Preferred machine for testing a laser plasma accelerator at CERN: eSPS

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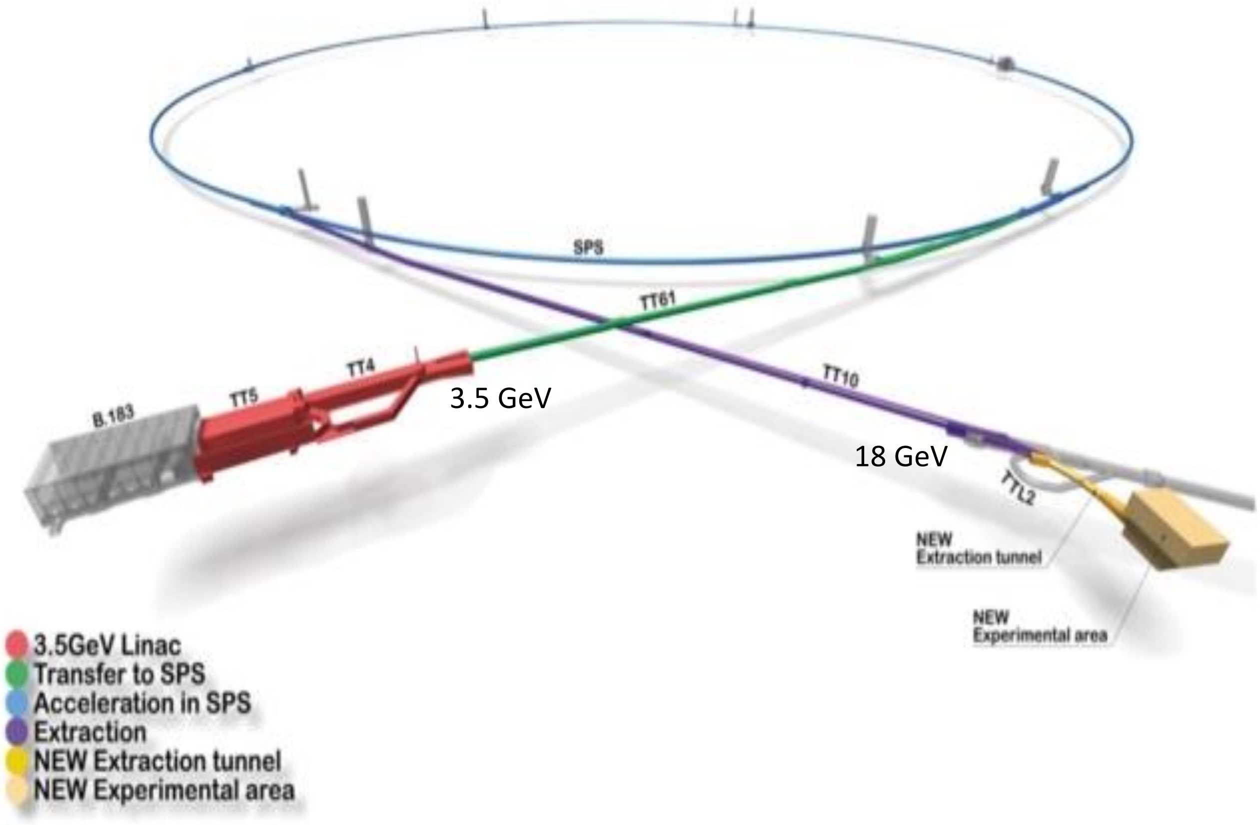

1.) CERNs Physics Beyond Collider study group
2.) E. Adli, AWAKE Collaboration, Nature 561,363 , 2018
3.) C. Edwards, CERNCOURIER, Sept. 2020

Conceptual design report (173 pages)

The proposed “eSPS” would be fed by a new linear accelerator and could serve plasma wakefield R&D and experiments in the dark sector.

The SPS is one of CERN’s longest running accelerators, commissioned in June 1976 at an energy of 400 GeV and serving numerous fixed-target experiments ever since. It was later converted into a proton-antiproton collider which was used to discover the W and Z bosons in 1983. Then, in addition to its fixed-target programme, the SPS became part of the injection chain for LEP, and most recently, has been used to accelerate protons for the LHC.

The changeover time for using the SPS as a proton accelerator to an electron accelerator is estimated to be around ten minutes.

First step:
Electrons would be injected into the SPS at an energy of 3.5 GeV by a new compact high-gradient linac based on CLIC's X-band radio-frequency (RF) cavity technology, which would fill the circular machine with 200 ns-duration pulses at a rate of 100 Hz.

An additional 800 MHz superconducting RF system, similar to what is needed for FCC-ee, would then accelerate after passing the eSPS the electron beam from 3.5 GeV to an extraction energy up to 18 GeV .

At the beginning the following physics experiments are considered

The requirements of the primary electron beam to be delivered by the eSPS were determined by the needs of the proposed Light Dark Matter eXperiment (LDMX), which would use missing-momentum techniques to explore potential couplings between hidden-sector particles and electrons in uncharted regions. The experiment could be housed in a new experimental area (see figure).
The beam energy for these experiments is 18 GeV.

The Laser Plasma Accelerator Program

will start with the development of a laser plasma accelerator
for 3.5 GeV electron beams. The parameters which have to be checked and optimized are

Emittance

Energy spread

Next step are the development of a Laser Plasma Accelerator for Positrons
In a second phase, the facility could be geared to deliver positron witness bunches, which would make it a “complete facility” for plasma wakefield collider studies.

Such a programme would naturally build on the work done by the AWAKE collaboration, which uses protons as a drive beam, and significantly broaden plasma wakefield R&D at CERN in line with priorities set out by the recent update of the European strategy for particle physics.

Positron production would be a crucial element for any future Higgs-factory, while it would also allow studies of the Low EMittance Muon Accelerator (LEMMA) – a novel scheme for obtaining a low-emittance muon beam for a muon collider, by colliding a high-energy positron beam with electrons in a fixed target configuration at the centre of mass energy required to create muon pairs.

SUMMARY

Present basic Idea:

a.) Starting with Dark Matter Experiments. The beam is injected with a conventional RF accelerating system into the eSPS and accelerated up to

18 GeV.

b.) add to the conventional 3.5 GeV linac a Laser Plasma linac system.

The laser plasma accelerator should work for electroncs and positrons.