PLANETARY EMISSIONS MANAGEMENT INC.

Near Surface Leakage Monitoring for the Verification & Accounting of Geologic Carbon Sequestration Using a Field Ready ^{14}C Isotopic Analyzer

DOE/EPA Collaborative Review –Tracking Geologically Sequestered CO_2: Monitoring, Verification & Accounting (MVA), Simulation and Risk Assessment
March 23 – 24, Pittsburgh, PA

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Making business sense of climate change

pem
planetary emissions management

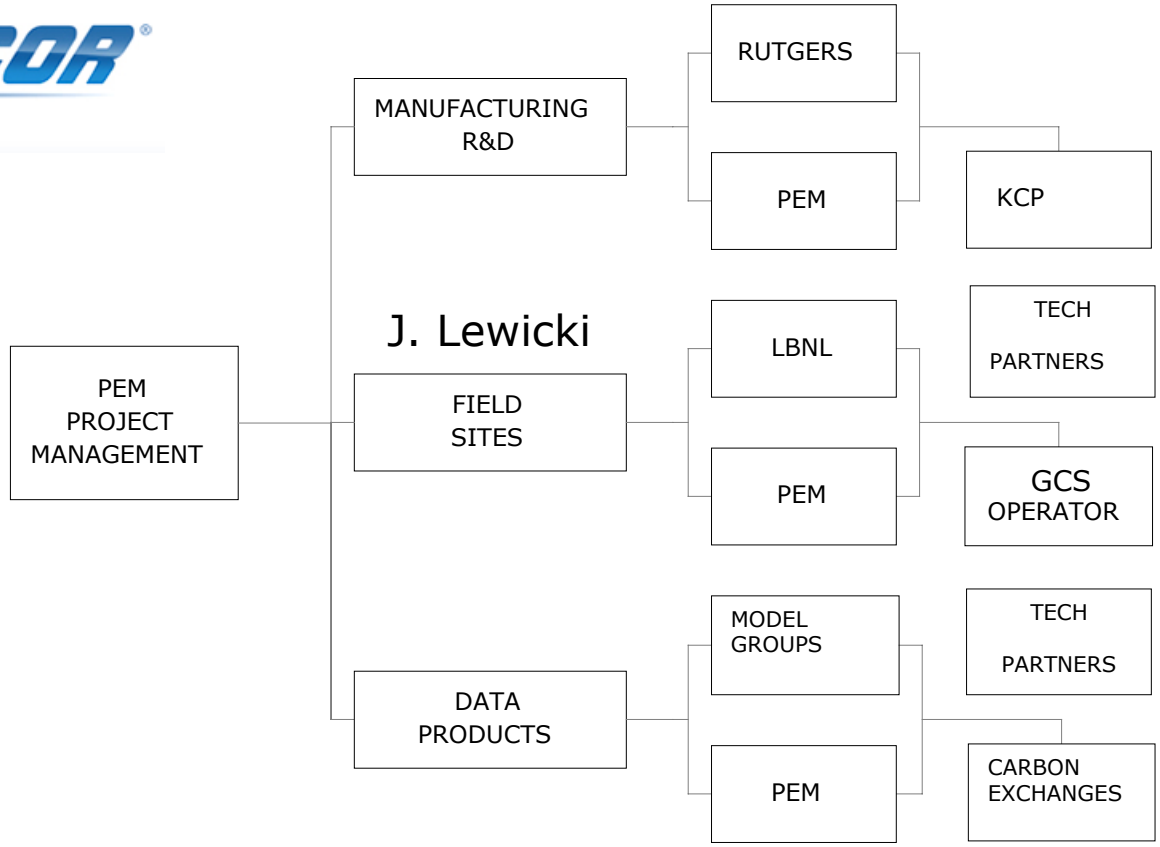
PEM Inc.

- **MVA focus, founded 2007**
- **R&D isotopic field analyzers** for biogenic CO_2 (^{13}C) and ff-CO_2 (^{14}C) fluxes over regional, national, international scales
- **Integration** of local, regional & international carbon budgets in a standardized framework
- **FI based on data** for trading, compliance & carbon management frameworks

PROBLEM & APPROACH

- **Problem MVA & FI**
  - Leakage of GCS ff-CO_2 to atmosphere?
  - Detect & locate, quantify, 1%, .01%, 0%?
  - Differentiation of ff-CO_2 from biogenic CO_2?
  - Data requirements for GCS credits?
- **Approach**
  - Multi-isotopic field analyzers (GMP)
    - $\Delta^{14}C$ as direct ff-CO_2 signal (~2 per mil)
    - $\delta^{13}C$ as ecosystem signal (<0.1 per mil)
  - Deploy in natural CO_2 vent geology/ecosystems
  - Deploy in active GCS sites
  - Verification process for GCS carbon credits

PROJECT OVERVIEW



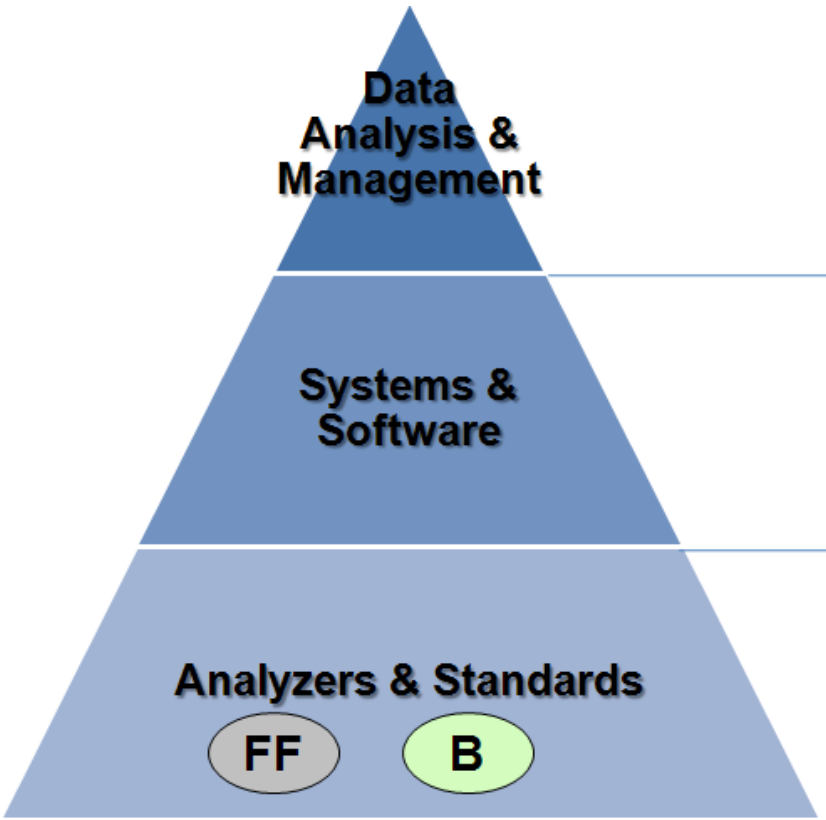
PEM FIELD ^{14}C ANALYZER

- **~2 per mil precision/1ppm ff-CO_2**
  - *In situ* analysis – no gas sample transport
  - No gas concentration needed
  - Limit of detection ~10^{-15} $^{14/12}C$
  - Simultaneous $^{13/12}C$, $^{14/12}C$ analyses
  - Flow through/batch mode
  - Fast analytical time (< 1 Hz)
  - Remote operation/query/diagnostics
  - NOAA inter-comparison/global reference
  - Cost factor (1,440+/day)

EXPAND LEAK DETECTION SKILL

- Link PEM GMP (13C,14C) with
  - Eddy covariance (micrometeorology)
  - Soil atmosphere (ff-CO_2 accumulation)*
  - DIC groundwater (ff-CO_2 accumulation)*
- Baseline measurements
  - Differentiate natural diurnal/seasonal flux
  - Vary device configurations (fixed/dynamic)
  - GCS signal "on" , "off" field measurements

VERTICAL DATA INTEGRATION



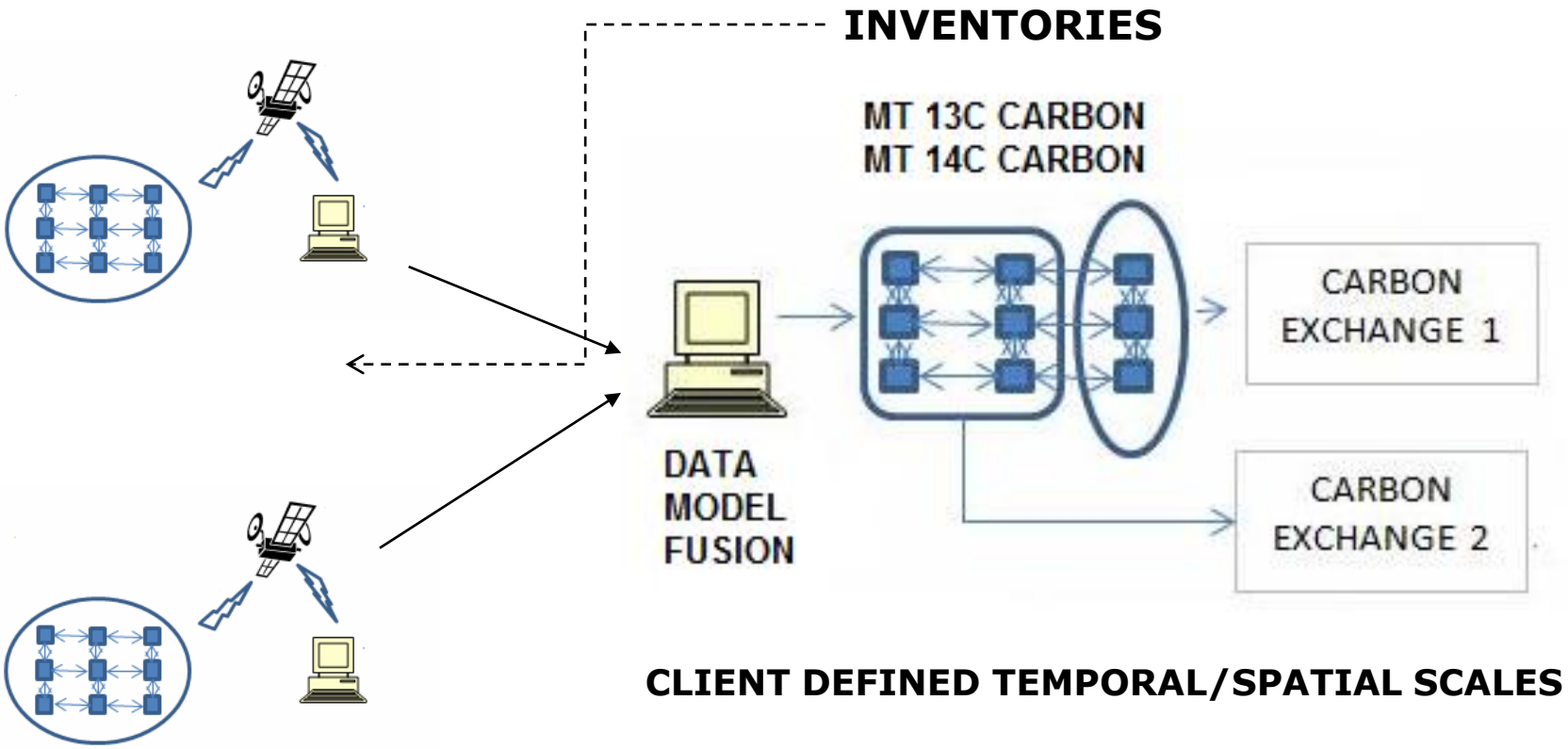
SYNTHESIS
Accounting
- Data/model fusion (time/space)
Trade
- Metric tons fossil & biogenic

DATA BUILDING
Verification
- 13C/14C analyzer inter-comparisons
Reference
- International frameworks

BASELINE HARMONIZATION
Monitoring/Measuring (GMP)
- PEM 13C/14C analyzers
Standardization
- PEM 13C/14C analyzer standards

PEM SYSTEM of SYSTEMS

PEM Patent Pending

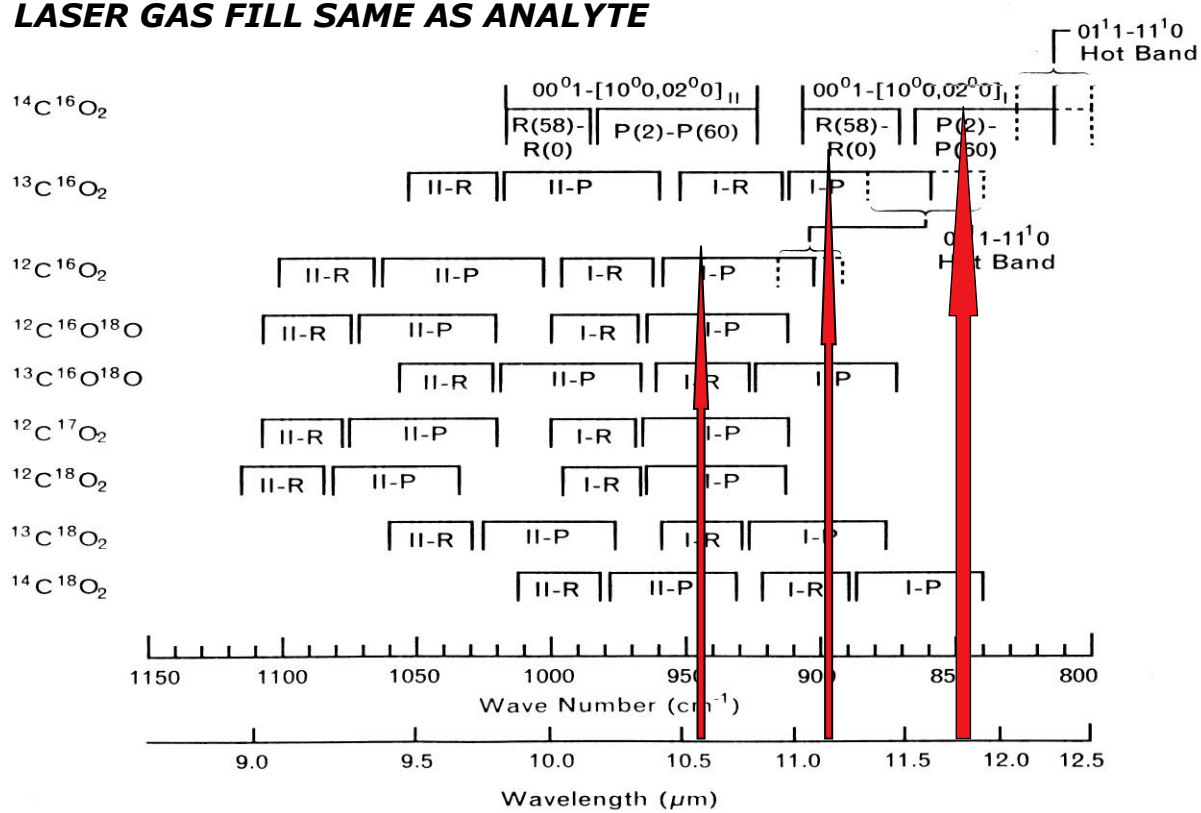


PEM ISOTOPIC LASERS

Laser Resonances in CO_2 are Isotope Dependent

• FREED
Ultrastable CO_2 Lasers

LASER GAS FILL SAME AS ANALYTE

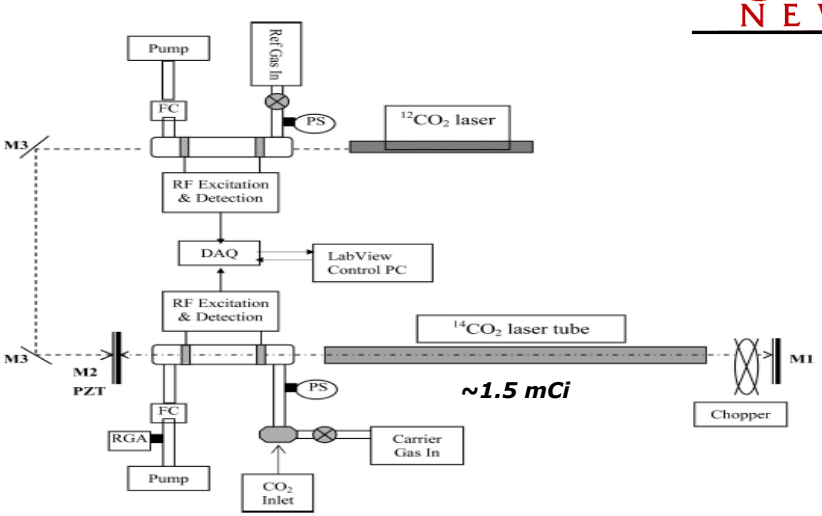


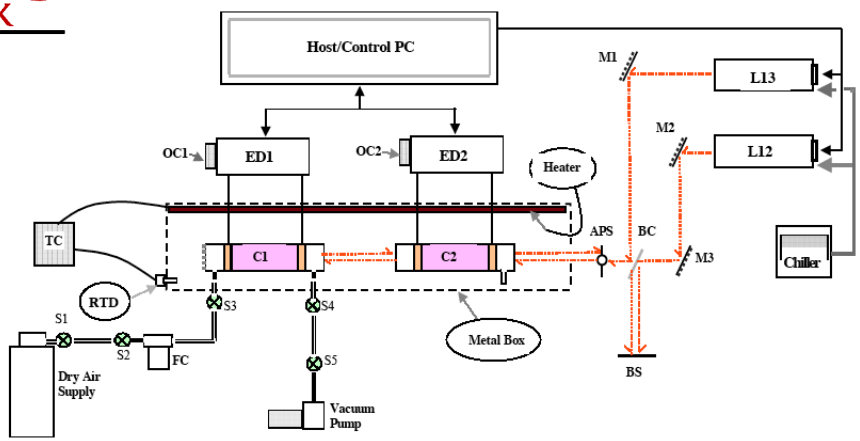
PEM TECHNOLOGY: GMP $^{13}C/^{14}C$

14C ICOGS

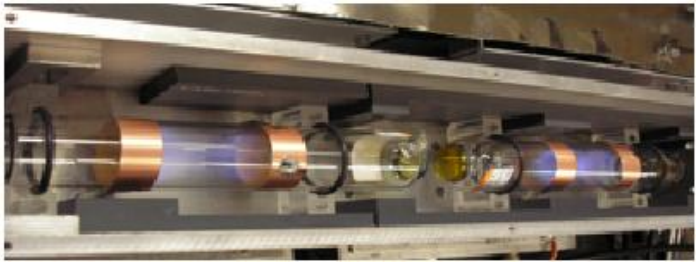
THE STATE UNIVERSITY OF NEW JERSEY
RUTGERS
NEWARK

13C





Optogalvanic Effect
~ S=nILAσC



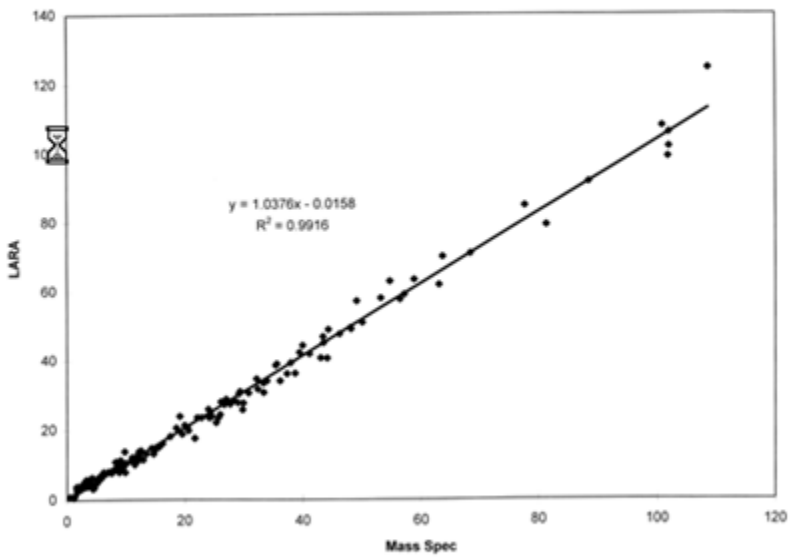
⊙ **Iterative maturation process**

pem planetary emissions management

STATUS: ^{13}C, ^{14}C ANALYZERS

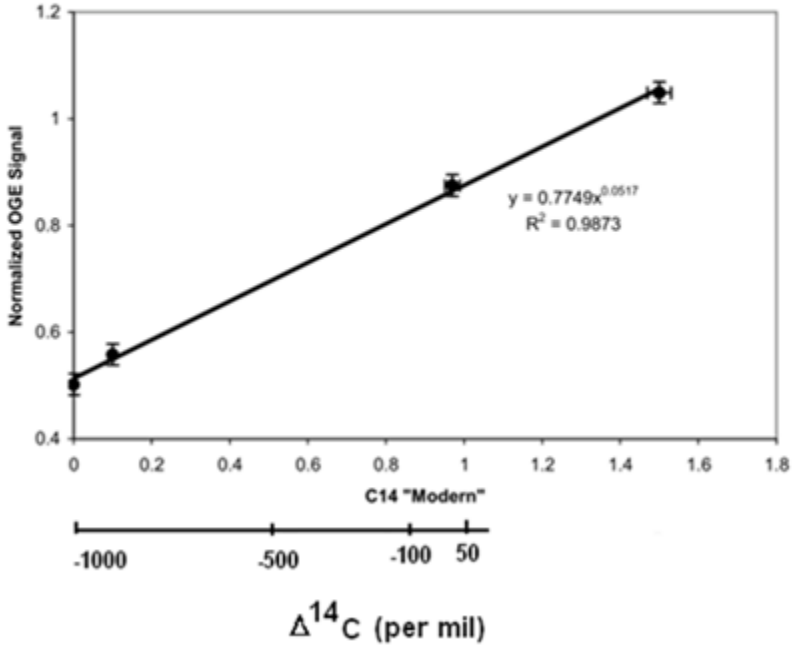
$\delta^{13}C$ OGE vs $\delta^{13}C$ IRMS

Murnick et al., SPIE vol. 2678: 454-463, 1996.



$\Delta^{14}C$ OGE vs $\Delta^{14}C$ AMS

Murnick et al., Anal. Chem. 80: 4820-4824, 2008.

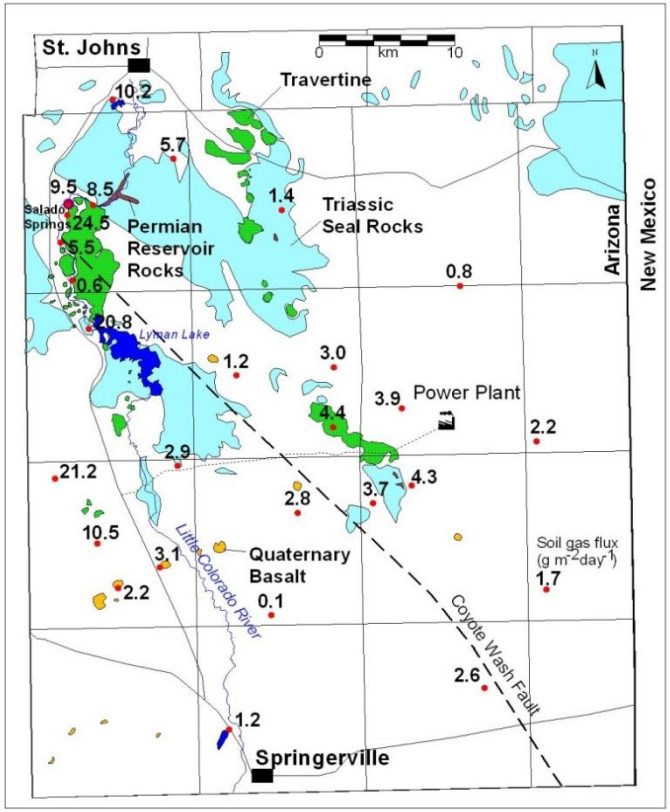


FIELD SITES: LBNL J. LEWICKI

(Lewicki et al., 2008)

218 to 3500 g m^{-2} d^{-1}

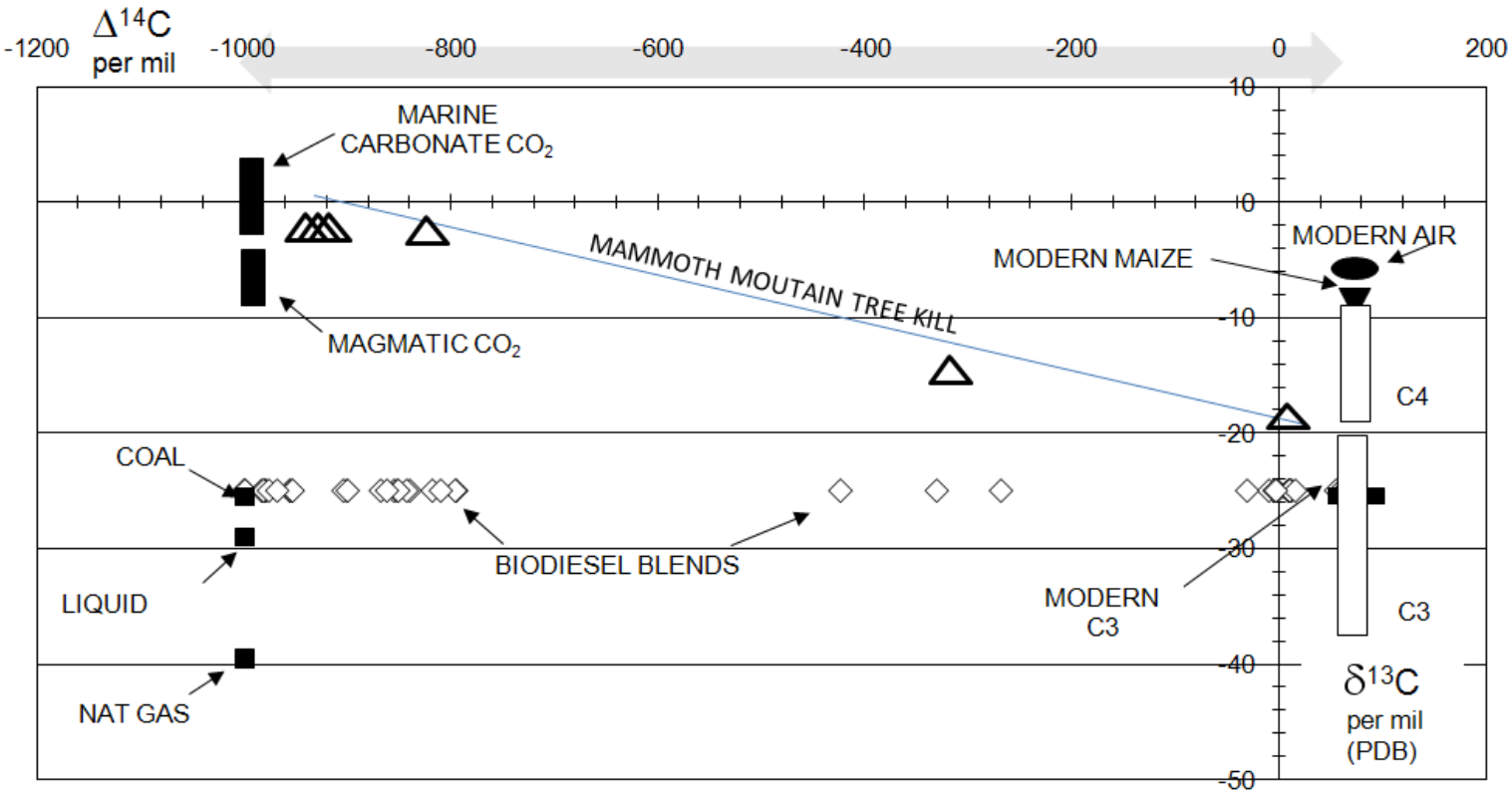
1 to > 10,000 g m^{-2} d^{-1}
46 to 136 t d-1
(Gerlach et al., 2001)



(Allis et al., 2005)

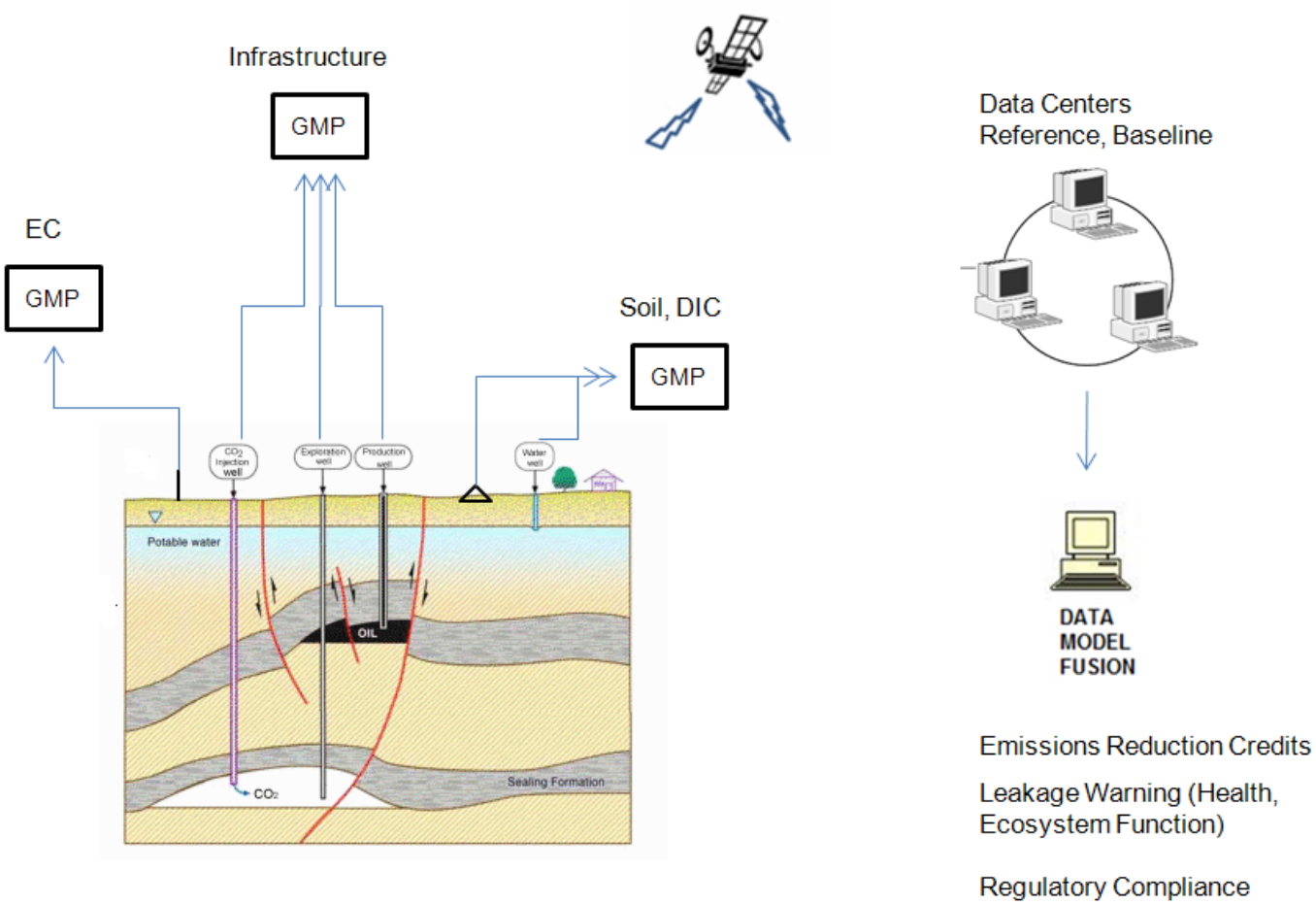
Springerville-St Johns, AZ
< 1 to 24 g m-2 d-1

PEM GMP $^{13}C/^{14}C$



Biodiesel blends (diamonds) (Reddy et al., 2008); $\delta^{13}C$ values for natural gas, liquid fuels and coal (filled squares) (Widory 2006) $\Delta^{14}C$ assumed to be -1000 per mil; modern grasses $\Delta^{14}C$ (solid bar) (Riley et al., 2008) $\delta^{13}C$ assumed to have average value for C3 grasses; modern maize $\Delta^{14}C$ (filled inverted triangle) (Hsueh et al., 2007) $\delta^{13}C$ assumed to have average value for C4 plants; modern air (oval) (Levin et al., 2003) $\delta^{13}C$ value of -7.6 per mil for 1995 to 2000; open box representing range of modern C4 plants (O'Leary, 1988) $\Delta^{14}C$ assumed to be modern ; open box representing range of modern C3 plants (O'Leary, 1998) $\Delta^{14}C$ assumed to be modern; solid box representing δ^{13} values for magmatic CO2 (Mary & Jambon, 1987) $\Delta^{14}C$ assumed to be -1000 per mil; solid box representing $\delta^{13}C$ values for marine carbonate derived CO2 (Ohomoto & Rye, 1979) $\Delta^{14}C$ assumed to be -1000 per mil. Data for Mammoth Mountain given by Farrar et al., 1995.

GCS MVA


Infrastructure
GMP
EC
GMP
Soil, DIC
GMP
Potable water
OIL
Sealing Formation
CO2
Data Centers
Reference, Baseline
DATA
MODEL
FUSION
Emissions Reduction Credits
Leakage Warning (Health, Ecosystem Function)
Regulatory Compliance