

LAGUNA-LBNO

Design Study

Large
Apparatus studying
Grand
Unification
Neutrino
Astrophysics

... and
Long
Baseline
Neutrino
Oscillations



THEME INFRA-2011-2.1.1.1

[Design studies for research infrastructures in all S&T fields]

Grant agreement for: Collaborative project

Annex I - "Description of Work"

Project acronym: LAGUNA-LBNO

Project full title: "Design of a pan-European infrastructure for Large Apparatus studying Grand Unification, Neutrino Astrophysics and Long Baseline Neutrino Oscillations"

Grant agreement no: 264520

Version date: 2011-07-14

Work Package 4
Long Base Line Neutrino Beams
Prospects and
Scenarios for Detector Magnetization

I. Efthymiopoulos , CERN

LL-CERN, Dec 17, 2012

► CERN Team WP4 - Today's situation:

Staff	
Ilias Efthymiopoulos	EN/MEF
Marco Calviani	EN/STI
Brennan Goddard	TE/ABT
Malika Meddahi	TE/ABT
Roland Garoby	BE/DHO
Elena Chapochnikova	BE/RF
Frank Gerigk	BE/RF
Rende Steerenberg	BE/OP
Michael Benedikt	BE/OP
Yannis Papaphilippou	BE/ABP
Lucio Rossi	TE/HDO
Antoine Kosmicki	GS/SE
John Osborne	GS/SE
Heinz Vincke	DGS/RP
Simone Gilardoni	BE/aBP

Fellows		
Christos Lazaridis	EN/MEF	100% (01-01-2012)
Philippe Velten	EN/STI	100% (01-02-2012)
Angelina Parfenova	TE/ABT	100% (01-07-2012)
Androula Alekou	BE/ABP	100% (01-09-2012)
Fanouria Antoniou	BE/ABP	50% (01-01-2012)
<i>Javier Alabau Gonzalvo</i>	<i>BE/ABP</i>	<i>50% (01-10-2012)</i>
Project Associate		
<i>PJAS (tbc)</i>	<i>BE/OP</i>	

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Project Associate		
<i>PJAS (tbc)</i>	<i>BE/OP</i>	

- All participants must fill time-sheets - sorry!!
- I was hopping to move to web-based time-sheets but not yet the case !
So go back to manual
- I have ~done an "automatic" template that I can distribute (by-mail only!)
- Instructions available at: http://rpc-eut.web.cern.ch/rpc-eut/documents/How_to_fill_a_timesheet.pdf



LAGUNA-LBNO Project News



- ▶ We are now in the **M14/36** of the project
- ▶ General meetings LAGUNA-LBNO every ~2-3 months
 - 12-14 March'12 @ PARIS-FR
 - 02-04 July'12 @ Oxford-UK
 - 01-03 Oct'12 @ CERN
 - 25-27 Feb'12 @ DESY
 - <https://laguna.ethz.ch/indico/conferenceDisplay.py?confId=8>
 - indico.desy.de/conferenceDisplay.py?confId=7047
 - [for accommodation & local information](#)
 - As usual presentations and report from WP4 activities

LAGUNA-LBNO General Meeting in Hamburg	
from Monday, February 25, 2013 at 09:30 to Wednesday, February 27, 2013 at 12:00 at DESY Hamburg	
Description	The 5th general LAGUNA-LBNO meeting will be held at DESY, Hamburg. Information go to: indico.desy.de/conferenceDisplay.py?confId=7047
Monday, February 25, 2013	
09:30 - 10:00	Registration Location: DWS, Kable Rd
10:00 - 11:45	Session 1: Intro & Reports (200 seats) Location: DWS, Kable Rd (Dennis Sciama Lecture Theatre)
10:00	Opening and Intro 30' Speaker: Scientific community host
11:45 - 12:15	break
12:30 - 13:00	Lunch (Oxford)
13:00 - 13:30	break
13:30 - 17:40	Dinner Reception to start at 18:30 for a 20:00 dinner Location: Balliol College (Hall)
20:30 - 23:00	
Tuesday, February 26, 2013	
11:30 - 12:00	break
12:30 - 13:00	Lunch
13:00 - 13:30	break
13:30 - 17:00	IB Meeting Location: Oxford (Dennis Sciama Lecture Theatre)
18:15 - 21:00	18:15 21:00
Wednesday, February 27, 2013	
11:30 - 12:00	break



LAGUNA-LBNO Project News



- ▶ LBNO Expression of Interest submitted to CERN SPSC
 - positive feedback so far, few meetings and discussions with the referees
 - important first step for the LBNO project the creation of a test area in SPS/North-Area/EHN1 for a LArgon detector prototype test
 - test with particle beams & possibly with ν -beam from the under-study SBL2NA
 - hope to get the green light to proceed for a Technical Proposal for the test setup
 - wait for the Strategy Group Recommendations and later Decisions on CERN's future projects
 - LBNO looks the best long-baseline option for future ν -physics experiments
 - possibility to add a beam from Protvino/Russia to the same detector under study
 - strong asset: future upgrade of the beam/facility with HP-PS, NF



LAGUNA-LBNO WP4 News



► Papers/presentations

- Design Parameters of a High-Power Proton Synchrotron for Neutrino Beams at Cern, Y.Papaphilippou et. al., paper submitted to IPAC12 N.Orleans - USA
- CERN High-Power Protons Synchrotron Design Study for LAGUNA_LBNO Neutrino Production, R.Steerenberg et al., paper submitted to HB2012, Beijing - China
- Design Study for a Future LAGUNA-LBNO Long-Baseline Neutrino Facility at CERN, J.Alabau-Gonzalvo et. al. (submitted to IPAC13)
- Beam Transfer Systems for the LAGUNA-LBNO Long-baseline Neutrino Facility from the CERN SPS, B.Goddard et.al. (submitted to IPAC13)
- Design Options of a High-Power Proton Synchrotron for LAGUNA-LBNO Long Baseline Neutrino Facility at CERN, J.Alabau-Gonzalvo et.al. (submitted to IPAC13)
- Beam dynamics studies for the High-Power SPL accumulator ring of the LAGUNA-LBNO project, A.Aleku et.al. (submitted to IPAC13)

► Study groups:

SG	Title	Coord	Status
1	High-Intensity beams with present CERN accelerators	RG	started
2	Proton beam transfer	BG	started
3	CN2PY Secondary beam design	MC	started
4	CN2PY Layout studies	IE/JO	delayed
5	HP-PS design	YP	good progress
6	Magnetic configuration of a LAGUNA detector	LR	not started yet
7	Near detector requirements	AB	started

► Deliverables:

No	Deliverable title	due date	Who
D1.1	First Report (project)	M18	IE/all
D1.2	Final Report (project)	M36	IE/all
D4.1	Final report future conventional beams	M36	TL/all
D4.2	Report on design and feasibility of magnet configurations	M36	TL/all

► Milestones

No	Milestone name	due date	Who
MS41	Impact of CERN SPS accelerator intensity upgrade	M24	SG-1
MS42	Assessment of SPS proton intensity	M18	SG-1
MS43	Magnetic configuration of LAGUNA detector	M12	SG-6

Additional Slides

For info

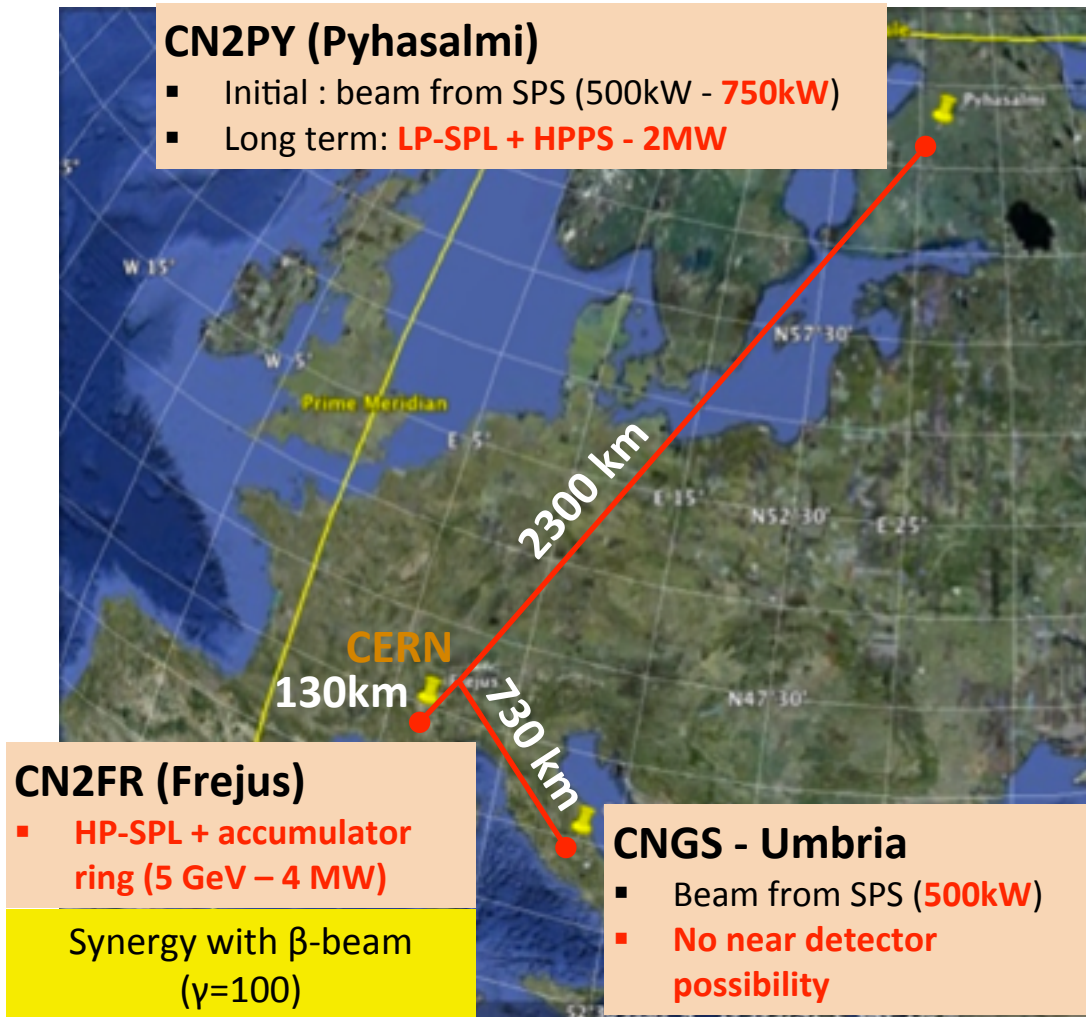


LAGUNA-LBNO General Info

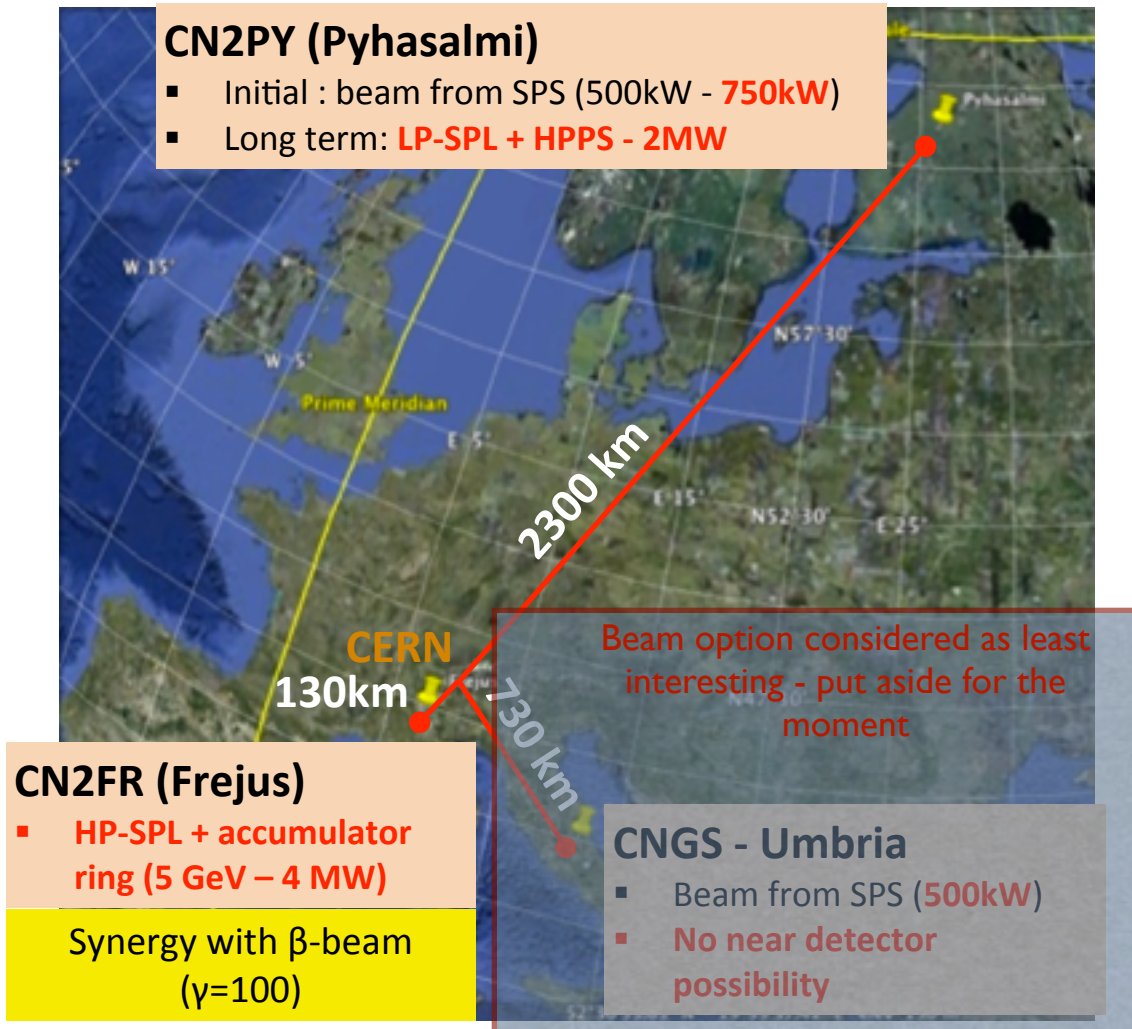


- ▶ EU/FP7 Capacities Project: http://cerneu.home.cern.ch/cerneu/eu_projects/fp7/#LAGUNA-LBNO
 - Duration: September 1, 2011 – August 31, 2014
- ▶ LAGUNA Project Web: <http://laguna.ethz.ch/LAGUNA/Welcome.html>
- ▶ LAGUNA-LBNO Indico : <http://laguna.ethz.ch/indico/index.py>
 - General meetings every few months, next one: October 1-3, 2012 @ CERN
- ▶ LAGUNA-LBNO CERN : <http://cern.ch/laguna-lbno>

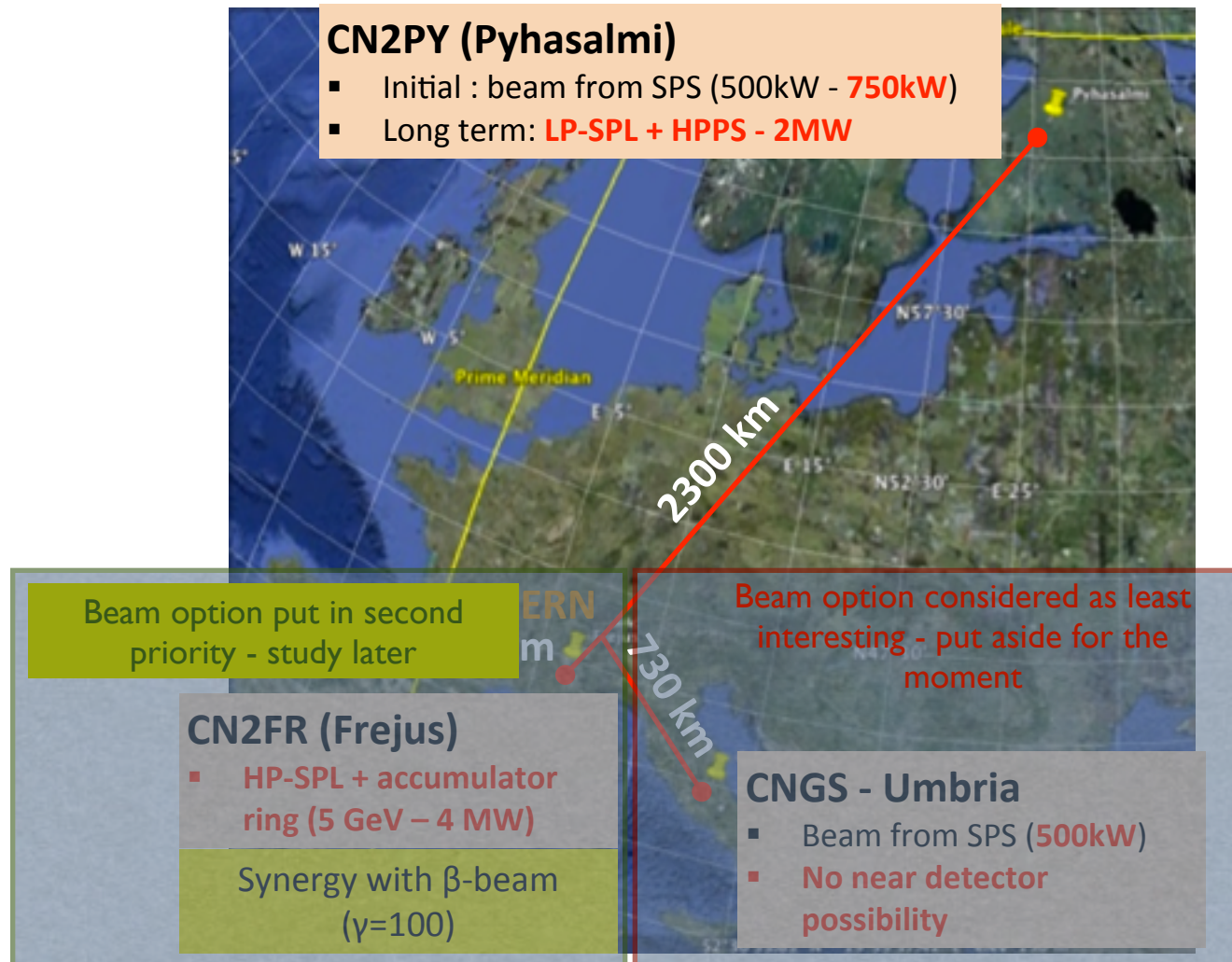
► Long-baseline options from CERN - Large underground detectors



► Long-baseline options from CERN - Large underground detectors

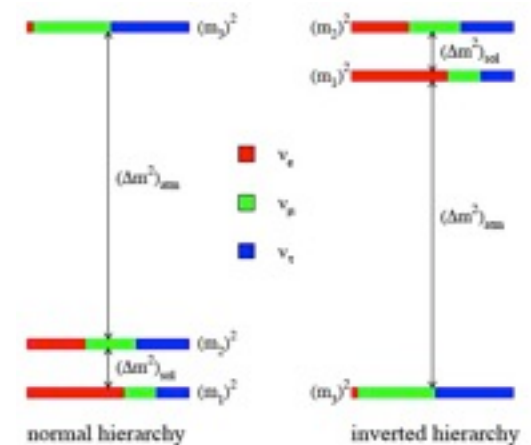
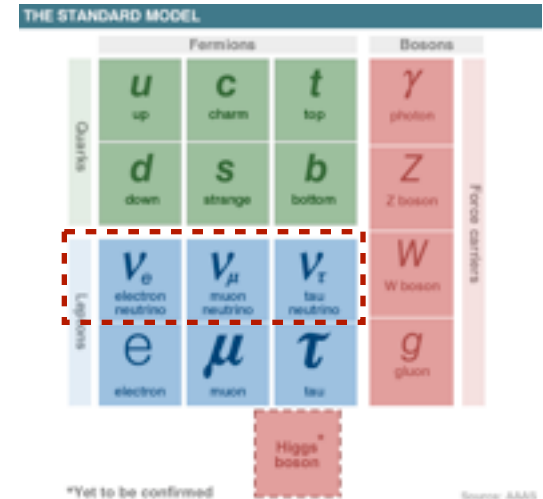


► Long-baseline options from CERN - Large underground detectors



Why study ν physics ?

- ▶ ν_s are part of the Standard Model (SM), yet **the least understood particles**
 - yet there are in large abundance in the Universe and play an important role in early universe
 - we know they have masses because they oscillate, but which (Majorana mass terms?) and why (hierarchy)? are there only 3-neutrino families of left handed- ν_s ?
- ▶ ν_s call for an **extension to the SM**
 - no unique theory of ν mass generation - hint for underlying theory?
- ▶ is there **CP-violation in the leptonic sector** as observed for the quarks?
 - this could impact the cosmological models for the matter-antimatter asymmetry in the universe
- ▶ the ultimate **theory of matter** must include quarks and leptons
 - full understanding of the leptons/neutrinos is required
 - can't be done with LHC or ILC, CLIC



Why long baseline ν beams?

- ▶ easy(!!) way to produce ν_s and study their properties
 - alternatives: ν from reactors, beta-decay, μ -decay
- ▶ long, very long, or short beam lines depends on the value of the parameters

Courtesy JJ Gadenas

Typical configuration:

▶ ν -source:

- π^\pm decay : ν -(super)beam
- rad-ion decay : β -beam
- μ^\pm decay : neutrino factory

▶ ν -detectors:

- near detector
- far detector(s) (on/off axis)

- ▶ Intensity (beam power to produce π, μ, ions) is the key factor

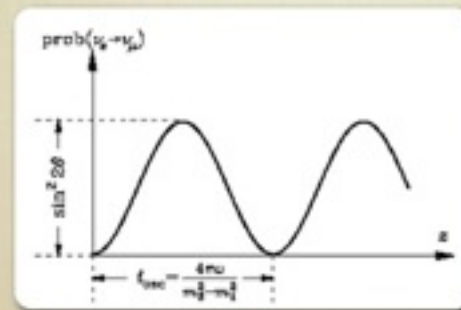
- **high-intensity accelerators and beams**



OSCILLATION PROBABILITY

$$P_{\nu_e \rightarrow \nu_\mu}(L) = \sin^2(2\theta) \sin^2\left(1.27 \frac{\Delta m^2 (\text{eV}^2)}{E(\text{GeV})} L(\text{km})\right)$$

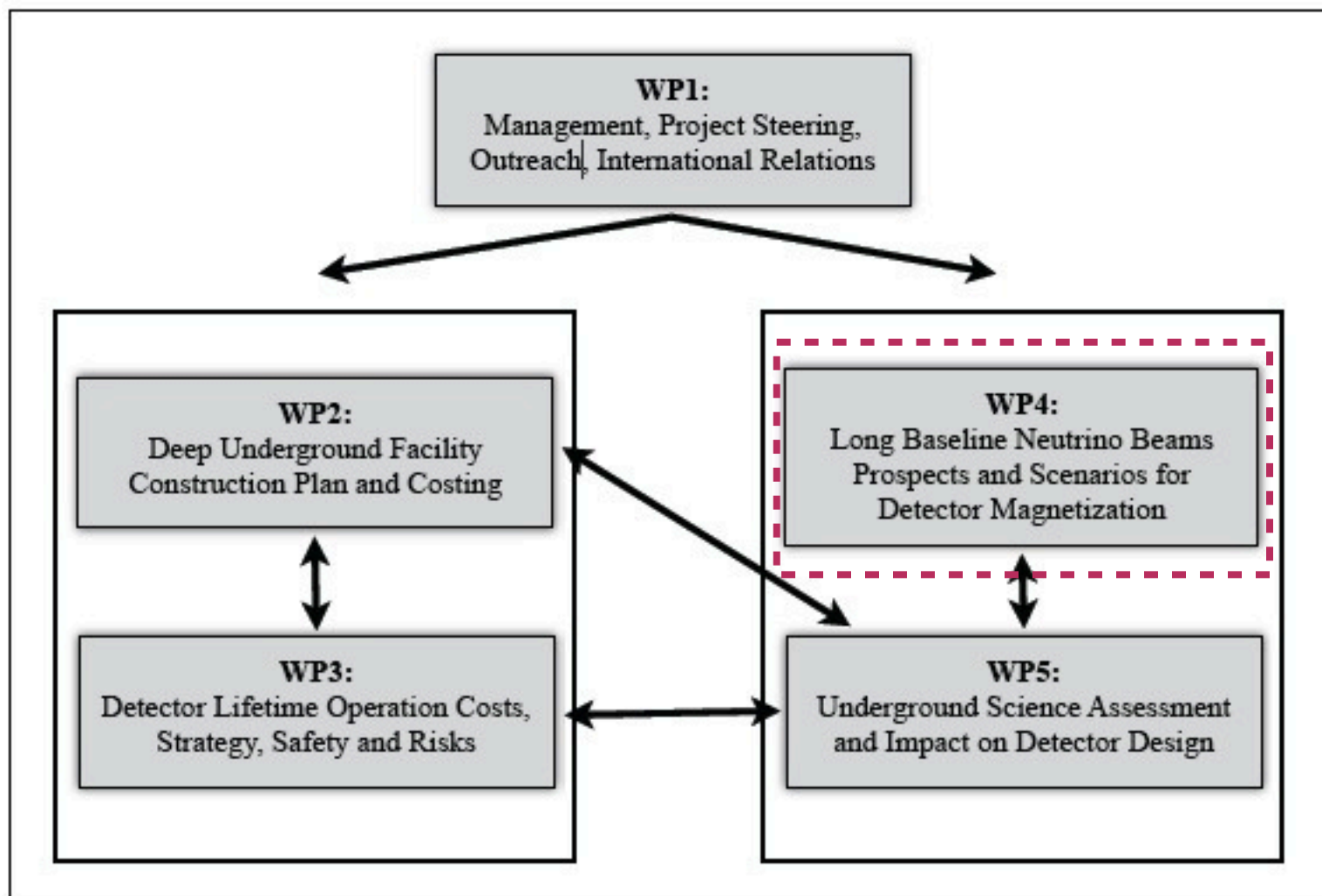
$$P_{\nu_e \rightarrow \nu_e}(L) = 1 - P_{\nu_e \rightarrow \nu_\mu}(L)$$



$$\Delta m^2 = m_2^2 - m_1^2$$

$$L_{\text{osc}}(\text{Km}) \approx \frac{E(\text{GeV})}{1.27 \Delta m^2 (\text{eV}^2)}$$

► General implementation





LAGUNA-LBNO – DS : WP4 Structure



- ▶ **Study Group 1: High Intensity Beams with Present CERN Accelerators** [coordinator: Roland Garoby]
 - Study of impact of CERN SPS accelerator intensity upgrade to ν beams (**Task 4.1**)
 - intensity reach of SPS within the foreseen LiU project – identify limitations to reach $\approx 750\text{kW}$ of beam power for ν s
 - Added: Handling of High-Intensity beams in the PS for neutrinos
 - issues involved, limitations and possible solutions

- ▶ **Study Group 2: Proton Beam Transfer** [coordinator: Brennan Goddard]
 - Design of the proton beam transfer lines for the CN2PY neutrino beam (**Task 4.3**)
 - initial for the 400 GeV protons from SPS and the extraction, later 30–50 GeV from HP-PS
 - Design of the proton beam transfer lines and injection/extraction schemes for HP-PS (**Task 4.4**)

- ▶ **Study Group 3: CN2PY Secondary Beam Design** [coordinator: Marco Calviani]
 - Design of the CN2PY neutrino beam pointing to Pyhasalmi LAGUNA site (**Task 4.3**)
 - Optimization studies for focusing systems and neutrino beam energy
 - Development of basic conceptual design of the target, focusing region, beam dump

► Study Group 4 : CN2PY Layout Studies [coordinator: John Osborn – IE]

- Upgrade of CNGS secondary beam technology (**Task 4.2**) to reach 750kW and further 2MW of proton beam power as required for CN2PY
 - layout and engineering design of target cavern, services tunnels, decay pipe, near detector
 - RP and environmental issues
- Definition of the accelerators and beamlines layout at CERN (**Task 4.5**)
 - implementation studies for the new beams (CN2PY) & accelerators (HP-PS), 3D layouts

► Study Group 5 : HP-PS Design Study [coordinator: Yannis Papaphilippou]

- Feasibility study of a 30-50 GeV high power PS (**Task 4.4**)
 - provide a new very high power and high energy proton source as upgrade option for the CN2PY beam
 - define a set of basic parameters of the machines, and perform feasibility studies of its layout (lattice, size etc.) and basic components (magnets, RF, etc.)
 - study the requirements of a LP-SPL to operate as injector to the HP-PS
- Further studies, beyond CN2PY
 - Option to use HP-SPL at ~5 GeV coupled to an accumulator ring to provide a v-beam to Frejus
 - Possible addition of a buncher ring to serve as proton driver for a future NF at CERN



LAGUNA-LBNO – DS : WP4



- ▶ **Study Group 6 : Magnetic Configuration of a Laguna Detector** [coordinator: Lucio Rossi]
 - Study of the Magnetic Configuration for the LAGUNA detector (**Task 4.6**)
 - study possible superconducting technologies and configurations, e.g. GLACIER detector, basic performance evaluation

- ▶ **Study Group 7 : Near Detector Requirements** [coordinator: Alain Blondel]
 - Definition of near detector requirements and development of conceptual design (**Task 4.7**)
 - understand the detector environment and requirements, study possible technologies, evaluate the performance

–



LAGUNA-LBNO – FP7 DS – DoW



WP4 : LB v beams, detector magnetization – Objectives

- ▶ Develop schemes for construction of **new neutrino beams at CERN** for the LAGUNA-LBNO programme
 - Study of designs to profit from an **increased SPS beam power to 750kW** including layout, and engineering of a **new conventional neutrino beam line** based on the CNGS technology, directed towards a LAGUNA site including a **near detector**
 - Study a new **high power proton accelerator** using the LP-SPL followed by a synchrotron and delivering **2MW of beam power at 30–50 GeV**.
- ▶ Define **layouts at CERN** for:
 - a 400 GeV proton line from SPS for the (0.75–2 MW) target region of a conventional super beam towards Pyhasalmi, including a near detector
 - the proton line from the SPL injecting in the HP-PS synchrotron and extracting protons towards the target of the conventional neutrino beam considered above
 - a 4–5 GeV proton line from SPL, accumulator and compressor ring and (4 MW) target for a superbeam to Frejus, including a near detector(?)
 - study **synergies with the R&D towards the NF** and its potential layout at CERN, using Pyhasalmi as far detector
- ▶ Study of the **magnetic configuration for the LAGUNA detectors**



WP4 – LB ν beams, near detector, detector magnetization



- ▶ **Task 4.1: Study of impact of CERN SPS accelerator intensity upgrade to ν beams**
 - intensity reach of SPS within the foreseen LiU project – identify limitations to reach $\approx 750\text{kW}$ of beam power for ν s

- ▶ **Task 4.2: Assessment of intensity upgrade of CNGS facility (secondary beam technology)**
 - secondary beam design to reach 750kW and further 2MW of proton beam power
 - target region, focusing systems, radiation issues, civil engineering, decay tunnel, services, near detector,

- ▶ **Task 4.3: Conceptual design of the CN2PY neutrino beam**
 - new beam line design (primary + secondary), with the beam pointing to Pyhasalmi LAGUNA site
 - **Subtask 4.3.1** : optimization studies for focusing systems and neutrino beam energy
 - **Subtask 4.3.2** : development of basic conceptual design of the target and focusing region
 - **Subtask 4.3.3** : layout study of the facility

WP4 – LB v beams, near detector, detector magnetization

► Task 4.4 : Feasibility study of a 30-50 GeV high power PS

- provide a new very high power and high energy proton source as upgrade option for the beam of Task 4.3
- feasibility study of a new HP-PS accelerator inspired from the PS2 design, injecting into CN2PY v beam
 - study the requirements of a LP-SPL to operate as injector to the HP-PS
 - define a set of basic parameters of the machines and perform feasibility studies of its layout (lattice, size etc.) and basic components (magnets, RF, etc.)
- study the option to use HP-SPL at ~5 GeV coupled to an accumulator ring to provide a v-beam to Frejus
 - focus on the basic parameters of the transfer lines and accumulator
 - study possible addition of a buncher ring to serve as proton driver for a future NF at CERN

► Task 4.5 : Definition of the accelerators and beamlines layout at CERN

- implementation studies for the new beams & accelerators of Tasks 4.3 and 4.4
- provide 3D layouts of the facilities

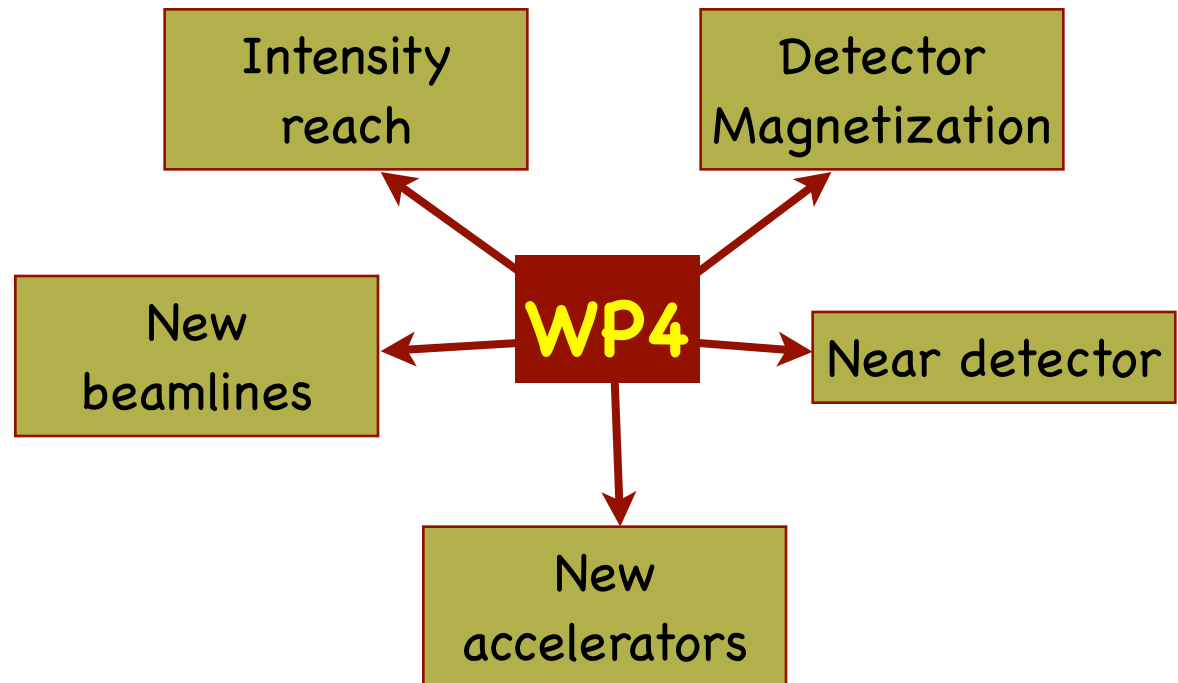
► Task 4.6 : Study of the Magnetic Configuration for the LAGUNA detector

- study possible sc technologies and configurations, e.g. GLACIER detector, basic performance evaluation

► Task 4.7 : Definition of near detector requirements and development of conceptual design

- understand the detector environment and requirements, study possible technologies, evaluate the performance

Participants	
ETH-Zurich	UOXF-DL
UniGe	U-Liverpool
CERN	RAL
JYU	IFIN-HH
CEA	UoB
CNRS-IN2P3	INR
TUM	KEK



LAGUNA-LBNO - FP7 Design

Manpower(*) - CERN	Total [my]
BE/HDO	0.3
BE/OP	0.6
BE/RF	0.3
EN/MEF	1.15
EN/STI	0.55
TE/ABT	1.20
TE/MS	0.30
GS/SE	0.45
Total	4.85

Fellows/PJA -EU	Total [my]
TE/ABT	2
BE/OP	2
BE/ABP	2
EN/MEF	2
EN/STI	2
Fellow (tbd)	2
PJAS (tbd)	2.50
Total	14.50

(*) Declared manpower to be accounted in the time sheets

Materials	Total
Total	115kCHF

- ▶ Budget (bc:60779) available for travel/meetings etc. bc: 60779

– items charged must follow EU rules, better check with me beforehand



LAGUNA-LBNO – DS :



▶ WP4 Structure and Organization and key participants

- **Study Group 1: High Intensity Beams with Present CERN Accelerators** [coordinator: Roland (at interim)]
 - Assembles activities of Task 4.1
- **Study Group 2: Proton Beam Transfer** [coordinator: Brennan – Angelina]
 - Assembles activities of Tasks, and 4.3.3
 - Proton beam transfer design and layout for CN2PY 400 GeV and HP-PS
- **Study Group 3: CN2PY Secondary Beam Design** [coordinator: Marco]
 - Assembles activities of Tasks : 4.2, 4.3.1, 4.3.2, and partly 4.3.3
- **Study Group 4 : CN2PY Layout Studies** [coordinator: John-Ilias]
 - Assembles activities of Tasks : 4.5, 4.3.3, and partly 4.4
- **Assessment of intensity upgrade of CNGS secondary beam technology (Task 4.2)** to reach 750kW and further 2MW of proton beam power
 - target region, focusing systems, radiation issues, civil engineering, decay tunnel, services, near detector,
- **Study Group 5 : HP-PS Design Study** [coordinator: Yannis]
 - Assembles activities of Tasks : 4.4
- **Study Group 6 : Magnetic Configuration of a Laguna Detector** [coordinator: Lucio]
 - Assembles activities of Tasks : 4.6
- **Study Group 7 : Near Detector Requirements** [coordinator: Alain Blondel/(?) – UniGe]
 - Assembles activities of Tasks : 4.7, synergy with LAGUNA-LBNO detector teams



LAGUNA-LBNO – DS :



▶ WP4 Structure and Organization and key participants

– Study Group 1: High Intensity Beams with Present CERN Accelerators [coordinator: Roland (at interim)]

- Assembles activities of Task 4.1

– Study Group 2: Proton Beam Transfer [coordinator: Brennan – Angelina]

- Assembles activities of Tasks, and 4.3.3
- Proton beam transfer design and layout for CN2PY 400 GeV and HP-PS

– Study Group 3: CN2PY Secondary Beam Design [coordinator: Marco]

- Assembles activities of Tasks : 4.2, 4.3.1, 4.3.2, and partly 4.3.3

– Study Group 4 : CN2PY Layout Studies [coordinator: John-Ilias]

- Assembles activities of Tasks : 4.5, 4.3.3, and partly 4.4

– Assessment of intensity upgrade of CNGS secondary beam technology (Task 4.2) to reach 7

- target region, focusing systems, radiation issues, civil engineering, decay tunnel, services, near detector,

– Study Group 5 : HP-PS Design Study [coordinator: Yannis]

- Assembles activities of Tasks : 4.4

– Study Group 6 : Magnetic Configuration of a Laguna Detector [coordinator: Lucio]

- Assembles activities of Tasks : 4.6

– Study Group 7 : Near Detector Requirements [coordinator: Alain Blondel/(?) – UniGe]

- Assembles activities of Tasks : 4.7, synergy with LAGUNA-LBNO detector teams

▶ Meetings for each study group organized by the coordinator

▶ Agendas and information on Indico/Web pages

▶ Beam parameters file in the Web – baseline reference

▶ General meetings (like this one) (bi?)-monthly

- make sure the information flows between the various study groups [my task!]

Key Milestones of 2011

► LAGUNA-LBNO Proposal to SPSC

- CERN-SPSC-2012-021 ; SPSC-EOI-007. - 2012.

► Laguna-LBNO also presented at the EU Strategy Symposium in Krakow

- see talk of M. Zito : <https://indico.cern.ch/conferenceDisplay.py?confId=182232>

