58 units on 19 sites
Covering 80% of French electricity consumption
Architecture of the DEMETERRES program

- Water Treatment
- Soil Treatment
- Phyto-Remediation
- « Safe-Food »

Soil Characterization

Guide of Intervention

New Post-accidental Remediation Strategies
Towards a mixed technology of (bio)remediation

Contamination

Cartography

Storage

Treatment of hot spots and low contamination
Towards a mixed technology of remediation

- Contamination
- Cartography
- Biomass production onsite or offsite
- Volume Reduction / Storage
- Safe-food and Phytoremediation
- Highly contaminated zones Physico-chemical treatment

Vienna, AIEA Workshop, 17 October 2016, Dr A. Vavasseur, CEA, France
Safe-Food

Radiation level distribution in no-entry zone and road map for decontamination

Phytoextraction

Vienna, AIEA Workshop, 17 October 2016, Dr A. Vavasseur, CEA, France
Safe-Food

**OBJECTIVES**
- Decrease by 50% Cs contamination in seeds
- Dicotyledonous (Arabidopsis) decrease by 50% leaves contamination

Phytoextraction

**OBJECTIVE**
- Increase by 200% Cs content in aerial parts

Using Genetics approaches

*Balsas teosinte*  
*Zea Mays*
Cs strongly interacts with clay in soil
Molecular approaches to modify

1- Root architecture to optimize or decrease Cs contamination

2- Decrease / Increase Cs biodisponibility in the rhizosphere by modifying proton and organic acid excretion

3- Decrease / Increase Cs transport \textit{in planta}
1- Change in Root Architecture
1- Change in Root Architecture

NB  avre12 Azygotous  AVRE12 Homozygous

0.0  10.0  20.0  30.0  40.0  50.0
DEPTH

Root Depth

C  C  D

0.0  10.0  20.0  30.0
Root number below 30cm

C, D

0.0  2.0  4.0  6.0  8.0  10.0  12.0  14.0  16.0

NIPB  AVRE12_AZ  AVRE12_HO
2- Decrease / Increase Cs biodisponibility in the rhizosphere

**AHA (H⁺) family**
- *AHA1* roots
- *AHA2* roots
- 11 family members

**organic Ac.**
- *ALMT*
- *MATE*
- *FRD3*
- ...

Vienna, AIEA Worshop, 17 October 2016, Dr A. Vavasseur, CEA, France
Strategy

Vienna, AIEA Workshop, 17 October 2016, Dr A. Vavasseur, CEA, France

Col

aha-x

Col

aha-x

no Cs⁺

500 μM Cs⁺

Roots

Shoots

Cs⁺ content (nmol/g dry weight⁻¹)

External Cs⁺ μM

External Cs⁺ μM
Arabidopsis thaliana genome
(White 2003, Encyclopaedia of Applied Plant Science)

- KIRC (AKT & KAT families) 7 genes
- KORC (SKOR & GORK) 2 genes
- VICC (GLR & CNGC families) 40 genes
- KUP (KUP/HAK/POT family) 13 genes
- CHX 26 genes
- KEA 6 genes
- 94 genes ! + NHX etc...

3- Decrease / Increase Cs transport *in planta*

From White & Broadley (2000)
New Phytol. 147, 241-256
Strategy

Identification of disrupted mutants (Shakers, KUP, KEA, CHX, NHX, HKT…)

Characterization of invalidated mutants:

- On agar plate: root length measurements, biomass production, chlorophyll contents... under low or high K⁺ with/without Cs,
- In hydroponic conditions: analyses of Cs uptake by tracer experiments, determination of Cs⁺ and K⁺ contents (ICP),...
- Construction of Arabidopsis plants more efficient in Cs transport
Strategy

No Cs

Cs 10 µM

Cs 100 µM

Vienna, AIEA Workshop, 17 October 2016, Dr. A. Vavasseur, CEA, France
Strategy

Col-0

kupx-1

kupx-2

Cs absorption (nmol/g Roots FW)
Strategy

Col-0

kupx-1

kupx-2

Cs absorption (nmol/g Roots FW)
Tests on contaminated soils

Soils from Fukushima

Non OGM

Stable retrotransposon

tos 17

Activated retrotransposon

 stabilized gene

Stable retrotransposon

Disrupted gene

tos 17
Institute of Environmental Research at Fukushima University

Dr Ryoung Shin, Kobe University

National Institute of Agronomy & Environmental Sciences (NIAES) Dr Tomohito ARAO

Forests & Forestry Products Research Institute (FFPRI) Dr M. Taoka

Institute of Environmental Research at Fukushima University

Pr Tsukada and colleagues

New Institute under construction

Visit of Japanese institutes in October 2014

Pr Mimura, Kobe University

Riken Institute Yokohama, Dr Ryoung Shin

University of Tokyo
Pr Tomoko Nakanishi

Vienna, AIEA Workshop, 17 October 2016, Dr A. Vavasseur, CEA, France
We are developing a soil collection typical of the diversity of the different nuclear sites in France, from sandy soils to those rich in clay to test the efficiency of the technologies developed in the frame of the Demeterres program.
Many thanks to the French program “investment for the future”, all the contributors to the program from the different Institutes and to our partners in Japan

Many thanks for you attention, it’s so difficult after the lunch !!