$\gamma\gamma$ *Technology Summary*

A. Finch

- The Gamma Gamma Planners Group
- Laser Cavity
- Crossing Angle / Backgrounds
- Damping ring
- Final Thoughts

At the *International Workshop on High Energy Photon Linear Colliders*.

5-8 September 2005, Kazimierz Dolny, Poland.

1st meeting of **Gamma Gamma Planners** group chaired by David Miller.

Tasks assigned to volunteers:

- **Background studies**: P.Niezurawski
- **Crossing Angle**: AF.Zarnecki
- **Beam monitoring/feedback**: AJF
- **Beam dump**: volunteer needed
- **Laser Cavity**: Meeting planned for October to be organised by DJM and AJF. Jeff Groenberg offered LLNL assistance.
- **Physics**:M.Krawczyk, S. Maxfield,AFZ

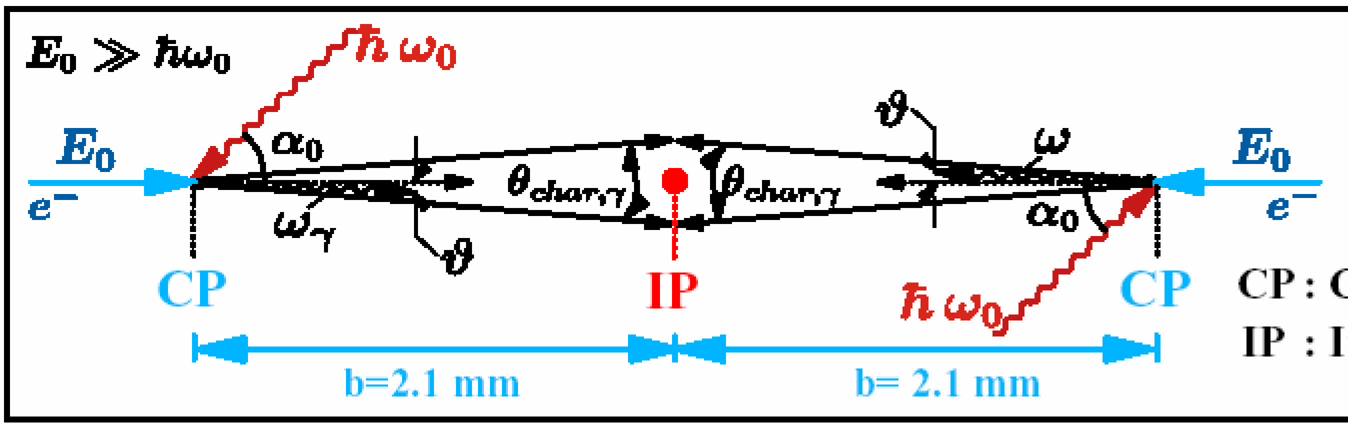
1 month later

David Miller suffers major stroke.

Laser Cavity meeting organisation taken over by AJF, moved to Jan 10^{th} 2006.

Essence of a Photon-Collider

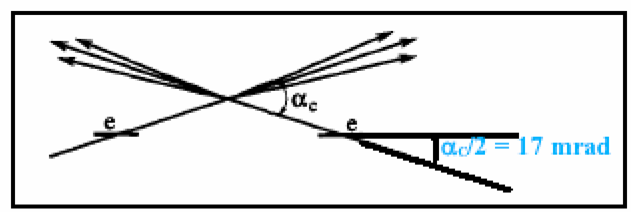
- Compton scattering of relativistic electrons against laser light: $\omega_{Laser} \xrightarrow[E_{kin,\, e^-}]{} \gamma$
- Photon-Collider: Linear Accelerator in e^-e^--mode + Compton-backscattering



CP : Conversion Point
IP : Interaction Point

Design parameter of IP (fixed values of TESLA-LC):

- Electron beam energy $E_0 = 250\,\mathrm{GeV}$
- e^- bunch cross section: $\sigma_x \cdot \sigma_y = 88 \times 4.3\,\mathrm{nm}^2$
- e^- bunch length: $\sigma_z = 0.3\,\mathrm{mm}$
- Distance between CP and IP: $b = 2.1\,\mathrm{mm}$
- e^- - e^- crossing angle: $\alpha_C = 34\,\mathrm{mrad}$ $(\approx 2°)$



for $E_0 = 250\,\mathrm{GeV}$ choose $\lambda \approx 1.06\,\mu\mathrm{m}$

$\Longrightarrow$ requires source of at least:

- high peak power ($\approx 2\,\mathrm{TW}$)
- high average power ($\approx 70\,\mathrm{kW}$)
- precise timing ($\lesssim 1\,\mathrm{ps}$)

•There are ~10^{10} electrons in a bunch

•Need ~ 10^{19} photons in laser for efficient Compton conversion (5 Joules)

•Less than 1 in 10^{9} photon used.

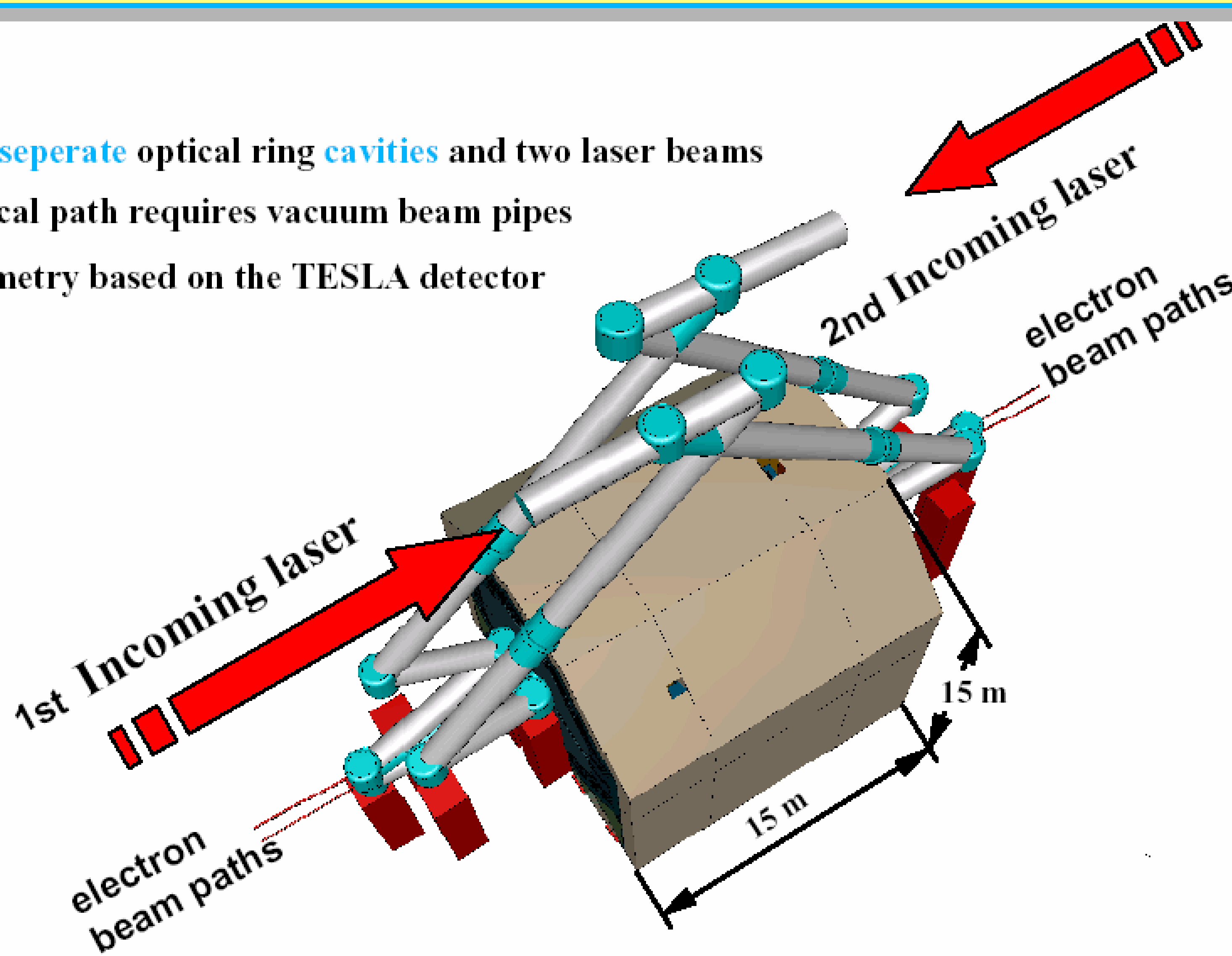
•Can reuse the laser pulse, which means

•Need a (much) lower powered laser

•Use a laser cavity

Proposed detector for an ILC photon collider

- two seperate optical ring cavities and two laser beams
- optical path requires vacuum beam pipes
- geometry based on the TESLA detector



Design study of an optical cavity for a future photon-collider at ILC "
G. Klemz , K. Moenig , I. Will

Background to Daresbury Meeting

"THE PHOTON COLLIDER AT TESLA", V.Telnov et. al

↓

" Design study of an optical cavity for a future photon-collider at ILC "

G. Klemz , K. Moenig , I. Will

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"Thoughts on R+D for Gamma Gamma Optical System" Josef Frisch

"Additional comments on R+D for Gamma Gamma Optical System "

Ken Strain

"Optical cavity for ILC g-g collider: feasibility and development "Mark Oxborrow

"Photon Linear Collider Laser Cavity Requirements. "

Andrea Freise

Jan 10th Meeting to discuss all the above…

All documents are available at:http://www.hep.lancs.ac.uk/LaserCavity/

Meeting to Discuss Laser Cavity Design for Photon Linear Collider - Daresbury, UK Jan 10th 2006

Present:

Mark Oxborrow
National Physical Laboratory

Graeme Hirst
Central Laser Facility RAL

Guido Klemz
DESY/Zeuthen

Klaus Moenig
LAL-Orsay/DESY-Zeuthen

Andrew Rollanson
Keele University

Ken Strain
Glasgow University

Valery Telnov
Novosibirsk

David Walker
Zeeko Ltd.

David Miller
UCL

Aleksander Filip Zarneki
Warsaw

Alexander Finch
Lancaster University

Steve Maxfield
Liverpool University

Result of the discussion on Jan 10th.

- Off the wall comments/questions:
  - Are the linear collider parameters really a given, for example the time structure?

    (Answer Is probably YES but it is important to ask the questions!)
  - Is it definitely best to have separate laser and optical cavity?

    (Answer not clear, needs to be seriously studied as well)

Result of the discussion

- Various concerns were allayed.
  - Mirrors can be manufactured
  - Adaptive optics should be able to cope.
  - Thermal distortion can be handled

- Unresolved doubts:
  - Optical damage.
    - Seems ok but there are no results in the literature using pulsed lasers with this repetition rate.
  - Locking of drive laser to cavity.
    - Seems difficult

Way Forward for the Laser Cavity…

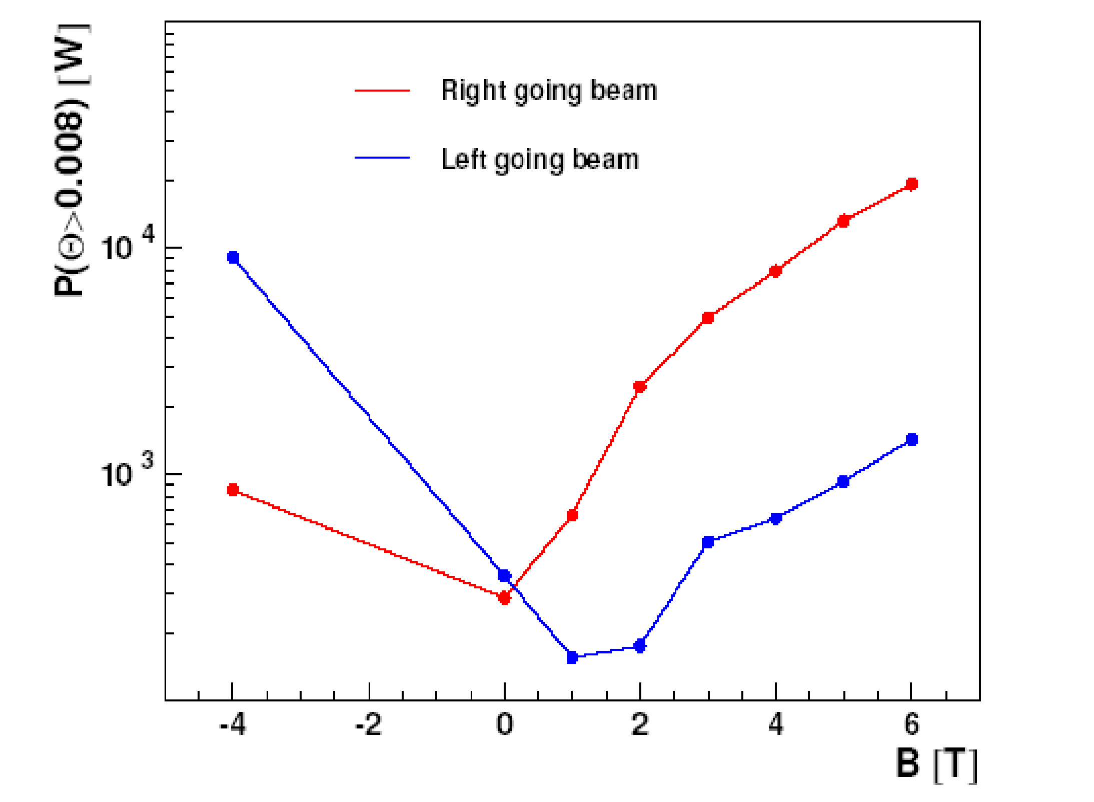
- Continue **networking**!
  - The few experts at this meeting were already able to give valuable input
- Need an **“End to End” simulation** of the dynamics of the design. This will help to identify which are the critical elements. Codes exist in Astronomy community.
- Study the **locking** issue further.
- Need to **investigate damage threshold** issues further using rapidly pulsed lasers, may need R+D if no-one else has studied it.
- Learn as much as possible from other related projects such as the work done for the polarimeter, the laser wire and the positron source.
- Alternative designs need to be looked at in at least as much detail.

Simulation of background using CAIN -Aleksander Filip Zarnecki

Magnetic Field

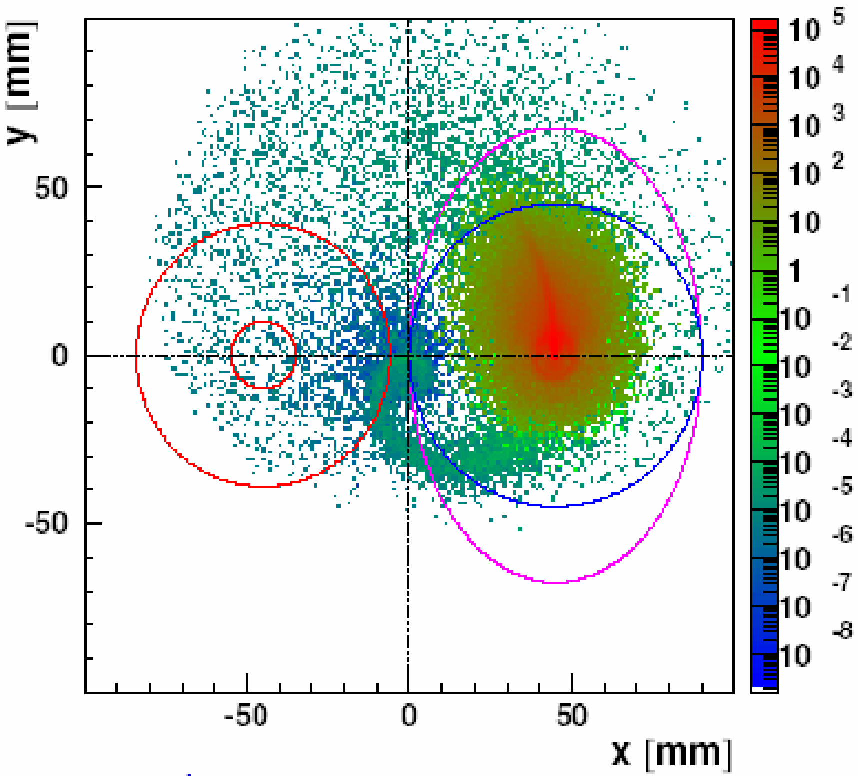
Energy flow outside an 8 mrad cone, observed 3 m from interaction point, as a function of the detector field:

The strength of magnetic field has a very strong influence on the expected background level!



Crossing angle

Transverse profile of the beam 4.5 m from IP,
20 mrad crossing angle, B=4 T.



blue: 10 mrad cone

red: 40 mm radius of final dipole, $L^{\star}$=4.5

About 1 kW emitted outside 10 mrad cone.

However, we can adjust the shape of the beam pipe for best extraction of the outgoing beam.

We should make the beampipe wider in the vertical direction.

magenta:
possible choice of elliptical pipe

Background levels

The beam pipe shape can be adjusted to the expected background.

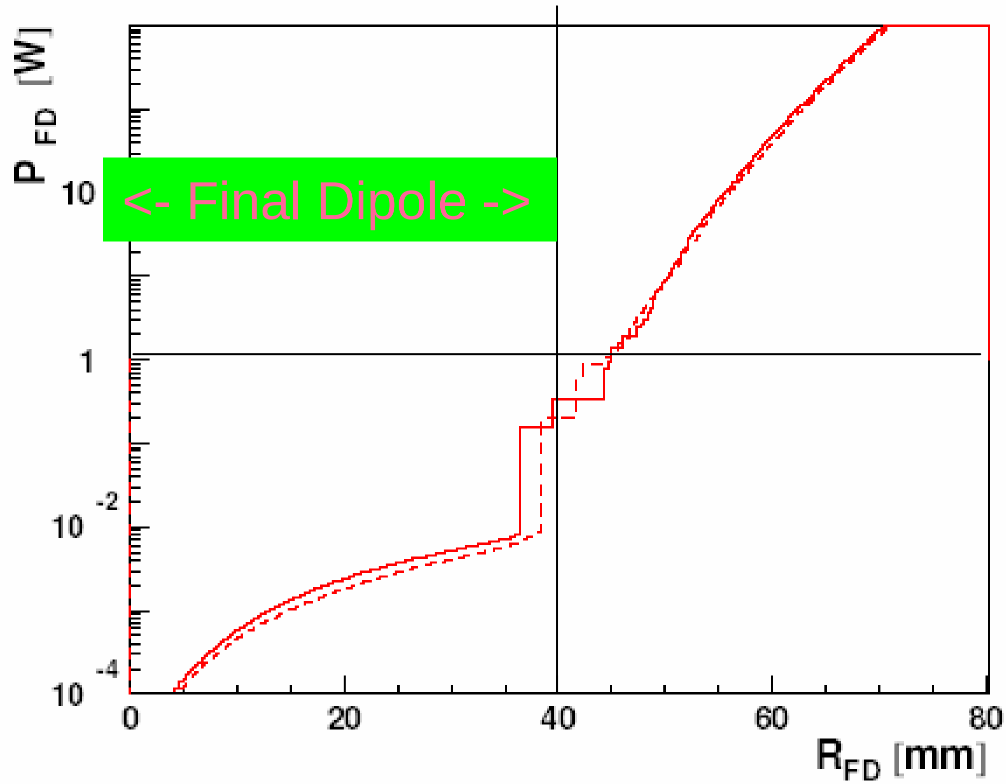
We can also consider surrounding all beams (incoming and outgoing electron beams, as well as las beams) by one large vacuum pipe within the detector volume (idea of V.Telnov)

The crucial point is the background from direct hits at the face of the Final Dipole.

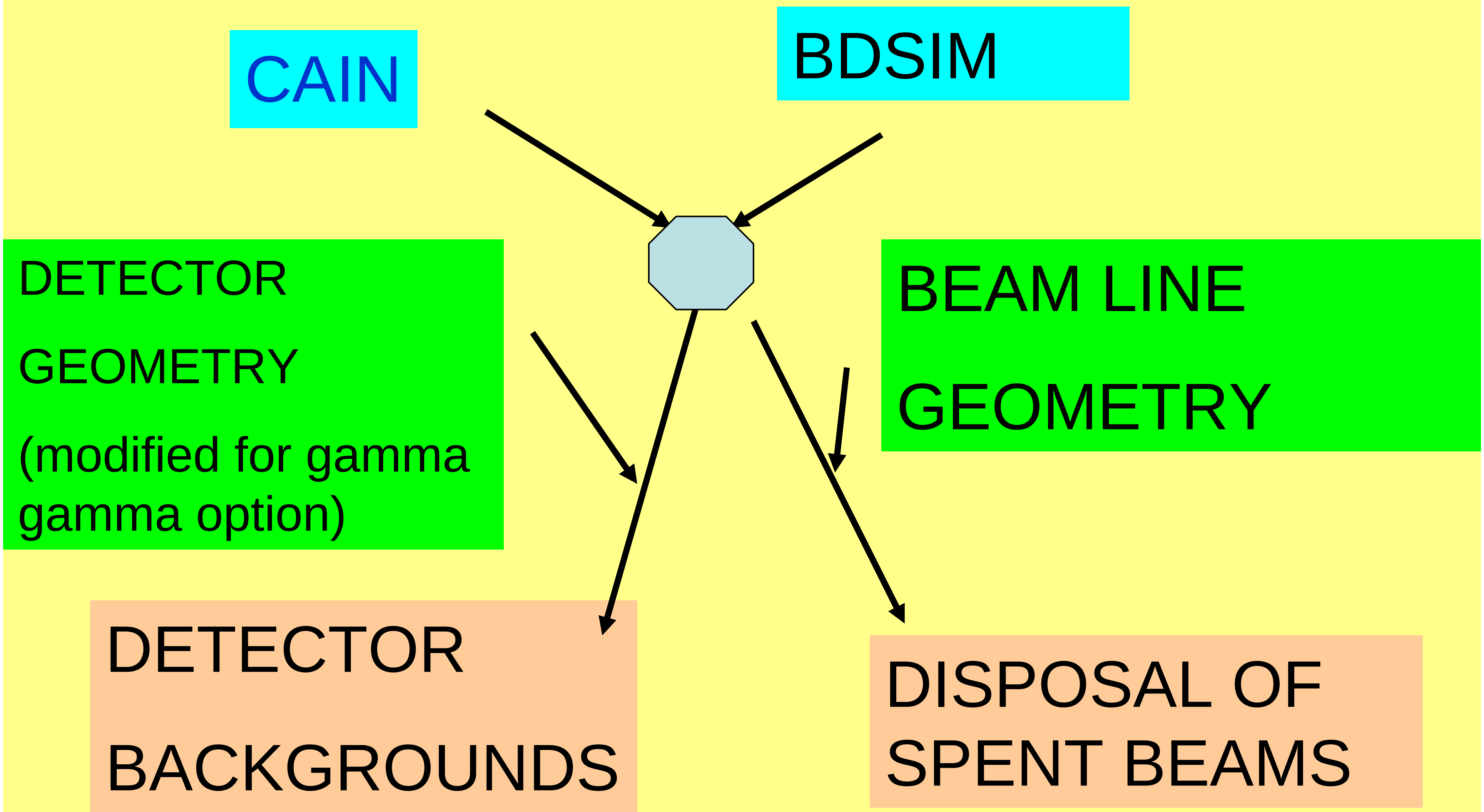
Power hitting the Final Dipole, as a function of the FD outer radius.

Deposit calculated 4.5 m from IP, for magnetic field of 4T.

⇒ Direct deposit below 1 W (for 40 mm radius)



Future directions for background studies…



Optimising ILC for PLC

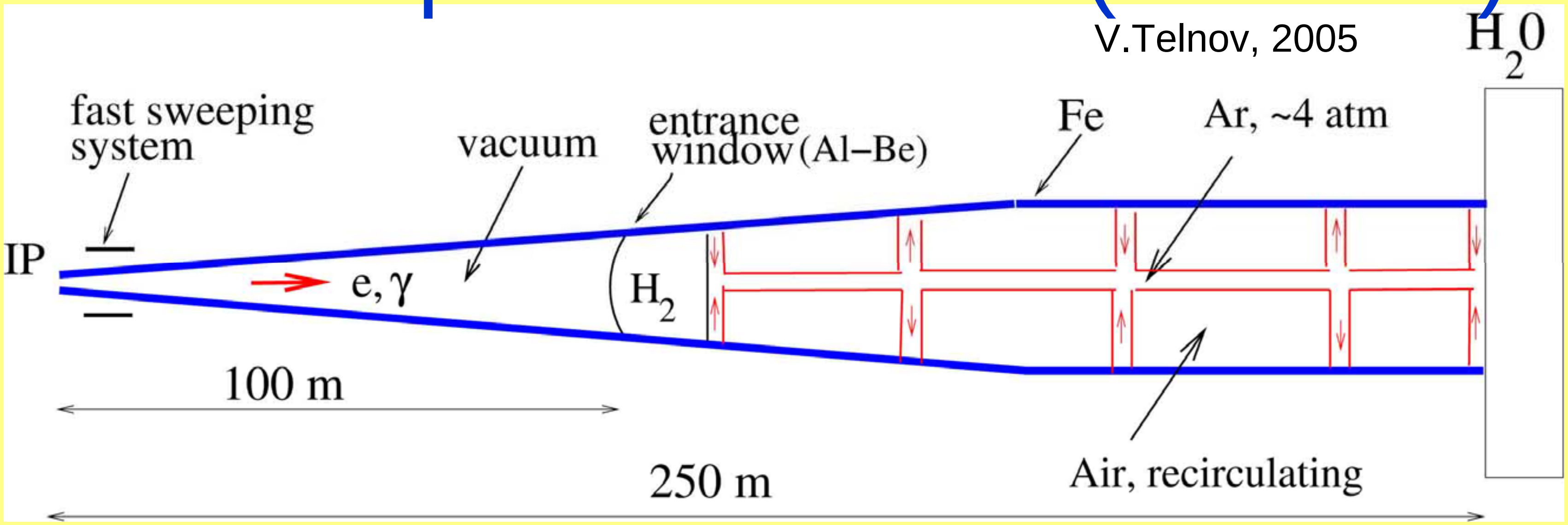
V.Telnov

Having beams with smaller emittances one could increase the $\gamma\gamma$ luminosity by a factor of up to 10.

This could be achieved by adding wigglers to the damping ring.

Needs input from Damping Ring experts so that baseline configuration does not exclude this upgrade option.

Possible scheme of the beam dump for the photon collider (VTelnov)



The photon beam produces a shower in the long gas (Ar) target and its density at the beam dump becomes acceptable.

The electron beam without collisions is also very narrow, its density is reduced by the fast sweeping system. As the result, the thermal load is acceptable everywhere.

The volume with H_2 in front of the gas converter serves for reducing the flux of backward neutrons (simulation gives, at least, factor of 10).

In order to reduce angular spread of disrupted electrons some focusing after the exit from the detector is necessary.

Needs detailed technical consideration!

Other topics

- Telnov
  - Laser cooling
- **S.Roychowdhury** On behalf of **V.Yakmenko, D.Cline ,I.V.Pogorelsky,V.N.Litvinenko**
  - Compton based Polarized Positrons Source for ILC.

Final Thoughts

- 25% of the ILC related Physics talks at this conference were related to gamma gamma.
- No mention of the gamma gamma option in detector concepts or DCR talks.
- Design of the baseline accelerator needs to take account of all possible upgrade options.
- The gamma gamma community are concerned that in the rush to prepare for the $e^+ e^-$ machine, allowance is not being made for a future upgrade to the Photon Linear Collider.