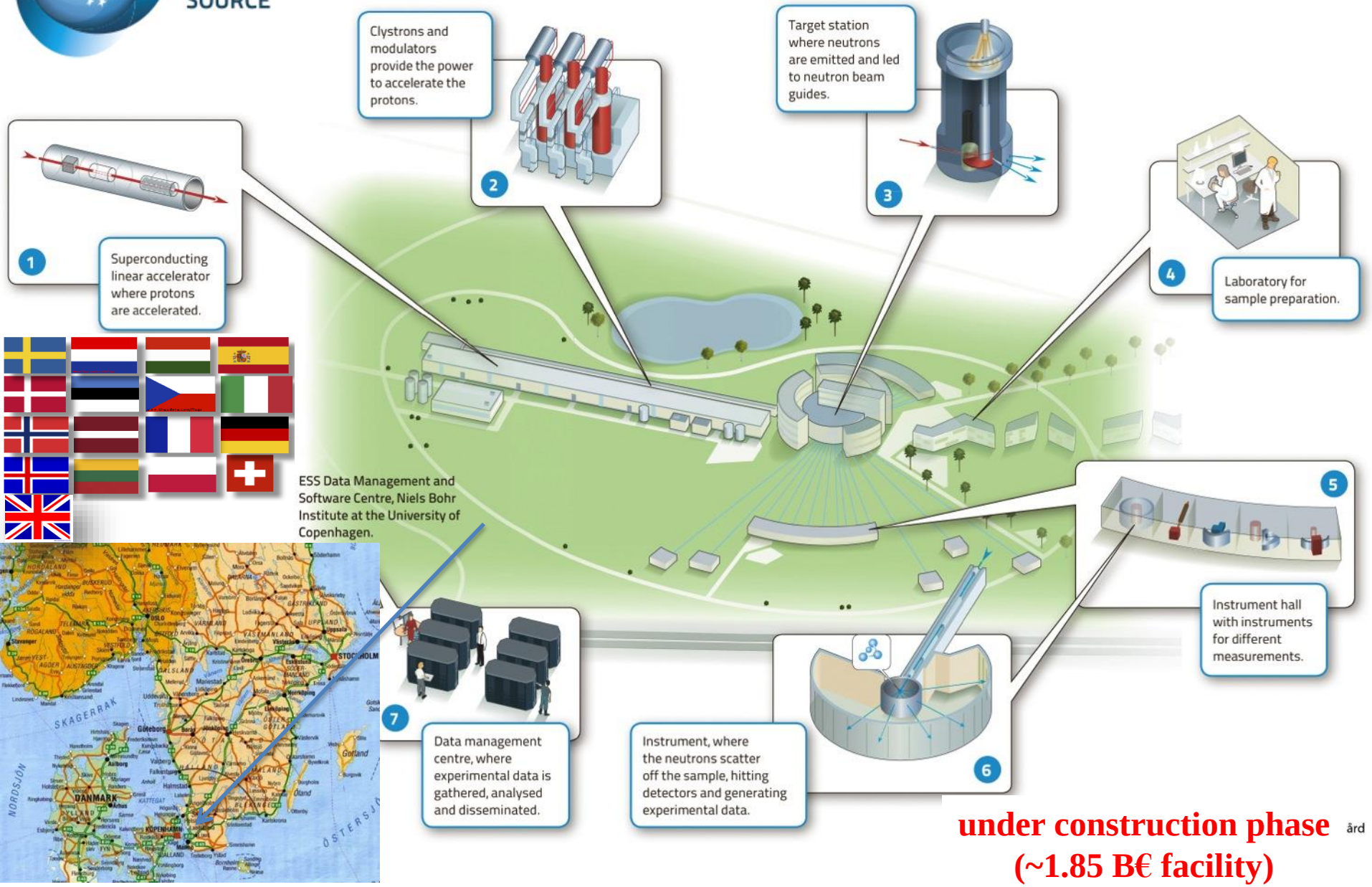
Muons at ESS

European Spallation Source

EUROPEAN SPALLATION SOURCE

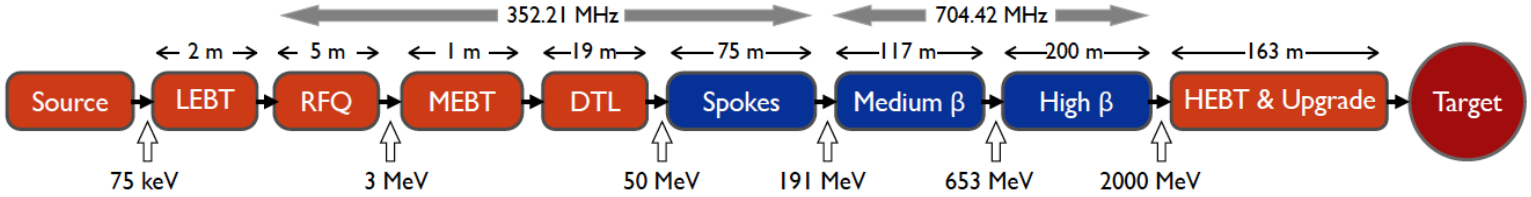


under construction phase

(~1.85 B€ facility)

ESS under construction

How to add a neutrino facility?



1.1×10^{15} protons/pulse

- Linac modifications: double the rate (14 Hz → 28 Hz), from 4% duty cycle to 8%.
- 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
- ~300 MeV neutrinos.
- Target station (studied in EUROν).
- Underground detector (studied in LAGUNA).
- Short pulses (~μs) will also allow DAR experiments.

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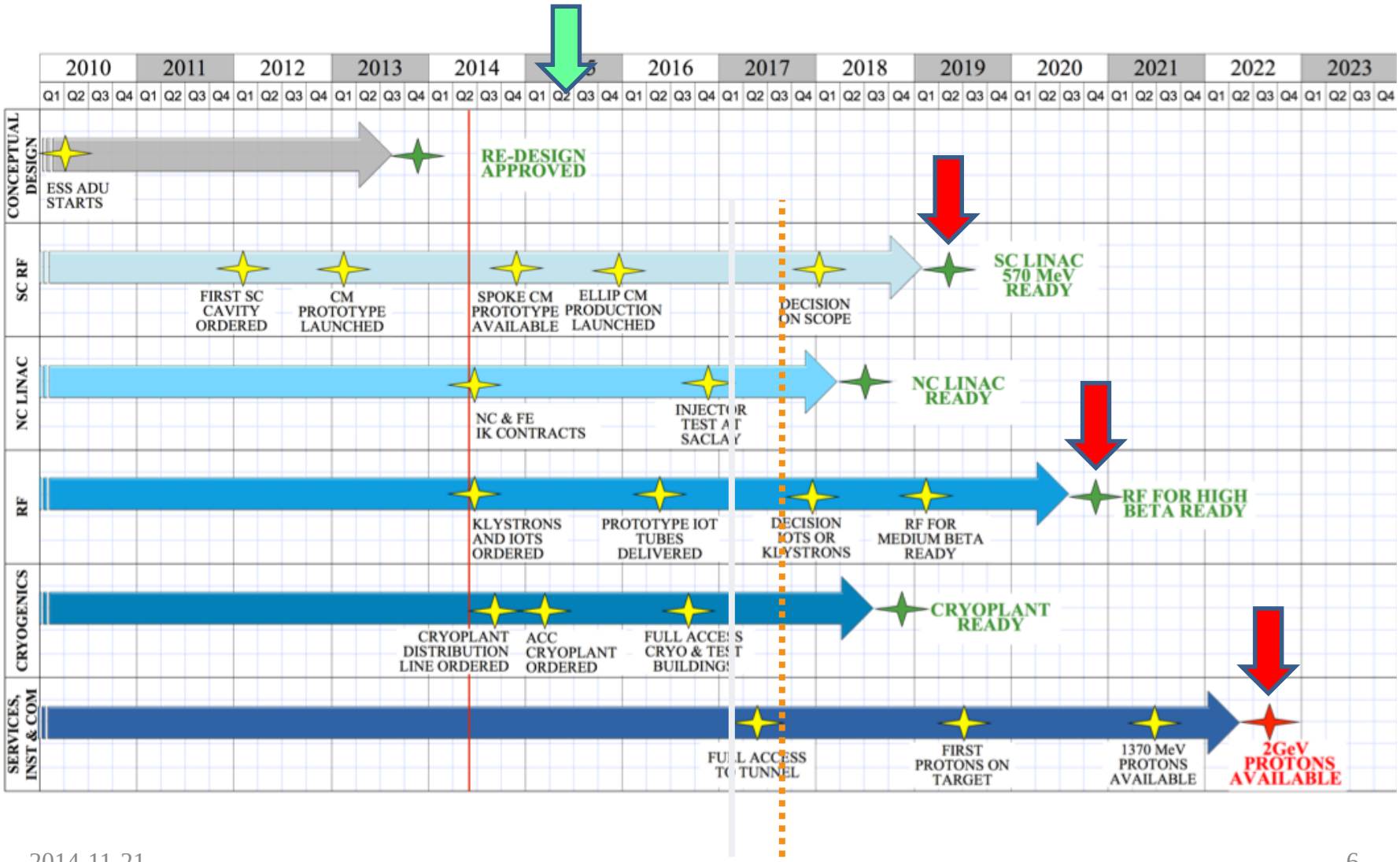
ESSνSB

- First proton beam by 2019
- Full power/energy by 2023

ESS LINAC PROJECT SCHEDULE



COST is supported by
the EU Framework Programme
Horizon 2020

EuroNuNet

(Combining forces for a novel European facility for neutrino-antineutrino symmetry-violation discovery)

COST contributes to the objective of strengthening the scientific and technological bases of the European Research Area by promoting the networking of researchers, engineers or scholars encouraging them to share, create and apply knowledge, thereby encouraging Europe to become more competitive.

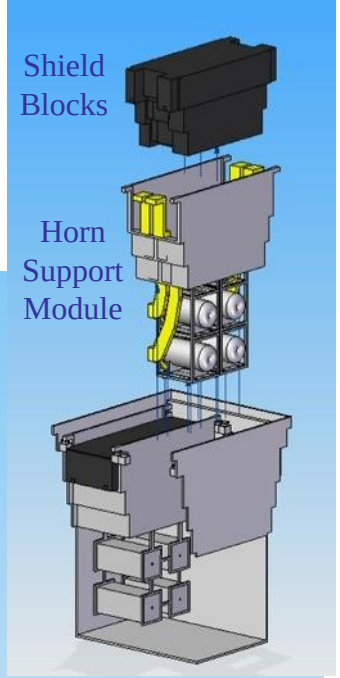
Recently a COST network application for ESSuSB was accepted.
Quotation from the evaluation report:

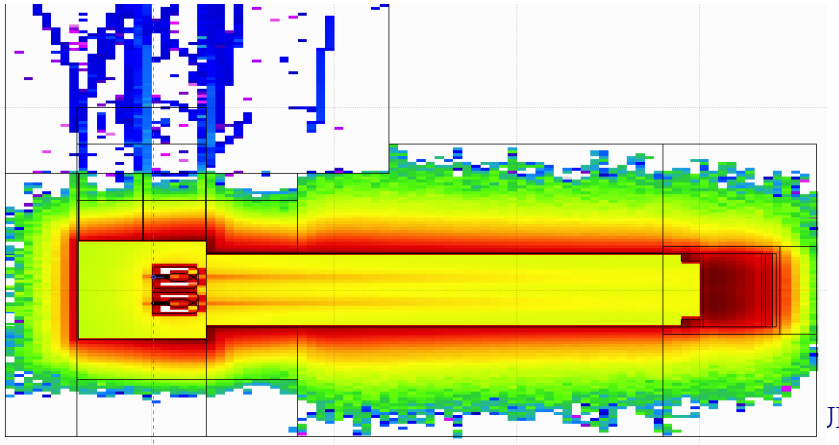
"The main strengths are that ***the present project is unique in Europe****, and at this moment there are no other similar plans in the continent and it is building on a number of previous European projects. Only two other, similar projects exist in the USA and Japan.*

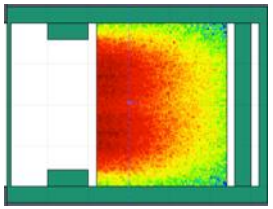
In addition, the project is not only complementary to the projects in the USA and Japan but ***clearly competitive*** *with them, because the infrastructure proposed, which plans to locate the detector at the second neutrino oscillation maximum, will provide a much better and larger accuracy than the other two projects."*

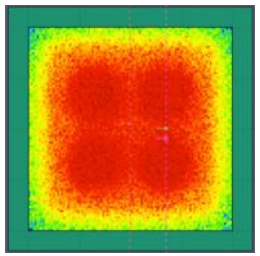
Target Station

General Layout

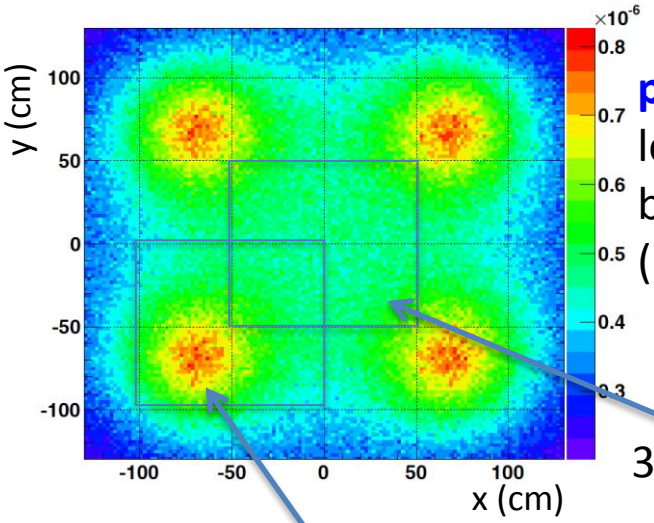








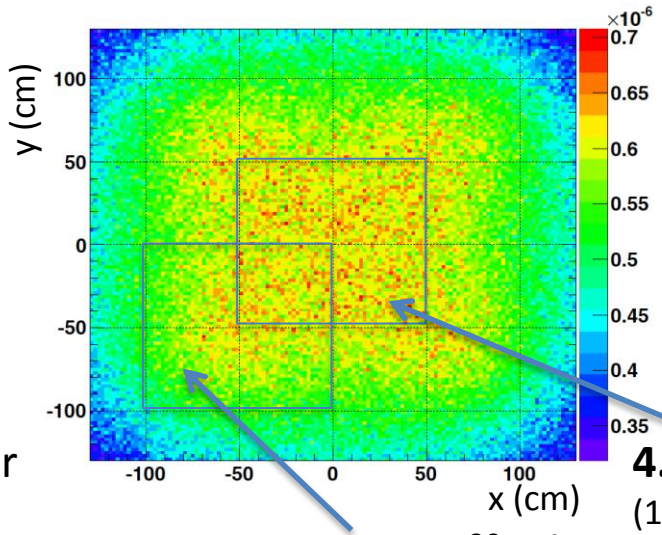
Distributions at the level of the beam dump



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

3.5x10^{20} π/year

3.7x10^{20} π/year

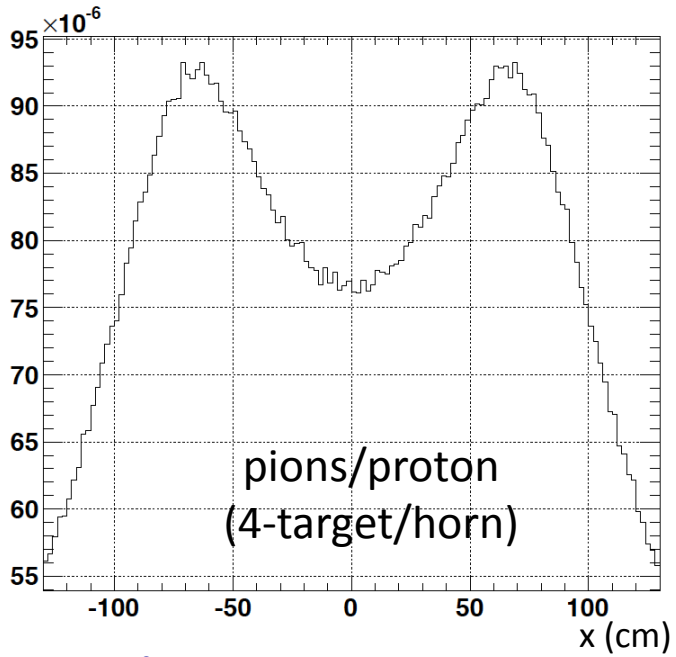


muons at the level of the beam dump (per proton)

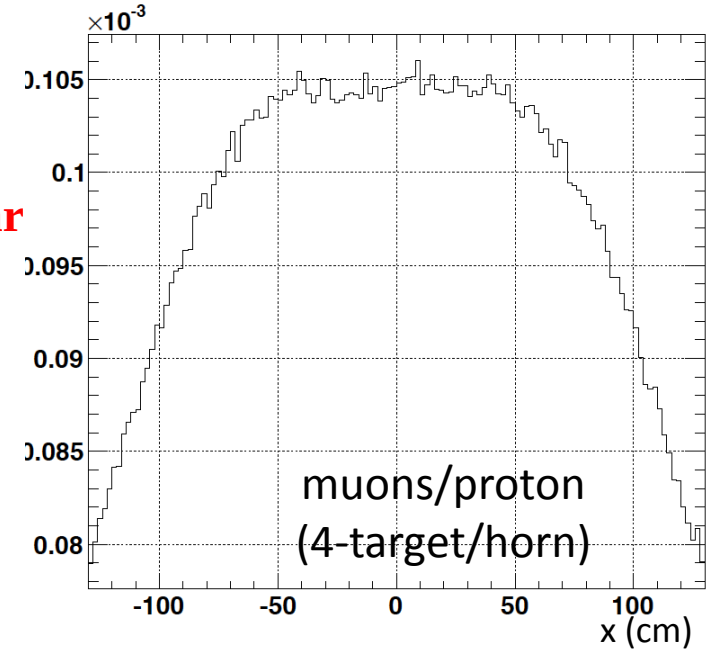
4.2x10^{20} μ/year

(16.3x10^{20} for 4 m^2)

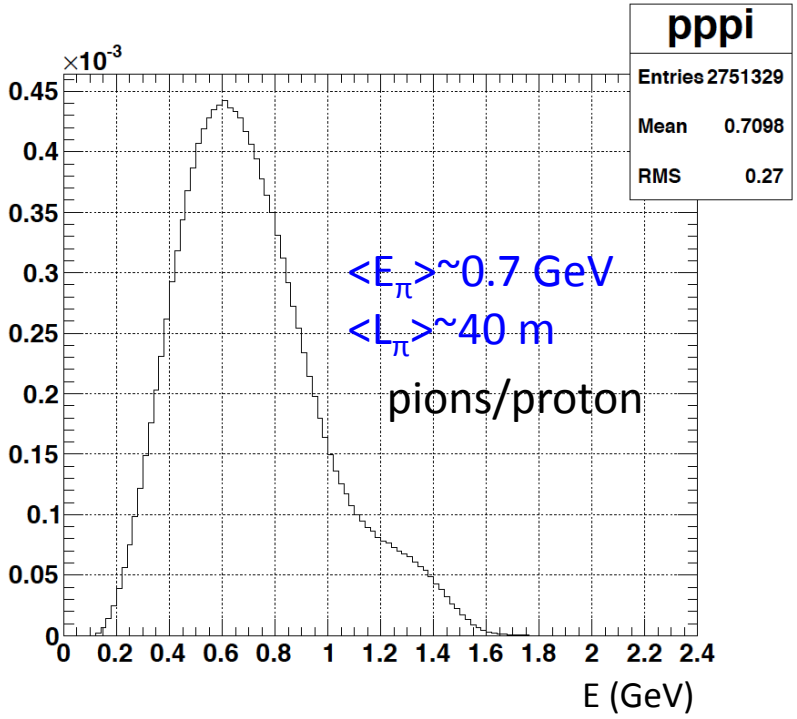
4.1x10^{20} μ/year

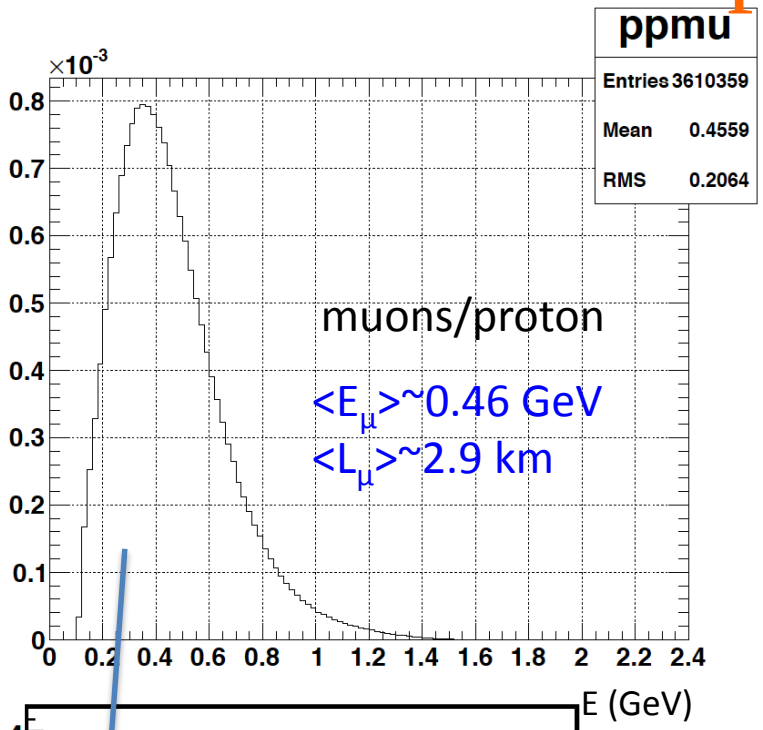


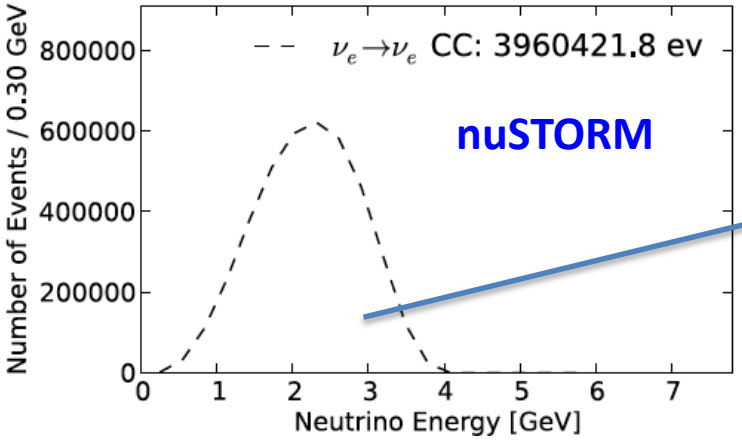
2.7x10^{23} p.o.t/year

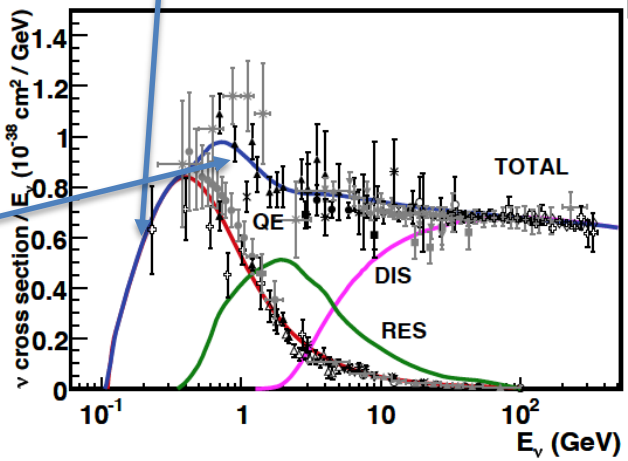


Distributions at the level of the beam dump



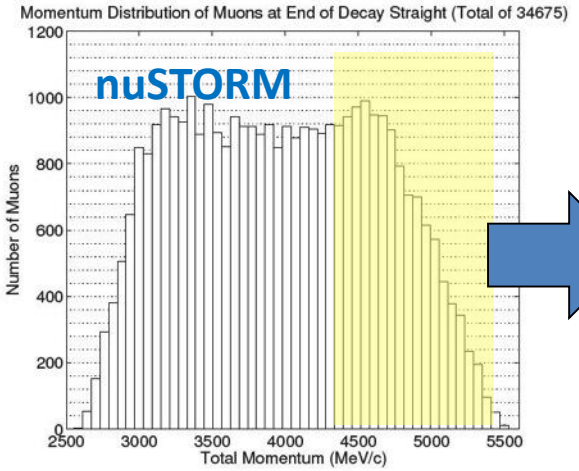


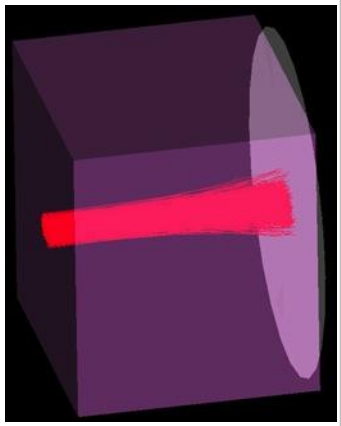




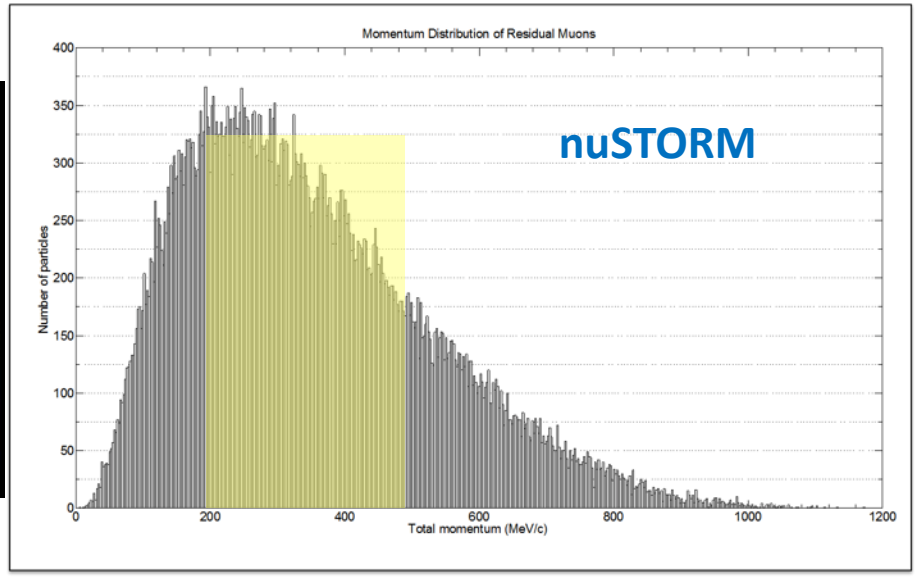
- significantly lower energy than nuSTORM muons (~3.7 GeV)
- good to measure neutrino x-sections around 200-300 MeV

Beam for 6D muon cooling



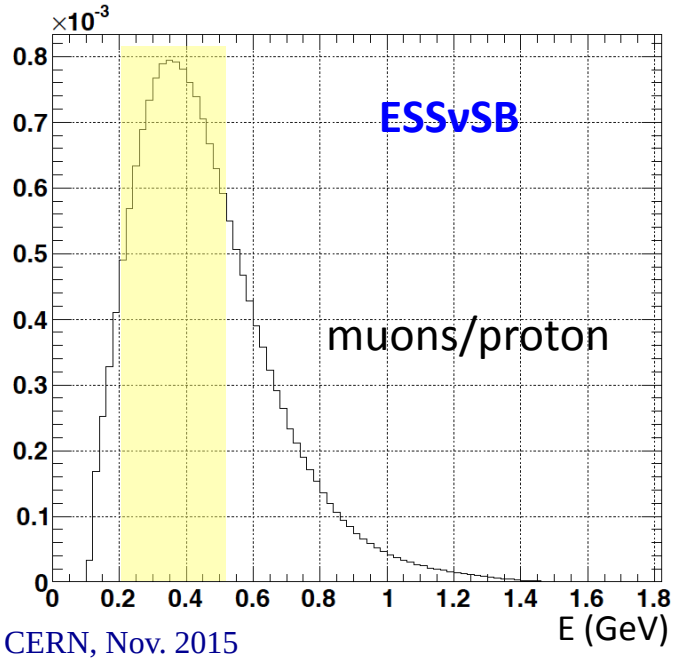


iron absorber



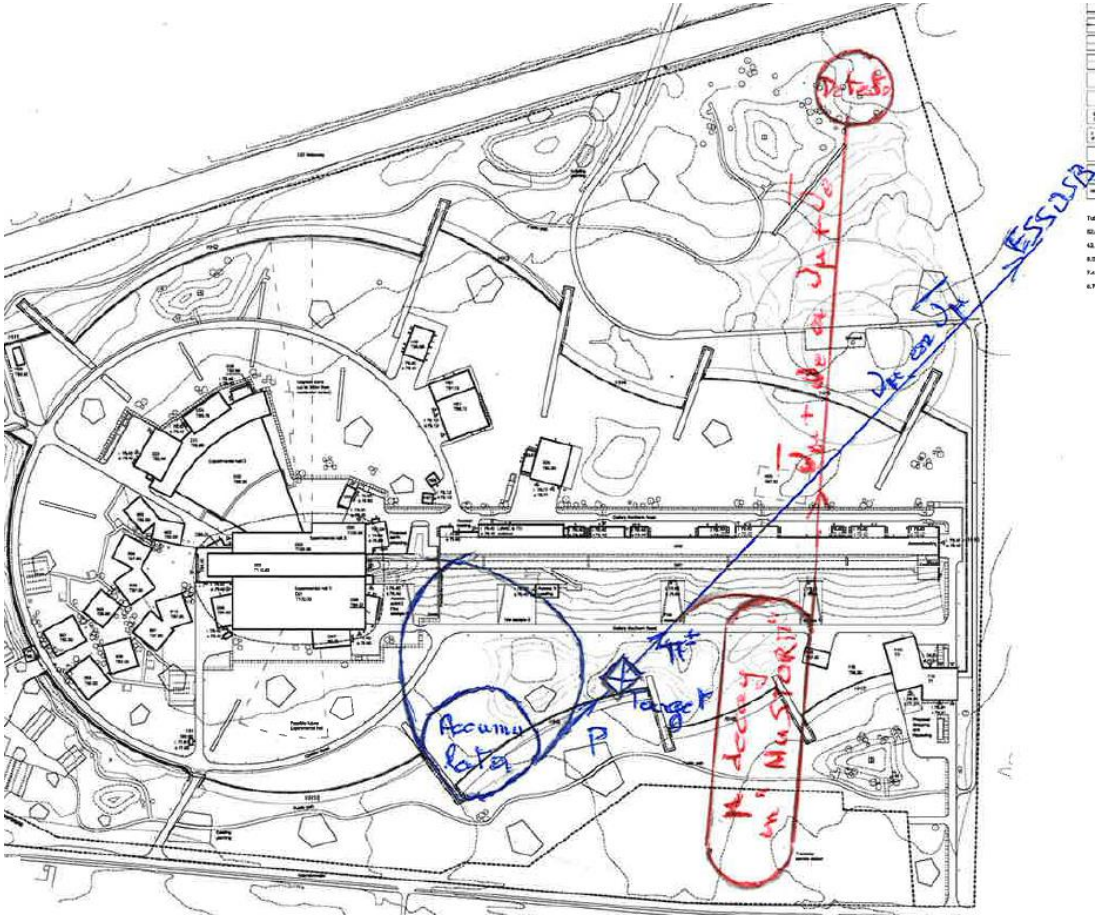
~10^{10} μ/pulse in 200 < P(MeV/c) < 500
(if 10^{21} p/5years → **4.32x10^{17} μ/year**)

Input beam for future 6D μ cooling experiments



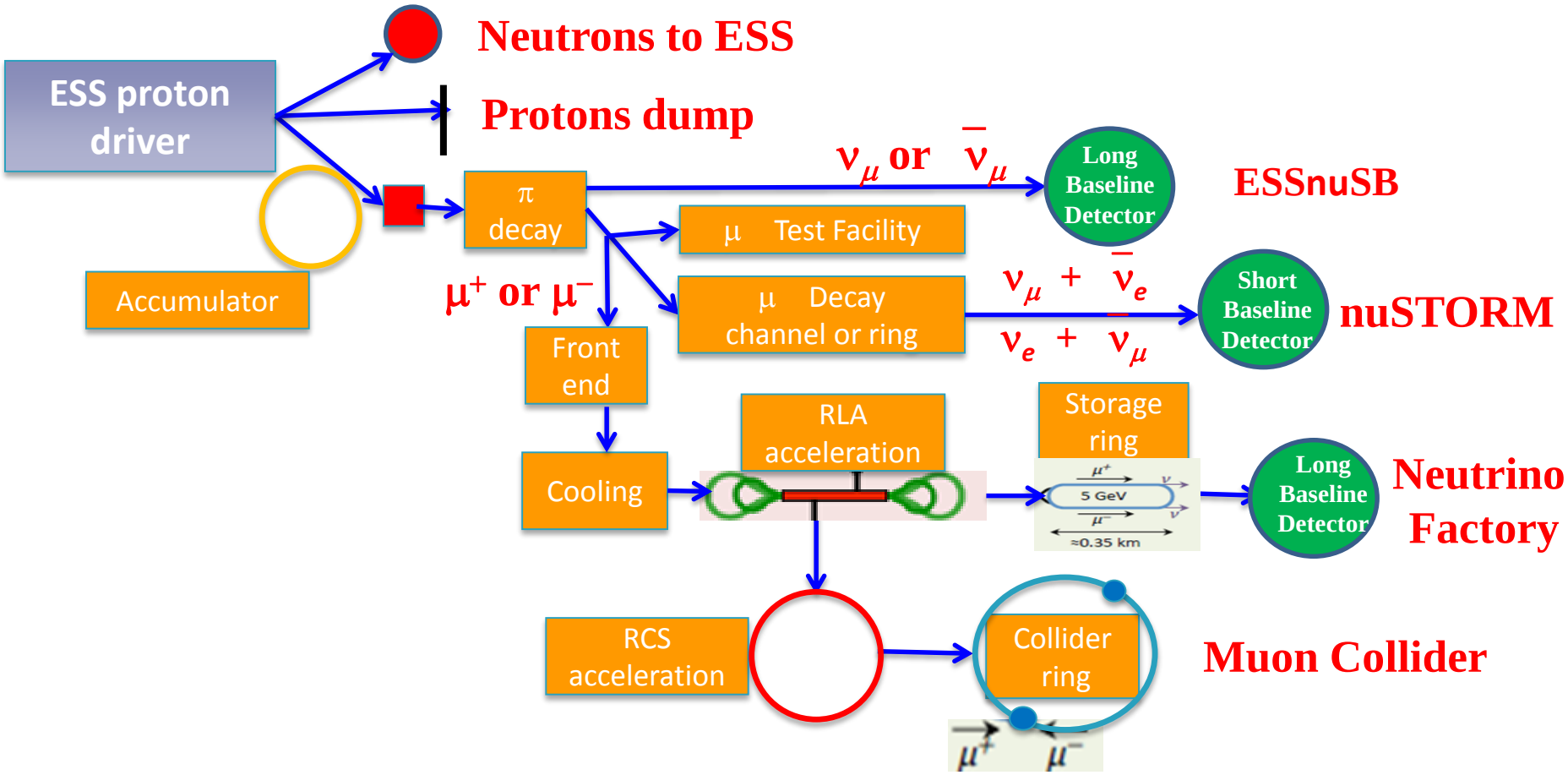
~10^{12} μ/pulse in 200 < P(MeV/c) < 500 (for 1 m^2)
(**2.6x10^{20} μ/year**, at the level of the beam dump)

ESS-NUSTORM: a tentative layout



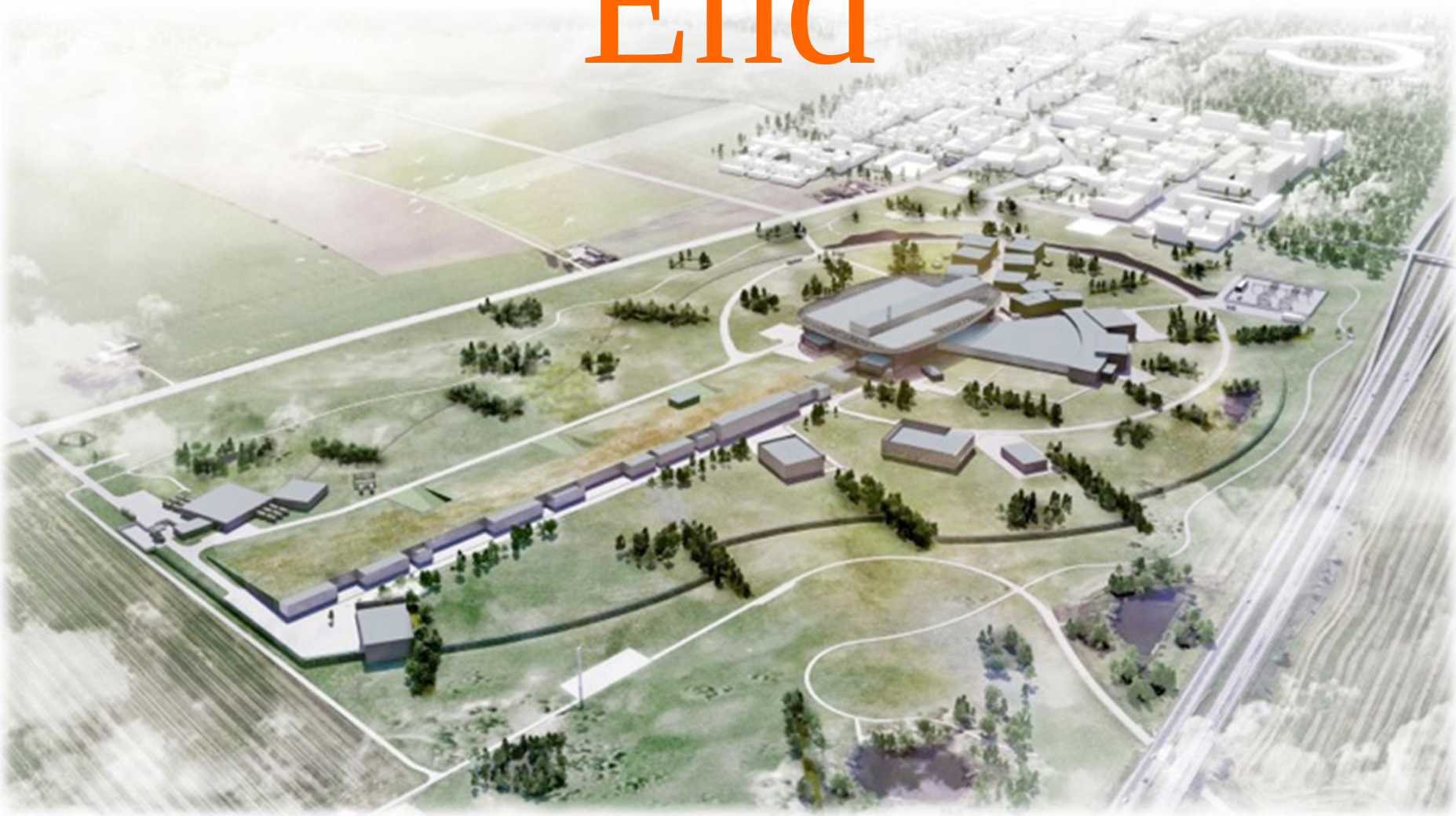
J.P.Delahaye ESS_NuSTORM

ESS neutrino and muons facility



J.P.Delahaye ESS_NuSTORM

End



Beam characteristics

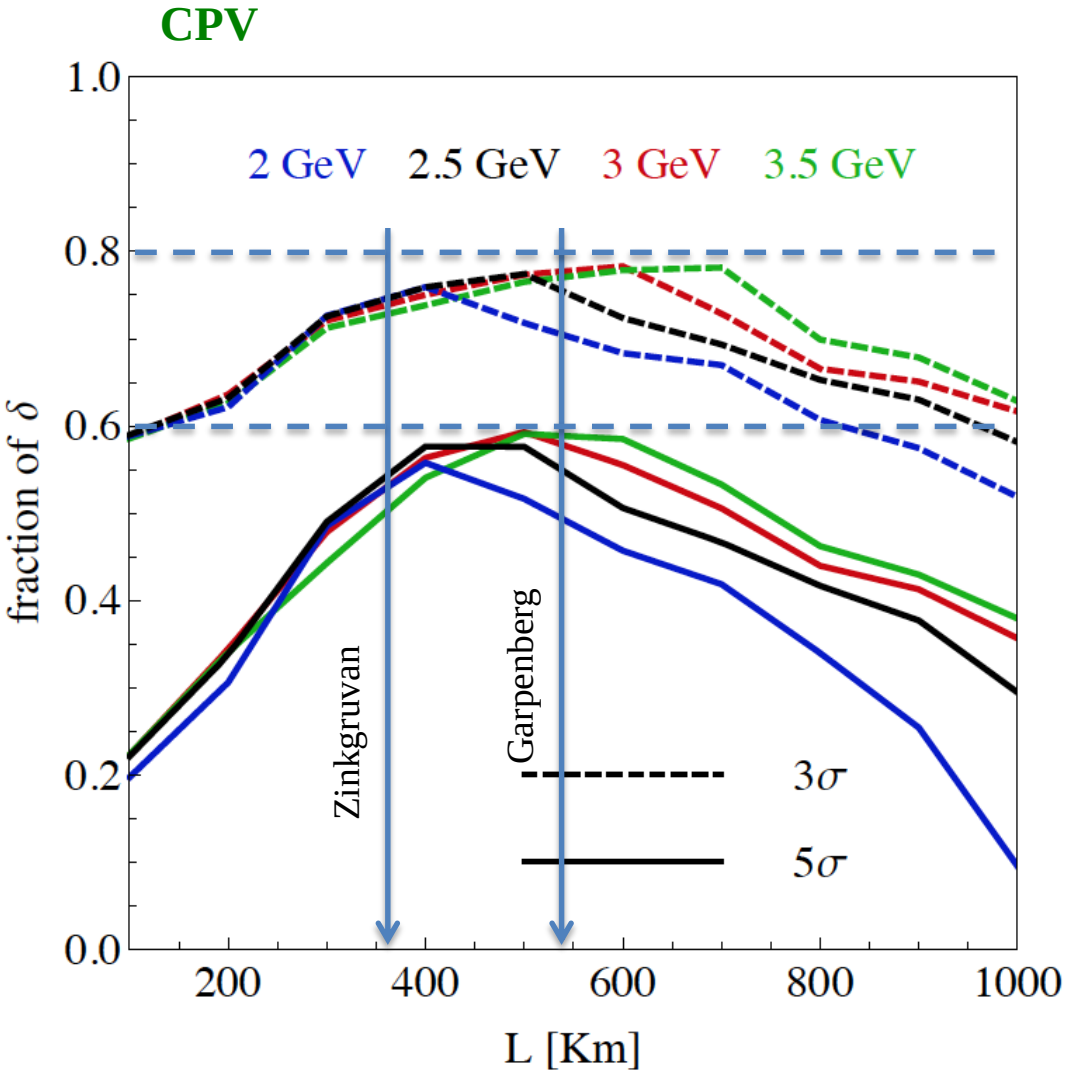
Main ESS facility parameters concerning the proton beam.

Parameter	Value
Average beam power	5 MW
Proton kinetic energy	2.0 GeV
Average macro-pulse current	62.5 mA
Macro-pulse length	2.86 ms
Pulse repetition rate	14 Hz
Maximum accelerating cavity surface field	45 MV/m
Maximum linac length (excluding contingency and upgrade space)	352.5 m
Annual operating period	5000 h
Reliability	95%

Number of neutrinos per m^2 crossing a surface placed on-axis at a distance of 100 km from the target station during 200 days for 2.0 GeV protons and positive and negative horn current polarities.

	Positive		Negative	
	N_ν $(\times 10^{10})/m^2$	%	N_ν $(\times 10^{10})/m^2$	%
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

Which baseline for ESS nuSB?



- **systematic errors: 5%/10% (signal/backg.)**