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In situ characterization by autoradiography for dismantling

S. Leblond, P. Fichet

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DE LA RECHERCHE À L'INDUSTRIE

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IN SITU CHARACTERIZATION BY AUTORADIOGRAPHY FOR DISMANTLING

CEA SACLAY, FRANCE

Pacific Basin Nuclear Conference | Sylvain Leblond Pascal Fichet

01 OCTOBER 2018



Dismantling context in France

- Immediate dismantlement policy
- Dismantling process
- LASE Laboratory
- Radioactivity imaging

Autoradiography to investigate surface contamination

- Autoradiography principle
- Phosphor screen detectors
- Autoradiography in dismantling facilities
- Depth contamination study

MAUD Project: towards a digital field detector

- An industrial project
- Design of a new type of detector
- Radioactivity localization
- Emitters characterization

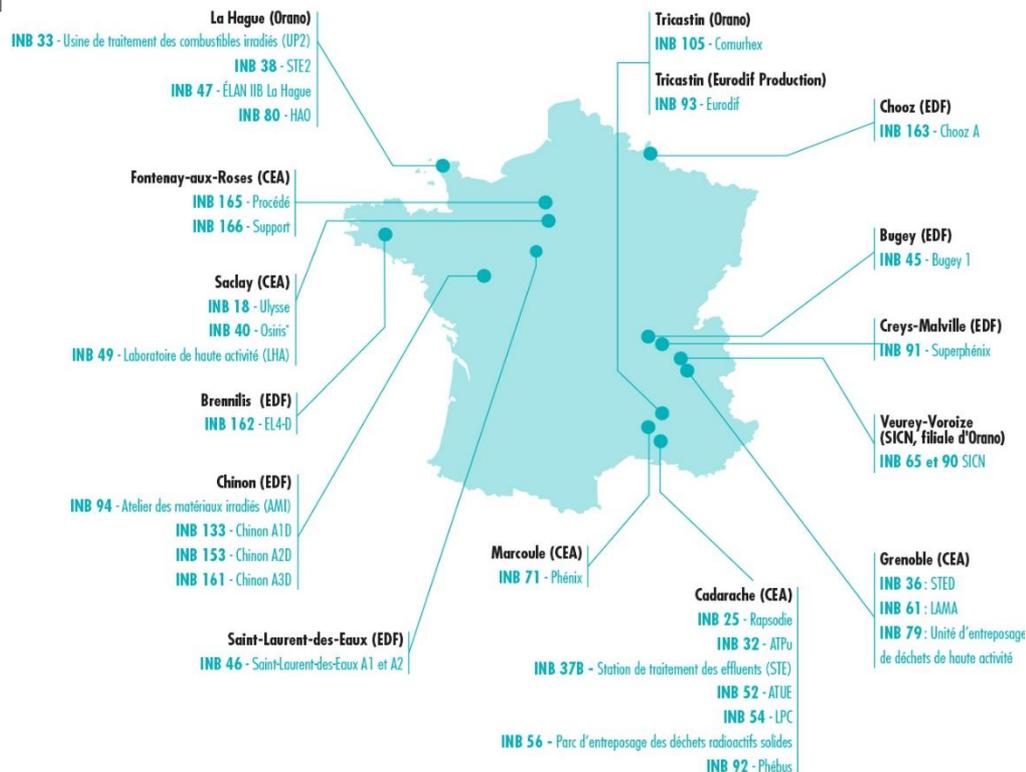
Conclusion

DISMANTLING CONTEXT IN FRANCE

- In France, the dismantlement should be started immediately after the shutdown of operation

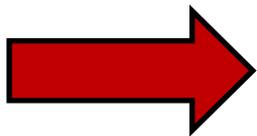
IMMEDIATE DISMANTLEMENT POLICY

- In France, the dismantlement should be started immediately after the shutdown of operation
- Numerous facilities from 50's & 60's have already stop to operate
- Several others should stop during the next decade

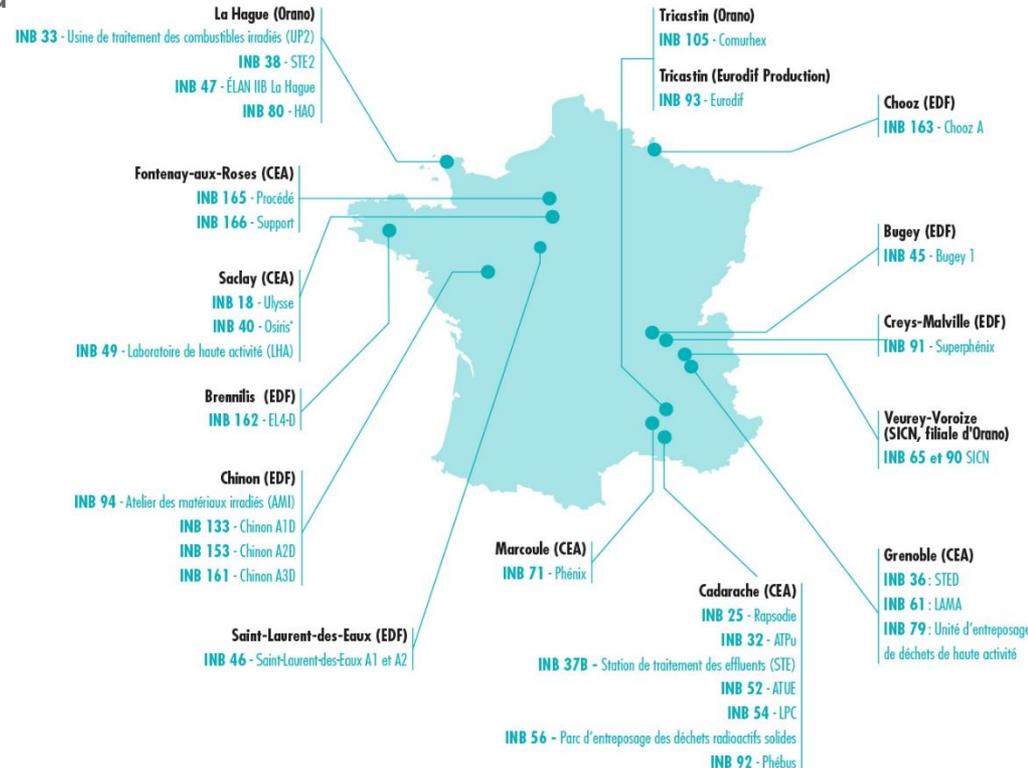


IMMEDIATE DISMANTLEMENT POLICY

- In France, the dismantlement should be started immediately after the shutdown of operation
- Numerous facilities from 50's & 60's have already stop to operate
- Several others should stop during the next decade
- Dismantling process is a tedious work : typically > 10 years

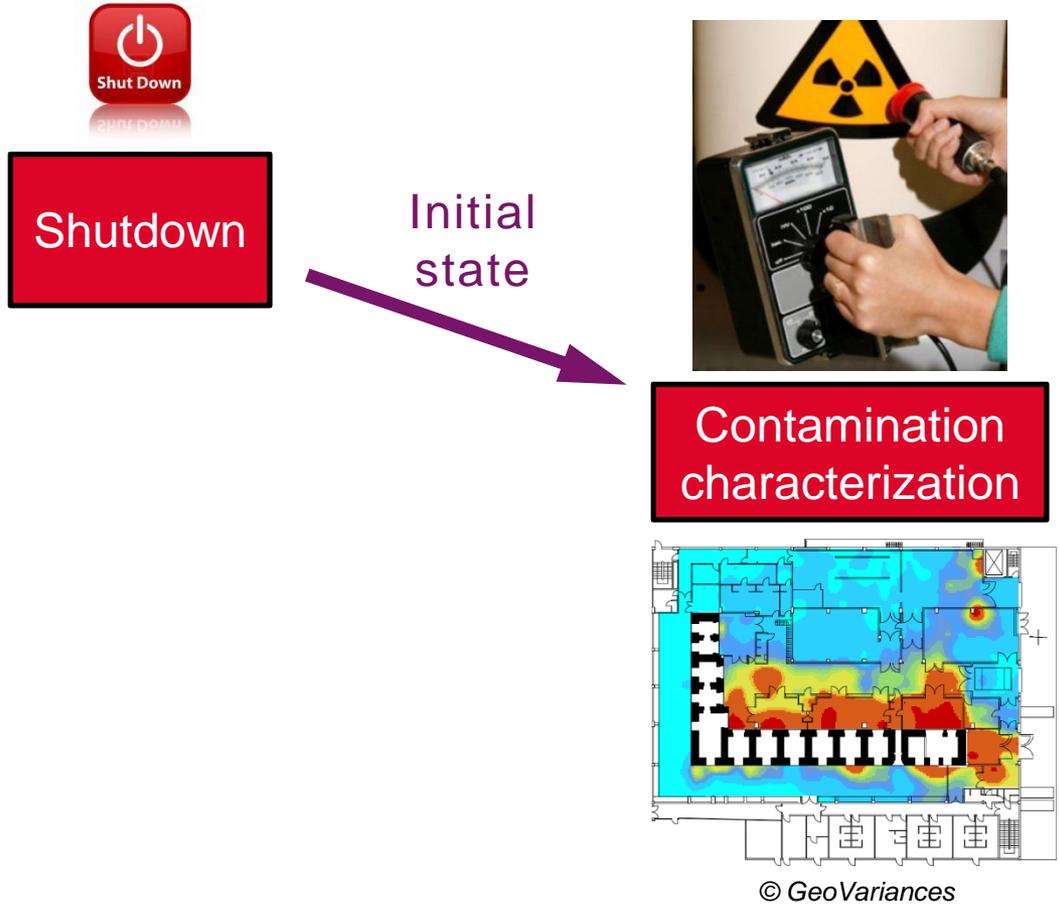


Dismantling applications are rapidly developing in France



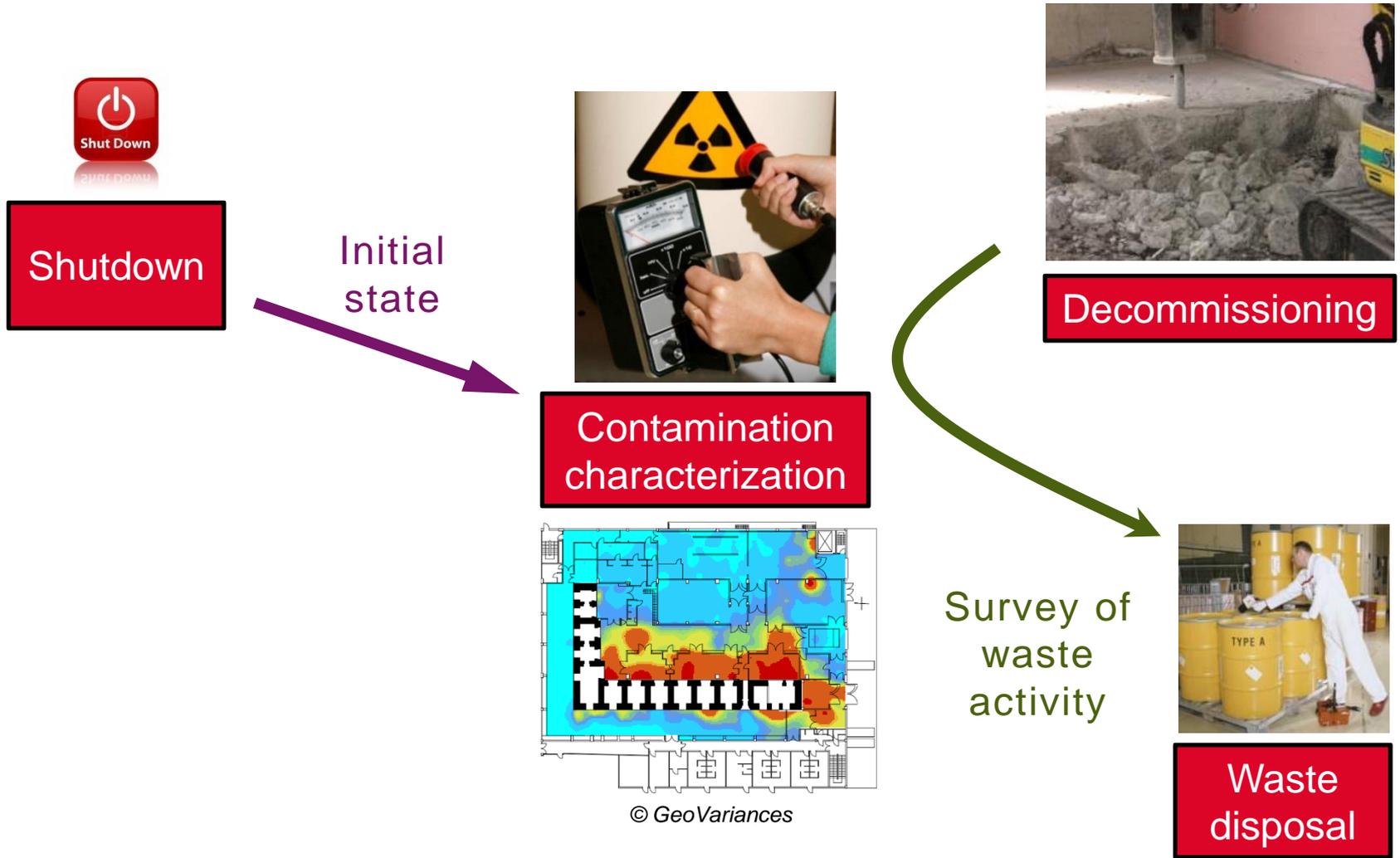
**Dismantling facilities in France
(from ASN - January 2018)**

DISMANTLING PROCESS

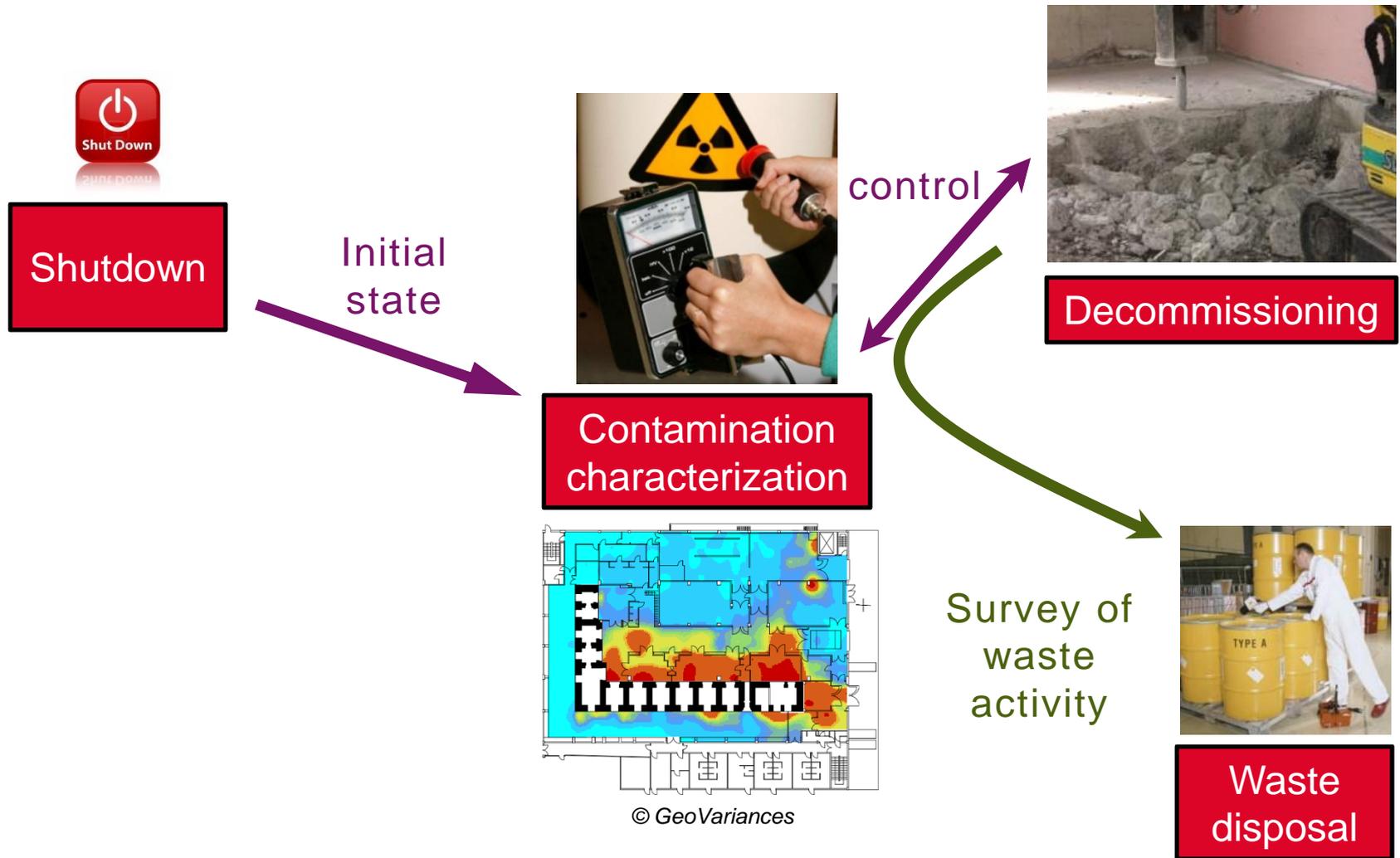


© GeoVariances

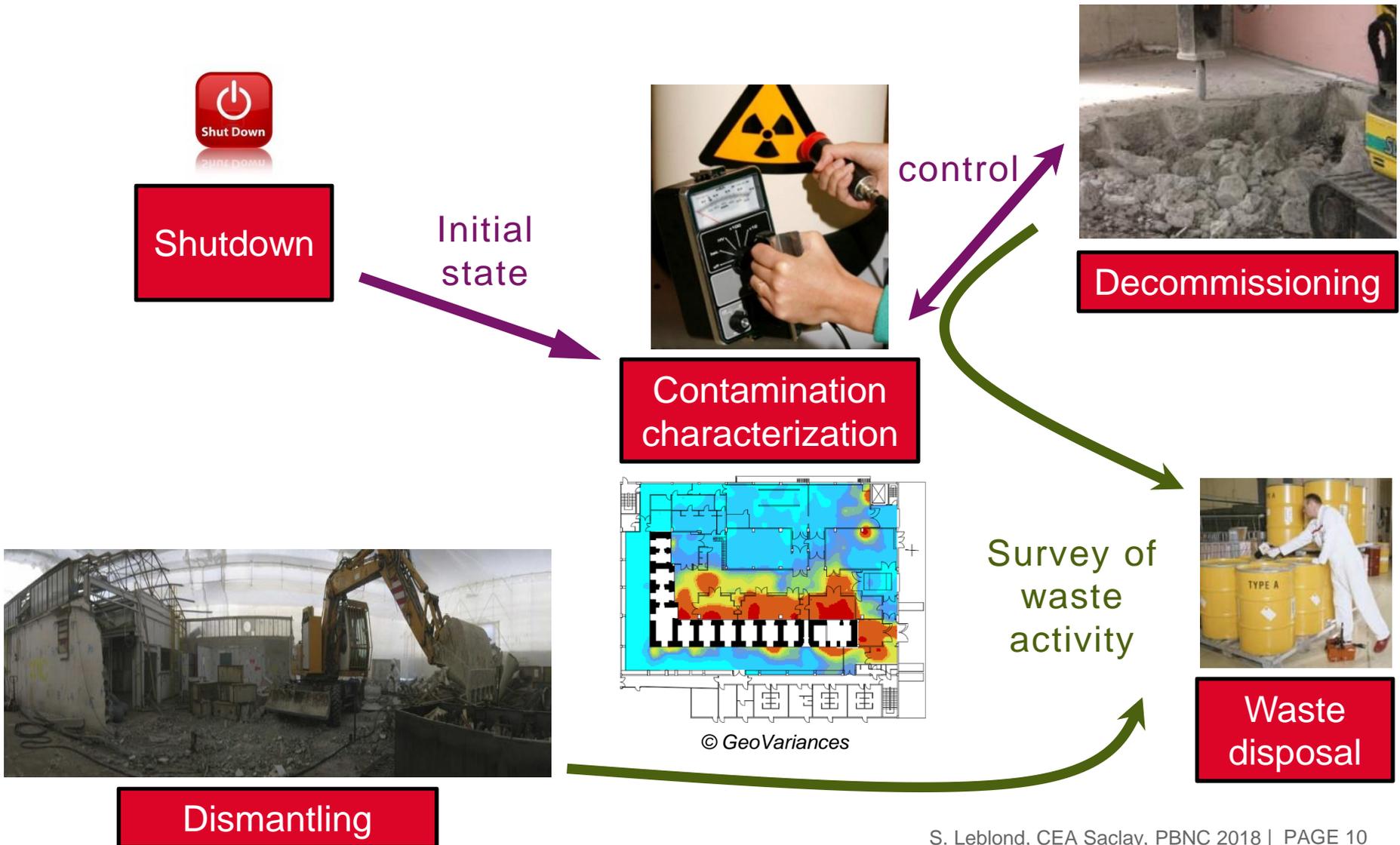
DISMANTLING PROCESS



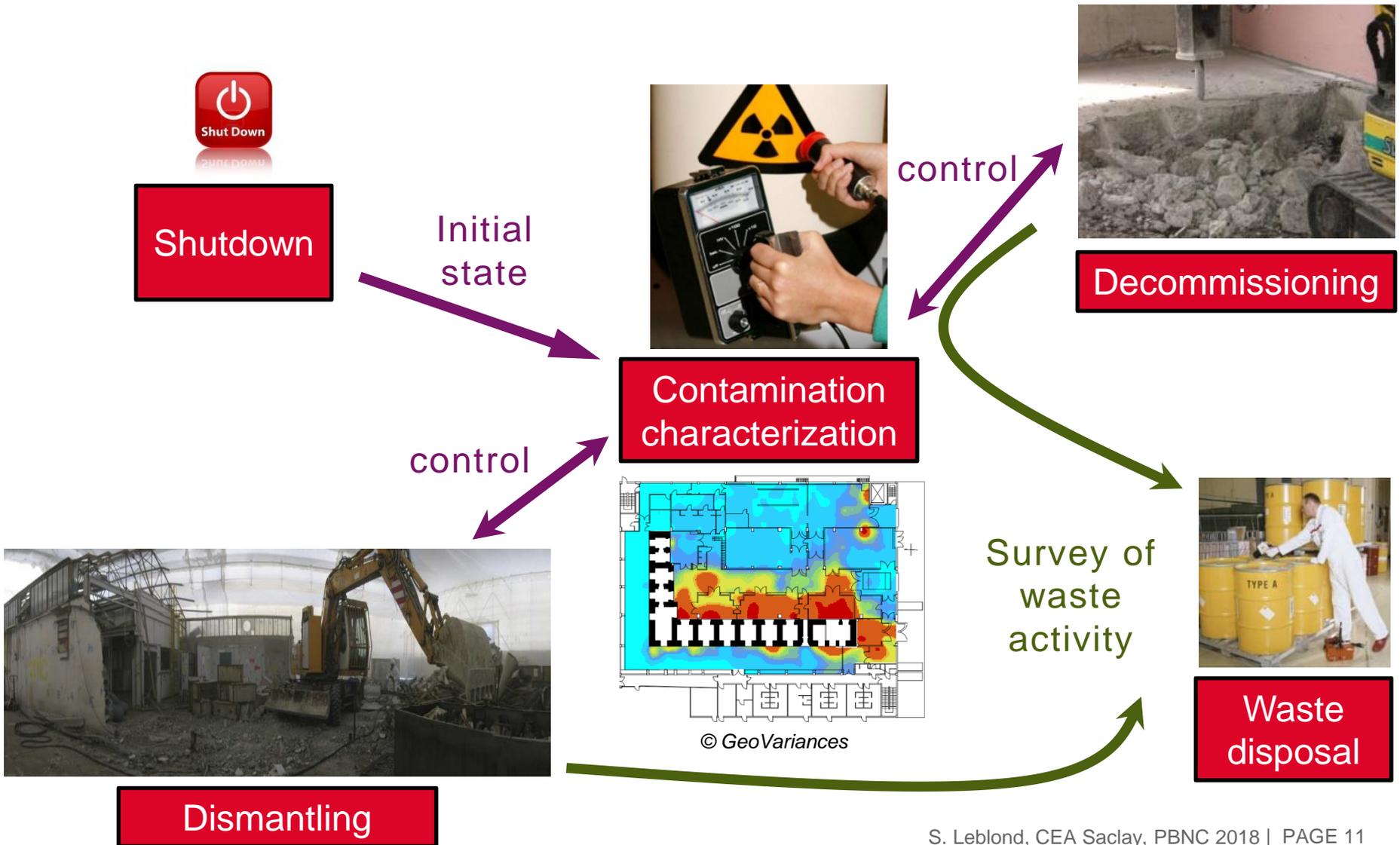
DISMANTLING PROCESS



DISMANTLING PROCESS



DISMANTLING PROCESS



DISMANTLING PROCESS

Mandatory



SHUT DOWN

Shutdown

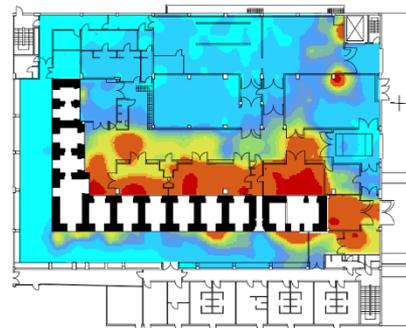
Initial state



control



Contamination characterization

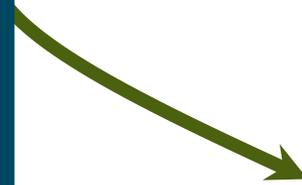


control



Decommissioning

Survey of waste activity



Waste disposal



Dismantling

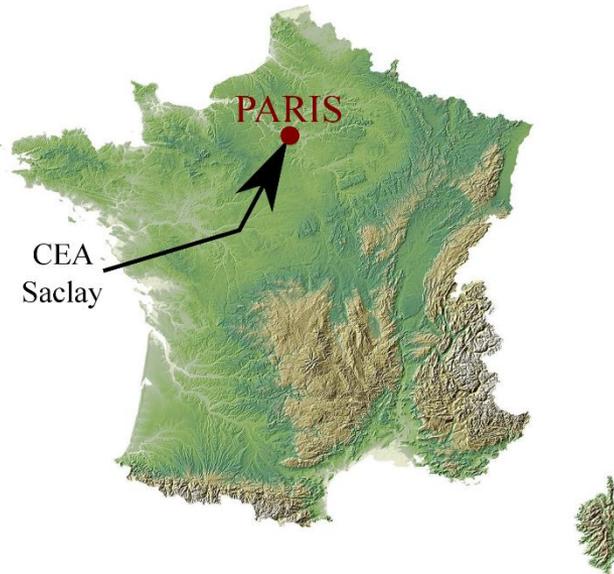
Waste characterization



- Radiochemical laboratory
- Supporting nuclear industry operators
- Analytical samples preparation
- Wide range of detection methods:
 - ❖ Liquid scintillation
 - ❖ Chromatography
 - ❖ ICP emission spectroscopy & mass spectrometry
 - ❖ Alpha & Gamma spectroscopy



Waste characterization



- Radiochemical laboratory
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 - ❖ Liquid scintillation
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To be improved:
Sampling process
Contaminant interferences
Waste production

...

Valuable for dismantling applications

- Provide real contamination mapping
- *In situ* analysis
- Guide sampling process



Grenoble

Valuable for dismantling applications

- Provide real contamination mapping
- *In situ* analysis
- Guide sampling process



Grenoble

Short range radiations

- Mainly α and β emitters
- Quickly stopped by any materials
- No existing real time camera suited for dismantling applications



Typical surface contamination detector

Valuable for dismantling applications

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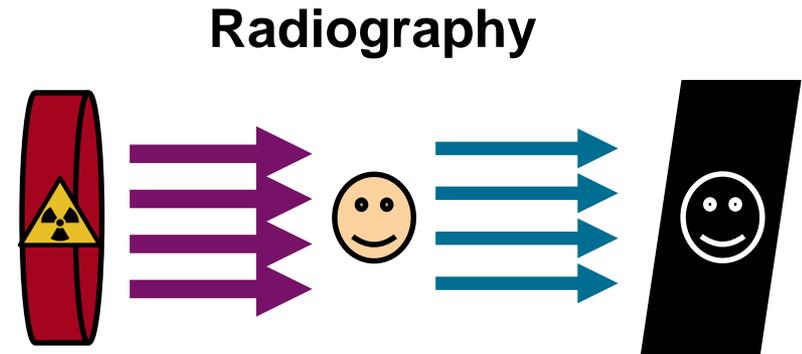
Typical surface contamination detector



Necessity for new type of detector

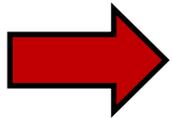
**AUTORADIOGRAPHY TO
INVESTIGATE SURFACE
CONTAMINATION**

- Provide image of radioactivity on a surface like standard radiography



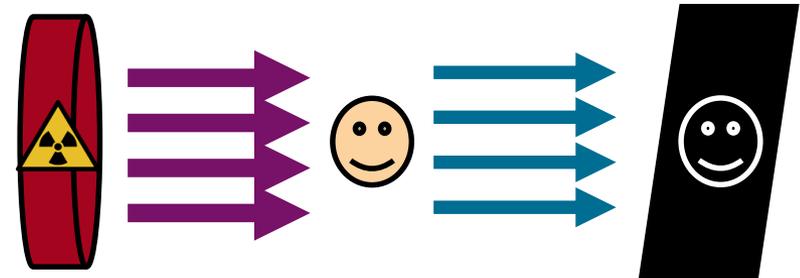
AUTORADIOGRAPHY PRINCIPLE

- Provide image of radioactivity on a surface like standard radiography
- The **source** of radiation is also the **target to image**

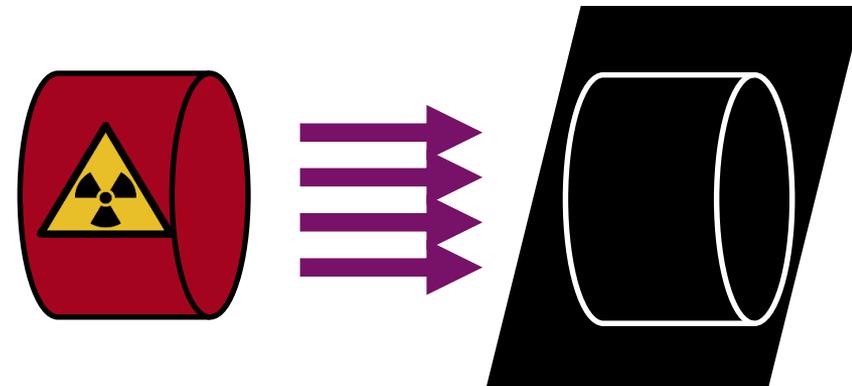


**No need for additional
radioactivity**

Radiography

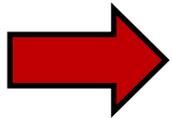


Autoradiography



AUTORADIOGRAPHY PRINCIPLE

- Provide image of radioactivity on a surface like standard radiography
- The **source** of radiation is also the **target** to **image**



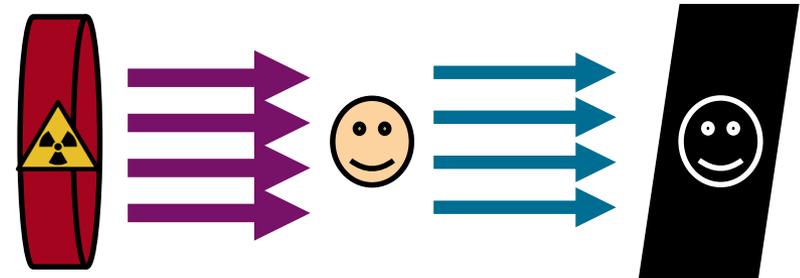
No need for additional radioactivity

- Widely used in bio-chemistry with radioactive tracers

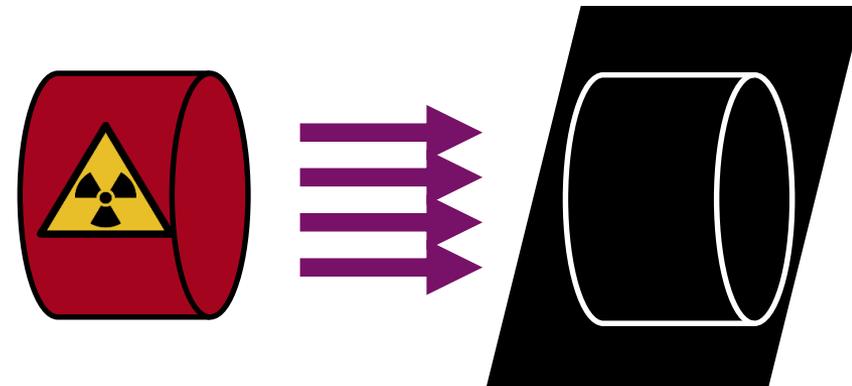


Mouse autoradiography

Radiography

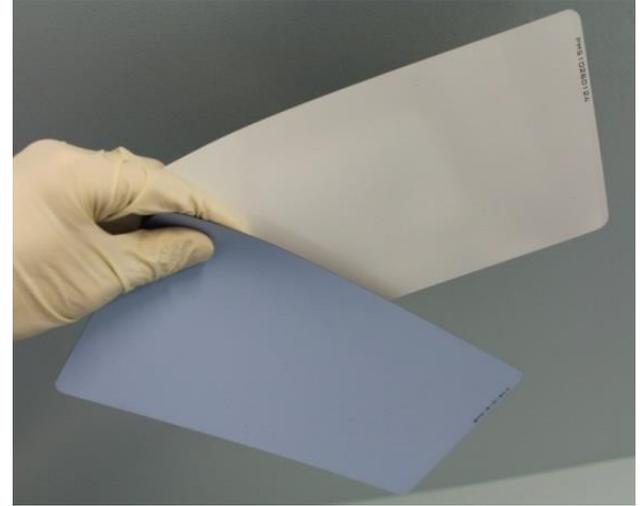


Autoradiography



Photography of Radioactivity

- Similar to old photographic film
- Storing radioactivity
- Can be revealed using a laser (or light)
- Signal intensity is proportional to activity

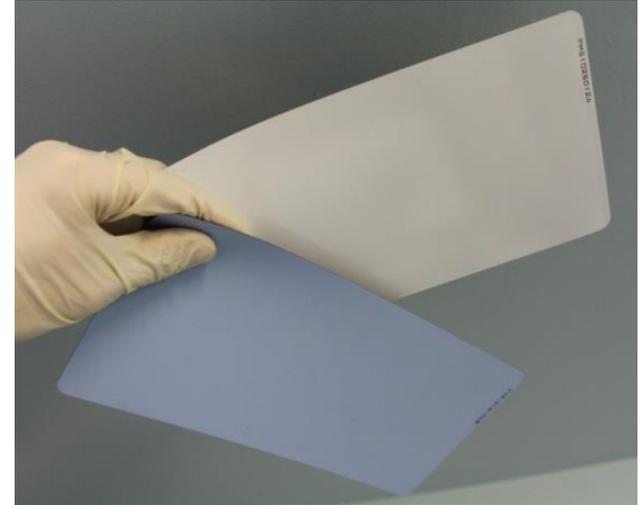
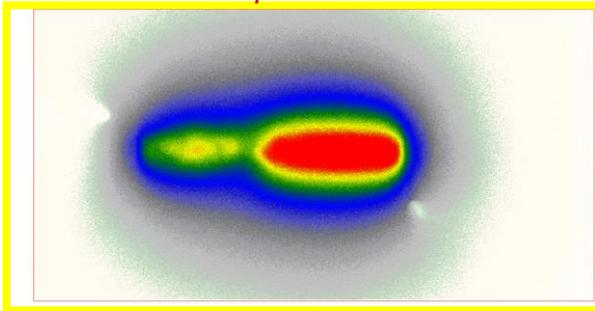


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Core sample from ^{129}I filter

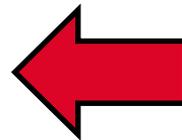
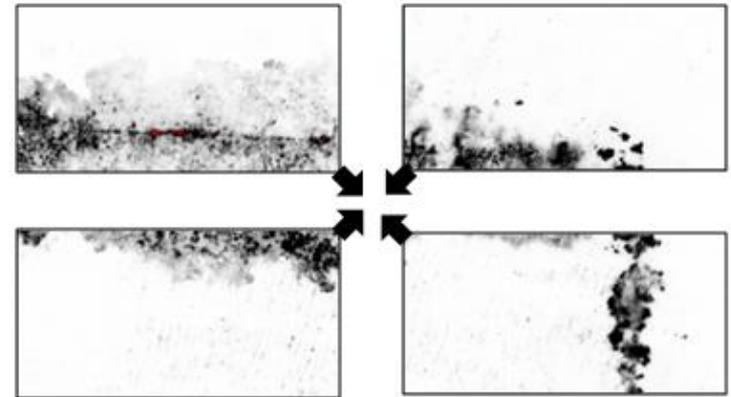
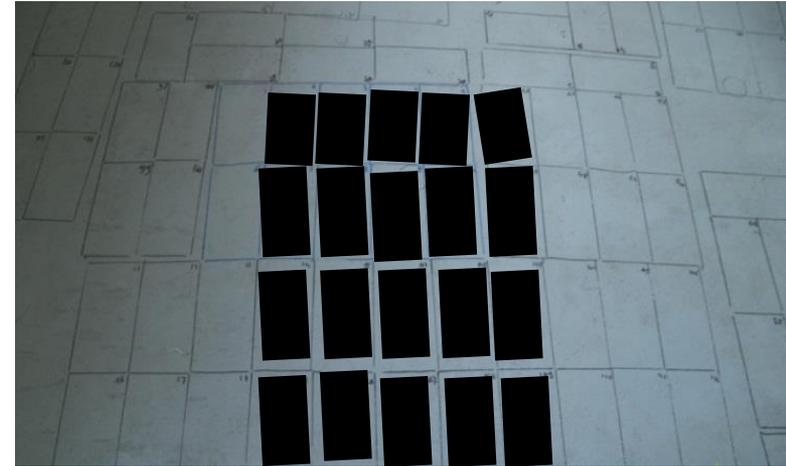
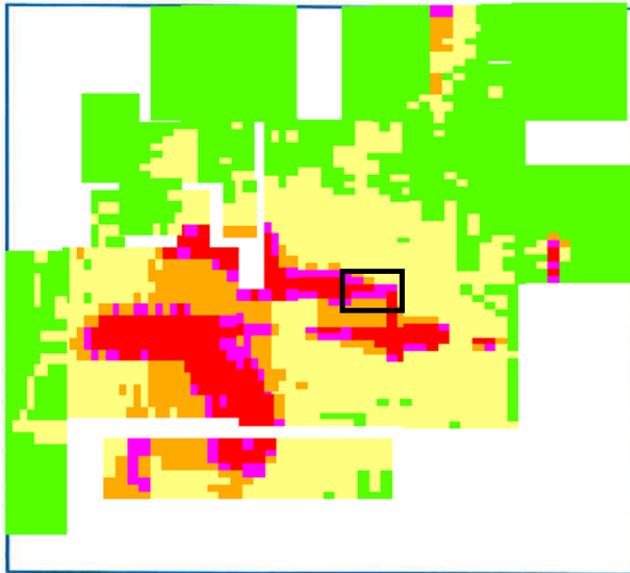


Perkin Elmer cyclone



Photography of Radioactivity

- Can be used in batches to map radioactivity
- Provide complete mapping of one area
- Help to localize contamination on surface at the scale of a facility

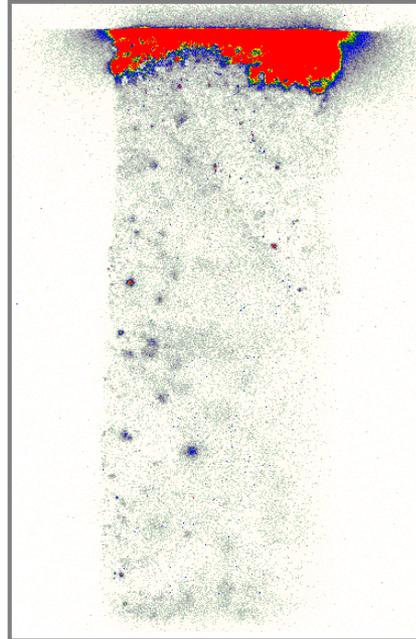


DEPTH CONTAMINATION STUDY

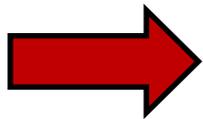
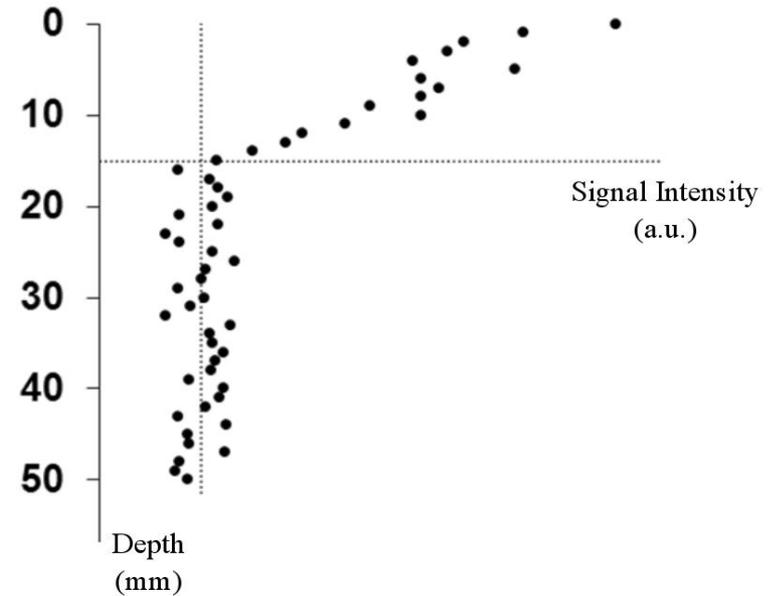
Concrete sample
with ^{14}C contamination



Autoradiography result



Signal evolution as a function of depth

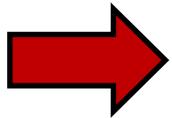


Autoradiography also provides a way to investigate alpha and beta contamination in depth

**MAUD PROJECT: TOWARDS A
INDUSTRIAL DIGITAL FIELD
DETECTOR**

Phosphor screen drawbacks

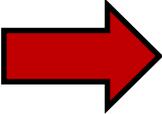
- Exposure time ? (24h+)
- Sensitive to ambient light
- Requires off-line analysis
- Radionuclide discrimination is difficult
- No industrial developments can be easily performed for dismantlement



**Autoradiography requires
development for dismantling
applications**

Phosphor screen drawbacks

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 **Autoradiography requires development for dismantling applications**

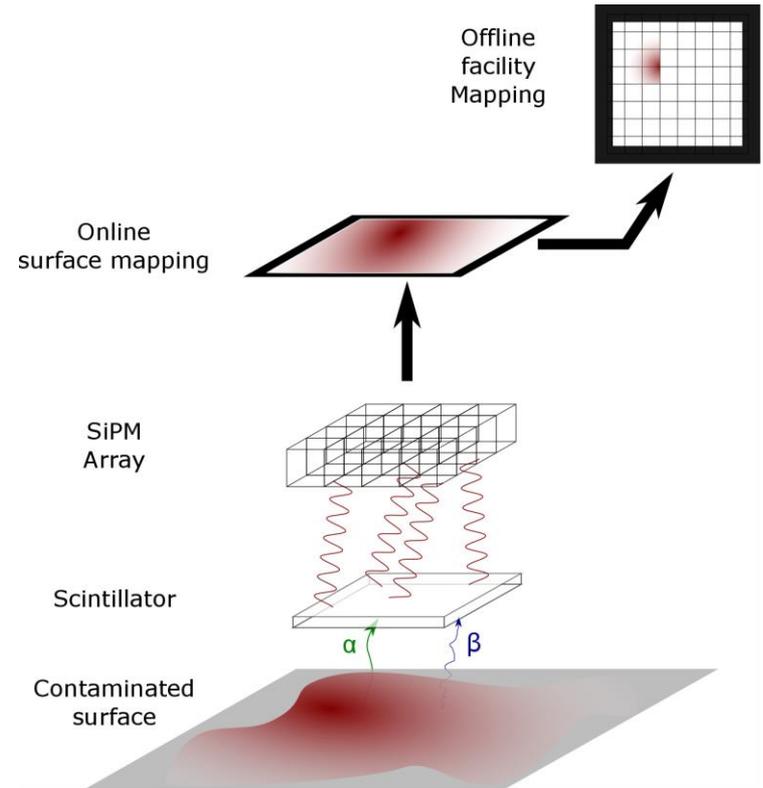
MAUD Project

- In situ measurement
- Real time measurement
- Radiations discrimination
- Developed for dismantling applications



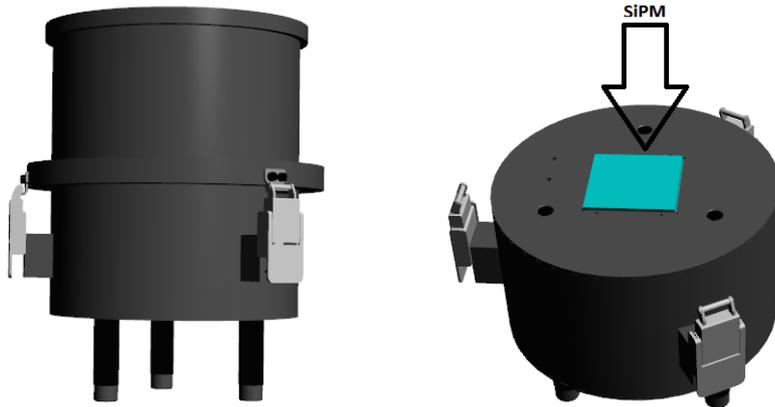
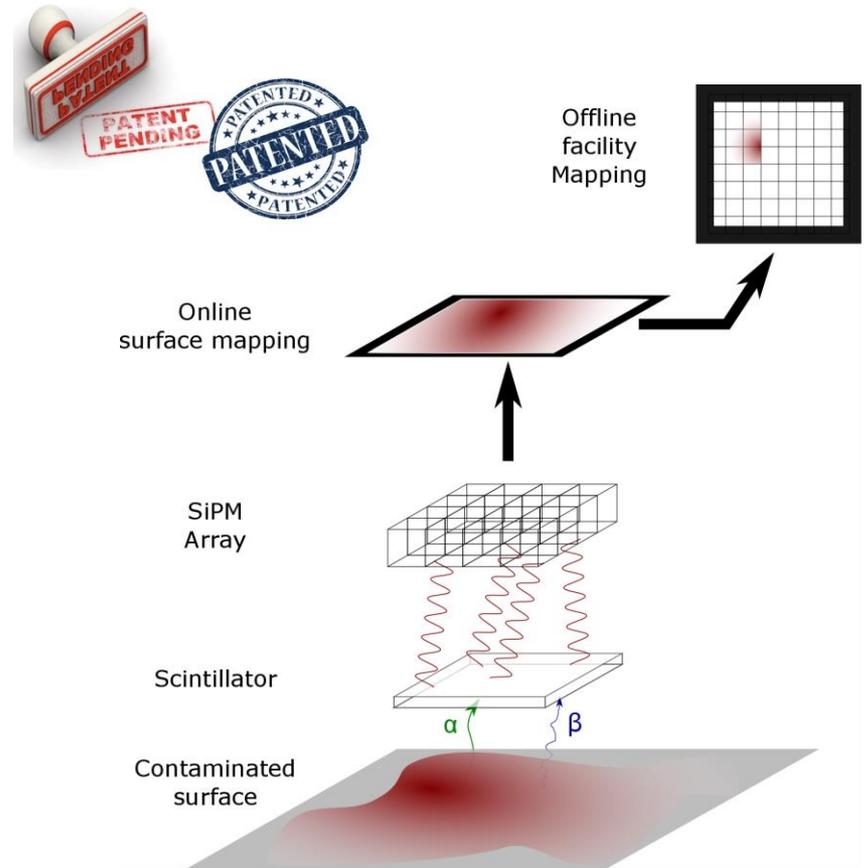
DESIGN OF A NEW TYPE OF DETECTOR

- Scintillation to detect radioactivity
- SiPM array to detect light
- Image resolution $\sim 25 \text{ mm}^2$
- Measurement of activity
- Sensitive to all α and β emitters (including tritium)



DESIGN OF A NEW TYPE OF DETECTOR

- Scintillation to detect radioactivity
- SiPM array to detect light
- Image resolution $\sim 25 \text{ mm}^2$
- Measurement of activity
- Sensitive to all α and β emitters (including tritium)
- First prototype in development

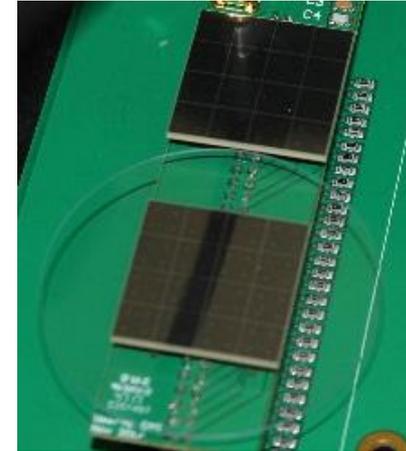


RADIOACTIVITY LOCALIZATION

β (^{36}Cl) source collimated (2mm)



SiPM + scintillator

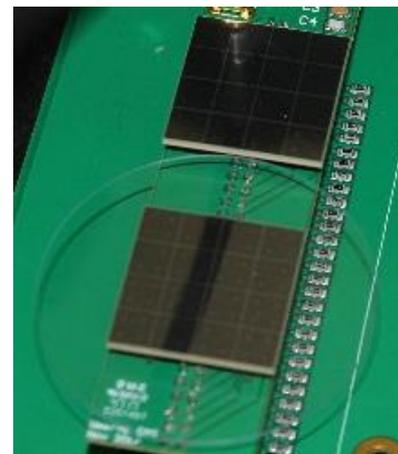


RADIOACTIVITY LOCALIZATION

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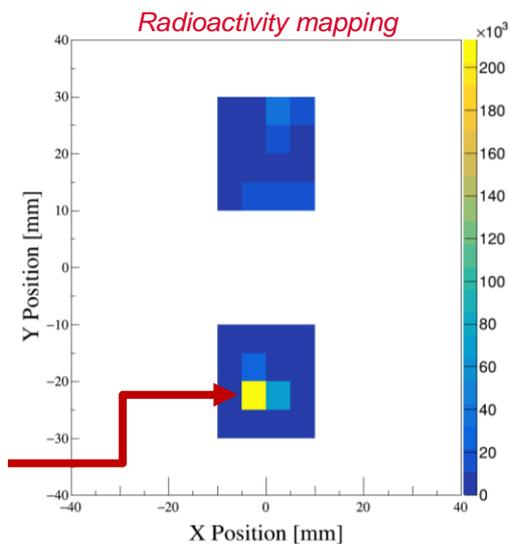
SiPM + scintillator



Preliminary results



Source location

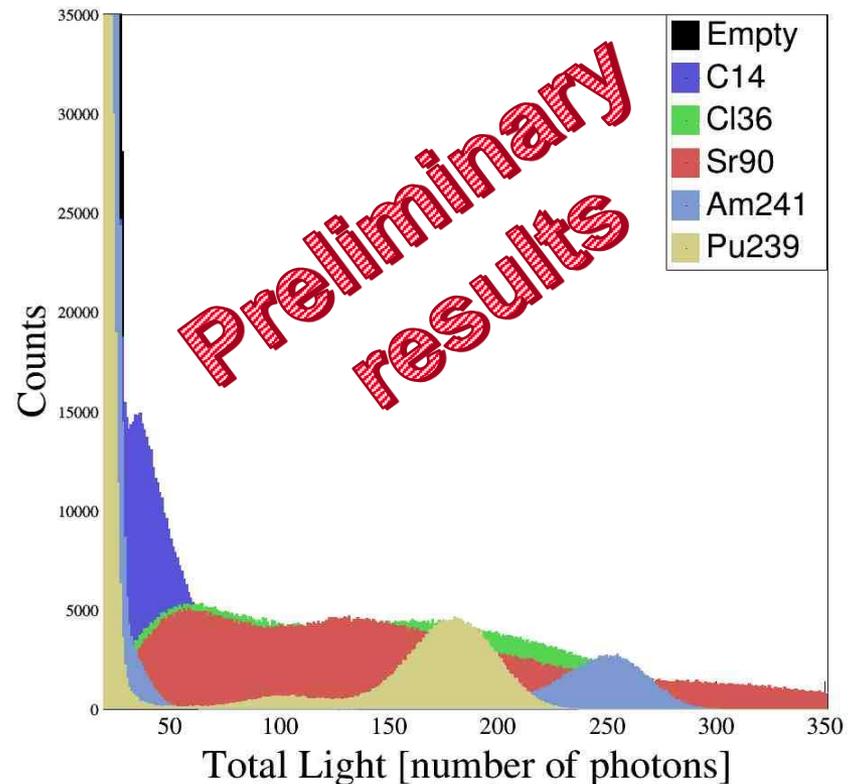


Light distributions

- Light collected is proportional to the energy loss in detector
- The radiation energy is unique for each radioisotope
- Contaminants can be characterized from the collected light distribution

Light distributions

- Light collected is proportional to the energy loss in detector
- The radiation energy is unique for each radioisotope
- Contaminants can be characterized from the collected light distribution
- Alpha and beta have very specific and distinct shapes



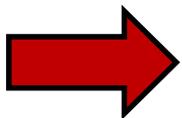
Autoradiography is a powerful tool for dismantling application

In-situ measurement
Radioactivity mapping
Depth contamination evaluation

However, current autoradiography
is not suitable for dismantling applications

MAUD project is aiming to develop industrial detector

Real time measurement
Activity estimation
Radionuclide characterization



Prototype detector will be tested in dismantling facility early 2019

Q & A



Commissariat à l'énergie atomique et aux énergies alternatives
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