



University of Colorado  
Denver

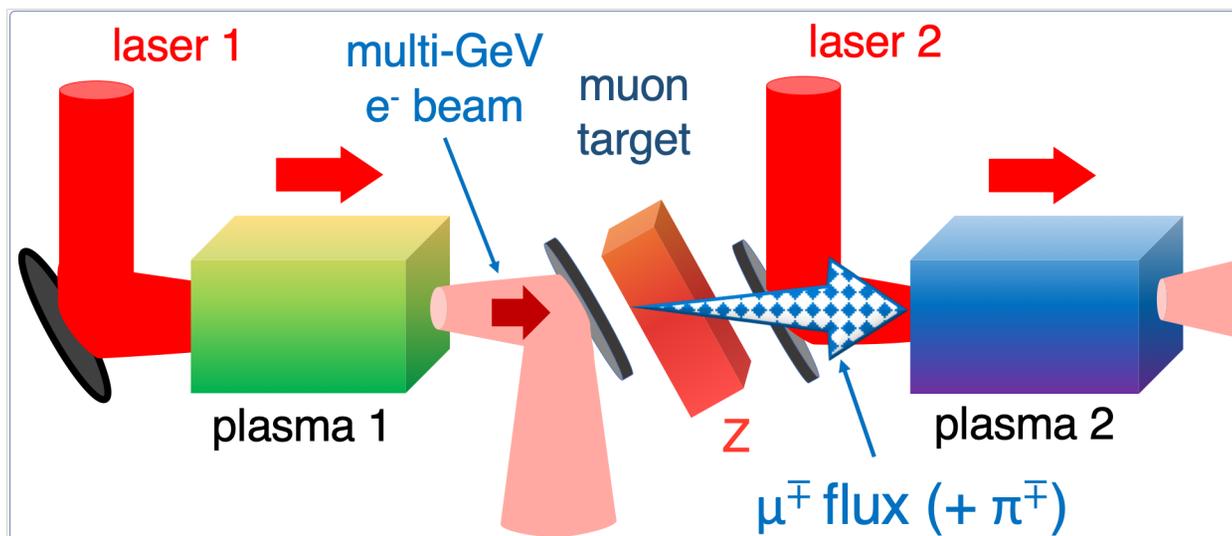


**Laser muon acceleration:  
ultra-short, micron-scale muon beam  
parameters and possibilities**

Aakash Sahai  
V. Shiltsev  
T. Tajima

[aakash.sahai@gmail.com](mailto:aakash.sahai@gmail.com)

# muon-pair photo-production Trapping & acc in plasma wave



PHYSICAL REVIEW ACCELERATORS AND BEAMS **21**, 081301 (2018)

**Quasimonoenergetic laser plasma positron accelerator  
using particle-shower plasma-wave interactions**

Aakash A. Sahai\*

*Department of Physics and John Adams Institute for Accelerator Science, Blackett Laboratory,  
Imperial College London, SW7 2AZ, United Kingdom*

## muon-pair photo-production



(R.1) photo-meson reaction:

$$\gamma + p \rightarrow \pi^+ + n$$

$$\gamma + n \rightarrow \pi^- + p$$

$$\gamma + Z_1 \rightarrow \pi^\square + Z_2, \text{ and}$$

(R.2) Bethe-Heitler muon pair-production reaction:

$$\gamma + Z \rightarrow \mu^+ \mu^- + Z$$

$$\varepsilon_\gamma \gg 2m_\mu c^2$$

$$\varepsilon_\gamma \sim E_{e^\pm} \gtrsim 3 \text{ GeV (for validity of below BH cross-section)}$$

$$\sigma_{\gamma Z_1 \rightarrow \mu^+ \mu^- Z_2} \simeq \frac{28}{9} Z^2 \alpha r_0^\mu{}^2 \left( \ln \frac{2\varepsilon_\gamma}{m_\mu c^2} - \frac{109}{42} \right)$$

$$\sigma_{\gamma Z_1 \rightarrow \mu^+ \mu^- Z_2} \simeq 10^{-31} m^{-2} = 0.5 \text{ milli-barn } (\varepsilon_\gamma \sim 200 \text{ MeV}, Z \sim 79)$$

## muon-pair photo-production - II



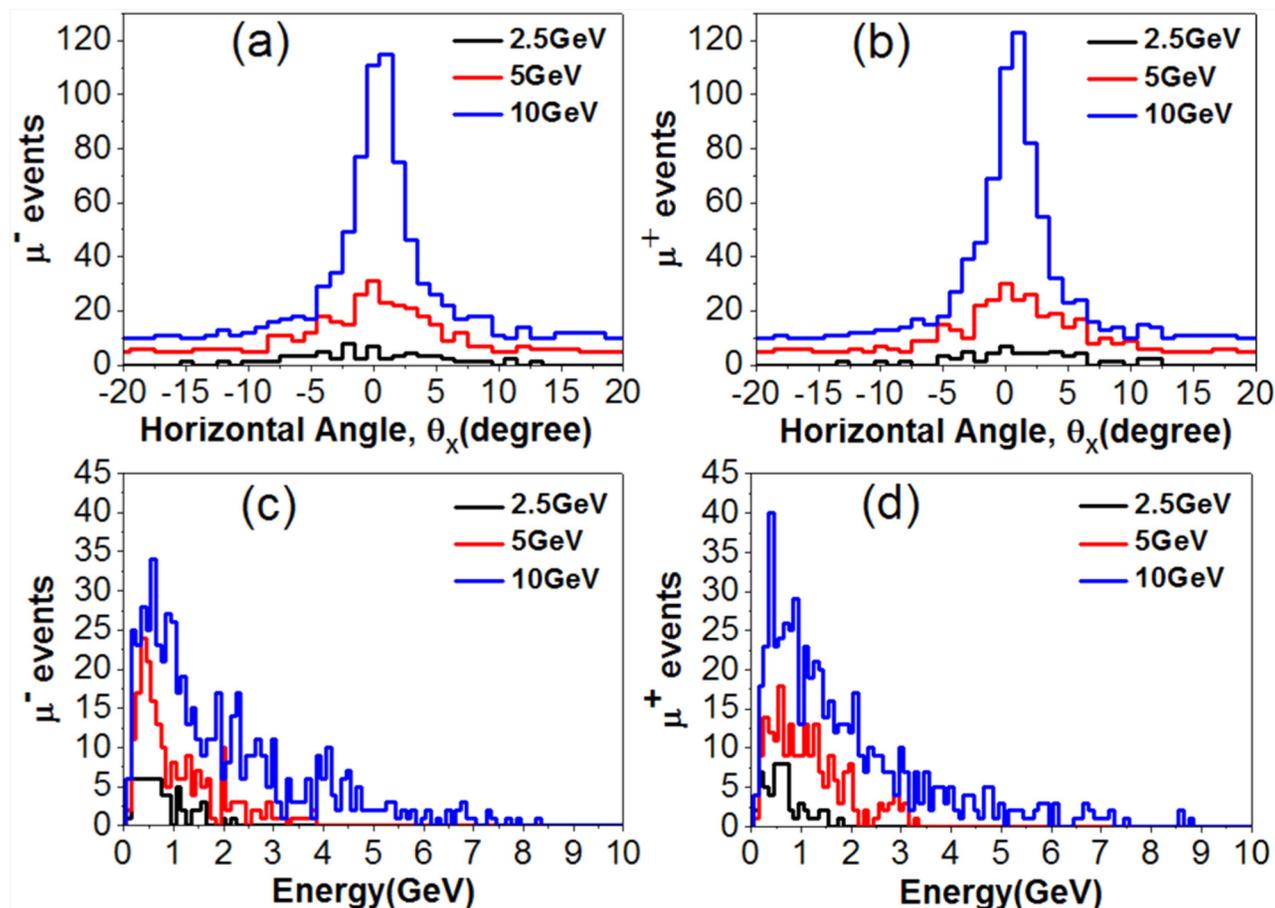
$$\mathcal{R}_{\gamma Z_1 \rightarrow \mu^+ \mu^- Z_2} \equiv \frac{dN_{\mu^\pm}}{dt} = \mathcal{L} \times \sigma_{\gamma Z_1 \rightarrow \mu^+ \mu^- Z_2}$$

$$\mathcal{L} = \frac{N_{\text{beam}}}{\sigma_{z\text{-beam}}/c} n_{\text{target}} T_{\text{target}}$$

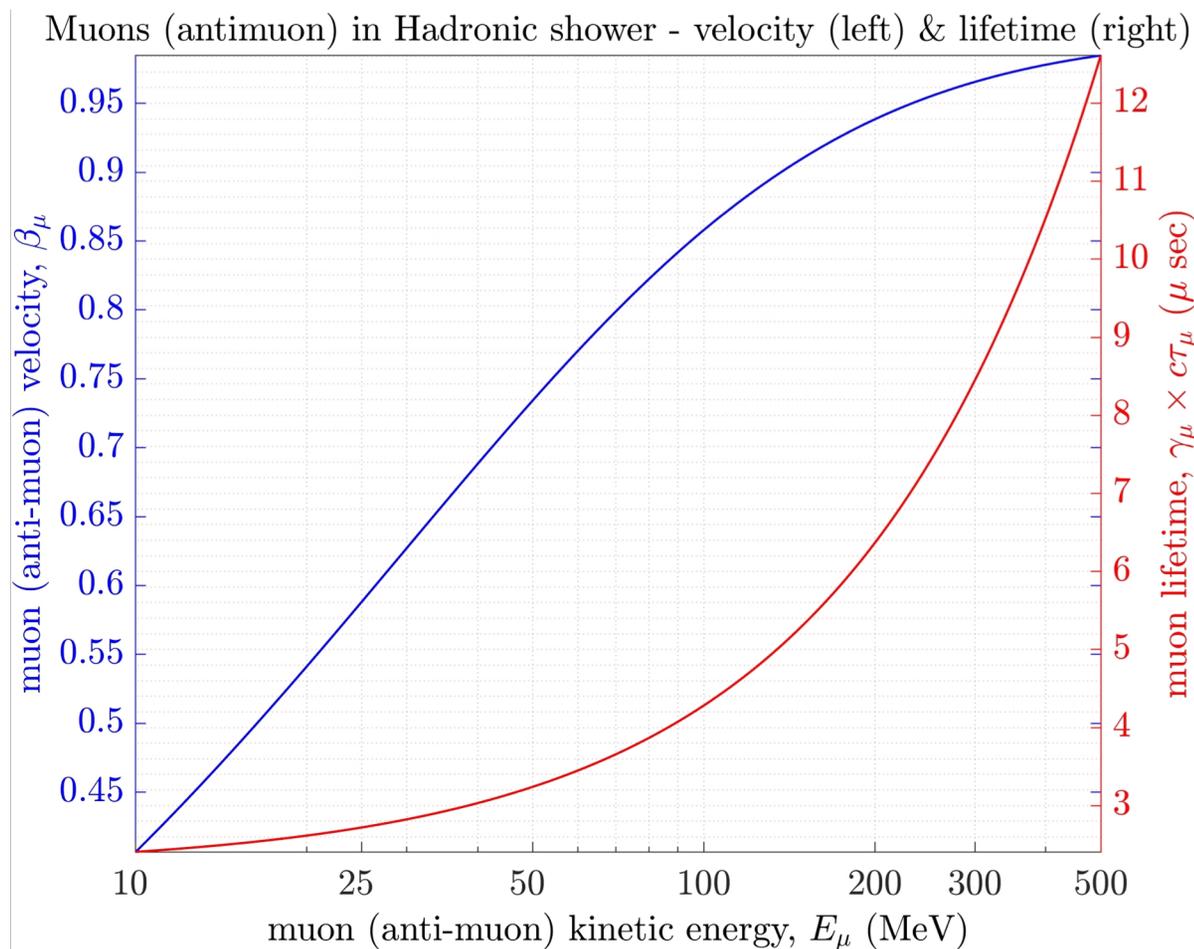
$$\mathcal{R}_{\gamma Z_1 \rightarrow \mu^+ \mu^- Z_2} \text{ (in 50fs)} = \frac{1\text{nC}}{e} 5.9 \times 10^{28} \text{m}^{-3} 1\text{cm} 0.5 \text{ milli-barn}$$

$$\mathcal{R}_{\gamma Z_1 \rightarrow \mu^+ \mu^- Z_2} \text{ (in 50fs)} \simeq 10^5 \text{ pairs (1nC, 50fs, } \sigma_r \sim 20\mu\text{m)}$$

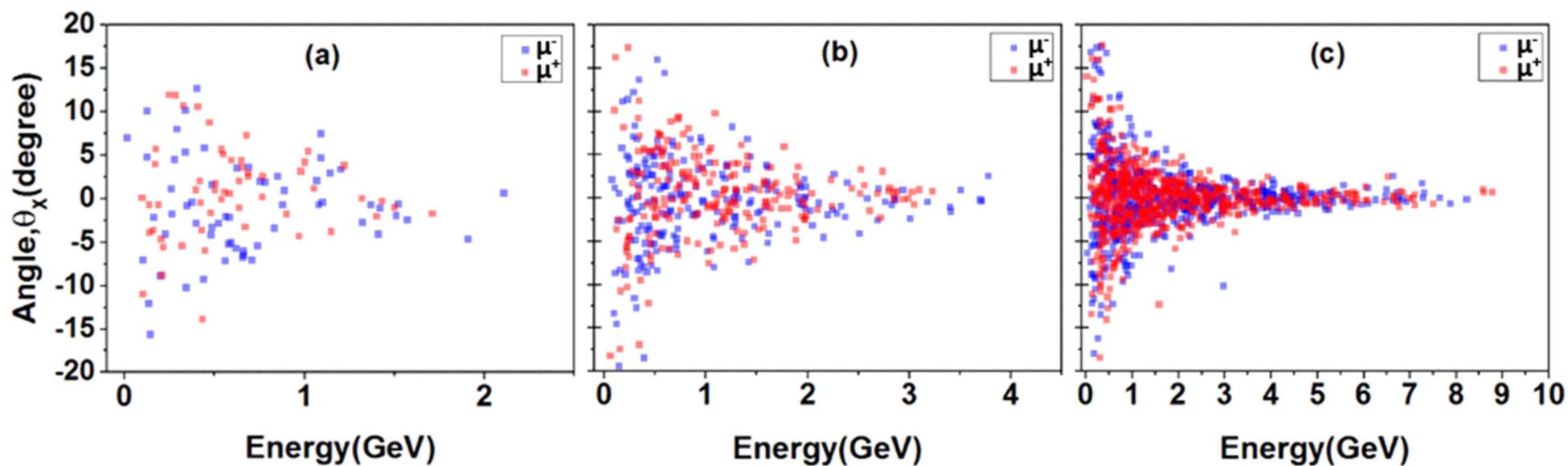
# $\mu$ -pair photo-production – Geant 4



## $\mu$ -pair photo-production – Geant 4 - II



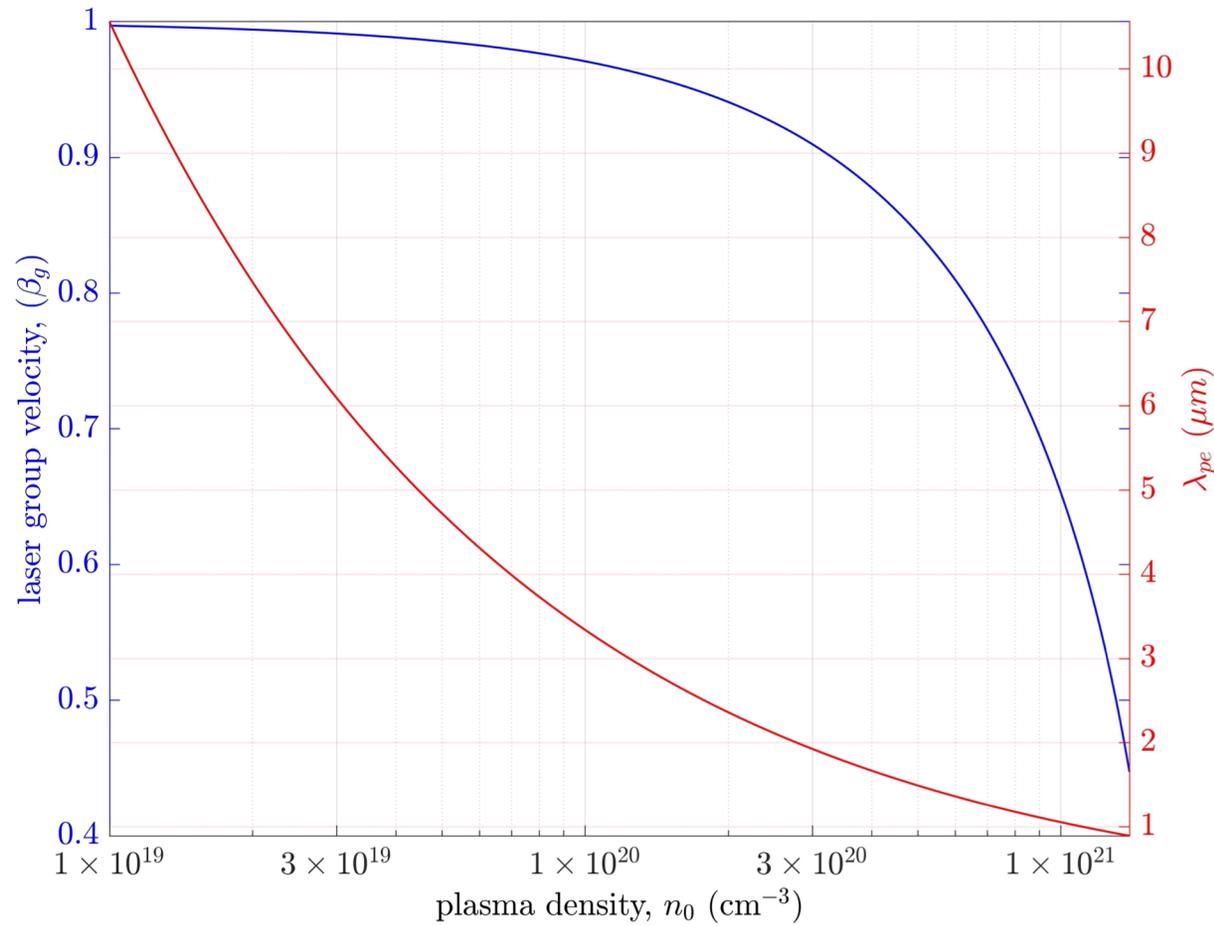
# $\mu$ -pair photo-production – Geant 4 - III



# $\mu$ -pair photo-production – trapping & acc

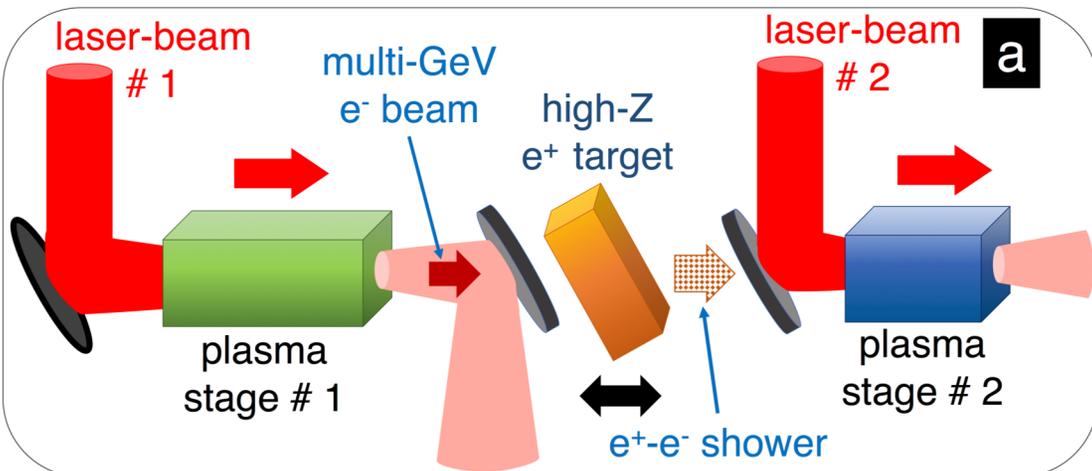


laser group velocity,  $(\beta_g)$  (left) & plasma wavelength,  $\lambda_{pe}$  (right) vs. plasma density,  $n_0$

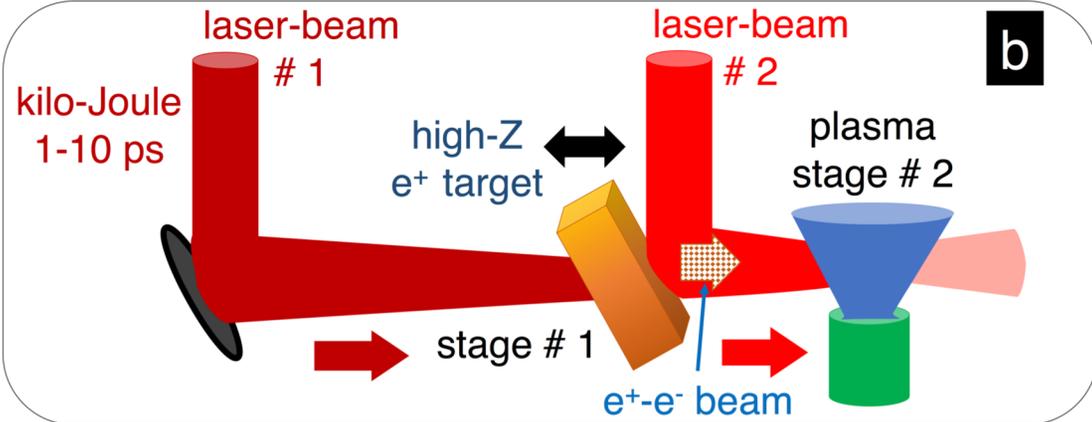


# Schematics – plasma $e^+$ accelerator

scheme A



scheme B



# $e^+$ -LPA - PIC-based beam phase-space

