# Positron Beam Sources for Plasma Acceleration Experiments

Working Group 8

ALEGRO Workshop, Oxford
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# Charge for this Session

Our goal is to examine the various techniques for generating positron beams for plasma acceleration. We are interested in *near-term* solutions applicable to a PWFA/LWFA research facility, and *long-term* solutions applicable to a linear collider.

At the end of the session, we will compare and contrast the various approaches in tabular form.

# Topics

We discussed 5 topics on positron generation for PWFA/LWFA experiments at the ALEGRO mini-workshop on positron acceleration in plasma on February 9th:

1. Positrons generated from a high intensity proton beam for the AWAKE experiment.
2. Positrons generated from a high intensity electron beam for FACET-II.
3. “In-situ” positron generation.
4. Positron beams from electro-static traps.
5. Positron beams from a high-power laser.

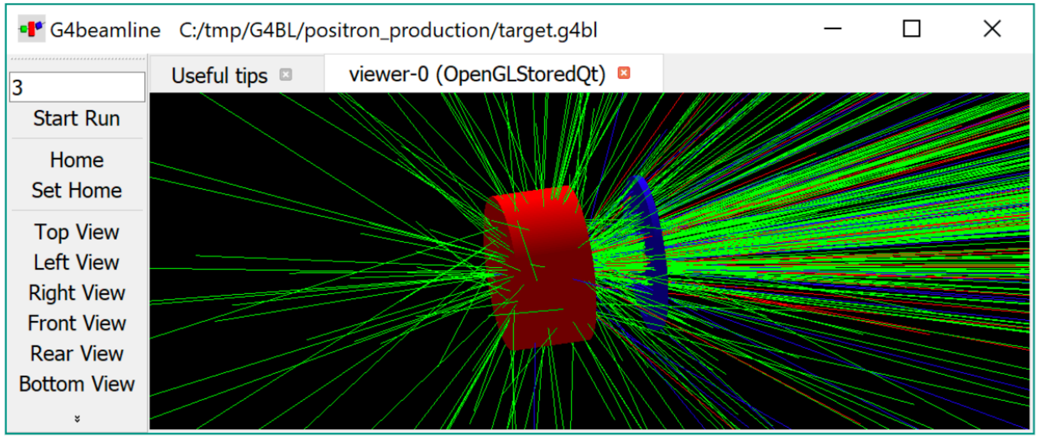
# Positron generation for AWAKE

AWAKE uses a 400 GeV proton beam to drive the plasma wakefield.

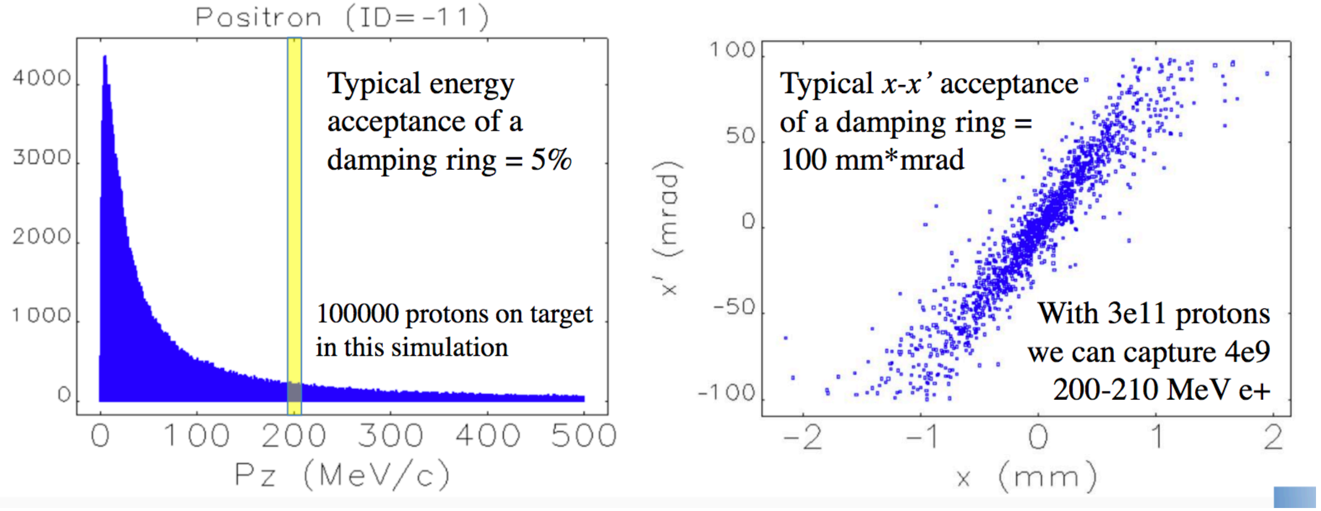
After the beam propagates through the plasma, there is still a lot of energy in the beam. Can we use the "spent" beam to create positrons?

A short study shows that yes, there should be enough positrons generated that can be captured, damped, and reaccelerated.

**G4beamline simulation of 400 GeV p-beam hitting 1 cm long W target:**




Mainly gamma-photons




A. Petrenko, CERN

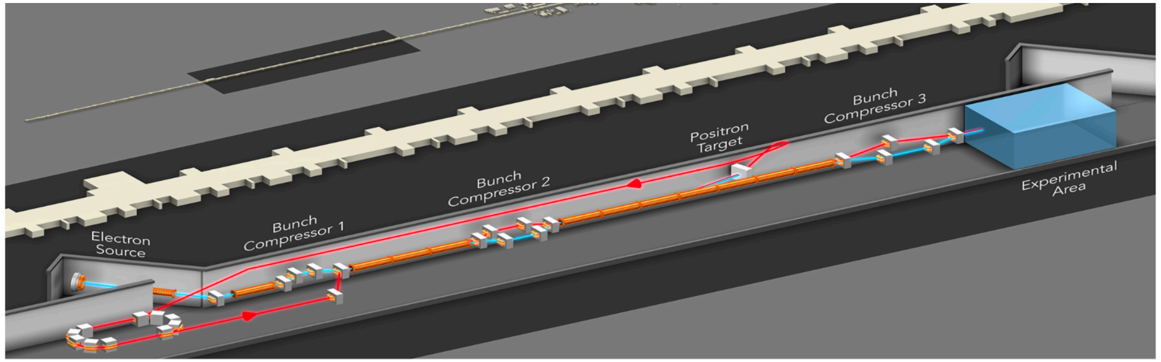
# High-Energy Electron Beam on Target

FACET-II uses a 10 GeV electron beam to generate positrons.

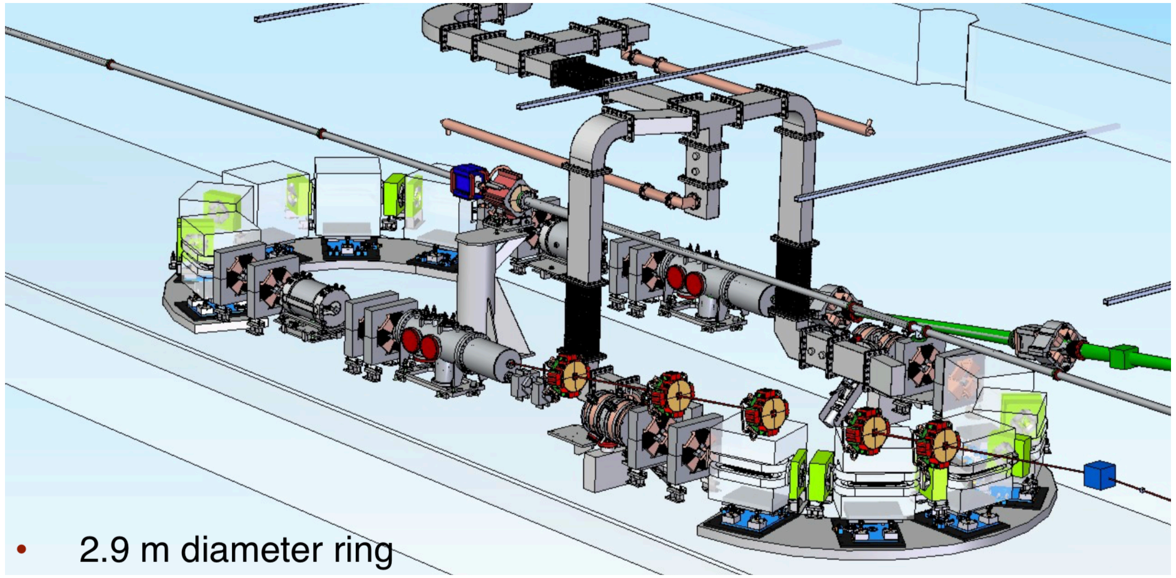
This takes advantage of existing infrastructure at SLAC.

A new, compact, damping ring will be built to cool the positrons.

Remember, SLAC (FFTB, FACET) is historically the only facility that has produced positron beams for PWFA experiments!




| Electron Beam Parameter | Baseline Design | Operational Ranges | Positron Beam Parameter | Baseline Design | Operational Ranges |
|---|---|---|---|---|---|
| Final Energy [GeV] | 10 | 4.0-13.5 | Final Energy [GeV] | 10 | 4.0-13.5 |
| Charge per pulse [nC] | 2 | 0.7-5 | Charge per pulse [nC] | 1 | 0.7-2 |
| Repetition Rate [Hz] | 30 | 1-30 | Repetition Rate [Hz] | 5 | 1-5 |
| Norm. Emittance $\gamma\epsilon_{x,y}$ at S19 [μm] | 4.4, 3.2 | 3-6 | Norm. Emittance $\gamma\epsilon_{x,y}$ at S19 | 10, 10 | 6-20 |
| Spot Size at IP $\sigma_{x,y}$ [μm] | 18, 12 | 5-20 | Spot Size at IP $\sigma_{x,y}$ [μm] | 16, 16 | 5-20 |
| Min. Bunch Length $\sigma_z$ (rms) [μm] | 1.8 | 0.7-20 | Min. Bunch Length $\sigma_z$ (rms) | 16 | 8 |
| Max. Peak current $I_{pk}$ [kA] | 72 | 10-200 | Max. Peak current $I_{pk}$ [kA] | 6 | 12 |



- 2.9 m diameter ring

# In-Situ Positron Generation

In this case, two high-energy electron beam hits a high Z-foil and generates a mix of positrons and electrons. The positrons generated by the trailing bunch are the correct phase of the wake in order to be captured.

An old concept, but never tested. Tests are planned at FACET-II.

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**Positron Injection and Acceleration on the Wake Driven by an Electron Beam in a Foil-and-Gas Plasma**

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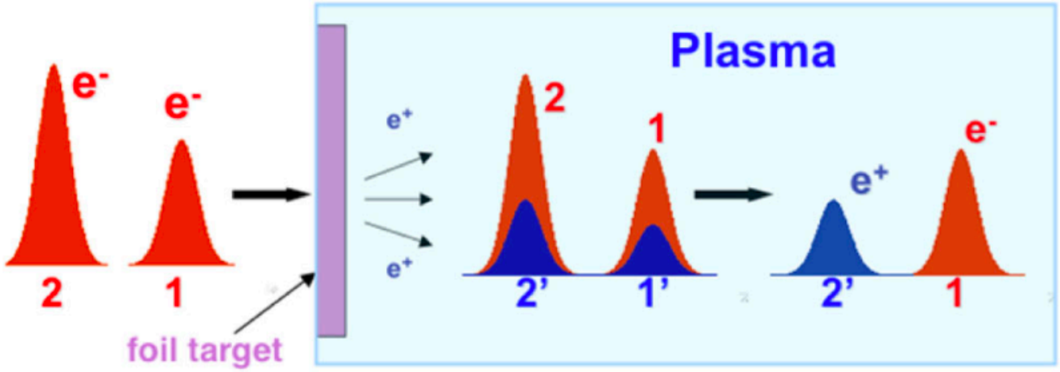
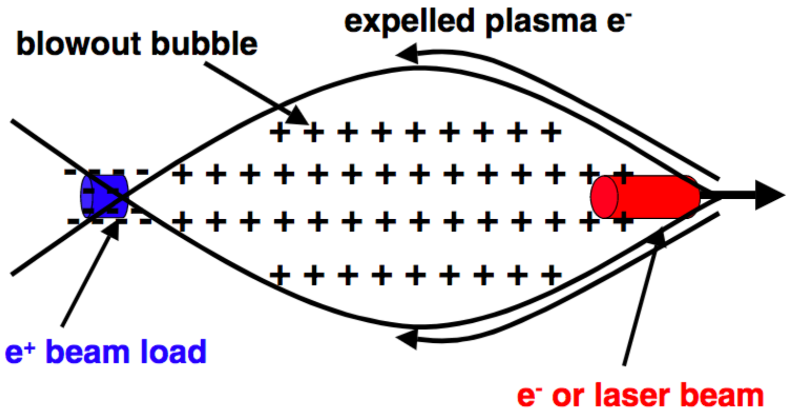
(Received 11 March 2008; published 17 September 2008)



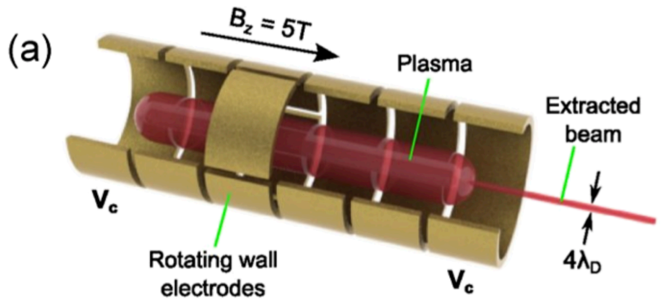



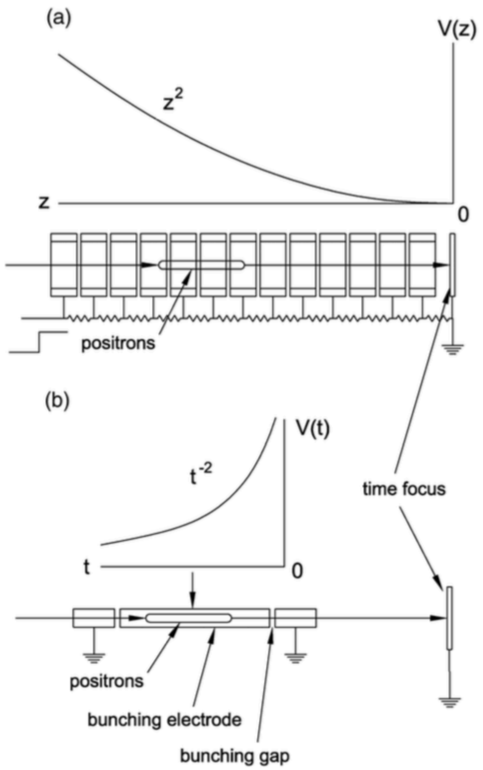
# Positron Beams from Electro-Static Traps

A new technology we consider is positron beams from electro-static traps.

This is a novel concept, but there are a lot of challenges.

More on this in talk by R. Greaves.



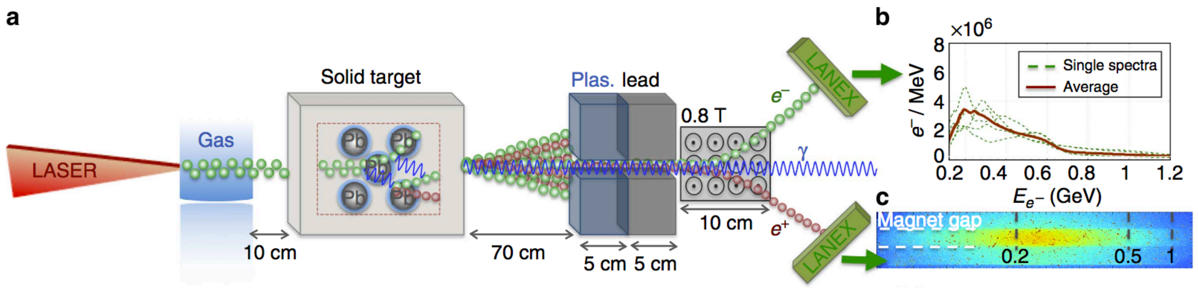

Danielson et. al. Rev. Mod. Phys. 2015

# Laser-Target Positron Generation

This technique utilizes high power lasers that already exist in laser-plasma laboratories.

This technique leads to temporally compact positron beams that are appropriate for LWFA experiments.

More on this in G. Sarri's talk.

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## Generation of neutral and high-density electron–positron pair plasmas in the laboratory

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# Comparison Table

| Concept | Emittance | Bunch Charge | Bunch Length | Rep Rate | Facilities/ Infrastructure | Comments |
|---|---|---|---|---|---|---|
| Positrons from high energy electron beams | | | | | FACET-II, new damping ring and return line, infrastructure exists | |
| Positrons from high energy proton beams | | | | | AWAKE, no infrastructure exists | |
| “In-situ” positron beam generation | | | | | FACET-II, only a high-z target is needed that is compatible with plasma source | |
| Positron beams from electro-static traps | | | | | Traps exist but they are not operated in beam mode | |
| Positron beams from a high-power laser sources | | | | | Eupraxia, RAL, U. Mich., Compatible with labs that already have high power lasers | |