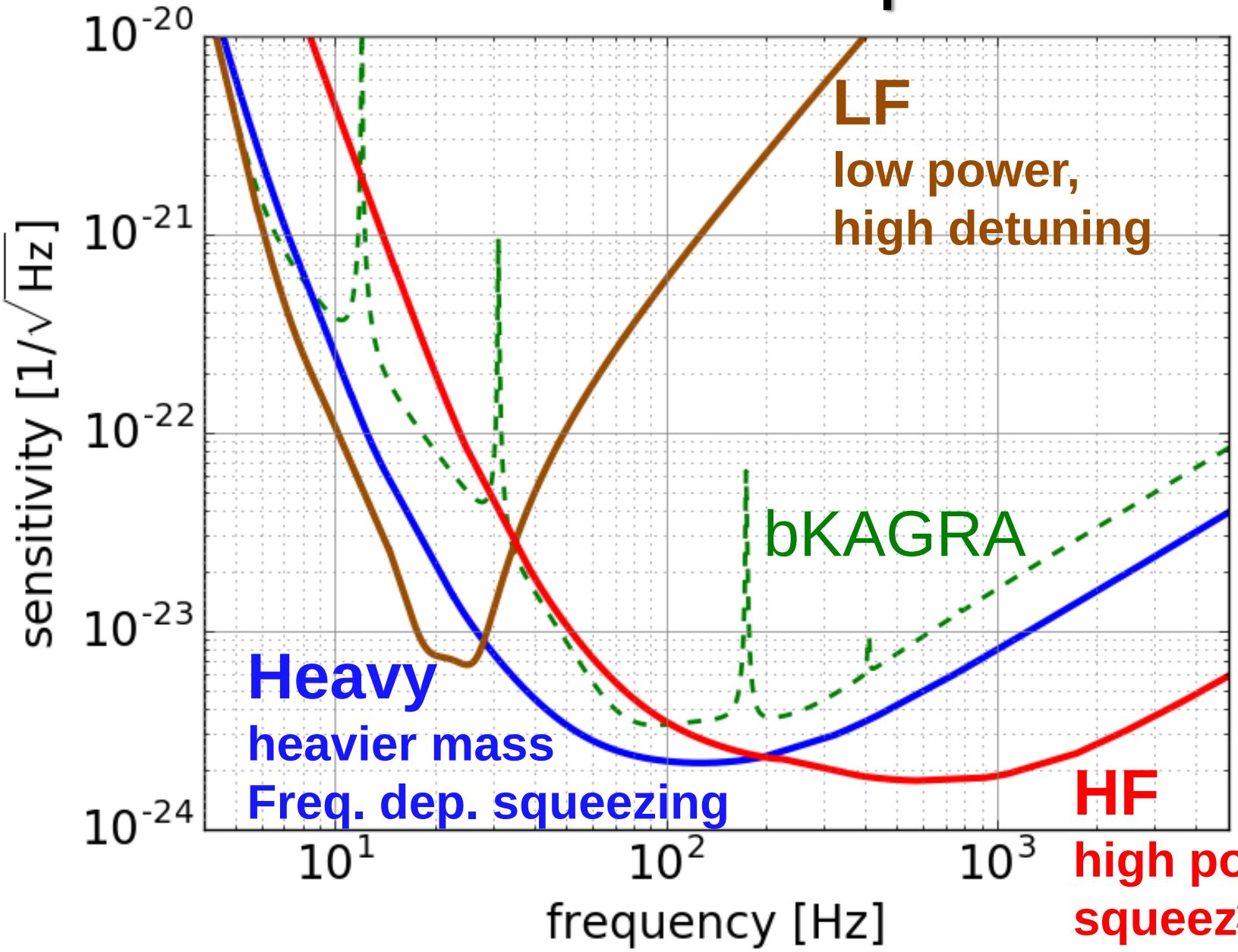
Summary of Issues for KAGRA+

Yuta Michimura

Department of Physics, University of Tokyo

KAGRA+ Concepts



Issues for LF

- Technical excess noises in low frequency
  controls noise
  scattered light
  Newtonian noise …
- Too much scientific focus? (IMBH)

→ a bit more broader band?
  variational configuration?

* Common issue
  Any coating improvement?

Issues for Heavy

- Availability of heavier mass mirror
  sapphire (A-axis? composite mirror?)
  silicon (new issue: laser wavelength)
- Feasibility of heavier mass suspension (~100 kg)
- Feasibility of frequency dependent squeezing at KAGRA site (~100 m filter cavity)

* Common issue
  Any coating improvement?

Issues for HF

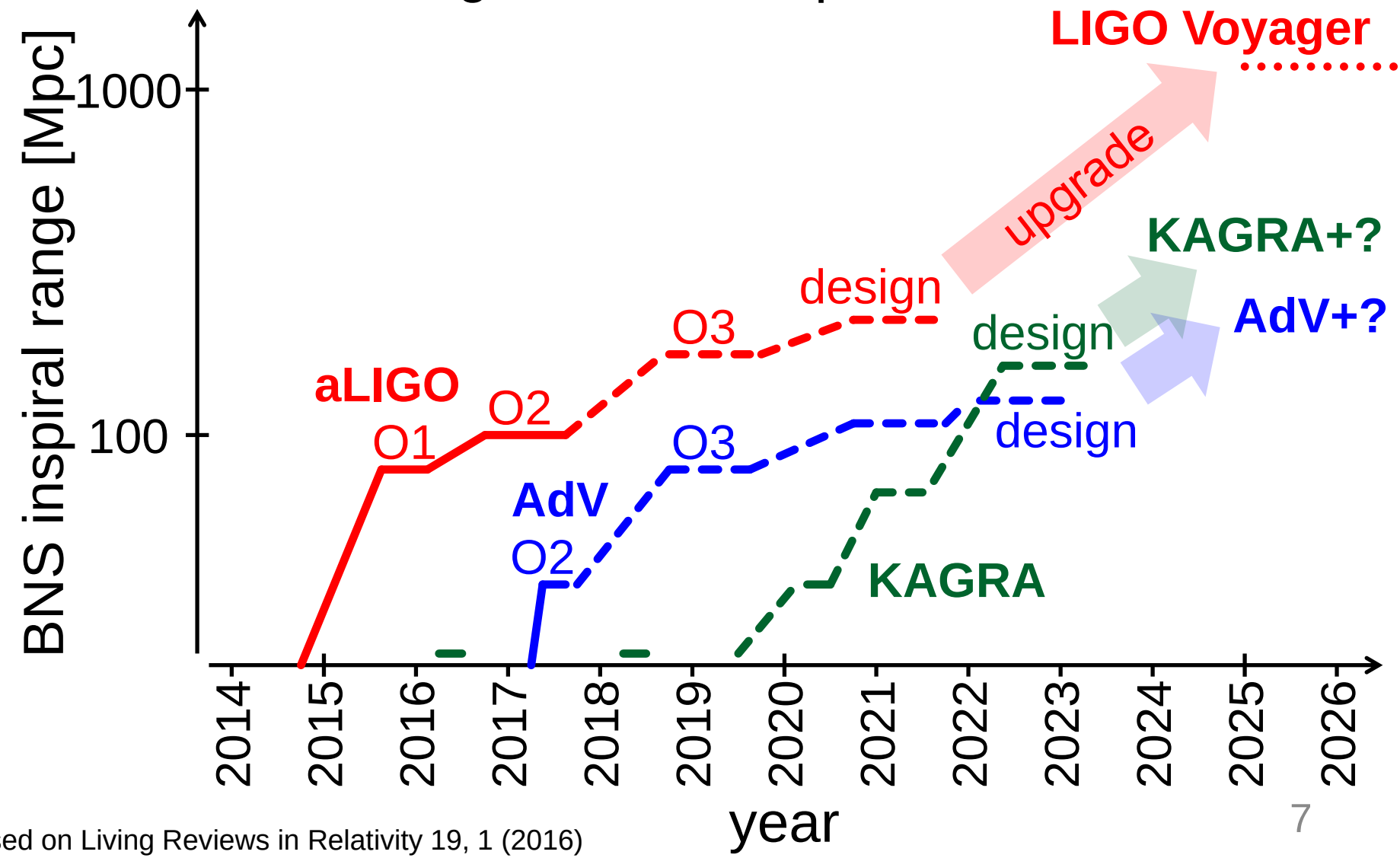
- Availability of high power laser (> ~500 W)
  pre-stabilizing system must be ~kW compatible
- Or higher gain power recycling (> ~100)
- Parametric instability
- Alignment instability (unstable pole at ~5 Hz)
  higher alignment control bandwidth might be OK for HF
- Thermal aberration of the mirror

* Common issue
  Any coating improvement?

Supplementary Slides

Expected Sensitivity Growth

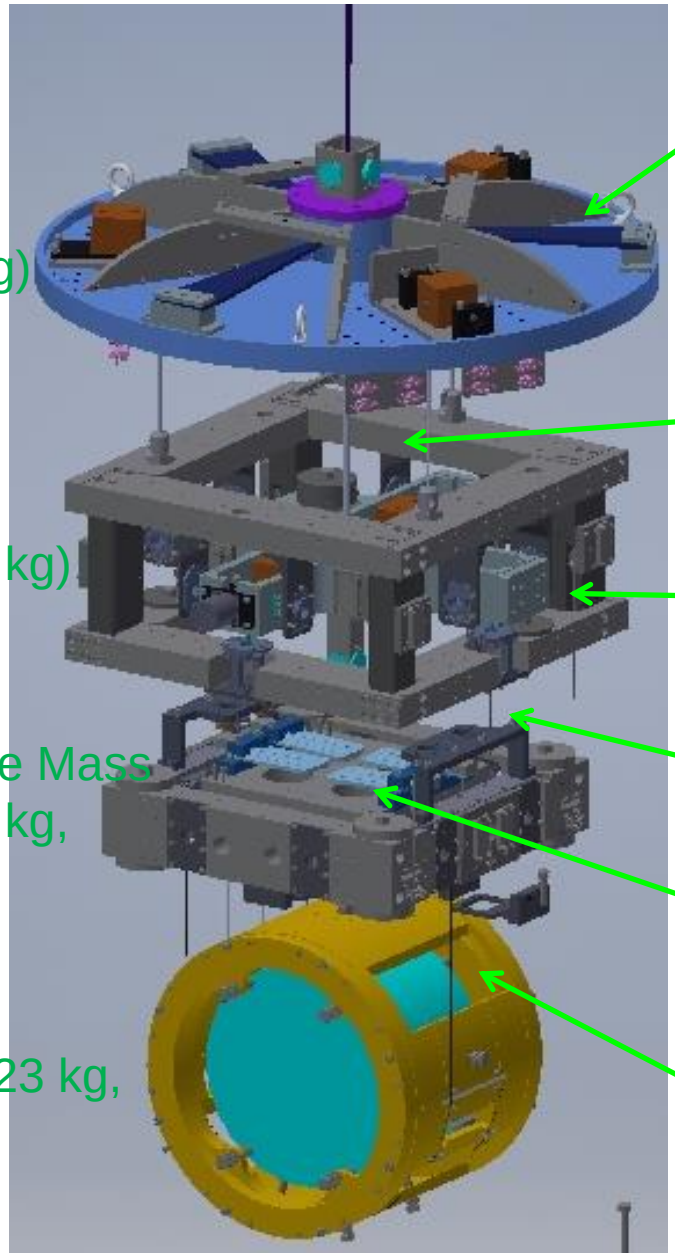
- From Observing Scenario Paper



Based on Living Reviews in Relativity 19, 1 (2016)

KAGRA Cryopayload

Provided by T. Ushiba and T. Miyamoto



Platform
(SUS, 65 kg)

Marionette
(SUS, 22.5 kg)

Intermediate Mass
(SUS, 20.1 kg,
16.3 K)

Test Mass
(Sapphire, 23 kg,
21.5 K)

3 CuBe blade springs

MN suspended by 1 Maraging steel fiber
(35 cm long, 2-7mm dia.)
MRM suspended by 3 CuBe fibers

Heat link attached to MN

IM suspended by 4 CuBe fibers
(24 cm long, 0.6 mm dia)
IRM suspended by 4 CuBe fibers

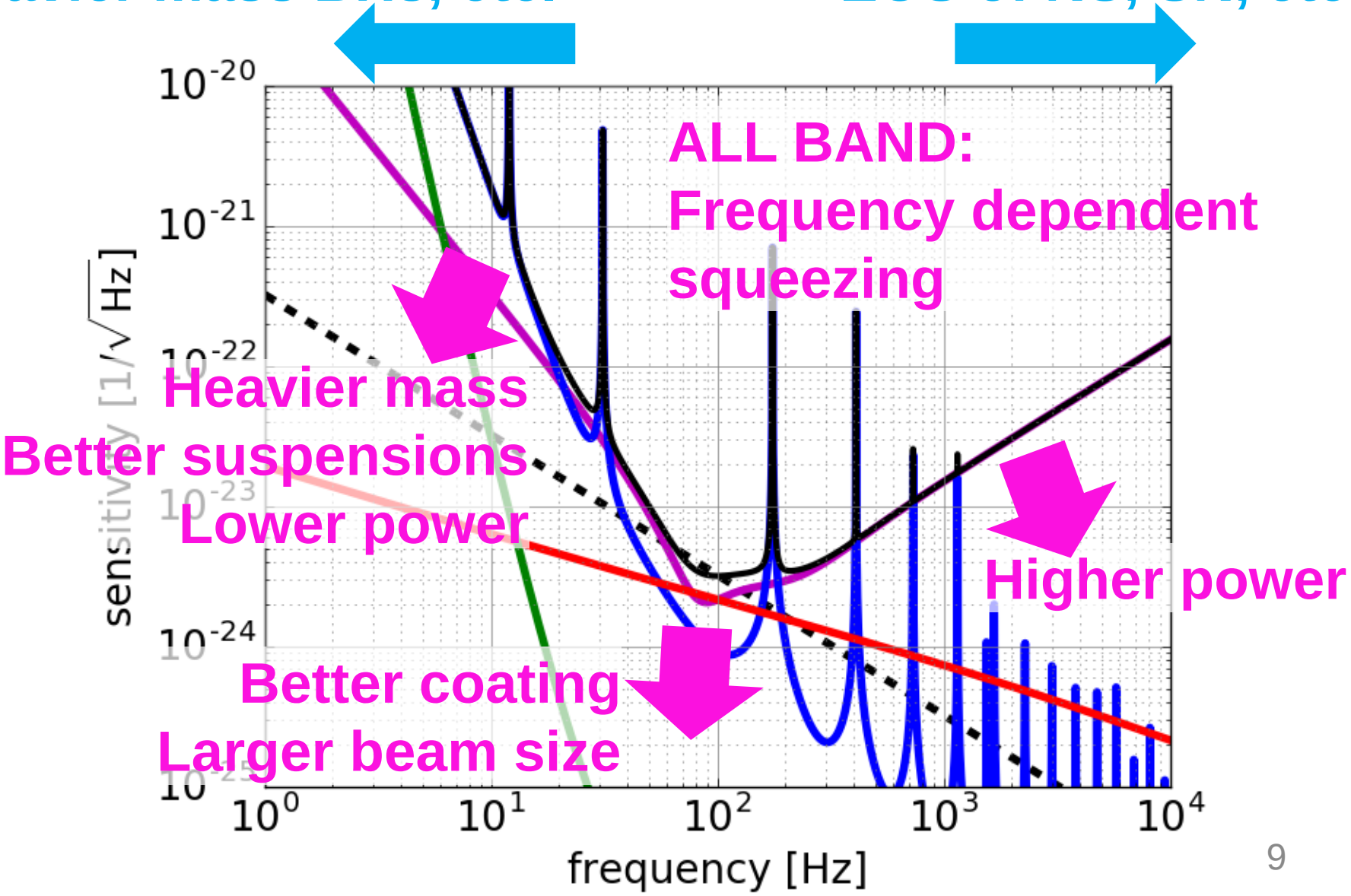
4 sapphire blades

TM suspended by 4 sapphire fibers
(35 cm long, 1.6 mm dia.)
RM suspended by 4 CuBe fibers

Effect in Sensitivity

Heavier mass BHs, etc.

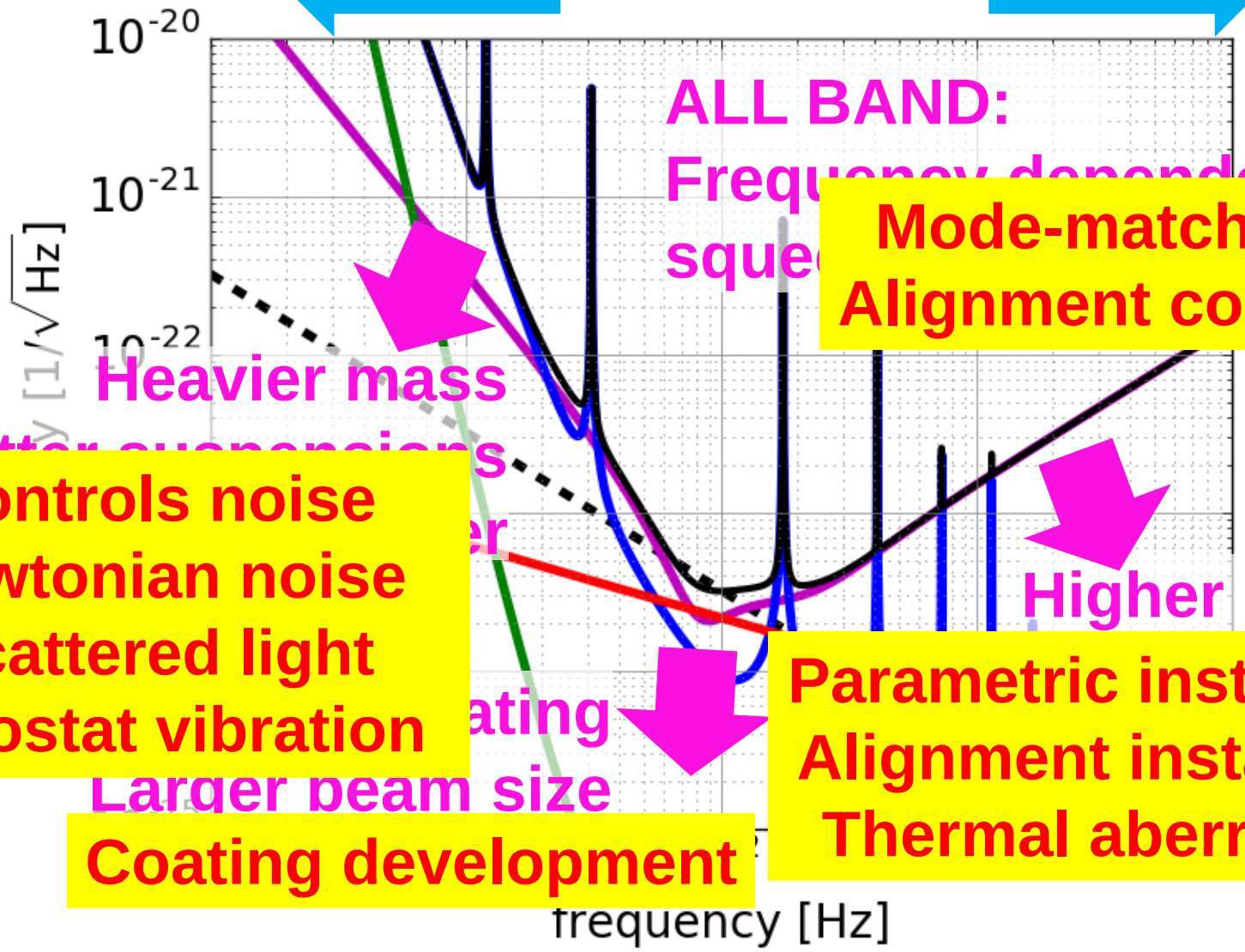
EOS of NS, SN, etc.



Technical Difficulty

Heavier mass BHs, etc.

EOS of NS, SN, etc.



ALL BAND:
Frequency dependent squeezing

Mode-matching
Alignment control

Heavier mass

Controls noise
Newtonian noise
Scattered light
Cryostat vibration

Higher power

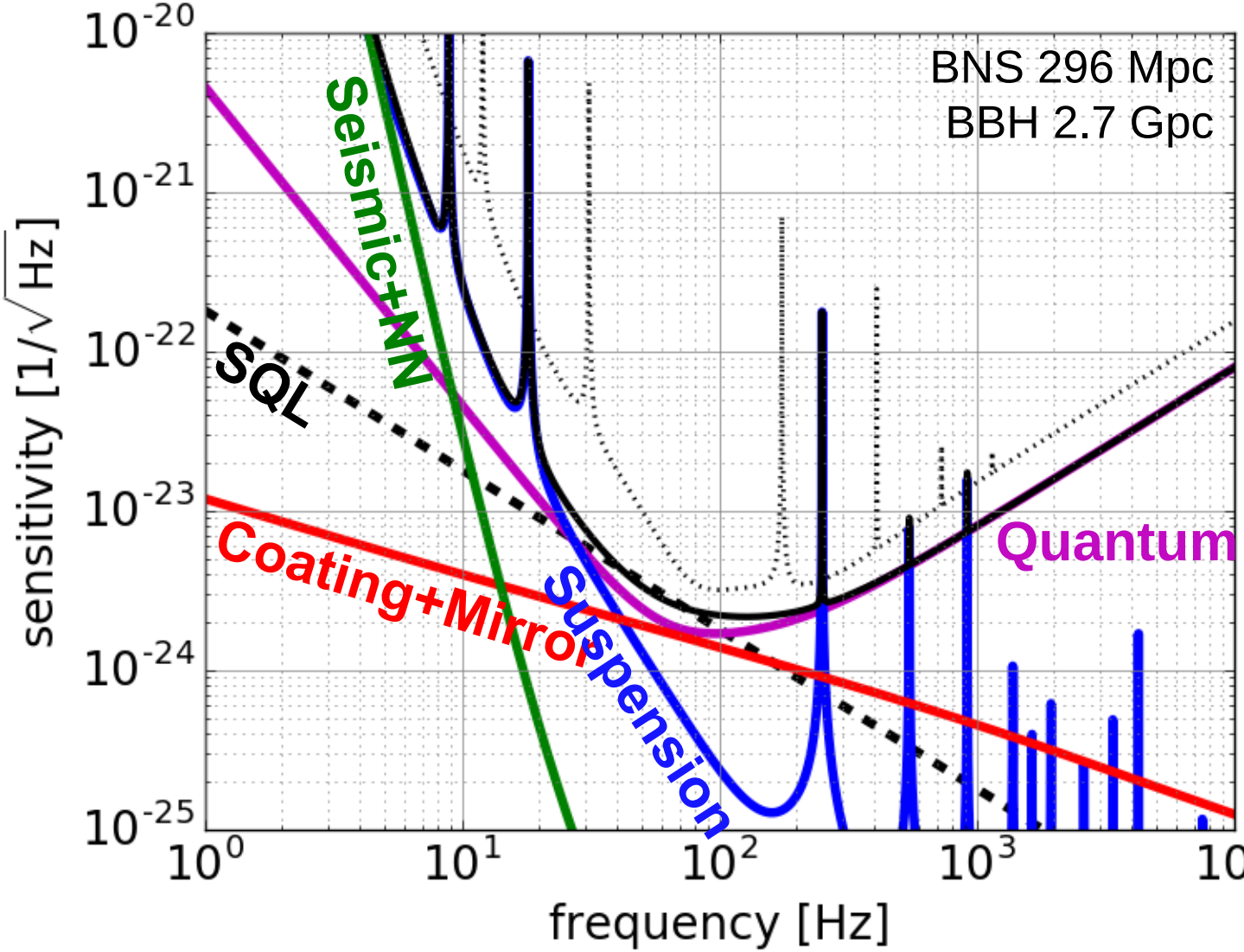
Parametric instability
Alignment instability
Thermal aberration

Larger beam size

Coating development

KAGRA+ Sensitivity: **Blue**

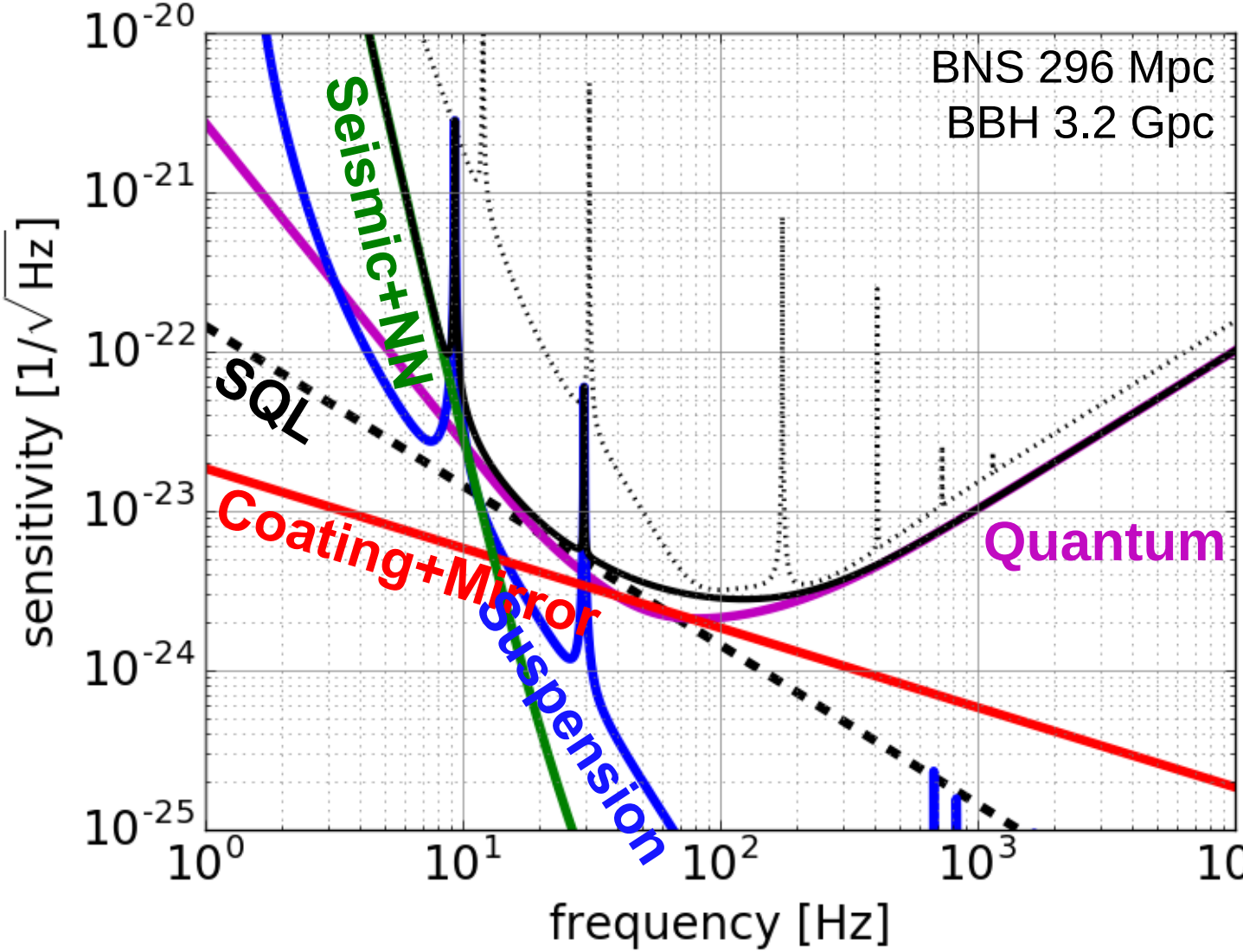
- Heavier sapphire and heavier IM, 20 K



Mass: 73 kg
(36 cm dia.,
18 cm thick)
P_BS: 620 W
Fiber: 35 cm
1.7 mm dia.
φ_susp: 2e-7
φ_coat: 5e-4
r_beam: 5.7 cm
100m F. C.
10 dB input sqz
T_SRM: 32 %

KAGRA+ Sensitivity: **Black**

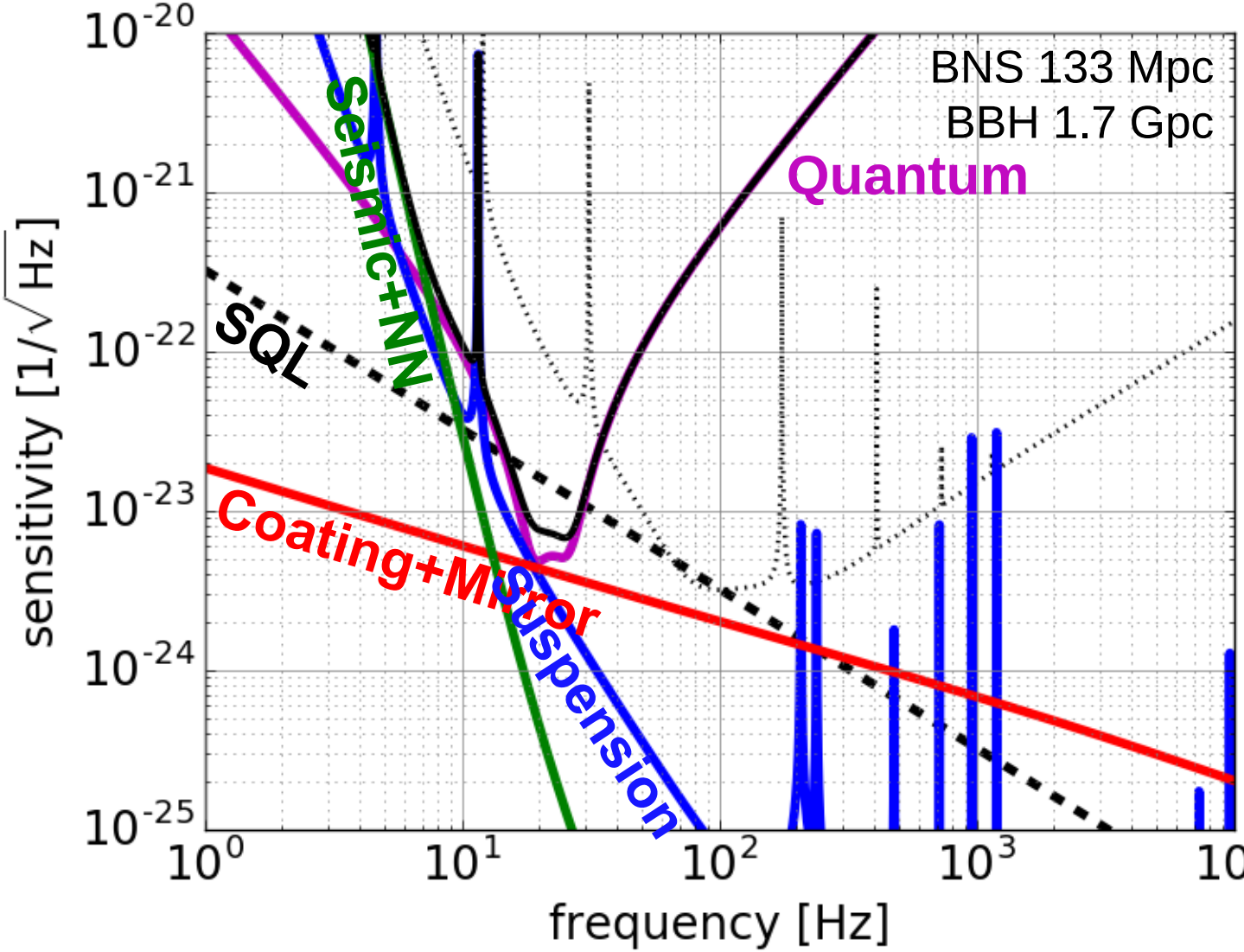
- Silicon 123 K, 1550 nm, radiative cooling



Mass: 114 kg
(50 cm dia.,
25 cm thick)
P_BS: 500 W
Fiber: 30 cm,
0.8 mm dia.
φ_susp: 1e-8
φ_coat: 1e-4
r_beam: 8.6 cm
100m F. C.
10 dB input sqz
T_SRM: 16 %

KAGRA+ Sensitivity: Brown

- Same test mass, low power, high detuning, 20 K

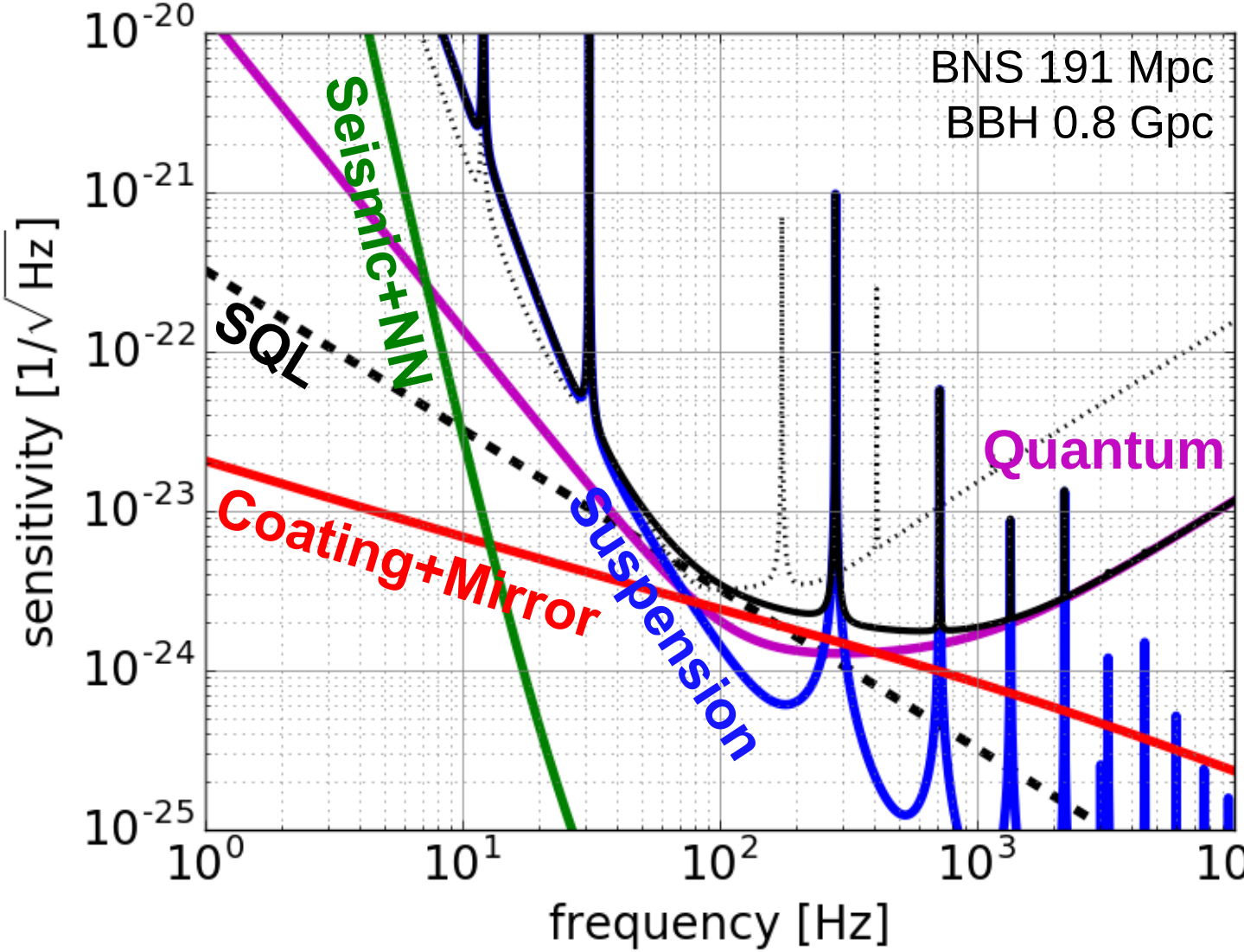


Mass: 23 kg
(22 cm dia.,
15 cm thick)
P_BS: 5.7 W
Fiber: 88 cm,
0.32 mm dia.
φ_susp: 2e-7
φ_coat: 5e-4
r_beam: 3.5 cm
No sqz

T_SRM: 4.35 %

KAGRA+ Sensitivity: **Red**

- Same test mass, high power, 24 K

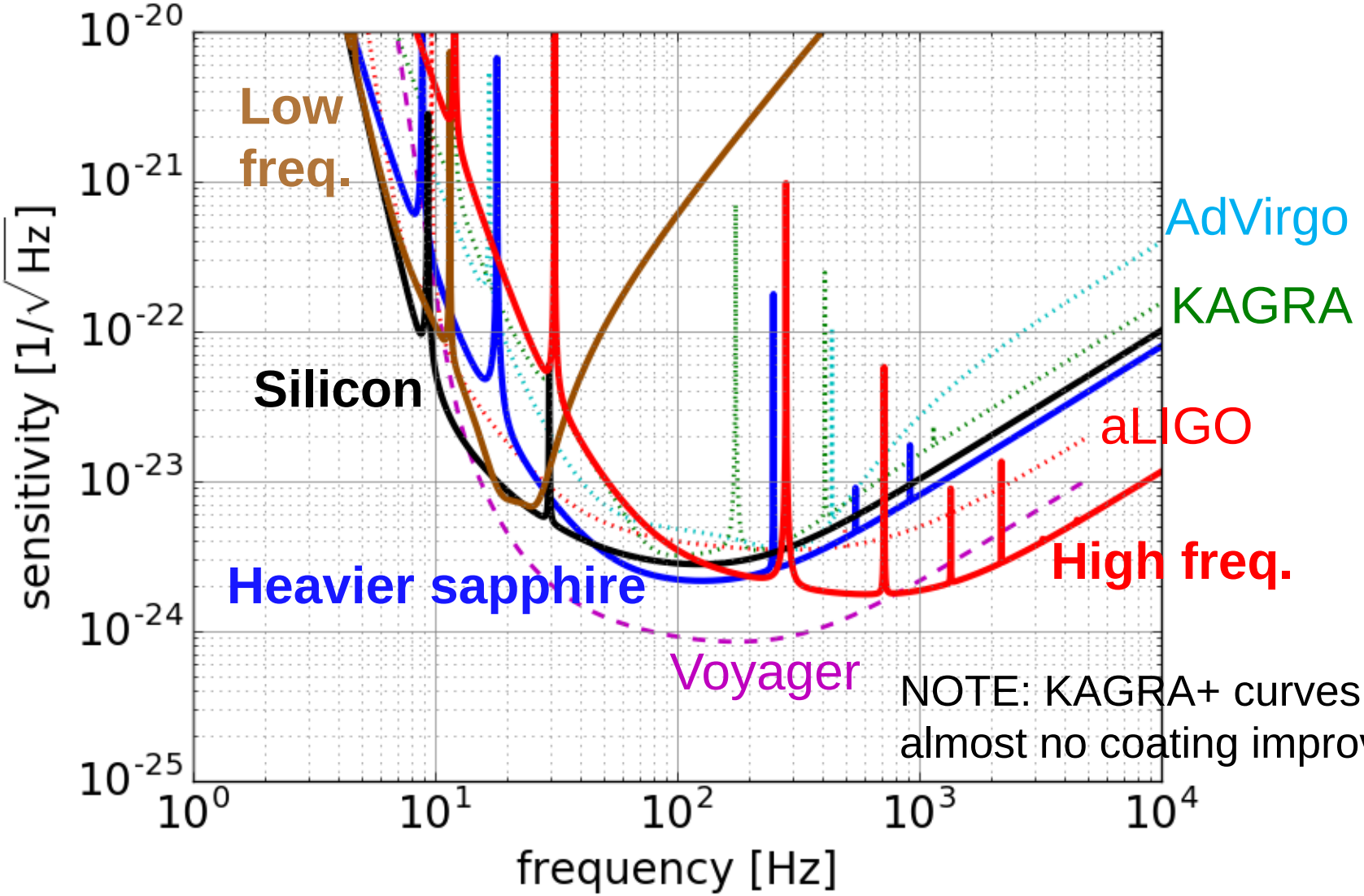


Mass: 23 kg
(22 cm dia.,
15 cm thick)
P_BS: 5.2 kW
Fiber: 20 cm,
2.4 mm dia.
φ_susp: 2e-7
φ_coat: 5e-4
r_beam: 3.5 cm
10 dB input sqz.

T_SRM: 4.94 %

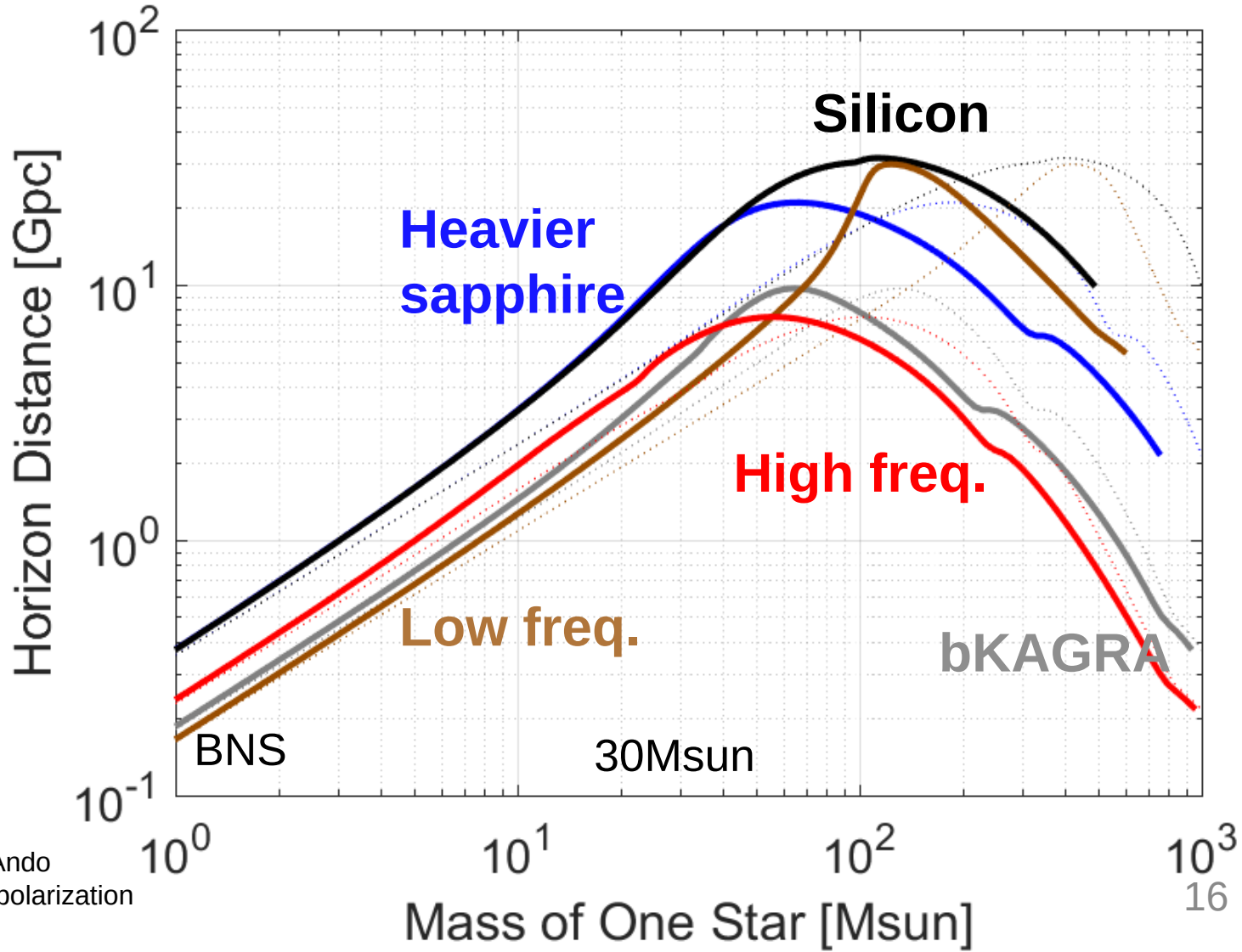
Sensitivity Comparison

- Also feasibility study necessary



Astrophysical Reach Comparison

- Science case discussion is necessary



Code provided by M. Ando
Optimal direction and polarization
SNR threshold 8

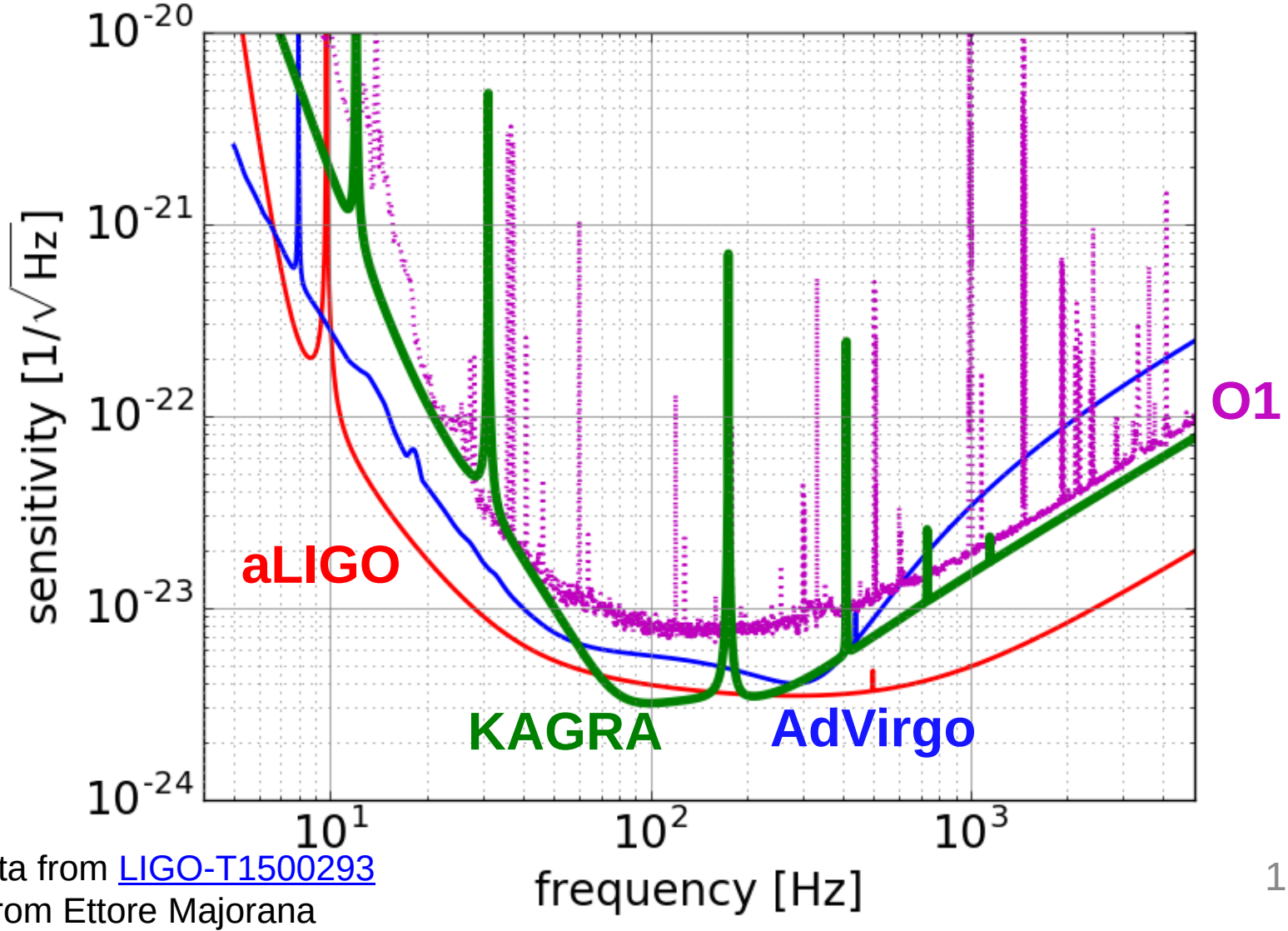
2G/2G+ Parameter Comparison

	KAGRA	AdVirgo	aLIGO	A+	Voyager
Arm length [km]	3	3	4	4	4
Mirror mass [kg]	23	42	40	80	200
Mirror material	Sapphire	Silica	Silica	Silica	Silicon
Mirror temp [K]	22	295	295	295	123
Sus fiber	35cm Sap.	70cm SiO_2	60cm SiO_2	60cm SiO_2	60cm Si
Fiber type	Fiber	Fiber	Fiber	Fiber	Ribbon
Input power [W]	67	125	125	125	140
Arm power [kW]	400	700	710	1150	3000
Wavelength [nm]	1064	1064	1064	1064	2000
Beam size [cm]	3.5 / 3.5	4.9 / 5.8	5.5 / 6.2	5.5 / 6.2	5.8 / 6.2
SQZ factor	0	0	0	6	8
F. C. length [m]	none	none	none	16	300

LIGO parameters from LIGO-T1600119, AdVirgo parameters from JPCS 610, 01201 (2015)

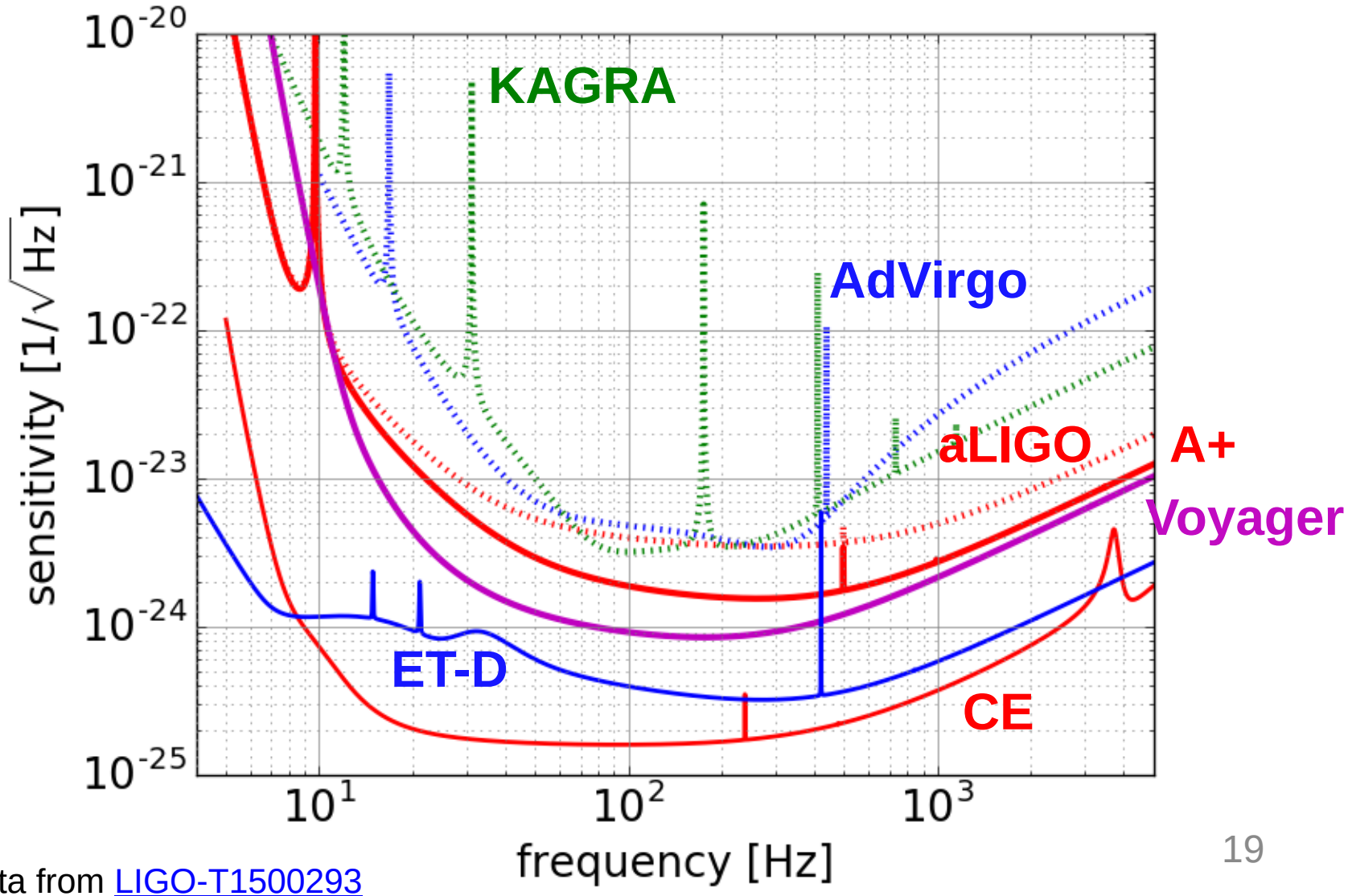
KAGRA vs Other 2G

- Updated AdV sensitivity from [CQG 32, 024001 (2015)]



Spectra data from [LIGO-T1500293]
AdV data from Ettore Majorana

2-3G Sensitivity Comparison



Spectra data from [LIGO-T1500293]