Homework Q&A: E-310/3-311/E-315

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Q: “E310: Formulate the experimental plan with quantifiable physics goals (list of key parameters) and where you’re now (FY24) and where you plan to be in FY25.”

Q refined:

“1. While the goal of E310 experiment is generally understood, it'd be helpful to have a list of parameters which you hope to achieve and, therefore, demonstrate success.

2. Given that you had only one shift in 2024, only some intermediate results are available - how they compared to what you aim for (item 1)?

3. What do you plan to accomplish in FY25 and beyond? - again, along the line of the attainment of ideally desired ones.”

Answer:

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Timeline granularity:

- Program goals: E-310: Trojan Horse-II, E-311, E-315 Afterglow Metrology
- FY24 goals — FY25 goals
- 8-hr shift

FY24: only one 8hr shift, so shift goals ≡ FY24 goals

Program goals have not changed since proposal acceptance, for E-310 they are:

The objectives above imply the following success definitions:

- Demonstration of TH injection with sub-10% shot-to-shot variability
- Demonstration of TH in (near)-collinear geometry
- Production of nm-rad scale (and corresponding boosted brightness) electron

with precision injection allow controlled designer beam production. The wider channel/lower plasma densities are useful for a number of reasons:

- to improve injection precision and stability
- to minimize residual energy spread [3]
- to avoid driver beam and wakefield hot spots as potential source of dark current [4]
- to harness constant accelerating fields over the whole channel length and to realize up to tens of GeV energy gains

The experiment shall for the first time realize plasma photocathodes [1,2]

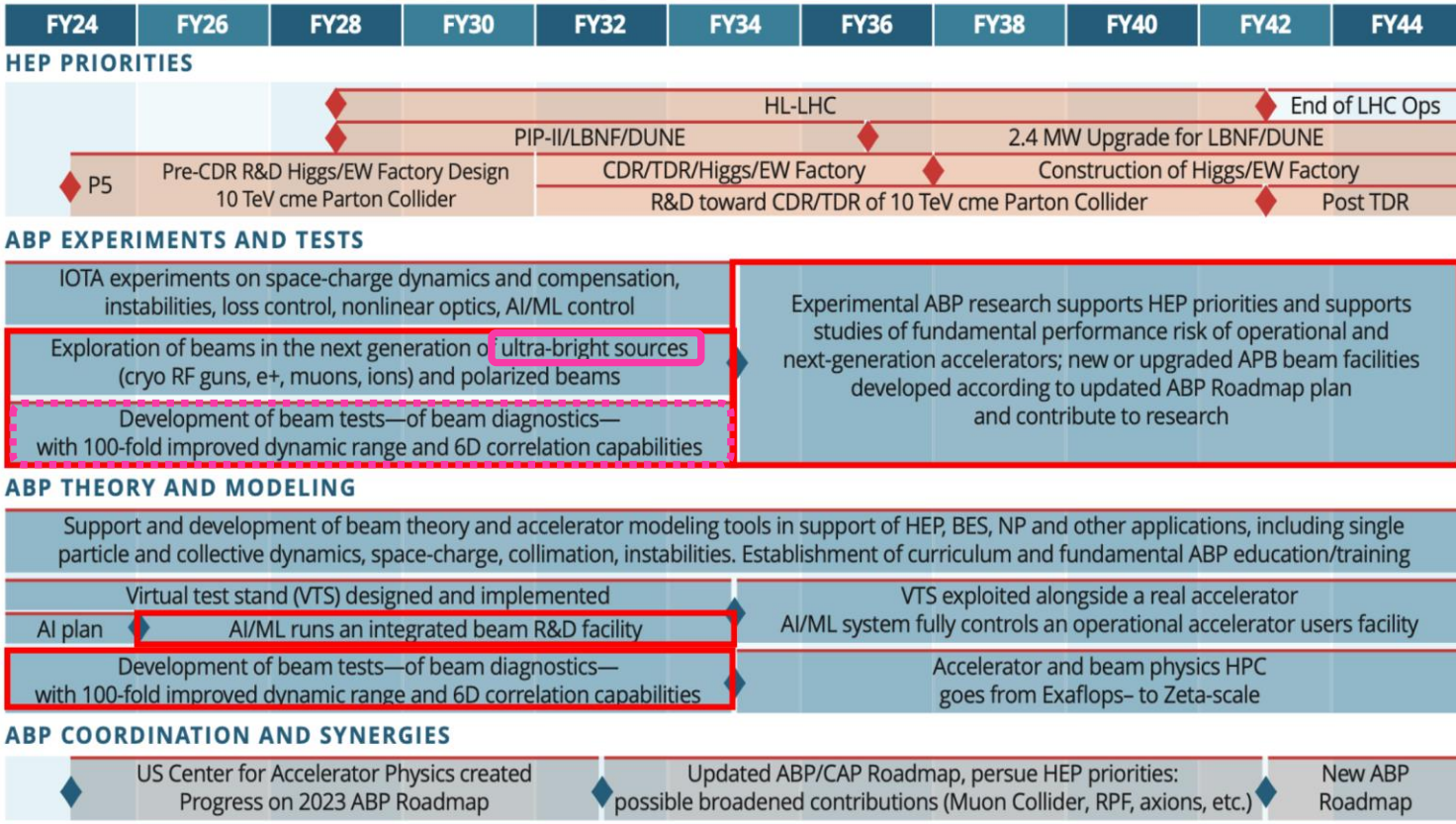
- in preionized channels which are wide enough to host large blowouts without being squeezed by channel boundaries (~500 µm vs. ~100 µm as in E210)
- with injector laser-driver beam geometries ≠ 90° (in particular, in collinear geometry)
- with injector laser and driver laser stability enhanced by an order of magnitude vs. E210

Accelerator and Beam Physics Roadmap for the next 20 years

E-310

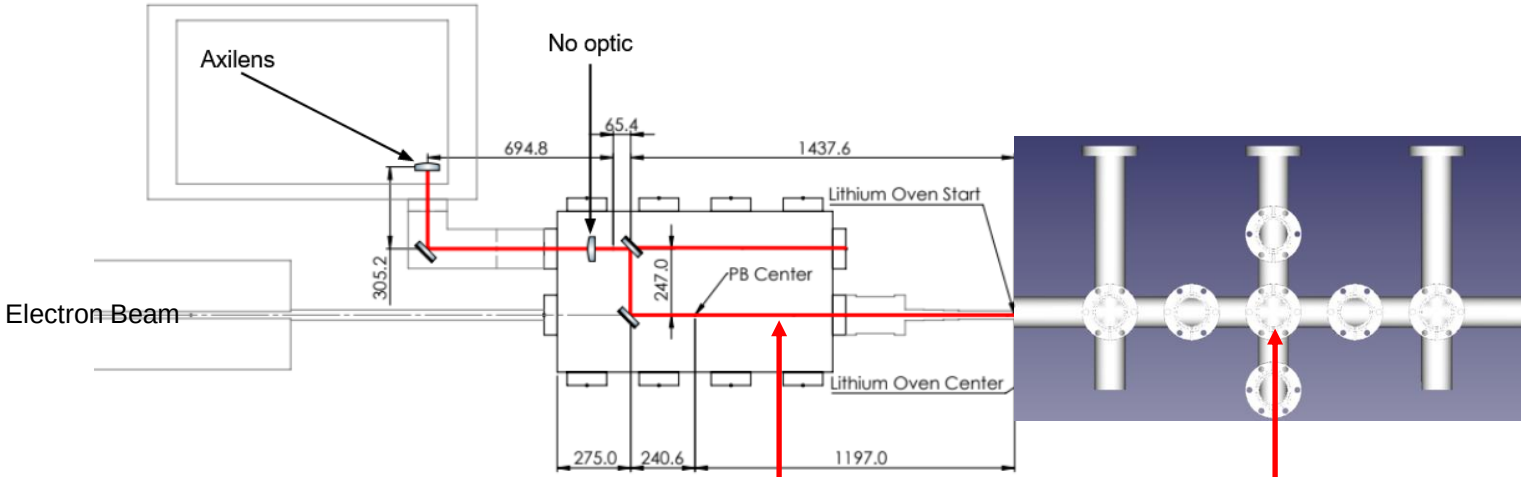
- Plasma injectors + brightness boosters
- Diagnostics and AI control
- Positron sources
- Beam test facility

Trojan Horse significantly shaped the roadmap.



There is an infinite breadth of physics that can be studied at FACET-II

To realize we need ionizing injector laser pulse: facility capability does not exist yet



⇒Only sub-component testing possible

Probe ionizer for E-315/E-308

Probe ionizer for E-310/E-311

FY24 ≡ singular 8-hr shift goals

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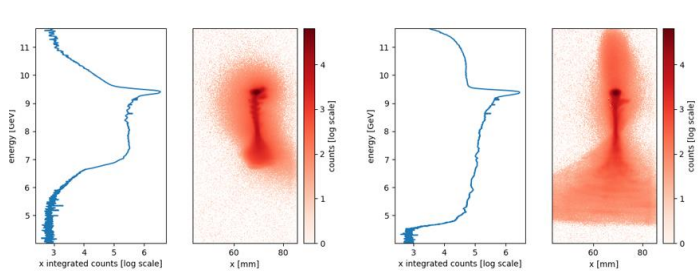
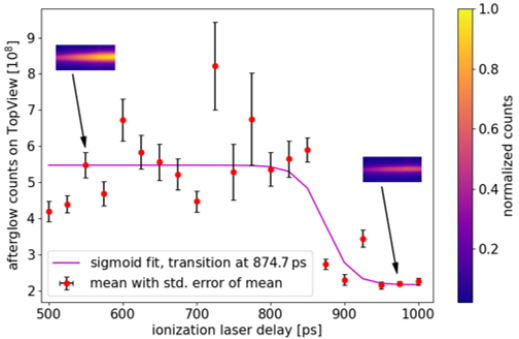
Shift Goals

1. Exploration of electron beam self-ionization in H2/He gas mixtures in the bypass line and PB
2. Exploration of ionization of mixed gasses in the PB by an axilens and interaction of the electron beam with the plasma volume

Stretch goal: Exploration of laser-ebeam timing required for plasma photocathode

All (over) achieved.





FY25 goals

- Test e-beam & preionization optics (fat channel)
- Get ionizer sub-component capability at PB and downstream
- Inject in bypass line 2.0
- Measure witness charge tunability by changing plasma photocathode laser energy, 1-100s of pC
- Demonstrate acceleration in long 1m-scale channel, 10-20 GeV energy
- Measure witness energy spread, direct beam-loading
- Measure emittance using existing diagnostics (butterfly method)

Request:

- More shifts!
- Ionizer
- More space (PB2)