Age Patterns in a sample of Spiral Galaxies

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Talk Outline

- Aim: Determine the temporal pattern of star formation in spiral galaxies (different morphological types)
- Data:
  - TTF (WHT&AAT), GALEX & SINGS images
- Work:
  - Image processing
  - Extinction correction
  - Calibration from Starburst99 model
- Results: Age maps

I. Aim

- To map the ages of star forming regions across spatially–resolved spiral arms
- Use a pixel-by-pixel mapping technique
- Hα emission line (6563Å) from HII gas ionized by young massive O-type stars ≥10M_* with lifetimes ≤20Myrs
- UV emission dominated by O-B stars with lifetimes ≤100Myrs
- As star forming region evolves, Hα emission drops off earlier than UV, so the flux ratio is sensitive to age ($F_{H\alpha}$ /F_{FUV})
- The flux ratio is independent of the total stellar mass and the distance to the galaxy. So it is not affected by uncertainties in these parameters

- SAMPLE: (Cianci 2003)
  - Nearby and face-on spirals galaxies have enough spatial resolution to see detail in the HII structures of spiral arms ($i < 30^o$)
  - Images avalible in GALEX NGS

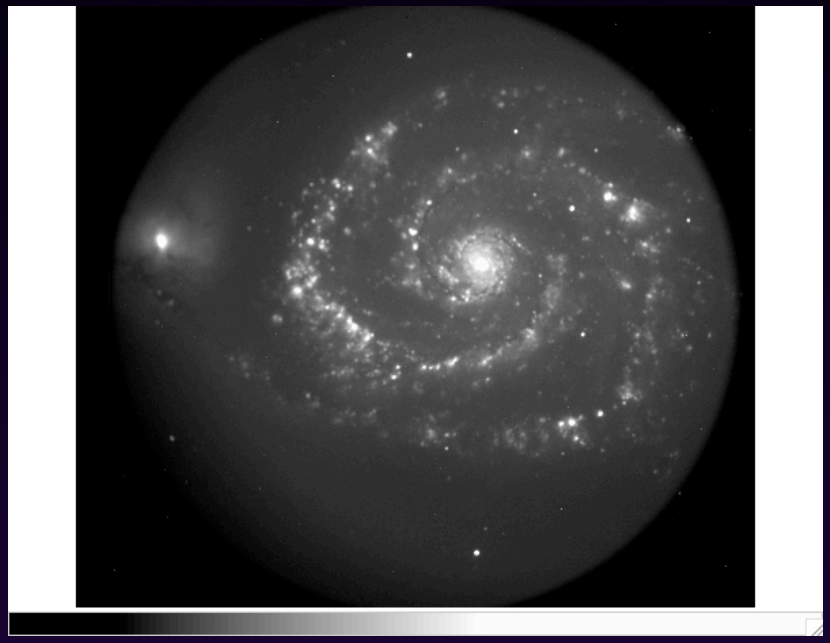
II. Data: The sample

GALAXY	RA J2000	DEC J2000	TYPE	REDSHIFT	HELIO RADIAL VELOCITY (km/s)	DIAMETER	MAGNITUDE
M74	01 36 41.70	+15 46 59.4	SA(s)c	0.002192	657	10.5 x 9.5′	9.95
NGC1068	02 42 40.71	-00 00 47.8	(R)SA(rs)b	0.003793	1137	7.1 x 6.0′	9.61
NGC2146	06 18 38.17	+78 21 21.6	SB(s)ab	0.002979	893	6.0 x 3.4′	11.38
IC2574	10 28 21.25	+68 24 43.2	SAB(s)m	0.000190	57	13.2 x 5.4′	10.80
NGC4631	12 42 08.0	+32 32 26.0	SB(s)d	0.002021	606	15.5 x 2.7′	9.75
M94	12 50 53.06	+41 07 13.7	(R)SA(r)ab	0.001027	308	11.2 x 9.1′	8.99
M63	13 15 49.25	+42 01 49.3	SA(rs)bc	0.001681	504	12.6 x 7.2′	9.31
M51	13 29 52.71	+47 11 42.6	SA(s)bcpec	0.00154	463	11.2 x 6.9′	8.96
M83	13 37 00.78	-29 51 58.6	SAB(s)c	0.001721	516	12.9 x 11.5′	8.20
M101	14 03 12.48	+54 20 55.3	SAB(rs)cd	0.000804f	241	28.8x26.9′	8.31

NASA Extragalactic Database

II. Data: The Taurus Tunable Filter (TTF)

M51



1000x1000
0.56″/px

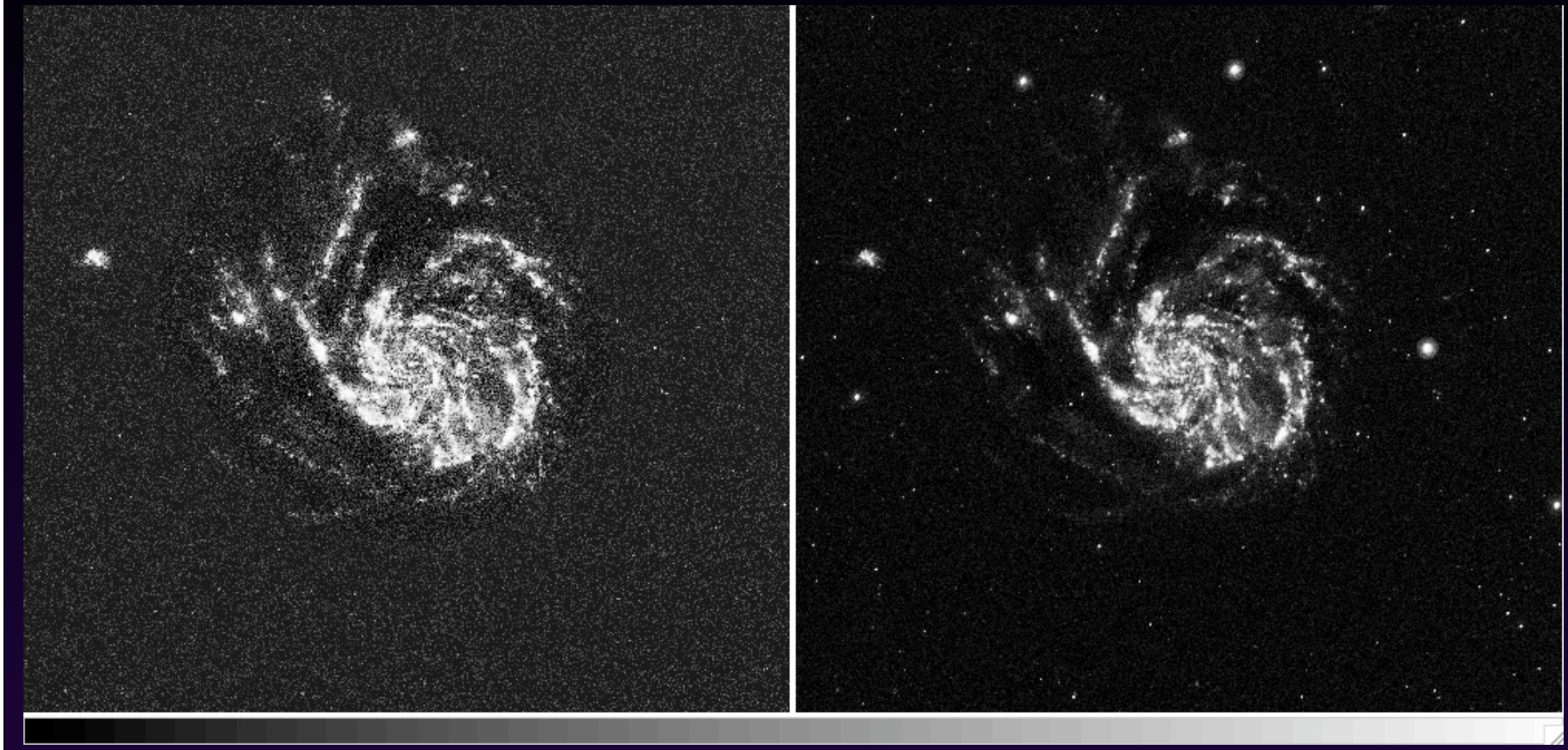
- The TTF forms a FP interferometer with highly polished plates.
- Used in 3.9m AAT (TAURUS-2 focal reducer at Cassegrain focus) from 13-16 February 2000 & 4.2m WHT from 4-6 March 1999 (Sonia Cianci 2000)
- Piezo-electric stacks alter plate separation and were used to center bandpass at Hα emission line (6563Å).
- Extremely narrowband imaging : bandwidth 10-14Å able to avoid the nearby [NII] lines at 6583Å
  - AAT images: 0.37″ per pixel, 10′ field of view
  - WHT images: 0.56″ per pixel, 15′ field of view
- Frequency switching could be used to obtain Hβ images but these were not available.

II.Data: Galaxy Evolution Explorer (GALEX)

- GALEX was launched on April 28, 2003
- 50cm diameter, modified Ritchey-Chrétien telescope with 1.2˚ circular field of view
- Data includes imaging and spectroscopy in two wavebands: FUV (λ_{eff} = 1528Å, $\Delta\lambda$=268Å), NUV (λ_{eff} = 2271Å, $\Delta\lambda$=732Å)
- Resolution: 4''(FUV), 5.6''(NUV)
- 1.5'' per pixel
- Undertook a number of surveys: One of these, the Nearby Galaxies Survey (NGS) targetted 200 well-resolved nearby galaxies
- Newest data release was in May 2006.

II.Data: Galaxy Evolution Explorer (GALEX)

M101



NUV

3840x3840
1.5″/px

FUV

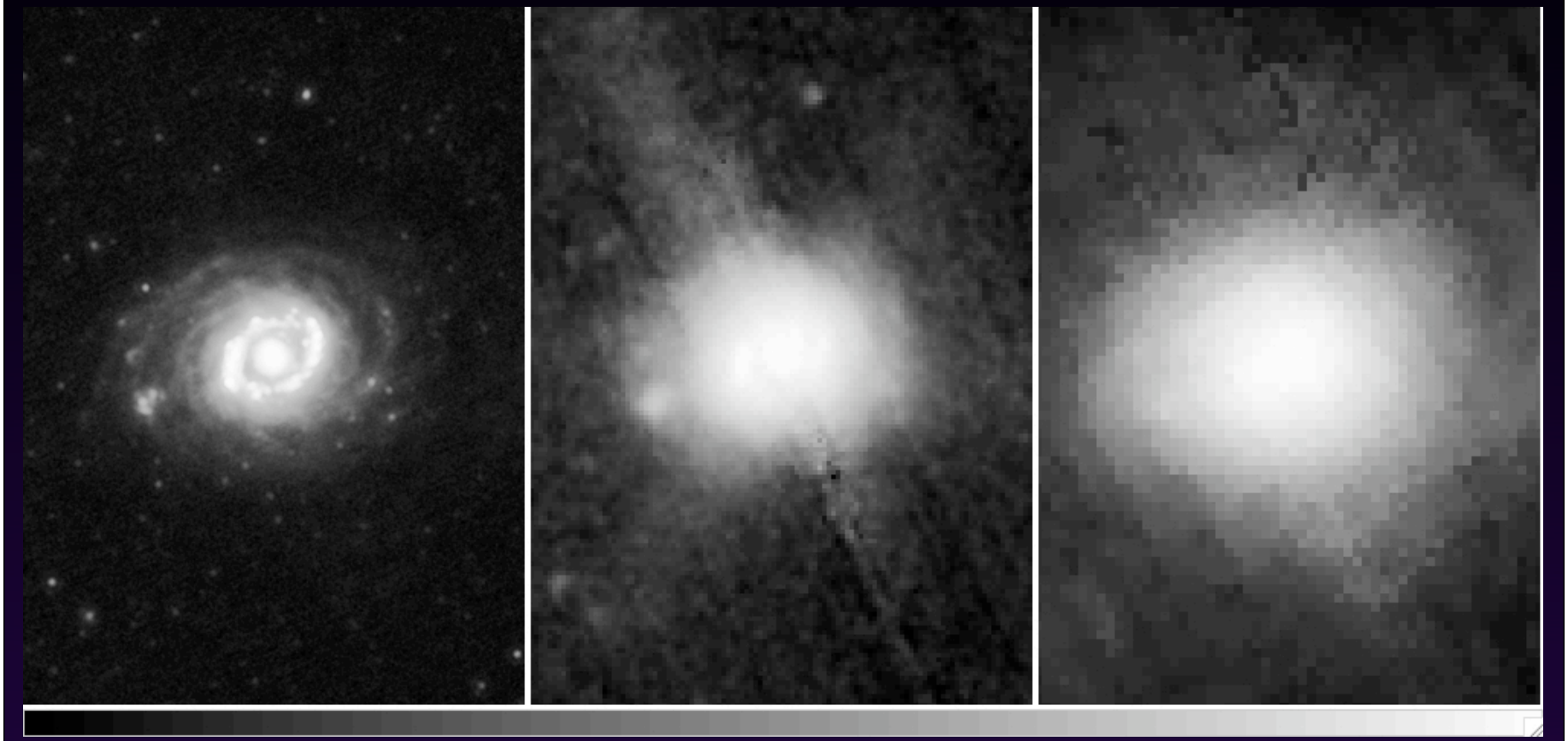
II.Data: Spitzer Infrared Nearby Galaxies Survey(SINGS)

- From NASA/IPAC Infrared Science Archive for NASA's Infrared and Submillimeter Data: SINGS Spitzer and Ancillary Data.
- The Spitzer Infrared Nearby Galaxies Survey (SINGS) is a comprehensive imaging and spectroscopic study of 75 nearby galaxies (D < 30 Mpc). (**Spitzer Space Telescope** launched by a Delta rocket from the Kennedy Space Center on August 25, 2003)
- **MIPS Data:**
  - The **image (FITS)** MIPS data available for download are listed based on bands of the observation [MIPS24, MIPS70 and MIPS160].
  - The pixel scale of the MIPS mosaics is wavelength-dependent: 1.5 arcsec at 24 mm, 4.5 arcsec at 70 mm, and 9.00 arcsec at 160 mm. The flux scale is MJy sr-1. The orientation is North up, East left.
  - $F\_TIR = \zeta_1 \nu_1 F(24\mu) + \zeta_2 \nu_2 F(70\mu) + \zeta_3 \nu_3 F(160\mu)$ (Dale&Helou 2002)

    $\zeta_1 = 1.559$, $\zeta_2 = 0.7686$, $\zeta_3 = 1.347$

II.Data: Spitzer Infrared Nearby Galaxies Survey(SINGS)

M94



720x600
1.5″/px

240x200
3″/px

120x100
9″/px

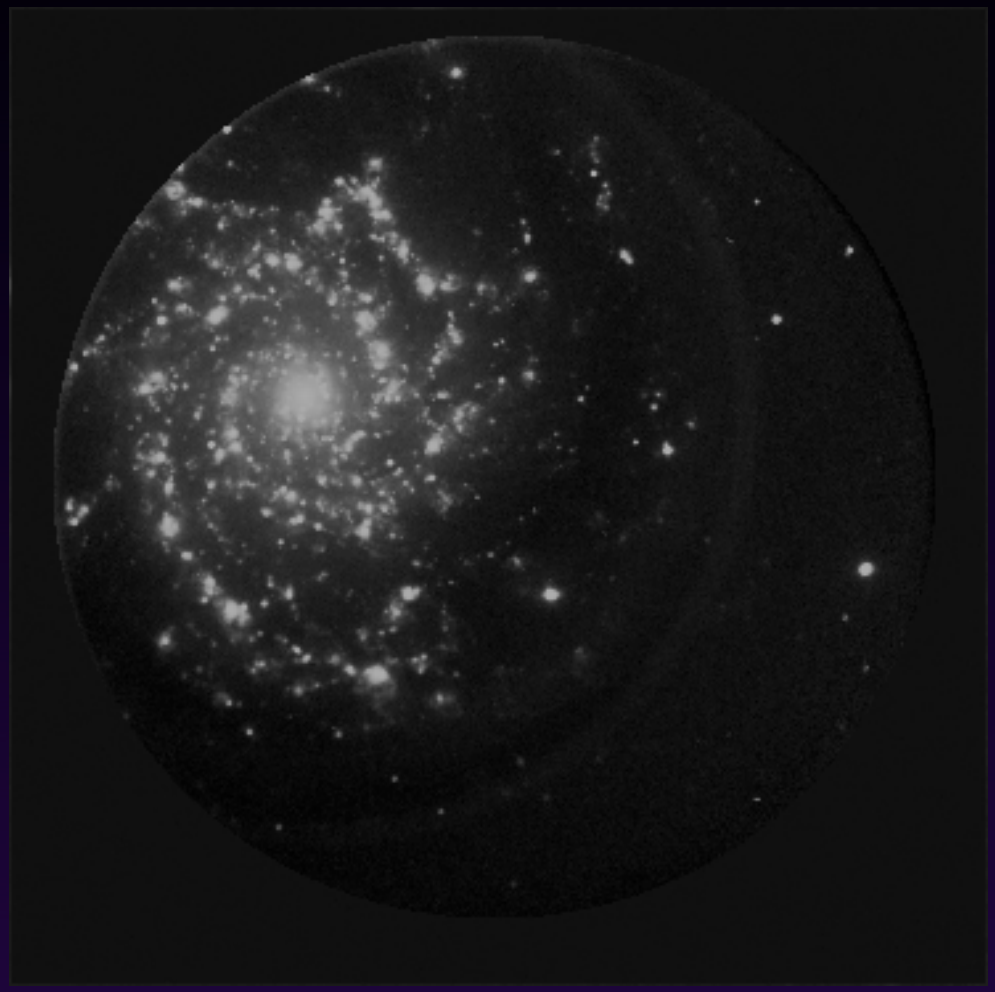
III.Work: Image Processing

- Images had already been partially processed: Hα images had been bias subtracted, flat-fielded, sky background and continuum subtracted as part of Cianci (2003). Gradient in the background was not subtracted out of some images properly (ex. M51)

- I have done:
  - Astrometrical solution and rotation (North up, East left)
  - Background subtracted and calibration in flux of Galex images and calibration in flux of Hα images.
  - Masking (bulge, foreground stars and field)
  - Cutting out the noise
  - Reescaling and alignment of Galex, Hα and IR images.

III.Work: Image Processing

M74



370x370
1.5″/px

III.Work: Correcting for dust

Galactic Extinction

- Schlegel et al. 1998 used diffuse IR emission as a measure of dust column density
- Removed contribution from dust within bright galaxies
- Mapped galactic extinction by colour excess E(B-V) in all directions (www.irsa.ipac.caltech.edu/applications/DUST)
- The GALEX team have interpreted the Cardelli et al. (1989) extinction curve to find the conversion factor in the two GALEX wavebands: (http://www.galex.caltech.edu/)
  - A(FUV) = 8.24 E(B-V)
  - A(NUV) = 8.20 E(B-V)
- A(Hα) = 2.6 E(B-V)

III.Work: Correcting for dust

Internal Reddening

- Face on spirals have little depth, but more dust in HII regions
- SINGS data not avalaible for all galaxies (M83, M101, NGC1068 and NGC2146)
- Hβ images not avalaible, so use UV spectral slope instead :

$$\beta = \frac{\log(f_{FUV}) - \log(f_{NUV})}{\log(\lambda_{FUV}) - \log(\lambda_{NUV})}$$

Kong et al.(2004)

$$log(L\_TIR/L\_FUV) = (0.70 \pm 0.06)\beta + (1.30 \pm 0.06)$$

Empirical expression for normal galaxies:

$$\beta = (0.37 \pm 0.07) A(H\alpha) - (1.15 \pm 0.08)$$

Cortese et al. 2006

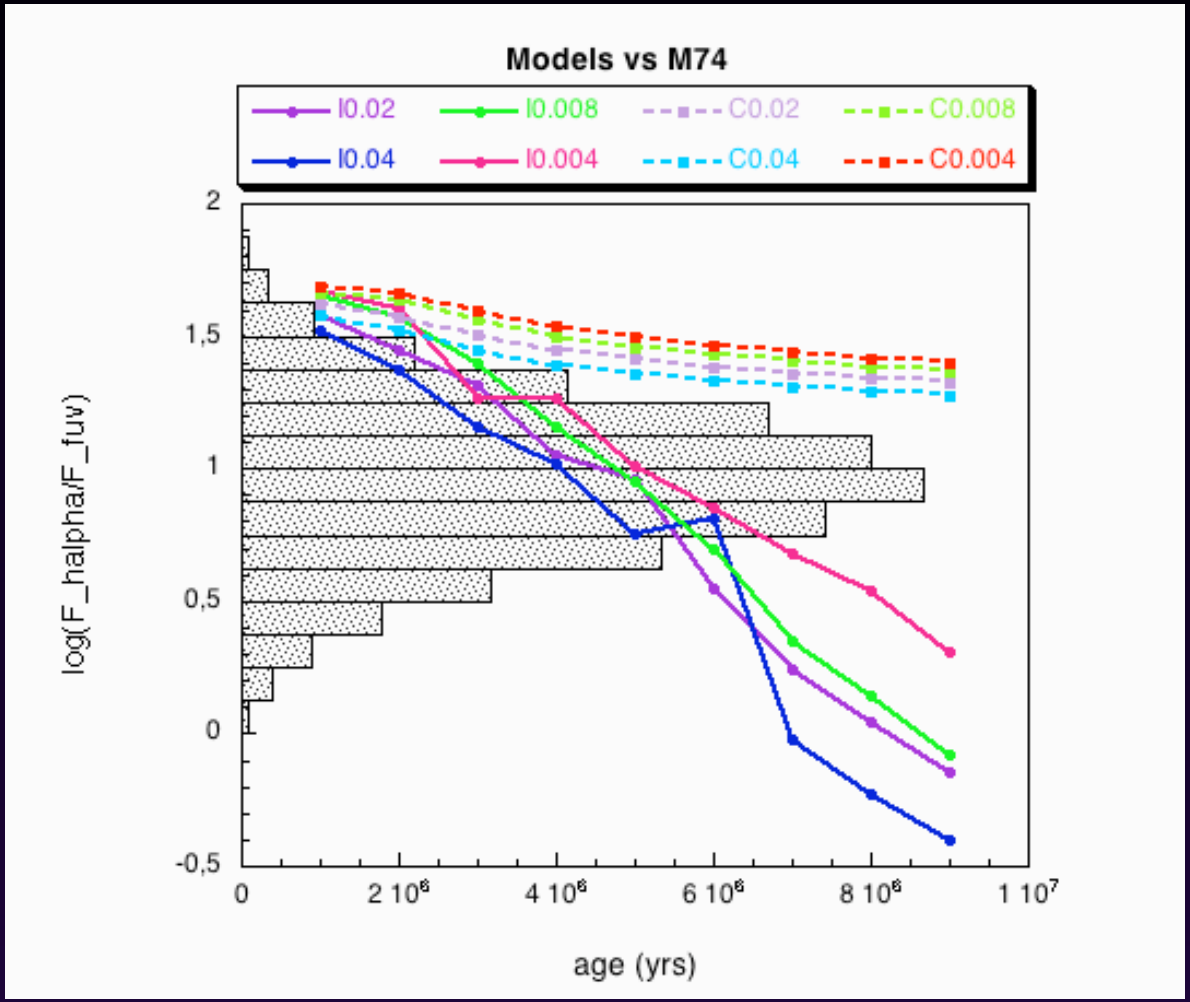
$$A(FUV) = 1.4\, A(H\alpha)$$

Boissier et al. 2005

III.Work: Starburst99

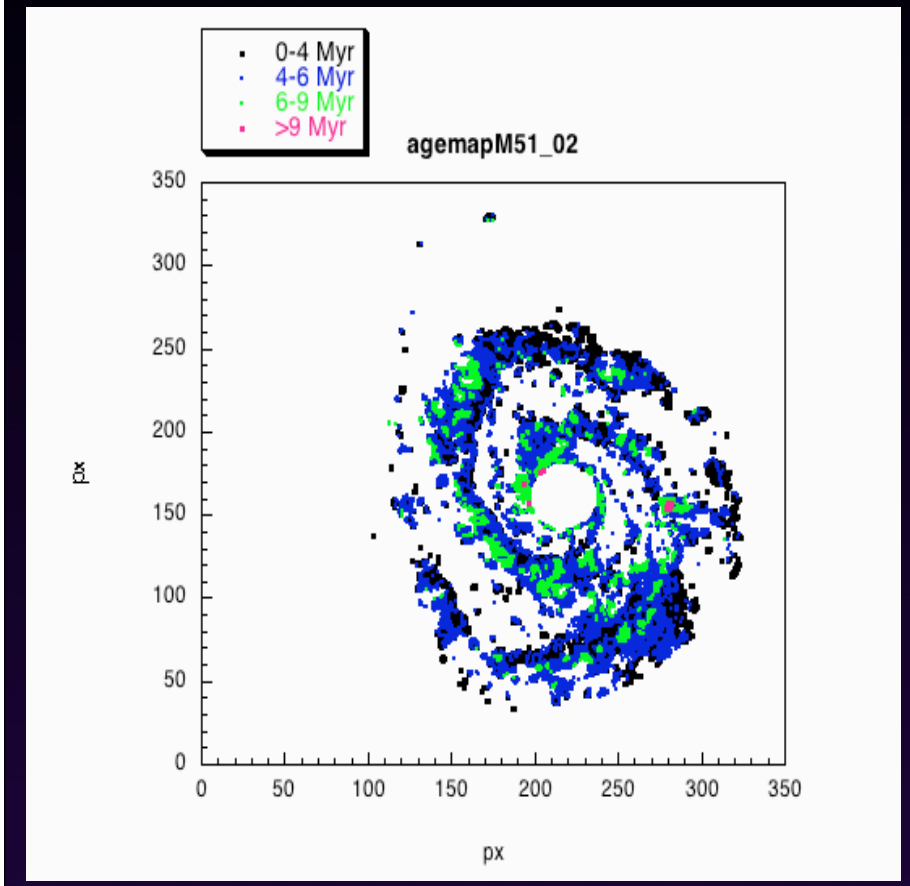
- Evolutionary synthesis model created by Leitherer et al. 1999
- Simulates evolution of stellar spectra
- Simulates flux through particular filters: GALEX imaging response profiles were integrated with the synthetic spectra
- Modelled flux ratio using output: $L_{H\alpha}$ and L_{FUV}
  - $\log (F_{H\alpha}/F_{FUV}) = \log(L_{H\alpha}/L_{FUV})$
- Physical constraints :
  - Salpeter IMF α=2.35, M_{up} = 100$M_\odot$, 30$M_\odot$
  - Metallicity: Z=0.02, 0.04, 0.008, 0.004
  - Star formation history: Instantaneous or Continuous

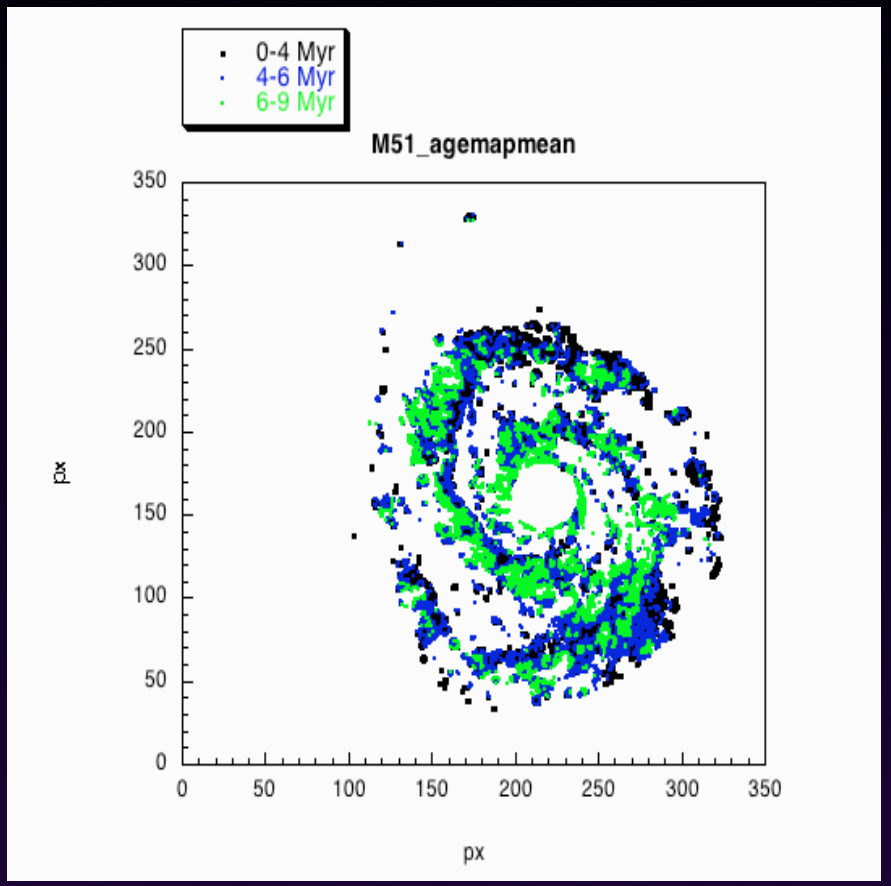
III.Work: Starburst99



III.Results: Age maps

M51

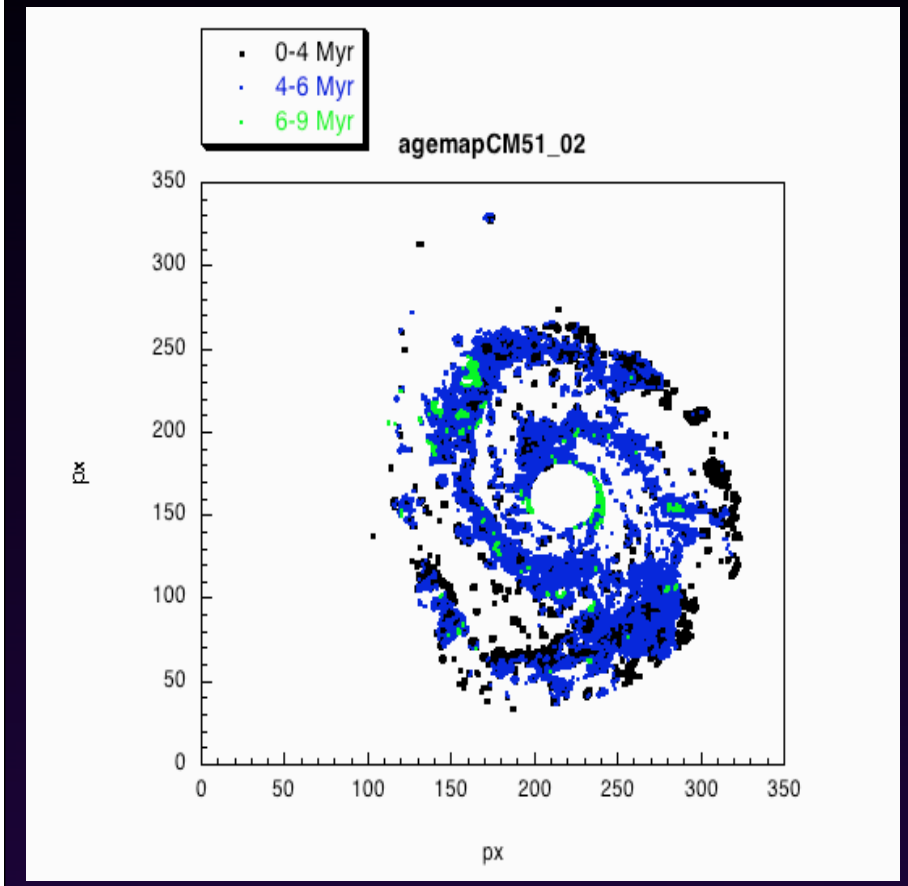


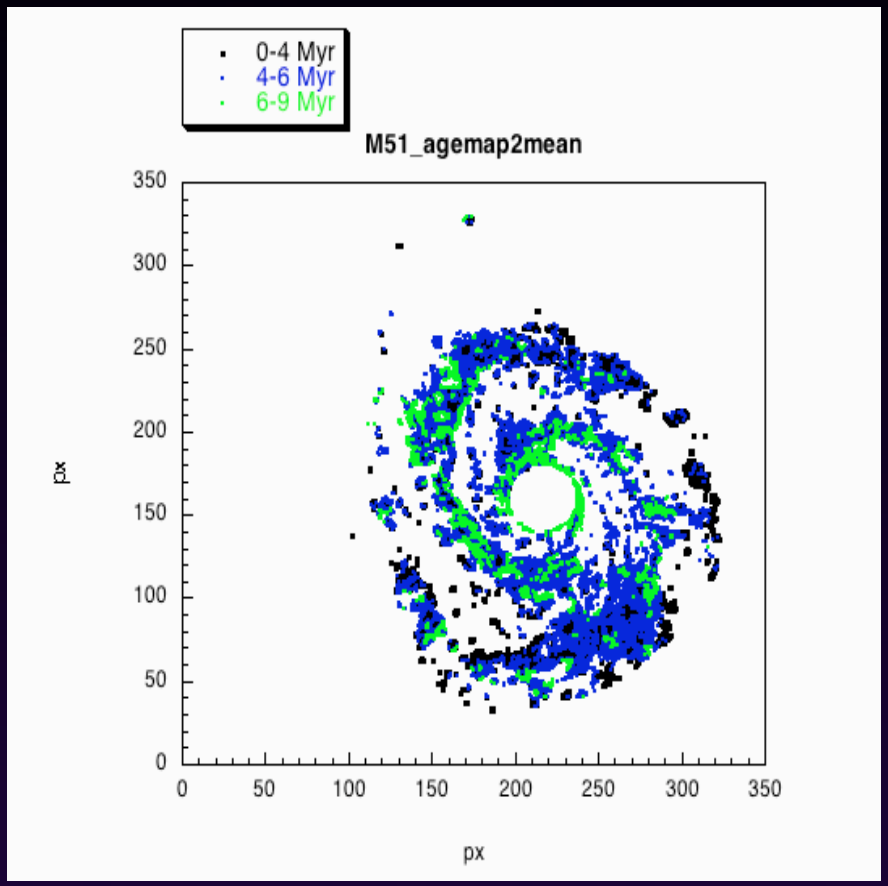


β_1

III.Results: Age maps

M51



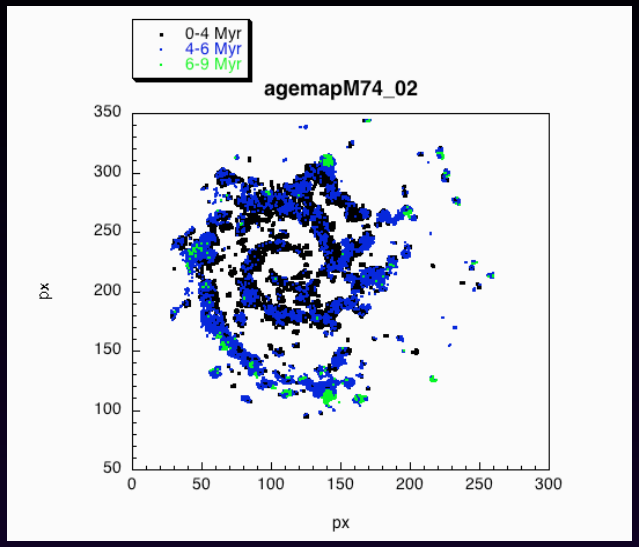


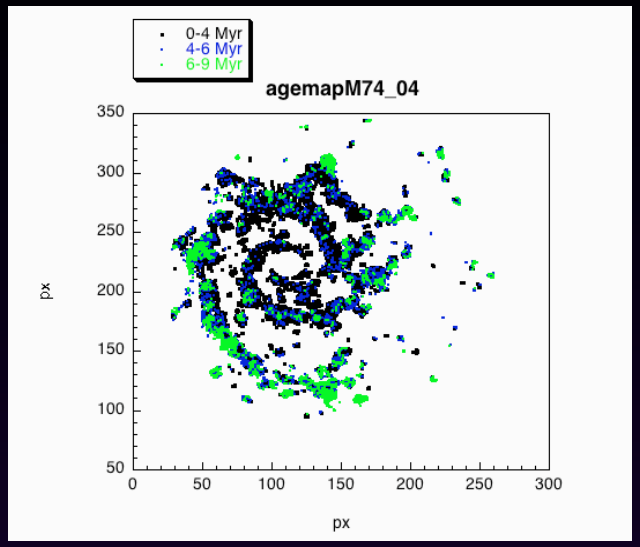
β_2

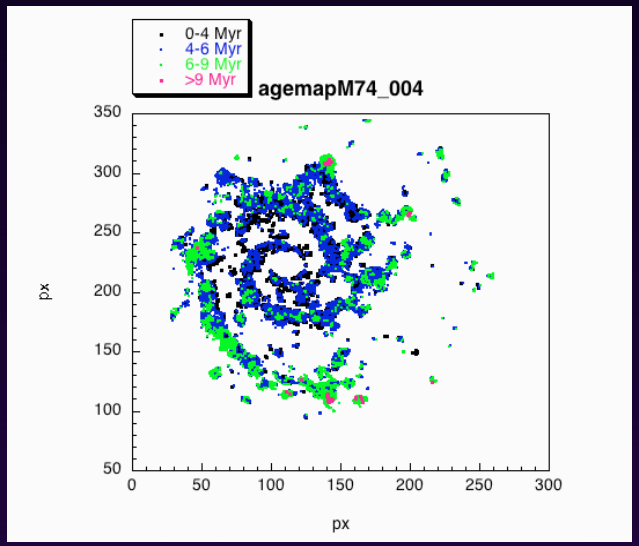
III.Results: Age maps

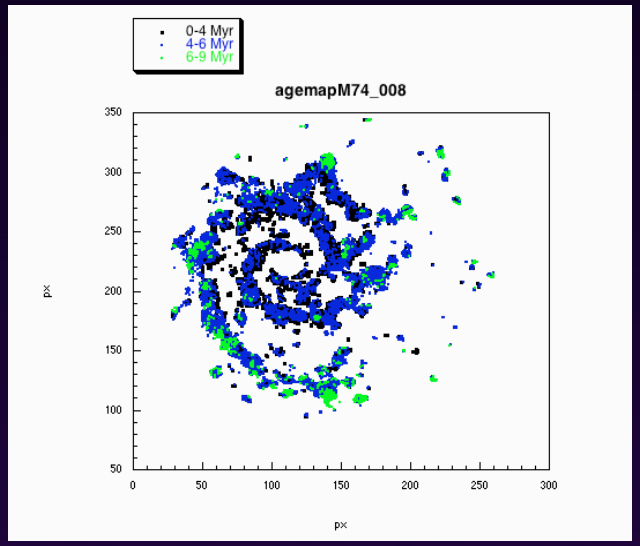
M74

β_1



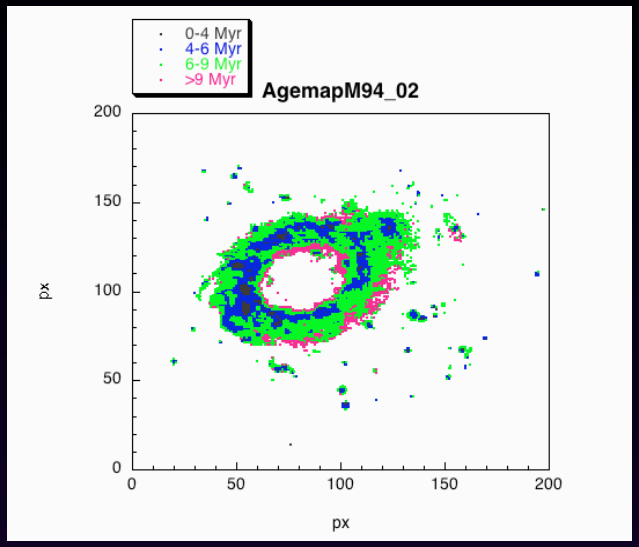


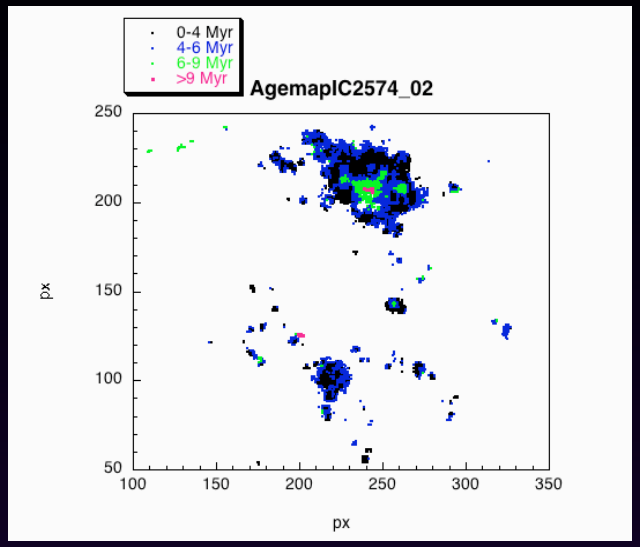


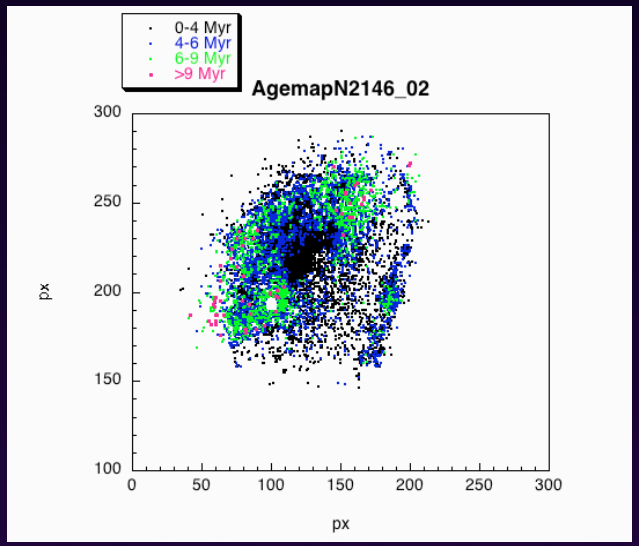


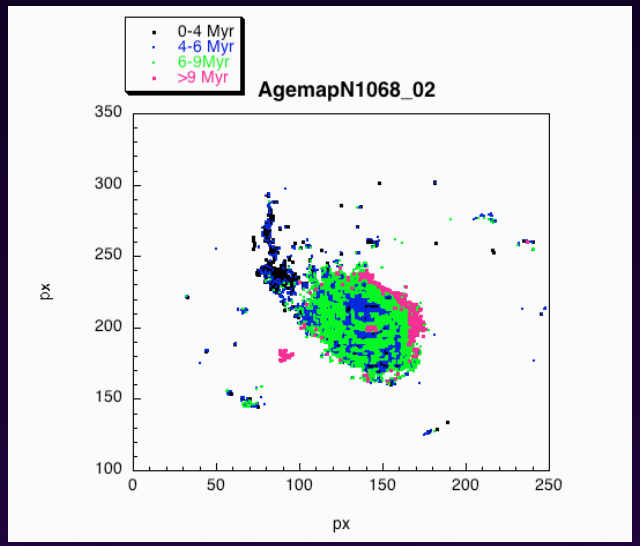
III.Results: Age maps

β_1









IV. Summary:

- Work in progress: Analysis
- Determine the better redenning correction among several methods and the better parameters for the model
- Calculate the pattern velocity of the wave front and the corotation radius
- ...

Thank you !