Mauro Mezzetto
Istituto Nazionale di Fisica Nucleare, Sezione di Padova

“ European neutrino physics plans

- General considerations
- CERN
- ESS
- Protvino
- ICARUS-Nessie
- nuStorm

A personal point of view about the future of accelerator neutrino physics in Europe

Thanks to Marcos Dracos, Tord Ekelof, Enrique Fernandez-Martinez, Yuri Kudenko, Andrea Longhin, Andre Rubbia for the useful discussions/informations about this talk.

The short (realistic) version

Forget about

Forget about

- CERN resources are fully challenged by LHC upgrades
- As a matter of fact the latest neutrino beam line fully funded by CERN had been WANF (Chorus, Nomad), more than 20 years ago. (CNGS had been funded by the largest part by external funding agencies, mainly INFN).
- The neutrino physics community is not converging to a single project and sometimes the different projects conflict.

Four large scale projects with high priority

f) Rapid progress in neutrino oscillation physics, with significant European involvement, has established a strong scientific case for a long-baseline neutrino programme exploring CP violation and the mass hierarchy in the neutrino sector. *CERN should develop a neutrino programme to pave the way for a substantial European role in future long-baseline experiments. Europe should explore the possibility of major participation in leading long-baseline neutrino projects in the US and Japan.*

- Full cost for a comprehensive accelerator based neutrino facility is large. Ideas for such facilities are being developed in Japan, the US and Europe.
- Consideration should include the physics potential from non-accelerator neutrino programme: i.e. sterile neutrino and mass hierarchy.
- Optimising the European contribution for neutrino physics vis a vie the European ambition of high energy frontier.

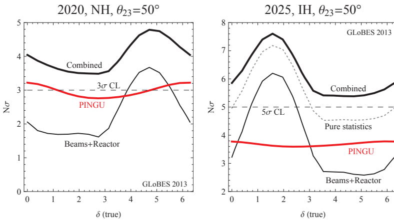
T. Nakada (European Strategy) ECFA-EPS Joint Session, Stockholm, Sweden, June 20, 2013 16

What could happen about MH in the next years

WG1 session: Mass Hierarchy determination I & II, Wednesday afternoon

- **NOνA** will start data taking in 2014: 2σ sensitivity in 6 years
- **INO** will start in 2017: 3σ sensitivity in 10 years
- **PINGU**, not funded, but not expensive (around 20 M$), could start in 2018: 3σ sensitivity in 3 years. ORCA could happen, but much later.
- **Juno** is running fast, could start in 2020, 3σ sensitivity in 3 years

W. Winter, arXiv:1305.5539



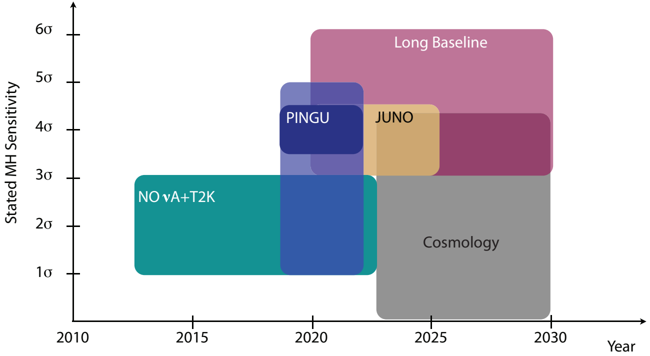
None of the above experiment will achieve 5σ sensitivity by itself, but their combination is synergic.

Long Baseline efforts in Europe (LBNO) can do better than any of these projects, but they will arrive (much) later. I don't see the point of measuring again and again MH, in the following I concentrate on CP violation.

See also . . .

White Paper: measuring the Neutrino Mass Hierarchy

arXiv:1307.5487



Defining LCPV target performances

5 σ with 50% coverage

Defining LCPV target performances

5 σ with 50% coverage ⟶ forget about SuperBeams

Defining LCPV target performances

~~**5 σ with 50% coverage**~~ → forget about SuperBeams

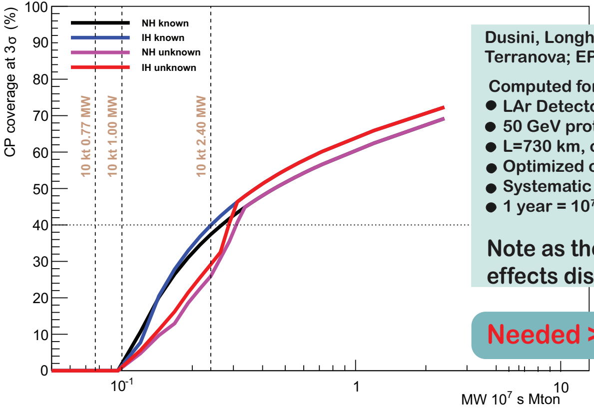
3 σ with 70% coverage

Defining LCPV target performances

~~5 σ with 50% coverage~~ → forget about SuperBeams

3 σ with 70% coverage

CP coverage at 3 σ (%), 5+5 y, err.sys. = 0.05 ONAXIS



Dusini, Longhin, MM, Patrizii, Sioli, Sirri, Terranova; EPJ C73 (2013) 2392

Computed for:

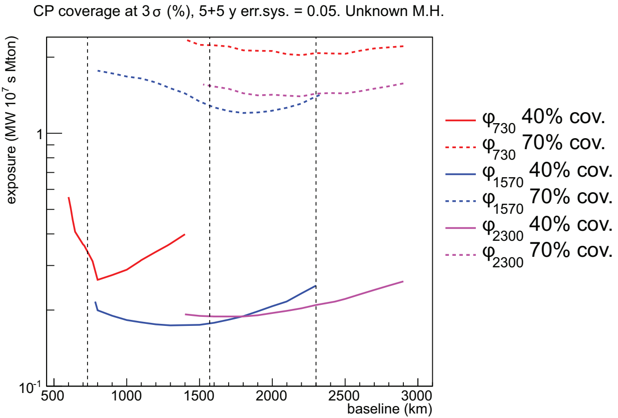
- LAr Detector
- 50 GeV proton beam
- L=730 km, on-axis
- Optimized optics
- Systematic errors: 5%
- 1 year = 10^7 s

Note as the MH degeneracy effects disappear with exposure

Needed >1 Mton x MW x year

There are no magic baselines for LCPV

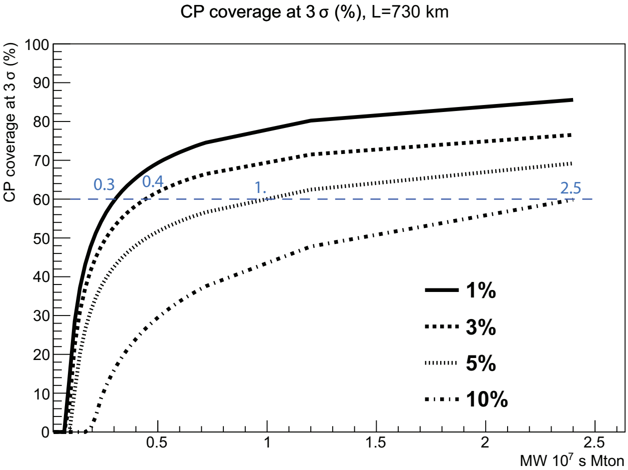
Dusini et al., EPJ C73 (2013) 2392



- LAr detector, 50 GeV/c proton accelerator
- Beam optics optimized with the same algorithm for 3 baselines: 732, 1570, 2300 km.
- For each optimization the baseline has been moved in a range
- Curves are for 40% and 70% coverage (3σ)

Systematic errors play a decisive role

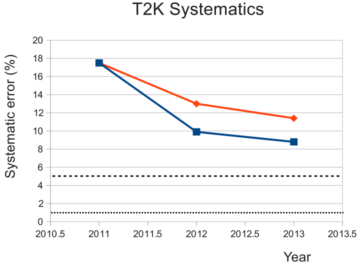
Dusini et al., EPJ C73 (2013) 2392



Again about systematic errors

WG1-WG3 joint session on Tuesday afternoon. In particular: A. Kaboth talk on T2K
5-6% maybe possible, smaller values require new concepts (i.e. Beta Beams, Nufacts).

- A sophisticated close detector station: ND280 + Ingrid
- The best quality hadroproduction data ever produced (NA61) already included
- A huge, qualified, effort by the largest collaboration ever seen in neutrino physics
- At present limited by statistics



- No possible compromise in close detectors design, at the contrary they probably need more attention than the far detectors.
- Please note that the longer baselines, with their steep decay tunnels, force compromises:
  - The close detector too close to the target station, to avoid too deep pits
  - Small volumes to save money in the deep pits

On systematic errors see also: Huber, MM, Schwetz, JHEP 0803 (2008) 21.
Coloma, Huber, Kopp, Winter, Phys.Rev. D87 (2013) 3, 033004.

Proton driver at the CERN side: SPS

Not the latest development in accelerator science . . .
It fed BEBC, CHARM, CDHS, CHORUS, NOMAD . . .

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PR 77/15
21 April 1977

INAUGURATION OF THE 400 GeV SPS ACCELERATOR

7 MAY 1977

Dear Sir or Madam,

Following our invitation of 23 February to attend the inaugural ceremony of the SPS, we should now like to give you details of the arrangements made for members of the Press :

09.00 hrs (*) Council Chamber, Administration Building, Meyrin, Switzerland :

Press Conference given by the President of Council, the Directors-General and various leading participants;

10h.00 hrs Visit to the 400 GeV accelerator, which is situated in an underground tunnel, 2200 metre in diameter, passing under the Franco-Swiss border at a depth of 40 metres;

P.T.O. .../..

(*) All times are indicated in "Swiss time" (Central European Time) i.e. an hour earlier than French time.

L'Organisation européenne pour la recherche nucléaire (CERN) a son siège à Genève, Suisse. Son domaine couvre quelque 560 hectares de part et d'autre de la frontière franco-suisse. Le CERN exploite un ensemble d'accélérateurs et d'appareils associés (un synchro-cyclotron de 0,6 GeV (SC), un synchrotron à protons (PS) de 28 GeV, des anneaux de collisions (ISR), un synchrotron à protons (SPS) de 400 GeV.) De grands détecteurs de particules (visuels ou électroniques) sont également utilisés avec les accélérateurs, de même que des équipements de dépouillement des données acquises. Les travaux du CERN étudient les caractéristiques et le comportement des particules fondamentales de la matière. Le CERN est financé par 12 Etats européens. Son personnel est de quelque 3500 personnes tandis que plus d'un millier de boursiers et attachés scientifiques se trouvent au Laboratoire pour des périodes variables. Le CERN fournit les matériaux de base à leur recherche à quelque 1550 scientifiques dont la majorité réside aux Universités et laboratoires de ses Etats membres.

The European Organization for Nuclear Research (CERN) has its seat at Geneva, Switzerland. The site extends over an area of 560 hectares on both sides of the Franco-Swiss border. CERN operates a complex of accelerators: a 600 MeV synchrotron-cyclotron (SC), a 28 GeV proton synchrotron (PS), the Intersecting Storage Rings (ISR), and a 400 GeV proton synchrotron (SPS), for a programme of sub-nuclear physics research. This research investigates the behaviour of the basic particles of matter. It involves the use of large particle detectors, of visual and electronic type, and extensive data processing facilities. CERN is funded by twelve countries in Europe. There is a staff of about 3500 and there are, in addition, 1000 Fellows and Scientific Associates based at the Laboratory for varying periods of time. CERN provides research material for some 1550 scientists, the great majority of them being at Universities and Research Institutes in the Member States.

Die Europäische Organisation für Kernforschung (CERN) hat ihren Sitz in Genf (Schweiz). Ihr Gelände ist 560 Hektar groß und liegt zu beiden Seiten der französisch-schweizerischen Grenze. CERN unterhält einen Komplex von Beschleunigern und Speicherringen—ein 600-MeV-Synchrozyklotron (SC), ein 28-GeV-Protonensynchrotron (PS), sich kreuzende Speicherringe (ISR), ein 400-GeV-Protonensynchrotron (SPS),—mit deren Hilfe ein Forschungsprogramm auf dem Gebiet der Hochenergiephysik durchgeführt wird. Diese Forschungen haben den Zweck, das Verhalten der Grundbausteine der Materie zu untersuchen. Dabei kommen große visuelle und elektronische Teilchen-Nachweisgeräte und ausgedehnte Datenverarbeitungsanlagen zu Verwendung. CERN wird von zwölf europäischen Ländern finanziert. Es hat etwa 3500 Angestellte, zu denen noch über 1000 Stipendiaten und wissenschaftliche Mitarbeiter kommen, die für kürzere oder längere Zeit das Laboratorium benutzen. CERN liefert Forschungsmaterial für etwa 1550 Wissenschaftler, die größtenteils an Universitäten und in Forschungsinstituten in den Mitgliedstaaten tätig sind.

. . . still the most powerful in neutrino physics

From PDG 2012

NEUTRINO BEAM LINES AT HIGH-ENERGY PROTON SYNCHROTRONS

Created in May 2012 with numbers verified by representatives of the synchrotrons (contact C.-J. Lin, LBNL). For existing (future) neutrino beam lines the latest achieved (design) values are given.

The main source of neutrinos at proton synchrotrons is from the decay of pions and kaons produced by protons striking a nuclear target. There are different schemes to focus the secondary particles to enhance neutrino flux and/or tune the neutrino energy profile. In wide-band beams (WBB), the neutrino parent mesons are focused over a wide momentum range to obtain maximum neutrino intensity. In narrow-band beams (NBB), the secondary particles are first momentum-selected to produce a monochromatic parent beam. Another approach to generate a narrow-band neutrino spectrum is to select neutrinos that decay off-axis relative to the momentum of the parent mesons. For a comprehensive review of the topic, including other historical neutrino beam lines, see the article by S. E. Kopp, "Accelerator-based neutrino beams," Phys. Rept. **439**, 101 (2007).

	PS (CERN)				SPS (CERN)				PS (KEK)	Main Ring (JPARC)
Date	1963	1969	1972	1983	1977	1977	1995	2006	1999	2009
Proton Kinetic Energy (GeV)	20.6	20.6	26	19	350	350	450	400	12	30 (50)
Protons per Pulse (10^{12})	0.7	0.6	5	5	10	10	18	50	6	135 (330)
Cycle Time (s)	3	2.3	-	-	-	-	14.4	6	2.2	2.56 (3.5)
Beam Power (kW)	0.8	0.9	-	-	-	-	55	510	5	250 (750)
Secondary Focussing	1-horn WBB	3-horn WBB	2-horn WBB	bare target	dichromatic NBB	2-horn WBB	2-horn WBB	2-horn WBB	2-horn WBB	3-horn off-axis
Decay Pipe Length (m)	60	60	60	45	290	290	290	994	200	96
$\langle E_\nu \rangle$ (GeV)	1.5	1.5	1.5	1	50,150†	20	24.3	17	1.3	0.6
Experiments	HLBC, Spark Ch.	HLBC, Spark Ch.	GGM, Aachen-Padova	CDHS, CHARM	CDHS, CHARM, BEBC	GGM,CDHS, CHARM, BEBC	NOMAD, CHORUS	OPERA, INCARUS	K2K	T2K

	Main Ring (Fermilab)							Booster (Fermilab)	Main Injector (Fermilab)	
Date	1975	1975	1974	1979	1976	1991	1998	2002	2005	2013
Proton Kinetic Energy (GeV)	300,400	300,400	300	400	350	800	800	8	120	120
Protons per Pulse (10^{12})	10	10	10	10	13	10	12	4.5	37	(49)
Cycle Time (s)	-	-	-	-	-	60	60	0.5	2	(1.333)
Beam Power (kW)	-	-	-	-	-	20	25	12	350	(700)
Secondary Focussing	bare target	quad trip., SSBT	dichromatic NBB	2-horn WBB	1-horn WBB	quad trip.	SSQT WBB	1-horn WBB	2-horn WBB	2-horn off-axis
Decay Pipe Length (m)	350	350	400	400	400	400	400	50	675	675
$\langle E_\nu \rangle$ (GeV)	40	50,180†	50,180†	25	100	90,260	70,180	1	3-20‡	2
Experiments	HPWF	CITF, HPWF	CITF, HPWF, 15' BC	15' BC	HPWF 15' BC	15' BC, CCFRR	NuTeV	MiniBooNE, SciBooNE	MINOS, MINERνA	NOνA, MINERνA, MINOS+

. . . but without large room for improvements

From S. Simone Gilardoni (CERN-PS), Laguna meeting at CERN

Present and future performance @ SPS extraction (in terms of beam power for Neutrino beams)

	Operation		SPS record		After LIU (2020)	
					Aim	Study
	LHC	CNGS	LHC	CNGS	LHC	post-CNGS
SPS beam energy [GeV]	450	400	450	400	450	400
bunch spacing [ns]	50	5	25	5	25	5
bunch intensity/10^{11}	1.6	0.105	1.3	0.13	2.2	0.17
number of bunches	144	4200	288	4200	288	4200
SPS beam intensity/10^{13}	2.3	4.4	3.75	5.3	6.35	7.0*
PS beam intensity/10^{13}	0.6	**2.3**	1.0	**3.0**	1.75	**4.0***
PS cycle length [s]	3.6	1.2	3.6	1.2	3.6	1.2/2.4*
SPS cycle length [s]	21.6	6.0	21.6	6.0	21.6	6.0/7.2
PS momentum [GeV/c]	26	14	26	14	26	14
average current [μA]	0.17	1.17	0.28	1.4	0.47	1.9/1.6
power [kW]	77	470	125	565	211	747/622

*Feasibility including operational viability (especially in PS) remains to be demonstrated

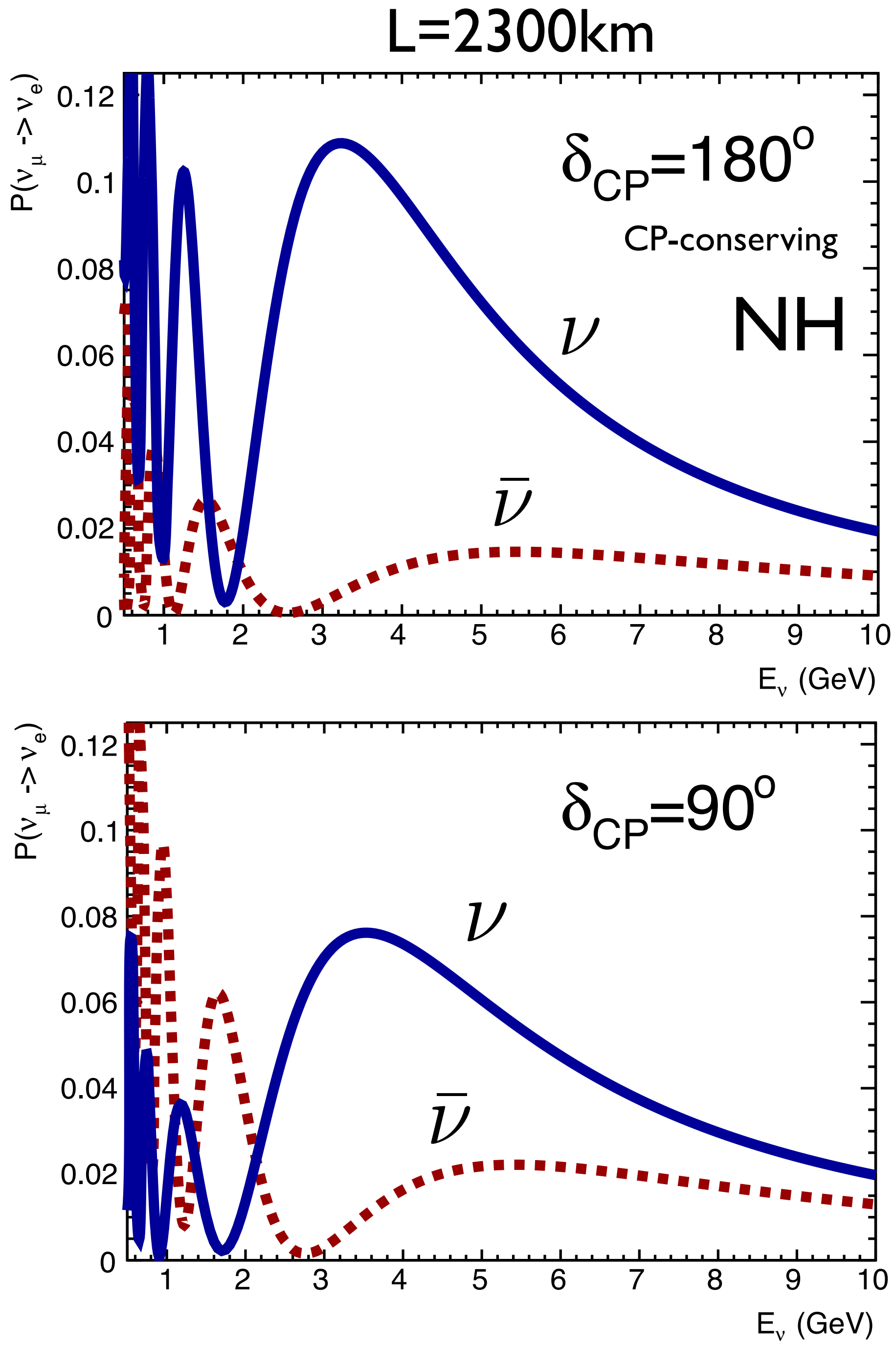
LBNO (CERN SPSC-EOI-007)

http://cdsweb.cern.ch/record/1457543

- **In June 2012, an enlarged LAGUNA-LBNO Consortium has put forward an Expression of Interested to CERN, focused on neutrino Mass Hierarchy determination and CPV discovery coupled to a full astrophysics programme at the Pyhäsalmi (Finland) site**
  - Based on the findings of several design studies – LAGUNA/LAGUNA-LBNO and EUROν.
  - Supported by rock, civil, detector engineering designs and many years of detector R&D
- **An incremental long-baseline program with a competitive 1st stage guaranteeing high level physics performance from the beginning.**
  - LBNO Stage 1 is based on a 20 kt fid. LAr detector (double phase) and a conventional beam from the CERN SPS of 700 kW at 2300 km.
  - If the findings from Stage 1 require, the detector and the beam will be upgraded to 70 kton mass and 2 MW proton power.
  - The costs, possible implementation schemes and physics potentials will be further studied until the end of 2014.
- **Initial positive feedback from SPSC (108th minutes, January 2013)**
  - **The SPSC supports the physics case and recognises its timely relevance in the rapidly evolving neutrino physics landscape.**
  - **SPSC notes that the Finnish Government could not commit to host LAGUNA-LBNO in the proposed Pyhäsalmi site**
  - **SPSC supports double phase LAr TPC as promising technique for future LBL**
  - **SPSC encourages LBNO to proceed with necessary R&D for validation of double phase LAr TPC on large scale**

LBNO main physics goals

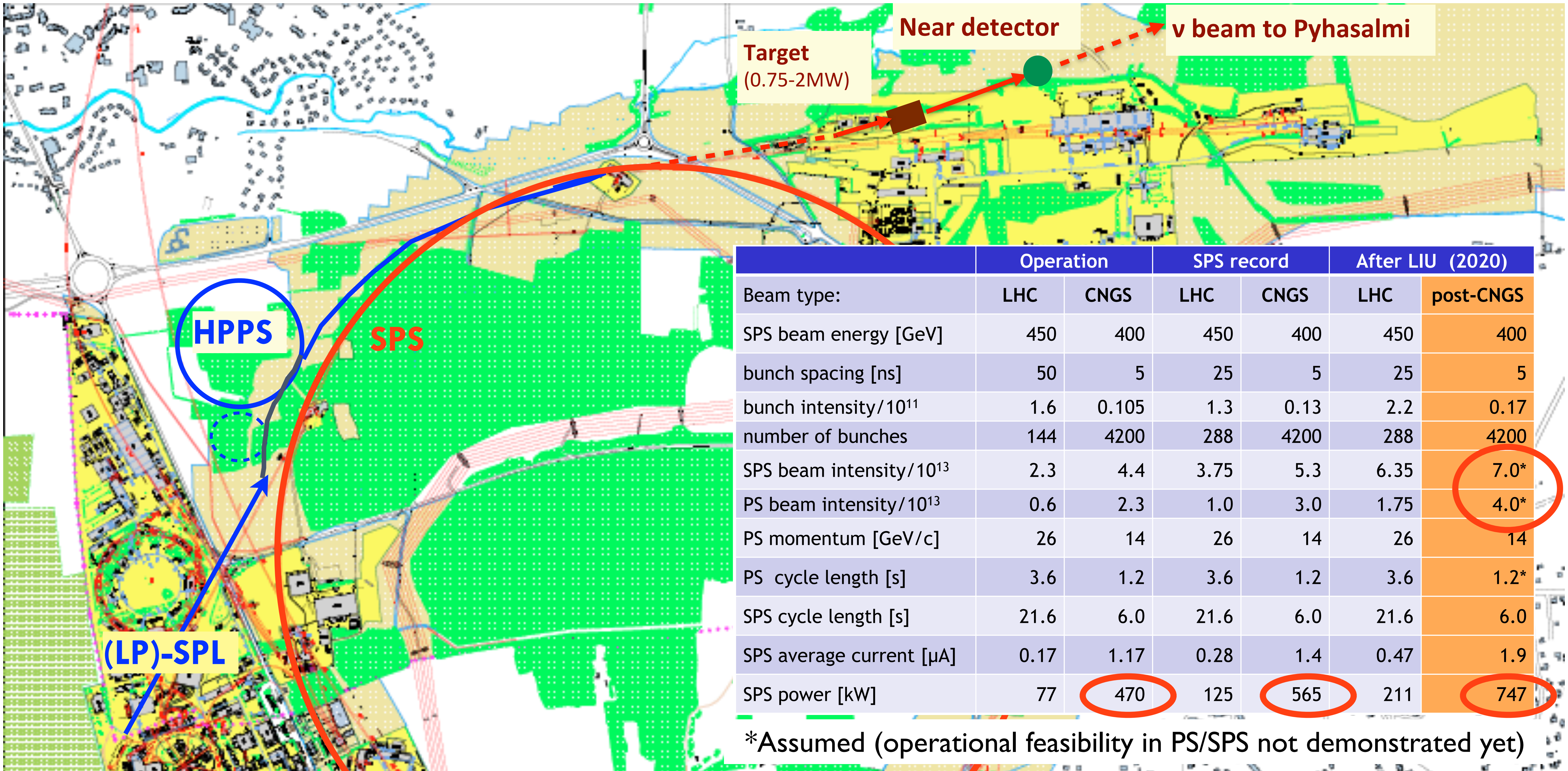
- **Long baseline neutrino oscillations at 2300km**
  - νμ→ νe & νμ→ ντ & νμ→ νμ & νNC
  - Direct measurement of the energy dependence (L/E behaviour) induced by matter effects and CP-phase terms, independently for ν and anti-ν, by direct measurement of event spectrum, in particular covering 1st and 2nd oscillation maxima
  - Mass hierarchy determination at >5σ C.L. in first two years of running
  - CP-phase measurement in initial phase and CPV "discovery" (⇒ 5σ C.L.) with upgrade to increase statistical importance of 2nd maximum
  - Test of three generation mixing paradigm



- **A full astrophysics programme**
  - Nucleon decays (direct GUT evidence)
  - Atmospheric neutrino detection with complementary oscillation measurements and Earth spectroscopy
  - Astrophysical neutrino detection
  - Searches for new sources of low-energy neutrinos

The CN2PY beam

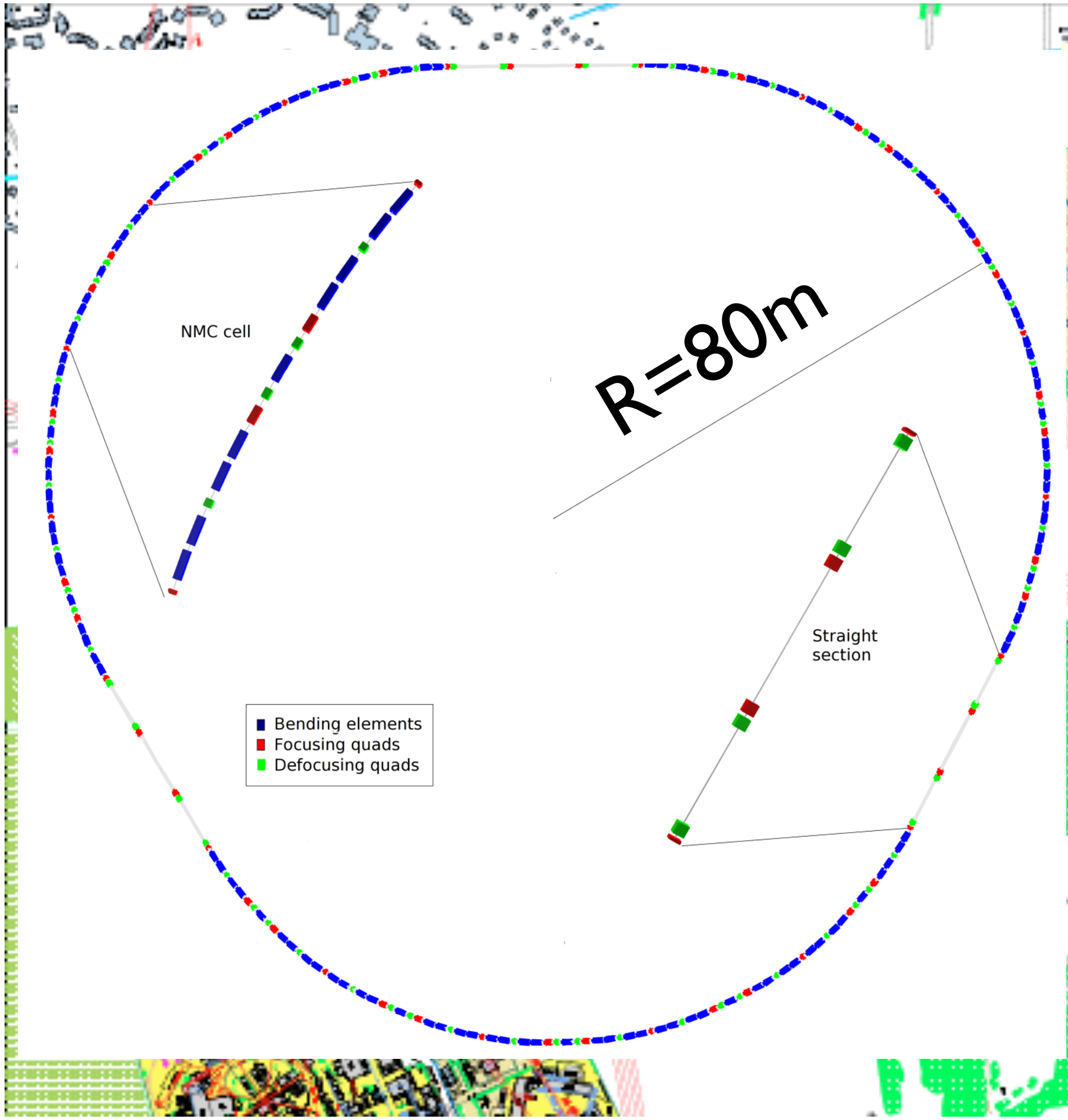
- **Phase 1** : use the proton beam extracted beam from SPS
  - **400 GeV**, max 7.0 10^{13} protons every 6 sec, **750 kW** nominal beam power, 10 µs pulse
  - Yearly integrated pot = (8–13)e19 pot / yr depending on "sharing" with other fixed target programmes.
- **Phase 2** : use the proton beam from the new HP-PS
  - **50**(70) GeV, 1 Hz, 2.5e14 ppp, **2 MW** nominal beam power, 4 µs pulse

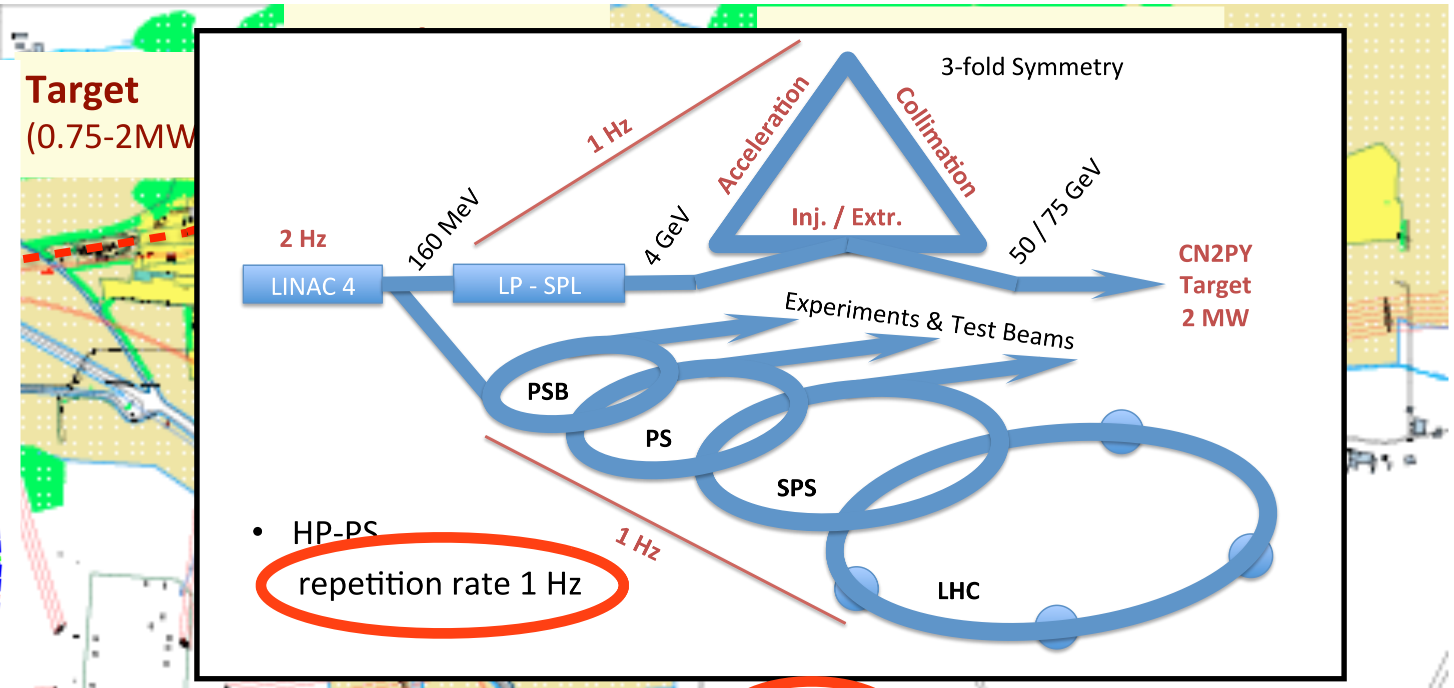


	Operation		SPS record		After LIU (2020)	
Beam type:	LHC	CNGS	LHC	CNGS	LHC	post-CNGS
SPS beam energy [GeV]	450	400	450	400	450	400
bunch spacing [ns]	50	5	25	5	25	5
bunch intensity/10^{11}	1.6	0.105	1.3	0.13	2.2	0.17
number of bunches	144	4200	288	4200	288	4200
SPS beam intensity/10^{13}	2.3	4.4	3.75	5.3	6.35	7.0*
PS beam intensity/10^{13}	0.6	2.3	1.0	3.0	1.75	4.0*
PS momentum [GeV/c]	26	14	26	14	26	14
PS cycle length [s]	3.6	1.2	3.6	1.2	3.6	1.2*
SPS cycle length [s]	21.6	6.0	21.6	6.0	21.6	6.0
SPS average current [µA]	0.17	1.17	0.28	1.4	0.47	1.9
SPS power [kW]	77	470	125	565	211	747

*Assumed (operational feasibility in PS/SPS not demonstrated yet)

High power HP-PS study



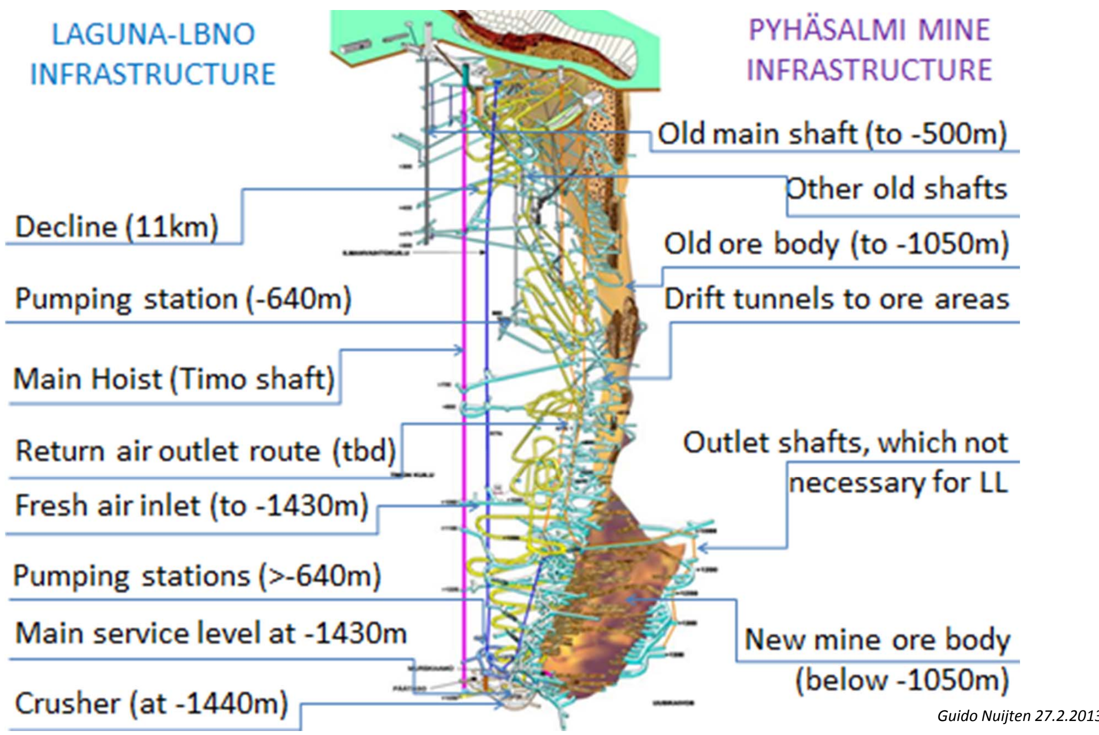


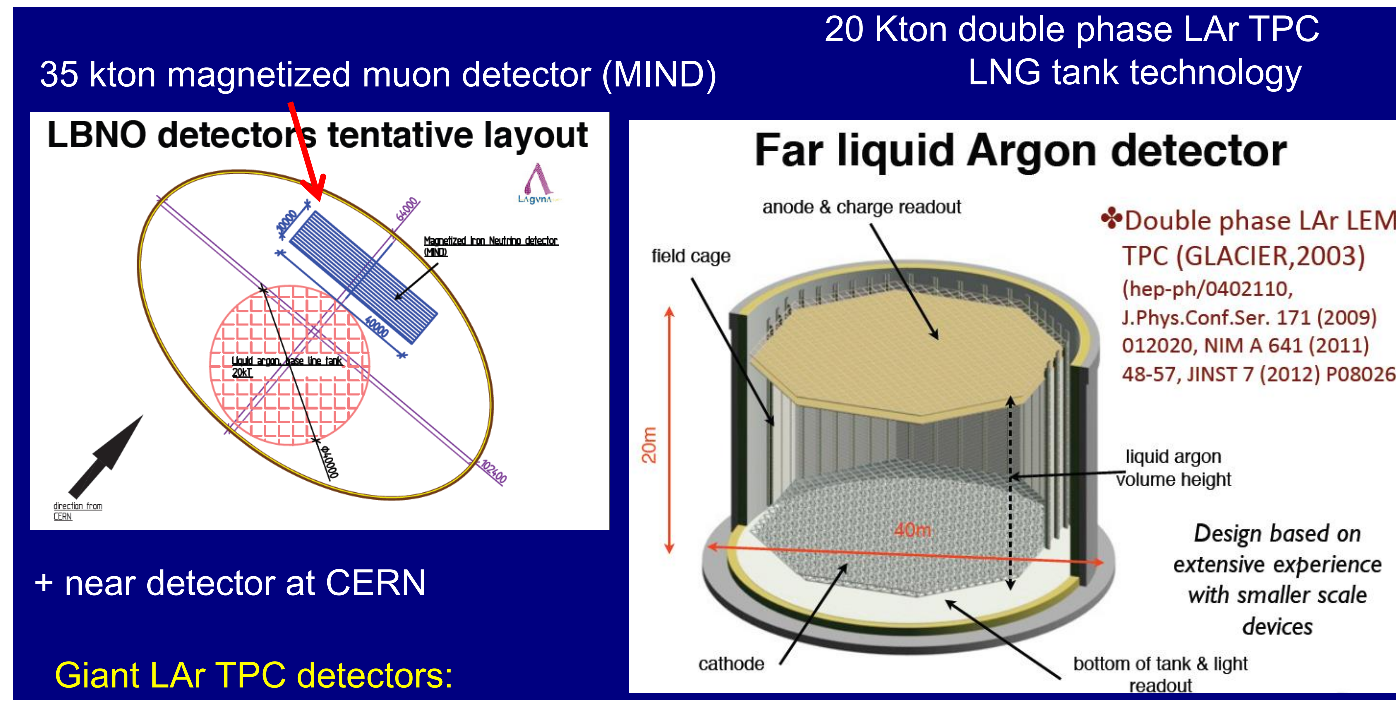
Parameter	50 GeV	75 GeV	Units
Inj. / Extr. Kinetic Energy	4 / 50	4 / 75	[GeV]
Beam power	2		[MW]
Repetition rate	1		[Hz]
f_{rev} / f_{RF} @ inj.	0.248 / 38.97		[MHz]
RF harmonic	157		-
f_{rev} / f_{RF} @ extr.	0.255 / 40.08	0.255 / 40.09	[MHz]
Bunch spacing @ extr.	25		[ns]
Total beam intensity	2.5 x 10^{14}	1.7x10^{14}	-
Number of bunches	147		-
Intensity per bunch	1.7x10^{12}	1.25x10^{12}	-
Main dipole field inj. / extr.	0.17 / 2.1	0.17 / 3.13	[T]
Ramp time	500	500	[ms]
Dipole field rate dB/dt (acc. ramp)	3.9	5.9	[T/s]

- Basic design well underway and main parameters available
- Optics design well advanced
- Injection and extraction concepts are available
- Basic ideas about accelerating RF system
- Basic ideas about collimation
- Consolidate optics and establish set of requirements for different magnet families.
- Design of magnet foreseen.

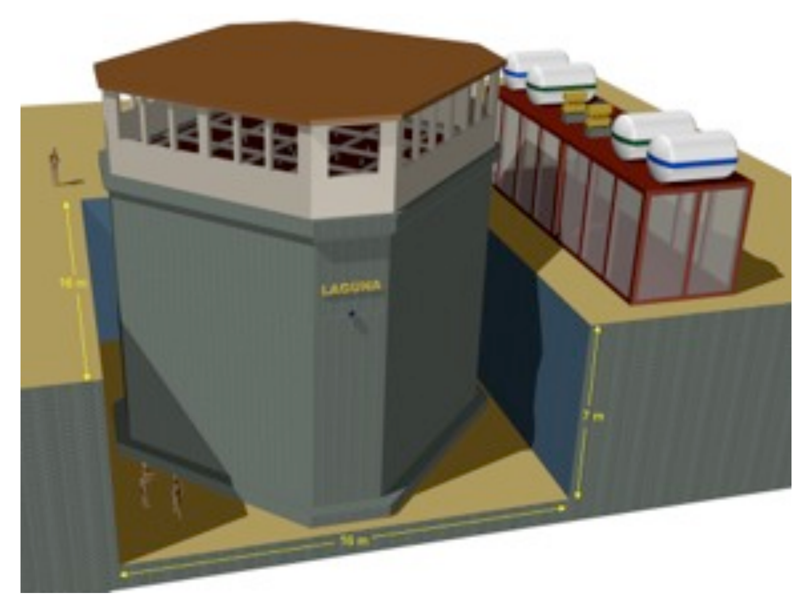
LBNO far site and detectors

- The LAGUNA LBNO collaboration is in the most advanced state for what concerns all technical implementation and site studies, costing and prototyping.
- The Pyhäsalmi site is extremely convenient (baseline, infrastructures, depth, excavation aspects). An extended site investigation is progressing well (750 m drilled) ➞Discussions will continue with Finland in order to define its real contribution, after some initial misunderstanding. Alternative sites in Scandinavia are been looked into.





- **Next milestone:** **Large-scale LBNO detectors prototyping at CERN, with priority emphasis on a large double-phase LAr demonstrator, using charged-particle test beams (2014-2017).**



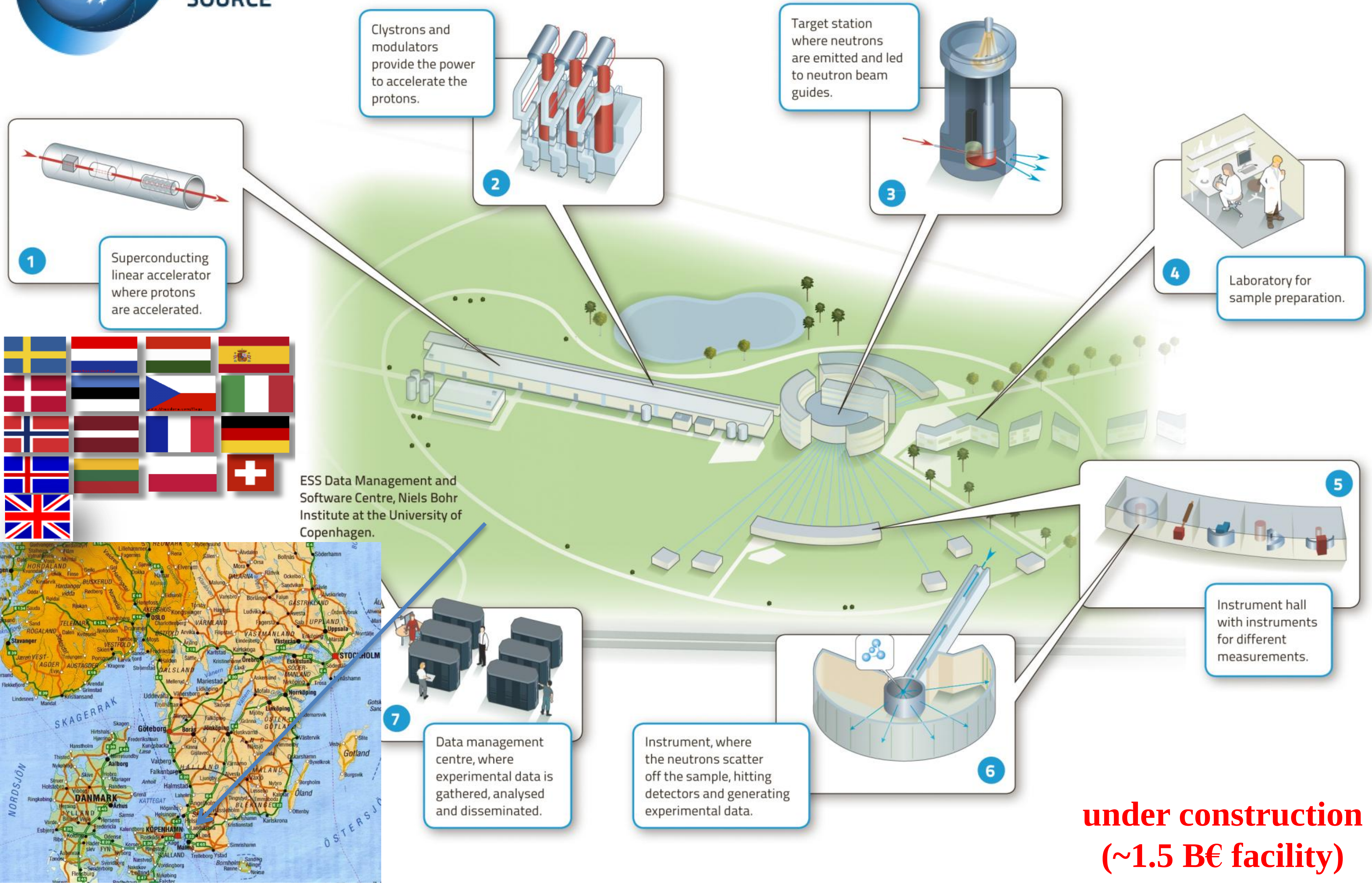
LBNO: Status

My personal understanding; for official statements see LBNO talk by A. Blondel, WG1, Tuesday afternoon

- Short term perspectives: build a 300 ton demonstrator at CERN and expose it to charged particle beams
- Support by host country (Finland): unclear
- High power 50 GeV synchrotron at CERN: not in the next 10-15 years
- Contacts with LBNE: ongoing
- As a matter of fact the double phase LAr technology is not considered a viable solution for multi-kton detectors by the ICARUS collaboration (which runs the only multi-ton LAr detector in the world) and is not the default technology of LBNE.

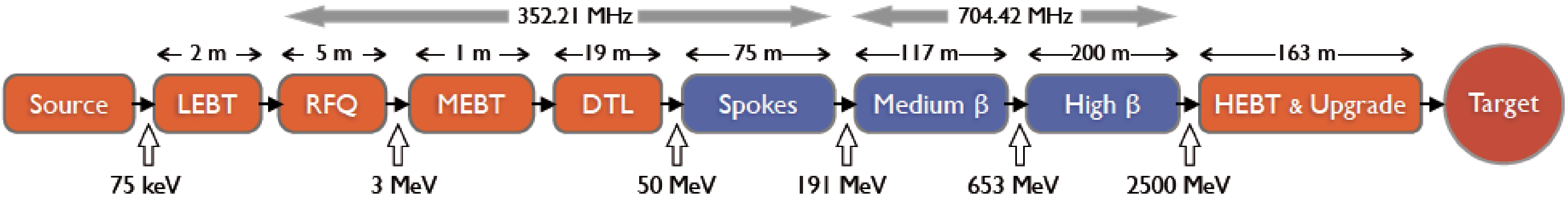
European Spallation Source

Dracos, Vassilopoulos, WG3, tomorrow
Dracos, WG1, Wednesday

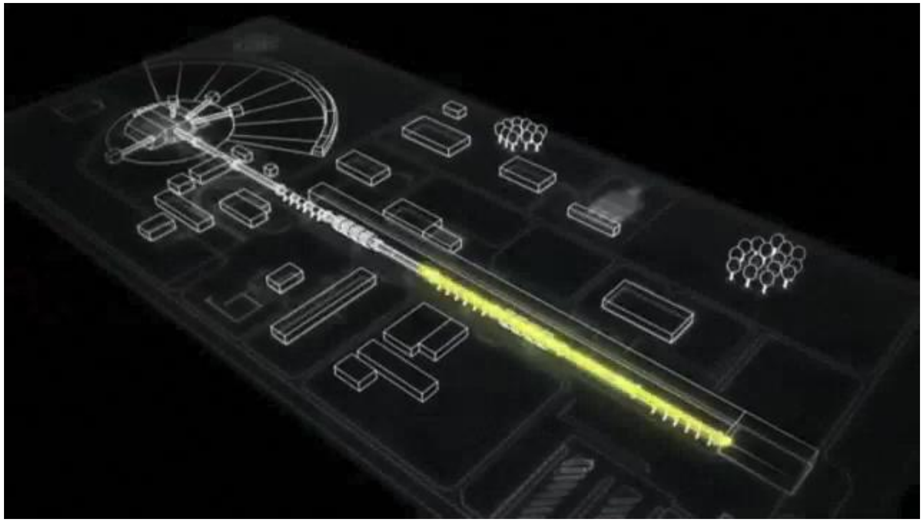


under construction
(~1.5 B€ facility)

ESS proton linac



- The ESS will be a copious source of spallation neutrons
- 5 MW average beam power
- 125 MW peak power
- 14 Hz repetition rate (2.86 ms pulse duration, 10^{15} protons)
- 2.5 GeV protons (up to 3.0 GeV with linac upgrades)
- **>10^{23} p.o.t/year**



ESS Schedule

2010 - ESS Company set up

2010 - 2012 **Technical Design Review**
2010 - 2012 **Pre-Construction & Site Planning**
2009 - 2012 **Licensing and Planning**
2010 - 2012 **Finalisation of international negotiations**

2013 - 2019 **Construction Phase - 7 instruments**
2019 - 2025 **Completion Phase - all 22-33 instruments in place**

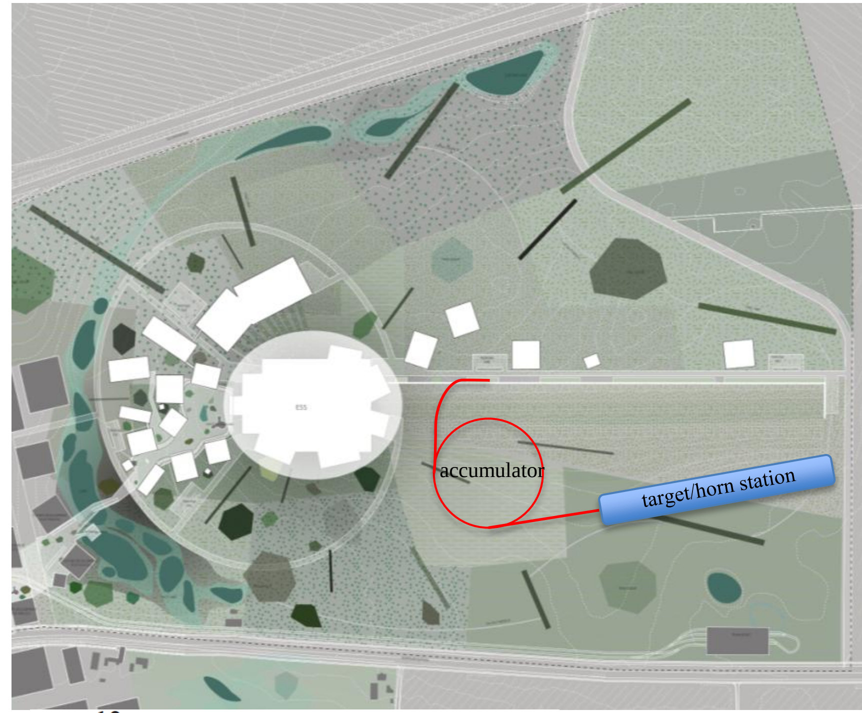
2026 - 2066 **Operations Phase**
2066 – 2071 **Decommissioning Phase**

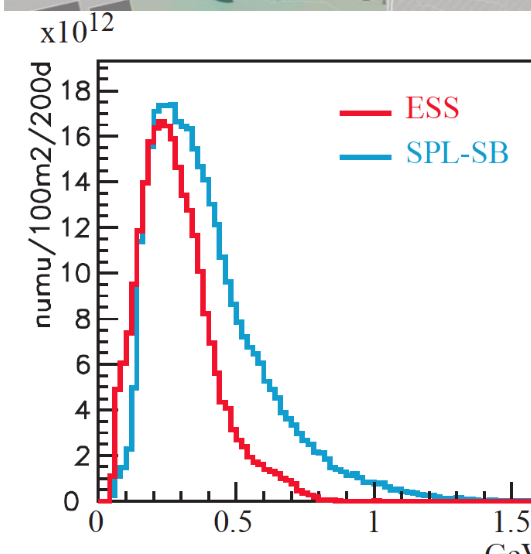
- 1st beam before the end of the decade
- 5 MW by 2023

How to add a neutrino facility?

- We must not affect the neutron program and if possible be synergetic
- Linac modifications: double the rate (14 Hz → 28 Hz)
- Accumulator (ø 143 m) needed to compress to few μs the 2.86 ms proton pulses, affordable by the magnetic horn (350 kA, power consumption, Joule effect)
  - H^- source (instead of protons)
  - space charge problems to be solved
- Target station (studied in EUROnu)
- Underground detector (studied in LAGUNA)
- ~300 MeV neutrinos
- Linac and accumulator could be the first step towards the Neutrino Factory

(http://lanl.arxiv.org/abs/1212.5048)



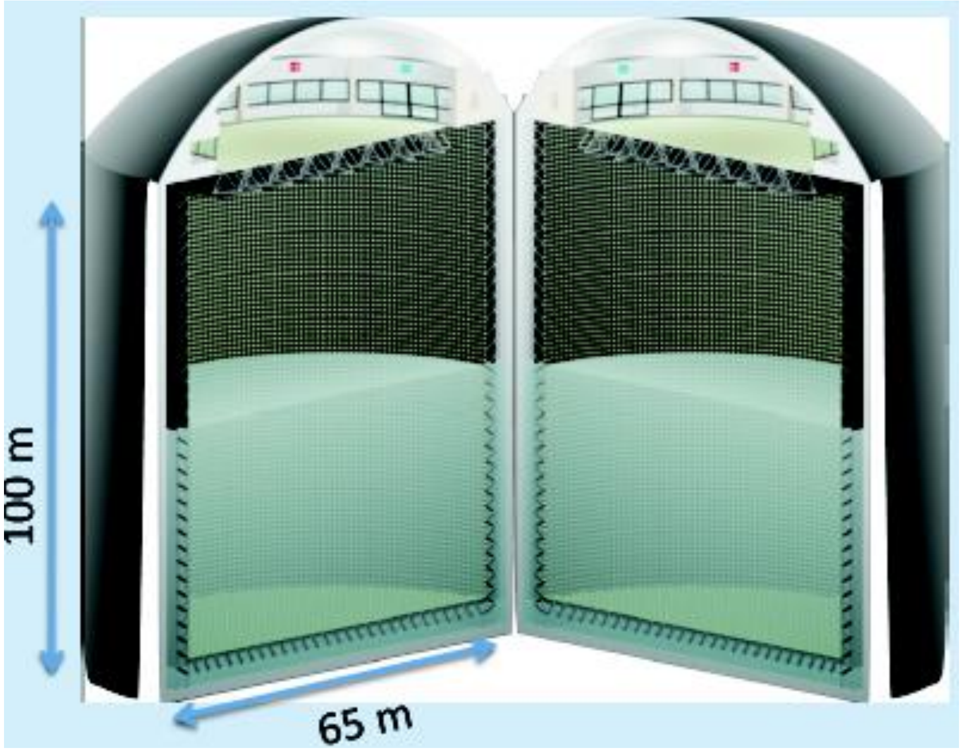


flux at 100 km

The MEMPHYS Detector (Water Cherenkov) (LAGUNA)

Mainly to study:

- **Proton Decay (GUT)**
  - up to ~10^{35} years lifetime
- **Neutrino properties and Astrophysics**
  - Supernovae (burst + "relics")
  - Solar neutrinos
  - Atmospheric neutrinos
  - Geoneutrinos
  - neutrinos from accelerators (Super Beam, Beta Beam)



Water Cerenkov Detector with total fiducial mass: 500 kt:
- 2 Cylindrical modules 100x65 m
- Readout: 22.2k 8" PMTs, 30% geom. cover.

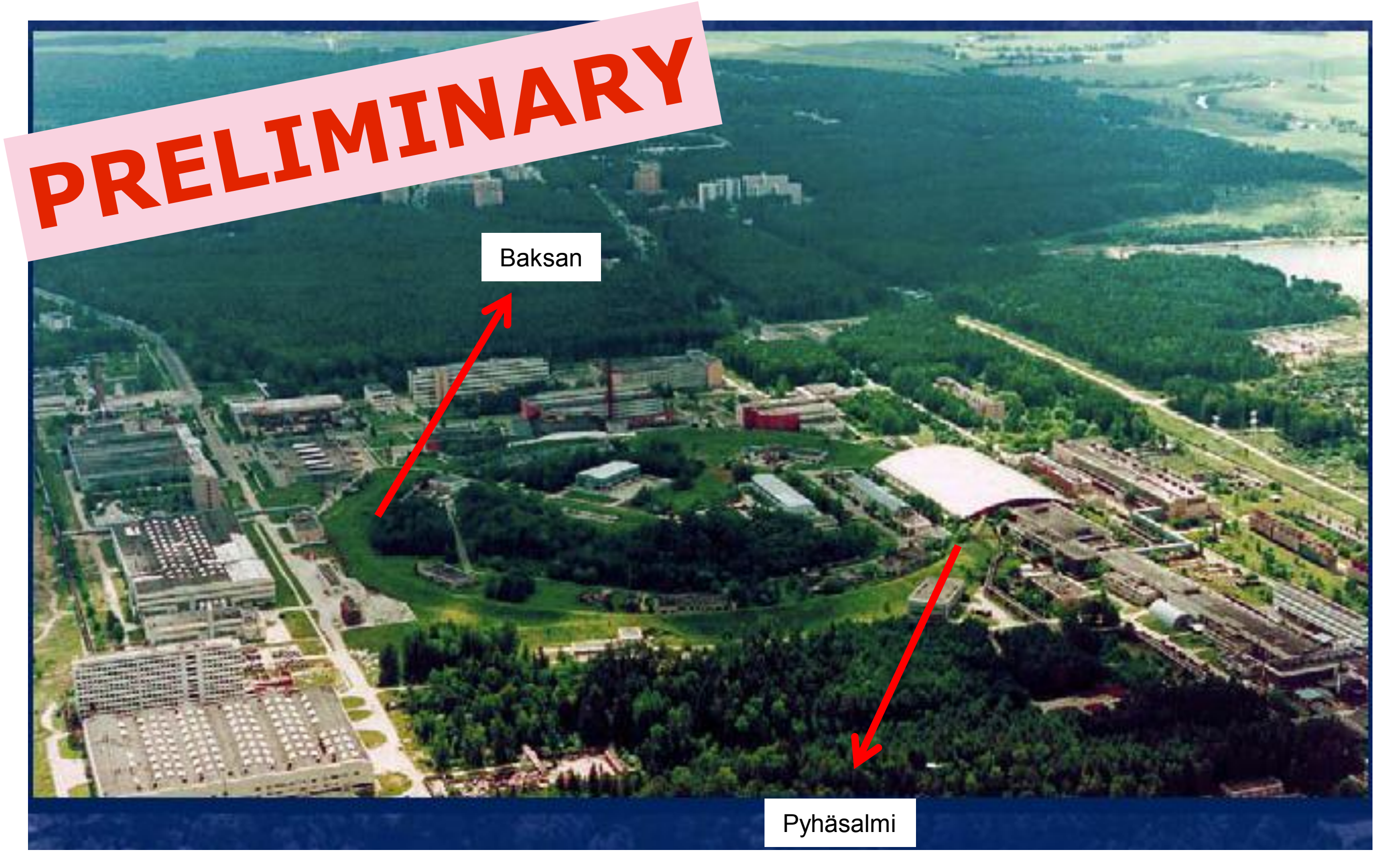
(arXiv: hep-ex/0607026)

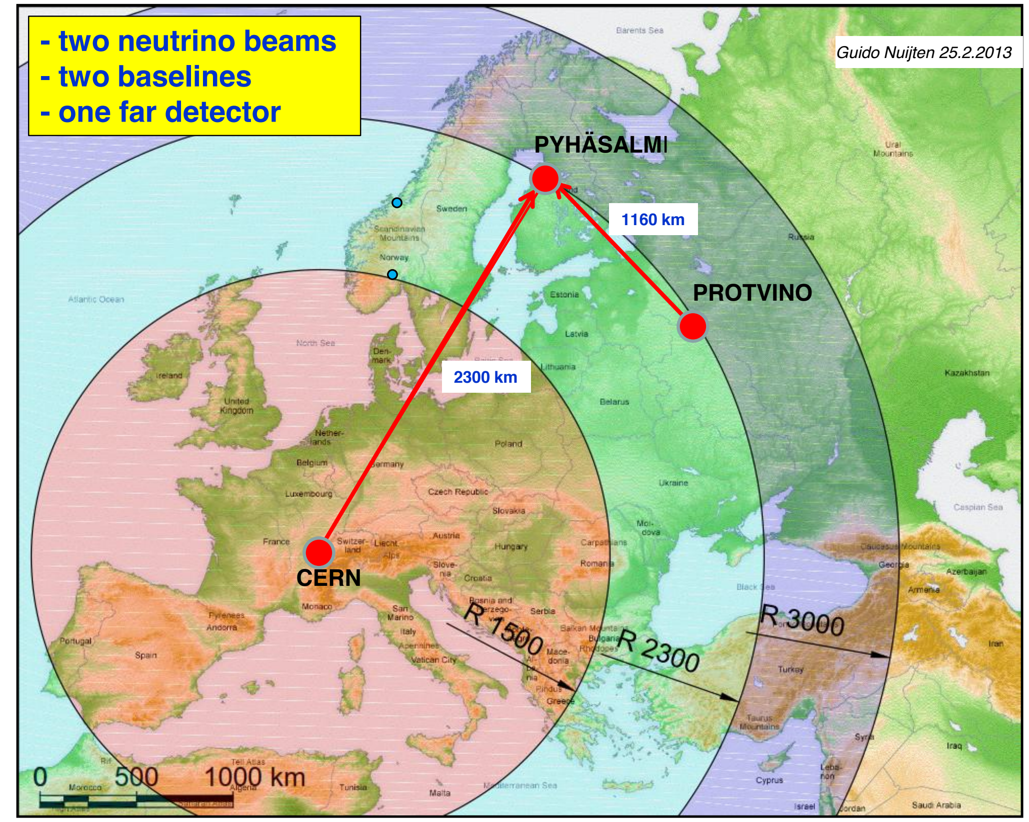
Conclusions

- ESS is under construction
  - very intense source of protons, 5 MW, 2-3 GeV
  - more than 10^{23} protons/year
  - well defined schedule
- Modifications are needed to transform ESS to neutrino facility
  - Double the rate
  - Add an accumulator
  - Add a target station
  - Underground detector (MEMPHYS), mines available

  } could be the first step towards the Neutrino Factory
- Very promising physics performance using EUROnu optimizations:
  - CPV: coverage up to 60%
  - MH: could reach 5 σ combining atmospheric neutrinos
- First ESS beam 2019, full power/energy by 2023.

Possibility of neutrinos from Protvino

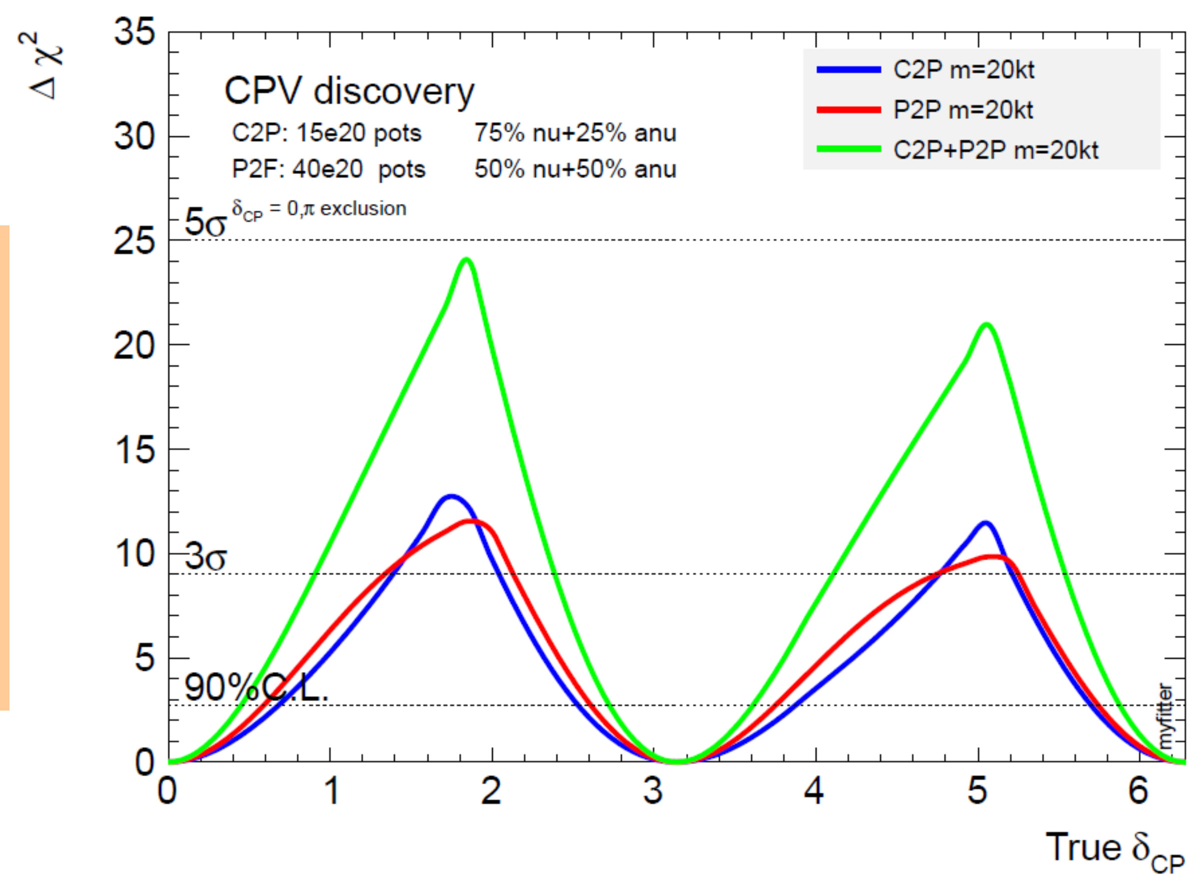




Desired parameters for neutrino beam:

Proton energy	70 GeV
Repetition rate	0.2 Hz
Intensity	2.2×10^{14} ppp
Power	450 kW
Neutrino channel	200-300 m
Angle to Pyhäsalmi	5.2 deg
Distance to ND	500 - 750 m
ND depth (at 500m)	46 m

≈1800 ν_μ CC / 20 kton / year (no osc.)



ICARUS-NESSIE

WG1 talk by Paola Sala about Icarus, Friday afternoon

- Build a new neutrino beam line in the North Area. TDR will be ready in one year, but this project is not mentioned in the CERN medium term plan recently approved.
- Reuse the ICARUS T600 LAr detector as a far detector
- Build a new 150 ton LAr detector as a near detector
- Reuse hardware from the OPERA detector to build spectrometers both in the far and in the near detectors.
- Build an open air instrumented magnet to measure the charge of low momentum muons
- The only project capable of measuring at 5 σ sterile neutrino in any possible manifestation both in neutrino and in antineutrino beams: $\nu_\mu \to \nu_e$ transitions, ν_μ disappearance, ν_e disappearance, NC disappearance.
- As a matter of facts the LBNO community considers this project a waste of time and resources (maybe using more polite statements), and the project is not attracting many physicists outside Italy.

nuSTORM

Definitely not confined to Europe, but with an important European participation WG1 talk by J. Morfin on Wednesday morning, WG3 session on Wednesday afternoon, plenary talk by A. Bross on Saturday morning

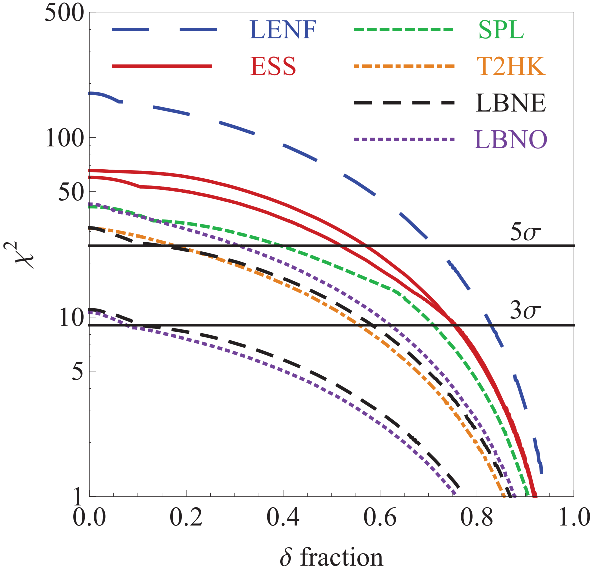
A great opportunity to develop the first stage of a Neutrino Factory.

Great physics performances on neutrino scattering and neutrino cross sections (unique on ν_e cross sections)

I have my own concerns about sterile neutrino potential (lack of statistics, no ν_e disappearance, poor performances in NC disappearance)

Some comparison plot

Courtesy of Enrique Fernandez-Martinez



Conclusions

- After the shutdown of CNGS, Europe risks to remain without neutrino beams for several years, stopping a 40 years long and glorious activity.
- LBNO potential is great, but it can't happen before LBNE or HK. Next years will be crucial to understand where SuperBeams will happen in the world.
- ESS is the most powerful accelerator suitable for the production of neutrino beams in the world. It is a funded project, with a clear timescale. The performances of an ESS-Memphys setup are the best on the SuperBeam market.
- Protvino could complement LBNO or ESS, greatly enhancing their physics potential. It could also be an interesting site for short baseline experiments.
- European physicists already demonstrated they don't need strategy committees to move where the physics case is excellent (T2K, IceCube, Minos etc.)
- It is of great importance that CERN keeps alive the R&D for future neutrino beams.