The near-IR stellar populations of active galaxies

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Motivation

- ✓ The NIR stellar content of active galaxies are still poorly known:

  • Some "early" studies based on: Brγ emission or 2.3μm CO bands (e.g. Rieke et al., 1980; Origlia et al., 1993; Oliva et al., 1995, Lançon et al., 2001);

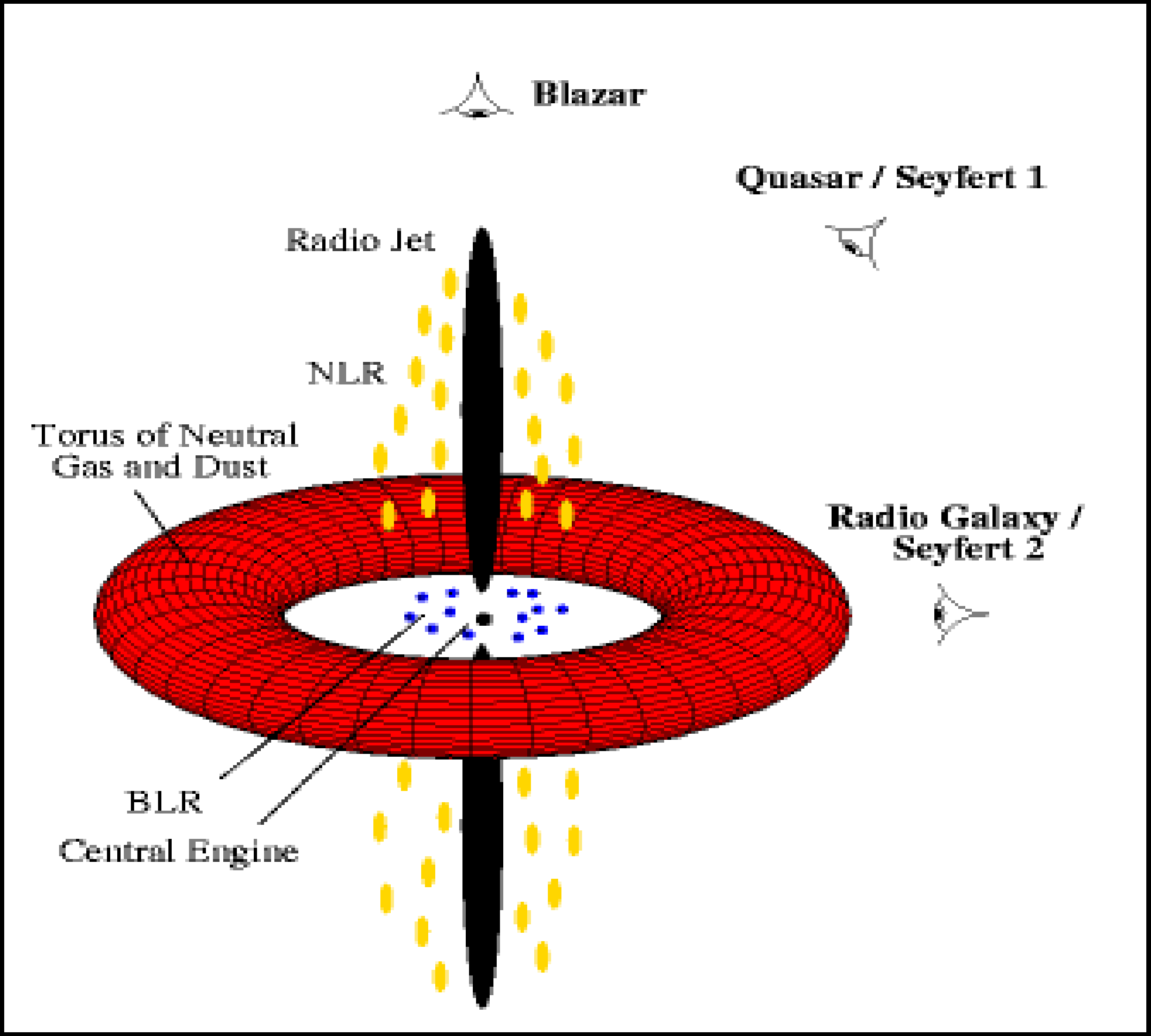
  • We present some studies based on the fitting of the whole NIR spectra (e.g. Riffel et al., 2007, 2008, 2009, 2010, 2011, Martins et al., 2010, 2013, Storchi-Bergmann et al., 2012, Dametto et all., 2014);

- ✓ The NIR is the most convenient spectral region, accessible to ground based telescopes, to probe highly obscured sources and to avoid the complete dilution of the stellar features by the AGN;

- ✓ The NIR host many interesting stellar features (e.g. CN, CO, ZrO, TiO, VO, C2, among many atomic lines).

- ✓ In the NIR it is possible to study - in a single shot - the 3 main AGN SED components;

The main NIR SED components



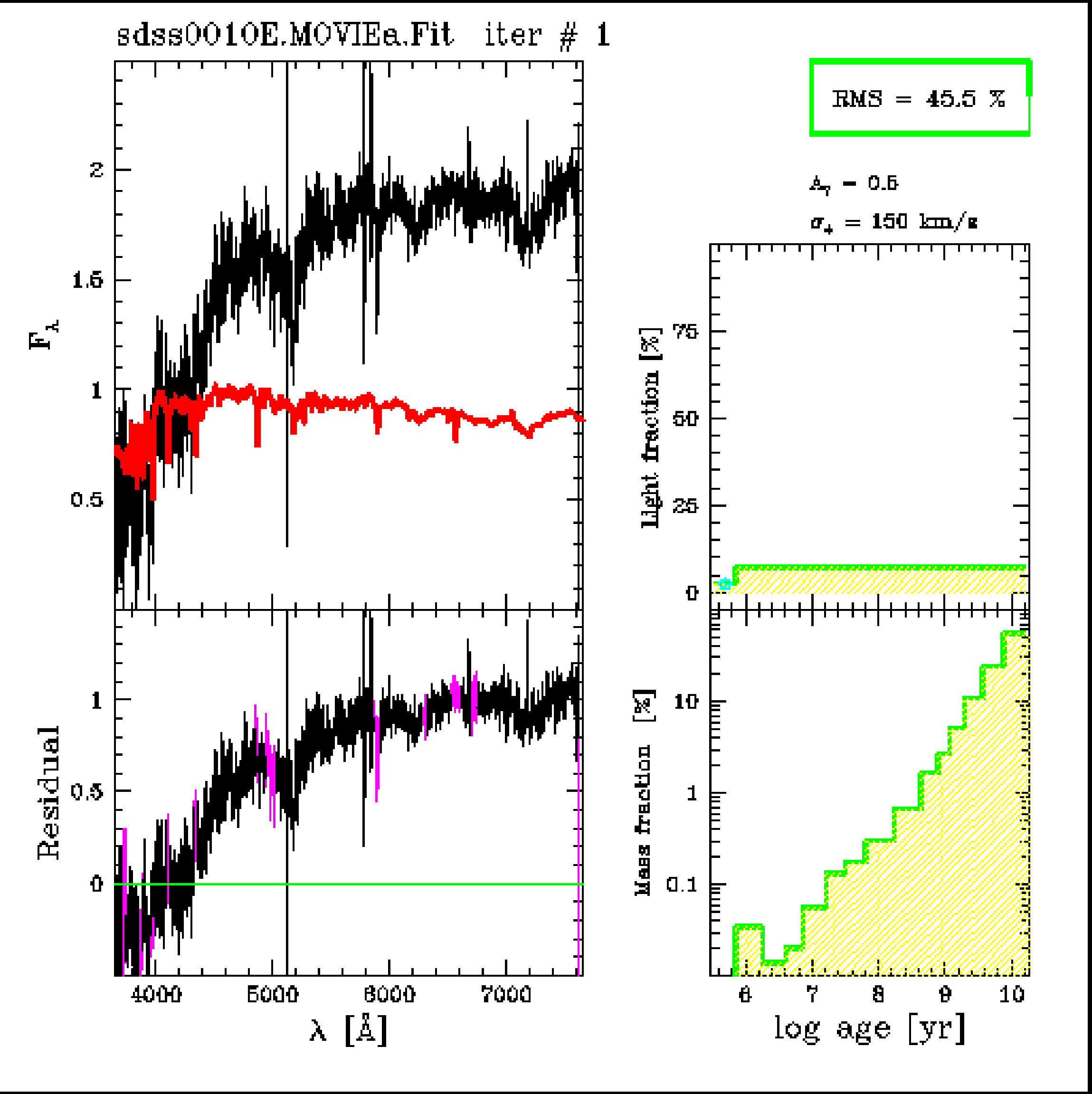
The unified model for AGNs
(Antonucci & Miller, 1985)

1- Stars;
(Bulge)
2- Power Law;
(SMBH - AGN)
3- Hot Dust;
(Dusty torus)

Spectral Synthesis

- ✓ Synthesis code

Courtesy of Roberto Cid Fernandes

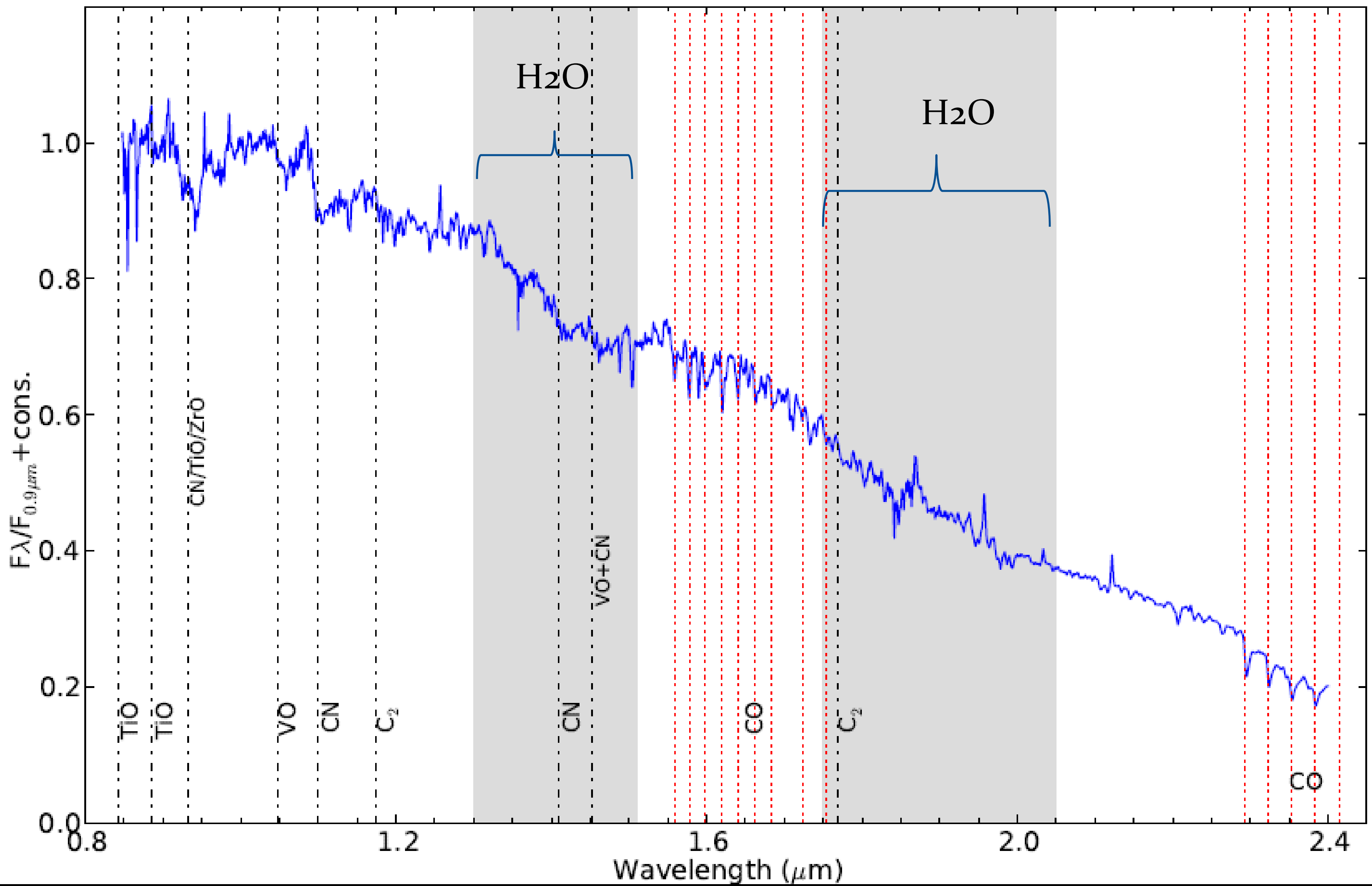


STARLIGHT: models the whole underlying spectrum, excluding emission lines and spurious data (Cid Fernandes et al., 2004, 2005);

Spectral Synthesis

- ✓ Synthesis code: STARLIGHT
- ✓ Base Set: what is used to fit the spectrum.

The ideal base should predict the Infrared Stellar Features



Riffel et al., 2015

Spectral Synthesis

- ✓ Synthesis code: STARLIGHT

- ✓ Base Set: what is used to fit the spectrum.

Stellar Population (SP): EPS models of Maraston (2005, 2011). They include the empirical spectra of TP-AGB stars and, thus, are able to predict features detected in the observations (e.g Riffel et al, 2007, 2008, 2014, Ramos Almeida, 2010, Lyubenova, 2012);

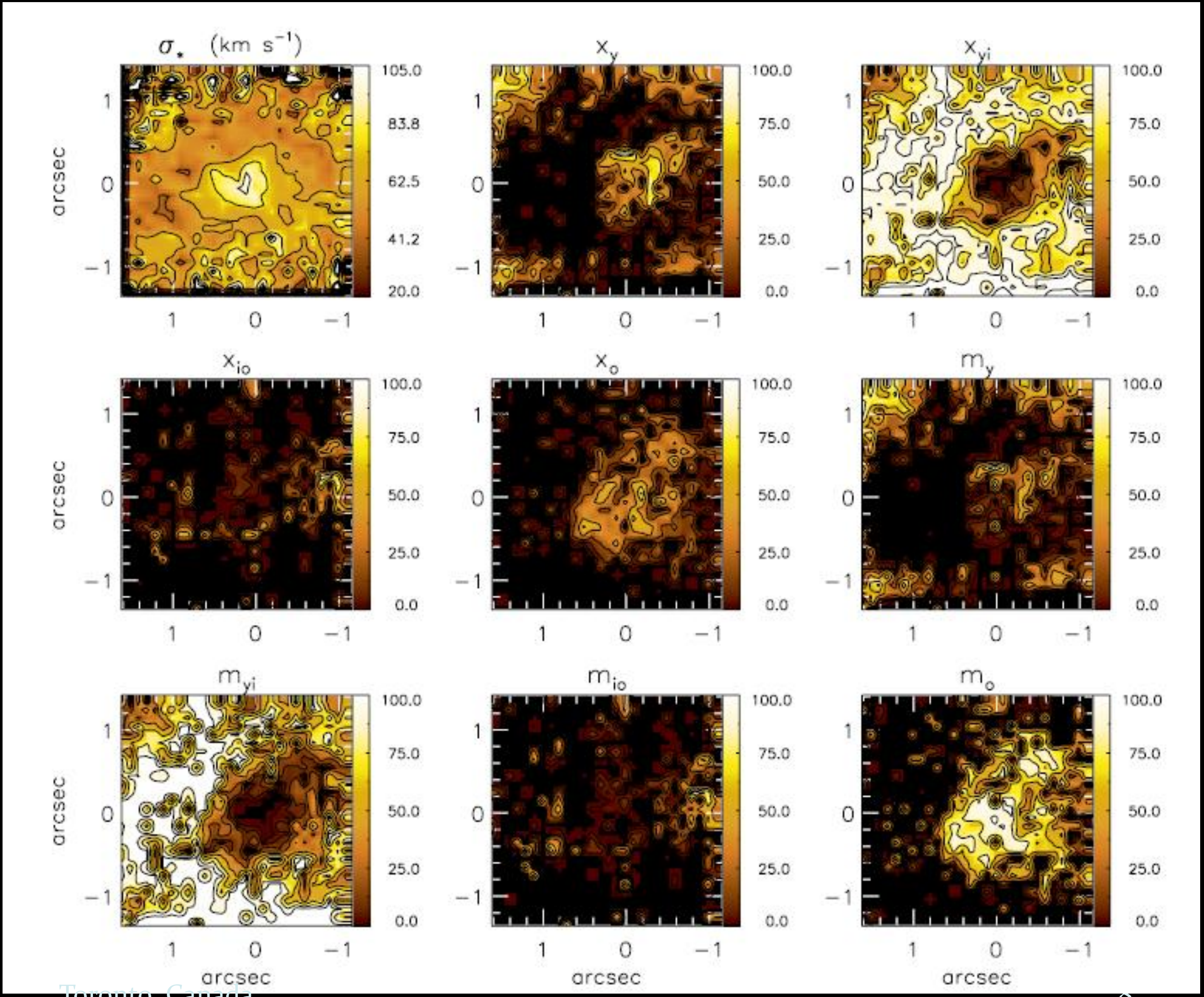
Featureless continuum (FC): Power Law of the form $F_\nu \sim \nu^{-1.5}$; represents the non-thermal contribution of the AGN (e.g. Cid Fernandes et al., 2004);

Planck distribution (BB): $700 \leq T \leq 1400$ K; to represent the hot dust.

Mapping the inner few parsecs using NIFS.

MRK 1066

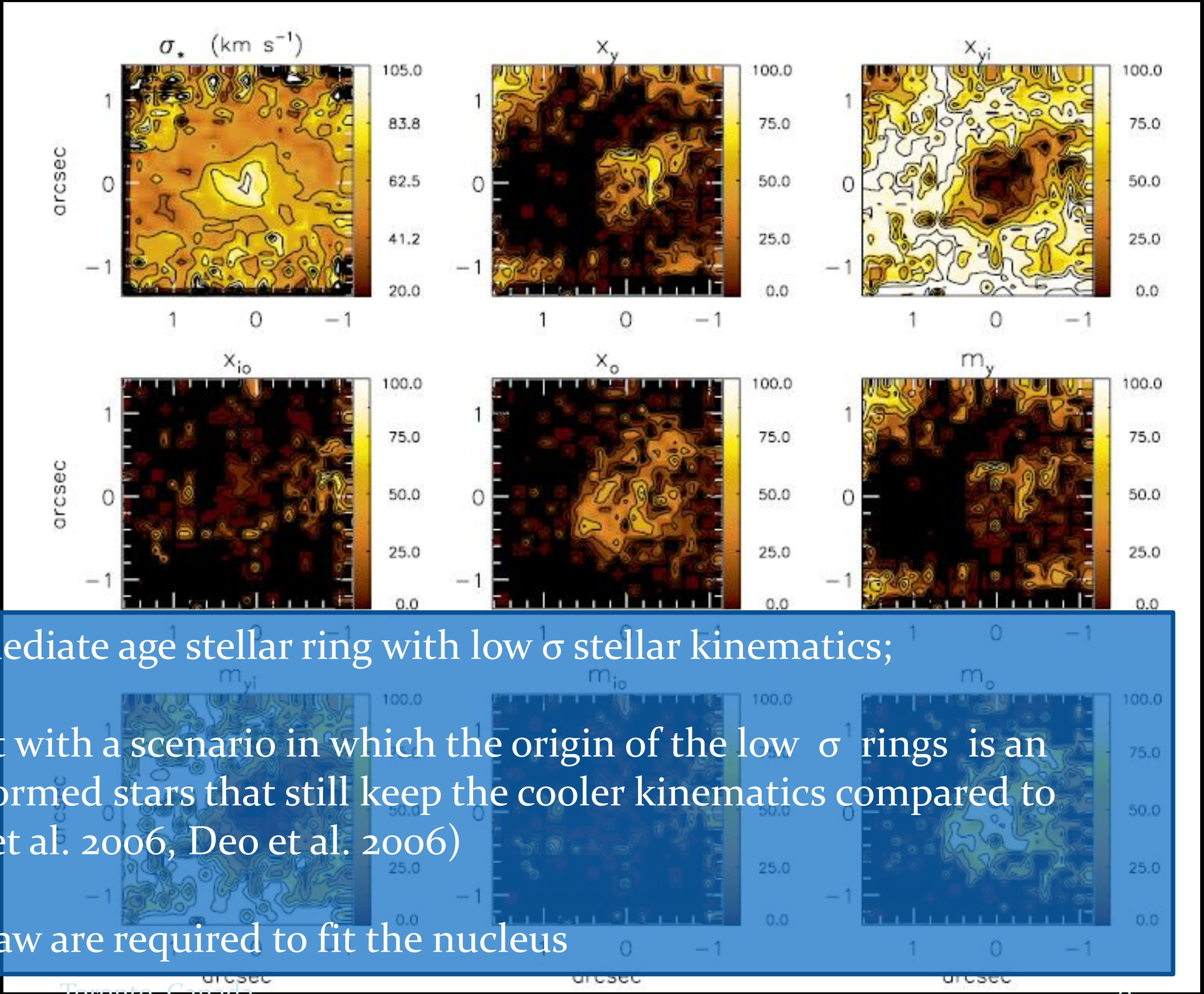
Riffel +, 2010



Mapping the inner few parsecs using NIFS.

MRK 1066

Riffel +, 2010



Correlation of intermediate age stellar ring with low σ stellar kinematics;

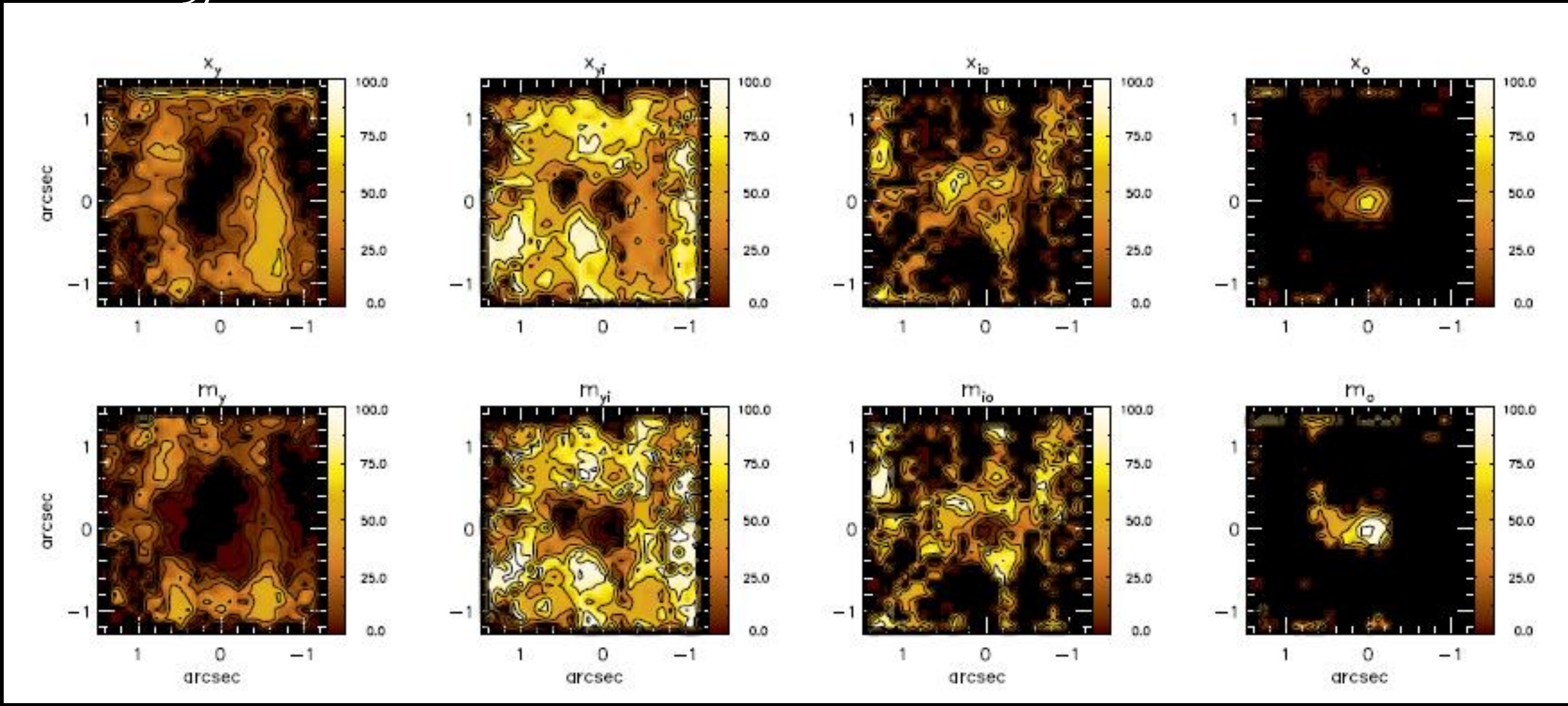
Such age is consistent with a scenario in which the origin of the low σ rings is an inflow of gas which formed stars that still keep the cooler kinematics compared to bulge stars (Barbosa et al. 2006, Deo et al. 2006)

Hot dust and power law are required to fit the nucleus

Mapping the inner few parsecs using NIFS.

MRK 1157

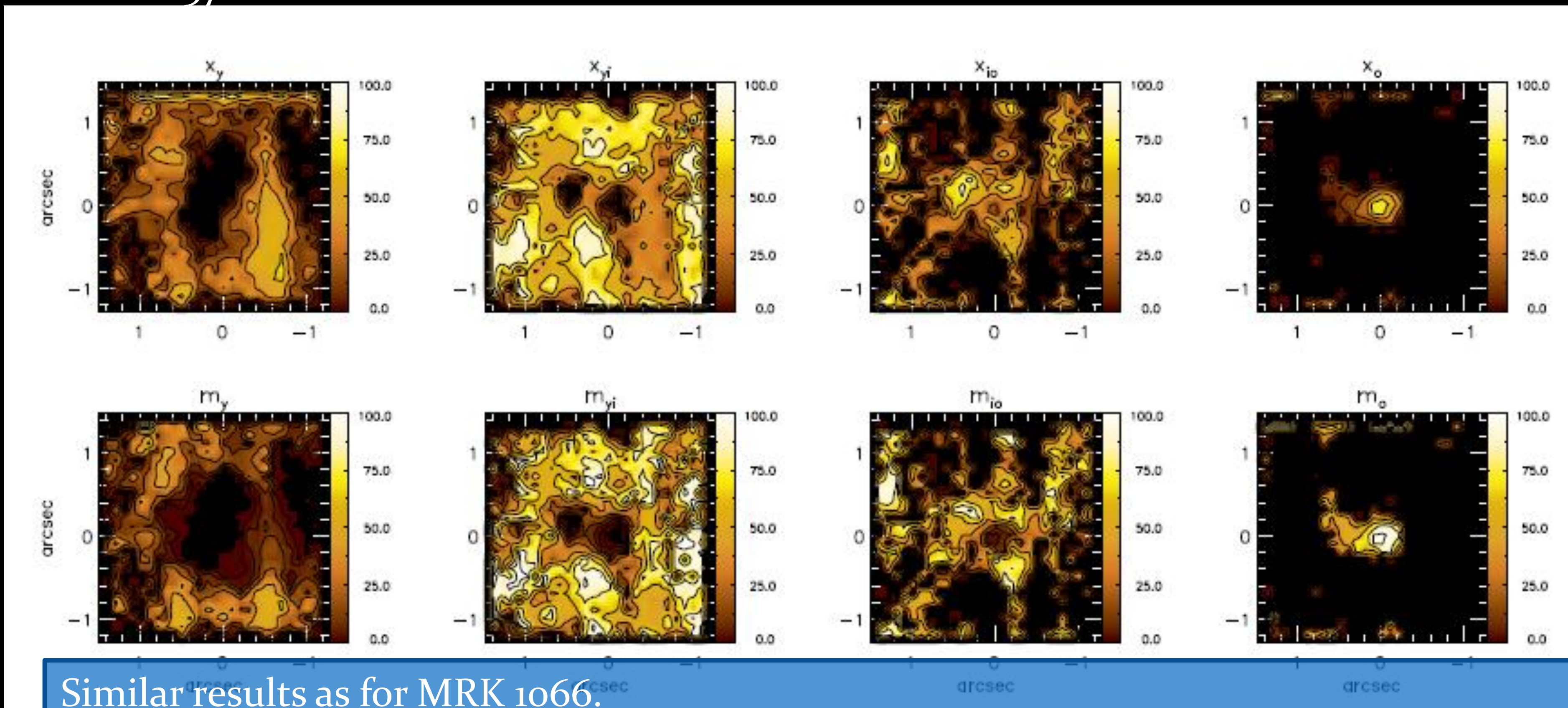
Riffel + 2011



Mapping the inner few parsecs using NIFS.

MRK 1157

Riffel + 2011



Similar results as for MRK 1066.

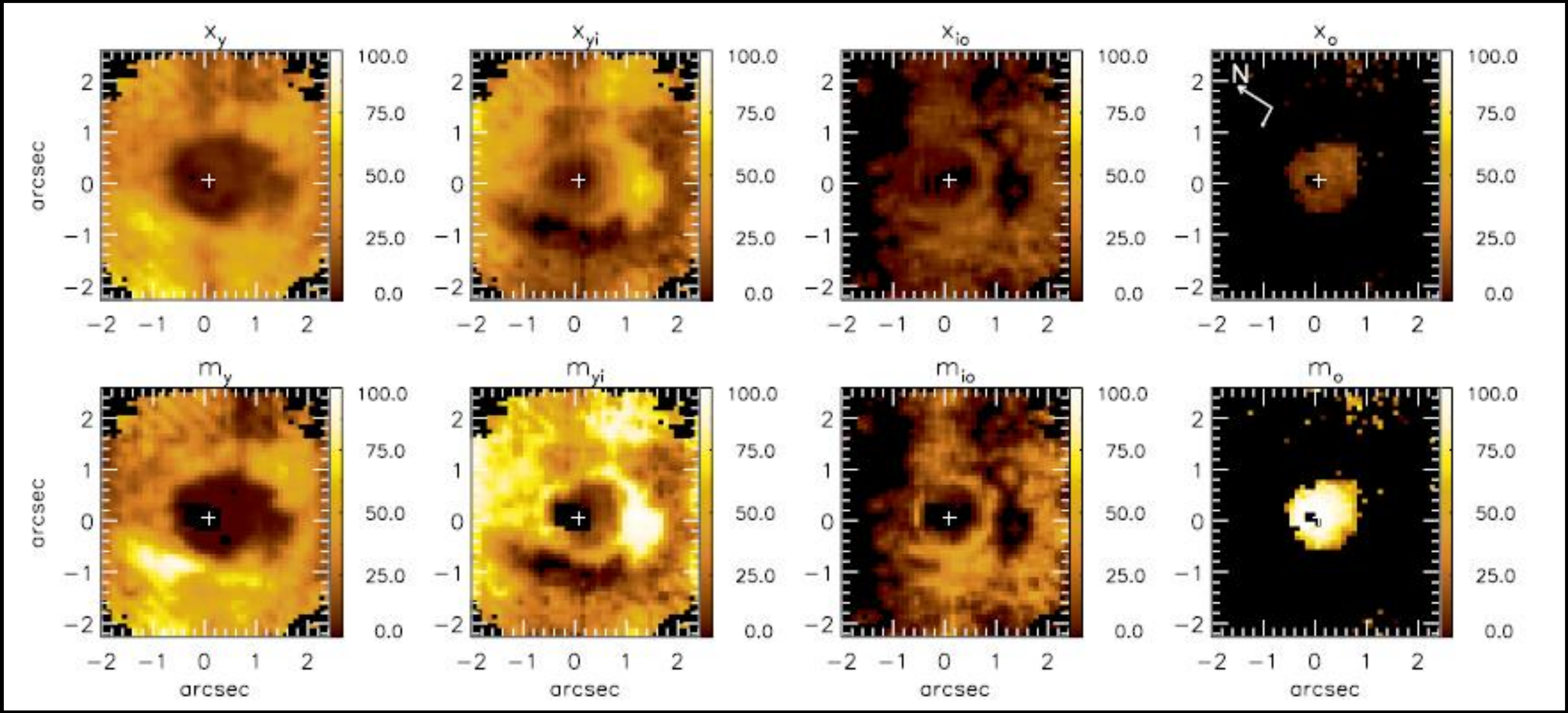
Correlation of intermediate age stellar ring with low σ stellar kinematics;

Hot dust and power law are required to fit the nucleus

Mapping the inner few parsecs using NIFS.

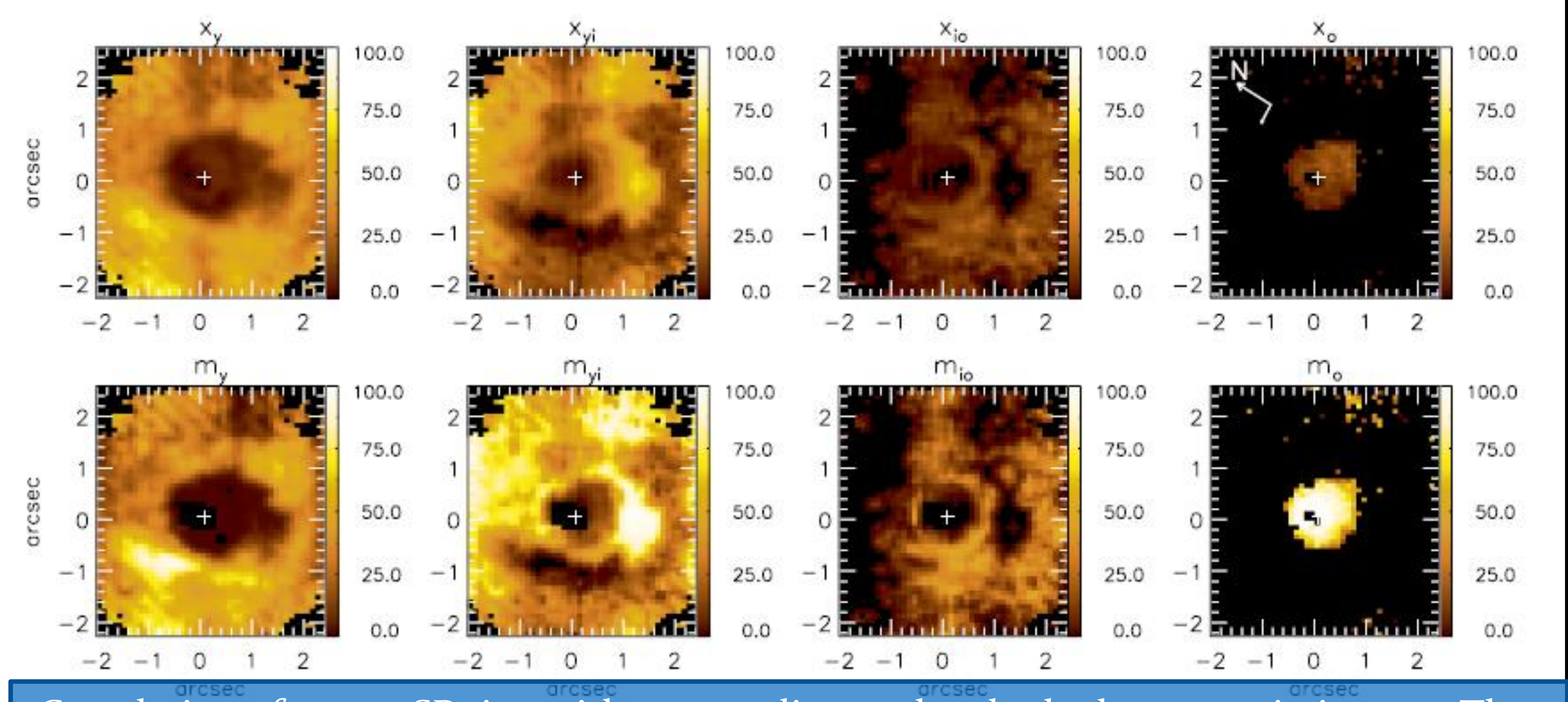
NGC 1068

Storchi-Bergmann + 2012



Mapping the inner few parsecs using NIFS.

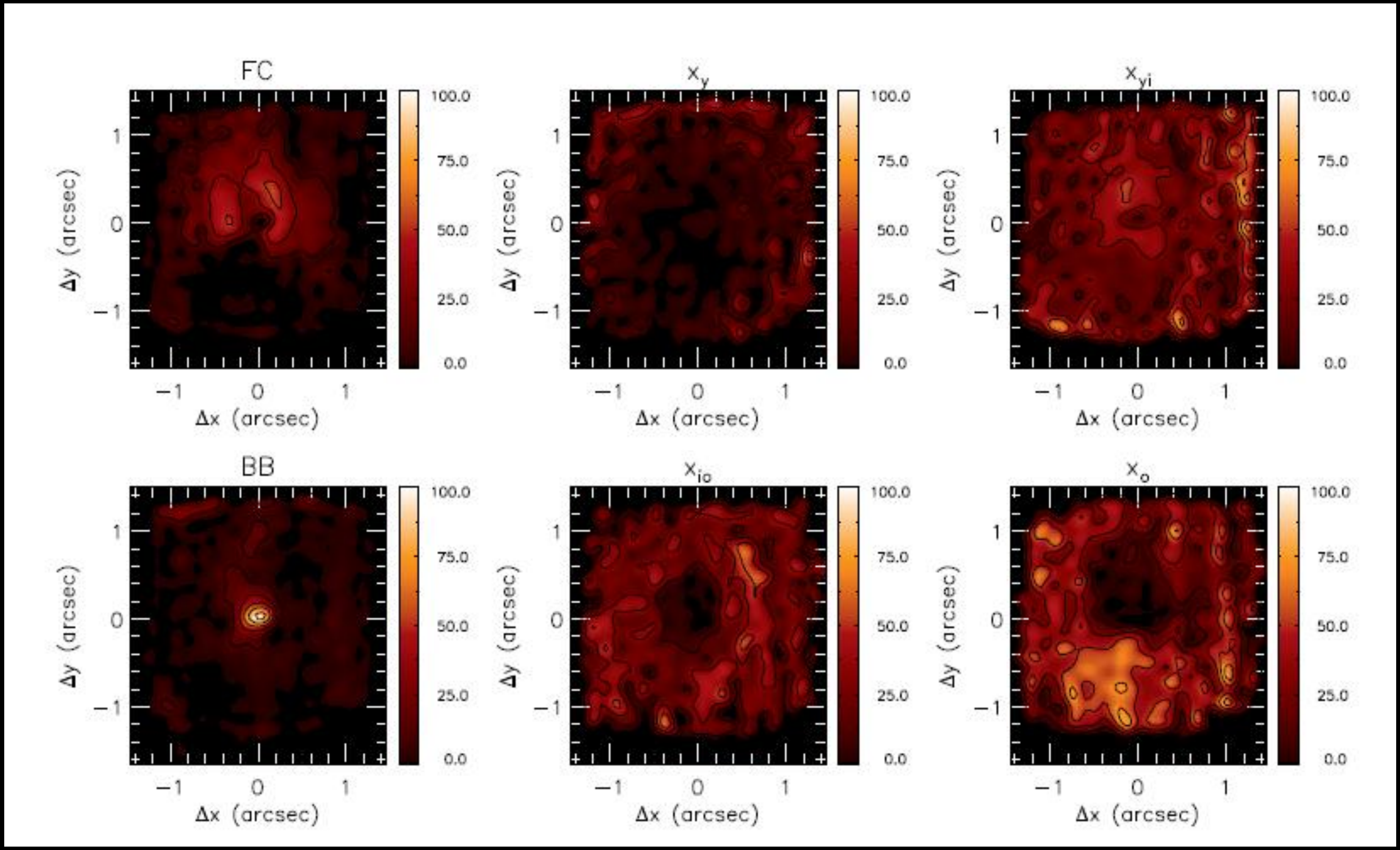
NGC 1068 Storchi-Bergmann + 2012



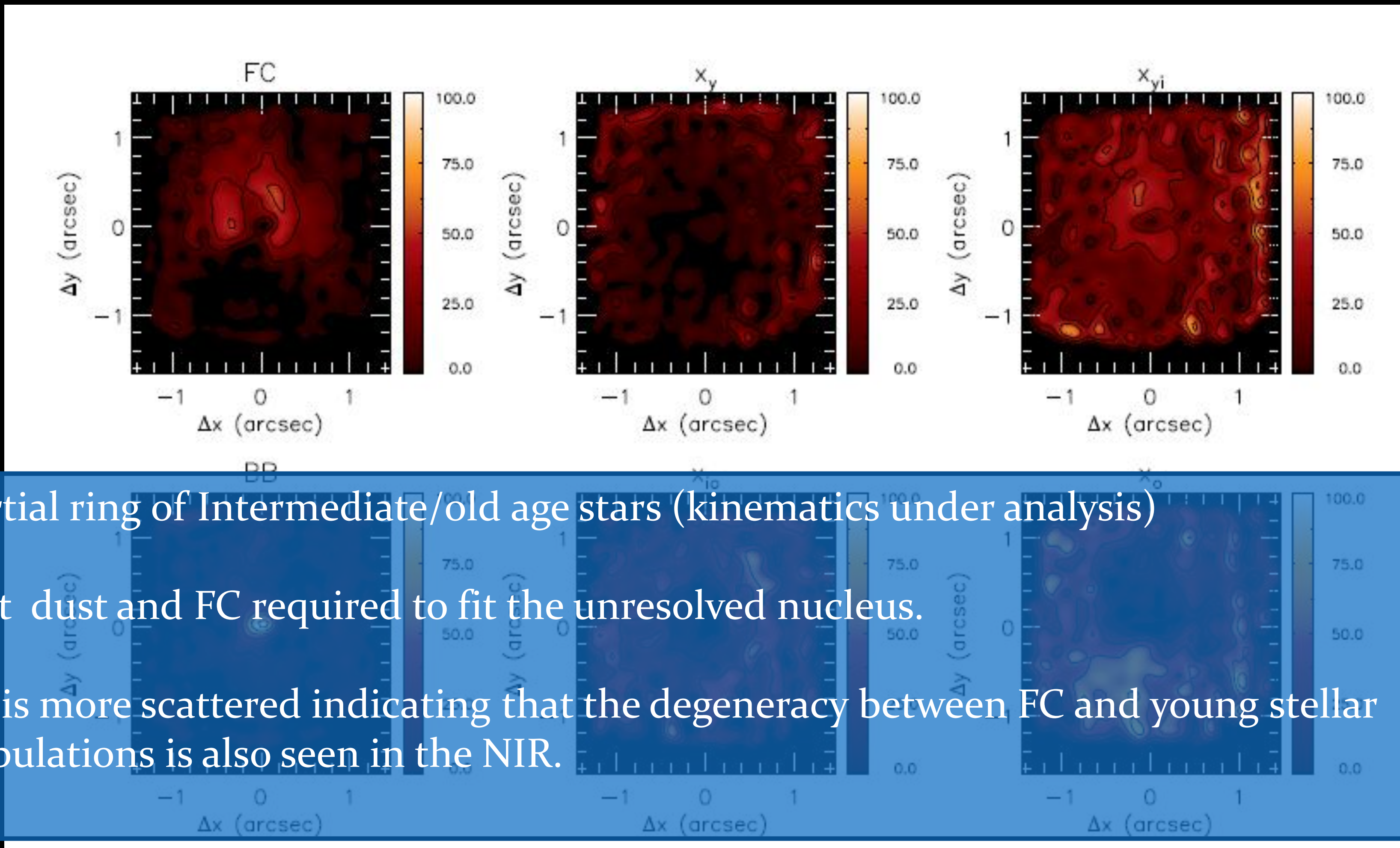
Correlation of young SP ring with a expanding molecular hydrogen emission gas. The H2 expanding shell of shocked gas can originate in stellar winds from the evolution of a super stellar cluster (Krips+2011).

Correlation of intermediate age stellar ring with low σ stellar kinematics.

Results – Mapping the inner few parsecs using NIFS Mrk 3 (see poster by Marlon Diniz.)



Results – Mapping the inner few parsecs using NIFS Mrk 3 (see poster by Marlon Diniz.)

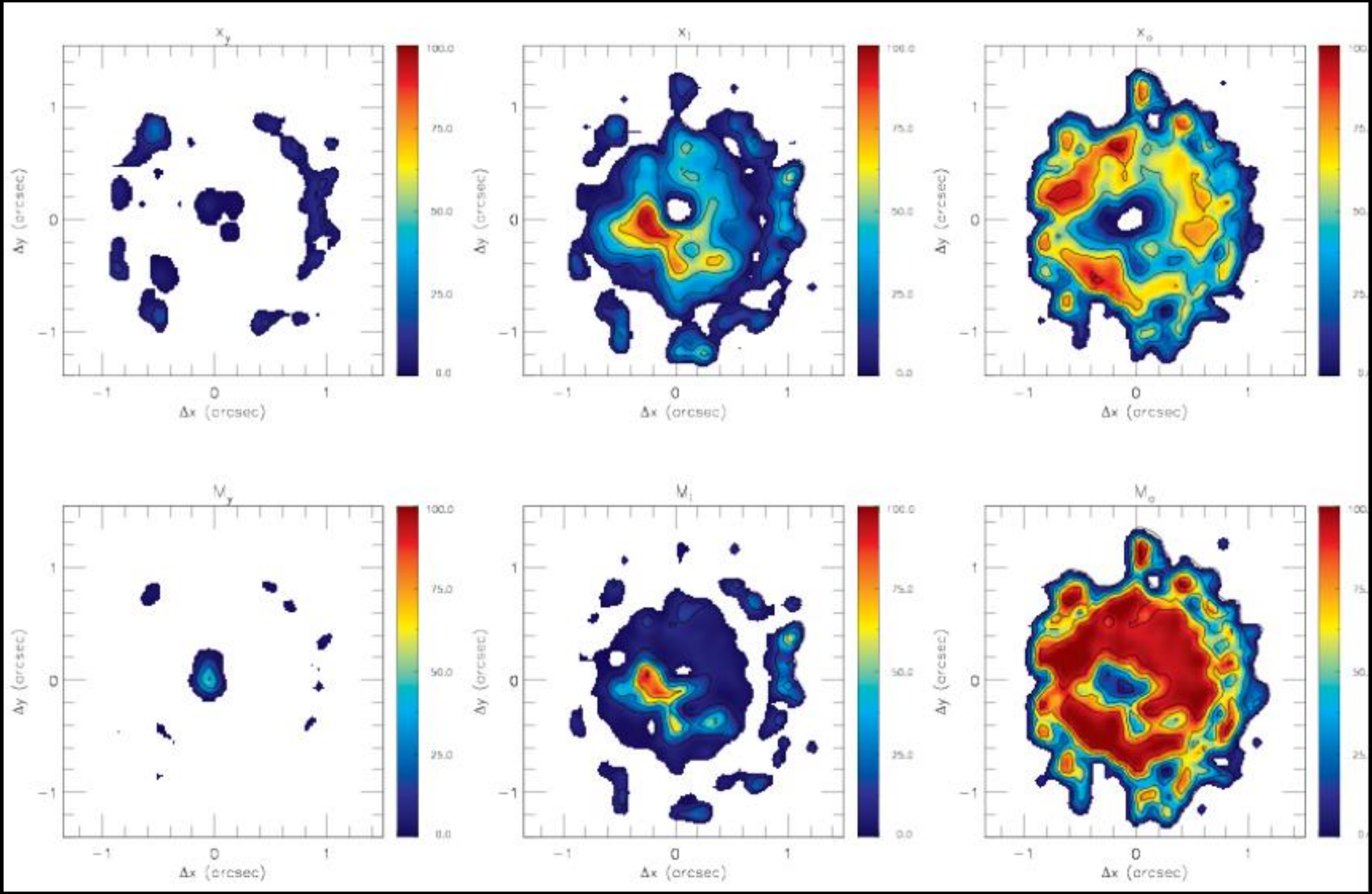


Partial ring of Intermediate/old age stars (kinematics under analysis)

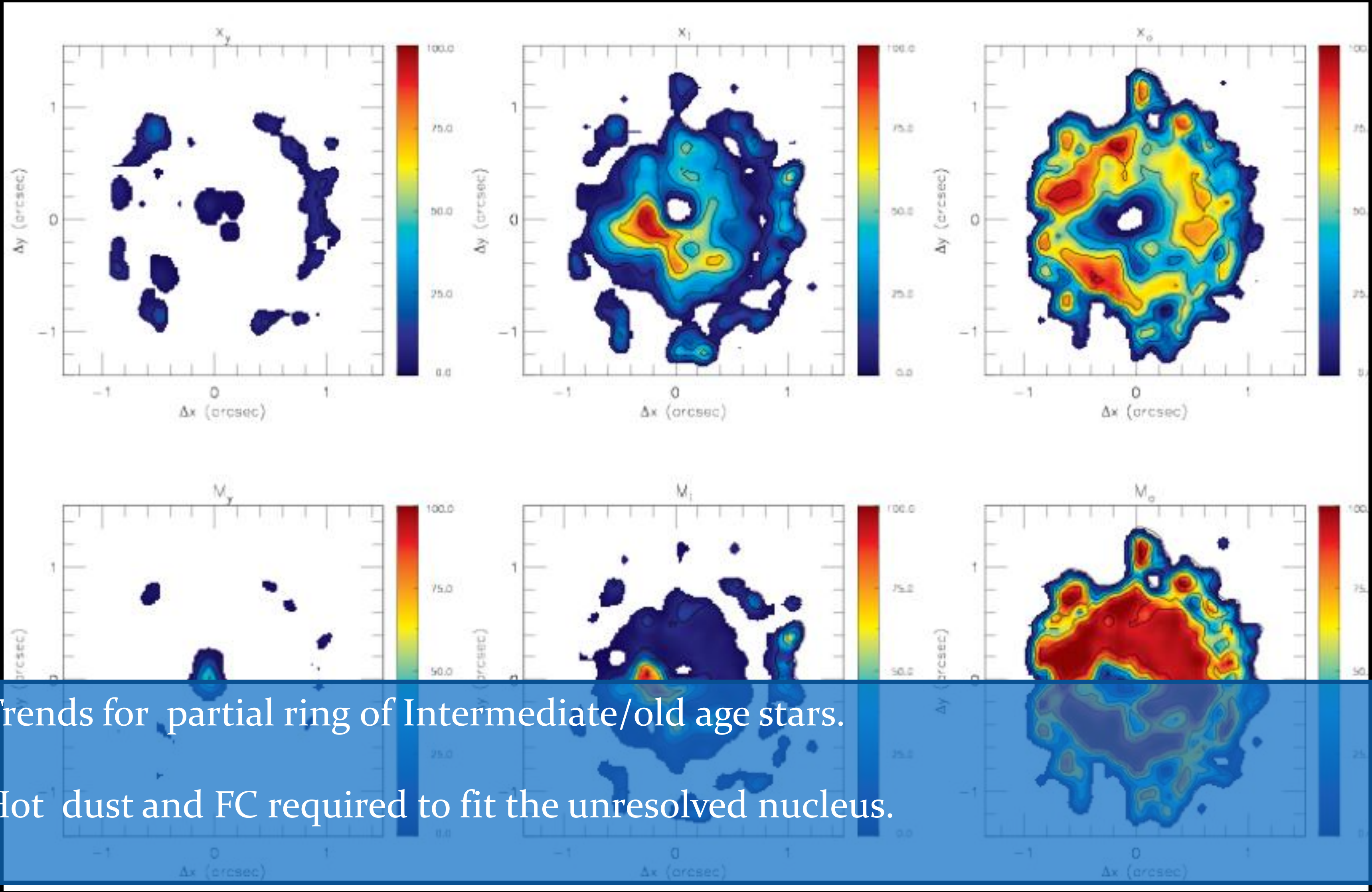
Hot dust and FC required to fit the unresolved nucleus.

FC is more scattered indicating that the degeneracy between FC and young stellar populations is also seen in the NIR.

Results – Mapping the inner few parsecs using NIFS NGC 5548 (see poster by Astor J. Schönell Jr.)



Results – Mapping the inner few parsecs using NIFS NGC 5548 (see poster by Astor J. Schönell Jr.)



Trends for partial ring of Intermediate/old age stars.

Hot dust and FC required to fit the unresolved nucleus.

The effects of TP-AGB stars in the NIR stellar populations.

Some issues/facts related with TP-AGB stars and galaxies stellar populations

→These stars maybe able to dominate the emission of stellar populations with ages ~0.2 - 2 Gyr (e.g. Mouhcine & Lançon 2002; Maraston, 2005) being responsible for roughly half of the luminosity at K-band (e. g. Kelson & Holden 2010).

→ The differences between the evolutionary simple stellar population (EPS) models mainly are due to the way how TP-AGB phase is treated.

How choose a model?

Two main 'classes'

TP-AGB 'light'
(e.g. Bruzual & Charlot, 2003)

NIR SSPs calibrated only with photometric points

Weak/no molecular features

TP-AGB 'heavy'
(e.g. Maraston, 2005, 2011)

NIR SSPs calibrated with C- and O- Rich stellar spectra

Strong molecular features

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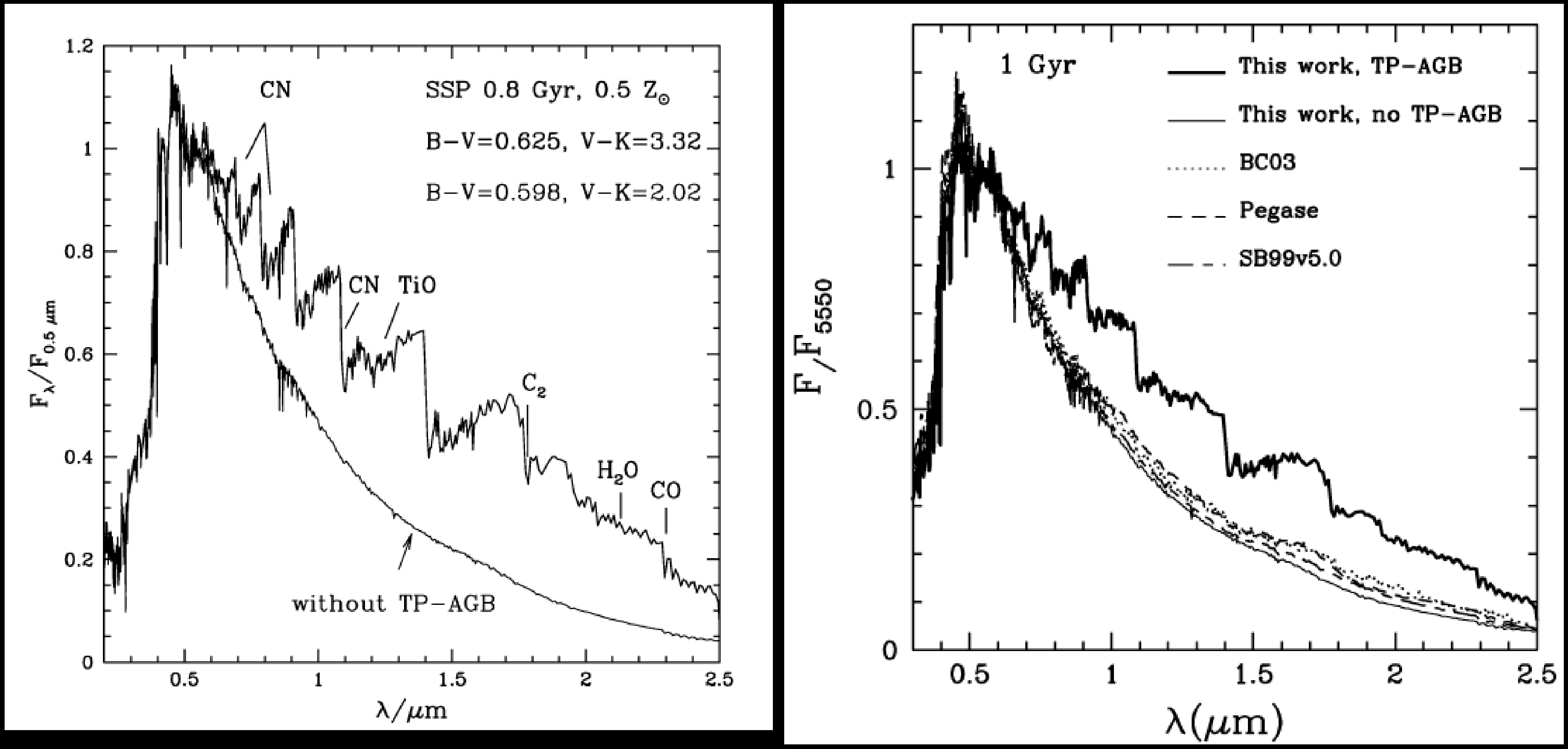
The presence (or not) of molecular features: is easy to be tested

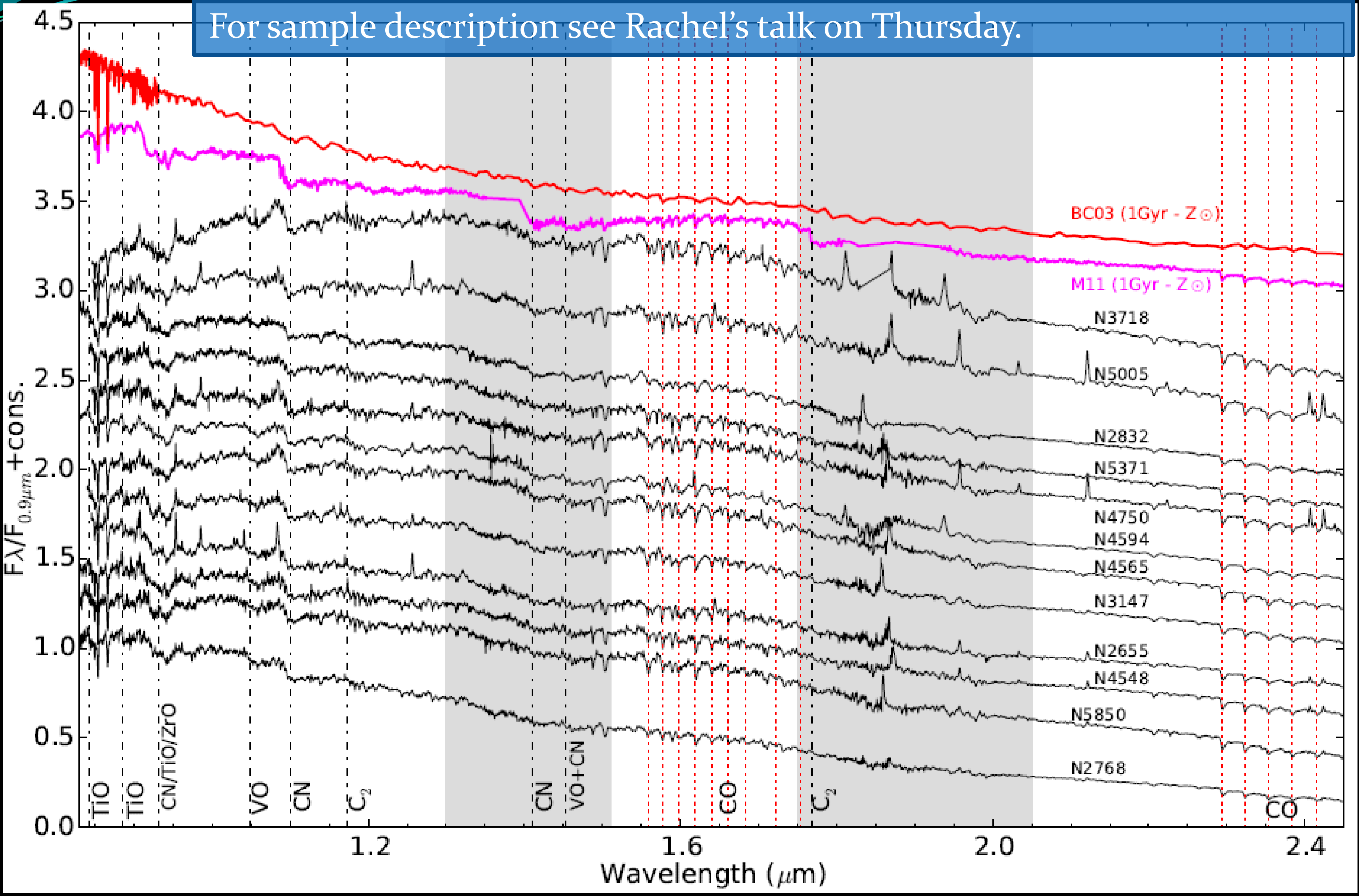
“Heavy” x “Light” TP-AGB Models



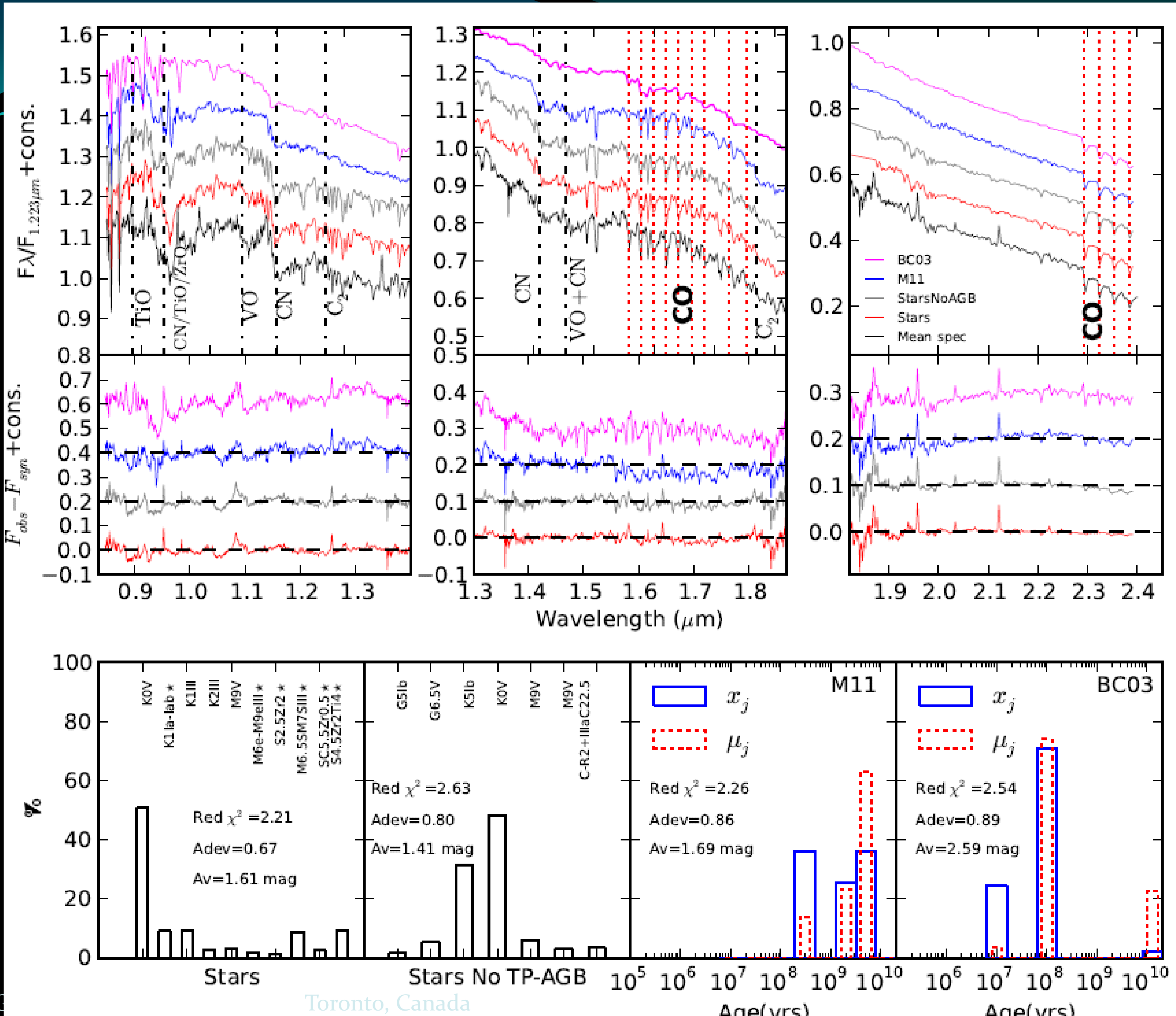
Figures from Maraston 2005

New Detection Infrared Stellar Features

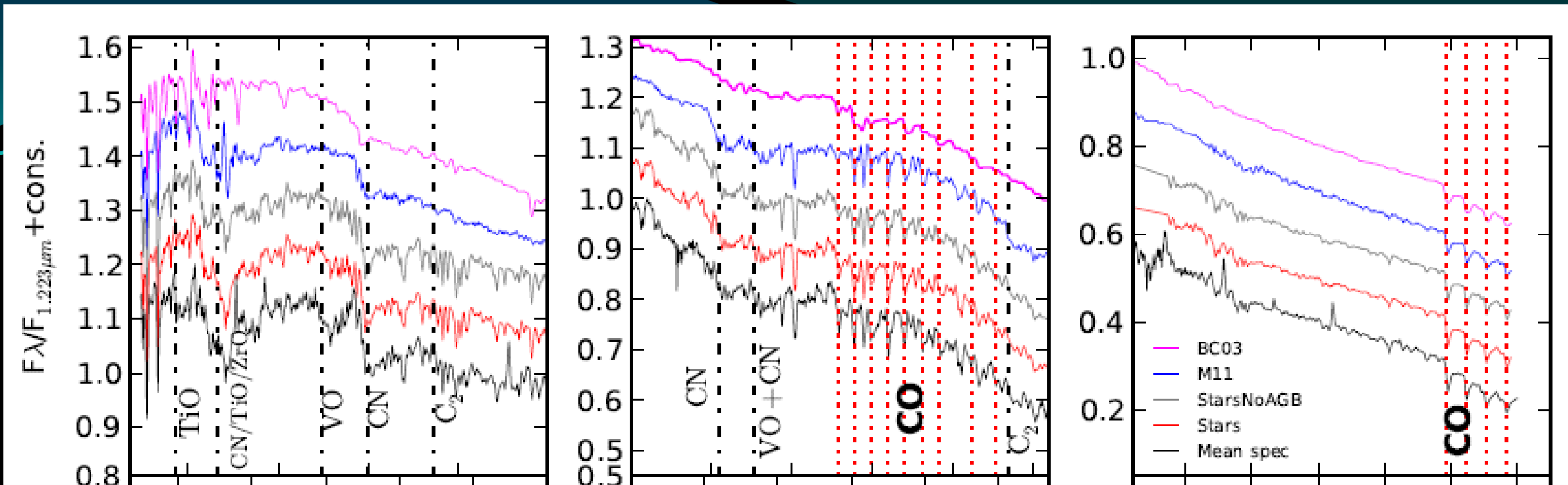
For sample description see Rachel's talk on Thursday.



Mason et al., 2015, Riffel et al., 2015



Riffel et al., 2015



The features are better reproduced using TP-AGB heavy models instead of the light ones. However they are not able to clearly reproduce line strengths.

They are also better reproduced when we use TP-AGB stars + MS and Giants (full IRTF library) then when we remove the TP-AGB stars from the base;

There seems to be a degeneracy: the features are reproduced - at some level- with Early-AGB and No TP-AGB stars (IMF, Life Times, Metallicities).

Riffel et al., 2015

Summary & Conclusions

✓ The simultaneous fitting of SP, FC and hot dust components allows a proper analysis of each one of them;

✓ A substantial fraction (~40%) of an intermediate age (~1 Gyr) stellar population is detected in the inner pc of Seyfert galaxies.

✓Hot dust is necessary to explain the excess observed in the K-band spectra of almost all Seyferts.

✓ There seems to be a correlation of young to intermediate age stellar populations with low σ stellar kinematics. It will be possible to check it with a volume limited complete sample of AGNs (Thaisa's talk).

✓ TP-AGB 'heavy' models do better reproduce the NIR features detected in active galaxies.

✓ The SSP models need improvements in the NIR spectral region (spectral resolution and prevision of features, Luminosities). Special care needs to be taken with the predicted features (TP-AGBs x E-AGB/giants (Z - effects)).

✓ It is very important to have a observational 'complete' NIR stellar library!

Thanks