## SFR and dust obscuration a z~2: galaxies at the dawn of downsizing

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with

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## SFR and dust obscuration a z~2:

- The galaxy evolution puzzle in 2008
- SFR properties and radio emission
- The VLA-COSMOS deep wide survey
  - The BzK COSMOS project
  - Stacking data: SKA science 20 years before SKA
    - SFR, stellar mass, dust and ... downsizing
    - Conclusions

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# When and how galaxies formed



(Marchesini et al., 2008)

Broad consensus on the evolution of the galaxy stellar mass function up to high redshift

About 45% of the present day stellar mass has been produced in about 3.6 Gyrs at 1 < z < 3

The remaining 50% has formed in the last 7.5 Gyrs at 1 < z < 0

# When and how galaxies formed



(Damen et al., 2008)

"The SSFR increases with z at a rate independent of mass"

"SSFRs of more massive galaxies are typically lower than those of less massive galaxies over the whole redshift range"

The downsizing pattern seems to be at work up to high redshift

#### **Radio emission and SFR**





SFR-FIR correlation (Kennicutt 1998)

 X

 Radio-FIR correlation (Yun et al, 2001; Bell 2003)

 X

 Radio interferometry with ~1 arcsec resolution

The "best" dust-unbiased SFR indicator

## The VLA-COSMOS wide survey



VLA large program (P.I. Eva Shinnerer) Full COSMOS field at 1.4 Ghz 1.5'' resolution rms ~ 10 µ Jy



(Schinnerer et al., 2007)

## The BzK COSMOS project



Chasing galaxies at  $z \sim 2$ : the BzK selection technique



#### The BzK COSMOS project





#### 30125 sBzK galaxies

WIRCAM/CFHT K (P.I. H. J. McCracken)

SuprimeCam/Subaru Bz (COSMOS Legacy dataset)

Кав ~ 23 mag

#### The BzK COSMOS project





Extremely effective selection of galaxies at 1.3 < z < 2.5 "Only" 616 objects (~2%) are 1.4 GHz detected EVLA Workshop - December 2008 9

## The stacking analysis



#### **1.4 GHz median stacking:**

- more robust than mean against detections
- rms goes down by ~  $\sqrt{N}$  *i.e.* 0.1/0.3  $\mu$  Jy
- "normal" star forming galaxy at high z
- next generation arrays science case (SKA)



Stacking is Exciting and Fun!

#### The stacking analysis



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Stack of 30125 sBzKs flux ~ 8.8  $\mu$  Jy rms ~ 0.1  $\mu$  Jy fwhm ~ 1 arcsec



Stacking is Exciting and Fun!

#### Radio stacks vs. B band mag



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 observed UV restframe light (1500 Å) is poorly correlated with the ongoing star formation activity

- counter intuitively: the faintest UV luminosity has the largest SFR

#### Radio stacks vs. Stellar Mass







- Tight correlation between galaxy stellar mass and star formation
- Similarly to the local Universe: the higher the stellar mass, the more the star formation

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#### Radio stacks vs. (B-z) color







- Tight correlation between (B-z) color and star formation activity

 The observed (B-z) color of z~2 star forming galaxies is a measure of the UV slope, *i.e.* the dust content

## Galaxies with higher SFRs are more dust extincted

## **Radio SFRs vs Stellar Mass**



A linear relation is present at all redshifts probed and its slope is increasing with redshift



 SDSS/AEGIS
 a = 0.7 @ 0/0.7 

 GOODS
 a = 0.9 @ 1 

 Log SFR = aLog M+c
 a = 1.15 @ 1.5 

The evolution of the slope sets the time scales of galaxy evolution by tracing when galaxies enter their active stage as a function of mass

#### **Radio SSFRs**





SSFR vs stellar mass is  $\sim$  flat at z = 1.5

Galaxies are all in their active epoch

No downsizing shows up in these data

(see also Dunne et al., 2008)

The dawn of downsizing has happened at z < 1.5

#### **Radio vs UV SSFRs**



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#### Massive starburst galaxies are as red as ETGs



#### **Radio vs UV SSFRs**



Massive starburst galaxies are as red as ETGs A<sub>1500</sub> is linearly proportional to Log M\*

#### Radio SFRs vs (B-z)







#### Radio SFRs vs (B-z)



#### A<sub>1500</sub> is a linear combination of Log M<sub>\*</sub> and (B-z)

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#### Conclusions



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**Dust-unbiased SFR is proportional to stellar mass** 

The most massive galaxies have the highest SFRs and dust attenuations

There is no downsizing yet at redshift 1.5

UV "corrected" flux is able to retrieve the total SFR

A<sub>1500</sub> can be expressed as a linear combination of LogM<sub>\*</sub> and (B-z) color

## The stacking analysis



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#### **1.4 GHz median stacking:**

- Total flux is retrieved by fitting a "dirty beam" convolved Gaussian to the stacked data (CLEAN gives the very same result !)
- The Gaussian FWHM is contributed by both Band Width Smearing effect and the physical source size (work in progress...)



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## The EVLA VISION: THINK BIG !



**EVLA will make the VLA-COSMOS a 30 hours project** 

We can finally think to follow up extensively all the optical-NIR extragalactic fields

Multifrequency observations will provide a detailed description of the radio sources spectra

Stacking analysis will disclose unprecedented views on galaxy evolution