2005 INTERNATIONAL LINEAR COLLIDER WORKSHOP

Photon Collider Technology Overview

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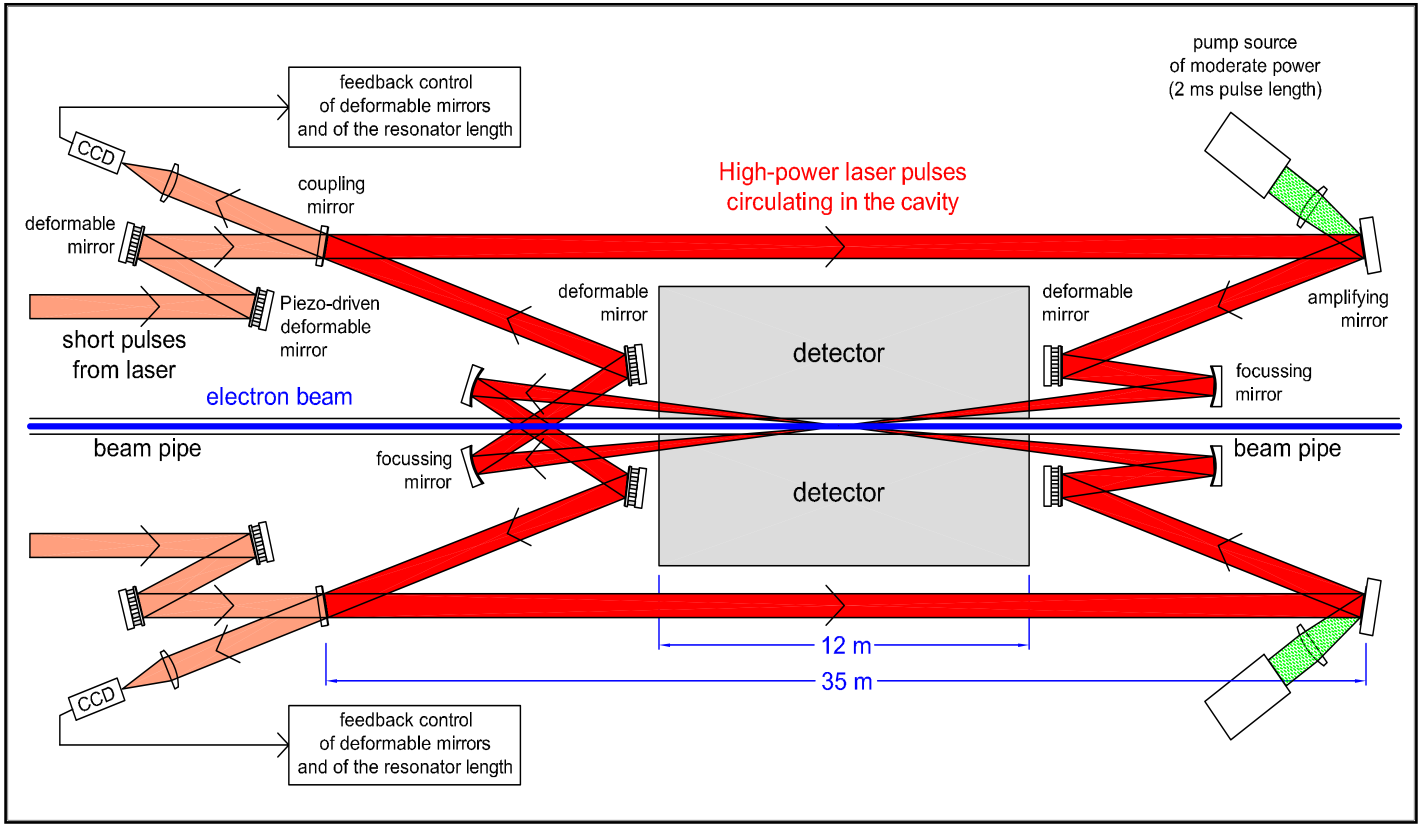
The photon collider concept is mature but there are many technical details still to be resolved

- Lasers
  - Optical stacking cavities
  - Drive laser architecture
- Accelerator
  - Crossing angle
  - Extraction Line
  - Beam Dump
  - Final Focus
  - Damping Ring modifications?
- Detector
  - Stay clears for optics
  - Shielding

Desy-Zeuthen / MBI Cavity design exploits ILC bunch structure to reuse pulses

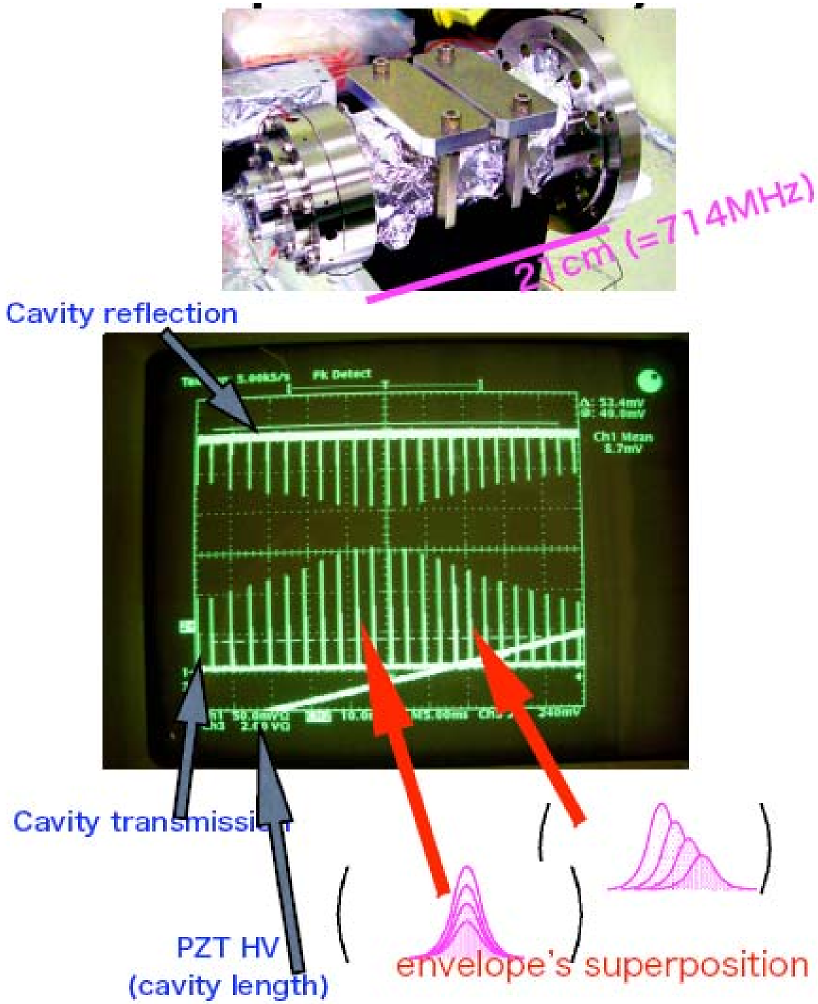
- Single pass laser systems are too expensive, however costs may come down in the future
  - Driven by laser fusion applications
- Cavity system seeks factor 100 reduction in laser power



Short pulse stacking cavities are under development

- Y. Honda et al. KEK
  - 7 ps pulses
  - Developed for laser wire application

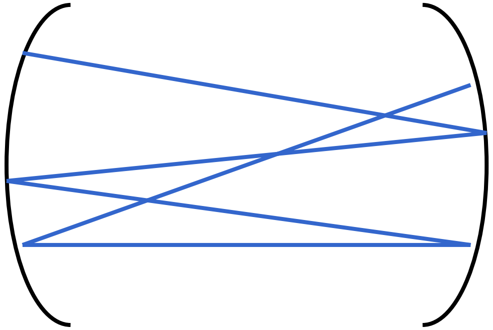
- A good start, but…
  - Nowhere near $\gamma\gamma$ power levels
  - Nowhere near $\gamma\gamma$ small laser focus
  - Nowhere near $\gamma\gamma$ cavity size ~20m



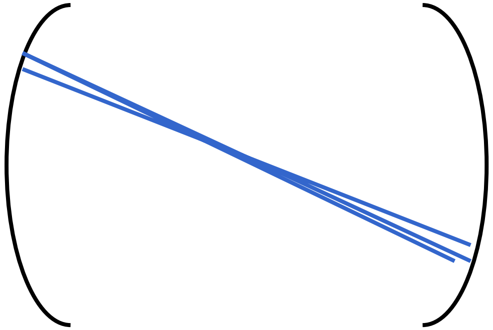
Y. Honda

Tolerances become tighter for the photon collider cavity

- Cavity stability is a function of how narrow the cavity focus is.
  - Light in a narrow focus cavity sees the same point on the mirror and errors add linearly
- Cavity stability is also a function of how big the cavity is
  - Pointing accuracy requirements scales linearly with size



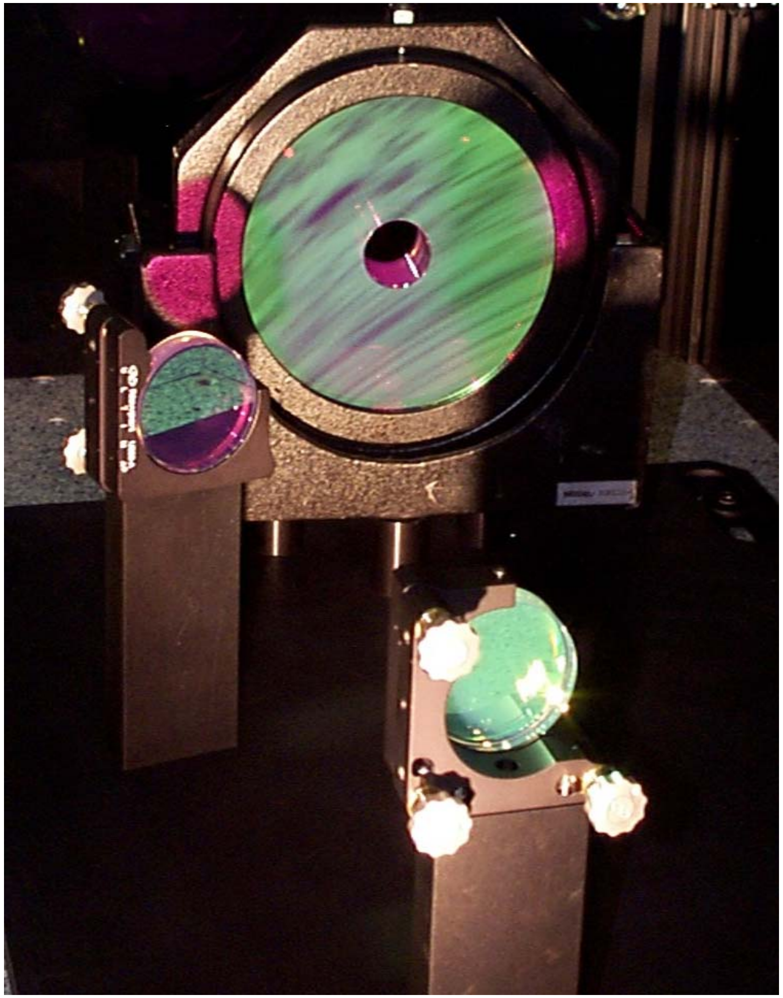
Light in weak focusing cavities tends to sample the entire space



Light in narrow focusing cavities tends to a particular point on the mirror

High average power creates heating, damage and non-linear effects

- When we go to high average power we must respect
  - Damage thresholds of the mirrors
  - Heating effects changing the shape of optics beyond tolerances
  - Non-linear effects from passage of ps pulses through transmissive optics
- This is a new regime for stacking cavities



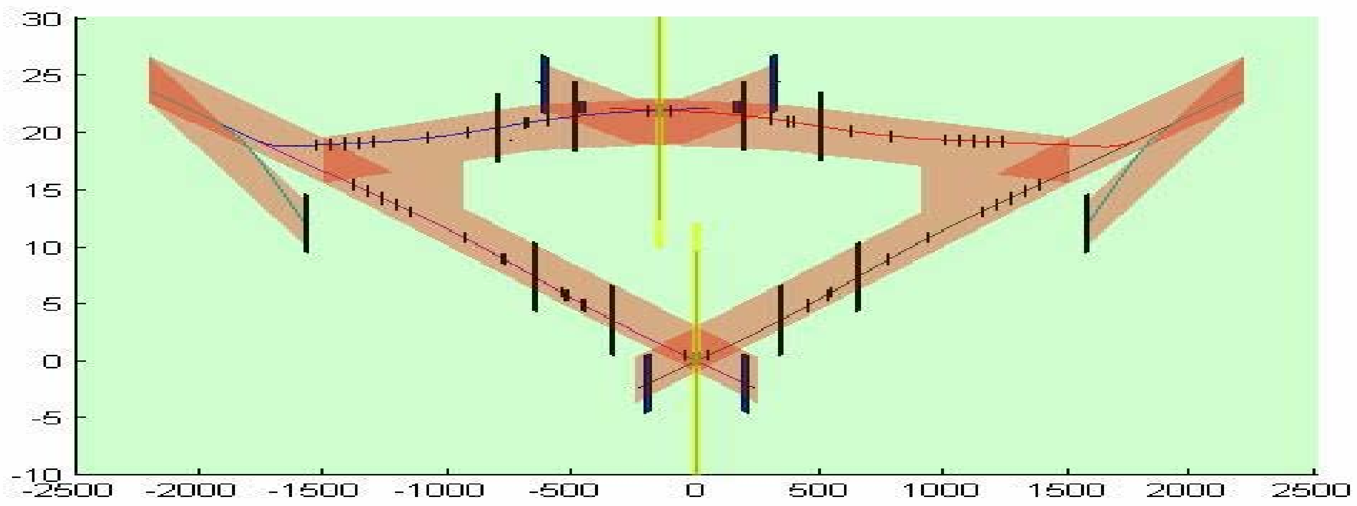
The Path Forward

- We should bring 2-3 senior optics and laser experts to complete the simulation and design of the cavity

- We can go forward in steps that are also useful to the basic ILC
  - Solve narrow focus issues for laser wire
  - Solve high average power issues for positron production
  - Solve large cavity issues for photon collider

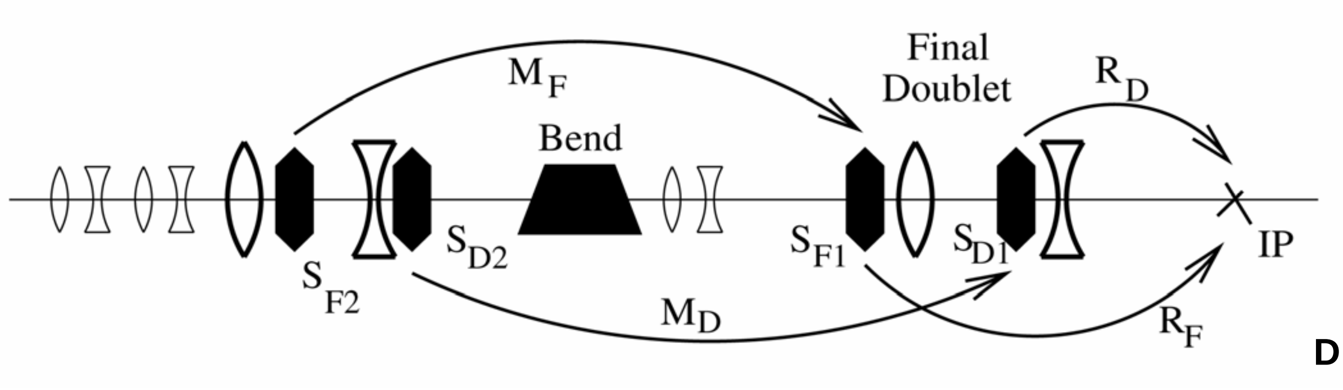
- Being synergistic with the base ILC program will give us the best chance of significant funding

Photon collider has specific needs for the beam delivery system



- In the accelerator systems the only major difference between e+e- and $\gamma\gamma$ is the need for e-e- capability
- We have specific requirements in the beam delivery system
  - Different final focus to maximize luminosity
  - Crossing angle and extraction line to handle disrupted beams

A dedicated final focus design can maximize luminosity



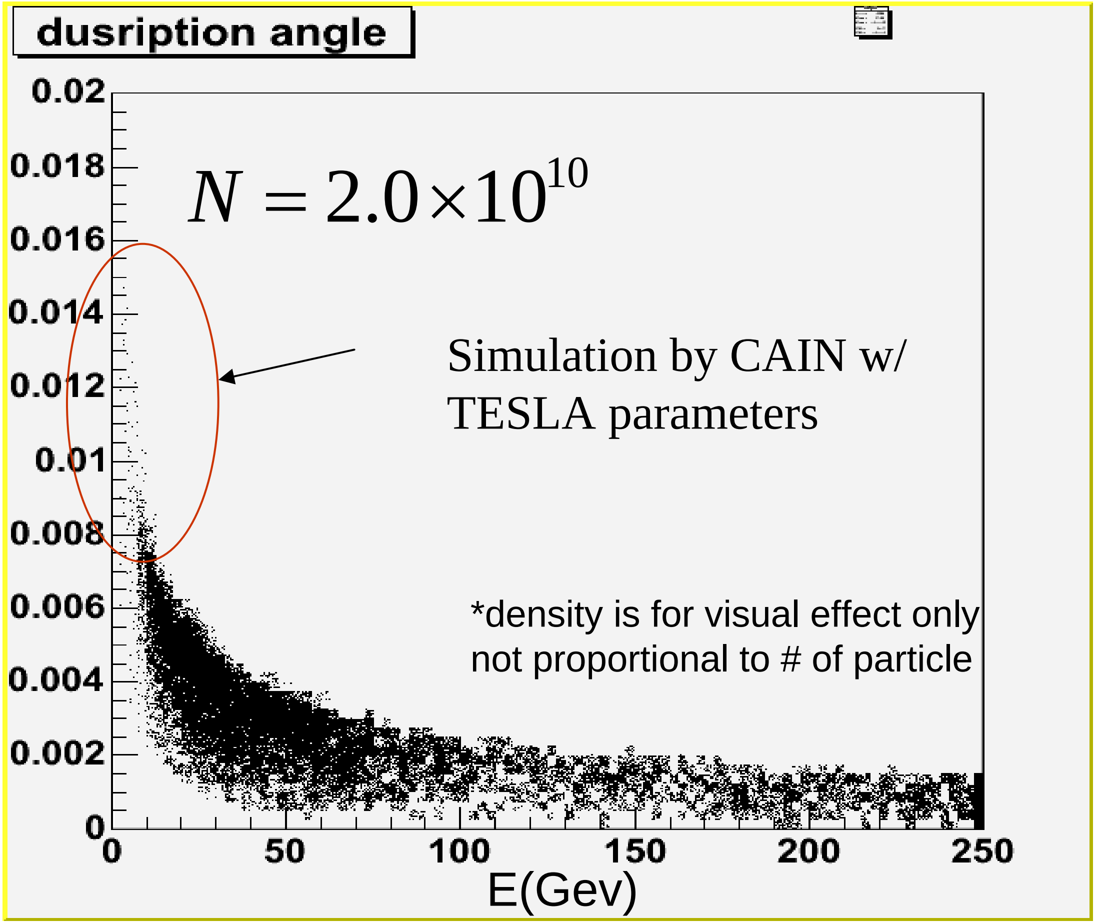
D. Asner

- Beam-beam interaction does not limit our usable luminosity
  - We want a small spot size at the IP
  - We should have our own optics which reduces the β_x
- There is a limit to how useful this is, dependent on the energy spread and the emmittance

- A beam transport simulation should be performed to decide on a baseline for our optics system

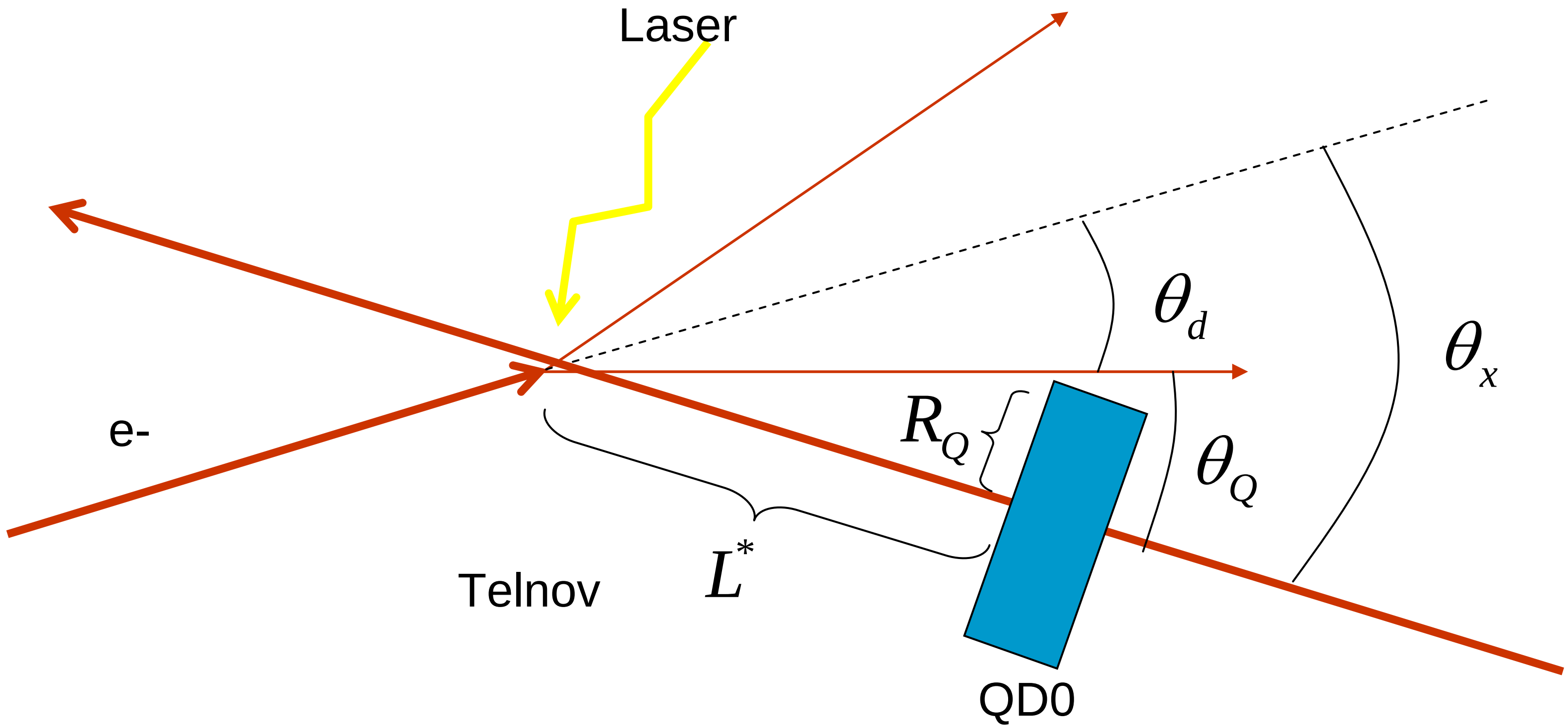
Disruption is a limiting factor in the $\gamma\gamma$ Interaction Region design

- Compton backscattering leaves a large energy spread
- Beam-beam deflection at the IP gives an angular kick to the beams
- This leads to the requirement of a large, field-free exit line



T. Takahashi

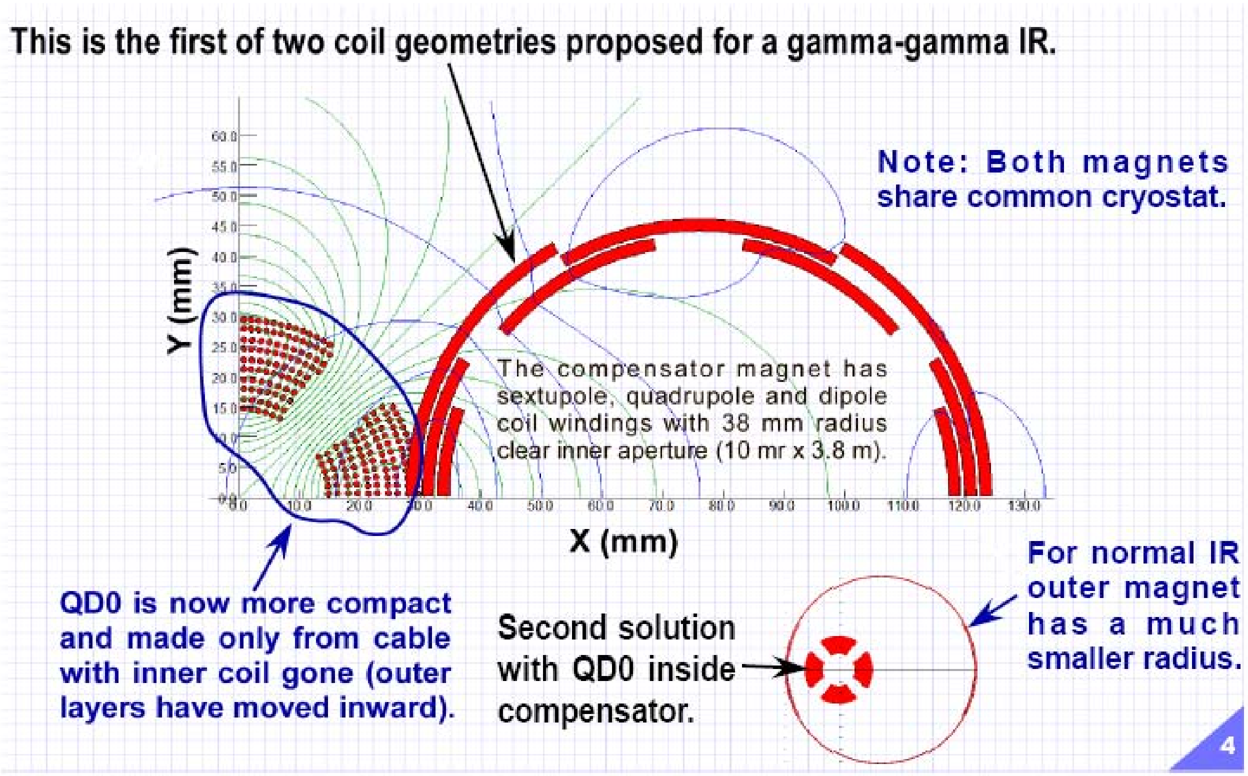
The photon collider must have a large crossing angle



T. Takahashi

- Physical overlap between the extraction line and the final focus quad sets the minimum crossing angle

Real designs for the extraction line magnets have been produced

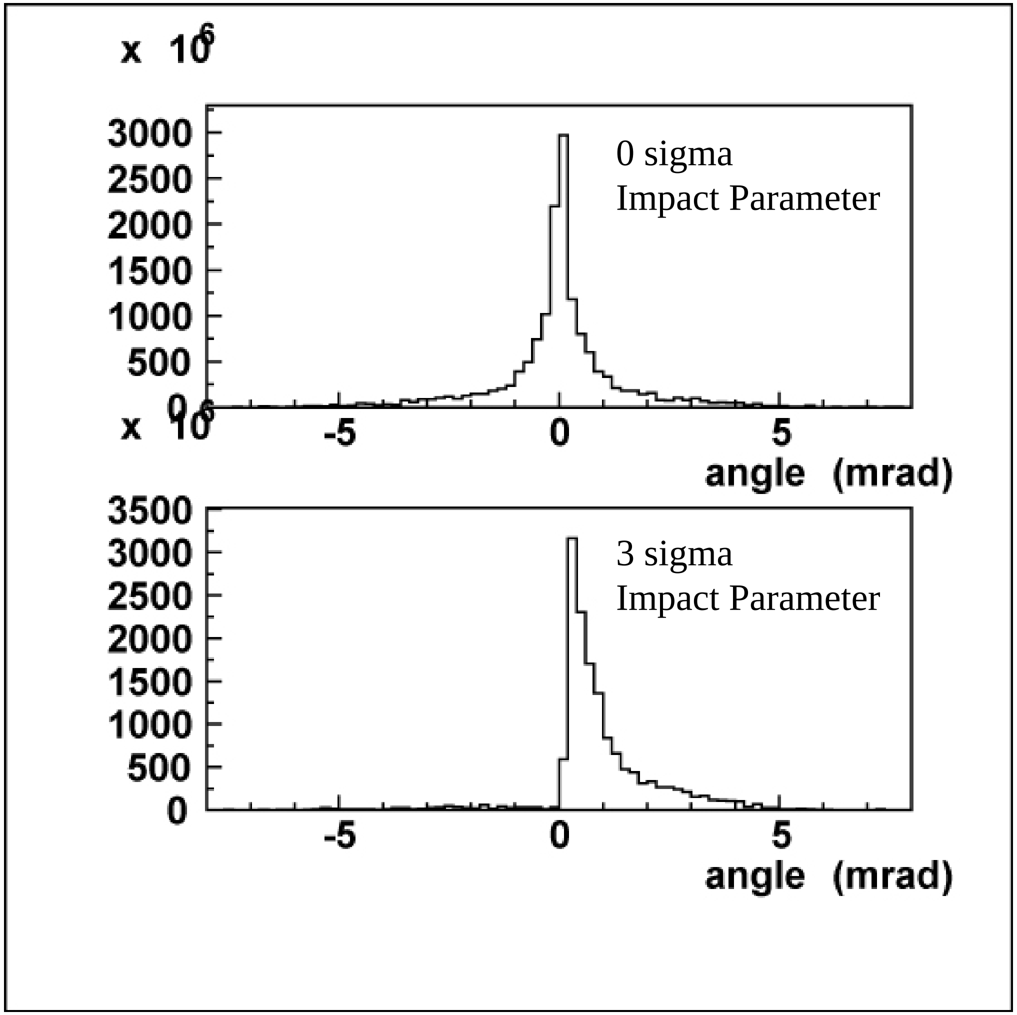


B. Parker

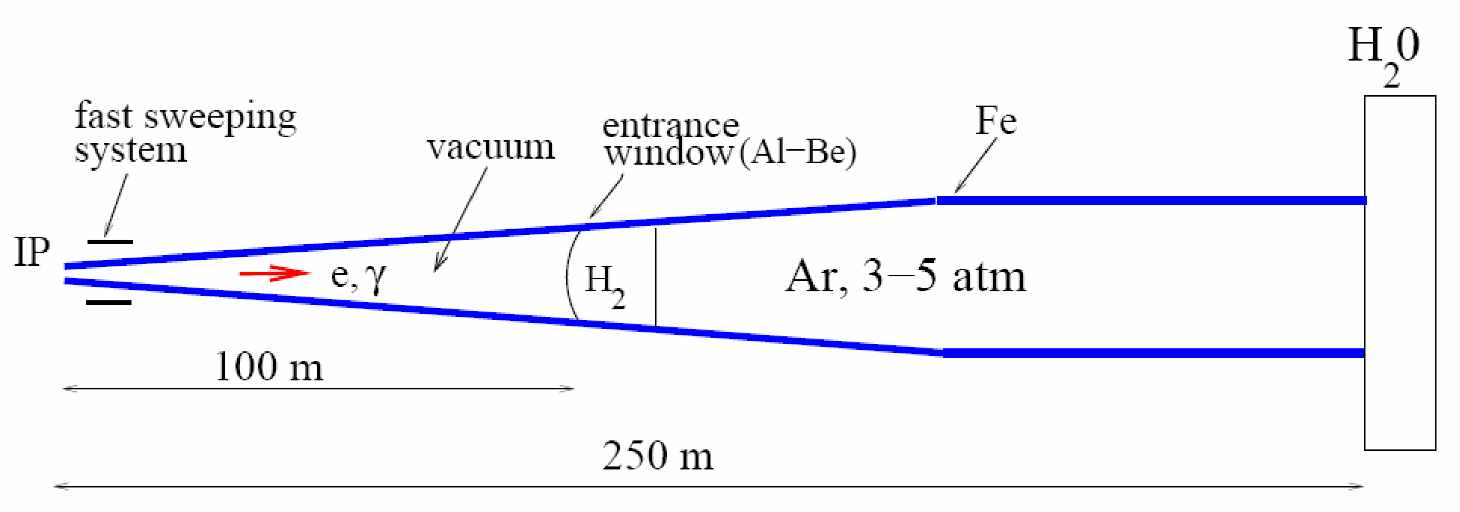
- The requirement of a field free extraction line is hard due to fringe fields from the final quads
- Some kind of compensation system is needed to cancel that
- Designs have been made that minimize the fields, but…
- We need to analyze the effect on the outgoing bunch
- We need to determine the heat load on the superconducters to see if it is workable

Beam deflection feedback system must be redesigned for disrupted $\gamma\gamma$ beam

- ILC uses beam-beam deflection to bring the beams into collision
- The disrupted beam in $\gamma\gamma$ complicated this
  - Low energy particles will dominate the effect
  - Can BPM's extract useful info from these disrupted bunches?
  - Can we design a workable feedback algorithm
- I think yes but this needs someone to do a detailed study



The beam dump has special considerations



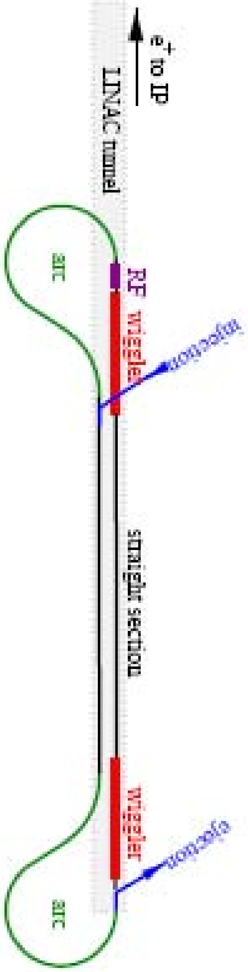
V. Telnov

- An undisrupted beam deposits enough energy to boil the water in the dump. ILC uses a fast sweeping system to disburse the beam.
  - This does not work for γγ
- Converting the photon beam to e+e- may be the only way to solve this problem

We can use lower emmittance beams than e+e- but we don't need them

- There are ideas to modify the damping ring to reduce emmittance (Telnov)
  - Photon collider can take advantage of smaller spot sizes

- These ideas should be pursued but very important that the baseline use standard ILC parameters

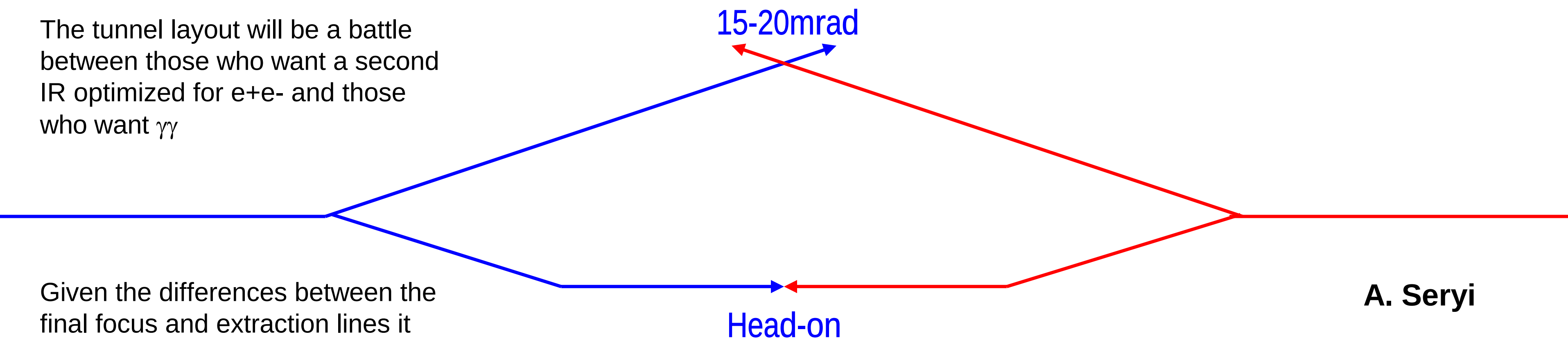


The Path Forward

- We have a good understanding of all the elements that go into the accelerator design for $\gamma\gamma$
- At this point I would suggest the goal of making a configuration document for Snowmass
  - Full tracking simulation from final focus to beam dump
  - Optimize final focus system for luminosity
  - Choose laser parameters
  - Layout extraction line magnet
  - Quantify beam losses and radiation loads in the extraction line
  - Quantify engineering issues in the beam dump
- Much of this work is already done, but we need to pull it into a coherent whole and get BDIR group to agree with our design

Creating a tunnel layout which accommodates $\gamma\gamma$ will be contentious

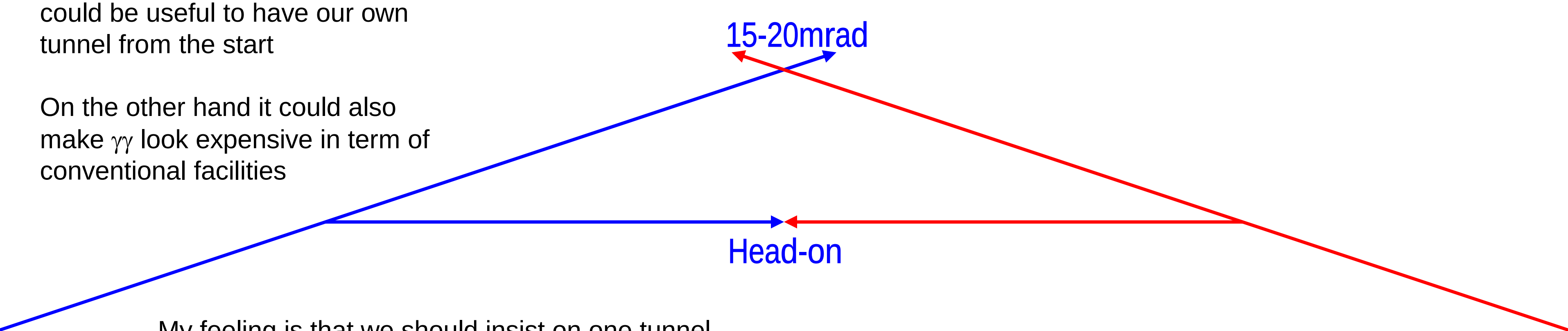
The tunnel layout will be a battle between those who want a second IR optimized for e+e- and those who want $\gamma\gamma$



A. Seryi

Given the differences between the final focus and extraction lines it could be useful to have our own tunnel from the start

On the other hand it could also make $\gamma\gamma$ look expensive in term of conventional facilities

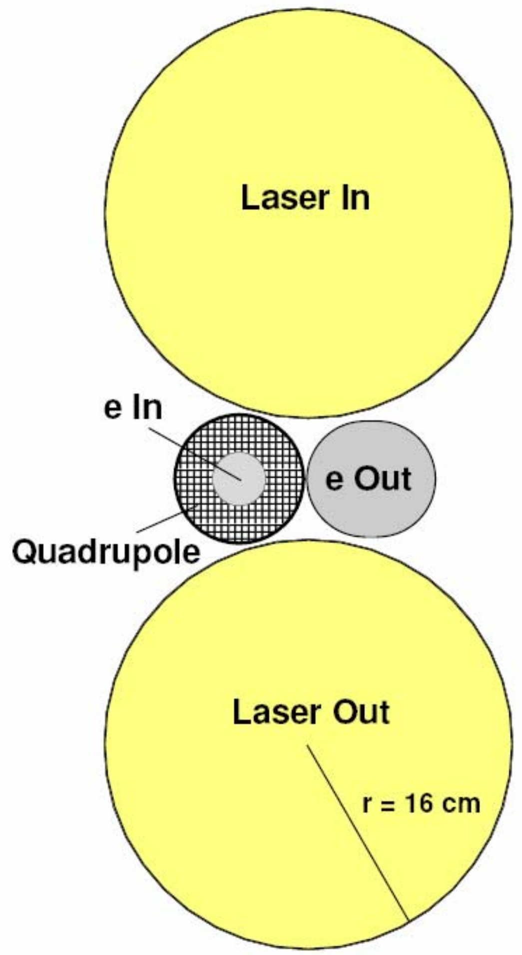


My feeling is that we should insist on one tunnel having a crossing angle good for $\gamma\gamma$ and worry about whether the experiment is e+e- or $\gamma\gamma$ later

A. Seryi

Detector Issues

- The lines of sight for the laser take up a large part of the forward region
- The e+e- program wants to have
  - Hermeticity for the energy flow
  - Low angle tracking for SUSY searches
- We should define an area of the forward region that would be replaced to change from e+e- to $\gamma\gamma$
- We would like to reuse as much of the detector as possible to keep costs down



K. Moenig

A significant program of work remains before the photon collider experiment is ready

- A program of serious laser development should be funded, beginning now.
  - This effort should be based on real laser experts
- A configuration for the beam delivery system should be produced
  - Some work remains to be done but it is work that can be done by HEP post-docs and beam physics people