

## The Challenge:

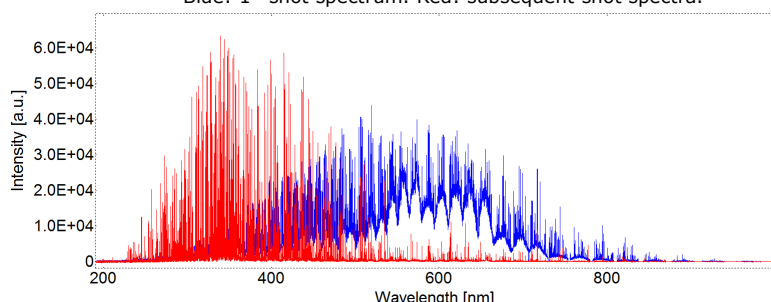
- Develop an innovative technique for materials characterisation inside the Windscale cave high-active environment.

## Overview/History:

- Laser induced breakdown spectroscopy (LIBS) has been used in various nuclear applications including power reactors, spent-fuel reprocessing plants and high-level waste plants.
- LIBS ideal for characterisation of metallic materials, impurities and surface contaminants.
- Requirement for a high resolution UV-vis-NIR spectrometer (Catalina EMU 120-65, with Echelle) identified due to complexity of spectra of some elements such as Zr, W, U, etc.
- Options for location of laser and spectrometer inside/outside cave and novel ways to guide laser light into cave/collected light to spectrometer evaluated.



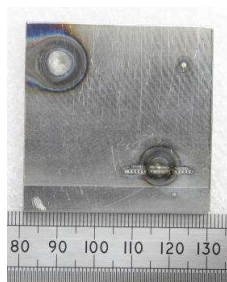
LIBS spectra from typical zircalloy clad materials.  
Blue: 1<sup>st</sup> shot spectrum. Red: subsequent shot spectra.



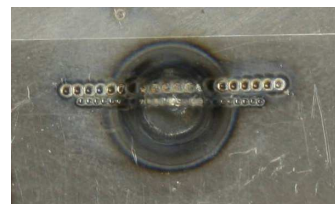
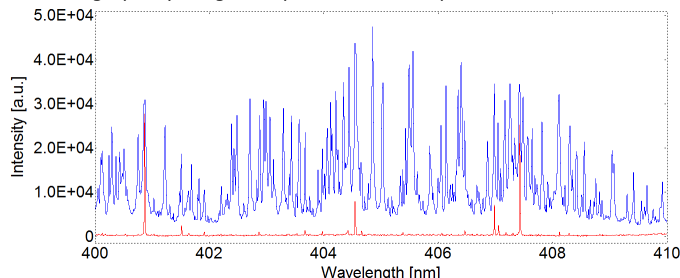
## Options for LIBS deployment identified by APL

1. "Through-Wall LIBS Endoscope" based on a suitably-modified wall plug with integrated optical path utilising laser-grade mirrors and fused-silica lenses and windows.
2. "In-Cell LIBS Head" incorporating a compact, radiation-hard pulsed laser plus beam focussing optics and plasma light collection optics. This design was first proposed by APL for use within a hot cell facility at Oak Ridge National Laboratory in the USA.
3. "Advanced Fibre-Optic LIBS Probe" of a design similar to that used at the Irradiated Materials Examination Facility (KAERI, Daejeon City, Republic of Korea).
4. "Compact Fibre-Optic LIBS Probe" of a design similar to that used at the Waste Vitrification Plant (Sellafield).

## Option 1 pursued for NNL application.



Identification of tungsten on zircalloy surface from TIG weld tips.  
Red: high purity tungsten spectrum. Blue: spectrum in affected area.

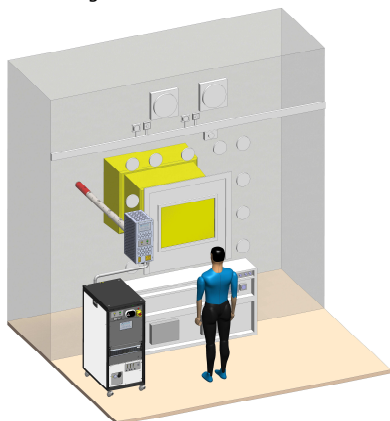


Line scan across affected area maps approximate levels of material on substrate.

## Approximate dimensions of periscope wall plug.

Length 1.4 m. Diameter 88.0 mm then 98.5 mm.

CAD image of cave workplace and LIBS equipment.



Development from lab bench LIBS system to wallplug delivery system.



## Validation and testing:

- Test pieces analysed on the bench system have been re-analysed using the wall plug periscope delivery system.
- Analytical performance of the periscope wall plug LIBS system proven to be comparable to that of the bench-top LIBS system.
- TRL7 achieved, TRL8 scheduled for October 2017.