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of Accelerator Science and Technology

Electromagnetic Background From Spent Beam Line

Michael David Salt (Cockcroft Institute – Optics, Backgrounds)
Robert Appleby (CERN – Design, Optics, Backgrounds)
Arnaud Ferrari (Uppsala Universitet – Design, Optics, Backgrounds)
Konrad Elsener (CERN – Design, Consultancy)
Edda Gschwendtner (CERN – Post-IP Co-ordinator)

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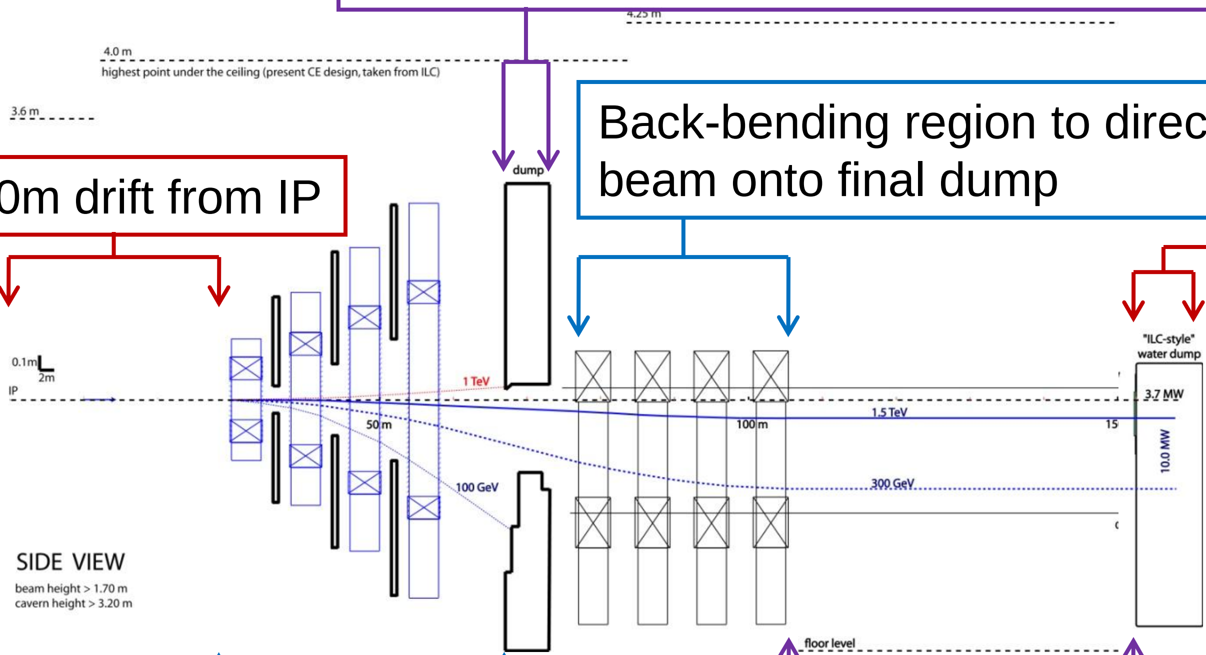
Extraction Line Overview

Intermediate dump for coherent-pair, wrong-sign particles

Back-bending region to direct beam onto final dump

30m drift from IP

Final dump



45m drift to final dump

Forward-bending region to separate disrupted beam, coherent pairs and beamsstrahlung photons

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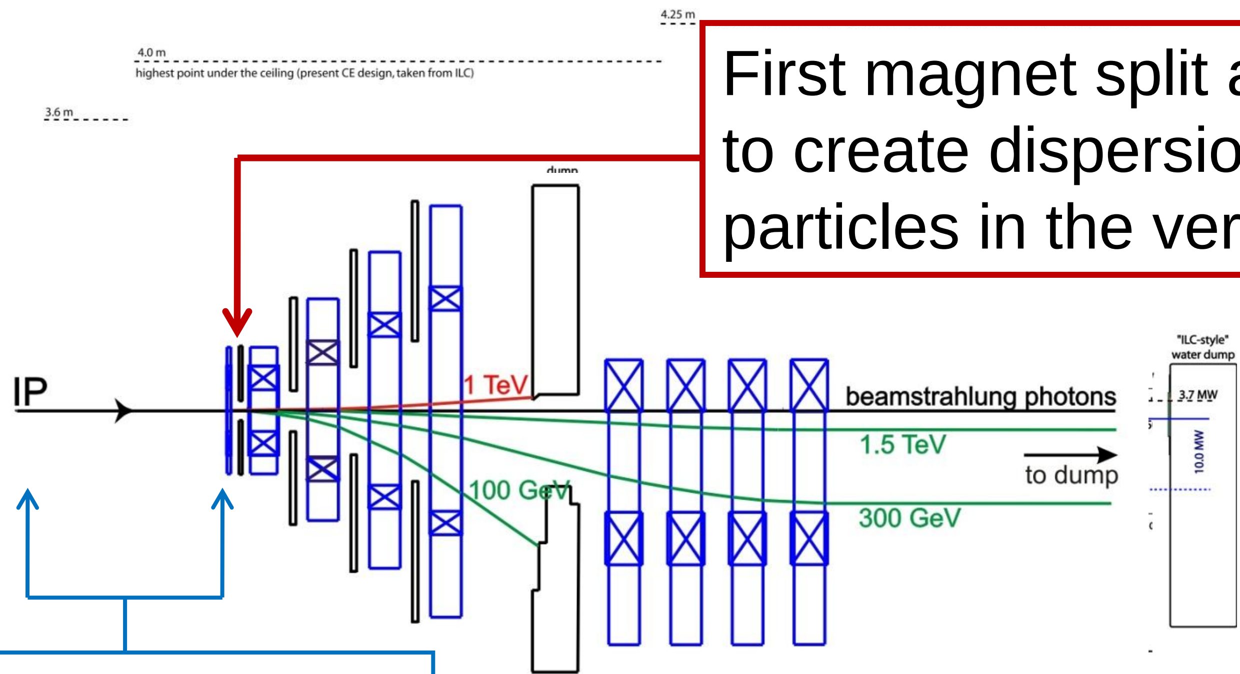
Extraction Line Overview

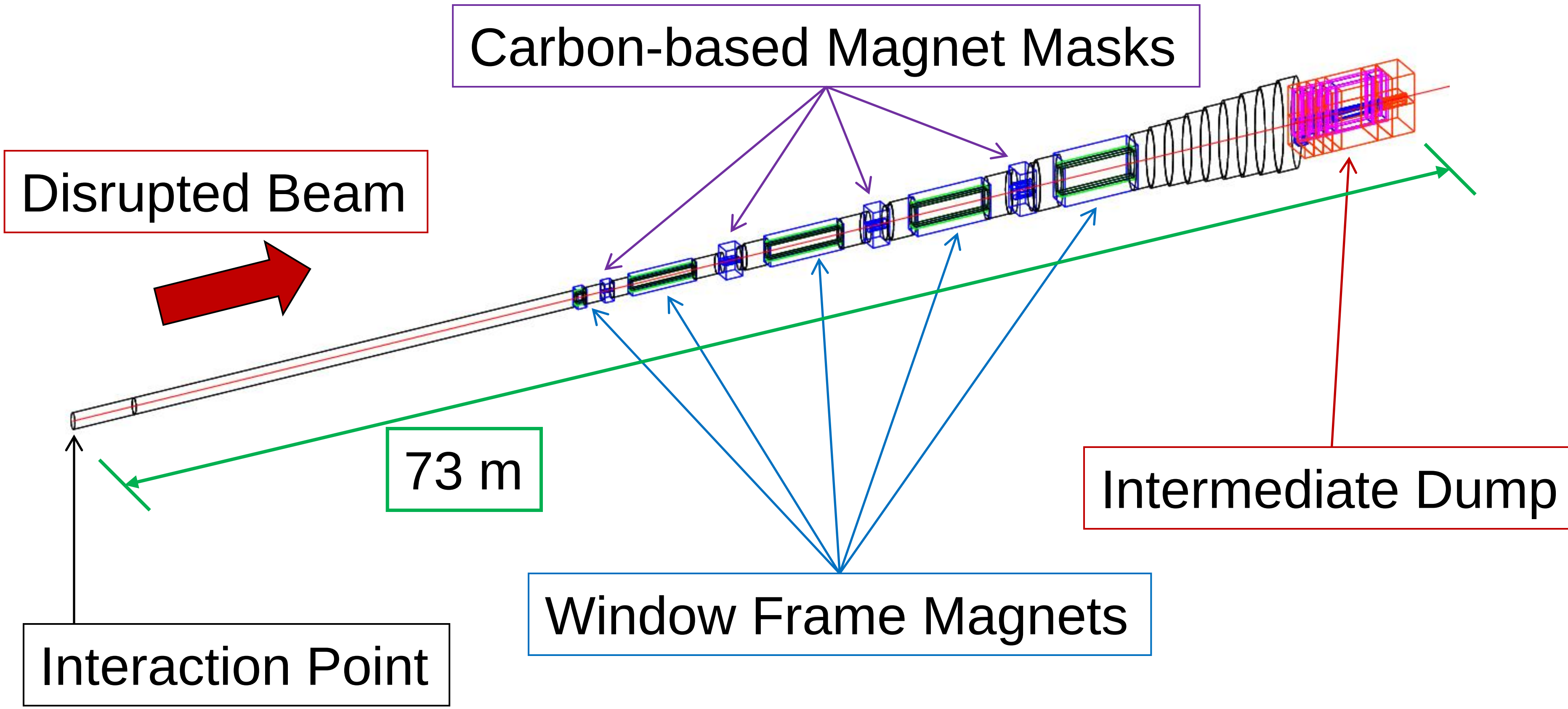
First magnet split and mask inserted to create dispersion to remove particles in the very-low energy tail



27.5 m drift from IP

*Design published in; "A. Ferrari, R. Appleby, M.D. Salt, V. Ziemann, *Conceptual design of a beam line for post-collision extraction and diagnostics at the multi-TeV Compact Linear Collider* , PRST-AB **12**, 021001 (2009)"

3D View up to the Intermediate Dump



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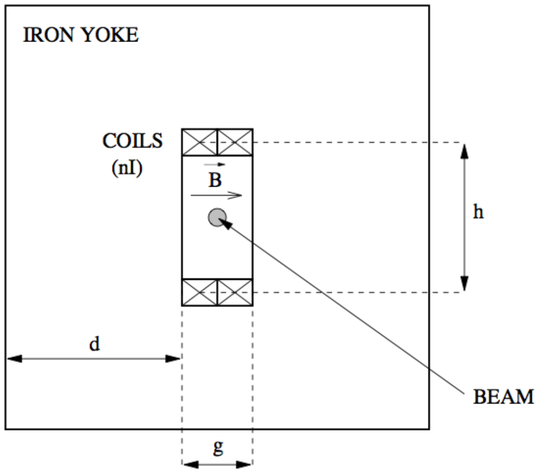
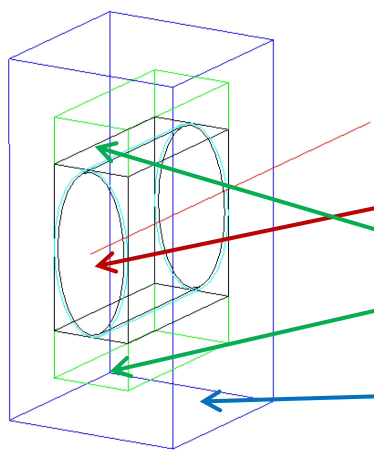
Window Frame Magnets



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



Elliptical vacuum tube

Copper coils (B = 0.8T for all window-frame magnets)

Iron flux return (acts as shield against backscatterered downstream photons)

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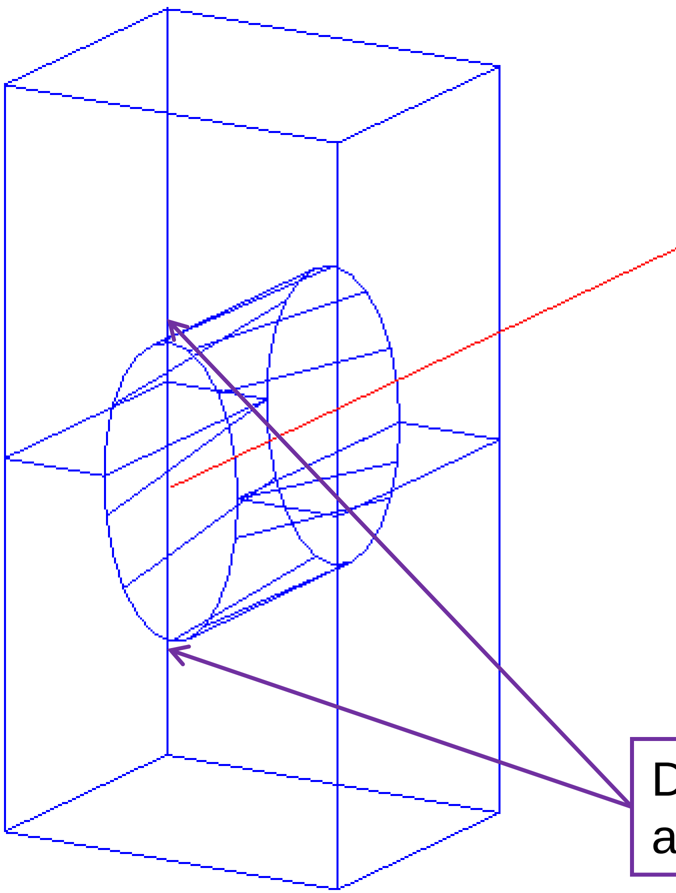
Magnet Protection Masks



Element name	Upper aperture limitation	Lower aperture limitation	Main beam loss [kW]	Same sign CP loss [kW]	Wrong sign CP loss [kW]
Coll 0	Y 6.6cm	Y 6.6cm	0	0	0.98
Coll 12	Y 8.7cm	Y 12.8cm	0.47	0.47	3.05
Coll 23	Y 25.2cm	Y 28.5cm	2.23	1.78	0.66
Coll 34	Y 43.5cm	Y 46.3cm	4.12	2.72	1.89
Dump 1			96.2	35.2	170.1

Due to vertical dispersion, most losses are on the top and bottom of the aperture

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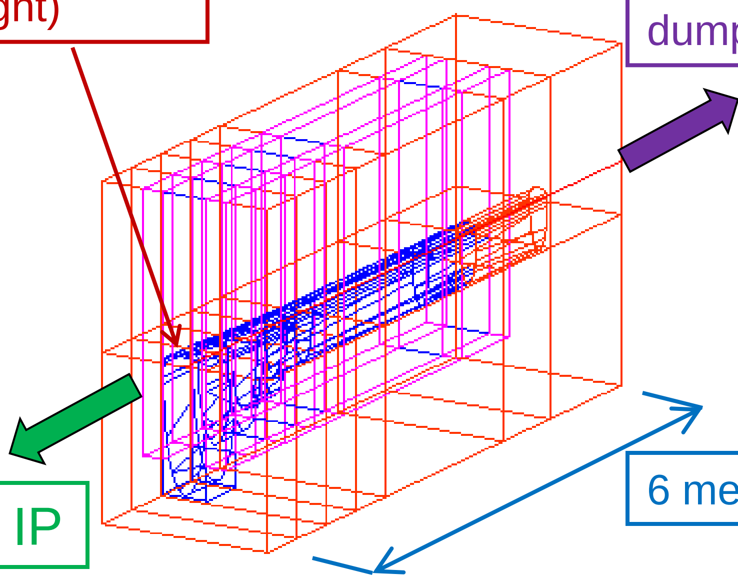
Intermediate (wrong-charge) Dump



- All wrong-charge particles absorbed by upper part of dump
- Right-charge particles with energy >16% of nominal pass through
- Losses:
  - Disrupted beam: 96.2 kW
  - Coherent pairs
    - Same-sign: 35.2 kW
    - Wrong-sign: 170.1kW

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Backgrounds due to Extraction-Line Losses

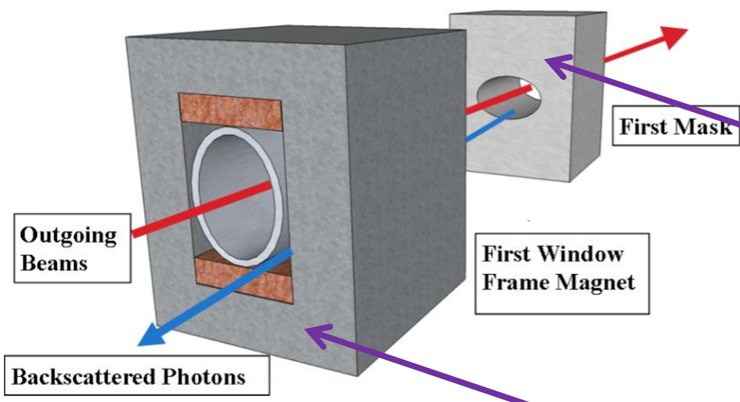
- Losses in the carbon-based absorbers dominated by electromagnetic showering
- Losses in water-based absorbers dominated by hadronic showering (neutrons)
- Shower evolution produces backscattered particles incident on the I.P. → Background Contribution

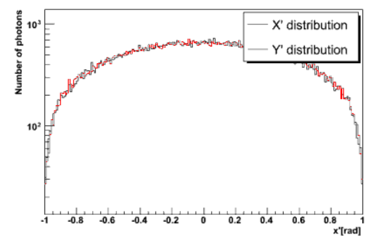
Photon Background Contribution Calculation

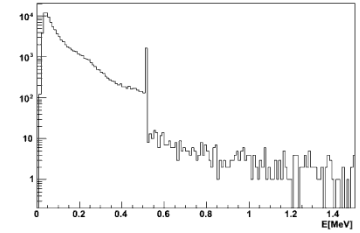
- First magnet and mask identified as key source due to I.P. proximity and lack of shielding
- Post-IP particles generated using gaussian beams and GUINEA-PIG[1] (1,353,944 coherent pairs)
- Post-IP particle trajectories and showering simulated using BDSIM[2], a GEANT4[3] Toolkit
- Cuts set at 10 keV, magnets and mask modelled using the Mokka interface
- Results obtained at s = 0.0 m, on-axis flux defined as R<1.38 m (maximum silicon extent)

[1] D. Schulte, Ph.D Thesis, University of Hamburg, 1996, TESLA 97-08.
[2] I. Agapov, G. Blair, J. Carter, O. Dadoun, The BDSIM Toolkit, EUROTeV-Report-2006-014-1.
[3] S. Agostinelli et. al., GEANT4 - A Simulation Toolkit, Nucl. Instrum. Methods A506 (2003) 250-303, http://geant4.CERN.ch.

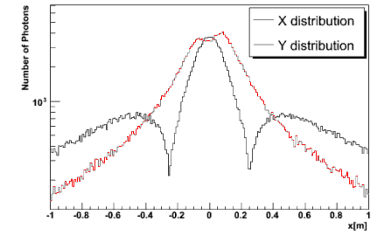
Photon Background Sources

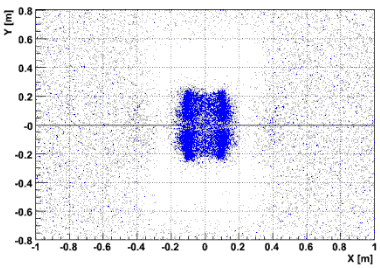


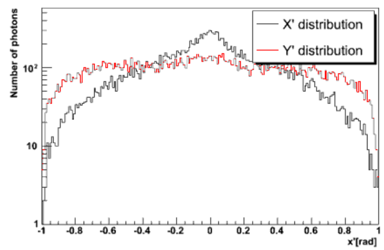


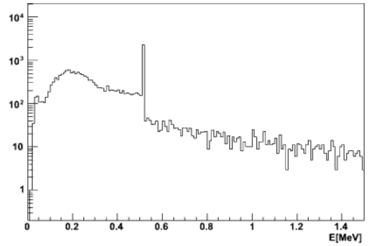


Backscattered photons at the entrance to the first mask (s = 29.0 m)









Backscattered photons at the entrance to the first magnet (s = 27.5 m)

Photon Backgrounds at the IP

- The photon flux at the IP, before considering any impact on the detector is;

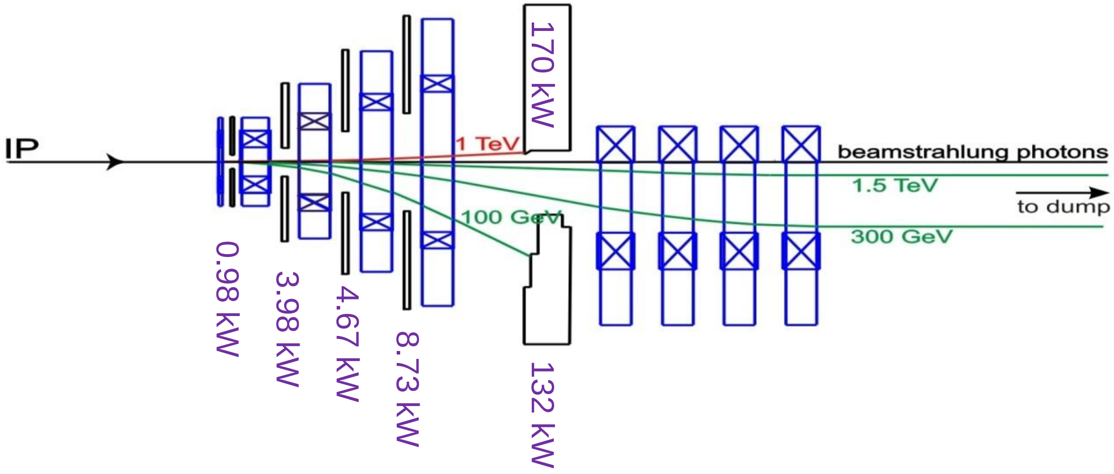
0.727 +/- 0.048 photons cm^{-2} per bunch crossing

11300 +/- 740 photons cm^{-2} s^{-1}

*Results published in; "M.D. Salt et.al.,*Photon Backgrounds at the CLIC Interaction Point due to Losses in the Post-Collision Extraction Line Design,* PAC2009 – Awaiting Publication"

Continued Simulation

- Model built up to and including the intermediate dump
- Trial run reveals massive electromagnetic showering leading to prohibitive computing costs
- Need to reduce computational demand
  - Electromagnetic leading particle biasing in GEANT4



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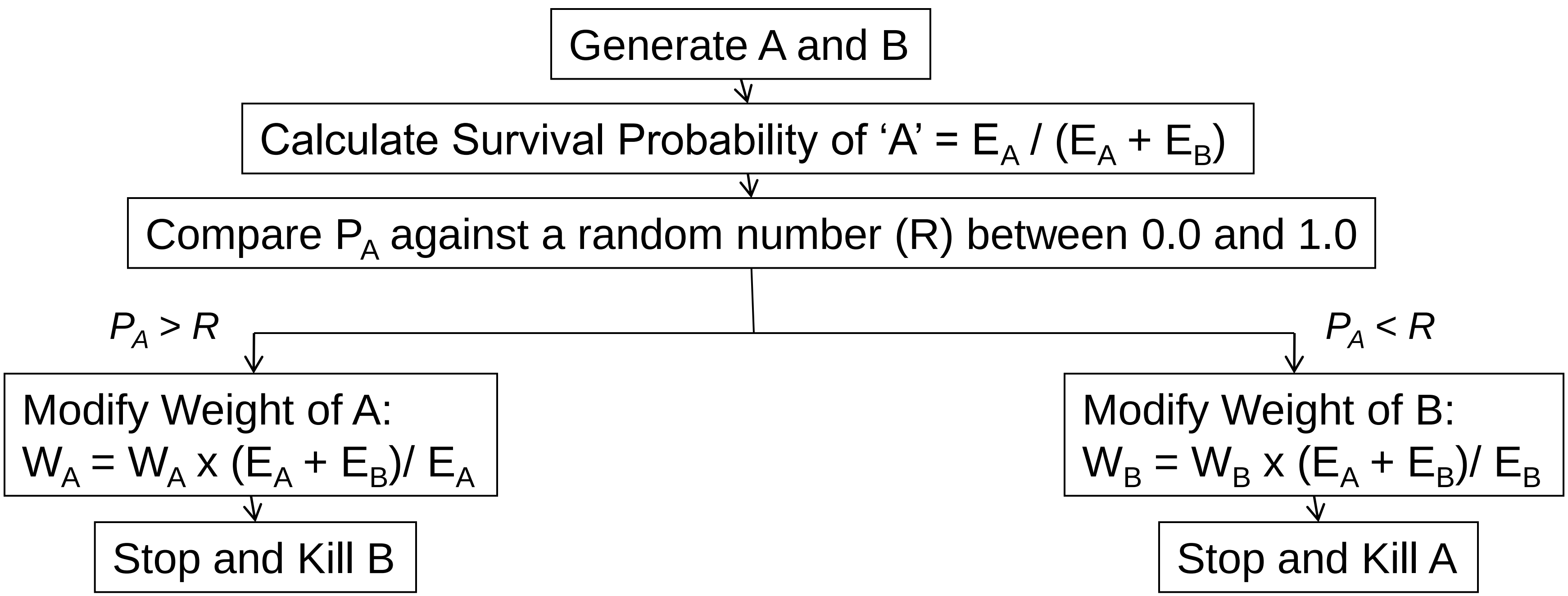
GEANT4 EM-LPB

- GEANT4 contains leading particle biasing for hadronic processes only
- EM shower parameterisations not suitable because flux numbers require single particle tracking
- User-defined EM-LPB method implemented and tested in GEANT4 (R. Appleby, M.D. Salt)
- Reduces computational demand by reducing shower multiplicity

LPB Algorithm

- Pair Production and Bremsstrahlung always produce two secondary particles, let us call them ‘A’ & ‘B’



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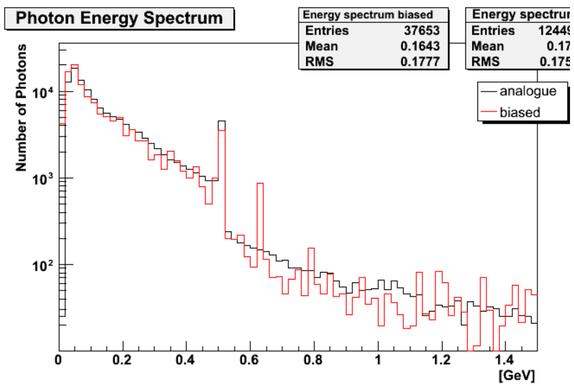
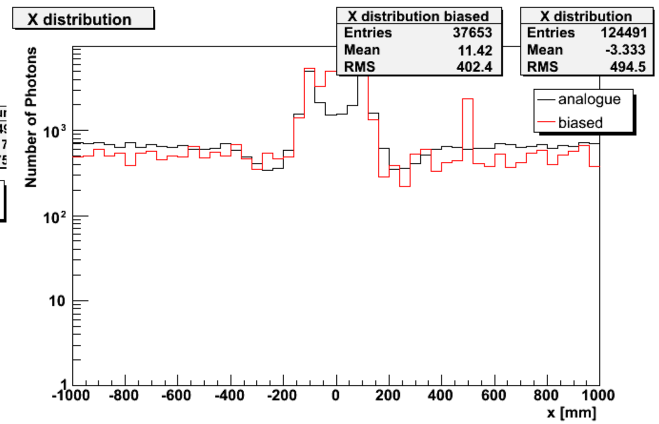
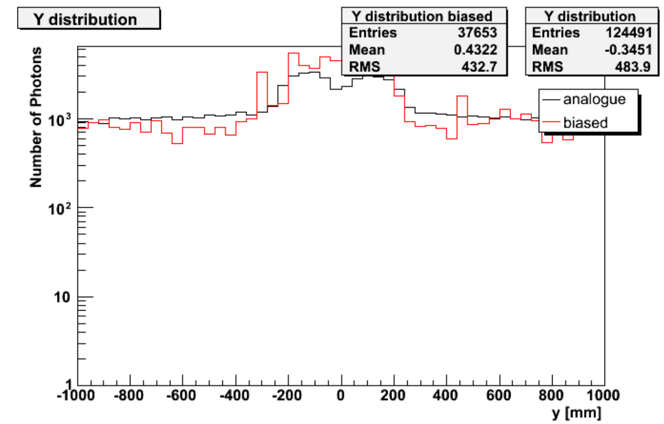
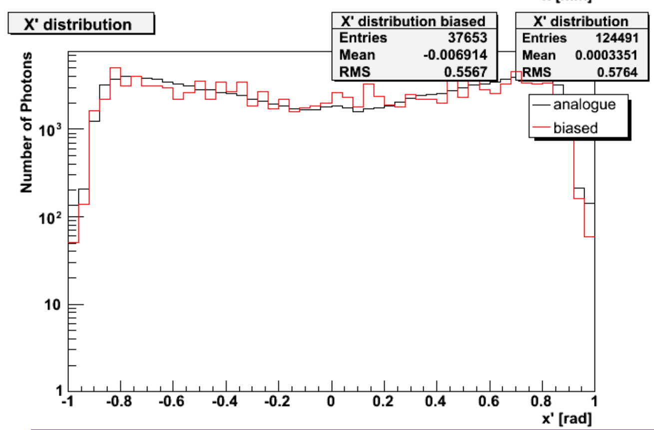
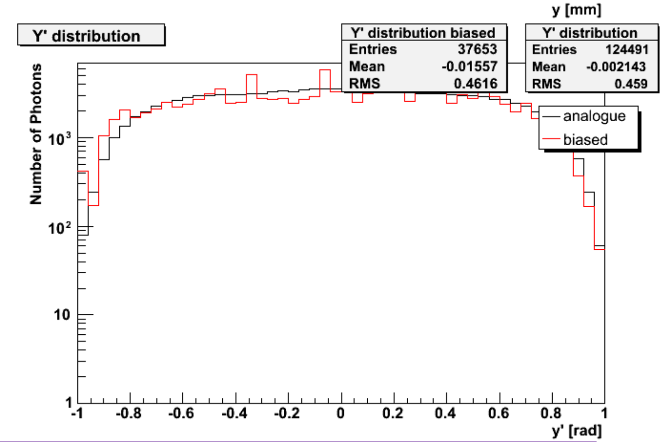
GEANT4 EM-LPB











Performance increase in this example ~ 6x reduction in real time (variable depending on application)

Photon flux is 0.727+/-0.048 photons per cm^2 per BX
Biased photon flux is 0.677+/-0.075 photons per cm^2 per BX

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Post-IP line and GEANT4 EM Leading Particle Biasing

- Leading particle biasing methods substantially reduce computation time
- Technique is just a few routines in GEANT4, and easily added to BDSIM through a new physics list
- Statistically, the results between the biased and analogue methods appear consistent
- Continue to use EM-LPB to create a photon background study for the full line
- Expand study to include realistic beams and forward region components

Summary

- Post-IP study presents many diverse challenges
  - Engineering (magnet design, tunnel clearances)
  - Optics (beam loss, beam exit size)
  - Physics (showering in material, backgrounds)
  - Instrumentation (post-IP luminosity monitoring)
  - Computation (keeping computing costs realistic)
- Done so far
  - Lattice design (minimalist non-focussing dispersive design)
  - Beam loss calculation and identification of key backgrounds
  - Photon background calculation from dominant source
- Much left to do
  - Background calculation from whole line including dumps
  - Detector model and effects to be added
  - Neutron study
  - Dump design

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Thank You

Michael.Salt@hep.manchester.ac.uk

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