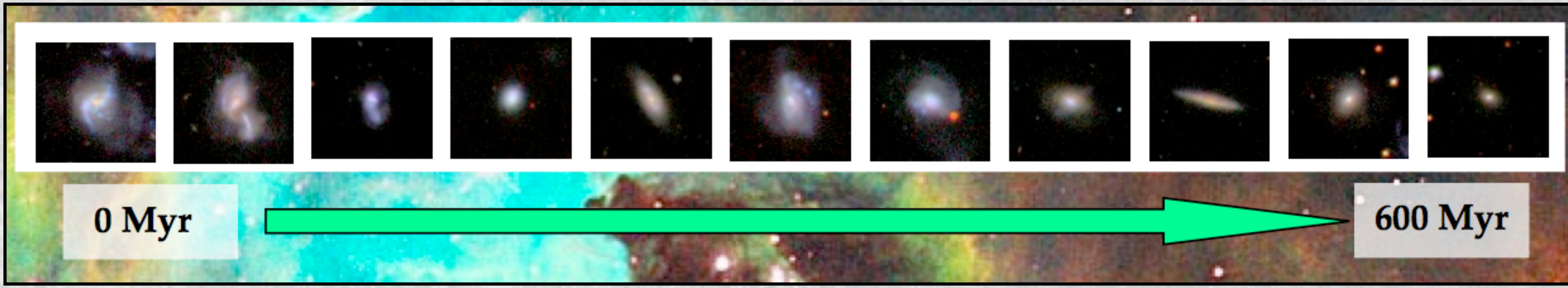


Tracking AGN activity following a starburst

Vivienne Wild

Kate Rowlands, Milena Pawlik, Peter Johansson, Jakob Walcher

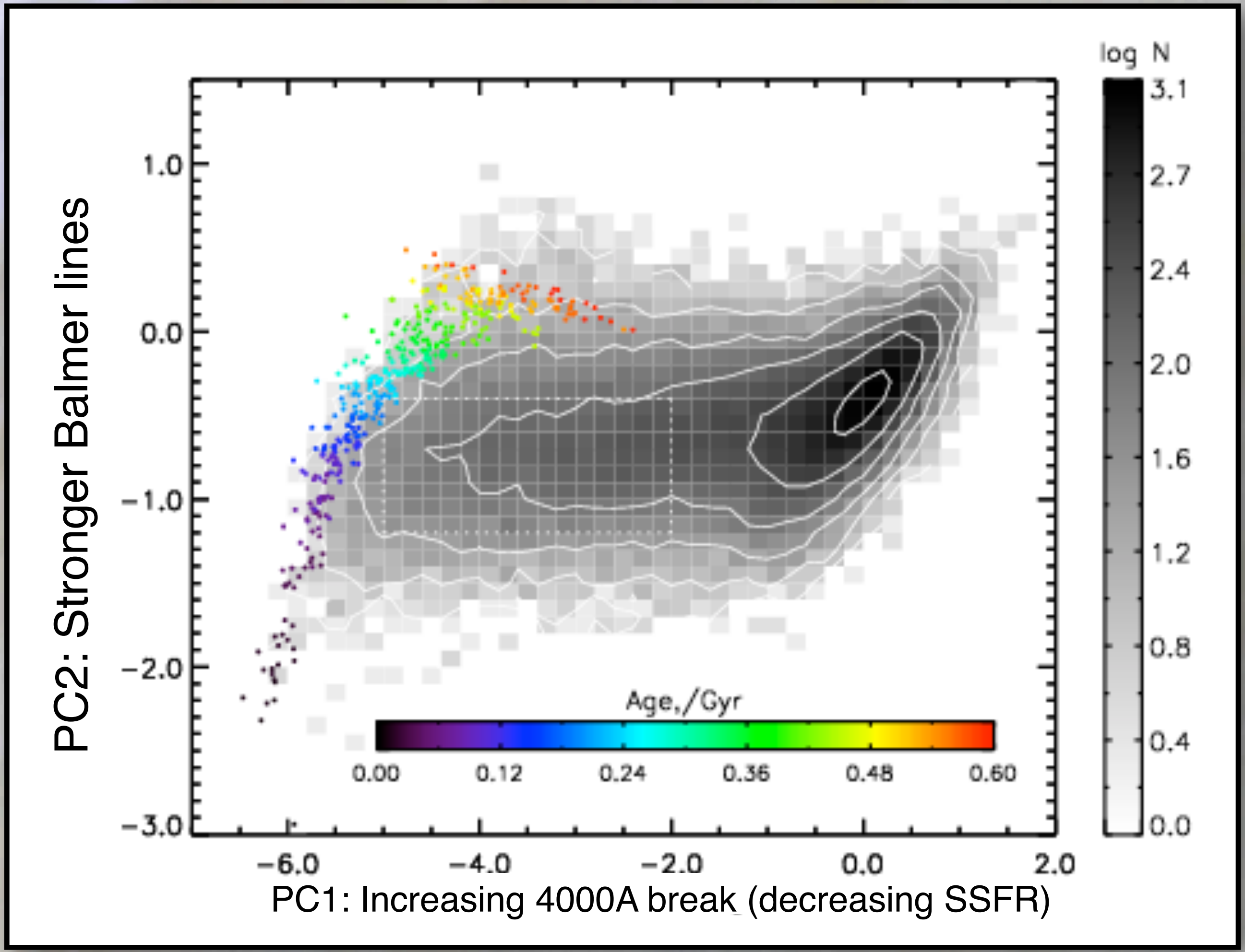
Nicole Nesvadba, Angela Mortier, Matt Lehnert, Bruce Sibthorph

Stephane Charlot, Tim Heckman, Guinevere Kauffmann

University of St Andrews

(Post)-starbursts in bulges at z~0

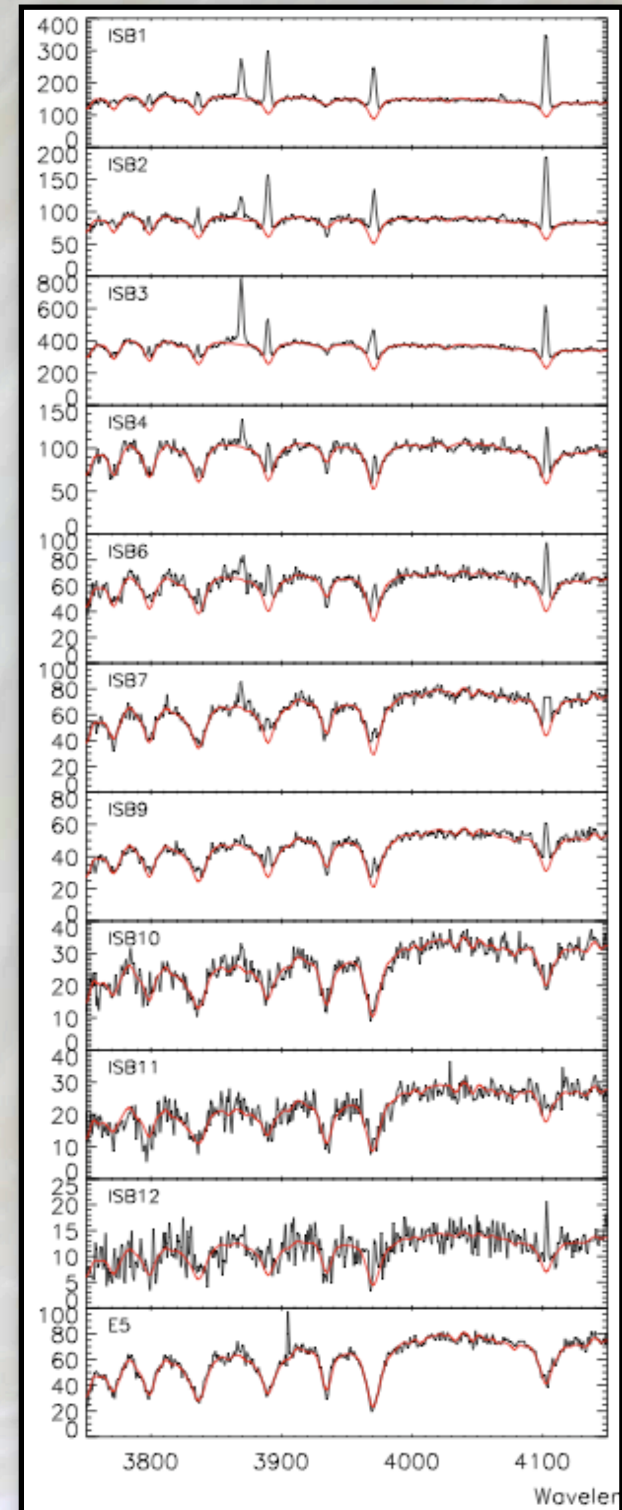
Vivienne Wild

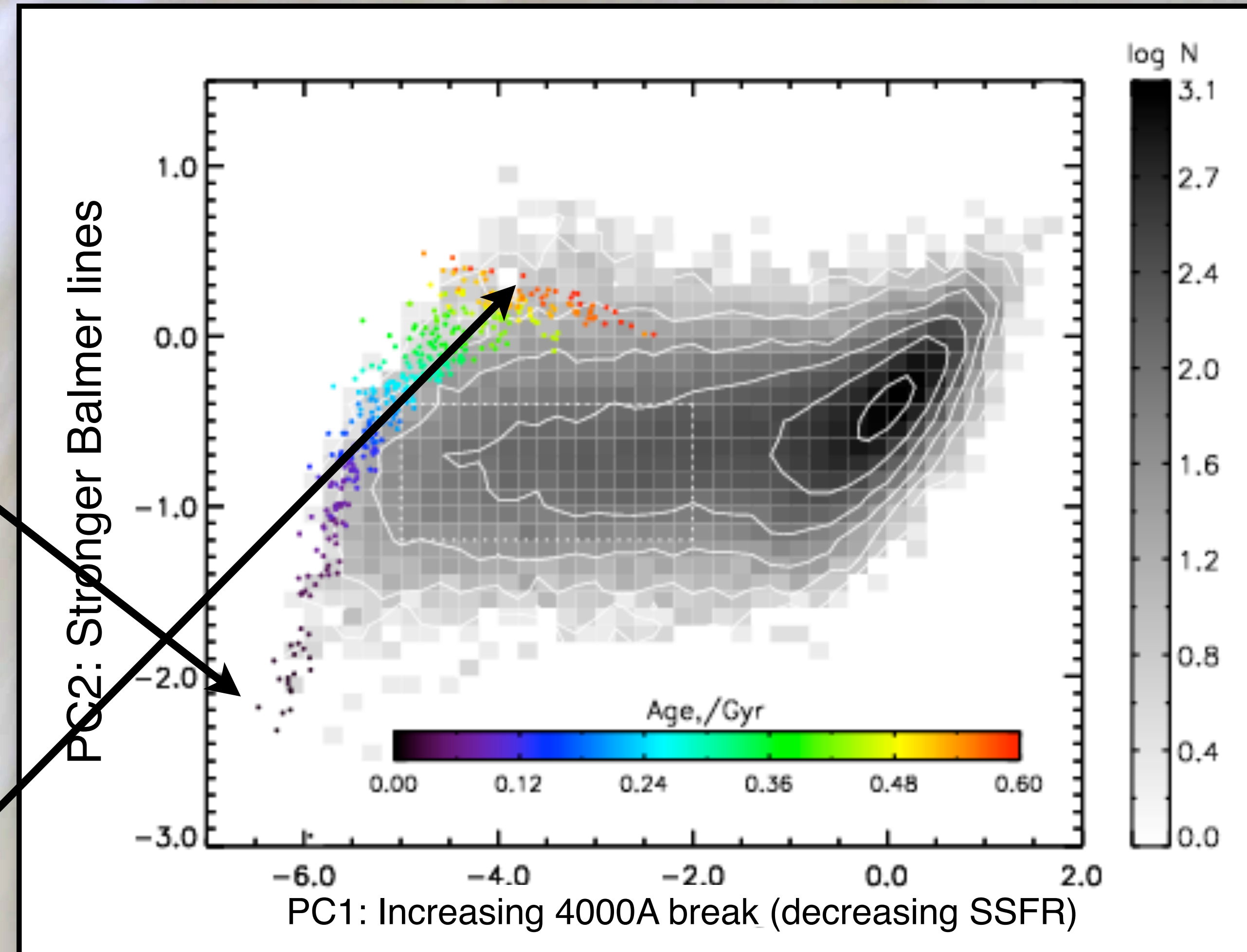


Wild et al. 2010a, MNRAS

(Post)-starbursts in bulges at z~0

Vivienne Wild

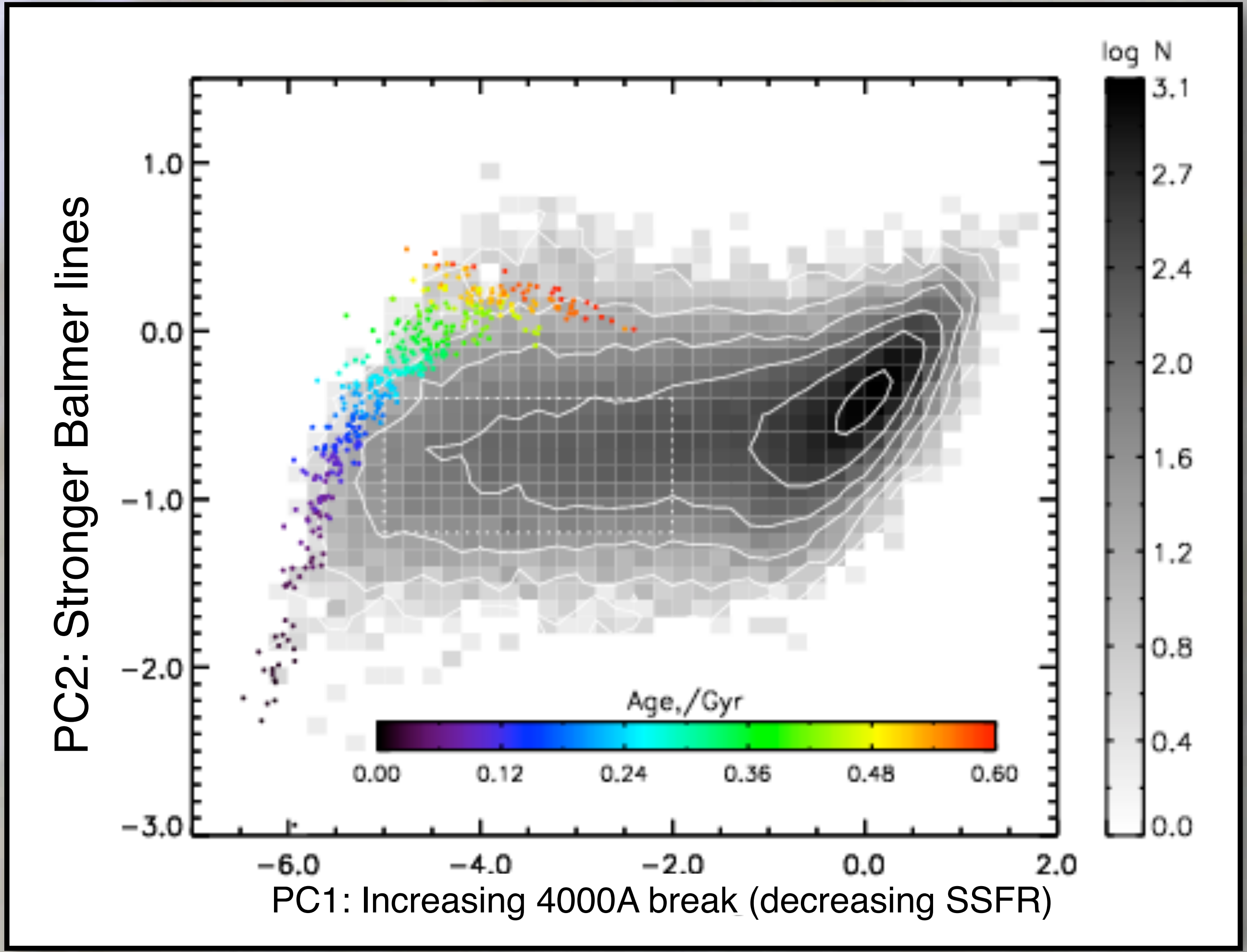




Wild et al. 2010a, MNRAS

(Post)-starbursts in bulges at z~0

Vivienne Wild



★ 400 **strongest (post)-starburst** bulge-galaxies in local Universe

- $0.01 < z < 0.07$ (3” SDSS fibre => 0.6 - 4 kpc diameter)
- Stellar surface mass density > 3 x 10^8 $M_\odot$ /kpc^2 (where majority of L[OIII]$_{AGN}$ originates)
- **Complete sample** to 600Myr: constant number per unit starburst age
- No broad line AGN

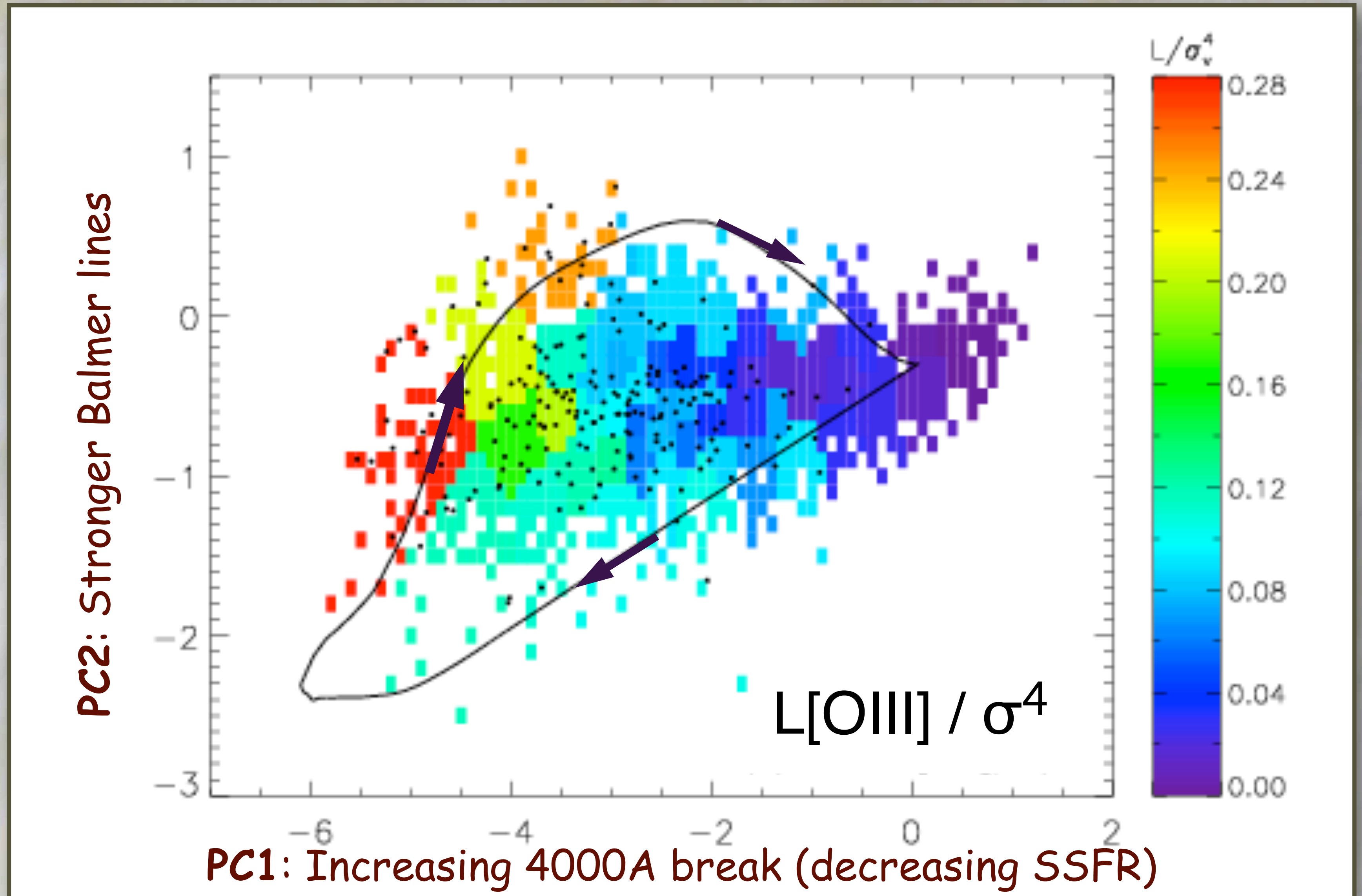
Wild et al. 2010a, MNRAS

The growth of black holes

Vivienne Wild

What type of star formation history is associated with highest mean rate of black hole growth?

(mean growth of black holes: $\dot{M}/M$)



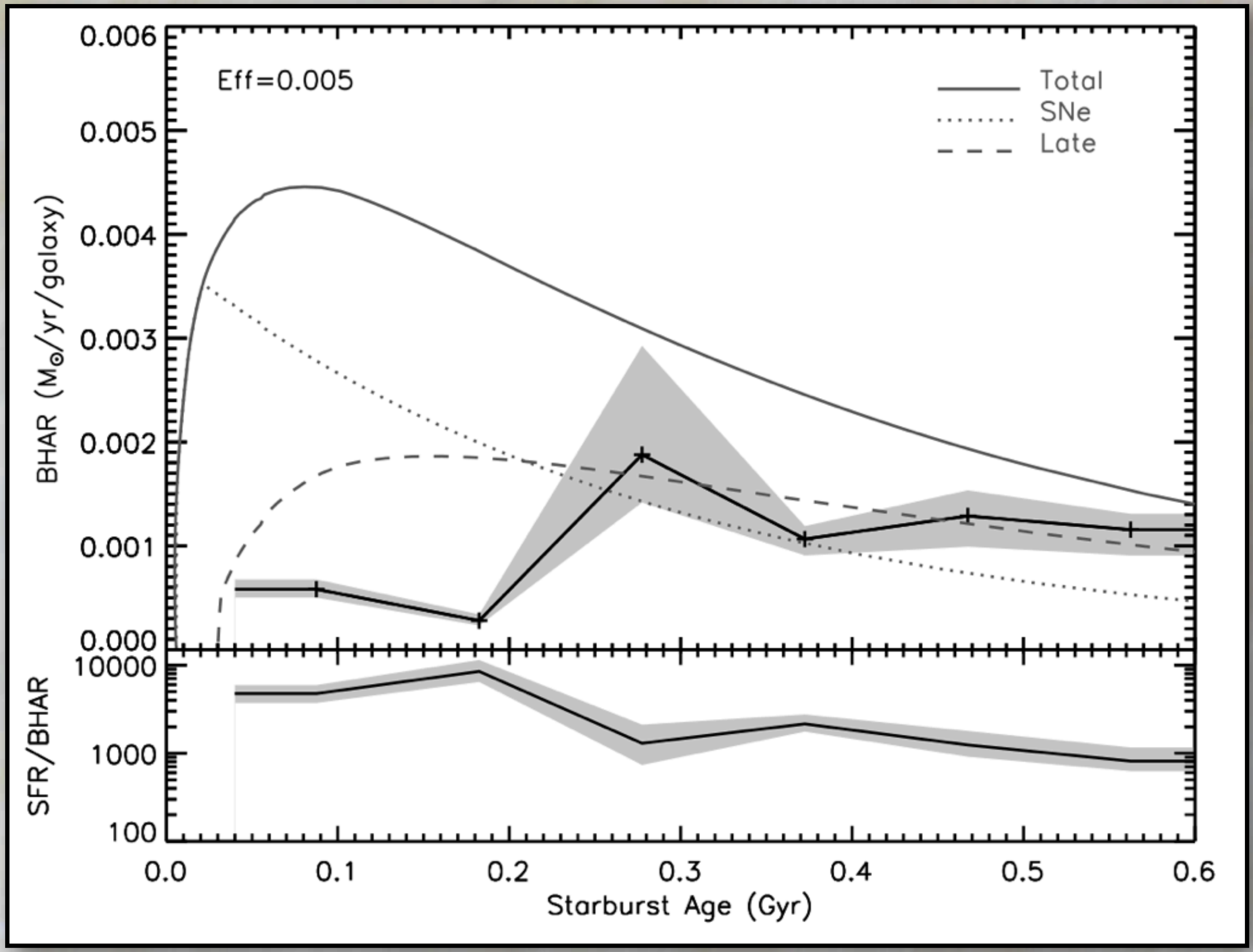
Plot method adapted from : Cappellari M., Copin Y., 2003

- ★ Increasing black hole growth rate with increasing SFR/M_{gal}
- ★ 50% of black hole growth is accounted for by only ~200 bulges (/ 33000)
  - distributed throughout the starforming, starburst and post-burst classes
  - 7% of SF bulges, 15% of PSB bulges, 29% of SB bulges
  - a recent starburst is a helpful, but not necessary, condition for low-z black hole growth

Wild et al. 2007

Zoom-in on (post-)starburst galaxies

Vivienne Wild



See also Davies et al. 2007

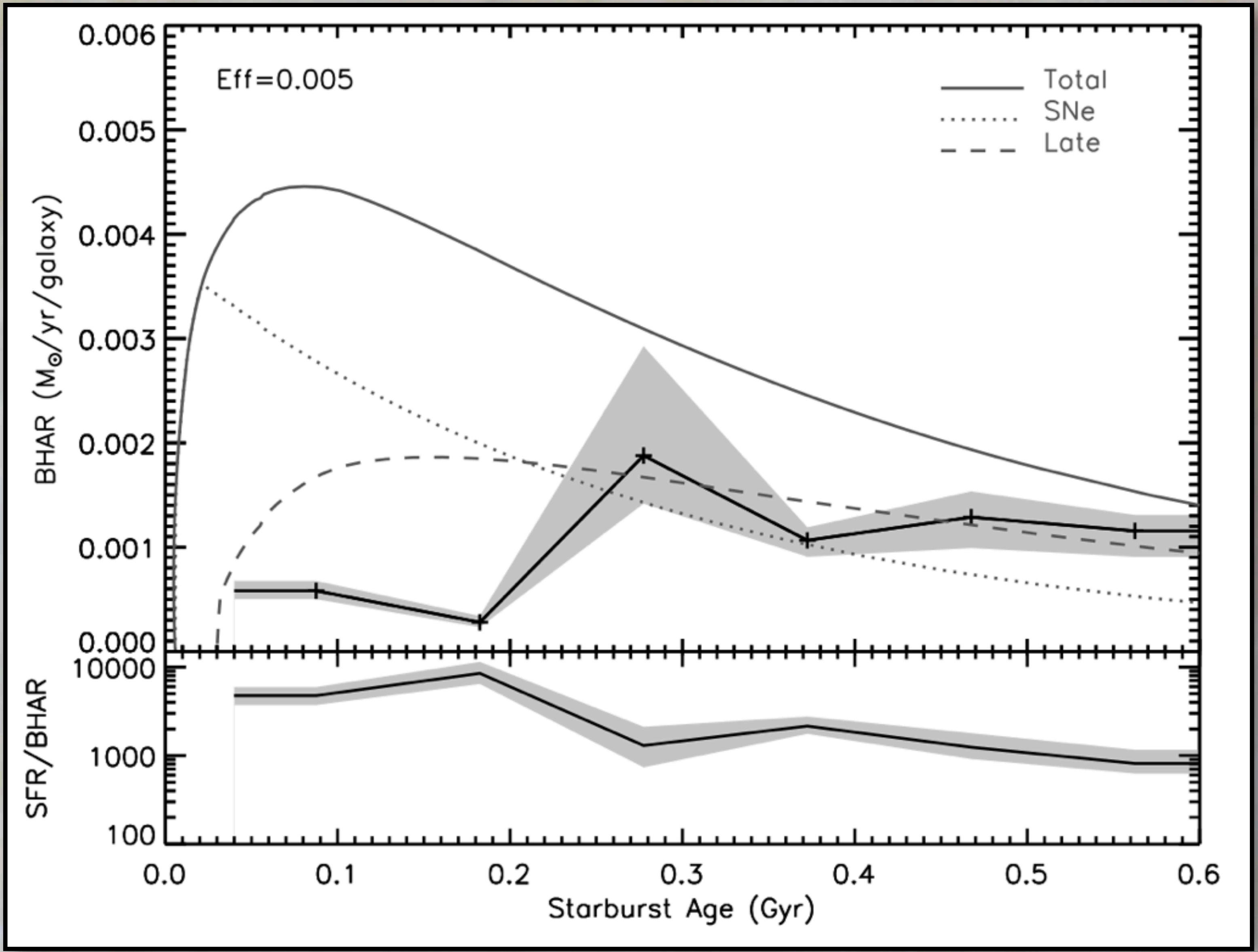
★ Low mass stars (slow ejecta) dominate mass loss

★ Accretion commences when fast ejecta have decayed

- **Feedback from fast stellar ejecta prevents accretion?**
- **Dynamical delay of gas infall? (Hopkins, 2011)**

Wild, Heckman, Charlot 2010

Zoom-in on (post-)starburst galaxies



Feeding BHs through stellar winds:

- Norman & Scoville 1998 (Both SNe and low mass stars)

Feeding BHs through SNe winds:

- Kawakatu & Wada 2008 (Energy from SNe support turbulent gas disk, turbulent viscosity leads to high accretion rate)
- Kumar & Johnson 2010 (SNe explosions facilitate transport of ang. mom. outwards, and gas inwards)

See also Davies et al. 2007

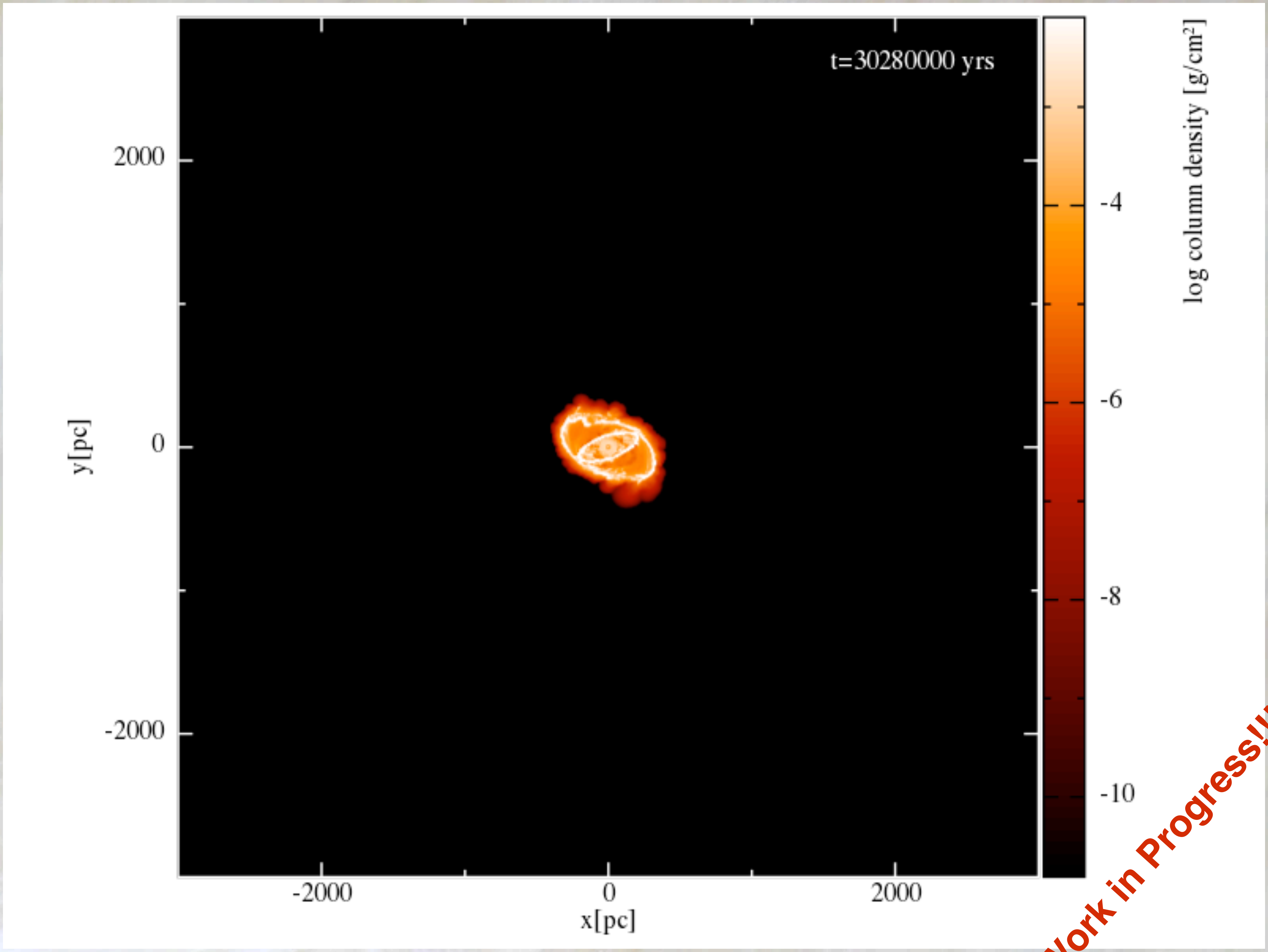
★ Low mass stars (slow ejecta) dominate mass loss

★ Accretion commences when fast ejecta have decayed

- **Feedback from fast stellar ejecta prevents accretion?**
- **Dynamical delay of gas infall? (Hopkins, 2011)**

Wild, Heckman, Charlot 2010

The impact of SNe winds in the GC



Prior to SNe: SMBH accretes $1.3x10^{-5} M_{\odot}/yr$

During run: SMBH accretes $2.10x10^{-5} M_{\odot}/yr$

Work in Progress!!!

Will Lucas (St Andrews)
(with Diego Falceta-Gonçalves, Ian Bonnell)

Mass resolution: $2M_{\odot}$; central potential with nuclear star cluster, nuclear stellar disk and bar; SMBH sink particle: $4x10^{6}M_{\odot}$; SNe rate to match SFR in GC ($0.1M_{\odot}/yr$)

What we think/believe...

Vivienne Wild

Q2: What physical processes are important in driving low-luminosity AGNs?

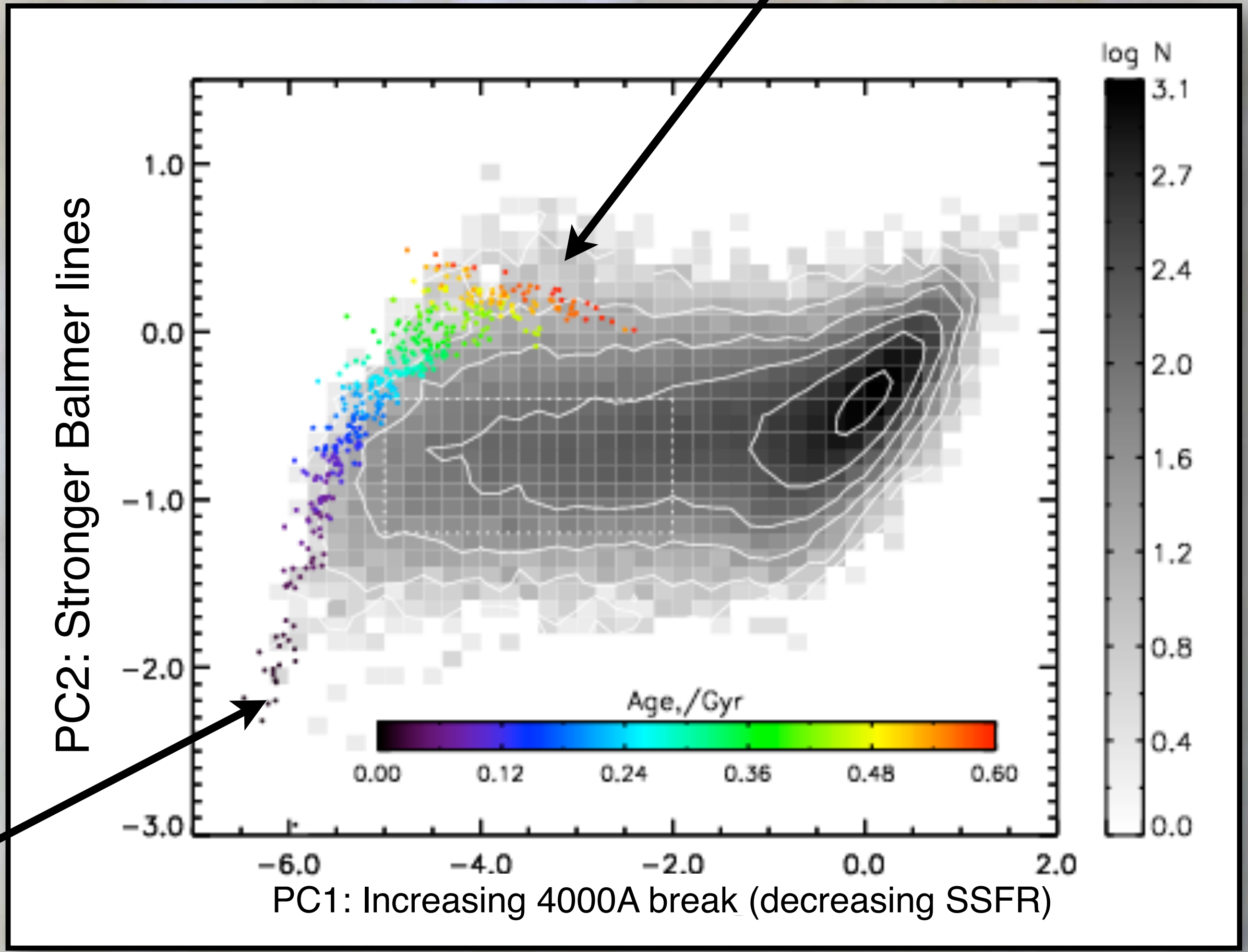
- **Mass loss: stellar winds** — No: 36 Yes: **66**
- **Mass loss: supernovae** — No: **62** Yes: 40

Q2: What physical processes are important in driving moderate-luminosity AGNs (Seyferts)?

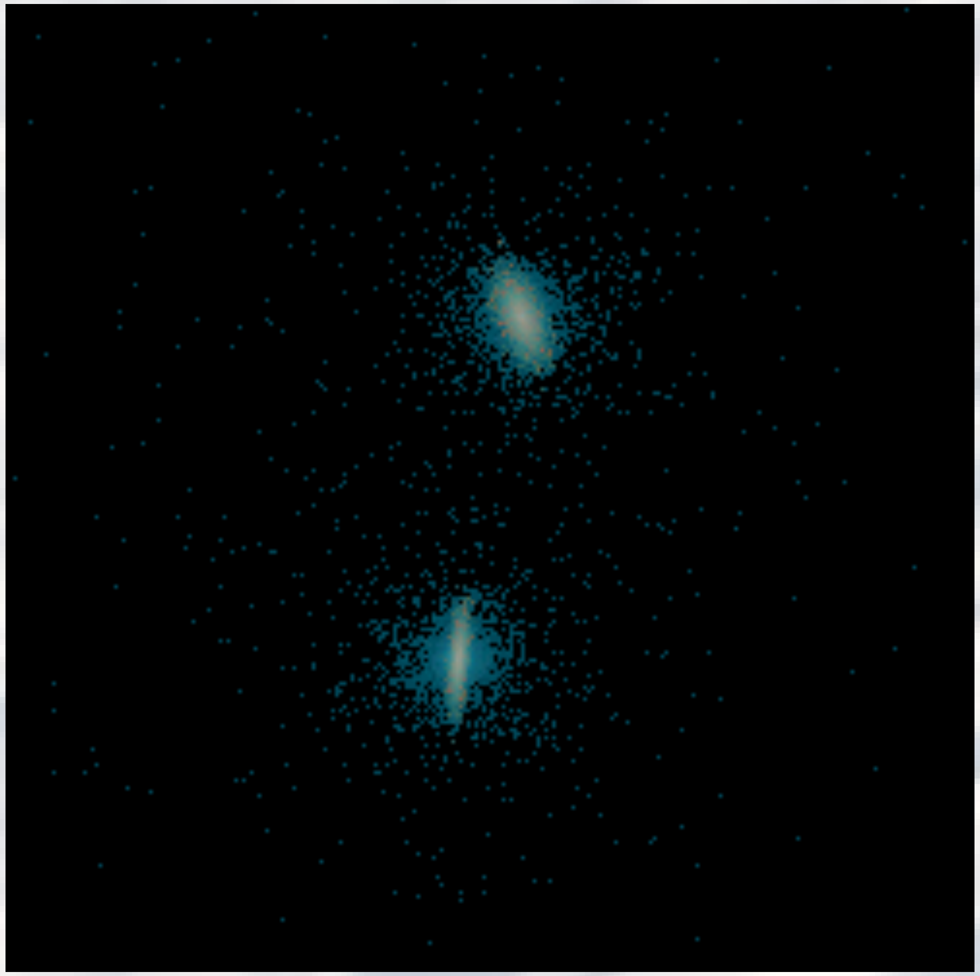
- **Mass loss: stellar winds** — No: **55** Yes: 47
- **Mass loss: supernovae** — No: **69** Yes: 33

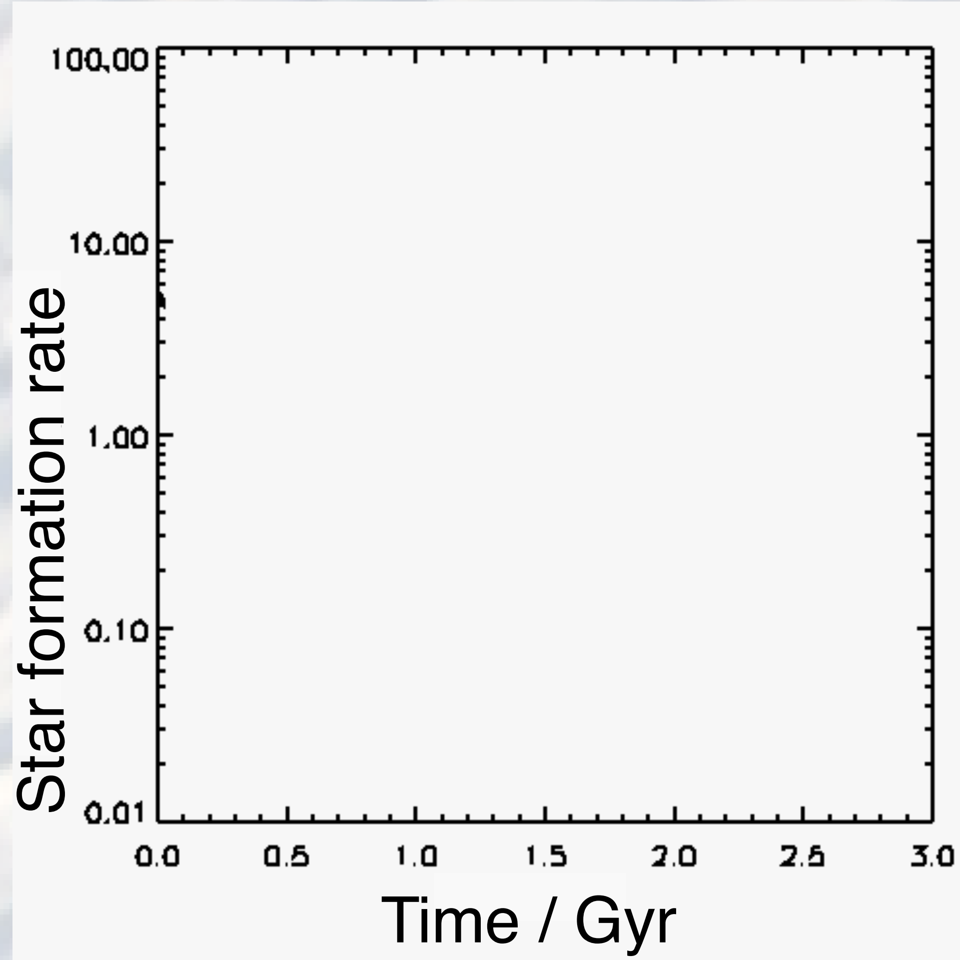
Dave Alexander, Monday

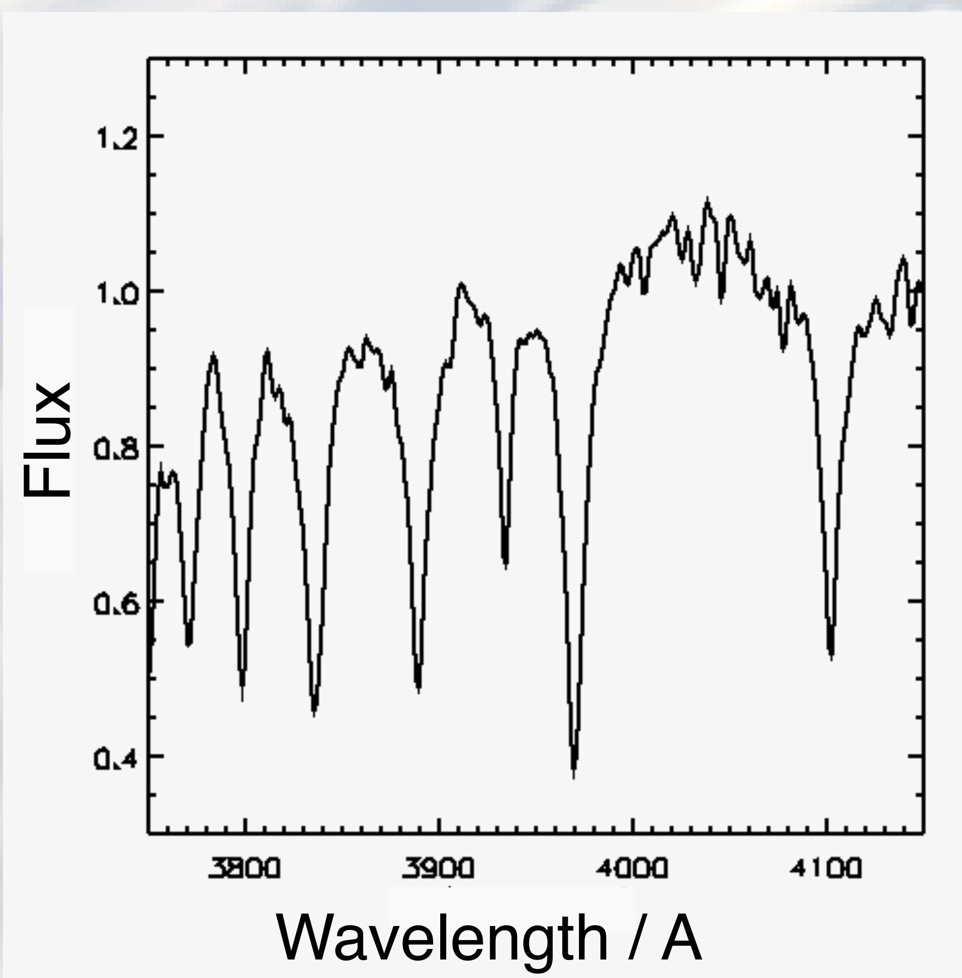
Effect:
Where are they going to?

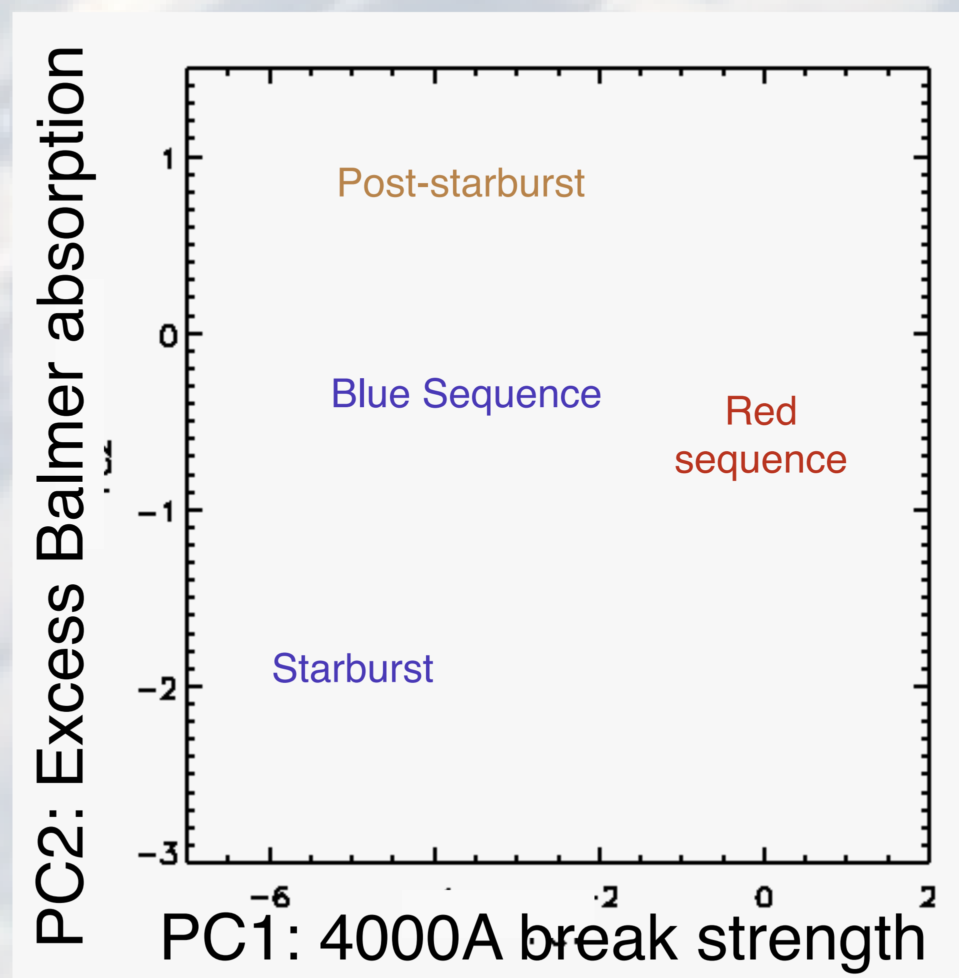


Cause:
Where did they come from?





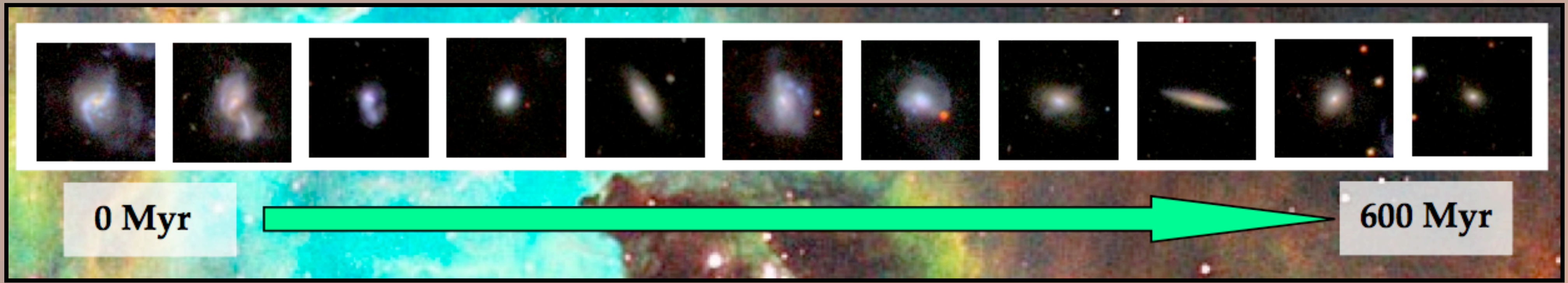


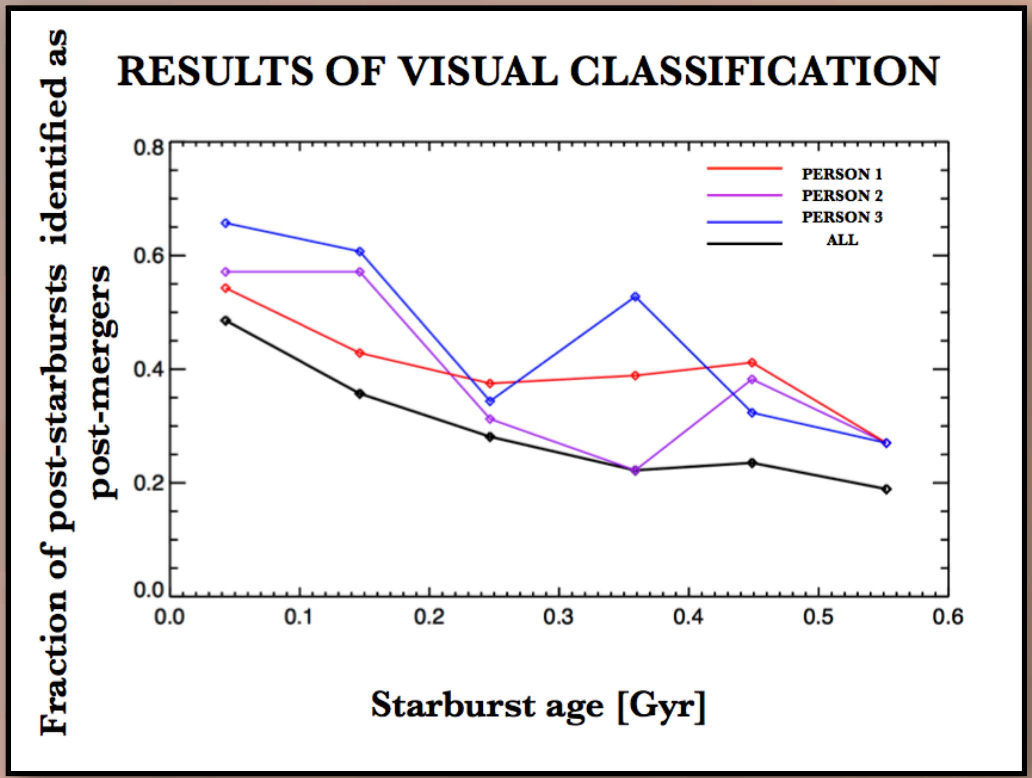


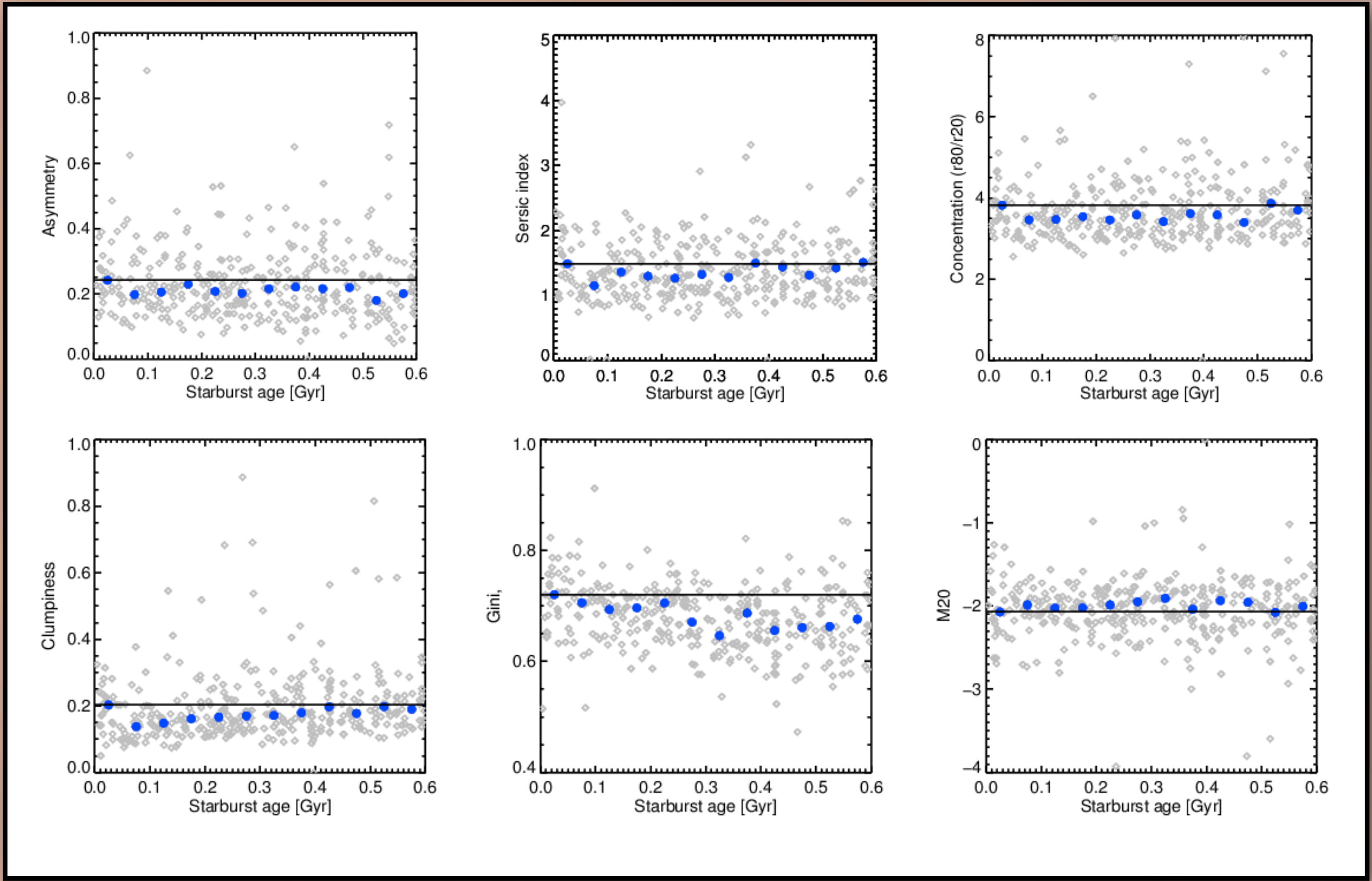
Wild, Walcher, Johansson et al. 2009

Cause: post-starburst = post-merger

Vivienne Wild





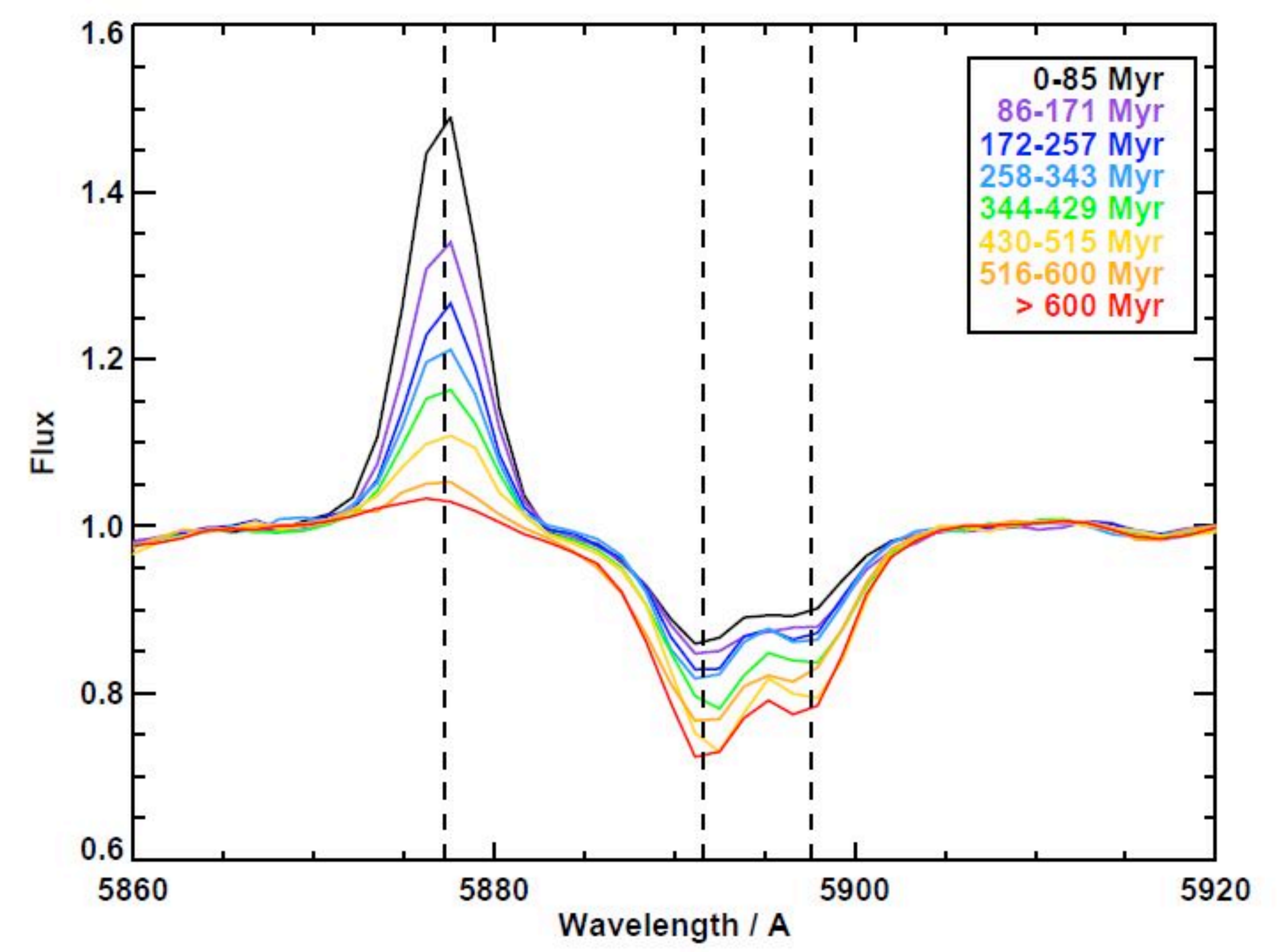


- ★ Clear decrease in visually identifiable post-merger signatures with age
  - From ~50% to ~20% of objects, as expected for fading low surface-brightness structures
- ★ Beware of automated measurements for identifying post-mergers!

Pawlik et al. in prep

(Lack of) Effect: Down-the-barrel outflows

Vivienne Wild



★ ~few hundred km/s outflows, in all age bins, especially face-on

- No evidence for changing outflow velocity with starburst age

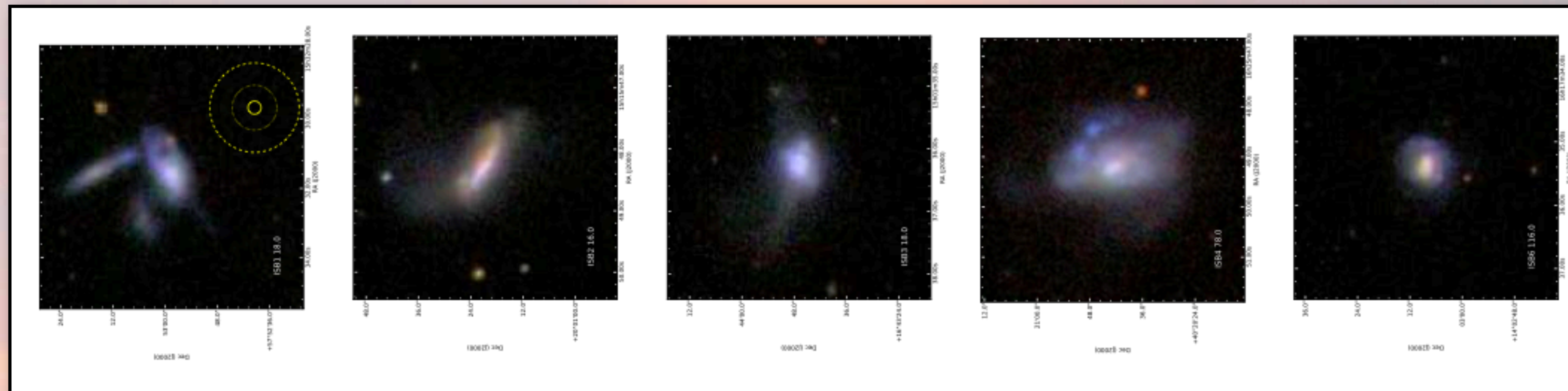
Elizabeth Cooke
(now in Nottingham)

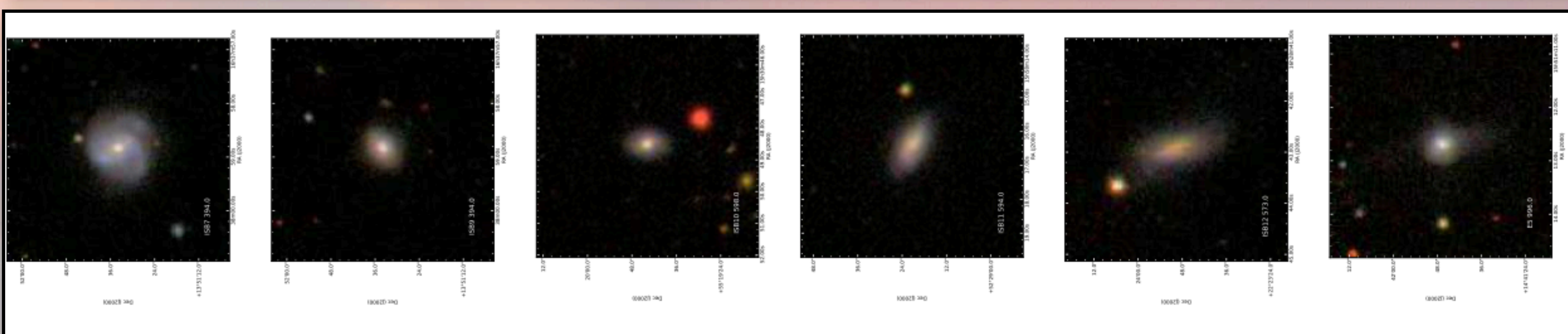
Cold gas and dust properties

Vivienne Wild

★ IRAM CO(1-0) and (2-1) + Herschel (PACS+SPIRE) observations of 11 galaxies along the (post-)starburst sequence

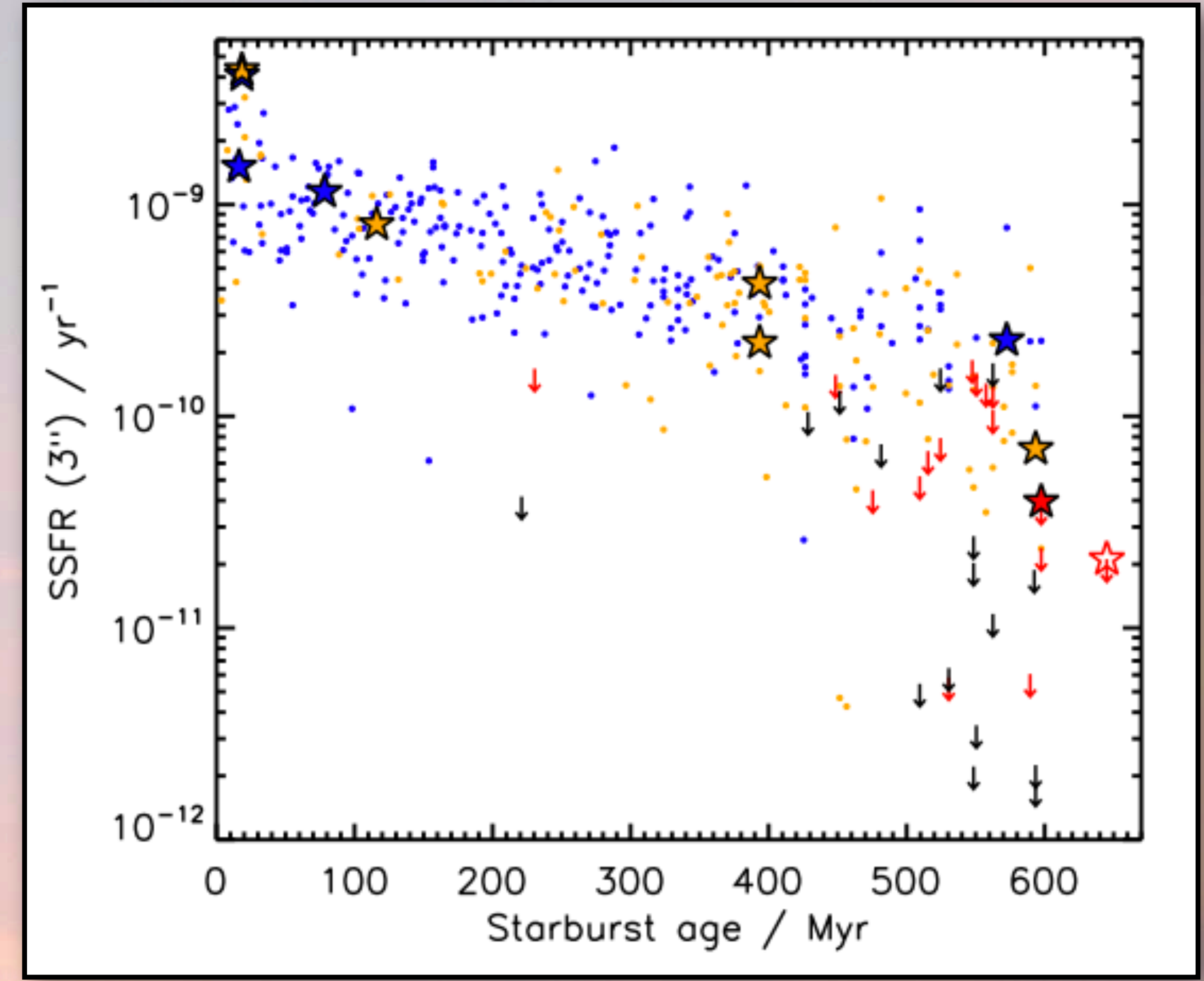
- Starburst ages of <20Myr to 1Gyr

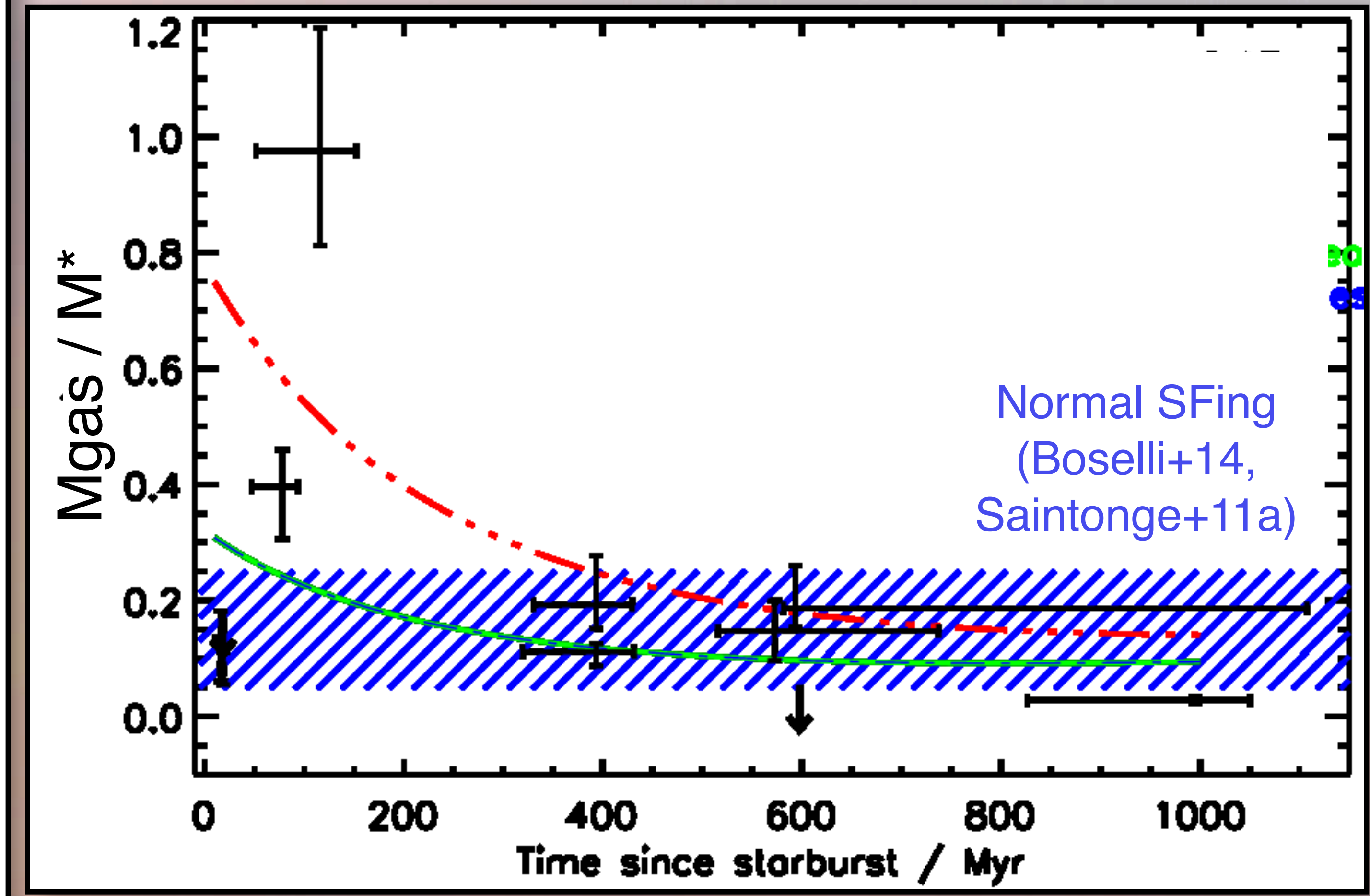




SFR vs. cold gas supply

Vivienne Wild



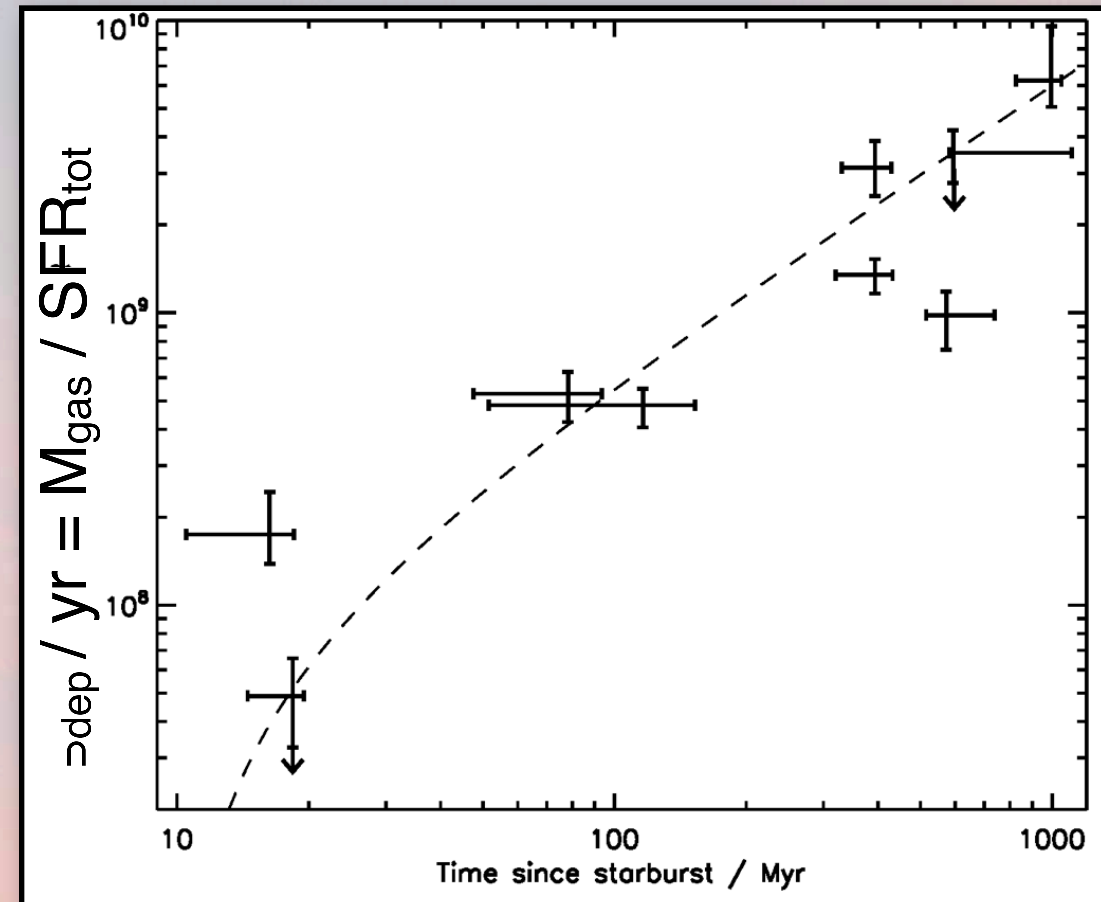


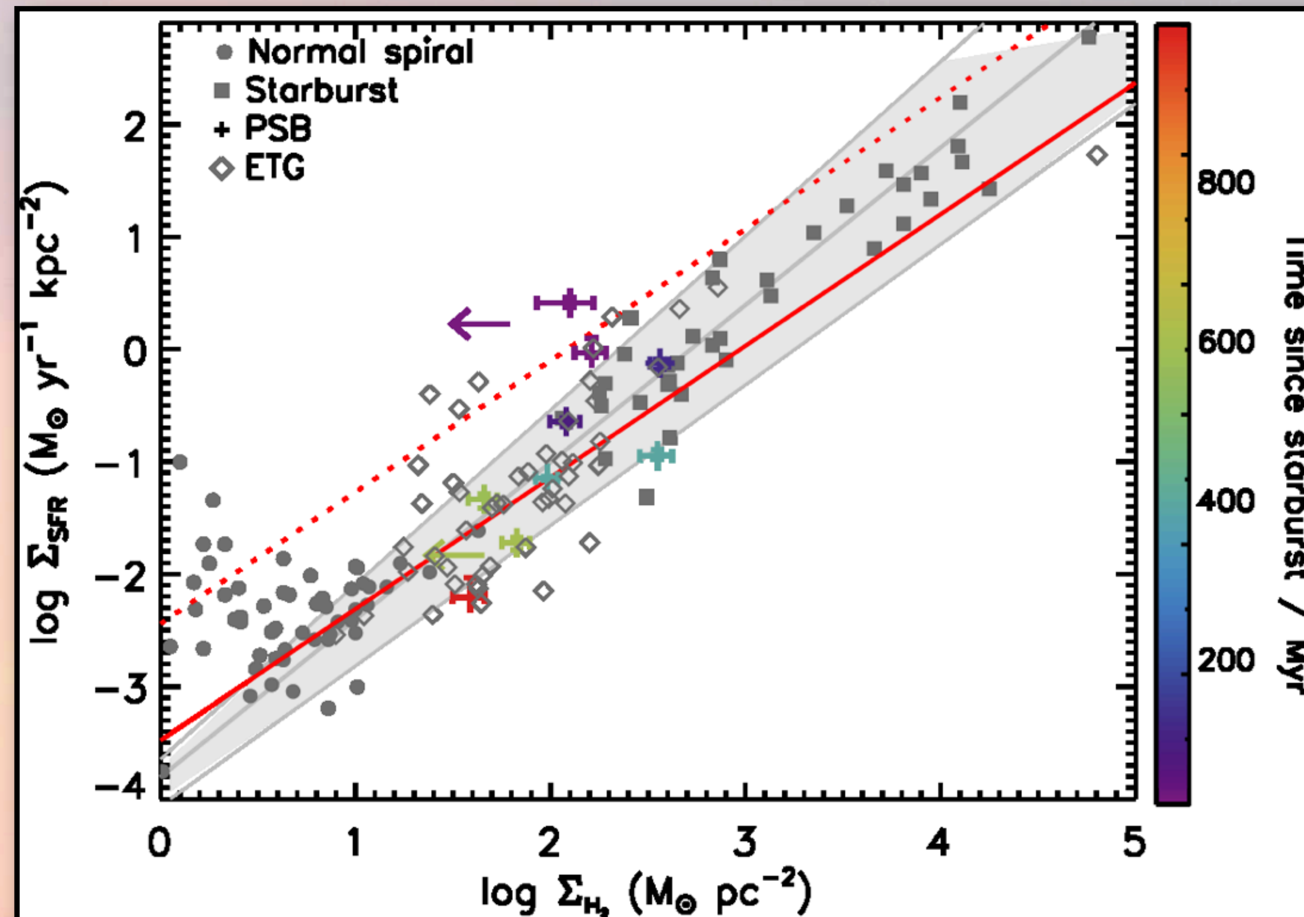
- ★ No evidence for expulsion of gas, either by starburst or AGN
- ★ Slow decline in gas supplies over ~500Myr? Needs more data....

Rowlands et al. in prep

SFR efficiency

Vivienne Wild



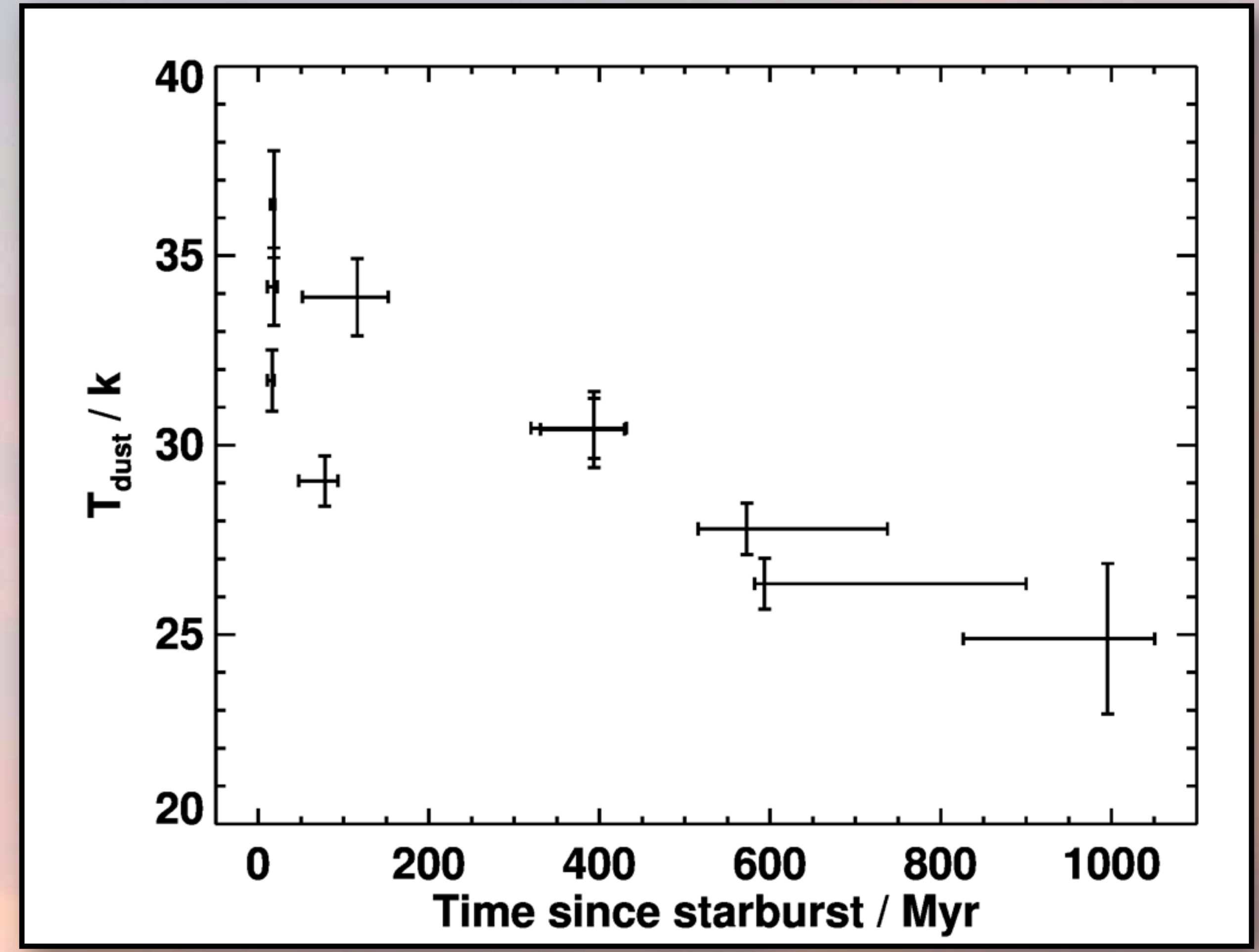


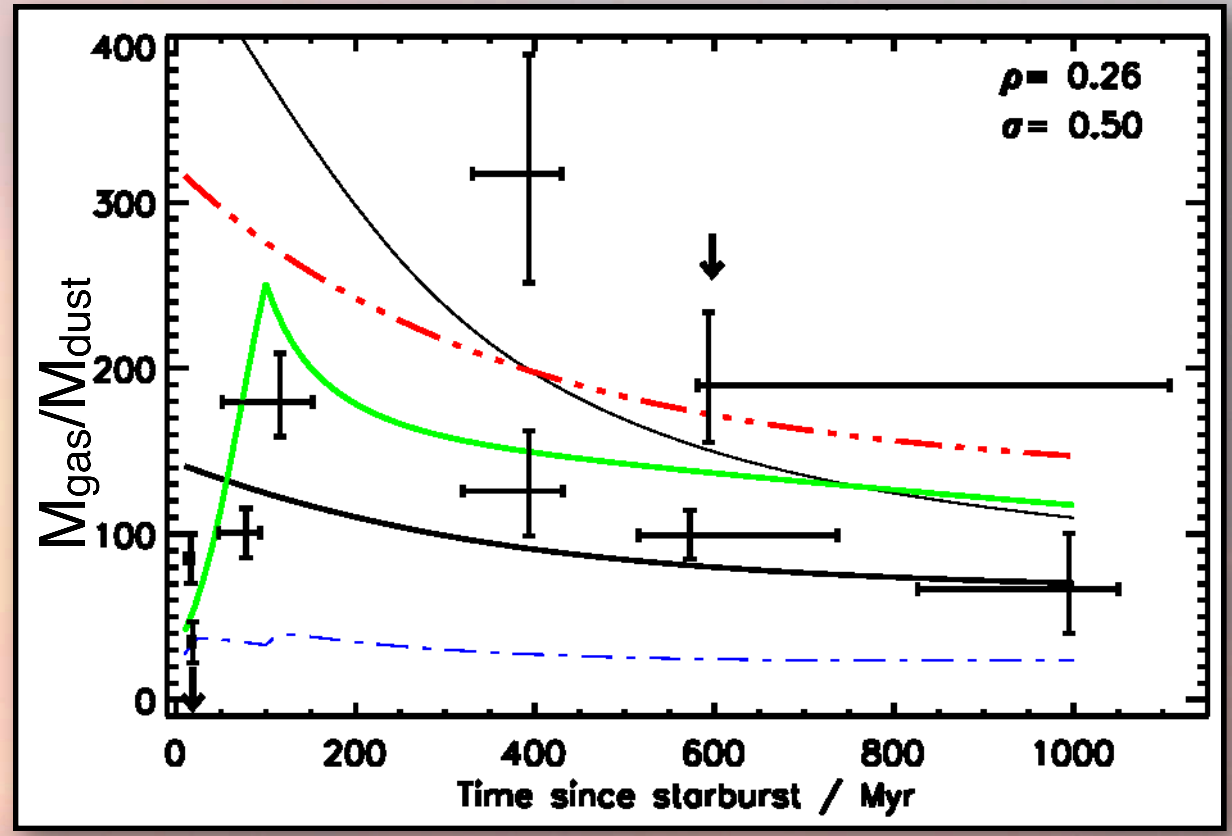
- ★ Gas depletion time increases linearly
- ★ Less efficient star formation at later times

Rowlands et al. in prep

Changing ISM conditions

Vivienne Wild





★ Steady decline of dust temperature

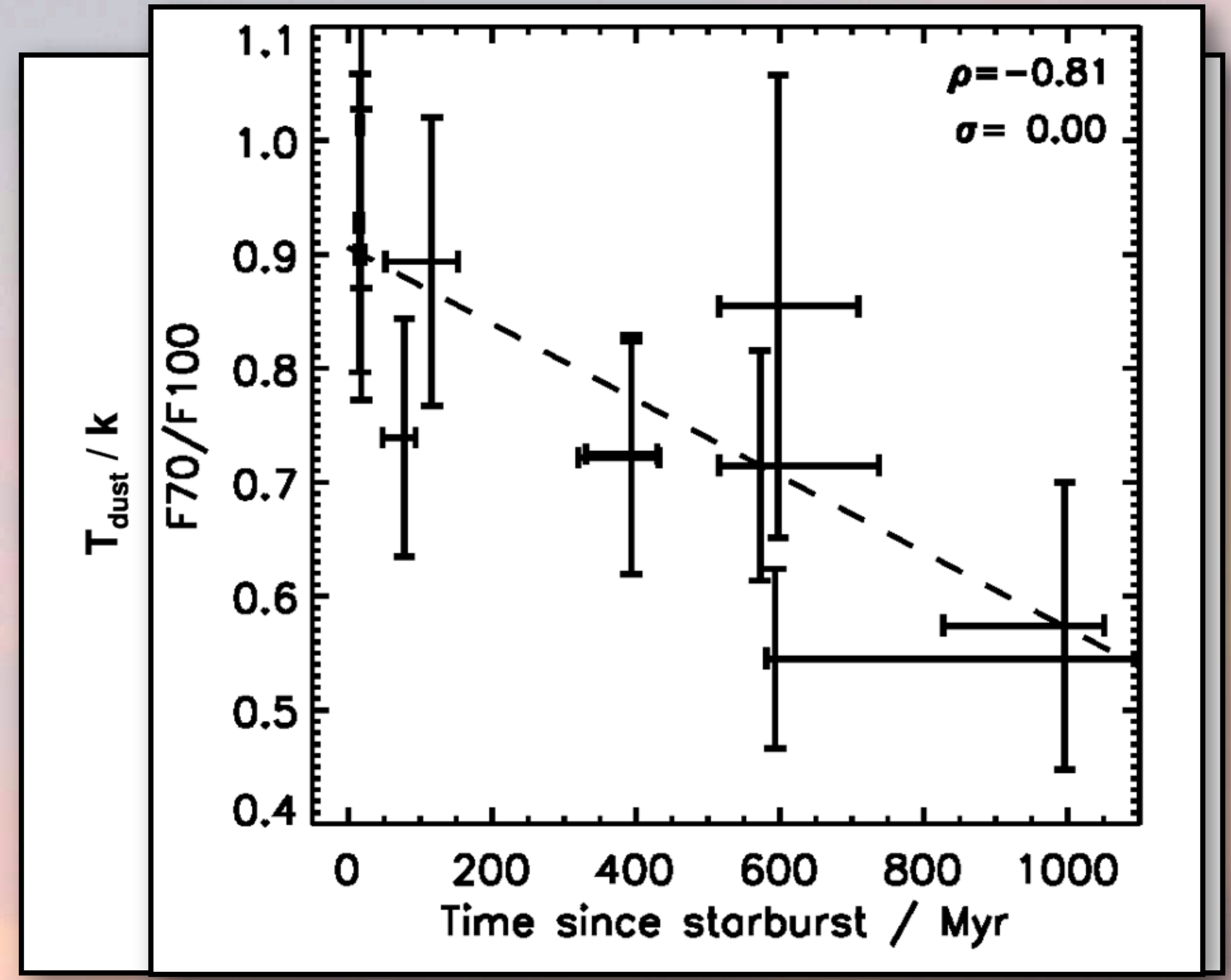
★ Dust created and destroyed

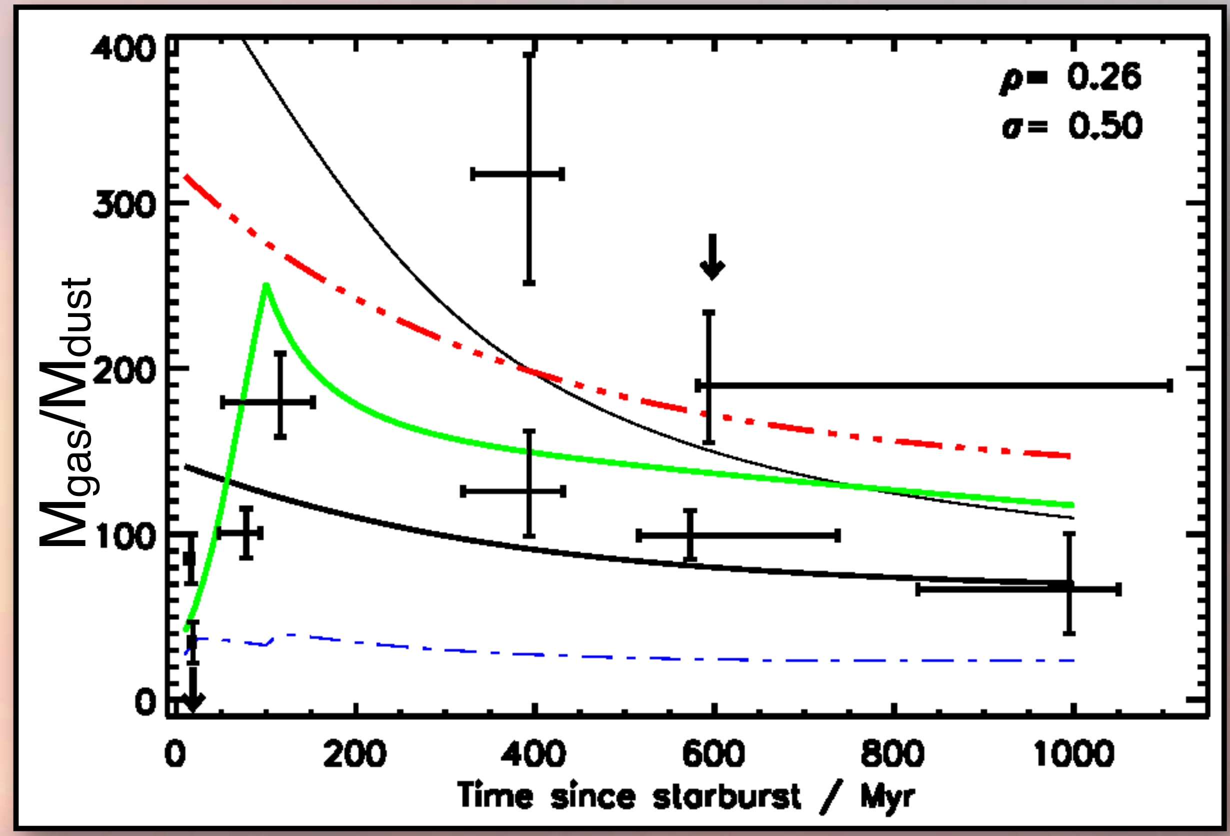
★ No clear impact of AGN (but need larger samples)

Rowlands et al. in prep

Changing ISM conditions

Vivienne Wild





- ★ Steady decline of dust temperature
- ★ Dust created and destroyed
- ★ No clear impact of AGN (but need larger samples)

Rowlands et al. in prep

Summary & Conclusions

Vivienne Wild

- ★ Recent starburst: helpful, but not necessary, condition for low-z BH growth
- ★ 250Myr delay between end of starburst and peak BH growth
- ★ All theories/simulations so far suggest SNe winds should feed BHs

Cause of starburst

- ★ >50% local strong post-starburst = post-merger
  - Good, otherwise difficult to explain such strong starburst in local massive galaxies

Effect of starburst/AGN

- ★ No evidence for change in ISM outflow velocity
- ★ No evidence for expulsion/disruption of global cold gas supply
- ★ ISM conditions steadily normalise following starburst:
  - Dust fraction and temperature declines with time
  - Requires dust formation in SNe + subsequent destruction of dust in ISM

"Fast" quenching: Merger⇒starburst⇒post-starburst (AGN?) ⇒"red and dead" galaxies?

- ★ >600 Myr? is this scenario even relevant at low-z?