High brightness injectors based on PWFA

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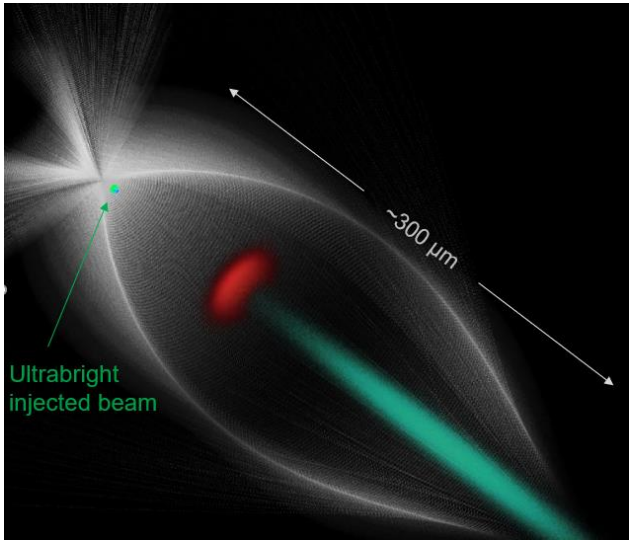
Plasma photocathode wakefield accelerator

Hidding *et al.*, *PRL 108*, 035001 (2012)
Manahan *et al.*, *Nat. Comm.* 8, 15705 (2017)
Deng *et al.*, *Nat Phys.* 8, 1156-1160 (2019)



- Laser-generated electron beams directly inside PWFA
- nm-level emittance & kA currents
- Laser controls beam properties
- Brightness transformer:

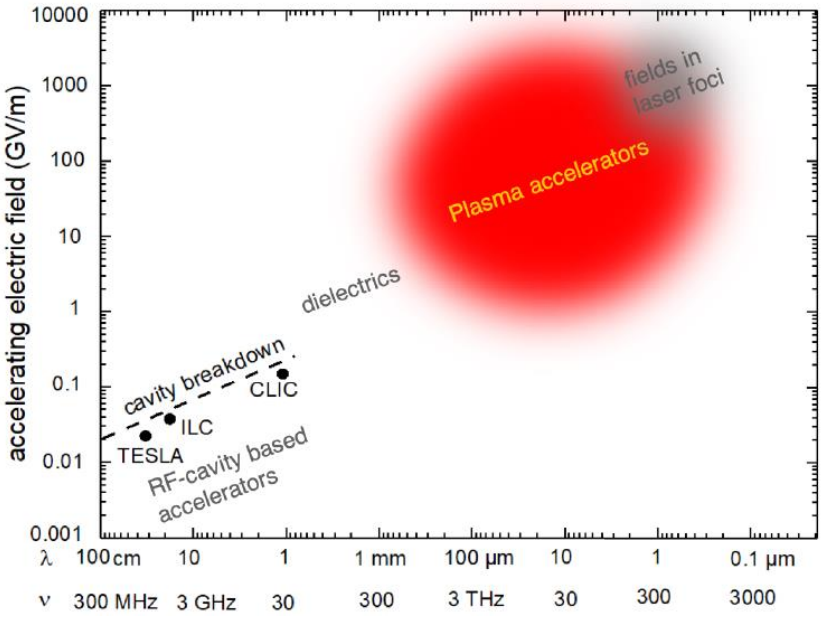
multi-kA current

$$B_{6D} = \frac{I}{\epsilon_n^2 \cdot 0.1\% \sigma_W}$$

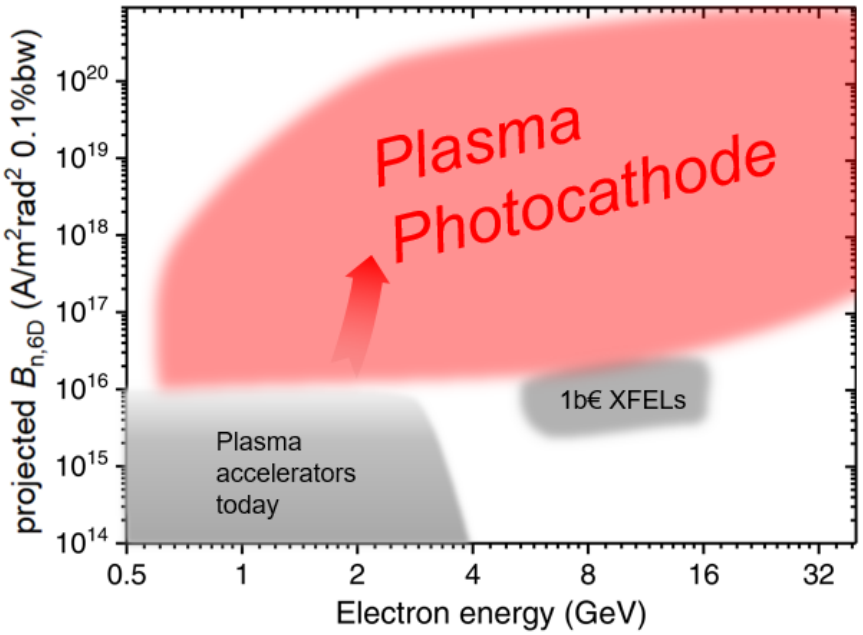
nm rad emittance; energy spread <0.01%

$$\mathcal{L} = f \frac{N^2}{(4\pi \sigma_x \sigma_y)}$$

Plasma acceleration: 1000x stronger



Plasma photocatode: 10000x brighter



Plasma photocathode wakefield accelerator

1. Probe low-emittance collider building blocks
   - ❑ Litmus test for emittance growth
   - ❑ Probe extraction & staging between plasma modules (~100 – 1000 required for TeV)

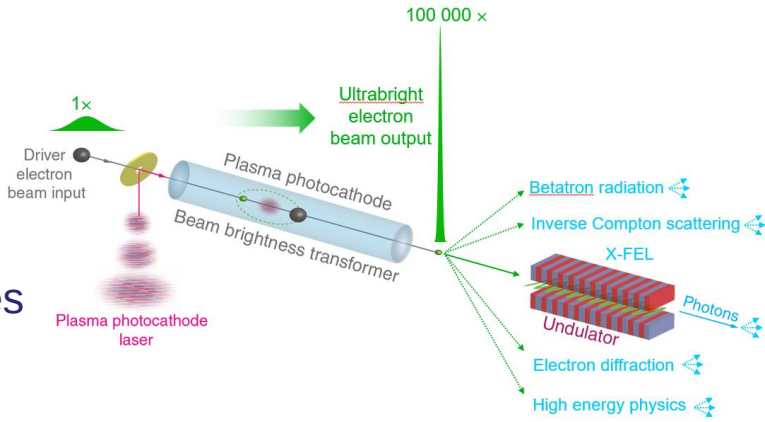
2. Injectors in conventional colliders
   - ❑ Generate long, ultralow-emittance high-charge beams
   - ❑ Tailor beam profiles via multiple lasers, generate multiple beams

$$\mathcal{L} = f \frac{N^2}{(4\,\pi\,\sigma_x \sigma_y)}$$

3. Spin-polarized electron beams
   - ❑ Polarized laser or electron source

4. Exploit extreme beam compression & currents
   - ❑ E.g. for strong-field QED

5. Novel brilliant x-ray and γ-ray beams
   - ❑ Light source and collider have strong R&D synergies
   - ❑ Particle and photon colliders



6. Synergies with plasma lens & plasma-based diagnostics

Novel ecosystem fully based on plasma- and laser-based building blocks required and under R&D for plasma-based collider and HEP applications