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Undulator Simulations in CAIN for the HALHF Positron Source

Recap

- Verify simulations regarding photon spectra
- Finding suitable parameters to maximise e^+-yield
- Prospects: collimator & polarization, automated optimization

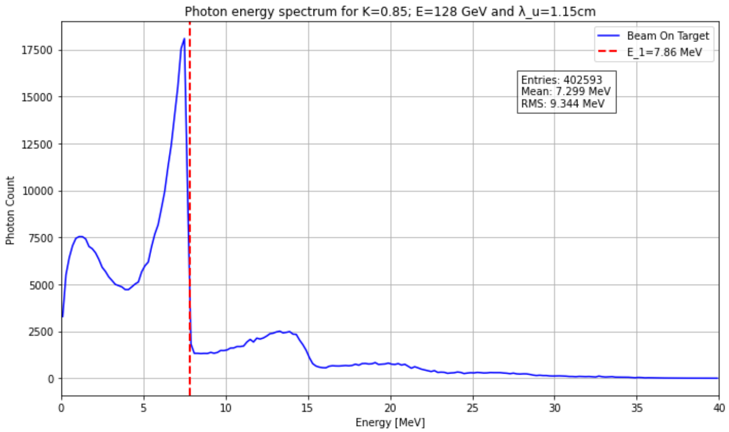

Fig 1: Photon Spectrum from CAIN-Simulations: K=0.85, E=128 GeV, λ_u=1.15cm (ILC)

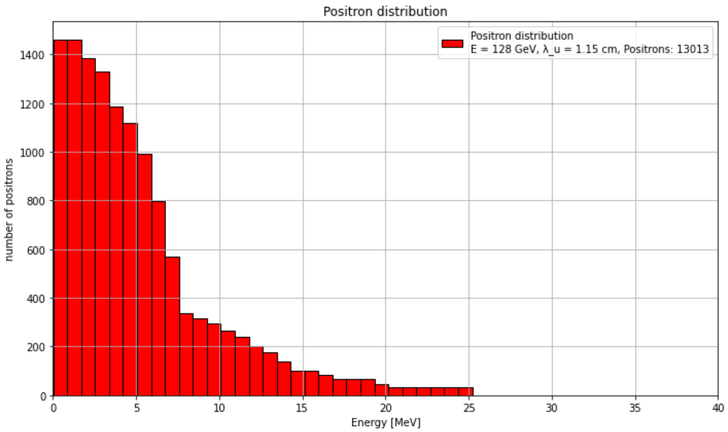

Fig 2: Resulting positron spectrum: K=0.85 E=128 GeV λ_u=1.15cm

Implementation of collimator at K=2.5, λ_u=4.3cm

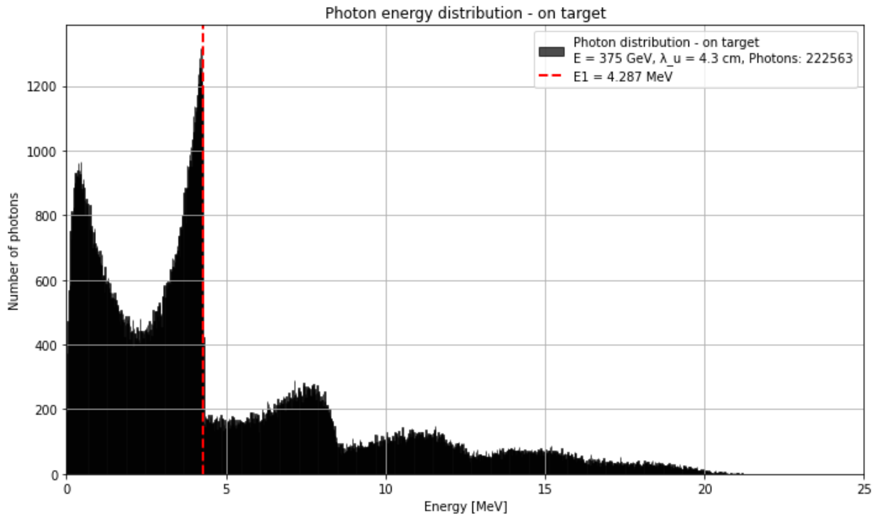

Fig. 3: Photon energy distribution without collimator

#Photons: 222,563

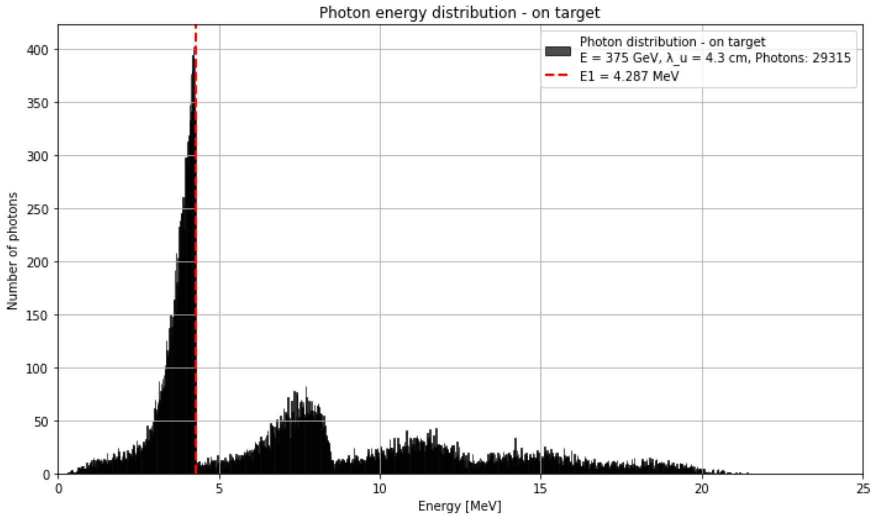

Fig. 4: Photon energy distribution with collimator (R=0.8mm)

#Photons: 29,315

HALHF-Parameters: E=375 GeV, ε_x=90 μm, ε_y=0.32 μm, σ_z= 0.15 mm

Photon target distribution at K=2.5, λ_u=4.3cm

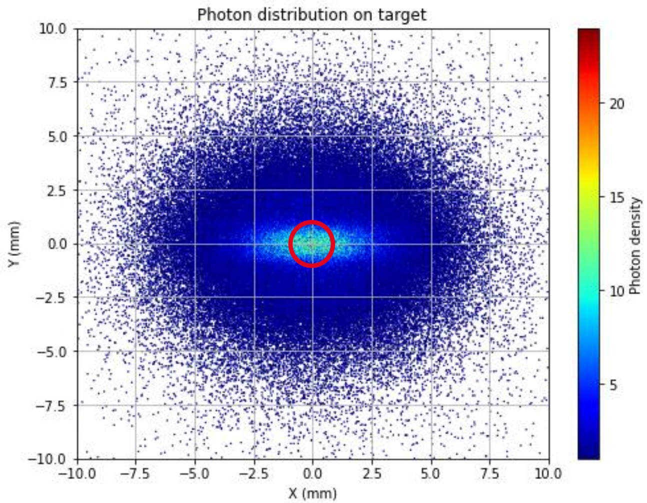

Fig. 5: Photon distribution on target without collimator

#Photons: 222,563

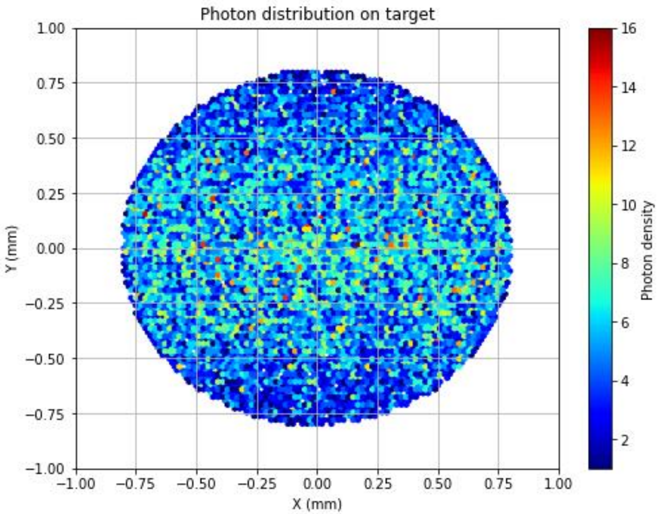

Fig. 6: Photon energy distribution on target with collimator (R=0.8mm)

#Photons: 29,315

HALHF-Parameters: E=375 GeV, ε_x=90 µm, ε_y=0.32 µm, σ_z= 0.15 mm

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Influence of collimator on helicity at K=2.5, λ_u=4.3cm

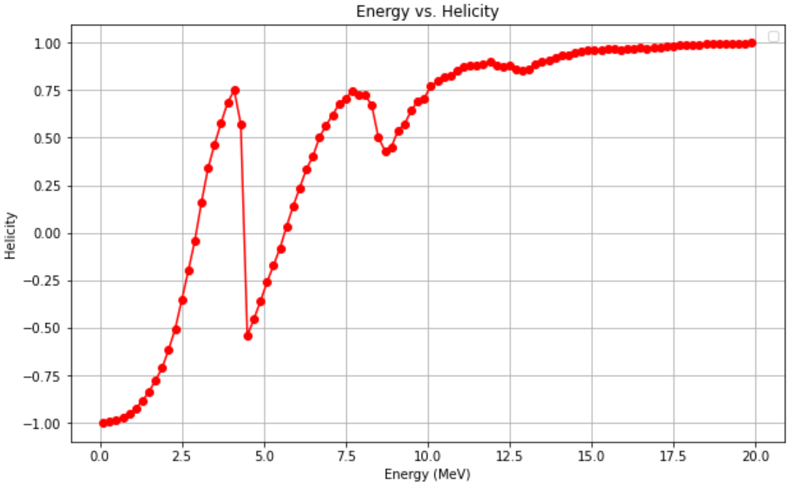


Fig. 7: Photon helicity on target without collimator

Average helicity: 0.030

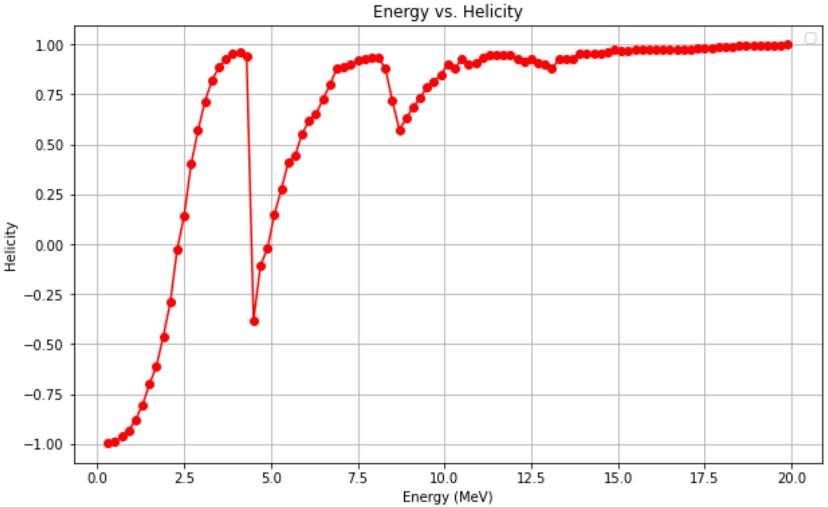


Fig. 8: Photon helicity on target with collimator (R=0.8mm)

Average helicity: 0.816

HALHF-Parameters: E=375 GeV, ε_x=90 μm, ε_y=0.32 μm, σ_z= 0.15 mm

Additional polarization figures K=2.5, λ_u=4.3cm

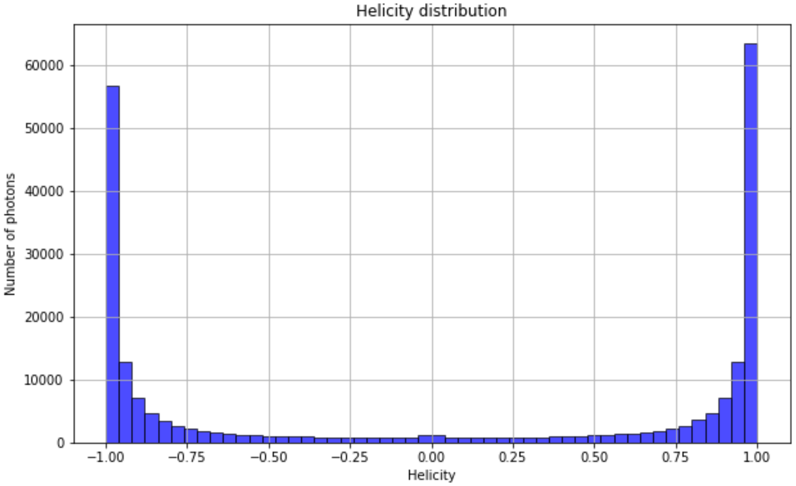


Fig. 13: Helicity distribution without collimator

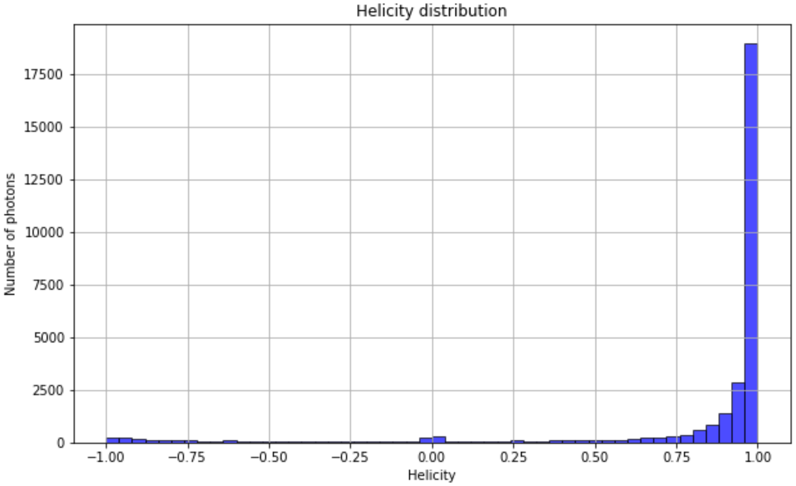


Fig. 14: Helicity distribution with collimator (R=0.8 mm)

HALHF-Parameters: E=375 GeV, ε_x=90 µm, ε_y=0.32 µm, σ_z= 0.15 mm

Automated optimization with optimas documentation (OD)

- Powerfull tool that can run multiple simulations at once
- open source python library
- enabling highly scalable parallel optimization
- OD can optimize on certain parameters while varying others
- usage of DESY Maxwell-Cluster

→ high-performance computing cluster

ILC-simulations with varying undulator parameter K

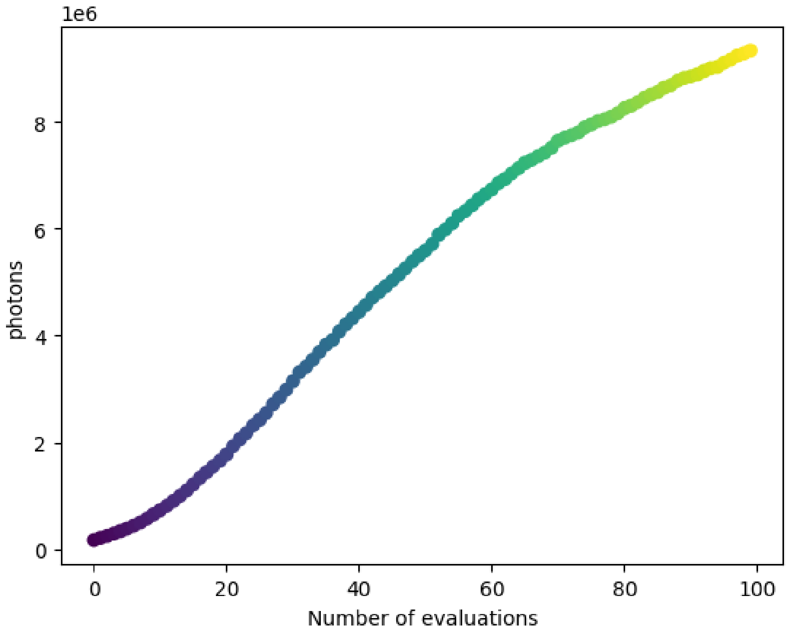
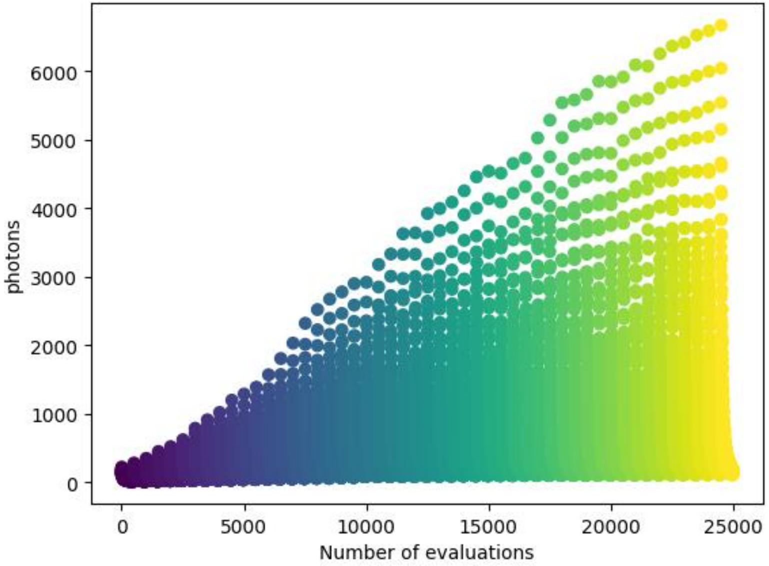


Fig. 9: First run using ILC parameters

- number of photons on target
- E, L, λ_u = constant
- 0.5 < K < 3.0
- 100 simulations in total

Automated simulations with optimas



- 0.5 cm < λ_u <5.0 cm
- 0.5 < K < 3.0
- 137m < L < 231m
- 25.000 simulations in total
- 40 min of computing time

Fig. 10: Second run using HALHF-Parameters

Prospects

- adapting optimization to maximize positron yield and polarization
- minimize length of undulator section
- implementing boundary conditions considering technical limitations
  - magnetic fields
  - thermal stress

➡ reach 1.5 e^+/e^- with collimator and shortest undulator section possible

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References

- M. Fukuda, A Study of Yield calculation for Undulator ILC positron source (2018)
- Andriy Ushakov, Positron Source Simulations for ILC 1 TeV Upgrade (2013)
- Klaus Floettmann, Investigations Toward the Development of Polarized and Unpolarized High Intesity Positron Sources für Linear Colliders (1993)

Additional polarization figures at K=2.5, λ_u=4.3cm

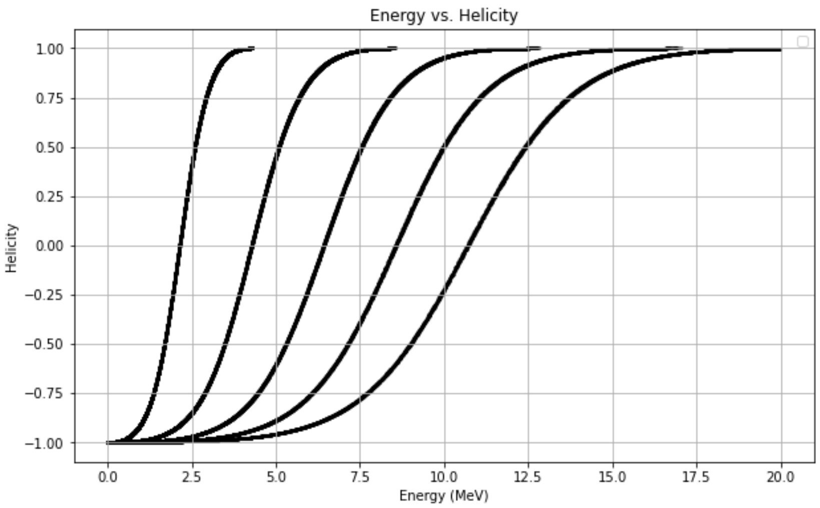

Fig. 11: Energy vs. Helicity without collimator

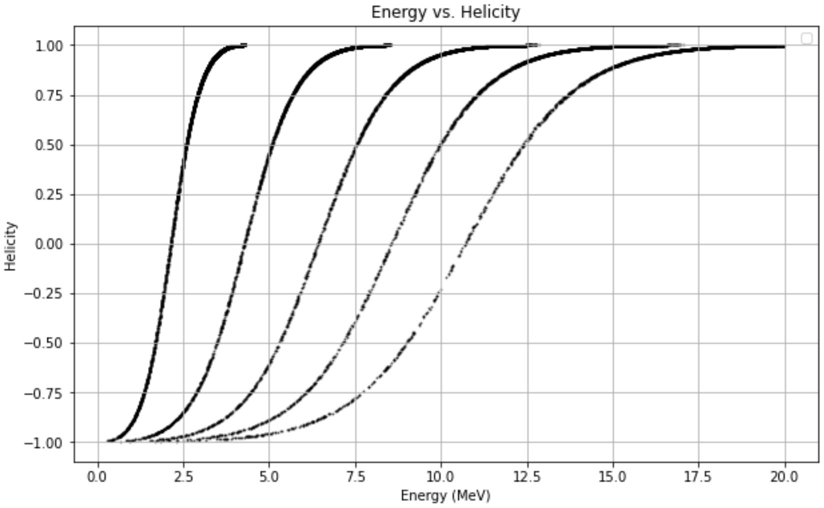

Fig. 12: Energy vs. Helicity with collimator (R=0.8 mm)