FP8 EU Enhancements Pellet Launching System

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REQUESTED SYSTEM CAPABILITIES

Main research needs (from JT-60SA Research Plan)

Physics:

- High density operation in ITER and DEMO relevant plasmas

- Explore accessibility to densities in vicinity of the Greenwald density

- Investigate power exhaust, develop radiation layers in scenarios

- ELM control

Engineering:

Actuator "pellet injection" on electron density and ELMs

Quantify actuation (in open loop) during the initial research phase I

Prepare closed-loop control experiments in the initial research phase II

➔ **Pellet actuation for fuelling (density gradient) control within the advanced real-time control scheme**

Pellet launcher injects pellets from the torus inboard – duration up to 100 s

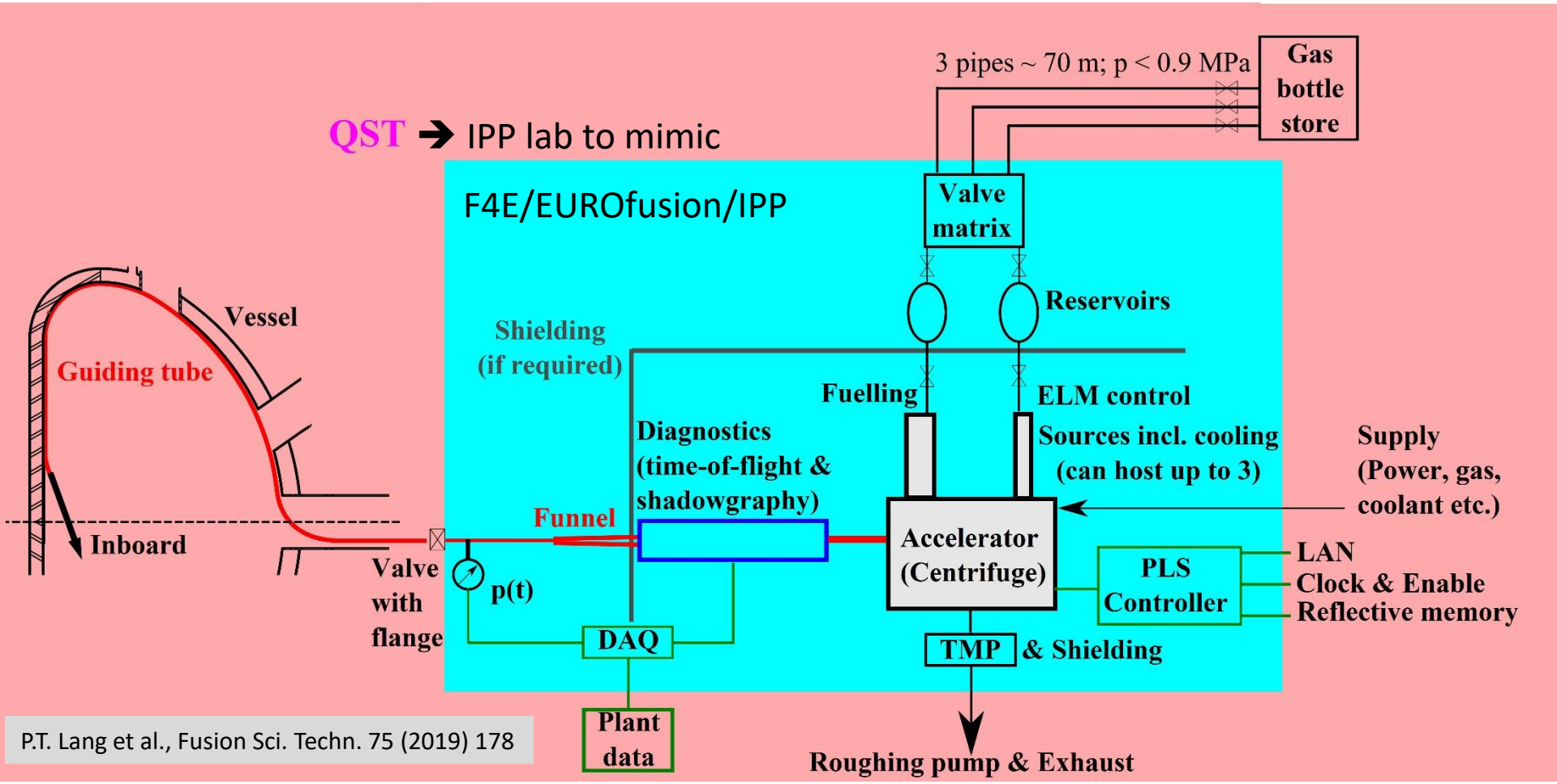
One pellet train composed from fuelling (2.4 mm) and pacing (1.2 mm) pellets

Fuelling up to 20 Hz, Pacing up to 50 Hz, Centrifuge: v_P = 500 m/s @ 100 Hz

PELLET LAUNCHING SYSTEM LAYOUT

PLS scheme with projected responsibility as shared between QST and F4E

Procurement of system components is up to F4E

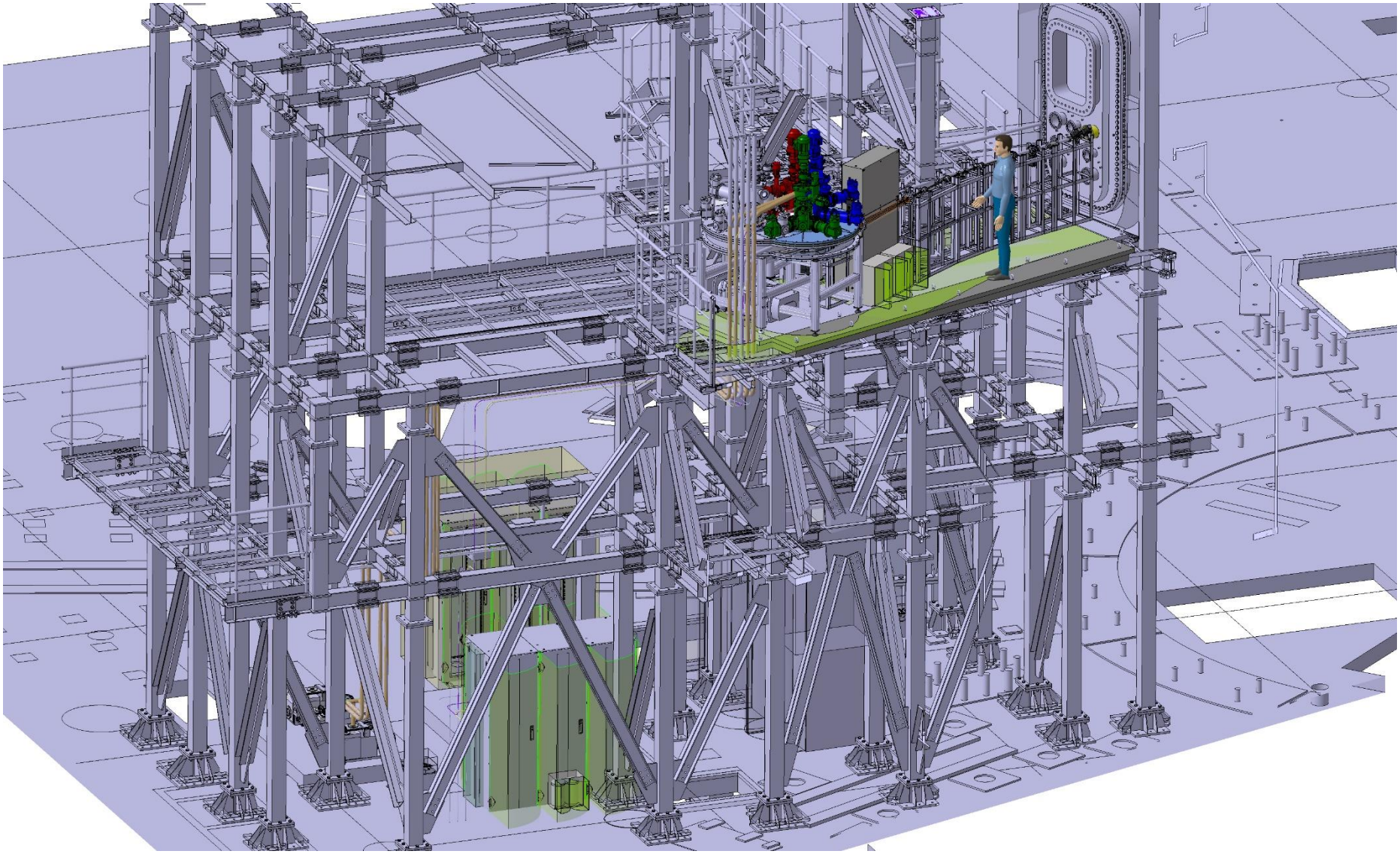


P.T. Lang et al., Fusion Sci. Techn. 75 (2019) 178

PLS tests and commissioning will take place in the IPP pellet lab ➔ Mimics QST part

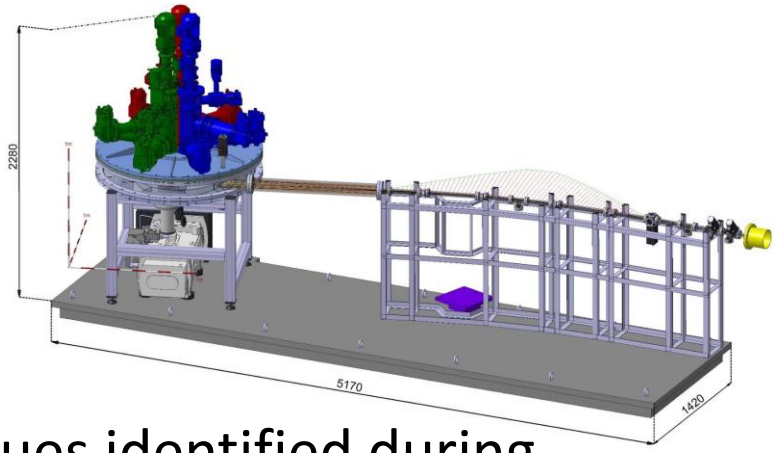
PELLET LAUNCHING SYSTEM LAYOUT

System integrated into the JT-60SA CAD model



CURRENT STATUS AND NEEDS

System blocks:



- **Testing at IPP**:
  Lab ready
- **Fuelling pellet source** (PELIN):
  Modifications underway to correct issues identified during testing. Delivery target mid-2022
- **Pacing pellet sources** (PELIN):
  Most hardware procured and delivered. Assembly will start after successful operation of FPS. Delivery target end 2022
- **Centrifuge**:
  Tender awarded, Kick off meeting will be proposed during May, delivery expected for mid-2024
- **Diagnostics**:
  Call for tender to be launched soon

IPP PELLET TEST BED

- Pellet Test Bed @ IPP is ready to host PLS
- Valve matrix (IPP contribution) functional

→ Demonstrated in test bed

Fuelling Pellet Source

First hydrogen ice extrusion demonstrated @PELIN premises
(PELIN report from 11.11.2021)

Two ice rods for higher throughput

Still some issues with timing of pellet delivery to be addressed

Main caveat: PELIN is a Russian company!

PLANNED WORK 2022 AND BEYOND

Planned activities in IPP lab :

- Installation and commissioning of **Fuelling Pellet Source** (FPS) on IPP cryostat test vessel – aspired mid-2022
- Installation and commissioning of **Pacing Pellet Source** (PPS) on IPP cryostat test vessel – aspired late-2022/early-2023
- Installation of **centrifuge** in IPP lab – aspired early-2024
- Installation of **diagnostic** system – aspired early-2024
- Integration of **pellet sources to centrifuge** and commissioning of PLS – aspired mid-2024

→ **Shipment** to Naka site after passing acceptance test – late-2024

EXTRUDER COMMISSIONING

Characterisation plan:

- Fuelling Pellet Source - Ø = L = 2.4 mm at up to 20 Hz
- Full performance with H_2 for > 100 s
- Full performance with D_2 for > 100 s
- Performance with HD
- Performance with admixed gases in H_2
- Considered: 0.5 and 1.0 mol% N_2, 1.0 and 2.0 mol% Ne

➔ If successful, demonstration of a state-of-the-art quasi steady state and reactor (T) compatible pellet source!

- Pacing Pellet Source - Ø = L = 1.2 mm at up to 50 Hz
- Full performance with H_2 for > 100 s
- Full performance with D_2 for > 100 s

PLANNED WORK 2022 AND BEYOND

What to do in case we do not get the pellet sources?

We have identified three potential options

- Develop “Beyond AUG” pellet source

  Could be fast (1 year) but only limited (100) number of pellets
- Request lending or manufacture clone of ORNL “big batch” extruder
- Go for DEMO-like steady state extruder

  Gain relevant extruder technology within EU

  Significant consumption of time and money

PUBLICATION PLAN

Currently four contributions submitted to SOFT 2022:

- P. T. Lang et al.:

Concept for a multi-purpose EU-DEMO pellet launching system

- B. Ploeckl et al.:

Testbed for the Pellet Launching System for JT-60SA

- C. Piccinni et al.:

Injection of Ar-doped pellets: towards a multifaceted plasma actuator

- I. Vinyar et al.:

Pellet fuelling source development for the JT-60SA tokamak