Positron Source Location:
End or Middle of the Linac

K. Floettmann
DESY

Option 1: Undulator at the End of the Linac

- Operation between 150 and 250 GeV:
  - Required undulator length changes with c. m. energy.
  - Installed undulator length sufficient for 1.5 e^+/e^- at 150 GeV, at higher energies a part of the undulator is switched off.
- Operation below 150 GeV:
  - Yield gets low and the luminosity is affected. When the luminosity drops by a factor of 2, change operation mode: Pulses to produce luminosity is produced at half the rep. rate and every other bunch is used to produce positrons. Requires a bypass line.
- Energy Upgrade:
  - Undulator can operate up to 1 TeV c. m., but efficiency gets worse, hence it might be desirable to change the undulator at one point.

Option 2: Undulator in the Middle of the linac

- Operation between 150 and 250 GeV:
  - Beam energy at the undulator entrance is constant (150 GeV), only the second part of the linac is used to vary the c. m. energy.
- Operation below 150 GeV:
  - To reach energies below 150 GeV the beam needs to be decelerated behind the undulator.
- Energy Upgrade:
  - Energy at the undulator entrance changes in case of the TESLA upgrade scenario.
  - Energy stays constant in case of USLCTOS scenario.

Required Undulator Length

	Undulator I B = 0.75 T, λ = 1.2 cm, K = 0.84		Undulator II B = 1.27 T, λ = 1.1 cm, K = 1.3	
elec. energy	150 GeV	250 GeV	150 GeV	250 GeV
undu. length	286 m	84 m	100 m	34 m
energy loss	4.6 GeV	3.8 GeV	4.6 GeV	4.4 GeV
E_1	10.4 MeV	29 MeV	7.2 MeV	20 MeV

Required undulator length to produce 1.5 positrons per electron and energy loss of the electron beam for two undulators and two electron beam energies. Assumed capture efficiency 17.5 %.

Advantages and Disadvantages of Option 1

- Additional reserve at 250 GeV operation (factor 3). Can be used to decrease the emittance in case of problems with the damping ring acceptance.
- Allows to achieve a higher polarization.
  - dep. on achievable undualator parameters a high polarization at 150 GeV might be difficult.

- Tuning required when beam energy changes:
  - How often is that required how much time does it take?
  - Is the source sensitive to parameter variations?
  - What needs to be adjusted when the energy is changed?

Sensitivity of the Undulator Based Source

		charge variation	rms emittance variation
electron beam energy	± 1 %	± 2 %	± 0 %
incoming photon beam spot size	+ 30 %	- 1.1 %	+ 2 %
photon beam off-set	± 0.5 mm	- 3.5 ‰	± 0 %
rf phase of the first capture section	± 5°	- 2.6 ‰	± 0 %
rf amplitude of the first capture section	± 5 %	± 0.7 ‰	± 0 %

Tuning requirement after change of energy (250-150 GeV)

- The solenoid settings are independent of the photon and positron energy, respectively. Also the phases of the cavities which are responsible for the longitudinal capture need no adjustment.
- The beam energy at the end of the capture section changes by ~ 6 MeV due to the difference in the positron energies at the target. In front of the energy collimator this needs to be corrected by the energy feedback system.
- With fixed collimator settings the edge emittance of the beam stays constant. The rms emittance changes by about 3% in the simulation (limited by statistics).

Advantages and Disadvantages of Option 2

- Very stable source operation.

- Tuning of the linac gets more difficult. Might require more time than source tuning for Option 1.
- Stability at very low gradient and deceleration mode needs to be understood.
- Beneficial effects of low gradient operation (lower power consumption, reduced failure rate) are limited to half of the linac.

Advantages and Disadvantages of Option 2

- Upgrade options at lower c. m. energy limited:
  - At low gradient the linac can accelerate a higher beam current or can be operated at higher rep. rate. This opens upgrade options at intermediate energies incase of Option 1.