QUEEN'S UNIVERSITY BELFAST

LUXE experiment at the Eu-XFEL

Monte-Carlo simulations

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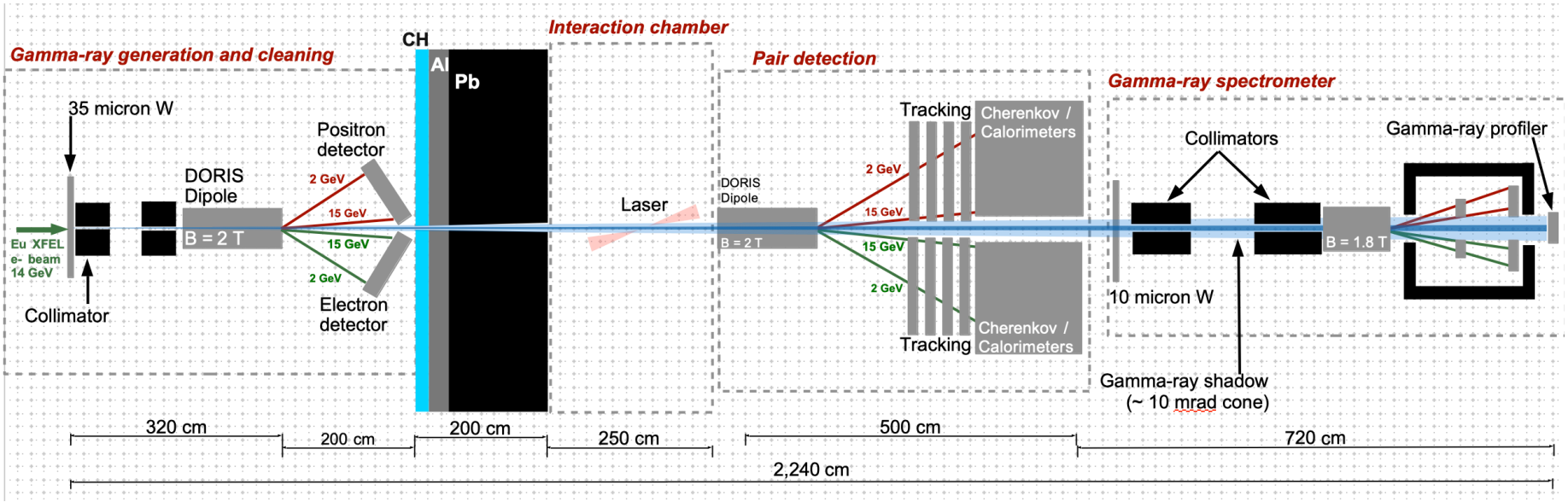
Scaled setup drawing

Setup



NOTES:

1. Assumption of 6×10^9 electrons at 14 GeV (setup easily extendible to 17 GeV). Setup designed to minimized noise in the "pair detection" area, where S/N better than 10^7 is desirable.
2. First two collimators have a diameter of 1mm and 4mm, while the beam dump is made of 20 cm of plastic, followed by 30 cm of Al and 1.5m of Pb. The aperture is conical, to accommodate the main gamma-ray cone from the first two collimators (10 mrad cone).
3. The light blue cone represents the shadow of photon noise coming from the rest of the setup, whereas the dark blue cone represents gamma-rays with energies > 1 GeV from the bremsstrahlung target.
4. The whole setup is in scale (each dashed box represents 20 x 20 cm) , including the gamma-ray cones and the particle deflections

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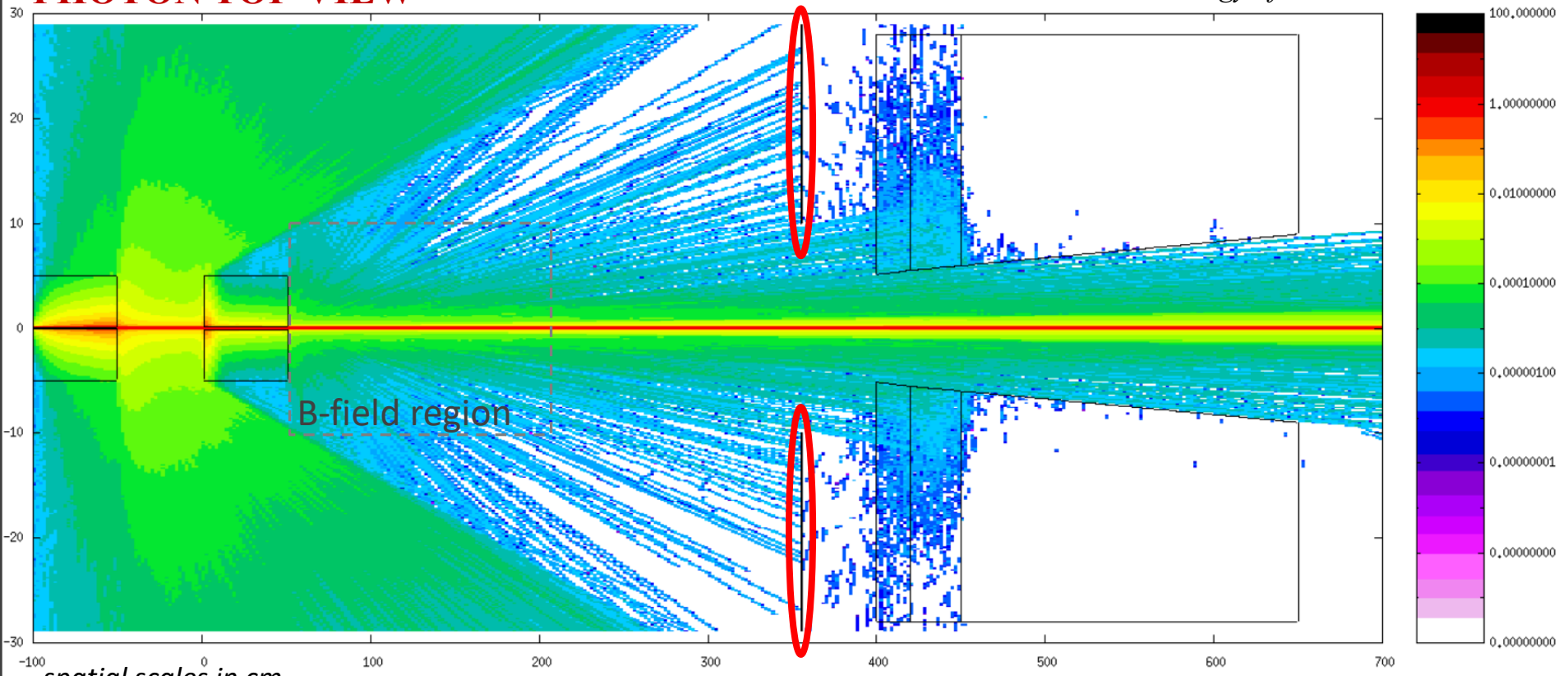
Particle distributions from FLUKA

Full simulation

Given that previous simulations have shown that the beam-dump completely kills the electron beam, we replace it with a total absorber (black-hole in FLUKA) to save computation time

PHOTON TOP-VIEW

Initial beam: 10^7 electrons with an energy of 14 GeV



spatial scales in cm

Ideal Absorbers (Blackhole)

colourbar in particles per primary per cm²
bin size = 0.25 cm²

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Full simulation

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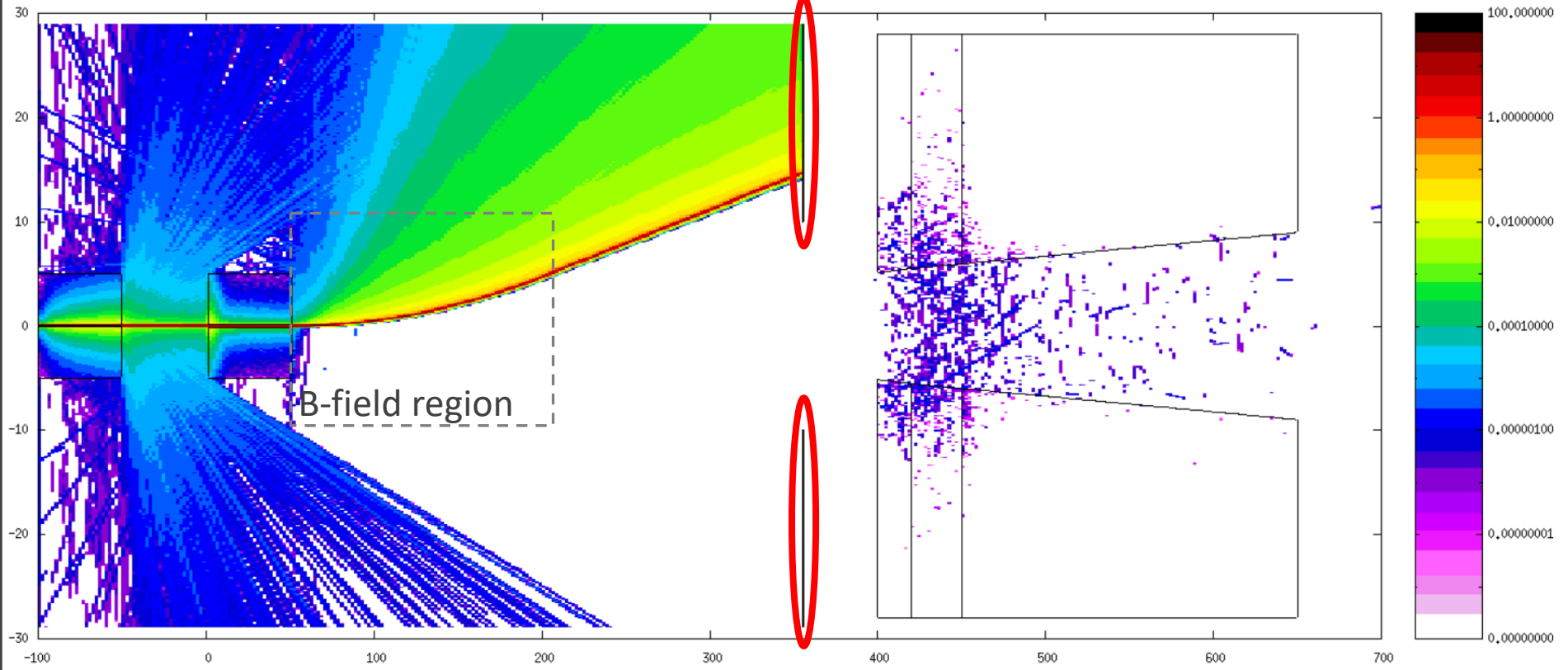
ELECTRON TOP-VIEW

Initial beam: 10^7 electrons with an energy of 14 GeV



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POSITRON TOP-VIEW

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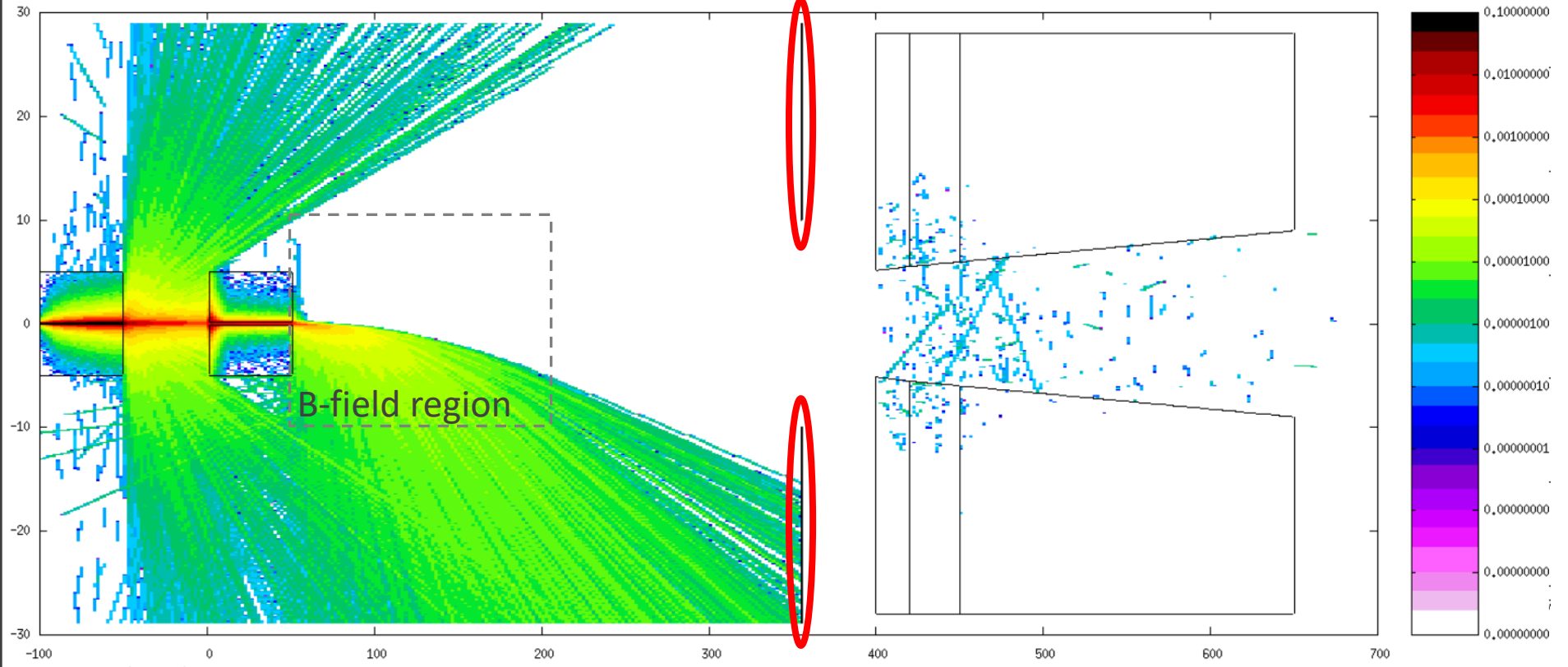


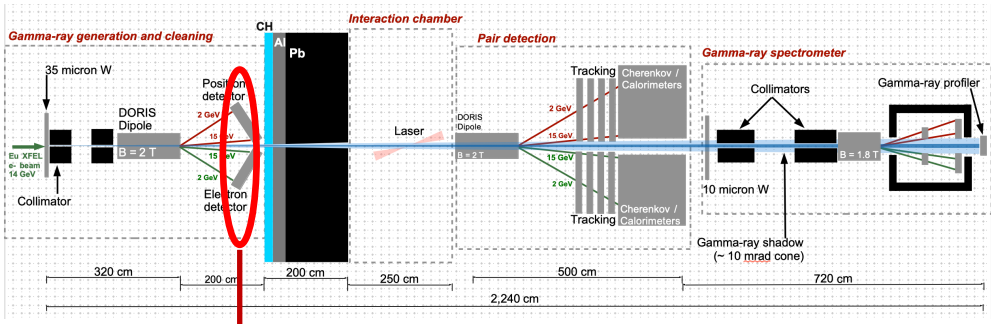
spatial scales in cm

Ideal Absorbers (Blackhole)

colourbar in particles per primary per cm²
bin size = 0.25 cm²

Particle distributions before the dump

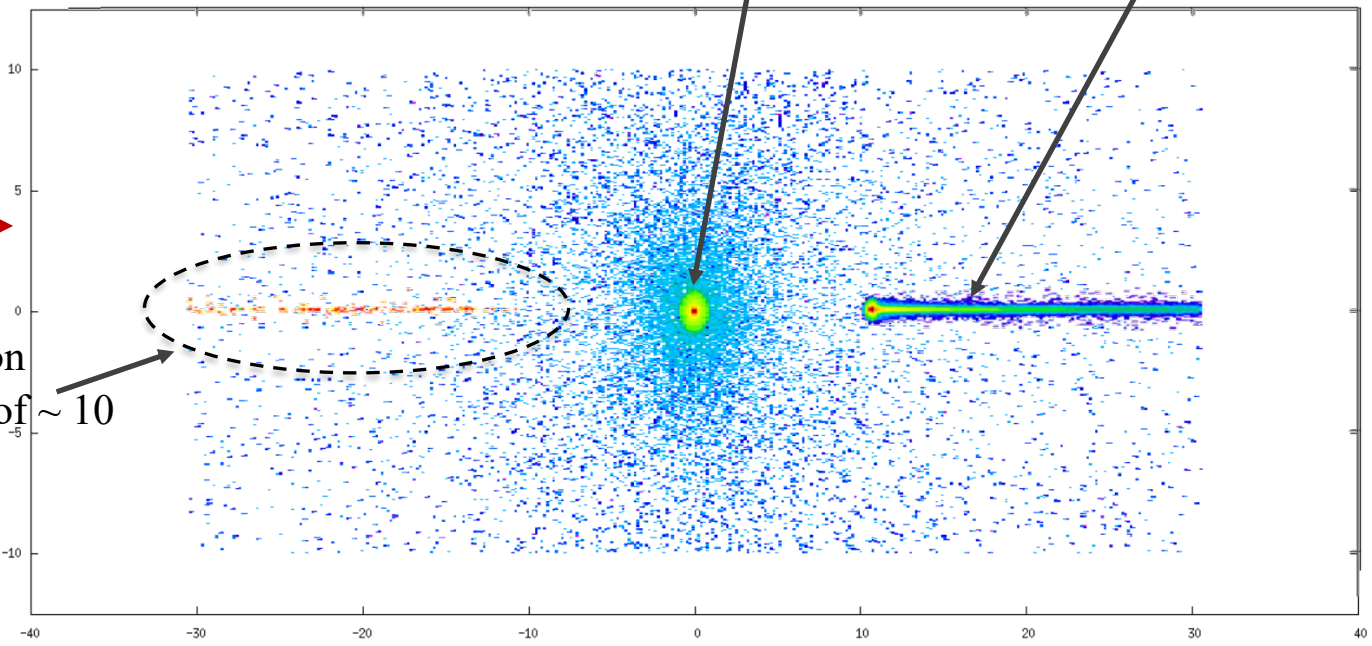
Particle distribution at the beam-dump



main gamma-ray beam

Electrons that can be measured as a "control" diagnostic

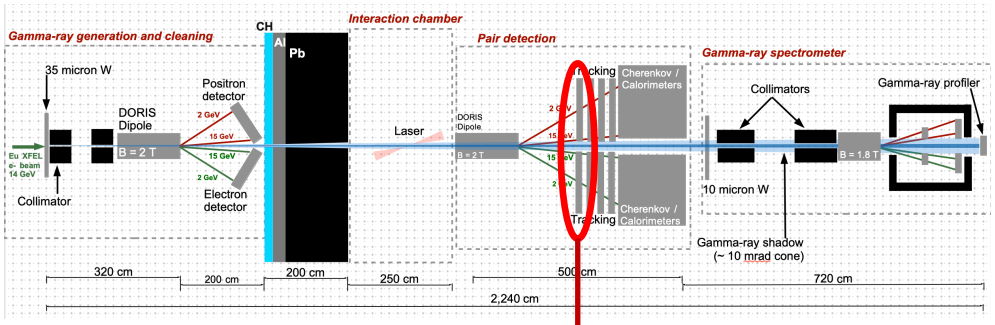
TRANSVERSE (X-Y) VIEW



Measurable positron signal with a S/N of ~ 10

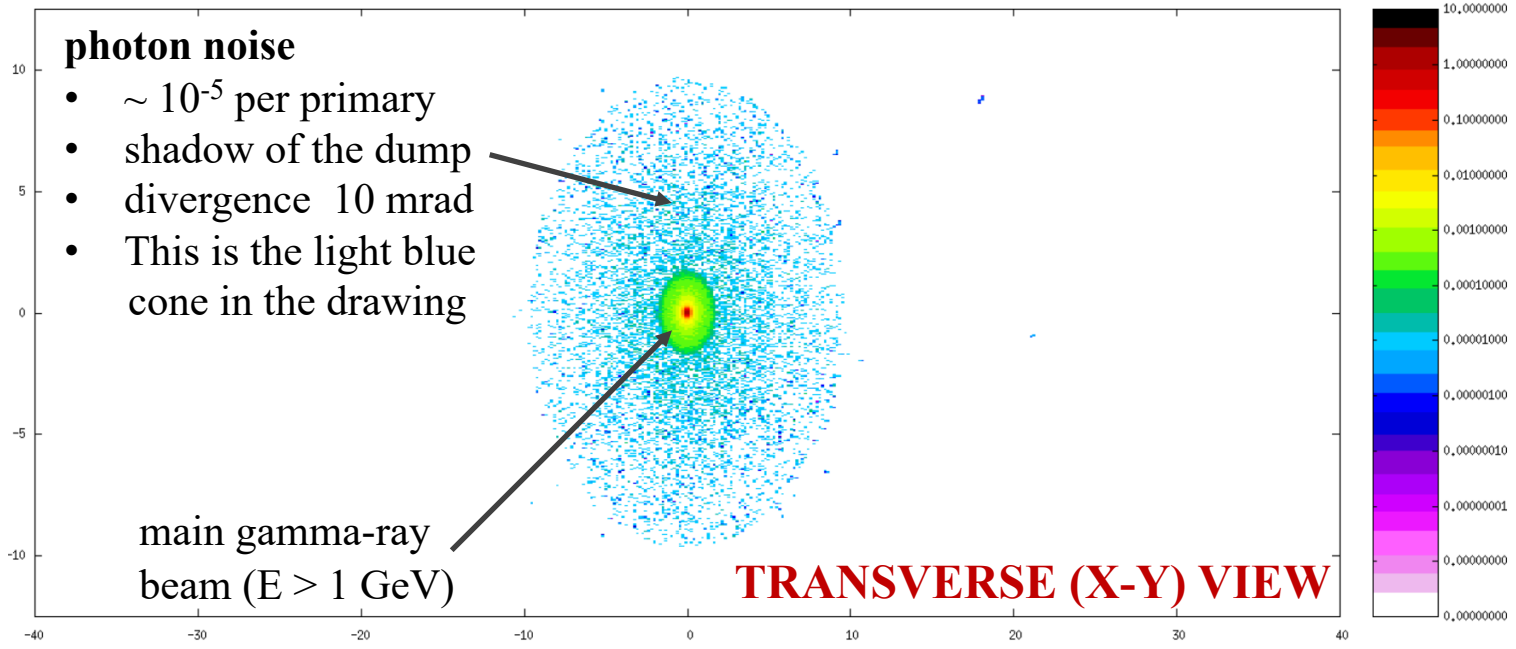
Particle distributions at the detectors

Particle distribution at the detection point

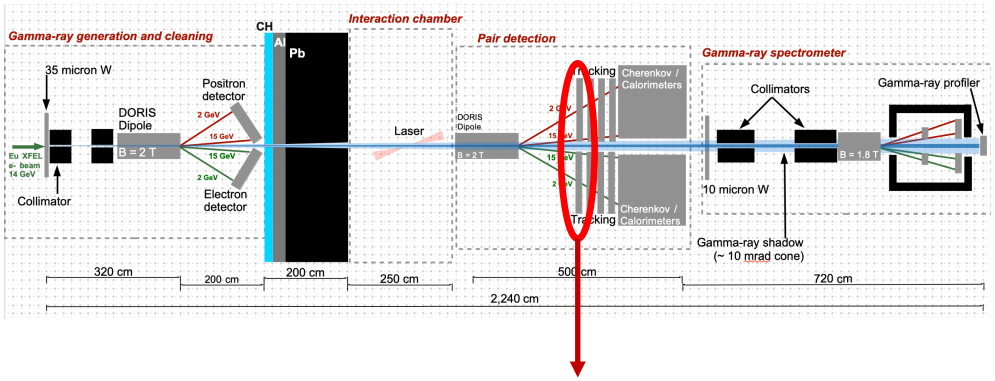


Here we show the particles arriving at the detector plane with the laser off (noise)

PHOTON DISTRIBUTION



Particle distribution at the detection point



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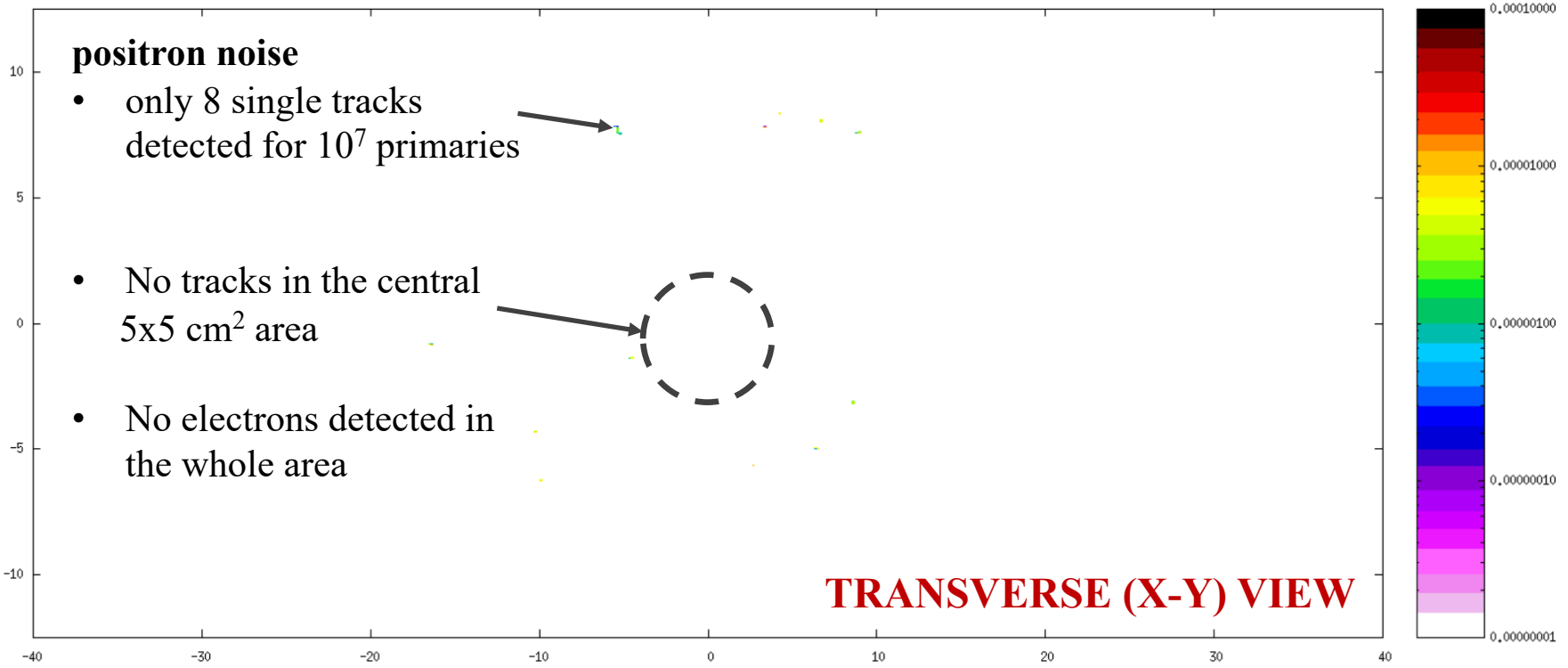
POSITRON DISTRIBUTION

positron noise

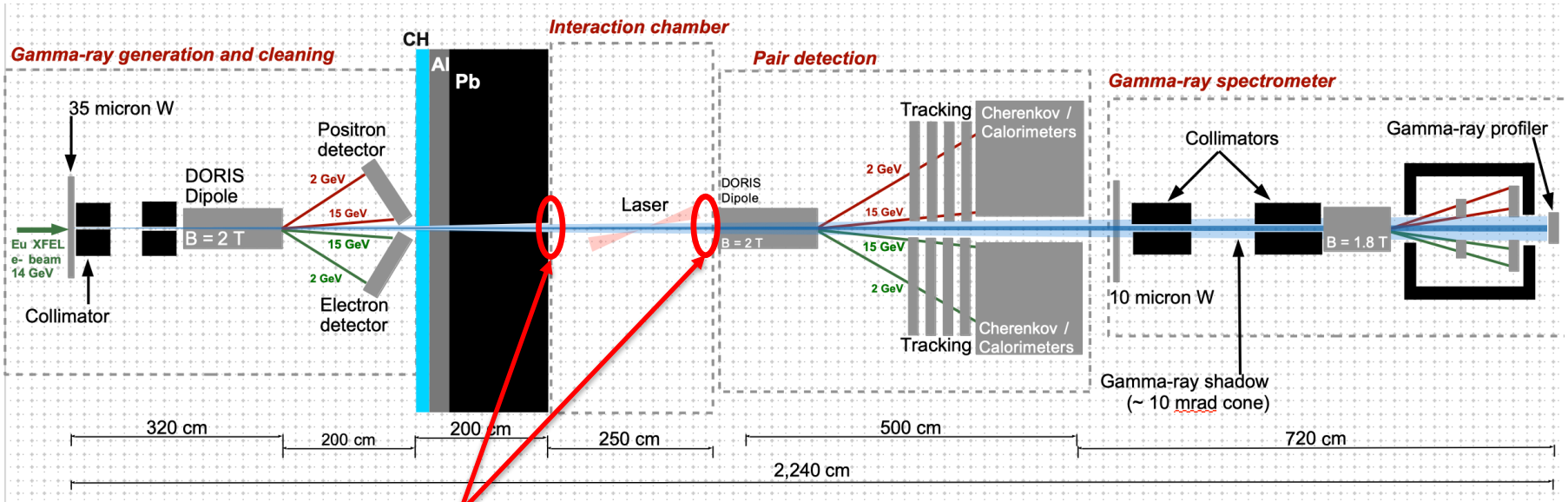
- only 8 single tracks detected for 10^7 primaries
- No tracks in the central 5x5 cm^2 area
- No electrons detected in the whole area



TRANSVERSE (X-Y) VIEW

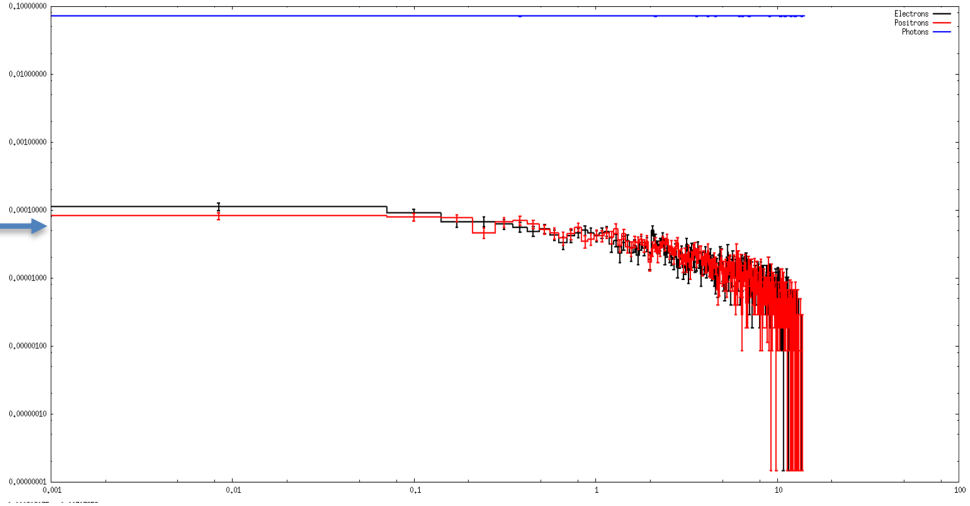
Potential problem:
entrance window of the vacuum chamber

Potential problem: vacuum chamber window



The interaction chamber has to be in vacuum.
We thus need a window in the regions highlighted.

Even assuming a 2 x 2 cm, 100 μm thick Be window will generate approximately ~10^{-4} electrons and positrons per gamma, when the main gamma ray beam propagates through it.



A "cleaning" magnet after dump would solve the problem at the entrance, but **NOT** at the exit of the chamber!

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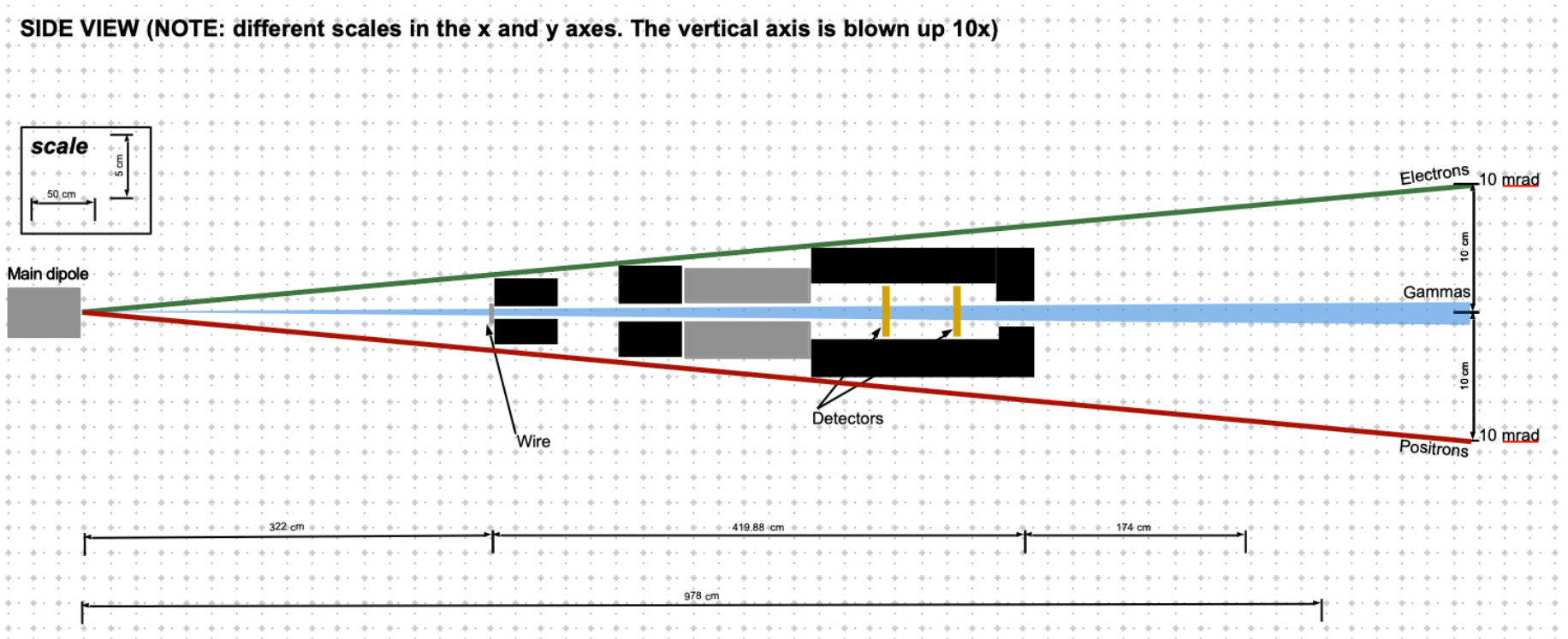
Gamma-ray spectrometer

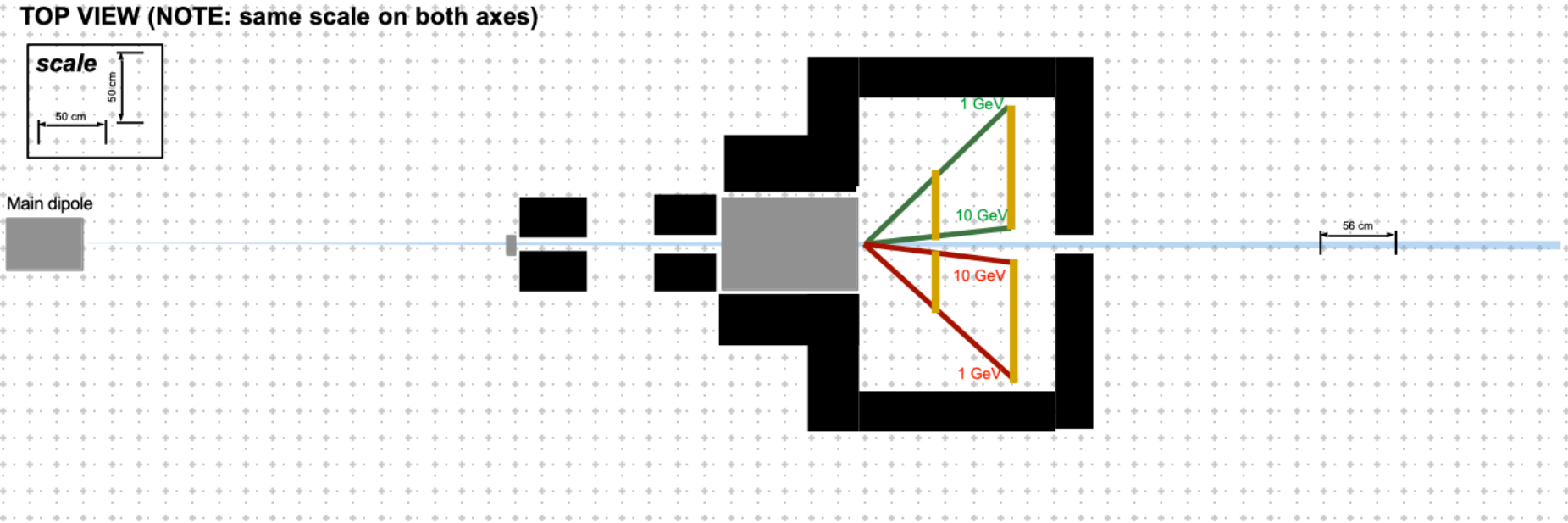
Pair spectrometer design



Main dipole separating electrons and positrons arising from the interaction point from the gamma rays

1. current setup includes a 1.8T, 1 m dipole magnet, but can be changed if more space is available
2. lead shielding depicted and simulated using FLUKA
3. The current setup assumes a 10 mrad kick from the main dipole at 10 GeV

Pair spectrometer design



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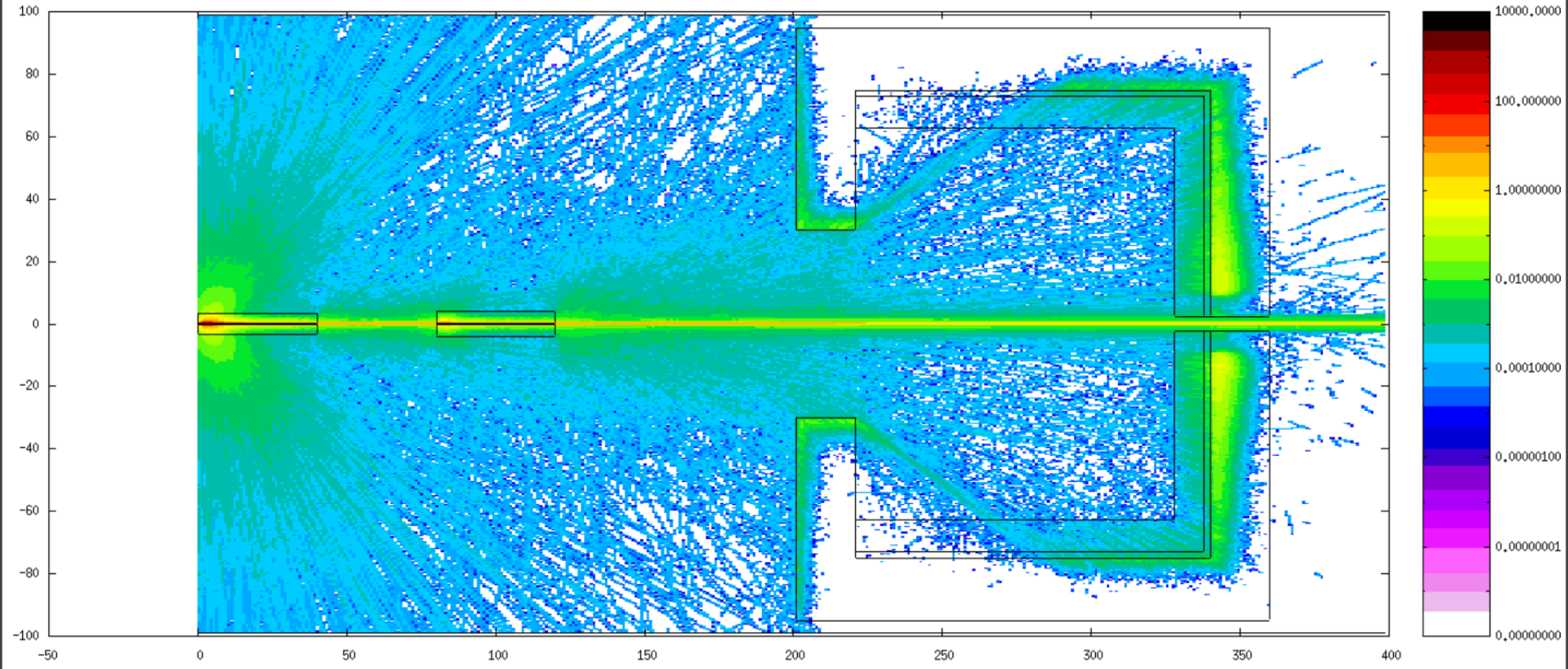
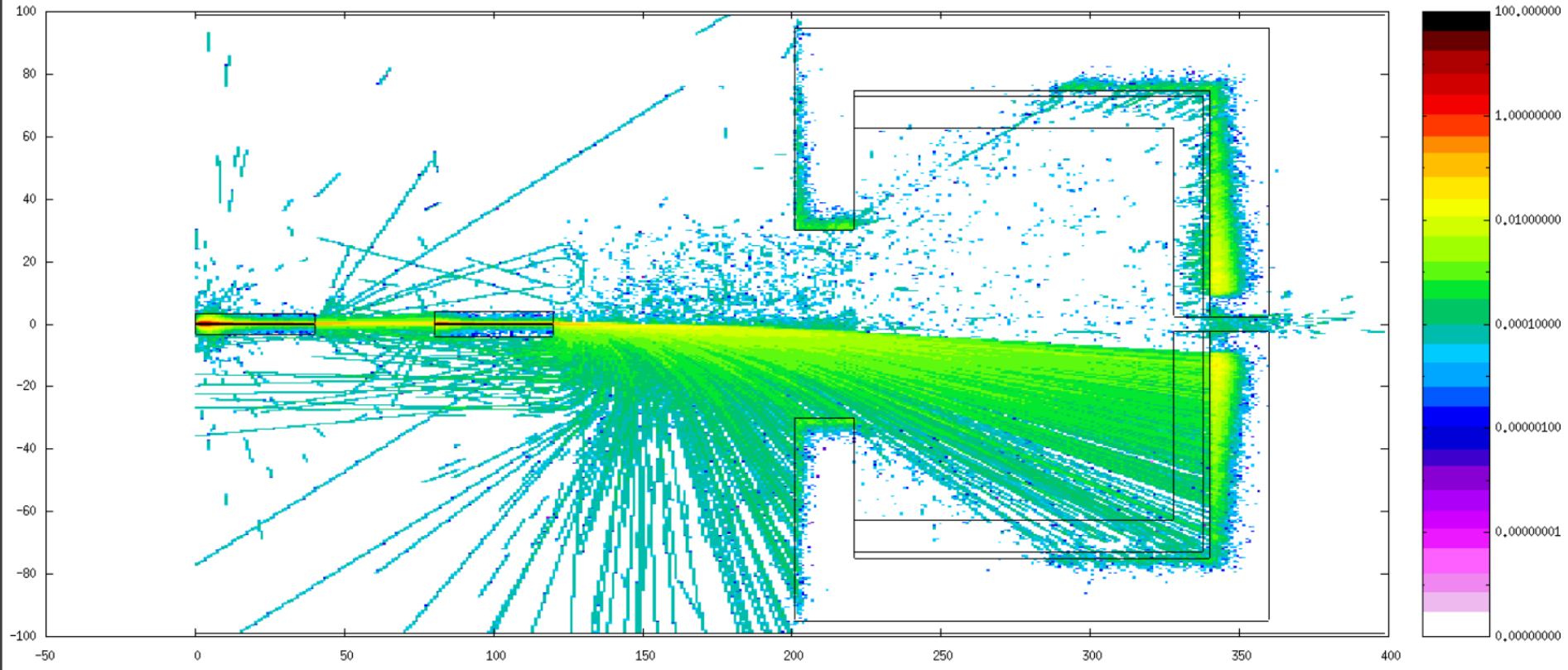
FLUKA simulations

TOP VIEW: photons



FLUKA simulations

TOP VIEW: positrons



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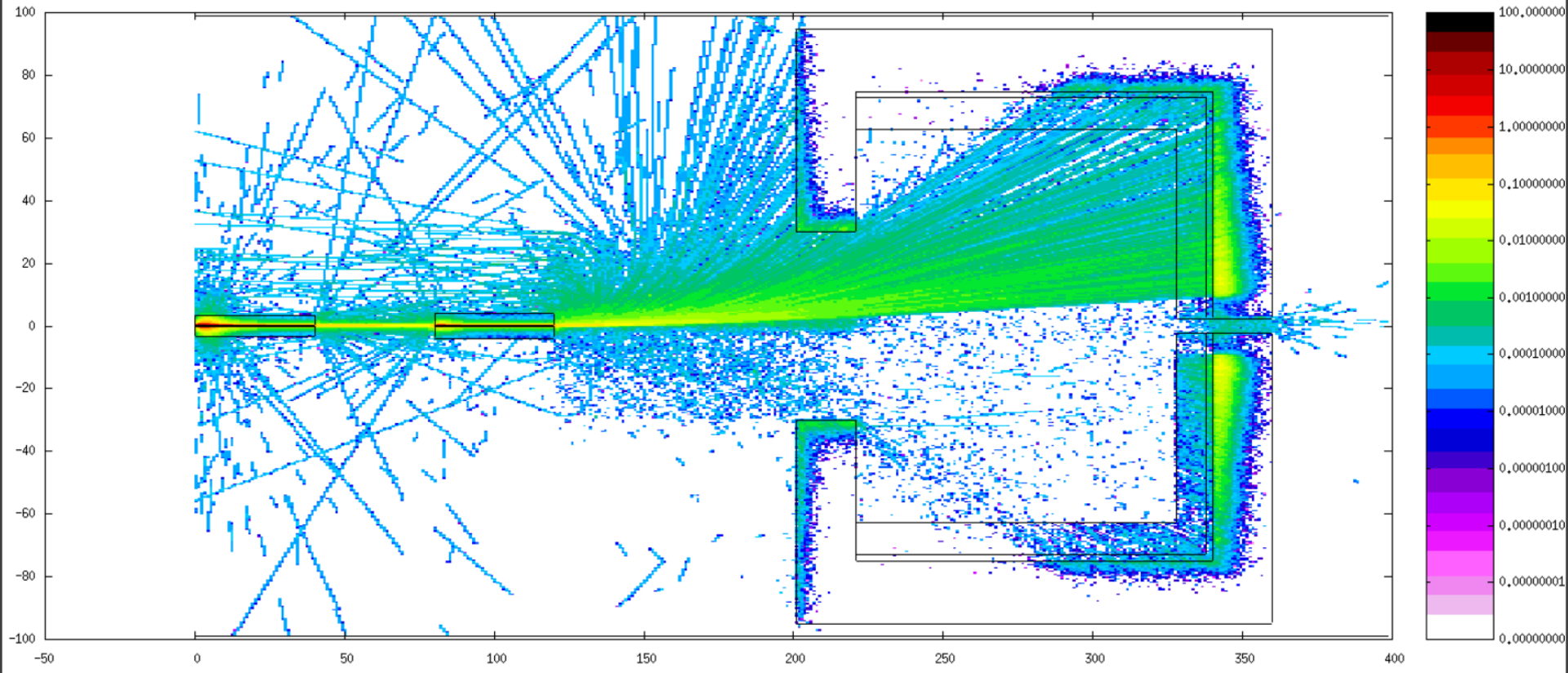
FLUKA simulations

TOP VIEW: electrons



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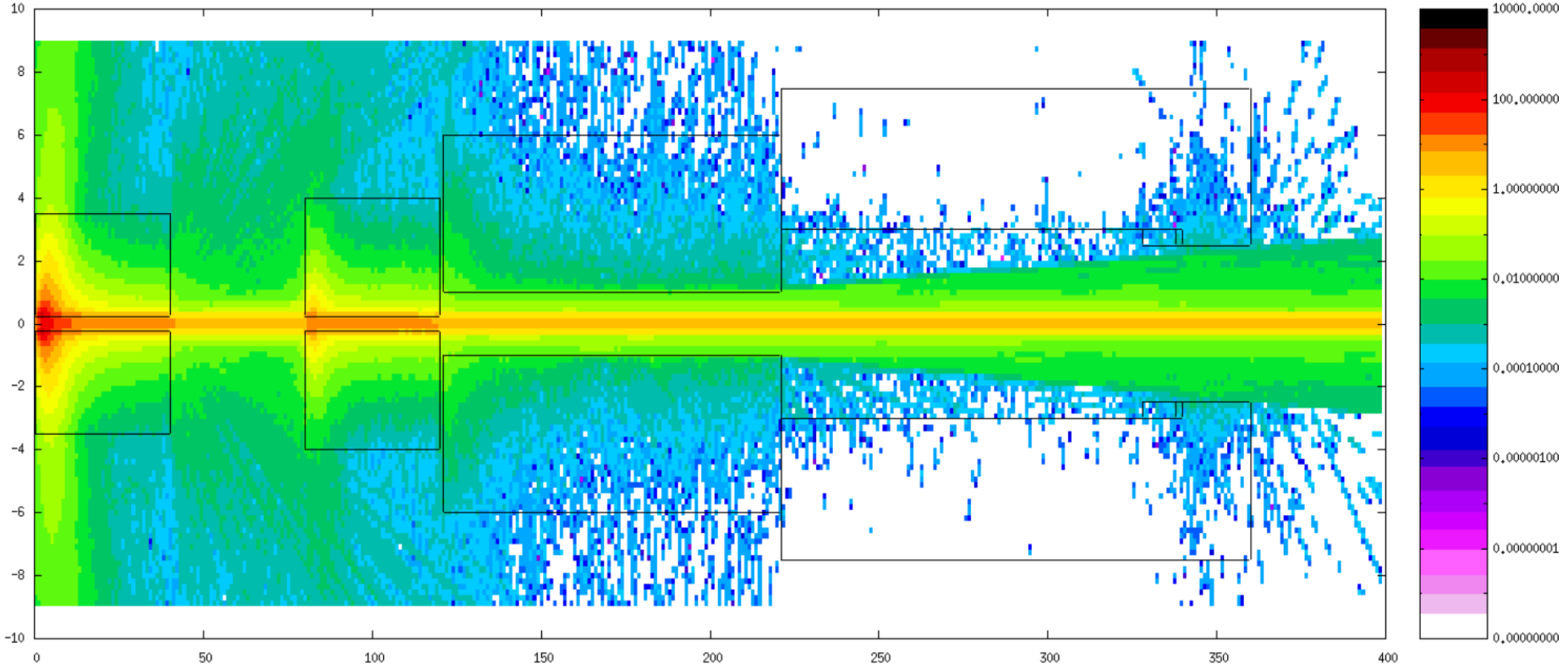
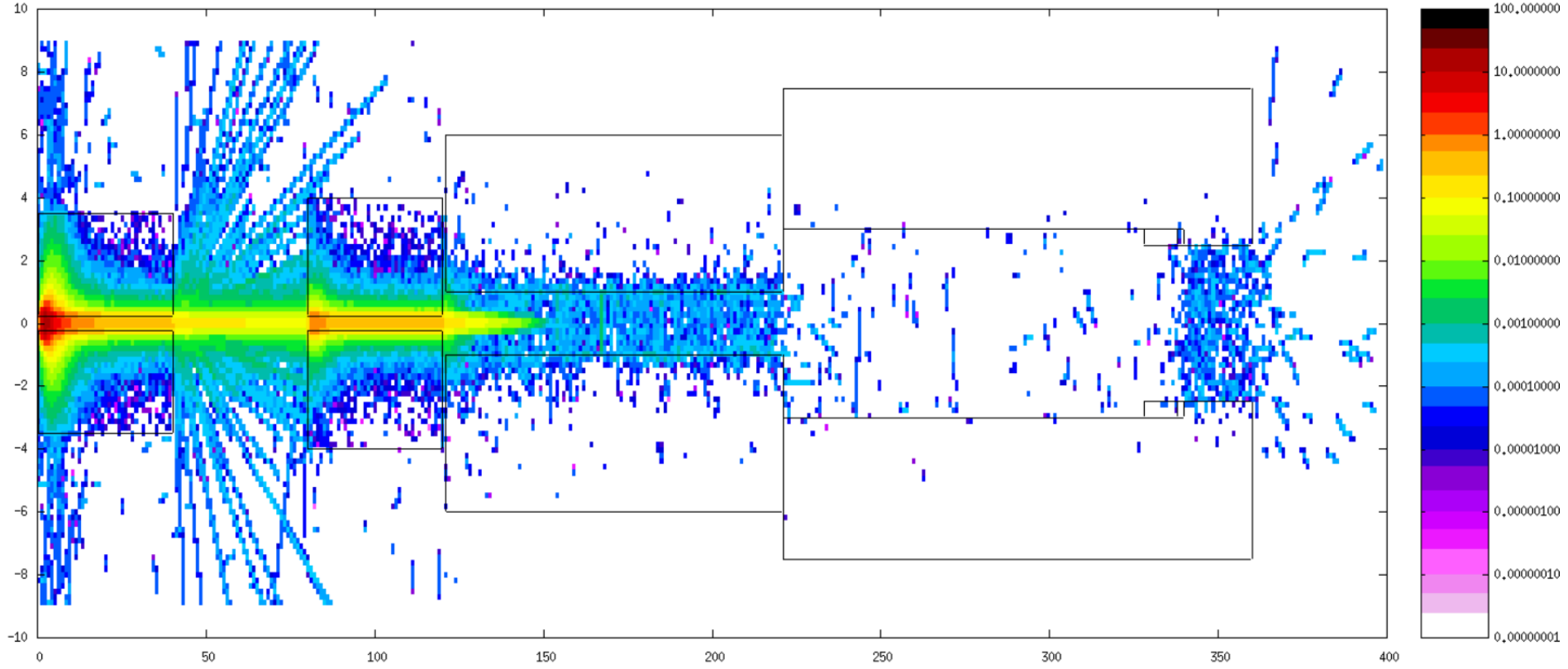
FLUKA simulations

SIDE VIEW: photons



FLUKA simulations

SIDE VIEW: positrons



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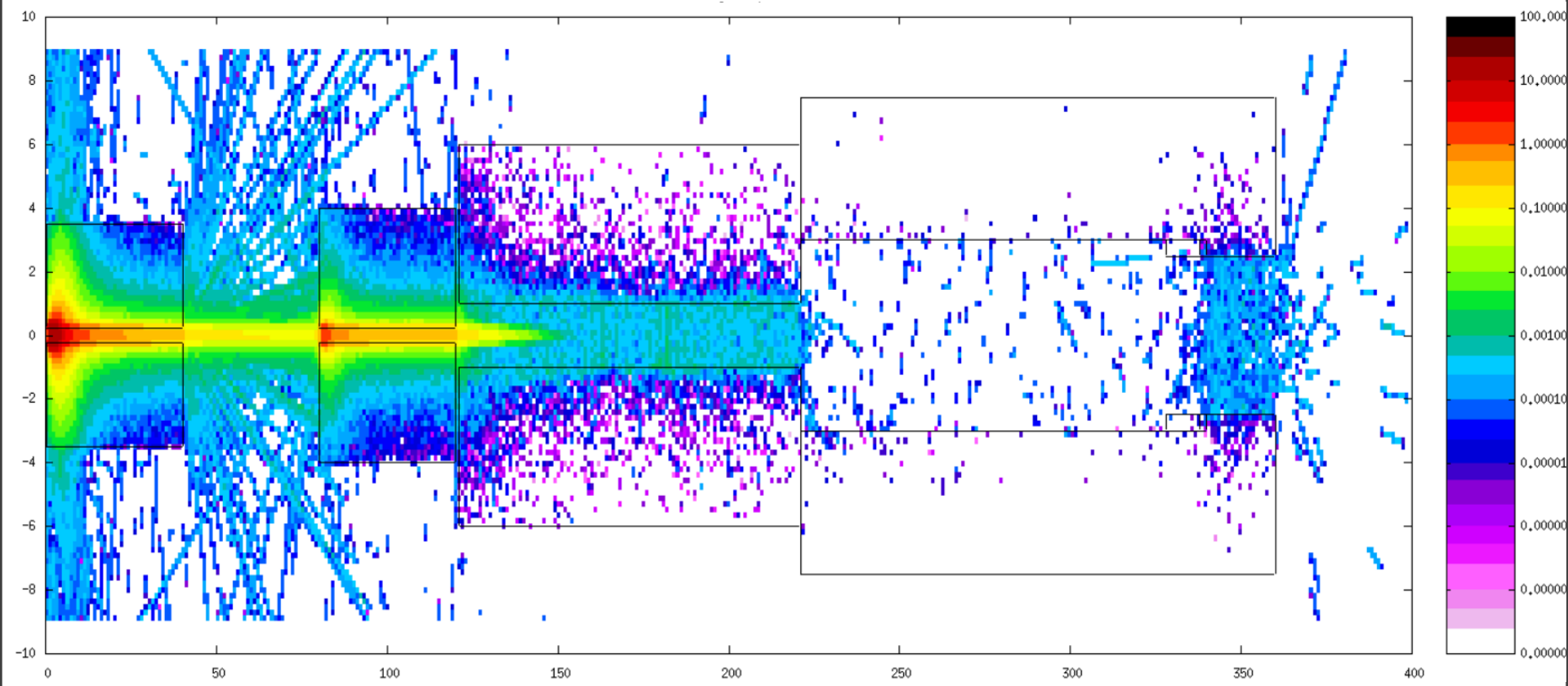
FLUKA simulations

SIDE VIEW: electrons



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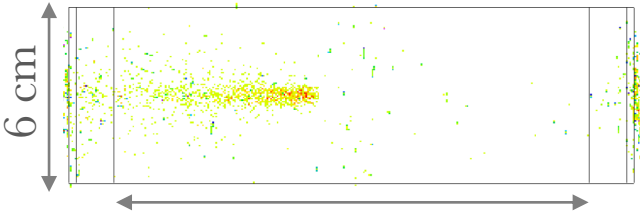
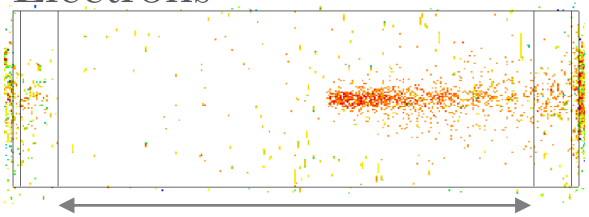
FLUKA simulations

simulated signal at the detector (X-Y) plane

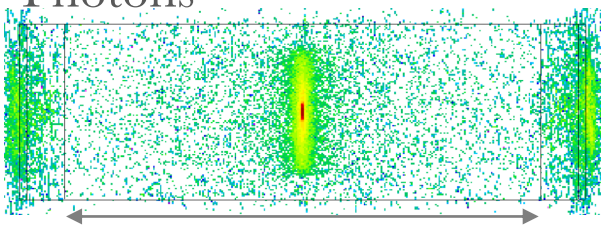
Positrons



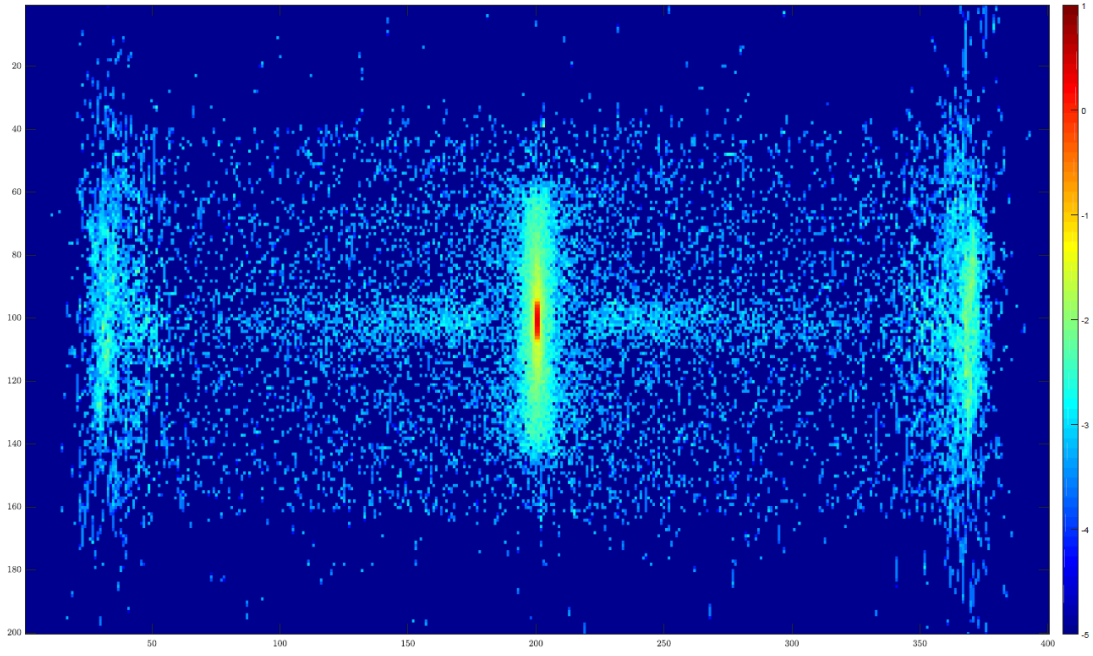
Electrons



Photons



Combined view



Current S/N ~ 10