Purpose: Contrast-enhanced stereotactic synchrotron radiation therapy (SSRT) is an innovative technique based on localized dose-enhancement effects obtained by reinforced photoelectric absorption in the target. Medium energy monochromatic x-rays (50 -100 keV) are used for irradiating tumors previously loaded with high-Z elements. SSRT clinical trials are being prepared at the European Synchrotron Radiation Facility. The first patients are scheduled in summer-autumn 2011. They should be treated at 80 keV, with 10 conformational beams. A dedicated treatment planning system (TPS) was developed for this purpose, based on the ISOgray commercial TPS (Dosisoft, Cachan, France).

Methods: The PENELOPE-based Monte Carlo virtual simulation module was adapted to SSRT specificities: simulation of lower energy photons and electrons (100 keV and lower) and polarized photons. The synchrotron beamline geometry was modeled. Dedicated Phase Space Files were built. Additional materials were implemented in the patient voxelized geometry, to model the high-Z element biodistribution in the tumor. A dedicated computation method for irradiation times (instead of monitor units) was implemented. The simulation process was optimized and parallelized. This dedicated TPS was validated with depth dose curves, dose profiles and absolute dose measurements performed at the ESRF in a water tank and in solid water phantoms with or without bone slabs. A PTW semiflex ionization chamber (0.125 cm3) and gafchromic films were used for the measurements.

Results: Computations and measurements in water match within 2 % or 2 mm both in depth and laterally. Computations including a bone slab also match within 2 % in depth, and 3 % or 3 mm laterally.

Conclusions: The treatment planning system was validated for dose computations in water and in presence of bone heterogeneities. The last step before treating the first patients is to validate the TPS on dedicated clinical cases, with the presence of contrast media in the tumor.