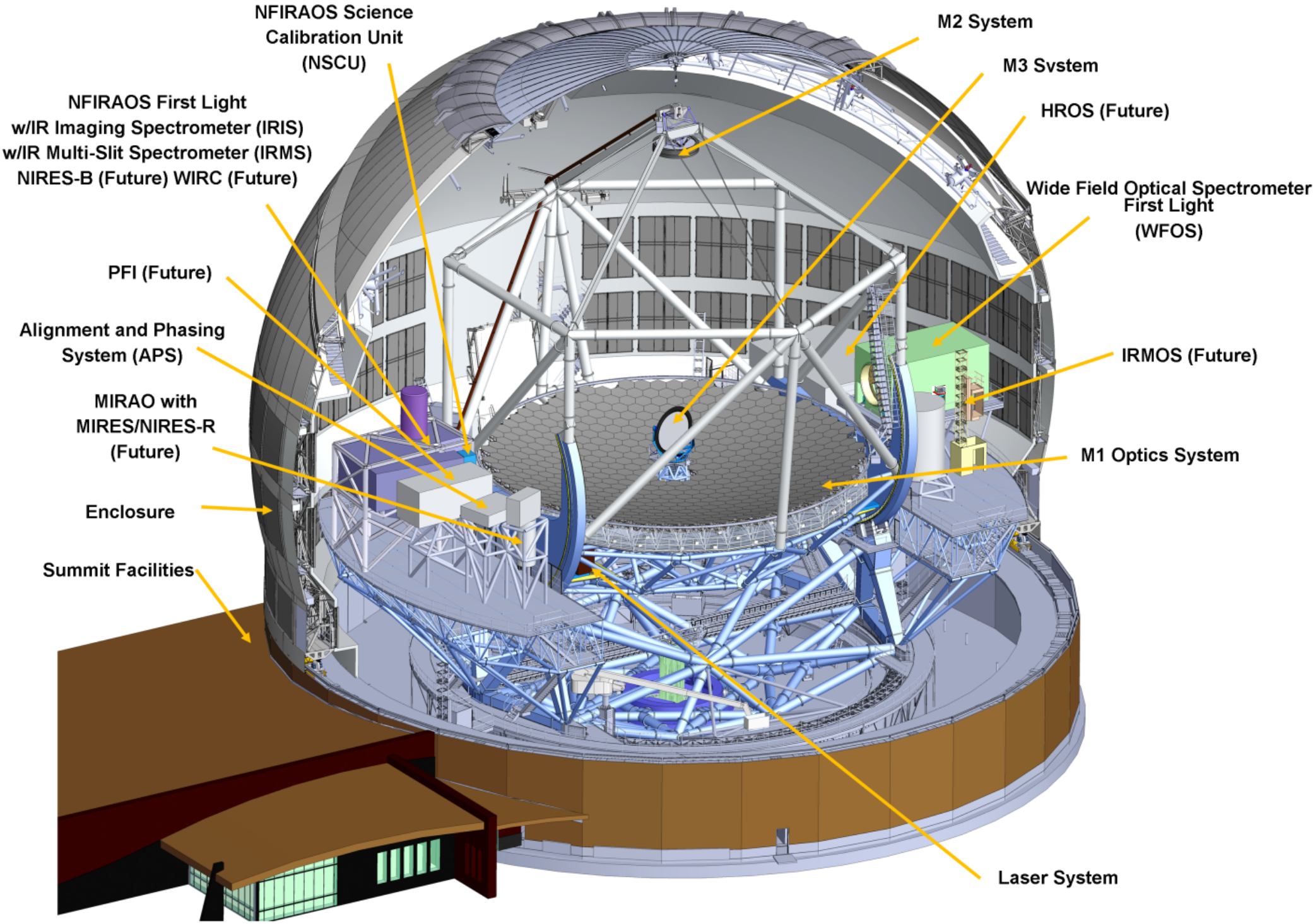
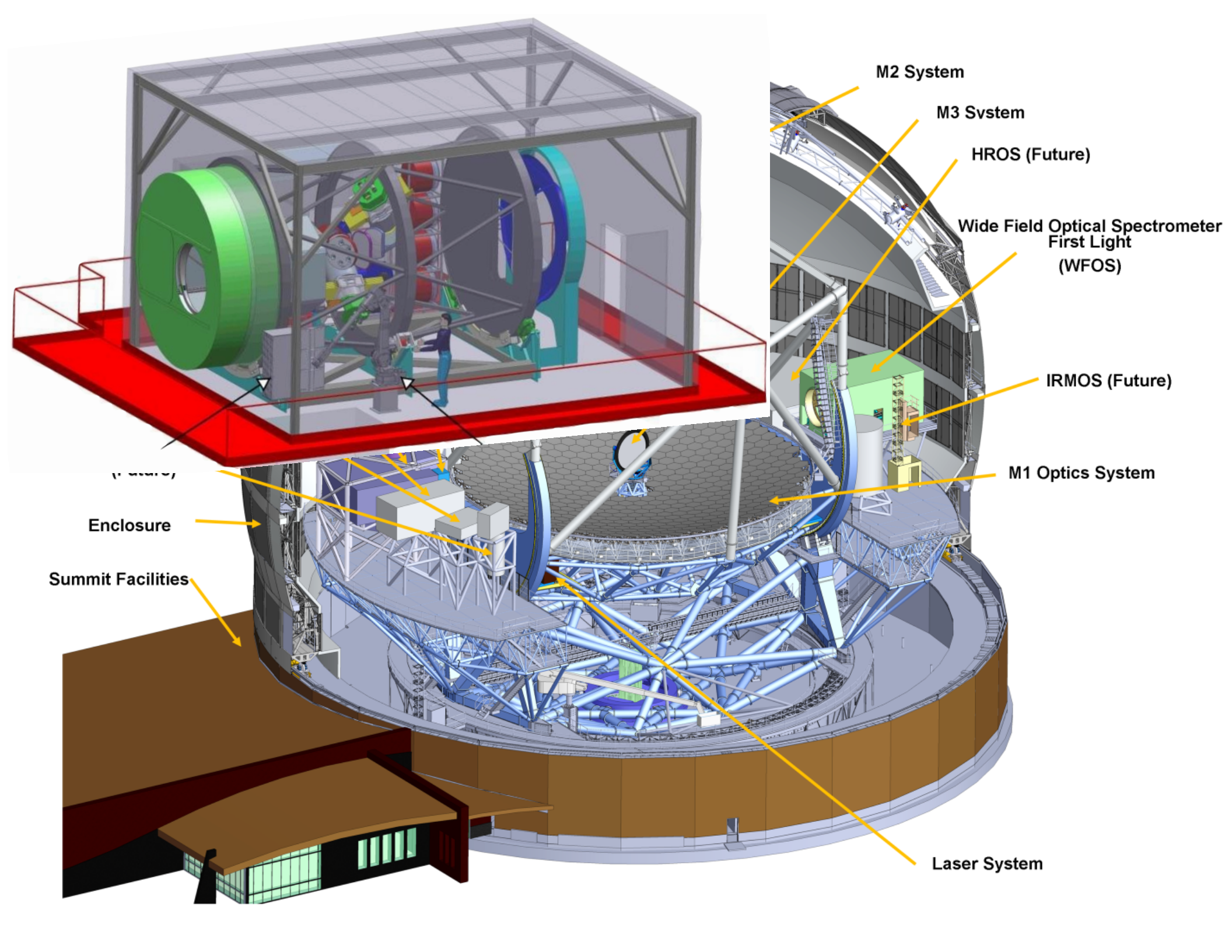
Dark Energy Science with TMT's Wide Field Optical Spectrograph (WFOS)

Kevin Bundy

Cosmic Visions
LBNL, November 2017


NFIRAOS Science Calibration Unit (NSCU)
M2 System
M3 Svstem
HROS (Future)
NFIRAOS First Light
w/IR Imaging Spectrometer (IRIS)
w/IR Multi-Slit Spectrometer (IRMS)
NIRES-B (Future) WIRC (Future)
Wide Field Optical Spectrometer First Light (WFOS)
PFI (Future)
Alignment and Phasing System (APS)
IRMOS (Future)
MIRAO with MIRES/NIRES-R (Future)
M1 Optics System
Enclosure
Summit Facilities
Laser System


M2 System
M3 Svstem
HROS (Future)
Wide Field Optical Spectrometer
First Light
(WFOS)
IRMOS (Future)
M1 Optics System
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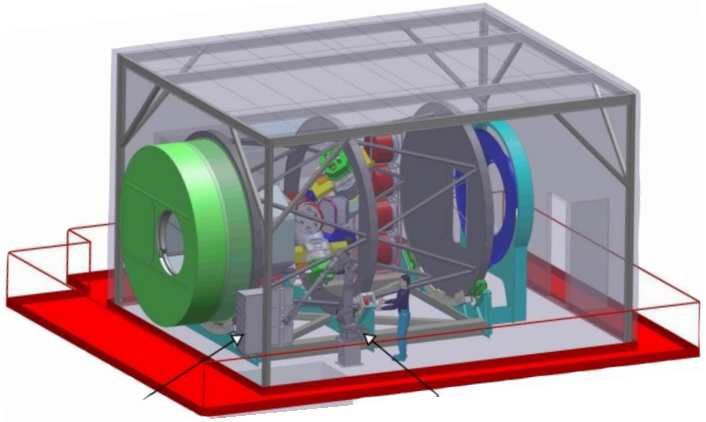
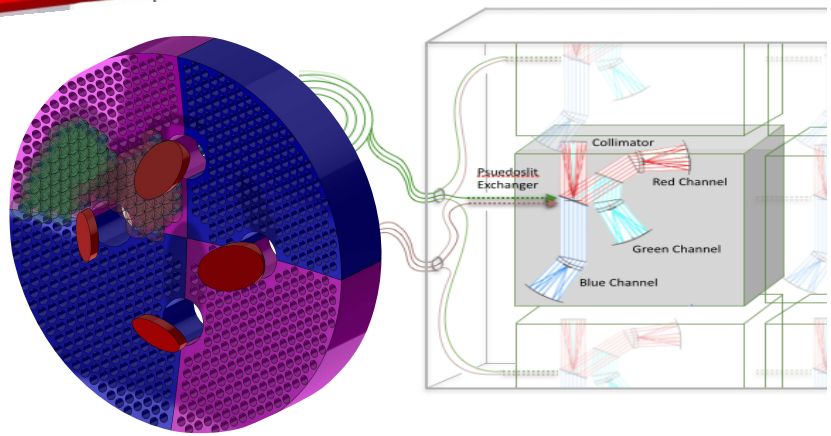
Summit Facilities
Laser System

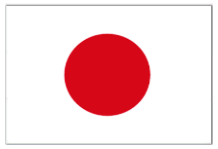


Slicer-WFOS

WFOS
Wide-Field Optical Spectrograph



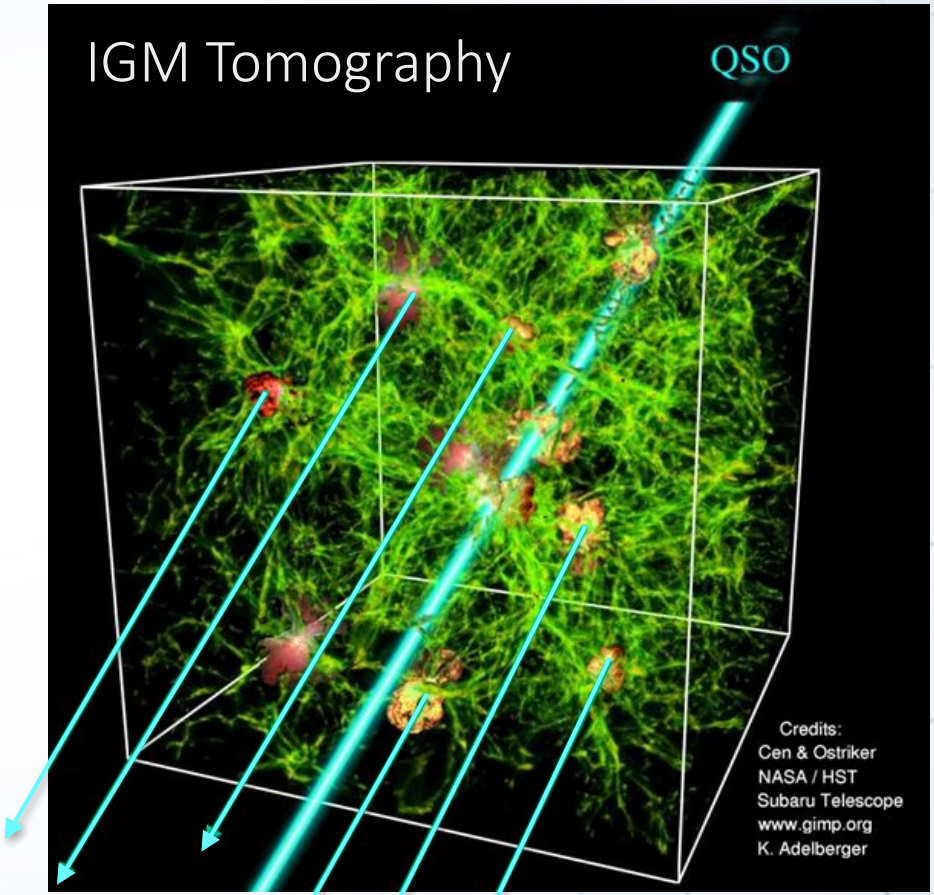
Fiber-WFOS

- UCO led since 2008 when it was called MOBIE
- 2016 - 2017: Opto-Mechanical Design Requirements phase
  - Bundy (PI) and Savage (PM) join UCO in Fall 2016
  - Review in May 2017: MOBIE-like design is too risky
- Aug 2017 - Mar 2018: Conceptual Design Phase 1
  - **March 2018** down-select: Slicer-WFOS vs. Fiber-WFOS
- TMT would have first light in 2027-2029
- Partners include: NAOJ (Japan), IIA (India), NIAOT (China), Caltech

Top-level WFOS Capabilities

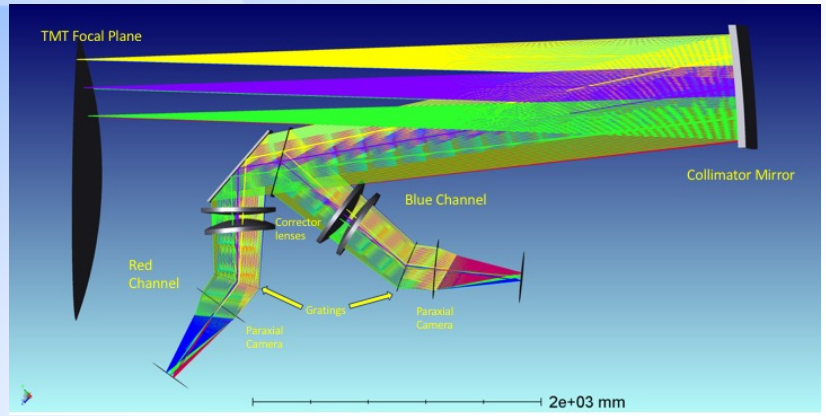
- Primarily multi-object survey instrument
- Also single-object rapid discovery/ identification for transient science
- R~5000 spectroscopy from 310 - 1000 nm
- R~1500 mode beneficial if multiplex and S/N improve
- GLAO ready



Studying proto-galaxies and the gas around them

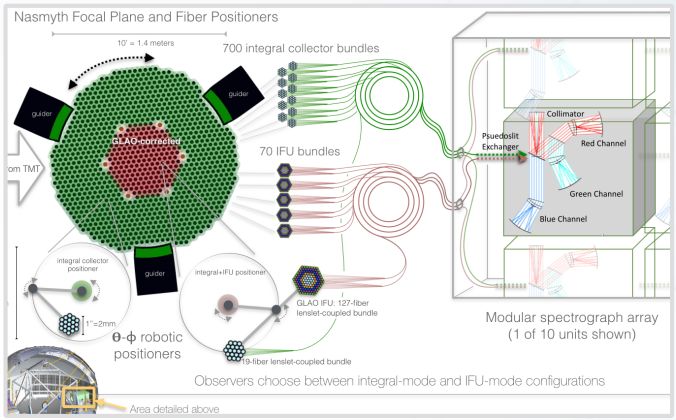
WFOS at a Crossroads…

Slicer-WFOS

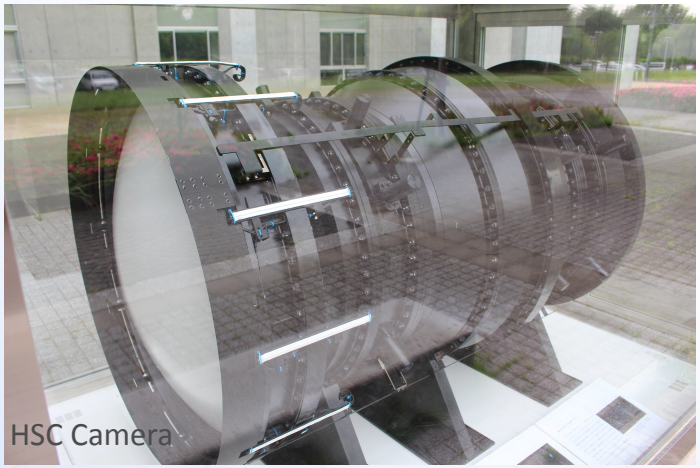


or…

Fiber-WFOS

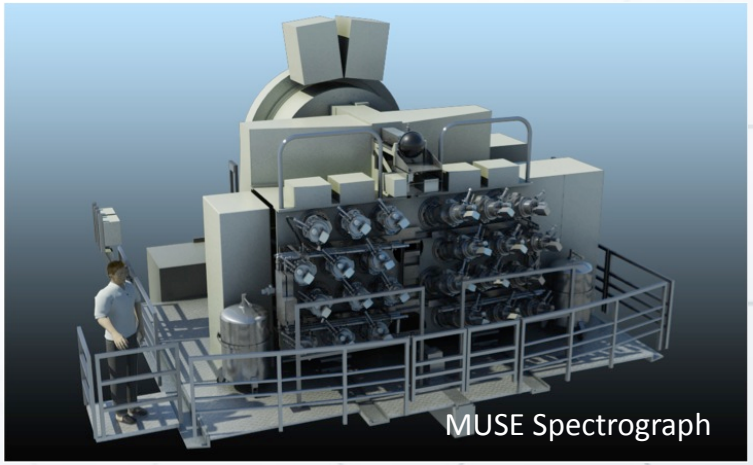


Monolithic



or…

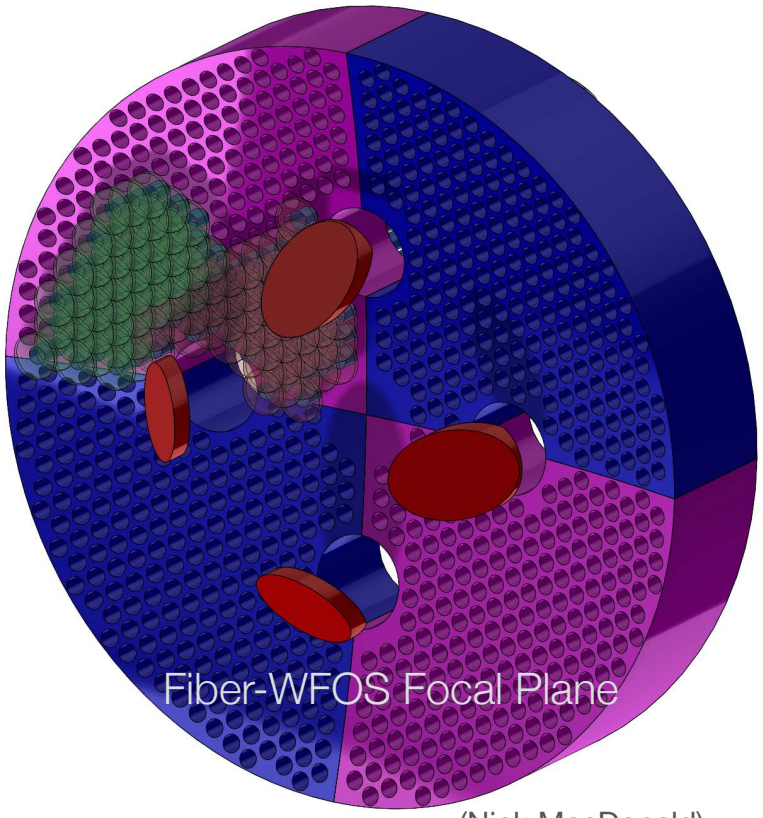
Modular?



Fiber-WFOS

Fiber-WFOS Specs

- **700 collecting** units,10 arcmin diameter field
- Each collector delivers R~5000
- Initial focus on sky-nodding or beam-switching
- 22” positioner pitch with overlap well matched to science cases
- Fibers feed a mounted array of ~10 spectrographs
- **~70 Deployed IFUs** in GLAO mode



(Nick MacDonald)

LSST Photo-z Training

LSST Forecasts

Newman et al. 2015

Product of errors on w and dw/da (i.e., expansion rate at a given time and its rate of change)

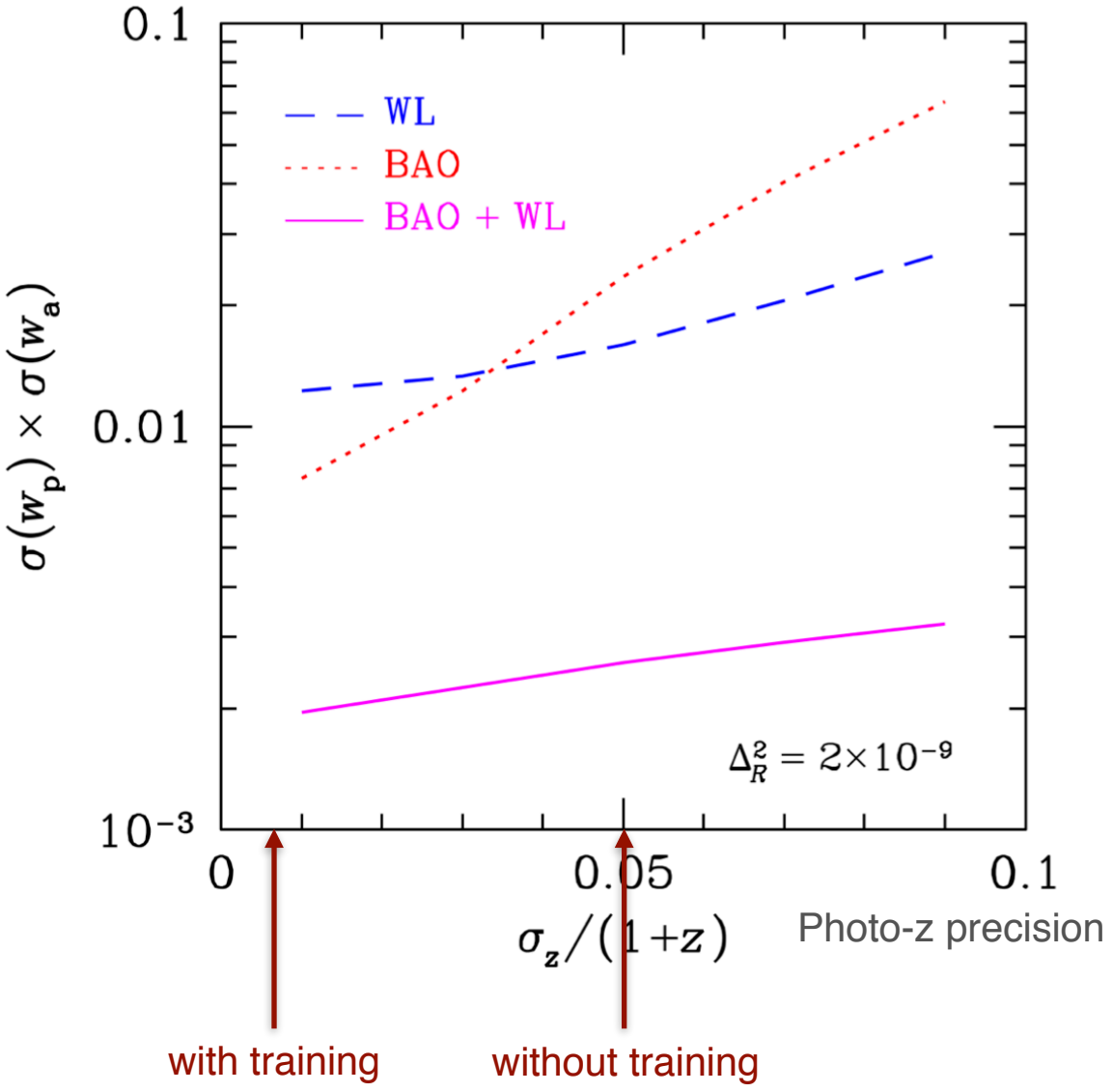


Photo-z training offers 50% gains on billion dollar experiments

LSST Photo-z Training

LSST Photo-z Training Requirements

Newman et al. 2015

- 30,000 spectroscopic redshifts
- 75% or 90% redshift success
- magnitude limited to i = 25.3 AB
- 15 fields of 0.09 deg^2 (324 arcmin^2) each

Implications for Fiber-WFOS:

- Ideal targeting density is ~6 arcmin^{-2}. (22k/deg^2)
- Fiber-WFOS is field-of-view limited
- For R=5', required multiplex = 700

Fiber-WFOS in 2030: Full-depth LSST training

LSST Photo-z Training

Photo-z training: fiber-WFOS beats all competition (!)

Instrument	*Survey time: LSST depth, 75% complete*	*Survey time: LSST depth, 90% complete*
Keck / DEIMOS	*10.2 years*	*64 years*
Subaru / PFS	*1.1 years* $36M	*6.9 years*
GMT MANIFEST (w GMACS)	*5-9 months*	*2.6-4.7 years*
fiber-WFOS (R=6')	*50 nights* $14M	*10 months*

Courtesy of Jeff Newman

Conclusions

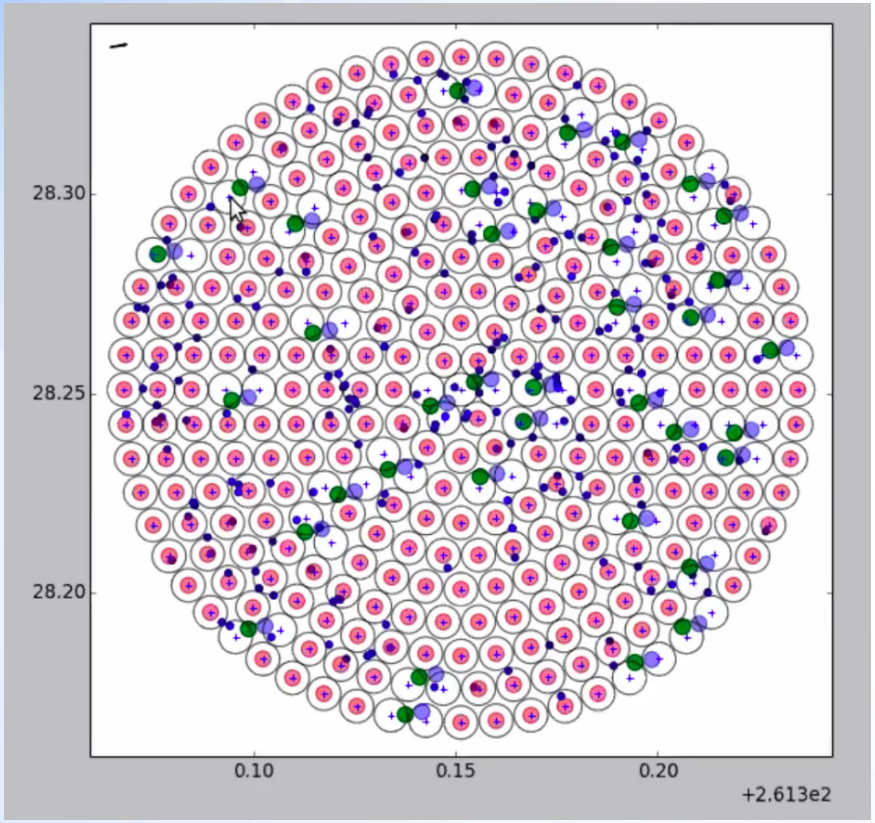
- Fiber-WFOS may be compelling for Dark Energy Science
- Fastest (Cheapest?) full-depth LSST photo-z training
- WFOS down-select in March 2018
- Push to near-IR? (GeCCD?)
- Other Fiber-WFOS probes to think about?

Constraints from Lya tomography?
Kinematic lensing with ~70 IFUs and GLAO?
Other ideas?

TMT would welcome your input and involvement!

Maximizing Photons: High Multiplex

Robotic target positioning



Fiber-WFOS target allocation simulations

Maximize efficiency with multilayered programs

Large survey programs

1. IGM *z*=2-5 tomography: 10 arcmin^{-2}
2. MW halo stars: 0.2 arcmin^{-2}
3. LSST Photo-z training: 6 arcmin^{-2}

GLAO programs

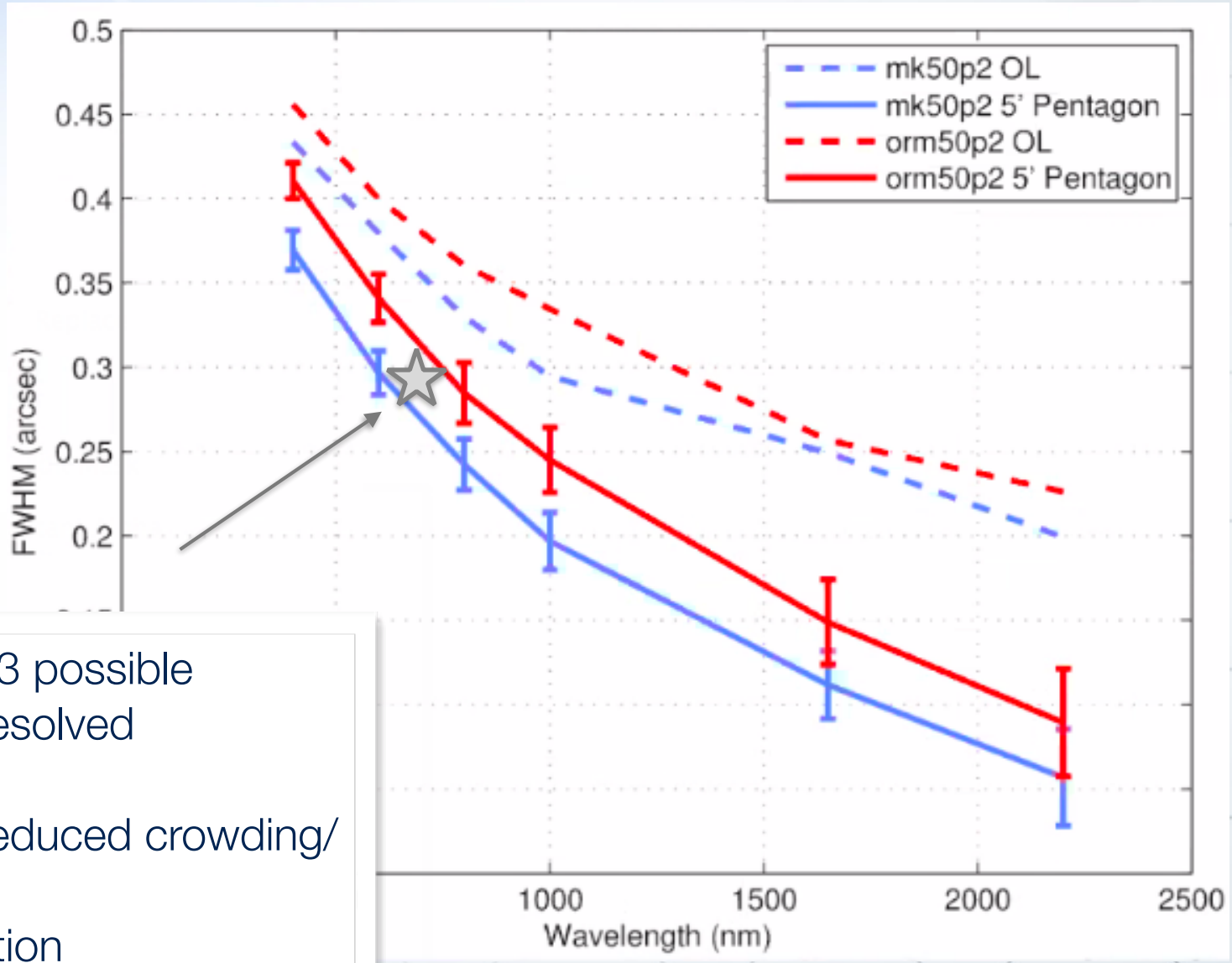
1. IFUs on z~1 galaxies: 10 arcmin^{-2}
2. z=5 galaxy properties: 5 arcmin^{-2}

Target of opportunity programs

1. Target of opportunity: 1 per pointing
2. EUCLID redshift targets: 20 arcmin^{-2}
3. LSST Photo-z training: 6 arcmin^{-2}

Gains with GLAO

- GLAO simulations for a realistic TMT adaptive secondary
- FWHM 0.3-0.4”
- FOV: 4-6’



- Sensitivity gains of 2-3 possible
- **New science** from resolved spectroscopy
- **New science** from reduced crowding/ confusion
- Cheaper instrumentation