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5th WP15 meeting (WP15 - Thin Film for Superconducting RF (TF-SRF)

Oleg Malyshev

WP15 coordinator

ARIES Annual Meeting , 22nd May 2018, RTU, Riga, Latvia

Agenda

9:00 - 12:30 1st year progress:

- 9:10 **Task 15.2.** Sample preparation
  - *Cristian Pira (10')*
  - Alban Sublet *(10')*
- 9:20 – 10:10 **Task 15.3.**
  - Sample deposition and deposited film characterisation
    - *Reza Valizadeh (10')*
    - *Michael Vogel (10')*
    - *Cristian Pira (10')*
  - Status of laser cleaning and polishing facility, sample characterisation - *Artur Medvid (10')*
  - Status of a film characterisation with thermal electron and exoelectron emission – *Aleksej Katasev (10')*
- **10:15 – 10:30 coffee break**
- **10:30 – 11:30 Task 15.4.**
  - Status of DC characterisation facilities
    - *Eugen Seiler (20')*
    - *Claire Antoine (5')*
    - *Oleg Malyshev (5')*
  - Status of RF characterisation facilities
    - *Oliver Kugeler (10')*
    - *Walter Venturini Delsolaro (10')*
- 11:30 **Milestone Report MS50** –
  - *Cristian Pira (30')*
  - Discussion – *all (30')*
- 12:30 - 14:00 Lunch
- 14:00 - 18:00 **Planning for 2nd year**
  - 14:00 **Task 15.3** coordination – *Reza Valizadeh*
  - 14:30 **Task 15.4** coordination - *Oliver Kugeler*
  - 15:00 Discussion - *all*

Milestones and deliverables

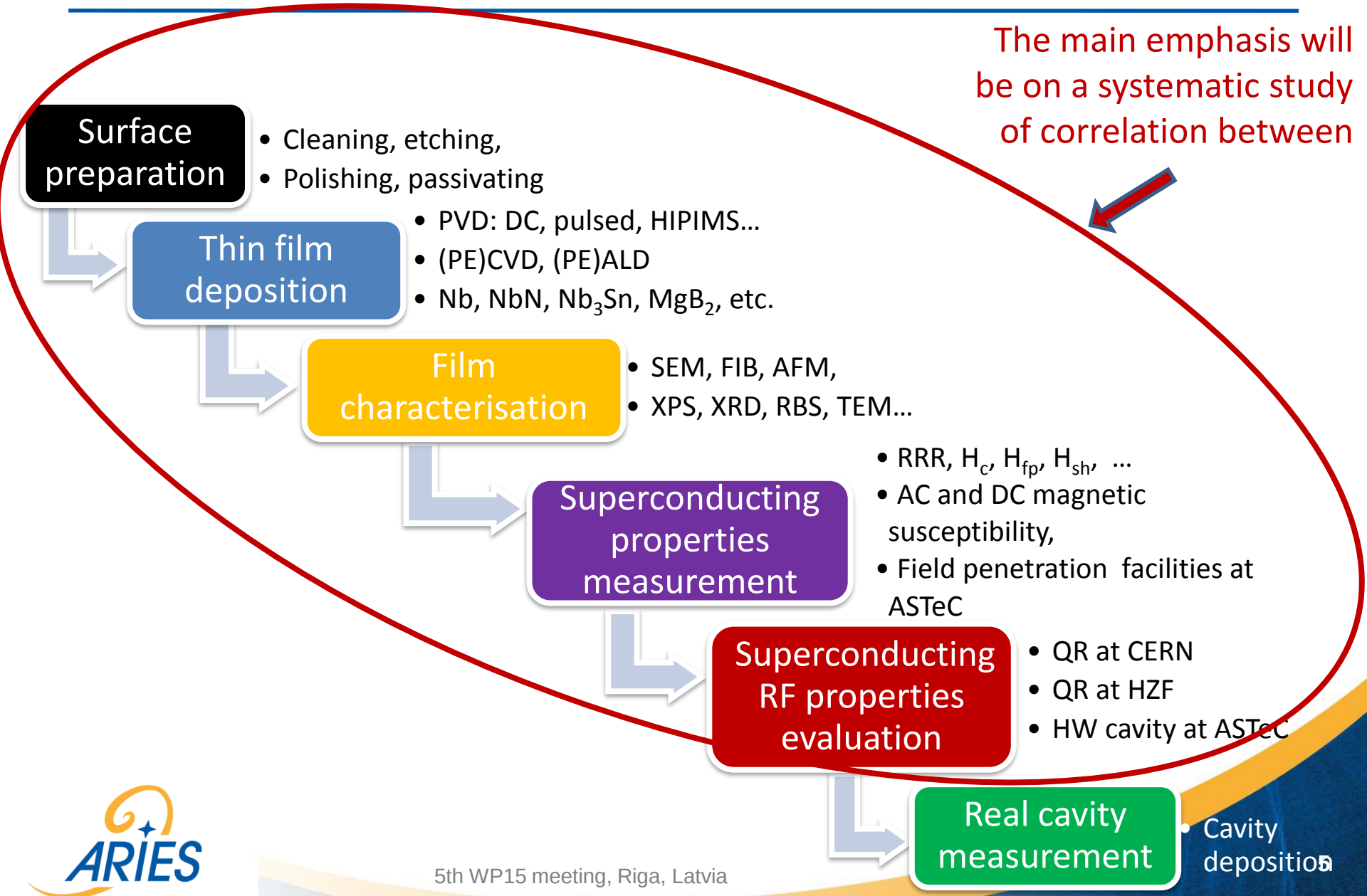
- ***D15.1: Evaluation of cleaning process**. Report defining an optimum cleaning and polishing procedure for surface preparation for Cu and Nb substrate for Nb coating minimising the substrate effect on the final film properties*
  - *Task 15.2 – coordinated by Cristian Pira*
  - *Month 12, postponed to month 14, i.e. to be ready by **30th May 2018***
- ***MS51: First samples exchanged** (system 1 and 2, e.g. NbN and Nb_3Sn and Superconductor-Insulator-Superconductor (SIS) multilayer coating) and deposited at partners*
  - *Tasks 15.3 and 15.4 – coordinated by Reza Valizadeh and Oliver Kugeler*
  - *Month 14, i.e. to be ready by **mid-June 2018***
- ***D15.2: Evaluation of systems 1 and 2**. Report on deposition, surface and structural analysis, DC and RF superconductivity evaluation of systems 1 and 2 (e.g. NbN and Nb_3Sn) and Superconductor-Insulator-Superconductor (SIS) multilayer coating*
  - *Task 15.3 – coordinated by Reza Valizadeh*
  - *Month 24, i.e. to be ready by 30th March 2019*

WP Description

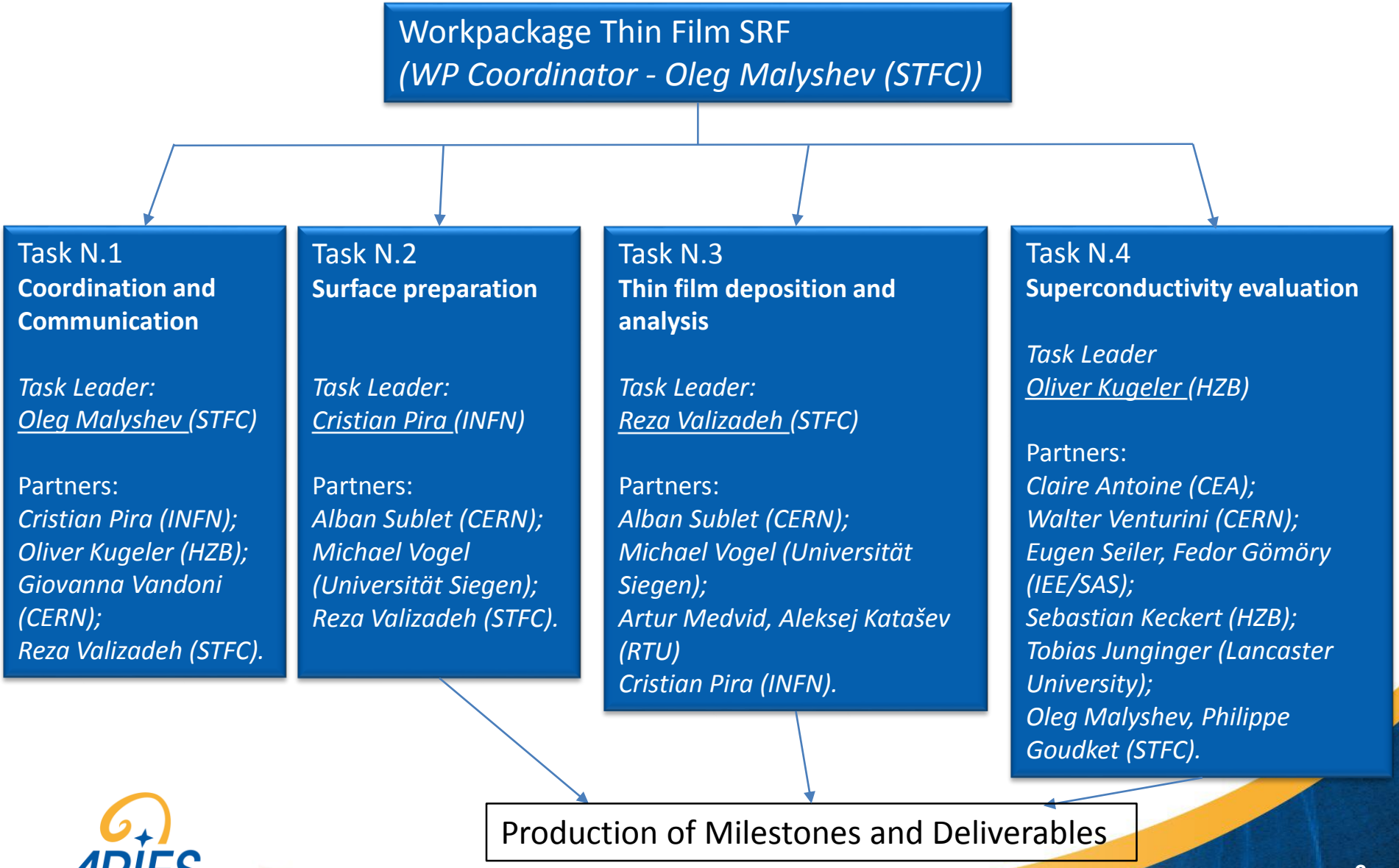
- The aim of this work package is to intensify systematic studies and development of the coating technology of superconducting materials to enable the superconducting coated RF cavities with Q(E) characteristics better than for the bulk ones.
- The main emphasis will be on a systematic study of correlation between
  - surface preparation,
  - deposition parameters,
  - film structure, morphology, chemistry
  - as well as AC and DC superconductivity parameters
    - such as T_c, H_c, H_{fp}, H_{sh}, RRR
    - of superconducting material Nb, NbN, Nb_3Sn, MgB_2, etc.
    - deposited on copper and bulk Nb,
  - and, finally, the behaviour at radiofrequency with the test cavities recently built at CERN, HZB and STFC.

What is proposed

The main emphasis will be on a systematic study of correlation between



Updated WP15 structure



Task 15.1: Coordination and Communication

Participants (beneficiaries):

Oleg Malyshev (STFC) – WP coordinator and Task 15.1 Leader,

Enzo Palmieri (INFN), Reza Valizadeh (STFC), Oliver Kugeler (HZB) – Task 15.2-15.4 leaders,

Giovanna Vandoni (CERN)

Objectives

- Define the global system taking inputs from different work-package (WP) tasks
- Coordinate and schedule WP tasks, to monitor work progress and inform the project management and WP participants
- Follow up the WP budget and resource use and prepare internal and deliverable reports

Description of work and role of partners

- This task will oversee and co-ordinate the overall activities, ensure the consistency of the work with the project plan and coordinate the WP technical and scientific tasks with tasks carried out by the other work packages when relevant.
- It includes organization of WP internal steering meetings, setting up of proper reviewing, reporting to the project management and distribution of the information within the WP and to the Project, and organisation of possible activity workshops or specialized working sessions.

Task 15.2: Substrate surface preparation

Participants (beneficiaries):

Enzo Palmieri (INFN) - Task Leader,

Alban Sublet (CERN), Michael Vogel (USIEGEN), Reza Valizadeh (STFC), Artur Medvid (RTU)

Objectives

- Coordinate the surface preparation for all samples.
- The surface treatment (mechanical, chemical and electrochemical, laser cleaning and polishing to improve film-substrate interface) of the substrate used for thin film deposition in Task 15.3 and the following measurements of surface resistance in Task 15.4.
- Define optimum cleaning and polishing procedure.
- Identify what could cause of delamination, lose thermal contact, etc.

Description of work and role of partners

- This task is focused on defining an optimum cleaning and polishing procedure which dictates the optimum RF properties of the films and on providing the partners with the sample substrates prepared exactly in the same surface chemical state and mechanical topographical finish, in order to minimise the substrate effect on the final film properties.
- The samples prepared at INFN will be used for deposition at other partner's laboratories.
- This task will include an intense coordination and exchange of information between partners.
- The results will be compared to the ones obtained with in-house prepared substrates.
- This task will provide samples or optimum cleaning and polishing procedure for sample preparation for Task 15.3.

Task 15.3: Thin film deposition and analysis

Participants (beneficiaries):

Reza Valizadeh (STFC) - Task Leader,

Alban Sublet (CERN), Michael Vogel (USIEGEN), Enzo Palmieri (INFN), Artur Medvid (RTU)

Objectives

- Coordinate the type of material, thicknesses and multilayer structures to be deposited with different deposition techniques available at the participating parties.
- Perform characterisation of deposited films with available surface analysis and characterisations tools.
- Define optimum deposition techniques and parameters.

Description of work and role of partners

- This task involves evaluating the best technique coming out of earlier programmes (EuCARD-2 WP12) for depositing new materials either in single or multiple layer(s).
- Partners (STFC, CERN and USIEGEN) will deposit various materials employing the deposition technologies and facilities available in their labs on the sample substrates prepared and provided by Task 15.2.
- RTU will perform three laser based tasks on selected samples: evaluation of long term thermal induced stability of the films deposited by other WP partners and film-substrate interface influence on the phase transitions, providing mapping over the whole specimen surface and, finally, laser annealing of superconducting films to increase the grain size and anneal defects on the films.
- All deposition and treatments techniques will need to be applicable to (planar) large (up to 100-mm) scale substrates as required by the RF testing devices in Task 15.4. This fairly large geometry of the sample was agreed as the testing standard – it forces the coating technique to function on a realistically large area but avoids the problem of coatings on curved surfaces as required for a resonator which is to be addressed at a later point.
- Subsequently, the mechanical, chemical, morphological properties and topography of the bare substrates and the deposited films will be analysed by all the partners and the results will be correlated with the ones obtained in Task 15.4.

Task 15.4: Superconductivity evaluation

Participants (beneficiaries):

Oliver Kugeler (HZB) - Task Leader,

Walter Venturini (CERN), Oleg Malyshev (STFC), Claire Antoine (CEA), Eugen Seiler (IEE/SAS)

Objectives

- Coordinate superconducting RF evaluation experiment in three laboratories (HZB, CERN and STFC)
- Perform experimental RF tests on selected samples of superconducting films deposited on copper discs on three facilities at CERN, HZB and STFC. Analyse the results obtained at different frequencies and different facilities.
- Upgrade the HZB QPR developed in EuCARD2 to enable flux penetration and flux mobility experiments
- Perform magnetic field penetration experiments of superconducting films deposited either on copper tubes to be studied on a dedicated facility at STFC or on a planar copper substrate to be studied on dedicated facilities at CEA and IEE/SAS to find the optimum film for single or multilayer coatings.
- Define criteria and evaluate the best technology for producing superconducting film for RF cavities.

Description of work and role of partners

- This task deals with the characterisation of the DC and RF superconducting properties of samples prepared within Task 15.2 and 15.3.
- *H_{c1} measurements* (Saclay, IEE/SAS) and *DC resistance measurements* (CERN, IEE/SAS) yield macroscopic information and can provide an exclusion criterion for the functioning of a manufacturing procedure.
- *Full penetration magnetic field H_{fp}* (STFC, IEE/SAS) provides an essential input for the multilayer films.
- Based on these, *RF tests are performed with the QPR/RF-testing facilities* (CERN, HZB, STFC) measuring BCS and residual resistance at different RF frequencies (400 MHz to 8 GHz), temperatures (from 1.5 K up to T_c) and fields up to 120 mT. Most conceivable cavity operation conditions are covered by this parameter space.
  - Due to the limited throughput of RF tests - realistically not more than 6 samples per year per facility - it is necessary to have 3 installations dedicated to RF testing within the task performing tests in parallel.
  - It is also planned to upgrade the HZB QPR that was funded by EuCARD2 with the capability to measure flux migration which is an important issue when aiming at the highest Q_0 values.

Schedule of milestones and deliverables

		Year 1				Year 2				Year 3				Year 4			
Task	Description	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1	1st WP meeting.	M1															
2	Evaluation of cleaning process for surface preparation for Cu and Nb substrate for Nb coating - (INFN).		M2		D1												
2-4	Evaluation of system 1 & 2 (e.g. NbN and Nb_3Sn coating) - STFC					M3			D2								
2-4	Evaluation of system 3 (e.g. MgB_2 and SIS multilayer coating)									M4			D3				
1-4	Final report.																D4

List of milestones and deliverables

Type	Delivery date (month)	Lead beneficiary	Related task/ responsible	Description
M1	m1	STFC	*Task 15.1*	1st WP meeting. Analysing outcome from EuCARD2 and current state of the field, finalising a detailed plan for WP
M2	m6	INFN	*Task 15.2*	First sample substrates cleaned at INFN for depositing at partners (Report to StCom)
D1	m12	INFN	*Task 15.2*	Evaluation of cleaning process. Report defining an optimum cleaning and polishing procedure for surface preparation for Cu and Nb substrate for Nb coating minimising the substrate effect on the final film properties.
M3	m14	STFC	Task 15.3, 15.4	First samples exchanged (system 1 and 2) and deposited at partners (Report to StCom)
D2	m24	STFC	Task 15.3, 15.4	Evaluation of systems 1 and 2. Report on deposition, surface and structural analysis, DC and RF superconductivity evaluation of systems 1 and 2 (e.g. NbN and Nb3Sn) and Superconductor-Insulator-Superconductor (SIS) multilayer coating
M4	m26	HZB	Task 15.3, 15.4	First samples exchanged (system 3 and SIS) and deposited at partners (Report to StCom)
D3	m36	HZB	Task 15.3, 15.4	Evaluation of system 3. Report on deposition, surface and structural analysis, DC and RF superconductivity evaluation of system 3 (e.g. MgB_2) and SIS multilayer coating
D4	m46	STFC	Task 15.3, 15.4	Final report on thin film technology [46] Report summarizing the results on the evaluation of cleaning and coating procedures for highest Q_0 and E_a

Performance indicators

Key Performance Indicator (KPI)	Description	Method to measure	Estimated target
Q_0 (or surface resistance)	Q_0 and surface resistance of thin films measured in Task 15.4 will be compared to ones with bulk Nb	Report	Q_0 with thin film sample is equal or higher than Q_0 with bulk Nb sample
Raise of RF critical field with thin films	Increase of E_a is coupled with a raise of RF critical field with thin films.	Report	20% higher than for bulk Nb

Critical risks for implementation

Description of risk	Likelihood	Impact	Proposed risk-mitigation measures
Change of management team or WP Coordinators during the project	Medium	Medium	Anticipate potential staff changes in the project management and WP coordinators and select suitable replacements within the consortium as soon as possible
Withdrawal of beneficiary (ies)	Low	Low	Other beneficiaries take over the responsibilities of the withdrawing partner or new beneficiaries are included in the project from the pool of collaborating institutes
Reduced or undelivered contribution by one or more of the beneficiaries to the work programme of the project	Low	Low	Redistribution of work and budget to other members of the consortium, with possible rescheduling of milestones and deliverables if needed
Failure of equipment for film deposition, surface analysis or superconductivity evaluation	Medium	Medium	Each task involves at least two teams with similar capability. In the case of such a failure the project will continue running with slower progress. There is a contingency in the WP deliverables which allows fixing failed equipment
Chosen film system does not provide the required SRF parameters	Medium	Medium	The WP team will work in tree directions: (1) In additional to traditionally used Nb film three other types of film systems will be studied as hot candidates (such as NbN, Nb_3Sn, MgB_2) (2) Pre- and post-deposition laser treatment to improve film adhesion and grain size. (3) The SIS multilayer coating with both Nb and new types film systems will be investigated

WP15 meetings

- How often to meet?
  - 2-3 times/year in person
    - WP15 meeting during the ARIES annual meetings (everybody is expected to come)
    - WP15 meeting at partner's institutes
  - 1-2 times/year by video conferencing or skype meeting

- Next meeting date and location?