Long Baseline ν beams at CERN

LAGUNA-LBNO
Design Study

I. Efthymiopoulos - CERN

EUCARD - Neu2012 Meeting
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ν beams at CERN - LAGUNA-LBNO

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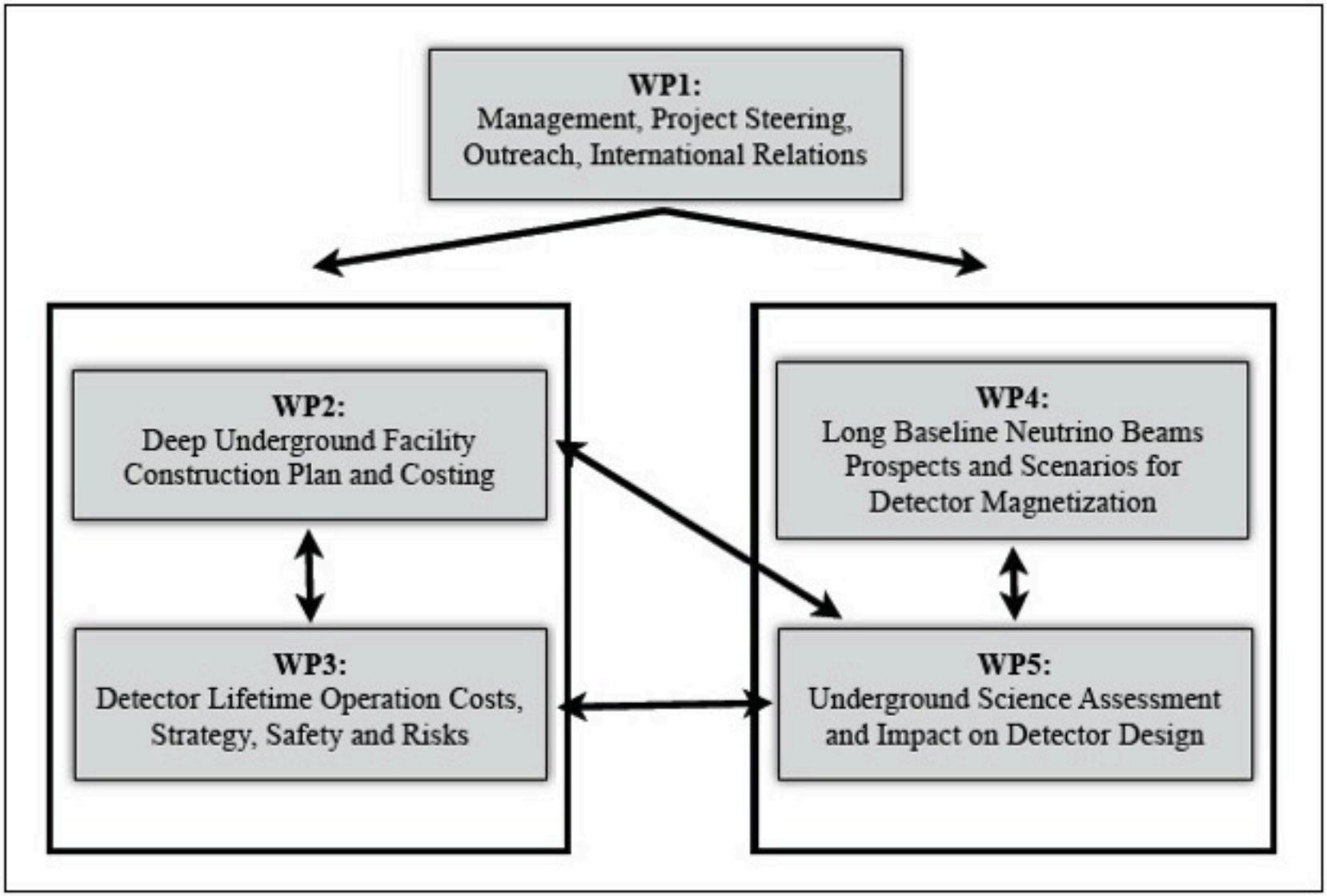

ν beams at CERN - LAGUNA-LBNO

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- **WP4 - Long baseline Neutrino Beams - Prospects and Scenarios for Detector Magnetisation**
  - Study the impact of SPS upgrade to neutrino beams
  - Feasibility of intensity upgrade of CNGS
  - Conceptual design of CN2PY ν-beam
    - ν-beam focusing studies
    - target station design
    - 3-D layout studies
  - Feasibility study of a 30-50 GeV high-power (<2MW) PS
  - Definition of the accelerators and beamline layouts at CERN
  - Study of the Magnetic Configuration of the LAGUNA detector

Build on the CNGS experience - study beams with good physics reach that can be realized in the framework of 10-15 years

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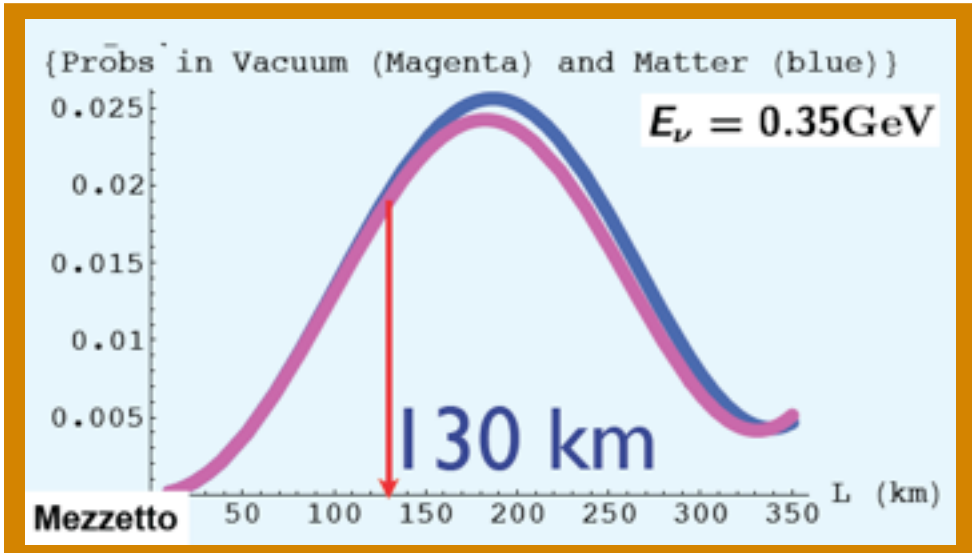
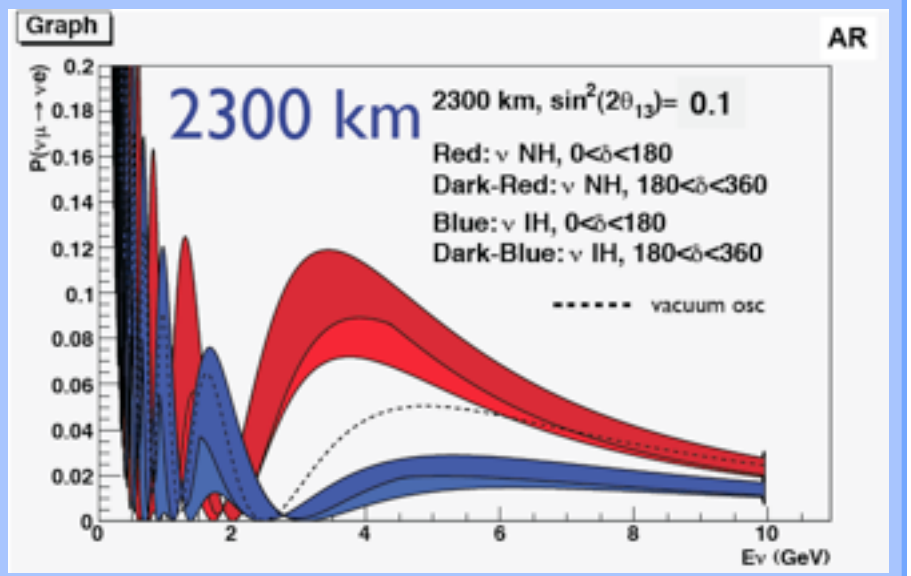
Long-Baseline ν-beams from CERN

- CERN-Frejus (130km) & CERN-Pyhasalmi(2300km): Very short/very long baseline combination for unique physics opportunities in Europe



- Determine CP-violation by comparison of ν/ anti-ν in absence of competing matter effects
- Very low energy beam, huge (WC) detector



- Determine CP-violation and mass degeneracy by spectrum measurement and resolve degeneracies and so called "π-transit" effect
- arXiv:0908.3741.v1 for "Magic distance"

A. Rubbia, LAGUNA

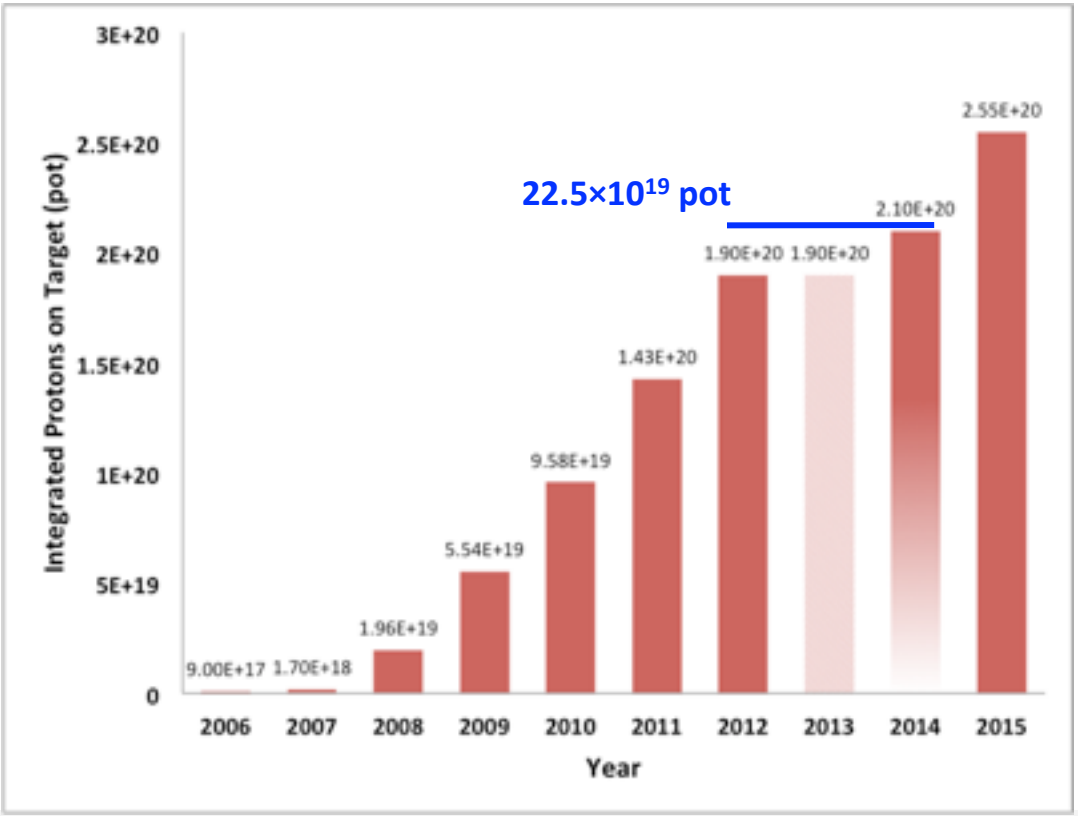
- ... and synnergies:
  - **CERN-Frejus :** adequate baseline/energy for β-beam
  - **CERN-Pyhasalmi :** adequate baseline for Neutrino-Factory from CERN or other labs (~7'000 km)

What future for CNGS?

- The presently approved program will be completed by 2014
  - assuming **4.7 × 10^{19} pot/y** for 2011, 2012

Note:

- Even after switching the beam off, CNGS won't be cost neutral
  - services must be maintained not to let the (highly activated equipment and tunnels degrade
  - at a certain time the facility must be dismantled
- Is always advantageous if a new use of the equipment & tunnels is found



CNGS Technology Upgrade Possibilities

- **Limitations:**
  - key elements of the secondary beam line: target, horns, beam windows
  - layout and RP considerations, SPS RF and beam extraction system
- **CNGS upgrade ⇔ SPS upgrade:**
  - Possibilities will be studied within the LHC Injector Upgrade project (**LIU**) and followed in **LAGUNA-LBNO**
    - **750kW** may be reachable, going beyond would require substantial consolidation of the facility

Int. per PS batch	# PS batches	Int. per SPS cycle	200 days, 100% efficiency, no sharing	200 days, 55% efficiency, no sharing	200 days, 55% efficiency, 60% CNGS sharing
		[prot./6s cycle]	*[pot/year]*	*[pot/year]*	*[pot/year]*
2.4×10^{13} - Nominal CNGS	2	4.8×10^{13}	**1.38×10^{20}**	**7.6×10^{19}**	**4.56×10^{19}**
3.5×10^{13} - Ultimate CNGS	2	**7.0×10^{13}**	2.02×10^{20}	1.11×10^{20}	6.65×10^{19}

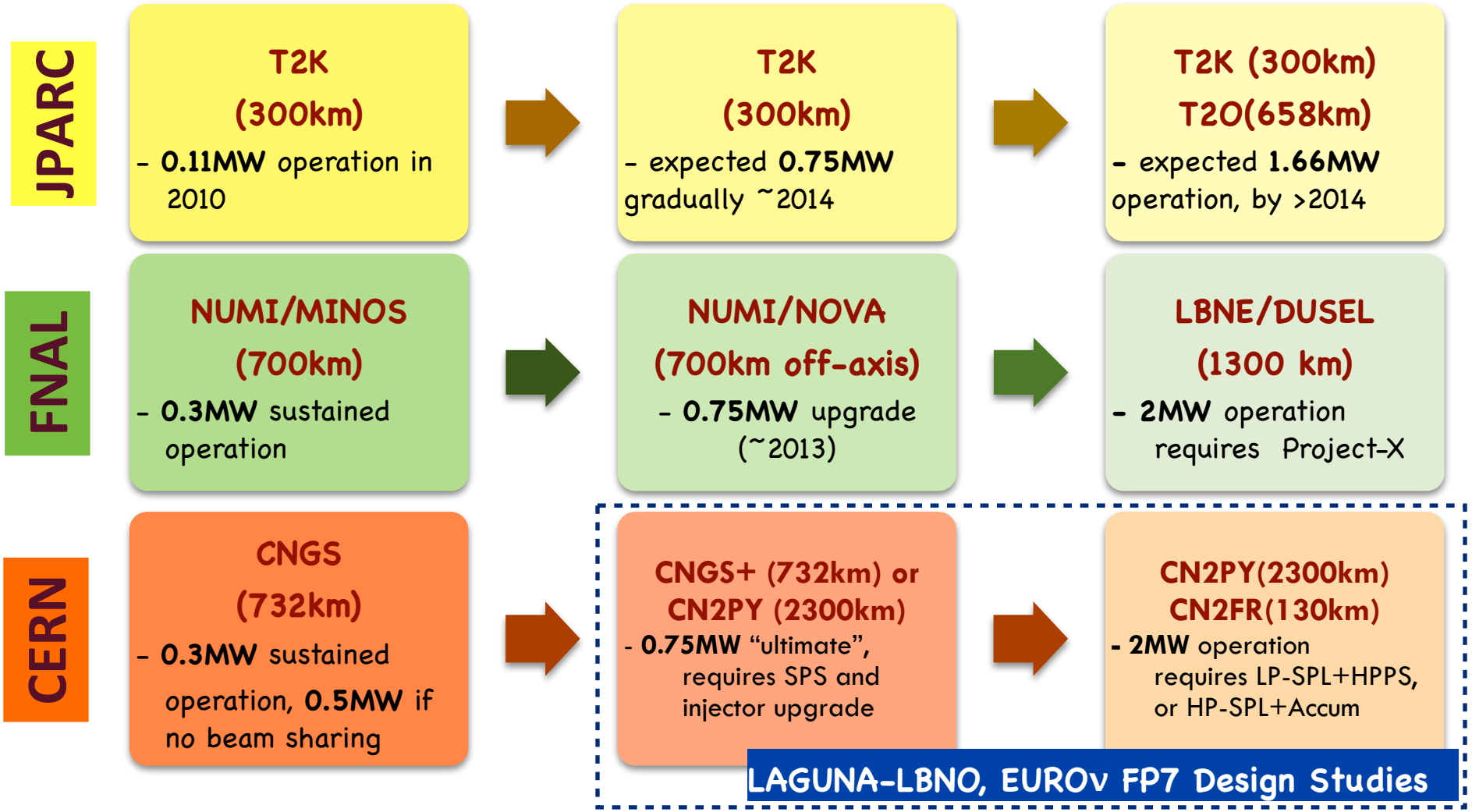
M.Meddahi, E.Schaposnicova - CERN-AB-2007-013 PAF

750kW design limit for the target

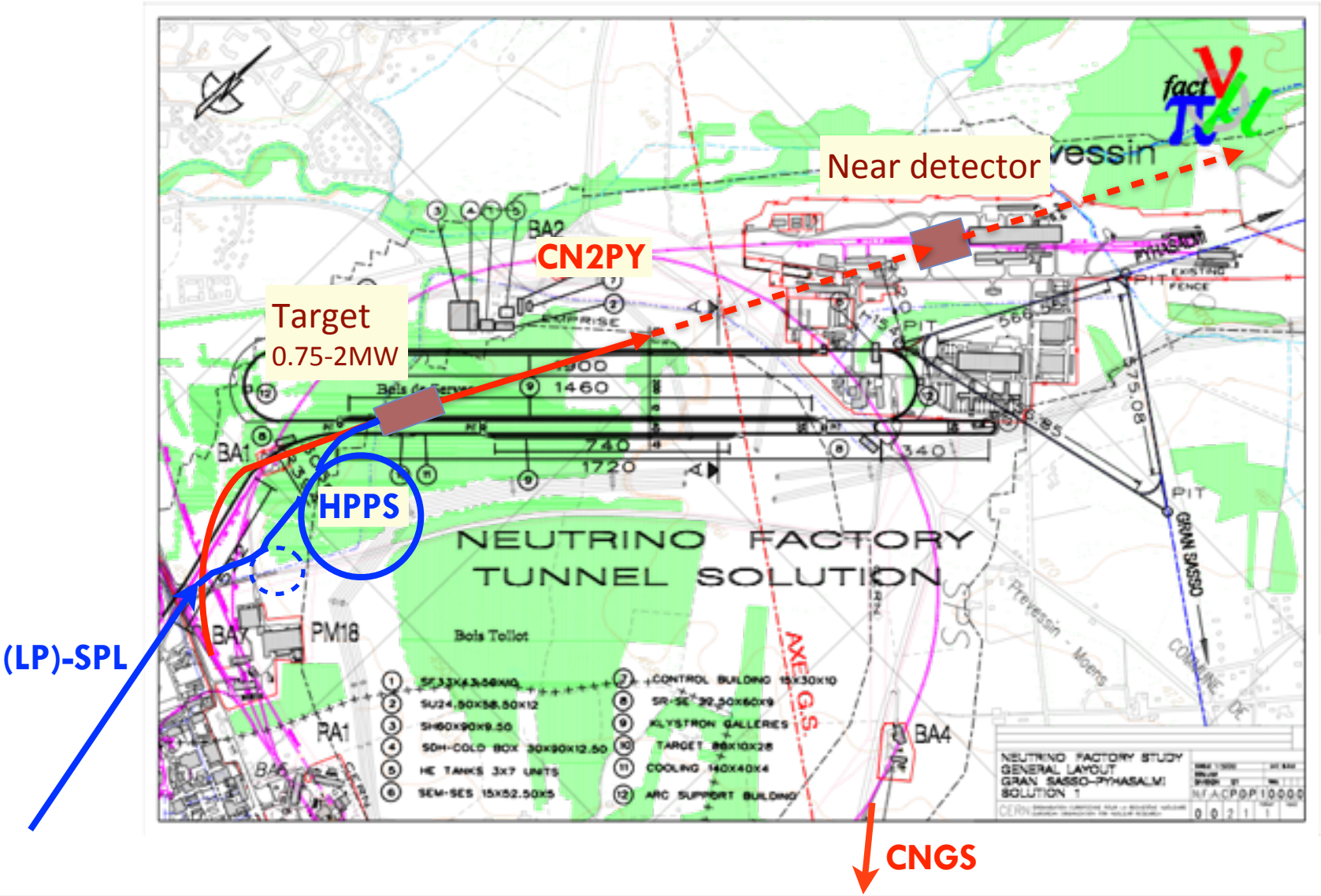
working hypothesis for RP calculations

A staged approach towards high-intensity facilities

- ~1MW an important (necessary) barrier



CERN ν-beam to Pyhasalmi - CN2PY



CN2PY Long-Baseline ν beam

- Re-use existing CNGS equipment for the proton beam line and as much as possible from the secondary beam
  - CNGS anyhow must be dismantled
- Target station design for 1(2) MW facility
  - Upgraded engineering for the CNGS target station, follow R&D for LBNE, T2K beams
  - Maintain target-horn separated; makes a HUGE difference in the design and operation
    - key advantage of the high beam energy
- The decay tunnel will be shorter (~200-300m) but steeper (~10 degrees)
- The near detector can be located in the CERN Prevessin area
  - design issues for such a detector to consider

LP-SPL & HPPS for CN2PY

- Aim for 1(2) MW at 50 GeV beam
  - 1.4E14 ppp, 1.2s cycle
- A LP-SPL would be sufficient
  - Power at injection (3 GeV) : 120 kW
- J-PARC is a good example of such configuration
- Design to consider synergies with other ν-beam options and possible needs for other CERN programs
- Layout (3-D) of possible implementation of such facilities at CERN
  - consider safety arguments (feedback from EUROnu studies)

ν beams at CERN – future possibilities

Stage I - Initial phase, sub MW facilities (~2015$_{approval}$ / ~2020$_{data\text{-}taking}$)

- Long baseline ν-beams from SPS (400 GeV) - **CN2PY**
  - CNGS technology, sub-MW class facility
    - Intensity upgrade, new focusing scheme for low ν-beam energies
  - Profit from SPS upgrade to high-power (750 kW)
- Short baseline ν-beam from PS (20 GeV) - **PSNF**
  - Dedicated experiment on sterile neutrinos
  - Test bed for detector and targetry R&D, x-section measurements

R&D projects for future facilities

Stage II - Upgraded facilities - MW range (~2018$_{approval}$ / ~2025$_{data\text{-}taking}$)

- Continue exploiting CN2PY beam
- Upgrade using LP-SPL as proton driver, new HPPS (30 GeV)
  - ~MW class facility
  - synergies with other programs at that time?
    - HPPS to feed the FT program while SPS being upgraded for HE-LHC?

R&D projects for future facilities

Stage III - The BIG picture – ultimate facilities (~2020$_{approval}$ / ~20?5$_{data\text{-}taking}$)

- Super beams, β-beams, Neutrino Factory
  - HP-SPL and new accelerators, MMW class facilities

Summary

- LAGUNA-LBNO WP4 will allow a complete spectrum of ν-beams studies to be made
  - two options: short and long baseline will be studied
  - CERN - centric, profiting from existing infrastructures and available experience
  - The studies for beams are in line and further extend EUROnu options

- Th e CN2PY beam option offers several advantages towards a staged, ready-to-start, ν-program for CERN and Europe
  - **Please treat MWs with care!**