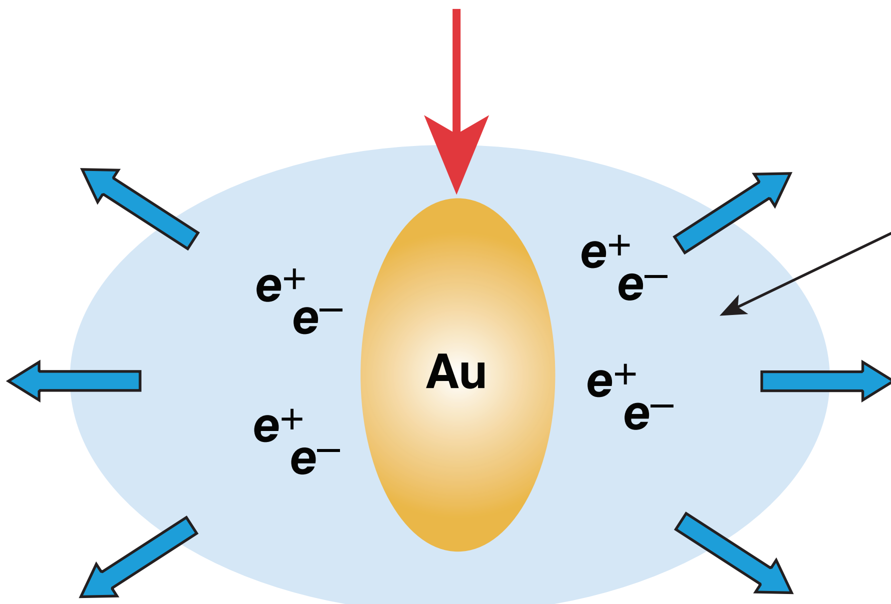
Design of a Positron–Electron Pair-Plasma Production Experiment on OMEGA EP



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Summary

Positron–electron pair creation will be significant on OMEGA EP, possibly generating a relativistic pair plasma

- The energy spectrum of pairs has been computed as a function of laser intensity
- Pair yields have been optimized
- Of the order of 10^{12} positrons can be made on OMEGA EP, assuming a total laser energy of 2.5 kJ
- High pair density is required for plasma creation
  - laser energy is more important than extreme intensity
- External magnetic fields can increase the pair density
- Pair-plasma is detectable by optical probing

Collaborators

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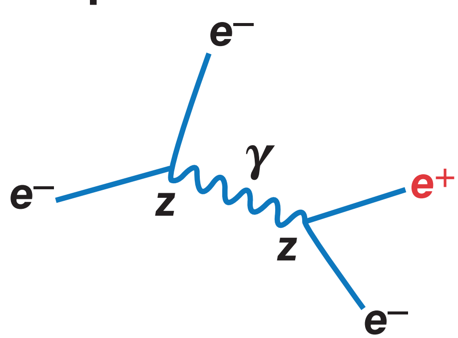
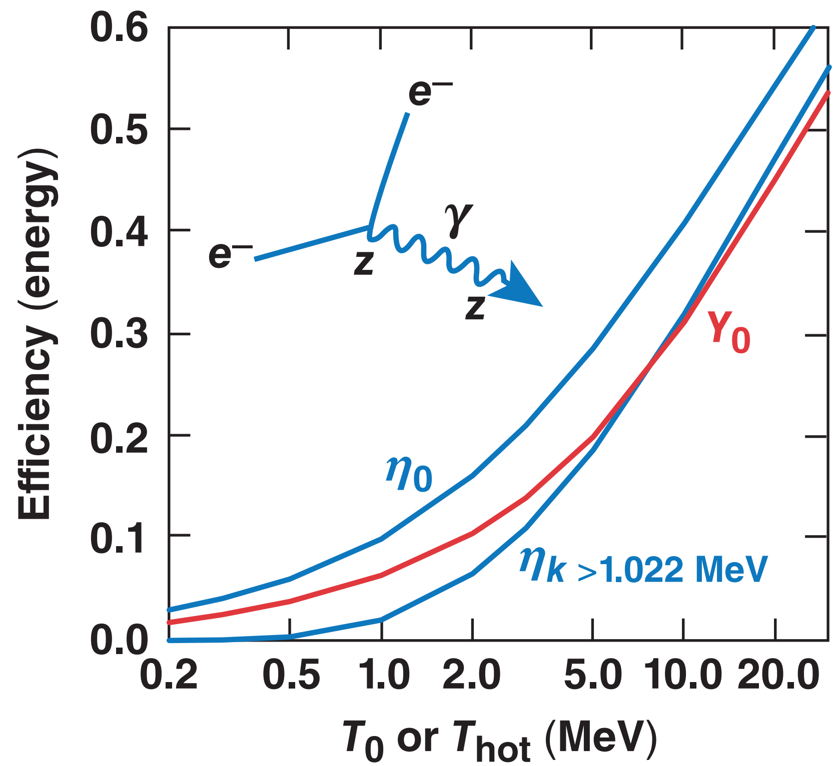
The conversion of high-energy bremsstrahlung (Bethe–Heitler process) is the dominant process for pair creation

- Trident <10% of B–H
- Two steps: first bremsstrahlung, then pair production



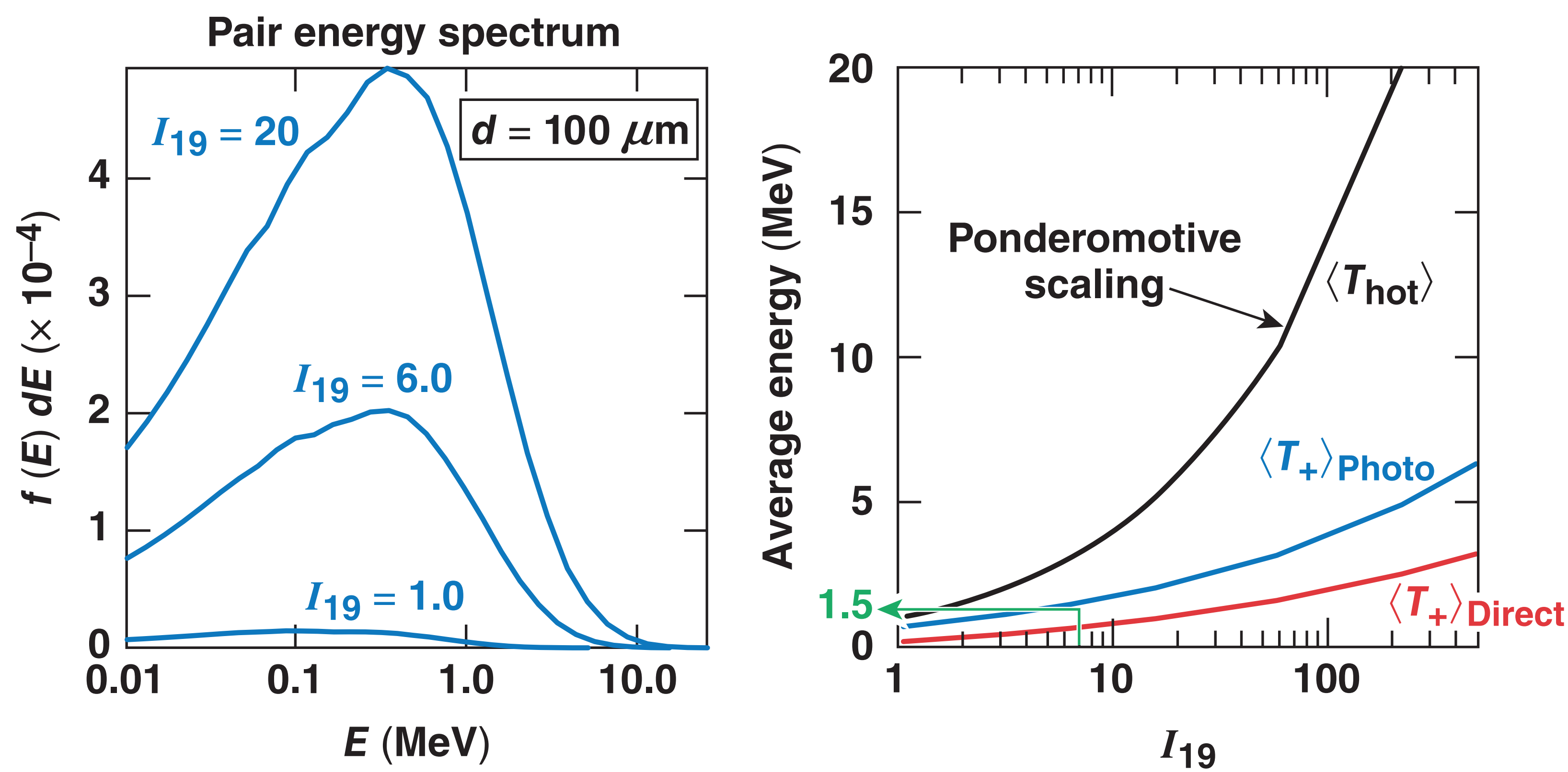
- Conversion into x rays can be very efficient of high-Z materials
- Gold (Z = 79) is a good choice
- Exponential energy spectrum for hot electrons (T_{hot})

X-ray-conversion efficiencies with refluxing hot electrons



The energy spectrum of the pairs has been computed as a function of laser intensity

- Spectrum insensitive to target geometry
- Knowledge of spectrum allows optimization of target thickness
- Useful for future computations of pair expansion



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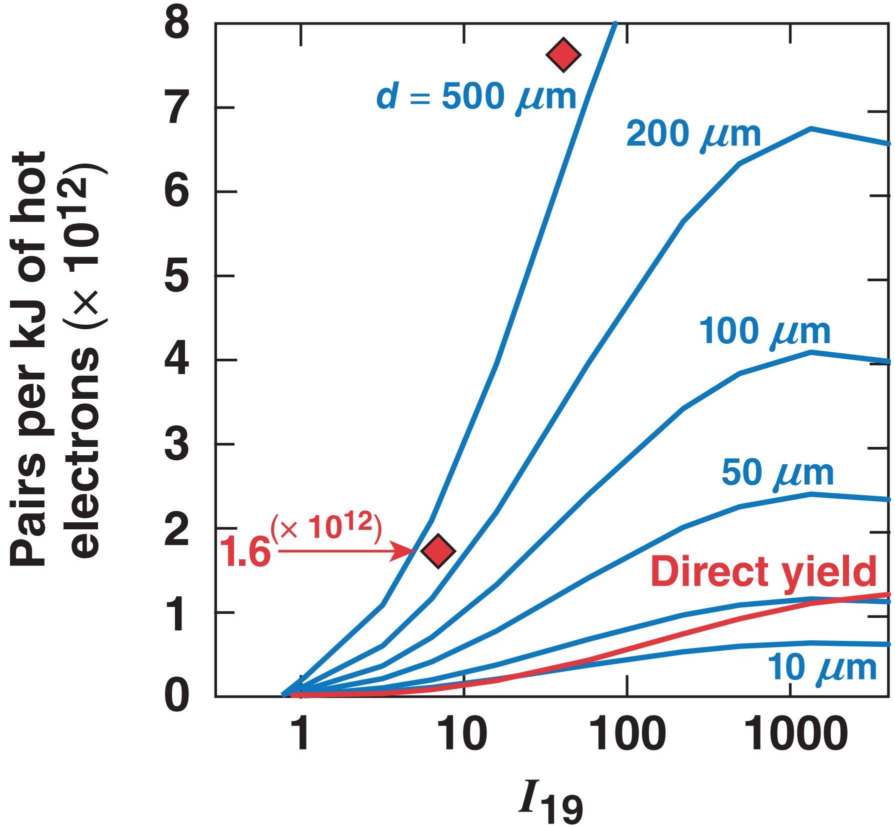
The target can be optimized for a given laser intensity to maximize the photo-production of pairs

UR LLE

- Linear attenuation length μ is of the order of $1/\mu \sim 1$ cm
- Pair production is a substantial contribution to μ
- Make target as thick as possible
- Pairs have to escape
- Range for 1 (2) MeV $e^{\pm}$ is 400 (840) μm
- Multiple scattering important

$1/\mu > r_{0+}(E_{\pm}) > d$

(Homogeneous and isotropic x-rays)



TC8009

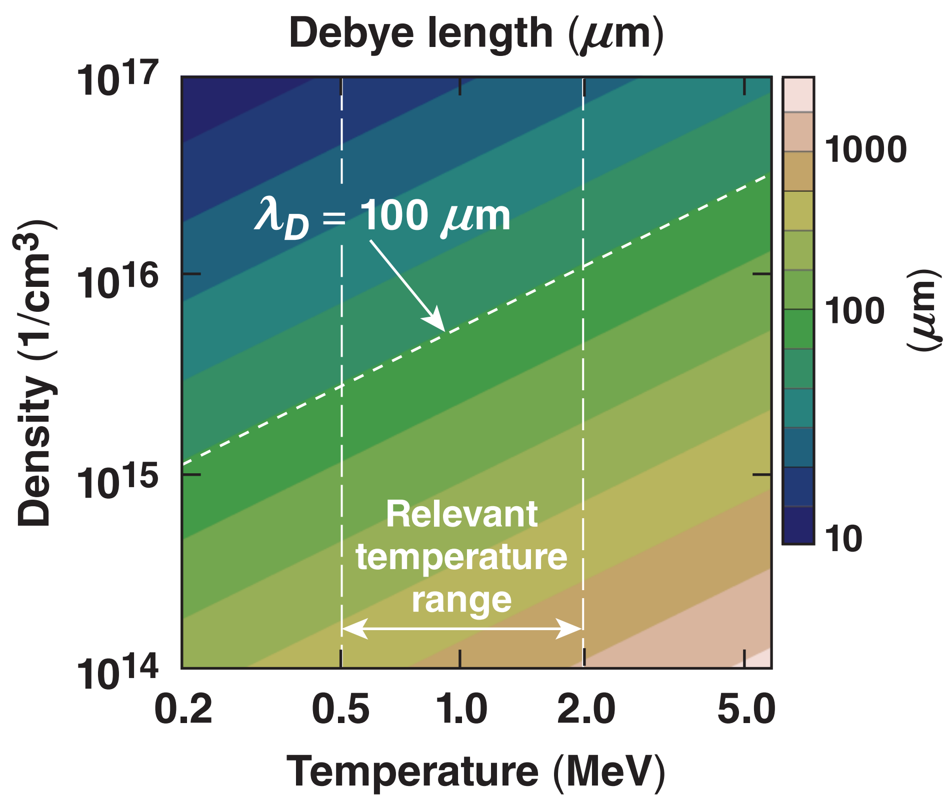
The positron–electron plasma density may not be high enough if the pairs are allowed to expand freely

UR LLE

- The goal is to optimize pair density and not just the total number
- Spherical expansion
- Production rate is important

$$L_n/\lambda_D = 1.6\frac{\left(N_+/10^{12}\right)^{1/2}(E/1\ \text{kJ})^{1/2}}{(\tau^*/1\ \text{ps})^{1/2}\ (\Theta/1\ \text{MeV})^{1/2}}$$

- Laser intensities of ~5×10^{19} W/cm^2 are sufficient
- Rate is not increased by going to higher laser intensities (total energy)
- Higher laser intensities give hotter pairs



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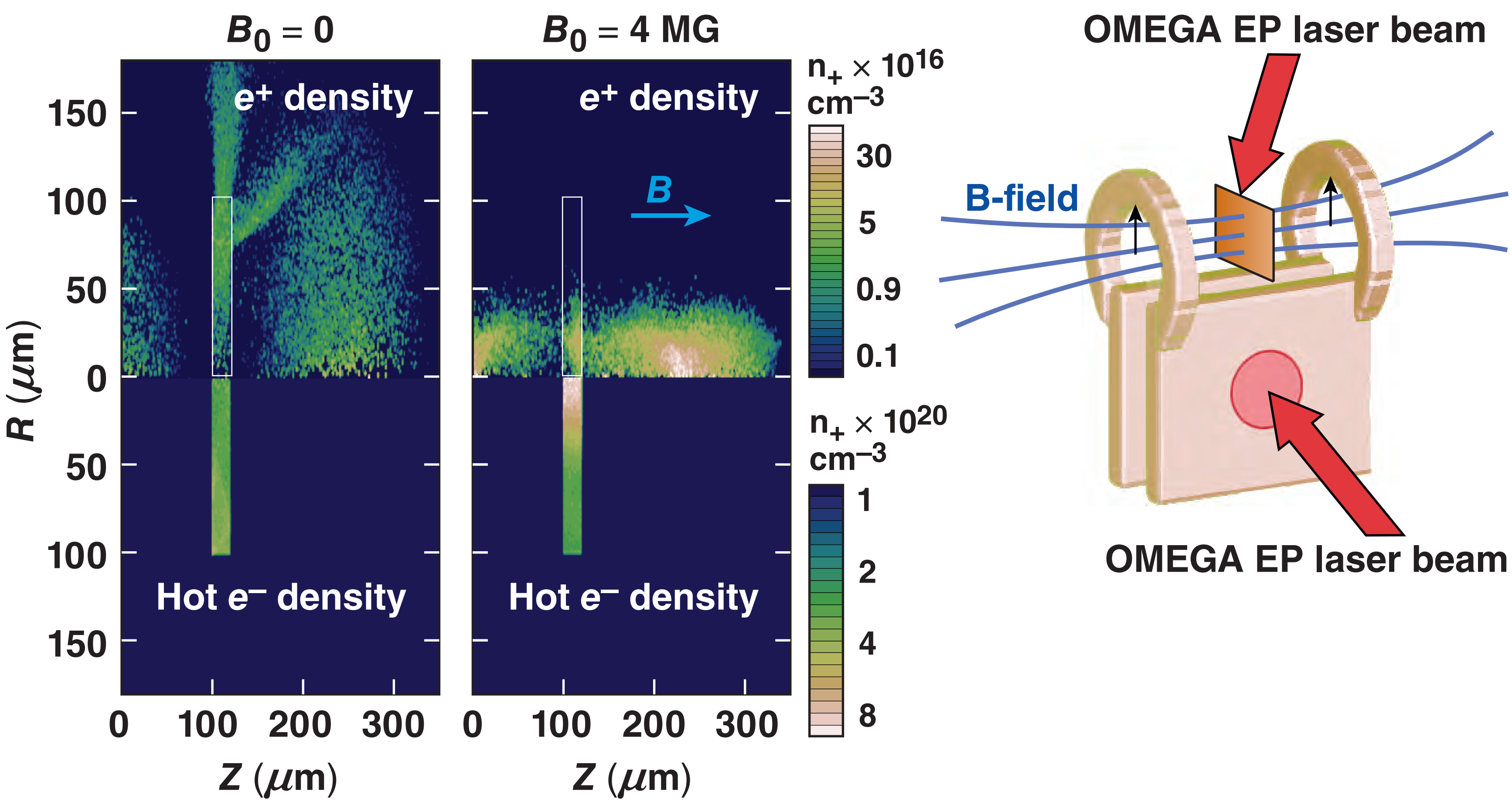
Externally applied magnetic fields can be used to increase the pair density

- The pairs are emitted in a jet along the direction of the imposed field.

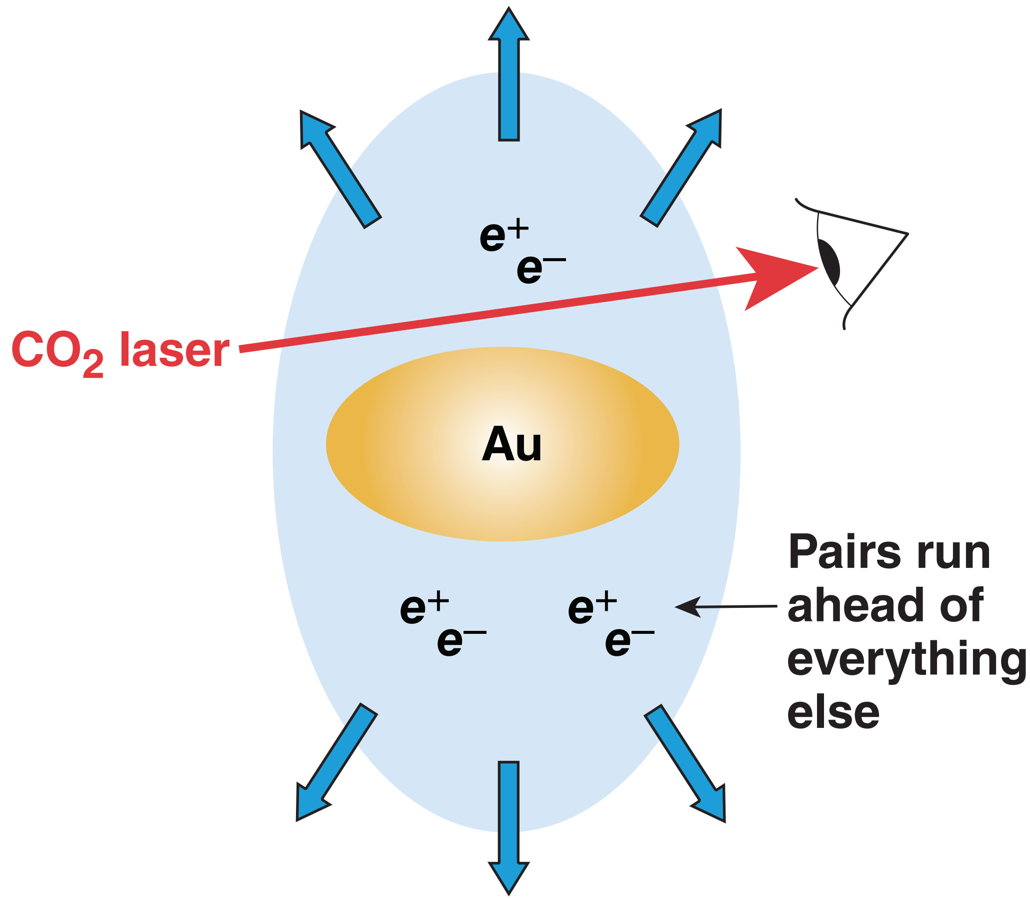


TC8011

D. Welch *et al.*, Nucl. Instrum. Methods Phys. Res. A 464, 134 (2001).

The pair plasma can be diagnosed with a short-pulse infrared laser

- Optical probing
  - short laser pulse to avoid “normal” plasma and ions
  - 1-ps, 10-μm, CO_2 laser
  - phase shift of 0.1% to 1% of λ_0 for a density of 10^{16} cm^{-3}
  - this shift is detectable
  - such a diagnostic will be added to future *LSP* calculations



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