

# Interferometer Design for bKAGRA Phase 1 and Beyond

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for the MIF subgroup

# bKAGRA Phase 1 (-2018.3)

- Goal:
  - Start observation run using 3km cryogenic interferometer by the end of March 2018
  - TM temperature should be (close to) 20 K
  - No requirement for sensitivity
- Configuration:
  - **3 km cryogenic Michelson**
  - minimum success: cryo Michelson with LSC
  - **strict deadline (KAGRA will die if cannot make it)**
  - concentrate on Michelson first  
**(no power recycling before Michelson operation)**
- Purpose:
  - Test cryopayload and cryogenic operation

# bKAGRA 2018.4-6

- Interferometer team will have time after Phase 1 until ITM cryopayload installation, which starts on July 2, 2018
- Configuration:
  - 3 km cryogenic **power-recycled** Michelson
  - no strict deadline, but we have to finish it before ITM installation starts
  - (try PRMI if it doesn't delay the final bKAGRA)**
- Purpose:
  - Test cryopayload and cryogenic operation
  - Try 3-km cavity locking, multi-DOF locking
  - Spatial mode check

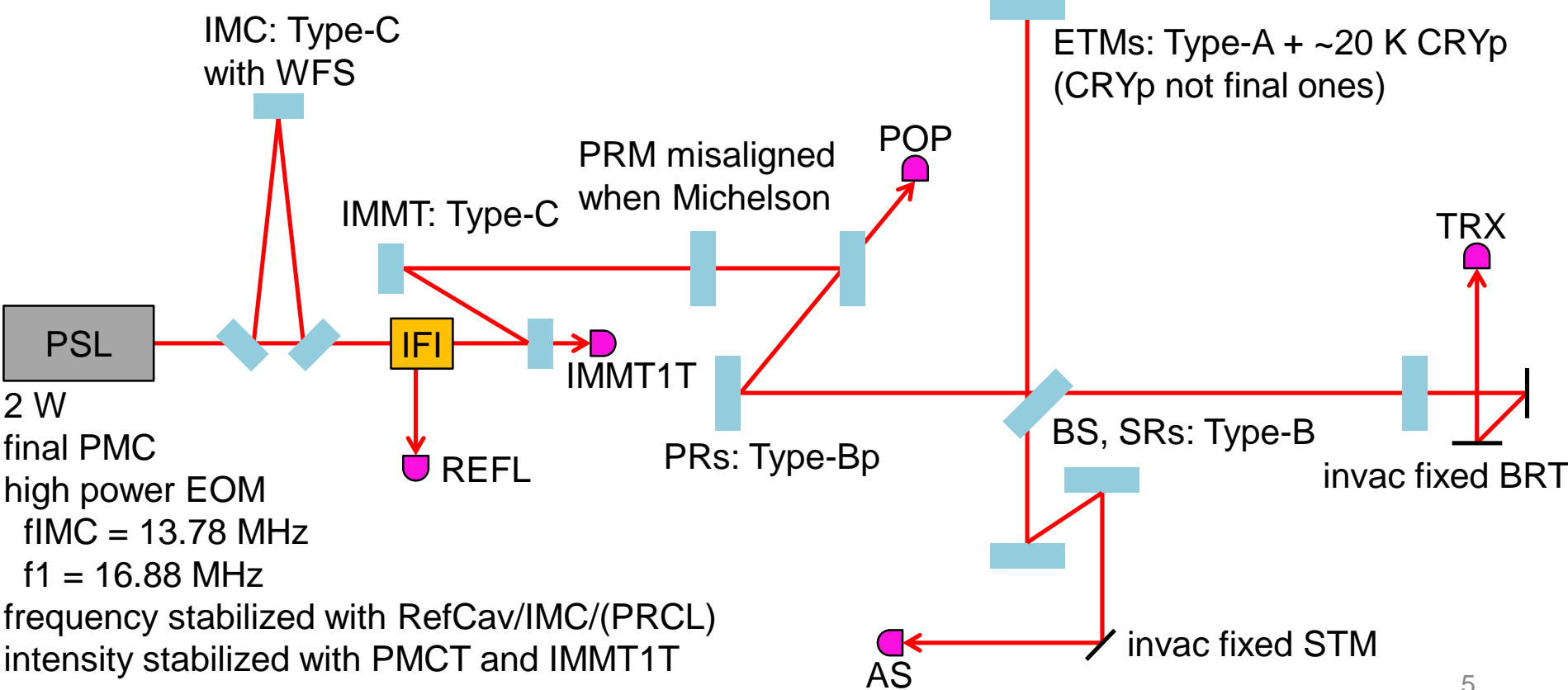
# Steps for Cryogenic MI and PRMI

- 2017.6.5 PRs installed -> ~1 month integration (-2017.7.6?)
- 2017.8.31 PSL+IMC ready
- Initial alignment to both ends, beam collimation  
(no PR2-PR3 length tuning if beam is collimated well enough)
- 2017.10.31 ETMY CRYp installed
- Return the beam from ETMY to BS  
(we don't try PR-ETMY cavity)
- 2017.11.15 SR2 and SR3 installed -> ~1 month integration (-2017.12.19?)
- 2017.11.22- ETMY evacuation -> 2017.12.8 cool down starts
- 2018.2.2 ETMX CRYp installed
- Return the beam from ETMX to BS
- Lock room temperature Michelson
- 2018.2.13- ETMY evacuation -> 2018.3.2 cool down starts
- by 2018.3.31 Start observation run with 3-km cryogenic Michelson  
[AFTER WE MEET THE DEADLINE]
- Shorten PR2-PR3 length by 2.4 cm (at max)
- Re-alignment
- connect remaining bellows/ducts and evacuate central area
- Lock cryogenic PRMI  
if not possible, lock more cryogenic Michelson  
\* PRMI could be unstable if PR2/3 RoC errors are the worst case

# Configuration

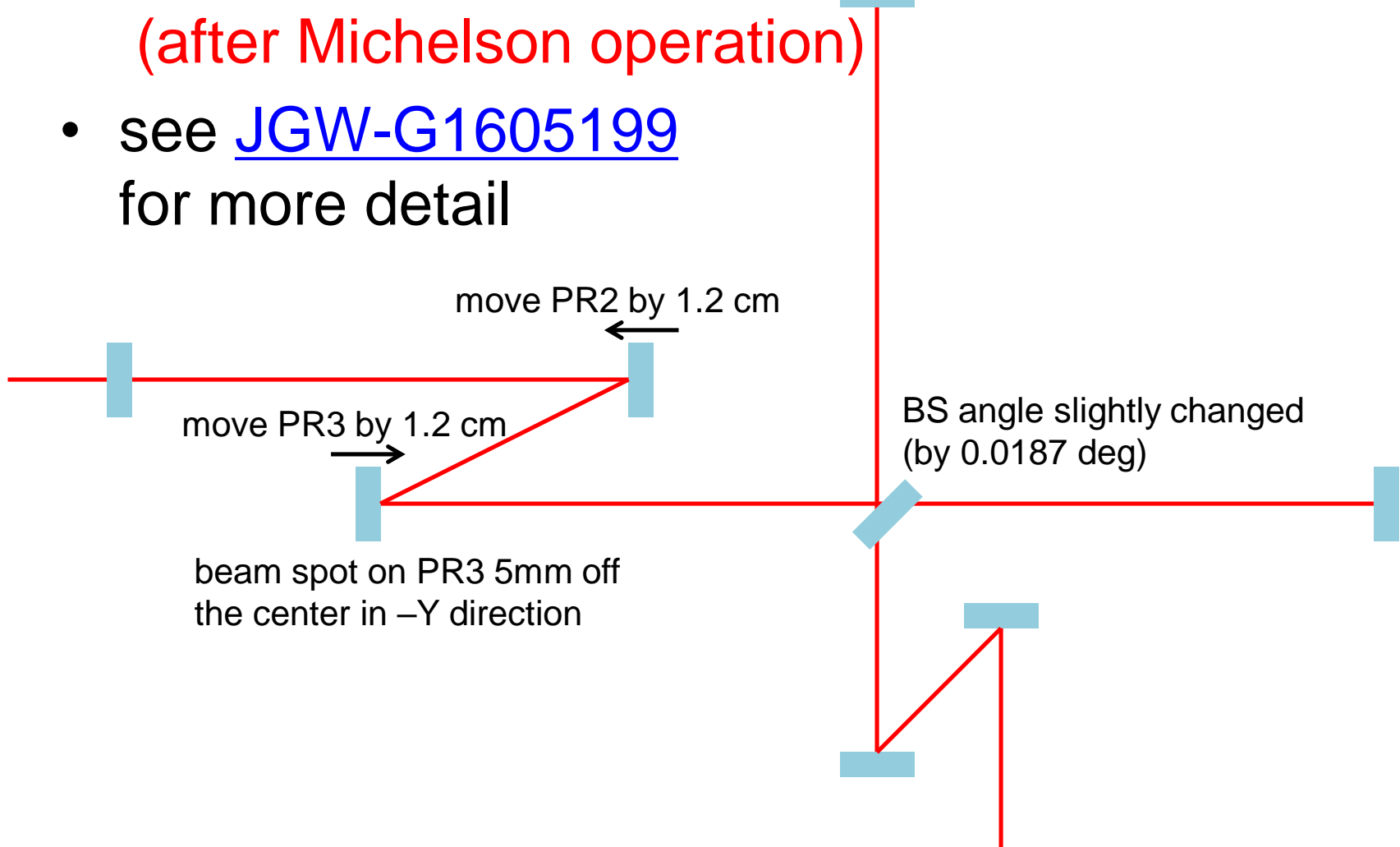
- Every detection port listed here has both PD and QPDs (for ASC), and placed on output optics tables in air
- Green lasers are also installed (but not necessary for Phase 1)
- No requirement for vacuum level

invac fixed BRT (could be on isolated table; GPT is on output optics table in air)



# Layout

- Adjust layout slightly to compensate ITM wedge
- Move PR2 and PR3 to stabilize mode of PR cavity  
(after Michelson operation)
- see [JGW-G1605199](#)  
for more detail



# Length Sensing and Control

- Only use f1 sidebands
- Sensing matrix for PRMI:

| [W/m]  | MICH      | PRCL      |
|--------|-----------|-----------|
| REFL_I | +9.92e-01 | -7.48e+07 |
| REFL_Q | +6.61e+04 | -3.52e+07 |
| AS_I   | +8.97e+02 | -2.23e-01 |
| AS_Q   | -1.67e+06 | +4.16e+02 |

# Alignment Sensing and Control

- Only use f1 sidebands (and TRX/Y DC)
- Sensing matrix for PRMI:

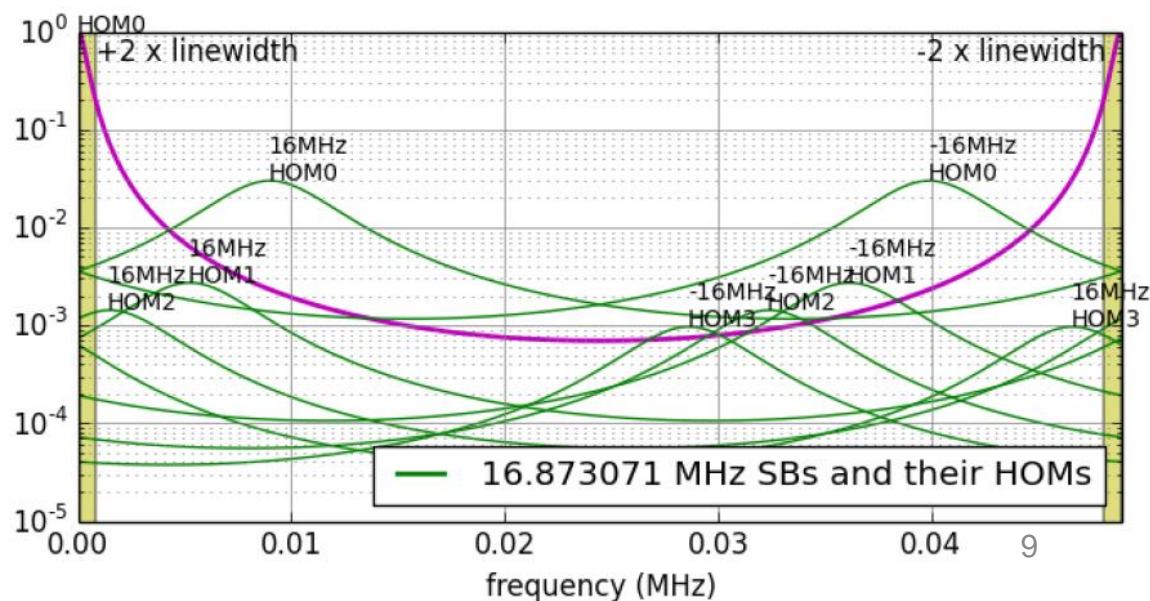
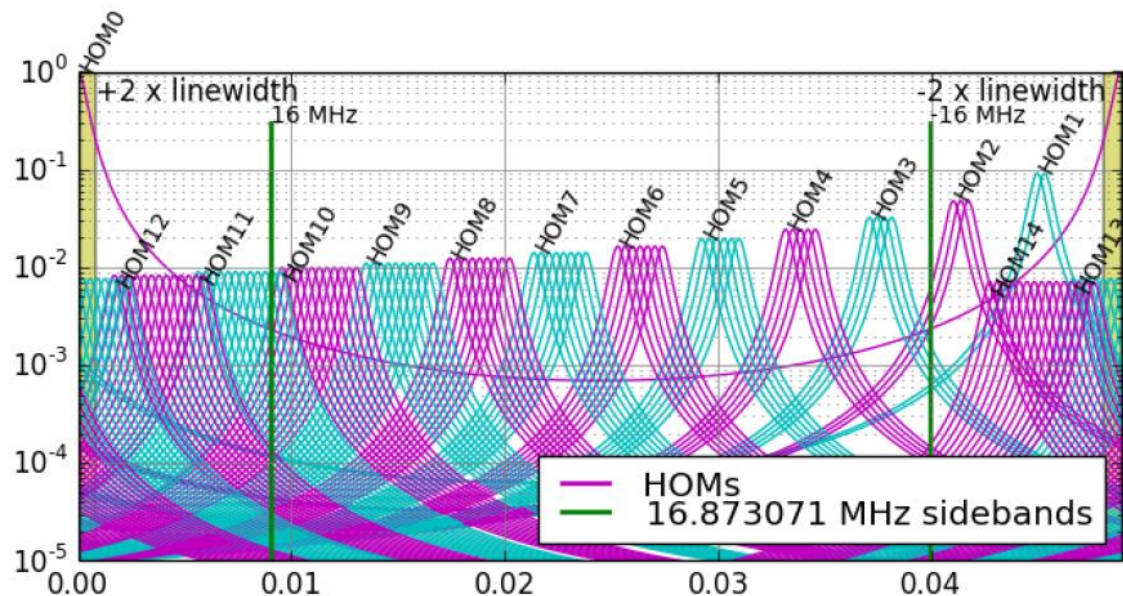
| [W/rad] | COMM      | DIFF      | BS        | PRM       | PR2'      | PR3'      |
|---------|-----------|-----------|-----------|-----------|-----------|-----------|
| REFLA_I | +4.98e+02 | +2.36e-01 | -4.16e+02 | -8.13e+01 | -2.08e-01 | -1.21e+03 |
| REFLB_I | -7.01e-01 | -2.91e+00 | -1.93e+00 | -2.10e+01 | -1.70e-03 | +3.47e+00 |
| ASA_Q   | +9.80e-01 | +1.87e+02 | +1.56e+02 | -1.39e-01 | +1.31e-03 | -2.27e+00 |
| POPA_DC | +4.04e+01 | +1.49e+01 | -2.41e+01 | +3.91e+02 | +8.07e+02 | -1.57e+01 |
| TRXA_DC | +2.30e+01 | +1.71e-01 | +1.93e+01 | -1.23e-01 | -5.66e-03 | -6.51e-01 |
| TRYA_DC | -2.30e+01 | +1.71e-01 | -1.91e+01 | -1.17e-01 | -3.25e-03 | -6.36e-01 |

- See [JGW-G1605541](#) and [JGW-T1605362](#) for more detail



# Transverse Mode Spacing for PRMI

- g-factor  
0.8750 in pitch  
0.8958 in yaw  
(with designed RoCs & lengths, PR2-PR3 length shortened by 2.4 cm)
- See [JGW-G1605541](#)  
[JGW-T1605362](#)  
for more detail
- how to measure: [LIGO-G080467](#)



# Commissioning Schedule FY2017

