Drive Laser TMG Evaluation Meeting Presentation

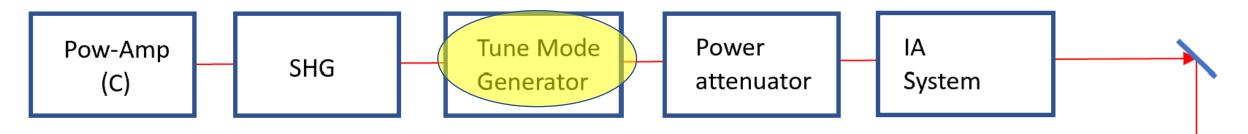
Shukui Zhang

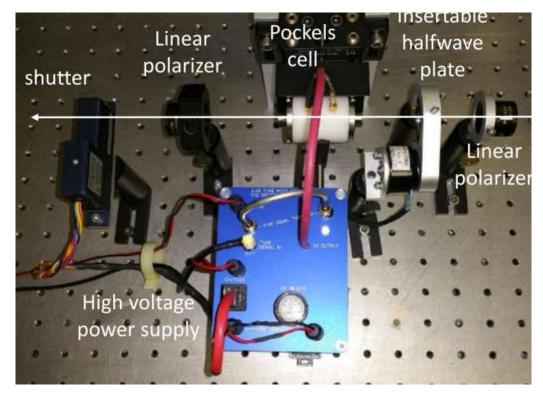
April 11, 2024



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Tune Mode Generator (TMG)



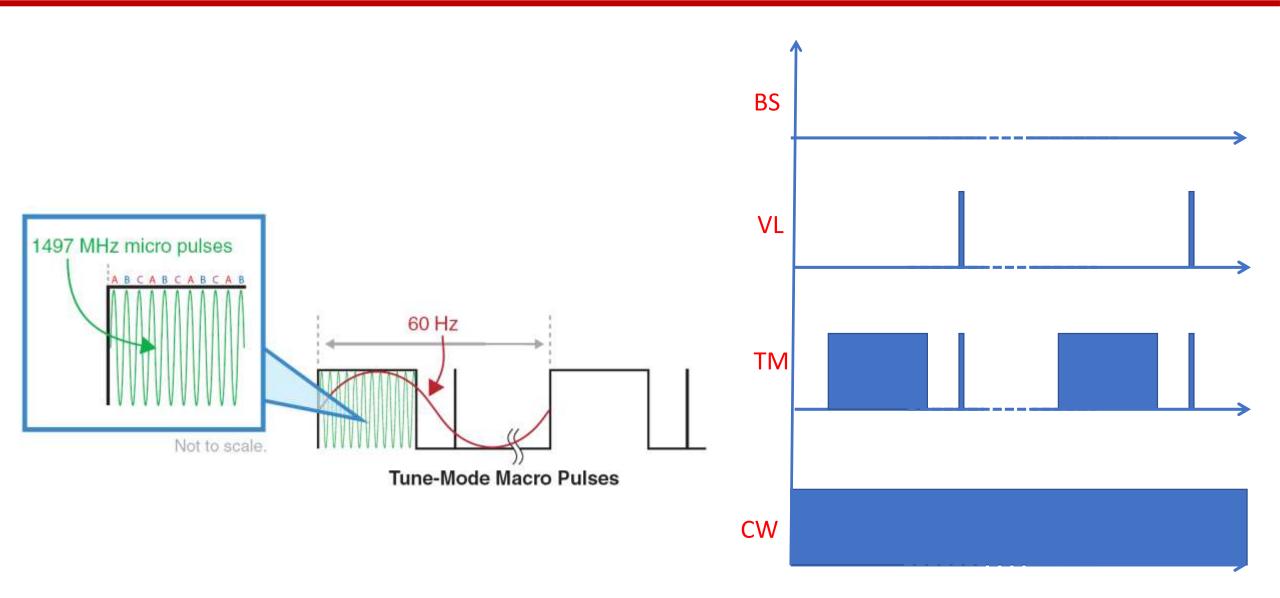


Combination of a Fast EO, polarizing optical elements and a slow mechanical shutter

- Provide time structures needed by CEBAF operation
- Protect machine

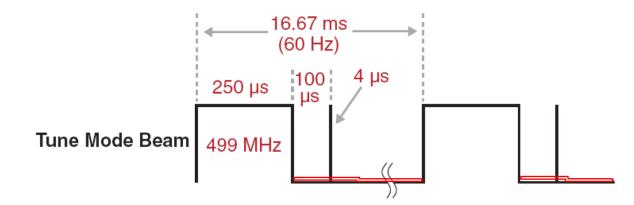


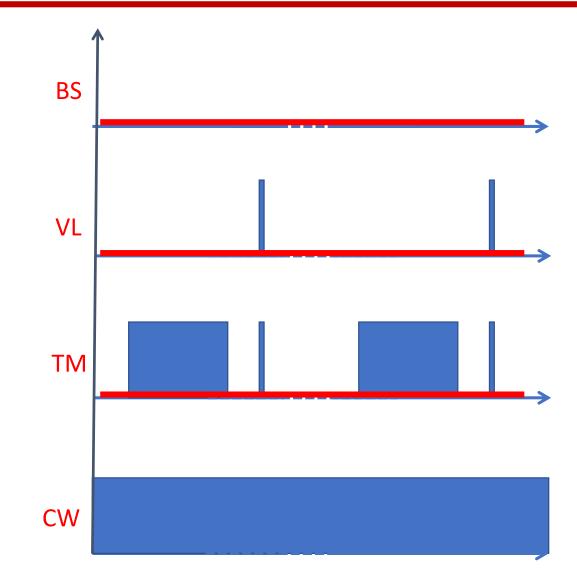
Time structures needed by CEBAF





Week background due to limited optical switch contrast



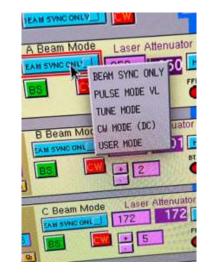




CEBAF Beam/Machine Modes

Beam mode	Macropulse duration at 60 Hz	Duty factor	Tune mode generator Pockels cell	Tune mode generator halfwave plate	Shutter
OFF Viewer limited	N/A 4–10 μs	0 0.02–0.06%	ON ON	IN IN	CLOSED OPEN
Tune mode	250 μs ON, 100 μs OFF, 4 μs ON	1.52%	ON	IN	OPEN
CW	N/A	10 <mark>0%</mark>	OFF	OUT	OPEN







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- 3/20/2024, Hall C lost beam.
 - Trouble-shooting showed mechanical shutter is good, the C laser TMG malfunctioning, replaced TMG. Machine resumed operation for a day
- 3/21/2024, vacuum problem in cebaf beam spreader, laser beam /power leak in BS mode. shutter did not seem closed.
- 3/22/2024, more extensive trouble-shooting performed, no
- Extensive trouble-shooting by CIS/SSG/AESCIS

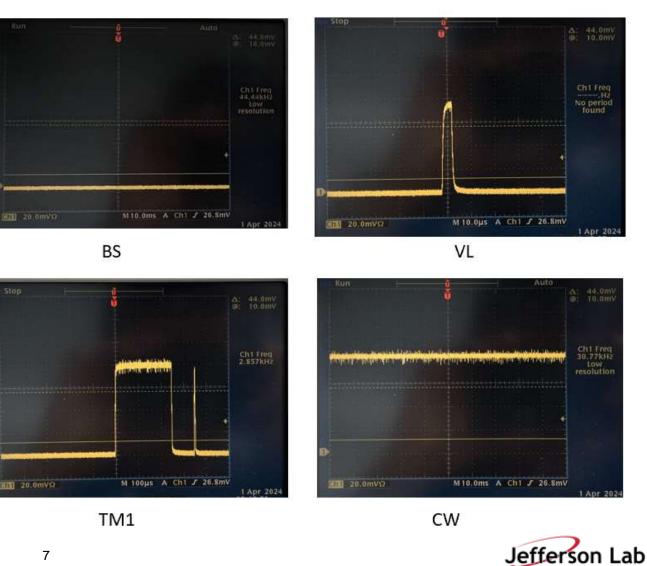


CEBAF Beam Power & Pulse Structure

Laser power vs beam mode Atten@1000

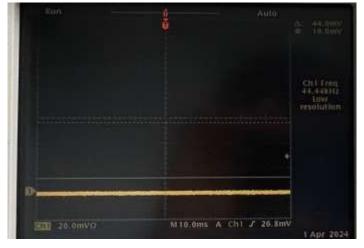
	A (mW)	B(mW)	C(mW)	D(mW)
BS	0	0	0	0
VL	0.55	0.13	1.62	0.018
ТМ	0.88	0.16	2.1	0.035
CW	77	18.4	198	5.3

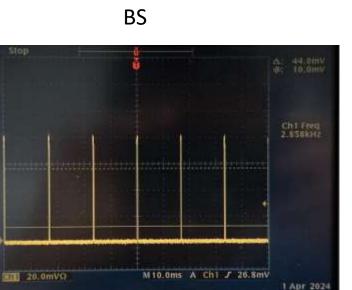
A Laser Pulse traces

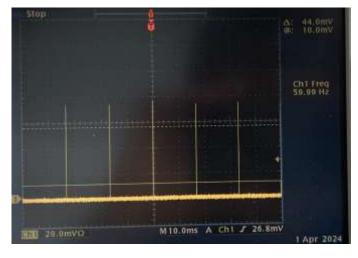


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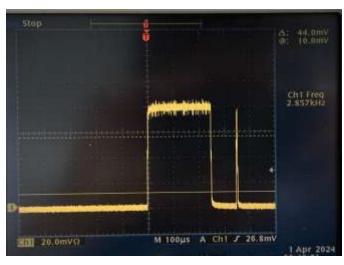
CEBAF Beam Power & Pulse Structure







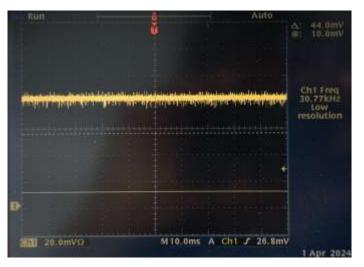
VL1



TM2

Stop S

VL2



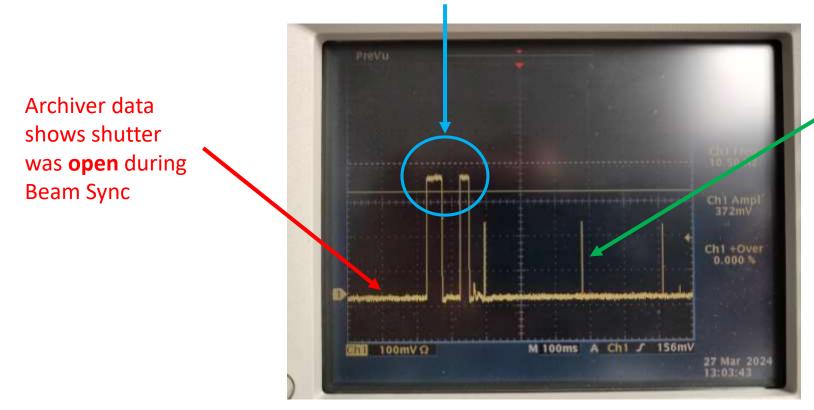


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TM1

Beam Mode	Pockels cell High Voltage	half wave plate	Shutter
Beam OFF	OFF	Inserted	Closed
Viewer-Limited	Pulsing	Inserted	Open
Tune	Pulsing	Inserted	Open
CW	OFF	Retracted	Open

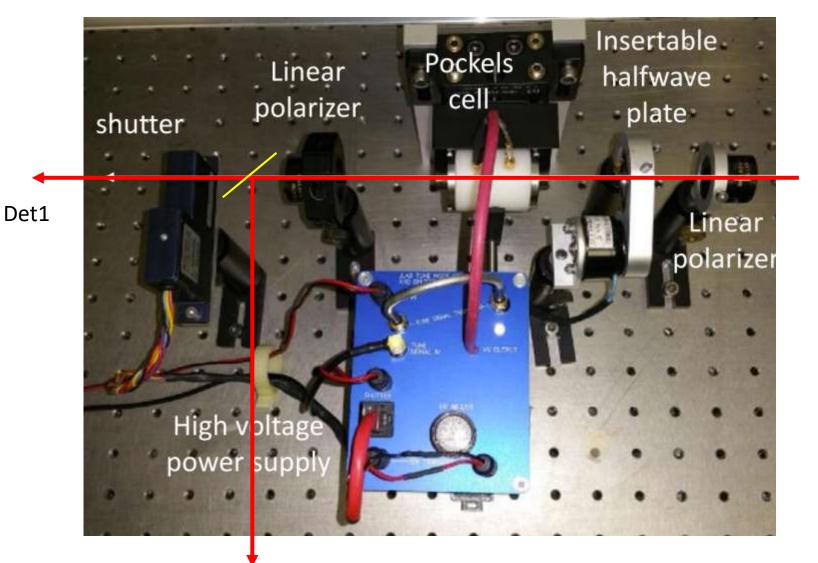
During transition to Viewer Limited this long (10's msec) would normally be shuttered



Shutter would then
open, allowing Viewer
Limited pulses
(0.004 msec) to pass

Recent Test: UITF Laser TMG temporal behavior vs beam mode

- Detector 1 (Yellow
 Oscope traces) located
 after shutter
- Detector 2 (Purple Oscope traces) located before shutter
- FSD triggered from UITF EPICS

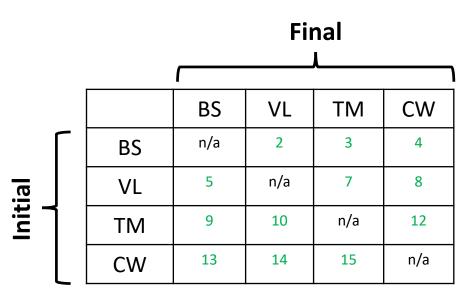


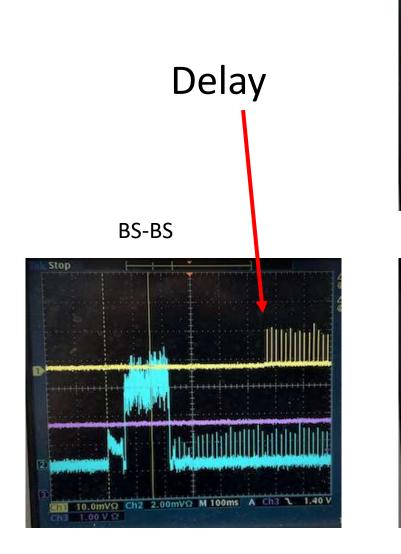


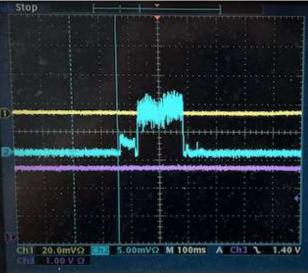
UITF Laser TMG temporal behavior vs beam mode

Purple: before shutter Yellow: After shutter Date: 4/5/2024

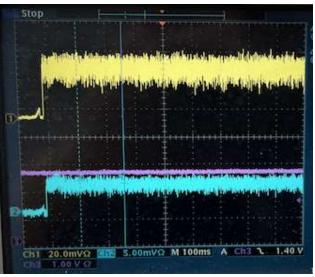
No FSD







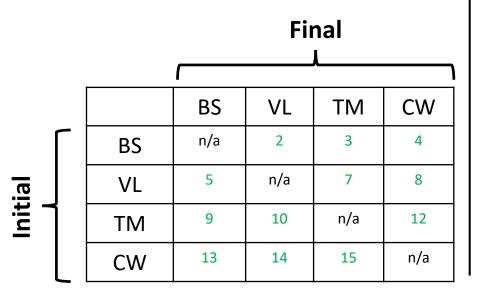
BS-VL

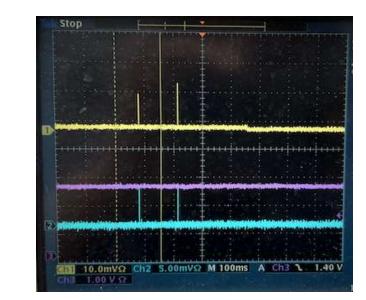




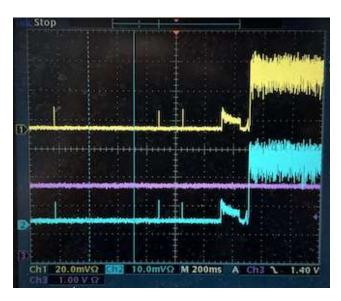
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No FSD





VL-BS



VL-CW

Juli

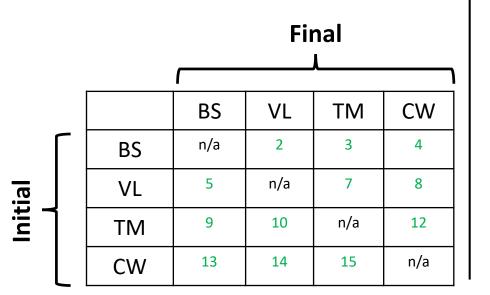
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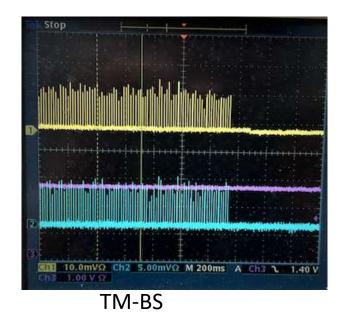
1.40 \

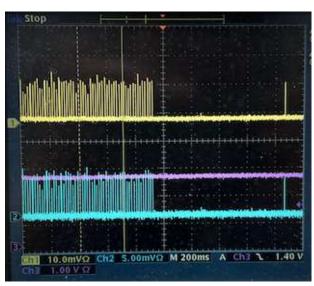
BS-BS

PreVu

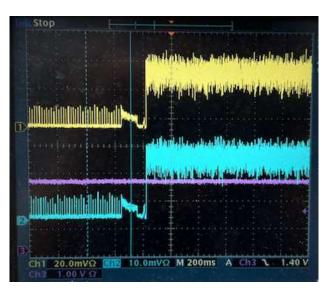
No FSD



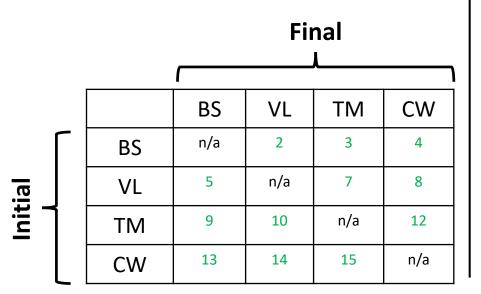


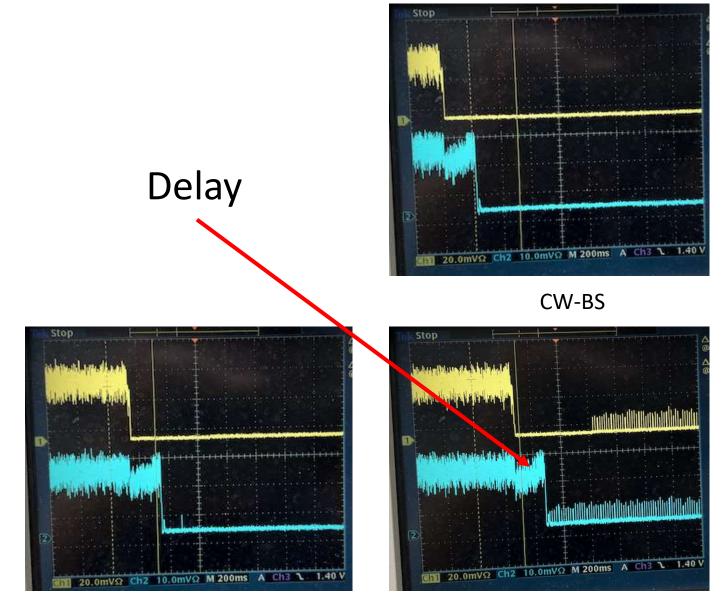






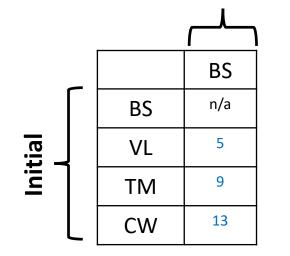
No FSD

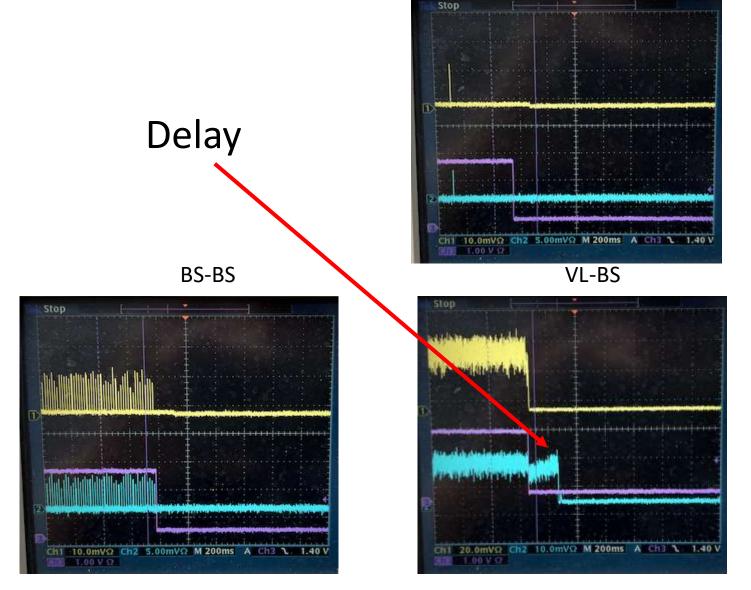




CW-VL

FSD from Static mode

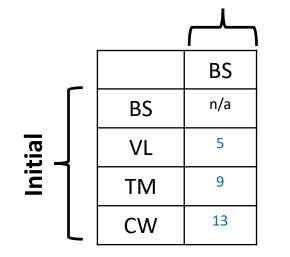


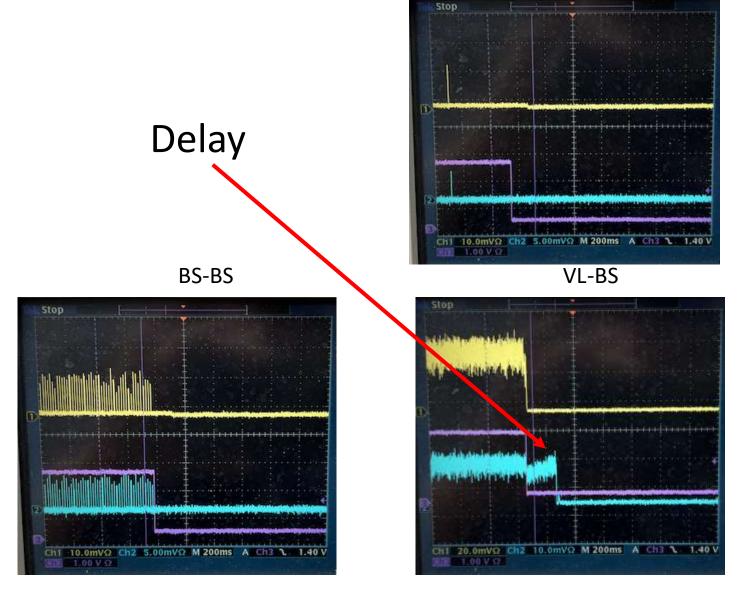


TM-BS

CW-BS

FSD from Static mode

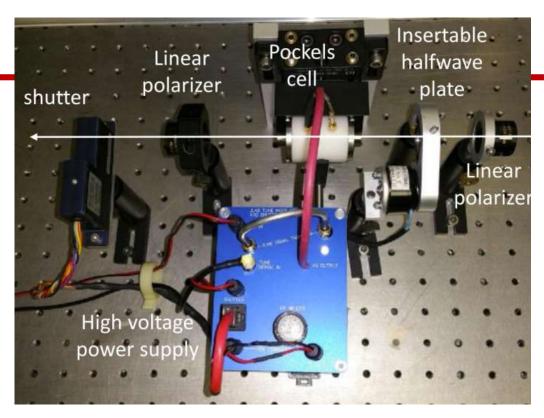


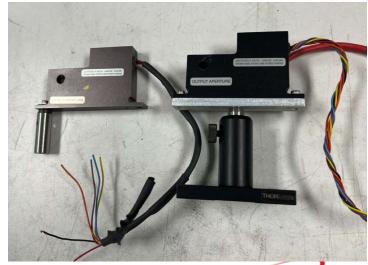


TM-BS

What may go wrong?

- Attenuator setting too high (280), laser power 10s x more than routinely set value
- Shutter open?
 - Triggers controls to TMG seem fine
 - Shutter needs DC voltage to keep open
 - Mechanical?
 - Shutter has been on its holder
 - A chance that laser beam may go above the shutter due to loosen screw



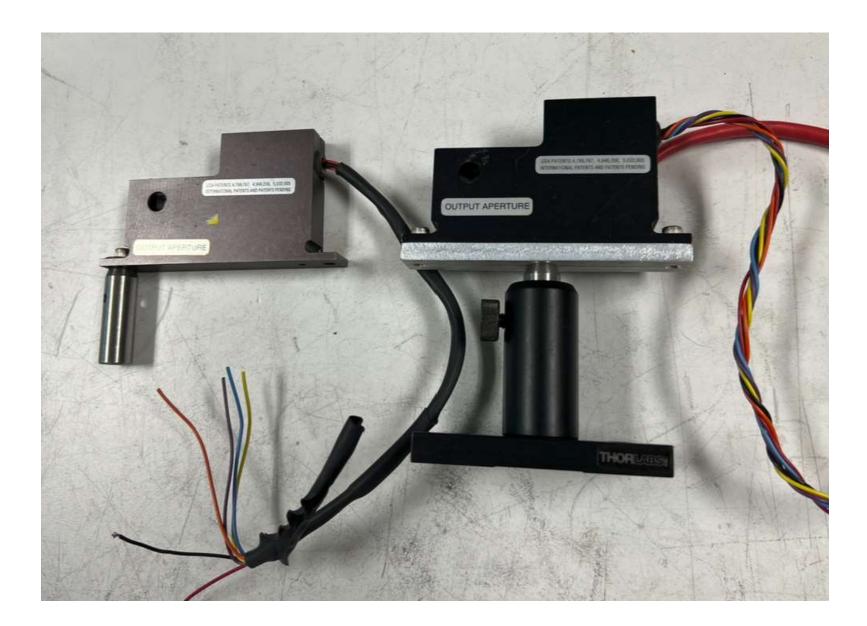


Jefferson Lab

Nothing can be 100% safe, Fail Safe May not Be Safe!

- Shutters may get heated up to high temperature
- High Temp may melt the glues
- The cantilever may fall, leave the shutters open

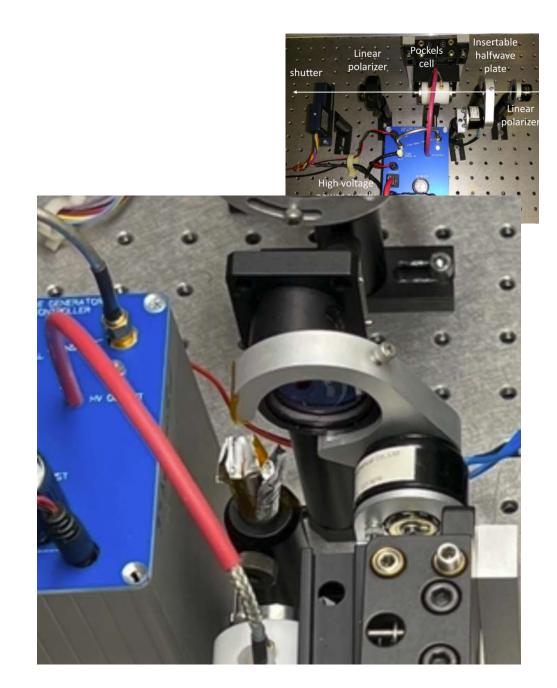




A deeper look into TMG

An even worse scenario, assuming the HWP fails, then what would happen

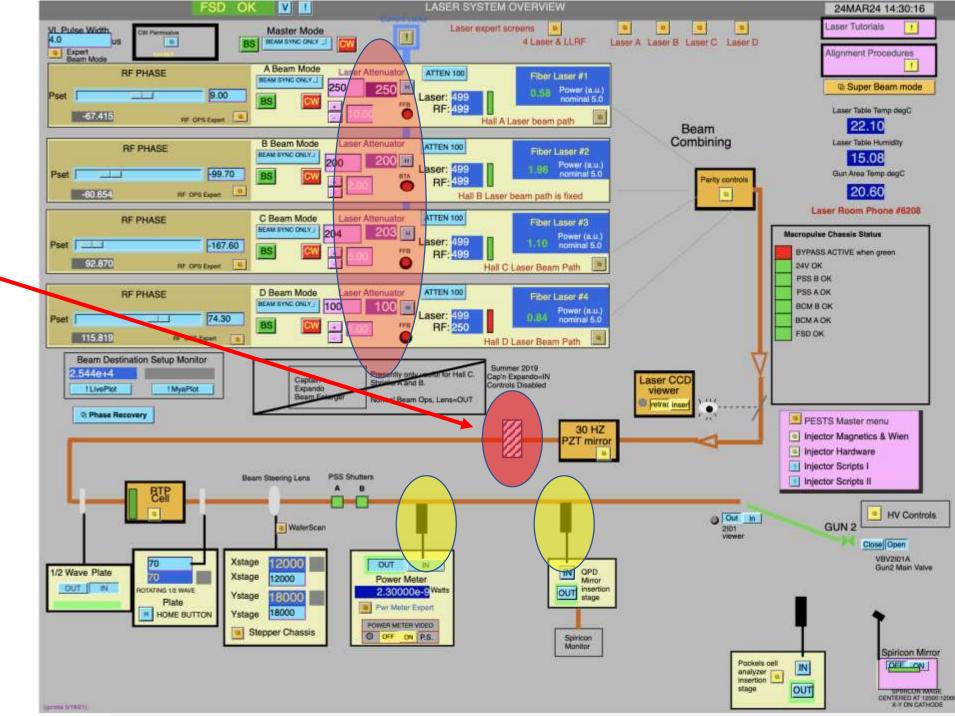
- BS mode 100% power, shutter closed
- VL/TM mode- >99% laser power going thru, shutter open
- CW mode 100% power going thru, shutter open
 - ✓ <u>It's necessary to monitor HWP</u> position
 - ✓ <u>Control follows if needed</u>



Risk Mitigation

Near terms: this additional shutter could be the simplest and most reliable approach to prevent similar incident to occur.

Only need to be synchronized with the 4 shutters, i.e. open/close with any of them



Risk Mitigation

Enhanced Procedure: multi-point check out

these blocks between an Het Check-Cost (HOC) checklist (Weising A. 1977) (1) Hight - Waveforms Endeated - for shacked, and was fillent not needed Perform that with fried attribution · Appoint France on a scope Staff performing HOD thes 1 - Weard increasing Indicate role if lases and homed - Onion type (19 star/81) - Viewer Landed (4 star/61) militate pass (+'UTail +) for each function. Veryan Lindset 130 autober a. Hall A (Sector in: IMG/THIG., Mexeplate/, Moder/) Date Mitche Of-mightly - Beam Syler bleather phrasel, waveglate in Tune Mode (208 cardin Verser Landed (shuffler spen, waveplate tri) Confidences When (4 she/dry "Tune blocks (deutter spers, waseplate eid Ionithopos Were (shufter open, wereplate out) Half & bettemaster ---- , power - _____ mill 1 made sync (2 mm/Hz) h. Hall & Stend its. 1945/1960. Herergister, Studier /J. itemer Leveland 34 yes, Vite teacht type: (chuffer ideach, similate rol Veryee' Lended (30 aL/0s viewer sanited jobufter spen, waveplate (r) Tune Mode of paylor Tana kilode (shuftar spart, waxwphate inj Take block (100 us/dk Continuous New (HopeW) 1. Hall (Scholm: TBR/TMG, Manuplate/, Startury) priver - RW - Basin Saint faith that thread, waveplate in Octavet syster 14 mar/dec Viewer Linked plauffer upon, waveplate inj Vervier Limited (d. co., Vilu) Veryw Limited (10 apple . Tune bunks (shuffler name, wavenade ind Contributions Were Schuller scores receipted a cut Tune Mircle (4 calu/MV) Tune Mode (208 uards) Continuince Wark 04 could've 8. Hall D [Serial In: TME/THIG - Wereplate/, Shother/) · mean type the dry things, wantplate the Weight' Limited plotter open, weighten't BRUM BYTE 14 (SAL BRU Turna twicele fashuttion opens, wasveplate with Vesser Limited 14 ma/divi Vesser Limited (20 au/dis) --- Costrausus Www (shutter span, www.plate.col) Tate Marke Monthled Calls Mode (2011 Juli) -Contribution Wave Drama/dry Tune Mode Generator Hot Check-Out (HCO) checklist (version 2, 4/2/24) Mary 8 - December 1 had a break and street in electronic lands and Allach checklish and scope Yaomi to TLUD, W00,04 army

Staff performing HCO:		
Date:		

Step 1 – Visual inspection (indicate n/a if laser not tested)

- Indicate pass $(\checkmark)/fail(\varkappa)$ for each function.
 - a. Hall A (Serial #s TMG/TMG-, Waveplate/, Shutter/)
 - Beam Sync (shutter closed, waveplate in)
 - ii. Viewer Limited (shutter open, waveplate in)
 - iii. Tune Mode (shutter open, waveplate in)
 - Continuous Wave (shutter open, waveplate out) iv
 - Mataa

Risk mitigation

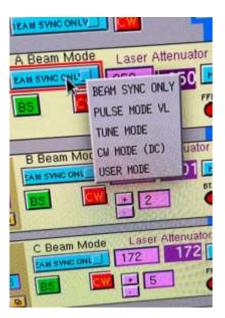
Immediate/short-term

- Laser power automatically go to minimum Ops setting such as "Atten/100" when switching mode
- Additional shutter

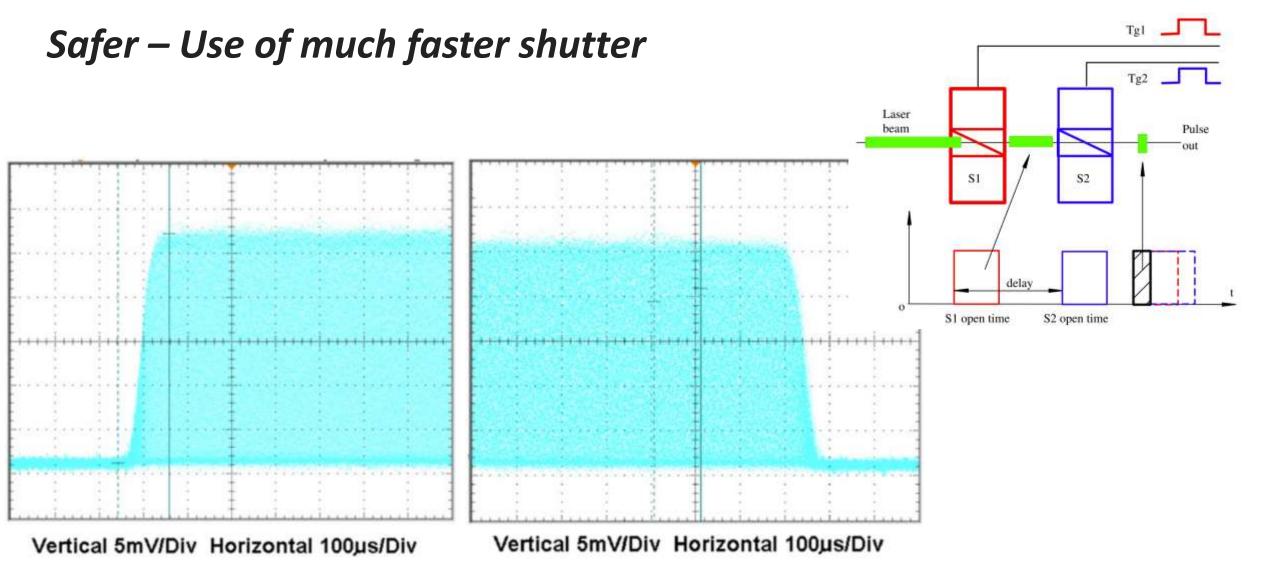
Long-term

- Implement variable rep rate, 1, 15, 30, to 60 Hz (existing, fixed)
- Go to "**B. Sync**" mode and the **lowest rep rate** (1Hz) whenever beam mode/machine status changes. Laser power detector goes in prior to "Beam Permit"
- Increase pulse contrast, new crystal
- Shutter open/close status signal-**position sensors**
- Realtime beam mode monitoring / **Oscope signal** to MCC
- More frequently **check up** on system parameters
- Faster shutters
- Improve procedures

Rename the attenuator? The attenuator reading scaling (0 up to 1000) may cause confusion, max attenuation is x1000, which actually gives the max laser power!

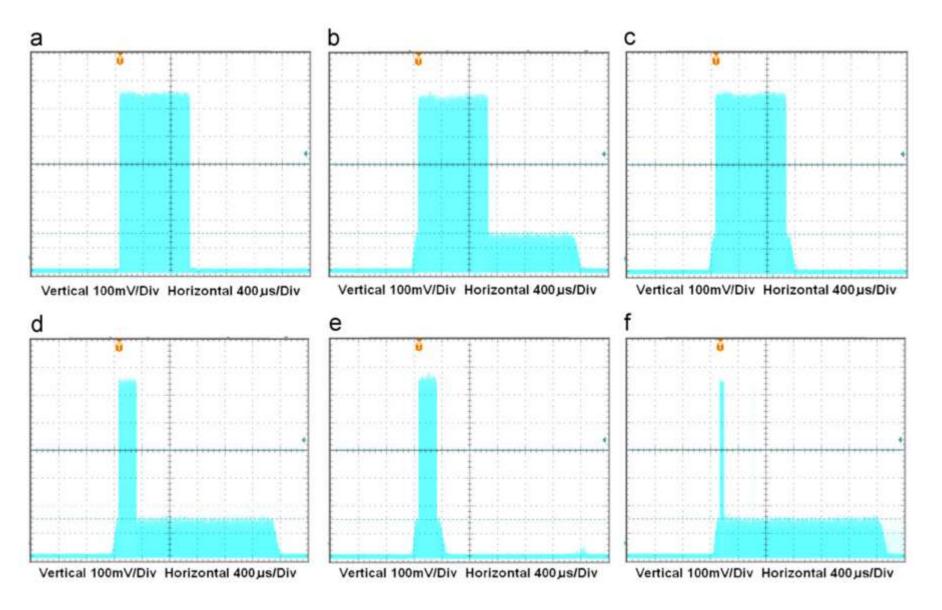






S. Zhang, etc., "A simple gating technique for high-average-current photo-injectors", Nuclear Instruments and Methods in Physics Research A 629 (2011) 11–15

Safer – much faster shutter



S. Zhang, etc., "A simple gating technique for high-average-current photo-injectors", NIMA 629 (2011) 11–15