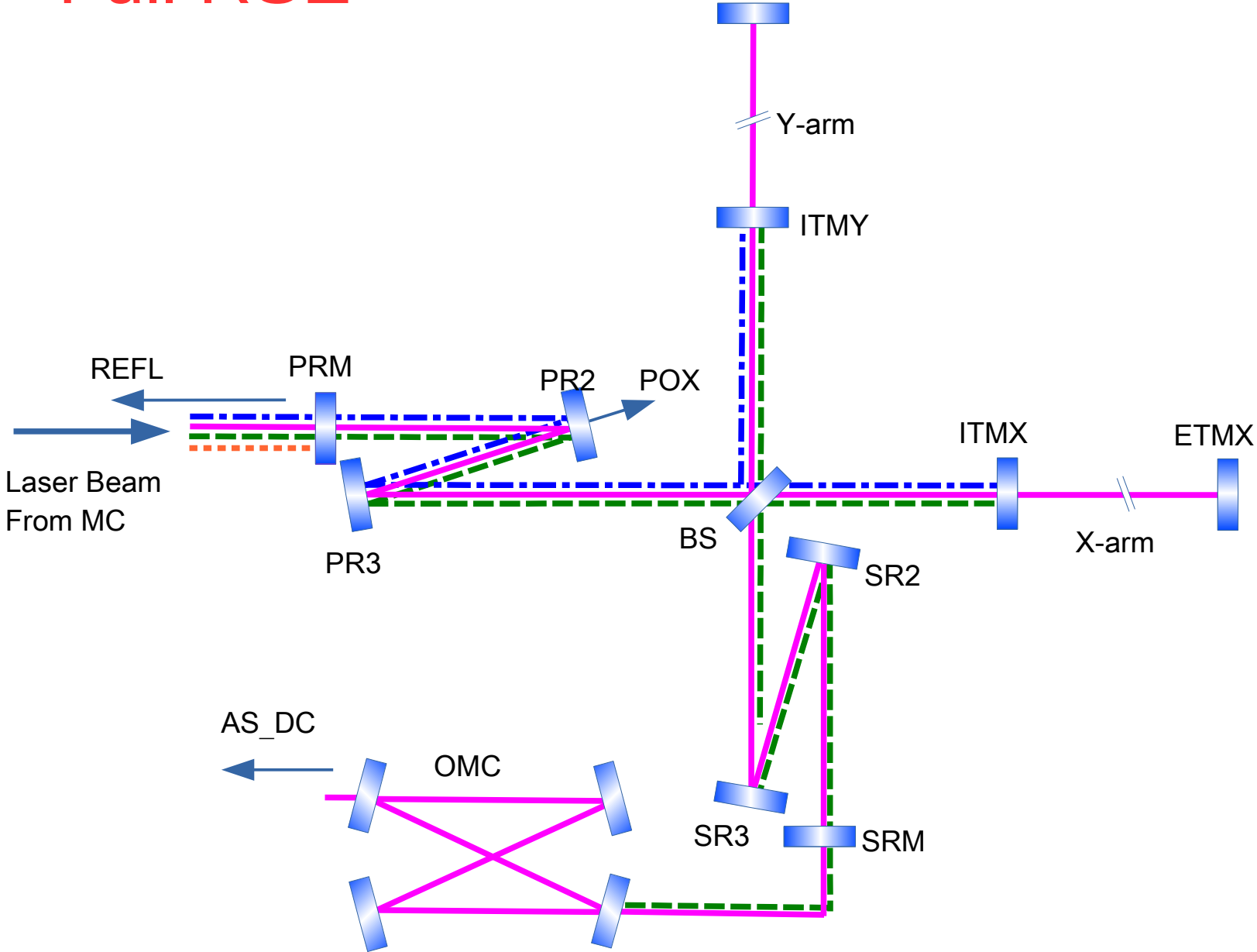


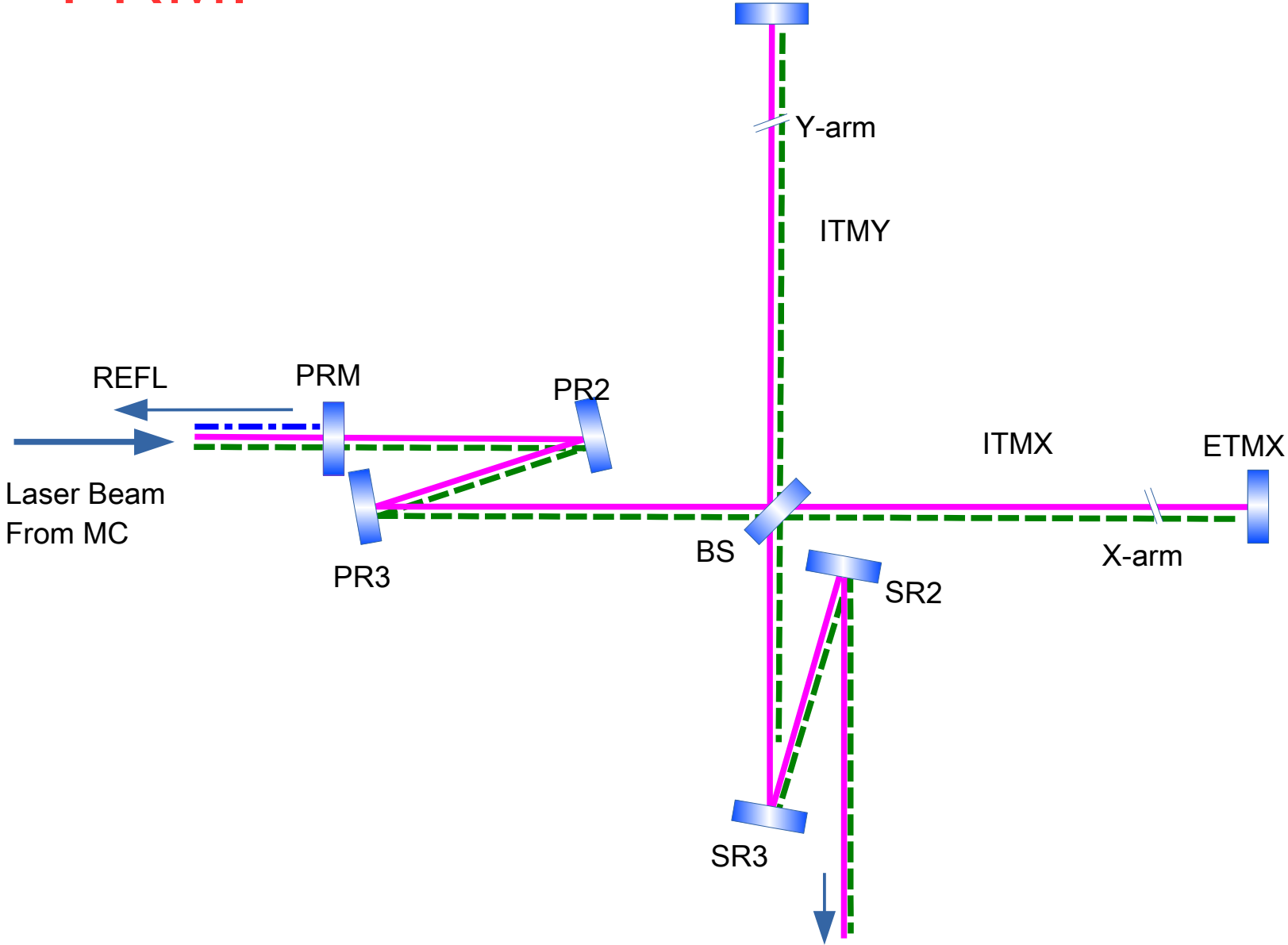
# PRMI optical layout considerations

Y. Aso: 2016/5/16

# Full RSE



# PRMI



# Is it possible to operate the PRMI ?

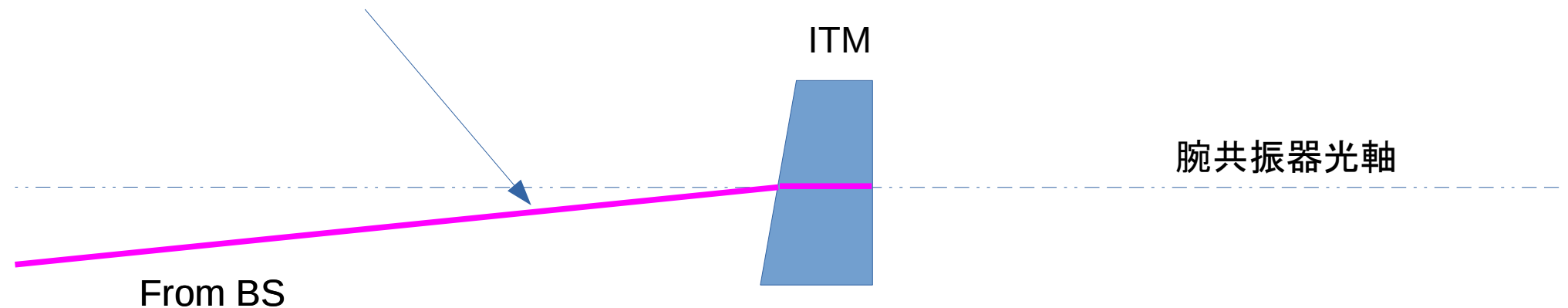
## Questions to be answered

- Can we form a Michelson without moving the input part (PR2 and PR3) too much ?
- Is the PRMI cavity stable ?
  - If so, what is the mode matching with the input beam ?
  - Is the cavity safe against the higher order mode resonances ?
- How to obtain the control signals
- Is it possible to do WFS ?

## Layout of the Michelson part

- ITMs have wedge. In the original optical layout, the incident beam onto the ITMs from AR is tilted from the arm cavity axis.

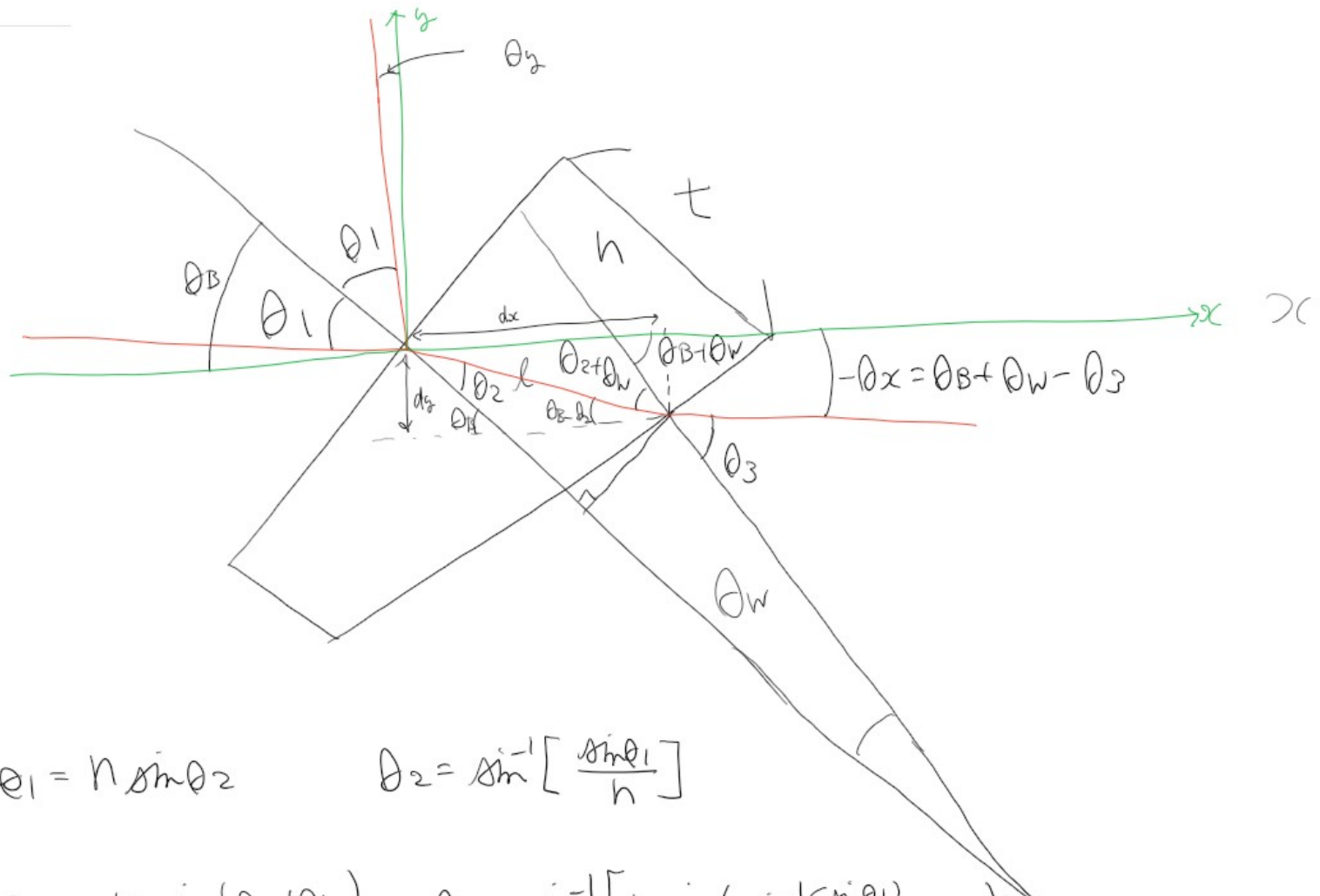
ITMにWedgeが付いているので  
斜めから入射する



- If we just keep the layout, without ITMs, the beams will hit the wall of the beam ducts.
- We need to adjust the directions of the reflected and transmitted beams from the BS

# BS input output

2014年12月11日 16:18



$$\sin \theta_1 = n \sin \theta_2 \quad \theta_2 = \sin^{-1} \left[ \frac{\sin \theta_1}{n} \right]$$

$$\sin \theta_3 = n \sin(\theta_2 + \theta_w), \quad \theta_3 = \sin^{-1} \left[ n \sin \left( \sin^{-1} \left\{ \frac{\sin \theta_1}{n} \right\} + \theta_w \right) \right]$$

$$-\theta_x = \theta_B + \theta_w - \theta_3(\theta_1) \quad \theta_y = \pi/2 - (\theta_B + \theta_1)$$

$$l = \frac{t}{\cos \theta_2} \quad d_y = l \sin(\theta_B - \theta_2) = t \frac{\sin(\theta_B - \theta_2)}{\cos \theta_2}$$

$$dx = l \cos(\theta_B - \theta_2) = t \frac{\cos(\theta_B - \theta_2)}{\cos \theta_2}$$

# Beam Angle Adjustment

- Align the beams using the incident beam angle to BS and the BS angle
- Incident beam angle is changed by moving the beam spot on PR3

## After optimization

BS angle: 0.0187deg change

PR3 beam spot position: 5mm off the center (in -Y direction)

3 sigma diameter of the beam on PR3 is 215mm  
The mirror diameter is 250mm

The 5mm offset is probably OK

# PRMI cavity stability

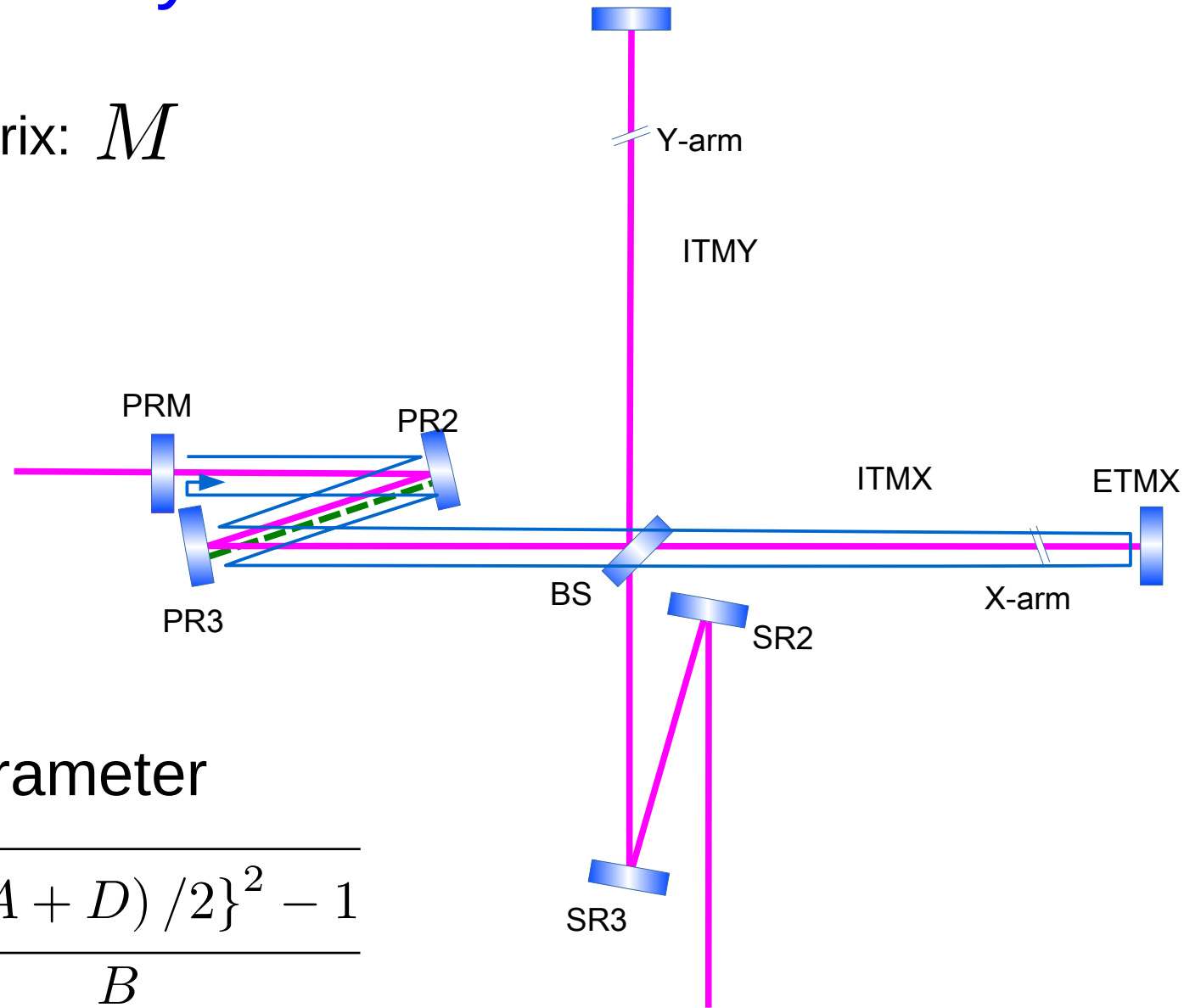
Round Trip ABCD Matrix:  $M$

Stability Condition

$$|\text{tr}(M)|/2 < 1$$

Eigen Mode q-parameter

$$\frac{1}{q} = \frac{D - A}{2B} + \frac{\sqrt{\{(A + D)/2\}^2 - 1}}{B}$$





# Stability check

$$|\text{tr}(M)|/2 = 1.1 \quad : \text{ not stable}$$

## Change the distance between PR2 and PR3 (Lp2)

- $d_{Lp2} = 2\text{cm}$  (move 1cm each)

$$|\text{tr}(M)|/2 = 0.93$$

mode matching = 97.5%

- $d_{Lp} = 2.8\text{cm}$  (move 1.4cm each)

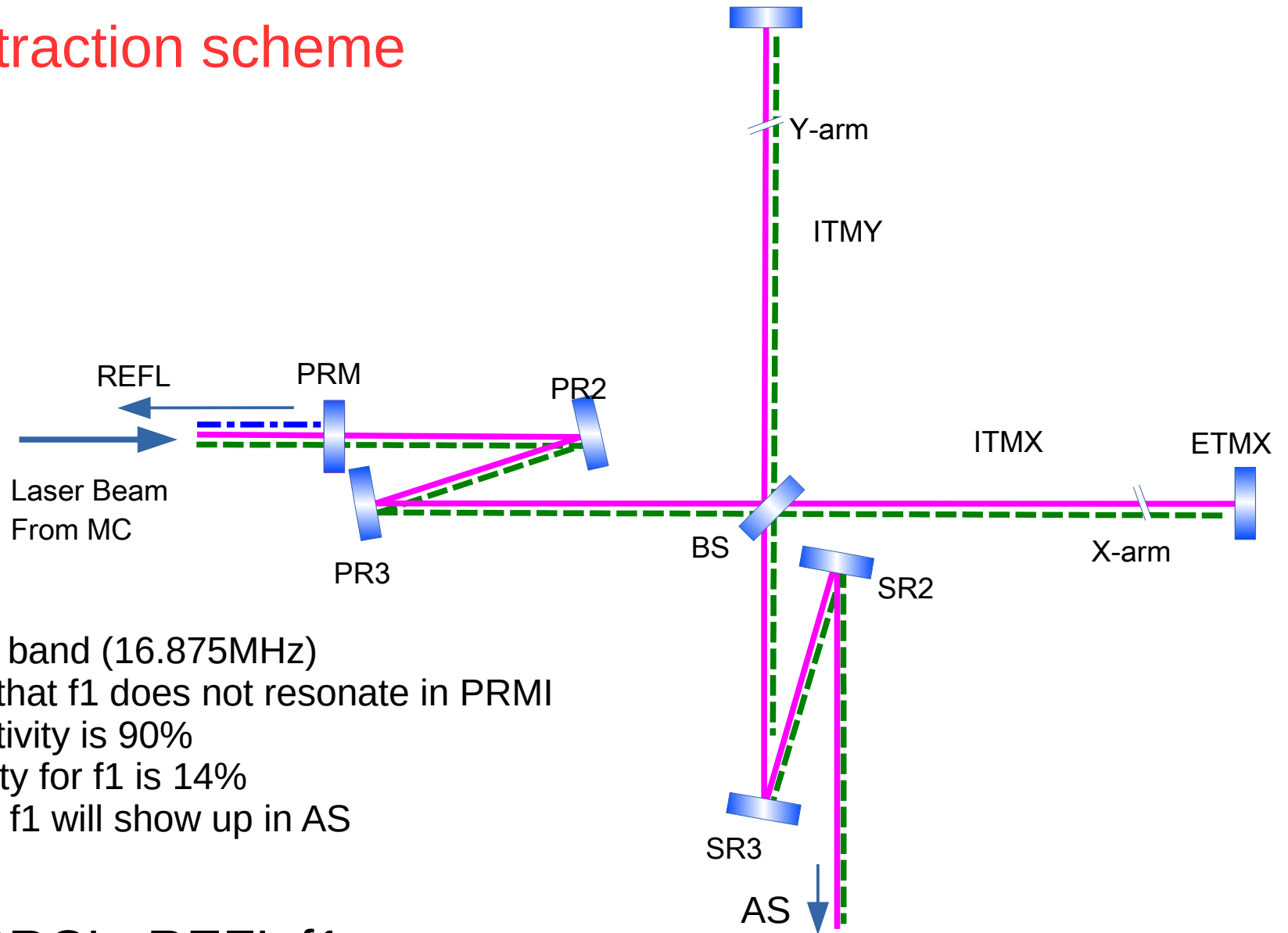
$$|\text{tr}(M)|/2 = 0.83$$

mode matching = 99.9%

## Remaining questions

- How much can we move PR2 and PR3 ? -> 1cm seems OK
- HOM structure diagram for PRMI
- How shall we obtain error signals for the length control ?
- Can we get WFS signals ?

# Signal extraction scheme



- Use f1 side band (16.875MHz)
- Make sure that f1 does not resonate in PRMI
- PRM reflectivity is 90%
- MI reflectivity for f1 is 14%
- 8.6% of the f1 will show up in AS

CARM+PRCL: REFL f1

DARM: AS f1