MAGiC - Work Packages Specification

Version 0.1

SUMMARY

The MAGiC Work Package will deliver a polarized single crystal diffractometer instrument ready for hot commissioning with spallation neutrons by 1st June 2021. The scope of the work is described along with the budget, schedule and project processes used. The total budget validated during the scope setting meeting is of 13 102 000 € including 8.8% of contingency. The MAGiC instrument is a collaborative project of three in-kind partners: Laboratoire Léon Brillouin (LLB), Forschungszentrum Jülich (FZJ) and Paul Scherrer Institute (PSI) sharing approximately 59%, 24% and 17%.

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1 PROJECT ORGANIZATION

1.1 Project Goal

The goal of the project is to deliver a complete Polarized Single Crystal Diffractometer ready for hot commissioning with spallation neutrons from the ESS target station. The overarching goal is that this instrument will provide the best possible scientific performance that will allow neutron diffraction on magnetic single crystals to be applied to more challenging and relevant systems in material science, such as quantum magnetism or epitaxial films.

1.2 General Project Strategies

A neutron scattering instrument is a complex machine consisting of different subsystems (optical system, detector system, etc.) that in turn consist of technical components. All of these subsystems together must fulfil the functional requirements for the scientific performance as well as constraint requirements for maintainability as well as safety requirements.

The general strategy to achieve this is that the Core Instrument Team (Instrument Scientist, Instrument Engineer) set the requirements for various subsystems and the ESS technical groups or in-kind partners in the corresponding technical area provide technical solutions that fulfil these requirements. Together with the core instrument team they design, procure or fabricate, install and test the technical components of the instrument. The instrument infrastructure supports the technical components, provides the necessary utilities and shields against radiation. This infrastructure will be designed by the core instrument team together with the relevant technical groups and procurement and installation will be coordinated within the instrument construction sub-project.

1.3 Governance structure

The governance structure is described in the NSS project specification and the instrument construction sub-project specification (3), references therein and the Memorandum of Understanding (MoU) for the MAGiC Instrument Consortium. The Instrument Consortium Executive Board (ICEB) oversees the project.

1.4 In-Kind Partners

The in-kind contributions to the project will be coordinated within the ICEB and specific contributions will be defined in technical annexes. Where necessary the ICEB may also formulate plans for future in-kind contributions.

1.5 Connections to other Projects or Assignments

The software tools for time-of-flight Laue data processing are not yet mature, so the ESS DMSC will ensure as part of its scope that appropriate software will be available when the instrument enters hot commissioning.

2. PROJECT SCOPE

2.1 Instrument Overview

The instrument consists of three main technical subsystems: the beam transport system (BTS), the sample exposure system (SES) and the scattering characterization system (SCS). In addition, the instrument includes the structures that house and support these subsystems and the software to control the instrument and process the data as described in the instrument product breakdown structure (PBS).

Beam transport system (BTS) (13.6.18.1)
The beam transport system transports a beam of neutrons from the moderator surface to the sample. The size, divergence and wavelength spectrum of the beam are tailored to the needs of the experiment.

Sample exposure system (SES) (13.6.18.2)
The sample exposure system positions the sample in a beam of neutrons and controls the physical and chemical environment of the sample as dictated by the needs of the experiment.

Scattering characterization system (SCS) (13.6.18.3)
The neutron absorption system detects the neutrons scattered by the sample to produce meaningful experimental data.

Experimental cave (13.6.18.5)
The experimental cave houses the beam defining elements of the BTS, the SES and the SCS. It shields the surrounding hall from the radiation generated by these systems as well as shielding the detector system from external radiation.

Control hutch (13.6.18.6)
The control hutch houses the experiment control and data processing terminals. During an experiment the user team spends most of their time in the control hutch.

Sample Preparation Area (13.6.18.7)
The sample preparation area contains all the necessary equipment for sample handling, mounting and storage between experiments.

Utilities Distribution (13.6.18.8)
The utility distribution covers the power, chilled water, gas and compressed air distribution across the three halls (D01, E02 and E01).

Support Infrastructure (13.6.18.9)
The support infrastructure covers the necessary infrastructure to operate the instrument (power, network, lighting, safety, ...) across the three halls (D01, E02 and E01).

Control Racks (13.6.18.10)
The control racks host the electronic needed to interface and monitor the multiple instrument elements across the various halls.

Integrated control and monitoring system (13.6.18.11)
The integrated control and monitoring system allows the user to control the experimental parameters and process the neutron data. It also contains the control and monitoring systems needed for the safe operation of the instrument.

The Preliminary System Design Description for the MAGiC Diffractometer and the documents referenced therein describe in detail the design baseline. These documents also show how the presented design meets the functional and constraint requirements.

3. WORK BREAKDOWN

3.1 Instrument Work Units

The Work Units are composed of all the deliverables with which a single responsible group contributes to the instrument construction WP. The deliverables that compose the work units are indicated in the WBS. The work unit documentation will contain the technical and project information related to the included deliverables. Following, the deliverables are extracted from the instrument WBS and associated with each Work Unit.

3.1.1 Instrument Team Work Unit

The instrument team will be responsible for the functionalities not included in the other work units.

13.6.18.0 MAGiC Integration
13.6.18.1 Beam Transport and Conditioning System

- <u>13.6.18.1.2 Beam Delivery System</u>
  - 13.6.18.1.2.1 Super-mirrors
  - 13.6.18.1.2.2 Vacuum Housing
  - 13.6.18.1.2.3 Guide positioning
- <u>13.6.18.1.3 Chopper System</u>
  - 13.6.18.1.3.1 Pulse Shaping Chopper
  - 13.6.18.1.2.2 Selection Chopper
  - 13.6.18.1.2.3 Band Chopper
- <u>13.6.18.1.4 Beam Geometry Conditioning</u>
  - 13.6.18.1.4.1 Focusing system
  - 13.6.18.1.4.2 Collimation Slits
  - 13.6.18.1.4.3 Aperture slits
  - 13.6.18.1.4.4 Support and Alignment
- <u>13.6.18.1.5 Beam Filtering System</u>
  - 13.6.18.1.5.1 Guide Field

13.6.18.1.5.2 Rotator
13.6.18.1.5.3 XYZ Polarization
13.6.18.1.5.4 Solid State Bender
13.6.18.1.5.5 RF Spin Flipper

13.6.18.1.6 Beam Validation

13.6.18.1.6.1 Incident Beam Monitor
13.6.18.1.6.2 Transmitted Beam Monitor

13.6.18.1.7 Beam Cut Off

13.6.18.1.7.2 Heavy Shutter
13.6.18.1.7.3 Secondary Shutter
13.6.18.1.7.4 Beam Stop

13.6.18.1.8 Vacuum System

13.6.18.1.8.3 Evacuated Flight Path

13.6.18.1.9 Shielding

13.6.18.1.9.1 In-Bunker
13.6.18.1.9.2 Beamline
13.6.18.1.9.3 Neutron Guide

13.6.18.2 Sample Exposure System

13.6.18.2.1 Sample Mounting

13.6.18.2.2 Ancillary Mounting

13.6.18.2.3 SE Equipment

13.6.18.2.3.1 Cryostat
13.6.18.2.3.2 Sample Positioning

13.6.18.2.4 Non-SE Ancillary Equipment

13.6.18.3 Scattering Characterization System

13.6.18.3.1 Polarization Analysis

13.6.18.3.2 Neutron Detector System

13.6.18.3.2.1 Large Detector
13.6.18.3.2.2 Small Detector
13.6.18.3.2.3 Detector Positioning

13.6.18.3.3 Vacuum System

13.6.18.3.4 Radial Collimator

13.6.18.5 Experimental Cave

13.6.18.5.2 Utilities Distribution

13.6.18.5.3 Support Infrastructure

13.6.18.5.4 Shielding

13.6.18.5.5 Cave Structure

13.6.18.5.6 SE Utility Supplies

13.6.18.6 Control Hutch

13.6.18.6.1 Support Infrastructure

13.6.18.6.1.1 Power
13.6.18.6.1.2 Network
13.6.18.6.1.3 Lighting
13.6.18.6.1.4 Ventilation

13.6.18.6.1.5 Fire Protection
13.6.18.6.1.9 Remote Area Surveillance
13.6.18.6.1.11 Public Address System
13.6.18.6.2 Hutch Building Structure
13.6.18.6.3 Control terminal

13.6.18.7 Sample Preparation Area

13.6.18.7.1 Utilities Distribution
13.6.18.7.1.1 Power
13.6.18.7.1.2 Chilled Water Distribution
13.6.18.7.1.3 Compressed Air Distribution
13.6.18.7.1.4 Gas Distribution
Support Infrastructure 13.6.18.7.2
13.6.18.7.2.1 Power
13.6.18.7.2.2 Network
13.6.18.7.2.3 Lighting
13.6.18.7.2.4 Ventilation
13.6.18.7.2.5 Fire Protection
13.6.18.7.2.6 O2 Monitoring
13.6.18.7.2.7 H2O Leakage Detection
13.6.18.7.2.9 Remote Area Surveillance
13.6.18.7.2.11 Public Address System
13.6.18.7.3 Cabin Building Structure
13.6.18.7.4 Laboratory Equipment and Sample Storage
13.6.18.7.4.1 Binocular
13.6.18.7.4.2 Glove Box
13.6.18.7.4.3 Fume Cupboard

13.6.18.8 Utilities Distribution

13.6.18.8. D01
13.6.18.8.1.1 Power
13.6.18.8.1.2 Chilled Water Distribution
13.6.18.8.1.3 Compressed Air Distribution
13.6.18.8.1.4 Gas Distribution
13.6.18.8.2 E02
13.6.18.8.2.1 Power
13.6.18.8.2.2 Chilled Water Distribution
13.6.18.8.2.3 Compressed Air Distribution
13.6.18.8.2.4 Gas Distribution
13.6.18.8.3 E01
13.6.18.8.3.1 Power
13.6.18.8.3.2 Chilled Water Distribution
13.6.18.8.3.3 Compressed Air Distribution
13.6.18.8.3.4 Gas Distribution

13.6.18.9 Support Infrastructure

13.6.18.9.1 D01

13.6.18.9.1.1 Power
13.6.18.9.1.2 Network
13.6.18.9.1.3 Lighting
13.6.18.9.1.4 Ventilation
13.6.18.9.1.5 Fire Protection
13.6.18.9.1.7 H2O Leakage Detection
13.6.18.9.1.9 Remote Area Surveillance
13.6.18.9.1.11 Public Address System

E02 13.6.18.9.2

13.6.18.9.2.1 Power
13.6.18.9.2.2 Network
13.6.18.9.2.3 Lighting
13.6.18.9.2.4 Ventilation
13.6.18.9.2.5 Fire Protection
13.6.18.9.2.7 H2O Leakage Detection
13.6.18.9.2.9 Remote Area Surveillance
13.6.18.9.2.11 Public Address System

E01 13.6.18.9.3

13.6.18.9.3.1 Power
13.6.18.9.3.2 Network
13.6.18.9.3.3 Lighting
13.6.18.9.3.4 Ventilation
13.6.18.9.3.5 Fire Protection
13.6.18.9.3.7 H2O Leakage Detection
13.6.18.9.3.9 Remote Area Surveillance
13.6.18.9.3.11 Public Address System

13.6.18.10 Control Racks

13.6.18.10.1 D01

13.6.18.10.1.1 DAQ Rack
13.6.18.10.1.4 Chopper Control Rack
13.6.18.10.1.8 Ancillary Automation Rack

13.6.18.10.2 E02

13.6.18.10.2.1 DAQ Rack
13.6.18.10.2.4 Chopper Control Rack
13.6.18.10.2.8 Ancillary Automation Rack

13.6.18.10.3 E01

13.6.18.10.3.1 DAQ Rack
13.6.18.10.3.7 Magnet Control Rack
13.6.18.10.3.8 Ancillary Automation Rack

13.6.18.11 Integrated Control & Monitoring

13.6.18.11.1 Instrument Control Integration

13.6.18.11.1.1 Generic Motion Control Integration
13.6.18.11.1.4 Ancillary Automation Control Integration

3.1.2 Sample Environment Team Work Unit

The Sample Environment Work Unit will deliver the integration necessary to operate equipment from the ESS sample environment pool as well as the control system integration of instrument specific sample environment.

13.6.18.5.7 SE Control Box
13.6.18.11.1.4 Magnet Control Integration

3.1.3 Motion Control and Automation Work Unit

The Motion Control and Automation WU will deliver the electronic hardware and software necessary to integrate instrument motion axis into the Integrated Control System (ICS). The WU will also provide control racks for all the instrument electronics.

13.6.18.10.1.2 DMSC Rack
13.6.18.10.1.3 Motion Control Rack
13.6.18.10.1.5 Vacuum Control Rack
13.6.18.10.1.6 Personal Safety System Rack
13.6.18.10.2.2 DMSC Rack
13.6.18.10.2.3 Motion Control Rack
13.6.18.10.2.5 Vacuum Control Rack
13.6.18.10.2.6 Personal Safety System Rack
13.6.18.10.3.2 DMSC Rack
13.6.18.10.3.3 Motion Control Rack
13.6.18.10.3.5 Vacuum Control Rack
13.6.18.10.3.6 Personal Safety System Rack
13.6.18.11.1.5 EPICS Integration

3.1.4 Personnel safety system (PSS) Work Unit

The Personnel safety system will deliver the personnel safety system for the full instrument and its integration at ESS level.

13.6.18.1.7.1 Personal Safety System
13.6.18.5.1 Personal Safety System
13.6.18.11.2 Personal Safety System Integration
- 13.6.18.11.2.1 Interlock System
- 13.6.18.11.2.2 Radiation Detection
- 13.6.18.11.2.3 Shutter Interface
- 13.6.18.11.2.4 H_2O Leakage Detection
- 13.6.18.11.2.5 O_2 Monitoring
- 13.6.18.11.2.6 Fire Protection

3.1.5 Neutron Beam Extraction System Work Unit

The monolith neutron beam extraction system will be designed by the instrument team but manufactured, delivered and installed by the ESS.

13.6.18.1.1 Neutron Beam Extraction System
- 13.6.18.1.1.1 Monolith Insert
- 13.6.18.1.1.2 Monolith Window

3.2 Excluded

All deliverables not explicitly mentioned in the work units description are excluded from the WP. Some exclusions that are nonetheless essential for the functionality and operation of the instrument are described below. These will be delivered by other parts of the ESS Programme where also the budget for these items is allocated.

3.2.1 Vacuum system

The vacuum system will deliver the integration of hardware and software to operate the instrument components under vacuum and to control the vacuum components through the integrated control system.

13.6.18.1.8.1 BTS Vacuum
13.6.18.1.8.2 Chopper Vacuum
13.6.18.11.1.3 Vacuum Control Integration

3.2.2 Data Acquisition, instrument control and data processing

The Data acquisition and, instrument control and data processing is excluded from the formal scope and hence budget of the WP. It will deliver the control software necessary to perform setup the instrument and conduct the experiment, process the data, as well as the hardware and the software to collect, store and analyze the data from the detector and beam monitor system.

13.6.18.11.3 DMSC Integration
- 13.6.18.11.3.1 Data System & Technology
- 13.6.18.11.3.2 Data Management
- 13.6.18.11.3.3 Instrument Data
- 13.6.18.11.3.4 Data Analysis & Modelling

3.2.3 Supporting laboratories and sample environment

Any sample environment equipment that is part of the ESS sample environment pool (magnets, cryostats, etc.) is excluded from the WP. The sample environment integration deliverable will provide a standard panel and mechanical interface that allows sample environment equipment from the ESS sample environment pool to be used at the instrument.

3.2.4 Conventional facilities

All civil construction activities not explicitly mentioned in the not explicitly described in the work units descriptions. This will be part of the CF WP.

The supply of cooling water, sprinkler water electricity and gases up to the distribution points in the installation galleries.

3.3 Deliverables

Each Work Unit in 3.1 is associated to a deliverable. The preliminary share between each partner is as follows:

FZJ Deliverables

13.6.18.1.3 Chopper System
13.6.18.1.4.2 Collimation Slits
13.6.18.1.6 Beam Validation
13.6.18.3.2 Neutron Detector System
13.6.18.10.1.4 Chopper Control Rack
13.6.18.10.2.4 Chopper Control Rack

PSI Deliverable

13.6.18.3.1 Polarization Analysis

LLB Deliverables

Every instrument Team Work Unit not affected to FZJ and/or PSI.

ESS Deliverables

Sample Environment Team Work Unit
Motion Control and Automation Work Unit
Personnel safety system (PSS) Work Unit
Neutron Beam Extraction System Work Unit
Vacuum System
Data Acquisition, instrument control and data processing
Supporting laboratories and sample environment
Conventional facilities

4. PROJECT SCHEDULE

4.1 Time Schedule

The schedule of the WP is organised in four phases: Preliminary Engineering Design (Phase 1), Final Engineering Design (Phase 2), Construction and Installation (Phase 3) and Beam Testing and Cold Commissioning (Phase 4). While the activities in various phases may overlap in time, the overall schedule is structured by the Tollgate (TG) reviews that mark the nominal end of each phase.

The schedule presented here will be refined and adapted as the project progresses, but the major milestones (section 4.2) serve as a basis for reporting.

4.2 Milestone Plan

The major milestones in the WP are divided into external milestones – that are outside the control of the instrument team but yet have a major impact – and progress milestones that are used to track progress and report to the Instrument Construction Sub-Project.

ID	External Milestones	Projected Date
1	Monolith Insert Ready for Installation	Dec-18
2	Monolith Insert Installed	Apr-19
3	Access to E01	Apr-19
4	Access to E02 - 1	Apr-19
5	Access to D01 - Bunker	Jun-19
6	Access to E02 - 2	Oct-19
7	Access to D01 - Main	Nov-19
8	Light Shutter Installed	Dec-19
9	First Proton on Target	Mar-20
10	Support Laboratories Available	Mar-21

ID	Progress Milestones	Projected Date
1	TG2	Jan-17
2	Final neutron optics design and early procurement	Jun-17
3	TG3	Feb-18
4	Experimental cave ready to install	Apr-19
5	SES, Infrastructure and Utilities ready to install	Jun-19
6	Control Hutch and Sample Preparation Laboratory ready to install	Nov-19
7	TG4	Feb-20
8	Shielding elements ready to install	Mar-20
9	Neutrons optics ready to install	Jun-20
10	Choppers ready to install	Jun-20
11	Detectors ready to install	Oct-20
12	TG5 (start of hot commissioning)	Jun-21

13	Polarization Analyzer ready to install	Jun-22
14	Switch to user program	Jan-23

4.3 Detailed Plan

The preliminary detailed plan (Gantt chart) is provided as an additional file (see Additional Files). A summary of the construction plan is presented in the following:

5.PROJECT BUDGET AND FINANCIAL REPORTING

5.1 Project Budget

The MAGiC complete cost estimates (with calculations) based on the agreed scope is provided as an additional file (see Additional Files). An overview is given here.

	01 Phase 1	02 Phase 2	03 Phase 3	04 Phase 4	Total (k€)
Shielding & Cave					
	0	0	1269	142	**1411**
Neutrons Optics & Polarization					
	0	0	4484	496	**4980**
Choppers					
	0	0	675	75	**750**
Sample Environment					
	0	0	165	20	**185**
Detectors & Beam Monitors					
	0	0	1324	248	**1572**
Data Acquisition and Analysis					
	0	0	0	0	**0**
Motion Control & Automation					
	0	127	152	83	**362**
Instrument Specific Technical Equipment					
	415	439	493	830	**2187**
Instrument Infrastructure					
	0	0	365	140	**505**
Vacuum					
	0	0	0	0	**0**
Contingency					
					1154
Total					
					13103

6. PROJECT RISK MANAGEMENT

6.1 Risk List

The most important project risks are presented in the table below. Technical risks for individual subsystems and components are described in the relevant design documents. The risk probabilities and consequences are listed before taking into account specific mitigation measures. The risks are divided into technical, cost and schedule risks and their probability and consequence on a scale of 1-5 (where 1 denotes low probability and minor consequence) according to ESS risk management practice.

Technical related risks

Risk	Proba.	Effect	Risk level	Mitigation
CDT detectors may not meet requirements	2	4	8	Close follow up with CDT development, backup solution by ESS.
CDT is out of business	2	5	10	Close follow up with CDT development, backup solution by ESS.
Solid State Bender misaligned	2	3	6	Use radiation hard alignment mechanism.
SSB demagnetization by fast neutrons	5	3	15	Shield magnets. Magnets out of direct line of sight.
Chopper failure	1	5	5	Use established vendor/technology
Heavy Shutter failure	1	5	5	Manual operation of the heavy shutter.
Insufficient shielding	2	5	10	Upgradable shielding design.
Neutron optics not meeting requirements	1	2	2	Accept lower performance.
Settlement of building	2	2	4	Re-align full optics.

Guide field not meeting requirements	1	3	3	Accept lower polarization
Polarization analyzer not meeting requirements	2	4	8	Realize prototype. Explore Backup Solution.
Important ground shine	2	3	6	Expand shielding under floor level. Accept higher background.
Superconducting magnet not meeting requirements.	4	3	12	Accept lower magnetic field. Use SE pool magnet.
Oscillating collimators failure.	1	2	2	Use static collimation.

Budget related risks

Risk	Proba.	Effect	Risk level	Mitigation
Detector cost estimates are exceeded	2	4	8	Use contingency, reduce detectors coverage.
Shielding needs to be increased	2	4	8	Use contingency
General cost increased	3	4	12	Use contingency
Personnel cost increased due to delay	4	3	12	Use contingency
Analyzer cost increased due to delay	2	4	8	Use contingency
Analyzer cost increased due to €/CHF exchange rate	3	2	6	Use contingency

Schedule related risks

Risk	Proba.	Effect	Risk level	Mitigation
Choppers delivery postponed due to high demand	3	3	9	Early procurement.
Neutron optics delivery postponed	3	5	15	Early procurement.
Detailed design delay	3	1	3	Increase manpower
Broken parts during installation and commissioning	2	4	8	Respect safety rules and proper personal training.
Availability of halls for installation delayed	3	5	15	Pre-build elements at partner institutes.

6.2 Risk Monitoring and Control

ESS risk management procedures will be followed. The risk register will be maintained in specialised software (*e.g.* Exonaut Risk) and updated in regular workshops. The updated risk register will also be available to the Instrument Construction Sub-Project and the NSS Project for higher level risk monitoring. If a risk is realised it will be reported to the Instrument Construction Sub-Project even if it has no direct consequence at that level.