CLIC Post-Collision Line Review

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for the Post-Collision Working Group

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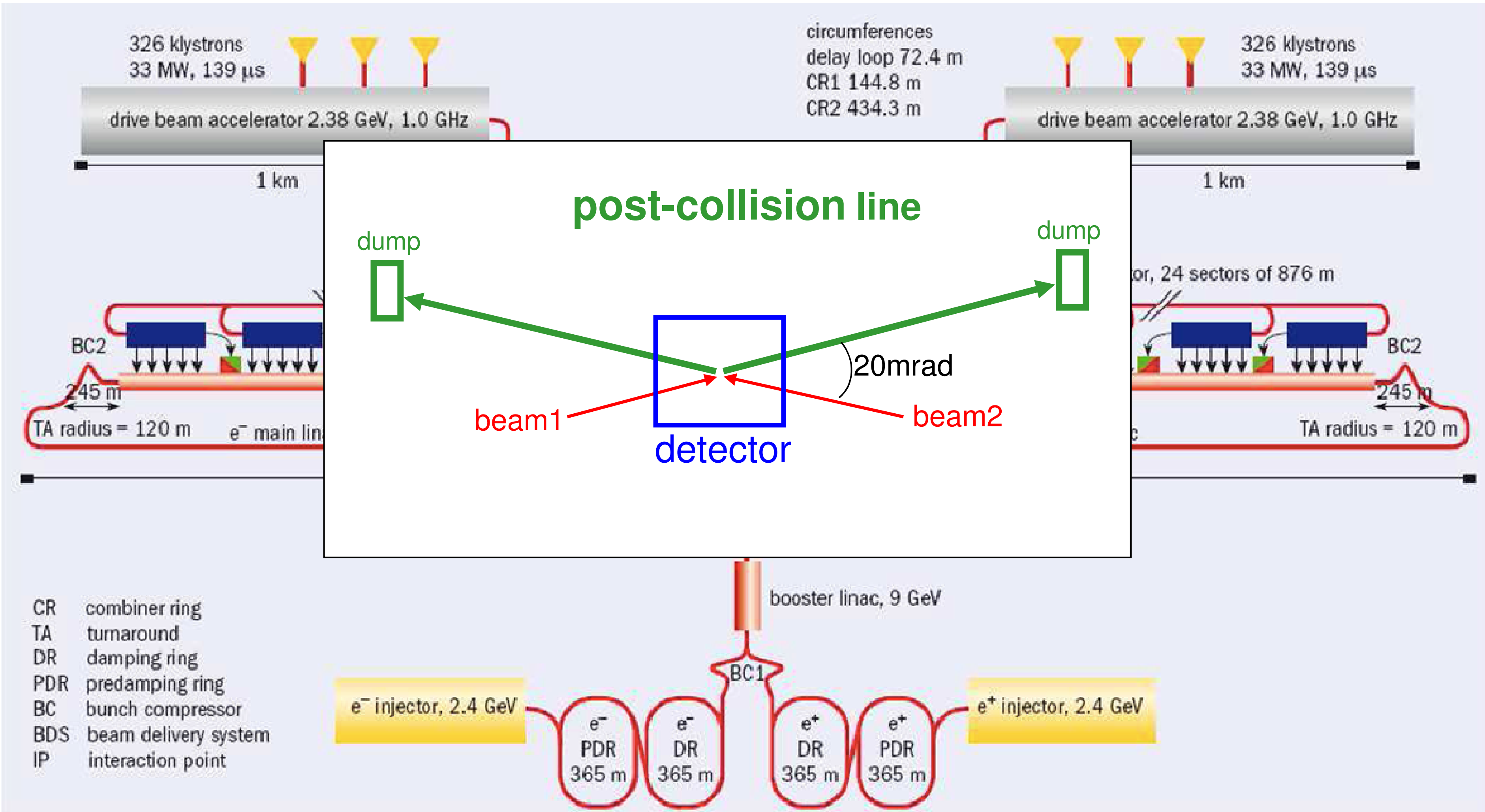
Outline

- Introduction
- Design Considerations
- Present Design
- Critical Issues
- Beam Diagnostics
- Summary

Post-Collision Line



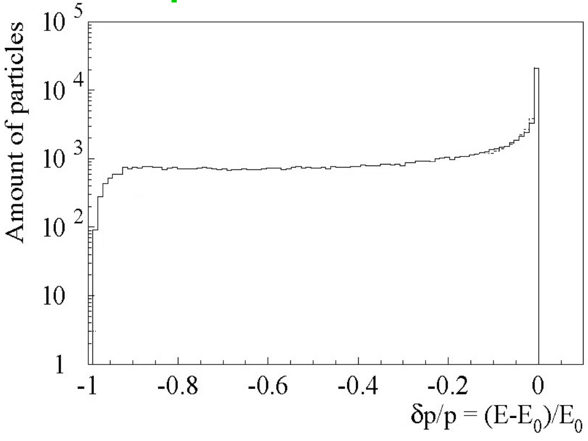
Introduction

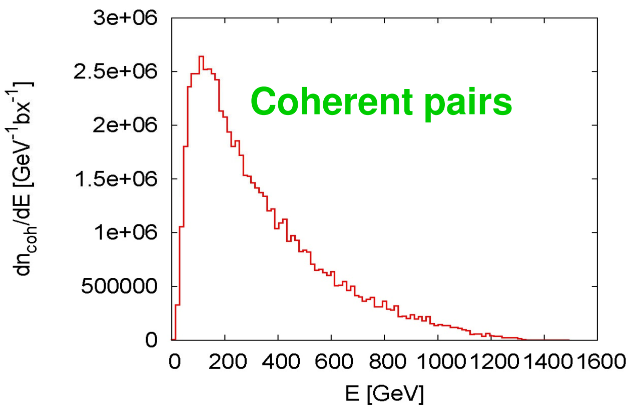
Parameter	CLIC
Max. Center of Mass energy [GeV]	3000
Luminosity $L_{99\%}$ [cm^{-2} sec^{-1}]	2 10^{34}
Bunch frequency [Hz]	50
Bunch spacing [ns]	0.5
# Particles per bunch	3.7 10^{9}
# Bunches per pulse	312
Bunch train length [μs]	0.156
Beam power per beam [MW]	14
Bunch length [μm]	44
Crossing angle [mrad]	20
Core beam size at IP horiz. σ_x* [nm]	45
Core beam size at IP vertic. σ_y* [nm]	0.9

Some Numbers

- e^+e^- collision creates disrupted beam
  - Huge energy spread, large x,y divergence in outgoing beam
    → total power of ~10MW
- High power divergent beamstrahlung photons
  - 2.2 photons/incoming e+e-
    → 2.5 E12 photons/bunch train
    → total power of ~4MW
- Coherent e+e- pairs
  - 5E8 e+e- pairs/bunchX
  → 170kW opposite charge
- Incoherent e+e- pairs
  - 4.4E5 e+e- pairs/bunchX
    → 78 W

disrupted beam at interaction point





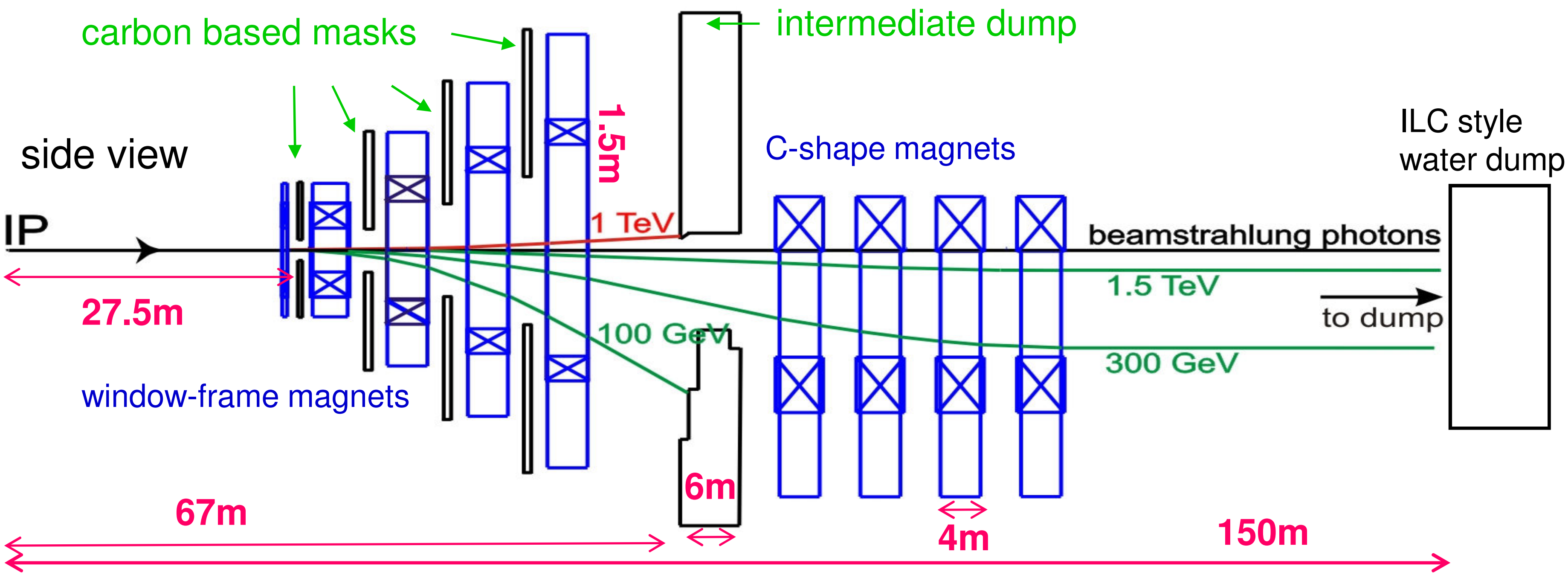
Design Considerations

- Safely transport outgoing electrons and photons from IP to the main dumps
  - Minimize beam loss from strong over-focusing, dispersion of low energy electrons/positrons
  - Protect magnets and diagnostic devices
  - Design of main dump (window, dump vessel, …) with necessary safety margin
  - Minimize background from post collision line to the experiments
  - Stay clear of the incoming beam
- Diagnostics (luminosity monitoring)

Conceptual Design

Baseline: vertical chicane with 2x4 dipoles

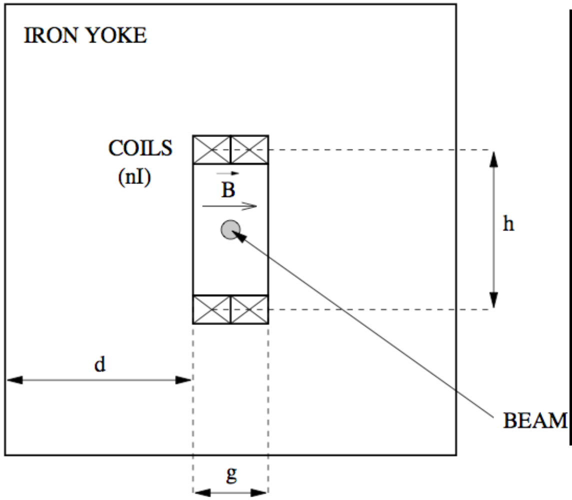
1. Separation by dipole magnets of the disrupted beam, beamstrahlung photons and particles with opposite sign from coherent pairs, from low energy tails
   - → Short line to prevent the transverse beam size from growing too much
   - → Intermediate dumps and collimator systems
2. Back-bending region with dipoles to direct the beam onto the final dump
   - → Long line allowing non-colliding beam to grow to acceptable size



Separation Dipoles, Masks

Dipoles: 4m length, 0.8T

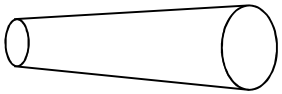
Magnet	Start [m]	Xpipe [cm]	Ypipe [cm]	G [cm]	**H [cm]**	nI [kA] turns
Dipole 1a	27.5	20.0	44.0	22.2	**57.7**	141.3
Dipole 1b	30.5	20.0	44.0	22.2	**57.7**	141.3
Dipole 2	38.0	27.0	70.2	29.6	**83.9**	188.4
Dipole 3	46.0	34.0	102.0	37.0	**115.7**	235.5
Dipole 4	54.0	41.0	139.4	44.4	**153.1**	282.6

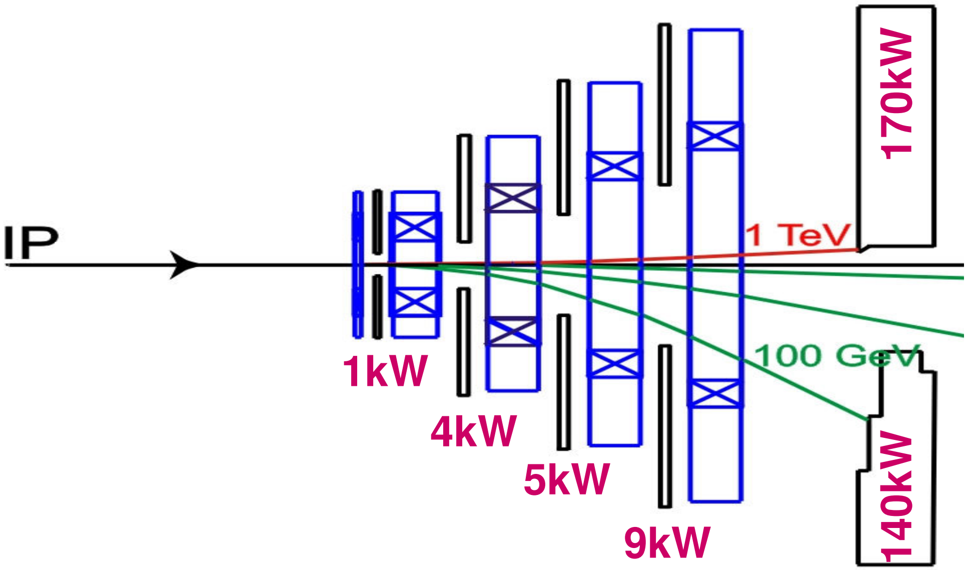


Carbon based masks

Element name	**aperture limitation**
Mask 0	**Y 13.2cm**
Mask 12	**Y 25.6cm**
Mask 23	**Y 57cm**
Mask 34	**Y 92.6cm**
Intermedi-ate Dump	**X 18cm** **Y 86cm**

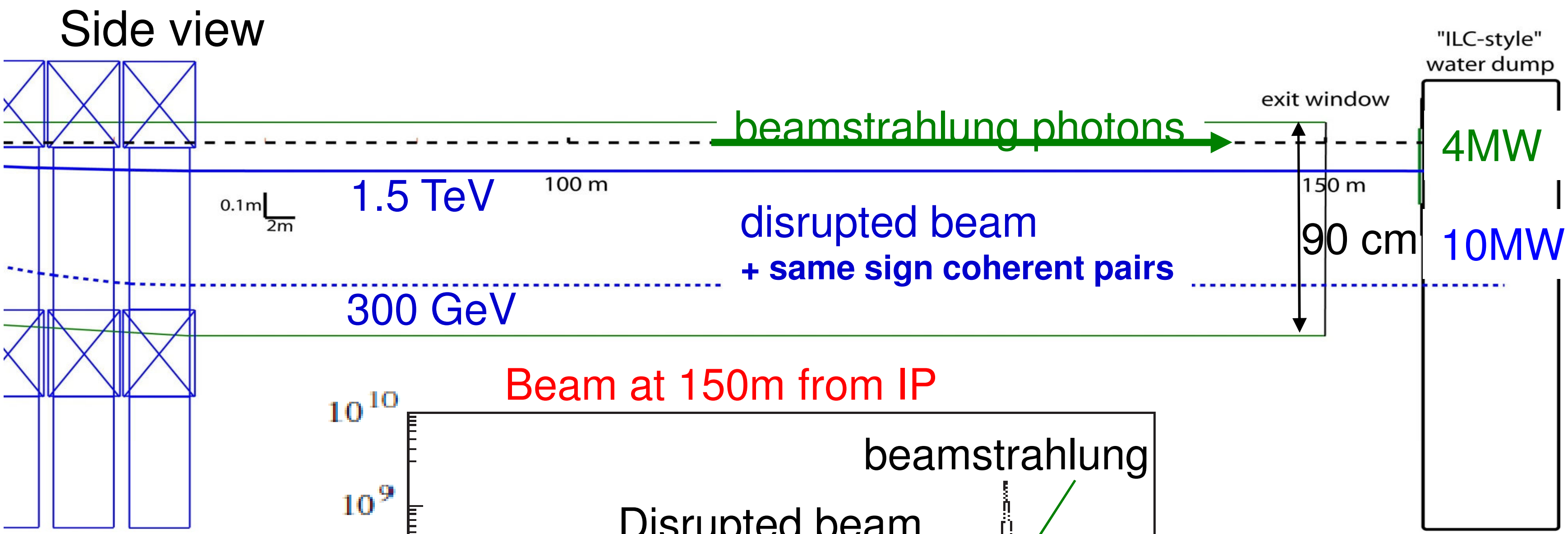
elliptical vacuum tube

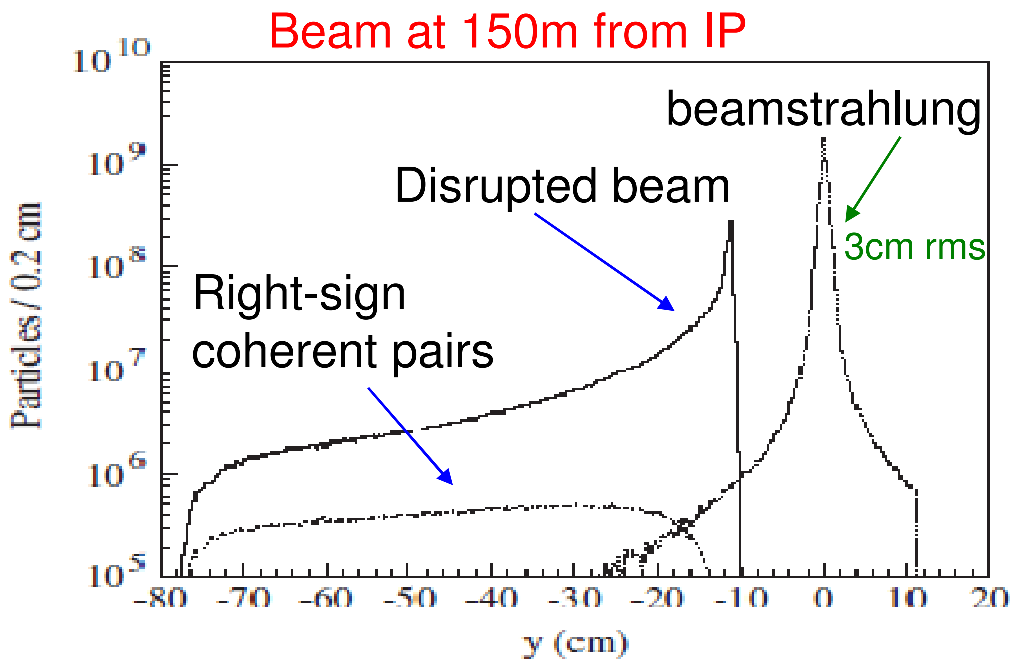




- All wrong-sign charged particles absorbed by intermediate dump
- Low energy tails caught in masks and intermediate dump
- All right-charged particles with $E>0.16xE_0$ and beamstrahlung photons reach the final dump

Present Conceptual Design





A. Ferrari, R. Appleby, M.D. Salt, V. Ziemann, PRST-AB **12**, 021001 (2009)

Critical Issues

Main Dump

Baseline:

ILC style water dump (18MW)

- Issues:
  - Window design
  - Pressure on dump walls, window…
- Blow up of the beam
  - Sweeping magnets
  - Defocusing
- Tail catcher along post-collision line

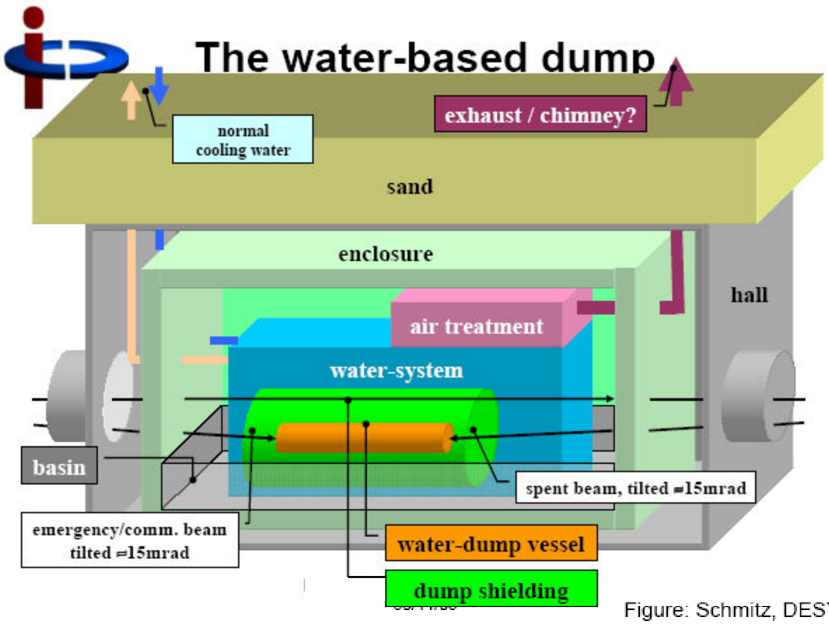
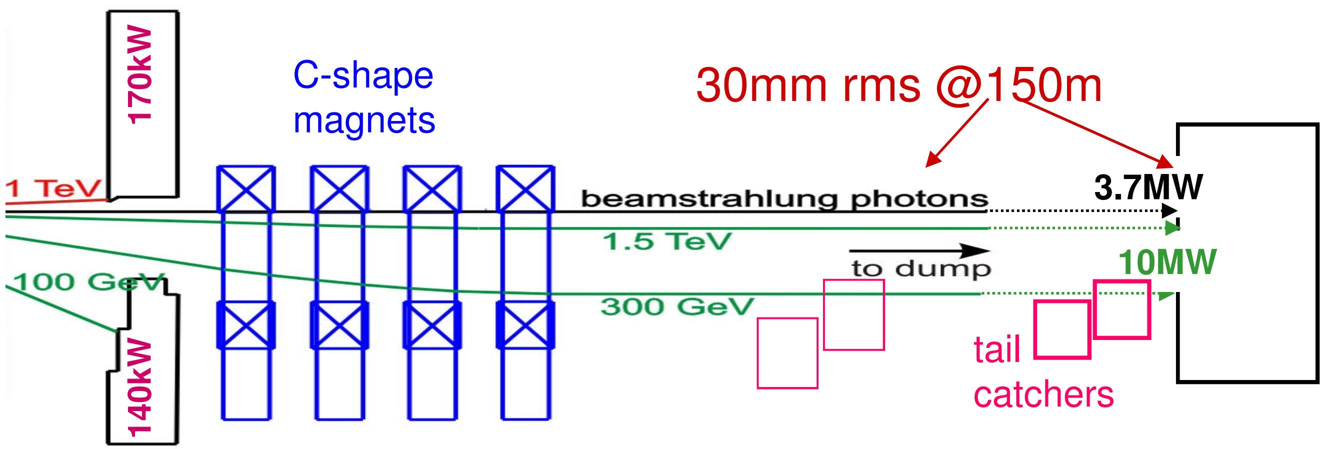
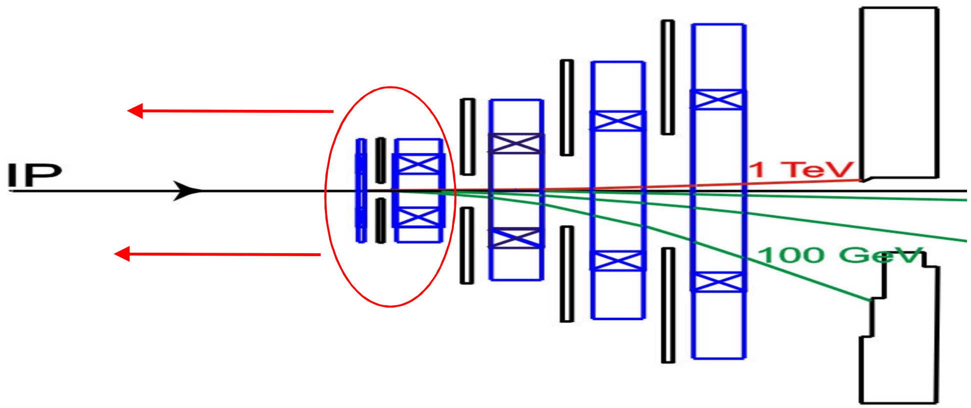
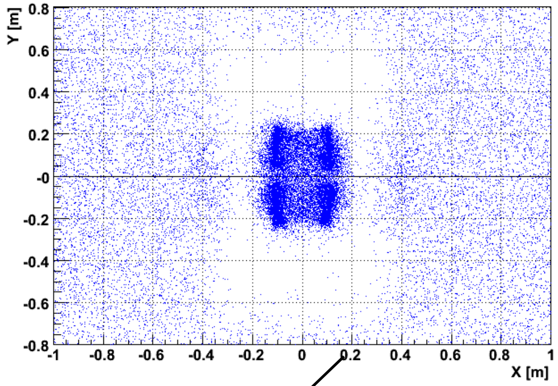


Figure: Schmitz, DESY

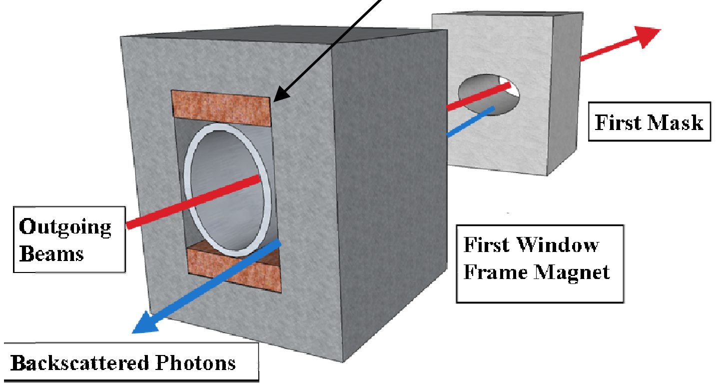


Background from Post-Collision Line to IP





Backscattered on-axis photons



On-axis photon flux at IP from first absorber: 1.1E4/cm^2/s

Next steps:

Extend geometry: add magnets, absorbers, intermediate dump, etc..

→ Photon background

→ Neutron background

Talk by Mike Salt, We 14:30, WG1+WG3

Beam Diagnostics

(Large number of coherent pairs imposes less ambitious diagnostics (w.r.t. ILC) in the post-collision lines:

no energy measurement, no polarimeter -both need to be in BDS)

Crucial item: luminosity monitors

→ Experiments measure luminosity (slowly!)

→ Need fast signal for monitoring and correcting beam

- beam-beam offset: effect on beamstrahlung photons and coherent pairs → related to luminosity!
- Monitoring per ≤ bunch train
- Measure relative changes

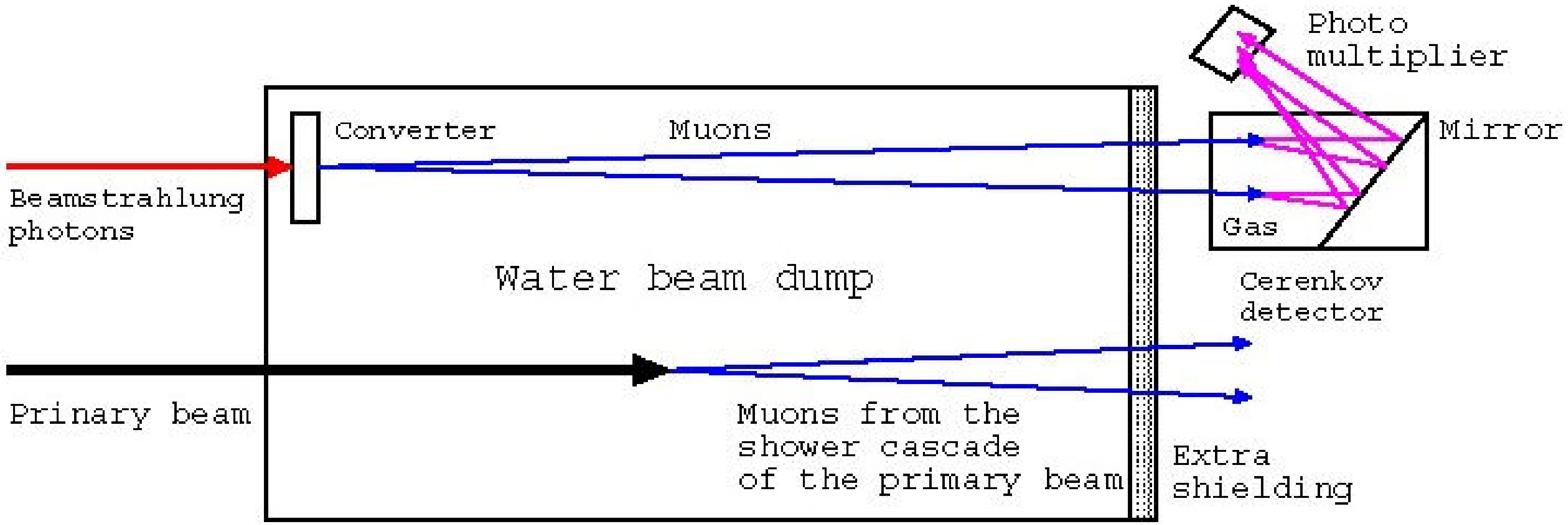
Some ideas on luminosity monitoring:

→ Volker Ziemann, EUROTeV-Report-2008-016

Luminosity Monitoring: $\mu^+\mu^-$ pair production

- Converter in main dump → muons
  → install detector behind dump
  - With a Cherenkov detector: 2 E5 Cherenkov photons/bunch

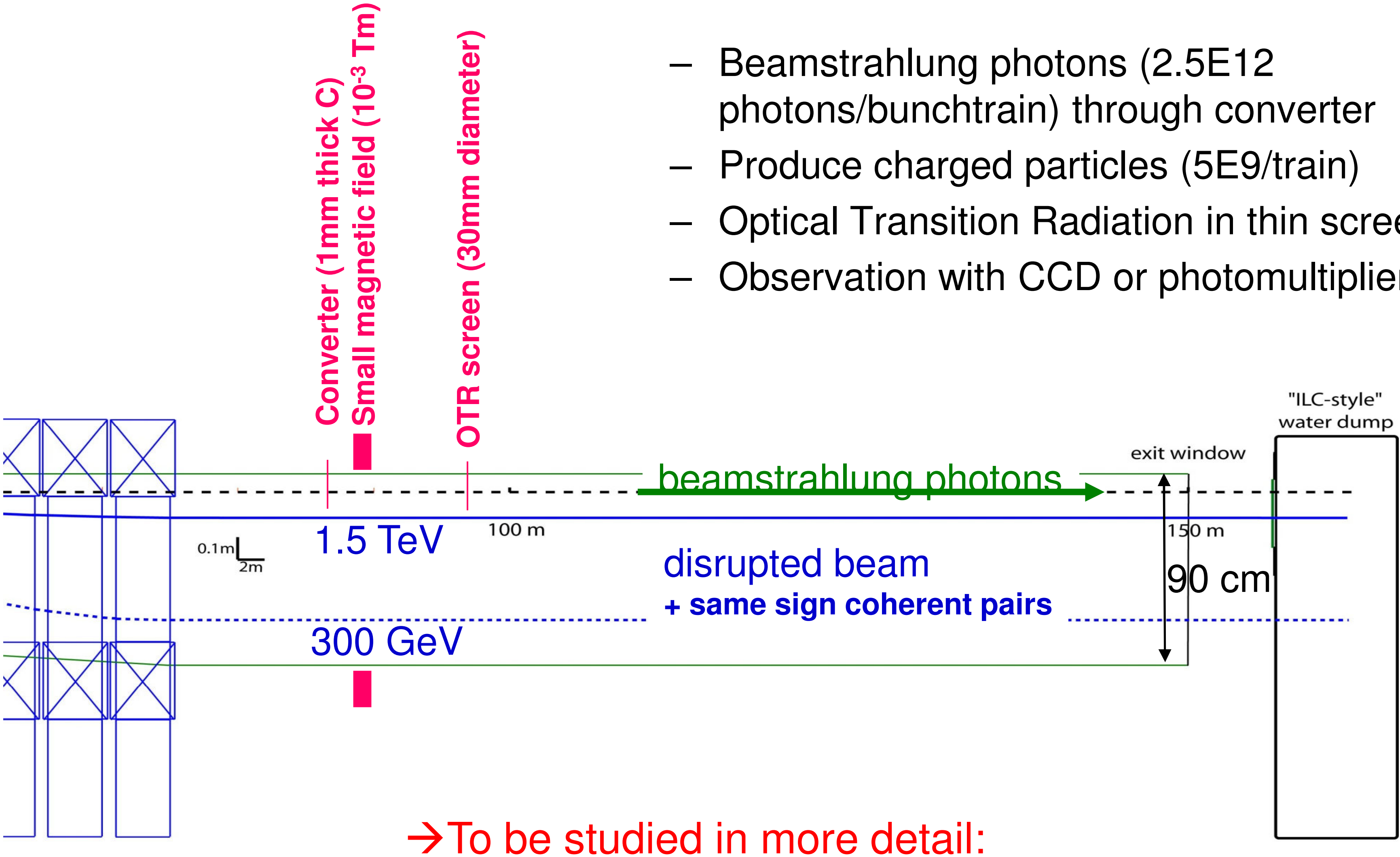
EUROTeV-Report-2008-016



→ To be studied in more detail: background, converter, detector, etc..

Luminosity Monitoring: e+e- pair production

- Beamstrahlung photons (2.5E12 photons/bunchtrain) through converter
- Produce charged particles (5E9/train)
- Optical Transition Radiation in thin screen
- Observation with CCD or photomultiplier



→To be studied in more detail:
→background, detector, etc..

Summary

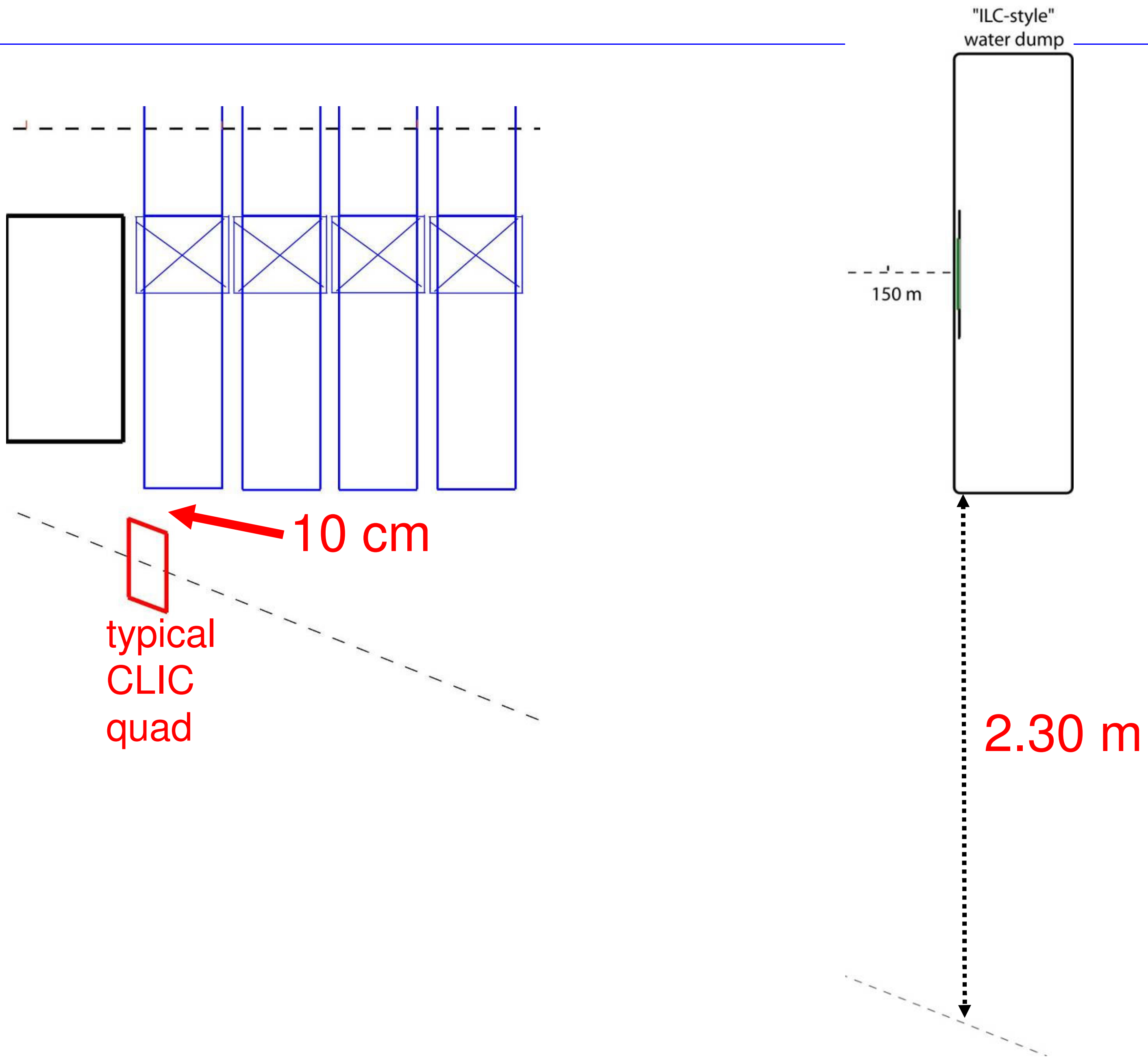
Conceptual design of the post-collision line exists

- We are in the process of forming a working group (project associate, PhD student…) concentrating on issues such as:
  - Calculations of Background to IP
    - Photons
    - neutrons
  - Beam diagnostics
    - Luminosity
    - Background to monitors

- More work needs to done on
  - Beam Dump
    - Type, entrance window
    - Background from dump
  - Large beam spot size at dump
    - Sweeping magnets or defocusing
  - Collimator and intermediate dump design
  - Magnet design
  - Radiation in post-collision line

→Contributions from ILC experts on Post-collision line, dump design, polarimetry are most welcome!

Extra slides


"ILC-style"
water dump
150 m
10 cm
typical
CLIC
quad
2.30 m