Purpose:
To explore advantages and uncertainties of IMPT for accelerated partial breast irradiation (APBI), and compare the dosimetry with passive scattering protons (PSPB) and clinic photon 3D radiotherapy (3DCRT).

Method and Materials:
Two theoretical proton IMPT plans, i.e. one with two tangential fields (OPPOSED_PAIR) and one with a tangential field and an en face field (ORTHOGONAL_PAIR), were created for 11 patients and compared with PSPB and 3DCRT. The impact of range and patient setup uncertainties and scanned spots mismatching between fields for IMPT plans was evaluated.

Results:
Compared with 3DCRT, IMPT plans with both beam configurations significantly reduced the dose to lungs, normal breast tissues, heart and breast skin and have significantly better dose coverage for target volume using ORTHOGONAL_PAIR and comparable coverage using OPPOSED_PAIR. Compare with PSPB, IMPT with both beam configurations was significantly better for V90 and V75 of breast skin, and V90 and V75 of ipsilateral normal breast, and comparable for V50 and V30 of breast skin, V100 of ipsilateral normal breast, V5Gy and mean dose of ipsilateral lung, maximum dose of heart and contralateral breast , and mean dose of contralateral lung. IMPT using ORTHOGONAL_PAIR was comparable for V10 of breast skin, V50 and V20 of ipsilateral normal breast, and V10Gy and V20Gy of ipsilateral lung, but significantly worse using OPPOSED_PAIR.

For IMPT, CTV coverage of 95% prescription dose was over 90% considering range and patients setup uncertainties, but could drop to 80% with scanned spots mismatching between two beams in worst scenario. The en face beam has significantly more dose fluctuation in chestwall region than tangential beam.

Conclusion:
IMPT plans showed potential for normal tissue dose reduction and target coverage improvement compared with PSPB and 3DCRT. It is robust considering range and patient setup uncertainties, but vulnerable to the scanned spots mismatching among different beams.