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Radiation Simulation and Beam Dump design for High Energy Electrons at the Australian Synchrotron

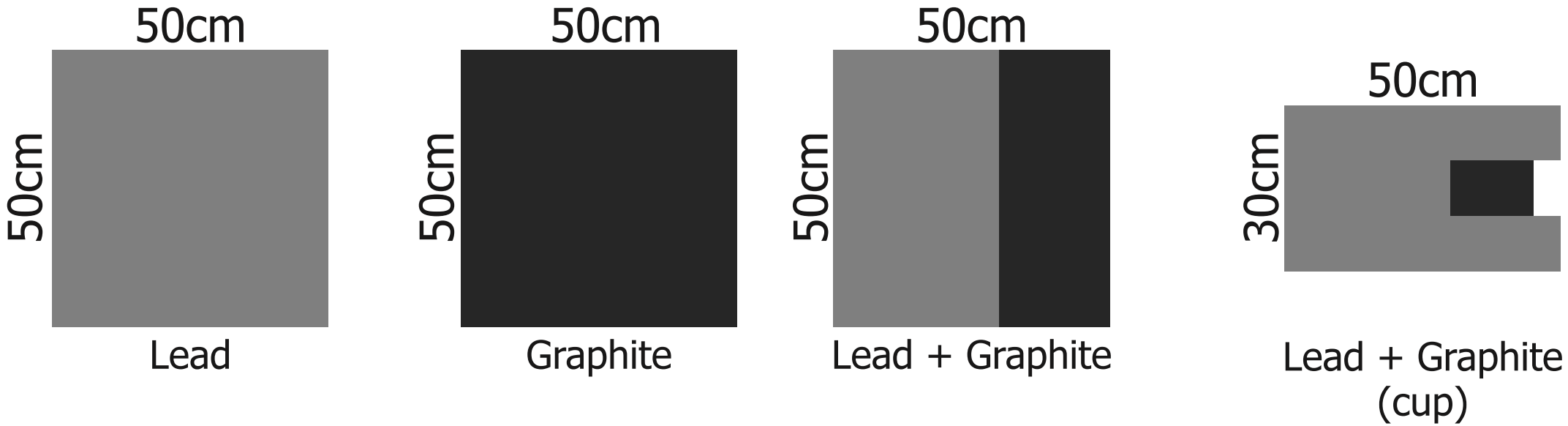
David Zhu, Eugene Tan

Science. Ingenuity. Sustainability.

Beam Dumps

- Future plans for a particle accelerator test facility requires beam dumps for the management of radiation in the around the accelerator.
- At the AS the typical design is to use Lead as the primary shielding material surrounded by HDPE to absorb the neutrons.
- A study incorporating low Z primary targets has reduced the overall radiation levels.

Beam Dump Configuration Study



100 MeV Electron Beam
4 nC/pulse @ 1 Hz

Graphite density used: 1850 kg/m^3

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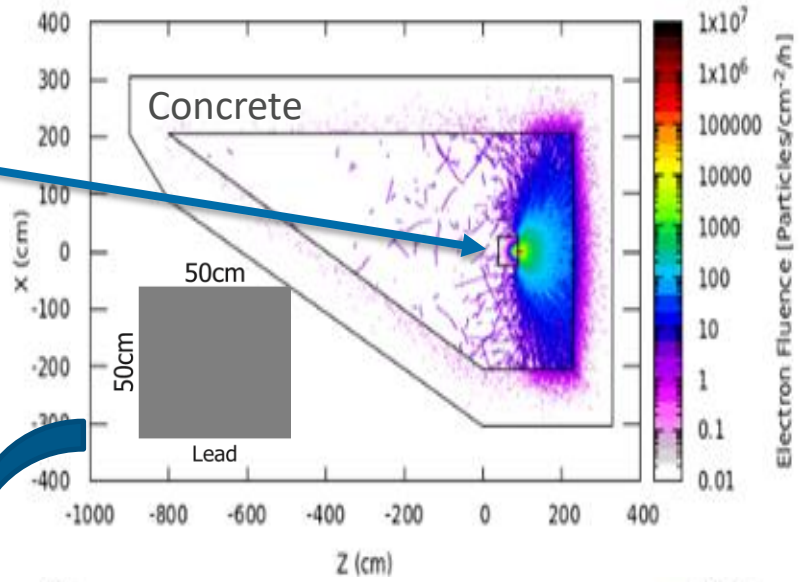
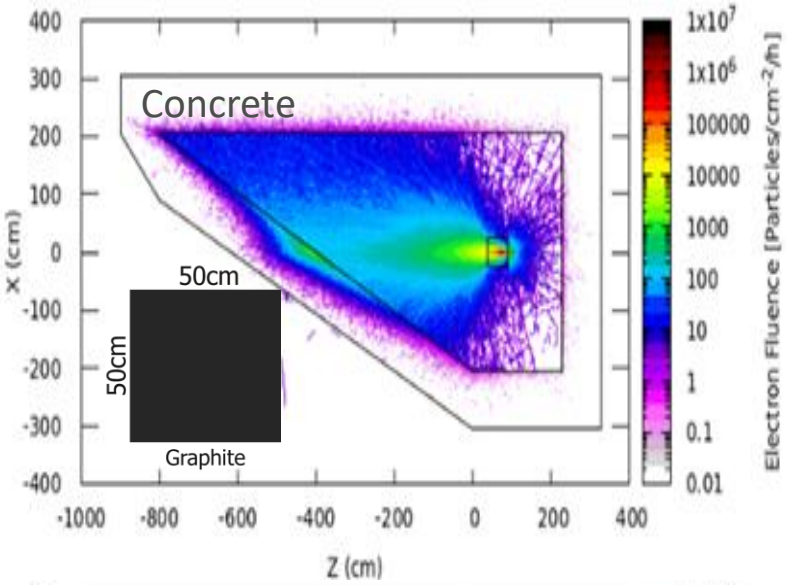
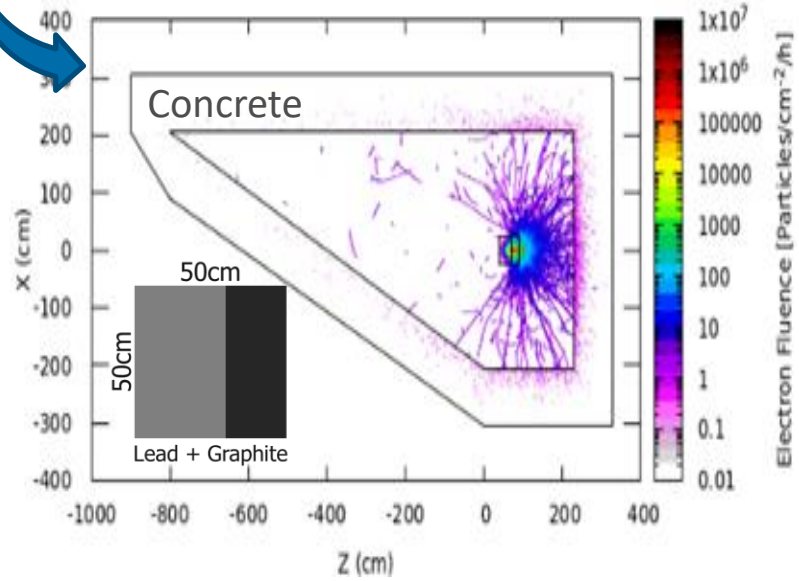
FLUKA Simulations – Electron Fluence

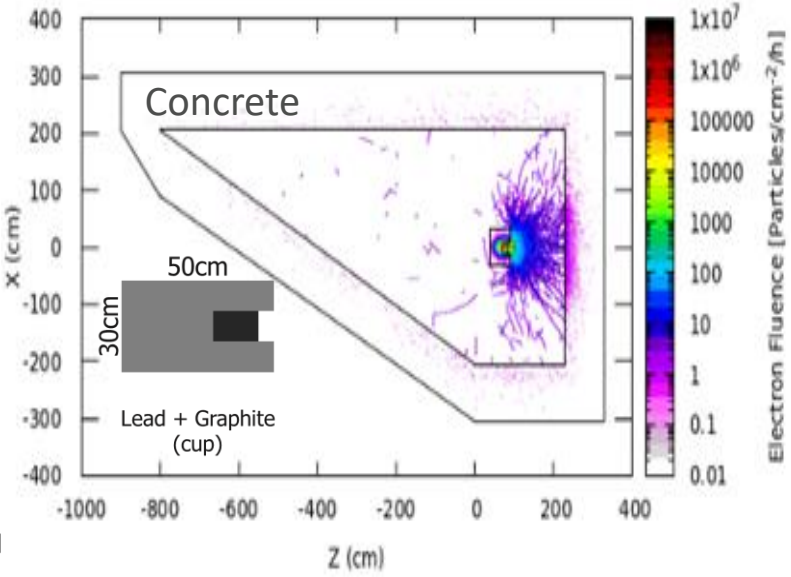
Electrons stopped after 25 cm.

Significant reduction in backscattered electrons









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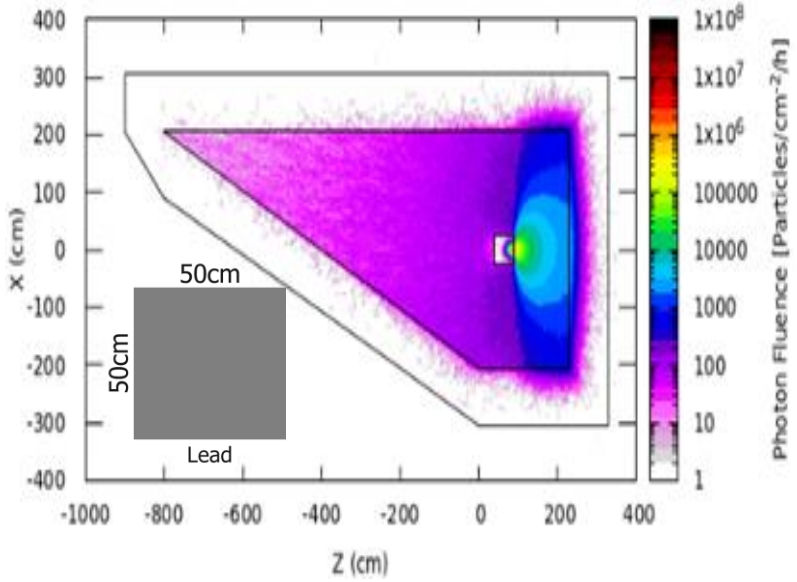
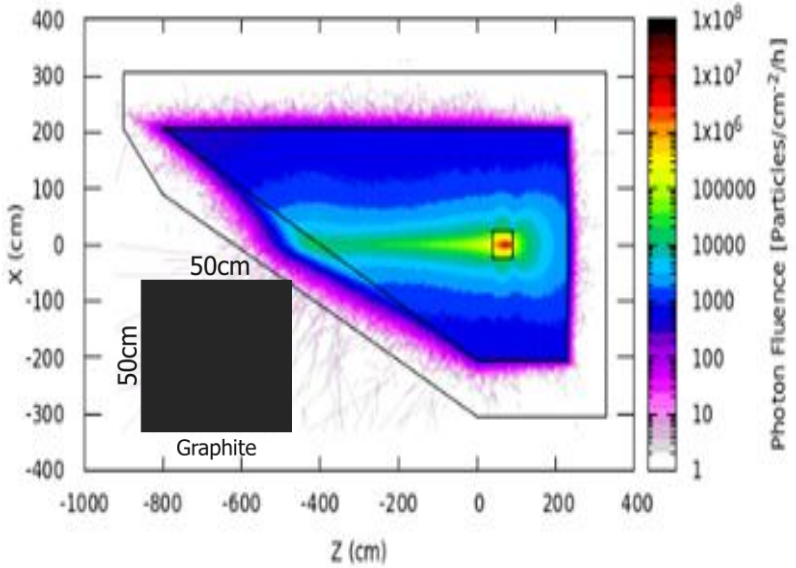
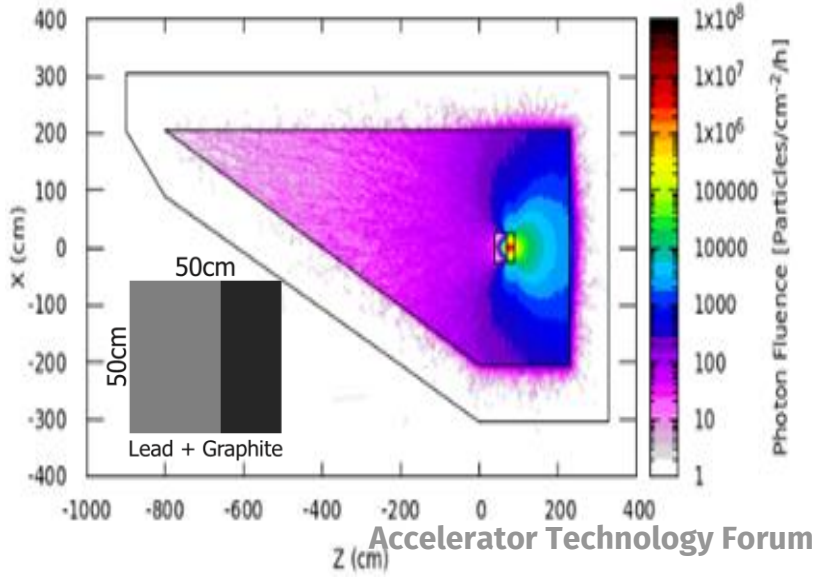
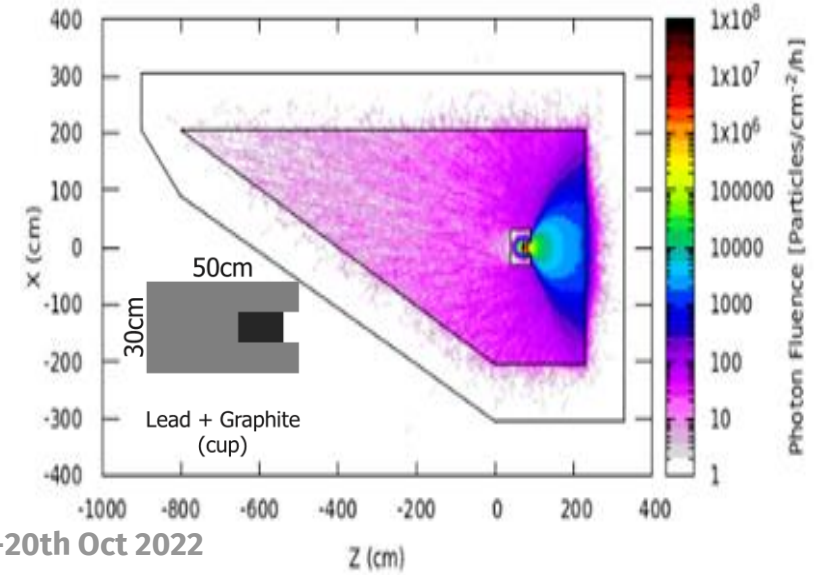
FLUKA Simulations – Photon Fluence









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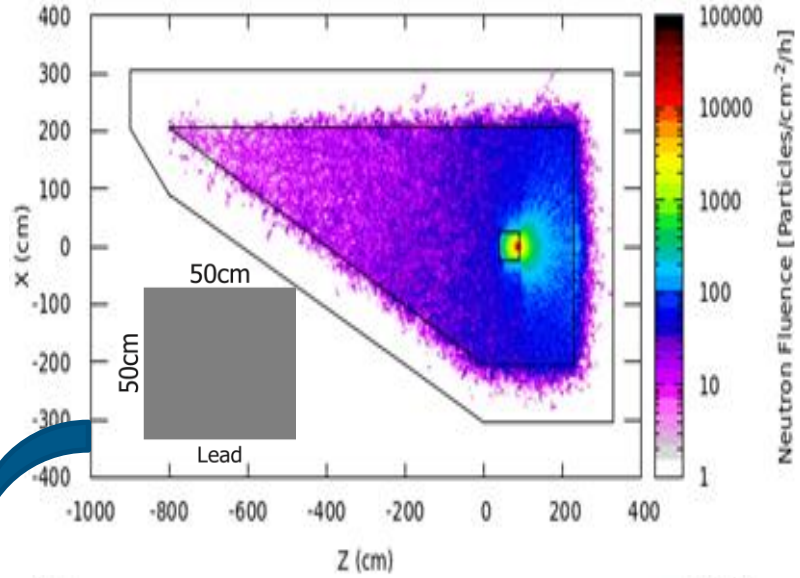
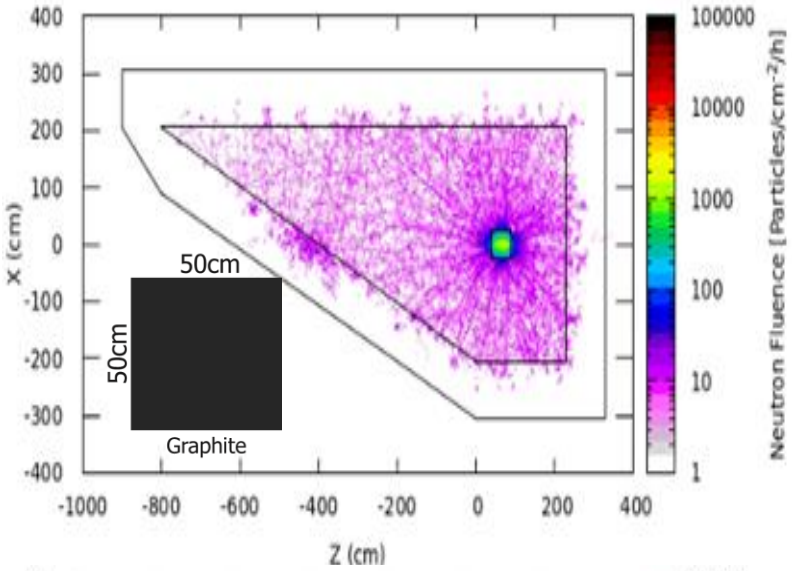
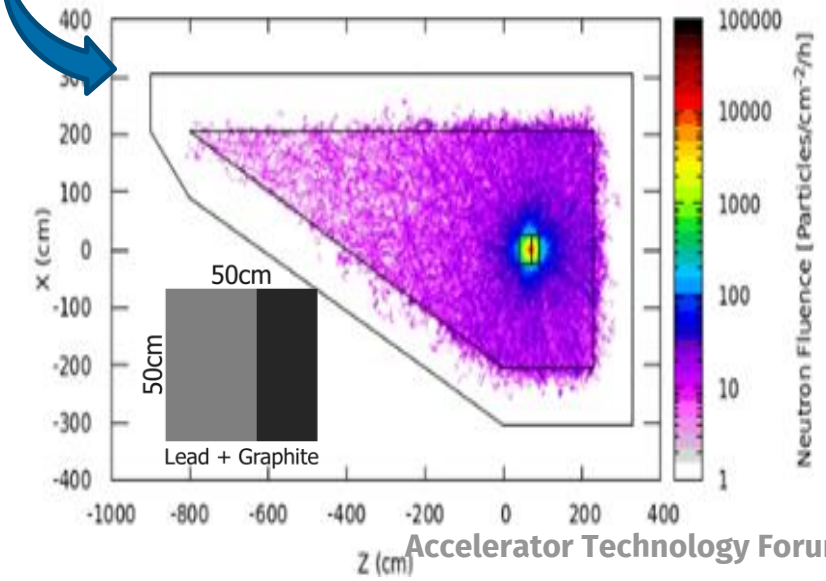
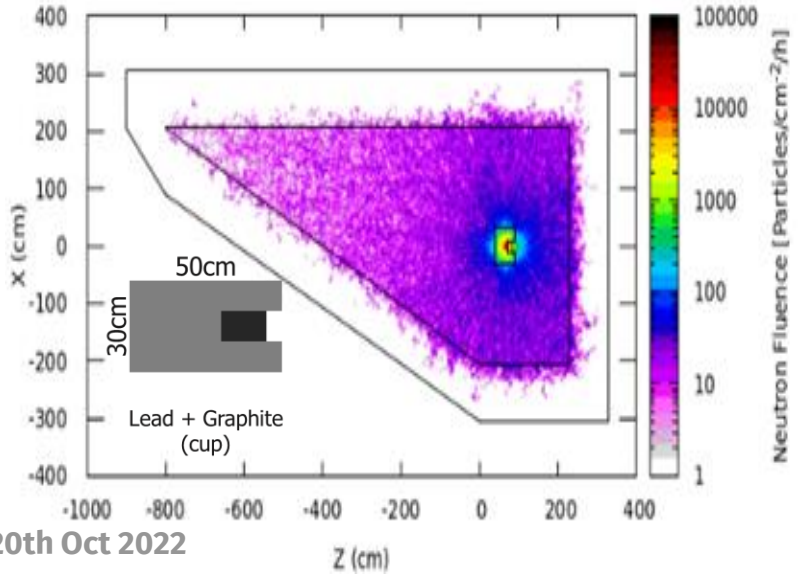
FLUKA Simulations – Neutron Fluence

Overall reduction in neutron generation









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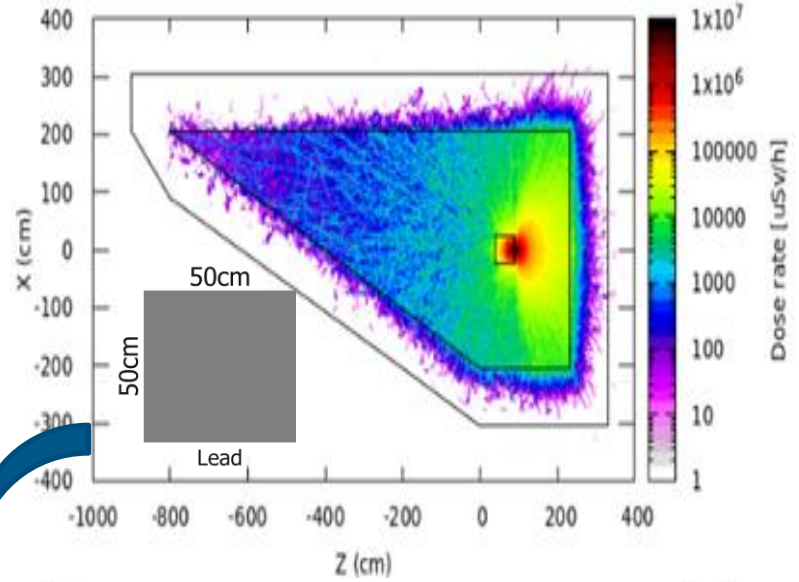
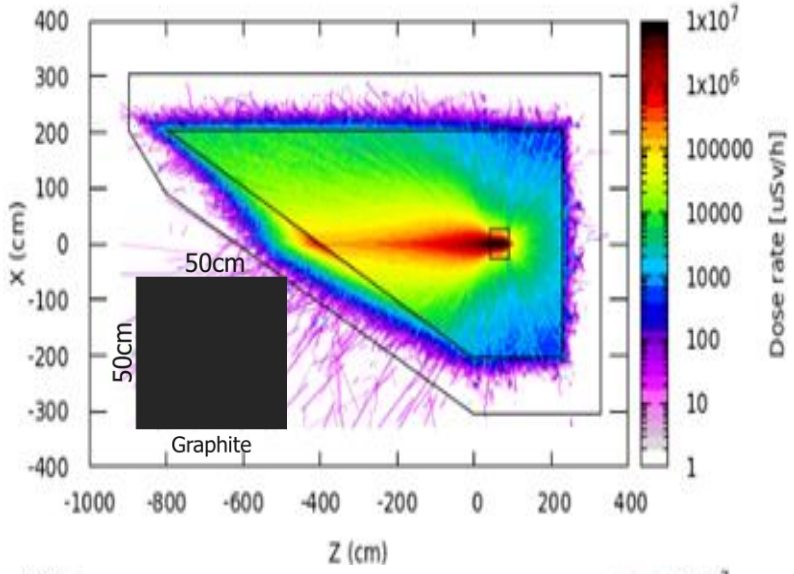
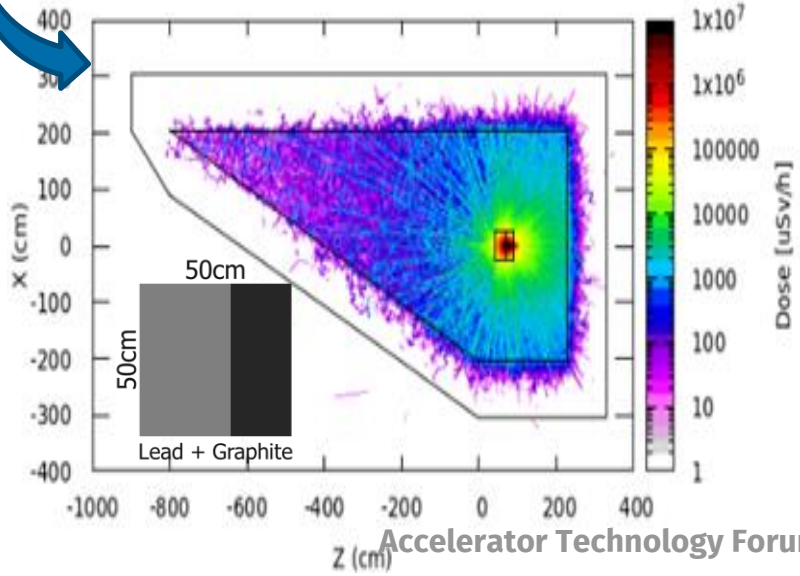
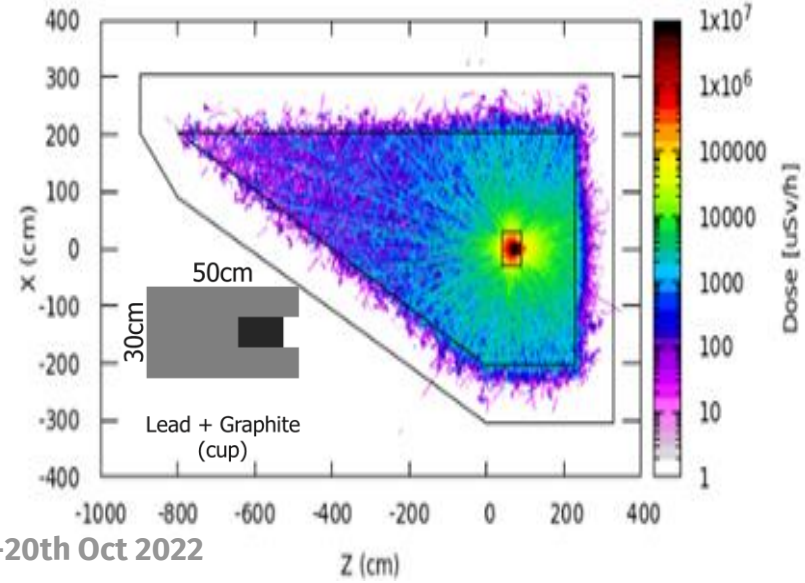
FLUKA Simulations – Total Dose Rate

Factor 5 to 10 reduction in total dose rate









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Results and Conclusions

- A 60%/40% combination of Lead to low-Z material can significantly reduce back scattered radiation and overall radiation levels.
- Possible future directions:
  - Measurements to verify simulations.
  - Compare graphite to Al (cleaner to work with)
  - Any benefit of layering (W/Pb/Cu/Fe/Al/C)? Order?
  - Use of permanent magnets to trap low energy electrons?

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PASSIVE PLASMA BEAM DUMP PRELIMINARY SIMULATION RESULTS

Overview

- Feasibility study into passive plasma beam dumps for 100 MeV electron beams (γ = 196)
- Previous papers focus on short electron beams (~ 10^{-15} s) whereas the beam generated by the Australian Synchrotron is comparatively very long (~ 10^{-12} s).
- Wake-T, a lightweight particle tracker, has been used to simulate the beam dump. Conventional Particle-In-Cell (PIC) codes typically require supercomputers.
- As no other studies used Wake-T for this particular application, benchmarking against results produced by other PIC algorithms was required. Jakobsonn et al 2019 was used to benchmark.

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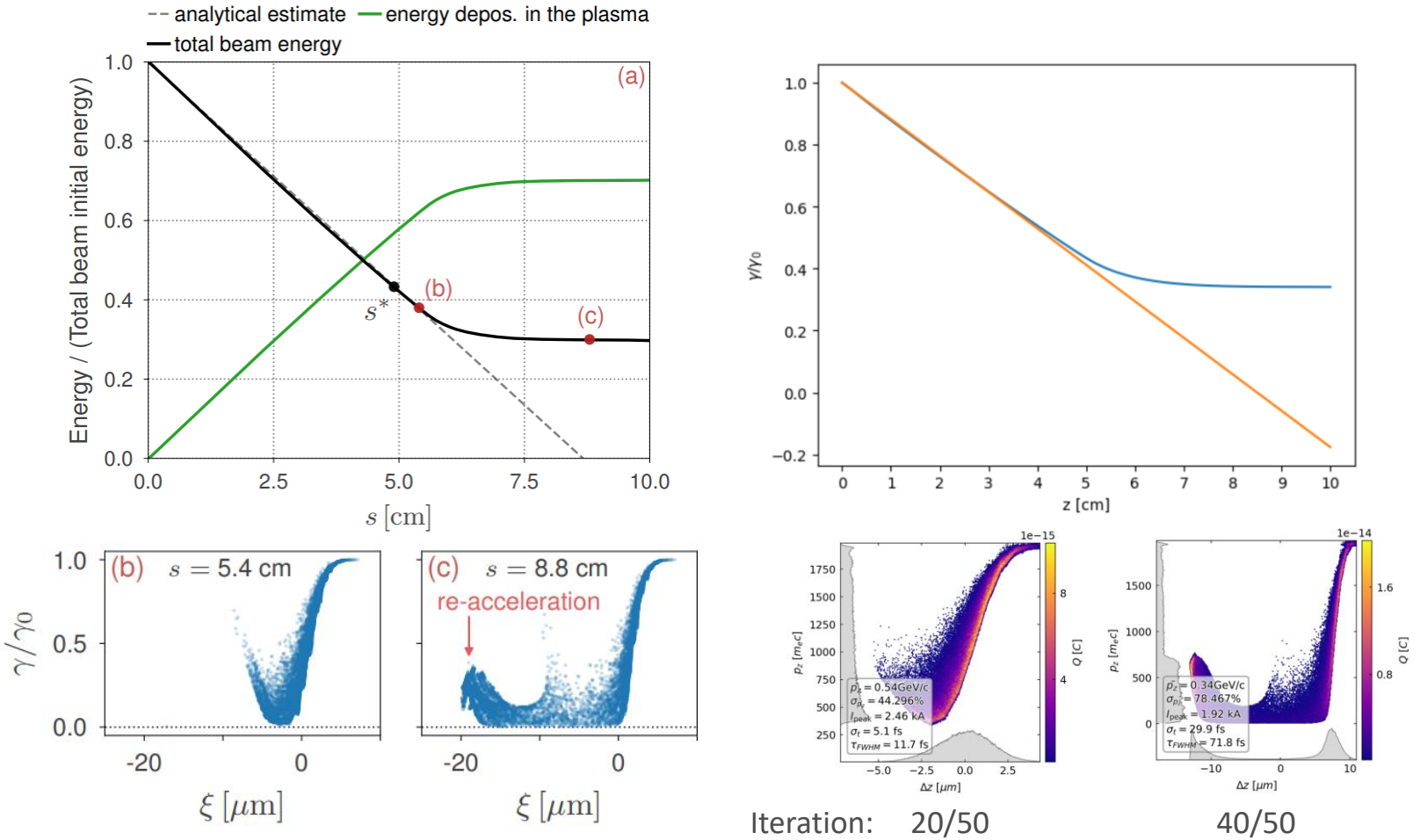
Benchmarking Wake-T



Jakobsson et al 2019

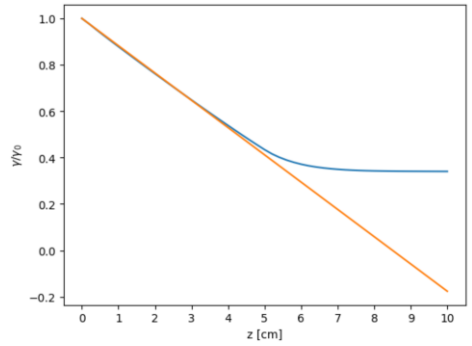
Iteration: 20/50 40/50

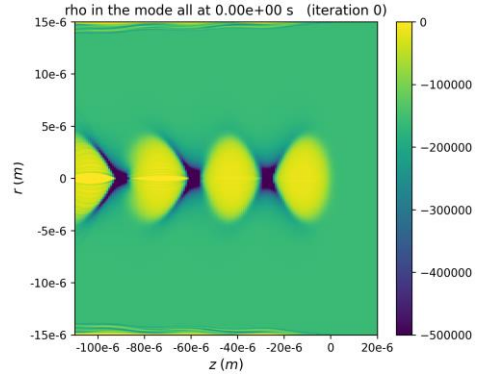
Wake-T

Bi-Gaussian electron beam in uniform plasma density, n_0=9.9x10^{-17}cm^{-3}. σ_r=1.4μm, σ_ζ=2.0μm, Q=30pc, Υ_0= 1960

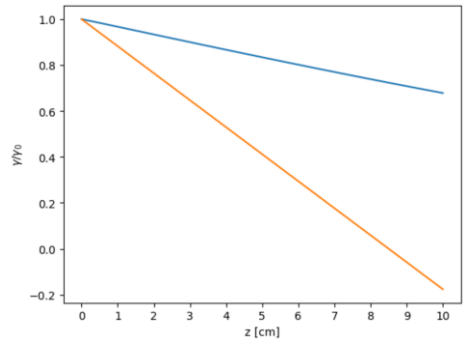
Increasing Beam Length

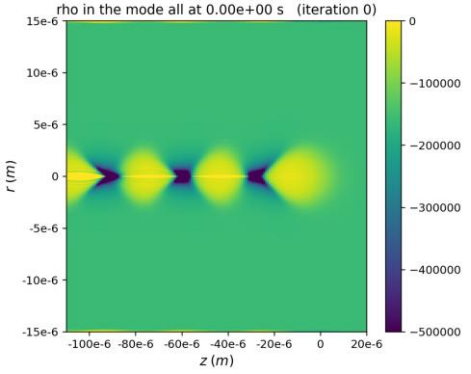
original beam length



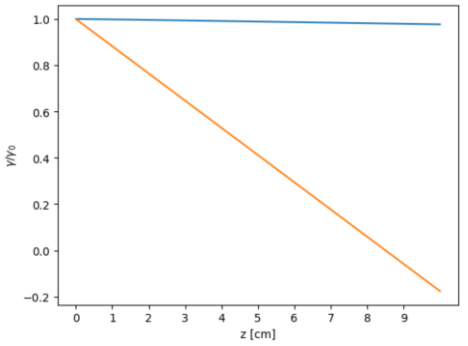


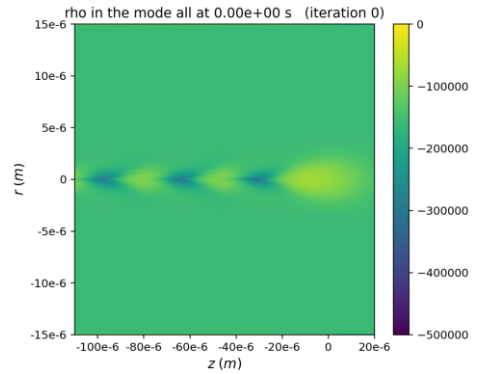
5x original beam length



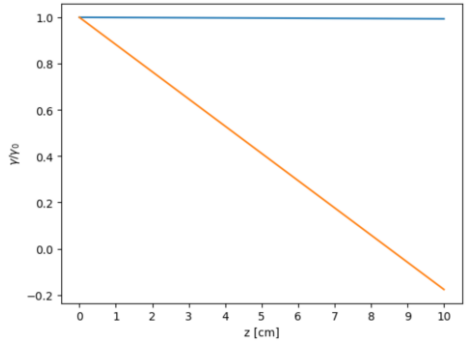


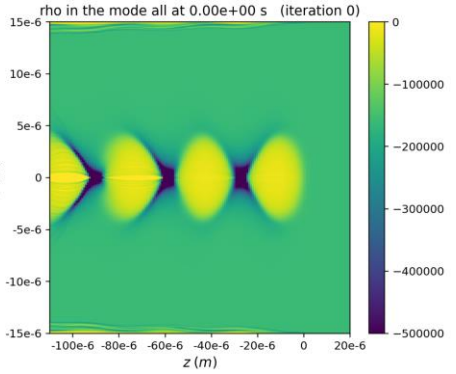
10x original beam length



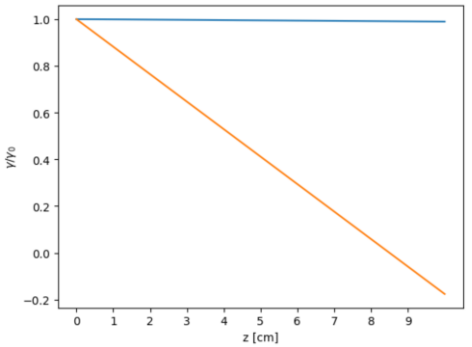


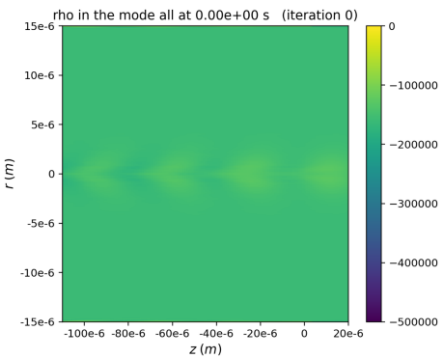
1x “bubble” length





2x “bubble” length





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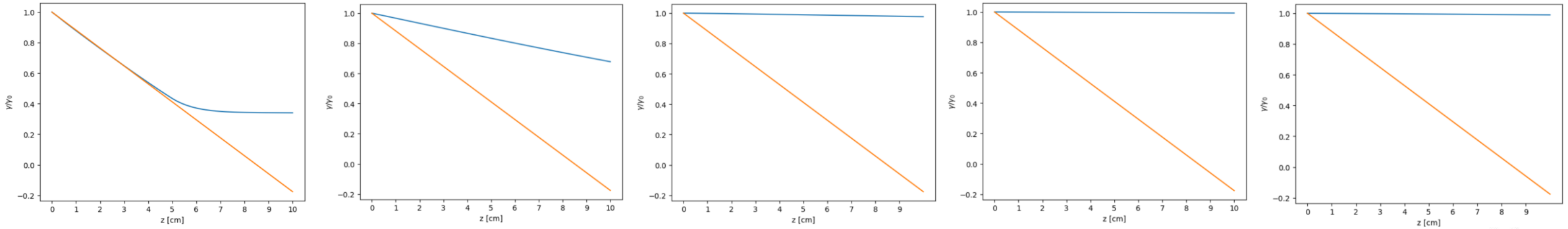
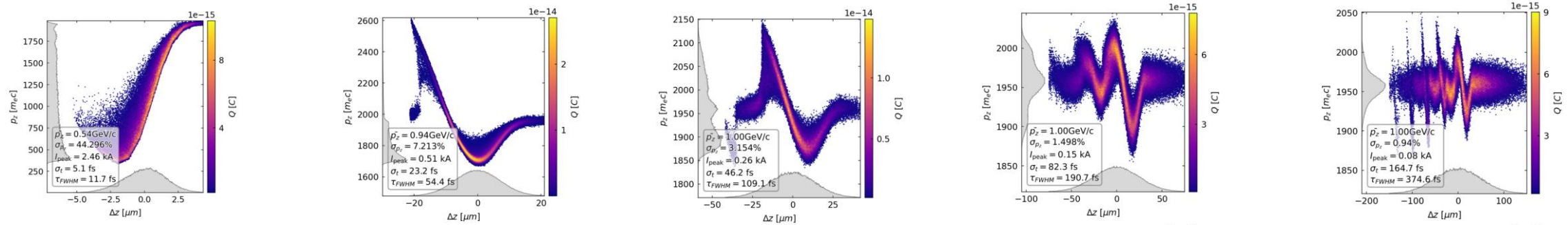
Increasing Beam Length: Evolution

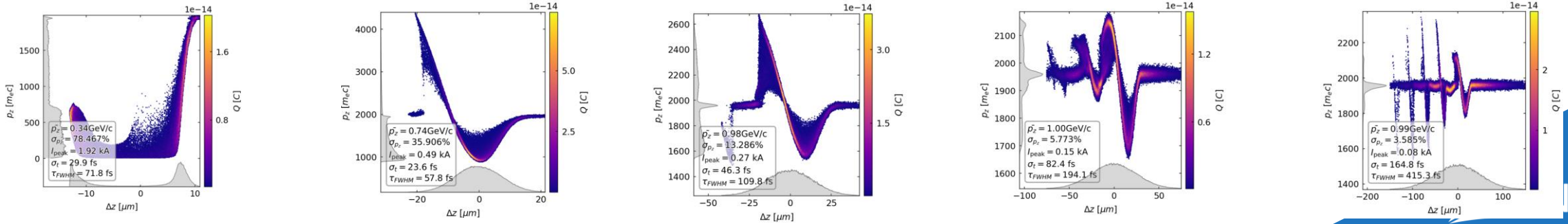
original beam length | 5x original beam length | 10x original beam length | 1x “bubble” length | 2x “bubble” length



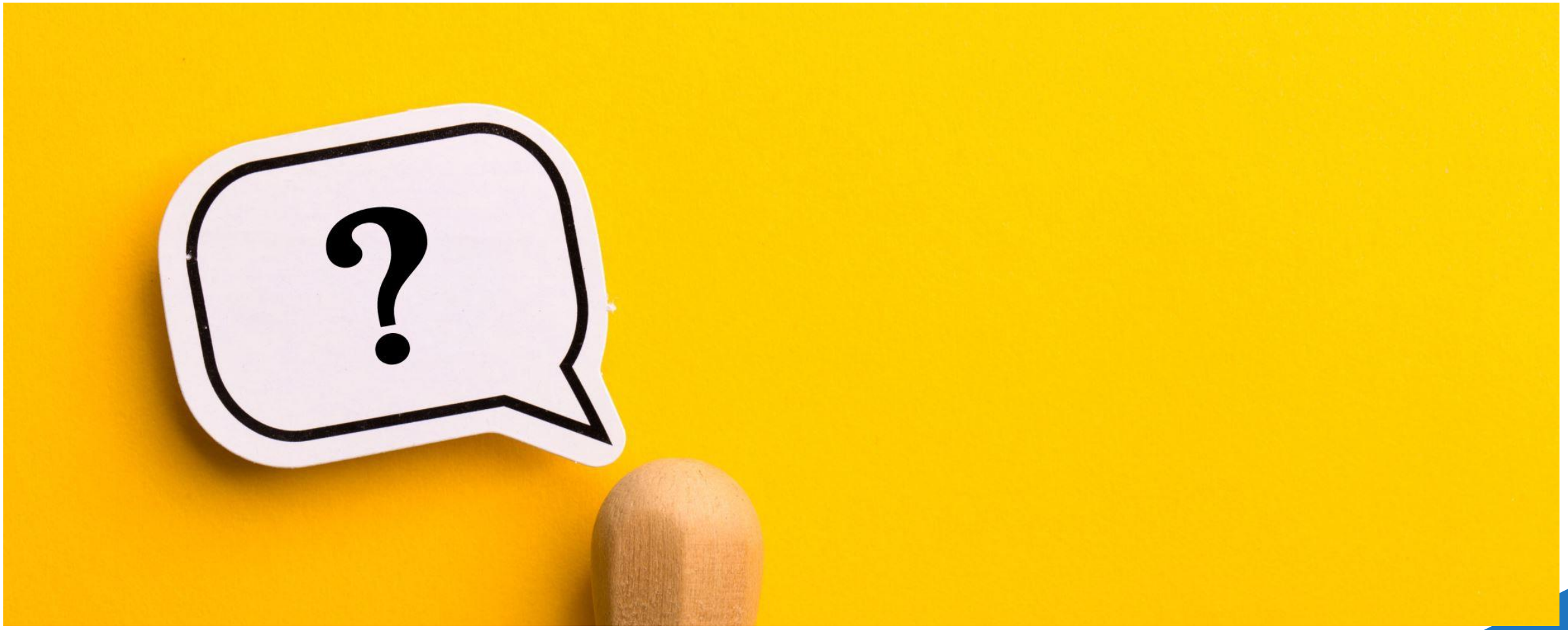
20/50



40/50



Questions and Feedback



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Thank You

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