Cornell Laboratory for
Accelerator-baSed Sciences and Education (CLASSE)

ERL 2011
the 50th ICFA Advanced Beam Dynamics Workshop on Energy Recovery Linacs

Progress with High Power Drive Lasers for the Cornell Injector

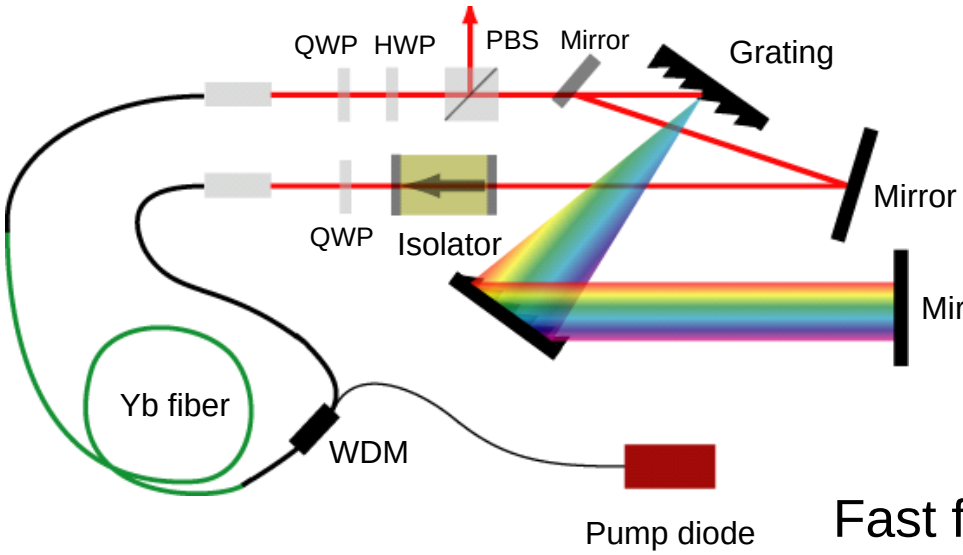
Bruce Dunham, Zhi Zhao, Adam Bartnik, Florian Loehl, Heng Li, Ivan Bazarov

Outline

Laser Systems for diagnostics and for high power

- 50 MHz laser for diagnostics
- 1300 MHz laser for high power
- Mirror issues
- Pockels Cells
- Power stabilization
- Extinction ratio
- Current ramp up

50 MHz Oscillator

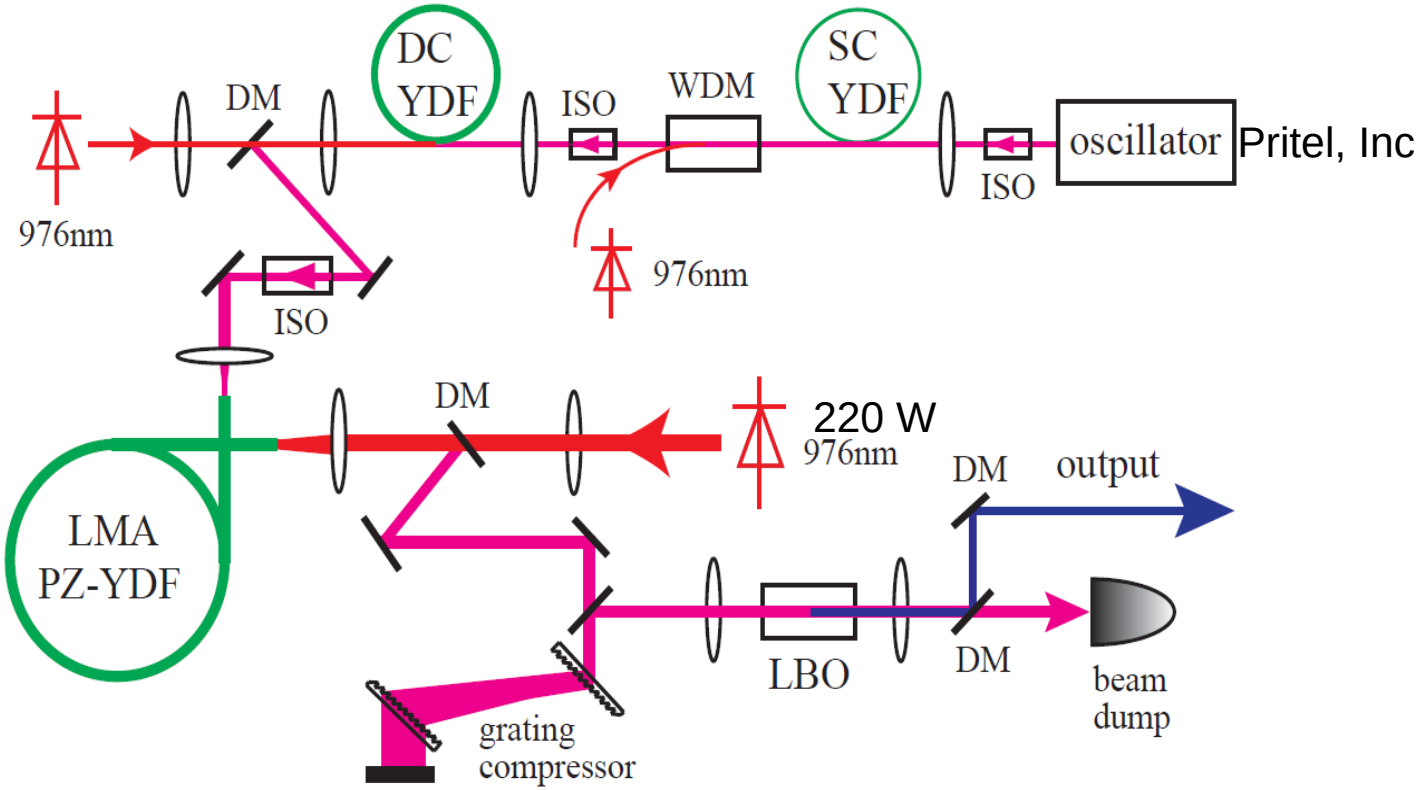


Key to 50 MHz laser with a homemade oscillator – environment. Temperature +/- 1 C and humidity +/- 5%

Fast feedback using a small piezo + mirror and slow feedback with a linear motor + digital feedback. Jitter is < 1 ps

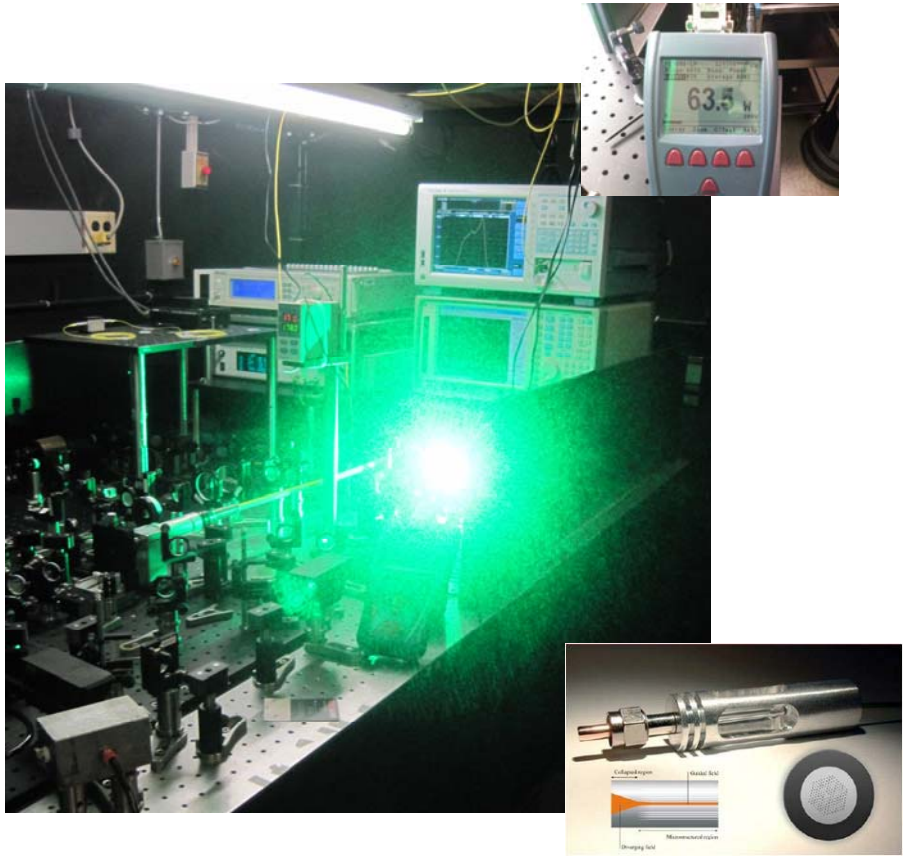
We use this laser so we can perform full bunch charge measurements at reduce rep rate (1300/50 = 26X less). It is now nearly maintenance free.

1300 MHz laser Schematic



SC: single-clad; DC: double-clad; ISO, optical isolator; DM: dichroic mirror; LMA PZ-YDF: large mode area single-polarization Yb-doped fiber; WDM: wavelength division multiplexer;

1300 MHz laser



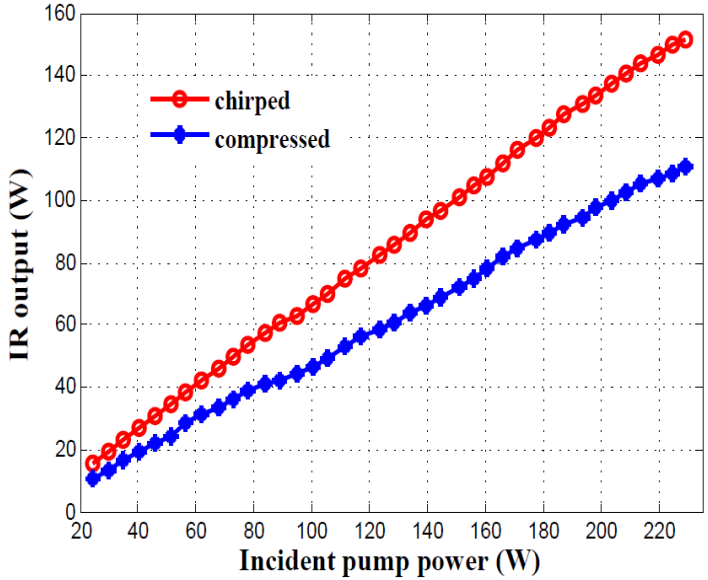
Commercial fiber terminator

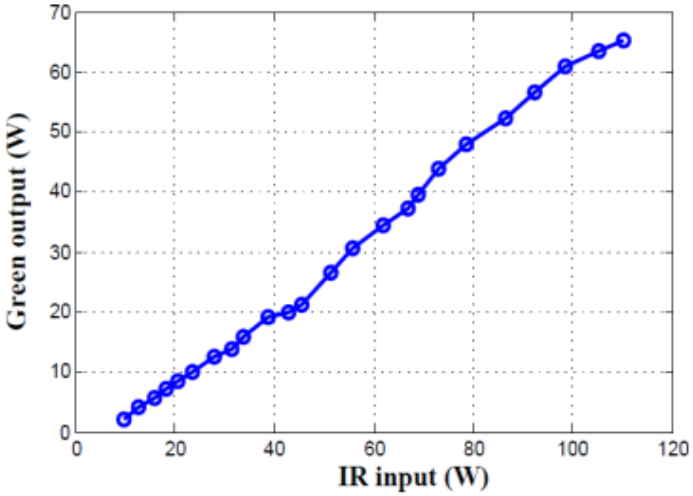
After recent improvements, we increased the average power from < 15 W at 520 nm to over 60 Watts!

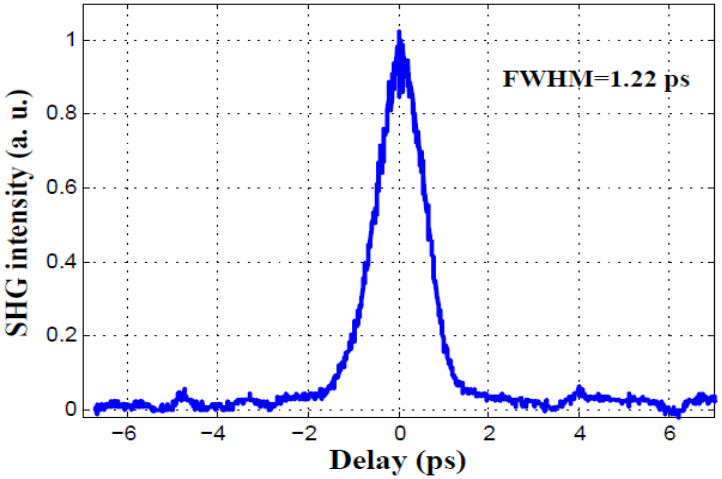
Added a second pre-amp, compressed the pulse after the amplifier to reduce non-linearities instead of before it, and starting using commercial, high-power fiber terminators.

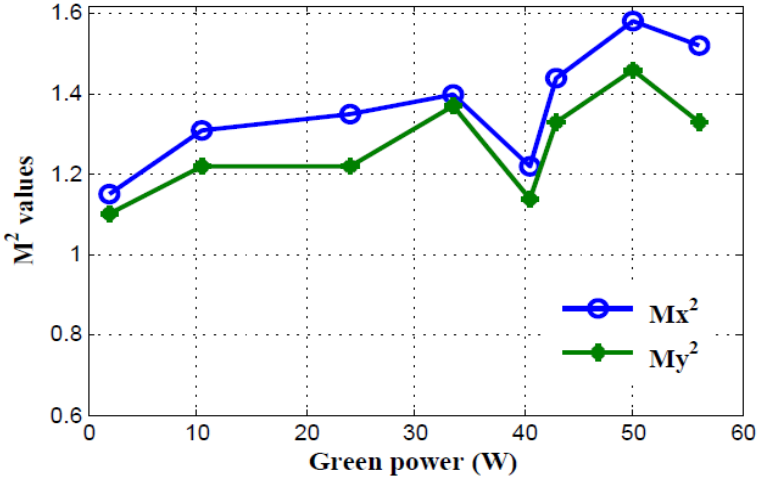
Now, we have more headroom for dealing with cathode lifetime, and shaping and transport losses

1300 MHz laser Measurements

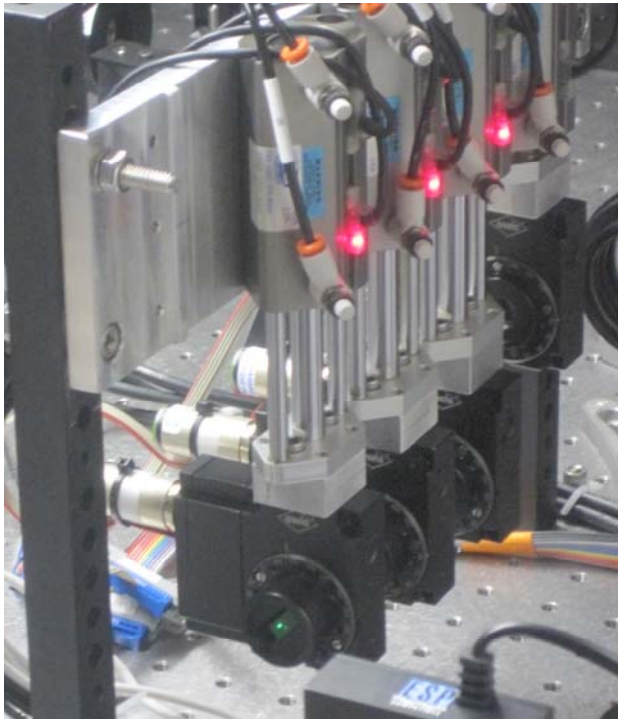




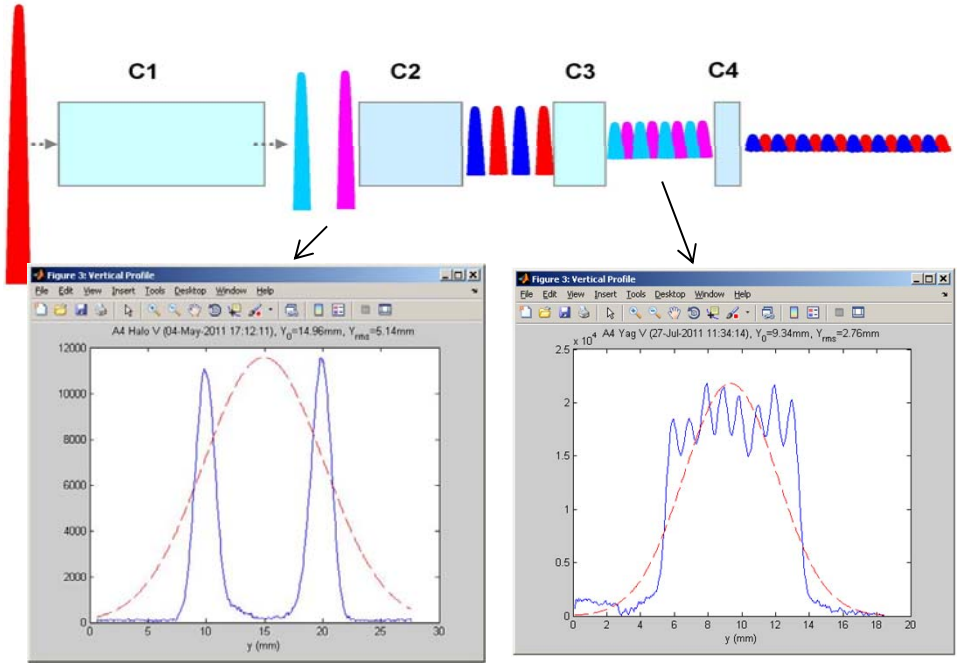




Longitudinal Shaping



Remote control for each crystal: can insert and retract them, and adjust the rotation angle. So, we can adjust the shape to optimize emittance



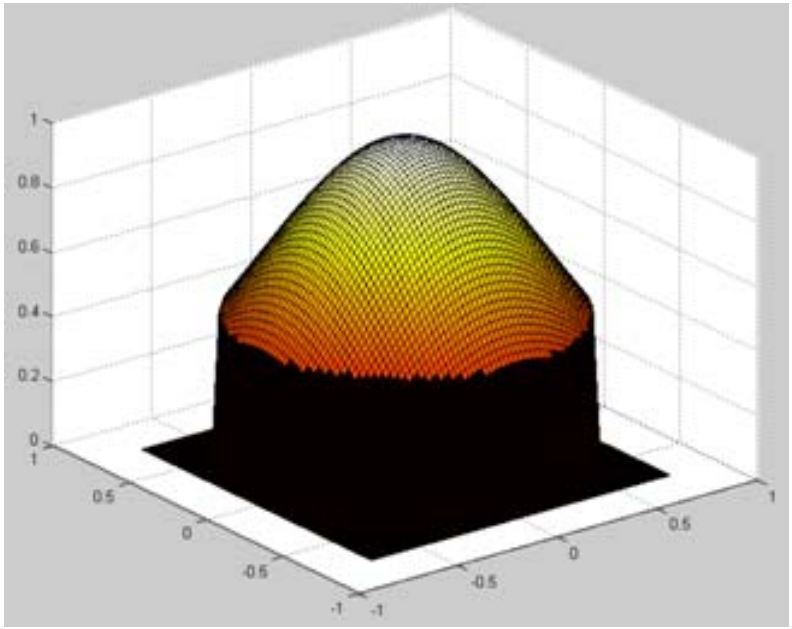
A series of birefringent crystals are used for longitudinal shaping. The only drawback is that the linear polarization shifts 90 degrees from one pulse to the next

Transverse Shaping

We tried commercial shapers for making flat-top beams, but they only work for perfect conditions.

Recent simulations are predicting that the best transverse shape is closer to a truncated Gaussian.

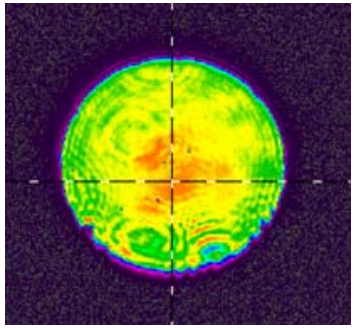
Experimentally, changing from flat-top reduce the emittance 10-20%. With the 'perfect' shape, another 10-20% reduction is possible.



Today, we simply image the laser to the cathode from a pinhole using a single lens.

Laser Mirror

Image on the cathode using normal dielectric mirror



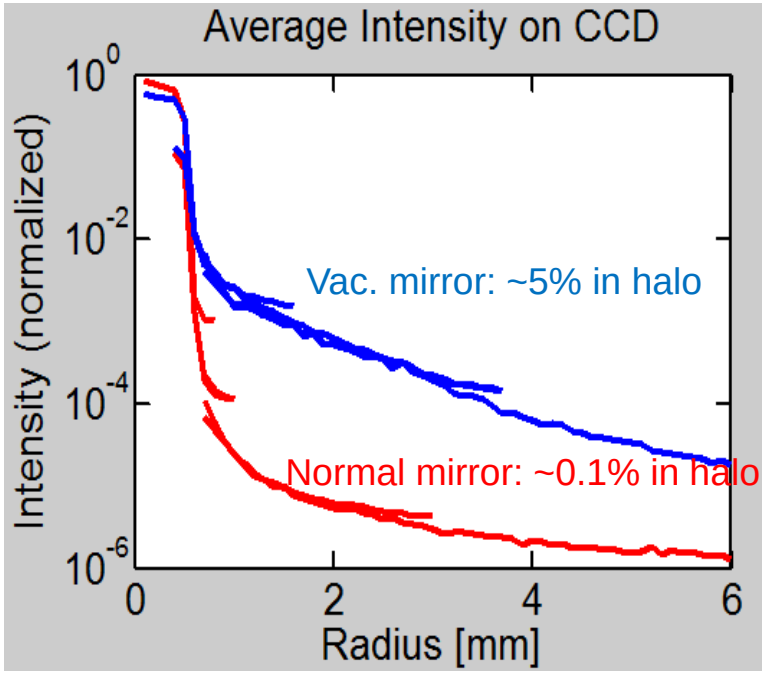
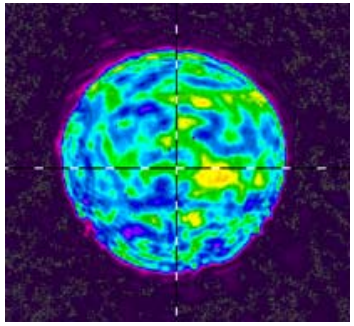


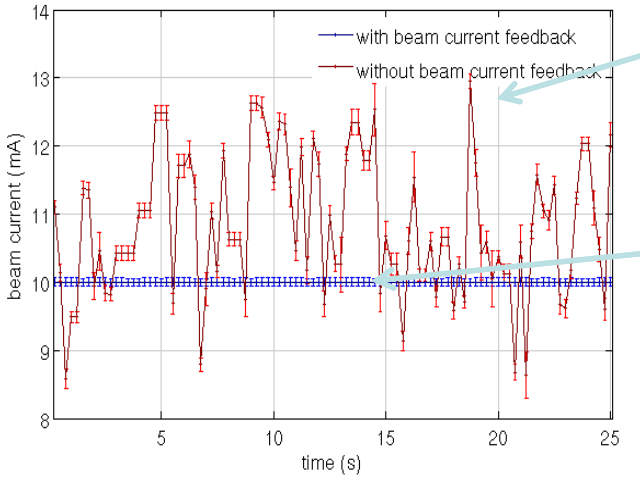
Image on the cathode using coated metal mirror

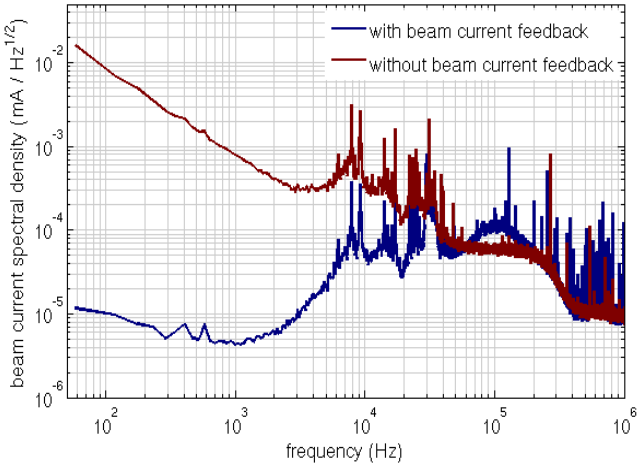


Our current mirrors scatter ~50x more light compared to dielectric mirrors (which we cannot use). This can generate halo from the cathode, so we are having new ones made soon.

Following work by a group at DESY

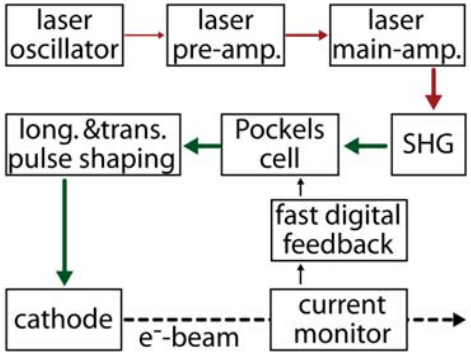
Fast Feedback - Current





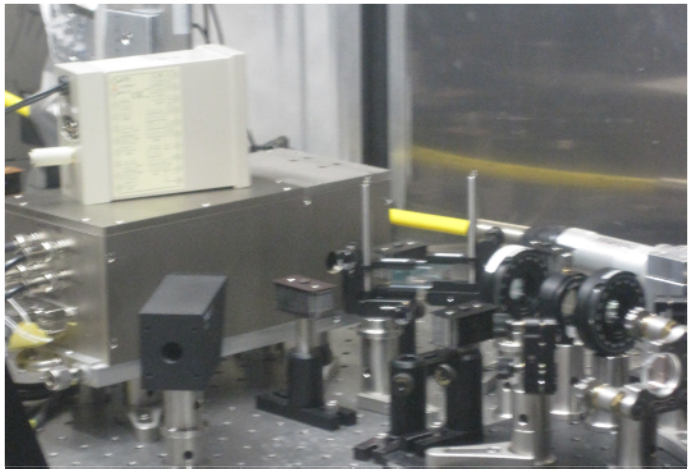
Beam current fluctuations made the RF unstable during high current operations. Due to laser intensity and position changes.

A fast-feedback system was installed, using a BPM as the sensor. This dramatically reduced the RF trip level.

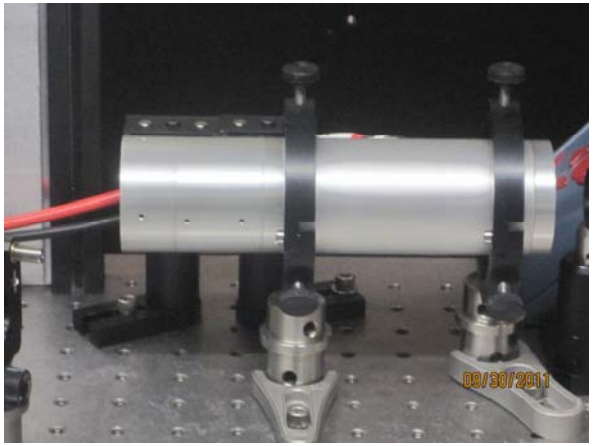


We also need the laser position stabilized to 10 μm. This feedback system is being designed, but is more difficult due to the large dynamic range needed

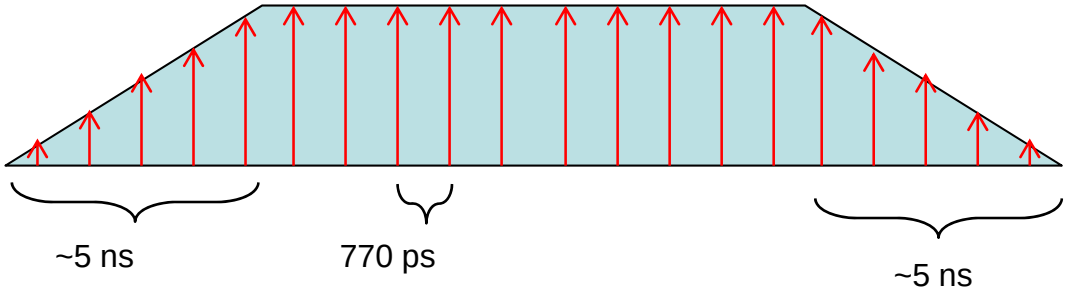
Pockels Cells



We use this BBO PC for its fast rise/fall time (5nsec) and high power handling capability (50W IR). It is limited to 5% duty factor. We now need a new device that can handle >100W IR



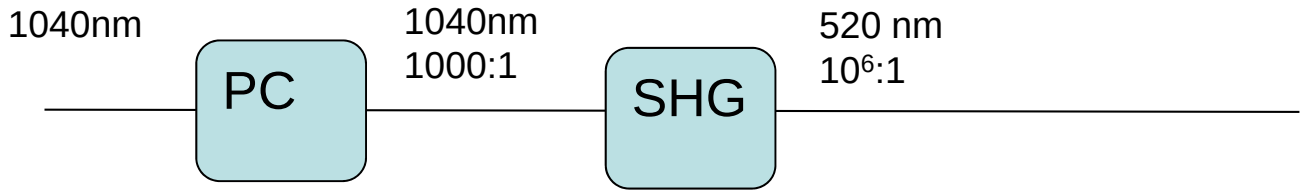
We use this Conoptics PC for fast feedback and as a fast shutter (< 1usec) for machine protection (@520 nm).



For some tests, even with 5nsec rise/fall, can end up with pulses at different bunch charges.

Extinction Ratio

We care about the extinction ratio during diagnostic measurements as the 'background' light can cause , and need about 10^6:1 for Pockels cell on:off



PC alignment is critical. Want the PC before the SHG crystal, as you gain ^2 from the 2nd harmonic generation process

Ramp up Method

Question for discussion: How to ramp up the beam current (laser power) during machine turn on?

1) Ramp up the bunch charge from 0 to the desired value in CW mode, or
2) Keep the bunch charge constant and ramp up the duty factor until it is CW

#1 is easy to do, but may be bad for beam loss as the focusing will change drastically during the ramp

#2 is what we want, but I do not know how do it with the usual Pockels cell.

Other issues: RF control response.

This work is supported by the National Science Foundation grant DMR-0807731