- **aLIGO IFO design: to be <u>slightly over-coupled</u> for the carrier**
    2% carrier reflectivity

- **Higher arm loss & misalignment:**
    ~ may cause the carrier critical- or under-couplling

Carrier Power Coupling into the IFO

Legend:
- Scat. Loss per Optic=37.5ppm
- Scat. Loss per Optic=45ppm
- Scat. Loss per Optic=60ppm

X-axis: TPRM
Y-axis: Power Coupling
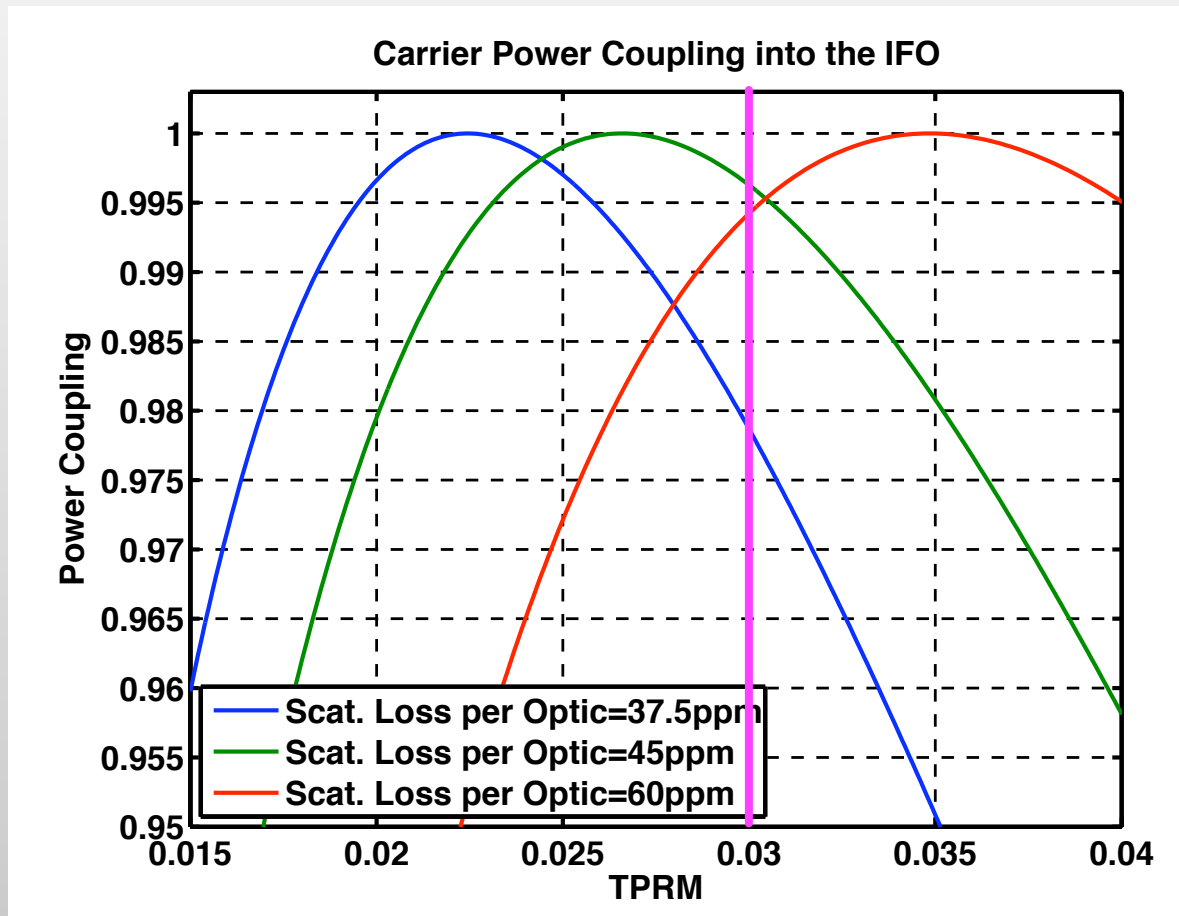
T070247 P.5

- What's wrong with the critical-/under-coupling (LSC)

LSC signals: $d(CA \times SB) = d(CA) \times SB + \cancel{CA \times d(SB)}$

$d(CA) = CARM_{+PRCL+MICH}, \quad d(SB) = PRCL_{+MICH}$

=> The vertex signals disappear or suffer sign flip

Mitigation: for lock acquisition   3f signals
for low noise operation   POP signals

- What's wrong with the critical-/under-coupling (ASC)

ASC signals: $d(CA \times SB) = CA_{01} \times SB_{00} + \cancel{CA_{00} \times SB_{01}}$

=> The sideband alignment signals disappear?

This may cause servo instability and keep us away from the best alignment

ASC singularity ~ introduction

- Some intuition ~ a three mirror cavity

WFS signal = CA_{01} x SB_{00} + CA_{00} x SB_{01}

ETM: **exicites only** CA_{01} => no singularity by the CA coupling

PRM: **exicites only** SB_{01} (CA_{01} is not resonant in PRC)
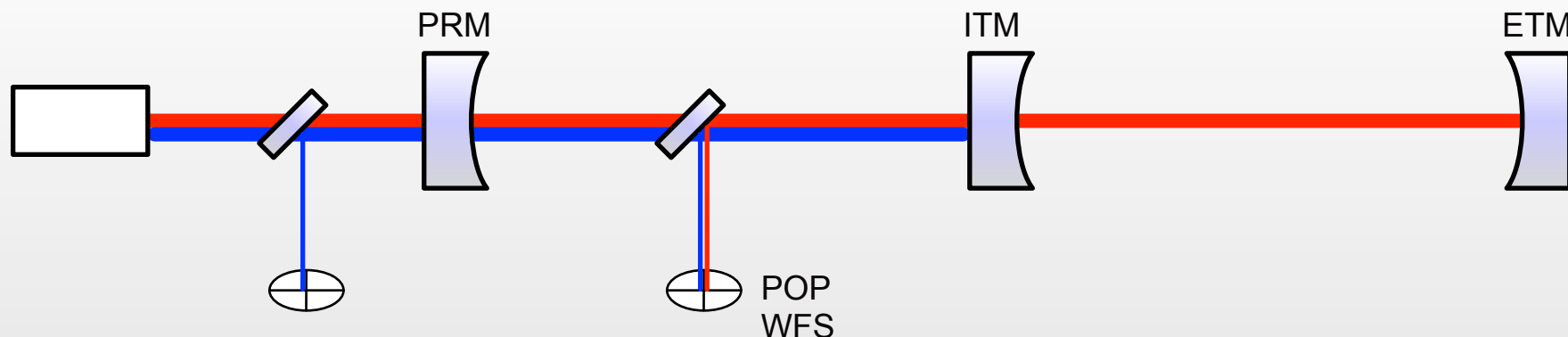=> singularity at the carrier critical-coupling

ITM: **excites both** CA_{01} & SB_{01}
=> cancellation of the two terms cause singularity but

Question:
Where (at which loss/recycling gain) does this happen?
==> Need simulation

- Possible mitigation: POP WFS (VF, RdR, DM)

PRM   ITM   ETM

POP
WFS

$$\text{WFS signal} = CA_{01} \times SB_{00} + CA_{00} \times SB_{01}$$

POP WFS:
At POP, we always have CA and SB => different mixture of the terms

Questions:
- Which signal should we use? (POP9, 45, or 36?)
- Is the noise level good enough for the low noise operation?
  Or are the signals only used for the acquisition stage?
==> Need simulation