# 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?)
- 2017.11.30- ETMY evacuation -> 2017.12.18 cool down starts
- 2018.1.26 ETMX CRYp installed
- Return the beam from ETMX to BS
- Lock room temperature Michelson
- 2018.2.12- ETMY evacuation -> 2018.2.28 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
- 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 invac fixed BRT (could be on isolated table; Green lasers are also installed GPT is on output optics table in air) (but not necessary for Phase 1) No requirement for vacuum level TRY IMC: Type-C ETMs: Type-A + ~20 K CRYp with WFS (CRYp not final ones) POP PRM misaligned when Michelson IMMT: Type-C **TRX PSL** IFI IMMT1T 2 W BS, SRs: Type-B final PMC PRs: Type-Bp **REFL** invac fixed BRT high power EOM fIMC = 13.78 MHzf1 = 16.88 MHzfrequency stabilized with RefCav/IMC/(PRCL) invac fixed STM

5

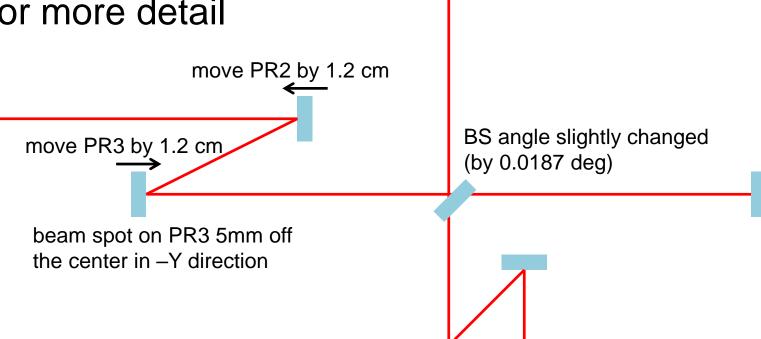
intensity stabilized with PMCT and IMMT1T

### Layout

- Adjust layout slightly to compensate ITM wedge
- Move PR2 and PR3 to stabilize mode of PR cavity

(after Michelson operation)

see <u>JGW-G1605199</u>
 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

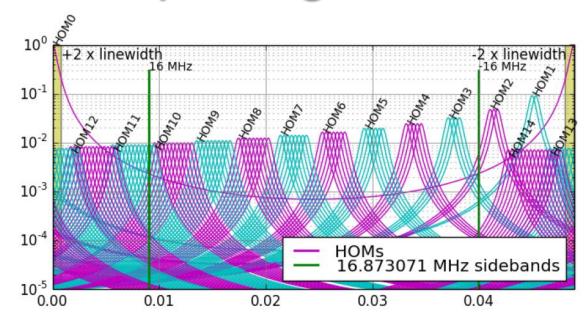
TRXA_DC +2.30e+01 +1.71e-01 +1.93e+01 -1.23e-01 -5.66e-03 -6.51e-01

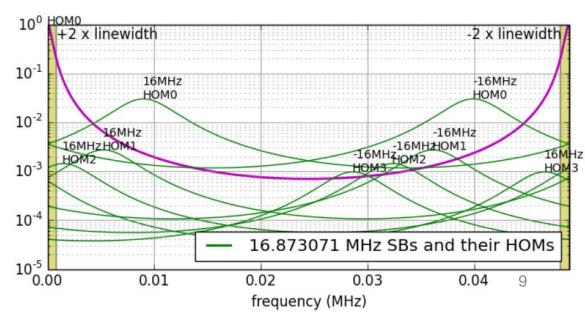
TRYA_DC -2.30e+01 +1.71e-01 -1.91e+01 -1.17e-01 -3.25e-03 -6.36e-01
```

 See <u>JGW-G1605541</u> and <u>JGW-T1605362</u> 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
   <u>JGW-G1605541</u>
   <u>JGW-T1605362</u>
   for more detail
- how to measure: LIGO-G080467





# Commissioning Schedule FY2017

