Extended Chief Meeting 190701

Polarization Issue in the Central IFO

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Structure of the slides

-- Start from experimental facts in our IFO

-- Move on to guess, hypotheses

What we have seen

-- Measured **PRC loss ~ 25%** (klog 9300, 9310).

-- Michelson contrast is not very good (~95%), and it also depends on the beam spot position (klog 9300)

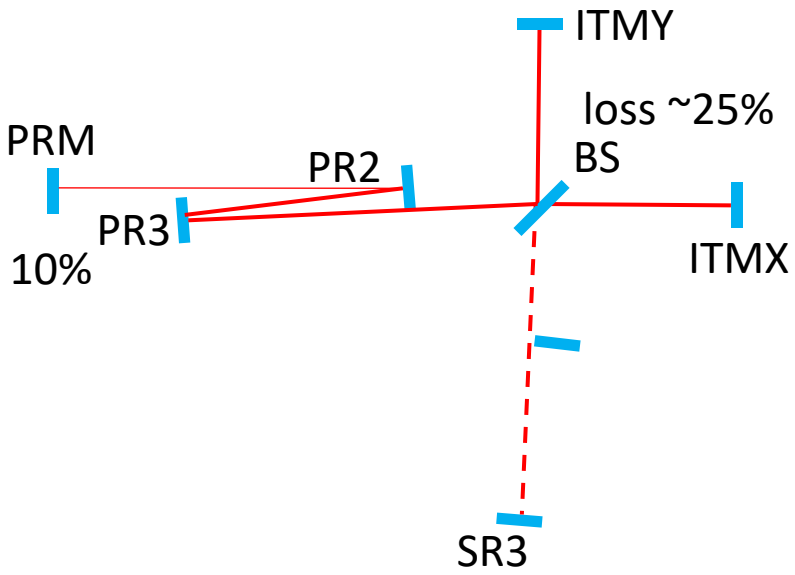
-- The **reflection from each ITM has ~ 5-10 % P-pol**, while the incident beam is purely S-pol (klog 9314, 9324).

-- Camera image of the reflection from each ITM is strange. Especially, **P-pol image is ugly** (klog 9315).

-- The power of P-pol beam in PRC has **a resonant-like feature** (klog 9325, 9333).

PRC loss and MICH contrast

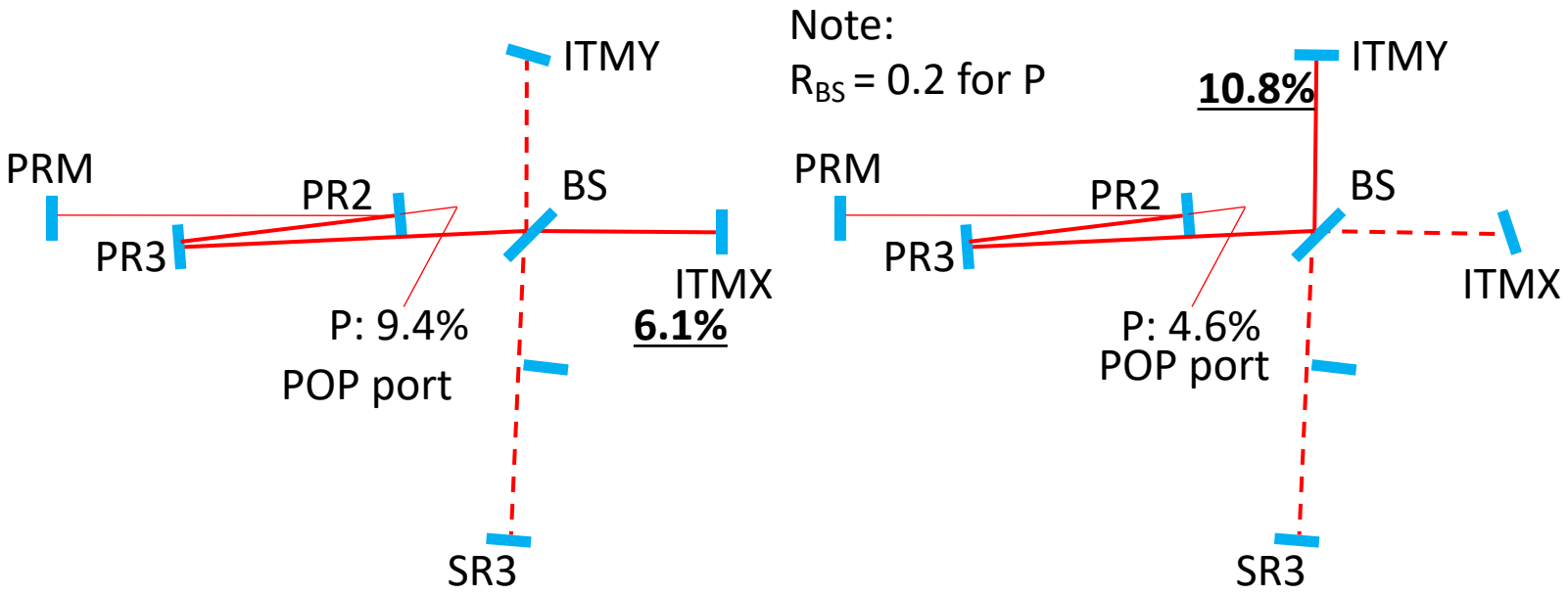
-- MICH contrast was 93.5 % with the incident beam was aligned to the X arm in an optimal way.
-- After moving the beam spot around the BS, it slightly improved to 95.7 %. => We expected PRG of ~15 from this.
-- Measured **PRG ~ 3**, which indicates **PRC loss ~ 25%** (klog 9300).



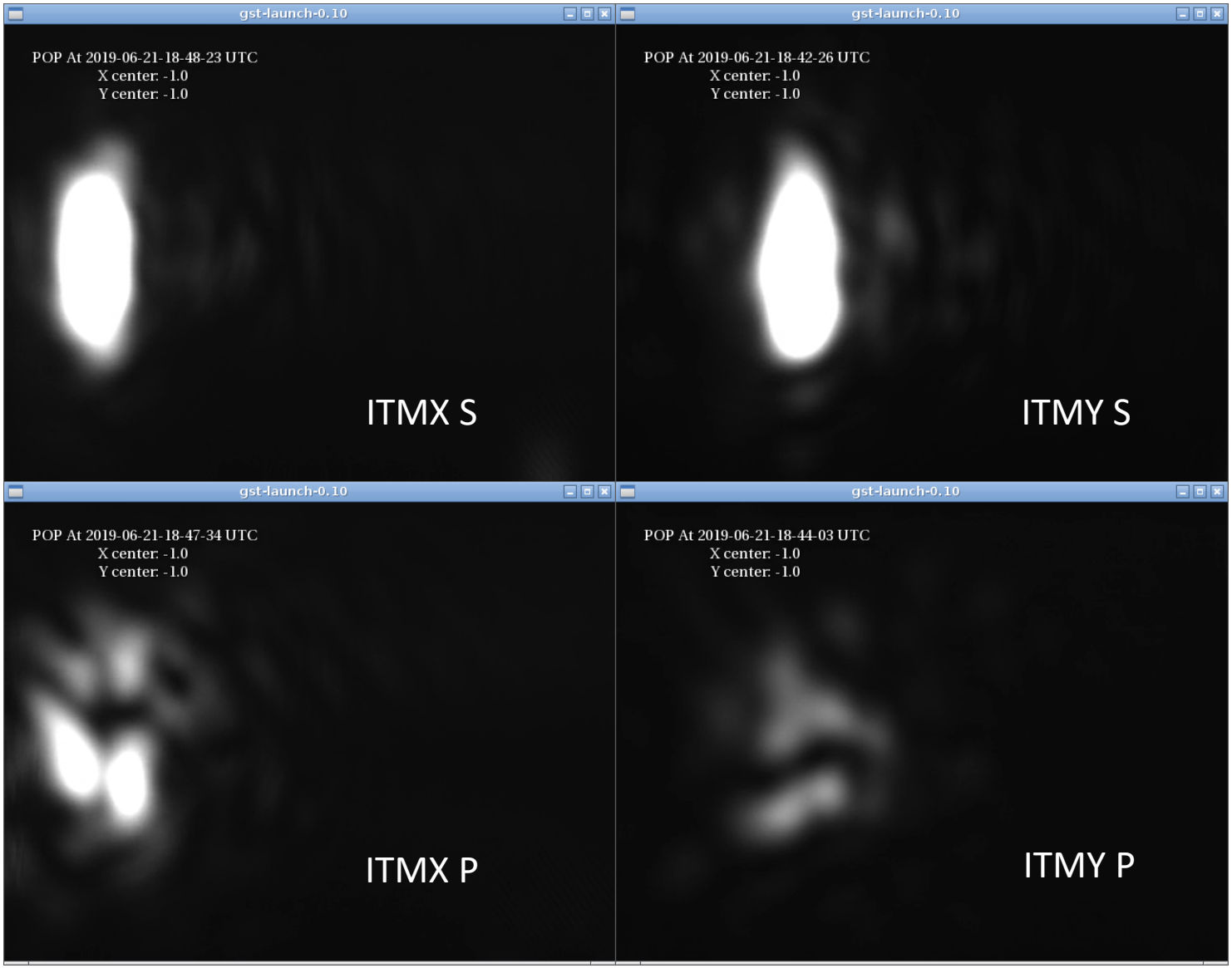
P-pol in the reflection beam

-- At the POP port, **9.4%** of the total power was **in P-pol** for the reflection from ITMX.
4.6% for the reflection from ITMY.

-- Polarization of the incident beam was measured at the transmission of PR2. P/S = 1/3000

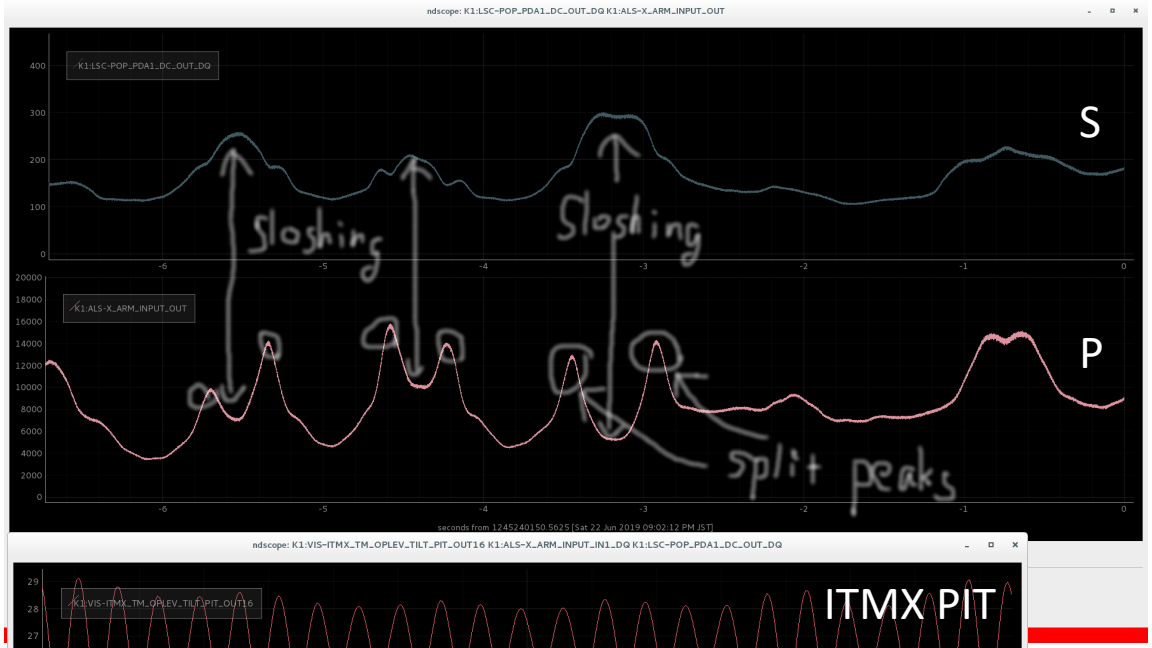


Camera image

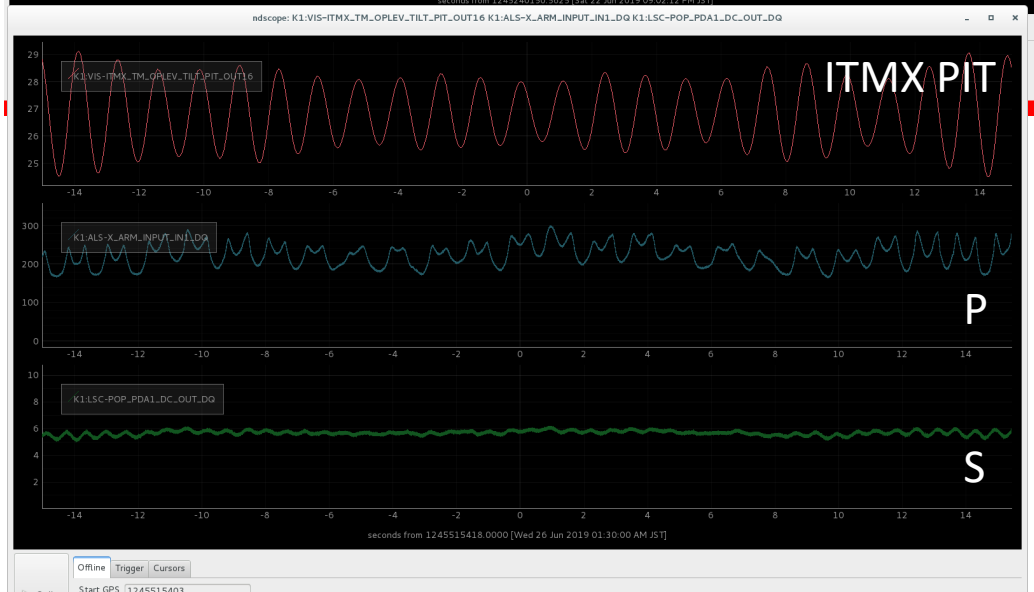


Resonance in P-pol

-- P-pol power in PRC is not proportional to S-pol power at all.



When PRMI was locked



When PRX was locked

Our hypotheses

-- Molecular on ITM AR surface due to cryogenic pumping
→ ITMY is now being warmed up. We will see.

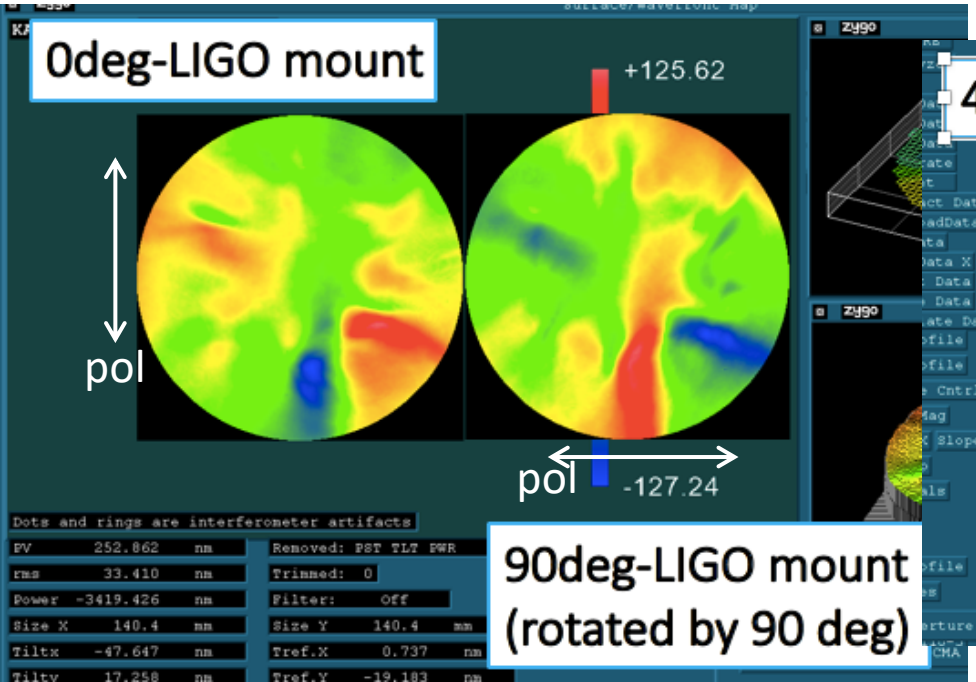
-- Any clipping or some scattering ?
→ Not likely. RIN / (beam spot shift) ~ 3e-4/mm for pitch, 6e-4/mm for yaw (klog 9352)

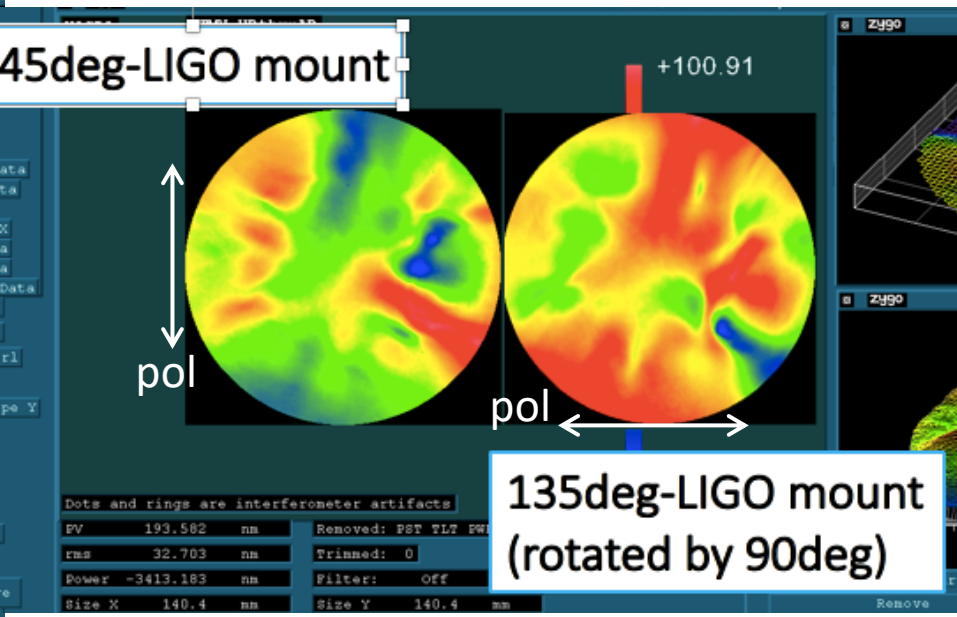
-- Birefringence in ITM substrates (see also G1910369, T1910380)

-- S-pol and P-pol form coupled cavities (G1910373)

Birefringence in ITMs

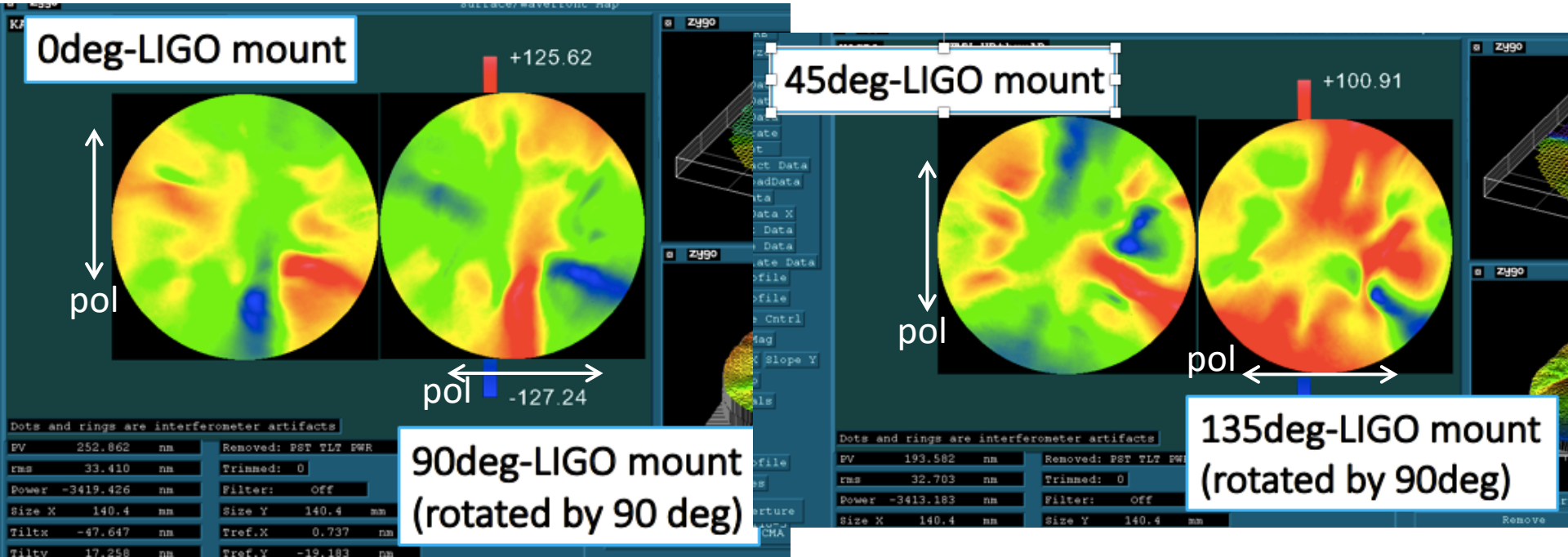
-- Birefringence in ITMY substrate was measured as a by-product (T1808715), but we had not realized it until recently.
-- Transmission wave front error with the substrate rotated.
Different (effective) thickness for different polarization.
=> Nothing but birefringence





Birefringence in ITMs

-- The amount of the polarization loss (S --> P) in ITMY can even be estimated from these results.
RMS of TWE for 45 or 135 deg ~ 30nm
loss = (2π 30nm x2 / λ)^2 = 12% (x2 from double pass)
(c.f. 10.8% from the measurement at the POP table.)



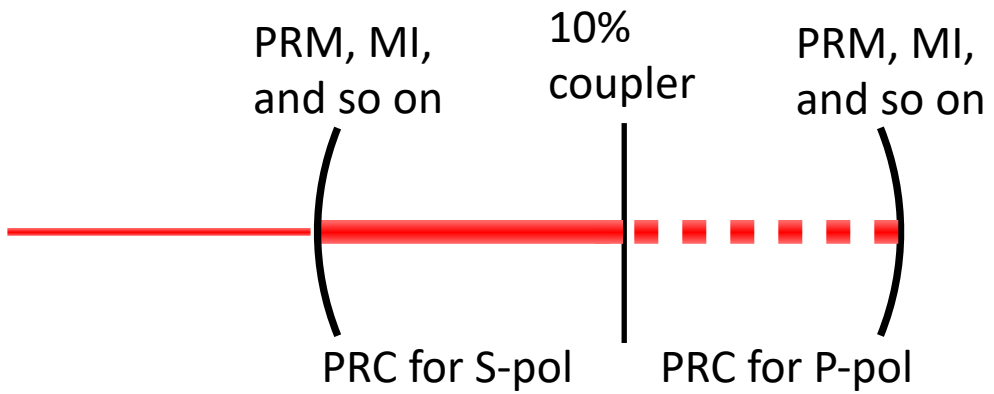
S-P coupled PRC

-- loss in PRMI ~ 25% > loss from birefringence ~ 10%

Other loss sources??

→ Not necessarily

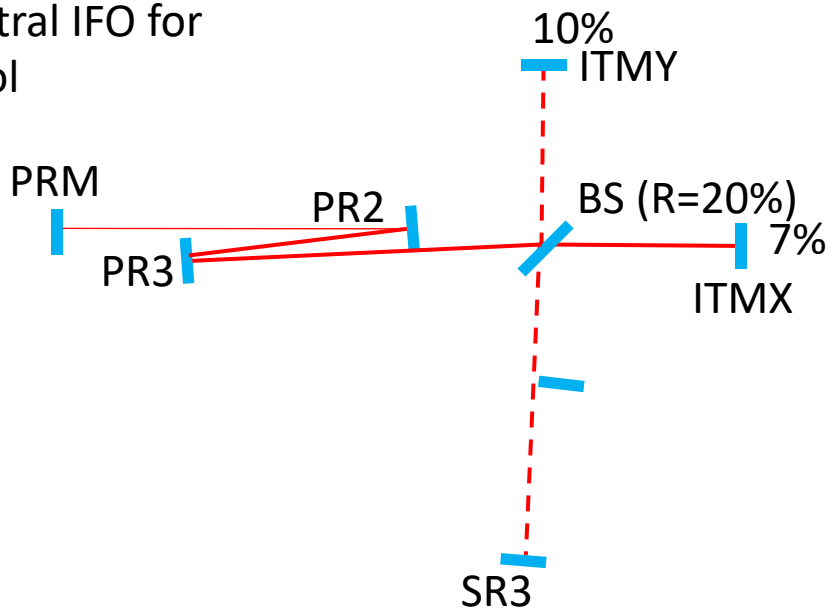
PRC for P-pol can enhance the loss

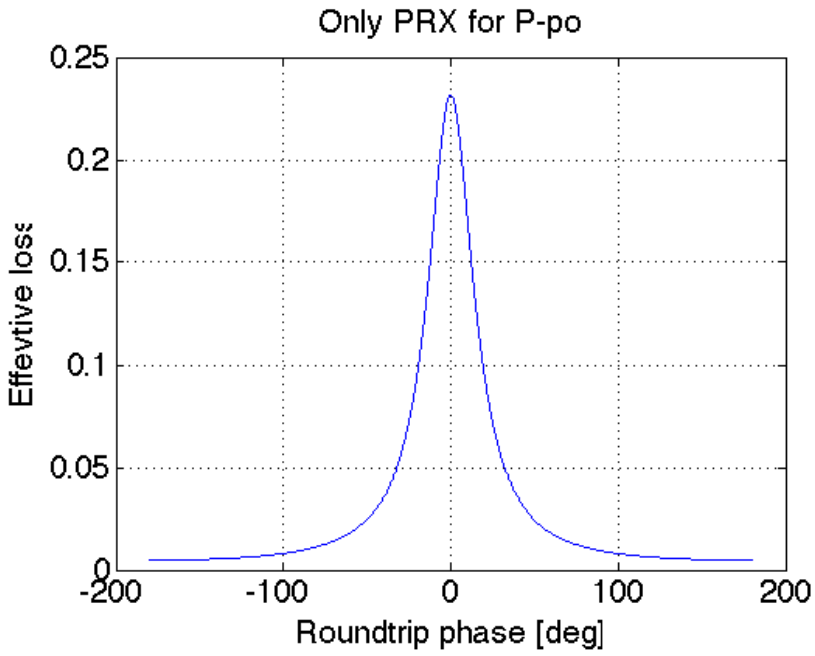


Rough calculation

Case 2:
Only PRX considered

Central IFO for
P-pol

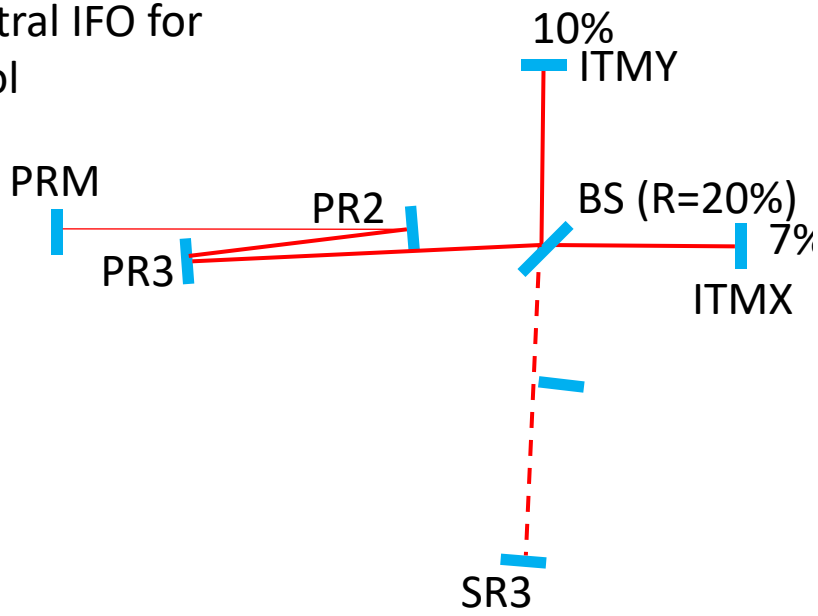


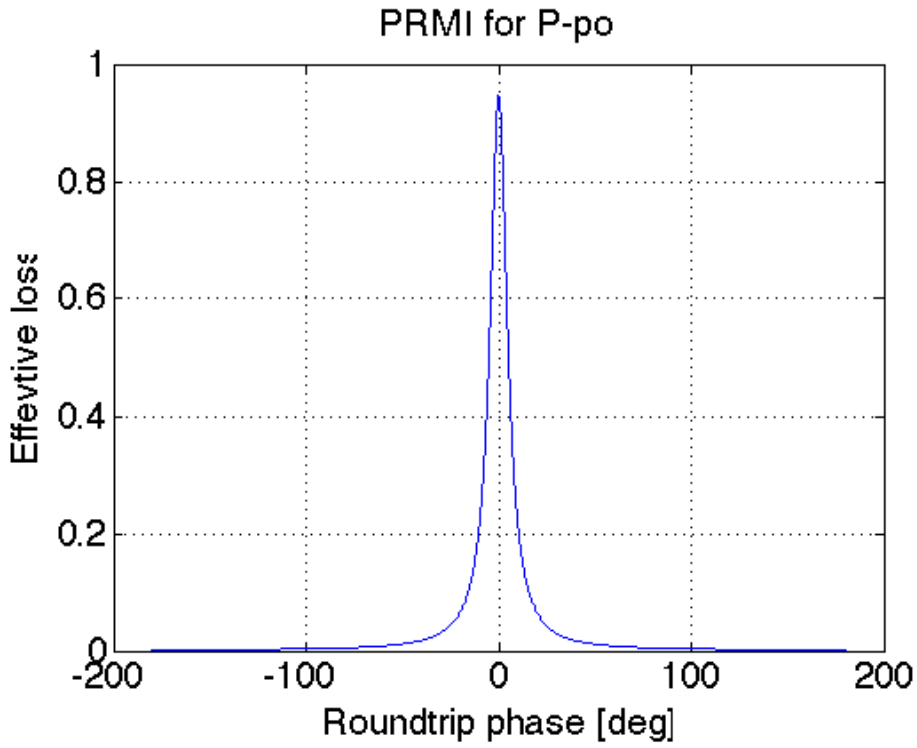


Rough calculation

Case 4:
PRMI considered

Central IFO for
P-pol





Summary

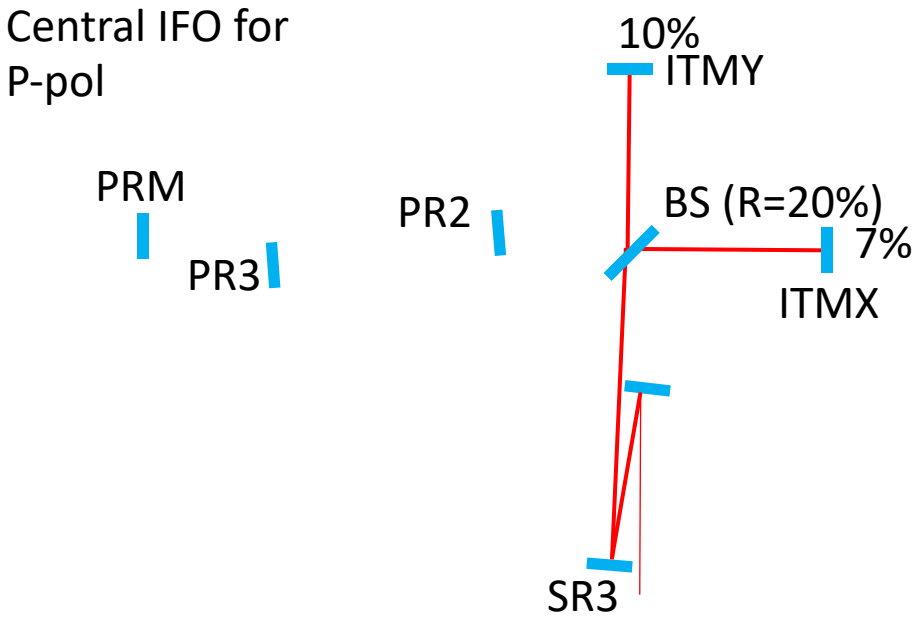
-- ~25% loss in PRMI
-- ~ 10% of the power of the incident beam is transferred to P-pol
-- PRC in P-pol shows a resonant-like feature, indicating PRC is a coupled cavity. Cavities for S and P are coupled.

-- Birefringence in ITM can explain ~10% conversion of the polarization.
-- ~25% loss of PRMI can happen if S-P coupling is taken into account.

Rough calculation

Case 1:
If P-pol generated in ITMX and ITMY interfered with each other so that AS is bright

=> 8 % loss



Rough calculation

Case 3:
Only PRY considered