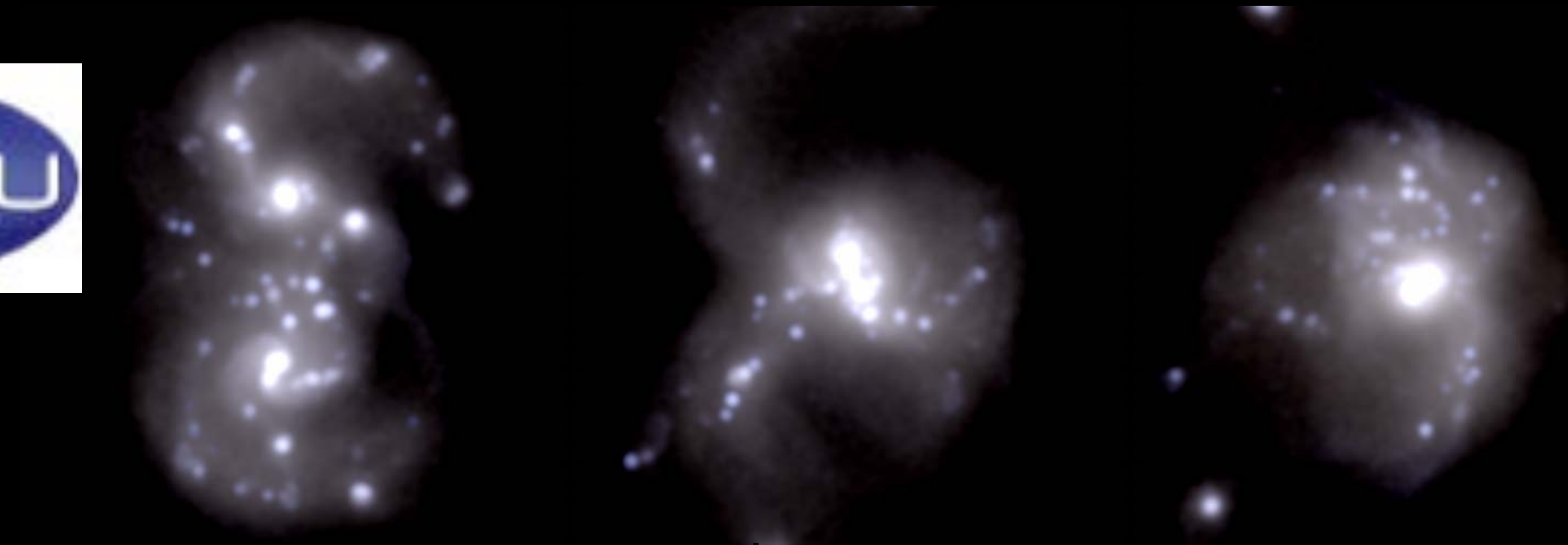
Journée scientifique du GT Cosmo d'OCEVU, Montpellier 28 mai 2014

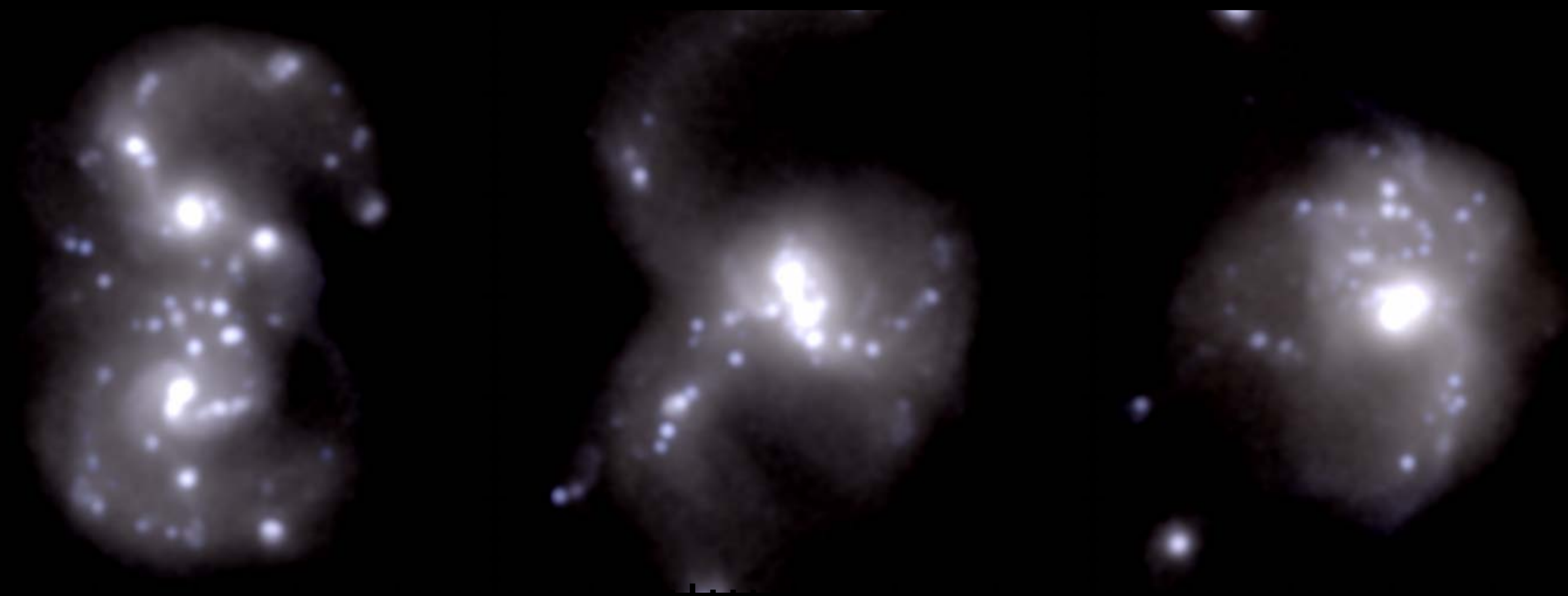


REGAL (What REgulates the growth of GALaxies) ?

PI: Thierry Contini (8 people from LAM and 5 from IRAP)

The missing piece to understand galaxy Evolution
Mechanisms of galaxy evolution since redshift 3.

Two complementary lines:
a) the investigation of the rich phenomenology of gas inflows and outflows
b) the exploration of the mechanisms that rule the building of galaxy disks in different environments.



MERGERS OF TEENAGE GALAXIES: FROM SIMULATIONS TO OBSERVATIONS

VALENTIN PERRET - PHD THESIS - 2014

Aix*Marseille université

LAM
LABORATOIRE D'ASTROPHYSIQUE DE MARSEILLE

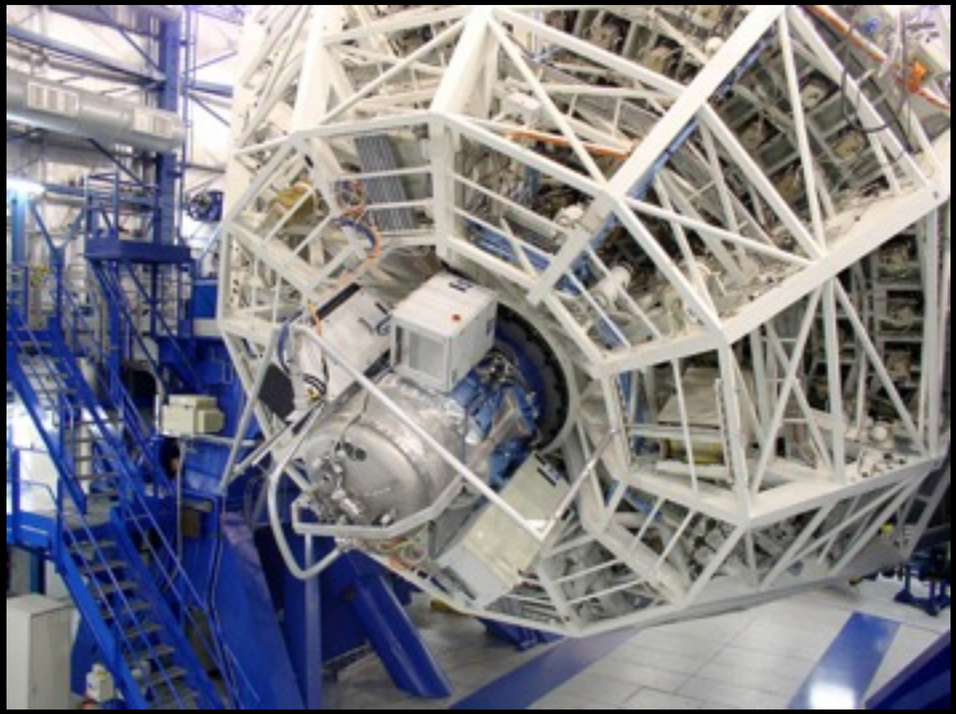
OBSERVATIONAL CONTEXT

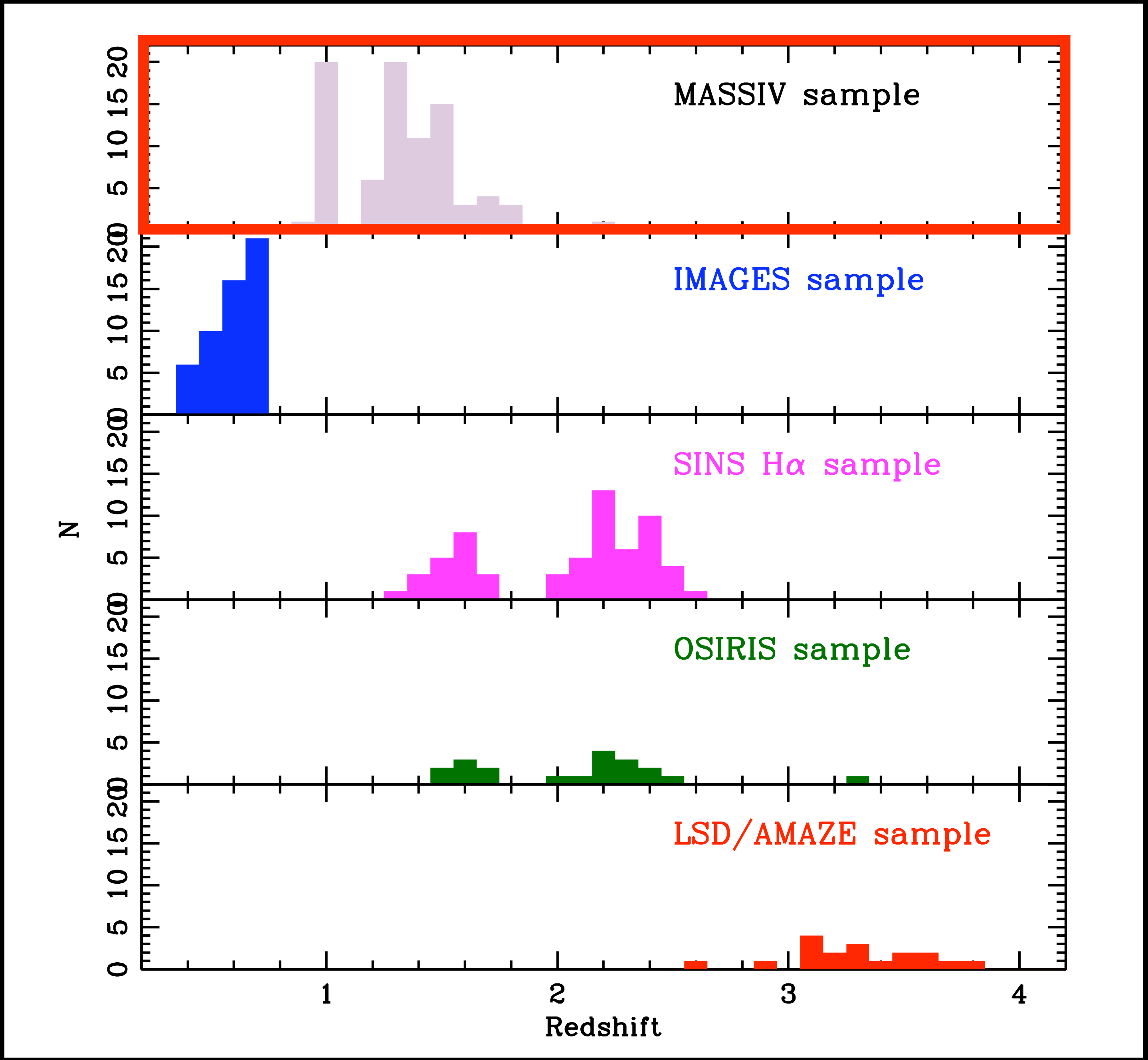
THE MASSIV SAMPLE

Mass Assembly Survey with SINFONI in VVDS

Contini et al. 2012

- ESO Large program (200 hours)
- Sample: 83 star-forming galaxies @ 0.9<z<1.8
- Observed with SINFONI IFU @ VLT
- Seeing-limited (<0.8")
- 13 galaxies observed with AO/LGS
- J/H Bands / H? emission line

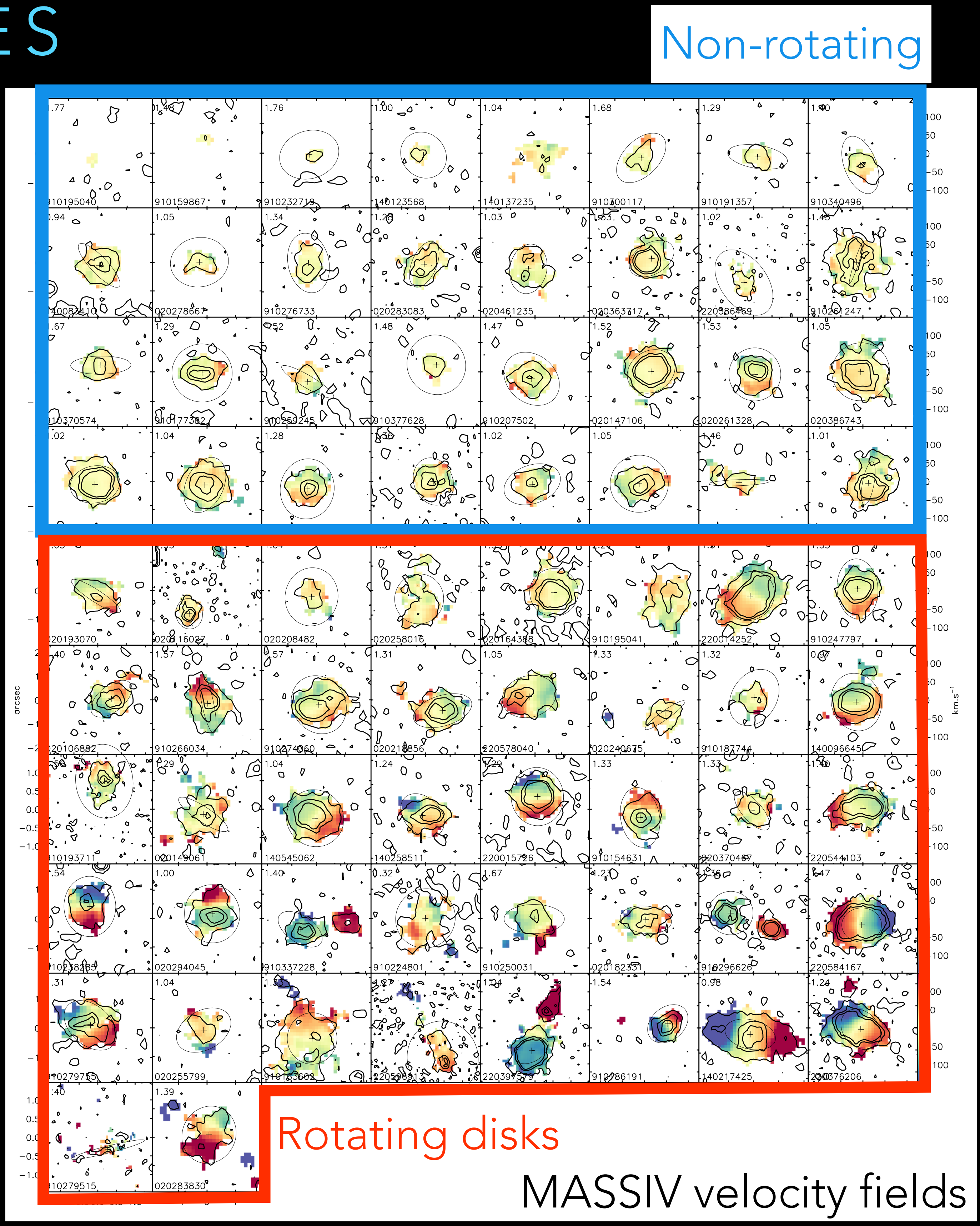




OBSERVATIONAL CONTEXT

FUNDAMENTAL ISSUES

- How clumps impact the measured kinematical properties?
- Nature of non-rotating objects:
  - mergers?
  - spheroids?
  - face-on disks?
- Can we unambiguously identify kinematical signatures of a recent merger?



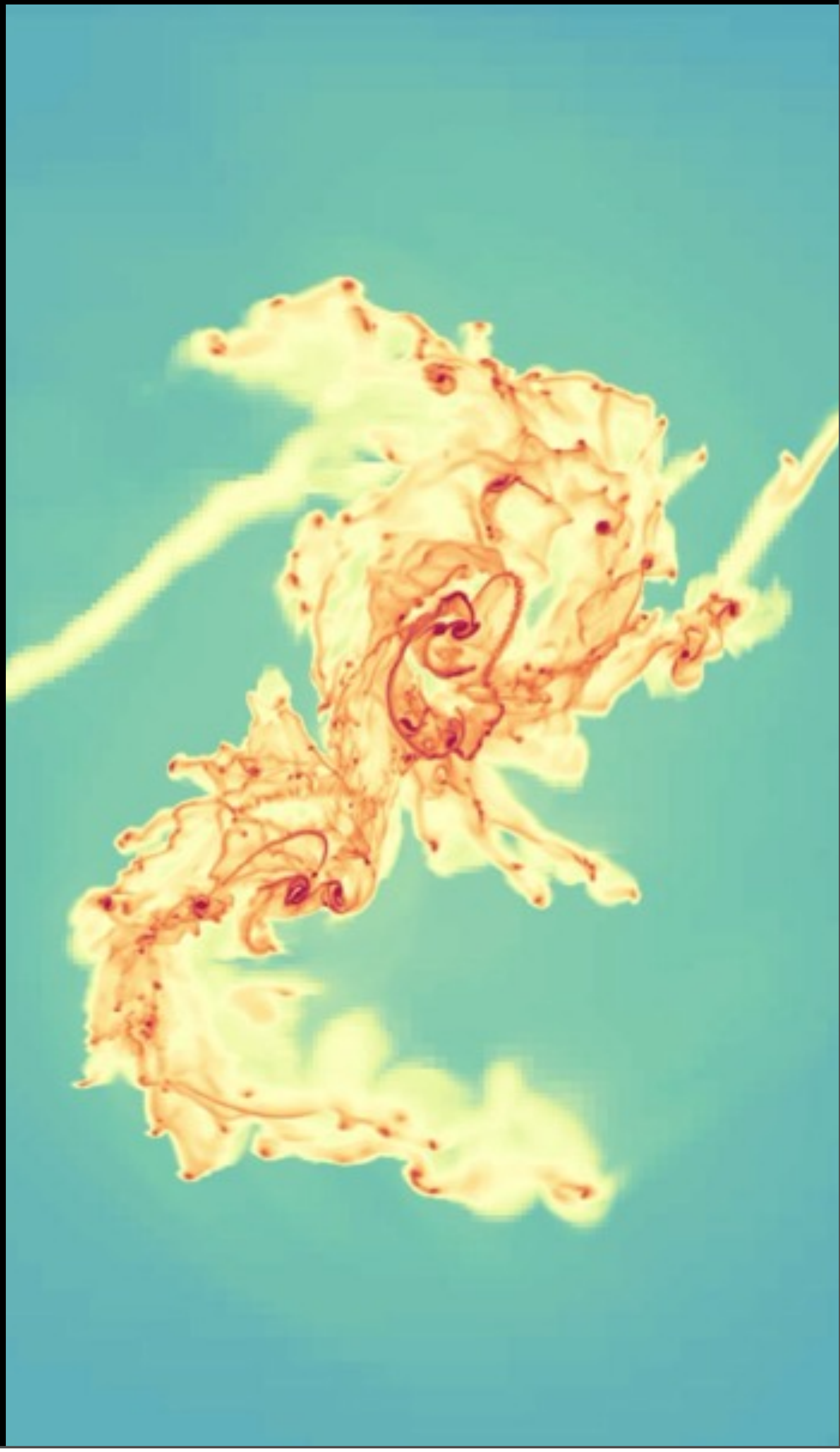
OBSERVATIONAL CONTEXT -REQUIRED SIMULATIONS : THE MIRAGE SAMPLE

[MERGING & ISOLATED HIGH-REDSHIFT AMR GALAXIES]

- Build a sample of high-z merging & isolated galaxies

- High gas fraction (~60%) to study the impact of the presence of massive clumps in such interactions

- Physical properties in accordance with observations in the range 1<z<2



SAMPLE DEFINITION

INITIAL CONDITION PARAMETERS

		G1	G2	G3
	Virial quantities			
1	$log(M_\star)$	10.60	10.20	9.80
2	R_{200} $[kpc]$	99.8	73.4	54.0
3	M_{200} $[10^{10} M_\odot]$	102.4	40.8	16.2
4	V_{200} $[km.s^{-1}]$	210.1	154.6	113.7
	Scalelength			
5	$r_\star$ $[kpc]$	2.28	1.62	1.15
6	r_{gas} $[kpc]$	3.71	2.64	1.88
7	$h_\star$ $[kpc]$	0.46	0.32	0.23
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	Mass fractions			
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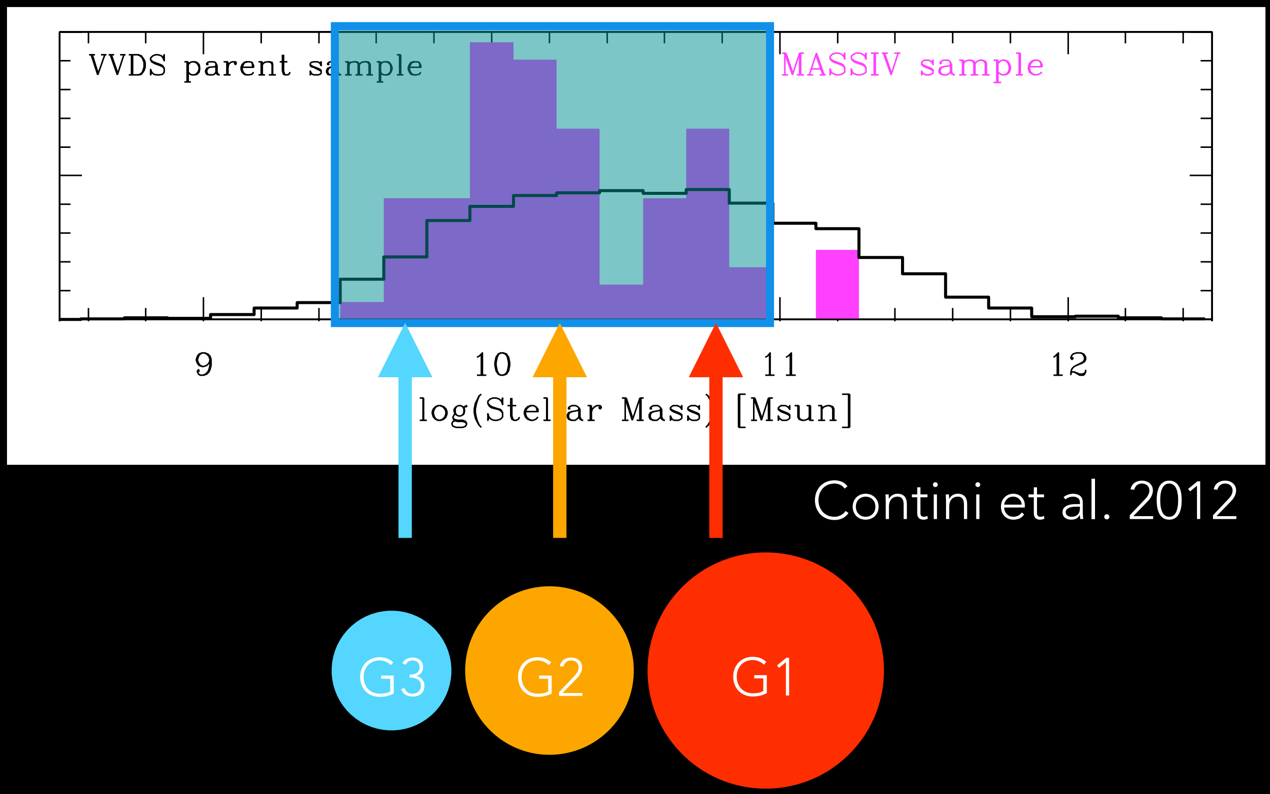
13	m_d		0.10	
	Collisionless particles			
14	N_{disk} $[10^6]$	2.00	0.80	0.32
15	N_{halo} $[10^6]$	2.00	0.80	0.32
16	N_{bulge} $[10^6]$	0.22	0.09	0.04
	Various quantites			
17	Q_{min}		1.5	
18	Z_{core}	0.705	0.599	0.479



Contini et al. 2012

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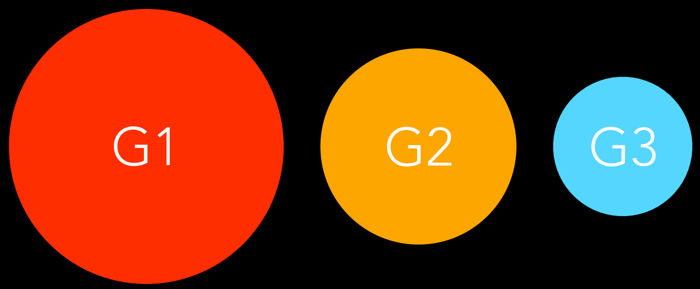
- Initial scales set using 1<z<2 mass-size relations of MASSIV
- Hernquist halo with low concentration
- High initial gas fraction
- Initially stabilized stellar disks
- Idealized initial conditions mimicking z=2 galaxies

SAMPLE DEFINITION

MERGERS CONFIGURATIONS

3 disk models

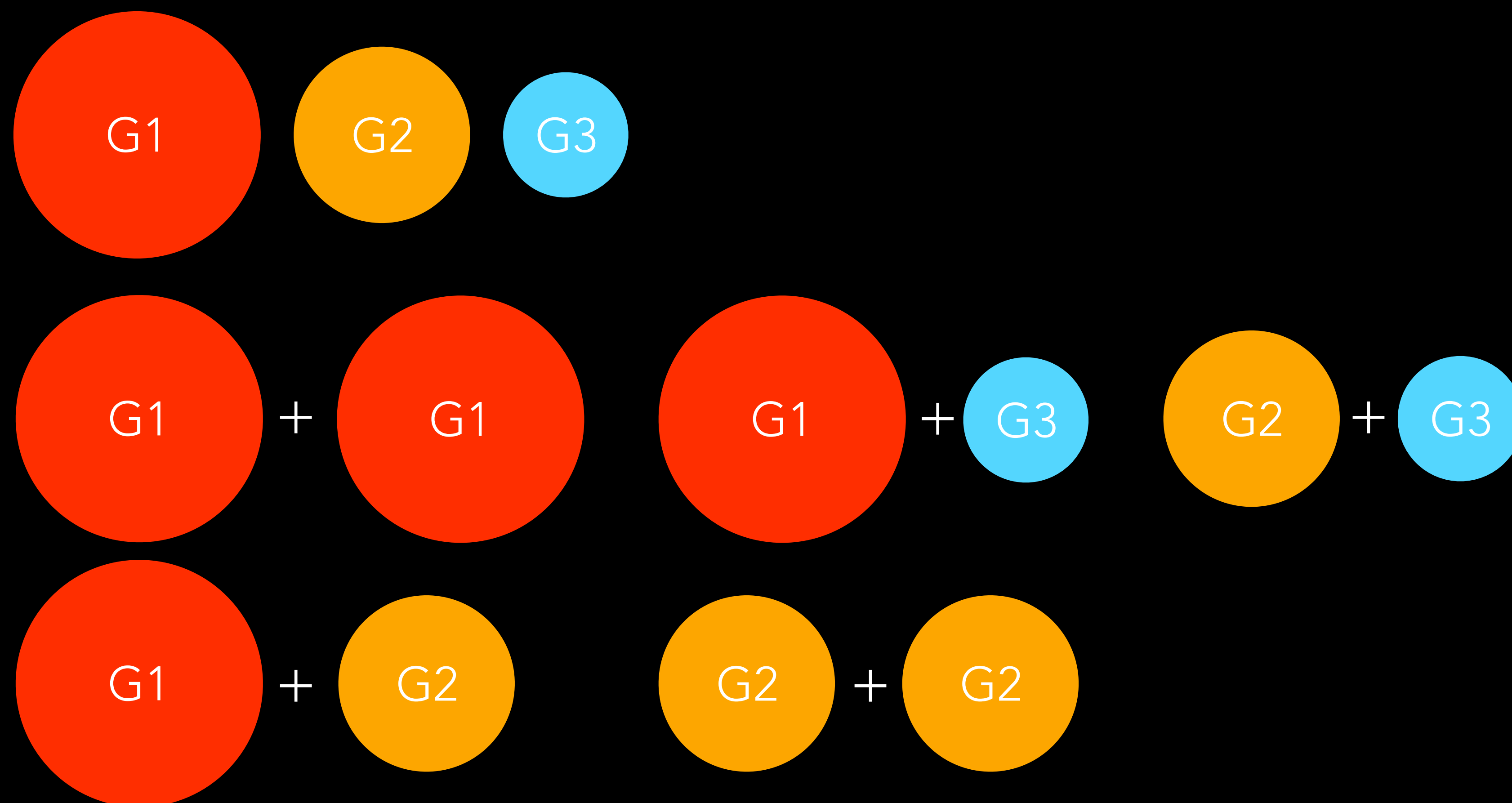


SAMPLE DEFINITION

MERGERS CONFIGURATIONS

3 disk models

5 mass configurations for the merger simulations



SAMPLE DEFINITION

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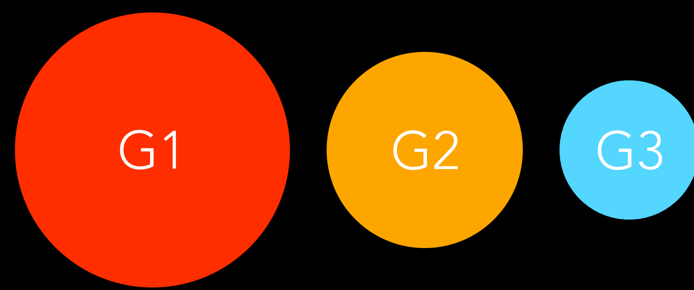

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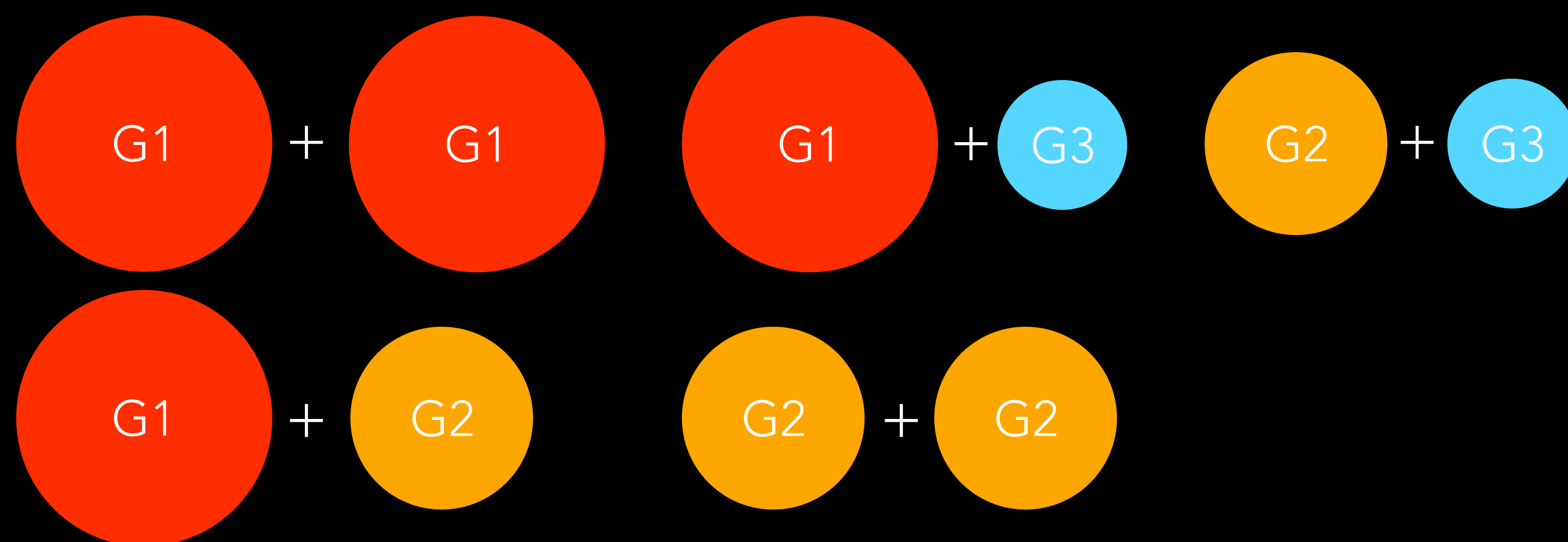
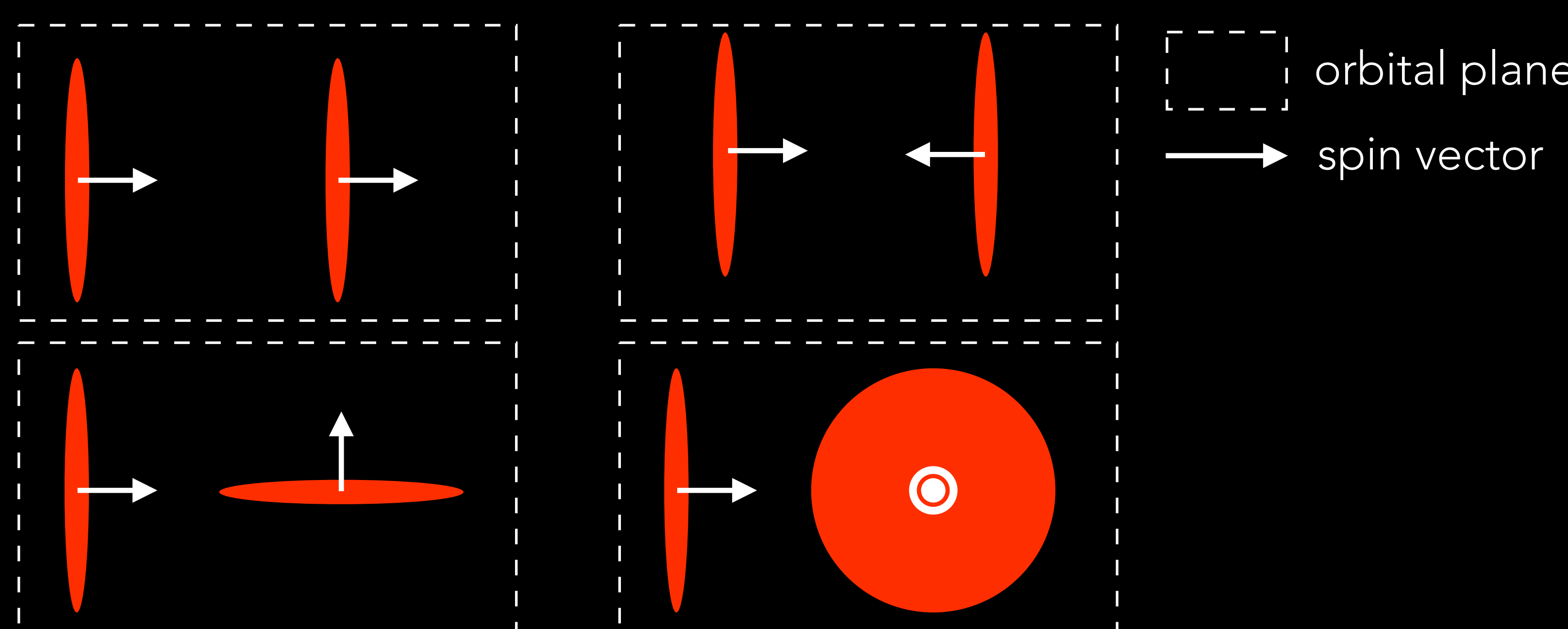


4 initial disk orientations



SAMPLE DEFINITION

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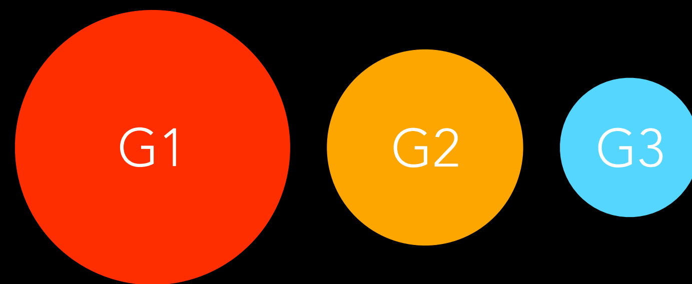

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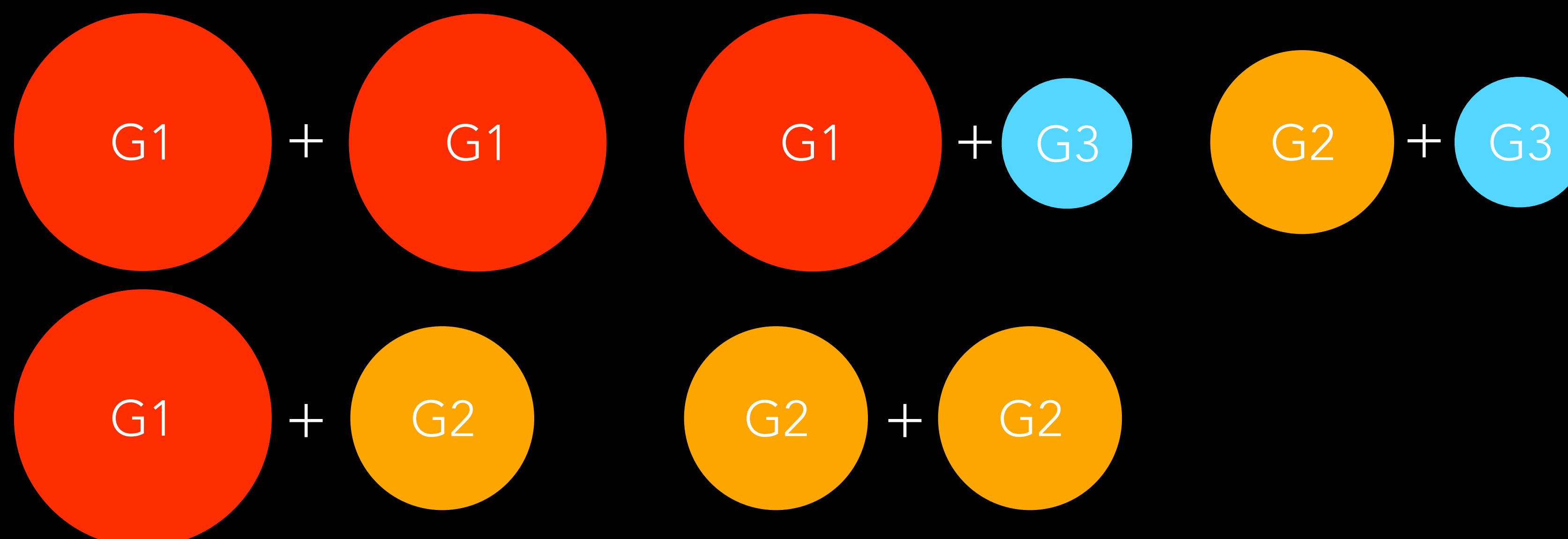

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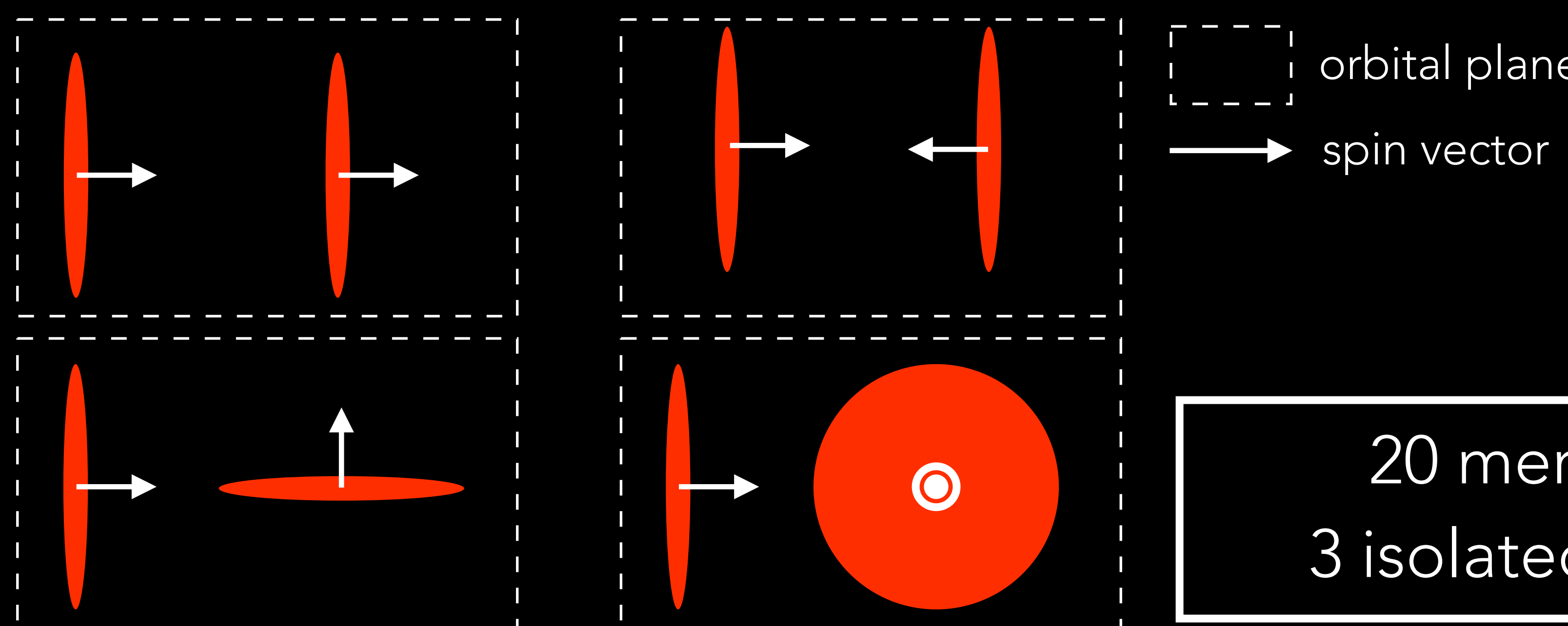
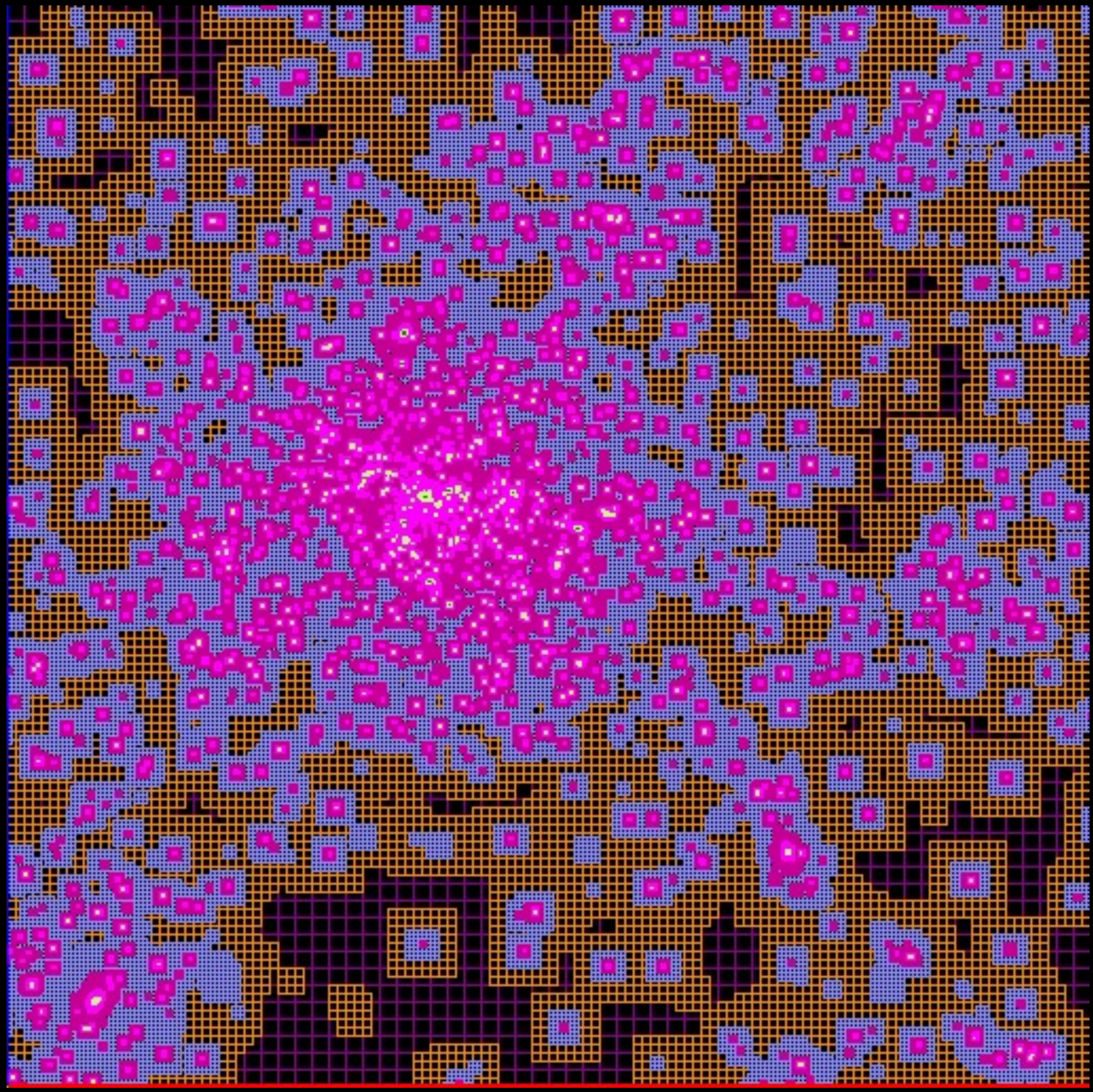


20 mergers
3 isolated disks

NUMERICAL RECIPES

- RAMSES code (Teyssier 2001):
  - AMR box size = 240 kpc
    Best resolution = 7.3 pc



Credits: R. Teyssier

NUMERICAL RECIPES

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  → OB-type stars feedback active: 20% of the stellar mass during 10 Myr (Salpeter IMF)

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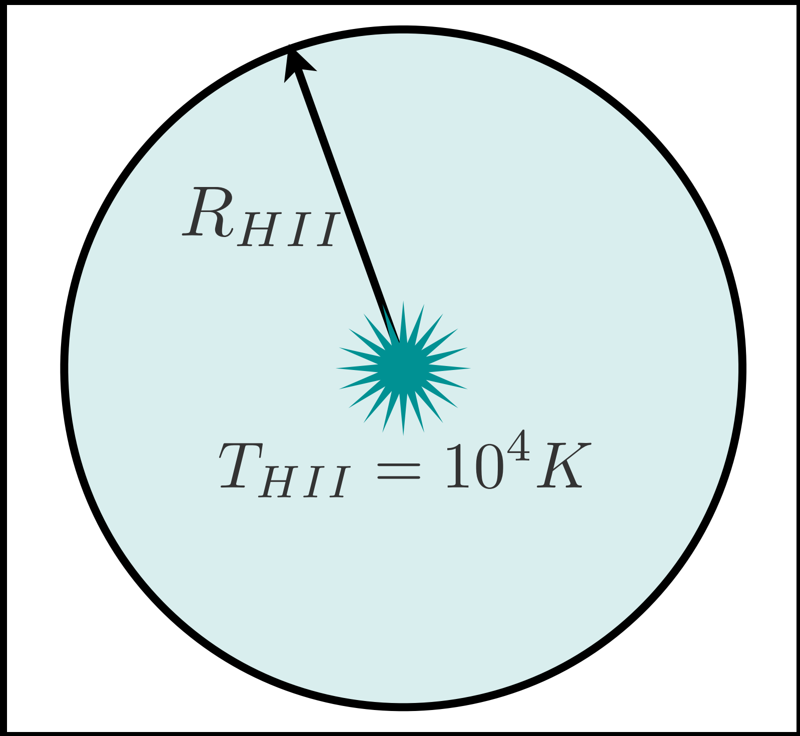

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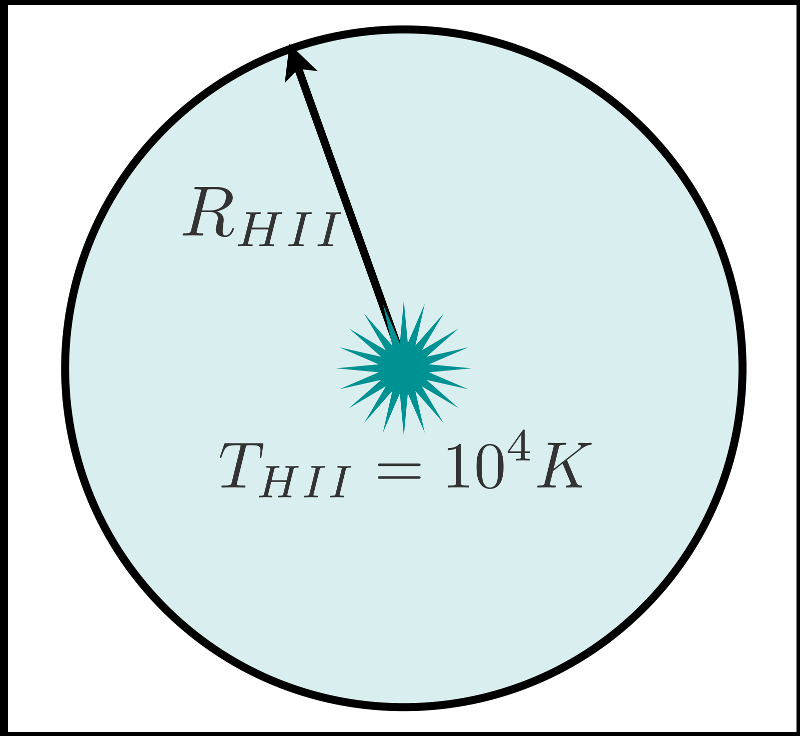

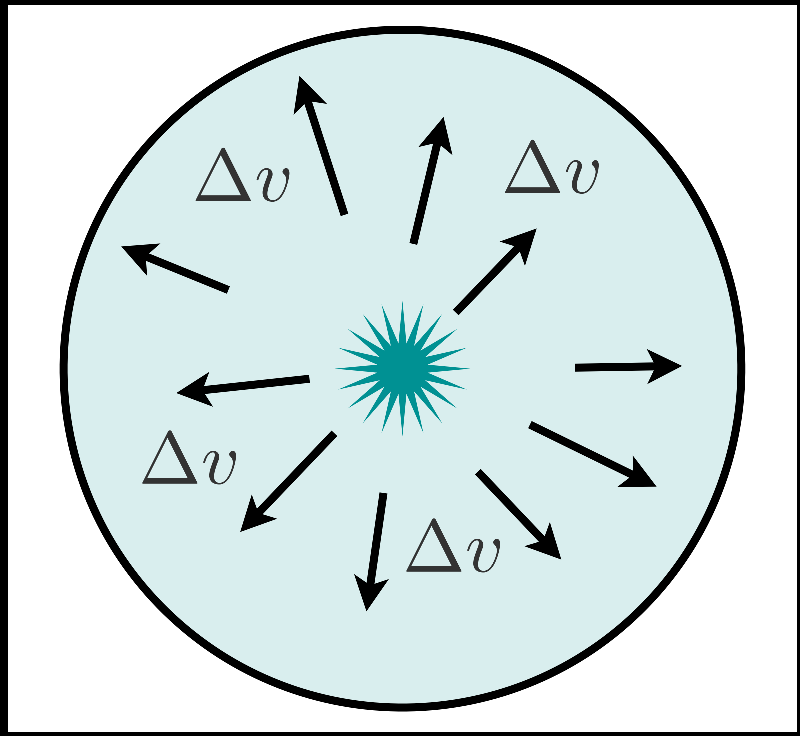

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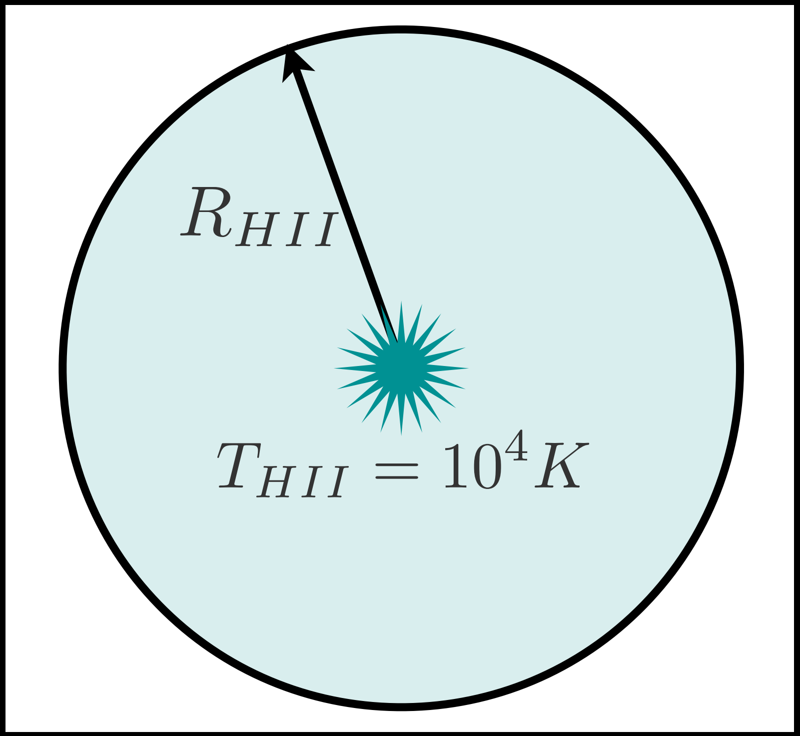
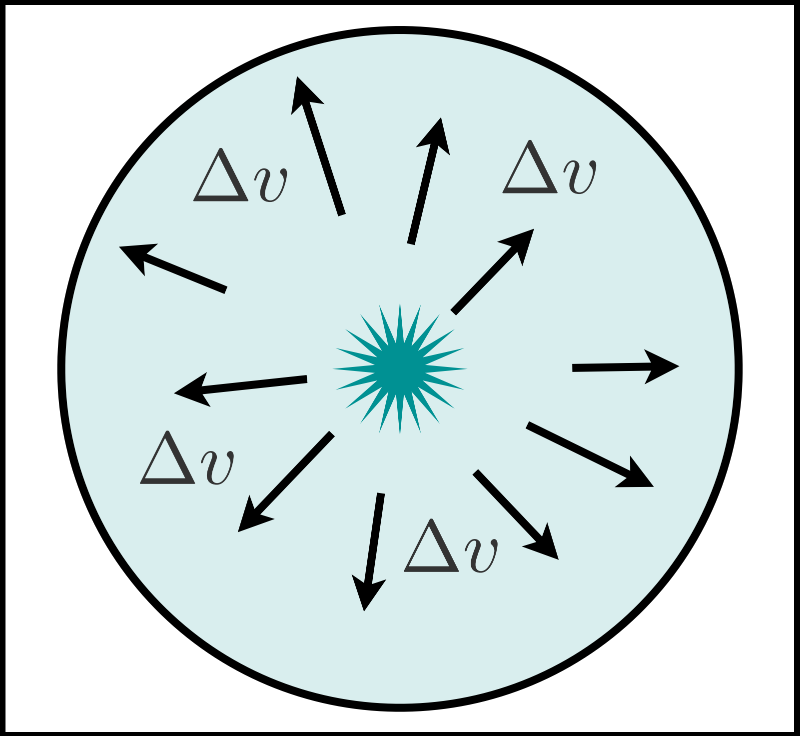
  - Radiative pressure: radial velocity kick accounting for photon scattering

  - Supernova thermal feedback:
    $2{\times}10^{51}$ ergs / $10M_\odot$
    → Turbulence modeled with a cooling switch
    t_{dissip}=2 Myr (Teyssier et al. 2013)





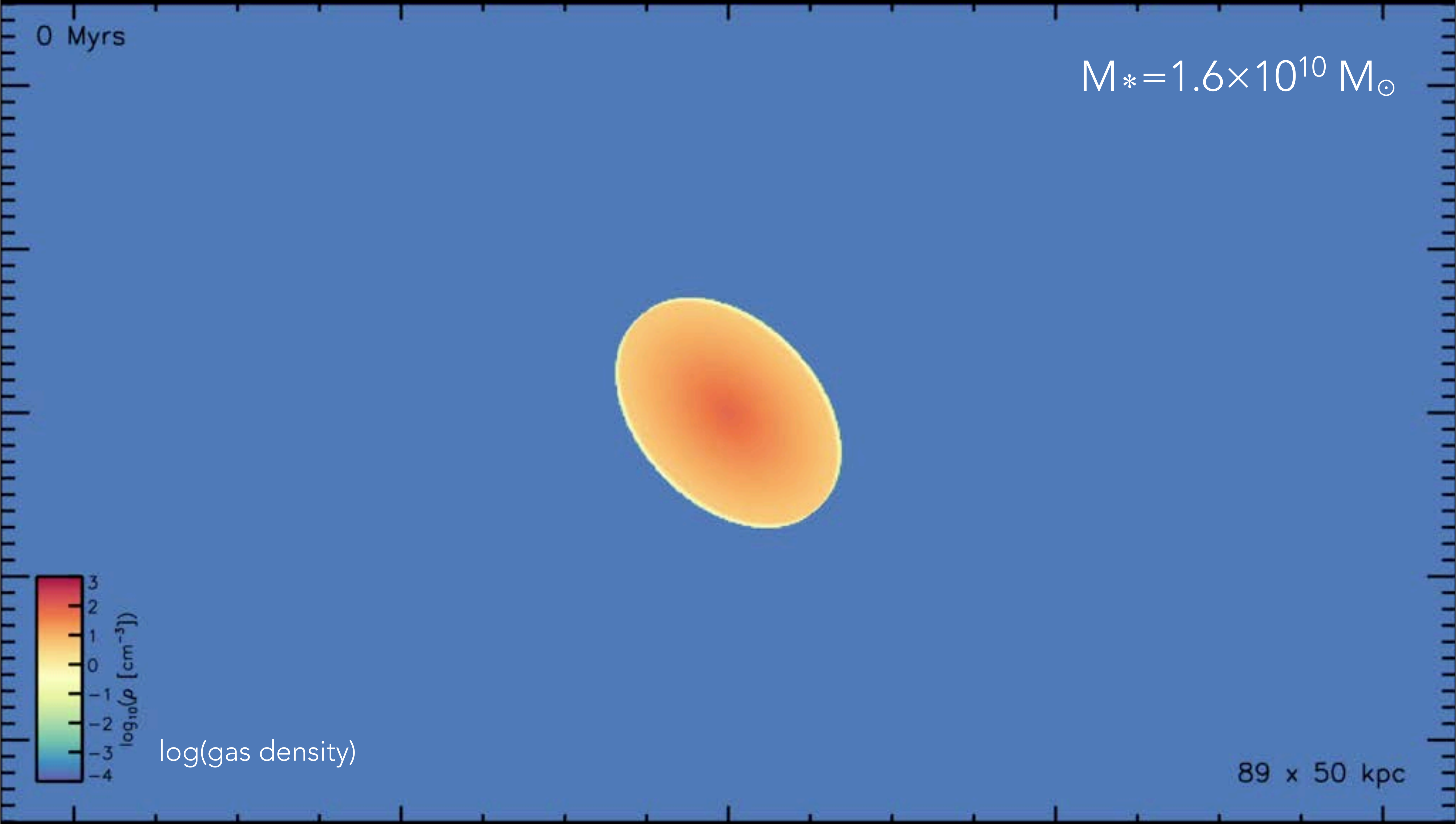
SAMPLE ANALYSIS
GAS DENSITY EVOLUTION

$M_* = 1.6 \times 10^{10}\ M_\odot$

log(gas density)

SAMPLE ANALYSIS

GAS DENSITY EVOLUTION



SAMPLE ANALYSIS

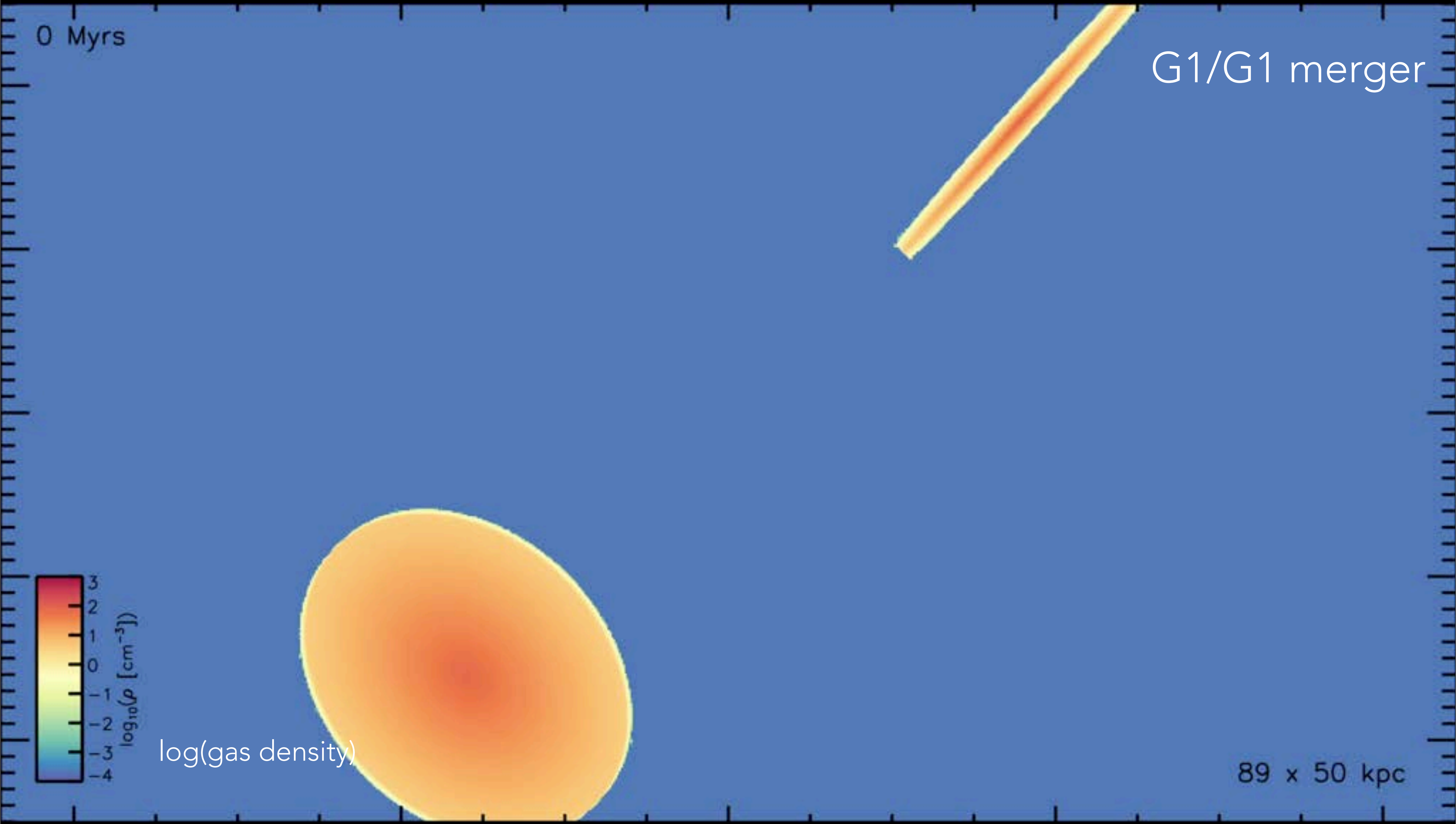
GAS DENSITY EVOLUTION

G1/G1 merger

log(gas density)

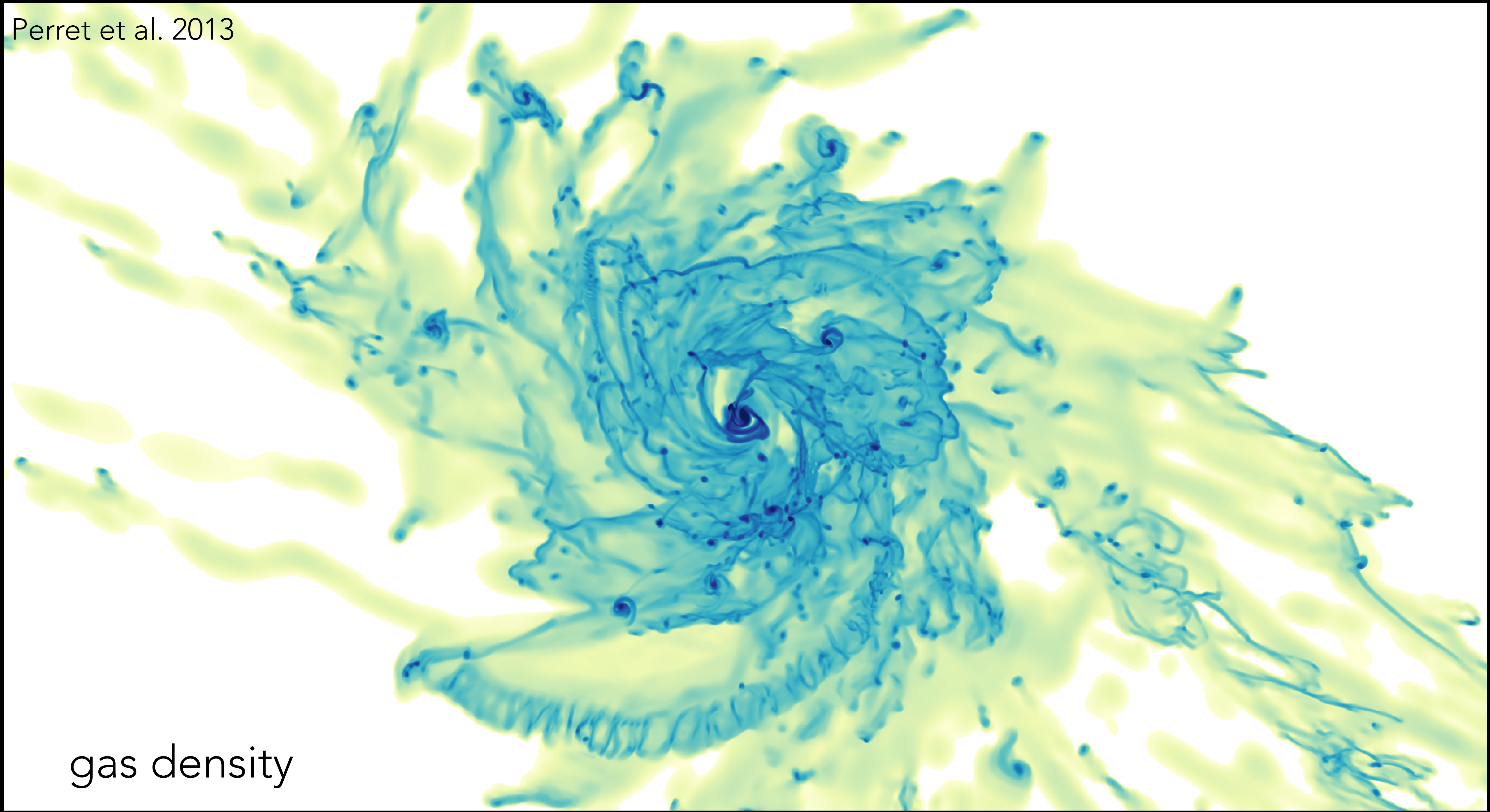
SAMPLE ANALYSIS

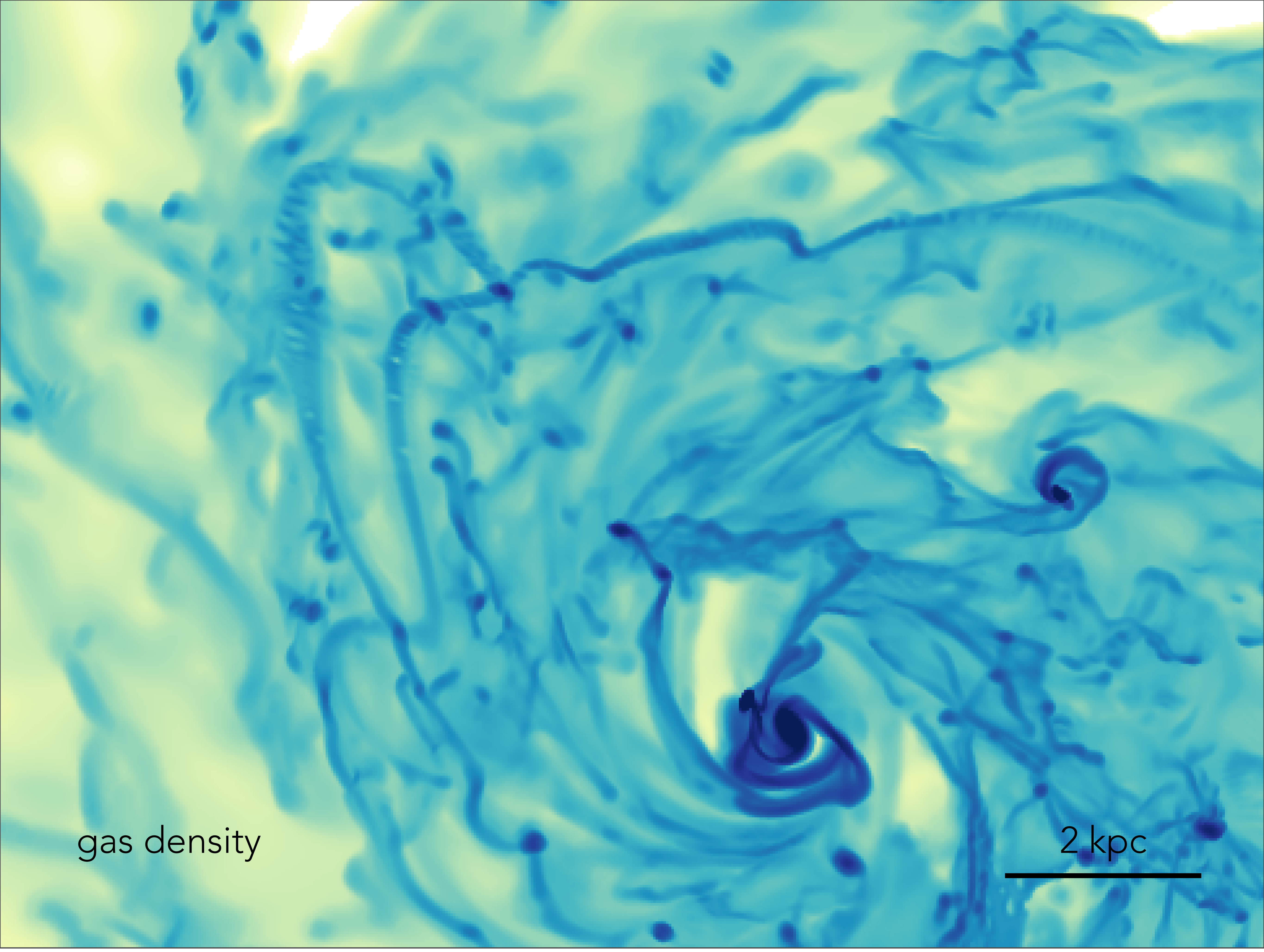
GAS DENSITY EVOLUTION



SAMPLE ANALYSIS

ISM TURBULENCE & FRAGMENTATION




gas density
2 kpc

SAMPLE ANALYSIS

CLUMP MERGER ILLUSTRATION

SAMPLE ANALYSIS

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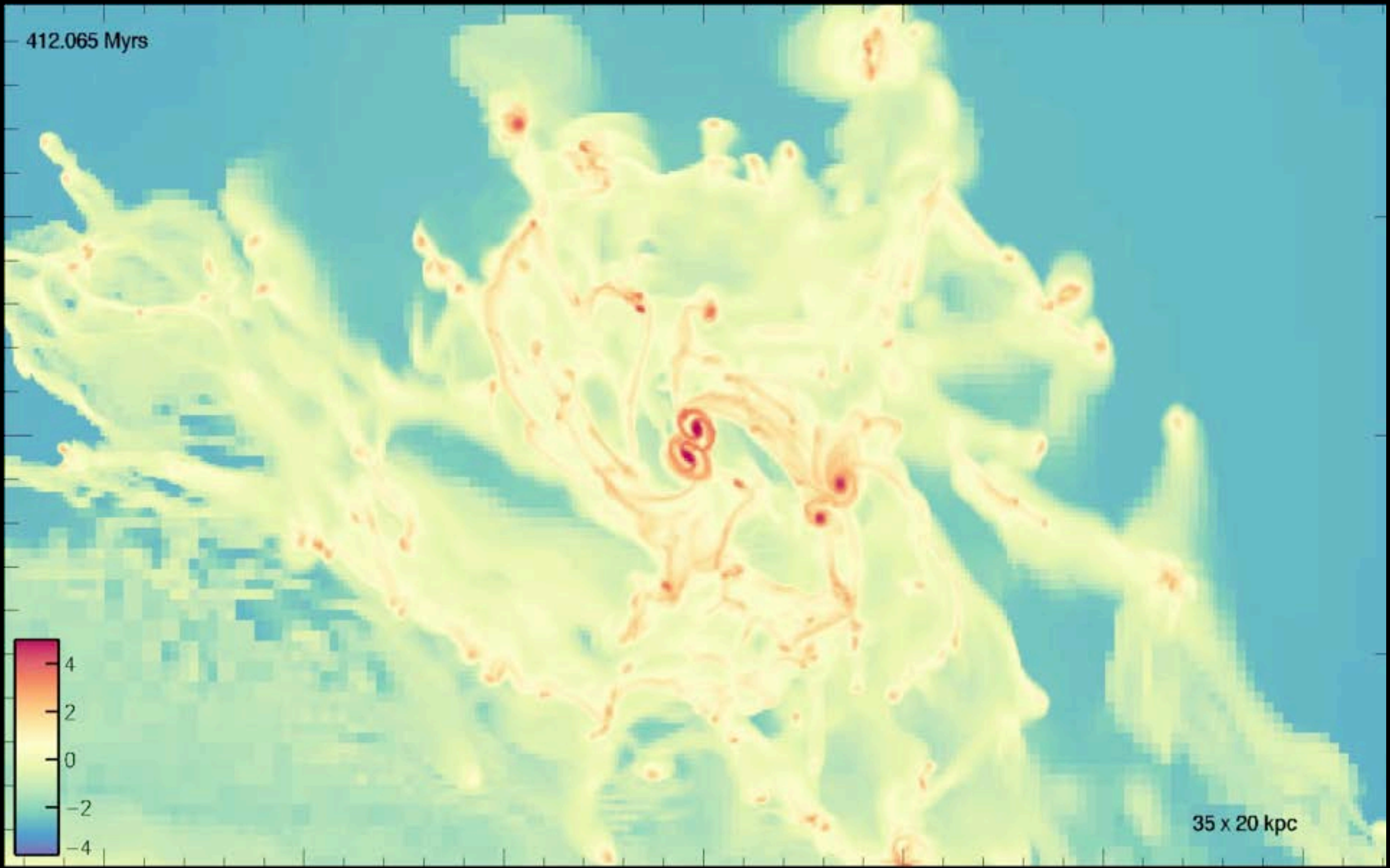


SAMPLE ANALYSIS
CLUMP MERGER ILLUSTRATION

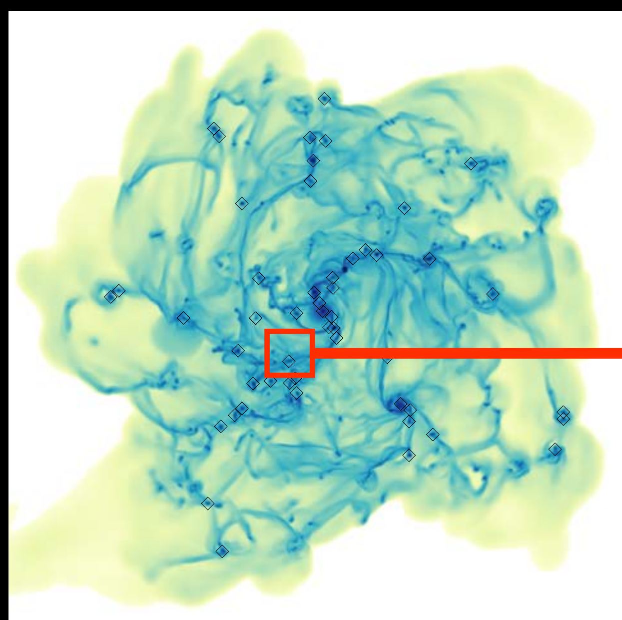
- **Gas-rich clump merger → massive gas outflows**
- **Clump merger ejections take place in the plane of the disk**
- **Outflows are sporadic**

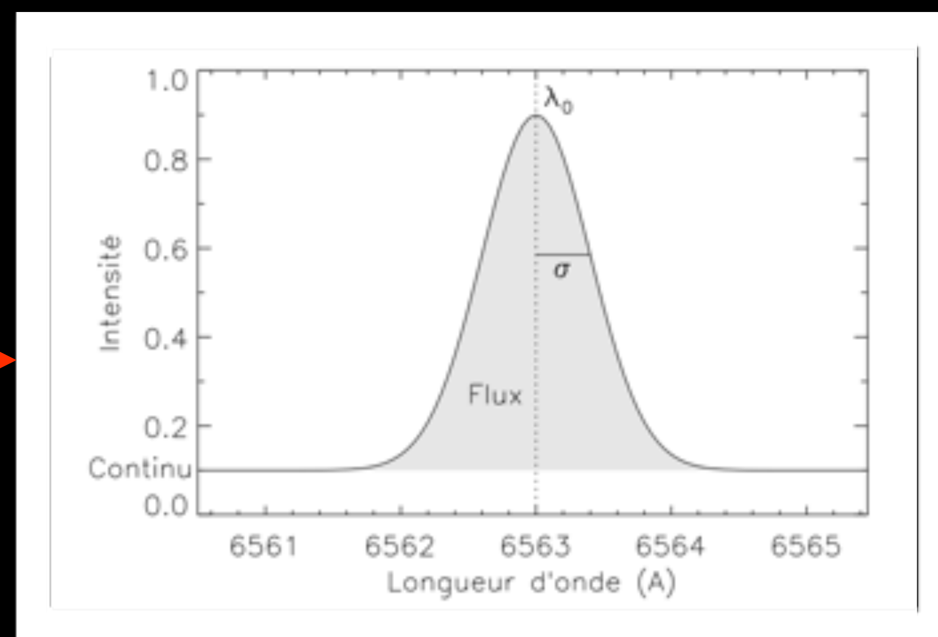
PSEUDO-OBSERVATIONS

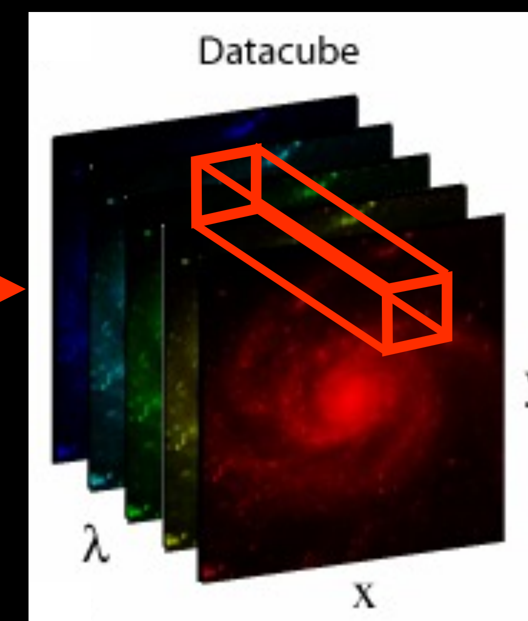
CREATION PROCEDURE

- computed for each hydrodynamical cell
- assumed to be Gaussian
- inserted into the mock cube

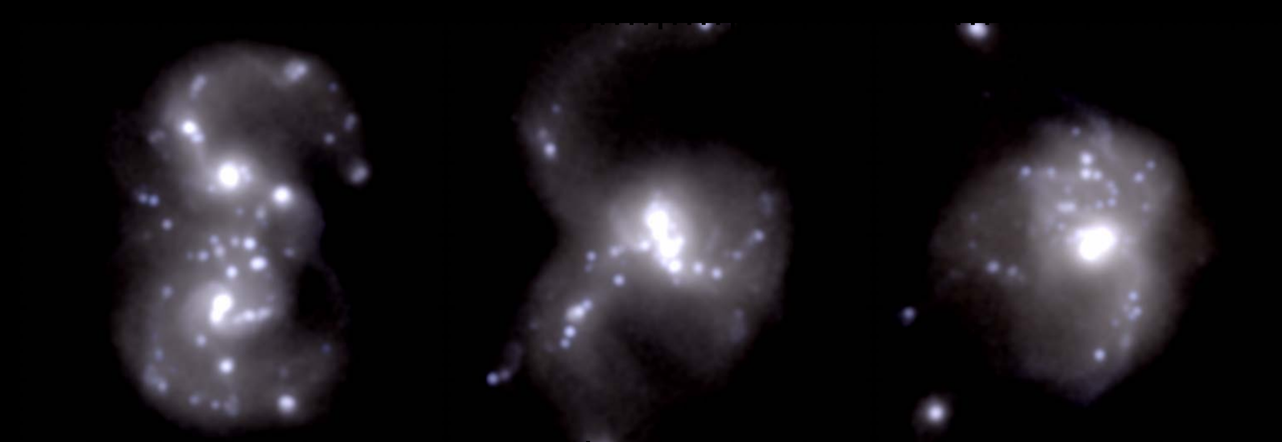
Simulation G2







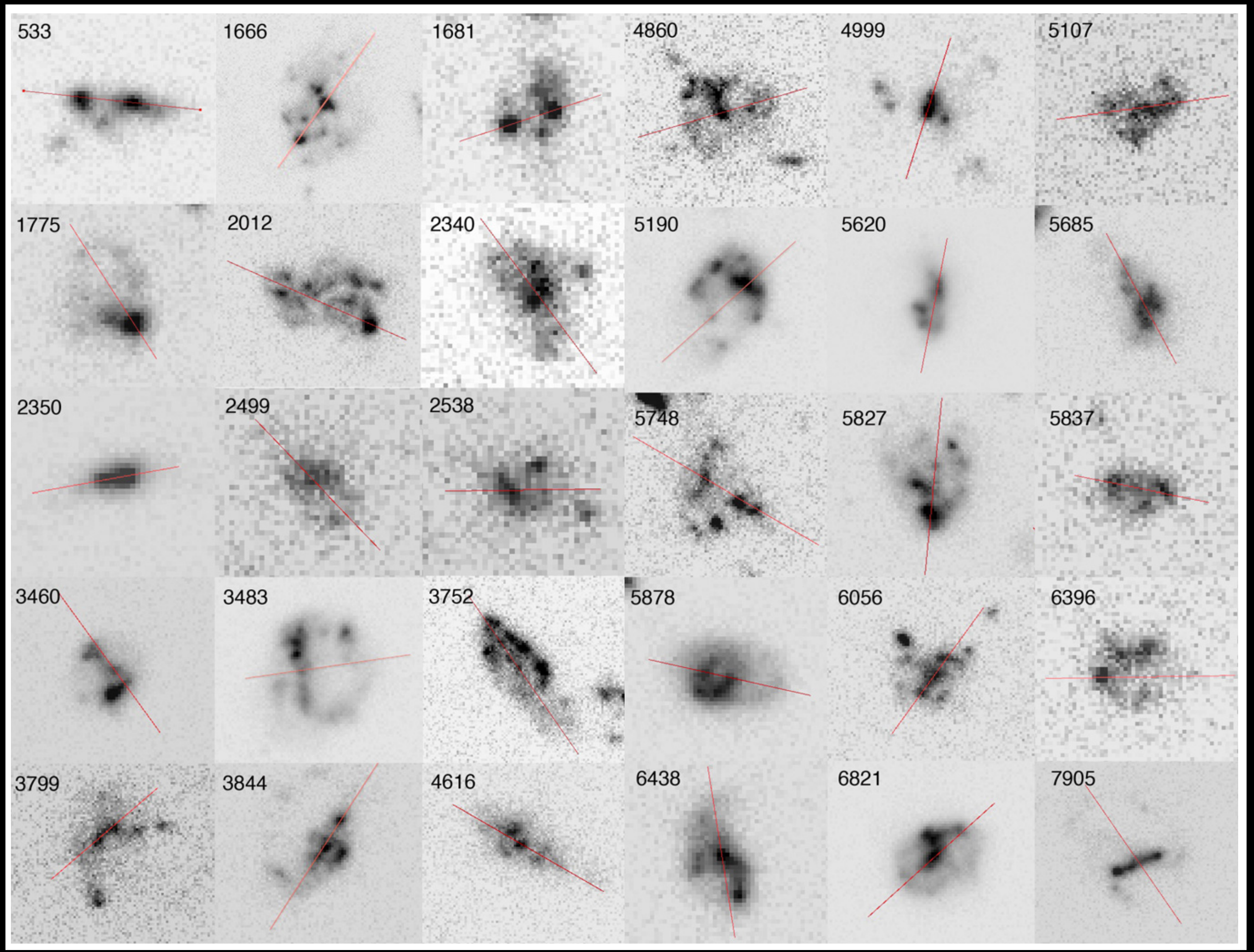
Set of mock observations using Starburst99 SEDs / filters transmission / instrument resolution



SDSS z~0.01 *ugr* composite images

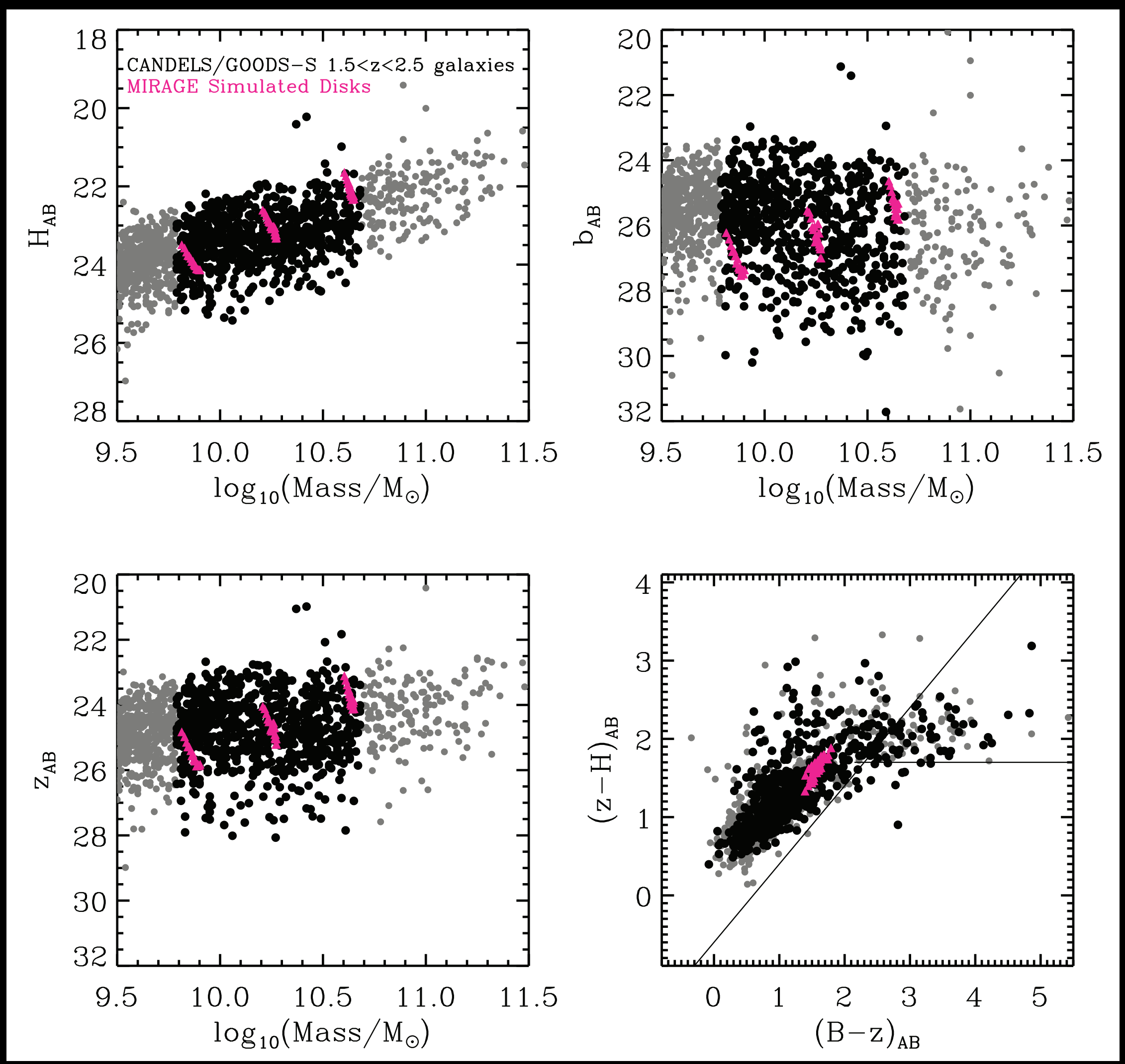
Kinematical and morphological studies for present facilities (KMOS, MUSE, SINFONI, ...) and forthcoming new generation of instrument (E-ELT, EUCLID,...)

- e.g. EUCLID will provide high quality imaging (FWHM~0.16”) for 2 billions of galaxies
- Can we trace the morphological transition that builds the local Hubble sequence?
- Clumpy galaxies fraction increase with redshift (Murata et al. 2014):
- More than half of the galaxies are clumpy at z>1 !
- Clumps may drive major morphological transition (e.g Bournaud et al. 2007, Elmegreen et al. 2009, Inoue et al. 2014, Perret et al. in prep)

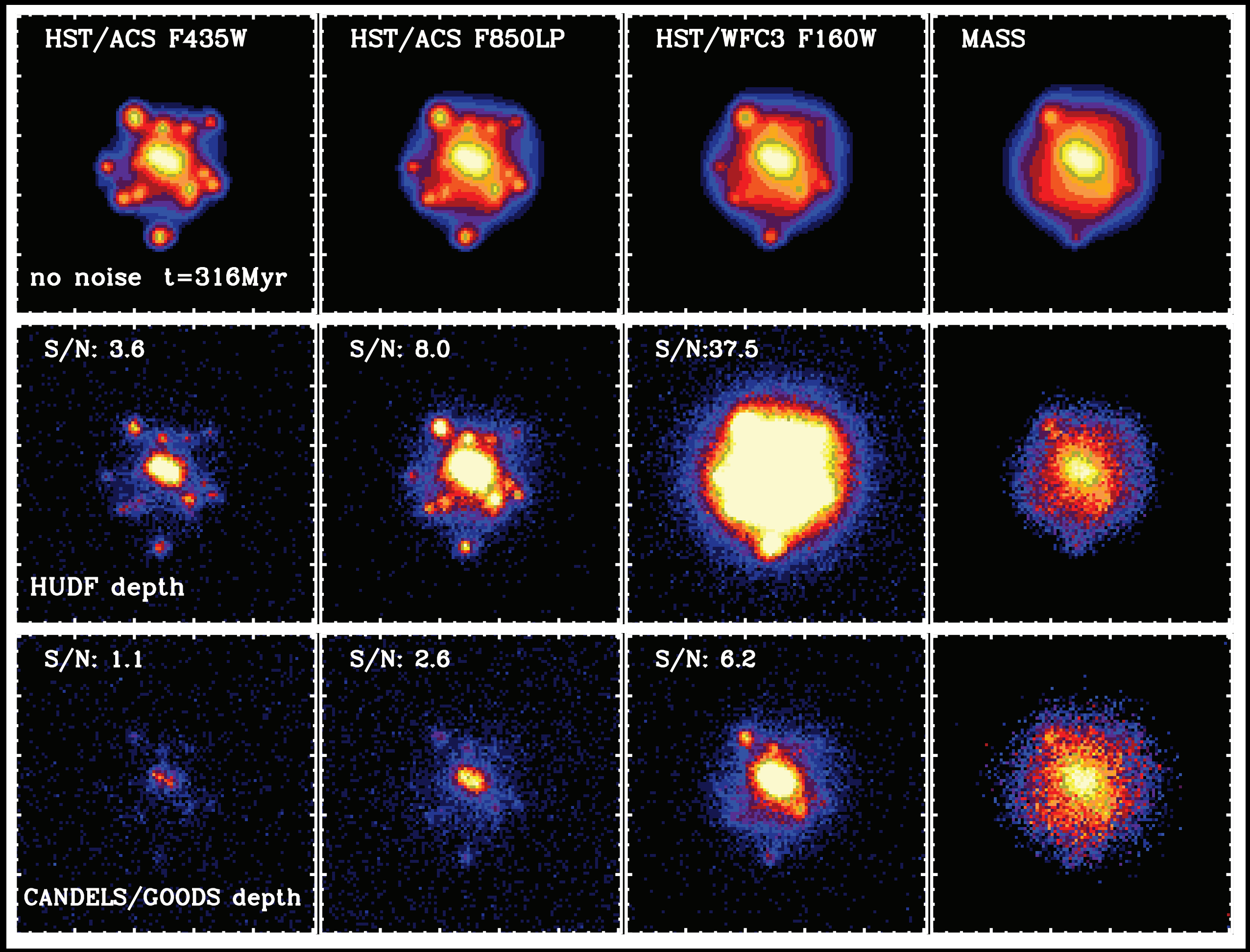


Clumpy galaxies @ <z>=1.7 observed with HST/ACS (Elmegreen et al. 2013)

MIRAGE: HST mock observations



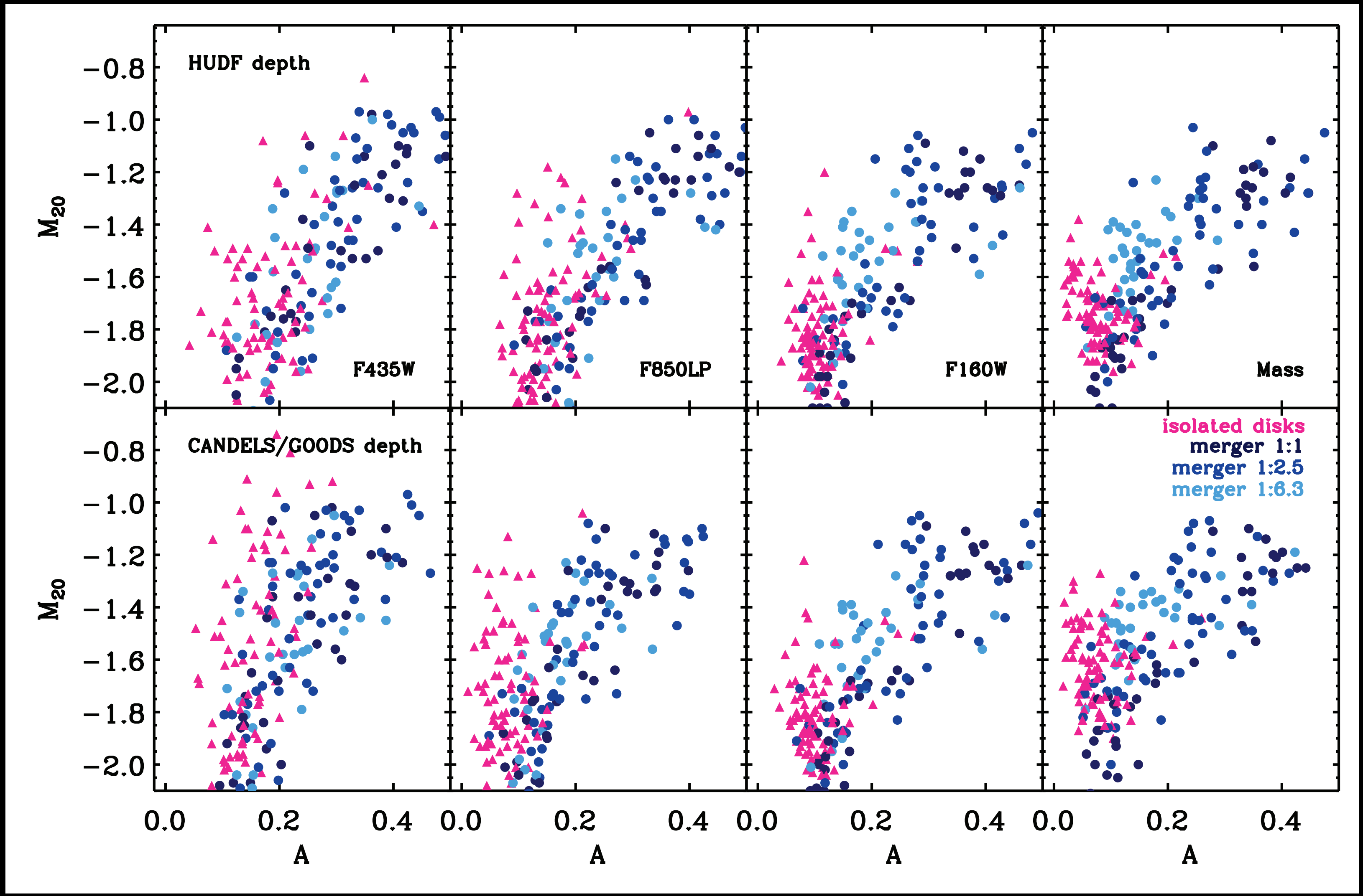
Location of the isolated MIRAGE disks on the color vs. mass diagram & BzH color-color plot.
Cibinel, Perret et al. in prep.



Postage-stamp example of one isolated MIRAGE disk.
Cibinel, Perret et al. in prep.

- Comparison MIRAGE vs. GOODS-S/CANDELS @ 1.5<z<2.5 using ~3000 pseudo-observations

Morphological detection of clumpy mergers

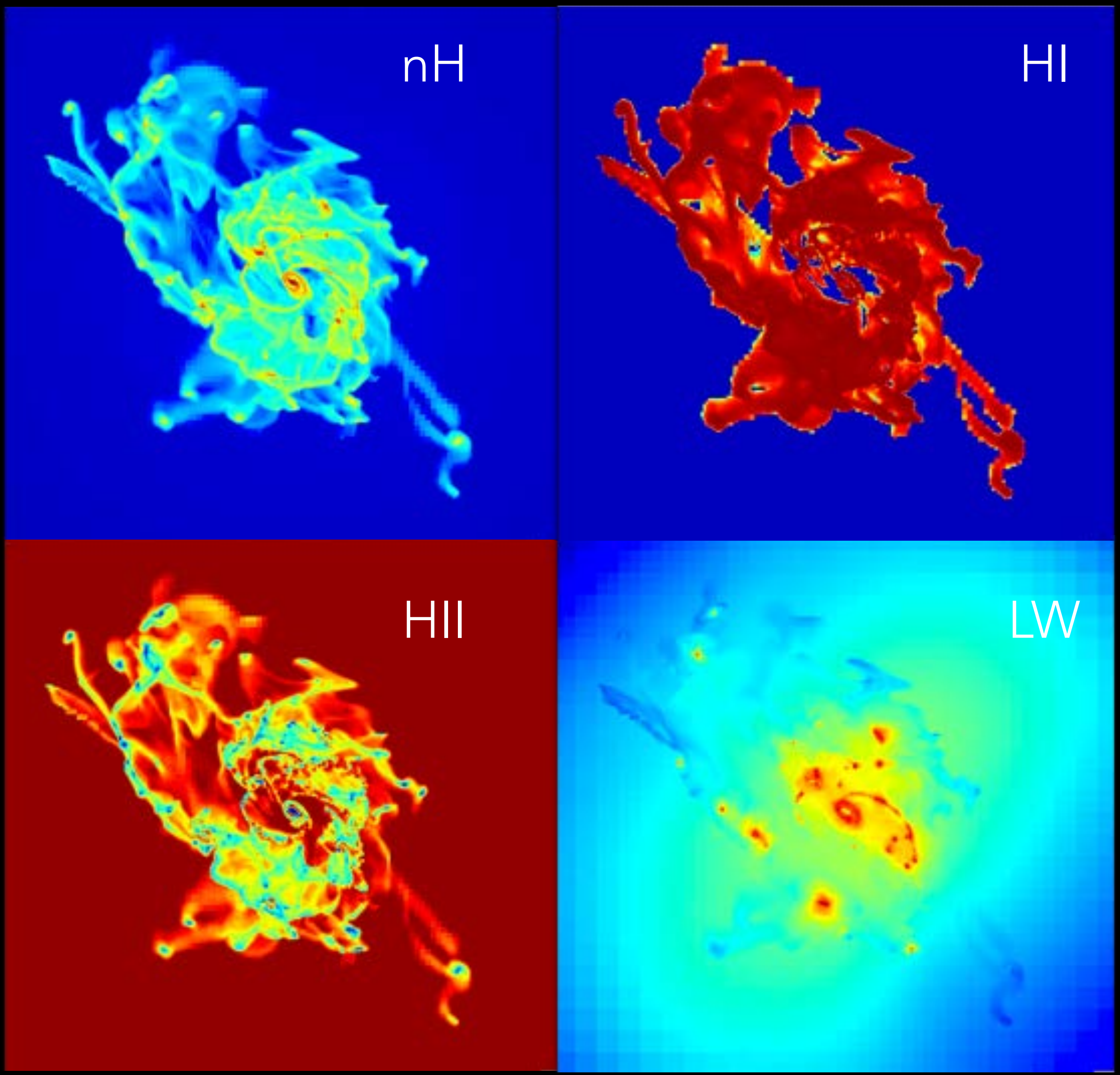


MIRAGE isolated disks and mergers on the M_{20} vs. Asymmetry plane.
Cibinel, Perret et al. in prep

- Mock observations depth degraded to HUDF (top) & CANDELS/GOODS (bottom)
- CAS parameters (Conselice et al. 2003) + Gini/M20 coefficients (Lotz et al. 2004)
- Morphological identification of mergers before coalescence in the context of clumpy turbulent galaxies

Full radiative transfer simulations

- RAMSES-RT idealized simulations project: full radiative transfer in gas-rich disks with pc-scale resolution
- Accurate physical description of radiative pressure = better modelling of clump morphologies



Perret et al., in preparation

REGAL (What REgulates the growth of GALaxies) ?

The missing piece to understand galaxy Evolution - Mechanisms of galaxy evolution since redshift 3.

a) the investigation of the rich phenomenology of gas inflows and outflows
b) the exploration of the mechanisms that rule the building of galaxy disks in different environments.

Based on
- new generation IFU survey (KMOS, MUSE,...) of high-z galaxies
- calibrate numerical simulations
to deepen the understanding of the physics driving galaxy evolution.

The collaboration involves
2.2 FTE/yr from LAM (8 people) and
2.5 FTE/yr from IRAP (5 people).

The request to OCEVU is:
2 PhD grants (2015-2018) at both sites,
2 x 3-year postdoc grants (2014-2017 at LAM, 2015-2018 at IRAP),
and ~ 21 k€/yr during 5 years.

Le ComEx approuve les recommandations du CS.
- Une bourse postdoctorale de 3ans, avec le postdoc localisé au LAM
- un financement de 2 k€ en 2014, et un prévisionnel de 7 k€ en 2015 et 2016, et de 5k€ en 2017.
- Les demandes additionnelles d'un post doc et de deux doctorants devront être faites dans les prochains AAP