

The background image shows the intricate steel truss structure of the Keck Observatory's interior. The structure is composed of numerous interconnected beams and supports, creating a complex geometric pattern. The lighting is warm, highlighting the metallic surfaces. A semi-transparent rectangular box is overlaid on the center of the image, containing the main title and meeting information.

# **Keck Observatory Status and Plans**

**Subaru Users Meeting  
January 2016**

**Hilton Lewis  
Director**



# **Table of Contents**

**25 Years since First Light**

**Science Productivity**

**Strategic Planning**

**Instrumentation**

**Major Projects**

**Science Highlights**

# 25<sup>th</sup> Anniversary KI First Light Nov. 24, 1990

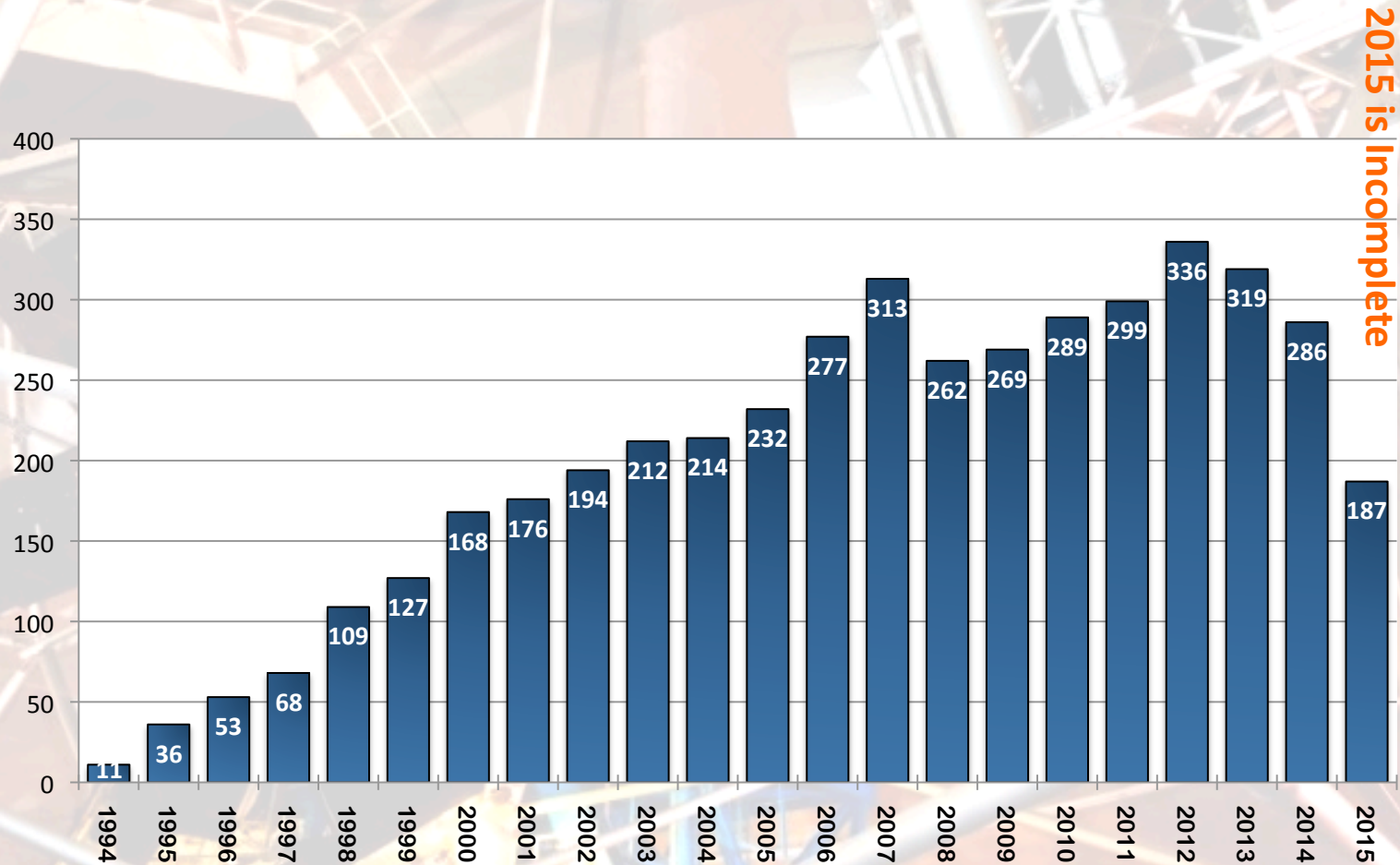
**“We believed it could, now we know it does”  
Dr. Ed Stone, Caltech Press Conference**





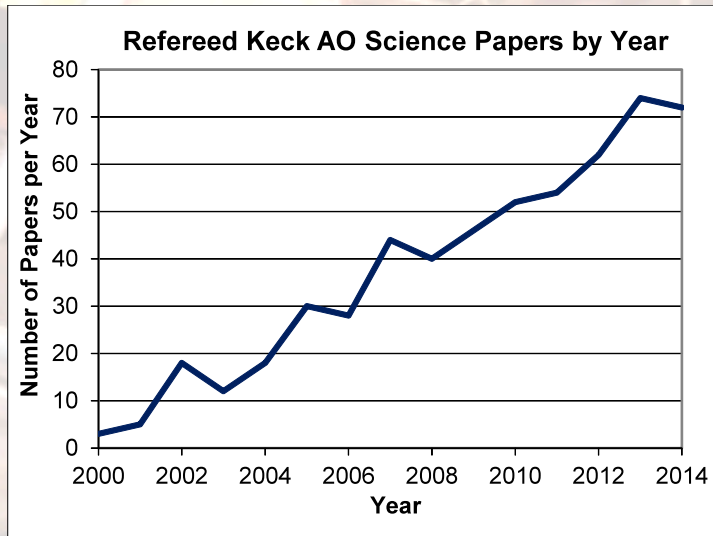
# SCIENCE PRODUCTIVITY

# Refereed Articles: using WMKO data



# Keck AO Refereed Science Papers

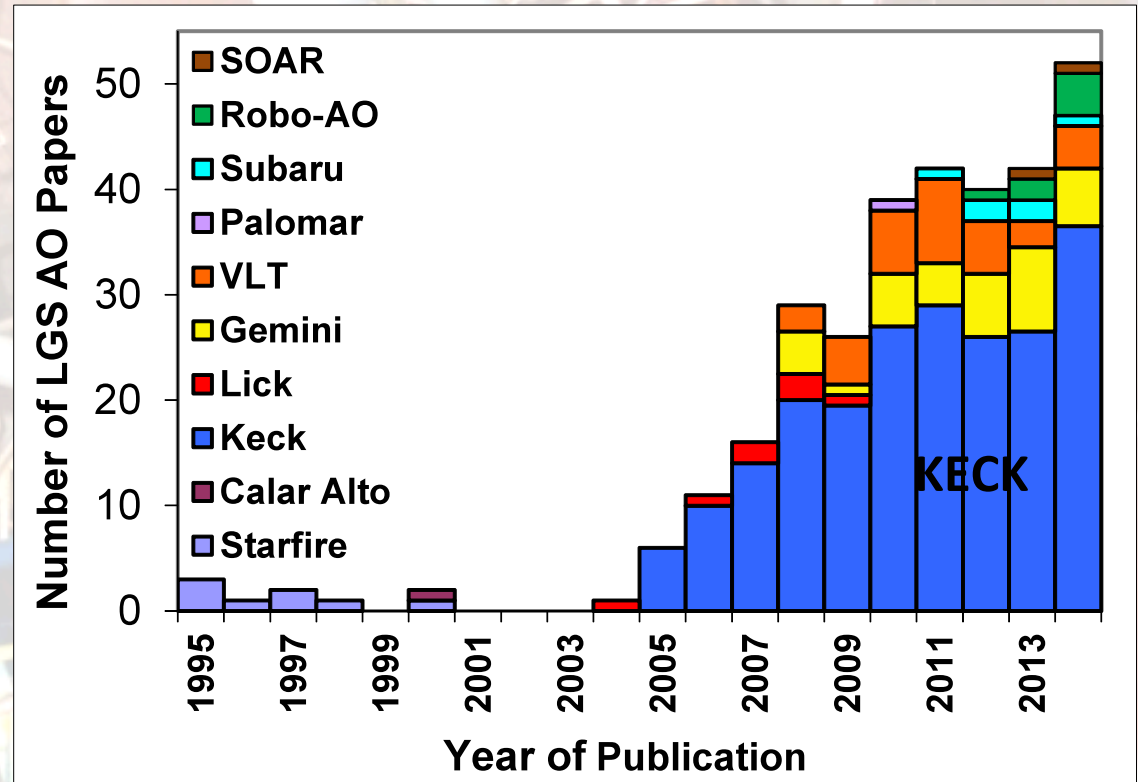
## NGS + LGS



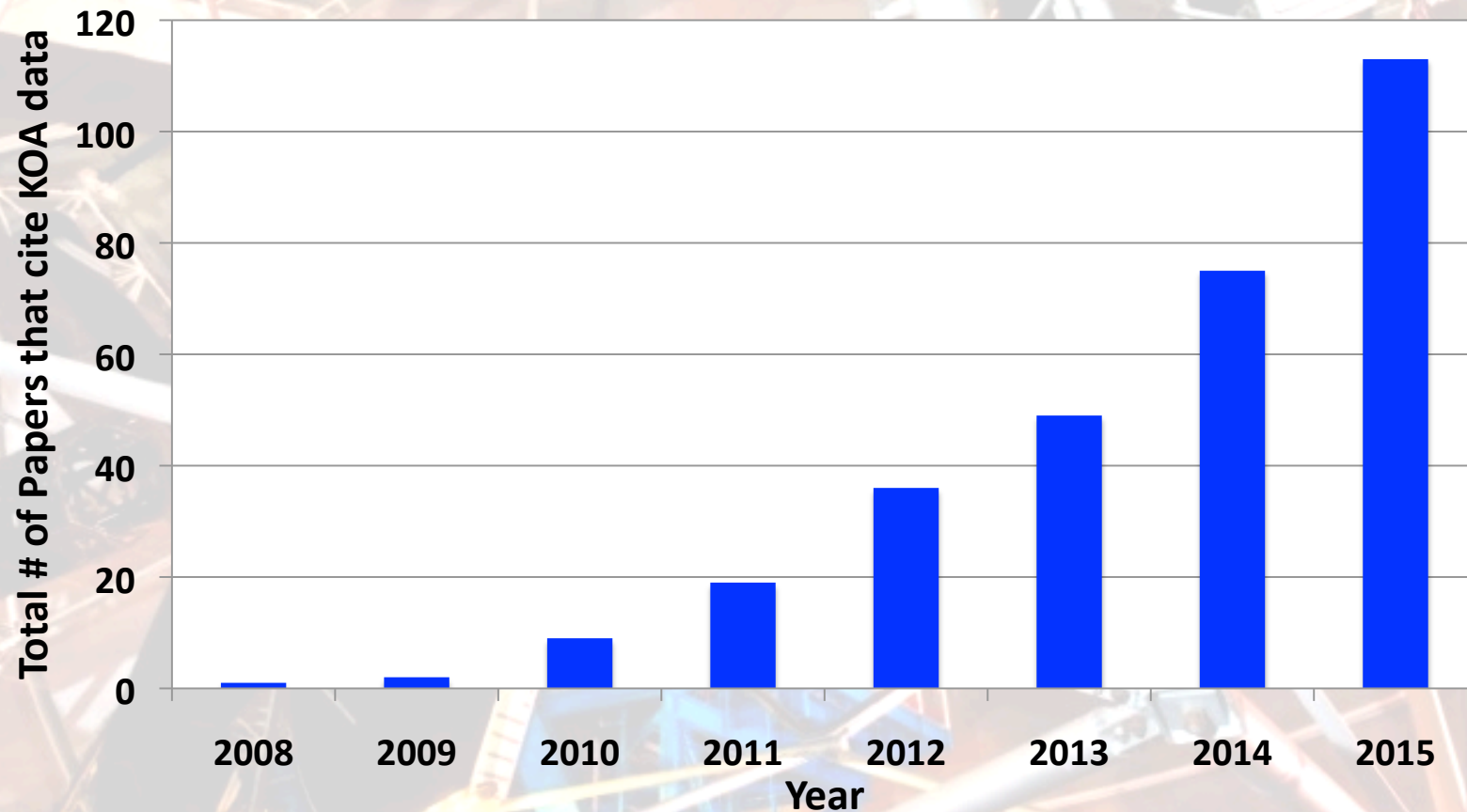
Through Aug. 2014:

- 606 total
- 228 LGS

## LGS AO Comparison

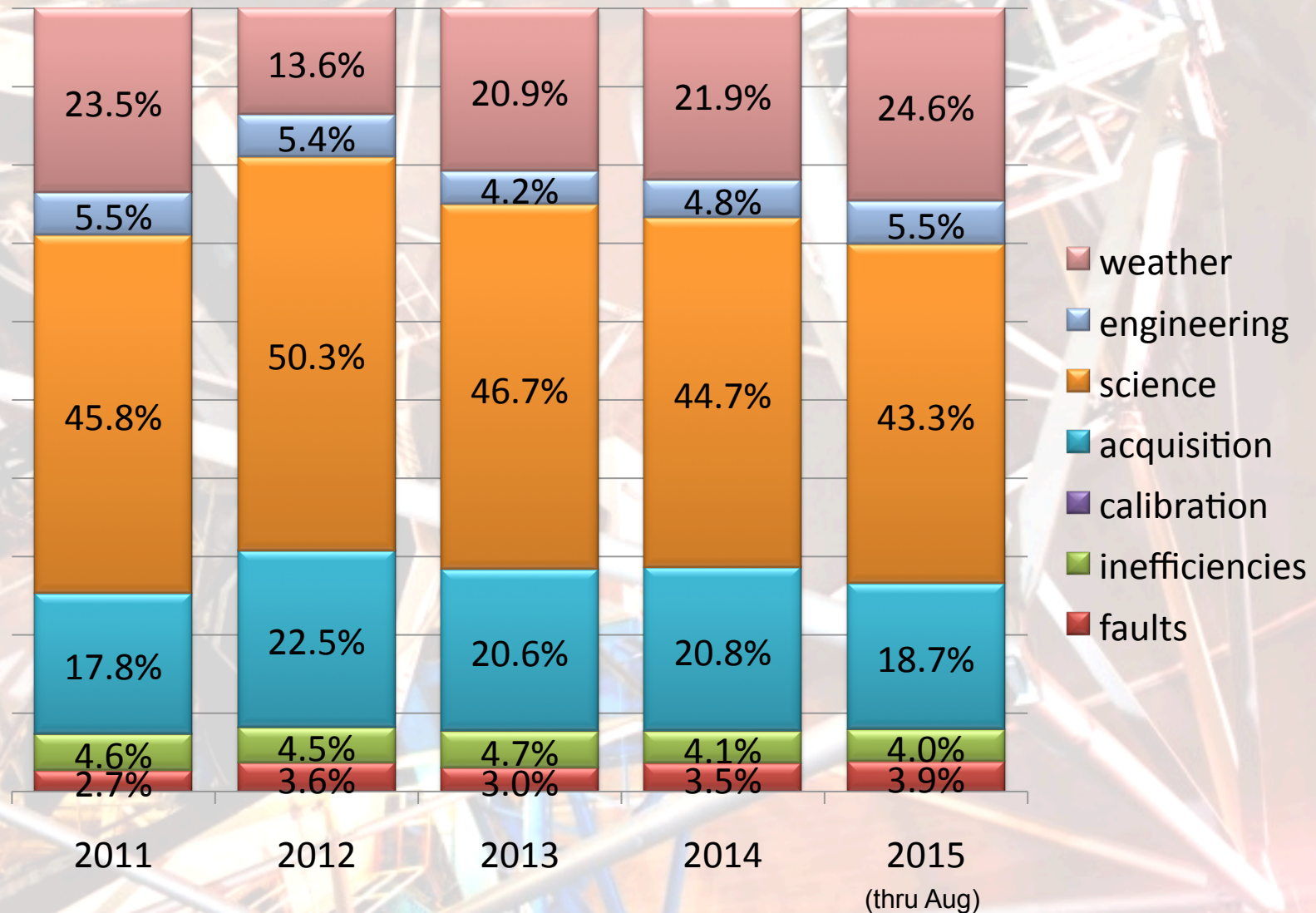


# Keck Observatory Archive Papers (cumulative)

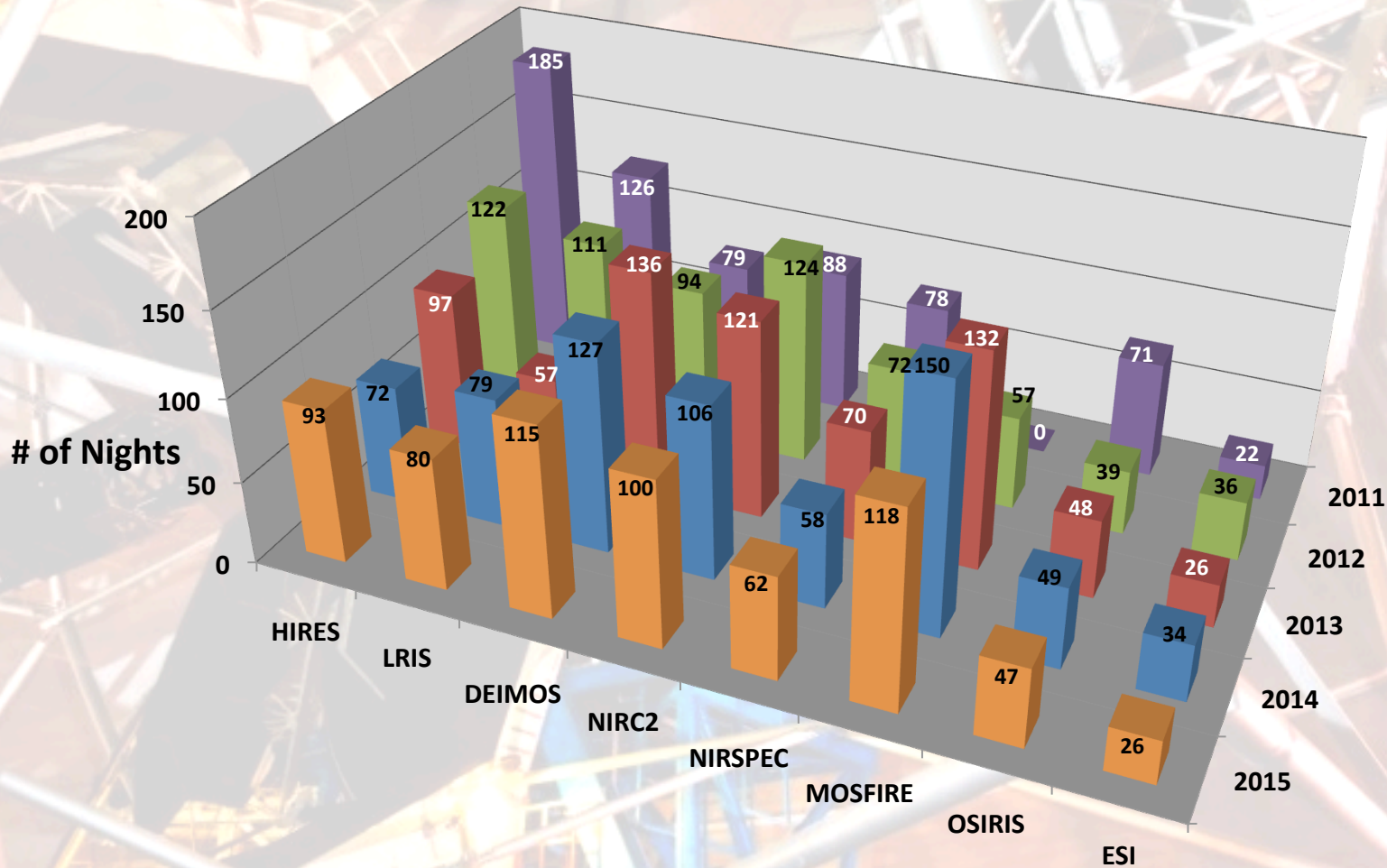


**Keck Observatory Archives - NASA Honor Award – Dec 2015**

# Operations Metrics 2011-2015



# Instrument Usage by Full Keck Community 2011 – 2015





# **STRATEGIC PLANNING**

# 2016 Strategic Plan Development

- Spearheaded by Chief Scientist Kinney
- Eight task groups
  - TMT, JWST, WFIRST/EUCLID, Subaru synergy, Time Domain Astronomy, Planet Finding, Adaptive Optics evolution, Strategic integration
- Task group reports detail scientific need, technical requirements, operational requirements
- Integration group determines the priorities
- Timescale
  - First drafts: January 2016
  - Final draft: February 2016
  - Approved document released: June 2016

# Keck-Subaru Workshop

## Sendai September 1-2, 2015

- **Goal**: Explore best ways to exploit complementarity of the two observatories for mutual good
- 37 attendees, 21 from Subaru, 16 from Keck
- Context setting then parallel panel discussions
  - Extra-galactic & early universe science: Kriek/Kodama
  - Galactic stars; Cohen/Aoki
  - Exoplanets & solar system: Tamura/Mawet
  - Time domain astronomy: Masomi/Kulkarni
- **Conclusion**: Rich and fertile fields for collaboration between the Subaru and Keck user communities

# Keck/Subaru Sendai Workshop

- Recommendations from Panels:
  - Subaru and Keck set aside a set number of nights for joint collaboration
    - BUT more nights identified in total than the full workshop group was prepared to accept
  - Ways to use proposed instrumentation at Keck and Subaru
  - Hold joint Subaru/Keck science meeting every year
- Agreed best to begin with a bottoms-up approach, starting with small collaborations that would grow over time. How to jump-start these collaborations was not addressed
- Final report completed and will shortly be posted

# Other Outcomes

- Have removed restrictions on which instruments are available for proposals for time exchange, at both Subaru and Keck
- Will soon announce date for next Keck/ Subaru collaboration meeting.
  - Next meeting will be held in USA (California)



# **INSTRUMENTATION**

# Instrument Status and Timeline

Project	Status	First light	Shared Risk
TCS Upgrade	Commissioning K2; Installing K1	Apr 2015	2016A/B
NIRES	Final I&T in lab	Apr 2016	2016B
K2 AO Fiber laser	1 <sup>st</sup> light successful, on schedule	Dec 2015	2016A
KCWI-Blue	Final I&T in lab	Jun 2016	2016B
Enhanced TRICK	Testing on sky	June 2015	2016B
OSIRIS IFS upgrade	Telescope integration/testing	Mar 2016	2016B
OSIRIS imager upgrade	Detailed design	Dec 2016	2017A
K1 Deployable Tertiary	Detailed design	Dec 2016	2017A
NIRSPEC upgrade	Starting design phase	Dec 2017	2018A
KCWI-Red	Detailed design pending KCWI-B	July 2018	2019A
SHREK	Passed system design review	Mar 2019	2020A

# Instrument Proposals

- LGS AO tomography + IR tip/tilt sensor
- Near-IR pyramid wavefront sensor and a M-dwarf exoplanet survey science demonstration
  - Collaborating with Subaru (Guyon) on algorithms and software (also with UH/Chun and CIT/Mawet)
- Precision Radial Velocity upgrade to NIRSPEC
  - Similar to Subaru/IRD; scientific collaboration to gain cadence on common target list possible?



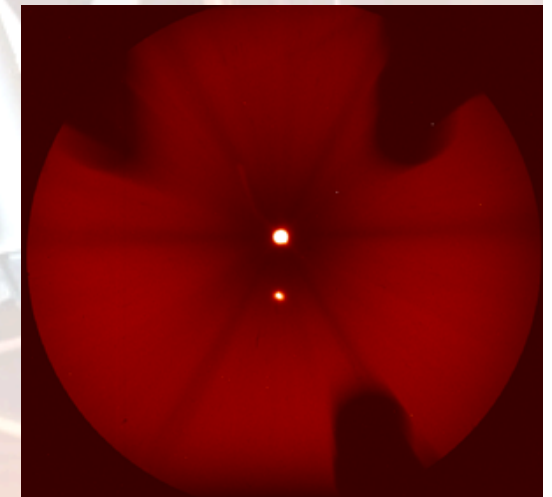
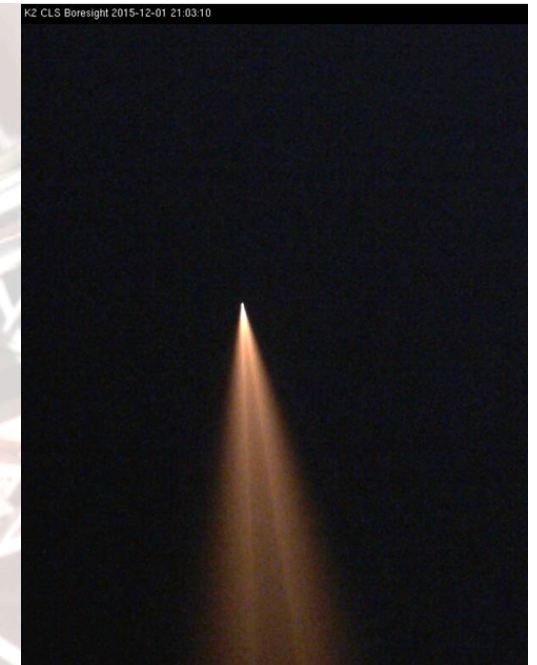
# MAJOR PROJECTS

# Segment Repair Project

- Pathfinder repair completed successfully and tested on sky, on schedule
  - Repair took less time than planned: 25 vs. 33 days
  - On-sky testing in November successful; wavefront error after warping  $<20\text{nm}$  RMS, best ever measured
- Next steps: production preparation
  - Production facility buildout is pacing item
  - Other major activities: staff ramp up, procurements
- Production starts in early summer 2016

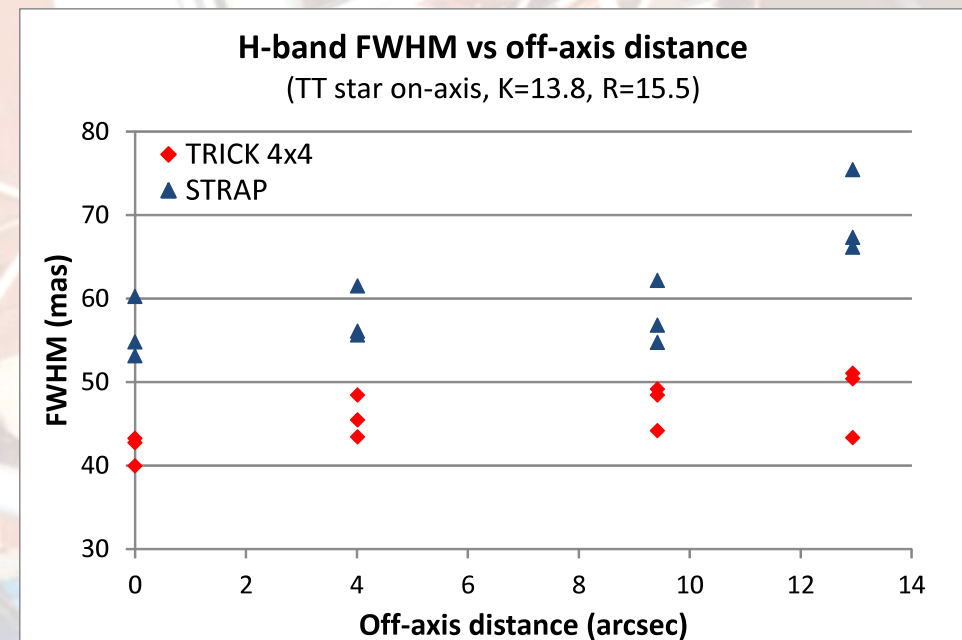
# New K2 Laser (Toptica)

- All subsystems installed on telescope, tested, functioning as designed
- Laser producing 22W as designed
- First light Dec. 1<sup>st</sup>, 2015
  - Mag 8.3 ,  $\sim 10x$  increase in return flux
  - 1.5" spot size
  - Demonstrated closed loop operation 50mas FWHM
- 60kW/12W dye laser replaced with  $\sim 2kW/22W$  laser, with better performance, significant cost savings



# KI Near-IR Tip-tilt Sensor

- Operational for H-band & shorter OSIRIS shared-risk
- More science verification & performance characterization demonstrating K-band IFU science mode in progress
- Enhanced-mode: Working on multiple stars for reduced focal anisoplanatism & parallel operation of visible & near-IR tip-tilt sensors



# TCS Upgrade Status

- Key technical performance metrics meets spec for pointing, tracking, offsetting and settling times
  - all better than old system
- Pointing performance tests are substantially better than requirement, very close to goal of 1”
  - Major improvement will reduce acquisition overhead
  - The most important corrections are provided by the azimuth journal tilt measurements.
- Keck 2 integration in final phase and handover to operations planned for March 2016
- All Keck 1 hardware installed and integration testing commenced. Handover to operations planned for June 2016

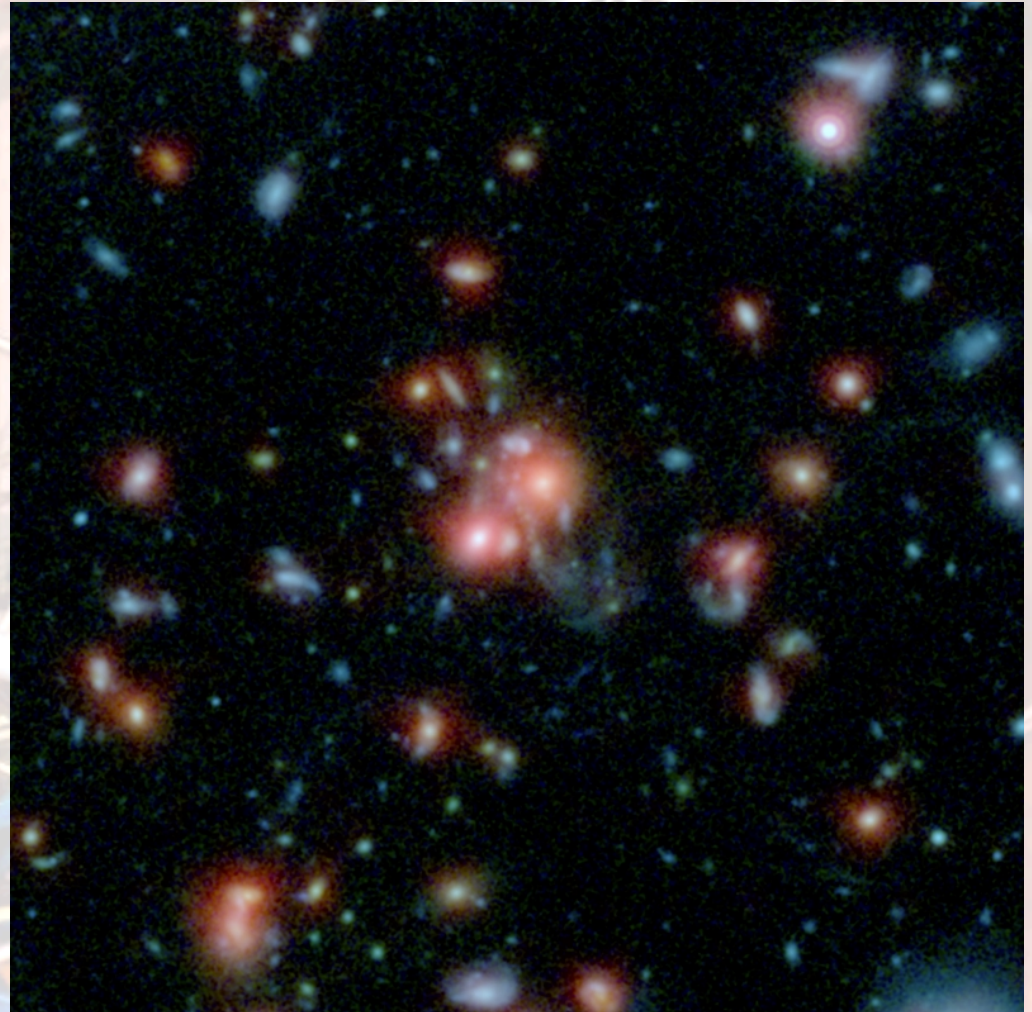


**SCIENCE HIGHLIGHTS**

# Brightest cluster galaxy discovered

## SpARCS1049+56

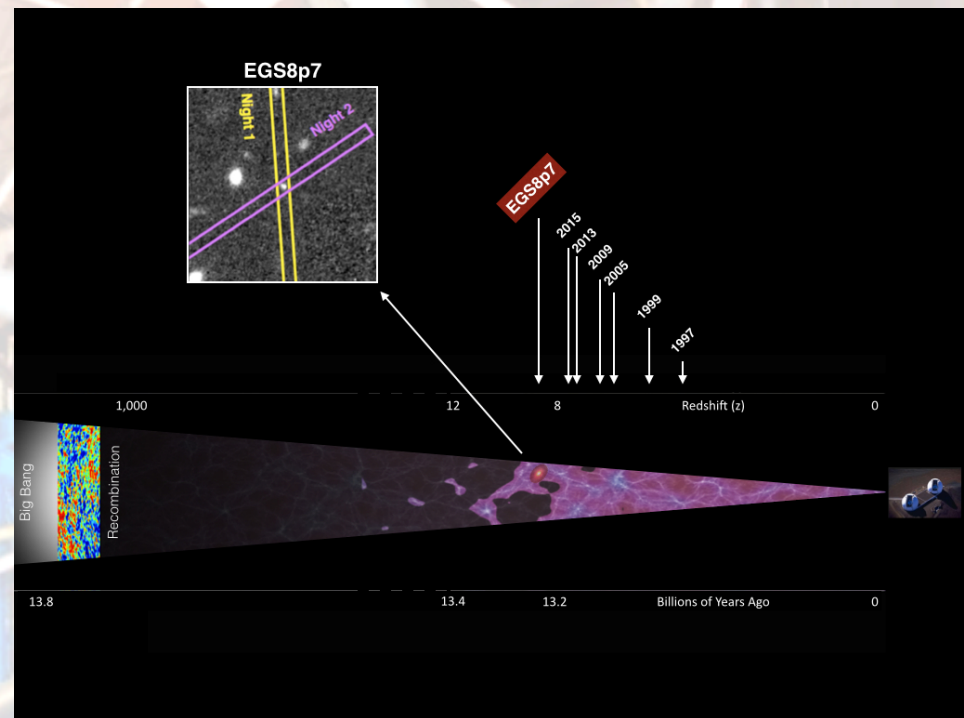
- From Keck, CFHT, HST, Spitzer, Herschel
- MOSFIRE determined distance as 9.8 billion light years ( $z=1.67$ )
- Contains 27 galaxies, total mass about 400 trillion suns
- Prodigious star formation rate  $\sim 800 M_{\text{solar}}$  per year; only case of wet merger at core of cluster



Credit: NASA/STScI/ESA/JPL-Caltech/McGill

# Most Distant Galaxy Confirmed

- Zitrin et al. (2015) using MOSFIRE confirm EGSY8p7 to be the most distant, spectroscopically confirmed galaxy to date ( $z=8.683$ ), when universe was less than 600MY old
- Unexpected  $\text{Ly}\alpha$  detection at this redshift



# Confirmation of Young Exoplanet

- Macintosh et al. (2015) use NIRC2 to confirm the presence of 51 Eridani b, discovered by the GPI team, and to characterize atmosphere (strongest atmospheric methane signal on record)
- 51 Eri is a member of  $\beta$  Pictoris moving group, making 51 Eri b among the youngest ( $\sim 20$  Myr) known exoplanets.
- 51 Eri b is the lowest mass, coldest planet (700K) ever imaged

NIRC2 L' image of the star 51 Eri b, which has been removed using a mask. 51 Eri b is denoted by the arrow.

