

KATANA water activation facility: path towards a benchmark-quality facility



MOTIVATION

- **Water activation** is a key unresolved challenge for water-cooled fusion systems (ITER, DEMO)
- Threshold reactions: **five orders of magnitude** stronger than in typical fission environments
- Coupled activation codes have matured, **validation data have not**

KATANA TODAY

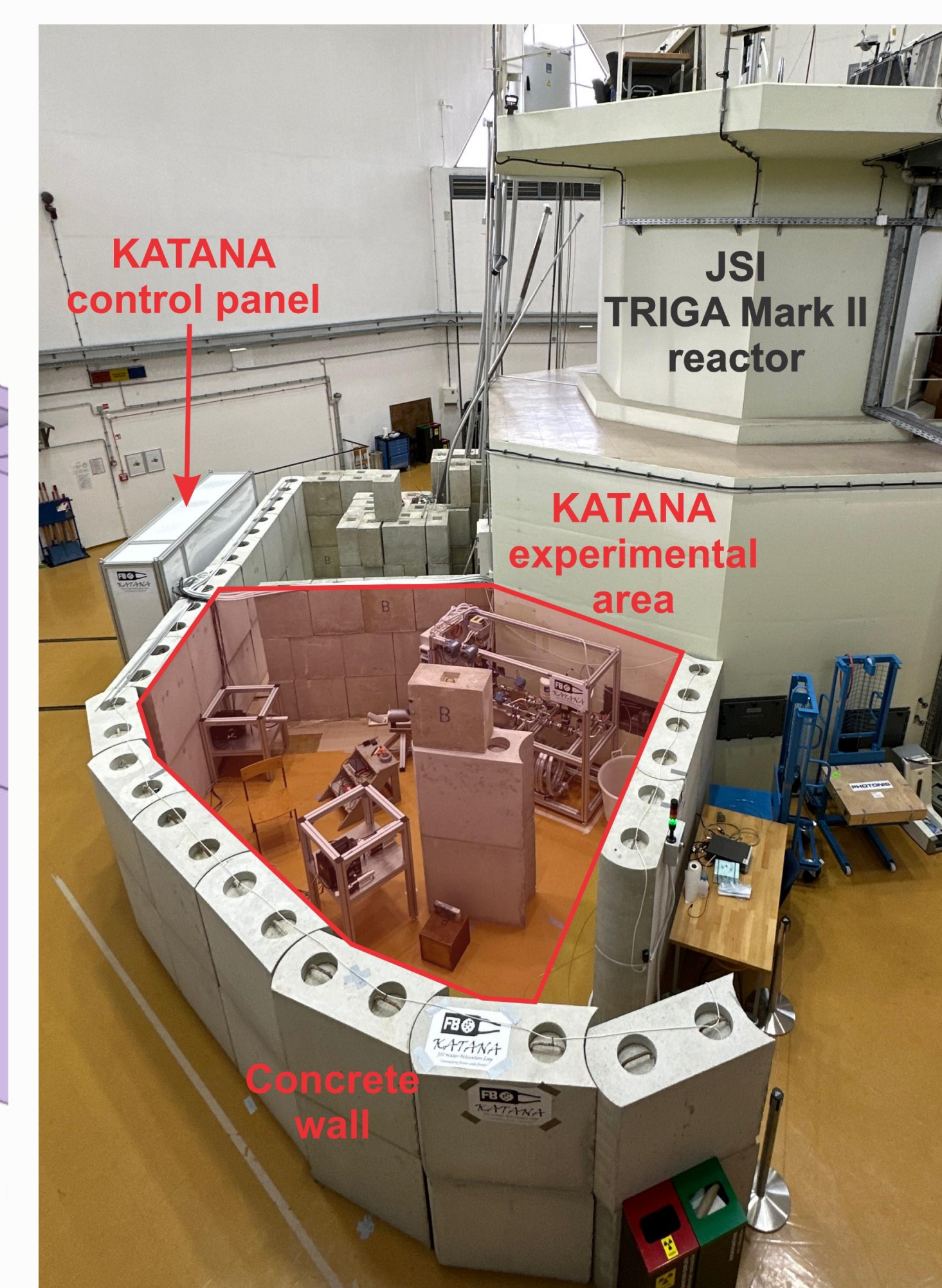
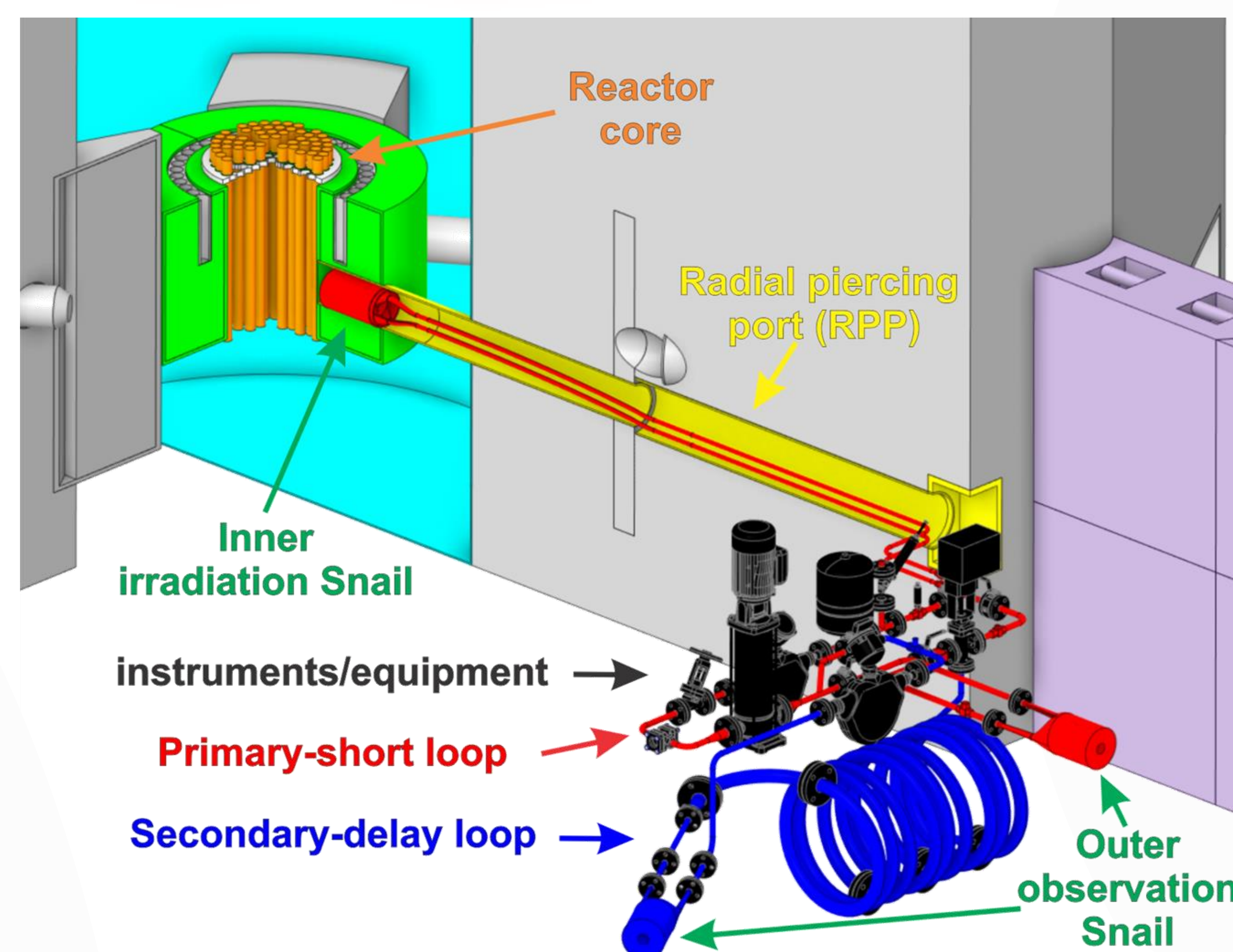
- The **only operational and accessible** closed-loop water activation facility
- Operating since **2024**: stable, reproducible high-energy γ and delayed-neutron fields
- Successfully performed **5 experimental campaign within the EUROfusion (WP PrIO/ DES)**
- **Not yet benchmark complete**: total uncertainty $\geq 20\%$ (^{16}N branching ratio reproduced to 20–31 %)

OBJECTIVES

- **Five-stage roadmap**: calibration and field characterisation first, then benchmark data and code validation
- **Four criteria** define benchmark quality: absolute calibration, characterised geometry and materials, a complete uncertainty budget and SINBAD-compatible documentation
- Establish **experimental validation of fluid activation codes**
- Establish KATANA as a **benchmark-quality facility**
- Establish KATANA as a **reference facility for high energy gamma detector calibration & shielding experiments**

KATANA: closed water activation loop

- **Well-defined and stable high energy irradiation source**:
 - Gamma: 6 MeV – 7 MeV, Neutron: ~ 1 MeV
- **Water activation based experiments** (^{16}N , ^{17}N , ^{19}O)
- Experimental validation of **fluid activation codes**
 - **FLUNED, RSTM, ActiFlow & GammaFlow**
- **Calibration** of neutron, γ detectors and dosimeters
- **Shielding experiments** using ITER-relevant materials
- **Integral cross-section** measurements
- Dose rates and γ spectrum measurement
-  **relevant conditions**
- Organise **5 experimental campaigns** within  **EUROfusion**
(150 h of TRIGA operation, > 30 researchers from >10 institutions)



ROADMAP TOWARDS A BENCHMARK-QUALITY FACILITY (5 stages)

Core activities

1

BENCHMARK-QUALITY EXPERIMENTAL CONDITIONS

- absolute γ calibration extended to ~ 8 MeV
- traceable neutron detector calibration
- inner-region neutron field characterisation
- shielding and collimation of background

2

BENCHMARK EXPERIMENTS AND CODE VALIDATION

- C/E validation of fluid-activation codes
- ITER-relevant shielding benchmarks
- integral $^{17}\text{O}(n,p)^{17}\text{N}$ cross section
- high-energy γ calibration platform

3

ITER-RELEVANT IRRADIATION HEAD

- hydraulic routing and residence time
- coupled CFD and neutronic co-design
- prototype, installation and verification
- activation assessment of the present head

4

LONG-TERM STABILITY OF IRRADIATION CONDITIONS

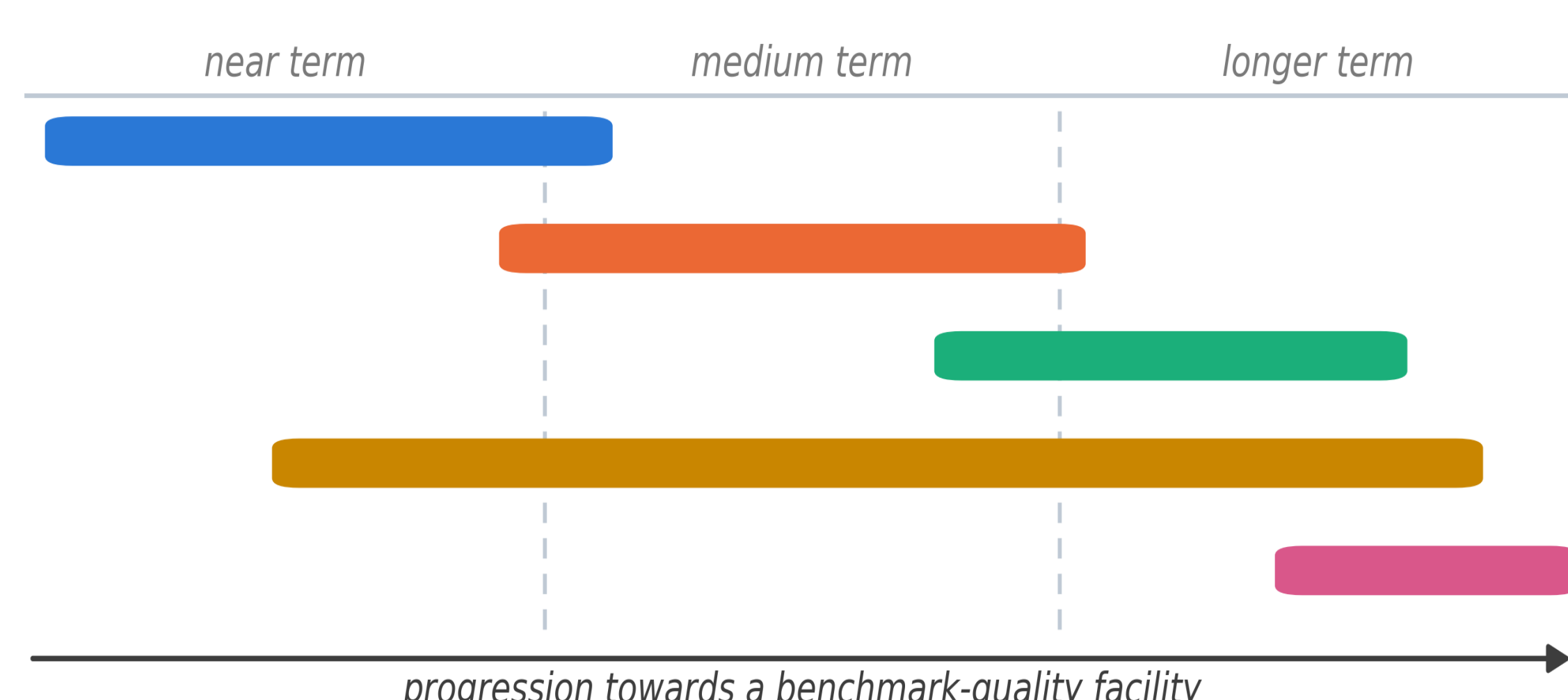
- TRIGA fuel-burnup effects on the field
- core-reshuffling strategy
- continuous supporting activity

5

UPGRADE PATH TOWARDS ACP STUDIES

- feasibility study for ACP circulation
- loop upgrade versus dedicated ACP loop
- technically grounded upgrade roadmap

Strategic extensions



TARGETS

- **C/E target**: agreement within combined experimental and computational uncertainty
- **Uncertainty target**: 5–15% for neutron and γ fluence, depending on configuration

PRINCIPAL RISK

- Stage 1 is the critical path