STScI | SPACE TELESCOPE SCIENCE INSTITUTE

EXPANDING THE FRONTIERS OF SPACE ASTRONOMY

# Large programs on Great Observatories

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## Context

- JWST will offer a range of program types for General Observers
  - Small, medium & large/treasury
  - In Cycle 1, the emphasis will be on small & medium programs
- The NAS Committee on Exoplanet Science Strategy report (September 5 2018) recommends developing a mechanism to support community-driven surveys of exoplanet atmospheres
- JSTUC (letter of Sept 13 2018) recommended considering options for implementing Legacy-style programs in all science areas; any such call “should be timed to allow the results from Cycle 1 to be adequately digested by the community”.
- Here, we review the development of legacy-style program offered by other Great Observatories

# Program scale and focus

Programs on different scales tackle different types of science programs

## Science focus

- Small-scale programs are generally focused experiments, targeting a small number of objects to address specific questions
- Medium-scale are also focused experiments, often detailed studies of 2-3 sources
- Large programs are often surveys, covering sufficient individual targets to allow reliable statistical analysis of intrinsic properties
- Large programs can provide reference datasets for multiple scientific investigations, and
- Large programs can be narrowly focused experiments that tackle large-scale issues that require extensive datasets or high-sensitivity observations

What range of observing programs are/were offered on NASA's Great Observatories and how have they evolved?


Historical perspectives
Chandra, HST, Spitzer & Herschel

## Chandra program types

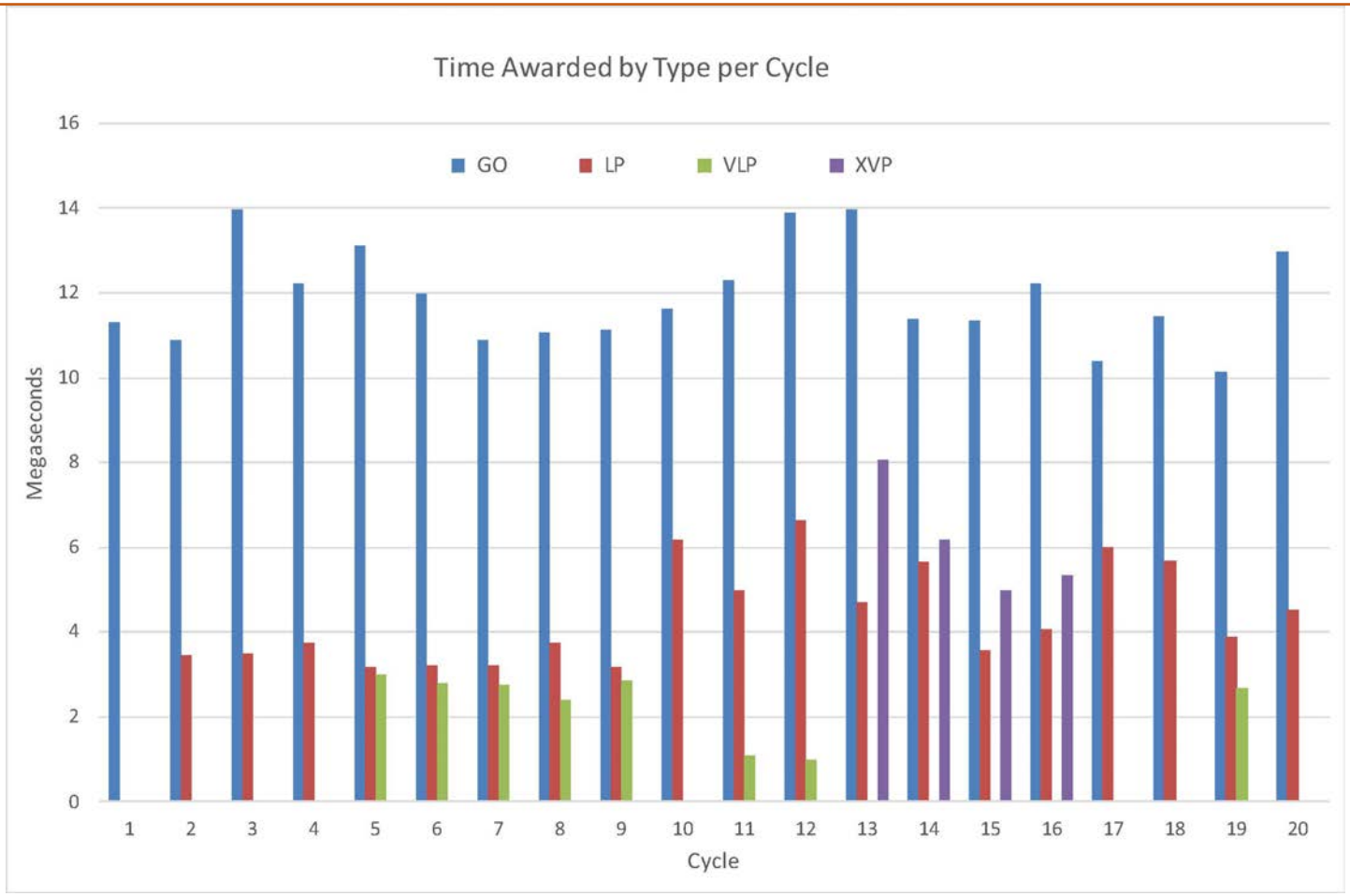
Chandra peer review typically has 14 Msec to allocate

- General Observer proposals were <300 ksec (Cycles 1-17) and <400 ksec (Cycle 18+)
- Large Proposals (LPs) are > 400 ksec and < 1 Msec
- Very Large Proposals (VLPs) are > 1 Msec (most are close to 1 Msec).
- X-ray Visionary Programs (XVPs) are multi-cycle and multi-Msec.

Implementation

- LPs have been implemented in Cycles 2 - present
- VLPs were implemented in Cycles 5-12 and Cycle 19-present
- XVPs were implemented in Cycles 13-16 to take advantage of a change in Chandra's orbit that allowed for more observing time
- No VLPs or XVPs in Cycles 17-18 to reduce backlog of highly-ranked LPs

# Allocations



## HST:

### Allocation strategies have evolved over the past 25+ years

Space Telescope Advisory Committee addressed the topic in the early 1980s:

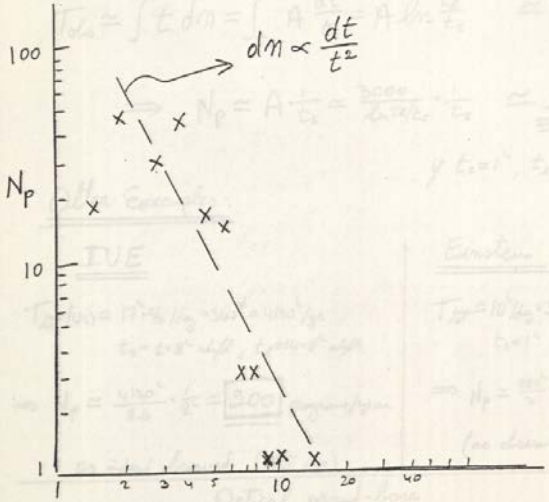
- Collected information on time allocation schemes on existing observatories (eg IUE)
- Recommended approximately equal time for small (1-10 hr), medium (10-70 hr) and large (70-500 hr) programs (10/1983)

# STAC report 10/1983

ATTACHMENT A.
(pg. 1)
M. Balcell
10/1983

Number of programs on IVE versus allocated time (in 8h shifts).

(185 programs total (U.S.))




(pg. 2)
M. Balcell

Program Number versus time (i.e., accepted proposals)

Use: $dN_p = A\frac{dt}{t^2}$ as observed on IUE.

$$N_p \simeq \int_{t_s}^{t_e} A\frac{dt}{t^2} = A\left(\frac{1}{t_s} - \frac{1}{t_e}\right) \simeq A\cdot\frac{1}{t_s}$$

$$T_{obs} \simeq \int t\,dn = \int_{t_s}^{t_e} A\frac{dt}{t} = A\ln\frac{t_e}{t_s} \simeq 3000^h/yr \text{ on-}$$

$$\Rightarrow N_p \simeq A\cdot\frac{1}{t_s} \simeq \frac{3000}{\ln t_e/t_s}\cdot\frac{1}{t_s} \simeq 530 \text{ ST prog. per yr}$$

if $t_s = 1^h$, $t_e = 300^h$.

Other Examples:

**IUE**

$T_{tot}$ (US) $\simeq 17^h\cdot 2/3\ /day \times 365^d = 4130^h/yr$

$t_s \sim 1\times 8^h$ shift, $t_e = 14\times 8^h$ shifts

$\Rightarrow N_p \simeq \frac{4130^h}{2.6}\cdot\frac{1}{8^h} \simeq \boxed{200}$ programs/year

as indeed observed (185/yr).

**Einstein**

$T_{tot} = 10^h/day \times 365^d \times 1/4 \simeq 880^h/yr$

$t_s = 1^h$, $t_e = 20^h$

$\Rightarrow N_p \simeq \frac{880^h}{3}\cdot\frac{1}{1^h} = \boxed{290}$ prog.

(as observed: ~220/yr).

**Optical ground-base**

$T_{tot} \simeq 300^d/yr$. $t_s = 1^d$, $t_e = 10^d$ $\Rightarrow N_p \simeq \frac{300^d}{2.3}\cdot\frac{1}{1^d} \simeq \boxed{130}$ prog.

as indeed observed.

# STAC report 10/1983

B. Long-Range Projects on ST

The policy attitude toward long-range versus short-range observing projects is frequently diffuse or non-existent in many observatories. The ST ScI would like to provide clear guidelines for that question. Do we want long-term programs (i.e., key-projects, that require substantial fraction of ST time, and are widely recognized as important for broad progress in astronomy)? The answer from STAC is unanimously yes. We may thus want to develop some guidelines for key-projects that would provide an optimum balance between long-range and short-range programs, using the community advice and keeping full fairness to the astronomical community.

Neta Bahcall discussed the distribution of the number of programs as a function of observing time at other observatories. The distribution on IUE and on Einstein shows a decreasing number of programs as a function of observing-time, following approximately a $\Delta Np \propto t_p^{-1}$ slope. (See attached copies of viewgraphs: attachment A.) This distribution yields a logarithmic time dependence of programs, which assigns approximately equal time for short, intermediate, and long-term projects. If such a distribution is followed by ST, taking into account 3000 hours of exposure time per year and a shortest program of typically 1 orbit ($\sim$1 hour), we obtain an expected number of $\sim$400 short programs on ST per year (with total exposure time of 1 - 10 hours), $\sim$40 intermediate programs (10-70 hours), and $\sim$6 long projects ($\sim$70 - 500 hours), per year. (STAC's recommendation to the ST ScI is to adopt such a distribution as approximate guidelines; see section G).

# HST: 1983 - 1998

Pre-launch: Key projects

- Three topics identified by the STAC
  - QSO absorption lines
  - Hubble constant from Cepheids
  - Medium Deep Survey – parallel imaging with WFC/WFPC2
- Proposals solicited as part of the Cycle 1 peer review
  - 158 and 330 GO orbits allocated (QSO/$H_0$) in Cycles 1-4

Cycle 1-8: Single-phase time allocation

- 6-15 panels ranked *all* proposals (regardless of size) within defined specialist areas (eg AGN, Binary stars, Cool Stars,…)
  - Panels allocated ~80% of the time
- TAC (panel chairs + TAC chair) served as a merging TAC
  - Allocated ~20% of the time

From Cycle 1 through Cycle 8, only 5 Large (>100 orbit) programs were selected, for a total of 990 orbits (4.4% of GO allocation)

**In an unconstrained environment, peer review committees favour programs that use less resources**

# 1998-present

## HST Second Decade report (1998)

- Recommended specific resources for Large programs
- Recommended establishment of Treasury and Archive Legacy programs

## Cycle 9 (1999): Two-stage time allocation

- ~1/3 time set aside for Large (>100 orbit) programs
- 9 panels covering broad topics (1 Solar System, 4 Galactic, 4 Extragalactic)
- Each panel has a specific orbit allocation dependent on proposal pressure

## Cycle 11 (2001): Treasury Programs

- To enable & support programs of broad community interest
- Programs address science areas that have broad impact; high-level data products generated

## Cycle 18-20 (2011-2013): Multi-Cycle Treasury Programs

- To address scientific questions that can only be tackled by very large (>450 orbit) programs

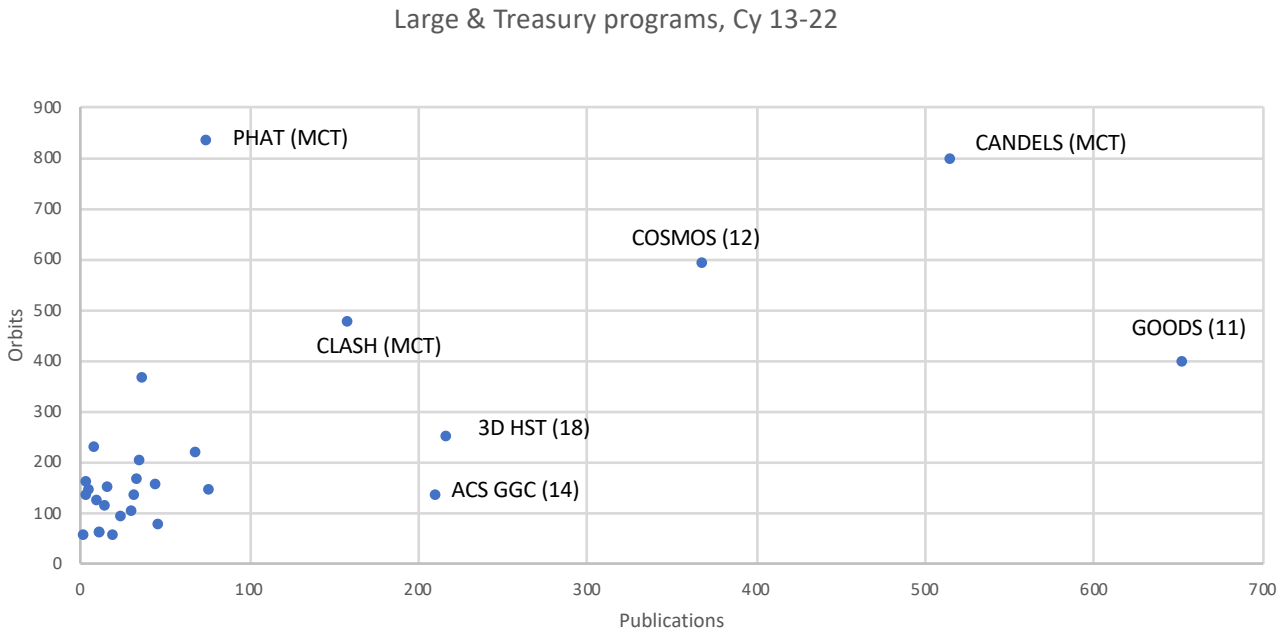
## Cycle 21 (2013): Medium Programs added

- To provide a viable avenue for programs requiring 35→ 74 orbits
- Large programs also redefined as 75+ orbits

## Cycle 24 (2016): Very Large Program (>350 orbits) opportunity included

- One program selected – Panchromatic Comparative Exoplanet treasury Program (498 orbits)

# Outcomes - publications

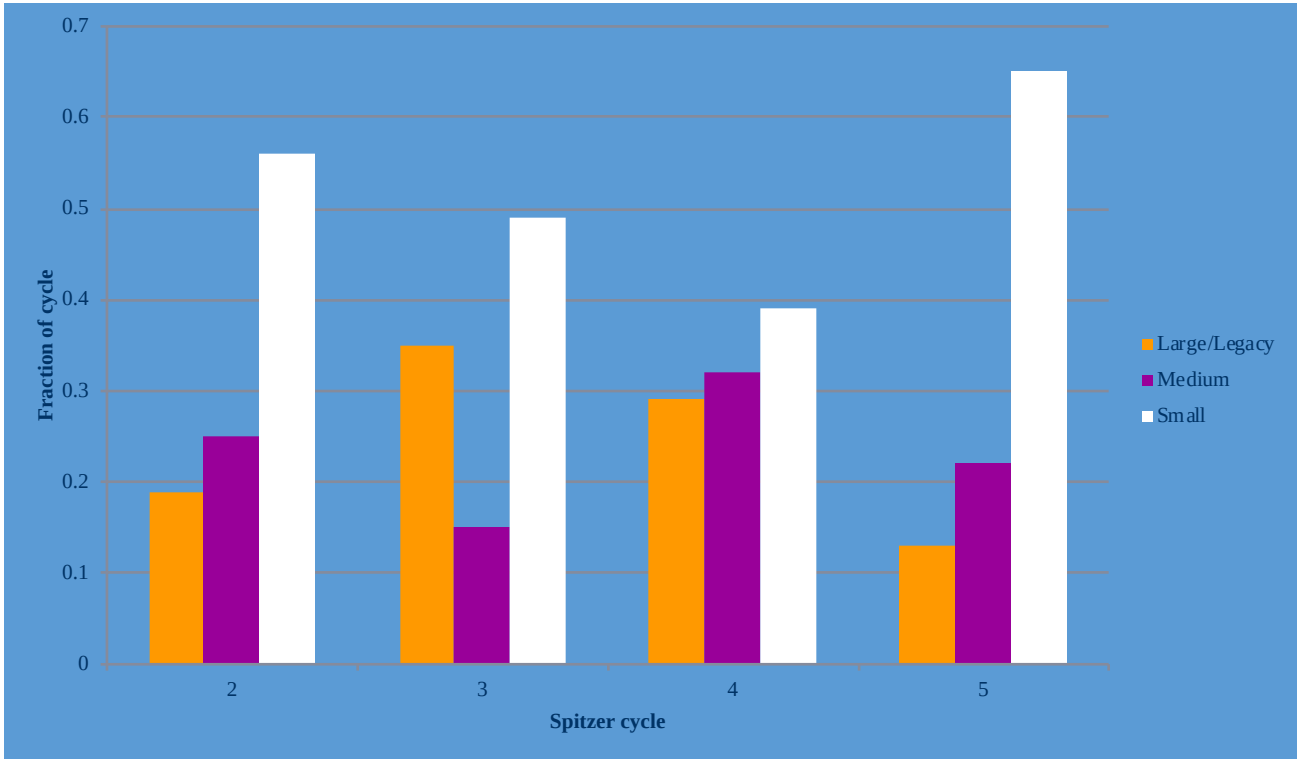



From HST Treasury, Archival Legacy and Large Programs web page
http://archive.stsci.edu/hst/tall.html

# Spitzer

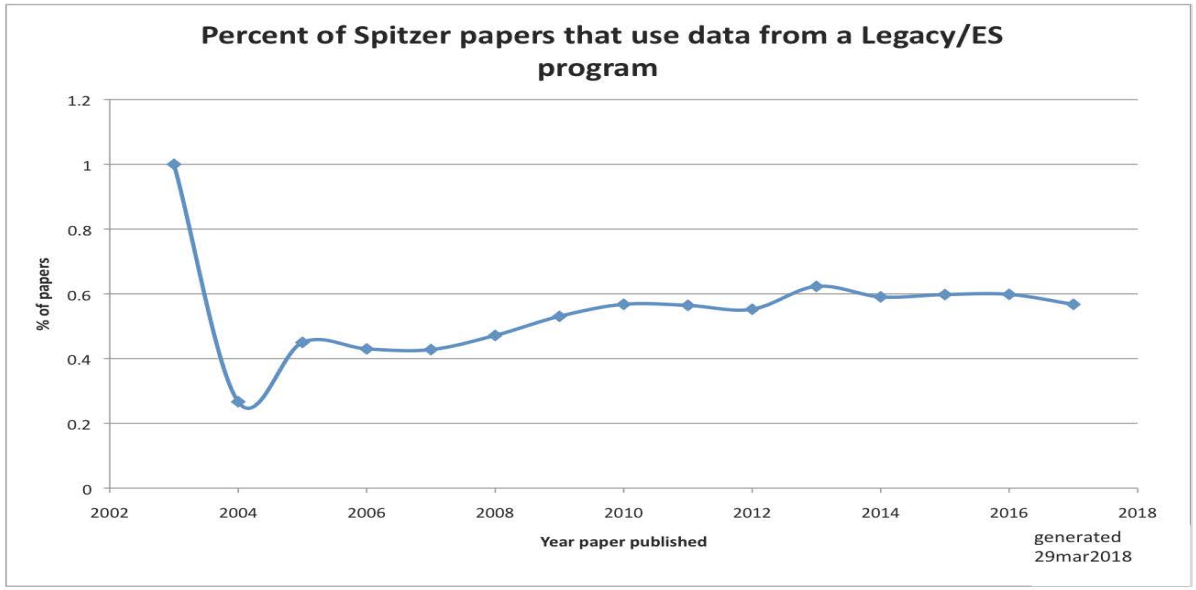
- 2.5 year prime mission lifetime requirement, goal of 5 years (lasted 5.5)
- Three steps were taken to maximise the science
  - Legacy Science program
    - Large, public programs scheduled for execution early in the mission
    - High-level data products returned to the archive
    - 6 programs selected pre-launch for 3160 hours → ~45% of Cycle 1
    - Timed to allow follow-up observations in Cycle 3
  - First-Look Science program
    - 100 hours of DD time for imaging (MIPS & IRAC): extragalactic, galactic, ecliptic
  - Second-look targets
    - Follow-up observations of sources likely to be discovered in the primary observations
- Spitzer Cycle 2
  - 3 categories: small (<50 hours), medium (50-200 hours) & large (>200 hours:)
- Spitzer Cycle 3-5
  - 3 categories: small, medium, large & legacy (>50 hrs & non-proprietary)
- Spitzer Cycle 6+
  - Frontier science and exploration programs (>500 hours)

# Spitzer - allocations




- Fraction of time allocated to different scale observing programs, Spitzer Cycle 2-5

# Outcomes


Percent of Spitzer papers that use data from a Legacy/ES program
% of papers
1.2
1
0.8
0.6
0.4
0.2
0
2002
2004
2006
2008
2010
2012
2014
2016
2018
Year paper published
generated 29mar2018

## Herschel

- Herschel had an expected lifetime of ~3 years
  - Launched in May 2009
  - Operated through May 2013
- Initial observations scheduled as large-scale Key Projects (~120 – 500 hours)
  - 21 Guaranteed Time projects for ~5,500 hours
  - 21 Open Time projects for ~5,500 hours
- AO-1 (typically <30 hours)
  - 33 Guaranteed Time programs for 555 hours
  - 241 Open Time programs for 6000 hours

# GO science on JWST

How much observing time will be available to GOs in early JWST cycles?

JWST time allocations are in wall-clock time

Total GTO allocation is 3,960 hours – ~3,700 hours in Cycle 1

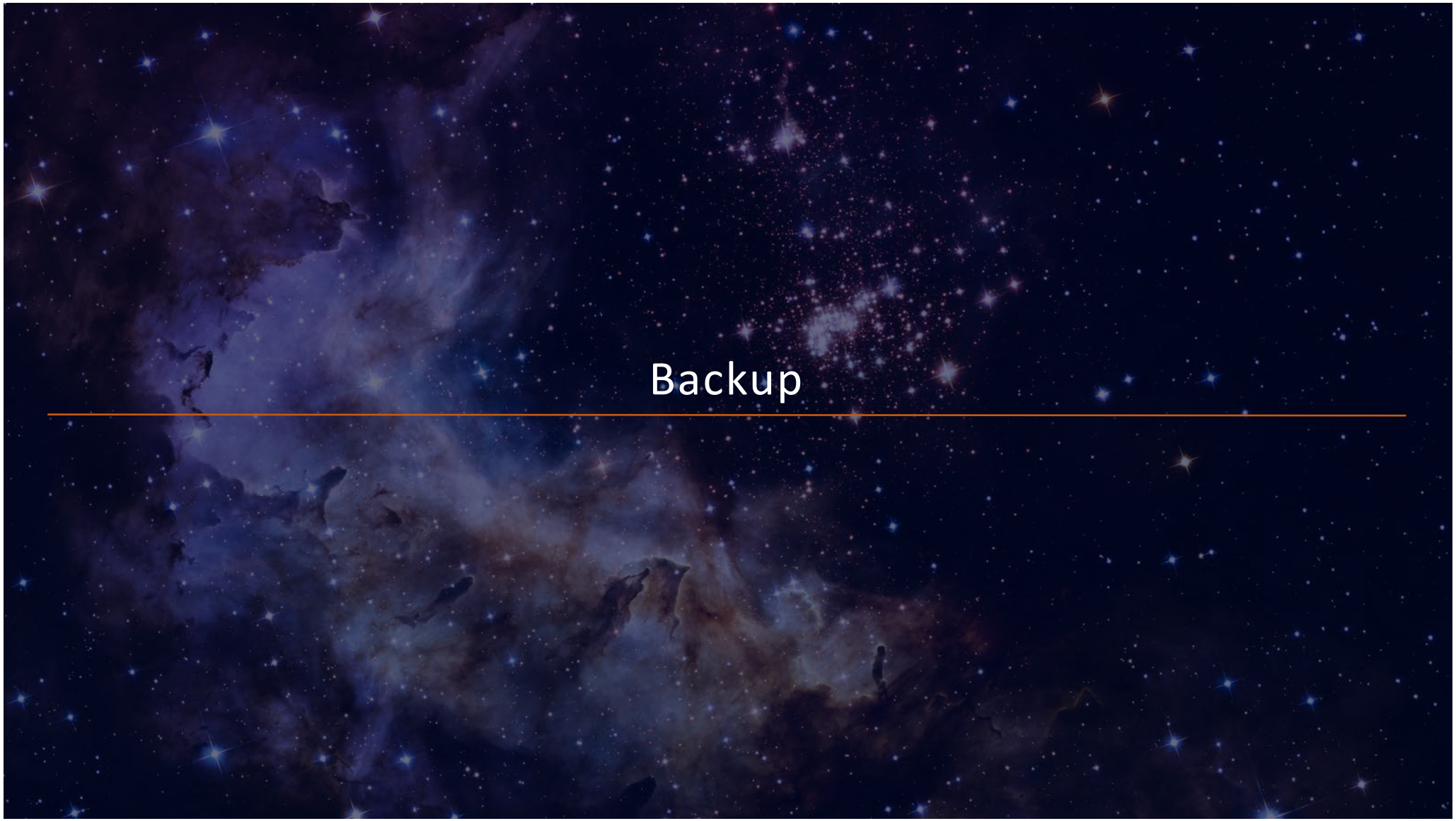
DD time is up to 10% of a cycle, 877 hours ➔ ~7900 hours for GO+GTO

Initial over-subscription of ~2,000 hours to establish high observing efficiency

| Cycle | Total | GTO | DD | GO |
|---|---|---|---|---|
| 1 | 8,766 | 3,700 | ≤876 | ~6,000 |
| 2 | 8,766 | 300 | ≤876 | ≥7,600 |
| 3 | 8,766 | 0 | ≤876 | ≥7,900 |
| 4 | 8,766 | 0 | ≤876 | ≥7,900 |

## Summary

- Spitzer & Herschel, nominal lifetimes <3 years, assigned a major fraction of their initial cycles to large-scale programs
  - Public programs for Spitzer absorbed ~45% of Cycle 1
  - Spitzer added very large programs in its extended mission phase
- HST and Chandra placed the focus on smaller-scale programs in their initial cycles
  - Both observatories introduced larger-scale programs in later cycles
- Separate resources are required to enable larger programs
  - HST, Chandra & Spitzer all set aside time for larger proposals
- Large programs can have a major scientific impact
- GO programs comprise the overwhelming majority of time for JWST from Cycle 2 onward


Backup