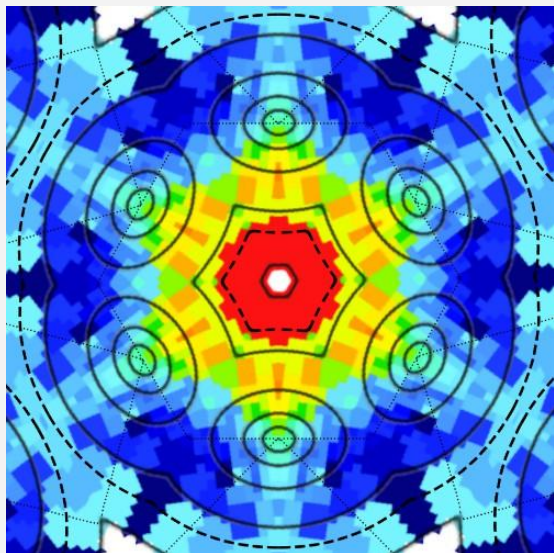


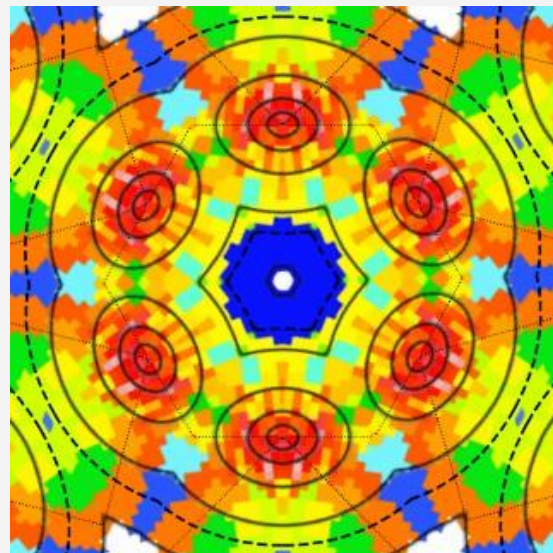
Extremely Large Kaleidoscope

Cosmology through spatially resolved stellar kinematics of strong lensing galaxies:
from Keck to JWST to ELTs

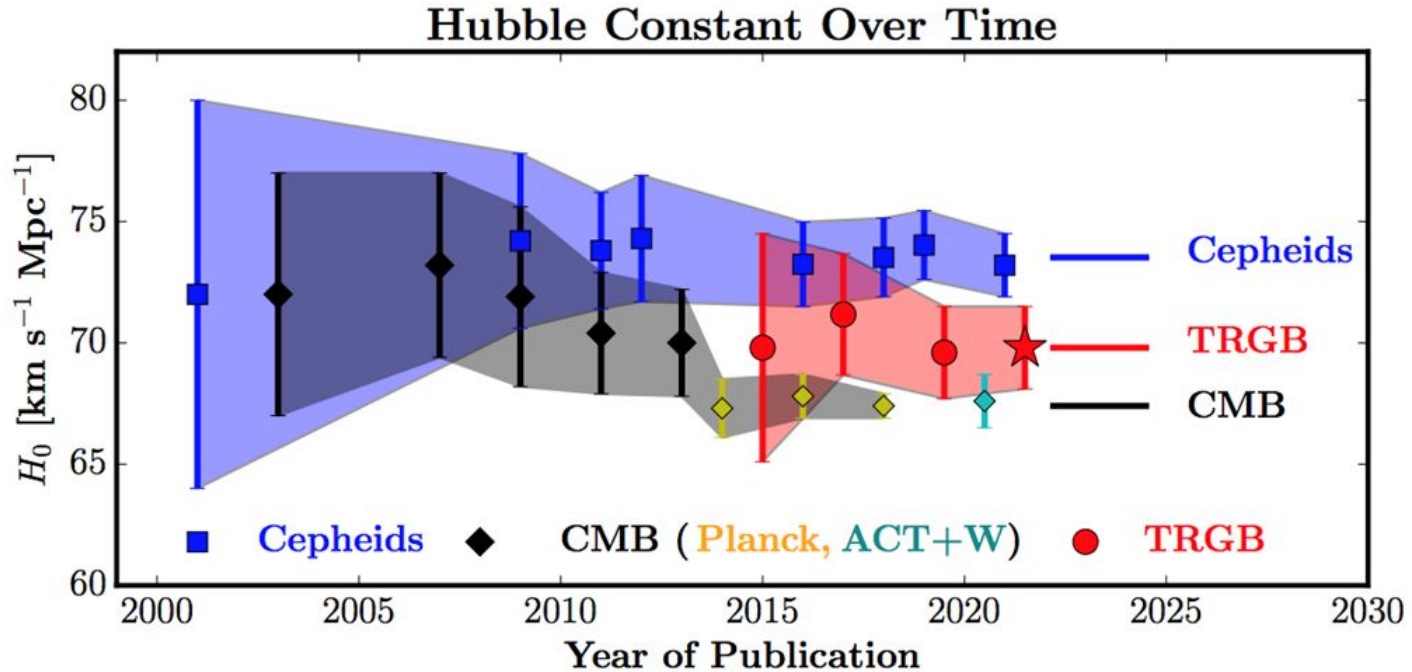


Shawn Knabel
with
Tommaso Treu

UCLA
ELT Science in Light of
JWST
12/11/2023



Motivation: Hubble tension



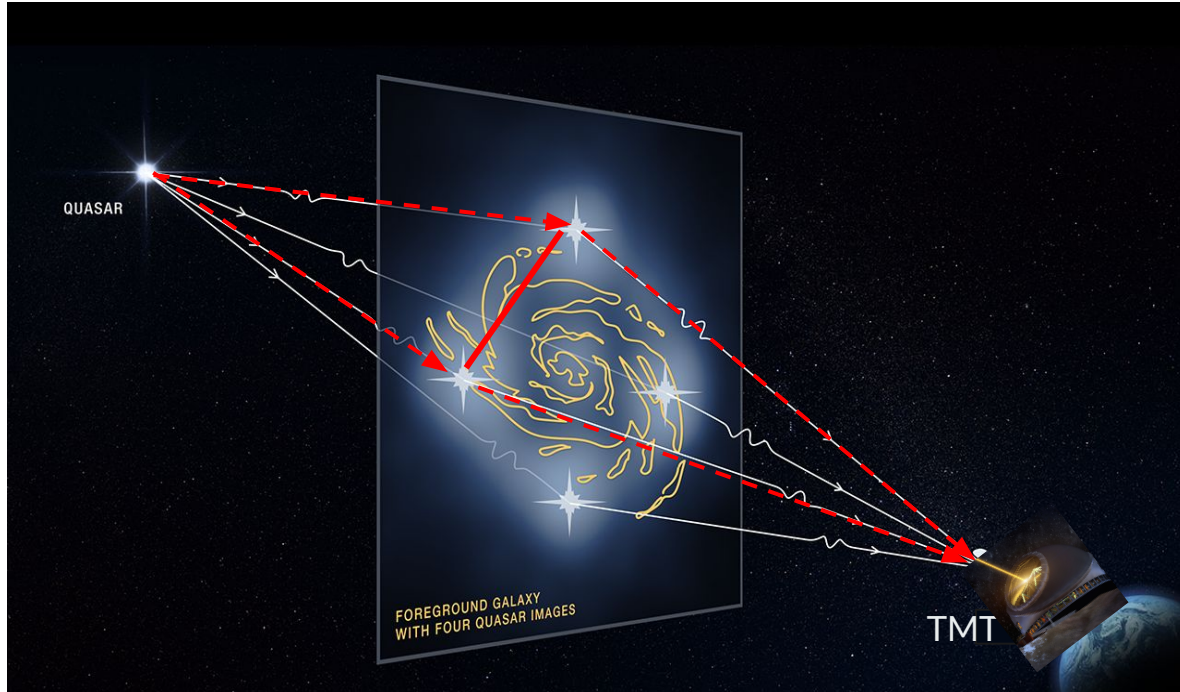
Freedman et al. 2021

Time delay cosmography

$$H_0 \propto D_{\Delta t}^{-1}$$

Ingredients:

1. time delay
2. difference in potential



NASA, ESA, and D. Player (STScI)

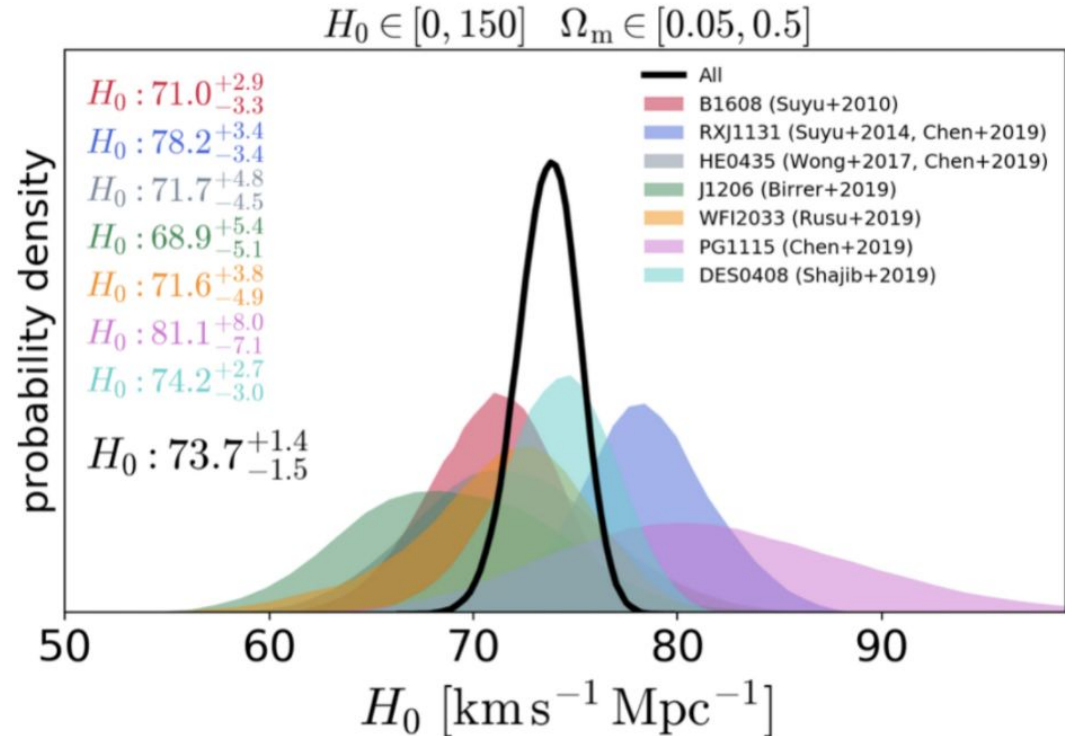
Time delay cosmography



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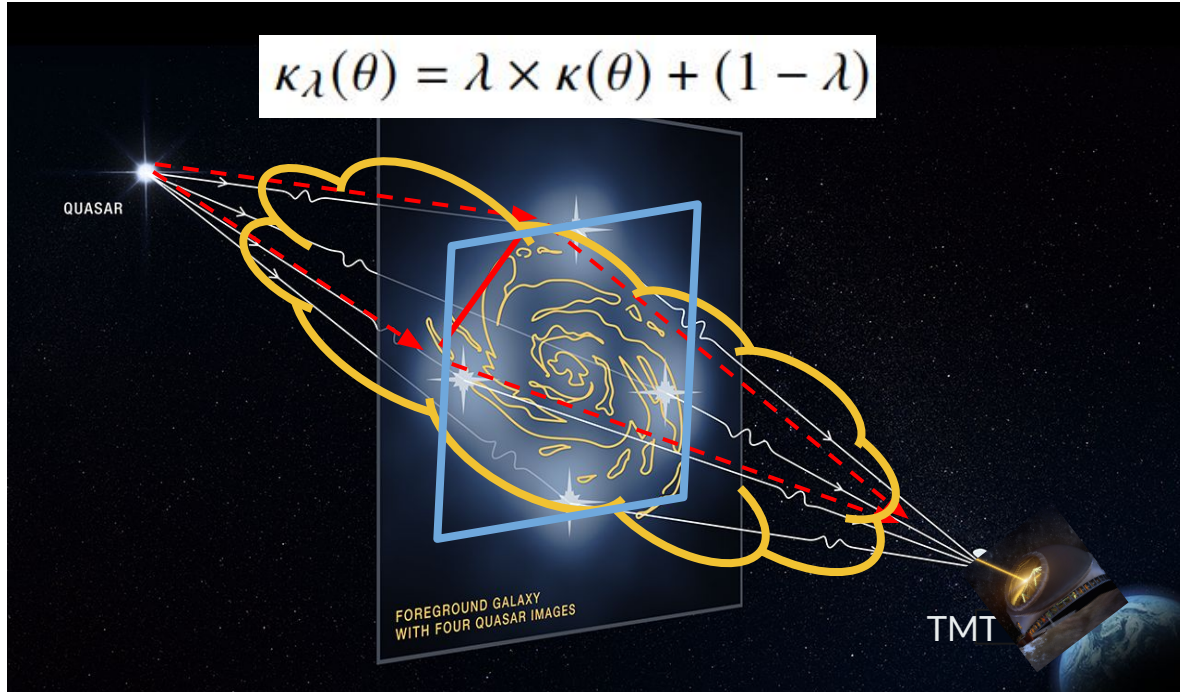


Mass Sheet Degeneracy MSD

$$H_0^* = \lambda H_0$$

$\lambda_{\text{external}}$ - environment

$\lambda_{\text{internal}}$ - kinematics



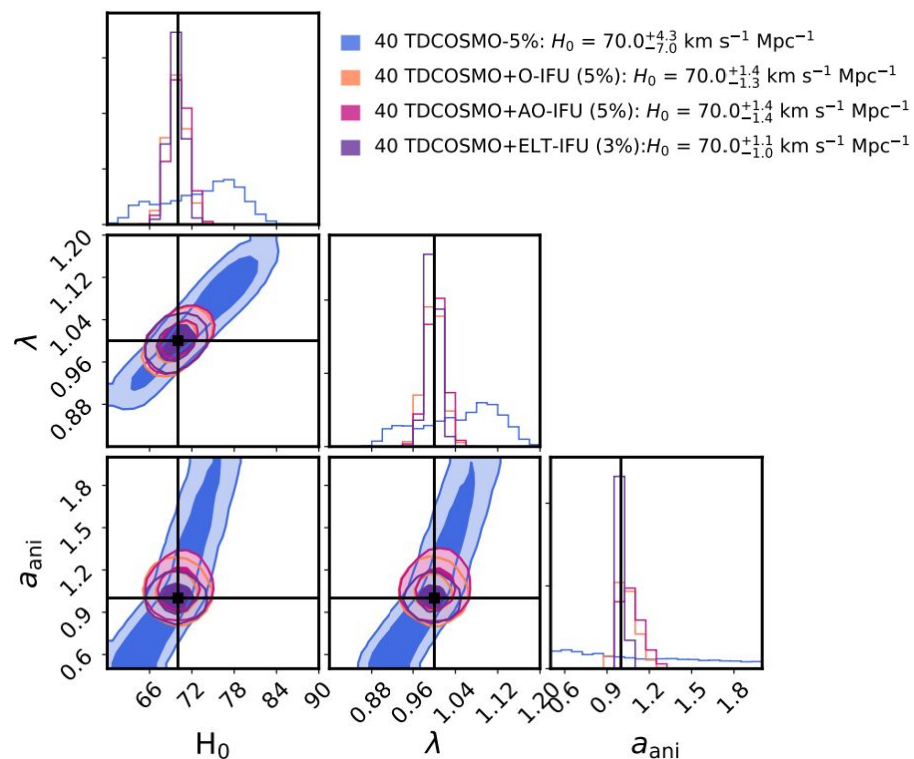
NASA, ESA, and D. Player (STScI)

Stellar kinematics, the MSD and MAD, and H_0

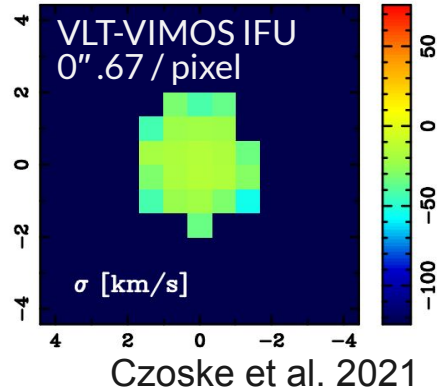
Mass-Anisotropy Degeneracy

Spatially resolved kinematics
necessary to solve degeneracy

<2% uncertainty achievable



Current state of the art & spherical Jeans modeling

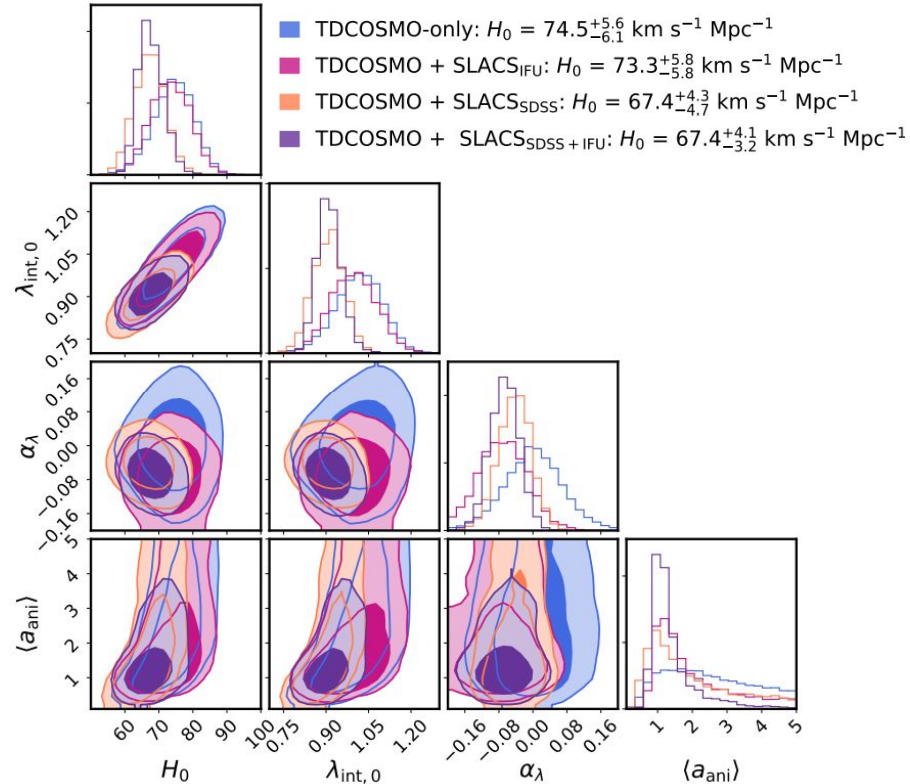


Hierarchical

7 TD lenses

33 non-TD lenses

degeneracy persists

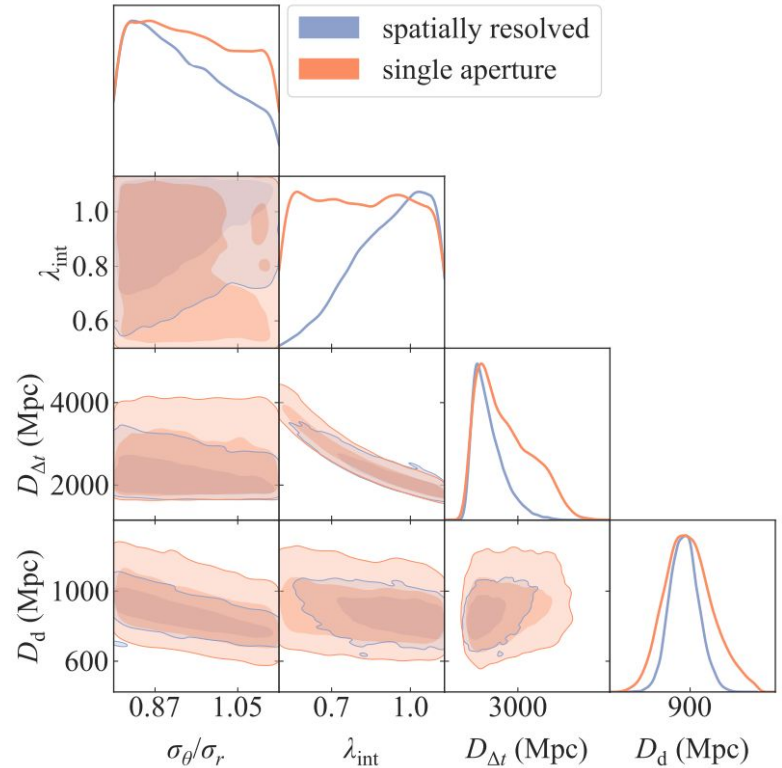
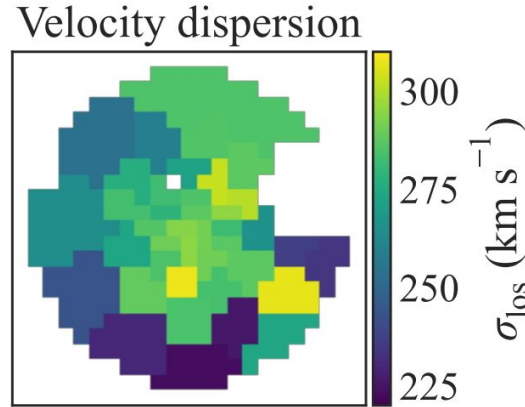


Birrer et al. 2021

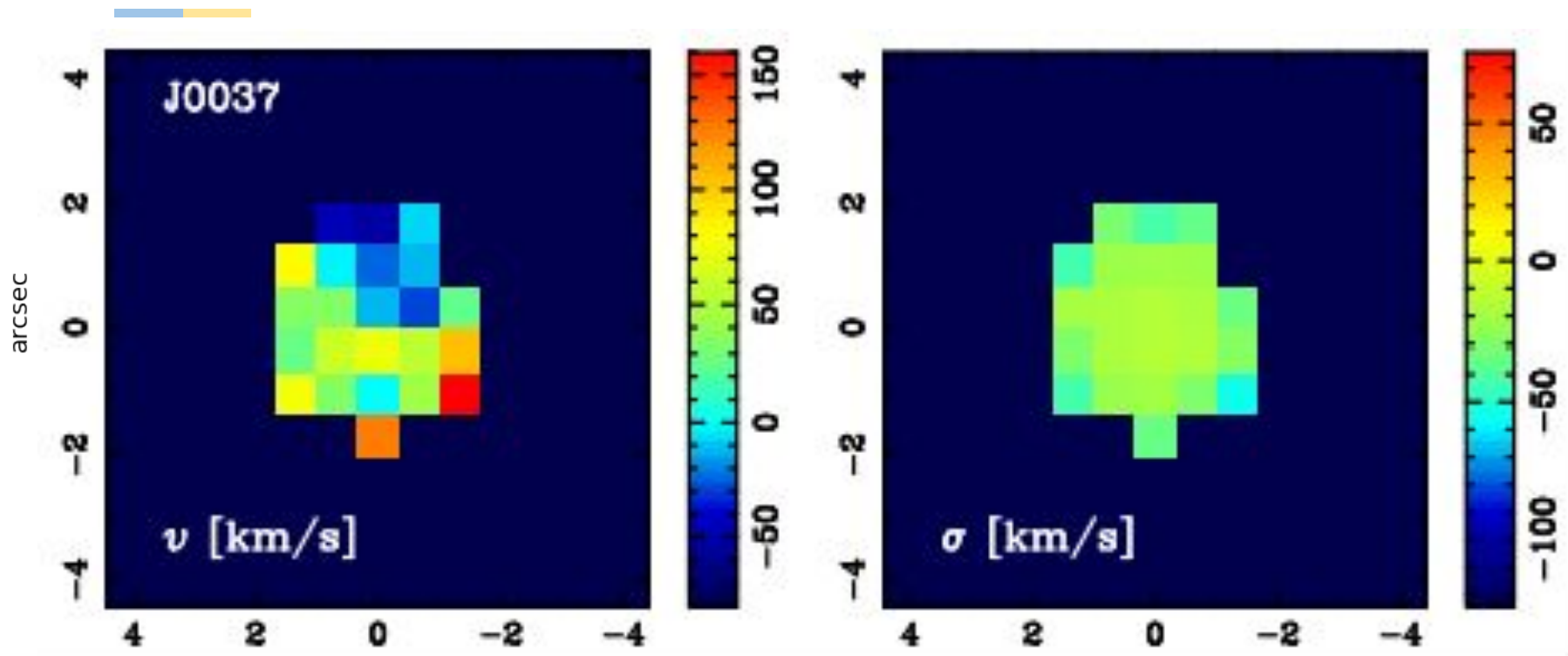
Keck KCWI spatially resolved kinematics



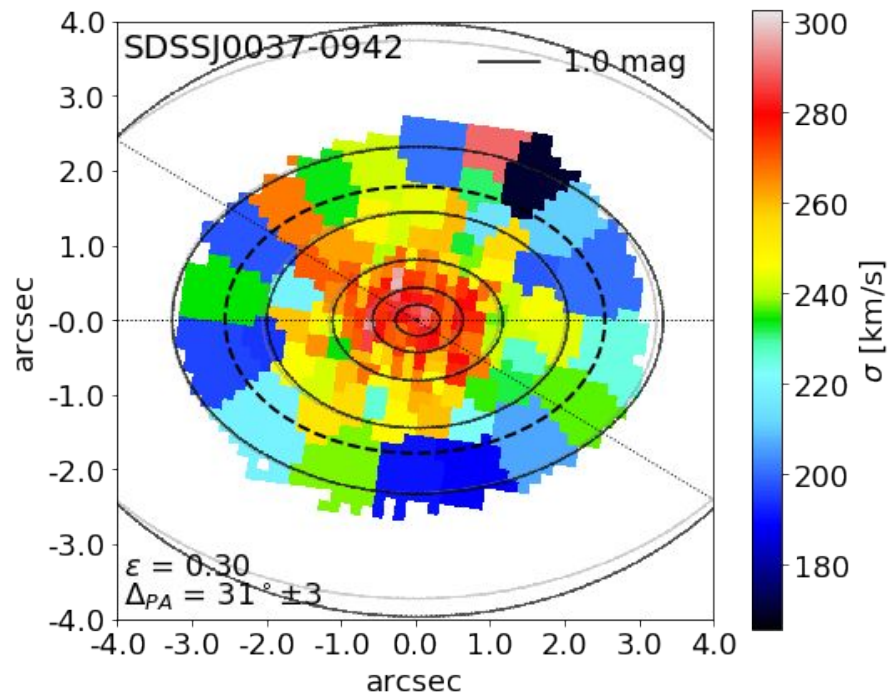
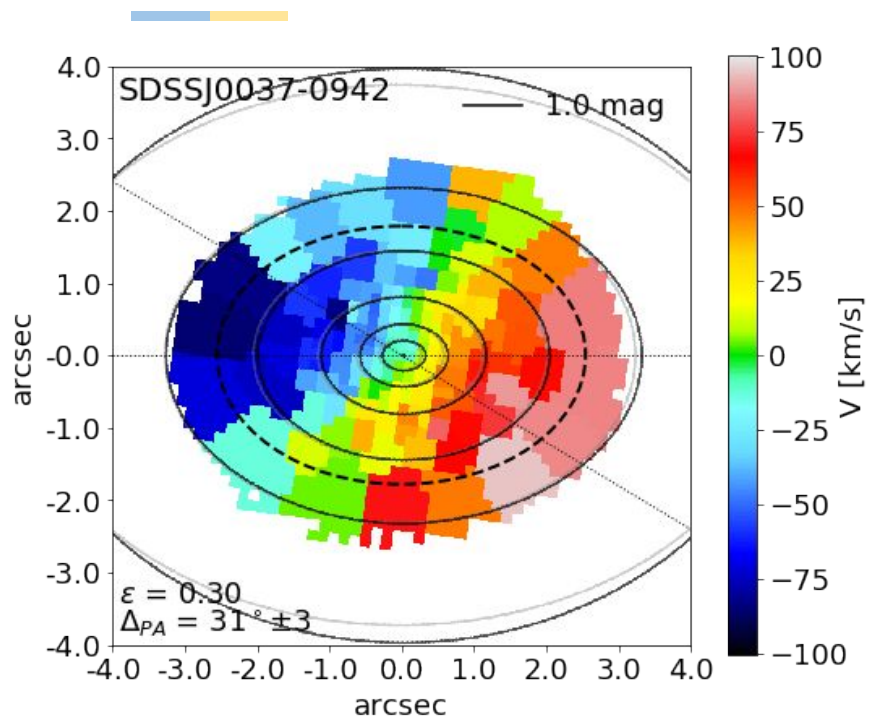
R ~ 3600
3600-5600 Å
dλ ~ 0.5 Å
0" .1457 scale
8"×20"

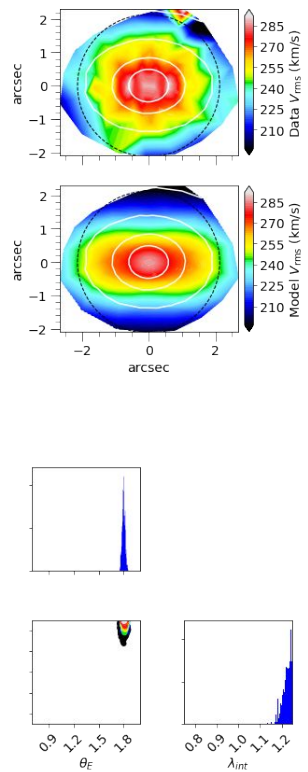
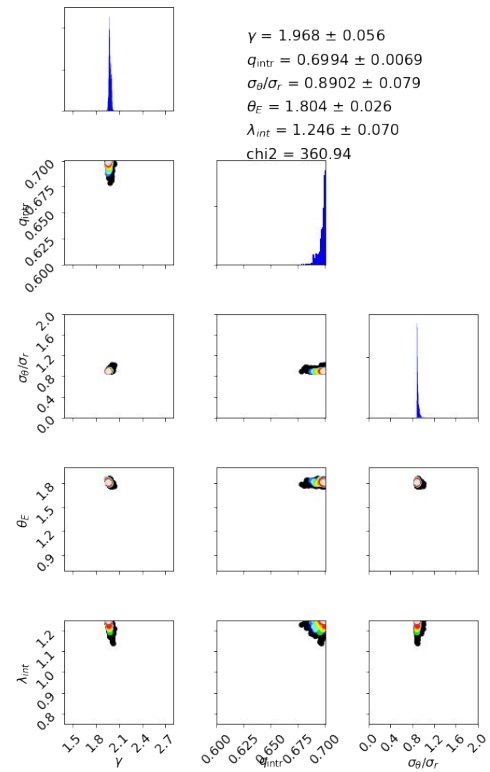
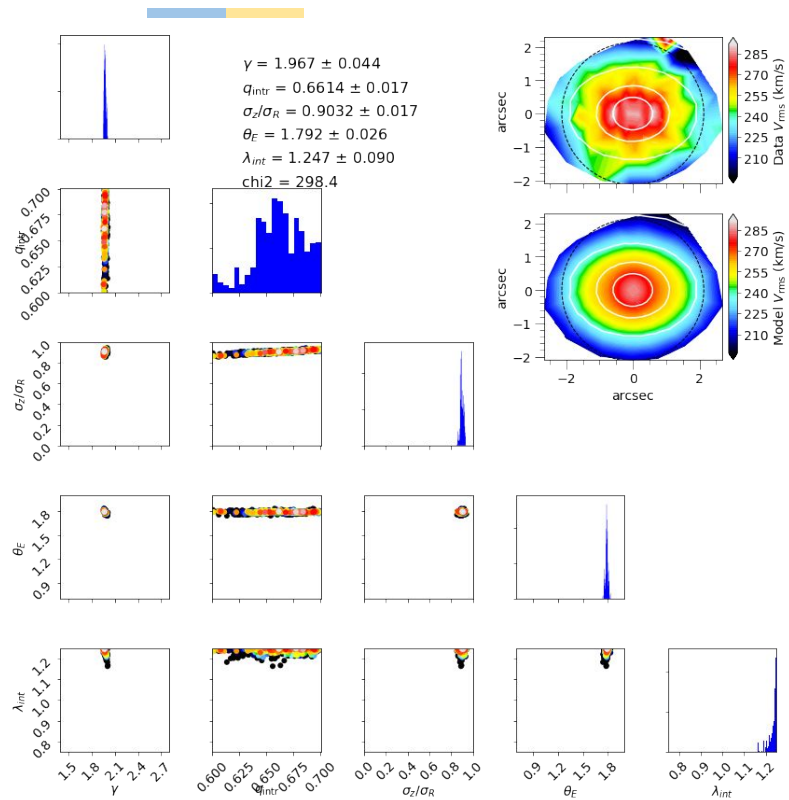


KCWI SLACS external dataset

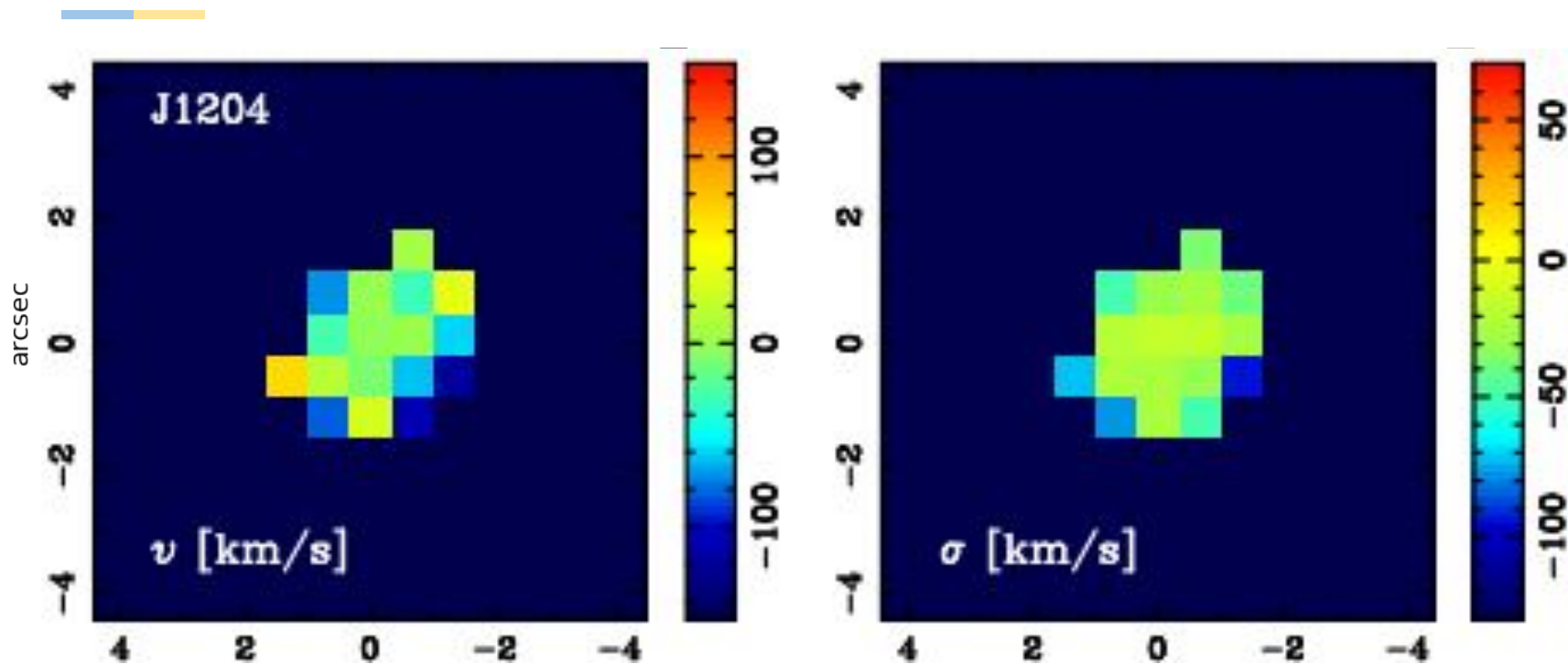


KCWI SLACS external dataset

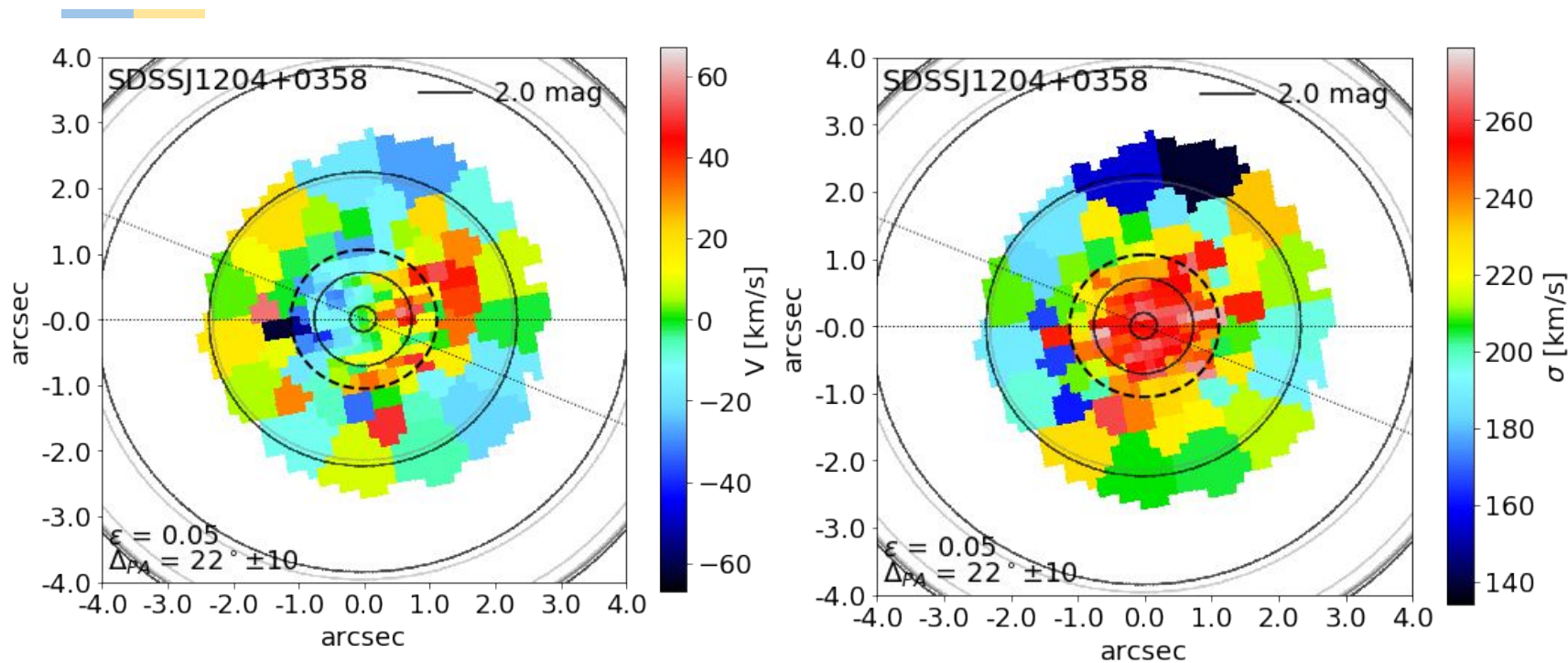




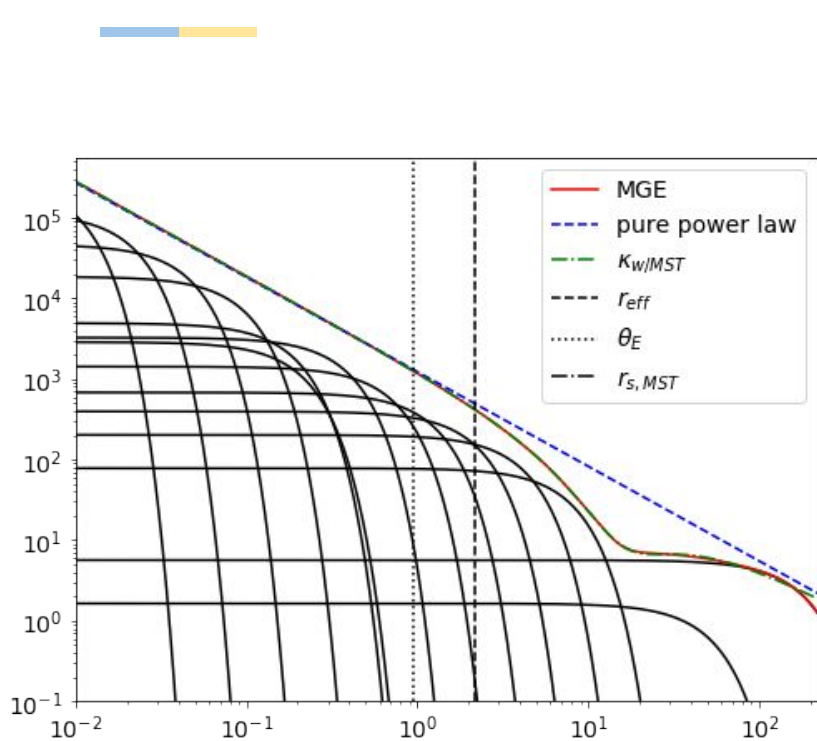
KCWI SLACS external dataset



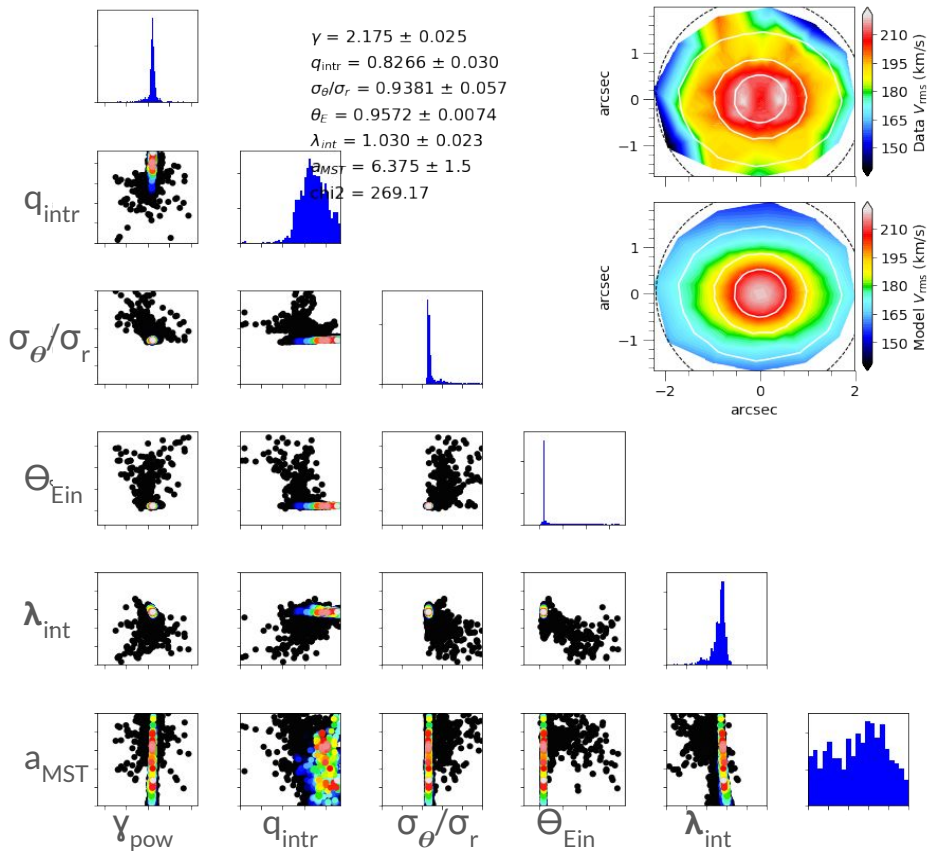
KCWI SLACS external dataset



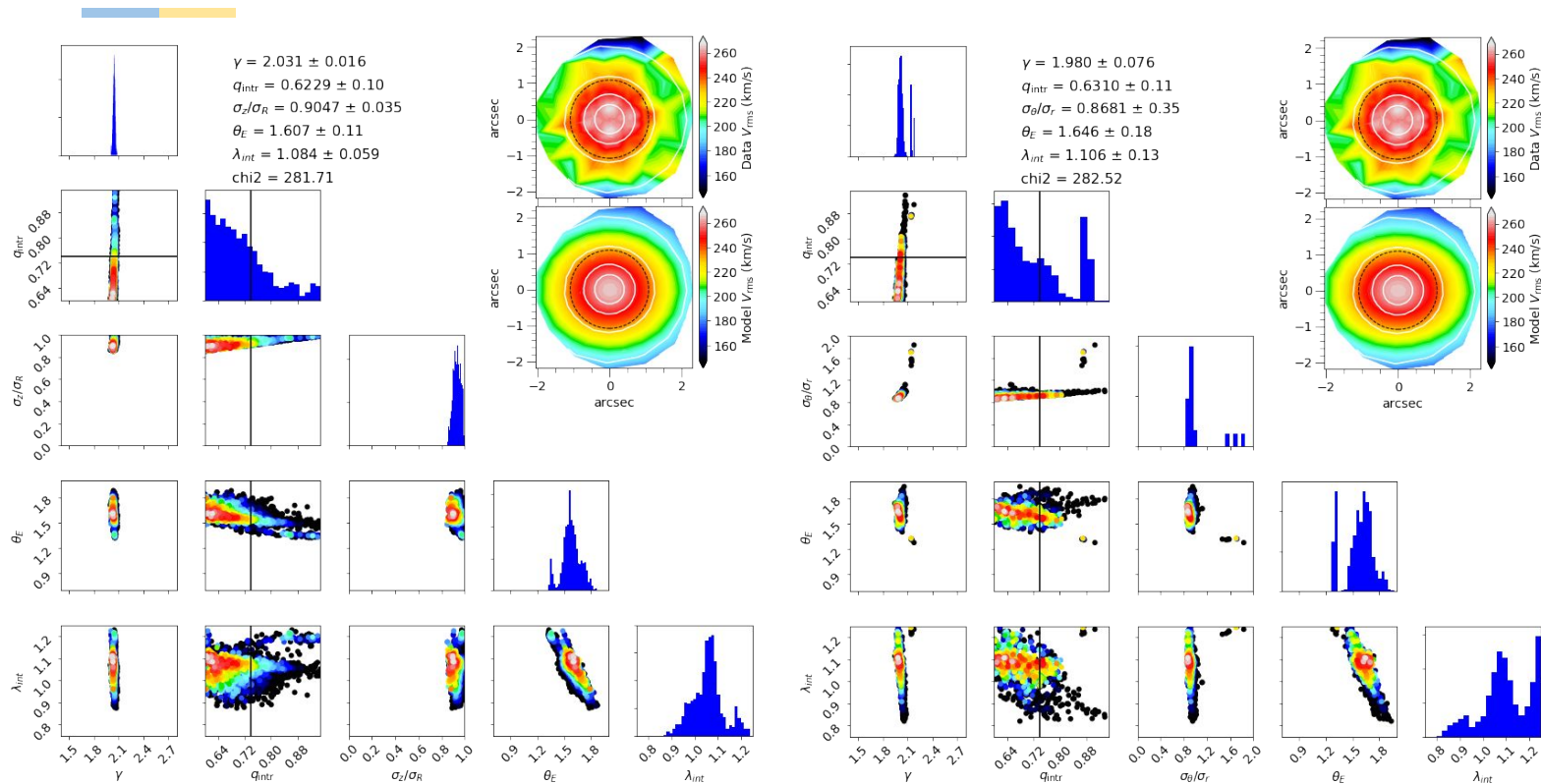
Constraints from axisymmetric Jeans modeling



Knabel et al. 2023b



Constraints from axisymmetric Jeans modeling



Axisymmetric forecast for JWST NIRSpec

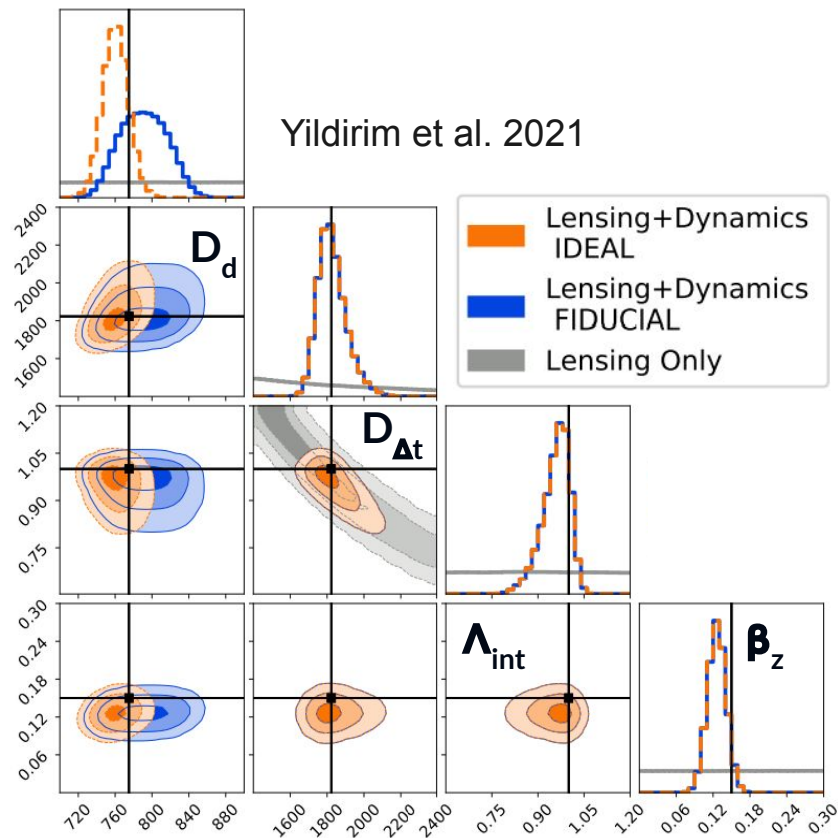
$R \sim 1000$

7500 - 14600 Å

$d\lambda \sim 6.36$ Å

0".1 scale

3"×3"



Axisymmetric forecasts for TMT

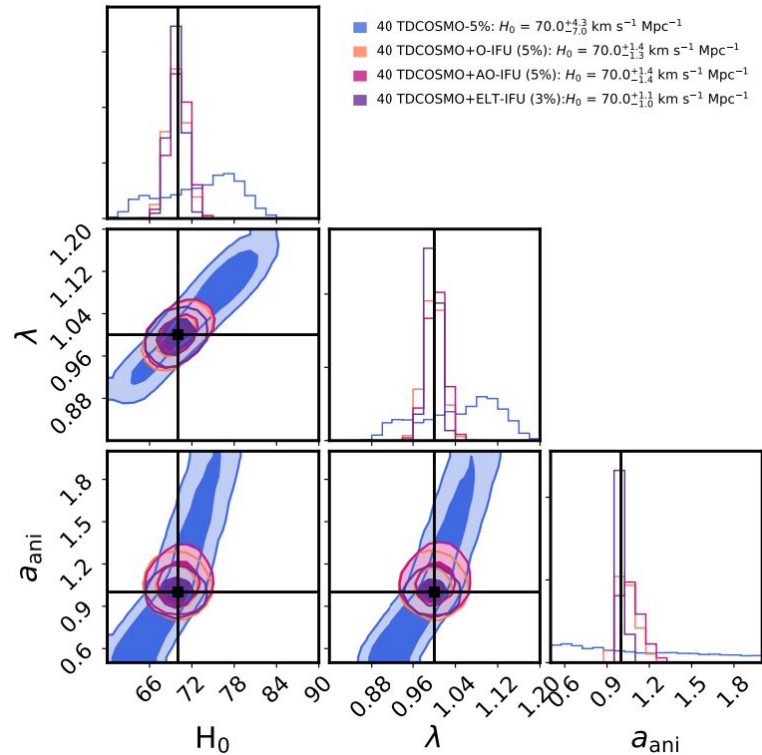
R ~ 4000-10000

0.84-2.4 μm

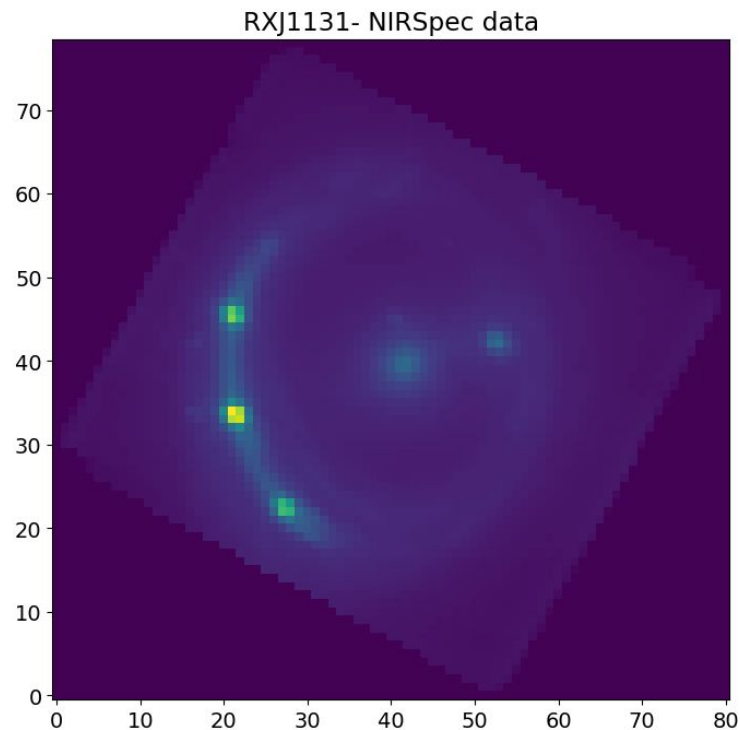
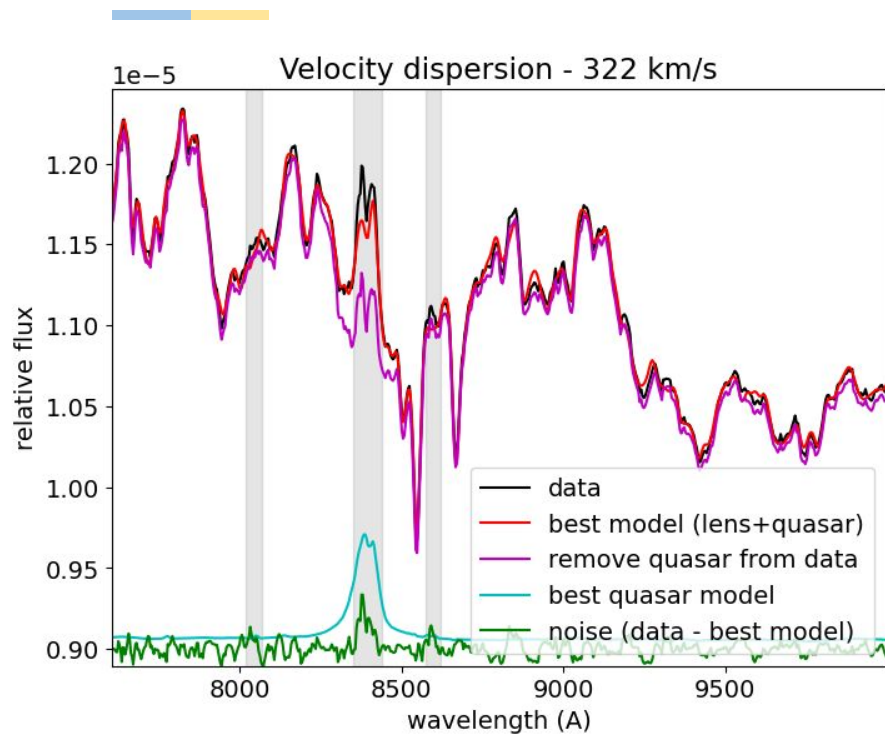
$d\lambda \sim 1\text{-}2 \text{ \AA}$

0" .05 scale

2.25" x 4.40"

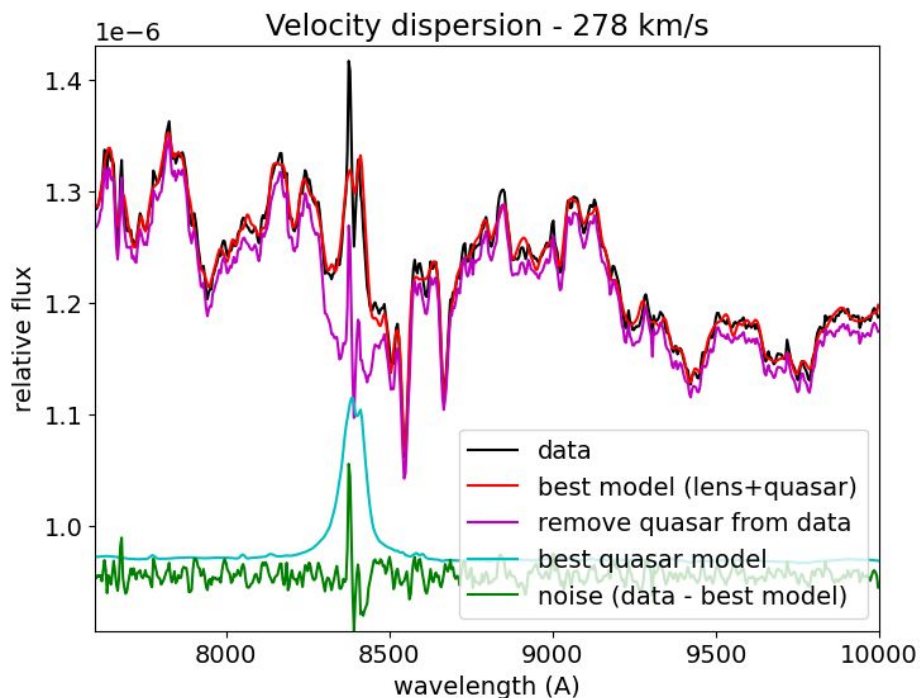
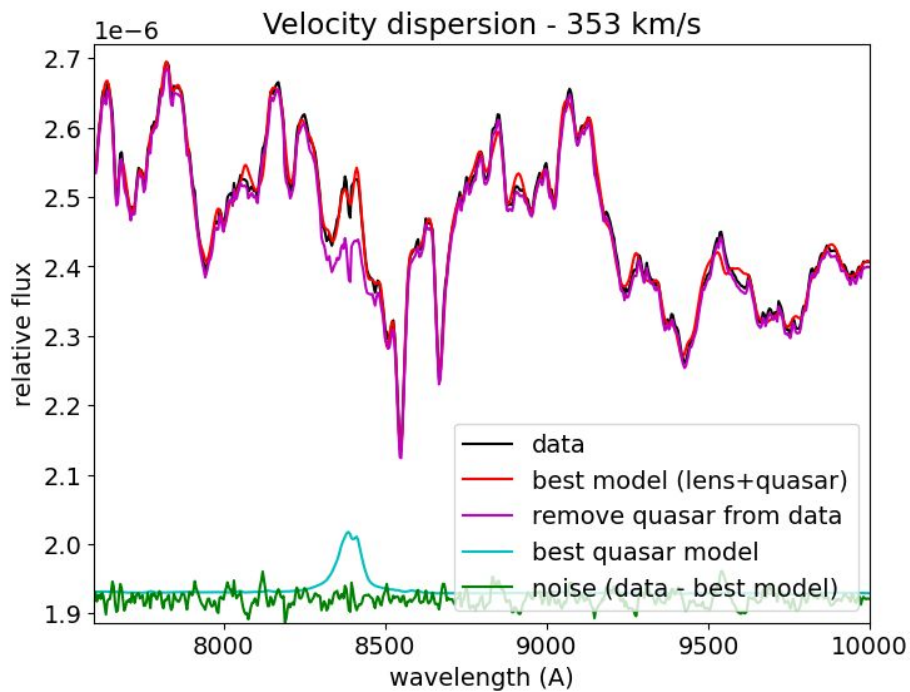


JWST NIRSpec - RXJ1131



PI: Sherry Suyu, many thanks to David Law!

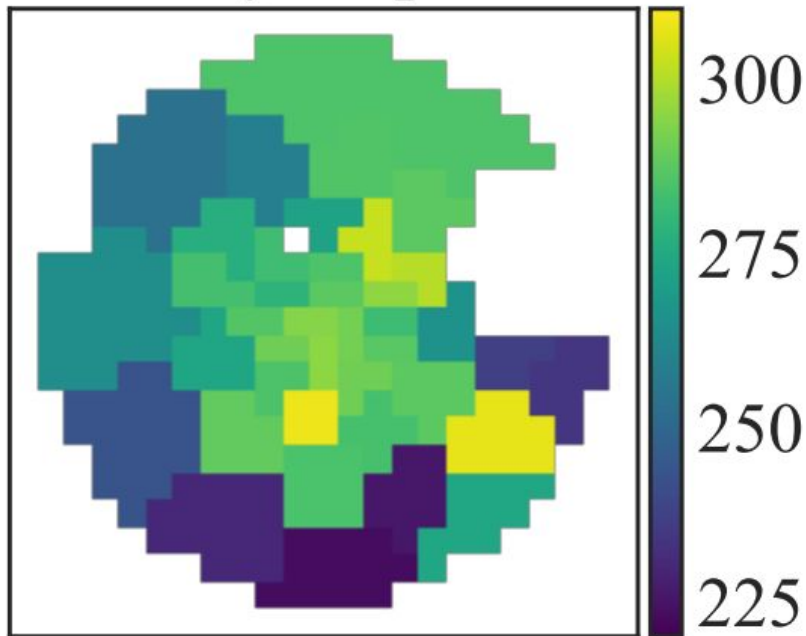
JWST NIRSpec - RXJ1131



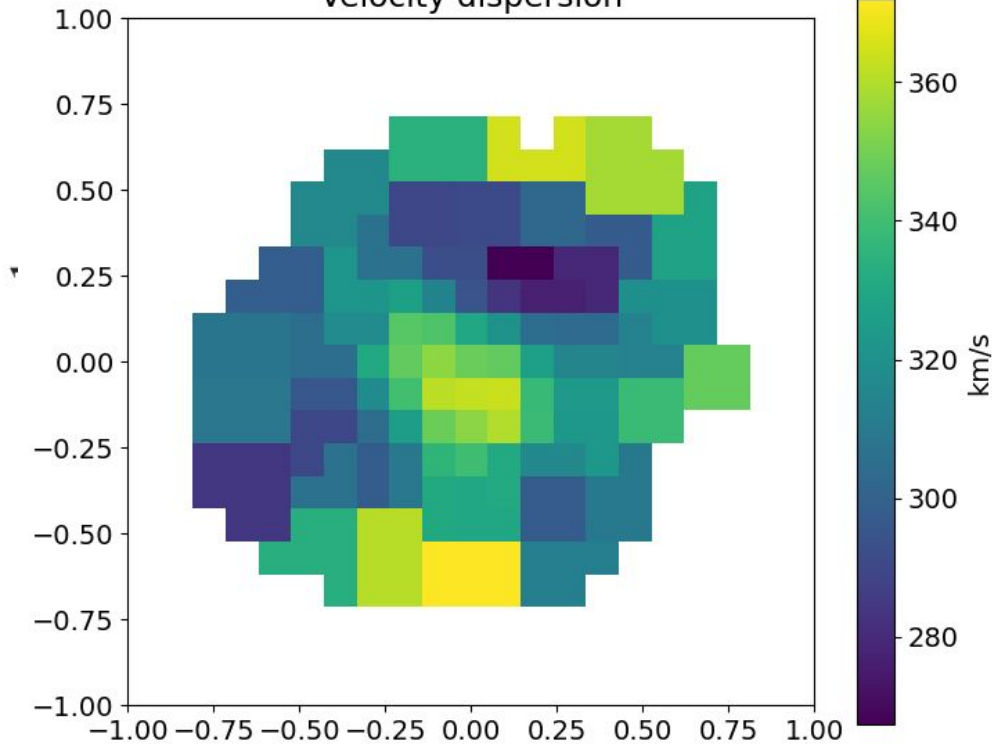
JWST NIRSpec - RXJ1131



Velocity dispersion



Velocity dispersion

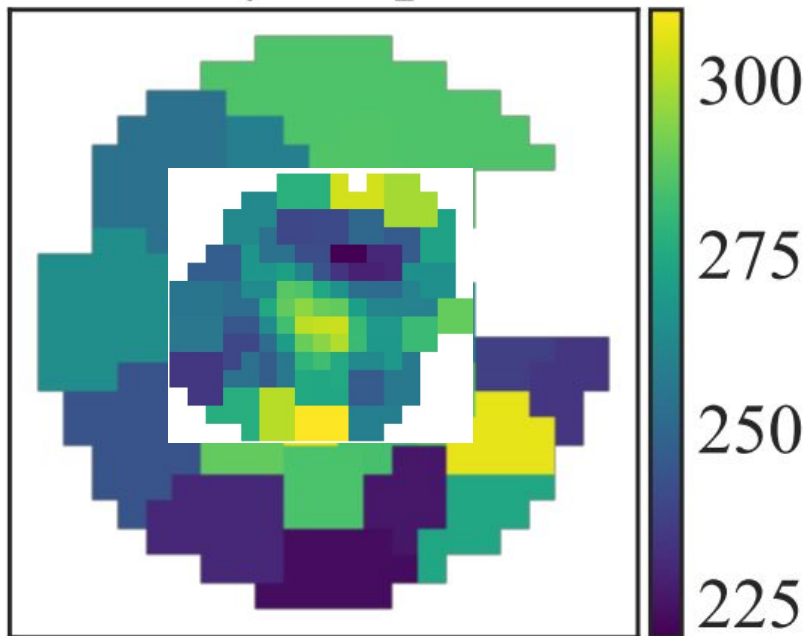


Knabel, Suyu, Treu, Law + ?

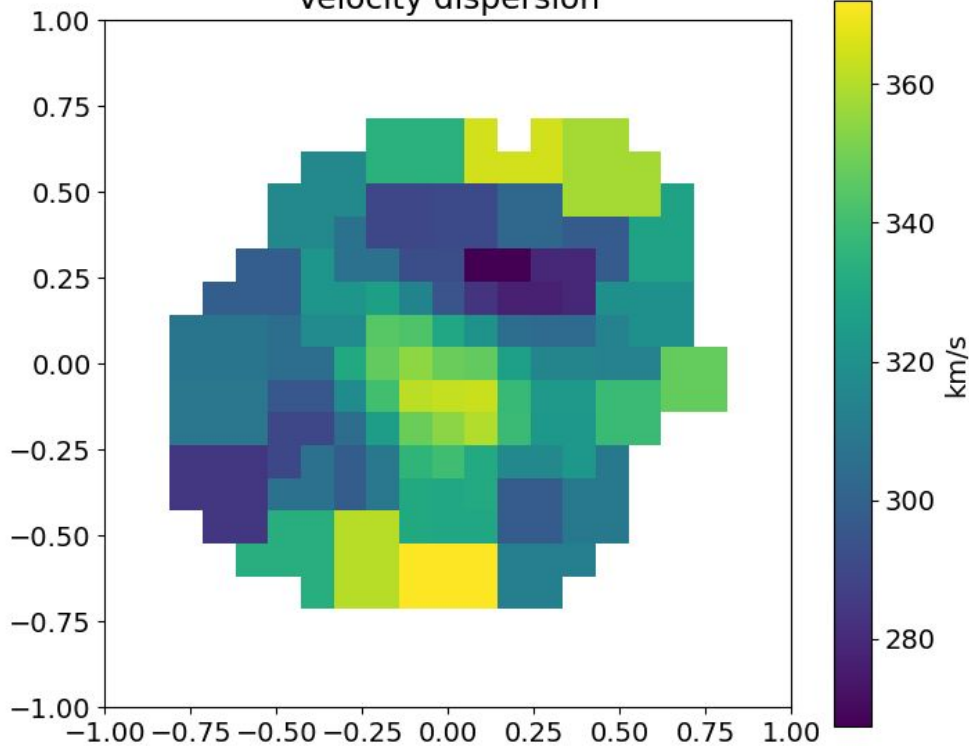
JWST NIRSpec - RXJ1131



Velocity dispersion



Velocity dispersion



Knabel, Suyu, Treu, Law + ?

Summary: what have we learned?



1. Spatially resolved kinematics from IFU spectroscopy strongly constrains uncertainties in time-delay cosmography.
2. Hierarchical inference and new samples have limit with current technology.
3. JWST and ELTs will grant greater precision to achieve close to 1% precision when combined with current methods.

Bonus : James Webb Space Kaleidoscope



Many thanks to
Tommaso and
the team :)

