IPMU INSTITUTE FOR THE PHYSICS AND MATHEMATICS OF THE UNIVERSE

東京大学 THE UNIVERSITY OF TOKYO

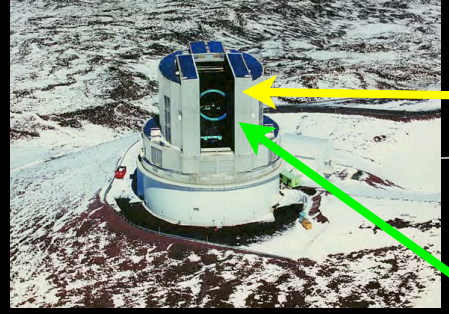
Updates on PFS

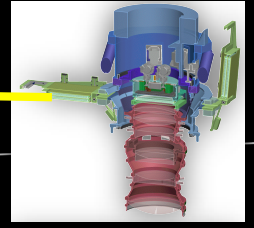
Hitoshi Murayama (IPMU & Berkeley)

PFS workshop, NAOJ, Dec 9, 2010

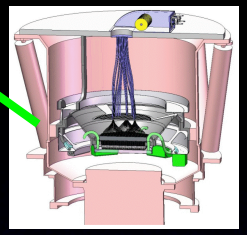
BERKELEY CENTER FOR THEORETICAL PHYSICS

BERKELEY LAB





imaging



spectroscopy

SuMIRe

Subaru

- Major study of dark energy
- Subaru Measurement of Images and Redshifts

1. imaging with 0.9B-pixels 3t CCD camera from 2011
2. spectroscopy with ≈2000 objects >2015

- *best measurements of dark energy params* in this decade
- 3D map of dark matter to observe structure formation
- same telescope for both imaging and spectroscopy *like SDSS but 8.2m!*

SuMIRe

Subaru Measurement of Images and Redshifts

- July 2009: Japanese LDP government announced economic stimulus package
- FIRST program announced, ¥270B for 30 researchers
- tried to save both HSC and multi-object spectrograph
- Sep 5, 2009: HM selected
- Sep 16, 2009: new DPJ government slashed ¥270B to ¥100B
- Jan 14: Subaru Users Mtg
- long wait for the final word

funding

- Mar 29, 2010: ¥3.2B awarded to HM
- Jun 1, 2010: ¥0.2B "boost" awarded
- agency decision:
  - HSC ¥1.2B
  - PFS ¥1.7B
  - overhead ¥0.5B
- cf. WFMOS ¥5.8B

Updates

- Apr 13: meeting with Miyama
- May 4: meeting with Marseille
- July 13: Subaru Advisory Committee
- July 20-21: first PFS collaboration meeting
- July 29: meeting with Caltech/JPL
- Aug 19-20: GOPIRA meeting @ NAOJ
- Aug 13: Astro 2010 rollout

How do we fit it in?

- Three basic strategies
  - find free labor
  - contribution from international partners
  - cost reduction
- Princeton is interested in going beyond 1μ, but neither within WFMOS scope nor current discussion; requires more funds

Aug 19-20: GOPIRA meeting @ NAOJ

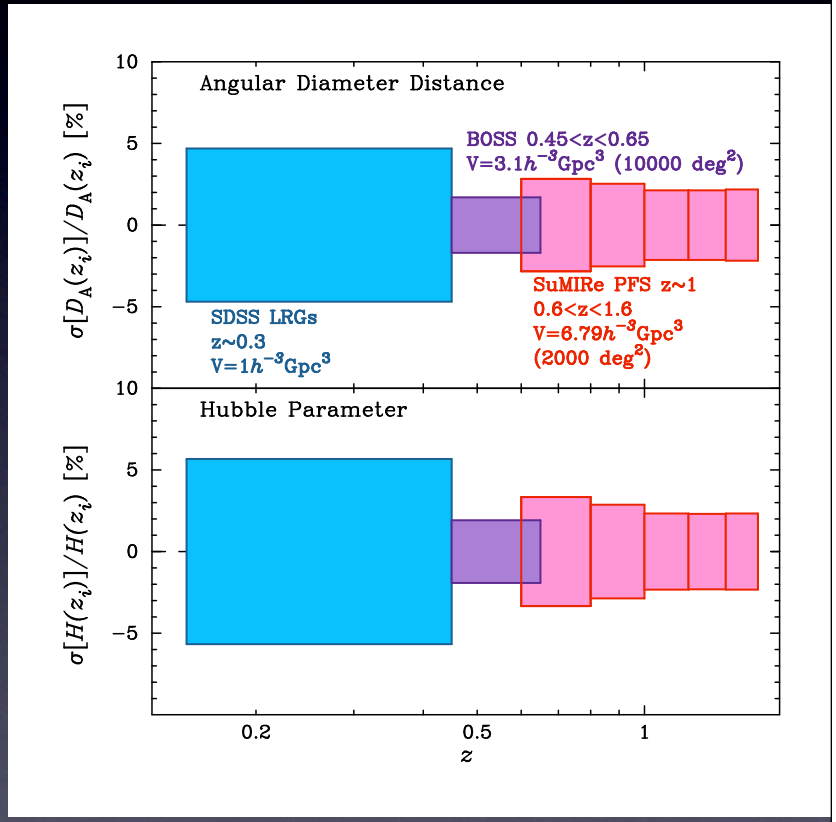
WFMOS design

- "big beam" spectrograph, 3 x (5m x 3m)!
  - Subaru people don't like this
- 6k×3k CCD from LBNL/JPL
  - better use Hamamatsu 4k×4k
- many moving parts to switch High & Low R
  - better have a static design

Aug 19-20: GOPIRA meeting @ NAOJ

technical specs

- BAO
  - correlate distance from BAO to redshift → dark energy
  - targets selected with HSC
  - go beyond BOSS: z≈0.6–1.6
  - most efficient (least exposure): OII emission 372.7, 373.0 nm
  - need 600-1000nm, R≈3000
  - measure w down to 3%
  - 4k×4k CCDs, ~500 fibers x 5



Aug 19-20: GOPIRA meeting @ NAOJ

additional science

- BAO
  - also reach z≈3 with Lyα
  - need blue: 400–600 nm
- weak lensing tomography
  - HSC weak lensing survey with photo-z
  - with real z, can do tomography
  - 3D map of dark matter
  - observe structure evolution w/o bias

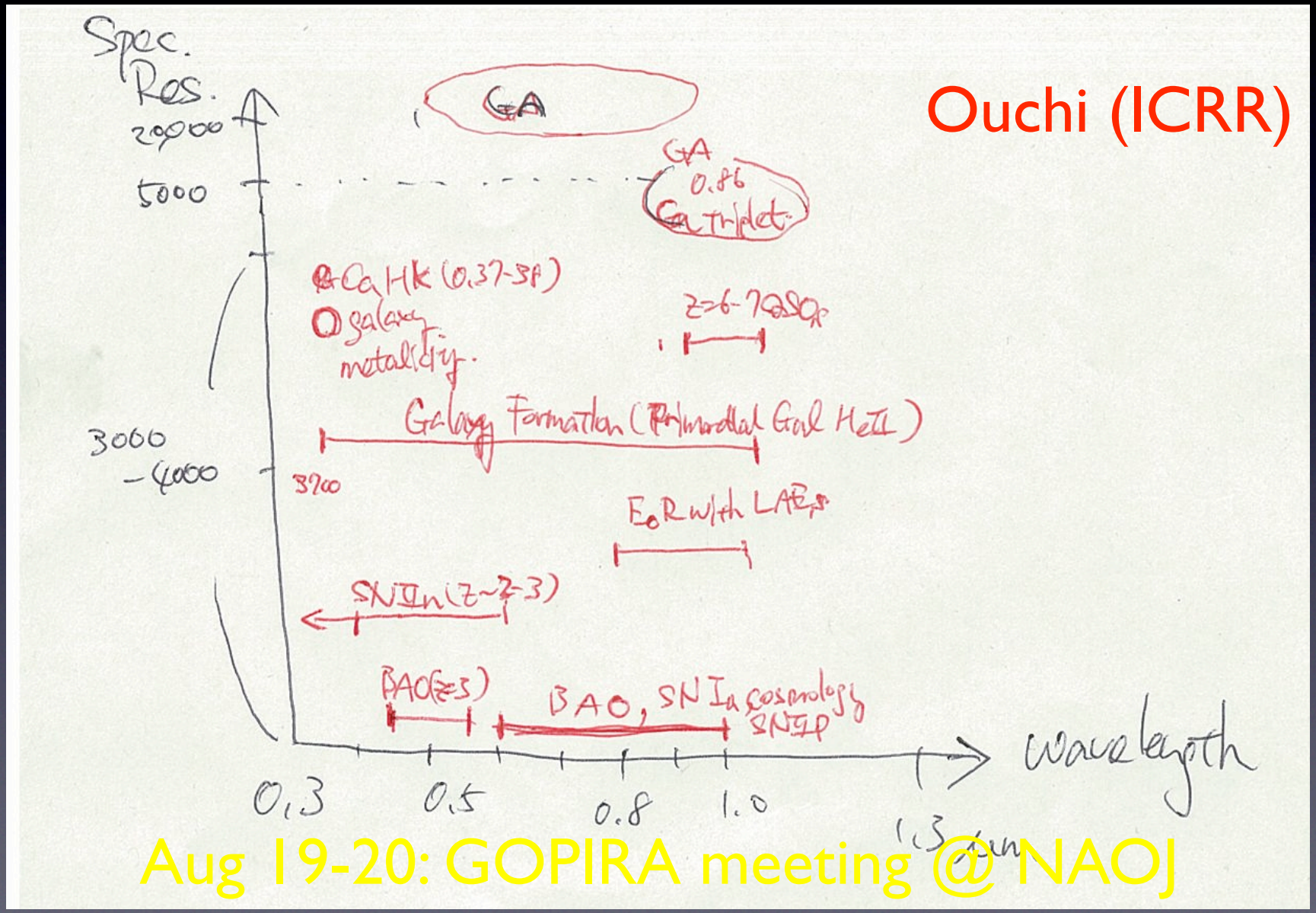
Aug 19-20: GOPIRA meeting @ NAOJ

other science?

- galactic archaeology based on dynamics
  - 393.5 (K), 397.0 (H), R~3000?
  - 850.0, 854.4, 866.5 (CaII), R~5000?
- Galaxy evolution with primordial HeII 164?
- EoR with Lyα emitters?
- AGN with OIII 500.7?
- SNe?
- minimize cost, maximize science!

Aug 19-20: GOPIRA meeting @ NAOJ

brainstorming



Ouchi (ICRR)

Aug 19-20: GOPIRA meeting @ NAOJ

Conclusions

- now likely that we *can* complete HSC
- spectrograph still uncertain but possible
- detailed specs will depend on funds available
- need *lots* of negotiations/discussions
- next week visit UK, Marseille, JPL
- Princeton and Brazil in September

Aug 19-20: GOPIRA meeting @ NAOJ

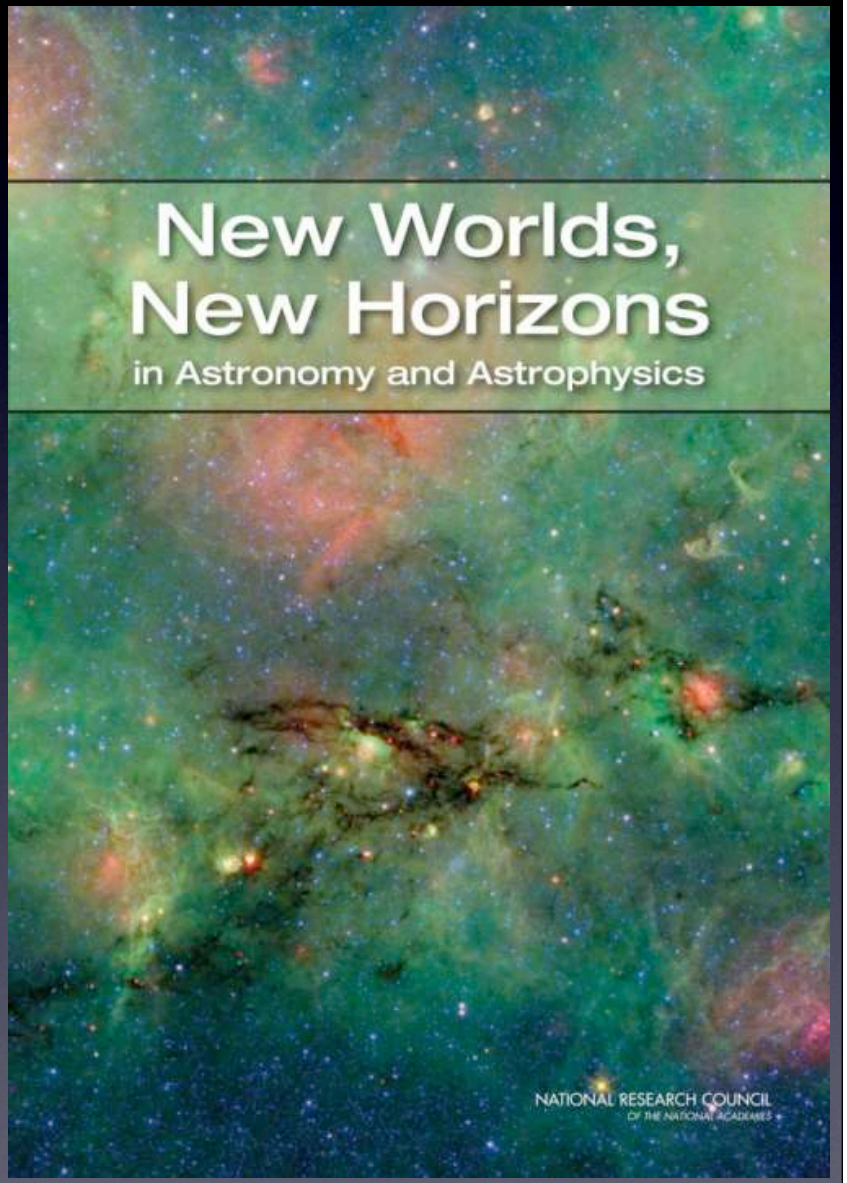
Need community input

- Subaru Future Instrumentation Workshop
- Sep 9 & 10, 2010 @ IPMU
- science scope, spectrograph specs
- *minimize cost, maximize science!*
- hoping for community endorsement at January Subaru Users Meeting

Aug 19-20: GOPIRA meeting @ NAOJ

Astro 2010

- Science Objectives
  - Cosmic Dawn
  - New Worlds
  - Physics of the Universe
    - Dark Energy
    - Dark Matter
    - Inflation
    - Test GR



Large Scale Space Program - Prioritized

1. Wide Field InfraRed Survey Telescope (WFIRST)
   ⇒Dark Energy
2. Explorer Program Augmentation
3. Laser Interferometer Space Antenna (LISA)
4. International X-ray Observatory (IXO)

Roger Blandford ASTRO 2010 roll-out

Large-scale Ground-based Program - Prioritized

1. Large Synoptic Survey Telescope (LSST) ⇒Dark
2. Mid-Scale Innovations Program Energy
3. Giant Segmented Mirror Telescope (GSMT)
4. Atmospheric Cerenkov Telescope Array (ACTA)

Roger Blandford ASTRO 2010 roll-out

Physics of the Universe

- The properties of dark energy would be inferred from the measurement of both its effects on the expansion rate and its effects on the growth of structure (the pattern of galaxies and galaxy clusters in the universe). In doing so it should be possible to measure deviations from a cosmological constant larger than about a percent. Massively multiplexed spectrographs in intermediate-class and large-aperture ground-based telescopes would also play an important role.

Updates

- Aug 23: meeting with UK group in Edinburgh
- Aug 25: meeting with Olivier Le Fèvre (LAM)
- Aug 27: video/phone meeting with Brazil
- Oct 14, 15: Visit to ASIAA, Taipei
- Oct 25-29: SDSS III/BOSS meeting @ IPMU
  - potential interest from John-Hopkins
- steering committee formed + Kobayashi
- regular telecon with Subaru Observatory

Updates

- Sep 9, 10: Subaru instrumentation WS @IPMU, discussed science case for PFS
- Oct 7, 8: DENET workshop @Caltech
- Oct 8: PFS steering committee meeting
- Oct 9: PFS collaboration meeting @Caltech

Aim of this meeting

- listen to Brazil proposal to join the collab.
- management plan from Hiroshi Karoji
- decide path(s) on spectrograph design
- additional science beyond BAO
- How to obtain endorsement from Subaru community

minimum cost, maximum science!

Oct 9: PFS collaboration meeting @ Caltech

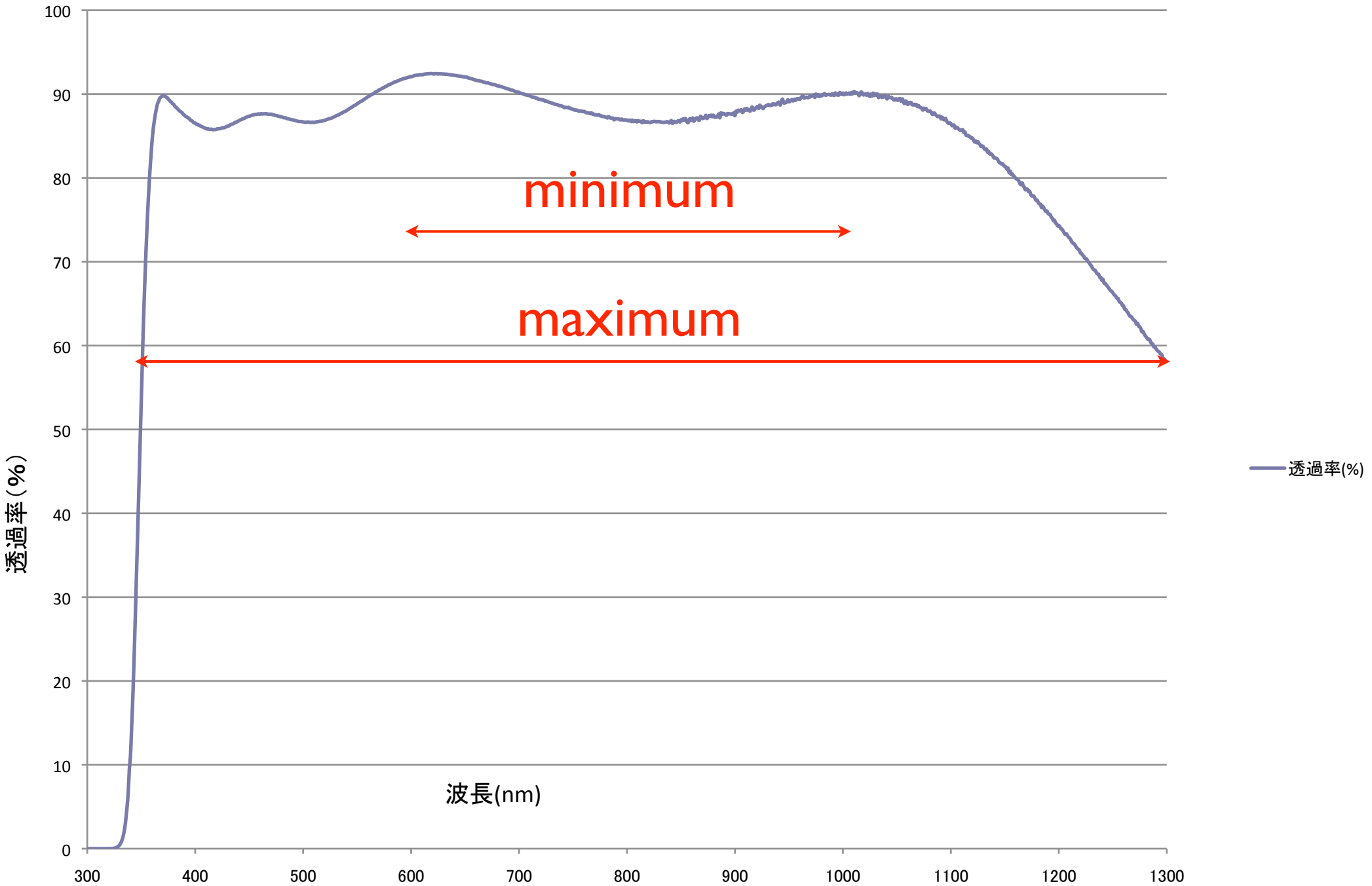
a simple observation

- multi-object wide-field spectroscopy on 8m-scale telescope would be *unique in the world*
- exploit investments in HSC
- main advantage over 2-4m: high-z galaxies!
- HSC & PFS = SDSS × $(8.2/2.5)^2$!
- to capitalize on it, aim for a versatile instrument

a simple comparison

- SDSS/BOSS
  - z<0.6, 1.3M galaxies
  - 380-920nm, R=1800-2200
- simply scale by 8.2/2.5 on lumi distance
  - z<1.6
  - 600-1500nm
- In addition, blue makes Lyα possible

transmission probability through the corrector lens coating

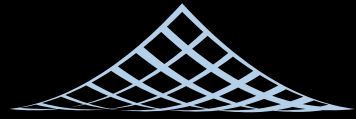


wavelength (nm)

specs

- minimal
  - 600-1000nm, R≈3000
  - one arm (4k x 4k)
- best galaxy survey in the foreseeable future
  - 400-1300nm, R≈2000-5000
  - three arms
  - OII covers z=0–2.5
  - Lyα covers z=2.2–10
  - continuous survey to very high z!

PFS collaboration



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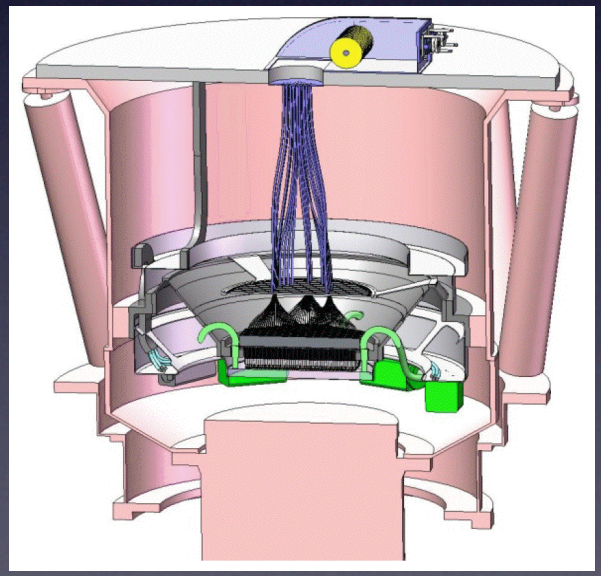
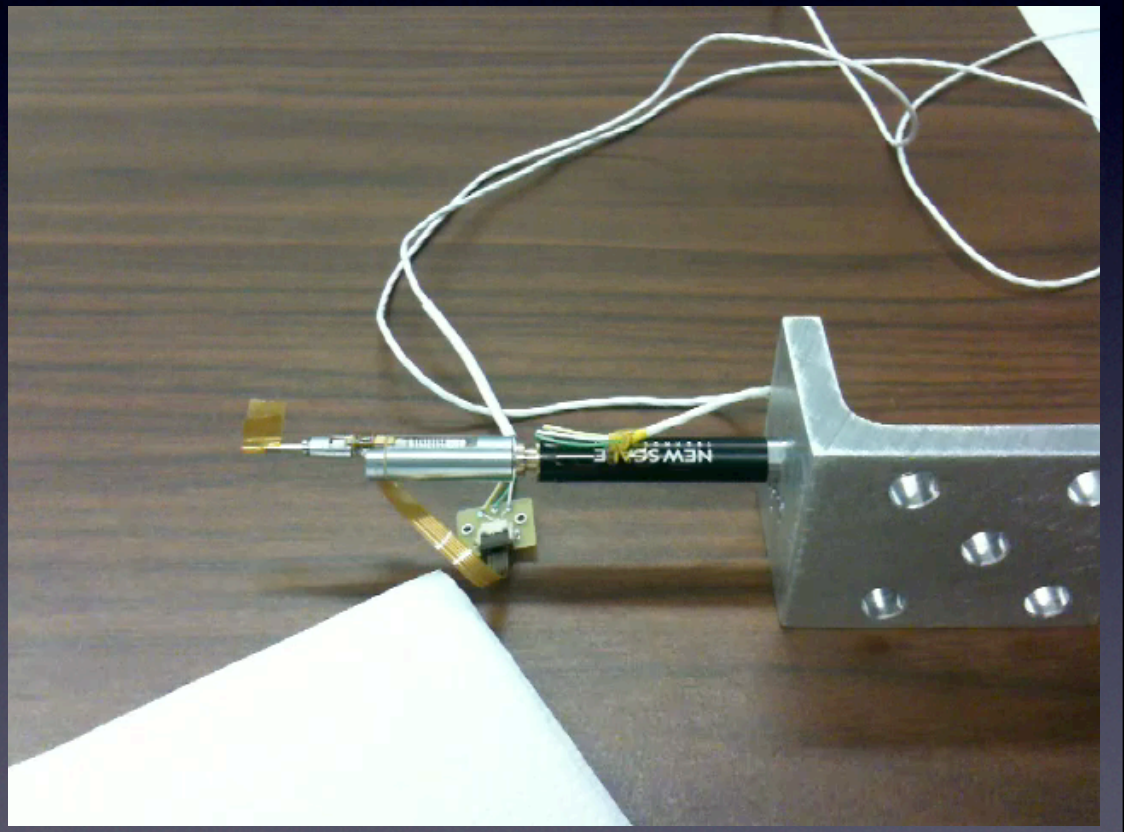
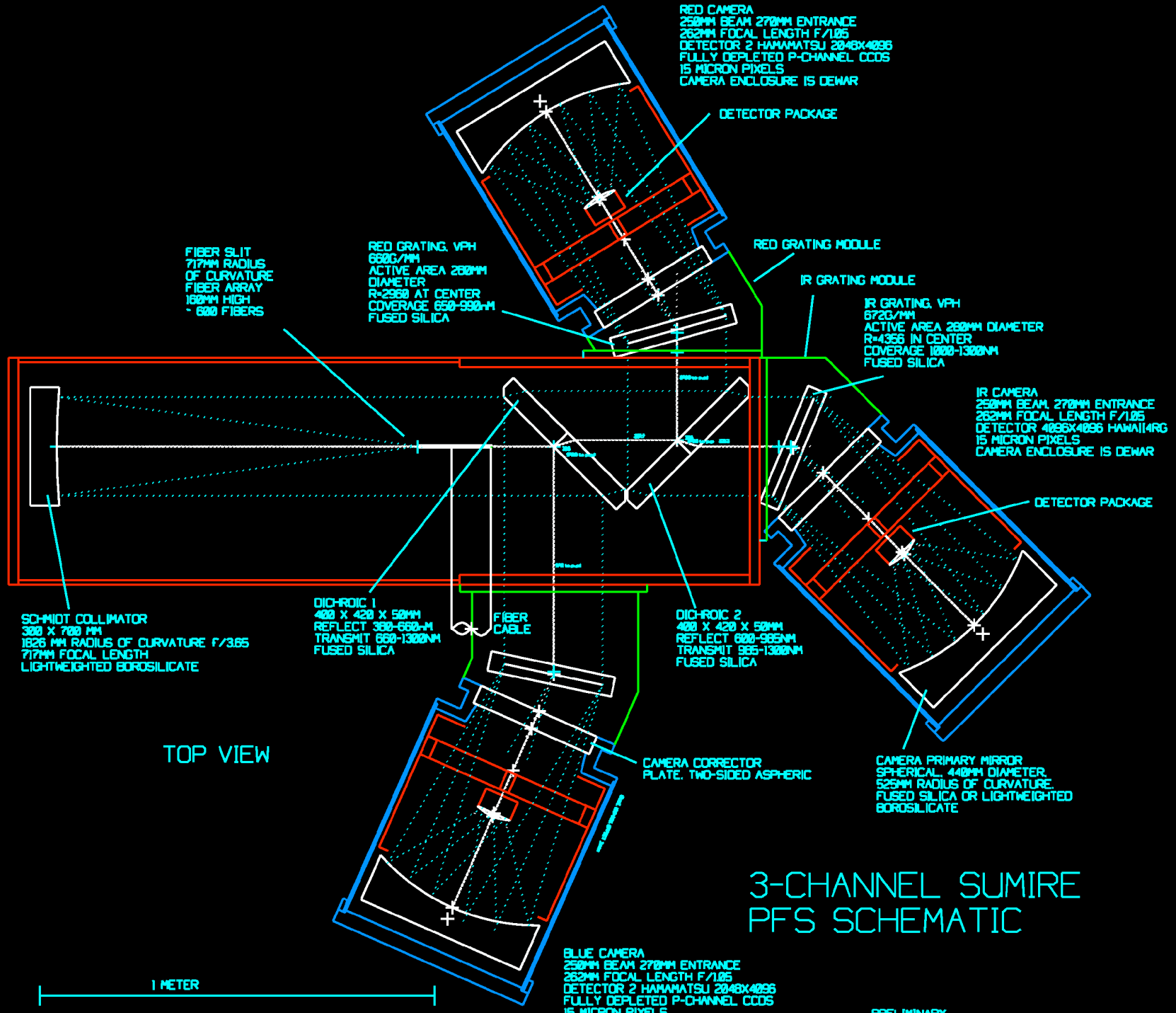
fiber positioner

- fiber positioner based on JPL cobra design
- 2400 fibers



WFMOS




RED CAMERA
250MM BEAM 270MM ENTRANCE
262MM FOCAL LENGTH F/1.05
DETECTOR 2 HAMAMATSU 2048X4096
FULLY DEPLETED P-CHANNEL CCDS
15 MICRON PIXELS
CAMERA ENCLOSURE IS DEWAR
DETECTOR PACKAGE
FIBER SLIT
717MM RADIUS
OF CURVATURE
FIBER ARRAY
160MM HIGH
~ 600 FIBERS
RED GRATING, VPH
660G/MM
ACTIVE AREA 260MM
DIAMETER
R=2360 AT CENTER
COVERAGE 650-990-M
FUSED SILICA
RED GRATING MODULE
IR GRATING MODULE
IR GRATING, VPH
672G/MM
ACTIVE AREA 260MM DIAMETER
R=4356 IN CENTER
COVERAGE 1000-1300NM
FUSED SILICA
IR CAMERA
250MM BEAM 270MM ENTRANCE
262MM FOCAL LENGTH F/1.05
DETECTOR 4096X4096 HAWAII4RG
15 MICRON PIXELS
CAMERA ENCLOSURE IS DEWAR
DETECTOR PACKAGE
SCHMIDT COLLIMATOR
300 X 700 MM
1626 MM RADIUS OF CURVATURE F/3.85
717MM FOCAL LENGTH
LIGHTWEIGHTED BOROSILICATE
DICHROIC 1
400 X 420 X 50MM
REFLECT 380-660-M
TRANSMIT 660-1300NM
FUSED SILICA
FIBER
CABLE
DICHROIC 2
400 X 420 X 50MM
REFLECT 600-985NM
TRANSMIT 965-1300NM
FUSED SILICA
TOP VIEW
CAMERA CORRECTOR
PLATE, TWO-SIDED ASPHERIC
CAMERA PRIMARY MIRROR
SPHERICAL, 440MM DIAMETER,
525MM RADIUS OF CURVATURE,
FUSED SILICA OR LIGHTWEIGHTED
BOROSILICATE
3-CHANNEL SUMIRE
PFS SCHEMATIC
1 METER
BLUE CAMERA
250MM BEAM 270MM ENTRANCE
262MM FOCAL LENGTH F/1.05
DETECTOR 2 HAMAMATSU 2048X4096
FULLY DEPLETED P-CHANNEL CCDS
15 MICRON PIXELS
CAMERA ENCLOSURE IS DEWAR
PRELIMINARY
JEG 2010/09/09

acquiring resources

- Caltech: NSF proposal
- JPL: internal funding
- Princeton: NSF proposal
- Brazil: two proposals
- Marseille: internal resources

Lots of science

- BAO, weak lensing tomography, redshift space distortion, neutrino mass
- galaxy formation, evolution, assembly
- QSO
- Epoch of reionization
- galactic archaeology based on dynamics

Conclusion

- PFS design evolved to a much more versatile instrument
- absolutely unique in the world!
- hear about possible science with this instrument from white-paper study
- need constructive criticism to each other
- make the best case to Users Meeting

Timeline

WL

DES

HSC

LSST

BAO

SDSS/BOSS

PFS

Euclid?

WFIRST?