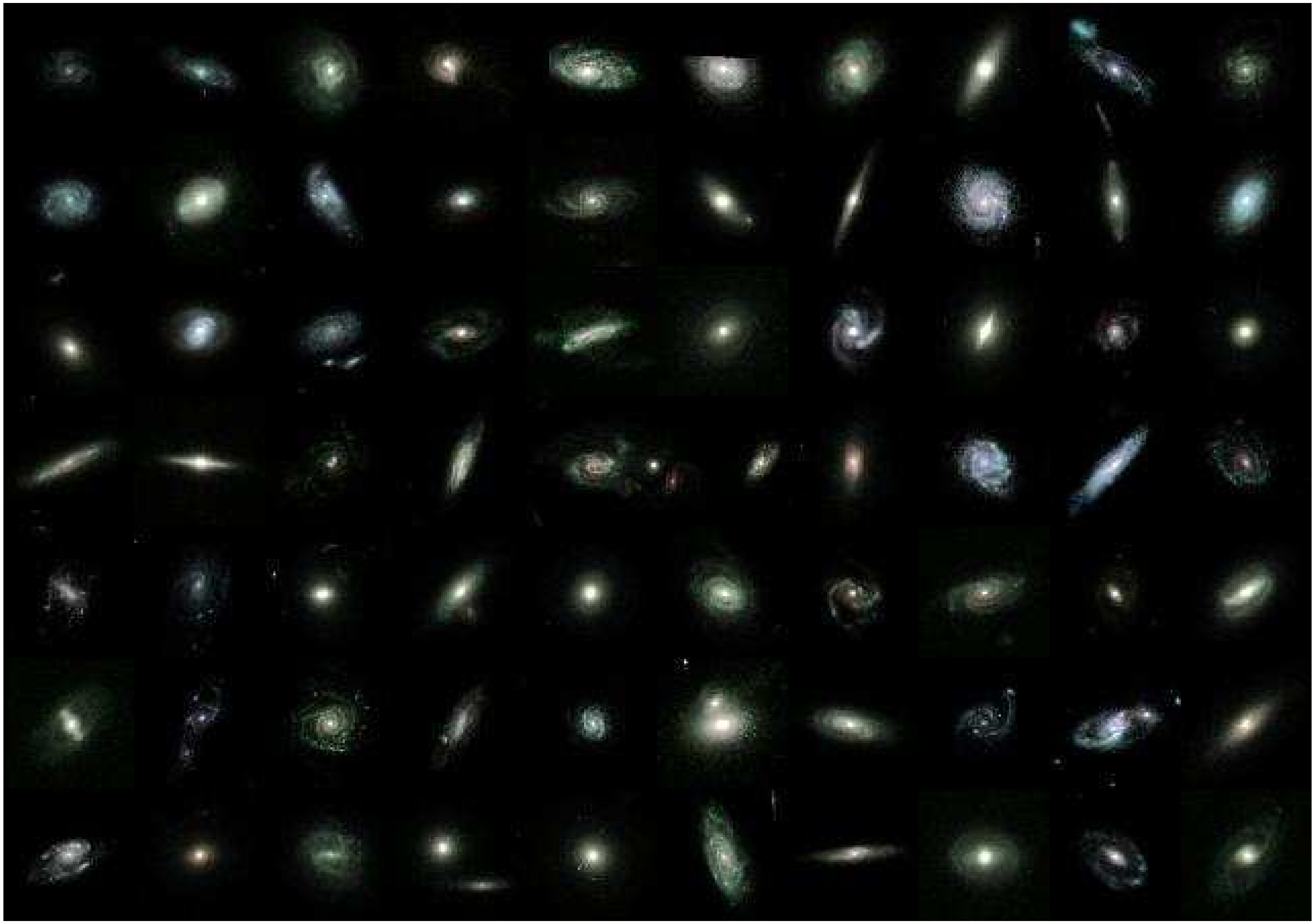
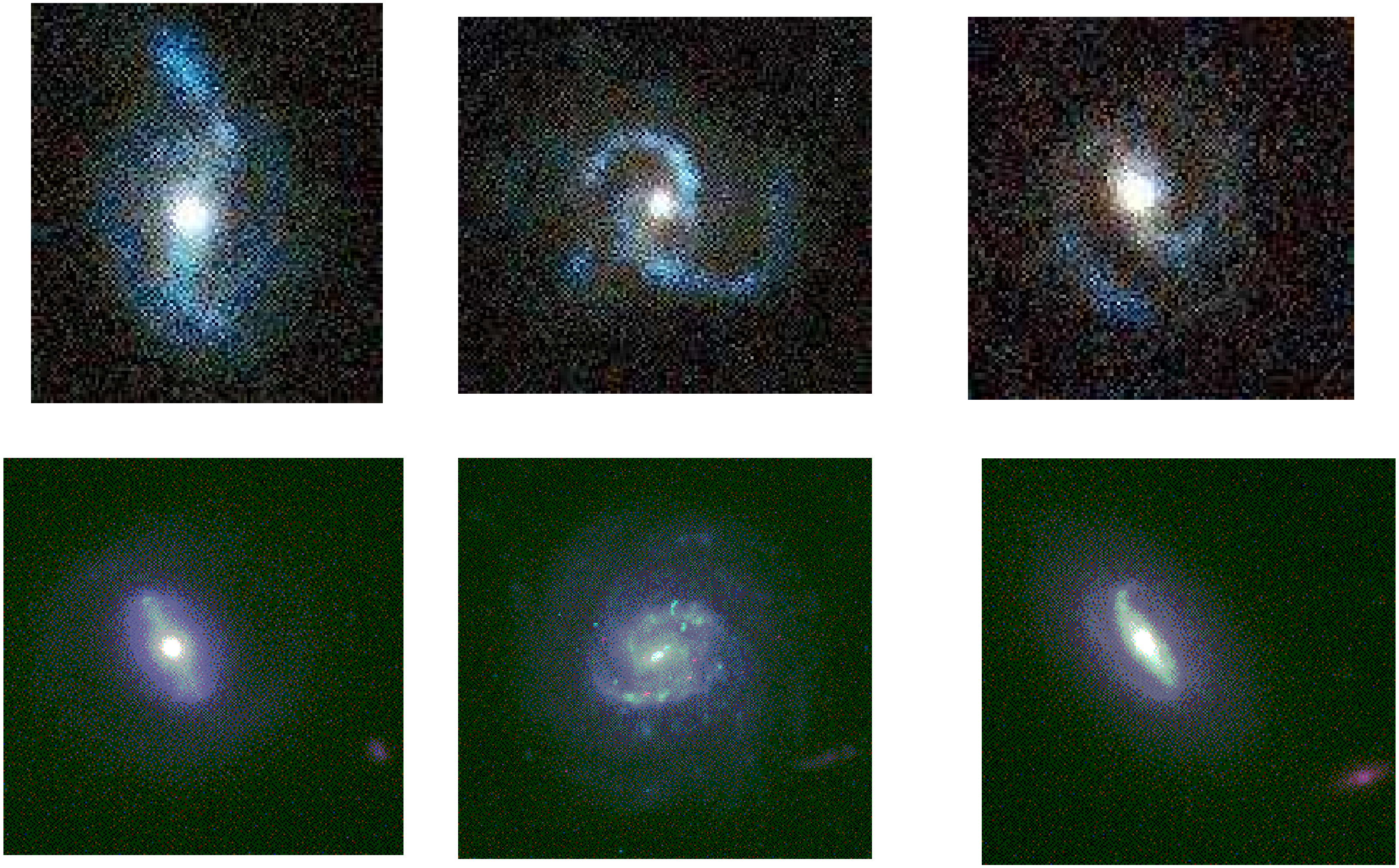


Diversity of Galaxy Morphologies out to z~1 in the GEMS survey



Barred galaxies at z = 0.4 - 0.9 (T=6-9 Gyr) from the GEMS survey

Science Drivers: Bars at z~1

- Are bars a recent phenomenon?Is there a dramatic decline in bar fraction f at z>0.6?-

  f=24% at z<0.6 while f=4% at z>0.6 from HDF (Abraham et al. 99; van den Bergh 2002)

  No decline in f at z>0.7 based on 4 galaxies in NICMOS HDF (Sheth et al. 2003)

- Evolution in properties (size, strength, [patttern speed]) of bars as f(z)

  → Disk and DM halo evolution

  → Is bar dissolution/formation a recurrent process?

  → Test for evidence of bar-driven evolution along Hubble sequence from z=1
  e.g., growth in bulge (pseudo-bulge, boxy bulges) , central mass concentration

  → Can bars solve cusp-core controversy (Weinberg & Katz 2002)

- Is bar (or interaction) frequency larger in starbursts vs non-starbursts
  larger in AGN vs non-AGN

Fraction + Properties (strength,size) of Bars as f(z)

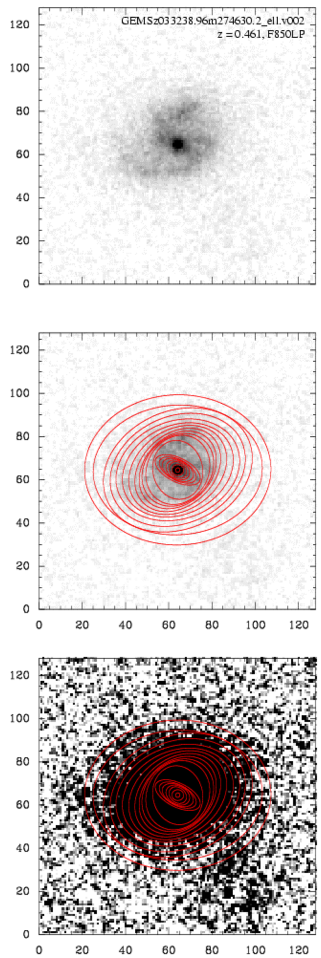
1) Use reddest observed (band) F850LP → best measure of stellar potential at each z

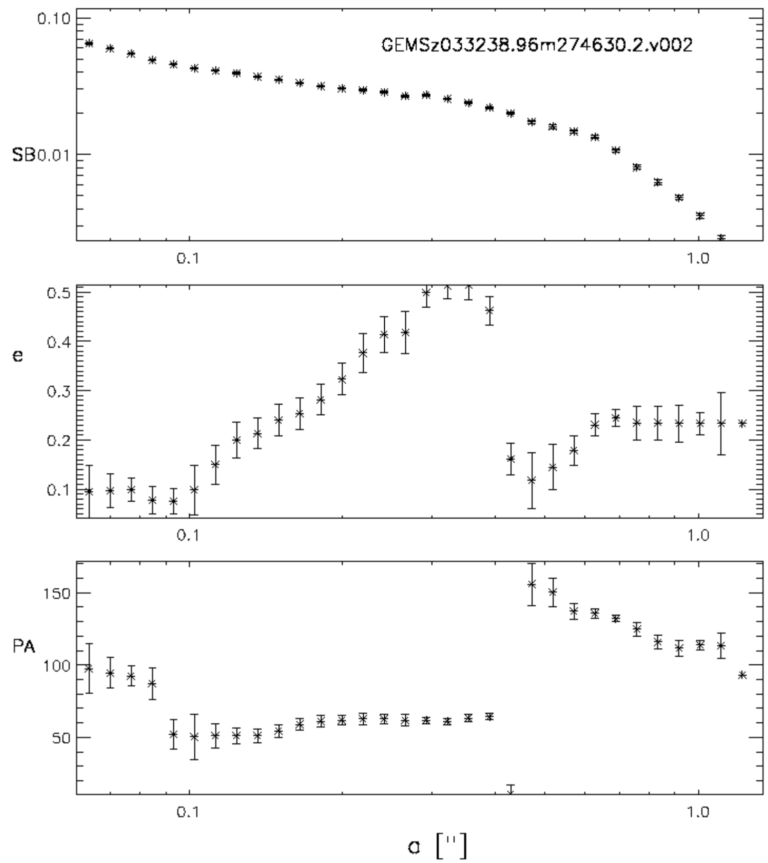
Redshift	**Rest-frame traced by F850LP**
0.24<z<0.56	I/R
0.61<z<0.93	V
0.94<z<1.31	B

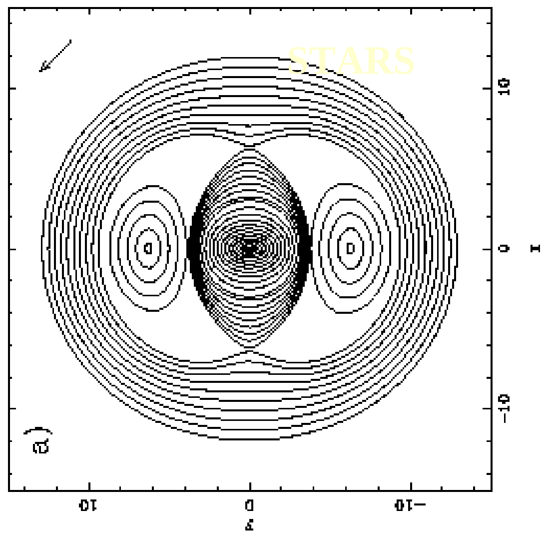
2) Work in a given rest-frame band at all z using both F606W and F850LP

Filter	**Rest frame B**	**Rest Frame R**
F606W *	0.24<z<0.56	
F775W	0.61<z<0.93	0.10<z<0.32
F850LP*	0.94<z<1.31	0.33<z<0.58

Isophotal fits to identify bars/disks





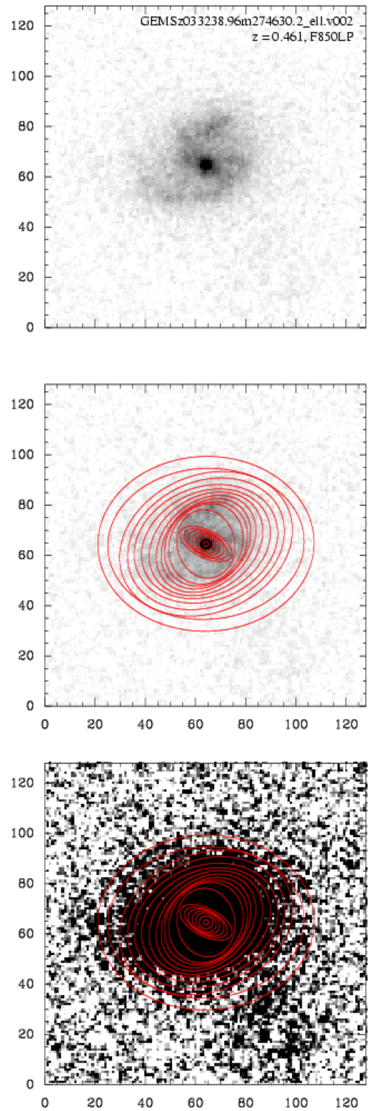


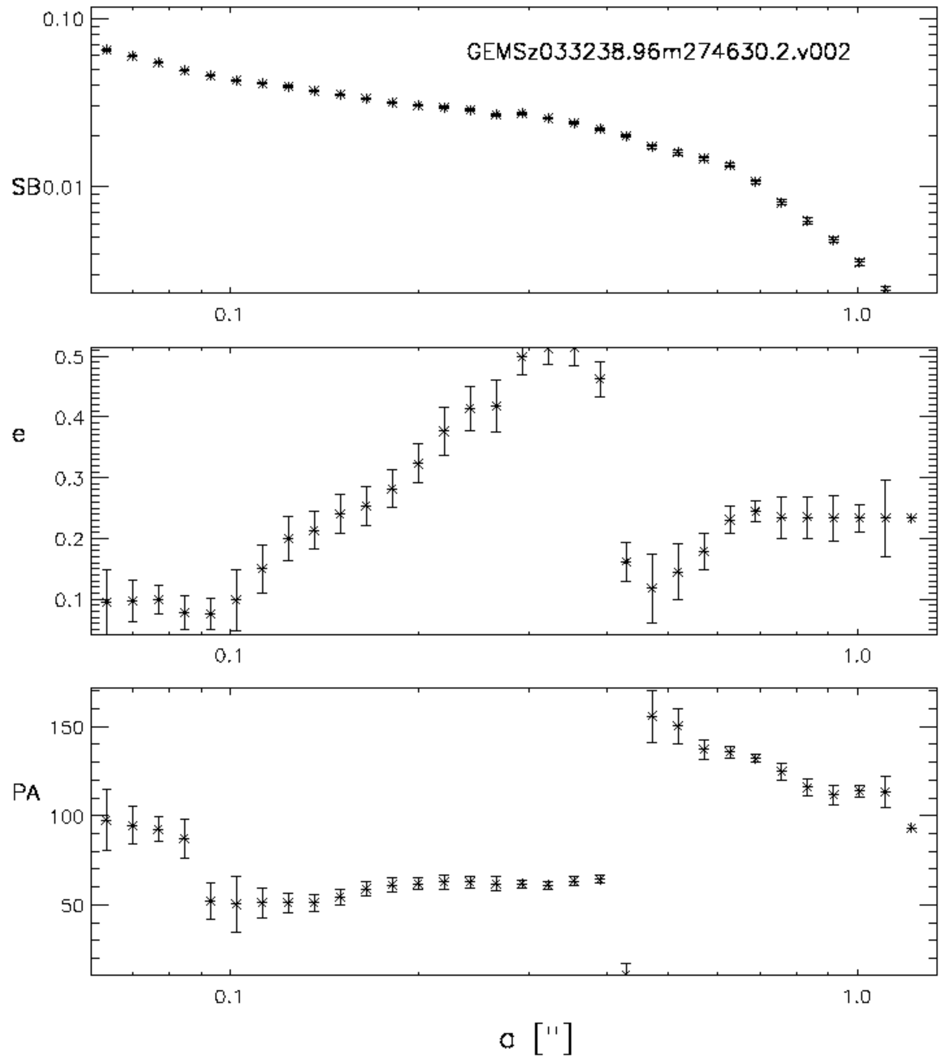
Family of periodic stellar orbits conserving E_J : e.g., x_1, x_2

* Isophotes = guide to underlying stellar orbits.

* Bar = [Rise in e to a global maximum along with a plateau in PA]
followed by
[a drop in e + generally a change in PA in the disk region]

(I) Quantitative automated method to identify/characterize bars





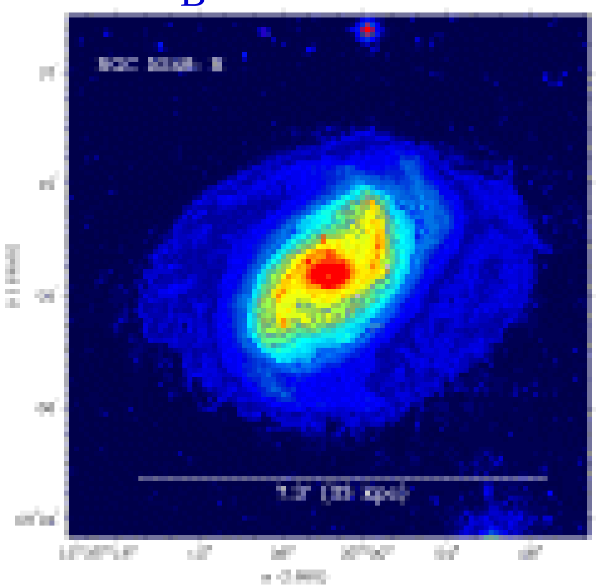
Class: Primary bar (b1)

Record disk = (e0, a0,PA0) bar = (e1, a1, PA1)

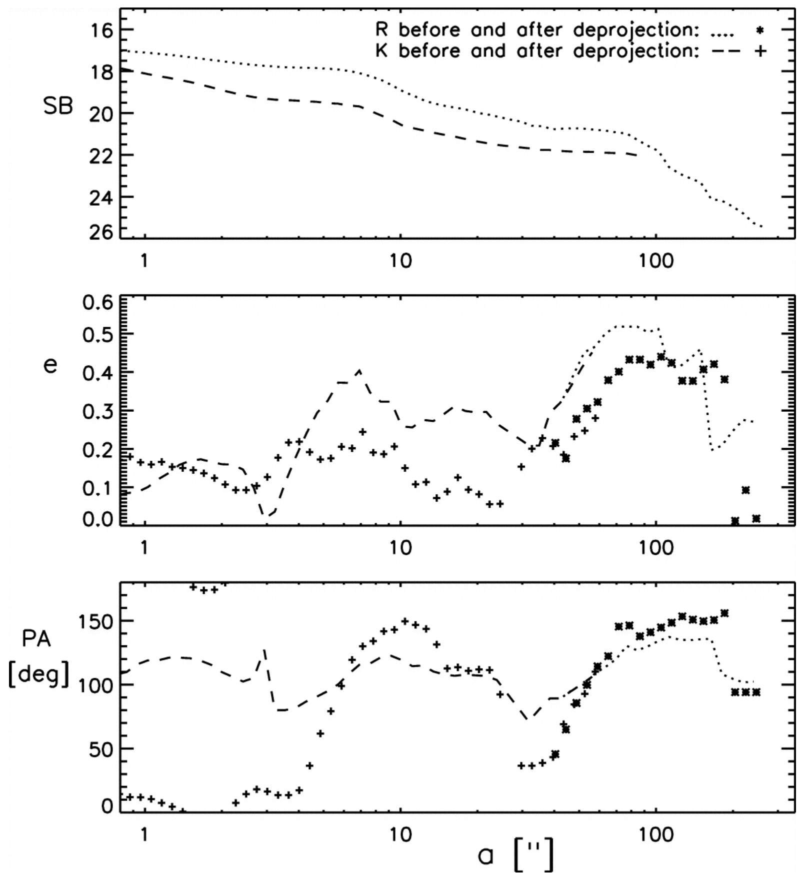
z=0.46, F850LP

Isophotal fits : Deprojection

B



(Jogee, Shlosman, Knapen et al 2003)



- Deprojection needed for intrinsic strength and size of bars. (+ identification)
- Deproject image before isophotal fit or deproject the fitted radial profiles
  Input = (Center, PA of line of nodes/outer disk, Ellipticity of outer disk)
- GEMS: Fit images, use radial profiles to get (e0, pa0) , then later deproject

Preliminary results

Bar fraction f in different rest-frame

Filter	0.24<z<0.6	0.6<z<1.3
F850LP	f=31% (restf=I/V)	f=29% (restf=V/B)
F606W	f=24% (restf= B)	f=9% (restf=UV)

Bar fraction f in rest-frame B/V

0.24<z<0.6	0.6<z<1.3
f=24% (F606W)	f=29% (F850LP)

(Jogee et al. 2004, in prep.)

1) No significant decline in bar fraction in rest frame B at z= 0.6-1.3 versus at z=0.2--0.6

vs. : f=24% at z=0.2--0.6 while f=4% at z>0.6--1.0 from HDF (Abraham et al. 99; van den Bergh 2002)

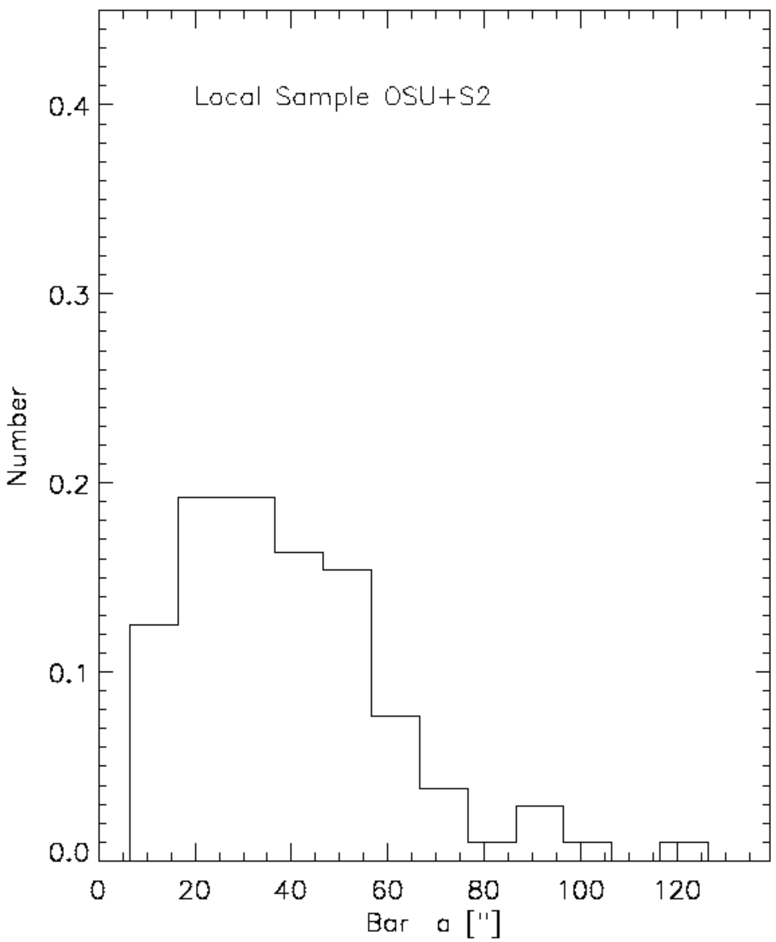
vs. : No decline in f at z>0.7 based on 4 galaxies in NICMOS HDF (Sheth et al. 2003)

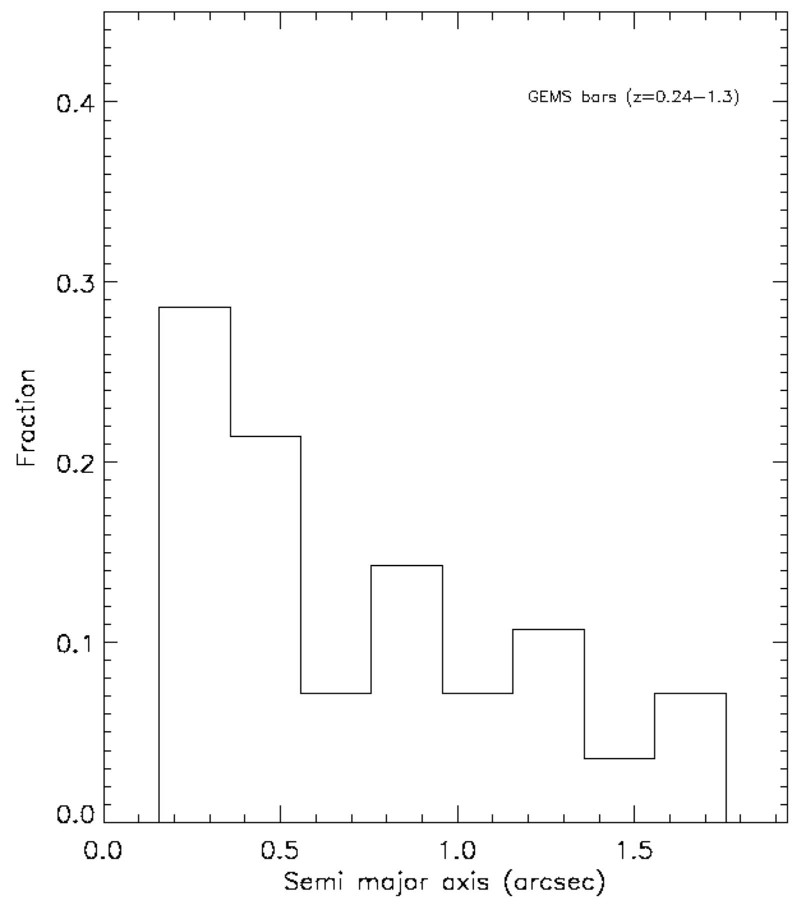
2) Effect of bandpasss shifting kicks in at UV wavelengths

3) All known systematic effects (e.g., resolution, SB dimming) would tend to lower f at z=0.6—1.2

→ comparable f suggest either comparable or higher bar fraction at z>0.6?

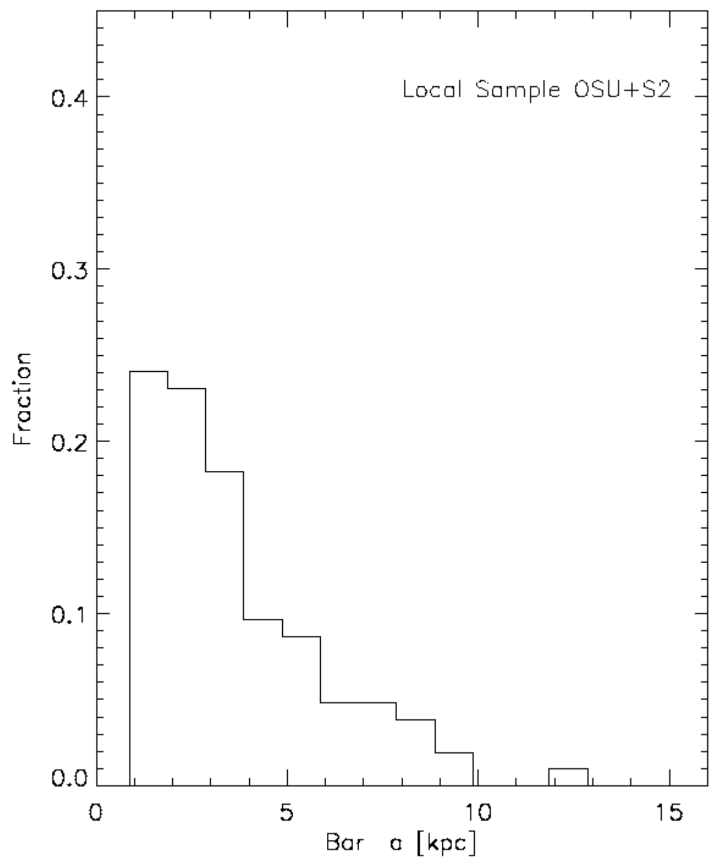
Preliminary results

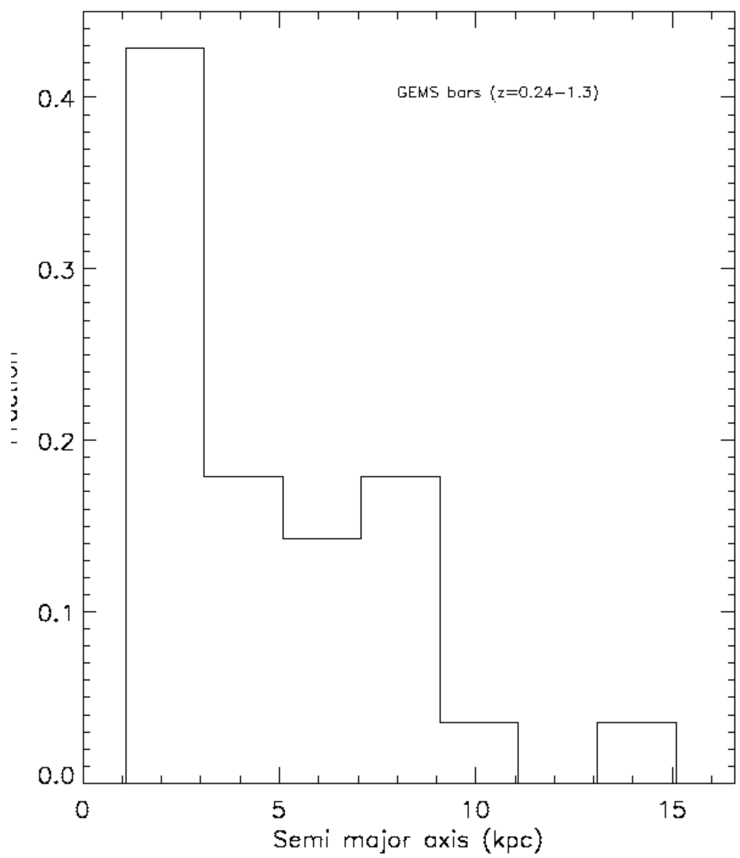




(Jogee et al. 2004, in prep.)

Preliminary results

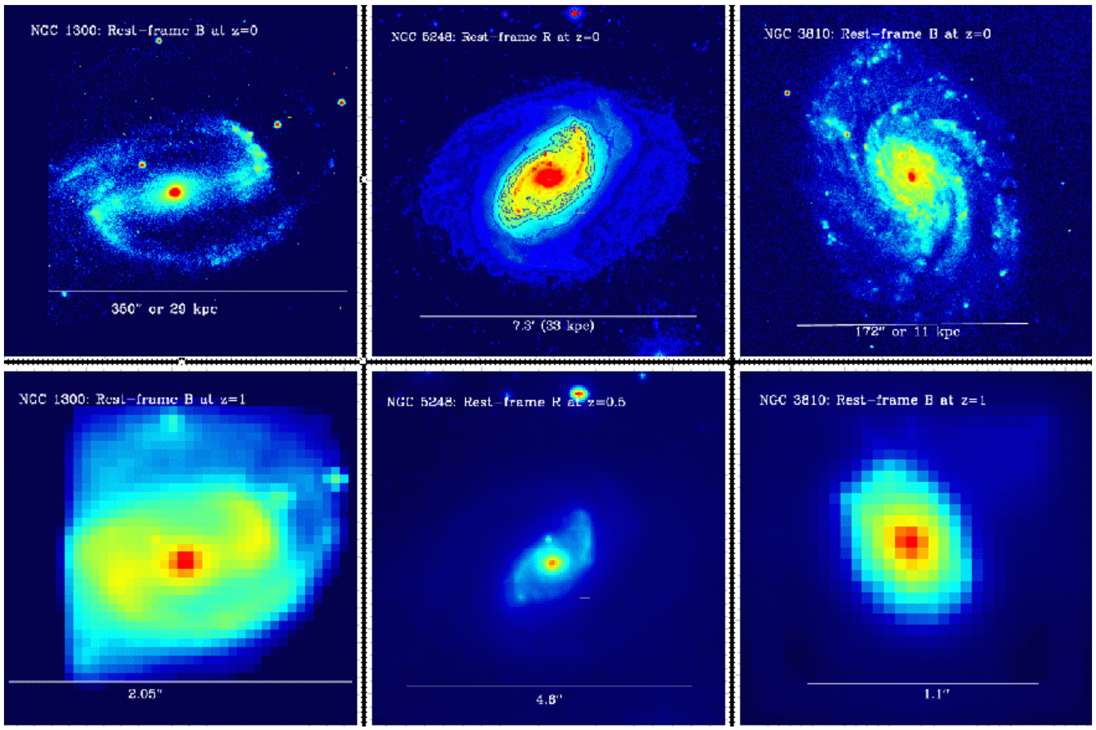




- Is strong fraction of short bars real?. Do bars grow inside out ?
- Is there (a-bar vs a-disk) correlation? Normalise bar with disk sizes
- Evidence for bar dissolution with time : e distribution
- Address systematic effects: redshifting

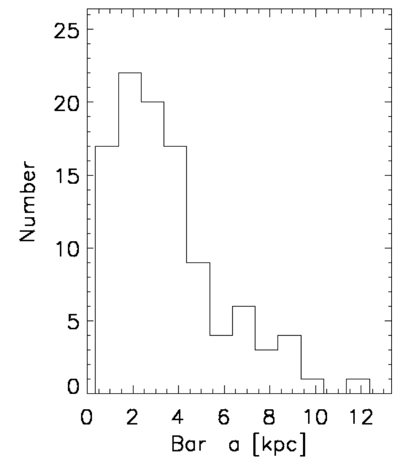
(Jogee et al. 2004, in prep.)

(II) Artificial Redshifting of Nearby Galaxies to address systematics



From z=0

To
z=0.6 (R)
z=1 (B)



(Jogee et al. 2003,04)

- Need to understand/correct for redshift-dependent systematic effects

Cosmological dimming, Loss in spatial resolution, [Bandpass shifting]

- Artificially redshift local "standard" sample of spirals (on which local F is based ?)

OSU sample, Sample of bright spirals . SDSS sample

(III) Theoretical/Numerical modelling

Explore stability and evolution of stellar bar

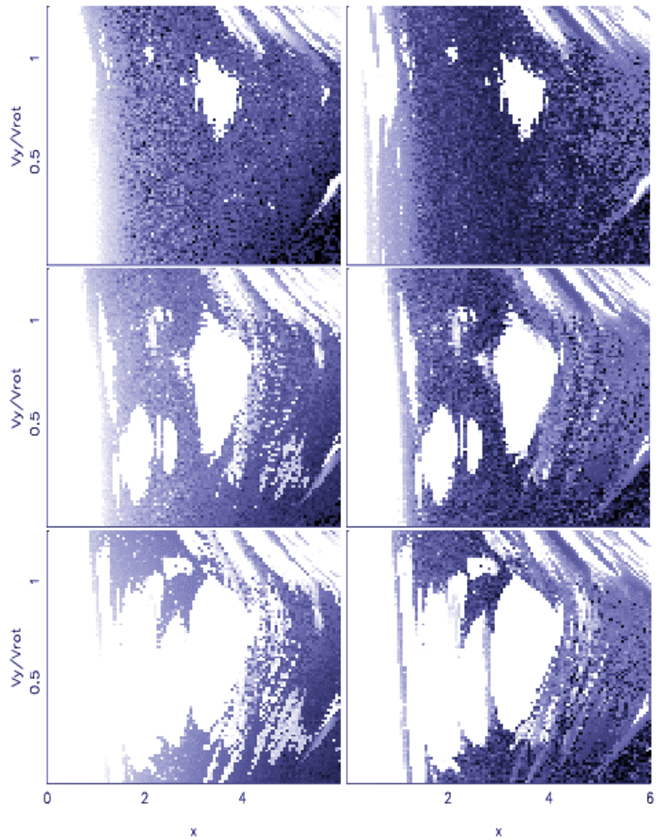
as f (environment typical of early times: gas fraction, interactions)

as f (triaxiality, central conc) of CDM halo (collab. w/ I Shlosman)

Stability of a bar embedded in different CDM halos

Halo axial ratios: Lower=1.0 Middle=0.99 Top =0.95
Color : White= regular orbits Blue = chaotic orbits.

(El Zant & Shlosman 2002)



Driving gas down to AGN scales in Disk Galaxies

Seyferts = 10^{-3} - 1 M_o yr^{-1} ; Quasars = $1\text{-}10^{2}$ M_o yr^{-1}

L=3e29
R=10kpc

- Large-scale bars,
- Moderate interactions

Major interactions and mergers?

R=200 pc
L=1e27

-Nuclear secondary bar (Shlosman et al. 1989; Friedli et al. 1993; Jogee et al. 1999: Jungwiert et al. 97)

- [Nuclear spirals] (Englmaier & Shlosman 2000; Jogee et al. 2002 ; Martini et al. 2003)

- Dynamical friction (Heller & Shlosman 1994; Jogee et al. 1999)
- Warped gas disk (Baker 2000; Schinnerer 2000)
- Viscous effect from SF? (Wada & Norman 2001)

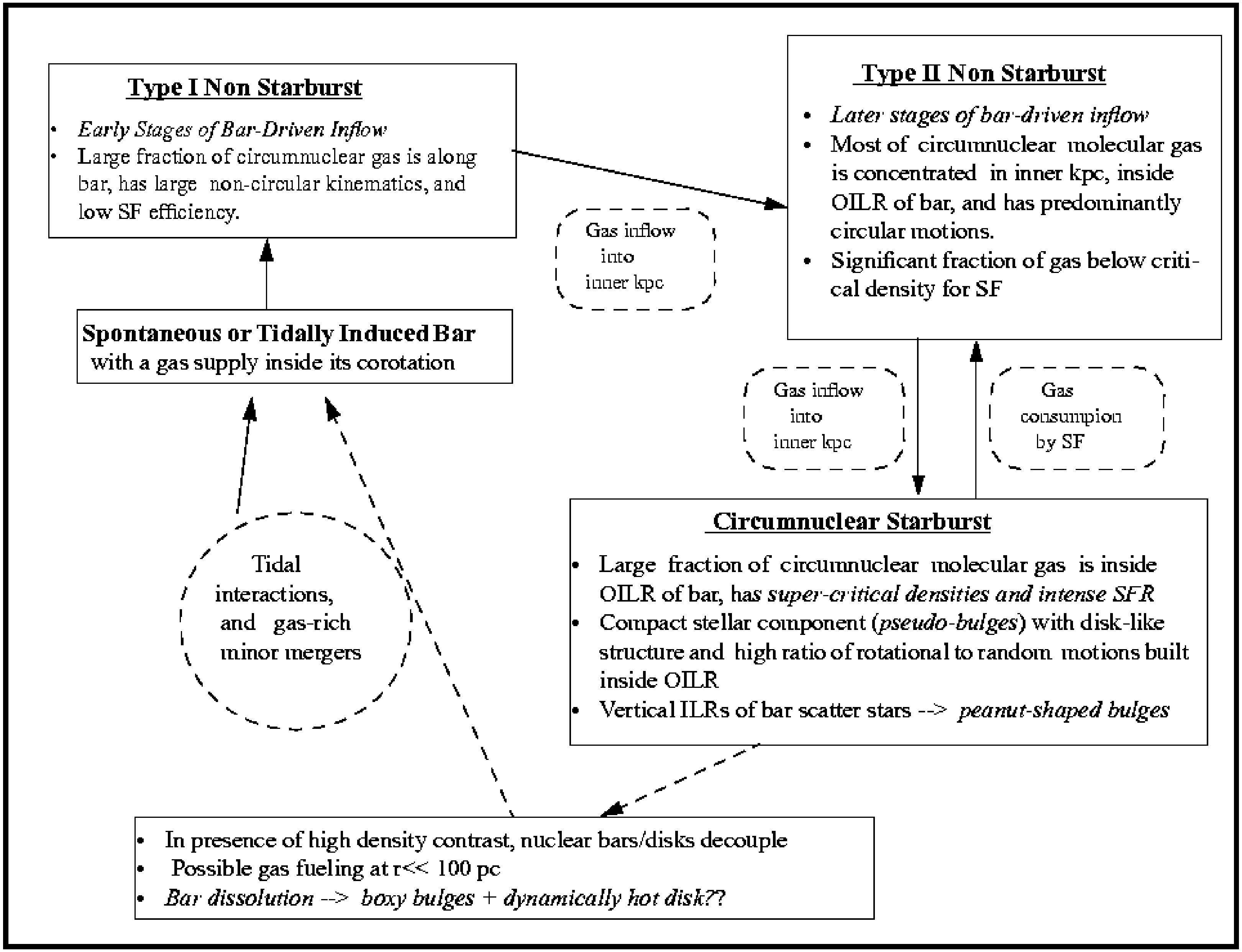
R=10 pc
L=1e26

R=1 pc

R=10^{-3}pc
L=1e24

-Magnetic torques and AGN winds (e.g., Emmering et al. 1992)
- Evolution of dense star cluster
-Viscous effects (Pringle 96)

(Jogee 2004, Chapter 7, "AGN Physics on all Scales")



Type I Non Starburst
• Early Stages of Bar-Driven Inflow
• Large fraction of circumnuclear gas is along bar, has large non-circular kinematics, and low SF efficiency.
Type II Non Starburst
• Later stages of bar-driven inflow
• Most of circumnuclear molecular gas is concentrated in inner kpc, inside OILR of bar, and has predominantly circular motions.
• Significant fraction of gas below critical density for SF
Gas inflow into inner kpc
Spontaneous or Tidally Induced Bar with a gas supply inside its corotation
Gas inflow into inner kpc
Gas consumpion by SF
Circumnuclear Starburst
• Large fraction of circumnuclear molecular gas is inside OILR of bar, has super-critical densities and intense SFR
• Compact stellar component (pseudo-bulges) with disk-like structure and high ratio of rotational to random motions built inside OILR
• Vertical ILRs of bar scatter stars --> peanut-shaped bulges
Tidal interactions, and gas-rich minor mergers
• In presence of high density contrast, nuclear bars/disks decouple
• Possible gas fueling at r<< 100 pc
• Bar dissolution --> boxy bulges + dynamically hot disk??