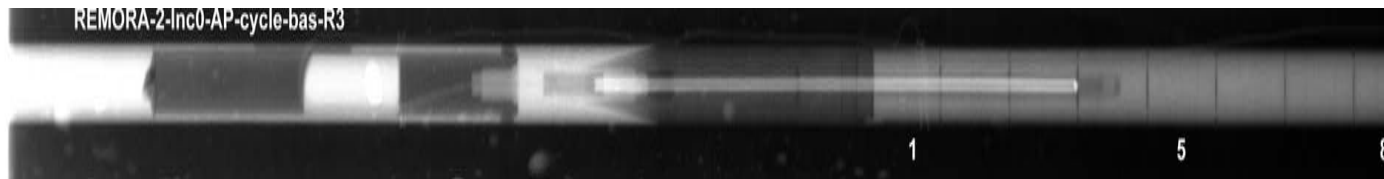


New digital sensor for radiography

Francis BERDOULA



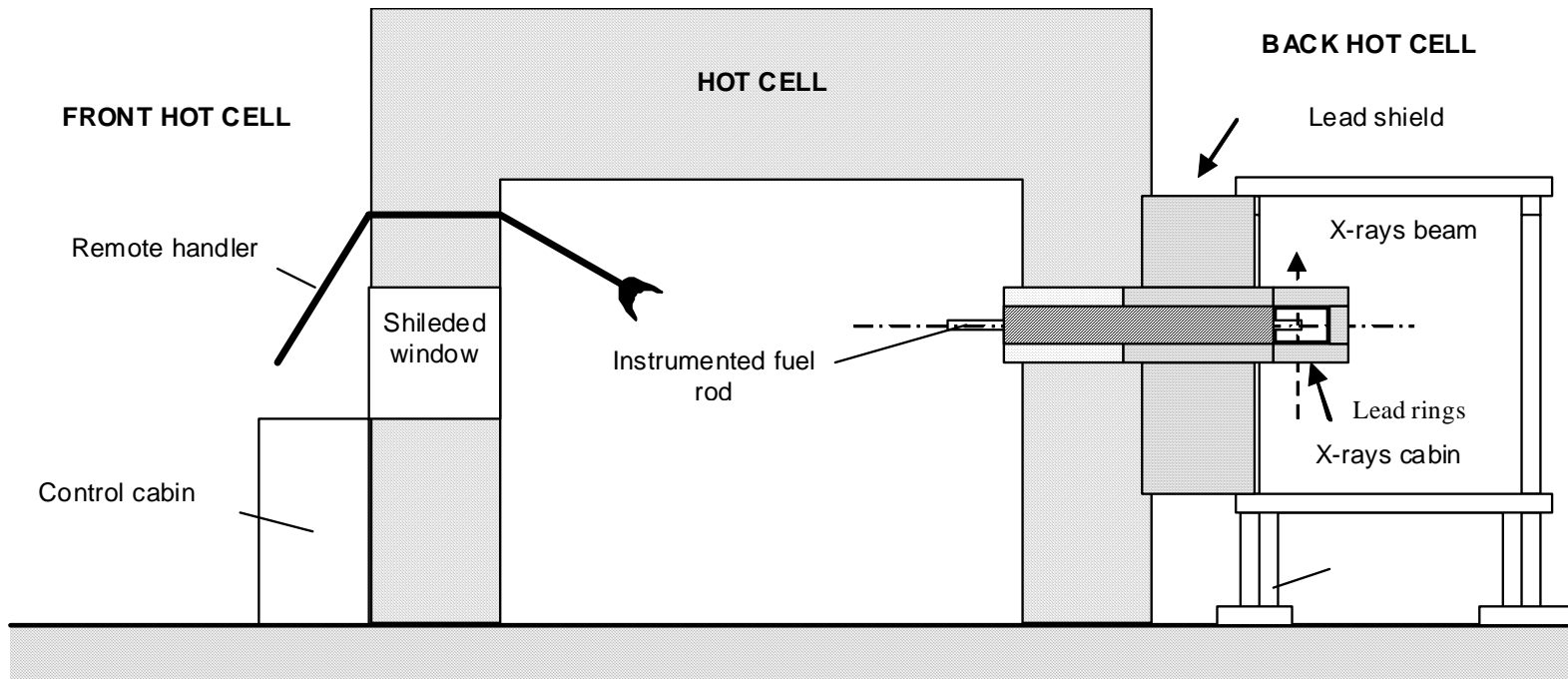


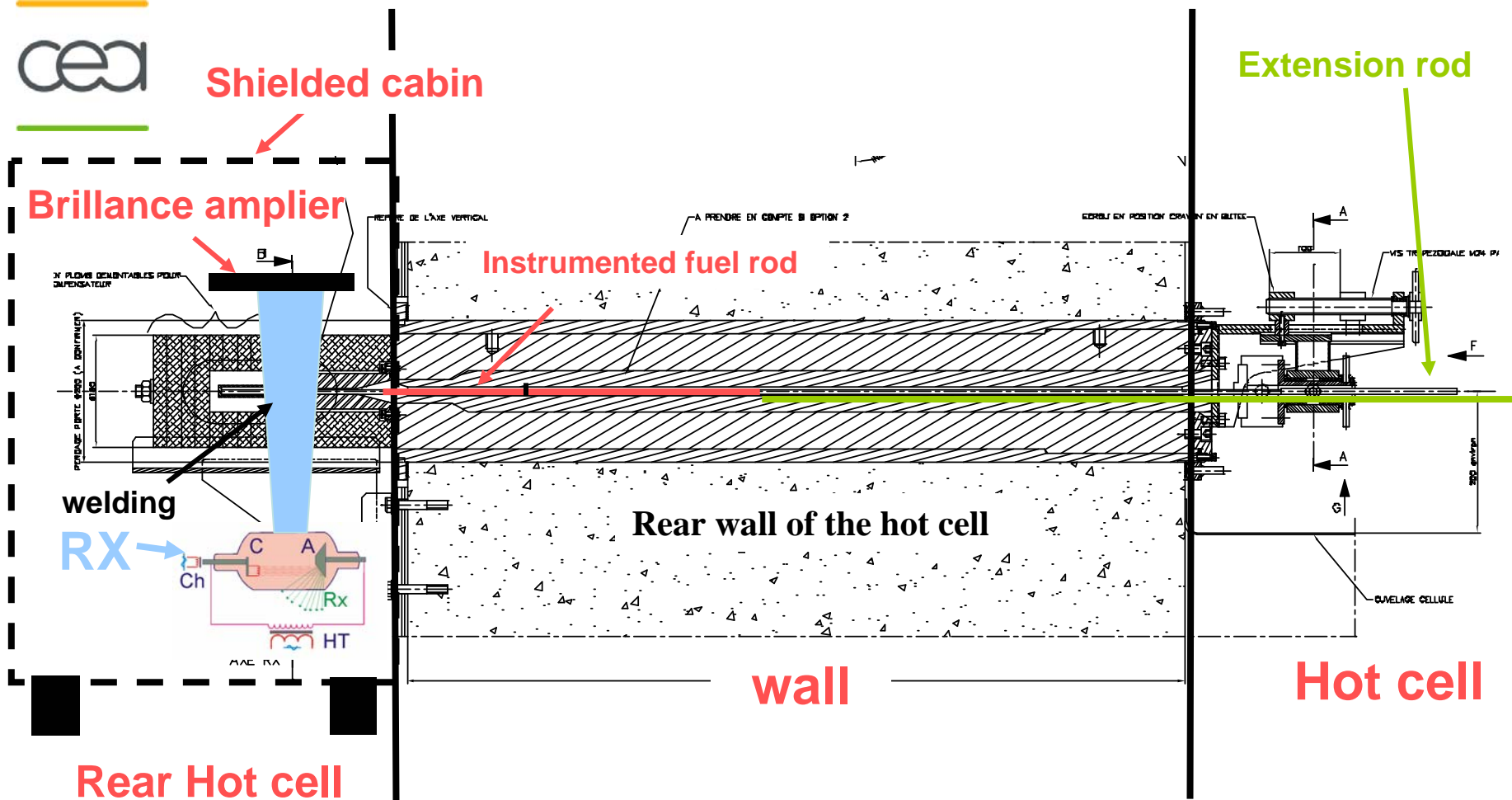
Contents

- Introduction : Overview X ray equipment in Hot laboratories (LECA Facility in Cadarache center)
- Objectives : X-ray weldings inspection for instrumented fuel rods
Brilliance amplifier,
 - ◆ *Zircaloy compensator,*
 - ◆ *Collimator.*
- X-rays views :
 - image contrast is significantly affected by strong noise background,
 - Difficulties to measure welding depth,
 - Permanent defaults,
 - Cracks and voids can be hidden with the noise background.
- Solutions :
 - ◆ *implementation of a new X ray digital sensor :*
 - A real-time radiographic system,
 - Enhance the image contrast,
 - Measure the defaults.
- Conclusion



Overview : X ray equipment in Hot cell

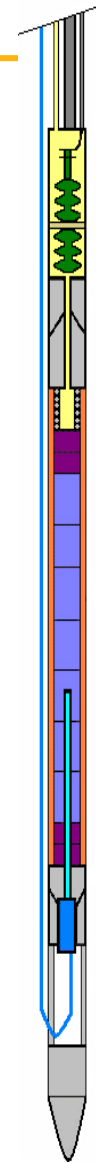
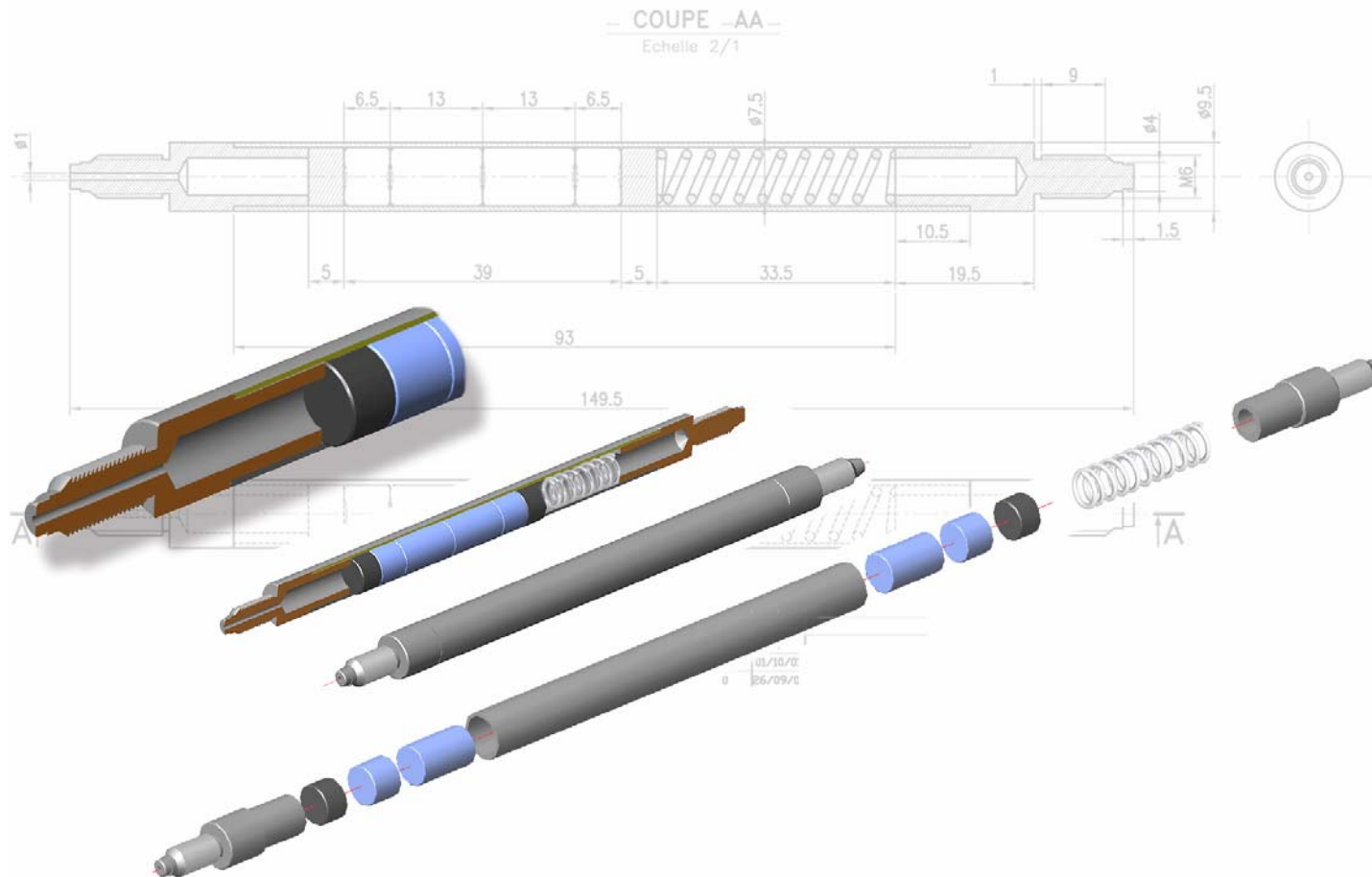
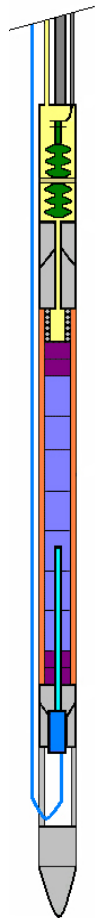




- The fuel rod is locked to an extension rod, then translated until the X-ray beam



Objectives : X-ray weldings inspection for instrumented fuel rods





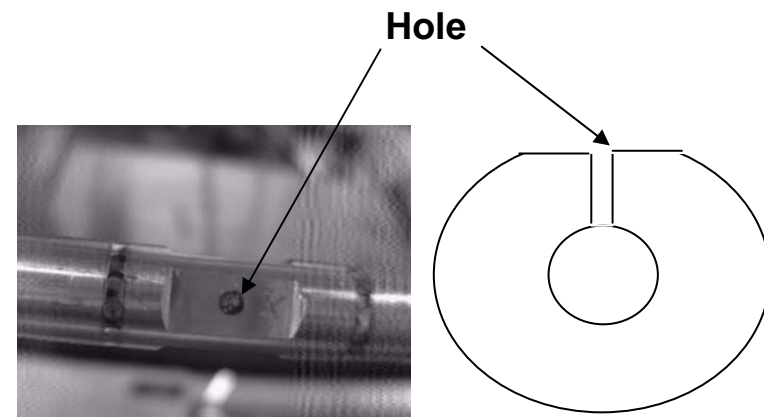
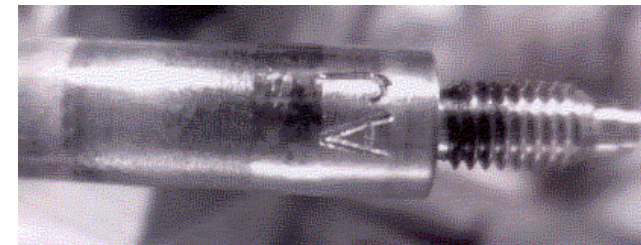
X ray inspected area

Circumferencial welding end plug

Check quality of welding along
3 axis (0,120 et 240°)

Sealed and welded hole

Check and measure welding depth



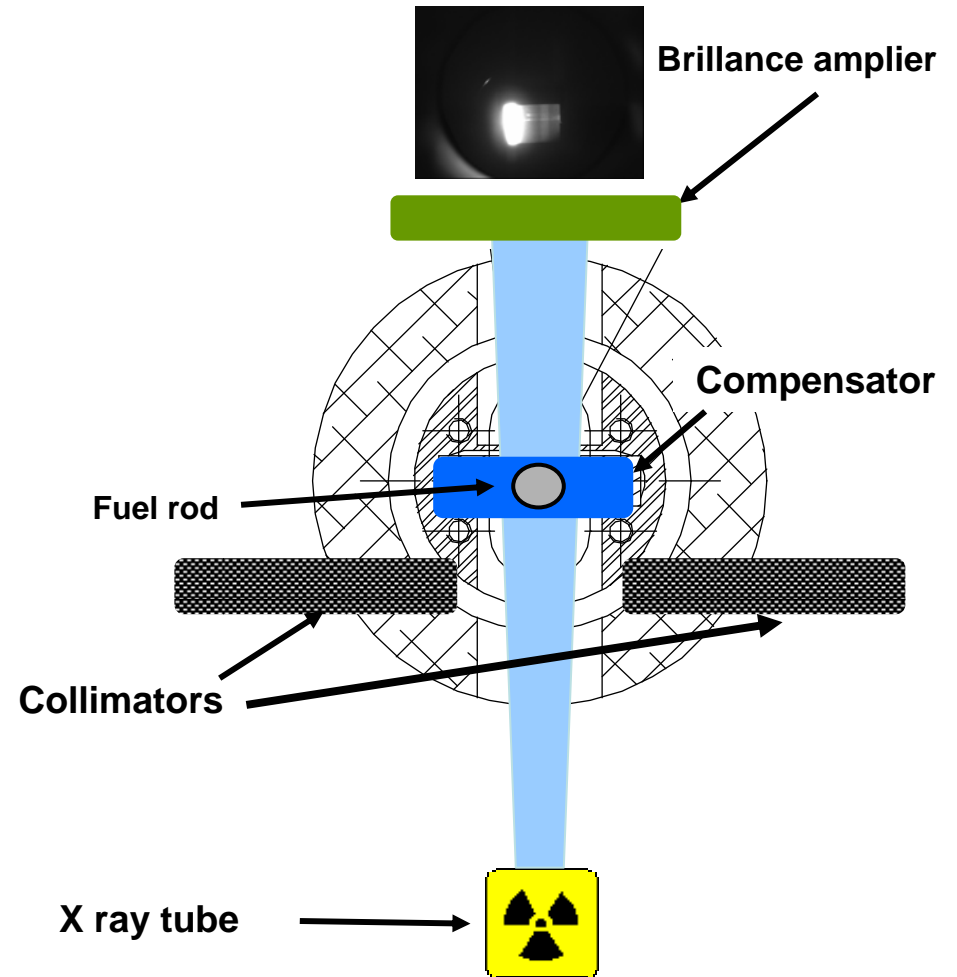

Front view

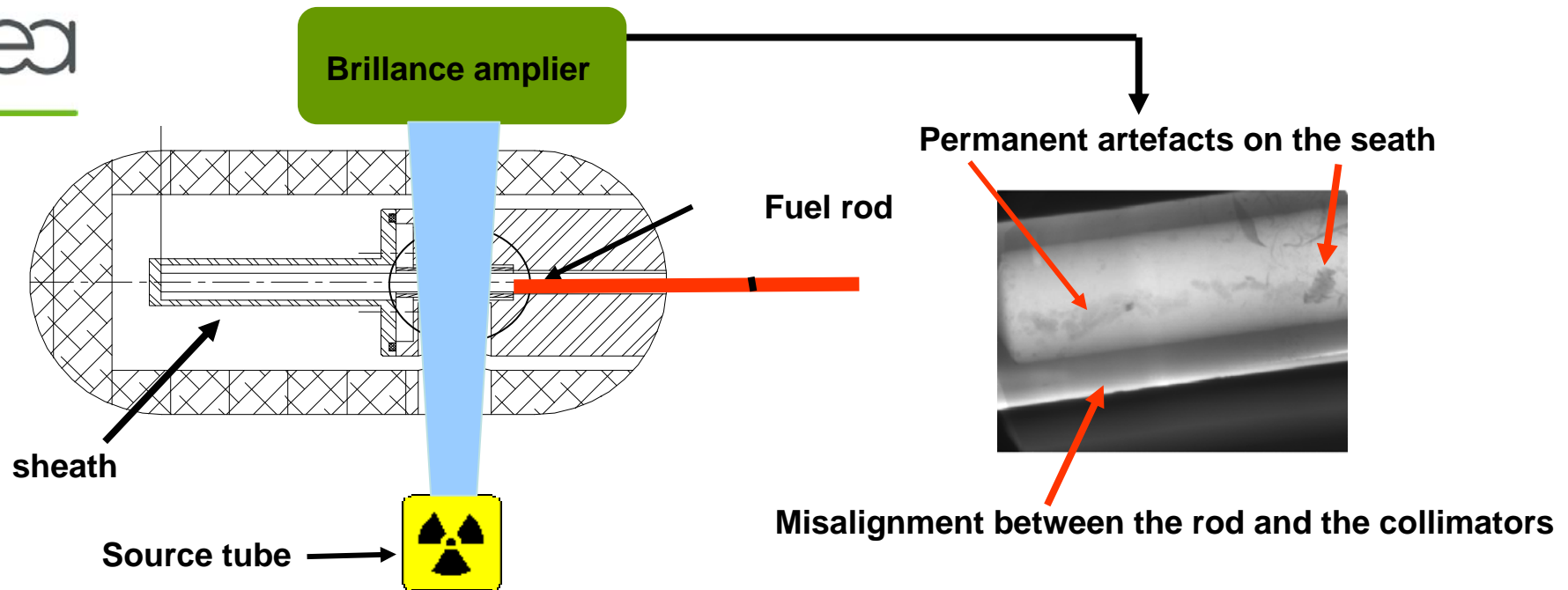


ZIRCALOY COMPENSATOR AND COLLIMATOR

- **Objectives** :
 - Enhance the image contrast,
 - Limit the noise background

Misalignement increase noise background



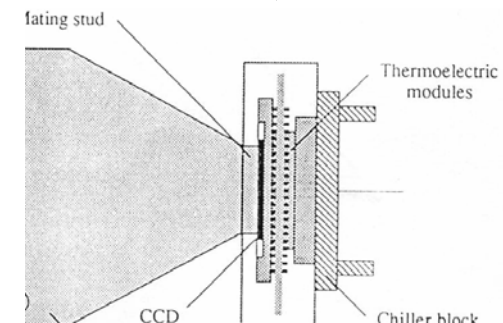
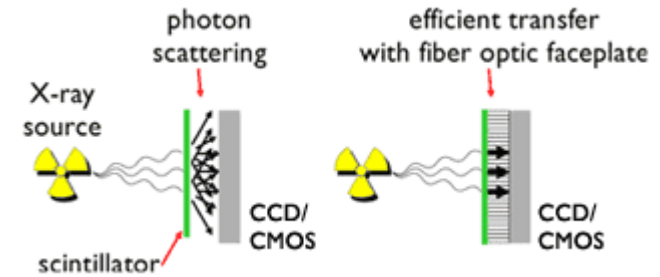


- Difficulties to handle and center the rod from the inside hot cell,
- Noise background → difficulties to measure the welding depth
- The final radiography view is low contrast



Solution : New digital sensor

- Implement a New Digital sensor (reliable fiber-to-sensor interface),
- Use of a fibre optic is the best option for protecting the CCD sensor against X-ray degradation,
- better image resolution,
- more efficient light collection and transmission,
- tapered, buttable modules can image larger areas.





This is an image contrast enhancement algorithm that overcomes limitations in standard histogram equalization (HE).

The two primary features is :

- adaptive HE (AHE), which divides the images into regions and performs local HE,

- the contrast limited AHE (CLAHE), which reduces noise by partially reducing the local HE.

- Bilinear interpolation is used to avoid visibility of region boundaries.



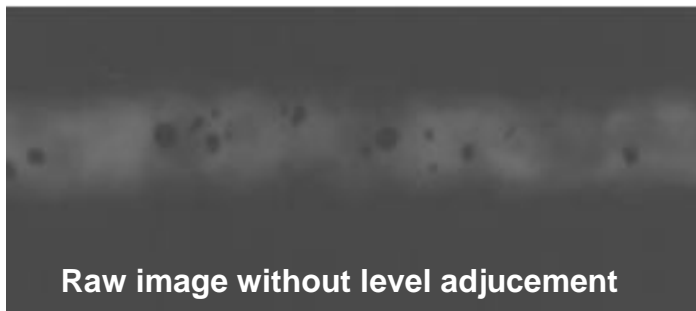
CLAHE

The aim of image enhancement is :

- To improve the perception of defects for operators,
- Or to provide `better' input for other automated image processing techniques.



Examples of digital treatment of radiographic views (1)



Original radiographic image

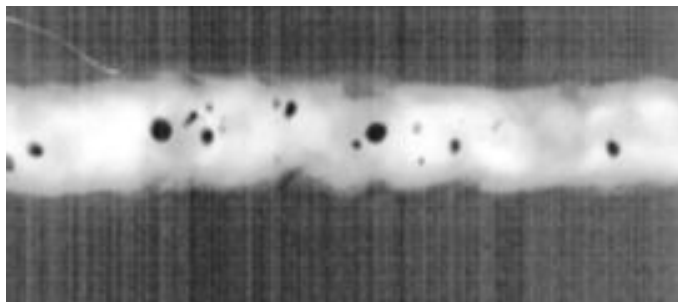
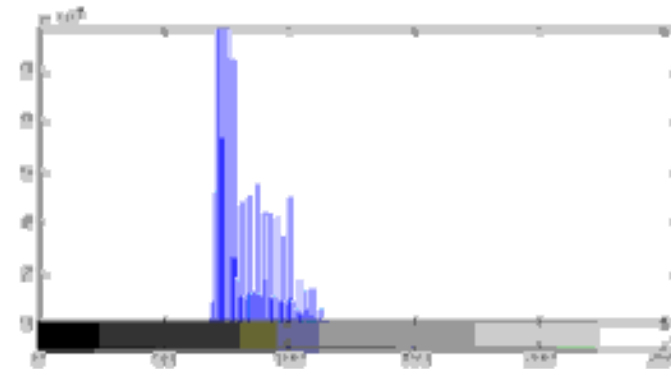
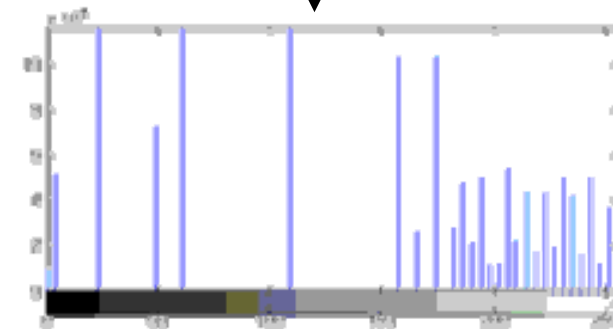


Image after histogram equalization (Histogram equalization)



Histogram of original image



Histogram after equalization



Examples of digital treatment of radiographic views (2)

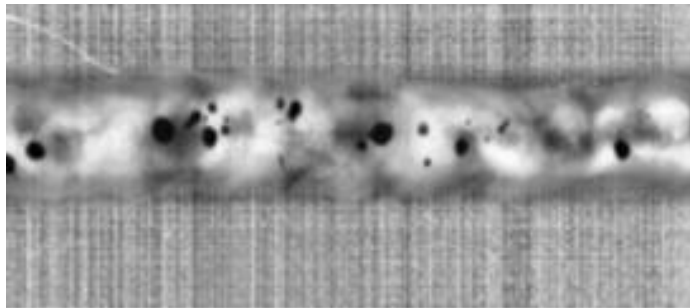
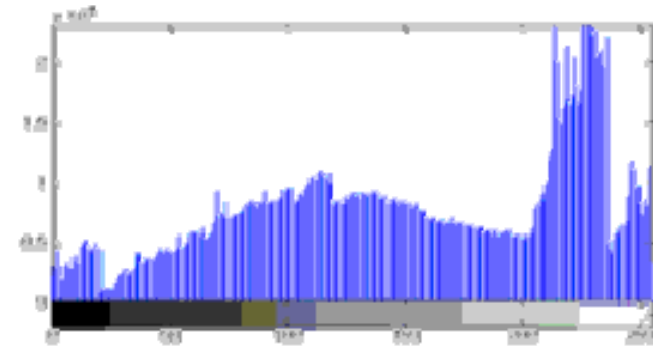


Image after AHE (contrast Histogram Equalization)



Histogram after AHE (contrast Histogram Equalization)

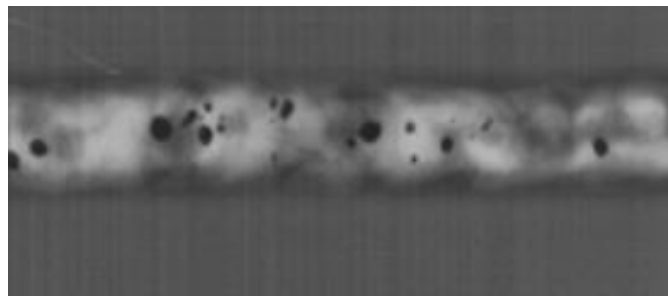
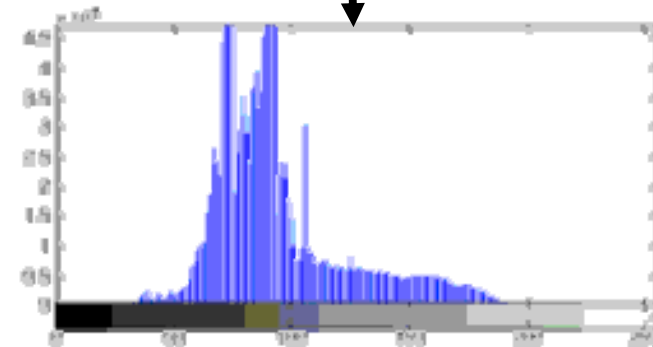


Image after CLAHE (Contrast Limited Adaptive Histogram Equalization)

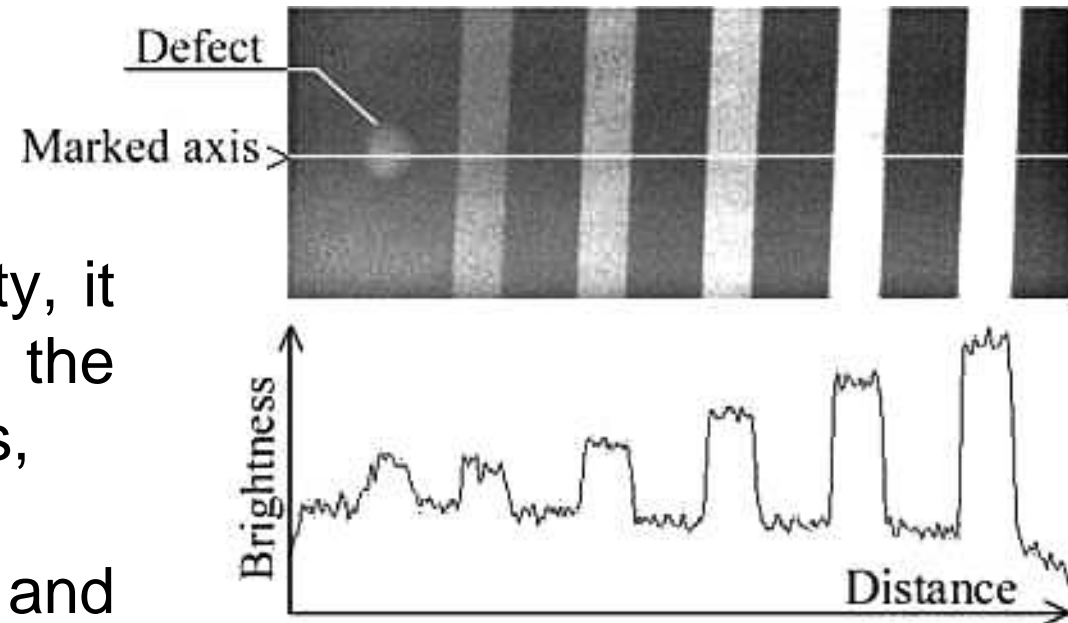


Histogram after CLAHE (Contrast Limited Adaptive Histogram Equalization)



To validate the weld quality, it is important to determine the dimensions of weld defects,

the main idea is to locate and measure the image brightness of the defect and compare it with that of defectless area.





Projects : automatic inspection

- The automatic digital processing of radiographic images has advantages over an operator as the decision-maker. These advantages are primarily not to be a X ray expert to evaluate flaws,
- A fully automatic X-ray testing system with electronic image analysis is studying. It will permit the quantitative evaluation of flaws and enhance the safety of quality control. In industry, comparison of both test methods shows that the decisions of the fully automatic system are more conservative and of a higher reproducibility than those gained with visual inspection,
- So, it is possible to use computer vision to detect the defects instead of a human being. **Image enhancement is a significant part for automated radiograph inspection systems.**



● **New digital sensor implemented successfully :**

- ◆ *Eliminate the noise background (misalignment fuel rods, gap between sheat and rods),*
- ◆ *Substract permanent defects,*
- ◆ *Enhance final image contrast,*
- ◆ *Measure of welding depth,*

● **Projects :**

- ◆ *Invest in automatic inspection equipment to help the operator in evaluation of flaws.*



THANKS YOU FOR YOUR ATTENTION !