Summary of Alignment Scheme of KAGRA in O3GK (~2020)

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Scope

- Summarize the alignment scheme used for O3GK and RSE trial in 2020
- To discuss if there are better schemes for O4 and beyond
- Here, we only discuss daily alignment (semi-auto alignment; SAL) for locking and ASC after locking
- We do not discuss the initial alignment

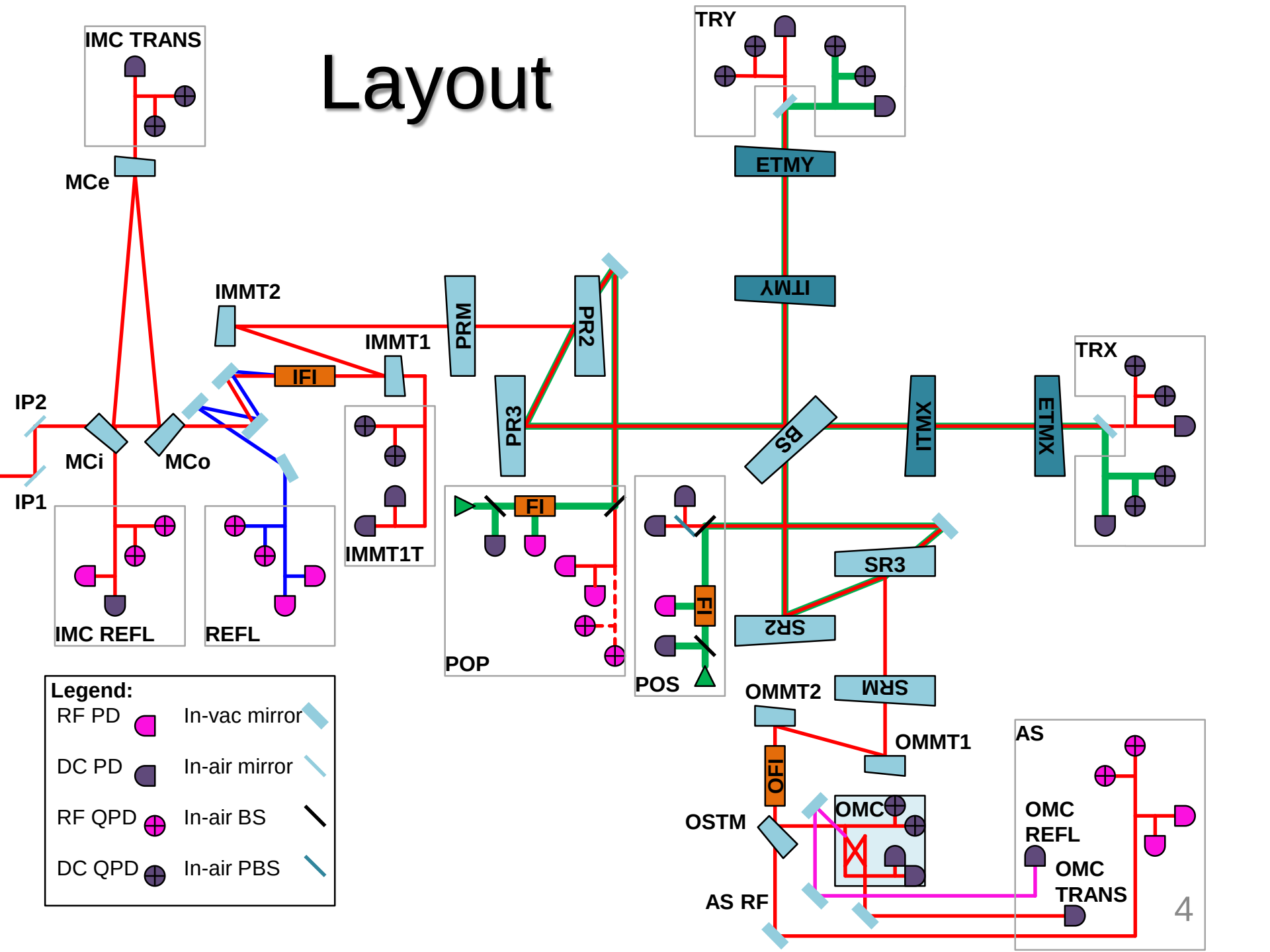
  for initial alignment, see, for example JGW-T1604823 (iKAGRA), JGW-T1605692 (bKAGRA Phase 1), JGW-G1808462 (X&Y arm)
- References

  JGW-G2011544: KAGRA beam alignment manual for beginners in O3
  JGW-G2011687:ASC Status and To-Dos
  JGW-T2112593: Cable diagram (PSL, IOO, IOO1, ALS0, ALS1, LSC0, ASC0)

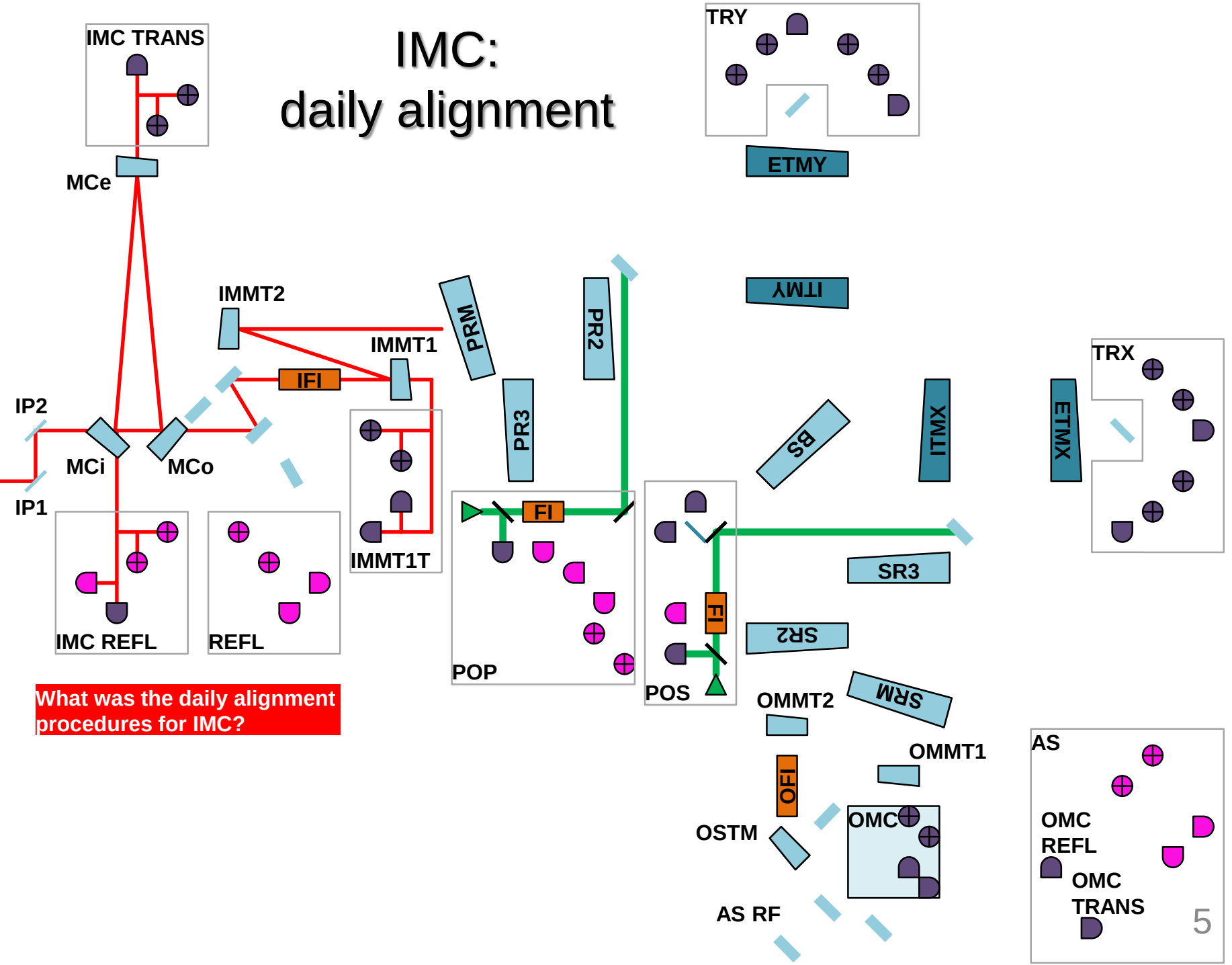
Acronyms

- **SAL (Semi-Auto Alignment)**
  Guardian based daily alignment where you can click buttons step by step. Manual checkings in-between the steps are necessary.
- **ADS (Alignment Dither System)**
  Dither optics and see the fluctuations in the transmitted power to control the alignment of the optics to maximize the transmitted power.
- **BPC (Beam Pointing Control)**
  Dither optics and see angle-to-length to control the alignment of the optics to control the beam spot positions on the optics.
- **WFS (Wave Front Sensor)**
  Modulation-demodulation scheme to control the alignment of the optics using RF QPDs.
- **IP (Input Pointing)**
  Two steering mirrors at the output of PSL (pre-stabilized laser) table for input pointing to IMC (input-mode cleaner).

Layout

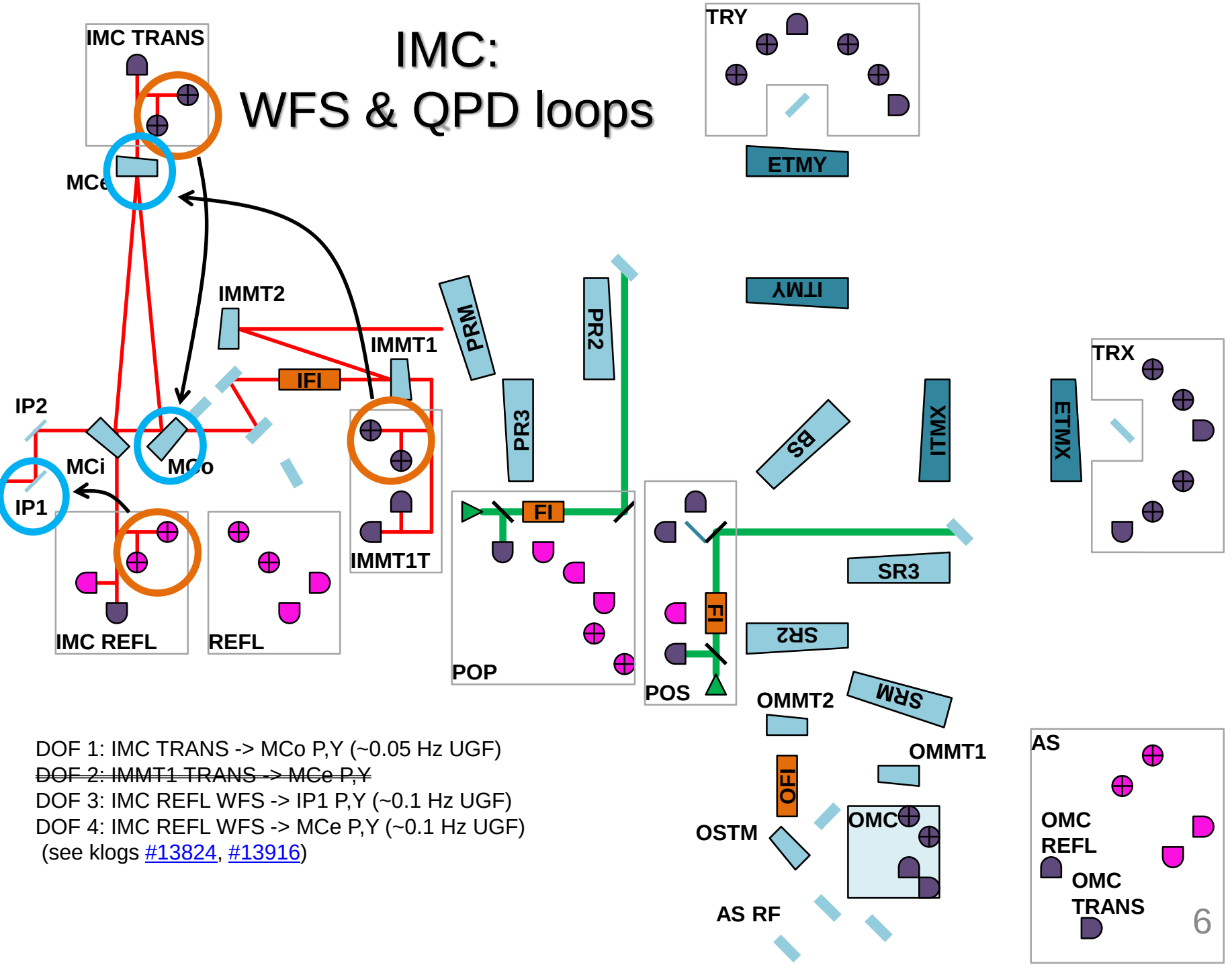

IMC TRANS
TRY
MCe
ETMY
IMMT2
IMMT1
PRM
PR2
ITMY
IFI
IP2
PR3
TRX
BS
ITMX
ETMX
MCi
MCo
IP1
IMMT1T
FI
SR3
FI
SR2
IMC REFL
REFL
POP
POS
SRM
OMMT2
OMMT1
AS
OFI
OSTM
OMC
OMC REFL
OMC TRANS
AS RF
Legend:
RF PD
DC PD
RF QPD
DC QPD
In-vac mirror
In-air mirror
In-air BS
In-air PBS

IMC: daily alignment



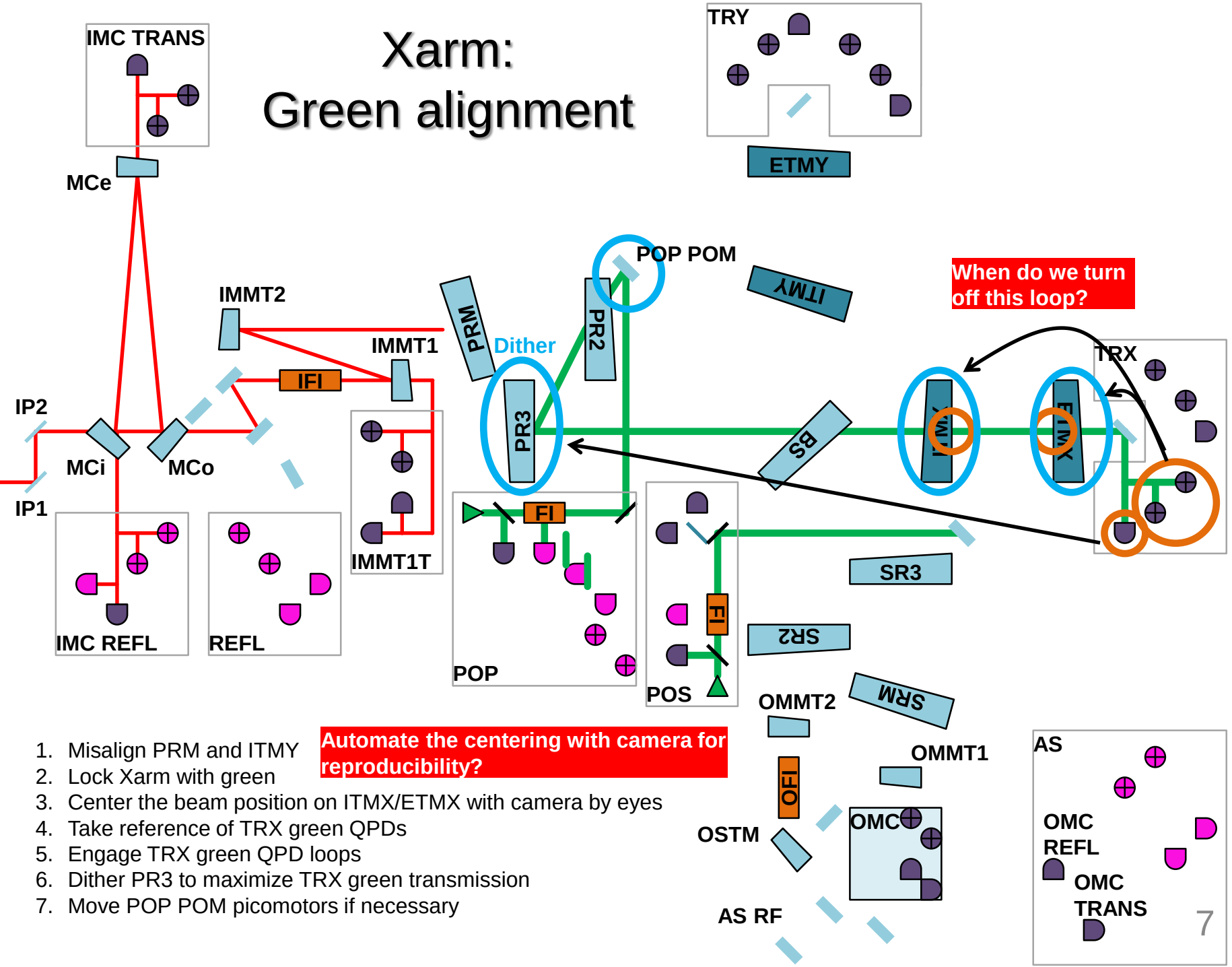
What was the daily alignment procedures for IMC?

IMC: WFS & QPD loops



DOF 1: IMC TRANS -> MCo P,Y (~0.05 Hz UGF)
~~DOF 2: IMMT1 TRANS -> MCe P,Y~~
DOF 3: IMC REFL WFS -> IP1 P,Y (~0.1 Hz UGF)
DOF 4: IMC REFL WFS -> MCe P,Y (~0.1 Hz UGF)
(see klogs #13824, #13916)

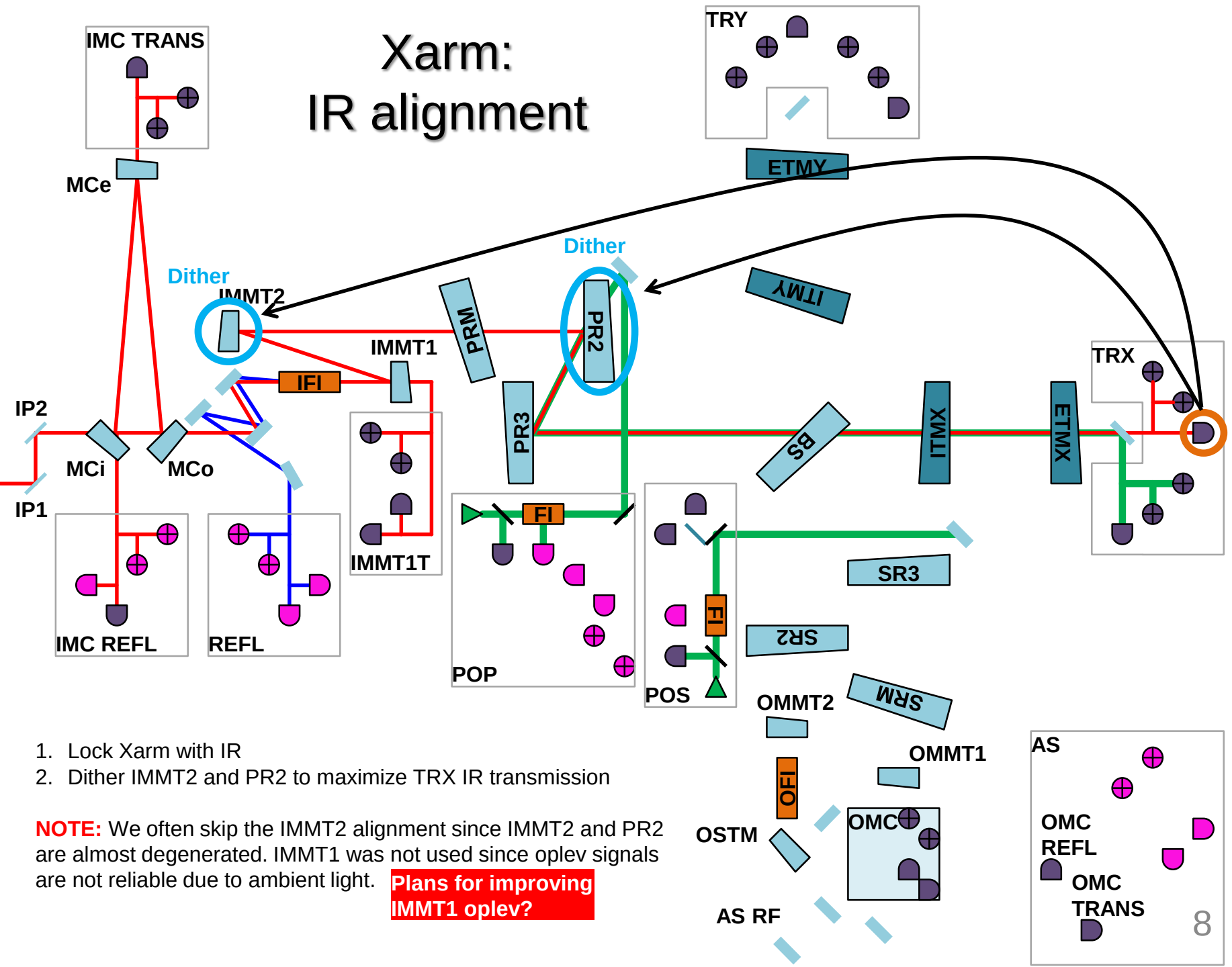
Xarm: Green alignment



1. Misalign PRM and ITMY
2. Lock Xarm with green
3. Center the beam position on ITMX/ETMX with camera by eyes
4. Take reference of TRX green QPDs
5. Engage TRX green QPD loops
6. Dither PR3 to maximize TRX green transmission
7. Move POP POM picomotors if necessary

Automate the centering with camera for reproducibility?

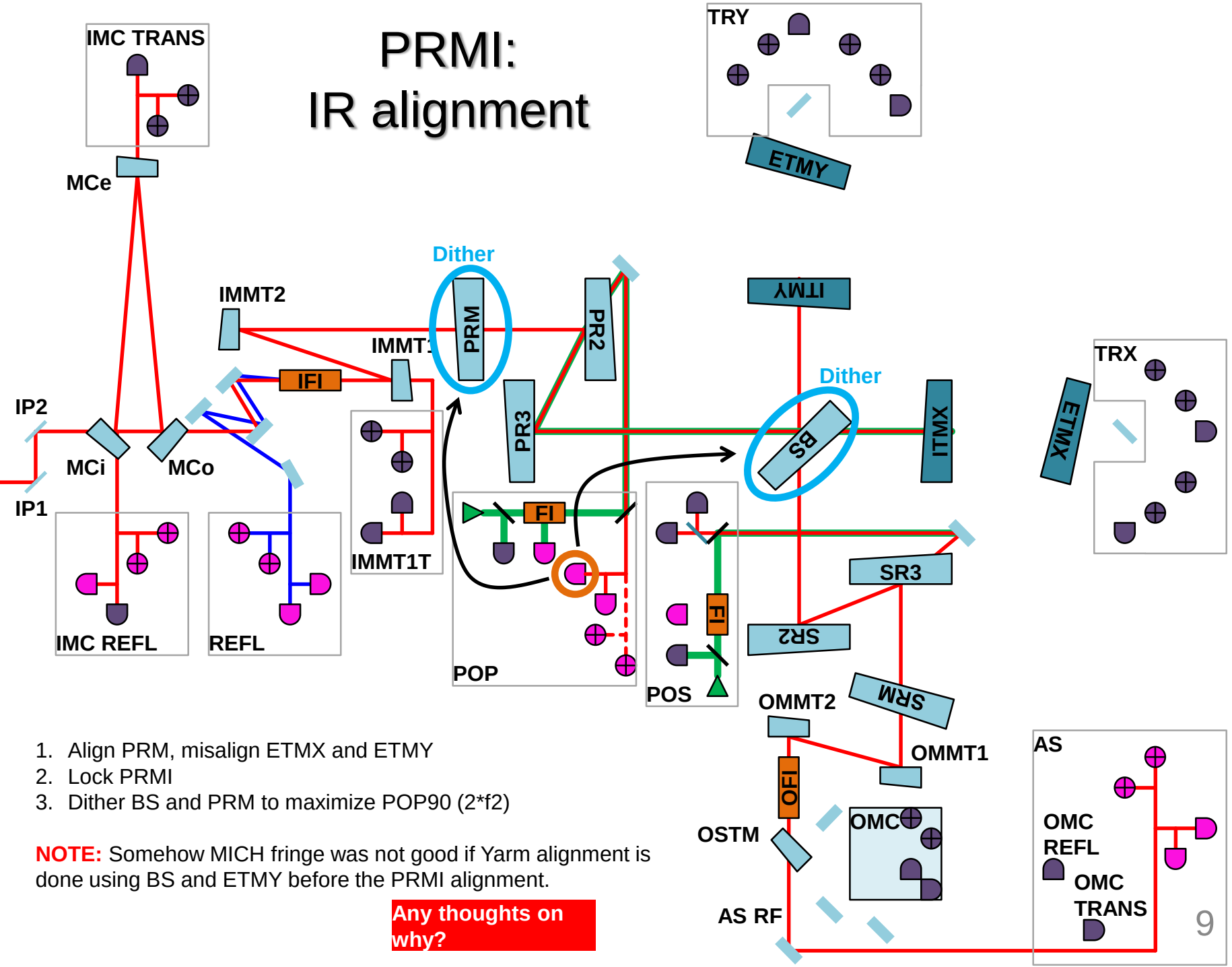
Xarm: IR alignment



1. Lock Xarm with IR
2. Dither IMMT2 and PR2 to maximize TRX IR transmission

NOTE: We often skip the IMMT2 alignment since IMMT2 and PR2 are almost degenerated. IMMT1 was not used since oplev signals are not reliable due to ambient light. **Plans for improving IMMT1 oplev?**

PRMI: IR alignment

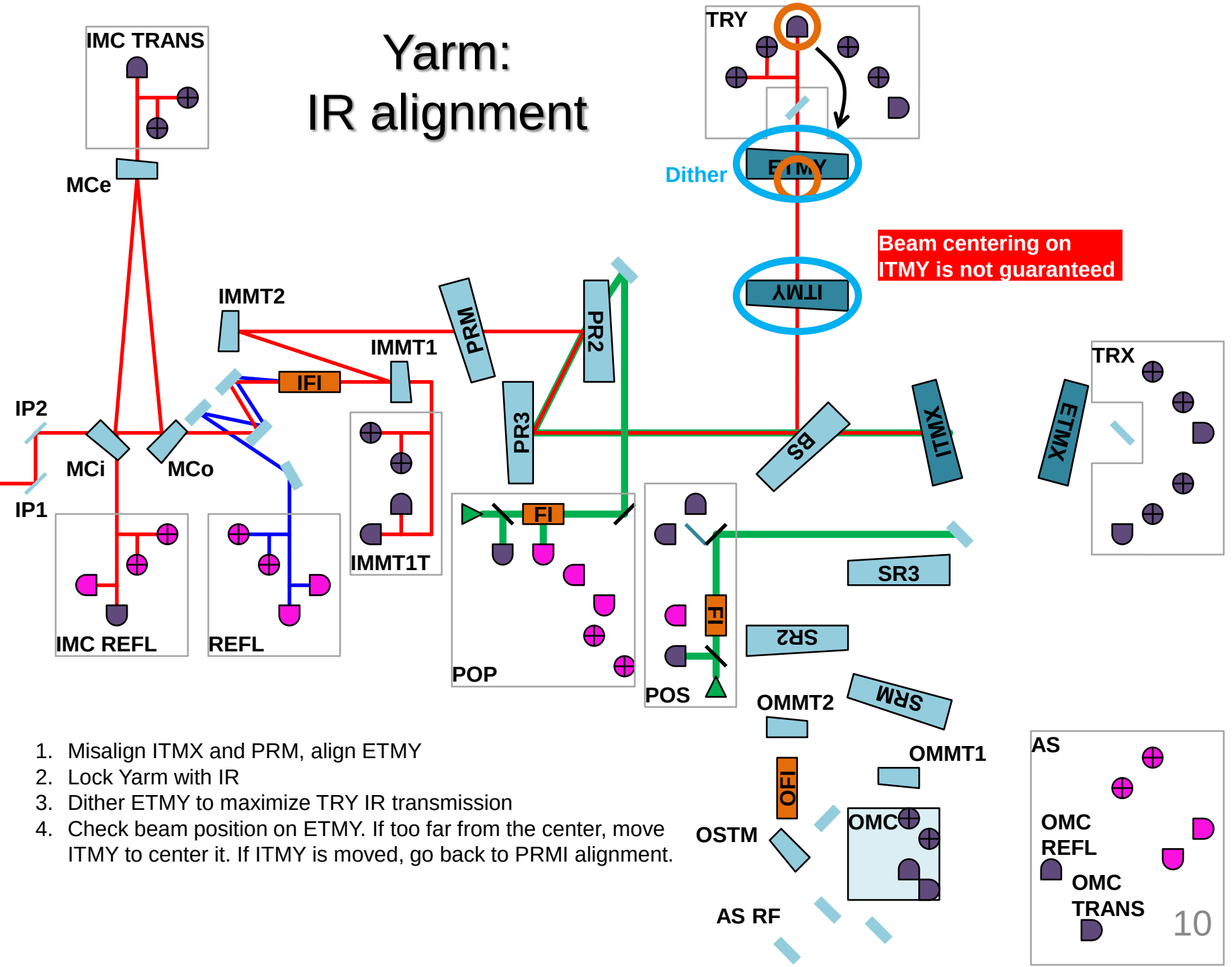


1. Align PRM, misalign ETMX and ETMY
2. Lock PRMI
3. Dither BS and PRM to maximize POP90 (2*f2)

NOTE: Somehow MICH fringe was not good if Yarm alignment is done using BS and ETMY before the PRMI alignment.

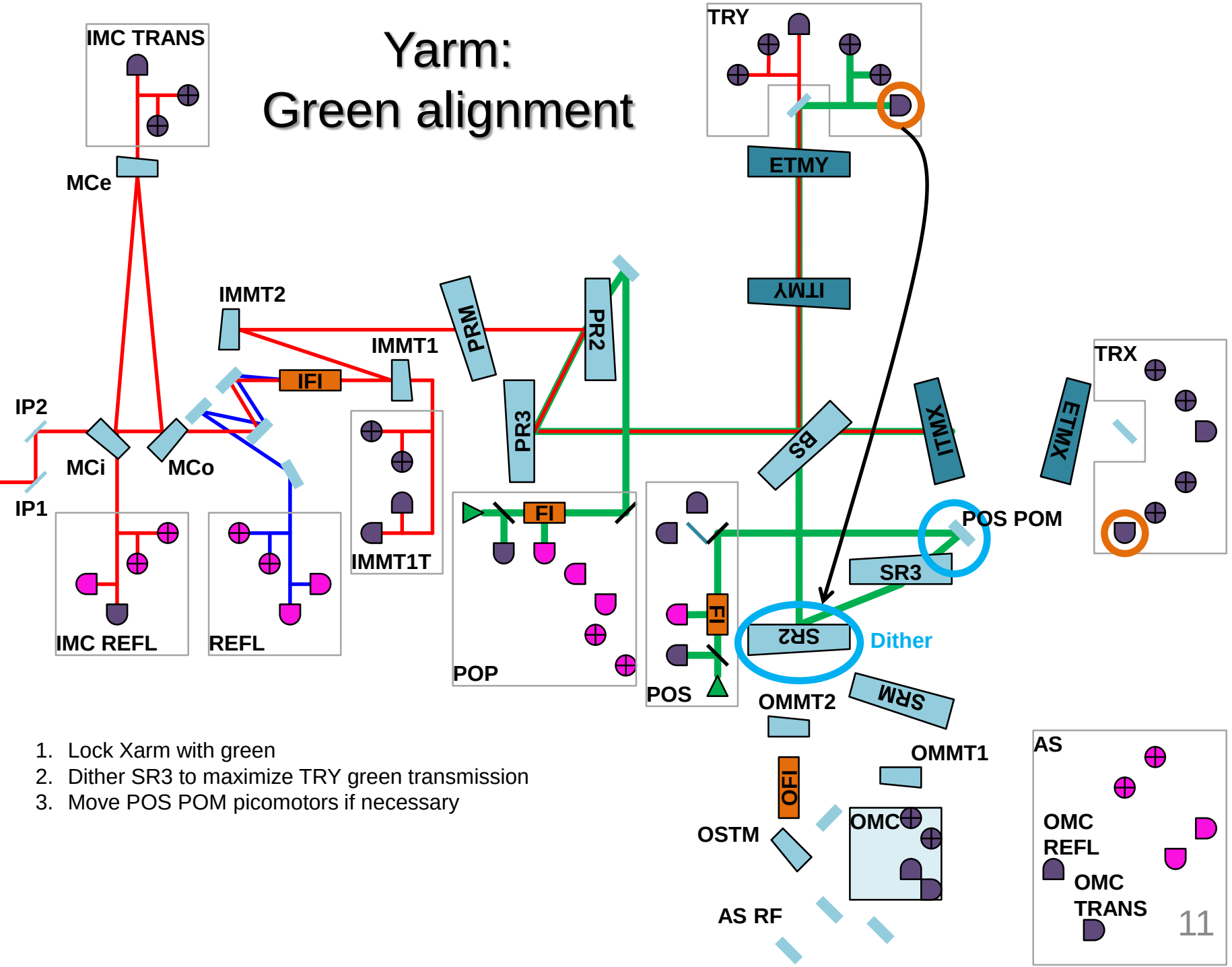
Any thoughts on why?

Yarm: IR alignment



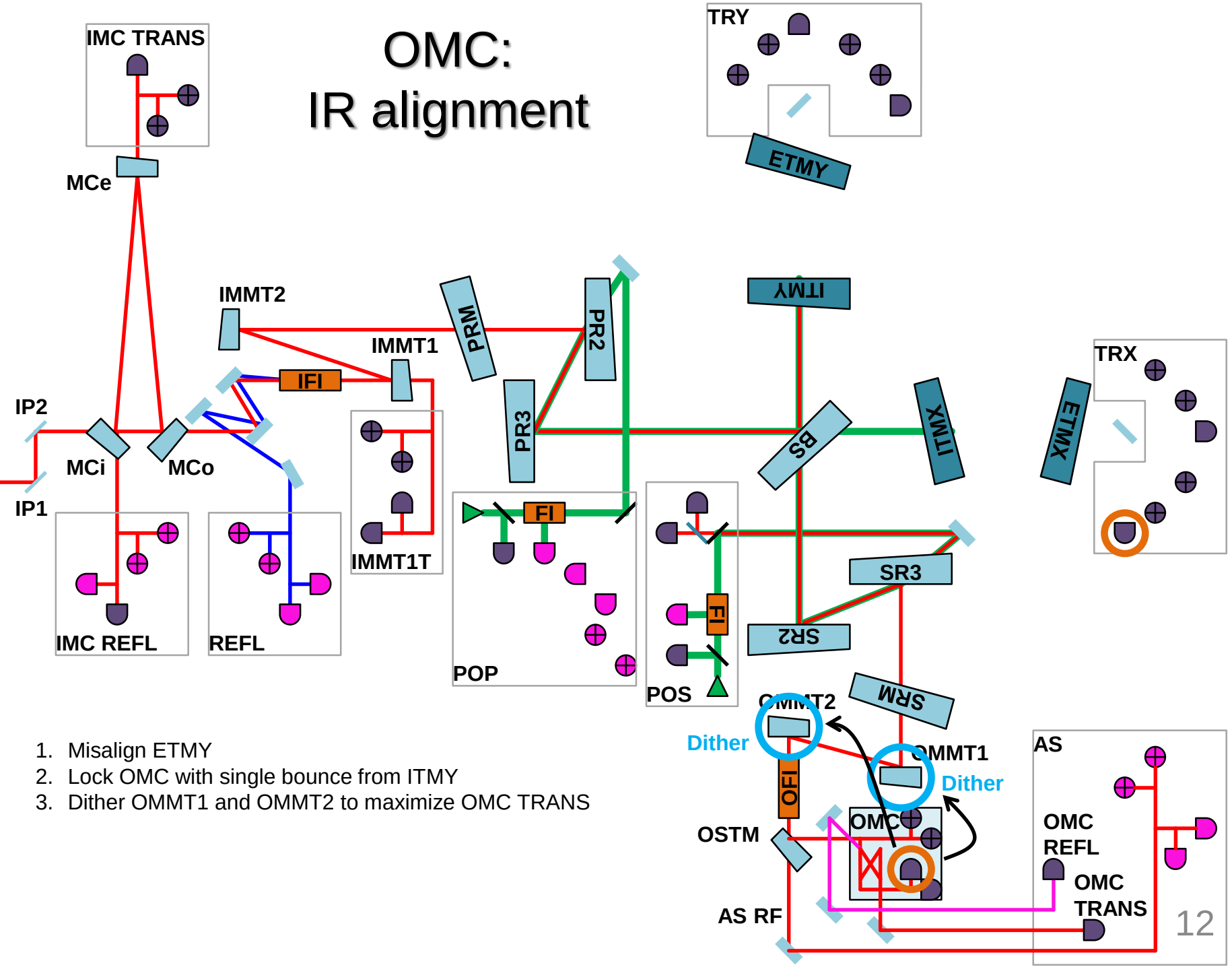
1. Misalign ITMX and PRM, align ETMY
2. Lock Yarm with IR
3. Dither ETMY to maximize TRY IR transmission
4. Check beam position on ETMY. If too far from the center, move ITMY to center it. If ITMY is moved, go back to PRMI alignment.

Yarm: Green alignment



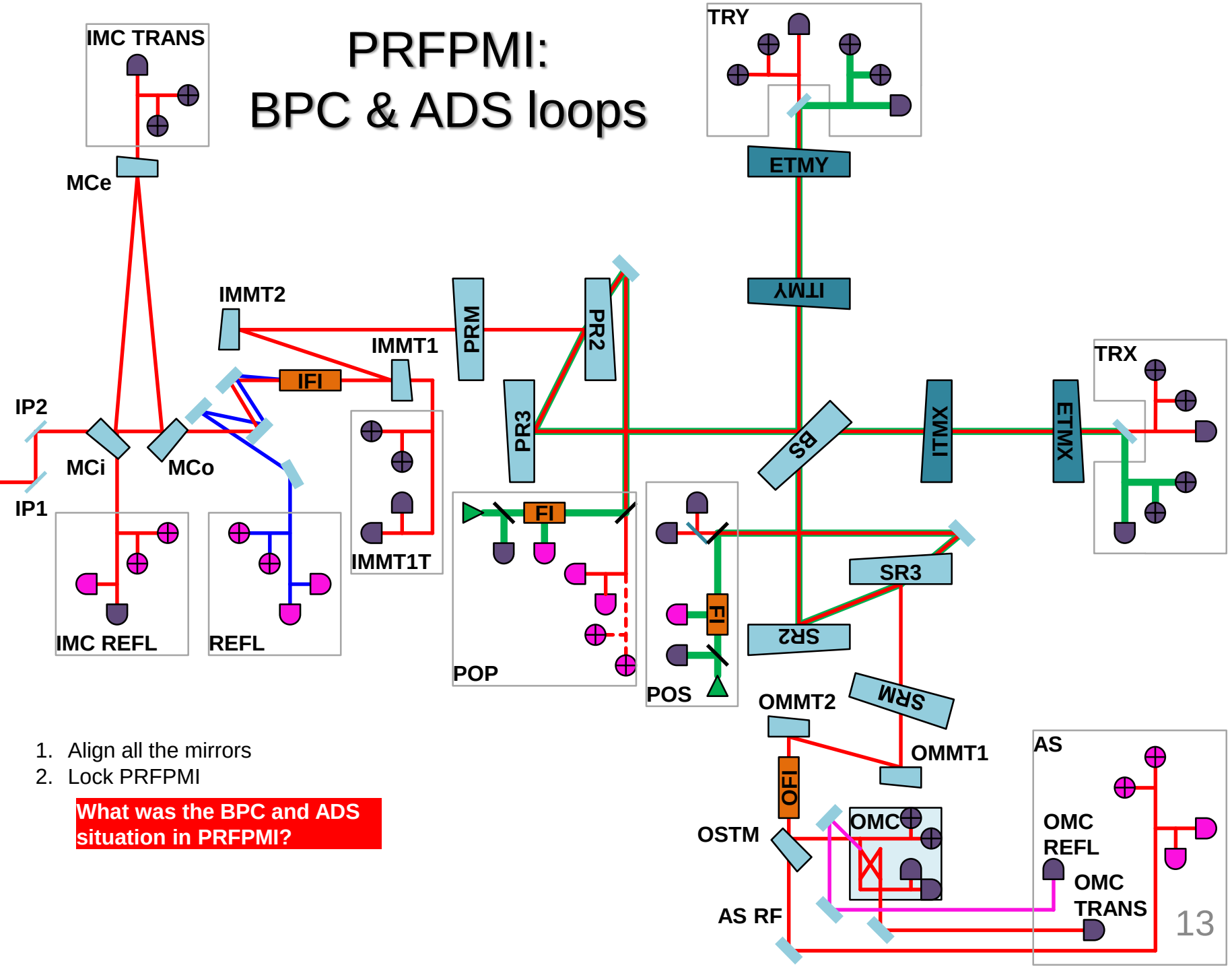
1. Lock Xarm with green
2. Dither SR3 to maximize TRY green transmission
3. Move POS POM picomotors if necessary

OMC: IR alignment



1. Misalign ETMY
2. Lock OMC with single bounce from ITMY
3. Dither OMMT1 and OMMT2 to maximize OMC TRANS

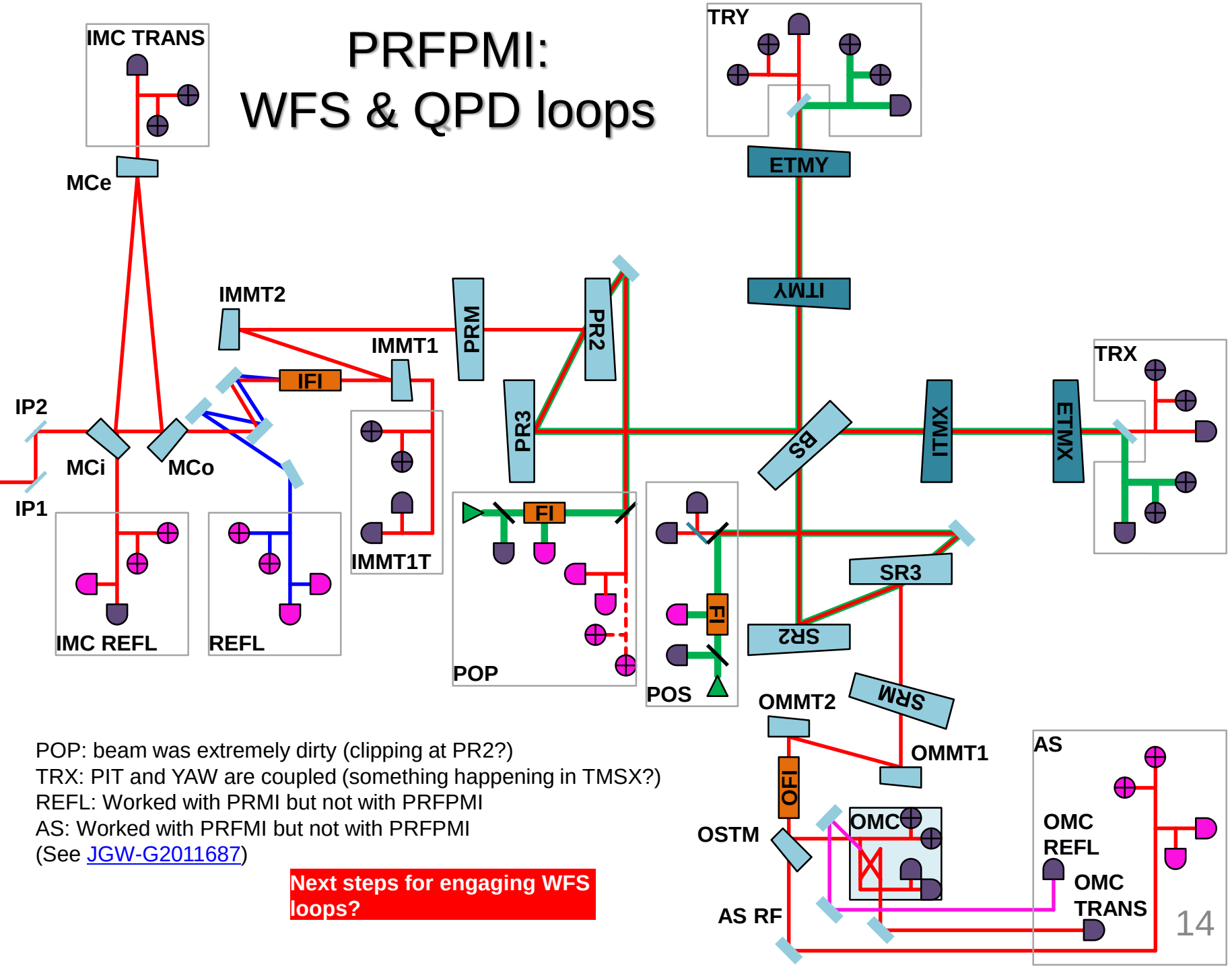
PRFPMI: BPC & ADS loops



1. Align all the mirrors
2. Lock PRFPMI

What was the BPC and ADS situation in PRFPMI?

PRFPMI: WFS & QPD loops



POP: beam was extremely dirty (clipping at PR2?)
TRX: PIT and YAW are coupled (something happening in TMSX?)
REFL: Worked with PRMI but not with PRFPMI
AS: Worked with PRFMI but not with PRFPMI
(See JGW-G2011687)

Next steps for engaging WFS loops?