THE SPATIALLY RESOLVED
STAR FORMATION “LAW” FROM
INTEGRAL FIELD SPECTROSCOPY

Guillermo A. Blanc
The University of Texas at Austin
P.I.:  Guillermo A. Blanc (UT, Austin)
Co.Is:  Niv Drory (MPE, Garching)
       Neal Evans (UT, Austin)
       Maximilian Fabricius (MPE, Garching)
       David Fisher (UT, Austin)
       Karl Gebhardt (UT, Austin)
       Lei Hao (Shanghai Observatory)
       Amanda Heiderman (UT, Austin)
       Gary J. Hill (UT, Austin)
       Shardha Jogee (UT, Austin)
       John Kormendy (UT, Austin)
       Irina Marinova (UT, Austin)
       Juntai Shen (Shanghai Observatory)
       Remco van den Bosch (UT, Austin)
       Timothy Weinzierl (UT, Austin)
       Peter Yoachim (UT, Austin)

- 32 Nearby Spiral Galaxies
- 72 1.7’x1.7’ VIRUS-P Pointings
- ~ 53,000 spectra: 3600 Å – 6850 Å
- Spectral Resolution: 5 Å (120 km/s)
- Coverage > 0.7 R25 for all galaxies
- Median S/N=40 per fiber
- High Resolution VIRUS-W (25 km/s)
MOTIVATION

• HOW DO GALAXIES FORM AND EVOLVE?

- GAS ACRETION (HOT/COLD)
- FEEDBACK (SN, AGN, STARS)
- SECULAR PROCESSES
- MERGER (MAJOR/MINOR)
- SFR (BURST/ GENTLE CYCLE)
GOALS

What sets the SFR across disks?

– Molecular gas availability: Star Formation “Law”

\[
\frac{\Sigma_{\text{SFR}}}{1 \, M_\odot \, \text{yr}^{-1} \, \text{kpc}^{-2}} = A \left( \frac{\Sigma_{\text{gas}}}{100 \, M_\odot \, \text{pc}^{-2}} \right)^N \times 10^{N(0,\epsilon)}
\]

– Constraint slope in the typical spiral galaxy ISM regime.

– Quantify intrinsic scatter in SFL, and its origin.

Measure robust SFRs using IFU spectroscopy.
NGC 5194 (Blanc et al. 09)

4 kpc
CENTRAL AGN

Crane et al. 1992
Bradley et al. 2004
DIFFUSE IONIZED GAS

- DIG accounts for 11% of total Hα luminosity
LOCALIZED STAR FORMATION $\text{H}\alpha$

HII Regions + DIG

HII Regions Only
THE FITTING METHOD
THE FITTING METHOD

\[ \log(A) = -1.31 \pm 0.02 \]
\[ N = 0.85 \pm 0.05 \]
\[ \epsilon = 0.43 \pm 0.02 \]

Black dots from Kennicutt et al. 2007
RESULTS

• 735 regions (D=170 pc) in the central $4.1 \times 4.1$ kpc$^2$

• Lack of correlation with the atomic gas surface density, which saturates around $10 \, M_\odot pc^{-2}$.

• Clear correlation with the molecular gas surface density, which drives the total gas SFL.

• Monte Carlo Fitting of total gas SFL parameters:
  – $N = 0.85 \pm 0.05$
  – $A = 10^{-1.31\pm0.02}$ = Depletion timescales of 2 Gyr
  – $\epsilon = 0.43 \pm 0.02$ dex.

• Consistent with a roughly constant SFE in GMCs, which is almost independent of the molecular gas surface density. NOT consistent with a $N\sim1.5$ slope.

• Good agreement with the theoretical SFL model of Krumholz et al. (2009).
CONCLUSIONS

• VENGA:
  – 53,000 independent regions (≈10^2 pc) over 32 nearby spirals
  – Mapping the structure, dynamics, and chemistry of both stars and gas in disks out to > 0.75 R_{25}

• ADVANTAGES OF IFS FOR STAR FORMATION STUDIES:
  – E(B-V) : Hα, Hβ
  – AGN shocked and photo-ionized regions: [OIII], [SII], Hα, Hβ
  – Separate DIG from HII regions: [SII], Hα
  – Balmer Absorption from stellar continuum fitting
  – No [NII] contamination in Hα fluxes
  – Reliable SFR from spectroscopically measured Hα
ONGOING AND FUTURE WORK

• Extend analysis to the full VENGA sample:
  – Sample different regimes in density, $Z$, dynamics, etc.

• Intrinsic Scatter:
  – Search for extra parameters
  – Scatter in SFR indicators
  – Scale dependence and connection to MW studies.

• Extend study to denser environments in starburst and mergers:
  – Non-linear regime of the SFL
  – VIXENS (P.I. Amanda Heiderman)