OCTOBER, 2017

- Laser developments
  - installed new laser diode and chiller
  - completed laser alignment
  - continuing systematic measurements to characterize high-power CW laser operation (with new laser diode)

- Laser integration
  - installed new laser MPS interlock controller, incorporated into updated safety interlock drawing
  - installed new power meter on gun table for low power CW operation
  - started work on laser beam stabilization (together with Controls)
  - continuing modifications for improved reliability of laser motion systems

- Shutdown activities
  - completed laser-trailer air conditioning upgrade
  - completed installation of fire detection system installation in laser trailer
  - installed additional electrical capacity in laser-trailer optical room, started similar in anteroom
  - continuing reorganization of 1002F electronics rack to accommodate new devices
  - continuing development of rf-to-laser phase and laser phase monitors
  - planned development pending: laser intensity feedback based on beam current measurement

- Laser safety
  - laser-related interlock extension - integration into RHIC PASS system underway (J. Reich, Access Controls); procured additional and spare shutters and controllers for interlock extension
  - installed two new interlock boxes (for new laser diode and for CeC)
  - submitted updated laser interlock schematic (with new interlock boxes and laser MPS) to drawing room
  - fabricated and installed latches for laser transport table enclosures

- Laser admin
  - continued preparations for November DOE review and December Internal Readiness Review
  - initiated hiring process for new laser engineer

- Other
  - SLAC visit (P. Inacker, P. Cirnigliaro, M. Minty), Oct. 18th -20th - trip summary available on request
  - SLAC visitor, J. Frisch, Oct. 25th-27th

NOVEMBER, 2017

- Laser developments
  - coordinating with Laserline to allow remote access to controller unit for adjustment of temperature set-point for new main amplifier pump diode (with support from B. Eisele and K. Kulmatycski)
  - continuing systematic measurements to characterize high-power CW laser operation (with new laser diode)
  - characterizing the intensity feedback with the high-power green laser

- Laser integration
  - installed enclosure and completed internal wiring for new laser MPS interlock controller
  - started machining of laser heat sinks for high-power slow shutters
  - completed modifications to linear motion controllers (including bench tests), re-installed controllers
  - completed modifications to half-wave plate (added switch to register fully retracted position)
  - installed focusing lens upstream of MPS photodiode

- Shutdown activities
  - completed electrical upgrade in laser-trailer
  - continued reorganization of 1002F electronics rack to accommodate new devices
  - continued development of rf-to-laser phase and laser phase monitors
  - coordinating 1002F access for laser testing and remaining work by non-laser experts to include
  - fire protection tests
    - access control upgrade completion (including shutter installation) and test
    - linear motion controller end-to-end tests
    - installation of new rf signal cable port, cable pulls and ensuring air-tightness (sealing) of port
    - seal existing cable feed-through port

- Laser safety
  - laser-related interlock extension - integration into RHIC PASS system underway (J. Reich, Access Controls)
  - completed updated (with new interlock boxes and laser MPS) laser interlock schematic (Design and Documentation group)

- DOE Annual Progress Review of LEReC review (November 14-15, 2017)
  - prepared and presented “LEReC: high-power fiber laser system for LEReC” (Z. Zhao)
  - prepared and presented “LEReC: laser transport status” (P. Inacker)
  - prepared and presented laser-related material for breakout session (M. Minty)

- Internal readiness review (IRR) preparation (December 6-7, 2017)
    - started presentation “Lasers – Operations, Hazards and Controls” (P. Inacker)
    - maintained and regularly updating tabulated list of installations required by time of Accelerator Readiness Review (ARR); as of 12/4/17:
    - Re-install mirror motion control motors (and perform end-to-end tests)
    - Re-install modified half-wave plate
    - Fabricated and install laser heat sinks (part of Access Controls Upgrade)
    - Complete laser and (locked) exit table enclosures
    - started procedure ‘LEReC and CeC IR2 laser enclosure integrity assurance” for inspecting and locking enclosures (P. Cirnigliaro)

DECEMBER, 2017

- Laser developments
  - New main amplifier pump diode temperature set-point optimized (by Laserline with networking and IT support from B. Eisele and K. Kulmatycski)
  - Associated chiller installed
  - High-power CW laser operation characterization measurements continued – confirmed no thermal lensing from laser oscillator, established 25W green through 4 crystals with no variation in spatial modes

- Laser integration
  - Fabricated and installed laser heat sinks for high-power slow shutters
  - Installed second Piezo mirror on relay table (for remote alignment)

- Shutdown activities
  - Installed conduit for temperature-compensated rf/timing cables
  - Sealed cable feed-through port
  - Continued development of rf-to-laser phase and laser phase monitors
  - Coordinating 1002F access for laser testing and remaining work by non-laser experts to include
    - fire detection, test of new sensors and their integration into alarm system
    - access controls certification of new laser interlock
    - linear motion controller end-to-end tests
    - cable pulls for new rf signals and ensuring air-tightness (sealing) of port

- Laser safety upgrade (J. Reich, P. Inacker et al)
  - Procured and installed interlock and logic controller modules into RHIC access controls for automated shut-off of laser (engineering controls)

- ARR preparation: IRR action item status update:
  - Re-install mirror motion control motors (done) and perform end-to-end tests (underway)
  - Re-install modified half-wave plate
  - Fabricated and install laser heat sinks (done)
  - Complete laser and (locked) exit table enclosures (done)
  - (New) Procure parts for vacuum interlock on long-haul laser transport tube between laser trailer and RHIC tunnel
  - Complete procedure ‘LEReC and CeC IR2 laser enclosure integrity assurance” for inspecting and locking enclosures (P. Cirnigliaro)

- Laser commissioning for FY18
  - Realigned laser transport (as far as conditions allow, so far to gun table)
  - High power laser setup (with newly installed diode and chiller)

JANUARY, 2018

- Laser developments
  - Diagnosed and repaired damaged fiber in pre-amplifier
  - Re-established high-power laser alignment through various crystals under test as needed for long-pulse (80 ps) pulse generation
  - Demonstrated extinction ratio of 10^6:1
  - Demonstrated 18 W green power, ~ 80 ps (theoretical) pulse temporal profile after stacking crystals with modest thermal lensing; submitted requested report on these developments to DOE

- Laser integration
  - Verified performance (end-to-end tests) of all installed, modified linear and rotary motion controllers (L. DeSanto et al)
  - Installed additional power meter on Gun Table

- Shutdown activities
  - Completed installation and testing of fire detection system (B. Streckenbach et al)

- Laser safety upgrades
  - Completed Access Controls certification of new PASS laser interlocks for LEReC and CeC (J. Reich et al)
  - Fabricated and installed laser locks for optical tables as required by new procedure
  - Completed new procedure, 'LEReC and CeC IR2 laser enclosure integrity assurance" for inspecting and locking laser enclosures (P. Cirnigliaro)
  - Trained (almost all) personnel in execution of laser-enclosure and laser turn-off procedures
  - In progress: complete vacuum interlock on long-haul laser transport tube between laser trailer and RHIC tunnel (a review recommendation, not a pre-start requirement)

- Accelerator Readiness Review
  - Completed various pre-beam installations (non-priority, but essential)
  - Finalized drawings and procedures
  - Prepared and presented status to ARR review committee (P. Inacker)

- Laser commissioning for FY18
  - Verified in-vacuum mirror alignment / laser transport from gun table (previously established) now with laser transport into vacuum, to gun cathode (via mirror) then out of vacuum (via another mirror) to out-of-vacuum laser 'exit chamber'
  - Continued high power laser setup (with new diode and chiller), demonstrated 18 W with proper pulse structure (DOE report) which, with previously demonstrate 60% transmission efficiency, is expected to meet project requirements and end-to-end demonstration to be scheduled in coordination with overall schedule
  - Continued development of rf-to-laser phase and laser phase monitors (K. Mernick et al)

- Continued development of laser intensity control (M. Costanzo, Z. Zhao)

FEBRUARY, 2017

- Laser developments (Z. Zhao, P. Inacker)
  - Transported 10W * 0.74 = 7.4W to gun table with 6 crystals, 80 ps pulse (02/14/18)
  - Transported 10W * 0.61 = 6 .1W to gun table with 4 crystals and interferometer, 80 ps (03/05/18)
  - Re-established setup of autocorrelator for pulse length measurements, device returned to company Femtochrome Research Inc for repair (Z. Zhao)

- Laser integration
  - Commissioned remote alignment for the laser transport (P. Inacker)
  - Commissioned remote control of high power Pockels cell for laser intensity control (M. Costanzo)

- Shutdown activities (none)

- Laser safety
  - Installed vacuum switches on long-haul laser transport tube between laser trailer and RHIC tunnel (MAC recommendation), integration into interlock system underway
  - Modified procedure for high-power laser alignment (P. Sampson et al) to be more efficient (no signature-delay wait period, backup personnel with signature authority)

- Laser commissioning for FY18
  - Continued development of new rf-to-laser phase and laser phase monitors (K. Mernick et al)

- Laser operations
  - Synchronized laser oscillator to external RF (K. Mernick)
  - Supported beam operations with
  - 4 crystals, 40 ps pulse for initial operations (>02/26/18)
  - 4 crystals and interferometer, 80 ps (>03/05/18)

- Preparation for 24/7 operation
  - Continued development of laser MPS
    - laser preamp power (M. Costanzo, expected mid-March)
    - chiller water pressure and temperature measurements
  - Intensity feedback for CW laser operations (M. Costanzo, Z. Zhao) in development
  - Intensity feedback for pulsed-beam operation (starting)
  - Ordered additional set of spare gain fibers
  - Tracked status of ordered spare chiller, EOMs; awaiting status update for spare laser oscillator (Calmar)

- Started development of high-power heat sinks for EOM (S. Bellavia, Z. Zhao)

MARCH, 2018

- Laser developments (Z. Zhao, P. Inacker)
  - Continued development of high power laser operation, investigating methods to mitigate thermal lensing effects while allowing flexible beam operation (e.g. transitions between pulsed and CW beams)
  - Started integration of repaired autocorrelator (for temporal profile measurements)
  - Started procurements for macropulse generation at RHIC beam revolution frequency (78 kHz)

- Laser integration
  - Installed and commissioned zoom lens on LEReC gun table (P. Inacker, L. Nguyen)
  - Modified gun table layout to allow for simultaneous measurement of high-power laser power and beam profile (P. Inacker)

- Laser operations
  - Updated laser shutdown procedure (P. Inacker, L. Hammons)
  - Supported operations with 3 crystals plus interferometer (40 ps pulse)
  - Reverted to operation with 4 crystals (40 pulse), typically with 12 W laser power after crystals, transmission efficiency 75%, extinction ration ~ 6E5

- Preparation for 24/7 operation
  - Continued development of laser MPS:
  - laser preamp power (M. Costanzo, ready to commission)
  - chiller water pressure and temperature measurements (P. Inacker, T. Curcio)

  - Intensity feedback for pulsed-beam operation developed: software-based feedback developments (J. Morris)
  - Intensity feedback for CW laser operations (M. Costanzo, Z. Zhao) awaits commissioning
  - Started development of synoptic display interface for operations (L. Nguyen); evaluating space optimization on laser table to allow for additional power and profile measurments
  - Tracked status of ordered spare chiller, EOM (received); awaiting status update for spare Calmar laser oscillator (Z. Zhao)
  - Started development of high-power heat sink for new EOM (S. Bellavia, Z. Zhao)
  - Resumed developments for additional laser lab needed for ‘hot-spares’ development (C. Folz, P. Inacker, L. Nguyen)

APRIL, 2018

- Laser developments
  - continued development of high power laser operation, investigating methods to mitigate thermal lensing effects while allowing flexible beam operation (e.g. transitions between pulsed and CW beams); this included placing the intensity control behind the EOM so that the EOM operates at constant power (Z. Zhao, P. Inacker) and software-related administrative controls (P. Inacker, Controls)
  - continued cross-correlator setup for high-resolution temporal profile measurements (Z. Zhao)
  - ordered Pockels Cell driver for macropulse generation at RHIC beam revolution frequency, delivery mid to late May (Z. Zhao, P. Inacker)

- Laser integration
  - developed 'wish-list' for additional drive laser diagnostics
  - documented present laser table layout in preparation for synoptic display for users and for space-optimizations as needed for additional diagnostics (L. Nguyen)
  - started development of software-based feedback for laser trajectory stabilization (L. Nguyen)
  - developing remote management of chillers (P. Harvey)

- Laser operations
  - supported operations with 4 crystals (40 ps pulse), typically with 12 W laser power after crystals, transmission efficiency 75%, extinction ration ~ 6E5
  - developed user-friendly control ('pet page') application (P. Inacker, J. Jamilkowski)
  - executed first-pass optimization of crystal stacking (rotation angles) using transverse mode-deflecting cavity
  - intensity feedback for pulsed-beam operation (J. Morris) awaits feedback input validation, design and commissioning
  - intensity feedback for CW laser operations (M. Costanzo, Z. Zhao) awaits commissioning

- Preparation for 24/7 operation
  - continued development of laser MPS:
  - completed fabrication of new laser MPS module (design by P. Inacker)
  - completed fabrication of diverse cables (P. Inacker, T. Curcio et al) for chiller water pressure and temperature measurement
  - identified low-flow in the 60 W amplifier return line, replaced chiller and re-tuned EOM bias and amplitude set-points accordingly (P. Inacker)
  - integrated new laser MPS module to laser room interlock system (P. Inacker)
  - spare parts: spare Calmar laser oscillator shipped 4/27/18 (Z. Zhao)
  - started development of high-power heat sink for new EOM (S. Bellavia, Z. Zhao)
- Other

- developed design and design requirements for new laser lab needed for component acceptance testing and validation of hot spares (P. Inacker)

MAY, 2018

- Laser operations
  - supported operations with 4 crystals (40 ps pulse), typically with 13 W laser power after crystals, transmission efficiency 70%, extinction ration ~ 5E5
  - developed LEReC Laser Overview application (PET page) for Operations with most important parameters and readbacks (with support from Controls
  - Software, J. Jamilkowski)
  - following completion of laser MPS commissioning, operated CW laser 24/7 (6/1/18 - night prior to scheduled RHIC maintenance on 6/7/18) with no faults

- Laser integration
  - completed laser-MPS with additional 2 layers including laser diode and sensor summary module for flow meters and temperature measurements
  - commissioned laser-MPS
  - identified and corrected various issues as found
    - low flow in the 60W amplifier diode
    - water purity issues (all chillers flushed and refilled now with added corrosion-inhibitors and algaecide)
  - circulating bath replaced with chiller serving rod amplifier and laser power dumps
  - developed manager for remote control of chillers (with support from Controls Software, P. Harvey)
  - continued development of remote optimization of EOM bias and amplitude voltage (with support from Controls Hardware, M. Costanzo)

- Laser developments
  - measured drive laser pulse lengths using auto-correlator (both IR and green)
  - started cross-correlator measurements (in green)
  - evaluated integration methods for software-based feedback for laser beam path stabilization, starting development of stand-alone system

- Other
  - submitted proposed layout and projected heat map for new laser lab to Facilities and Experimental Support Group (C. Folz)

JUNE, 2018

- Laser operations

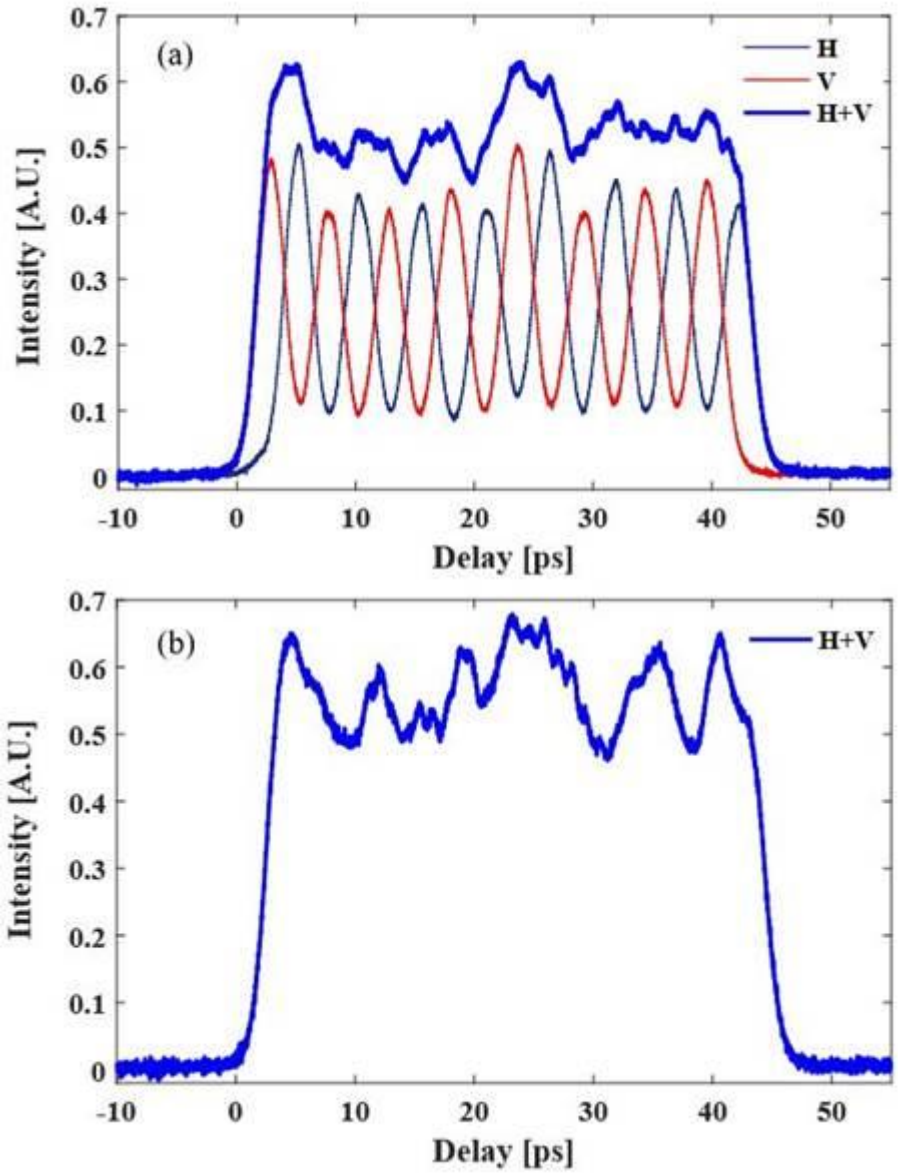
    - supported operations under same conditions as last month (40 ps pulse)
    - improved stability of IR laser power, added shielding around Calmar oscillator (M. Minty, L. Nguyen)
    - ran laser 24/7 so far without failure including two 5+ days of consecutive operation, limited only by administrative choice to preserve component lifetime
    - performed (invasive) long-term measurements of extinction ratio (>1 shift, over nights), results motivated further investigations which are underway

- Laser integration

    - upgraded the relay table camera for larger acceptance (10 mm x10 mm), finished setup of the Gun table filter wheel (L. Nguyen)
    - installed more diagnostics on the gun table: IR power monitor, photodiode for 60W Amp (P. Inacker et al)
    - identified major sources of laser power fluctuations: humidity for EOM, temperature for second harmonic generation, SHG stage (P. Inacker)
    - to mitigate thermal sensitivities in the SHG, ordered new crystals to enable critical phase matching (P. Inacker)
    - continued development of remote optimization of EOM bias and amplitude voltage (with support from Controls Hardware, M. Costanzo)

- Laser developments

    - measured laser temporal profile using cross-correlator (Z. Zhao)



(a) Separate measurements of temporal profile for each of two polarization directions (blue, red), measurement of both polarization states (solid blue)
(b) Two polarization components are projected onto 45 degree and detected through cross-correlation for higher resolution measurement

JULY, 2018

- Laser operations

  - supported operations
  - ran laser 24/7 without laser-MPS faults, interruptions only by scheduled laser-development work
  - documented and improved time response of elements used to turn off laser following MPS fault; presently <15 ms, reduced from ~18ms (design laser shutoff time design was 5 ms, see below)
  - continued developments for improved long-term extinction ratio during CW operations

- Laser integration

  - installed fast photodiode for use with new application for remote optimization of EOM bias and amplitude voltage (M. Costanzo et al)
  - developed remote on/off control for intensity feedback (M. Costanzo)
  - installed fast photodiode for laser-to-rf phase monitoring

- Laser developments

  - characterized transverse profile as a function of number of crystals used to develop longitudinal pulse profile; installed 1 interferometer in place of fourth crystal
  - installed Pockels cell in series with EOM - after PC conditioning, measured (long-term) minimum extinction ratio of >200:1 for CW operations (>1000:1 during 30 mA operation); requirement is now 300:1 (previously 100:1) for 50 mA based on measured MPS shutoff time; evaluated future mitigation options
  - mounted new critically phase-matched crystals for mitigation of thermal sensitivities

- Laser maintenance

  - replaced chiller, flushed out cooling systems
  - procured additional spares (ultrafast detectors, fiber couplers, optical lenses etc.)
  - set up spare laser oscillator for parallel testing

- Other

  - LEReC mini-review presentations (P. Inacker and Z. Zhao, 07/02/18)
  - Developed plans for improved environmental control in laser trailer (C. Folz), measured equipment-related heat loads (T. Curcio et al)
  - Progressed with plans for temporary laser test area for validating ‘hot spares’ and laser-related developments (at ATF, M. Palmer et al)
  - Pursued plans for dedicated laser test area for future developments (All)

AUGUST, 2018

- Laser operations

    - supported operations with 24/7 laser operation; system failures: one instance of loss of mode-lock a few hours after installation of additional dehumidifier in laser trailer, one turn-off (during thunderstorm)
    - initiated laser-support call-in lists (7/30/18)
    - realigned EOM and SHG stage to improve extinction ratio; monitored stability of ER during CW operations
    - demonstrated requirement of 1% rms electron beam intensity stability during high-current CW beam operation (see developments below)

- Laser integration

    - completed application for remote optimization of EOM bias and amplitude voltage (M. Costanzo)
    - successfully tested critical phase matching with crystals cut for conversion of 1030 nm to mitigate thermal sensitivities in the SHG, will order crystals cut for 1035 nm (P. Inacker)
    - completed development of new PolyScience chiller managers for laser MPS (P. Harvey, L. Nguyen)
    - installed new power meter on gun exit table, performed laser alignment through gun vacuum chamber with electron beams generated both on and off cathode geometrical center (T. Miller, L. Nguyen, P. Inacker)

- Laser developments

    - Added fast photodiode for phase measurements (Z. Zhao, K. Mernick)
    - Concerning laser and electron beam intensity stability:
        - installed additional dehumidifier in laser trailer (B. Streckenbach), gently tweaked – over days - laser trailer temperature setpoints and evaluated related laser stability parameters
        - implemented local (in laser trailer) laser intensity feedback, encountered difficulty with photodiode sensitivity to yet-unidentified noise sources (P. Inacker, M. Costanzo, J. Jamilkowski, J. Morris)
        - developed modified beam intensity feedback approach using detection at 704 MHz (to reduce sensitivity to noise) and a nested feedback design consisting of a global fast feedback on laser intensity (as measured on the gun table) and a slower loop on electron beam intensity (K. Mernick)
        - installed new fast photodiodes on relay and gun tables (P. Inacker, L. Nguyen)
        - installed additional RF amplifiers for remote logging of various photodiodes (K. Mernick, P. Inacker, C. Dawson, S. Jao)

        - installed diverse hardware including FPGAs, fast current transformer signal splitters, cables etc. for nested feedback (K. Mernick, T. Hayes, M. Paniccia, T. Curcio et al)
        - developed firmware for laser and beam intensity feedback (K. Mernick, F. Severino, T. Hayes et al)
        - demonstrated fast feedback on laser intensity (8/31/18) and both slow (electron beam intensity) and fast feedback (9/7/18)
    - With the developments listed above, achieved ~ 0.6% rms laser intensity stability (measured with fast photodiode) and ~ 1% rms electron beam current stability (measured with fast current transformer) with both laser and beam intensity feedback

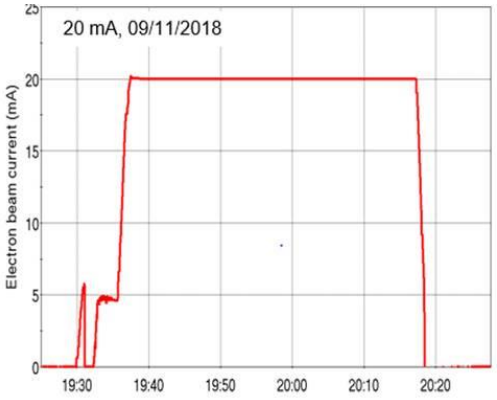
- Other

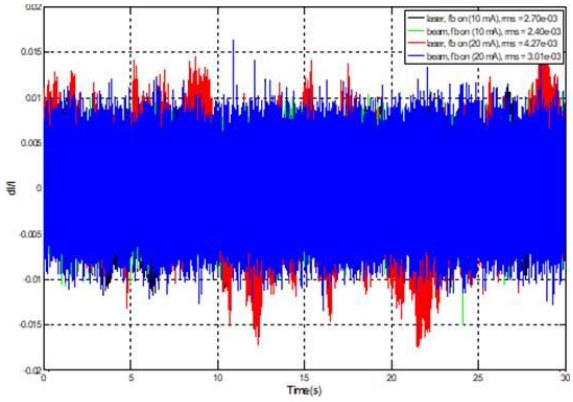
    - Secured dedicated work station and cabling for slow laser beam position stabilization system (L. Nguyen)
    - Ordered fast beam position stabilization system (P. Inacker)
    - Mounted spare Calmar oscillator in laser trailer above existing laser components, verified performance / applicability as spare - mode-lock and spectral quality (L. Nguyen)
    - Evaluated high bandwidth (6 GHz) scopes (P. Inacker for Laser Group) from 3 vendors, coordinated by D. Gassner
    - Discussed possibilities and plans for establishing laser work area for LEReC laser component spares testing and laser development in new clean room located at the Accelerator Test Facility (M. Palmer, M. Babzien, P. Inacker, M. Minty)
    - Evaluated 1002F heat load (T. Curcio et al), measured 1002F heat load (P.K. Feng, C. Folz et al) for evaluation of possible improvements to laser trailer environmental control

SEPTEMBER, 2018

- Laser operations

    - supported 24/7 laser operation through end of Phase 2 commissioning period
    - demonstrated high power laser operation with full extraction to laser dump with electron beams generated off cathode geometrical center (T. Miller, L. Nguyen, P. Inacker)
    - demonstrated < 0.5% rms electron beam intensity stability during 20 mA CW beam operation with nested feedback (laser intensity and beam current) loops





- Laser integration

    - continued integration of laser and beam intensity feedback (K. Mernick, F. Severino, T. Hayes, P. Inacker et al)
    - developed aperture scanning software using new power meter on laser exit table (T. Miller, L. Nguyen, J. Laser and J. Jamilkowski)

- Laser developments

    - Completed post-run baseline measurements of laser performance (P. Inacker, L. Nguyen)
    - Started checkout of all amplifiers and system realignment

- Other

    - Developed plans and schedule for remainder of 2018, prepared and presented Laser System Status at LEReC Retreat (P. Inacker)
    - Received fast beam position stabilization system and high bandwidth oscilloscopes
    - Continued planning for dedicated laser development lab