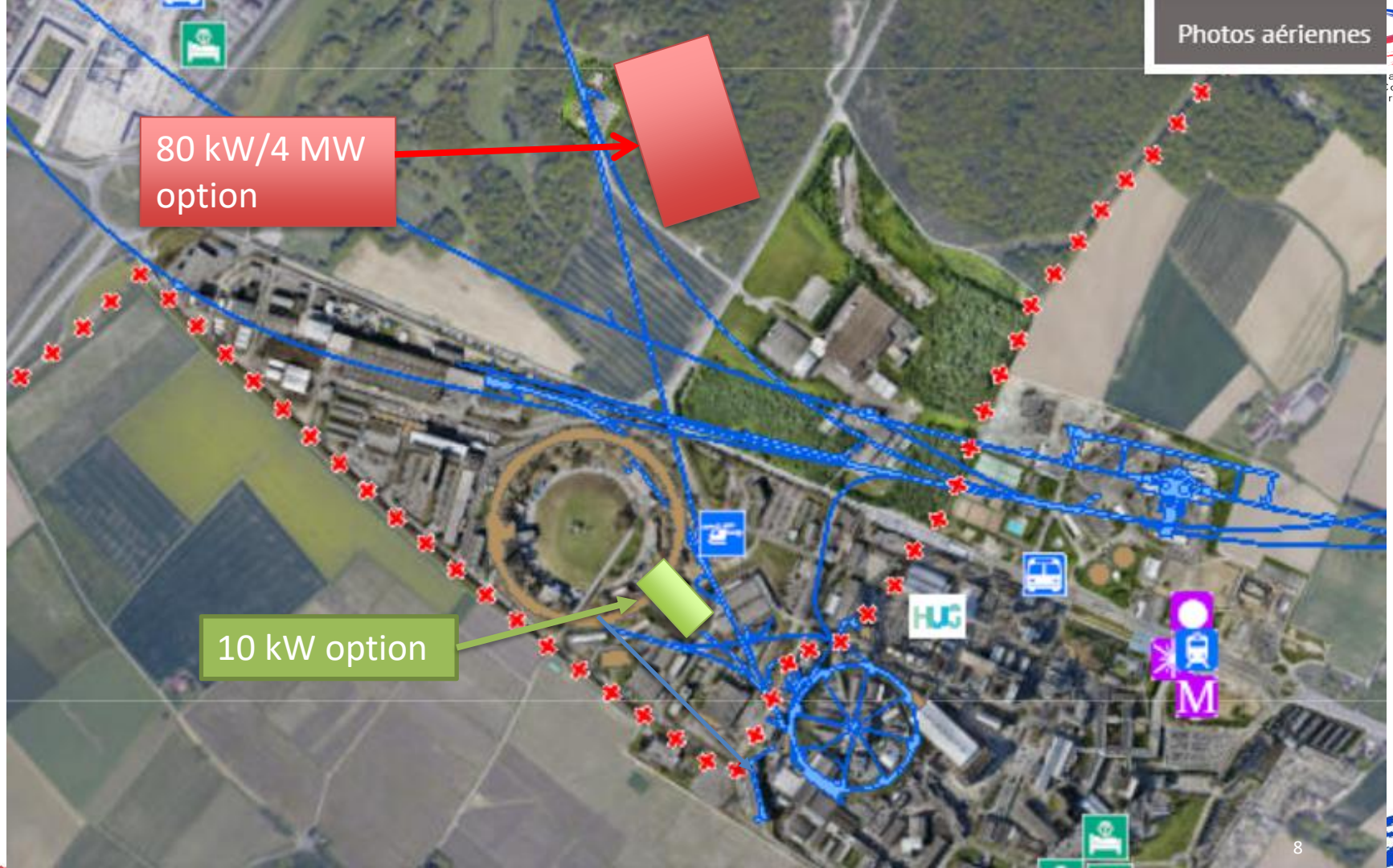


Implementation at CERN

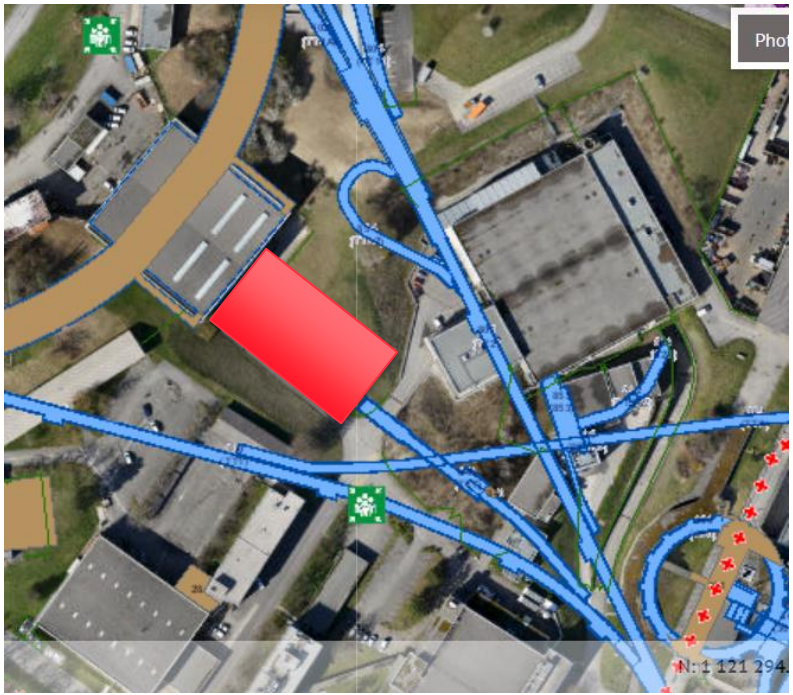
- We have a potential perfect storm in front of us…
- In the years 2025-2035 there will be a limited pressure from the FCC-ee study on equipment groups at CERN and in collaborating Institutes.
- Engineering design will start only after 2030, component construction only after 2035
- In the same period 1000+ people will retire, a considerable amount of know how will have to be transferred and maintained
- **CERN needs to have a project of a size that is sufficiently large to provide a platform for training of new arrivals, but not too big to jeopardise the main activities (HL-LHC commissioning and operation, FCC).**
- **The Demonstrator can therefore be organised to be complementary** and in support of the FCC-ee. Level of resources involved should be modulated in this respect.
- The Demonstrator can play the role that the various CTF facilities have played in the past: a nice framework for the development of new technologies as well as a place where young people can take relevant scientific and technical responsibilities, in a less stressful environment than LHC or FCC. It can be a fantastic gymnasium for part of the 1000+people that will be hired

Demonstrator Options at CERN

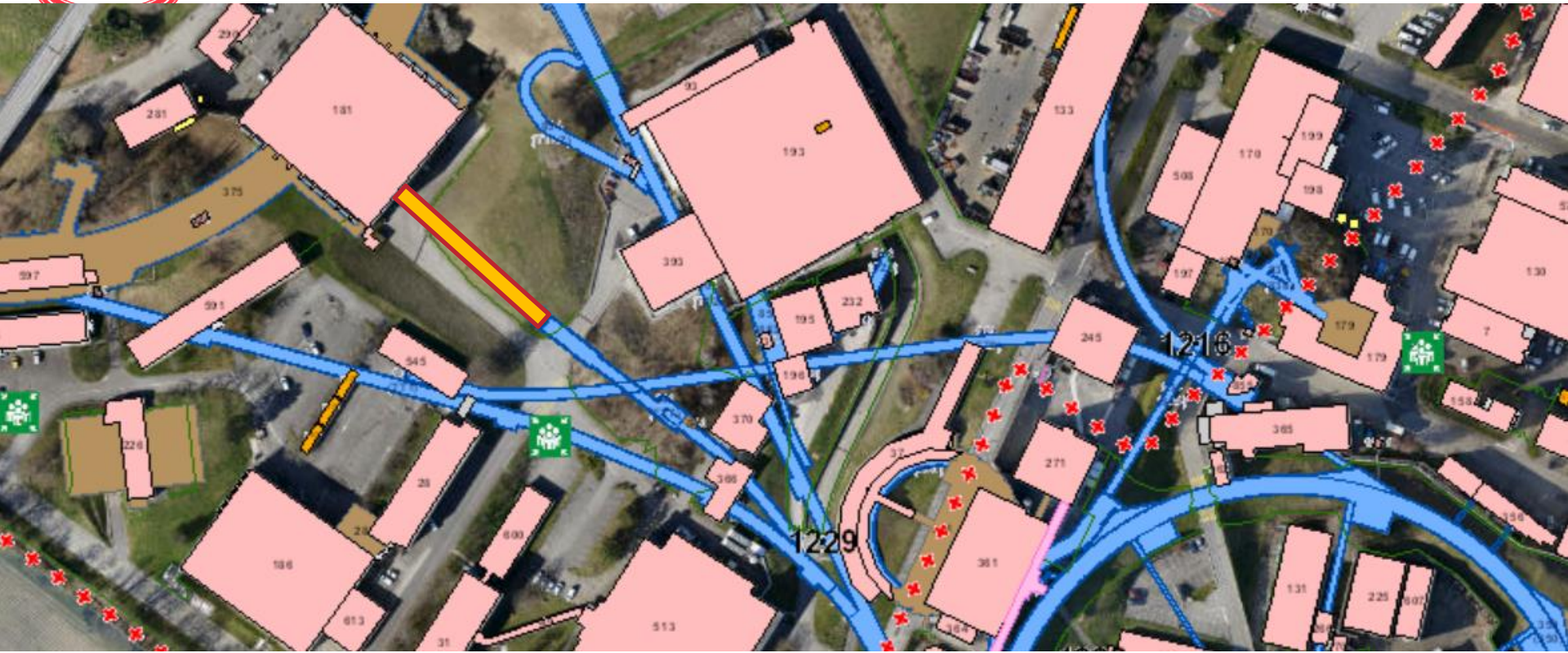
- Two options are being studied at CERN for the implementation of the Muon Cooling Demonstrator
- Both options allow using the maximum intensity per pulse 10^{13} ppp (or more) in pulses of few ns at 20+ GeV.
- The difference is in the repetition rate:
  - Up to one pulse every few seconds on the high-power site
  - One or two per minute on the low-power site.
- Cost and timeline are different as we will see in the next slides


Photos aériennes
80 kW/4 MW option
10 kW option
HUG
M

TT7 Low Power option



- Reusing the line of the BEBC-PS180 Collaboration, presently decommissioned.
- Extending it towards B181 (presently used as magnet factory)
- Shallow tunnel (10m underground)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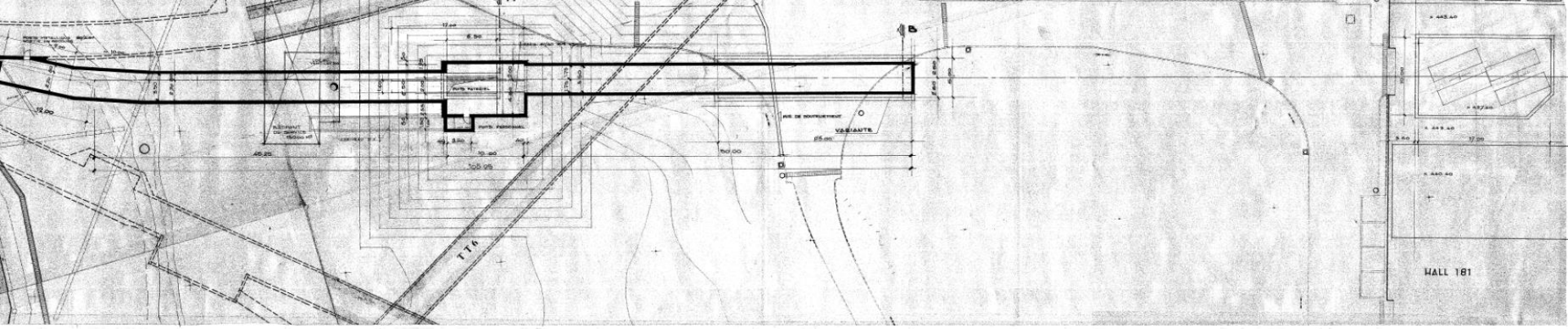
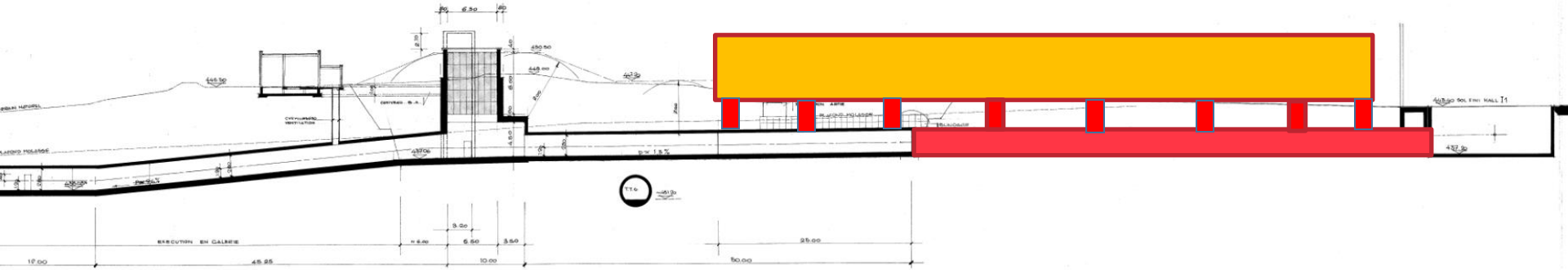
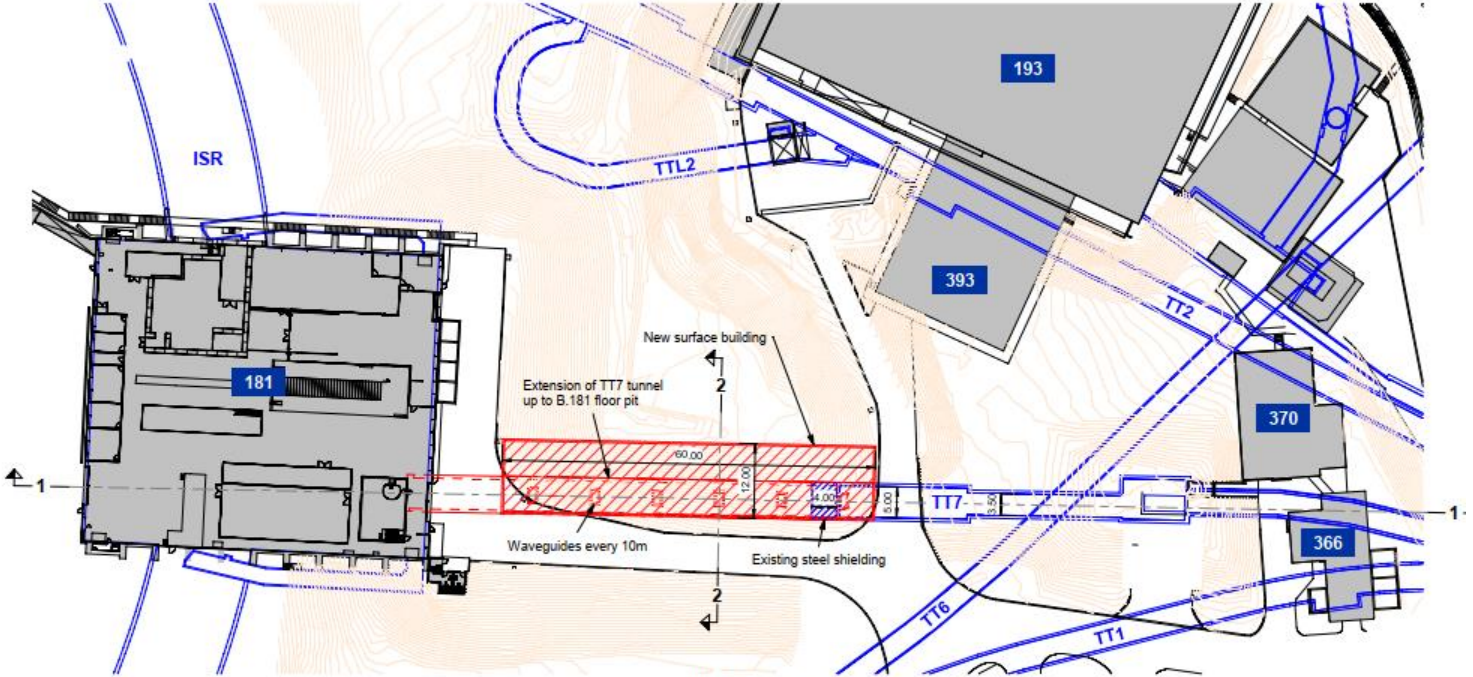
1229





Building above the tunnel with waveguides every 10m

TT7 Low Power option



PLAN VIEW

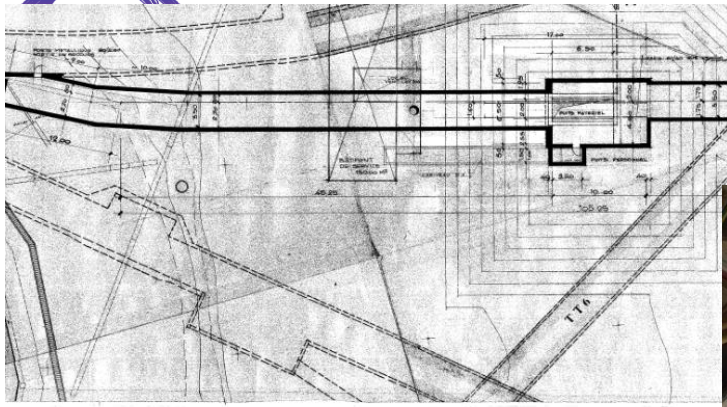
Sc. 1 : 500

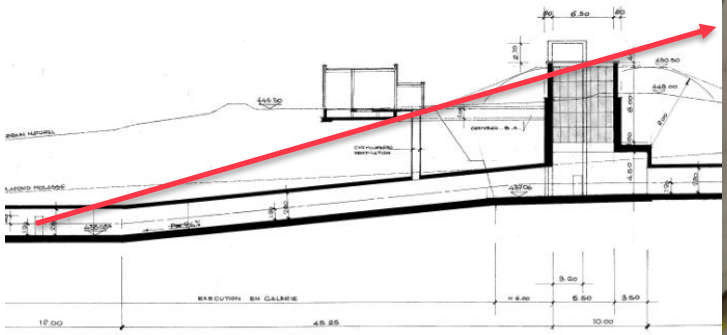
TT7 low power option

- Average power limited to 10 kW
- Peak intensity ~10^{13} ppp.
  - One pulse every ~ 20÷30 seconds instead of every 5 seconds
- Controls, power and services on surface
- Tunnel already existing, used as repository of very low activity waste to be released before use
- Present tunnel not accessible easily. Maybe not large enough for the chicane.

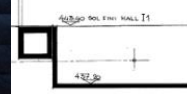
Surface

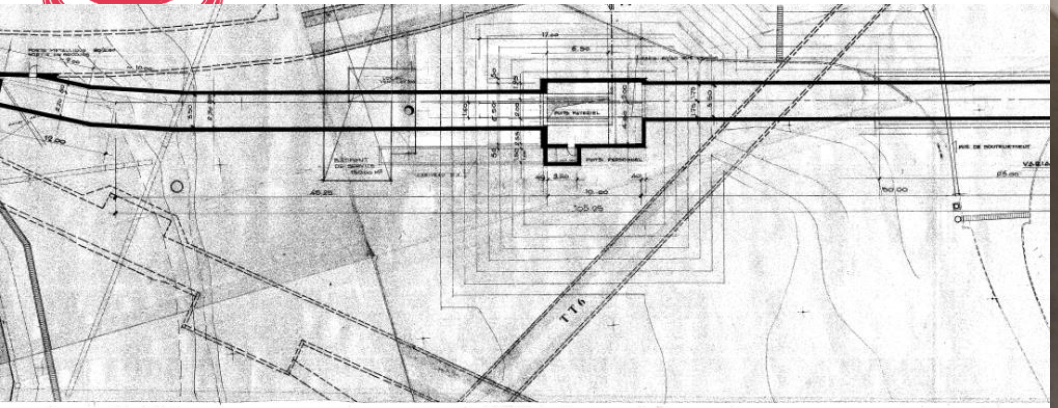
Access gallery (locked during runs)

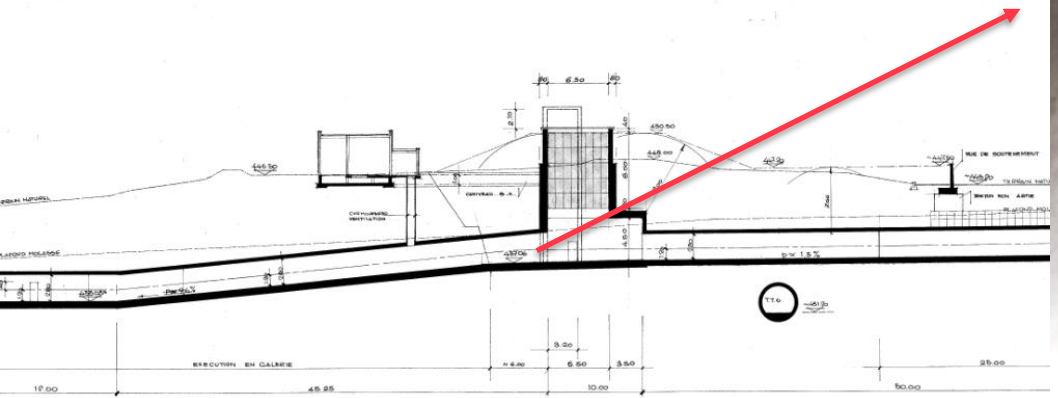


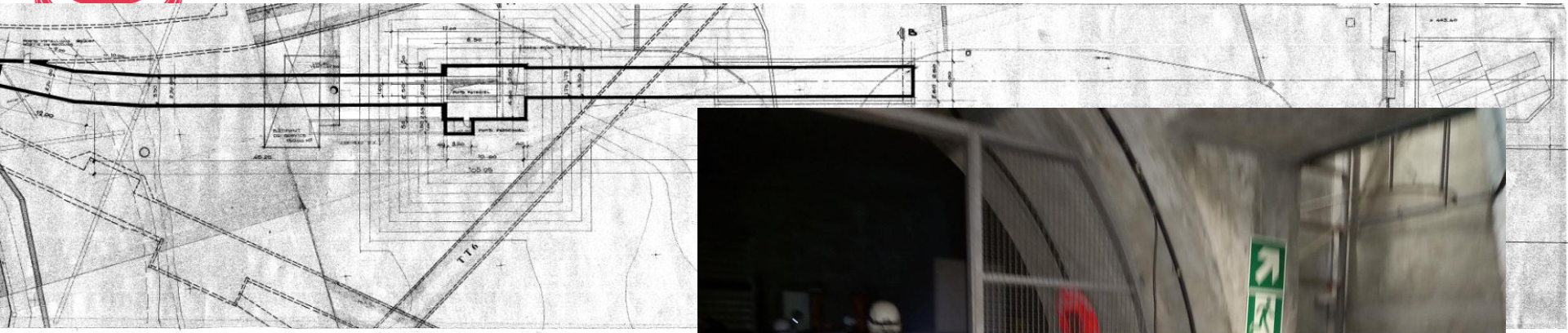


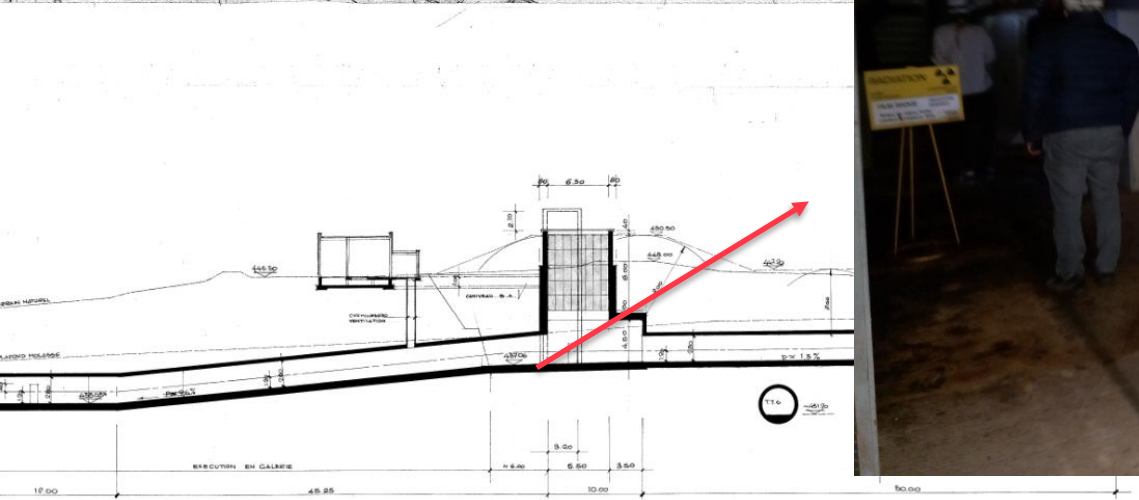

WALL 181

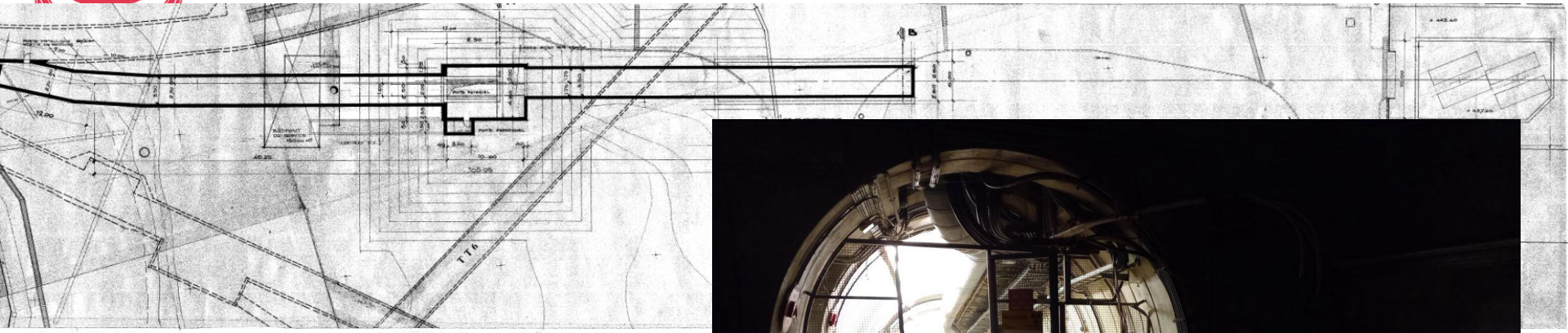



TT6


EXECUTION EN GALERIE
TT6


TT6


EXECUTION EN GALERIE
12.00
45.25
10.00
50.00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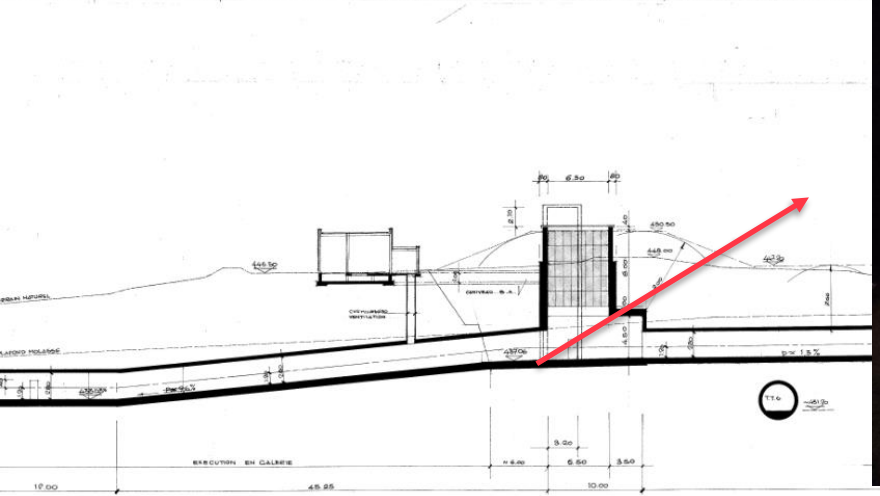
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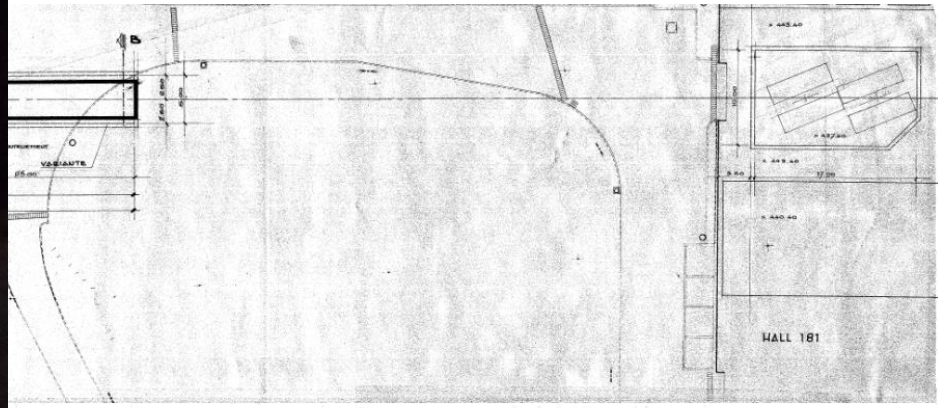
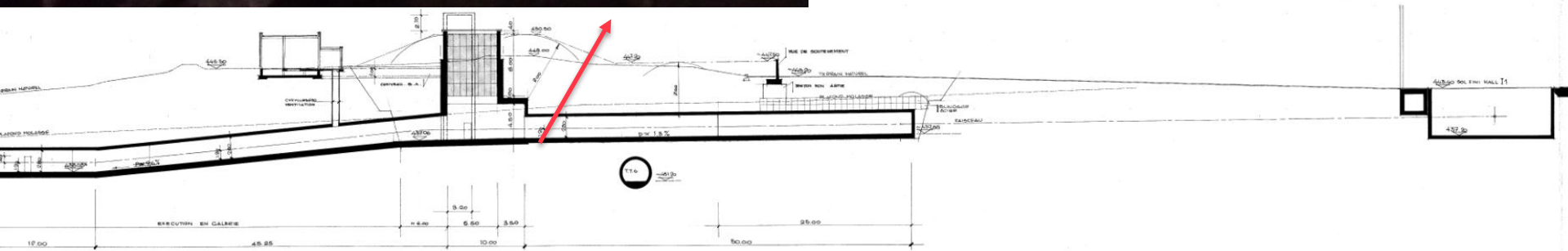
TT6

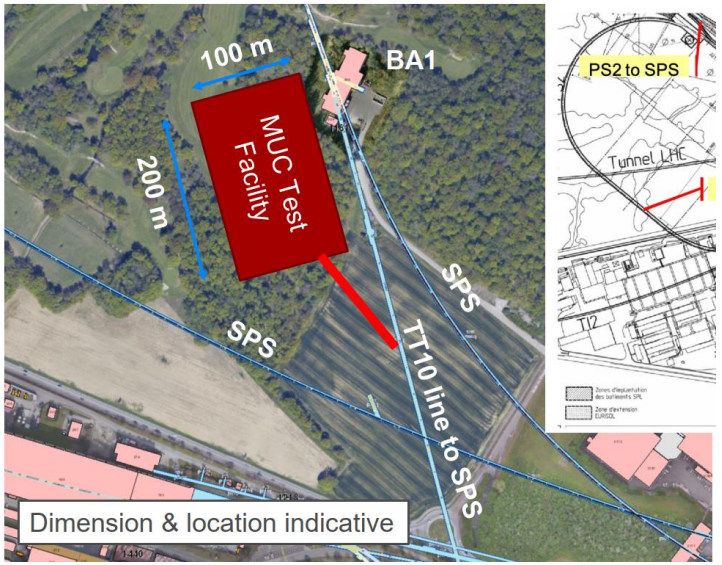

HALL 181


EXECUTION EN GALERIE
12.00
45.25
3.00
6.50
3.50
10.00
25.00
50.00

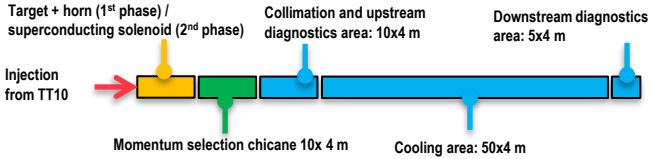
High-Power Option

TT10 line High Power option

- TT10 is the transfer line from the CERN PS (≤26 GeV) to the CERN SPS.
  - O(80kW) on target can easily be achieved.
  - >10^{13} protons can be sent on a target at 20GeV+ in pulses of few nsec (n_TOF beam).
  - 4 MW does not appear to be a showstopper in this layout with beam at a depth of 40 m (detailed studies will have to be performed).
  - Future upgrades towards a collider and HP-SPL are in principle compatible with this layout.

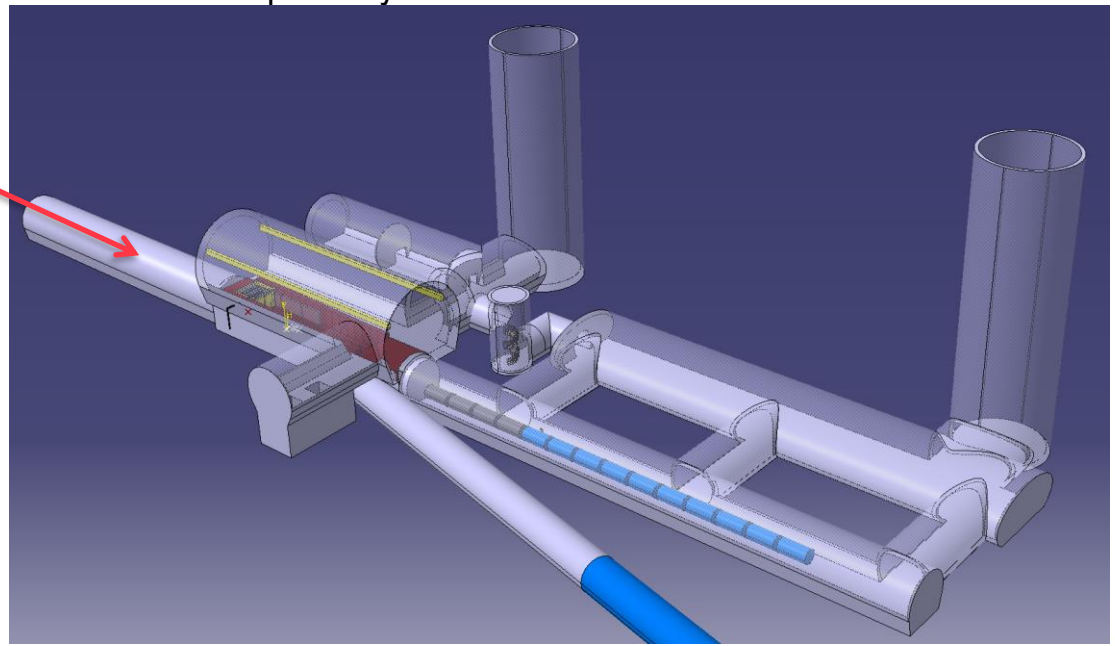


Conceptual layout

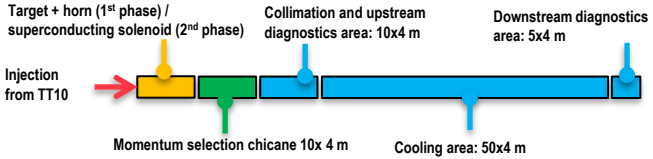


MUC Demonstrator VERY Conceptual layout

CERN TT10 branch

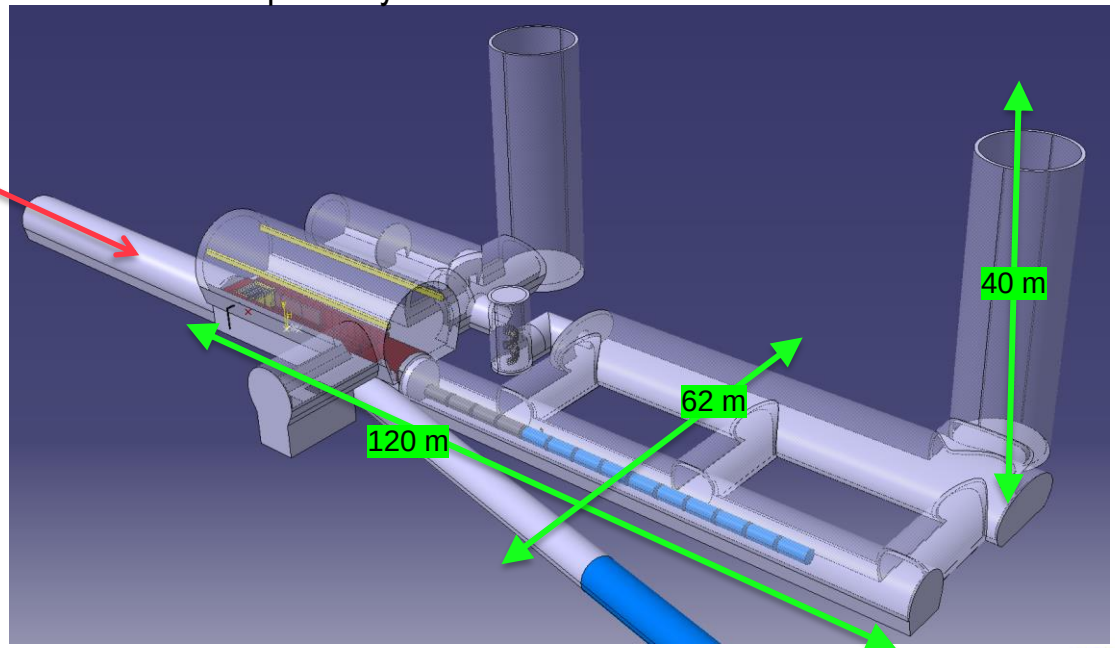


Conceptual layout



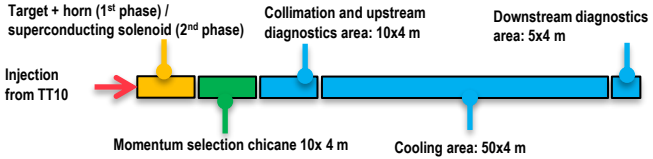
MUC Demonstrator VERY Conceptual layout

CERN TT10 branch

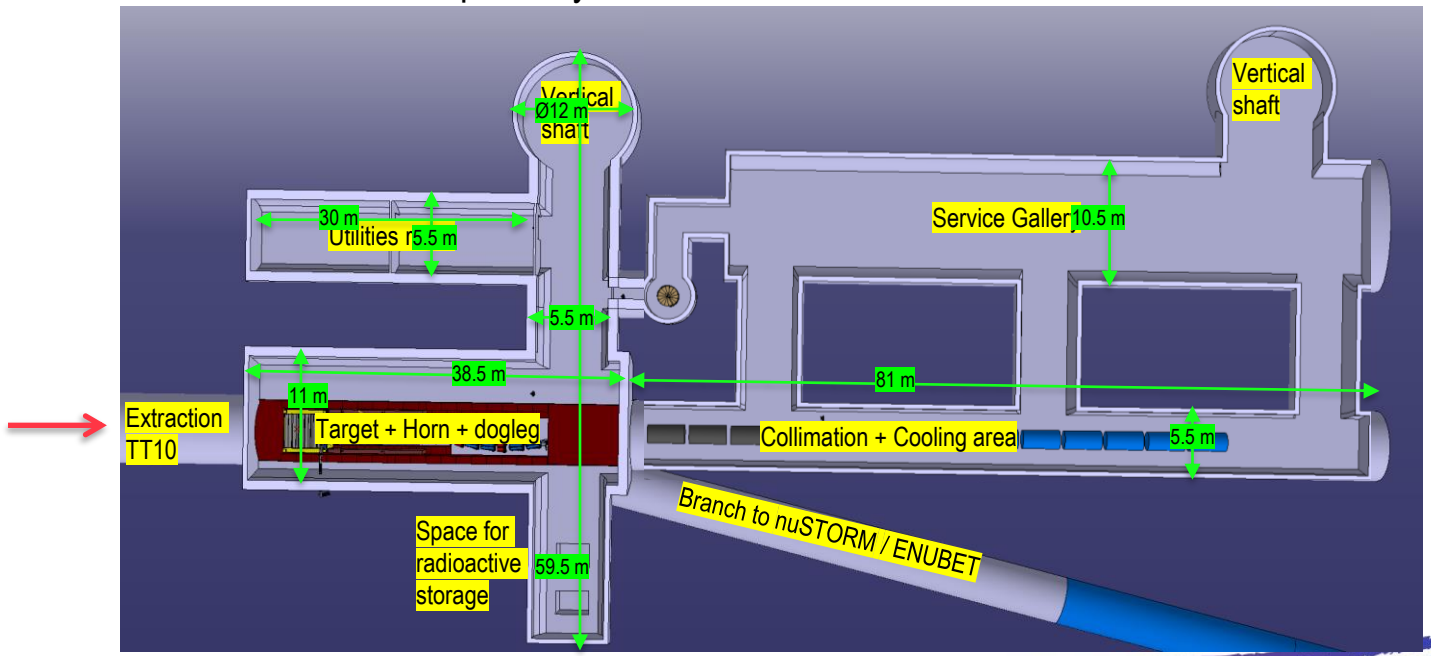


Indicative dimensions. Model is very flexible at this stage

Conceptual layout

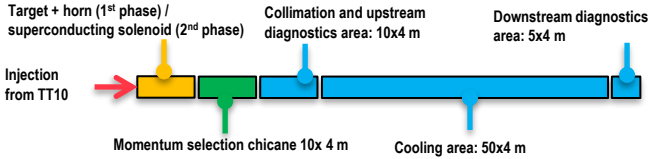


MUC Demonstrator VERY Conceptual layout



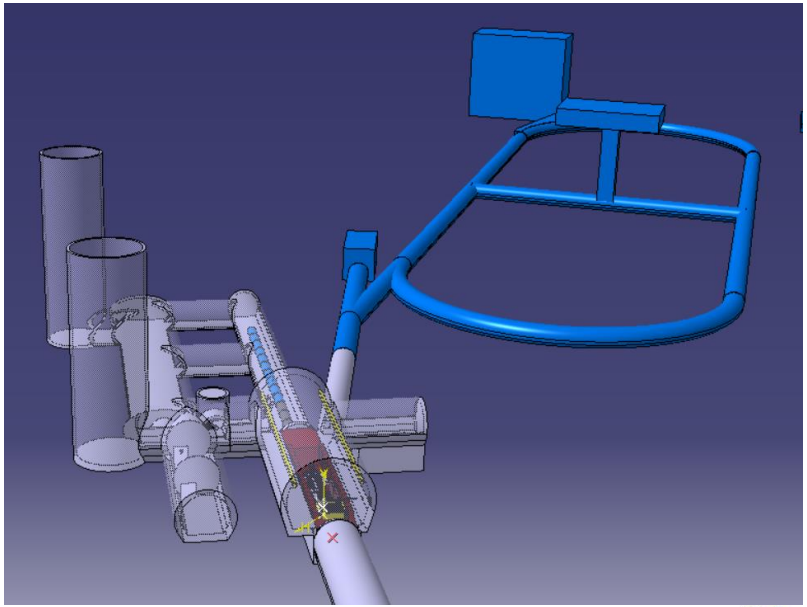
Indicative dimensions. Model is very flexible at this stage

Conceptual layout



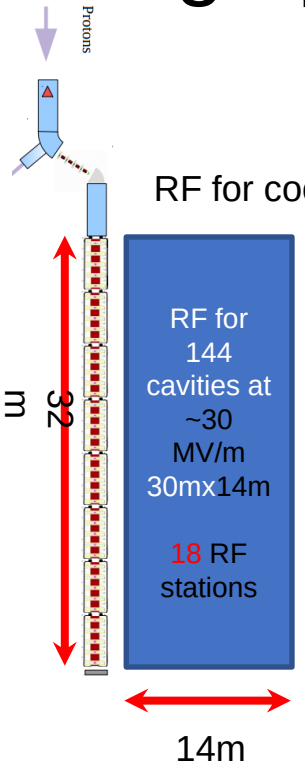
MUC Demonstrator VERY Conceptual layout

- The Facility is flexible enough to accommodate other experiments.
- nuSTORM and potentially ENUBET could be branched from the MUC Demonstrator Facility.
- The same target complex would be used profiting from its shielding and general target systems infrastructure, utilities, and accesses.
- The double deflection of the beamline could reduce radiation streaming towards the nuSTORM ring.
- Synergies between experiments would reduce costs on both sides.
- 26 GeV/c beam from the PS is appropriate for nuSTORM



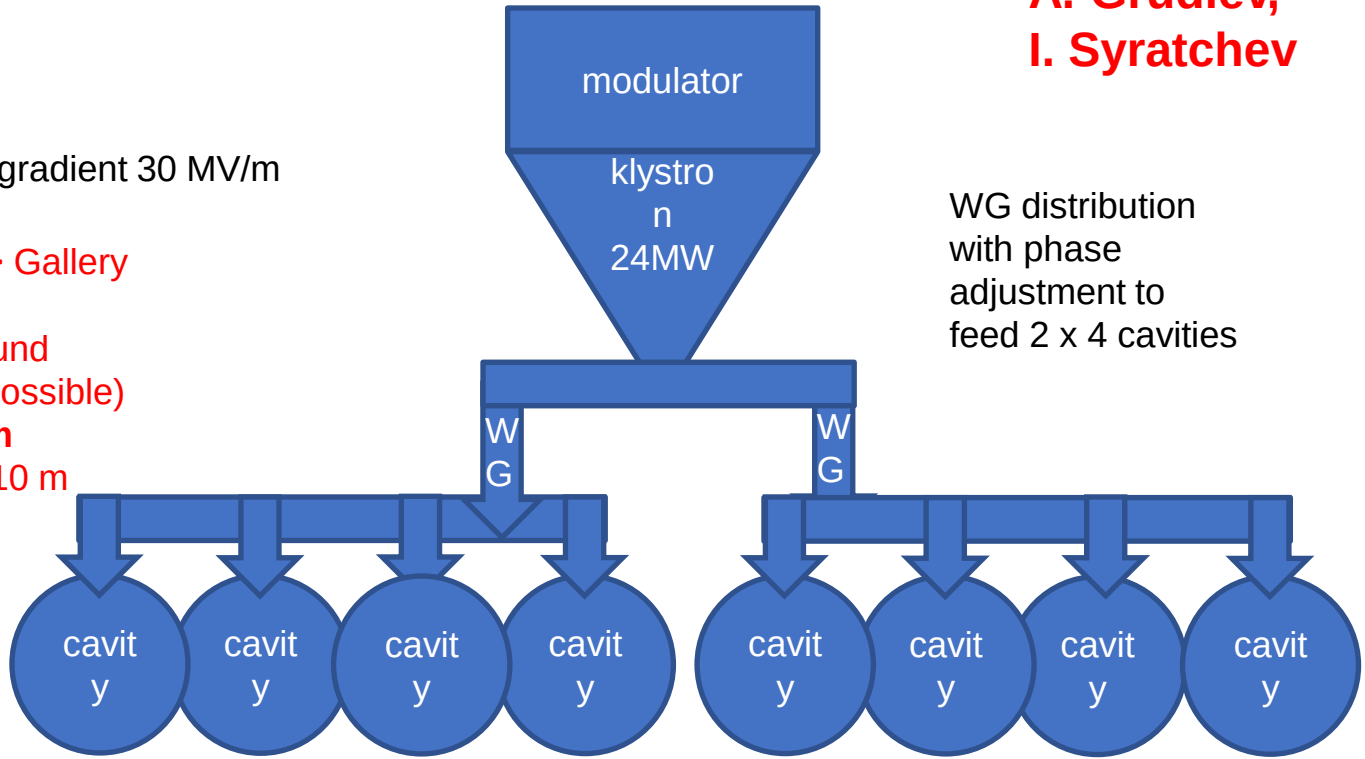
Muon cooling demonstrator layout
High peak power klystron: 24 MW

Courtesy
A. Grudiev,
I. Syratchev



RF for cooling: Max. gradient 30 MV/m

Building -> Gallery :
(underground might be possible)
30m x **15m**
Height: 8-10 m



WG distribution with phase adjustment to feed 2 x 4 cavities

Safety

- We will have many hazards underground:
  - High Magnetic Fields
  - “High” Power target
  - Cryogenic fluids
  - Liquid/Gaseous Hydrogen
- Cost of safety mitigation measures might become important if not adequately foreseen in the design of the infrastructure.

Implementation at CERN: a possible roadmap

- If we assume approval of the European Strategy Update in 2028 by CERN council, we have the following scenario scenarios:
- *Period from **today until 2028***
  - Need to increase our budget in order to build a few prototypes: Cooling cell, RF test stand, Mover system mock up etc…
  - Advance the design in order to have execution drawings available for construction
  - Build prototypes, test them before 2027/28
  - Funds to clean up TT7, evacuate radioactive waste, install a fast extraction in the PS and the beam transfer line to TT7
  - Preliminary test of some material with Protons.

Implementation at CERN: a possible roadmap

- 2028-2035
  - FCC is approved:
    - We (already have) convinced the management that the demonstrator is essential
    - We continue on the low power side, at a pace compatible with running HL-LHC and the FCC programme, still aiming at a reasonable facility by 2035.
  - FCC is further delayed or not clearly approved
    - We request the full budget for the high-power option
    - We speed up in order to start installation in TT10 by 2033, first beam 2035.

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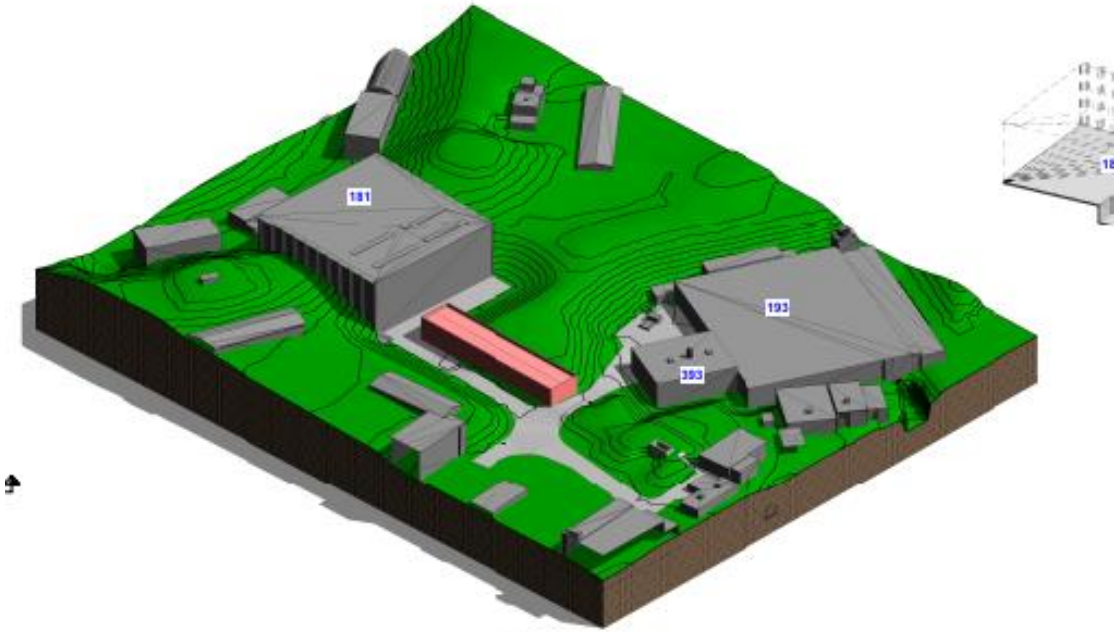
CERN

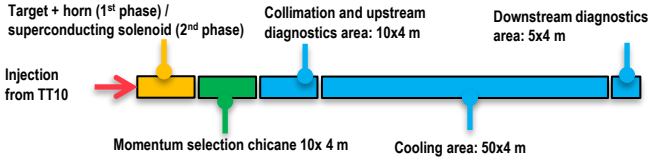
Thank you
for your attention

TT7 Low Power option

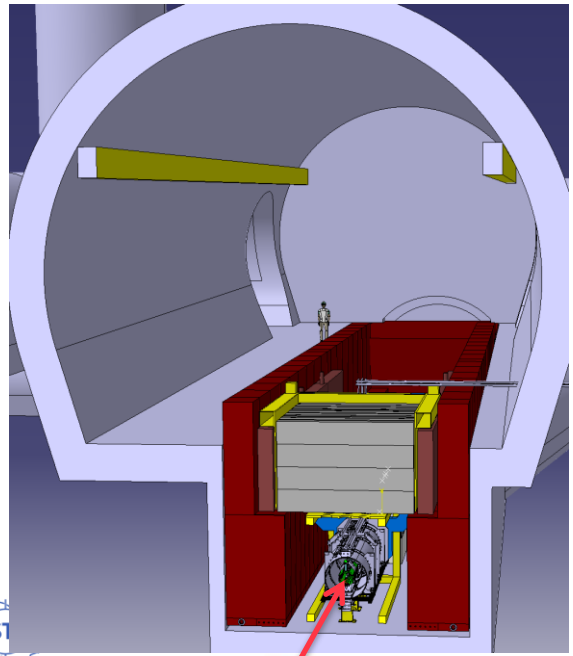


3D - Surface

Conceptual layout

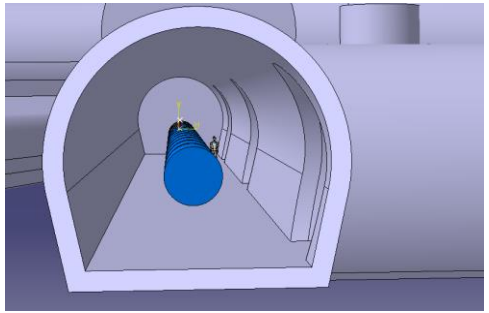


MUC Demonstrator VERY Conceptual layout



Target + Horn + chicane hall

Cooling tunnel



Services Gallery