Thermal effects in LIGO II: modelling with Melody

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AIC

LIGO-G000424-00-D

Tools and Validation -*Melody*

- *Melody* is used for optical mode analysis of the interferometer
  - » *Melody* includes thermo-refractive effects, and will soon have thermo-elastic effects included
  - » Melody/MATLAB is a *complicated* set of object oriented MATLAB codes
  - » Extensive testing has been required to find methods through which these can be used reliably over a wide range of interferometer parameters
  - » Setting up problems in Melody is *NON-TRIVIAL:* it is important that experience is pooled.

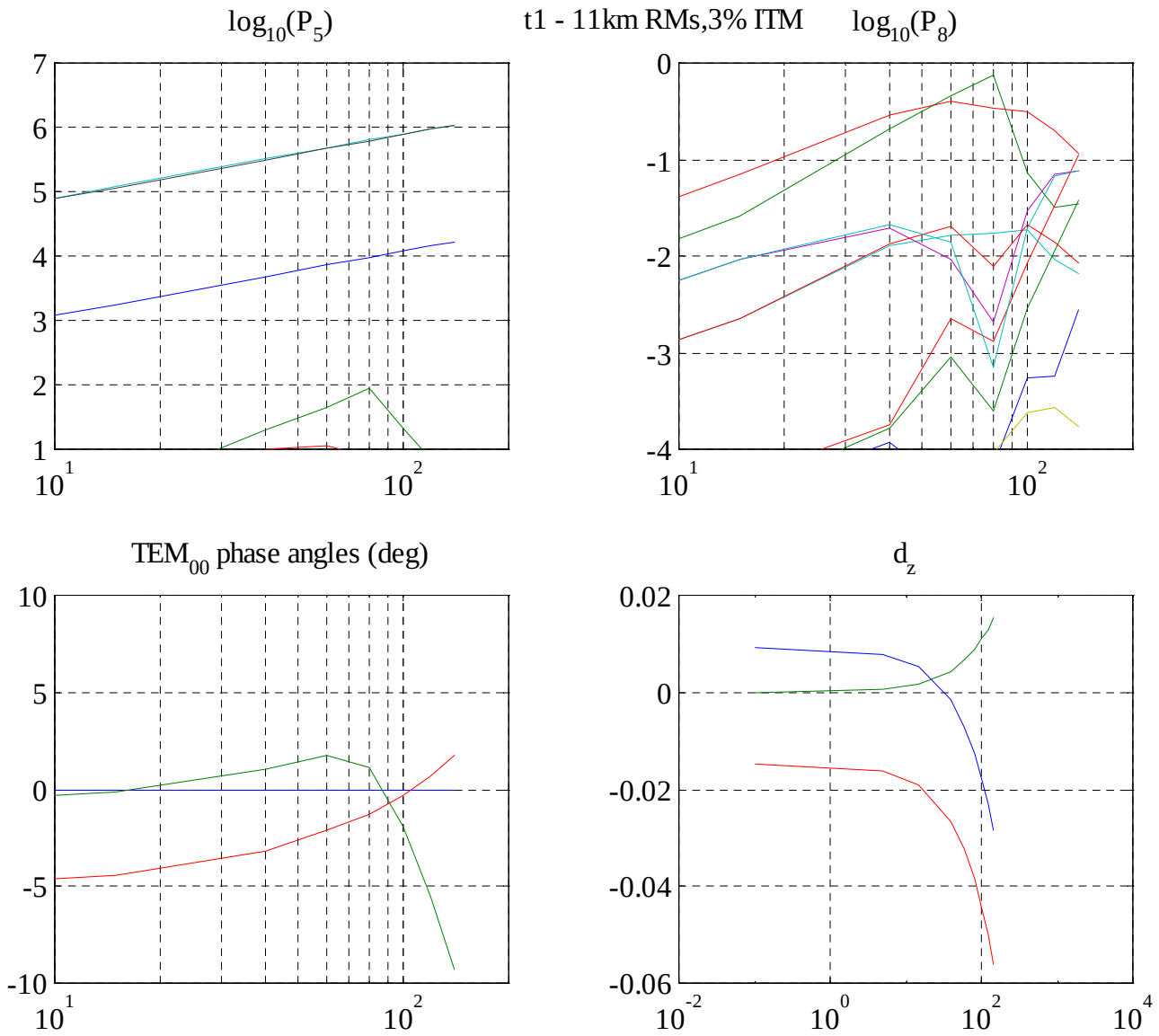
Thermal Effects

- Melody was originally written with silica optics in mind
  - » thermo-elastic effects are not included as yet
  - » thermo-elastic effects in sapphire are important, but probably just require a trim of the present results
- Melody includes Hello-Vinet model for the ITMs and RMs, and an astigmatic model for the BS
- A figure of 40ppm/cm is assumed for the sapphire absorption coefficient
  - » A total input power of up to ~125W is assumed in the RF scheme
  - » About 80W would be sufficient with DC scheme.

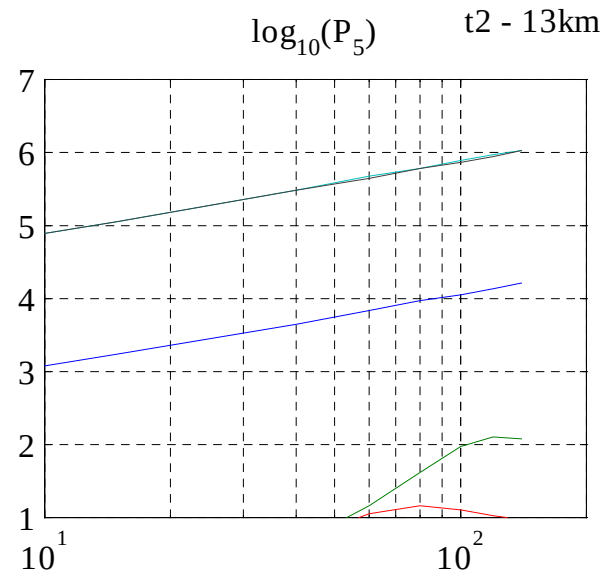
Results - RF scheme

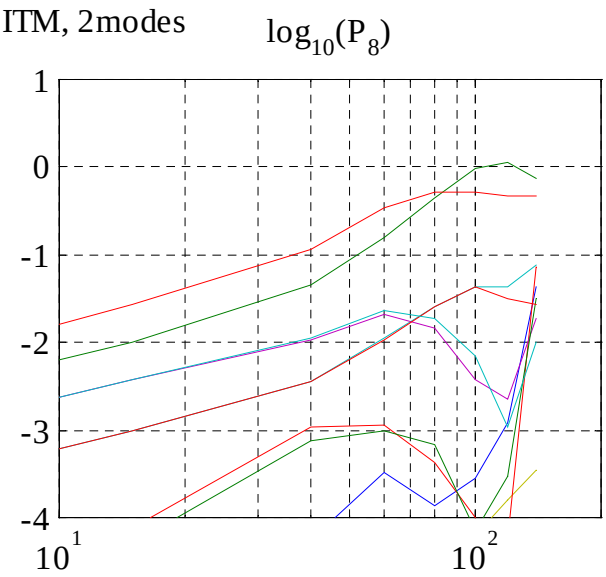
- With T_ITM = 3% and 10X Active thermal compensation,
  - » 40 ppm/cm is close to the *maximum* tolerable absorption.
  - » It must not vary too much between pairs of ITMs. (Figure TBD.)
- With T_ITM = 1% the situation is improved considerably.
  - » Thermal effects are less significant.
  - » The system looks stable with 125W input.
  - » With 1% ITMs the RMs should have their *roc* about ~11 km, concave.
- The optimisation of T_ITM is a key part of the thermal design.

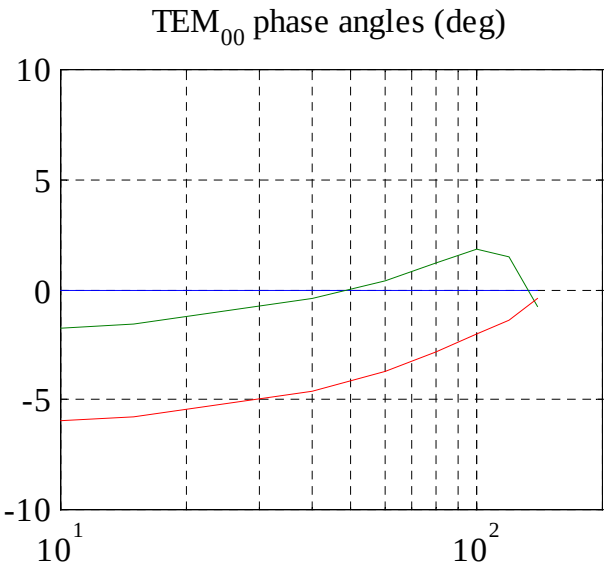
Results: 3% ITM, 11km RM

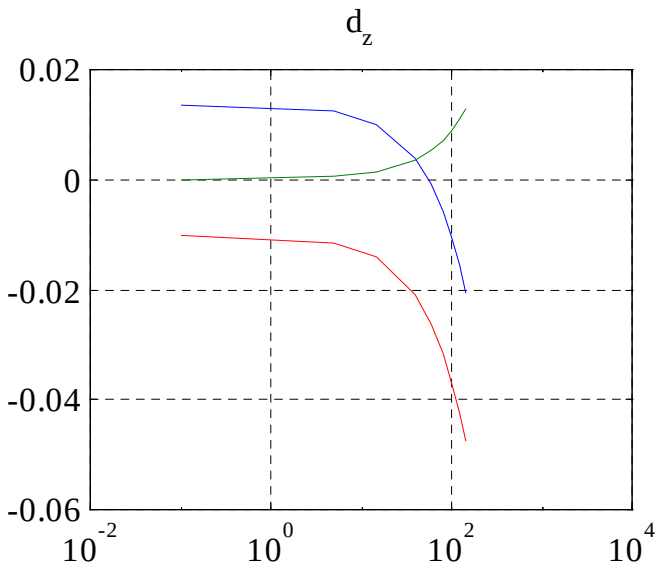


Results: 3% ITM, 13km RM

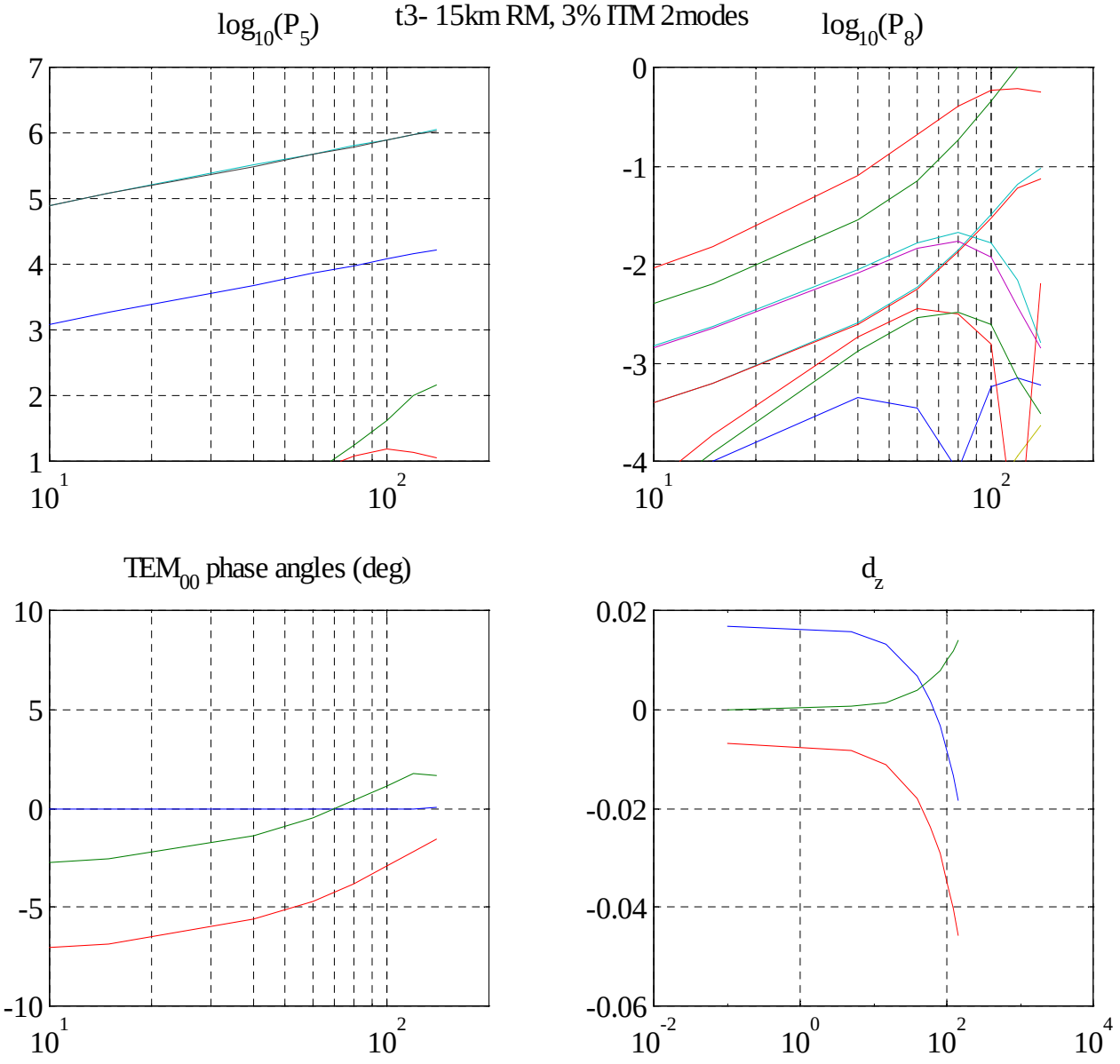




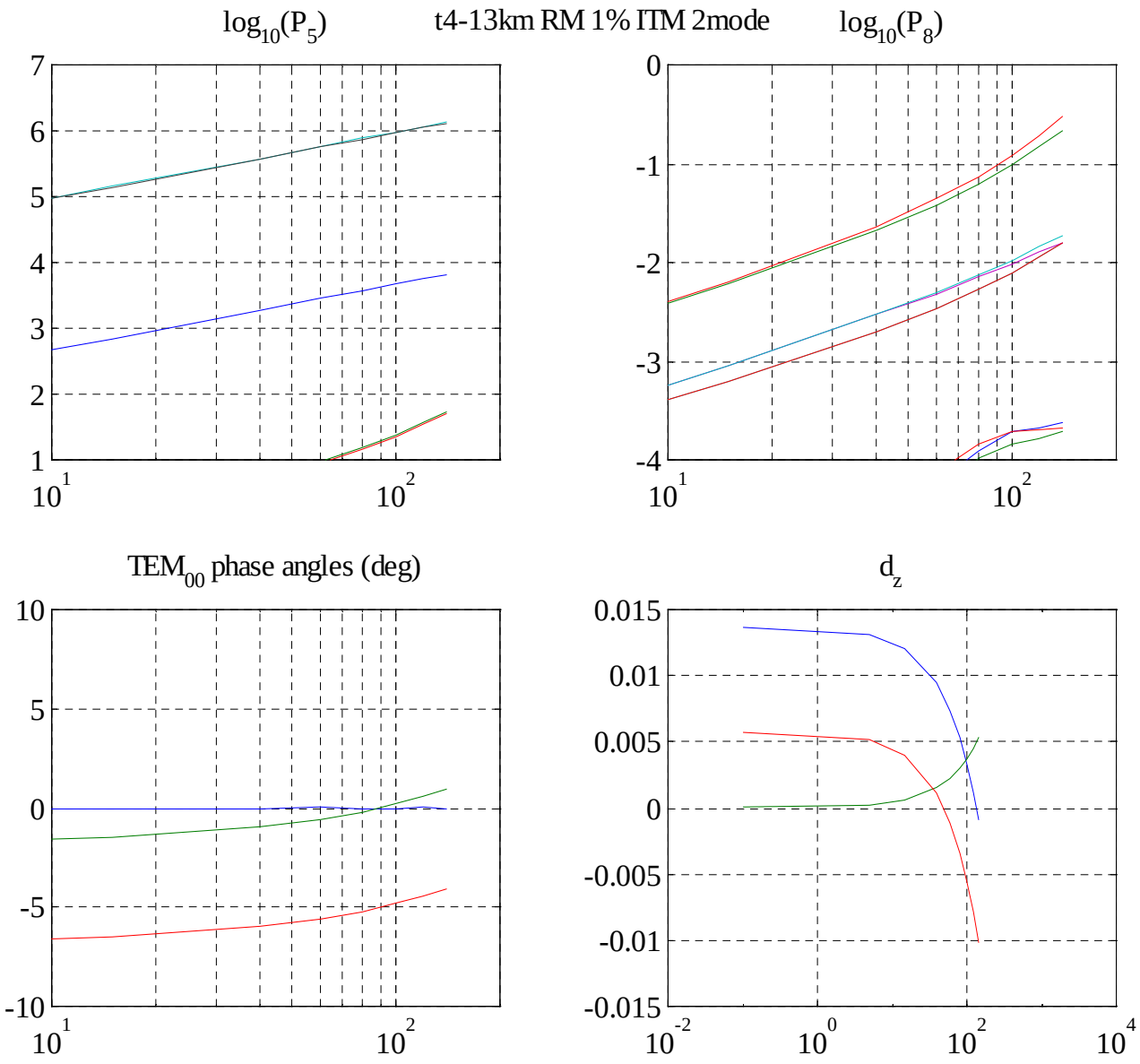




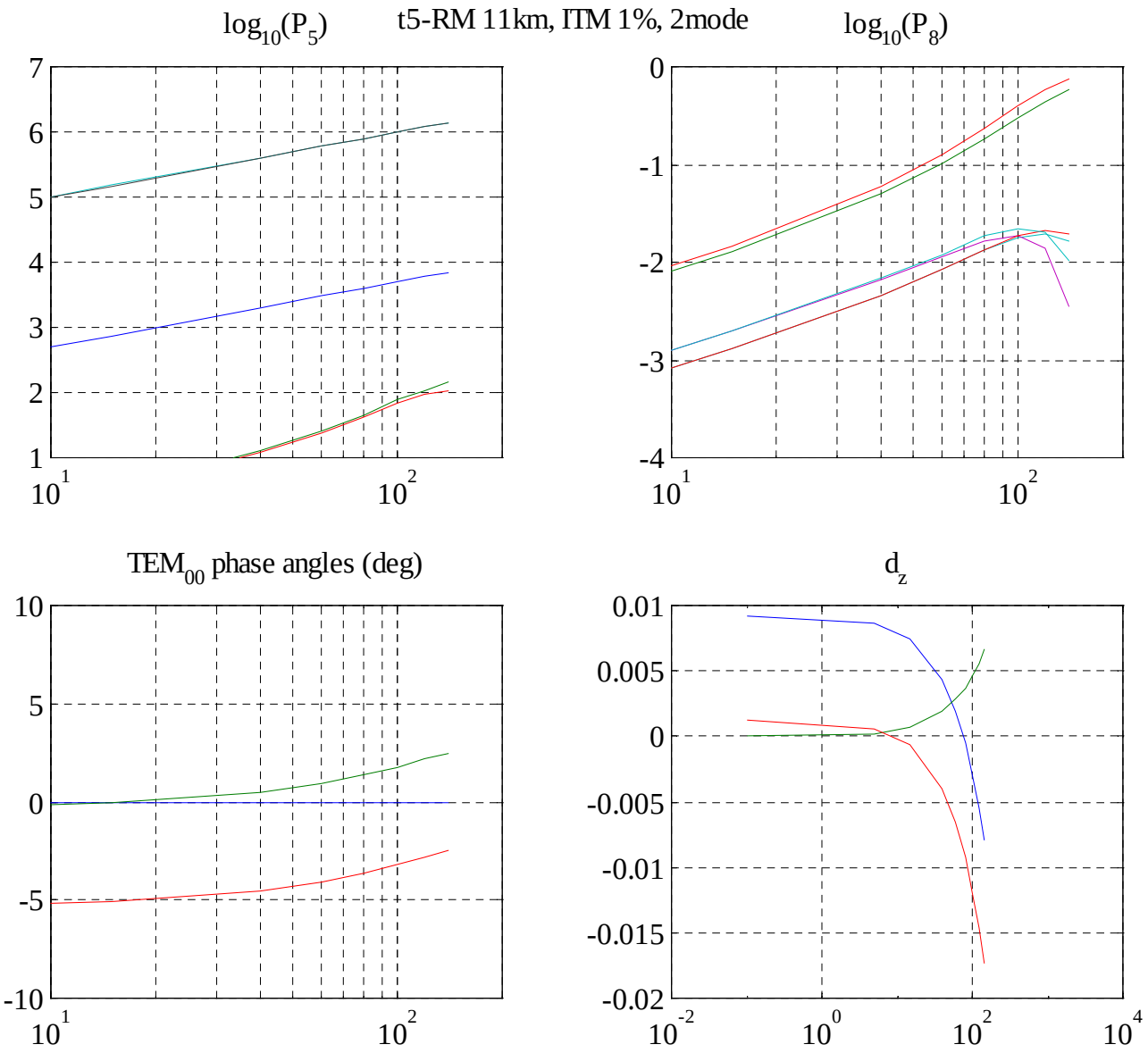
Results: 3% ITM, 15km RM



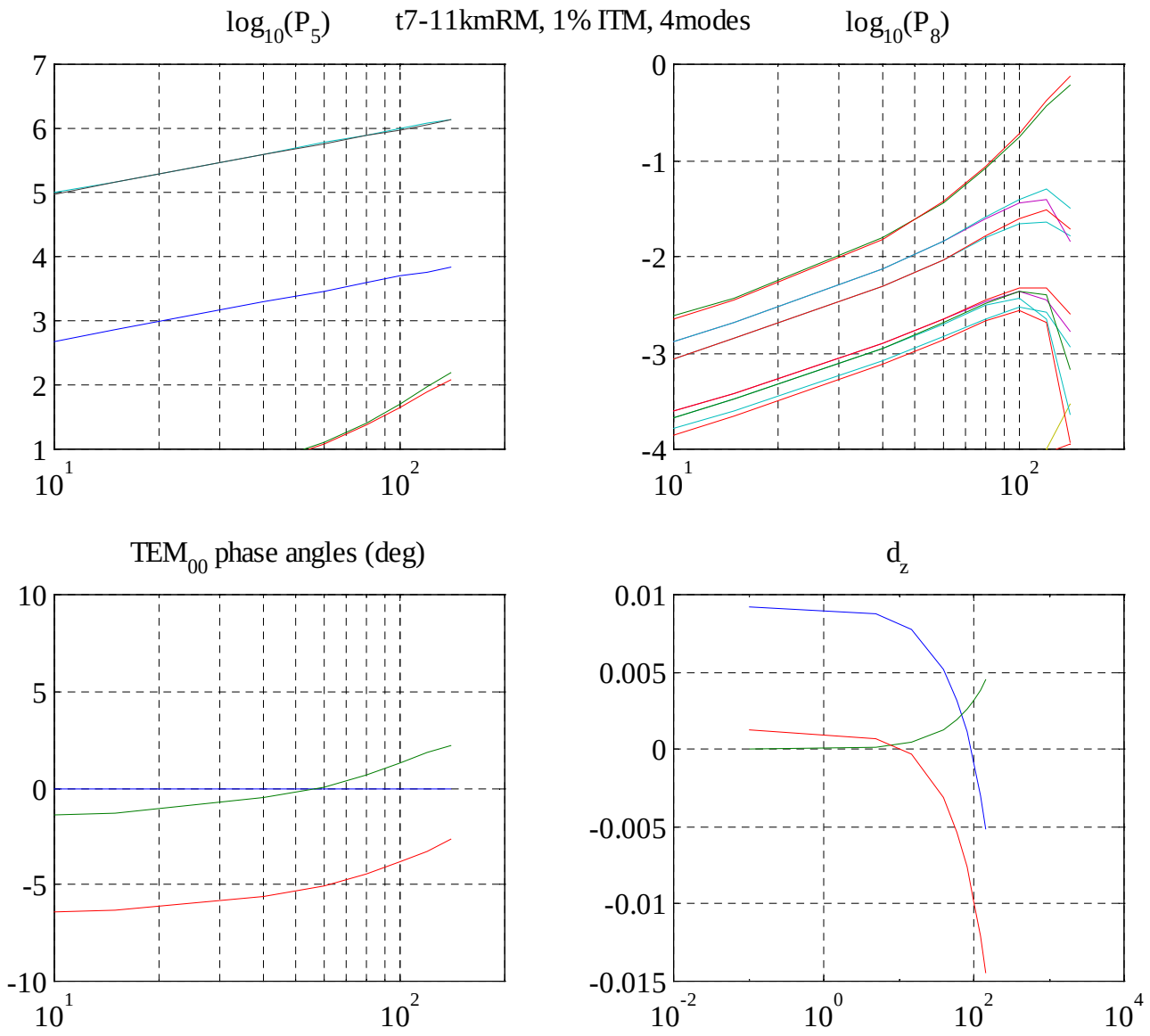
Results: 1% ITM, 13km RM



Results: 1% ITM, 11km RM



Results: 1% ITM, 11km RM



Results - DC Scheme

- It is difficult to identify a clear thermal limit
- 100W, with 40ppm/cm absorption and 10x ATC ***seems stable***