



## QC Laser-Based Sensor for $^{13}\text{CO}_2/^{12}\text{CO}_2$ Isotopic Ratio Measurements *Preliminary studies*

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- Research motivation
- Previous DFG sensor experiment
- Laser characteristics
- Line strategy
- Calculated spectra

PS/RICE  
Workshop  
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### Motivation for high precision $\delta$ value measurements

$$\delta^{13}\text{C} = \left\{ \frac{[^{13}\text{C}/^{12}\text{C}]_{\text{sample}}}{[^{13}\text{C}/^{12}\text{C}]_{\text{std}}} - 1 \right\} \cdot 1000 \text{ (}\text{‰}\text{)}$$

Required precision  $\leq 0.1 \text{ ‰}$

- Atmospheric Chemistry
- Volcanic gas emission studies
- Combustion diagnostics
- Non invasive medical diagnostics
- Plant Biology

## Criteria for CO<sub>2</sub> absorption line selection

- Line Strength
- Temperature stability  $\Delta T = \frac{\Delta \delta k T^2}{1000 \Delta E}$
- Interference effects by other atmospheric gases
- <sup>12</sup>CO<sub>2</sub> and <sup>13</sup>CO<sub>2</sub> absorption lines in same wavelength scan range

## <sup>12</sup>CO<sub>2</sub> & <sup>13</sup>CO<sub>2</sub> absorption line selection

Erdelyi et al. and NCAR biocomplexity line selection

|                               | Frequency (cm <sup>-1</sup> ) | Intensity<br>cm <sup>-1</sup> /molec.cm <sup>-2</sup> | Lower State<br>Energy (cm <sup>-1</sup> ) |
|-------------------------------|-------------------------------|-------------------------------------------------------|-------------------------------------------|
| <sup>12</sup> CO <sub>2</sub> | 2299.642                      | 2.093E-20                                             | 1339                                      |
| <sup>13</sup> CO <sub>2</sub> | 2299.795                      | 3.10E-20                                              | 197                                       |

$\Delta T = 6\text{mK}$

Alpes Laser line selection

|                               |          |          |     |
|-------------------------------|----------|----------|-----|
| <sup>12</sup> CO <sub>2</sub> | 2314.304 | 9.15E-20 | 942 |
| <sup>13</sup> CO <sub>2</sub> | 2314.408 | 1.99E-21 | 917 |
| <sup>12</sup> CO <sub>2</sub> | 2315.281 | 9.73E-20 | 921 |
| <sup>13</sup> CO <sub>2</sub> | 2315.360 | 1.43E-21 | 994 |

$\Delta T = 250\text{mK}$

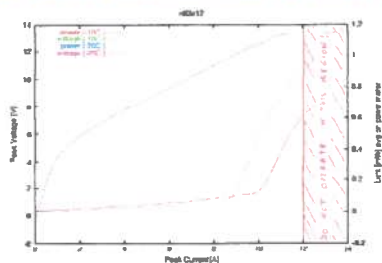
$\Delta T = 90\text{mK}$

Interesting absorption line selection

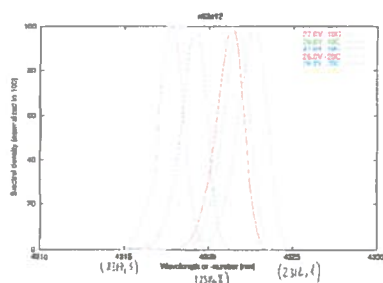
|                               |        |       |     |
|-------------------------------|--------|-------|-----|
| <sup>12</sup> CO <sub>2</sub> | 2311.1 | 1E-19 | 704 |
| <sup>13</sup> CO <sub>2</sub> | 2311.4 | 5E-21 | 704 |

$\Delta T \rightarrow \infty$

## Alpes 4.3 $\mu\text{m}$ QCL characteristics – April 2003



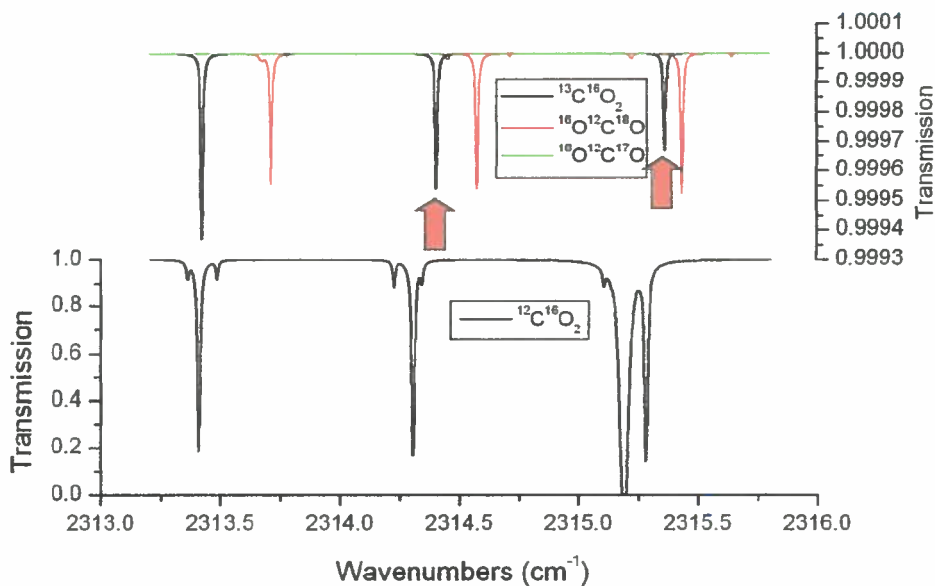
High threshold current  
 $\downarrow$   
 High thermal dissipation



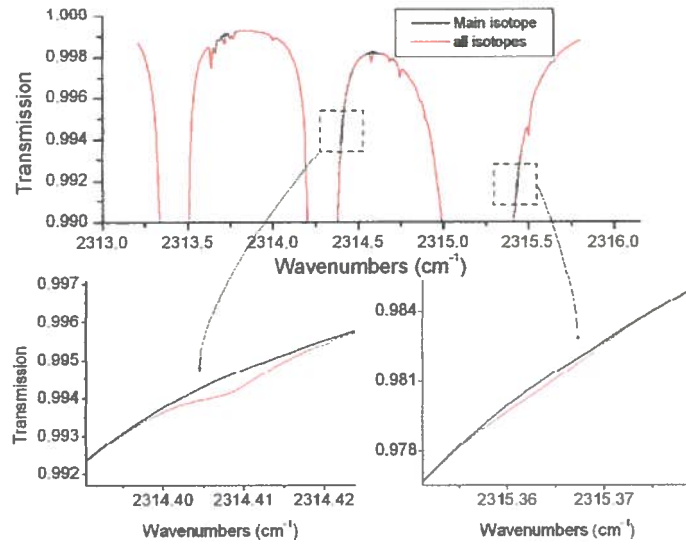
Frequency tuning range at  
 -20 and -10 °C:  
 2313.5 - 2316.15  $\text{cm}^{-1}$

Issue:  
 Unknown spectral characteristics

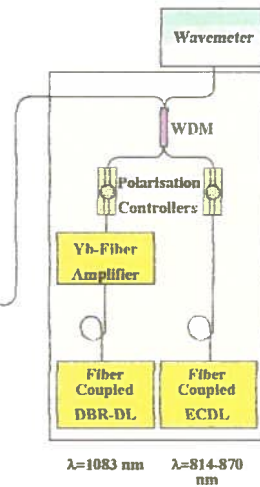
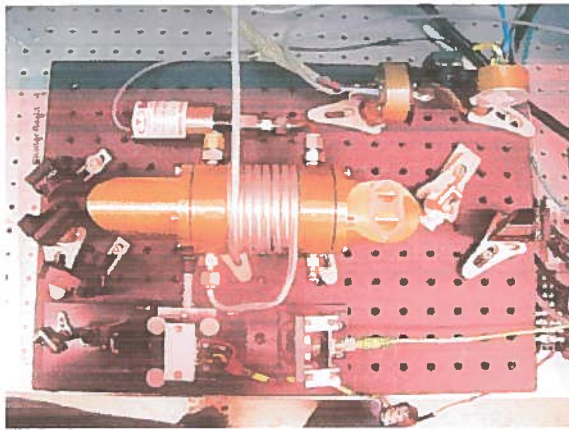
## Simulated HITRAN spectra



## Simulated HITRAN spectra



## DFG based CO<sub>2</sub> Isotopic Ratio Sensor Platform- 2000-2001



M.Erdelyi, D.Richter and F.K.Tittel, Applied Physics B, 75, 289-295, October 2002

## Proposed QCL based CO<sub>2</sub> Isotopic Ratio Sensor Platform

