

Background / Purpose

Purpose: PHITS Monte Carlo (MC) code was used to accurately determine the water-equivalent thickness (WET) of the buildup housing. The air chamber and total effective point of measurement (EPOM), and the proton-and chamber-specific factor f_q , the MC-derived component of the beam quality correction factor (k_{Q,Q_0}), for a commercial ionization chamber array (ICA) in monoenergetic and spread-out Bragg peak (SOBP) proton beams

Motivation: Accurate detector-specific corrections are essential for ensuring reliable patient-specific QA (PSQA) in intensity-modulated proton therapy (IMPT)

Methods

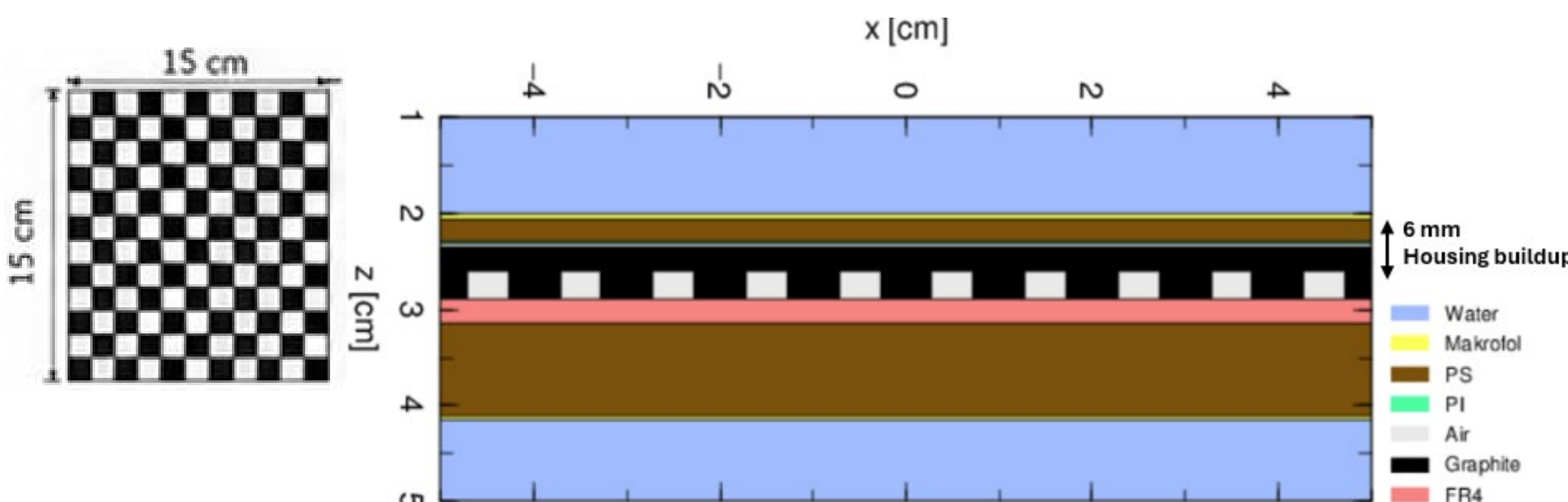
- Parallel 150 to 250 MeV proton beams
- SOBP: 150 – 250 MeV with a nominal range from 13.6 to 39.5cm in water
- All f_q and P_{vol} (volume averaging perturbation factor) were calculated with a combined uncertainty $< 0.5\%$

Highlighted PHITS settings

- Physics list: INCL, ATIMA, EGS5
- Cut-off energies for electrons, positrons and photons: 10keV
- Delta-ray production threshold: 10keV
- Max flight mesh: one-tenth of thickness of dose scoring volume
- Ionization potential of water: 78 eV

Detector Model (PTW OCTAVIUS 1500XDR)

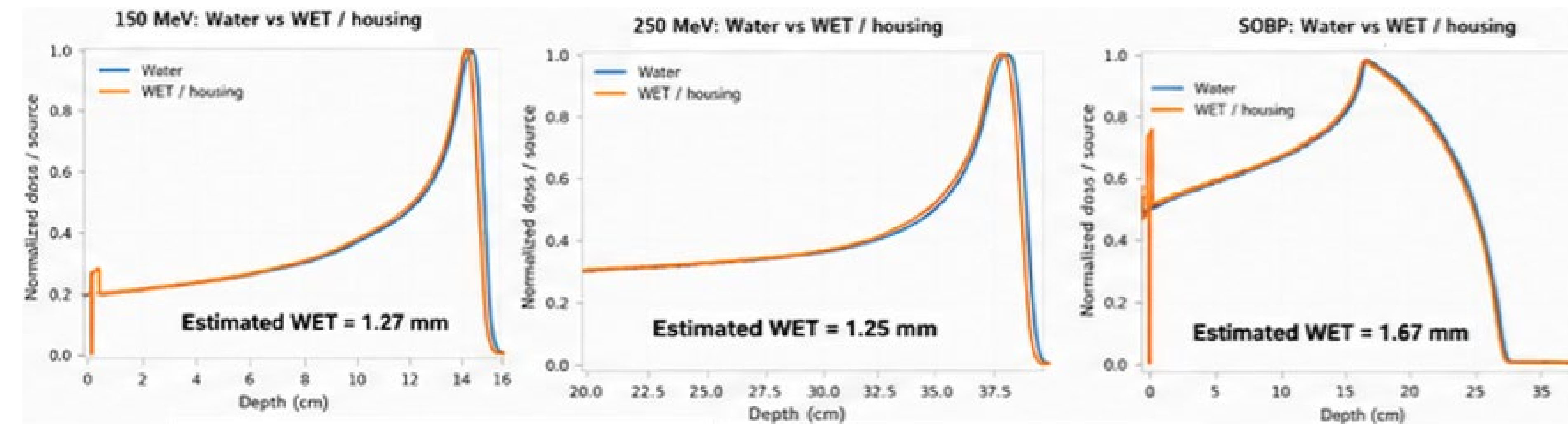
- Top-view chamber geometry (left) and cross-section (right). Not to scale



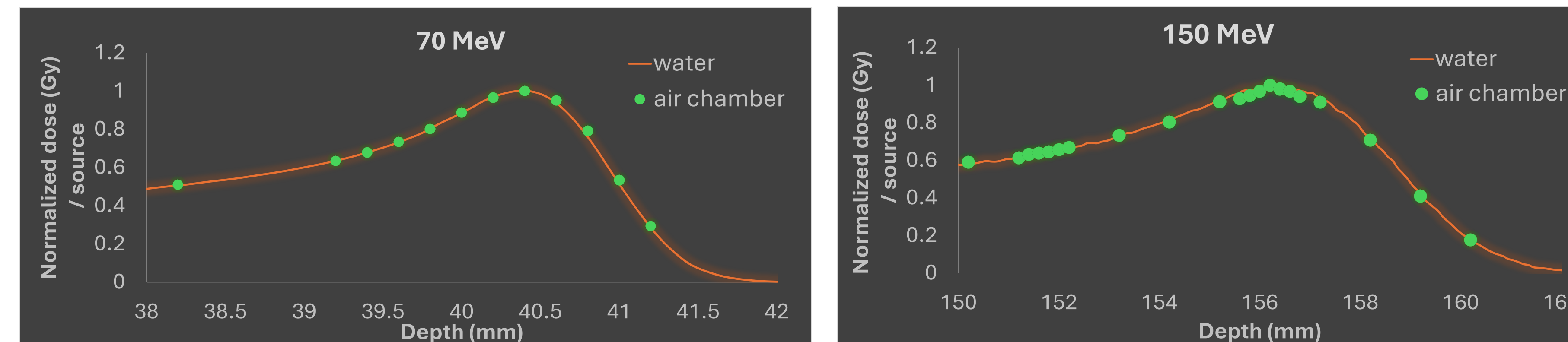
- Plane-parallel ionization chamber air cavity: 4.4 mm x 4.4 mm
- Gap between chamber: 3mm

Results

Housing Buildup WET estimated from Bragg Peak Curve Shifts



Air Chamber EPOM Determination Estimated 1.2 mm downstream of air chamber surface



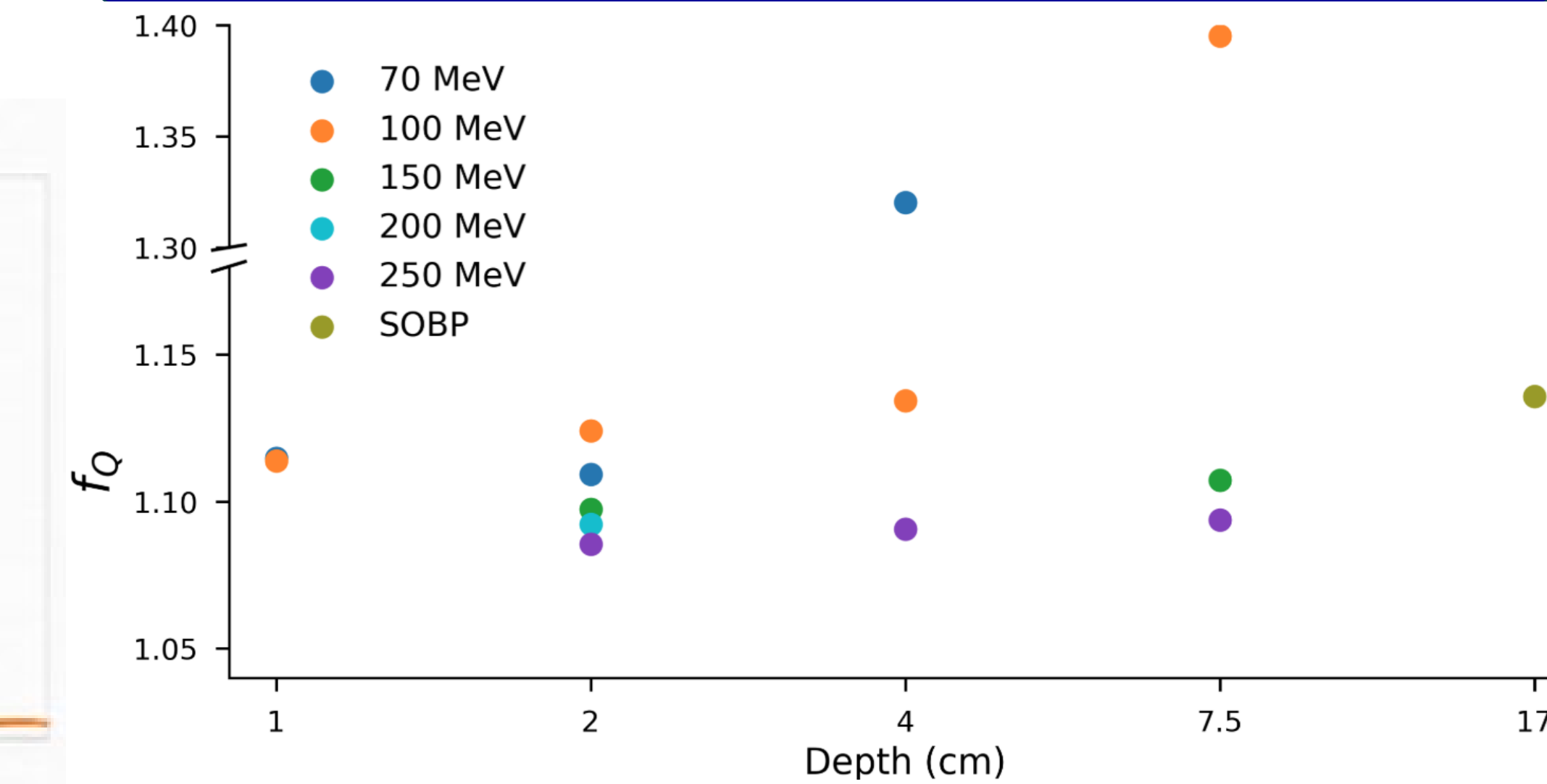
Air chamber EPOM was determined by translating the entire ICA in the water phantom at 0.2 mm steps and finer 0.1 mm around the Bragg peak. The dose to air cavity was scored at each depth position, .The maximum air-cavity dose was compared to the maximum dose of air chamber filled with water. Given the 3 mm air cavity gap, the EPOM was defined as the depth within this gap at which air cavity peak dose best matched the corresponding water cavity peak dose

✓ Conclusions

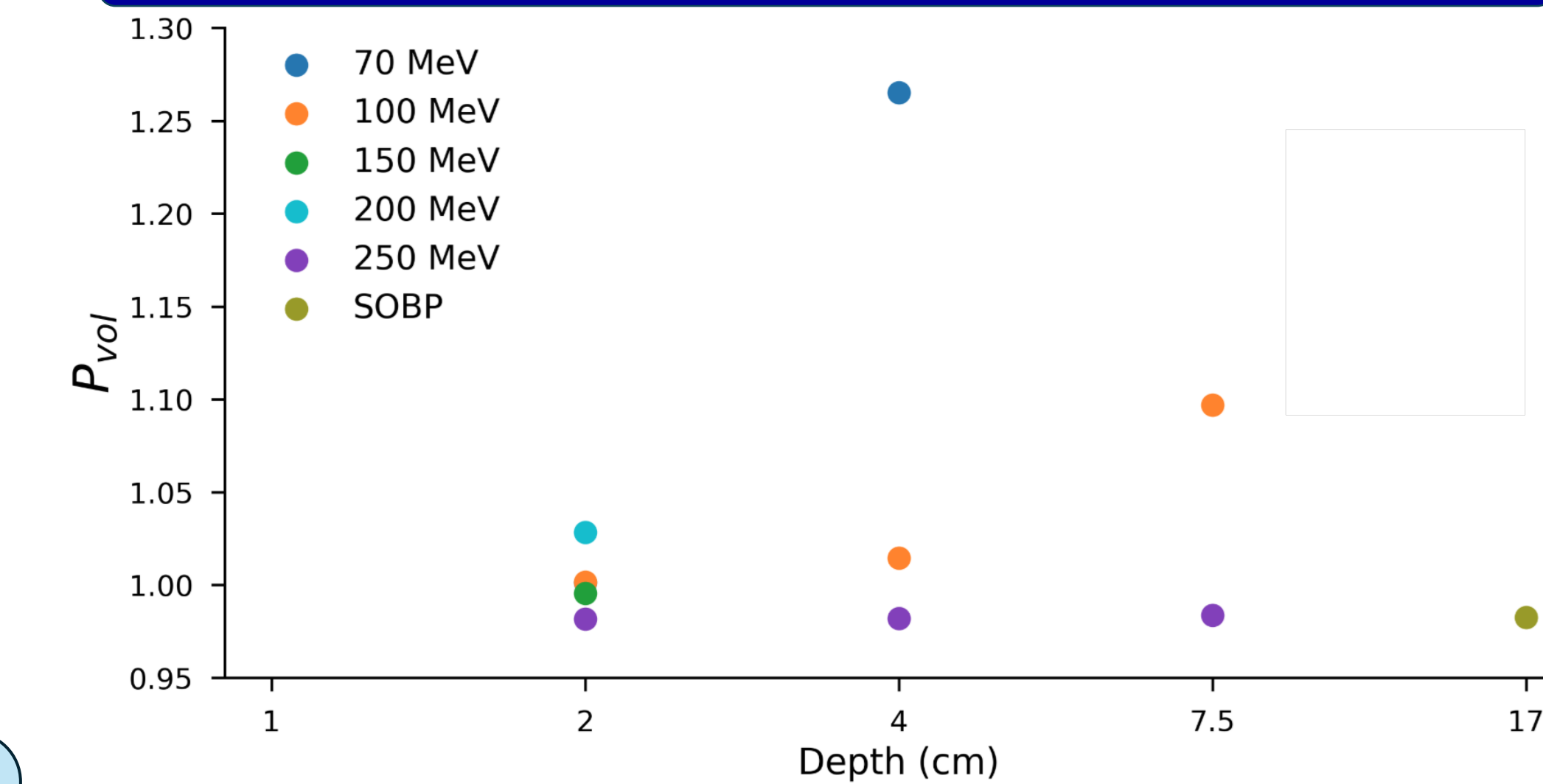
- Estimated housing buildup WET ≈ 1.3 mm for 150 – 250 MeV
- Estimated EPOM ≈ 1.2 mm below surface of air chamber
- Calculated dose plane should be obtained by a total 8.5 mm offset from the ICA surface
- P_{vol} remained small overall, but increased in regions with steeper dose gradients

- Variation of f_q was relatively small at 2 cm depth
- At 4 and 7.5cm measurement depths, f_q showed more pronounced energy dependence
- The energy-dependent f_q should be considered when defining dose difference level in PSQA

Proton- and Chamber-Specific Perturbation Factor



Volume Averaging Perturbation Factor



Reference

IAEA, *Absorbed Dose Determination. Rev. 1.* Technical Reports Series No. 398. Vienna, 2024