



# Spitzer Warm Mission Workshop Introduction

**Lisa Storrie-Lombardi**  
**Sean Carey**  
Spitzer Science Center

## Workshop Format



- ◆ Introduction to the Warm Mission *Monday*
  - *Overview*
  - *Mission plans and questions*
- ◆ Presentations from the Steering Committee
  - *Solicited white paper reports*
- ◆ Contributed white paper summaries
- ◆ Splinter Group discussions
  - *Solar Systems*                      *Our Galaxy*
  - *Nearby Galaxies*                      *Distant Galaxies*
- ◆ Archive presentation *Tuesday*
- ◆ Splinter group summaries
- ◆ Discussion



◆ Steering Committee

- *Chair: Pat McCarthy (OCIW)*
- *Nearby Universe: Daniela Calzetti (U. Mass)*
- *Extrasolar Planets: Drake Deming (GSFC)*
- *Stars, Brown dwarfs: Jill Knapp (Princeton)*
- *Solar System: Carey Lisse (JHU-APL)*
- *Galactic Structure and ISM: Mike Skrutskie (U. Virginia)*
- *Star Formation: Steve Strom (NOAO)*
- *Distant Universe: Pieter van Dokkum (Yale)*



**Warm Mission Overview**

## Life after Helium



- ◆ Observatory has ample reserves on consumables, power, etc.
  - *cryo-telescope assembly expected to equilibrate at 25~29K*
- ◆ IRAC will have essentially unchanged sensitivity at 3.6 and 4.5\_μm
  - *All other detectors non-operational*
- ◆ Spitzer archive will still be brimming with data
- ◆ Community will be in the first round of extracting science from the archive

Spitzer Warm Mission Workshop -- June 4-5, 2007

LSL - 5

## The Spitzer Warm Mission

The Vision: To Fully Exploit NASA's and the Community's Investment in the Spitzer Mission

We will do this by:

- I Capturing the full legacy of Spitzer into a robust, permanent archive
- II Expanding the science from Spitzer beyond the Liquid Helium lifetime through a vigorous archival research program
- III Utilizing the continuing observatory capabilities for unique, vital science possible only with Spitzer

## I. The Data Archive: A Great Asset



- ◆ At the end of the Spitzer cryo-mission, we must reprocess the full data set to uniform calibration and minimal artifacts
  - *Will leave a legacy for science utilization that will remain vital for decades*
  - *Will apply the full knowledge & understanding of Spitzer*
  - *Usefulness of Spitzer and return on investment will be enhanced by new generations of users*
  - *Exact contents will depend on resources (therefore NASA environment), and community needs and inputs*



Spitzer Warm Mission Workshop -- June 4-5, 2007

LSL - 7

## II. Exploiting the Spitzer Data Archive: Community Support



- ◆ Quality and uniformity are critical for new science leveraging the entire archive
  - *Optimized calibration, minimized artifacts in the final processing*
- ◆ Full realization of the science potential of the permanent archive requires:
  - *Adequate funding to the science community*
  - *Support by active scientists at SSC, providing expertise and adapting software*
- ◆ Without a dedicated support plan, archival research funding would be available only through ADP, and technical support at the SSC would be minimal
  - *Was \$2M in 2004 for ~30 mission data sets*
  - *As currently established the ADP funding is inadequate to support a meaningful Spitzer archival program*

Spitzer Warm Mission Workshop -- June 4-5, 2007

LSL - 8

### III. Warm Spitzer: A Unique Asset



- ◆ At end of cryogenic phase, Spitzer will still be a unique space observatory
  - Telescope should equilibrate at  $<30K$  in solar orbit
  - IRAC  $5' \times 5'$  FOVs @  $3.6, 4.5\mu m$  will operate in parallel
  - *3-5  $\mu m$  sensitivity essentially unchanged from cryogenic phase, unmatched until JWST flies*
    - ◆ No measurable degradation in the IRAC arrays to this point
  - Observatory represents over a billion dollars cumulative investment
- ◆ Powerful capabilities
  - Finely tuned, calibrated science instrument
  - Wide-field, superb mapping engine
  - Time-domain access on all scales from milli-seconds to years
- ◆ Well-honed operations
  - ~ 6 years of experience and optimal efficiency
  - Stable, efficient ground support and data analysis system

### Spitzer Post-Cryo Sensitivity

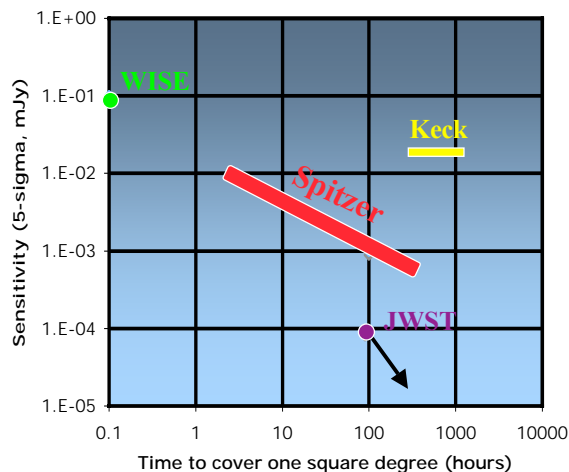


IRAC 3.6 &  $4.5\mu m$  bands match WISE bands 1&2 and lie in JWST sweet spot

~3 orders of magnitude between WISE and JWST sensitivity will be the domain of Spitzer/IRAC as the tool of choice

Shallow integrations will follow up on WISE

Deepest integrations will provide path-finding science for JWST



See WISE memo for details  
<http://ssc.spitzer.caltech.edu/documents/wisememo.doc.pdf>



## IRAC Performance and Operations in the Warm Spitzer Mission

Spitzer Warm Mission Workshop -- June 4-5, 2007

LSL - 11

### Operating Environment Assumptions

- ◆ Spitzer will be passively cooled after cryogen runs out
  - *Telescope* ~ 24-25 K
  - *Multiple Instrument chamber (IRAC)* ~ 25-29 K
- ◆ Warm up above MIPS, IRS and 5.8 and 8.0  $\mu\text{m}$  operating temperatures occurs within 12 hours of cryogen running out
- ◆ Telescope temperature equilibrium occurs within 4 weeks
- ◆ OPZ (operational pointing zone) remains the same
- ◆ Same effective downlink rate as cryogenic operations
  - *IRAC data rate is halved*
- ◆ Pointing system exhibits same stability and accuracy

Spitzer Warm Mission Workshop -- June 4-5, 2007

LSL - 12

## Predicted IRAC Performance



- ◆ Observations with 3.6 and 4.5  $\mu\text{m}$  (InSb) arrays only
- ◆ Temperature of arrays actively controlled
  - *Arrays heated to operating temperature of 30 K*
- ◆ Testing of similar arrays at 30 K at University of Rochester
- ◆ No significant increase in dark current
- ◆ Slight increase in read noise
- ◆ Most observations should still be background / photon dominated
  - *For frame times >30 seconds, arrays should be background limited for all backgrounds*
- ◆ Latents could be more significant but possibly decay faster
  - *Redundancy will be important*

## Warm IRAC AOT



- ◆ Data taking at 3.6 and 4.5  $\mu\text{m}$  only
  - *Can choose to take data in only one channel to reduce data volume*
- ◆ Dither and mapping options remain the same
- ◆ Full frame mode
  - *0.4\*, 2, 6\*, 12, 30, 100, 200, 400\*second frame times (\* potential new frame times)*
  - *Use of 200 and 400 second frame times contingent on improved noise properties for deep images*
- ◆ High Dynamic Range mode
  - *12, 30, 100, 200, 400\* second frame times*
- ◆ Subarray mode
  - *0.02, 0.1, 0.4 second frame times*

## Warm AOT in Spot



IRAC Post-Cryo Mapping

Unique AOR Label: IRACPC-0000

Target: None Specified

New Target Modify Target Target List...

### Instrument Settings

Readout Mode

- Full Array
- High Dynamic Range
- Subarray

Field of View

- 3.6um
- 4.5um

Data Collection

- 3.6um
- 4.5um

For each Pointing

Number of Frames: 1

Frame Time (secs): 12

### Mapping and Dithering

Mapping Mode

- No
- Yes

Set Mapping Parameters

Dither Pattern

- No
- Yes

Set Dither Parameters

Flux Density... Calc. Obs. Time... Comments... Sensitivity... Special... Vis. Window...

OK Cancel Help

Spitzer Warm Mission Workshop -- June 4-5, 2007

LSL - 15

## Anticipated Calibration Strategy



- ◆ Once per week
  - Dark observations at all frame times
  - Flat-field observation
  - Primary stellar calibrators
  - Muxgain test
- ◆ Once per day
  - Secondary stellar calibrator
- ◆ Every 12 or 24 hours
  - Thermal anneal of 3.6  $\mu\text{m}$  channel (contingent on need to mitigate long term latents)
- ◆ ~7% of time needed for calibrations
  - Currently 10-12%

Spitzer Warm Mission Workshop -- June 4-5, 2007

LSL - 16



## Warm Instrument Characterization



- ◆ First month of warm mission
  - *Sample, simple science programs during weeks 2-4 to fill gaps during functional observations*
- ◆ Week 1 -- Functional checkout
  - *Aliveness test, Determine temperature set points, optimize array biases*
- ◆ Week 2 -- Array properties
  - *Set Fowler sampling and finalize frame times*
  - *Calculate noise properties*
  - *Latent characterization*
  - *AOT checkout*
- ◆ Week 3 -- Baseline calibrations
  - *Dark and Flat calibrations*
  - *Stellar calibrations*
  - *Focus check*
  - *Distortion map*
  - *PRF measurement*
- ◆ Week 4 -- Science Verifications
  - *Deep image*
  - *Photometric monitoring*
  - *Galactic shallow survey*

Spitzer Warm Mission Workshop -- June 4-5, 2007

LSL - 17



## Warm Mission Plans

Spitzer Warm Mission Workshop -- June 4-5, 2007

LSL - 18

## Mission Plans



- ◆ Pre-launch mission plan
  - 5 to 5-1/2 year cryogenic mission
  - 1-1/2 to 2 year warm mission
  - 1 year close-out
  
- ◆ Current Proposal
  - 5-1/2 year cryogenic mission
  - 5 year warm mission
  - 1 year close-out
  
- ◆ Bottom Line
  - \$110 million for 3 additional years of warm observing operations
    - ◆ \$50 million for operations + \$60 million for user community

Spitzer Warm Mission Workshop -- June 4-5, 2007

LSL - 19

## Operational Aspects



- ◆ Expect high observing efficiency to continue
  - Execute 6500-7000 hours of science/year
- ◆ **The challenge is to conduct this mission cost-effectively: maximize the science to cost ratio**
- ◆ Planning is based on model of **half current staff** at SSC, JPL & LMA when final reprocessing of cryo-mission data is complete
  - To operate mission with this work-force requires substantial simplifications of operations
    - ◆ Substantially reduced number of supported programs
    - ◆ Simplification of planning & scheduling
    - ◆ Fewer scheduling interrupts
    - ◆ Reduced engineering staff for performance analysis and anomaly response

Spitzer Warm Mission Workshop -- June 4-5, 2007

LSL - 20

## Operational Aspects (2)



- ◆ Look for economies of scale without sacrificing the science
  - *Maintain peer-review process*
    - ◆ Make it less expensive
      - *Annual review costs \$250k not counting the FTEs supporting it*
  - *Shift emphasis to large and “huge” programs, since we’ll have 7000 hours per year to allocate*
  - *Fund data analysis and archival research at an appropriate level*
  - *Streamline science and mission operations to the max*
  - *Engage the community in the planning process*
    - ◆ **You are here!**

## Community Support



- ◆ Continue providing substantial support for the community
  - *Currently send \$30-35 million/year to the User Community*

◆ GO/Legacy	\$18-22 million
◆ Archive/Theory	\$2 million ( <i>\$2.7 in Cycle-4</i> )
◆ GTO science funding	~\$7 million
◆ Fellowship program	~\$1.6 million
◆ Overhead	\$3 million (~10%)
◆ Spitzer constant (\$/hour) ~ \$3k	
  - *Warm Mission Plan -- \$20 million/year to User Community*

◆ Warm Observing	\$10 million
◆ Archive/Theory	\$7.8 million
◆ Fellowship program	\$1 million
◆ Overhead	\$1.2 million (~6%)
◆ Spitzer constant (\$/hour) ~ \$1.4k	

## Schedule Milestones



### ◆ 2007

- *Community Workshop*      *Today!!!*
- *August*      *Issue Cycle-5 Call for Proposals*
- *November 16*      *Cycle-5 proposals due*

### ◆ 2008

- *February*      *Cycle-5 proposals selected*
- *April/May*      *Senior Review meets*
- *July*      *Cycle-5 begins*
- *July/Aug*      *Senior Review report*
- *August*      *Issue Cycle-6 CP*
- *November*      *Cycle-6 proposals due*

*Senior Review process sets the Cycle-6 proposal schedule*

## Schedule Milestones (2)



### ◆ 2009

- *February*      *Cycle-6 proposals selected*
- *March/April*      *Cryo mission ends*
  - ◆ *Best estimate is end of March, +/1 one month*
  - ◆ *No mission has predicted cryo-lifetime to better than 5% = 3 months!!*
- *One month science verification phase when cryogen runs out*
- *May/June*      *Cycle-6 begins*

*We need ~1000 warm hours ready to execute before Cycle-6 is selected.*

## Questions?



- ◆ What are the most important science drivers for a warm Spitzer mission?
- ◆ What should be the duration of the warm mission?
- ◆ What public 'HDF-style' program should be prepared for the cryo/warm transition period?
- ◆ What is the appropriate balance between smaller and larger programs?
- ◆ Are ToOs an important component of the warm mission? If yes, at what level?
- ◆ Should any science programs be specifically solicited for the warm mission?
- ◆ Are there any 'huge' (> 5000 hours) projects that should be done? If yes, how should they be selected and organized?
- ◆ How does the community participate in science of big projects if not part of the executing teams?
- ◆ Can most of the review process be done remotely instead of bringing 100 people to Pasadena annually for a week?
- ◆ Should the review of observing proposals and archival/theory proposals be held at the same time or 6 months out of phase?



## Strawman Plan

## Strawman - Warm Transition



### ◆ Warm Spitzer Heritage Program

- *Cryo-warm Transition Program*
- *We must have ~1000 hours ready to execute by February 2009*
- *Program selected and advertised in advance based on input from Workshop or separate selection process*
- *Execute in 'HDF' style*
  - ◆ Observations designed by science committee (External+SSC)
    - *Executed by SSC staff*
    - *Should specific enhanced data products be produced by SSC?*
  - ◆ No proprietary period
  - ◆ No direct funding
  - ◆ Archival funding available via regular review process
    - *Should we carve out a specific dollar amount to support archival research with these data?*

## Strawman - Observing Proposals



### ◆ Proposal Categories - Observing

- *Small < 100 hours (Should this be 50 hours?)*
  - ◆ AORs required 1-year proprietary period
  - ◆ 1000 hours maximum per cycle (2175 hours awarded in Cycle-4)
  - ◆ Director's time (5-10%)
    - *Could this be used for small category? (<10 hrs?)*
- *Medium 100-500 hours*
- *Large 500-2000 hours*
- *Huge > 2000 hours*
- *Big programs*
  - ◆ Template AORs with proposals
  - ◆ No proprietary period
  - ◆ Really big programs could be executed over 2 years
- *No direct funding for proposals < 10 hours*
  - ◆ Page charges for successful Spitzer proposers paid directly by the SSC?
- ◆ Do we have the right breakdown in categories?
- ◆ Should there be a preordained distribution of time between categories?

## Strawman - Archive/Theory



- ◆ Proposal Categories - Archive/Theory
  - Continue to offer 1-year Archive/Theory proposals
    - ◆ ~\$50-100k
    - ◆ Provide a 'menu' of choices with \$-values so that these can be funded with RSAs
  - Legacy Archive
    - ◆ Multi-year archive programs
    - ◆ Return enhanced data product deliverables to SSC/IRSA
    - ◆ Up to \$500k
  - Large Archive
    - ◆ Multi-year archive programs
    - ◆ No enhanced data product deliverables
    - ◆ Up to \$300k
  - Multi-year Theory
    - ◆ Should we support larger theory proposals too?
- ◆ What fraction of the total community funding should go to Archive/Theory?
- ◆ Should the amount for each category be preordained?

## Strawman - Review Process



- ◆ Hold annual proposal calls and review meeting
  - Does the process need to be annual (would 18 month centers do?)
- ◆ Do the review process in two phases
  - Save \$200k per year on review costs = one FTE
  - Phase 1: remote review of all proposals and submission of grades
    - ◆ Top 10% of small proposals awarded time?
      - Additional 'small' allocation determined by lottery from proposals ranked 10-XX%
    - ◆ Top 20-25% (or highest ranked 1000 hours) of small proposals awarded time?
    - ◆ Big programs (medium, large and huge) forwarded to TAC to provide oversubscription factor of 2
  - Phase 2: face-to-face meeting of TAC to select big programs
  - Archive/Theory/Observing all reviewed together
- ◆ Variant:
  - Review Archive/Theory six months out of phase with observing
  - Same review panels and TAC
  - TAC meets remotely to select Legacy archive programs

## Strawman - Program Support



- ◆ Program reviews
  - *Cursory technical checks*
  - *No duplication checks after selection*
- ◆ Scheduling
  - *Continue to schedule in weekly blocks*
  - *24-36 hr PAOs (periods of autonomous operations)*
  - *Low impact ToOs -- no restrictions*
  - *Select one-high impact ToO/year (currently we select up to 10)*
- ◆ Archive/Data Rights
  - *No embargo checking for large, public surveys*
    - ◆ Advertise this in Cycle-5 as it may impact those programs

## Summary



All science, technical and programmatic elements are conducive to a robust Spitzer Warm mission, consisting of :

- I. Capturing the legacy of Spitzer through a permanent archive**
- II. Pursuing a vigorous Spitzer archival research program**
- III. Utilizing the warm observatory until its natural end**
  - *Unique resource will provide superb science that is unmatched at 3.6 and 4.5  $\mu$ m until JWST starts its science mission*

The astronomical community has a major role in shaping the Spitzer warm mission. Thank you for your participation.





## Logistics

## Questions Summary (1)



- ◆ What are the most important science drivers for a warm Spitzer mission?
- ◆ What should be the duration of the warm mission?
- ◆ What public 'HDF-style' program should be prepared for the cryo/warm transition period?
- ◆ What is the appropriate balance between smaller and larger programs?
- ◆ Are ToOs an important component of the warm mission? If yes, at what level?
- ◆ Should any science programs be specifically solicited for the warm mission?
- ◆ Are there any 'huge' (> 5000 hours) projects that should be done? If yes, how should they be selected and organized?
- ◆ How does the community participate in science of big projects if not part of the executing teams?
- ◆ Can most of the review process be done remotely instead of bringing 100 people to Pasadena annually for a week?
- ◆ Should the review of observing proposals and archival/theory proposals be held at the same time or 6 months out of phase?

## Questions Summary (2)



- ◆ Warm Transition Program
  - *Should specific enhanced data products be produced by SSC?*
  - *Should we carve out a specific dollar amount to support archival research with these data?*
- ◆ Observing Proposals
  - *What hour range should be defined as 'small'? .. < 50 ? ... < 100?*
  - *Use DDT for small category?*
  - *No direct funding for very small programs?*
  - *Do we have the right breakdown in categories?*
  - *Should there be a preordained distribution of time between categories?*
- ◆ Archive/Theory Proposals
  - *What fraction of the total community funding should go to Archive/Theory?*
  - *Should the amount for each category be preordained?*
- ◆ Review Process
  - *How often do we need to select programs?*
  - *Should we use a lottery element for any of it?*