Stellar populations in the central kpc of Seyfert galaxies

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Low luminosity AGN
AGN fueling

- Low accretion rates: ~10^{-2} $M_\odot$/yr
  - Need small amount of gas
  - Small-scale accretion events (King & Pringle 07)

- Angular momentum problem
  - Presence of gas in the inner 100pc in Seyfert galaxies
  - Transport down to few 0.1pc = remove totally the angular momentum!

- fuelling mechanisms:
  - Galaxy interaction, mergers
  - Stellar bars, bar within bar scenario

Low luminosity AGN
AGN fueling

- No statistically-significant difference between Seyfert and non-active galaxies on spatial scales that encompass galaxy interaction, large-scale and nuclear bars and spirals
- Presence of dust and isophotal disturbance in Seyferts
  (Hunt & Malkan 04, Simões Lopes et al. 07)

- Kinematic study needed along with imaging
  - Kinematic differences between Seyferts and non-active galaxies?
  - Signature of fuelling mechanisms
  - Role of the host on nuclear activity?

Low luminosity AGN
SF & nuclear activity

- Connection between nuclear activity and SF

- Role of the SF in the nuclear activity:
  - SF and AGN require fuel
  - SF consume the gas for the AGN
  - Stellar mass loss as fuel of the central engine

- Stellar population properties/nuclear activity
  - Differences Seyfert/non-active galaxies?
  - Context AGN fuelling/galaxy formation

Low luminosity AGN
AGN fueling

- Morphology & dynamics, stars & gas

  28 pairs Seyfert/non-active galaxies

  matching large scales properties

- Two complementary surveys
  - VHIKINGS (Mundell et al. 07)

    VLA: HI (21cm)

    Galactic disk + nearby environment
  - Sauron/Seyfert (Dumas et al. 07)

    Sauron: 3D spectroscopy

    Ionized gas + stars

    Central regions (< kpc)

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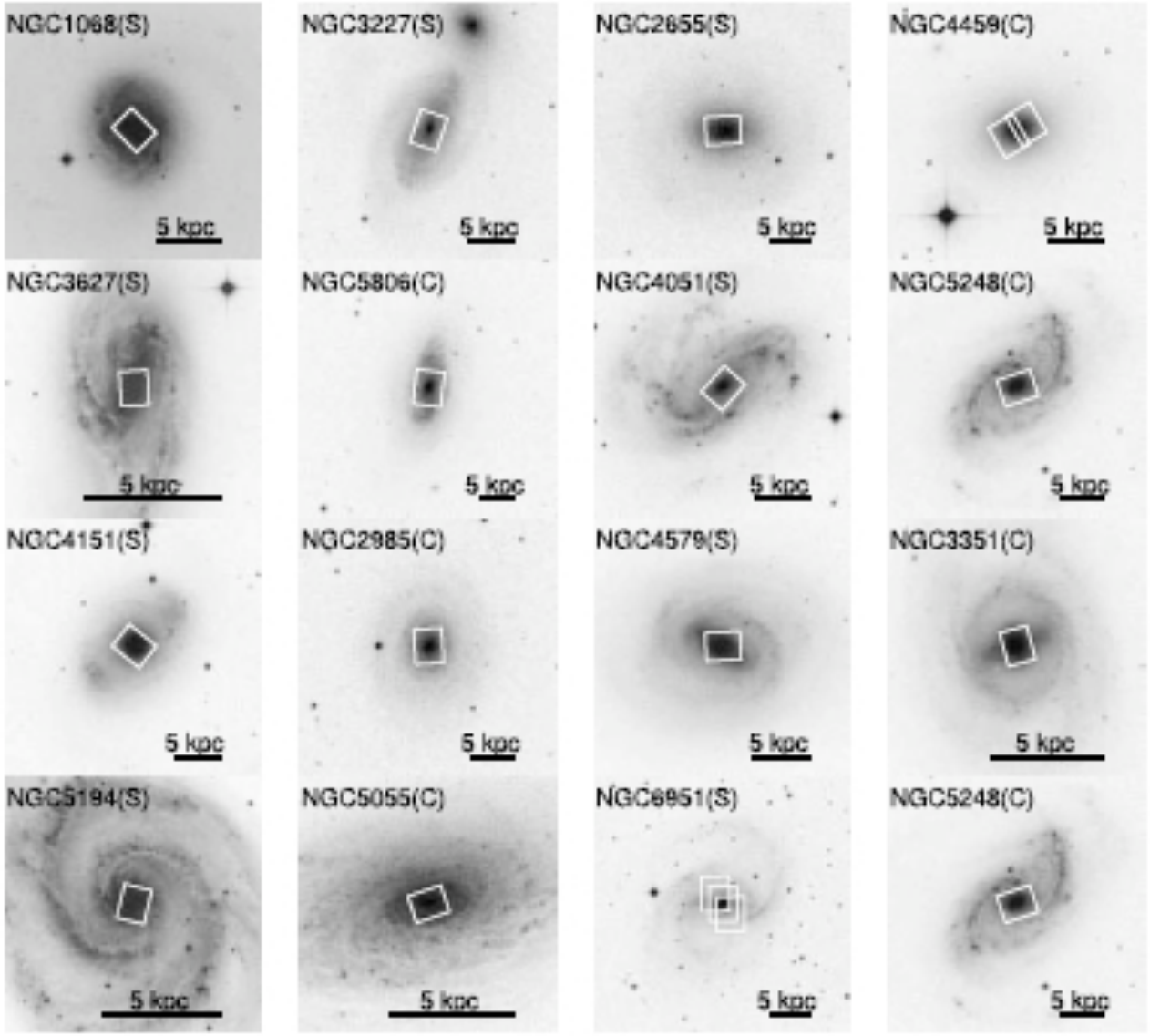
SAMPLE
SAURON/SEYFERT



- V_{sys} < 1600km/s
  Fe stellar absorption lines
- 15 galaxies:
  7pairs + 2 Seyferts
- FOV= 41"x33"
  2kpc to 20pc

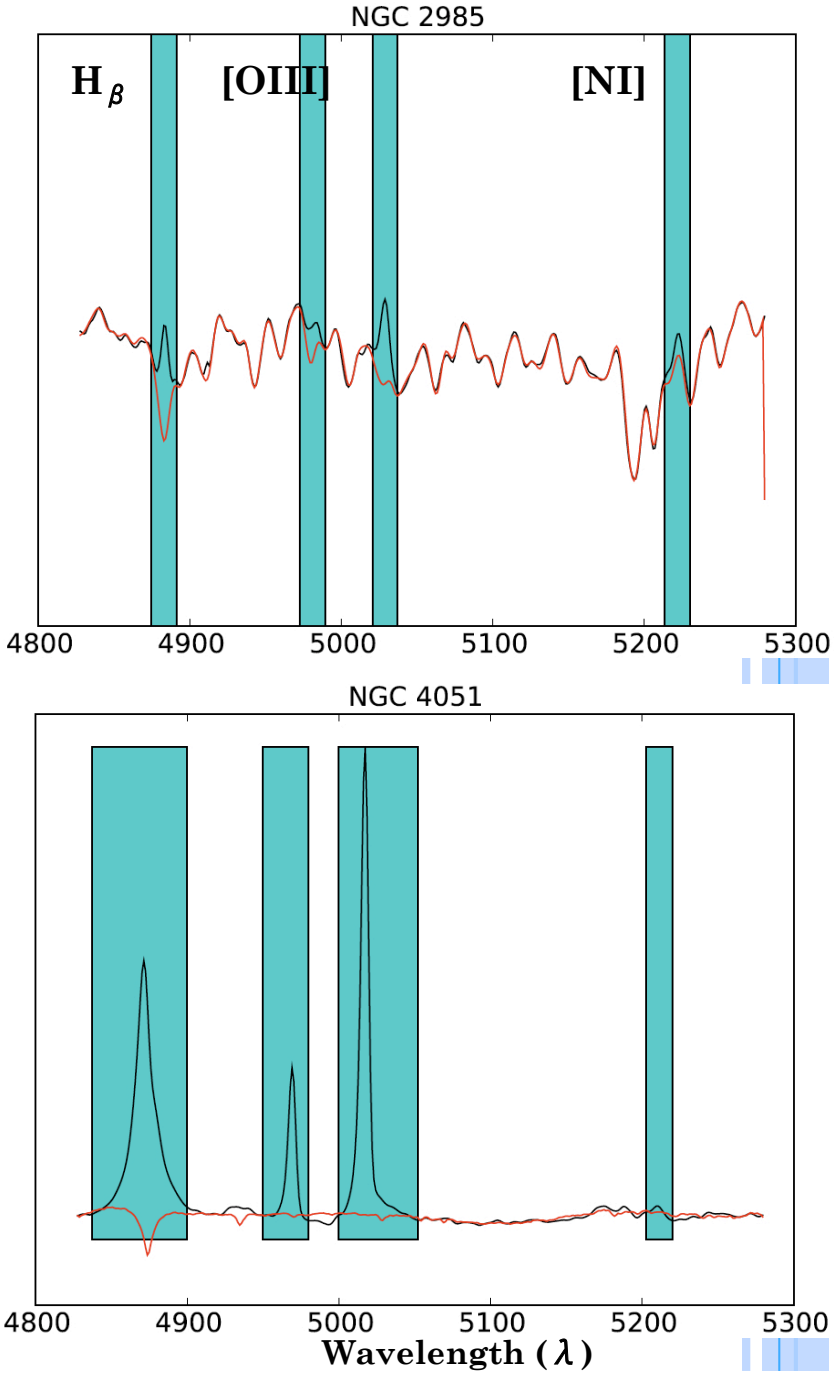
SAURON DATA
STELLAR KINEMATICS

- Spatial binning S/N>60

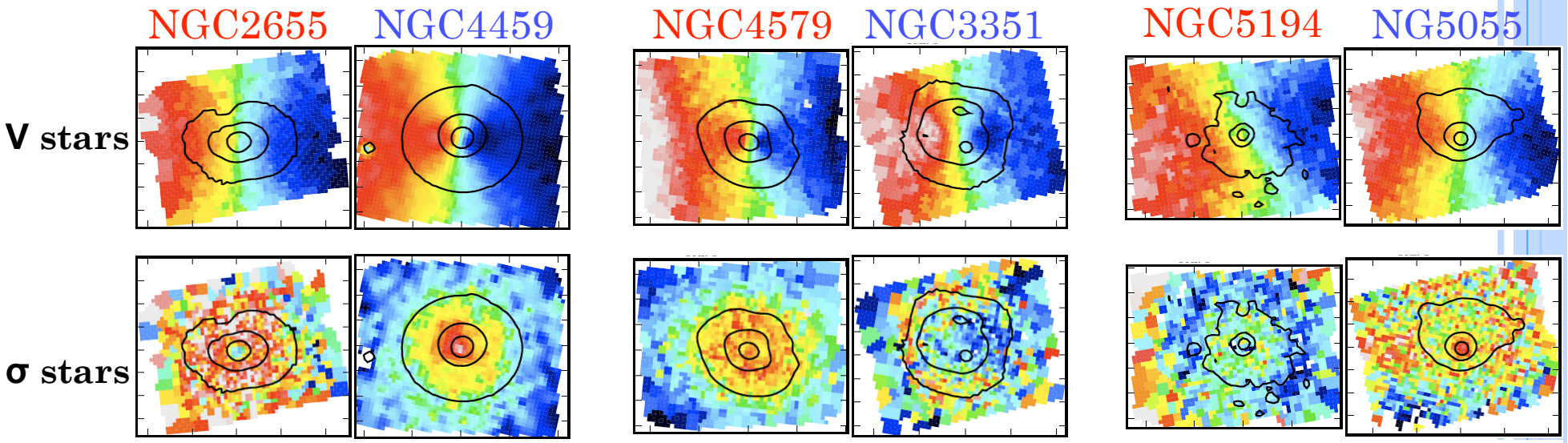
- Mask of emission lines
  - Broad lines
  - Multi-components

- Deconvolution: pPXF method

(Cappellari & Emsellem 2004)
  - LOSVD distribution: V, σ, h_3, h_4
  - Optimal template

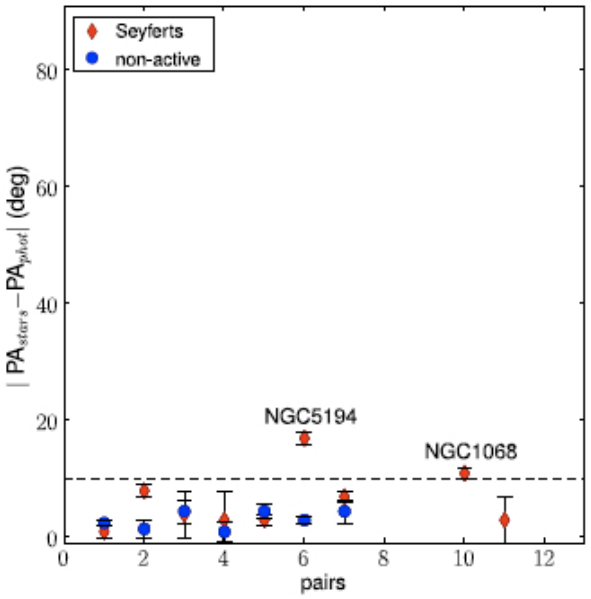


SAURON MAPS
STELLAR KINEMATICS



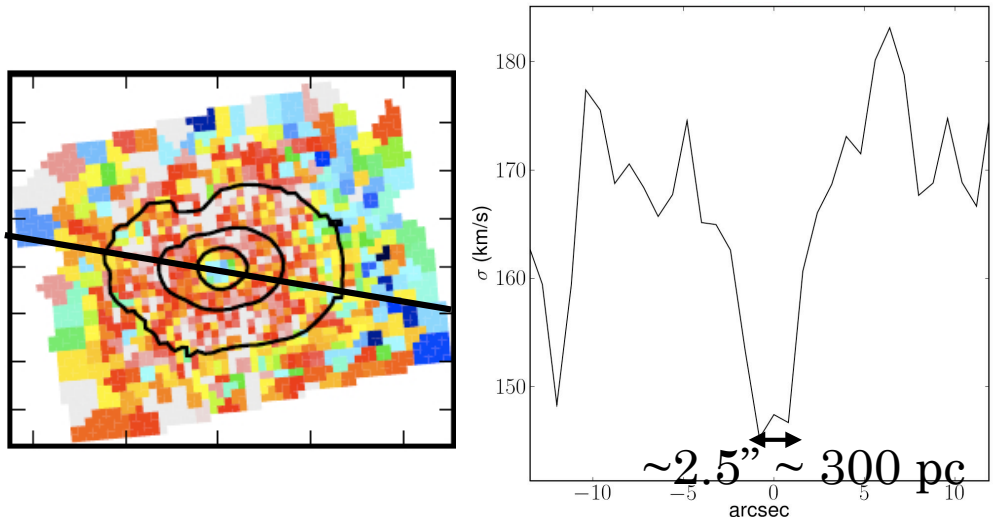
- Regular rotation patterns
- kinematic and photometric PA aligned

dominated by disc-like rotation for both Seyfert and control galaxies



SAURON MAPS
STELLAR KINEMATICS

- Presence of σ-drops:

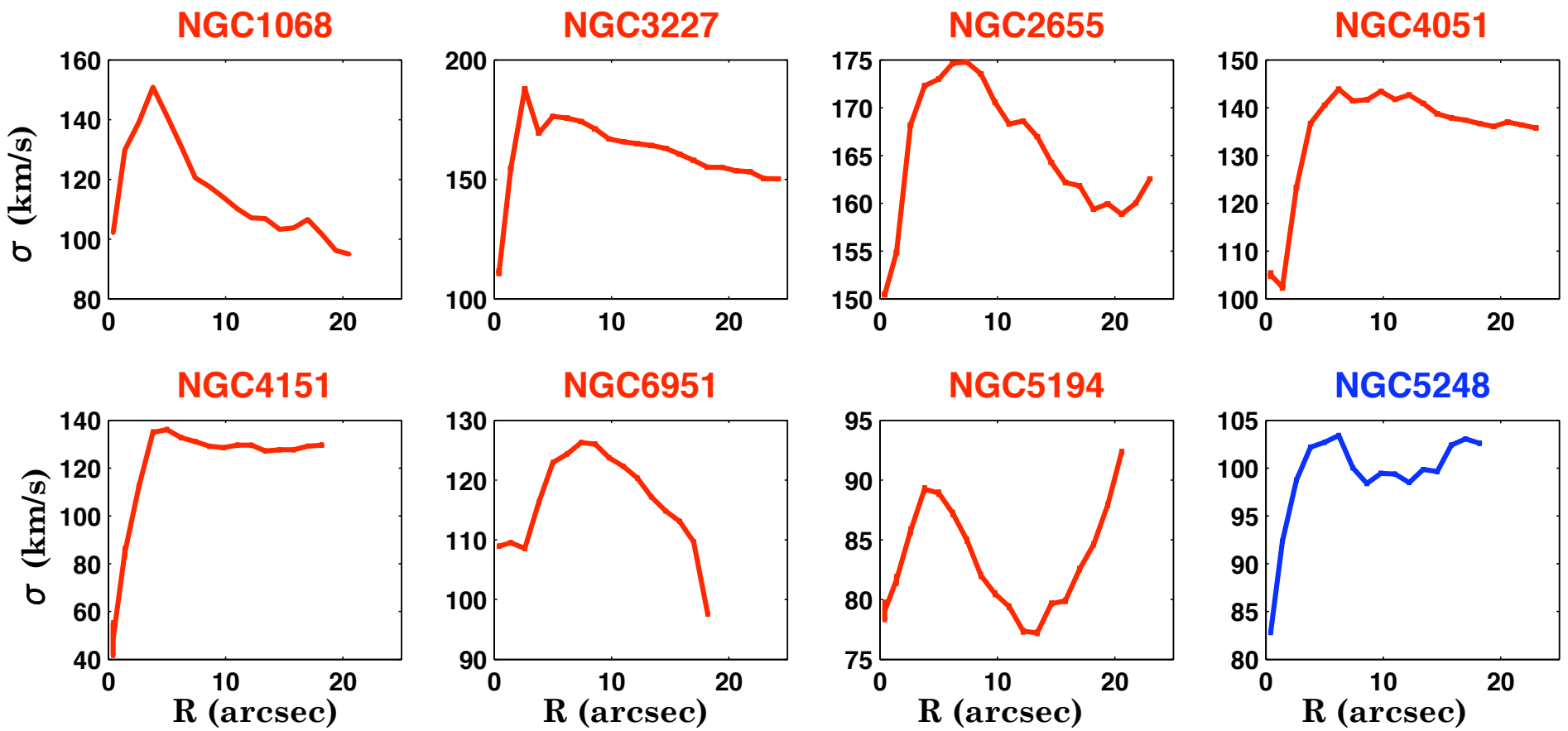


NGC2655

- Star formations, recent accretion event (Wozniak et al. 2003)
- Common in nearby spiral galaxies (Ganda et al. 2006, Peletier et al, 2007)
- Nuclear stellar disk

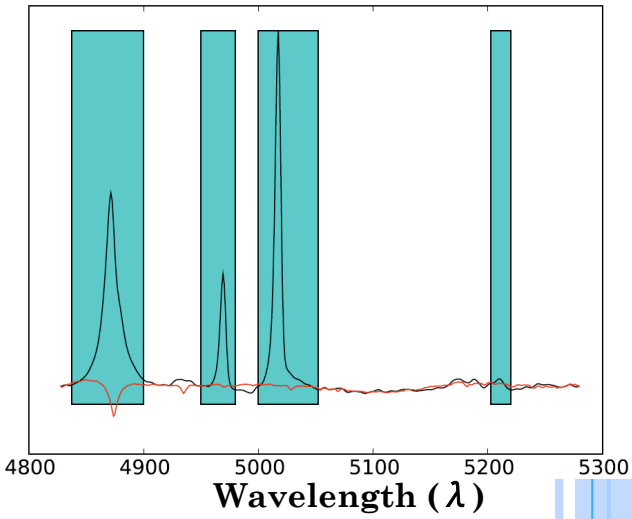
SAURON MAPS
STELLAR KINEMATICS

- Presence of σ-drops:
  - 6 Seyferts (75%), 1 non-active galaxy 17%



SAURON MAPS
STELLAR KINEMATICS

NGC4051 S1



- Presence of σ-drops:
  - 6 Seyferts (75%), 1 non-active galaxy 17%
  - Seyferts 1 : BLR emission line contaminate the central regions

  ⇒ Remain 50% of Seyfert and 17% of Control

  - σ-drops frequency ~40% in early type galaxies (e.g.Peletier et al. 07)
    - Seyferts consistent
    - Control galaxies significantly lower

SAURON MAPS
ABSORPTION-LINE STRENGTH

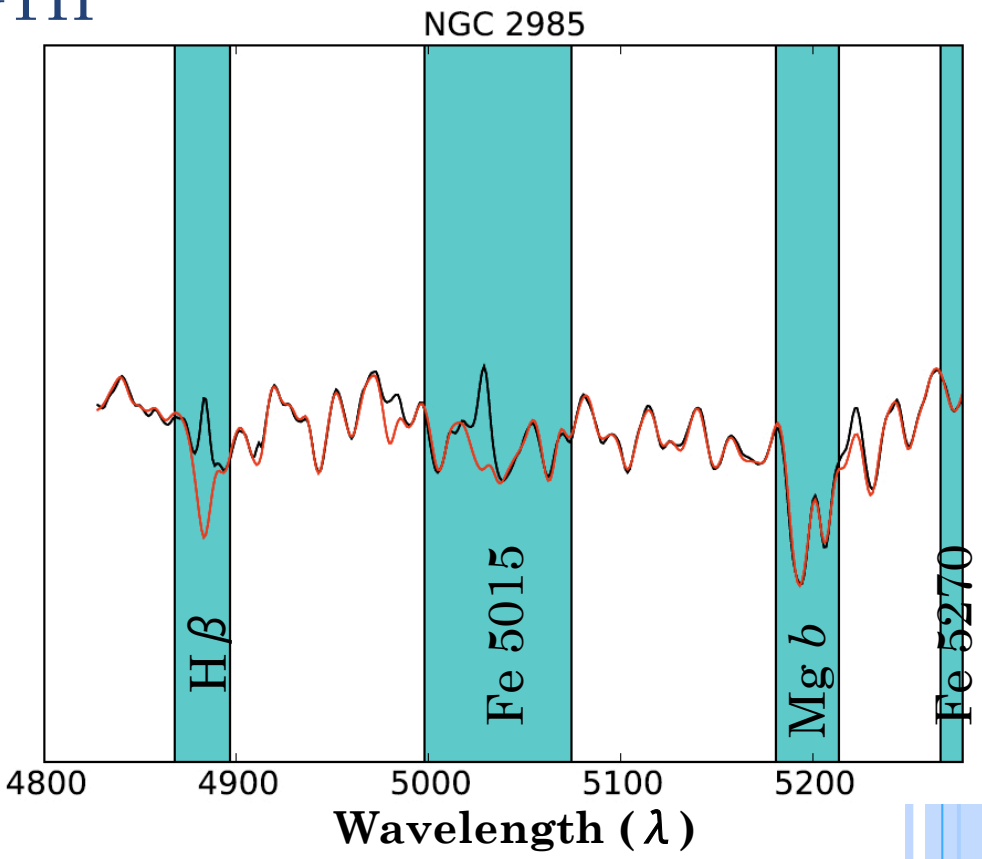
- Line strength indices
  - Lick/IDS system
  - Stellar population properties:

  Age, metallicity, abundances

- Sauron wavelength range
  - All FOV 4825-5275Å

  ⇒ H β , Fe5015, Mg b
  - ~FOV/2 4825-5380Å

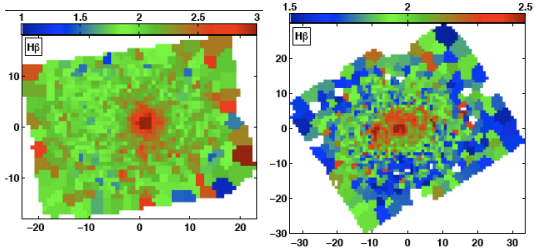
  ⇒ H β , Fe5015, Mg b +Fe5270

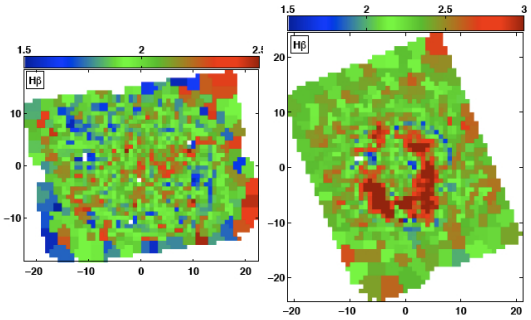


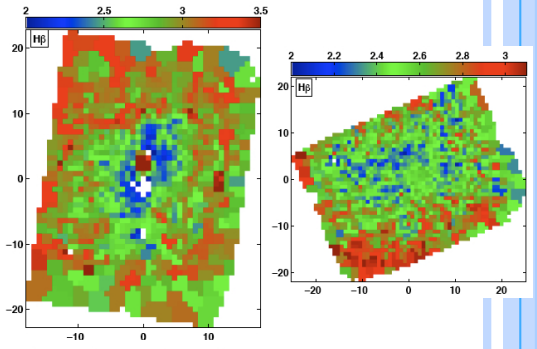
SAURON MAPS
ABSORPTION-LINE STRENGTH

NGC2655 NGC4459 NGC4579 NGC3351 NGC5194 NG5055

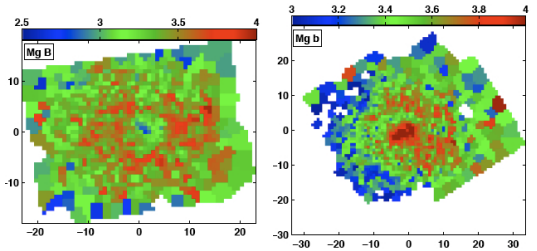
Hb

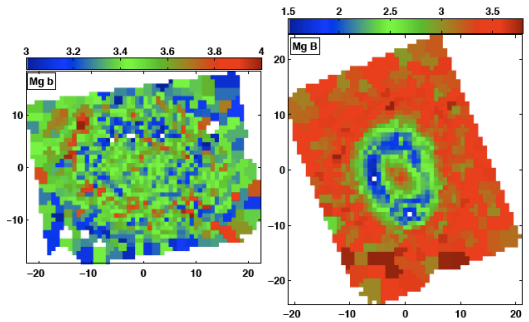


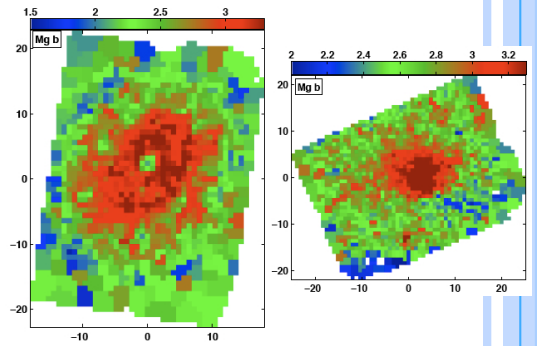




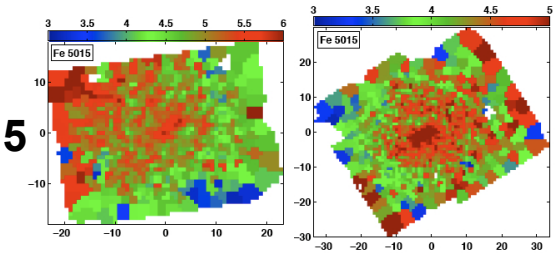
Mg b

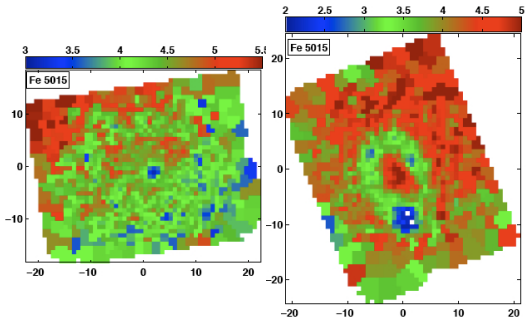


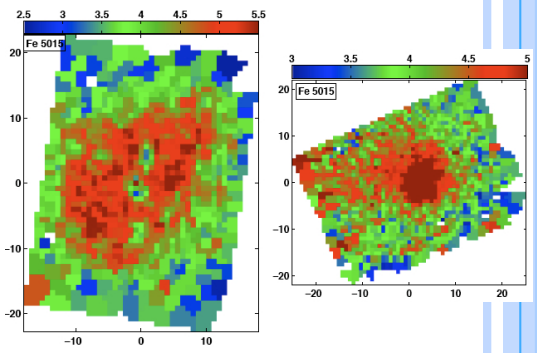




Fe 5015

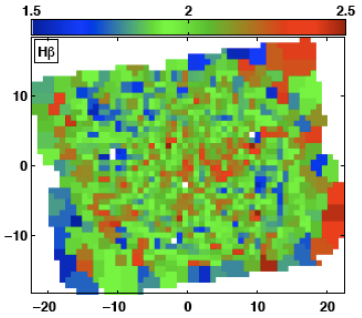




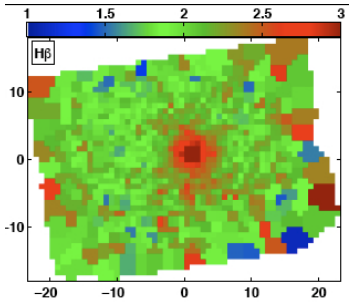


SAURON MAPS
ABSORPTION-LINE STRENGTH

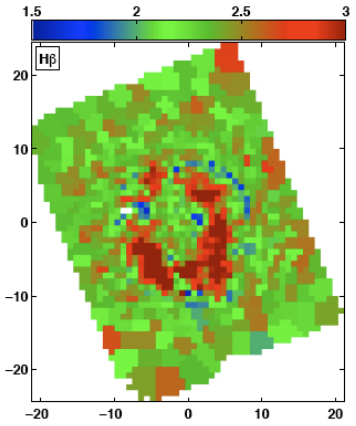
- Smooth distribution
  - ⇒ NGC4579
  - ⇒ 50% Seyfert, 33% non-active



- Structures with high H β , low Mg b & Fe 5015: young stars
  - Compact central regions
  - ⇒ NGC2655
  - ⇒ 37% Seyfert, 17% non-active



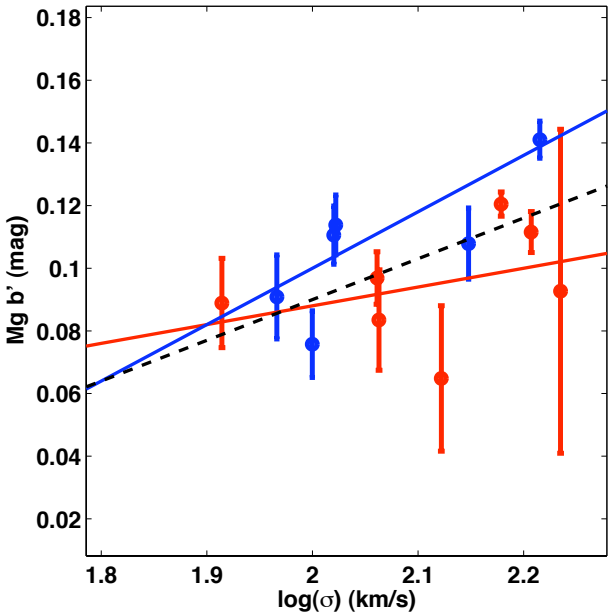
  - rings
  - ⇒ NGC3351
  - ⇒ 13% Seyfert, 50% non-active

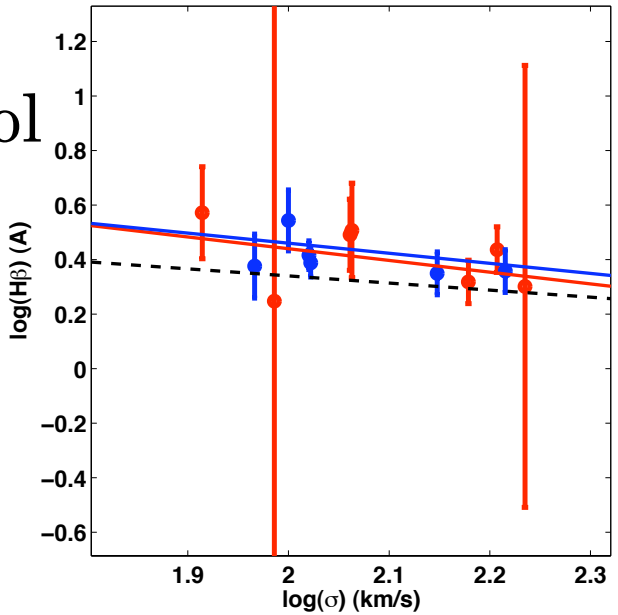


INDEX-σ RELATIONS

- Central values R < Re/10
- Mg *b*-σ & H β -σ relations
  - Early type (Morelli et al. 08) - - - -
  - This work: Seyferts ——
    control ——
- No significative difference Seyfert/control

⇒ Consistent with early type galaxies relations





AGE, METALLICITY, ABUNDANCE
SSP ANALYSIS

- Central values R < Re/10

- Single-burst population models of Thomas et al. 2003
  - age
  - Metallicity
  - Abundance ratios

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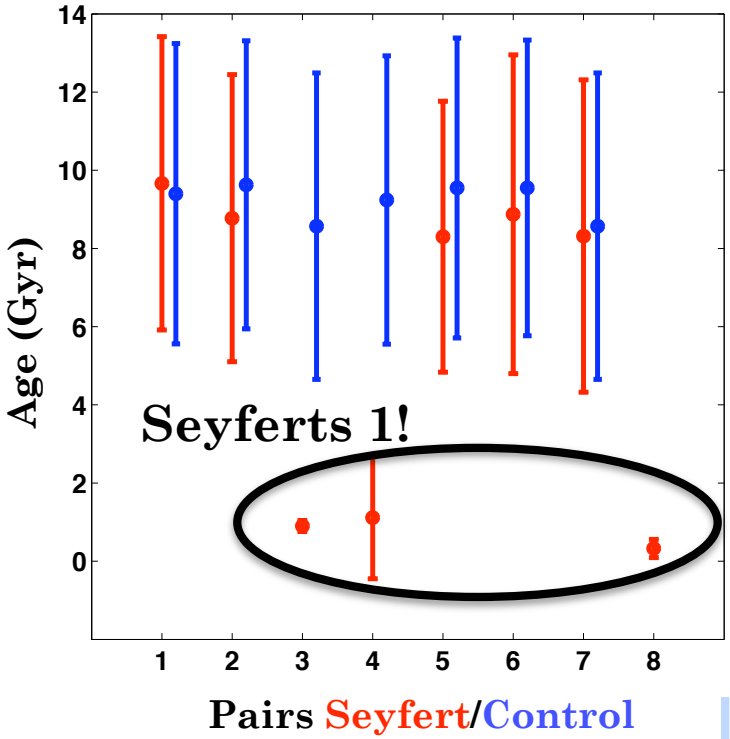
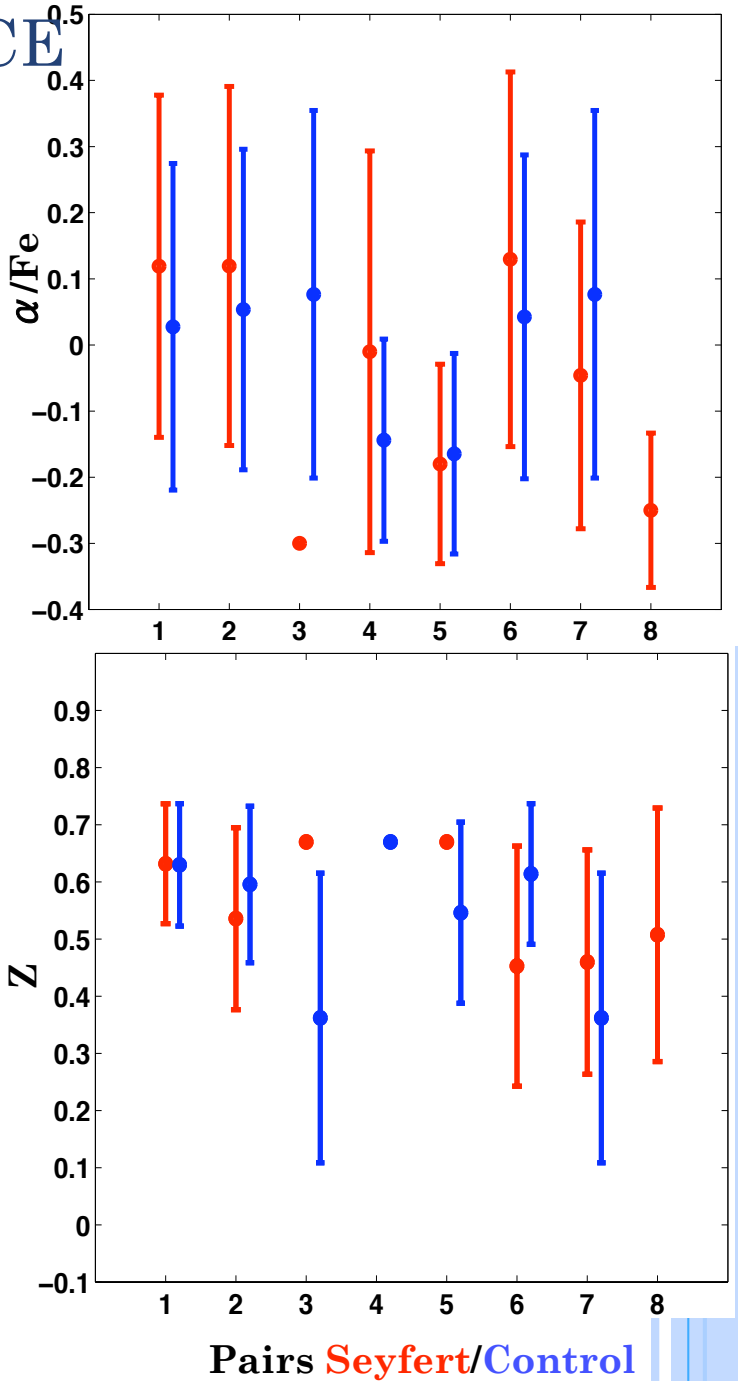


- Age
  - Seyfert slightly younger than control
  - Non statistically difference: ages between 8 and 10 Gyr
  - Seyferts 1: problems

AGE, METALLICITY, ABUNDANCE SSP ANALYSIS

- Central values R < Re/10
- α/Fe enhancement
  - Between -0.2 and 0.2
  - Control galaxies: median=0.04
  - Seyferts: median = 0.12
- Metallicity
  - Between 0.4 and 0.7
  - Median at 0.6 for both Seyfert and control galaxies



CONCLUSIONS

- σ-drops 50% Seyfert / 17% Control
  BUT Control frequency too low

- Line strength indice – σ relation
  - Seyfert & Control galaxies consistent with early type spirals

- Seyfert systematically younger and super-solar α/Fe enhancement
  BUT differences small!

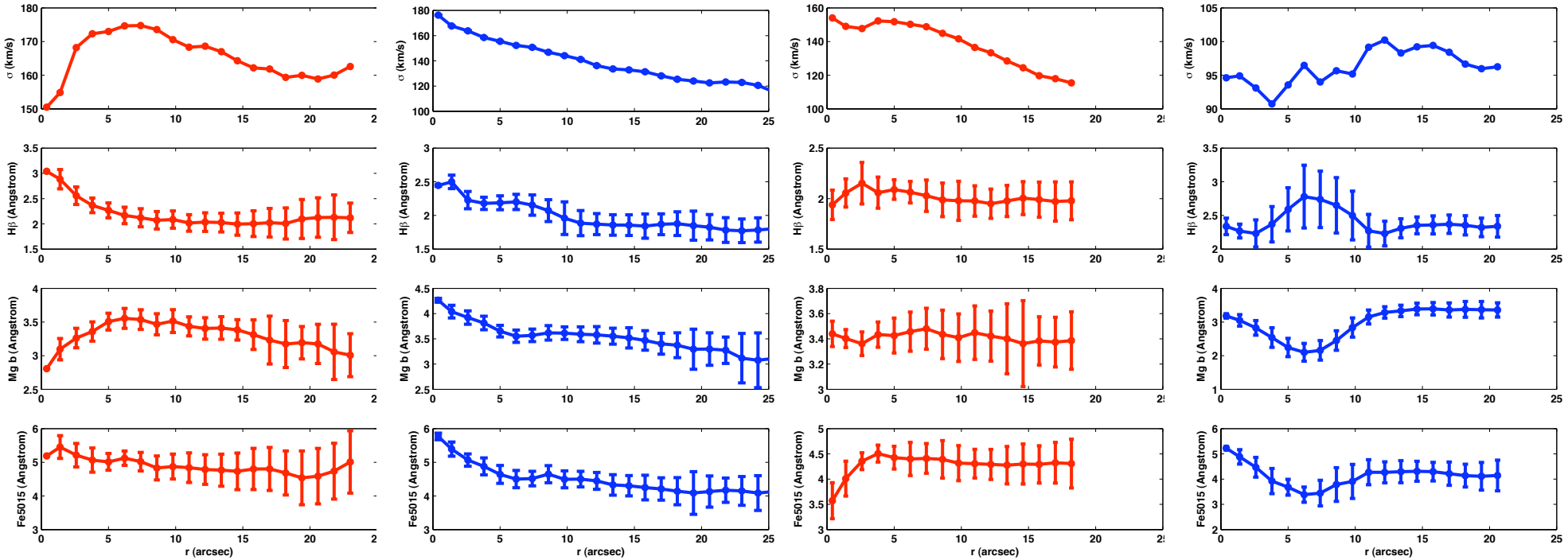
Non significant difference between
Seyfert and Control galaxies

CONCLUSIONS

- Maps of age, z and α/Fe
  - Structures
  - gradients
- SSP analysis
  - Over simplification
  - If 2 population: SSP => old low Z population (Allard et al 06)
- NEED Two-population analysis
  - Link with sigma-drops: nuclear stellar disk
  - SF history in the nuclear region

RADIAL PROFILES

NGC2655 NGC4459 NGC4579 NGC3351

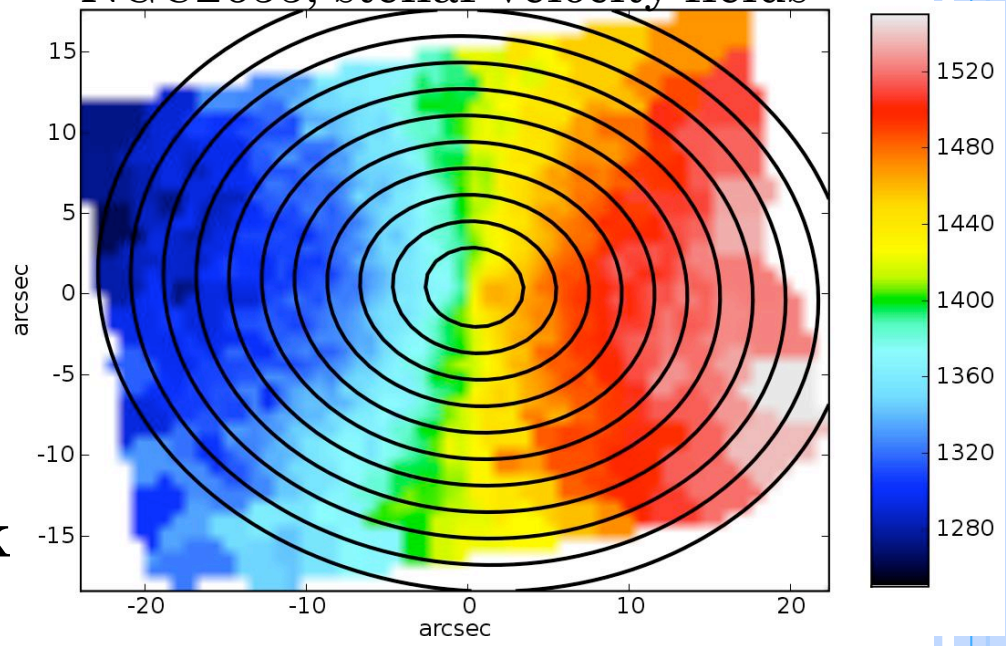


KINEMATICS STUDY
PYRING

$$V_{LOS} = V_{sys} + V_{\phi}(R,\phi)\cdot\cos(\phi)\cdot\sin(i) + V_{R}(R,\phi)\cdot\sin(\phi)\cdot\sin(i)$$

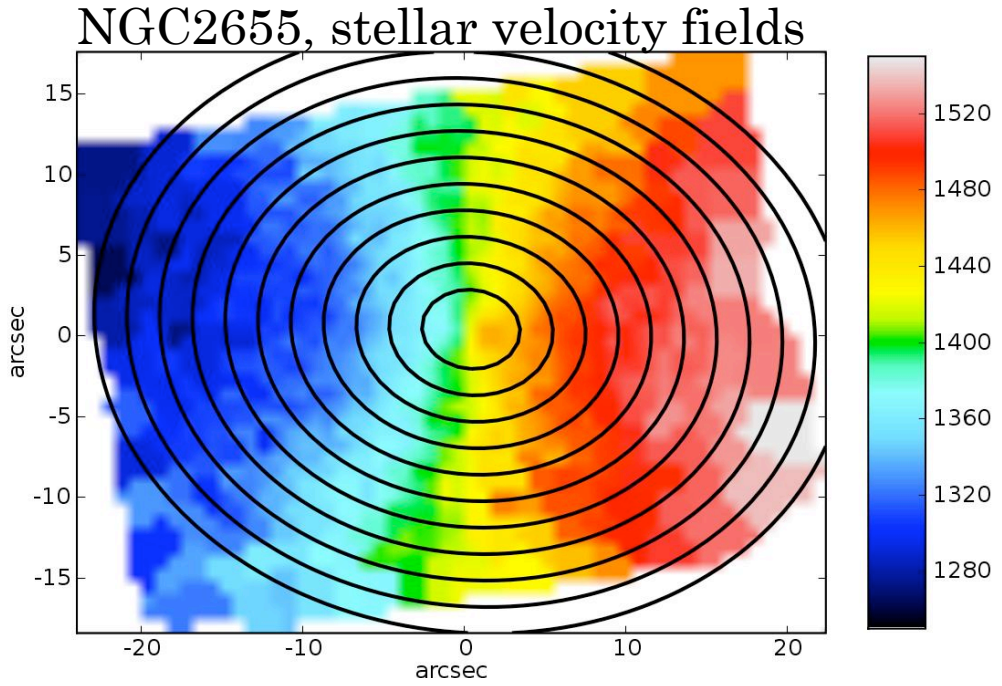
$$\begin{cases} \cos(\phi) = \dfrac{-(x - X_c)\cdot\sin(PA) + (y - Y_c)\cdot\cos(PA)}{R} \\ \sin(\phi) = \dfrac{-(x - X_c)\cdot\cos(PA) - (y - Y_c)\cdot\sin(PA)}{R\cos(i)} \end{cases}$$

NGC2655, stellar velocity fields



- 2D infinitesimally thin disk
- Tilted-ring method
- Fit of kinematics parameters: V_{sys}, PA, i, center, V_R, V_Φ

RADIAL PROFILES



- Elliptical rings: center, PA, I from fit of the stellar velocity field
- Radial profiles computed by averaging σ and line strength maps over these rings