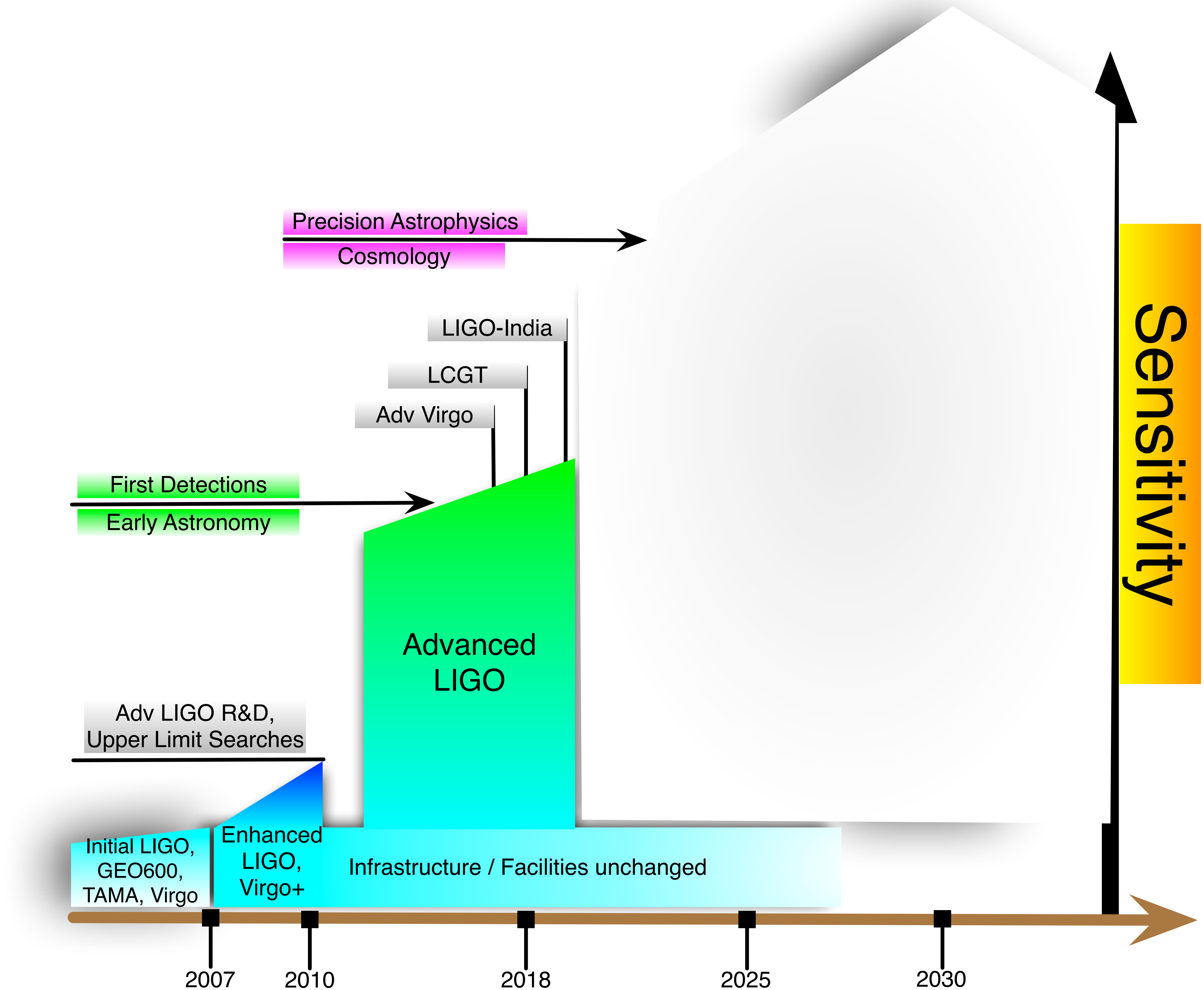
LIGO III: Blue Concept

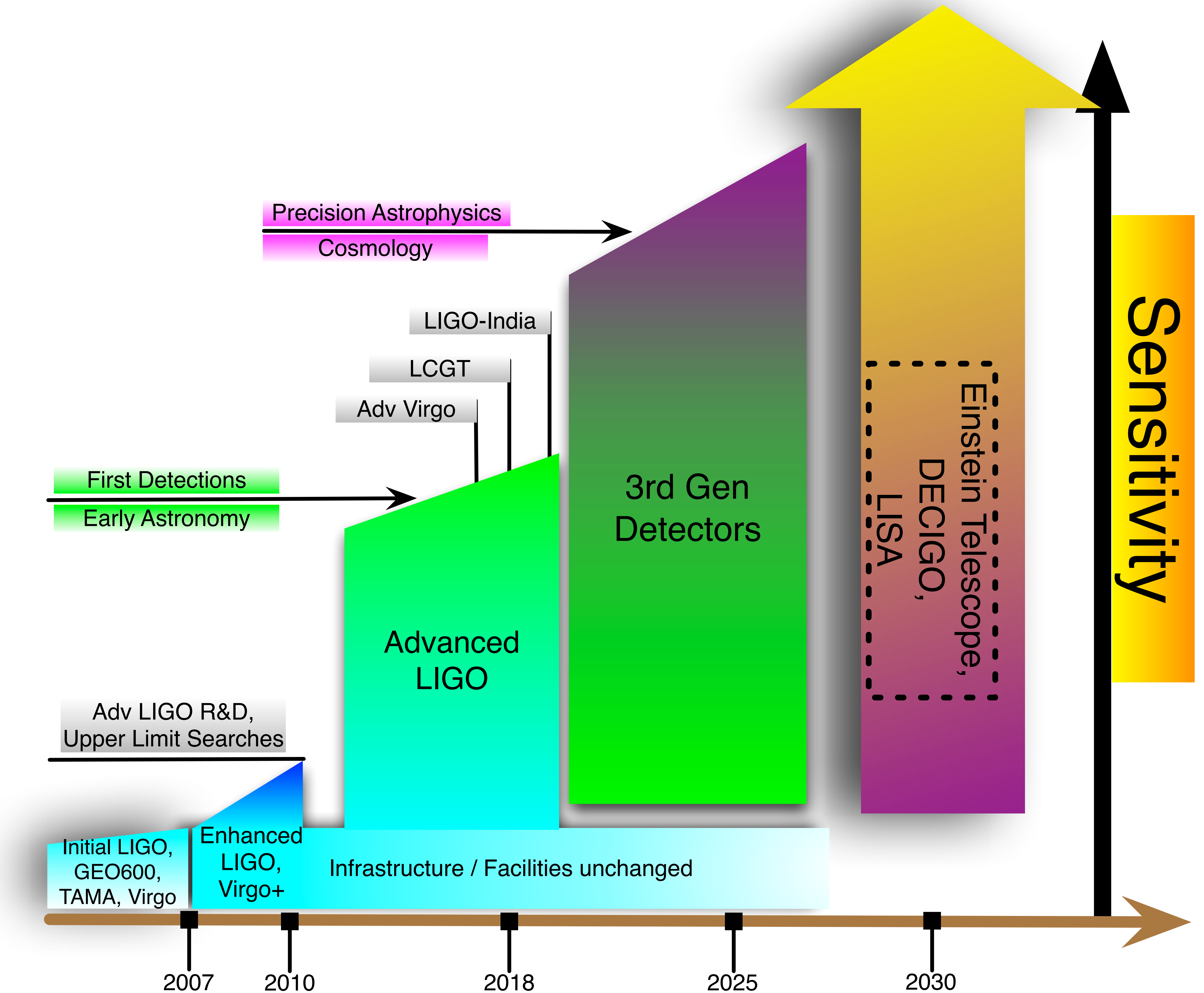
Where do we come from?
What are we?
Where are we going?
-- **Paul Gauguin**

Rana Adhikari for the Blue Team

G1200573-v1



Precision Astrophysics
Cosmology
LIGO-India
LCGT
Adv Virgo
First Detections
Early Astronomy
Advanced LIGO
Sensitivity
Adv LIGO R&D, Upper Limit Searches
Initial LIGO, GEO600, TAMA, Virgo
Enhanced LIGO, Virgo+
Infrastructure / Facilities unchanged
2007
2010
2018
2025
2030


Precision Astrophysics
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First Detections
Early Astronomy
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3rd Gen Detectors
Einstein Telescope, DECIGO, LISA
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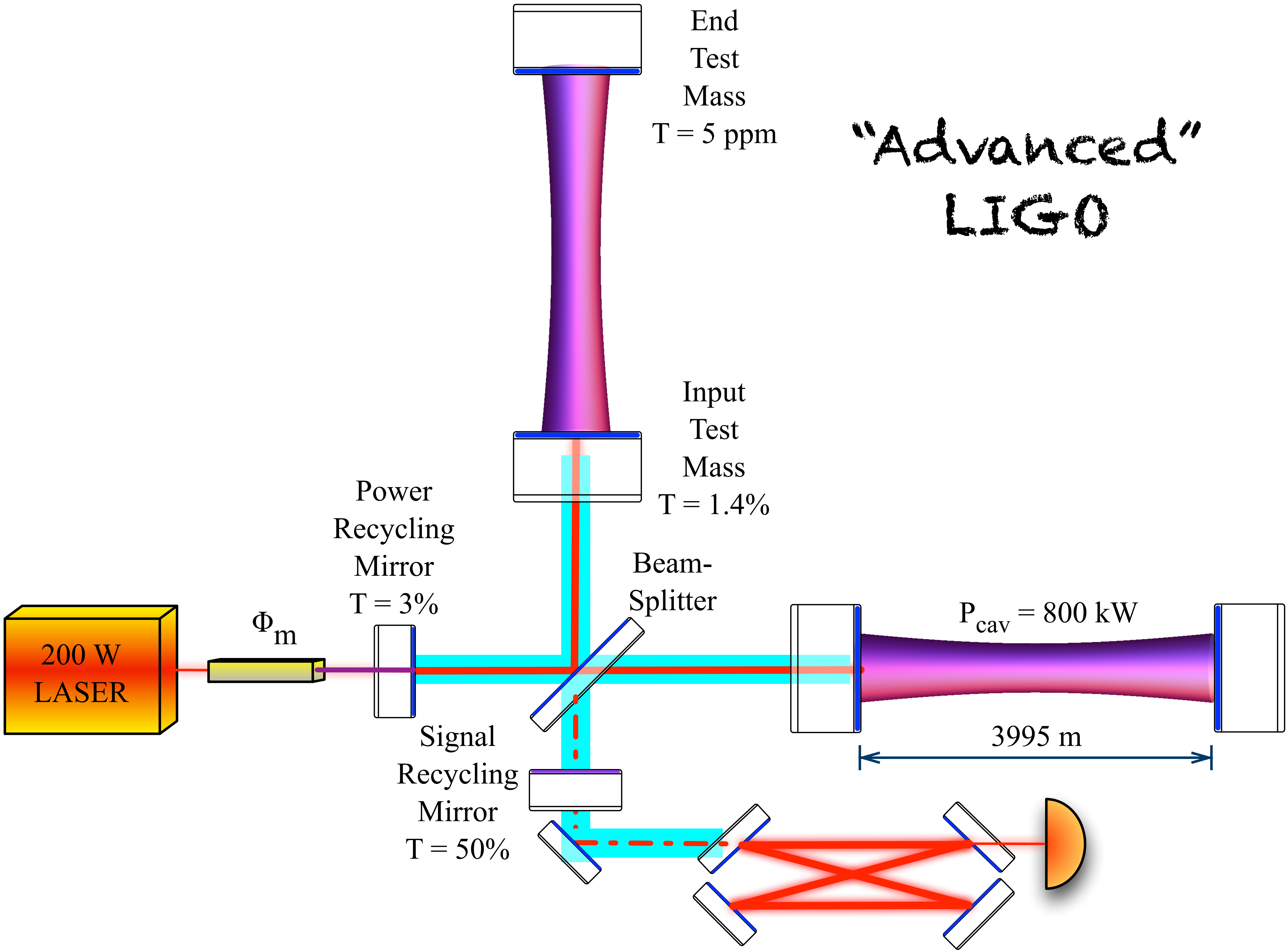
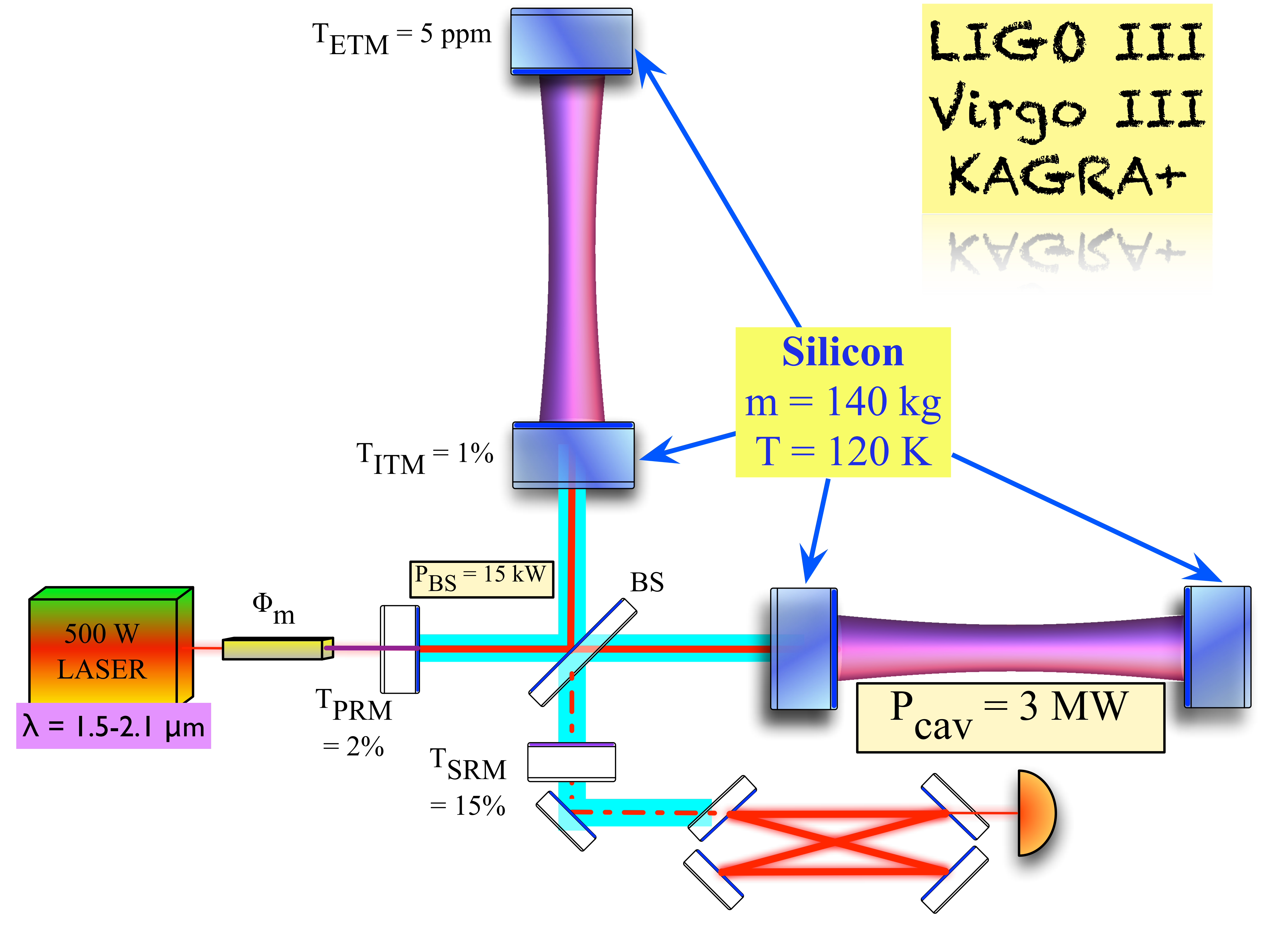
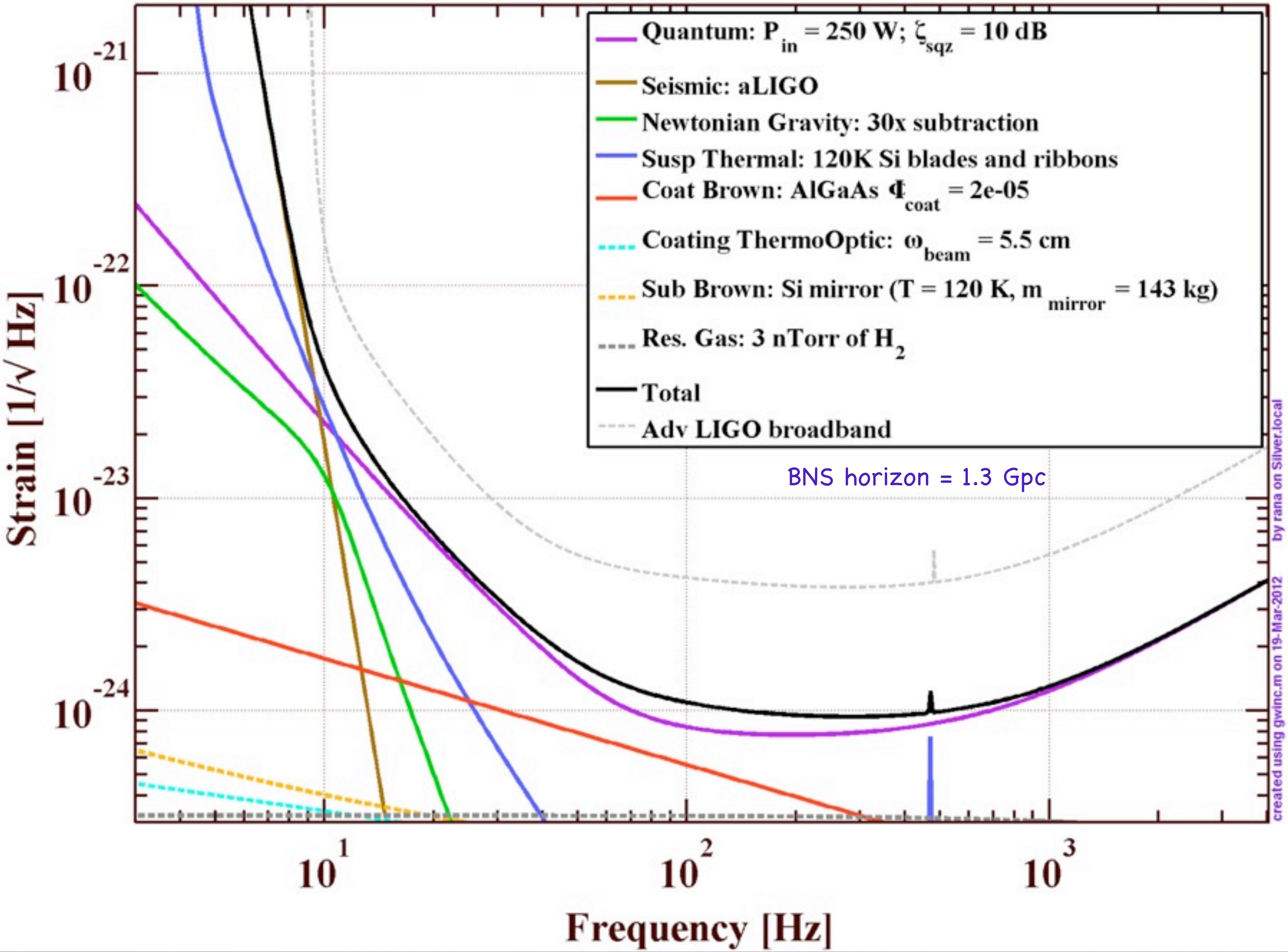

End
Test
Mass
T = 5 ppm
"Advanced"
LIGO
Input
Test
Mass
T = 1.4%
Power
Recycling
Mirror
T = 3%
Beam-
Splitter
Φ_m
200 W
LASER
P_{cav} = 800 kW
Signal
Recycling
Mirror
T = 50%
3995 m



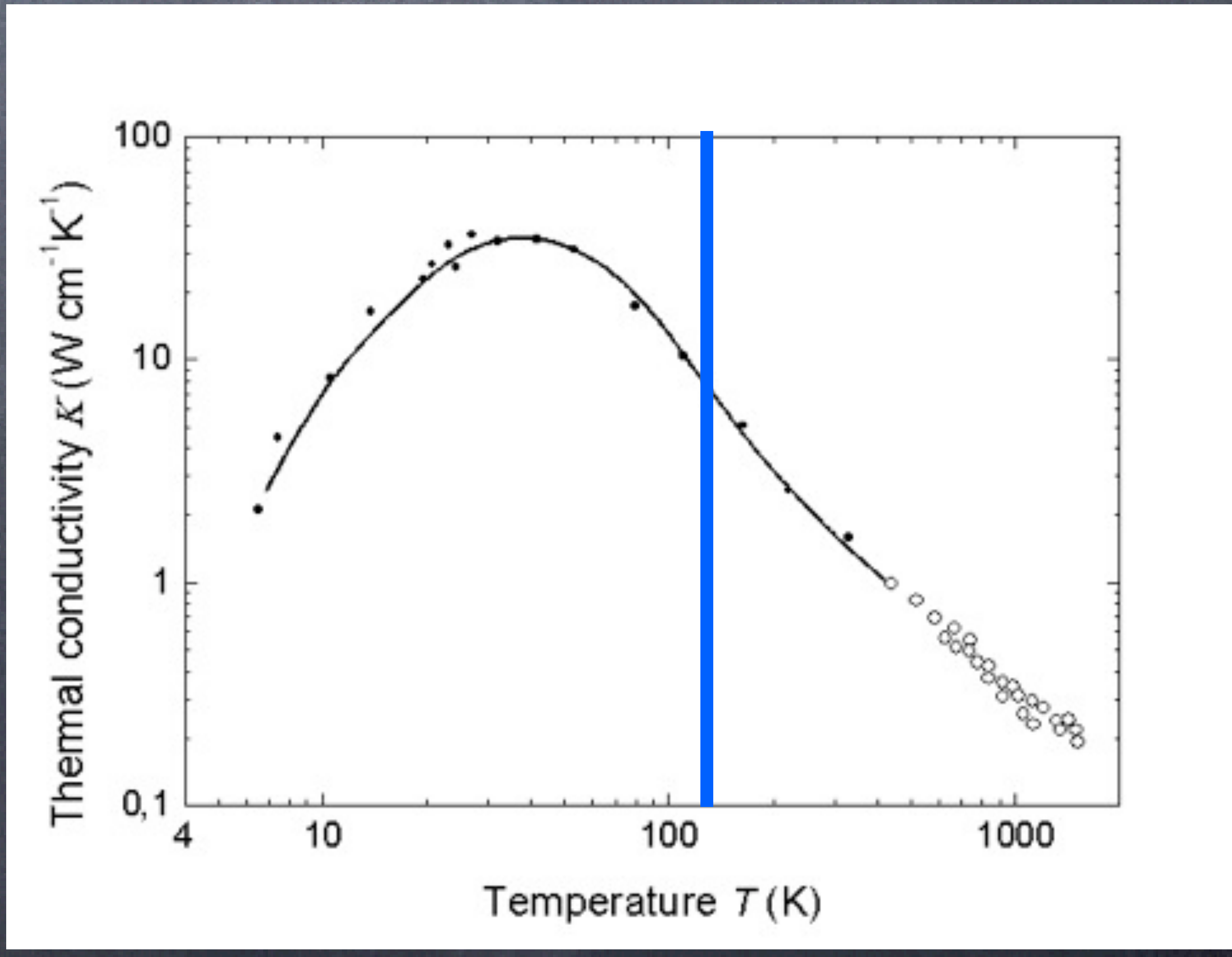
$T_{ETM} = 5$ ppm
LIGO III
Virgo III
KAGRA+
Silicon
m = 140 kg
T = 120 K
$T_{ITM} = 1\%$
$P_{BS} = 15$ kW
BS
Φ_m
500 W
LASER
λ = 1.5-2.1 μm
T_{PRM}
= 2%
T_{SRM}
= 15%
$P_{cav} = 3$ MW



Quantum: P in = 250 W; ζ sqz = 10 dB
Seismic: aLIGO
Newtonian Gravity: 30x subtraction
Susp Thermal: 120K Si blades and ribbons
Coat Brown: AlGaAs Φ coat = 2e-05
Coating ThermoOptic: ω beam = 5.5 cm
Sub Brown: Si mirror (T = 120 K, m mirror = 143 kg)
Res. Gas: 3 nTorr of H 2
Total
Adv LIGO broadband
BNS horizon = 1.3 Gpc
Strain [1/√Hz]
Frequency [Hz]
created using gwinc.m on 19-Mar-2012 by rana on Silver.local

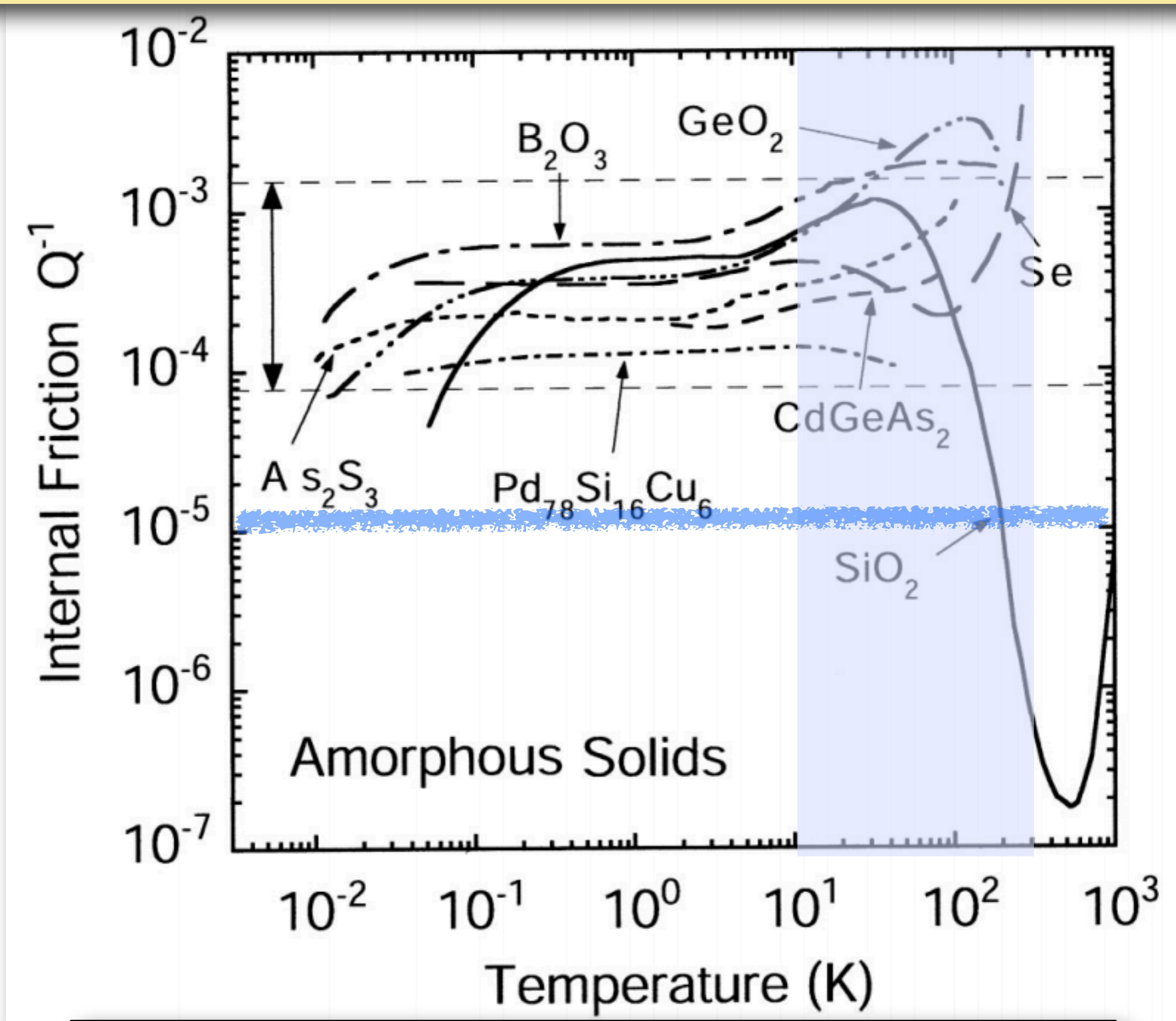
Design Elements

- FD Squeezing Input is the winner
- Coatings: AlGaAs, AlGaP, AlGaN, AlGaSb,...
- Quad SUS w/ Si ribbons on last stage
- 120-160 kg mass: Si @ 119-121 K
- Si: High power (3 MW in arms)
- 1555-2222 nm laser; P = 444 W
- 10-30x Newtonian Noise sub.



Why Crystal Mirror Coatings?

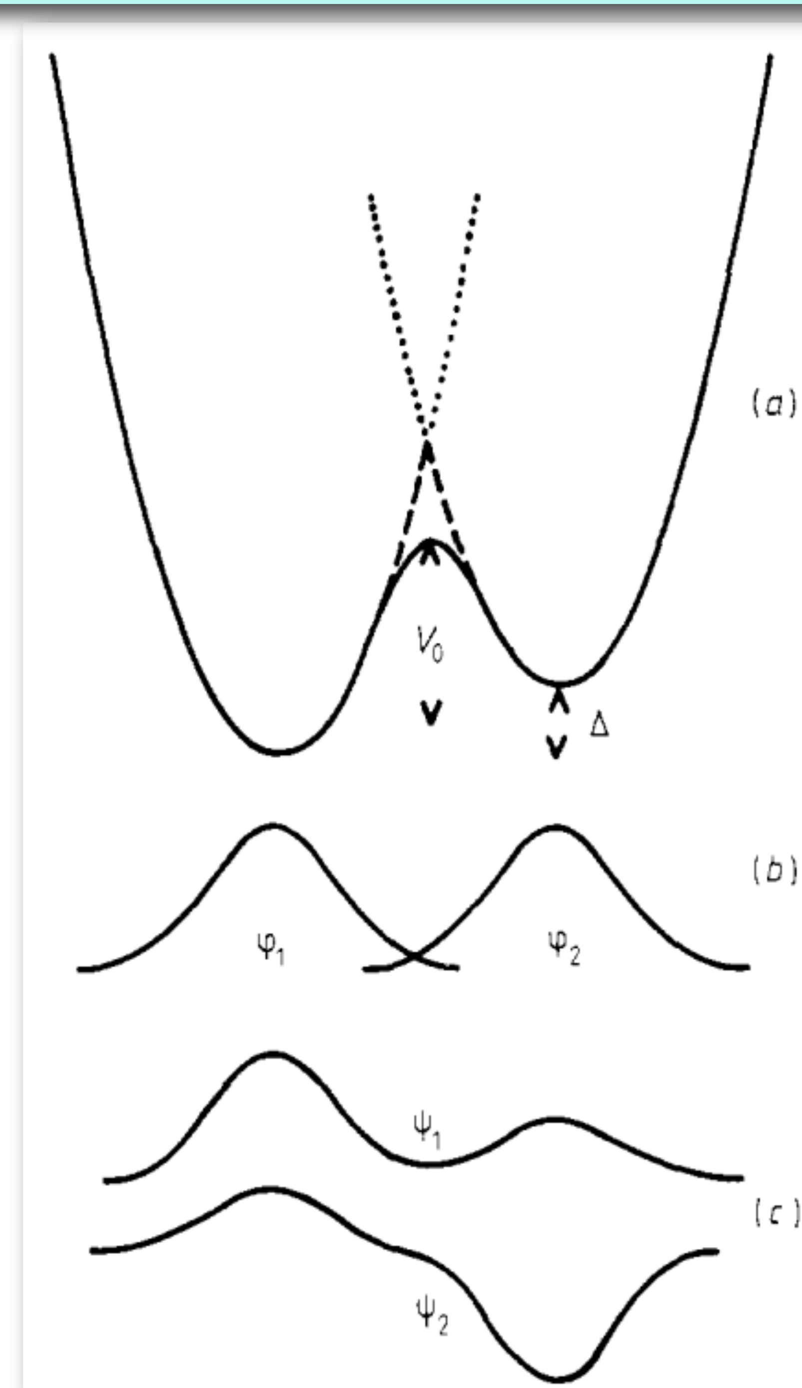
Why a ratio of 10^4 in dissipation?



R.O. Pohl, et al., Rev. Mod. Phys. (2002)

- ***Nearly all high quality optical coatings use amorphous oxides.***
- ***Nearly all amorphous materials have a (low Q) large internal friction.***

2-level tunneling model

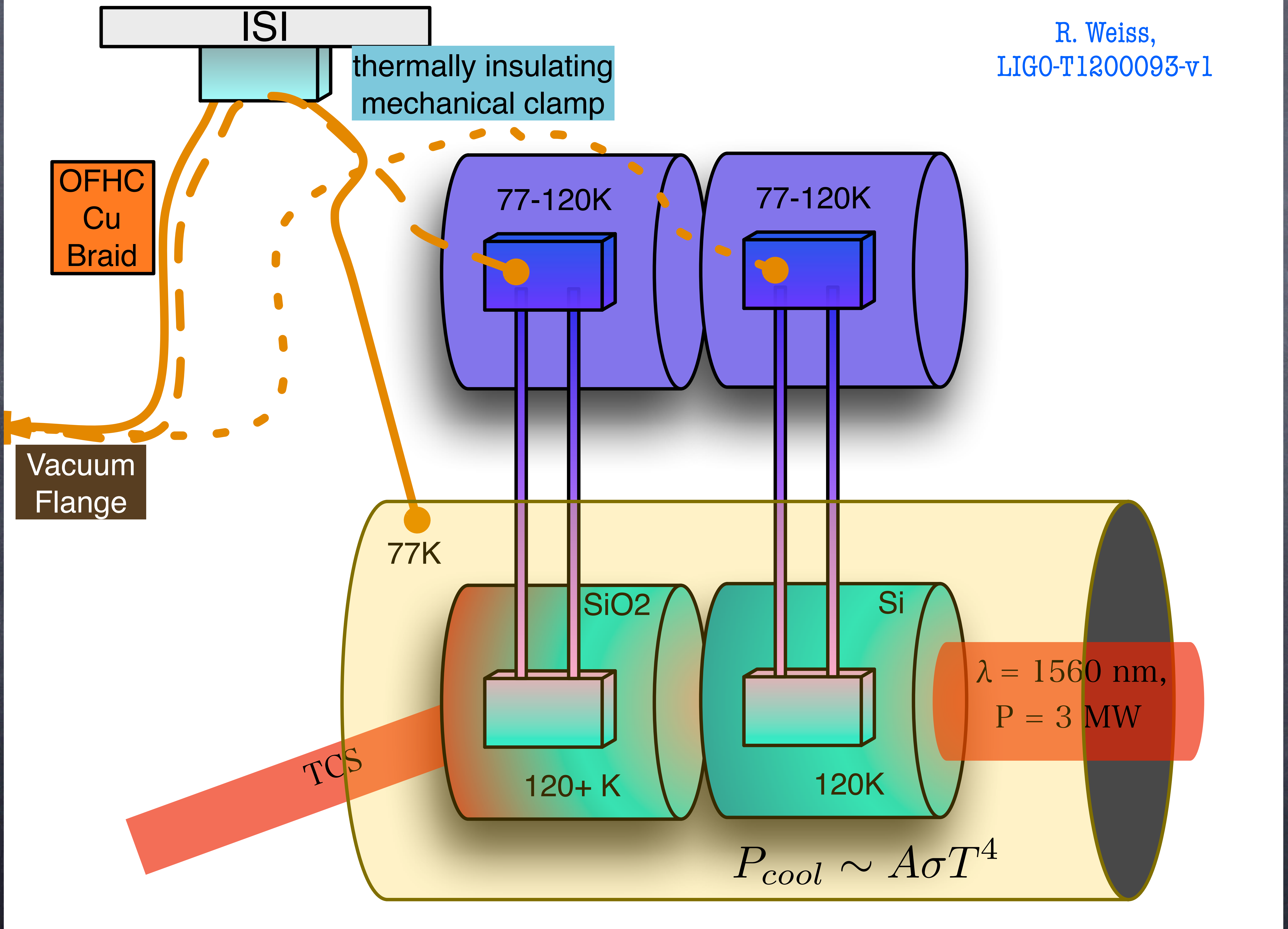


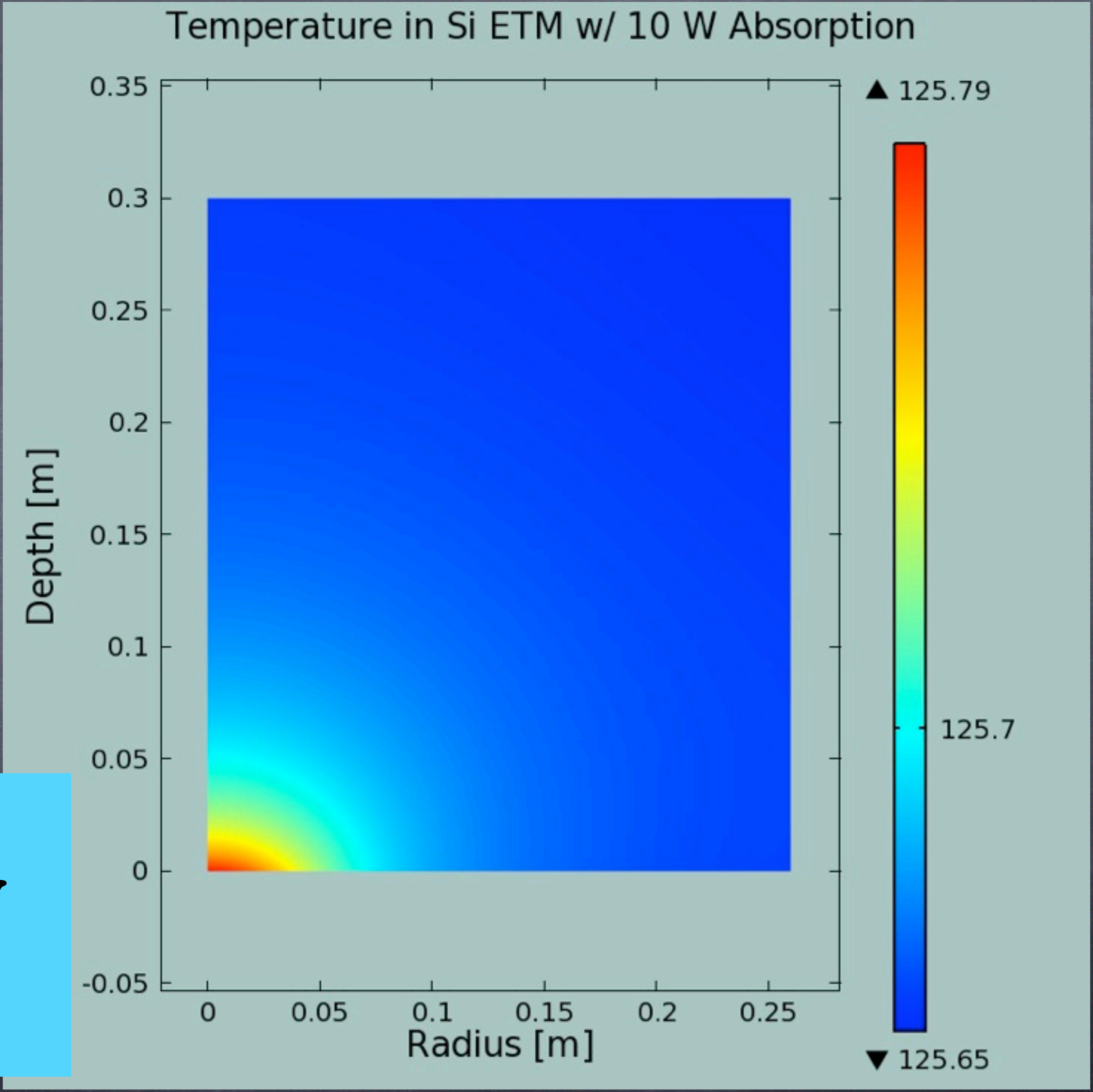
W.A. Phillips, Rep. Prog. Phys. (1987)

Xylophone Concept is totally Wrong

- Xylophone Concept:
  (Cold / Low Power / Low f) ⟷ Low Radiation Pressure
  (Hot / High Power / High f) ⟷ Low Shot Noise
- THE REAL high power limit is thermal distortion: limited by thermal conductivity (k)
- $k_{silica} = 1.4$
  $k_{silicon}$ @ 120 K = 500

150 kg Silicon:
- Sigg/Sidles: OK
- PI: not so bad
- RPN: usual


ISI
thermally insulating mechanical clamp
R. Weiss,
LIGO-T1200093-v1
OFHC Cu Braid
77-120K
77-120K
Vacuum Flange
77K
SiO2
Si
λ = 1560 nm,
P = 3 MW
TCS
120+ K
120K
$P_{cool} \sim A\sigma T^4$



Radiative Cooling Only i.e. no fiber cooling reqd

Juicy Research Opportunities

- Develop Si ribbons & blades
- Need reliable Absorption meas. @ 1500-2000 nm @ 120 K
- AlGaX coatings on Silicon are unproven
- Develop a 500 W laser at 1500-2000 nm
- Cryogenics for 77-130 K
- Si: High power (3 MW in arms)
- 30x Newtonian Noise subtraction