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Towards on-line monitoring of ^{14}C in atmospheric CO_2

H.A.J. Meijer[1], D. Paul[1,2], E. Ilkmen[2], and D.E. Murnick[2]

[1]Centre for Isotope Research, University of Groningen, The Netherlands
[2]Department of Physics, Rutgers University, Newark, NJ 07102

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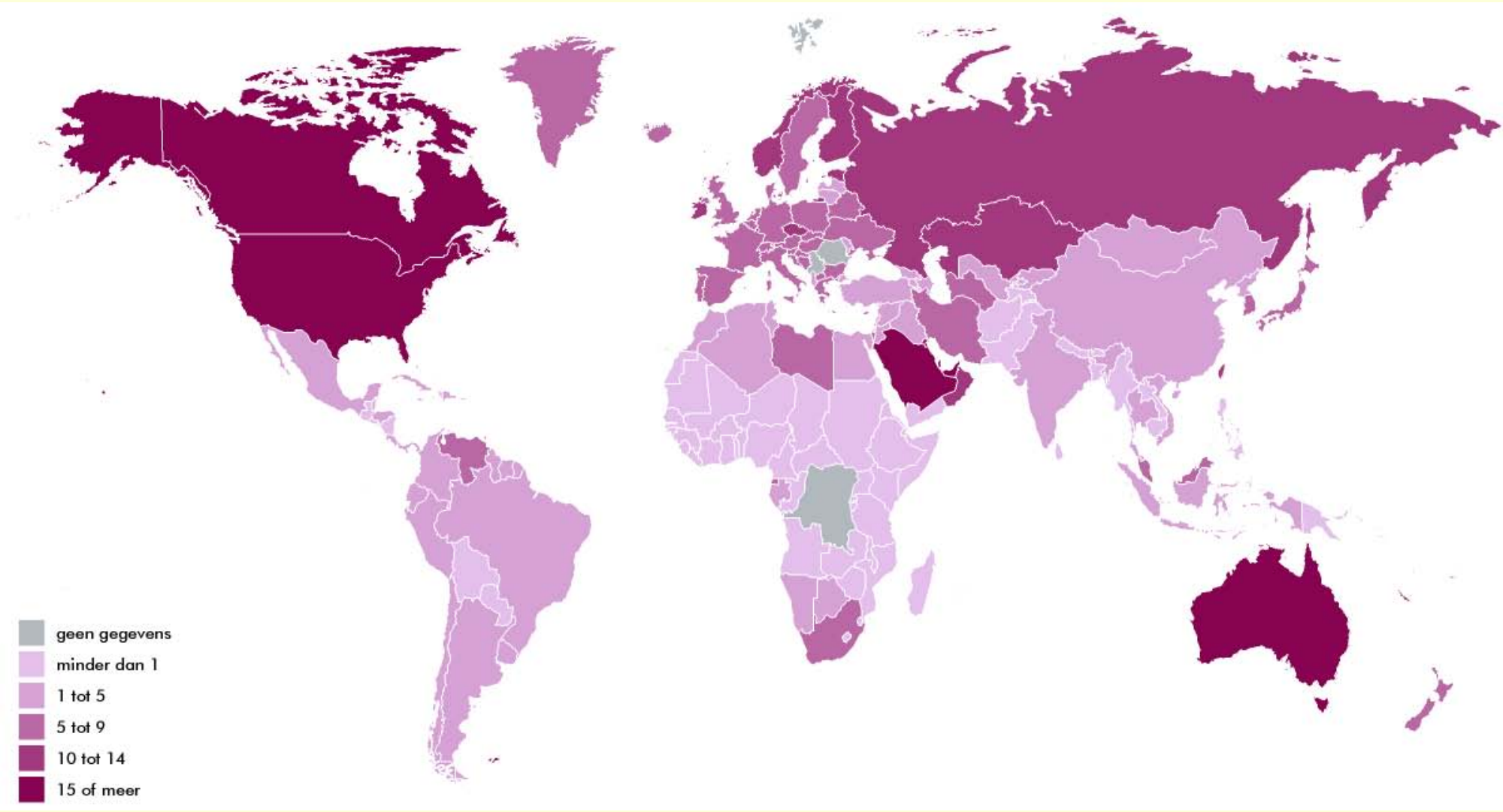
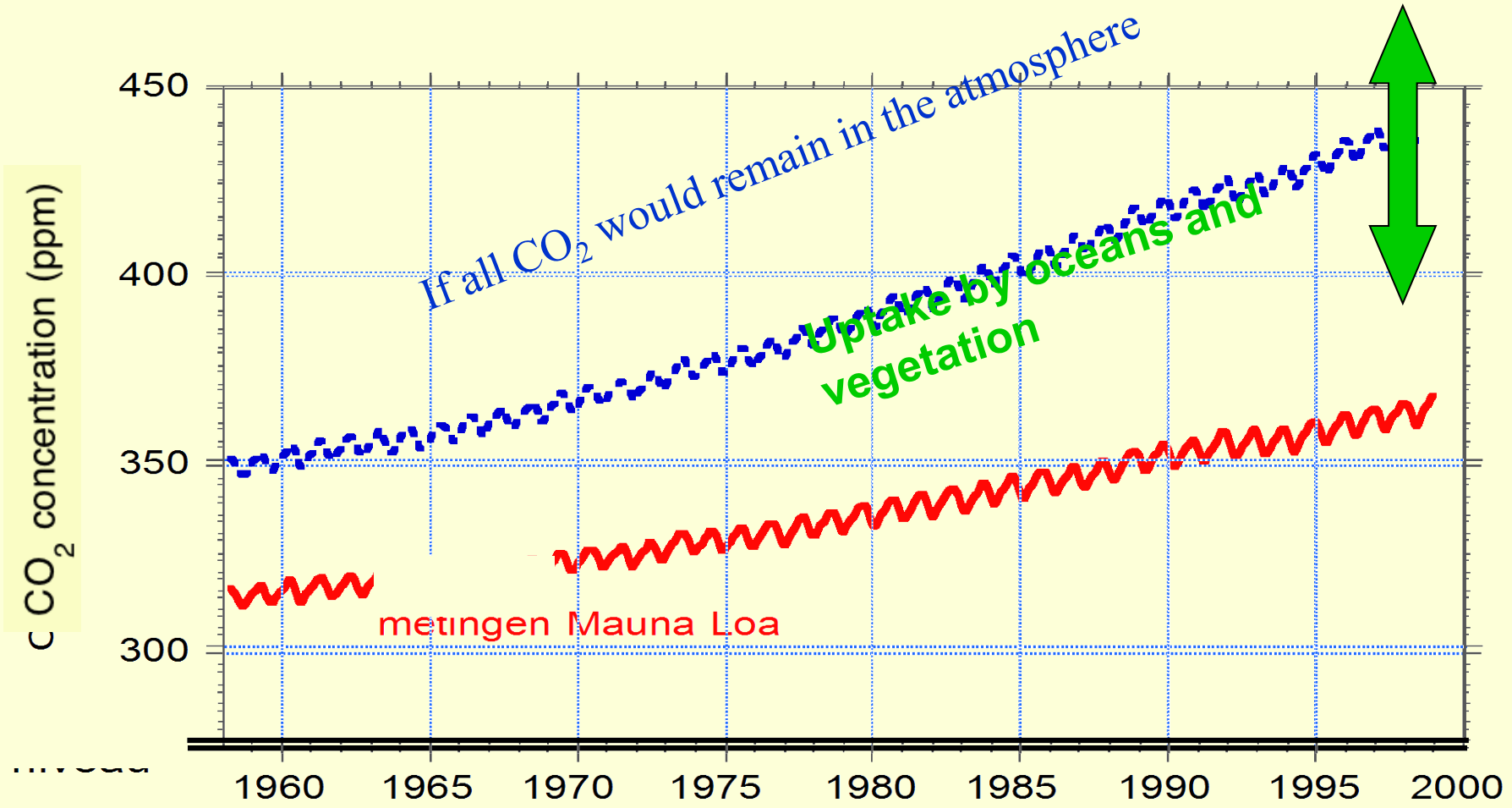
- Why?
- How?

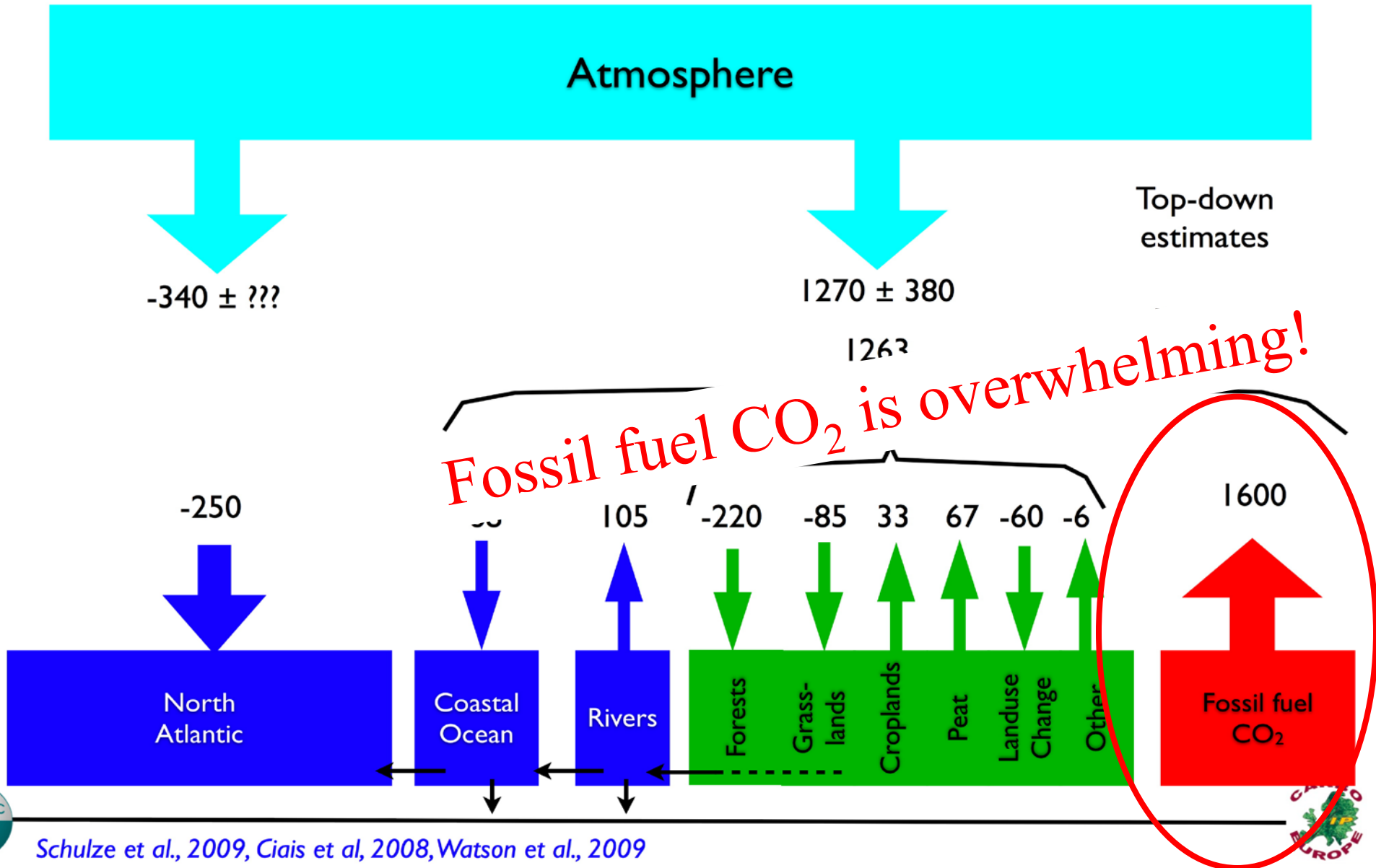
Anthropogenic CO_2 production



The increase of atmospheric CO_2 is half of what we expect



The European carbon balance (TgC/yr)
(positive numbers: flux into the atmosphere)



Schulze et al., 2009, Ciais et al, 2008, Watson et al., 2009

Need of methods to distinguish "natural" from fossil CO_2

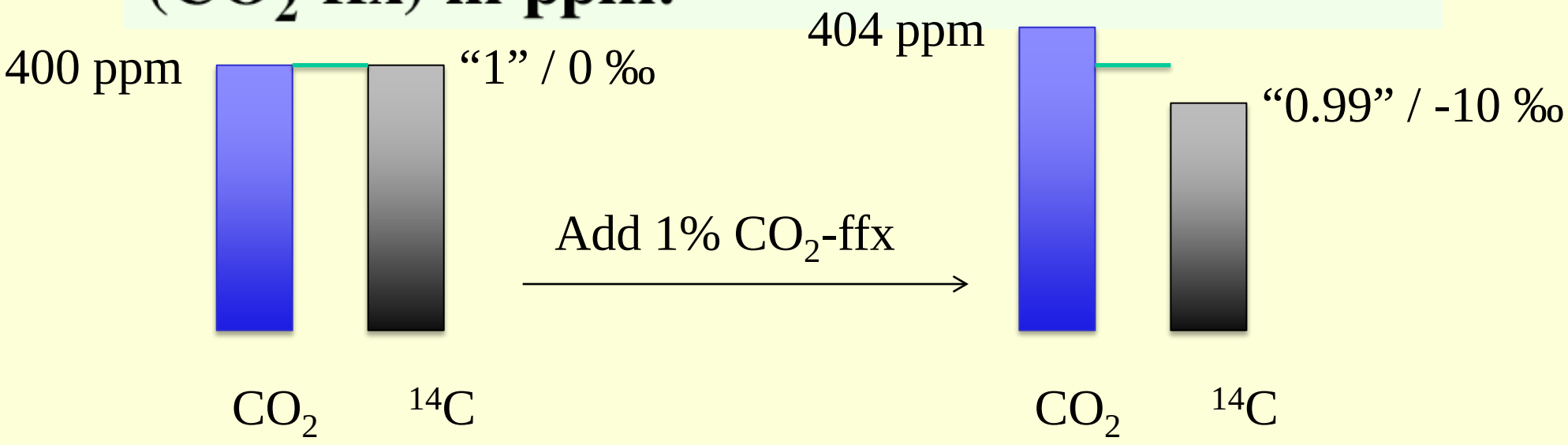
- Fossil fuel CO_2 is by far the dominant net source
- Commercial statistics are not accurate enough: neither in place, nor in time
- The Kyoto (and successor!) treaties require reliable and verifiable CO_2 emission data to independently check measures and agreements

#1 candidate:
^{14}C: "Radiocarbon"

^{14}C or Radiocarbon

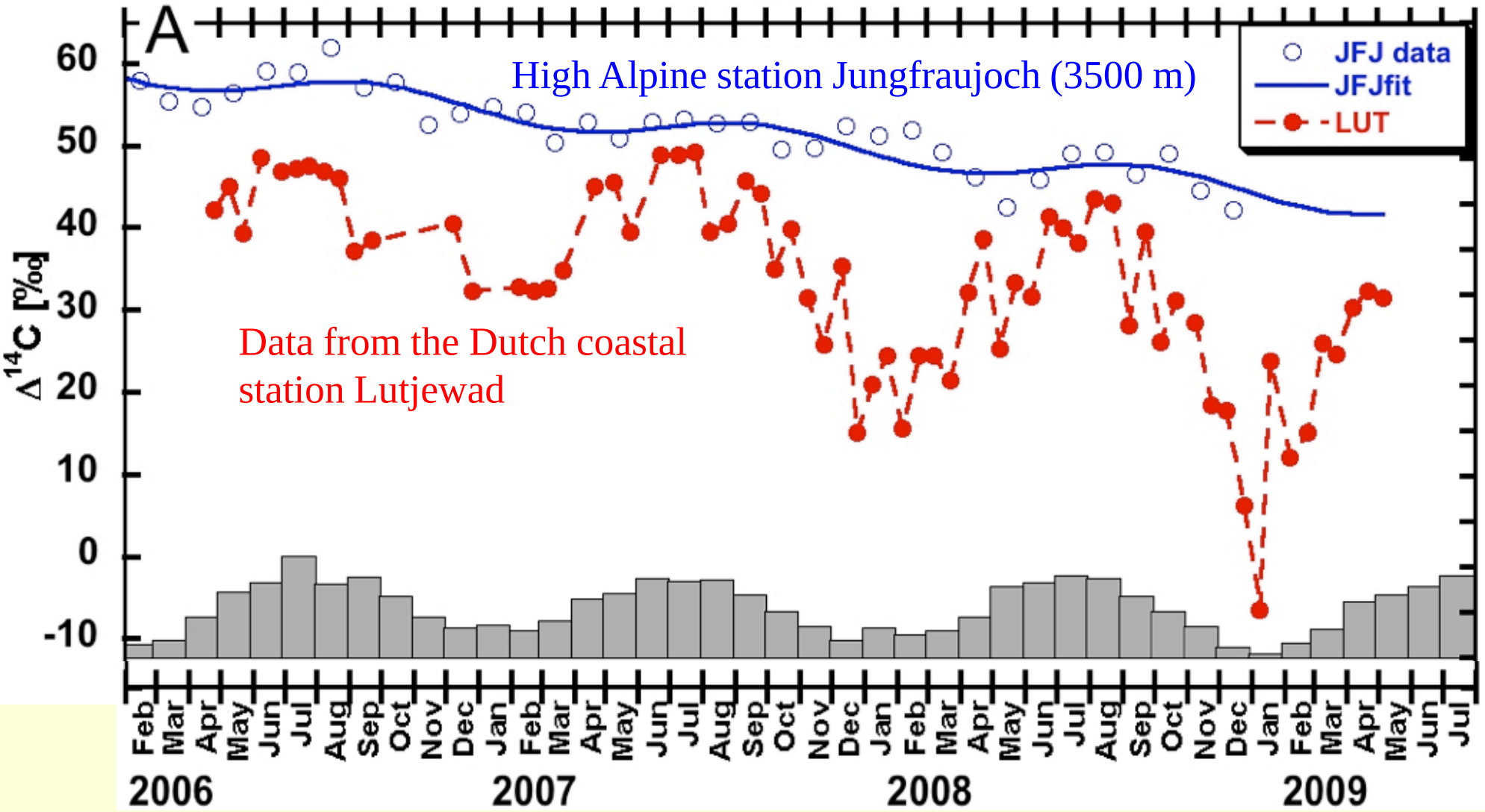
- Radio-active (half life 5730 yrs), so fossil fuel is ^{14}C-free
- Extremely rare: abundance of 10^{-12} in modern carbon

Calculation of regional CO_2-ff excess (CO_2-ffx) in ppm:



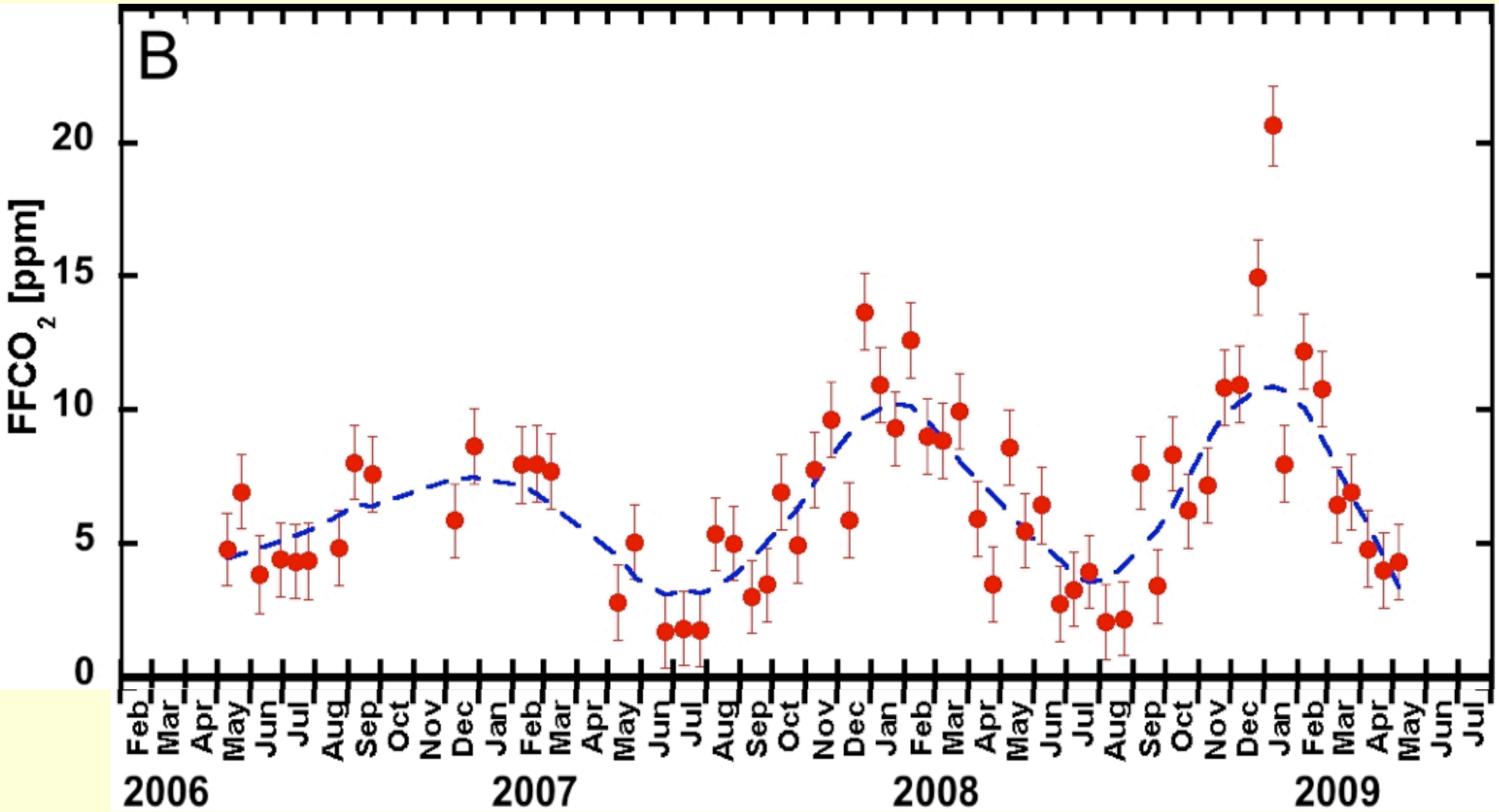
1 ‰ precision in ^{14}C corresponds to 0.4 ppm CO_2-ffx

$^{14}CO_2$ in The Netherlands compared to European background



Van der Laan et al.,
Tellus (2010), 62B, 389–402

Measurements of the fossil fuel CO_2 concentration for the Netherlands



^{14}C measurements are expensive and labor-intensive

Samples need to be taken individually (either “grab samples” or integrated ones)

Need to be transported to an AMS facility

Need extensive pretreatment: Extraction of CO_2, graphitization, target preparation

Require a complicated and expensive facility:

AMS installation CIO Groningen University

The alternative: ICOGS

Intra Cavity Opto Galvanic Spectroscopy

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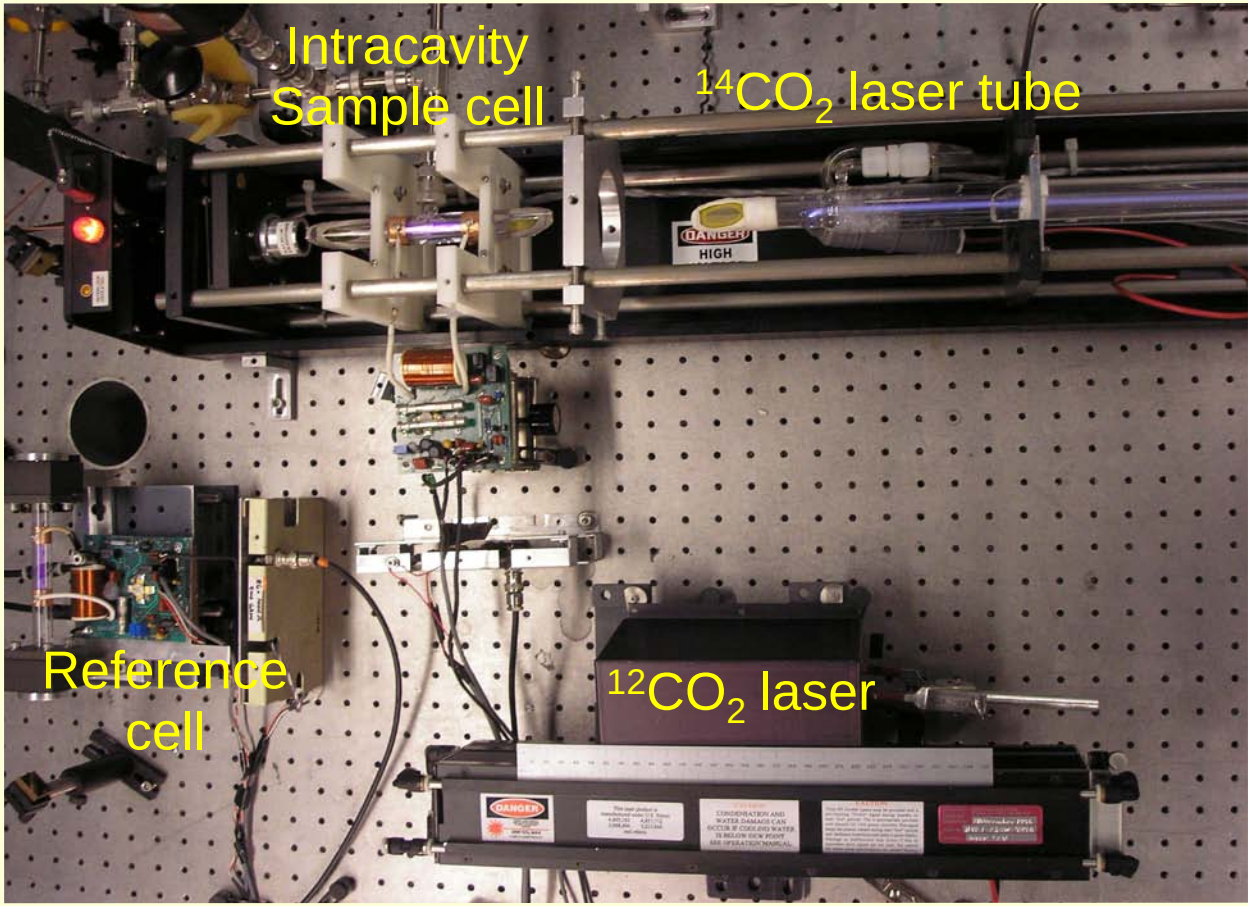
Potential for continuous in situ $^{14}CO_2$ measurements



Daniel E.Murnick et al.,
Analytical Chemistry 2008, 4820-4824

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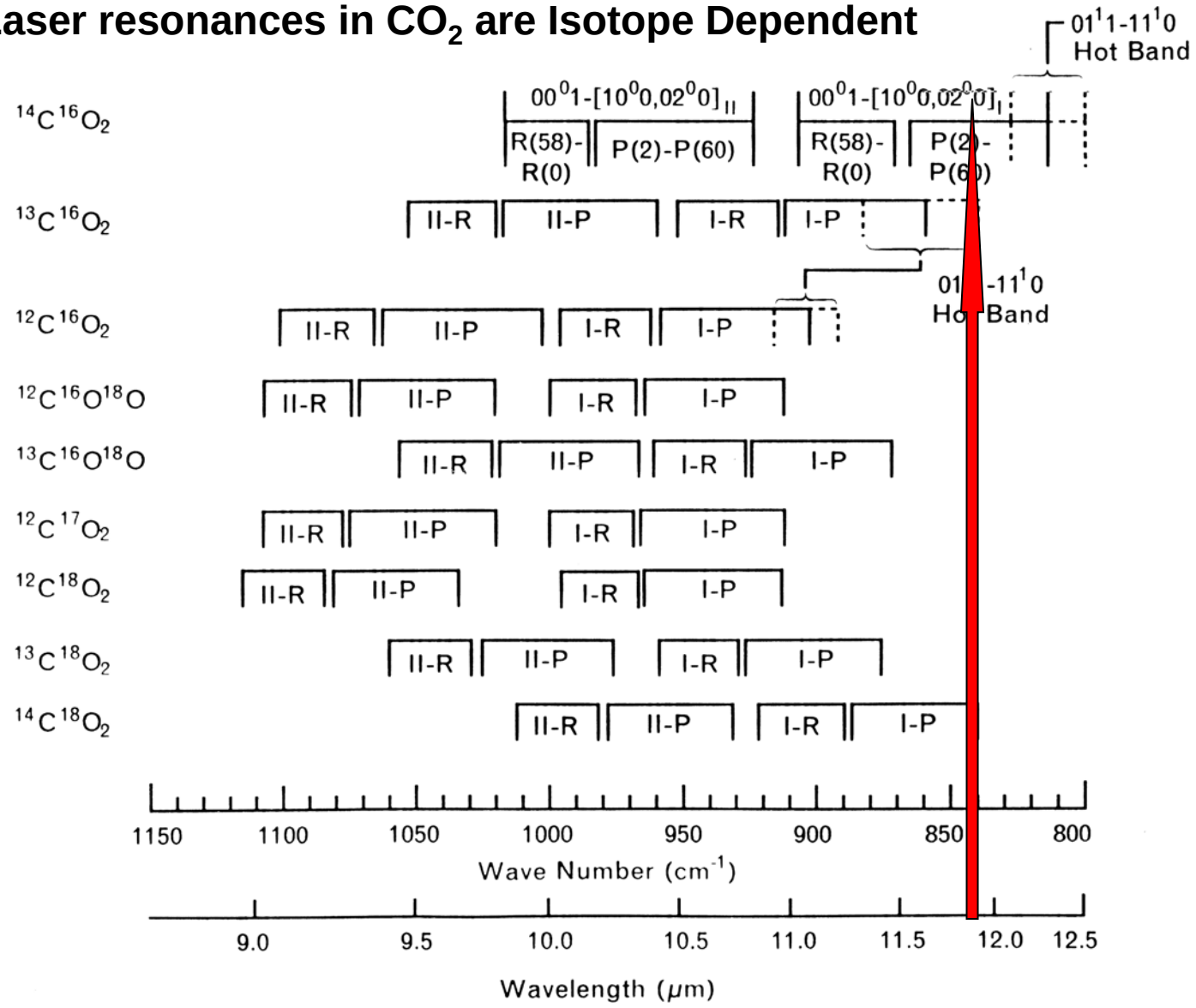
Laser resonances in CO_2 are Isotope Dependent



SELECTIVITY

$^{14}CO_2$ laser transition

At 11.8μ

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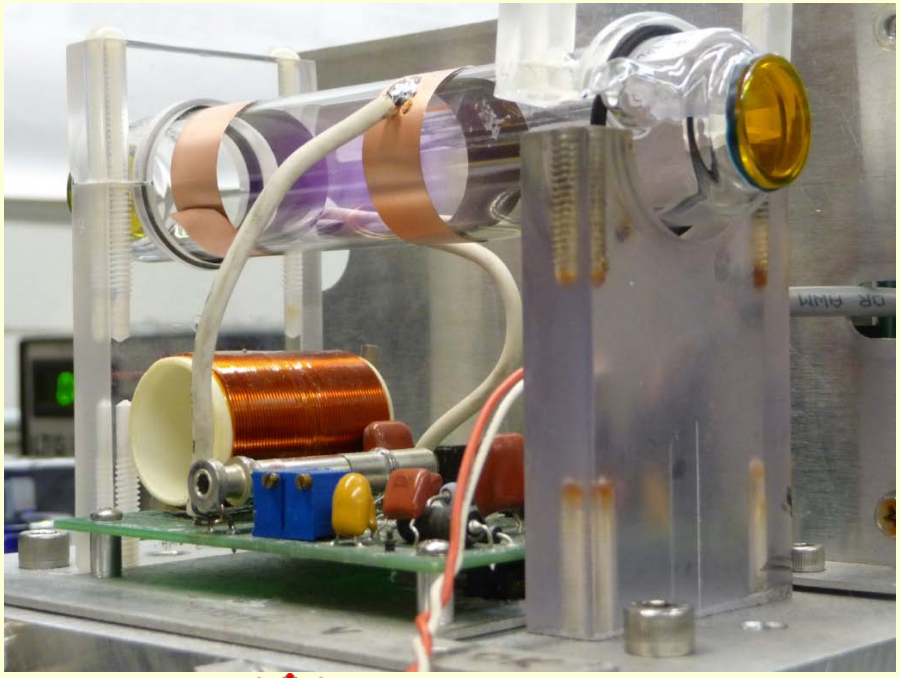
SENSITIVITY achieved through THE OPTOGALVANIC EFFECT (OGE) and high (intra-cavity) laser power

Laser radiation changes distribution of various species within an electrical discharge which changes the electron energy distribution function. This leads to an *easily measurable* impedance change of the system .



ICOGS, similar to IRMS and AMS, produces a Double Ratio Signal:

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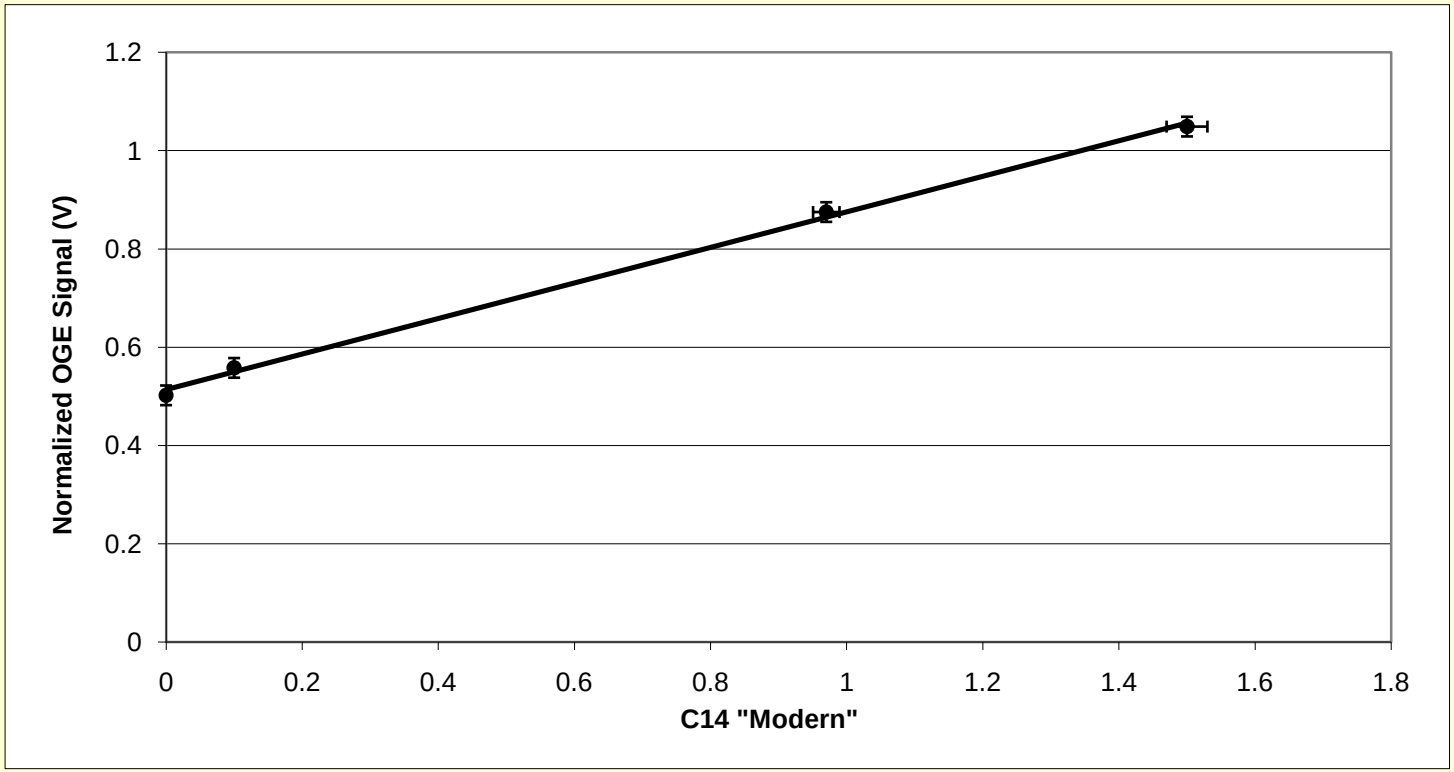
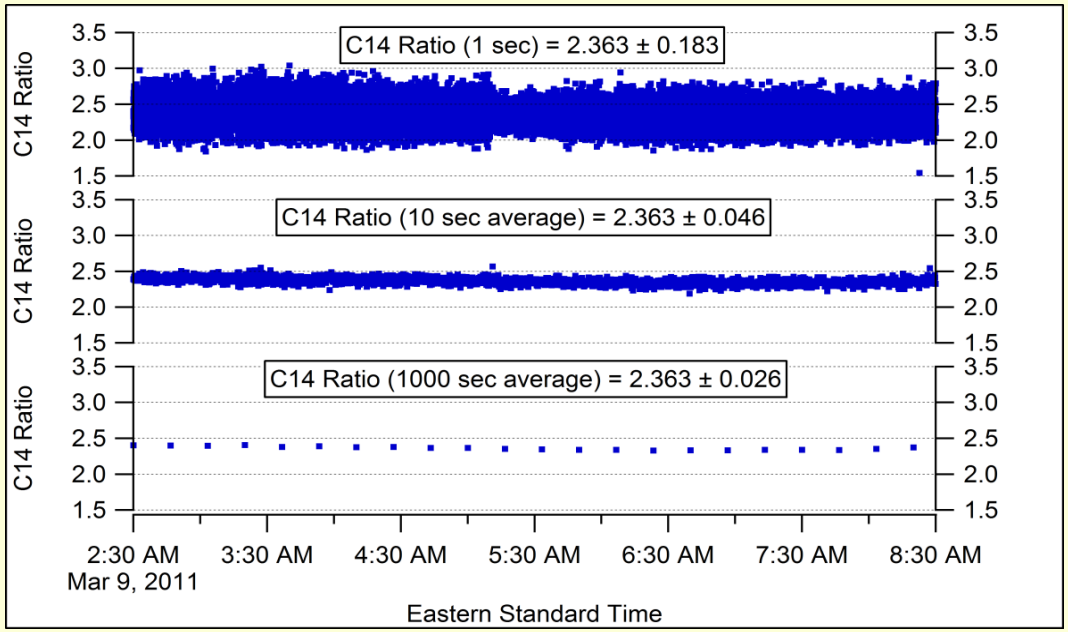
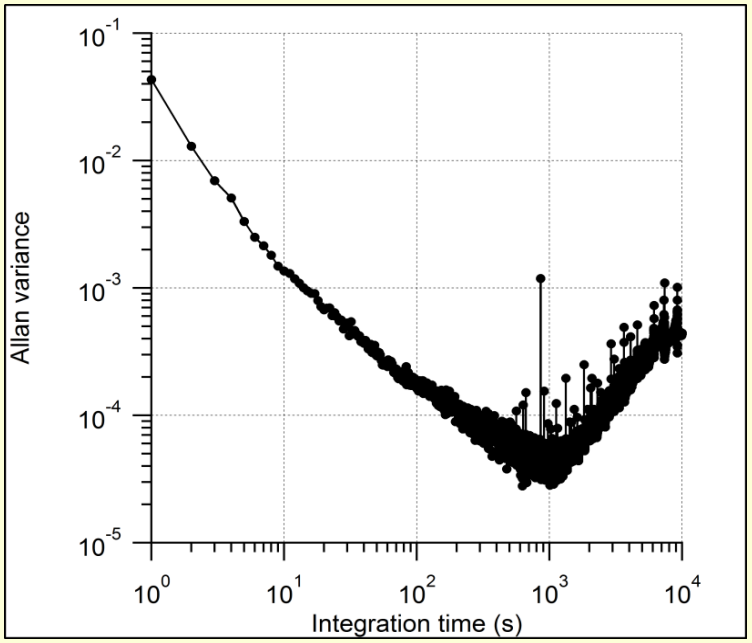
$$\text{“DR”} = \frac{{}^{14}C_{sample}/{}^{12}C_{sample}}{{}^{14}C_{ref}/{}^{12}C_{ref}}$$



High Potential: signal precision corresponds to <1‰





Items to be (re)solved:

non-linearity
Drift of reference cell
P and T dependence
Electrical Noise
^{13}C dependence

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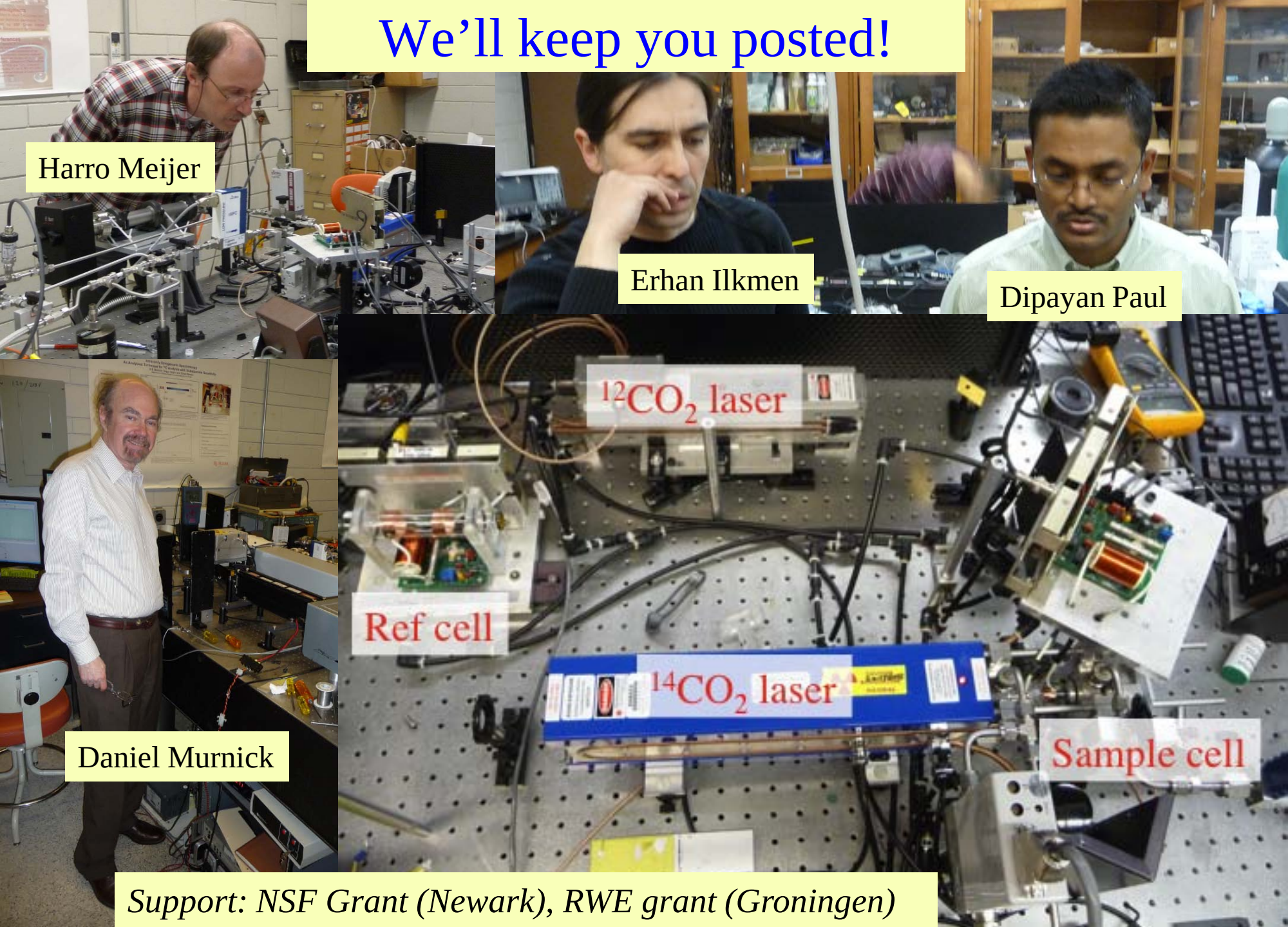
We'll keep you posted!



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