The Hall A Compton Polarimeter Upgrade

Sirish Nanda
Jefferson Laboratory

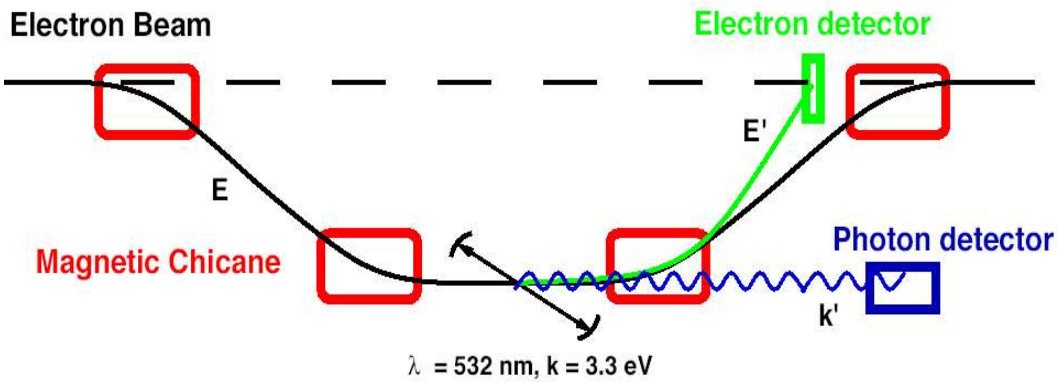
PReX Collaboration Meeting
December 7, 2008

The Hall A Compton Polarimeter Upgrade

Motivation:

Improve accuracy of polarization experiments by providing 1% beam polarimetery down to 1 GeV. High precision Parity violating experiments are feasible with this upgrade

Scope:



New Electron Detector

High resolution silicon microstrips to improve tracking resolution

New Photon Detector

Improve systematic uncertainties experienced in the counting method
While preserving counting abilities

High Power Green Fabry-Perot Cavity

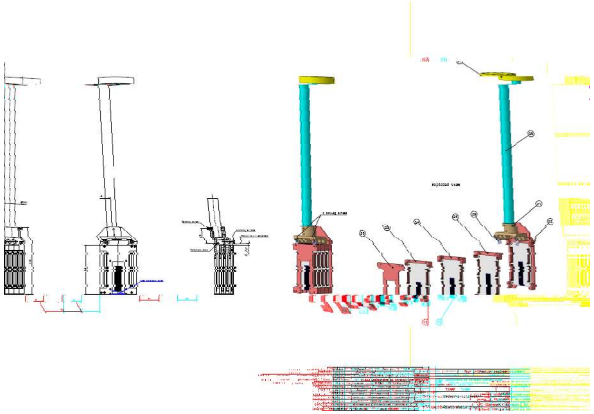
Twice the Analyzing power of present IR cavity
➲**Four-fold increase in Figure-of-Merit**

Participating Institutions: **Jefferson Lab, Saclay, Syracuse, Clermont-Ferrand, Uva, Duke,Carnegie-Mellon**

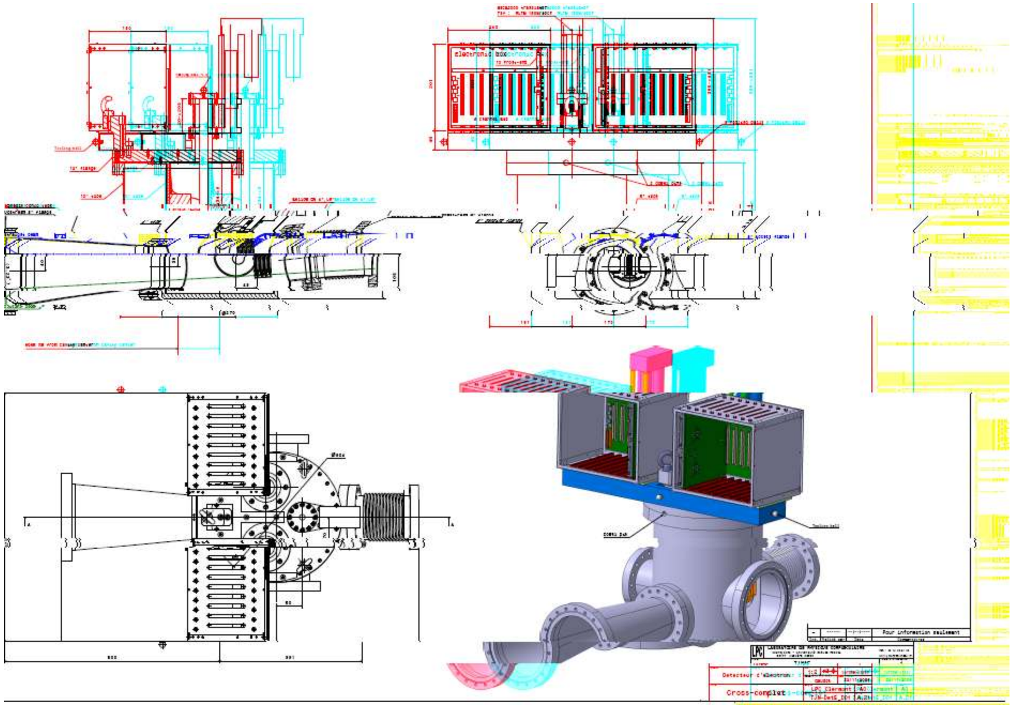
Electron Detector

LPC Clermont-Ferrand (contact: B. Michel)

- ## Scope
  - 768 ch 240 μm pitch silicon μstrips
  - 4 Planes, 192 strips/plane, 1 cm spacing between planes
  - 120 mm Vertical motion to allow coverage of Compton edge from 0.8-11 GeV
  - New custom front-end, FPGA trigger module (ETROC)
  - New DAQ and Analysis Software



Electron Detector Assembly



Electron Detector Status

- **Detector & Electronics** *(Michel Brossard)*
  - Four planes of Silicon microsrtips delivered by Canberra Systems
  - Defects found in the detector's connectors after tests at Clermont (Brossard)
  - Canberra is to replace with new detectors in time for Feb 08 Installation

- **Mechanical** *(Francois Daudon)*
  - Detector chamber and mechanics manufactured
  - Parts assembled and tested at Clermont-FD

  Controls *(Jack Segal, Sue Witherspoon)*
  - Vertical Motion controller being configured
  - EPICS interface being developed
  - Use existing beam FSD interlock electronics

- **DAQ** *(Bob, Alex etc…)*
  - CODA readout for new ETROC
  - New electron event decoder (?)
  - New Analyzer (?)
  - *The new detector will be compatible with old DAQ and Analysis with only 48 strips active, Just in case…*

- **Support Structure and Installation** *(Alan Gavalya, Tim Whitlach)*
  - Survey alignment scheme finalized
  - Support structure in design
  - Preliminary installation plan developed

Installation begins February 08

Photon Detector

Carnegie-Mellon University (Contact: Gregg Franklin)

- Calorimeter
  - Single crystal GSO, 6ϕx15 cm cylinder, Single PMT
  - High light output, fast decay time (less than 60 ns)
  - Can do triggered counting as well as integration.
  - GSO Crystal ordered from Hitachi Chem. Delivery this month
  - Mechanical support in design phase
  - Tests planned at CMU (Diana)
- Integrating DAQ
  - New Flash ADC ordered (Bob)
  - Beam tests in Feb 08

Green Fabry-Perot Cavity

Jefferson Lab (contact: SN)

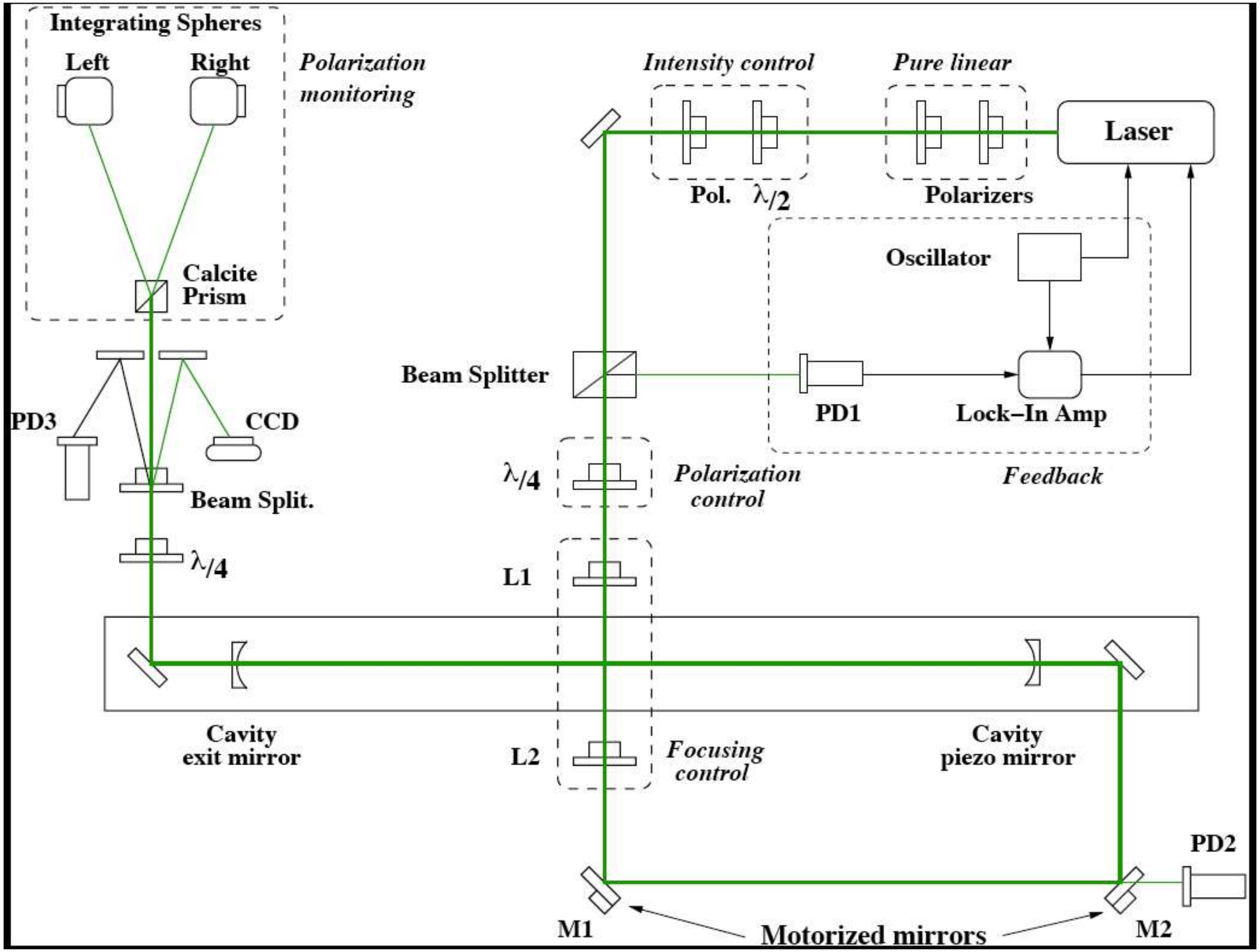
- **Specification**
  - Intracavity power 1.5 kW
  - Wavelength 532 nm
  - Mode CW, TEM_{00}
  - CIP Spot size (σ) 65 μm
  - Locking PDH

- **Solutions**
  - Primary: a) Tunable “smart” single pass Green Laser -> “Passive” High Finesse cavity
    - » Feedback to laser

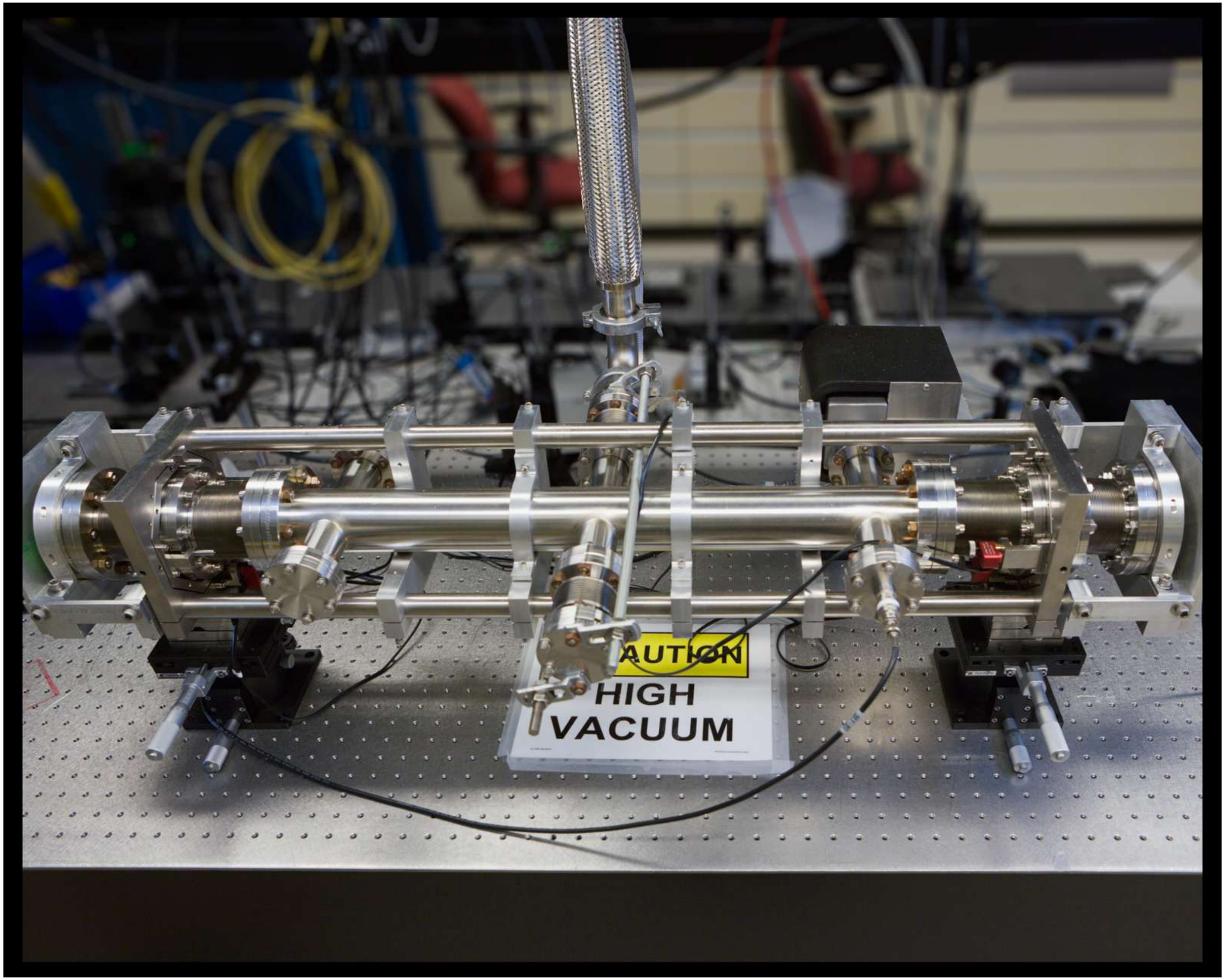
    b) Tunable “smart” IR Laser + single pass PPLN SHG -> “Passive” High Finesse cavity
    - » Feedback to laser

  - Alternate: non-tunable “dumb” Green Laser + Electro-optic modulator -> “Active” low Finesse cavity
    - » Feedback to cavity

Optical Setup



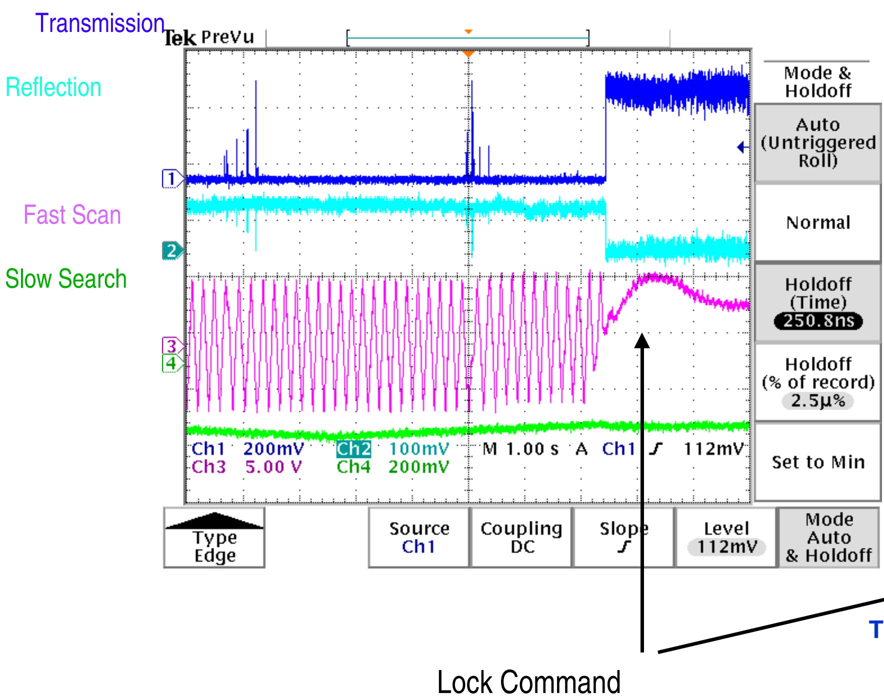
Assembled Cavity



Photograh: Alan Gavalya

Cavity Locking Algorithm

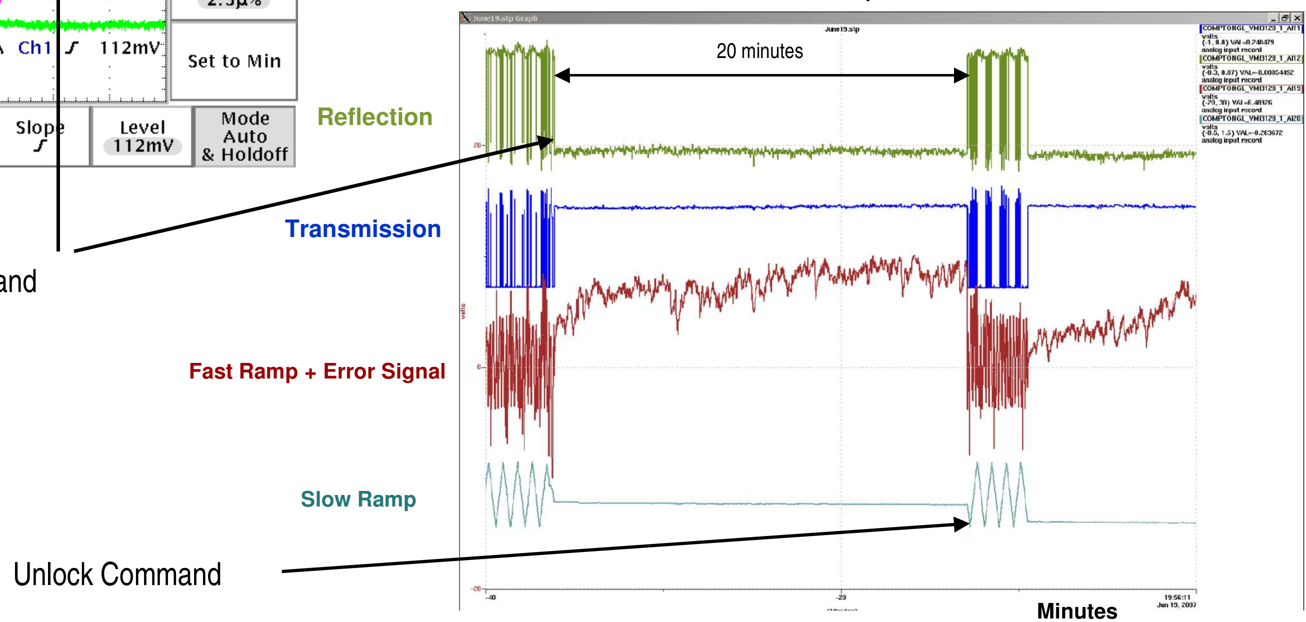
10-sec Scope Trace



Locking@low finesse

- On-demand lock with homemade Cavlock
- Stable and reliable Lock for hours
- Production version being implemented (Fernado Barbosa)

40-min Strip Chart

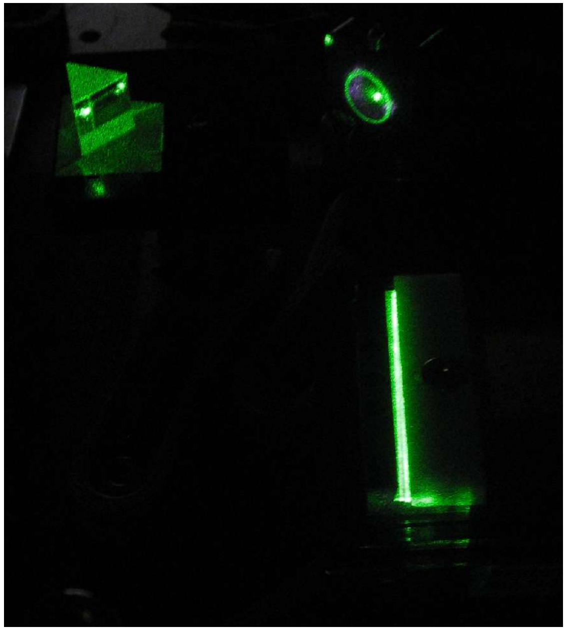


PPLN Doubler

- **Passive SHG with periodically poled (PP) Lithium Niobate (LN)**
  - Use the Lightwave Nd:YAG laser as 1064 nm pump
  - Double frequency with Quasi-phase matching of pole period
  - LN is more efficient that KTP used in the Prometheus laser
- **PPLN double progress**
  - QPM is sensitive to temperature
  - Homemade TEC based stabilization with < 10 mK temperature long term stability
  - Better than 20 mK temp uniformity along a 50 mm crystal
  - Better mode matching of beam waist and better alignment
    - Net result:

      We have achieved 17%/W conversion efficiency.

      Far better than published results!
- **PPLN preserves the IR laser's linewidth, feedback abilities**
  - We can use existing laser control system
  - We can use existing locking electronics
  - Remaining technical issues:
    - Coupling free space laser to a fiber
    - Coupling to a 10W Ytterbium Fiber Amplifier
    - Mitigating with high power damage, safety issues



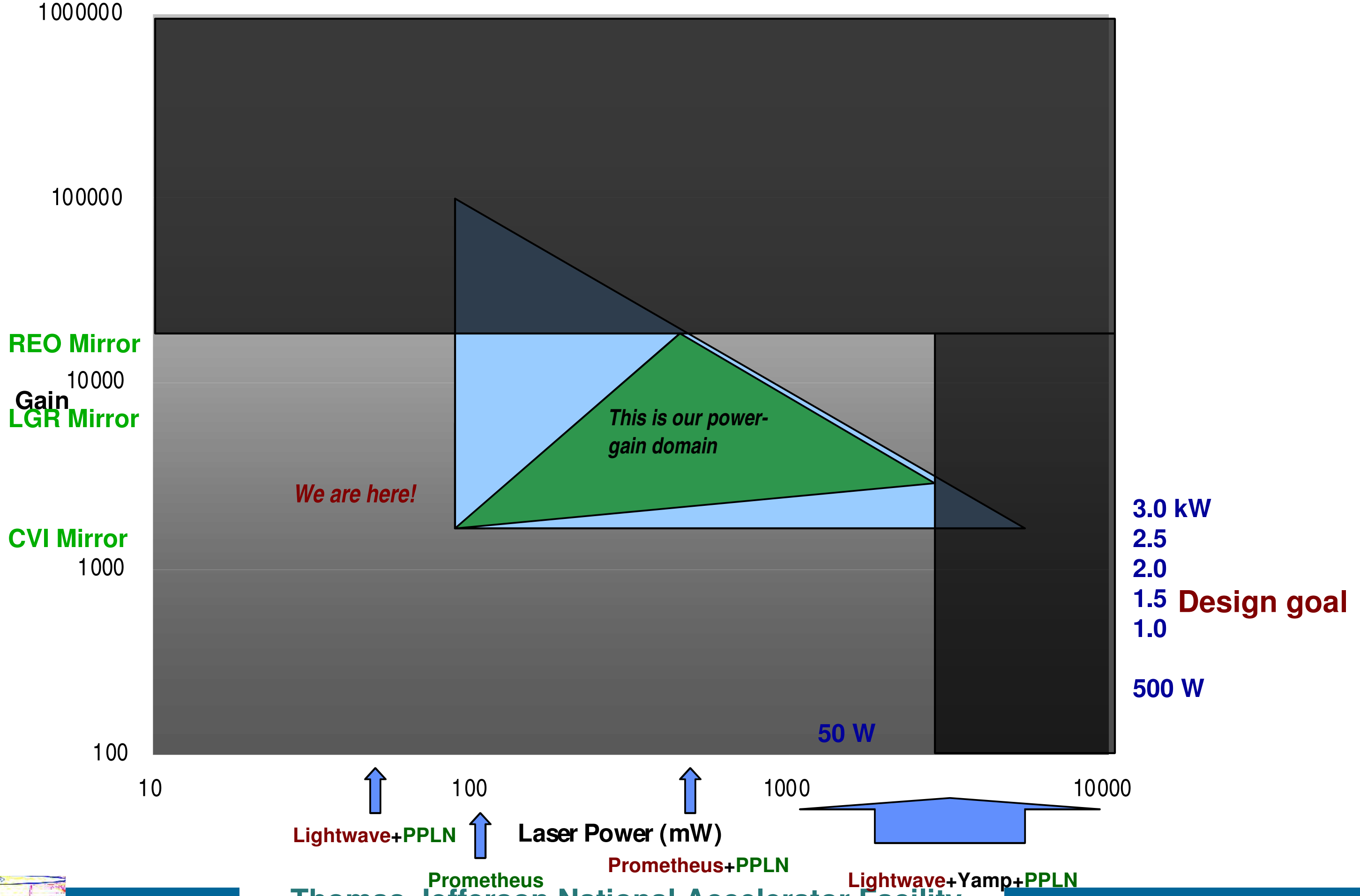
INTRA-CAVITY POWER: *The challenge*

$P_{cav} = \alpha.\beta.g.P_{laser}$ where α = Optics transport efficiency (~72%)

β = Cavity Coupling efficiency (~25%)

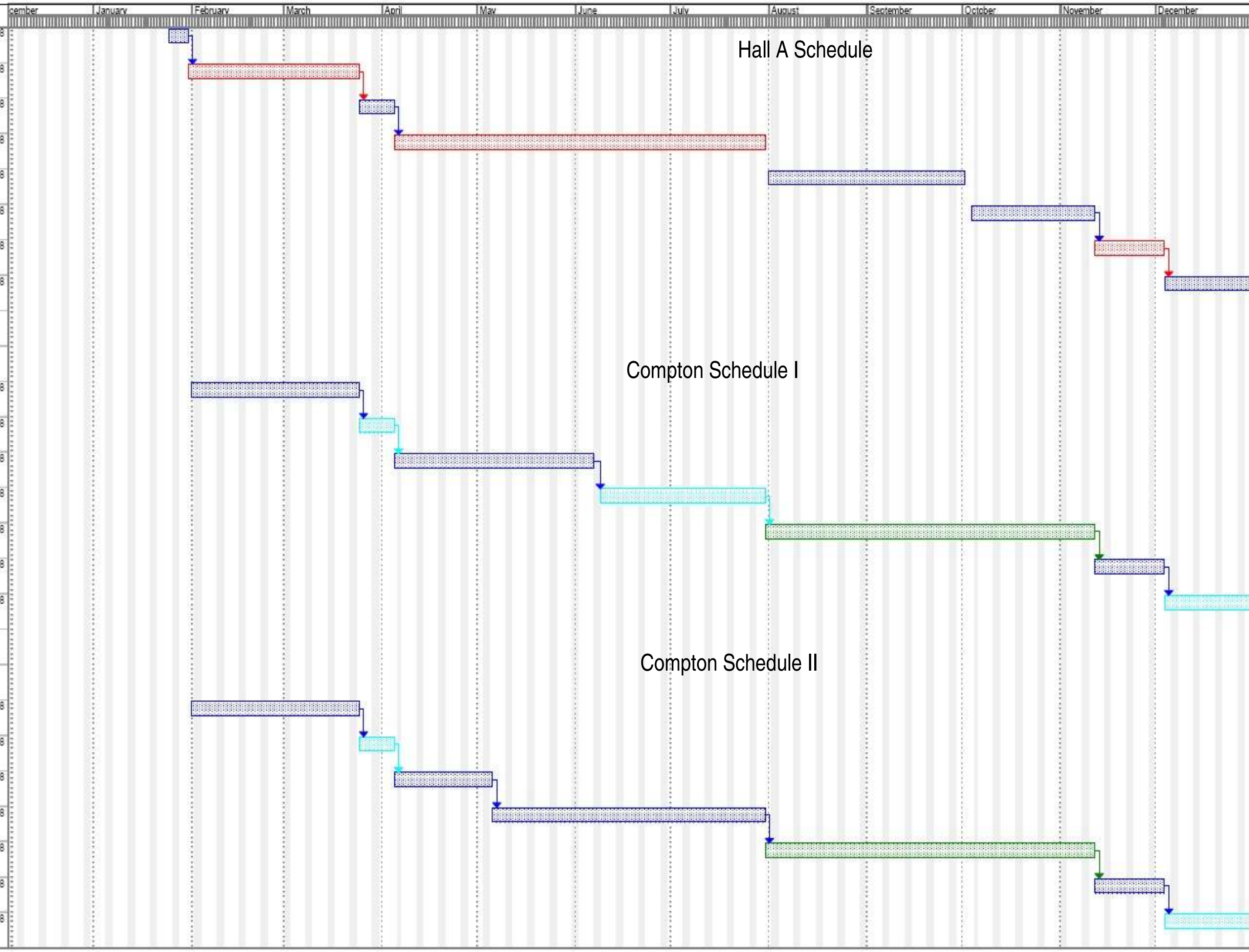
g = Cavity gain

Cavity Power Balance



Schedule

ID	Task Name	Duration	Start	Finish
1	PREx Test	4 days?	Fri 1/25/08	Wed 1/30/08
2	Down	38 days?	Thu 1/31/08	Mon 3/24/08
3	E04-007	9 days?	Tue 3/25/08	Fri 4/4/08
4	Installation	84 days?	Sat 4/5/08	Wed 7/30/08
5	E06-010	44 days?	Fri 8/1/08	Wed 10/1/08
6	E06-014	28 days?	Sat 10/4/08	Tue 11/11/08
7	Down	16 days?	Wed 11/12/08	Wed 12/3/08
8	E05-015	20 days?	Thu 12/4/08	Wed 12/31/08
9				
10				
11	E-det Installation	37 days?	Fri 2/1/08	Mon 3/24/08
12	E-det Commissioning	9 days?	Tue 3/25/08	Fri 4/4/08
13	Laser/Cavity Installation	46 days?	Sat 4/5/08	Fri 6/6/08
14	Cavity commissioning	38 days?	Mon 6/9/08	Wed 7/30/08
15	Production	75 days?	Thu 7/31/08	Tue 11/11/08
16	G-det Installation	16 days?	Wed 11/12/08	Wed 12/3/08
17	G-det Commissioning	20 days?	Thu 12/4/08	Wed 12/31/08
18				
19				
20	E-det Installation	37 days?	Fri 2/1/08	Mon 3/24/08
21	E-det Commissioning	9 days?	Tue 3/25/08	Fri 4/4/08
22	G-det Installation	22 days?	Sat 4/5/08	Mon 5/5/08
23	Cavity Installation I	62 days?	Tue 5/6/08	Wed 7/30/08
24	Production	75 days?	Thu 7/31/08	Tue 11/11/08
25	Cavity Installation II	16 days?	Wed 11/12/08	Wed 12/3/08
26	Commissioning	20 days?	Thu 12/4/08	Wed 12/31/08



Summary

- **Electron detector ready for Feb 08 Installation**
- **Photon detector ahead of schedule, will be ready for Summer 08 installation**
- **Green FP Cavity facing technical challenges** *e.g. locking, power gain*
- **Progress with Green FP cavity**
  - Robust locking at low finesse has been achieved
  - Lock feedback loop tune in progress at medium finesse,
    - short locks achieved
  - High finesse setup to follow
- **PPLN doubler is a success story! Likely candidate with Y fiber Amp for our production solution**

Funds are adequate. Project is manpower Limited!
In search of an expert on laser/photonics instrumentation…