Green Fabry-Perot Cavity Update

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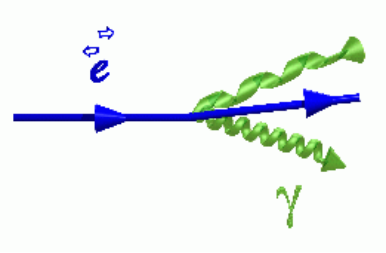


Hall A Parity Collaboration Meeting, Jefferson Lab

April 17-18, 2009

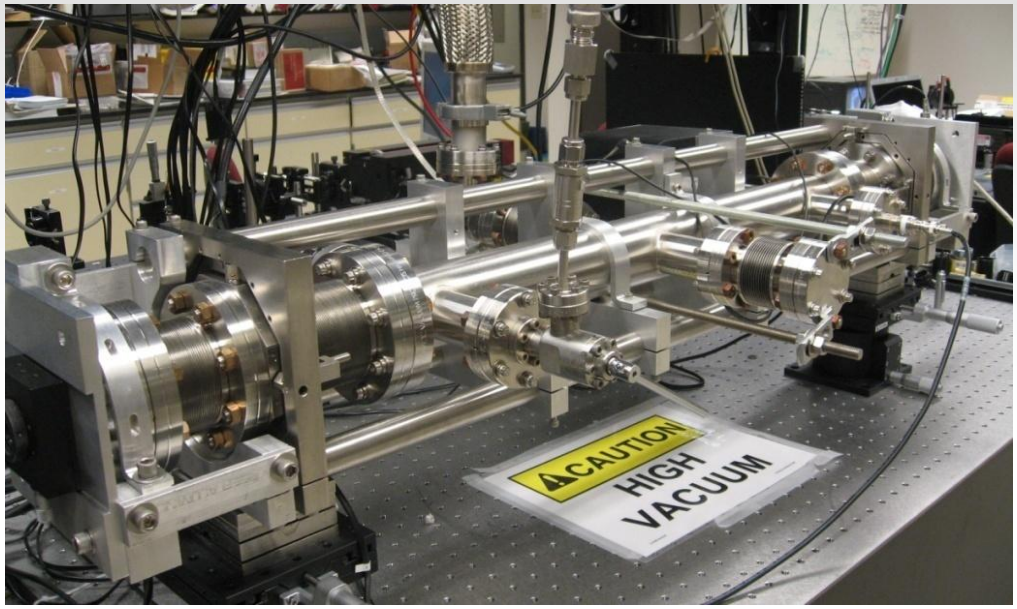
Outline

- Motivation & Installation Goal
- Challenges in Green Cavity Development
- Cavity Locking Electronics Progress
- New Clean Room & Mirror Cleaning
- Cavity Locking Progress
- Characterization of Cavity Parameters
- Current Status & Future Plans

Motivation

- Provide a polarized photon target for electron beam polarization measurement experiments.
- Replace the existing 1064 nm (IR) cavity with a 532 nm (green) cavity with 1.5kW intra cavity power, resulting in performance enhancement
- Achieve 1.0 % systematic and statistical error in polarimetry for low energy electron beam experiments like PREx .
- Cover a broad operating range of polarization measurements for beam energy between 1.0 GeV~11.0GeV
- Cut short the polarization measurement time to achieve good accuracy and makes high precision polarimetry feasible.

Installation Goal



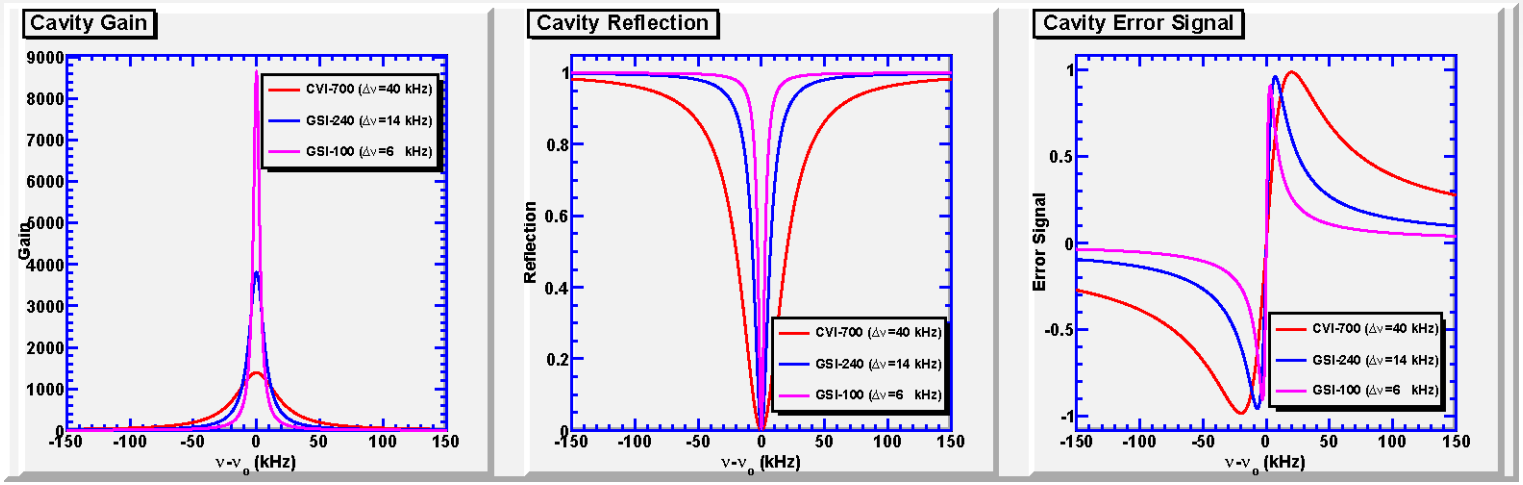
Wavelength	532 nm
Power	1,500 Watts
Gain	3,800
Q-factor	4.0×10^{10}
Length	0.85 m
Mode	CW, TEM_{00}
Free Spectral Range	176 MHz
Cavity Band Width	14.1 kHz
Mirror Reflectivity	99.9748 %
CIP spot size (σ)	87 μm

Solution :

Low power tunable IR seed laser + High power fiber amplifier (IPG) + single pass PPLN SHG → Low Finesse Cavity, Feedback to seed laser PZT to lock

Challenges in Green Cavity Development

- Medium and high gain cavity locking was never achieved due to cavity band width narrowing and inadequate locking electronics.

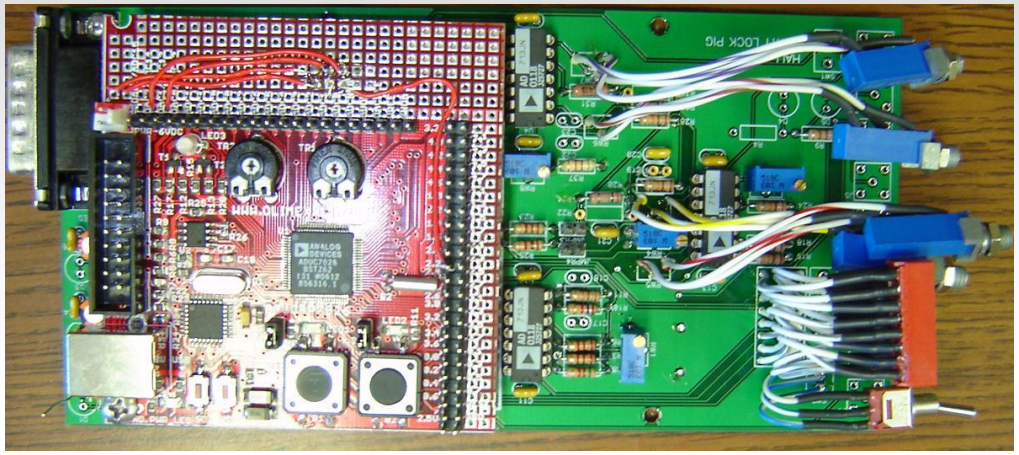


- Low gain cavity locking was robust, but the power level was much low due to losses in cavity mirrors.

- Room environment was dirty and not suitable for handling cavity mirrors.

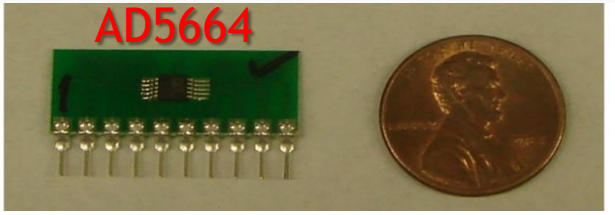
- Cavity mirror storing and cleaning method wasn't correct.

Cavity Locking Electronics Progress

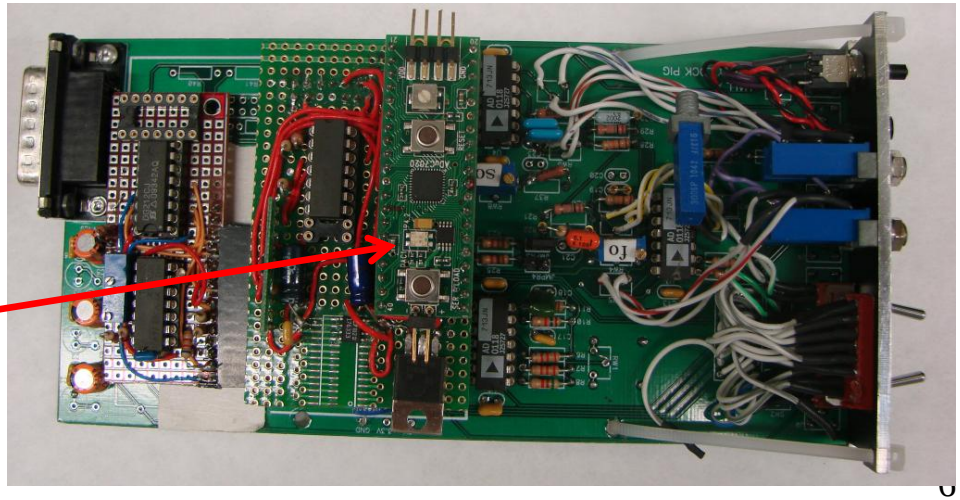


The first PCB version of CavLock box has been assembled (Dan Sexton)

16-bit buffered voltage-out DAC module AD5664 successfully integrated to Olimex ADuC7026 micro controller (summer student: Larry Lee)



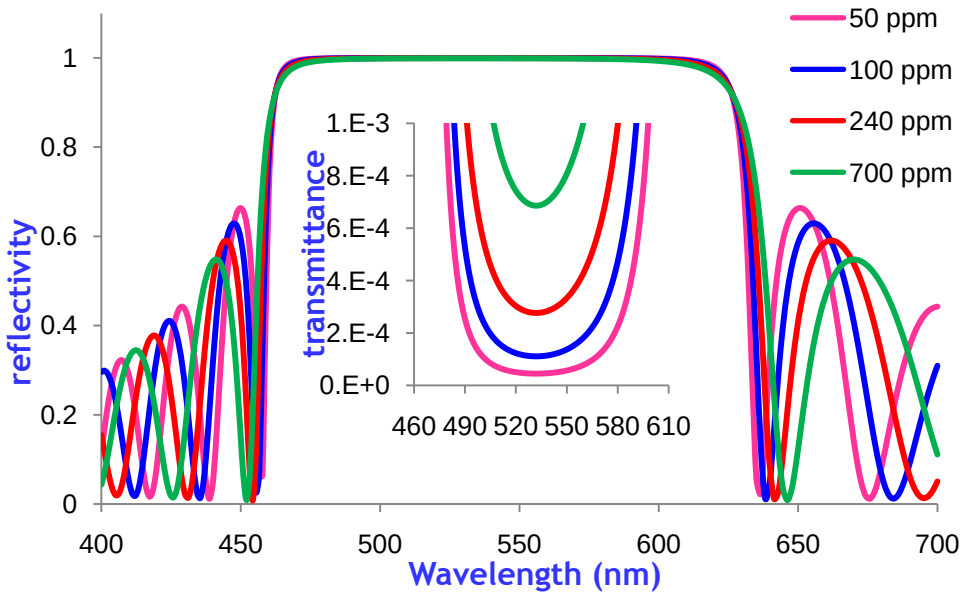
ADuC7020 miniboard has been tested and chosen as a candidate for the next upgrade of CavLock

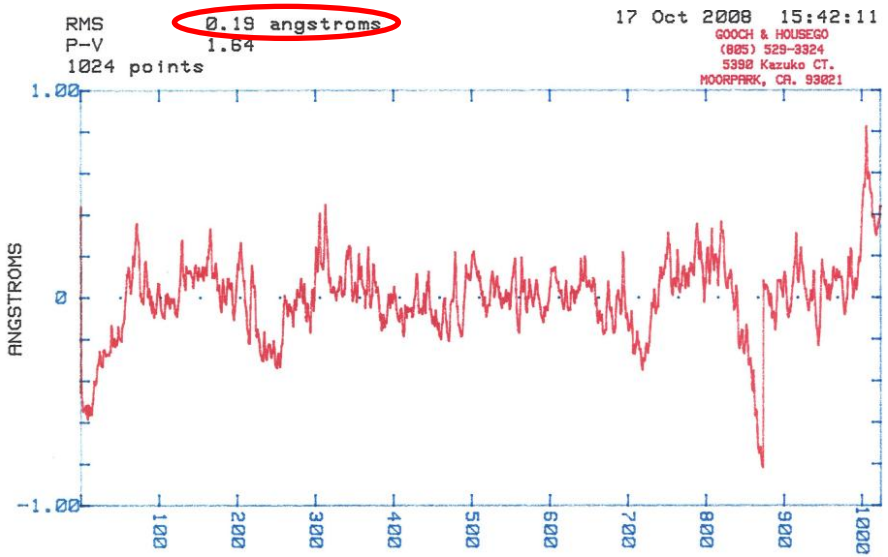


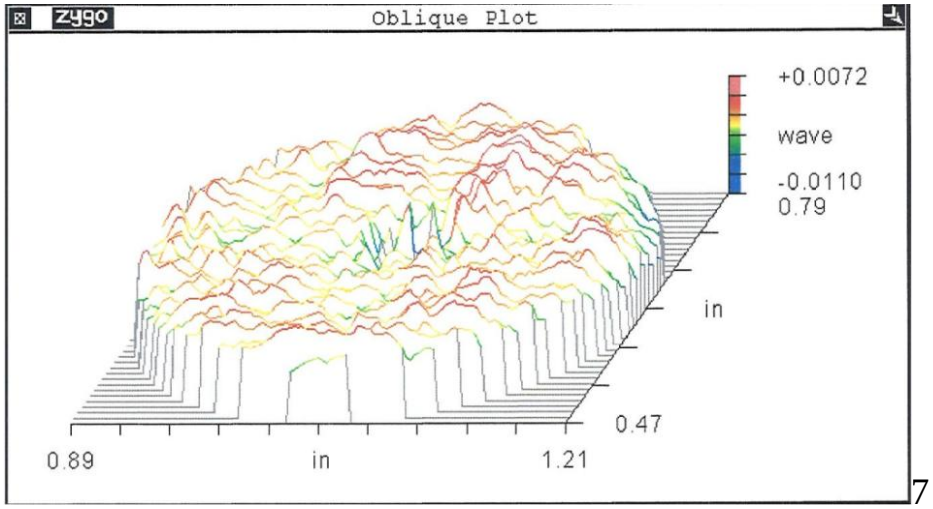
New Cavity Mirrors

ROC=0.5m, Φ=10mm, Thickness=5mm
Substrate: fused silica
Surface RMS roughness < 0.5 Å

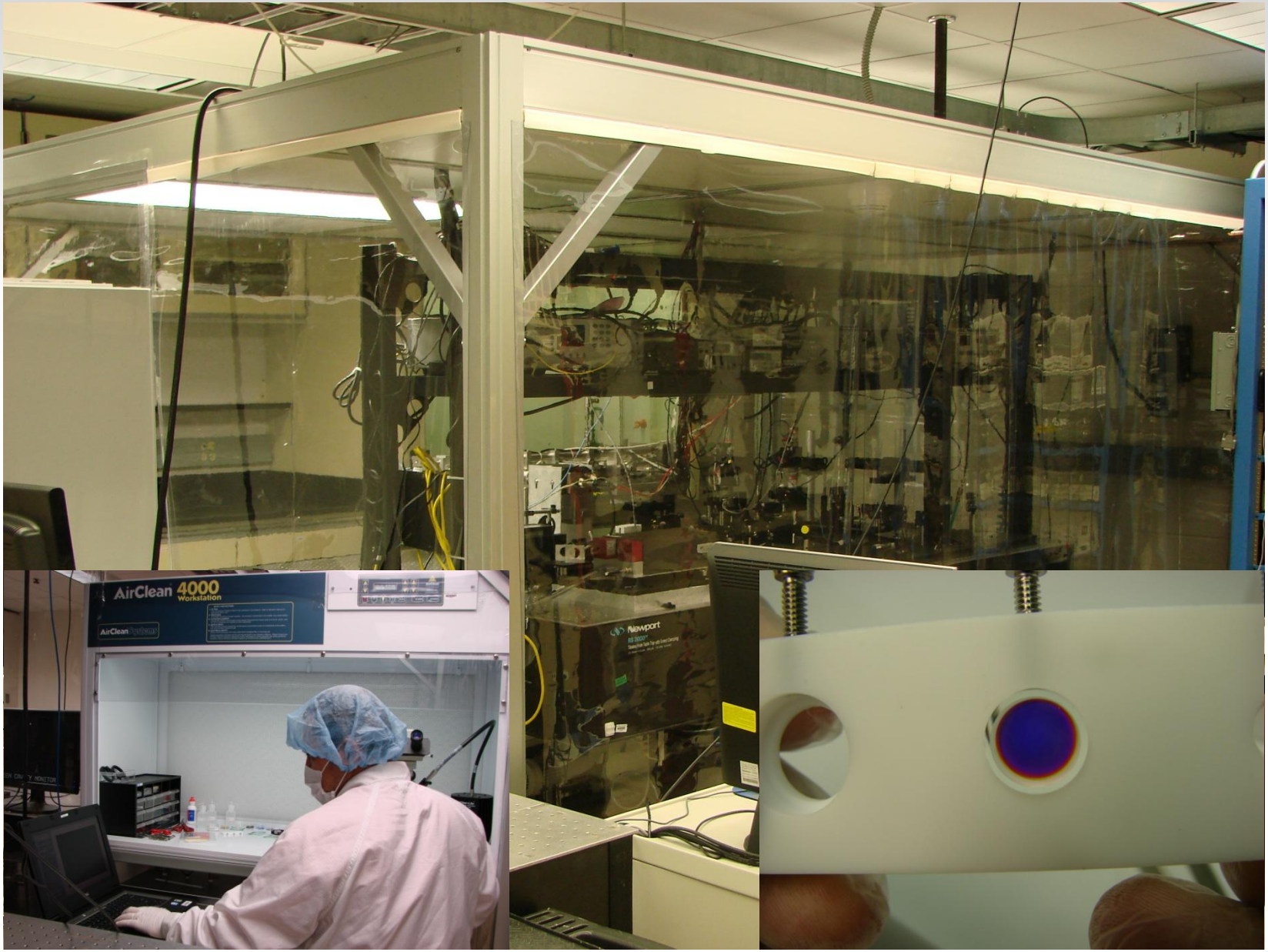
	#1	#2	#3
Transmission (ppm)	242	95	48
Loss (ppm)	< 10	< 10	< 10
Max Gain	3811	8617	14270
Bandwidth (kHz)	14.16	5.90	3.26







Clean Room



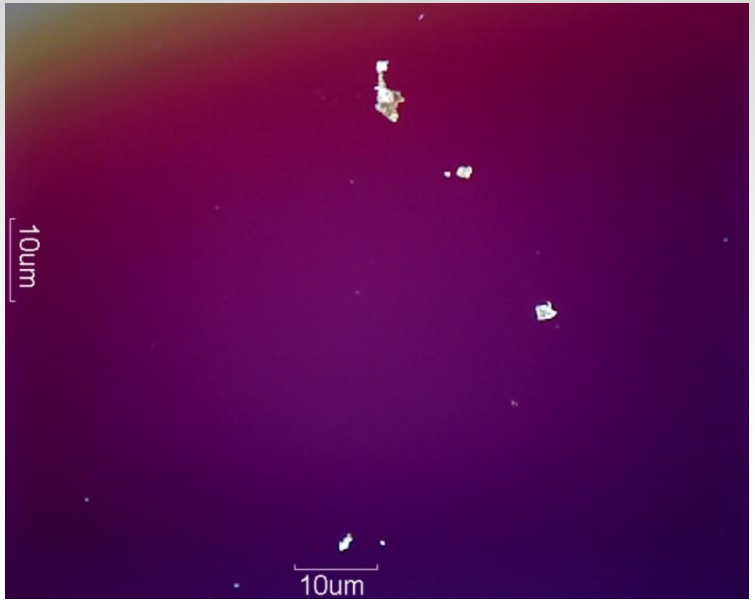
Mirror Cleaning

- Tried out many cleaning methods including contact and non-contact methods.
- Micro-90 Concentrated Alkaline Cleaning Solution worked best

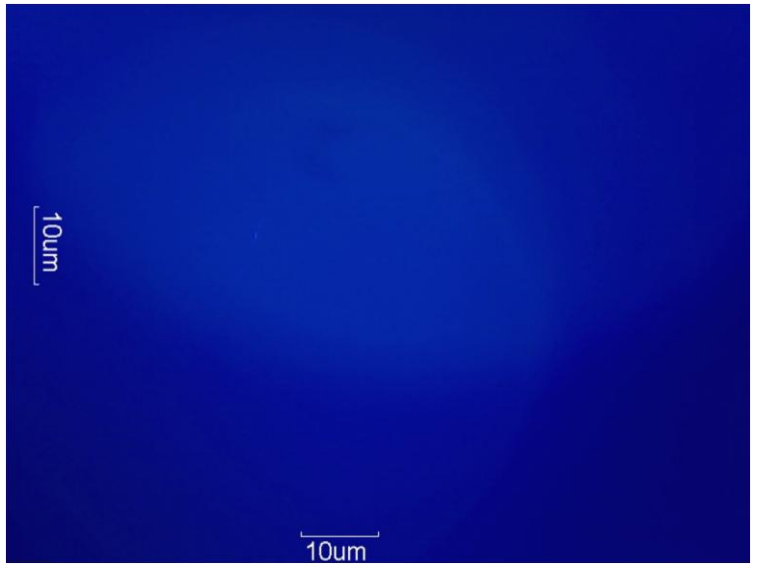
Laurell spin processor

PG-8 Ionized Air Gun

Out of Box

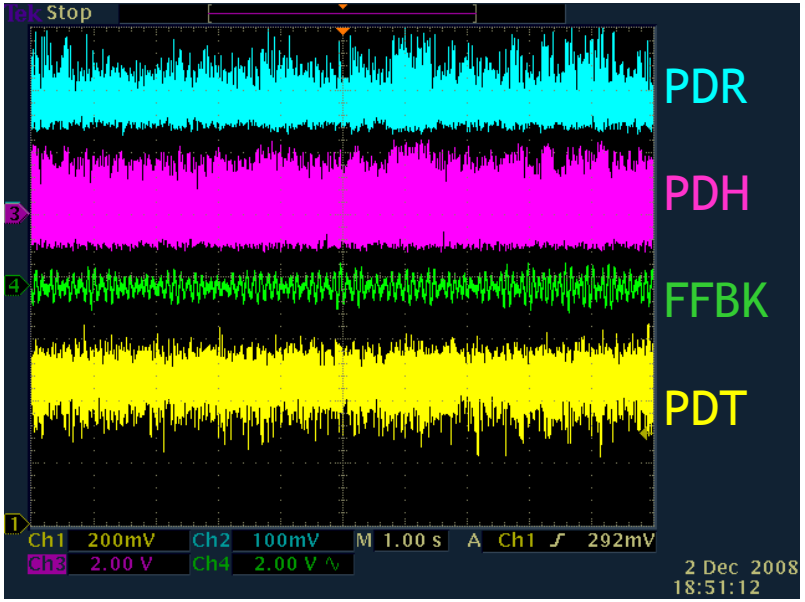


Cleaned with Micro

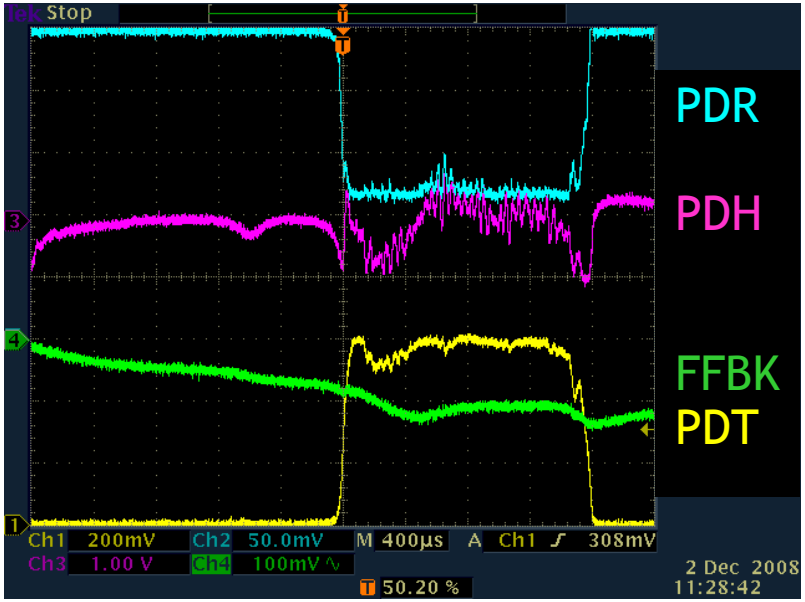


GSI-240-A Cavity Locking with Prometheus laser

- Obtained a long lasting noisy lock on December 2008 with Prometheus laser and measured 150W of intra cavity power for the first time
- Tried to remove the noise in the lock by careful tuning of the feedback loop, but it didn't take us there



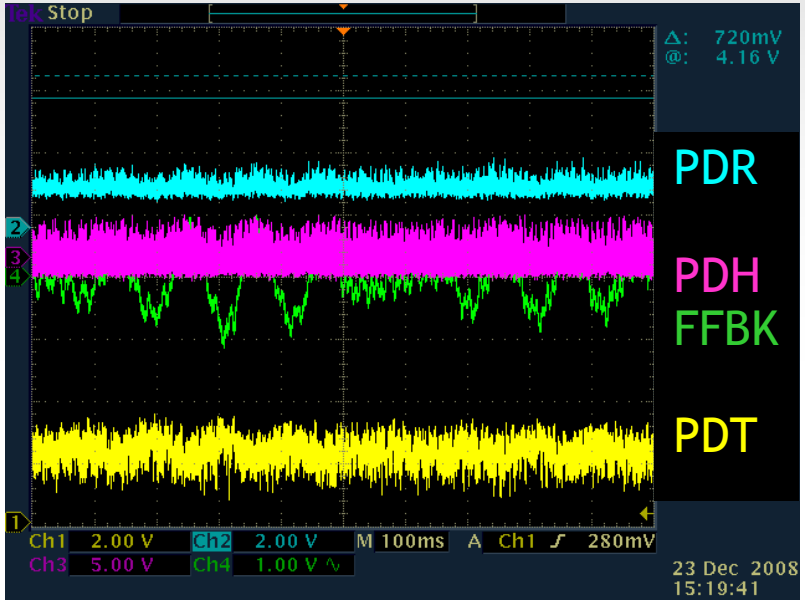
sustainable lock with noise



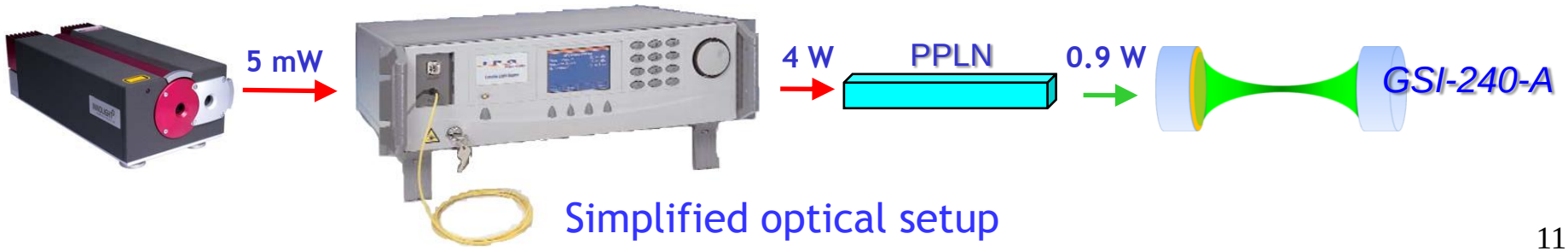
smoother lock with short duration

GSI-240-A Cavity Locking with Fiber Amplifier

- The IR output of the Prometheus laser fiber coupled to the IPG fiber amplifier
- Pumped 4W of the IR beam to the PPLN crystal and produced ~ 1W of green power
- Obtained a same noisy lock as Prometheus laser locking with the same electronics
- Proved IPG fiber amplifier can be locked to 240 ppm cavity !

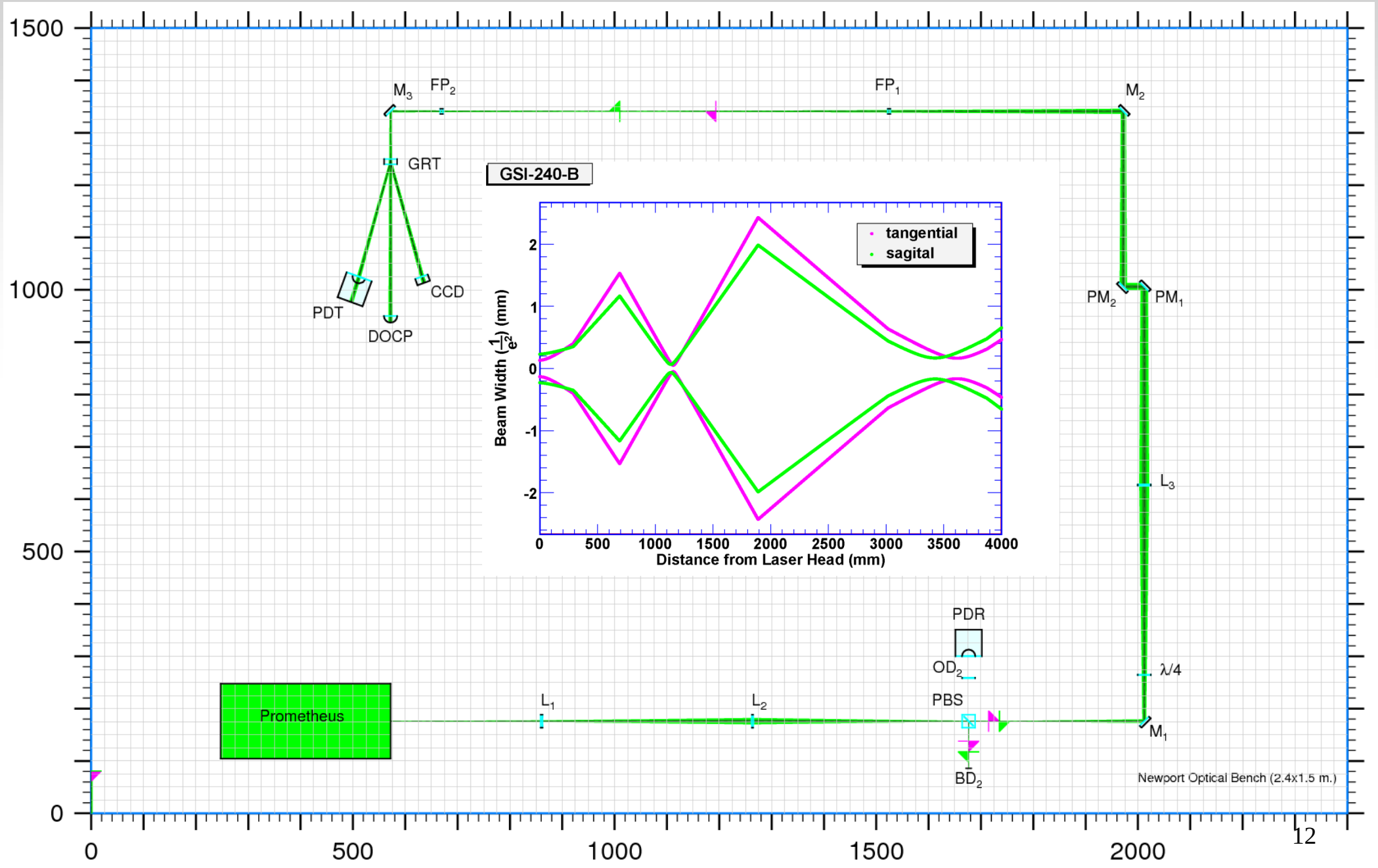


First fiber amp locking



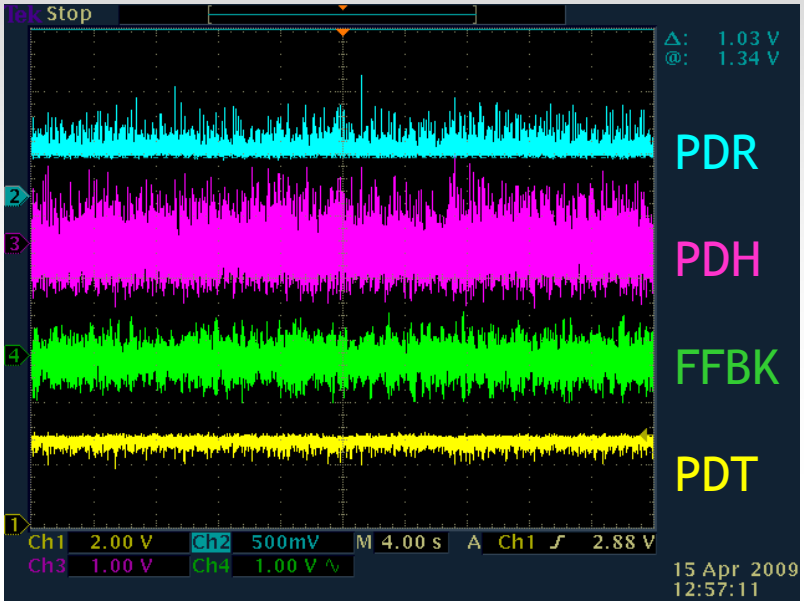
Simplified optical setup

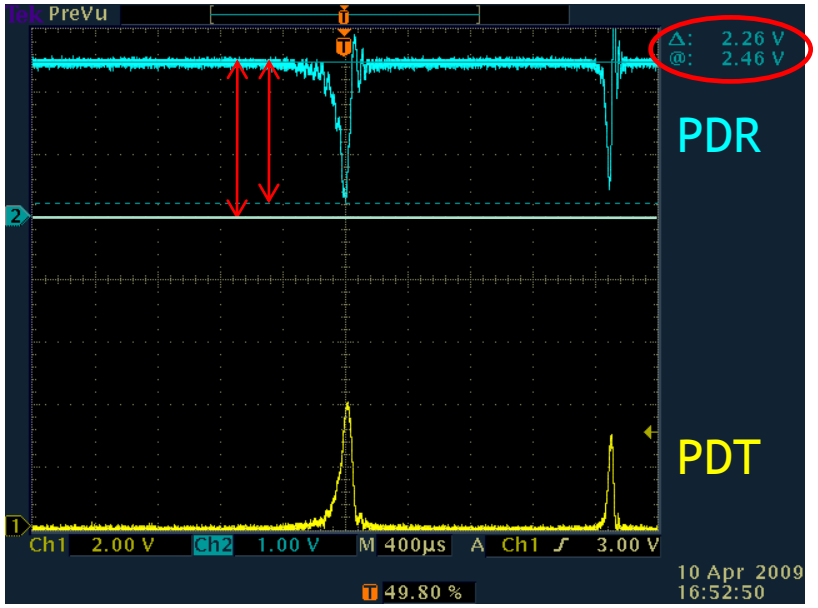
2D CAD Drawing of GSI-240-B Cavity Optical Setup by OptoCad

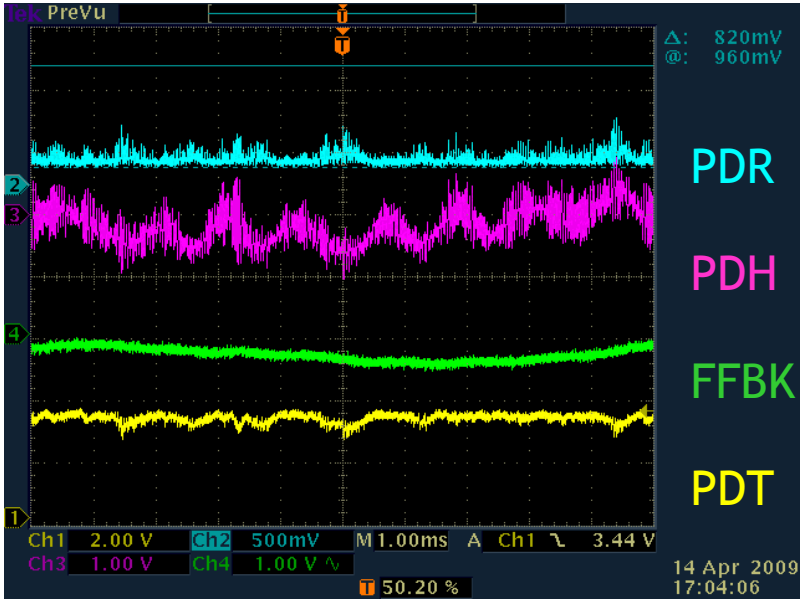


GSI-240-B Cavity Locking with Prometheus laser

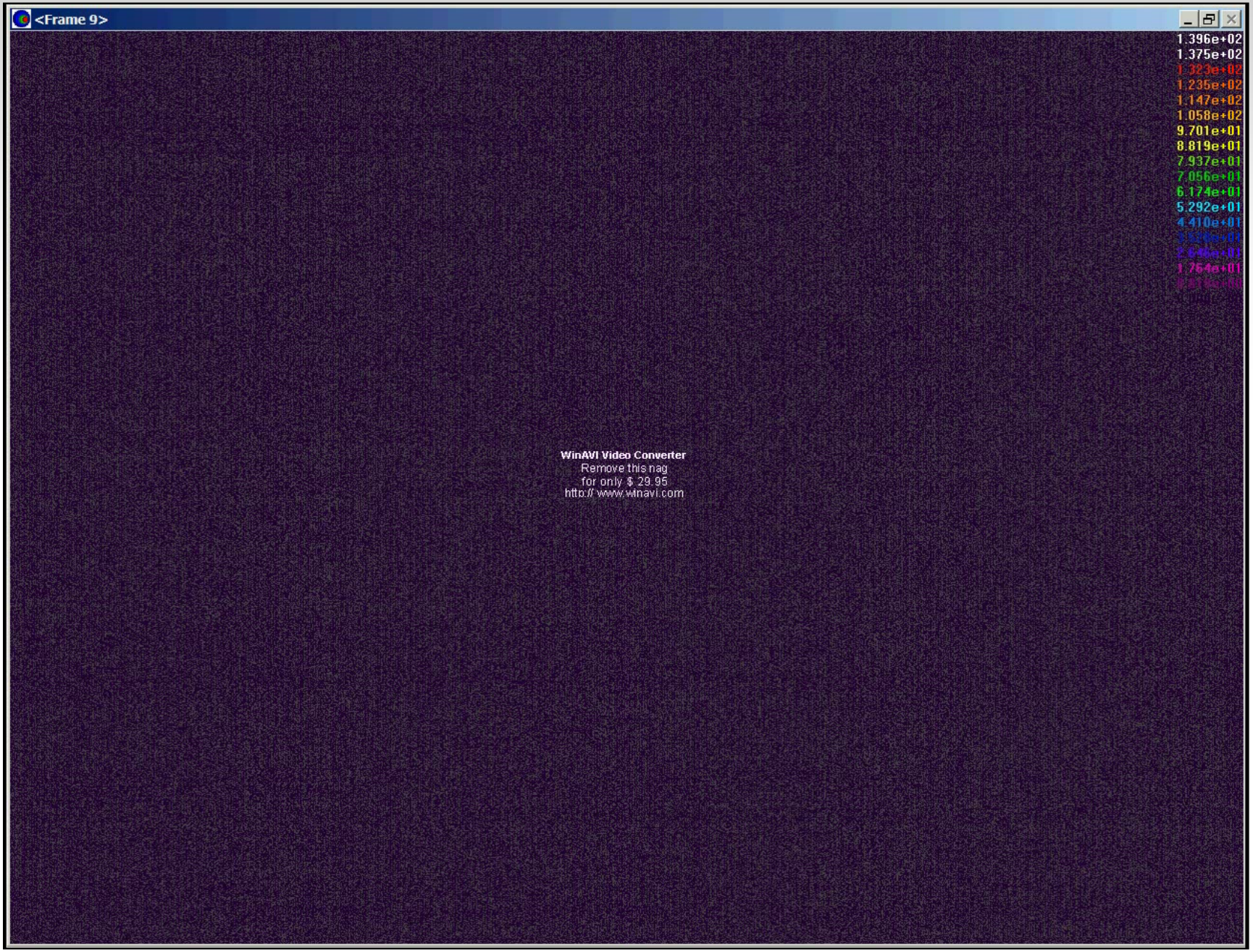
- Simplified and improved the transport optics by removing the cylindrical lenses
- Obtained 85 % of optical coupling to the cavity consistently for the first time
- Obtained reasonable duration of stable lock with reduced noise by only fast feedback to the laser



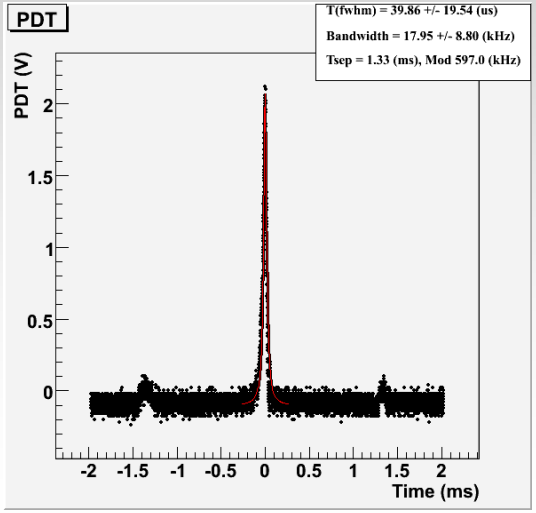


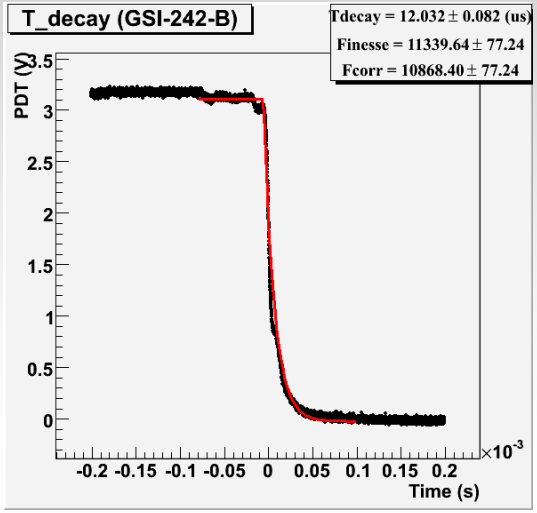


GSI-240-B Cavity Locking with Prometheus laser



GSI-240-B Cavity Preliminary Data





	Goal	Measurement (Scan)	Measurement (Lock)
Power Injected Pi (mW)	85	85.1 ± 5.2	85.1 ± 5.2
Cavity Decay Time (us)	10.8	8.9 ± 0.35	10.0 ± 0.08
Cavity Gain	3811	2855 ± 149	3009 ± 131
Cavity Bandwidth (kHz)	14.1	17.2 ± 0.67	15.9 ± 0.13
Transmission T (ppm)	242	210 ± 18	240 ± 14
Loss L (ppm)	10	29 ± 2	32 ± 2
Mode Match Coupling	0.95	0.93 ± 0.08	0.81 ± 0.07
Intra Cavity Power (W)	308	205 ± 16 (*)	176 ± 14 (*)

* Power meter needs to be recalibrated

Current Status & Future Plans

- Cavity locking electronics progress is in good track
- Established a clean environment to work with cavity mirrors
- Developed a reliable mirror cleaning technique
- Proved fiber amplifier can be locked to 240 ppm cavities
- Improved the optical coupling to the cavity significantly
- Resolved the noise problem and achieved a stable lock
- Need to finish complete and accurate characterization of current cavity
- Start working on profiling and mode matching of PPLN green beam to the current cavity
- Test and debug the upcoming new electronics

Thank You