A primary electron beam facility at
CERN - eSPS

Oxford January 2021
S. Stapnes (CERN)
on behalf of the working group "PBC-acc-e-beams" (eSPS team)
Background: Proposed $e^+e^-$ linear colliders – CLIC

The Compact Linear Collider (CLIC)

- **Timeline:** Electron-positron linear collider at CERN for the era beyond HL-LHC (~2035 Technical Schedule)

- **Compact:** Novel and unique two-beam accelerating technique with high-gradient room temperature RF cavities (~20,500 cavities at 380 GeV), ~11km in its initial phase

- **Expandable:** Staged programme with collision energies from 380 GeV (Higgs/top) up to 3 TeV (Energy Frontier)

- **CDR in 2012. Updated project overview documents in 2018 (Project Implementation Plan). See resource slide.**

- **Cost:** 5.9 BCHF for 380 GeV (stable wrt 2012)

- **Power:** 168 MW at 380 GeV (reduced wrt 2012), some further reductions possible

- **Comprehensive Detector and Physics studies**
Motivations

Physics:
Large increasing interest in Light Dark Matter – using e-beams, the original trigger for the “eSPS proposal” – LDMX physics & detector talks

Accelerator R&D:
Any next machine at CERN is “beyond LHC”, i.e. 20+ years away – what can be done using smaller setups on a much shorter timescale?
  - Linac an important next step for X-band technology
  - Relevant for FCC-ee, e.g RF systems needed in the SPS, injectors
  - Strategic: Will bring electrons back at CERN fairly rapidly (linacs and rings) – important relevance for the developments and studies needed for future e+e- machines at CERN – being linear or circular
  - Future accelerator R&D more generally: Accelerator R&D and project opportunities with e-beams as source
  - Main directions: Novel Acc. studies and CLEARER (a higher energy version of CLEAR)
Direct Detection and Accelerator Based Production

\[ \sigma v \sim \varepsilon^2 \alpha_D \frac{m_{A'}^2}{m_{\chi}^2} = \frac{y}{m_{\chi}^2}, \quad y = \varepsilon^2 \alpha_D \left( \frac{m_{\chi}}{m_{A'}} \right)^4 \]

But, cross sections can be loop- or velocity-suppressed in the non-relativistic regime of direct detection:

\[ \sigma \sim \left( \frac{m_{A'}}{m_{\chi}} \right)^2 \frac{y Z^2}{\alpha_D m_{\chi}} \Rightarrow y \sim \left( \frac{m_{A'}}{m_{\chi}} \right)^2 \frac{m_{A'}^2 \alpha_D}{Z^2} \]

Conservative choice: \( \alpha_D = 0.5 \) and \( m_{A'} = 3m_{\chi} \)
A’ created close to threshold in the em-field around the target nucleus, since the A’s, heavier than the electrons, take most of the incoming electron energy —→ soft recoil electron, large missing energy

$M_{A'} = 10\text{--}1500$ MeV

Inclusive Single e' Background

$E_e < 1.2$ GeV

$(0.3 E_{\text{Beam}})$
Select these

Reject these

The experiment is to a big degree a question of rejecting these
EoI to the SPSC Oct 2018: https://cds.cern.ch/record/2640784

Also submitted in “compact form” to ESPP update 18.12.2018
https://indico.cern.ch/event/765096/contributions/3295600/

CDR on arXiv in September 2020

Yellow Report in December 2020:

This volume should be cited as:
A primary electron beam facility at CERN — eSPS: Conceptual design report,
Torsten Åkesson, Steinar Staples (eds.)
CERN Yellow Reports: Monographs, CERN-2020-008 (CERN, Geneva, 2020)
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Accelerator implementation at CERN of LDMX type of beam

- X-band based 70m LINAC to ~3.5 GeV in TT4-5
- Fill the SPS in 1-2s (bunches 5ns apart) via TT61
- Accelerate to ~16 GeV in the SPS
- Slow extraction to experiment in 10s as part of the SPS super-cycle, or full use
- Experiment(s) in new hall bringing beam back on Meyrin site using TT10

<table>
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<tr>
<th>Parameter</th>
<th>S-band linac (Section 3.2)</th>
<th>X-band linac (Section 3.3)</th>
<th>SPS (Section 4.2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy [GeV]</td>
<td>0.05–0.25</td>
<td>3.5</td>
<td>3.5–18</td>
</tr>
<tr>
<td>Electrons per bunch</td>
<td>$10^6 – 10^{10}$</td>
<td>$10^6 – 10^{10}$</td>
<td>$10^9$</td>
</tr>
<tr>
<td>Bunch length [ns]</td>
<td>$10^{-4} – 4 \times 10^{-3}$</td>
<td>$10^{-4} – 2.5 \times 10^{-3}$</td>
<td>$0.15 – &lt; 0.7$</td>
</tr>
<tr>
<td>Bunch spacing [ns]</td>
<td>Multiples of 0.33</td>
<td>Multiples of 0.33</td>
<td>5</td>
</tr>
<tr>
<td>Bunches per cycle</td>
<td>1 – 200</td>
<td>1 – 200</td>
<td>$3 \times 10^3$</td>
</tr>
<tr>
<td>Cycle length [s]</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
</tr>
</tbody>
</table>
Linac in TT5/TT4

- Flexible bunch pattern provided by photo-injector
  - 5ns, 10ns, … 40ns bunch spacing (only constrained by the SPS)
- High repetition rate, for example
  - 200 ns trains at 50 or 100 Hz
- Installed in TT4/TT5, transfer via existing tunnel to the SPS
- Room for accelerator R&D activities at end of linac (duty cycle in many cases low for SPS filling so important potential)
Technology spread

Prototype components
Laboratory with commercial
- Accelerating structures
- pulse compressors
- alignment
- stabilization
- etc.

Full commercial supply
- X-band klystrons
- solid state modulators
- etc.

Systems and 100 MeV-range facilities
- XBoxes at CERN
- (NEXTEF KEK)
- Test stand at Tsinghua
- Frascati
- NLCTA SLAC
- Linearizers at Electra, PSI, Shanghai and Daresbury
- Deflectors at SLAC, Shanghai, PSI, DESY and Trieste
- NLCTA
- Smart*Light
- FLASH

Normal-conducting, low-emittance GeV-range facilities

Operational
- SACLA
- SwissFEL

X-band GeV-range facilities
Planning:
- EU-Praxia
- eSPS
- CompactLight
- XARA

Gradients
Linac in buildings 183, TT5, TT4 and TT61

- 0.1 GeV S-band injector
- 3.4 GeV X-band linac
  - High gradient CLIC technology
  - 24 RF units to get 3.4 GeV in ~70 m

Reviewed: All services, EL, CV, access, safety, shielding/radiation, transport/installation, etc
Table 3.3: Beam parameters at the end of the CLEAR injector.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value range</th>
<th>Value for eSPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy [MeV]</td>
<td>50 to 250</td>
<td>200</td>
</tr>
<tr>
<td>Bunch charge [nC]</td>
<td>0.001 to 1.5</td>
<td>0.05</td>
</tr>
<tr>
<td>Norm. emittance [μm]</td>
<td>~3 for 0.05 nC/bunch</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>~20 for 0.4 nC/bunch</td>
<td></td>
</tr>
<tr>
<td>Bunch length rms [mm]</td>
<td>0.3 to 1.2</td>
<td>0.8</td>
</tr>
<tr>
<td>Energy spread rms [%]</td>
<td>below 0.2</td>
<td>0.1</td>
</tr>
<tr>
<td>Number of bunches</td>
<td>1 to 200</td>
<td>40</td>
</tr>
<tr>
<td>Micro-bunch spacing [ns]</td>
<td>multiple of 0.33</td>
<td>5</td>
</tr>
</tbody>
</table>

Table 3.6: Parameters of the X-band accelerating structure.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>First cell</th>
<th>Last cell</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aperture iris radius [mm]</td>
<td>3.7</td>
<td>2.7</td>
</tr>
<tr>
<td>Iris thickness [mm]</td>
<td>1.35</td>
<td>1.35</td>
</tr>
<tr>
<td>Q-factor</td>
<td>7090</td>
<td>7020</td>
</tr>
<tr>
<td>Group velocity [% of c]</td>
<td>3.6</td>
<td>1.34</td>
</tr>
<tr>
<td>R/Q [kΩ/m]</td>
<td>14.3</td>
<td>17.5</td>
</tr>
<tr>
<td>Number of cells</td>
<td>69</td>
<td></td>
</tr>
<tr>
<td>Active length [mm]</td>
<td>575</td>
<td></td>
</tr>
<tr>
<td>Input power for &lt;60MV/m&gt; [MW]</td>
<td>30.5</td>
<td></td>
</tr>
<tr>
<td>Rise time (1/bandwidth) [ns]</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Filling time [ns]</td>
<td>88</td>
<td></td>
</tr>
</tbody>
</table>
Linac components “available”

- Examples:
  - Klystron
  - Modulator
  - Accelerating structure
  - Pulse compressor

Assembled systems in continuous operation at CERN
Transfer tunnel, TT61, from the Linac into the SPS

Injection into the SPS

Bunch to bucket injection in the SPS longitudinal RF structure.

For example: total of 75 trains of 40 bunches 3000 bunches 10^{12} electrons in the ring
SPS RF, use Crab Cavity Bypass in SPS-LSS6

- Movement in/out of SPS-ring by 510mm – movement approx. 10 min with 2K Helium (~30 W)
- Independent vacuum system
- Look also as longer dynamic by pass giving more flexibility
**SPS RF: 800 MHz, 5-Cell**

- In mechanical bypass, moved in/out of beam in ~10 min. No proton constraints for beam loading/impedance. Aperture ok for LHC beam
- Moderate HOM damping using 4 LHC-type HOM couplers for electron beam
- As mentioned, study the feasibility of dynamic by-pass for electrons – equivalent to in line beam

<table>
<thead>
<tr>
<th>per cavity</th>
<th>unit</th>
<th>value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>[MHz]</td>
<td>801.58</td>
</tr>
<tr>
<td>Voltage</td>
<td>[MV]</td>
<td>5.0</td>
</tr>
<tr>
<td>R/Q</td>
<td>[Ω]</td>
<td>196</td>
</tr>
<tr>
<td>Epk, Hpk</td>
<td>[m^{-1}, mT/MV]</td>
<td>30, 60</td>
</tr>
<tr>
<td>RF Power</td>
<td>[kW]</td>
<td>~50</td>
</tr>
</tbody>
</table>

- **Sample Configuration (10 MV for e^-)**

- **Two 5-cells in a CM ~ 5m**

- **FCC-800 MHz prototype**

*First approximation – requires detailed study to optimize RF system*
Crab Cavity Bypass – SPS-LSS6

Surface Infrastructure
(HPRF, LLRF, Access Control
Cryogenics, Electrical etc.)

HL-LHC Crab cavities in SPS

Cryo Refrigerator
Many other SPS issues addressed in the EoI and CDR: beam-stability, energy losses, internal beam dump, injection, instrumentation, magnetic field stability, etc.

Figure 4.7: Transverse damping times (a) and energy loss per turn (b) versus electron energy in the SPS.

Table 4.3: Collective effects estimations for the eSPS.

<table>
<thead>
<tr>
<th>Parameters and thresholds</th>
<th>Q40</th>
<th>Q26</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase advance (b/v)</td>
<td>135°/90°</td>
<td>90°/90°</td>
</tr>
<tr>
<td>Eq. hor. emittance @ injection [nm.rad]</td>
<td>1.62</td>
<td>3.56</td>
</tr>
<tr>
<td>Eq. hor. emittance @ extraction [nm.rad]</td>
<td>34.7</td>
<td>74.0</td>
</tr>
<tr>
<td>Eq. Bunch length [mm]</td>
<td>10.0</td>
<td>14.0</td>
</tr>
<tr>
<td>Injected hor. emittance [nm.rad]</td>
<td>0.43</td>
<td></td>
</tr>
<tr>
<td>$\epsilon$ per bunch</td>
<td>$10^8$</td>
<td></td>
</tr>
<tr>
<td>Bending radius [m]</td>
<td>70.1</td>
<td></td>
</tr>
<tr>
<td>Average chamber radius [m]</td>
<td>0.04</td>
<td></td>
</tr>
<tr>
<td>Longitudinal impedance [Ω]</td>
<td>6.4</td>
<td></td>
</tr>
<tr>
<td>Transverse impedance [MΩ/m]</td>
<td>9.77</td>
<td></td>
</tr>
<tr>
<td>SC tune shift @ injection [$10^{-4}$]</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>SC tune shift @ equilibrium [$10^{-4}$]</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>SC tune shift @ extraction [$10^{-4}$]</td>
<td>1.2</td>
<td>0.6</td>
</tr>
<tr>
<td>LMI impedance threshold @ injection [Ω]</td>
<td>17912</td>
<td>33988</td>
</tr>
<tr>
<td>LMI impedance threshold @ equilibrium [Ω]</td>
<td>21.67</td>
<td>41.12</td>
</tr>
<tr>
<td>LMI impedance threshold @ extraction [Ω]</td>
<td>682</td>
<td>1294</td>
</tr>
<tr>
<td>TMCI impedance threshold @ injection [MΩ/m]</td>
<td>5060</td>
<td>6900</td>
</tr>
<tr>
<td>TMCI impedance threshold @ equilibrium [MΩ/m]</td>
<td>506</td>
<td>690</td>
</tr>
<tr>
<td>TMCI impedance threshold @ extraction [MΩ/m]</td>
<td>1121</td>
<td>1612</td>
</tr>
<tr>
<td>Tune shift due to ions [$10^{-5}$]</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>FII rise time [ms]</td>
<td>6.7</td>
<td>15.0</td>
</tr>
<tr>
<td>CSR LMI bunch length threshold @ injection [m]</td>
<td>0.41</td>
<td>1.76</td>
</tr>
</tbody>
</table>
Slow extraction to experiments

Extraction
Slow extraction principle, in frequency space

- Spread in oscillation frequency within the beam follows
  - Transverse distribution
  - Longitudinal distribution in presence of chromatic lattice
- Position of the resonant condition is set by the machine
- Synchrotron radiation constantly diffuse the particles to fill the tail in the distribution
- The extraction rate can be controlled by changing the position of the resonant condition

![Graph showing extraction rate and resonant condition](image)
Figure 4.9: Extraction process in the horizontal phase space at the electric septum (a). Particle trajectories in the transverse horizontal space in the extraction region with apertures and the injected 14 GeV/c proton beam envelope in grey (b).
Electron beam transfer line from the SPS to experiments

- Uses existing TT10 line, designed to transport 10/20 GeV beams

- Collimation in the line for control of beam distribution and intensity
  - ~ Gaussian beam can be made almost flat by careful collimation

- Beam size might be increased greatly at the target
  - Size of beam-spot chosen to deliver number of electrons/cm$^2$/bunch-crossing on target
  - For instance a 2cm vertical and 20cm horizontal beam is feasible
  - There is flexibility on the choice of both horizontal and vertical beam sizes

Figure 4.10: Beam sizes and optical functions from the SPS to the experimental target.
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Figure 5.26: Access control layout in TT4.

Figure 5.39: Dose rate levels for different loss scenarios. From top to bottom: S-Band linac operation, low energy experimental area operation, X-Band linac operation to the high energy experimental area, X-Band linac RF conditioning, simultaneous beam operation to both experimental areas with maximum nominal beam losses.
Extracted beam and experimental area

In total ~50 m new tun
Instrumentation (from EoI)

Linac:
- **Position**
  - Re-use of CTF3 inductive pick-ups
  - Simple button BPMs would also do the job
- **Beam Size**
  - OTR screens (can also be combined with streak camera for bunch length)
- **Intensity**
  - Re-use of CTF3 inductive pick-up or standard beam current transformers

SPS:
- **Position**
  - Standard orbit system (consolidated in LS2)
  - Should be able to measure to $1e9$ (limit $\sim 5e8$)
- **Beam Size**
  - Wiresscanners
  - Possible use of synchrotron radiation
- **Intensity**
  - DC Transformer OK for total current
  - Fast BCT does not distinguish 5ns spaced bunches
  - Could do batch by batch but at limit of resolution (tbc)

Extracted beam:
- **Position & Intensity**
  - Use of fibre monitors.
    - Developed for new EHN1 (neutrino platform) secondary lines
    - Scintillating (or Cherenkov) fibres
    - Low material budget
    - > 90% efficiency for single particles demonstrated
  - R&D required to make them UHV compatible

The challenge of measuring very low intensity beam can be circumvented using a higher intensity for beam setup
Beam structures

Capability stand-alone:
Extracting ~10 electrons per 5ns means $10^{16}$ electrons in ~ 80 days
Including up-times and efficiencies: dedicated year overall

Using 800 MHz and/or more electrons per extraction will increase rate

Or as part of super-cycle, or extract entire beam every 1-2s (beamdump)
Potential use of such a facility

(linac more than 90% free)

**Physics:**
LDMX - Other hidden sector exp., incl. dump-type experiments using the available electrons - Nuclear physics

**Accelerator physics opportunities:**
CLIC: Linac goes a long way towards a natural next step for use of technology (collaborate with INFN and others also using technology for X-band linacs in coming years)
Relevant also FCC-ee, for example the RF systems, injector, etc

Plasma studies with electrons
Use electron (3.5 GeV) beam as driver and/or probe – studied by AWAKE WG

Plasma-lenses, impedance, high grad studies, medical (electrons), training, instrumentation, THz, ESA and detector irradiation. Some results: https://acceleratingnews.web.cern.ch/article/first-experimental-results-clear-facility-cern (new article in preparation)

Positron production (interesting for linear or circular colliders and plasma) and studies with positrons for plasma, and possibly LEMMA concept for muon collider

General Linear or Ring related Collider related studies using SPS beam
Example: damped beam for final focus studies (beyond ATF2), FCC-ee related studies
Figure 3.15: Schematic layout for a second injector dedicated for plasma wakefield acceleration research. The injector could be installed at the beginning of TT61 and connected via a dogleg to an experimental area at the end of the linac.

Figure 6.3: Top panels: snapshots of the drive bunch ($-0.1 \leq \xi \leq 0.0$ mm) and plasma densities (no witness bunch, colour scale for $n_e/n_0$) at two locations along the plasma ($z = 5$ and 62 cm). Bottom panels: corresponding snapshots of the drive bunch electrons longitudinal momentum. The simulation parameters used were: $n_0 = 5.6 \times 10^{15}$ cm$^{-3}$, $\sigma_z = 100 \mu$m, $\sigma_r = 70 \mu$m, $N = 4.3 \times 10^{10}$ ($n_0/n_e = 1$), thus $E_{WB} = 7.24$ GeV/m.
Providing a test facility at CERN with high availability, easy access and high quality e-beams.

Performing R&D on accelerator components, including innovative beam instrumentation prototyping, high gradient RF technology realistic beam tests and beam-based impedance measurements.

Providing an irradiation facility with high-energy electrons, e.g. for testing electronic components in collaboration with ESA or for medical purposes (VHEE), possibly also for particle physic detectors.

Performing R&D on novel accelerating techniques – electron driven plasma and THz acceleration. In particular developing technology and solutions needed for future particle physics applications, e.g., beam emittance preservation for reaching high luminosities.

Maintaining CERN and European expertise for electron linacs linked to future collider studies (e.g. CLIC and ILC, but also AWAKE and FCC-ee injectors), and providing a focus for strengthening collaboration in this area.

Using CLEAR as a training infrastructure for the next generation of accelerator scientists and engineers.

Experiments/Activities in 2019 – 38 weeks
(Possibly not a complete list)

- JUAS Practical Work Days
- NPL – Irradiation/dosimetry
- CHUV – FLASH dosimetry
- AWAKE Cherenkov BPM
- CLIC Wake-Field Monitors
- EOS bunch length monitor
- Inductive BPMs
- CLIC Structure wake-field kicks
- R2E – ESA Monitor Flash
- R2E – displacement damage
- THz Smith-Purcell radiation
- THz high power generation/bunch length monitoring
- Ionization chambers dosimetry
- R2E irradiation studies SEU-SEE
- R2E irradiation studies SEU-SEE
- Plasma Lens (Oslo, DESY, Oxford U.)
- VHEE radiobiology/plasmid irradiation (Manchester U.)
- AWAKE spectrometer calibration
- Cryogel radiation length evaluation (FCC detectors R&D)
- Cherenkov X-ray pre-tests (Belgorod)
- Irradiation of DCDC converters for detectors (EP/ESE group)
- IRRAD Beam Profile Monitors prototype tests
- WSM-BPR diagnostics tests
- Cherenkov Plasmonic
- Double-bunch generation
- High Charge bunch compression

A recent report about 2020 (link)
Positrons (not part of cost and schedule below)

<table>
<thead>
<tr>
<th><strong>Parameter</strong></th>
<th><strong>Symbol</strong></th>
<th><strong>Value</strong></th>
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<tbody>
<tr>
<td>Electron drive bunch</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy</td>
<td>$W_0$</td>
<td>3.5 GeV</td>
</tr>
<tr>
<td>Charge</td>
<td>$Q$</td>
<td>1.7 nC</td>
</tr>
<tr>
<td>Bunch rms length</td>
<td>$\sigma_z$</td>
<td>200 $\mu$m</td>
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<tr>
<td>Positron bunch</td>
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<td></td>
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<tr>
<td>Energy</td>
<td>$W_0$</td>
<td>3.5 GeV</td>
</tr>
<tr>
<td>Charge</td>
<td>$Q$</td>
<td>&gt; 1 nC</td>
</tr>
<tr>
<td>Bunch rms length</td>
<td>$\sigma_z$</td>
<td>200 $\mu$m</td>
</tr>
<tr>
<td>Capture energy</td>
<td>$W_c$</td>
<td>335 MeV</td>
</tr>
<tr>
<td>Final emittance</td>
<td>$\varepsilon$</td>
<td>&lt; 20 mm mrad</td>
</tr>
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</table>
Total costs from CDR – example of breakdown for Linac

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost [MCHF]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source and linac</td>
<td>49.8</td>
</tr>
<tr>
<td>SPS transfer, acceleration and extraction</td>
<td>23.4</td>
</tr>
<tr>
<td>Civil engineering</td>
<td>14.0</td>
</tr>
<tr>
<td>Ancillary systems</td>
<td>23.8</td>
</tr>
<tr>
<td><strong>Sum</strong></td>
<td><strong>111.0</strong></td>
</tr>
</tbody>
</table>

Figure 7.2: Summary of the cost estimate for the project.

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost [MCHF]</th>
</tr>
</thead>
<tbody>
<tr>
<td>RF cavities</td>
<td>11.52</td>
</tr>
<tr>
<td>Klystrons</td>
<td>11.42</td>
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<tr>
<td>Modulators</td>
<td>10.32</td>
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<td>Waveguides</td>
<td>6.53</td>
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<tr>
<td>Vacuum</td>
<td>3.12</td>
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<tr>
<td>Controls</td>
<td>2.47</td>
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<tr>
<td>Magnet</td>
<td>1.66</td>
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<tr>
<td>Instrumentation</td>
<td>1.41</td>
</tr>
<tr>
<td>Source</td>
<td>1.00</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>0.35</td>
</tr>
<tr>
<td><strong>Sum</strong></td>
<td><strong>49.80</strong></td>
</tr>
</tbody>
</table>

Figure 7.3: Summary of the linac and source cost estimate.
Figure 7.1: Possible eSPS implementation schedule.
Concluding remarks

• Important physics opportunities with e-beams at CERN
• Based on previous usage of the CERN accelerator complex, and building on the accelerator R&D for CLIC and HiLumi/FCC, an electron beam facility would be a natural next step
  • No show-stoppers have been found when exploring this option
  • Interest in pursuing this option as beam close to ideal for LDM searches of this type
• Will also provide many opportunities for important and strategic accelerator R&D at CERN – and opens the door to future electron facilities in general
• CDR completed and on the arXiv (link), CERN Yellow Report published in Dec 2020 (minor changes wrt arXiv version)
• Can this be implemented? Further progress resource limited (or priority limited) at CERN ...
• Can (some of) this be done elsewhere?
• Clear common features with 1 GeV X-band linac at LNF – and we will continue to collaborate for this project
• We also hope LDMX at SLAC (starting at 4 GeV) can be done ....

With warm thanks to the entire eSPS team