SiD and MDI issues

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Thanks to:

Toshiaki Tauchi, Andrei Seryi, Tom Markiewicz

Reference: A. Seryi talk at SLAC LCD mtg 14 July 2005

MDI ←→ detector issues

Incoming beams crossing angle
Detector hall footprint (incl. assembly, maintenance)
Focal length of final quads: L*

Beampipe radius
Bunch time interval

Detector solenoid field
Detector-integrated dipole (DID)
Antisolenoids

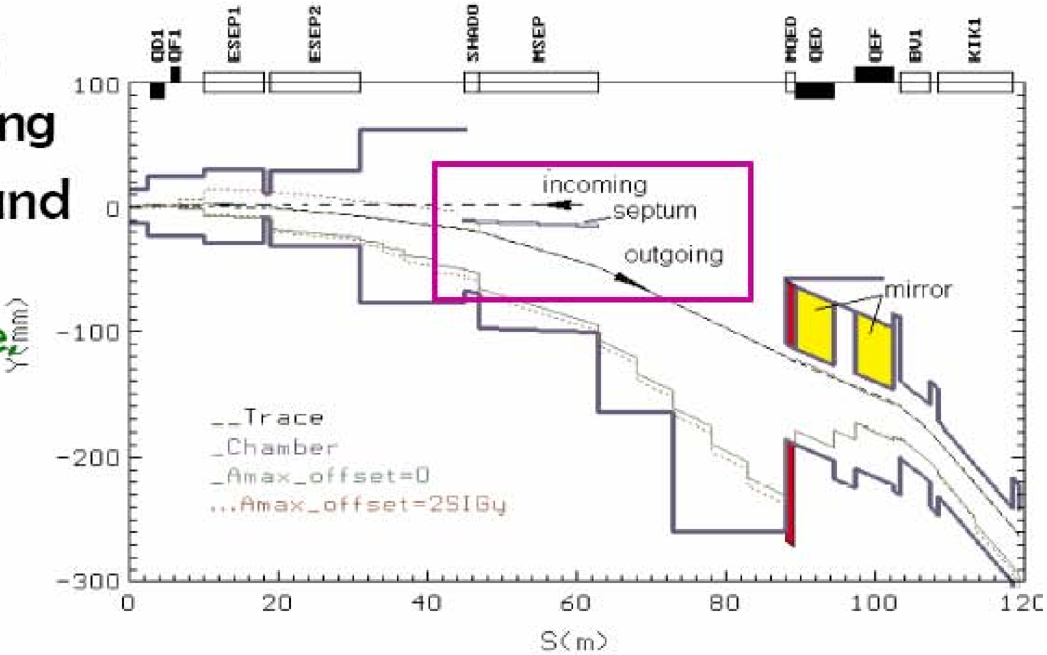
Backgrounds
Z0 running

Crossing angle issues

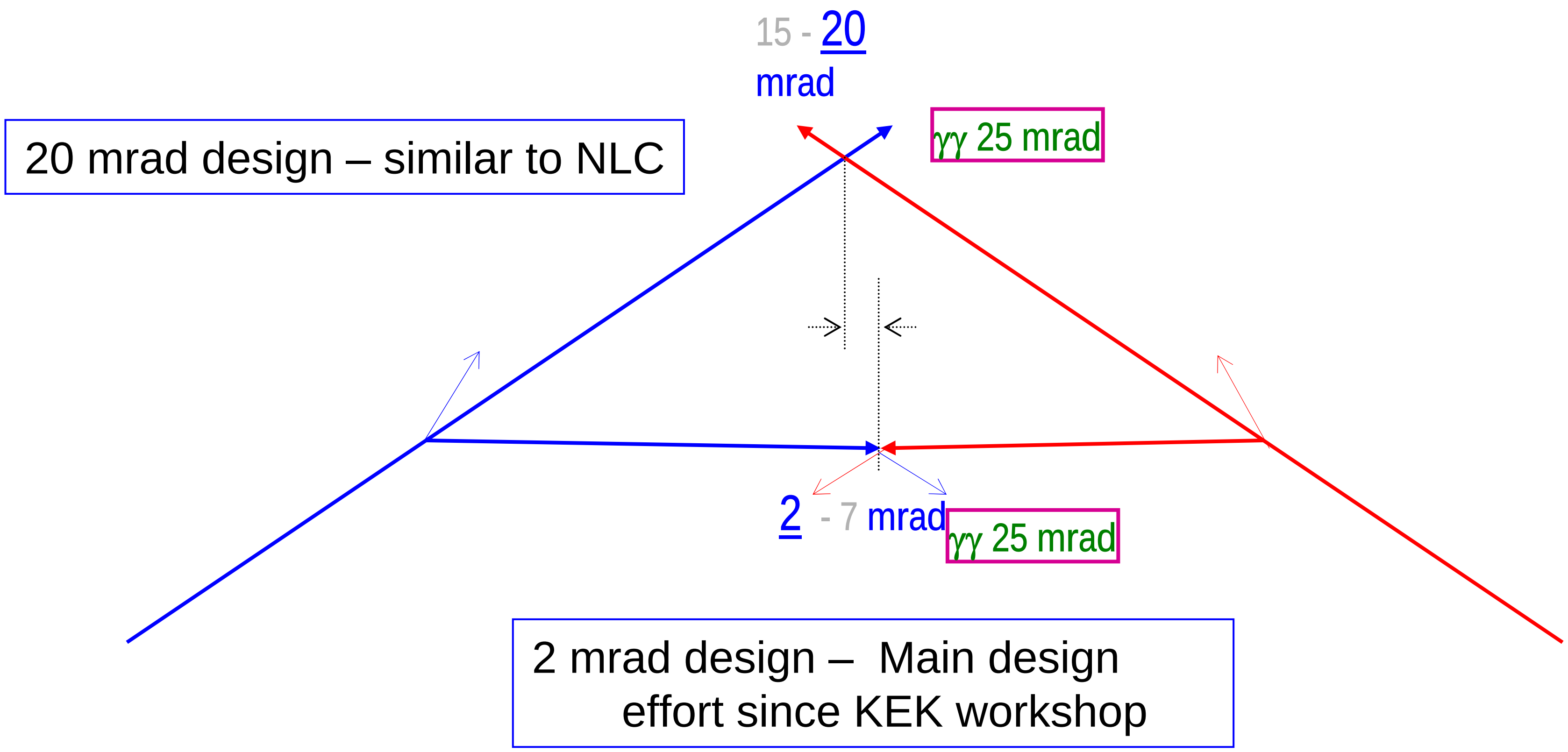
- **Get incoming beams into collision, outgoing beams into extraction lines**
- **Without frying the detector, final-focus magnets, beamline instrumentation: downstream E-spec, polarimeter, beamline calorimeters …**
- **Historically crossing angles of 0 (TESLA), 7 mrad (GLC), 15-20 mrad (NLC) had been studied**
- **At November 2004 1st ILC Workshop (KEK) WG4 agreed to study in detail ‘extreme’ cases of 2 and 20 mrad**
- **The viability of the 2 mrad scheme will be a major focus of study/discussion at Snowmass**
- **I will discuss only e+e- detector issues**

TRC summary of head-on scheme (TESLA)
(from Andrei Seryi)

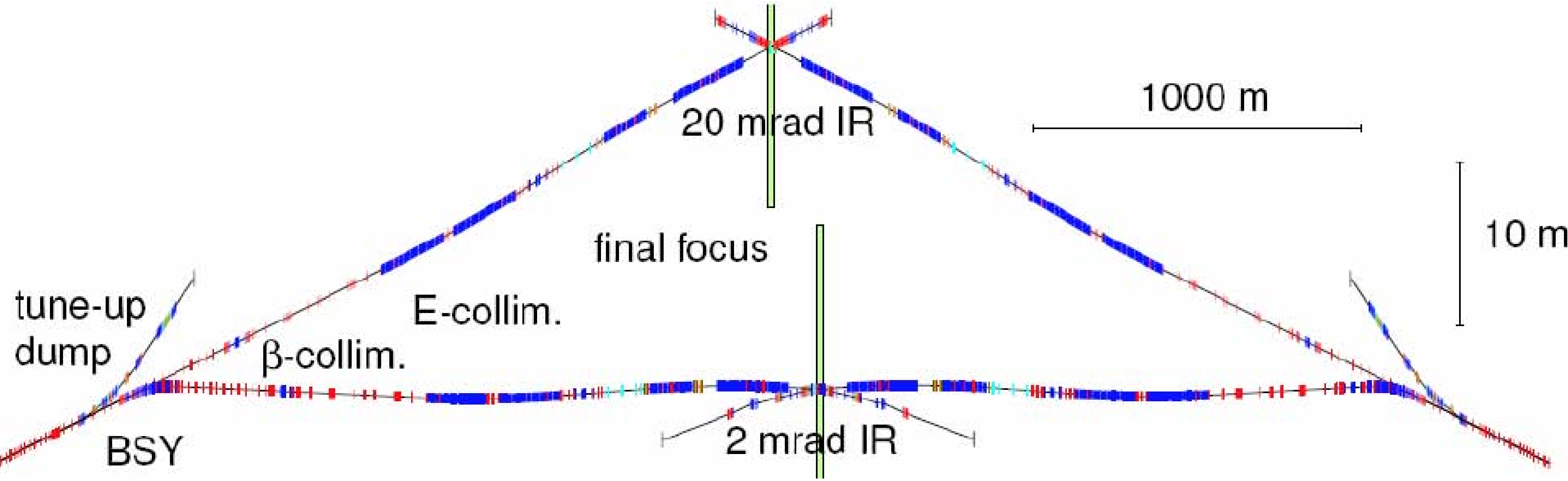
- SLAC actively participated in ILC-TRC in 2002, including
- evaluation of BDS design and head-on scheme
  - Large losses in extraction line, especially at 1 TeV
  - Incompatible with post-IP E/Polarization diagnostics
  - Electrostatic separator 100kV/cm at 1TeV – feasibility in high SR environment
  - MPS issues
  - γ losses at (or near) septum: ~5-15kW
  - Parasitic collision 26.5 m from IP @ 1TeV
  - SR masking over-constrained



‘Strawman’ Layout of 2 Interaction Regions
(KEK ILC Workshop Nov 04)



‘Strawman’ Layout of 2 Interaction Regions



Crossing angle choice correlated with:

- **Detector hall footprint: transverse + longitudinal separation of 2 IR halls**
- **Bunch spacing: longitudinal separation of 2 IPs**
- **Space for downstream diagnostics**
- **…**

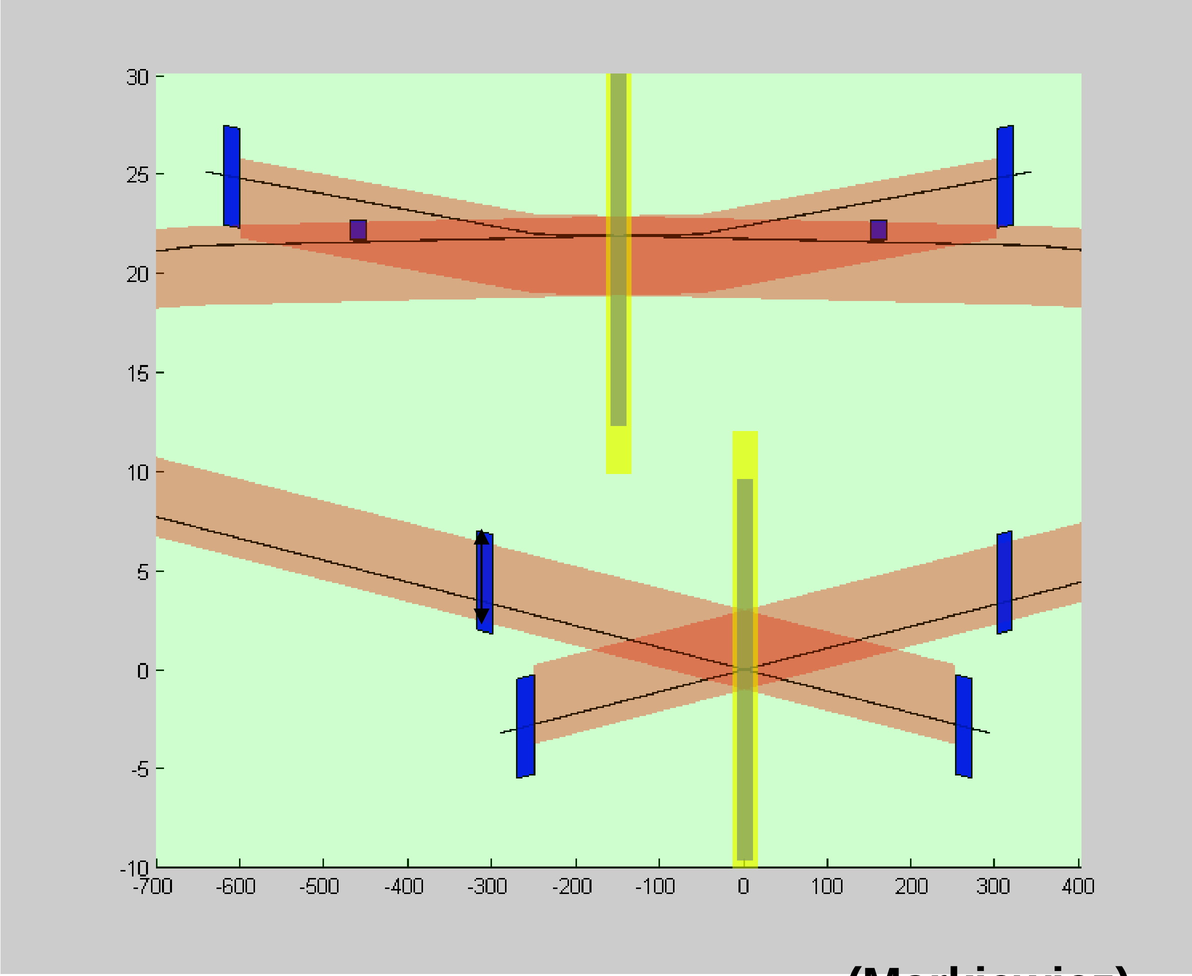
Transverse and Longitudinal IP Separation

Need to maintain ~5m concrete shielding between one IR hall and tunnel to other IP

NB z separation =

N * bunch sep/ 2 c

Need to understand SiD footprint vis a vis assembly/installation procedures + detector access: eg. need to break beamline?



(Markiewicz)

Issues for the two strawman schemes
(simplified summary)

20 mrad:

Incoming + outgoing beams 'independent'
Disrupted outgoing beam easier to handle

Crab cavity required to restore luminosity
Compact SC quads required

Loss of detector acceptance due to exit hole, non-azimuthal symmetry
Higher e+e- related backgrounds due to pairs hitting mask

2 mrad:

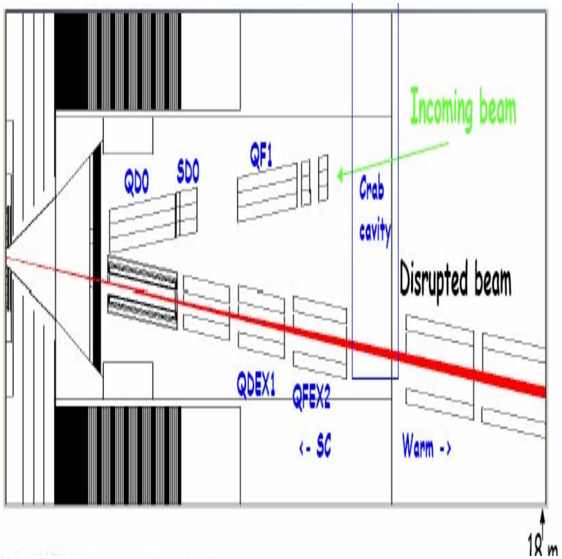
Incoming + outgoing magnets shared
Need to bend outgoing beam, large energy spread -> beam losses

Crab cavity not absolutely essential
Pushes FD magnet technology

Better acceptance + azimuthal symmetry
Lower e+e- backgrounds since fewer pairs hit mask

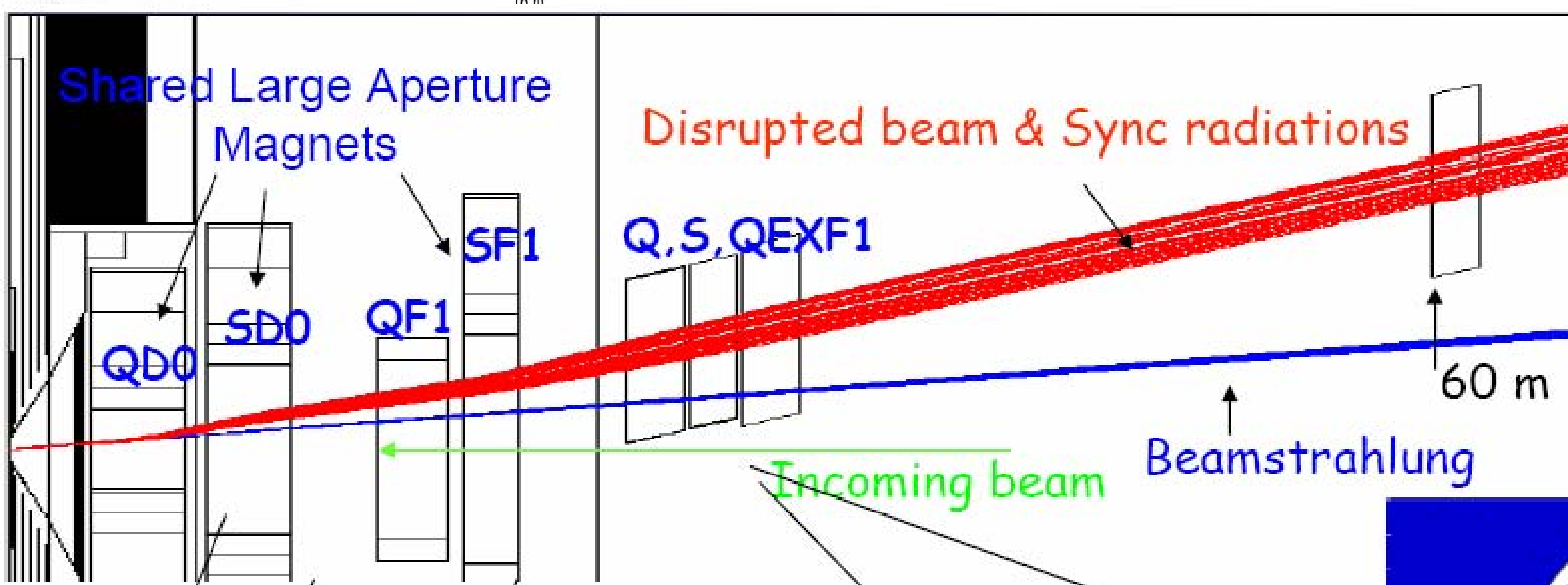
Comparison of 2 + 20 mrad IRs

20 mrad



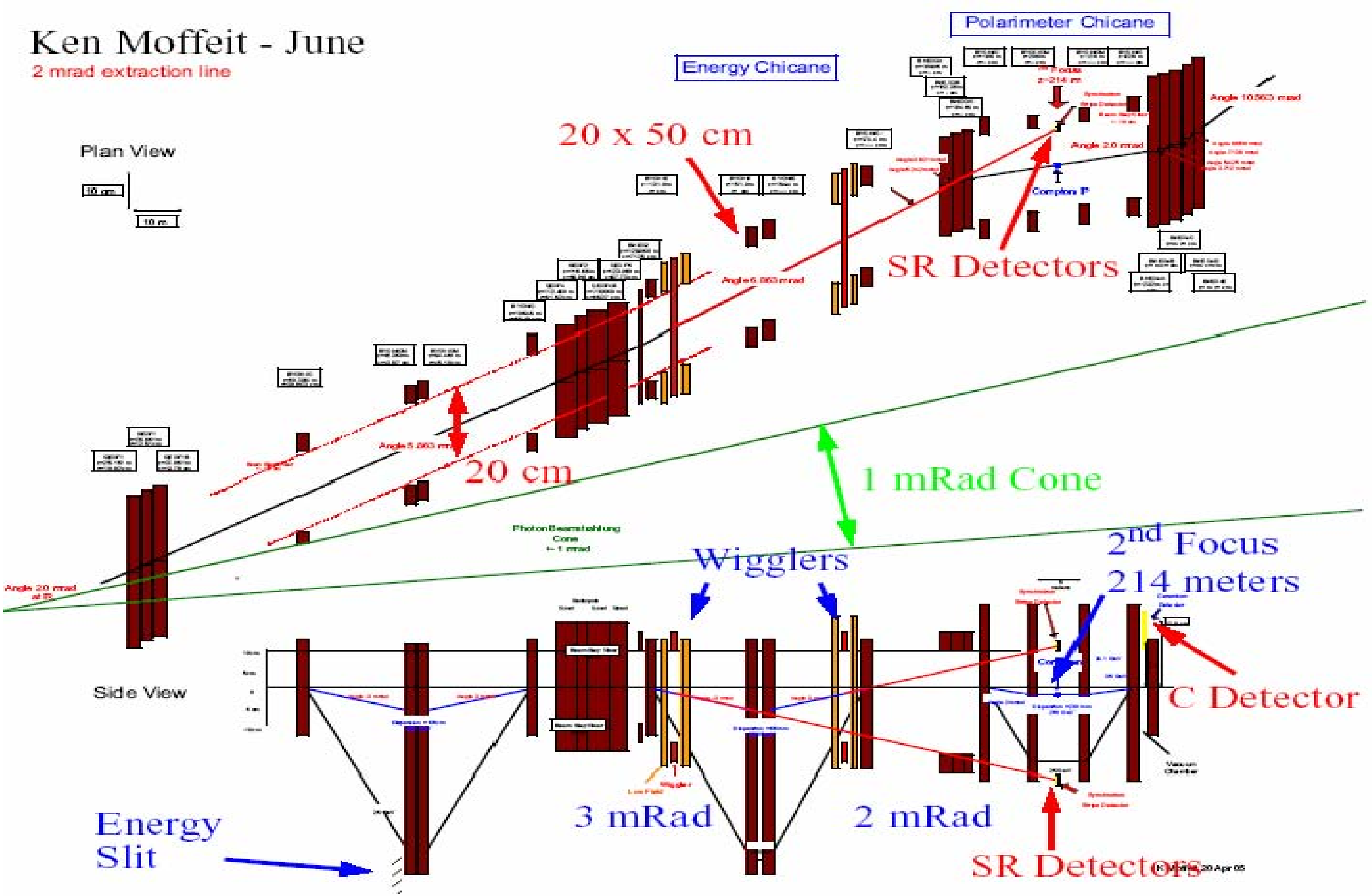
Seryi

2 mrad



Downstream diagnostics in 2 mrad scheme

(Ken Moffeit)



L* and beampipe radius

- L* constrains detector size (in forward regions)
- Naively: longer L* → allows extended detector
- Range under discussion: 3.5m < L* < 4.5m

  This range is acceptable to SiD (?)
- Longer L*

  → larger beam size in final doublet

  → tighter collimation (for fixed beampipe radius)
- Current collimation (8 sigma-x) for L* = 3.5m and r = 1.5 cm is 'tight' → increase by eg. x2 not possible

→ See Sonja Hillert talk on physics ←→ beampipe radius

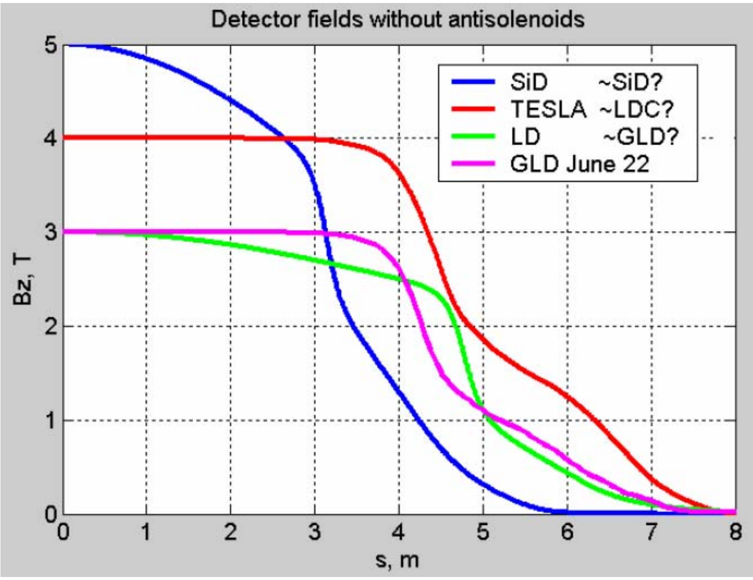
L*: Machine Considerations
(Andrei Seryi Summary)

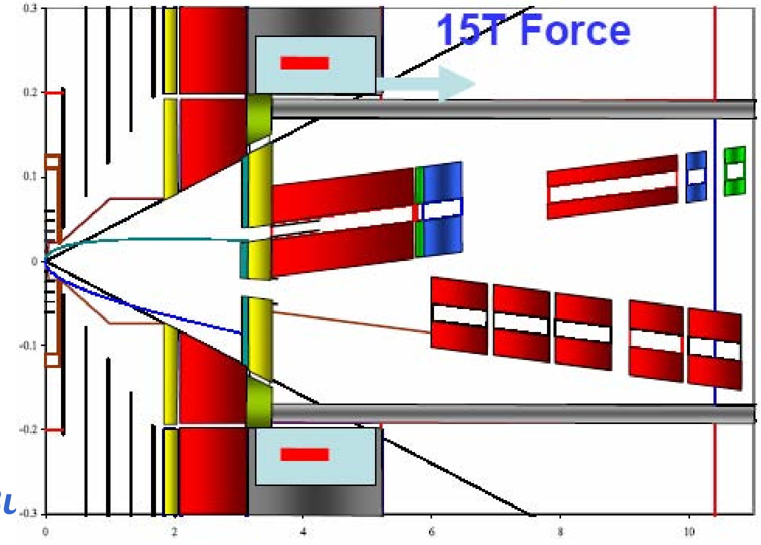
- Longer L* , negative effects
  - increase sensitivity to errors
  - increase chromaticity and reduce bandwidth
  - increased synchrotron radiation in detector field (for larger detector)
  - increase optimal length of final focus
  - require larger FD aperture => larger external size
- Longer L*, positive effects
  - reduce required gradient
  - remove QD0 from high field of detector

    } => may allow NbTi magnets instead of Nb3Sn
  - easier engineering design
    - e.g. 20mrad magnets in separate cryostats
  - shorter lever arm for support => better stability
  - antisolenoid compensation is easier
- Will consider the range 3.5-4.5 and expect that differences will be tolerable

Magnetic Effects 1: antisolenoids

- End fringe field of solenoid impacts QD0
- **Esp. undesirable for low-energy beam running eg. Z0 (unless lower B-field)**
- Solution: 'antisolenoid' to shield QD0:





NB:
Acceptance penalty
Mechanical forces

Magnetic Effects 2: detector integrated dipole

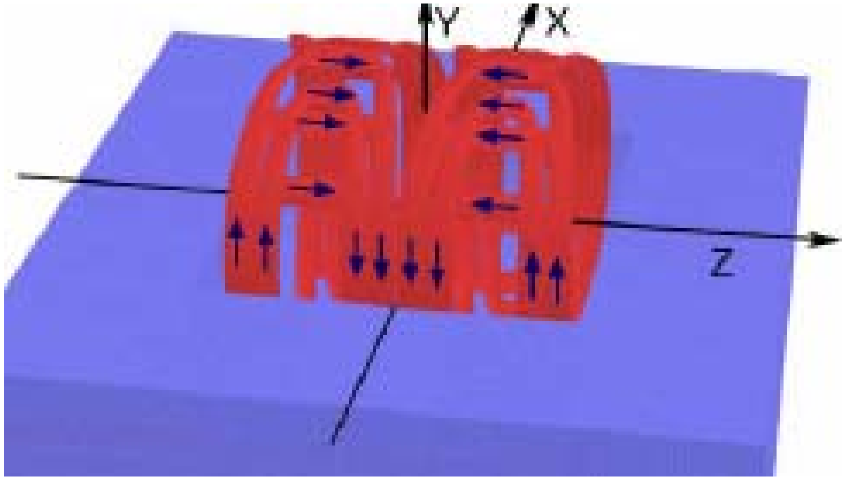
- **With crossing angle detector solenoid field steers beams vertically:**

  angle at collision point – reduced luminosity

  synchrotron radiation – blows up beam size

- **Probably liveable with at 2 mrad**

- **Cancel w. 'detector integrated dipole' (DID)**
  (or fancy optics)



Magnetic Effects: Bottom Line

Bottom line:

Does SiD care whether the solenoidal field is non-uniform within the detector fiducial volume due to the introduction of antisolenoids and DID?

- the field isn't uniform anyway!

Gut feeling:

no, the field will have to be mapped anyway;

the tracking system needs to know field to some accuracy;

→ would be good to quantify this

Backgrounds

EM, hadronic, muon backgrounds are major issues:

Dependence on crossing angle, L*, 14+1 machine parameters sets …

→ See Takashi Maruyama's talk in MDI session Wednesday

Need a quantitative response from SiD on whether fluxes are acceptable for different cases

MDI 'Urgent Questions' (1)

- FROM the Co-Chairs of the Worldwide Study of Physics and Detectors for the ILC
- MACHINE DETECTOR INTERFACE QUESTIONS WHICH THE ILC DETECTOR CONCEPT GROUPS ARE ASKED TO ANSWER AS FULLY AS THEY CAN BEFORE SNOWMASS.

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, 2005 document ... 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?

MDI ‘Urgent Questions’ (2)

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 you 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?

Suggested SiD MDI strategy for Snowmass

Initial responses to 18 questions drafted (thanks all!):

http://acfahep.kek.jp/subg/ir/bds/mdi/SiD/SiD.urgent.Qs.htm

The accelerator sessions in week 1 clash perfectly with SiD sessions!

Most important for MDI is WG4: beam delivery system

Wednesday 13.30-15.30 joint detector concepts/WG4/MDI session:

Introduction - D. Miller
Machine parameters* (Q3,6,7,8,15)
IR/Detector design, geometry, magnets (Q1,2,6,7,8,10,12,13,17,18)
Backgrounds (Q3,4,5,11)
Forward region, energy spect., polarimetry (Q9,10,14)
Discussion

Propose to defer dedicated SiD MDI sessions until week 2:

try to flesh out the preliminary answers to the 18 questions