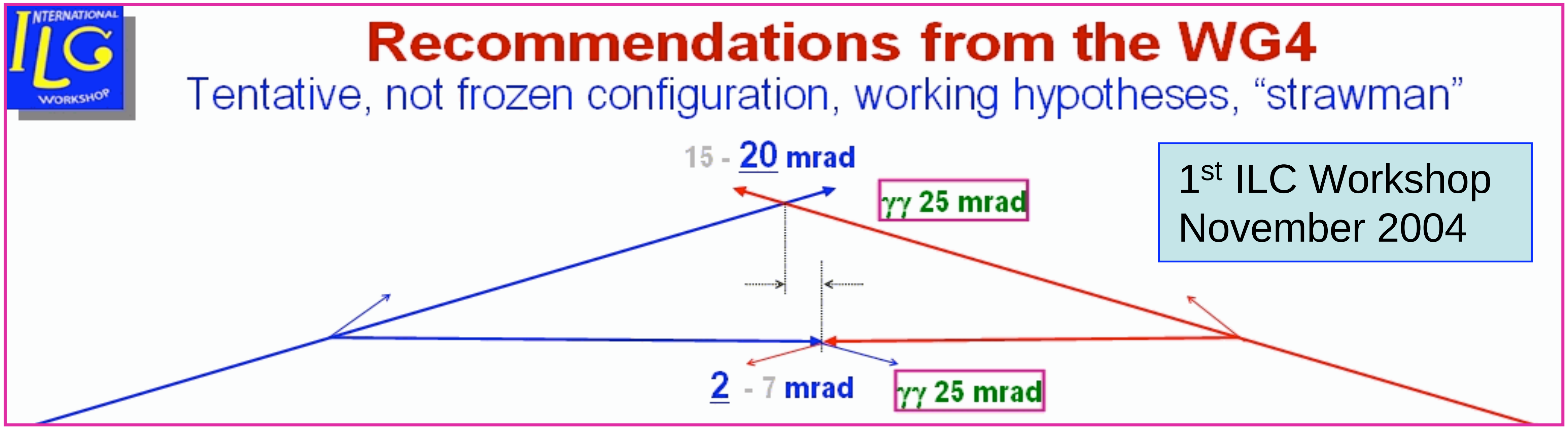
Machine Parameters

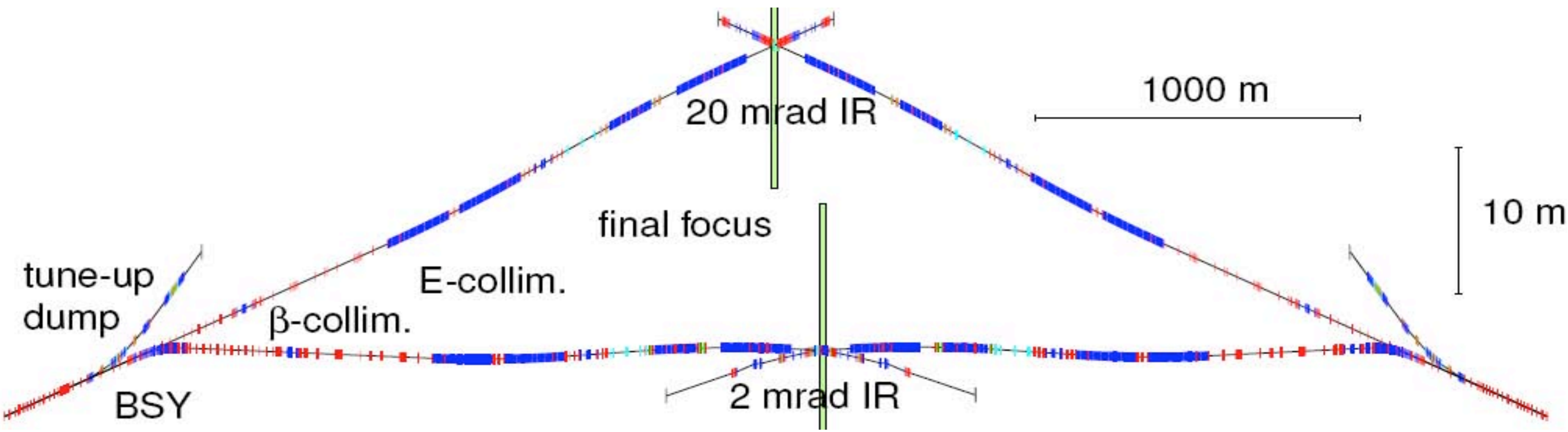
Q3(LowQ),6(L*),7(VTX_R),8(2&20mr),15(Zpole),16(e-e-)

T.Tauchi, MDI Session (Detector-Concepts-Accelerator)

16 August 2005, SNOWMASS



International BDS group has put the Strawman tentative configuration into real design.



Summary of MDI issues

System	Machine	Detector
BDS	Crossing angle 2 IPs; "identical" experiments Collimation depth Precise E/P measurements	Backgrounds: μ, synchrotron γ
IR	L* : distance of Final-Q from IP	Min. angle: very forward cal. Precise luminosity measurement Backgrounds; pairs, mini-jets, back-scattered γ, n Instrumentation; pair/Shintake monitors, feedback, Nano-BPM, laser-wire etc.
Extraction	Crossing angle Choice of Final-Q (L*) Precise E/P measurements	Backgrounds; disrupted beam, back-scattered γ, n Beamstrahlung monitor

Q3: Would you mind if the baseline bunch-spacing goes to ~150 ns instead of ~300ns; with ~1/2 the standard luminosity per crossing and twice as many bunches

SiD: The SiD detector technology that we have considered so far is all intrinsically fast on the scale of 150 ns, so that the issue of the 150 ns spacing really is an issue for the electronics. (Note that this distinction is ill defined for the vertex detector) The SiD electronics concept (so far) for non-very-forward systems involves measurement of the amplitude and time of signals as they occur, buffered up to four measurements per train. When the issue of 150 ns first came up, we changed the clock (and ADC) architecture to 13 bits, so we think that, unless the background per train were to go up by a large factor, we would not be concerned about the difference between 300 and 150ns bunch spacing.

The very-forward detectors would measure every pulse. Again, given the primitive state of thinking, we don't believe we mind whether there are 3000 or 6000 buffers. Note that this design may have some relevance for the machine instrumentation.

The vertex detector is most likely going to evolve from some CMOS like structure that does not involve shifting charge as in a CCD. Since the number of hit pixels per train would not change significantly, and 150 ns is slow compared to the logic times involved in these structures, it should not matter. Note that this conclusion is based on the rather minimal R&D that has been accomplished to date.

LDC : There is currently no strong reason known why 150ns bunch distance should be significantly worse than 300ns inter-bunch spacing. Careful attention however needs to be given to the number of events integrated over in the different subdetectors. However assuming that backgrounds etc scale as the luminosity, the total occupancy of detectors should not change, and no fundamental problems are to be expected. With the timing resolution expected in some key detectors like the TPC no problems are expected at 150ns bunch spacing to separate bunches.

GLD : CAL has no problem for the DAQ will be sufficiently fast.
The TPC timing resolution is about 1.5 nsec so that tracks from a bunch 150 nsec apart would not be confused. The integrated random background over the TPC readout time of 50 μsec would be the same for the two bunch spacing options.

parameter	unit	Nominal	Low Q	Large Y	Low P	High Lum
E_{CM}	GeV			500		
Beam intensity	10^{10}/bunch	2.00	1.00	2.00	2.00	2.00
No. of bunches	/train	2820	5640	2820	1330	2820
T_{sep}	nsec	307.7	153.8	307.7	461.5	307.7
$\gamma \varepsilon_x$	10^{-5} /bunch	1.00	1.00	1.20	1.00	1.00
$\gamma \varepsilon_y$	10^{-8} /bunch	4.00	3.00	8.00	3.50	3.00
β_x	cm	2.10	1.20	1.00	1.00	1.00
β_y	μm	400	200	400	200	200
bunch length	μm	300	150	500	200	150

Suggested parameter Sets by WG1 and A.Seryi for High Lum-1,2

parameter	unit	Nominal	Low Q	Large Y	Low P	High Lum	High Lum-1	High Lum-2
E_{CM}	GeV				1000			
Beam intensity	10^{10}/bunch	2.00	1.00	2.00	2.00	2.00	2.40	2.00
No. of bunches	/train	2820	5640	2820	1330	2820	2820	2820
T_{sep}	nsec	307.7	153.8	307.7	461.5	307.7	307.7	307.7
$\gamma \varepsilon_x$	10^{-5} /bunch	1.00	1.00	1.20	1.00	1.00	1.00	1.00
$\gamma \varepsilon_y$	10^{-8} /bunch	4.00	3.00	8.00	3.50	3.00	2.3	2.3
β_x	cm	3.00	1.50	1.10	1.20	1.00	3.00	2.16
β_y	μm	300	200	600	200	200	310	310
bunch length	μm	300	150	600	200	150	300	300

Simulation Results by CAIN

parameter	unit	Nominal	Low Q	Large Y	Low P	High Lum
E_{CM}	GeV	500				
Luminosity	10^{34} $cm^{-2}s^{-1}$	2.07	1.98	1.73	2.00	5.08
N_{gamma}	/electron	1.296	0.834	1.911	1.861	1.798
Inc. Pairs:E>3MeV	10^4 /bunch	6.45	2.47	7.07	15.9	18.5

parameter	unit	Nominal	Low Q	Large Y	Low P	High Lum	High Lum-1	High Lum-2
E_{CM}	GeV	1000						
Luminosity	10^{34} $cm^{-2}s^{-1}$	3.42	3.48	3.18	3.60	10.33	6.91	5.67
N_{gamma}	/electron	1.472	1.01	2.515	2.218	2.336	1.765	1.730
Inc. Pairs:E>3MeV	10^4 /bunch	11.9	4.98	16.5	33.1	45.6	25.05	20.21

Q6: What is your preferred L*? Can you work with 3.5m < L* < 4.5m? Please explain your answer.

SiD : The L* preferred for SiD is that which is most likely to produce the most luminosity with the least background, while not interfering with the acceptance of SiD. So it is difficult to answer, as it appears to be coupled to questions of crossing angle and required stability for the final quads. (We are not interested in a tube stabilizing the quads that goes through the middle of the detector). The range 3.5m < L* < 4.5m seems generally acceptable to us.

LDC : The current forward region / interaction region design of LDC is done with an L* of 4.05m. Changes in L* require extensive re-optimisations of the background conditions. However there are no fundamental reasons to prefer one or the other solution.

GLD : We prefer L* of greater than 4.7m, assuming that the superconducting final quadrupole magnet (QD0) has a 20cm long transition length from cold to warm in front. Two major reasons are (1) to confine low-energy particles within the Be beam pipe, which are backscattered from the CH2 mask in front of BCAL with 2cm inner radius; i.e. maximum radii of 1.6, 1.92 and 1.99 cm at L*=4.5, 4.1 and 3.6m, respectively, and (2)for FCAL/mask to shield TPC active region against photons backscattered at BCAL in GLD, where FCAL and BCAL locate at 2.5 and 3.5m, respectively, from IP. Full simulation are necessary if the backscattered background can be tolerable at shorter L*, which are under studies. First results are expected to be presented at SNOWMASS.

Q7 : What are your preferred values for the microvertex inner radius and length? If predicted backgrounds were to become lower, would you consider a lower radius, or a longer inner layer? If predicted backgrounds became higher, what would be lost by going to a larger radius, shorter length

SiD : This is a very detailed question that needs a lot of simulation work. We understand that Sonja Hillert (from the UK LCFI Collaboration) will present important new results on this topic at Snowmass, in the context of the CCD-based VXD design.

Our present geometry is given in lcsim.org; Rvtx=1.4cm. The SiD approach for now is to go with a shortened barrel plus four layer endcap, but this approach needs some engineering to know just how thin the endcap can be, and additional study of how it performs given a realistic material budget. This will not be settled by Snowmass. We find detailed optimizations for this question slightly premature. We see it evolving for years as more realistic luminosity requirements and backgrounds are evaluated and the physics requirements better understood.

LDC : The value of 1.5cm used in the current LDC detector concept was obtained by an optimisation between requirements from physics (primarily charm tagging) and constraints from the machine. The TESLA design became very difficult for apertures below 1.5cm in the central region. The physics case is currently being re-visited, in particular under the new aspects of charge reconstruction of heavy flavour states. Fist results are expected for the snowmass meeting. The machine constraints will need to be restated once a ILC interaction region has been finalised.

GLD : The preferable innermost radius of VTX might be less than 2cm and the polar angular coverage must be |cos θ | < 0.95 , for good tagging efficiency of charm and bottom quarks as well as jet charge determination. However, the minimum radius must be limited by background consideration on synchrotron radiation profile and a core distribution of incoherent pairs. While the synchrotron radiation profile can be controlled by the collimation depth in BDS, the minimum radius depends on the machine parameters for different beamstrahlung and distruption effects during collisions. If the background is high, the inner radius of the VTX must increase by 10 to 20%. This increase affects the impact parameter resolution and the flavor tagging efficiency, while the effect would be at most 10 to 20% change.

ECM (GeV)	Option	B (T)	R_{core} (mm)	R_{Be} (mm)	R_s (mm)	R_{VTX} (mm)	Z_{VTX} (mm)
500	Nominal	3	10.5	12.5	30	16.6	52.4
		4	9	11	28	14.9	47.4
		5	7.5	9.5	25	13.2	42.0
500	High L	3	16.5	18.5	42	24.1	75.4
		4	13.5	15.5	36	20.2	63.6
		5	12	14	33	18.4	57.9
1000	High L	3	18.5	20.5	42	25.8	80.5
	High L’	**3**	**13**	**15**	**34**	**19.4**	**61.1**
	High L’’	**3**	**11.5**	**13.5**	**32**	**17.8**	**56.1**

Q8: Are you happy that only 20mr and 2mr crossing angles are being studied seriously at the moment? Are you willing to treat them equally as possibilities for your detector concept.

SiD : We think the present strategy of studying 2mr and 20mr as 'extreme' cases is acceptable. However, SiD would be interested in the smallest crossing angle that does not compromise downstream E and P measurement, does not increase backgrounds, does not significantly increase the risk of backgrounds, and does not reduce the reliability of the machine (e.g. thermal load on FF superconducting quad). This may well be more than 2 and less than 20 mrad. If 2mrad will not allow downstream monitoring of polarization and energy, we would like to see study of a "smallest possible crossing angle" solution which does.

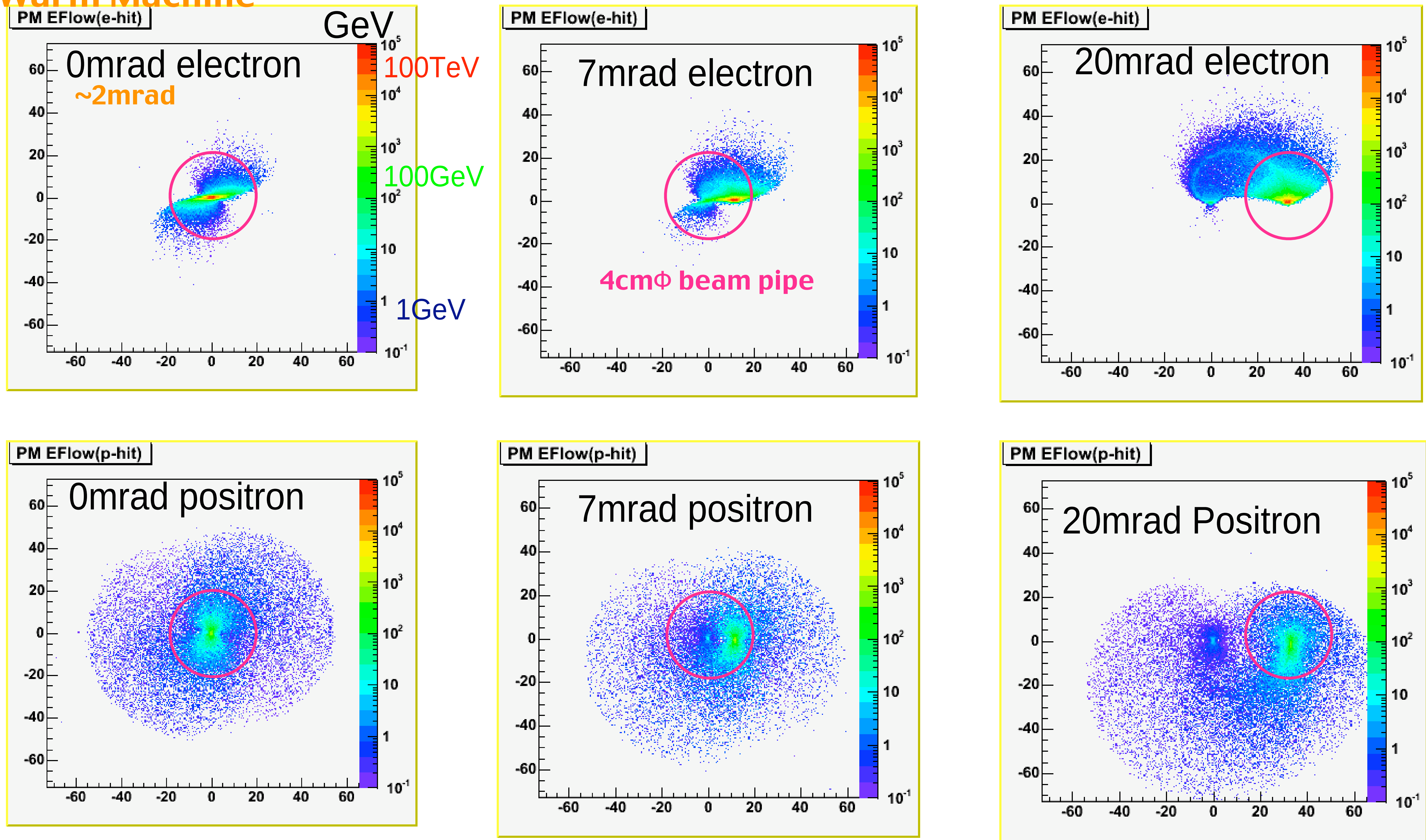
LDC : The two proposed crossing angle schemes - 20mrad and 2mrad - seems a good starting point for the studiess ongoing at the moment. They cover probably the range of problems found in a small and in alarge crossing angle regime. We feel however that we should reserve the option to revisit the chosen crossing angles as more results on backgrounds, impact on the physics, and impact on the machine design are better understood. LDC is currently studying both the small and the large crossing angle scheme.

GLD : We prefer the smallest crossing angle even including headon with acceptable backgrounds, an extraction line including polarimeter and energy spectrometer, while as well known the 2mr and 20mr have been determined to be strawman's crossing angles by the ILC-WG4, November 2004. If the 2mr encounters a serious difficulty, we would like to suggest a further study on the minimum crossing angle in the range of 2 and 20mr.

Pair distribution at Z=330cm, B=4T

TRC500 **Warm Machine**

Energy flow in 0.5mm square mesh / bunch



Q15: Is Z-pole calibration data needed? If so, how frequently and how much? What solenoid field would be used for Z-pole calibration? Are beam energy or polarization measurements needed for Z-pole calibration

SiD : We have not yet given this issue real study, but expect to need some runs at the Z to get enough tracks to align the tracking detectors and perhaps to cross calibrate the calorimeters. Ideally these would be at full field. Experience from SLD shows that of order 500k Zs was just about sufficient to align a system of 96 CCDs including non-planar shape corrections for the sensors in the vertex detector. We think that the trackers need to be designed with an alignment friendly awareness - nice overlap regions and lever-arms and preferably a high degree of symmetry.

We have not thought much about aligning the endcap yet. That could require more data.

If the central tracker alignment were based on the SLD VXD alignment strategy, the statistics required may well be higher given the larger volume and many more overlapping regions to deal with.

We would expect to have to (re-)align after each major detector access. In principle this ought to be no more than a few times per year.

LDC : In general Z-pole data are considered to be very useful for detector calibration. No detailed study exists at the moment on the needed luminosity and/or precision. Based on the experience at LEP2, and folding in the fact that the granularity of the detectors is much larger and the requirements on the precision more stringent, one run with $10pb^{-1}$ at the beginning of a year and an additional approximately $1pb^{-1}$ per year are deemed sufficient, to establish and track the calibration. At the start of the ILC larger data samples might be needed to establish a base calibration.

The Z calibration is particularly important for the precision period of the ILC. A good calibration can probably be established without extensive Z running, based on Z or WW events. However this needs to be studied in more detail.

GLD : We are evaluating these issues for each detector. Also, we need how much luminosity is extected on Z-pole during the usual experimental run at ECM=500GeV. At present, we assume the luminosity(L) of $10^{33}/cm^2/s$ for VTX and CAL calibration runs, while L= $10^{32}/cm^2/s$ is assumed in the TPC calibration. Preliminary results are listed below;

VTX; If we have 1 fb^{-1} integrated luminosity, which can be achieved by 10 days run with 10^{33} luminosity, we can accumulate $3x10^6$ muons (50M Z). Then we can get 1000hits/cm^2 at the outermost layer of the VTX. This number would be enough to get precise position calibration of the VTX. So we would like to propose to have; 1 fb^{-1} Z-pole run: Once per run period (=one year?) and 100 pb^{-1} Z-pole run : Once per month.

CAL requires sufficient number, about 100, of MIP particles passing in every 1cm x 1cm segmentation for 100 m^2 scintillator in the electromagnetic calorimeter. If muon pairs are only used (BR is 3.3%) on Z-pole, integrated luminosity of 10 fb^{-1} would be necessary, i.e. 100 days with L= 10^{33}!. CAL group must study seriously if hadronic events can be used for the calibration, or some clever method.

TPC by R.Settles and M.Thomson: The answer needs a guess at how often problems with the detector will occur that require calibration data. To not just make a blind guess, we took the data from Lep2 running, where this procedure (Z pole running for calibration) was used several times when detector problems cropped up. The last year of Lep2 running (2000), where things were really being pushed by the machine, the track record was: Z Running needed at Lep2: =>per detector<= 3/pb at the beginning of the year, and one run of 0.5/pb during the year. So, we propose then to use the following working hypothesis: Z Running for ILC: =>per detector<= 10/pb at the beginning of a year, and one run of 1/pb during a year , since the detector(s) will be more complicated. If I remember correctly, the projected Z-pole luminosity for Tesla for "calibration" (i.e. no special beam gymnastics to push up the luminosity like would be needed for the "GigaZ") would be $10^{32}/cm^2 sec$ so that calibration at the beginning of the year would take =>per detector<= 30hours of beam and during the year =>per detector<= 3hours of beam. To repeat, this is just a guess, but at least it is based on past experience. At the very beginning of the ILC operation, much more Z running would be needed for calibration of the detector(s). This will mainly be determined by the calorimeter; Calice has studied this but I don't remember what their number is, maybe somebody else does...

Q16: Would you like te e-e- option to be included in the baseline, and if so what minimum integrated luminosity would you want ?

SiD : Not for now, unless SUSY is discovered

LDC : As stated in the scope document, we feel that e-e- should be included as an option, but not be considered part of the baseline.

GLD : Probably no, since there is no strong desire in GLD group at present. However, the e-e- option may be kept for the physics motivation may become relevant in future, in such way as SUSY or new physics would demand.

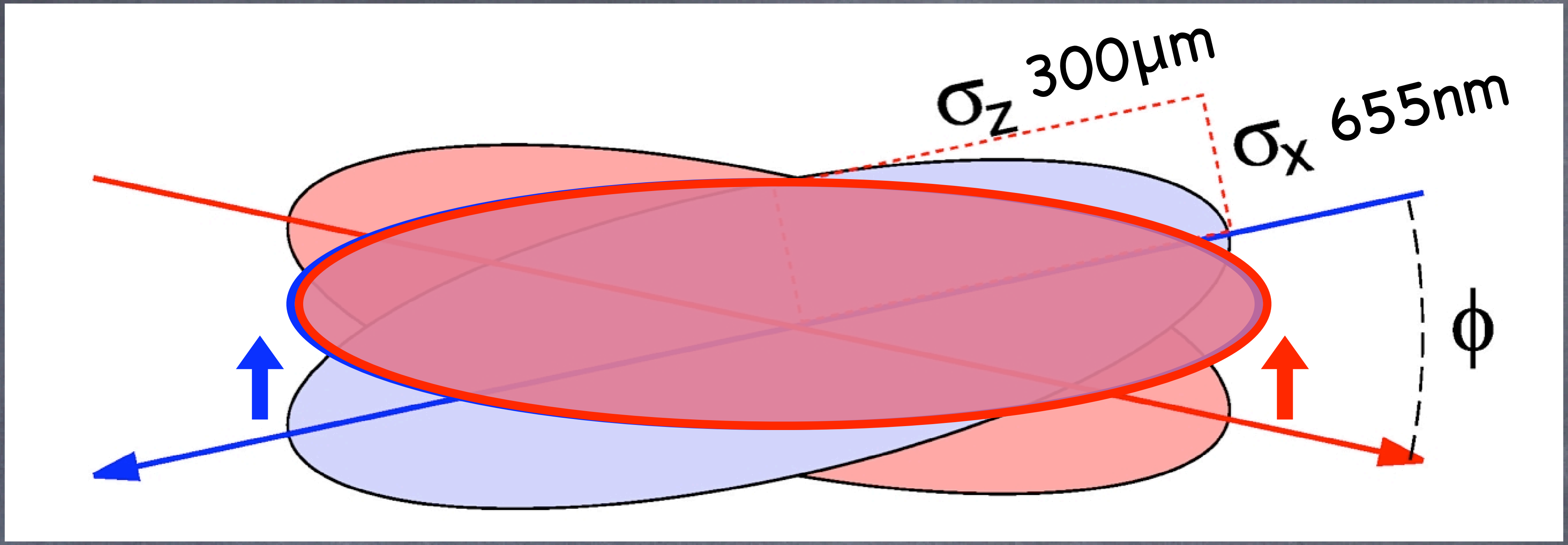
Beam Parameter Range

- Wide range of intensity, bunch number, beam sizes; Nominal, LowQ, LargeY, LowP and Highlum(1,2) .
- LowQ is desirable from the background issues.
- A.Seryi's Highlum2 is the best in the Highlum parameters both at Ecm=500 and 1000GeV; also from the background issues.

L^*

- $3.5 < L^* < 4.5(4.7)$m for SiD, LDC and GLD
- Optics : chromaticity $\approx L^*/\beta^*_y$
  note) Optics is "easier" with local chromaticity correction.
- Final Q choice especially in larger crossing angle
- Synchrotron radiation profile in FDs
  collimation depth is larger at longer L^* ?

Horizontal Crossing Angle



Small angle : $\Phi < 2\sigma_x/\sigma_z > \Phi$: Large angle

~ 4.4 mrad

Small angle	Large angle
common final Q at extraction line	independent extraction line
smaller dead cone (θ)	asymmetric angular accept. for 2 beam holes
smaller backscattering	larger backscattering
no DID	DID must be essential

Anti-solenoid at final Q is common.

Z pole Run

- How much is luminosity ?
- If the positron source is available at Z-pole, luminosity would be linear to Ecm; i.e. $3.6 \times 10^{33}/cm^2/s$ is expected; 0.3/fb/day
- Absolute energy calibration is necessary for CAL; total channel number $=10^6$ for segmentation of $1cm^2$, a few month with muon pairs from Z ! Need clever idea.
- TPC : 10/pb at beginning of year and 1/pb per year.

Option

- $\gamma\gamma(e\gamma)$ collisions with e^-e^- operation ;
  Physics complemetary to e^+e^- collisions
- 2 IR must be essential for the option needs large crossing angle ≥ 20mr and large modification of IR region and extraction line.
- GG6 (option) discussion is important.