ASIAA Perspective on HSC/PFS

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Goals of ASIAA/NAOJ Collaborations

- Pursue Transformational Science
- Access Advanced Technology
- Cost Saving: Sharing Budget > 10^9 USD
- Preserve Regional Manpower (Brain Drain)
- Focus Taiwan Efforts
- Train staff and students via Collaborations
- Lock in long term funding
- Pursue Institutional Collaborations

Taiwan Strategy for Collaborations

- 2-Track approach
  Japan: regional development
  U.S.:   access US facilities
  principle: if we use, we should pay
- Preferred Contributions: "in-kind" to pump resources into Taiwan infrastructures
  principle: contribute instead of buy
- Open Competition for Time: no guarantee
  principle: best science wins; collaborate
- Project funding + University funding
  principle: develop job market, manpower

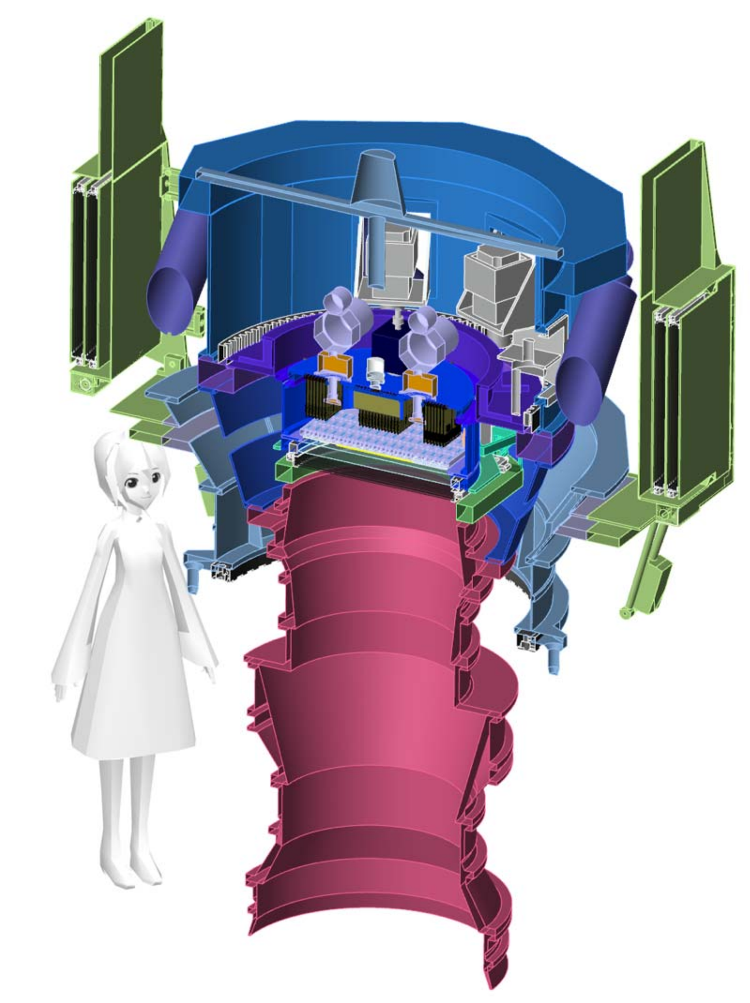
Summary: HSC Taiwan Status

- 03.2007: HSC proposal approved by ASIAA Advisory Panel
- 12.2007: HSC proposed in 2009, 2010 ASIAA Budget (5M USD)
- 12.2007: HSC start-up funds requested for current 2008 fiscal year
- 10.2008: AS/NINS sign HSC agreement
- 01.2009: HSC funding approved
- 12.2009: PFS mentioned in 2011, 2012 ASIAA Budget (2011 Budget Frozen at 2010 level)
- 2009-2010: Build Filter Exchanger,

  Procure CCDs, Lens Testing System

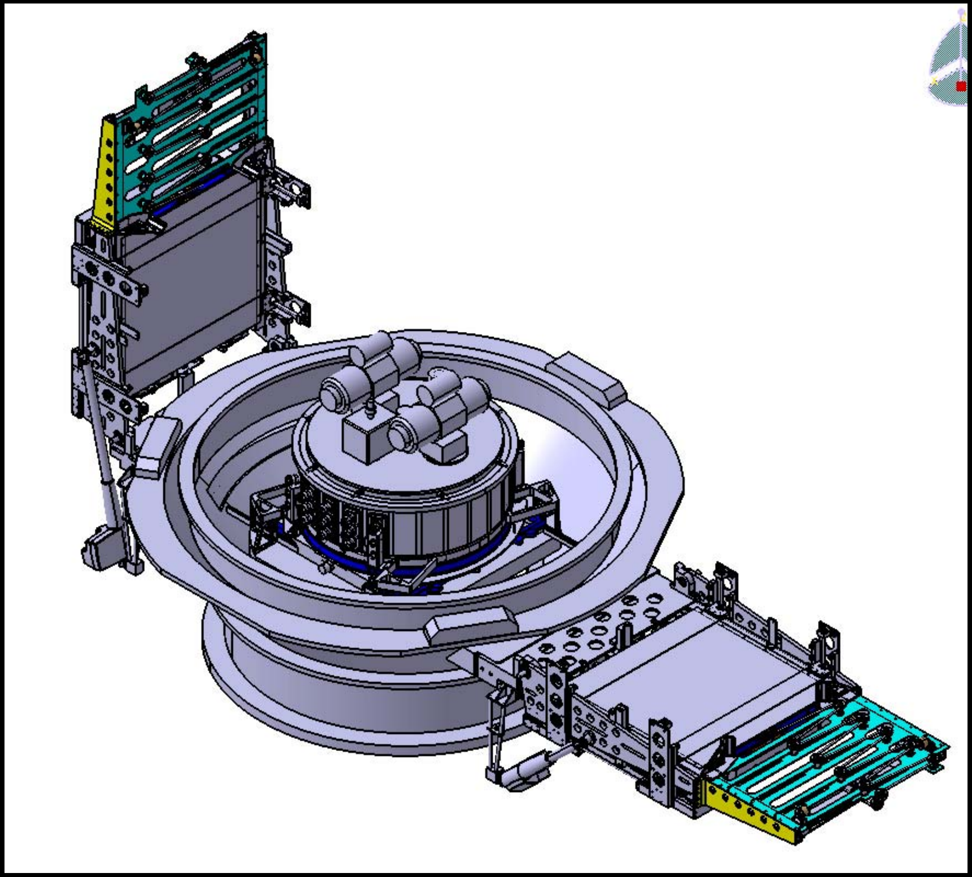
HSC Hardware Development in IAA

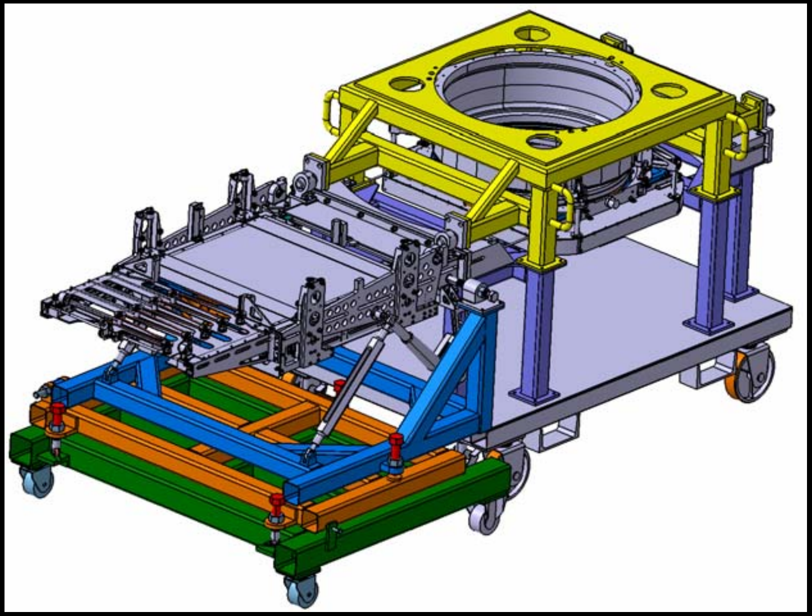
- Filter exchanger system
  - Collaboration with ASRD
  - Separated subsystem to HSC
- CCD procurement and test
  - Collaboration with NAOJ
- Wavefront testing instrument
  - WFC testing system
  - Collaboration with Canon and GSEO



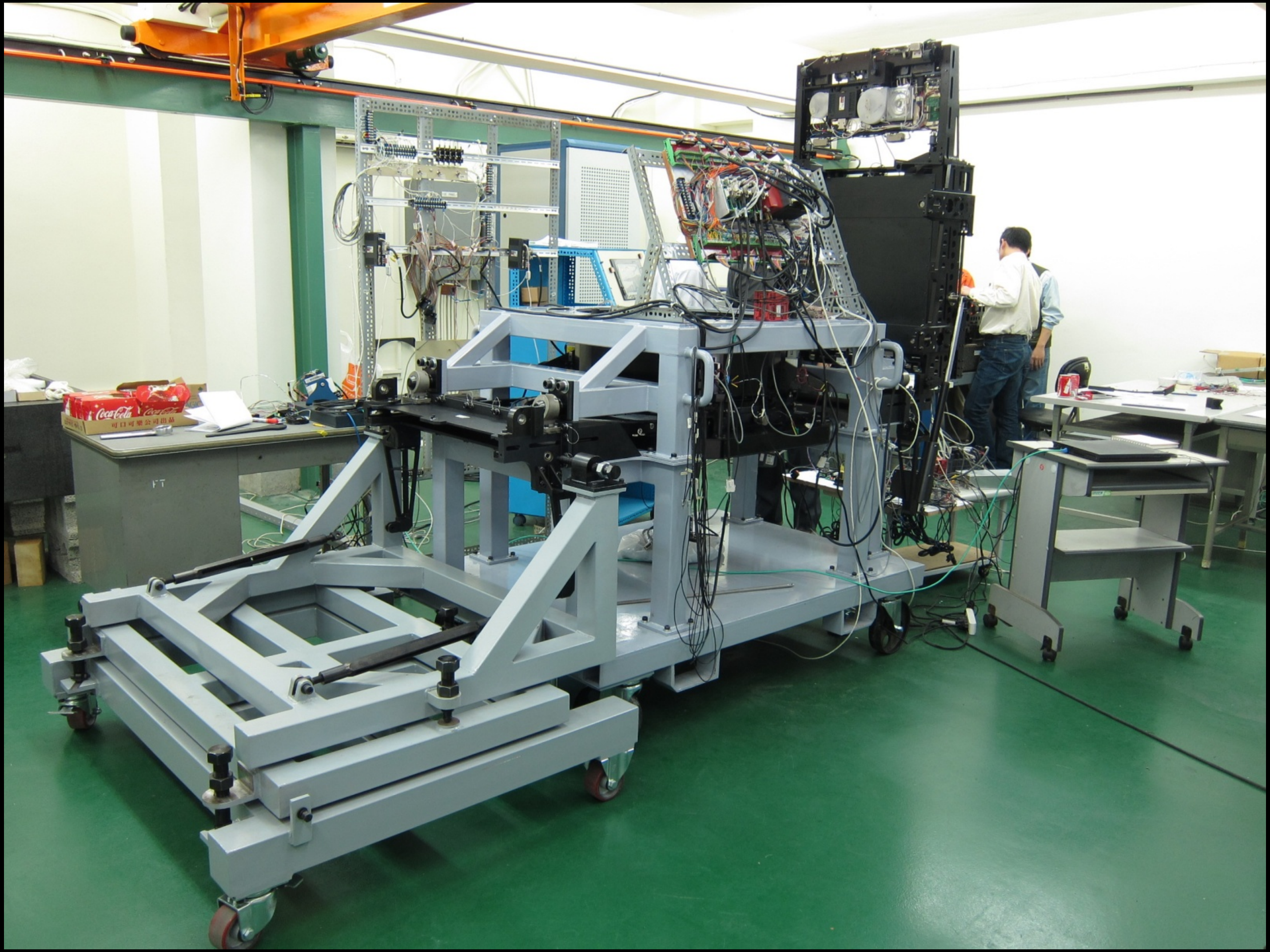
Alignment and Shipping Structure

- **6 degree of freedom for adjustment during the alignment and integration**

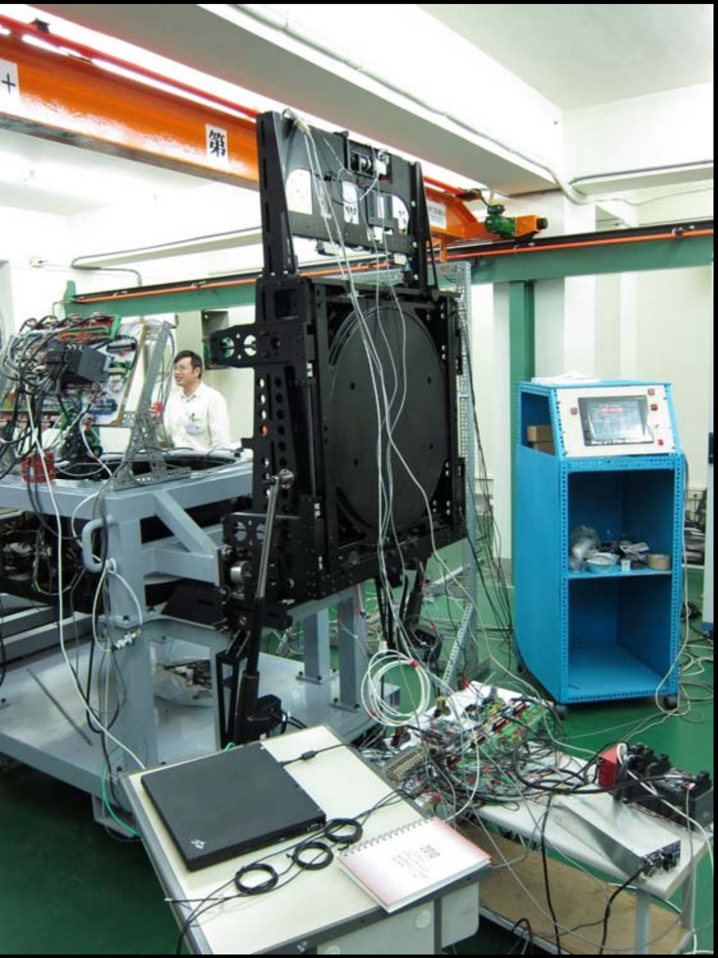


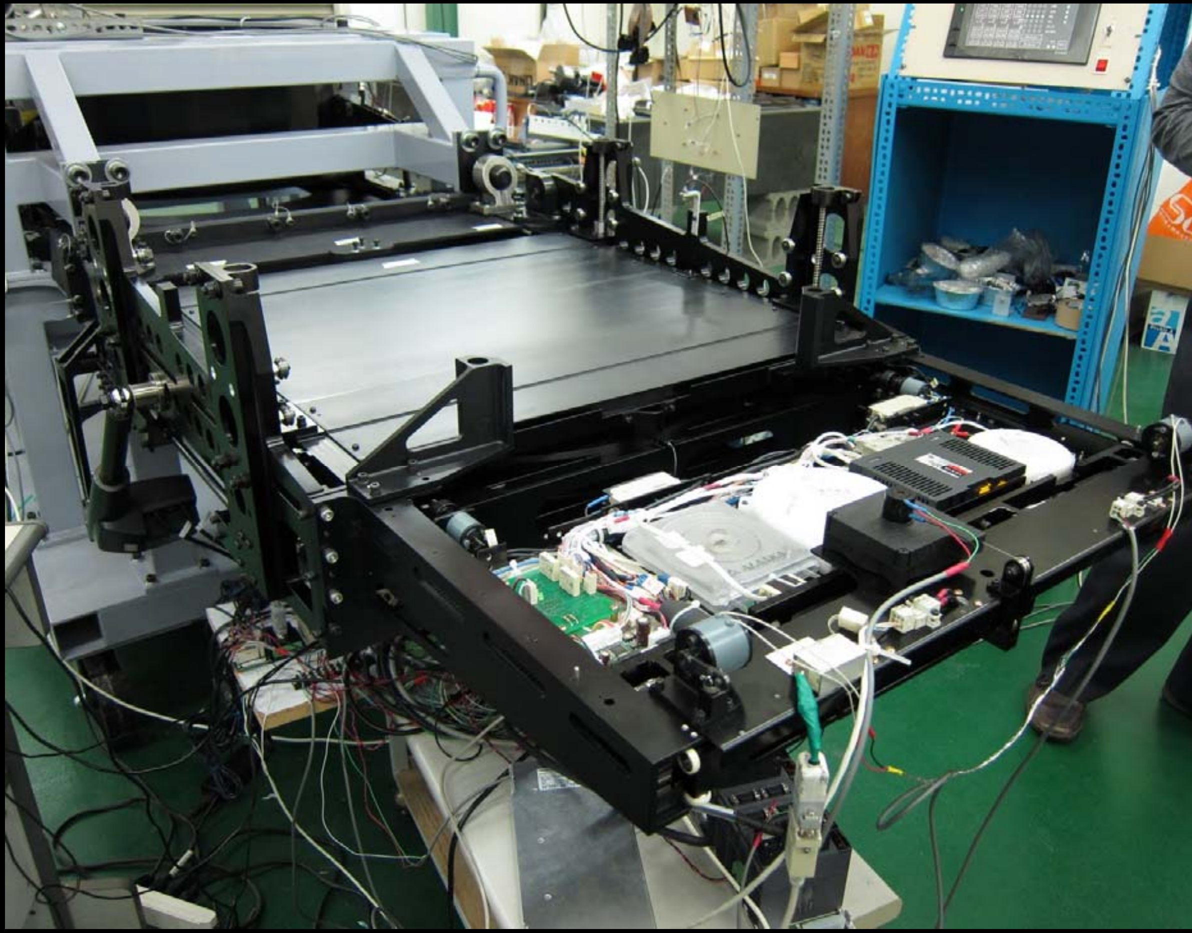


Filter Exchanger under testing



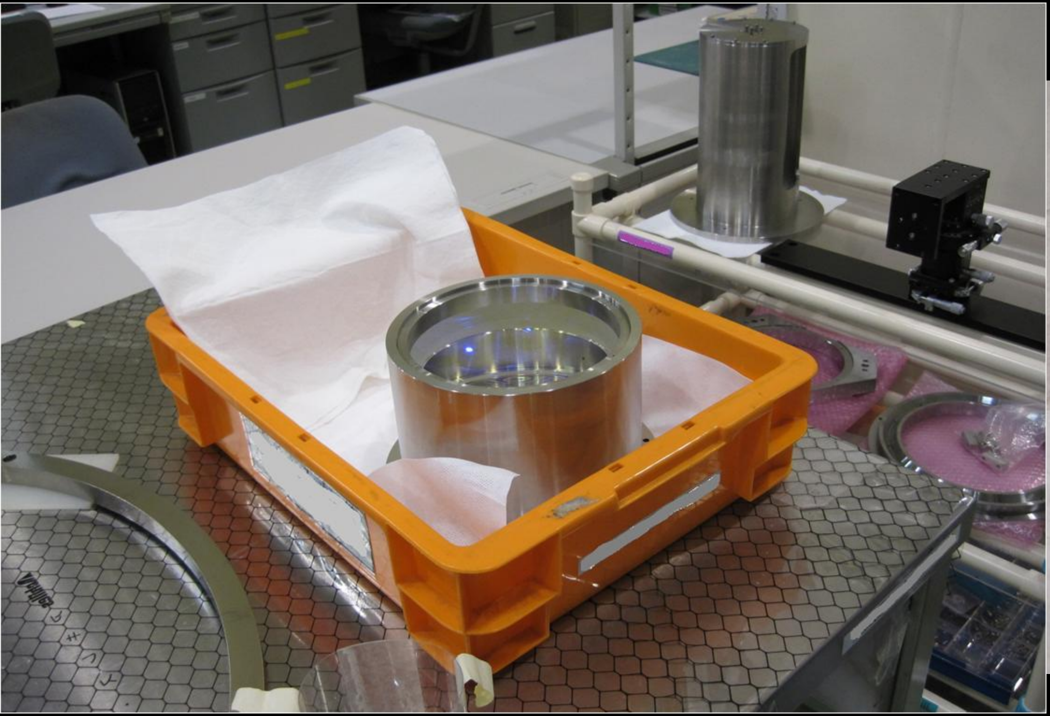
Shipping to Japan on Mar 8, 2011





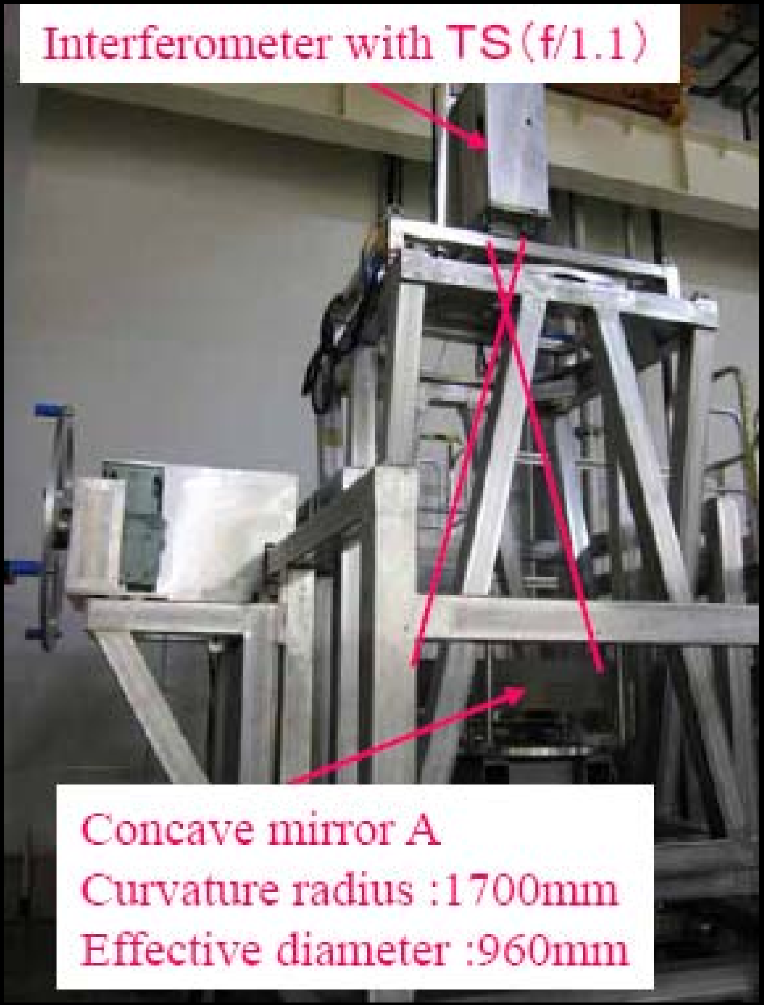
The Filter Exchanger Works

Null Lens Fabrication



Null lens delivered in May 2010 by GESO
Diameter of the largest lens is 170mm
Surface error RMS within 15 nm

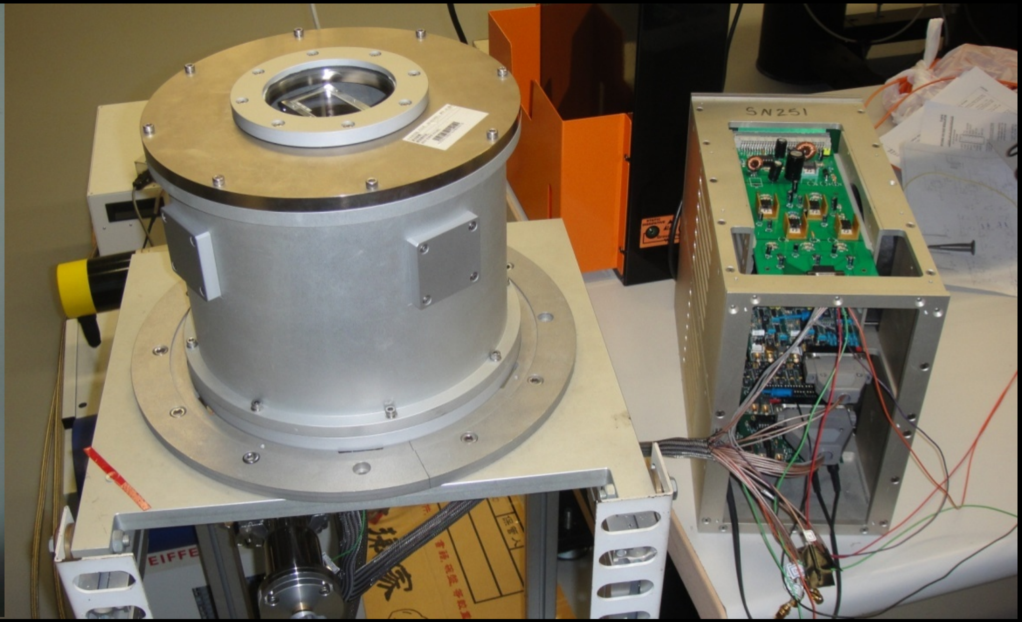
Wavefront Testing Instrument



Repeatability for configuration A (Average 20)=3.49nmRMS <5nmRMS
Repeatability for configuration B (Average 100)=3.0nmRMS <5nmRMS

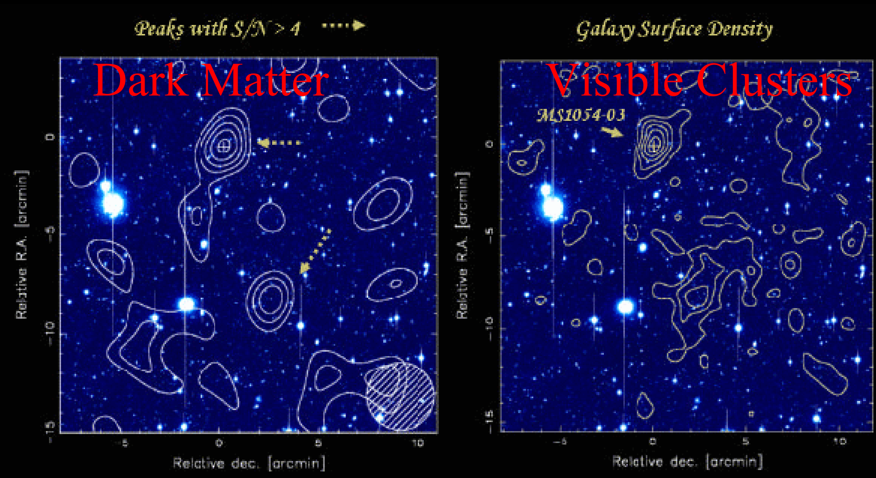
CCD Procurement and Testing

125 CCDs delivered by the end of Sep 2010
Assembly testing of focal plane in NAOJ now



Subaru HSC/PFS Science

Galaxy Cluster Abell 2218 **HST** • WFPC2
NASA, A. Fruchter and the ERO Team (STScI, ST-ECF) • STScI-PRC00-08



Wide Field Imaging + Spectroscopy

Weak Lensing Survey; z>6

Cluster Dark Matter Distribution

WL-induced Tangential Ellipticity

DE EoS w parameter constraints

Galaxy Survey at z>7

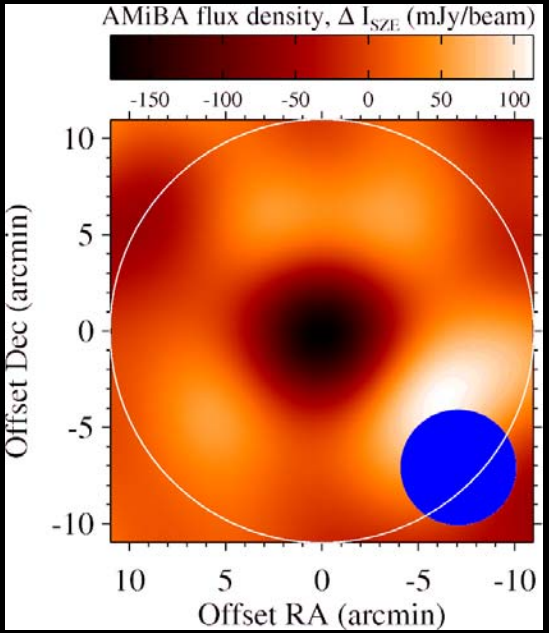
Mergers rates at z>1 (pair, SMBH)

Evolution of Initial Mass Function

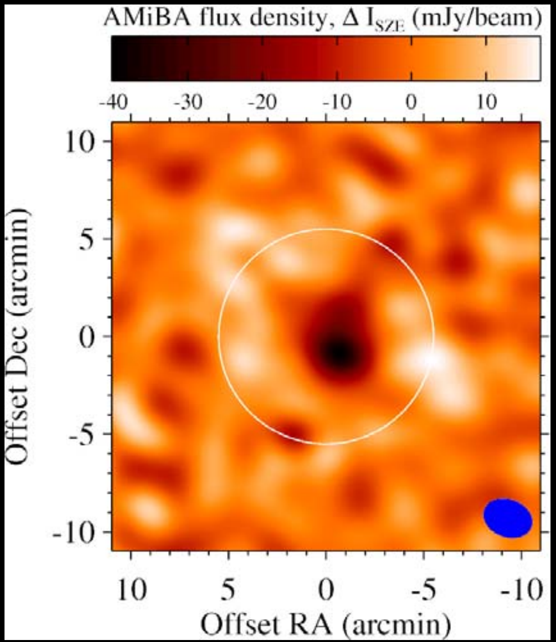
Brightest Cluster Galaxies

AMiBA 7 vs. 13 SZE Maps of A1689

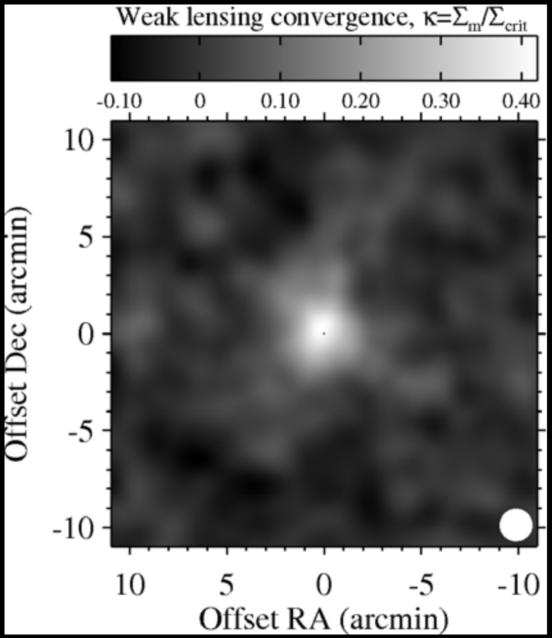
AMiBA-7 (60cm)



AMiBA-13 (1.2m)



Subaru WL



AMiBA-7: 7.1hr on-source integration (6s)

AMiBA-13: 3.4hr on-source integration (10σ)

Higher Resolution AMiBA map better tracks Weak Lensing Image

SuMIRe (HSC+PFS) WL Measurement of Cosmological Distance-Redshift Relationship

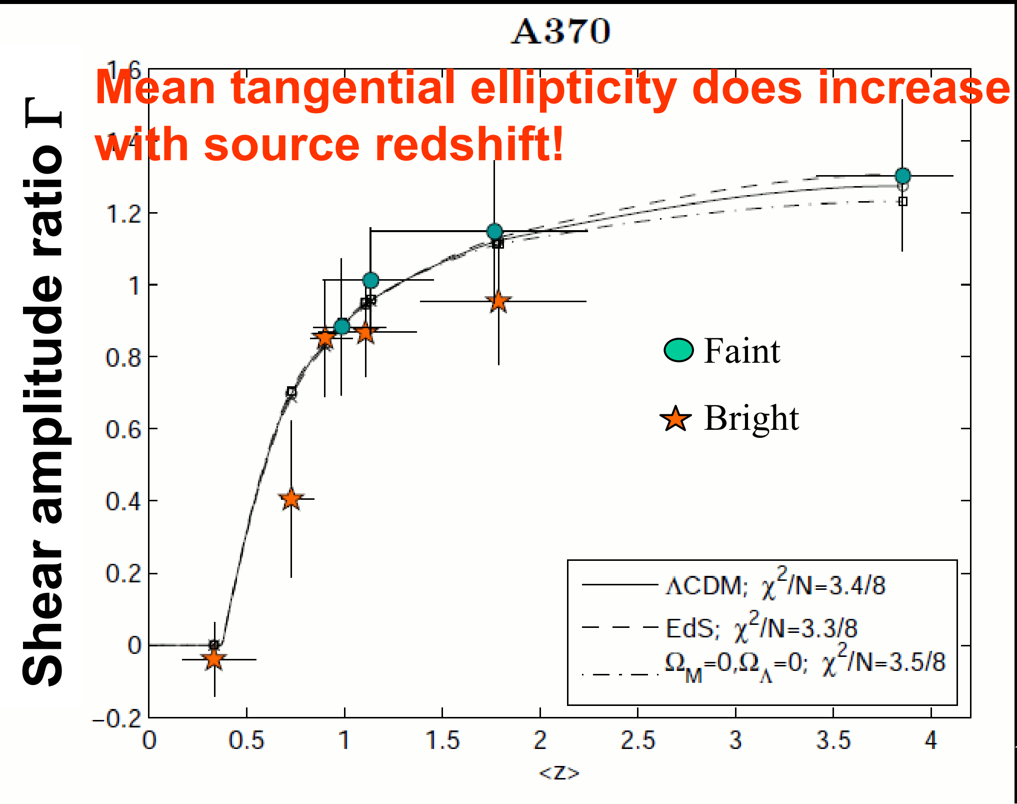
K. Umetsu

For a given lens, WL-induced ellipticity γ should increase with source redshift, providing a model-independent means of measuring cosmic geometry.

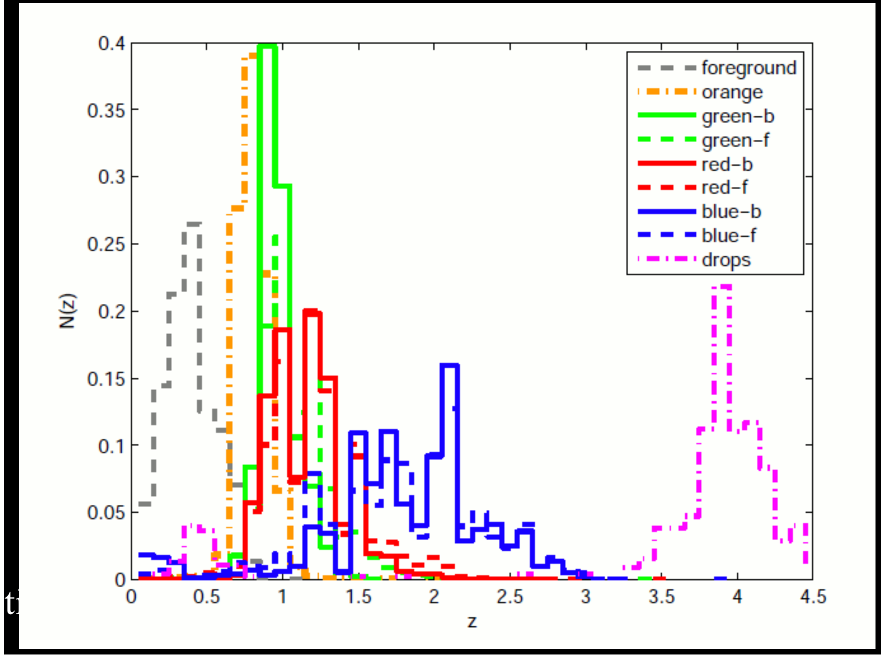
$$\gamma \propto \frac{D_{LS}(z_s)}{D_{OS}(z_s)} \propto \frac{r(\chi_S - \chi_L)}{r(\chi_S)}$$

$$\chi(z) = \int_{1/(1+z)}^{1} \frac{da}{a^2 H(a)}$$

First detection of this effect behind 3 clusters by Medezinski, Broadhurst, Umetsu et al. 2011 (MNRAS, in press, arXiv:1011.1955)



COSMOS photo-z distributions of BR_cz'-selected background samples



Dark Energy Constraint from the SuMIRe Deep Survey

K. Umetsu

Sensitivity for the DE equation-of-state parameter, w (Taylor+2007):

$$\frac{\Delta w}{w} = \frac{2}{\gamma_t} \left(\frac{d \ln \Gamma}{d \ln w} \right)^{-1} \frac{\sigma_e}{\sqrt{N_b}},$$

Using $\Gamma(w) \sim |w|^{-0.02}$ (Taylor+ 07) and summing over background galaxies behind 100 massive clusters with $M_{vir} = 5\times10^{14} M_{sun}/h$ (σ_e=0.4, $<z_{gal}>$=1.1, n_{gal}=30 galaxies arcmin^{-2}), we have:

$\Delta w \sim 0.6$ @w = -1 (cosmological constant)

Other geometric probes (SNIa and BAO): $\Delta w \sim 0.3$

Our shear-ratio statistic has a different parameter degeneracy from other probes, so that combining WL with other probes will improve the sensitivity to determine the DE EoS parameter.

W-H. Wang

High-z Galaxy Surveys

- Various high-z galaxies surveys are carried out in ASIAA:
  - deep near-IR surveys with CFHT in the GOODS-N and GOODS-S.
  - deep submillimeter surveys with SMA and soon ALMA.
- The primary goal is to find z > 7 galaxies and duty galaxies at z > 1.
- If PFS can have good red (~ 1 um) sensitivity, it can be used to follow up the high-z or dusty objects in our surveys. Our z > 7 candidates are found with ground-based near-IR imaging. Unlike candidates found by HST, they are relatively bright and spectroscopy is possible.

- Brightest Cluster Galaxies out to z ~ 1.5

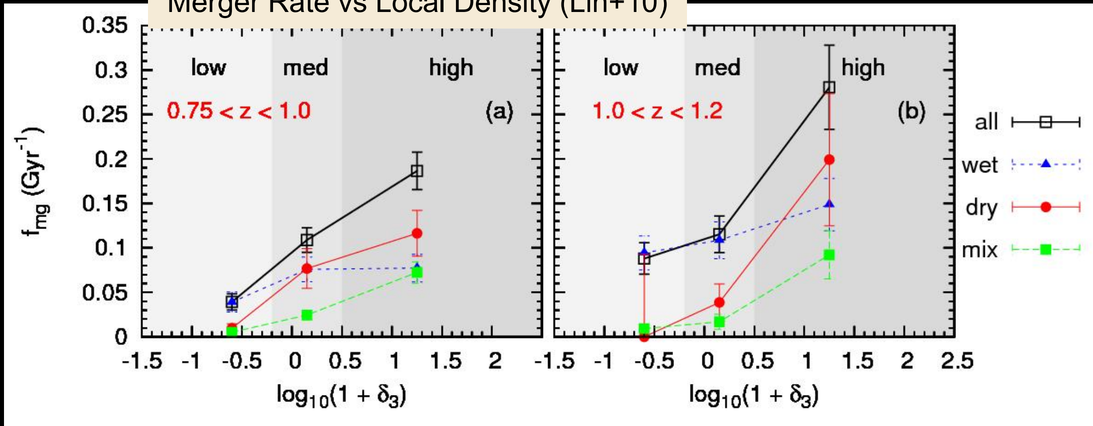
Y-T. Lin

L-W. Lin

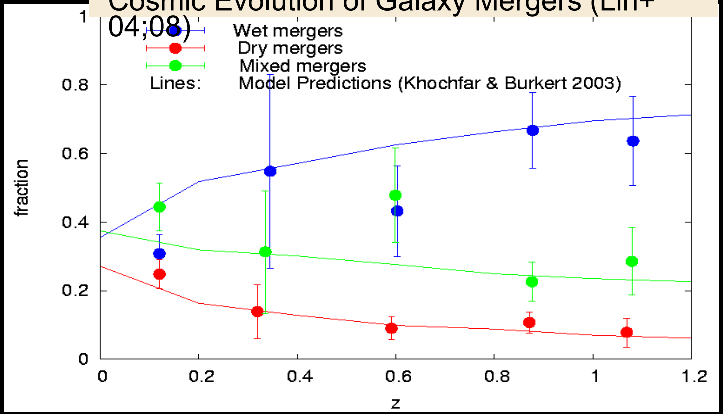
Galaxy Mergers

- What we already know about galaxy mergers?
  - Galaxy mergers rates steadily increase with redshift up to z~1
  - Gas-rich mergers are more prominent at higher redshifts
  - Gas-poor mergers are important to assemble massive early-type galaxies, in particular in over-dense environment.

Merger Rate vs Local Density (Lin+10)



Cosmic Evolution of Galaxy Mergers (Lin+ 04;08)



- What we don't know ?
  - What are the merger rates beyond z > 1?
  - What is the role of mergers in various physical environments, such as in field, groups, and clusters?
  - What are the connections between AGNs and mergers?
  - Are brightest cluster galaxies (BCGs) formed through mergers?

- What we will try to address via PFS ?
  - Evolution of galaxy mergers rates up to z~7
  - How much mergers contribute to the evolution of global star formation rates?
  - The interplay between galaxy mergers and AGN activities
  - The importance of wet/dry/mixed mergers in various environments

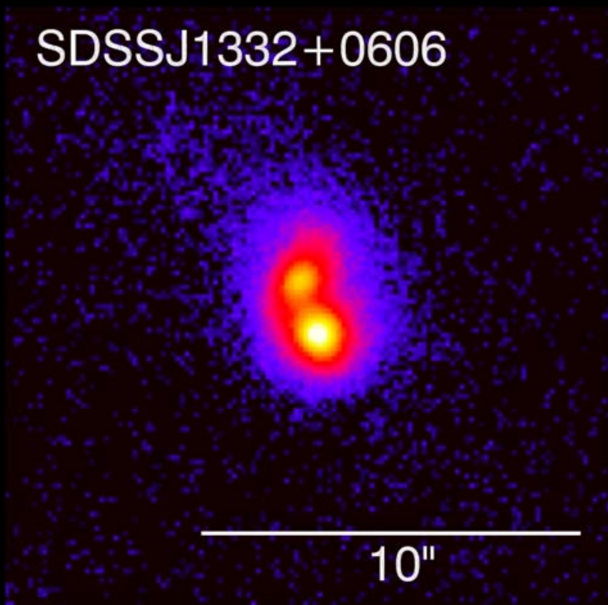
L-W. Lin

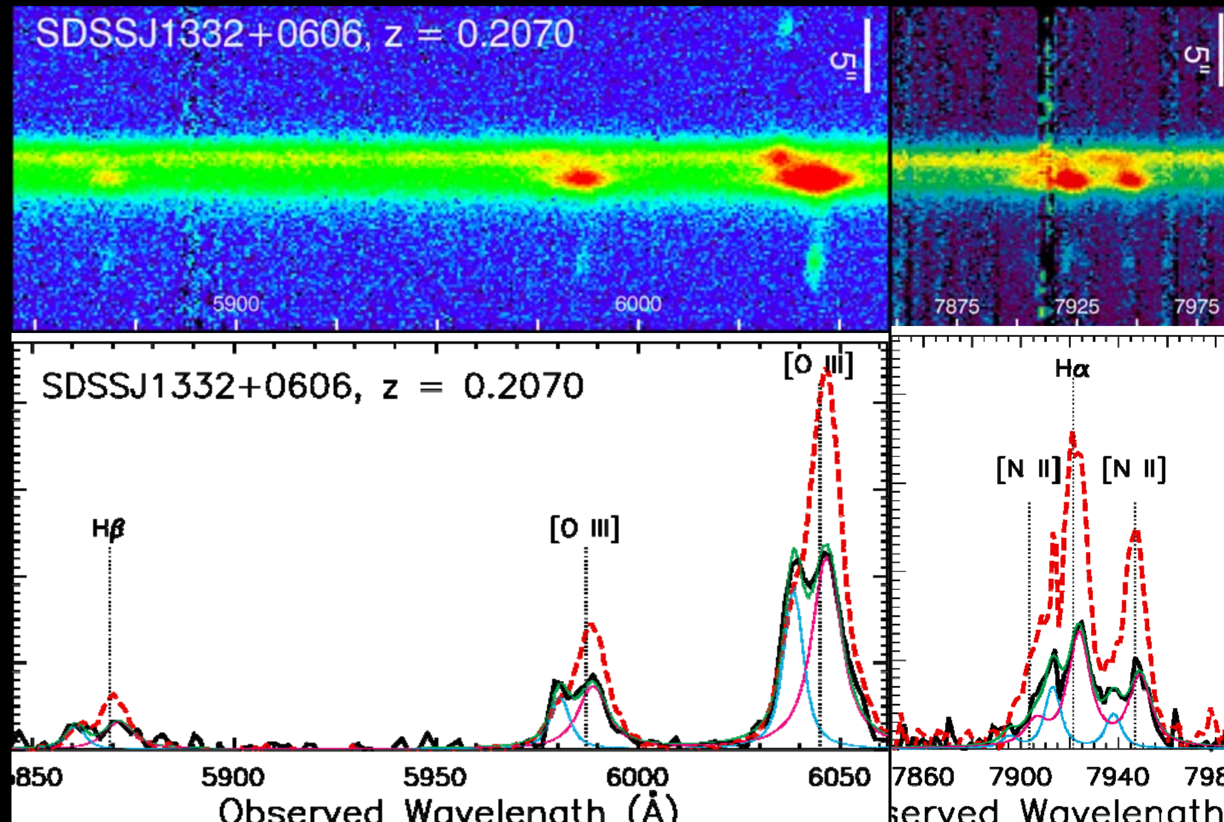
Approaches — Study Close Pairs

- Challenges for selecting close pairs
  - Close pairs/Mergers are rare objects (a few % at z <1) => require a large survey to detect them
  - Kinematic pairs are selected with Δv < 500km/s => corresponding to $\Delta z/(1+z)<0.00167$ (can never be achieved by photoz at high redshifts!!)
- Requirement for merger studies via PFS :
  - *Spectral resolution (R >2000):* to resolve the line-of-light velocity difference for selection of kinematic pairs
  - *High Sampling Rate (>50%):* to successfully detect close pairs and calibrate true pair fraction
  - *Wide coverage (> A few tens of square degrees):* to sample various environments (fields, groups, clusters)
  - *Wide spectral coverage (extending to NIR is preferred):* to measure redshifts and to obtain star formation rate and AGN diagnostics

Y-T. Lin

Census of Binary SMBH Mergers





- **Liu et al (10) identified galaxies with double [OIII] lines from SDSS; subsequent NIR and spectroscopic follow up strongly suggests binary SMBH mergers**
- **HSC+PFS would provide a huge sample to help better understand the SMBH merger process, constrain the merger rate, and triggering of AGN**

Taiwan Approach to HSC/PFS Project

- Separate Construction and Science

Construction: Gain Instrumentation Experience
Add to Resources
Science: Grow through Collaborative Research
Access Large Telescopes for
Transformational Science

- Preserve and Share EA Manpower, Resources