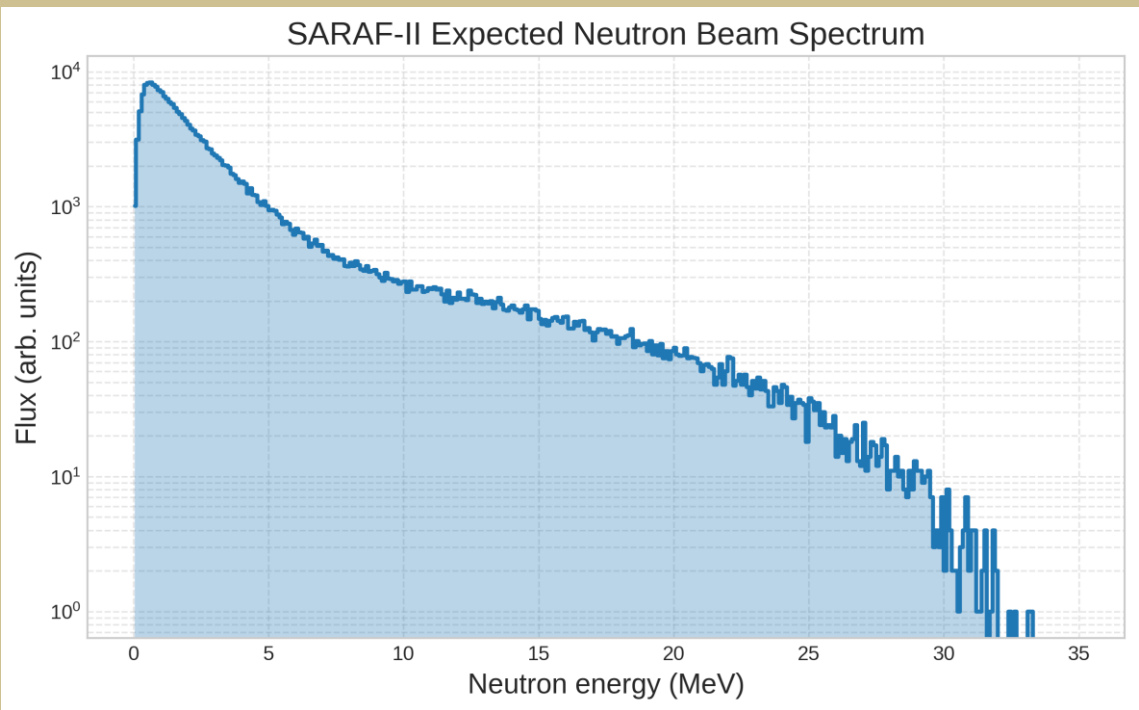
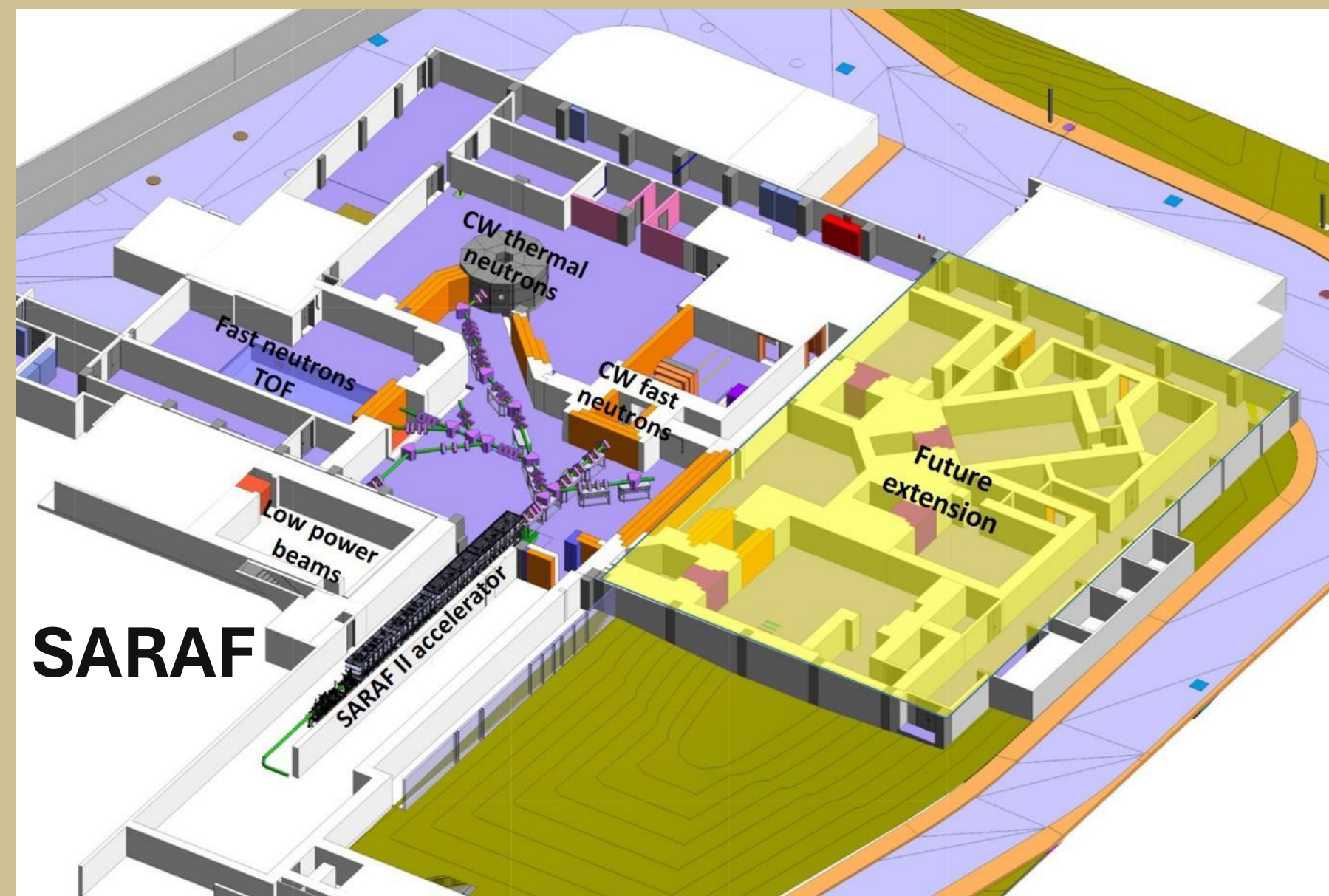


Development of a Multi-Purpose Optical TPC for Neutron-Induced Reaction Studies at SARAF

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Introduction

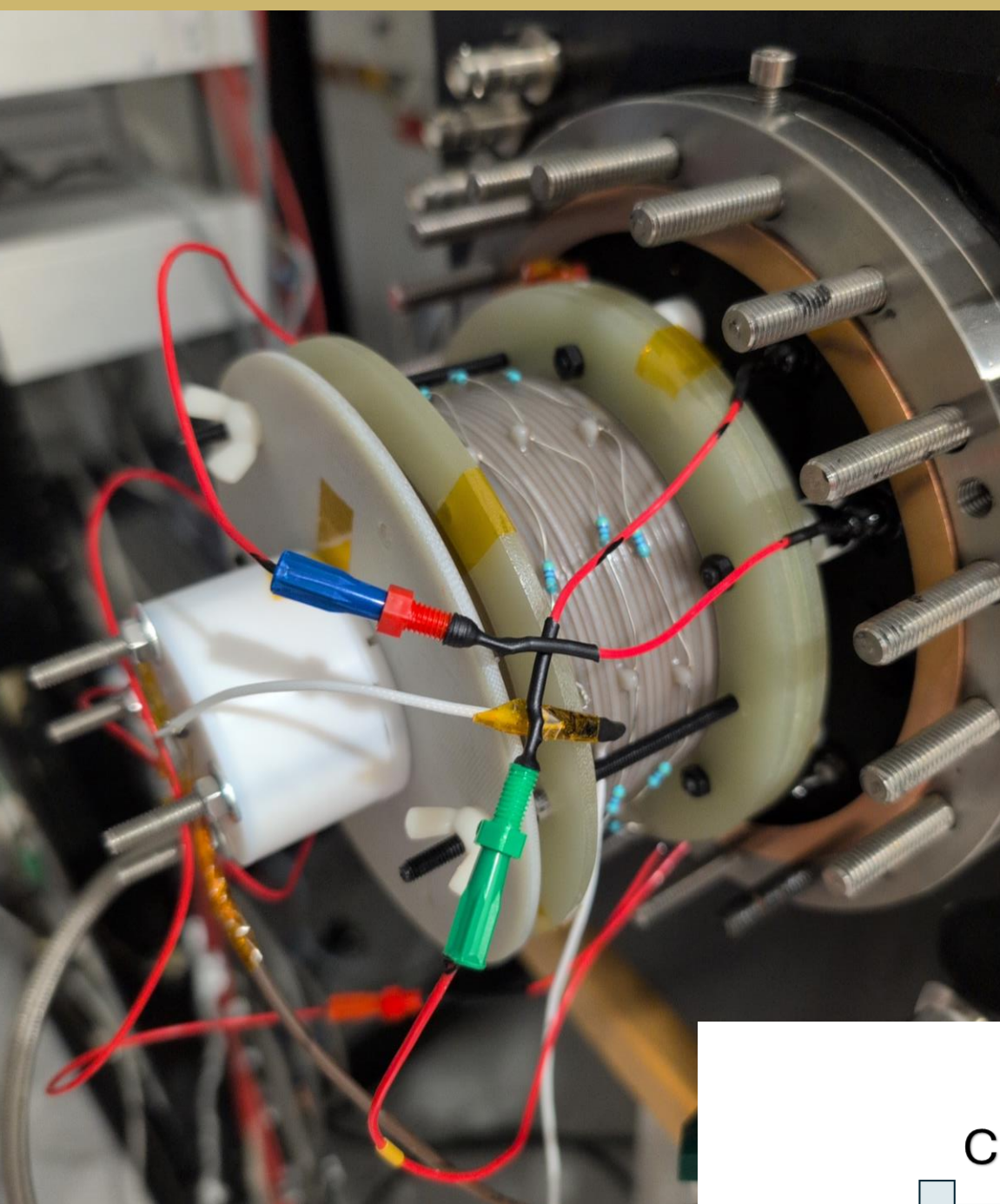
- Motivation:** Cross sections of many neutron-induced reactions that shape stellar nucleosynthesis and Big Bang nucleosynthesis remain uncertain.
- Important reactions:** ${}^7\text{Be}(n,p){}^7\text{Li}$; $p(n,\gamma)d$; ${}^{16}\text{O}(n,\alpha){}^{13}\text{C}$...



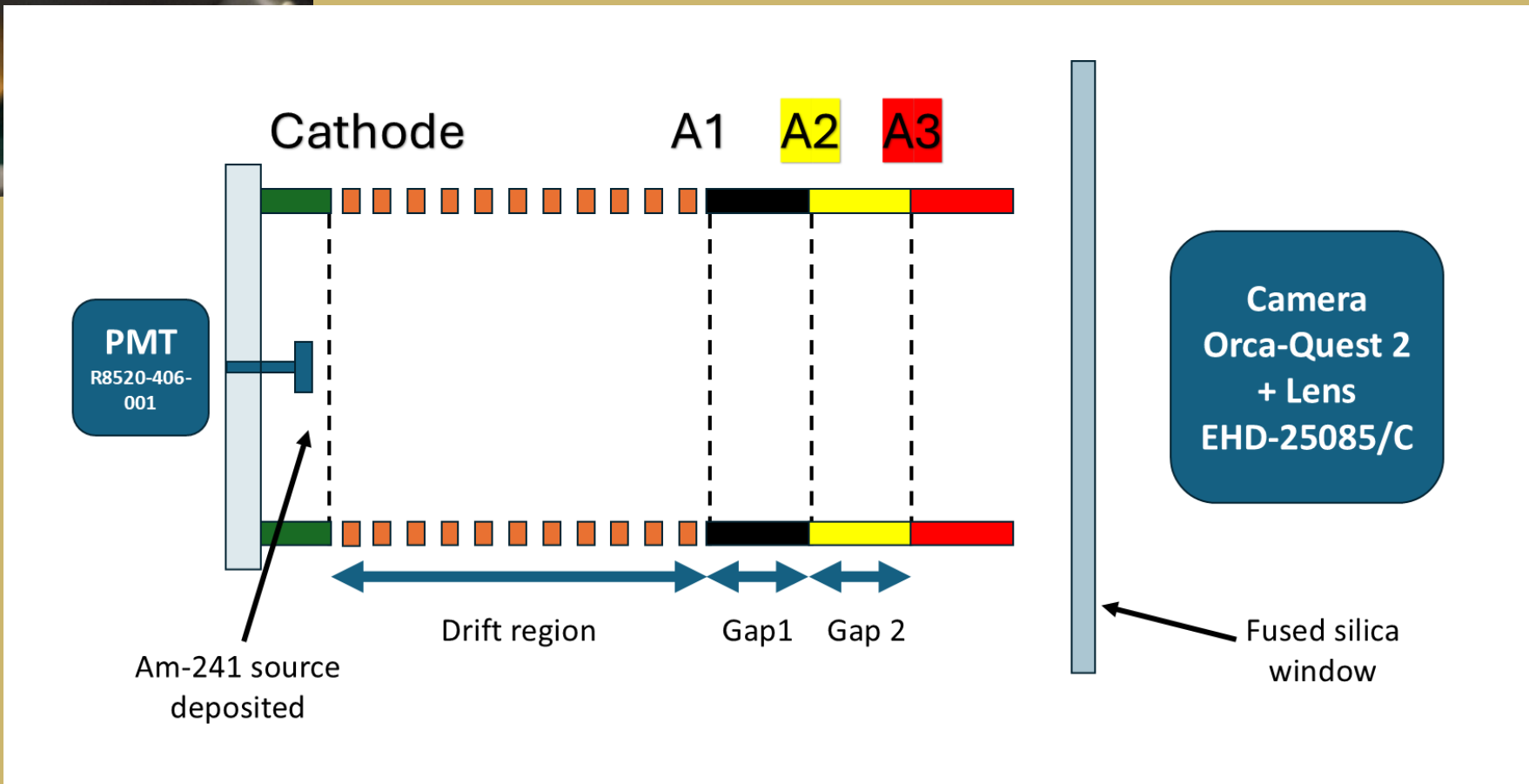
- Facility:** SARAF-II will provide a broad energy, intense and sub-nanosecond pulsed fast-neutron beamline for TOF measurements.

- Instrument:** A multi-purpose Optical Time Projection Chamber (OTPC) to study neutron reactions on varied targets via charged particle track imaging.
- Prototype:** Early OTPC now operating: enables α -track imaging, gas-mixture characterization, performance evaluation of amplification structures, and informs next-gen detector design.

OTPC prototype setup



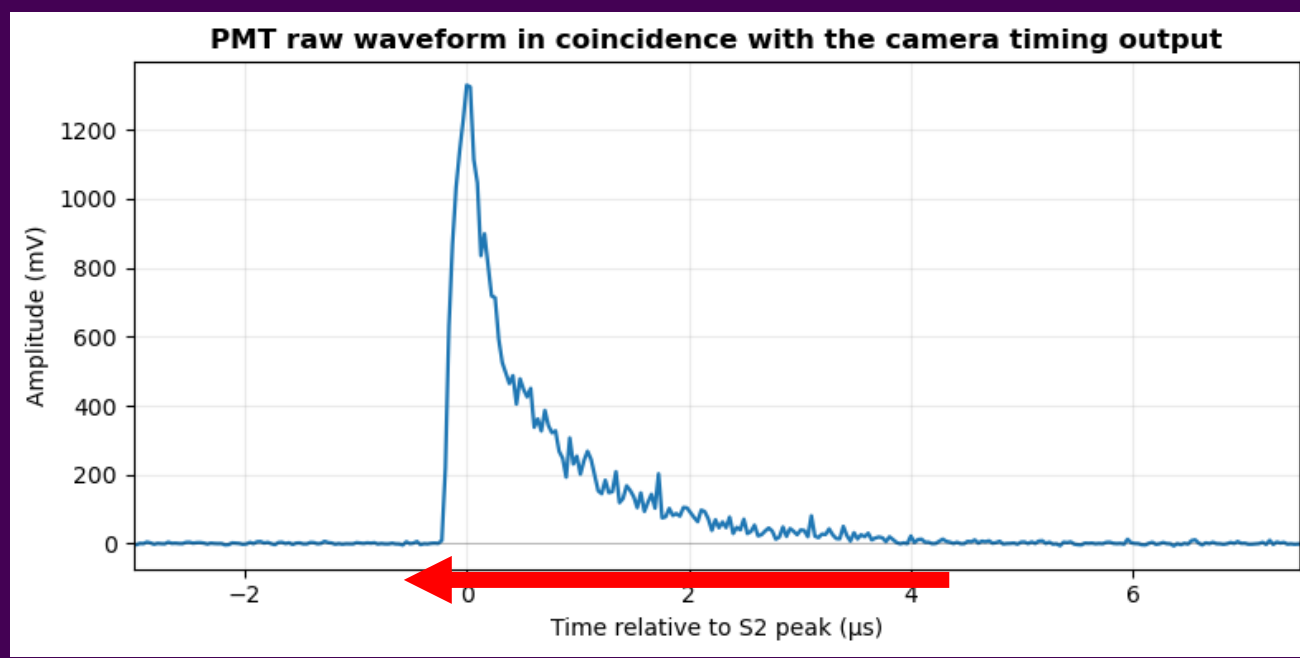
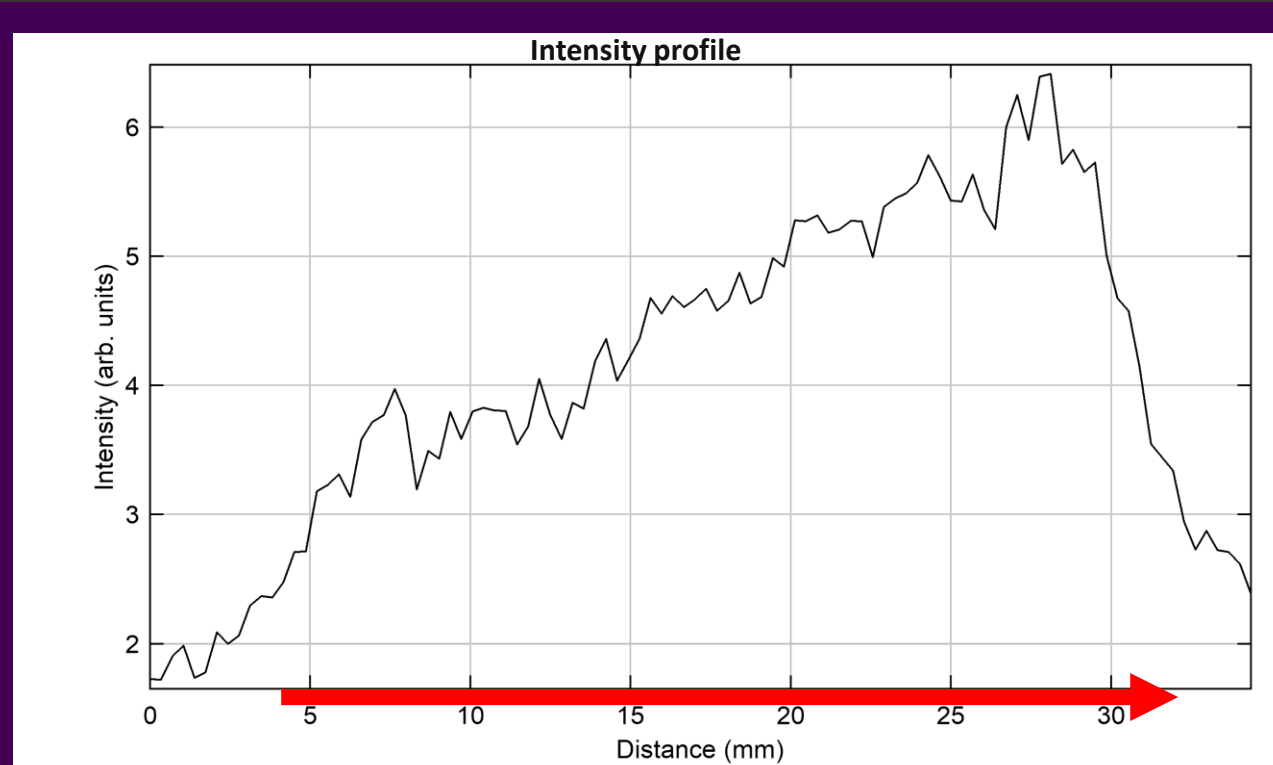
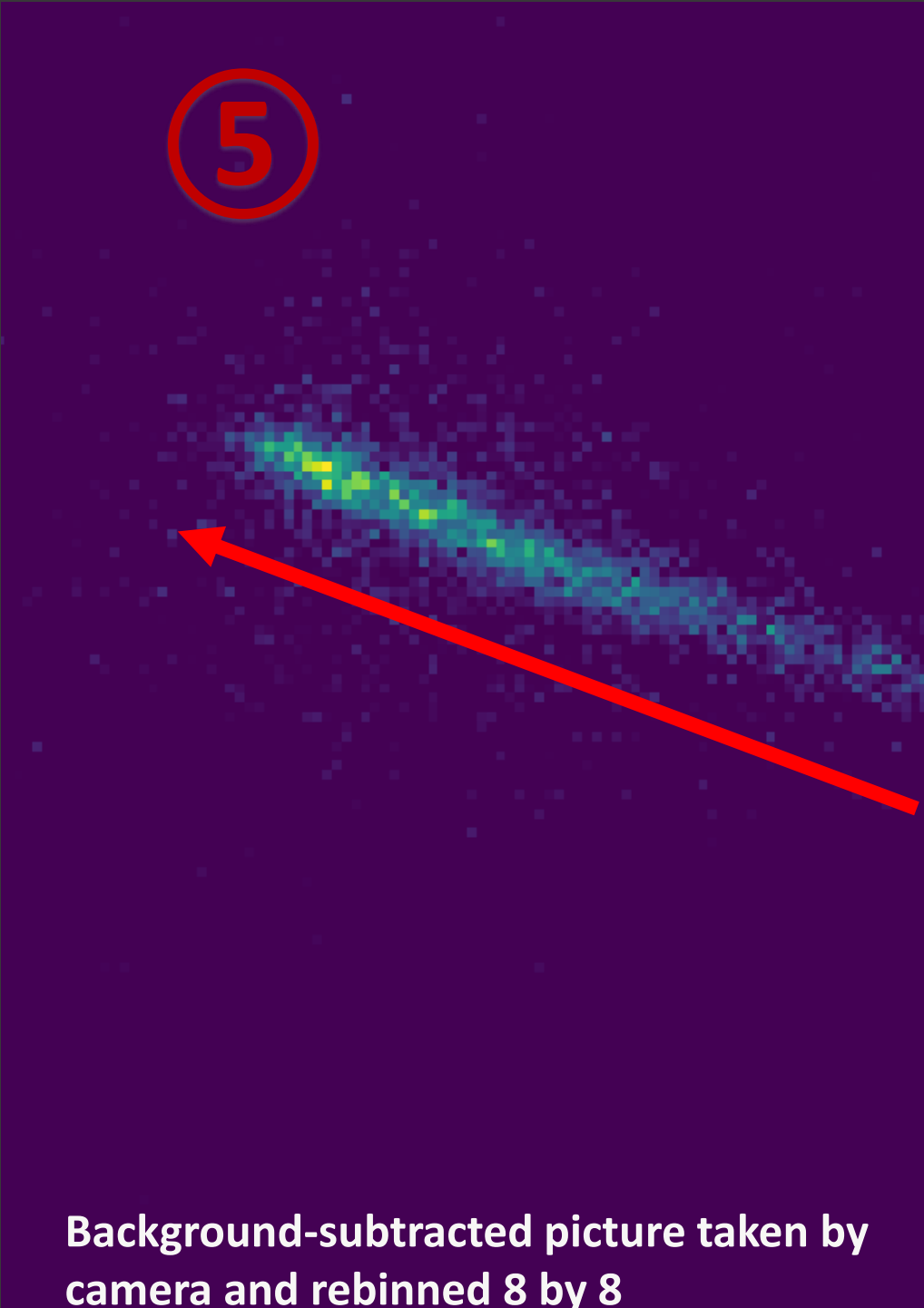
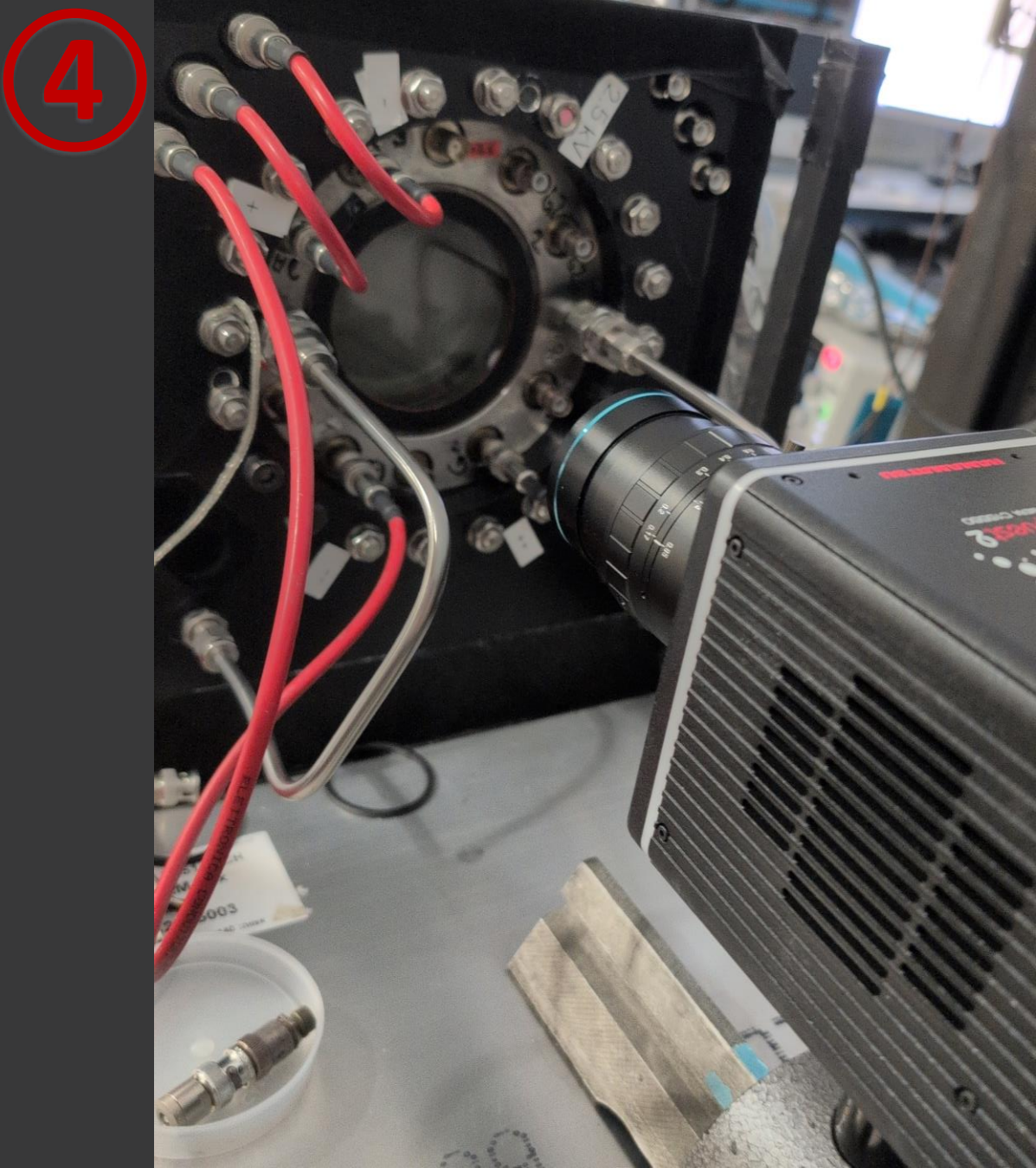
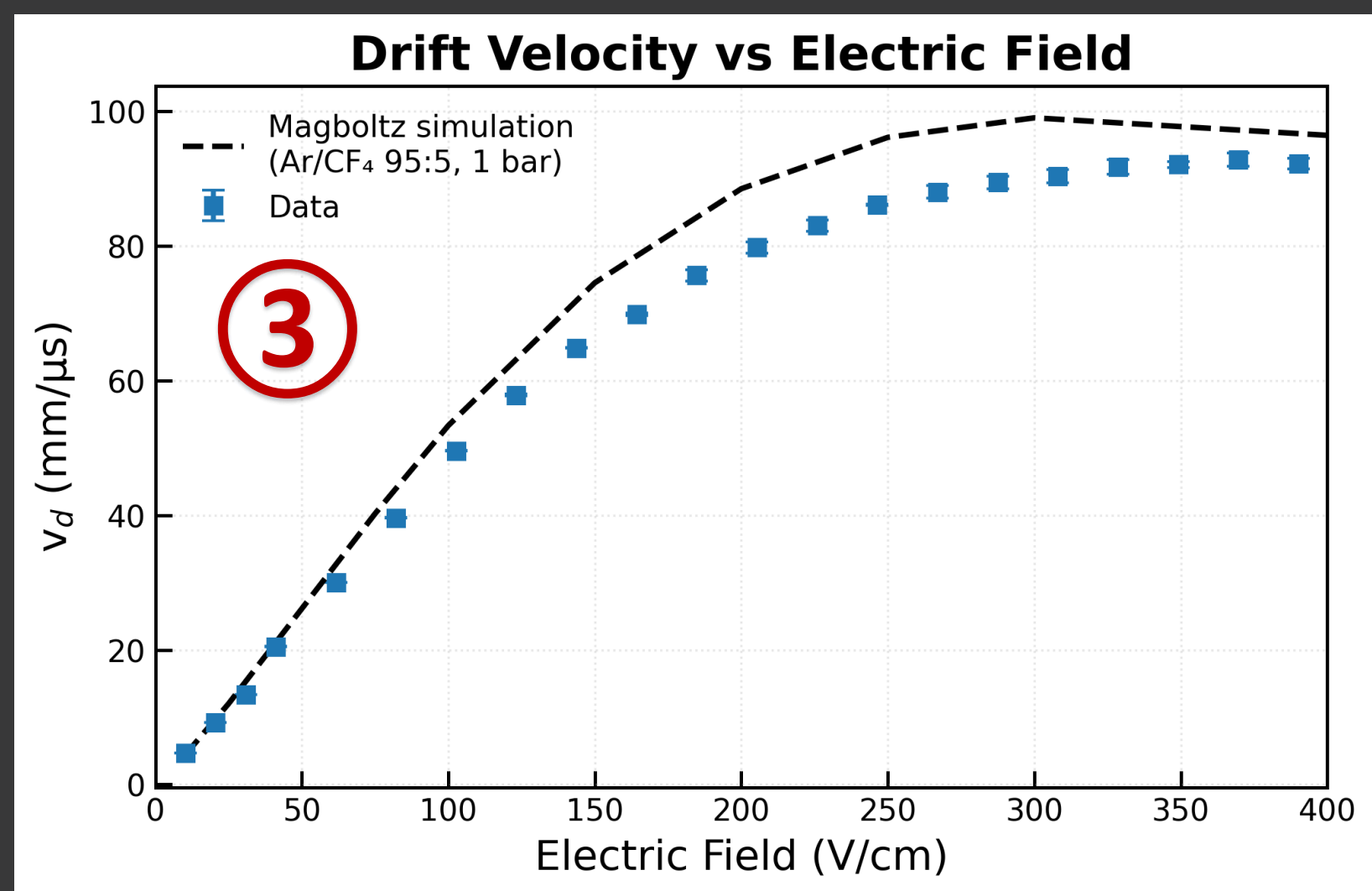
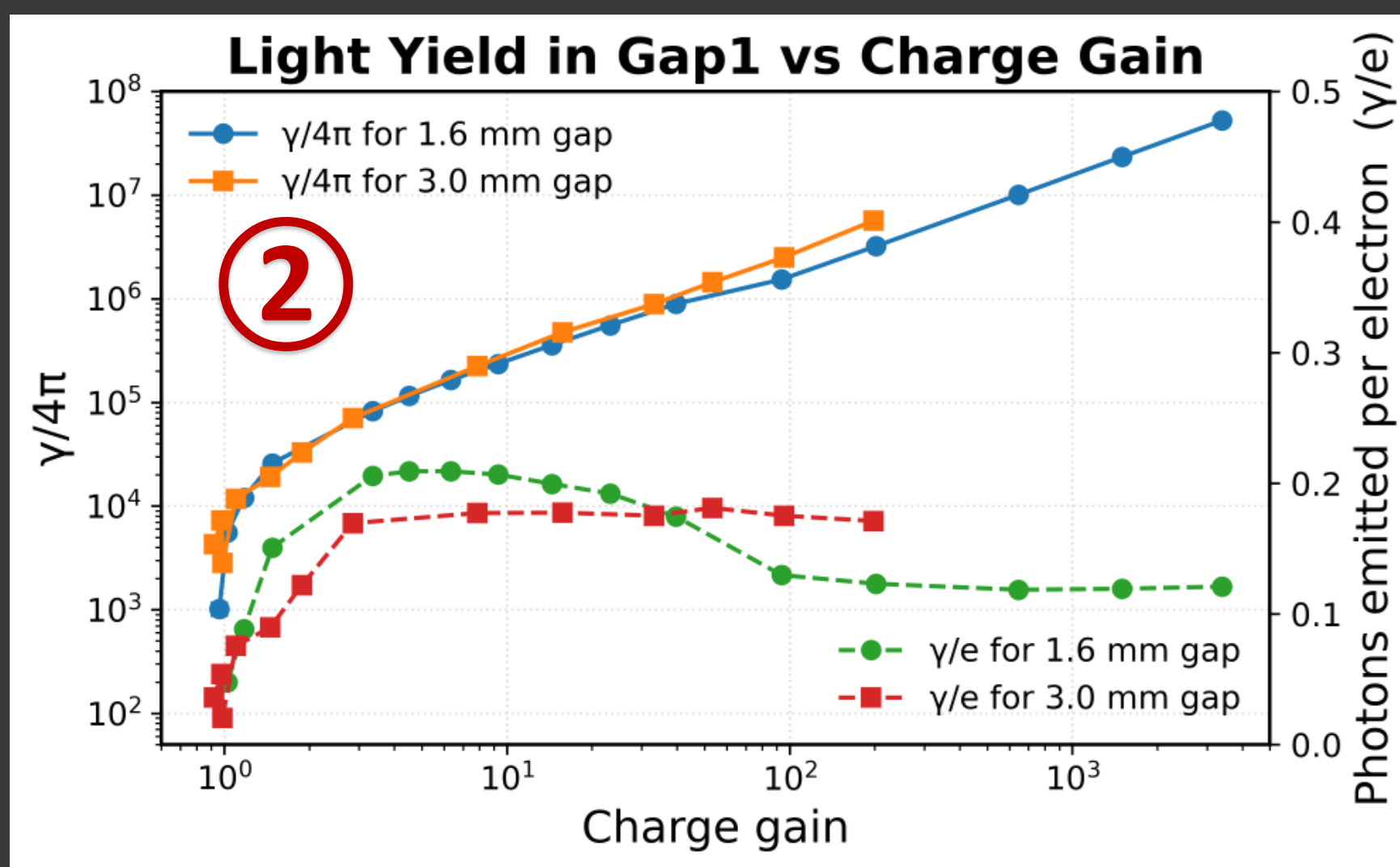
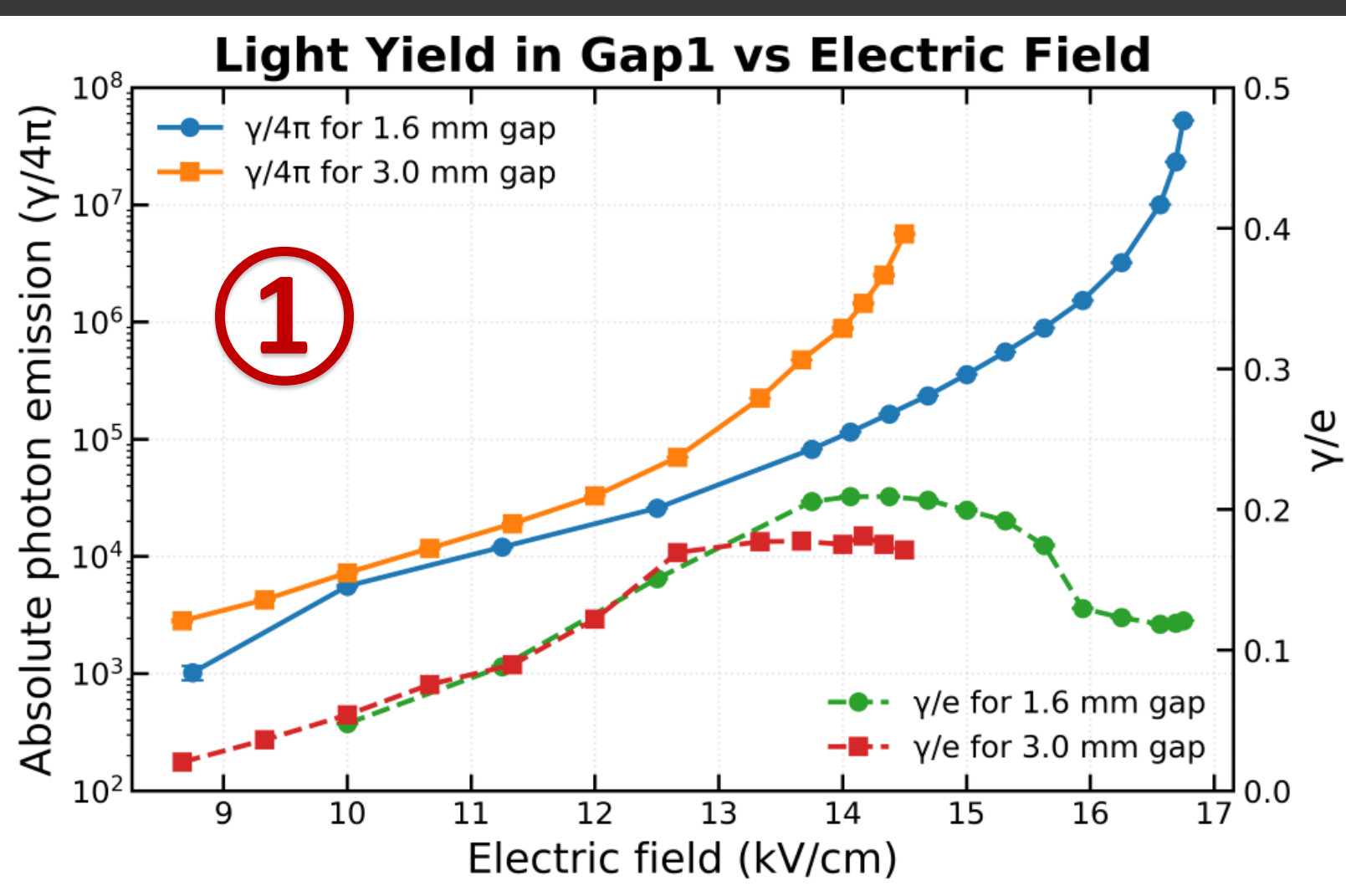
- Gas:** Ar/CF₄ (95:5) baseline gas for intense photoyield and moderate operating voltages at 1 bar.
- Geometry:** Circular field cage, \varnothing 10 cm, drift length \approx 5 cm, sufficient to contain 5 MeV α -tracks.
- Amplification:** Two-step parallel meshes multiplier with three meshes (A1, A2, A3)



- Charge readout:** Charge-sensitive preamplifiers connected to the meshes.
- Light readout:** In-vessel PMT records S1 (primary) and S2 (avalanche) scintillation.
- Track imaging:** qCMOS camera + F0.85 lens.

OTPC successfully images α tracks with stable two-stage amplification

- and 2 Characterization of scintillation performance of the first gap with two different thicknesses (1.6 and 3 mm).
- Electron drift velocity vs Electric field in the drift region.
- View of the camera focused on mesh A3.
- An α track picture with its light intensity profile (overlay top right) and the corresponding PMT waveform (overlay bottom right) obtained in a 2-gap configuration (First gap: 1.6 mm and Second gap: 3 mm).



Next-gen detector

- Field cage and pressure vessel:** Custom-made vessel, field cage design finalized.
- Gas system:** Pressure tunable from 10 mbar to 1 bar, in production.
- Commissioning:** Late 2025 – Early 2026.
- In-detector targets:** Boron-10 targets have been produced for measurements with a neutron source.
- Simulation framework:** A standalone Geant4-based simulation framework for a multi-purpose TPC is under development to benchmark key physics processes.
- Final camera:** In discussion.

