Science Opportunities with Positrons at FACET-II

Spencer Gessner, SLAC

FACET Science Workshop
October 19, 2023
Plasma Linear Colliders

Challenge for our field: How do we accelerate positron bunches in plasma?
Positron PWFA experimental research has been conducted at SLAC, utilizing pre-existing SLC infrastructure.

S. Gessner et al., Nat. Comm. 7 11785 (2016).

*E333 experiment planned for filament regime positron PWFA. Plus many new ideas!
At FACET, we made an exciting and unexpected observation:

**Monoenergetic acceleration of self-loaded positron bunches**

The FACET results inspired the development of novel concepts for accelerating positrons in plasma.
FACET Sparked New Ideas in Positron PWFA Research

Novel concepts on electron beam-driven acceleration of positrons in plasma:

Positron Acceleration in Plasma Wakefields

G.J. Cao, C.A. Lindström, E. Adli, S. Corde, S. Gessner

Plasma acceleration has emerged as a promising technology for future particle accelerators, particularly linear colliders. Significant progress has been made in recent decades toward high-efficiency and high-quality acceleration of electrons in plasmas. However, this progress does not generalize to acceleration of positrons, as plasmas are inherently charge asymmetric. Here, we present a comprehensive review of historical and current efforts to accelerate positrons using plasma wakefields. Proposed schemes that aim to increase the energy efficiency and beam quality are summarised and quantitatively compared. A dimensionless metric that scales with the luminosity-per-beam power is introduced, indicating that positron-acceleration schemes are currently below the ultimate requirement for colliders. The primary issue is electron motion; the high mobility of plasma electrons compared to plasma ions, which leads to non-uniform accelerating and focusing fields that degrade the beam quality of the positron bunch, particularly for high efficiency acceleration. Finally, we discuss possible mitigation strategies and directions for future research.

Gevy Cao will cover all of those topics and more!
Repairs on the positron source vacuum system are underway (see talk by C. Hast).

The next step is to install a compact positron damping ring in S10. We have a prototype for one of the magnets.

Lastly, we will reconfigure the S20 to chicane to allow for simultaneous delivery of electron and positron beams.
## Agenda

<table>
<thead>
<tr>
<th>Start Time (PST)</th>
<th>Duration</th>
<th>Title</th>
<th>Name</th>
<th>Affiliation</th>
</tr>
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<tbody>
<tr>
<td>9:00 AM</td>
<td>45m</td>
<td>Positron beam loading in uniform regime</td>
<td>Shiyu Zhou</td>
<td>Tsinghua</td>
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<tr>
<td>9:45 AM</td>
<td>45m</td>
<td>Plasma Temperature Effects in Positron PWFA</td>
<td>Severin Diederichs</td>
<td>DESY</td>
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<tr>
<td>10:30 AM</td>
<td>30m</td>
<td>Coffee Break</td>
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<tr>
<td>11:00 AM</td>
<td>30m</td>
<td>Energy recover in positron PWFA wake</td>
<td>Max Varverakis</td>
<td>Cal Poly</td>
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<tr>
<td>11:30 AM</td>
<td>60m</td>
<td>Positron PWFA review and scaling laws</td>
<td>Gevy Cao and Carl Lindstrom</td>
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<tr>
<td>12:30 PM</td>
<td>30m</td>
<td>Lunch</td>
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<tr>
<td>1:00 PM</td>
<td>30m</td>
<td>Beam-based laboratory astrophysics</td>
<td>Gianluca Gregori</td>
<td>Oxford</td>
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<tr>
<td>1:30 PM</td>
<td>20m</td>
<td>Electron trapping in positron driven wakefields</td>
<td>James Allen</td>
<td>SLAC/Stanford</td>
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<td>1:50 PM</td>
<td>10m</td>
<td>Discussion</td>
<td>Mark Hogan</td>
<td>SLAC</td>
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<td>2:00 PM</td>
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<td>Adjourn</td>
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