



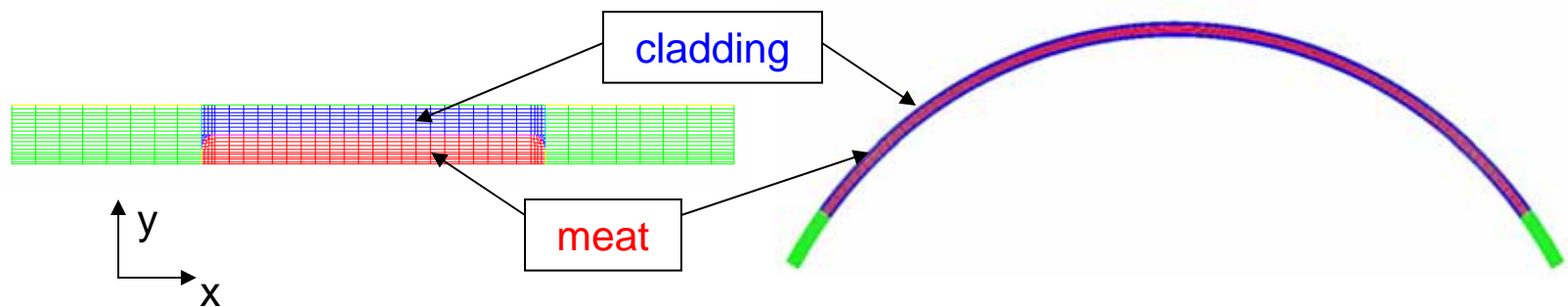
# Mechanical calculations on U-Mo dispersion fuel plates with MAIA

V. Marelle, F. Huet, J. Noirot and P. Lemoine

# MAIA code



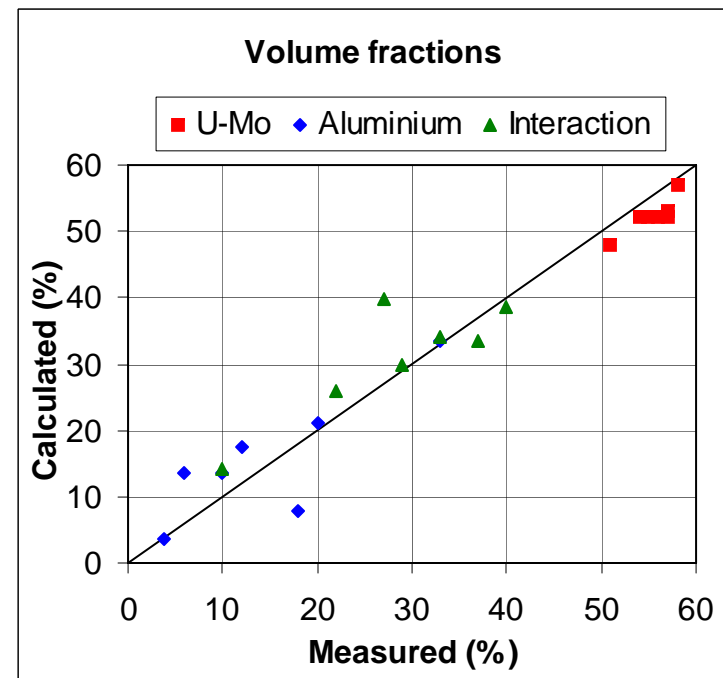
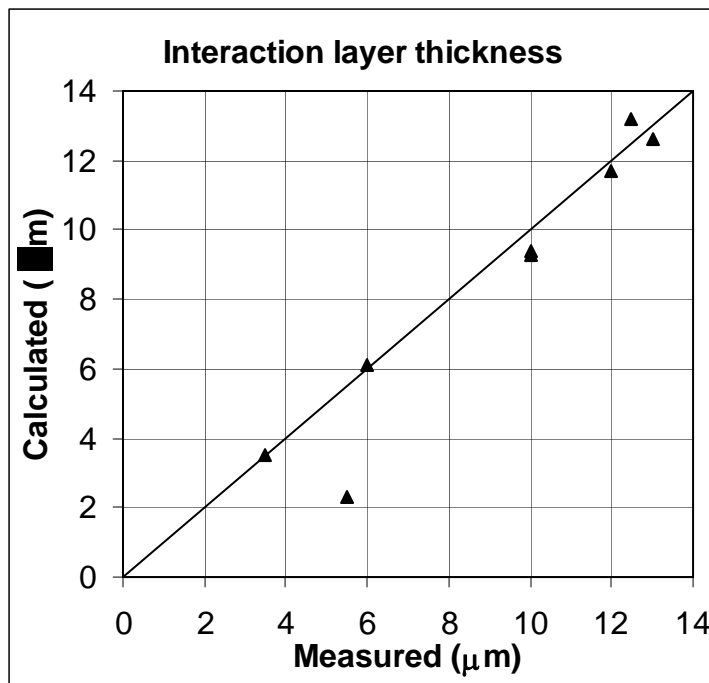
- **Best estimate dispersion fuel plate calculation throughout irradiation lifetime**
  - Temperatures, meat evolution, cladding oxidation, strains and stresses
  - 2D code
  - U-Mo or  $U_3Si_2$  fuel particles
  - Plane or curved plates
- **Thermal and mechanical calculations**
  - Finite Element Method resolution with CAST3M (CEA code)
  - Meat is treated as a homogeneous material



# Validation



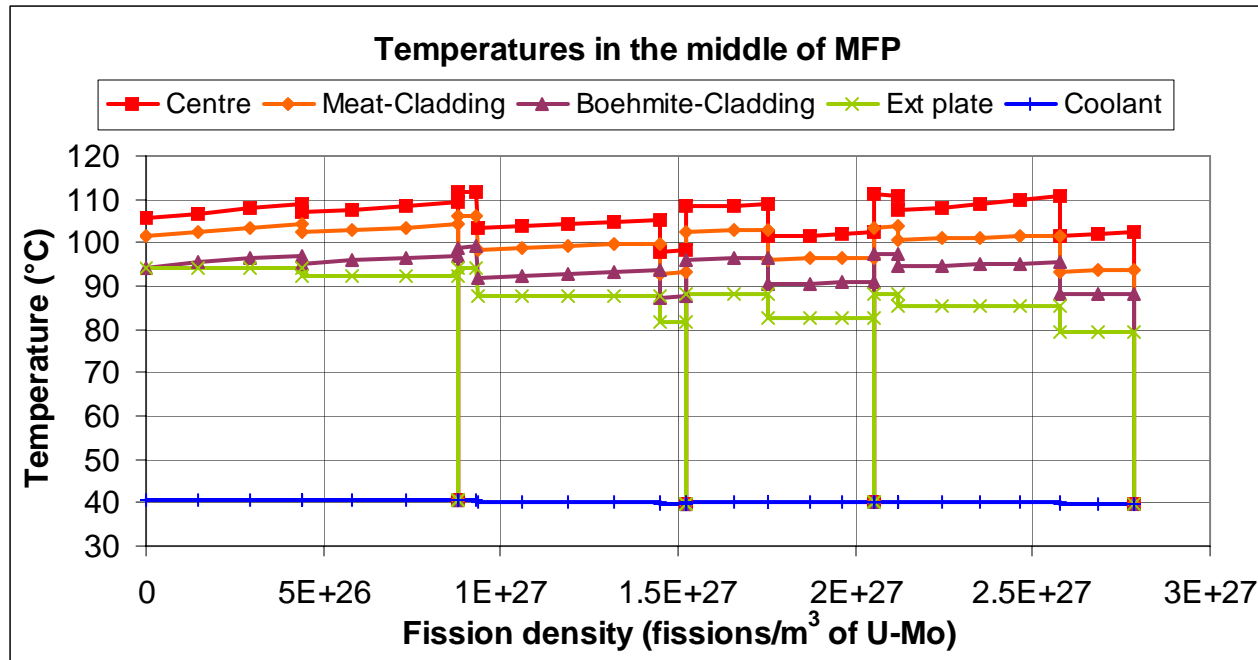
- Qualification of MAIA with analytical results (temperature, oxidation thickness)
- MAIA validation on IRIS 1 and RERTR-3 experiments
  - Good agreement with PIE
- Benchmark with DOE-ANL code PLATE



# IRIS 2 : Temperatures

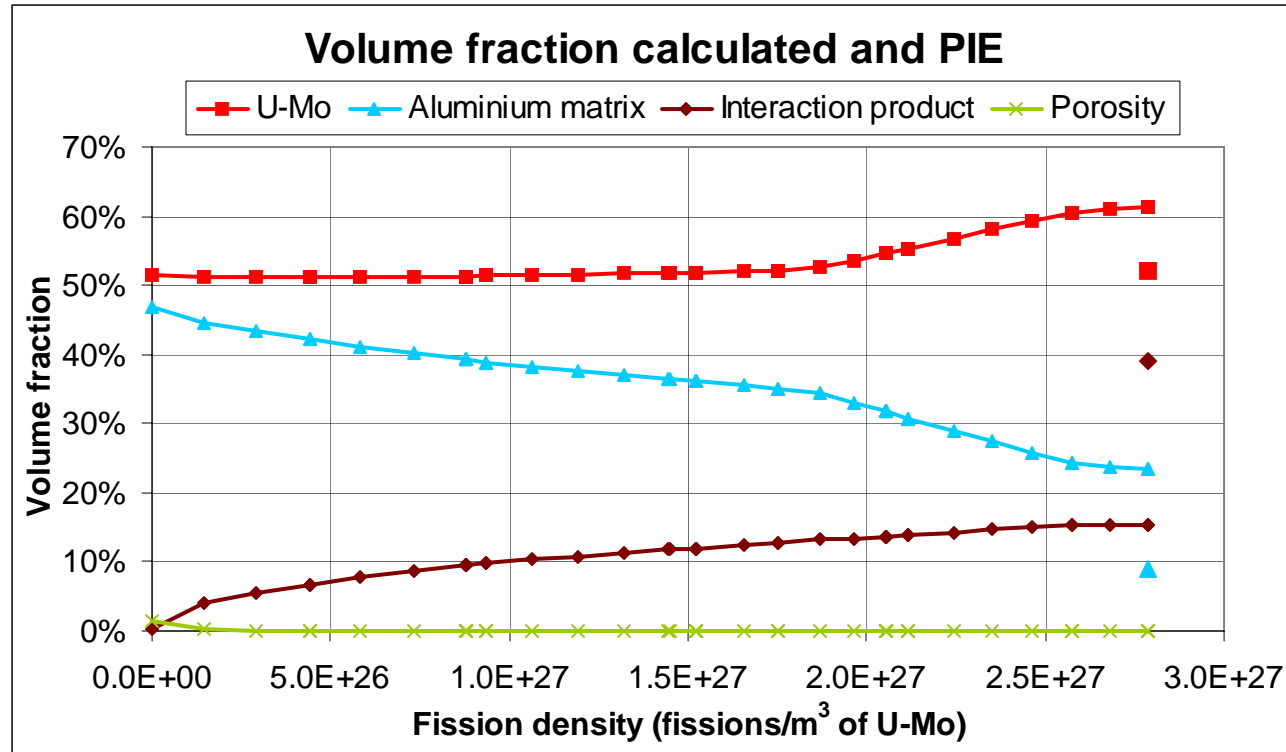


- Calculation in the maximum flux plane of the plate P#02
- Maximum temperature : 112°C
- External plate temperature : 94  $\searrow$  79°C



	MAIA	PIE
<b>Oxide layer thickness</b> ( $\mu\text{m}$ )	12	~13

# IRIS 2 : Volume fraction

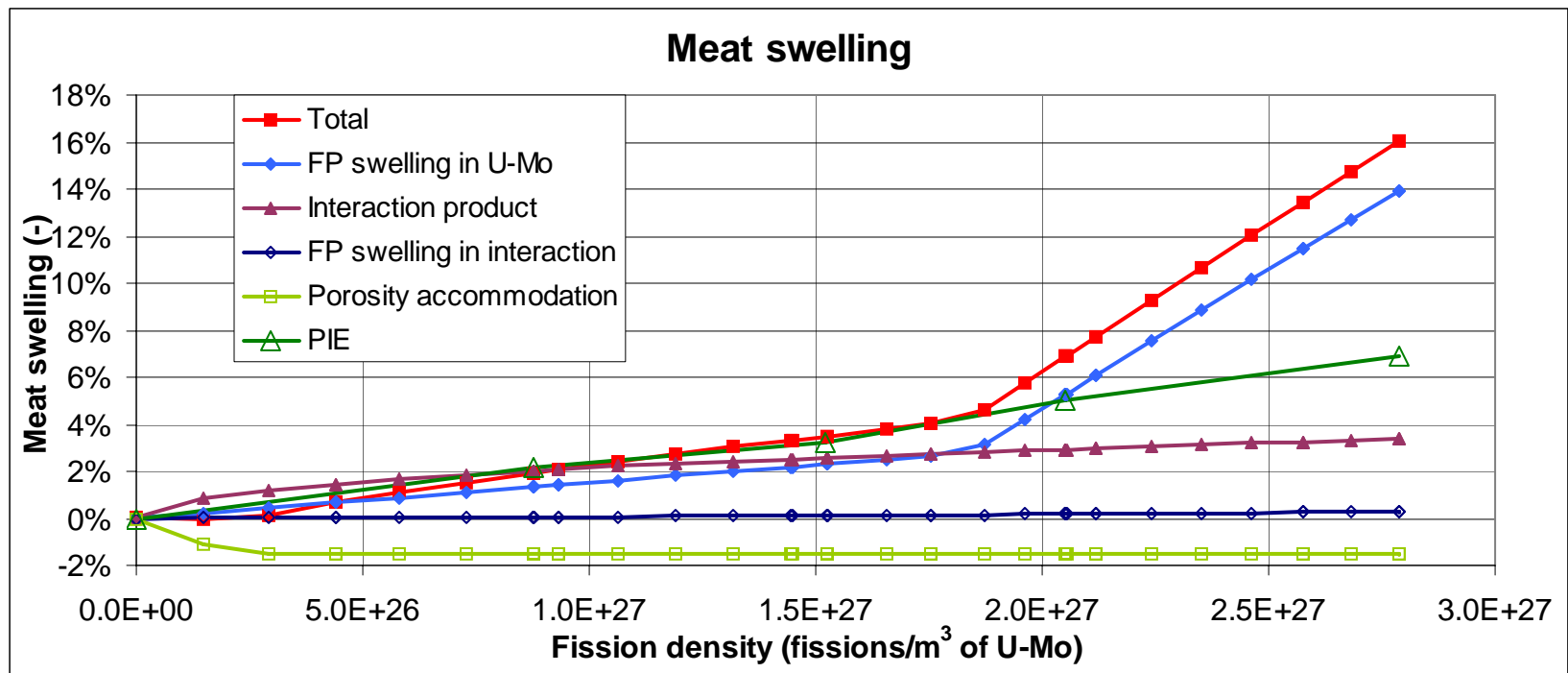


	MAIA	PIE
Interaction layer thickness (μm)	4	~8

- Improvement of the modelling needed to fit with PIE

# IRIS 2 : Meat swelling

- **Total meat swelling : 16%**
  - Mainly due to fission product swelling in U-Mo
  - Low as-fabricated porosity (1.5%) so no delay in total meat swelling as calculated for ground powder plates such as IRIS 1
  - Substantial rise of the swelling rate after  $1.8 \cdot 10^{27}$  fissions/m<sup>3</sup> (recrystallization of the U-Mo alloy)
    - not consistent with PIE (part of pillowing taken into account in model ?)



# Mechanical calculations

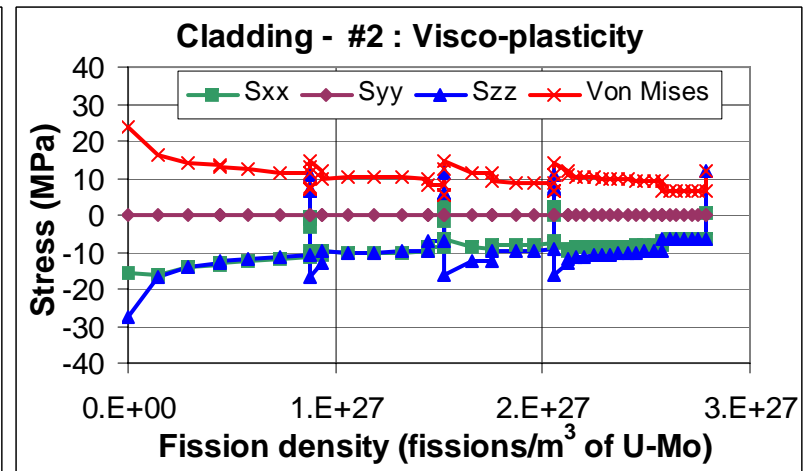
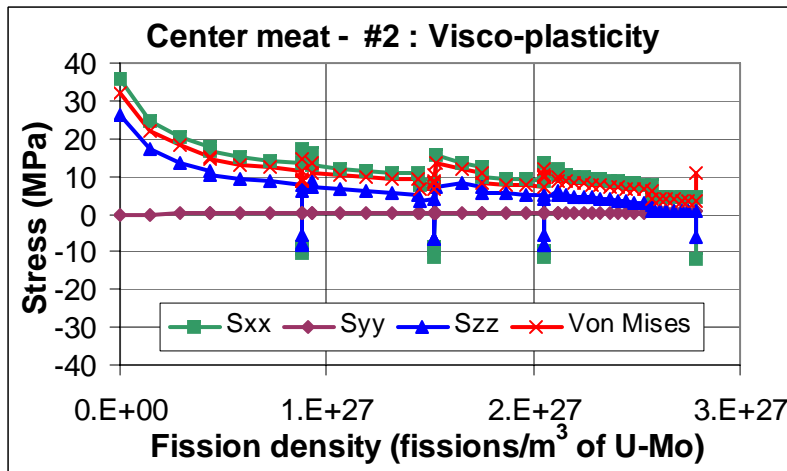
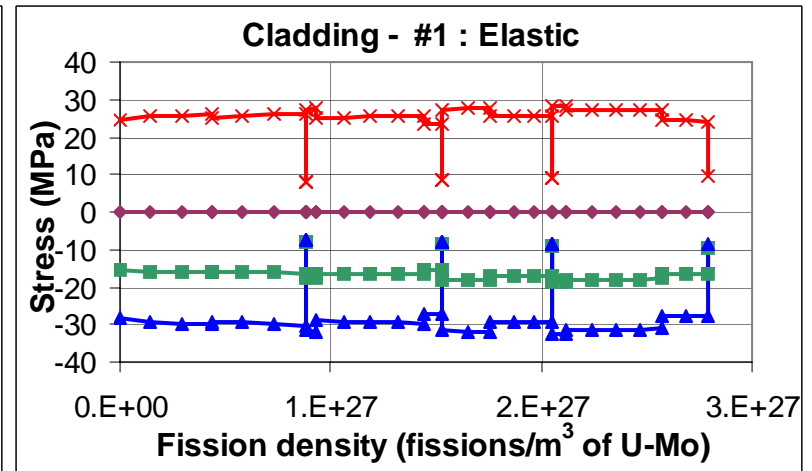
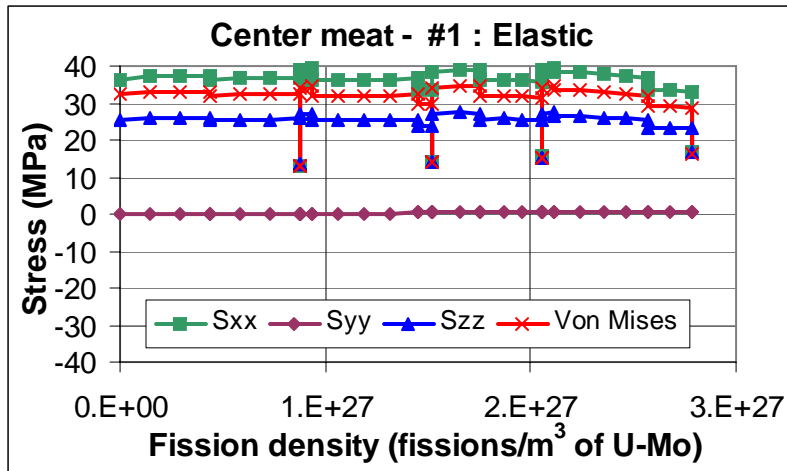
---



- **Parametric study on IRIS 2**
- **Influence of :**
  - Constitutive laws
  - Isotropic swelling hypothesis

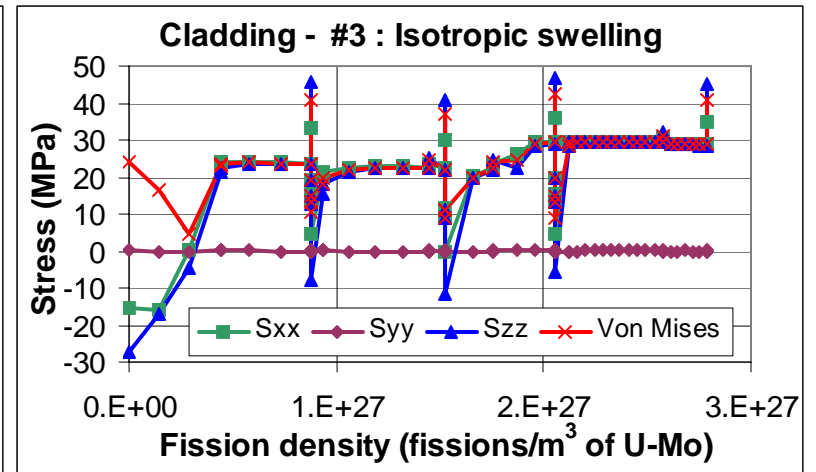
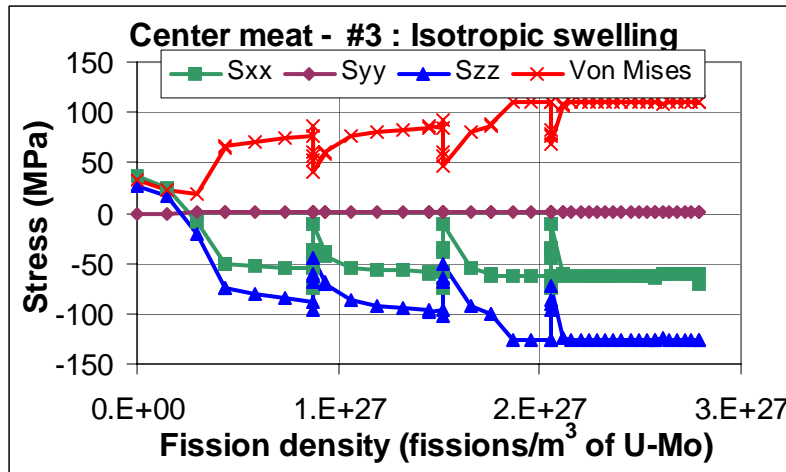
<b>Case</b>	<b>#1</b>	<b>#2</b>	<b>#3</b>
<b>Constitutive laws</b>	Elasticity	Cladding : viscoplasticity Meat : plasticity	Cladding : viscoplasticity Meat : plasticity
<b>Meat swelling</b>	Plate thickness direction only	Plate thickness direction only	Isotropic

# Stresses : Case #1 and #2



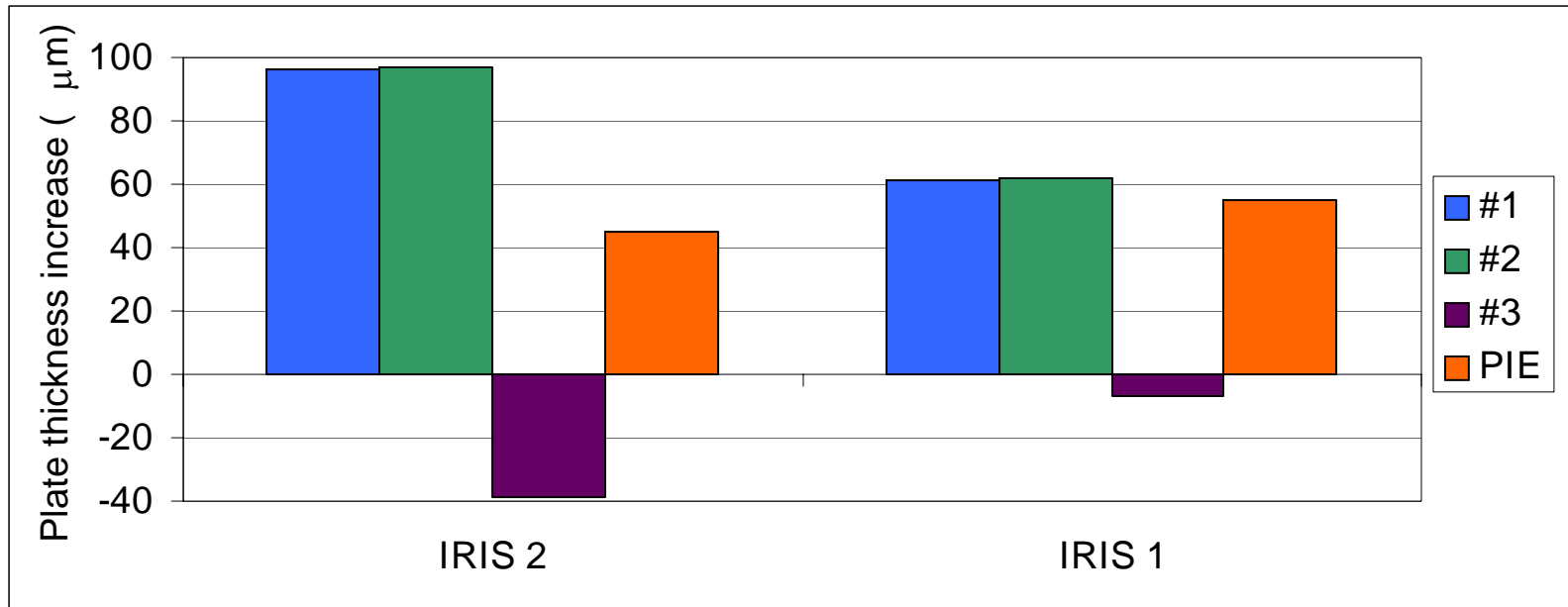
- **Meat : tension – Cladding : compression**
  - Higher thermal expansion coefficient of the cladding
- **Stresses < 40 MPa**

# Stresses : Case #3



- **Much higher stresses**
  - Yield stress reached in the meat
- **Meat : compression – Cladding : tension**

# Plate thickness increase



- **Similar results for cases #1 and #2**
  - Meat swelling >> viscoplastic strains
- **Case #3 : plate thickness decrease**
  - High strains in the cladding width and length
  - Hypotheses not realistic
- **Comparison with PIE**
  - Good agreement for IRIS 1
  - For IRIS 2, overestimation of the plate thickness increase
    - In the pillowing zone, 480 µm given by PIE

# Conclusion

---



- **MAIA is a consistent code for dispersion fuel plates**
- **Besides temperature and meat evolution calculations, MAIA performs mechanical results**
- **Useful tool to analyse and explain the behaviour of dispersion fuel plates**
- **Improvements in the modelling needed**
  - U-Mo swelling
  - Options of the mechanical calculations have to be optimised
    - Meat swelling mainly in plate thickness
    - Mechanical characterizations : constitutive laws