Unveiling the local and distant Universe with Subaru's Prime Focus Spectrograph (PFS)

Laerte Sodré Jr.
Departamento de Astronomia
Instituto de Astronomia, Geofísica e Ciências Atmosféricas
Universidade de São Paulo

FIRST LIGHT: STARS, GALAXIES AND BLACK HOLES IN THE EPOCH OF REIONIZATION
Escola São Paulo de Ciência Avançada
July 28 – August 7, 2019

Subaru Prime Focus Spectrograph (PFS)

- wide field (1.3 deg wide hexagonal FOV)
- massively multiplexed: ~2400 optical fibers
- 4 spectrographs, each with 3 arms: blue, red, NIR

- built by an international collaboration

- PI: Hitoshi Murayama (Kavli IPMU)

- start of the PFS survey: 2021
  (~300 – 360 nights during ~5 years)

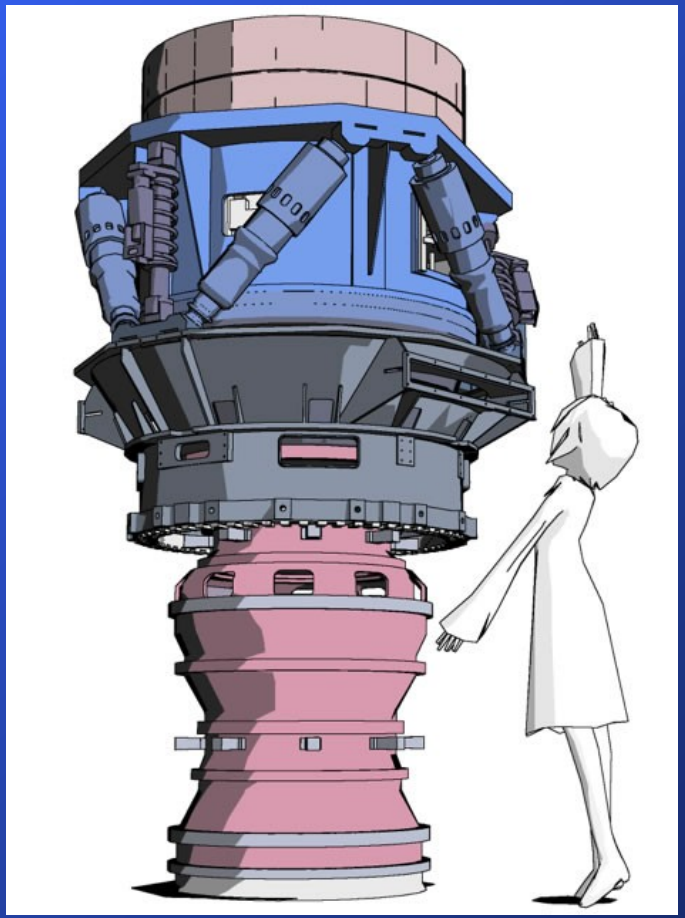
- goal: address questions on cosmology, galaxy and AGN evolution, and Galaxy archaeology to understand the dark sector of the universe

a bit of history

- 2001 – Gemini Science Committee recommends to launch discussions on new instruments
- 2002 – Sam Barden presents the concept of KAOS (Kilo-Aperture Optical pectrograph)
- 2003 – Gemini meeting @Aspen: concept of WFMOS (based on KAOS)
- 2004 – Hiroshi Karoji proposes WFMOS @ Subaru
- 2005 – Gemini commissions two competing conceptual designs for WFMOS
- 2008 – DeGaS concept (Dark Energy Galactic Archaeology Spectrograph) – PI: Richard Ellis
- 2009 – Gemini approves the DeGaS proposal
- 2009 – Gemini abandons the WFMOS proposal: $$!
- 2009 – Japan/Subaru assumes the project
- 2020/21: first light and beginning of the survey

SuMIRe
Subaru Measurement of Images and Redshifts

- Imaging and spectroscopy on the Subaru telescope



- imaging:
- HyperSuprimeCam (HSC)
- 0.9B pixels, 3 ton camera
- 1.5 degree diameter FOV
- HSC survey: 2014-2019
  Subaru Strategic Program (SSP)

- spectroscopy: PFS

PFS collaboration

Caltech

NASA Jet Propulsion Laboratory
California Institute of Technology

国立天文台 NAOJ

中央研究院 ACADEMIA SINICA

CPPC

PRINCETON UNIVERSITY

Max-Planck-Institut für Astrophysik

KAVLI IPMU INSTITUTE FOR THE PHYSICS AND MATHEMATICS OF THE UNIVERSE

MPE Max-Planck-Institut für extraterrestrische Physik

LNA LABORATÓRIO NACIONAL DE ASTROFÍSICA

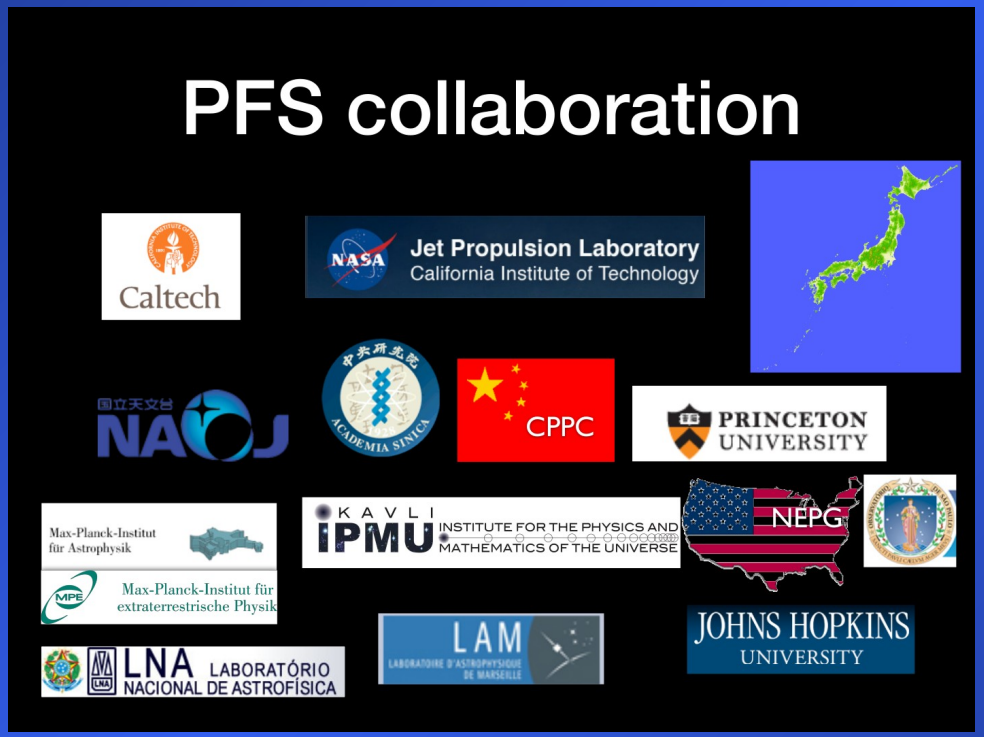
LAM LABORATOIRE D'ASTROPHYSIQUE DE MARSEILLE

JOHNS HOPKINS UNIVERSITY

PFS/SuMIRe

Prime Focus Spectrograph for the Subaru Measurement of Images and Redshifts survey

- **PI: Hitoshi Murayama Kavli IPMU (U. Tokyo)**
- **Brazil (USP+LNA): optical fiber subsystem**

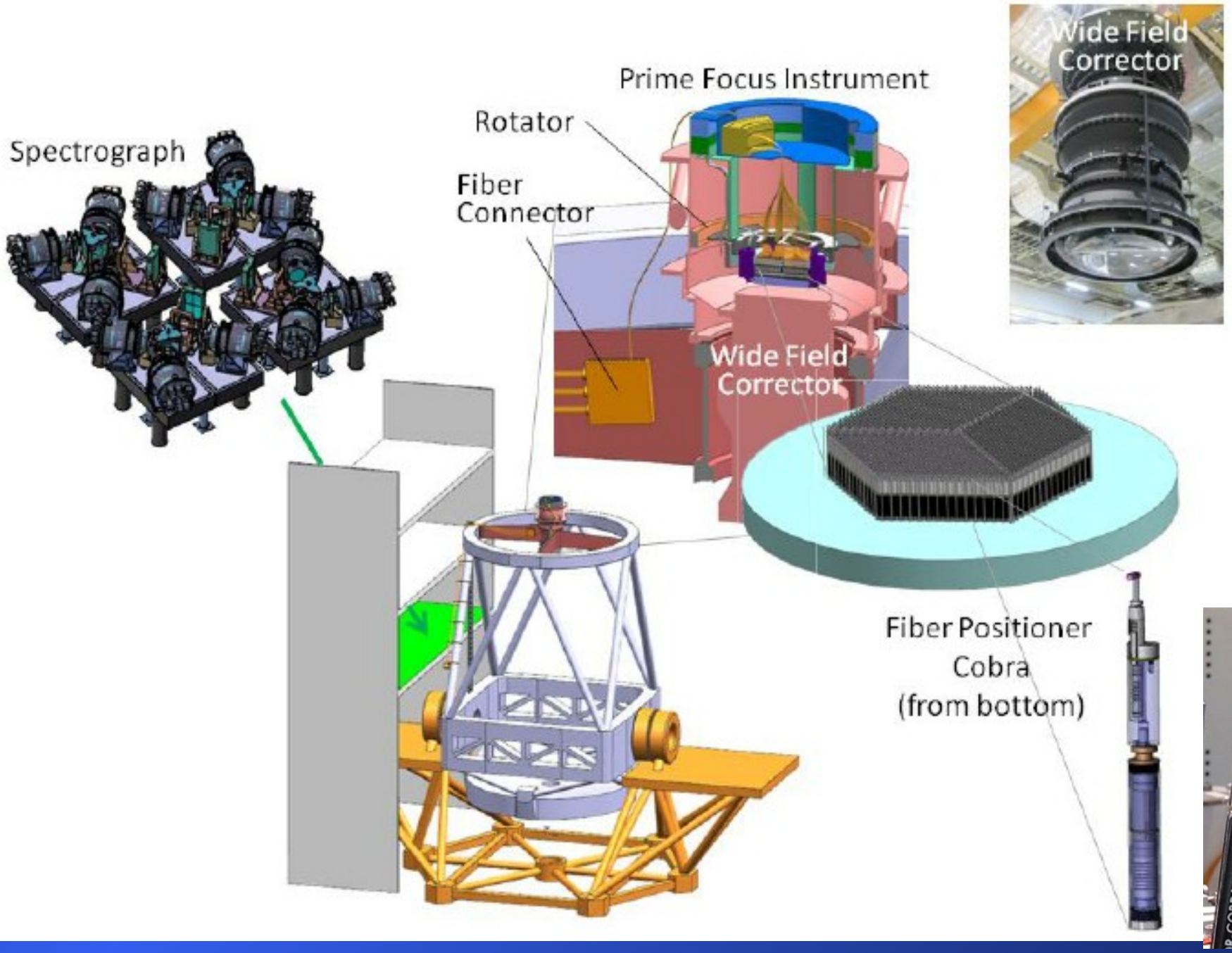


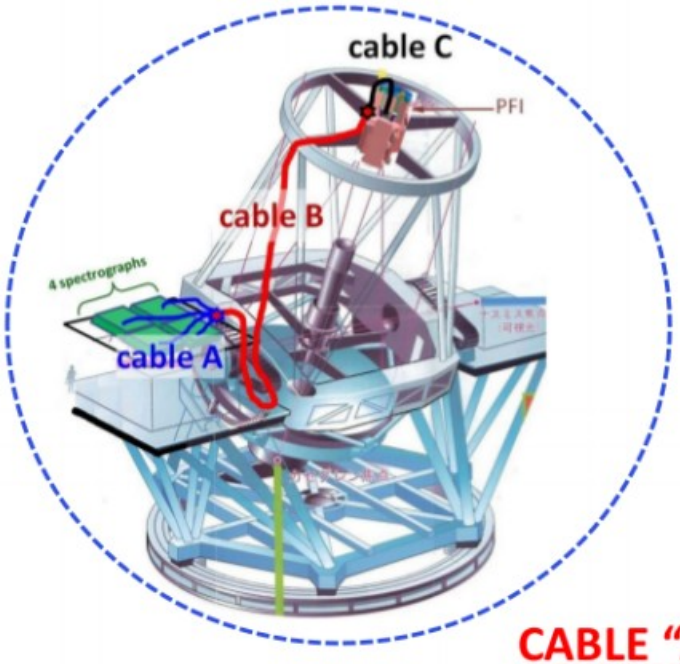
Laboratório Nacional de Astrofísica

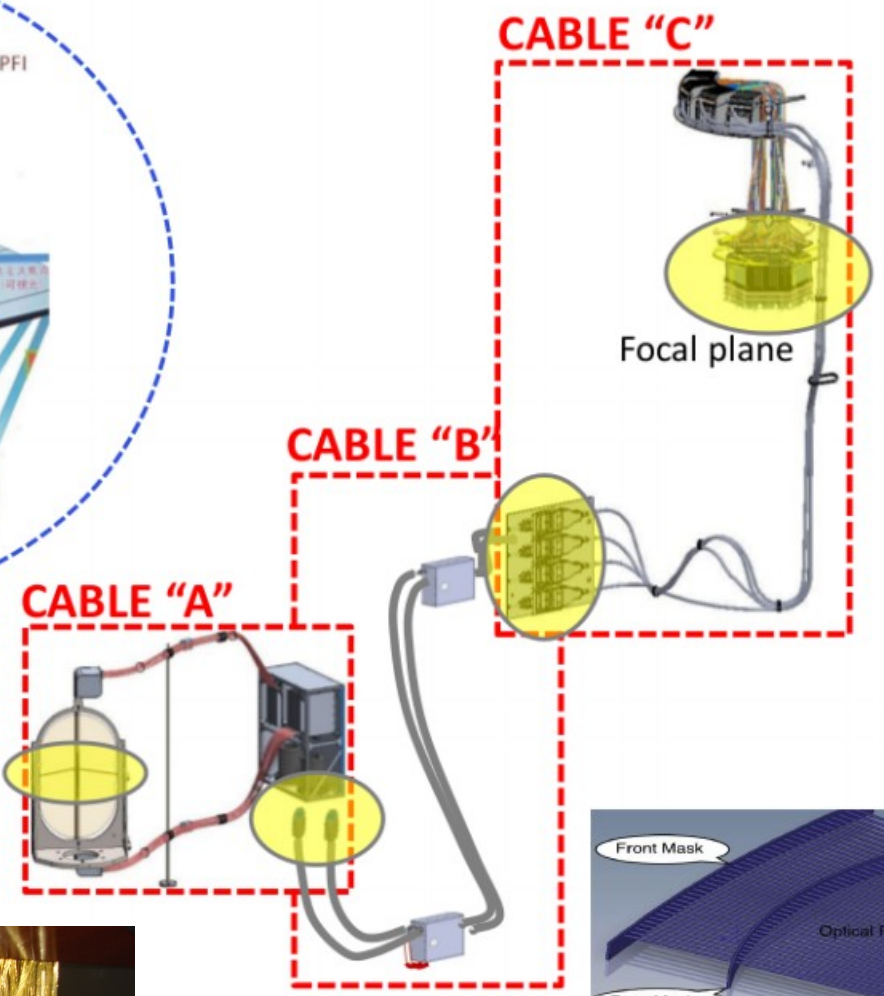
PFS Fast Facts

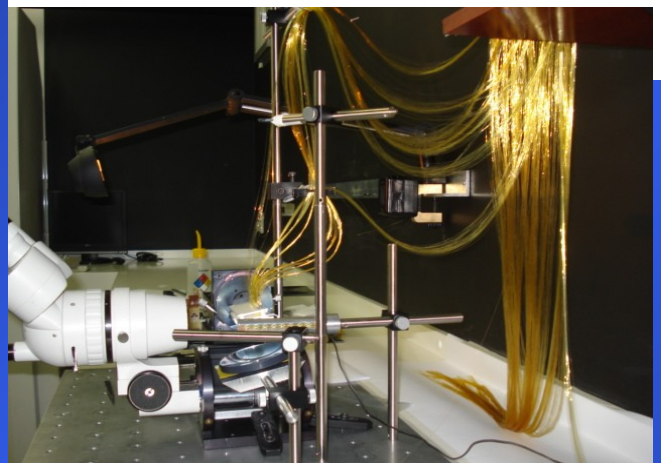
- Subaru Prime Focus Spectrograph: spectroscopic part of the SuMIRe project
- wide field: ~1.3 deg diameter
- high multiplicity: 2394 fibers
- fiber diameter: ~1.05 arcsec
- minimum fiber separation ~30 arcsec
- quick fiber reconfiguration: ~60 – 120 sec (TBC)
- VIS-NIR coverage: 380-1260nm simultaneously
- low resolution mode: ~2.5 A resolution
- medium resolution mode (around 800nm): ~1.6 A resolution
- science operations: from 2021

by Naoyuki Tamura

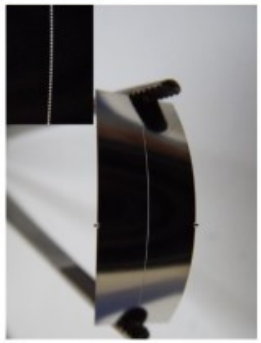

Prime Focus Instrument
Rotator
Fiber
Connector
Spectrograph
Wide Field
Corrector
Wide Field
Corrector
Fiber Positioner
Cobra
(from bottom)


cable C
PFI
cable B
4 spectrographs
cable A


CABLE "C"
Focal plane
CABLE "B"
CABLE "A"
Slit



Front Mask
Optical Fibers
Rear Mask



landscape of fiber-fed spectrographs in large (D > 6m) telescopes

- **Gran Telescope de Canarias (10.4m) – MEGARA – IFU & MOS capabilities MOS with ~100 fibers in a 3.5 x 3.5 arcmin^2**

- **Hobby Eberly Telescope – VIRUS spectrograph 150 IFUs, each with 230 optical fibers**

- **VLT@ESO - FLAMES/GIRAFFE – 130 fibers, FOV = 25 arcmin diameter**

thanks to Alessandro Ederoclite

The competition

Facility	Telescope Diameter (m)	Surface Area (m^2)	Field of view (deg^2)	Multiplex Number
MAYALL DESI	3.8	9.6	8	5,000
SUBARU PFS	8.0	48.75	1.33	2,400
VLT MOONS	8.0	48.75	0.136	1,000
MSE	11.2	96.0	1.5	4,000
SpecTel	**11.4**	**87.89**	**4.91**	**15,000**

arXiv:1907.06795

The science (Takada et al. 2014)

- **Local cosmology through galaxy archaeology:**
- **Milky Way & Andromeda history through the observation of ~10^6 stars**
- **Chemo-dynamical evolution and dark matter in Local Group dwarf galaxies**

- **Galaxy evolution:**
- **Galaxy populations and structures @ 1<z<2**
- **“Lyman break” & “Lyman alpha” galaxies @ 3<z<7: glimpses on reionization**
- **IGM tomography**

- **Cosmology:**
- **Baryon Acoustic Oscillations (BAO) @ 0.8 < z < 2.4 (9.3 h^{-3} Gpc^3)**
- **Cosmological distances with accuracy of 3%; structure growth with 6%**
- **Neutrino hierarchy**

opportunities

- PFS will be a major player in the study of the high-z universe during the next decade

- Consider joining an institution member of PFS for your postdoc!

Pelé kicking a spheroidal galaxy
In the high-z universe

M. Takada et al., 2014, PASJ, 66, 1 (arXiv:1206.0737)
N. Tamura et al., 2018, SPIE 10702E

http://sumire.ipmu.jp/en/2652
https://www.youtube.com/watch?v=5mW3v2k8Ofo