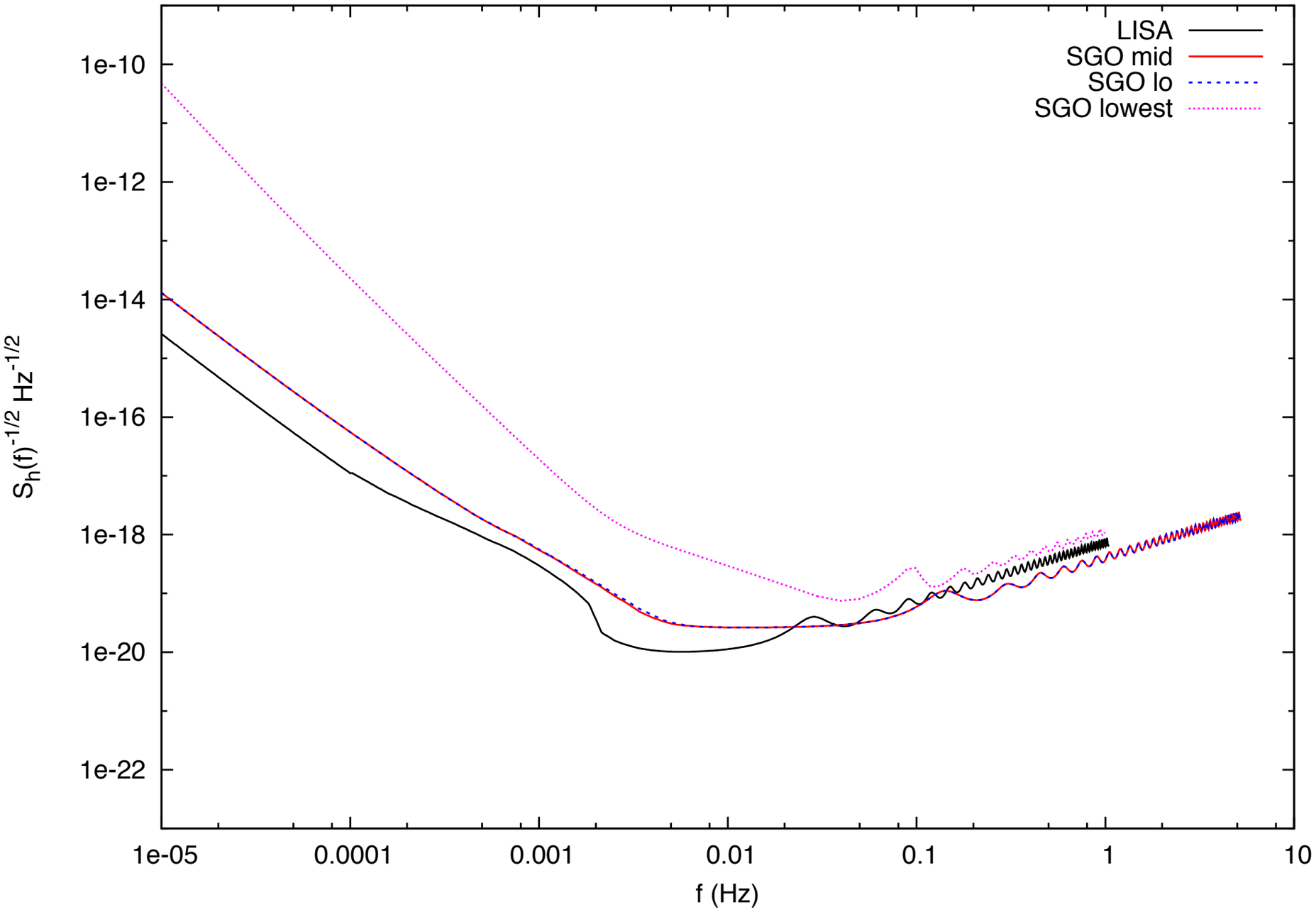
# GROUP 3 CONCEPTS

## Discussion

Workshop for Gravitational-Wave Mission Architectural Concepts 20-21Dec 2011

1. Shao
2. SGO Mid
3. SGO Low
4. SGO Lowest
5. SGO High = LISA (not presented)

# Group 3:
# LISA variants



| | High | Mid | Low | Lowest | Shao |
|---|---|---|---|---|---|
| # S/C | 3 | 3 | 4 | 3 | 3 |
| Distance | 5Gm | 1Gm | 1Gm | 2/1Gm | 5Gm |
| # Links | 6 | 6 | 4 | 4 | 6 |
| Orbit | 22° HC | 9° Drift | 9° Drift | 9° Drift | 22° HC |
| # of PM/ SC | 2 (LTP) | 2 (LTP) | 1 (LTP) | 1 (LTP) | 2 (Torsion) |
| Lifetime | 5+3.5 | 2+2 | 2+2 | 2+0 | 5+3.5 |
| Telescope | 40cm | 25cm | 25cm | 25cm | 40cm |
| Laser power | 1.2W | 0.7W | 0.7W | 0.7W | 1.2W |
| Cost | 1,660M | 1,440M | 1,410M | 1,190M | 990M* |

* Different Costing Method

| Comparison of Science Performance for different versions of SGO | | | | |
|---|---|---|---|---|
| **Concept** | SGO High | SGO Mid | SGO Low | SGO Lowest |
| Nominal Lifetime | 5 yrs | 2 yrs | 2 yrs | 2 yrs |
| **MBH mergers** | | | | |
| Total # Detections | $70 \sim 150$ | $25 \sim 35$ | $25 \sim 35$ | $\sim 4$ |
| Median Redshift | $\tilde{z} \sim 5$ | $\tilde{z} \sim 5$ | $\tilde{z} \sim 5$ | $\tilde{z} \sim 4$ |
| Mass Precision @ $z = \tilde{z}$ | $\frac{\sigma_M}{M} \sim 0.2\%$ | $\frac{\sigma_M}{M} \sim 1\%$ | $\frac{\sigma_M}{M} \sim 1\%$ | $\sim 3\%$ |
| Spin Accuracy @ $z = \tilde{z}$ | $\sigma\chi \sim 0.3\%$ | $\sigma\chi \sim 2\%$ | $\sigma\chi \sim 3\%$ | - |
| Distance Accuracy @ $z = \tilde{z}$ | $\frac{\sigma_{D_L}}{D_L} \sim 3\%$ (WL) | $\frac{\sigma_{D_L}}{D_L} \sim 3\%$ (WL) | $\frac{\sigma_{D_L}}{D_L} \sim 20\%$ | - |
| Sky Localization @ $z = \tilde{z}$ | $\sim 1$ deg$^2$ | $\sim 1$ deg$^2$ | $\gtrsim 100$ deg$^2$ | - |
| # Detections @ $z < 2$ | $\sim 7$ | $1 \sim 2$ | $1 \sim 2$ | $< 1$ |
| Mass Precision @ $z = 1$ | $\frac{\sigma_M}{M} \lesssim 0.1\%$ | $\frac{\sigma_M}{M} \lesssim 0.1\%$ | $\frac{\sigma_M}{M} \lesssim 0.3\%$ | - |
| Spin Accuracy @ $z = 1$ | $\sigma\chi \lesssim 0.1\%$ | $\sigma\chi \lesssim 0.1\%$ | $\sigma\chi \lesssim 1\%$ | - |
| Sky Localization @ $z = 1$ | $\lesssim 0.1$ deg$^2$ | $\lesssim 0.1$ deg$^2$ | $\lesssim 10$ deg$^2$ | - |
| **EMRIs** | | | | |
| # Detections | $40 \sim 4000$, to $z \sim 1.0$ | $2 \sim 200$, to $z \sim 0.2$ | $\lesssim 40$, to $z \sim 0.15$ | 0 |
| Mass Accuracy | $\frac{\sigma_M}{M} \sim 0.01\%$ | $\frac{\sigma_M}{M} \sim 0.01\%$ | $\frac{\sigma_M}{M} \sim 0.01\%$ | – |
| MBH Spin Accuracy | $\sigma\chi \sim 0.01\%$ | $\sigma\chi \sim 0.01\%$ | $\sigma\chi \sim 0.01\%$ | – |
| **Compact Binaries** | | | | |
| # Verification binaries | 10 | 8 | 7 | 0 |
| # Resolvable binaries | $\sim 20,000$ | $\sim 4,000$ | $\sim 2,000$ | $\sim 100$ |
| **Discovery Space** | | | | |
| Detects early-universe $\Omega_{gw}$ | $\gtrsim 10^{-10}$ | $\gtrsim 10^{-9}$ | – | – |
| Can Detect+Verify Bursts? | ✓ | ✓ | – | – |

# SHORT PRO/CON LIST

- SGO-High:
  Pro: Uniquely strong science
  Never costed as US only
  Con: LISA has been studied extensively

- SGO-Mid:
  Pro: Smallest six-link LISA concept
  LISA-like, but cheaper
  Con: Fairly large drift rate (limits lifetime?)

- SGO-Low:
  Pro: Greater design variation from LISA
  Con: Increased risk (4 links vs 6)
  Less science/no cost savings over mid

- SGO-Lowest:
  Pro: more radical design change; lowest cost
  Con: Very limited science left

- Shao:
  Pro: Explores design space
  New concepts applicable to many other designs
  Con: No heritage/no experience with new proof mass concept.
  Additional S/C shield appears to add complexity/cost.

# SHORT PRO/CON LIST

- SGO-High:
  Pro: Uniquely strong science
  Never costed as US only
  Con: LISA has been studied extensively

- **SGO-Mid:**
  **Pro: Smallest six-link LISA concept**
  **LISA-like, but cheaper**
  **Con: Less science than LISA (~Conklin/Hellings)**

- SGO-Low:
  Pro: Greater design variation from LISA
  Con: Increased risk (4 links vs 6)
  Less science/no cost savings over mid

- SGO-Lowest:
  Pro: more radical design change; lowest cost
  Con: Very limited science left

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  Pro: Explores design space
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# ANY OBJECTIONS?

http://en.wikipedia.org/wiki/Frankenstein

# SHORT PRO/CON LIST

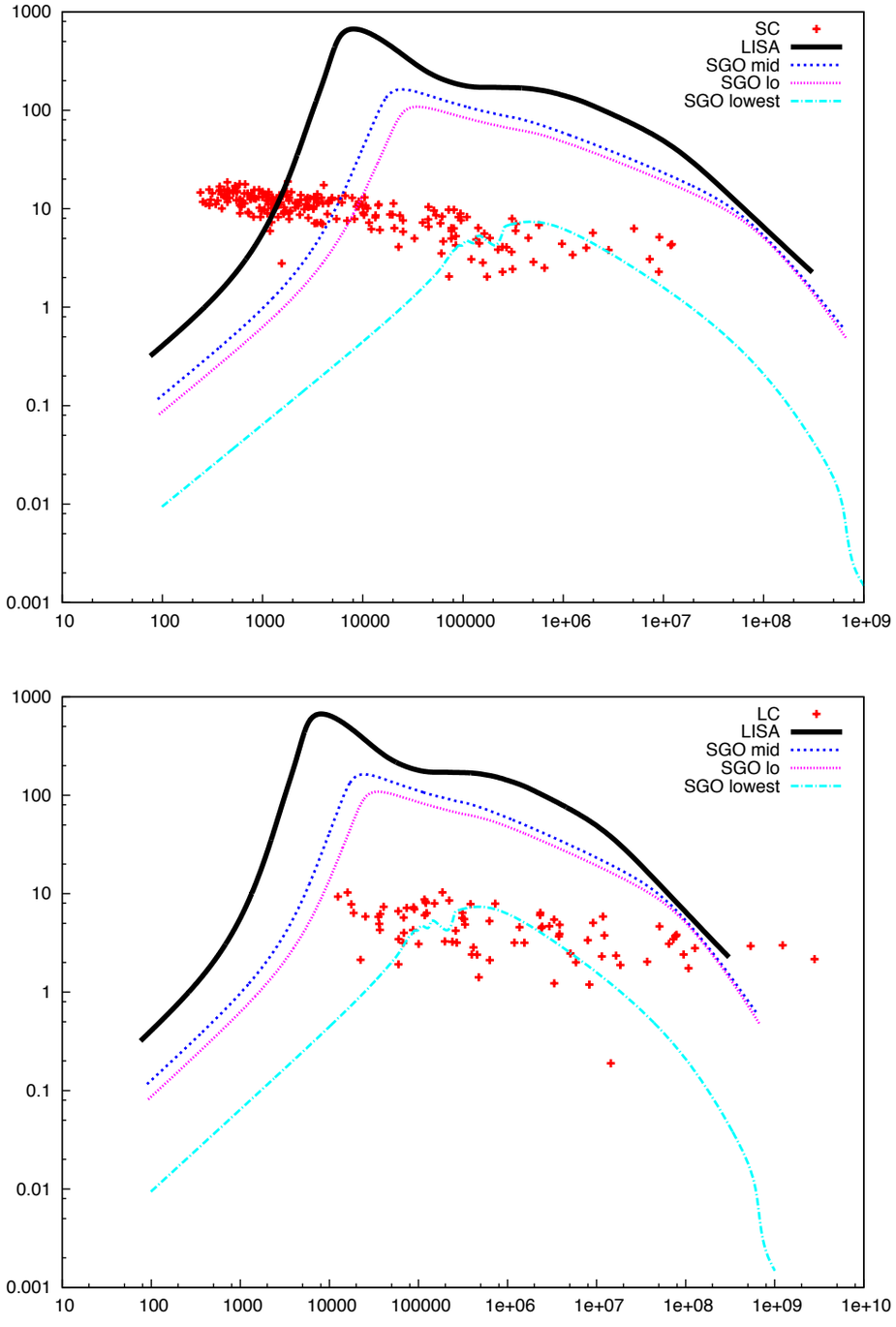
- SGO-High:
  Pro: Uniquely strong science

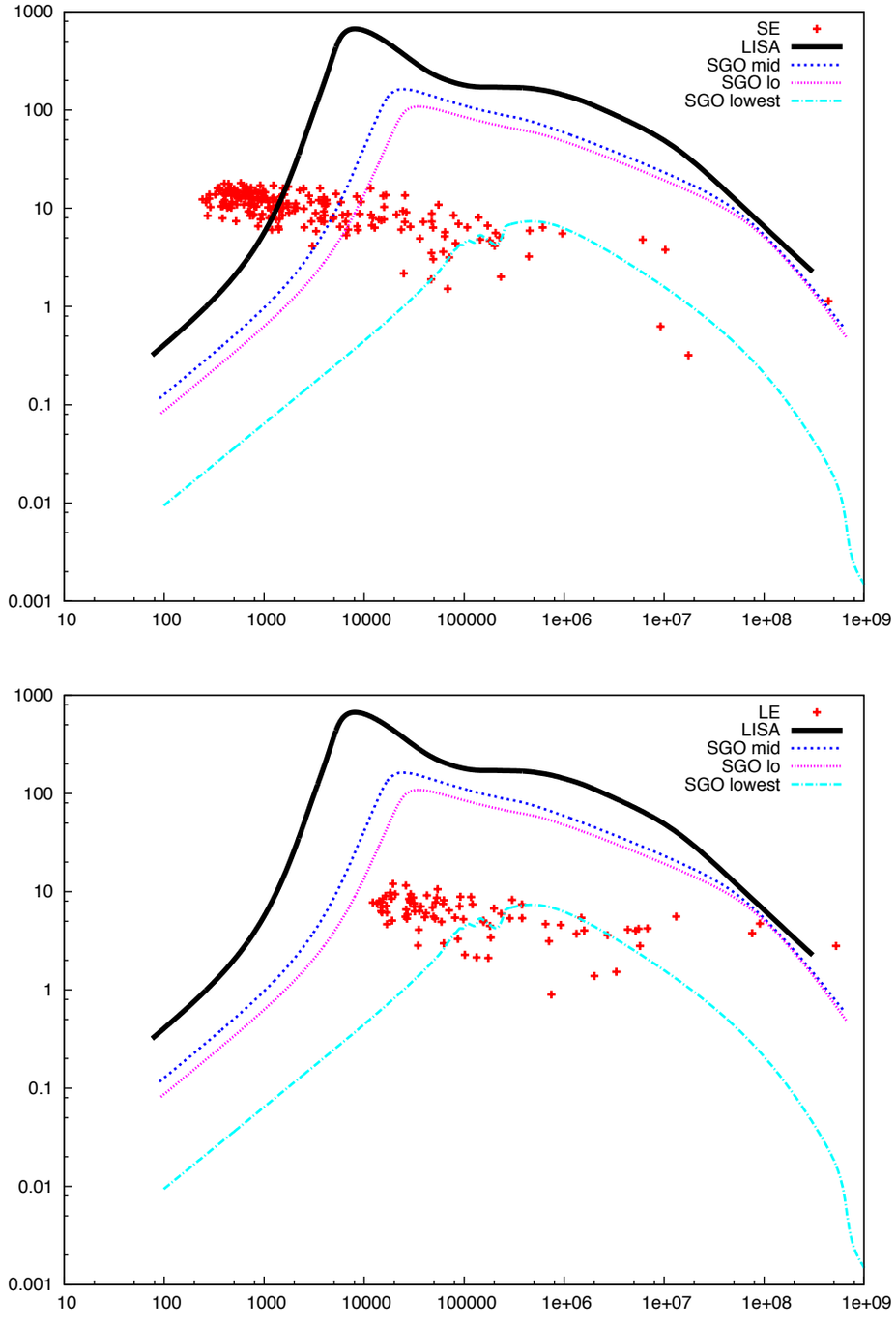
**Discussion points:**
- **For HIGH: To compare apples w. apples**
  - **New situation w/o ESA**
- **For Shao: New technology, has never been studied**
  - **Con: Is Team X the right place to study new technology??**

- SGO-Low:
  Pro: Greater design variation from LISA
  Con: Increased risk (4 links vs 6)
  Less science/no cost savings over mid

- SGO-Lowest:
  Pro: more radical design change:
  with new proof mass concept.
  Additional S/C shield appears to add complexity/cost.

# Group 3: Massive BH Horizons





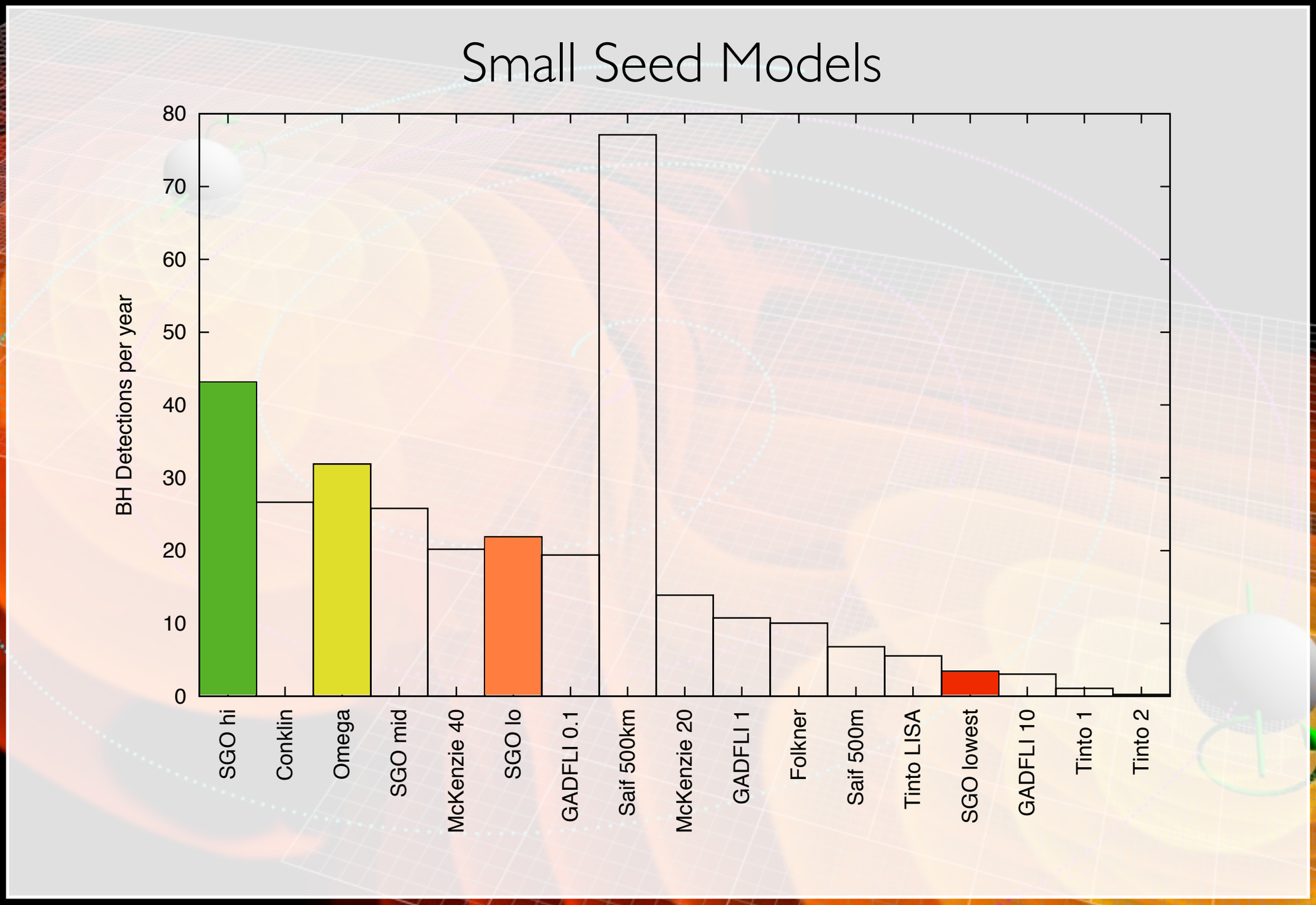




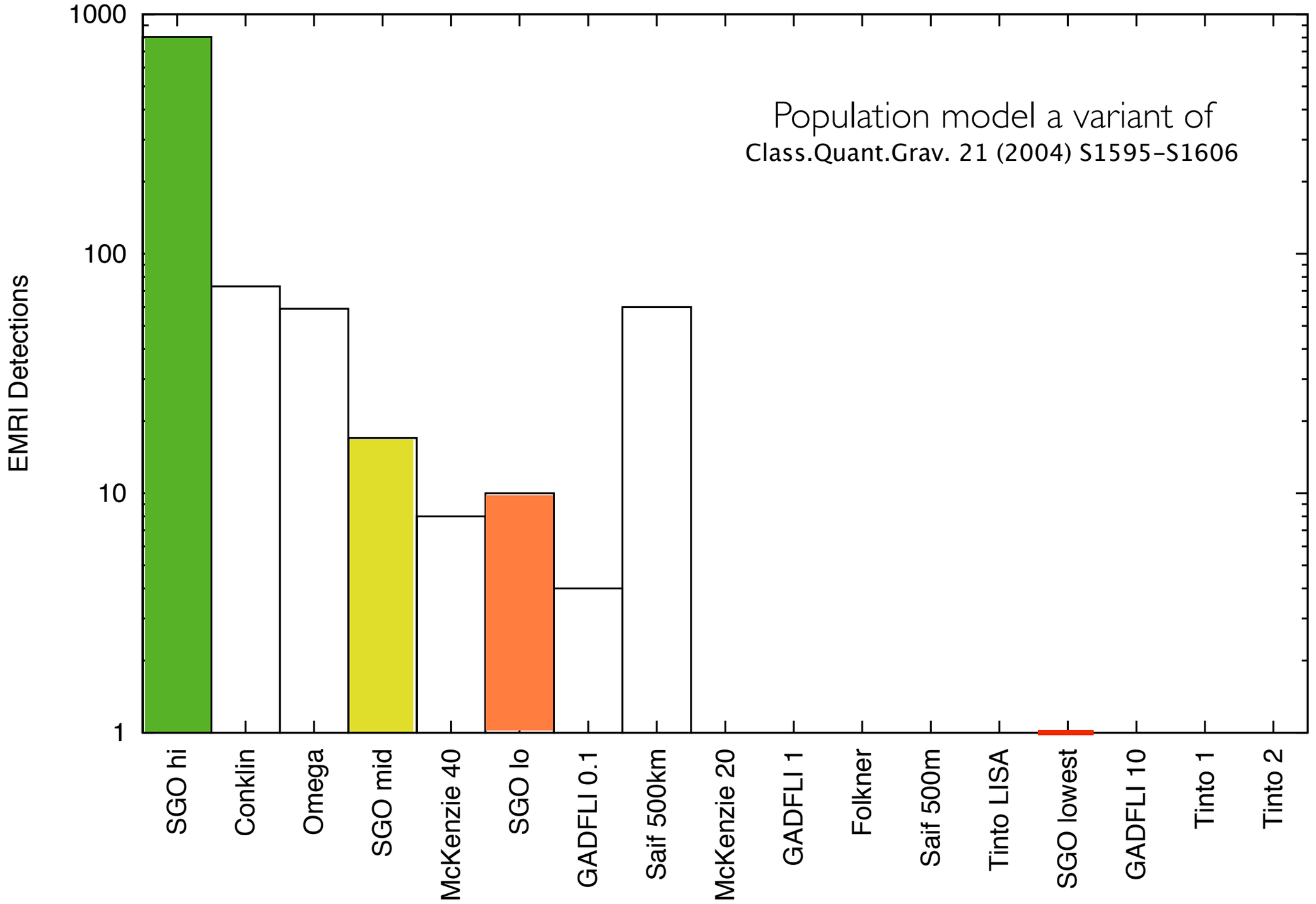

$z$

$M$

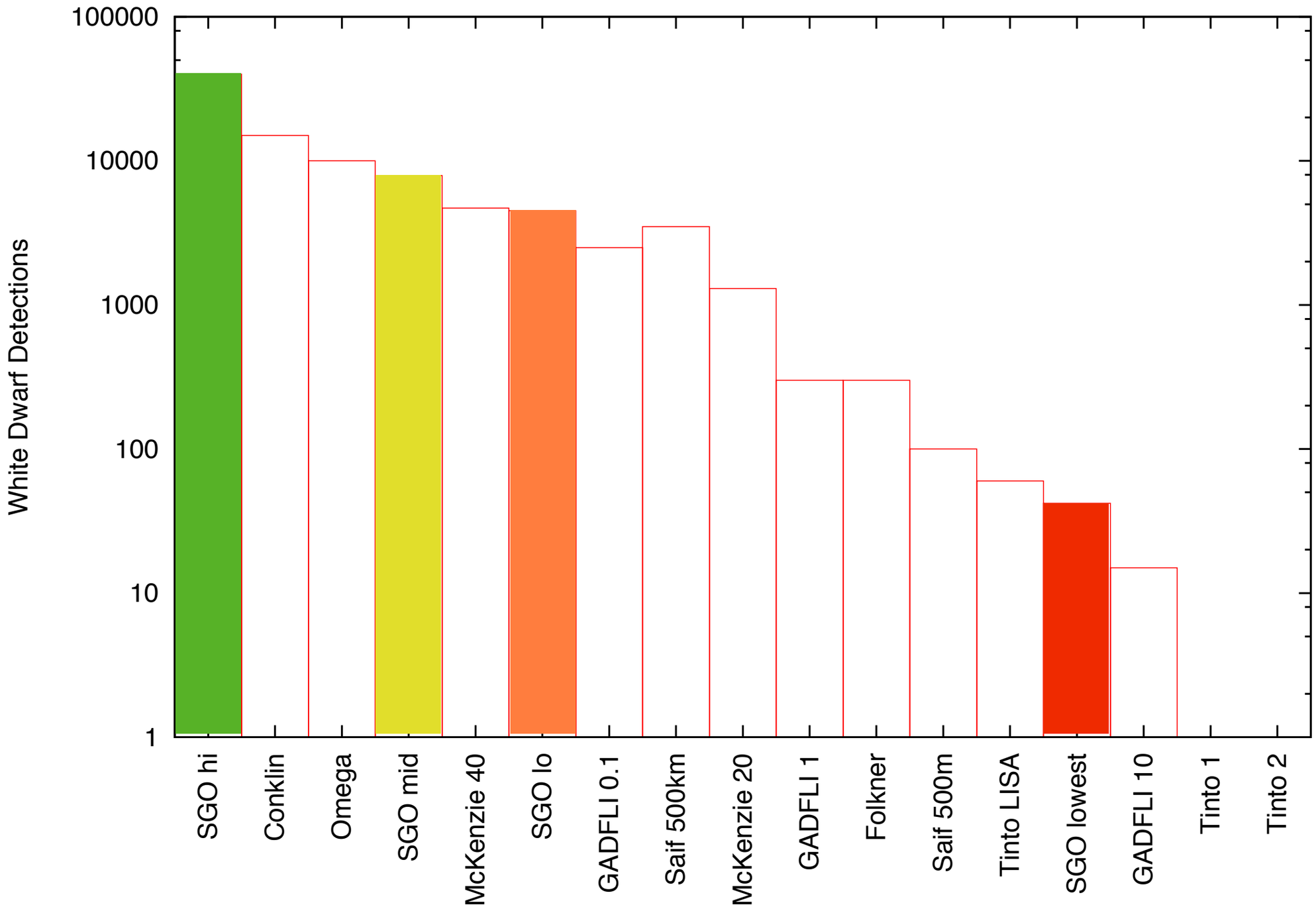
# Massive BH Detection #'s



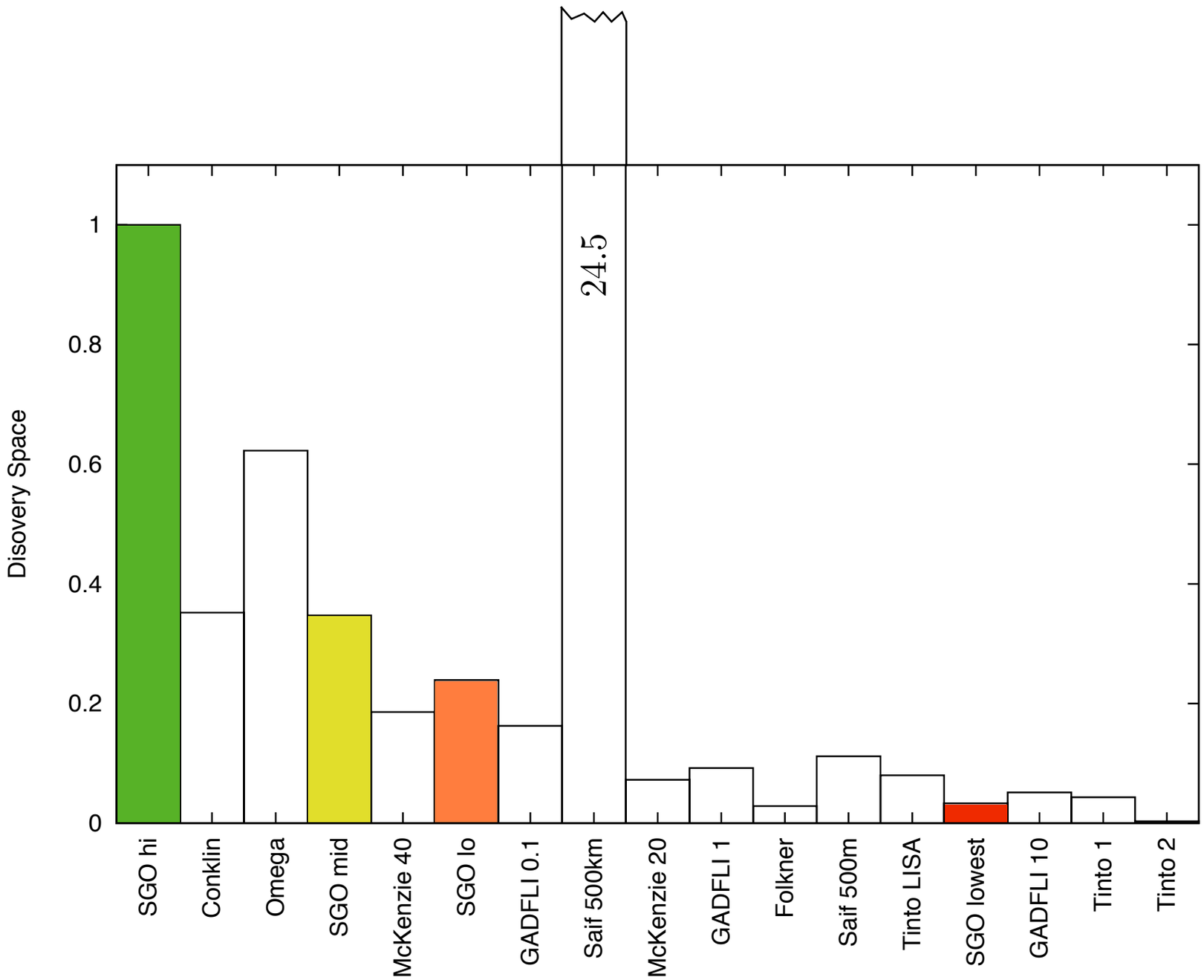
# EMRI Detections



# WD-WD Detection #'s

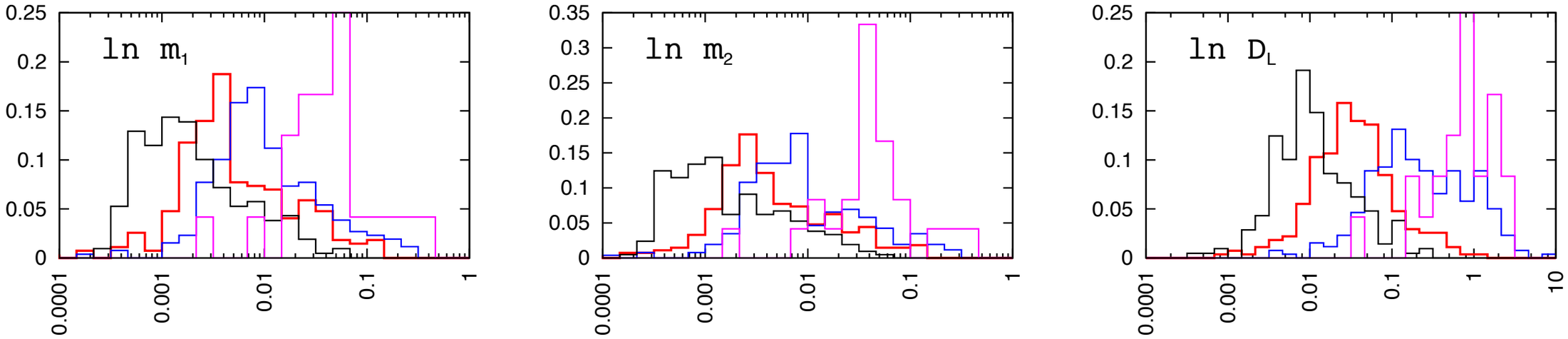


# Discovery Space



# Parameter Estimation

## Massive BHs, LISA-like missions




SGO hi  SGO mid  SGO lo  SGO lowest

Similar detection numbers, but each descope x 3-10 loss in resolution