すばる次世代広視野補償光学システム: 分光シミュレーションと狭帯域撮像

岩田生、美濃和陽典 (国立天文台 ハワイ観測所)、すばる次世代AOワーキンググループ

「有本さんを説得できるサイエンス」

Spectroscopy Simulation

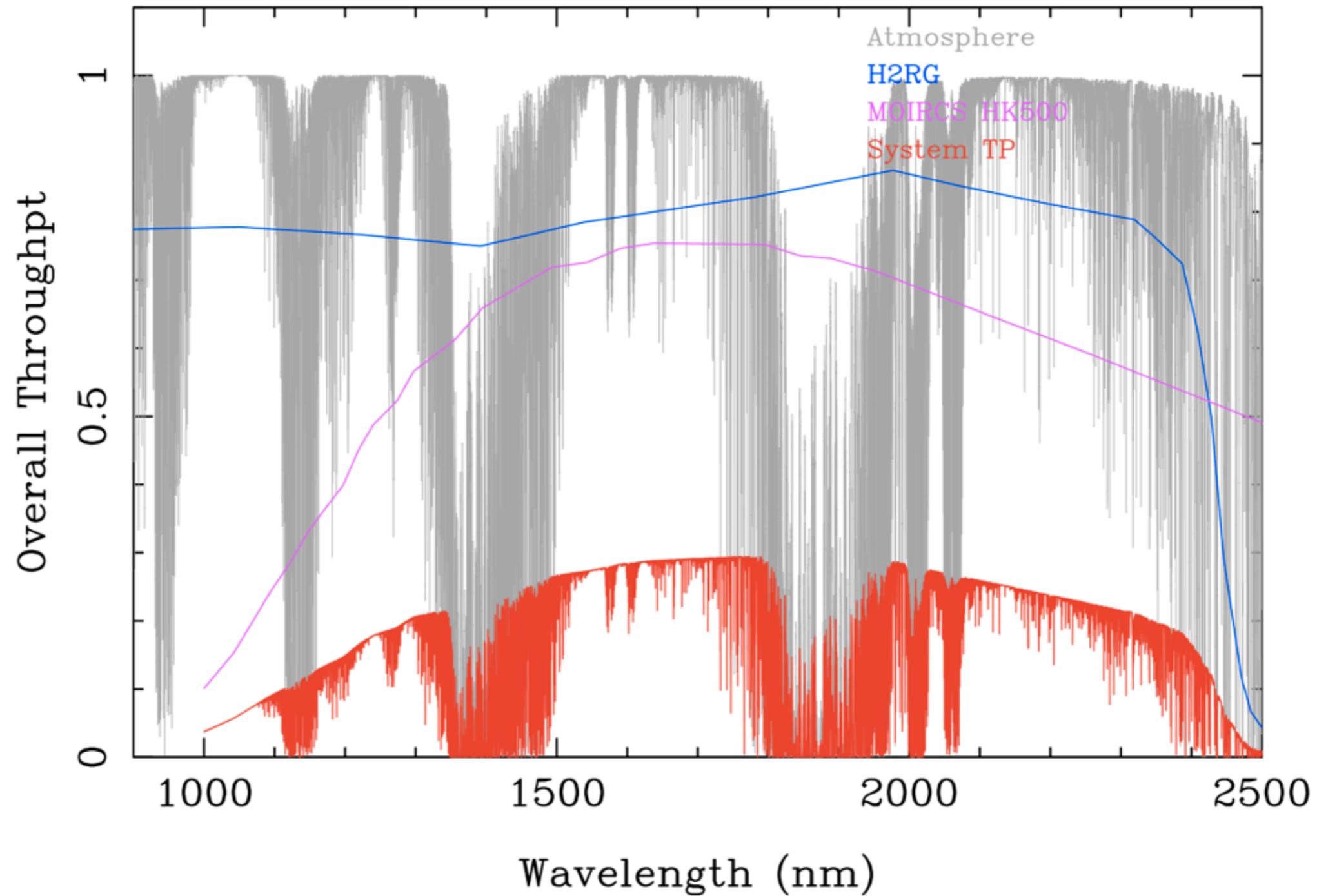- ## Spectrograph:

  - 7.5AA Dispersion (R~2500 at 2.2μm), 3.75AA Dispersion

  - Spatial Sampling: 0.06" or 0.12"

  - Coverage: 1.3 - 2.5 μm

  - Dark: 0.1e-/sec

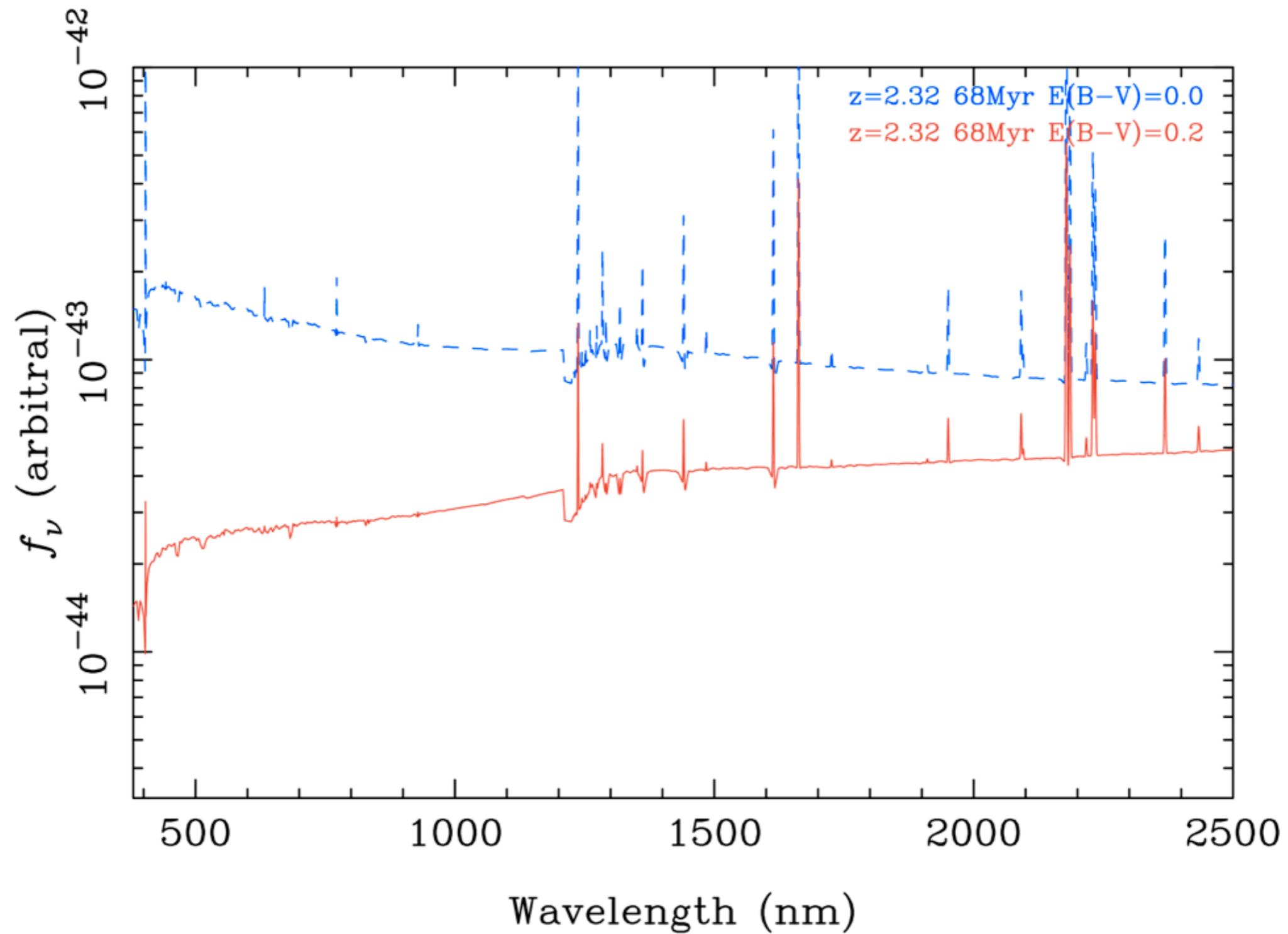 - Read-noise: 10e-/pix

- ## Throughput:

  - 5 optical components for spectrograph, each 90%

  - Primary and secondary mirrors, each 90%

  - Disperser: MOIRCS HK500 Grism

  - H2RG QE from Teledyne

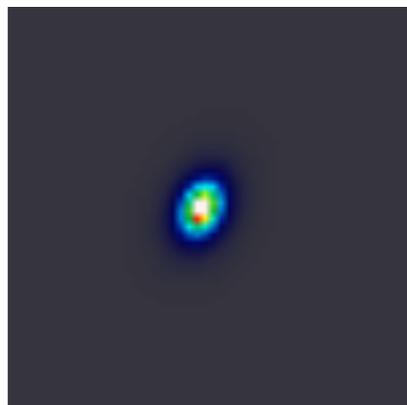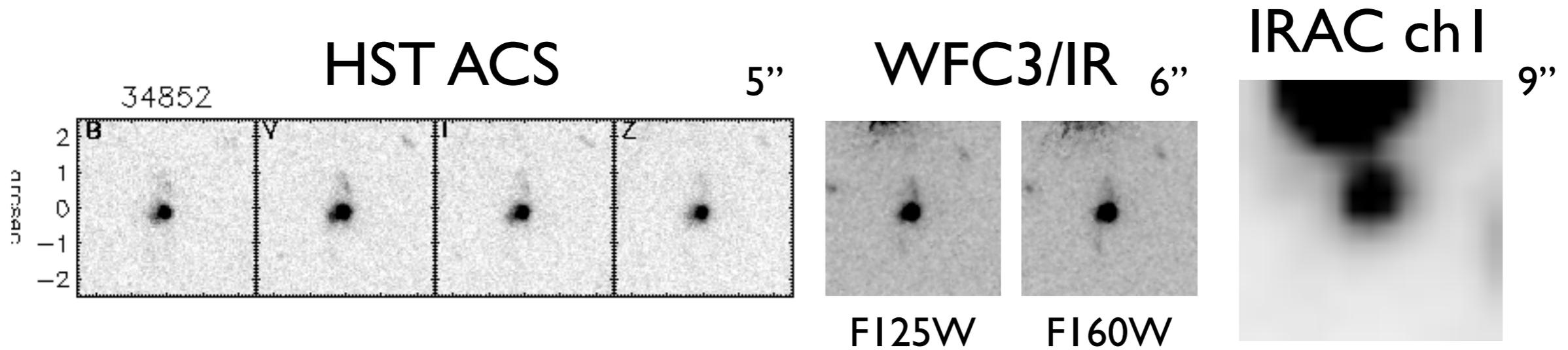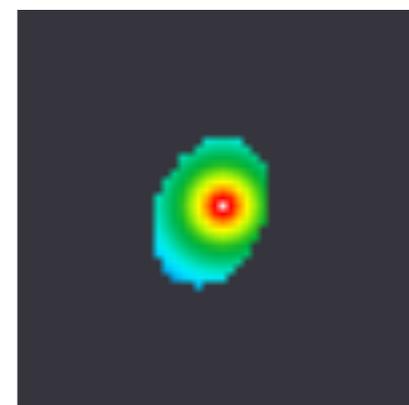# Assumed Throughput, Including Atmosphere

Input SED

z=2.32 68Myr E(B-V)=0.0
z=2.32 68Myr E(B-V)=0.2

sBzK (1) K(AB)=21.86

HST ACS
5"

34852

WFC3/IR
6"

F125W   F160W

IRAC ch1
9"

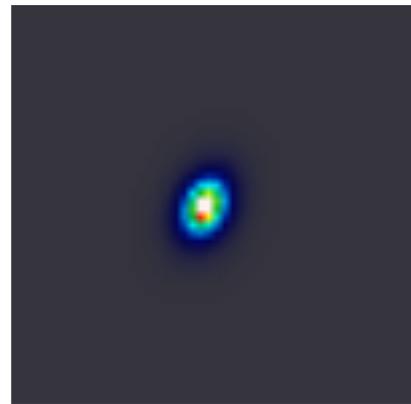model by GALFIT (F160W)
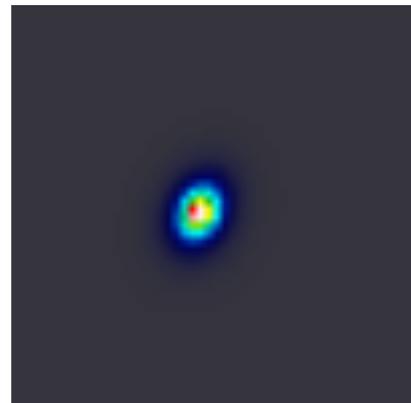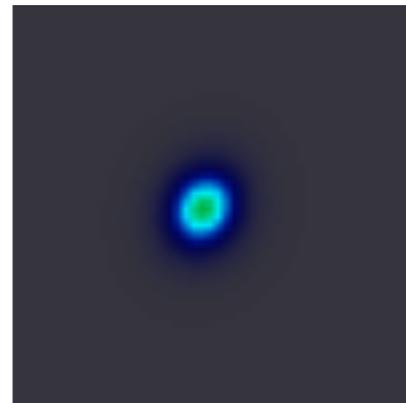Re=1.4 kpc

Vel. Dispersion
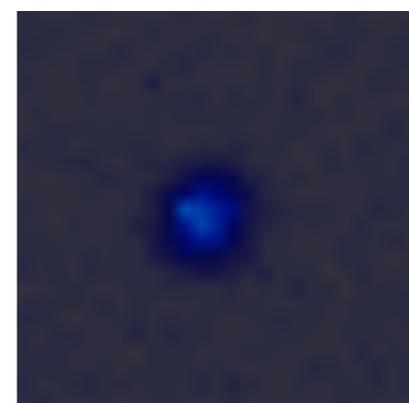Peak 100 km/s

Rotation
-200 to 200 km/s

sBzK (1) K(AB)=21.86
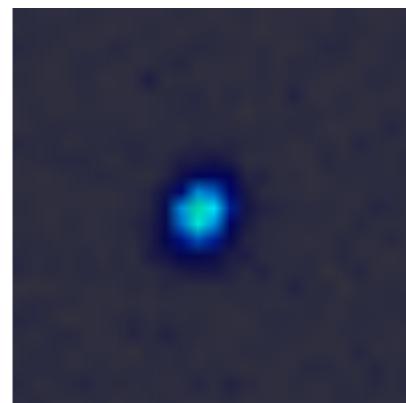

Model
Flux

Input
Diffraction Limited
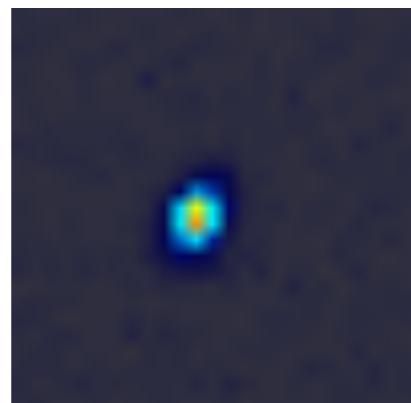GLAO
Seeing
Condition="moderate"
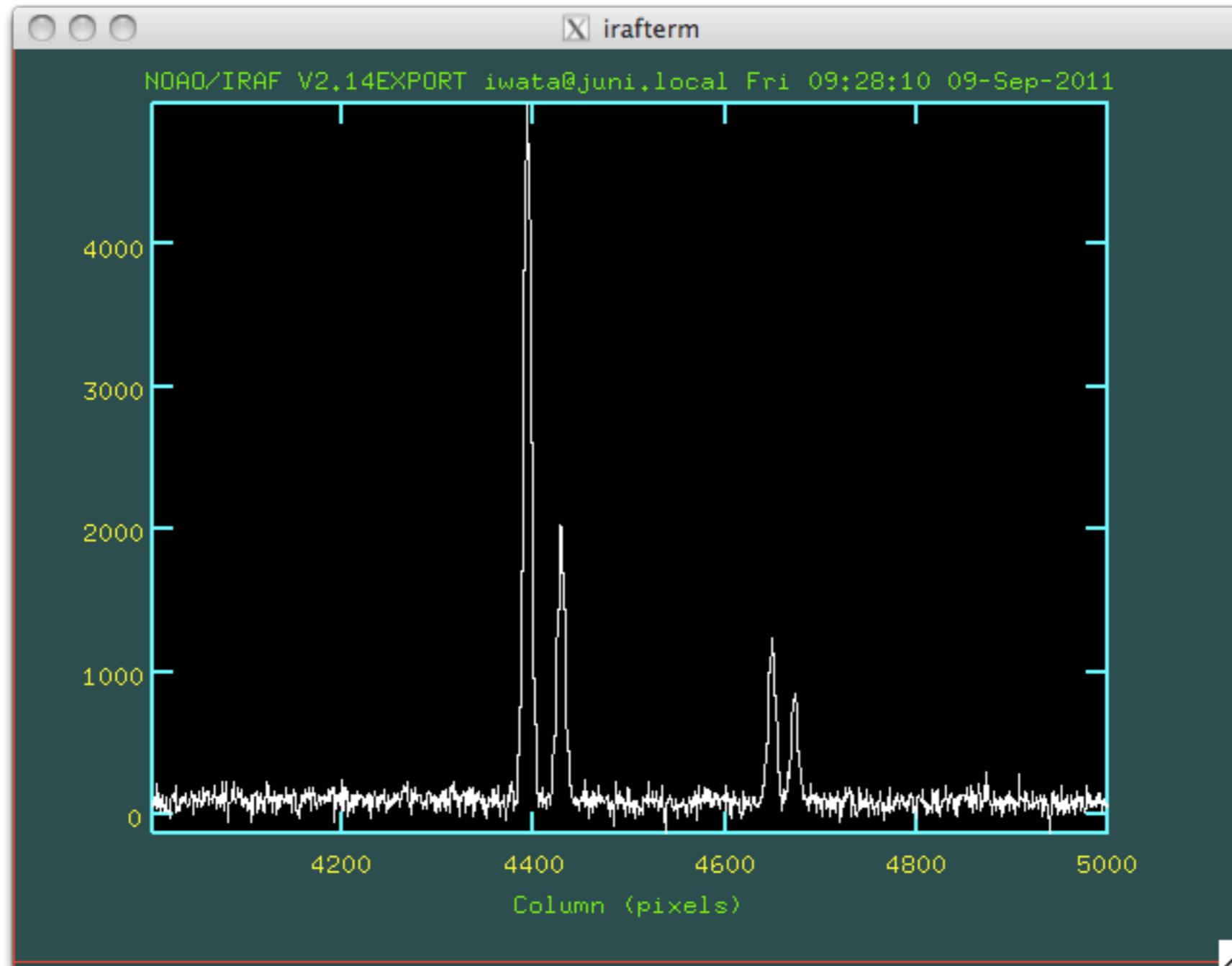
Output S/N
1200s x 9
0.12" Sampling

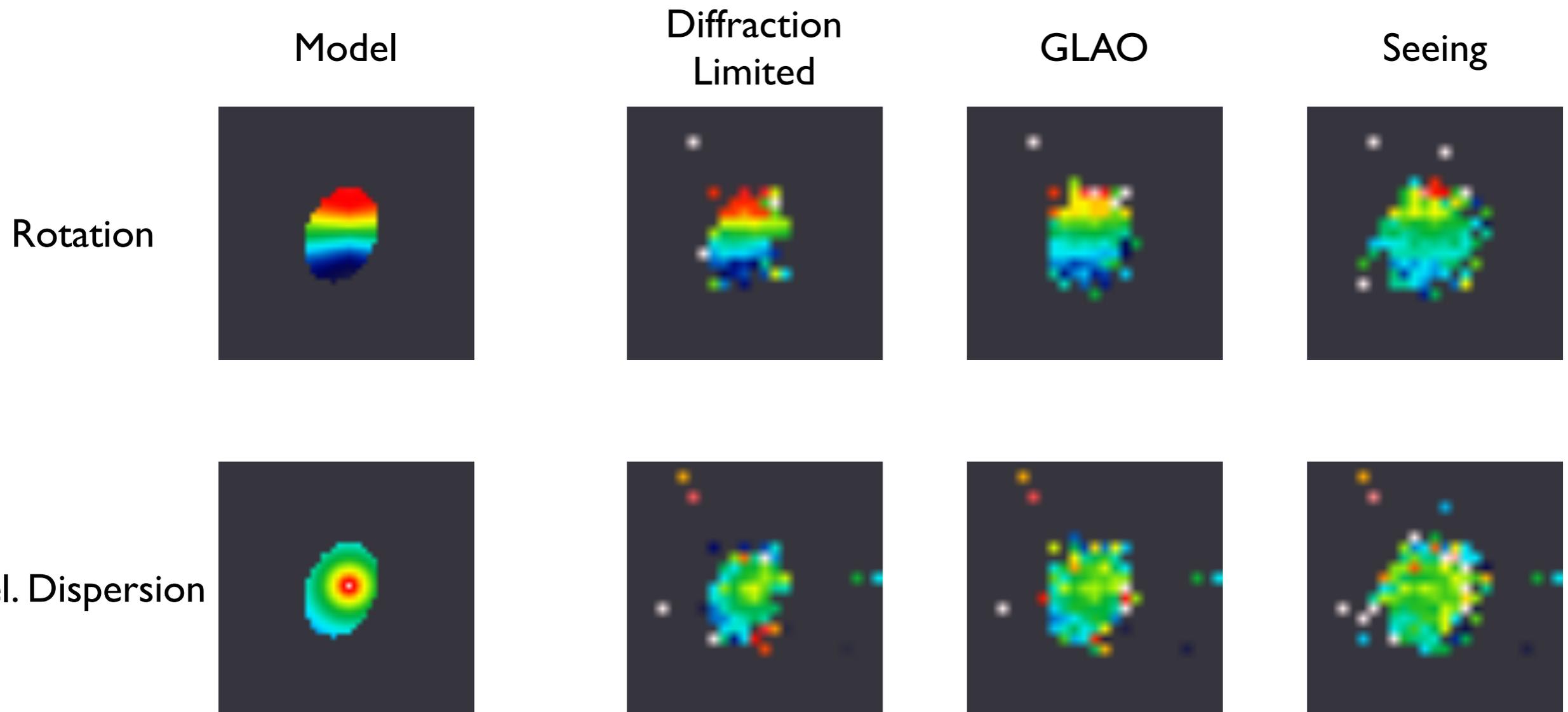0   150

Output Spectra 1200s x 9 Center 0.12"x0.12"

sBzK (1) K(AB)=21.86: Hα Kinemetry

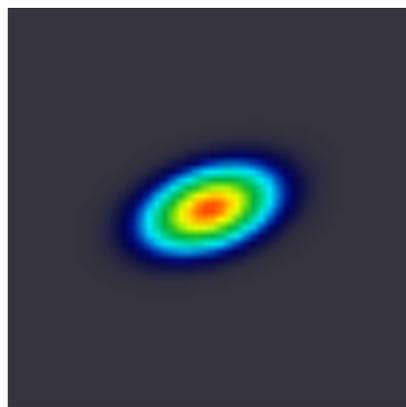|	Model	Diffraction Limited	GLAO	Seeing
Rotation				
Vel. Dispersion				

sBzK (1) K(AB)=21.86: Rotation Curve

34852 (K=21.86AB)

sBzK (2) K(AB)=22.75

HST ACS · 5"

WFC3/IR · 6"

IRAC ch1 · 9"

F125W · F160W
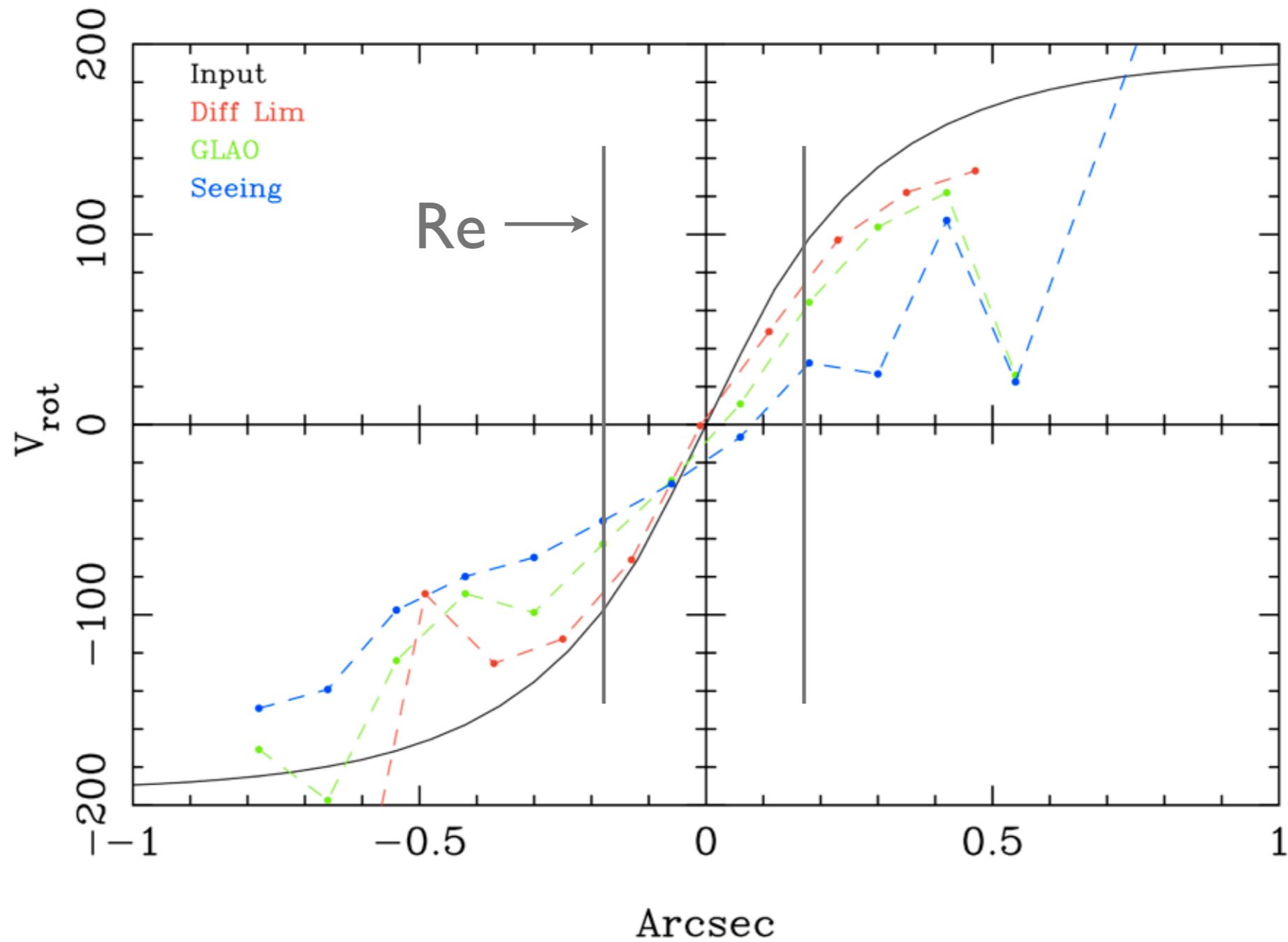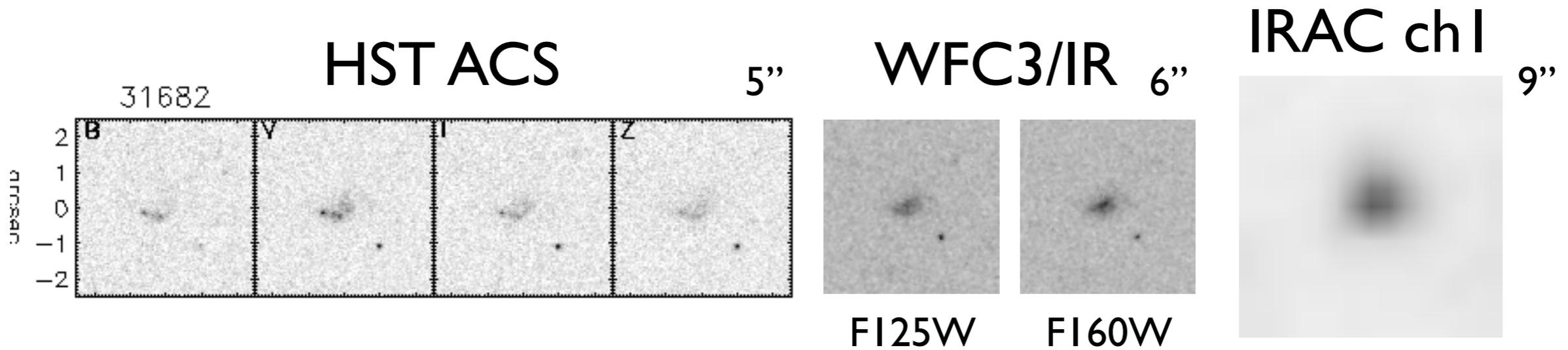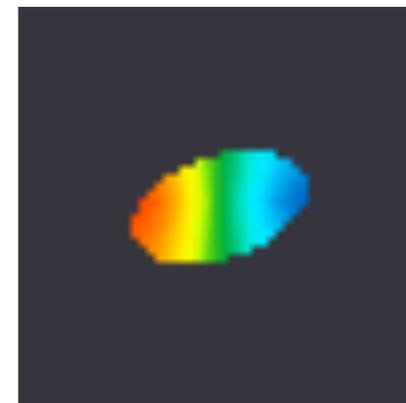
model by GALFIT (F160W)
Re=3.0 Kpc
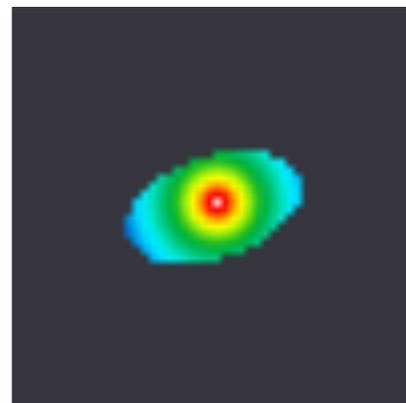
Vel. Dispersion
Peak 100 km/s

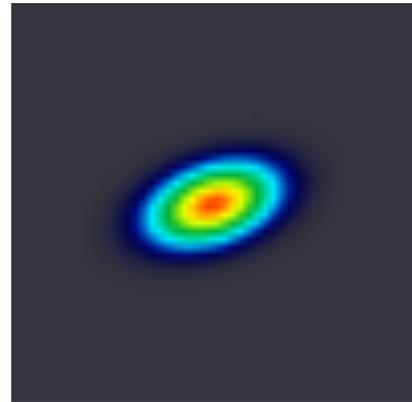Rotation
-132 to 132 km/s

sBzK (2) K(AB)=22.75

Model — Flux

Input — Diffraction Limited / GLAO / Seeing
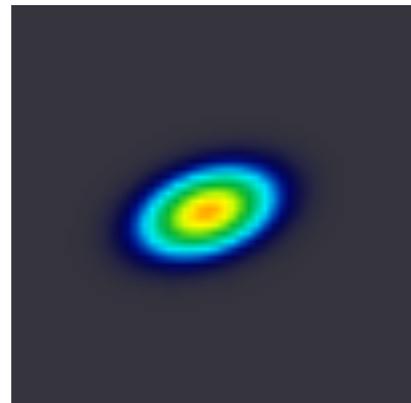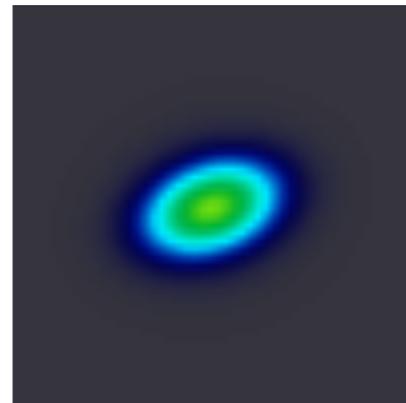
Condition="moderate"

Output S/N
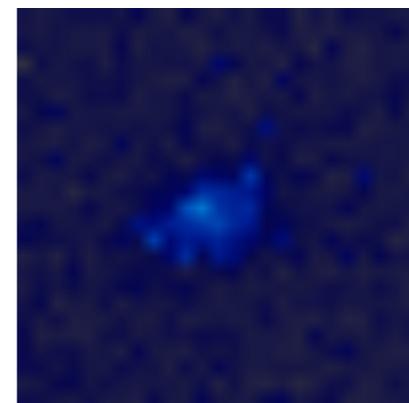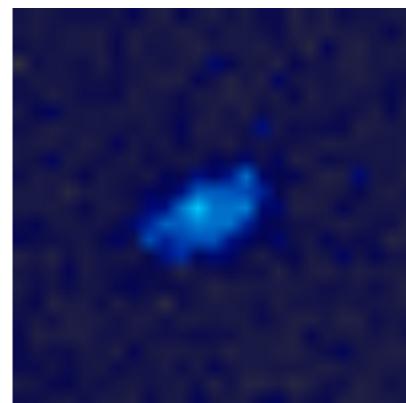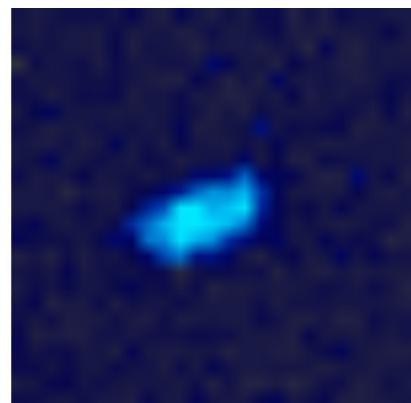
1200s x 9
0.12" Sampling

0   50

sBzK (2) K(AB)=22.75: Hα Kinemetry
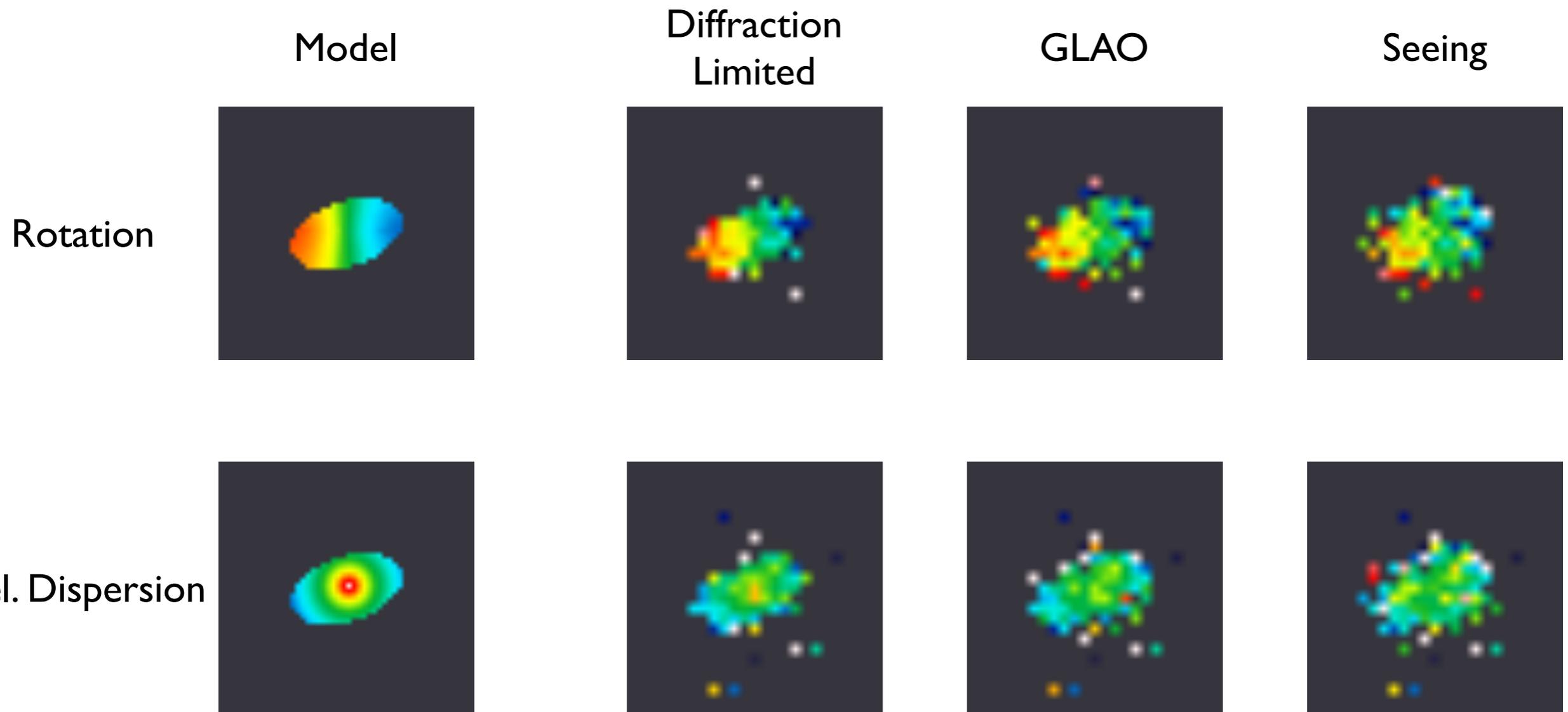
sBzK (2) K(AB)=22.75: Rotation Curve

31682 (K=22.75AB)
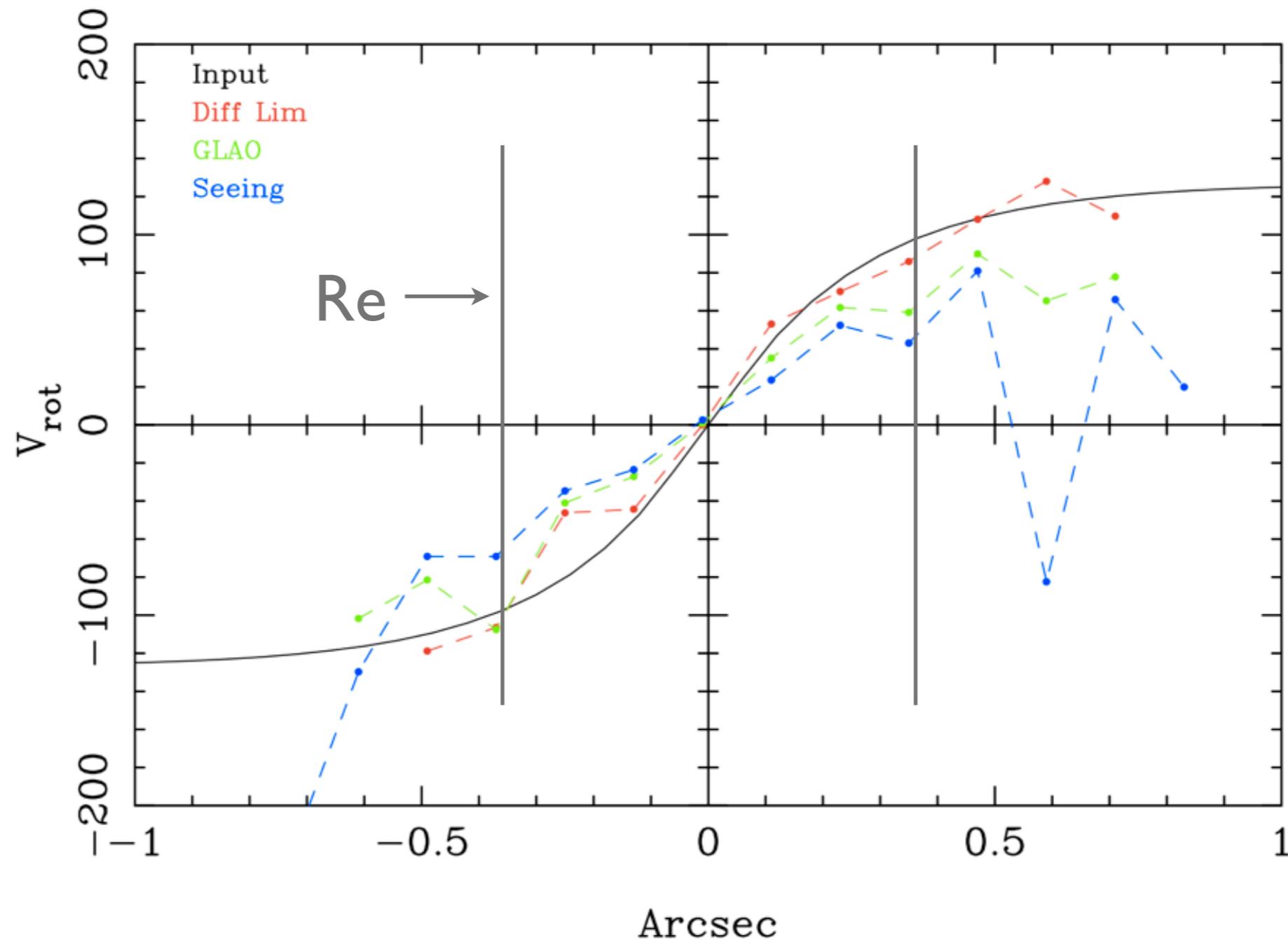
Finding AGN Component at the Center

- Flux Distribution: z=2.3 sBzK

- Input AGN Spectrum at the Central Pixel (0.06")

- Other Parts: Spectrum of Star-Forming Region

- Observe with 0.12"/pixel Sampling IFS

BPT Diagram

pBzK: K(AB)=22.75 z_{phot}=1.51

HST ACS   5"

28381

WFC3/IR   6"

F125W   F160W

IRAC ch1   9"

model by GALFIT (F160W)
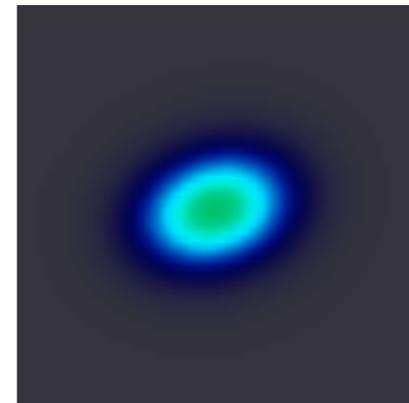Re=0.7 Kpc

z=1.51 SSP 1Gyr
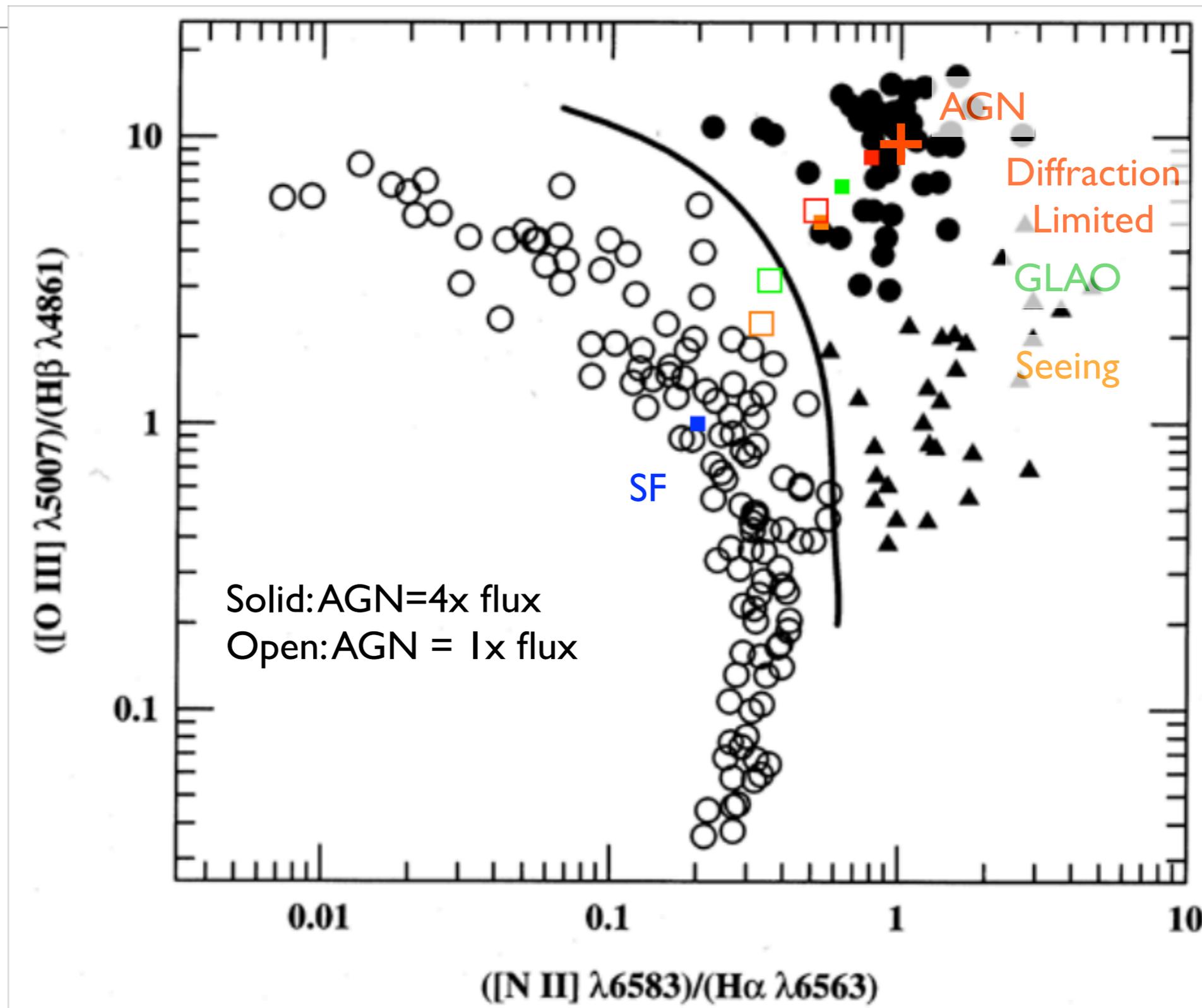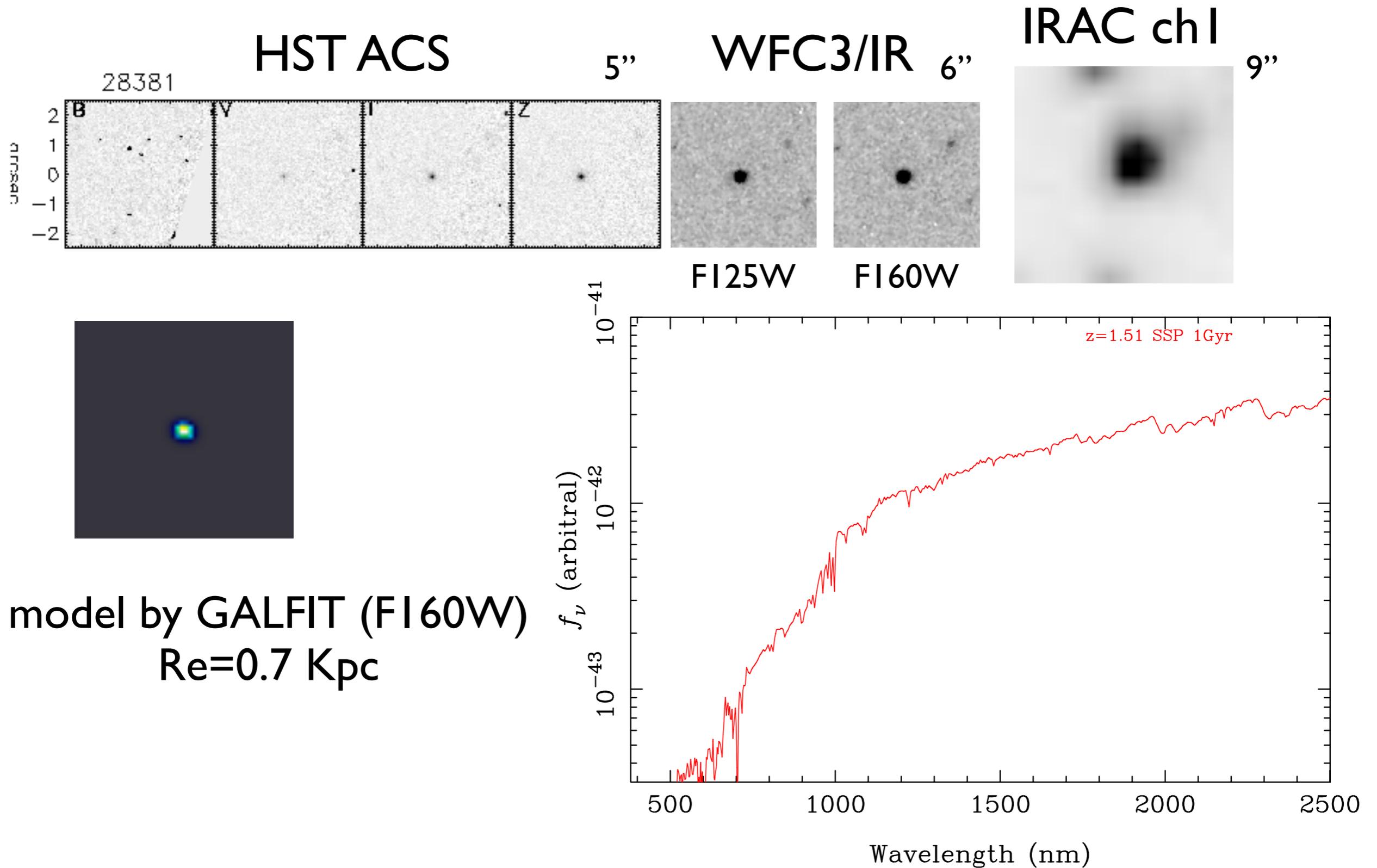
pBzK: K(AB)=22.75 z_{phot}=1.51
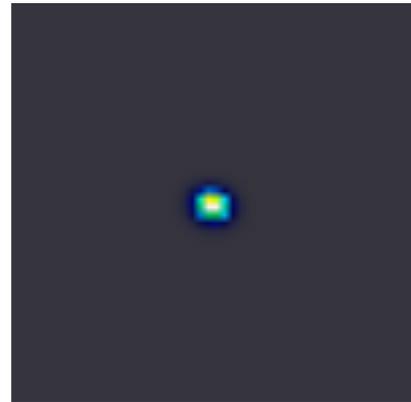
Model

Flux

3" x 3"

Input
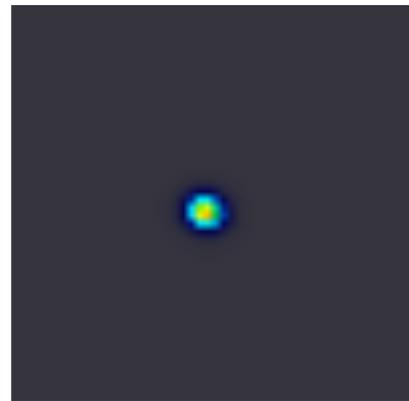
Diffraction Limited

GLAO

Seeing

Condition="moderate"

pBzK: K(AB)=22.75 z_{phot}=1.51

1,200 sec x 9, R~3,500, 0.4" Slit

Diffraction Limited
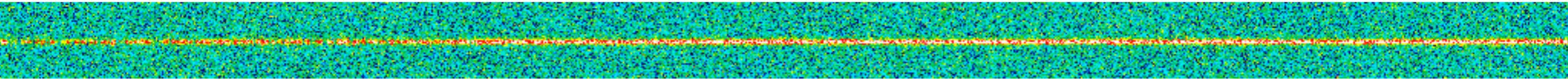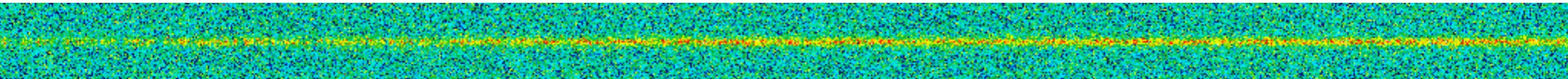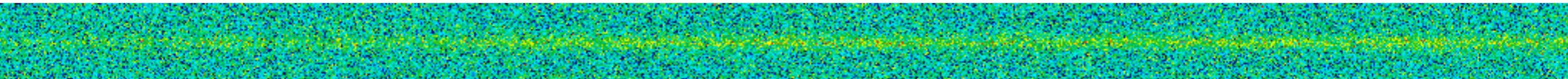
GLAO

Seeing

pBzK: K(AB)=22.75 z_{phot}=1.51

1,200 sec x 9, R~3,500, 0.4" Slit

pBzK: K(AB)=21.08 z_{phot}=1.61

HST ACS 5"

45538

WFC3/IR 6"

F125W   F160W

IRAC ch1 9"
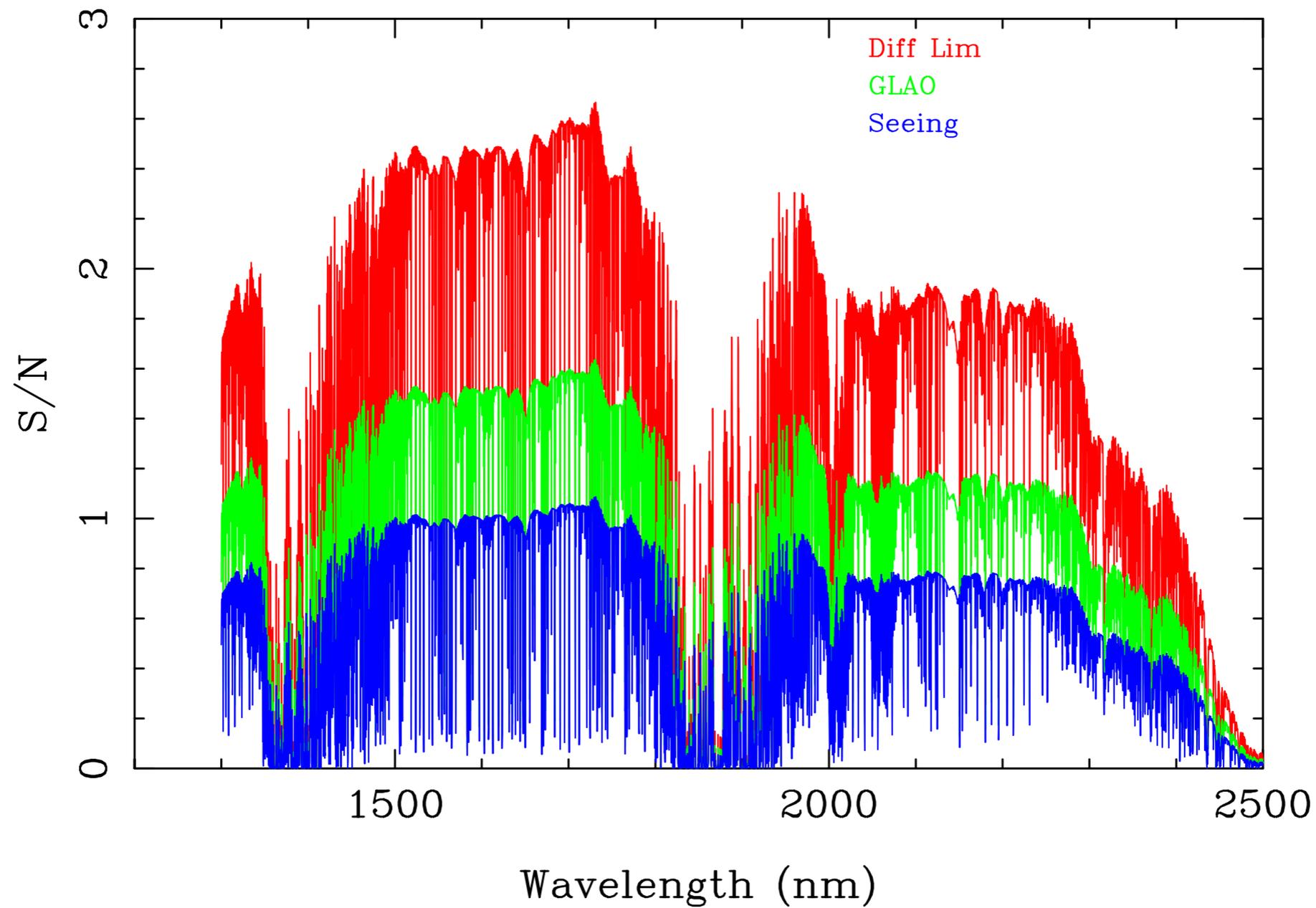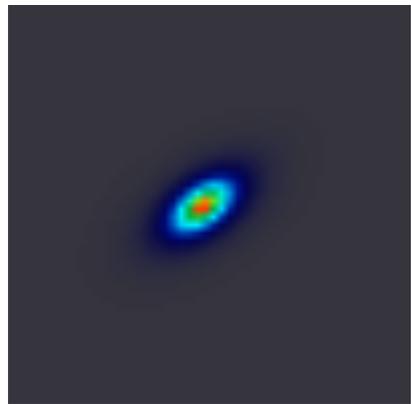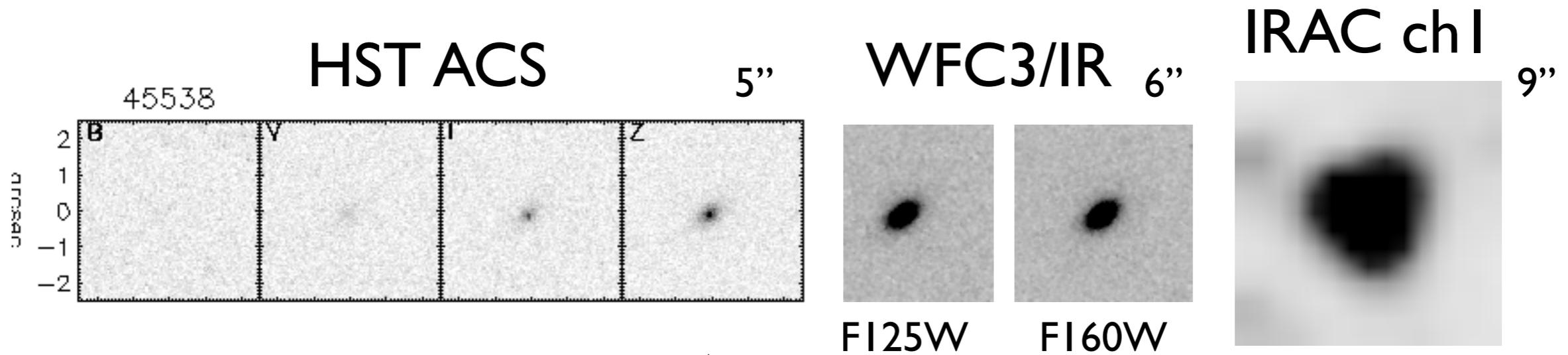
model by GALFIT (F160W)
Re=2.5 Kpc

z=1.51 SSP 1Gyr
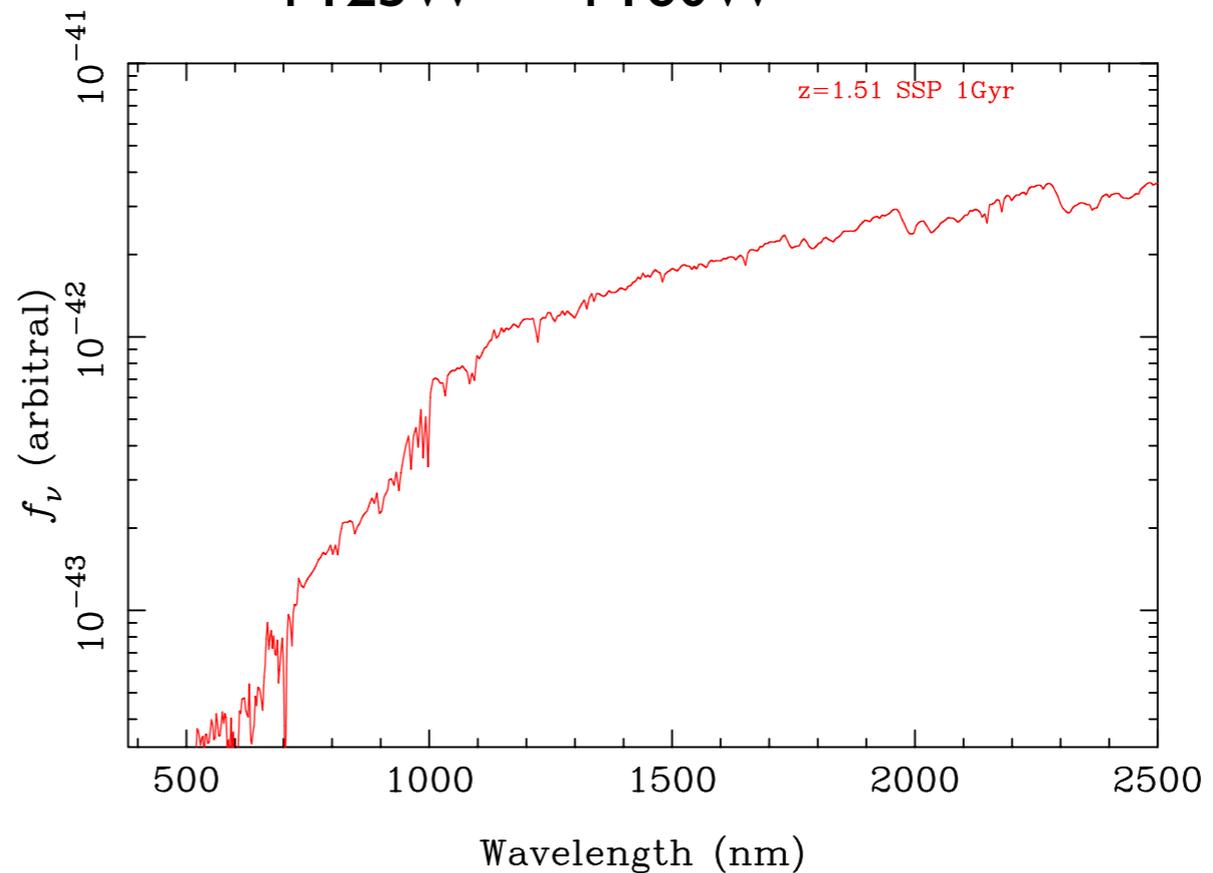
pBzK: K(AB)=21.08 z_{spec}=1.61

1,200 sec x 9, R~3,500, 0.4" Slit
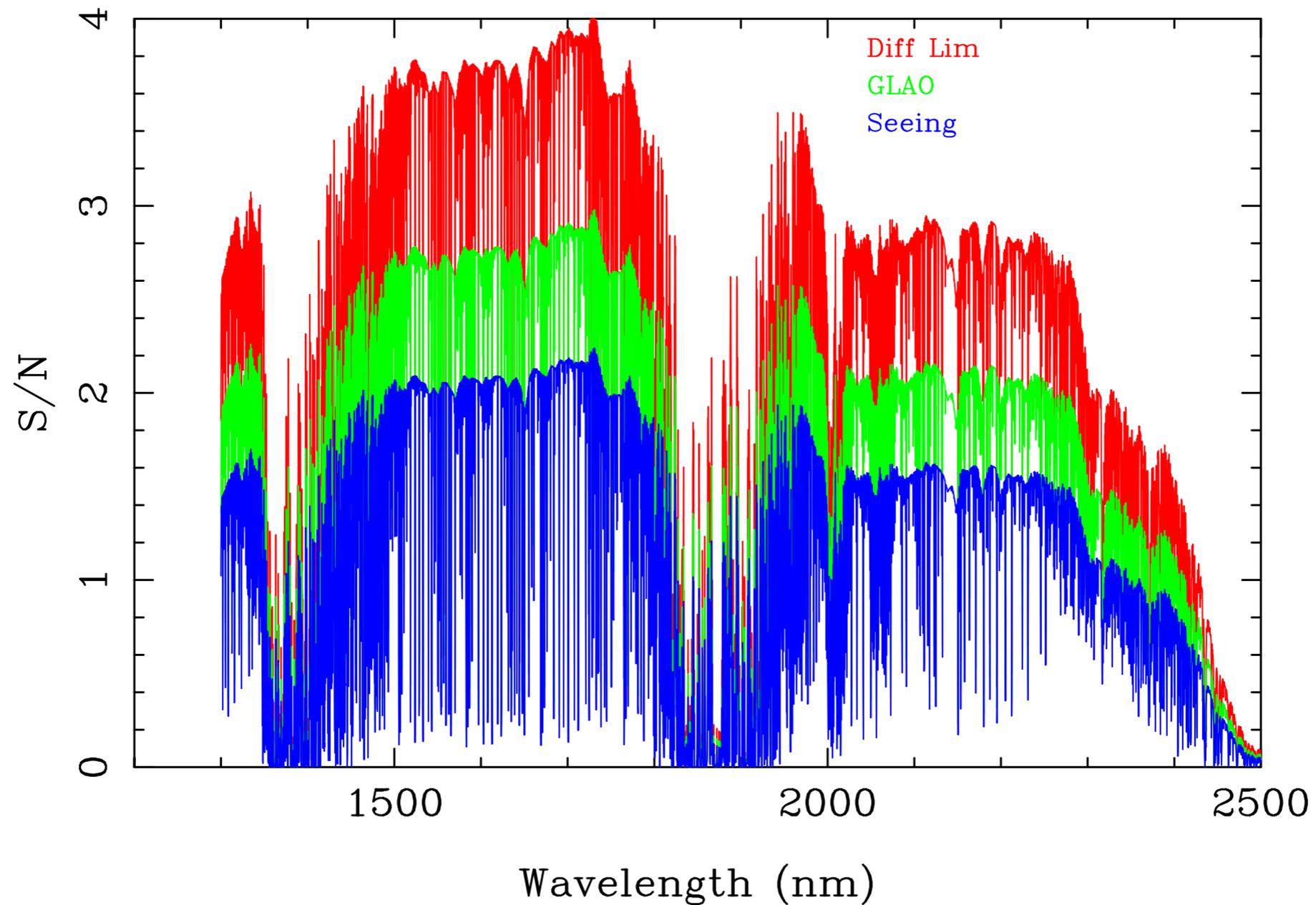
分光シミュレーション

- スリット分光: GLAOはNatural Seeingでの観測と比べると最大約2倍のS/N

- z~2 sBzKの面分光による力学構造の調査

  - 回折限界ではK=23AB程度の暗い銀河でも可能

  - GLAOでは明るいものに限られるか

    - モデル化して空間的なdilutionの影響を評価する必要

- 中心部のAGN成分の検出

  - 回折限界では中心に集中したAGNを検出可能

  - Seeing Limitedでは周囲の星形成に埋もれてしまう

  - GLAOでも影響を受けるがSeeing Limitedよりは軽減

GLAOで期待される検出数

MOIRCS Deep Survey (GOODS-N)でのz~2銀河の個数密度（Kajisawa et al.）

GLAO視野 ～ 100 arcmin²
z=1.3-1.7: ~100 個（K~23）
z=2.1-2.6: ～ 80 個 (K~23)

z=1.3-1.7

z=2.1-2.6

個数密度（個/arcmin²）

Kバンド等級（AB）
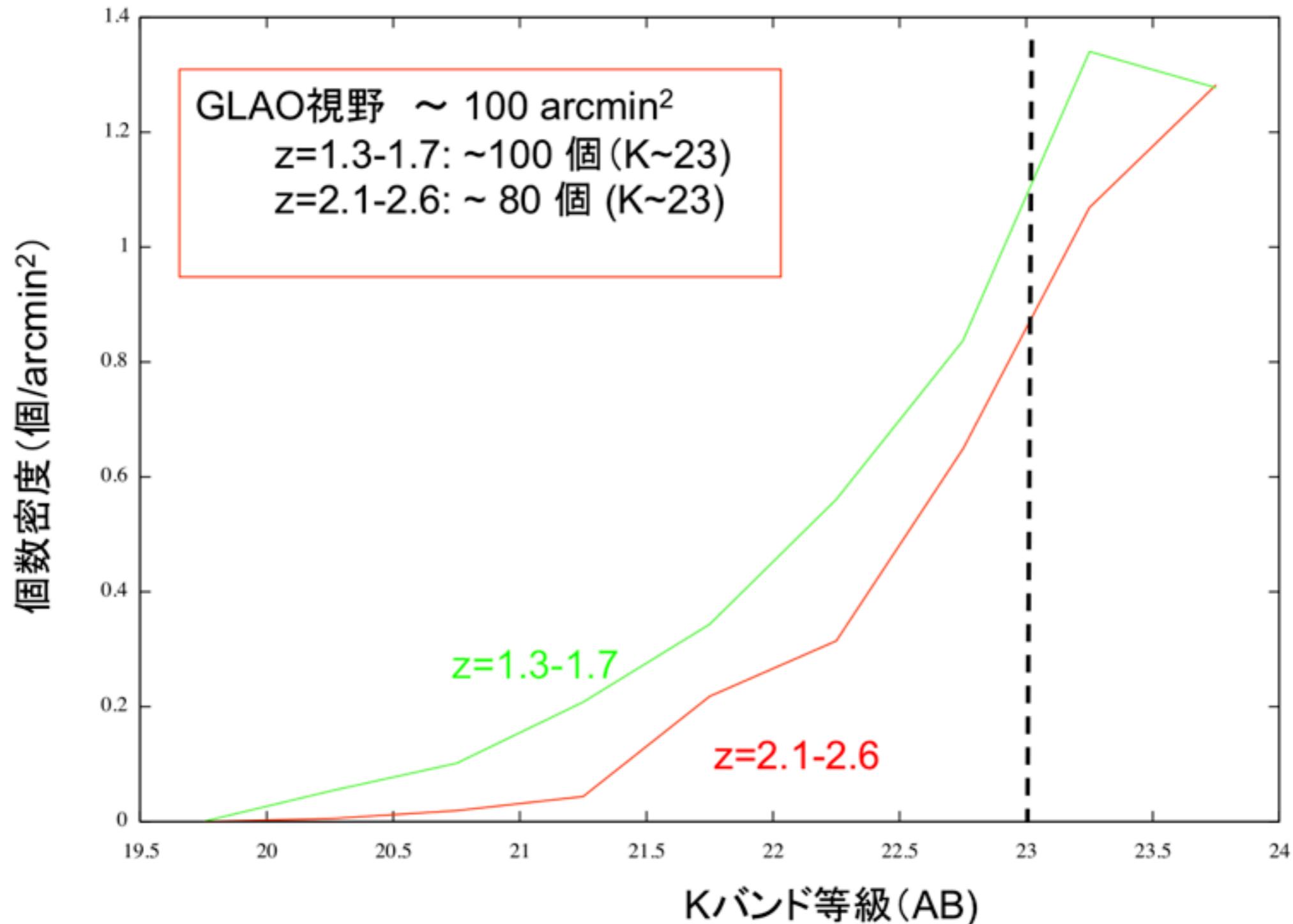
GLAO+多天体分光装置でのサーベイ

- 1.3<z<1.7, 2.1<z<2.6 Photo-z Sample - 100 / 80 per FoV
  - BzK, LBG, LAE, DRG / ERO, SMG / IRG etc.
- R~1,000 分光 - zyJ + HK - 2 Nights per Field

- 50 Nights - 25 FoVs - 2,500 Galaxies at z~1.5, 2,000 Galaxies at z~2.3

- Target Fields?
  - Total Survey Area: <1 deg^2
  - HSC UD fields - SXDS (UKIDSS) and COSMOS (Ultra-VISTA)
    - UltraVISTA: Y~25, JHK~24 AB (5σ)

Field of View for MOS

• 分散方向は**2k pix**の範囲をカバーするよう設計

   • Slit配置範囲は 分散方向**6k (=10.2')**の確保を最低限の要件とする

   • 空間方向はどれだけ確保できるか
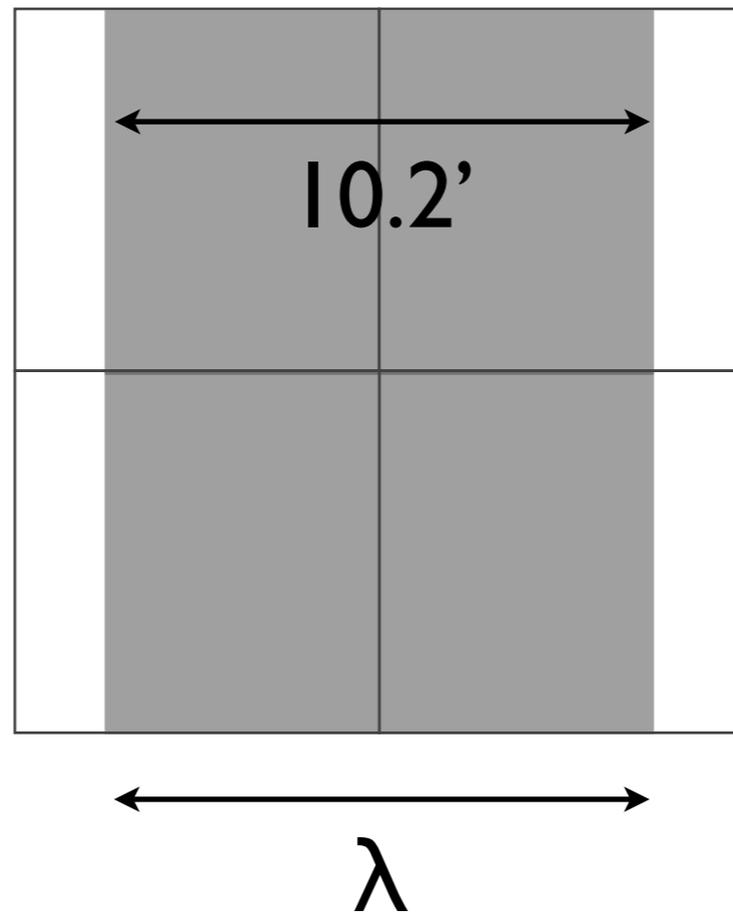
分散素子パラメータ案(1) R~1000

	λ [μm]	Sampling [Å/pix]	Coverage with 2K pixels* [μm]
zJ	0.9-1.5	3.3	0.67
HK	1.3-2.5	7.0	1.43

* assume H4RG-15 and multi-slit MOS

分散素子パラメータ案(2) R~3000

	λ [μm]	Sampling [Å/pix]	Coverage with 2K pixels [μm]
Y	0.9-1.1	1.1	0.22
J	1.1-1.4	1.3	0.27
H	1.4-1.8	1.6	0.34
K	1.9-2.5	2.3	0.47

1<z<3分光サーベイ: 科学的意義

- **「銀河進化の最盛期の全貌を理解する」**

- 多天体分光(Multi-Slits): シーイング改善による感度向上+広視野化による効率向上

  - より暗い天体まで、より高い統計的精度で

  - ~0.5等暗く、~10倍多いサンプル

- (多天体)面分光機能はどれくらいEssentialか?

- SINFONIのサーベイやMOSFIREのサーベイと比べて、2020年代に行う意義はどこにあるか?

How fine can we resolve them?
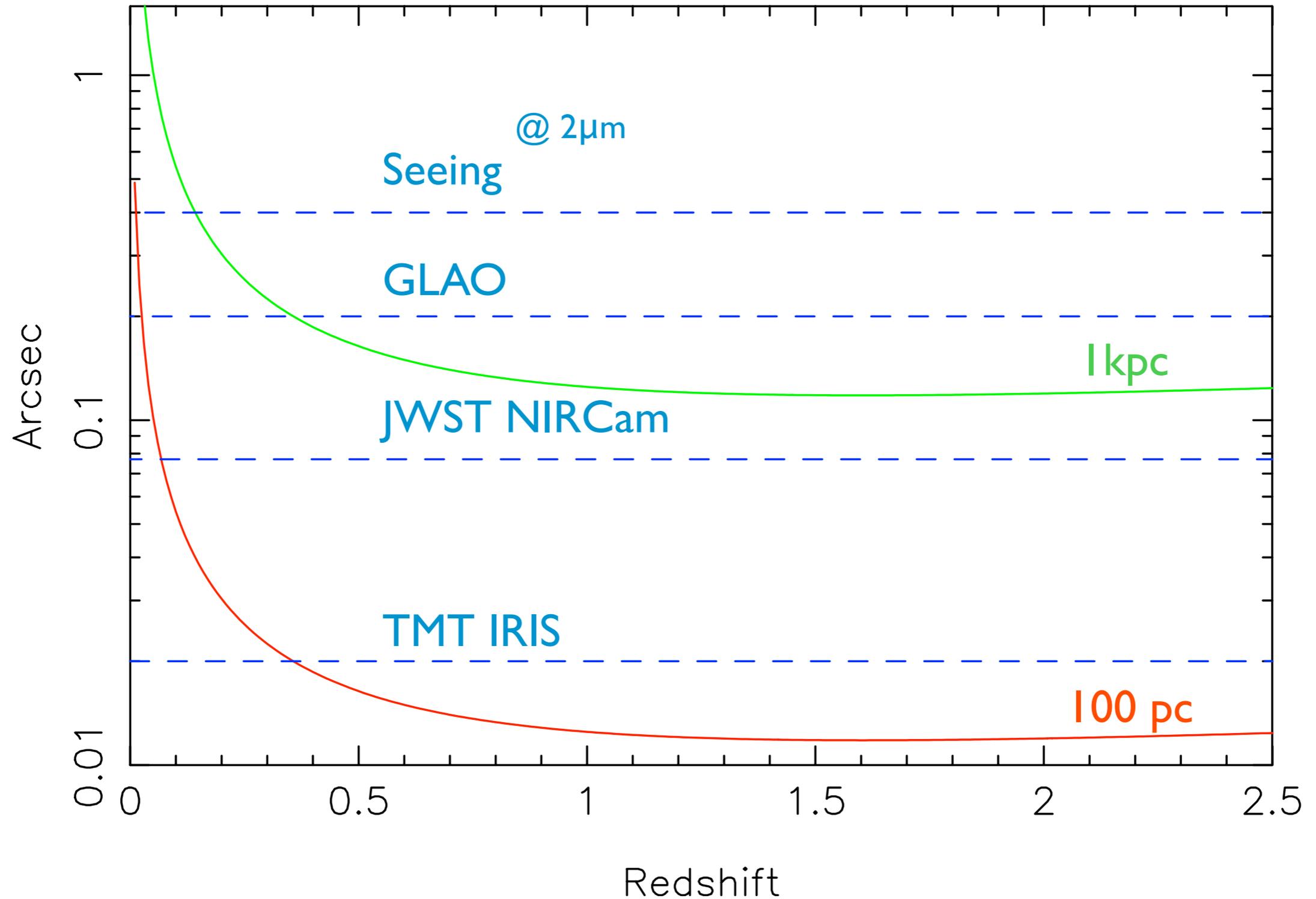
Emission-Line Sensitivities
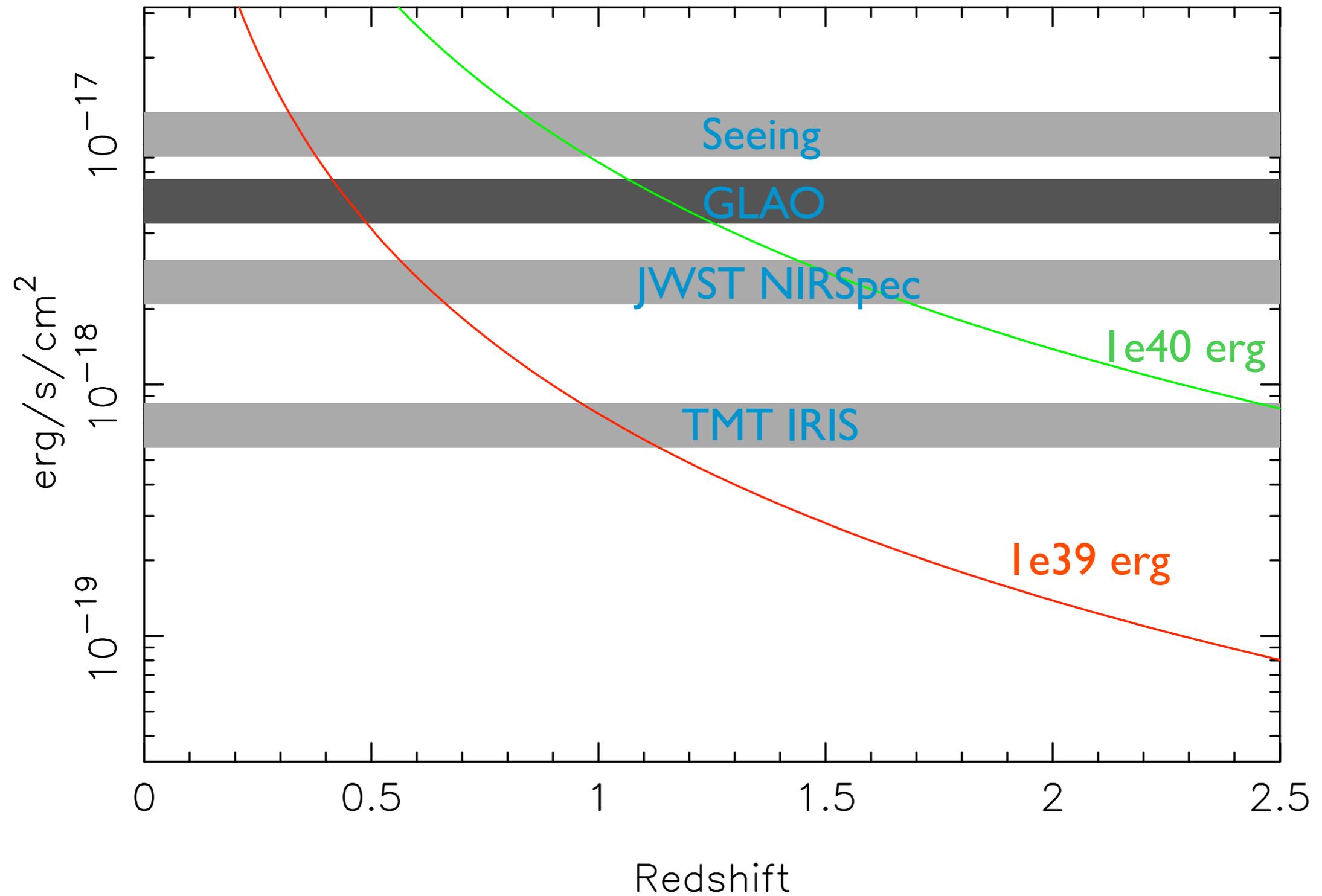
GLAO Narrow-Band Imaging Search for z>7 LAEs
「最遠方銀河の検出と宇宙再電離の理解」

Subaru GLAO NBFs Transmissions, Atmospheric Transmissions, and Sky Lines
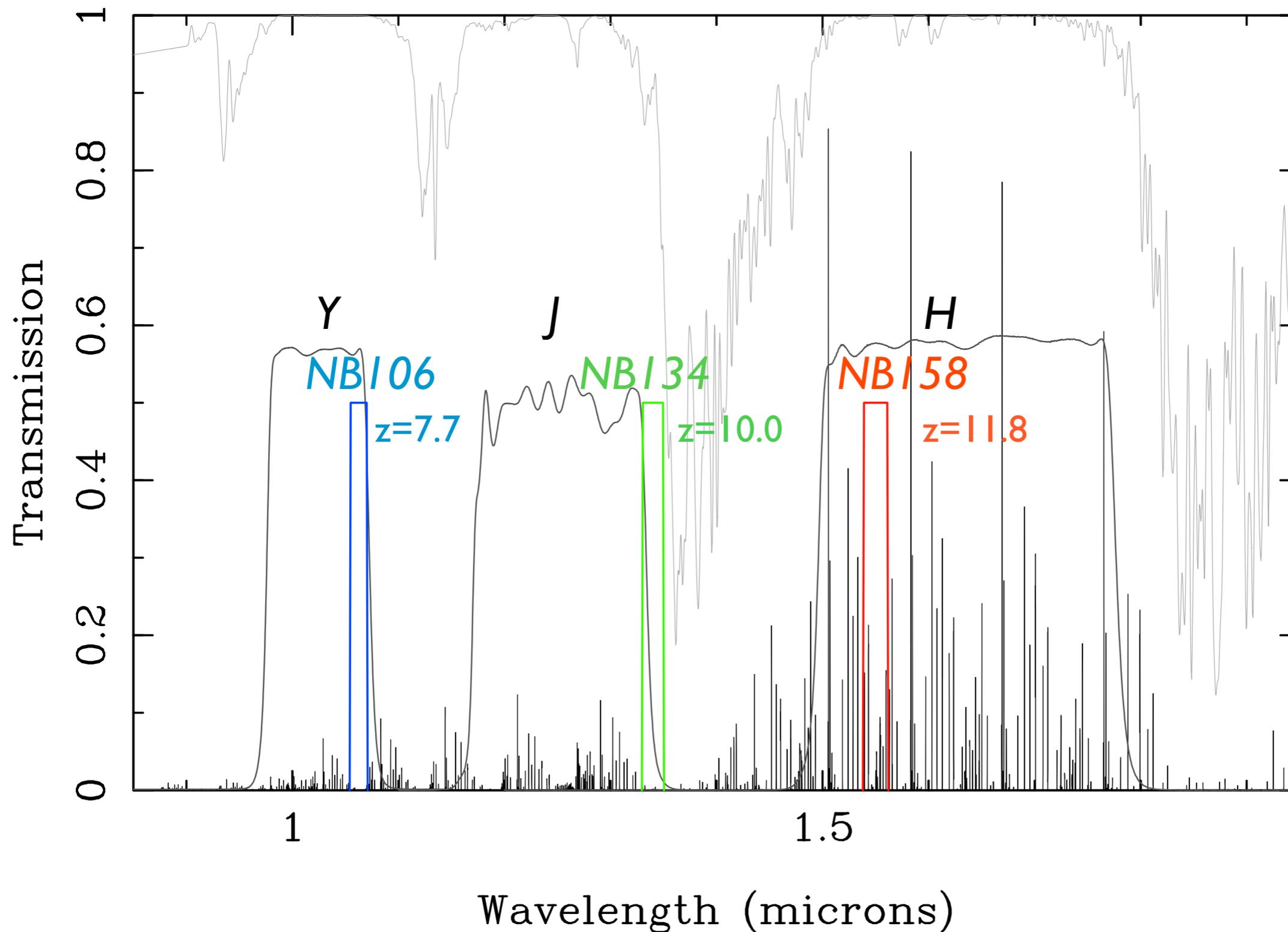
NBF, Point Source, 10hrs

FoV / Shot (arcmin^2)

Lim. Mag(10σ)

LAE LF at z=5.7 and 6.5

z=5.7

z=6.5

Kashikawa et al. 2011 ApJ 734, 119
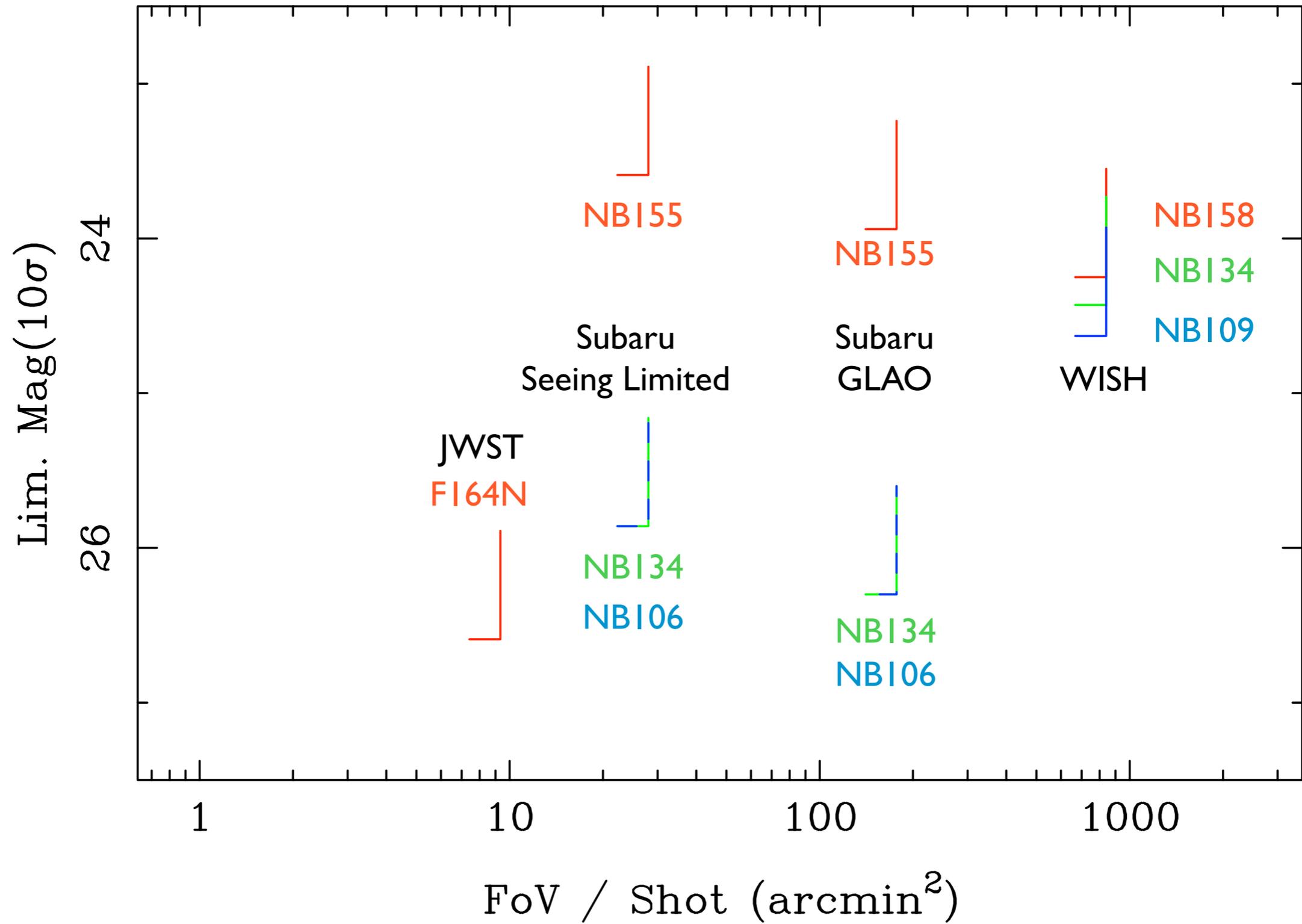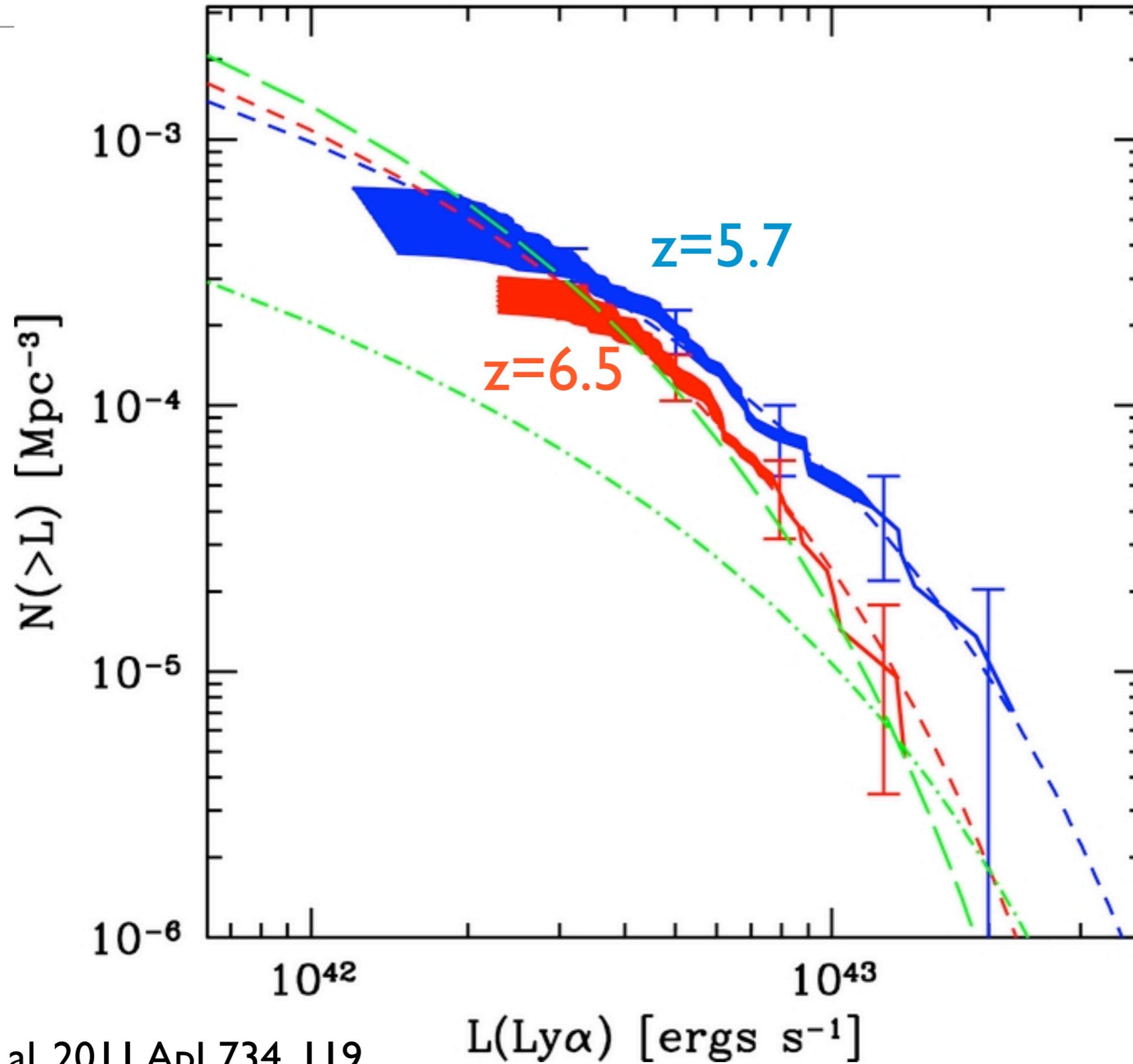
Expected Number per FoV
for On-source 10hrs Exposures

No Evolution from z=6.5 i.e., ~Maximum Number

	Number / FoV			
	Seeing	GLAO	WISH	JWST
z~8	0.5	8.3	0.2	--
z~10	0.2	3.3	0.01	--
z~12	3E-08	8E-06	7E-04	0.3

Expected Number per FoV
for On-source 10hrs Exposures

Based of SAM by Kobayashi et al.

	Number / FoV		
	Seeing	GLAO	JWST
z~8	0.4	3.9	--
z~10	0.03	0.5	--
z~12	~0	~0	0.003

GLAO+広視野近赤外線カメラでのサーベイ

- NB106 (z~8), NB125 (z~9), NB134 (z~10) 各on-source 10 hrs / FoV ~ 6 Nights / FoV

- 60 Nights = 10 FoVs (90 Nights including weather)

- Expected Numbers: z~8: ~40, z~10: ~5
  - Targets for TMT IRIS

- Survey Area: ~1,500 arcmin^2

- Target Fields: SXDS and COSMOS
 - JHK ~ 25AB (5σ) from UKIDSS and UltraVISTA may not be deep enough

Cross-Correlation of Galaxies and IGM 21cm Emission

Cross-Correlation of HI 21cm Emission and Galaxies

- Wyithe and Loeb 2007, MNRAS 375, 1034; Furlanetto and Lidz 2008, ApJ 660, 1030
- Advantage of Galaxy - 21cm line cross correlation over 21cm signal alone:
  - Eliminates foreground contaminations
  - Possible S/N improvement
 - Ionizing efficiency for different galaxy types
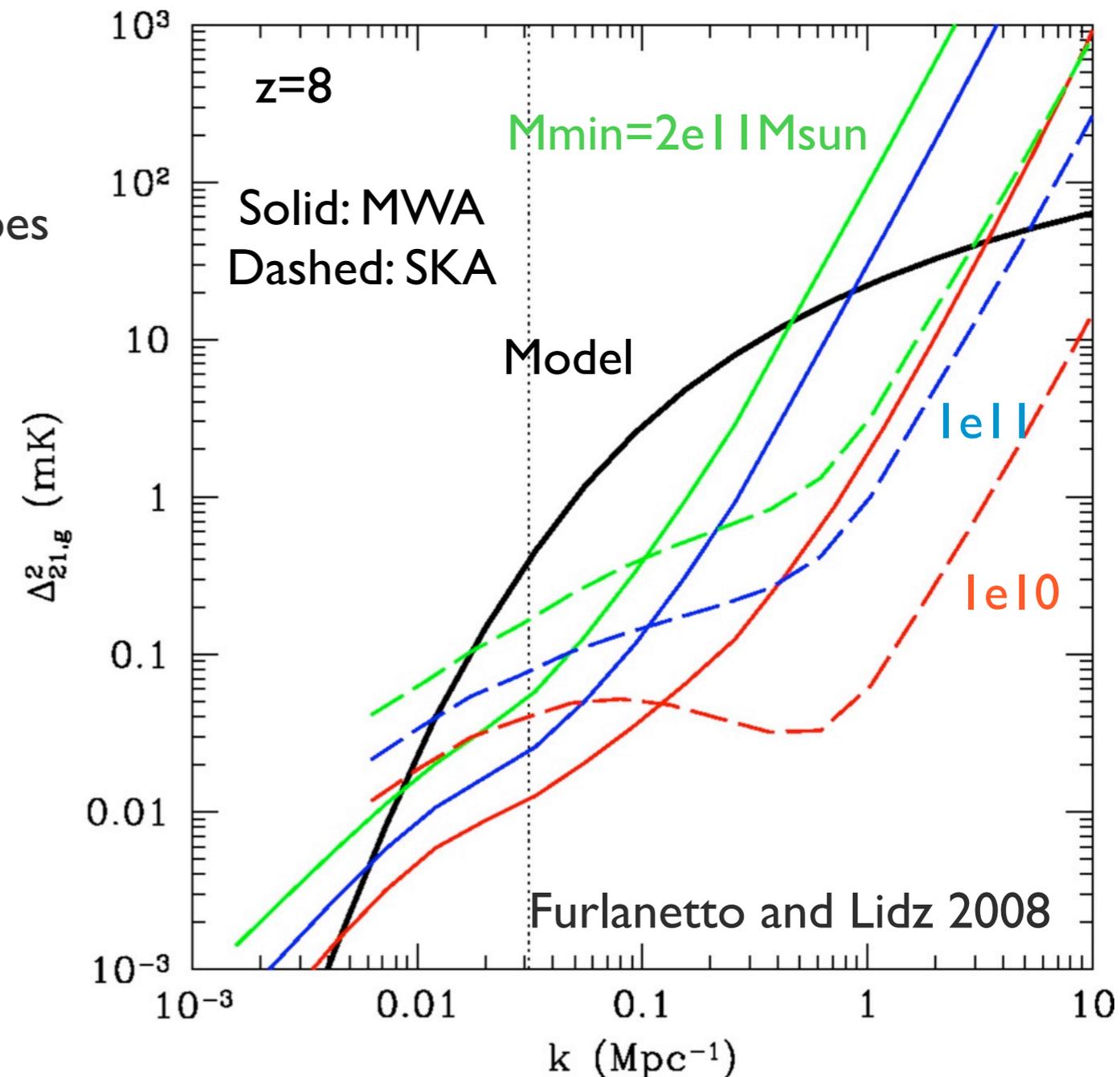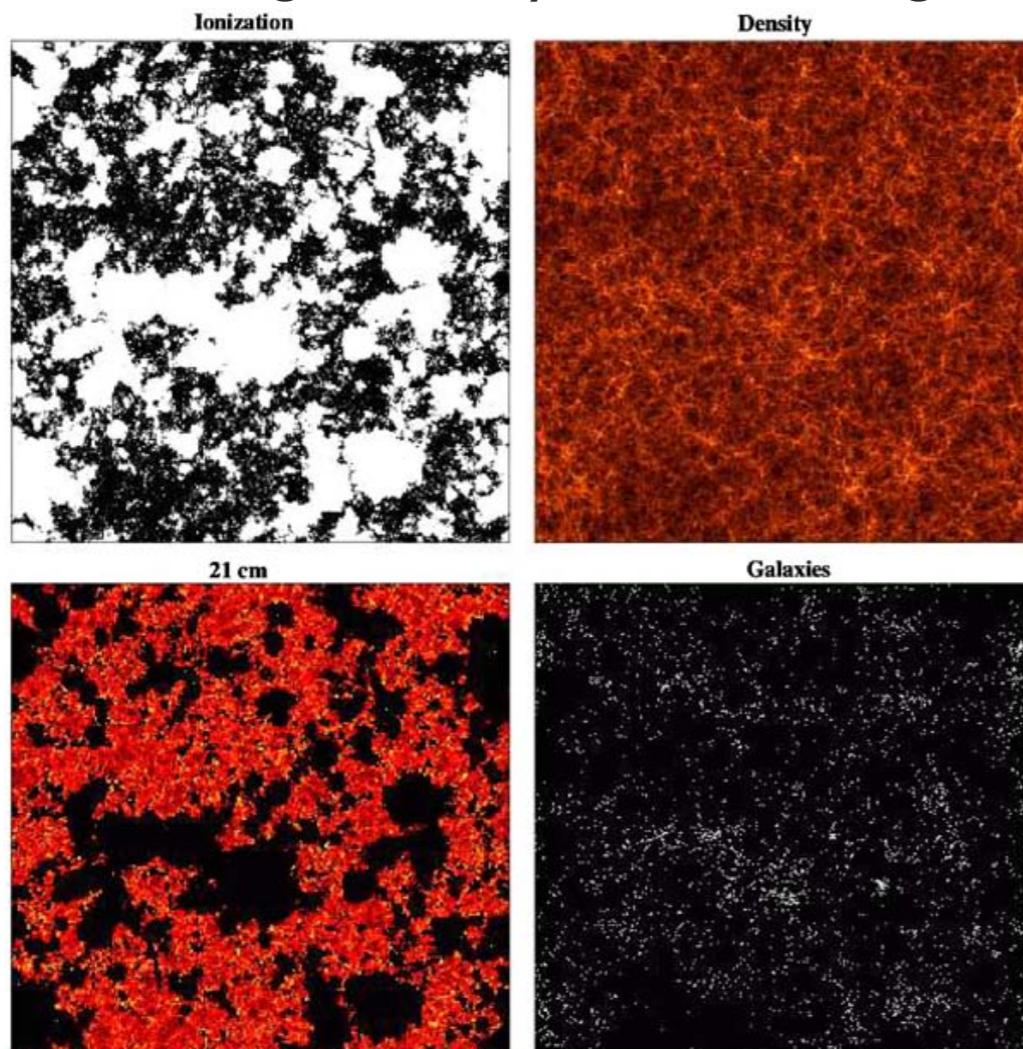
Resolving History of Reionization

Lidz et al. 2009, ApJ 690, 252
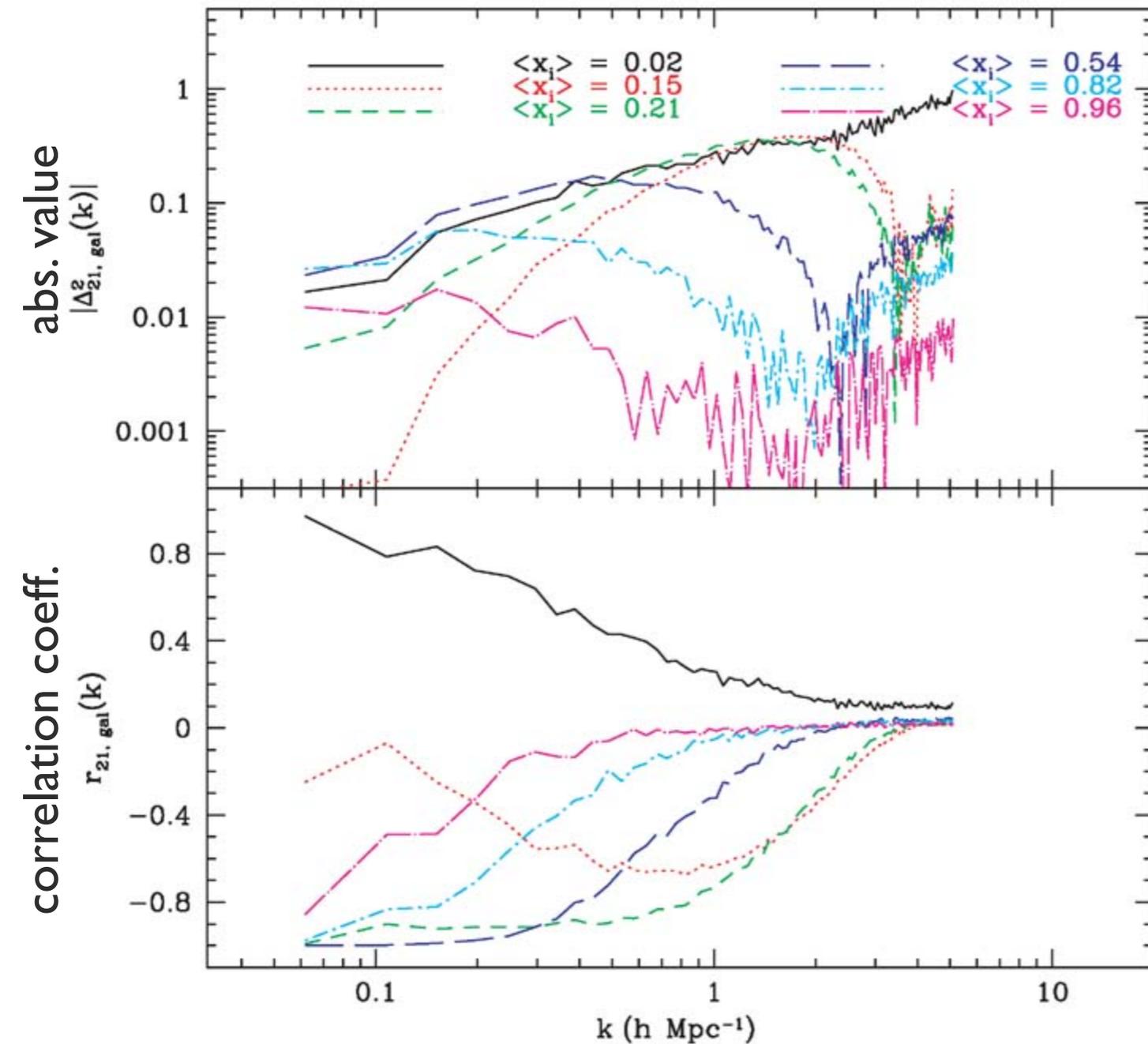
- Beginning: galaxy and 21cm are positively correlated

- Galaxies ionize overdense regions. Underdense regions remain neutral - Brief period of low amplitude cross-correlation (Xi=0.15 in the left model)

- Galaxy and 21cm quickly become anticorrelated

Requirements on the Galaxy Survey

Furlanetto and Lidz 2008
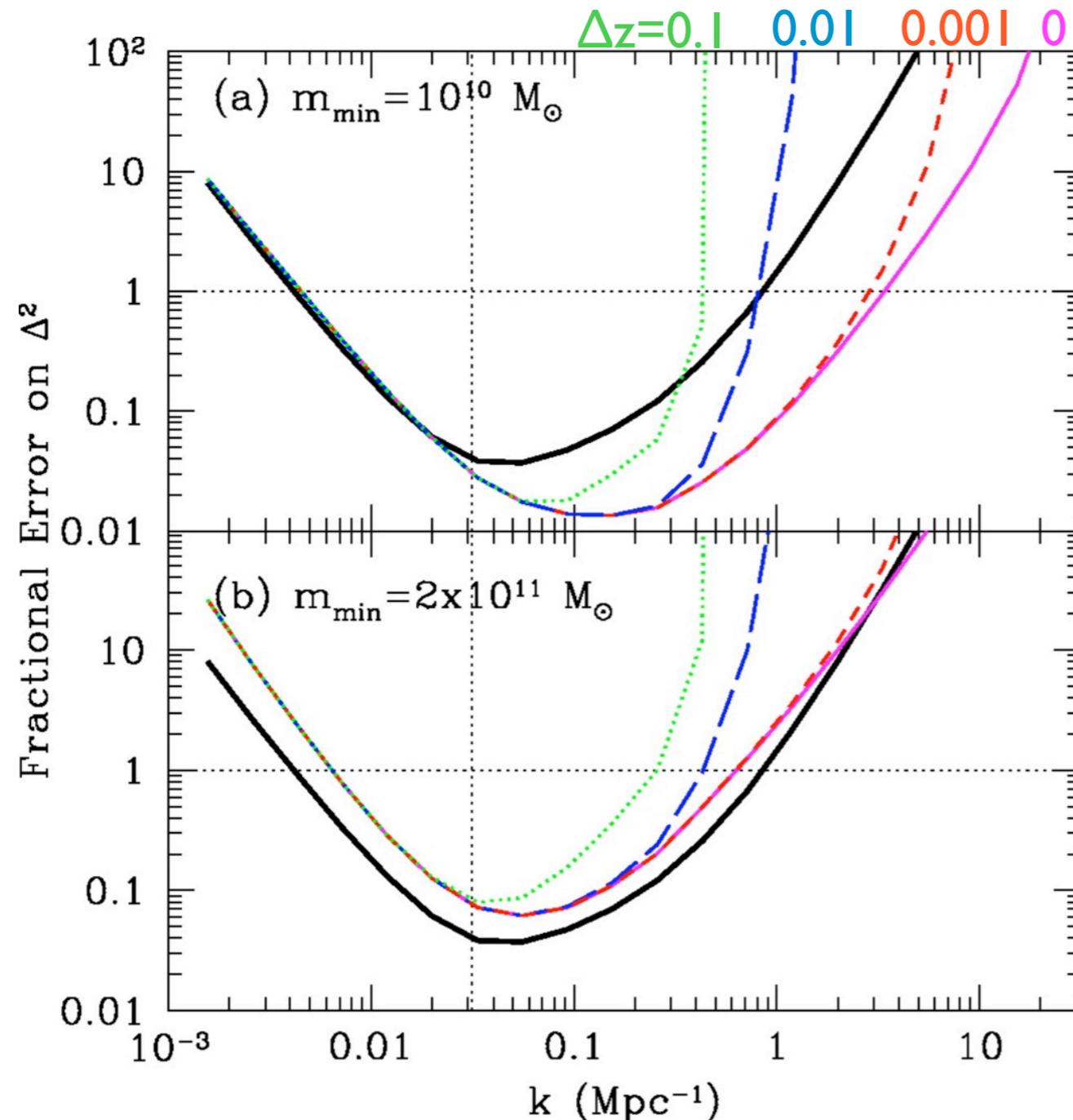
- Accurate redshifts
  - LAE survey would be good
- Large area coverage
  - to improve S/N
  - >100 deg^2 survey area, coordinated with 21cm line obs.