WEST COAST REGIONAL CARBON SEQUESTRATION PARTNERSHIP
westcarb.org

WESTCARB Annual Business Meeting

Continuous Observation Well Sampling and CO_2 Plume Detection

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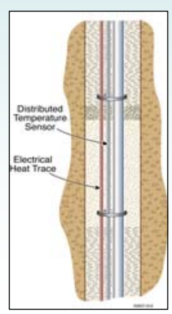
WEST COAST REGIONAL CARBON SEQUESTRATION PARTNERSHIP 1

Local CO_2 Plume Detection at Observation Well

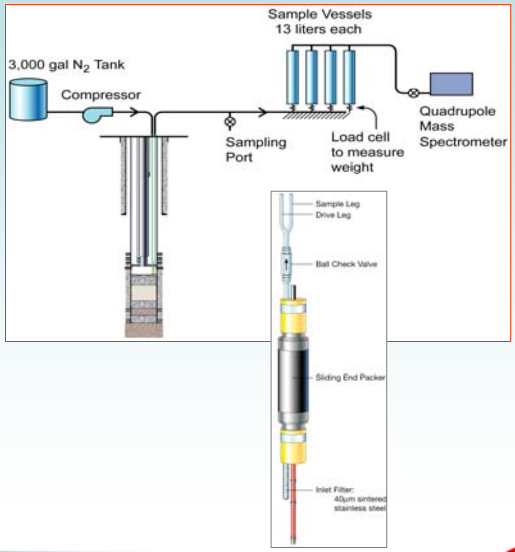
- Continuous well fluid sampling via U-tube

- Thermal property monitoring via Distributed Thermal Perturbation Sensor (DTPS)



WEST COAST REGIONAL CARBON SEQUESTRATION PARTNERSHIP 2

U-Tube System



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3

U-Tube System





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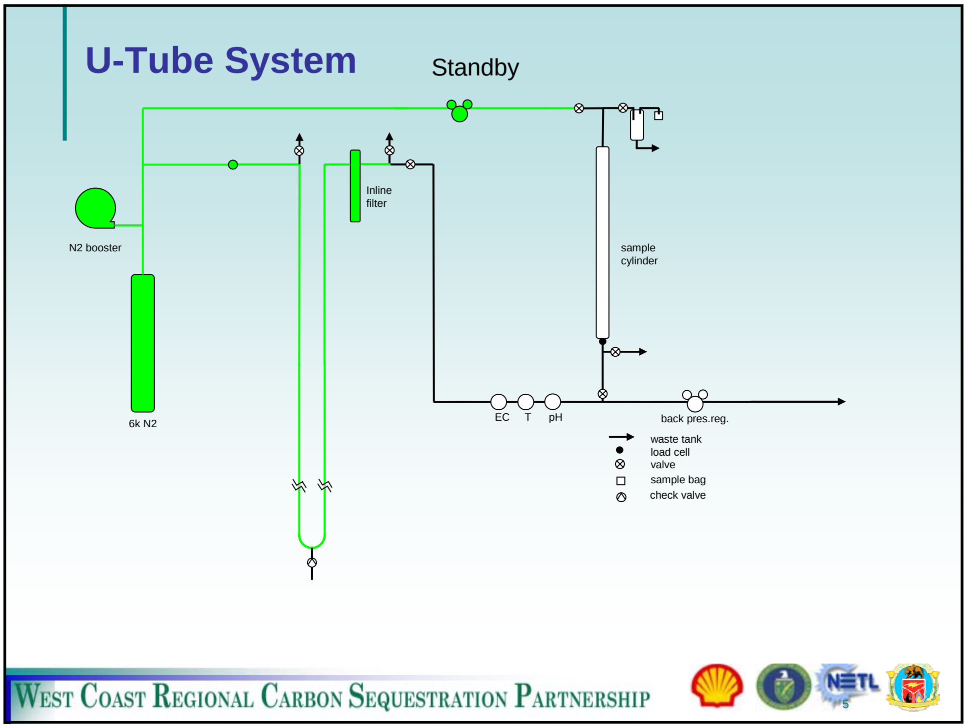
4


U-Tube System
Standby
Inline filter
N2 booster
6k N2
sample cylinder
EC
T
pH
back pres.reg.
waste tank
load cell
valve
sample bag
check valve
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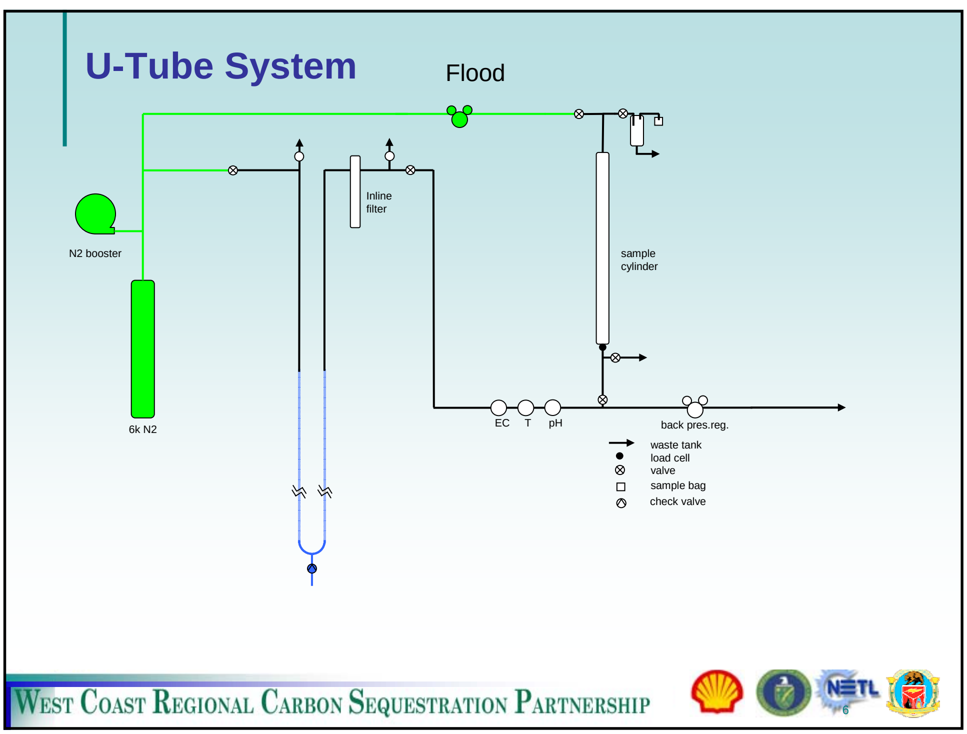
U-Tube System
Flood
Inline filter
N2 booster
6k N2
sample cylinder
EC
T
pH
back pres.reg.
waste tank
load cell
valve
sample bag
check valve
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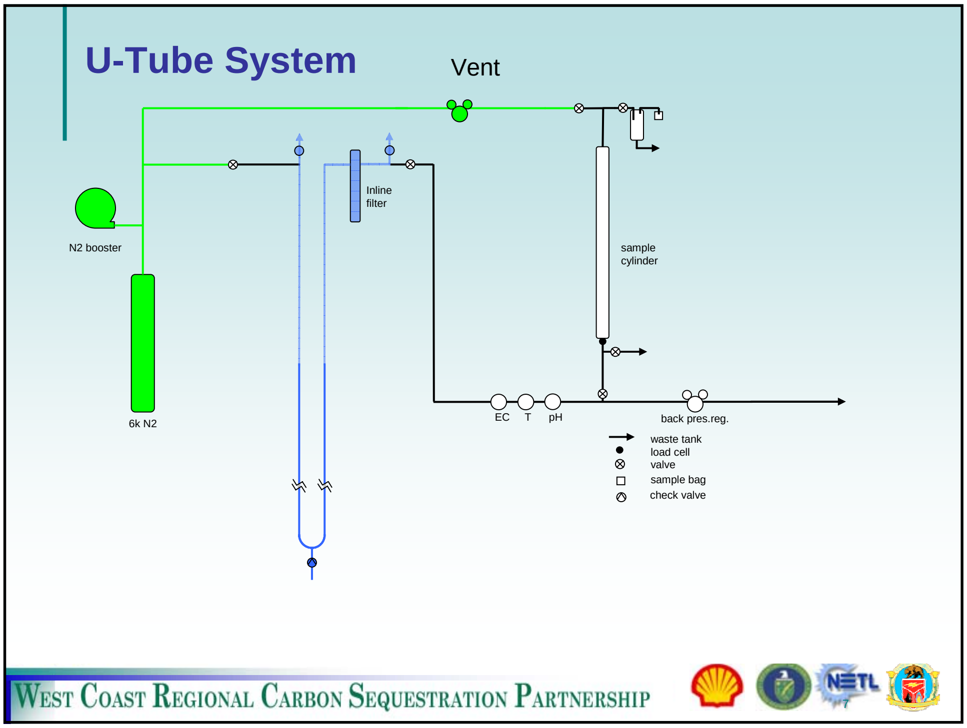
U-Tube System
Vent
Inline filter
N2 booster
sample cylinder
6k N2
EC
T
pH
back pres.reg.
waste tank
load cell
valve
sample bag
check valve
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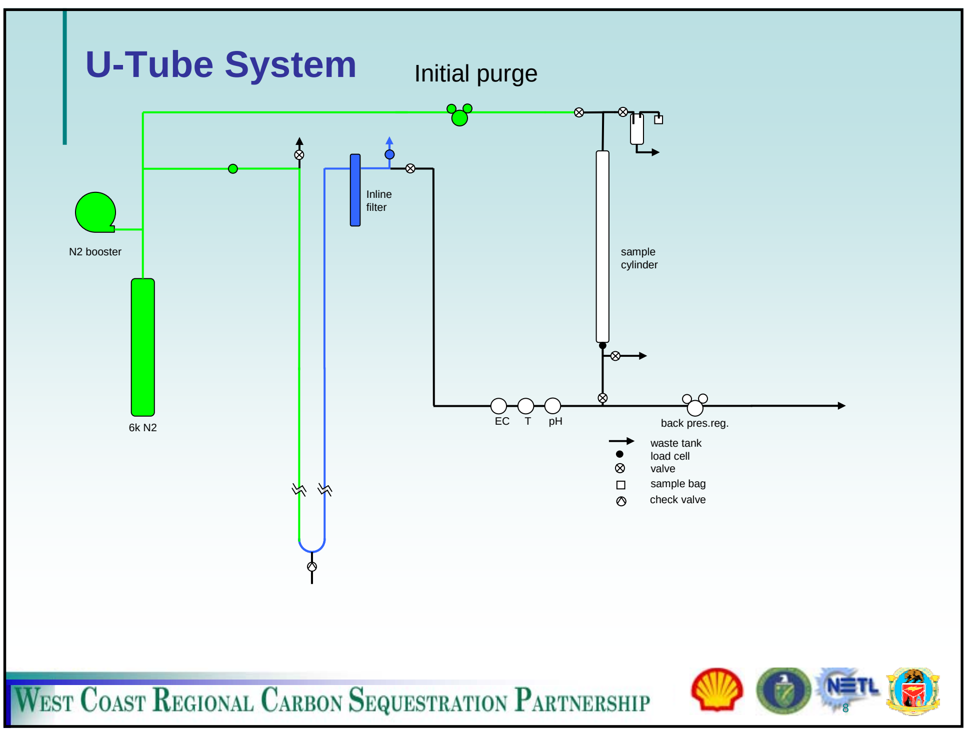
7


U-Tube System
Initial purge
Inline filter
N2 booster
sample cylinder
6k N2
EC
T
pH
back pres.reg.
waste tank
load cell
valve
sample bag
check valve
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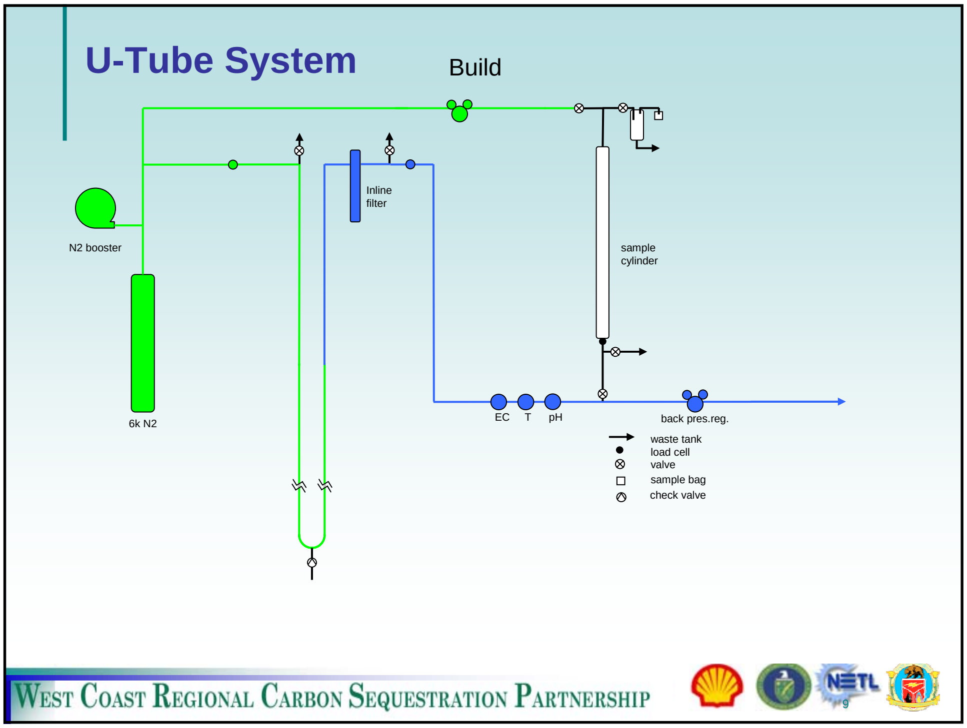
8


U-Tube System
Build
Inline filter
N2 booster
sample cylinder
6k N2
EC
T
pH
back pres.reg.
waste tank
load cell
valve
sample bag
check valve
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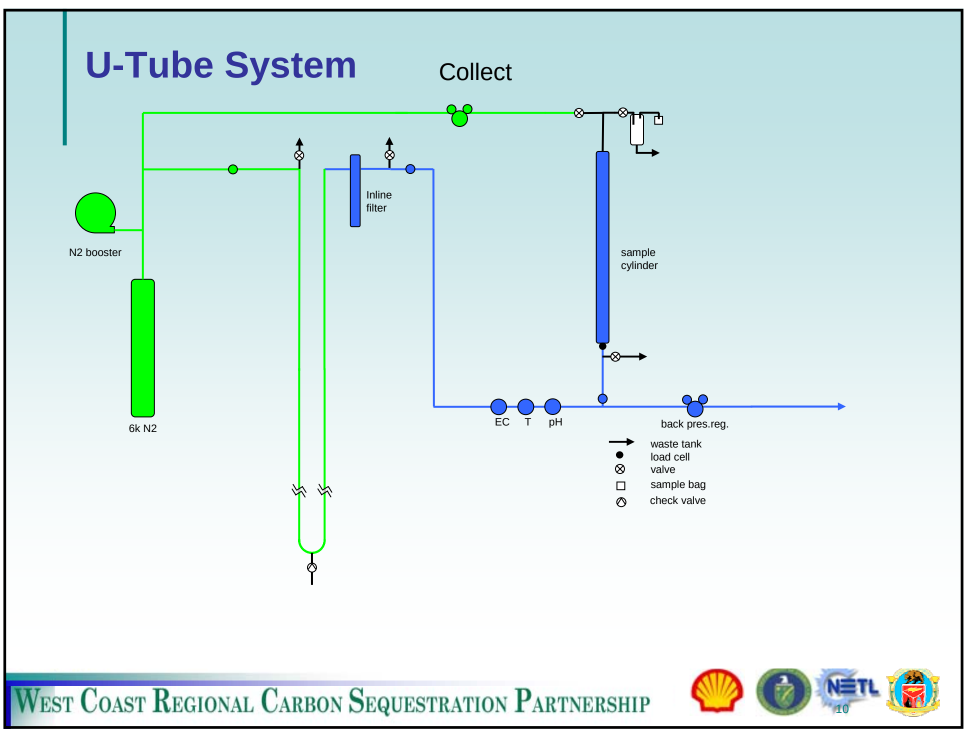
9


U-Tube System
Collect
Inline filter
N2 booster
sample cylinder
6k N2
EC
T
pH
back pres.reg.
waste tank
load cell
valve
sample bag
check valve
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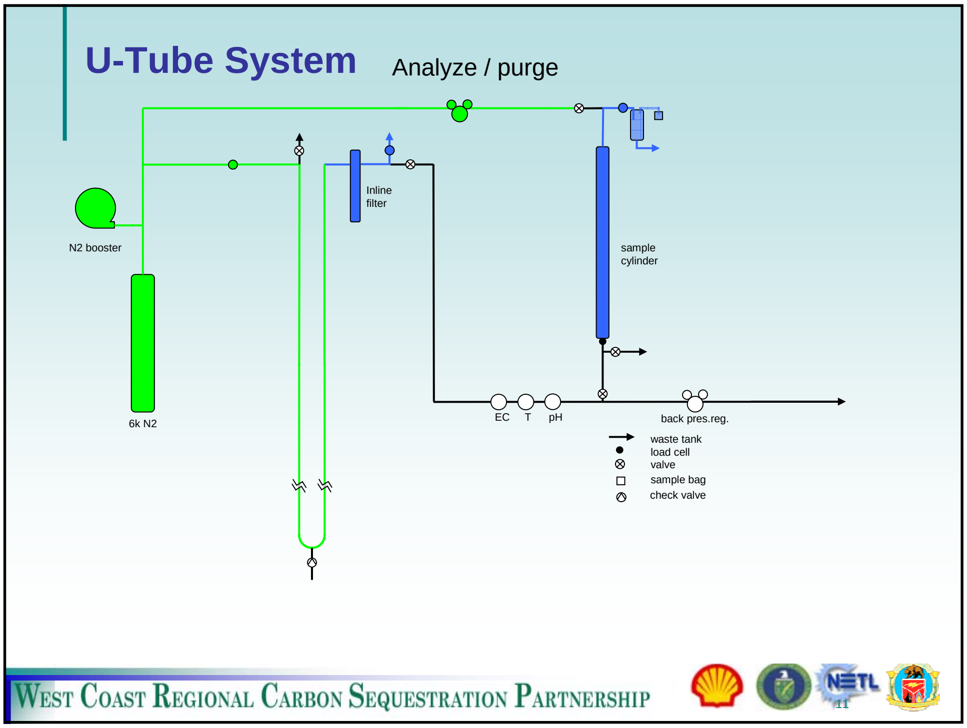
10


U-Tube System
Analyze / purge
Inline filter
N2 booster
sample cylinder
6k N2
EC
T
pH
back pres.reg.
waste tank
load cell
valve
sample bag
check valve
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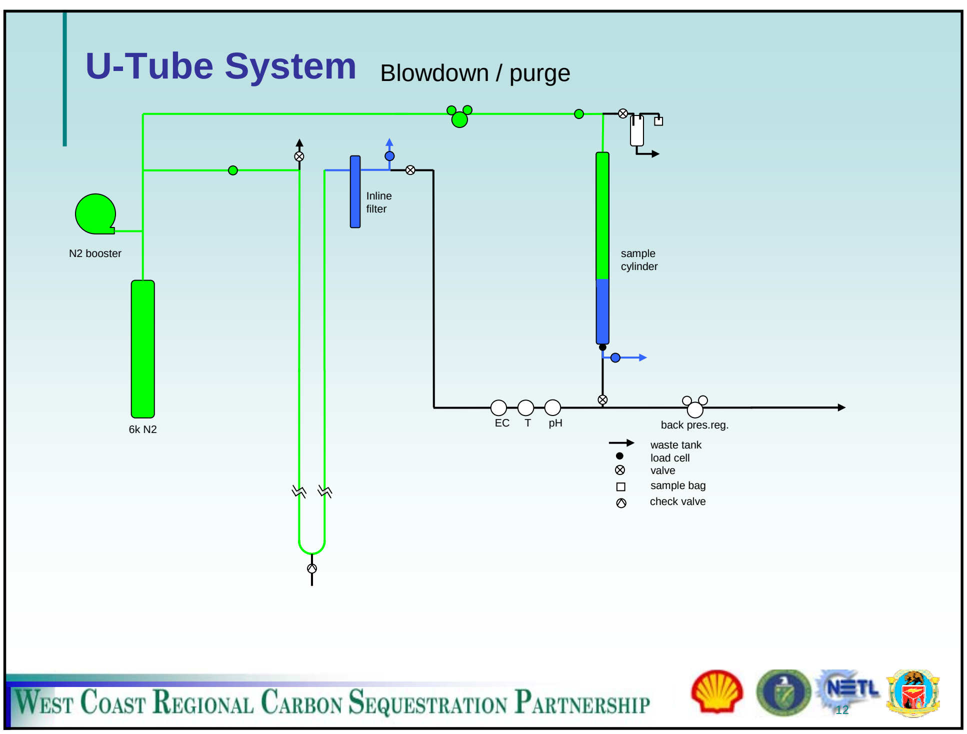
U-Tube System
Blowdown / purge
Inline filter
N2 booster
sample cylinder
6k N2
EC
T
pH
back pres.reg.
waste tank
load cell
valve
sample bag
check valve
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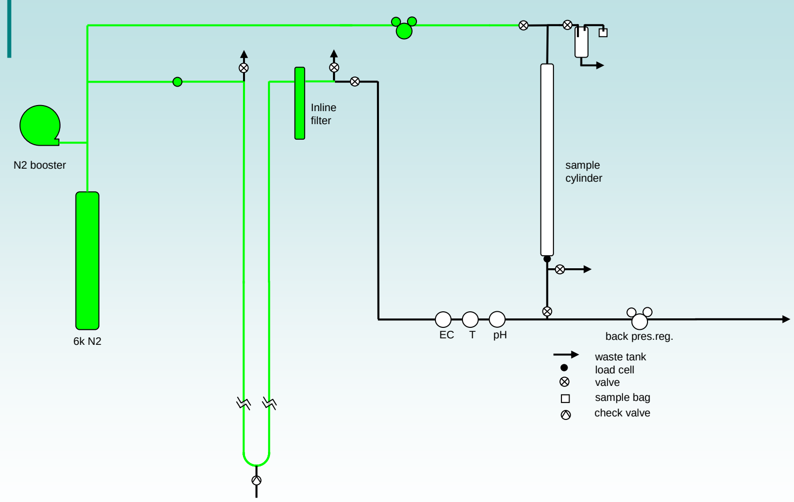
U-Tube System

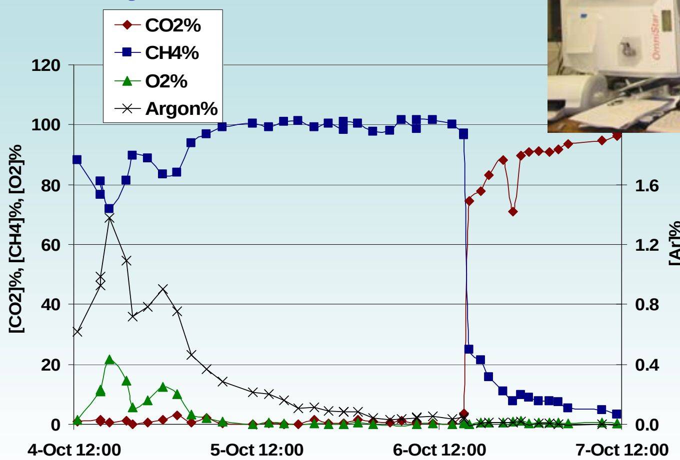
Standby



U-Tube System advantages over other sample methods

- High sample frequency (1 to 2 hour intervals)
- Downhole equipment kept simple (check valve)
- Large sample volume (tens to hundreds of liters compared to 1 liter for Kuster)
- Samples retrieved at reservoir conditions (pressure, fluid components)
- Real time analysis of sample stream (mass spec, pH, conductivity) also at reservoir conditions
- Frees up production tubing for other uses

U-Tube System CO2 detection



- Arrival detected by mass spectrometer

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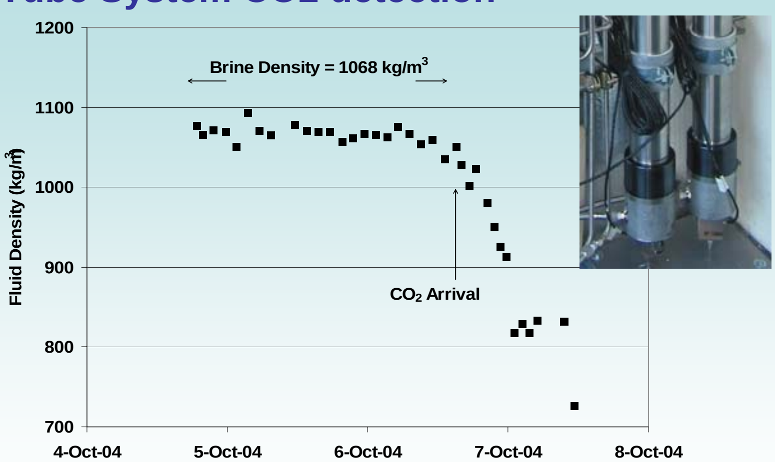
15

U-Tube System CO2 detection



- Arrival detected by well fluid density (load cells under sample cylinders)

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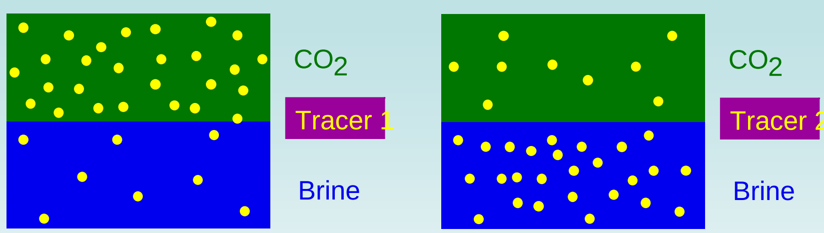
16

U-Tube System other uses Geochemistry, Heterogeneity

- Samples brought to surface can be maintained at reservoir pressure for later laboratory analysis (fluid rock interaction, isotopic signatures)
- Long-term monitoring / sample retrieval
- Detection of injected tracers to determine established CO2 travel times (over time)
- Use of phase partitioning tracers to estimate residual saturation (how much CO2 is trapped, bearing on formation storage capacity during and after injection) and relative mobility of CO2 and brine.

Phase partitioning tracers



Henry's law

$$P_{gas}^{tracer} = K_h \times {}_{aq}^{tracer}$$

- In a dynamic system (moving fluid) differences in solubility lead to different travel times for the two tracers which can be determined by arrivals detected by the sampling system

Phase partitioning tracers

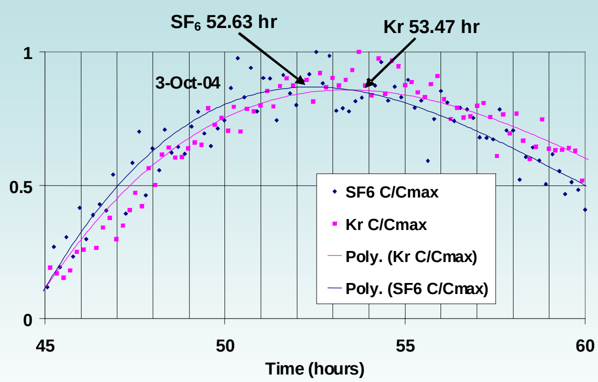
- Aqueous phase (brine) saturation is can be found using tracers "y" and "u" by

$$S_a = \frac{1 - t_y/t_u}{1 - t_y/t_u + \zeta_u t_y/t_u - \zeta_y}$$

- Where t is the travel time of tracer y or tracer u and ζ is the aqueous phase distribution coefficient (solubility) which is a known property of each tracer.

- Commonly used tracers are noble gasses (Ne, Ar, Kr, Xe) and SF6 which are inert and differ by their Henry's coefficients

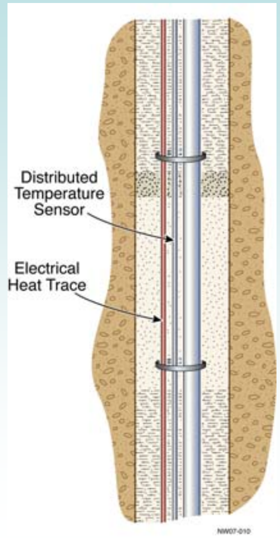
Phase partitioning tracers



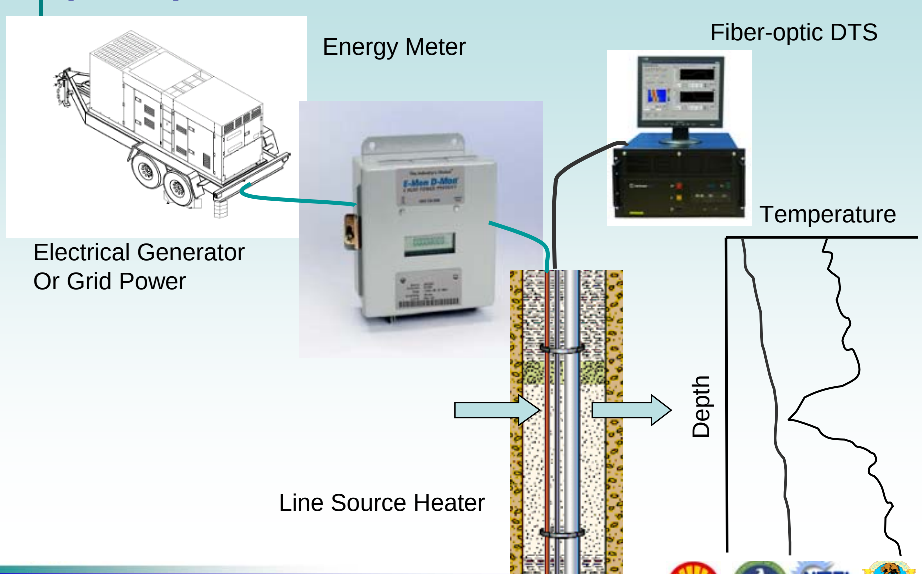
- Arrival time of SF6 vs Kr in sample stream (as determined by concentration)

Distributed Thermal Perturbation Sensor (DTPS)

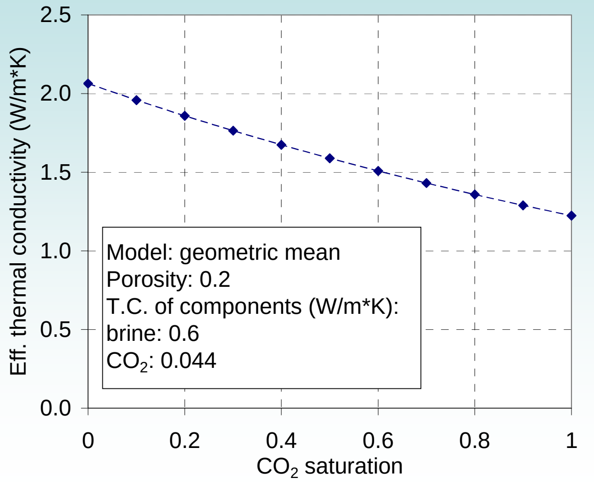
- DTPS consists of a borehole length electrical resistance heater and fiber-optic DTS
- Apply constant heating along wellbore (monitoring entire length of well)
- Temperature transient is recorded (interested in cooling period, less local effect)
- Estimate
  - formation thermal properties
  - fluid advection
  - Saturation
- Long-term monitoring
- Passive mode (no heating)



Distributed Thermal Perturbation Sensor (DTPS)



DTPS: CO2 replaces Brine



About 40% reduction of effective t.c. by replacing brine by CO_2

Effect is almost proportional to saturation

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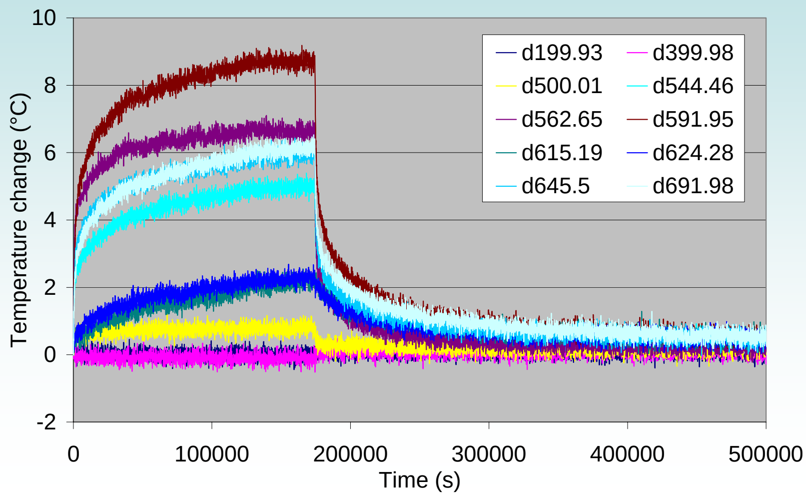
DTPS: Measured cooling at different depths raw data



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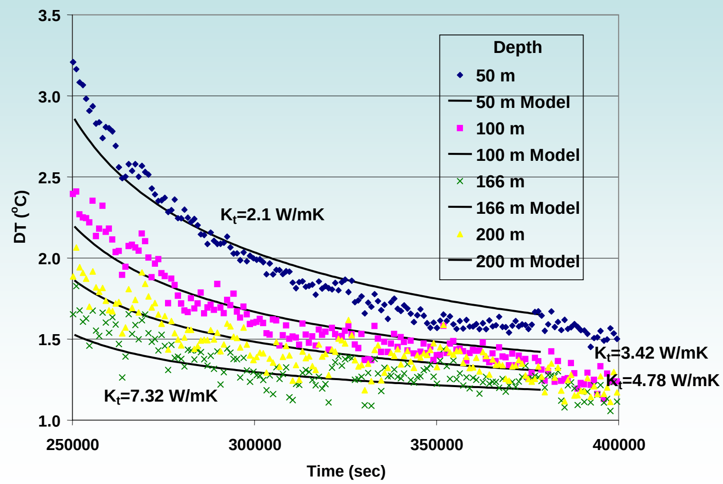
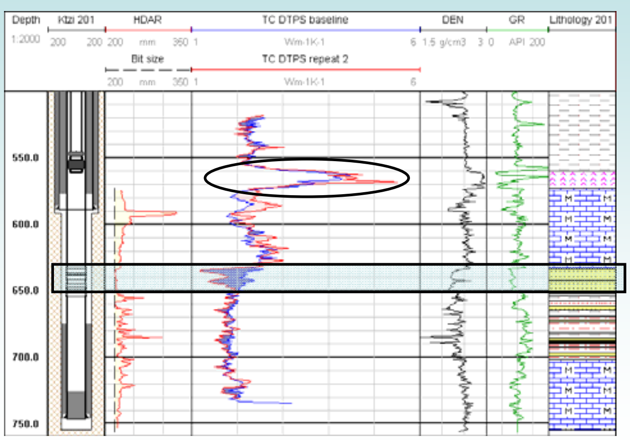
DTPS: Measured cooling at different depths determining Kt



Freifeld et al., 2007 (Highlake site, Canada)

DTPS: Measured cooling at different depths determining Kt



Good overall fit to baseline results (e.g. K2 marker horizon).

Distinct zone with decrease in thermal conductivity: main zone of CO2 injection.