Theoretical Description of Target Processes

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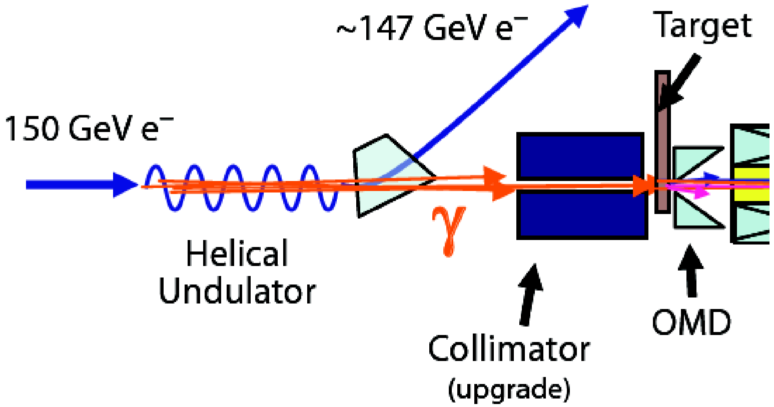
Outline

- Introduction
- Positron creation in target
- Thermal shocks in target
  $\longrightarrow$ Hydrodynamic model
- Outlook: Quasi-classical approximations in source
  $\longrightarrow$ target, undulator, imperfect undulator, . . .

Introduction

- Positron source, e.g. ILC RDR:



- Polarized γ on target $\Rightarrow$ polarized e^+
- Leading production process: e^+e^- pair creation
- Possible problems: thermal shocks in target
- Rotating wheel targets
- Prototype in Daresbury (Ti alloy) $\longrightarrow$ Ian/Leo
- Alternatives: Liquid metals (Bi-Pb, Hg) [e.g. A.A. Mikhailichenko, CBN06-1, 2006]

Positron creation in target

[e.g. A.A. Mikhailichenko, PhD Thesis, 1986 (CBN 02/13, 2002)]
[K. Flöttmann, PhD Thesis, 1993]
[V.N. Baier, V.M. Katkov, Phys. Rept. **409** (2005) 261]

- Leading process: e^+e^- pair creation
- Quasi-classical approximations
- Simulation with e.g. GEANT, FLUKA
  $\longrightarrow$ tested against data
- Program CONVERSION.EXE [A.A. Mikhailichenko]
  - Includes: undulator $\rightarrow$ target $\rightarrow$ lens $\rightarrow$ acceleration
  - Output: efficiencies, effective polarizations
    $\longrightarrow$ hard to test/compare details of processes in target

Thermal shocks in target

- Rapid energy deposition of γ beam $\Rightarrow$ pressure shock wave
- Hydrodynamic model [e.g. A.A. Mikhailichenko, CBN06-1, 2006]

  $\longrightarrow$ Temperature $T = T(\vec{x}, t)$, pressure $P = P(\vec{x}, t)$

  described by hydrodynamical equations
- Simulations at LLNL and Cornell

  [talks at Argonne meeting, Sept. 2007, by T. Piggott and A.A. Mikhailichenko, respectively]
- Cornell simulations
  - FlexPDE
  - Results: *"Ti target not surviving with present margins"*

Thermal shocks in target

Plan: Check hydrodynamic model behind simulations

E.g. for Cornell simulations [A.A. Mikhailichenko, CBN06-1, 2006, talk at Argonne meeting]

- Temperature: $\nabla(k\nabla T) + \dot{Q} = \rho c_V \dot{T}$

  $\dot{Q}(\vec{x}, t)$: density of energy deposition; c_V: heat capacity

- Pressure: $\ddot{P} - \nabla(c_0^2 \nabla P) = \Gamma / V_0 \dot{Q}$

  c_0: speed of sound; $\Gamma = \Gamma(V) = V/c_V (\partial P/\partial T)_V$

- $$\dot{Q} = \sum_j \frac{2cQ_{\text{bunch}}}{\pi\sqrt{\pi}\sigma_z\sigma_\perp^2 l_T} \frac{z}{l_T} \exp\left(-\frac{(z+z_0-c(t-jt_0))^2}{\sigma_z^2}\right) \exp\left(-\frac{r^2}{\sigma_\perp^2}\right)$$

  $\int \dot{Q}(\vec{x}, t) dV dt = Q_{\text{bunch}}$; $\sigma_z, \sigma_\perp$: bunch dimensions; l_T: target thickness

Outlook

Check other quasi-classical approximations in source

- Theoretical description of intensity/polarization
- Processes in target

  $\longrightarrow$ Simulation programs tested against data
- Instead: check approximations in undulator
  - Approximation $\frac{\sin^2 N\pi x}{x^2} \to N\pi^2\delta(x)$ in Eq. (10) for $\frac{dI(\omega)}{d\Omega}$

    in [B.M. Kincaid, J. Appl. Phys. **48** (1977) 2684]
  - Imperfect undulator

    $\Rightarrow$ imperfect e^- beam $\leftrightarrow$ impact on γ beam, polarization

- Comments, suggestions, . . . ?