TRIUMF

DarkLight: Experiment Location and Beam Optics

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Darklight Collaboration Meeting
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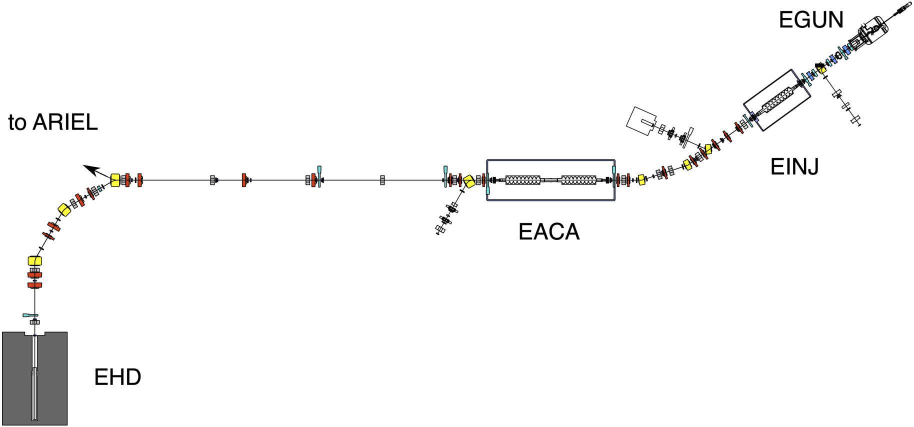
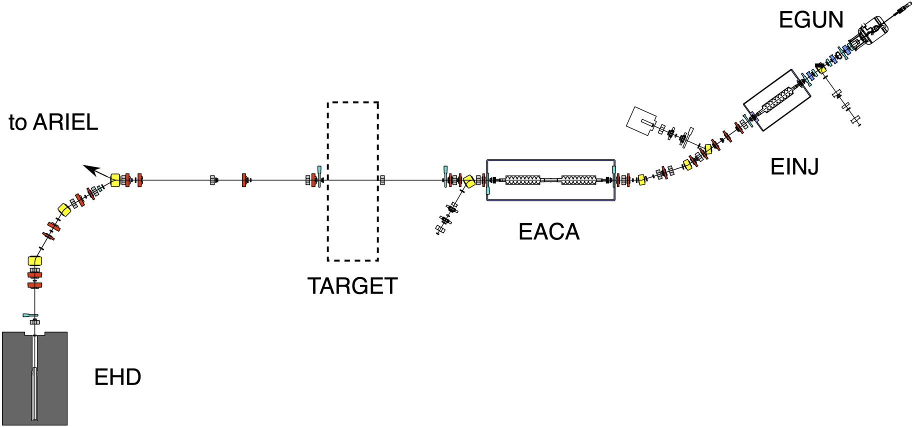
Outline

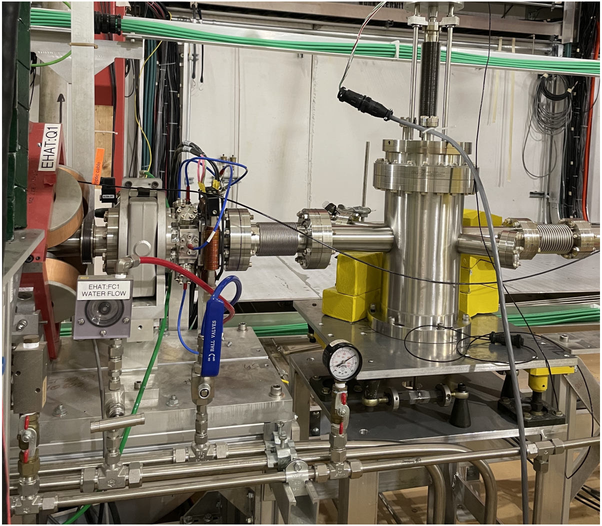
e-Linac Layout



e-Linac Layout: Initial Experiment Location

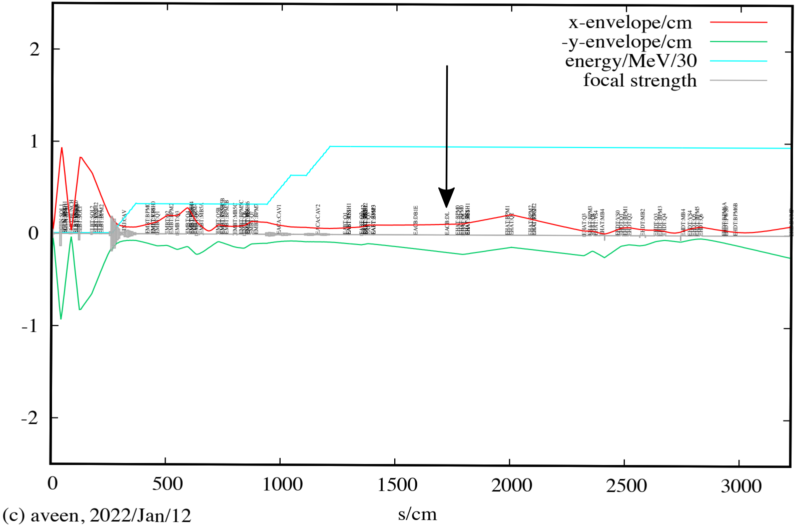


e-Linac Layout: Initial Experiment Location



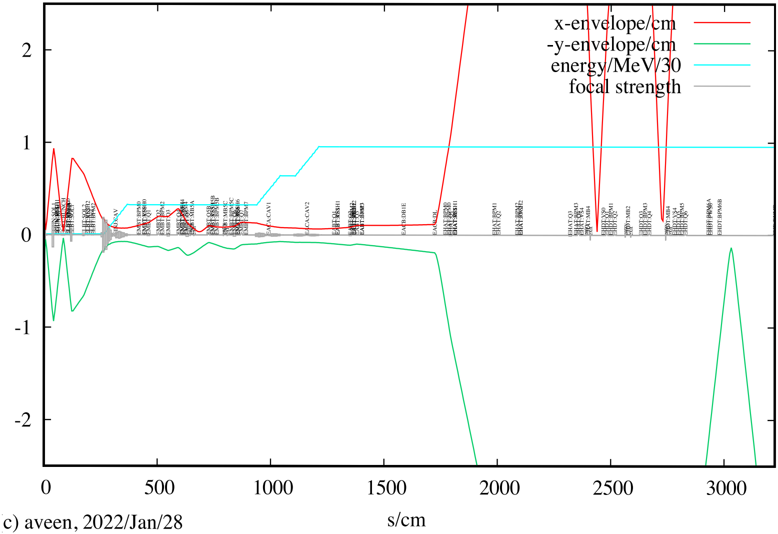
DarkLight target chamber in the e-hall.

TRANSOPTR Beam Optics Simulation



Typical 2 RMS e-Linac beam envelope. Radius of beampipe is 2.5 cm.

TRANSOPTR Beam Optics Simulation



Envelope including ≈ 7 mrad RMS scattering from 1 µm foil.

⇒ very difficult to transport. Pachal (2021)

Beam Optics Limitations

Beam loss requirement $\Rightarrow$ maximum 1 Watt per meter.

Assuming a Gaussian distribution for a 10 kWatt beam, this loss will occur at a 3.7 RMS envelope.

Maximum tolerable foil thickness at this location would be $\approx$ 7 nm.

Not feasible $\Rightarrow$ revise experiment location.

Revised Experiment Location

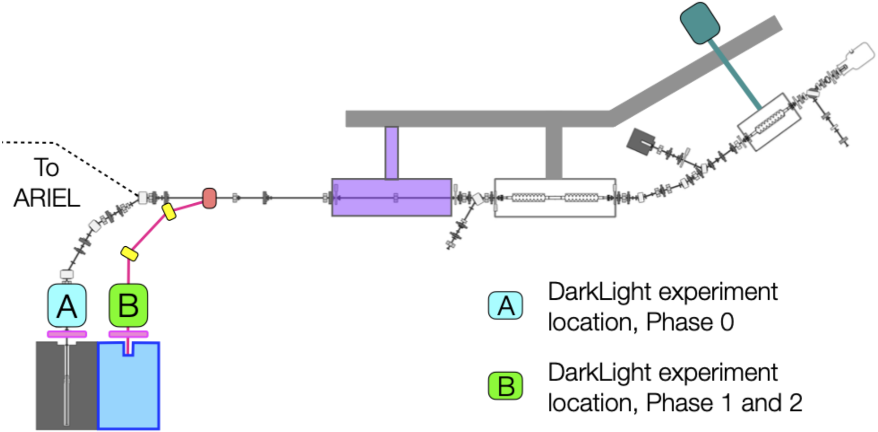


Figure obtained from Katherine Pachal.

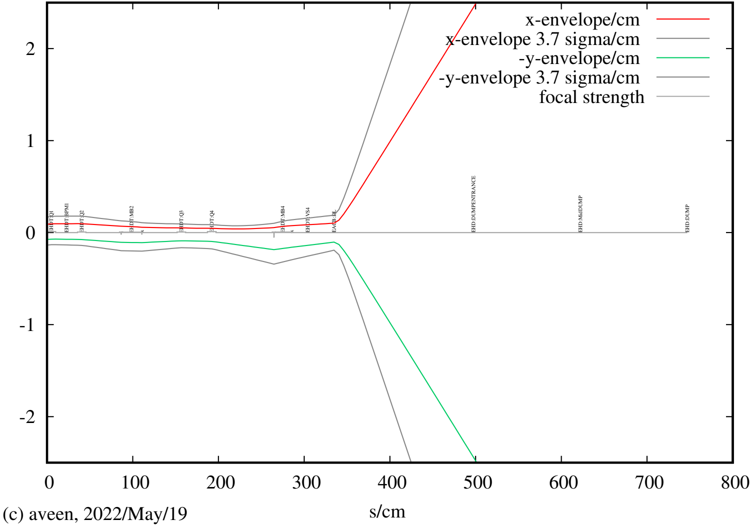
Revised Experiment Location: Phase 0

Re-located near the high-power dump for initial round of data taking.

Revised Experiment Location: Phase 0

Limited space available in this section.

TRANSOPTR Beam Optics Simulation



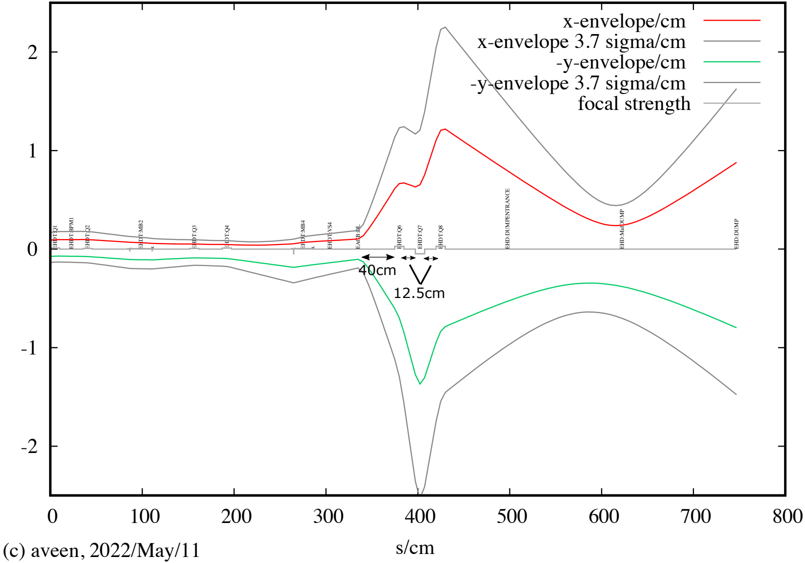
Envelope with no additional optics ⇒ must add focusing elements.

TRIUMF Quadrupoles

Inner diameter: 5.2 cm
Outer diameter: $\approx$ 28 cm
Diagonal length: $\approx$ 40 cm
Length in beam direction: $\approx$ 10 cm
Integrated field strength: $\approx$ 0.3 T

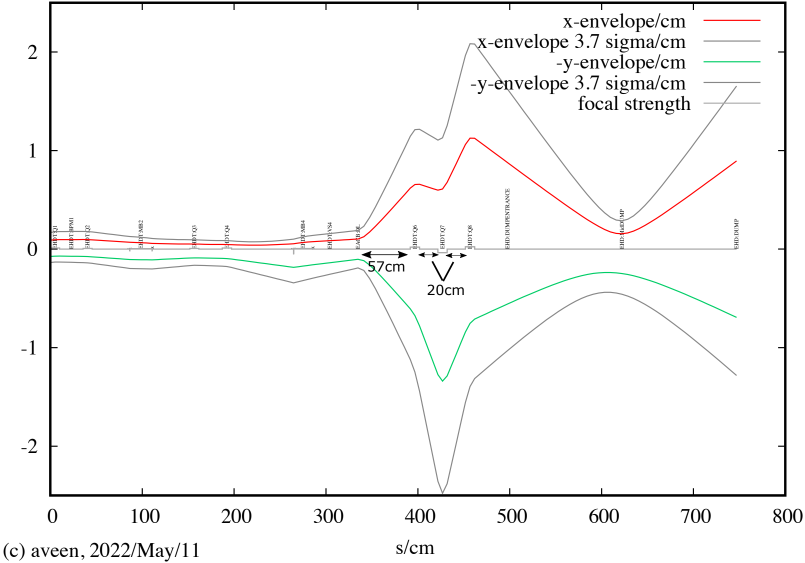
Baartman (2011)

Quadrupole triplet option ⇒ 1 micron foil



3.7 RMS envelope contained within beampipe aperture.

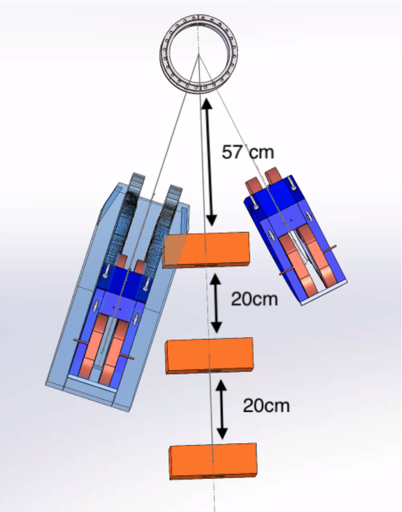
Quadrupole triplet option ⇒ 0.5 micron foil



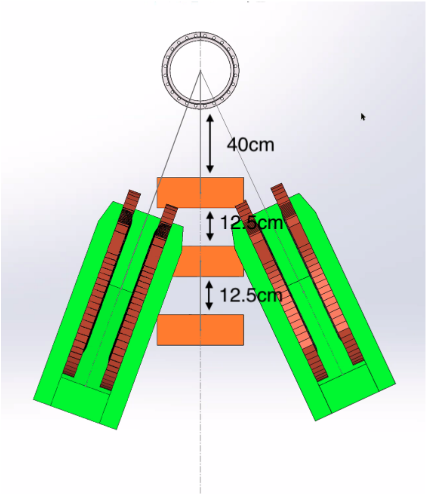
3.7 RMS envelope contained within beampipe aperture.

Quadrupole triplet issue ⇒ Spectrometer magnets

0.5 micron setup:



1 micron setup:



Overlap between elements ⇒ will need to compromise somewhere.

Summary

- Phase 0 location moved in front of current e-Linac beam dump;
- Satisfactory beam envelope can obtained using quadrupole triplet for 1 and 0.5 micron foils at this location;
- BUT would need to compromise on size of quadrupoles or spectrometer magnets for it to fit in allocated space;
- Also planning to explore the option of permanent magnet.

Thank you

Merci

References I

Richard Baartman. Quads for ARIEL electrons. Technical Report TRI-BN-11-02, TRIUMF, 2011.

Katherine Pachal. A look at beam spread and radiation from foils. Technical report, TRIUMF, 2021.

CFI Phase 1

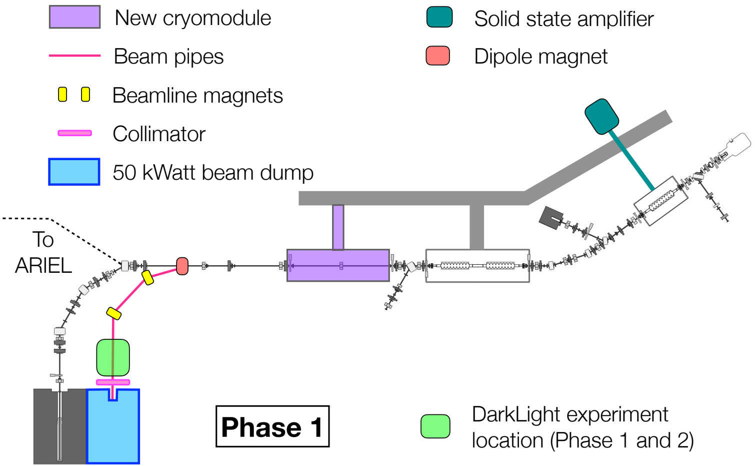


Figure obtained from Katherine Pachal.

CFI Phase 2

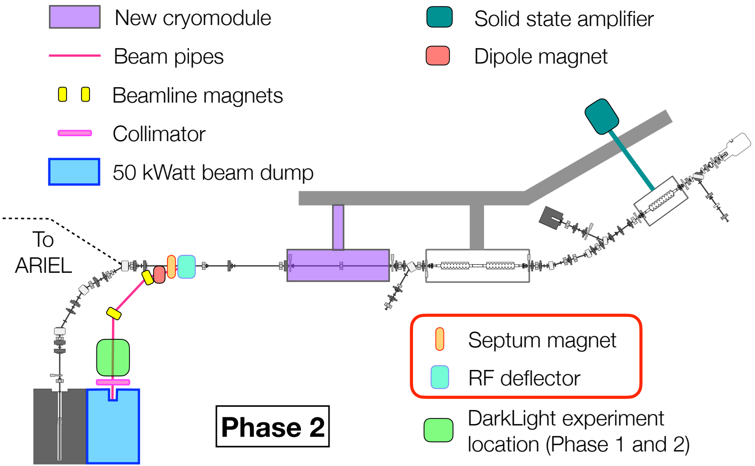


Figure obtained from Katherine Pachal.

Mathematica computation

```
In[•]:= f[x_] = 1/(σ*√(2π))*Exp[(-x^2/(2σ^2))]
```

$$\text{Out}[\bullet]= \frac{e^{-\frac{x^2}{2\sigma^2}}}{\sqrt{2\pi}\,\sigma}$$

```
In[•]:= Assuming[σ > 0, Integrate[f[x], {x, -∞, ∞}]]
Out[•]= 1

In[•]:= Assuming[σ > 0, Solve[Integrate[f[x], {x, a, ∞}] == 1/10000, a]]
```

Solve: Inverse functions are being used by Solve, so some solutions may not be found; us

$$\text{Out}[\bullet]= \left\{\left\{a \to \sqrt{2}\,\sigma\,\text{InverseErfc}\left[\frac{1}{5000}\right]\right\}\right\}$$

$$\text{In}[\bullet]:= \sqrt{2}\,\text{InverseErfc}\left[\frac{1}{5000.}\right]$$

```
Out[•]= 3.71902
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