What are neutrinos?

- The lightest fundamental particle
- Elusive and difficult to detect
- Plentiful – they are everywhere
  - Big Bang
  - The Sun
  - The Earth
  - Supernovae
- Travel as fast as light (almost!)
- Three different flavours
- The flavours oscillate!

Neutrino Discoveries and Nobel Prizes

- Pauli 1930/1945 [prediction of the neutrino]
- Cowan & Reines 1956/1995 [discovery of the neutrino]
- Davis and Koshiba 2002 [solar & cosmic neutrinos]
- Kajita & McDonald 1998/2001/2015 [neutrino oscillations]

What is Matter and Antimatter?

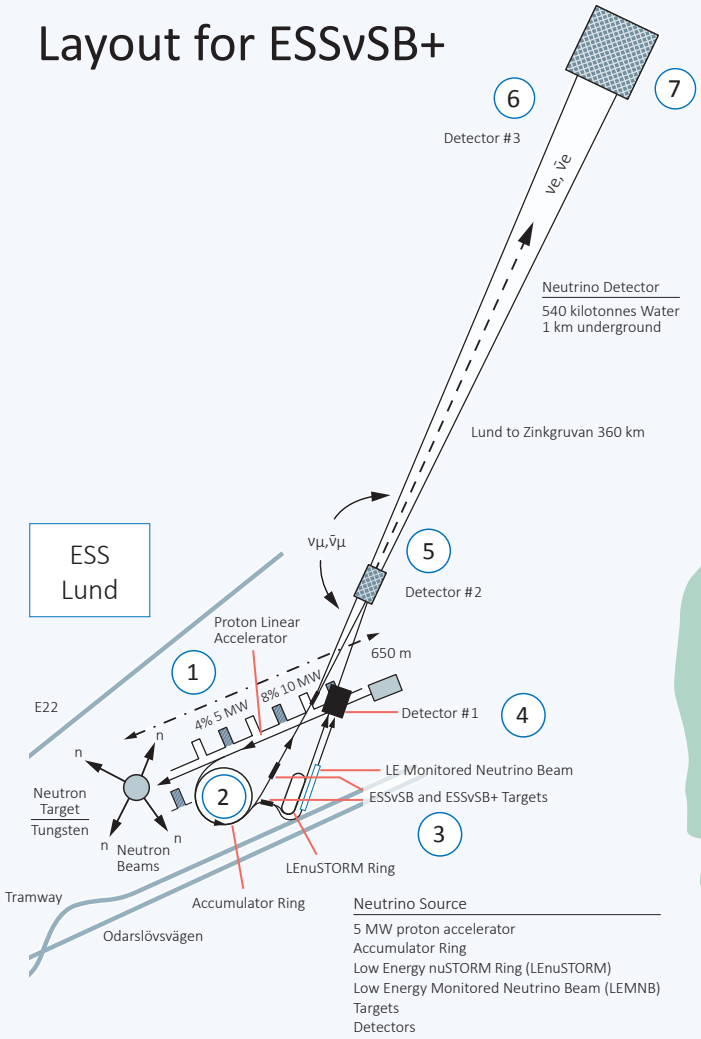
- There were equal quantities after the Big Bang
- But there is 'no' antimatter now. Why?
- Symmetry was broken. How?
- Otherwise we would not exist

... so why was the symmetry broken?

– ESSvSB with the help of ESSvSB+ will provide the answer!


European Spallation Source

Layout for ESSvSB+



1. ESS Proton Linac accelerates pulses at 5+5 MW
2. 5 MW pulses for ESSvSB compressed in the Accumulator Ring
3. Proton pulses hit the Targets producing Pions that are focussed forward
4. Muon neutrinos generated from muons decay in LEnuSTORM are measured in Detectors #1 and #2 for ν cross-section and sterile neutrino searches, and muon and electron neutrinos generated from pions and muons decay in LEMNB are measured in Detector #1 for muon-tag-normalized ν cross-sections
5. Muon neutrinos from the decay of the forward focused pions constitute the main ESSvSB neutrino beam and are monitored by Detector #2
6. Neutrinos oscillate and are detected by Detector #3 at Zinkgruvan (360 km from ESS)
7. Data is collected and distributed to the rest of the world

Timeline and Costs

Advantages of ESSvSB+

- Highest production intensity [5 MW driver]
- Largest detector mass [540 kilotonnes]
- Greatest sensitivity [2nd oscillation maximum]
- Precise ν cross-section measurements at low energy