TIARA PP

TIARA Mid Term Meeting
14th June 2012 – Madrid

TIARA-PP WP 9 : TIHPAC

Test Infrastructure for High Power Accelerator Components

Sébastien Bousson
(CNRS/IN2P3/IPN Orsay)

On behalf of the WP9 participants: CERN, IPNO, ESS

WP 9 Main Goal

WP9 raised from the following consideration: What would be the necessary test infrastructures for developing the key elements of the EURISOL project ?

EURISOL is the next generation of a facility aiming at the production of radioactive ion beams (RIB) using the ISOL technique.

Among all the technical challenges raised by this project, 2 key components have been identified which will require an important R&D program and an intense experimental program to fulfill the Eurisol requirements:

- ***The multi-MW target complex***
- ***The low beta superconducting cavities (used for the driver and for the post-accelerator linac)***

Sub-Task 1:
Multi MW target development

Sub-Task 1: Multi MW target

The main idea of sub-task 1:

Develop a versatile target concept to be tested with beams at all possible locations, meaning over a wide range of beam power (several kW to MW).

Full scale test of the final MMW target available only in the final facility !

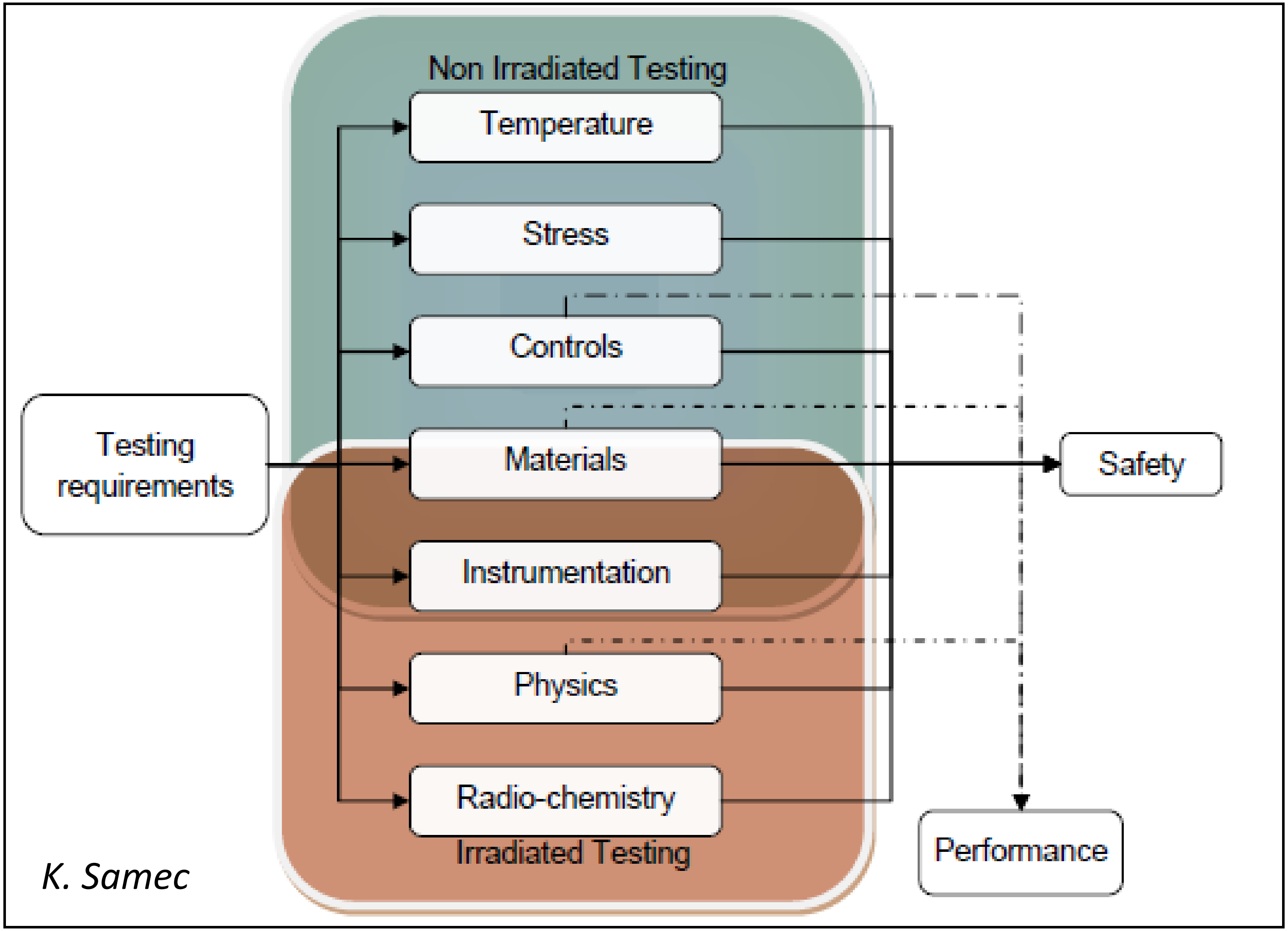
Achieving the design of the full scale target (ex. 4 MW for Eurisol) will require several partial tests: sub-components, irradiation at lower power, instrumentation tests…

For that, a versatile target is required to test concepts, instrumentation, material science (like fatigue, heat transfer), safety (primary/secondary fluid interactions), etc…

The target itself should be adaptable, but keeping all services (heat exchanger, loop…) externalized (i.e. common for all target geometries).

Sub-Task 1: Multi MW target

Break-down of items/systems to be tested:



Sub-Task 1: Multi MW target

TIARA identified needs:

- Reliable neutron sources to be developed to accommodate the growing power delivered by accelerator development in Europe
- Beam power in GeV range implying spallation
- High beam power deposition densities

Fundamental parameters for the TIARA high-power target development:

Parameters	Value
Beam power	200 kW- 5 MW
Beam energy	70-Mev – 1 GeV
Heat deposition in target	10 kW/cm3
Source neutron production rate	up to 10^{18} n/s
Source surface neutron flux	up to 10^{15} n/cm²s
Target cooling medium	Helium / liquid metal
Target material	Be, Ta, W, Pb, Bi

Sub-Task 1: Multi MW target

Specifications/requirements have been identified for the different test facilities (irradiated/non-irradiated; liquid/metal target; safety issues…)

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Example: specifications for solid target testing

1. Necessity: replicate helium flow conditions in the target, hence to set up a loop using gas as a coolant with the following main components:

- Gas loop 16 Bar rated tightness.
- Pumps rated at 2 kg/s (for He at 10 Bar , 5193.2 [J/kgK] , 2 [kg/m3]).
- Heat exchangers able to handle 5 MW * 70% = 3.5 MW.
- Gas flow meter.
- Dedicated multiple helium leak detectors (for wheel target design tests).
- Pressure taps and Pitot tube locally.
- Thermocouples mounted in gas stream
- Data acquisition through appropriate gas-tight connectors to all sensors.
- Control and power.
- Adequate data storage.

Example: specifications for solid target testing:

2. To replicate the beam: produce an environment that is realistic in terms of heating. Different heating methods are to be used:

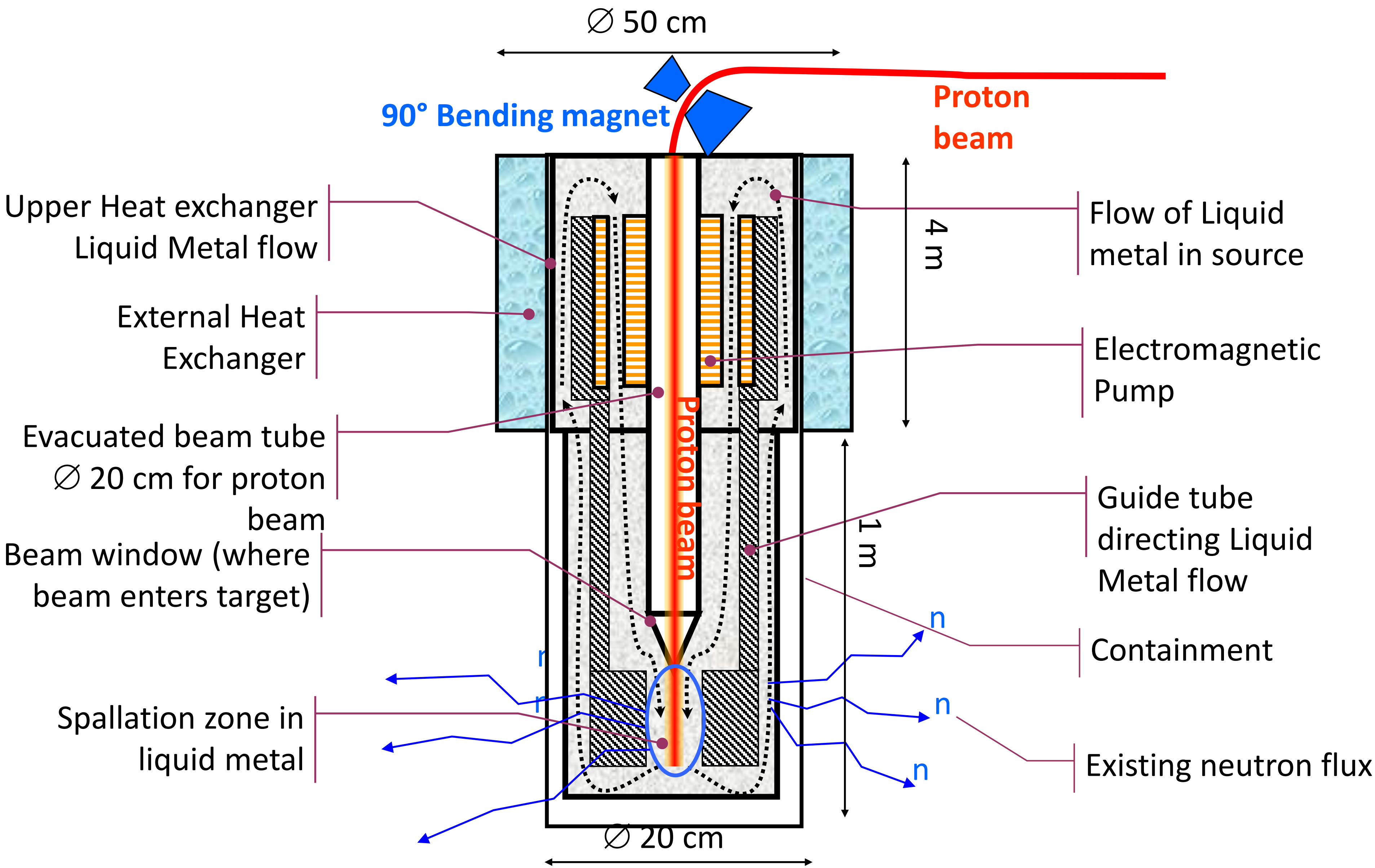
- Volume heating: induction for the solid target replication deposition from the beam sufficient to reach 3.5 MW (5 MW @ 70% deposited beam fraction)
- Surface heating Laser rated at 10 kW to test the window or any other point of entry of the beam, depending on the configuration chosen (wheel).
- As a backup to the induction method, conventional Ohmic resistors may be used. They lack the power density required for the full beam but may be used however for smaller sub-scale testing. Power limit ~200 kW

Example: specifications for solid target testing:

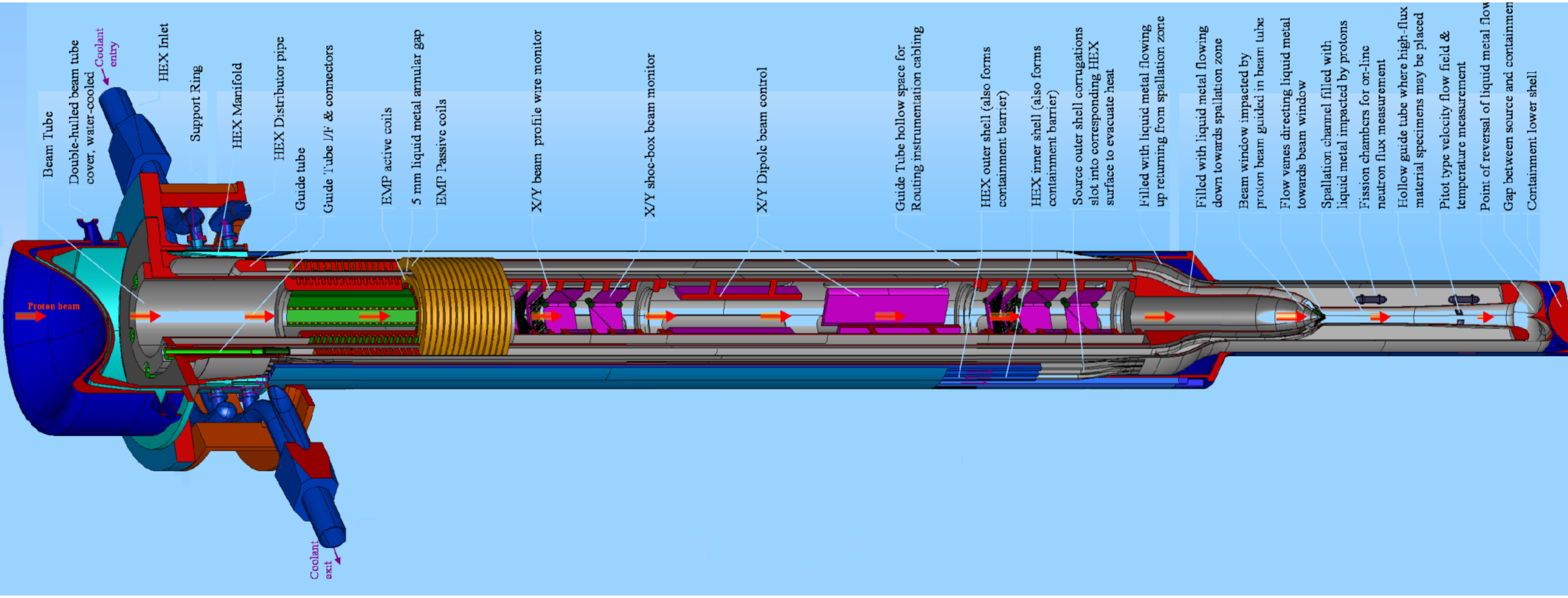
3. To assess the effect on the target, it shall be adequately instrumented:

- Thermal and mechanical stresses: strain gauges of different types. The majority should withstand up to 300°C and may be based on gratings deposited on conventional thermoplastic. A few will be needed to withstand up to 1000°C and can rely on interferometry/fiberglass strain gauge technology
- Thermocouples on structure.
- Infrared camera to capture thermal maps, it is a method that is particularly well adapted to a Helium environment which is transparent to IR
- Low acquisition rates are sufficient for structural response.

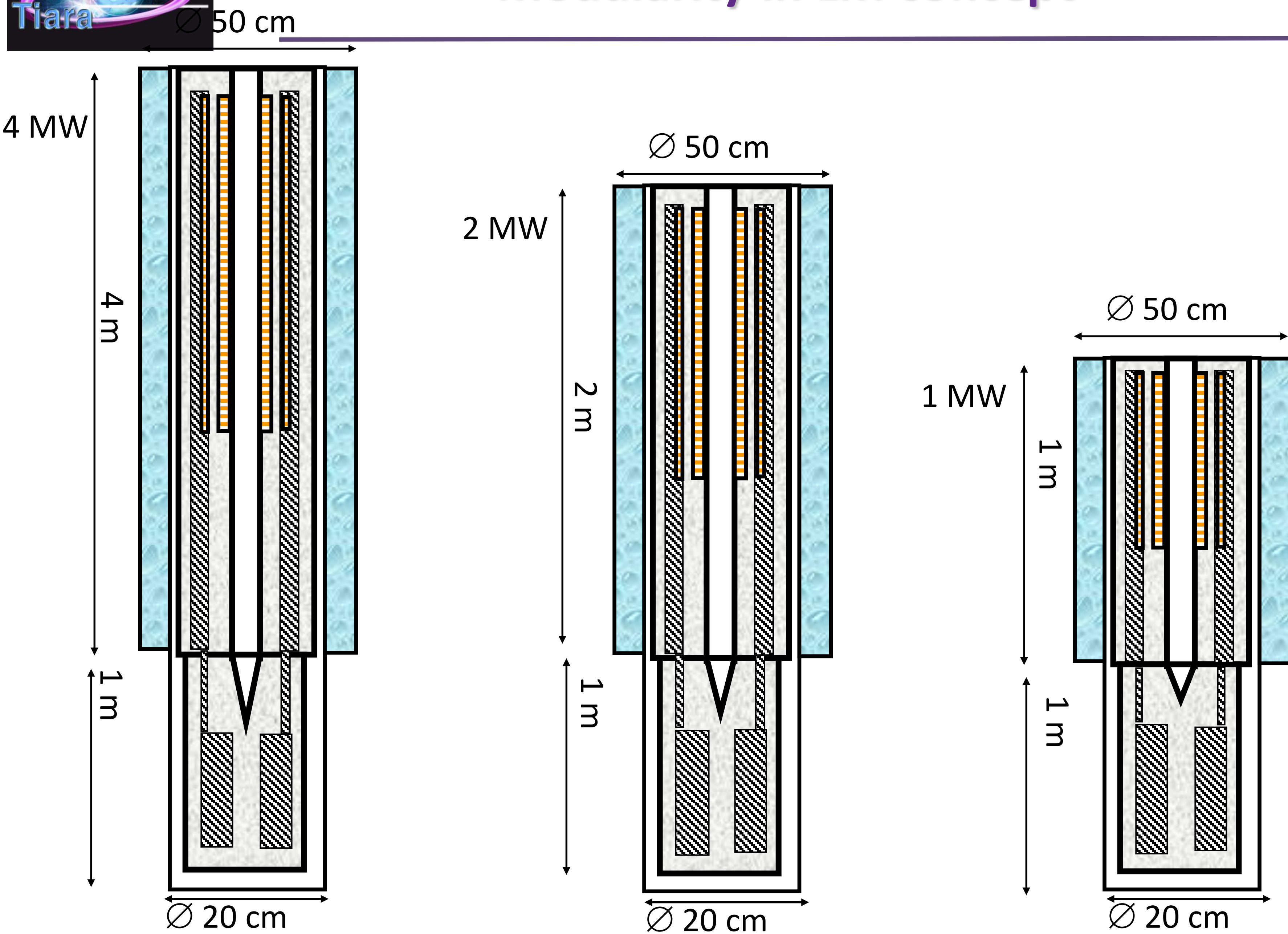
Preliminary liquid concept - Schema



Preliminary liquid concept - Engineering detail



Modularity in LM concept

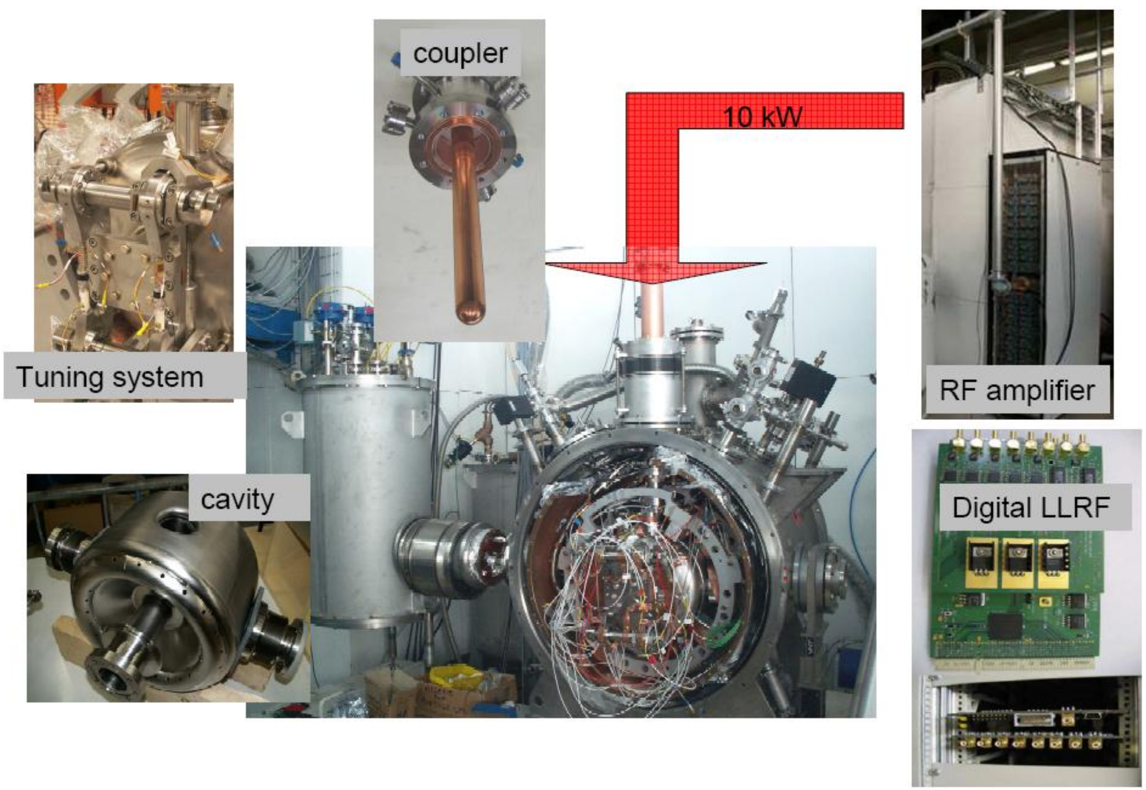


Sub-Task 2:
low beta cavity test cryomodule

Sub-Task 2: low beta cavity test cryomodule

Before assessing that a SC cavity is validated for an operational use in an accelerator, the final experiment is a cryogenic test at nominal RF power of the fully equipped cavity (power couplers, cold tuning systems…)

Very few “accelerator configuration” test cryostat are existing in Europe and they are only designed for elliptical cavity testing (CHECHIA , HOBYCAT, CRYHOLAB).



Such a cryostat, specific and devoted to low beta SC cavities will be a useful complementary equipment.

Sub-Task 2: low beta cavity test cryomodule

As defined in the WP9 work plan, work has started with the study of user requirements to establish specification for the low beta cavity test cryostat.

Identification of the user requirements for the test cryostat:
4 main categories of requirements have been identified:

1. Geometric dimension (cavity type and physical capacity)
2. Integration of couplers and cold tuning system
3. Cryogenic requirements
4. Assembly requirements

EU Project driven requirements:

EURISOL, MYRRHA, ESS, IFMIF, HIE-ISOLDE

With potential interest for:

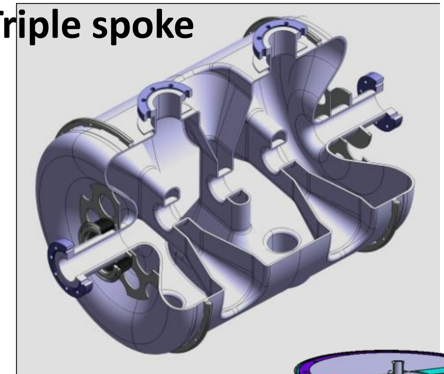
LRF (HUELVA), ESS-BILBAO, ion or RIB post-accelerators,…

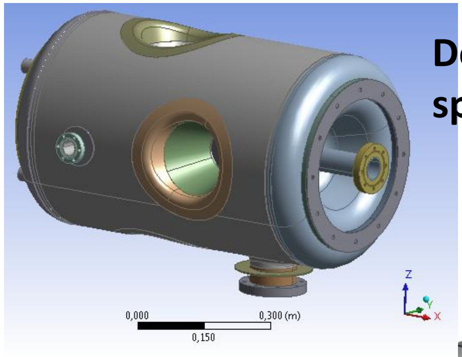
… and many others outside Europe !

Sub-Task 2: low beta cavity test cryomodule

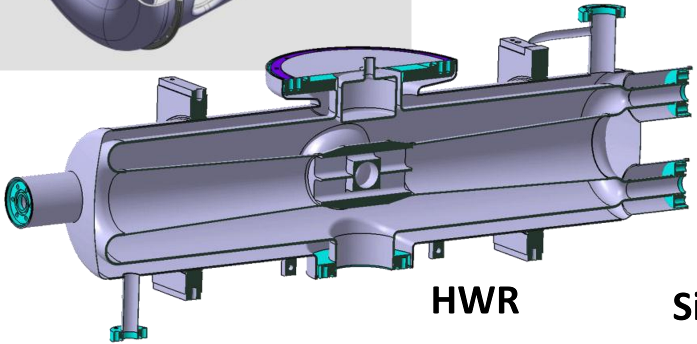
- Different cavity geometries (type), beta, and frequencies
  - Half-wave resonators
  - Quarter wave resonators
  - Spoke cavities (single, double or triple spoke)
  - Others: re-entrant, CH,…
- Integration of the possibility to mount a superconducting magnet for residual magnetic field test or potential pollution during assembly
- Vertical or horizontal positioning to be envisaged for some cavities

Triple spoke

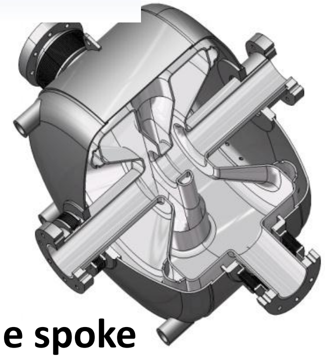




Double spoke

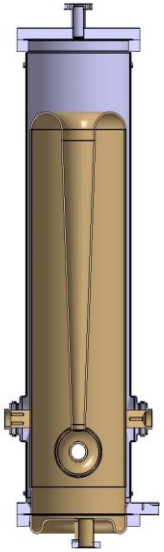


HWR

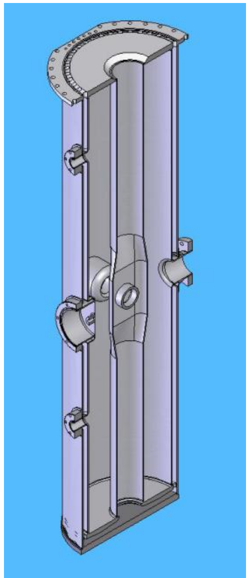


Single spoke

QWR



HWR



QWR

Sub-Task 2: low beta cavity test cryomodule

Integration of couplers and cold tuning system

Integrating couplers and tuners for different geometries is the main concern for this versatile cryostat

- **Power couplers:** For all cavity type, geometries are very different: the cryostat should have the possibility to have couplers located on the the bottom or on the side of the module (on top: option discarded).
- **Cold tuning system**: Also very different from one to each other: tuning by deformation, volume insertion, integration of piezo actuators; using cold or warm motors .

Only a cryostat with high flexibility (many openings & access) can solve this issue.

Sub-Task 2: low beta cavity test cryomodule

Cryogenic specification

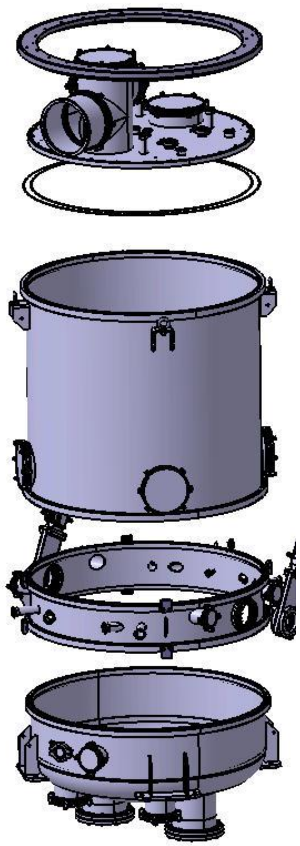
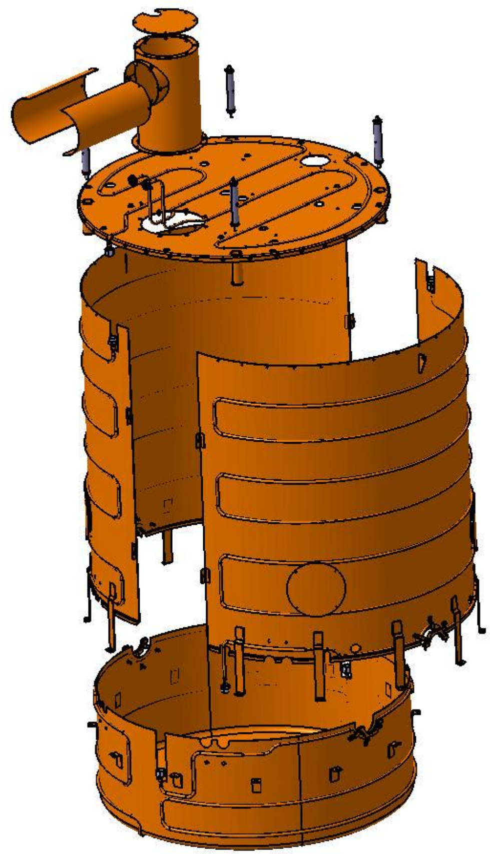
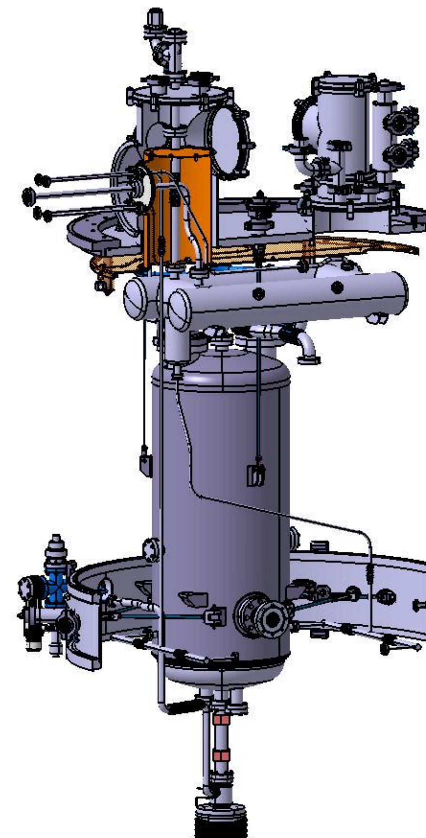
- Operating temperature: 4.2 K or depressed He bath (2 K typically)
- Power: the cryogenic system should be able to handle about 50 watts (in average) of dissipated power at 2 K
- Cooling time: in order to avoid the ”100 K effect”, the module should be able to cool down rapidly (typically, not more than one hour between 130 K and 70 K)

Assembly requirements

- The cryostat assembly has to be feasible in a huge variety of clean rooms : height requirements not too important, as simplest as possible assembly tooling, lowest possible amount of material entering in the clean room (pollution control) => concerns with the clean air blowing direction
- No requirements on any alignment device (has only meaning in a real accelerator module)

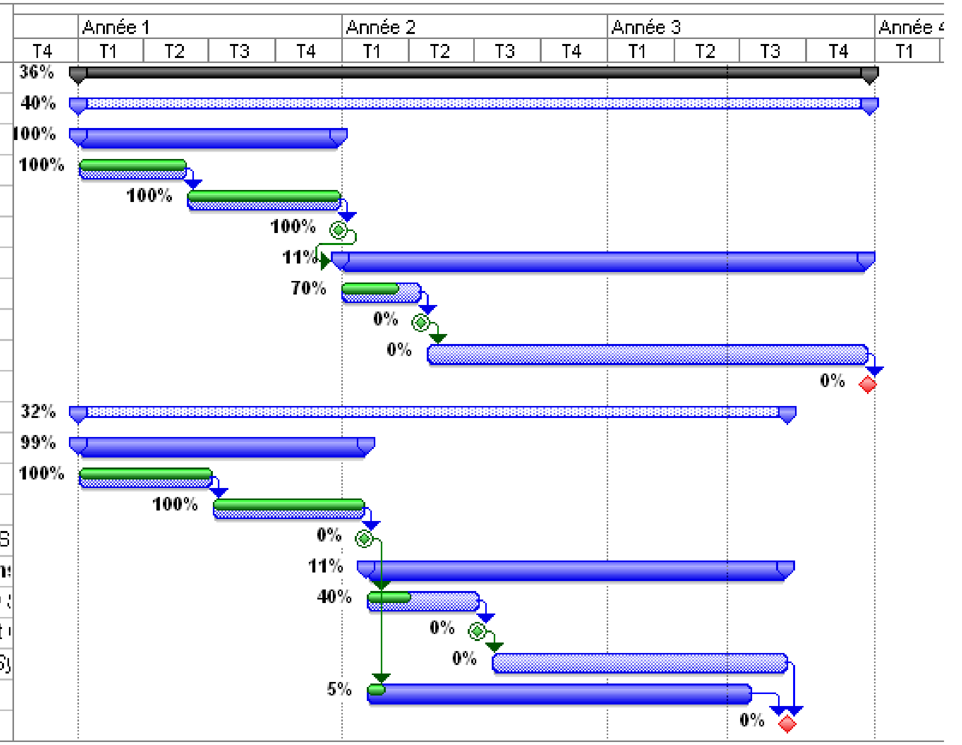
Sub-Task 2: low beta cavity test cryomodule

- Once the user requirements and specifications of the test cryostat was achieved, conceptual design study has started.
- The starting idea is to adapt the Spiral-2 high beta cryomodule:
    - with simplification (no beam ports, no alignment requirement)
    - but adding complexity (more openings, versatility, adaptability)

WP 9 Work Status: Gantt chart

N°	Task Name
1	**WP9 : TIHPAC (Test Infrastructure for High Power Accelerator Components)**
2	**Task 9.1 M-MWIF: Multi MW Irradiation Facility for complex target testing**
3	9.1.1 DSITF: Definition and specifications of Irradiation Test Facility
4	*9.1.1.1 IIF: Identification of the required Irradiation Facility*
5	*9.1.1.2 SIF: Specifications of the irradiation test facility*
6	M9.1 DSIF: Report on the Definition and Specifications of the Irradiation test Facilities
7	9.1.2 DSITF: Design Study of the high power Irradiation Test Facility
8	*9.1.2.1 PDITF: Preliminary Design study of high power Irradiation Test Facility*
9	M9.2 PDIF: Preliminary Design report on the high power Irradiation test Facility
10	*9.1.2.2 TDITF: Technical Design report on the high power Irradiation Test Facility*
11	**D9.1 TDIF: Technical Design report of the high power Irradiation test Facility**
12	**Task 9.2 DCTC: Design of a low beta Cavity Test Cryostat**
13	9.2.1 DSTC: Definition and Specification of the low beta SC Test Cryostat
14	*9.2.1.1 IUR: Identification of Users Requirements*
15	*9.2.1.2 STC: Specifications of the low beta SC Test Cryostat*
16	M9.3 URCS: Report on the User Requirements and setting up of the test Cryostat S
17	**9.2.2 DTSCS: Design of the test cryostat (vacuum tank, shielding, supporting system**
18	*9.2.2.1 PDTSCS: Preliminary Design study Tank, Shielding, and Cavity supporting S*
19	M9.4 PDCC: Report on the Preliminary Design study of the low beta SC Cavity test
20	*9.2.2.2 ADTSCS: Advanced Design study Tank, Shielding, and Cavity supporting Sy*
21	**9.2.3 CDCCB: Conceptual design study of the associated cryogenic cold box**
22	**D9.2 TDCC: Technical Design report of the low beta Cavity test Cryostat**



WP 9 Work Status: task completion

Task	Short Name	Description	% Achievement
9.1	**M-MWIF**	**Multi MW Irradiation Facility** for complex target testing	**40 %**
9.1.1	DSIF	Definition and Specification of the Irradiation test Facility	100 %
9.1.1.1	*IIF*	*Identification of the Irradiation test Facility*	*100 %*
9.1.1.2	*SIF*	*Specifications of the Irradiation test Facility*	*100 %*
9.1.2	DSIF	Design Study of the high power Irradiation test Facility	35 %
9.1.2.1	*PDIF*	*Preliminary Design study of the high power Irradiation test Facility*	*70 %*
9.1.2.2	*TDIF*	*Technical Design report on the high power Irradiation test Facility*	*0*
9.2	**DCTC**	**Design** of a fully equipped low beta **Cavities Test Cryostat**	**30 %**
9.2.1	DSTC	Definition and Specification of the low beta SC Test Cryostat	100 %
9.2.1.1	*IUR*	*Identification of the User Requirements*	*100 %*
9.2.1.2	*STC*	*Specifications of the low beta Test Cryostat*	*100 %*
9.2.2	DTSCS	Design of the vacuum Tank, Shielding, and Cavity supporting System	25 %
9.2.2.1	*PDTSCS*	*Preliminary Design study Tank, Shielding, and Cavity supporting System*	*40 %*
9.2.2.2	*ADTSCS*	*Advanced Design study Tank, Shielding, and Cavity supporting System*	*0*
9.2.3	*CDCCB*	*Conceptual Design of the associated Cryogenic Cold Box*	*5 %*

WP 9 : Milestones & Deliverable monitoring

Milestones

Num	Nat	Name	Description	Month	Status
M9.1	R	DSIF	Report on the Definition and Specifications of the Irradiation test Facilities	**12**	**Issued M12**
M9.2	R	PDIF	Preliminary Design report of the high power Irradiation test Facility	**16**	**Planned for M21**
M9.3	R	URCS	Report on the User Requirements and setting up of the test Cryostat Specifications	**13**	**Issued this week**
M9.4	R	PDCC	Report on the Preliminary Design study of the low beta SC Cavity test Cryostat	**18**	**Planned for M20**

Deliverables

Num	Nat	Name	Description	month
D9.1	R	TDIF	Technical Design Report of the Multi-MW test Irradiation Facility	**36**
D9.2	R	TDCC	Technical Design Report on the SC Cavity test Cryostat	**33**

- Two first milestones reached
- Slight delay expected for M9.3 & M9.4 but without further consequences
- **Work is progressing well, but still a lot to do !**

WP 9 : Work Status

TIARA Project

Work Package 9: TIHPAC - Test Infrastructure for High Power Accelerator Components TIHPAC

Task 9.1: Multi MW Irradiation Facility for complex target testing

Milestone n◦M 9.1: DSIF Report on the Definition and Specifications of the Irradiation test Facilities

Planned Date (month): *12*
Achieved Date (month): *12*
Lead Contractor: *CERN*

Project acronym:	*TIARA*
Project full title:	*Test Infrastructure in Accelerator Research Area*
Start of the Project:	*1st January 2011*
Duration of the project:	*36 Months*
DSIF Author:	*Karel Samec* *Nucl.& Mech. Eng.* *CERN Associate* *ENSI Nuclear specialist*
Task Coordinator:	*Yacine Kadi* *Prof. Dr. Phys.* *CERN staff physicist* *HI-Isolde facility manage*

Report M9.1

TEST INFRASTRUCTURE AND ACCELERATOR RESEARCH AREA

WP 9 – TIHPAC

Test Infrastructure for High Power Accelerator Components

Test Infrastructure for High Power Accelerators Components TIHPAC

Milestone 9.3:

User requirements and specifications for the low beta superconducting cavity test cryostat

Hervé Saugnac
Sébastien Blivet
Sébastien Bousson
CNRS / IN2P3/ IPN Orsay

Wolfgang Hees
ESS

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Report M9.3

Thank you !