High-Density U-Mo Fuels—Latest Results and Reoriented Qualification Programs

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Outline

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Introduction

- Third annual summary of fuel development and qualification work in Argentina,France, Russia, and the United States
- Last year reported that work was being revamped to address failures of U-Mo dispersion fuels in several tests
- This year's report will summarize revamped programs

U.S. Program

- Focused on three main topics during past year
  - Investigation of unstable swelling of U-Mo dispersion fuel
  - New irradiation tests to investigate potential ways to fix the swelling problem
  - Increased emphasis on development of monolithic U-Mo fuel, especially fabrication process scale-up

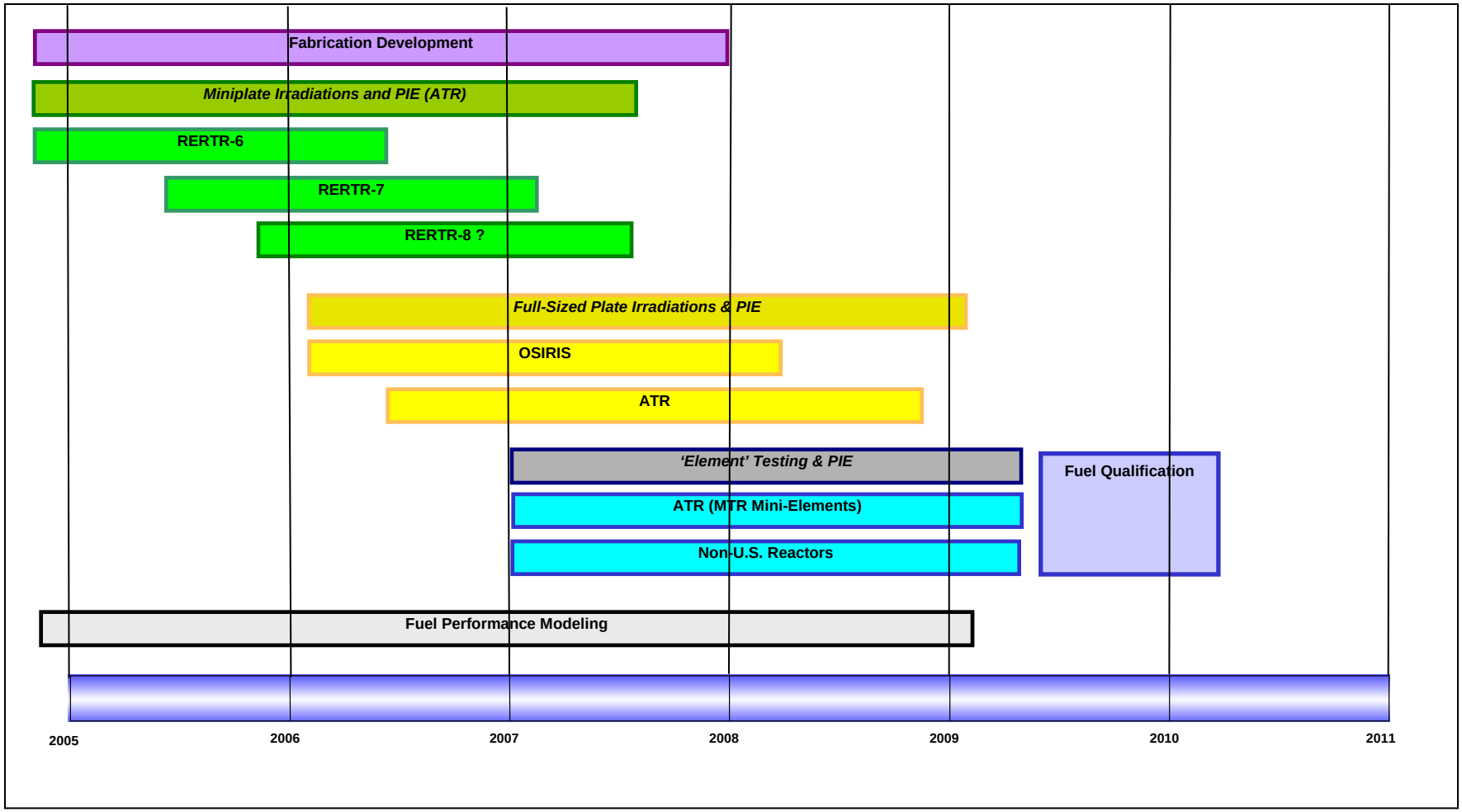
U.S. Program

- Investigation of unstable swelling of U-Mo dispersion fuel
  - Fundamental mechanism not yet understood
  - Considerable empirical evidence
    - Unstable swelling results from fission gas generated in reaction product.
    - Extent of interaction, hence fuel-meat temperature, not controlling factor
    - Composition of reaction product very important
    - Onset of unstable swelling correlated to burnup (amount of fission gas available) and to fission rate
      - Sharp fission-rate threshold
  - Concentrating on addition of silicon to matrix Al to mitigate or eliminate problem

U.S. Program

- New irradiation tests
  - Another set of miniplate tests in ATR (RERTR-6 and RERTR-7) to test behavior of
    - Matrix aluminum alloys with different amounts of silicon additions
    - Monolithic fuel
  - Tests of full-sized plates in ATR and OSIRIS (IRIS-5 , in collaboration with French program)
  - Tests of full-sized assemblies
- Monolithic fuel plate fabrication development
  - Addressed in another paper in this session

U.S. Program Schedule



French Program

- Focused on development of fuel for Jules Horowitz Reactor
- Program encompasses development of dispersion and monolithic U-Mo fuels
  - Manufacturing
  - Out-of-pile investigations
  - Irradiation and postirradiation programs
  - Code development

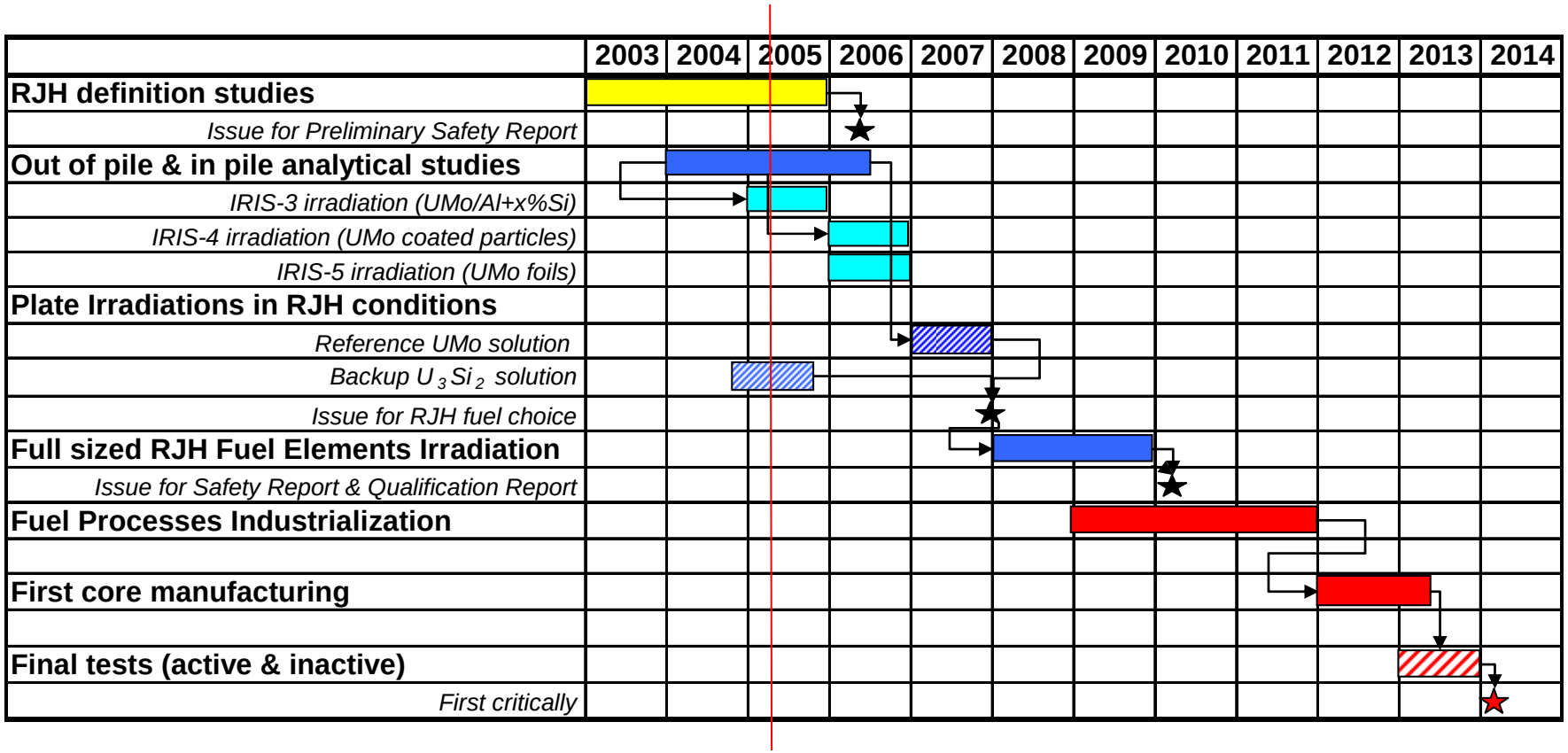
French Program

- Out-of-pile investigations
  - Thermodynamic studies of phase equilibria in U-Mo-Al ternary system
  - Metallurgical studies on diffusion couples to gain understanding of interaction phenomena and how to prevent the interaction
  - Ion-beam neutron-irradiation-simulation studies of interaction layer and dispersion meat

French Program

- Irradiation and postirradiation programs
  - Full-sized plate irradiations in OSIRIS
    - IRIS-3 to test parametrically the effect of adding Si to aluminum of matrix
    - IRIS-4 to study the effect of coating fuel particles with protective layer
    - IRIS-5 to test behavior of monolithic fuel plates (in collaboration with U.S. program)
- Code development
  - Continued development of MAIA code (in collaboration with U.S. program)
- Additional information in other papers

French Program Schedule



Argentine Program

- Focused on three main areas
  - Investigation of fuel/matrix interaction products
    - Chemical diffusion experiments using diffusion couples
    - Thermal compatibility experiments using compacts
  - Investigation of coated fuel particles as means to eliminate or mitigate the dispersion fuel swelling problem
    - Developing dip coating and chemical vapor deposition techniques to produce multi-layer coatings

Argentine Program

- Focused on three main areas (cont'd)
  - Development of manufacturing technique for monolithic fuel clad in Zircaloy
    - Method has been used to produce diffusion couples
  - Additional information in other papers

Russian Program

- Fuel development and qualification activities underway to cover fuel types used in most Russian-designed research reactors
  - Tube-type fuel elements containing U-Mo dispersion
  - Pin-type fuel elements containing U-Mo dispersion and monolithic U-Mo
- Performed in collaboration with U.S. program

Russian Program

- Irradiation and PIE of U-Mo dispersion mini-pins in MIR reactor in Dimitrovgrad
  - PIE of mini-pins at 20% average burnup showed excellent behavior
  - Mini-pins have been irradiated to 60-65% average burnup
    - Test suspended by indication of fission-product release
    - Visual examination of pins has not revealed the source of the fission products

Russian Program

- Irradiation of pin-type fuel assemblies in WWR-M reactor in Gatchina
  - Fuel assembly containing UO_2 dispersion has reached >35% burnup
  - Fuel assembly containing U-Mo dispersion has reached >12% burnup
  - Goal burnup 60%

Russian Program

- PIE of failed U-Mo dispersion tubes at IRM
  - 36%-enriched U; 5.4 gU/cm^3
  - Two fuel tubes irradiated to 40% equivalent LEU average burnup showed excellent behavior
  - Two fuel tubes irradiated to 60% equivalent LEU average burnup experienced unstable swelling like that experienced in U.S. and French tests
    - Currently working to better define irradiation conditions

Russian Program

- Irradiation of full-sized pin-type and tube-type U-Mo IRT fuel assemblies
  - Prototypic of fuel assemblies suitable for conversion of WWR-SM in Uzbekistan
  - Design activities underway
  - Fabrication at end of year
  - Irradiation next year
  - PIE the following year
- Additional information in other papers

Conclusion

- As result of failures of U-Mo dispersions
  - Major effort underway to understand, if possible, and to eliminate or mitigate unstable swelling in U-Mo dispersion
  - Development of monolithic U-Mo fuel being accelerated
  - All programs working to complete basic fuel qualification by the end of 2010