# Meeting of GWP09, Emittance Review
## Summary Notes + Action Items by P. Burrows, M. Woods

**November 28, 2007**

Participants : Phil Burrows Mike Woods, Steve Smith, Andrei Seryi, Mark Woodley, Deepa Angal-Kalinin, Grahame Blair, Pavel Karataev, Vic Scarpine, Alex Lumpkin, Angeles Fauste-Goffe, Kiyoshi Kubo, Toshiaki Tauchi, Yosuke Honda

Meeting page:
http://ilcagenda.linearcollider.org/conferenceDisplay.py?confId=2380

**Notes regarding laserwire system and presentation by Grahame:**

0. A good reference on the laserwire system is given in Ref. [1].
1. Requirements. Need a clear statement and summary table of requirements, including current assumptions. Would like to have a short document summarizing the requirements, a system schematic and the laser specs. Document should include a short description of the measurement procedure.
   - Would like to see requirement stated in terms of something like want a 5% absolute (and/or 5% relative) measurement of train (or bunch) emittance every n (60?) seconds? Need to motivate this from accelerator physics beam tuning procedure and implications for allowable emittance growth in BDS. Ref. [1] indicates that goal is (1-5)% within a single train. Why isn't 5% per 10 seconds adequate?
   - What is the actual intra-train scan frequency needed? 10kHz is 10 scans per train. How is this interleaved between the 6 laserwire IPs mentioned? Also, this talk mentions 6 laserwire IPs whereas the accelerator physics talk only indicated 4 laserwire IPs for a 2D emittance measurement in the RDR BDS; this needs to be resolved.
   - For the system parameters, a 1% emittance measurement of a 1-micron spot is not required. Should baseline be a 5% measurement of a 2-micron spot? (Can consider later upgrades for smaller spots and more accurate measurements.)
   - For the 6 laserwire IPs, is a common laser used or are 6 independent lasers used? Is there a single laser room on the surface with one penetration? Would like a "CFS" schematic outlining this configuration.
   - Should we consider single bunch laser system and emittance measurements for baseline and multi-bunch laser as a future upgrade? Need to motivate multi-bunch system for baseline. Is there enough confidence in expected signal:background to plan for the lower power multi-bunch system for the baseline?
   - Does 150ns bunch spacing present significant problems?

- Do we understand the system specs well enough to pursue R&D for the fiber laser? Why not wait for further industry developments?
- Would like to know key references for laserwire emittance measurements.

2. Page 3 discusses the beam matrix determination from 4D spotsize measurement (6 wirescanner stations) as a function of the spotsize error. Can one get a more robust beam matrix determination by further optimization of the laserwire locations or by changing the FODO lattice? What further theoretical accelerator physics work is needed to optimize this measurement? Does the relative precision needed depend on spotsize? Plots indicate 10% spotsize measurement gives good convergence – what is motivation for 5%?
3. Errors from bpm resolution and dispersion. Disagree with results on p.5. First, would prefer to use sigma_BPM to use for unresolved beam jitter at the laserwire location (just assume there's a bpm there; expect that only the BPM resolution should matter and not the actual beam jitter). Assume a 1-micron beam, 1-micron laser and 0.1% energy spread.
    - BPM resolution. One finds that 300nm bpm resolution would give 5% contribution to the spotsize and 140nm bpm resolution would give 1% contribution. These disagree with numbers on slide 5. BPM resolution should enter in quadrature to spotsize determination, not linear as 2nd equation implies.
    - Dispersion. One expects $\delta(\sigma_e)/\sigma_e = \eta\delta(\eta)\cdot 10^6 m^{-2}$. For eta=1mm, a 5% uncertainty in eta would give a 5% spotsize contribution (and 1% uncertainty in eta would give a 1% spotsize contribution). If eta is 0.3mm, then 55% uncertainty in eta would give a 5% spotsize contribution. These disagree with numbers on slide 5. Need to state how dispersion will be accurately measured.
4. For slide 5 on Compton statistics:
    - include a pulse length factor if the laser pulse is longer than 2ps.
    - Statistics are inversely proportional to the spotsizes measured. Would like to see table of statistics results for different spotsize assumptions. Appears that only have ~350 Compton gammas for perfectly overlapped beams for 1-micron laser and electron spotsizes and substantially less for horizontal spotsize measurement. These statistics are very low; hence concerned about backgrounds.
    - Detector efficiency: —a calorimeter would presumably give an efficiency of 1. So presumably a thin detector with 5% rad. length is used to give an efficiency of 0.05? Can then get much better efficiency if detect Compton electrons -- if so, why not detect the electrons? Or why not use a calorimeter to increase photon efficiency?
5. For slide 8 and regarding compatibility with polarimetry:
    - Can a photon detector can work in 0-deg line wrt upstream trajectory--need to worry about synchrotron radiation from 1st dipole in chicane and upstream quads; also other sources of background. Should the measurement be done with Compton electrons rather than gammas -- how do statistics look with electron detection?

- Need to consider backgrounds possible from MPS energy collimator and beam halo. Since fewer than ~1000 Compton scatters/bunch are expected, then if significant backgrounds exist will want instead a higher power single-bunch laser rather than multi-bunch.

6. Laser beam uncertainties. The laser beam spotsize at the Compton IP is $\sigma_l = M^2 \lambda f_\#$. For $M^2$=1.3, 266nm wavelength and 1.5 optics, this gives a 520nm laser spotsize. The sensitivity of the measured spotsize to $M^2$ then depends quadratically on the ratio of the laser spotsize to the electron spotsize. 1% $M^2$ uncertainty is only required if want 1% electron spotsize sensitivity to this when the laser and electron spotsizes are comparable. If 2-micron spotsizes are a baseline, then would probably choose 532nm for laser wavelength and 5% $M^2$ uncertainty should then suffice. Is laser imaged onto IP to reduce pointing jitter? What is experience with $M^2$ measurements, stability and uncertainties?
7. Are beam tests planned or needed to compare capabilities with 4D and 2D measurements, including quad scans? Is it possible to have fewer than 4 laserwire stations?

**Notes regarding Accelerator Physics presentation by Deepa and Mark:**

1. For the MPS collimator in the "polarimeter" chicane, would like more specification to assist background studies for polarimeter and laserwire. 3 meters of space is reserved for a tapered collimator. For 10% collimation should we assume +-2mm gap over 1 meter length for background studies (nominal 250 GeV beam energy)? Then we can see what flux hitting that collimator starts to present background problems.
2. For initial baseline operation (up to 250 GeV beam energy), is it sufficient to assume 2-micron electron beam sizes? Later "upgrade" (ex. 500 GeV beam energy) could accommodate 1-micron electron beam spotsize?
3. Are spotsize diagnostics desired between collimation region and IP. For example:
   i. Location to measure IP divergence angles at 540 meters upstream of IP, where horizontal spotsize is 350um and vertical spotsize is 60 microns. Use ODR for this?
   ii. Location to measure spotsizes at IP phase, for example at 450 meters upstream of IP where there is both a horizontal and vertical waist (though there is some horizontal dispersion). Horizontal spotsize is 16 microns and vertical spotsize is 84nm (Shintake monitor?).
4. There are 10 beam parameters to measure ($\varepsilon_{x,y}$, $\beta_{x,y}$, $\alpha_{x,y}$ and the 4 coupling terms <xy>, <x'y>, <xy'>, <x'y'>). 4 wire scanners each measuring x,y,u give 12 measurements. But as discussed in the NLC ZDR[2] Section 11.3.2 a true 4D measurement has 6 wire scanner locations. What are the implications of having 4D (6 wire scanners) versus 2D (4 wire scanners) and should 6 wire scanners be implemented? (The ZDR notes for example that the 4D measurement takes twice the z length as a 2D measurement.) What quad scans are needed if have 4D (6 laserwires) or 2D (4 laserwires) measurement systems; is it possible to have fewer

than 4 laserwire stations? Can luminosity be delivered during a quad scan? Also see note 2 above for laserwire discussion —what further accelerator physics studies are needed to optimize the emittance measurements?

5. Need more review of list of items on last slide of presentation about possibilities to shorten system, how coupling corrections are done etc. Questions addressing upstream polarimetry are discussed in more detail in the Nov. 29 meeting and minutes.
6. Would like to know key references addressing emittance measurements for ILC.

## Notes regarding ODR/OTR presentation by Pavel:

1. Would like to see an R&D program investigating capability for 2-micron electron beam spotsize measurement. Also should study dependence of measurement capability using information from the wavelength spectrum and dependence on beam energy. First, would like to see theoretical investigation for this and then if this looks promising to follow up with experimental proposals. What slit width is needed for 250 GeV beams? Would be good if can be 2mm or larger. Also need to worry about possible wakefield effects from slits.
2. Is beamsize determined in real time, or is extensive offline analysis required?
3. Can individual bunches in a bunch train be resolved for i) 300ns bunch spacing and ii) 150ns bunch spacing?
4. Are there any coherent effects or bunch length effects that are important?
5. What spotsize accuracies are achievable? As a function of spotsize.
6. How reproducible are results, ie. measurement jitter? Would be nice to see histogram of results from 100 shots, both modeled and measured.
7. If ODR can be used for horizontal spotsize measurements can that reduce # of laserwire IPs?
8. Would like to know key references addressing ODR measurements for ILC.

**Action items** (suggested due dates are to complete these by Feb. 15):

1. Laserwire Group
   i. Generate a scope document as described in Note 1.
   ii. Laserwire group should work with accelerator physics group (Deepa et al.) regarding studies and optimization of emittance measurements as discussed in Notes 2 and 7.
   iii. Requirements for BPM and dispersion measurements: address issues in Note 3.
   iv. Compton statistics: address issues in Note 4.
   v. Synchrotron radiation backgrounds to a laserwire photon detector -- should an electron detector should be pursued instead? Address issues in Note 5.
   vi. MPS collimator backgrounds to laserwire detectors: address issues in Note 5.
   vii. Laser beam spotsize and requirements for laser wavelength and $M^2$ uncertainties: address issues in Note 6.
   viii. Give key references for laserwire system.

2. Accelerator Physics WG
   i. Give specifications for the MPS collimator (note 1) to allow background studies for laserwire and polarimeter detectors. (Acc. Physics and Collimation WG leaders)
   ii. Work with the laserwire group to address notes 2 and 4 about optimizing the emittance measurement.
   iii. What other wire scanner locations are needed in the final focus (note 3)?
   iv. Give key references for emittance measurements.

3. ODR Group
   i. Develop R&D plan to address minimum spotsize measurable with this technique.
   ii. Provide short answers to questions in notes 2-7.
   iii. Give key references for ODR measurements.

**References:**

[1] I. Agapov, G.A. Blair and M. Woodley, Phys. Rev. ST Accel. Beams 10, 112801 (2007), http://prst-ab.aps.org/abstract/PRSTAB/v10/i11/e112801.

[2] NLC Zeroth-Order Design Report, http://www.slac.stanford.edu/pubs/slacreports/slac-r-474.html.