Laser Systems: Status and Upgrades

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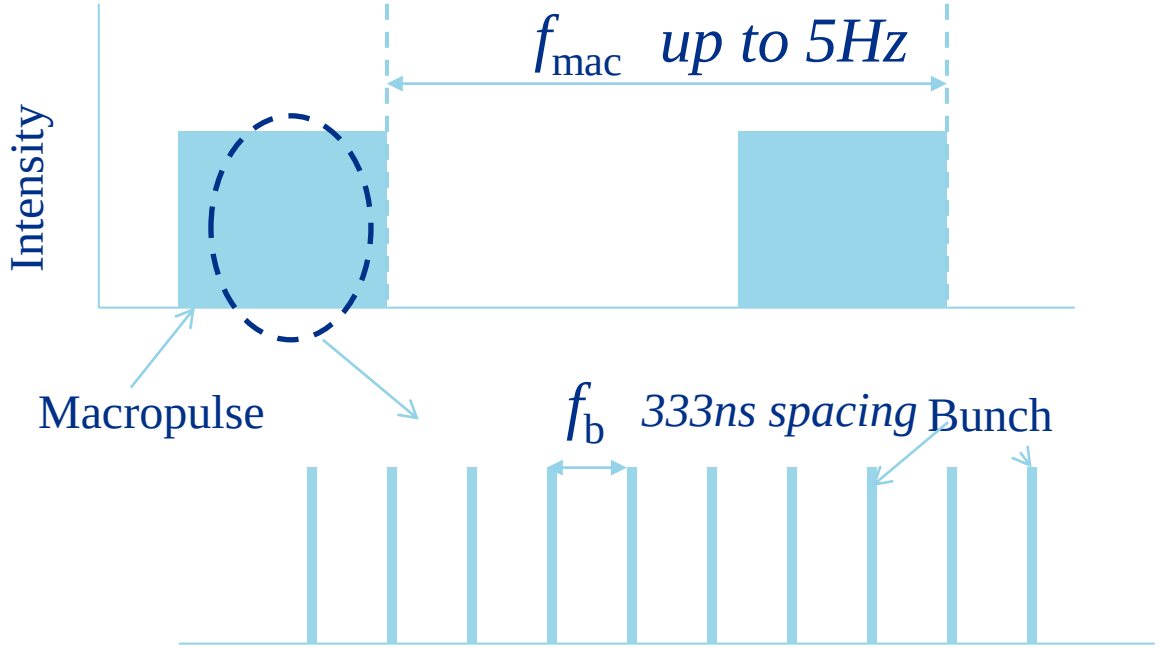
IOTA/FAST Collaboration Meeting

13 March 2024

Outline

- Current laser status
  - Laser structure
  - Laser diagram and user interface
  - Laser performance
- Near future laser related upgrade
  - Seed laser upgrade
  - Amplifier upgrade
  - Other emerging laser activity

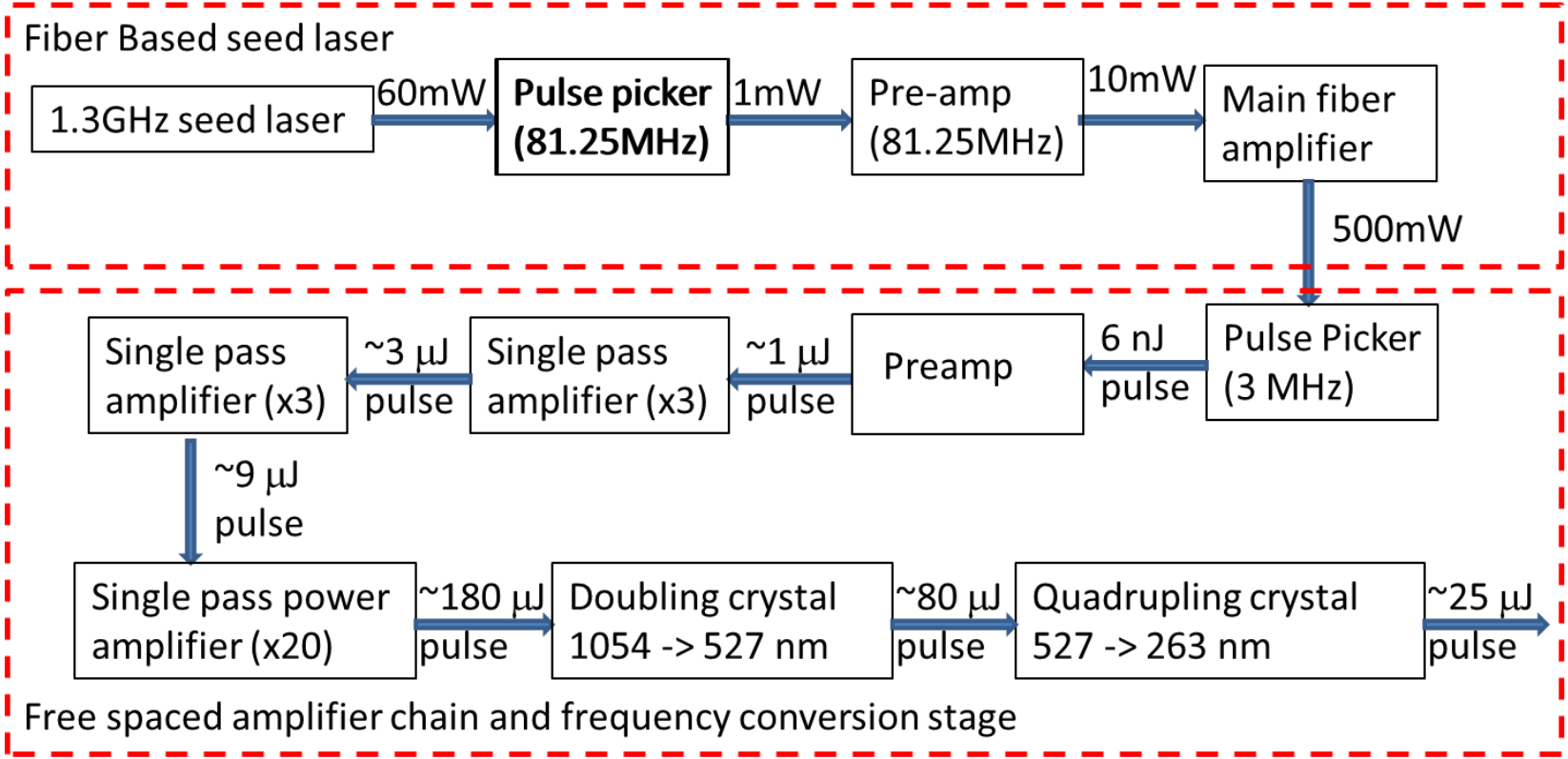
Basic Laser Time structure



Laser Capability

Laser parameter	Nominal Value	Range	Note
Wavelength	263nm	N/A	
Bunch Length	3 ps (RMS)	3-20ps (RMS)	Long pulse is established with pulse stacking. It has been built and tested inside the laser lab.
Micro Bunch Frequency	3MHz	0.1~9MHz	
Macro pulse Frequncy	1Hz	<5Hz	5Hz laser operation has been tested inside the laser lab.
Beam size at cathode	1mm (RMS)	0.1~1.5mm (RMS)	Beam size is controlled with both Iris and imaging optics.
Micro bunch # within Macro bunch	10	<3000 at 3MHz. The maximum duration is 1ms	1ms pulse at 3MHz is demonstrated inside laser room. Only tested during Gun commissioning stage.

System Diagram



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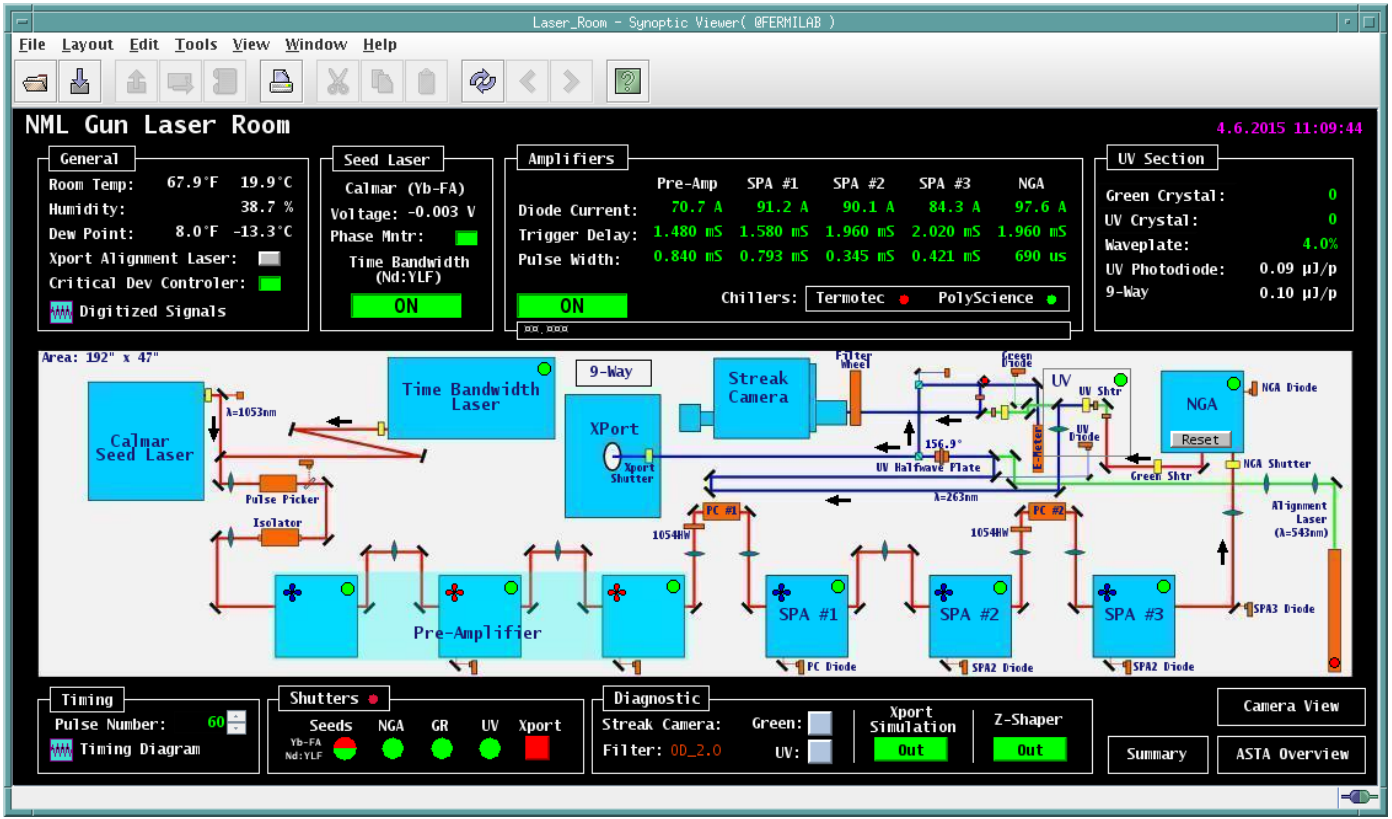
Graphic User Interface



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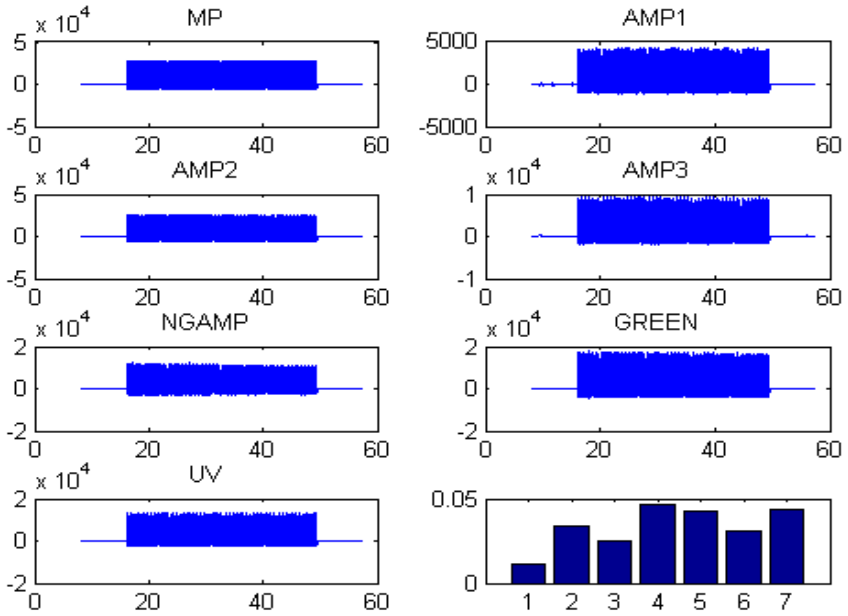
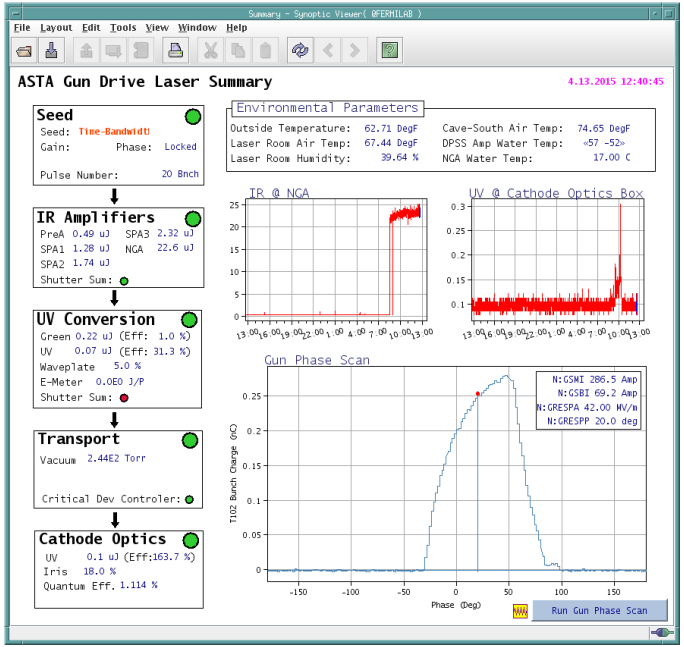
System Performance (normal running condition ~100 pulses)





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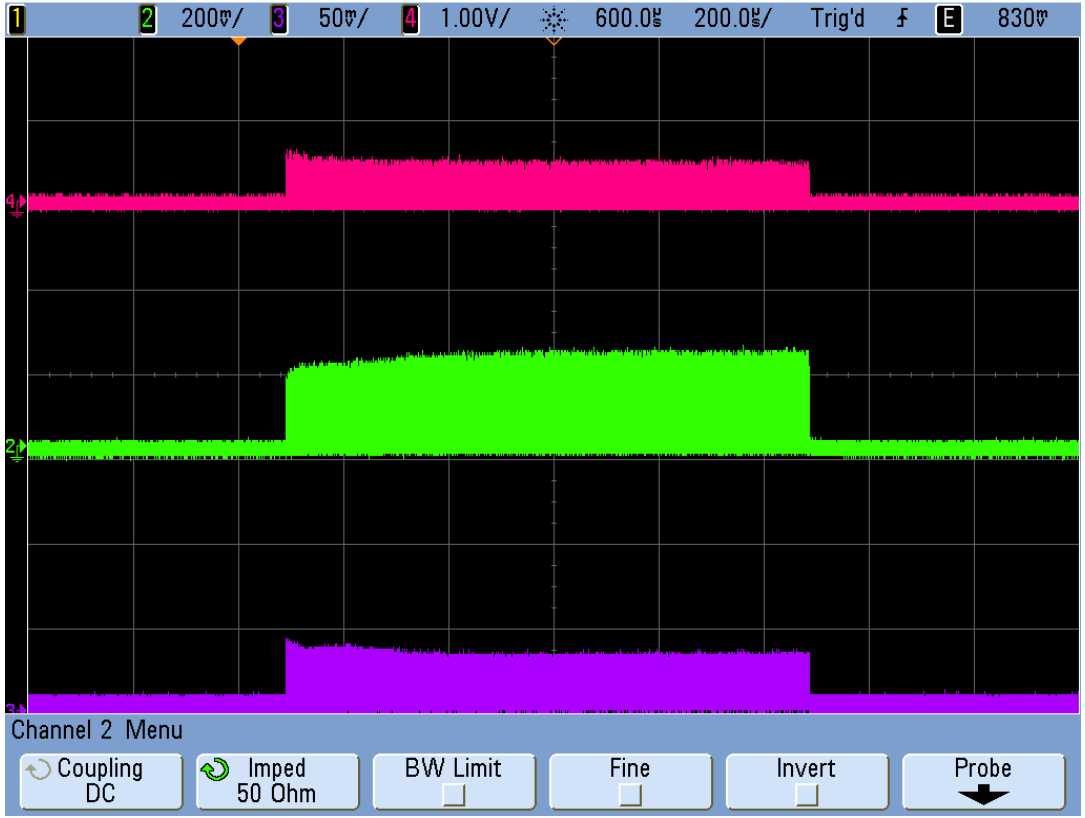
Long pulse result (inside laser lab) 1ms long 3000 pulses



IR (1054nm)

Green (527nm)

UV (263nm)

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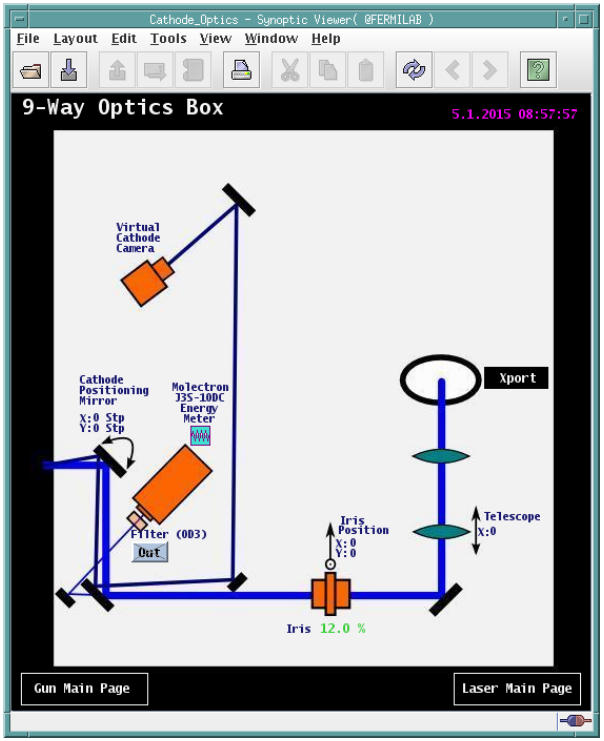
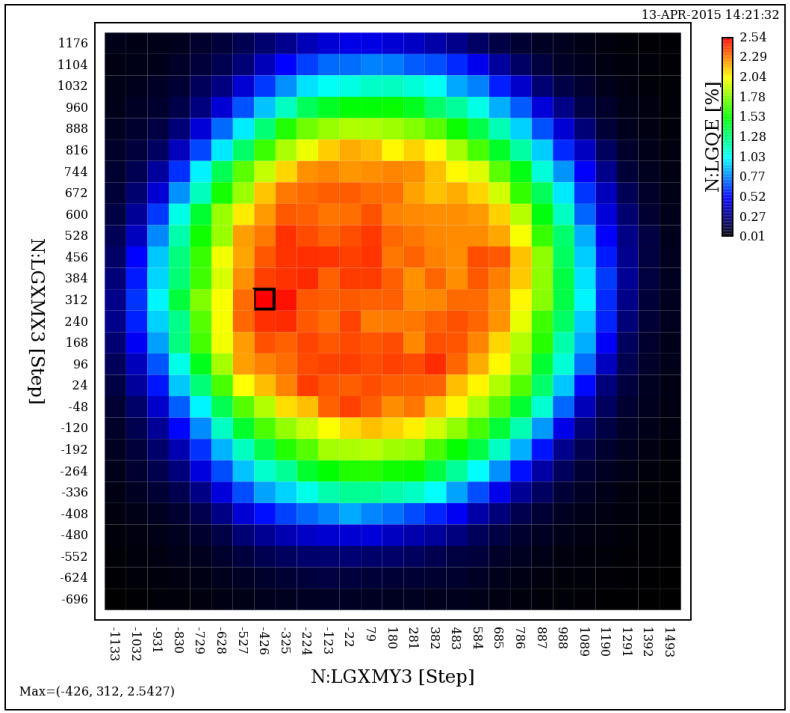
QE Scan (Scan is done after cathode is put in)





some degration was found at run 4 scan. QE dropped.

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Current Status

- Laser is up running with 3MHz pulse train and 5Hz repetition frequency
- User interface is setup
- Long pulse train can be setup inside the laser room
- During Run4 Laser related stoppage is minimized
- Right now we are in shutdown for IPI installation however the work is still ongoing
  - Start of OSC research program (See Jonathan's talk)
  - Upgrade of the drive laser for next run

Upgrade plan for future possible FAST/IOTA collaboration

- Second laser room in ESB is in construction phase to provide space for FAST/IOTA users
  - Let the user preparing their own laser just as FAST GREEN experiment
  - At the same time we can have our own laser system installed for the next phase of OSC experiment
- Amplifier Upgrade opportunity
  - Make the laser turn-key system with more fiber amplifier
- Seed Upgrade opportunity
  - Our ultimate goal is to be able to provide users with controllable bunch length start from 1ps to 100ps

Amplifier upgrade

- As shown in the diagram a larger portion of the amplifier chain is based on free space solid state amplifier
- We purchased a rod-based fiber-amplifier from Optical engine last year.
  - For next electron LINAC running we would like to replace majority of the free space amplifier with single stage of fiber-amp
    - Better beam shape
    - Easier alignment
    - Turn-key system

Seed Laser upgrade- long term goal

- Currently 1.3GHz fiber laser with a bunch length of 5-6 ps. Fairly stable.
- Most question asked by different collaborator
  - For my experiment can we change the bunch length to longer or shorter
- Can we deliver that?
  - Longer? Yes. If we want to make the bunch length longer we normally will stack the bunch together in time. But the setup is not easy and the range is very limited as well. Maybe up to 20ps long
  - Shorter? Sorry we can’t do it.

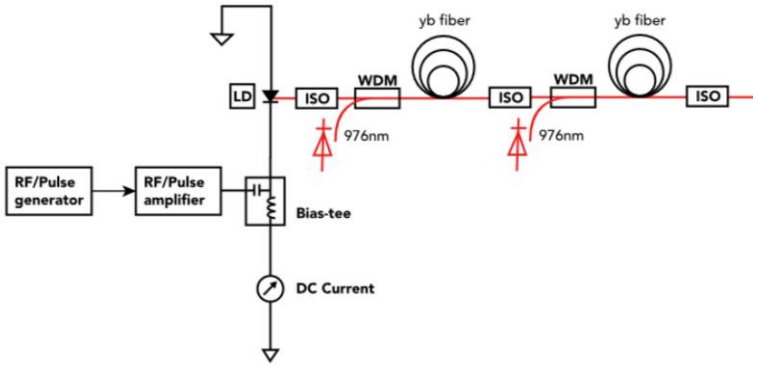
Long seed pulse generation

- Concept

A Versatile and Highly Reliable Green-light Drive Laser for High Current Photoinjectors

S. Zhang†

Jefferson Laboratory, 12000 Jefferson Avenue, Newport News, Virginia, 23692, USA



- We can experimentally test the laser response (amplified and not amplified)
- Lastly, we compare simulation to experimental results to confirm the MATLAB model

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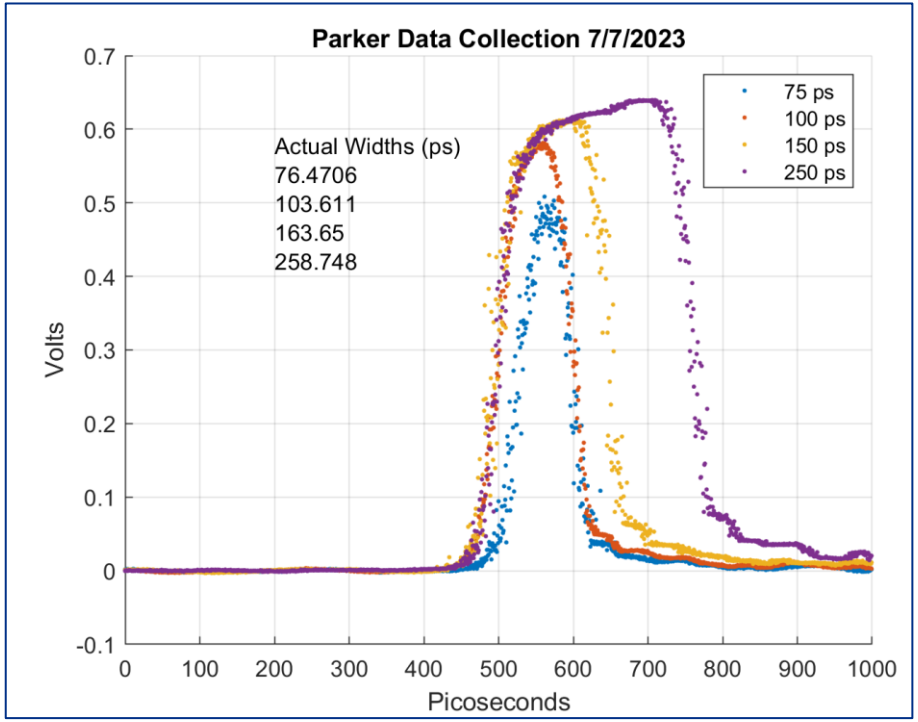
Long pulse generation - Electronic pulse generation



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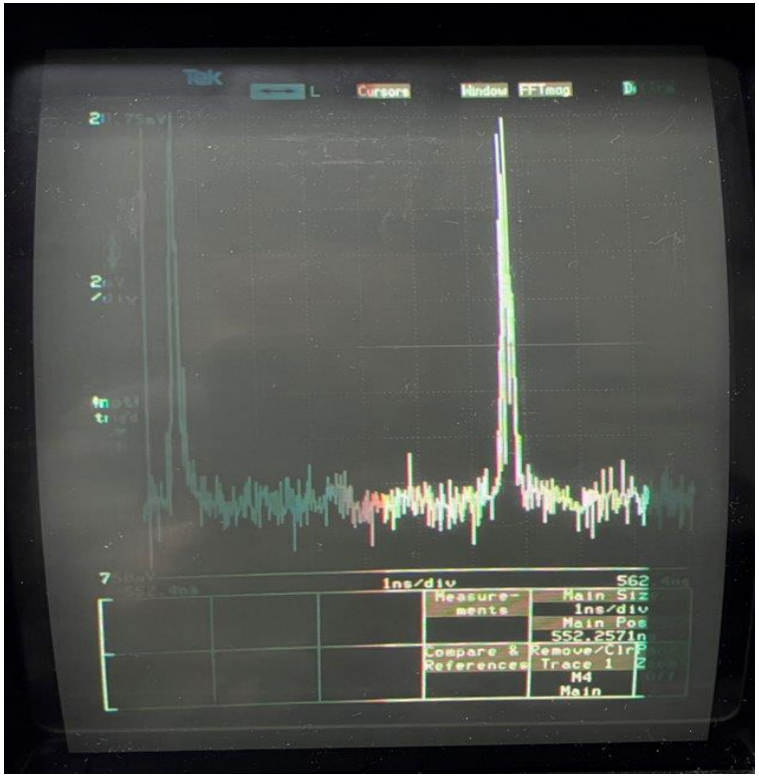
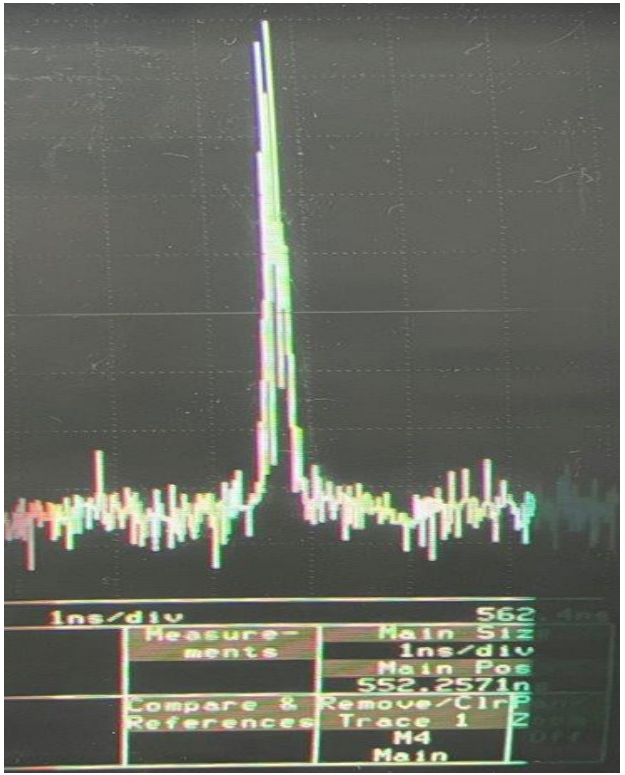
Very prelimary result





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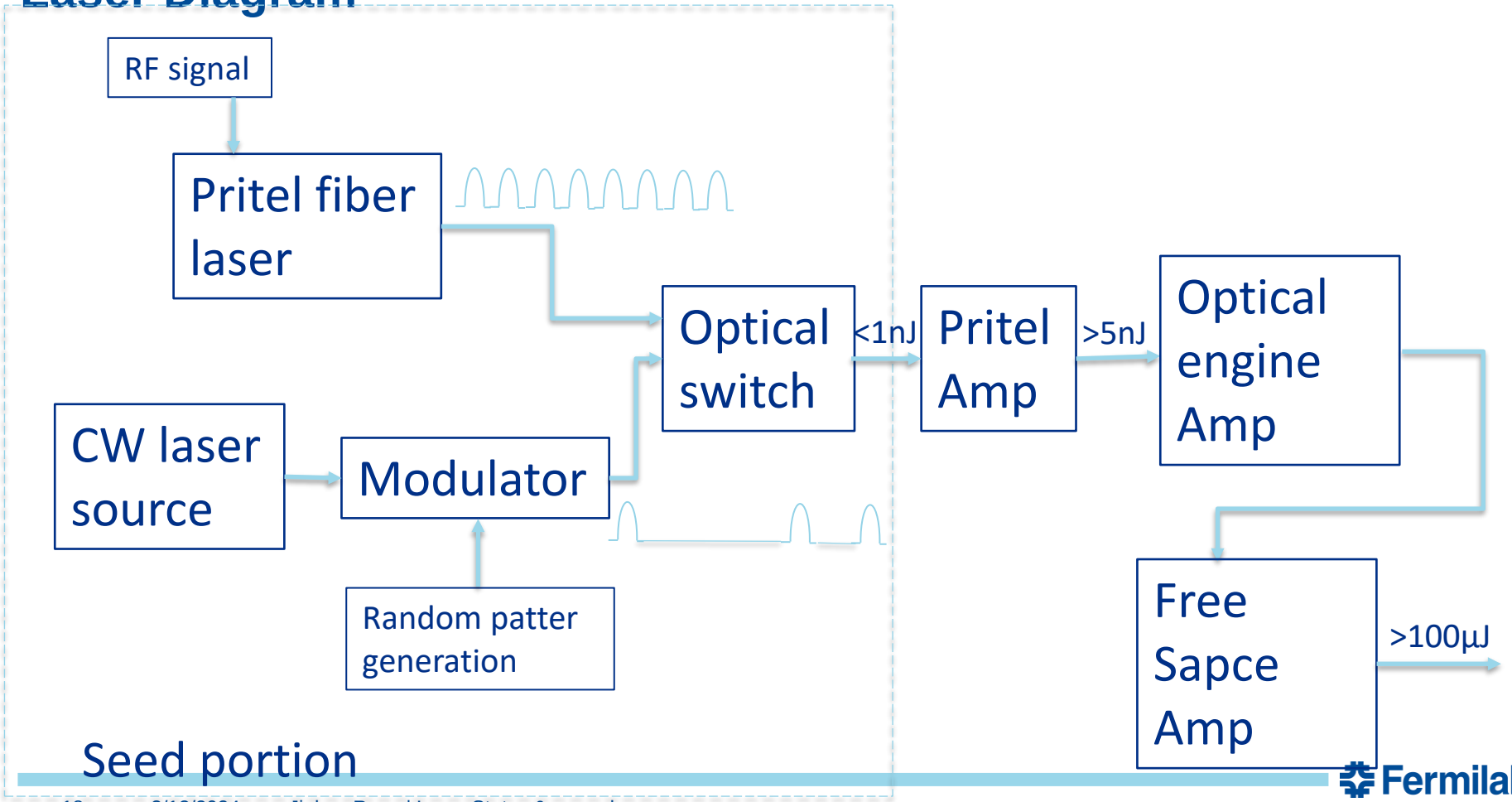
Pros and cons

- Pros
  - Be able to adjust pulse width quickly
  - Easy to setup and control arrive time
  - Very suitable for Laser wire experiment
- Cons
  - Pulse will be limited to 20ps to around 100ps FWHM
    - Longer than 100ps can still be delivered with fiber base modulator concept just as used in Laser stripping in Booster

Possible application:

- PIPII Laser wire system
- Laser striping system
- OSC pump laser system
- Photocathode laser system

Laser Diagram



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Conclusion

- Overview of the current laser system
- Ongoing laser related work
  - ESB laser room
  - Seed laser upgrade
  - Amplifier upgrade

Waiting for our collaborator’s input