The Single Aperture Far Infrared Telescope (SAFIR)

Making Dreams Come True

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“From Spitzer to Herschel and Beyond: The Future of Far-IR Space Astrophysics”
SAFIR - A Probe of Cosmic Beginnings

“To take the next step in exploring this important part of the spectrum ...”
2000 NRC Decade report

• Resolve the FIR background - trace star formation to z>5
  Astrophysics at the most active epoch

• Probe the earliest epochs of metal enrichment
  Structure of the galaxy-forming universe before metals

• Track the chemistry of life in the warm cosmos
  Prebiotic molecules from clouds to planets

• Identify nascent solar systems from debris disk structure
  Birth of planetary systems

This is YOUR observatory
SAFIR - Value to NASA and the Community

“... a single 8-10 meter telescope operating in the far IR could serve as a building block for the Life Finder, while carrying out a broad range of scientific programs beyond JWST and SIRTF.” 2003 Origins Roadmap

- Scientific successor to Spitzer, Herschel, and SPICA
  Promotes rich set of mission opportunities (e.g. SPECS)
- Powerful scientific partner to JWST, SOFIA and ALMA
- Commonality in technology needs with many missions clear path to large science arrays enabling new spectrometer architectures demonstrated command of passive cooling cryocooler advances deployable large aperture advances

Huge science need coupled with feasibility
### Flowdown to Mission Concept

*What SAFIR is ...*

<table>
<thead>
<tr>
<th>Aperture</th>
<th>~10m</th>
<th>high-z galaxies, debris disks</th>
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<tbody>
<tr>
<td>Temp</td>
<td>&lt;15K</td>
<td>L* galaxy @ z=5 zodi-limited operation</td>
</tr>
<tr>
<td>( \lambda ) range</td>
<td>20-500( \mu \text{m} )</td>
<td>primary coolant lines chemistry, structure diagnostics peak of early galaxy SED</td>
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<tr>
<td>Spatial res</td>
<td>2&quot; @ 100( \mu \text{m} )</td>
<td>proto-planetary disks, early galaxies, bulge/disk fmttn</td>
</tr>
<tr>
<td>Lifetime</td>
<td>&gt;5 years</td>
<td>productivity</td>
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Clear paths to realizing the requirements
SAFIR Vision Mission Study
A strategic planning tool for the future

• Funded by NASA OSS 4/04, 1-year study effort

• PI Dan Lester, 14 CoIs, 9 collaborators
  Andrew Blain  Dominic Benford  Matt Bradford
  Mark Dragovan  Bill Langer  Charles Lawrence
  David Leisawitz  John Mather  Lee Mundy
  Harvey Moseley  George Rieke  Gordon Stacey
  Hal Yorke  Erick Young

• Involvement of 4 NASA centers
  GSFC, JPL (co-lead centers),
  MSFC (SOMTC), JSC (Exploration)

• Contributions from 4 key aerospace contractors
  Ball, Boeing, NGST, Lockheed-Martin

Building close partnership on FIR space astronomy
SAFIR Vision Mission Study
Products and Considerations

- Science Summary - “Tall Goals”
- Design Reference Mission
- Technology Assessment - “Tall Poles”
  SAFIR technology roadmap
- Architecture Options
  industry studies, key trades,
  human/robotic opportunities
- “Team-Us” integrated design study
  (JPL Team X review with participation
  by key 2003 GSFC IMDC review staff)

Formal case for goals-compliant and achievable SAFIR
Flavors of SAFIR
Architectures of value to space FIR

- JWST-like
  max system validation

- sparse aperture
  max baselines
deployment simplicity

- “DART” w/ membrane mirrors
  large aperture/weight ratio

commonality in technology needs
among these and other OSS missions

- deployment, active surface control
- large format, low noise detectors
- cryocoolers, thermal management
- large, lightweight optical structures
Critical Thermal Technologies
And Key Trades for SAFIR

- Cryogenic, deployable large apertures
  actuators, latches
  lightweight mirror substrates

- Optimized background reduction strategies
  shield architectures
  low emissivity designs (off-axis?)
  field of regard versus insolation
  orbit (L2, drift-away, out of plane, distant?)

- Cryocoolers
  shield cooling (gas flow, capillary technologies)
  ACTDP extension (100mW @ 4K)

State of Art suggests cosmic BLIP is achievable!
Components of the Background

Sky background

Telescope background

FIR sensitivity needs drives thermal requirements
Critical Focal PLane Technologies
And Key Trades for SAFIR

• Compact, efficient spectrometer architectures

• Large format ($10^3$-$10^4$) broadband arrays
  semi- and superconducting (TES) bolos
  Ge, Si BiB photoconductors

• Quantum noise-limited heterodyne spectrometers

• Low power dissipation and thermally isolated
  focal plane arrays and instruments
  cryogenic mpxrs
  superconducting electronics

FIR focal plane tech investments offer big payoff
At least one challenge for SAFIR definition is prompt harvest and digestion of Spitzer science surprises.

- Heating mechanism of cold dust and importance of PAHs in galaxy energetics.
- Clear discrimination between AGNe and starbursts.
- Morphology of dust in debris clouds. Reconciliation of lobed structure at mm wavelengths with mid-IR.
- tbd …

Designing SAFIR to build on Spitzer (& etc.) results.
Consistent with the new NASA Space Exploration initiative, the SAFIR study will consider enabling opportunities that could be brought by humans and or robots. Strategic alignment with Space Architect’s office.

SAFIR as a test template for large astronaut-aided science facilities in space. Strong Code T & Code S interest. JSC Code EX to oversee efforts in a responsible way. NExT heritage.

- Construction/Deployment?
- I&T/system validation?
- Servicing?

Enabling opportunities for astronomy in the new NASA?
the road ahead

- completion of SAFIR Vision Mission Study
- 2005 OSS Strategic Planning
- ST-9 technology demo mission (2008)
- next NRC Decadal Survey (kickoff 2008)
- evolution of Exploration Initiative …

Consensus on, and good articulation of, priorities by our community is important factor in our success.