The proposed ESS neutrino Super Beam (ESSνSB) and its physics case

Såtind Conferegnce 2018

Tord Ekelöf

Uppsala University

Why is there only matter and no antimatter in Universe?

The Sakharov conditions (necessary but not sufficient) to explain the Baryon Asymmetry of the Universe (BAU):

1. At least one B-number violating process.

2. C- and <u>CP-violation</u>

3. Interactions outside of thermal equilibrium

Grand Unified Theories can fulfill the Sakharov conditions. However, in each m^3 of the Universe there are on average ca 10^9 photons, one proton and *no* antiproton. The CP violation measured in the quark sector is far too small (by a factor 10^9) to explain this 10^9 photon to baryon ratio.

Now, <u>neutrino CP-violation, so far not observed,</u> may very well be large enough to permit an explanation of BAU through the *leptogenesis* mechanism which relates the matter-antimatter asymmetry of the universe to neutrino properties: decays of heavy Majorana neutrinos generate a lepton asymmetry which is partly converted to a baryon asymmetry via sphaleron processes.

Three neutrino mixing

If neutrinos have mass: $|\nu_l\rangle = \sum U_{li} |\nu_i\rangle$

$$U_{li} = \begin{pmatrix} U_{e1} & U_{e2} & U_{e3} \\ U_{\mu1} & U_{\mu2} & U_{\mu3} \\ U_{\tau1} & U_{\tau2} & U_{\tau3} \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 \\ 0 & c_{23} & s_{23} \\ 0 & -s_{23} & c_{23} \end{pmatrix} \cdot \begin{pmatrix} c_{13} & 0 & s_{13}e^{i\delta} \\ 0 & 1 & 0 \\ -s_{13}e^{-i\delta} & 0 & c_{13} \end{pmatrix} \cdot \begin{pmatrix} c_{12} & s_{12} & 0 \\ -s_{12} & c_{12} & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

where $c_{ij} = \cos\theta_{ij}$, *and* $s_{ij} = \sin\theta_{ij}$

$$P_{\nu_\mu \to \nu_e (\bar{\nu}_\mu \to \bar{\nu}_e)} = s_{23}^2 \sin^2 2\theta_{13} \left(\frac{\Delta_{13}}{\tilde{B}_\mp}\right)^2 \sin^2\left(\frac{\tilde{B}_\mp L}{2}\right)$$

atmospheric

Non-CP terms

$$+c_{23}^2 \sin^2 2\theta_{12} \left(\frac{\Delta_{12}}{A}\right)^2 \sin^2\left(\frac{AL}{2}\right)$$

solar

$$+\tilde{J} \frac{\Delta_{12}}{A} \frac{\Delta_{13}}{\tilde{B}_\mp} \sin\left(\frac{AL}{2}\right) \sin\left(\frac{\tilde{B}_\mp L}{2}\right) \cos\left(\pm\delta_{CP} - \frac{\Delta_{13} L}{2}\right)$$

interference

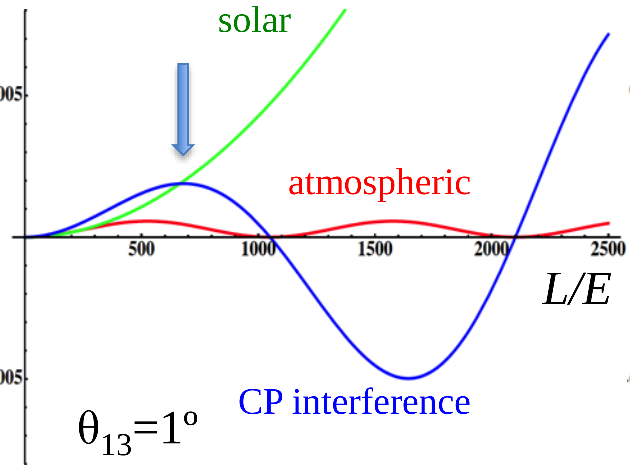
CP violating

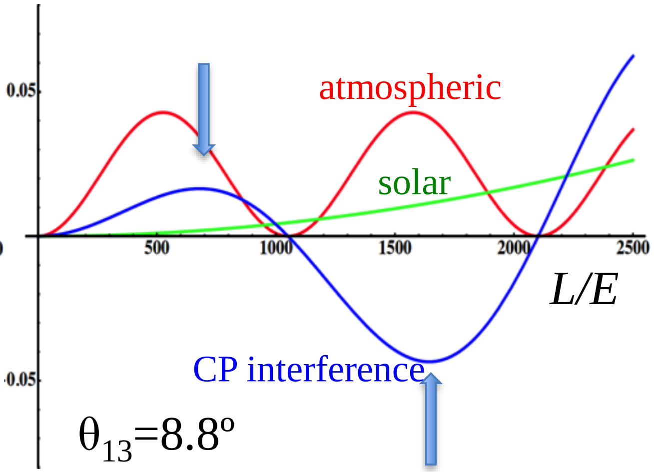
$$\tilde{J} \equiv c_{13} \sin 2\theta_{12} \sin 2\theta_{23} \sin 2\theta_{13}, \ \Delta_{ij} \equiv \frac{\Delta m_{ij}^2}{2E_\nu}, \ \tilde{B}_\mp \equiv |A \mp \Delta_{13}|, \ A = \sqrt{2} G_F N_e$$

Neutrino Oscillations with "large" θ_{13}

for small θ_{13} 1st oscillation maximum is better

(arXiv:1110.4583)

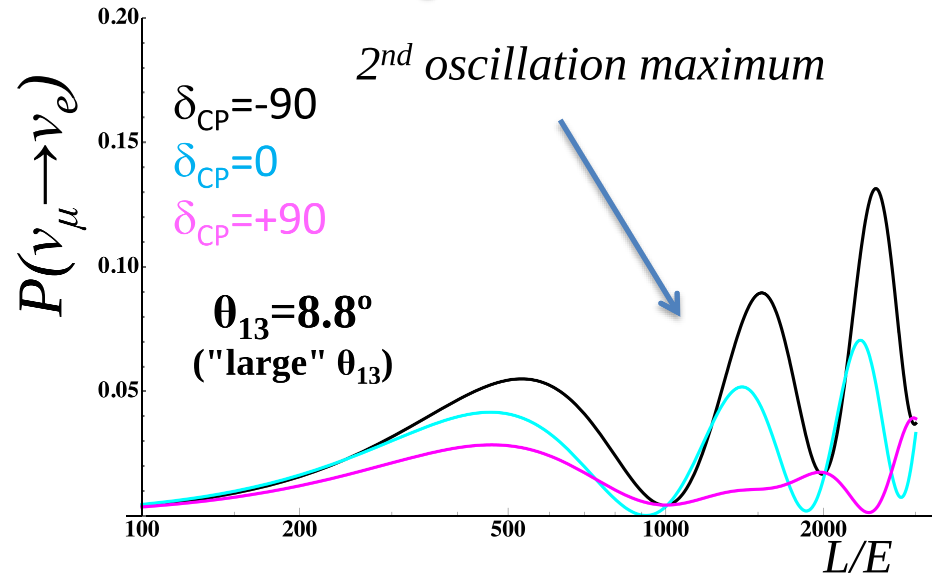




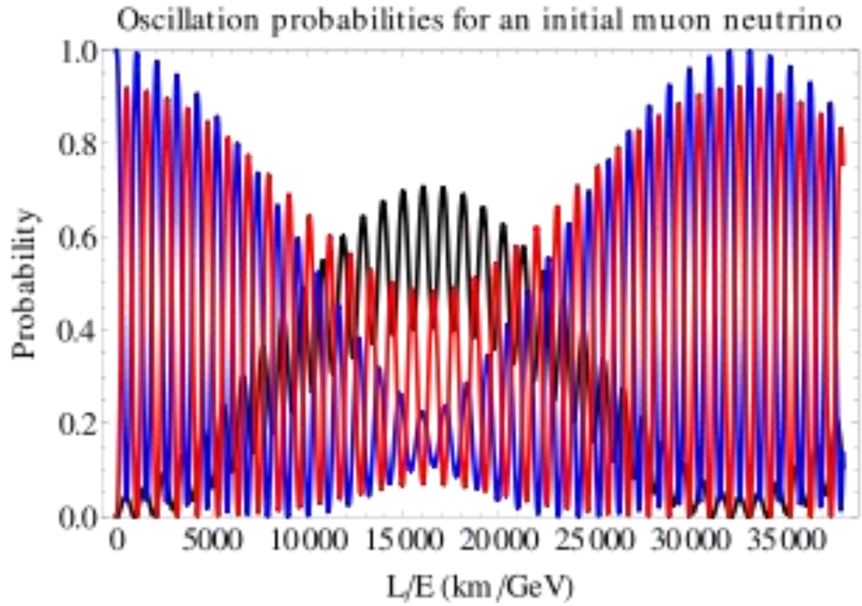
for "large" θ_{13} 1st oscillation maximum is dominated by atmospheric term

- 1st oscillation max.: $A=0.3\sin\delta_{CP}$
- 2nd oscillation max.: $A=0.75\sin\delta_{CP}$

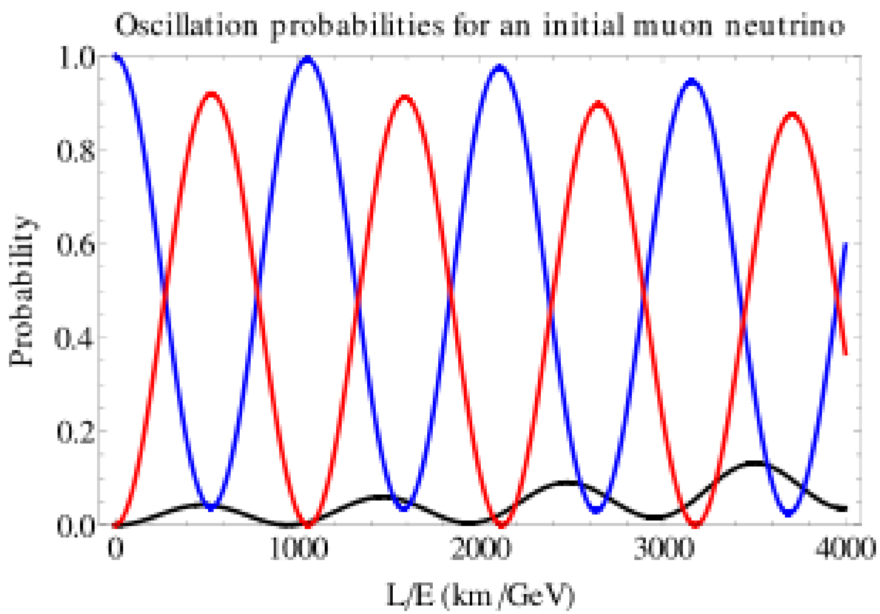
(see arXiv:1310.5992 and arXiv:0710.0554)



more sensitivity at 2nd oscillation max.

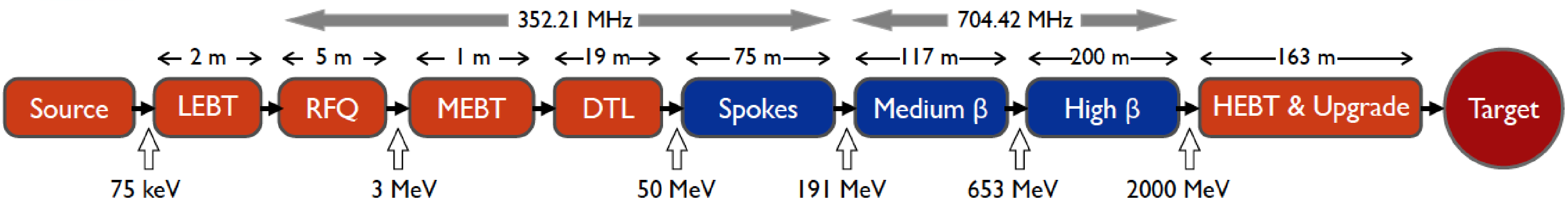


Blue is mu neutrino, red tao neutrino, black electron neutrino

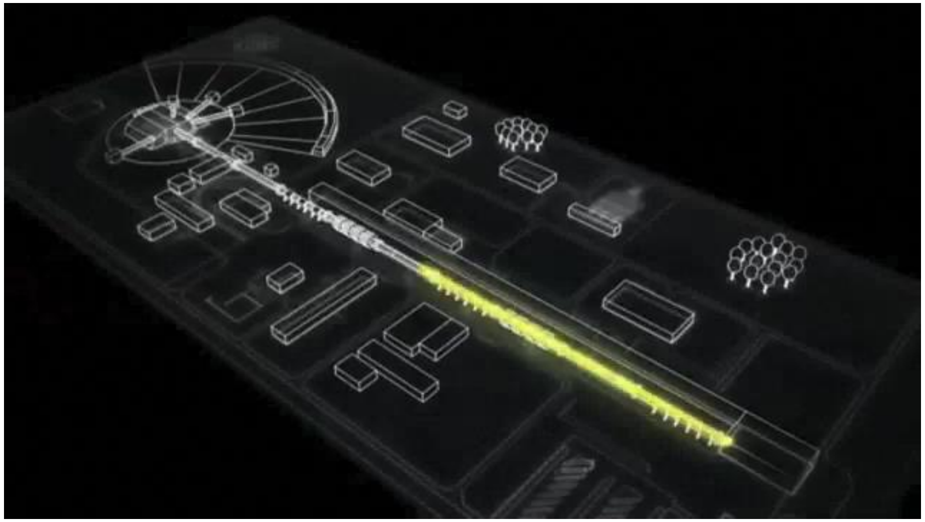


Values used for the above curves
$\sin^2 2\theta_{13} = 0.10$
$\sin^2 2\theta_{12} = 0.861$
$\sin^2 2\theta_{23} = 0.97$
$\Delta m^2_{12} = 7.59\times10^{-5}$ eV^2.
$\Delta m^2_{32} \approx \Delta m^2_{13} = 2.32\times10^{-3}$ eV^2
$\delta = 0$; normal mass hierarchy.

ESS proton linac

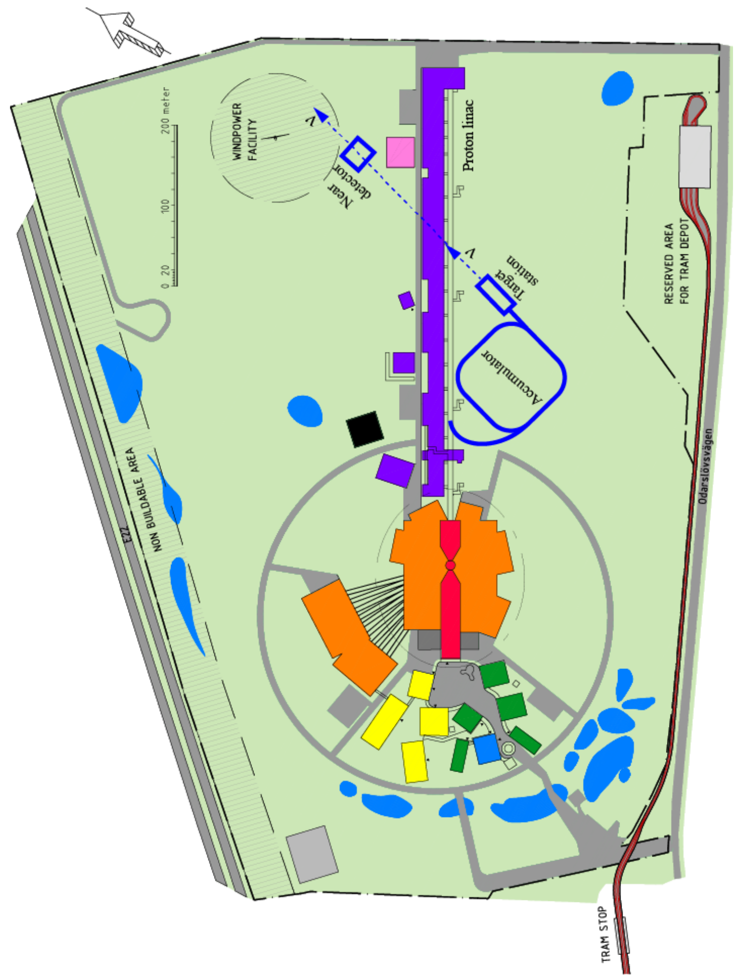


- The ESS will be a copious source of spallation neutrons.
- 5 MW average beam power.
- 125 MW peak power.
- 14 Hz repetition rate (2.86 ms pulse duration, 10^{15} protons).
- Duty cycle 4%.
- 2.0 GeV protons
  - up to 3.5 GeV with linac upgrades
- **>2.7x10^{23} p.o.t/year.**

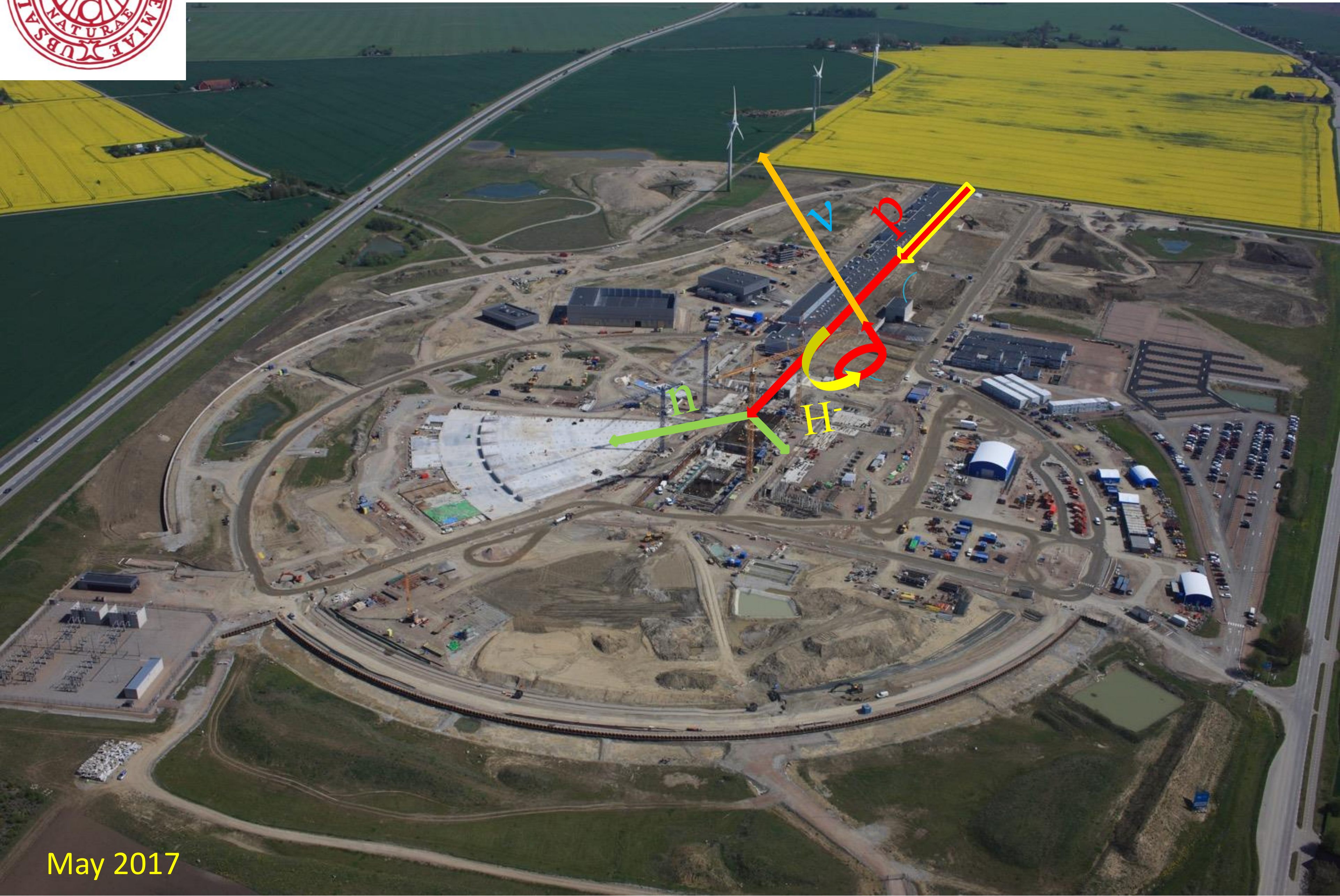


How to add a neutrino facility?

- The neutron program must not be affected and if possible synergetic modifications.
- Linac modifications: double the rate (14 Hz → 28 Hz), from 4% duty cycle to 8%.
- Accumulator (C~400 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.
- ~300 MeV neutrinos.
- Target station (studied in EUROν).
- Underground detector (studied in LAGUNA).
- Short pulses (~μs) will also allow DAR experiments (as those proposed for SNS) using the neutron target.



The neutron and neutrino beams

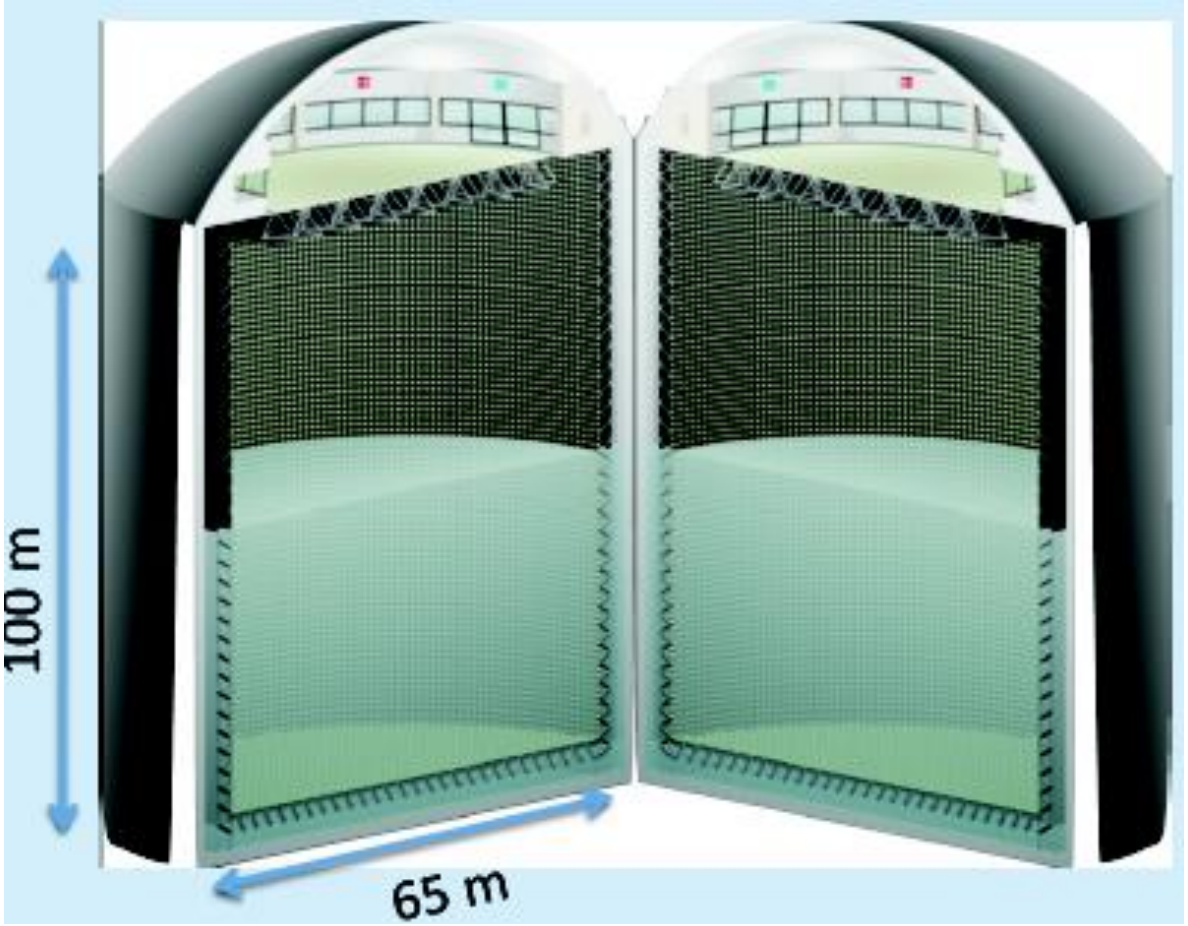


The EUROnu MEMPHYS MegatonWater Cherenkov Detector

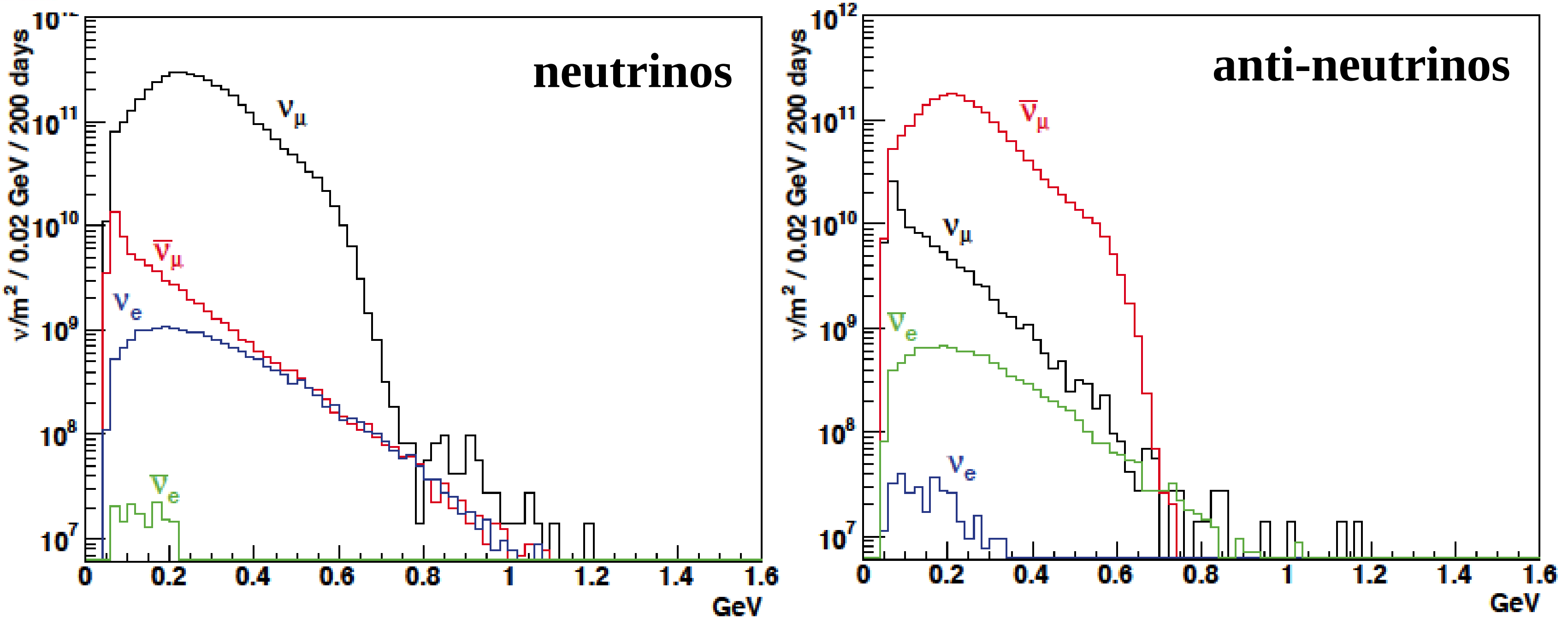
MEMPHYS like Cherenkov detector(MEgaton Mass PHYSics studied by LAGUNA)

- 500 kt fiducial volume (~20xSuperK)
- Readout: ~240k 8” PMTs
- 30% optical coverage

(arXiv: hep-ex/0607026)



ESSνSB ν energy distribution (without optimisation)

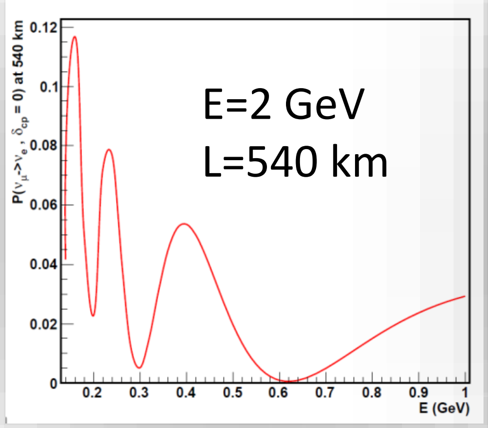


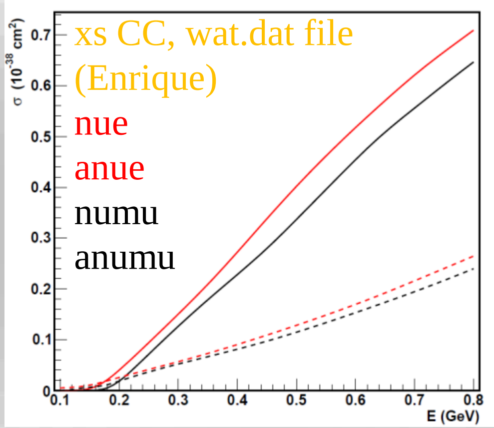
- almost pure ν_μ beam
- small ν_e contamination which could be used to measure ν_e cross-sections in a near detector

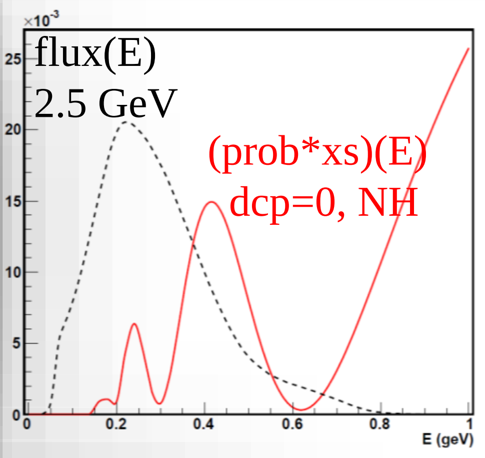
	positive		negative	
	N_ν $(\times 10^{10})/\mathrm{m}^2$	%	N_ν $(\times 10^{10})/\mathrm{m}^2$	%
ν_μ	396	97.9	11	1.6
$\bar{\nu}_\mu$	6.6	1.6	206	94.5
ν_e	1.9	0.5	0.04	0.01
$\bar{\nu}_e$	0.02	0.005	1.1	0.5

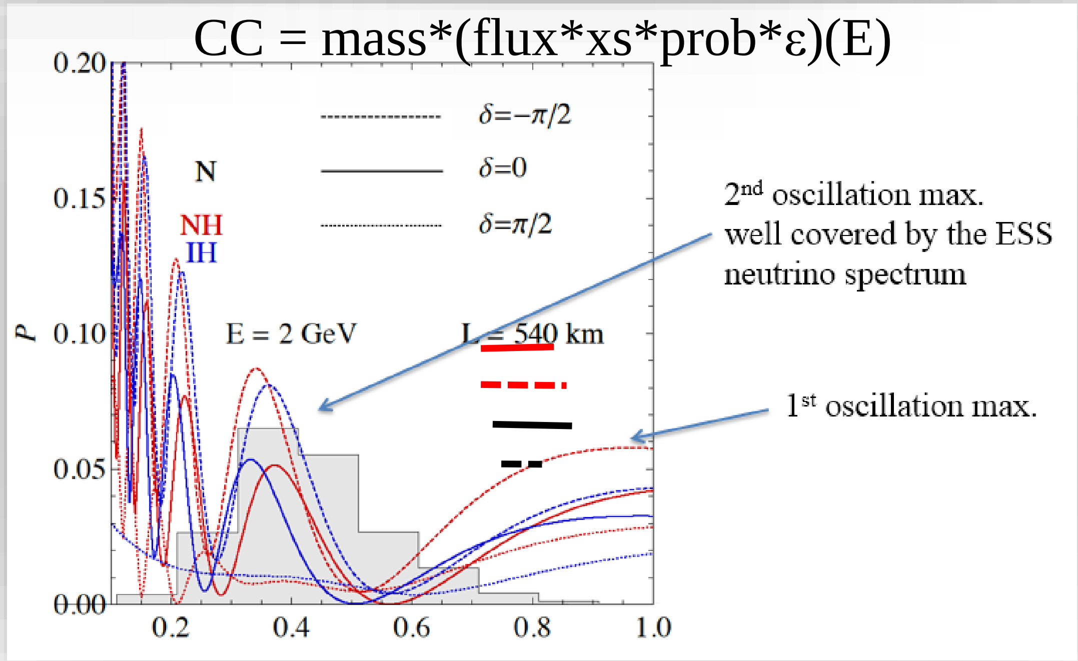
at 100 km from the target and per year (in absence of oscillations)

Convolution (prob*xs) vs flux







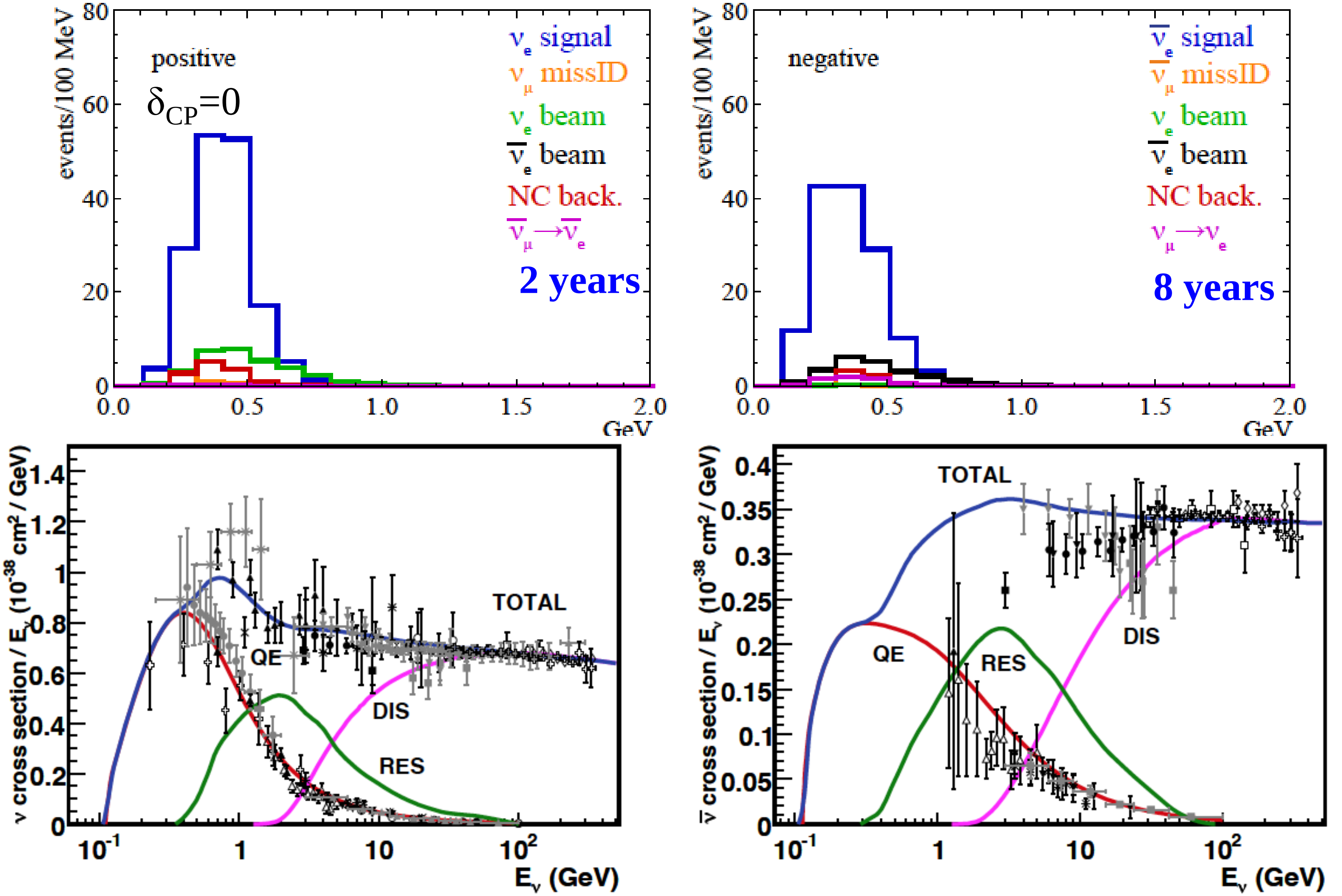


Neutrino spectra

540 km (2 GeV), 10 years

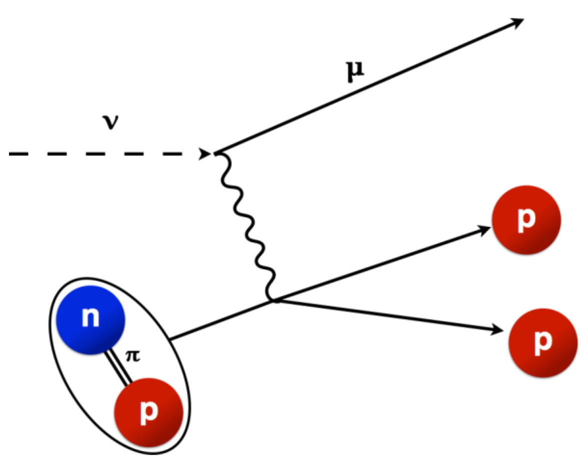
below ν_τ production, almost only QE events

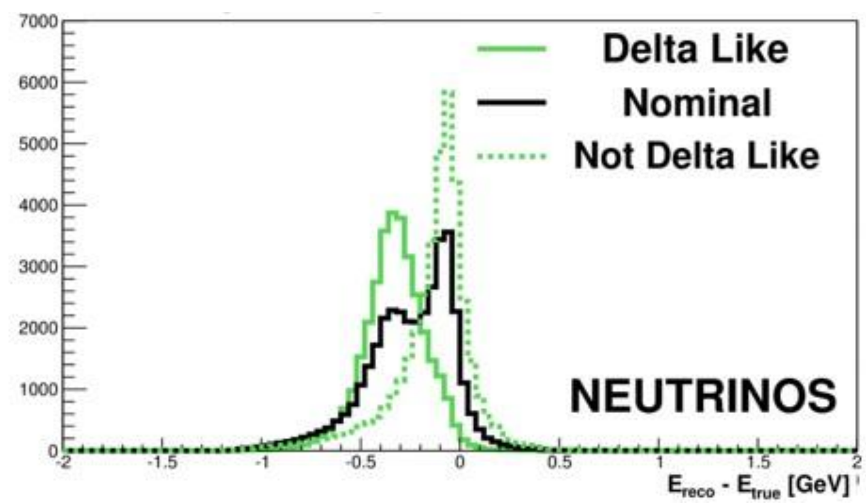
neutrinos **anti-neutrinos**



Systematic error sources

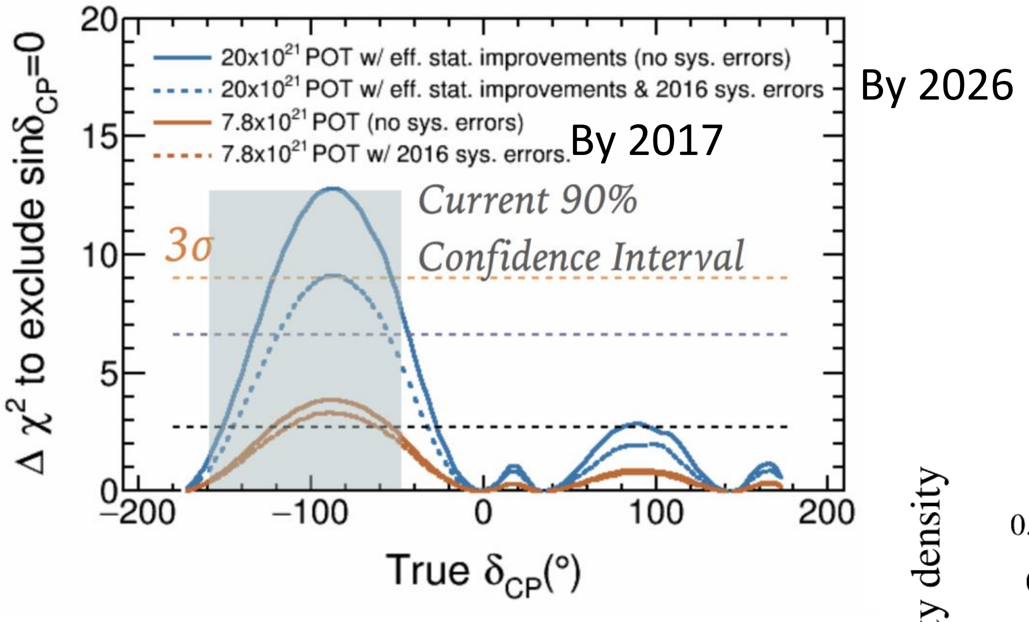
1. ν_e in the beam from K and μ decays
2. Events with π^{o} and γ production
3. ν_μ misidentified as ν_e
4. ν-nucleus cross-section uncertainty for QE, RES and DIS scattering
5. E_ν reconstruction error due to multi-nucleon effects

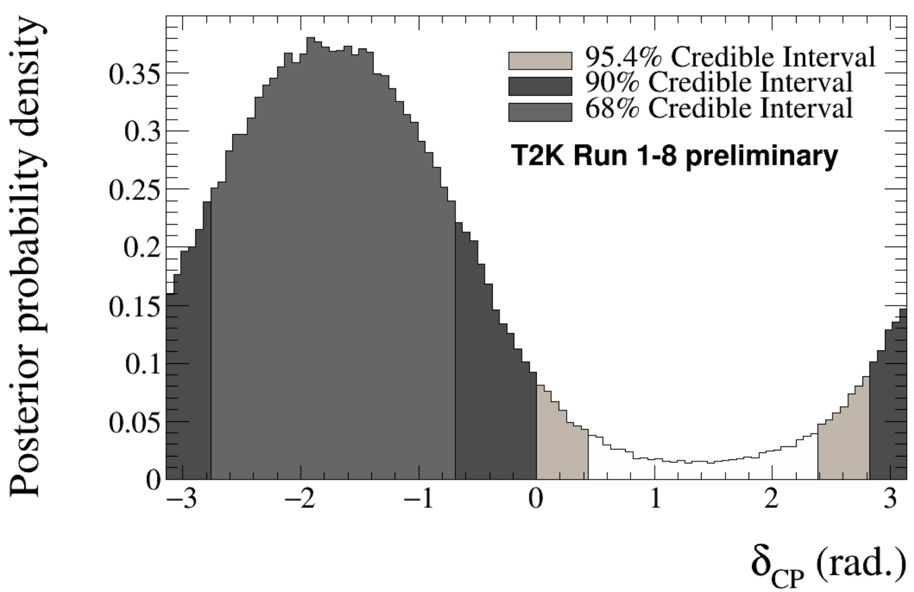




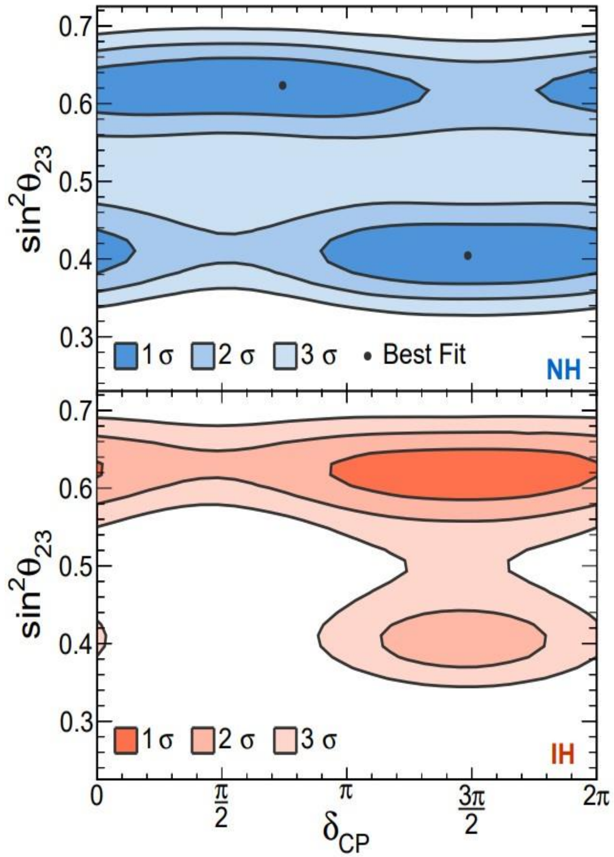
Super-K has achieved a **systematic error level of 5-6%** after ca 10 years of operation using a by now very sophisticated Near Detector.

Status of T2K δ_{CP} search

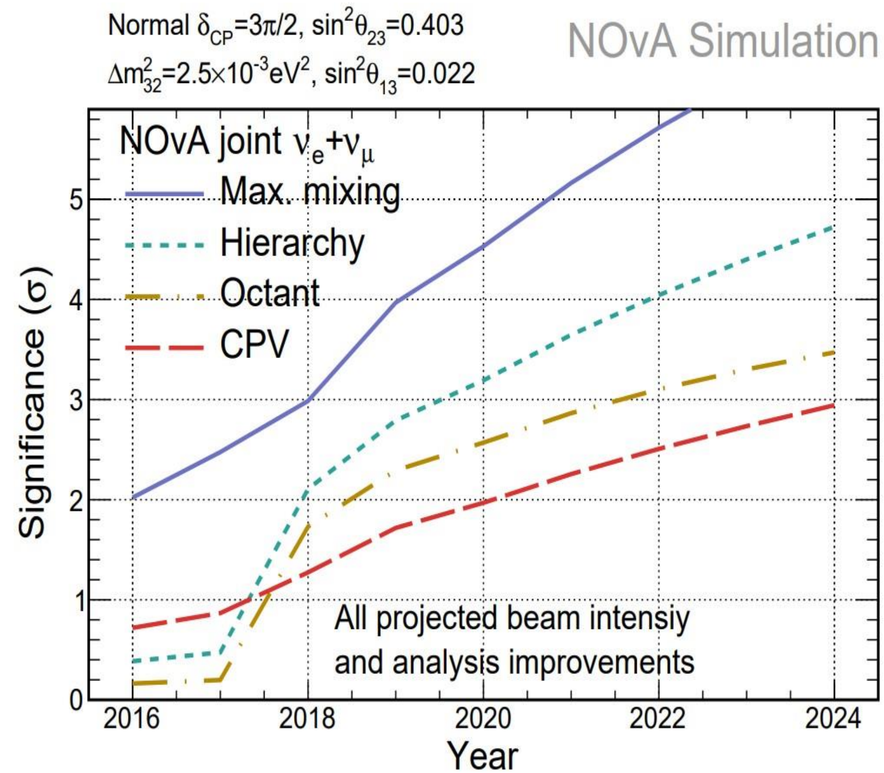




Status of NOvA δ_{CP} search



Significance at which the value of δ_{CP} is disfavored for each of the four possible combinations of mass hierarchy

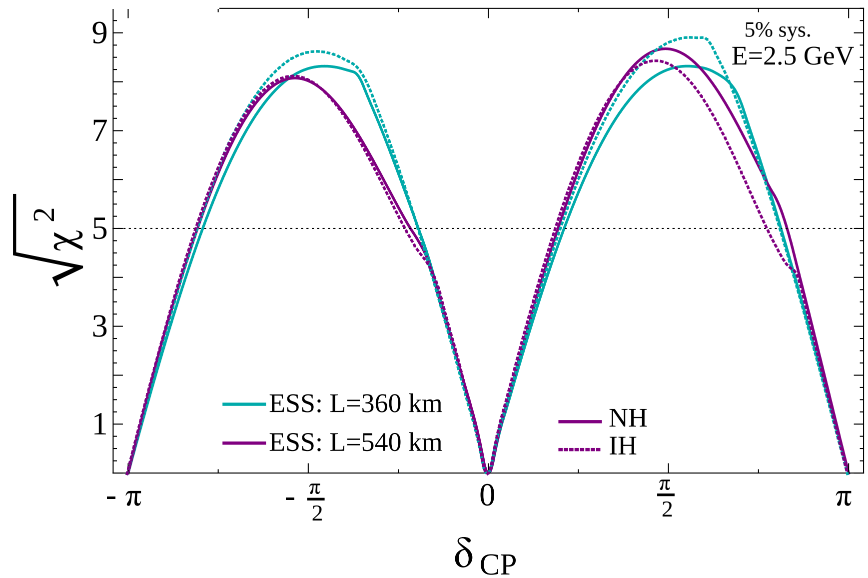


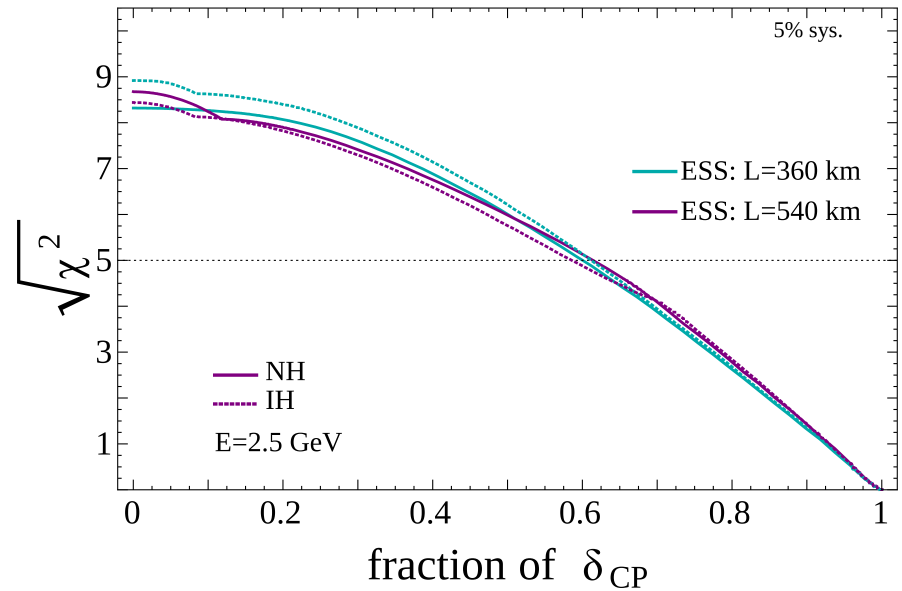
- Two statistically degenerate best fit points in Normal Hierarchy :

$\sin2\theta_{23}$= 0.404, δ_{CP}= 1.48π, and

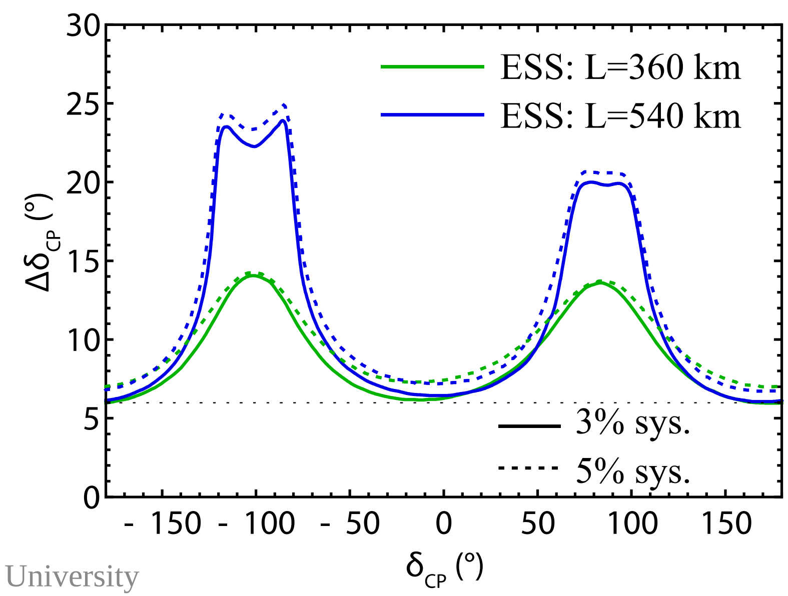
$\sin_2\theta_{23}$= 0.623, δ_{CP}= 0.74π

ESSnuSB δ_{CP} sensitivity

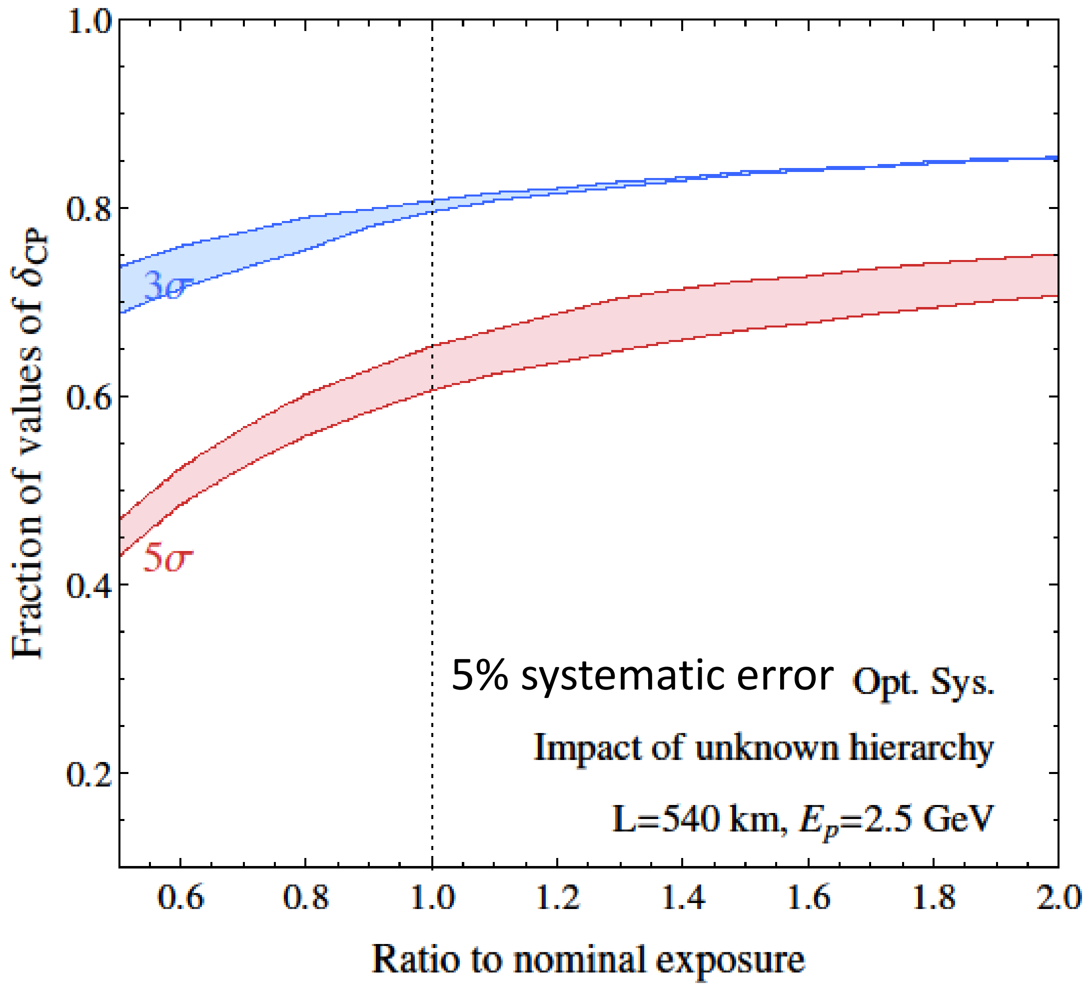




- little dependence on mass hierarchy (not so long baseline),
- δ_{CP} coverage at 5 σ C.L. up to 60%,
- δ_{CP} accuracy down to 6° at 0° and 180° (absence of CPV for these two values),
- not yet optimized facility.



Systematic errors and exposure

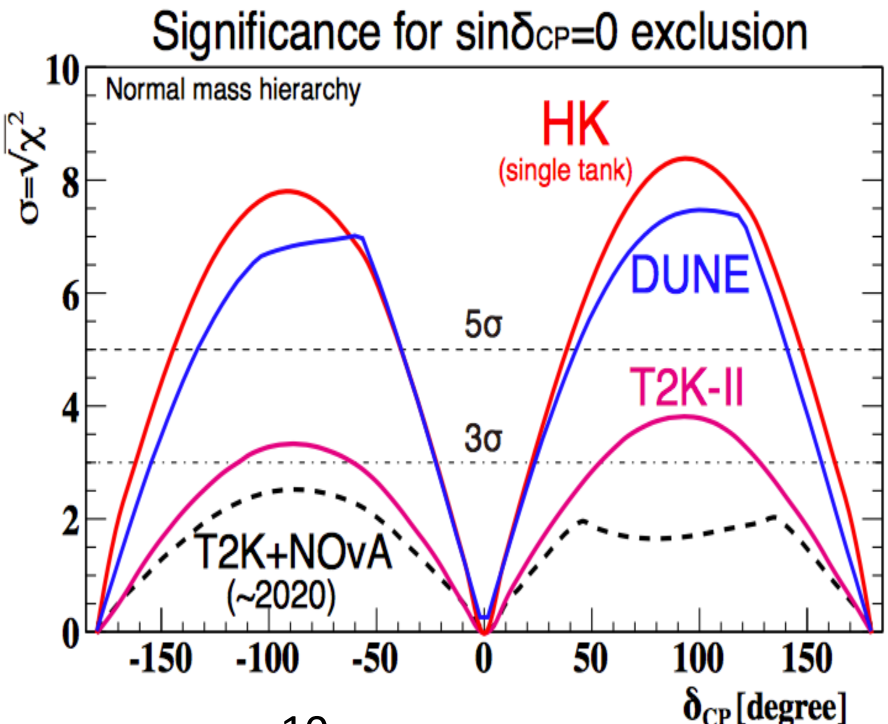


High potentiality

(courtesy P. Coloma)

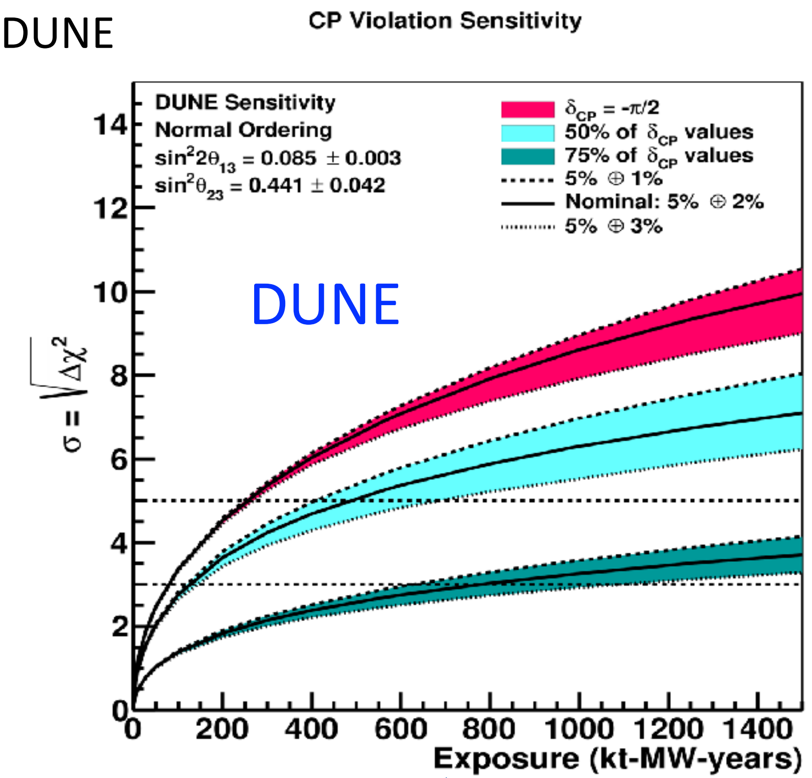
DUNE and HK δ_{CP} sensitivity

- DUNE: 1-3% ν_e signal normalisation uncertainty
- For CP, important to keep uncertainty at ≲2%



10 years exposure

DUNE



10 years at 1 MW

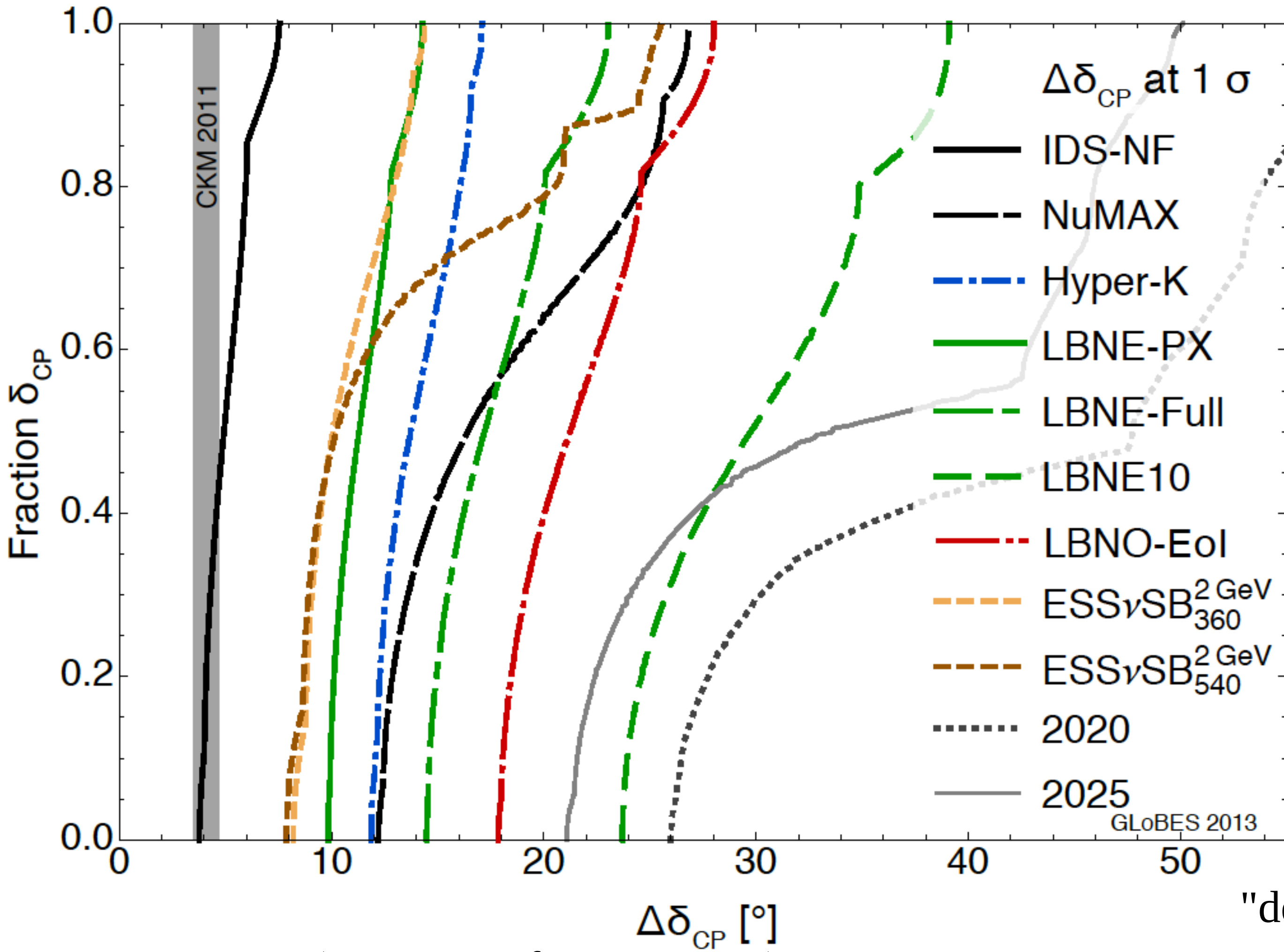
Systematic errors

Systematics	SB			BB			NF		
	Opt.	Def.	Cons.	Opt.	Def.	Cons.	Opt.	Def.	Cons.
Fiducial volume ND	0.2%	0.5%	1%	0.2%	0.5%	1%	0.2%	0.5%	1%
Fiducial volume FD	1%	2.5%	5%	1%	2.5%	5%	1%	2.5%	5%
(incl. near-far extrap.)									
Flux error signal ν	5%	7.5%	10%	1%	2%	2.5%	0.1%	0.5%	1%
Flux error background ν	10%	15%	20%	correlated			correlated		
Flux error signal $\bar{\nu}$	10%	15%	20%	1%	2%	2.5%	0.1%	0.5%	1%
Flux error background $\bar{\nu}$	20%	30%	40%	correlated			correlated		
Background uncertainty	5%	7.5%	10%	5%	7.5%	10%	10%	15%	20%
Cross secs × eff. QE†	10%	15%	20%	10%	15%	20%	10%	15%	20%
Cross secs × eff. RES†	10%	15%	20%	10%	15%	20%	10%	15%	20%
Cross secs × eff. DIS†	5%	7.5%	10%	5%	7.5%	10%	5%	7.5%	10%
Effec. ratio ν_e/ν_μ QE*	3.5%	11%	–	3.5%	11%	–	–	–	–
Effec. ratio ν_e/ν_μ RES*	2.7%	5.4%	–	2.7%	5.4%	–	–	–	–
Effec. ratio ν_e/ν_μ DIS*	2.5%	5.1%	–	2.5%	5.1%	–	–	–	–
Matter density	1%	2%	5%	1%	2%	5%	1%	2%	5%

Systematic uncertainties in long-baseline neutrino oscillations for large θ13
Pilar Coloma, Patrick Huber, Joachim Kopp, and Walter Winter
Phys. Rev. D 87, 033004 – Published 11 February 2013

δ_{CP} accuracy performance

(USA snowmass process, P. Coloma)

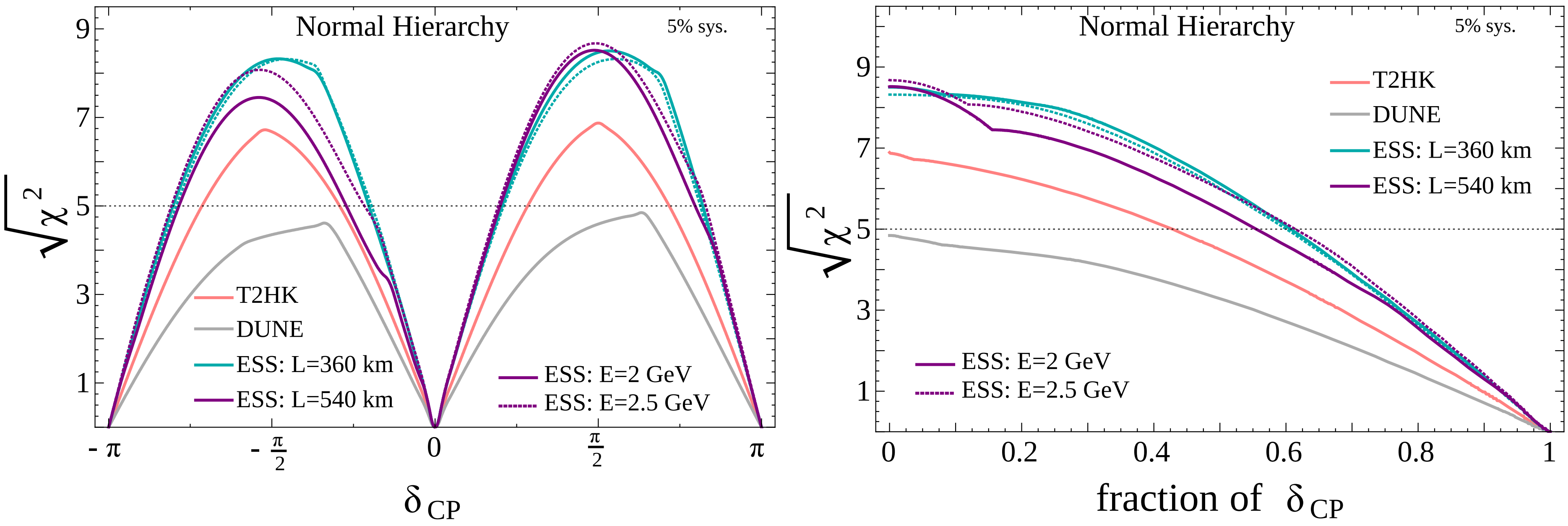


"default" column

for systematic errors see (7.5%/15% for ESSnuSB):

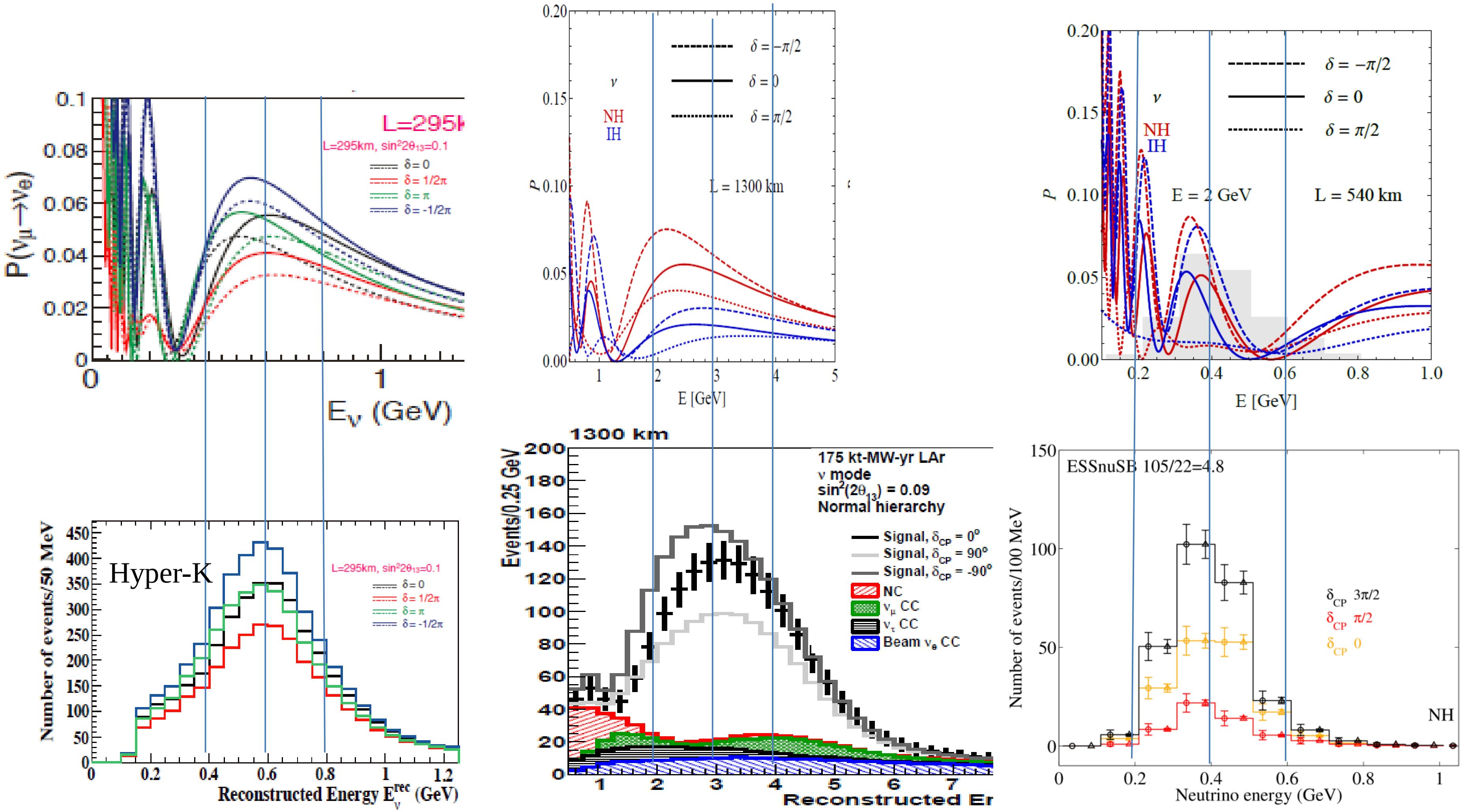
- Phys. Rev. D 87 (2013) 3, 033004 [arXiv:1209.5973 [hep-ph]]
- **arXiv:1310.4340 [hep-ex] Neutrino "snowmass" group conclusions**

Comparisons under the assumption of 5% systematic error and 10 years of data taking for ESSnuSB, Hyper-K and DUNE



The sensitivity of the neutrino energy distribution to δ_{CP}

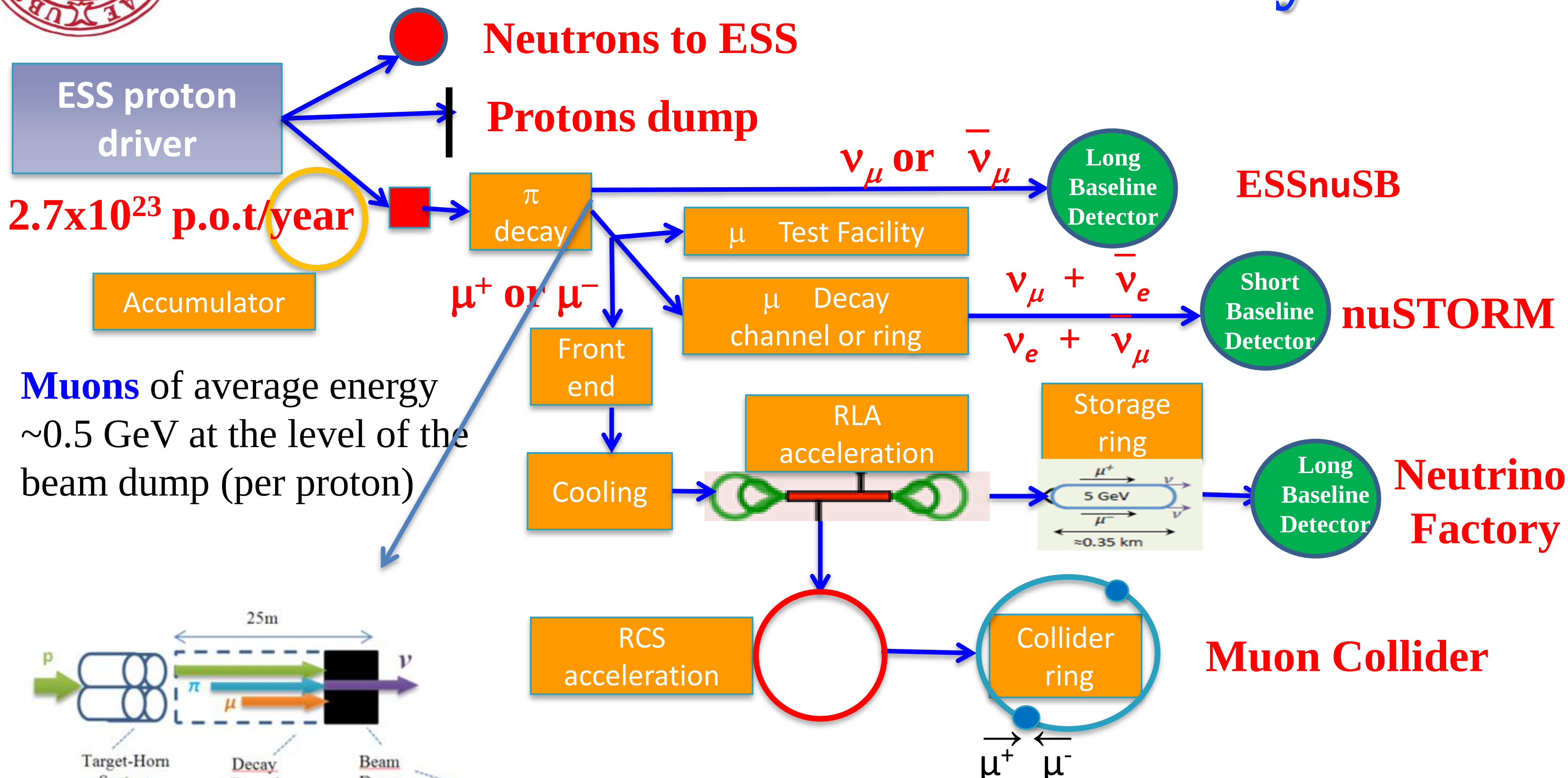
Hyper-K first maximum — LBNE/DUNE first maximum — **ESSnuSB second maximum**



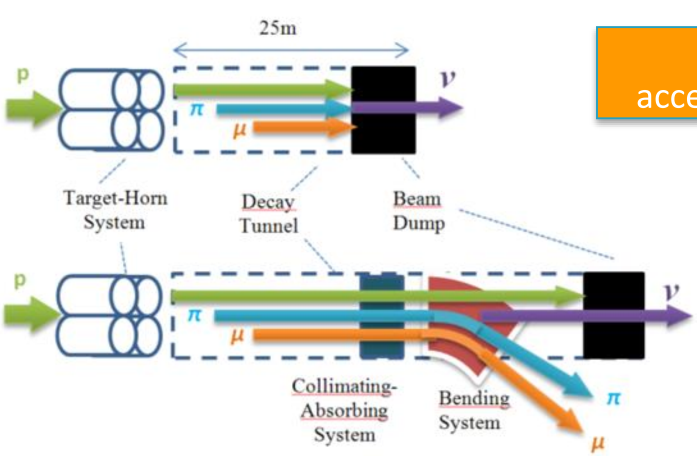
Relative difference in counts at maximum between $\delta_{CP} = 3\pi/2$ and $\pi/2$:

430/275 = 1.6 — 150/100 = 1.5 — **105/22 = 4.8**

Future further option form a ESS neutrino and muon facility



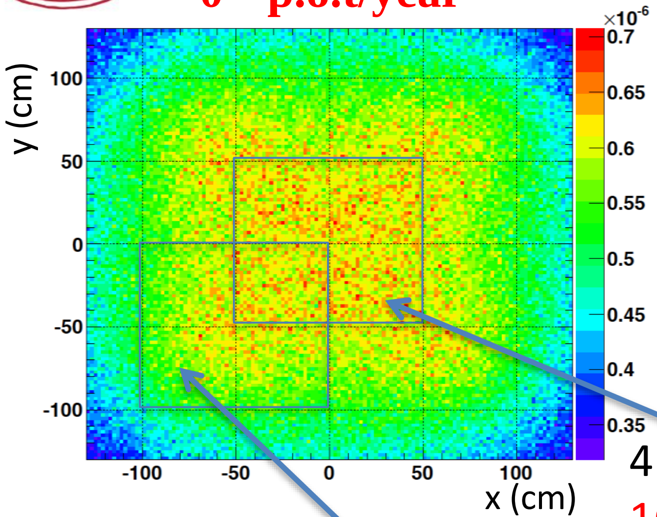
Muons of average energy ~0.5 GeV at the level of the beam dump (per proton)



more than 4x10^{20} μ/year from ESSS compared to 10^{14} μ used by all experiments up to now (10^{18} μ for COMET in the future).

Muons at the level of the beam dump

0^{23} p.o.t/year

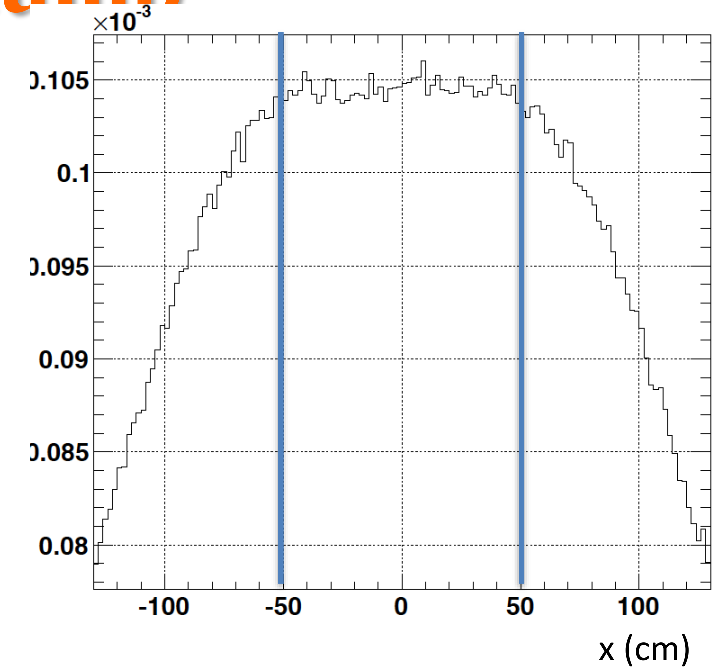


muons at the level of the beam dump (per proton)

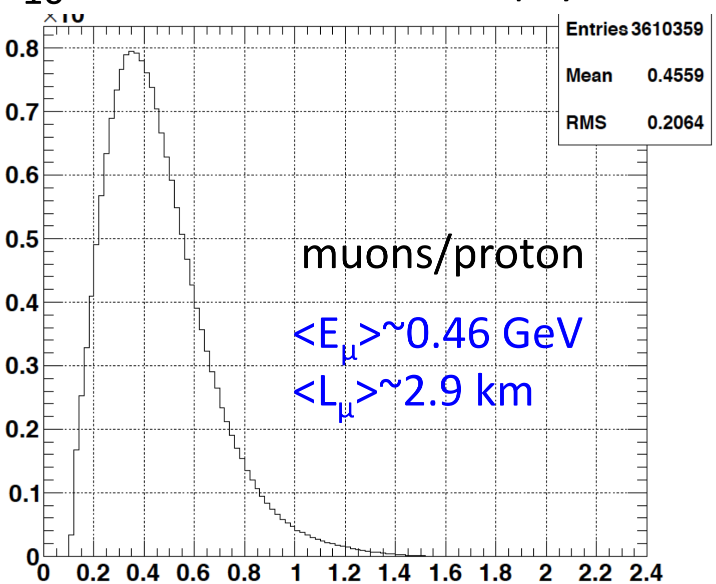
4.2×10^{20} μ/year

16.3×10^{20} for 4 m^2

4.1×10^{20} μ/year



10^{-3}

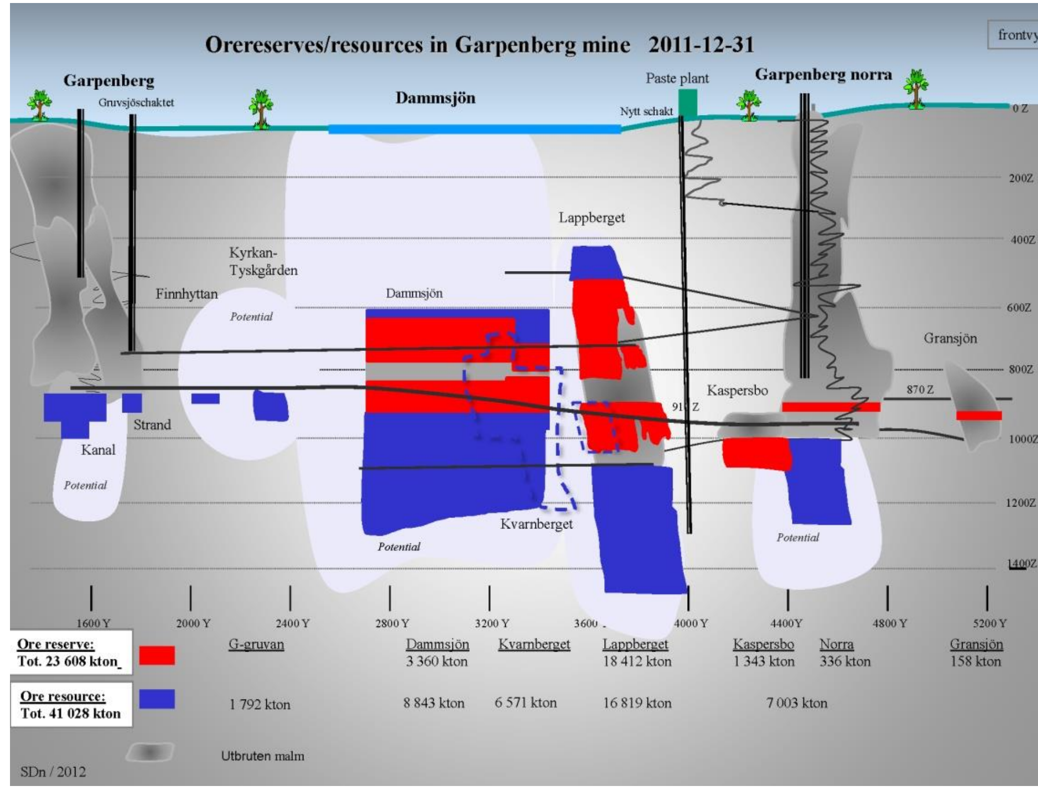


- input beam for future 6D μ cooling experiments (for muon collider),
- good to measure neutrino x-sections (ν_μ, ν_e) around 200-300 MeV using a near detector,
- low energy nuSTORM,
- Neutrino Factory,
- **Muon Collider**.

The MEMPHYS Detector to be located down in the Garpenberg Mine

Distance from ESS Lund **540 km**

Depth 1232 m



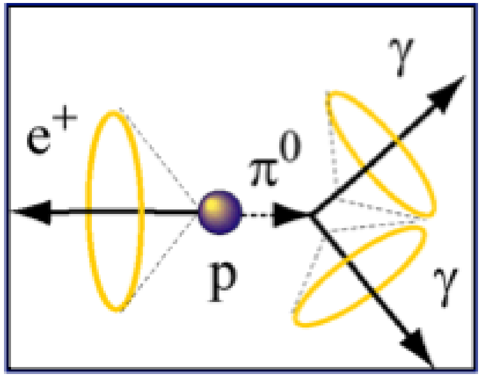
Truck access tunnels

Granite drill cores

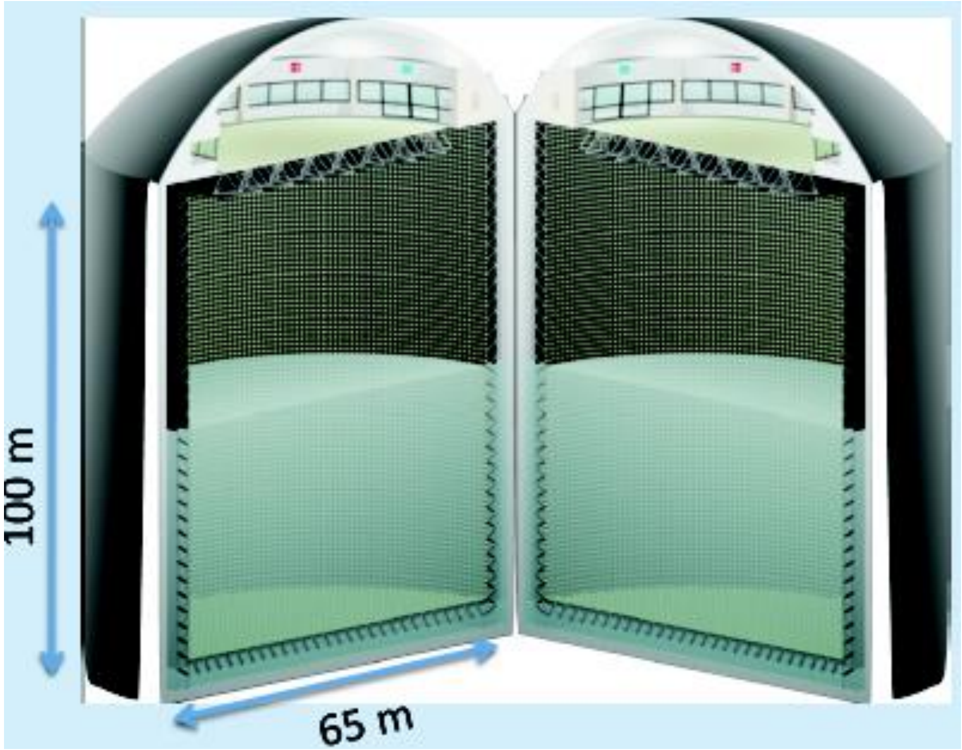
Recently a new ore-hoist shaft was taken into operation, **leaving the old Garpenberg Norra shaft free for other uses**

The MEMPHYS WC Detector

underground detector physics

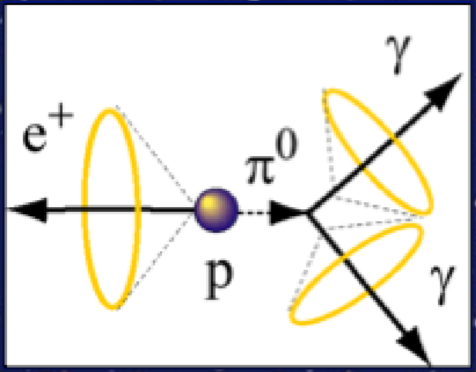


- Proton decay
- SuperNova neutrinos
- Supernovae "relics"
- Solar Neutrinos
- Atmospheric Neutrinos
- Neutrino Oscillations



- 500 kt fiducial volume (~20xSuperK)
- Readout: ~240k 8” PMTs
- 30% optical coverage **(arXiv: hep-ex/0607026)**

Proton Decay



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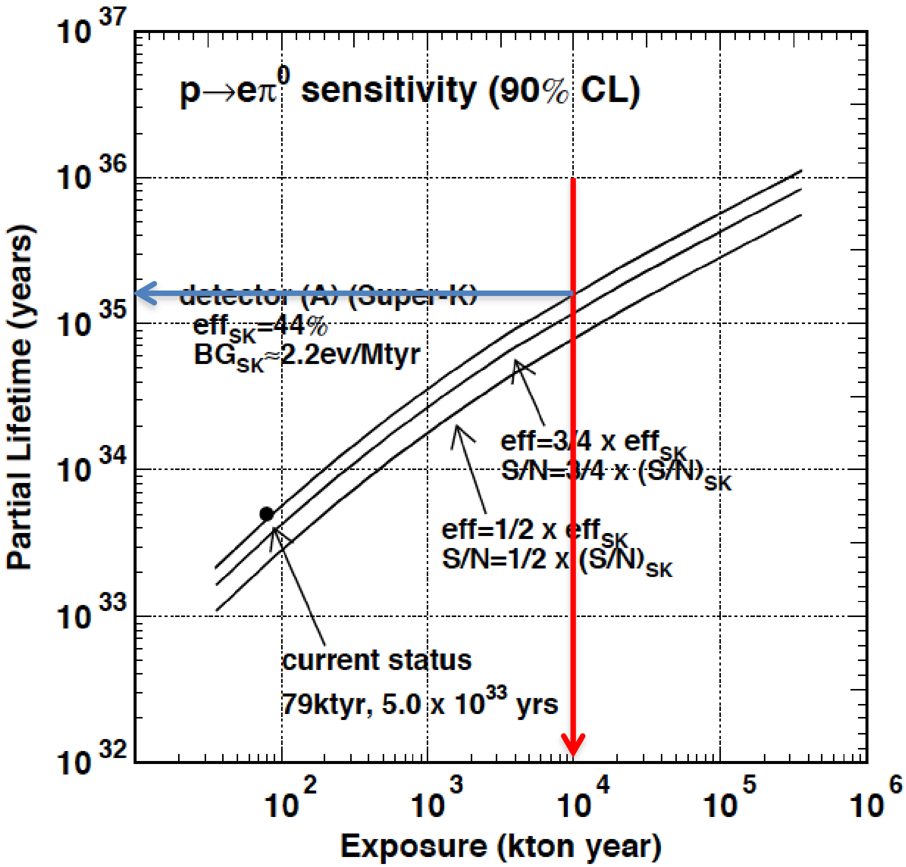
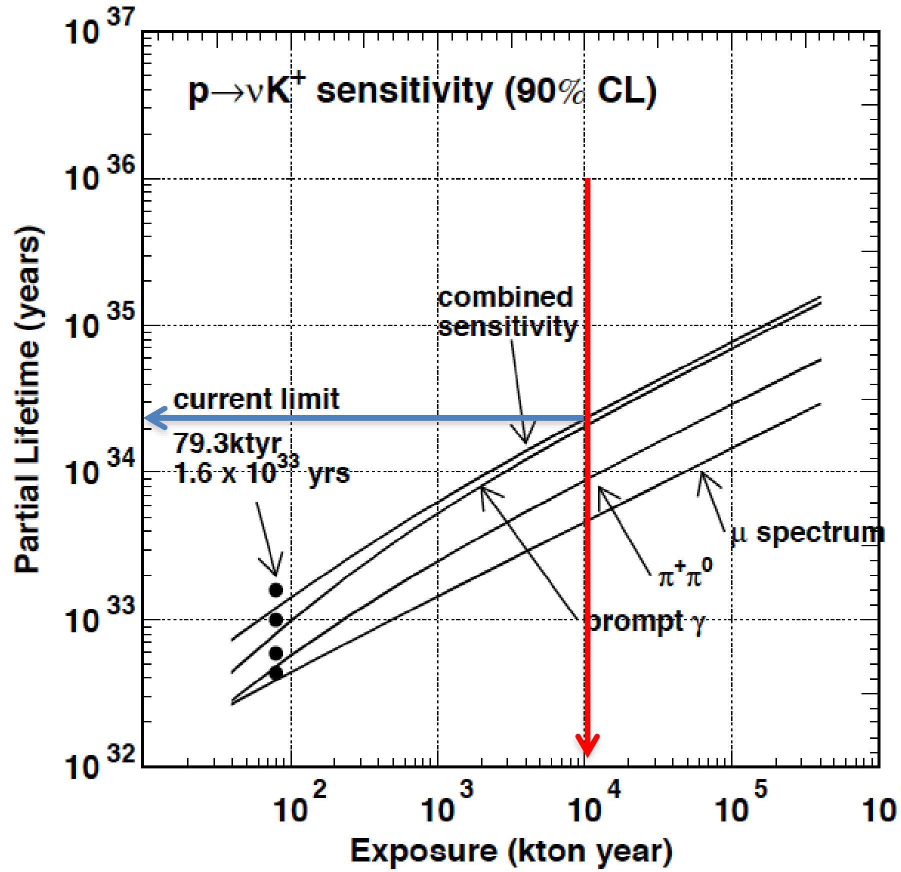
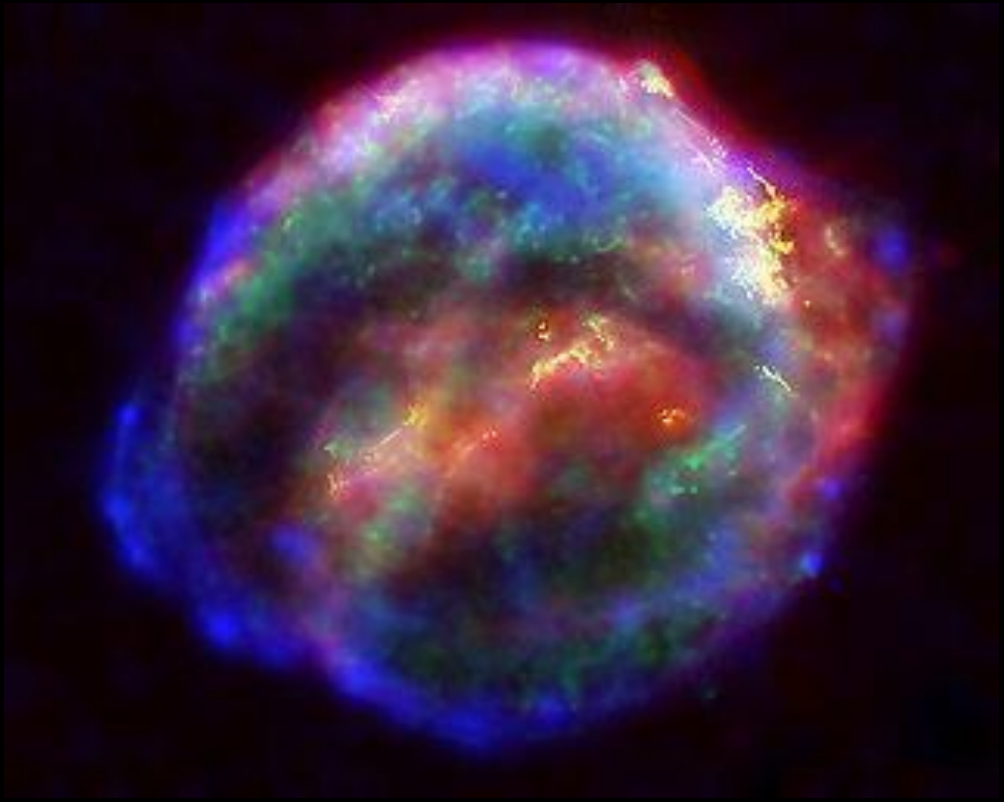
ESSnuSB-MEMPHYS sensitivities
proton decay





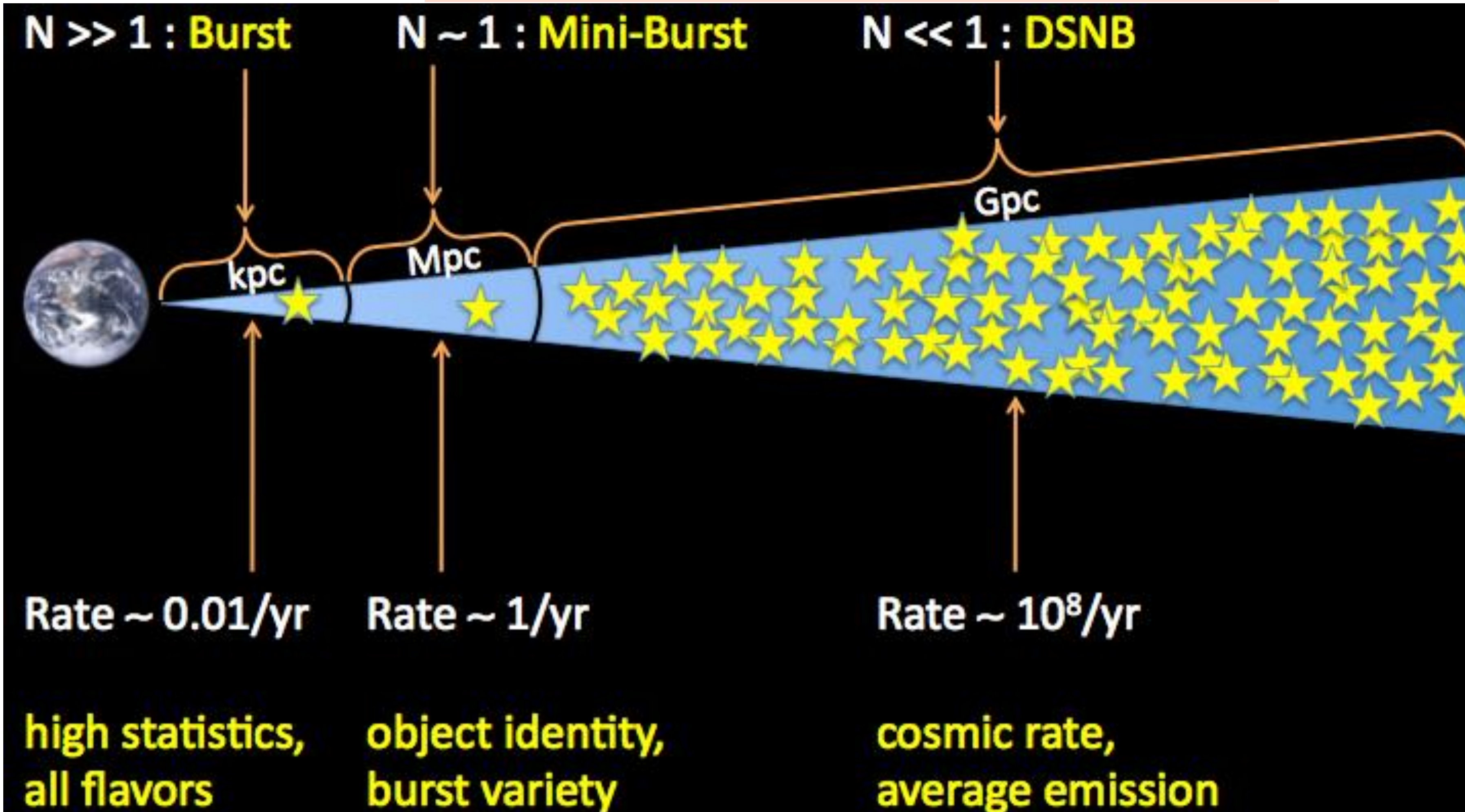
(arXiv: hep-ex/0607026)

Supernova



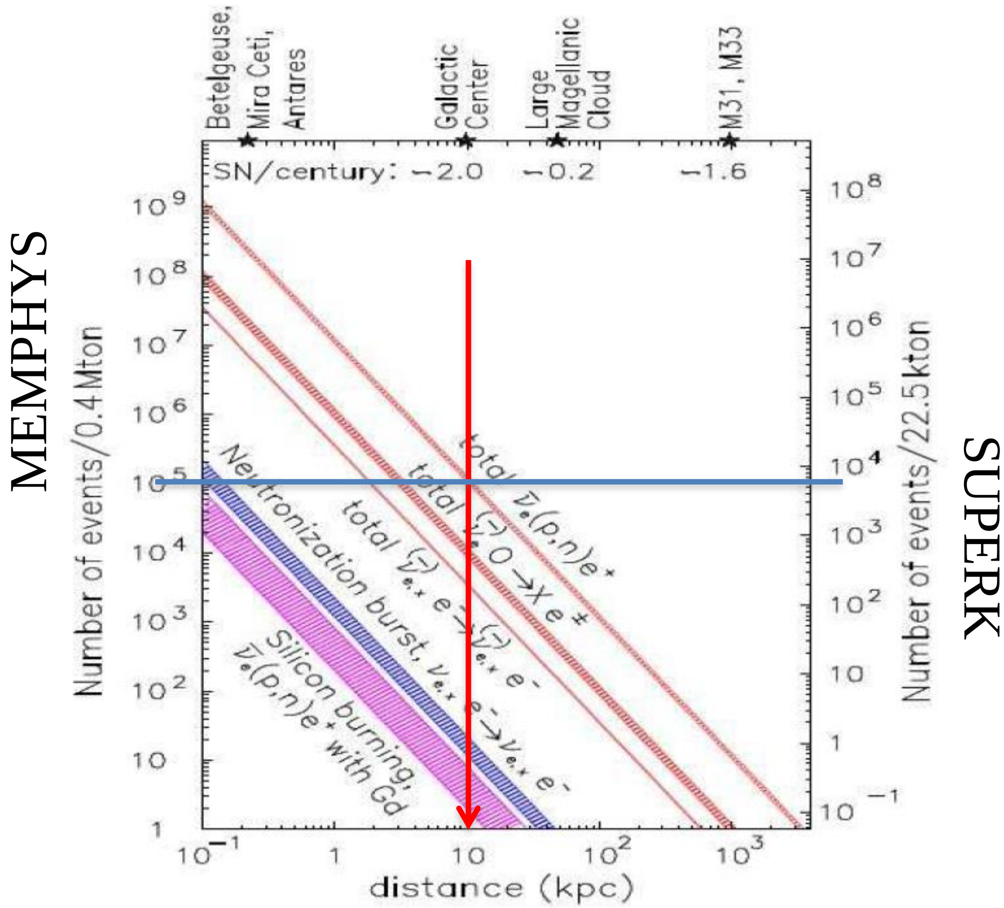
Distance scale and exp'd rate

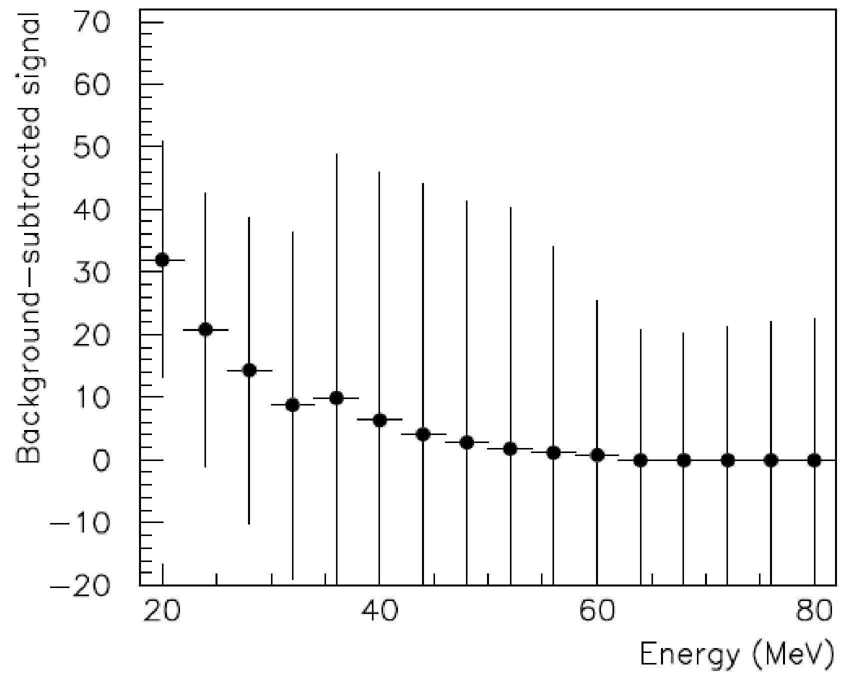
Milky way | Nearby galaxies | Distant galaxies



Beacom@NU2012

ESSnuSB-MEMPHYS sensitivities
Supernova explosion and relics





For 10 kpc: ~10^5 events

Diffuse Supernova Neutrinos
(10 years, 440 kt)

ESSvSB organization and plans

EU COST Action for networking approved in Spring 2016 for 2016-2019

- **EuroNuNet** : *Combining forces for a novel European facility for neutrino-antineutrino symmetry violation discovery* (**http://www.cost.eu/COST_Actions/ca/CA15139**)

- **Major goals of EuroNuNet**:
  - to aggregate the community of neutrino physics in Europe to study the ESSνSB concept in a spirit of inclusiveness,
  - to impact the priority list of High Energy Physics policy makers and of funding agencies to this new approach to the experimental discovery of leptonic CP violation.
  - 13 participating countries (network still growing).

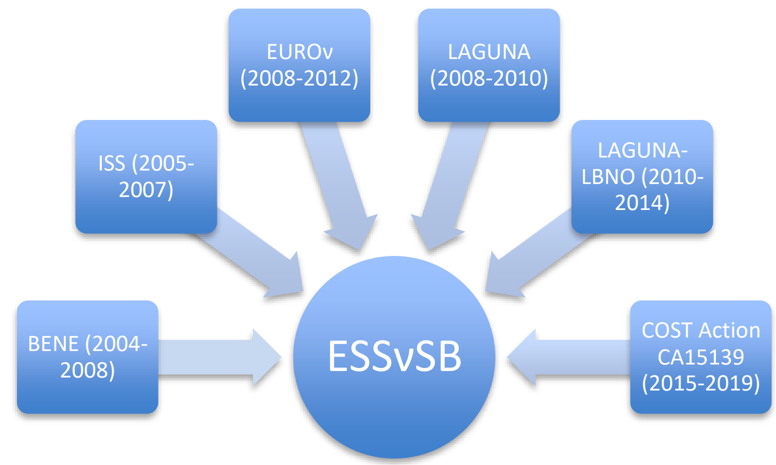
15 European Countries + Turkey members of EuroNuNet

Export Edit View Member Assign MC1 candidates Email to selected

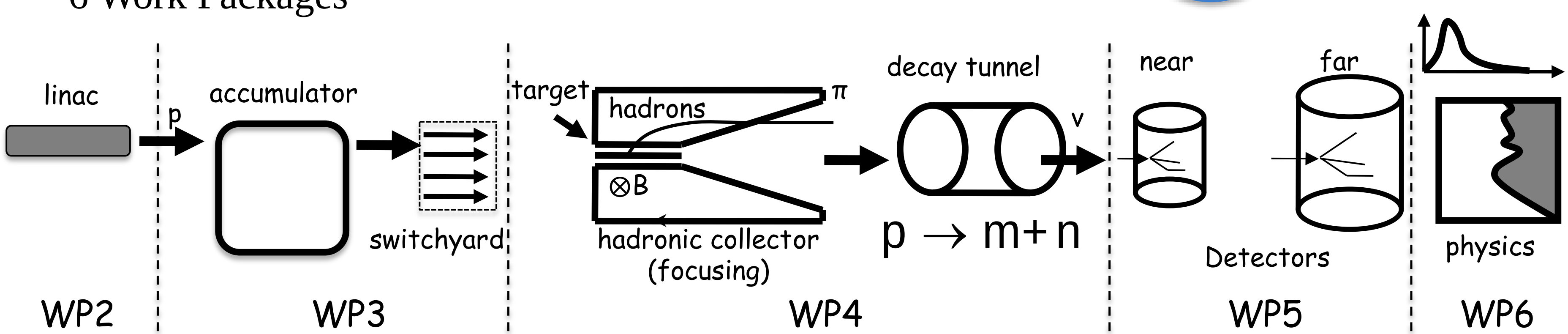
#	CTRY	Title	Firstname	Lastname	Group	Position	Institution
1	n/a	Dr	Marcos	Dracos	MC Members	MC Chair	IN2P3
2	n/a	Prof	Joakim	Cederkall	MC Members	MC Vice-Chair	Lund University
3	ES	Dr	Enrique	Fernandez-Martinez	MC Members	MC Member	Universidad Autónoma de Madrid
4	FR	Dr	Sebastien	BOUSSON	MC Members	MC Member	CNRS/IN2P3
5	FR	Dr	Elian	Bouquerel	MC Members	MC Member	CNRS/IN2P3
6	UK	Prof	Silvia	Pascoli	MC Members	MC Member	Durham University
7	EL	Dr	Georgios	Fanourakis	MC Members	MC Member	NCSR 'Demokritos'
8	HR	Mr	Budimir	Klicek	MC Members	MC Member	Rudjer Boskovic Institute
9	IT	Prof	Francesco	Terranova	MC Members	MC Member	Universita' di Milano Bicocca
10	IT	Dr	Mauro	Mezzetto	MC Members	MC Member	INFN
11	NO	Prof	Farid	Ould-Saada	MC Members	MC Member	University of Oslo
12	PL	Prof	Piotr	Cupial	MC Members	MC Member	AGH University of Science and Technology
13	SE	Prof	Joakim	Cederkall	MC Members	MC Member	Lund University
14	SE	Prof	Tord	Ekelof	MC Members	MC Member	Uppsala Univerity
15	TR	Prof	Yamac	Pehlivan Deliduman	MC Members	MC Member	Mimar Sinan Fine Arts University
16	TR	Prof	Aysel	Kayis Topaksu	MC Members	MC Member	Cukurova University
17	BG	Prof	Roumen	Tsenov	MC Members	MC Member	Faculty of Physics-Sofia University
18	CH	Prof	Alain	Blondel	MC Members	MC Member	University of Geneva
19	EL	*Prof*	*Spyros*	*Tzamarias*	*MC Members*	*MC Member*	
20	FR	Dr	Eric	Baussan	MC Members	MC Substitute	CNRS/IN2P3
21	SE	Prof	Tommy	Ohlsson	MC Members	MC Substitute	KTH Royal Institute of Technology
22	CH	Dr	Alessandro	Bravar	MC Members	MC Substitute	University of Geneva
23	SE	*Dr*	*Mattias*	*Blennow*	*MC Members*	*MC Substitute*	
24	n/a	*Prof*	*Jingyu*	*Tang*	*MC Observers*	*COST International Partner*	
25	n/a	Dr	Mats	Lindroos	MC Observers	International Organisations	European Spallation Source ESS AB
26	n/a	Dr	elena	wildner	MC Observers	European RTD Organisatior	CERN
27	n/a	Dr	Jean-Pierre	Delahaye	MC Observers	European RTD Organisatior	CERN

EU Design Study for ESSnuSB approved by EU in December 2017 for 2018-2021

- **Title of Proposal**: Discovery and measurement of leptonic CP violation using an intensive neutrino Super Beam generated with the exceptionally powerful ESS linear accelerator
- **Duration: 4 years**
- **Total cost: 4.7 M€**
- **Requested budget: 3 M€**
- 15 participating institutes from
  11 European countries including CERN and ESS



- 6 Work Packages



Impact criterion
4.5 of 5 points

The project will have significant impact on enhancing attractiveness of Europe in future neutrino programs in the long baseline scheme. *The technical and scientific impacts due to the upgrade of ESS linac power, the construction of a high flux neutrino beam, implementation of the near and far detectors and also the potential discovery of CP violation in the lepton sector are high.* ***The project is strongly supported by the main players in the field****. CERN established a strong scientific case for long baseline neutrino program exploring CP violation. In addition, the proposed design is recognized to address all critical issues by the scientific community.* ***The project has a potential to increase and diversify the user community of ESS. Building an infrastructure in an currently unused mine will also have a local social impact.***

Design Study ESSνSB (2018-2021)

Call:	H2020-INFRADEV-2017-1
Funding scheme:	RIA
Proposal number:	777419
Proposal acronym:	ESSnuSB
Duration (months):	48
Proposal title:	Feasibility Study for employing the uniquely powerful ESS linear accelerator to generate an intense neutrino beam for leptonic CP violation discovery and measurement.
Activity:	INFRADEV-01-2017

N.	Proposer name	Country
1	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE CNRS	FR
2	UPPSALA UNIVERSITET	SE
3	KUNGLIGA TEKNISKA HOEGSKOLAN	SE
4	EUROPEAN SPALLATION SOURCE ERIC	SE
5	UNIVERSITY OF CUKUROVA	TR
6	UNIVERSIDAD AUTONOMA DE MADRID	ES
7	NATIONAL CENTER FOR SCIENTIFIC RESEARCH "DEMOKRITOS"	EL
8	ISTITUTO NAZIONALE DI FISICA NUCLEARE	IT
9	RUDER BOSKOVIC INSTITUTE	HR
10	SOFIISKI UNIVERSITET SVETI KLIMENT OHRIDSKI	BG
11	LUNDS UNIVERSITET	SE
12	AKADEMIA GORNICZO-HUTNICZA IM. STANISLAWA STASZICA W KRAKOWIE	PL
13	EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH	CH
14	UNIVERSITE DE GENEVE	CH
15	UNIVERSITY OF DURHAM	UK
	Total:	

partners: IHEP, BNL, SCK•CEN, SNS, PSI, RAL

Very supportive letter from ESS director

The ESSnuSB Design Study will start with akick-off meeting at the ESS site in Lund, Sweden on 15-16 January 2018

ESSνSB has already started engaging postdocs.


NUFACT2017
Uppsala, Sweden
September 25 – 30, 2017
Co-organized by the EuroNuNet
Scientific Program Committee:
A. Blondel, University of Geneva
A. Bogacz, JLAB
A. Bross, FNAL
M. Dracos, IPHC/CNRS
T. Ekelöf, Uppsala University (Chair)
M. Goodman, ANL
D. Harris, FNAL
T. Hasegawa, KEK
P. Huber, Virginia Tech
E. Kemp, UNICAMP
T. Kobayashi, KEK
T. Koseki, KEK
Y. Kuno, Osaka University
K. Long, Imperial College London
J. Morfin, FNAL
H. da Motta, CBPF
T. Nakaya, Kyoto University
J. Nelson, College of William & Mary
M. Olvegård, Uppsala U. (Scient. Secr.)
V. Palladino, INFN Napoli
P. Soler, University of Glasgow
H. A. Tanaka, University of Toronto
F. Terranova, University Milano-Bicocca
Working group conveners:
WG1- Neutrino oscillations
J. Bian, University of California, Irvine
F. Di Lodovico, QMUL
M. Ho, IHEP
WG2- Neutrino Scattering Physics
M. Martini, CEA-Saclay
A. Minamino, Yokohama University
G. Perdue, FNAL
WG3- Accelerator Physics
C. Densham, STFC/RAL
B. Freemire, Northern Illinois University
T. Sekiguchi, KEK/J-PARC
WG4- Muon Physics
R. Craig Group, University of Virginia
M. J. Lee, CAPP, Institute for Basic Science
A. Papa, PSI
WG5: Neutrinos beyond PMNS
W. M. Bonivento, INFN Cagliari
P. Coloma, FNAL
S. Kumar Agarwalla, IOP Bhubaneswar
UPPSALA UNIVERSITET
The 19th International Workshop on Neutrinos from Accelerators
For more information, visit: https://indico.uu.se/e/nufact2017

Mats Lindroos' summary of his talk on the ESS linac

- ESS is well into construction and the accelerator project is progressing according to plan towards first beam for target in October 2020
- The ESS facility is built by a collaboration of some 100 research institutes and universities
- Installation has started of cryogenics and for the ion source
- The Accelerator Division is recruiting according to plan and will be ready to take ownership of the accelerator, install it, commission it and enter it into operation
- Most future large scale project are likely to be IK projects and this is a very powerful model. Together we are strongest!

(TE: "IK projects" assumes the full involvement of the AMICI-type EU Technological Infrastructures like STFC, DESY, PSI, INFN, CEA, IN2P3, CERN, IFJ-PAN, KIT & FREIA)

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Mamad Eshrai's conclusion of his talk on ESS linac upgrade

• The identified major modifications for the doubling of the beam power via a higher repetition rate and higher beam energy are (in no particular order):

▸ Three new electrical substations along the RF gallery.

▸ A third main electrical station, alongside the 2 existing ones.

▸ HV cable trenches and pulling of additional HV cables from the main station towards the new substations. New HV cables between the substations and the modulators in the RF gallery.

▸ Installation of 8 new cryo modules and associated RF stations to **increase energy to 2.5 GeV**.

▸ Change of klystron collectors, so that 60% more average power can be produced. If klystrons are at the end of their lifetime, they could be exchanged against more powerful models.

▸ Installation of additional capacitor chargers to allow faster pulsing of the modulators. This is only possible if the modular design developed in-house is adopted.

▸ Installation of a H- source + RFQ + MEBT + beam funnel alongside the existing protons source.

▸ Exchange trim magnets and associated power supplies against pulsed versions

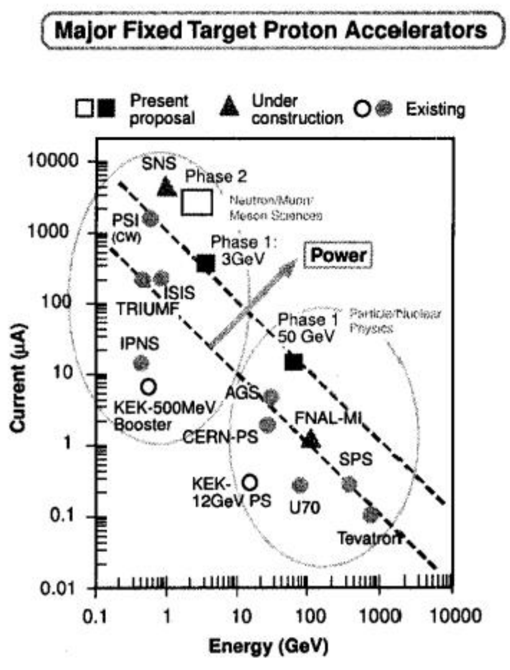
• **The reviewers, Frank and Eric, did not find any show stoppers for theaddition of 5 MW H- acceleration capability in the current state of the ESS linac**.'

Ref.: Frank Gerigk and Eric Montesinos, CERN-ADD-NOTE-2016-0050

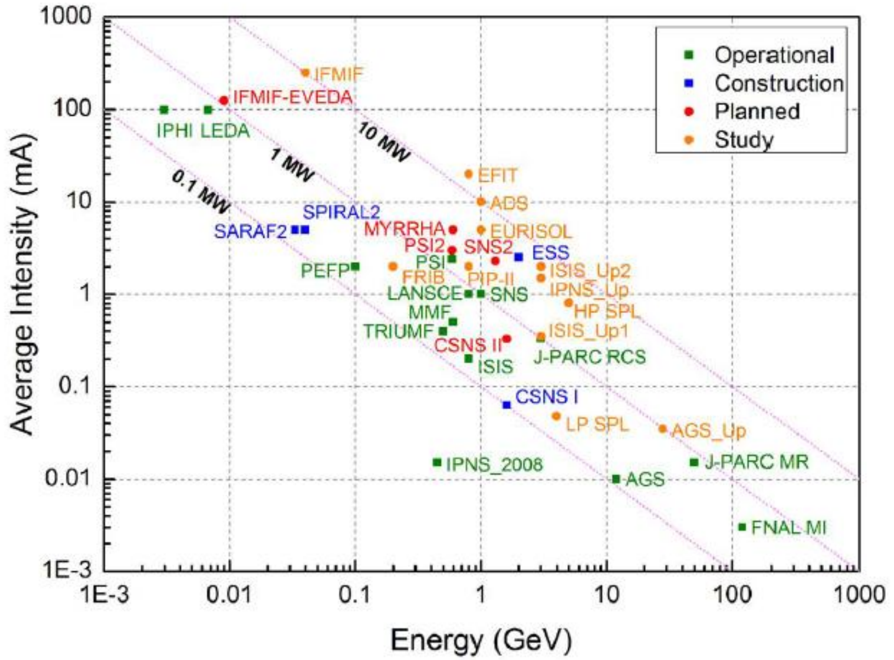
A slide from Mauro Mezzeto's Future Outlook talks

Proton drivers

Year 2000



Year 2017, Talk of C. Plostinar



Garpenberg Research Infrastructure Project for Neutrinos (GRIPnu)

http://www.physics.uu.se/digitalAssets/374/c_374310-l_1-k_gripnu-english-version.pdf

A Socio-economic and Industrial Study of the Consequences of constructing a World-leading Neutrino Detector in Garpenberg in Region Dalarna commissioned by Garpenberg Council

Translated from Swedish by Colin Carlile, Uppsala University March 2017

Summary Description of the GRIPnu project

Project Leader: Hedemora Enterprise AB

Geography: North Central Sweden, Skåne-Blekinge and East Central Sweden

Type of project: National Regional funds programme, Investment Priority 1b

The national strategy for ESS, the European Spallation Source, indicates that the very significant investment in international research infrastructures that is taking place in southern Sweden will also be reflected more widely within Sweden. The GRIPnu project enables the ESS venture to add a second node which would have significant positive effects in central Sweden, and enable contacts to be established between both academia and industry. The ESS accelerator will be the world's most powerful accelerator with a beam power of 5 MW. A European research consortium ESSnuSB, within the framework of the EU COST Action, has been active since 2012, planning an ambitious world-leading research project on neutrinos, which is based upon the use of the ESS accelerator in Lund, and within which the FREIA Laboratory in Uppsala, currently is strongly committed.

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DT Måndag 9 oktober 2017

EU satsar 30 miljoner på Garpenbergsgruvan

HEDEMORA Kan Garpenberg bli en internationell forskningsstation om neutriner?

Ja, möjligheten finns och har ökat. EU har nyligen beslutat att skjuta till 30 miljoner kronor för att se om det går att bygga en neutrinodetektor nere i gruvan.

– Det är mycket glädjande, säger Tord Ekelöf, projektledare vid Institutionen för fysik och astronomi vid Uppsala universitet.

Tidningen har tidigare berättat att det pågår ett arbete för att se om det går att göra om delar av gruvan till en stor forskningsanläggning.

Det pågår diskussioner om att bygga neutrinodetektorer på ett fåtal platser i världen. I Europa ligger Garpenberg längst framme, men USA eller Japan kan hinna före.

Det pågår diskussioner om att bygga neutrinodetektorer på ett fåtal platser i världen. I Europa ligger Garpenberg längst framme, men USA eller Japan kan hinna före. FOTO: KJELL JANSSON

Anledningen till att Garpenbergsgruvan har kommit på tal är att den ligger på rätt avstånd från Lund. Och i Lund byggs materialforskningsanläggningen ESS (European Spallation Source). När den är klar ska forskarna få fram neutroner med hjälp av en stor accelerator. ESS väntas vara i full drift år 2025.

Tord Ekelöf, och en rad andra europeiska forskare, tror att ESS även kan användas för att få fram de mycket mindre partiklarna neutriner.

– En neutrino är en riktig elementarpartikel och har en miljard gånger mindre massa än en neutron. En neutron stoppas av ett stenblock, men en neutrino kan gå genom hela jorden utan att hejdas, säger Tord Ekelöf.

Tanken är att forskarna ska skicka en mycket intensiv stråle med neutriner från Lund till Garpenberg. På 1000 meters djup ska det, enligt planen, göras ett hålrum på en miljon kubikmeter, 100 meter högt och 100 meter brett. Det ska fyllas med renat vatten och när neutrinon stöter på en atomkärna i vattnet kan den omvandlas till en laddad partikel, till exempel, en elektron, vilket leder till att en ljusblixt sänds ut.

För att kunna detektera ljusblixtarna och därmed neutrinon ska det sättas upp ett stort antal ljusdetektorer på bergväggarna.

– Att bygga det här är en väldig utmaning. Det är ingen lätt uppgift att beräkna hur det ska se ut, säger Tord Ekelöf.

Universiteten i Lund och Uppsala, KTH i Stockholm och tekniska universitetet i Luleå är inblandade i projektet, totalt är det 15 europeiska universitet och laboratorier som är med.

Tillsammans ska de göra en "designstudie", där det undersöks om det går att skapa en neutrinodetektor i Garpenberg. Studien kommer att ta fyra år. Efter det behövs ytterligare en studie för att se hur det ska förverkligas tekniskt, den väntas ta tre år.

När det är klart tar det sju år att bygga detektorn. Så tidsperspektivet är att den kan vara i gång framåt år 2032. Pengarna som EU beviljade i augusti, ska bland annat gå till att anställa åtta nyexaminerade forskare och ett flertal doktorander.

Stödet som EU nu ger via forskningsfonden Horizon 2020 går till den första delstudien, men för att bygga anläggningen krävs hela sju miljarder kronor.

– Det kan inte Sverige betala själv. Man måste nå en europeisk finansiering ungefär som för ESS, säger Tord Ekelöf.

Han hoppas att provborrningarna ska kunna påbörjas nere i Garpenbergsgruvan under 2018.

> **"En neutrino är en riktig elementarpartikel och har en miljard gånger mindre massa än en neutron. En neutron stoppas av ett stenblock, men en neutrino kan gå genom hela jorden utan att hejdas."**
> Tord Ekelöf

Tord Ekelöf, projektledare, är här 1059 meter under marken i Garpenbergsgruvan.

Inger Wilstrand, vd för Hedemora näringsliv, tycker att det är positivt att EU skjuter till pengar.

– Det visar, som jag ser det, att det har legitimitet i EU-kretsen, säger hon.

Lokalt arbetas det för att få fram pengar till provborrningarna. Tidigare har det sagts att det krävs en miljon kronor per borrhål och ett 15-tal hål behöver borras.

Om det byggs en neutrinodetektor så får det många positiva effekter, tror Wilstrand.

– Det skulle vara attraktivt för länet och dess företag och öka besöksnäringen eftersom det skulle komma forskare från hela världen, säger Inger Wilstrand.

Text
Kenneth Westerlund
023-936 75
kenneth.westerlund@mittmedia.se

ESSnuSB Schedule

Planned schedule:
2018-2021 Design Study -> Conceptual Design Report
2022-2024 Preparatory Phase -> Technical Design Report
2025-2026 Preconstruction phase
2027-2033 Build-up of ESSnuSB
2034-2035 Commissioning
2036-2045 Data taking -> CP angle and other measurement

In order to get EU financing 2021 for the Preparatory Phase convincing Design Study results need to be delivered already by autumn 2019 as input to the CERN Strategy Council preparation of its input to the ESFRI update in 2020

.

Summary

- Significantly better CPV sensitivity at the 2nd oscillation maximum.
- ESS will have enough protons to go to the 2nd oscillation maximum and increase its CPV sensitivity.
- CPV: 5 σ could be reached over 60% of δ_{CP} range (ESSνSB) with large potentiality.
- The large ν detector has a rich astroparticle and p lifetime program.
- Rich muon program.
- COST network project CA15139 supports this project.
- ESSνSB Design Study is approved and will start 1 January 2018.