Effect of changes for running at lower energies

following the

Physics Questions Committee's
Status Report
provided to the SB2009 Working Group
of Detector colleagues

Brian Foster, Jim Clarke, Andrei Seryi
for the Physics Question Committee

AAP Review
Oxford, January 6-8, 2010

Members

- B. Foster — Co-Chair
- A. Seryi — Co-Chair
- J. Clarke
- M. Harrison
- D. Schulte
- T. Tauchi

First Meeting took place 19/11/09. Present were above plus J. Brau, F. Richard, S. Yamada.

The report was presented on Dec 9, followed by detailed discussion and studies initiated by detector colleagues

In this presentation, will focus on the questions relevant for low energy running (Lumi, energy spread, etc.), which correspond to question Q1-3 & Q6 of the SB2009 Working Groups of detector colleagues

Questions from SB2009 WG

1. To assess the physics impact, we need beam parameters at several key energies:
    1. 250 GeV (to compare with LoI),
    2. 350 GeV (a likely operating energy for SB2009),
    3. 500 GeV (again to compare with the LoI).
2. Beam parameters should include electron/positron beam energy spread.
3. We would like to understand the effect on backgrounds/luminosity spectrum for SB2009 with vs without traveling focus.
4. Despite the questions of feasibility, the conventional positron source remains very interesting in order to maximize yield and therefore luminosity. Please provide estimates of the expected luminosity and beam energy spread that would be possible with either a conventional positron source, or an undulator source, at cms energies between 200 and 300 GeV. Will the conventional source possibility remain an option in the re-baselined design? What R&D will be pursued either within the GDE or by other groups to ensure its development?
5. How stable would the Luminosity, Energy spread, and positron polarization be during a threshold scan, for example for ttbar or Susy?
6. Can you provide a rough sketch of L(Ecm), Energy spread(Ecm), and Pol e+(Ecm) showing how they might be expected to vary between Ecm=91 and 500 GeV?

Health Warning

- For the purposes of this exercise, we should not take absolute numbers too seriously but rather differences between RDR and SB2009 under similar assumptions.
  - **Accuracy of results depends on accuracy of the accelerator tools and models used for the calculations. Generally accuracy of tools well established. There is still uncertainty in beam parameters (such as bunch-to-bunch jitter in the train, for example) and in characteristics of the systems that could only reliably be obtained from measurements (for example, collimator wake fields). These uncertainties may translate to systematic uncertainties of many tens of percents. However, since the models are applied to different parameter sets in a uniform manner, the uncertainties between *different parameter sets* should be smaller, ~ 10 – 20%.**

Questions

1. To assess the physics impact, we need beam parameters at several key energies:
   - **250 GeV (to compare with LoI),**
   - **350 GeV (a likely operating energy for SB2009),**
   - **500 GeV (again to compare with the LoI).**

Proviso: The 500GeV parameters are provided officially in SB09 tables and can be compared with RDR case. The 250 and 350GeV parameters were never officially provided, the tables used by Detector concept colleagues were provided via private communication, or via work-in-progress presentations at workshops. The GDE Physics Questions Committee will make its best effort to provide the needed 250 and 350 GeV parameter sets, expecting that the semi-official character of these sets will be understood.

Beam Parameters

	RDR			SB2009 w/o TF				SB2009 w TF			
CM Energy (GeV)	250	350	500	250.a	250.b	350	500	250.a	250.b	350	500
Ne- ($*10^{10}$)	2.05	2.05	2.05	2	2	2	2.05	2	2	2	2.05
Ne+ ($*10^{10}$)	2.05	2.05	2.05	1	2	2	2.05	1	2	2	2.05
nb	2625	2625	2625	1312	1312	1312	1312	1312	1312	1312	1312
Tsep (nsecs)	370	370	370	740	740	740	740	740	740	740	740
F (Hz)	5	5	5	5	2.5	5	5	5	2.5	5	5
γex ($*10^{-6}$)	10	10	10	10	10	10	10	10	10	10	10
γey ($*10^{-6}$)	4	4	4	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
βx	22	22	20	21	21	15	11	21	21	15	11
βy	0.5	0.5	0.4	0.48	0.48	0.48	0.48	0.2	0.2	0.2	0.2
σz (mm)	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
σx eff ($*10^{-9}$ m)	948	802	639	927	927	662	474	927	927	662	474
σy eff ($*10^{-9}$ m)	10	8.1	5.7	9.5	9.5	7.4	5.8	6.4	6.4	5.0	3.8
L (10^{34} $cm^{-2}s^{-1}$)	0.75	1.2	2.0	0.2	0.22	0.7	1.5	0.25	0.27	1.0	2.0

- The methodology how the parameters were defined is described in TILC08 talk of A.S.
- The major difference between SB2009 and the RDR is the luminosity at 250 GeV. See later.

Questions

2. Beam parameters should include electron/positron beam energy spread.

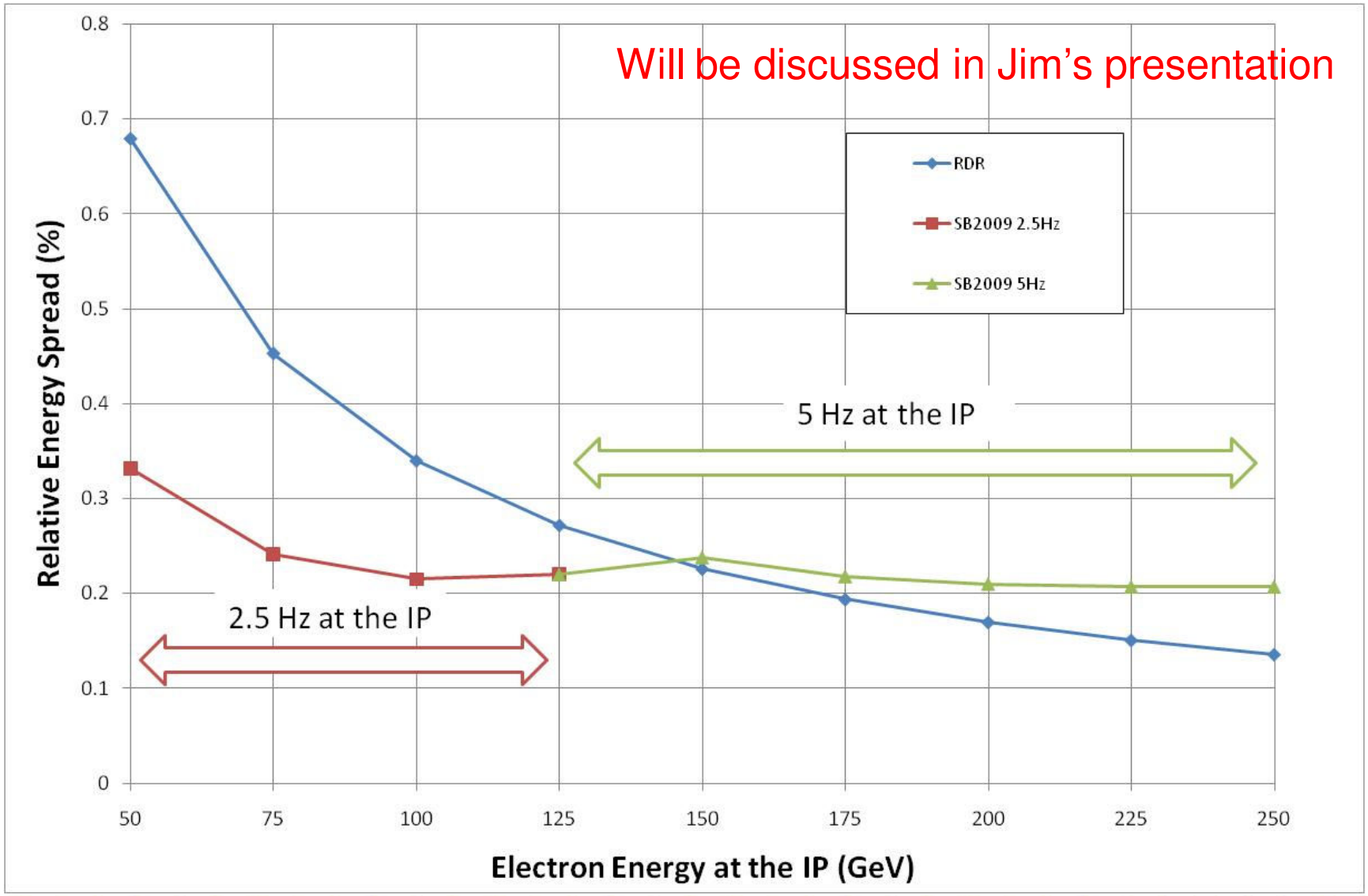
dE/E in %	250 GeV CM	350 GeV CM	Official 500 GeV CM
RDR, electrons	0.272	0.194	0.136
RDR, positrons	0.180	0.129	0.09
SB09, electrons	0.220	0.218	0.207
SB09, positrons	0.130	0.093	0.065

Will be discussed in Jim's presentation

Based on energy spread of 1.08% in SB2009 and 1.5% in RDR at 15 GeV.

Electrons passing the undulator emit SR - added in quadrature to inherent energy spread.

Questions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RDR
SB2009 2.5Hz
SB2009 5Hz
5 Hz at the IP
2.5 Hz at the IP
Relative Energy Spread (%)
Electron Energy at the IP (GeV)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
50
75
100
125
150
175
200
225
250

Questions

3. We would like to understand the effect on backgrounds/luminosity spectrum for SB2009 with vs without traveling focus.

	RDR			SB2009 w/o TF				SB2009 w TF			
Par/E	250	350	500	250.a	250.b	350	500	250.a	250.b	350	500
δE %	0.6	1.2	2.4	0.3	0.6	1.6	4.1	0.3	0.6	1.6	3.6
Npairs* 10^3	97	156	288	48.7	97.4	214	494	57.4	115	255	596
L	0.75	1.2	2.0	0.2	0.22	0.7	1.5	0.24	0.27	1.0	2.0
L (1%)/L	0.97	0.92	0.83	0.98	0.96	0.88	0.73	0.94	0.89	0.77	0.72

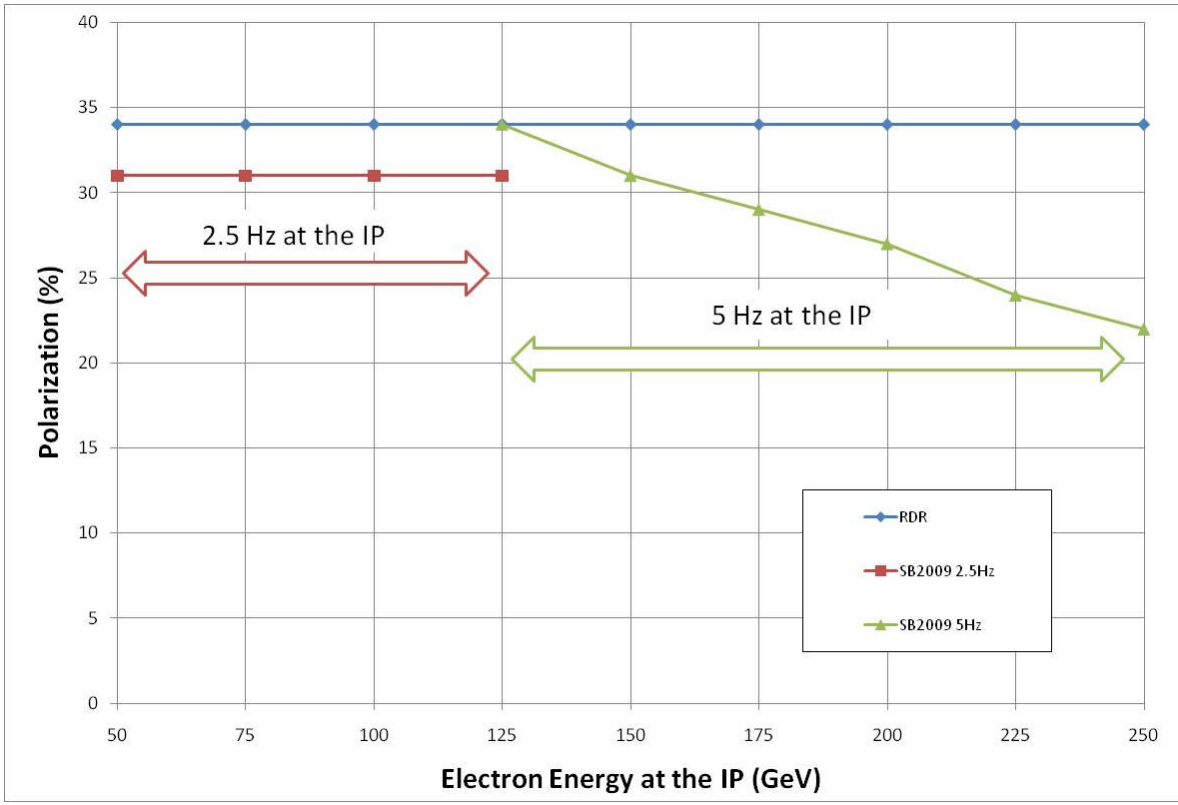
Npairs is an analytical estimate – Guineapig etc many be different by many 10s of %.

Questions

6. Can you provide a rough sketch of L(Ecm), Energy spread(Ecm), and Pol e+(Ecm) showing how they might be expected to vary between Ecm=91 and 500 GeV?

Points above 250 GeV exist in previous tables, except for e^+ polarisation, given here:
e^- polarisation is unchanged in SB2009 @ ~80%.

(Note: the 91 GeV is for calibration. We are working on a parameter set for this case).



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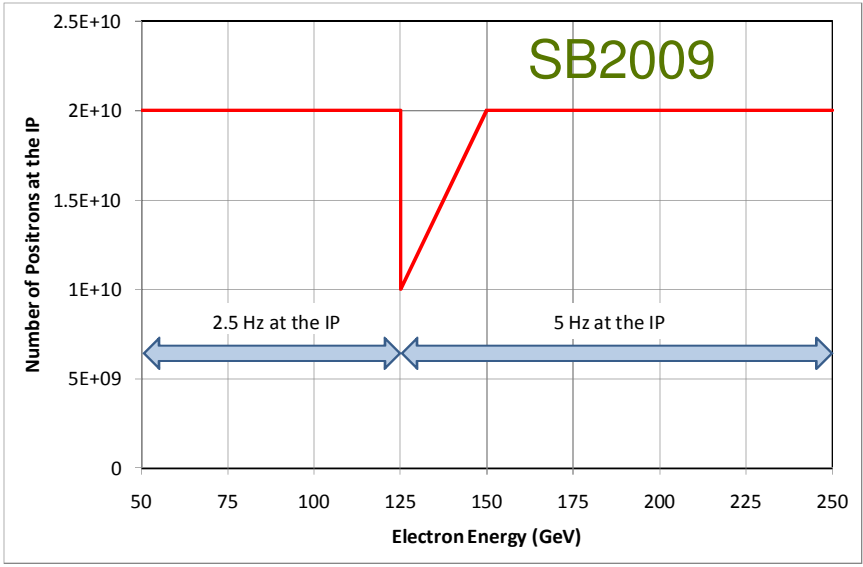
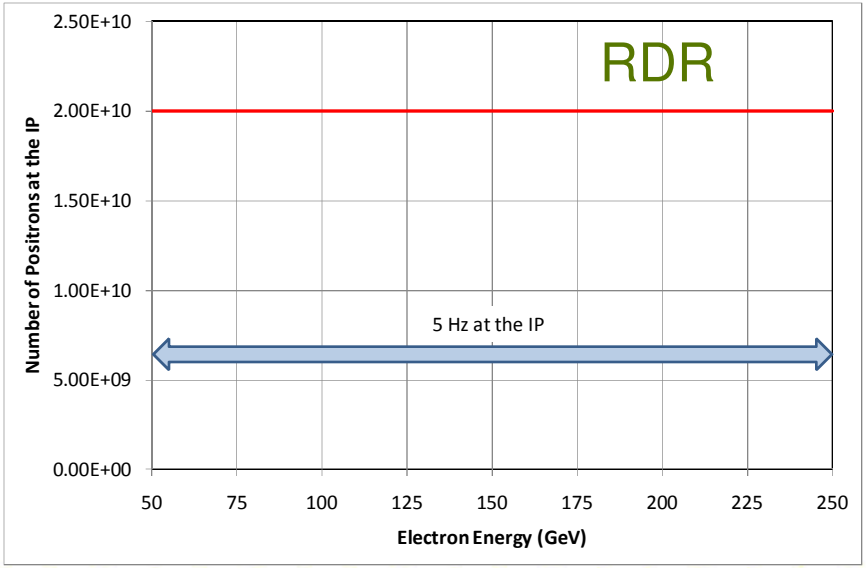
- Major difference between SB2009 and RDR is L @ 250 GeV. Naively this would be 1/4 RDR – optimisation saves a bit to make it ~1/3.

Beam Parameters

- However, one factor of 2 can be "tuned away" once we know M_{Higgs}. Either we increase the undulator length which moves "V" above to left, and/or increase the frequency above 5 Hz (and increase 2.5 Hz proportionally).

Will be discussed in Jim's presentation





Further developments

- SB2009 WG of Detector colleagues provided an interim status report (on Jan 4, 2010), informing that
  - **"The very low SB2009 luminosity at 250 GeV will have a negative impact on the physics strategy of the ILC. This is a major concern. Detailed studies are underway to quantitatively address this concern, and the implications of the other SB2009 parameters"**
  - **"The GDE Physics Questions Committee document provides semi-official estimates of luminosity at 250 GeV center of mass energy which are significantly lower than what has been assumed for the LOI studies. This low luminosity would make it difficult to perform the Higgs physics measurements with the prescribed precision, a major motivation for the ILC project. This is a serious concern for the physics community."**
  - **"The ILC scope document specified that the machine should produce 500 fb-1 in four years in the center of mass energy range of 200 to 500 GeV. The low 250 GeV luminosity is inconsistent with this specification, and the strategy to react to this needs study."**

Parameters for the Linear Collider

Update November 20, 2006

2. Baseline Machine

- The maximum centre-of-mass energy should be 500 GeV. Removing safety margins in the energy reach is acceptable but should be recoverable without extra construction. The maximum luminosity is not needed at the top energy (500 GeV), however, 500 GeV should be reachable assuming nominal gradient. The machine should allow for an energy range for physics between 200 GeV and 500 GeV, with operation at any energy value as dictated by the physics (e.g. at the maximum of the Higgs production cross section).

- Luminosity and reliability of the machine should allow the collection of approximately $\mathcal{L}_{eq} = 500\ fb^{-1}$ in the first four years of running, not counting year zero which is assumed to mainly serve for machine commissioning and short pilot physics run(s).[1] Full luminosity at the highest baseline energy is not required in the first few years of the physics program. If absolutely necessary, it would be acceptable to run in the first year with fewer than the full number of klystrons and ramp up to the full complement by approximately year 4 of physics running. If new physics results dictate that the full luminosity of $2x10^{34}\ cm^{-2}s^{-1}$ at 500 GeV is essential for exploring those phenomena, operating time should be traded off against increased klystron procurement to permit highest energy running at full luminosity in a reasonable time.

- The collider has to allow for energy scans at all centre-of-mass energy values between 200 GeV and 500 GeV. The time needed for the change of energy values should not exceed about 10% of the actual data-taking time. Therefore, the down-time for switching between energy values should not exceed a few shifts within a particular scan, and should not take more than a few weeks when changing between different energy scans.[2]

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[1] It is assumed here that the design luminosity and the efficiency/reliability of the machine will only be reached gradually within the first years of operation (10, 30 and 60% in years 1,2 and 3, resp.) and that the design luminosity and reliability will be reached in year four (i.e. 100% in year 4) of physics running, not counting year 0.

[2] Collection of 10 fb^{-1} at one energy value requires 1-2 weeks of data-taking at design luminosity (1/25 of the year); a full scan of 100 fb^{-1} may take half a year.

Summary

- The parameter sets for low energy running have been considered and provided to the Detector colleagues
- Although generally speaking SB2009 does worsen the physics performance, particularly at low energy, the changes are relatively mild and can be to a large extent ameliorated
- We plan to have more discussion with Detector colleagues about the ways to ameliorate the loss of luminosity at 250GeV CM