LIGO-G2301014

# Mariner: The Cryogenic Upgrade of the 40m Prototype Interferometer

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#### **Caltech 40m Prototype**

The prototype's mission: integration test of the state-of-the-art detector technology

Technology demonstration for generations of GW detectors FP/PRFPMI iLIGO, RSE aLIGO Current: BHD A+ (-> poster)

-> Voyager: Cryogenic prototype



## **Roles of the prototype interferometer**

- Increase feasibility and readiness of the main detector
- Accumulate experience with known/unknown issues
- Focus: "Integration"

Less complicated subset of the main detector



#### **Mariner: Prototype of Voyager**

#### Key technologies "Si test mass / Radiative cooling / 2050nm Laser"

aLIGO(A+)  $\lambda$ =1064nm, 125W 4km DRFPMI FD-SQZ / BHD / OMC SiO<sub>2</sub> 40kg Room temp Quad SUS

Voyager 2050nm, ~150W <-Same <-Same Si~200kg Radiative cooling 123K <-Same bottom 2 cooled

Mariner <-Same, ~10W 40m FPMI (Phase I) None (Phase I) <-Same ~6kg <-Same **Double SUS** bottom 2 cooled

## Laser / Optics at 2050nm

Less common than 1064nm but solutions exists

Multiple options for laser: ECDL / EC-OPA / LD-pump Tm, Ho:YLF Laser / TDF laser 2050nm semiconductor laser for LIDAR NASA JPL Double stage TDF amp (10mW->10W) CSIR-CGCRI

#### **PSL** combo

PMC / IMC / others: SiO<sub>2</sub> optics EOM / AOM / Faradays: Off-the-shelf

#### **Photodiodes**

ex-InGaAs PD: works at 2um / to be tested ex-InGaAs QPDs: to be manufactured High QEPD: not in the scope at the moment





2.05 1/2125 hutterfly components with integrated oppical isofator



NASA JPL



Glass & Ceramic Research Institute (CSIR-CGRI)

### **Solution for Locking: Arm Length Stabilization**

"Arm stabilization before locking" Using an aux laser locked to the cavity Equivalence: Fractional fluctuations  $(d\nu/\nu = dL/L)$ How to relate  $d\nu/\nu$  at 1550nm and 2050nm Frequency comb Transfer cavity (dichroic rigid cavity)



## Si Test Mass / Coating

- Substrate: φ15cm x t14cm, ITM FZ / ETM MCZ
- Dichroic coating Phase I: Conventional SiO<sub>2</sub>/Ta<sub>2</sub>O<sub>5</sub>, Phase II: aSi
- Barrel Coating for high emissivity
  Black Si + SiO<sub>2</sub> reinforcement layer
  Investigation with wafers
  for robustness and mech. loss







## Cryogenics

#### Radiative test mass cooling Double cryo shields / LN2+cryo cooler add on to the existing vacuum chambers shields extended into the arm tubes

# R. Bhatt's talk on Fry afternoon



## **Cryogenic suspension**

50cm double stage suspension emulates the last two stage of Voyager quad

Priority targets: Cooling demonstration, Handling of pos and angular drift Operation of the cooled interferometer

Steel wire for Phase I Si ribbons / Si blades later



# **Cryogenic suspension**

Preliminary radiative cooling test 6cm single pendulum in a low profile cryostat "Aquadag" (carbon based paint) Cooled down to ~120K in ~80h



OSEMs (LED/PD functions well at 70 readout response ir





### **Status / Summary**

Mariner: three key technologies - Si test mass / radiative cooling / 2050nm laser

Technologies available

- Integrated as an interferometer

Installation

- after balanced homodyne test concludes

- staging the components in the labs