Group 1: No Drag Free Subsystem

(also called the Long Arm systems)

RFI Response Assessment Summary

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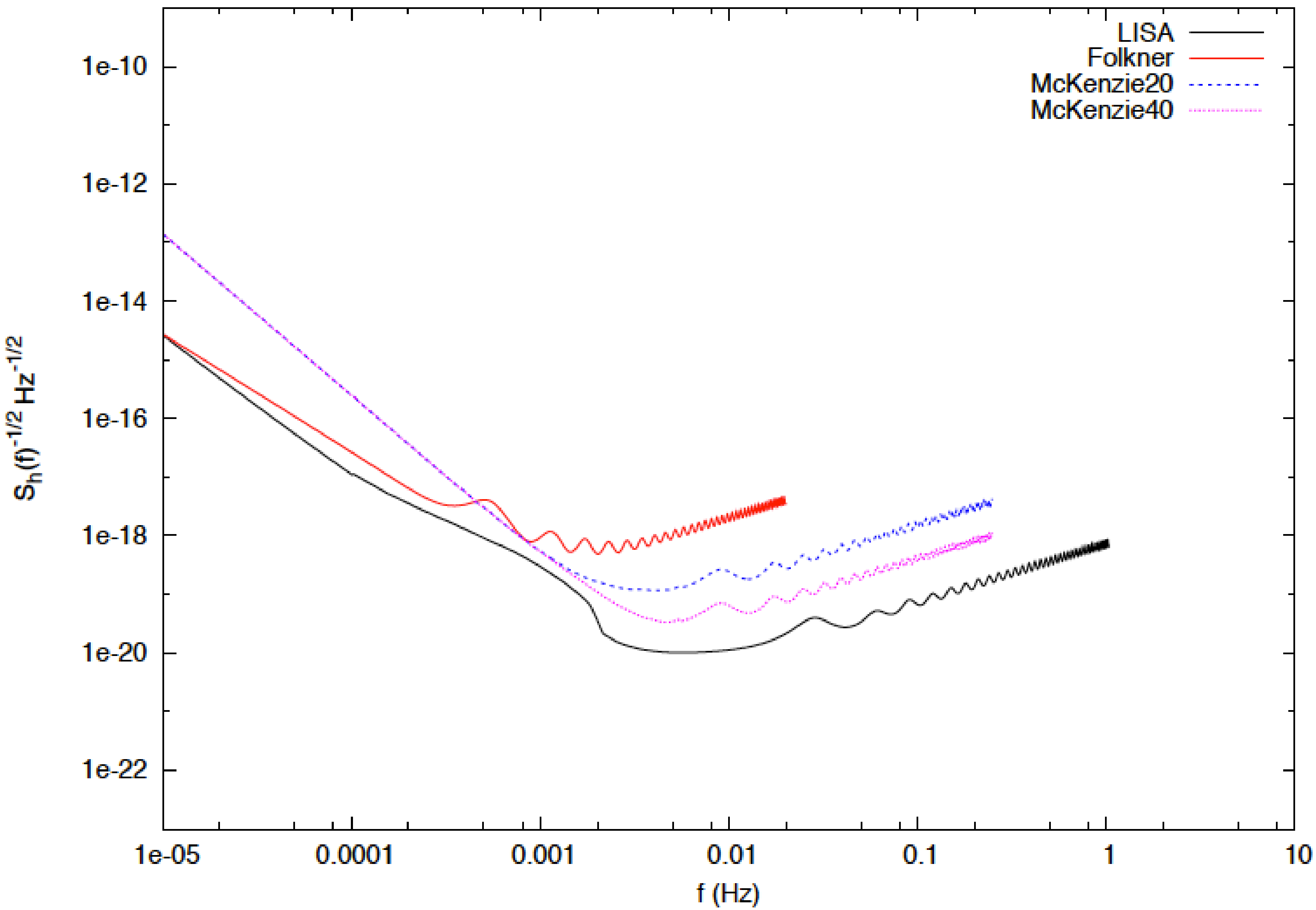
Group 1: No Drag Free

Summary:

	Folkner		LAGRANGE (McKenzie et al)	
	Pro	Con	Pro	Con
Concept	No drag free; extension of GRAIL	Highly accurate measure of solar luminosity/wind, s/c surface temp rqd	No drag-free, clever use of geometry	Highly accurate measure of solar luminosity/wind, s/c surface temp rqd
Science	Three arms/6 links gets polarization info	few MBH's, less sky than LISA, no EMRIs	some MBH's, some EMRIs at 40 cm	less sky than LISA, less polarization (closer to linear)
Payload/ Instrument	Three arms	weak laser signal (50)-2; phase locking with required performance not demonstrated		somewhat weaker laser system, opening angle, 2 types of payload, no 3rd arm
Spacecraft	simple	comm is harder	simple, comm is relatively easy	2 non-identical payloads
Mission design		long cruise phase, high doppler rate	easy	Requires station-keeping
Ops		data rate	comm	
Risk	No drag free	can't test spurious effects		can't test against spurious effects, but can calibrate
Readiness	No Drag Free	New sensors	no drag free	New sensors
Cost	No drag Free subsystem	Long transfer time and associated prop cost, including substantial maneuvering	no drag free subsystem	Two s/c types

Group1: No Drag Free

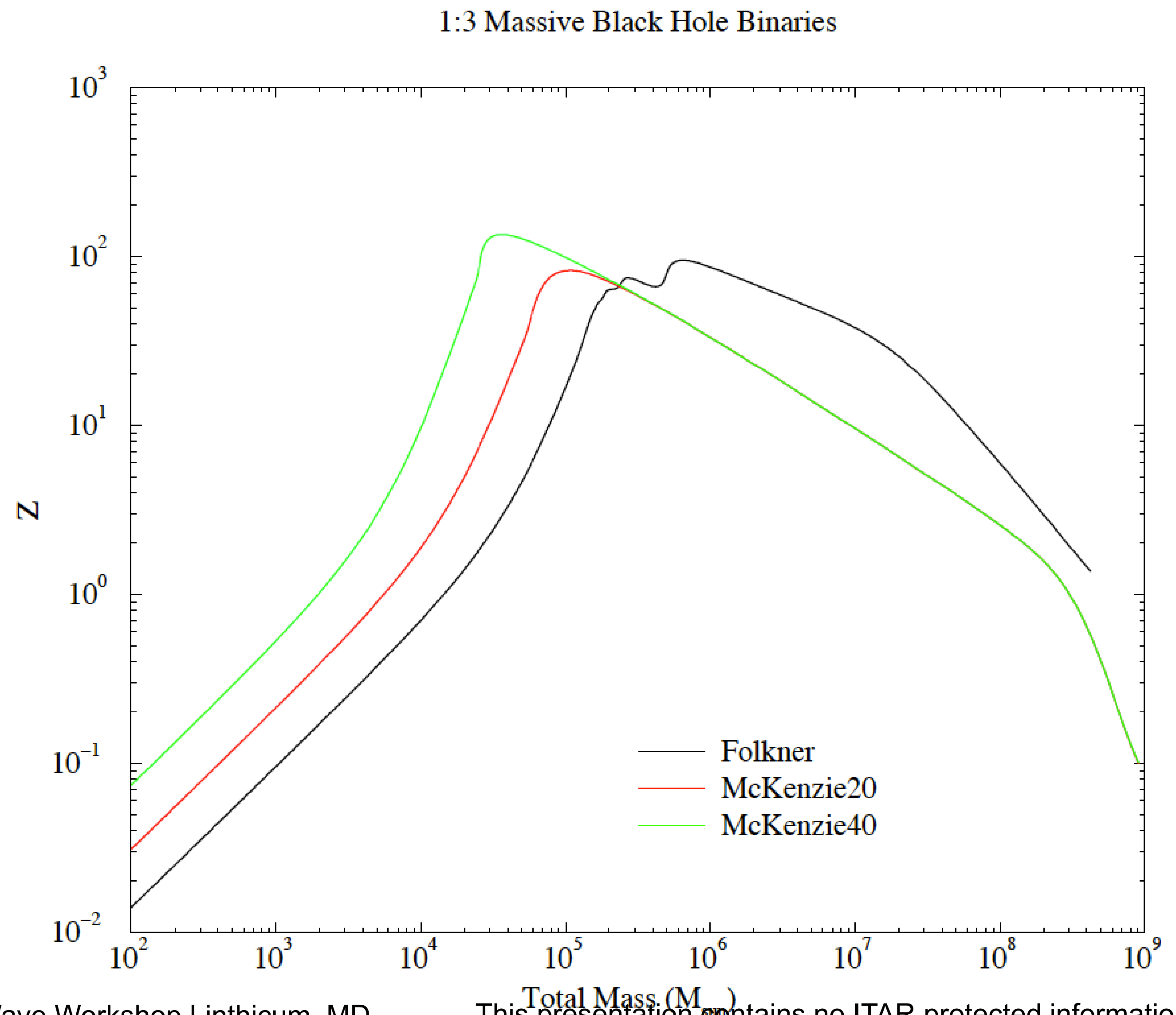


Group 1 Science Assessment Summary

Decadal-endorsed

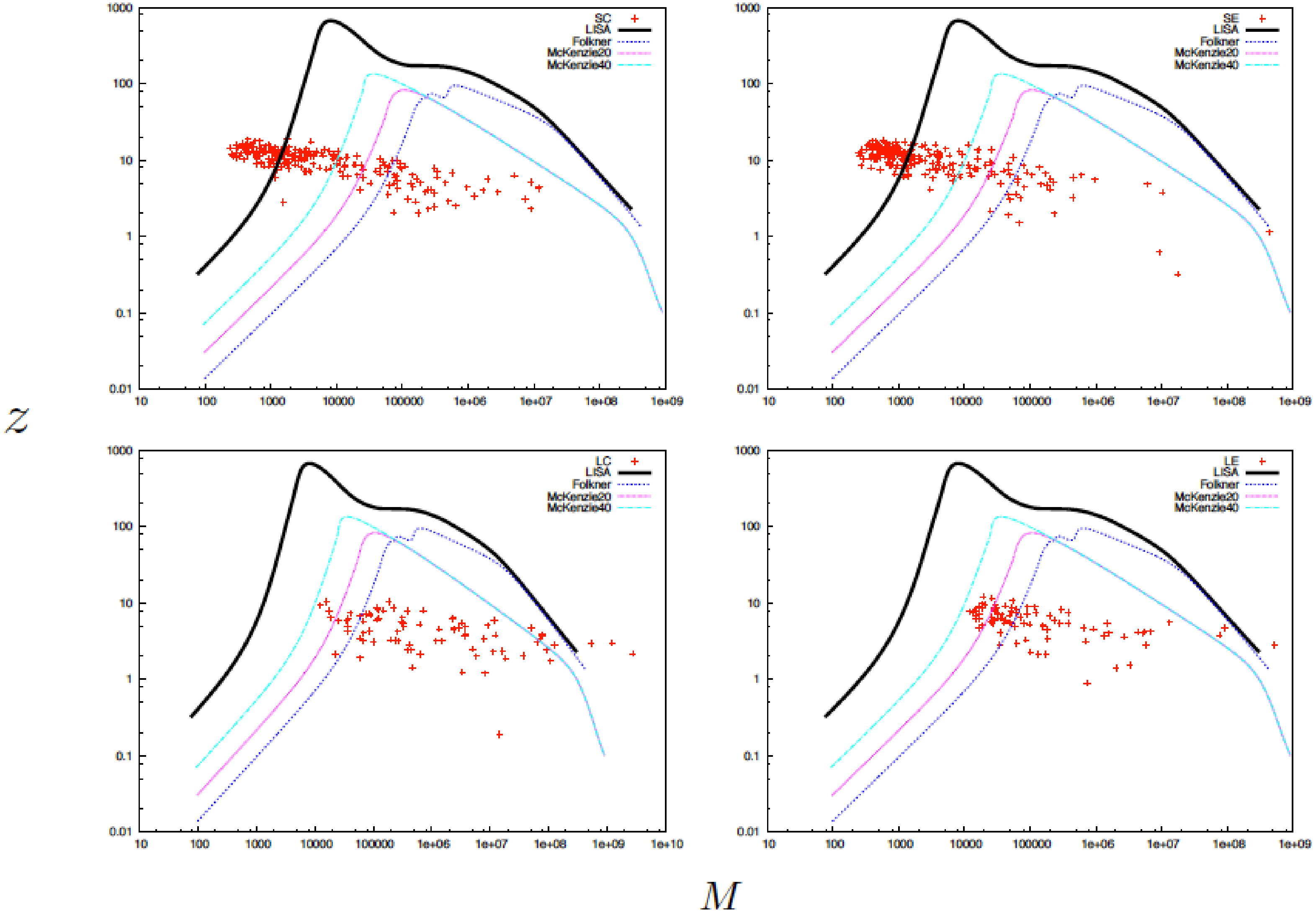
Category	Units	Folkner	LAGRANGE/ McKenzie20	LAGRANGE/ McKenzie 40	SGO-High
Massive BH - SS	events/year	10	14	20	42
Massive BH -LS	events/year	14	18	21	23
EMRI	events	0	0	8	800
Discovery Space	SGO-High = 1	0.02	0.04	0.18	1
WD-WD Detections		300	300	4000	25000

Group 1 MBHB Horizons



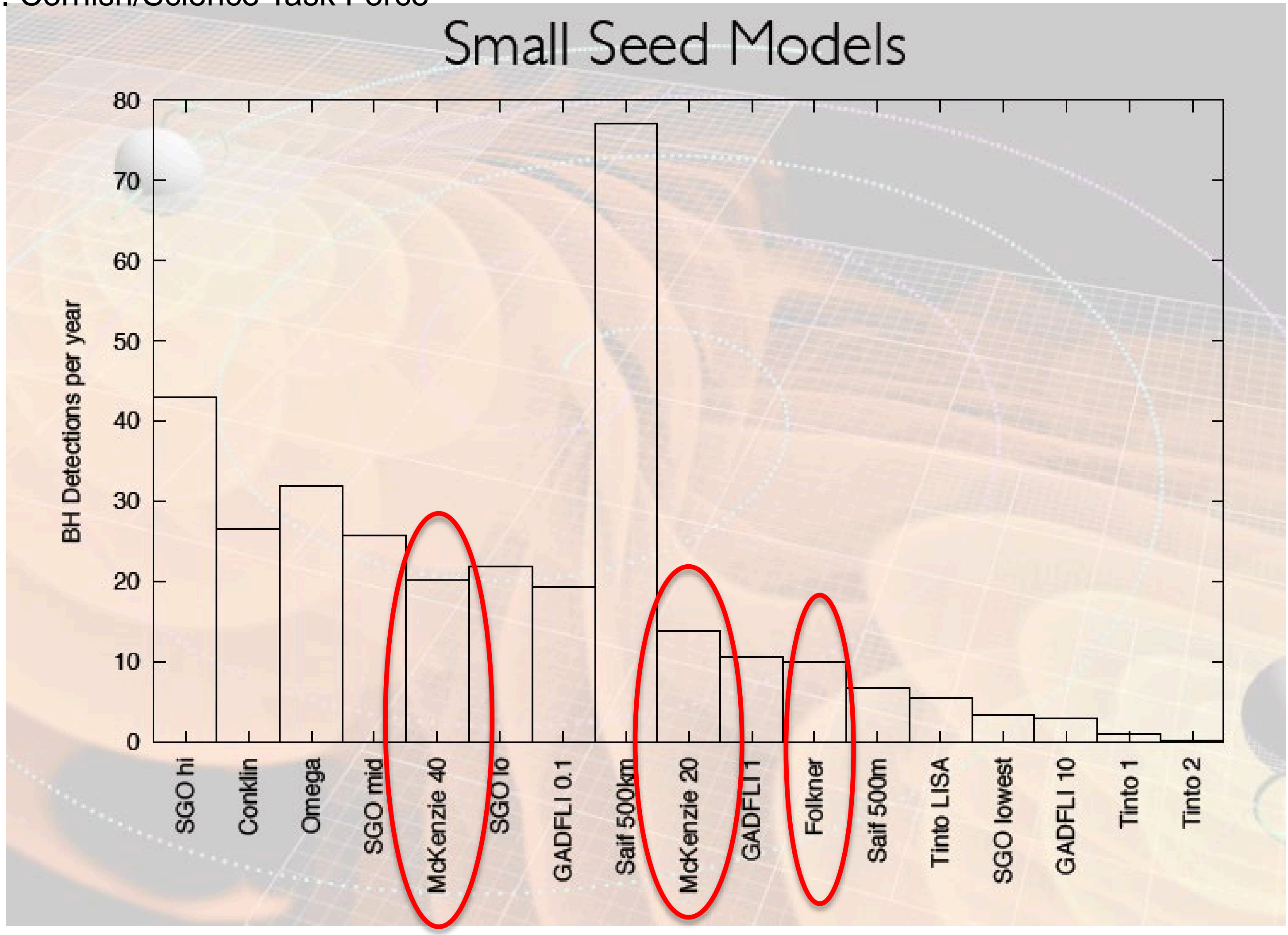
Group 1: Massive BH Horizons

From N. Cornish/Science Task Force



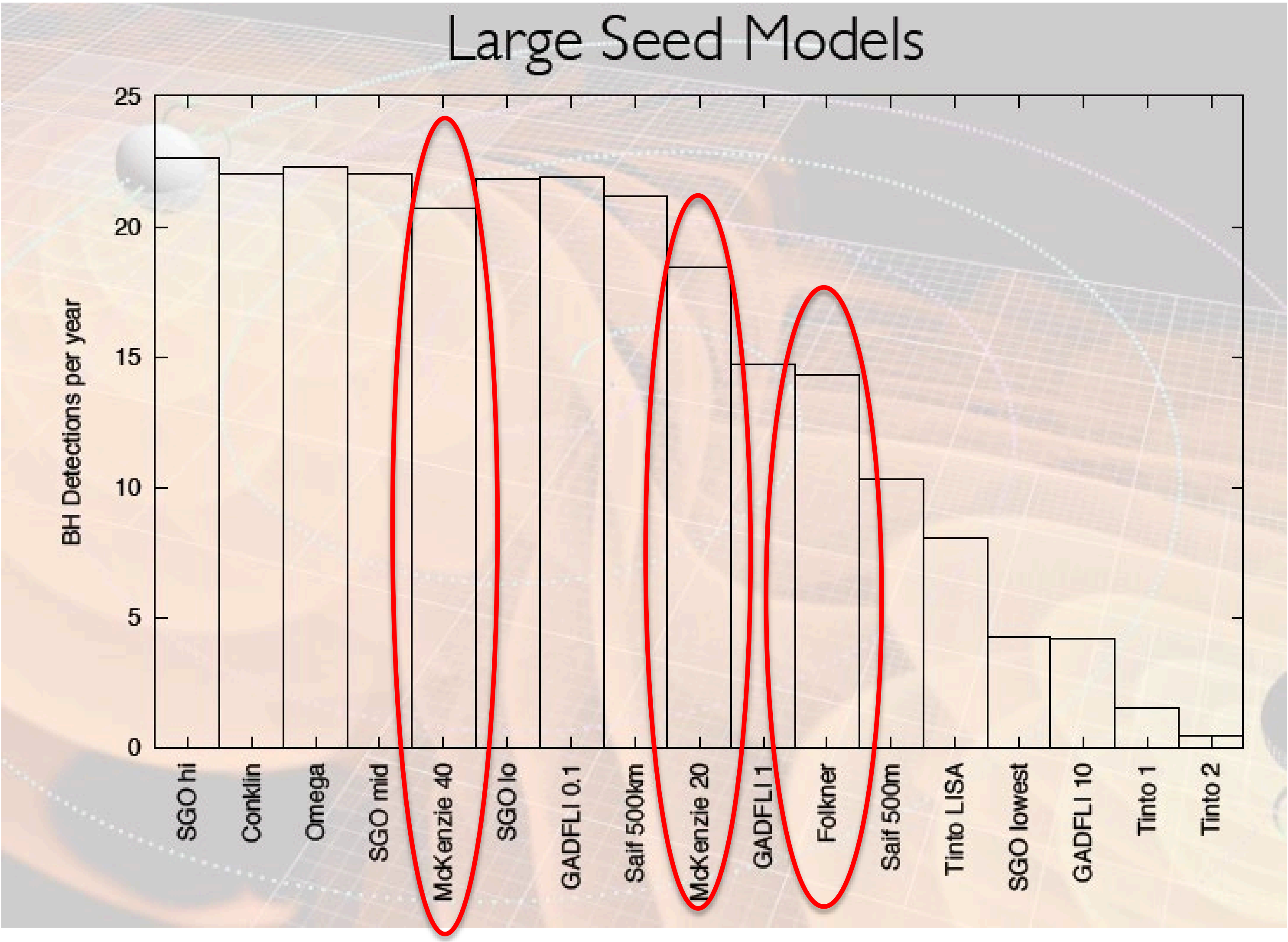
Group 1 Massive BH Detections

From N. Cornish/Science Task Force

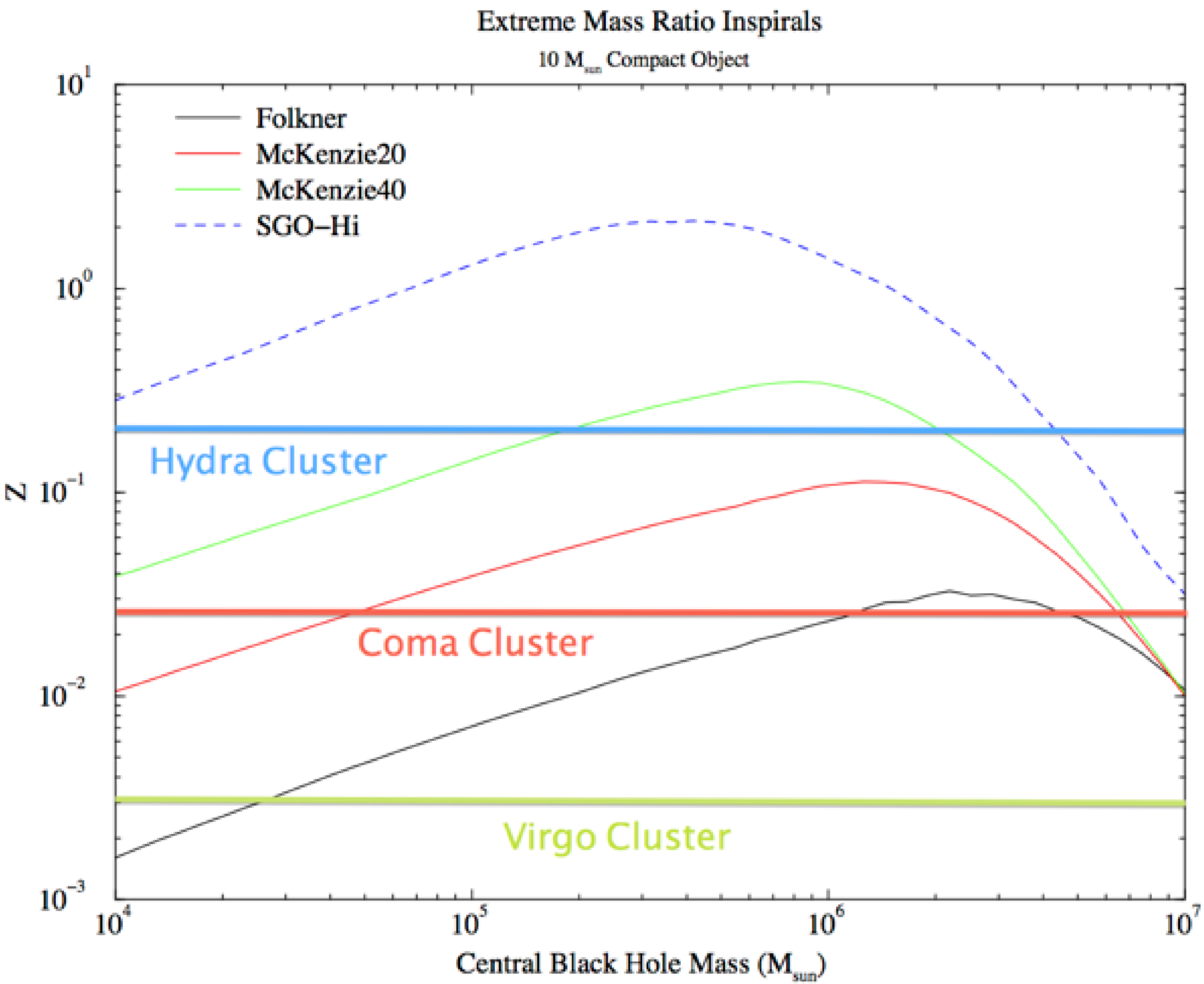


Group 1 Massive BH Detections

From N. Cornish/Science Task Force

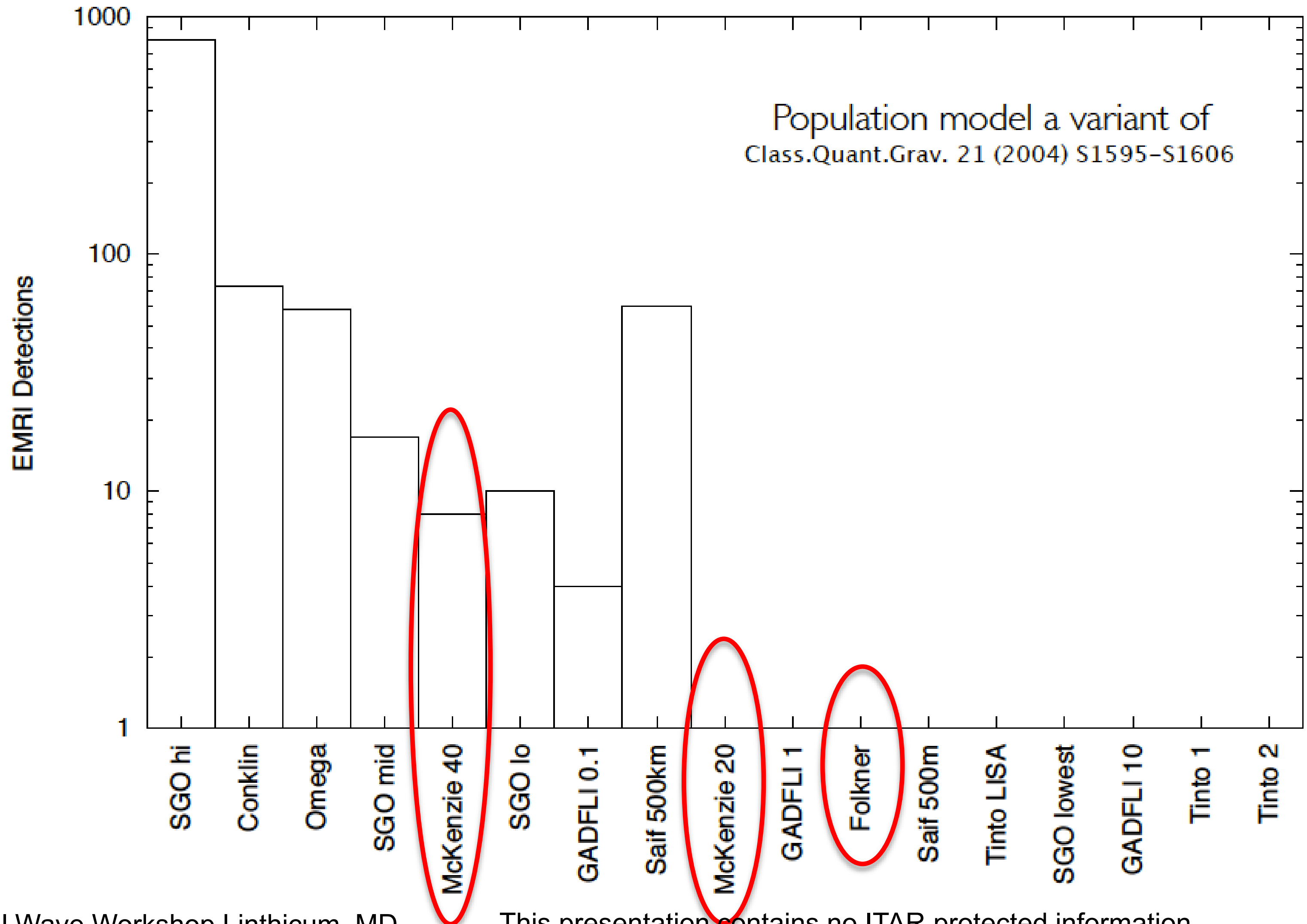


Group 1: EMRI Horizons

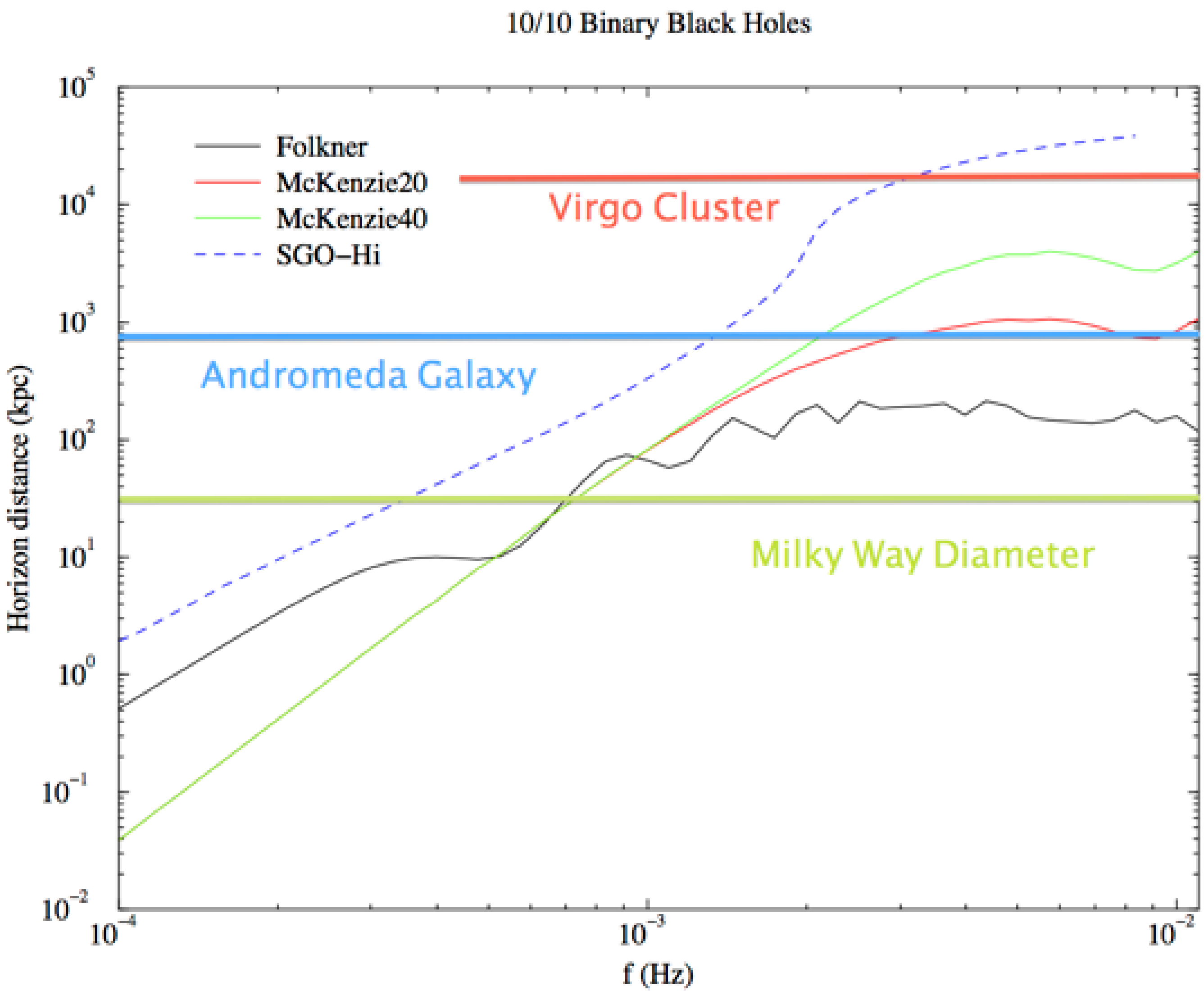


Group 1: EMRI Detections

From N. Cornish/Science Task Force

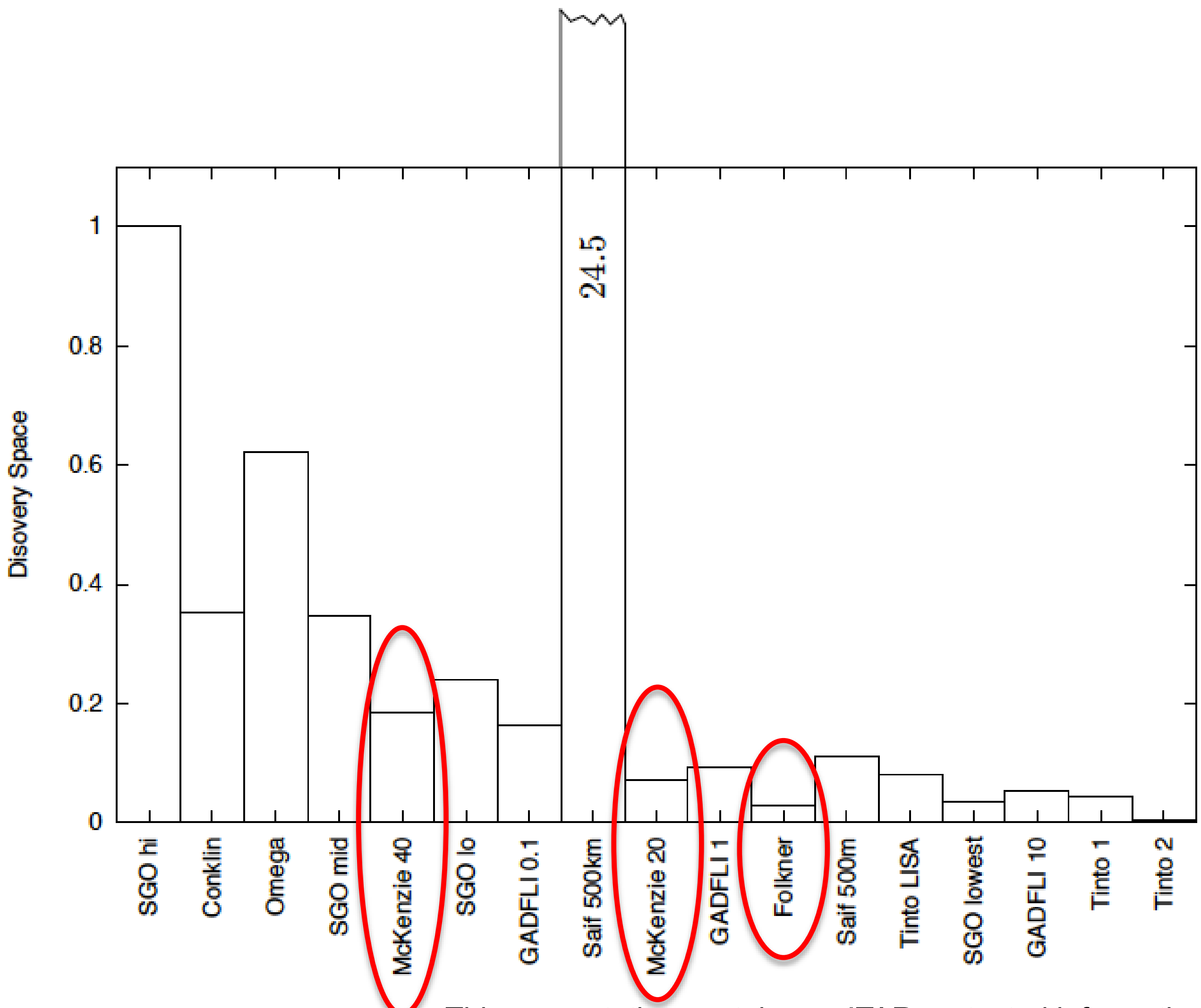


Group 1: 10/10 Binary Black Holes

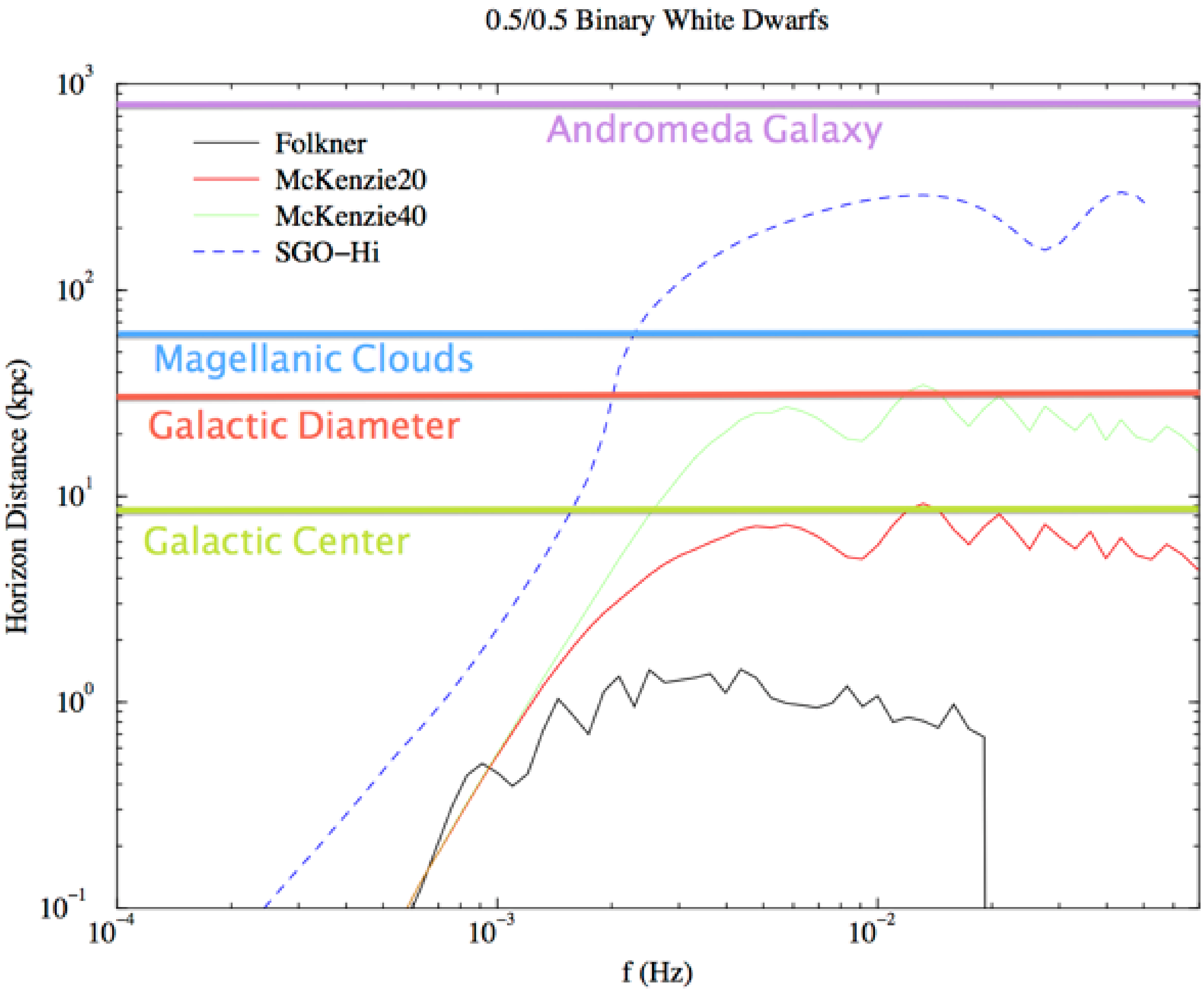


Group 1: Discovery Space

From N. Cornish/Science Task Force

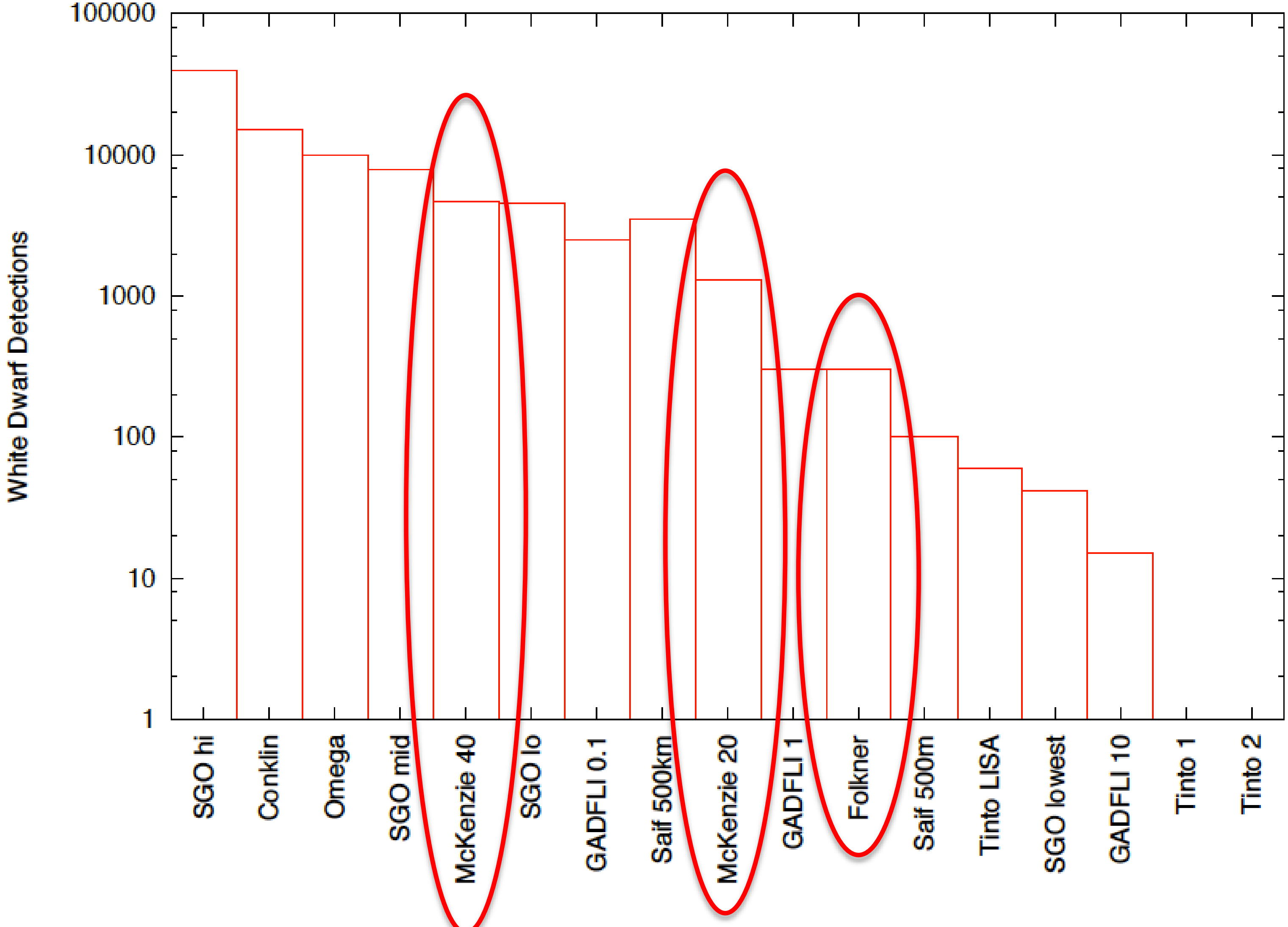


Group 1 Binary WDs



Group 1: WD-WD Detections

From N. Cornish/Science Task Force



Group 1 Science Assessment Summary

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- LAGRANGE has better overall performance for MBH, but Folkner can see highest mass systems if large seeds. (Comparable range, different mass sensitivity)
- LAGRANGE has better horizon distance for EMRIs, but detections are only likely for 40 cm optics.
- Discovery space is larger for LAGRANGE, although Folkner has better low frequency performance.
- Minimal likelihood of stellar mass black hole detection.
- Substantial improvement in DWD detection and Galaxy coverage for LAGRANGE 40 cm optics.

Group 1: Science Orbits (Relative to SGO-High & -Mid)

- **Constellation Flexure**
- **Folkner - Very Small, GMAT QO: (⊗L/L ~0.0005 / ⊗(~ 0.05° / ⊗v ~ 4 m/s)**
- **McKenzie - Small, RFI (⊗L/L ~0.05 / ⊗(~ 0.14° / ⊗v ~ 110 m/s)**
  vs. SGO-Mid: (⊗L/L ~0.06 / ⊗(~ 0.6° / ⊗v ~ 2 m/s) 2-year
  vs. SGO-High: (⊗L/L ~0.01 / ⊗(~ 0.8° / ⊗v ~ 13 m/s) 5-year
- **Station Keeping Needed**
- **Folkner - No – highly stable for 2 years+**
- **McKenzie - Yes (certainly for satellite at L2)**
- **Communications (perhaps should be under operations (?))**
- **Folkner - Hard for direct ops, moderate for nominal science ops**
- **McKenzie - Moderate (Distance like SGO-Mid)**

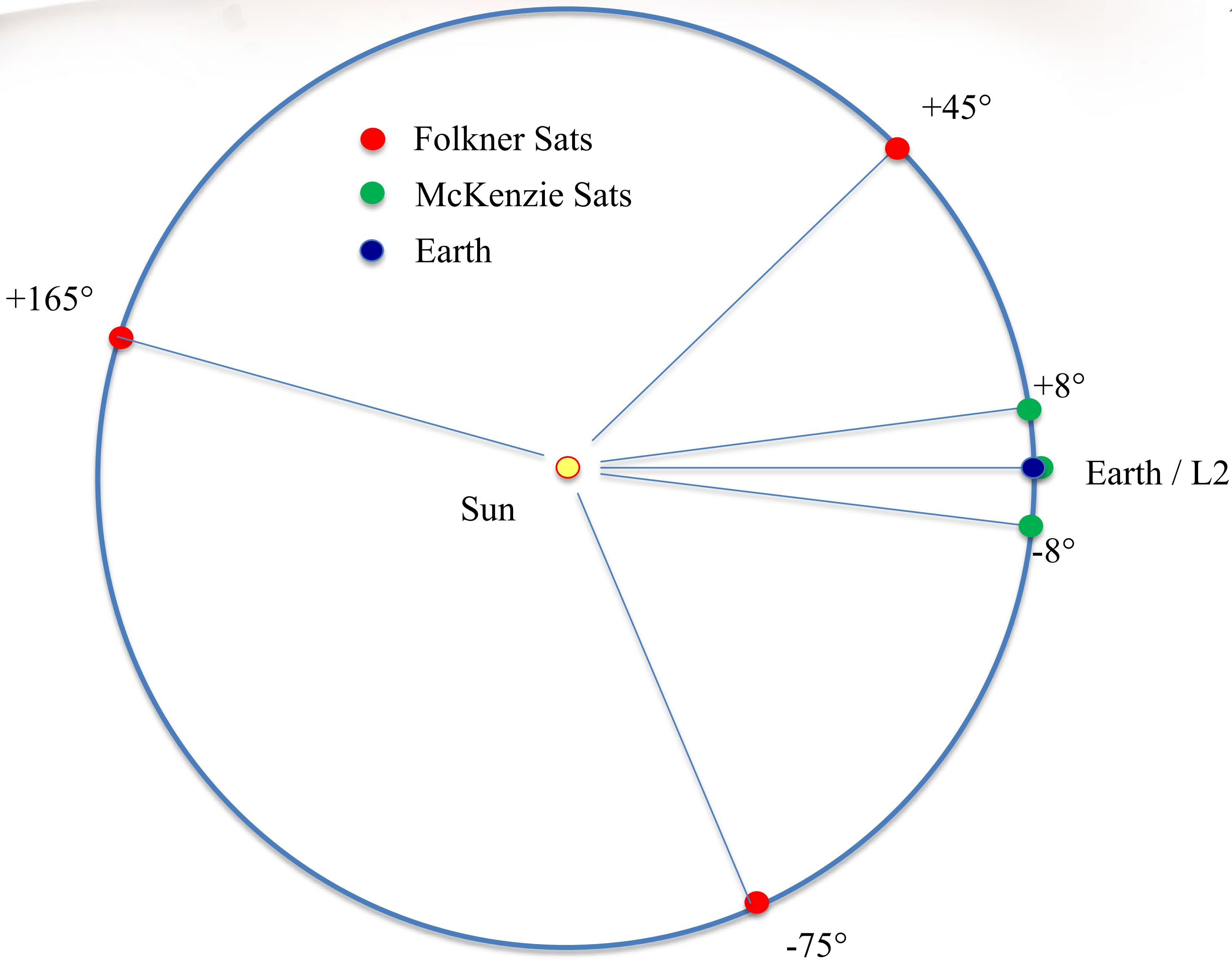
- **Thermal Variation due to Solar Angle – No Variation**
- **Thermal/Power Variation in Biannual Eclipse Seasons – No Variation**
- **Sunlight in Optical Path – Not an Issue**

Green is better than SGO-like, Red is worse, and Blue is similar

Group 1: Trajectories – Pros and Cons (Relative to SGO-High & -Mid)

- **Launch Vehicle C3**
- **Folkner - Small: ~ -1.7 $(km/s)^2$ (set up for Lunar assist)**
- **McKenzie - Small, ~ -1.7 $(km/s)^2$ (if using Lunar assist to get to L2)**
- **vs. SGO-Mid 0.1 $(km/s)^2$, or SCO-High: 0.3 $(km/s)^2$**
- **Propulsion Module**
- **Folkner - Large, ⊗V ~ 2000 m/s (~ 630 after Lunar assist, ~ 1300 at target**
- **McKenzie - Moderate, ~ 450 m/s (225 to escape L2/Earth, 225 at target)**
- **vs. SGO-Mid ⊗V ~ 130 m/s (each), or SCO-High: ⊗V ~ 1100 m/s (each)**
- **Trajectory Duration**
- **Folkner - Long, ~ 3.5 years to get to 165°**
  (assuming 4 satellite orbits get to 165°)
- **McKenzie - Moderate, ~ 12 to 18 months (after leaving L2)**
  vs. SGO-Mid ™~ 18 months, or SCO-High: ™~ 14 months

Group 1: Orbits



Group 1: Other considerations

- **Other considerations:**

- **Weak light phase locking**
- **Folkner - adequate performance demonstrated?**
    - **Dick (2008) reference shows performance to ~ 10 Hz**
- **McKenzie -**
- **Instrumentation**
- **Folkner -**
- **McKenzie – GOES space weather instruments rather than SWEPAM? This applies to both missions. Radiometer (VIRGO-like), SWEPAM or GOES ion sensors, accelerometer (GOCE-like)**
- **Spacecraft**
- **Folkner**
- **McKenzie - Look for cost reduction with 4 identical spacecraft**

SUMMARY

- LAGRANGE seems to have better or comparable science performance in all categories
- 40 cm telescope offers more considerably more science in all areas.
- Both missions are confined to the ecliptic plane and rotate with a 1 year period.
- If LAGRANGE is sent forward, look for cost reduction opportunity by making payloads and spacecraft identical
- Current configuration looks like 2 distinct spacecraft are needed: corner and end spacecraft
- Could be a trade study or a design change
- Consider 20 vs 40 cm telescopes