SHORT BASELINE NEUTRINO BEAM AT CERN PS

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Contents

- The Experiment: aim, lay-out & needs
- PS Proton Beam Production Scheme
- The Infrastructure
- Target System and Decay Tube
- Present status
- Concluding Remarks

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Why a New Neutrino Facility ?

- The idea for this facility was triggered by a letter of intent from an experimental collaboration that presently is being transformed into a concrete proposal.
- However, it can also be used for other experiments/studies:
  - Neutrino cross section measurements at very low energies (on or off-axis)
  - Target R&D
  - Detector studies, etc……

The Proposed Experiment

- Abstract of the Letter of Intent:

By C. Rubbia et al.

The LNSD experiment at LANSCE has observed a strong 3.8 σ excess of $\overline{\nu}e$ events from an $\overline{\nu}\mu$ beam coming from pions at rest. If interpreted as due to neutrino oscillations, it would correspond to a mass difference much larger and inconsistent with the mass-squared differences required by the standard atmospheric and long-baseline neutrino experiments. ***Therefore, if confirmed, the LNSD anomaly would imply new physics beyond the standard model, presumably in the form of some additional sterile neutrinos.*** *.....*

- Aim:

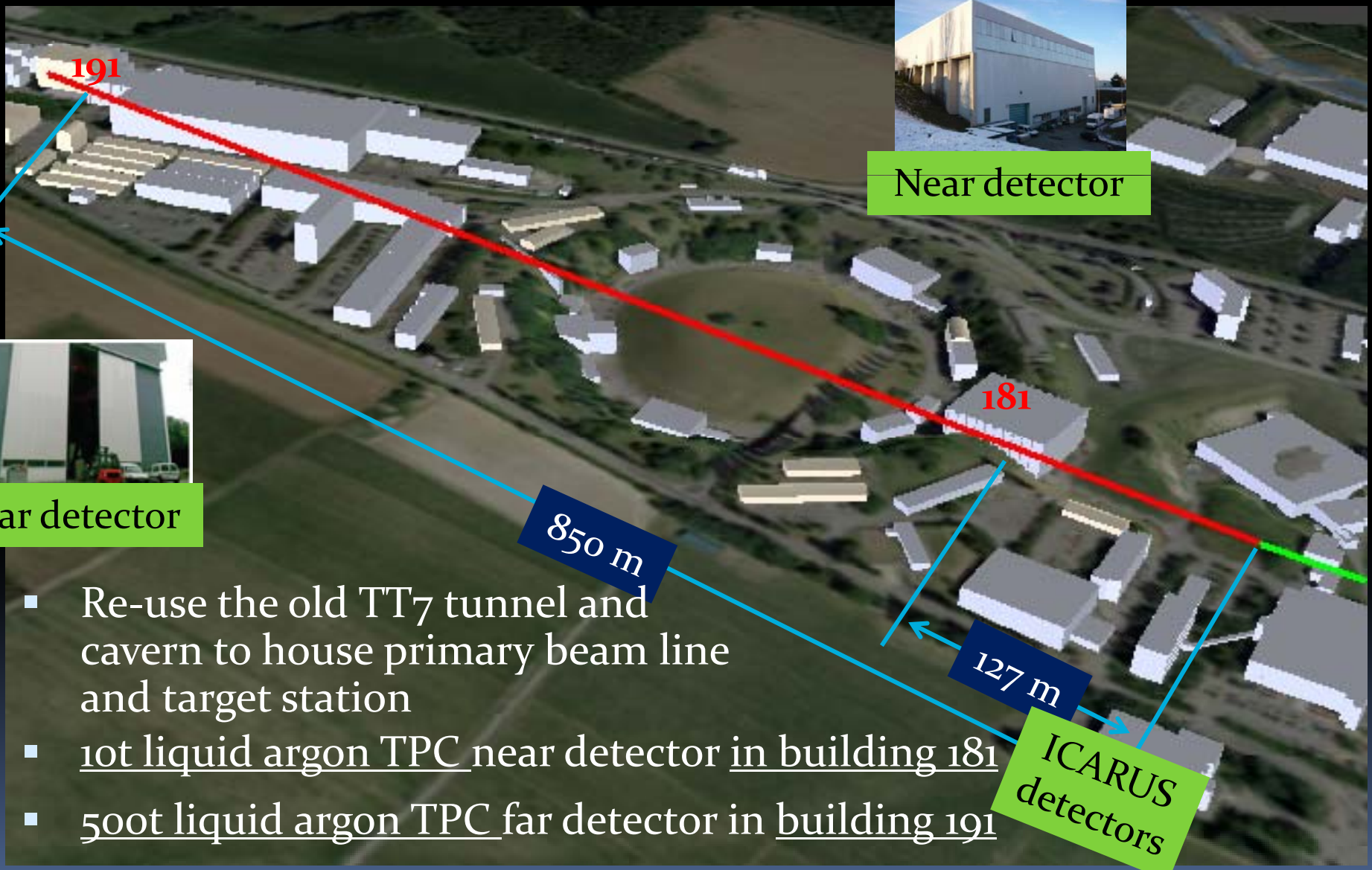
Investigating the existence of sterile neutrinos *through the measurement of $\nu\mu \rightarrow \nu e$ oscillations by using a low energy $\nu\mu$ or $\overline{\nu}\mu$ beam in combination with a close and far liquid argon time projection chamber.*

Where to put this neutrino facility ?

- CERN went through many changes and constructions in the past and we have some “unused tunnels”
- Therefore we went to the:

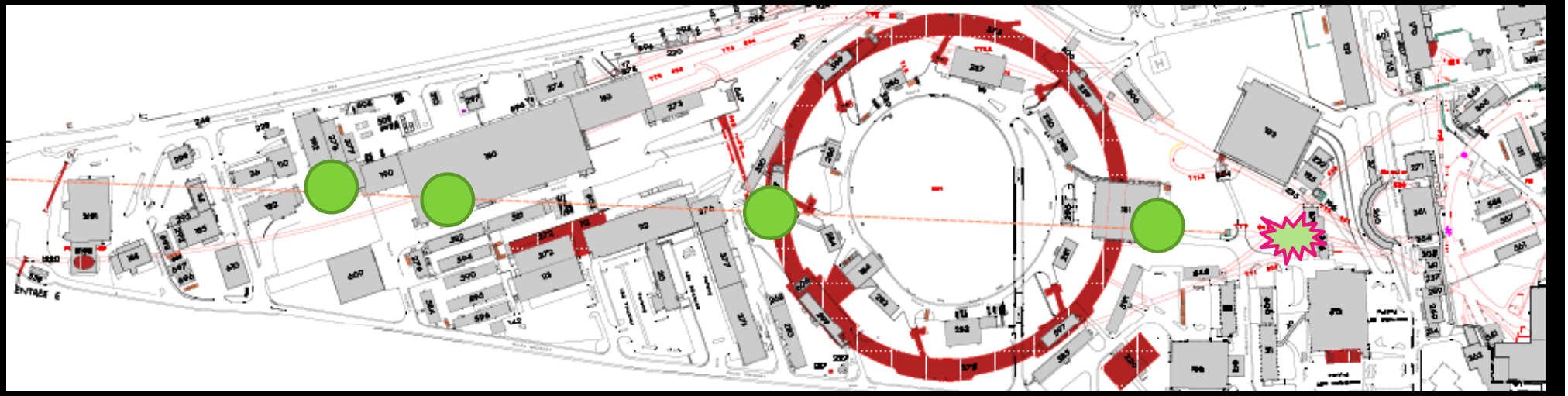
to get ideas for this facility

The Proposed Experimental Lay-out



- Re-use the old TT7 tunnel and cavern to house primary beam line and target station
- 10t liquid argon TPC near detector in building 181
- 500t liquid argon TPC far detector in building 191

Potentially Interesting Experiment Locations



- Building 181 → close detector sterile neutrino's
- Building 375 (ISR tunnel)
- Building 180
- Building 191 → far detector sterile neutrino's
- Detailed positions of the central secondary beam path is precisely known and drawings are available for the buildings mentioned

Experimental Requirements

- 2.5×10^{20} protons over 2 years
- Proton beam momentum ~ 20 GeV/c
  - Secondary ν_μ *and* $\overline{\nu}_\mu$ beam with Eν ≤ 2 GeV
- The challenge lies in:
  - producing this extra amount of protons from the CERN PS.
  - designing the optimum and reliable target and focussing system

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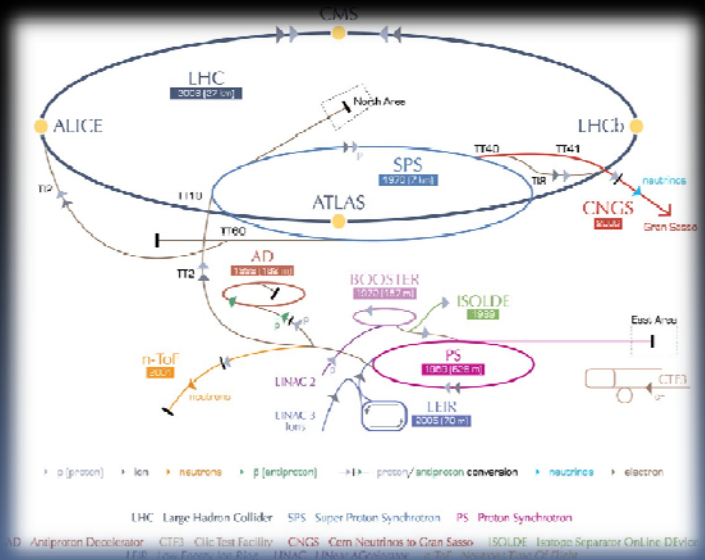
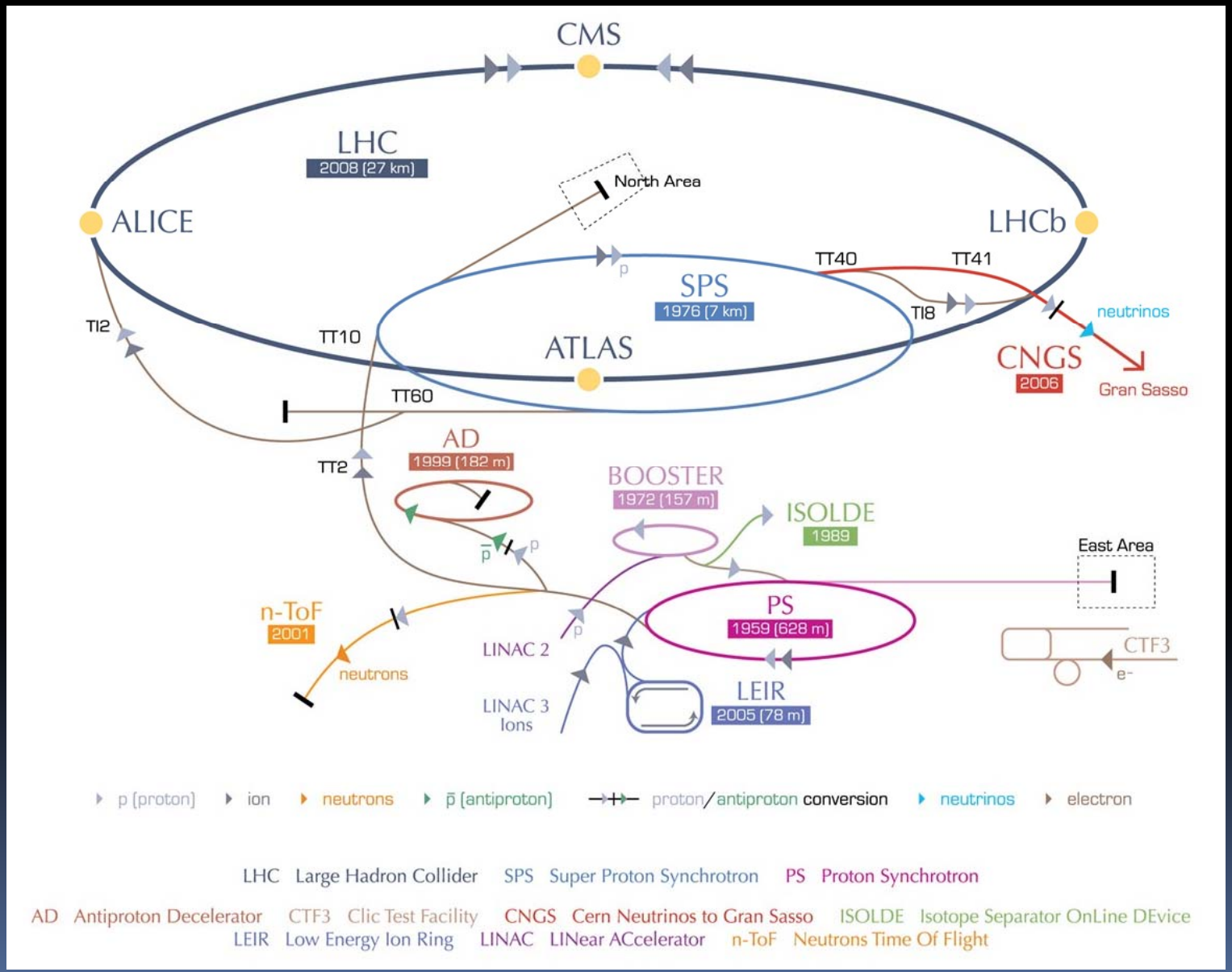
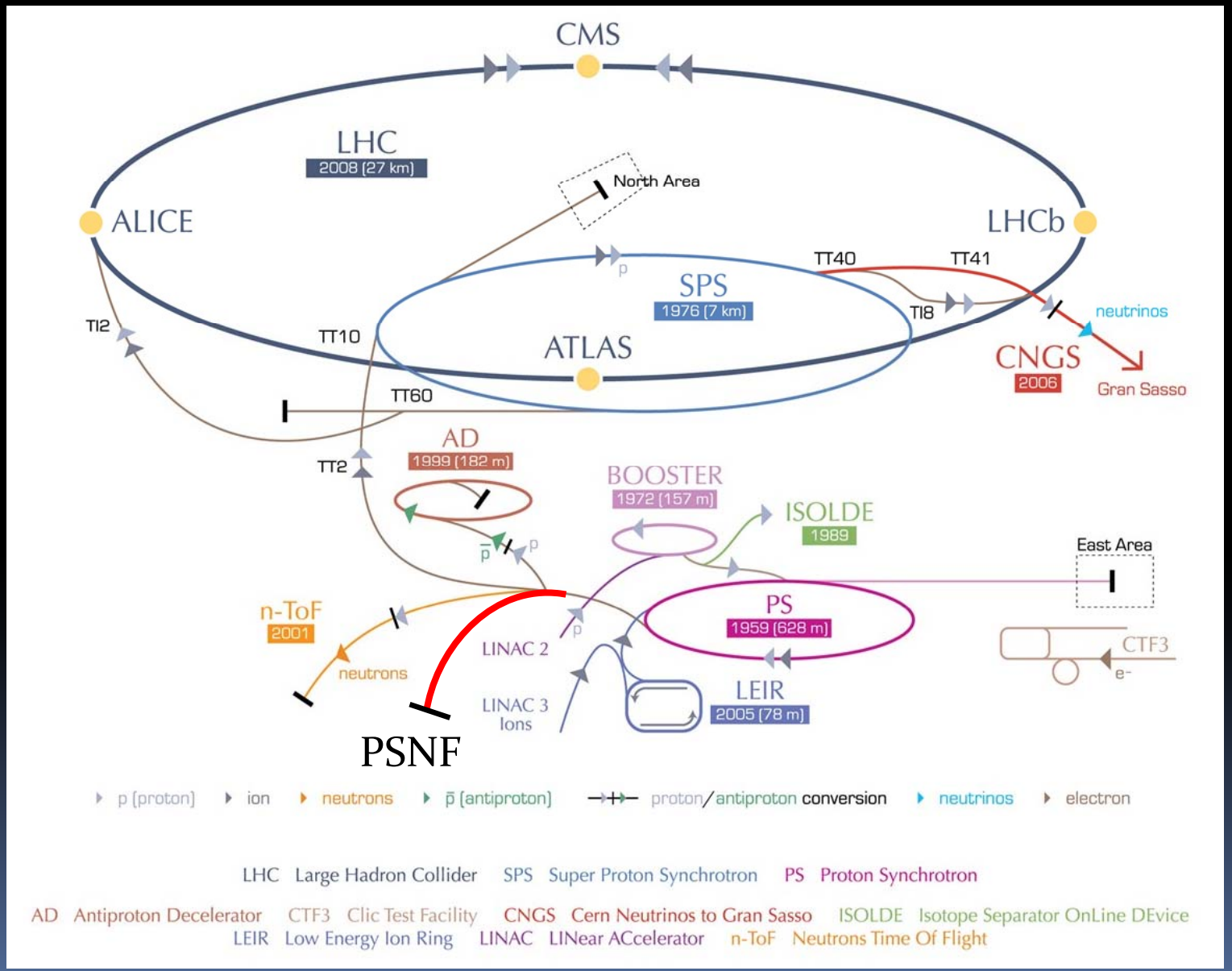


The actual CERN Accelerator Complex

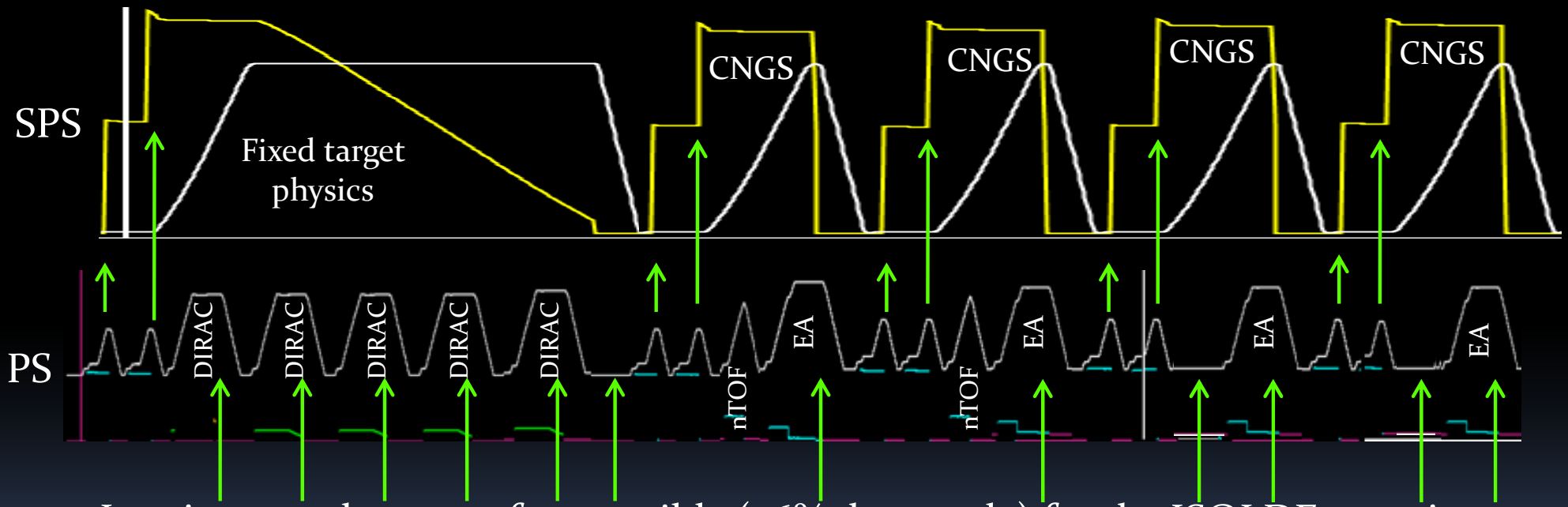


The Accelerator Complex with PSNF



Beam Scheduling

- Super Cycle outside LHC filling periods (39.6 sec):
  - SPS provides beam to Fixed target physics, CNGS and LHC
  - PS provides beam to the SPS, East Area, AD, nTOF
  - PSB provides beam to PS and ISOLDE



Leaving 12 pulses out of 33 possible (36% duty cycle) for the ISOLDE experiment behind the PS booster. They request actually~ 50%

- No place for more cycles in the super cycle left to produce the required extra protons

How to produce the extra protons

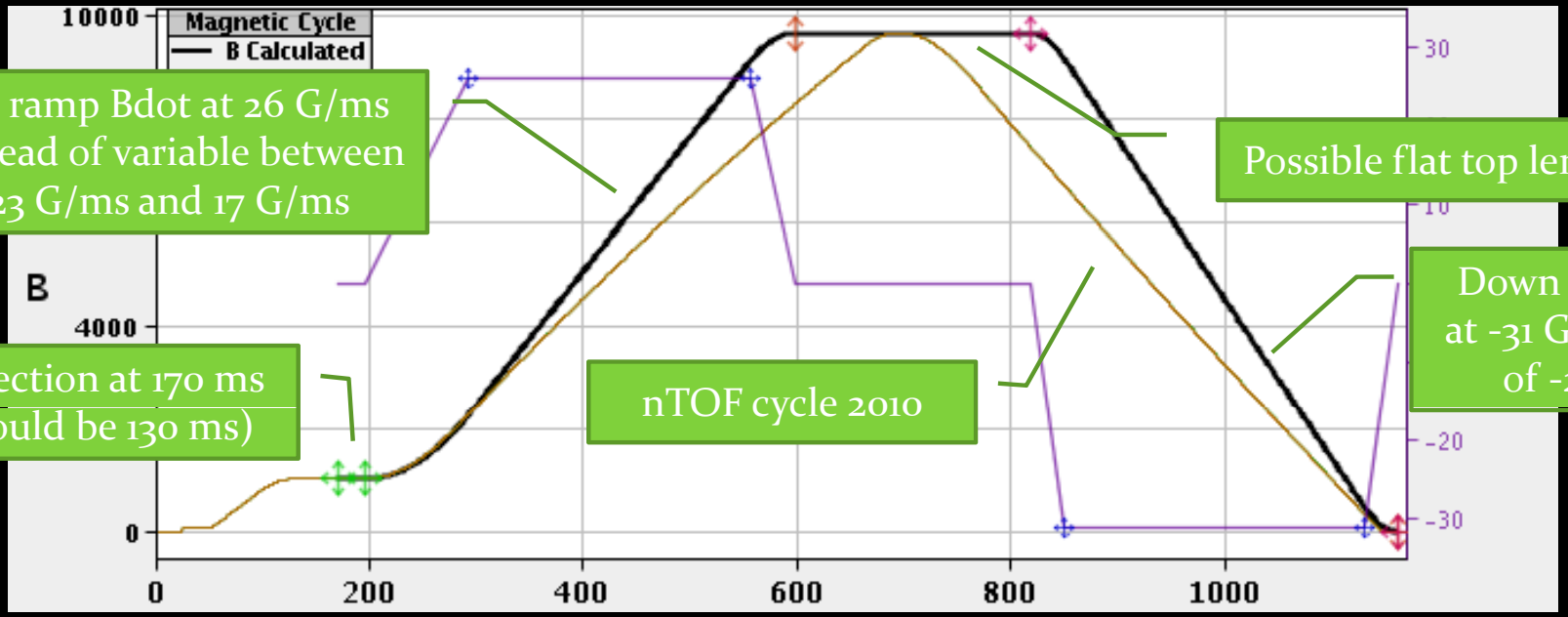
- The DIRAC experiment in the East Experimental Area has mentioned plans to move to the SPS, freeing 5 cycles
- However, the nTOF facility requests extra cycles, leaving again little possibilities
- Only possibility left :

  Make even more efficient use of the PS

Beam sharing

- On the nTOF cycle only 1 bunch is produced, while 8 can be produced.
- The nTOF cycle can routinely produce $3x10^{13}$ protons in 8 bunches:
  - 7 bunches for the PSNF ($2.6x10^{13}$)
  - 1 bunch for the nTOF facility ($3.8x10^{12}$)
- Putting in total 7 of these cycles in the super cycle:
  - PS can produce ~ $6.7x10^{19}$ protons per typical run
  - PS would need 3½ runs (years) to accumulate $2.5x10^{20}$ protons, instead of the requested 2 years.
- More efficient use of the CERN PS and no loss of integrated protons for nTOF (slight increase)

Beam sharing cycle



- One cycle with 2 fast extractions separated by ~200 ms
  - 1st extraction: 7 bunches (2.6×10^{13}) to PSNF
  - 2nd extraction: 1 rotated bunch (3.8×10^{12}) to nTOF
- Requiring adapting the PS extraction and a fast switching magnet in the common part of the transfer line

PS to TT7 Transfer Line

- No real design made yet
- Magnet needs for beam transfer line:
  - ~ 16 Main Dipoles
  - ~ 14 Quadrupoles
  - ~ 6 Corrector Dipoles
  - Fast switching magnet (~ 200 ms) for sharing
- Beam instrumentation:
  - Beam current transformer
  - Beam positioning monitors
  - Beam profile measurement
  - Beam loss monitors

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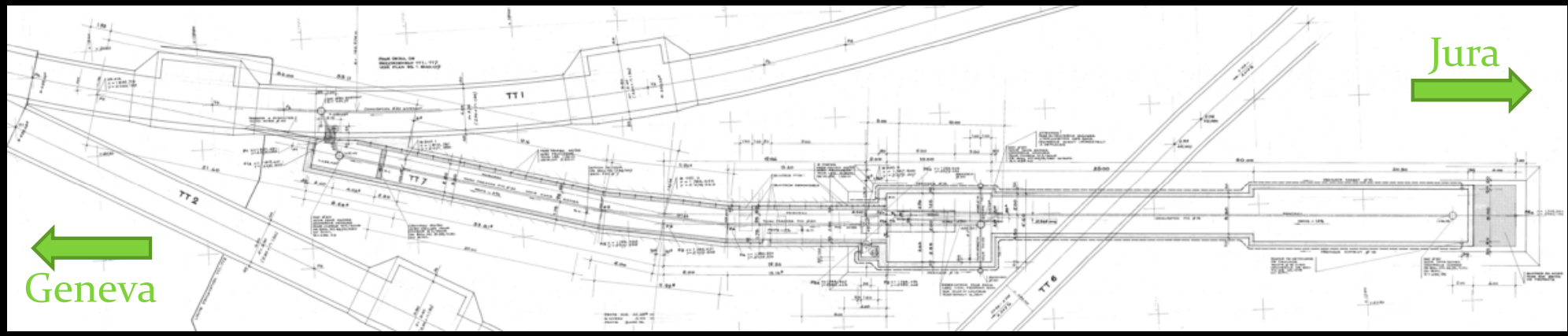
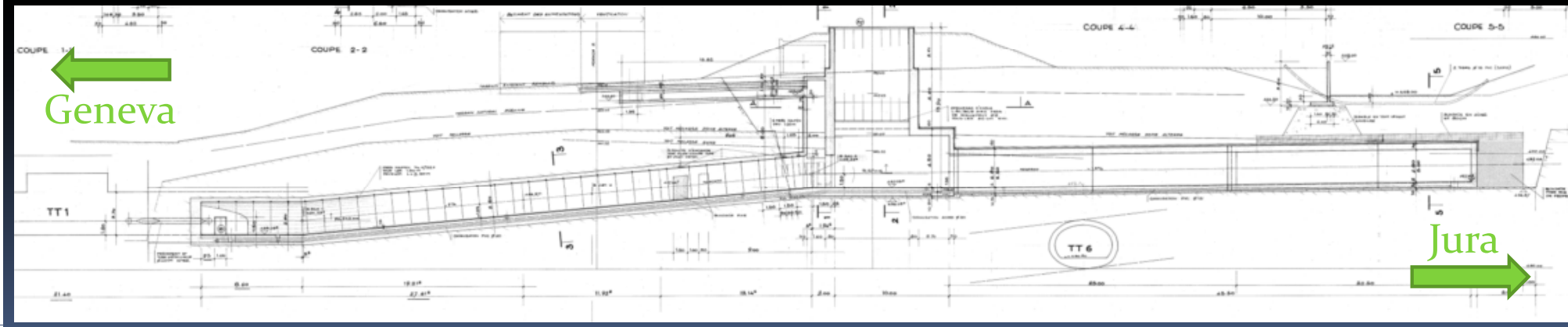
Re-use existing infrastructure

- In the 80's the PS also provided protons beam to a target for neutrino physics:
  - CDHS
  - CHARM
  - BEBC experiment
  - CHARMII
- The infra-structure is presently not use and could after thorough consolidation be re-used to house:
  - Primary proton transfer line
  - Target and focusing
  - Decay channel

The TT7 Tunnel

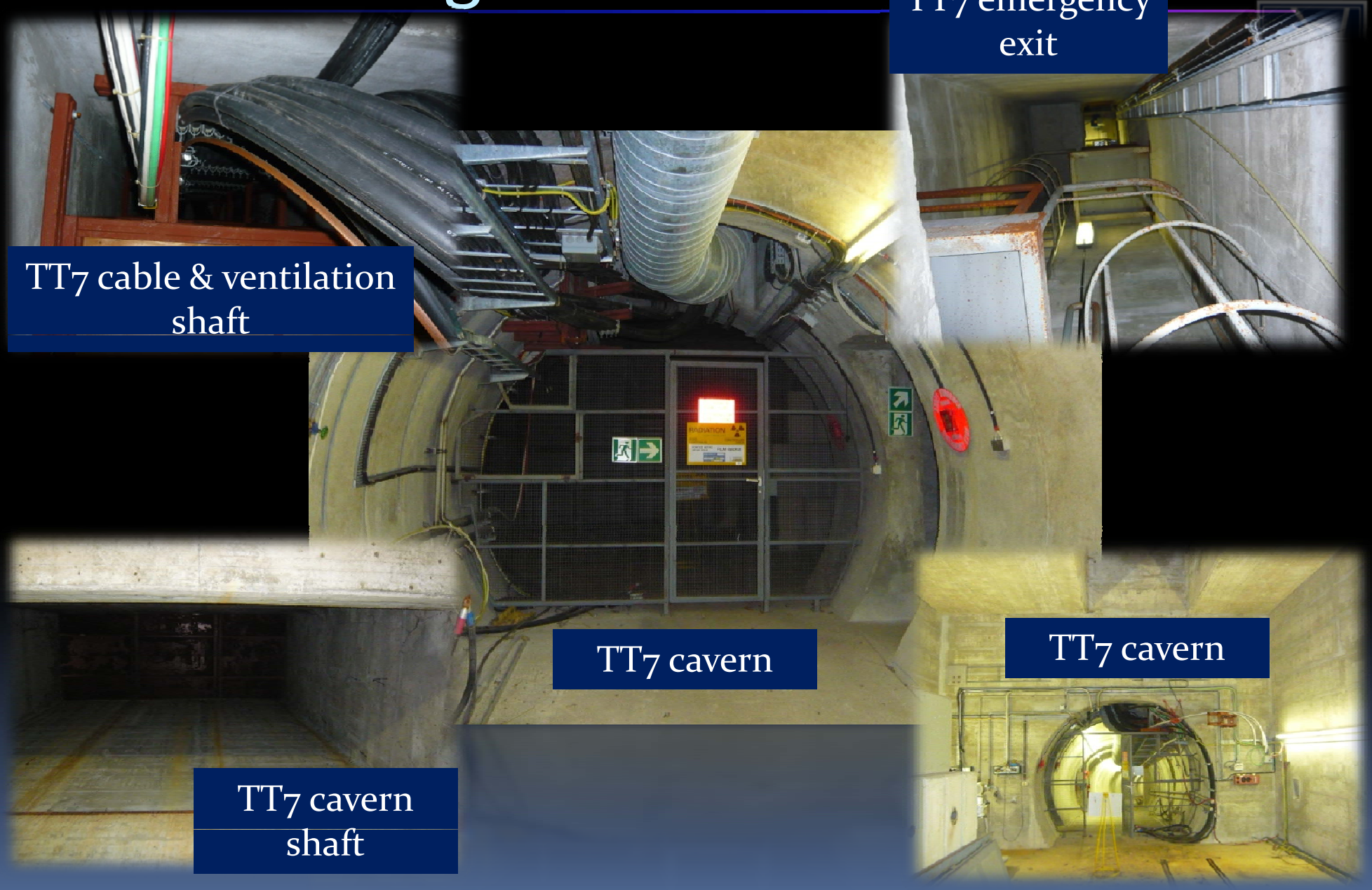
- The TT7 tunnel:



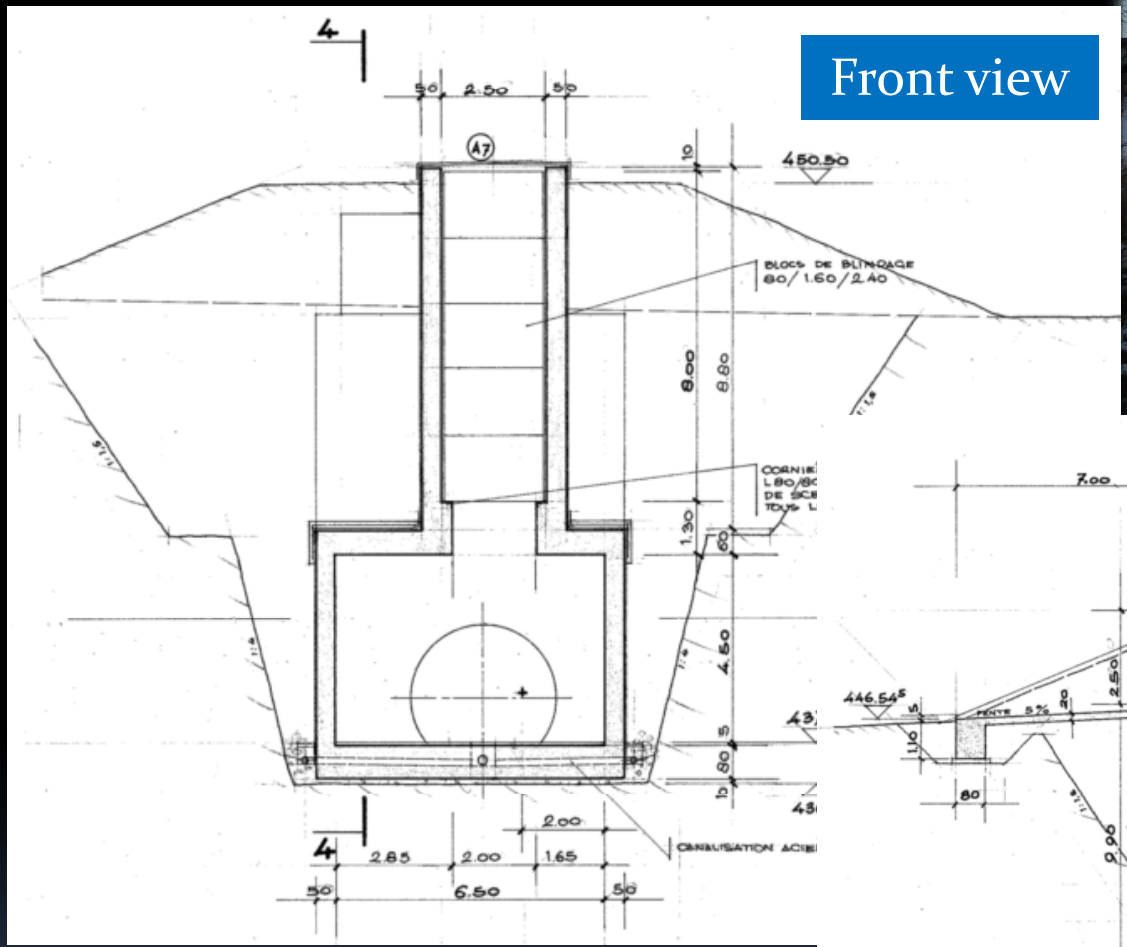


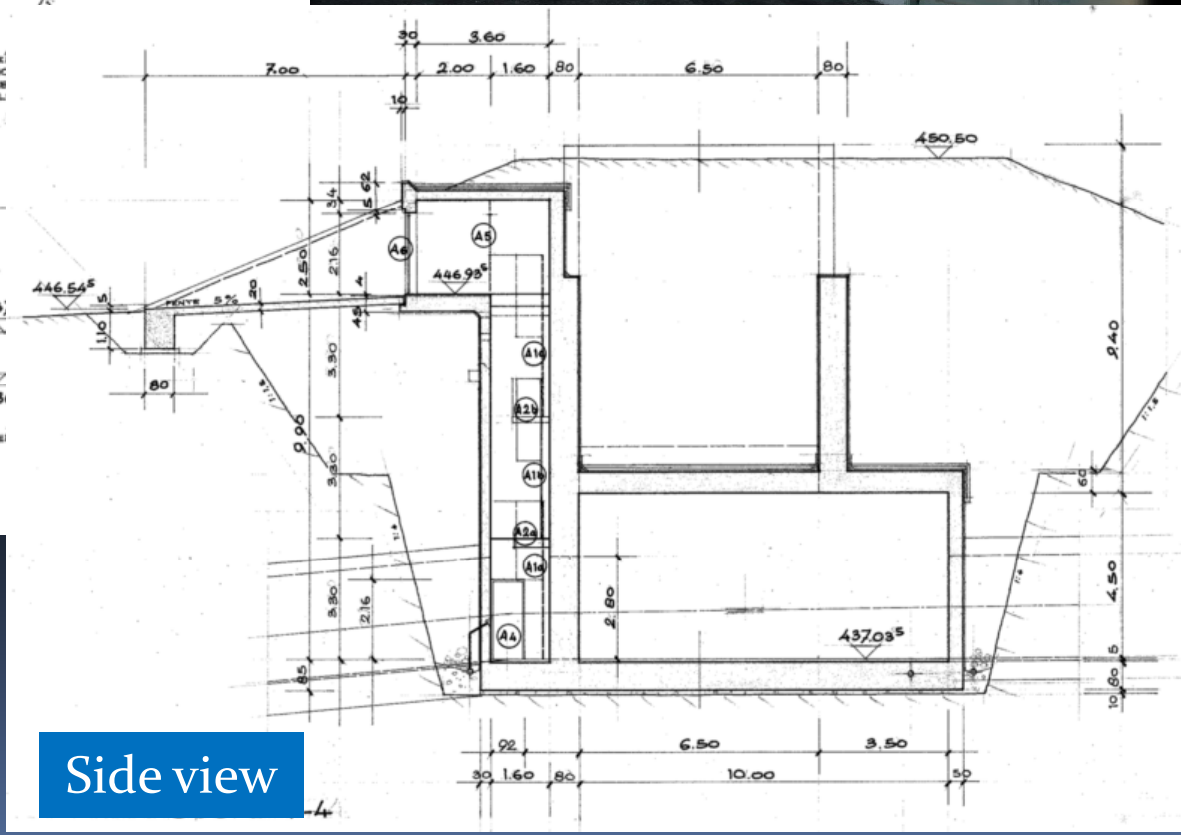
The TT7 tunnel toward the target

The TT7 Target Cavern



TT7 Cavern

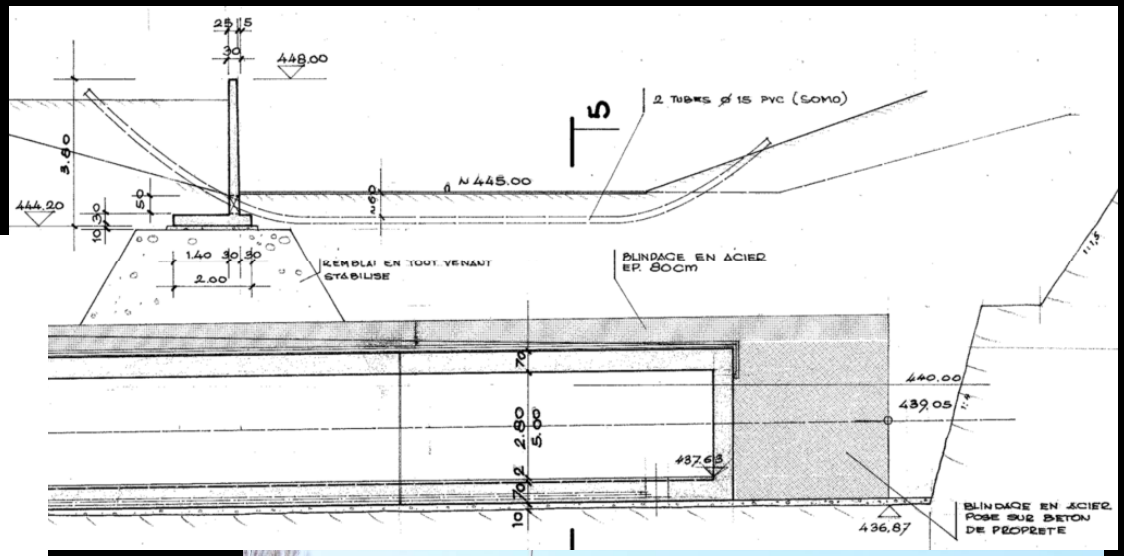


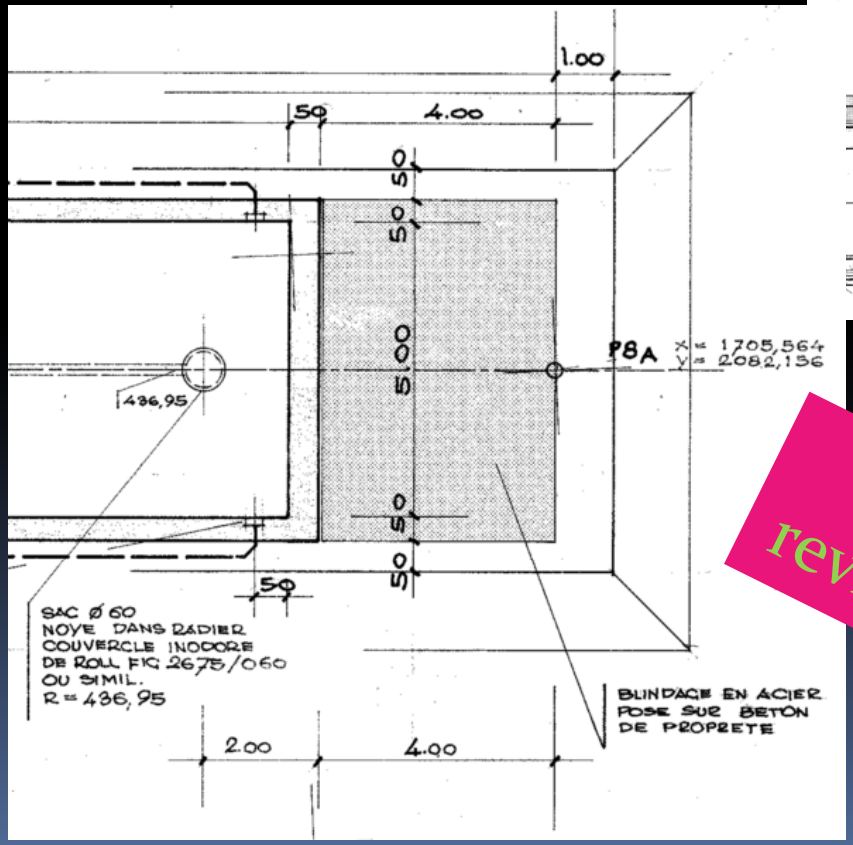


- 8 meter under ground
- Material access shaft

Beam Dump / Hadron Absorber

- 4 meter thick beam dump (none sealed iron blocks)
- 65 meter of earth
- No cooling





To be reviewed !

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Target & Focusing System

- The design has not started, but some ideas are being discussed.
  - Target inside horn (Eν ≤ 2 GeV)
  - Beam synchronous pulsed horn
  - Type of target material to be used
- As many ideas have been discussed during the last days some form of collaboration could be useful when the design of the target and focusing system can be started

Preliminary Target ideas

- Two candidate materials considered are:
  - Carbon
  - Beryllium
- In both cases the interaction length is around 41 cm therefore at least 80 cm long target would be needed
- For a 26 GeV/c beam with 1×10^{13} ppp on a 100 cm long target with a radius of 3.5 cm the deposited energy per pulse is:
  - 2.5 kJ for carbon (2 kW)
  - 1.8 kJ for beryllium (1.5 kW)

Primary Beam Parameters

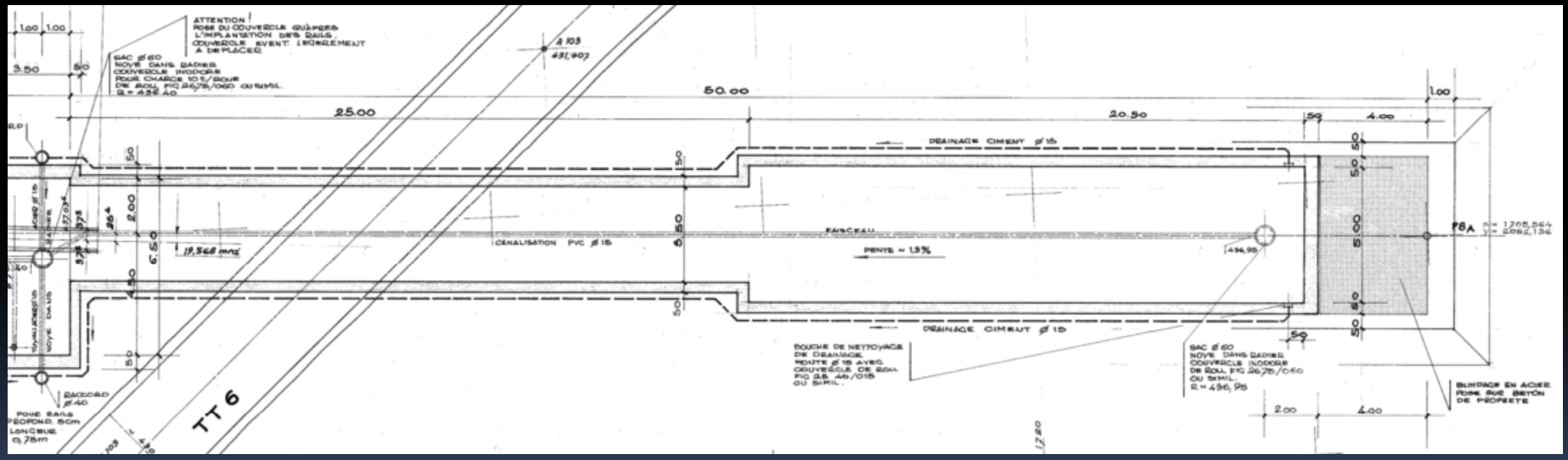
	PS Parasitic	PS Dedicated	PS Ultimate	CNGS	T2K
Proton beam momentum	20 GeV/c	20 GeV/c	26 GeV/c	400 GeV/c	30 GeV/c
Protons per pulse	2.6×10^{13}	3×10^{13}	4×10^{13}	4×10^{13}	3.3×10^{14}
Maximum repetition rate	1.2 s.	1.2 s	1.2 s	6 s	2.1 s
Beam energy	84 kJ	96 kJ	166 kJ	2.9 MJ	1.6 MJ
Average beam power	**70 kW**	**80 kW**	**140 kW**	**425 kW** [1)]	**750 kW**
Beam size at target (1σ)	Ø <6 mm	Ø <6 mm	Ø <6 mm	Ø <0.5 mm	Ø 4 mm

1) Target is designed for average beam power of 750 kW

- The energy deposition for the PS Ultimate beam is:
  - ~ 10 kJ per pulse for carbon (8.5 kW)
  - ~ 7.2 kJ per pulse for beryllium (6 kW)

Decay Tunnel

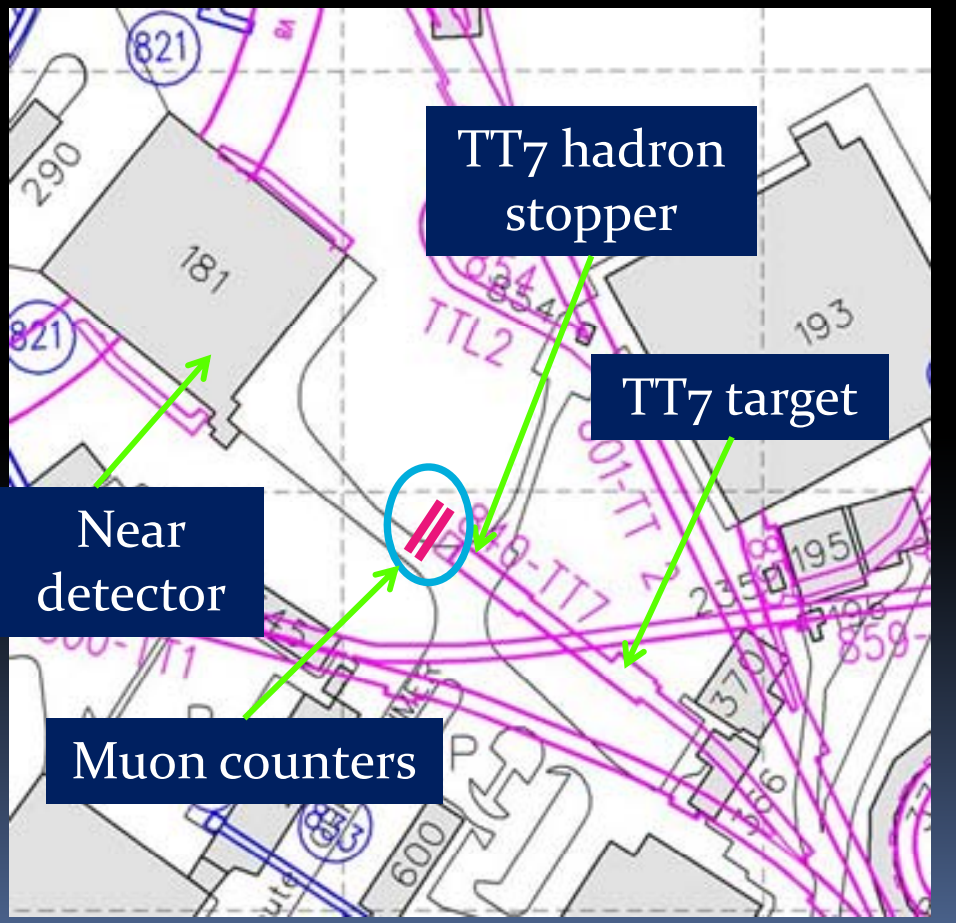
- The available decay tunnel is 50 meters long
- Cross section:
  - 3.5 x 2.8 m2 for the 1st 25 m
  - 5.0 x 2.8 m2 for the remainder



- No vacuum or helium filled decay tube available → to be considered

Secondary Beam Measurement

- Installing muon counters after the hadron dump will allow:
  - Monitoring the intensity
  - Measure the distribution
  - Steering with primary beam
  - Target alignment
- The present infrastructure does not foresee in this.



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Present Status

- At present the design and construction of this facility is not part of the CERN Mid-term plan
- However, the concrete experimental proposal is being written by C. Rubbia et al.
- Only preparatory work was done:
  - Re-position TT7 tunnel in CERN coordinate system
  - Identify exact central secondary beam path through the different buildings
  - More details on the targeted building was gathered
  - Some preliminary target calculations were made
  - The primary proton production beam was successfully tested

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Concluding Remarks

- A very exciting physics experiment is proposed for the 50 years old CERN PS
- For the moment the design and construction of this facility is not part of the CERN mid-term plan
- TT7 and nTOF beam sharing makes efficient use of the CERN PS:
  - The proposed experiment could be completed in 3½ runs
  - nTOF would gain also on the number of integrated protons
- Large part of the required infrastructure is available, but needs to be consolidated
- Everything else needs to be designed and constructed
- The facility can also be (re-)used for other low energy neutrino physics, target R&D, Detector R&D, etc…

Thank you for your attention