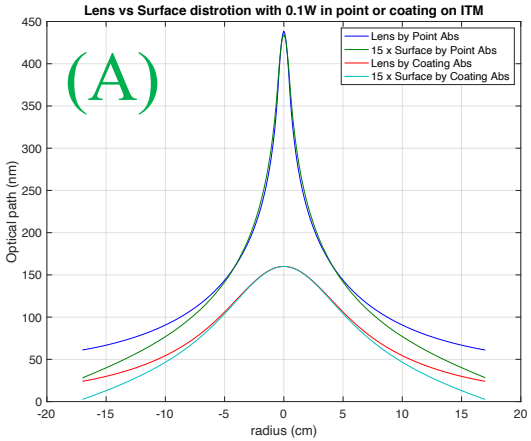
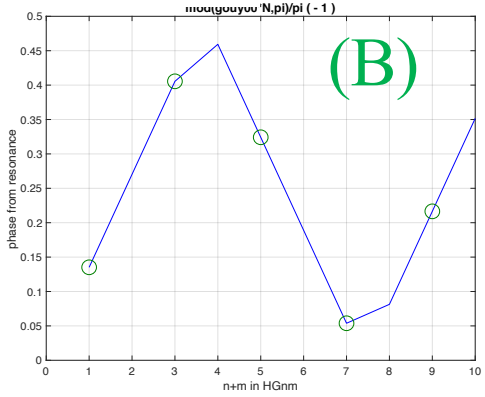
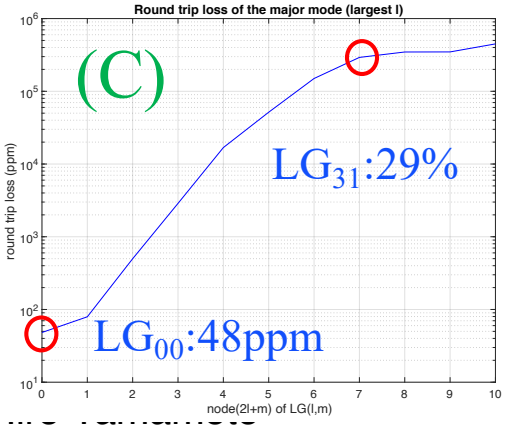
Cause and effect of point absorbers on test masses

- Mirror
  - (A) Point absorption on mirror surface causes thermal distortion of the surface and substra
    - Many HOMs are induced on reflection
- FP cavity
  - (B) aLIGO arm is close to resonance of TEMnn n+m=7, and this mode is amplified in the cavity,
  - (C) HOM has long power tail and induces large RTL
    - Mirror coating aberration reduces HOM, and reduces excess RTL by PA
- aLIGO IFO, DRFPM
  - Large RTL reduces PRG
  - Curvature mismatch of fields from two arms reduces PRG







Mirror reflection induces all HOMs
FP cavity picks up 7th mode

Fig.1 Modes of induced fields

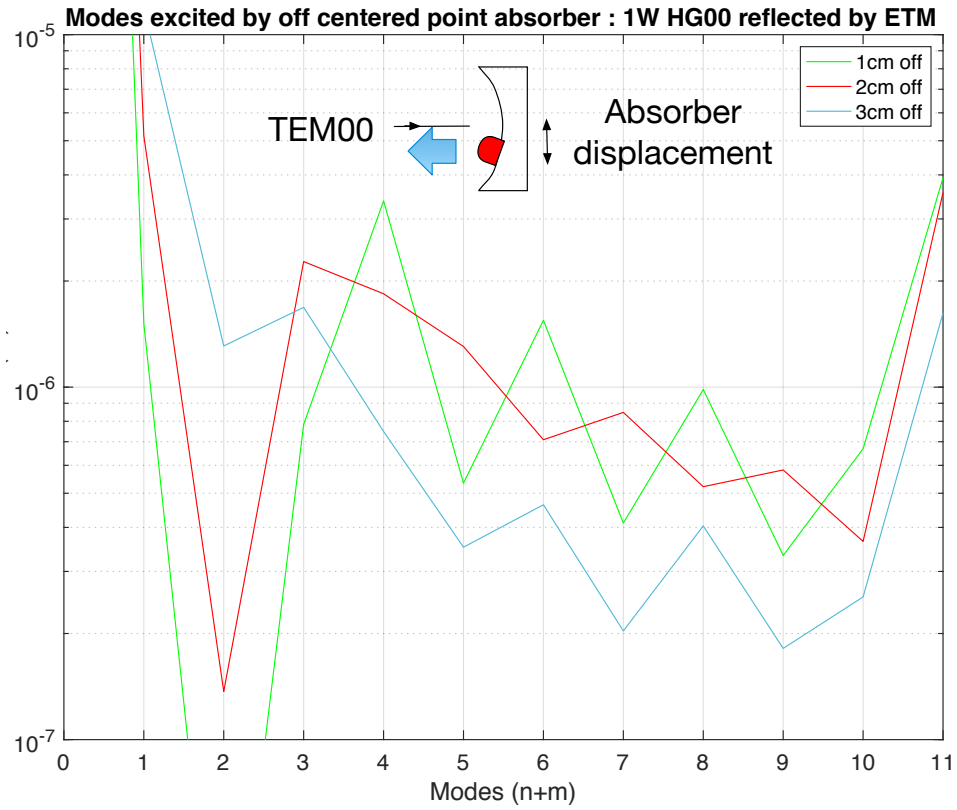
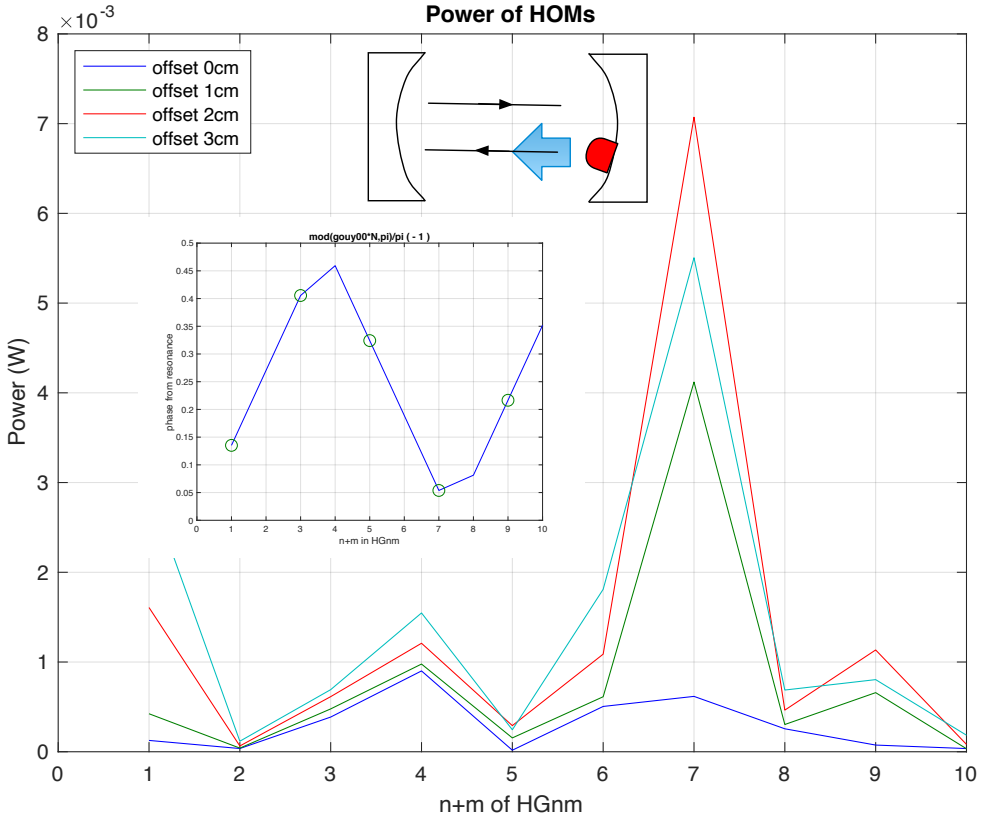
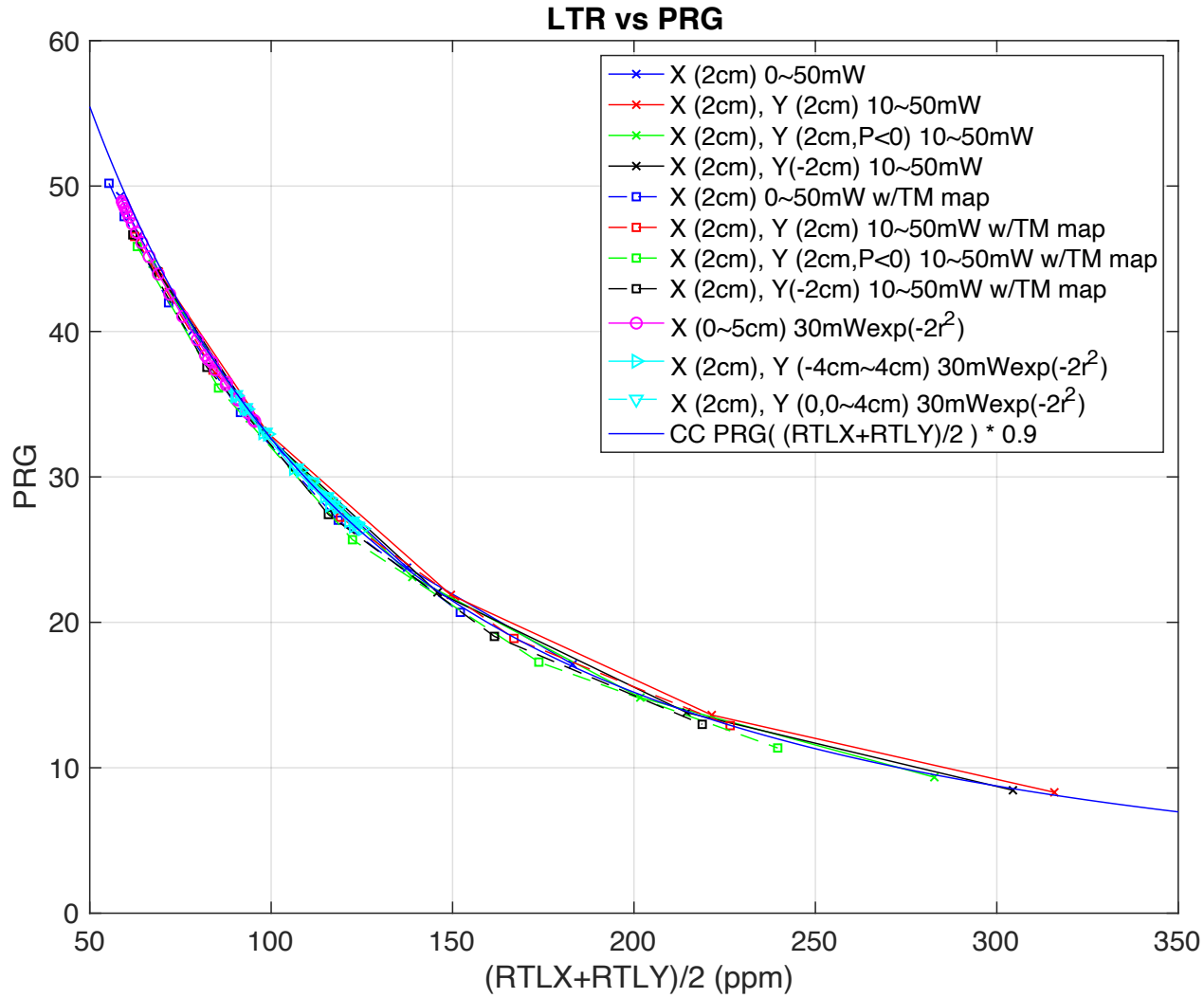


Fig.2 Modes of resonating field in FP



PRG = CC(sum of arm losses)

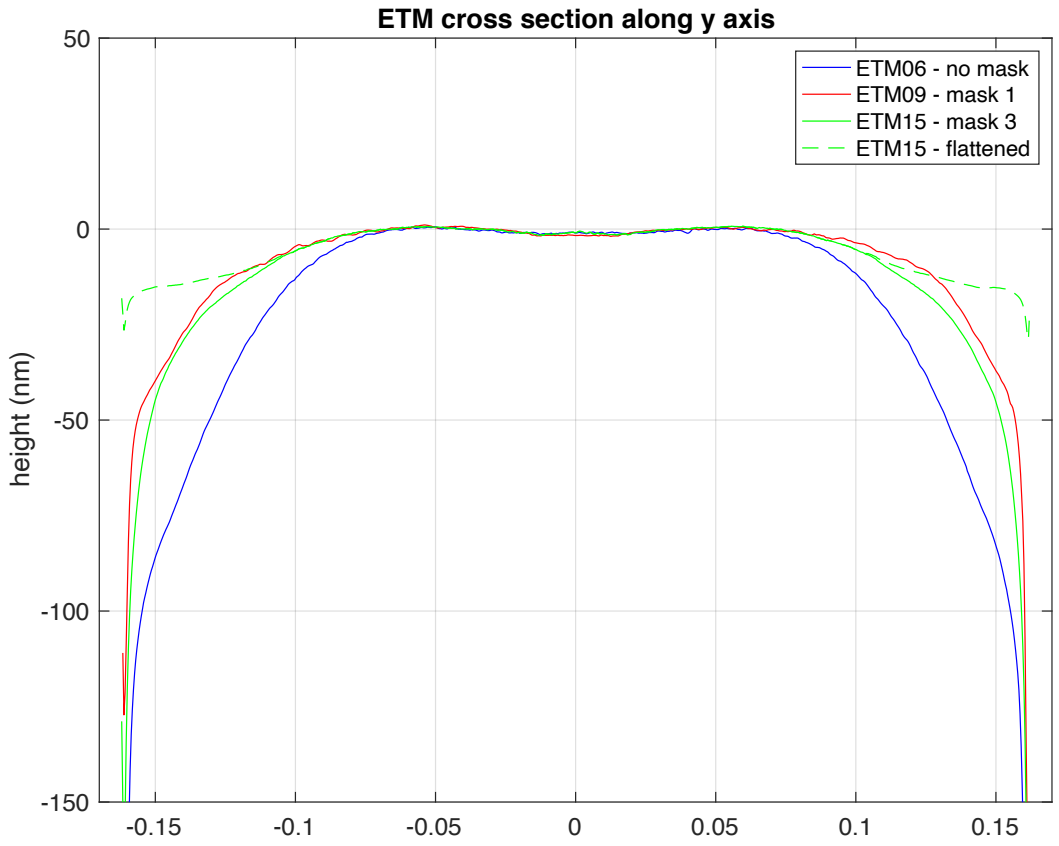
one or two point absorbers (RoC unaffected)

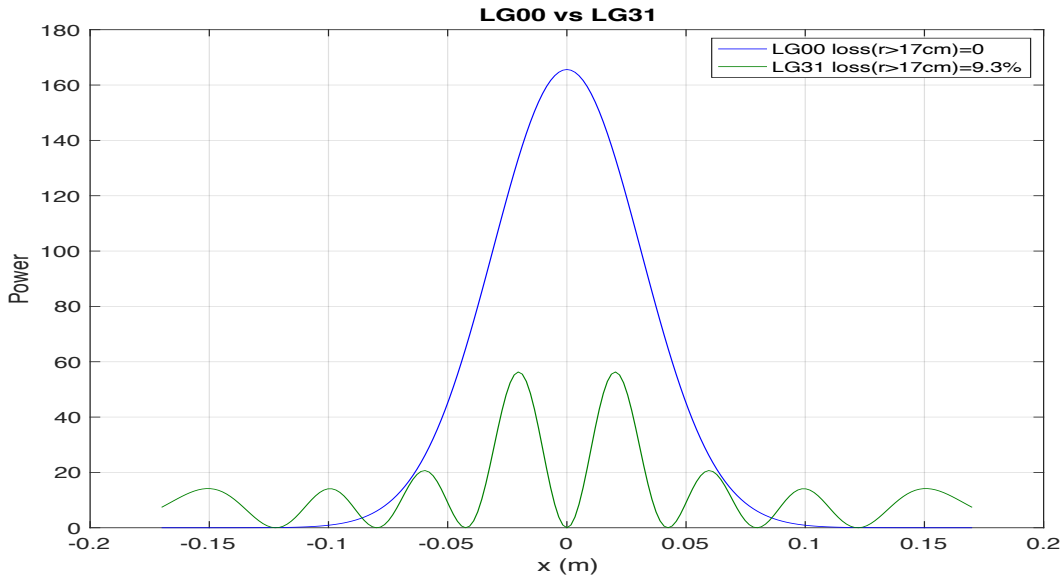


LIGO

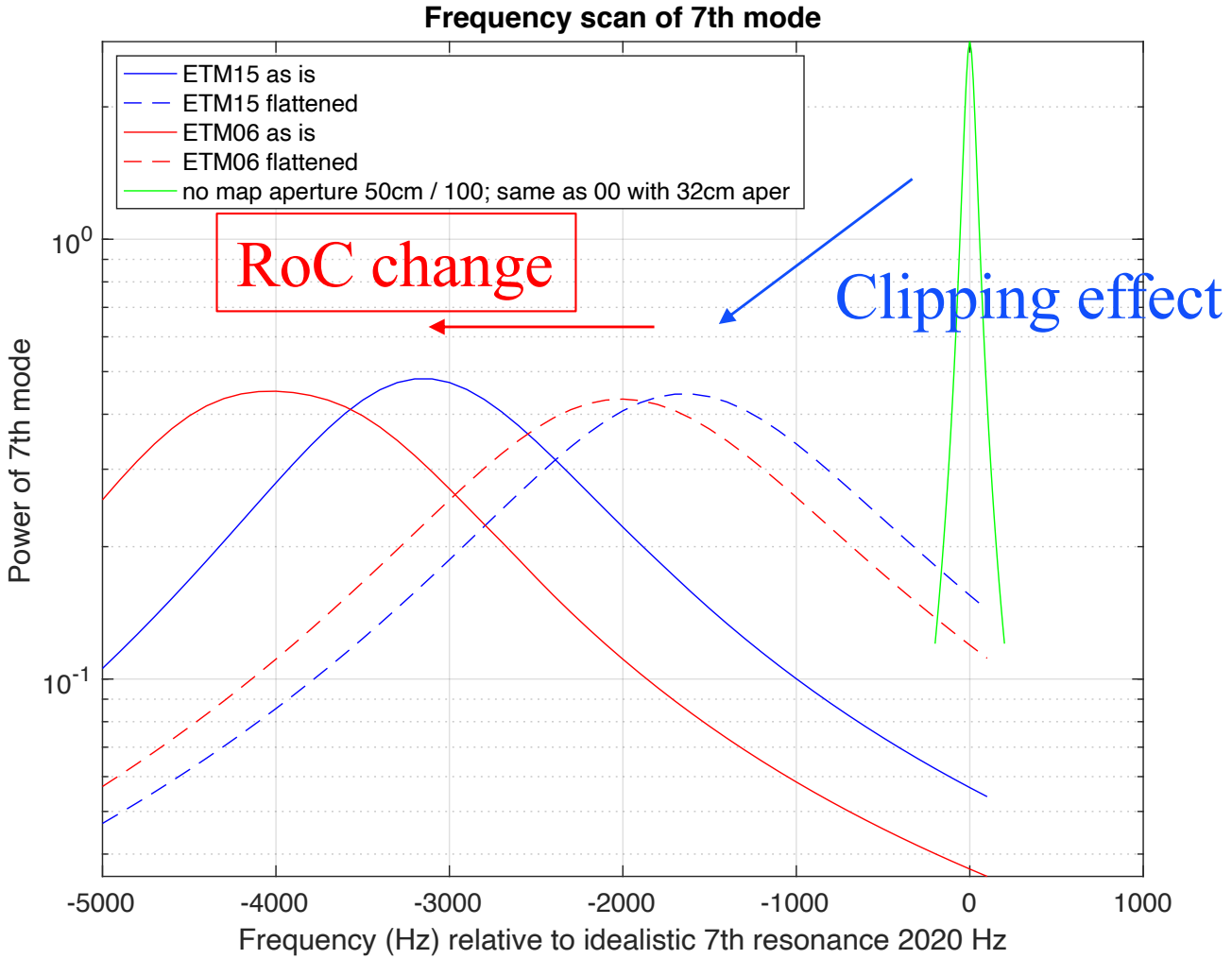
SEPTEMBER 14, 2015

Effect of the phasemap non-uniformity on the loss by the point absorber

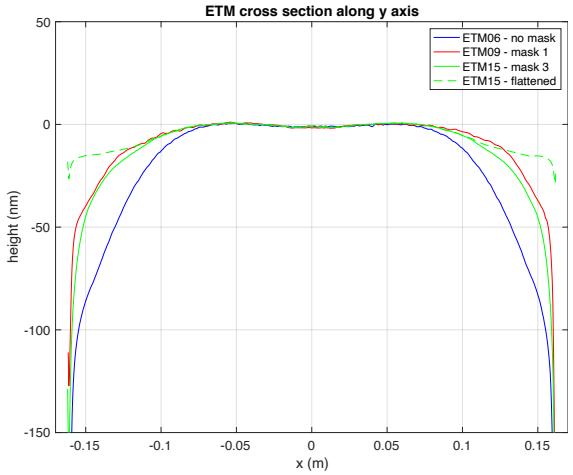


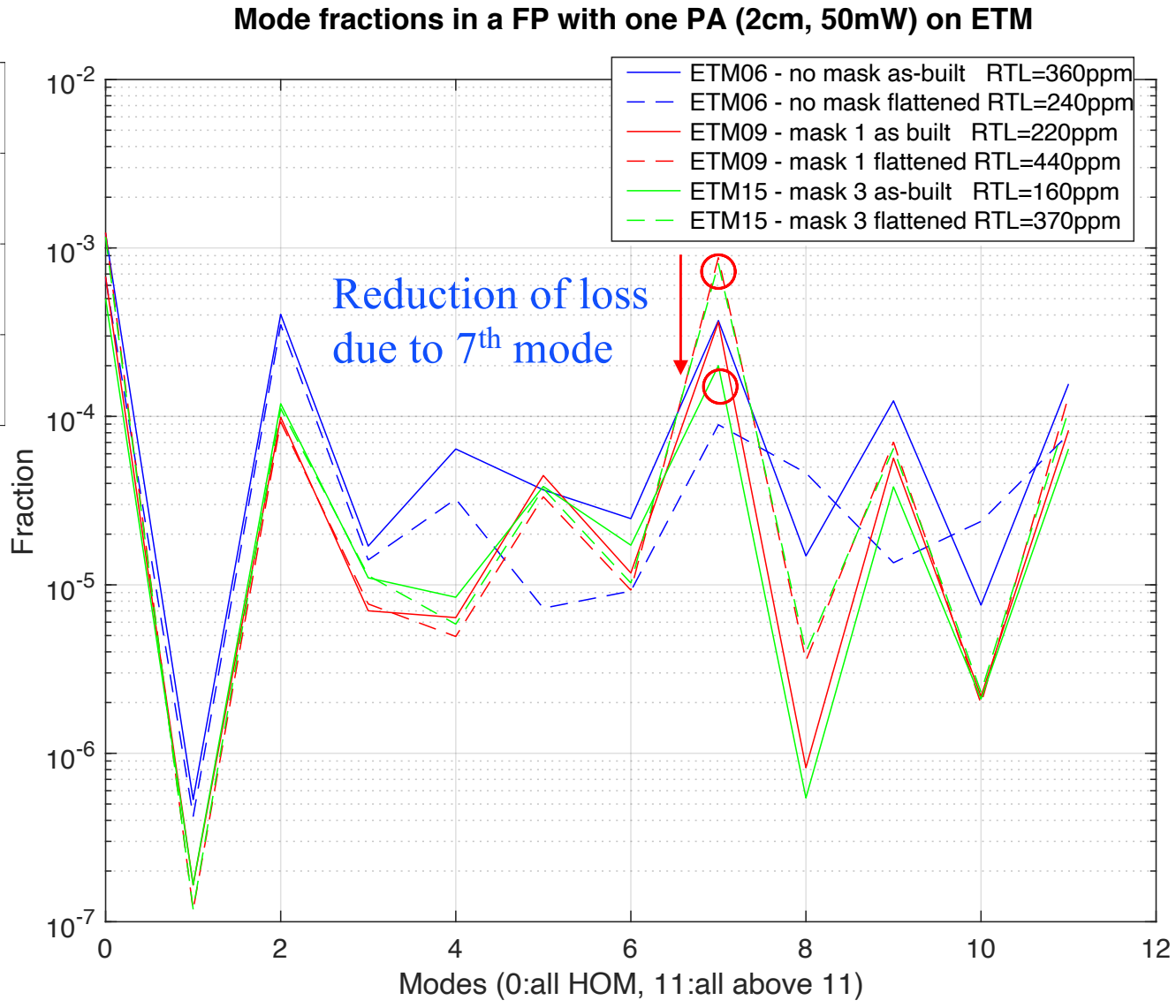


Effects of clipping loss and effective RoC change



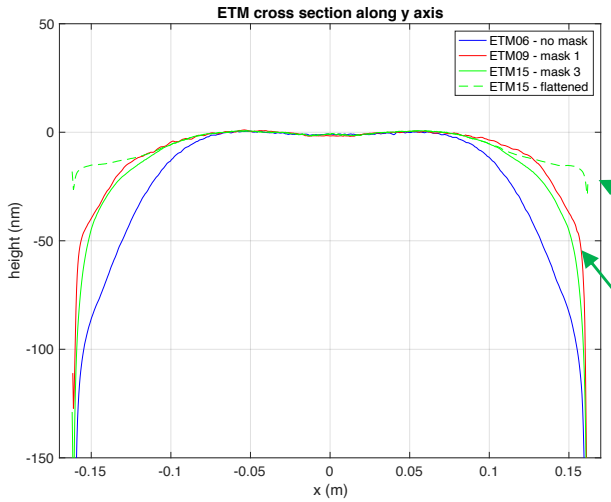
Phasemap vs HOM&RTL in FP cavity

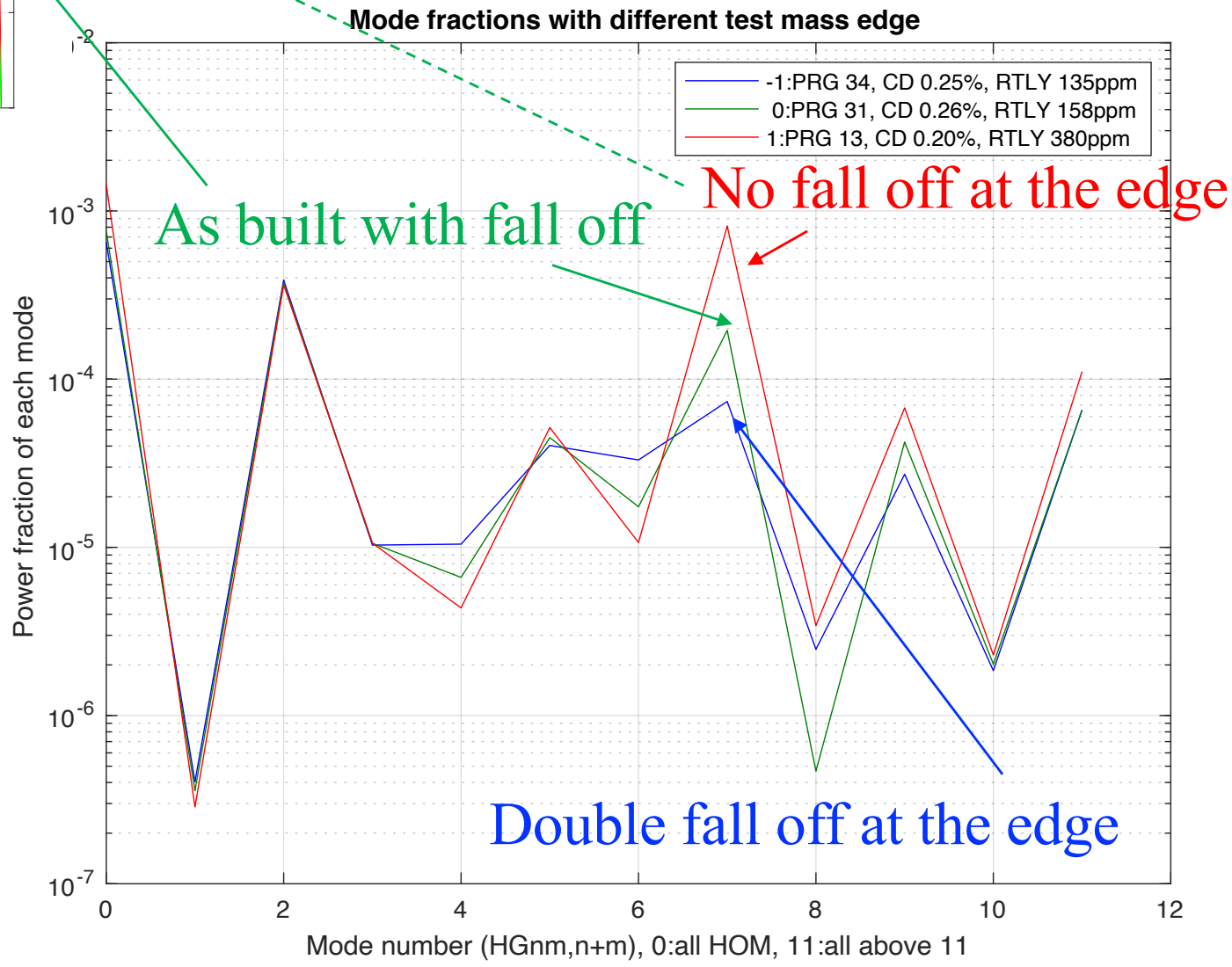




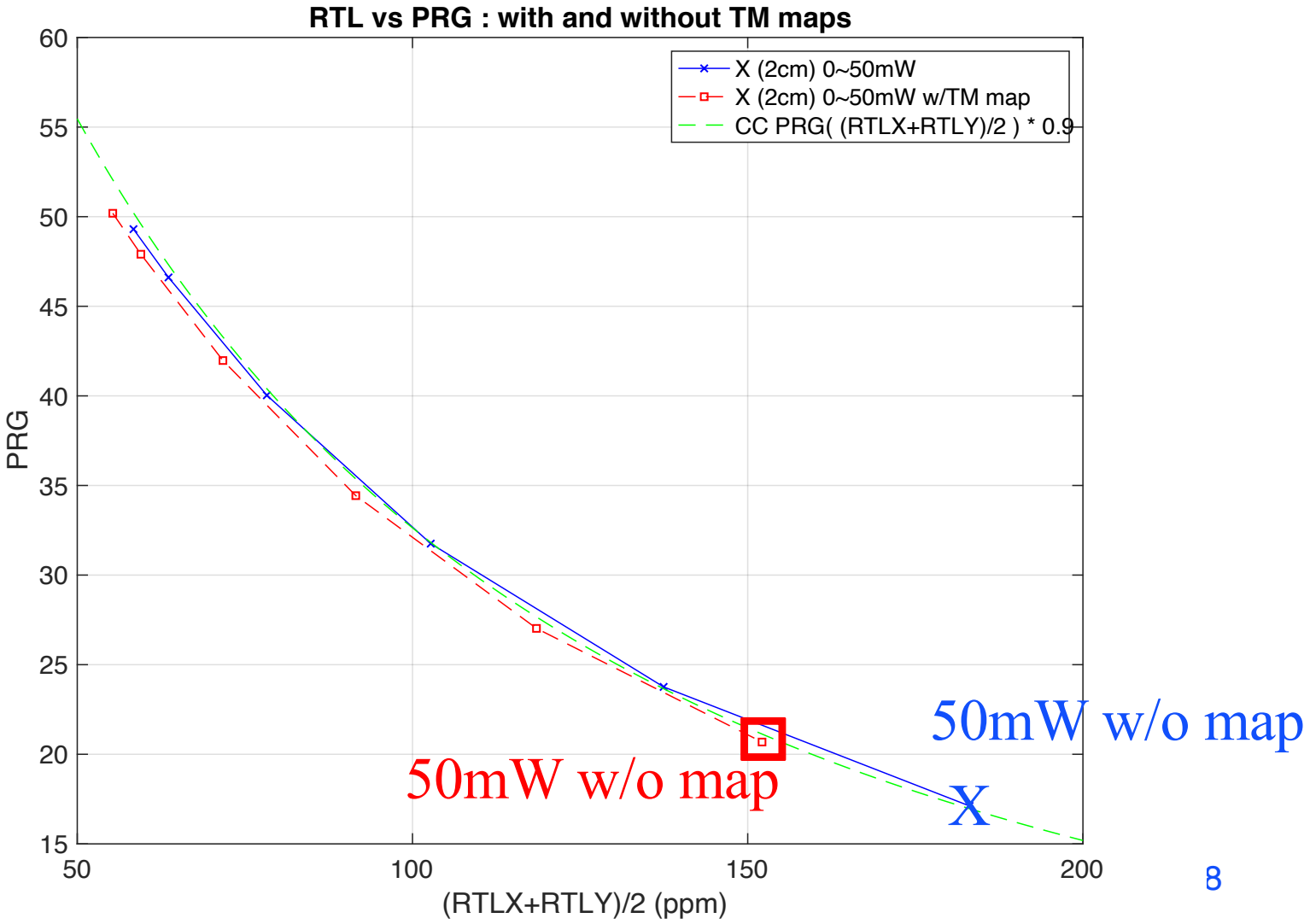
LIGO-G2000282

Effect of fall off on PRG with ETM15





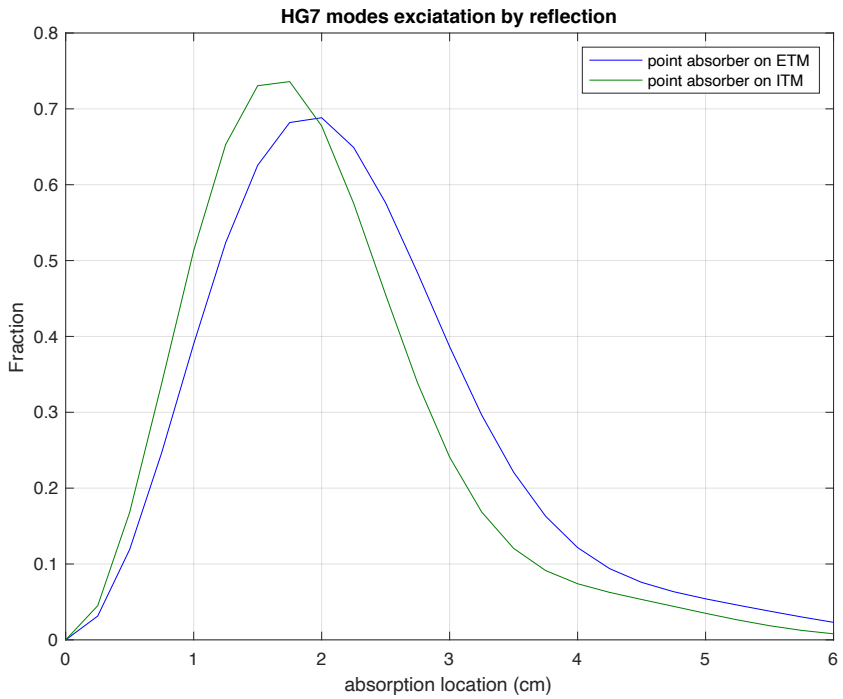
Test mass phasemaps reduces excess RTL by PA

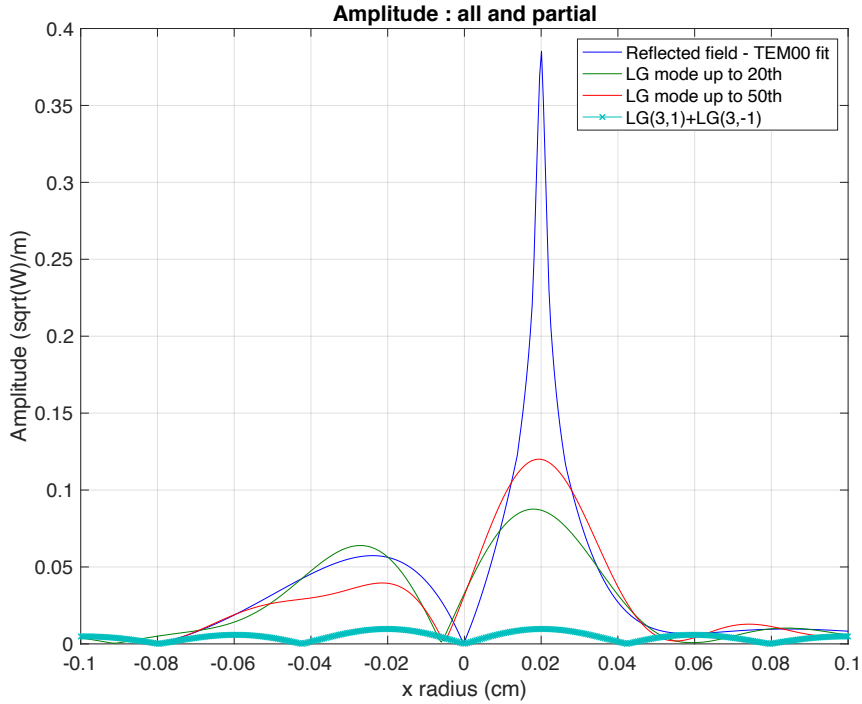


Extra

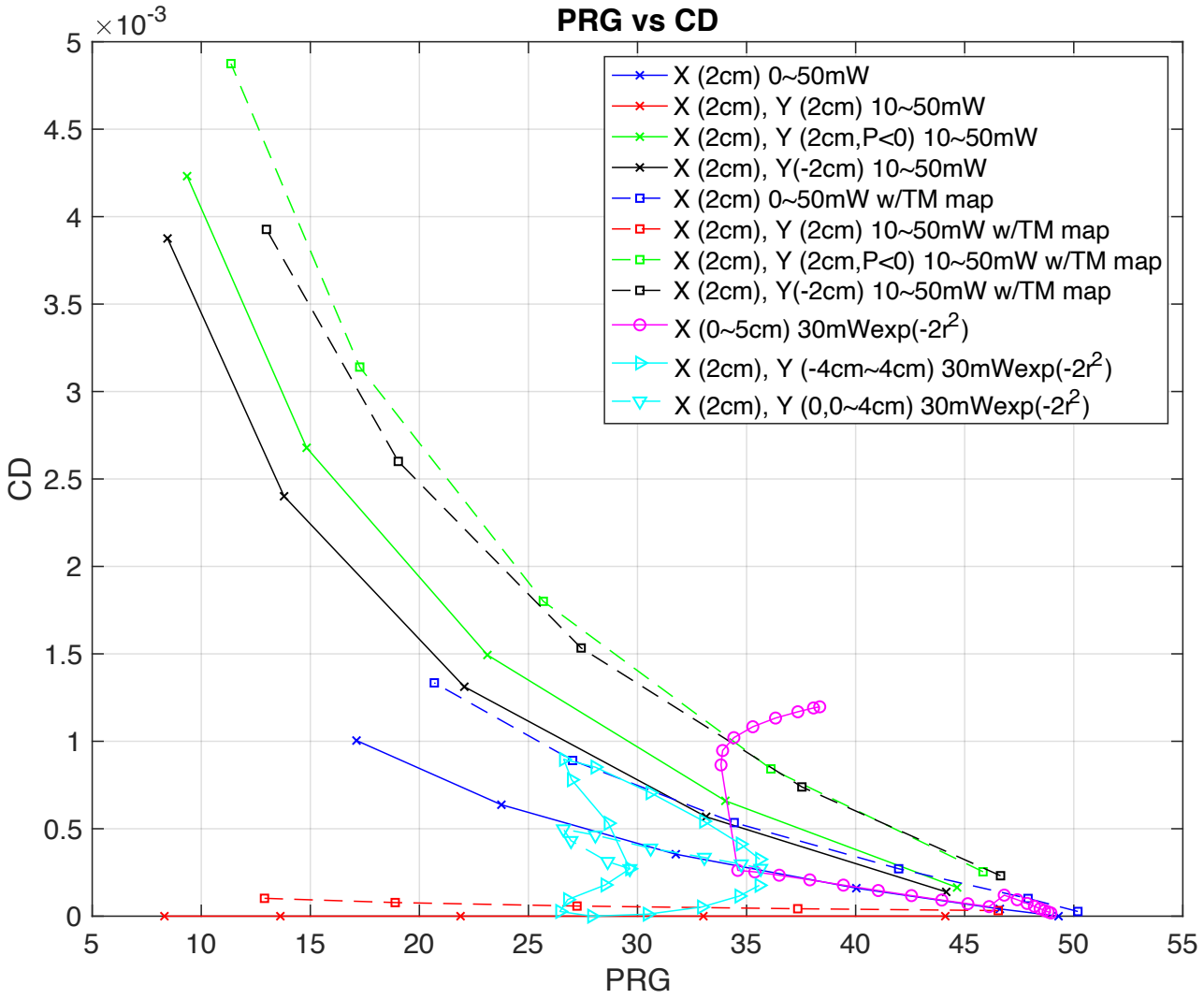
Absorber location dependence

first peak of LG(3,1) is at 2cm

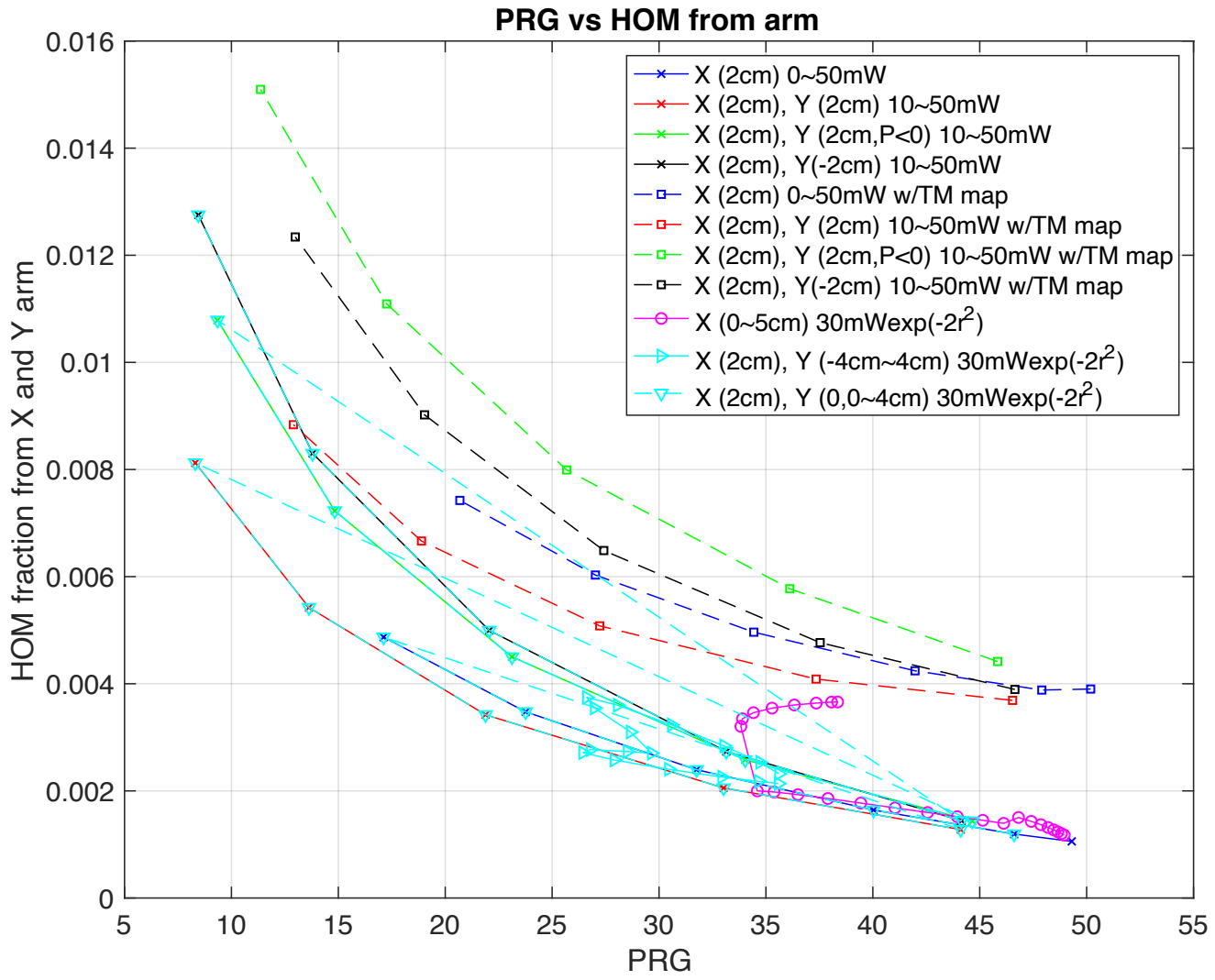




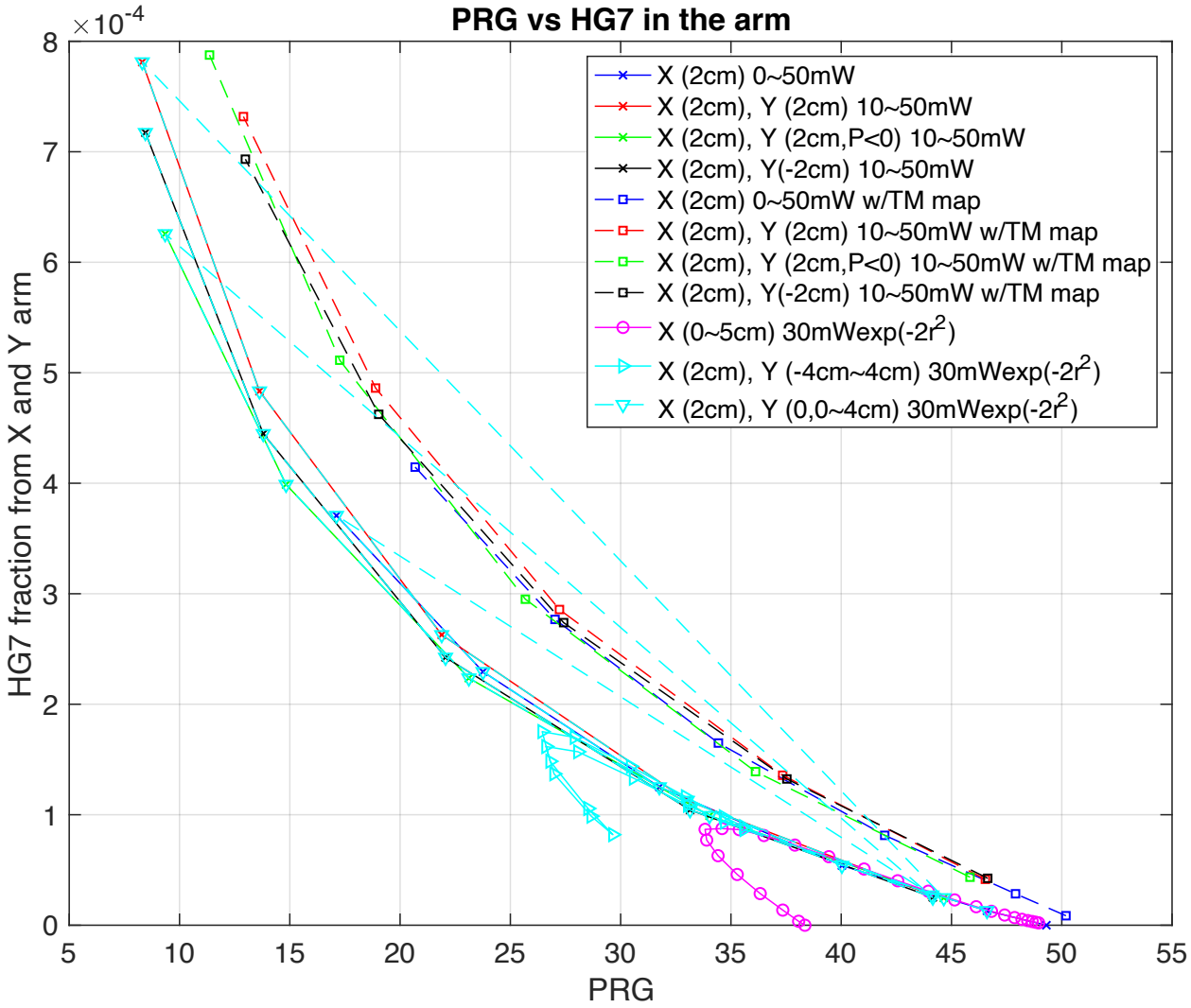
PRG vs CD
same sets as RTL vs PRG



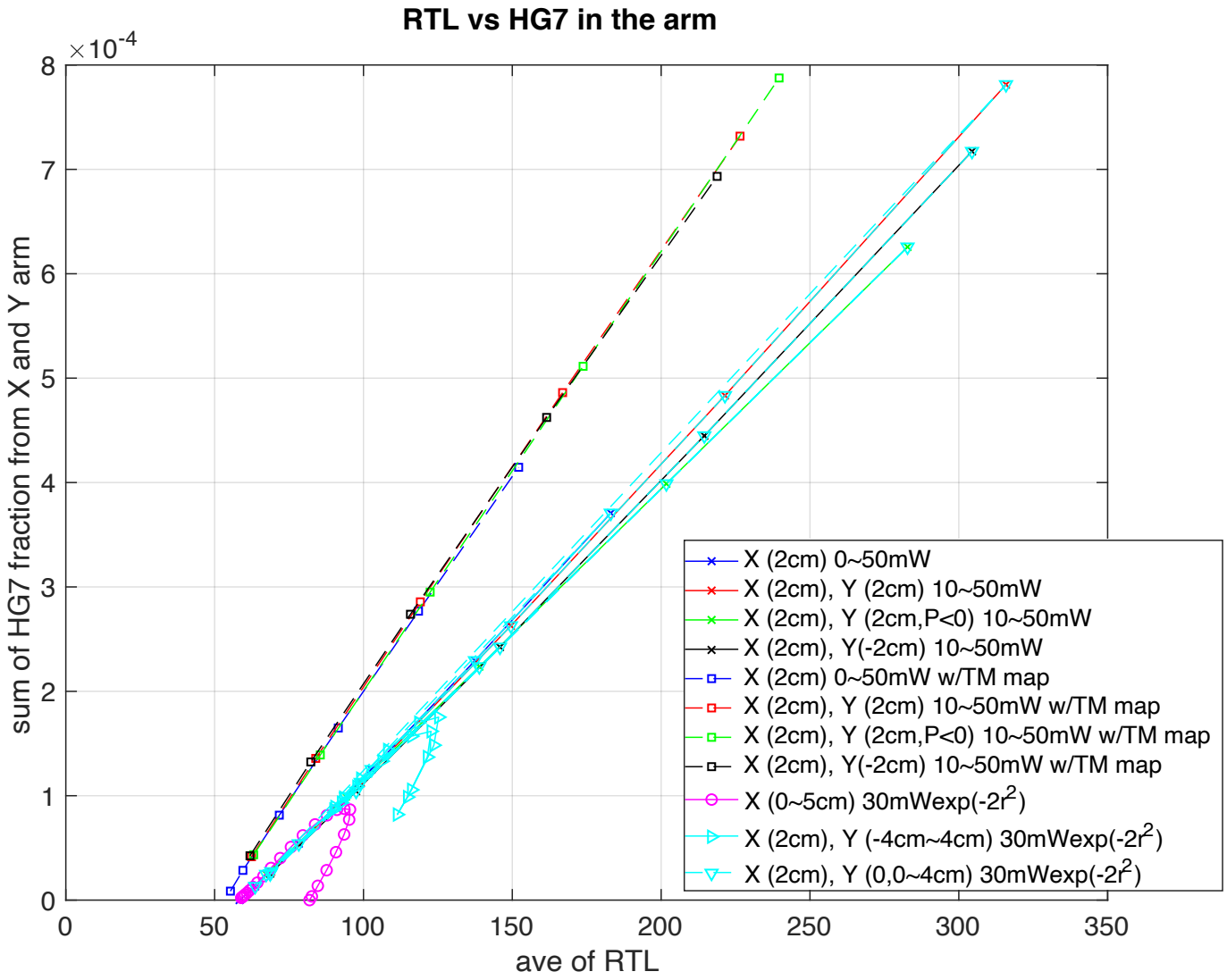
PRG vs HOM
same sets as RTL vs PRG



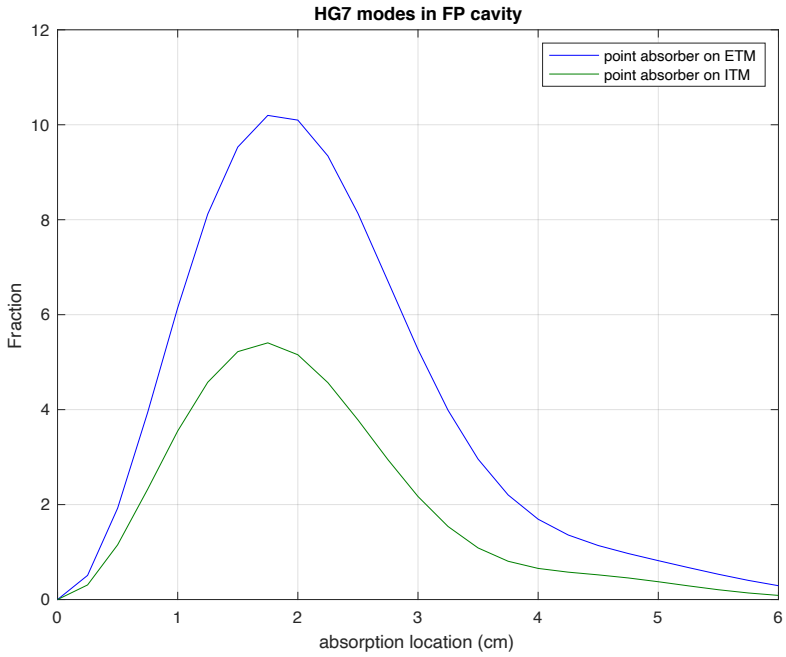
PRG vs 7th mode same sets as RTL vs PRG



RTL vs HG7 fraction same sets as RTL vs PRG

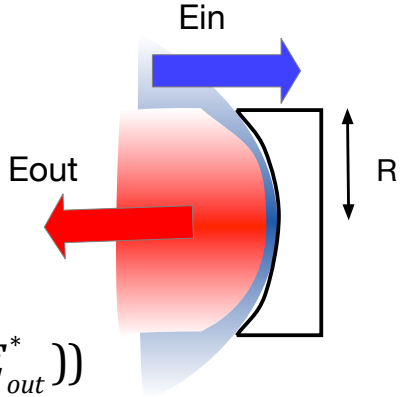


Effect of the difference of clipping losses on ITM and ETM



$$E_{in} = LG(l,m)$$

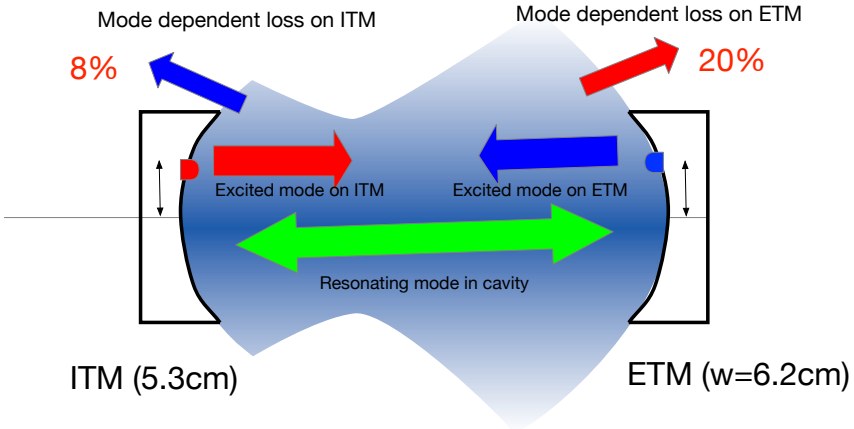
$$E_{out}(r) = \begin{cases} E_{in} & r < R \\ 0 & r > R \end{cases}$$



$$\Delta P(R) = \int |E_{in} - E_{out}|^2$$
$$= \int (|E_{in}|^2 + |E_{out}|^2 - 2\mathrm{Re}(E_{in} \cdot E_{out}^*))$$
$$= \int (|E_{in}|^2 - \mathrm{Re}(E_{in} \cdot E_{out}^*))$$
$$= 1 - \int \mathrm{Re}(LG(l,m) \cdot E_{out}^*)$$
$$= 1 - C(l,m,R)$$

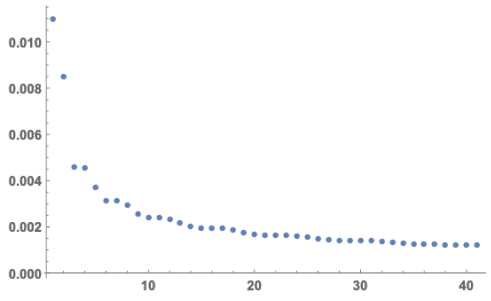
Power loss by clipping and conversion to other modes

$$P_{out}(l,m,R) = |C(l,m,R)|^2 = (1 - \Delta P(R))^2 \approx 1 - 2\Delta P(R)$$



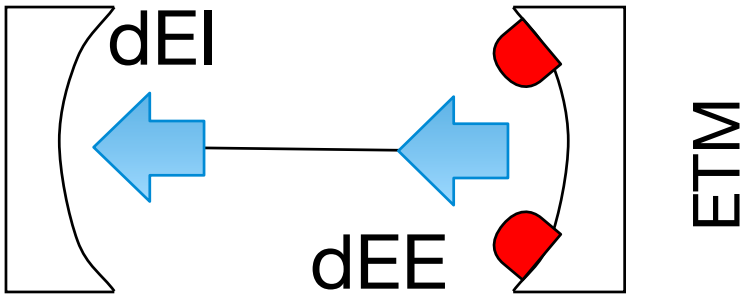
Explicit calculation for LG00 input

Extra loss - ∑LG(n) power



Hiro Yamamoto

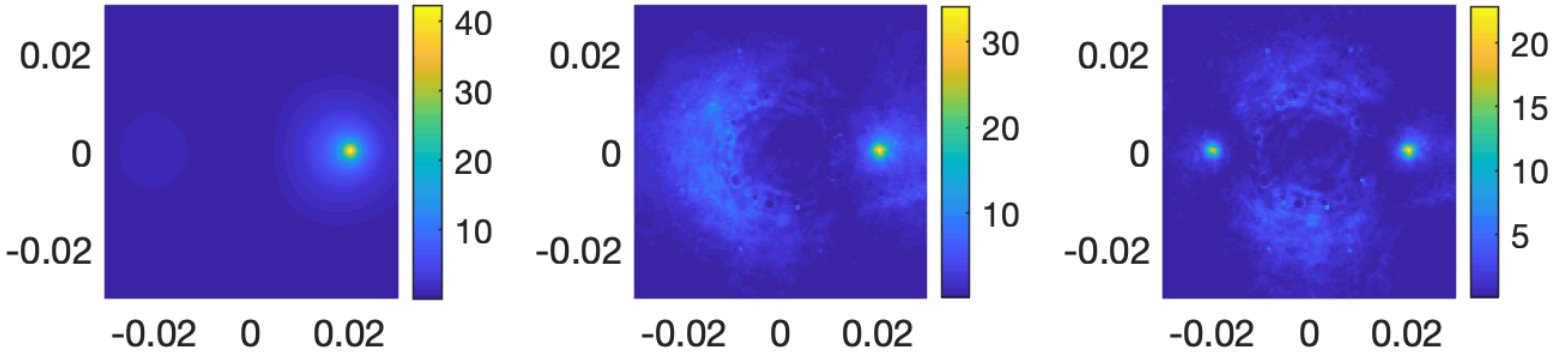
dE = E-TEM00
on ITM&ETM



dRTL = RTL – RTL0, RTL0 = RTL(without map and absorber) = 48ppm

dEE

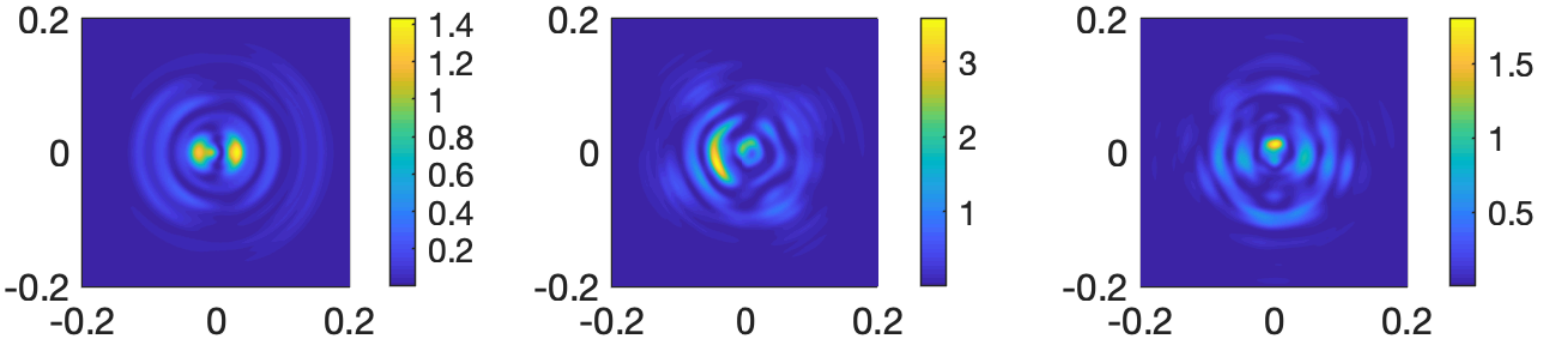
±3cm



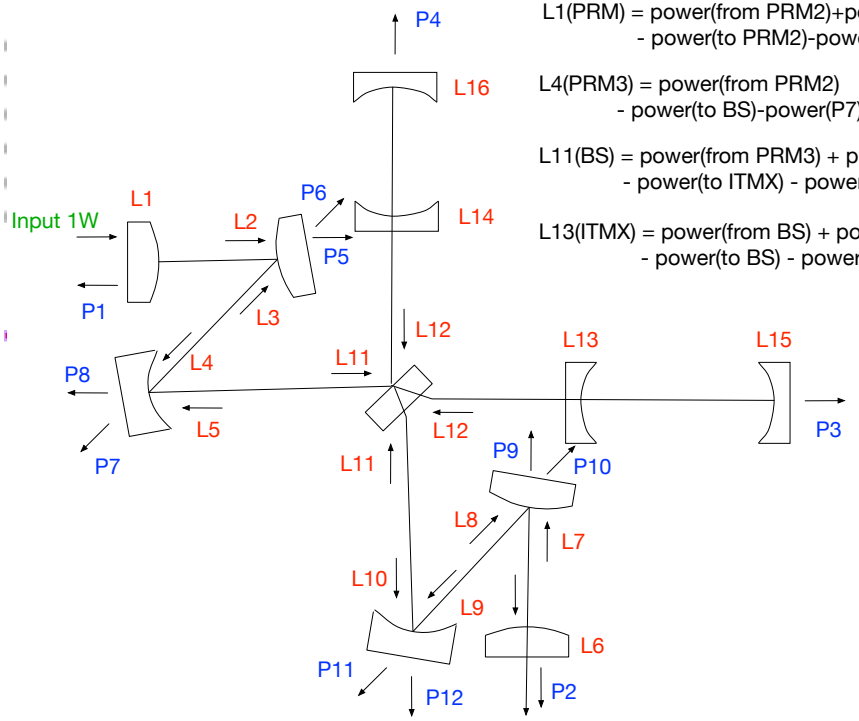
one absorber 10mW	one absorber 10mW	two absorbers 10mW
at x=2cm, y=0	at x=2cm, y=0	at 2cm & -2cm
No mirror maps	L1 x arm maps	L1 x arm maps
dRTL=10ppm	dRTL= 17ppm	dRTL= 11ppm

dEI

±20cm



How 1W input is lost

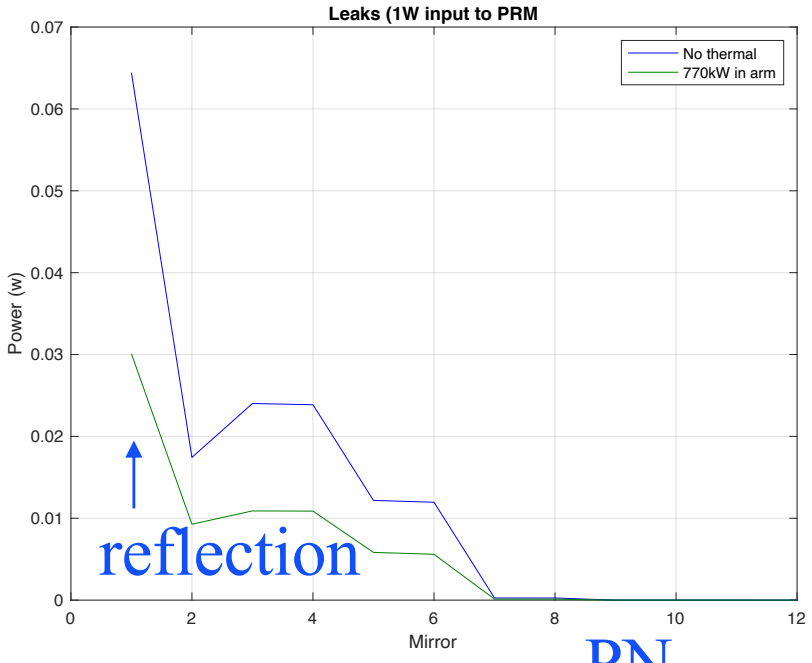


L1(PRM) = power(from PRM2)+power(input)
- power(to PRM2)-power(reflected)

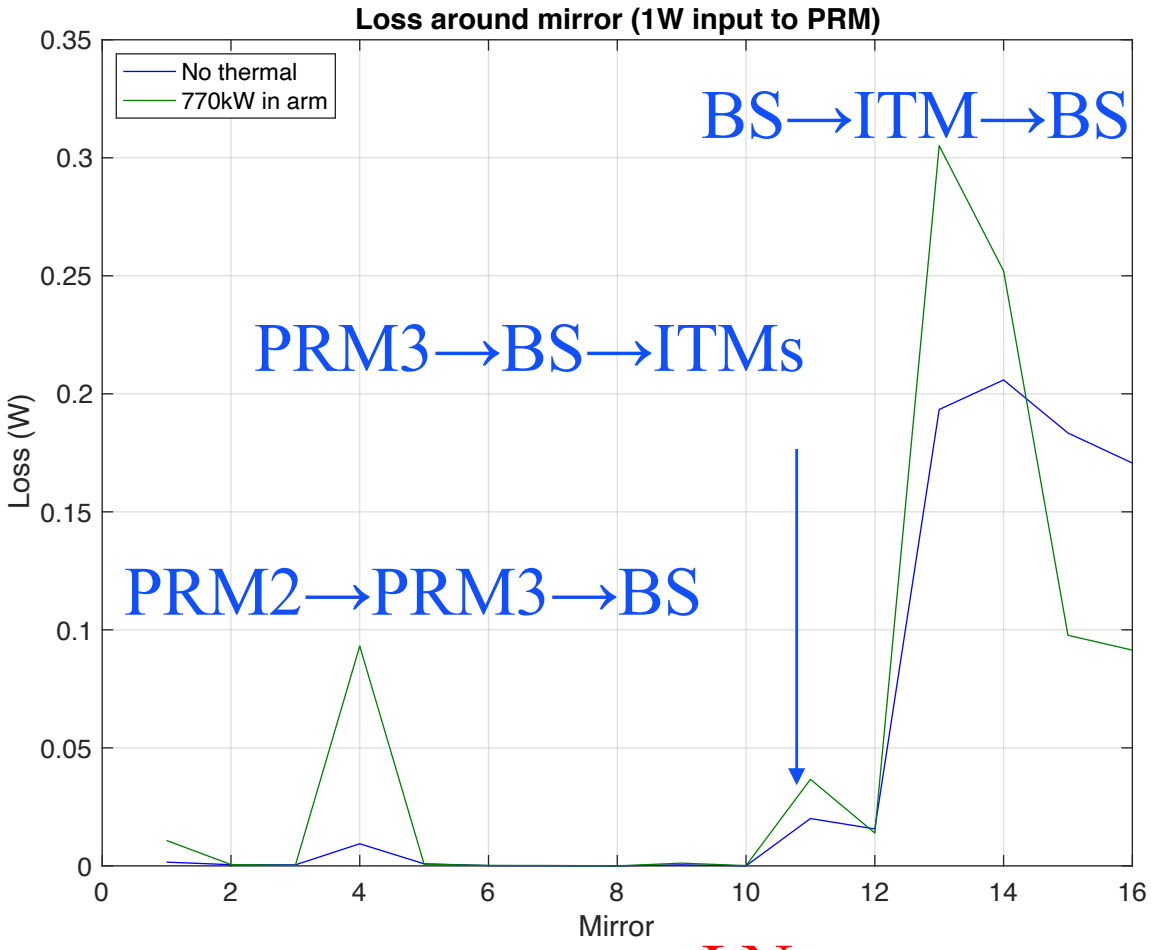
L4(PRM3) = power(from PRM2)
- power(to BS)-power(P7)

L11(BS) = power(from PRM3) + power(from SRM3)
- power(to ITMX) - power(to ITMY)

L13(ITMX) = power(from BS) + power(from ETMX)
- power(to BS) - power(to ETMX)



PN



LN