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IRSN
INSTITUT DE RADIOPROTECTION ET DE SÛRETÉ NUCLÉAIRE

IER 296: TEX-MOX EXPERIMENT PREPARATION

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MEMBRE DE
ETSON

Outline of the talk

Overview/reminder of TEXMOX motivation

Summary of CED-2

Single slide on prototype system

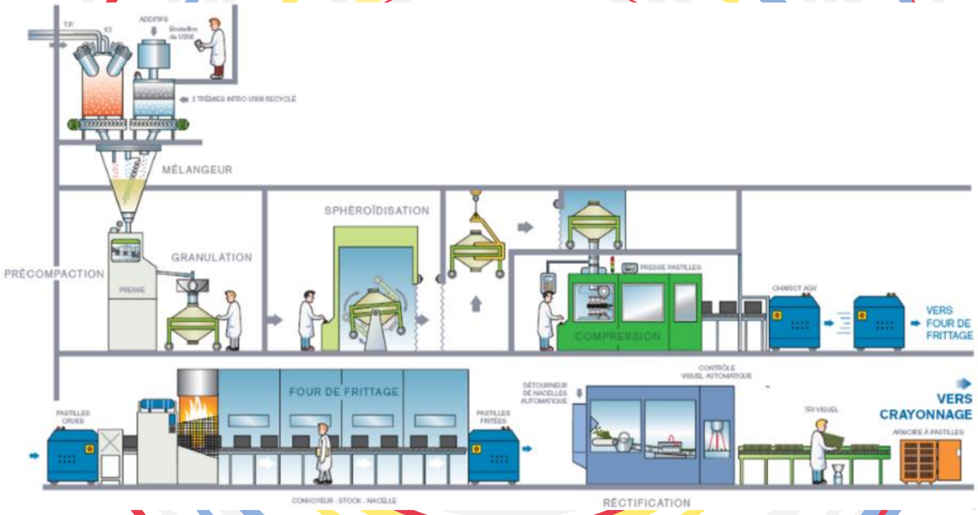
Overview of Fiber Bragg system

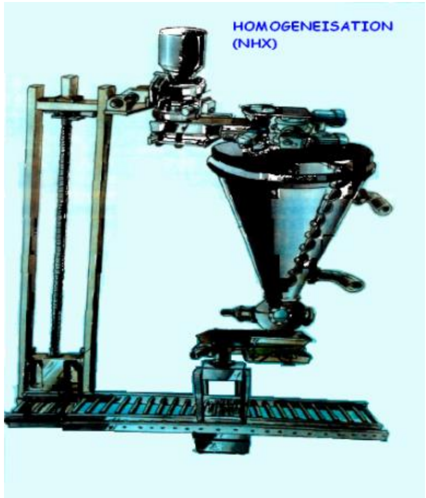
Results of Fiber Bragg system

Motivation

For fuel fabrication and criticality safety issues, moderator quantities are very low

In many units, only the powder humidity (few %) is considered





Majority of configurations are in the intermediate energy spectra

Motivation

Needs for ^{238}U, ^{235}U, ^{239}Pu, ^{240}Pu, ^{241}Pu

Unfortunately, there is a lack of good quality experimental data for these isotopes and energy spectra

Huge impact on the production by limiting the mass allowed or the Pu content in French MELOX facility

The TEX Pu results highlighted C-E 1000 pcm bias with JEFF3.1.1 just for 239Pu

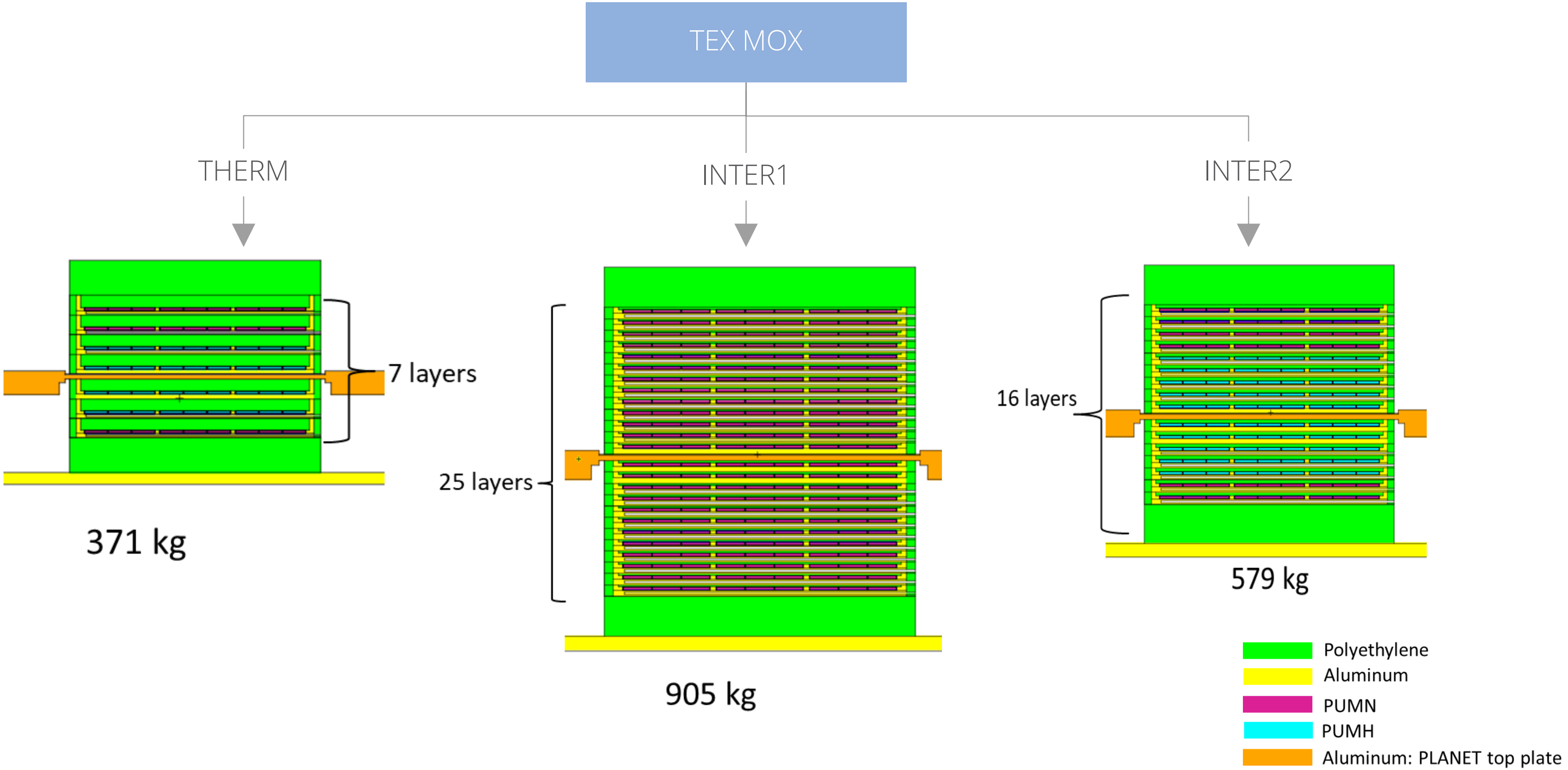
Consequence: a 2000 pcm bias is considered in the upper safety limit (USL)

Is 2000 pcm bias enough to bound the lack of validation?

This experimental needs were identified by NEA/WPNCS SG5:

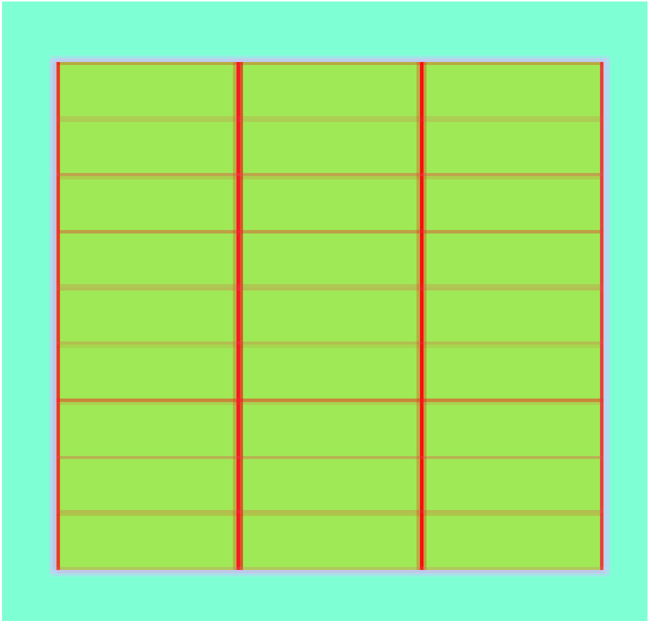
- 238U and 240Pu : 1st priority
- 239Pu and 235U : 2nd priority

Summary of TEXMOX



Summary of TEXMOX

- **Fuel :** ZPPR plates
  - PUMN (Pu/Pu+U weight ratio of 28.8%, ^{240}Pu content of 11.6%)
  - PUMH (Pu/Pu+U weight ratio of 34.9%, ^{240}Pu content of 26.4%)
- **Spacer:** Aluminum
- **Moderator:** Polyethylene
- Optimized to match with French industrial application cases provided by ORANO



1 layer : 27 6" PUMN plates

Summary of CED-2

Thanks to LLNL and LANL reviews

CED2 officially published by IRSN February 15th 2024

Descriptions of fuel plates

After measurements campaign in June 2023

THERM configuration :
Ck around 0.8 - 0.9

INTER1 &2 configuration :
Ck around 0.7 - 0.9

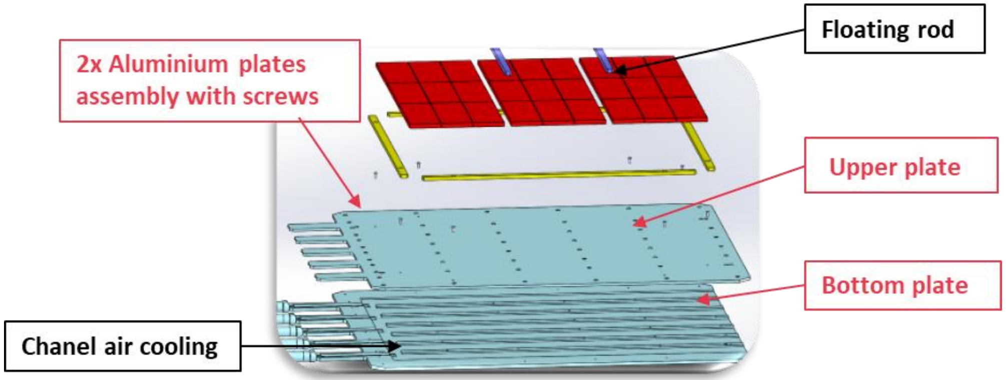
Models proposed and their optimization to match application cases

Uncertainties assessment

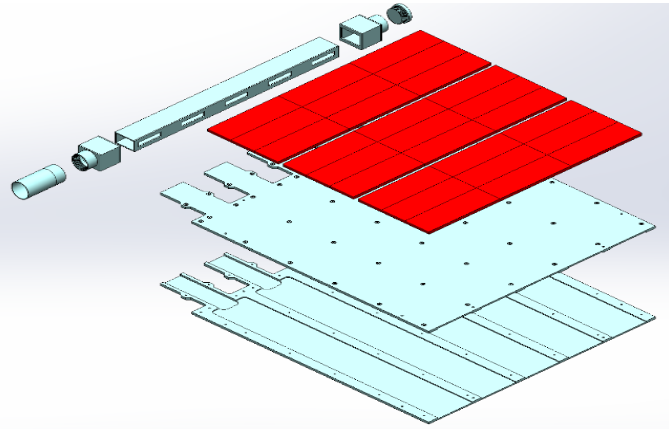
- Mass, impurities, dimensions, gaps…
- Densities: up to 150 pcm
- Select high purity aluminum and HDPE (up to 90 pcm)
- Total : up to 200 pcm

Summary of CED-2

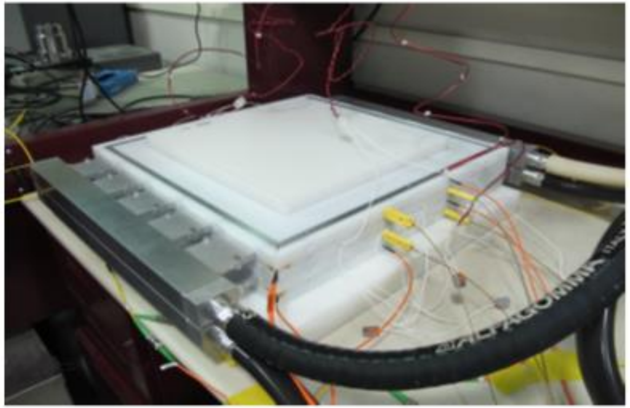
- Thermal Challenges
  - As reminder, ZPPR plates involve ^{241}Am
  - → Thermal power 250W to 550W (whole stack)
  - Potential temperature w/o cooling system: above 60°C
  - Cooling system designed to address this concern

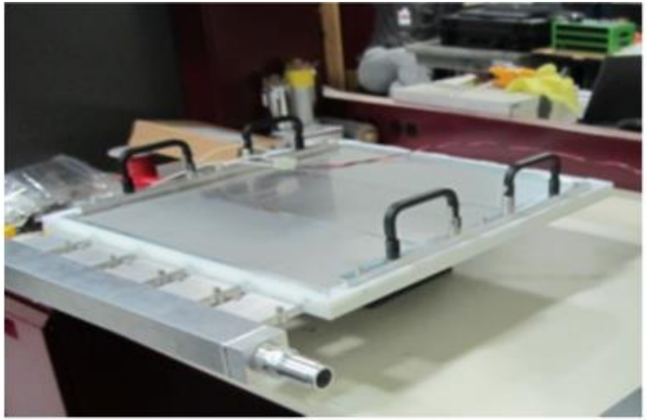


- Collaborative work between LANL and IRSN on thermal behaviour and cooling system
  - Active cooling system is efficient to warrant temperature below 40°C (313K) during the experiment
  - If the fans are off, passive cooling is sufficient to maintain CH2 temperature below 60°C (333K)



Prototype



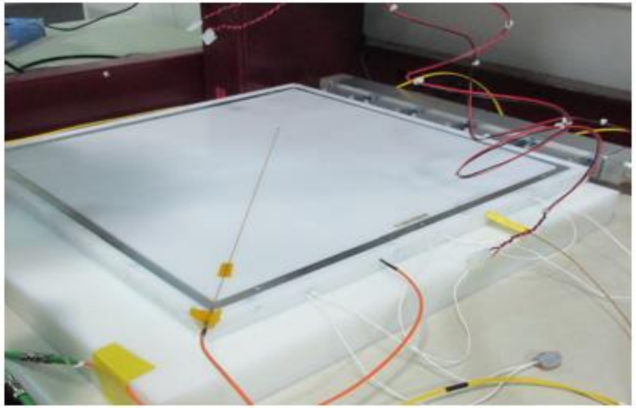


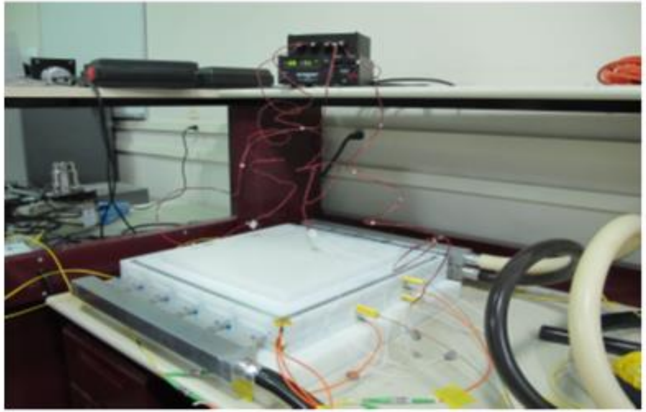
- Need of a prototype to test

- The design itself:
  - Will there be any leakage?
  - Any difficulty to handle it ?
  - How do we connect it to extraction system with hoses ?

- The performance of the design:
  - Any thermal gradient?
    - Vertical or horizontal ?
  - Behavior of the system with different heating powers (mimick PUMN and PUMH)?

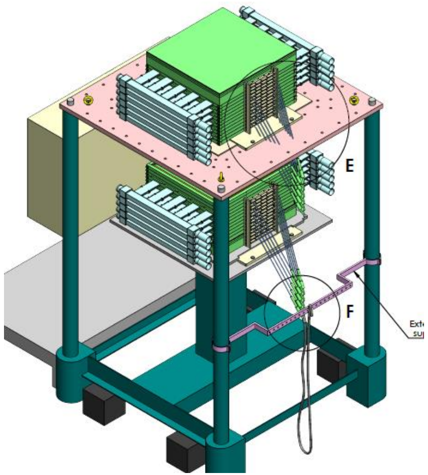
- See Nick's following talk.

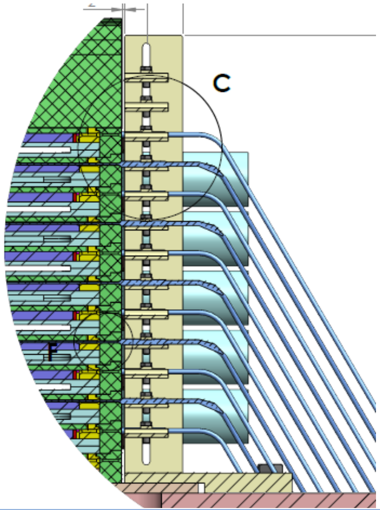


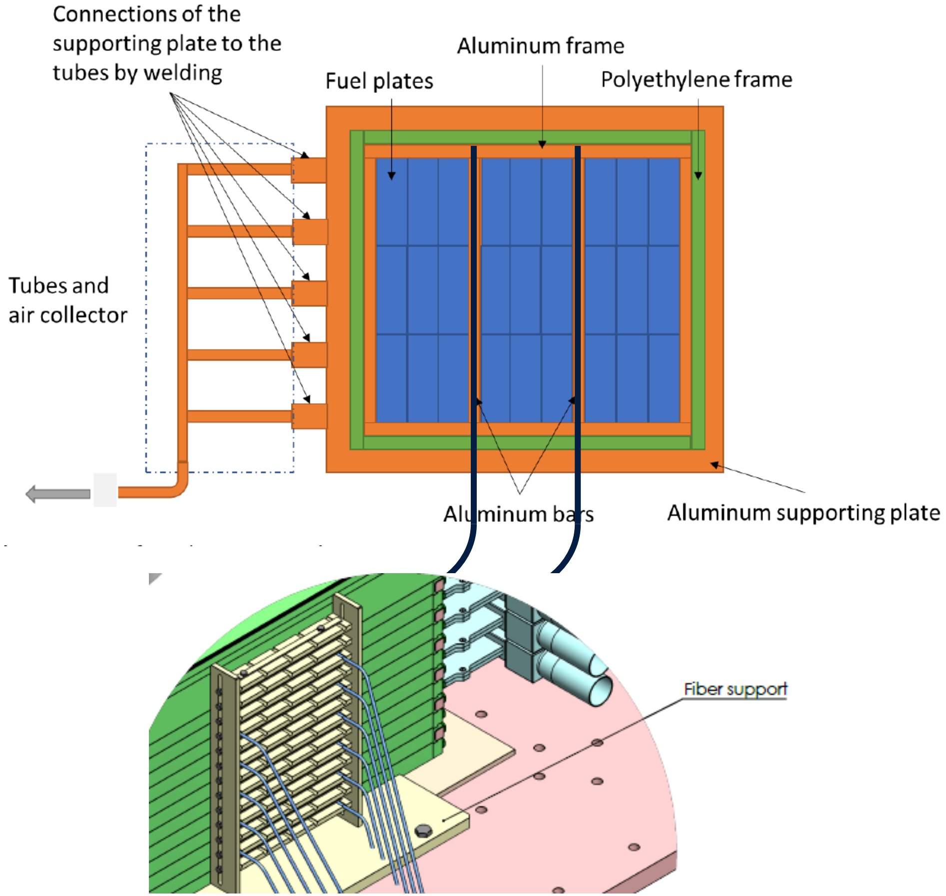


Fiber Bragg Grating (FBG) temperature probes

- FBG can be inserted into the Aluminum bars
- That is to say up to 20 temperatures per layer
  - Horizontal gradient can be identified
- Need of an holder close to the stacking

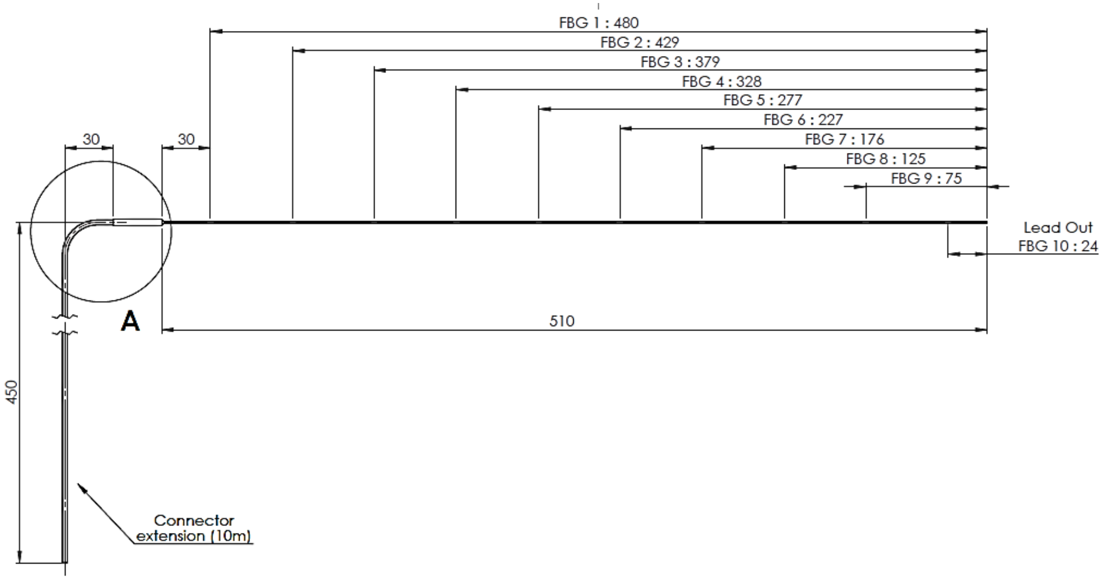


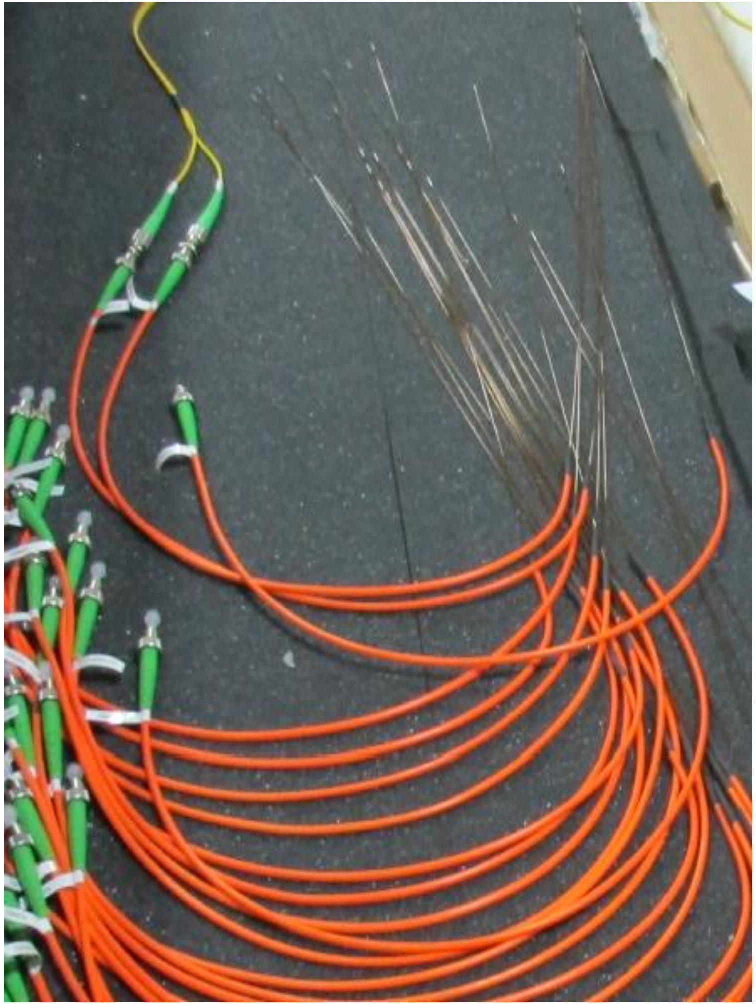




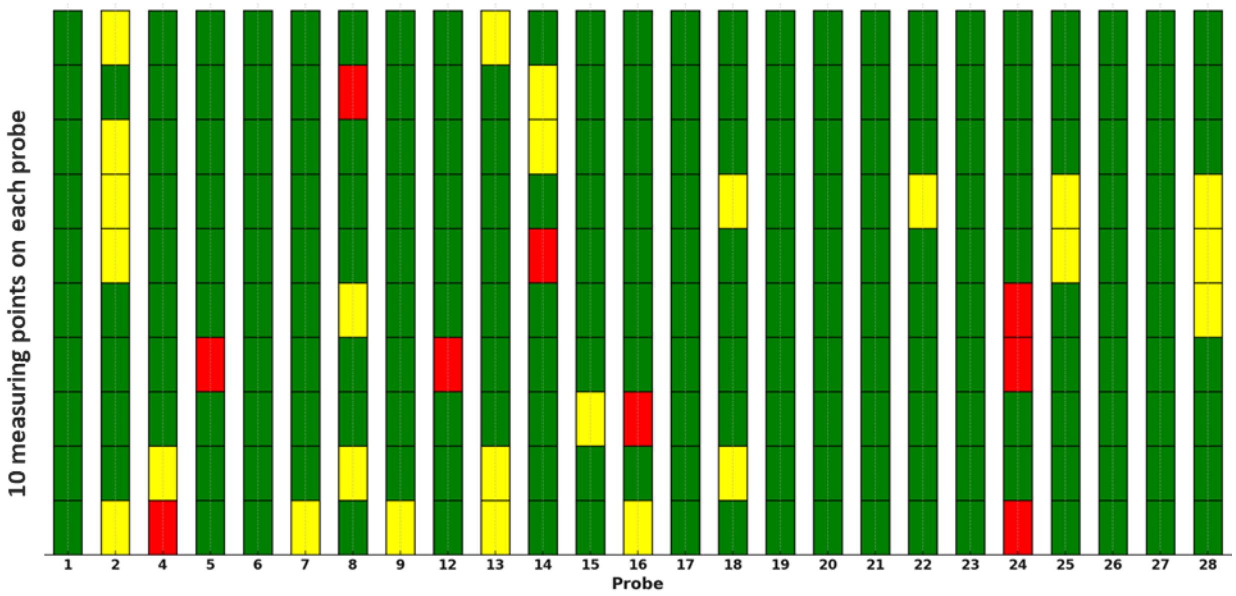
Fiber Bragg Grating (FBG) temperature probes

- IRSN purchased 28 FBG probes (and all DAS) for TEXMOX experiments
- Calibrated in August by the vendor (with IRSN assistance)
- Tested in September @ Los Alamos with LANL and IRSN team on the prototype





Fiber Bragg Grating (FBG) temperature probes



- **Majority of Measurements are Green** : Indicating sensors are functioning well, with measurements within ±1°C of the global average.

- **Moderate Deviation Yellow** : Deviation between ±1°C and ±1.5°C from the global average.

- **Significant Deviation Red** : Deviation greater than ±1.5°C.

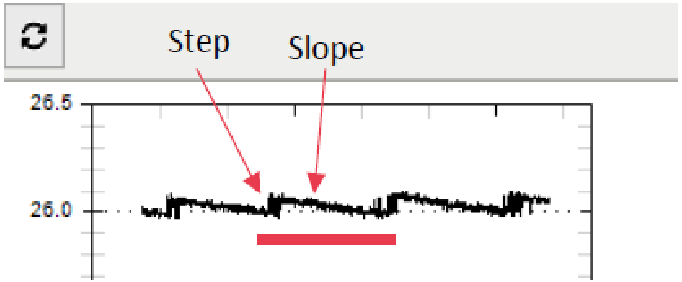
Fiber Bragg Grating (FBG) temperature probes

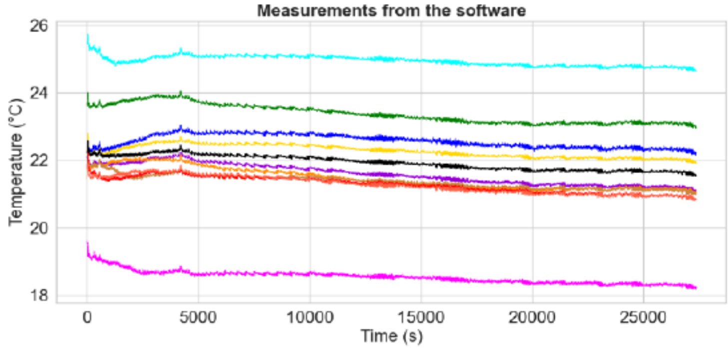
- Non-continuous behavior with steps and slopes
  - → only a variation of +/-0.1°C : negligible

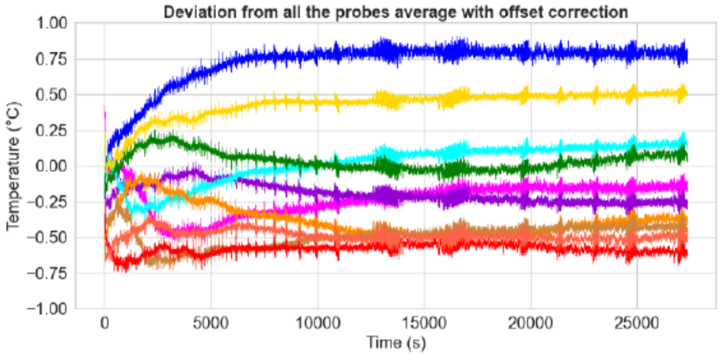
- Discrepancies between sensors directly from software
  - Up to +/- 3°C

- Possible to correct the offset to handle this problem
  - Propositon from the vendor
  - In fact, some mechanical stress can change the offset temp.
  - With correction done after measurements
    - *i.e.* with post treatment script
    - Discrepancies between all sensors < +/- 1°C

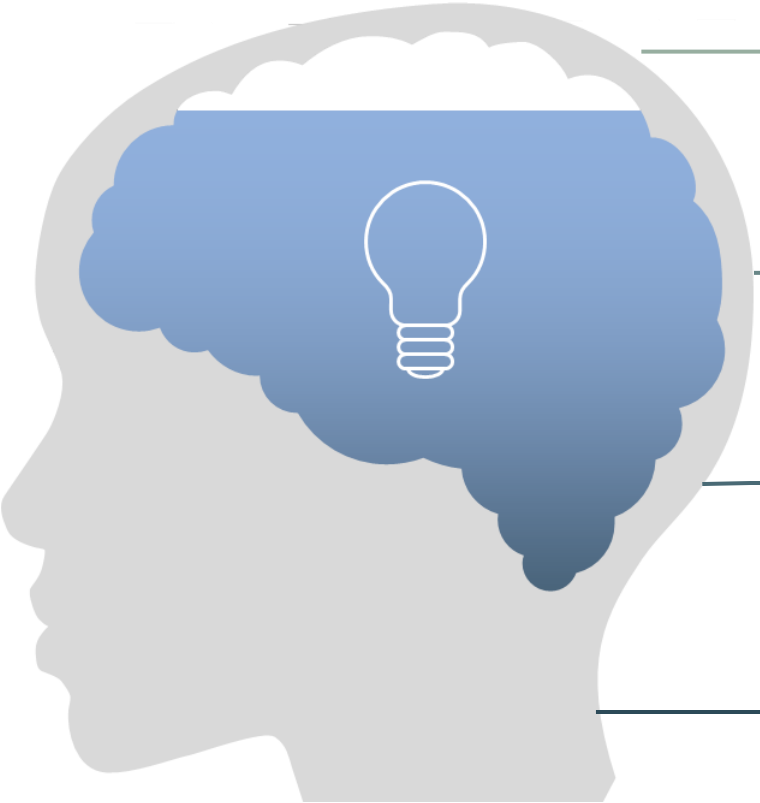
- → IRSN recommends to :
  - Correct the offset
  - Match thermocouples and FBG per layer







Summary



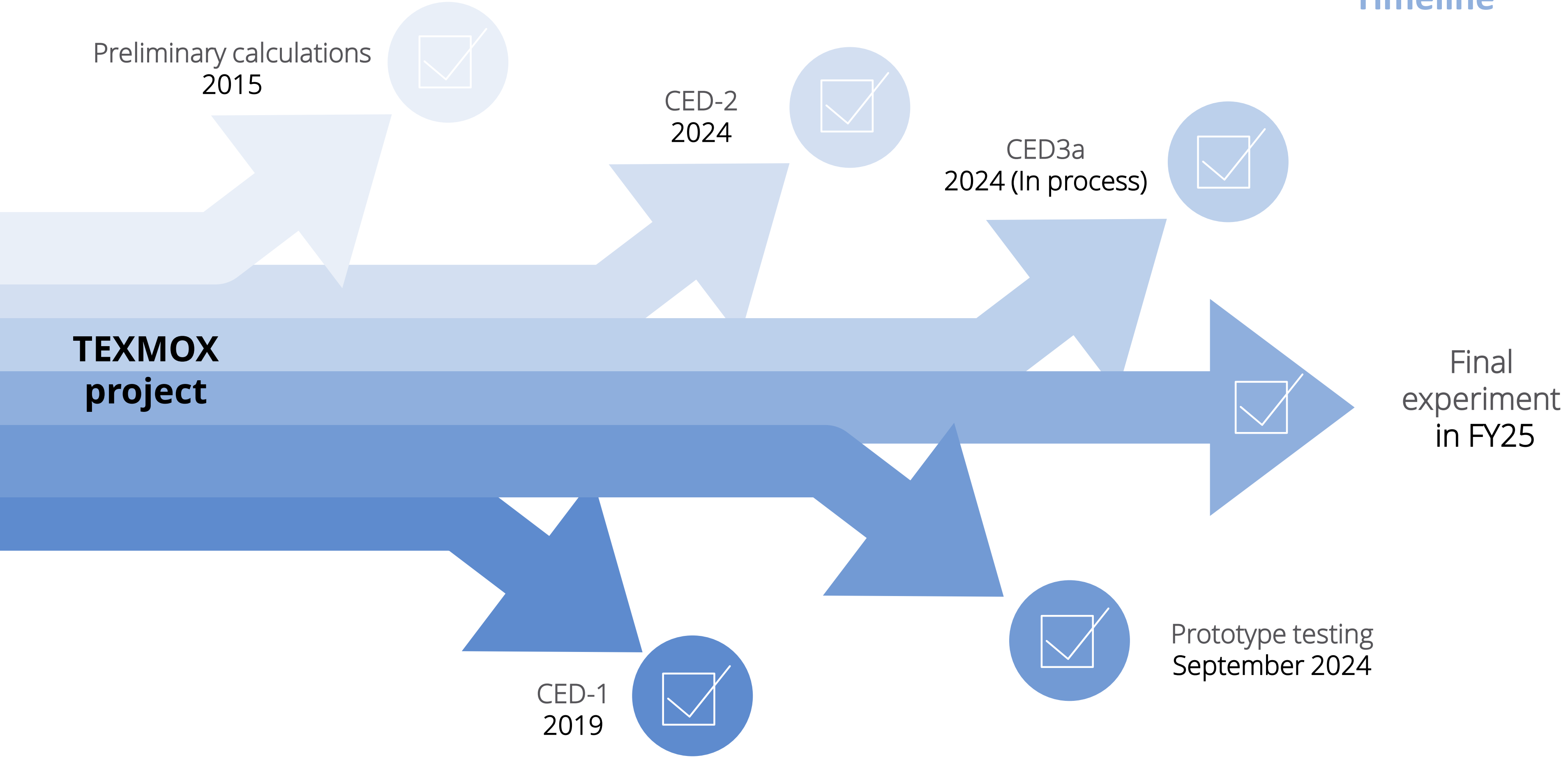
The cooling system is operational. In all the tested scenarios, the temperature is way below the possible deformation/melting of polyethylene

FBG are accurate enough for TEXMOX experiments

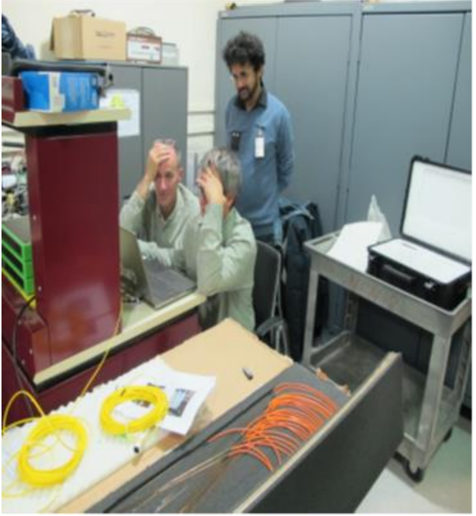
Some tiny details to figure out (fans, hoses…)

Ready and expecting TEXMOX in FY25 !

Timeline

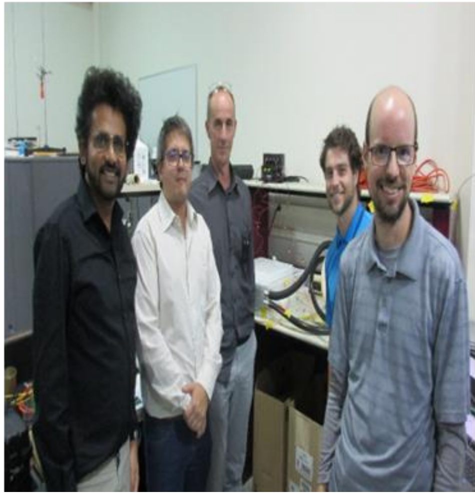


Preliminary calculations
2015
CED-2
2024
CED3a
2024 (In process)
TEXMOX
project
Final
experiment
in FY25
CED-1
2019
Prototype testing
September 2024

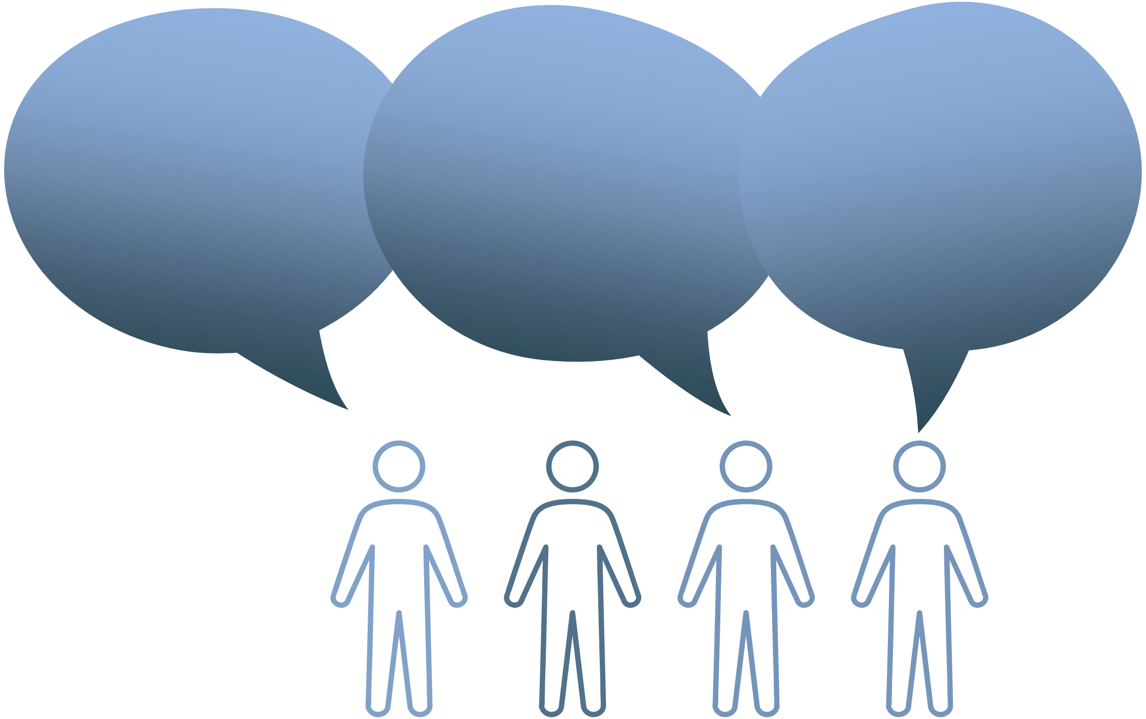






Questions !!



Backup slides !

Pros and cons of cooling system

Pros:

Thermically stable system, no thermal gradient in space

Easier to get various configurations (with different moderator thicknesses) with same heat parameters

Cons:

- Adding weight on PLANET system
- More difficult to handle
  - Increase of dose exposure?
- Risk of failure of the system
  - Melting of PEHD on PUMN plates
- Necessity to validate:
  - cooling performance
  - industrialization and manufacture of cooling plates,
  - assembly of the plates in two parts