# AbstractID: 7509 Title: Comparison between the lateral penumbra of a double scattering proton beam and the lateral penumbra of a scanning beam

**Purpose:** Intensity modulated proton radiotherapy can reduce the dose to the critical structures by optimizing the distribution and intensity of the individual pencil beams. However, the finite size of a pencil beam and the scattering in air degrade the lateral penumbra in the patient, which could be inferior to the penumbra of a collimated scattered beam. In this study we compare the lateral penumbra of a pencil beam to the one of a collimated broad divergent beam, such as the one produced by a double scattering system, for different air gaps, range compensator (RC) thicknesses and pencil beam size ($\sigma_0$).
**Method and Materials:** The penumbra of the collimated broad divergent proton beam has been modeled using the generalized Fermi-Eyges theory. The model was validated with measurements of the lateral profile in water. We analyzed 2400 treatment fields to establish typical clinical beam configurations such as air gap, RC-thickness and collimator-to-patient distance (CSD), which we used to predict the penumbra (80% - 20%).
**Results:** The model predicts the penumbra with accuracy of 0.3mm. The penumbra of a pencil beam at shallow depth is in general inferior to the penumbra of a collimated beam but is superior at larger depths. The penumbra equivalent depth (PED) exhibits a small dependence on the proton range, but it is strongly affected by the CSD. For CSD 10cm, RC-thickness 6cm, and SSD 210cm, PED is 11cm for $\sigma_0$=5mm.
**Conclusion:** Given the source size and source position the model allows to predict the lateral penumbra of a double scattering system with good accuracy. Typically, for the configuration considered, for proton ranges larger than 11cm the pencil beam penumbra is superior to the collimated one. The inferiority at shallow depth can be compensated with a collimation of the scanning beam.