

Questions on Collimation and Polarization

Eugene Bulyak

NSC KIPT, Ukraine

Outline

- 1 Introduction
 - Origin
 - Control of Polarization
- 2 Reminder
 - Compton Source of PolPosis
- 3 Undulator Sources
 - Similarity to Compton

Can Collimation Improve Polarization?

at PosiPol 2012

- ...
- Wei Gai: *Positron source optimization* Path toward higher polarizations - **Photon collimators**
- Friedrich Staufienbiel: *Polarization upgrade: A multi stage photon collimator conceptual design for polarization upgrade* has been done at DESY
- ...

Contrast to Compton sources of positrons where collimation has no significant effect on polarization

Control of Polarization

Consider gammas and positrons as composition of two subensembles – **positive** and **negative** (left and right, clockwise and anticlockwise, etc.) instead of the traditional «intensity–polarization» presentation.

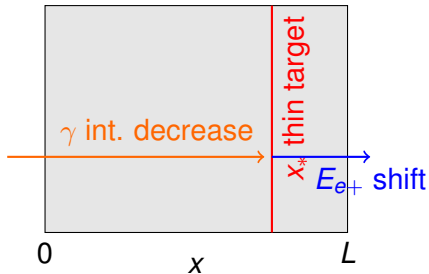
Gammas and positrons are born of both polarization

Two ways of control: preselection and postselection

- Preselection (selection of 'good' gammas) \Rightarrow **collimation**
- Postselection (selection of 'good' positrons) \Rightarrow **acceptance adjustment**
(selection of positrons energies)

Compton Source: Fates of Gammas and Positrons

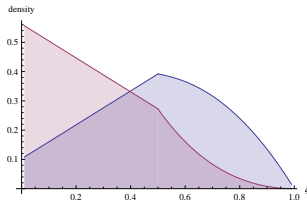
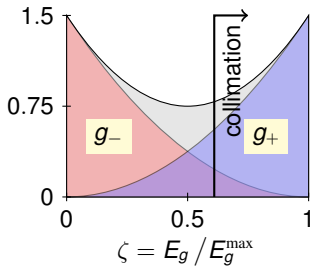
From: E.Bulyak et al. *Optimal Conversion Target*. ALCPG11, Eugene, 03/21/2011



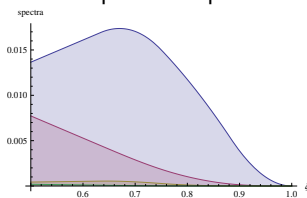
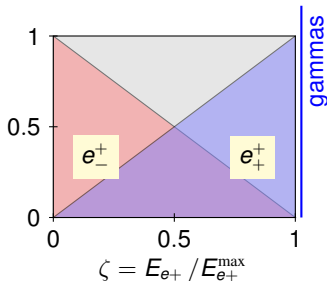
- Balance of gammas
 - $\exp(-\kappa L)$ gammas pass through target
 - $1 - \exp(-\kappa L)$ gammas convert into positron–electron pairs
- Balance of positrons
 - Total production $1 - \exp(-\kappa L)$
 - $(1 + \lambda/\kappa) [1 - \exp(-\kappa L)] - \lambda L$ escape from target
 - Fraction with $E_{ac} \leq E \leq E_{max}$ accepted

For each spectrum of gammas, the target material (κ, λ) , and the threshold accepted positrons energy E_{ac} there exists the optimal target thickness with maximal yield of positrons

Transformation of Laser Photons into Positrons

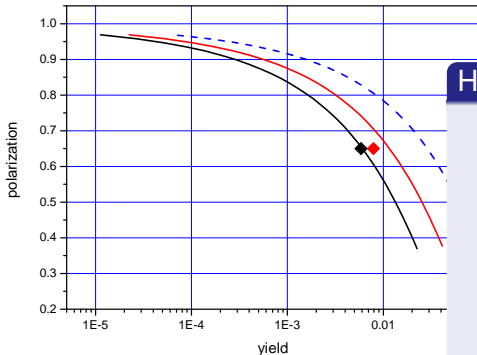


Source spectra for preselection 0.5



Thick-target spectra for preselection 0.75

Maximal yield and polarization



Higher the polarization:

- lower the yield
- higher the quality of positron beam (smaller energy spread, emittance)
- thinner the conversion target, lower the power load

Envelopes for Ti and W targets (optimal thickness)

Diamonds: simulation,
courtesy [A. Schalicke](#), [S. Riemann](#)

Conclusion

Compton Sources, Fundamental Harmonic

- Collimation has no significant effect on positrons polarization
- Preselection low-energy cutoff should match that of postselection:

$$\min E_{\gamma}^{\text{optimal}} \approx \min E_{+} + 0.5 \text{ MeV}$$

- $\min E_{\gamma}$ higher \rightarrow will decrease positrons yield
- $\min E_{\gamma}$ lower \rightarrow will increase power load in target

Equivalence of Thomson and undulator radiation

From: G. Geloni, V. Kocharyan, and E. Saldin *On quantum effects in spontaneous emission by a relativistic electron beam in an undulator*. arXiv://physics/1202.0691v1 (2012)

... the electron recoil related with the quantized nature of photons depends on the entire angular distribution of the radiation, which is fundamentally linked to the Thomson scattering phenomenon in the case for a small undulator parameter $K \ll 1$

....

It is straightforward to underline the well-known equivalence between the previously obtained results and Thomson scattering of radiation. In fact, in the limit for $K^2 \ll 1$ and $N_w \gg 1$ and in the reference system of the electron, the undulator magnetic field is seen as a plane wave interacting with the electron with frequency

$$\omega_R = \gamma c k_w .$$

Issues in Undulator Sources vs. Compton ones

Desirable to be clarified

Why does collimation (preselection) in the undulator-based sources of positrons take effect on polarization?

(Polarization of positrons in Compton sources is insensitive to collimation.)

- Deflection parameter $K \leq 1$: collimation cut off higher harmonics?
- ...

It would be desirable to discuss this issue on our WebEx meetings

Validation of the Model (A. Schalicke, S. Riemann)

Dependence on the target thickness, Ti and W

