

Mode matching of the Recycling Cavities and the arm cavities of iLCGT

2011/7/27, Yoichi Aso

Difference between iLCGT and bLCGT

- TM ROCs are different
 - bLCGT: 1.5km - 1.9km
 - iLCGT: Flat-7.3km
- ITM locations are different
 - iLCGT: 26.6m further away from BS
- Arm cavity length is (slightly) different
 - iLCGT: 3km - 26.6m - 25m ?
 - bLCGT: 3km

What happens, if we use the same PRM, PR2 and PR3 for iLCGT, ?

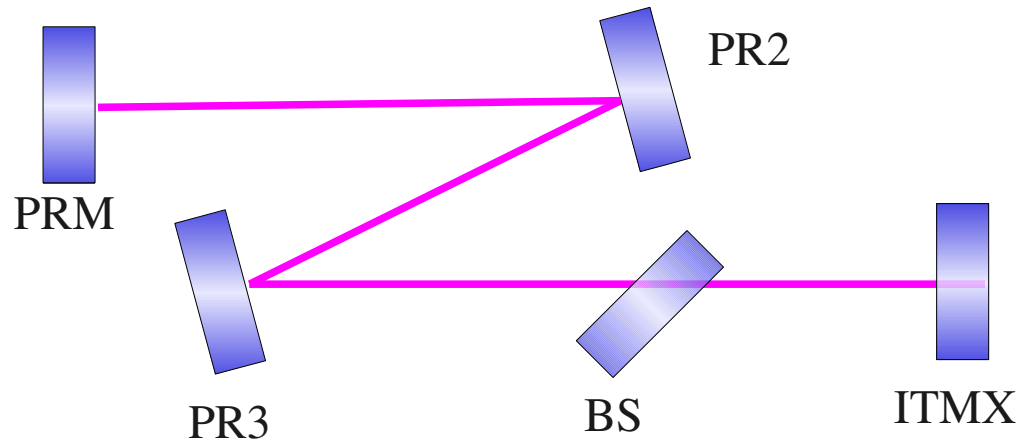
1st. step: Optimize the ROCs of PR3 and PR2 for bLCGT

Method

- Propagate a beam matching the arm cavity mode from ITMX to PRM
- Repeat this with different combinations of PR3 and PR2 ROCs.
- PRM ROC is set to the ROC of the beam hitting PRM.
- Do the same for SRC

Target

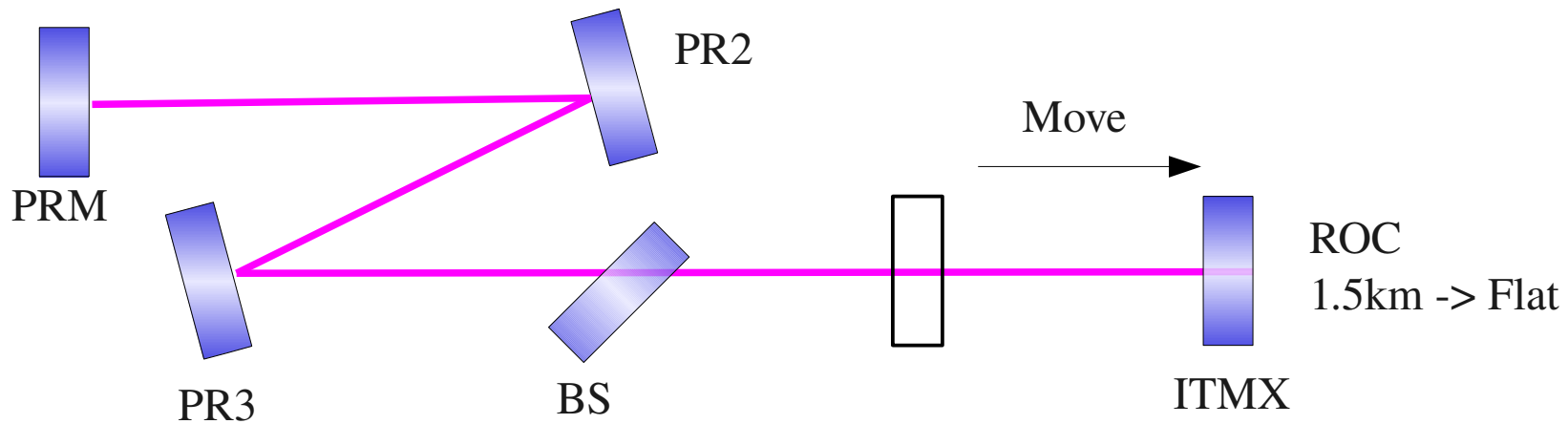
- Gouy phase change from ITMX to PRM is 20 deg.
- Beam spot sizes on PR2 and PRM are equal



PRC/SRC parameters after the optimization

PRM ROC	PR2 ROC	PR3 ROC	PRM Spot Size	PR2 Spot Size	PR3 Spot Size
304.989m	-2.800m	24.574m	4.03mm	4.03mm	36.08mm
SRM ROC	SR2 ROC	SR3 ROC	SRM Spot Size	SR2 Spot Size	SR3 Spot Size
304.830m	-2.813m	24.585m	4.03mm	4.03mm	35.93mm

2nd step: Move and Change ITMs

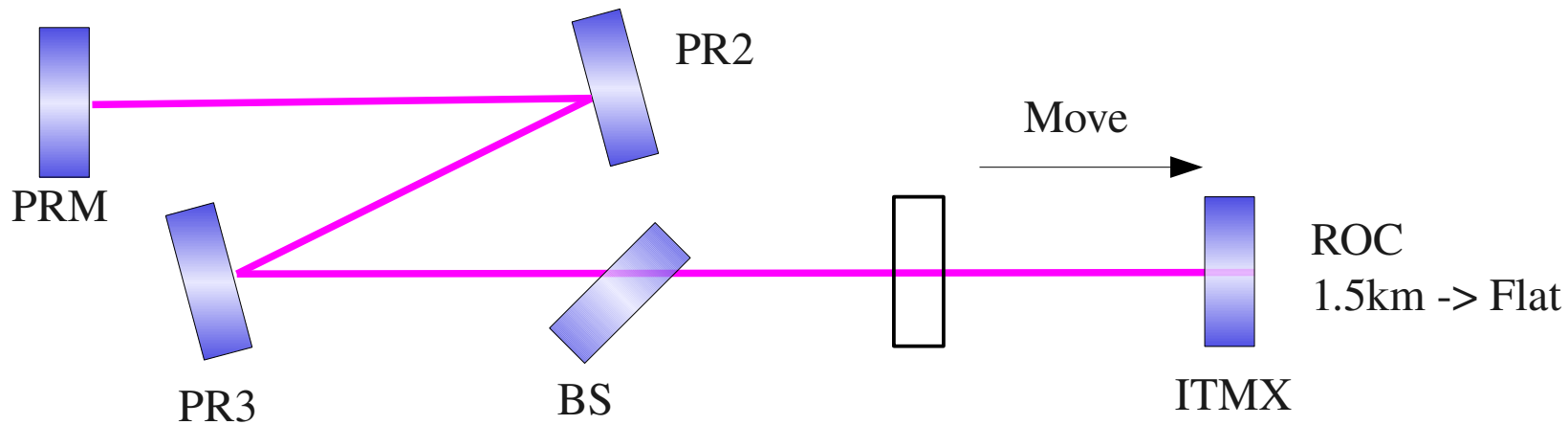


Need to tweak the positions and orientations of PR2, PR3 and BS to make the beam normal incidence to ITMs

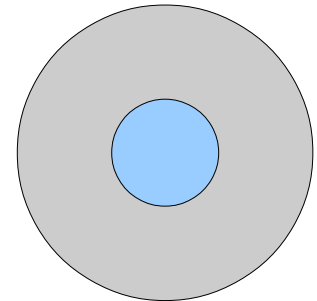
Test: Is this PRC stable ?

- Calculate the round trip (PRM -> ITM -> PRM) ABCD matrix
- See if $-1 < (A+D)/2 < 1$ is satisfied ==> **No !** $(A+D)/2 = -1.85$
- We cannot use this configuration.

3rd step: Tweak the ROCs of PRM and PR2

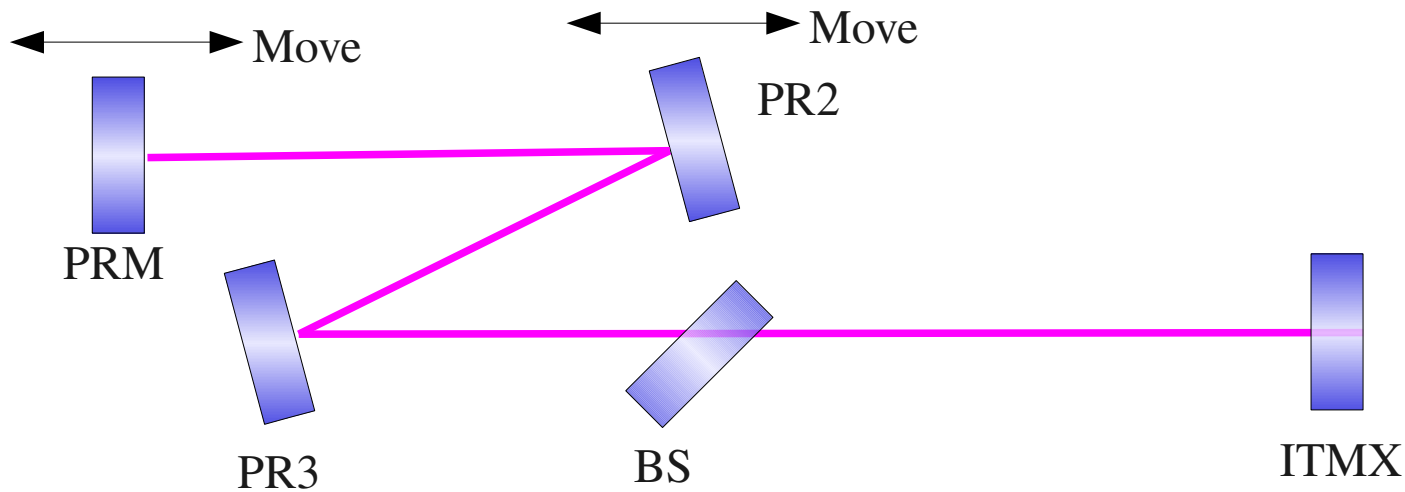


- Beam spots on PRM and PR2 are small (4mm)
 - We may use smaller mirrors (like 2 inches) attached to aluminum mass instead of monolithic ones (for iLCGT)
 - PRM and PR2 are easier to modify than PR3
- Tweak the ROC of PR2 to make the Gouy phase shift 20 deg.
- Adjust the ROC of PRM to fit the beam on it.
- Need to change the MMT after MC
 - We can also use compound mirrors for the MMT



PRM ROC	PR2 ROC	PR3 ROC	PRM Spot Size	PR2 Spot Size	PR3 Spot Size
43.954m	-2.372m	24.574m	4.95mm	4.95mm	34.56mm
SRM ROC	SR2 ROC	SR3 ROC	SRM Spot Size	SR2 Spot Size	SR3 Spot Size
43.886m	-2.382m	24.585m	3.44mm	3.44mm	34.42mm

4th step: Tweak the distance between PR2 and PR3



- Instead of changing mirror ROCs, move PRM and PR2
- Keep the PRC length unchanged
- Find the optimal displacement to match the eigen mode of PRC with the arms
- By moving PR2 by 17cm and PRM by 34cm, the two modes match very well

Mode matching between the input beam from MMT and the PRC eigen mode = 99.8%
Mode matching between the PRC eigen mode and the arm cavity eigen mode = 99.99%
(Using the same mirrors and the same MMT, optimized for bLCGT)

Conclusion

- Flat ITMs make the PRC and SRC unstable
(even without the 26.6m dislocation of ITMs)
- One solution is to make dedicated PRM and PR2 for iLCGT
 - PRM and PR2 for iLCGT can be compound mirrors
- Another solution is to move PR2 and PRM
 - Move PR2 by 17cm and PRM by 34cm
 - The mode matching is not perfect but good enough
- The same applies to SRC