Starburst-AGN duality with Gaia:

Observational evidences

Theoretical models

The case of radiogalaxies

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The main questions on
Star Formation and AGN

- **The accurate astrometry of Gaia is able to identify the possible relation between the star formation activity and the super massive black hole.**

- **To identify Starburst-AGN relation**

- **Modelling :**
- **Standard Starburst/HII region/single massive stars**
- **Standard Host galaxies by types**
- **Galaxy nucleus/mergers/ Seyfert/ with BP/RP and RVS**

- **Theories:**
  Jet-cloud interactions (Bicknell, 2000)
  Major or minor mergers (N-body/hydro simulations)

- **LF of active/radio Galaxies completing the LF of QSOs**

Observational evidences of SF-BH relation

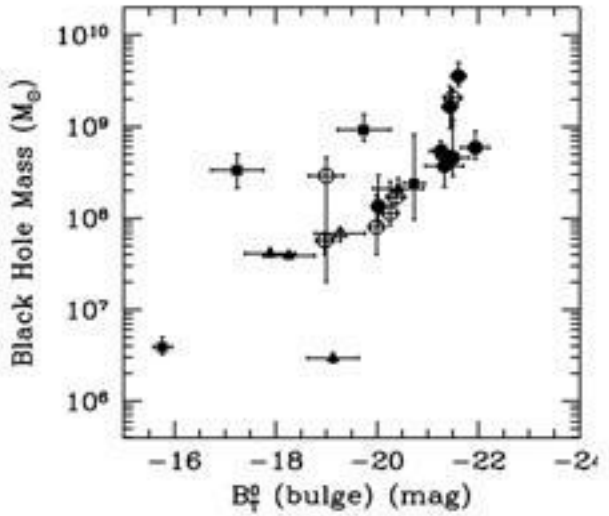
- The correlation

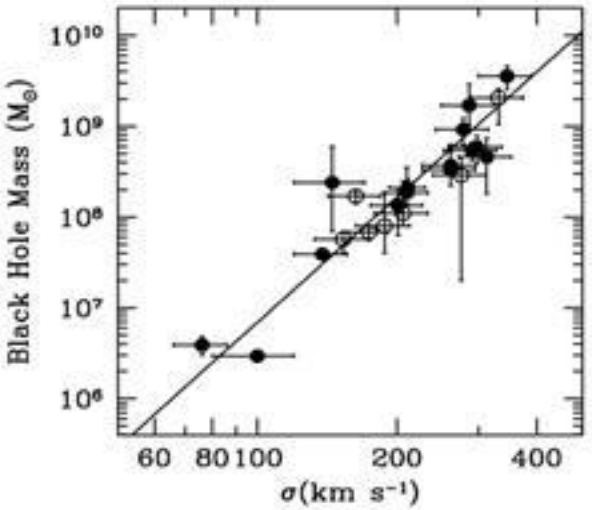
  Mass_(BH) versus StellarMass (Ferrarese et al, 2002) l

- Giant HII regions in radio/seyfert galaxies
- Nearby Merger galaxies
- Powerful radio galaxies: evidence of starbursts

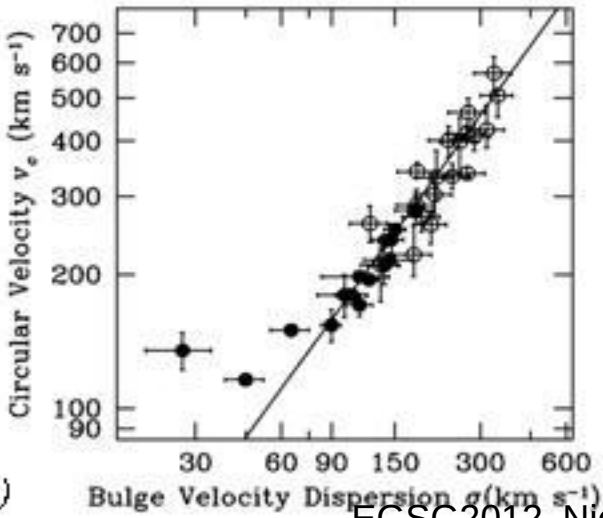
Fundamental Correlations Between MBHs and Their Host Galaxies

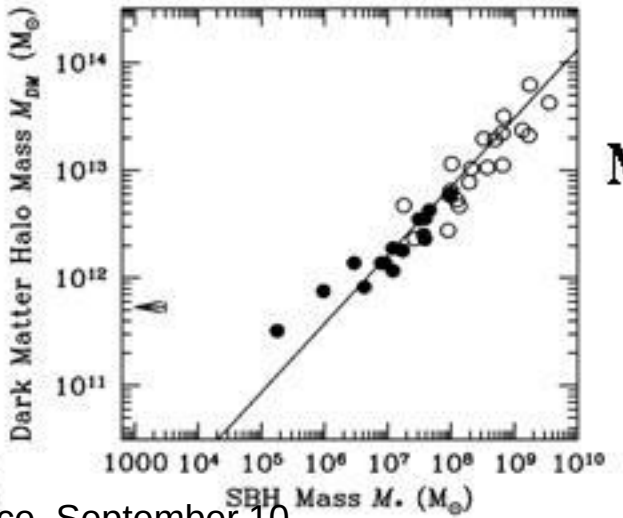
$M_\bullet \sim L_{\rho}^{0.9} \sim M_{\rho}$





$M_\bullet \sim \sigma^{4.5}$





$M_\bullet \sim M_H^{1.6}$

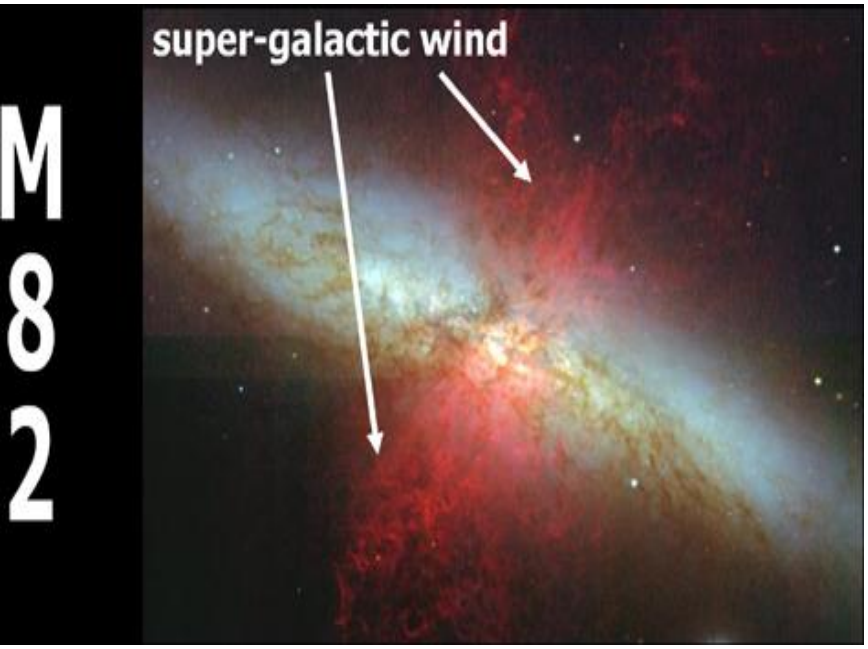
(Ferrarese 2002)

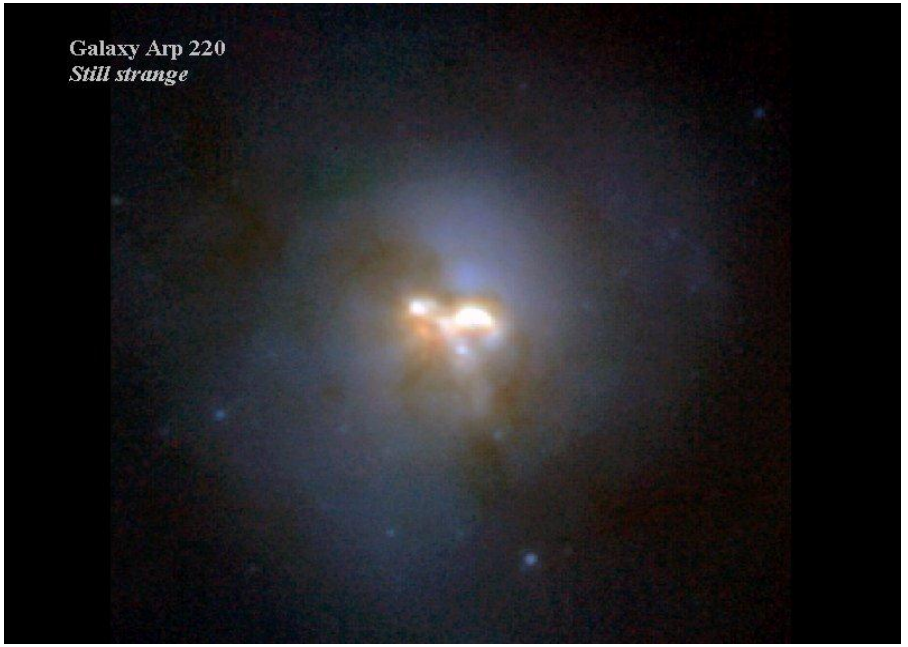
EVIDENCES of RELATIONs Massive Black Hole and stellar Masses

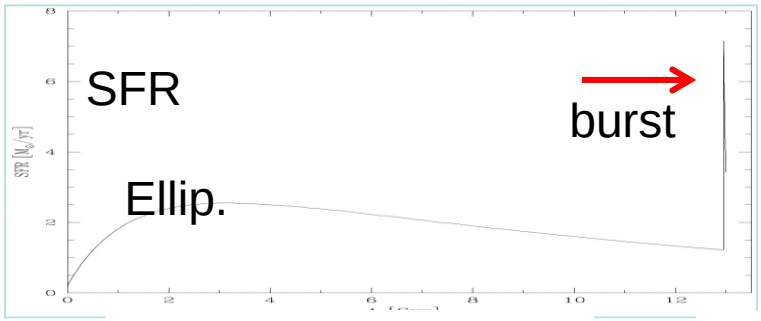
Other evidences in the INFRARED : ULIRG

« The Starburst Template M82 » is hosted in a massive Elliptical

« Are Interacting galaxies as ARP 220 forming Elliptical galaxies?

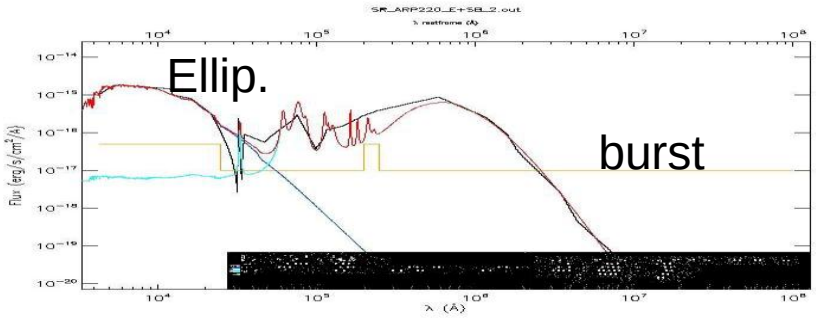






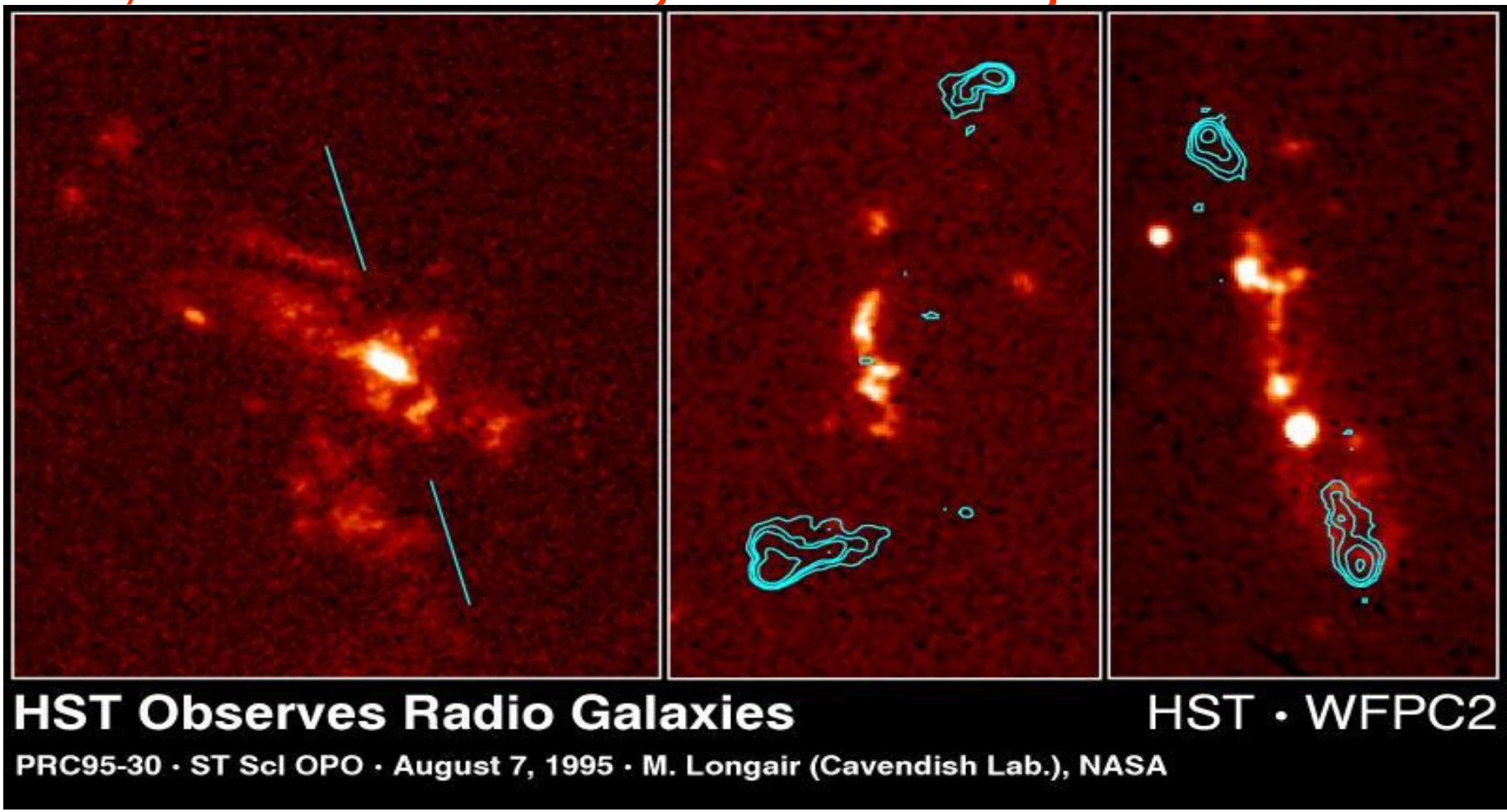
Silva et al, 1998

SFR.



age

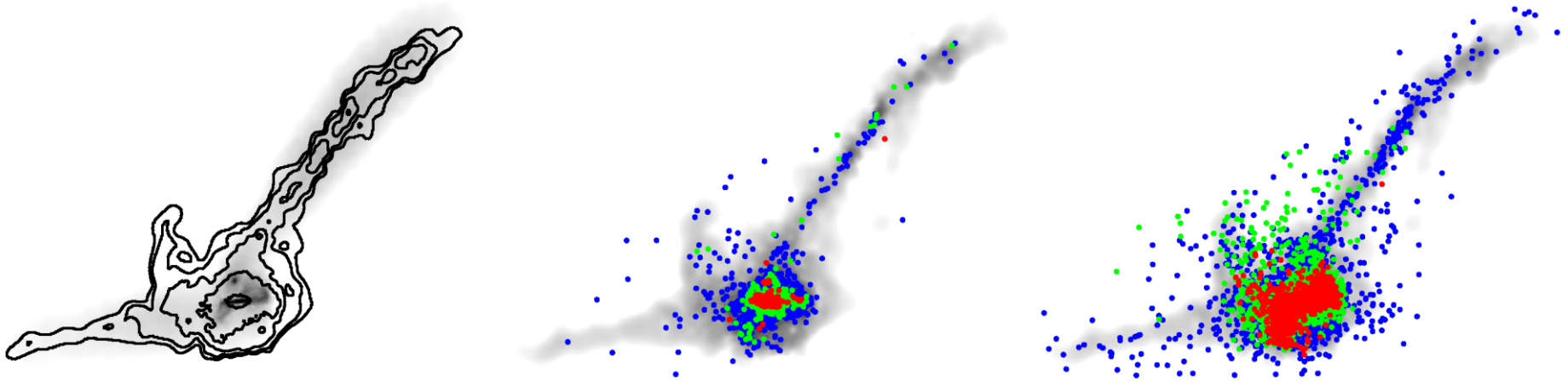
Radio Galaxies The problem of alignement of axes: , star formation by interaction jet-cloud



Shocks or Photoionization by AGN or massive stars

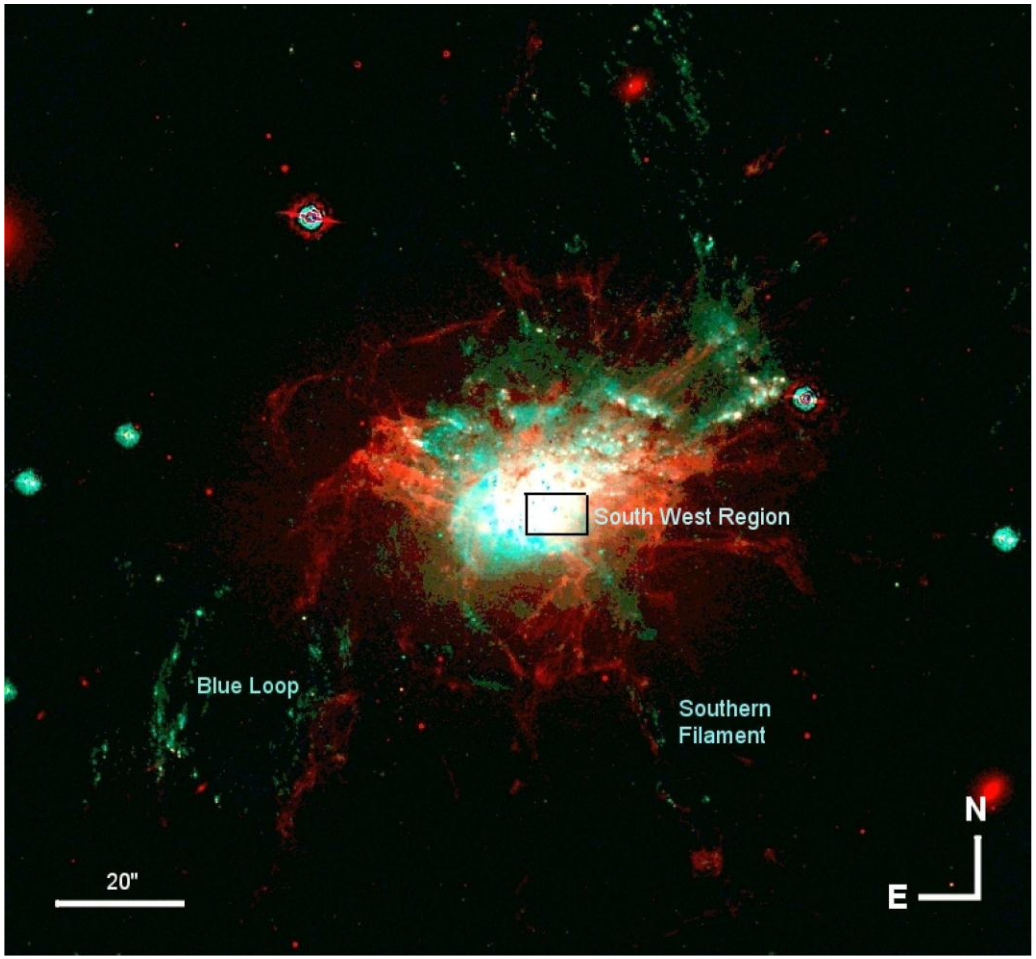
Star formation by mergers

- **In the antennae or the merger N7252 (Chien & Barnes, 2010)**



Star formation in NGC1275

Canning et al, 2010



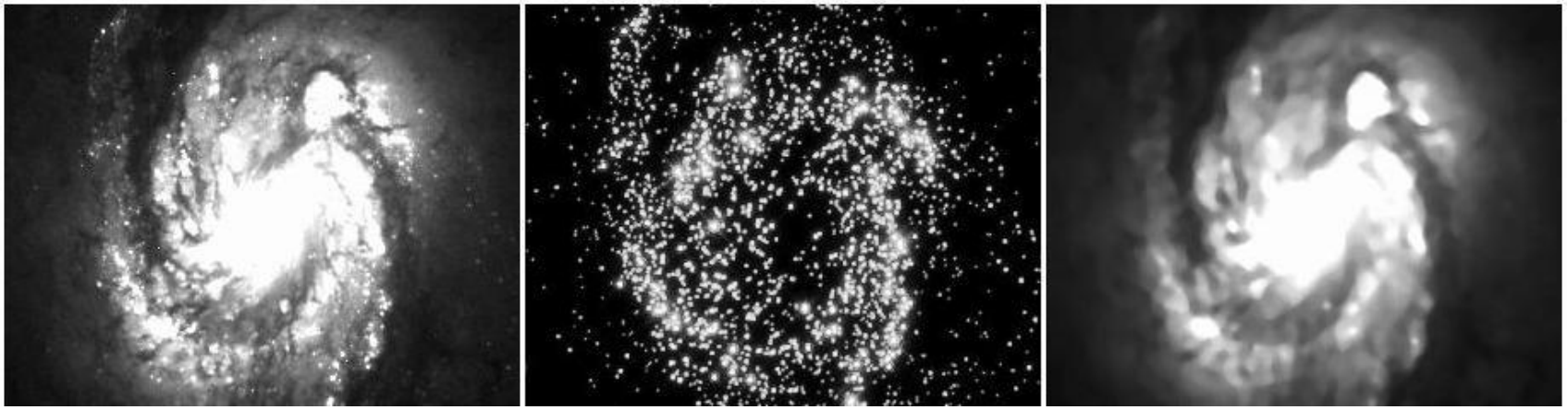
Models at low resolution

- Starburst The optical SED and IR dust emission

- The Hubble galaxies by types

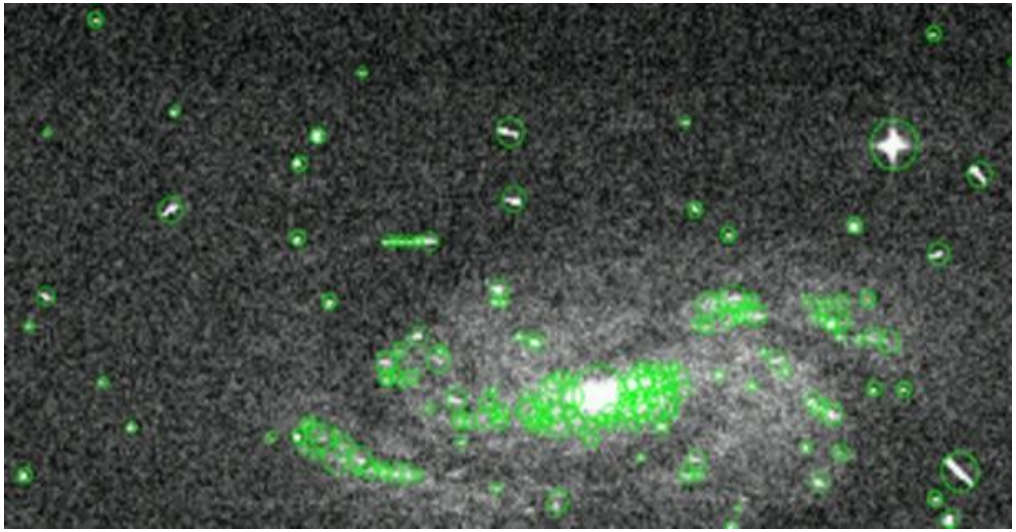
For BP/RP

Distant resolved Galaxies



Deconvolution using StarFinder (Diolaiti et al. 2000)

M100



SM 32”x32”
from HST-PC

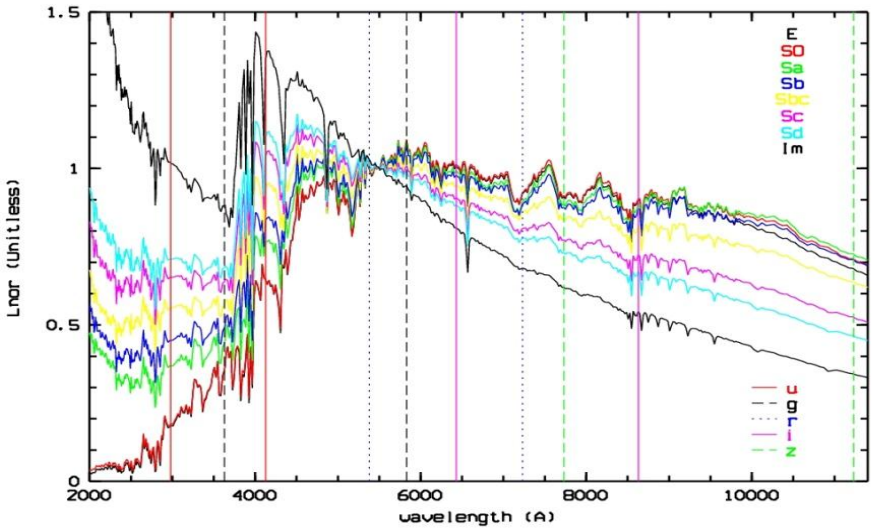
BP/RP LOW RESOLUTION

Evolution of galaxies by the code Pegase

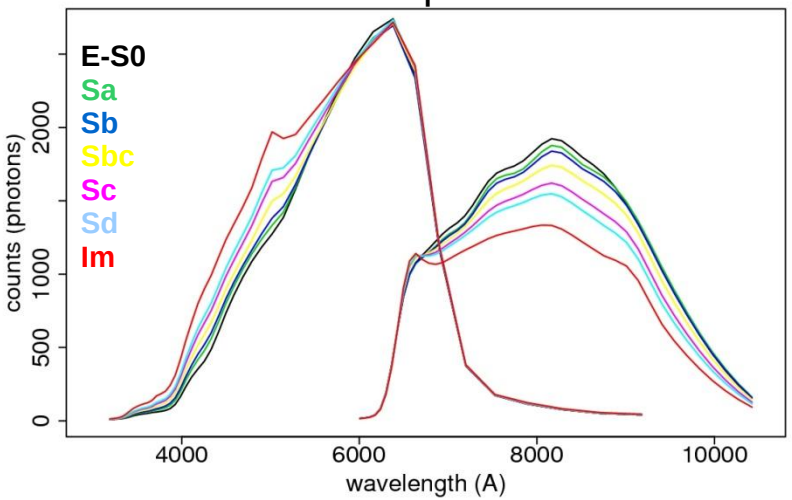
CU8 Gaia Collaboration:
M. Kontizas, P. Tsalmantza,
A. Karampelas (U. Athens)
B. Rocca-Volmerange, A. Sourie (IAP, Paris)
R. Sordo, A. Vallenari (Padova)
C. Bayler-Jones (Heidelberg), Ioannis Bellas-V.
And E. Tsalmantza (U. Athens)

BP/RP: Classification and parametrization of the simulated Gaia spectra Tsalmantza, Kontizas, Rocca-Volmerange, Bayler-Jones et al, 2007, 2009

PEGASE spectra



Gaia spectra



Gaia BP/RP spectra

↓ Discrete source classifier

Galaxy spectra

↓ Av

Galaxy spectra with known Av

↓ z

Galaxy spectra with known Av, z

↓ Galaxy type & Astrophysical Parameters

Galaxy spectra with known Av, z, type, APs

The results presented here are produced using Support Vector Machines for galaxy spectra with noise and **G=18.5**

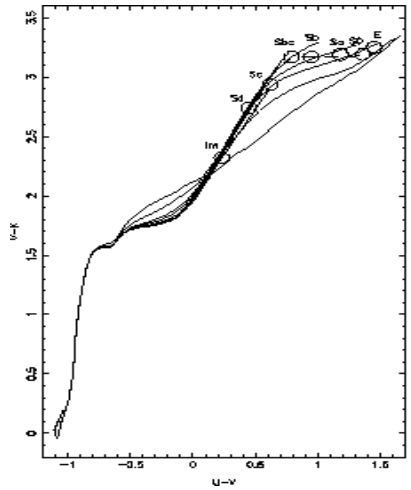
OTHER CALCULATIONS FOR G=15 and 20

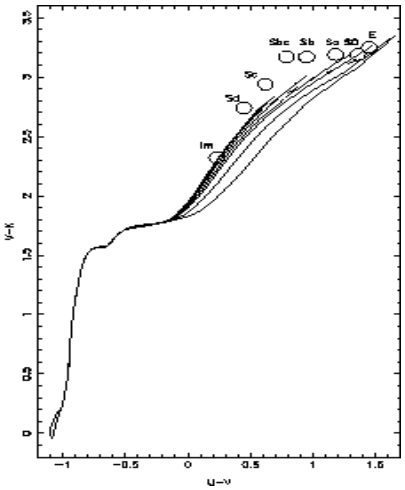
Fits of color/color diagrams by type at z=0 with models

PEGASE: Fioc & Rocca-Volmerange,1997

No statistics on observed spectra

Models
With reddening



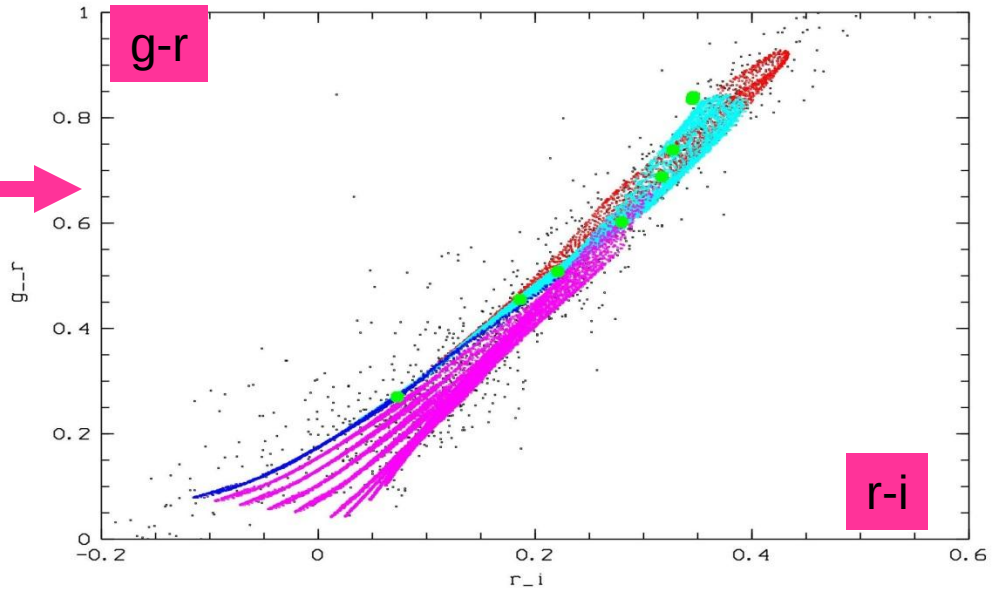


Models
No reddening

At z~0,SLOAN data (SSDS) versus PEGASE models

Tsalmantsa, Kontizas, Rocca-Volmerange et al, 2006

(Gaia cooperation on galaxy library)



Models at High spectral resolution (for RVS)

A new library: Munari et al 2005 **(2500-10500A) covering the λ domain of the RVS.**

+ Collaboration with A. Vallenari and Rozanna Sordo for SSPs

Based on Kurucz models

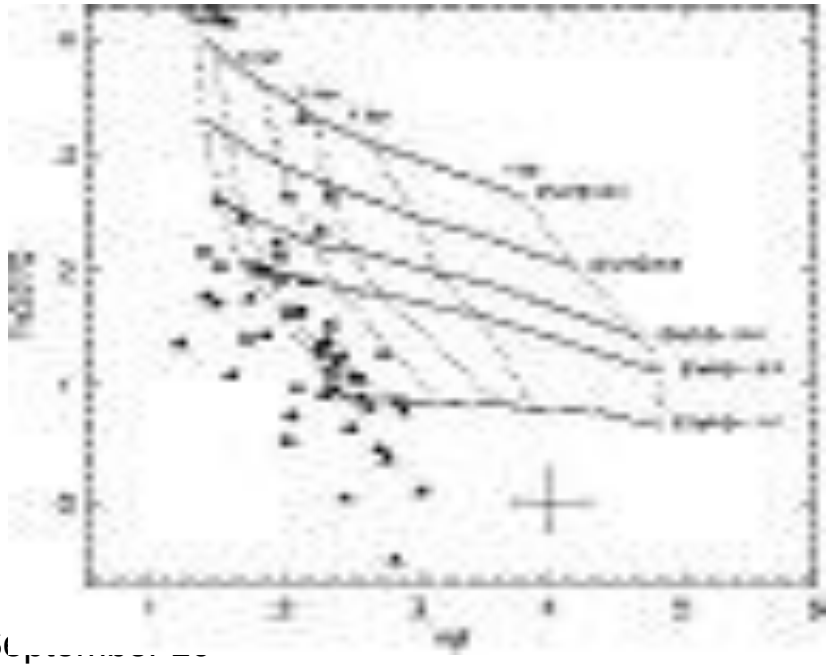
- 1A/pixel
- Teff limited to **> 3500 K**
- Paramètres α/Fe, ξ,v_{rot}

- 2 tracers Paschen 14 and FeI

For disentangling AGE-Metallicity

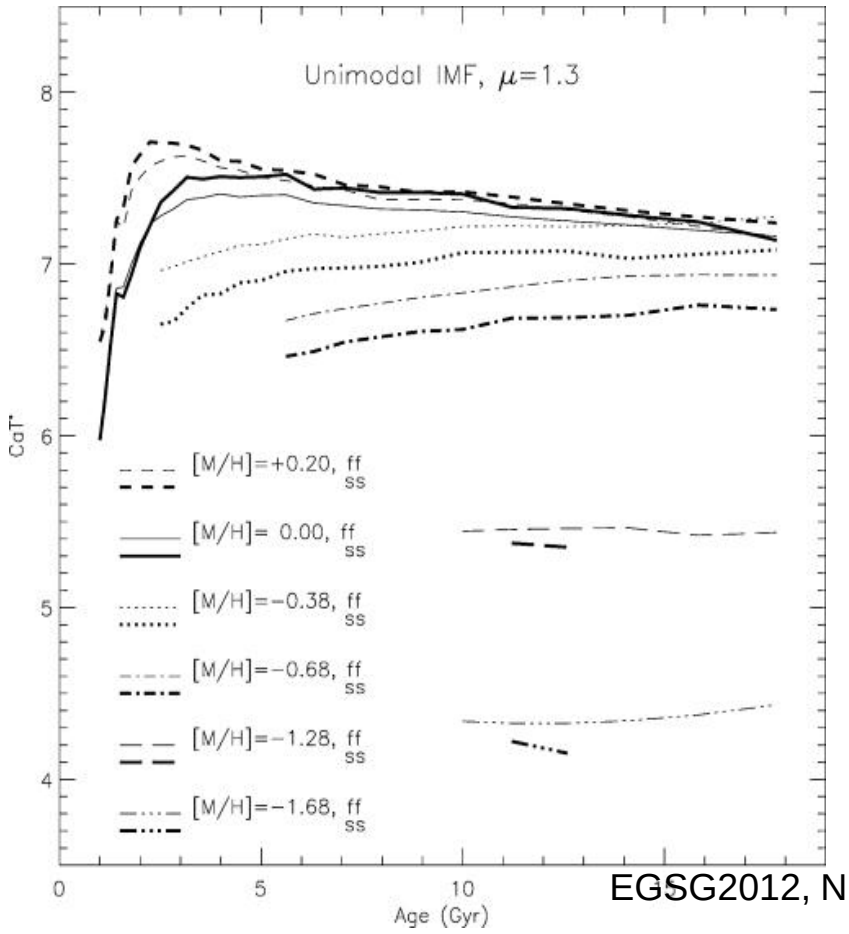
- But non calibrated as Lejeune et al 2000's on observational stellar colors

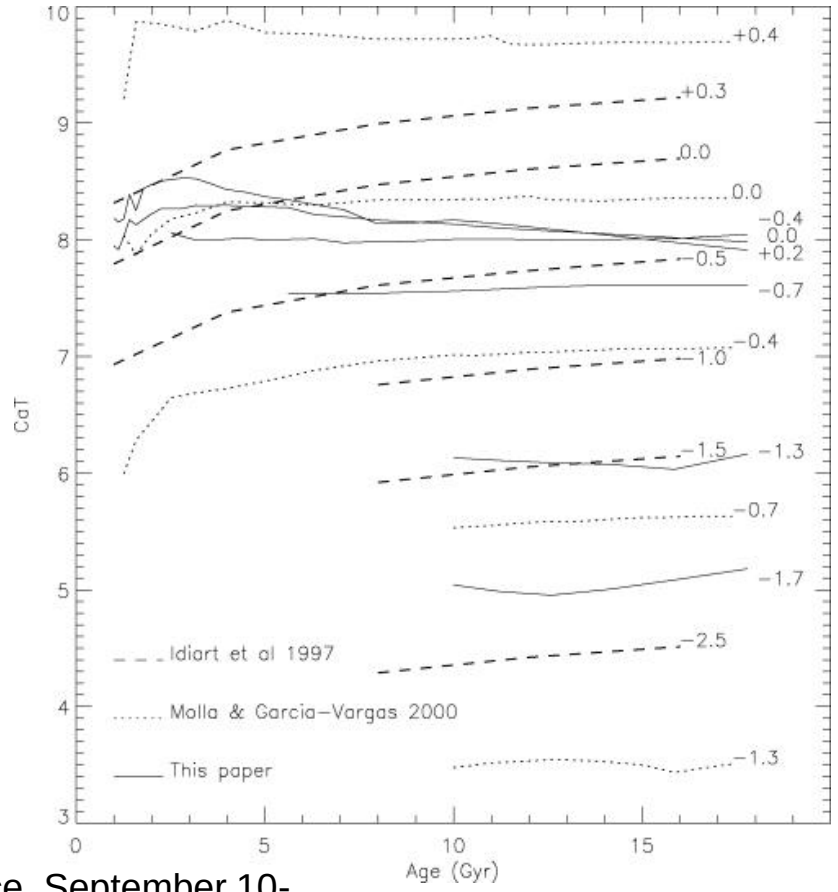
Pa14/FeI



La relation Age-metallicité(1)

- Le triplet du Ca: Cenarro et al,



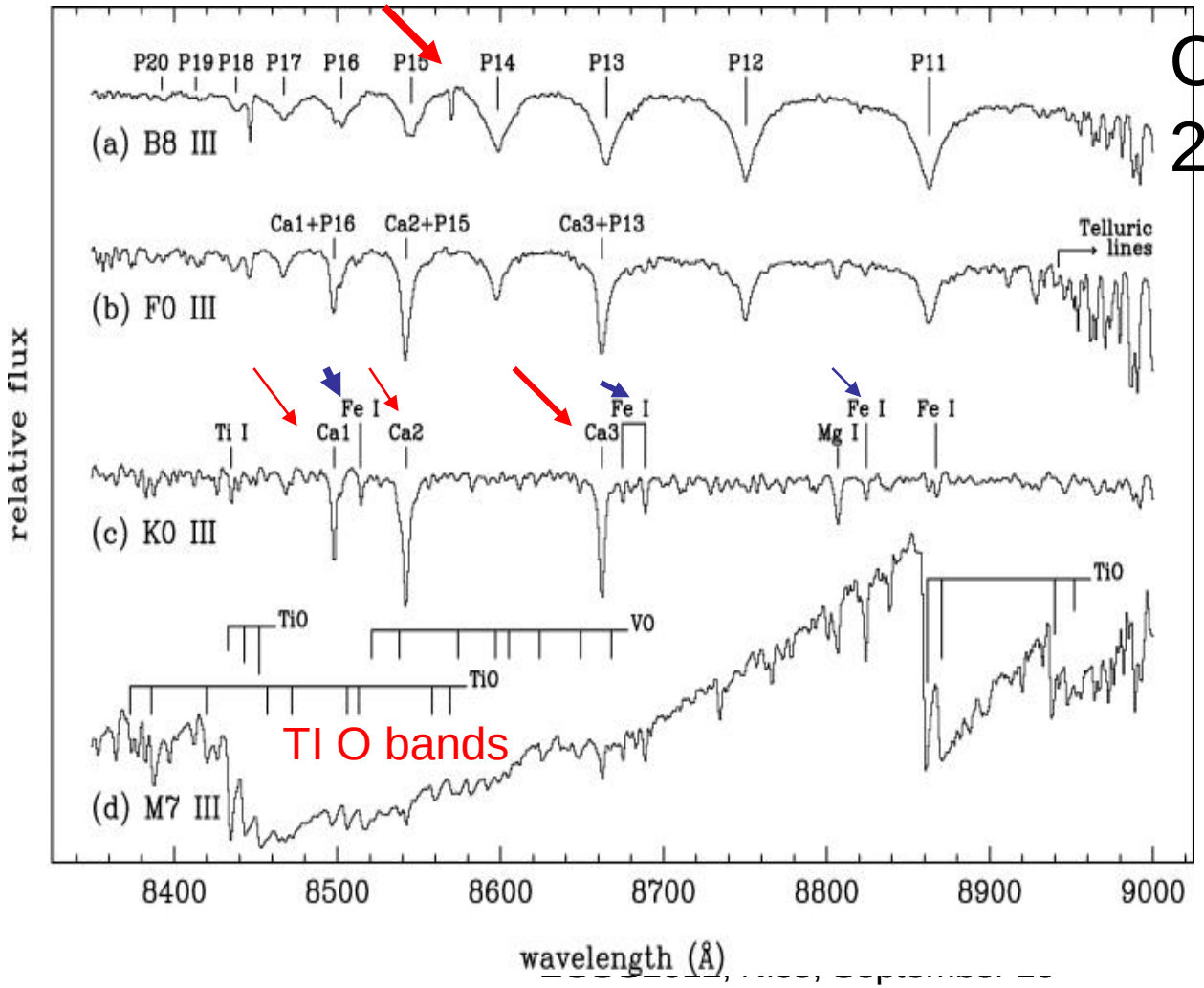


Higher resolution stellar librairies

Completness, λ range, Δλ/ λ power, theoretical/observational

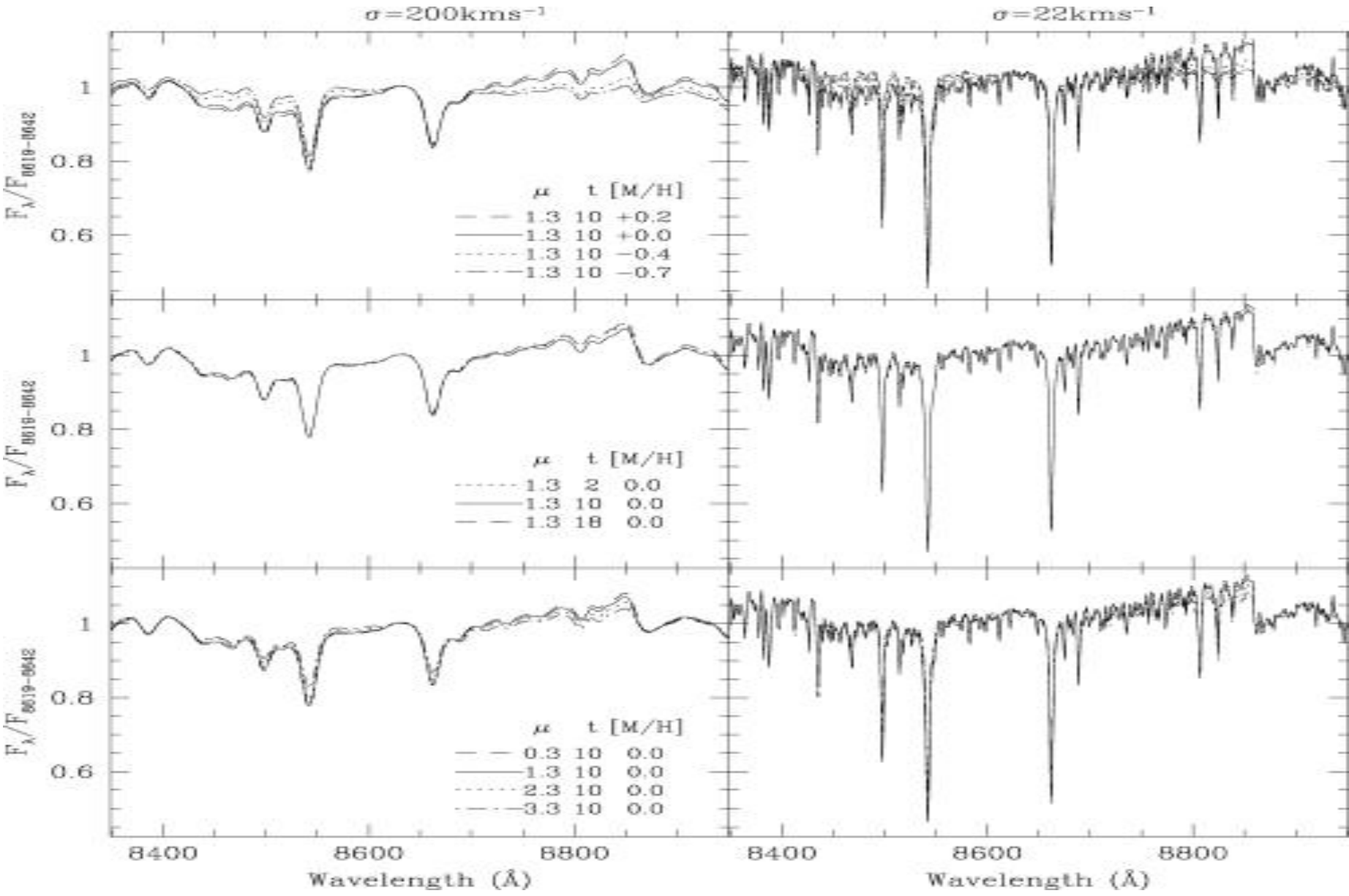
	atm. *spectra*	*resol.* power	*N*	*range of* λ(Å)	$T_{\rm eff}$(K)	log g	[M/H]	*new* *ODF*	*TiO*	*pred.* *lines*	*variation of* [α/Fe]	ξ	$V_{\rm rot}$
Chavez et al. (1997)	Kurucz	250 000	711	4 850	4 000	1.0	−1.0	no	no	no	no	yes	no
				5 400	8 000	5.0	+0.5						
Zwitter et al. (2004)	Kurucz	20 000	61 196	7 653	3 500	0.0	−3.0	yes	yes	no	yes	yes	yes
		11 500, 8 500		8 747	47 500	5.0	+0.5						
Murphy & Meiksin (2004)	Kurucz	250 000	6 410	3 000	5 250	0.0	−5.0	no	no	yes	no	no	no
				10 000	50 000	5.0	+1.0						
Martins et al. (2005)	Kurucz	0.3 Å/pix	1 654	3 000	3 000	−0.5	−1.0	no	yes	no	no	no	no
	Phoenix, Tlusty			7 000	55 000	5.5	+0.3						
Rodriguez-Merino et al. (2005)	Kurucz	50 000	1 770	850	3 000	0.0	−2.0	no	no	no	no	no	no
				4 700	50 000	5.0	+0.5						
Brott & Hauschildt (2005)	Phoenix	2 Å/pix	44 000	10	2 700	−0.5	−3.5		yes		yes	no	no
				50 000	10 000	5.5	+0.5						
Munari et al, 2005	Kurucz	20 000	51 288	2 500	3 500	0.0	−2.5	yes	yes	no	yes	yes	yes
		11 500		10 500	47 500	5.0	+0.5						
		8 500, 2 000											
		1, 10 Å/pix											

On the λ domain of the RVS: Tracers of Ca, H and Fe lines

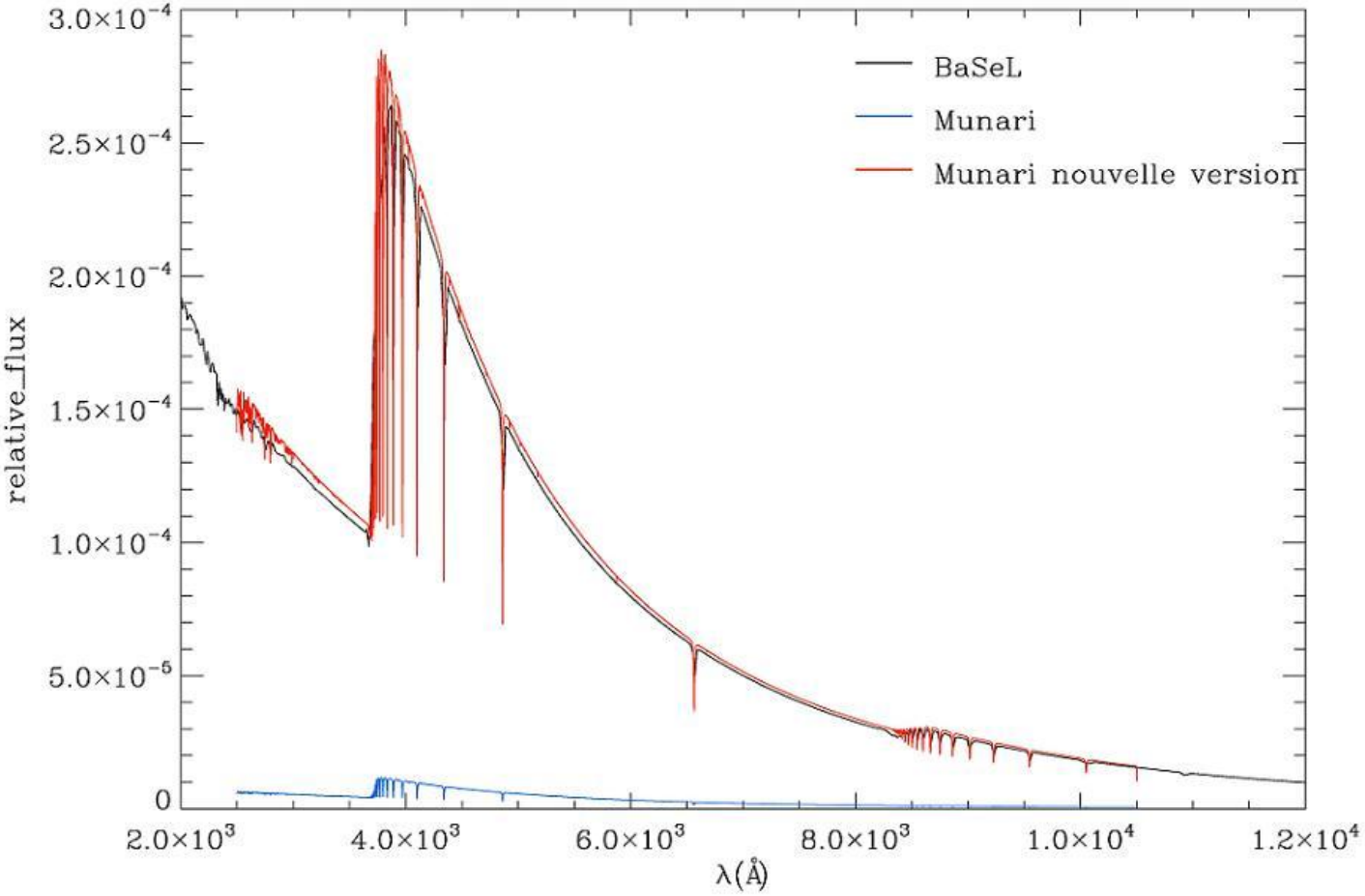


TI O bands

Cenarro et al, 2001, 2003

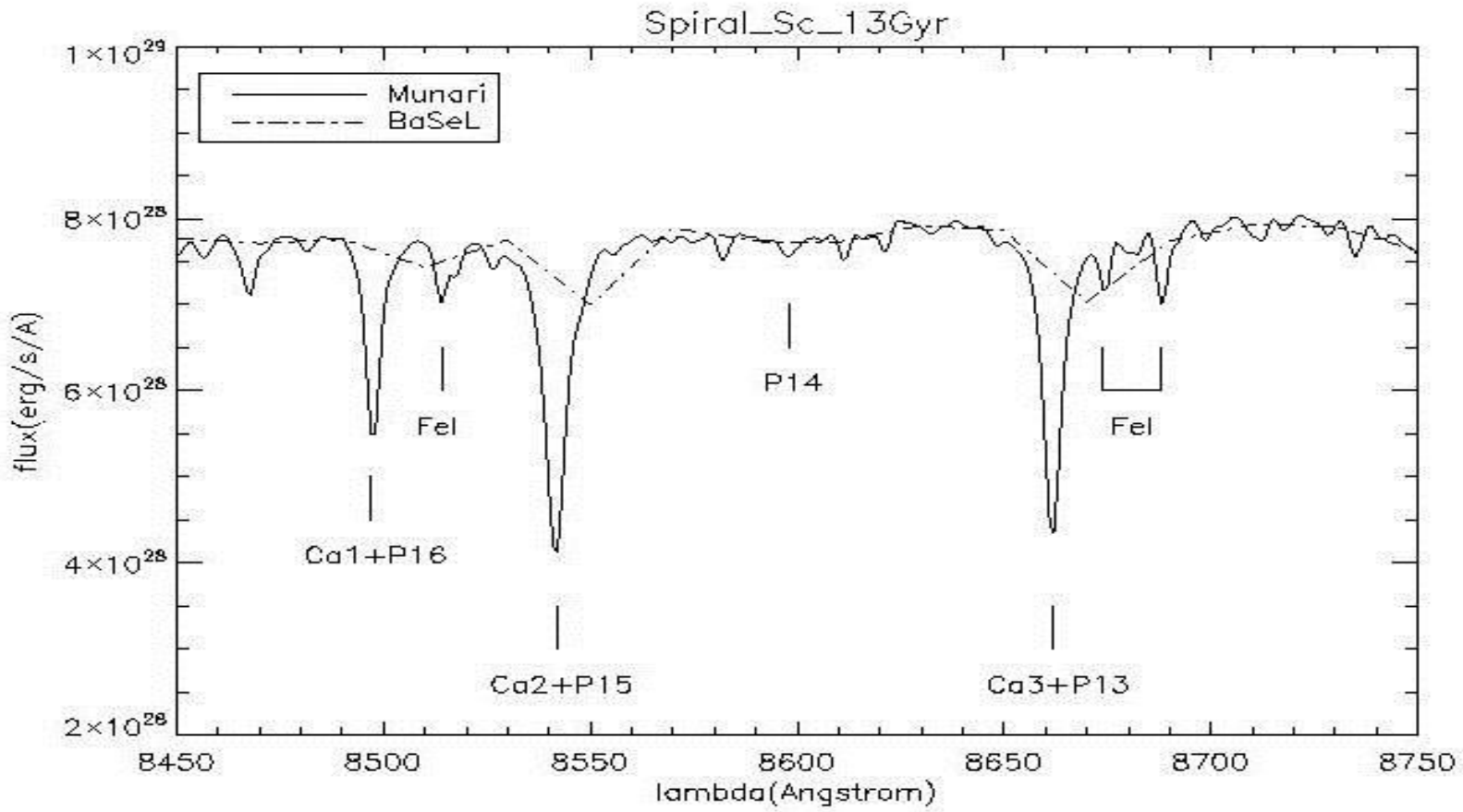

σ=200kms⁻¹
σ=22kms⁻¹
F_λ/F_8619-8642
μ t [M/H]
1.3 10 +0.2
1.3 10 +0.0
1.3 10 −0.4
1.3 10 −0.7
μ t [M/H]
1.3 2 0.0
1.3 10 0.0
1.3 18 0.0
μ t [M/H]
0.3 10 0.0
1.3 10 0.0
2.3 10 0.0
3.3 10 0.0
8400
8600
8800
Wavelength (Å)

Recalibration of HR (Munari et al) spectra computed by Pegase and compared to LR (BaSel) spectra with the same code



The CaT of Our Galaxy (Spiral) with Pegase.2 +Munari.al, 2005

low/high spectral resolution

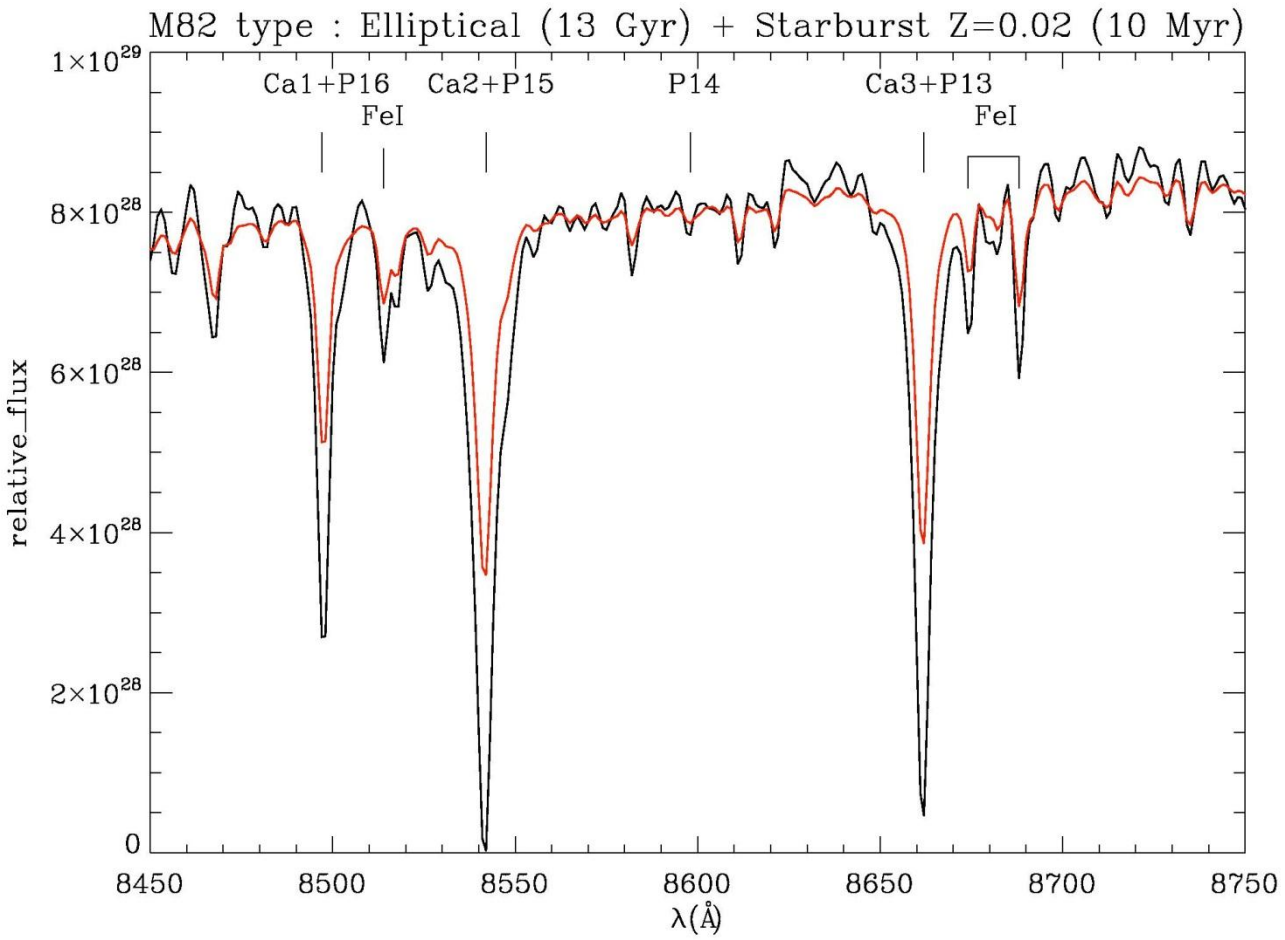


Galaxies and starburst from RVS

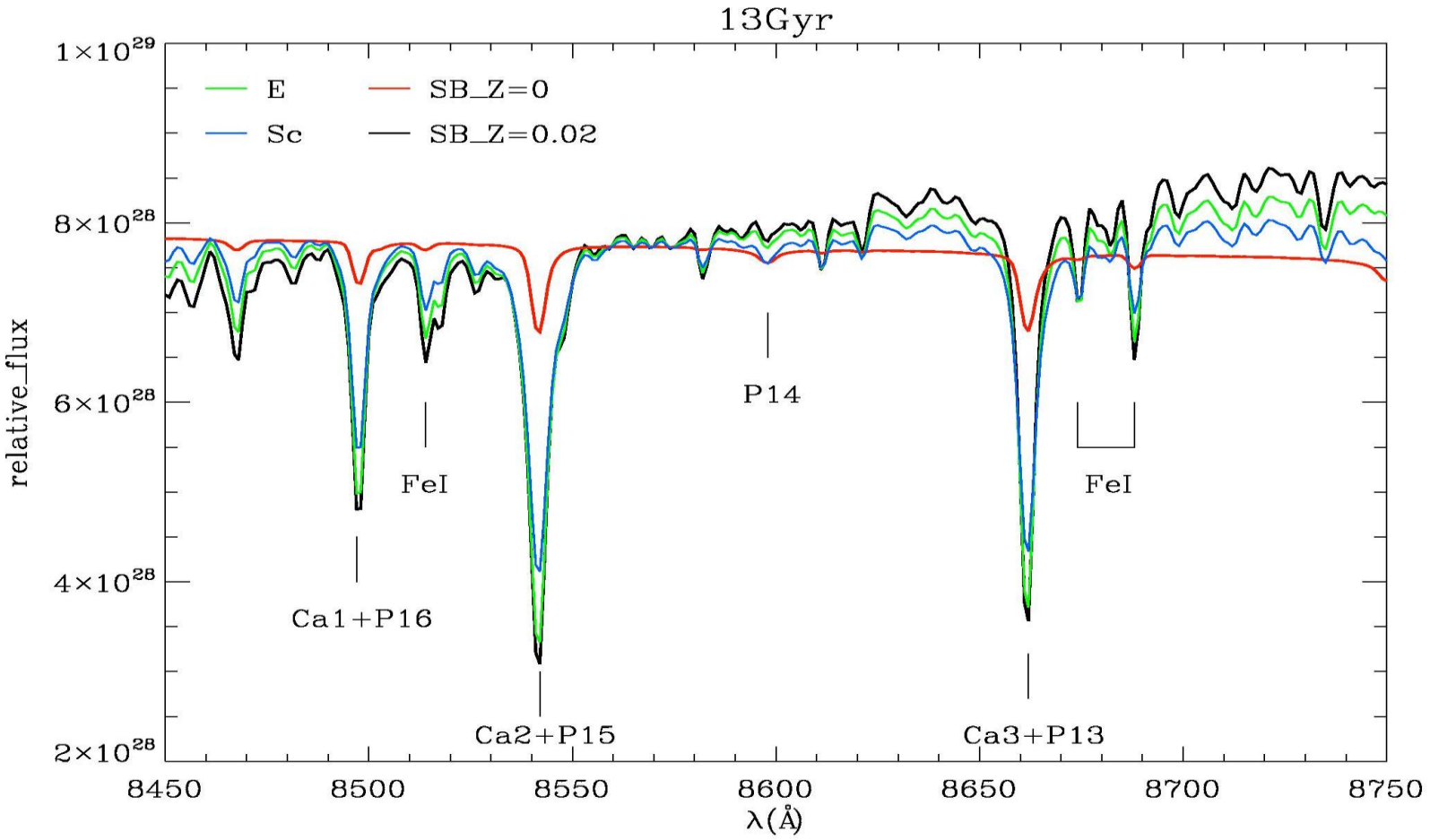
M82: Elliptical (red line)

+ Nuclear Z=0.02 starburst (1/100^{e} mass)

(black line)



Type effect :Elliptical, Spiral Sc and Starbursts



The case of radiogalaxies

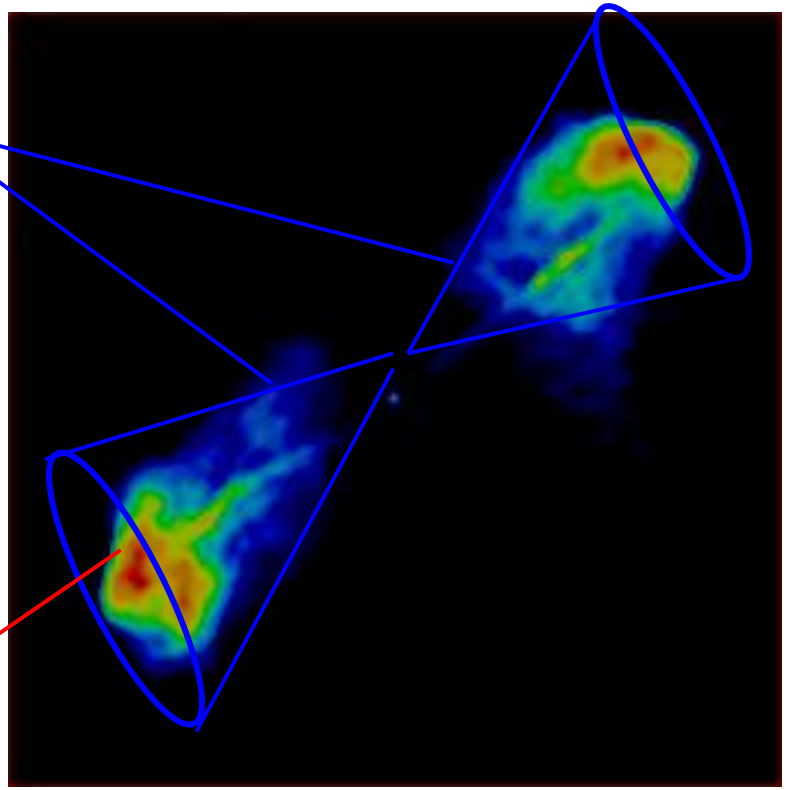
Starburst + AGN + evolved population

- With Pegase.3
- black body emission for AGN

Rocca-Volmerange et al, submitted

Partly Linked to the Processus of ionization in RGs

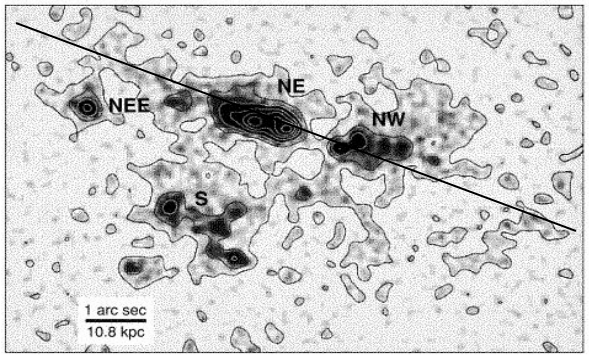
Ionization

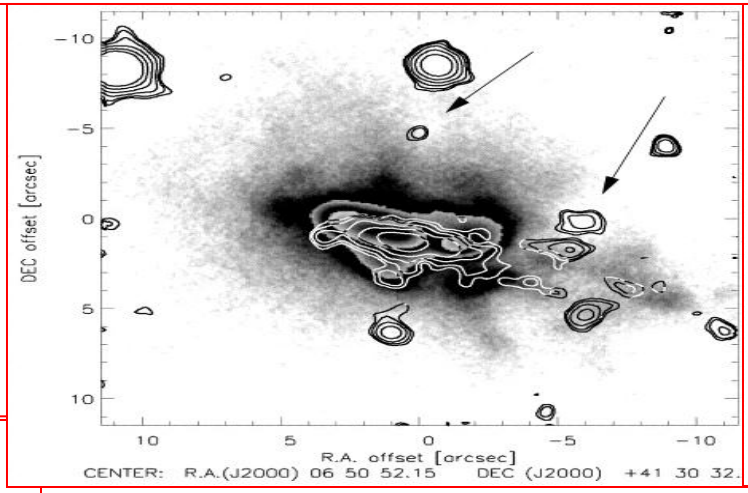


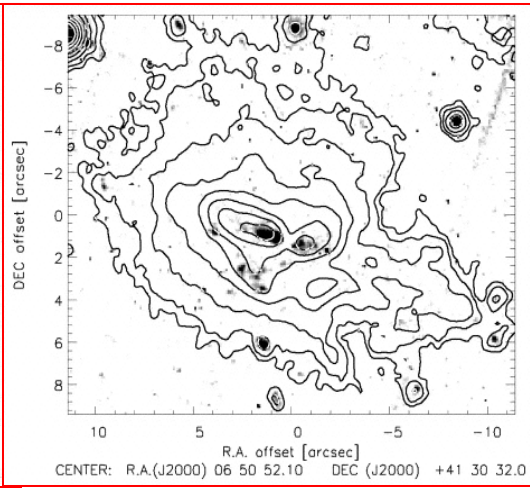
Shocks from ejecta radio

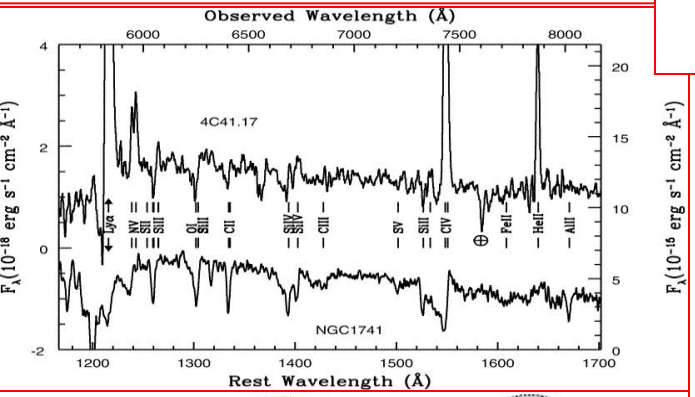
And star formation ?

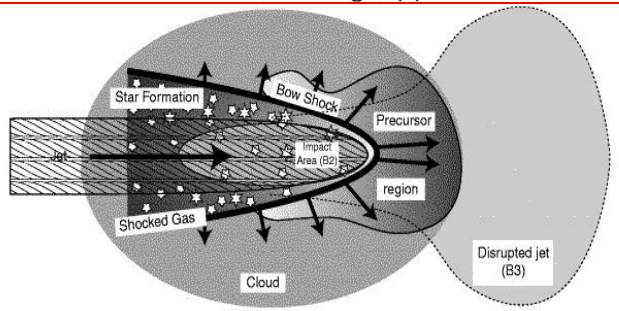
An example:
the template radio galaxy 4C41.17 (z=3.8)











- Huge Lyα Clouds of 100-200 kpc of ionized gas (cocoon) (Dey et al, 1997, Van Breugel et al, 1999, Reuland et al, 2003).

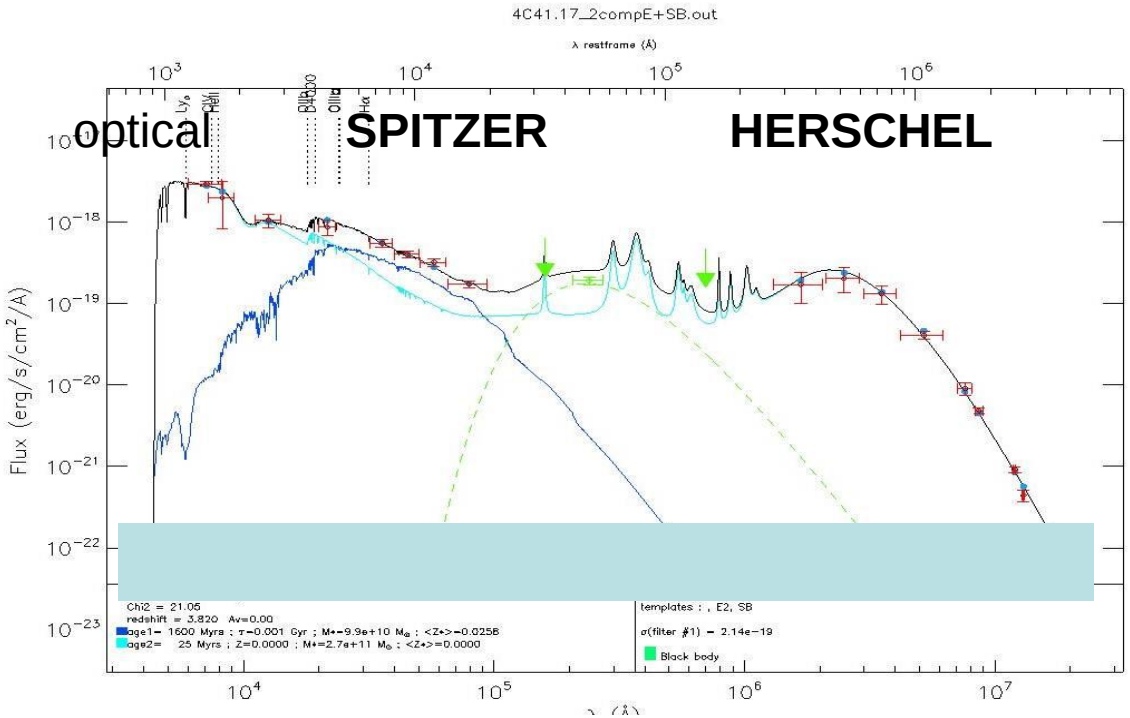
Stellar lines are detected along the radio axis (Dey et al, 1997), as WR starburst

- **Star formation along the radio jet** and south-East component, Bicknell et al, 2000

4C41.17 (z=3.8) : the best fit of multi-lambda SED The sum (black) of 2 evolving components:

(Rocca-Volmerange, Drouart, De Breuck, Vernet, Seymour et al, Astroph, submitted)

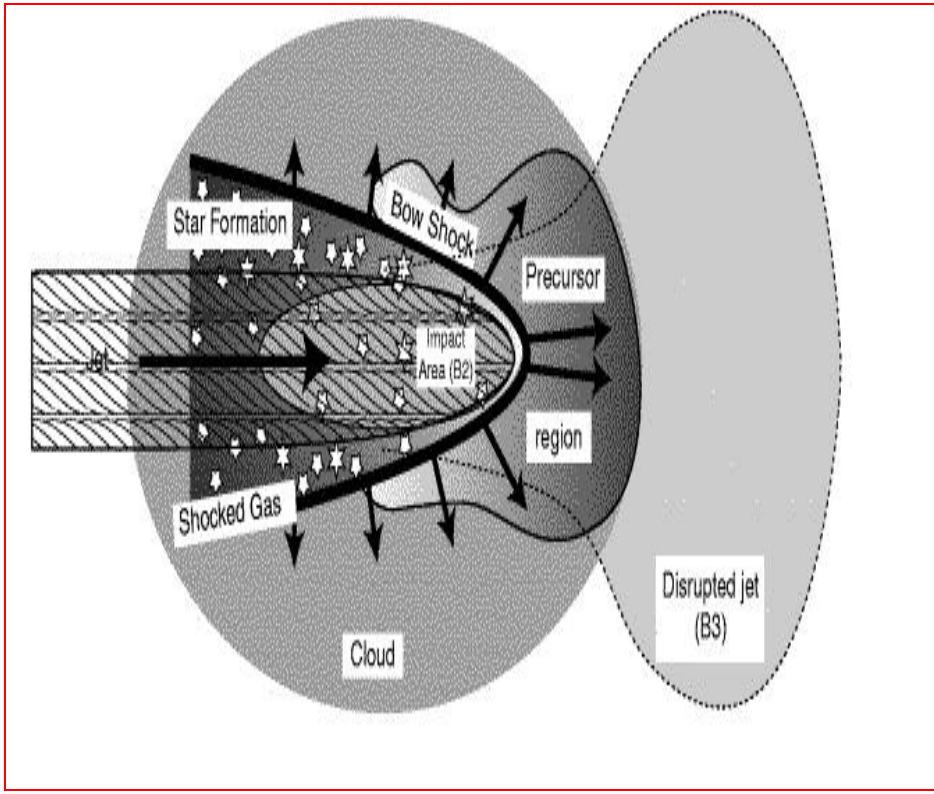
,



- A young Burst in the optical and Far-IR to summ (light blue)
- \+ The evolved population of an elliptical galaxy (dark blue)
- \+ The AGN model (dashed green)

Star formation by

- **Jet-cloud interaction triggering star formation Bicknell et al, 2010**



AND/ OR

- **Major Merger ➔ PostStarburst in a dense medium >10^22p. cm-2**

- **Star formation and AGN are detectable from Gaia Astrometry**

Modelling Starburst and Host Galaxies wih PEGASE (www2.iap.fr/pegase)

The code

- www.iap.fr/pegase

Versions :

- **PEGASE.2 (UV- NIR),** available on Pegase site

(Rocca-Volmerange, 1986, Guiderdoni & Rocca-Volmerange 1987, 1988, Fioc & Rocca-Volmerange, 1997, 1999, (PEGASE.2),

- **PEGASE-HR** and photometric redshift ZPEG

(Le Borgne et al, 2002, 2004)
available on Pegase site

- **PEGASE.3 (UV-FIR)** with dust emission coherent with extinction

(Fioc & Rocca-Volmerange et al. , near to be submitted)

Conclusions with Gaia

- Starbursts and Hubble types at low resolution(BP/RP) and high-resolution RVS
- Star formation triggered by AGN

In the future:

- To calibrate absolute magnitude of galaxies

Adapted to Gaia detection

- Modeling star formation in galaxies
- Evolution of blue nucleated dwarfs
- Degeneracy age-metallicity if galaxies detected):

Low metallicity : Paschen lines (P14)

High metallicity➔ evidence of Ca lines