

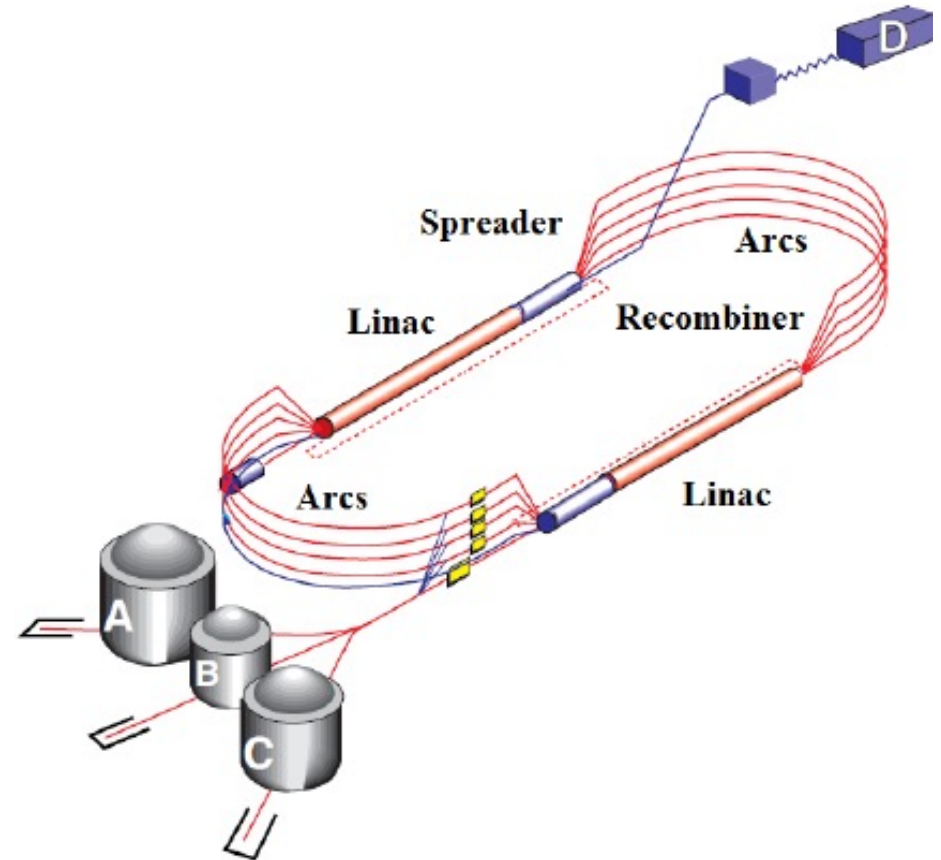
# Progress on Photo-injector Drive Laser for K-Long Beam

## Outline

- K-Long Beam Requirements
- Low Rep Rate Laser & Beam Test at UITF
- Future Work

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November 10, 2022



# K-Long Experiment Requirements

- M. Anaryan, *PAC48, JLab, August 11, 2020*

Beam Energy 12GeV, 5uA, bunch spacing 64~128ns

To accomplish physics program, 100 days per LH2 and LD2 is required

- Different interpretation of **2 key parameters**

By S. Pokharel

| Current (μA) | Rep Rate (MHz) | Sub-harmonic of 499 MHz | Bunch Charge (pC) | Equivalent 249.5 MHz current (μA) |
|--------------|----------------|-------------------------|-------------------|-----------------------------------|
| 2.5          | 15.59 (64 ns)  | 32 <sup>nd</sup>        | 0.16              | 40                                |
| 2.5          | 7.80 (128 ns)  | 64 <sup>th</sup>        | 0.32              | 80                                |
| 5.0          | 15.59          | 32 <sup>nd</sup>        | 0.32              | 80                                |
| <b>5.0</b>   | <b>7.80</b>    | 64 <sup>th</sup>        | <b>0.64</b>       | 160                               |

- Questions to be answered:

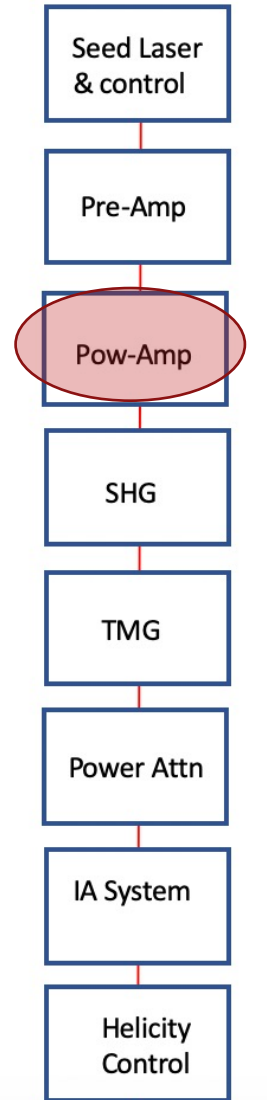
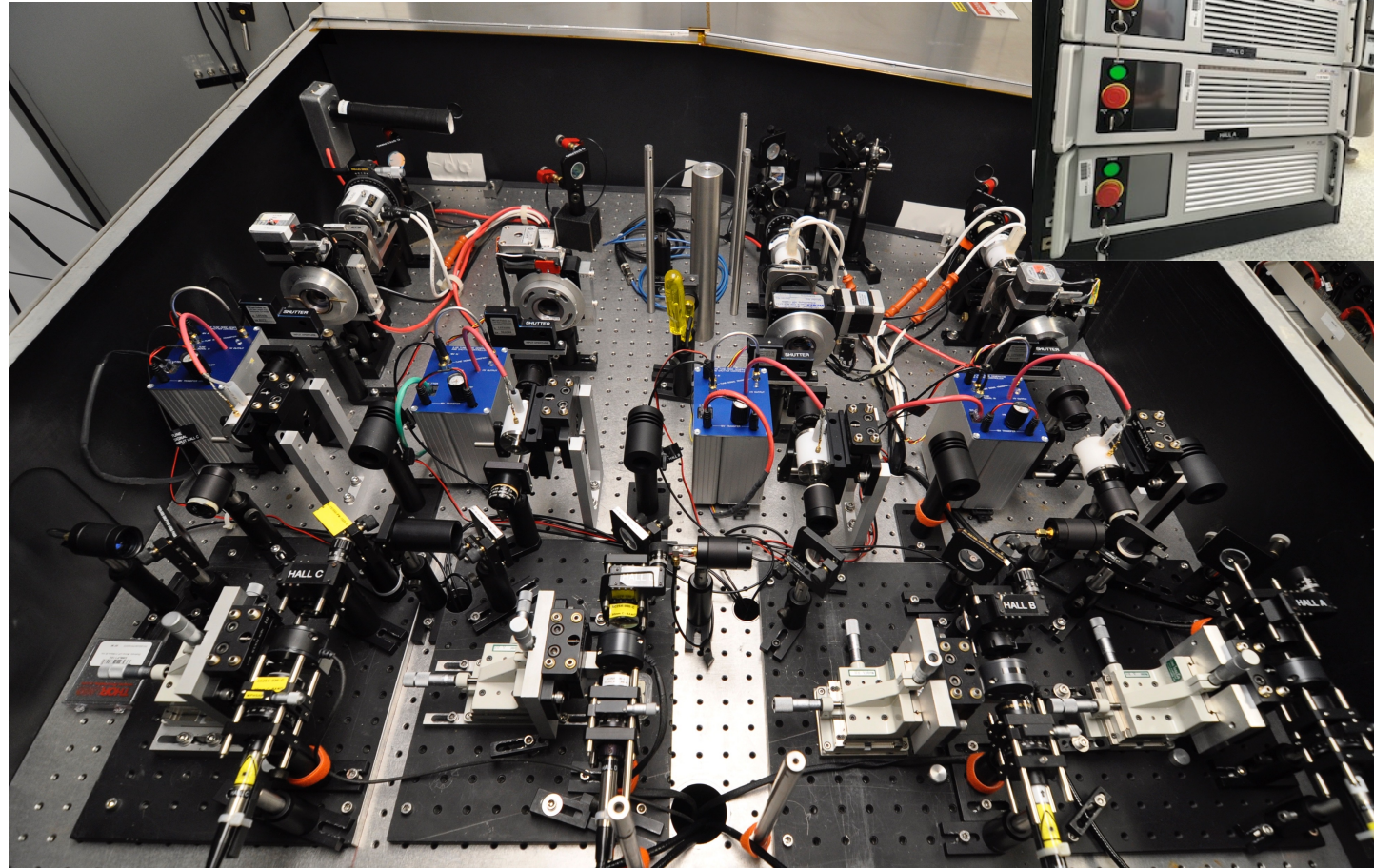
Among other things,

- Would the existing lasers work for KL experiment?
- Solution if not?

# CEBAF Photo-Gun Drive Laser System

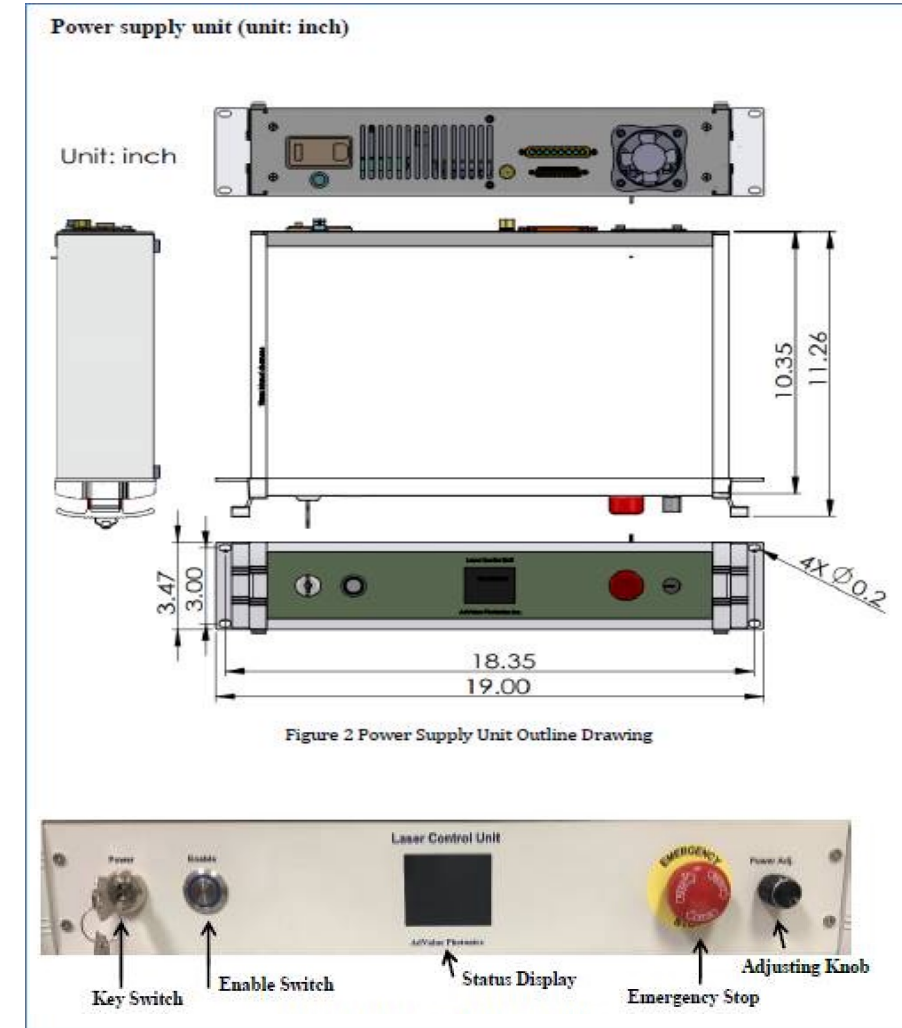
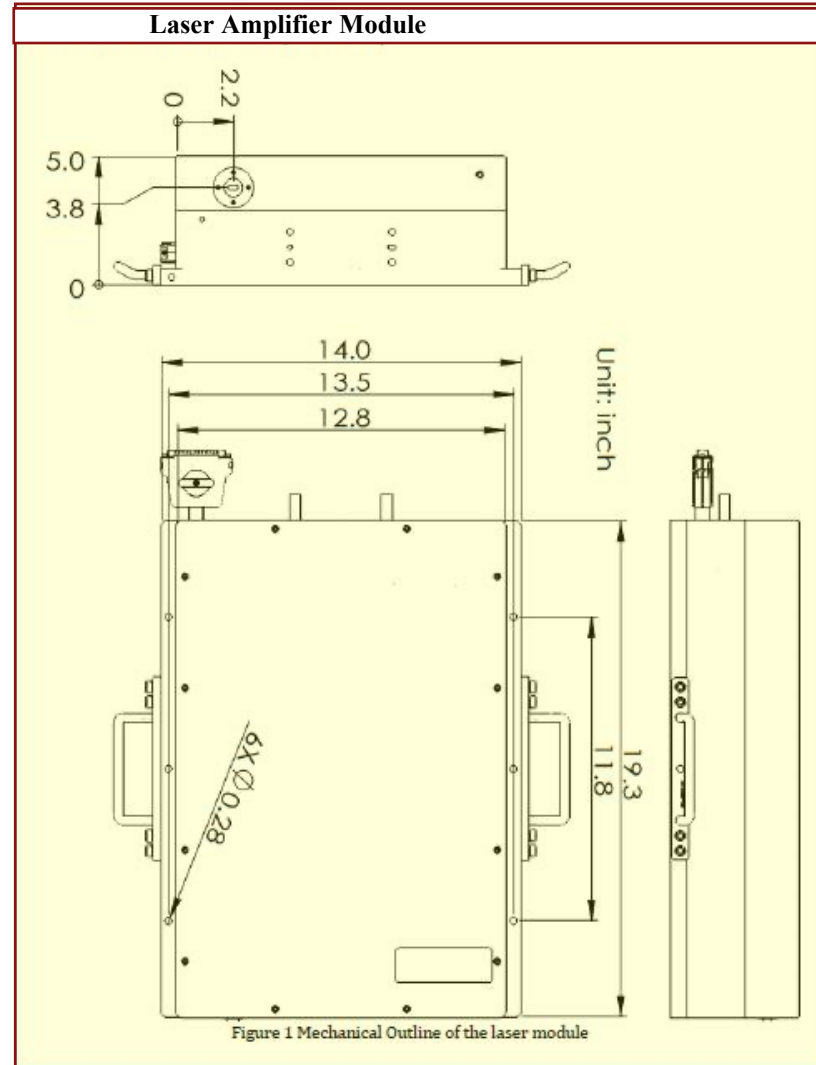
- 1.5um Gain-switched seed
- MOPO+SHG
- Polarization/Helicity control
- 499/249MHz CW
- TMD for low duty cycle beam
- 30~50ps pulse
- 780nm/SHG
- mW~100s mW
- 4 independent lasers to 4 Halls (A, B, C, D)

- Relatively low pulse energy
- Not suitable for low rep-rate, high pulse energy operation.



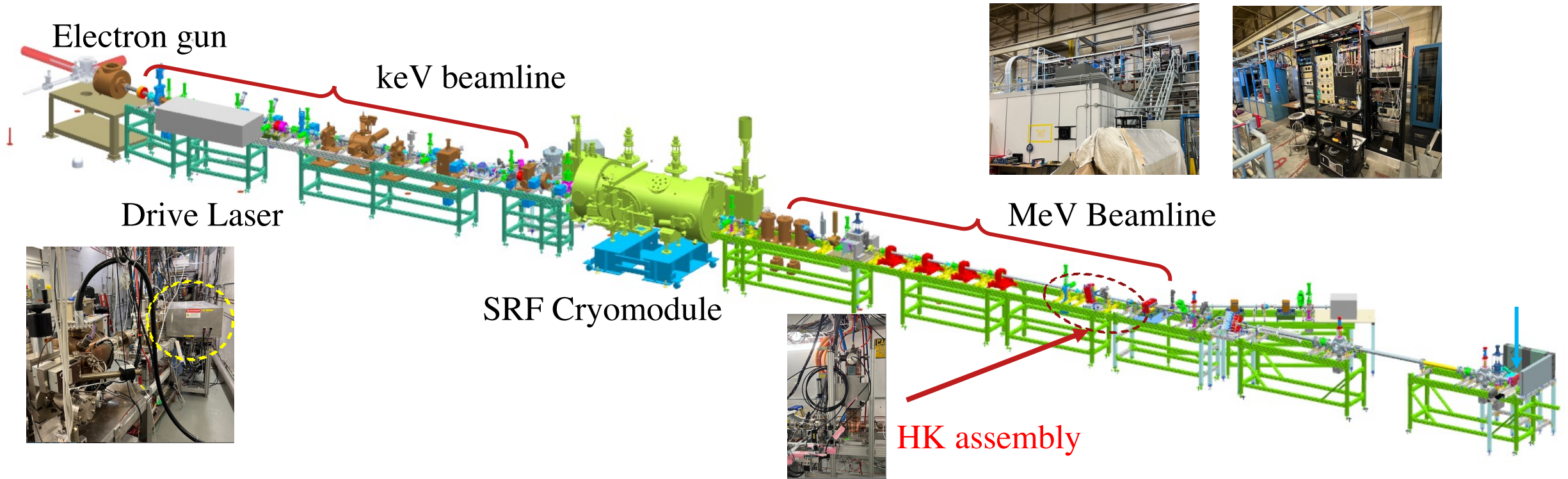
# Proposed Earlier: 1.5um High Pulse Energy Fiber Laser Amplifier

- For input signal (customer seed laser pulses):  
wavelength 1.5  $\mu\text{m}$ ,  
average power  $>1$  mW  
Pulse length 30~50 ps
- Average power  $>10$  W  
Pulse energy  $> 1\mu\text{J}$   
Pulse rate  $>1$  MHz  
Linear polarization  
Output beam: free-space, collimated
- Package: [amplifier module + control unit], turn-key system



# UITF & Harmonic Kicker Project

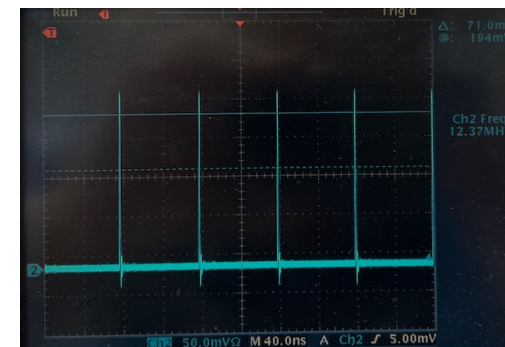
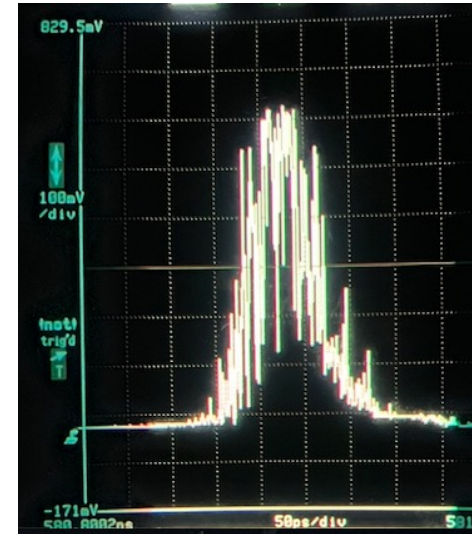
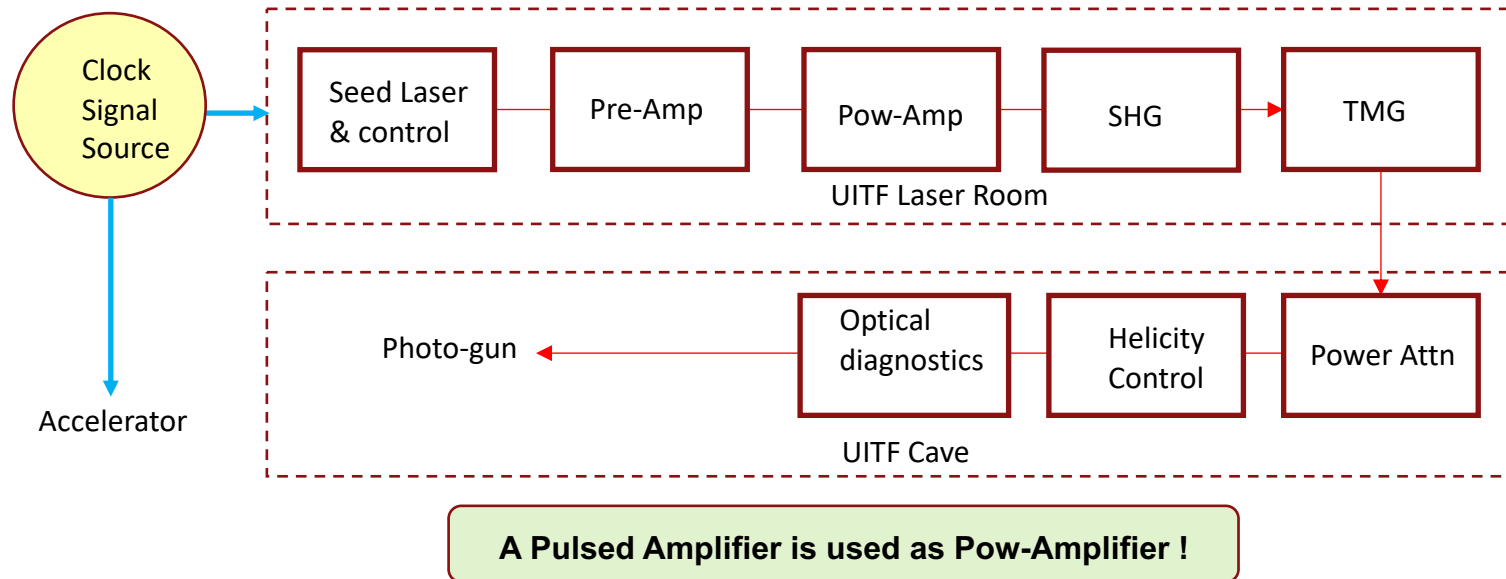
- 200kV DC gun, 10MeV Booster,
- 100nA (MeV), 3mA (keV), 50ps bunch length, Rep rate up to 1.5GHz, Polarized/un-Polarized



- Harmonic Kicker (HK) requires 12.37MHz bunch rep rate, very close to KL beam requirement
- Test in Nov, 2022 (going on right now)

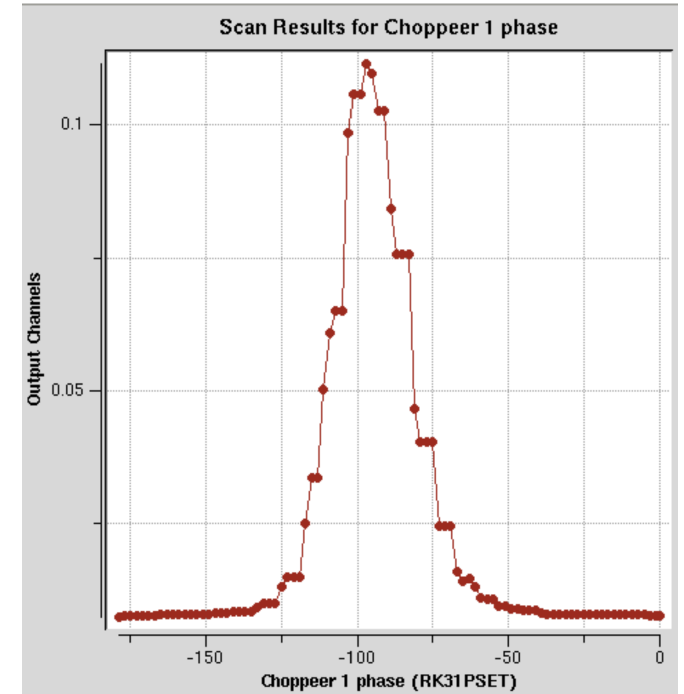
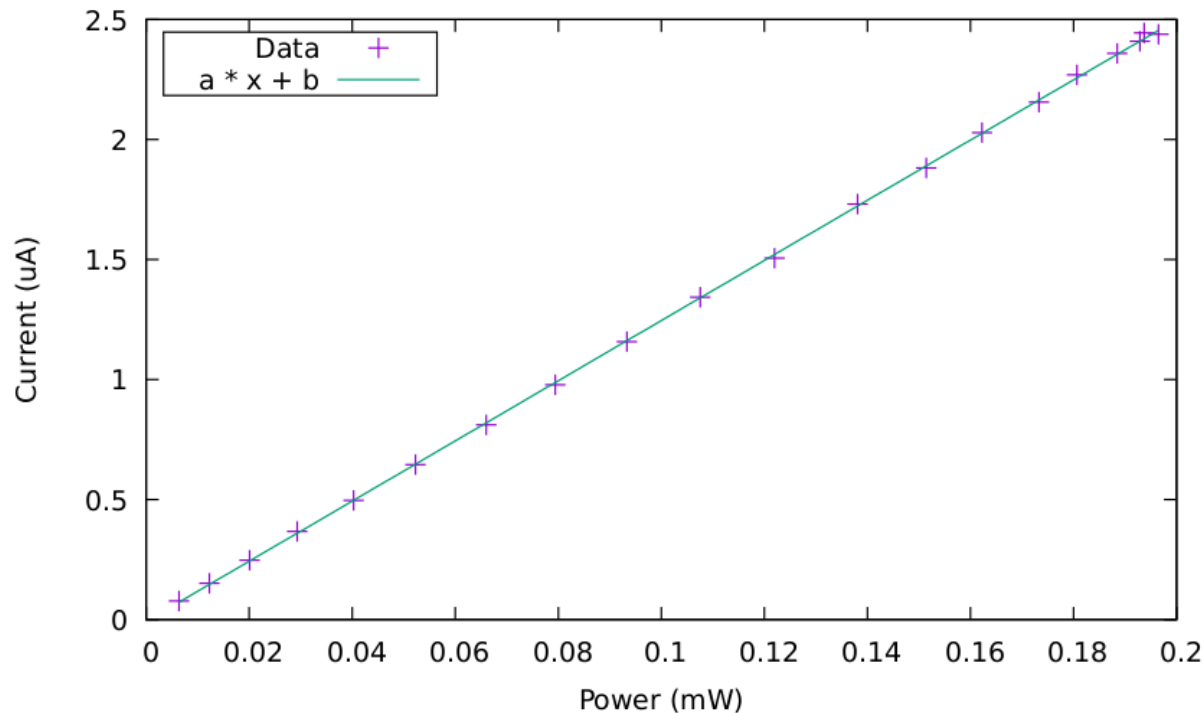
# UITF Drive Laser & Low Rep Rate Test

- A gain-switched seed laser driven by external a RF signal synchronized with a clock signal source that also provides RF signals to accelerator
- A low freq. (12.37MHz) was chosen
- Amplification to reach required power level, Freq conversion
- The scheme has been demonstrated at LERF (different wavelength)



# Recent E-beam Measurement

- The measurement at UITF shows bunch length  $\sim 50\text{ps}$
- $2.5\mu\text{A}$  at  $12.37\text{MHz}$ ,  $0.2\text{pC/bunch}$
- Current linearly increase with laser power  $12.5\ \mu\text{A/mW}$ ,  $1\text{pC/bunch}$ ,  $\text{QE}\sim 2\%$

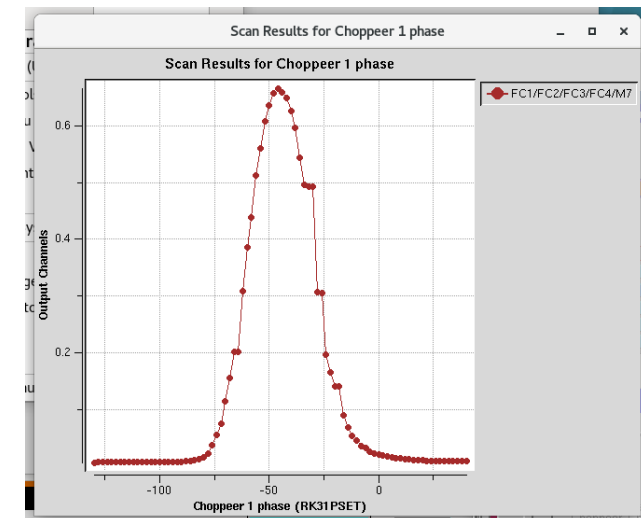
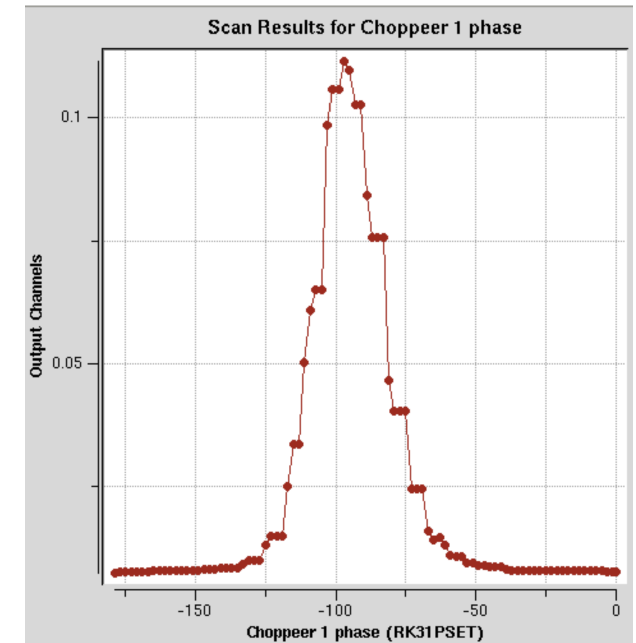
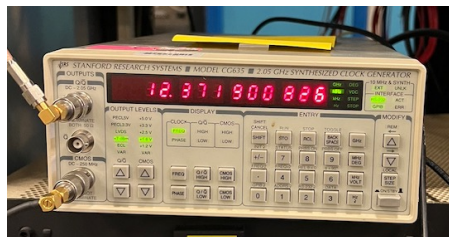


| IHAM605 Emittance Measurement | Geometric Emittance (m*rad) | Normalized Emittance (m*rad) |
|-------------------------------|-----------------------------|------------------------------|
| X-Plane                       | 2.9383e-08                  | 3.1626e-07                   |
| Y-plane                       | 2.1955e-08                  | 2.3631e-07                   |

Beam measurement by Max Bruker

# Prospects

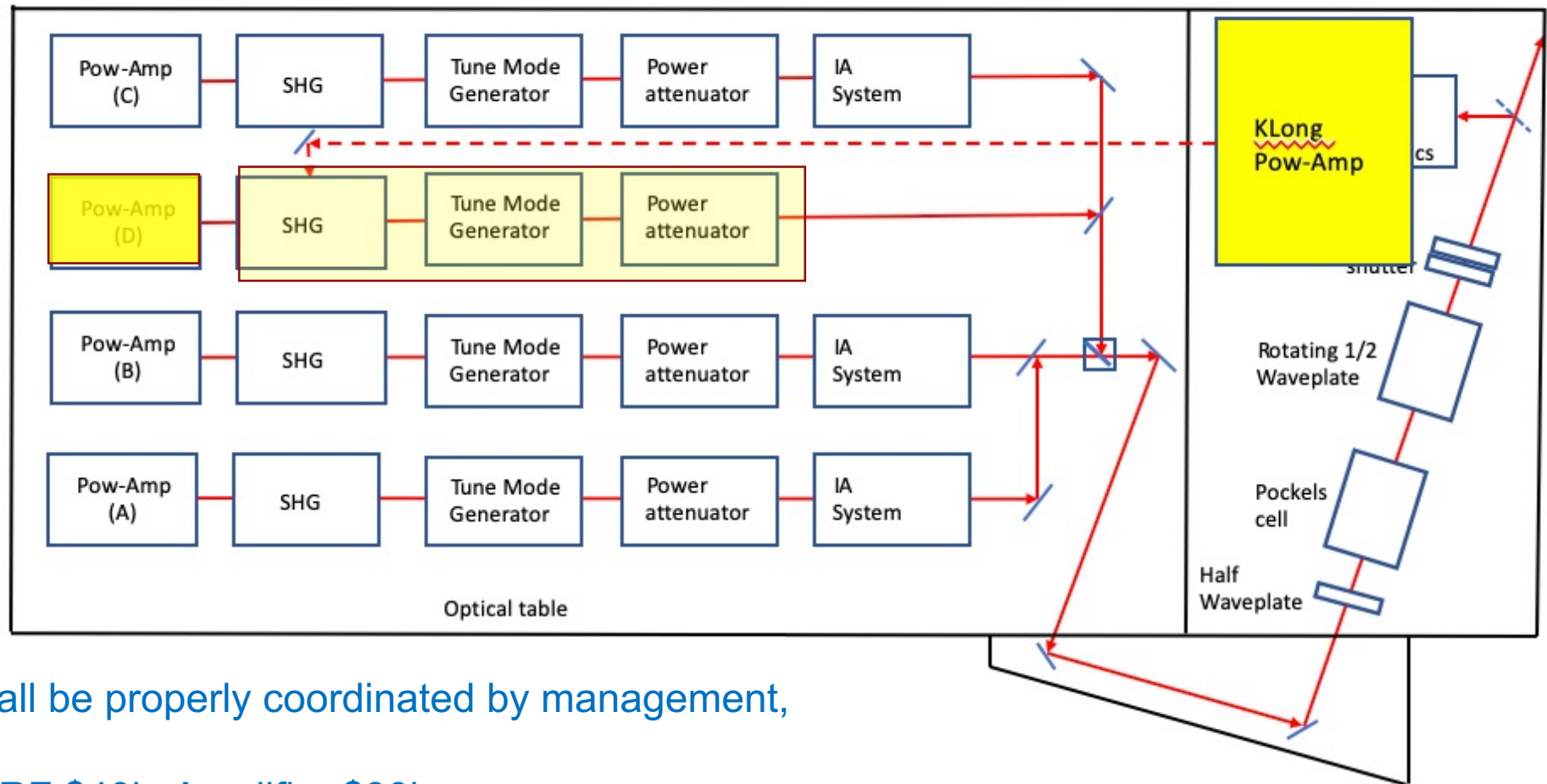
- For CEBAF,  $QE \sim 0.2\%$ , need  $\sim 5\text{mW}$  780nm laser power
- KL beam current (5uA) can be readily met
- Still need more beam tests to confirm
- One standing issue
  - A phase drift up to 10s of degrees btw Laser and accelerator observed
  - While this should **not be a show-stopper**, but is not expected either, the simple synchronization scheme appears to be the cause after investigation
  - Solution: to add a dedicated low rep RF signal (more costly)





# Implementation at CEBAF

- Add new low freq RF (8 or 15MHz)
- Modify seed and replace amplifier
- Use the existing section downstream of the D laser
- Additional optics match



- Cost & Schedule (shall be properly coordinated by management, ACC, Hall D, etc):
  - Laser seed and RF \$40k, Amplifier \$30k
  - > 6 months
  - Installation & test about 2 week

# Questions & Comments?

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