WG4:
(Beam Delivery, Interaction Region, …)

SUMMARY

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On behalf of WG4 participants

15 November 2004

First ILC Workshop at KEK, November 13-15, 2004

ILC BDIR design choices

- **Crossing Angle**
  - Head on
  - Very small vertical crossing angle
  - Small horizontal or crossing angle (~2mrad)
  - Large horizontal crossing angle (7-20mrad, ~35 mrad)
- **Final Doublet Technology**
  - Compact SC or PM quad, or large bore SC
- **L***
  - e.g. 3,4,5m
- **Detector VXD inner radius**
- **Instrumentation Choices**
- **MPS Questions**
- **Detector Questions**
- **Collimation Choices**
- **Beam Stabilization choices**
- **Risk Mitigation**

Options

- **Gamma-gamma**
  - **In, particular, consequence of ~35 mrad crossing angle on e+e- luminosity**
- **e- e-**
- **e+ polarized**
- **Above 1 TeV running**
- **Consequence of simultaneous running of both IRs**

Work process and cooperation in WG4

- **Good communication within the group and with detector community is especially important**
- **Prior the ILC Workshop at KEK:**
  - **Several phone mtg. (Europe, Japan, US), in October**
  - **Created the Unified task list, based on regional lists**
  - **Identified the tentative critical design choices and topics**
  - **Prepare the talks by multi-regional teams, and discuss drafts before the Workshop**
- **Future milestones**
  - **MDI workshop in January 6-8, @ SLAC**
  - **LCWS, March 2005, SLAC**
  - **BDIR Workshop in Oxford, Spring 05**
- **Enhanced ways of communications will be tried, for the MDI workshop, optimized, and extended to the whole group**
- **Snowmass 2005**
  - **Goal is to come to Snowmass with a consistent design**

WG4 process, day one

Overview of the critical design choices

Witold Kozanecki & Thomas Markiewicz & Toshiaki Tauchi

Brief statements from labs/regions

UK	Philip Burrows
France	Olivier Napoly & Philip Bambade
Germany	Karsten Buesser
CERN	Frank Zimmermann
Japan	Tomoyuki Sanuki
Asia	Rohini Godbole
Americas	Tom Markiewicz
Italy	Pantaleo Raimondi
Russia	Valery Telnov

Discussion

WG4 process, day two & three

Topical talks and detailed discussions of the design choices

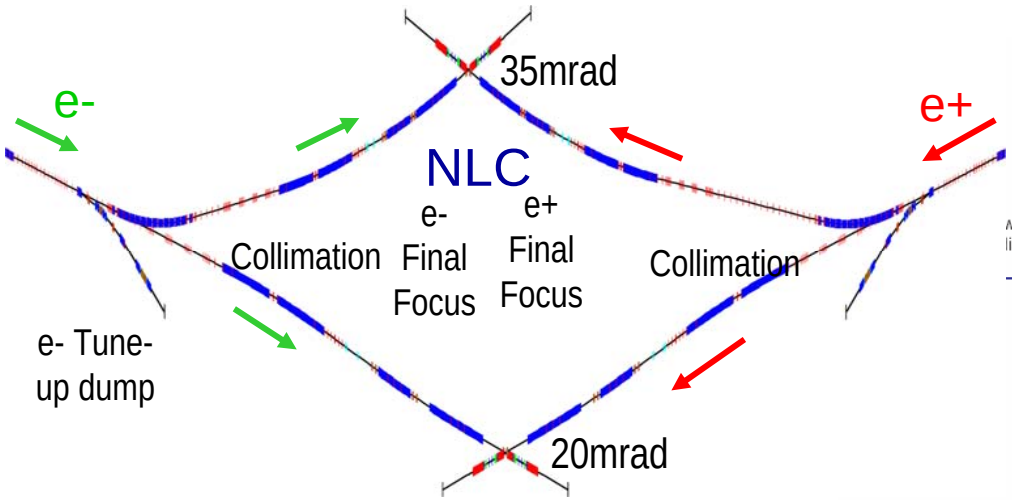
IR Layout	Toshiaki Tauchi & Philip Bambade
Final Doublet	Takanori Mihara & Olivier Napoly
Collimation & Backgrounds	Nikolai Mokhov & Takashi Maruyama
Optics	Deepa Angal-Kalinin & Nick Walker
IP collision optimization	Philip Burrows & Fred Asiri
Beam Instrumentation	Eric Torrence & Yasuhiro Sugimoto
Simulations (HEP)	Karsten Buesser & Hitoshi Yamamoto
Discuss impact of options	Rohini Godbole & Harry Weerts
Gamma-gamma option	Tohru Takahashi & Valery Telnov
Critical beam tests	Mike Woods & Shigeru Kuroda
Strawman BDIR configuration	Tom Markiewicz & Frank Zimmermann
Discussion	
Crab cavity for B-factories	Kazunori Akai

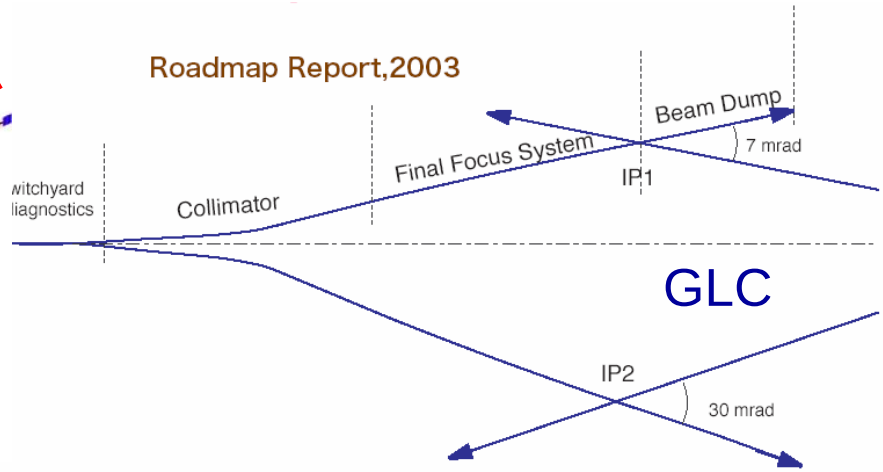
The name of the person presenting the talk is underlined

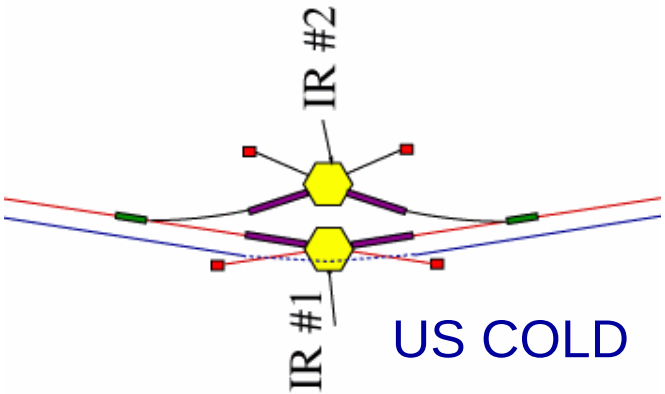
Interests on regions and labs

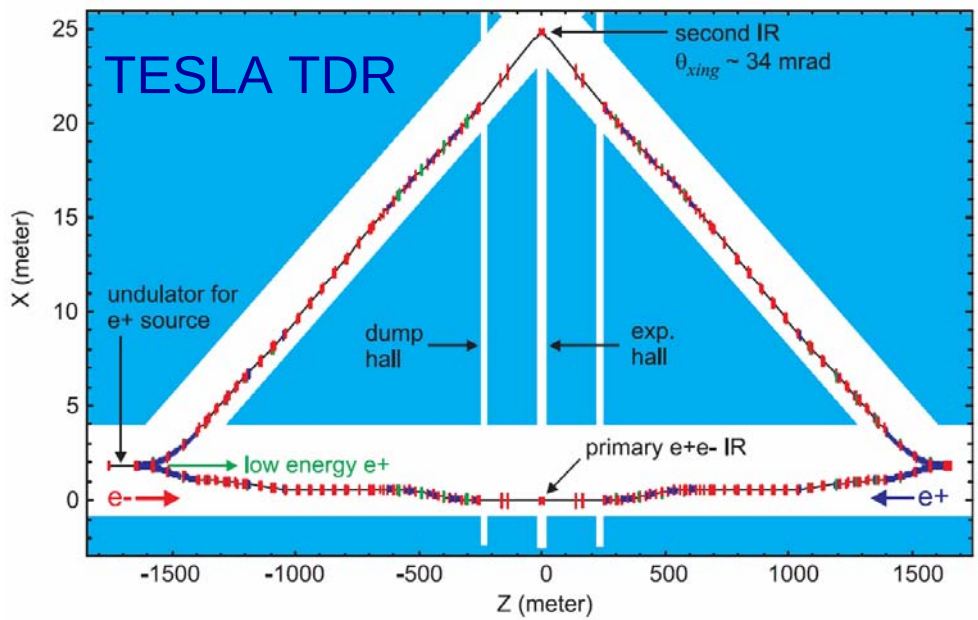
- **Vast interests in many regions on many aspects of BDIR work.**
- **Just some examples**
  - **UK : optics, collimation, instrumentation, fast feedback, …**
  - **France : optics, IR configuration, SC large bore quad, …**
  - **Germany : fast lumi monitor, TTF2, IR eng. design …**
  - **CERN : simulation codes, halo models, alignment…**
  - **Japan : ATF FF facility, PM final doublet, …**
  - **Asia (India): $\gamma\gamma$, instrumentation, collimation…**
  - **Americas : compact SC quad, ESA beam tests, overall design…**
  - **Italy : crystal collimation, more resources after CTF3 …**
  - **Russia : $\gamma\gamma$, instrumentation, possibly, advanced materials for collimation &material damage studies, manufacturing of beamlines**

Overall BDIR Layouts







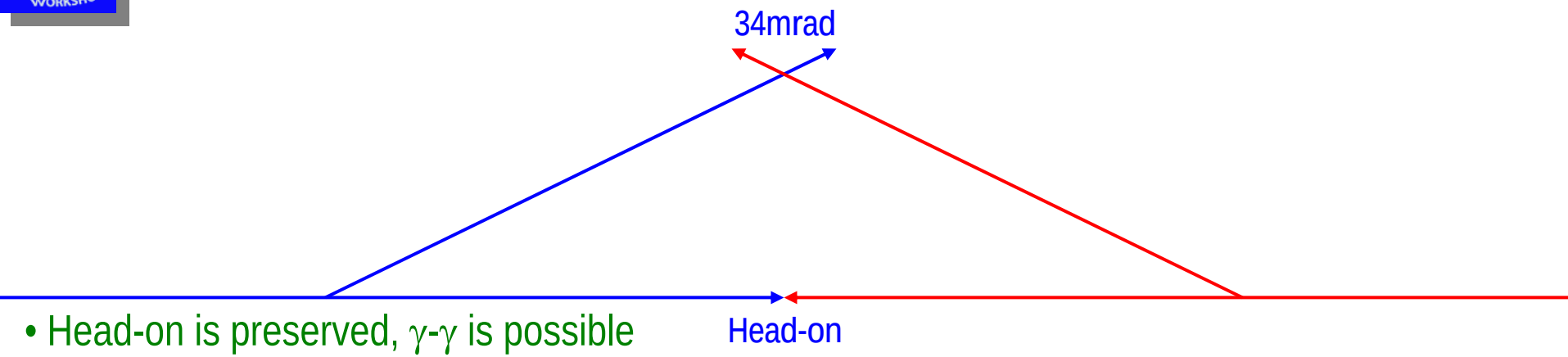


Why layouts are needed

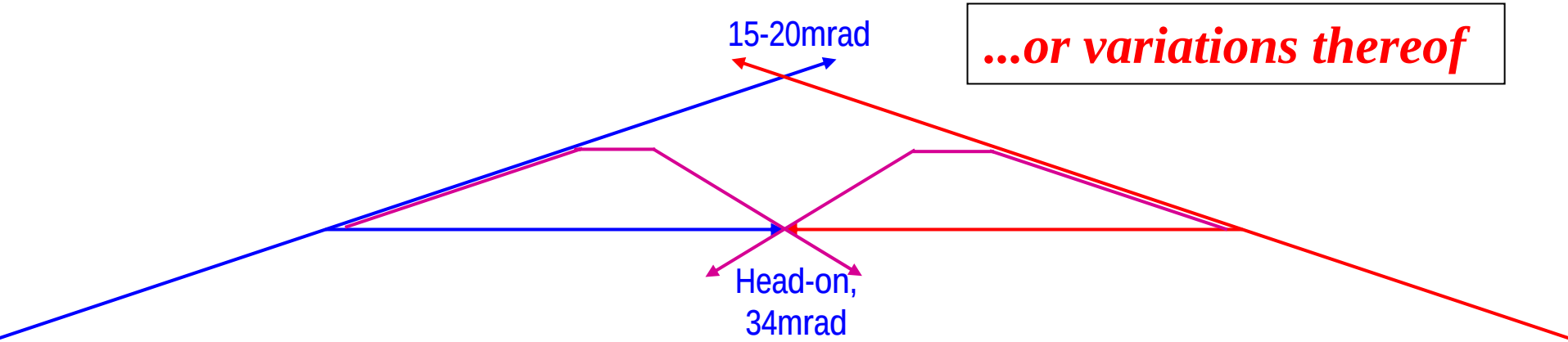
- **Not all layouts are possible from the viewpoint of construction and conventional facilities. For instance:**
  - **detector hall size may have limitations**
  - **angle between tunnels may not be arbitrary**
  - **IR hall separations (in x and in z) constrained by shielding...**

- **Performance evaluation often requires complete design of BDIR, and, in many cases, from the injector to IP. For instance:**
  - **evaluation of stability**
  - **feedback performance**
  - **tunability of the machine**
  - **radiation environment in one IR while other is running**
  - **optics of one of BDS depends on space taken by big bend**
  - **....**

Possible layouts: 2 extremes



- Head-on is preserved, γ-γ is possible
- If γ-γ is not ready, e^+e^- for 34 mrad IR is compromised
- At 1TeV, difficult to extract beams in head-on IR; large bend for one of IRs

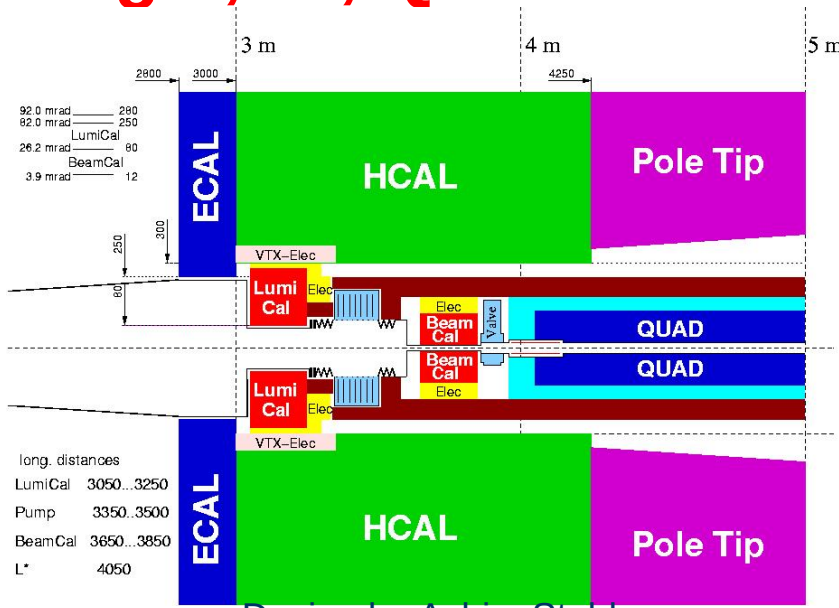


...or variations thereof

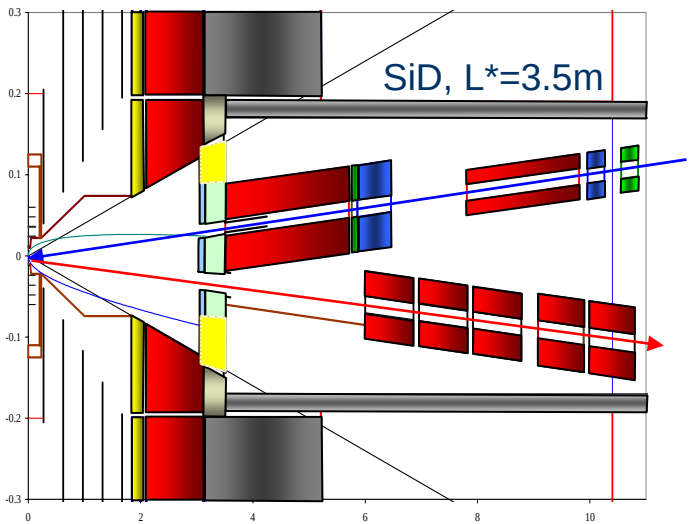
- Head-on is preserved, optimal (15-20 mrad) for e^+e^-, γ-γ is possible
- If cannot extract 500GeV beam cleanly with head-on IR → impact on physics !
- The bending @ the (higher-energy) X-ing IR is minimized

IR layout, Crossing angle, L*, QD0

- **Cold LC can choose zero or non-zero angle**



Design by Achim Stahl
TESLA proposed design for L*>4.05m



- **For the non-zero x-ing, minimum angle has hard limit, set by**
  - **availability of final quad (QD0)**
  - **L***
  - **Design choice that beam goes (or not) outside of QD0**

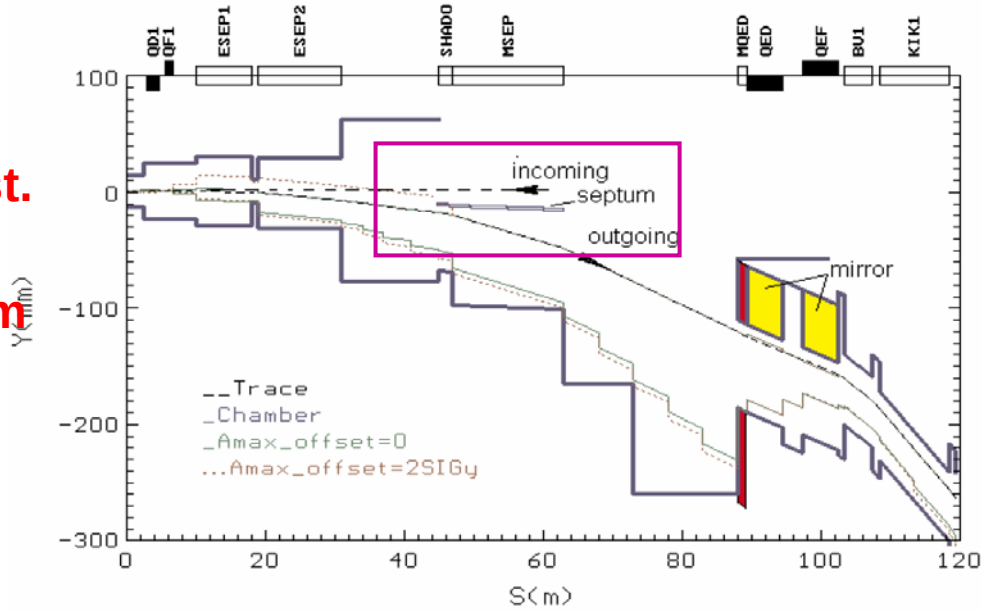
IR layout, crossing Angle, …

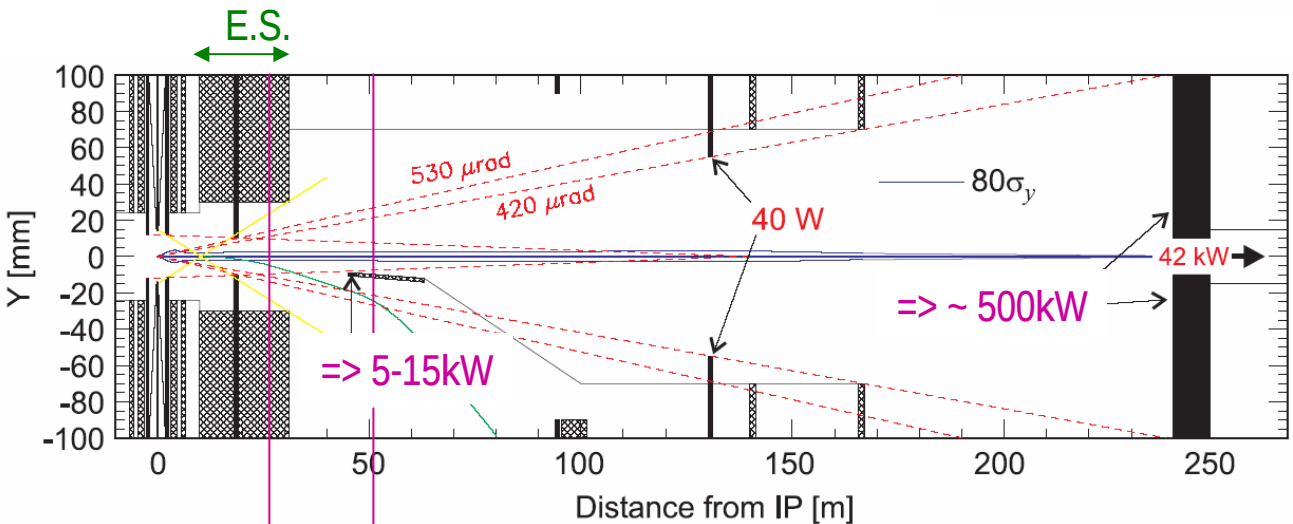
- **For the nonzero x-ing, the maximum angle has softer limit, set by**
  - **Estimated performance of Crab Cavities (Δt~ 16 fs @ 20 mrad)**
  - **Beam optics effects: ε growth due to SR in detector, ~ $(B_s L^* \theta)^{5/2}$**
  - **Wider pair distribution, but partly mitigated by larger exit hole**
  - **Modest loss of efficiency for dark matter/SUSY candidates / rejection of background. Physics study needs to advance**

Difficult to quantify, but clear decrease of performance at 35 mrad with respect to optimal 7-20mrad

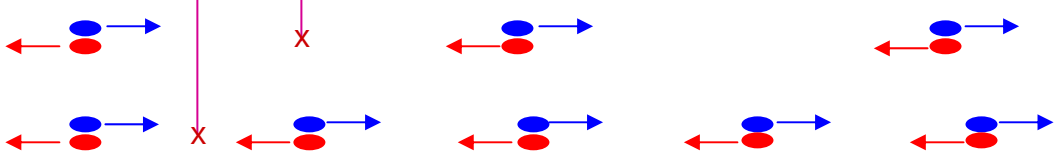
Beam extraction in head-on TESLA scheme

- Large losses in extraction line, especially at 1 TeV
- Incompatible with post-IP E/Pol. diagnst.
- Electrostatic separator (ES) needs 50kV/cm (LEP: 30 kV ops) and 100kV/cm at 1TeV – feasibility in high SR environment?
- MPS issues (detector survival if ES sparks?)





- γ losses at (or near) septum: ~5-15kW, irradiation, background, survivability
- Parasitic collision 26.5 m from IP @ 1TeV
- SR masking overconstrained



337ns (101m), 500 GeV CM

176ns (53m), 1TeV CM

Small Vertical θ_c (0.3 mrad)

300μr vertical x-angle solution

R. Brinkmann

Is margin sufficient?

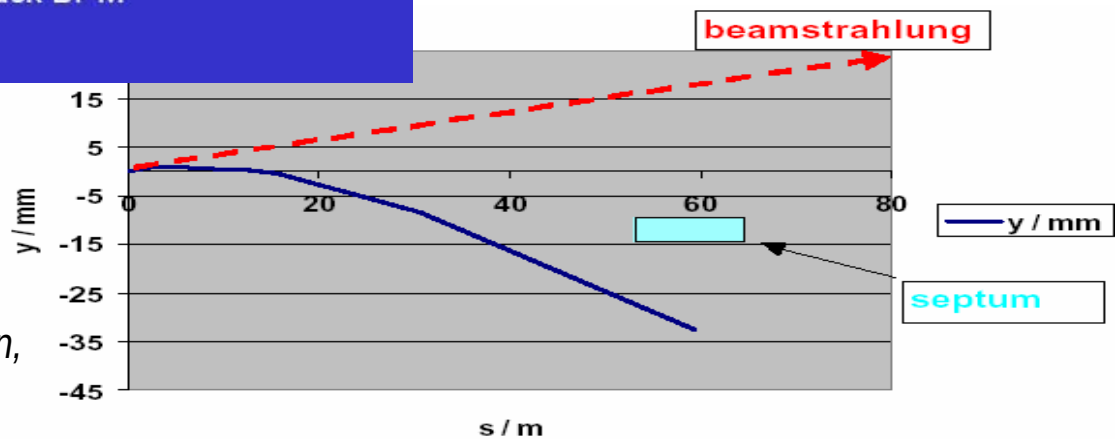
- shines BS away from septum blade *and*
- away from incoming beam @ BS dump
- needs quadruplet instead of doublet to obtain spent beam bandwidth
- crab-crossing needed but not so bad as that needed for 20mr horizontal crossing angle

??

- ~1mm difference of in and out beams at feedback BPM
- much optics and tracking work to do!!

- **Head-on preserved**
- **Solves septum problem (margin sufficient?)**
- **Electrostatic separator is still needed**
- **New: vertical crab-crossing (phase stability similar as was in NLC)**
- **Final Doublet needs to become Quadruplet**

Still need Electrostatic Separator!



R. Appleby, D.Angal-Kalinin, O.Napoly, J.Payet

Small Horizontal θ_{c1} (1.5-2 mrad)

Inspired by

Design of a final focus system for CLIC in the multi-bunch regime

Olivier NAPOLY
CEA, DSM/DAPNIA/SEA
CEA/Saclay, F-91191 Gif-sur-Yvette Cedex, France

December 10, 1997

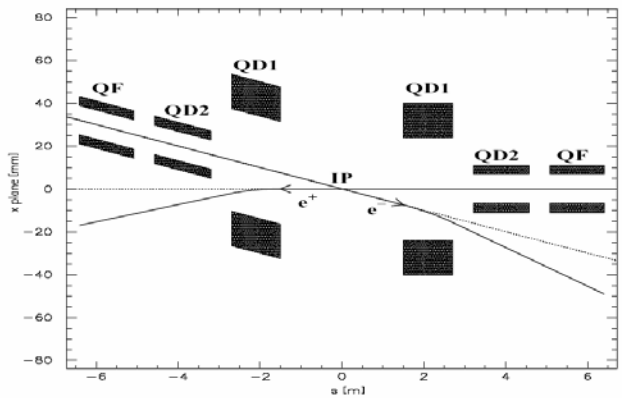
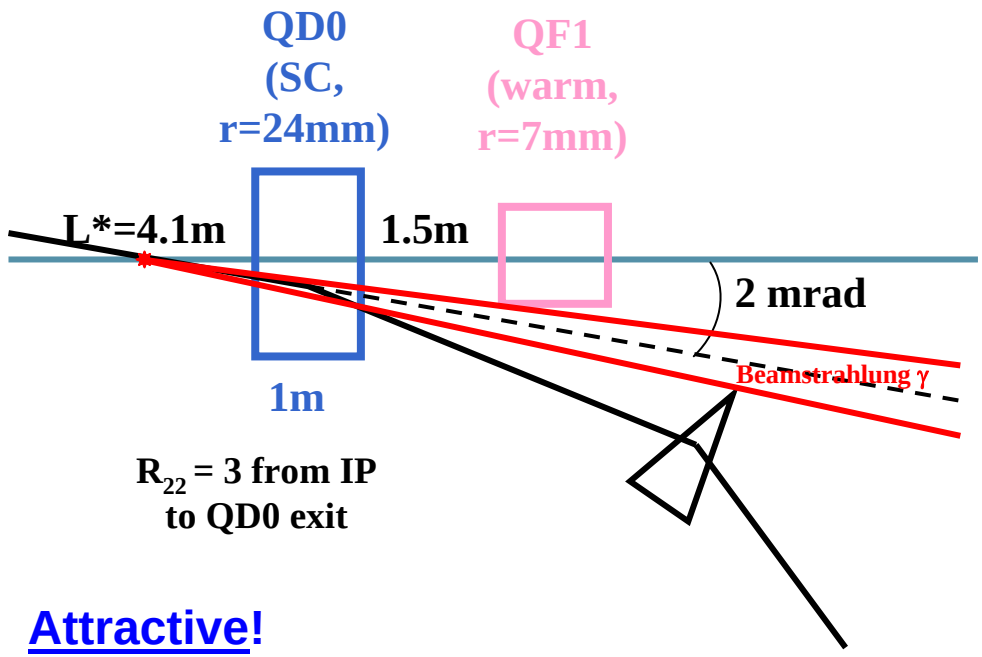


Figure 3: Magnet layout with a 5 mrad crossing-angle. The e^+ and e^- orbits (solid lines) correspond to the nominal energy of 250 GeV.



Attractive!

- **retains major advantages of head-on: SUSY coverage, no (or v. little) crab**
- **avoids septum, electrostatic separator, parasitic Xing**

Under study by

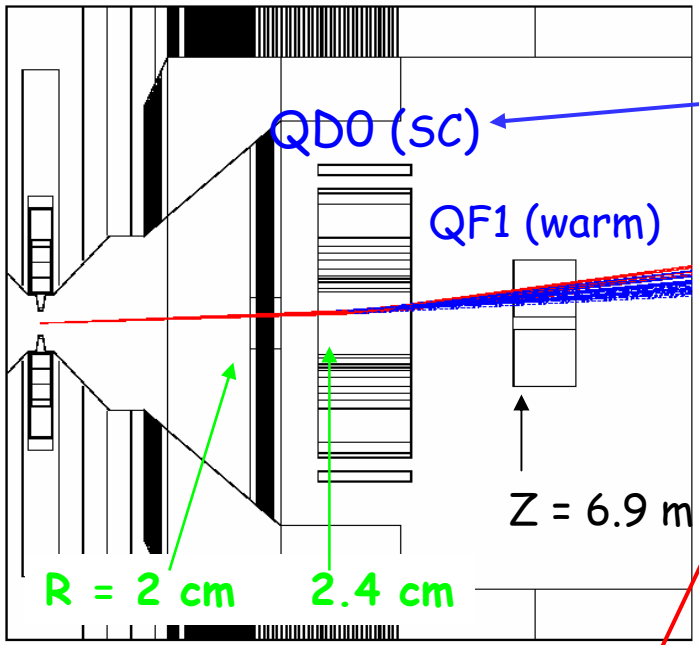
- R. Appleby, D. Angal-Kalinin

- P. Bambade, O. Napoly

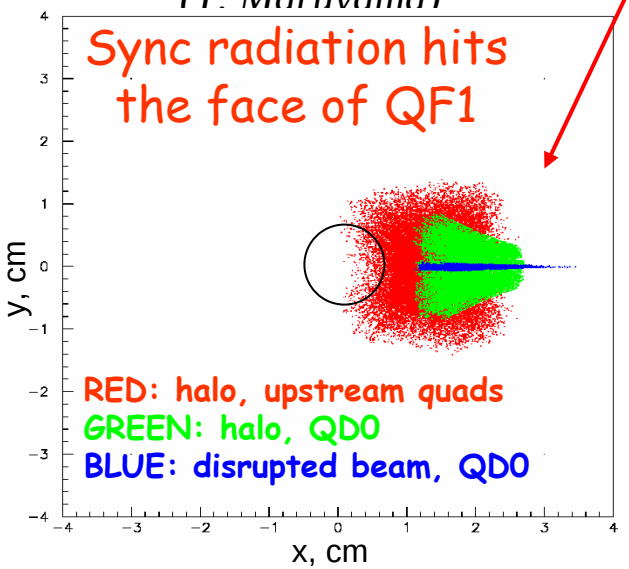
- A. Seryi, T. Maruyama

Small Horizontal θ_{c1} (1.5-2 mrad)

(continued)

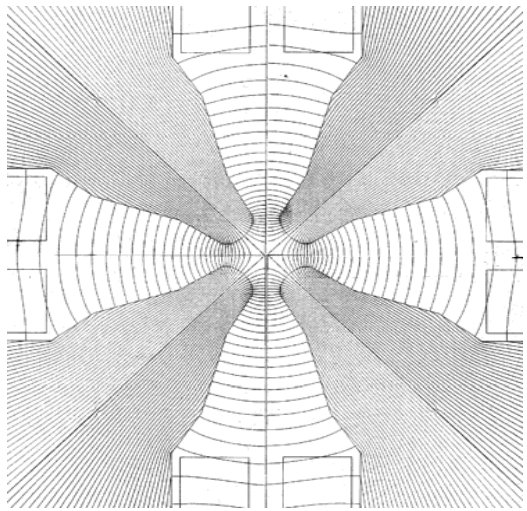


(T. Maruyama)



Issues (open / in progress)

1. Heat load on QD0 (disrupted e^{+-}): OK?
2. Halo SR γ hitting QF1 (& reflecting back → VXD): OK?
3. SR, halo & pair masking
4. Effect of fringe field on disrupted beam
5. Clean extraction @ 1 TeV c.m. ?



Physics needs for e+e- and options

- **Physics prefers L* beyond front of calorimeter**
- **Physics prefers a small vertex detector radius**
- **Some physics channels prefer small x-ing angle**
- **Some physics needs downstream instrumentation**

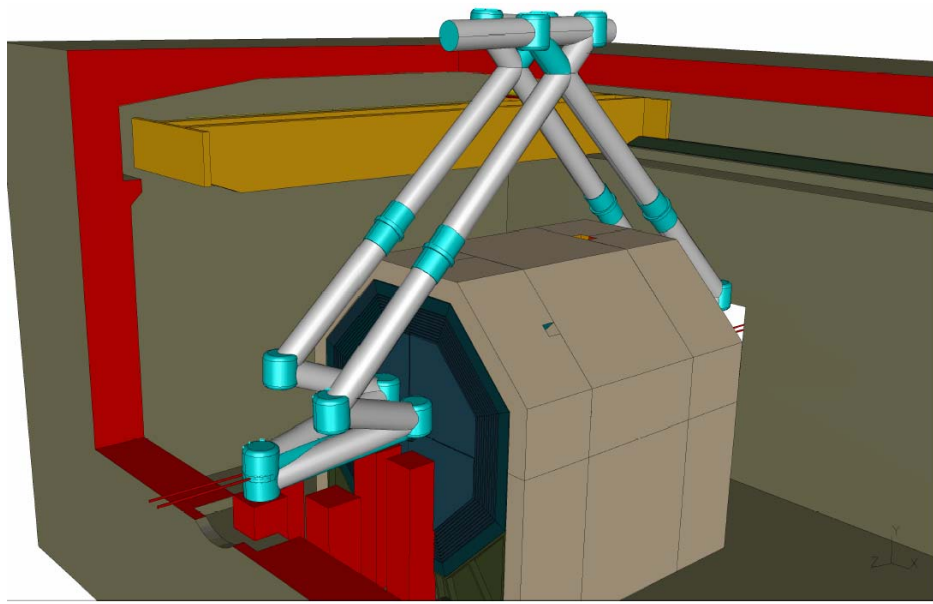
BUT:

- **Physics needs above all a reliable well diagnosed luminosity delivering machine!**

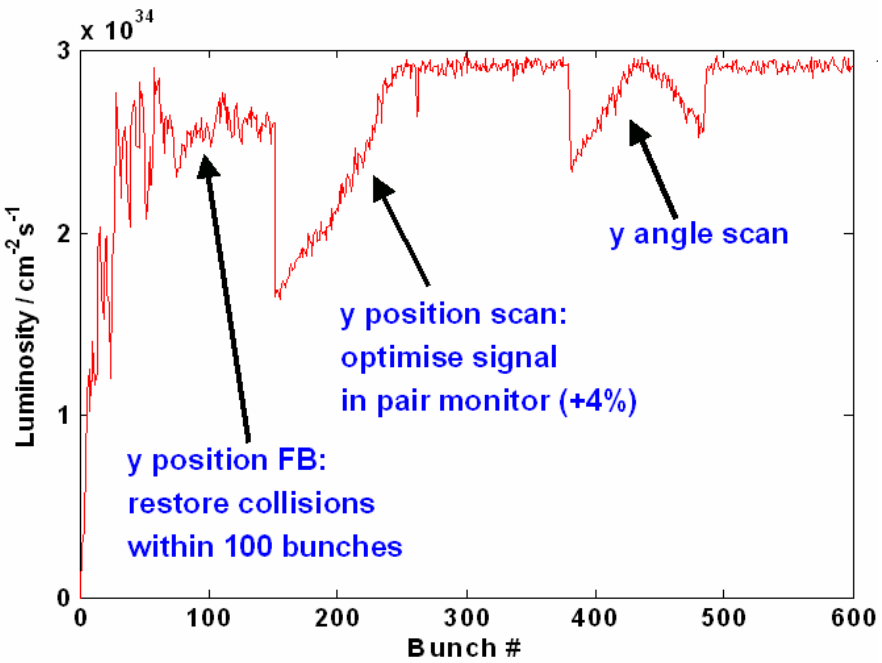
- Studies done, comparing “0” to “20” mrad => modest losses in efficiencies for dark matter/SUSY candidates/ rejection of background (loss of tagging electrons close to beam)
- In the scenario where $\gamma\gamma$ needs > 20 mrad and around 20 mrad there is impact on e+e- physics
  - Optimize initial IR & detector for e^+e^- i.e run at x-angle less or equal to at most 20 mrad
  - Modify detector & IR for $\gamma\gamma$ running when needed

Gamma gamma option technology

- **The min crossing angle determined by spread of e-beam and size of QD0**
  - **Min feasible seem to be 25mrad, based on compact SC quad**
  - **Further reduction involve extremely difficult IR design**
- **Special beam dump with large aperture and separate extraction line**
- **3000 bunches => optical cavity is needed to reduce laser power by ~100**
  - **all items in in R&D stage**
  - **prototyping, demonstrations are needed before a run decision**

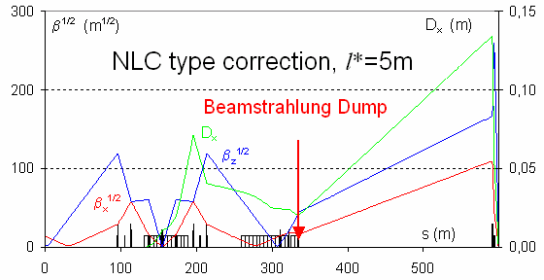


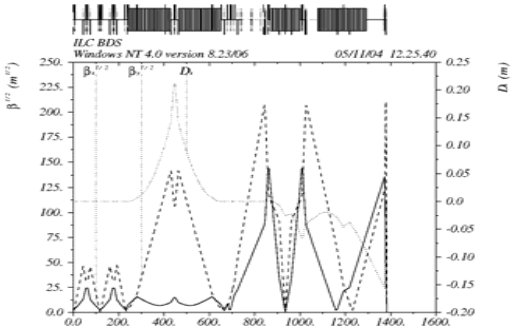
IP collision optimization



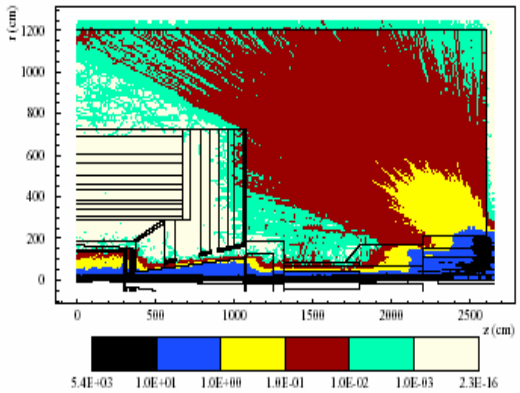
- **Working assumption: fast feedback, still need a lot of work to ensure that**
  - Jitter coming from the linac is manageable for the feedback, for diagnostics, for tuning of the machine
  - SC quad stability relaxed, still need to verify its stability
  - Requires studies of stability of the linac quadrupoles
  - Establishing stability specs for in tunnel components
  - Evaluations of sites, once they are known
- **More realistic simulations, with background, will be done**
- **Stabilization of ILC-like beam extracted from ATF will be a very useful test**

Collimation, background, optics, final doublet, instrumentation

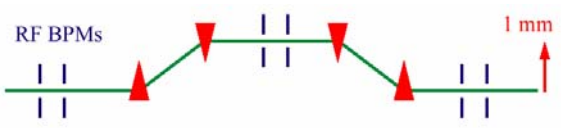


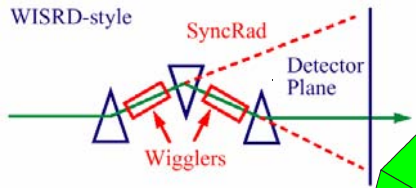


Two versions of optics for ILC BDS

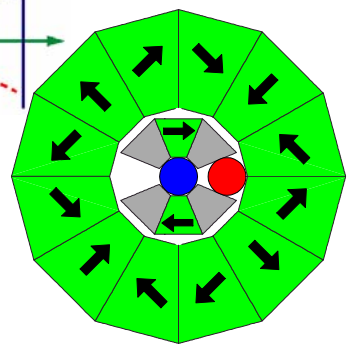


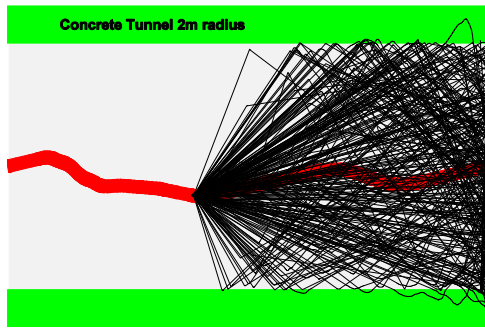
Charged hadron flux due to operational beam loss in LHC IP5

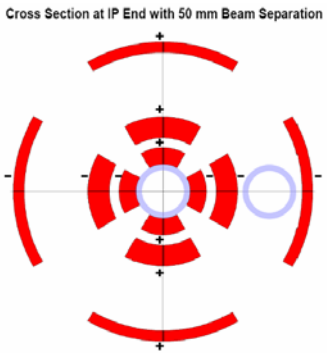


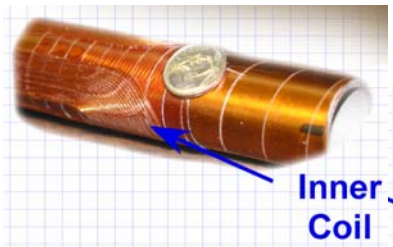


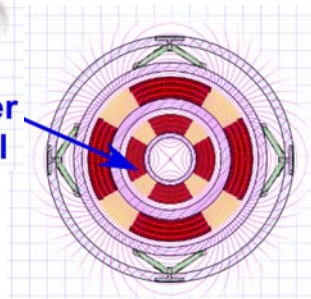
Two different designs of the energy spectrometers



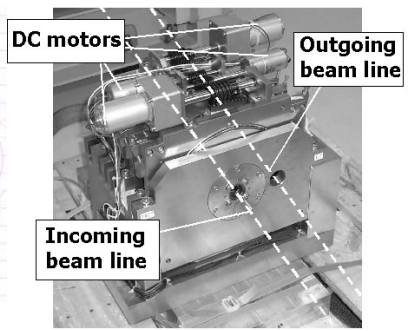




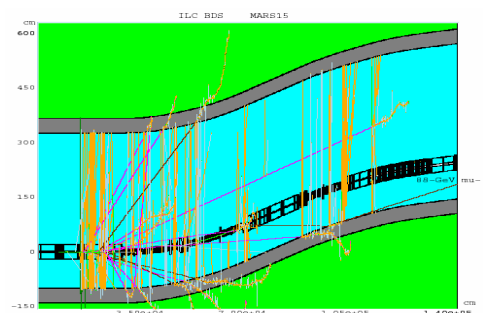




SC compact quad, and the one with exit hole with zeroed fieldc



PM adjustable quad for small crossing angle



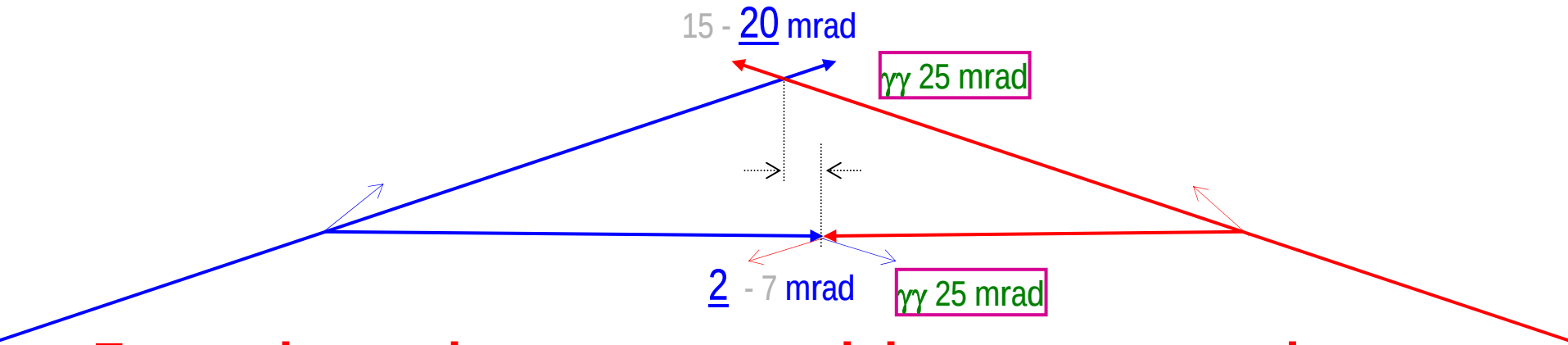
Modeling the BDIR

Recommendations from the WG4

- **Having considered and discussed the critical design choices,**
- **the Working Group came to consensus on the recommendation for the working hypotheses on the BDIR configuration**
- **With the final decision to be remained to be made by GDI,**
- **the proposed configuration is the direction where WG4 will focus its work**

Recommendations from the WG4

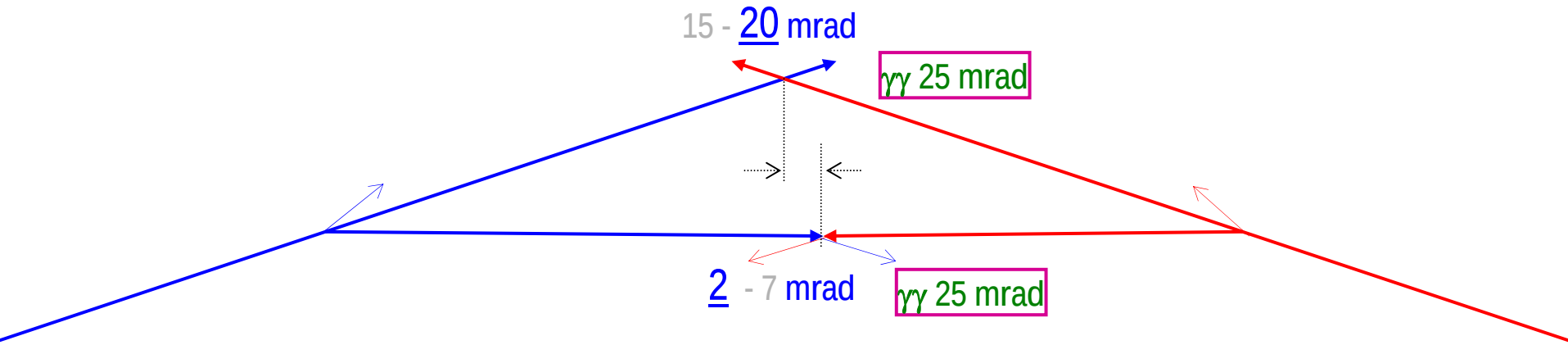
Tentative, not frozen configuration, working hypotheses, “strawman”



- **Focus the work on most promising concept, and**
  - **Minimize impact of crossing angle on physics**
  - **Minimize risk on machine performance**
  - **Separate extraction lines with pre- & post-IP diagnostic in both IRs**
  - **Optimize configuration for e+e-**
  - **Modify detector and IR for γγ when needed**
  - **Provide γγ option by developing civil engineering plans to create ~25 mrad at 1st or 2nd IR**
  - **Do not pre-decide, which IR may become γγ**
  - **Guarantee ability to upgrade one detector while another is running**
  - **Separate the collimation and MPS functions**

Recommendations from the WG4

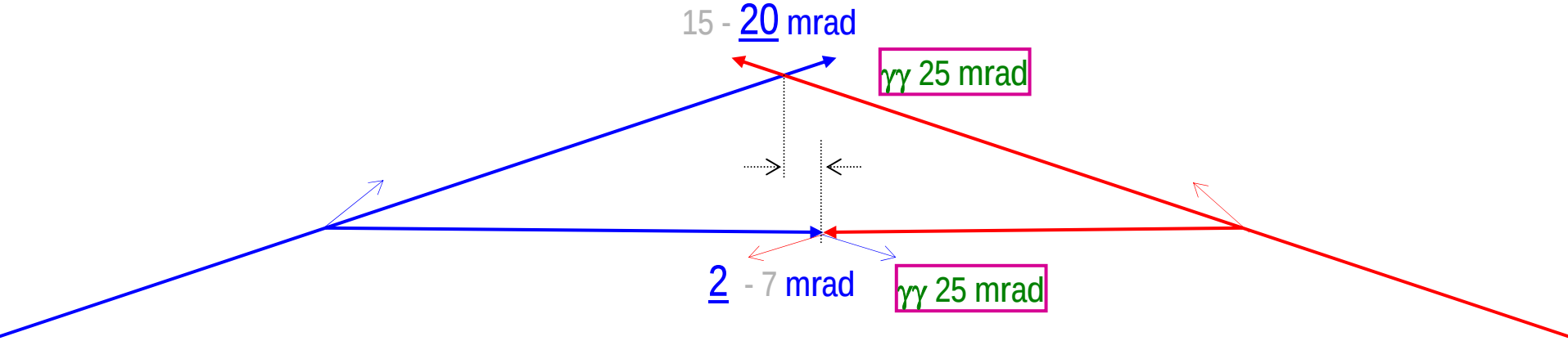
Tentative, not frozen configuration, working hypotheses, “strawman”



- **One of impacts of configuration choice on other WGs**
  - **Longitudinal separation of collider halls may require the bunch separation to be fixed**
    - Not 337ns @ 500GeV and 176ns @ 1TeV,
      but, for example, 2*176ns @ 500GeV and 176ns @ 1TeV
  - **Alternative: provide IR halls separation by lengthening the site**

Recommendations from the WG4

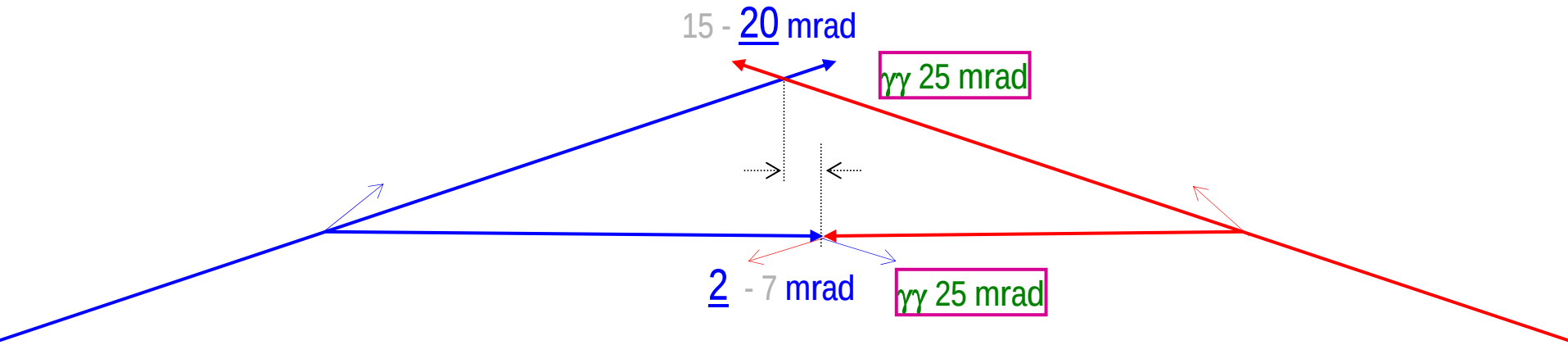
Tentative, not frozen configuration, working hypotheses, "strawman"



- **Urgent work for next 8 month**
  - **Improve and enhance communication within groups working on the design, and with detector community**
  - **Complete optics design for both IRs with all diagnostics and extraction**
  - **Request the physics community to evaluate physics impact of the "strawman" configuration**
  - **Evaluate how detector concepts affect optimization of L*, and what FD technologies are suited best**
  - **Develop civil engineering plans, including provision for $\gamma\gamma$ option possible at 1st or 2nd IR at maximum energy**

Recommendations from the WG4

Tentative, not frozen configuration, working hypotheses, “strawman”

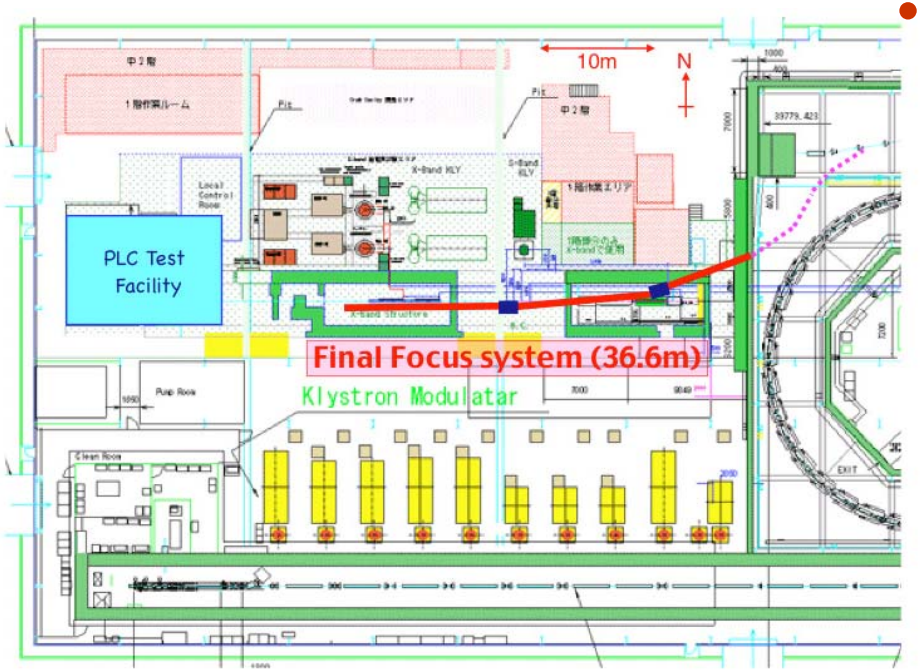


- **Urgent work for next 8 month (continued)**
  - **Reevaluate background tolerances of the detectors**
  - **Develop engineering design of crab cavity with electronics**
  - **Energy deposition and accidental beam loss studies, reevaluate the beam-beam induced loads in IR**
  - **Evaluate parameter changes options considered by WG1 (e.g. smaller IP beta-functions, bunch charge, separation) and parameters needed for γγ (smaller x size)**
  - **Make more realistic simulations of feedbacks and diagnostics**

Beam tests

- Beam tests are crucial for CDR => TDR time scale Risk mitigation
- Long lead time => need early commitment and fast action
- Many beam tests are ongoing
  - Laser wire development (PETRA and ATF)
  - Nano-BPM (ATF)
  - Fast feedback (ATF)
- … have been proposed and hopefully will soon start
  - Energy spectrometer prototype at ATF & ESA (End Station A) at SLAC
  - Collimation wakefield tests at ESA
  - Stabilization of bunch train at ATF
  - Material damage tests
- … and being considered
  - Bunch induced Electro-Magnetic Interference on the detector
  - IR mockup at ESA
  - Final focus and photon facilities at ATF

Final Focus and Photon Facility at ATF



- **Goals and benefits**
  - Achieve 35nm vertical beam size
  - Get experience of tuning the compact final focus
  - Learn to reliably maintain the small spot size
  - Provide $\gamma\gamma$ test area
  - Bridge the 15 years gap from FFTB
  - Create an accelerator physics facility to train young people

- **Recommendation from the WG4**
  - Strong feeling that such a facility is desirable
  - Starting from existing design, the WG will evaluate, optimize the design if necessary, write a proposal, and come with concrete recommendations at the BDIR Workshop (~Spring 05, Oxford)

Summary of the summary

- A lot of interest, resources and ongoing work focused on BDIR in many regions and labs
- WG4 made significant progress and was able to come with recommendations on the working hypotheses for the BDIR configuration
- Good communication prior and at this meeting was one of the keys, and enhanced communication will help to make rapid further progress
- The urgent work needed in the next 8 month, to become closer to the complete design, and in many cases the people who will do the work, have been identified
- The MDI workshop (January 6-8, SLAC), the LCWS, and BDIR workshop (Spring 05, Oxford), will be our milestones to bring us to Snowmass (August) with a major progress towards detailed design