A positron source for applications using the TARANIS laser

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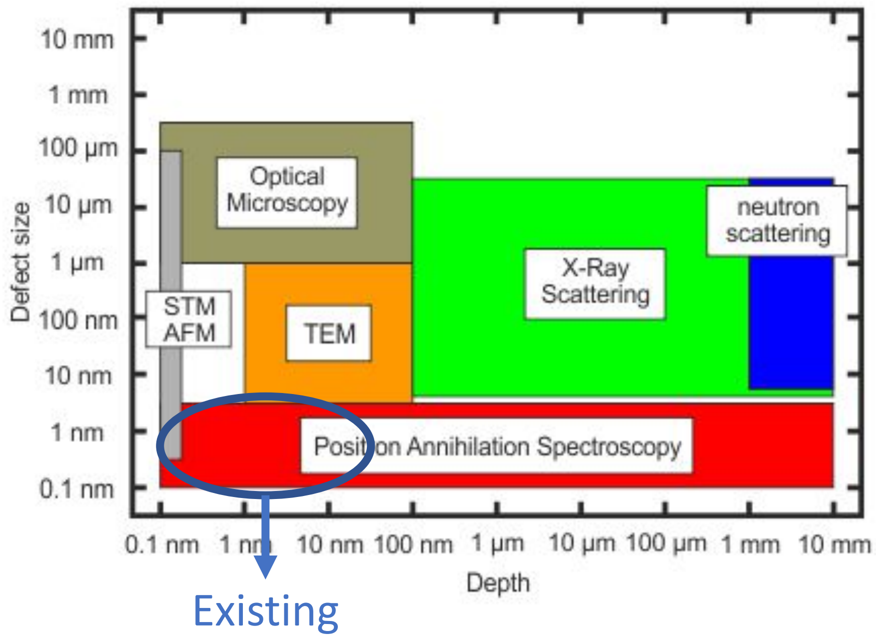
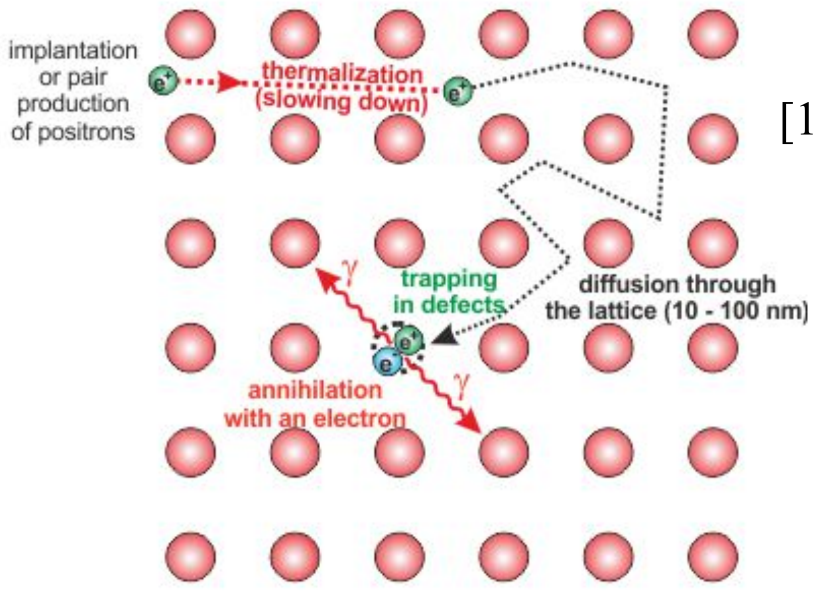
Context & motivations

❖ Motivation : Positron annihilation lifetime spectroscopy (PALS)





[1]

[1] : Maik Butterling, illustration from HZDR website, https://www.hzdr.de/db/Cms?pNid=3225

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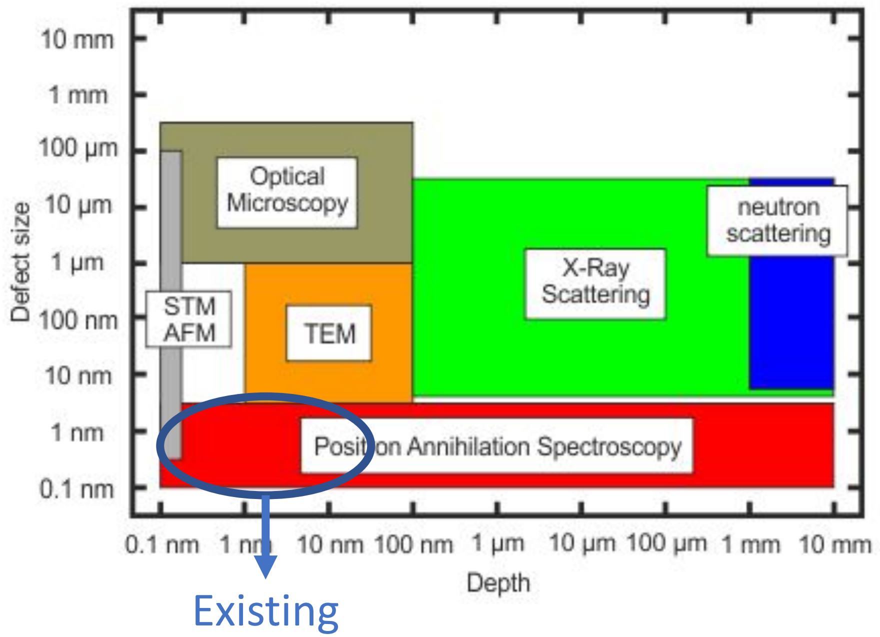
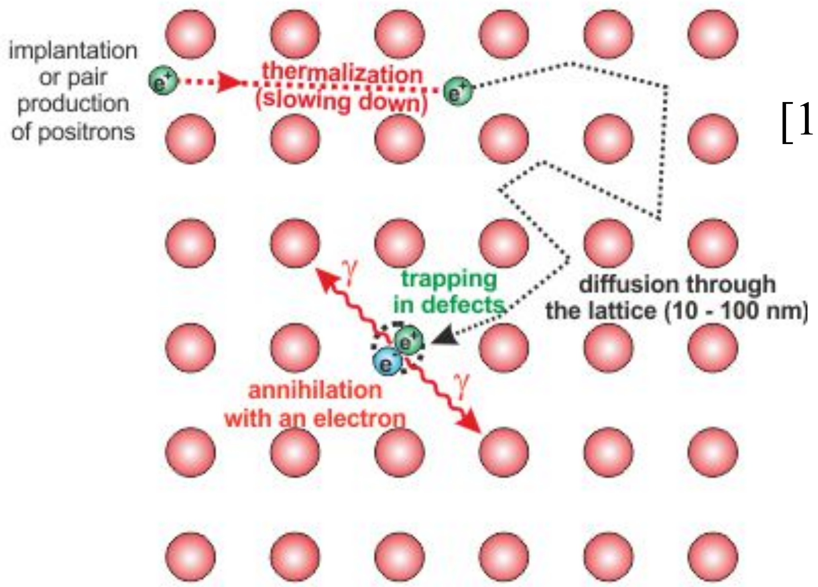
Context & motivations

- Motivation : Positron annihilation lifetime spectroscopy (PALS)
- Existing methods : low energy (~10s keV), ~100s ps
- Laser generated positron potential :
  - Higher energies → larger probing depth
  - Shorter pulse → better resolution





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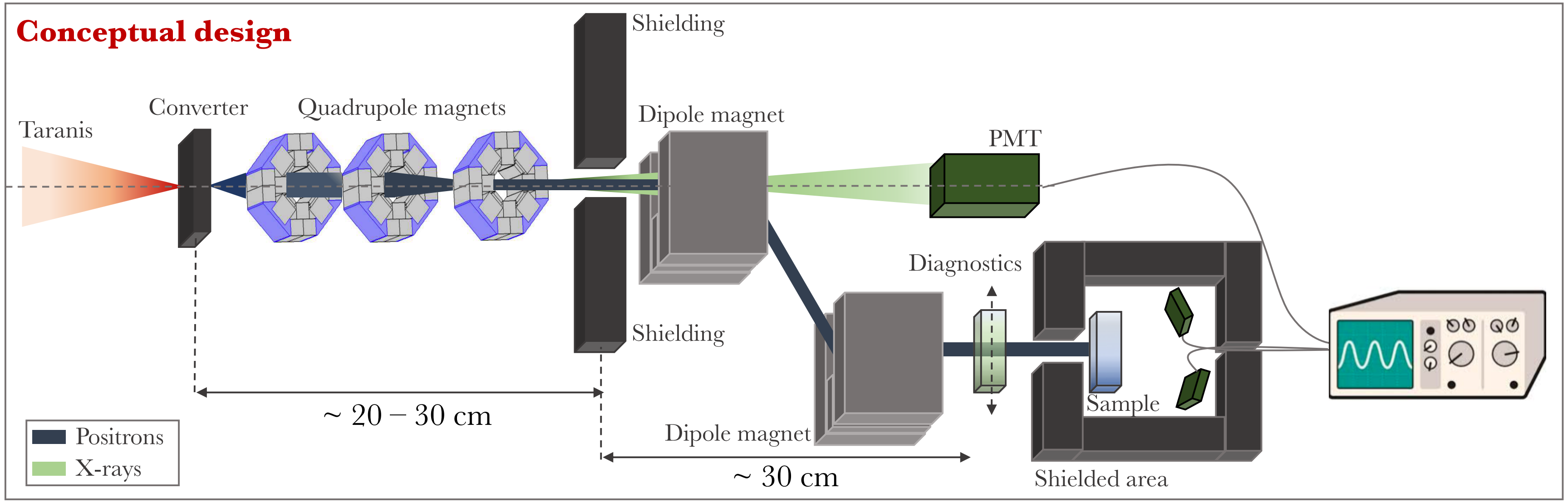
TARANIS laser and conceptual design at QUB



	TARANIS (compressed)
Wavelength	1053 nm
Pulse duration	600 fs
Energy on target	15 J
Max. Intensity	$2x10^{19}$ Wcm^{-2}
Rep. rate	1 shot / 10 minutes

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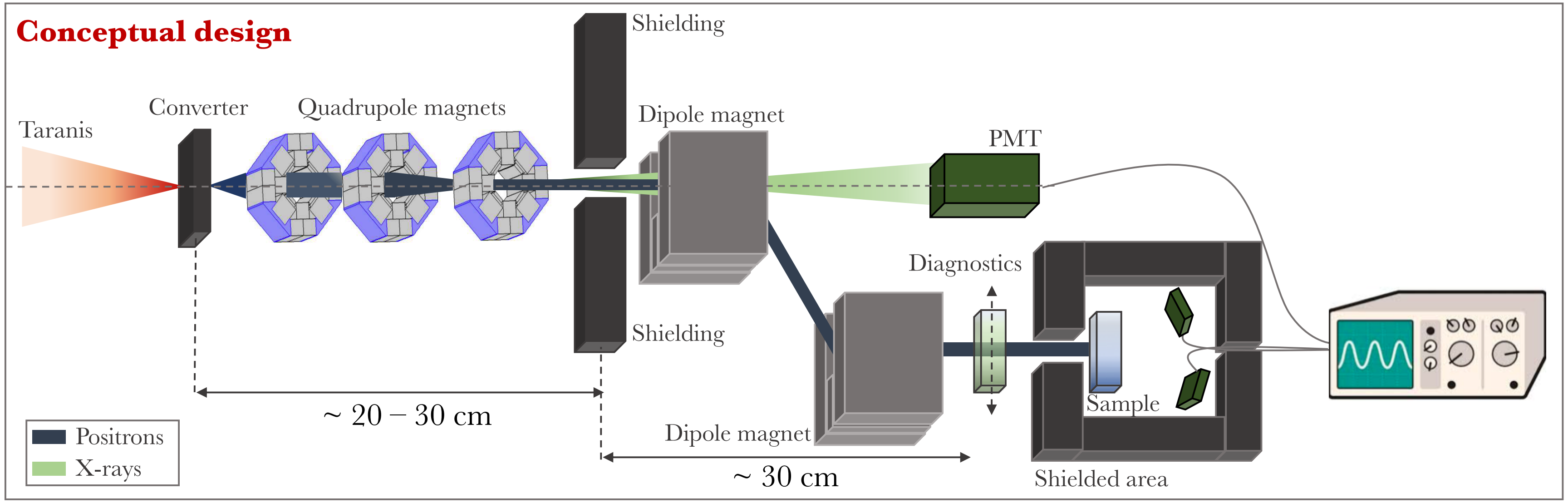

EuPRAXIA

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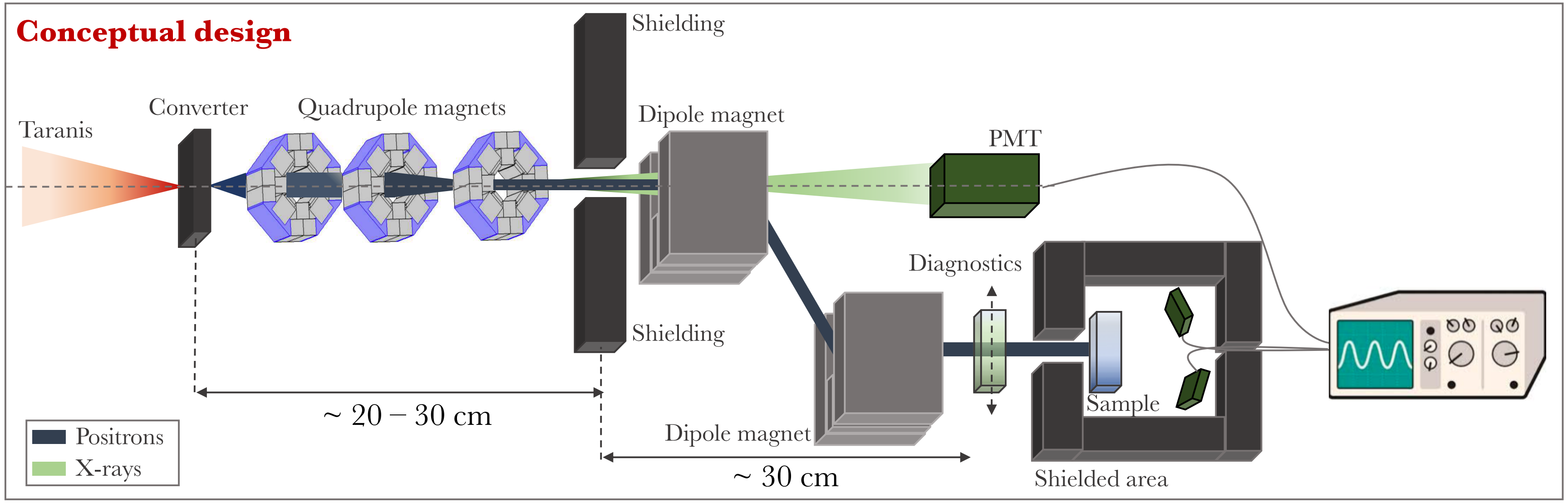

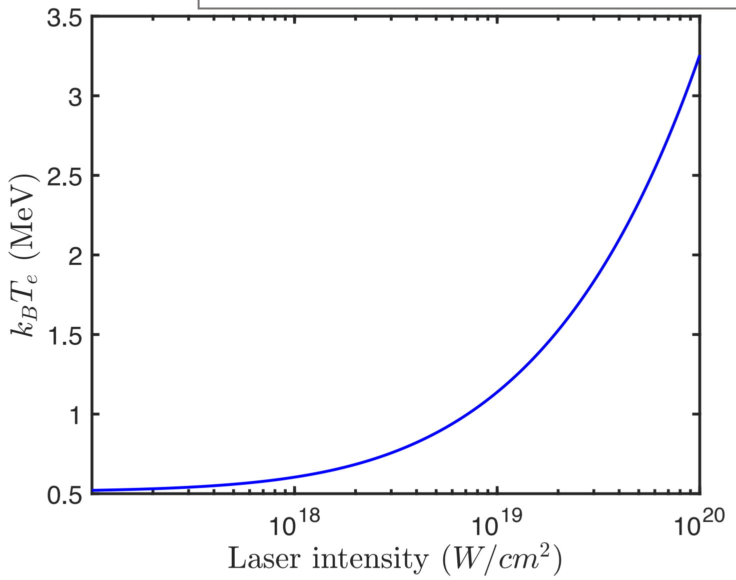

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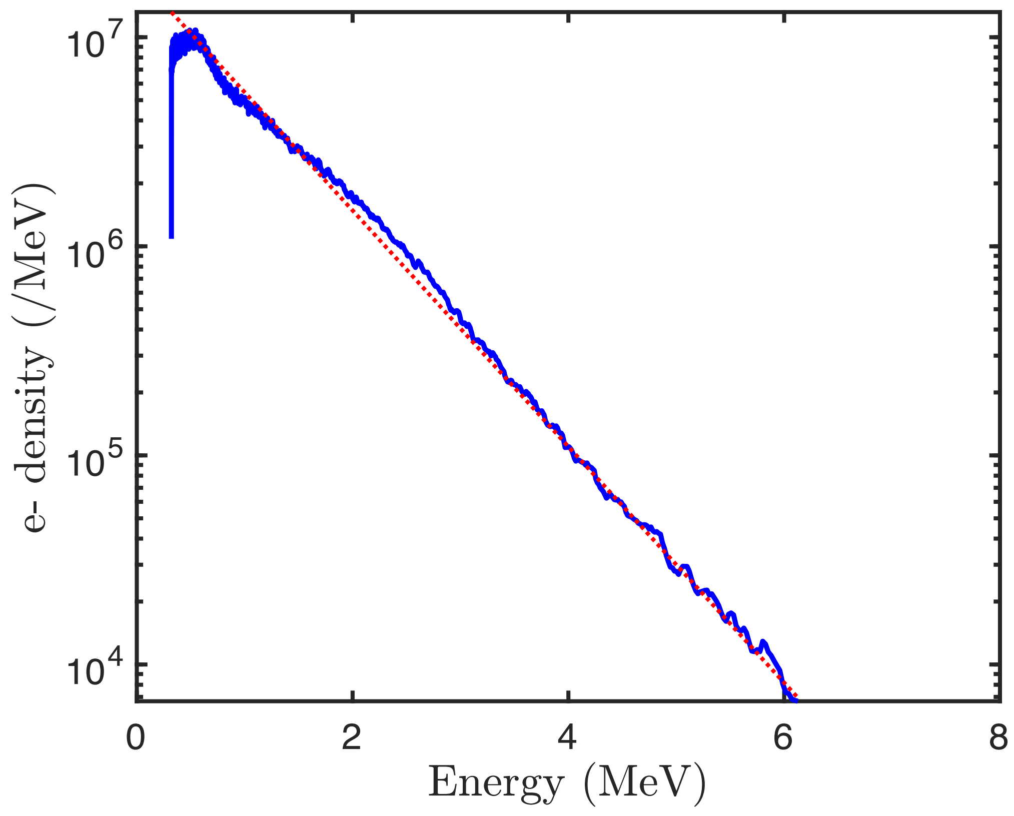
Electrons from thin Au targets

- Shots on 50 μm thick Au targets
- Fit with K×$exp(-E/k_B T_e)$
- $k_B T_e$~1 MeV
- These electrons can be used to generate positrons with thicker targets



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    - Generation of X-rays via Bremsstrahlung
    - Generation of electron-positron pairs by propagation of high energy photon in nucleus field (Bethe-Heitler process [1])

[1] : W. Heitler (1954) The Quantum Theory of Radiation. Oxford: Clarendon Press.

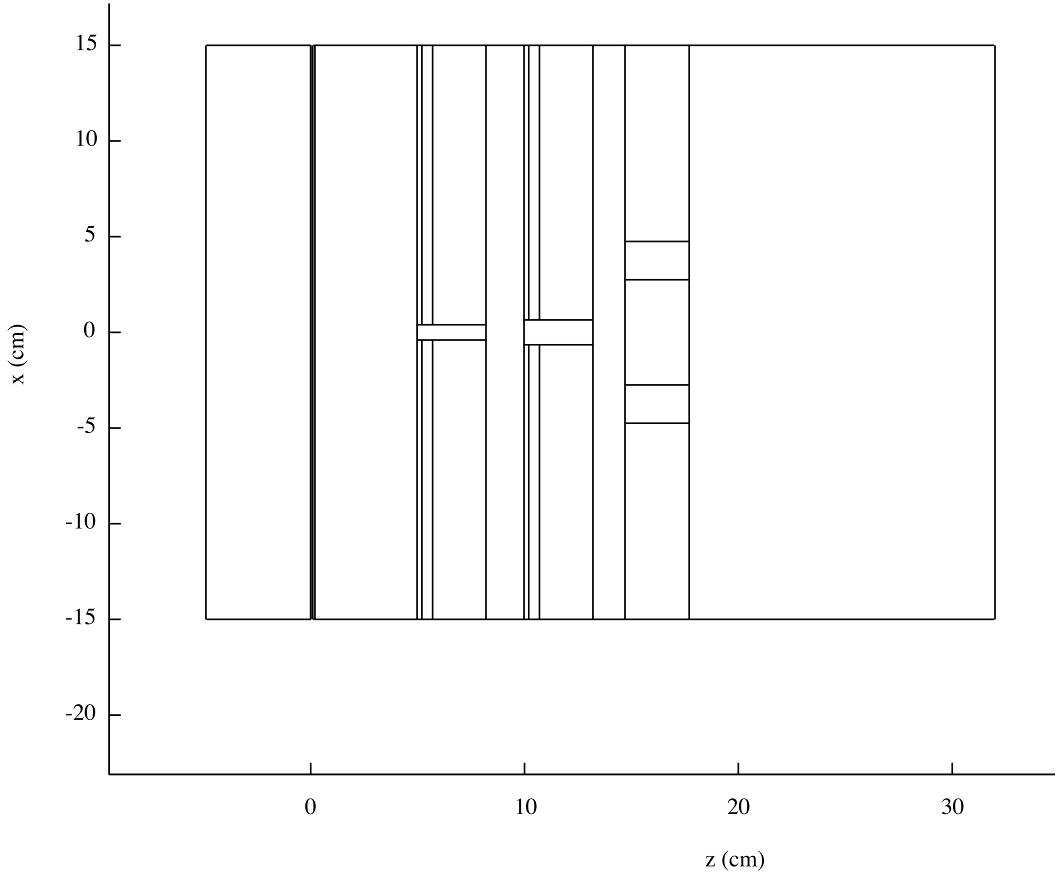
FLUKA simulations

- Serie of simulations performed using the MC scattering code FLUKA

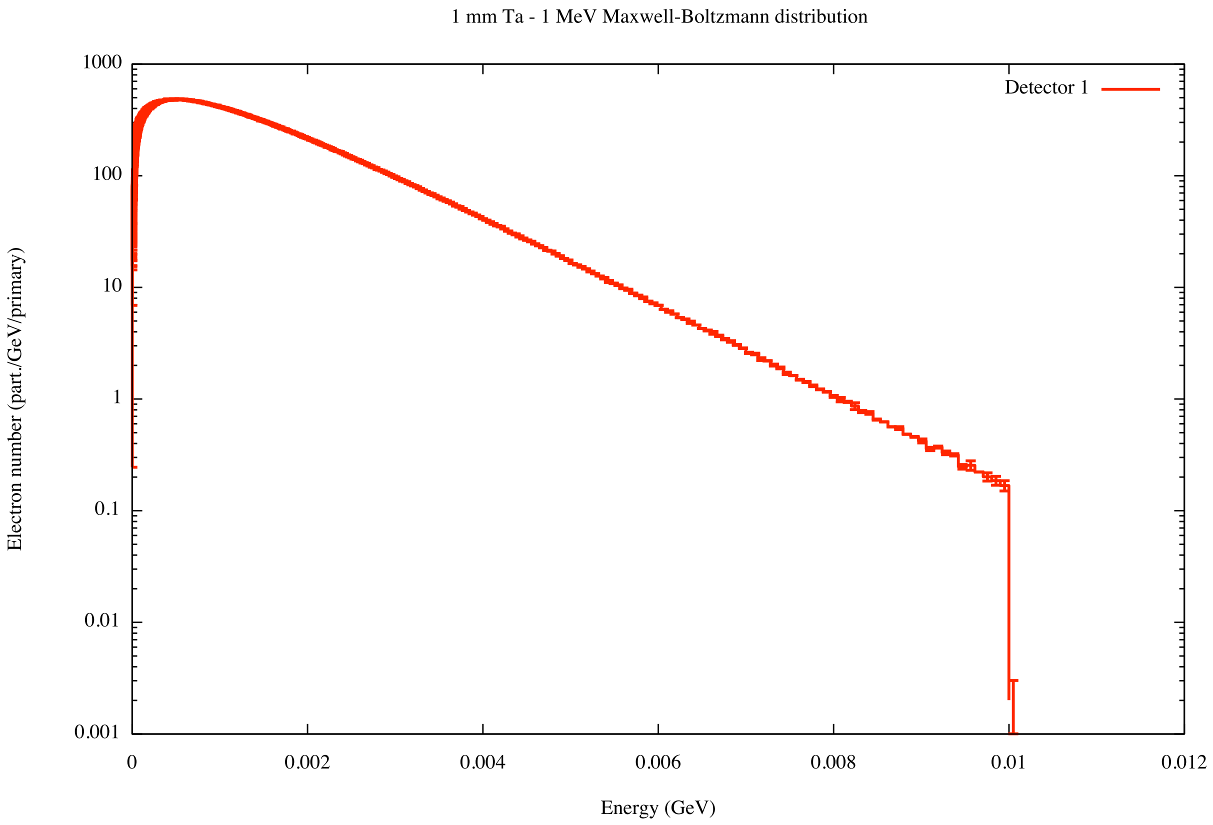
- Used to optimize shielding and positron collection

Geometry & initial electron population

- Fluka simulations of electron population interacting with a 1 mm thick Ta target



- Electron spectrum fitted to an experimental spectrum using 50 μm Au target



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Electrons and positrons spectra

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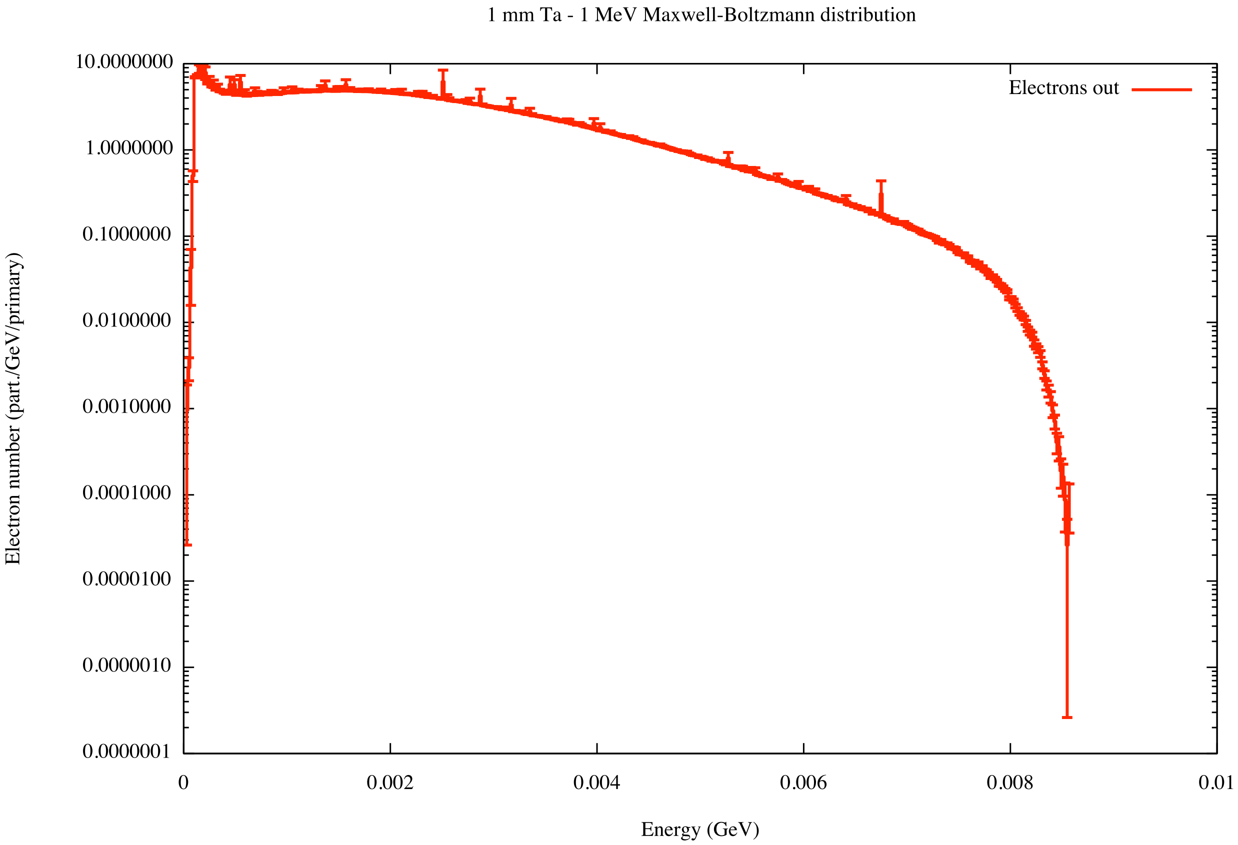
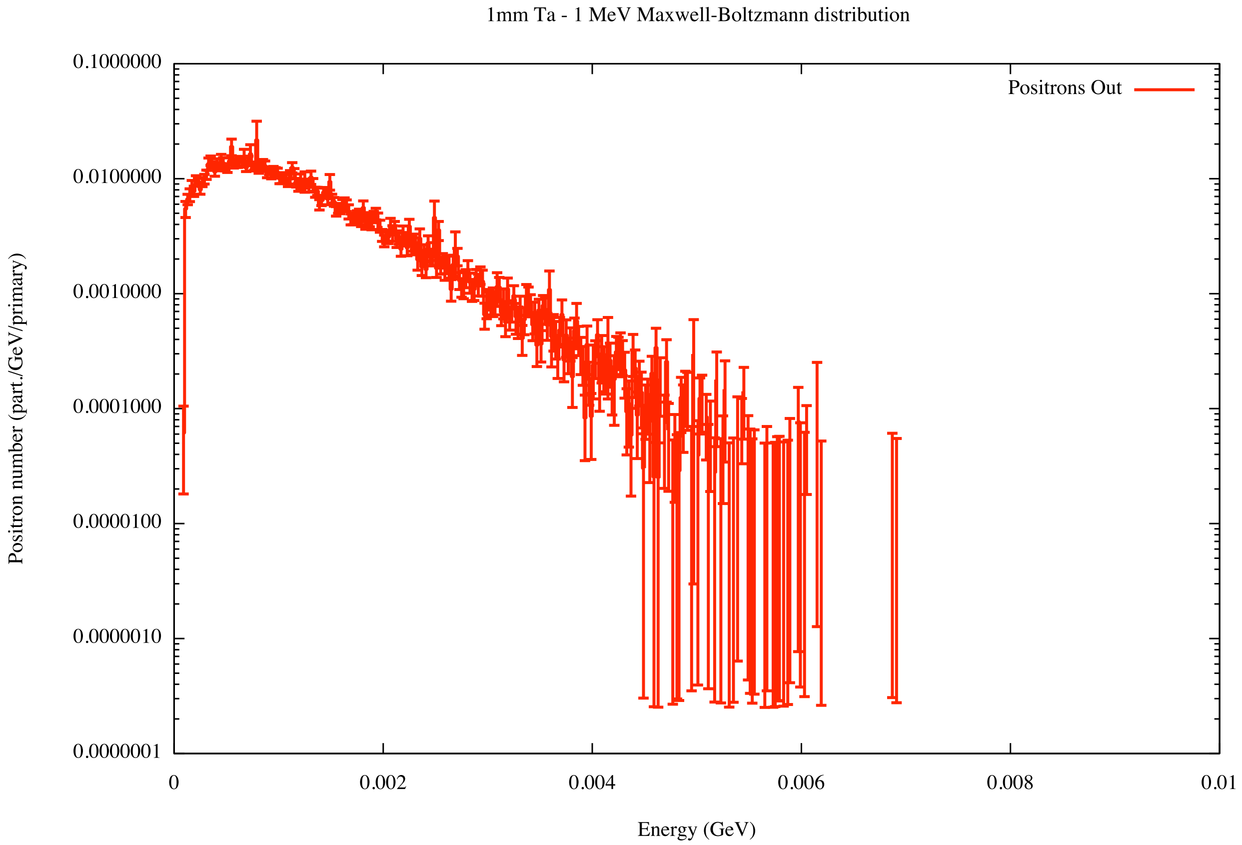
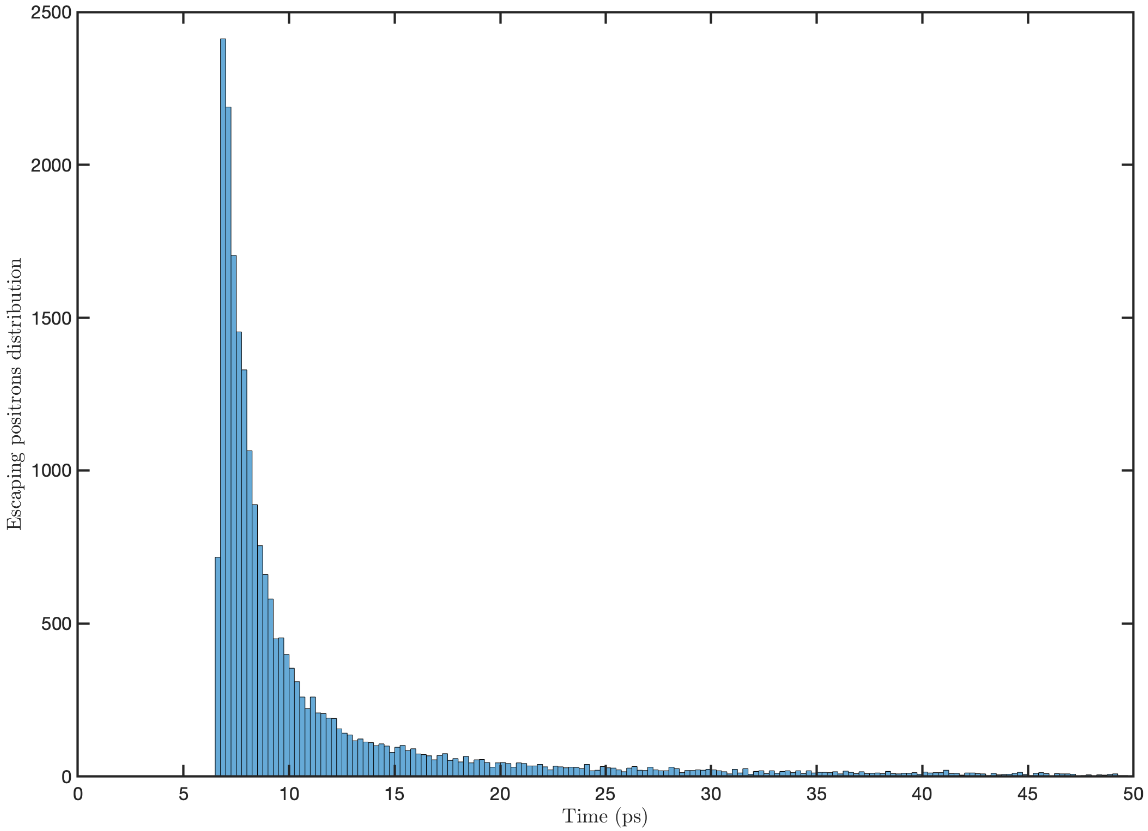
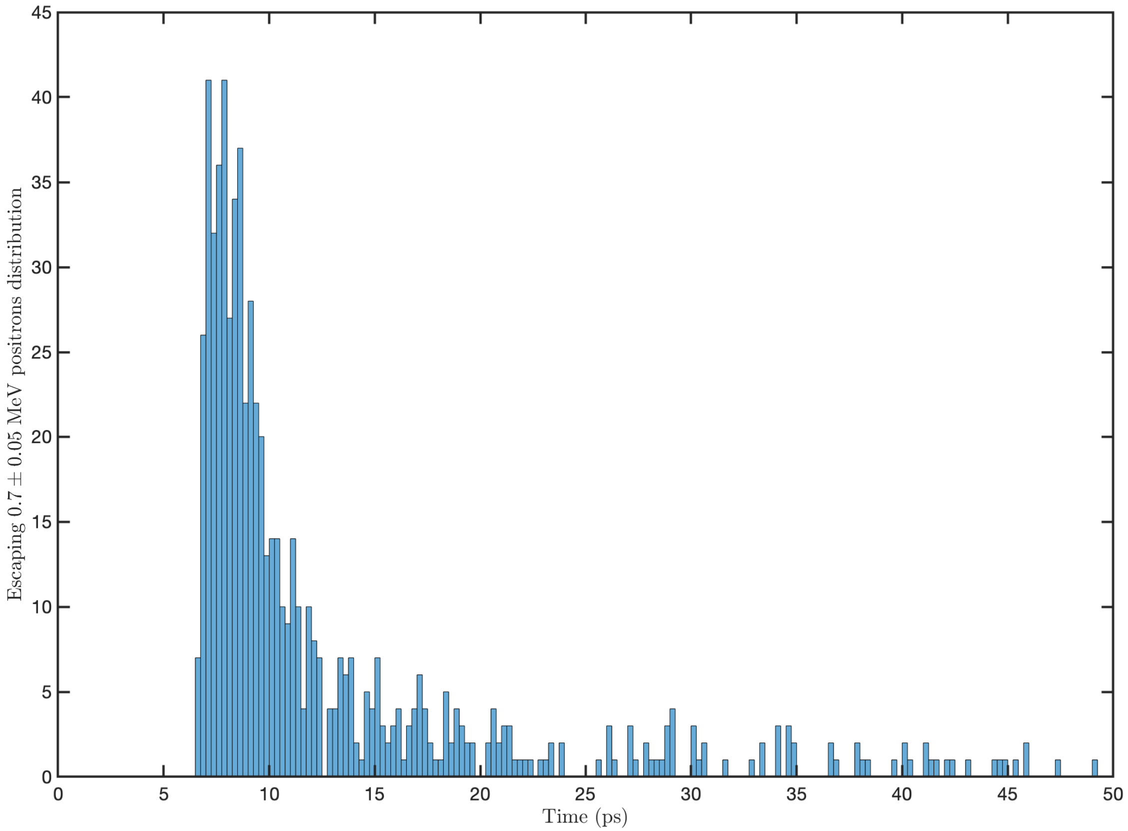




Positron beam time duration

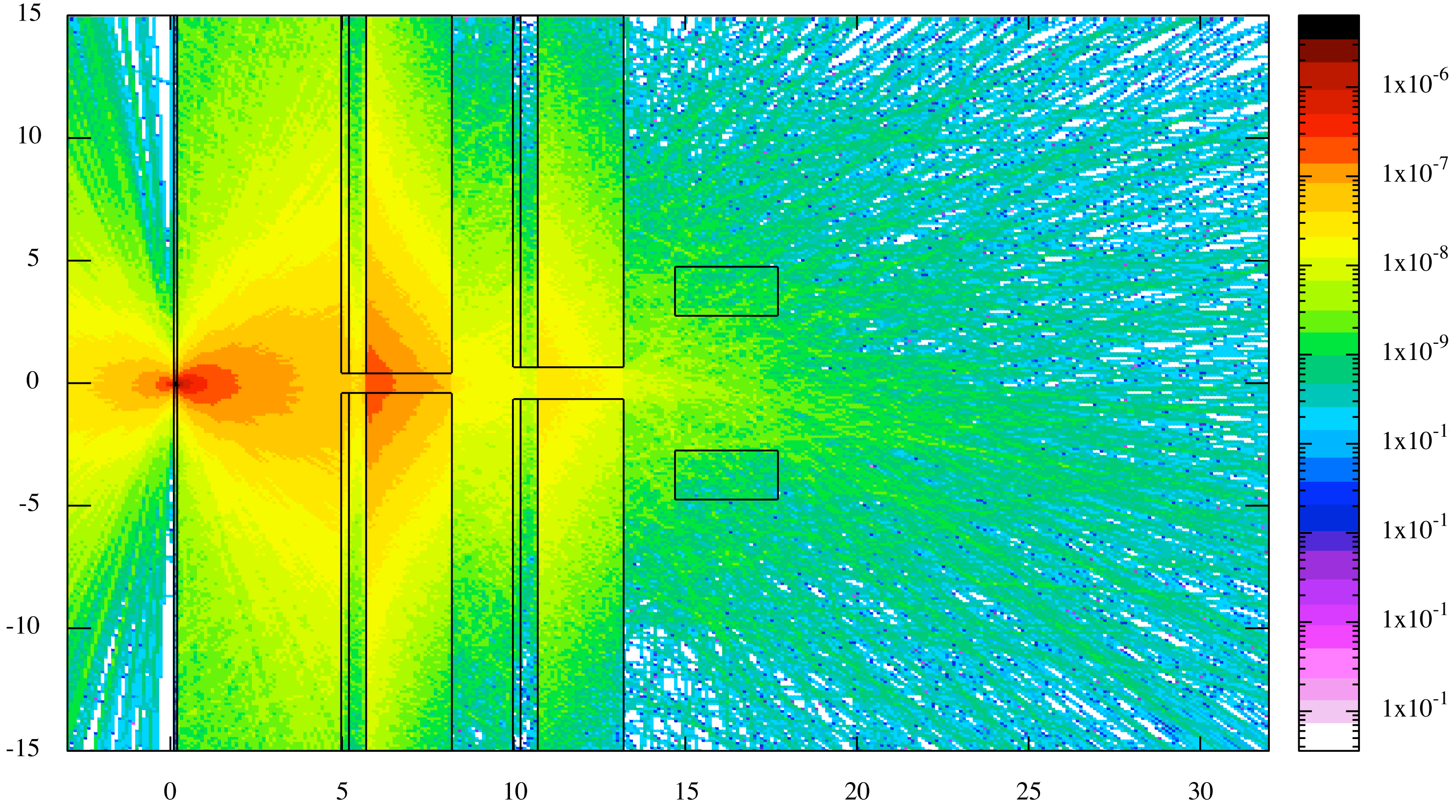
- Short positron bunches escape the target : 2 - 3 ps
- Laser pulse duration must be taken into account : ~ 0.8 ps
- Final bunch length duration well below 100 ps





Angular distribution

- Important X-ray generation : noise on detectors
- Shielding needed
- Highly divergent beams ~60°



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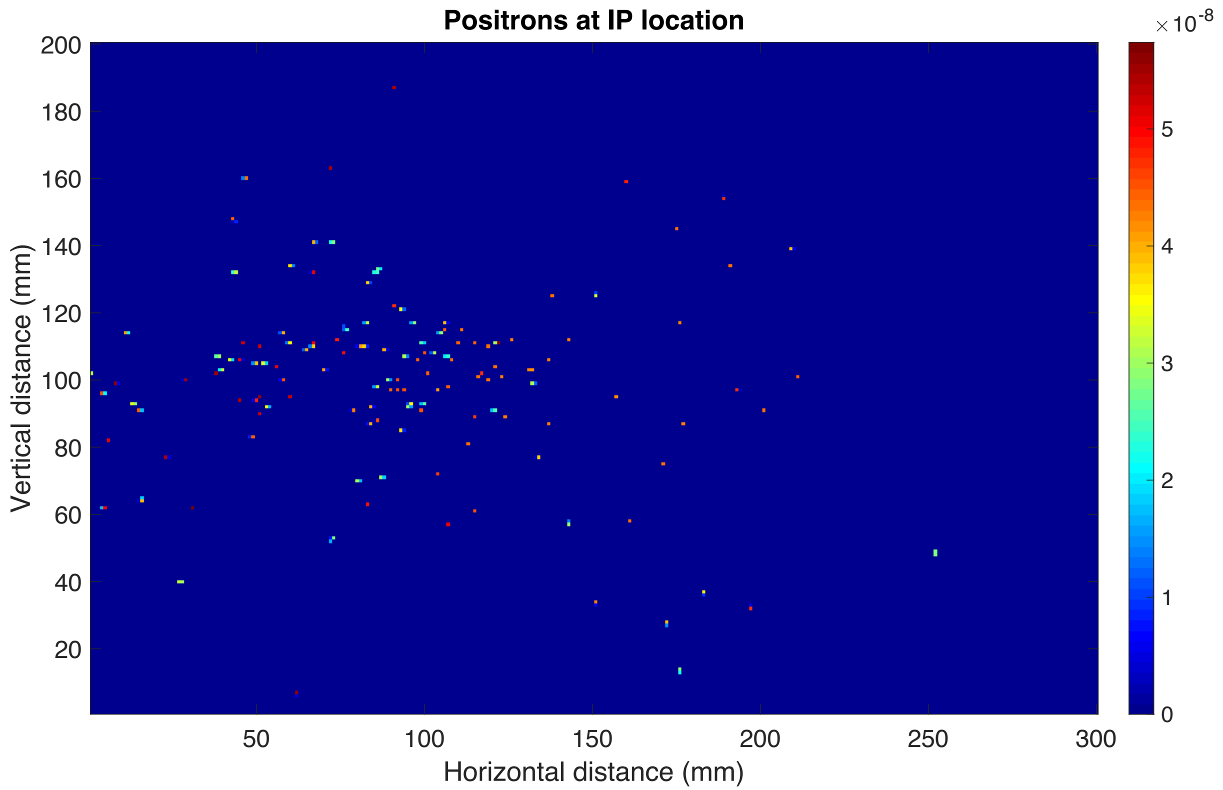

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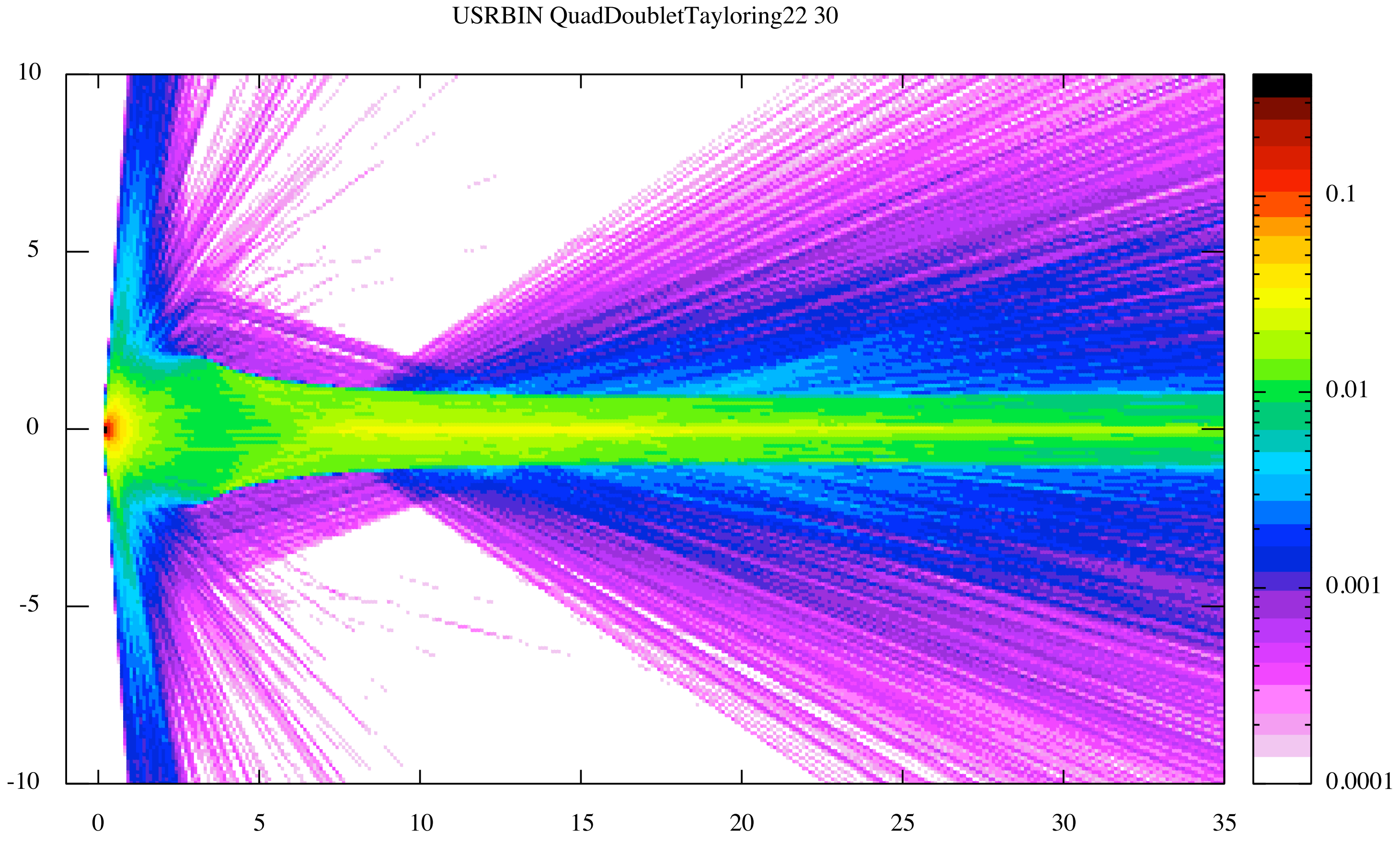
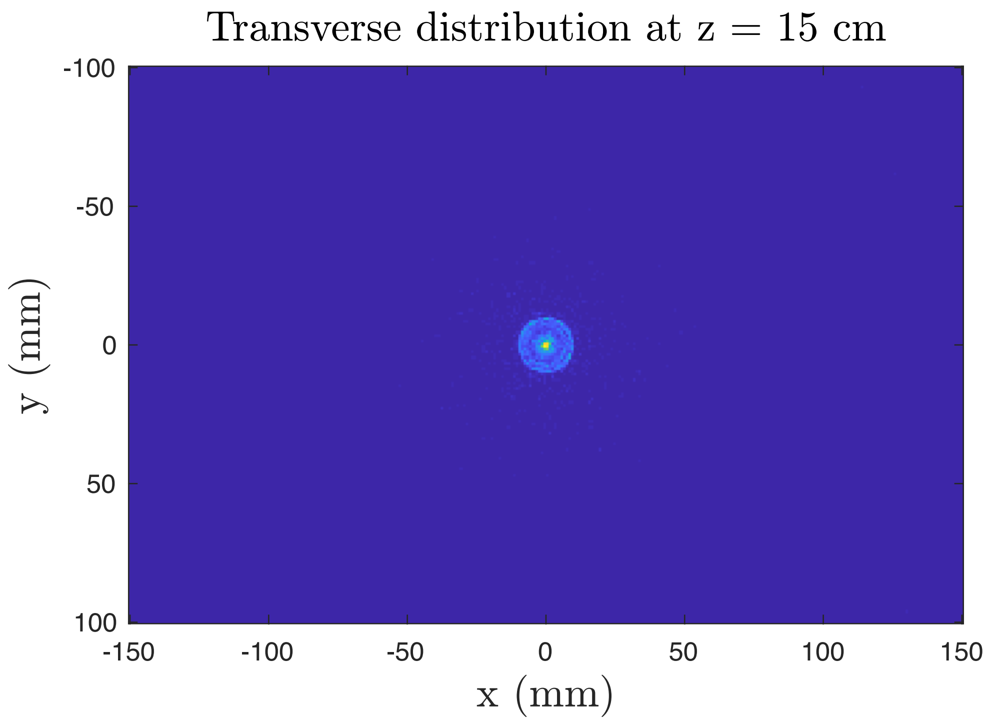
Quadrupole doublet for positron collimation

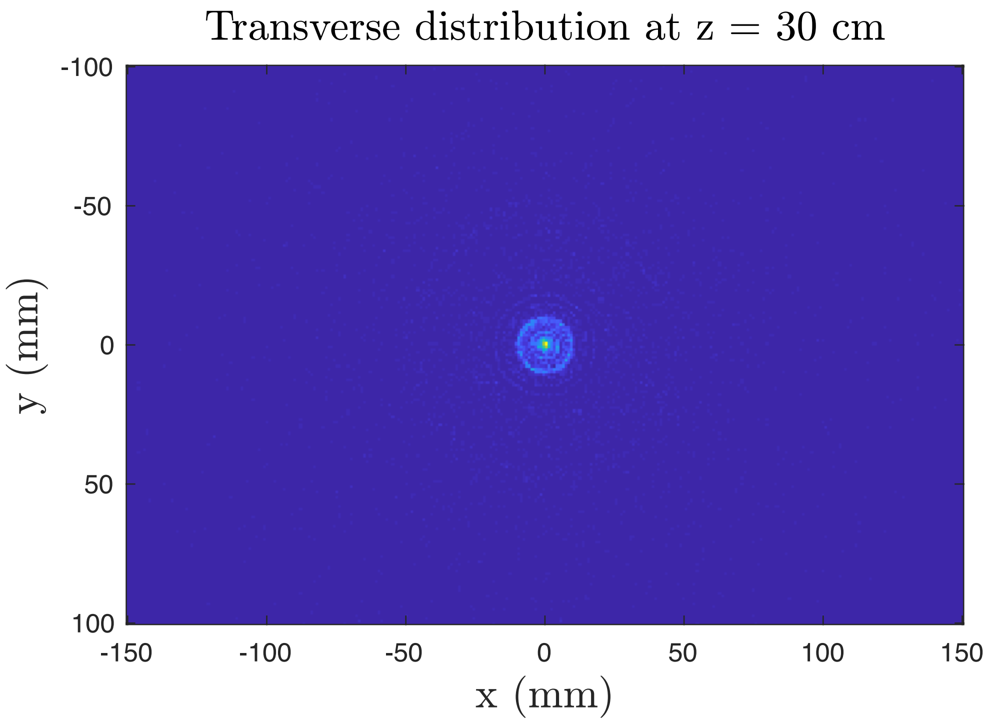
- Quadrupole doublet close to the target to collect more positrons and increase signal on detector



Quadrupole doublet for positron collimation

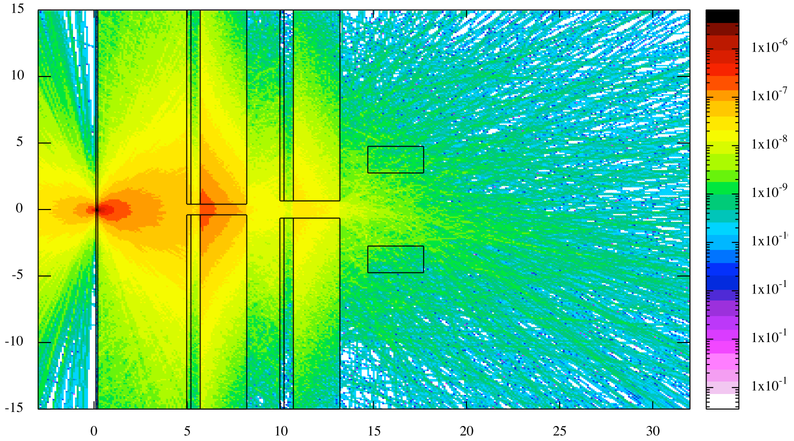
- Positron bunch collimated
- Can be transported to detector

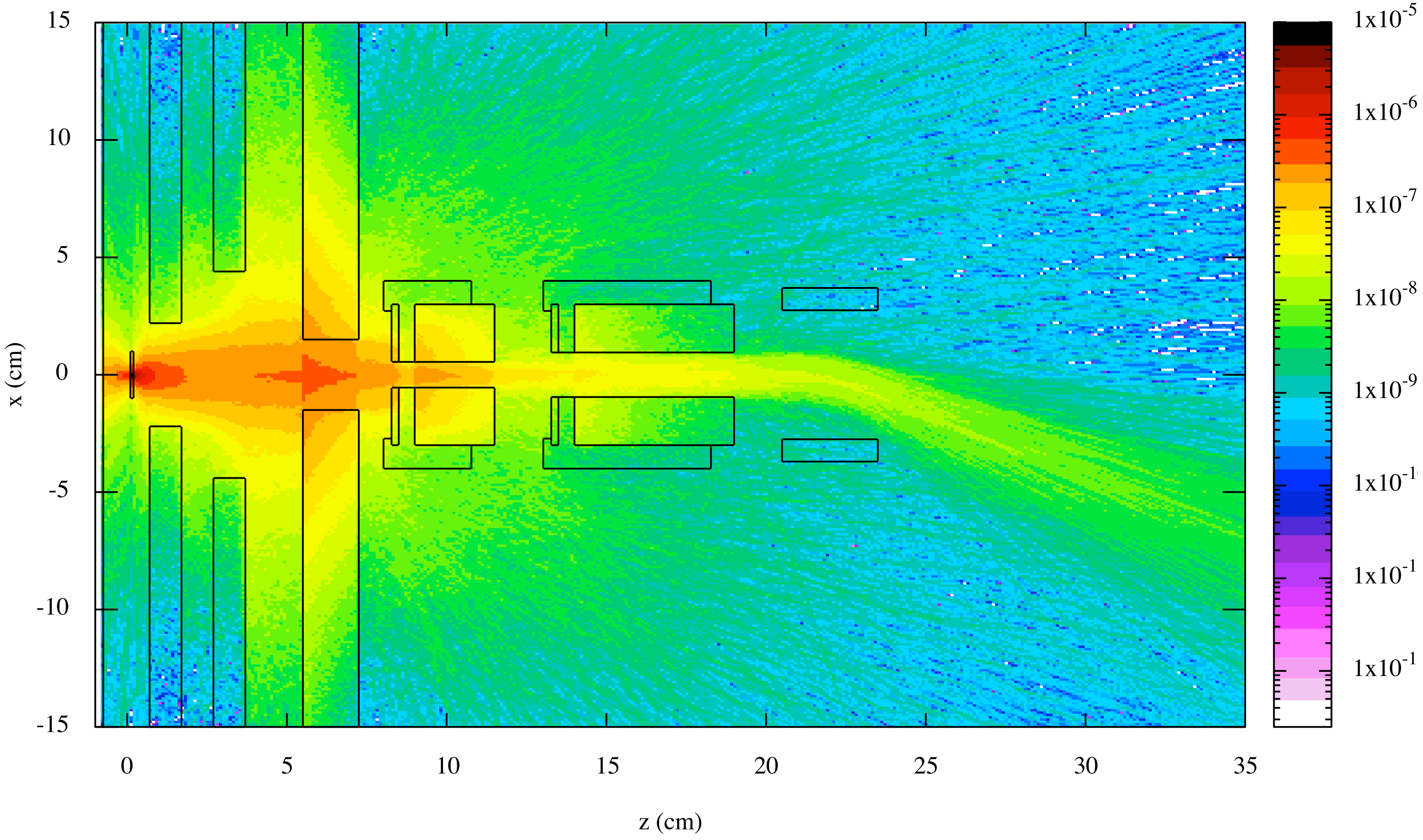




Shielding and quadrupole magnets to increase S/N

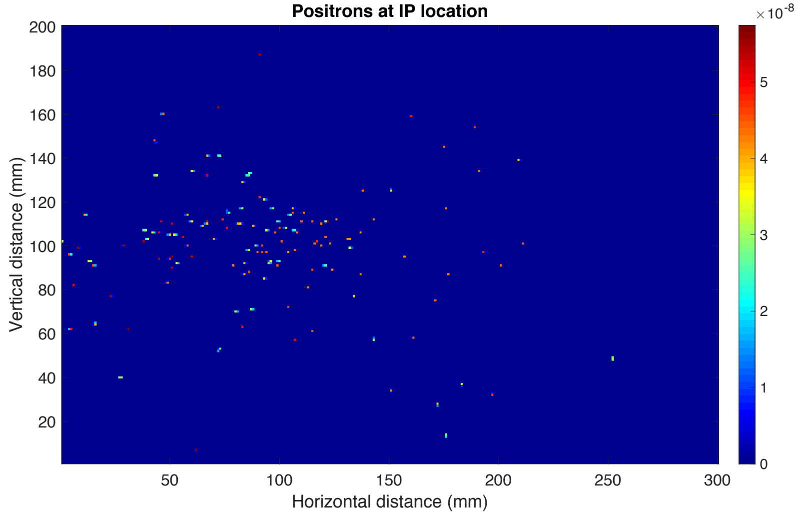
❖ Using shielding to reduce noise on detector and quadrupole magnets to increase the collection efficiency

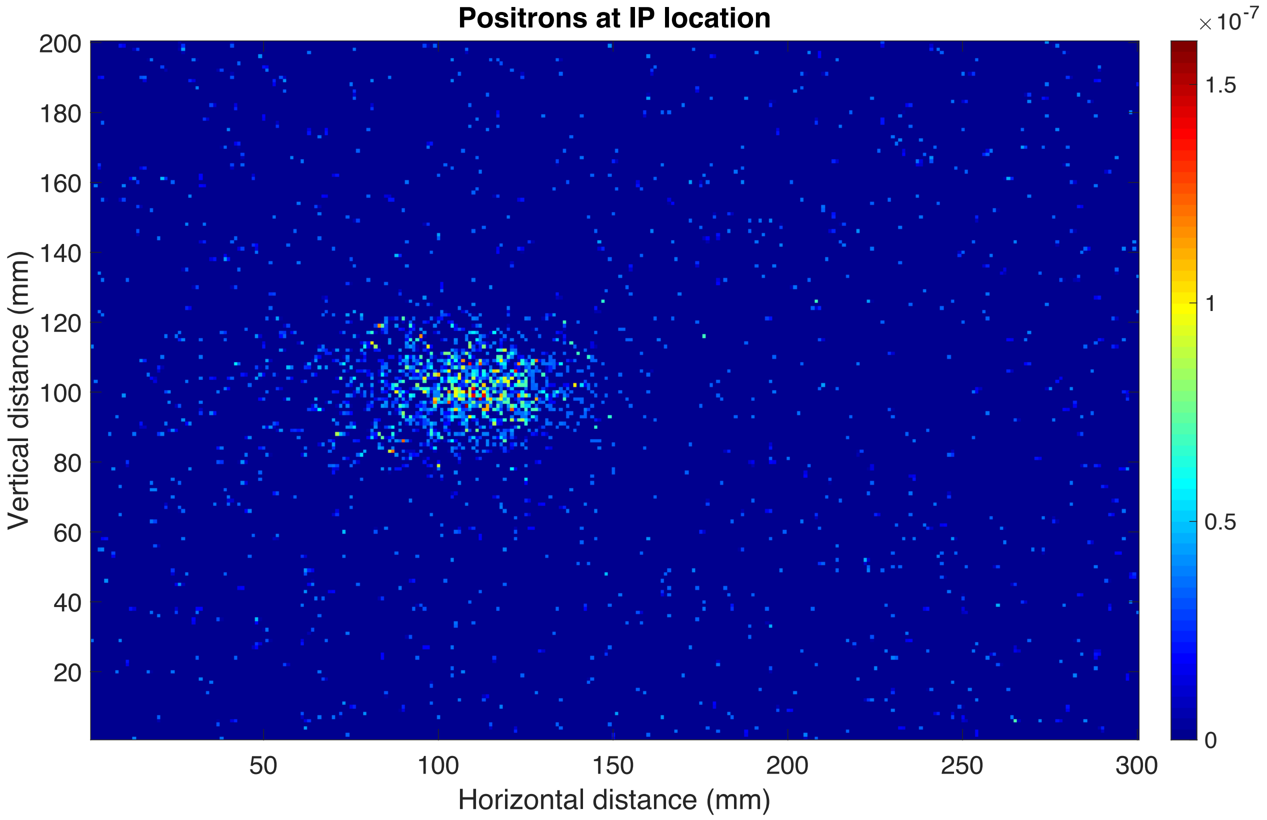




Shielding and quadrupole magnets to increase S/N

- Positron beam made clearer with the use of quadrupoles





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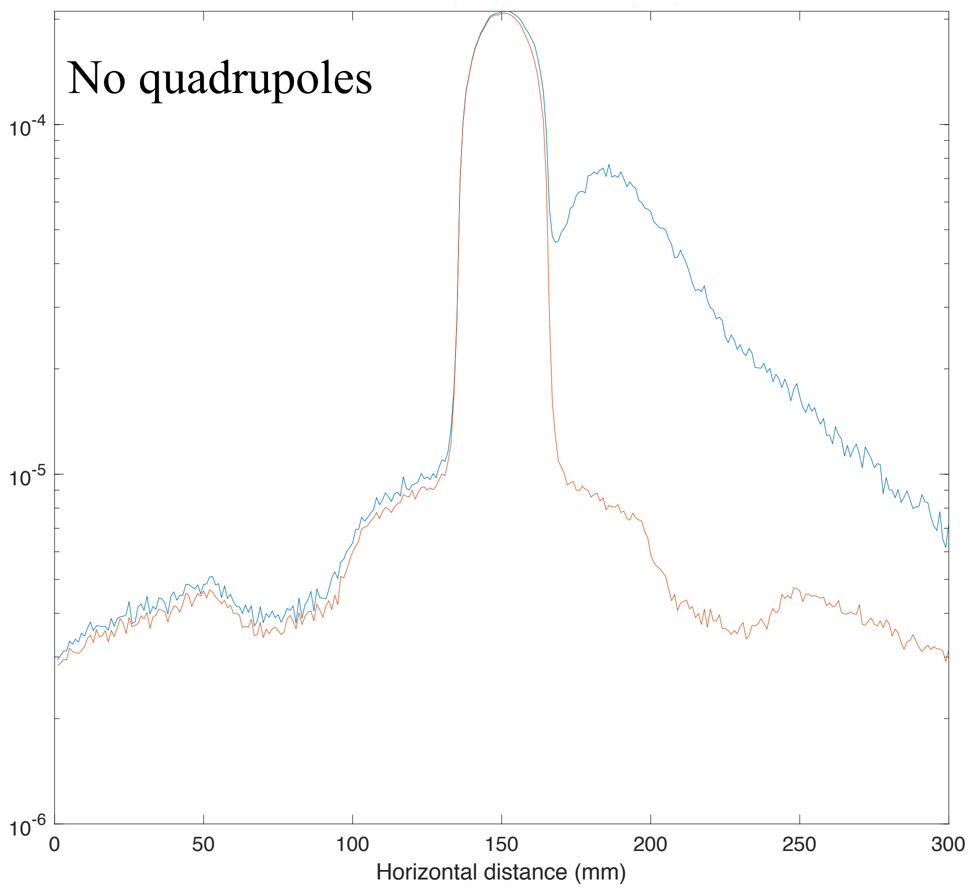

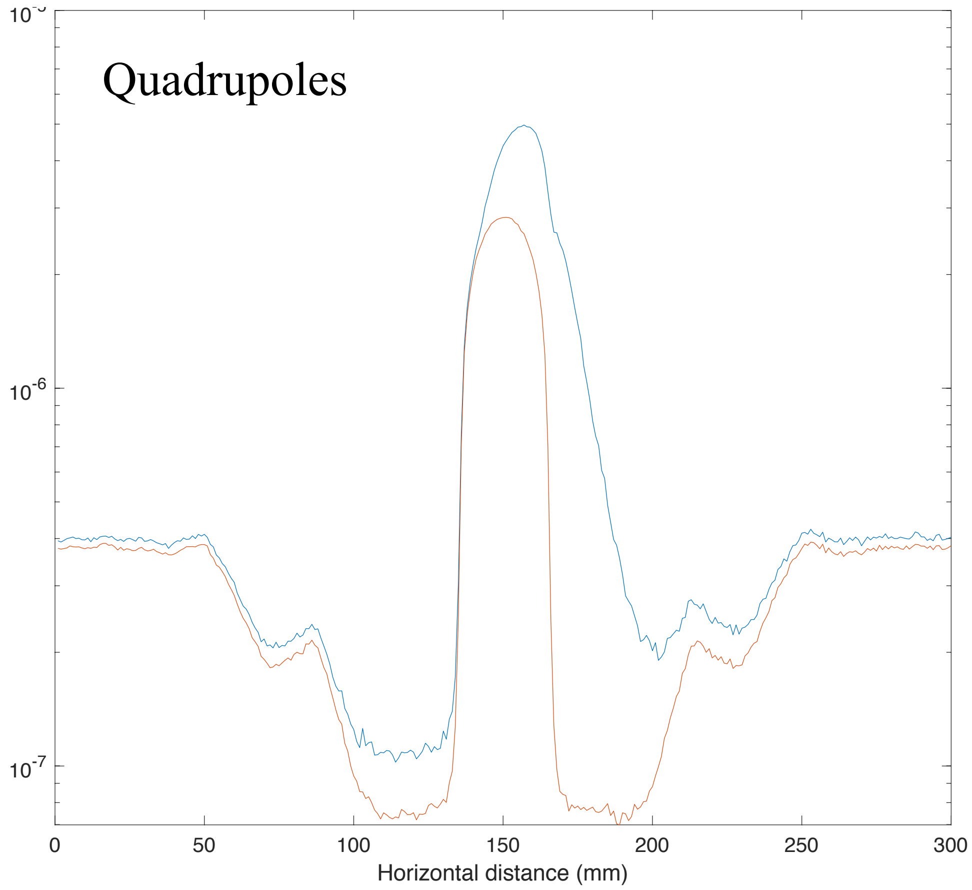

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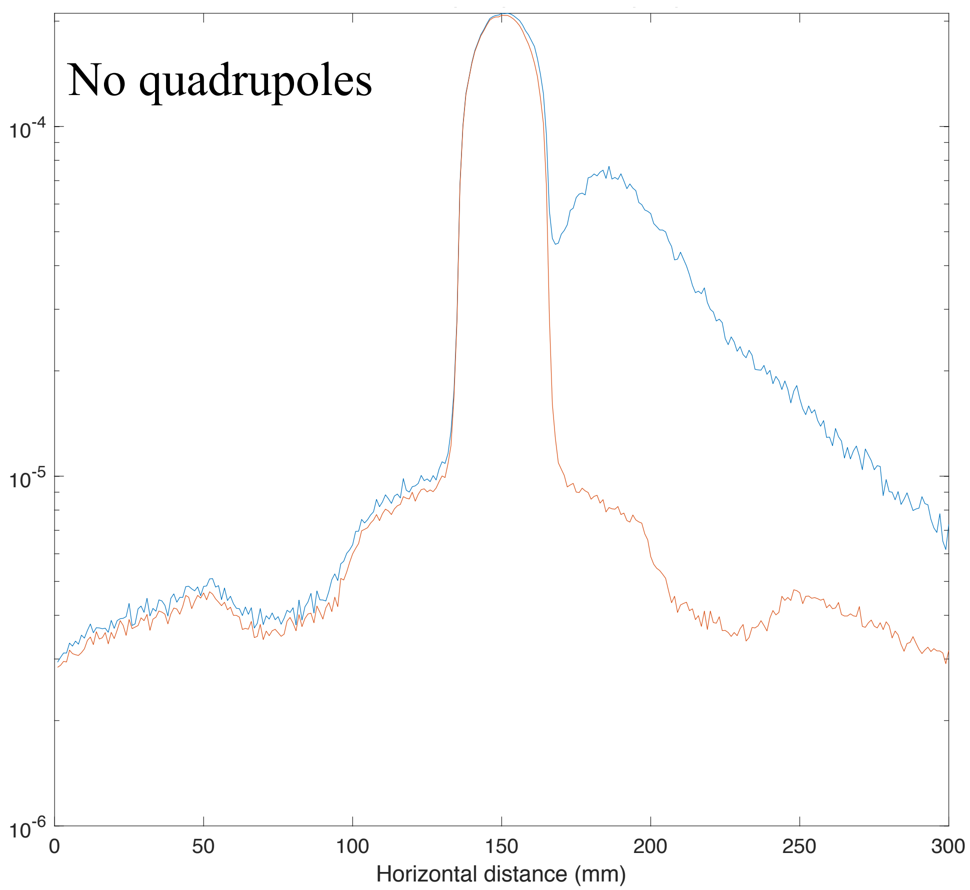
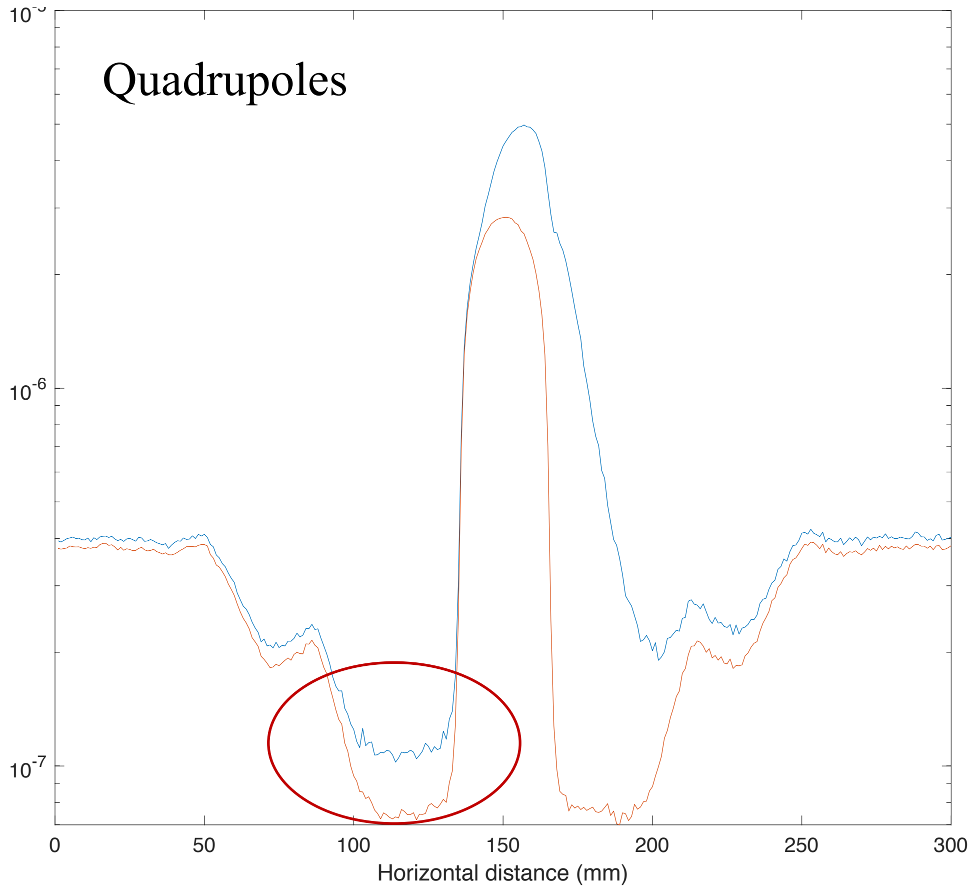
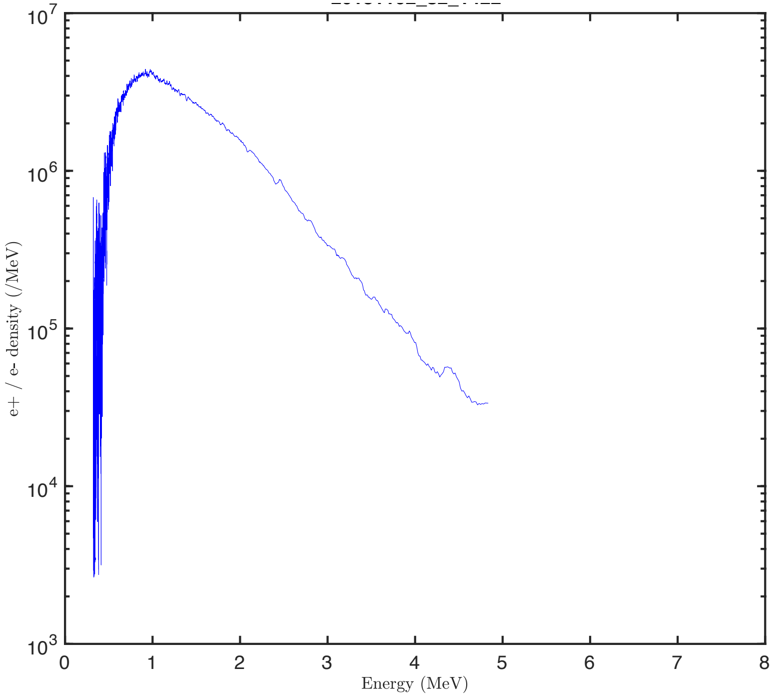
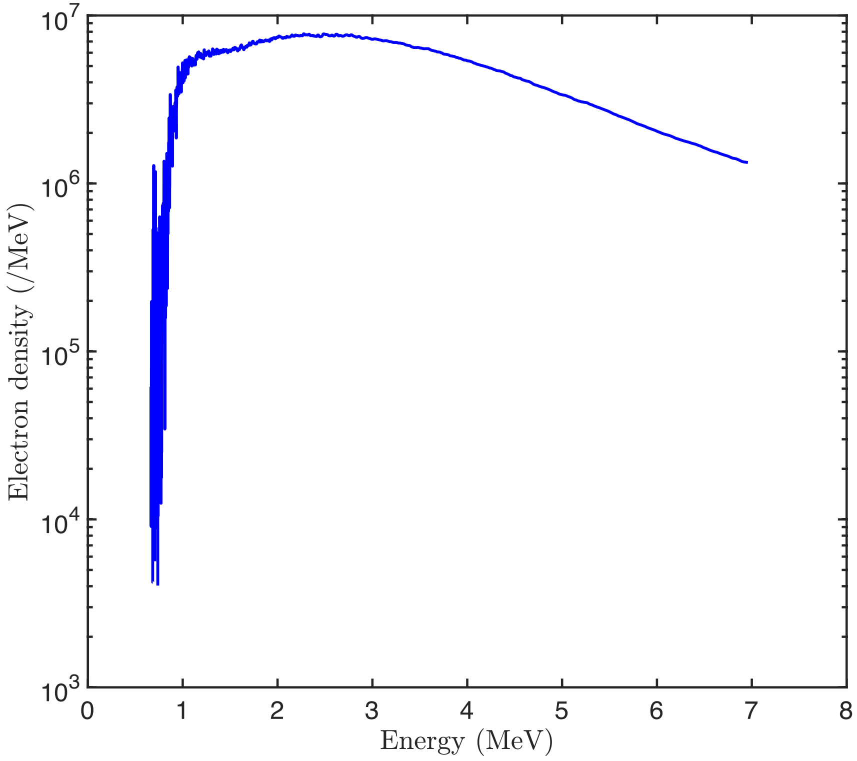


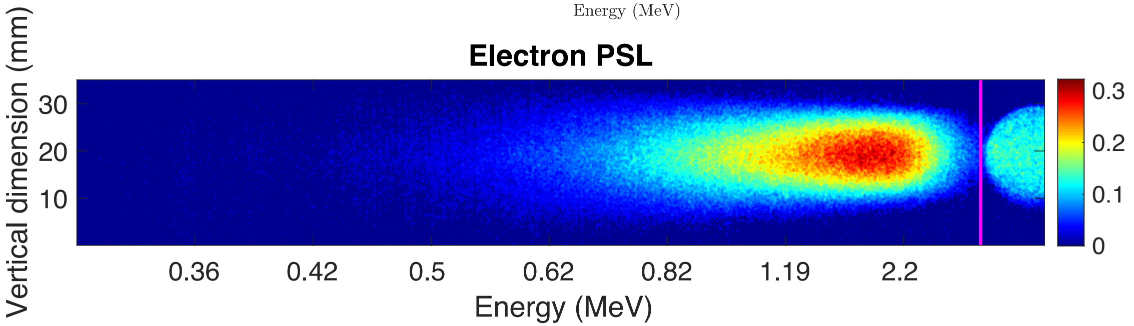


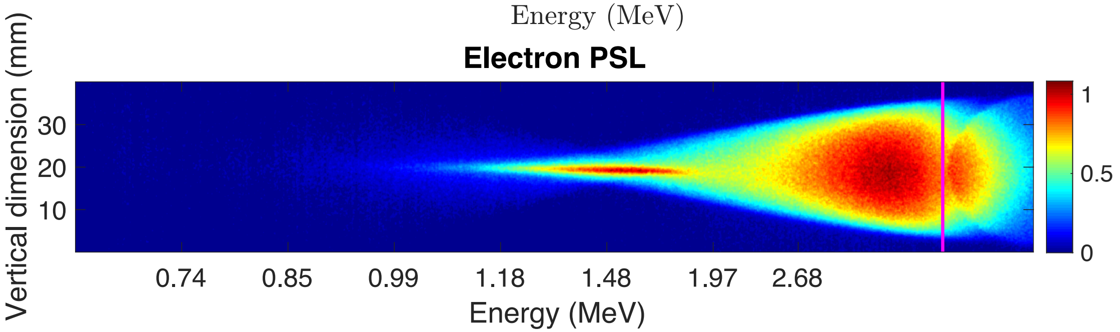
Preliminary experimental results on electrons

- Clear electron signal with improved shielding









Summary & outlook

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- Tests of quadrupoles in October - November
- Implementation of dogleg configuration for energy and energy bandwidth tunability


Thank you !