MDI Status

T. Tauchi, KEK /MDI panel

The 8th ACFA Workshop on Physics and Detector at the Linear Collider, EXCO, Daegu, Korea, 11th July 2005

LCWS2005

Under the GDI/GDE

(Global Design Initiative/Effort)

Detector /Physics

WWS

detector R&D panel

concept costing panel

concept support

MDI panel

MDI

↔

collective view of requirements from detector /physics

Machine

ILC-WG4

for BDS Design

MDI consists of WWS-MDI and ILC-WG4, and it is coordinated by the MDI panel.

LCWS2005

MDI Subgroups toward the CDR

	Topics	Current Sub Group Conveners		
I	IP Layout , crossing angle	T.Tauchi	P.Bambade	T.Markiewicz
II	Background	A.Sugiyama	K.Busser	T.Maruyama
	Very forward region	H.Yamamoto	W.Lohmann	E.Torrence
	Beam RF effect	Y.Sugimoto		M.Woods
III	Energy, luminosity spectrum	K.Kubo	S.Boogart	M.Hildreth
	Polarization	T.Omori	K.Moenig	K.Moffeit

LCWS2005 MDI Critical Issues

1. Two IPs for two experiments concurrently, with same luminosity and energy ?

    cross check of physics results,

    large number of experimentalists (multiple detector concepts)

2. Choice of crossing angle (Φ) and final quadrupoles (iron, super, permanent ..)

    Small angle:0-2mrad; minimum veto angle and luminosity without crab cavity,

    but, difficult extraction line design; background and beam diagnostic (E,Pol)

    also difficult for γγ, $e^-\gamma$ collisions and no multi-TeV (Ecm > 3TeV)

    Large angle:20mrad; opposite to the above issues

    but, we may need to control the spin precession, i.e. $\Delta y' = B\Phi/(2B\rho)$

3. L^* and R_Q; L^*=3.5m for SiD, >4.3m for GLD, >4m for LCD; $R_Q < 0.01\ L^*$ at $\Phi=0.02$

4. Collimation depth from vertex innermost radius (Rvtx=1cm?)

5. Energy spectrometer : upstream or downstream or both

6. Polarimeter : upstream or downstream or both

7. Options for beam parameters and IR/extraction line layout

    e^-e^- , $e^-\gamma$, γγ collisions with round beams

    fixed target experiment; e.g. lepton number violation, c,b physics

1. Interim MDI in WWS

MDI Panel - First Report in June 18

WWS Co-Chairs - Urgent questions in June 23

Detector Concept Groups

GLD - MDI, SiD - MDI, LDC - MDI ?

2. Interim MDI in ILC-WG4

MDI/WWS has been collaborating with ILC-WG4;

e.g. MDI mini-workshop@SLAC, BDIR workshop@RHUL

3. MDI in WWS and GDE

Organization of GDE for CDR and TDR ?

parameter, cost, civil works, instrumentation, reliability.....

First MDI Report

The ILC design impacts Detector design and Physics capability, beyond the delivered luminosity and energy reach. **Present aims of the MDI Panel are to:**

1 – help evaluate design choices for the ILC baseline configuration that affect the experimental program in a major way and for which the experimental community needs to be consulted.

- provide a list of these design choices, describe their MDI context, and help prepare questions to pose to the ILC Accelerator effort and to the World-Wide Study / Detector Concept groups.

2 – help evaluate impact of the ILC machine design on the experimental program and also impact of the Detector Concept designs on the machine, in the context of developing CDRs and TDRs for the machine and the Detector Concepts.

- provide a list of these design issues, describe their MDI context, and help prepare questions to pose to the ILC Accelerator effort and to the World-Wide Study / Detector Concept groups.

3 facilitate discussions and exchange of information between the ILC Accelerator effort and the World-Wide Study / Detector Concept groups prior to the Snowmass meeting this summer.

4 report on this work at the Snowmass meeting and to co-ordinate related MDI discussions at that meeting.

II. Summary of urgent questions and requests to Experimenters (Detector Concept Grps)

1. Provide GEANT (or equivalent) geometry description of detector components within 10 meters in z of the IP and within a radial distance of 50 cm of the beamline.
2. Provide a field map of the solenoid for the region described in item 1.
3. Provide the information in items 1. and 2. for both 2-mrad and 20-mrad crossing angles.
4. The 20-mrad crossing angle geometry requires beam trajectory correction with a Detector Integrated Dipole (DID) as described in LCC-143[1]. Is this acceptable?
5. Overlap of the solenoid field with the final focus quads requires an optics correction with an antisolenoid as described in LCC-142[2]. Is this acceptable?
6. Can LDC decrease the field in the area of 5-6m from IP?(2T, which 2-5 times larger than in SiD and GLD)
7. Can the detector be configured with L* anywhere in range 3.5-4.1m? Stage preferred L* and give reason.
8. Can the detector tolerate the background conditions for the ILC parameter sets described in the Feb. 28, 2005 document at www-project.slac.stanford.edu/ilc/acceldev/beamparameters.html ? Evaluate this for both 2-mrad and 20-mrad crossing angle geometries. If the high luminosity parameter set poses difficulties, can the detector design be modified so that the gain in luminosity offsets the reduction in detector precision?
9. Provide background tolerance levels for each detector subsystem.
10. Evaluate and compare expected precision for upstream and downstream energy and polarization measurements. Do this for both 2-mrad and 20-mrad crossing angle geometries?
11. Evaluate electron id and 2-photon veto requirements and performance for the BEAMCAL detector at 5-40 mrad polar angle.
12. Describe detector assembly procedure.
13. What size is required for the IR hall?
14. For e-e-, what is the minimum useful integrated luminosity?
15. Is Z-pole calibration data needed? If so, how frequently and how much?
16. What solenoid field would be used for Z-pole calibration?
17. Are beam energy or polarization measurements needed for Z-pole calibration?
18. How frequently would e+ polarization need reversals?
19. Evaluate impact of reducing bunch spacing to 150ns.

III. Summary of urgent questions and requests to Machine (ILC Working Groups)

1. Provide GEANT (or equivalent) geometry description of beamline components within 10 meters in z of the IP and within a radial distance of 50 cm of the beamline.

2. Provide a field map of the beamline magnets for the region described in item 1. Include information on detector solenoid field map as provided by the Detector Concept groups.
3. Provide the information in items 1. and 2. for both 2-mrad and 20-mrad crossing angles.
4. Evaluate the collimation depth for 2-mrad and 20-mrad crossing angle geometries for each of the Detector Concept designs.
5. Evaluate potential use of BEAMCAL for fast IP luminosity feedback, beam parameter determination and beam aberration tuning. Do this for both 2-mrad and 20-mrad crossing angle geometries ?
6. Compare EPS issues for 2-mrad vs 20-mrad.
7. Compare EMI issues for 2-mrad vs 20-mrad.
8. Compare technical difficulties for IR and IR magnet design for 2-mrad vs 20-mrad.
9. Compare expected luminosity and efficiency for 2-mrad vs 20-mrad.
10. Do the IR magnets need active stabilization? If so, provide details.
11. For e-e-, evaluate feasibility of beam-beam deflection feedback
12. For e-e-, what is the expected luminosity?
13. Estimate Δcost to provide polarized positrons.
14. Compare expected delivered luminosity for polarized vs unpolarized e+.
15. Compare technical risk for polarized vs unpolarized e+.

IV. MDI Issues I: ILC Design Choices

The community has a goal to develop an ILC baseline design by the end of 2005. This baseline has a starting point with the LC Parameters document (http://www.fnal.gov/directorate/icfa/LC_parameters.pdf), which gives guidance on most of the ILC design choices listed below. In Section 6, we start a discussion on an MDI evaluation of these design choices.

1. Linac crossing angle and tunnel design.
2. IR Crossing Angles
3. 2 versus 1 IR/Detector and their scopes
   (includes simultaneous or sequential running of 2 IRs)
4. e-e-
5. e-gamma and gamma-gamma
6. Z-pole running and Z-pole calibration
7. Polarized Positrons
8. Fixed Target
9. ILC Parameters:
   nominal + 3 variants + 1 high luminosity option, for both 500 GeV and 1 TeV

(see http://www-project.slac.stanford.edu/ilc/acceldev/beamparameters.html)

V. MDI Issues II: Machine and Detector CDRs, TDRs

The community is preparing reference designs for the machine and detectors that will evolve into CDRs and TDRs. Here we list additional MDI issues that arise in this context. In section 5 we start a discussion on the MDI evaluation of these issues.

1. Radius and length of vertex detector and collimation depth
2. L* and minimum veto angle
3. IR quad stabilization
4. IR magnet design
5. Fast feedback: IP beam position monitors, kicker, pair detector
6. Beam parameter diagnostics and beam tuning
7. Electron id, 2-photon veto w/ pair detector
8. Beam instrumentation for luminosity spectrum, energy, polarization
9. EPS (experiment protection system); rad hard specs for accident scenarios; Abort kicker system and #bunches in queue
10. Beam RF and other EMI (electromagnetic interference) effects on detector signal processing and DAQ
11. evaluation of beam background levels and corresponding detector tolerances
12. dark current between bunches (use of Linac rf kicker?)
13. detector assembly ↔ BDS commissioning

VI. MDI Evaluation of MDI Issues I: ILC Design Choices

Here we begin the process of performing an MDI evaluation regarding baseline ILC design choices. The MDI context and impact is summarized in bullet form and then we pose a DRAFT set of questions for the machine and experimental communities. Highest priority should be given to Issues 1-3, 7 and 9.

1. Linac crossing angles, tunnel design

i) MDI context and impact

- Articulation between TeV and multi-TeV physics programs
- Impact on ILC precision physics program from coupling TeV and multi-TeV projects
- Desire for running overlap of TeV, multi-TeV programs/facilities (compare/refer to Tevatron, LHC)
- Impact on IR layout and detailed design (e.g. crossing-angle)

ii) Questions for experimenters

iii) Questions for machine

- Evaluate dependence of energy reach and luminosity on Linac crossing angles
- Evaluate requirements on tunnel designs (size,depth,straightness) for a later upgrade beyond 1TeV
- Evaluate impact on BDS layout including location of dumps for a later upgrade beyond 1 TeV
- Evaluate additional cost to ensure multi-TeV extendibility in the ILC baseline design (size, depth and straightness of tunnels, layout of BDS and dumps, anything else?)

iv) General questions to the community

- Should all needed provisions for multi-TeV extendibility be included in the ILC baseline design?
- Are we able to predict them all?
- Is the additional cost acceptable?
- To what extent do we compromise the designs of both projects by linking them?
- Can we afford not to link the two, if the additional cost is estimated, say, at the 5-10% level?

2 IR crossing angle geometries (0, 2mrad, 20mrad)

i) MDI context and impact

- **Vertex radius and length, collimation depth**
- **L* and minimum veto angle**
- **IR magnet design; solenoid compensation with DID, anti-solenoid; crab crossing**
- **Fast feedback: IP beam position monitors, kicker, pair detector**
- **Beam parameter diagnostics and beam tuning**
- **Electron id, 2-photon veto w/ pair detector**
- **extraction line beam instrumentation**
- **EPS**
- **EMI**
- **Beam backgrounds**

ii) Questions for experimenters

·evaluate background conditions (synchrotron radiation, pairs, neutrons, muons, hadrons) for choices of crossing angle, vertex radius/length, L* and minimum veto angle; compare these conditions to tolerance levels for the detector subsystems

·evaluate impact of local solenoid compensation inside the detector volume, as needed in the 20 mrad crossing-angle scheme, on the performance of tracking detectors (e.g. in the context of the alignment procedure of silicon detectors using tracks, and also in the context of the experimental determination of field distortions in a TPC).

·quantify effect on precision of upstream and downstream polarimetry from angle between beam trajectory and solenoid axis

·compare precision of downstream polarimetry for different crossing angles

·compare precision of downstream energy measurements for different crossing angles

·evaluate/summarize impact of crossing angle choice on electron id and 2-photon veto in the BEAMCAL at 5-40 mrad.

iii) Questions for machine

·what EMI could be expected from the crab cavities relative to other sources of EMI that could affect detector electronics near the beam pipe?

·how does choice of crossing angle affect the fast feedback system? - how important is the pair detector to this?

·how does choice of crossing angle affect beam parameter diagnostics and beam tuning capability? - how important is the pair detector to these? Can other methods (e.g. pair distributions in vertex detector) be used to replace info from the pair detector?

·Evaluate EPS issues for the different crossing angle designs, in particular if an rf kicker is used in a head-on scheme.

·Compare relative delivered luminosity for different crossing angle designs, for the different ILC beam parameters (nominal + variants + high lumi)

·Are there particular difficulties in designing some of the special magnets which are needed in the 2 and 20 mrad crossing-angle schemes? Do any of these represent technical risks?

·Is there a risk to luminosity from having to rely on a large crab-crossing correction to recover the luminosity in the 20 mrad crossing scheme? Is there a technical risk associated with the operation of the crab-cavities?

iv) Common questions for IR design teams

·how does support of IR magnets depend on crossing angle?

·If stabilization of IR magnets is needed using support tube, optical anchor or other active feedback, does crossing angle affect implementation of these?

·Evaluate the dependence of collimation depth on crossing angle choice, and impact on beam delivery, backgrounds and design of vertex detector.

3 2 versus 1 IR/detector (Note: separate panels are also addressing this)

i) MDI context and impact

- **Scope for 2 IRs/detectors:**

a) 2 IR/detectors in baseline. Similar physics potential; operating concurrently. (One could be later upgraded for specialized applications.)

b) 1 IR/detector in baseline. 2nd IR/detector later for specialized applications.

c) 1 IR/detector. Could be later upgraded for special applications.

d) 1 IR and 2 detectors; push-pull system.

- **# spin rotators**
- **Kickers**
- **level of integration and competition for BDS, IR and detector teams: in scenario a) above, each of the 2 IR/detectors may be designed and operated by a more integrated BDS-IR-detector team as compared to the other scenarios.**

ii) Questions for experimenters

- Evaluate detector cost
- Evaluate desirability of each of 4 scopes given above, from physics as well as more general arguments, e.g. increased competition and increased community support in the 1st scenario, integrating lessons from the 1st IR/detector into the final design of the 2nd in the two staged scenarios,...
- For case a) evaluate need for simultaneous running of 2 experiments and merits of timescale for switching beam between 2 IRs (train by train, day-day, week-week, month-month?)

iii) Questions for machine

- Evaluate cost for 2nd IR (everything but detector)
- Evaluate possibility for simultaneous running of 2 IRs with train-train switching (kickers, spin rotators, MPS, efficiency, simultaneously optimizing luminosity and minimizing backgrounds for both IRs);

is there an impact expected on overall performance ?

4 e-e-

i) MDI context and impact

- **crossing angle**
- **polarimetry and spin rotators for both beams**
- **reversible power supplies**
- **magnet polarity choices, in particular for IR magnets with small crossing angles and for any envisioned permanent magnets**

ii) Questions for experimenters

- what is the minimum useful integrated luminosity ?
- How large a centre-of-mass energy dilution from beamstrahlung is acceptable for physics channels studied in the e-e- mode ?
- Should the possibility of switching to e-e- be included in the baseline machine ?
- In the case of 2 IR/detectors operating concurrently (see 3.i.a above), should both be able to switch to e-e- ?

iii) Questions for machine

- evaluate expected luminosity
- evaluate compensation of solenoid angle wrt beam trajectory for non-zero crossing angles
- evaluate feasibility of beam-beam deflection feedback for beam parameters yielding acceptable luminosity and beamstrahlung loss

5 e-gamma and gamma-gamma

i) MDI context and impact

- **crossing angle**

ii) Questions for experimenters

iii) Questions for machine

- what is the minimum crossing angle ?
- what are the “R1” issues ?

6 Z-pole running and Z-pole calibration

i) MDI context and impact

- **Luminosity**
- **Beam polarization and energy measurements**
- **Positron polarization**
- **Tolerable amount of beamsstrahlung**

ii) Questions for experimenters

- Evaluate if Z-pole calibration data are needed and how frequently? Do radiative returns provide sufficient calibration data?
- What solenoid field for calibration data? For Z-pole physics
- What integrated luminosity is needed for calibration data?
- Are beam polarization or energy measurements needed for calibration data?
- Evaluate need for Z-pole physics capability in baseline design.
- What luminosity is needed for Z-pole physics?
- Is positron polarization also needed for Z-pole physics?
- What precision is needed for beam polarization and energy measurements for Z-pole physics?
- How much beamsstrahlung can be tolerated for Z-pole physics?

iii) Questions for machine

·What luminosity can be expected? With <0.01% beamsstrahlung

7 polarized positrons

i) MDI context and impact

- **helical undulator source**
- **spin rotators for both beams**
- **polarimeters for both beams**
- **possible kickers for spin rotator systems**

ii) Questions for experimenters

- evaluate need for polarized positrons in baseline
- how frequently does e+ polarization need reversals?

iii) Questions for machine

- estimate Δcost to provide polarized positrons
- compare delivered luminosity for polarized vs unpolarized
- compare technical risk for polarized vs unpolarized

8 fixed target

i) MDI context and impact

·extraction line design

·beamline from end of Linac

ii) Questions for experimenters

·what is needed in baseline design to allow later upgrade?

·What is the physics case?

iii) Questions for machine

9 ILC parameter sets

i) MDI context and impact

- **Backgrounds**
- **Extraction line beam diagnostics**
- **Time separation between bunch crossings**

ii) Questions for experimenters

·evaluate impact of backgrounds for the 4 parameter sets at 500 GeV and 1TeV

·evaluate impact of reducing the time separation between bunch crossings to 154 ns

·evaluate impact on extraction line energy and polarization measurements for the 4 parameter sets at 500 GeV and 1 TeV

·evaluate desirability of high luminosity parameters compared to larger beamsstrahlung energy spread, backgrounds and impact on extraction line diagnostics

iii) Questions for machine

·will the 3 variant and high luminosity scenarios have similar efficiencies as nominal ?

VII. MDI Issues II: Machine and Detector CDRs

This section still in preparation. An evaluation process similar to that in Section 6 will be used.

Urgent questions from WWS

1 What factors determine the strength and shape of the magnetic field in your detector? Give a map of the field, at least on axis, covering the region up to +-20 m from the IP. What flexibility do you have to vary the features of this field map

2 Provide a GEANT (or equivalent) geometry description of the detector components within 10 meters in z of the IP and within a radial distance of 50 cm from the beamline.

3 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?

4 For each of your critical sub-detectors, what is the upper limit you can tolerate on the background hit rate per unit area per unit time (or per bunch)? Which kind of background is worst for each of these sub-detectors (SR, pairs, neutrons, muons, hadrons)

5 Can the detector tolerate the background conditions for the ILC parameter sets described in the Feb. 28, 2005document at www-project.slac.stanford.edu/ilc/acceldev/beamparameters.html ? Please answer for both 2-mrad and 20-mrad crossing angle geometries. If the high luminosity parameter set poses difficulties, can the detector design be modified so that the gain in luminosity offsets the reduction in detector precision?

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

7 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?

8 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?

9 Is a 2mr crossing angle sufficiently small that it does not significantly degrade you ability to do physics analysis, when compared with head-on collisions?

10 What minimum veto and/or electron-tagging angle do you expect to use for high energy electrons? How would that choice be affected by the crossing angle? How does the efficiency vary with polar angle in each case?

11 What do you anticipate the difference will be in the background rates at your detector for 20mr and for 2 mr crossing angle? Give your estimated rates in each case.

12 What is your preliminary evaluation of the impact of local solenoid compensation (see LCC note 143) inside the detector volume, as needed with 20mr crossing angle, on the performance of tracking detectors (silicon, and/or TPC, etc.)?

13 Similarly, what is you preliminary evaluation of the impact of compensation by anti-solenoids (LCC note 142) mounted close to the first quadrupole?

14 Do you anticipate a need for both upstream and downstream polarimety and spectrometry? What should be their precision, and what will the effect of 2 or 20 mr crossing angle be upon their performance?

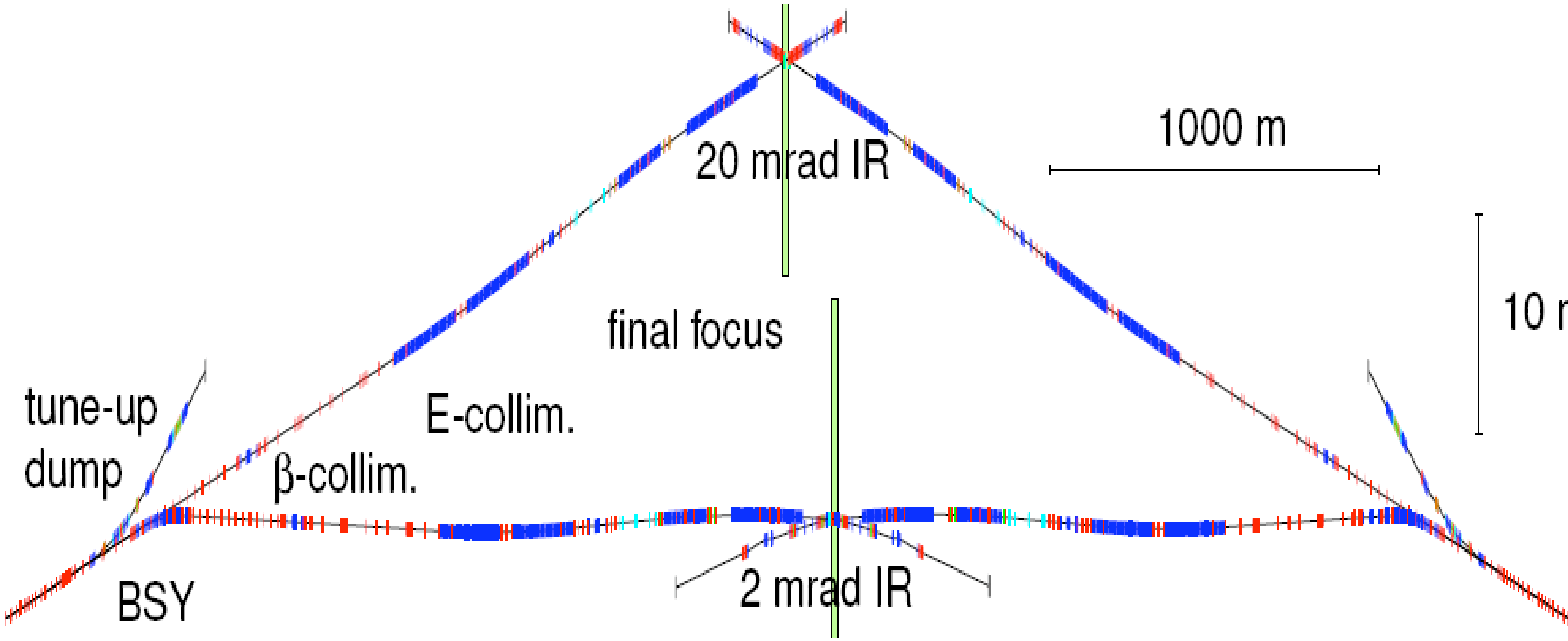
15 Is Z-pole calibration data needed? If so, how frequently and how much? What solenoid field would be used for Z-pole calibration? Are beam energy or polarization measurements needed for Z-pole calibration?

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

17 What will be your detector assembly procedure?

18 What size is required for the detector hall?

ILC Strawman BDS Layout



Two IPs ?

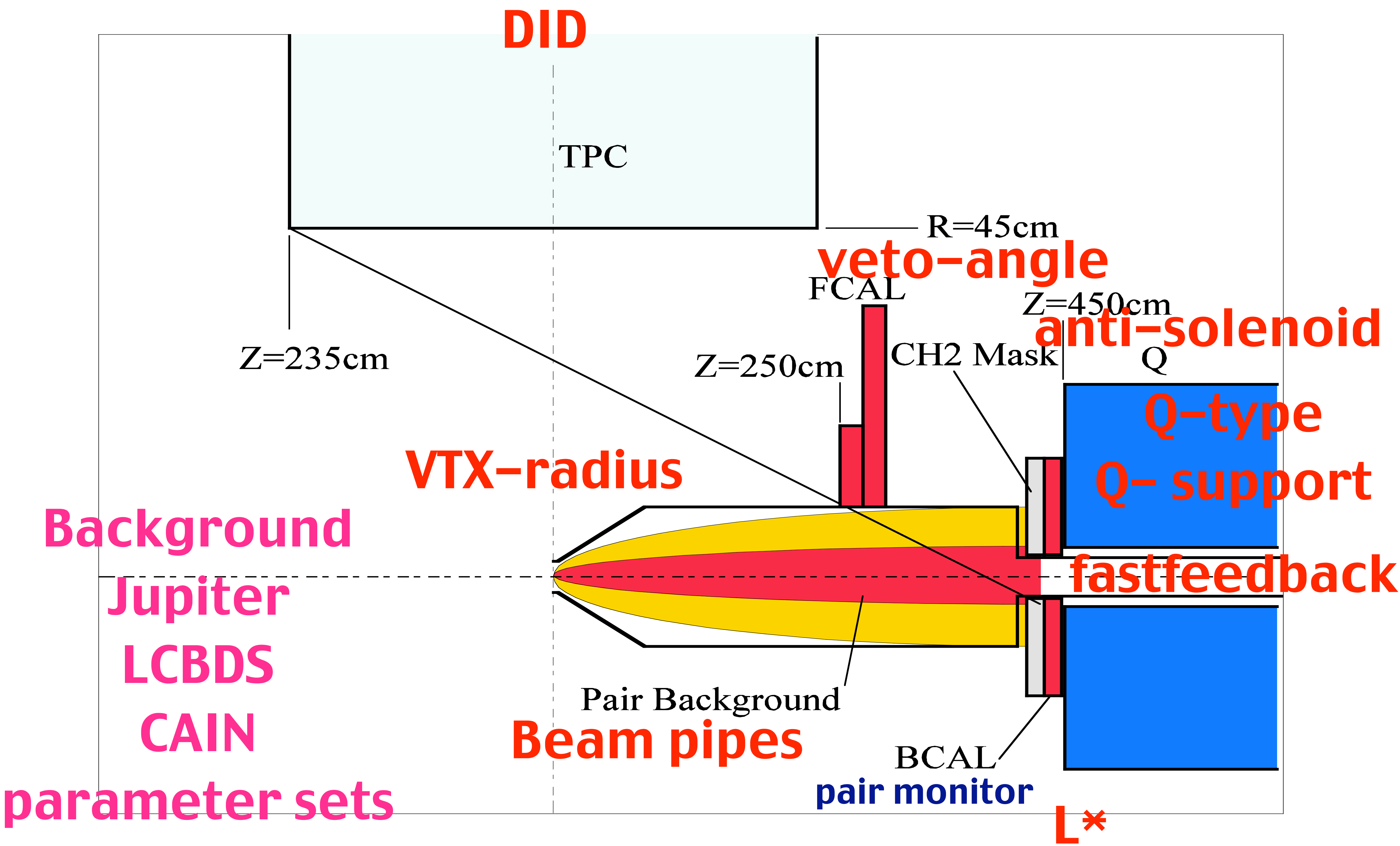
Collimation depth, collimation?

Polarimeter/E-chicane at upstream, downstream ?

Mark Woodley

Interaction Region

to be designed with 2mr and 20mr crossing angles



5 Parameter Sets

Major input parameters to CAIN

Parameters listed in the suggested ILC beam parameter range, Rev. 2/28/05

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

Results of CAIN (v21e)

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

Parameters listed in the suggested ILC beam parameter range, Rev. 2/28/05

parameter	unit	Nominal	Low Q	Large Y	Low P	High Lum
E_{CM}	GeV	500				
Luminosity	10^{34} $cm^{-2}s^{-1}$	2.03	2.01	2.00	2.05	4.92
N_{gamma}	/electron	1.257	0.823	1.664	1.756	1.725
Inc. Pairs	10^4 /bunch	25.9	8.37	35.0	61.2	63.7

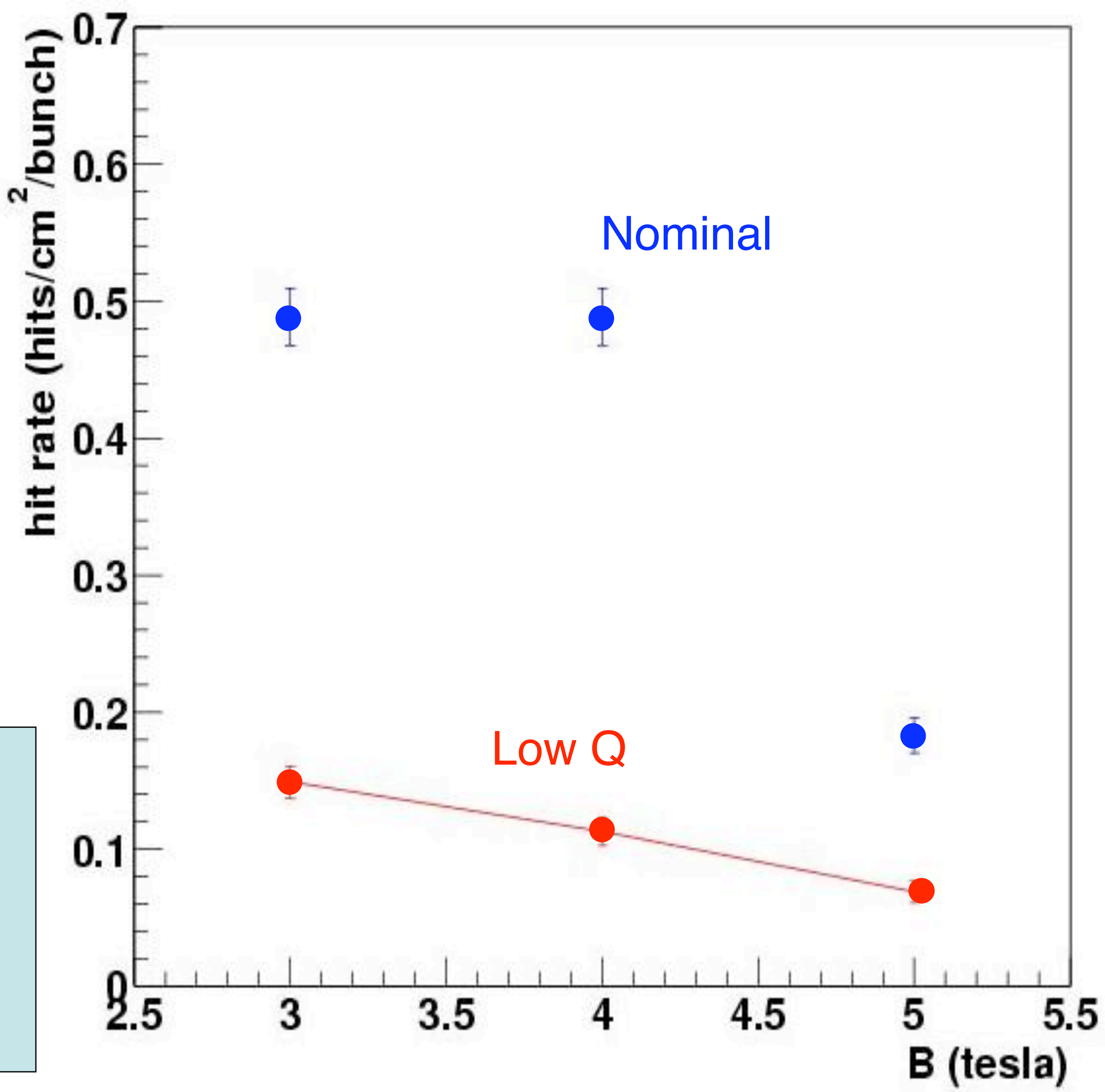
Advantage of Low Q

Y.Sugimoto and T.Fujikawa

Simulation Study

- Pair background hit rate on the 1st layer of the Vertex Detector (R=24mm)
- Simulation using CAIN and JUPITER
- Hit rate of the Low Q option is ~1/3 of the nominal option, as expected

Pair B.G. hit rate (/cm^2/bunch)		
B(tesla)	Nominal	LowQ
3	0.488	0.149
4	0.48	0.113
5	0.183	0.069



Summary

- To complete the IR design (IR task force in GLD) for 2mr and 20mr crossing angle
- Preferred L* and crossing angle; impact on BDS
- Preferred parameter set; impact on ILC design
- Simulation of background by LCBDS and Jupiter (detailed BDS and Detector model)
- To reply the urgent questions by 1st August