Purpose:
To integrate bioluminescence imaging (BLI) with an existing image-guided small animal irradiator, for the acquisition of planar and tomographic BLI data. This will enable simultaneous/intrinsically co-registered high resolution imaging (CBCT) and functional imaging (BLI) during radiation therapy and quantitative and longitudinal tracking of tumor response of small animal models.

Methods:
The image-guided small animal irradiator consists of a variable kVp x-ray tube mounted opposite an aSi flat panel detector. The tube is used for both cone-beam CT imaging (1mm focal spot, energies from 40-100 kVp) and for targeted irradiation (5mm focal spot, typically 225 kVp). Ttube and panel are mounted on a c-arm gantry, fixed at the front by a stabilizing ring. The BLI integration employs two intensified CCD cameras fixed to the gantry 180° apart from each other and imaging perpendicular to the x-ray treatment/imaging axis. Multiple bioluminescent images can be acquired at any angle as the gantry rotates. Using two cameras will improve BLI tomography by providing either multispectral information (using a different spectral band for each camera) or by limiting the effects of the luciferase pharmacokinetics by limiting rotation to 180° and acquiring images simultaneously from each camera to provide full rotational coverage.

Results:
Cone-beam CT imaging, at a resolution of 0.1mm in all dimensions, provides image quality comparable with a dedicated microCT scanner. Targeting accuracy of the treatment beam is 0.20 mm. Design of the BLI integration is complete and assembly initiated. Characterization the BL imaging will include quantification of signal with luciferase concentration, and camera calibration and registration with the x-ray system via phantom tests.

Conclusions:
Integration of BLI with image-guided small animal irradiation offers the potential to deliver functionally targeted radiation dose distributions, as well as monitor spatial and temporal functional changes that occur with radiation therapy.