Discussion #5

1. **Starburst/AGN diagnostics: detection**
2. **Starburst/AGN diagnostics: quantitative**
3. **Impact of AGN on starburst and vice-versa**
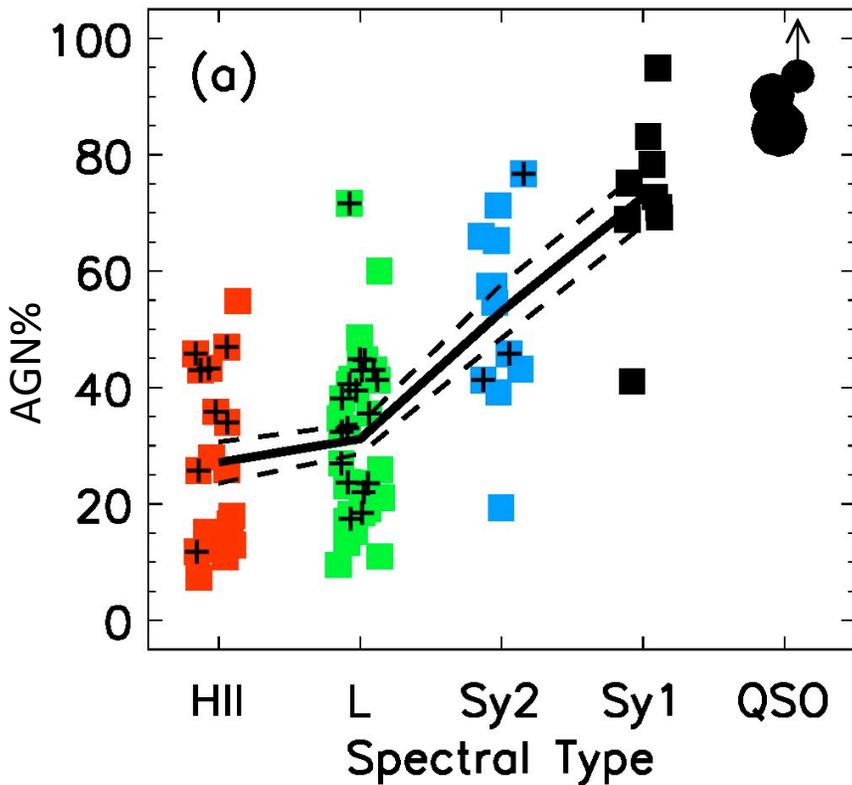
Starburst/AGN Diagnostics: Detection

- **How reliable are OIR diagnostics?**
  - **In dusty systems?**
    (what are the many optical composites among ULIRGs?)

Starburst/AGN Diagnostics: Detection

- **How reliable are OIR diagnostics?**
  - **In dusty systems?**
    (what are the many optical composites among ULIRGs?)
- **What about MIR?**
  - **What is the cause of the (often) low (MIR line/FIR) ratios in many ULIRGs and some IR-bright QSOs?**
  - **Density, radiation field, covering factor?**

Method

- 6 diagnostics: [O IV]/[Ne II], [Ne V]/[Ne II], EW(PAH), L(MIR)/L(FIR), 15/5 μm ratio, 30/15 μm ratio...

- All agree to within ±10-15% on average
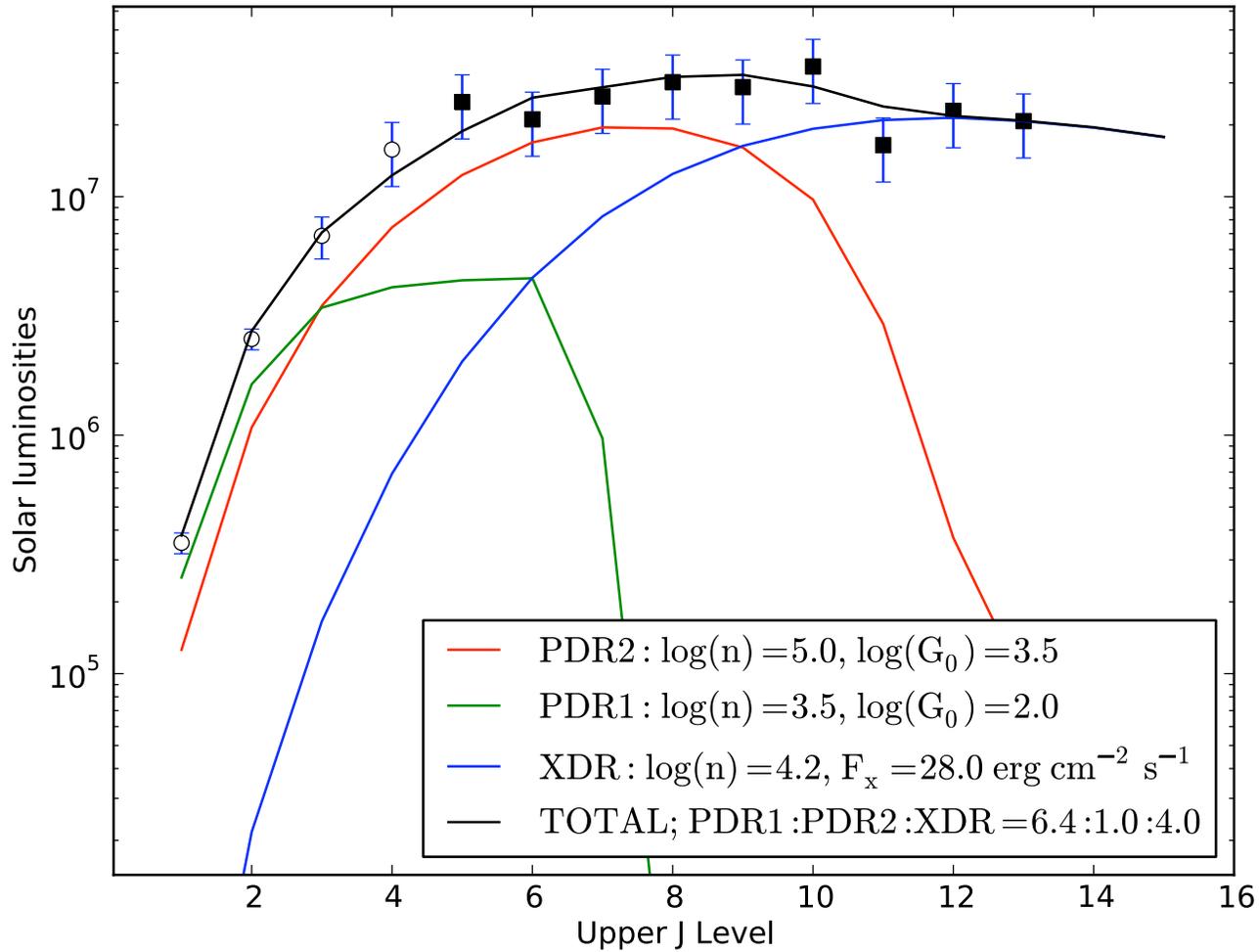
Results

- Strong correlations with optical spectral types!

- AGN% increases along merger sequence, but substantial stochastic variations

(SV, Rupke, et al. 2009a)

Starburst/AGN Diagnostics: Detection

- **How reliable are OIR diagnostics?**
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- **What about MIR?**
  - **What is the cause of the low (line/FIR) ratios?**
  - **Density, radiation field, covering factor?**
- **Can FIR-Submm-mm help?**
  - **CO ladder ➜ PDR vs XDR**

CO Ladder: PDR vs XDR

Legend:
- PDR2 : $\log(n) = 5.0$, $\log(G_0) = 3.5$
- PDR1 : $\log(n) = 3.5$, $\log(G_0) = 2.0$
- XDR : $\log(n) = 4.2$, $F_x = 28.0$ erg cm^{-2} s^{-1}
- TOTAL; PDR1 : PDR2 : XDR $= 6.4 : 1.0 : 4.0$

Axis labels: Solar luminosities (y-axis), Upper J Level (x-axis)

(van der Werf et al. 2010)

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  - **Density, radiation field, covering factor?**
- **Can FIR-Submm-mm help?**
  - **CO ladder ➔ PDR vs XDR**
- **How useful is the radio (if there's no jet)?**
  - **Minor bolometric contributor, free-free absorption,**
  - **Is monitoring essential?**
- **How useful are the hard X-rays?**
  - **Sensitive to absorption/scattering along line of sight to nucleus**

Chandra/XMM/Suzaku Results
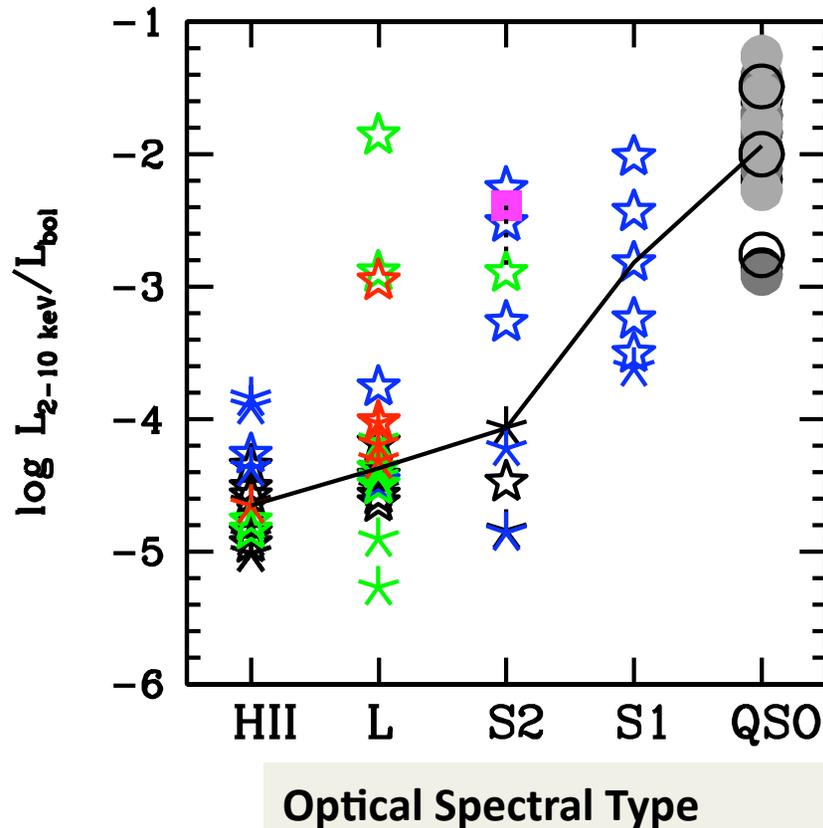
- ■ <AGN%> ~ L(2-10 keV)/L_{BOL}
- ■ Generally good agreement with Spitzer results:
  - – Strong correlations with optical spectral types
 - – AGN% increases along merger sequence, but with substantial stochastic variations

$\log\ f_{25\mu m}/f_{60\mu m}$

log $L_{2-10\ keV}/L_{bol}$

HII   L   S2   S1   QSO

Optical Spectral Type

(Teng & SV 2010, submitted)

Starburst/AGN Diagnostics: Quantitative

- **L[O III] as an indicator of dM/dt(BH)?**
  - **SB contamination…**
  - **Dust extinction**
- **MIR: [O IV], [Ne V]…**
- **How useful are the hard X-rays?**
  - **Absorption/scattering correction**
  - **Bolometric correction**
- **How useful is the radio? (SB vs radio-quiet AGN)**
  - **Large bolometric correction**
  - **Free-free absorption**
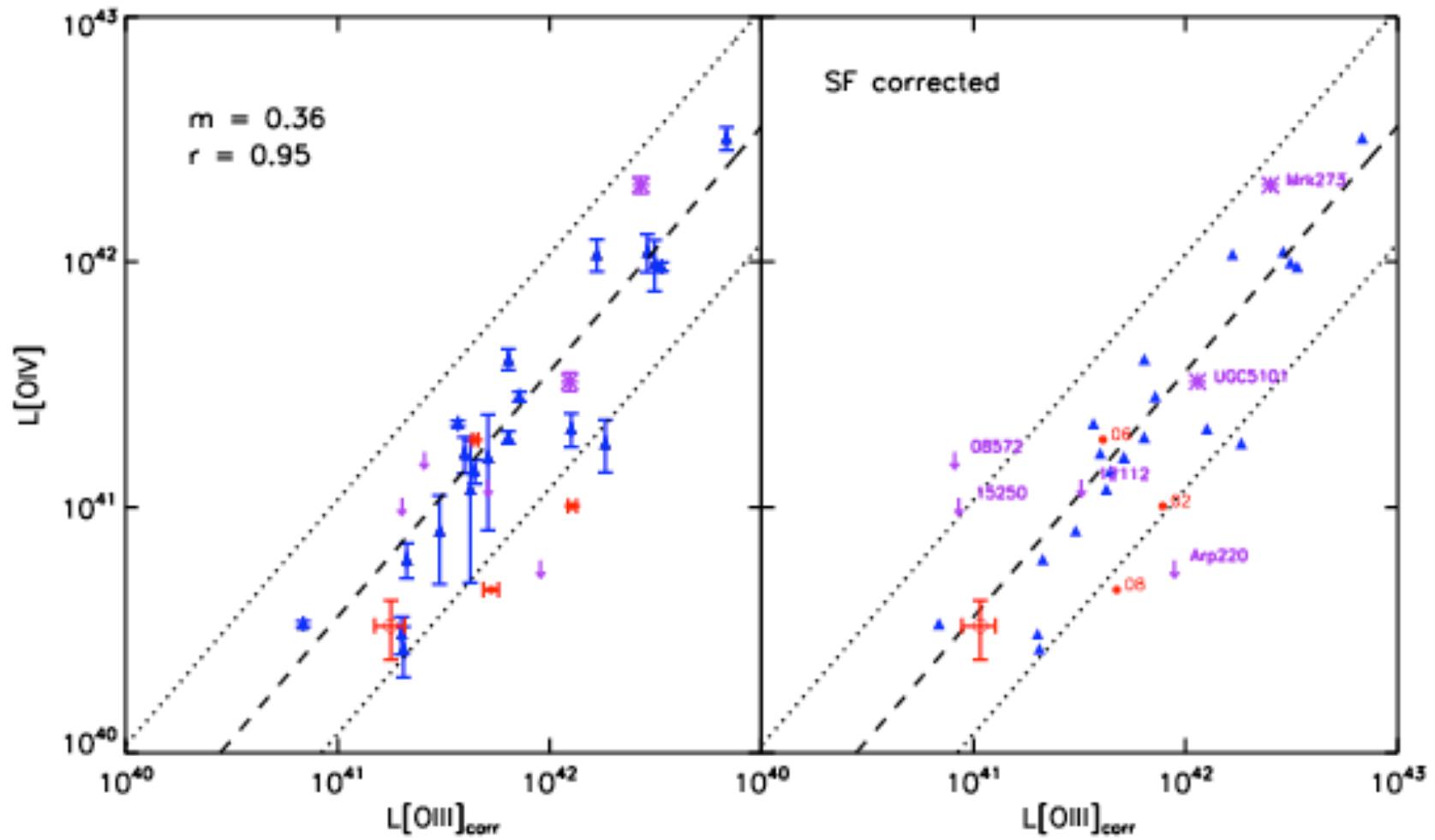
(Wild et al. 2010; LaMassa et al. 2010)
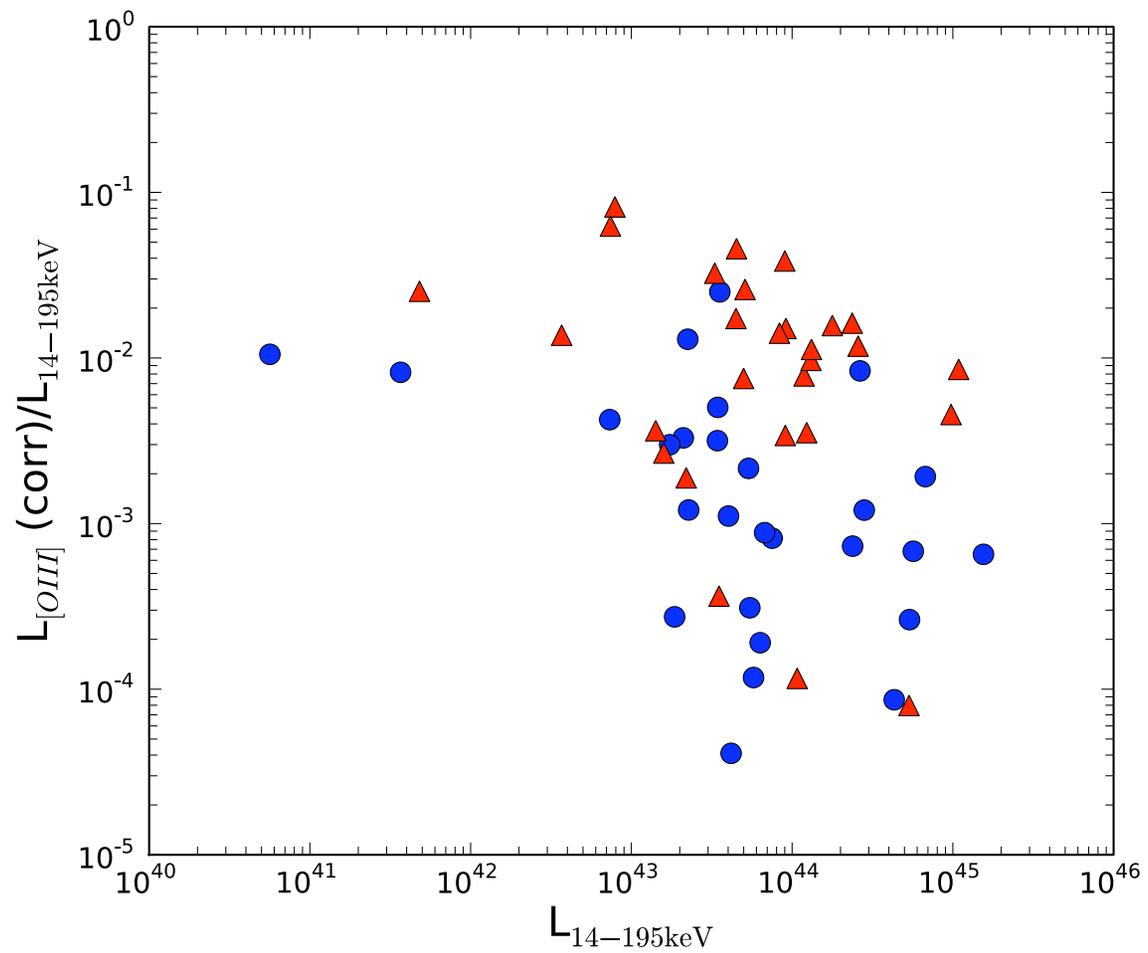
(Winter et al. 2010)

AGN – Starburst Connection

- AGN – SB connection or AGN – SF connection?
- Selection effects: bimodal distributions of SFH
- Use of fundamental plane / what do latest results imply?
- What are the observational/theoretical prospects of understanding inner ~100 pc?
  - Bar-within-bar, nuclear spirals, stochastic process?
  - Feeding the AGN with 0.1% of SB material, AGB winds?
  - Stellar population = $f(L_{AGN})$???
  - AGN = $f(SB)$???