Status of BDS design, MDI questions, etc.

for the international BDS design team,
Andrei Seryi

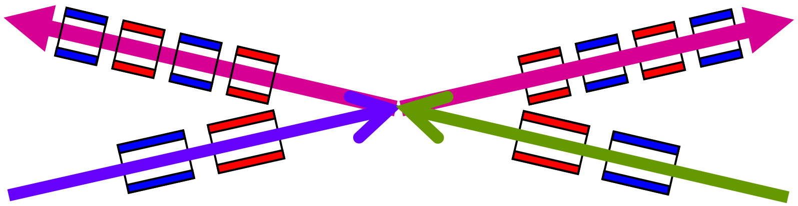
July 14, 2005

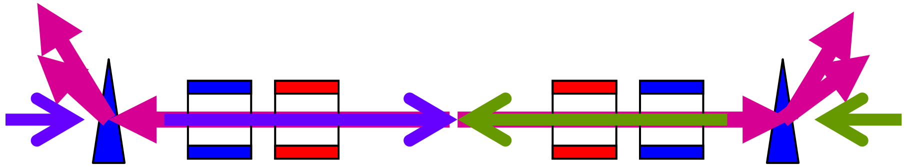
Content

- Status of 2 and 20 mrad crossing angle solutions
- Effects of detector field
- Accelerator motives for short or long L*
- Accelerator motives for larger beam pipe radius
- Machine problems with Z pole running
- Antisolenoids and DID
- Detector assembly
- BDS Baseline Configuration Document
- ATF2 and ESA
- WWS/MDI & WG4 questions to Detector Concepts

Choice of crossing angle has crucial influence on the machine performance, reliability, and affect physics reach

- NLC @ 3ns bunch spacing => 20mrad x-ing; TESLA @ 300ns => chose head-on



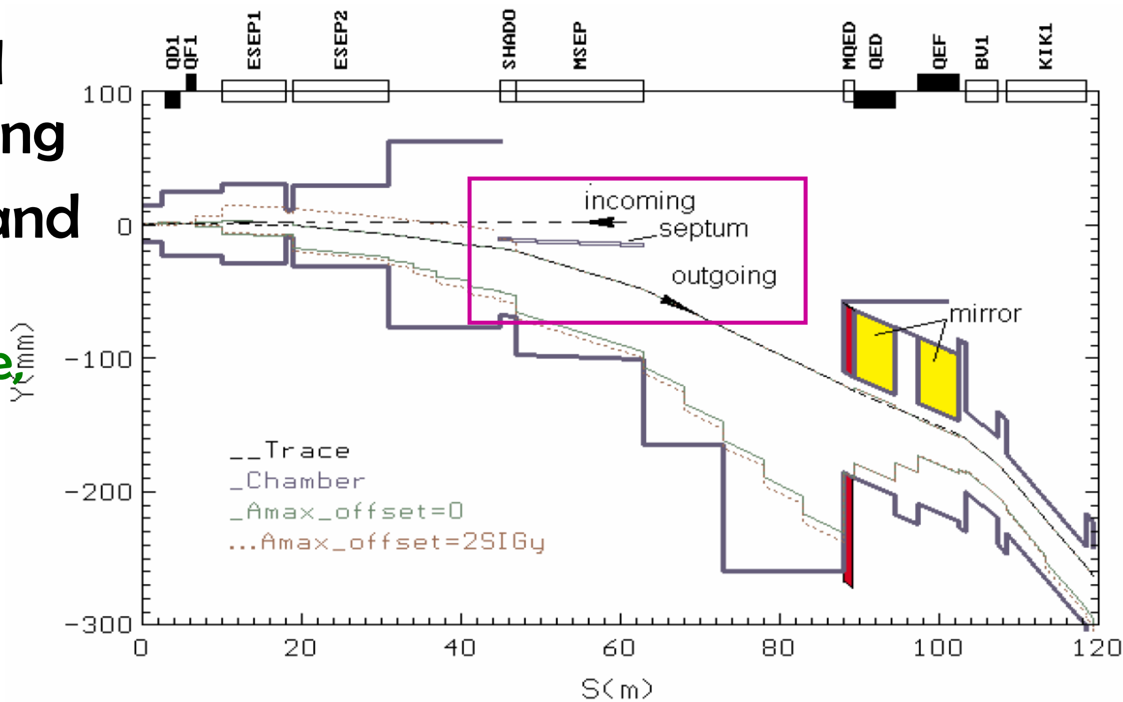


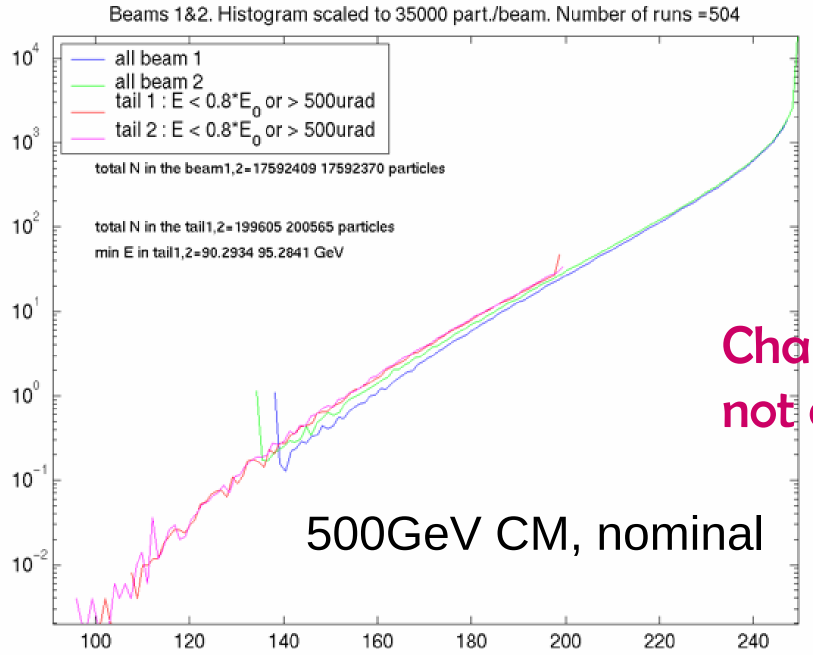
- Incoming and outgoing beam are independent (+)
- Disrupted beam with large energy spread captured by alternating focusing, no need to bend the beam after collision => easier to minimize beam losses (+)
- Require compact SC quads and crab cavity
- The exit hole un-instrumented => loss of detector hermeticity (-)
- Low energy pairs spread by solenoid field => somewhat larger background (-)

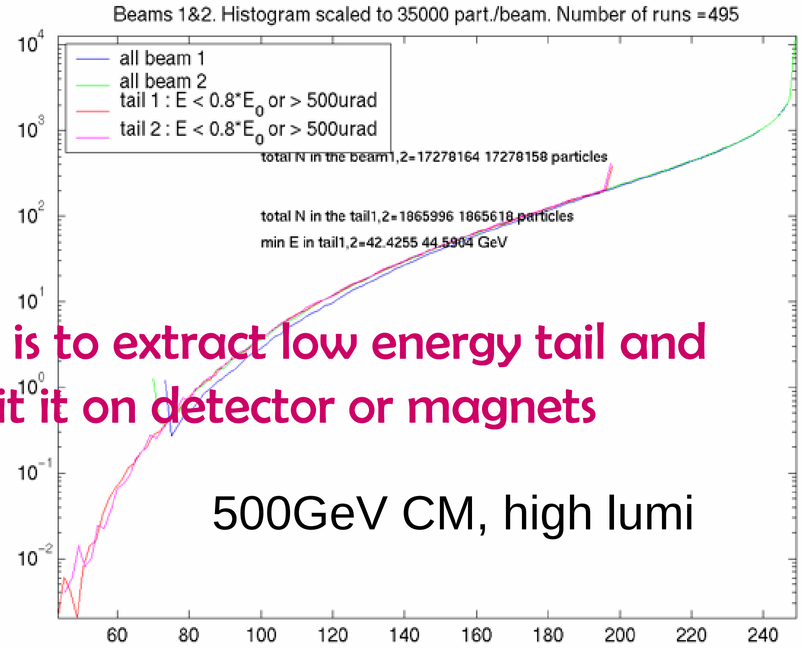
- No extra exit hole => somewhat better detector hermeticity (+)
- Low energy pairs spread less => somewhat better background (+)
- Require electrostatic separator with B-field or RF-kicker
- Incoming and outgoing magnets shared => difficult optics, collimation apertures set by outgoing beam (-)
- Need to bend disrupted beam with large energy spread => beam loss, especially at high energy, MPS (-)

Evaluation of head-on design by TRC

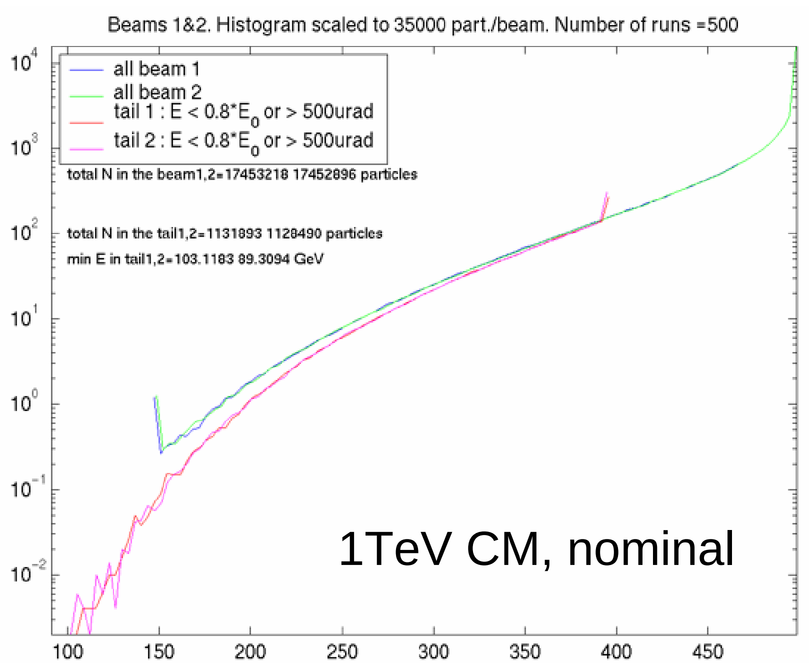
- SLAC actively participated in ILC-TRC in 2002, including
- evaluation of BDS design and head-on scheme
  - Large losses in extraction line, especially at 1 TeV
  - Incompatible with post-IP E/Polarization diagnostics
  - Electrostatic separator 100kV/cm at 1TeV – feasibility in high SR environment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

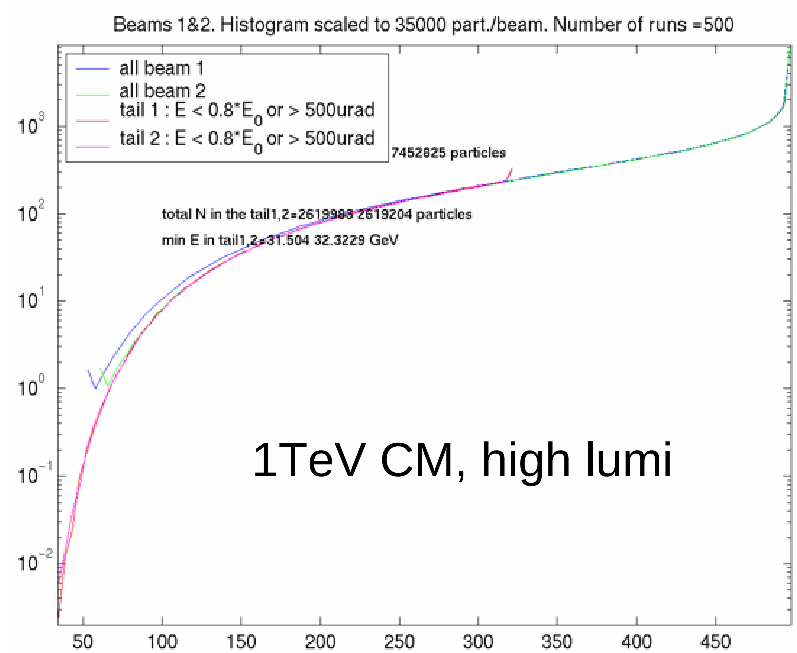






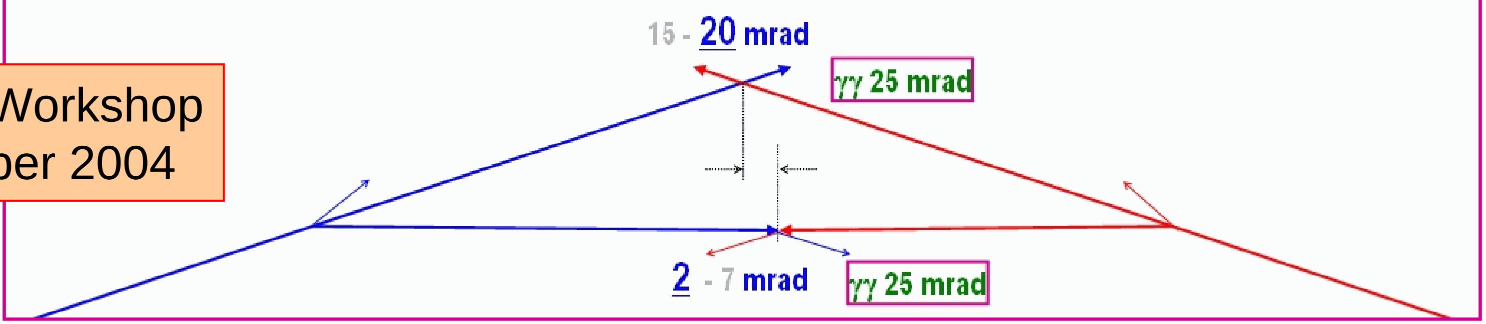
Challenge is to extract low energy tail and not deposit it on detector or magnets



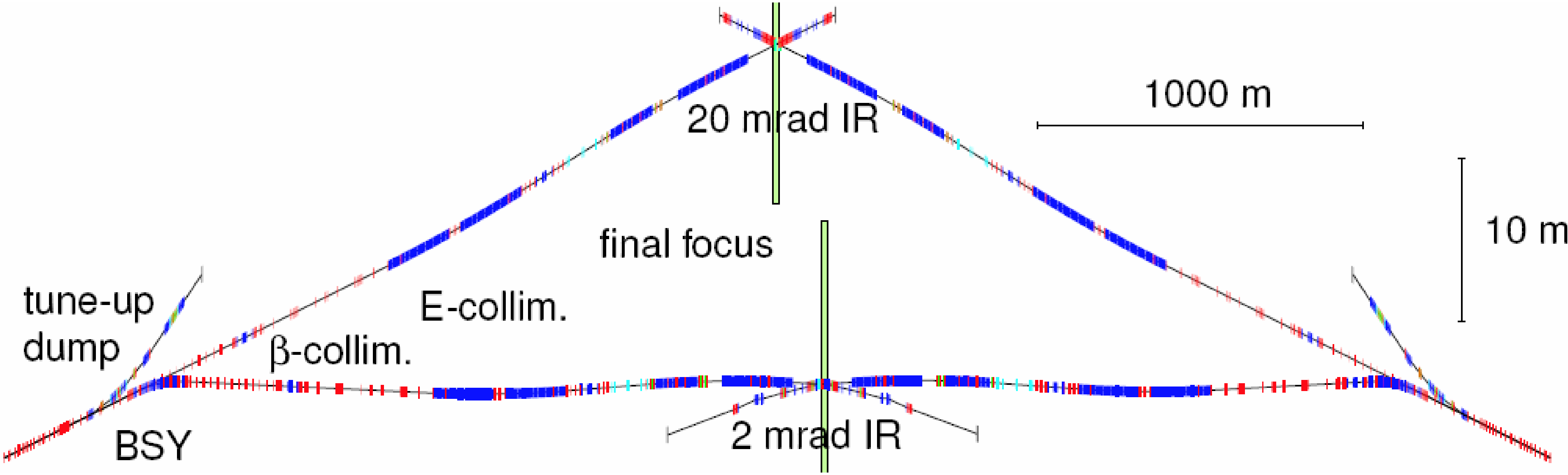


Recommendations from the WG4

Tentative, not frozen configuration, working hypotheses, "strawman"



1st ILC Workshop
November 2004

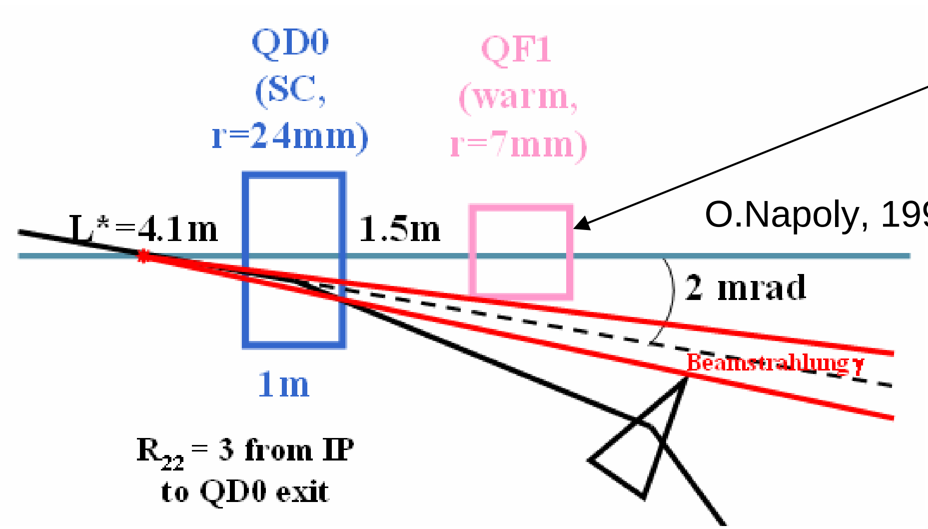


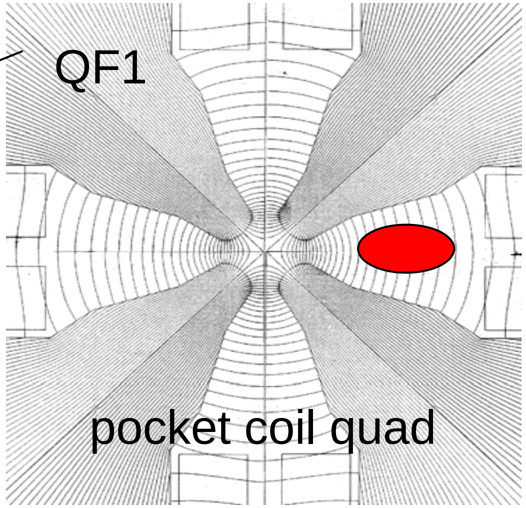
International BDS group is working hard to turn the Strawman tentative configuration into real design:

- Full optics for all beamlines; Well developed and optimized 20mrad optics and magnets design; Created the method and made several iterations of optics and magnets for 2mrad IR; Upstream and downstream diagnostics for both IRs

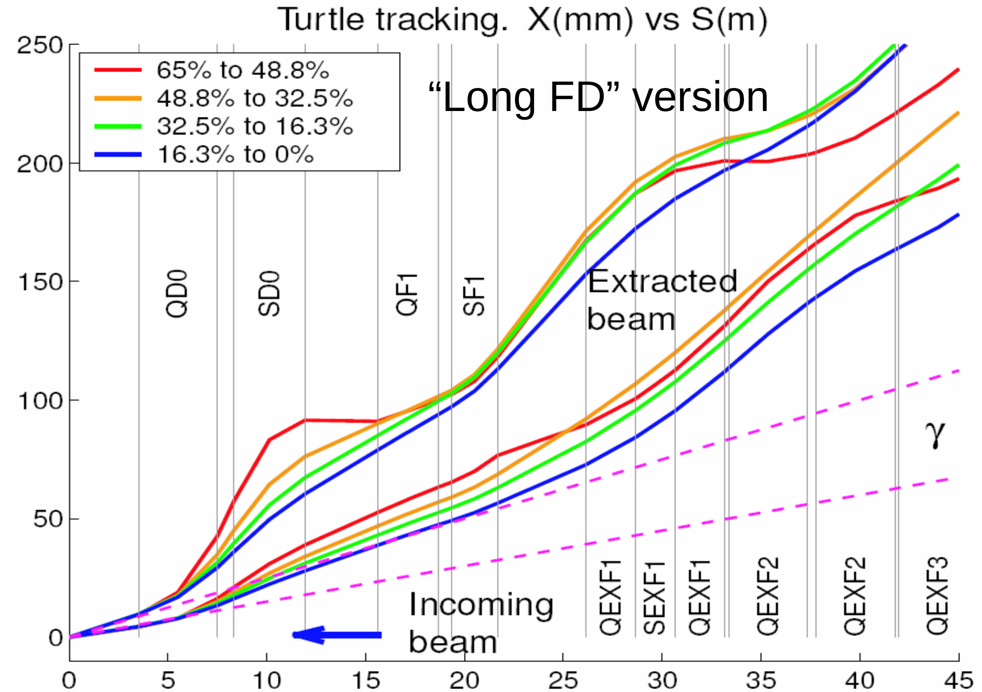
2mrad IR: from concept to optics

SLAC-BNL-UK-France
Task Group



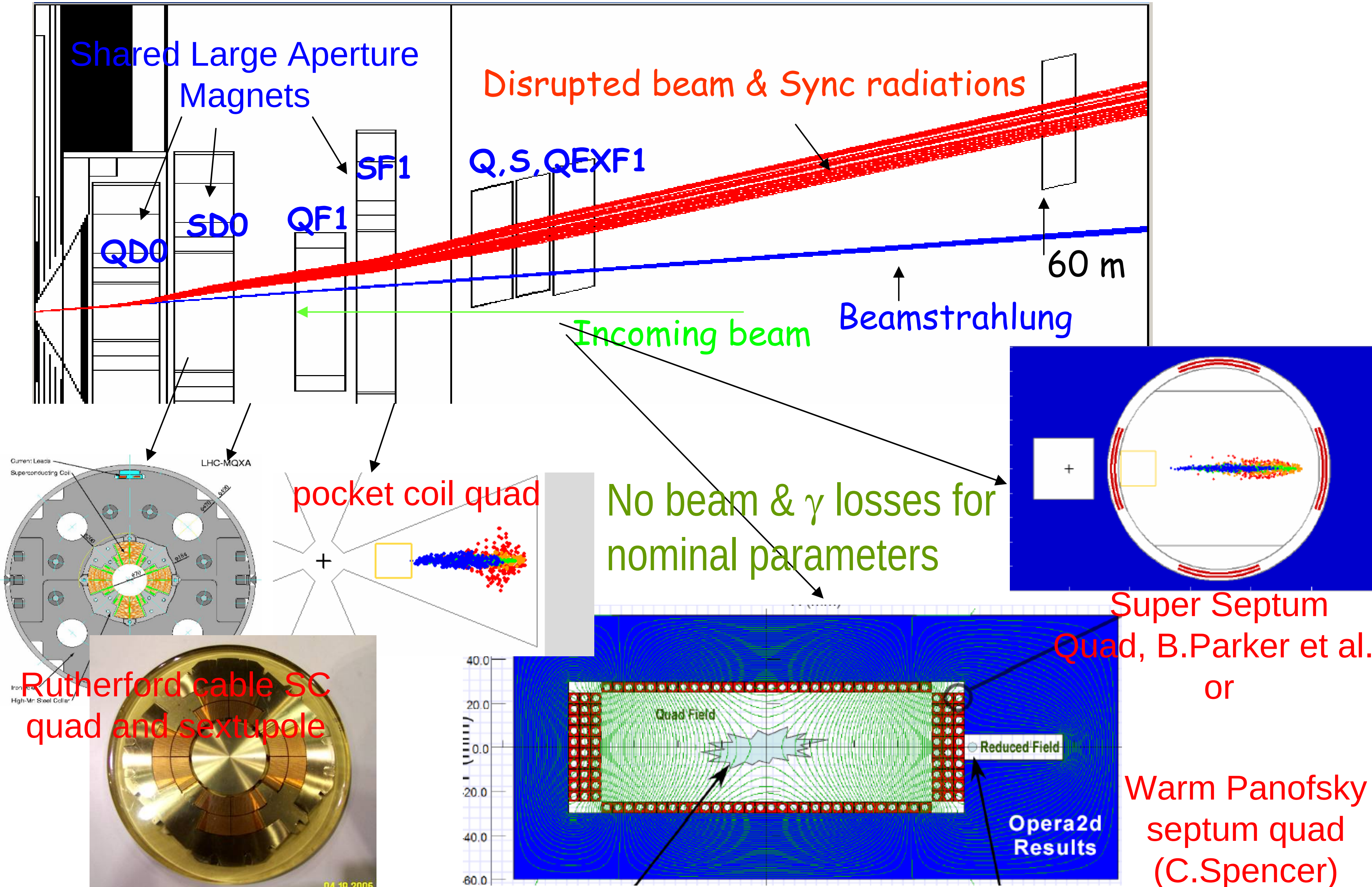


- FF and extraction line optimized simultaneously
- Quads and sextupoles in the FD optimized to
  - cancel FF chromaticity
  - focus the extracted beam



2mrad IP Extraction Line in Geant

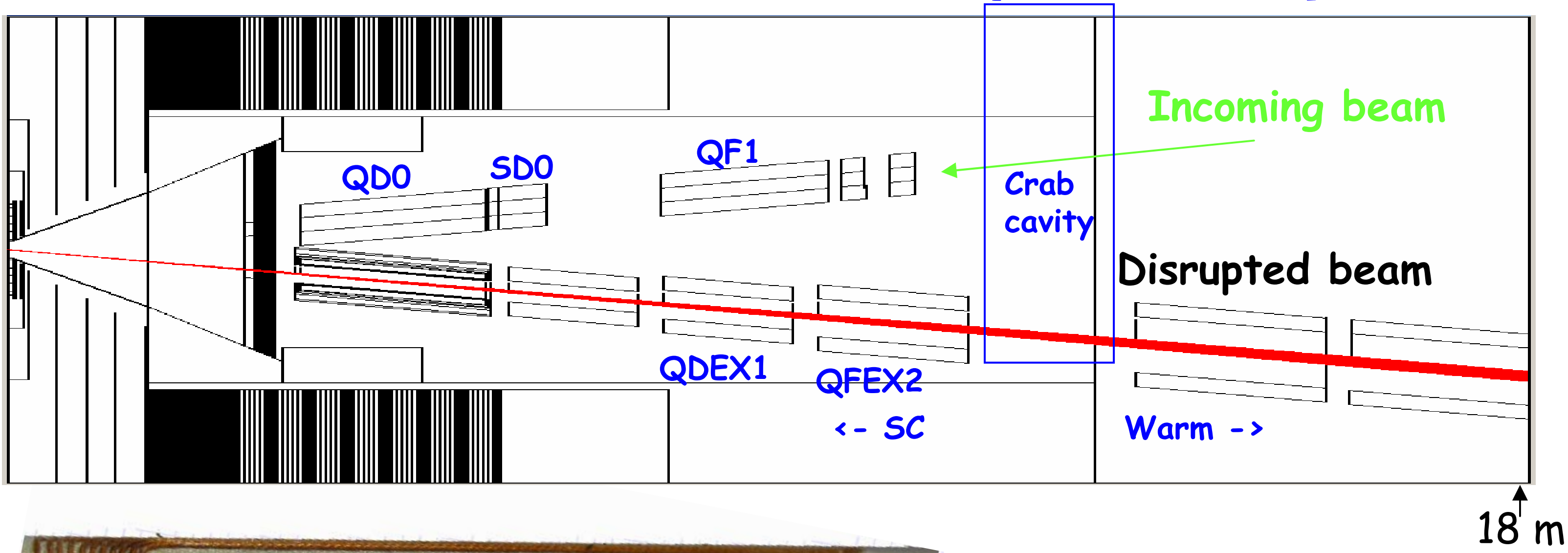
SLAC-BNL-UK-France
Task Group

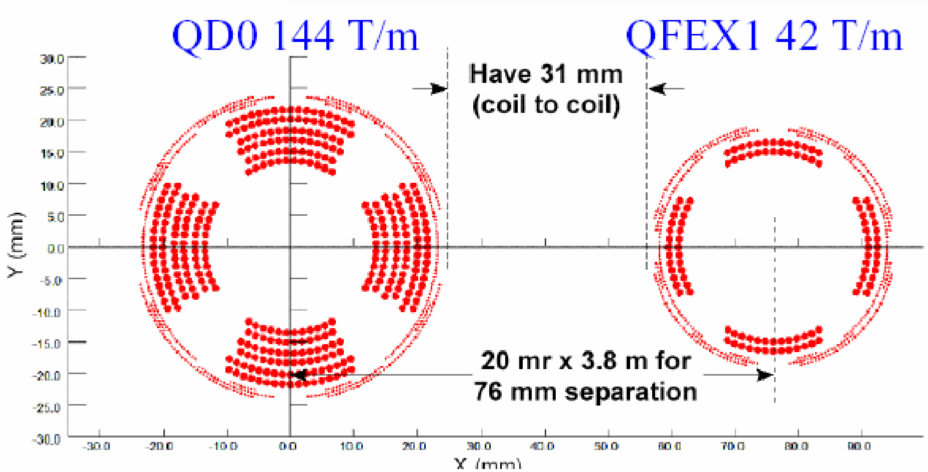


Converging on 2mrad optics

- Have designed several versions of optics, with short or long final doublet, with diagnostics included in the latest versions
- Have learned the process and now need to select a version which will be used for evaluation of background, etc.
- Earlier versions pushed FD magnet technology beyond what can be achievable
- Now designing a version based on well established NbTi technology for 500GeV CM and may require advanced Nb3Sn magnets for 1TeV

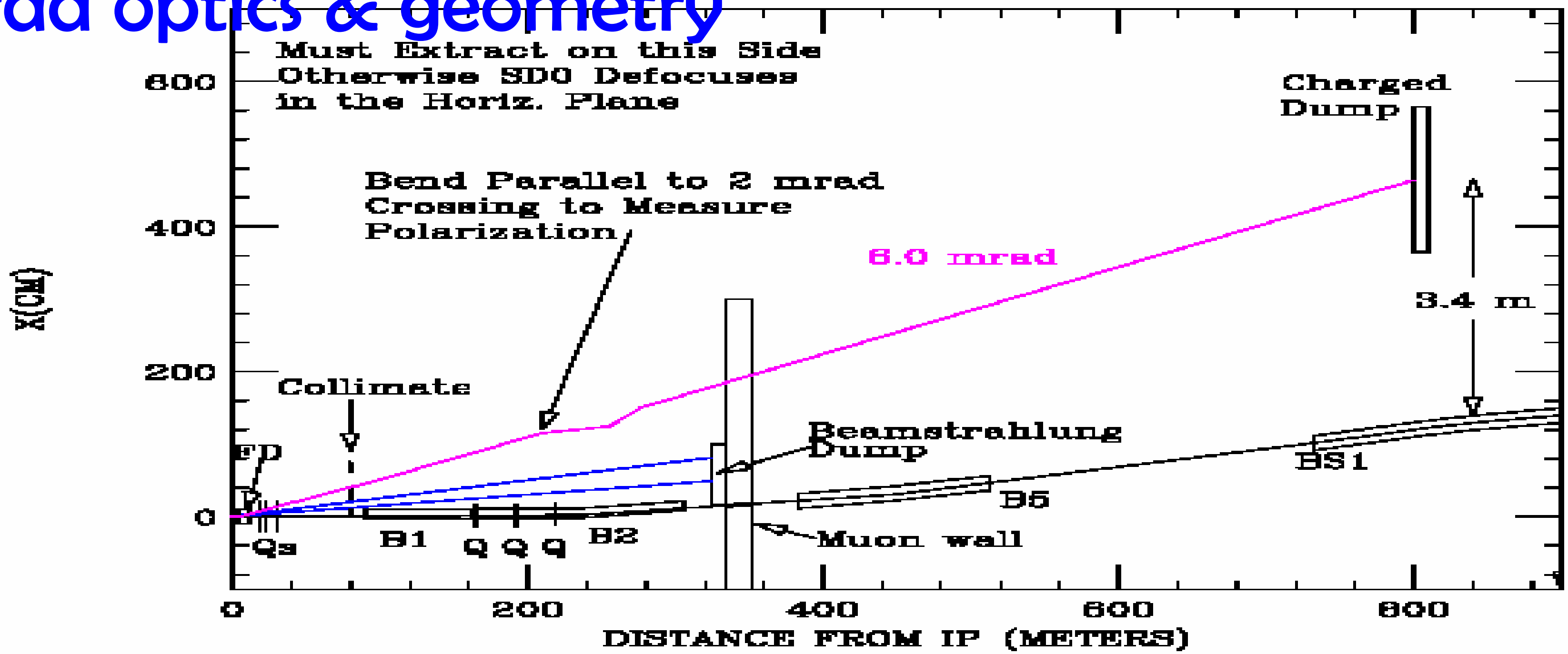
20mrad IR, extraction & compact SC quads



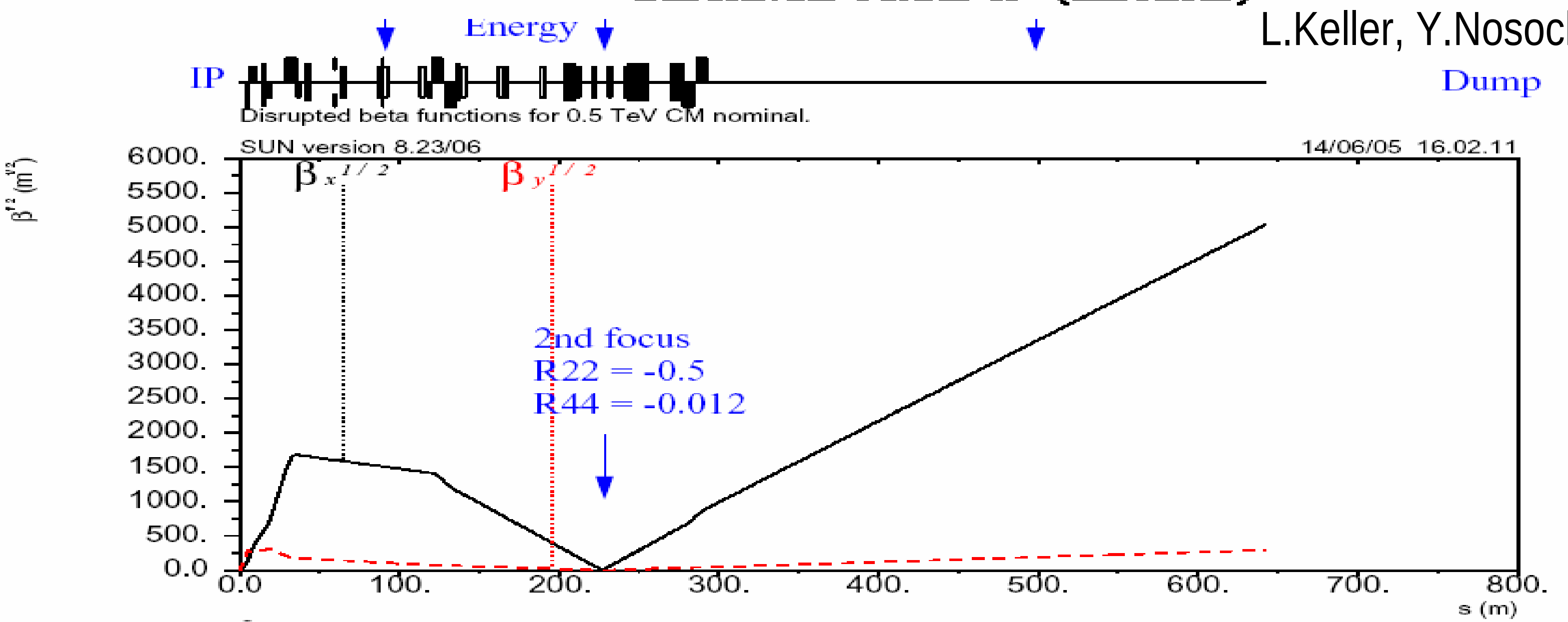


- Based on compact SC quads
- Latest achievements in BNL direct wind technology => even tighter bend radius => quad is more compact => extraction quad has same L*as QD0
- Sixth final layer wound on the QD0 prototype at BNL last week. Next => tests

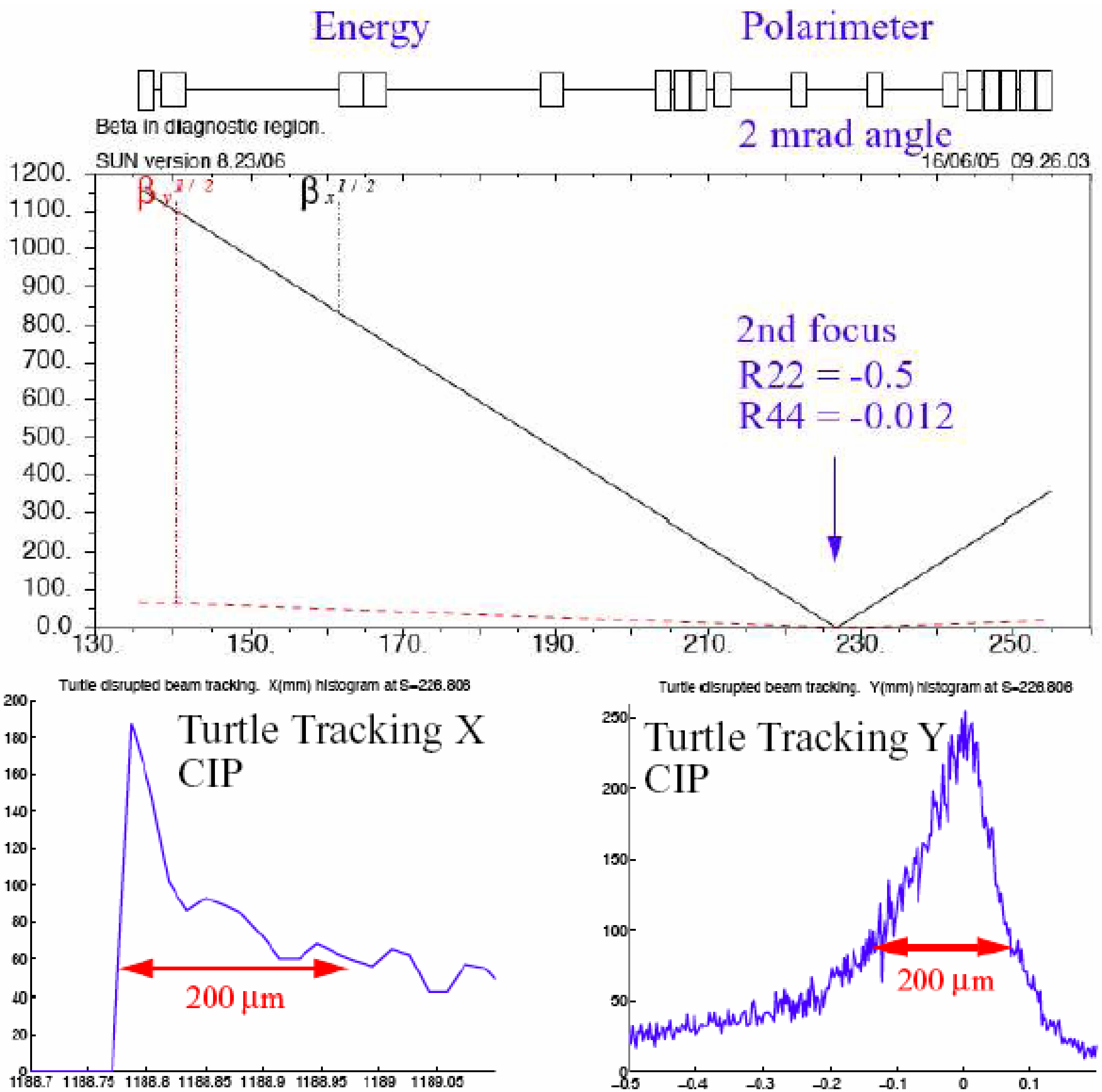
2mrad optics & geometry



L.Keller, Y.Nosochkov, et al

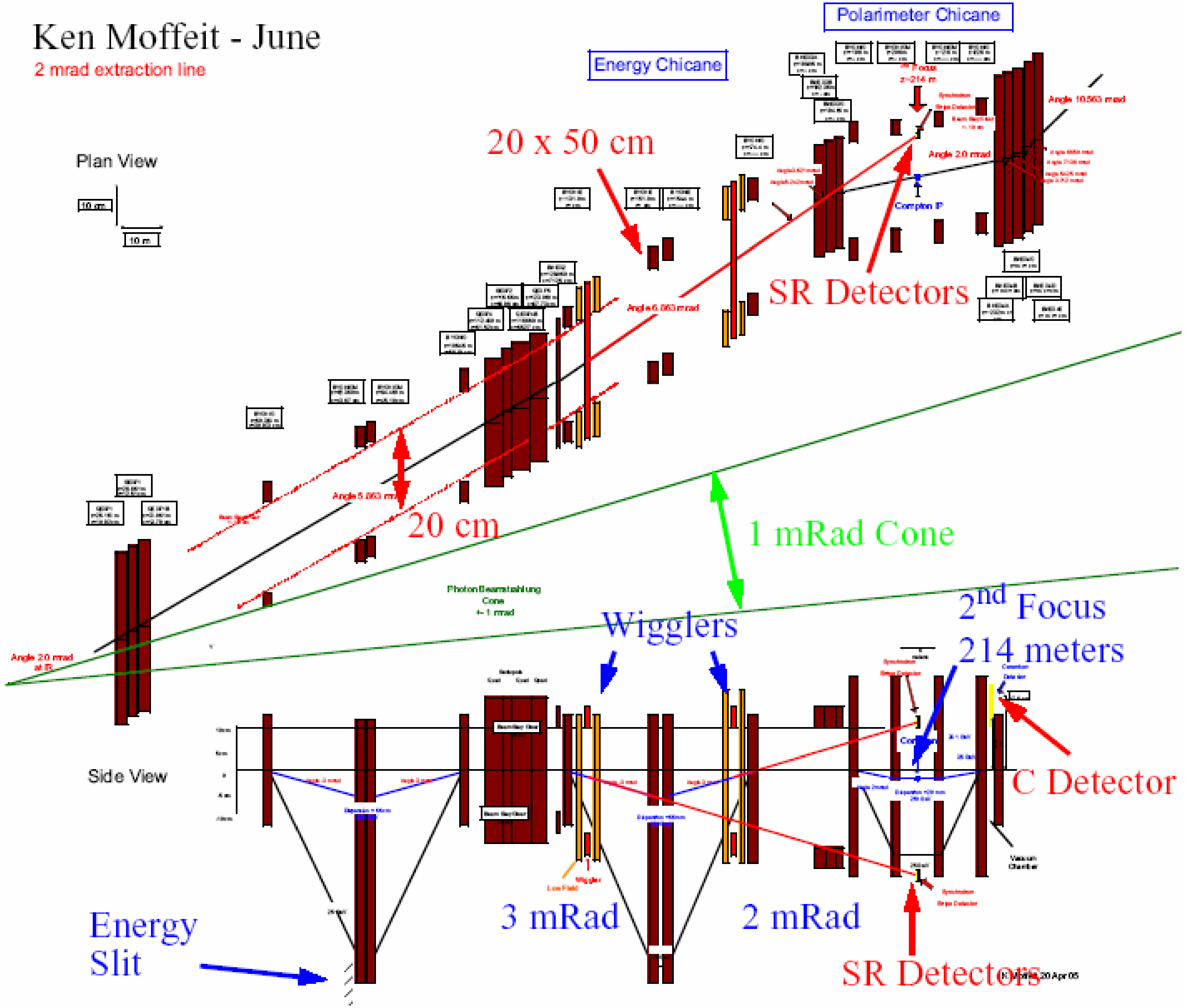


2mrad downstream diagnostics



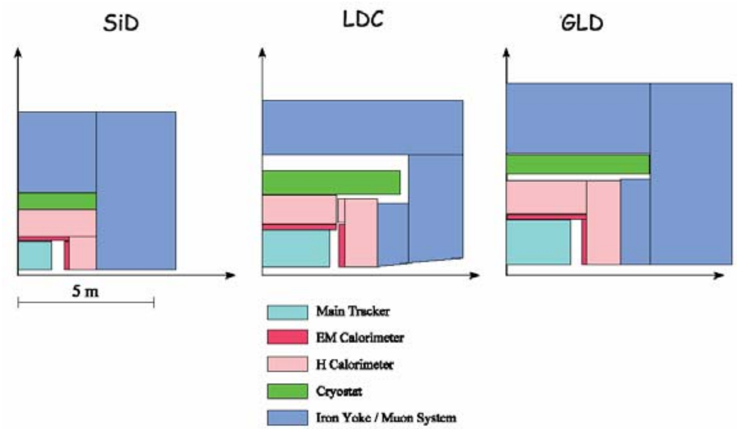
Y.Nosochkov, et al

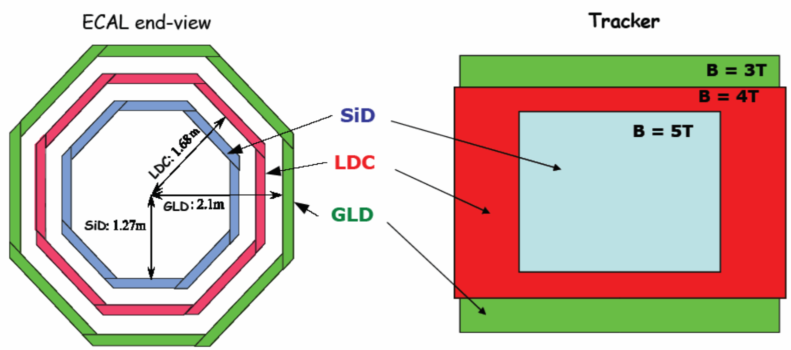
2mrad downstream diagnostics



Detector field and sizes

- Detector size => preferred L*
  - range 3.5m – 4.5m seem to satisfy (?) considered detector concepts
- Longer L* is natural for larger detector, but
  - Longer L* => increase beam size in FD => collimate tighter if r VX is fixed
  - => desired to increase r VX for larger detectors
  - Can't we just collimate tighter?
    - Presently with L*=3.5m collimate at ~8sigmaX
    - Deeper collimation mean scraping larger fraction of the beam (plan for 0.001 but hope for 1E-6)
    - Absolutely cannot collimate twice tighter (would scrape the beam core)





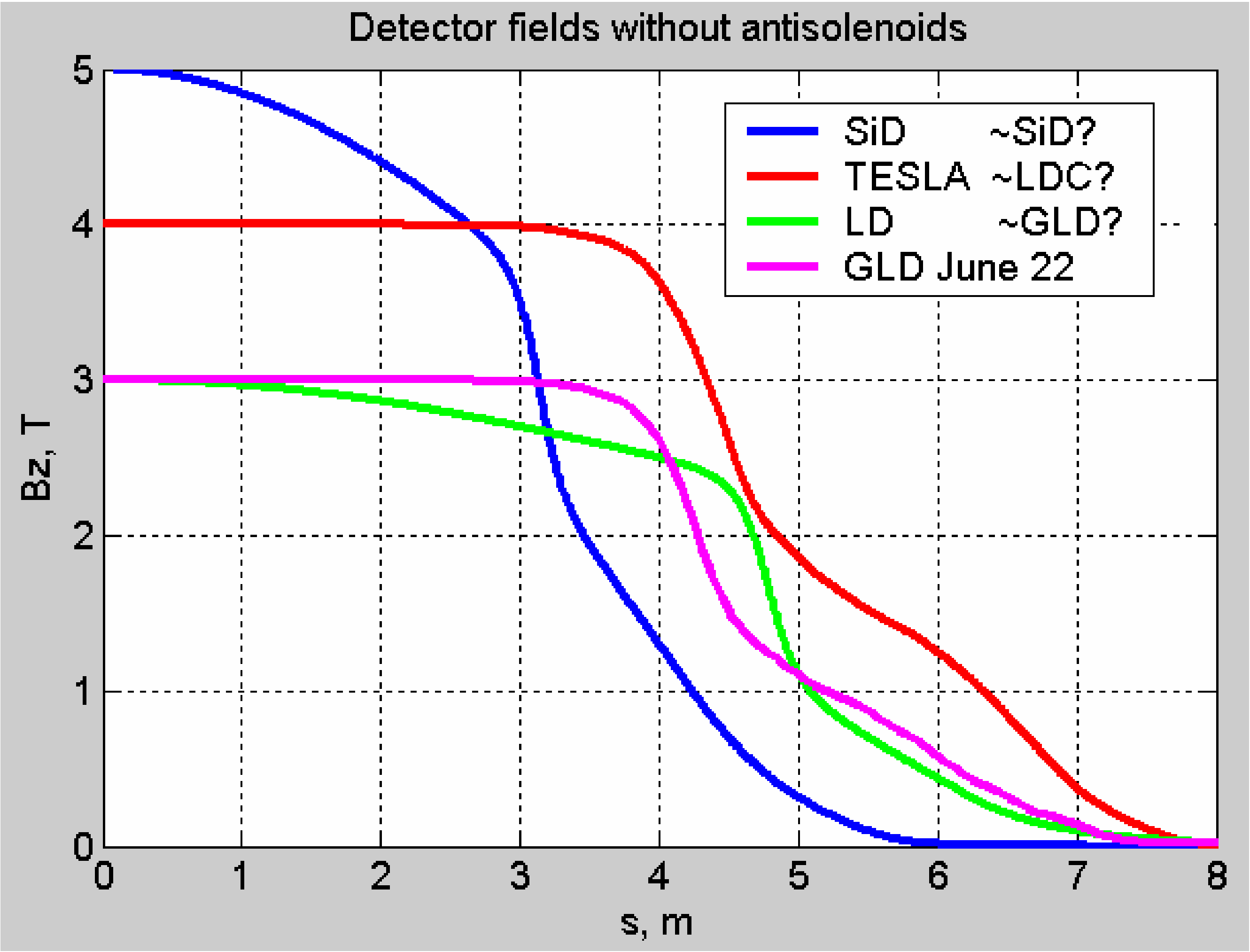
Other effects of L*

- 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
  - easier engineering design
    - e.g. 20mrad magnets in separate cryostats
  - shorter lever arm for support => better stability
  - antisolenoid compensation is easier

  (reduce required gradient; remove QD0 from high field of detector) => may allow NbTi magnets instead of Nb3Sn

- Will consider the range 3.5-4.5 and expect that differences will be tolerable

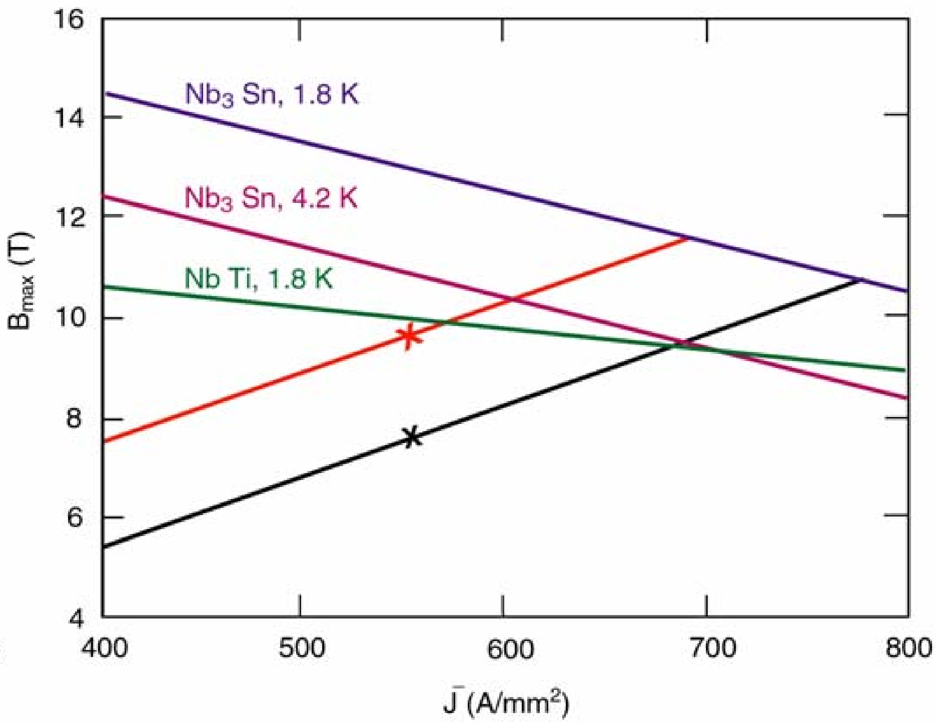
Fields of the detectors



- GLD field is recent, other are old (may be obsolete)

Nb_3Sn Quadrupole Program Main Goals

- Motivation for Nb3Sn technology : external 4T solenoid field (TESLA TDR)
- Nb3Sn Dipoles shoot for 15 T field (cf. CARE/NED)

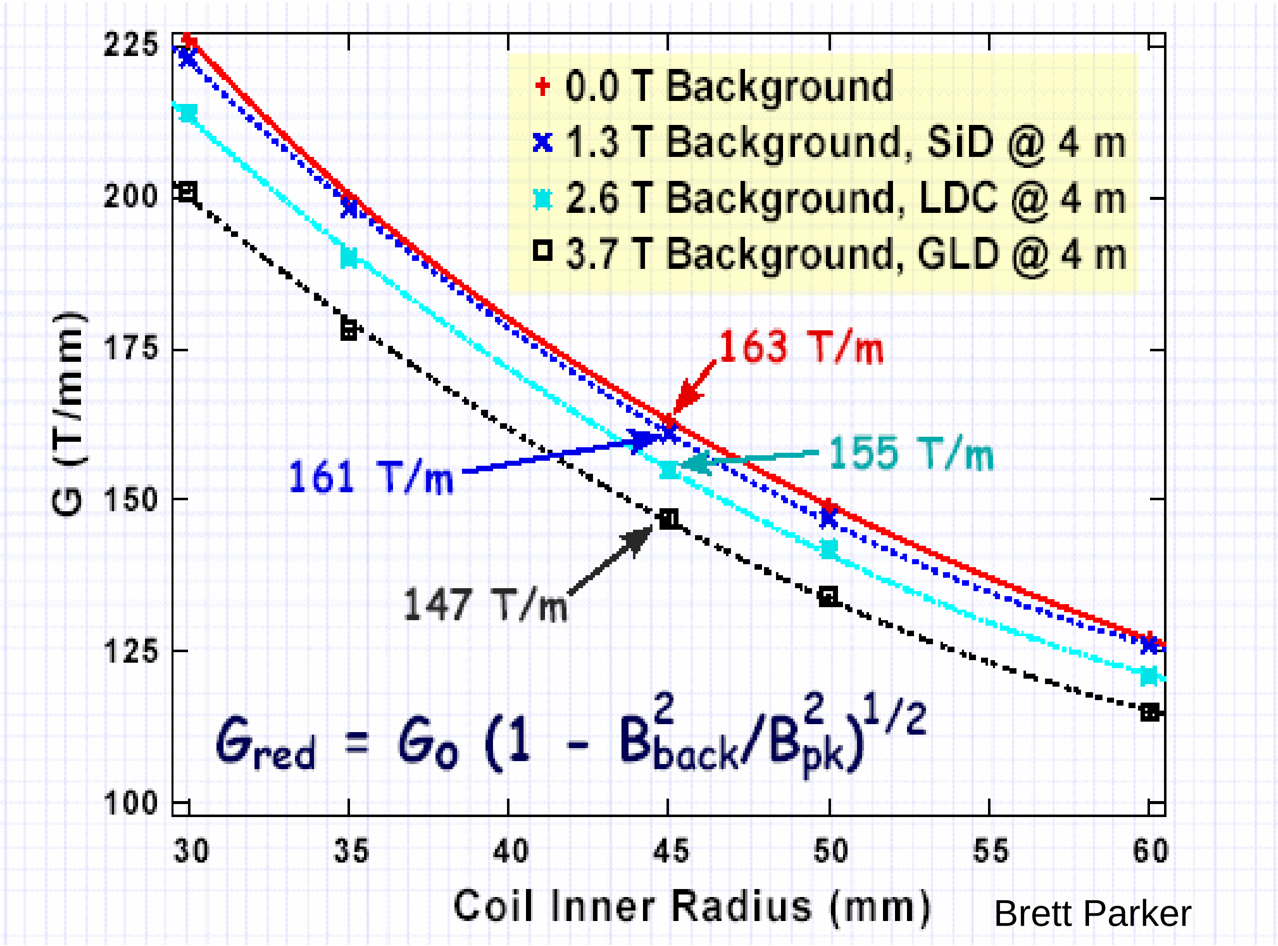


TESLA quadrupole inside the solenoid
$B_{max} = f(J_c)$

X Quadrupole alone (Ø 56 mm, G = 250 T/m)

X Quad + 4T solenoid

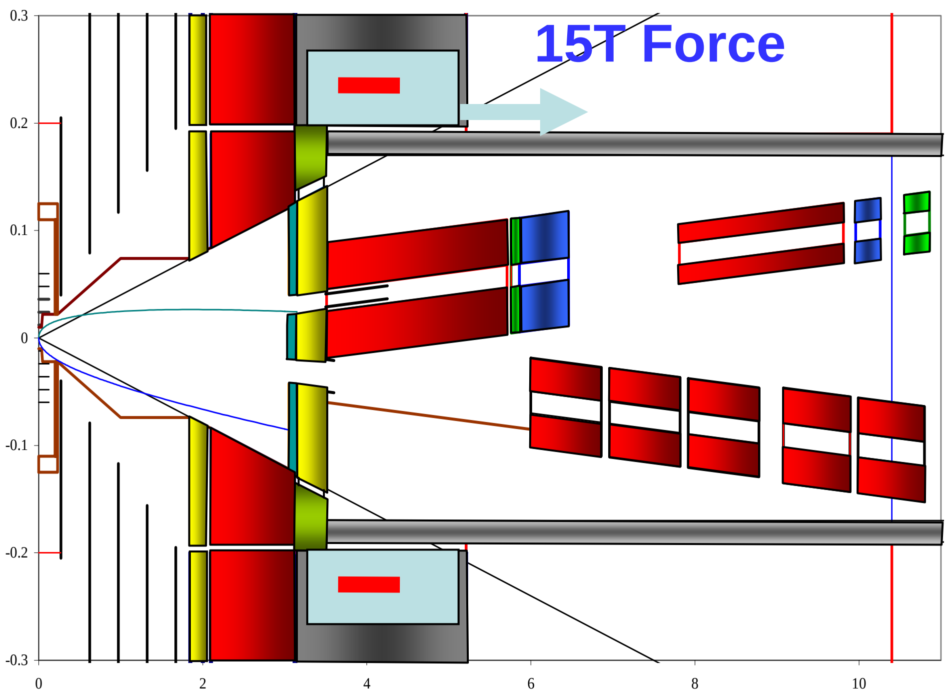
Available gradient for 2mrad QD0



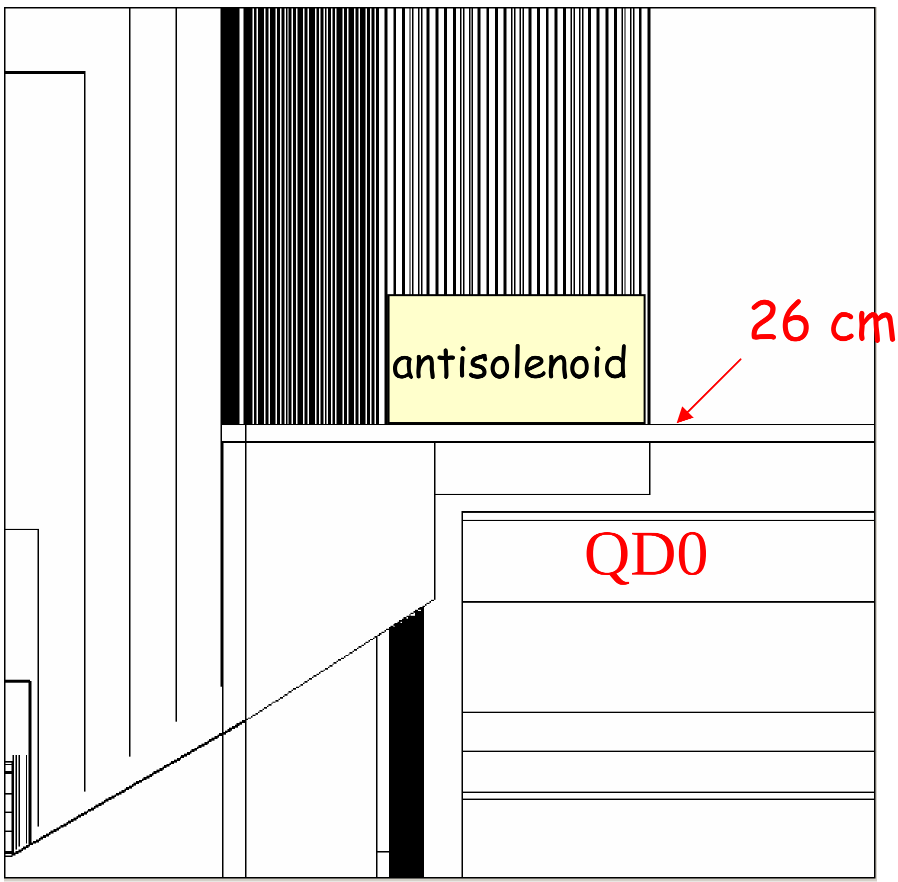
- Brett's scaling model of gradient versus inner aperture for NbTi quad, versus background field

Antisolenoids

- Were proposed to make easier changing the beam energy down to 50GeV without reducing the detector field (PRSTAB 8, 021001 (2005))

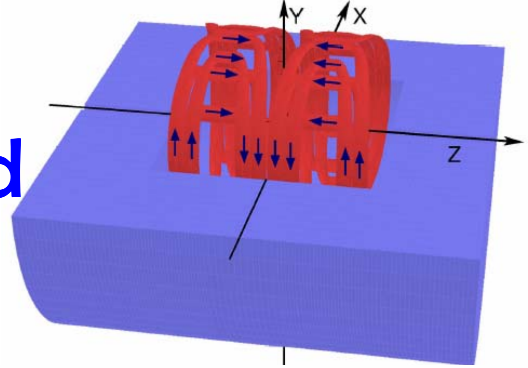


20mrad IR (older picture, now QEX has same L* as QD0)

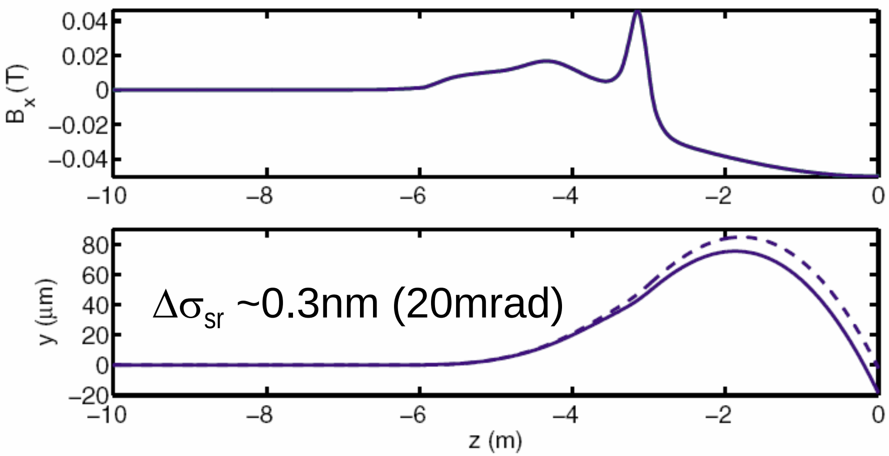


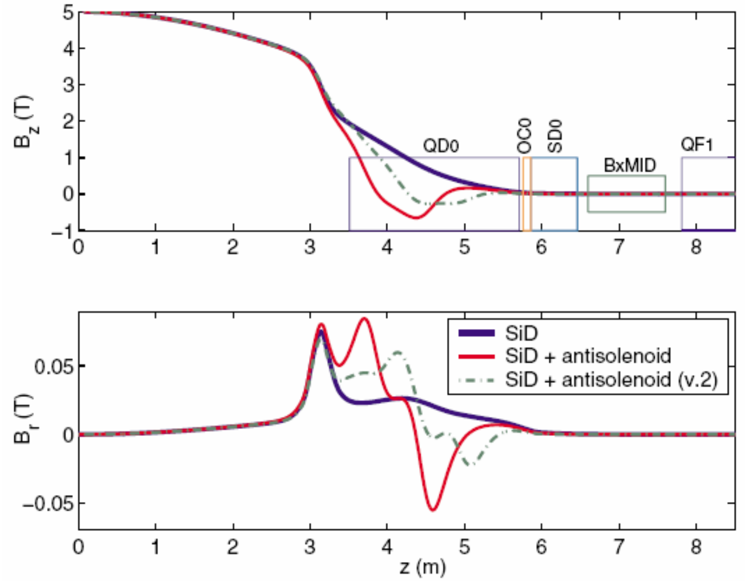
2mrad IR

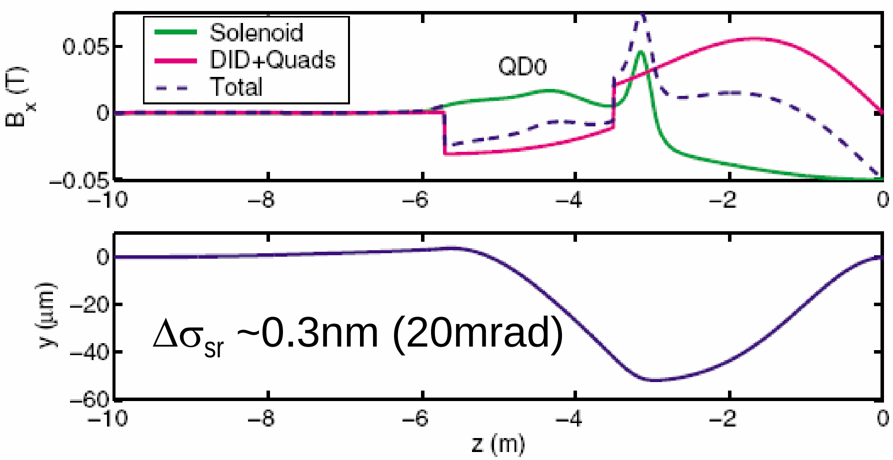
Detector integrated dipole

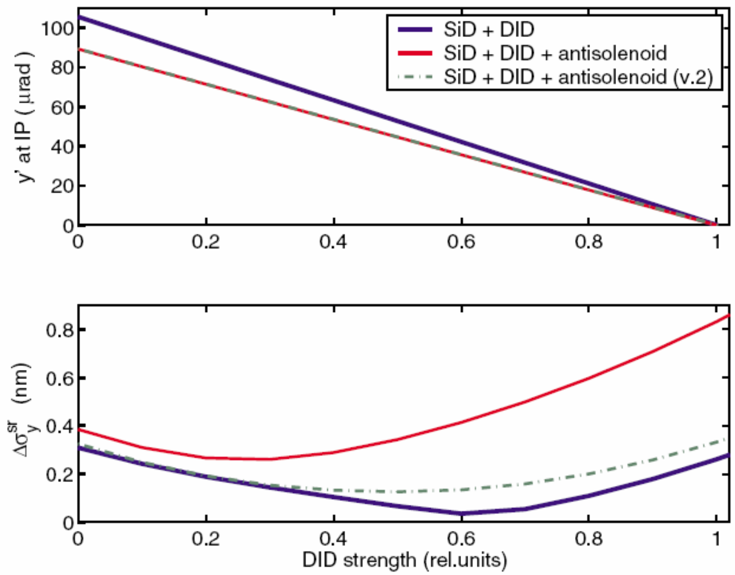


Reduce or zero the vertical angle at IP and simultaneously minimize of SR beam size growth (PRSTAB 8, 041001 (2005))

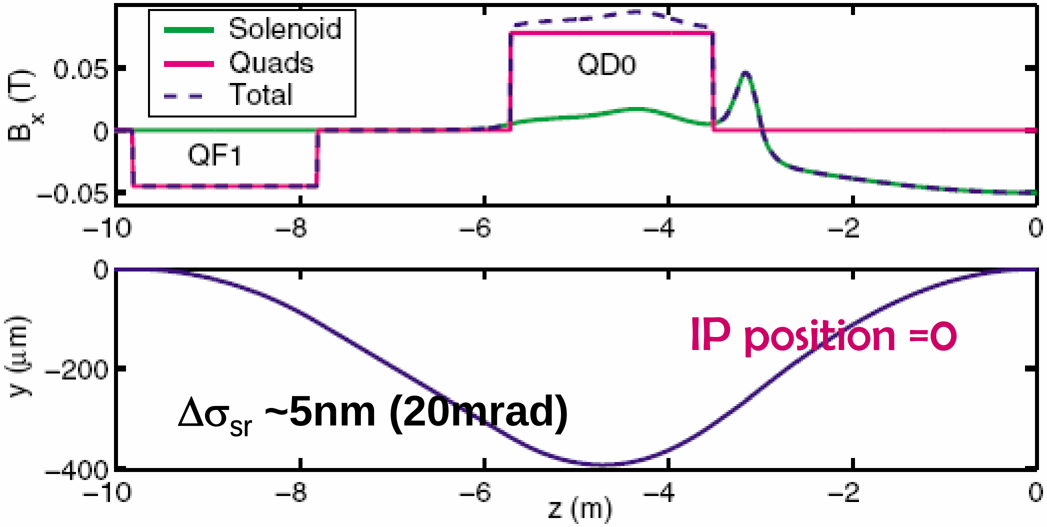


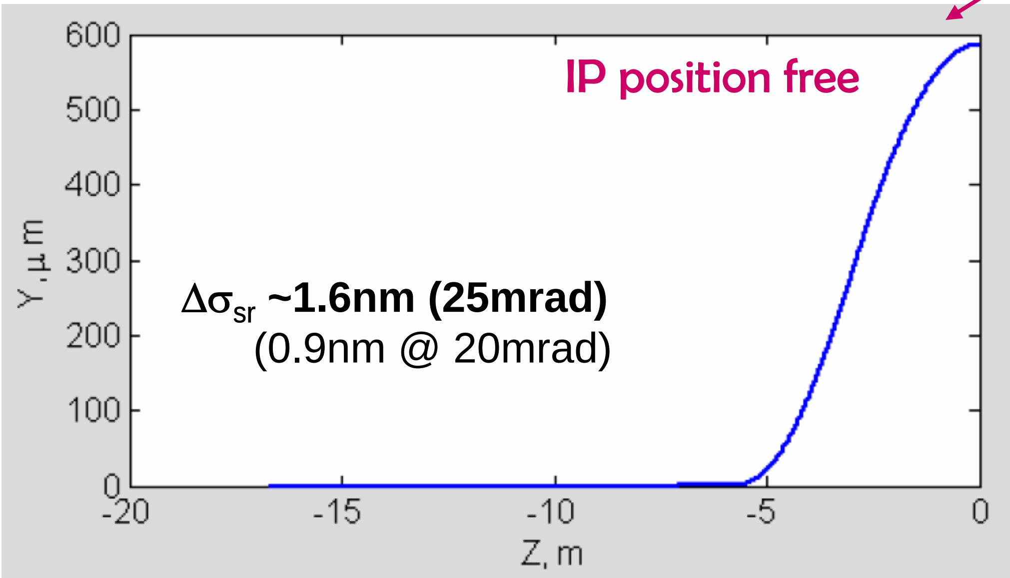






If DID is not used, and angle compensated by FD





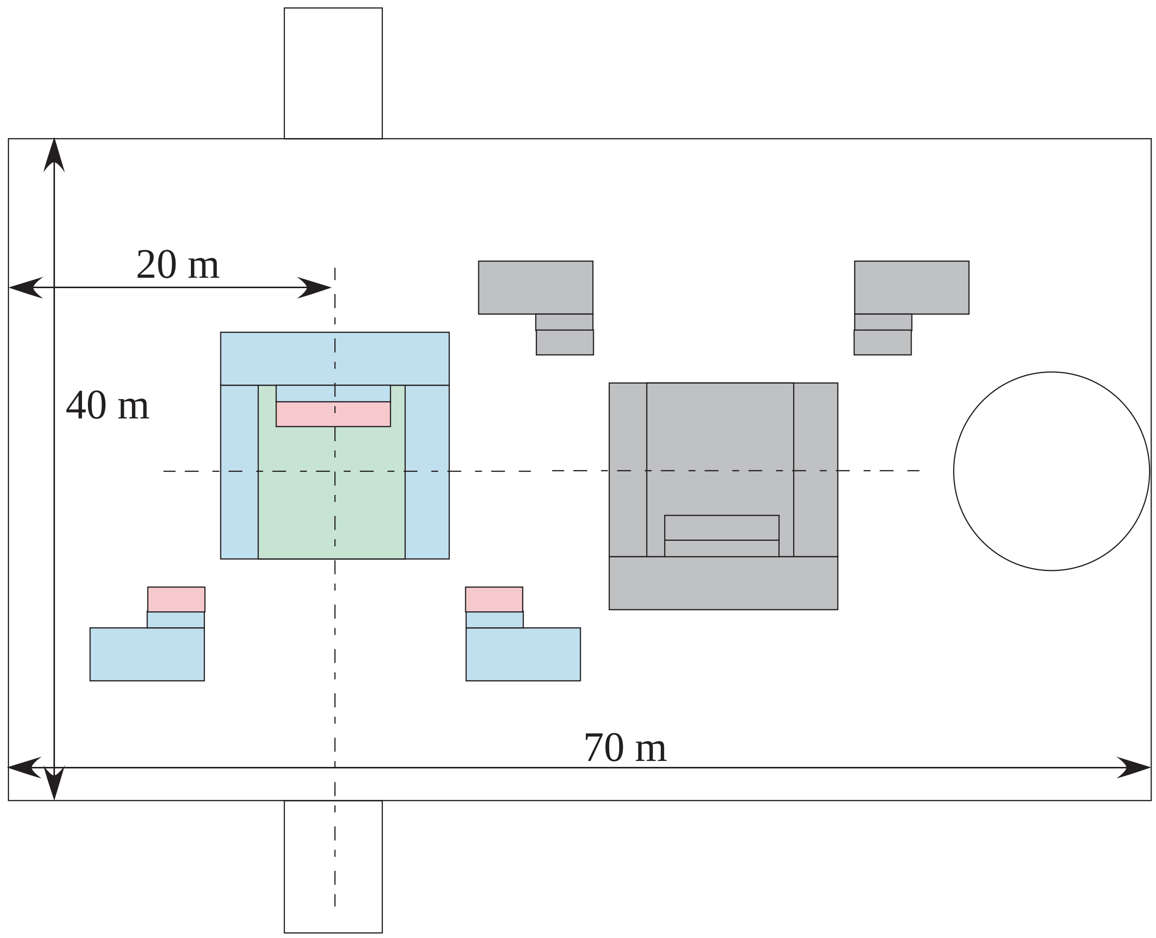
- Offset QD0 & QF1 to cancel IP angle & IP offset => too large SR beam size growth
- If one abandon the constraint of IP position fixed w.r.to beamline [V.Telnov, LCWS05], can in principle use only offset of QD0 and SR beam size growth is reduced
- But variation of IP position in the vertex (by 3mm at Z!) created many problems such as reduced collimation depth, etc
- Example shown are for SiD with L*=3.5m and will be worse for longer detectors and L*

Detector assembly procedures

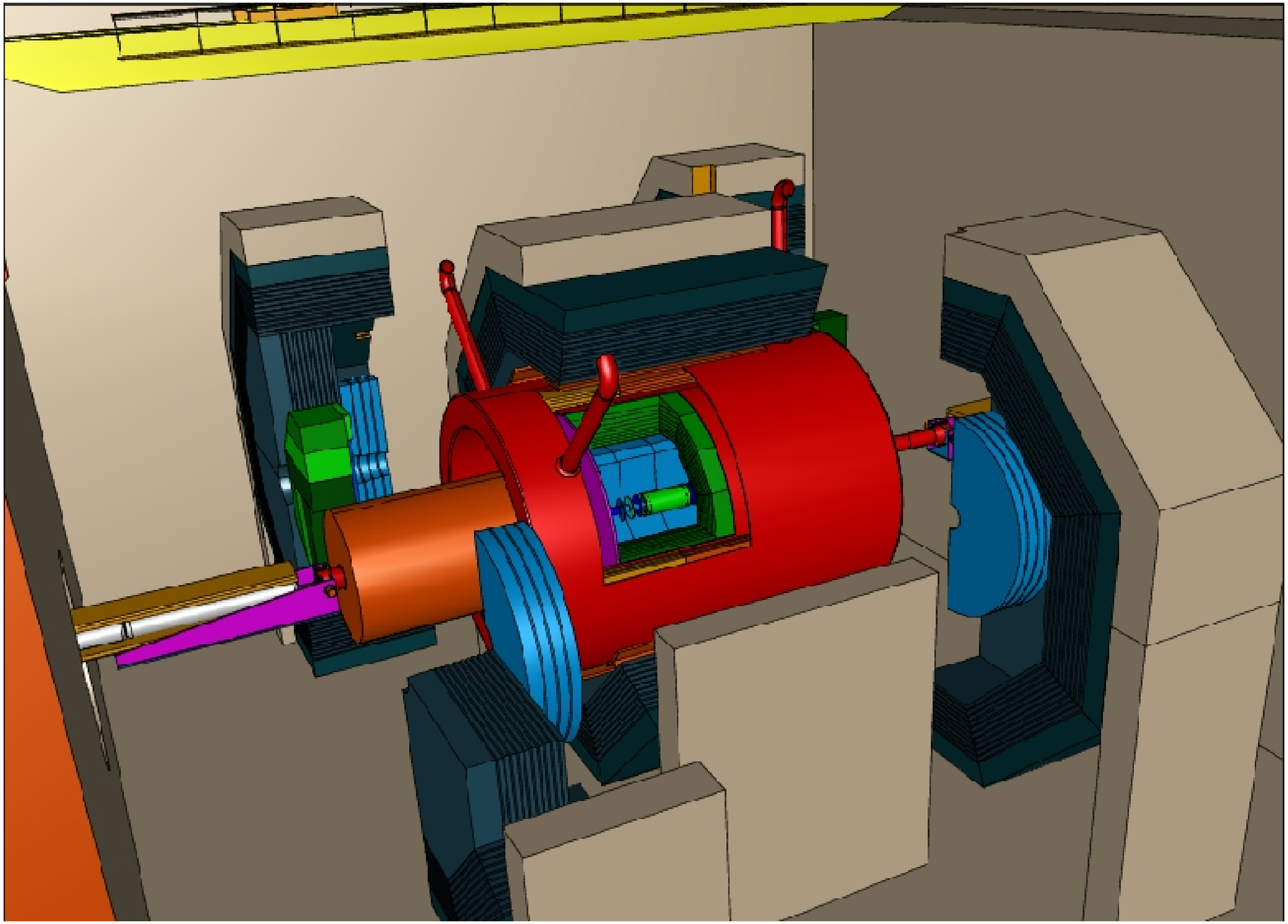
- Affect:
  - size of detector hall
  - beamline assembly procedure & design
  - endcap splitting to the side or sliding upstream makes difference for beam line design
  - external sizes of SD0, QF1 and SF1 magnets are also constraint if endcap is sliding along the beamline
  - if endcap sliding would require disassembling part of beamline, or even opening vacuum, this may have a lot of consequences
- GLD and LDC have different approach to detector opening procedure than SiD
  - merits of each approach need to be compared

GLD assembly & experimental hall

Y. Sugimoto

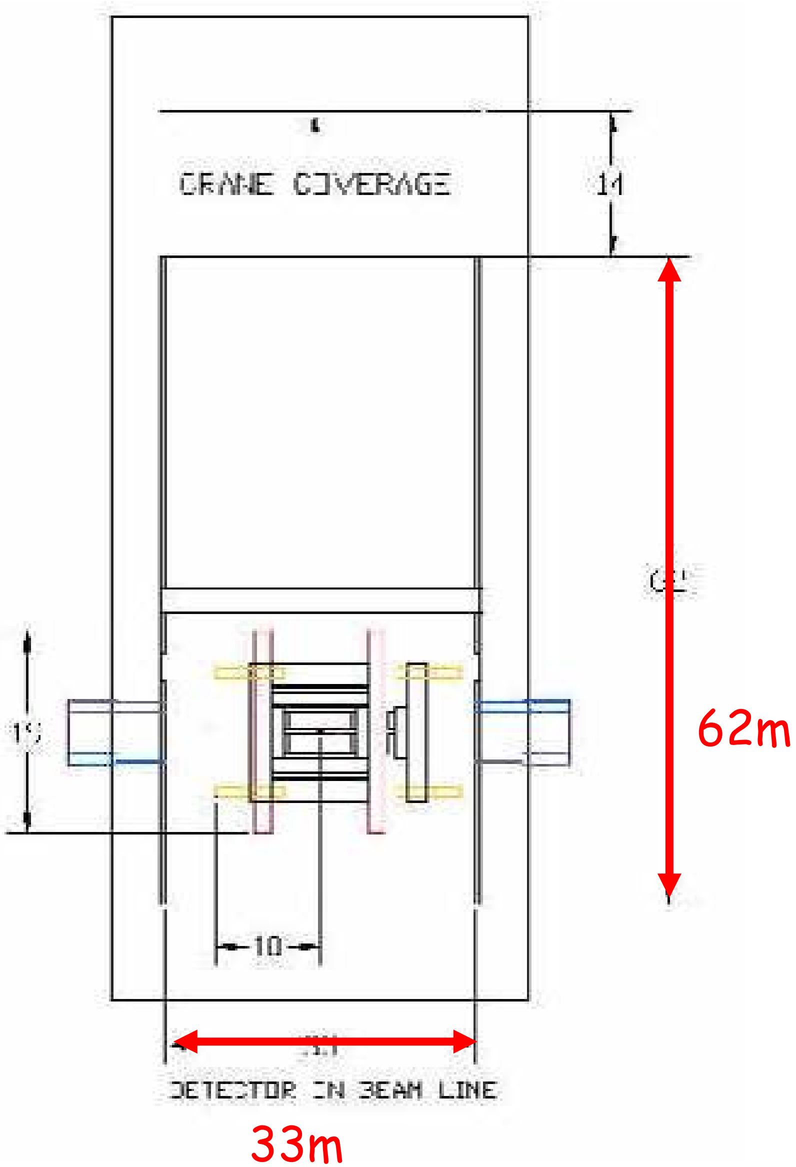


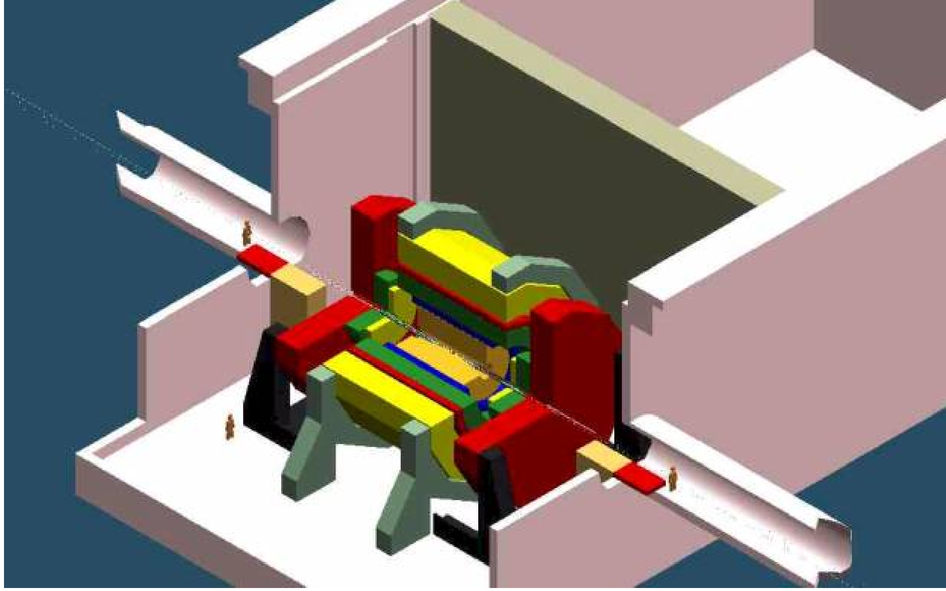
LDC assembly



Tesla style detector LC-DET-2001-056

SiD assembly





Sizes may be not up to date

ILC Beam Delivery System (BDS), Pre-Snowmass Baseline Configuration Document (BCD). DRAFT

BDS BCD Created and discussed on June 20-23, 2005, at WG4 BDS workshop in London.

Last updated July 13, 2005
This is DRAFT and evolving document. It will be further discussed via the BDS mail-list.

Contents:

http://www-project.slac.stanford.edu/ilc/acceldev/beamdelivery/bds_bcd.htm

Table with main features

BDS Baseline	Baseline R&D	Option and Option R&D
One of IRs with 20+mrad crossing, separate incoming and extraction lines	Many. See specific items below.	15-25mrad
One of IRs with ~2mrad crossing, first FD magnets shared	Many. See specific items below.	Head-on with electrostatic separator or RF kicker; Or same 20mrad design for this IR as well
IR magnet design based on compact SC direct wind quads for 20mrad, separate cryostats for QD0 & QEXF, the incoming L* = extraction L*.	Prototype compact SC QD0, study its magnet and vibration properties.	Common cryostat SC quads, other technology? Different (longer) L* for extracted beam?
FF optics based on local chromatic correction with L* in the range from 3.5m to 4.5m for both IRs	Get experience with compact FF at AFT2	Even longer L* of 5m or more
2mrad extraction beamline with E and polarization diagnostics, with separation of e+- and γ after first extraction line doublet	Prototype the SC super septum quads or Panofsky style septum quads	Other ideas for magnets?
Large bore SC magnets for 2mrad, minimal external size, with antisolenoid and movers inside? The 500GeV CM quads are based on traditional NbTi technology.	Prototype needed	Alternative SC materials which allow larger aperture, but brittle in manufacturing (Nb3Sn) are considered for 1TeV upgrade and should be prototyped (work on a prototype for LHC is ongoing).

Crab cavity system based on 1.3 or 3.9GHz located near FD in 20mrad IR and near SD4 in 2mrad IR	Prototype crab cavity with proper damping of high order modes	Crab cavity system based on warm RF cavity
Main beam dumps based on water vortex scheme rated for 18MW beam. Common e+- and γ dump for 20mrad, separate γ dump for 2mrad. Separate beam dumps rated for full power for all beamlines (total six beam dumps). Undisrupted beam size increased by distance.	Prototype and tests of beam dump window?	Elliptical wide window. Gas beam dump (1km of Ar in Fe). Beam sweeping and/or graphite rod to increase undisrupted beam size.
Betatron collimation based on collimation in FD and IP phase, with survivable spoilers	Measurements of collimator wakefields. Beam damage studies at ESA	Betatron collimation with consumable spoilers. Their prototype.
IR magnet support with passive vibration protection	IR prototype at ESA	Active stabilization of FD support
Antisolenoid as part of detector in 20mrad IR	Do we need prototype or design studies sufficient?	No antisolenoid, only skew quad correction
Antisolenoids as part of large bore QD0	Prototype QD0, solve decoupling force on solenoid from the quad	No antisolenoid, only skew quad correction
Detector solenoid with Detector Integrated Dipole for both 20mrad and 2mrad	Design studies sufficient, no prototypes	No DID
Incoming beamline BPMs are cavity based submicron resolution	Prototype large aperture cavity BPMs. Get experience with cavity BPM system at ATF2.	Stripline BPMs are not an option?
Diagnostics with orthogonal coupling correction section followed by a 4-wire-scanner 2D (projected) emittance measurement section with laser wire system with beam sizes > 17*1.5 microns	Prototype laser wire at PETRA and ATF/ATF2, achieve needed resolution of micron beam	Lengthened diagnostics section with larger beam sizes at laser wire scanners. Employ Shintake monitor instead of laser wire for submicron resolution in the diagnostics section.
Fast intra-train digital feedback system with BPMs on the IP face of FD and kickers near FD	Prototype intratrain feedback at ATF and ATF2, beamtest of BPMs in background conditions at ESA	No other options? Additional fast feedback at the entry to BDS and maybe in the mid-linac is an option?
~~FD movers for 2mrad IR: movers are located inside of the cryostats of the large aperture magnets~~. No individual movers for IR magnets: field moved by week dipole in quads and week quad in sextupoles.	Prototype the movers. Piezo or magnetostrictive technology?	Other techniques?
~~FD movers for 20mrad IR: mechanical movers for each magnet individually, located outside cryostats, based on FFTB scheme.~~ No individual movers for IR magnets: field moved by week dipole in quads and week quad in sextupoles.	Prototype at ESA: IR mockup?	Other techniques?

etc…

BDS design (is being/will be) supported by R&D work at these facilities

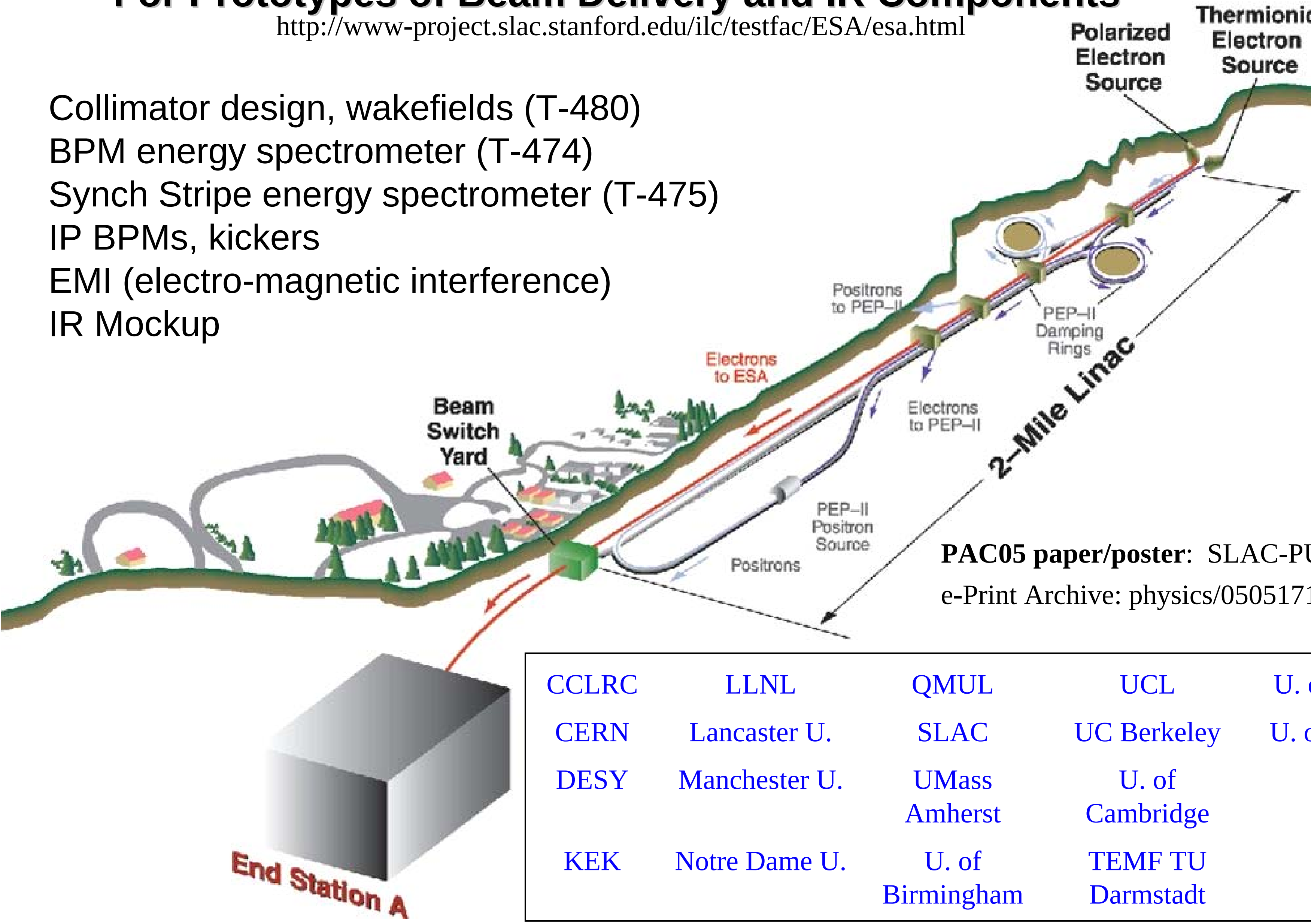
- Proposed End Station A at SLAC
  - Study Interaction Region issues and instrumentation
  - Mockup of full IR
- Existing ATF at KEK (DR and BDS related studies)
  - Instrumentation (Nano-BPM, laser wires, optical anchor)
  - Fast Intra-train feedback (FONT/Feather)
  - nm resolution BPM test & demonstration
  - Preparation of 'ATF-2'
- Proposed ATF-2 at KEK
  - BDS facility, use very low emittance ATF beam

End Station A Test Facility

For Prototypes of Beam Delivery and IR Components

http://www-project.slac.stanford.edu/ilc/testfac/ESA/esa.html

- Collimator design, wakefields (T-480)
- BPM energy spectrometer (T-474)
- Synch Stripe energy spectrometer (T-475)
- IP BPMs, kickers
- EMI (electro-magnetic interference)
- IR Mockup



PAC05 paper/poster: SLAC-PUB-11180
e-Print Archive: physics/0505171

CCLRC	LLNL	QMUL	UCL	U. of Bristol
CERN	Lancaster U.	SLAC	UC Berkeley	U. of Oregon
DESY	Manchester U.	UMass Amherst	U. of Cambridge	
KEK	Notre Dame U.	U. of Birmingham	TEMF TU Darmstadt	

ATF2 design & goals

ATF2 collaboration, presently >88 people from 21 labs and institutions and growing

Address luminosity challenges of ILC

Follow up on FFTB, create facility

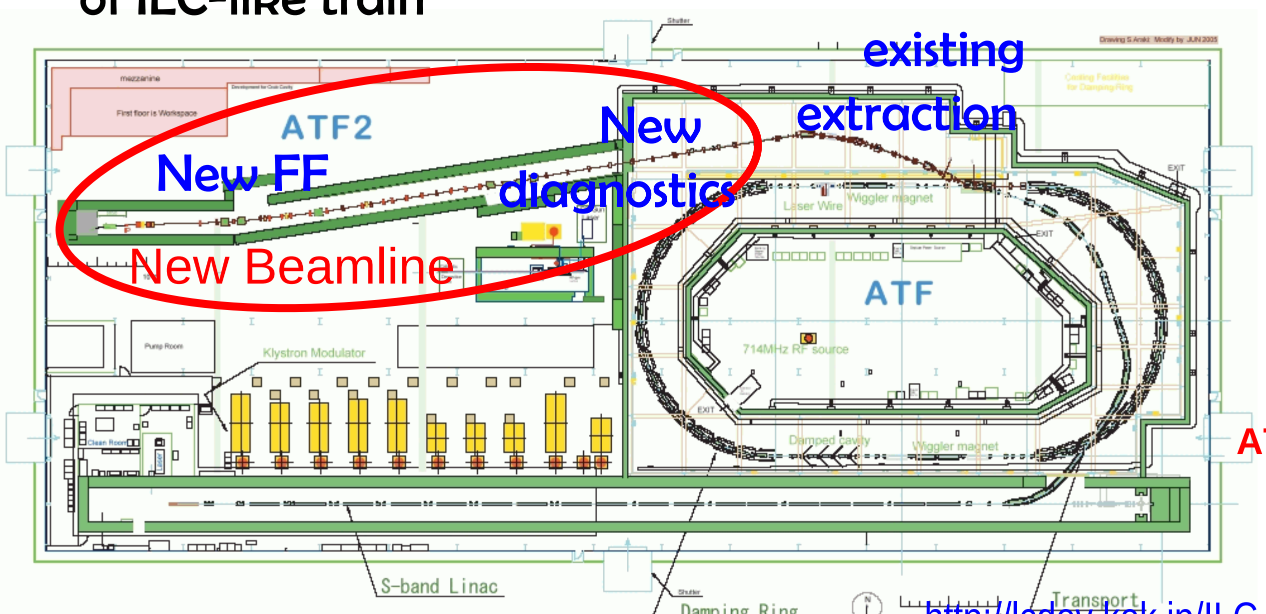
to train young generations of accelerator physicists

(A) Small beam size

Learn to obtain σ_y ~ 35nm
and maintain for long time

(B) Stabilization of beam center

Learn to keep it stable at IP within < 2nm
using nano-BPM and bunch-to-bunch feedback
of ILC-like train



KEK, Tsukuba
IHEP, Beijing
BINP, Novosibirsk
CCLRC/DL/ASTeC,Daresbury
CEA, Gif-sur-Yvette
CERN, Geneva
Hiroshima University
Kyoto ICR, Kyoto
LAL, Orsay
LLNL, Livermore
NIRS, Chiba-shi
North Carolina A&T State University
Oxford University
Pohang Accelerator Laboratory
Queen Mary University of London
Royal Holloway, University of London
DESY, Hamburg
SLAC, Stanford
UCL, London
University of Oregon
University of Tokyo

ATF2 proposal was web-released just after BDIR workshop in London,
=> KEK, SLAC, CERN, … preprints

http://lcdev.kek.jp/ILC-AsiaWG/WG4notes/atf2/proposal/public/

18 urgent questions to Detector Concepts

- 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?

…

18 urgent questions to Detector Concepts

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?

Detector Concepts start to prepare answers…

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

Reply and Comments by GLD: IR task force

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?
   - Concept (GLD) by Y.Sugimoto, field data (iron structure and field distribution (pdf), and the field map (htm or xls)) by H.Yamaoka, flexibility (field non-uniformity) by TPC group
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.
   - GEANT-4 geometry(homepage) by A,Miyamoto, while the study by IR task force
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?
   - Tracking detectors do not mind. CAL group ? IR task force for FCAL, BCAL, pair monitor, fast feedback ? This corresponds to LowQ option of the ILC parameter sets ; incoherent pairs in VTX .
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)?
   - VTX, TPC and CAL groups
5. 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 ? 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?
   - IR task force
6. What is your preferred L*? Can you work with 3.5m < L* < 4.5m? Please explain your answer.
   - L* > 4.5m, explanation by IR task force; references: pdf and ppt by Y.Sugimoto.

Summary

- Before Snowmass, need active dialog on the baseline configuration
- Need that discussion of Questions and Answers start before Snowmass
- Hope that any inconsistencies can be identified and resolved before Snowmass, so that
- At Snowmass, one will be able to crystallize on the baseline