Stable Cavity Optical Parameters, Guoy Phase, and G Factor

Muzammil A. Arain and Guido Mueller
Department of Physics, University of Florida, Gainesville, Florida

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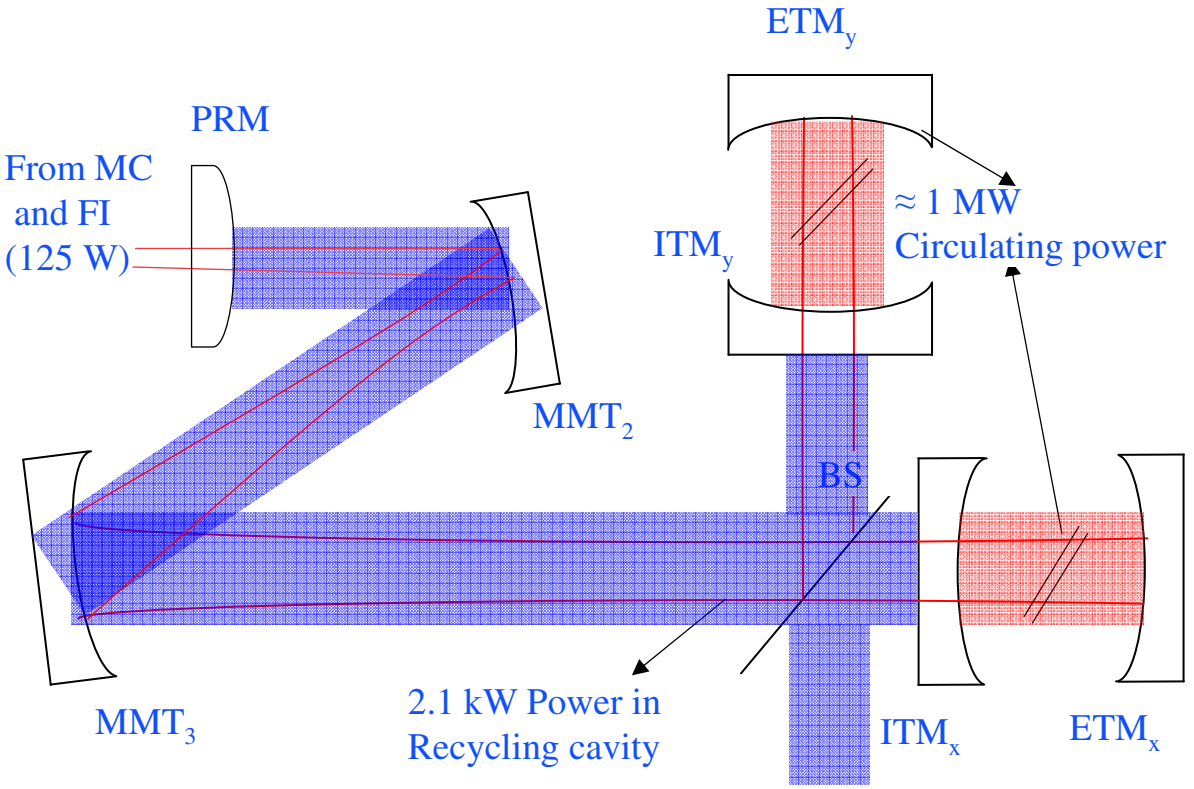
Advanced LIGO Configuration

Stable Power Recycling Cavity



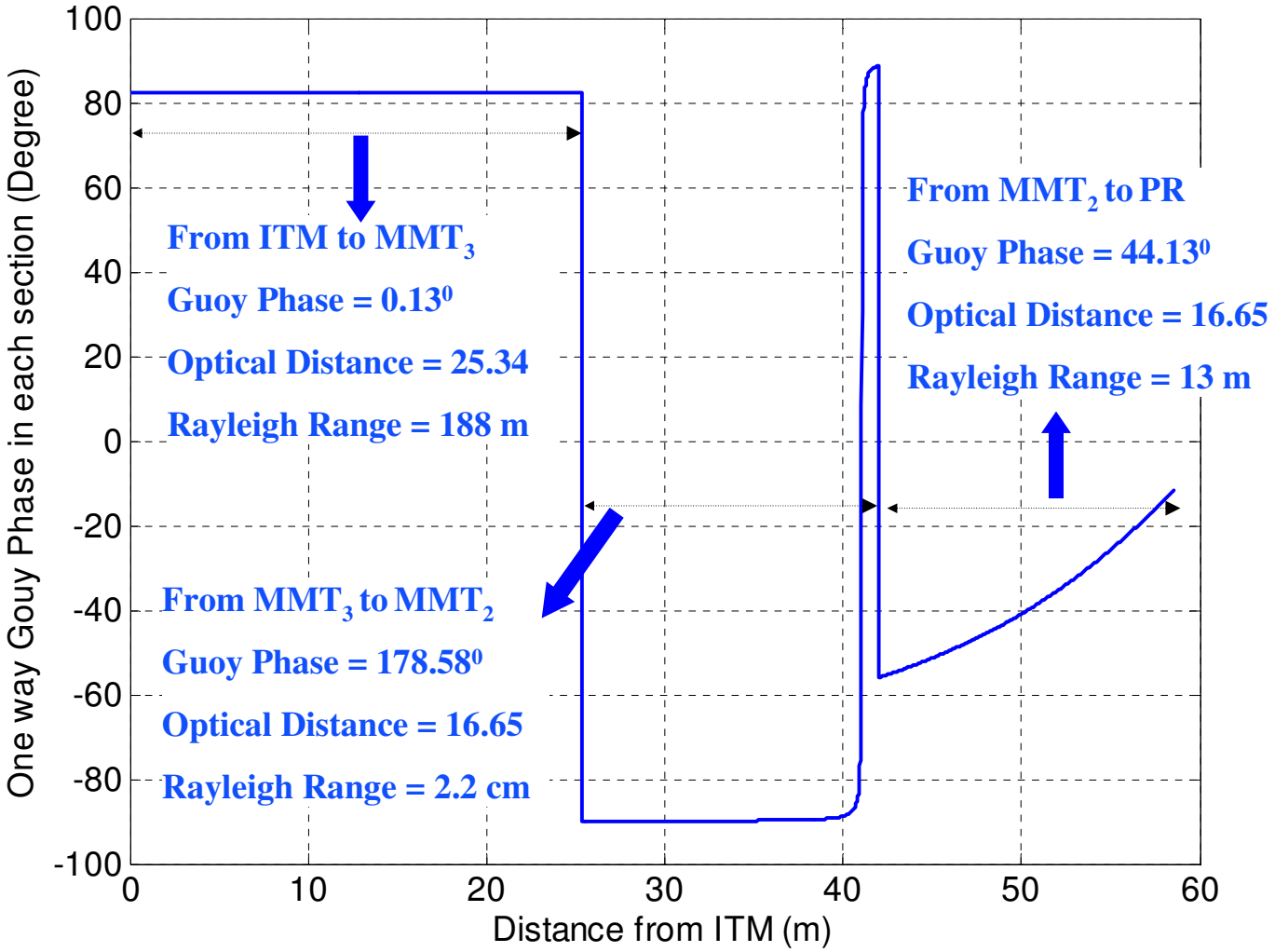
Arm cavities formed by the test masses

Power (signal) recycling cavity

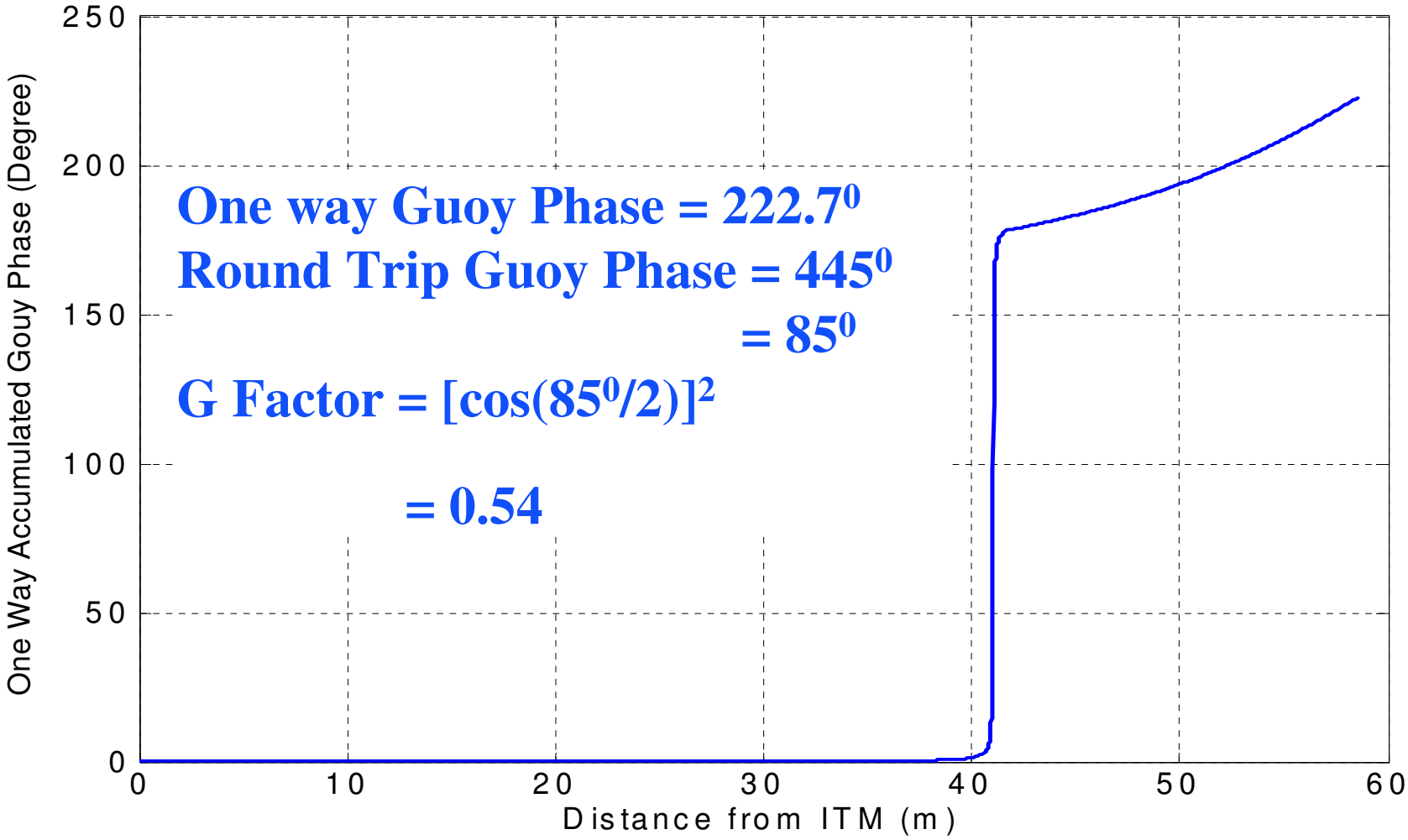
Optical Parameters for Stable Cavity

Definition	*Unit*	*Value)*
w_{mc} = Waist Size in MC	mm	2.1028
d_{mf}= Distance b/w MC waist and FI	m	3.1925
d_{fp} = Distance from FI to PR	m	0.5539
PR radius of curvature	m	-70.3
d_{12}= Distance b/w PR and MMT_2	m	16.585
R_2 = MMT_2 ROC	m	1.856
d_{23}= Distance b/w MMT_2 and MMT_3	m	16.655
R_3 = MMT_3 ROC	m	31.059
d_{mb}= Distance b/w MMT_3 and BS	m	20.655
d_{bs}= BS Effective thickness	mm	68.783
d_{bt}=Distance b/w BS and ITM	m	4.5
R_{itm} = ITM ROC	m	2076
w_c = Reqd. beam waist size in arm	mm	11.53
w_{itm} = Spot Size at ITM	cm	6
d_c= Beam waist location from ITM	m	2000
θ_1= Incident angle at PR	degree	0
w_1= Spot Size at PR	mm	2.2
θ_2= Incident angle at MMT_2	degree	0.745
w_2= Spot Size at MMT_2	mm	3.7
θ_3= Incident angle at MMT_3	degree	1.265
w_3= Spot Size at MMT_3	cm	6.11

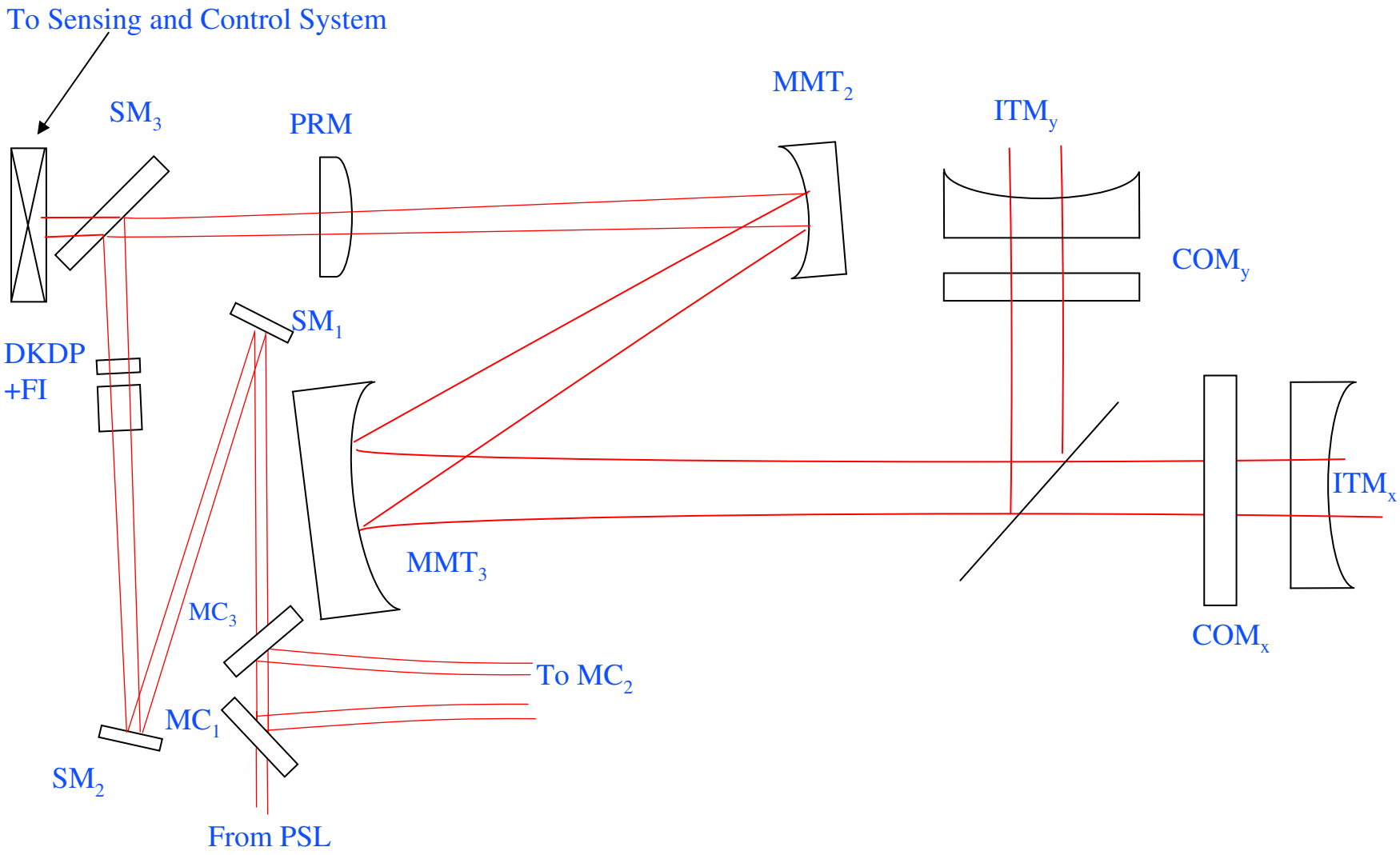
Guoy Phase Distribution



Accumulated Guoy Phase



Current Optical Layout



Changing the G-Factor

- Option 1: Insert a Lens after ITM
  - » Details at

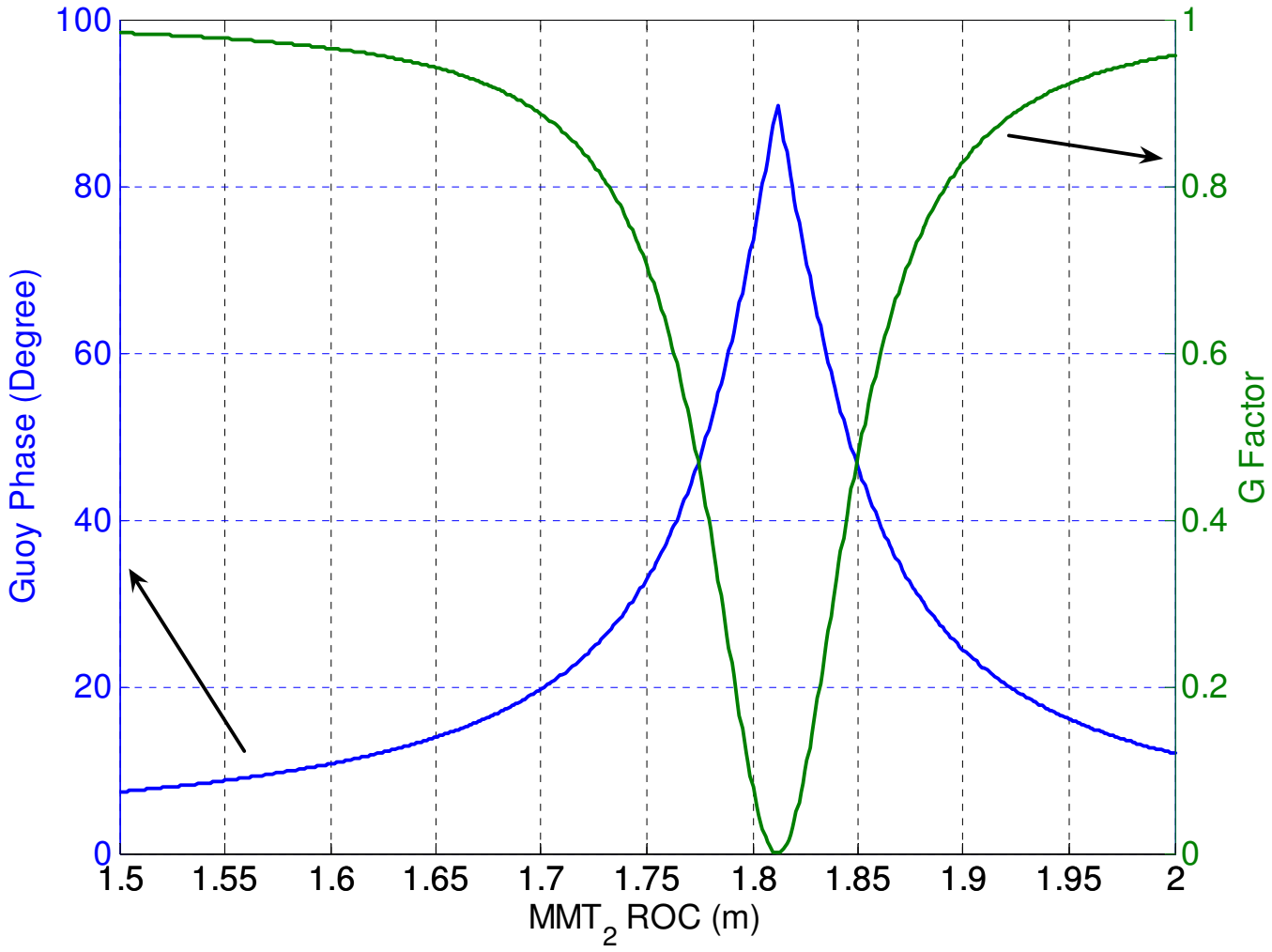
  http://ilog.ligo-wa.caltech.edu:7285/advligo/Recycling_Cavity_Geometry?action=AttachFile&do=get&target=TunableGFactorLayout1.pdf
- Option 2: Change ROC of MMT_2
  - » This requires another mode-matching telescope to couple to the MC mode, Options:

  1. Use a pair of lenses between PRM and Faraday Isolator
  2. 3. Squeeze two mirrors between Faraday Isolator and current PRM position

AR Side of the PRM can be used as one Lens

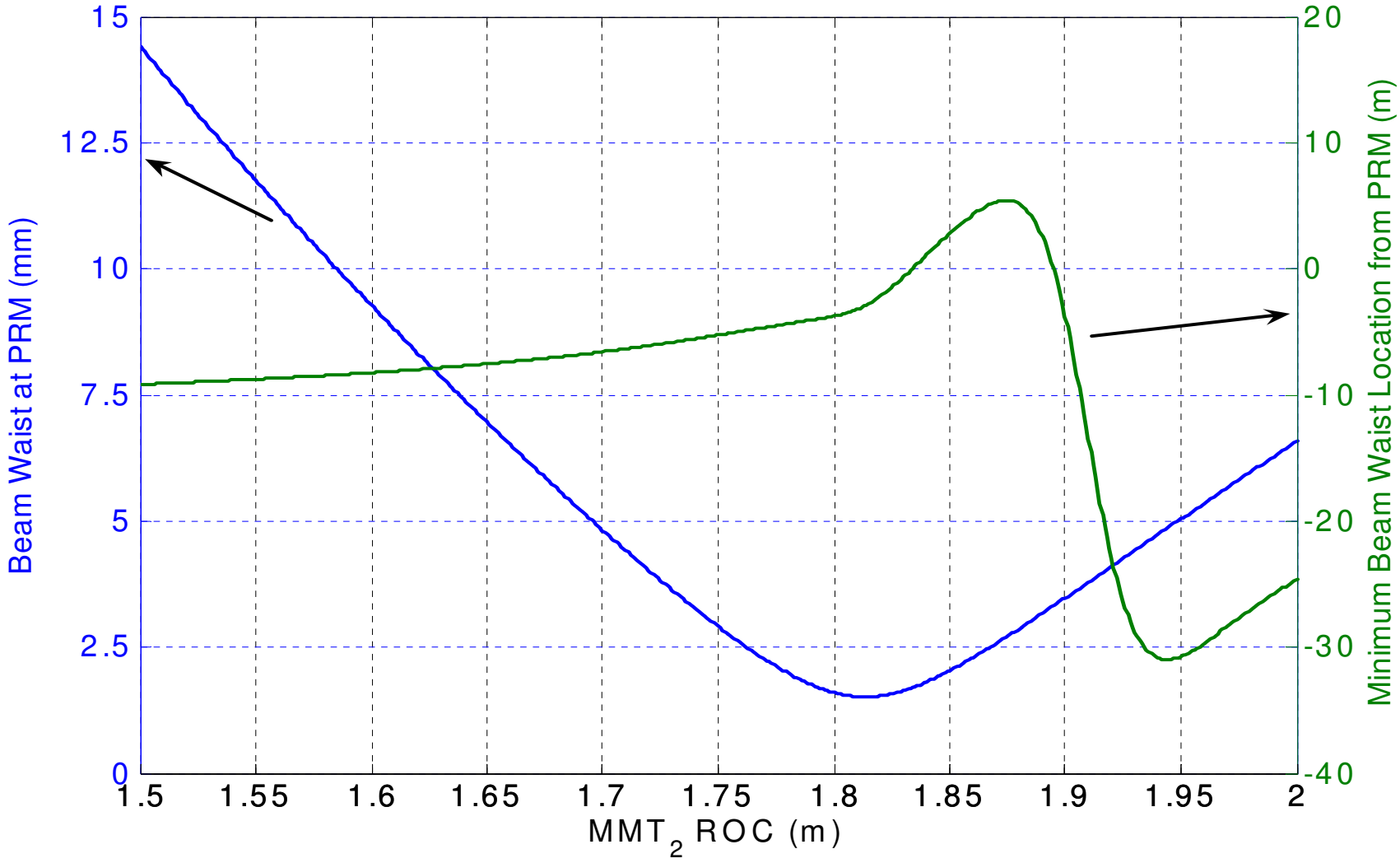
Only one additional lens/mirror is required

Selecting Guoy Phase through MMT_2

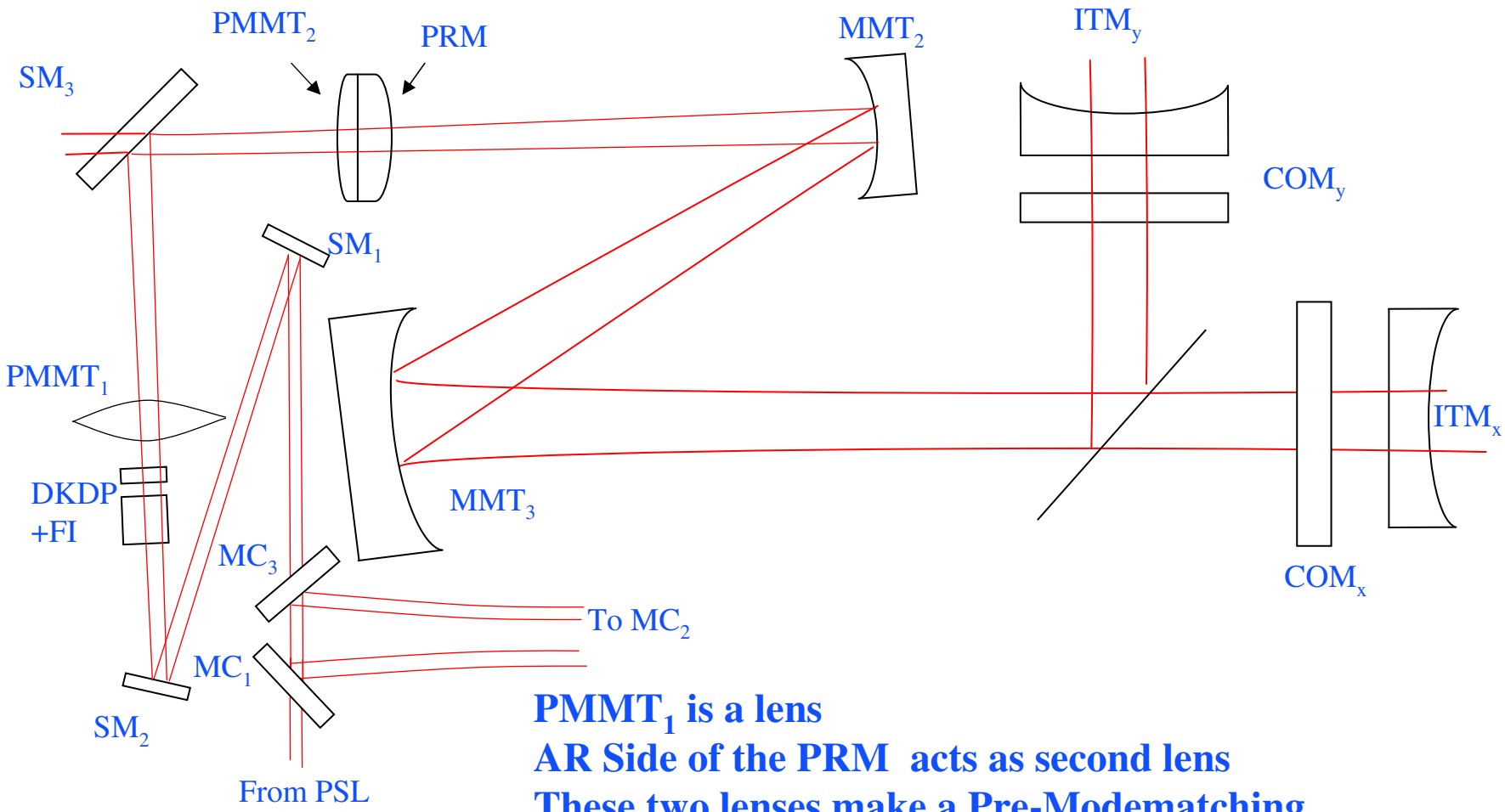


- Any Guoy phase can be realized by selecting MMT_2 ROC
- Optical distances will remain same
- Introduces mode mismatch between COC and IOO
- Needs another Mode matching telescope
- Need to monitor beam size at PRM

Beam Size at PRM

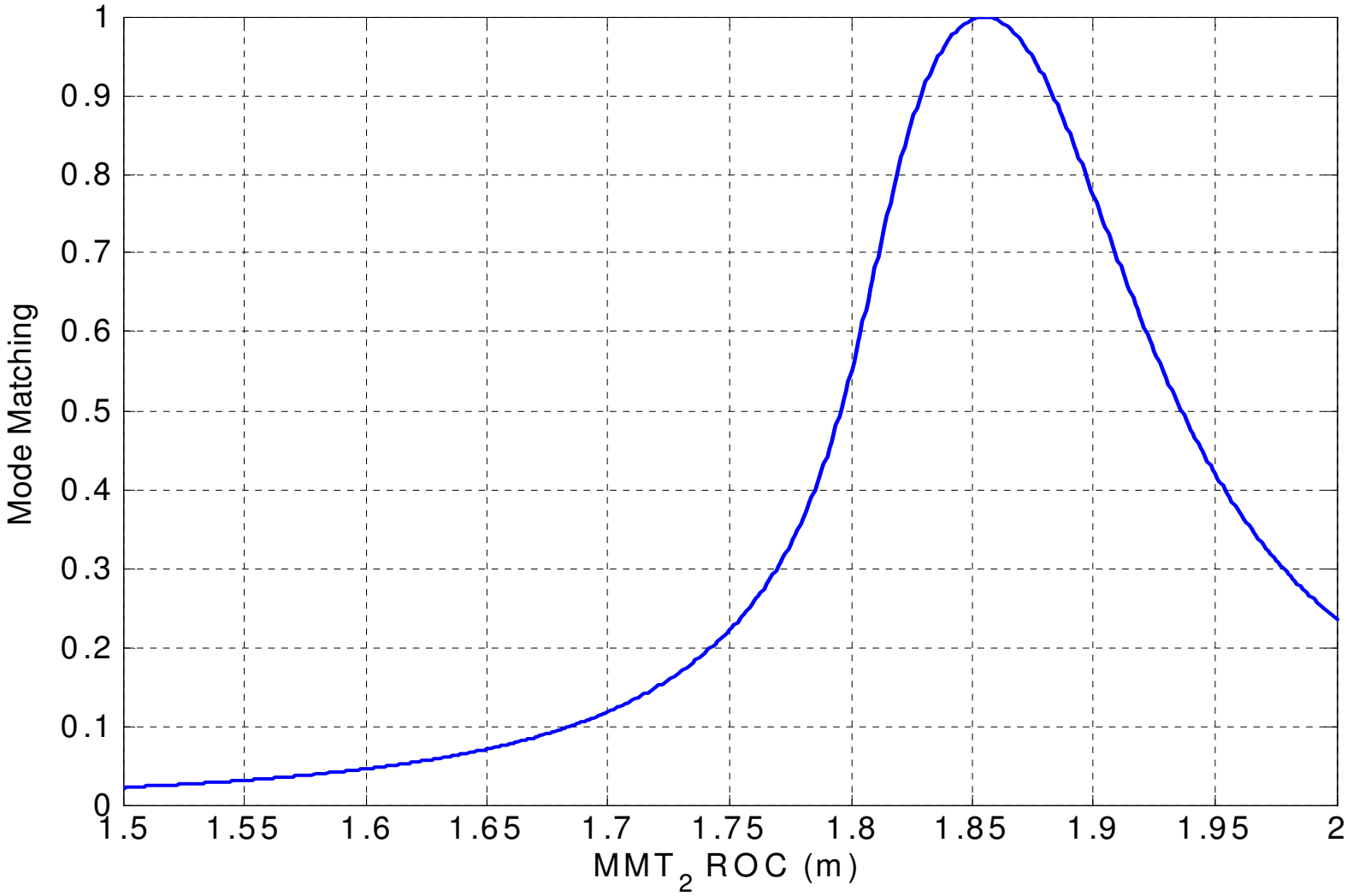


Option 1: Lens



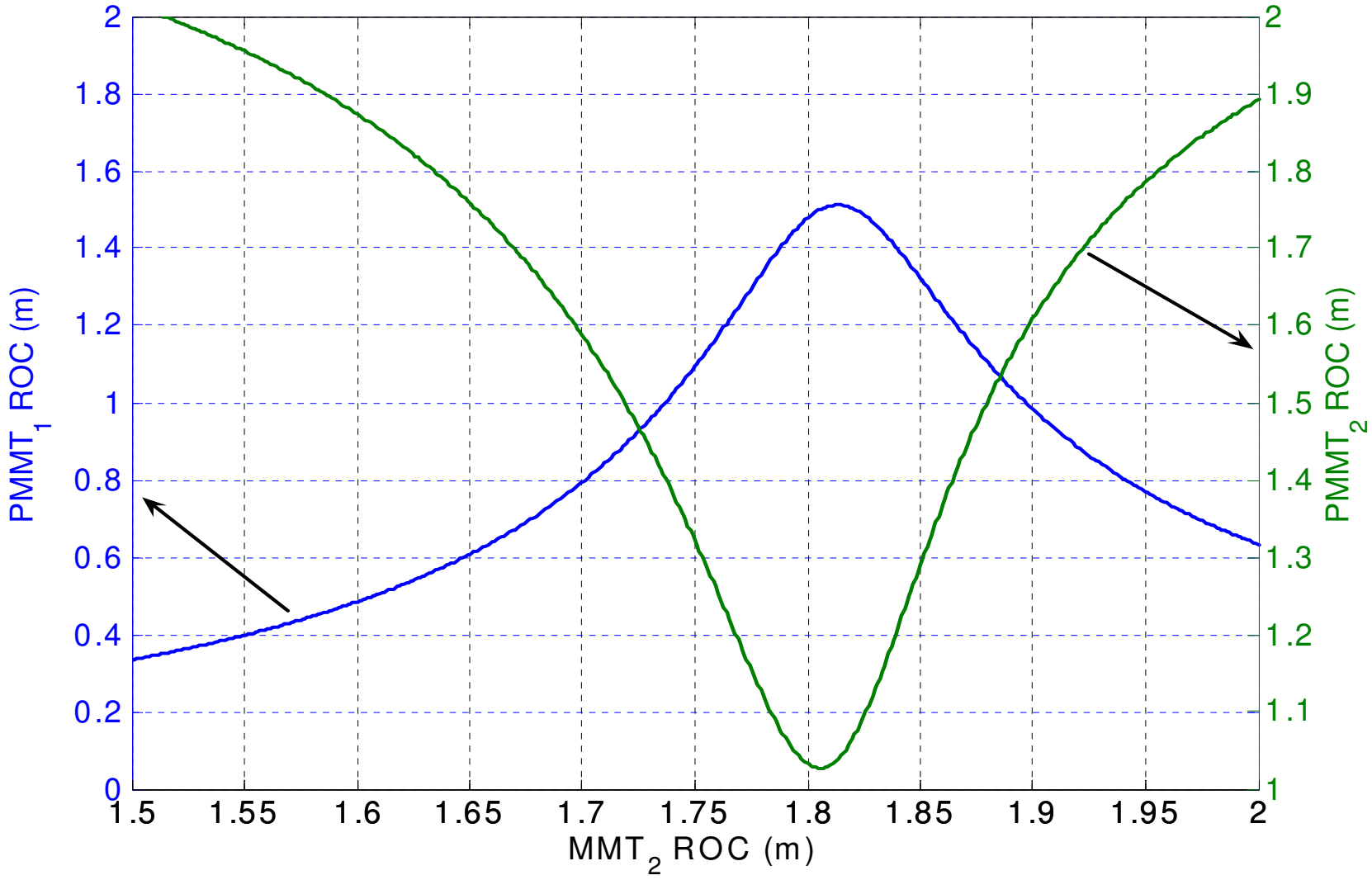
$PMMT_1$ is a lens
AR Side of the PRM acts as second lens
These two lenses make a Pre-Modematching Telescope

Mode Matching from the Existing MC

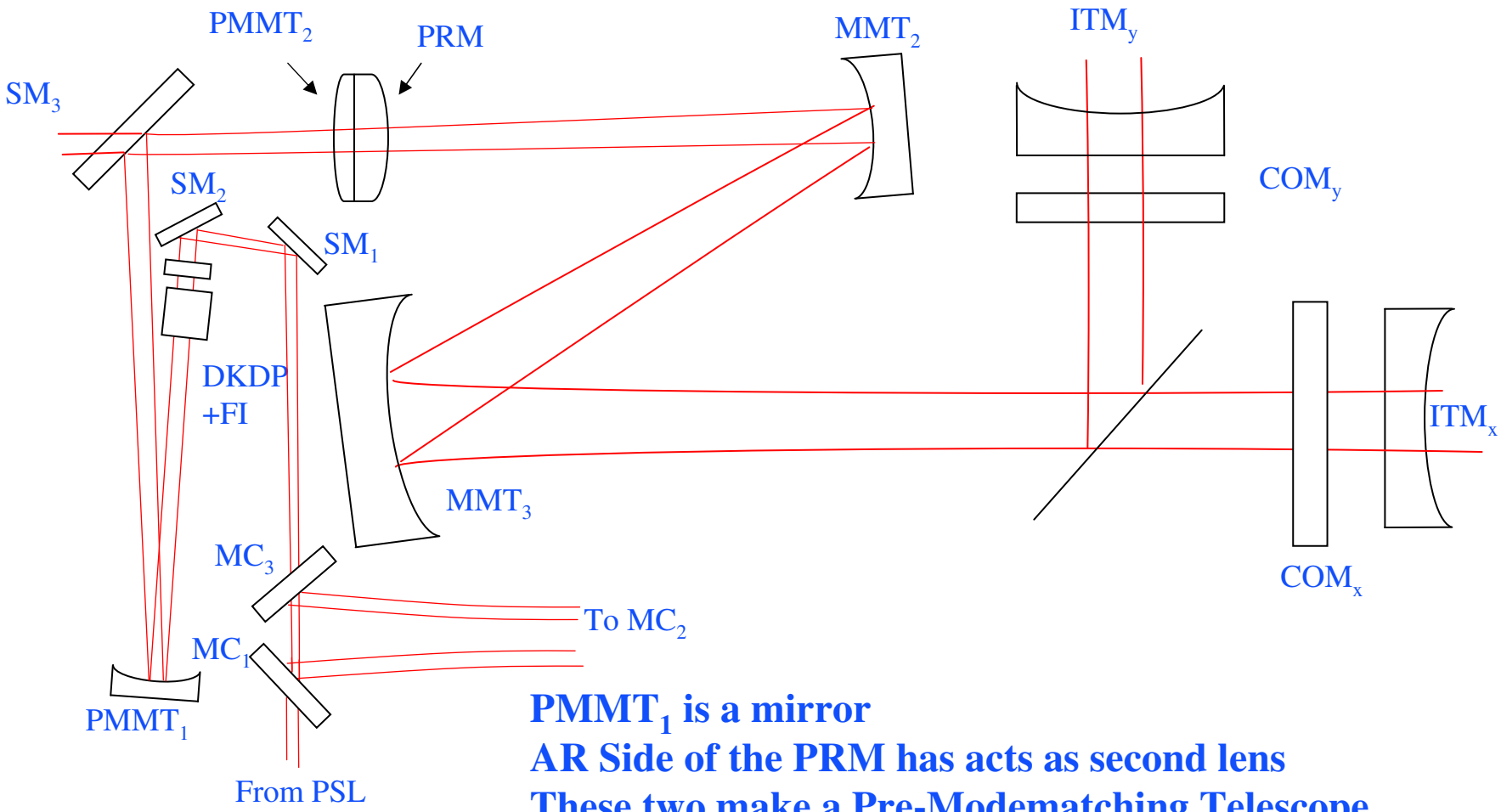


Needs another Mode Matching Telescope

Pre-Modematching Telescope Parameters

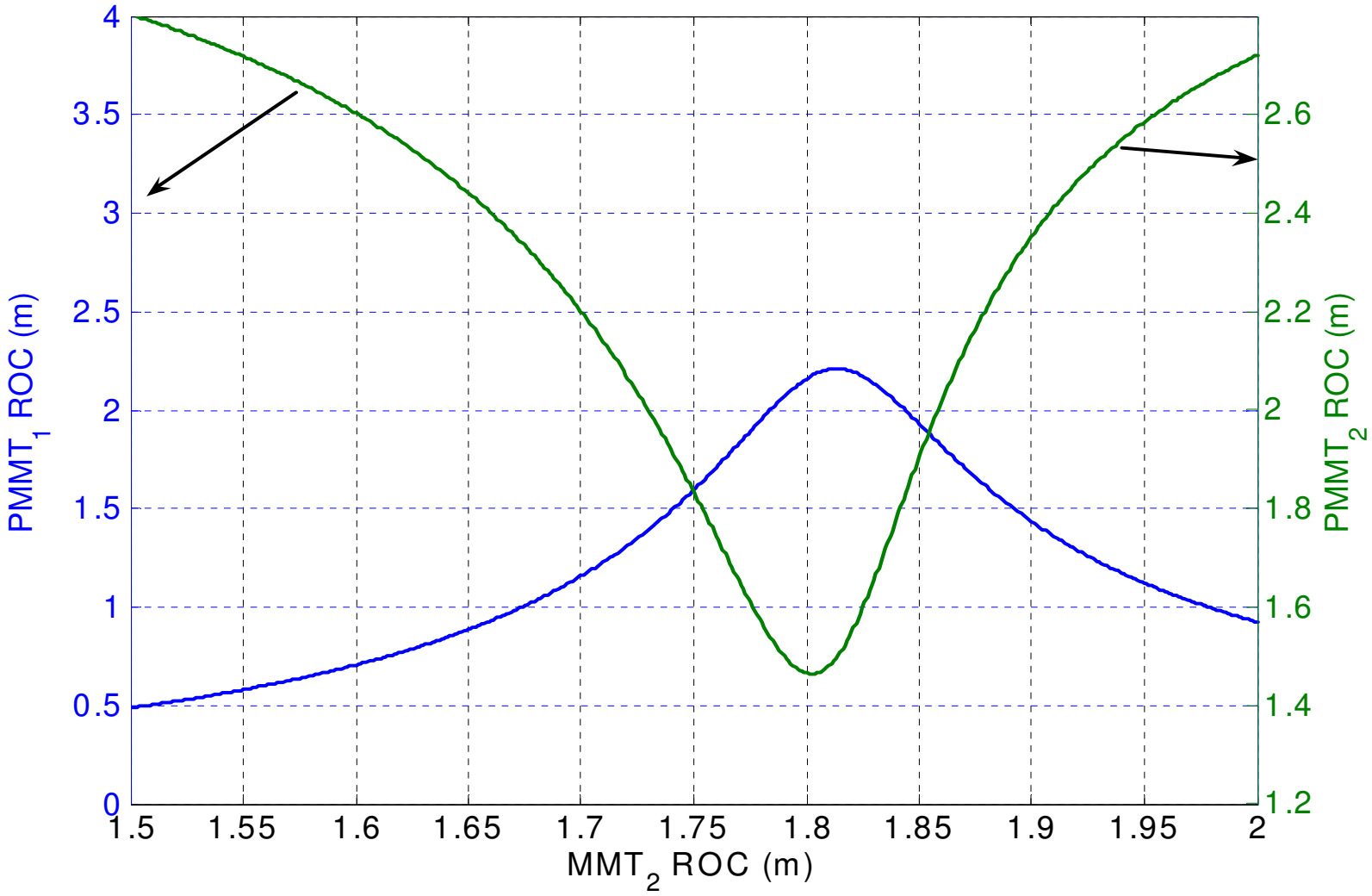


Option 2: Mirror

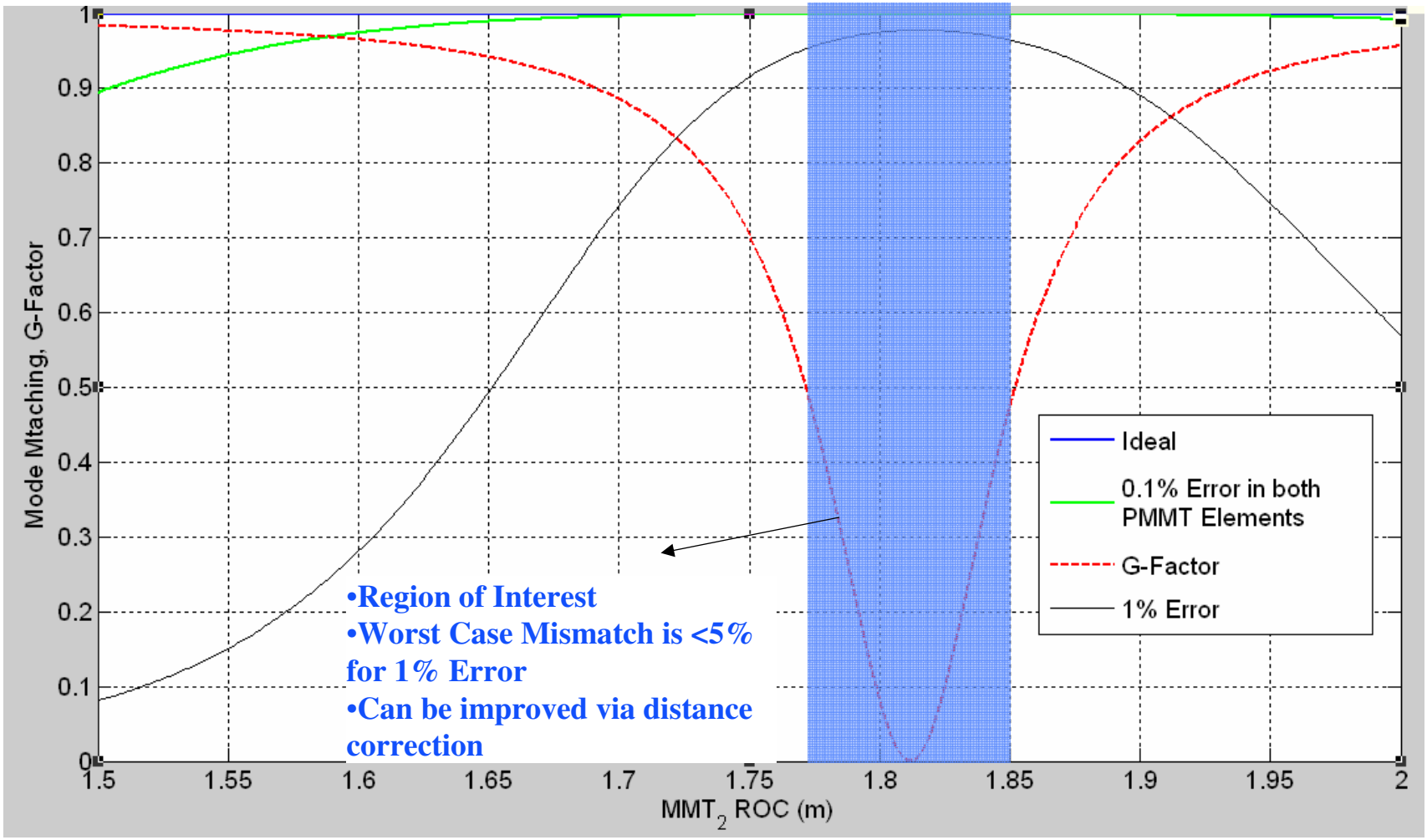


$PMMT_1$ is a mirror
AR Side of the PRM has acts as second lens
These two make a Pre-Modematching Telescope

Pre-Modematching Telescope Parameters

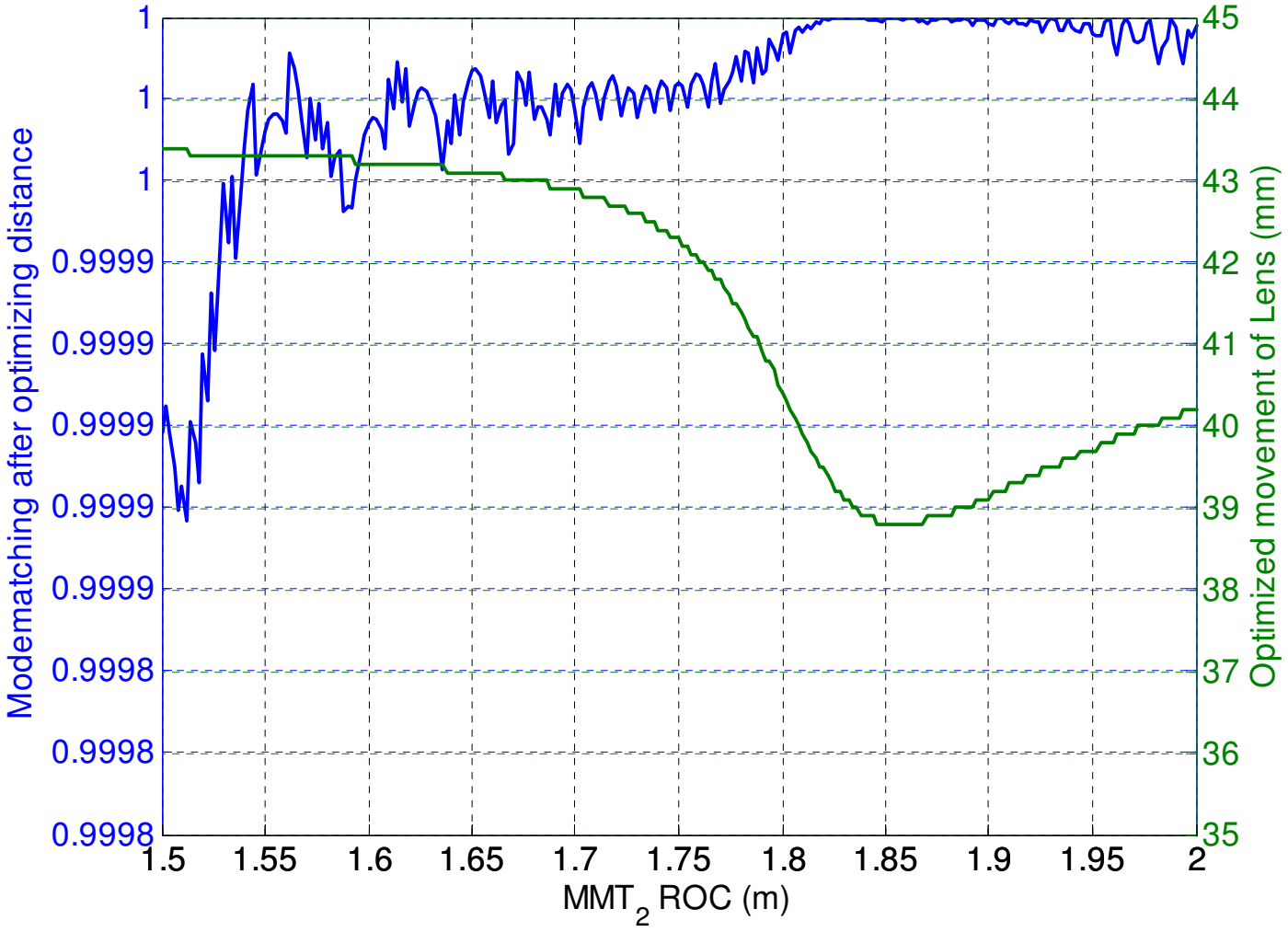


Sensitivity of the PMMT



Optimizing Modematching by Moving $PMMT_1$

For 3% (Tolerance) error in ROC of both $PMMT_1$ and $PMMT_2$ Elements



Summary

- Current G-Factor of the Stable Cavity = 0.54
- To Change the G-Factor to close to zero, additional mode matching is required
- A Pre-Modematching telescope is feasible with either lens or mirror for a G-factor of 0-1.
- A suitable G-factor (and the corresponding beam sizes) can be agreed upon in future with the same optical layout.