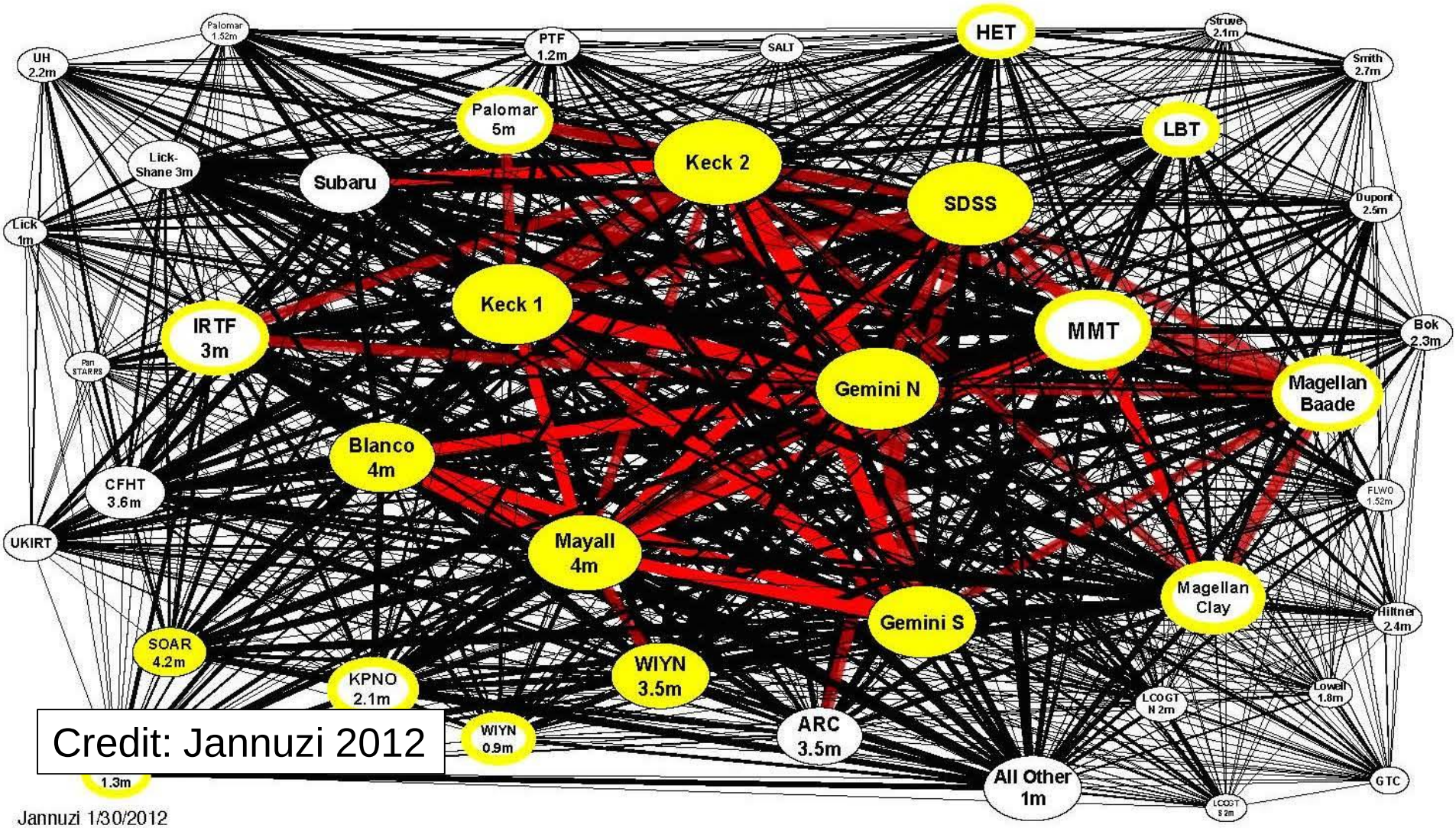
NOAO Today and Tomorrow

David Silva, NOAO Director

Context
The System as social network



Credit: Jannuzi 2012

Context
The System as social network

- OIR System = distributed, uncoordinated social network
  - US leadership has not been achieved top-down
  - US leadership achieved by individual nodes or groups of nodes
  - Is this model sustainable?

- NOAO is one strong node among other strong nodes
  - NOAO is not the dominant node (nor will be or need be)

- LSST is critical future node but is not stand-alone
  - Cross-network activity needed to maximize LSST impact
  - NOAO, Gemini, LSST → natural node grouping for LSST-related research and federal leadership

Context
The System as social network

- Intra-network collaboration and development is…
  - Fundamentally ad hoc
  - Driven by self-interest (scientific, institutional, personal)
  - Driven by need for resources (capital)
  - Not driven by consensus science goals
  - Not driven by egalitarian ideal of “open access”
  - Not driven by desire for US leadership

- International (“inter-network”) collaboration ascendant
  - Driven by need for resources (capital)
  - *Foreign “networks” confused about where/how to connect*

Context
What makes the NOAO node unique?

- Core mission → service to entire national community
  - Accepted as “fair broker” & “community organizer”
  - Nodes with similar missions: Gemini, NASA/IRTF, NASA/Keck
- Federal facility, public asset
  - Aligned with agency priorities, community aspirations
  - Natural target for federal investment (esp. non-NSF)
  - Natural connector to foreign national centers
- Strong partnerships with DOE labs and projects
  - Fermilab, LBNL, and (emergent) SLAC
  - DES, DESI, LSST
- Wide-field 4-m telescopes → survey platforms
  - Wide-field imaging and spectroscopy

NOAO Today

NOAO Today

Extending Community leadership into a new era

- Inflection point: Portfolio Review (2012)
  - New NSF programmatic and financial constraints
  - New Community research aspirations
  - Conclusion: dramatic evolution required

- As always, NOAO goals remain the same…
  - Excellent research tools and services for the Community with the resources we have
  - Seek/create opportunities for more such tools and services in the future

NOAO Today
Foundations for Community excellence

- Key technology
  - Dark Energy Camera (DECam) @ Blanco
  - Dark Energy Spectroscopic Instrument (DESI) @ Mayall
  - Large Synoptic Survey Telescope (LSST)
- Key science projects
  - Dark Energy Survey (DES)
  - DESI Key Project
  - Community-led surveys with DECam and DESI
  - Community-led research with data products from all of above
- Key partnerships
  - Federal centers (Fermilab, LBNL, SLAC, NCSA, Gemini, LSST)
  - Community-based Science Collaborations (DES, DESI, LSST)
  - Non-Federal projects (TMT)

NOAO Today
Foundations for Community excellence

- Open access to telescope nights
  - Gemini North and South, Blanco, SOAR, SMARTS
    - Exciting new instruments arriving at all these facilities

- Open access to data and data services
  - DES images and catalogs
  - DESI key project spectra and targeting catalogs
  - NOAO Survey program images and catalogs

NOAO South

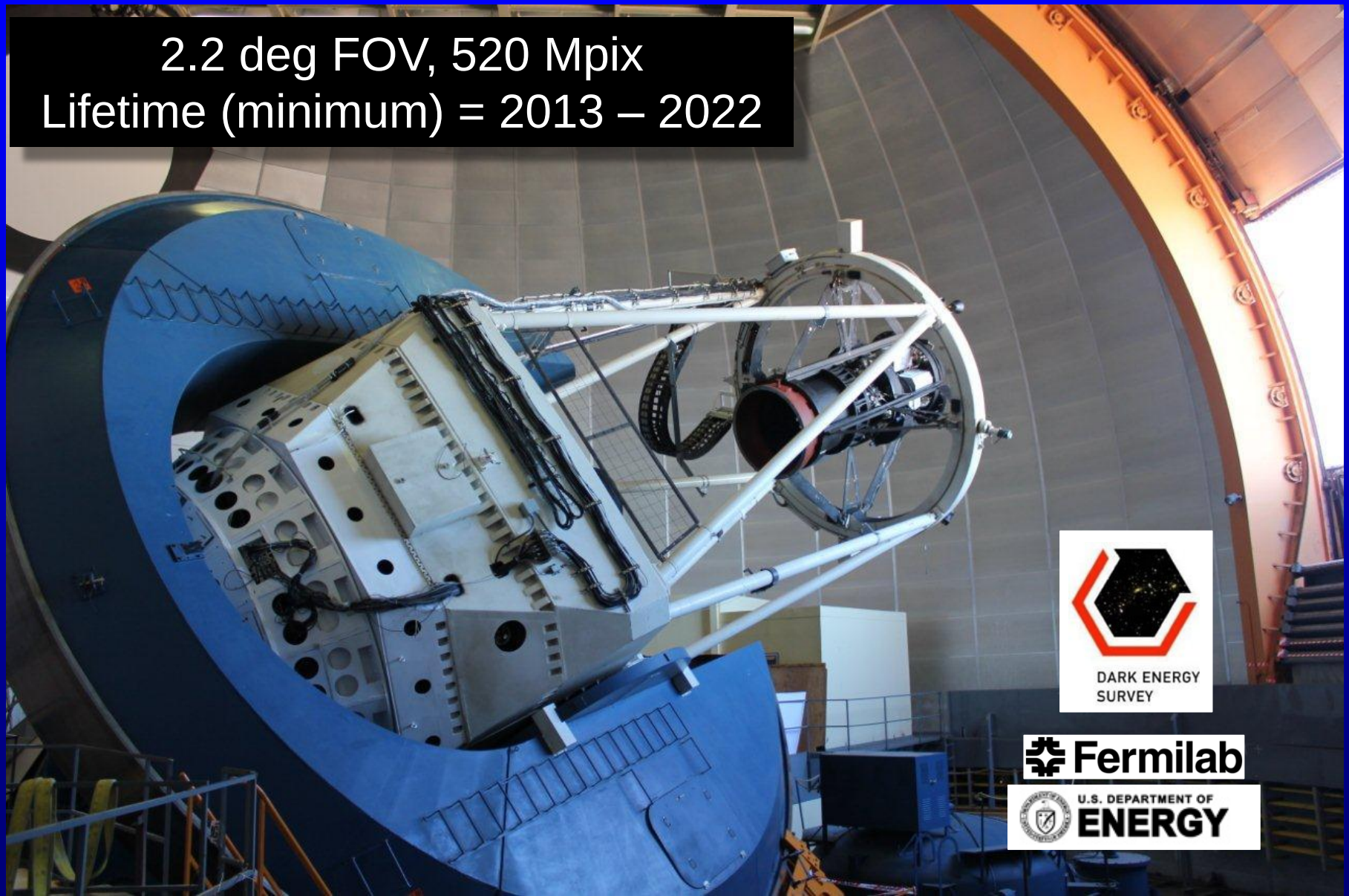
An open-access machine for scientific leadership

Strong scientific synergy with Gemini South **now**, LSST later

- Blanco 4-m
  - Dark Energy Camera
  - COSMOS = optical multi-object imaging spectrometer (NEW)
  - TripleSpec4 = near-IR spectrometer (Coming 2015)
  - *Also: access to AAOmega and HERMES at AAT*
- SOAR 4.2-m
  - Goodman = optical multi-mode spectrometer
  - SAM = GLAO optical imager
  - STELES = optical echelle spectrometer (Coming 2016)
- SMARTS (1.5-m, 1.3-m, 0.9-m)
  - Near-IR, optical imaging
  - Fiber-fed echelle spectroscopy

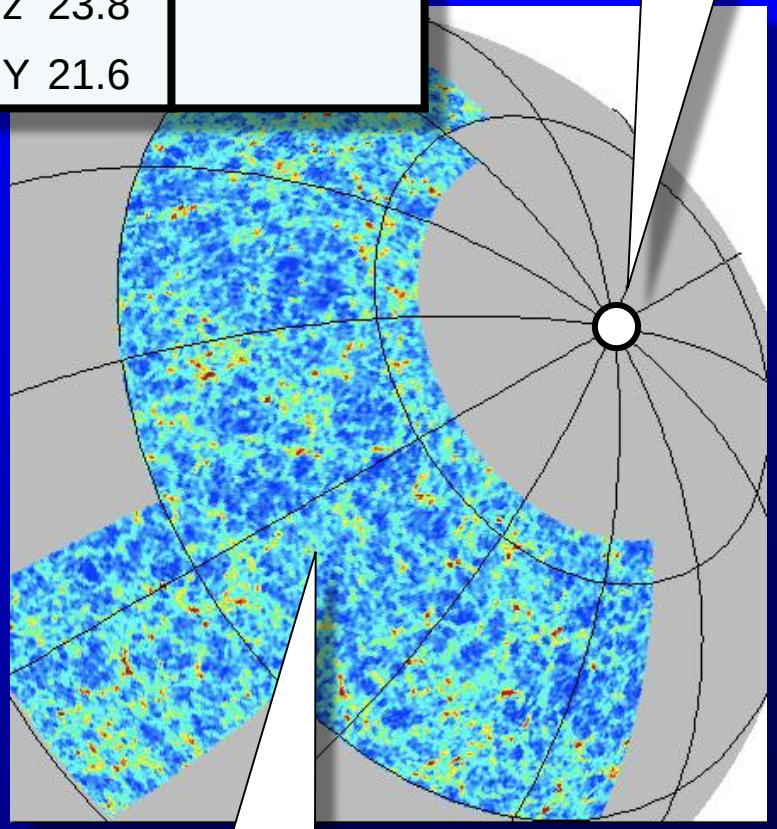
NOAO South

Dark Energy Camera (DECam) @ Blanco 4-m



NOAO South
DES, what is it?

DES+VHS (10σ)			
g	24.6	J	20.3
r	24.1	H	19.4
i	24.0	Ks	18.3
z	23.8		
Y	21.6		



- Dark Energy Survey
- Imaging survey with DECam @ Blanco
- 25% of southern sky (5000 sq deg)
- Billions of numbers (measurements)!
  - 300 million objects
  - Several hundred parameters per object
- All data products will be public

- Status
  - Year 1 completed, Year 2 underway
  - Raw data, rolling release
  - Processed single-visit images (Y1), rolling
  - First pubic catalogs (Y1 + Y2), Q2 FY17
  - Second public catalogs (all survey), FY19+

NOAO South

DES, what are we measuring?

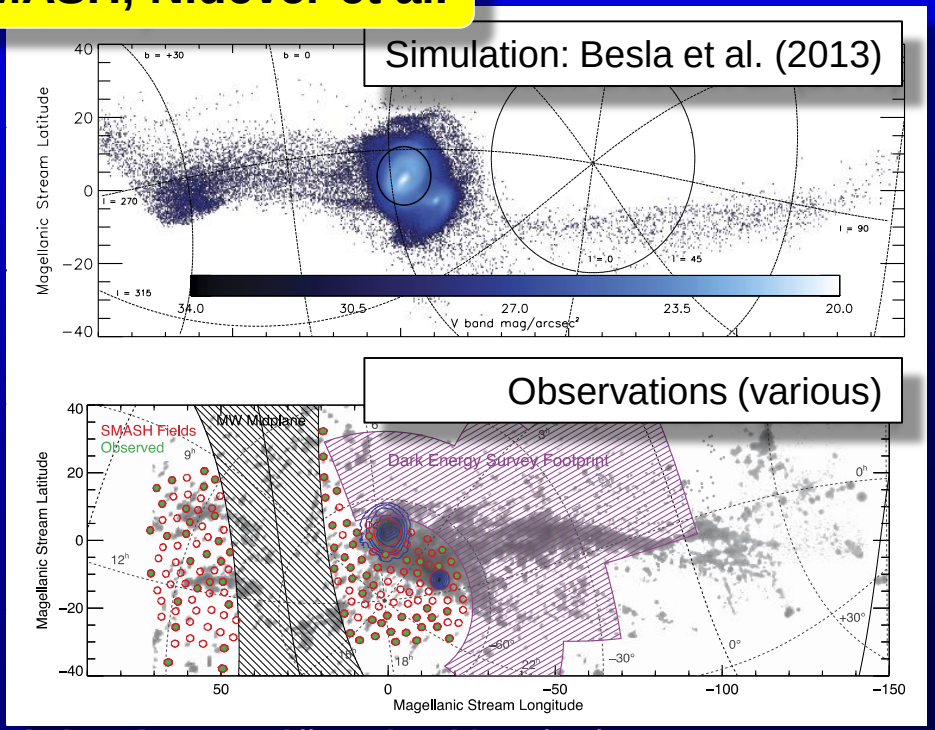
Combined DES DE Figure-of-Merit ~ 260

- Galaxy clusters
  - Approx. 100,000 clusters to z = 1 and beyond
  - Synergy: South Pole Tele (SPT), VISTA Hemisphere Survey (VHS)
  - *Angular power spectrum → geometry*
  - *Mass function = N(z) vs. mass → structure*
- Weak lensing
  - Shape measurements of 300 million galaxies
  - *Line of sight mass distribution vs. redshift → geometry, structure*
- Baryon Acoustic Oscillations (BAO)
  - Approx. 300 million galaxies to z = 1 and beyond
  - *Metric angular separation vs. redshift → geometry*
- Supernovae
  - 30 square degree time-domain survey
  - Approx. 4000 well-sampled SNe Ia to z ~1
  - *Hubble diagram → geometry*

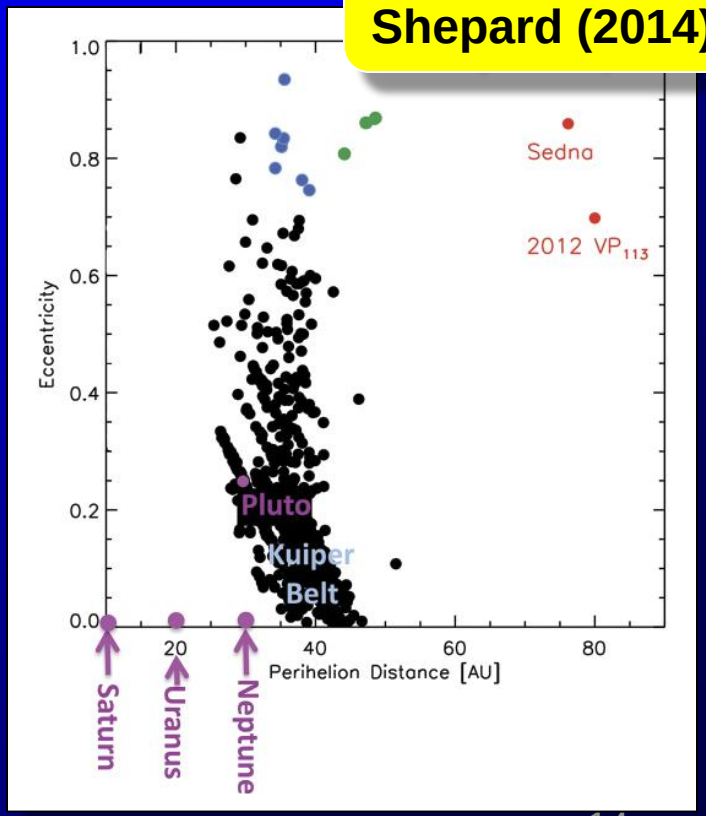
NOAO South
DECam, beyond cosmology (examples)

- Characterizing dwarf planet population in Inner Oort cloud
- Mapping Magellanic Cloud interaction debris
- Mass tomography in rich high-redshift clusters
- Characterizing NEO/PHA population at 10-m scale

SMASH, Nidever et al.



Trujillo & Shepard (2014)



Dark Energy Spectroscopic Instrument (DESI)

5000-fiber spectrometer @ Mayall 4-m

Components

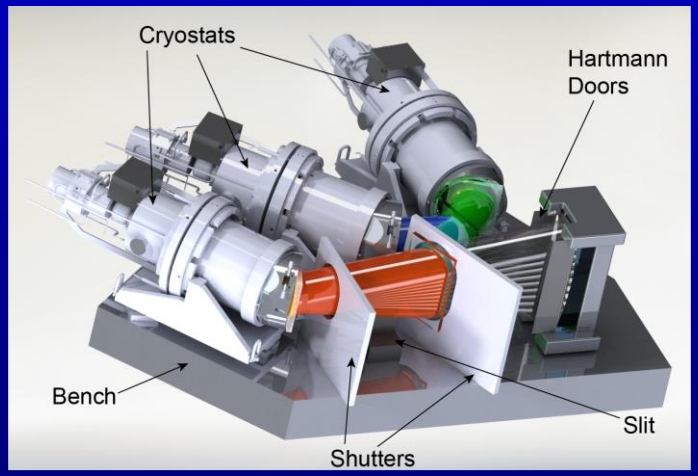
A new prime focus corrector (creating an 8 deg^2 FOV)

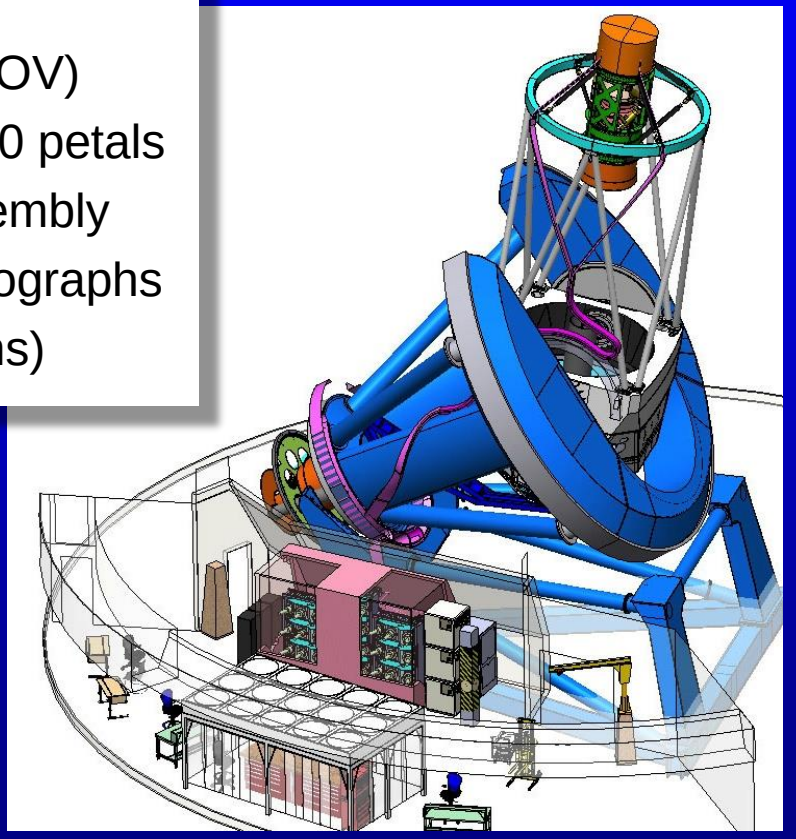
A focal plane with 5000 fiber positioner robots in 10 petals

A new top ring and cage, barrel and hexapod assembly

A fiber optic system to transport the light to spectrographs

Ten 3-arm spectrographs (cf., BOSS spectrographs)

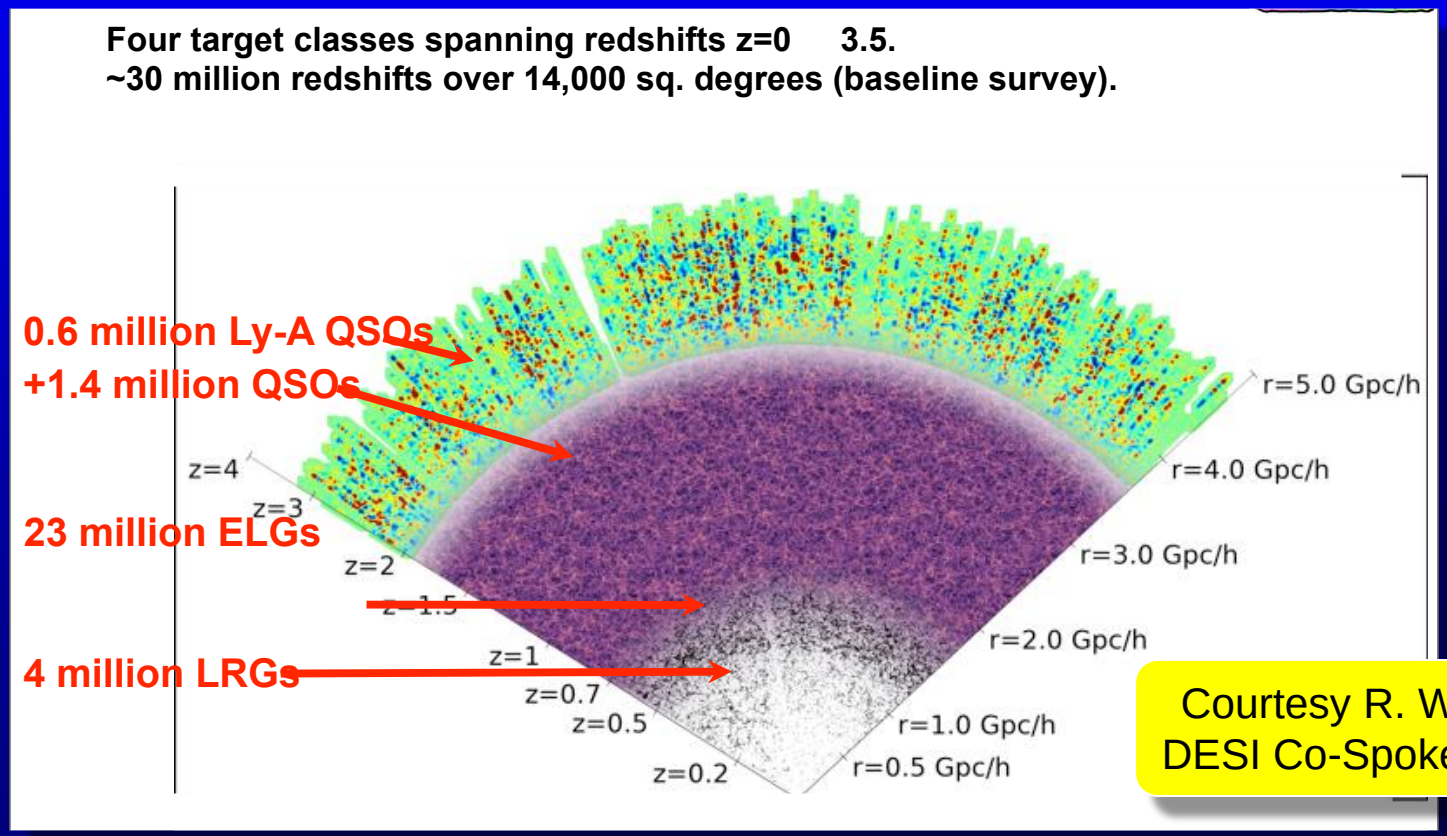




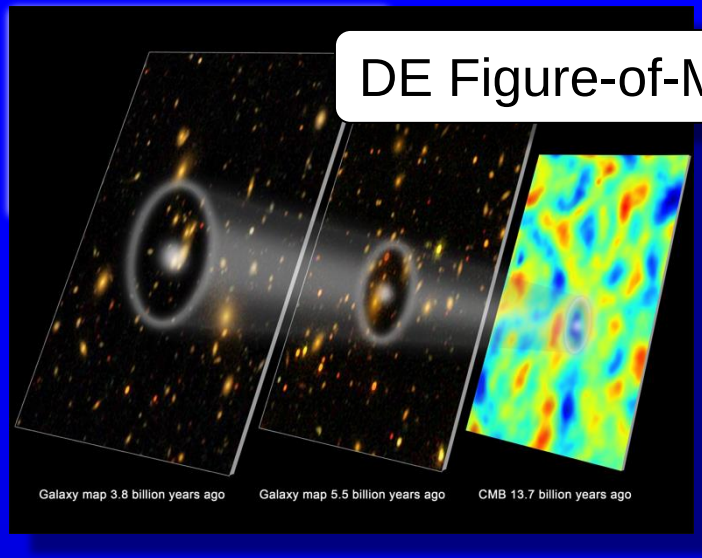
Images: M. Levi
DESI Project Director

KPNO
DESI, the experiment

- Stage IV dark energy experiment
- Five year survey (2019 – 2023)
- 20 million objects to redshift = 1.7



Courtesy R. Wechsler
DESI Co-Spokesperson

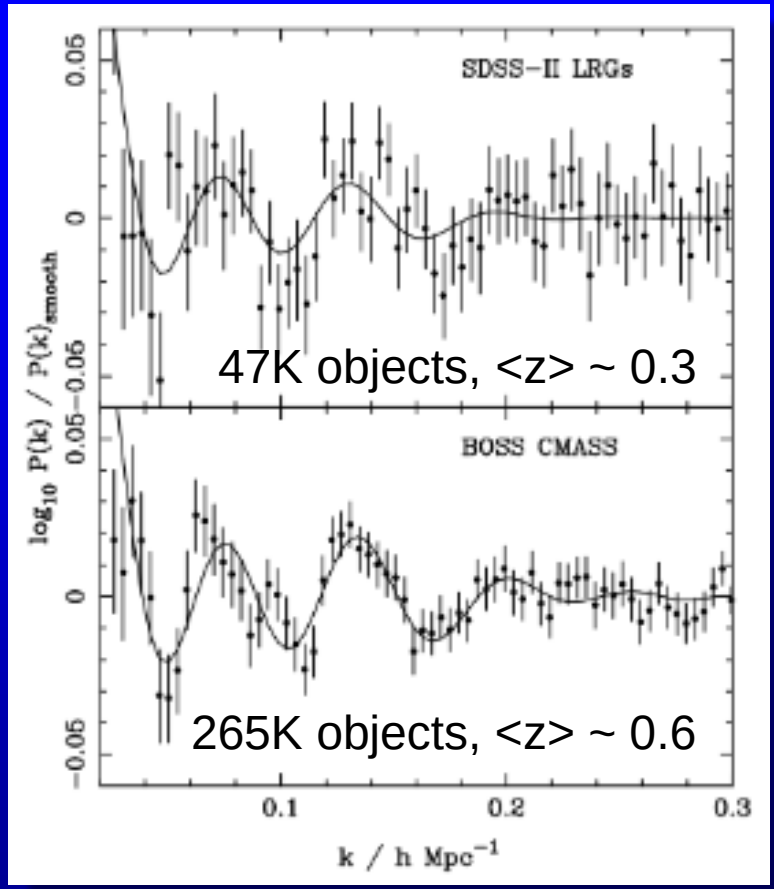


DE Figure-of-Merit ~ 600

KPNO

What is DESI measuring?

- Baryonic Acoustic Oscillations (BAO)
  - *Sensitive to geometry vs. redshift*
  - Angular diameter distance
  - Line-of-sight (Hubble constant)
- Redshift space distortions (RSD)
  - *Gravitational growth vs. redshift*
  - Correction to BAO “smearing”
- Estimates of total neutrino mass



Anderson et al. 2012

DESI ➔ 20,000K objects, <z> ~ 1

KPNO
DESI, beyond cosmology

Much can be done in bright time

Representative large projects (Badenes et al. 2013)

- Galactic Archeology Survey (500 nights)
  - Extensive probe of Galactic kinematics sub-structures
  - Realize full 6D + chemistry potential of Gaia
  - 12500 sq. deg
  - > 10 million stars
  - Piggy back: stellar binaries
- Galaxy Evolution Survey (110 nights)
  - Track stellar mass evolution over last 8.5 Gyr (z ~ 1.2)
  - 100 sq. deg.
  - 400,000 objects

KPNO
WIYN, a new federal mission

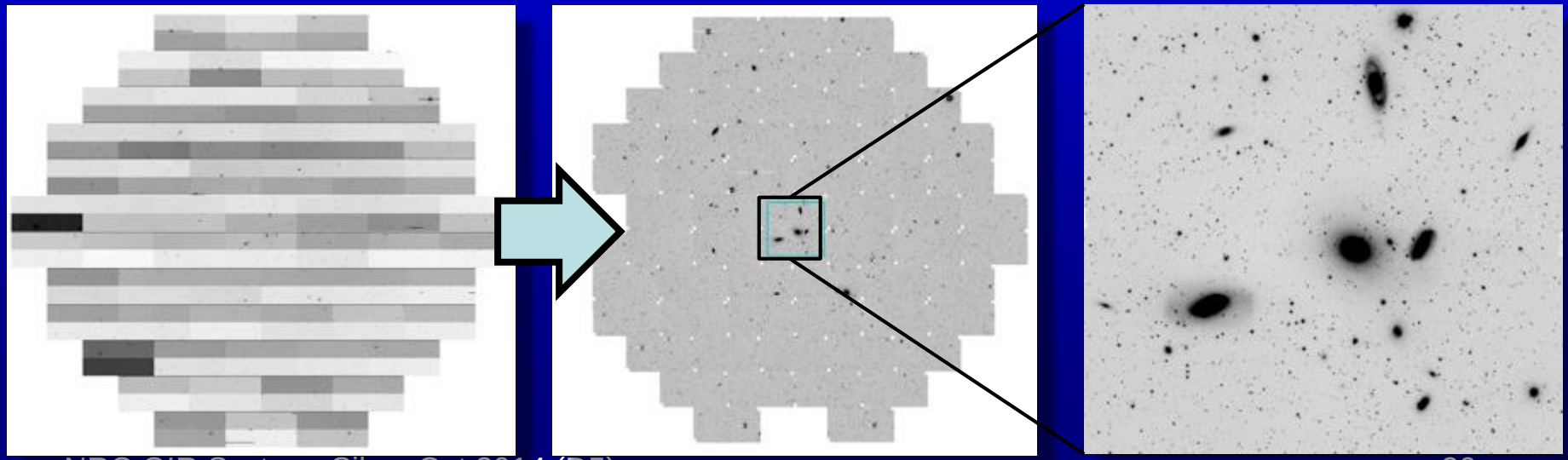
- Topic: exoplanet research
- Stage 1 → GO program with current instruments (2015B – 2018)
- Stage 2 → GO/GTO programs with new instrument (2018 – TBD)

- Supports NSF research interests, NASA mission goals
- NOAO will act as federal proxy
- NOAO will have operations role(s)
- NASA/NSF program details to be defined by end of year
- Not finalized but looking good

NOAO System Science & Data Center
Baseline mission today

- US National Gemini Office (US-NGO)
- Time Allocation Committee
- NOAO Science Archive
  - Capture and serve raw data from all NOAO facilities
  - Capture and serve final data products from NOAO Surveys
  - Production of science-ready calibrated images for Mosaic, NEWFIRM, DECam, ODI

Calibrated DECam stack (credit: F. Valdes)



NOAO System Science & Data Center
Towards a new data science theme

- The new frontier → databases from DECam, DESI, LSST with…
  - 100s of millions of astronomical objects
  - 10s of billions of measurements
  - Too much information for small groups to handle!
  - They need centralized support services

Adopt
Adapt
Deploy

- NOAO must…
  - Enable high impact catalog-based research now
  - Deploy services and tools for efficient data access, data exploration & visualization and statistical analysis
  - Adopt “best practice” tools from community (not re-invention)
  - Help train next generation of data-oriented astronomers
  - Help community develop experience needed for LSST era

NOAO System Science & Data Center
Under development: NOAO Data Lab

- Access to scientifically compelling giga-object catalogs (DES, DECam community catalogs)
- Large catalog exploration, visualization and analysis
- Image access & pixel processing at image cutout level
- Collaborative workspaces
- Processing power and storage sufficient for above

Adopt
Adapt
Deploy

- Steps
  - Foundation documents being created now
  - CoDR in Q2 / FY15
  - Beta systems in Q2 / FY16
  - Ready for DES public release in Q2 / FY17

NOAO System Science & Data Center
Towards a national event broker service

- The Alert Stream Challenge (two examples)
  - Anything that moves or changes brightness since last visit
  - ZTF (2018) → many 10^5 events per night
  - LSST (2023) → ~ 10^7 time event events per night

Build

- What's Needed
  - National "event broker" service with user plugins
  - Parse events into increasingly narrow bins, concluding with "rarest of rare"
  - Publish event classifications (world readable)

NOAO System Science & Data Center
Under development: ANTARES

- Arizona-NOAO Temporal Analysis and Response to Event System
  - Multi-disciplinary collaboration → U. Arizona Computer Science dept.

- ANTARES project
  - Implement a scalable system
  - Implement initial built-in event parsing filters
  - Design to accommodate community developed filters
  - Design to serve community-at-large
  - Will be tested on pre-LSST event streams (e.g. GAIA, ZTF)

Build

- LSST scale system will need new funding

Community engagement
Workshops

Planned 2015 workshops

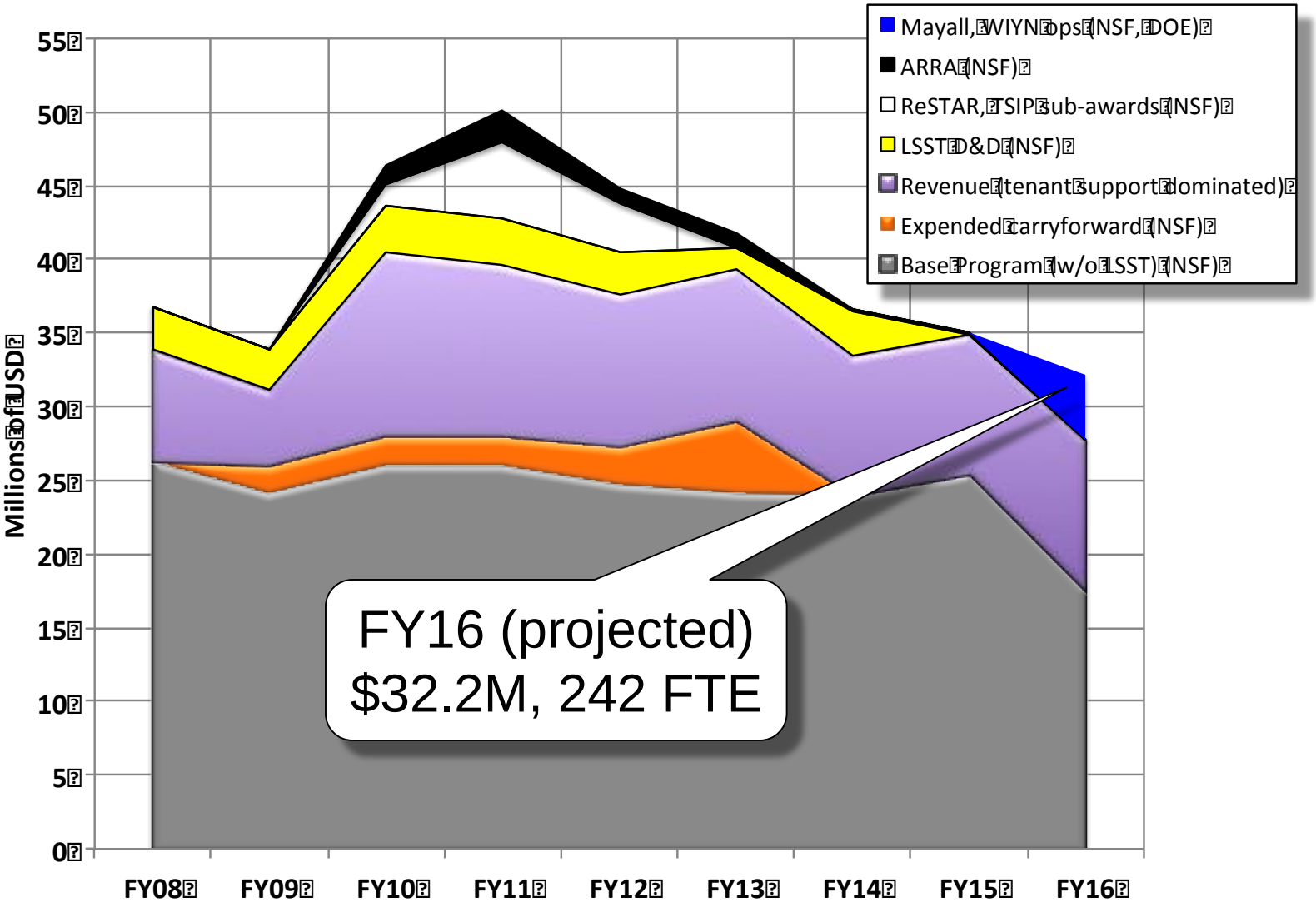
- Gemini Data Reduction (January, Seattle AAS)
- Tools for Astronomical Big Data (March, Tucson)
- DECam Community Science Workshop (March, Tucson)
- Third LS School for Data Science (August, La Serena)

Community engagement
TMT/TIO

- Associate Member, TMT International Observatory (TIO)
  - Acting for AURA, representing previous AURA investment
  - Representation on TIO Board and SAC

- NSF and TMT 5-year Cooperative Agreement (CA)
  - CA goal: develop model(s) for possible future partnership
  - CA assigns NOAO various community engagement roles
  - Activities:
    - Organizer, US TMT Science Working Group
    - Co-organizer, annual TMT Science Forum
    - Co-organizer, TMT Town Halls, January AAS
    - Co-creator, US TMT Participation Plan (deadline: 2015 Q4)

NOAO funding history



If not NOAO, who?

NOAO Tomorrow

If not NOAO, who?

NOAO in the 2020s
Meta

- Will NOAO remain relevant?
- Will NOAO remain a national leader?
- Will NOAO continue to provide high quality services?

To maximize success, NOAO…

- …requires reliable, predictable investment and consistent guidance
  - New committees, new direction every 3 years → de-stabilizing to NOAO, confusing to the community-at-large
  - Ending old missions is necessary but not sufficient
  - More (likely targeted) funding also required
- ...must concentrate on areas of excellence
  - Cannot be everything to everyone
  - What is highest priority for 2020s?
  - Here are some areas to consider…

If not NOAO, who?

NOAO in the 2020s
Gateway to telescopes

- National “open access” manager (esp. ELTs)
- Federal OIR interface to foreign “networks”
  - ESO, NAOJ, KASI, NAOC, ASIAA…
  - Non-federal OIR interfaces exist
  - Federal RMS interfaces exist through NRAO

- *This is straightforward*
- *Expensive part is funding the access…*

If not NOAO, who?

NOAO in the 2020s
Data services

"Best in class" → collect/identify, link/serve

Build only when necessary

- Desktop analysis systems
  - IRAF (frozen), IDL Astronomer User Library, Astropy…
- Public data products
  - DES, DESI, NOAO Surveys, etc.…
- University developed data science tools and services
  - Data visualization, machine learning, statistical methods
- Gateways to cloud computing services (federal, commercial)
  - Natural linkage to NCSA, various DOE centers
  - Keep "NOAO cloud" as small as possible

If not NOAO, who?

NOAO in the 2020s
LSST services (data science)

- *Level the playing field…*

- National event broker with user-provided plugins
  - *Build on ANTARES*
  - Collaborator: NCSA
- Tool, services repository/provider
  - *Build on NOAO DataLab*
  - Data visualization, data analysis
- Community educator (e.g., schools, workshops)
  - Focus on students, early career & under served (e.g., MSIs)

If not NOAO, who?

NOAO in the 2020s
LSST services (follow up)

- Re-configure Blanco, Mayall, SOAR, WIYN as necessary
  - Operations modes, instrumentation suites → all adaptable
  - Extend DESI, DECam operations (or even switch North/South)

- Coordinator of LSST follow up @ Gemini South, NOAO South
- Coordinator of LSST follow up @ other “open access” nodes

If not NOAO, who?

NOAO in the 2020s
Technology development

- Technology development program in USA is stressed
  - *Telescopes, instruments, detectors, data systems*
  - ⌘ NSF-supported group at NOAO is gone (mostly working for LSST and/or other major projects)
  - State-supported groups being down-sized
  - NASA, DOE, DOD, industry moving in different directions
  - Poor incentives for early career scientists
- Possible roles for NOAO as national “node”
  - *NOAO played these roles in the past, it should again*
  - Home for technology minded scientists
  - Home for engineers and managers
  - Enabler of federal/university collaborations
  - Enabler of federal/international collaborations

NOAO Today and Tomorrow
Summary

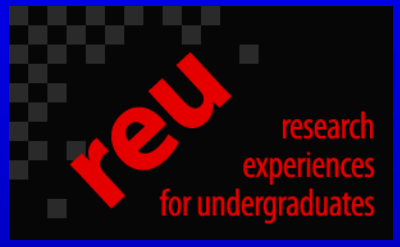
- Goal: enable high impact Community research
- Foundations
  - Open access to world-class imagers and spectrometers
  - Open access to world-class data sets
  - New survey machines (DECam, DESI, LSST)
  - New rich mega-object catalogs
  - New tools for data science
  - New tools for time-domain exploration
  - New bridges to future major facilities
  - Strong partnerships with NSF, DOE, and their centers


End of presentation

Education & Public Outreach

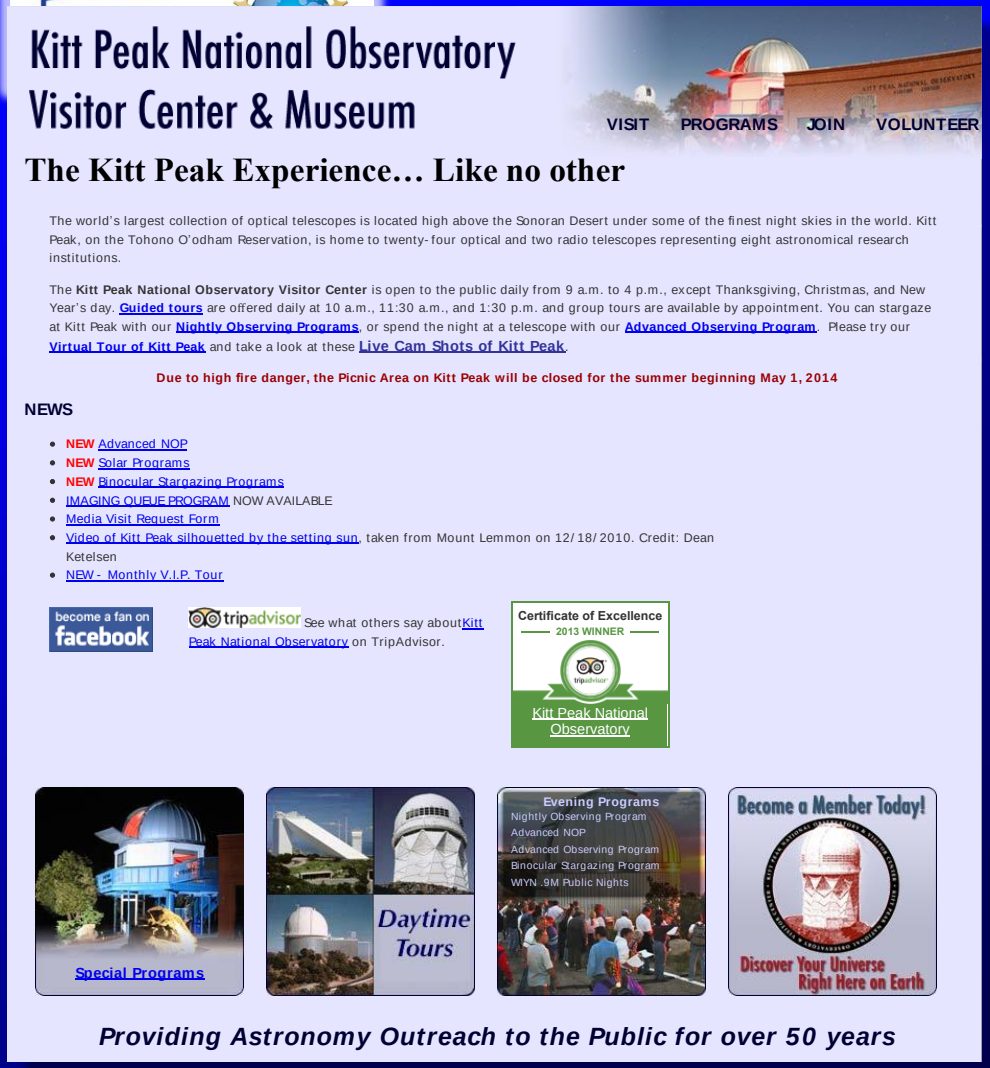
Think global, act local, build on success

Projects have short- and long-term objectives, time plans and milestones, partners, management plans, audiences, strategies, innovations, risks, projected outcomes, metrics and formative assessment. Most have independent evaluation.



Education & Public Outreach

Kitt Peak Visitor Center



Kitt Peak National Observatory
Visitor Center & Museum

VISIT PROGRAMS JOIN VOLUNTEER

The Kitt Peak Experience… Like no other

The world's largest collection of optical telescopes is located high above the Sonoran Desert under some of the finest night skies in the world. Kitt Peak, on the Tohono O'odham Reservation, is home to twenty-four optical and two radio telescopes representing eight astronomical research institutions.

The **Kitt Peak National Observatory Visitor Center** is open to the public daily from 9 a.m. to 4 p.m., except Thanksgiving, Christmas, and New Year's day. **Guided tours** are offered daily at 10 a.m., 11:30 a.m., and 1:30 p.m. and group tours are available by appointment. You can stargaze at Kitt Peak with our **Nightly Observing Programs**, or spend the night at a telescope with our **Advanced Observing Program**. Please try our **Virtual Tour of Kitt Peak** and take a look at these **Live Cam Shots of Kitt Peak**.

Due to high fire danger, the Picnic Area on Kitt Peak will be closed for the summer beginning May 1, 2014

NEWS

- NEW Advanced NOP
- NEW Solar Programs
- NEW Binocular Stargazing Programs
- IMAGING QUEUE PROGRAM NOW AVAILABLE
- Media Visit Request Form
- Video of Kitt Peak silhouetted by the setting sun, taken from Mount Lemmon on 12/18/2010. Credit: Dean Ketelsen
- NEW - Monthly V.I.P. Tour

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Evening Programs
Nightly Observing Program
Advanced NOP
Advanced Observing Program
Binocular Stargazing Program
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DES, Year 1, DIQ