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FFT Modeling for the H1 as-built configuration

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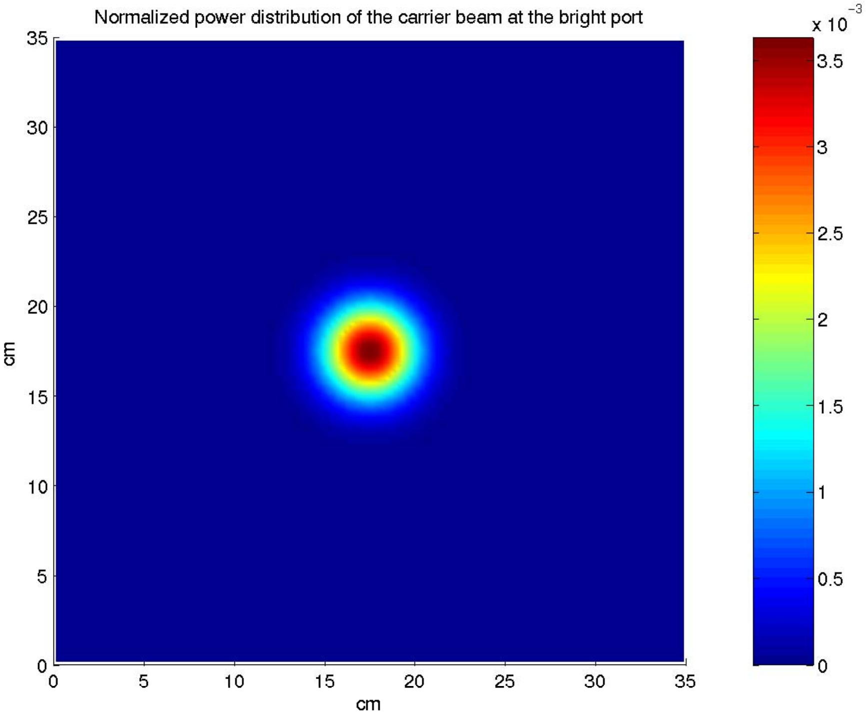
This is a seminal work in order to validate the results of the FFT model, when the optical coupling between the arms and the recycling cavity is not optimal.

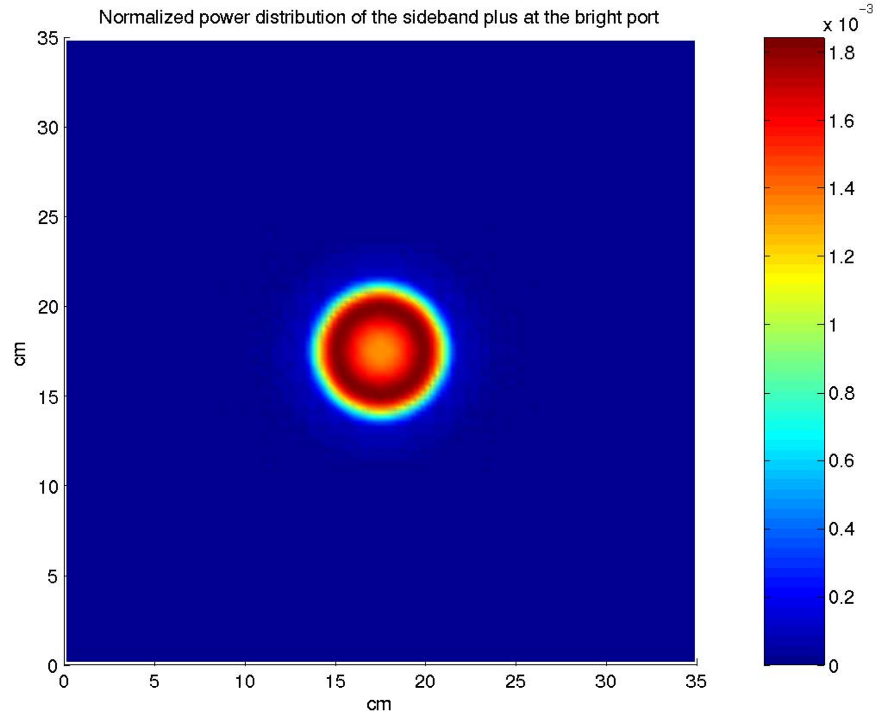
We need a lens to make the arms and the recycling cavity matched

Such lens will be provided by the thermal compensation system and the natural focusing effect due to the power stored in the arms when the system is locked.

Both these effects are being modelled by Phil Willems; the resulting change in the refractive index and the local thermal expansion of the material make the optical path length through the mirror vary. Such variation can be included in the FFT model as an effective modification of the thickness of the mirror and its coating surface. Phil Willems and I are going to investigate the impact of these corrections on the shape of the carrier and the side band beams, both in the case of passive thermal lens and when thermal compensation is actively on.

Power distribution of carrier and side bands

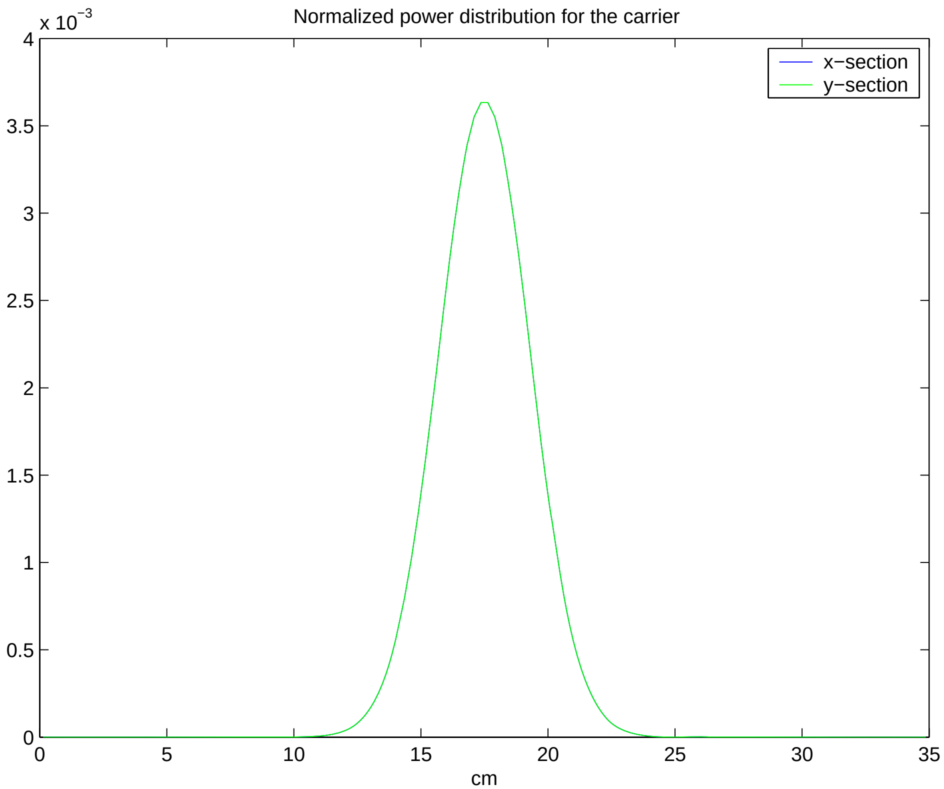


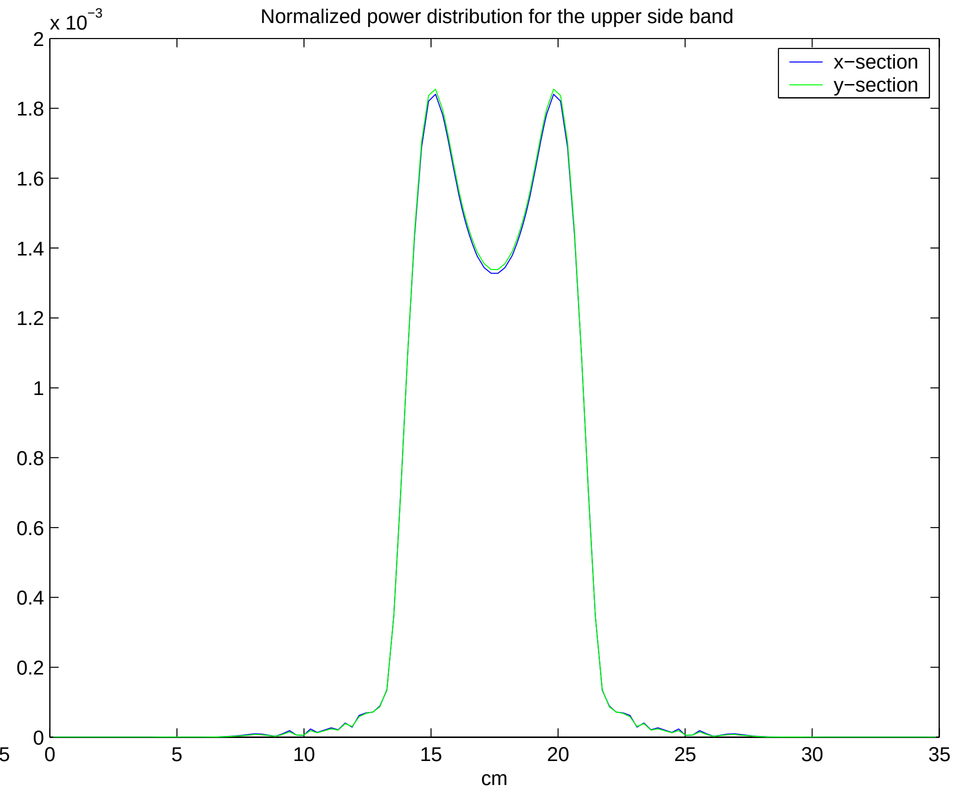


The side band power is distributed on a very large transverse section and the mode is far from being Gaussian.

The recycling cavity is completely degenerate for the radii of curvature of the mounted mirrors, as no thermal lens has been included in this model.

Power profile along two orthogonal radii

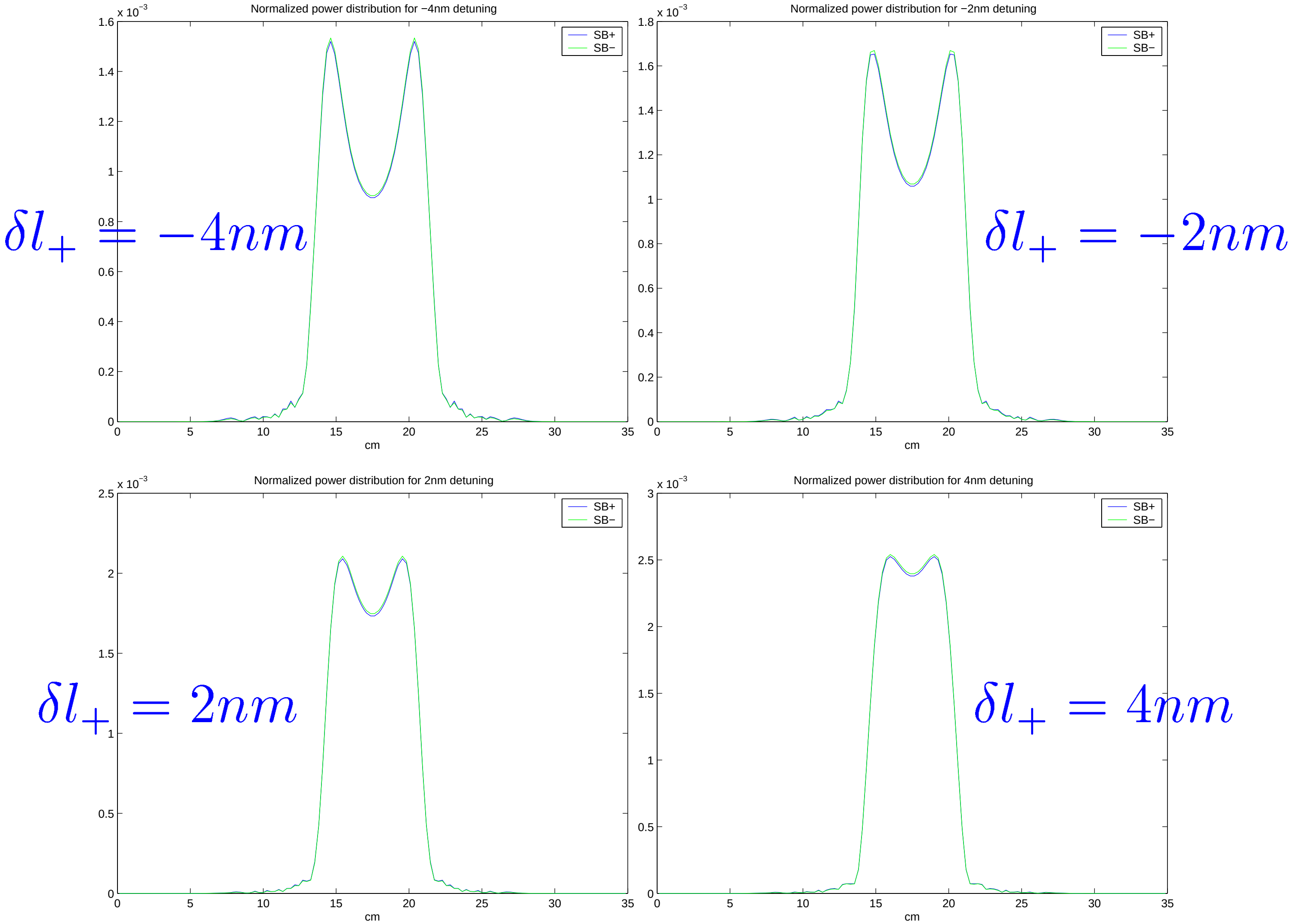




The side band power is distributed on a larger area than for the carrier, with an equivalent spot size of about $5cm$, in disagreement with what is currently observed in LIGO I.

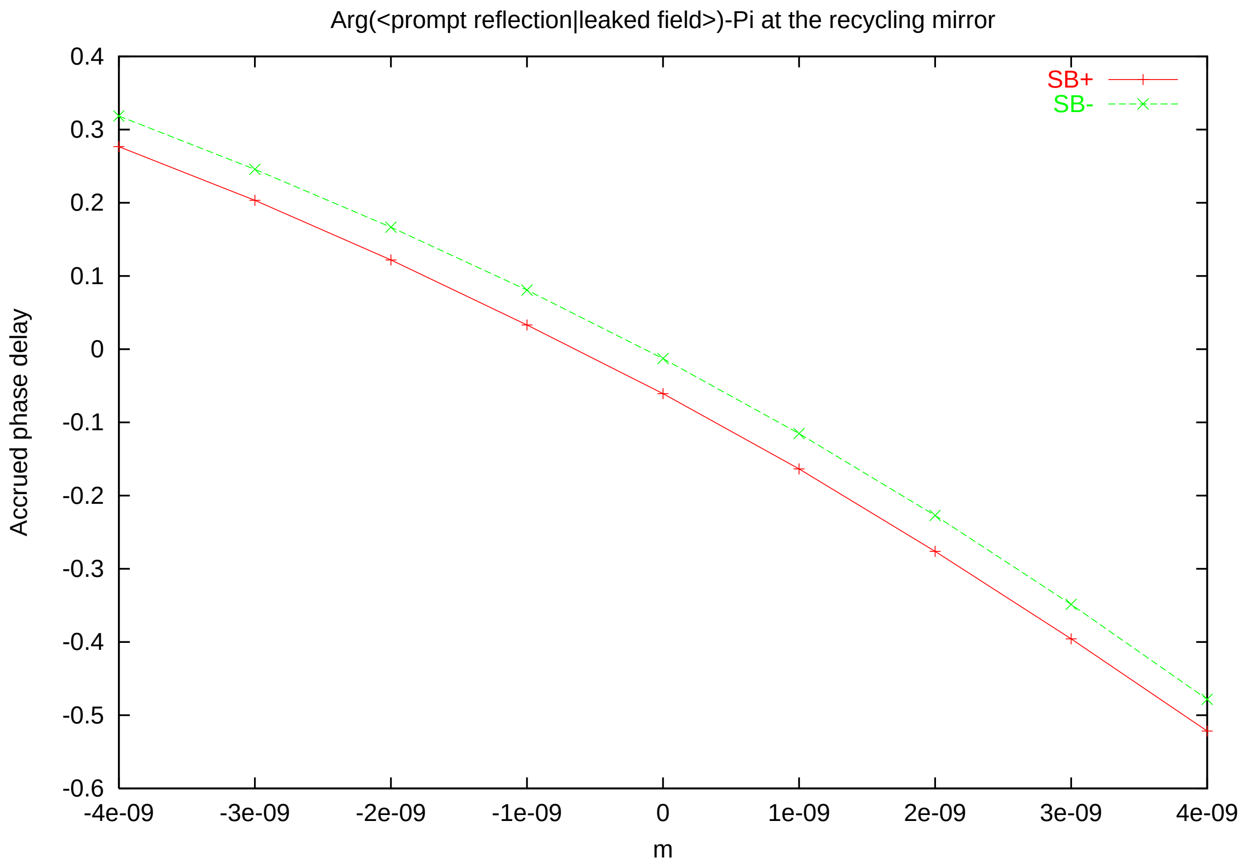
For comparison see the images included in the document G030348 by Daniel Sigg.

Side band power distribution for different off-sets

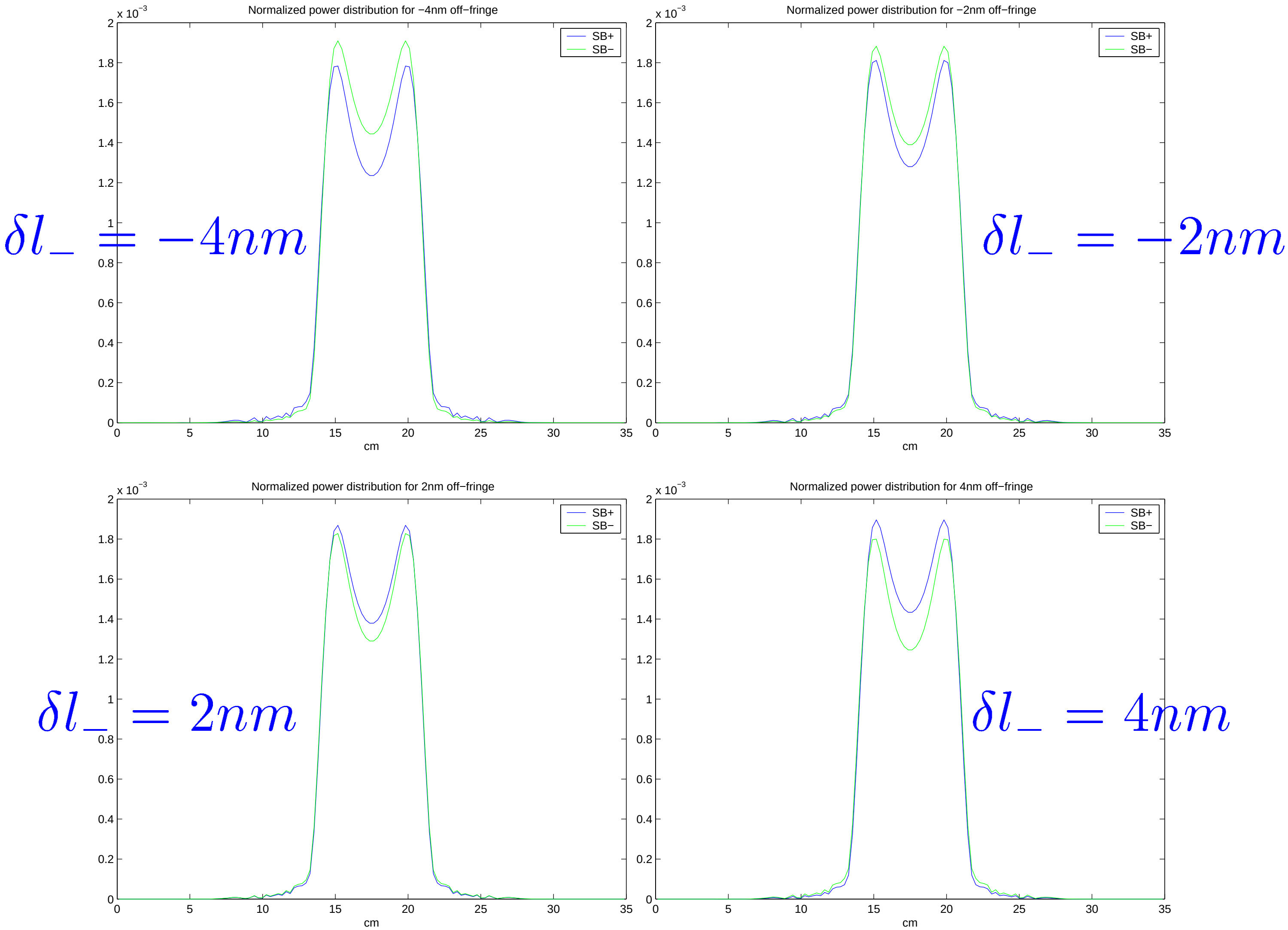


Technical meaning of $\delta l_+ = 0$

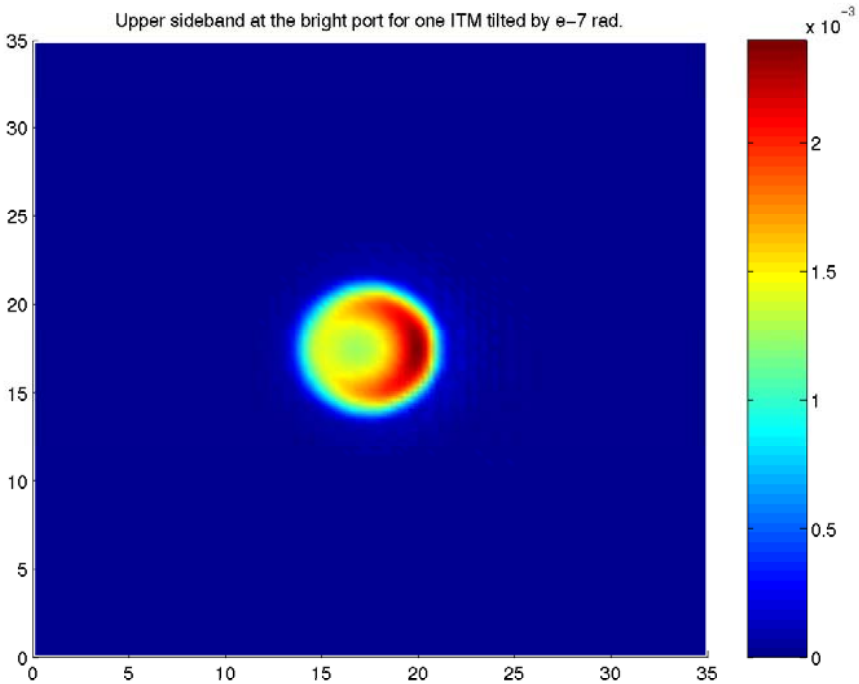
The FFT model locks l_+ on the optimal value for the optical gain. Resonance is achieved when the phase of the reflected field changes through $\simeq \pi$.

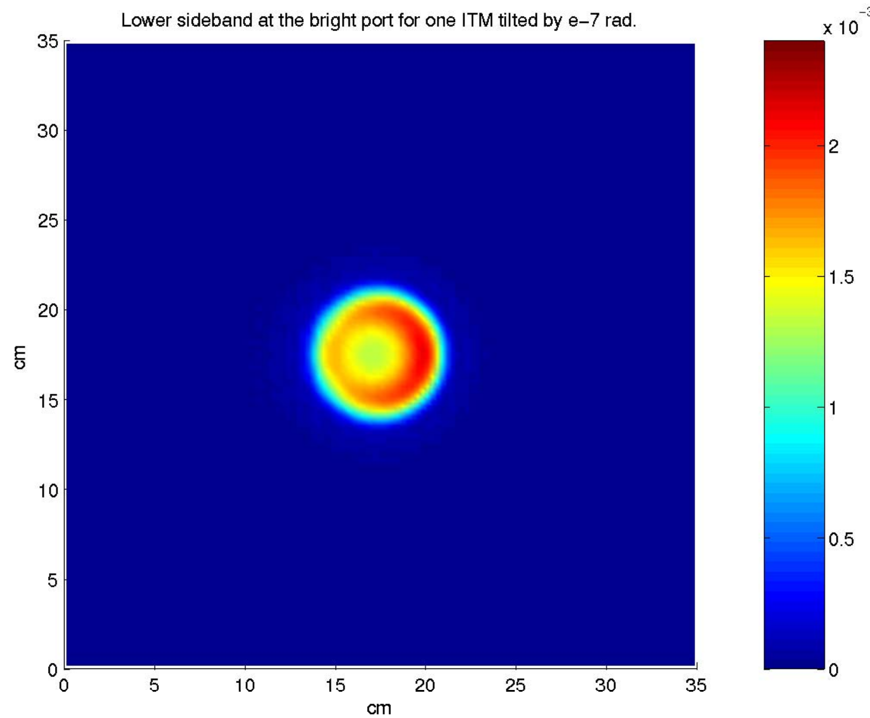


Side band power distribution for some arbitrary off-fringe

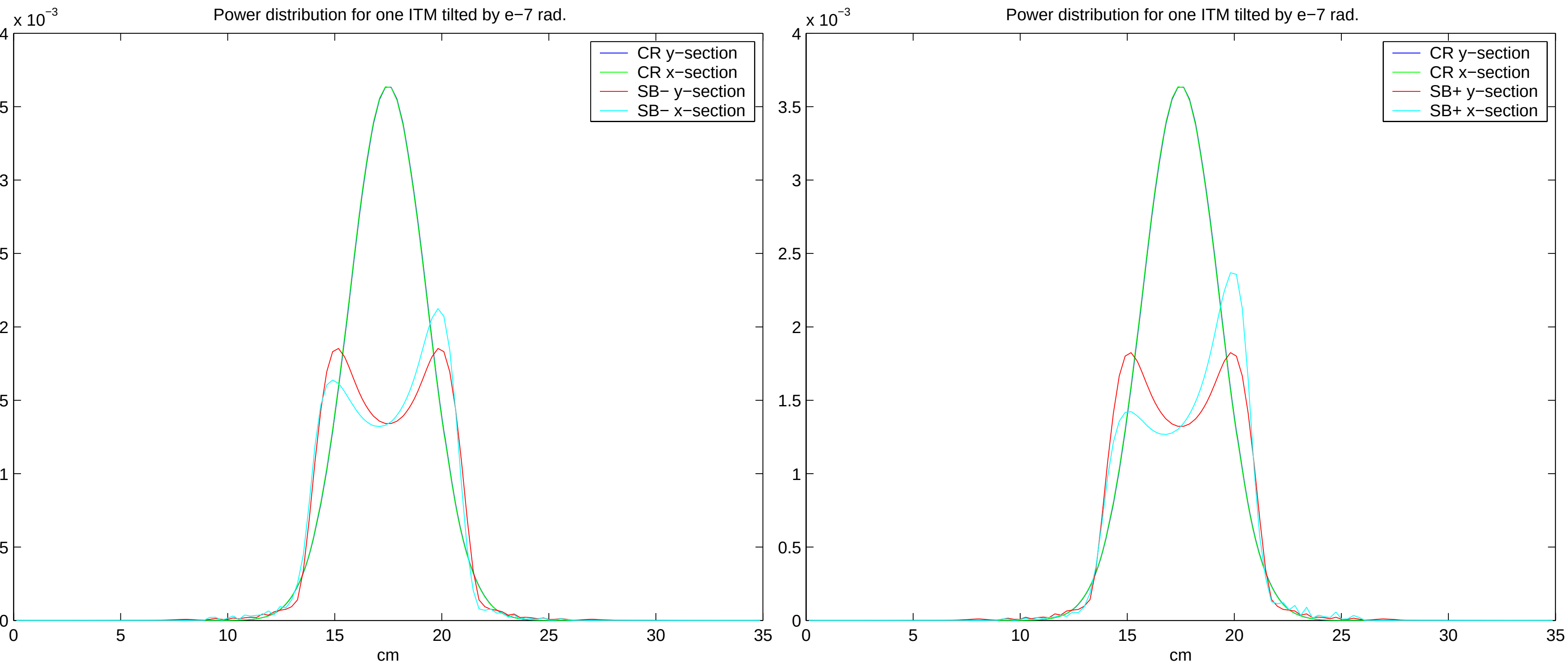


Side band power distribution for one ITM misaligned





The sidebands are significantly affected by a tilt of $10^{-7} rad$ in one ITM. On the contrary the carrier is only slightly modified. For a comparison on the same power scale, the transverse distribution has been normalized and the maps have been scanned along the vertical and horizontal axis. The carrier shows no significant asymmetry while the side bands are distributed in a different way.



The ITM misalignment induces a large deviation from an axially symmetric form, in the power distribution of the side bands and particularly in the upper one.

In order to investigate how this couples with the differential length, several simulations have been run by moving the beamsplitter a little out of the dark fringe (in both directions).

Side band power distribution for ITM tilted and off-fringe