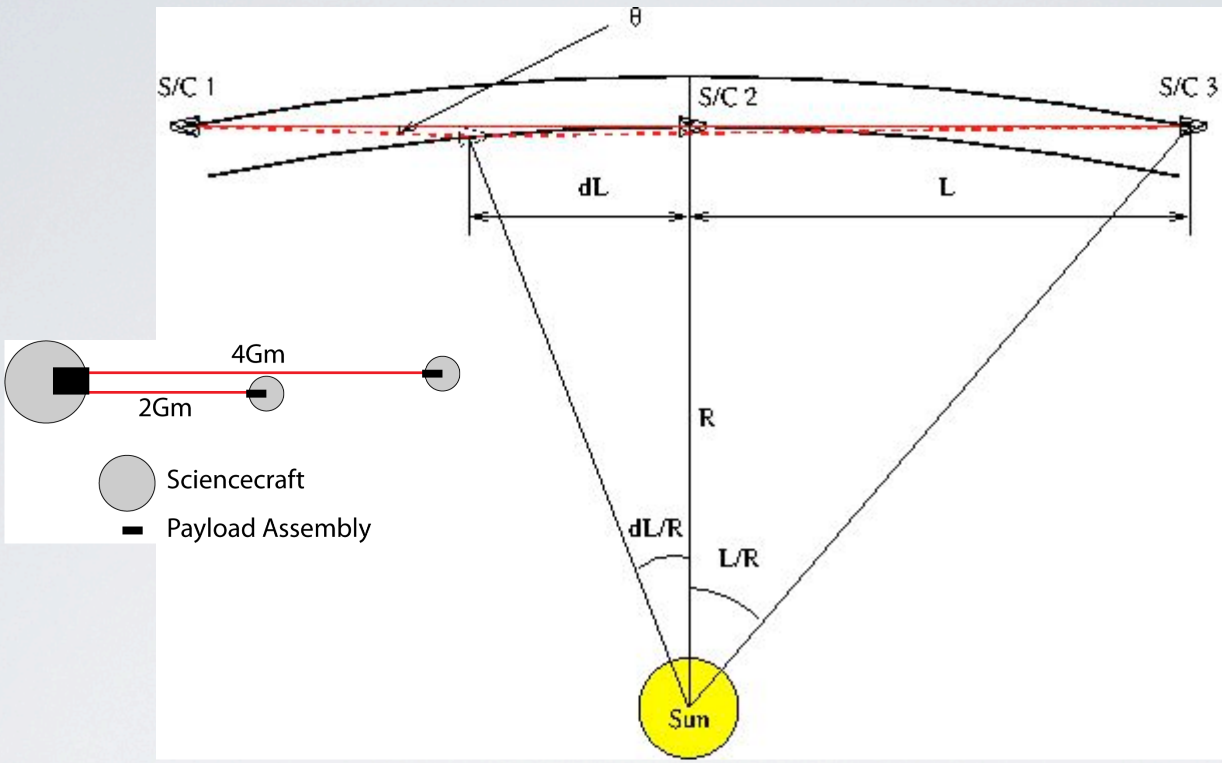


SGO LOWEST

Cost savings through payload reduction in a linear configuration.

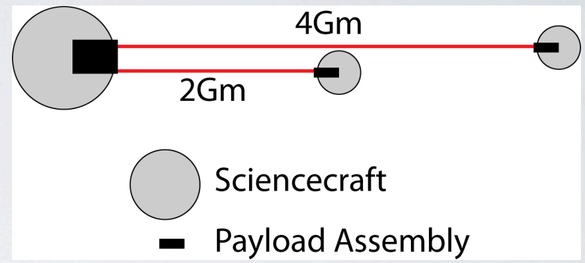
John Baker(GSFC) - for SGO Core Team

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

RATIONALE

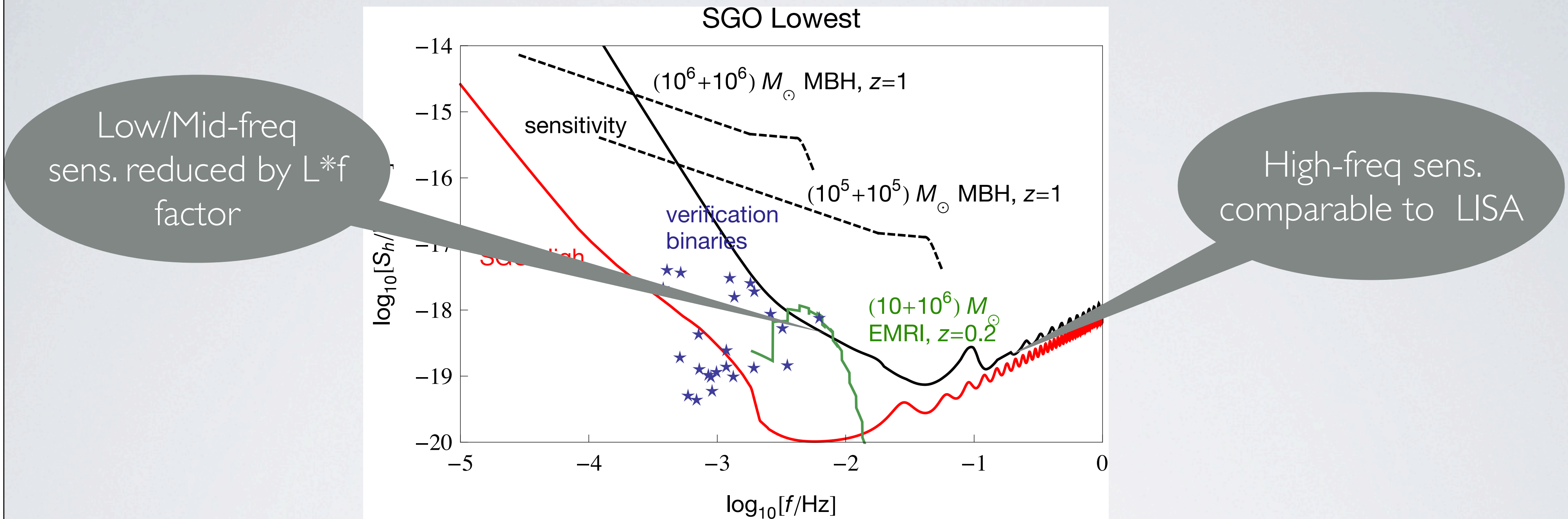
- Objective: Conceive lowest-cost concept preserving some of LISA science
- Cannot eliminate a spacecraft or much of payload subsystems
- Save by: aggressively reducing payload multiplicity
- Leads to: linear "three daughter" concept
- 3 S/C kept maximally similar to minimize nonrecurring expenses.

LINEAR GW MEASUREMENT



- How is laser frequency noise dealt with?
- Laser frequency noise is canceled using Time-Delay-Interferometry (TDI) exactly as with LISA.
- Like S/C Doppler tracking meas. of GW using two S/C to cancel laser noise. Need 3 separated S/C.
- Measure temporal GW variations:
  - High-freq: sensitivity compares with LISA
  - Low-freq: limited sensitivity.

SCIENCE



- Dramatically lower sensitivity below 30 mHz
- Only minimal LISA science is achievable...

SCIENCE COMPARISON

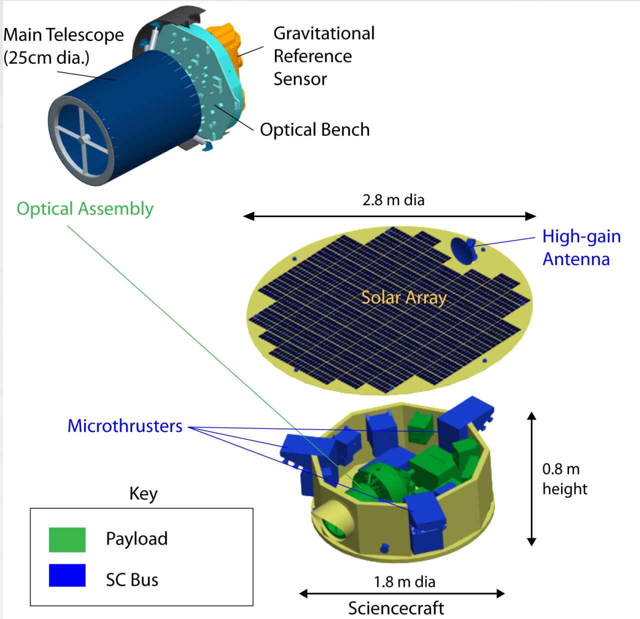
Comparison of Science Performance for different versions of SGO				
Concept	SGO High	SGO Mid	SGO Low	SGO Lowest
Nominal Lifetime	5 yrs	2 yrs	2 yrs	2 yrs
MBH mergers				
Total # Detections	$70 \sim 150$	$25 \sim 35$	$25 \sim 35$	~ 4
Median Redshift	$\tilde{z} \sim 5$	$\tilde{z} \sim 5$	$\tilde{z} \sim 5$	$\tilde{z} \sim 4$
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 @ $z = \tilde{z}$	~ 1 deg^2	~ 1 deg^2	$\gtrsim 100$ deg^2	-
# Detections @ $z < 2$	~ 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	$\sim 20,000$	$\sim 4,000$	$\sim 2,000$	~ 100
Discovery Space				
Detects early-universe Ω_{gw}	$\gtrsim 10^{-10}$	$\gtrsim 10^{-9}$	–	–
Can Detect+Verify Bursts?	✓	✓	–	–

RISK

- Elimination of redundancy (vs. LISA)
  -single-string design
  -Only 4 links, 1 IFO
- Stringent orbit requirements
  -stationkeeping likely requires mN range for μN thrusters
  -trajectory risk without P/M
- Some additional complications
  -double infield guiding
  -double heterodyne separation of two far S/C signals
- Plausible risk that no MBHs are detected

COST SAVINGS

SGO High estimate	**1.66**
Launch vehicle savings	-0.01
Optical assembly count reduction	-0.13
Payload mass or redundancy reduction	-0.11
Mission duration reduction	-0.11
Propulsion module elimination	-0.11
SGO Lowest total	**$1.19B**



- Savings:
  - Roughly half of payload eliminated (one telescope/proof-mass per S/C)
  - Simple circular drift-away orbits may also allow elimination of prop. module
  - Shortened operational phase (strictly ~2 yrs)
- Cost model based on LISA; accounts for NRE, replication learning curve, parameterized mass-scaling of payload+SC
- Modest additional savings (~$0.1B) might be achieved by GRS elimination as in McKenzie concept

SUMMARY

- Linear concept seems close to lowest possible cost concept
- Only minimal LISA science is achievable:
- ...with significant additional risks
- Cost $1.1-1.2B: saves 35% of SGO-high (i.e. US LISA) costs
- A comparably estimated lower-cost mission seems unlikely.