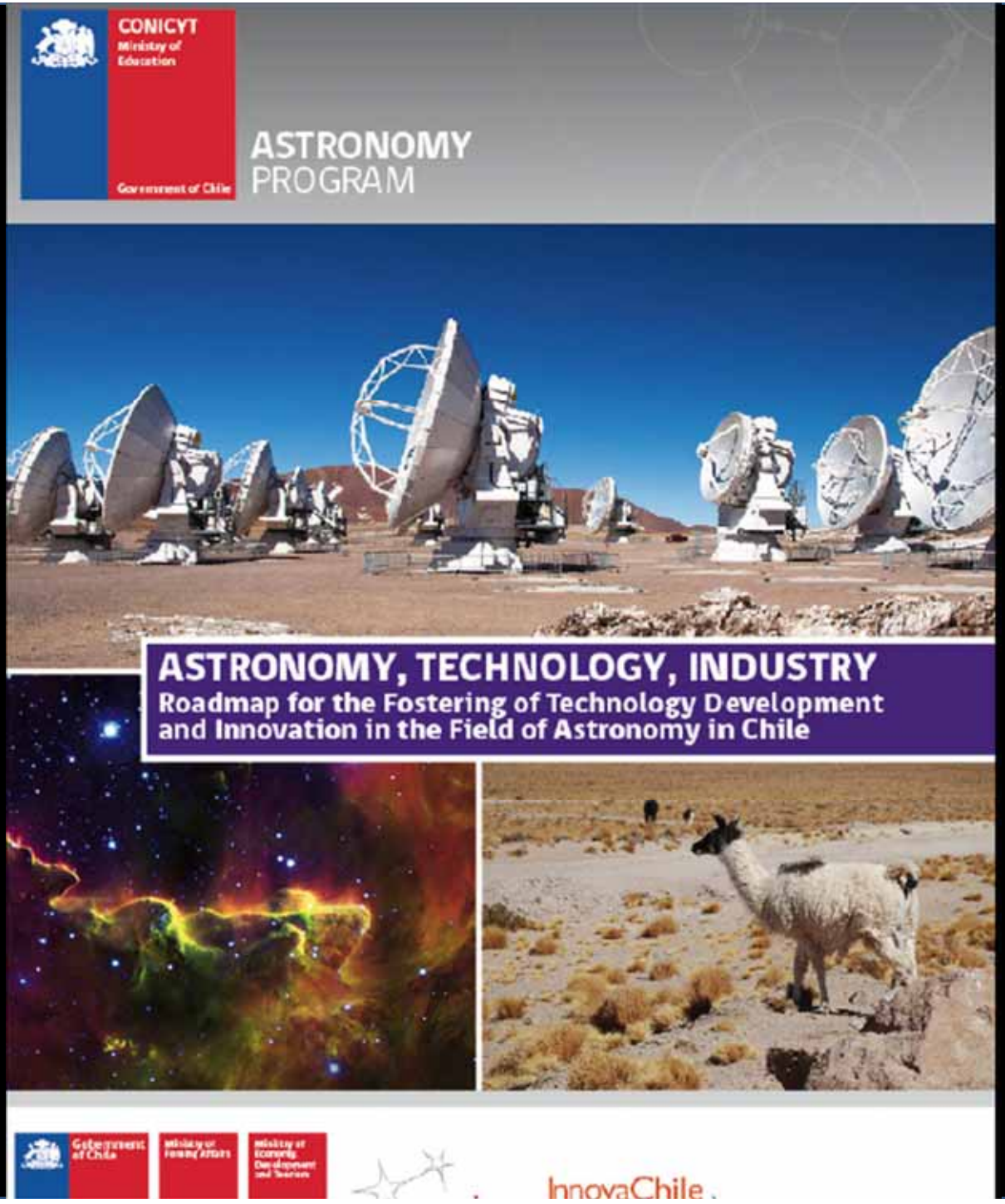
ASTRONOMY, TECHNOLOGY, INDUSTRY

Roadmap for the Fostering of Technology Development and Innovation in the Field of Astronomy in Chile

Gary H. Sanders

Santiago, Chile

October 24, 2012


CONICYT
Ministry of Education
Government of Chile
ASTRONOMY
PROGRAM
ASTRONOMY, TECHNOLOGY, INDUSTRY
Roadmap for the Fostering of Technology Development and Innovation in the Field of Astronomy in Chile
InnovaChile

A personal note

- I am very pleased to have the chance to provide the best advice that I can, remembering the wise and gracious assistance provided to me and the Thirty Meter Telescope project, by the government of Chile, as we explored the opportunity to realize our project here
- Thank you again!

Thirty Meter Telescope at Cerro Armazones and MinRel (2009)

Our Team

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Dr. Angel Otárola, Thirty Meter Telescope

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Mr. Andrés Barriga, Innovation Division, Ministry of Economy

Mr. Guillermo Acuña, Innovation Division, Ministry of Economy

Ms. Karen Molina, DECITY, Ministry of Foreign Affairs

Mr. Cristian González, National Innovation Council for Competitiveness

With the collaboration of: Ms. Andrea Zuñiga Cabrera, Ms. Paola Jarpa Riquelme, Mr. Patricio Vásquez and Ms. Camila Serra, all from CONICYT

We worked over 18 months in face to face meetings and by videoconference

Our task

"The skies over Chile are well recognized as a global natural resource for astronomy. How can this natural resource best benefit Chile? To be sure, the presence of so much of the world's telescope inventory already benefits Chile with prestige and an ever growing community of international scientists. Astronomy appears frequently in the Chilean media. Astronomy and its community have become part of the cultural tapestry of modern Chile. Looking ahead, nearly 2/3 of the world's telescope light collecting area in the visible and infrared wavelengths may soon be located in northern Chile and Chile already hosts the highest sensitivity collecting area in the millimeter and sub-millimeter radio bands. It is imperative to ask how this global asset, located in Chile, can be leveraged beyond global astronomy to benefit Chilean science, education, industry and development. Furthermore, is there a path by which Chile can leap beyond incremental gains in leveraging this asset to leap frog into the front ranks of global astronomy technology and innovation?"

Chile already makes a large investment in hosting astronomy

- This investment is beyond Chilean skies as a natural resource and asset
- Under the ESO treaty, and through Public Law 15.172, Chile grants international observatories privileges and immunities including relief from many taxes and import duties
  - This is a very large financial investment in the observatories
- Chile has succeeded in attracting most of the world's great observatories
  - This is a great success
- How can Chile build further on this large investment?

What could Chile do?

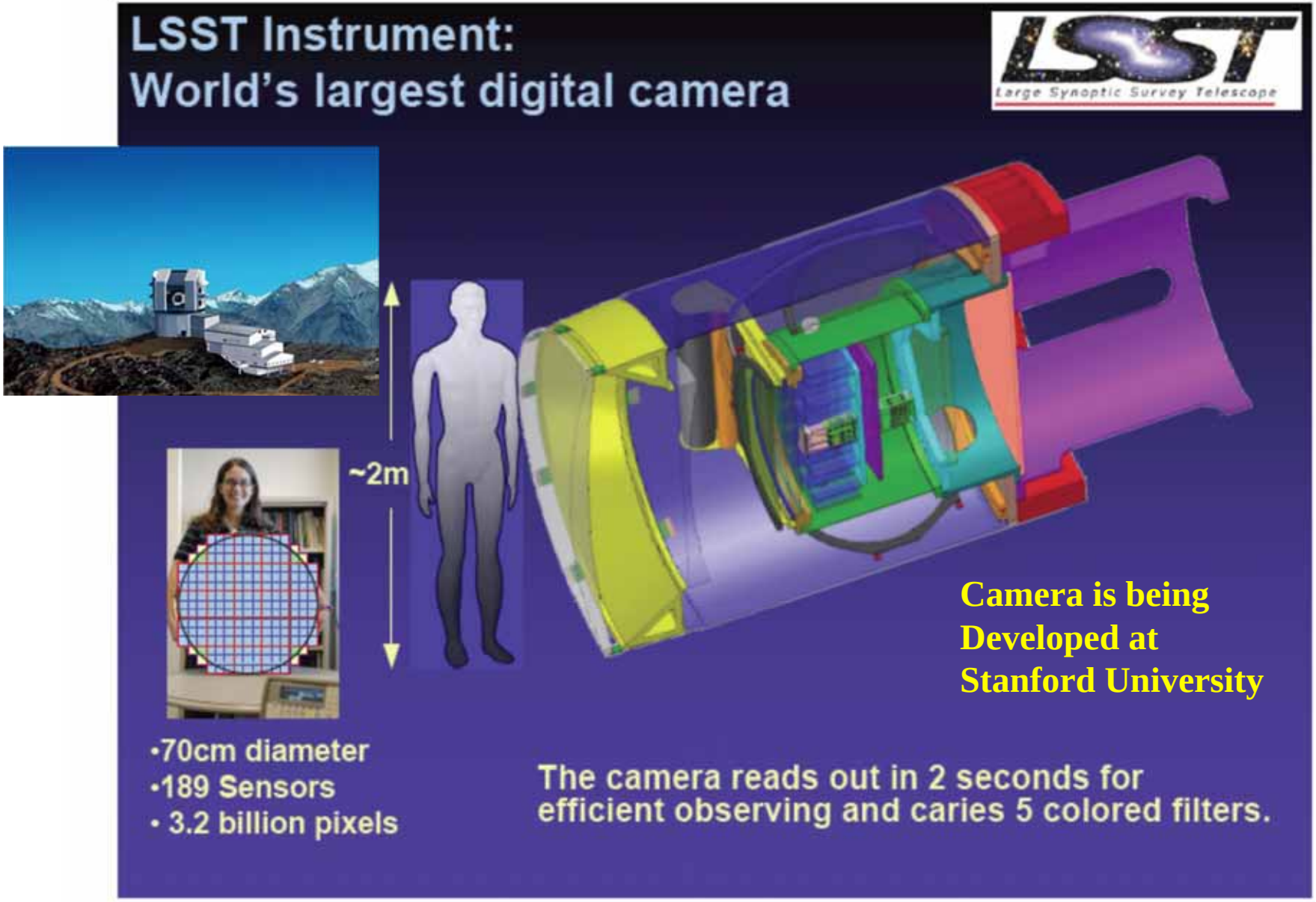
"Chile can seek to leverage its many international observatories to strengthen general education, or science, technology, engineering and mathematics (STEM) education. Chile may act to stimulate Chilean astronomy itself. Industrial development can occur through captured innovation, elevation of skills and engineering challenges within Chilean industry and expansion of the service industries supporting the observatories. Chile can move into a more collaborative posture with international observatories and with international firms leading technology delivered to observatories in Chile. All of these thrusts are advantageous to promoting Chile's advancement through its clear skies natural resource. "

…But, some questions…

- Can Chile leapfrog from astronomy and astro-engineering collaborator and supporter to world class practitioner and innovator?
- Can Chile use its astronomy resource and hosted international observatories to emulate a “Silicon Valley” model?
- Can Chile move beyond exploiting the visiting astronomy “industry” to growing its own tree of innovation whose roots are planted in Chile’s fertile skies?

Our principal recommendation

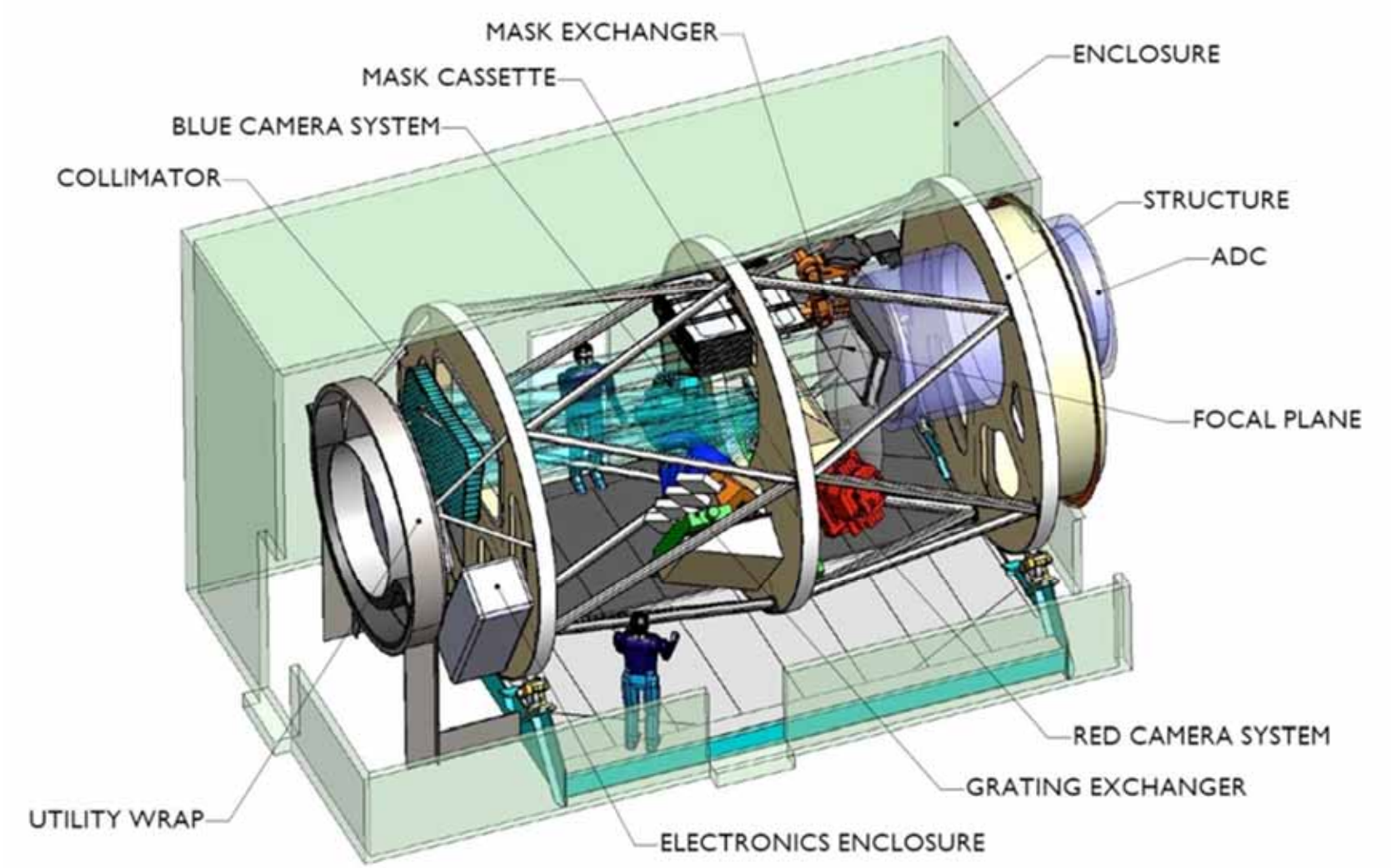
"However, we recommend that, in order to advance Chile in **indigenous** science, technology and innovation, Chile should follow a roadmap to develop indigenous scientific and technological leadership in one or two carefully selected technology areas at the core of astronomy research by Chilean astronomy and engineering groups, applicable at the international observatories hosted by Chile. This strategy is recommended in order to leap frog Chilean science, technology and innovation to world class rank within a decade….build outward from Chilean astronomical interests, to start at the root of innovation ecology and to make a rapid step to a leading position in global astronomy technology."



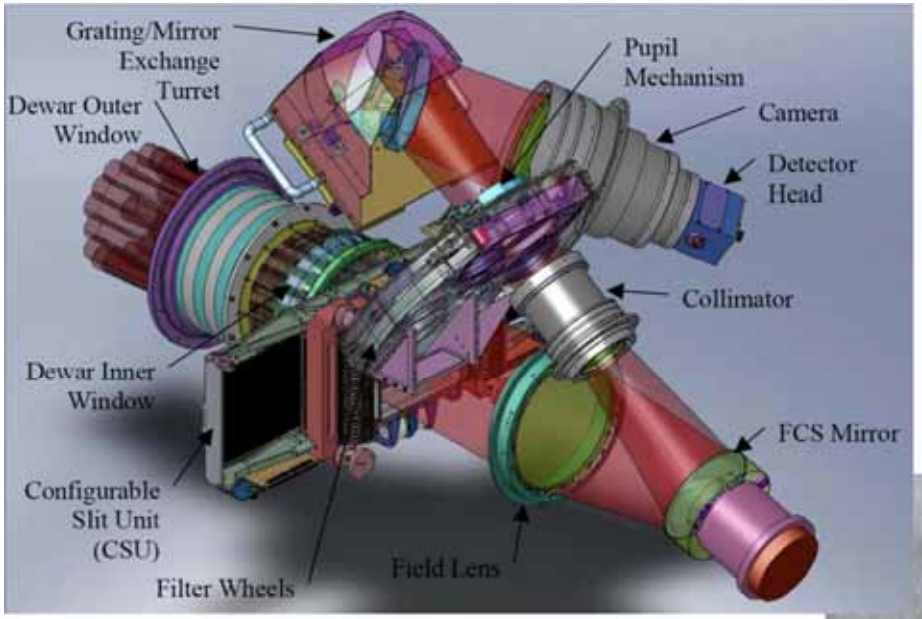
30 Terabytes of data per night

Courtesy of M. Rubio

MOBIE Schematic View



InfraRed Multi-slit Spectrometer (IRMS) for Keck and TMT

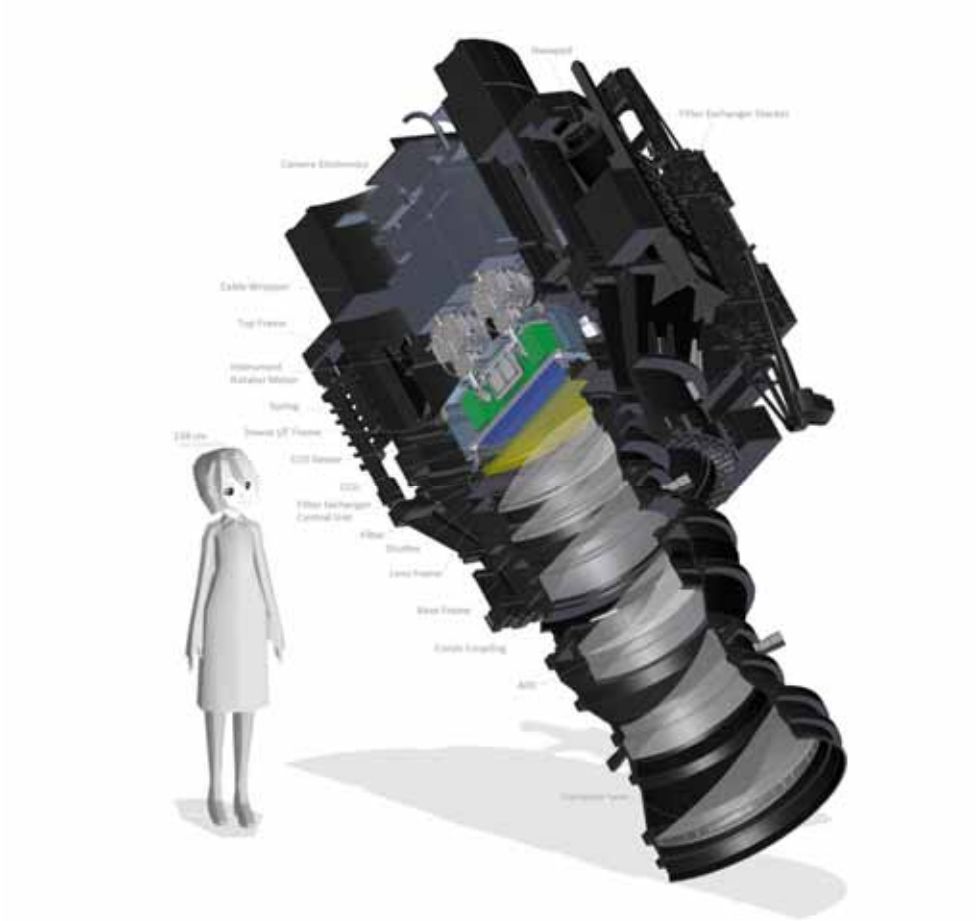


TMT/IRMS
or
Keck/MOSFIRE

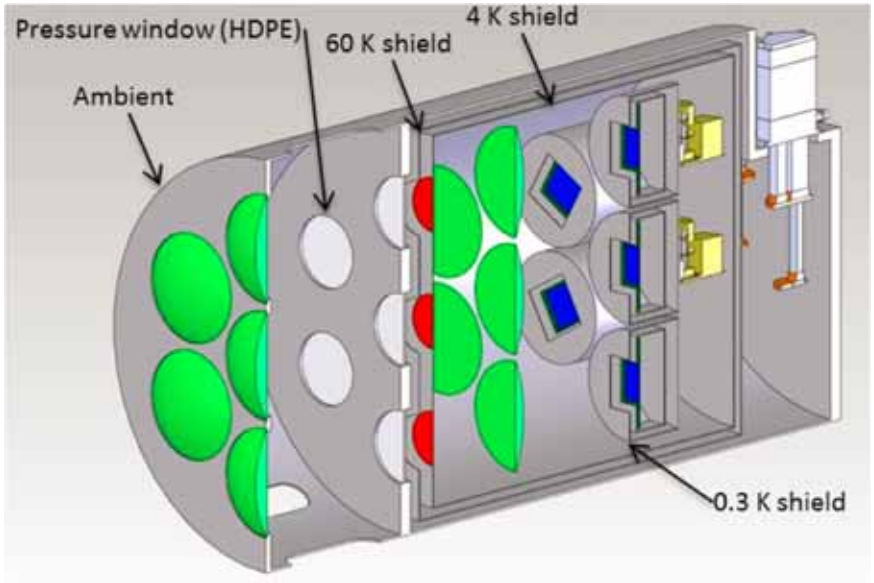
Keck, February 2012

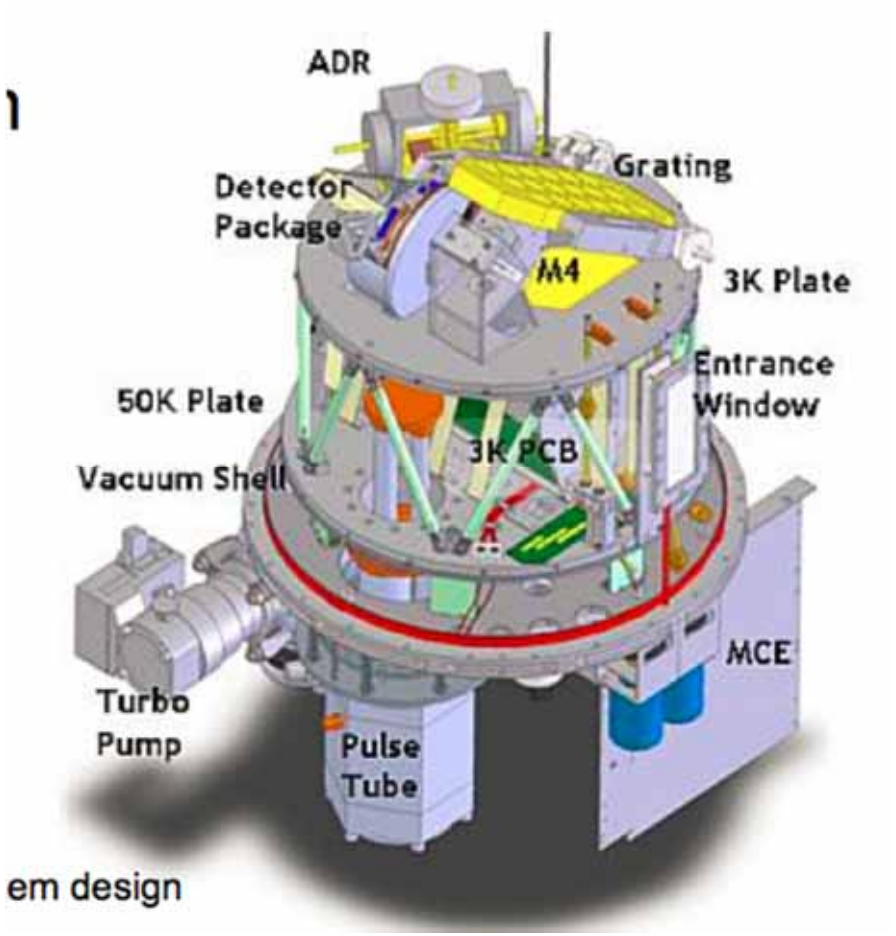
Astro-engineering challenges:
Precision optics, precision mechanics, cryogenic temperatures, cryogenic mechanisms, advanced optical sensors, large data sets, advanced system engineering, rigorous project management

Hypersupreme Cam
NAOJ – Subaru Observatory



CCAT SWCAM & Zeus-2
Radio instruments





Astro-engineering → Innovation

- The astro-engineering practiced by the international observatories is the source of innovation from astronomy
- As practiced, the roots of this innovation tree are in America, Europe and Japan
  - Astro-engineering is practiced by a small, elite community in these regions
    - Community numbers of order 1000 people (my estimate)
  - Chileans have begun to enter this community as students, apprentices, individual contributors, collaborators or supporters

Imported or indigenous innovation ?

- Collaborating with international groups by Chilean universities and industry can yield benefits for Chile (as in the ADERE report)
  - "Imported" innovation
  - How to translate these imports into Chilean benefits?
    - Is there the rest of the innovation ecology in Chile?
  - The roots of these innovations are outside Chile
- We take a longer and more ambitious view
  - Grow the roots here
  - "Indigenous" innovation
  - Create the rest of the innovation ecology in steps

How?

- Learn from efforts in Asian countries
  - Invest in centers of excellence that target leadership positions
  - Attract overseas citizens back home
  - Recruit world class leaders to start new efforts
  - Biomedical, materials, photonics, green energy, …
- One type of Chile adaptation of these models
  - Astronomy/astro-engineering because you have the world's largest astronomy "industry" already
  - Centers of excellence, attract overseas Chileans, recruit world class leaders to Chile,…

Our principal recommendation

"However, we recommend that, in order to advance Chile in **indigenous** science, technology and innovation, Chile should follow a roadmap to **develop indigenous scientific and technological leadership in one or two carefully selected technology areas at the core of astronomy** research by Chilean astronomy and engineering groups, applicable at the international observatories hosted by Chile. This strategy is recommended in order to leap frog Chilean science, technology and innovation to world class rank within a decade….build outward from Chilean astronomical interests, to **start at the root of innovation ecology** and to make a rapid step to a leading position in global astronomy technology."

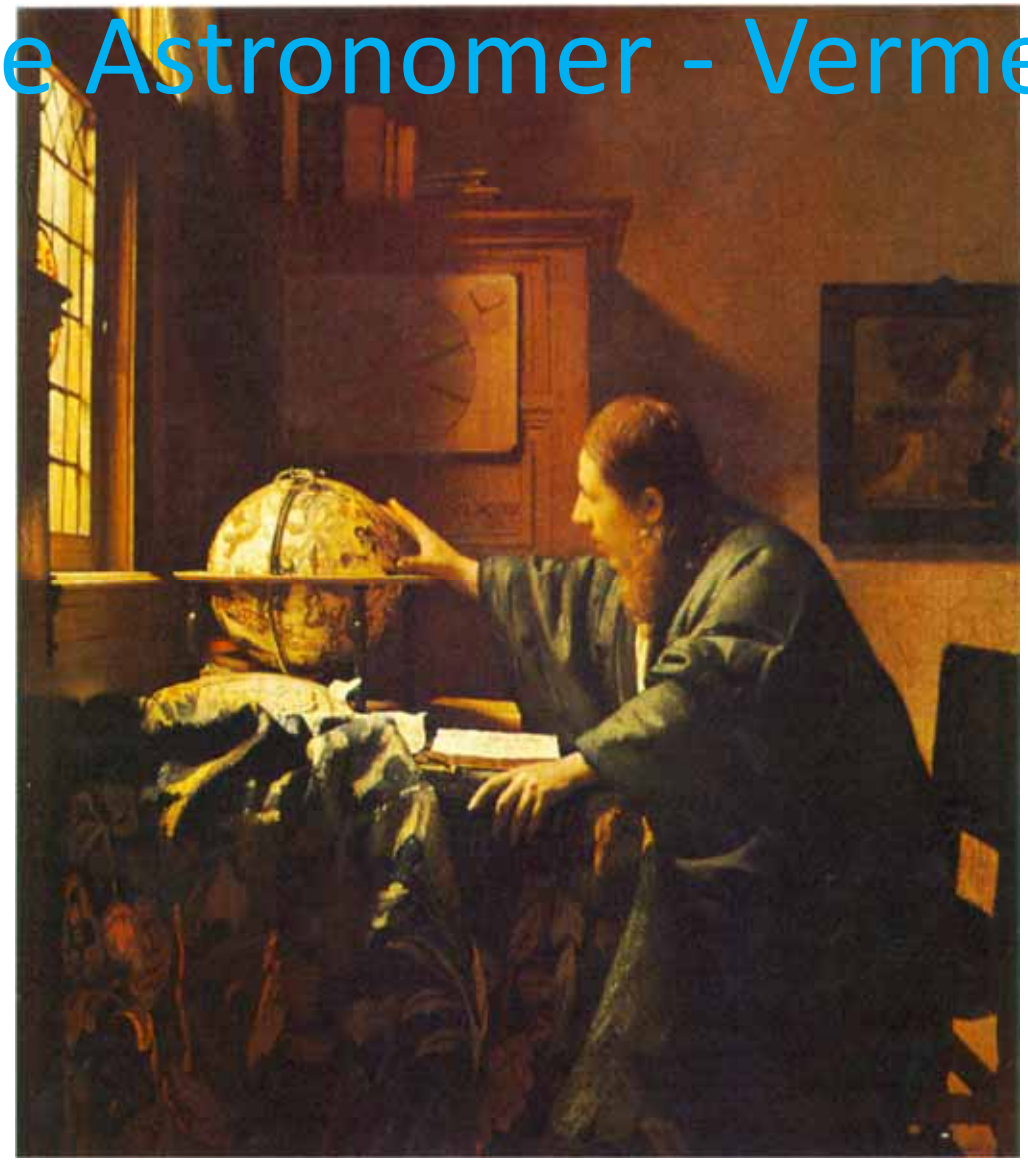
"…one or two carefully selected technology areas at the core of astronomy…"

1. Chilean astronomy community → decadal plan for astronomy → Chilean instruments need to follow decadal plan with Chile's 10% observing time → apply for center of excellence funding for instruments → build instruments and support external innovation
2. Select from existing Chilean astro-engineering interests → apply for center of excellence funding for instruments → build instruments and support external innovation
3. Attract international center of excellence interests → apply for center of excellence funding for instruments → build instruments and support external innovation

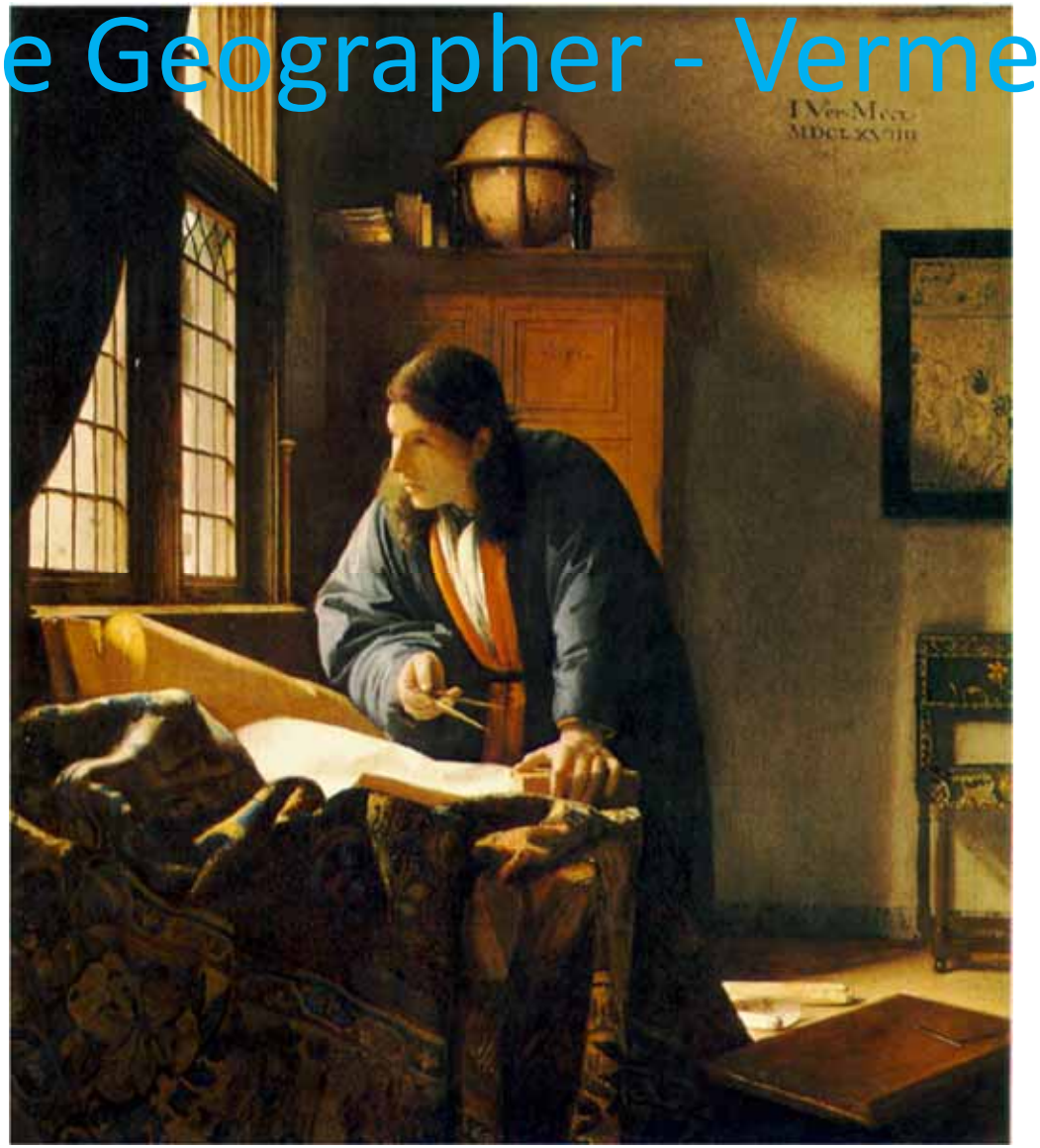
"…one or two carefully selected technology areas at the core of astronomy…"

- To enlist the astronomy community, base chosen activities in science
- Carry out a community planning study with the Chilean astronomy community to identify, perhaps,
  - One optical/infrared astronomy science case and instrument and
  - One radio astronomy science case and instrument
- Approximately one year will be needed to carry out this process

The Astronomer - Vermeer



The Geographer - Vermeer



The Collaborators – A Caltech "forgery"

The selected instruments

- Are the basis for proposals by Chilean astronomers to use the 10% observing time granted to Chilean astronomers at an international observatory
  - The 10% time is an asset that belongs to Chile, you own it
  - You are able to assign the observing time
  - Your instrument must pass peer review by the involved observatories
    - Precedent in astronomy for this is called “visitor instruments”
  - Data centers are included in my use of “instruments”

Scale of projects

- Up to $5 - $10 million US $ each, over a decade
- 5 – 7 years to realize once leader is in place
- 5 – 20 year scientific lifetime
- Requires experienced leadership
  - Chilean, returning or recruited leaders
- Each instrument project may be viewed as a center of excellence initiative
  - Structure this initiative to deliver a technical legacy
    - Make technical “spinoff” part of strategic follow-up

Subordinate or Leading ?

"We propose that this initiative not be a mere lateral or subordinate collaboration with the international observatories, though such an "apprenticeship" might be viewed as a logical progression. **We propose that Chile seek a leading role. Chile's astronomy skies lead the world. Chilean indigenous astronomy and its spinoffs should lead as well."**

Subordinate or Leading ?

The international observatories will expect this

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The international observatories will not expect this

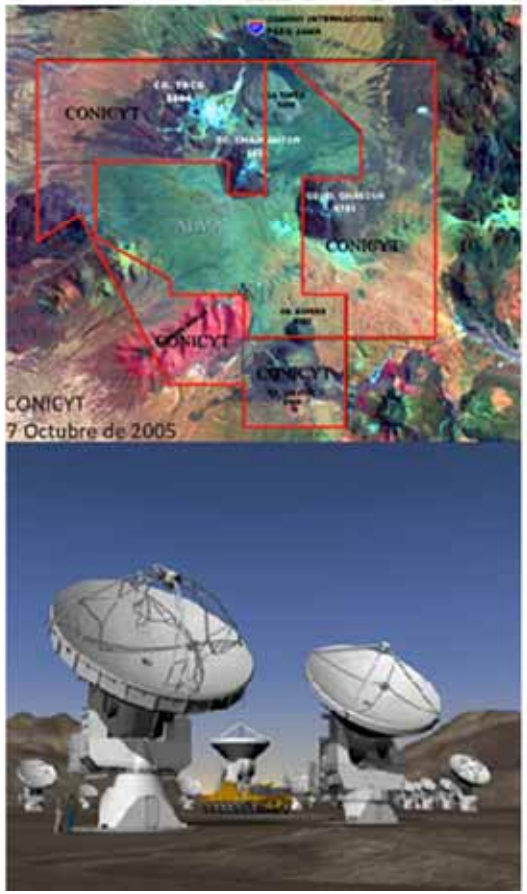
Persistence over a decade

"…we propose an initiative to start the more complete exploitation of Chile's remarkable skies and the extraordinary international observatories established under those skies. These first steps do not require active partnership with industry nor with the observatories though such partnership is not excluded. What is required is earnest involvement of the government agencies and the Chilean astronomy community. **Persistence is also required for a process that will take one to two years to launch and a decade to bring to delivery.** Success will deliver the instrumentation for a first rank Chilean astronomy thrust and a world class Chilean astro-engineering capability able to catalyze innovation beyond astronomy."

Comisión Nacional de Investigación Científica y Tecnológica – CONICYT

Parque Astronómico Atacama

- **Características**
  - –Ubicación: Llano de Chajnantor, cercano a San Pedro de Atacama.
  - –Tamaño: 36,347 ha.
  - –Cielos claros, fácil acceso, comunicación de infraestructura y aislado de zonas urbanas.
- **Observatorios**
  - – mini-TAO, ACT, PolarBear, CCAT (estaciones de monitoreo)



Courtesy of M. Rubio

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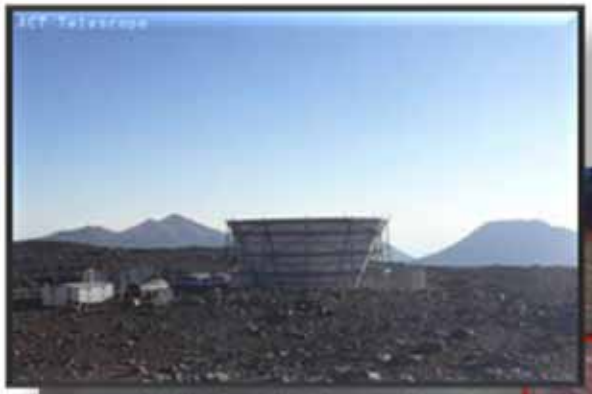
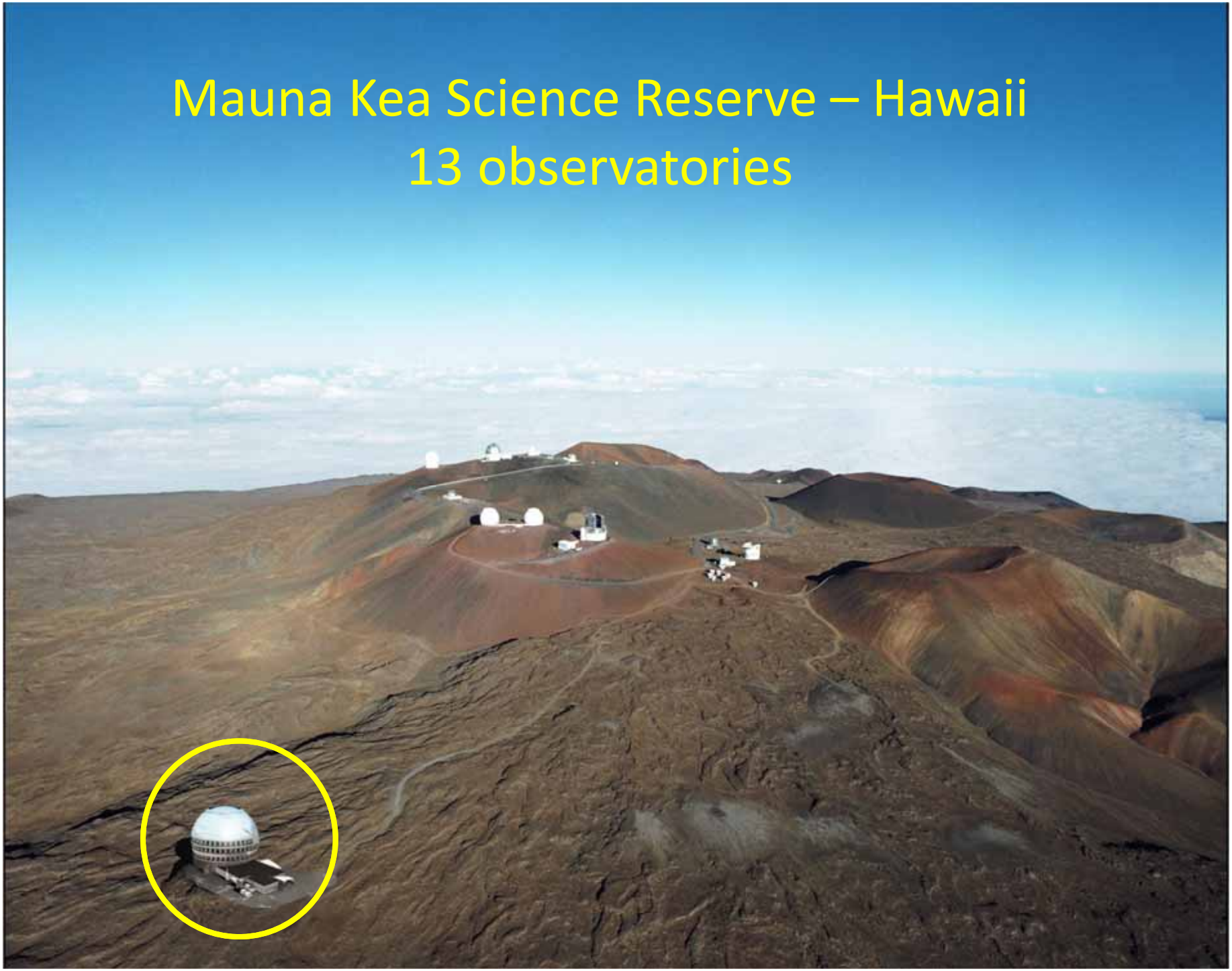


ALMA

Courtesy of M. Rubio

Mauna Kea Science Reserve – Hawaii
13 observatories



Astronomy park

- The Mauna Kea Science Reserve provides a successful setting for 13 observatories
  - Common services and maintenance are established
  - Preservation of the sensitive lands are achieved
  - Safety and eco-tourism are enhanced
- This can provide lessons learned for the inevitable arrival of more observatories in Chile
- Manage this resource pro-actively rather than re-actively

Process of the roadmap study

- Interagency working group did scoping study, discussions
  - Set goals and defined methodology
  - MinEcon did its own very useful parallel study of industry opportunities, through a contractor (ADERE report)
- Survey questionnaires sent to universities and international observatories
  - Universities respond in great depth in writing and by meetings
  - Only a few small observatories responded in writing and by meetings
    - Large observatory organizations formally resisted

Other benefits of this study

- Interagency stakeholder identification
- Collaboration in
  - developing the ADERE terms of reference
  - Supporting the ADERE study
- Supporting the creation of a liaison office for astronomy
- Brainstorming with MinEcon, Corfo, Innova…
- These may guide how we can implement recommendations from the Roadmap

Criticisms of this roadmap

- Lead – CONICYT, MinEcon, CORFO,… – Who?
  - Roadmap is a joint study including science and technology opportunities
    - Science → technology → innovation → markets
    - ADERE report is a parallel and very important resource
  - Agencies should follow up in their own areas with cooperation and coordination
- Role of an international consultant has led to resistance by some
  - Unpaid, external, non-advocate international advice is the high standard used in global science

Implementing the Roadmap: Step 1

- Decadal astronomy study (1 year to accomplish)
  - Community workshop to start process
  - Community white papers on science and on instrument initiatives
  - “Town hall” workshops
  - Engagement with international observatories – white papers from observatories for Chilean led instruments
  - Chilean study group leads the formulation of plan
  - Second panel provides peer review of first panel decadal plan
  - Products
    - Science priorities
    - Instrument project recommendations
    - Plan to engage the selected observatories
    - Plan for balance between current program and new thrusts
    - Vision for science and technology future path

Implementing the Roadmap: Step 2 or alternate Step 1

- Interagency group studies (6 months to accomplish)
  - Possible technology opportunities from astronomy instrumentation projects
  - How to follow the work to exploit opportunities as they arise
  - Decide on funding methods, announcements of opportunities and agencies to support the projects
  - Decide on recruitments, leadership, organization of projects, attracting centers of excellence
  - Review proposals for the projects

Implementing the Roadmap: Next Step

- Award and start projects (3 – 9 months to accomplish)
  - 3 months if leadership, participants are in Chile and available
  - 9 months if recruiting a Chilean or external leader or establishing external party in center of excellence
  - Proposal review by interagency group representing astronomy, innovation, economy, etc.
  - Involved observatories invited to submit evaluations to interagency review panel

Implementing the Roadmap: Final Step

- Project execution
  - Consistent government official leading oversight
  - Semiannual substantive project performance reviews through entire project
    - Standing expert non-advocate review committee
  - Project reviews and oversight include ongoing assessment of technology, innovation, spin-off, STEM, human capital opportunities

Implementing the Roadmap

- Project activities start 12-24 months after start of implementation process
- Instruments available about 5 years later as target date

The Roadmap is not about astronomy

- Astronomy in Chile presents the opportunity
- Astro-engineering (including astro-informatics) leading to innovation is the focus
- Implementation should be part of the economic incentives and opportunities to be offered by the appropriate agencies
- Liaison officer in MinEcon can play a crucial role
- Cross collaboration between universities, industry, MinRel, MinEcon, CONICYT is key to success of any implementation