# Photon Collider Requirements

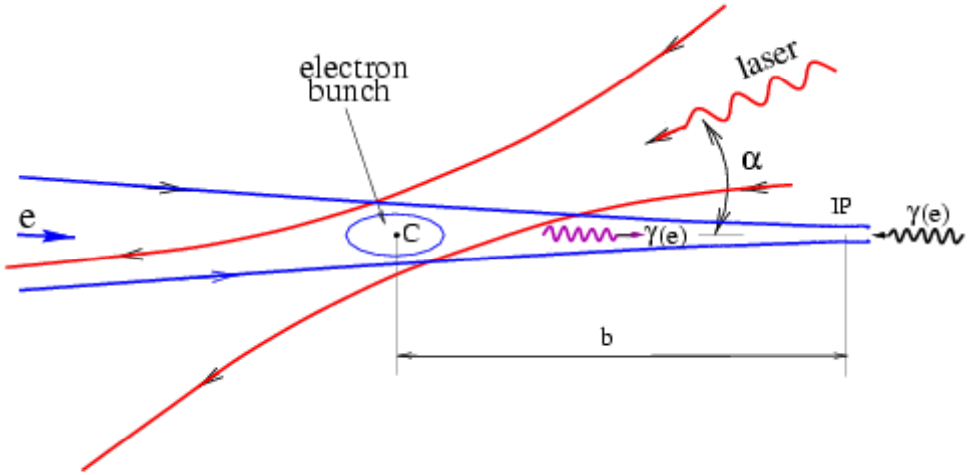
Jeff Gronberg / LLNL

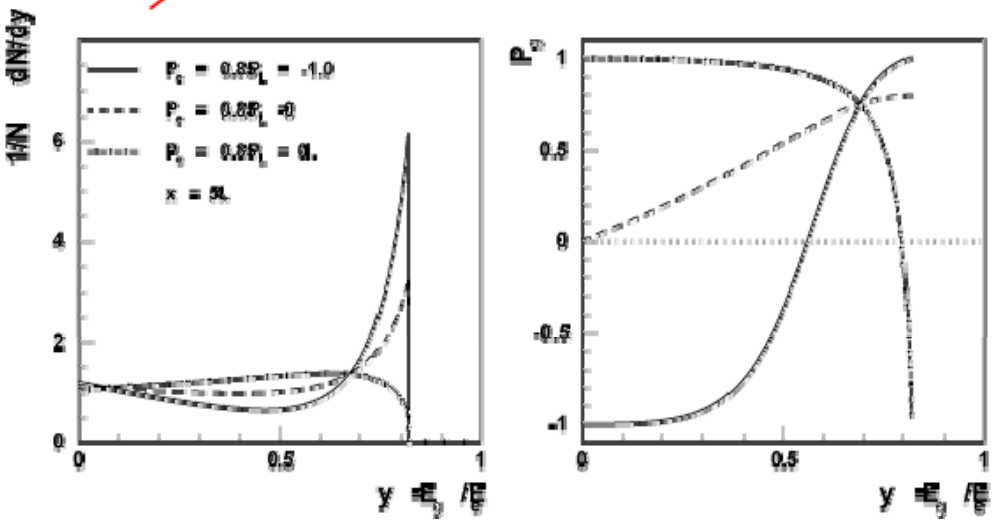
October 12, 2007

BDS KOM - SLAC

This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

# Photon Linear Collider (PLC)



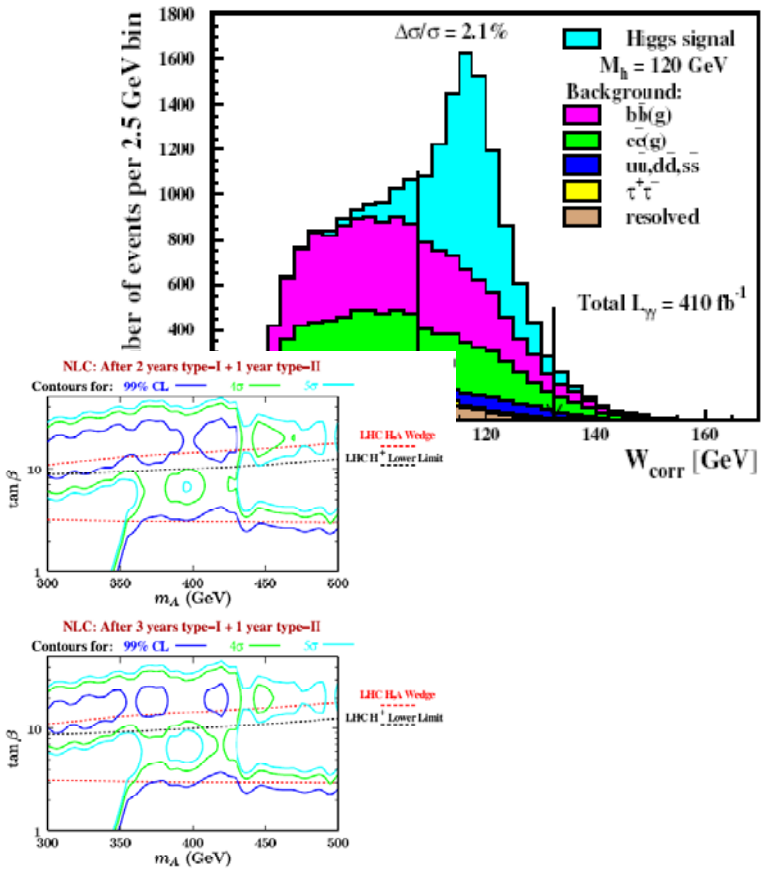




- Laser Compton interaction produces beam of high energy photons
  - **Eγ <= 0.8 $E_{beam}$**
- Peak has high circular polarization
  - **Linear polarization is also possible**
  - **CP studies**

**V. Telnov**

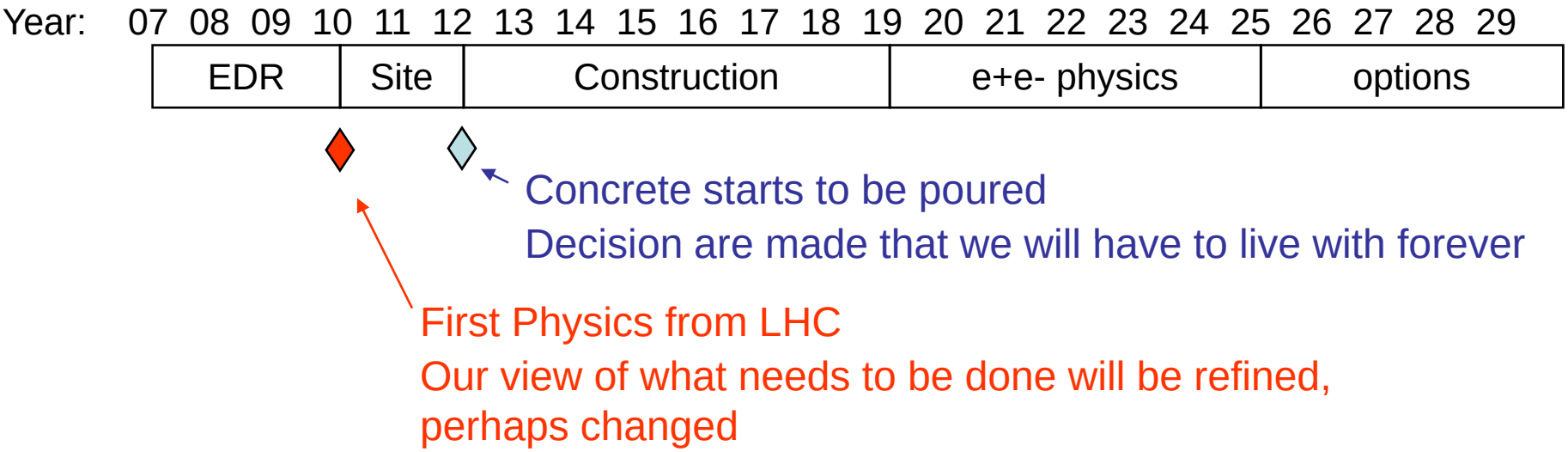
# Photon Linear Collider physics is a valuable addition to the base program

- PLC allows direct production neutral C=+ parity spin zero objects
  - **Higgs**
- Greater energy reach for SUSY H and A
  - **Covers LHC wedge**
- Linear polarization allows initial state of definite CP
- Double and single W production probes anomalous couplings
- Etc.




Physics case was reviewed at Jeju 2002 by the wider community
Photon Collider was determined to add real value to the physics program

# The options seem a long way off but have an impact on baseline machine requirements

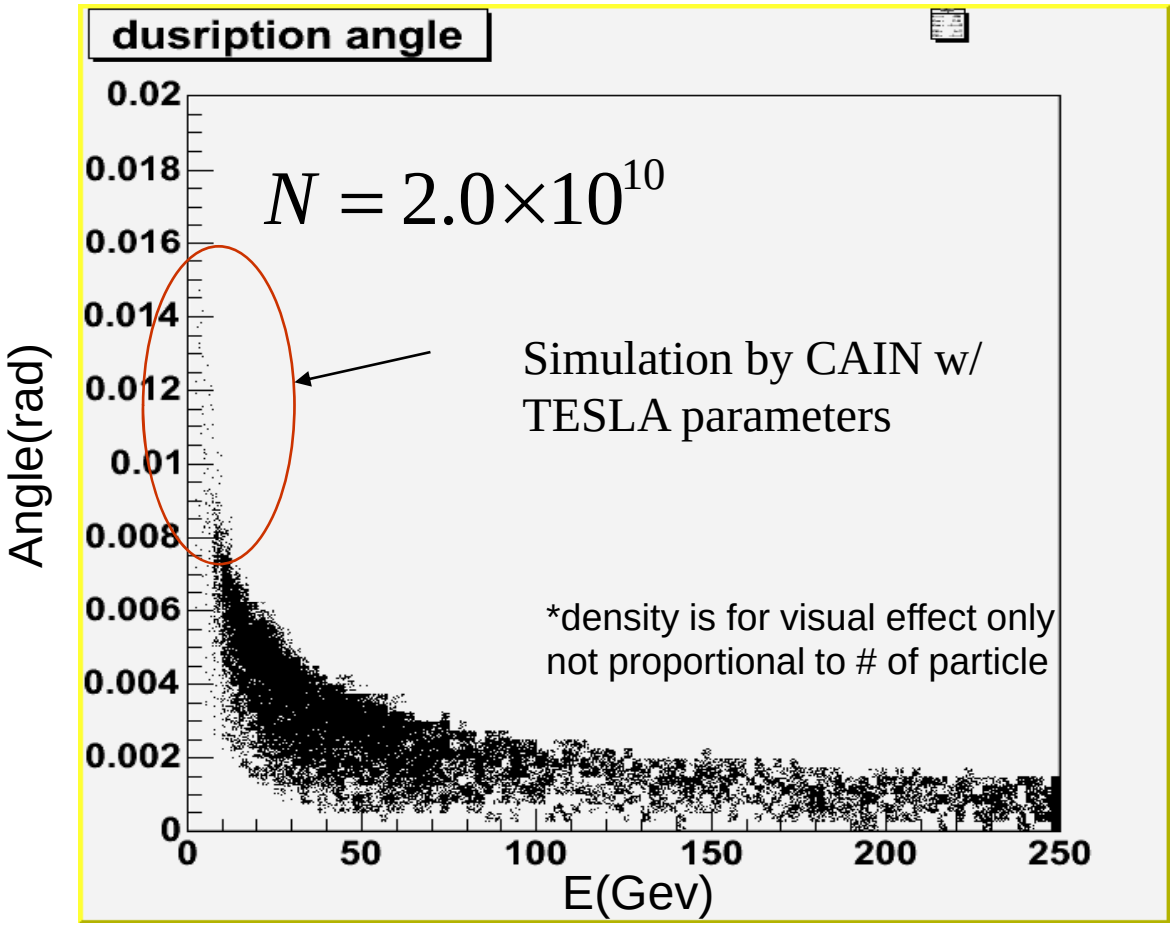



- What additionally is needed for $\gamma\gamma$?
  - **Lasers and optics integrated with the detector**
  - **Crossing angle**
  - **Special beam dump**
  - **$e^-e^-$ operations**

- What has to be included in the baseline requirements upfront?
- What can be delayed for later years?

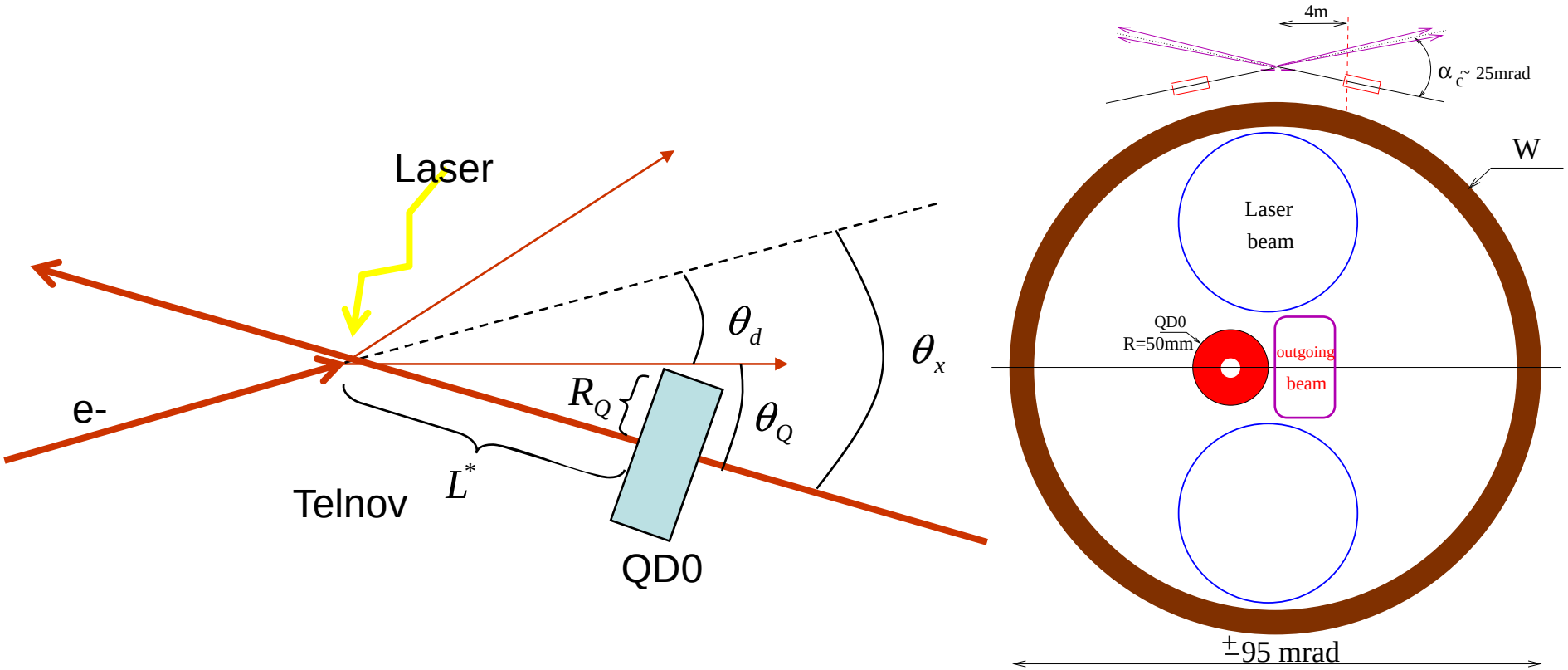
# The crossing angle requirement has no flexibility

- A large crossing angle is required to remove the disrupted beam from the IP
- Compton backscattering leaves a large energy spread in the electron beam
- Beam-beam deflection at the IP gives an angular kick to the beams




**T. Takahashi**

# The Photon Collider must have a 25 mr crossing angle



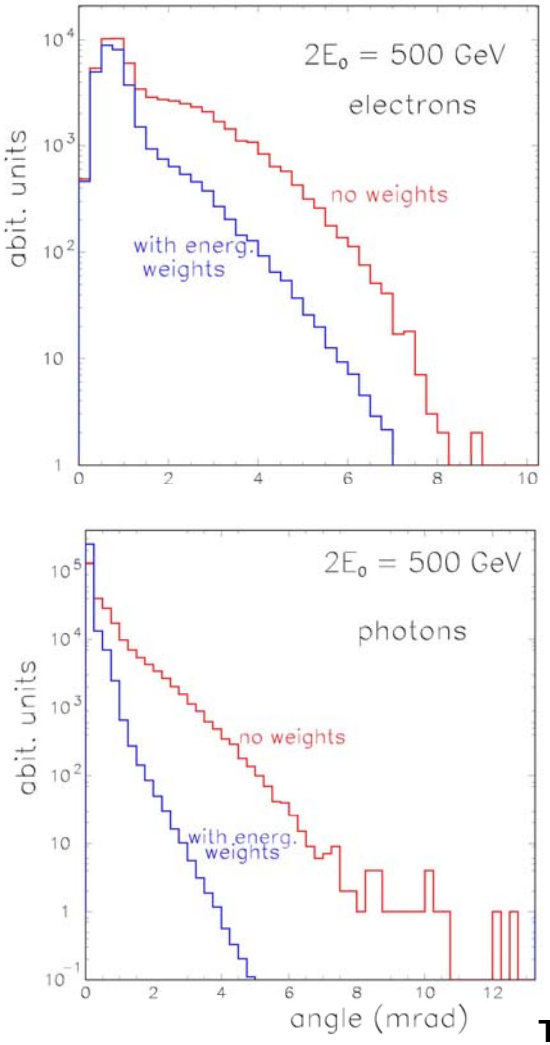

- Physical overlap between the extraction line and the final focus quad sets the minimum crossing angle

# The outgoing beam sets unique requirements for the extraction line and dump

- The outgoing beam from the photon collider is a complicated object
- There are three main components
  - **Two with a large angular spread**
    - Disrupted electrons
    - Beamstrahlung photons
  - **One quite narrow**
    - Compton photons

| Component: | Angle | Size at 250m |
|---|---|---|
| Electrons | 10 mrad | 2.5 m |
| Beamstrahlung Photons | 3-4 mrad | ~1m |
| Compton Photons | (.04,.015) mrad | (1,0.35) cm |

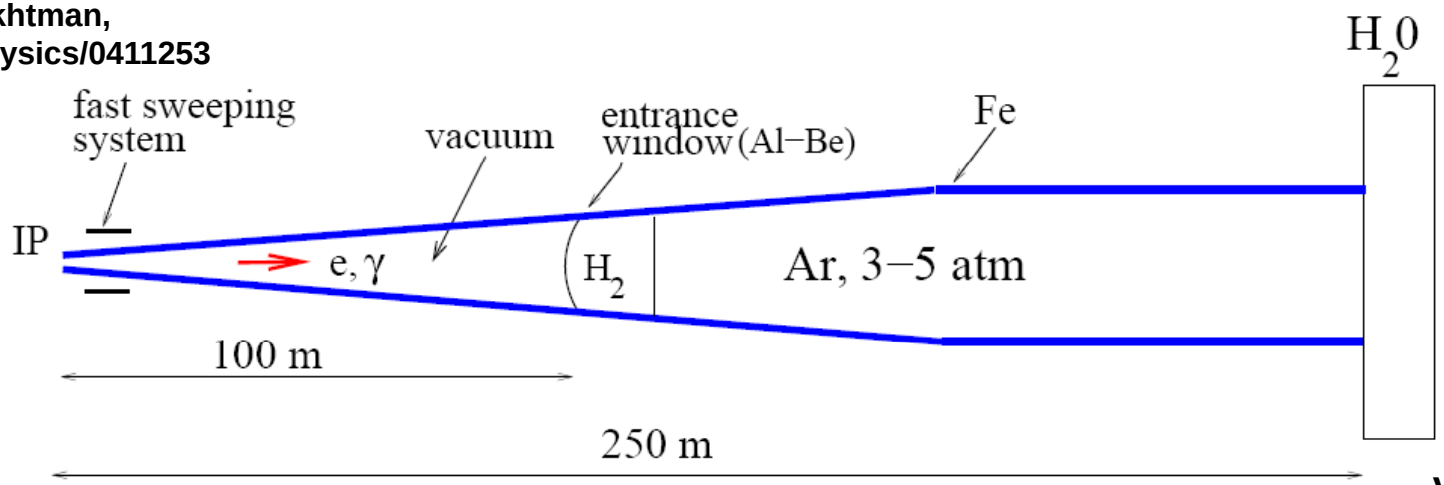
V.Telnov, physics/0512048, Snowmass2005




Telnov

# An initial conceptual design has been simulated

**Telnov, Shekhtman,**
**LCWS04, physics/0411253**




**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**
- Use gas volume to convert the photon beam to $e^+e^-$ pairs
  - **Water ΔT = 75,50,25 $^0$C @ 5,4,3 atm Ar**
  - **Window ΔT = 40 $^0$C**
  - **$H_2$ volume as neutron moderator**
    - Reduces flux by a factor of 10, gives 1.5 x $10^{11}$ neutrons / year

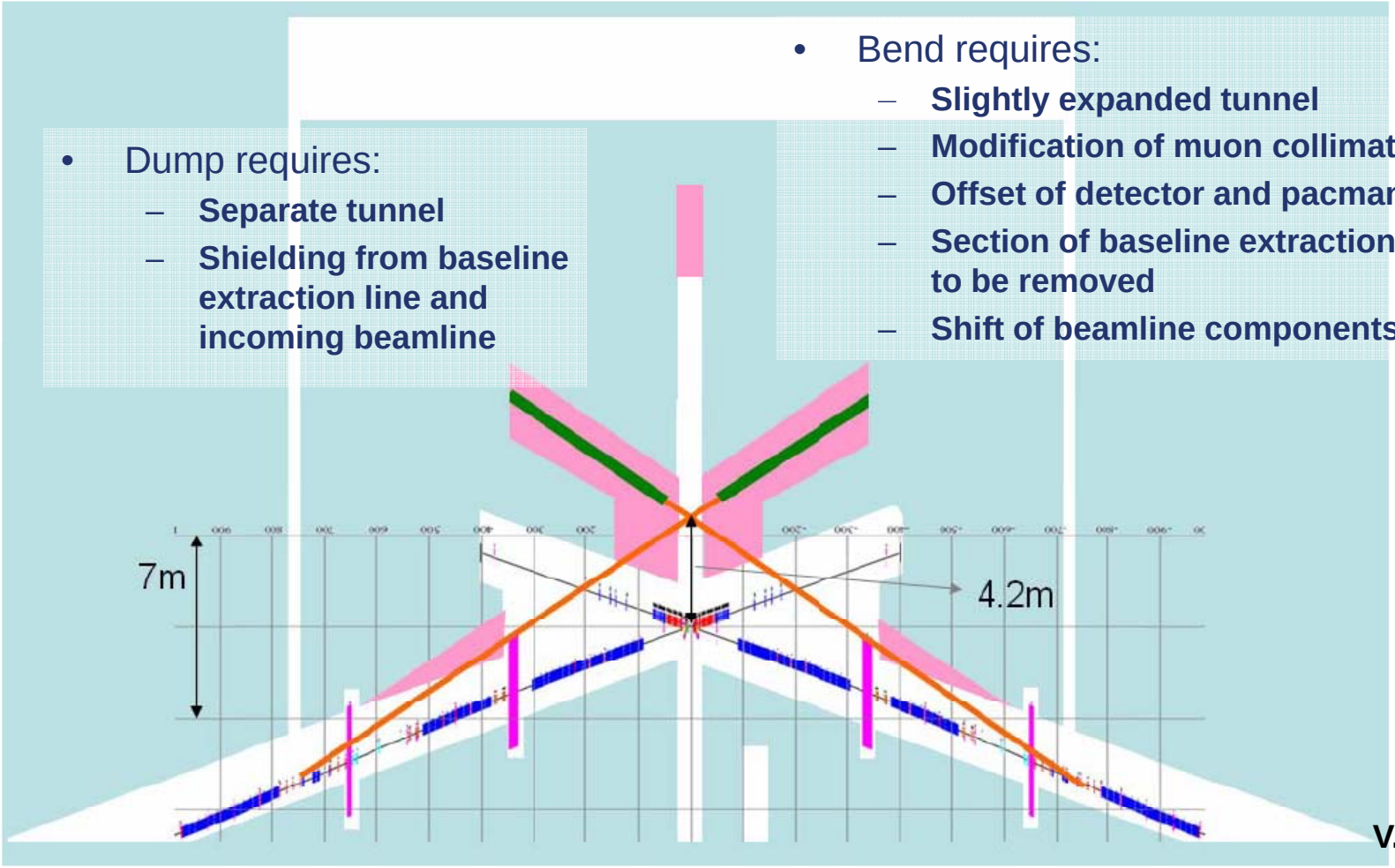
# Proposed least cost solution for γγ: Extra 5.5mr of bend at 700m

14mr => 25mr

A.Seryi, LCWS06

- Dump requires:
  - **Separate tunnel**
  - **Shielding from baseline extraction line and incoming beamline**

- Bend requires:
  - **Slightly expanded tunnel**
  - **Modification of muon collimators**
  - **Offset of detector and pacman**
  - **Section of baseline extraction line to be removed**
  - **Shift of beamline components**

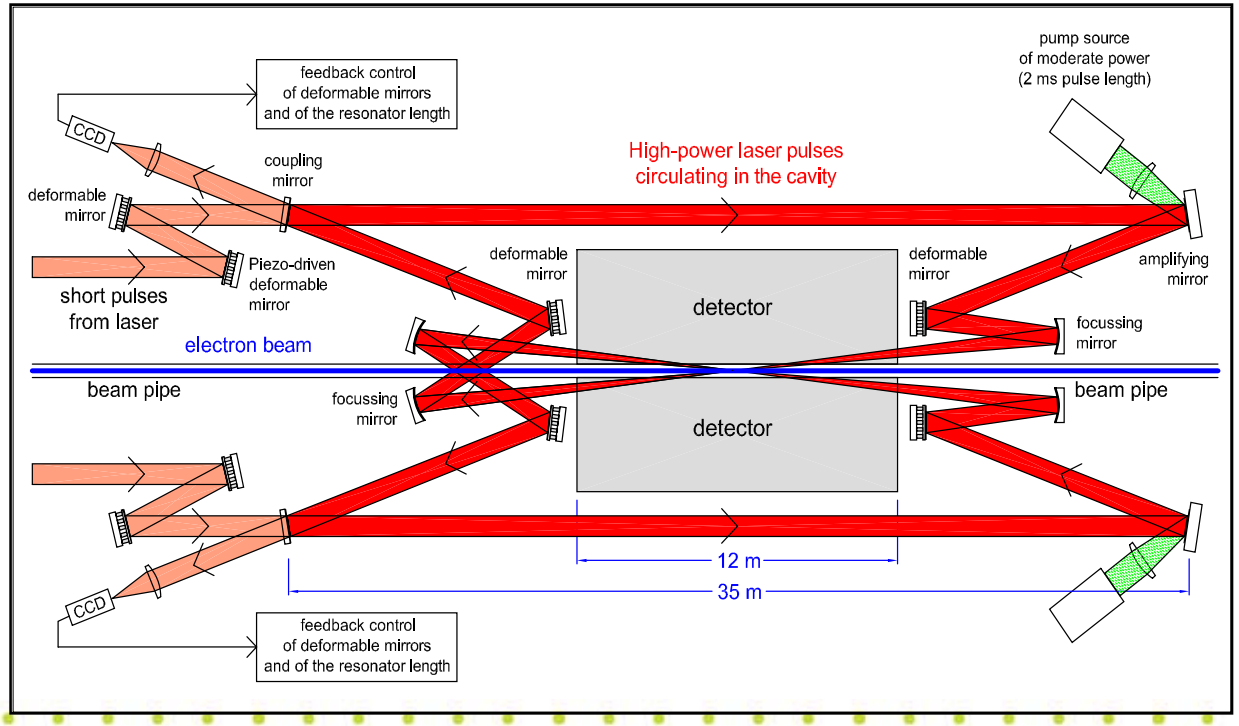



**V. Telnov**

**CF group asserts that further tunneling after baseline operations is unacceptable**

# Recirculating optical cavities are a solution which minimizes the required laser power

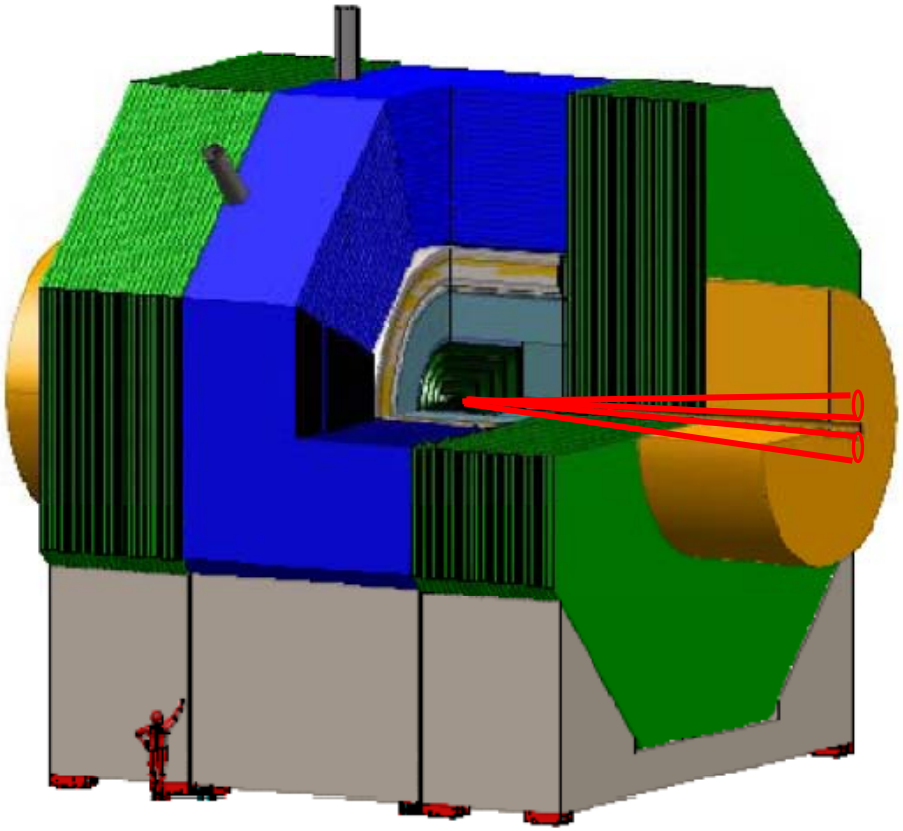
- Developed by MBI/DESY-Zeuthen
  - **One cavity / beam**
  - **Factor 300 power reduction**
  - **Cavity length 369 ns**
- All optics are outside the detector
  - **Line of sight needs to reach the IP**
  - **Need optical path around the detector**




**G. Klemz**
**K. Moenig**

# Laser line of sight will impact the detector design

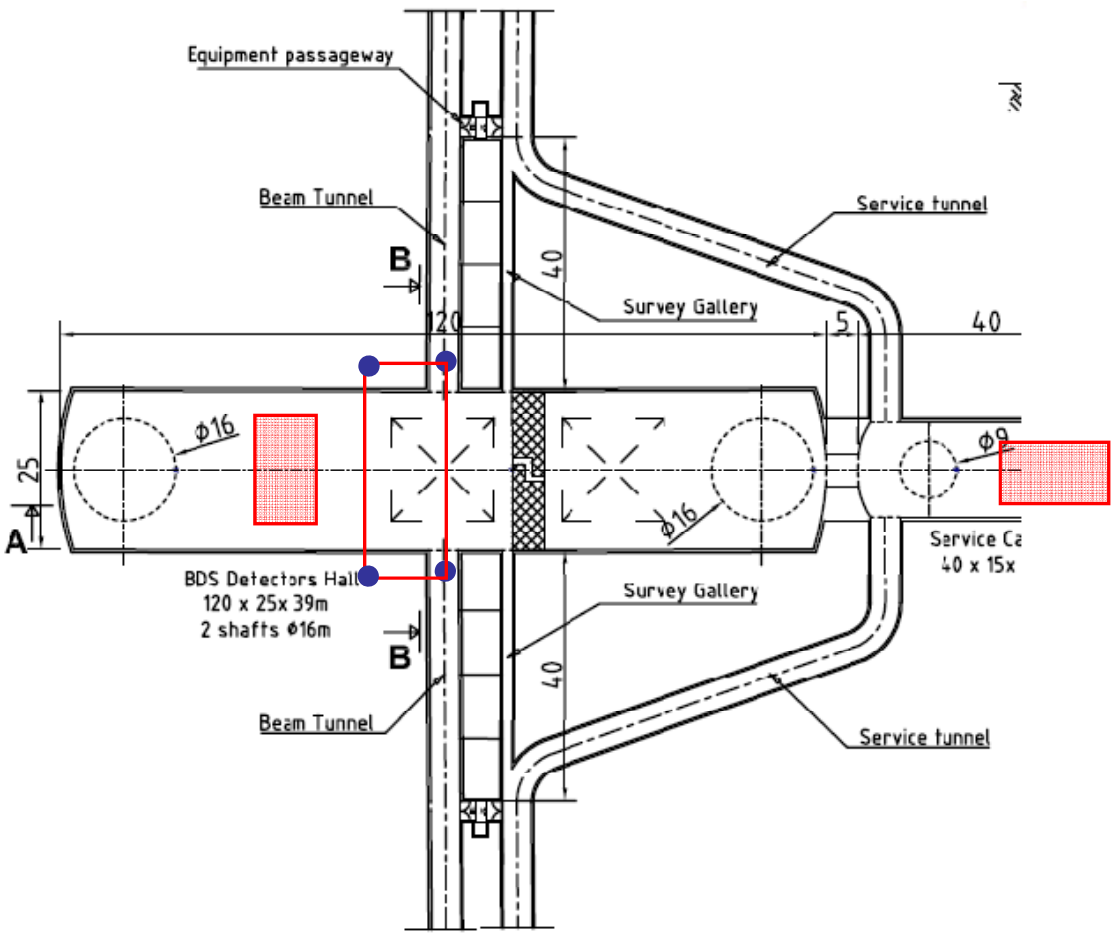
SiD CAD model



**K. Krempetz**

- The final focus mirror is ~1m dia
  - **A straight line of sight must be provided to the IP**
  - **There are two mirrors on each side**
    - One above the beampipe and one below
  - **This will penetrate the endcap, pacman and will require changes to the beam tube**
- Space above and below the beamline must be provided for the optics in the BDS tunnel
- These lines of sight will impact the shielding behavior of endcap and pacman
- This may have an impact on design of the support structure and stabilization

# Space for the laser plant and cavity must be provided

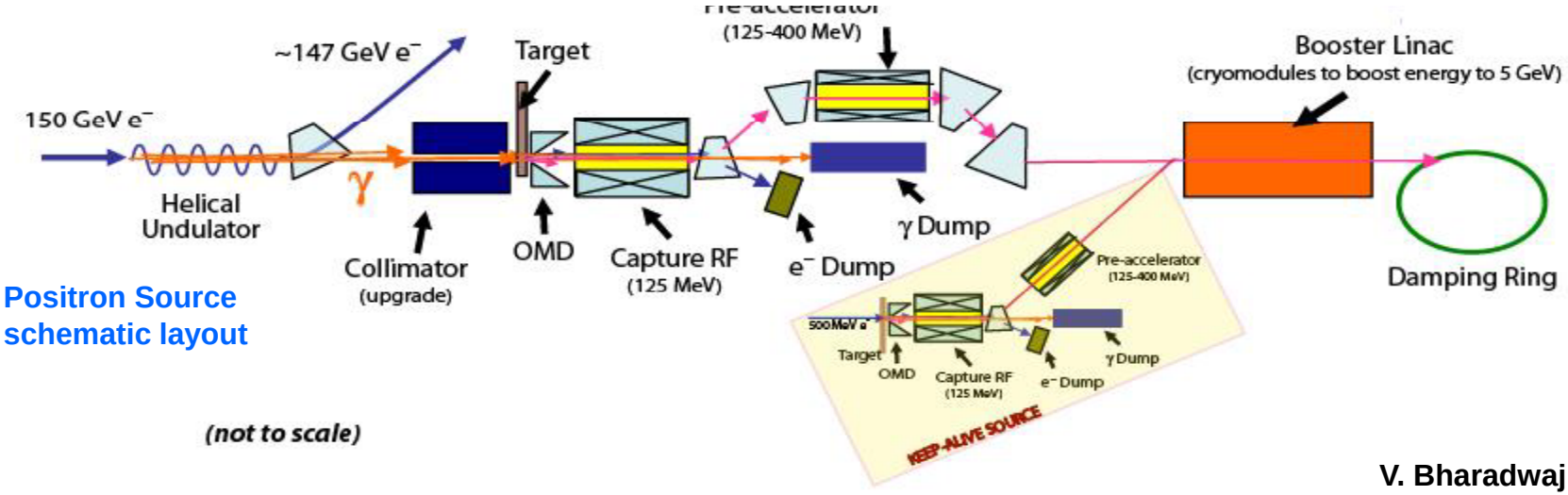



**J. Osborne**

- The cavity is driven by a short pulse laser which needs a clean room below ground
  - **Possible locations**
    - service cavern
    - Detector hall (temporary)
- A path for the laser light needs to be provided
  - **Locations for turning mirrors and diagnostics**
- Need to pursue least cost solution with CFS group

# PLC requires $e^-e^-$ running

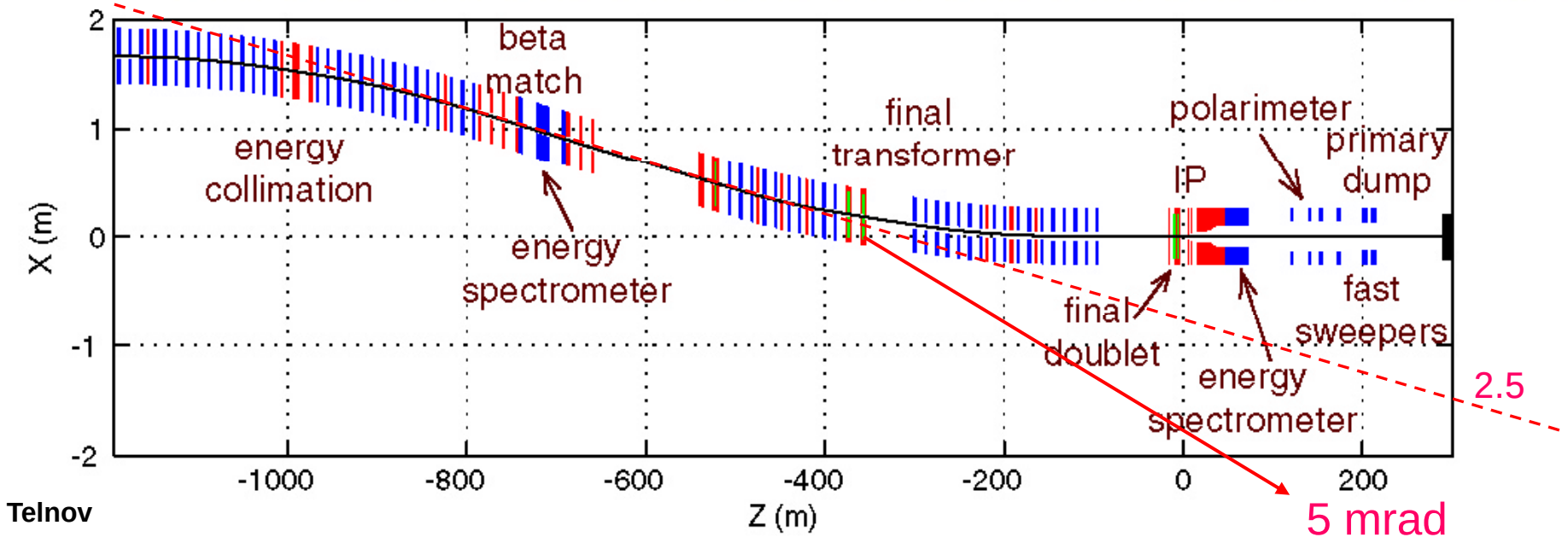
- Photon collider requires e-e- operations.
  - **Positrons can Compton backscatter, but…**
  - **High electron polarization increases $\gamma\gamma$ luminosity**
  - **$e^-e^-$ collisions reduces physics backgrounds**
- For electron operation in the positron arm some capabilities must be in place
  - **Polarized electron source**
  - **Capability to switch some magnet and kicker polarities**
  - **Undulator bypass (probably)**




**Positron Source schematic layout**

**V. Bharadwaj**

# Feasibility of the beam line changes

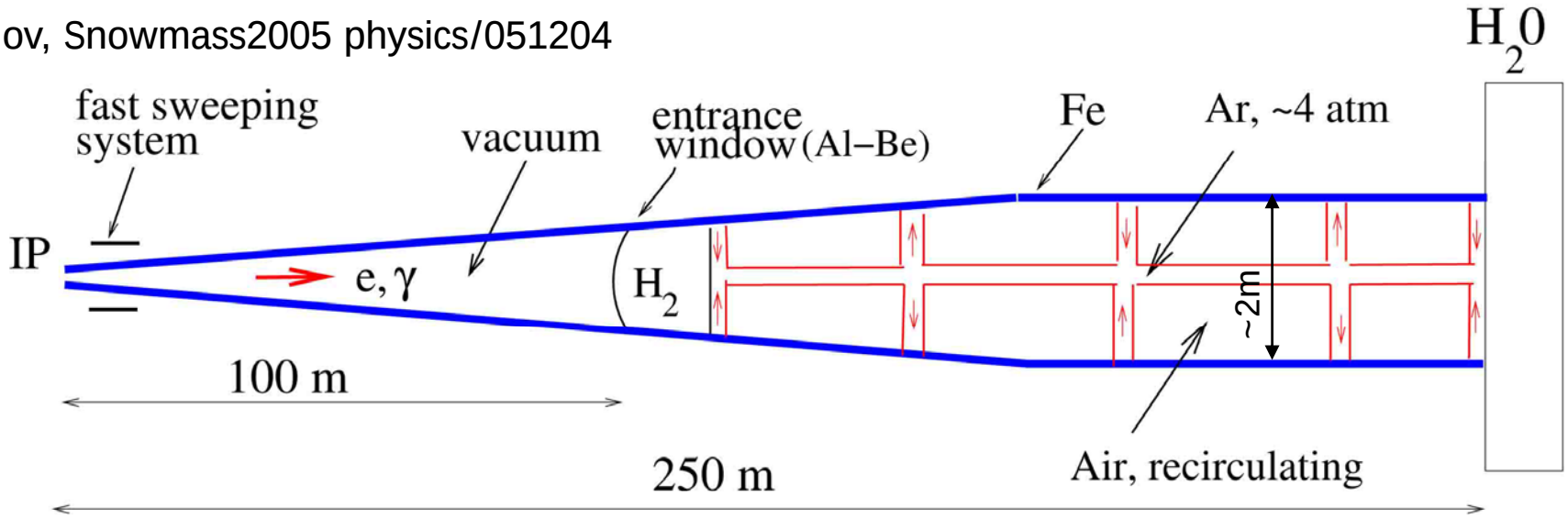



Telnov

- The current final focus design has two 2.5mr bends for background reduction
- One bend could be reversed to provide an extra 5mr
  - **Mark Woodley thinks there is no problem delivering beam to the IP with this change**
- This change may impact collimation and backgrounds
  - **Needs further simulations**
- This will intersect the baseline extraction line
  - **Needs confirmation that there is space to remove a section**
- Do we move the magnets at change over?
  - **Find least cost solution**

# Dump design impacts the CFS costs

Telnov, Snowmass2005 physics/051204




- We have a basic conceptual design for the beam dump
- However, CFS requirements for the extraction line tunnel depend on detailed knowledge of the design

- Need detailed simulations of:
  - **Energy depo in windows and volumes**
    - Shock waves
    - Cooling
    - Hydrodynamics in the gas
  - **Radiation field and activation**
  - **Optics for focusing disrupted electrons**
- Need specification for services:
  - **Gas handling**
  - **Cooling**
  - **Radiation protection**

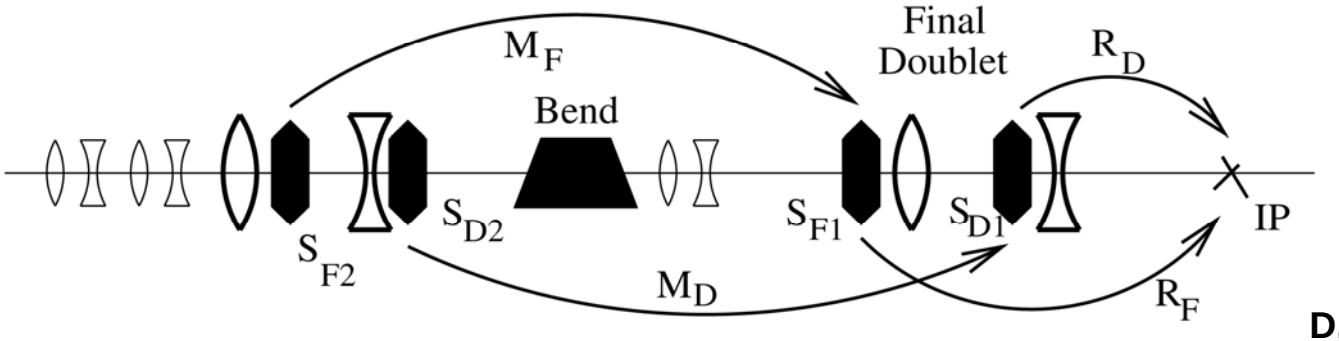
# EDR Work Packages

- Goal: Quantify the cost of maintaining the photon collider as an option in the baseline
  - **The necessary conventional facilities and services are the cost drivers**

- Electrons in the positron arm
  - **Electron source is already included in the Keep Alive Source**
  - **Magnets must be capable of switching polarity**
- 25 mr crossing angle
  - **Requires wider tunnel in beam delivery**
  - **Beam optics solution is workable but backgrounds should be evaluated in more detail**
- Extraction line and dump
  - **Significant additional tunnel**
  - **The beam dump design should be simulated in detail so that a more rigorous specification of tunnel and support services can be made**
- Laser and optics
  - **Space for a 10m x 20m clean room should be set aside in the service cavern with power and services specified**
  - **Space in the BDS tunnel to place the focusing optics should be specified**
  - **Modifications to the PACMAN to allow laser path and it's impact on backgrounds should be understood**

Extra slides

# A dedicated final focus design can maximize luminosity

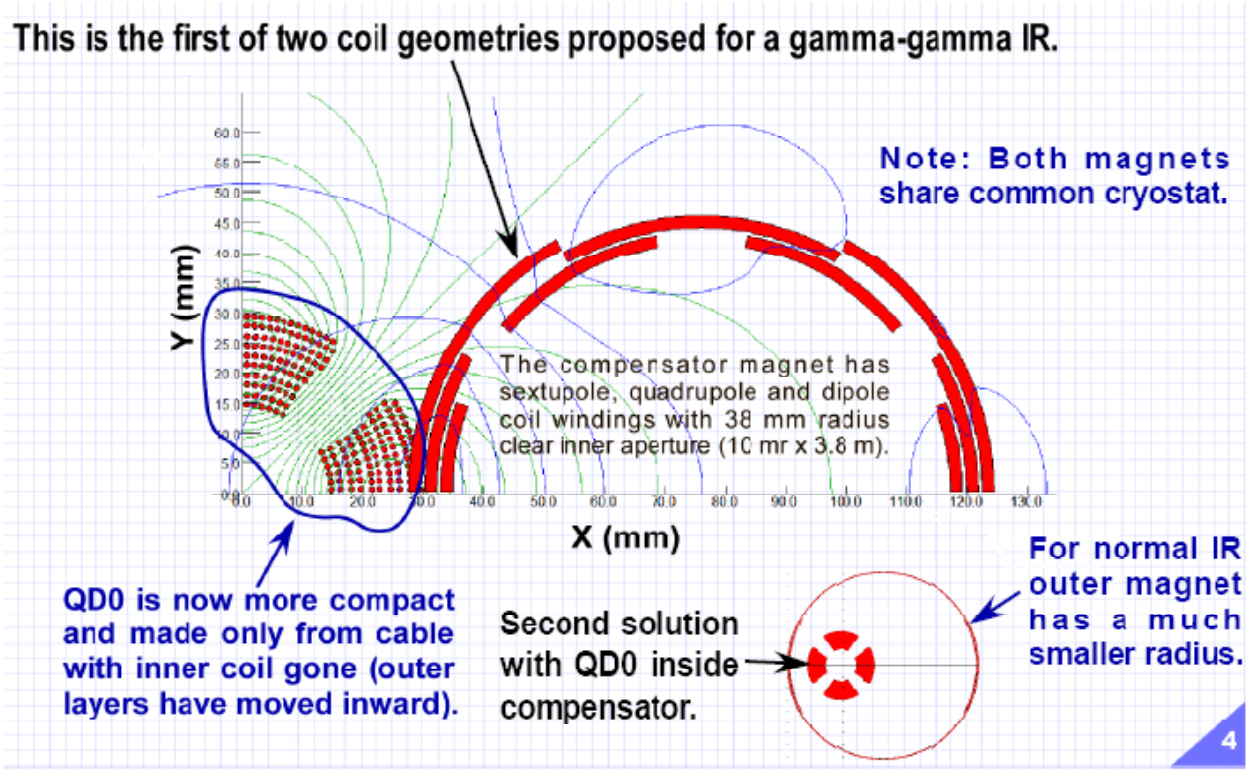



**D. Asner**

- 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 $\beta_x$**
- 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

# Real designs for the extraction line magnets have been produced

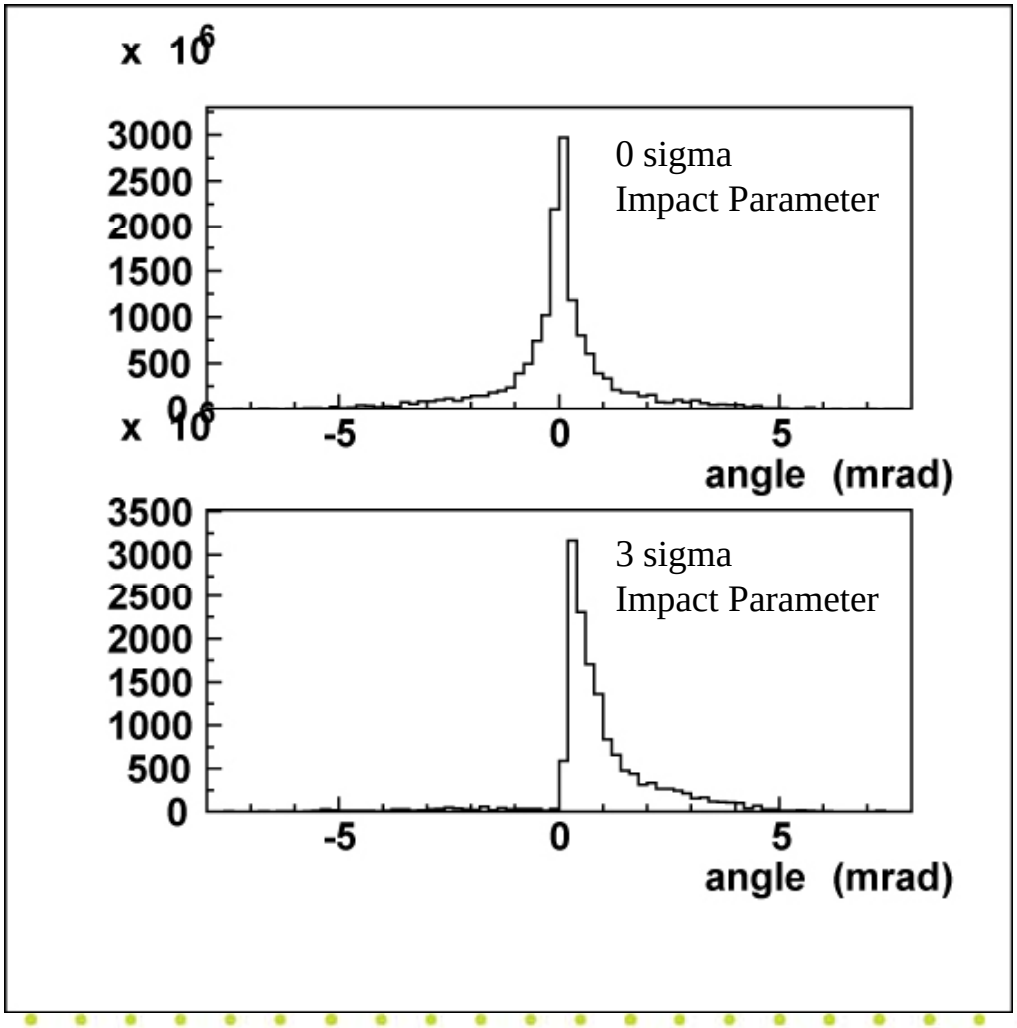



**B. Parker**

- 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

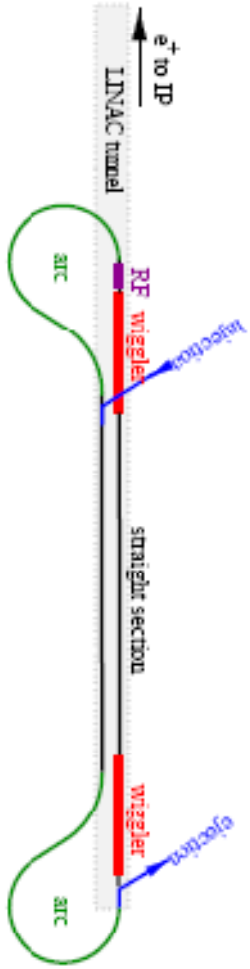
# Beam deflection feedback system must be redesigned for disrupted $\gamma\gamma$ beam

- 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

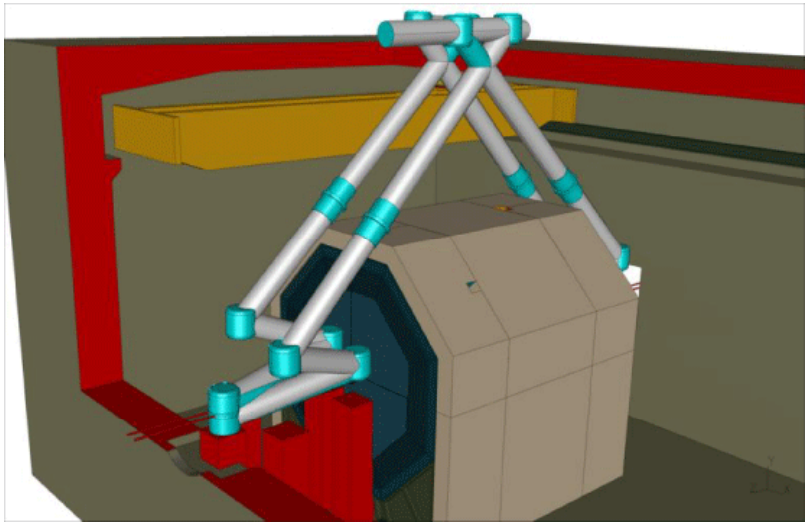


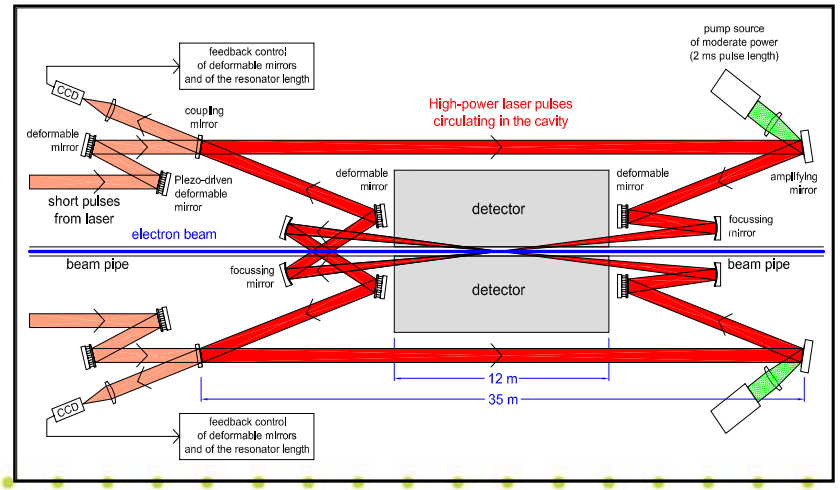
# We can use lower emmittance beams than e+e- but we don't need them

- 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



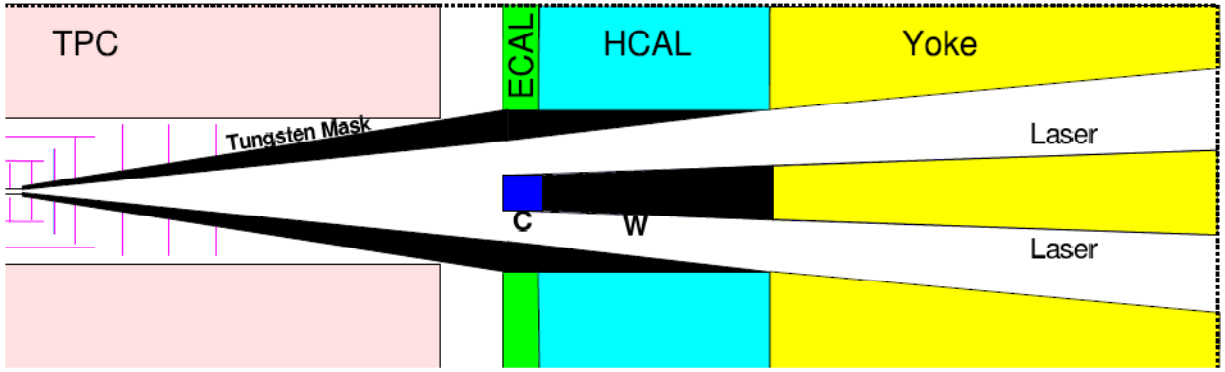
# The baseline laser is two resonant stacking cavities



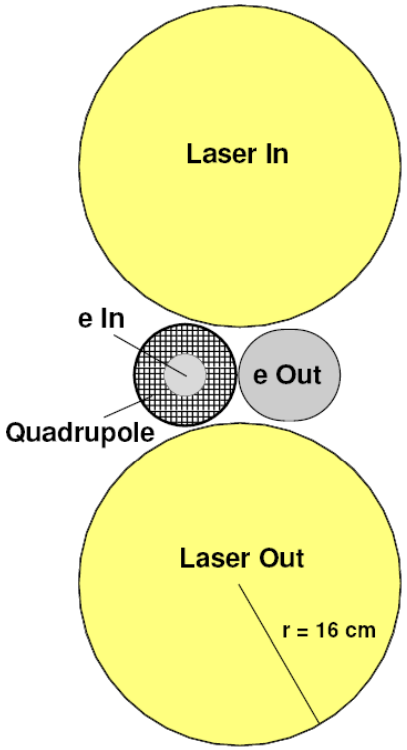



- DESY-Zeuthen/MBI design
  - **One cavity per beam**
  - **369ns round trip matched to the beam spacing**
  - **Factor 300 enhancement of laser energy in the cavity**
    - Enormous reduction in laser power required

# PLC modifications required from the detector



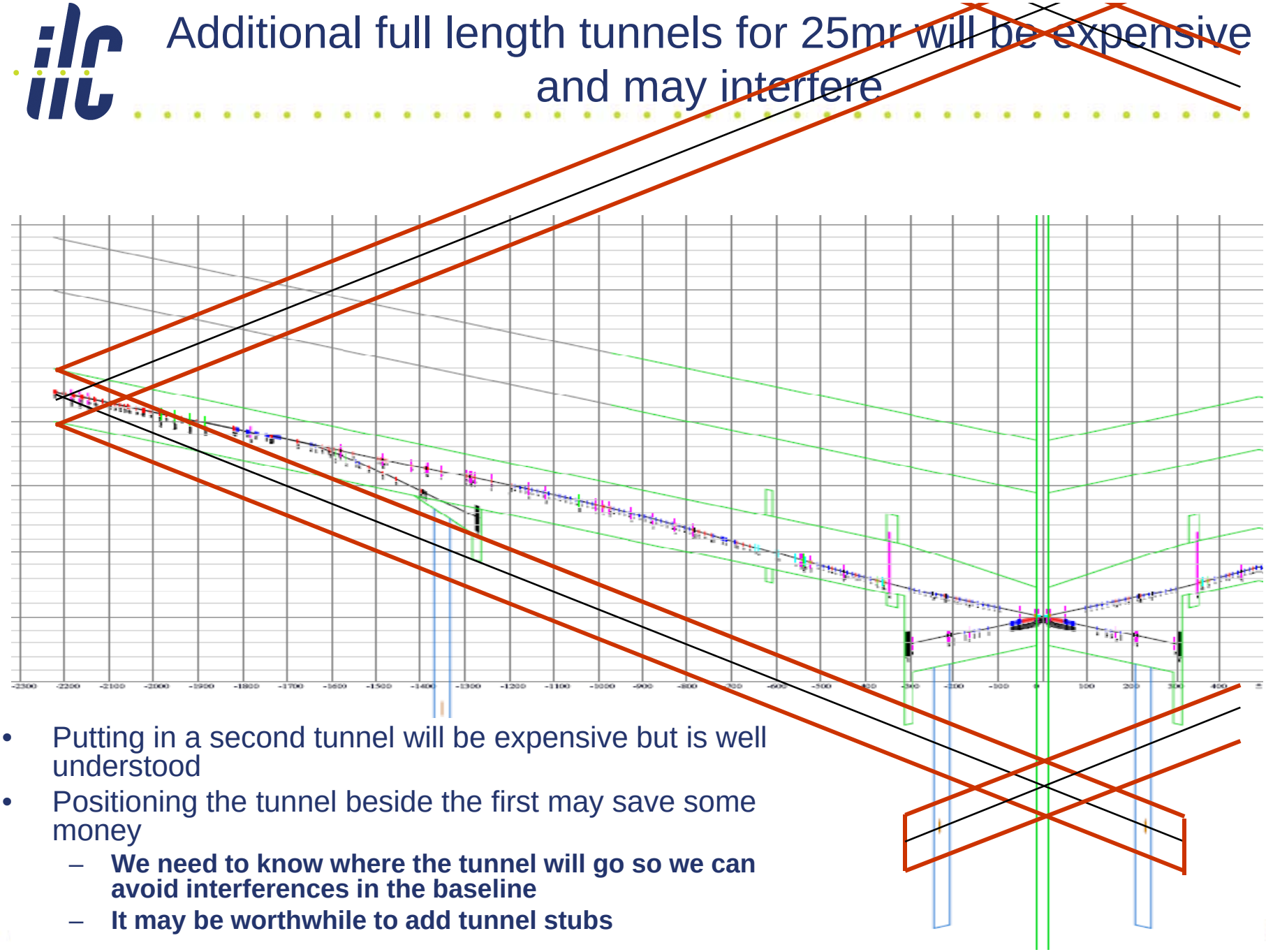

- Photon collider requires:
  - **Line-of-sights for each laser cavity**
  - **Expanded aperture exit line**
  - **Modified masks**
  - **Space in the hall for laser plant**
  - **etc.**




It will be enormously cheaper to retro-fit a detector for photon collider operations if some attention is paid today

**K. Moenig**

# Additional full length tunnels for 25mr will be expensive and may interfere



- Putting in a second tunnel will be expensive but is well understood
- Positioning the tunnel beside the first may save some money
  - **We need to know where the tunnel will go so we can avoid interferences in the baseline**
  - **It may be worthwhile to add tunnel stubs**