

Thermal Infrared Ground Based Instruments: Lessons Learned (PPT)

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DOI

[10.5281/zenodo.4452600](https://doi.org/10.5281/zenodo.4452600)

Publication date

2020

Document Version

Final published version

Citation (APA)

Packham, C., & Brandl, B. (2020). *Thermal Infrared Ground Based Instruments: Lessons Learned (PPT)*. Ground-based thermal infrared astronomy – past, present and future. <https://doi.org/10.5281/zenodo.4452600>

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A Big Thanks & Kudos...

- ▶ ...to Leo and Valentin as SOC Chairs
 - ▶ Tough meeting to plan/organize, but am very impressed with the meeting
 - ▶ Zoom, slack, gather, really helps the interactions
- ▶ ...and to long-term and new-term friends and colleagues, it's wonderful to see everyone again, even in a 'zoom box'! 🤪

Change of Plans...

- ▶ We thought it might be more useful/interesting to present results of a survey than another update on MICHI as
 - ▶ I have presented on MICHI in many other venues, and would be happy to provide published papers/presentations to anyone (just email or slack message me)
 - ▶ TMT is not in the construction phase, is trying to understand the site, and is waiting for the USA's Decadal Survey to be published
- ▶ We hope that the 'hive-mind' survey can be useful to those planning for new TIR instruments
 - ▶ And their host observatories

TIR Instruments

- We made a partial census of TIR instruments on ~4m+ telescopes, and contacted the PI and/or instrument scientist (IS) for that instrument
 - Bernhard is in process to update & improve that listing
- We received a total of 13 responses from 21 persons contacted
 - Note that some persons were PI/IS for >1 instrument

Instrument	Telescope	Tel D
MIRSI	IRTF	3.2
iShell	IRTF	3.2
TIMMI	ESO 3.6m	3.6
TIMMI-2	ESO 3.6m	3.6
UIST	UKIRT	3.8
CGS4	UKIRT	3.8
SpectroCam-10	Palomar	5.0
MICHELLE	Gemini-N/UKIRT	8.1
TEXES	Gemini-N/IRTF	8.1
OSCIR	Gemini-N/S	8.1
COMICS	Subaru	8.2
VISIR	ESO VLT	8.2
IRCS	Subaru	8.2
LWS	Keck	10.0
LWIRC	Keck	10.0
T-Recs	Gemini-S	10.4
CanariCam	GranteCan	10.4
MICHI (MIREs)	TMT	30
METIS	ESO ELT	39
MIDI	ESO VLTI	140
MATISSE	ESO VLTI	140

Instrument	Telescope	Tel D	λ coverage [μ m]	Years in ops
MANIAC	ESO La Silla	2.2	N	
BigMac	WIRO	2.3		
AT1	IRTF	3.2		retired (80s)
BASS	IRTF	3.2		
BOLO-1	IRTF	3.2		retired (80s)
CSHELL	IRTF	3.2		
HIPWAC	IRTF	3.2		
iShell	IRTF	3.2	3 - 5	active
MIRLIN	IRTF/Hale-5m/Keck-II	3.2		
MIRSI	IRTF	3.2	2 - 20	2003 - now
MIRSI	IRTF	3.2	2 - 20	active
NSFCam/2	IRTF	3.2		
Protocam	IRTF	3.2		retired (90s)
SPEX	IRTF	3.2		
CAMIRAS	CFHT	3.6		
IRSPEC	ESO 3.6m	3.6		1986 - retired
TIMMI	ESO 3.6m	3.6	5 - 17.5	1992 - 1998
TIMMI-2	ESO 3.6m	3.6	5 - 24	2000 - 2006
CGS-3	UKIRT	3.8	NQ	1990 - 1998
CGS-4	UKIRT	3.8	NQ	
MAX	UKIRT	3.8		
MIRACLE	UKIRT	3.8	LMN	
UCL-S	UKIRT/IRTF/AAT	3.8	N	1980 - 1992
UIST	UKIRT	3.8	1 - 5	
NIMPOL/MIRAS	AAT	3.9	NQ	
SCORE	Palomar	5	8 - 13	retired
SpectroCam-10	Palomar	5.0		
CLIO/2	Magellan	6.5		active
MIMIZUKU	TAO/Subaru	6.5		
MIRAC 1/2/3/4/5	MMT/Magellan	6.5	3 - 25	active



Thank You
To...

Comments from:

John Lacy

Markus Kasper

Ralf Siebenmorgen

Alan Tokunaga

Naoto Kobayashi

Bruno Lopez

Alistair Glasse

Ulli Kaeufl

Hirokazu Kataza

Eric Pantin

Matt Richter

Pat Roche

Augmented/embellished by Chris

Note the total lack of gender balance...

10 Survey Questions

<p>1. What went especially “right” with the instrument you were associated with? Please make a note of the instrument name and observatory it was [primarily] deployed to.</p>	<p>2. What technical or design aspects were challenging with the instrument you were associated with?</p>	<p>3. What would you have done differently in the design / construction, based on your experience?</p>	<p>4. What went especially “right” in the interaction between the observatory and the instrument team that you were associated with?</p>	<p>5. What was challenging in the interaction between the observatory and the instrument team that you were associated with?</p>	<p>6a. Are you satisfied with the scientific harvest / return from your instrument?</p>	<p>6b. In your own research field, if you did not have ground-based thermal-IR observations, what aspects of your models would be unconstrained?</p>	<p>7. Some suggest that the MIR ground-based community is [too] small(i) Why do you think this is? (ii) How could this community be broadened?</p>	<p>8. What advice would you give to instrumentation people considering construction of a thermal-IR instrument for the next generation of 30m-class telescopes?</p>	<p>9. What advice would you give to observatory people considering hosting a thermal-IR instrument for the next generation of 30m-class telescopes?</p>	<p>10. Anything else you would like to say to us?</p>
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~~A Run Through of Each Answer~~

- We don't want to do something so boring as read through each response, and have such a 'dry' presentation
- Instead, we looked for common threads between the answers; we could clearly identify
 1. Communication
 2. Detectors
 3. Chopping
 4. Data reduction
 5. Reviews
 6. Observatory contact
 7. TIR as a niche area?
 8. Advice regarding 30m's

Communication (Internal & to Observatory)

- 😊 Michelle/UKIRT - Integrated, operated and performed very well on UKIRT, in large part due to the close relationship between the telescope group in Hilo and the build team in Edinburgh
- 😊 MIRI/JWST - A triumph of (primarily European) international collaboration, thanks in large part to the integration of a professional but pragmatic project management team from Astrium/Airbus, and the development of a close relationship between the optics group in NASA/GSFC + Ball Aerospace and the EC consortium builders
- 😊 MATISSE: What went right : the Consortium & the ESO collaborative spirit
- 😞 The telescope/build team relationship was not maintained on transfer, where a policy of telescope group contracting instrument teams was coming into vogue, with the result that the instrument was neglected and underused

Detectors

- **Difficult things** - cryogenics, **detector performance**, reliability - plus telescope problems - chopping secondary guiding in chop/nod positions
- **Buy and characterize the detectors first**
- A more developed equipment at ESO to test the mid-IR detectors and a permanent pro-active policy for getting the best ones
- Access to last generation detectors and more equipment and may be human resources at ESO Garching in this domain
- **Detector stability/noise drives chopping...**



Chopping

- Ensure that the telescope is designed to chop efficiently
- Chopping is one of the most limiting things for the 8m's; make it efficient, tip/tilt correction, and without 'ringing'
 - Major limiting factor for the 8m's
- In the design phase, we would not like to depend on the chopping secondary. But after the first light, the chopping secondary becomes one of the most critical capabilities of the telescope
- Understanding the background, integration into the VLT operations scheme
 - Synchronization with the telescope (e.g. avoiding the passive support to move during an integration)

From Chris: Chopping on 30m's

- ▶ Impossible to chop on the 30m's using M2, hence internal (pupil plane) choppers planned
 - ▶ Eliminate the problems associated with the chopping M2...hopefully without making new problems!



Data Reduction



- Try to have operations and data flow down to science grade data products as close as possible to the standards of optical instruments. Or better try to exceed the quality of the data products
- Audience poll – Q1: Making a ‘fancy’ pipeline takes a lot of effort, how do you wish to reduce your data for publication? Choose one option:
 1. Provide only raw data (do-it-yourself)
 2. Provide data after a basic reduction (instrumental artifacts corrected, i.e., flatfielded, dead pixel corrected, 'mosaicing' for imaging and 'optimal extraction' for spectroscopy)
 3. Provide higher level data products (co added, flux calibrated, close to publication quality)

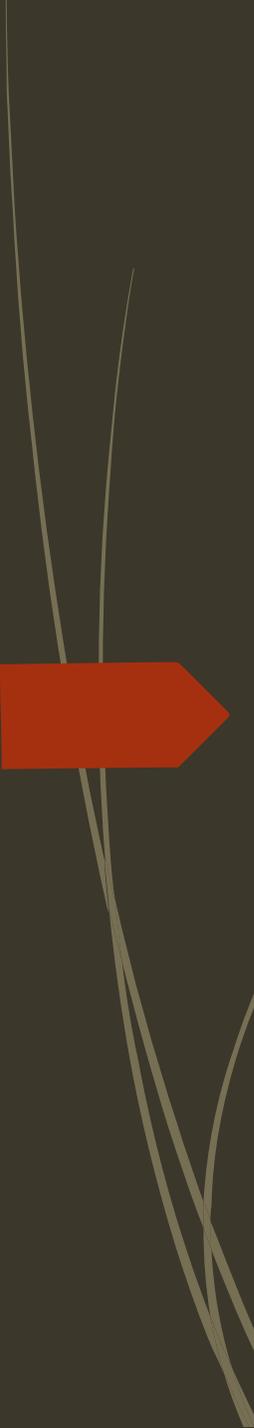
[A full pipeline for a 2nd generation VLT instrument is in the ballpark of 20 FTEs]
- Audience poll – Q2: Is this true for all modes or just complex modes?

Reviews

None of the issues we finally had to solve had been spotted in the design reviews, even though, in hindsight, some were quite obvious

During ALT the instrument was plagued by substantial electrical problems which were due to a concatenation of design errors

Reviews are not for ESO, they are for the instrument team to close loops, write documents, reflect, etc.



Observatory Contact: Good

- 😊 Get an observatory person to work with the instrument development, especially for anything on an ELT. This will greatly help the handoff of the instrument to the observatory
- 😊 Embedding observatory staff within the instrument team is key to aid communications and the roll-out
- 😊 The spirit of collaboration
- 😊 We got lots of support during development & commissioning
- 😊 The IRTF provided all of the support we needed, but let us run things the way we wanted
- 😊 Strong support for visitor instruments such as great flexibility in scheduling
- 😊 Mutual understanding
- 😊 Team spirit
- 😊 Our instrument was built in-house, so the instrument team was very familiar with observatory team. We solicited advice from the observatory team to make sure that the observatory personnel are satisfied with how the instrument is handled and how it is maintained
- 😊 The telescope team improved to reduce the thermal background using our data

Observatory Contact: Bad

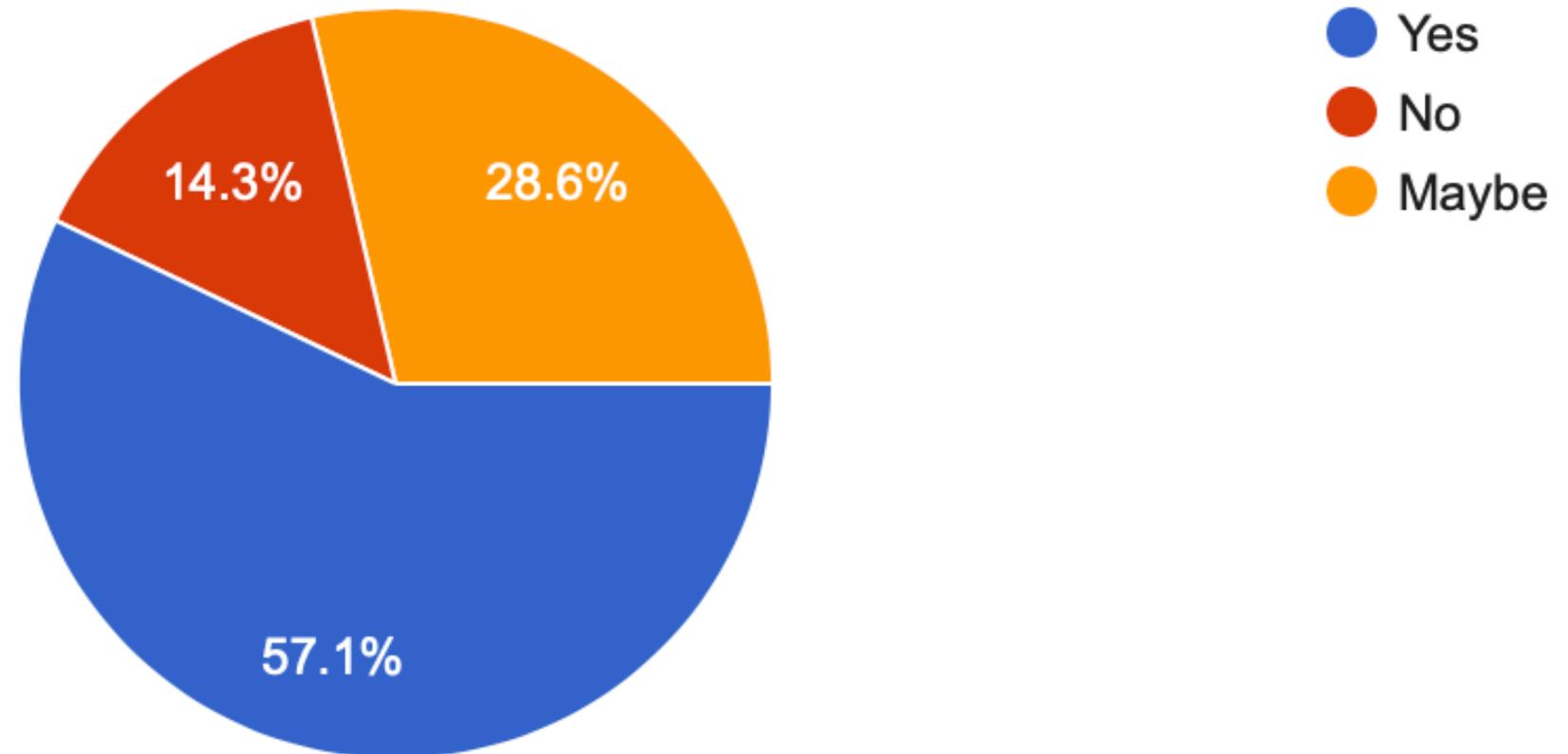
- 😓 Because the telescope/observatory was being built in parallel, it was very hard to get interface information from the observatory, which turned out to be one of the biggest overhead for the development
- 😓 We were able to develop a relationship of mutual respect and shared goals. This was challenging but vital.
 - 😓 For XXX this was not the case and the telescope/instrument interface was a disaster
- 😓 Many scientifically useful suggestions were discarded as "too time consuming" or "too expensive" to implement and support
- 😓 The administration wasn't always so enthusiastic about what we were doing. Or perhaps it was that they had unrealistic expectations about how much demand there would be for a rather nichey instrument
- 😓 Communication is the hardest part of the interaction. So the project manager needs to make sure the communication is effective.
- 😱 They made up there own reading of the contracts

TIR as a Niche Area?

- ▶ The observation technique is not simple, and we need more steps for data reduction. There is not enough support for the data reduction process
- ▶ If the observer doesn't need to study, understand, and fix the peculiarities of the ground-based setup him/herself, but just be able to take the perfectly calibrated data from the pipeline (as usually possible for space observatories), the number of observers will significantly increase
- ▶ Could the answer simply be that the kind of exciting research that people want to do is just out of reach from the ground? Of course the ELTs will change this because of the very high angular resolution. It seems that the sensitivity achieved on 8 and 10 m telescopes was simply insufficient
- ▶ Main drawbacks of ground-based MIR is relatively poor sensitivity and low spatial resolution compared to NIR. Improving sensitivity is most important
- ▶ The ground-based thermal IR sensitivity is poor compared to that now available and imminently with JWST even more so, from space. The focus of observations will inevitably be on very compact structures to remain competitive and this pushes the science into niches such as high spatial and spectral resolution, and polarimetry. I am not sure that the community is too small given the likely opportunities
- ▶ No direct link to mainstream astronomy; results need to be "marketed" much more aggressively
- ▶ The science drivers are critical and people need to make sure that there is a compelling science case and that it is complementary to space-based facilities
- ▶ Keep the number of observing modes as small as possible (then steadily upgrade in the future)
 - ▶ This is easier to do with a compact, well aligned community, so maybe being a niche is not a problem at all
- ▶ Be decisive in cutting marginal modes; include sacrificial modes at Phase A if you are particularly cynical (polarimetry is good for this).
- ▶ Be patient. Focus on the gains that will be made with a 30m

6a. Are you satisfied with the scientific harvest/return from your instrument?

14 responses



Advice Regarding the 30m's

- Don't make the mistake to scale efforts and support by the size of the community!
- Be aware of the potential and limitations of ground-based vs. space-based MIR observations
- Simpler, less challenging design and hopefully therefore more rapid delivery.
- Don't underestimate the demands in getting the instrument working reliably so that commissioning, and exploitation can happen rapidly after delivery. **Decide which operating modes are essential and get those working quickly so that early science is successful**
- But also be aware of what can be done from a 30m ground-based telescope that can't be done from space. I think specifically of **high spatial and spectral resolution observations**, spatial because the diffraction limit can be smaller and spectral because instruments can be bigger. **Be sure the telescope is capable of diffraction-limited performance in the MIR, with a tip-tilt adaptive secondary**
- Dynamic scheduling, low Rh nights should be given to mid-IR
- Find a way to schedule the instrument for a reasonable fraction of the time, or don't install it. Ensure that the telescope systems are working well enough to deliver the science - especially near-diffraction-limited images
- For the thermal-IR instrument, improvement of the observatory side to reduce the thermal background variance is essential. This improvement will result in a significant advance in the thermal-IR region
- **Chances are that the t-IR instruments will be the first ones to work at or close to the diffraction limit**
- The suite of instruments for a 30m class telescope has to be viewed differently than how one would consider the suite of instruments on an 8 or 10 m telescope. The TMT had an initial plan of accommodating 12 or so instruments. I now think that an ELT should have a maximum of perhaps 3 or 4 instruments at any one time so that each instrument has more time on sky during its lifetime. When instruments cost more than \$30M or \$50M you want it to have as much time on sky as possible and to decommission when the main objectives are achieved. Then let another instrument have a chance on the telescope. So I think this requires a change in thinking about observatory instruments for such large telescopes



Conclusions & Invitation to Discussion

- ▶ Communication, internal and to observatory is crucial
 - ▶ Embedding observatory staff within the instrument team is key to aid communications and aid in the roll-out
 - ▶ Despite all our C21st communication tools, seemingly continuous “lessons learned” workshops, etc., it’s amazing that this is still the foundational point
 - ▶ Humans are humans...!
- ▶ Detectors and chopping have been major pacing items
 - ▶ Will GeoSnap help with this?
- ▶ Better data reduction tools could be key to broaden the community
- ▶ Reviews are key for the team to pull the docs together, not necessarily the actual review
- ▶ Somewhat of a dichotomy about making the instruments simple (for rapid roll-out) vs. the limited number on 30m’s and the large community they are planned to serve
 - ▶ Or perhaps prioritize the most important modes and focus on them first
- ▶ TIR might be the 1st to reach diffraction limit on the 30m’s, and can well exploit high spatial/spectral resolution