Status, Work plan and Milestones
ESS Instrumentation Task

Introduction

The ESS Instrumentation Group is responsible to develop and define the appropriate instrumentation suite for the ESS target stations. The instrument group shall guide the site layout by providing a representative footprint of the target stations and make a suggestion for an initial instrument suite, which optimises the use of the two target stations considered.

Considered instruments will be world leading in the various fields of sciences using neutrons. To reach this goal the ESS Instrumentation Group works closely with the SAC and the Target and Moderators Group of ESS.

Organisation of ESS Instrumentation Group

The ESS Instrumentation Group is linked directly to the ESS Central Project Team and part of the Core Group Activities of the ESS project on the same level as the other two technical tasks accelerator and moderator and target systems.

It is represented by the ESS Instrumentation Task leader F. Mezei (HMI) and its deputy R. Eccleston (ISIS).

Lead laboratory for the ESS Instrumentation Task is HMI, Berlin, where an ESS Instrumentation Office has been established run by the task leader assistant T. Gutberlet (HMI).

An ESS Instrumentation Task Group has been established. It consists of nine subgroups for different neutron instrument fields (powder diffraction, direct geometry spectrometers, indirect geometry spectrometers, neutron spin echo spectrometers, SANS, reflectometry, single crystal diffraction, structure factor determination, engineering). At current 36 instrument scientists of various institutes and universities are working in the ITG subgroups in order to study performance and options of instrumentation for ESS. Each group is represented by a group convenor.

Specific R&D efforts related to instrumentation is directed at several of the ESS MoU institutes in co-ordination with the ESS Instrumentation Group.

The ESS Instrumentation Group efforts are in close contact with the efforts of the other technical tasks Accelerator and in particular Target and Moderators and also SAC by common milestones. Common information flow is secured by project and core group meetings and topical workshops.

Activities ESS Instrumentation Task Group

The ITG has held several meetings since it was established in Oct. 2000 in Berlin, Heathrow and Munich. Minutes of the meetings are available at the ESS ITG webside [1].

The first task was to provide background material needed to select between the two target stations for ESS. The nine ITG subgroups reviewed the general performance of neutron instrument groups at the suggested target stations, 50Hz short pulse, 10Hz short pulse and 16.6Hz long pulse target station, respectively.

This task involved agreeing on a set of educated guesses on moderator performance in collaboration with the Target and Moderator Group and external advisors to provide a realistic basis for instrumental considerations. These guesses had been based on partial and often contradictory data available in the literature, primarily from ISIS,

LANL, SNS, and the work of the Hokkaido group. The types of moderators considered were: (a) Ambient water: de-coupled poisoned, de-coupled un-poisoned, coupled, (b) Liquid hydrogen: de-coupled poisoned, de-coupled un-poisoned, "fully extended premoderated" coupled. Differences between moderators on different target stations had been considered. Reports have been prepared and are available at the ESS ITG webside (appendix to Heathrow meeting).
To assess the opportunities for generic instrument groups on the ESS and to determine the optimum target station combinations the ITG addressed issues relating to generic instrument groups as follows: Powder Diffraction, Chopper Spectrometers, Crystal Analyser Spectrometers and High Resolution Backscattering, Neutron Spin Echo, Small Angle Scattering, Reflectometry, Single Crystal Diffraction, Protein Crystallography, S(Q) determination and Engineering. Quantitative evaluation of the performance of this generic set of neutron scattering instruments was completed for 3 target station options: (a) 5 MW average proton beam power in 50Hz, 1 ms short pulses, (b) 1 MW average proton beam power in 10Hz, 1 ms short pulses, (c) 5 MW average proton beam power in 16.6Hz, 2 – 2.5 ms long pulses. Comparisons were made with existing instrumentation in order to assess the new opportunities and scientific impact. Results were collected in a report presented at the ESS SAC/ENSA workshop at Engelberg [2].

Activities ESS Instrumentation Office
The ESS Instrumentation Office has organized the ITG meetings and established the ITG webside. The office was launched Jan. 1999.
Topical workshops have been organised on

- Int. Workshop Protein Crystallography with Neutrons
  25.-26. Feb. 2000, Berlin
- Neutron Spin Echo Spectroscopy – Future Aspects and Applications
  16.-17. Oct. 2000, Berlin
- ESS Instrumentation Task Group Meeting
  17.-18. Oct. 2000, Berlin
- ESS Instrumentation Task Group Meeting
  16. Feb. 2001, London-Heathrow
- Moderator Concepts and Optimization for Spallation Neutron Sources
  12.-14. March 2001, Berlin
- Workshop on VITESS 2 and other Packages for Simulation of Neutron Scattering Instrumentation
  25.-27. June 2001, Berlin
- Int. Workshop Position-Sensitive Neutron Detectors – Status and Perspectives
  28.-30. June 2001, Berlin
- ESF Exp. Workshop on Time Resolved Investigations by Neutrons and X-rays
  5.-7. Sept. 2001, Sommerfeld
- ESS Instrumentation Task Group Meeting
  11. Sept. 2001, Munich

Reports and proceedings of organized workshops have been published [3].
In addition information on the ESS Instrumentation R&D has been made available at several conferences and journals [4]. Current status and results of R&D were presented at the ESS General Meetings (Ancona 1999, Seggau 2001).

Instrumentation Development Activities at ESS MoU Partner Institutes

Since the 1997 ESS reports several ESS MoU institutes participated in instrumentation related R&D. In particular R&D was established at Risø Nat. Lab, Denmark, INFM, Italy, CNRS, Italy, IRI TU Delft, Netherlands, ISIS, England, Atominstitut, Austria, FZ Jülich, Germany and HMI, Germany. A comprehensive report on these activities has been published [5]. Additional reports on common projects between FZ Jülich and HMI are also available [6].

Specific R&D topics elucidated have been in particular

- Instrument simulation (HMI, Risø, Ciemat)
- New detector systems (HMI, CNR & INFM, IRI)
- New optical components (AI)
- 3He neutron spin filters (HMI)
- TOSCA, VESUVIO (CNR & INFM)
- Development of polarised neutron instruments (IRI)
- Disc chopper system for pulsed sources (HMI, BNC)
- TOF-NSE prototyping (FZJ, HMI, ILL)
- Cold neutrons TOF spectrometer prototyping (HMI, LANSCE)
- TOF single crystal diffractometry (HMI)
- Optimisation of back scattering spectrometer (HMI, LANSCE, BNC, SNS)
- Advanced neutron optics for beam extraction and delivery (HMI, LANSCE)
- General instrument development (HMI, ISIS, Risø, IRI, Ciemat, AI)

References:

1. www.hmi.de/bereiche/SF/ess/ess_02_en.html;
   Particle Transport Simulations of the Neutronic Performance of Moderators of the ESS Mercury Target-Moderator-Reflector System, D. Filges, R.-D. Neef, K. Nünighoff, C. Pohl, B. Haft, S. Bennington, www.hmi.de/bereiche/SF/ess/ess_02_en.html
2. ESS Instrument Group Report: “Performance evaluation for a set of generic instruments on ESS”, ed. by F. Mezei, R. Eccleston, May 2001
3. Protein Crystallography with Neutrons – Status and Perspectives, T. Gutberlet, U. Heinemann, M. Steiner, Acta Cryst. D 57, 2001, 349-354;
   Int. Workshop on Neutron Spin Echo Spectroscopy, Proceedings to be published in Lecture Notes in Physics;
   "Moderator Concepts and Optimization for Spallation Neutron Sources and 3rd JESSICA Workshop", comp. by T. Gutberlet, May 2001;
   VITESS Workshop, Proceedings to be published;
   Int. Workshop on Position-Sensitive Neutron Detectors, Proceedings to be published;
   ESF TINX Workshop Report, to be published in SRN
4. "ESS R&D Activities on Neutron Instrumentation, T. Gutberlet, F. Mezei, M. Steiner, Notiziario, 5, 2000, 52-54;
   "Highlights of the ESS instrument development program", F. Mezei, ICANS XV, Tsukuba, Nov. 6.-9. 2000;
   "ESS Instrument Development Programme – Activities and Results, F. Mezei, R. Ecclestone, T. Gutberlet, ICANS XV, Tsukuba, Nov. 6.-9. 2000;
5. "Status of ESS R&D Instrumentation Efforts", Status Reports July 2000, ed. by F. Mezei, Oct. 2000

6. "Joint Research and Development Work for the European Spallation Source ESS in the Forschungszentrum Jülich and Hahn-Meitner-Institut Berlin", Progress Report for the Period July. 1, 1998 to June. 30. 1999, ed. by H. Ullmaier
"Joint Research and Development Work for the European Spallation Source ESS in the Forschungszentrum Jülich and Hahn-Meitner-Institut Berlin", Progress Report for the Period Jan. 1, 2000 to Dec. 31. 2000, ed. by H. Ullmaier

Work plan from 2002 to 2003

ESS Instrumentation Group

The next milestone for the Instrumentation Task is to establish, study and evaluate a reference suite of about 20 "day one" instruments for ESS, distributed between the two target stations. This accomplishment will be part of the ESS proposal to be presented in May 2002, in order to give a specific idea of the huge research capabilities ESS will offer. It will underpin the scientific case for ESS, to be presented by the Scientific Advisory Council (SAC) in May 2002 and provide basic input for the ESS conventional facility design in terms of space requirements, general layout, shielding needs, utilities etc.
It will guide the Instrumentation Task Group to identify and address key R&D needs for the realisation of an outstanding instrument suite for ESS, which will decisively surpass any other facility existing now or by the time of ESS coming on line.

The work is subdivided in the following items:

1) Reference of instrument suite (Core activity)
2) Identify instrument R&D needs (Core and Necessary activities)
3) Research and Development as identified in instrument R&D needs (Core, Necessary and Relevant activity)
4) Optimisation of Moderators for instrument suite (Core activity)
5) Definition and Costing of infrastructure (Core activity)
6) Non-neutron scattering applications (Core activity)

The work items are closely related with the activities of Target and Moderator Group tasks and SAC.
The reference instrument suite will be constantly upgraded to until construction decisions need to be made. It is crucial, that the study of the now proposed instrument suite also includes the evaluation of new, innovative instrument design options, concepts and tools to best satisfy the science objectives behind the currently proposed suite. In addition emerging, totally new experimental approaches might open up research opportunities, which cannot be foreseen today. An incomplete, random list of already proposed innovative concepts to be considered as options (part of which are being or getting prepared for experimental test and/or prototyping): dynamic phase space transformation, neutron beam bunching by magnetic fields, refractive neutron lenses, focusing mirrors, focussing Bragg optics, repetition rate multiplication, wavelength band multiplication, pulse shaping choppers, adjustable resolution

chopper systems, supermirror optical beam delivery system, ballistic neutron guides, spin echo for SANS and reflectometry, zero field spin echo approaches, etc.

1) Reference of instrument suite

The intention of this task comprises the following steps (a) establish the reference instrument suite on the basis of the recommendations from SAC Science Groups, (b) Develop and optimise specific design concepts for instruments, in particular for long pulses and coupled moderators, (c) Identify and study innovative approaches, technical challenges and R&D needs, (d) Establish instrument layouts and floor space needs, (e) Optimise the distribution of reference suite instruments on the short and long pulse target stations, (f) Optimise the moderator set needed on the two target stations, (g) Iterate optimisation of target/moderator characteristics with Target Moderator Group.

2) Identify instrument R&D needs

The intention of this task is the identification of instrument R&D needs (components, methods, data analysis) in enhanced interaction with the user community.
The goal will be achieved by combination of two approaches:

(a) The Instrumentation Task Group will identify technological challenges posed by the construction of optimised instruments and further work which will be required, such as background measurements, Monte Carlo simulations etc.
(b) The ESS MoU partners and representatives of the European neutron scattering community, including networks such as SCANS, TECHNI and ENPI, will be consulted for their suggestions and needs.

3) Research and Development as identified in 2)

The intention of is item is to identify the R&D requirements for the instrumentation. Examples of areas of activity are: (a1) Choppers i.e. T0 choppers – 100Hz running, low transmission, (a2) Disk and pulse shaping choppers, (b) Detectors i.e. high count-rates, low γ sensitivity, position sensitivity, high stability, (c) Data Acquisition Electronics, (d) Instrument Control Software, (e) Data Visualisation software, (f) Polarisation, (g) Neutron Optics and Guides, (h) Shielding and guid,e (i) Instrument prototyping.
Core Working Groups will be formed to focus on specific areas, to establish development work that is currently underway within the European community, and to pursue research and development programmes as identified under 2). Effort should also be devoted to developing experimental techniques that are not well catered for at pulsed sources at present. Neutron polarimetry is an example.

4) Optimisation of Moderators for instrument suite

In order to assure that the target stations selected optimally cover the expected spectrum of applications, it will be necessary to examine the moderator requirements of a reference suit of instruments in view of refining the choice of moderators for each target station. The choice includes selecting the moderator temperatures, coupling status, number of moderators per target station, position of the various types of moderators etc. In addition, R&D needs for more "exotic" moderators, such as composite, cool, filtered, more delicate moderator materials etc. will have to be identified. Although the choice will be subject to review and evolution until 2005, it will be necessary to define a reference set of moderators from an early stage to serve as a basis of a number of R&D and preliminary design efforts.

The following input is requested from the Target and Moderator Group from the Instrument's Group point of view: (a) Up-grade target characteristics database, (b) Optimise specific long pulse target station design, (c) Investigate poison burn out i.e. lifetime of poisons and impact of burn-out on neutron parameters, (d) Continue target station moderator refinement, including "Hot source" options. The iteration of moderator/instrument system will be accomplished in close collaboration and feedback between Target and Moderator and Instrument Task Group.

5) Definition and Costing of infrastructure

The intention of this item is the definition and costing of instrument specific infrastructure requirements. Define Laboratory space for operation and development of sample environment equipment, choppers, neutron optics, guides detectors, electronics, software, polarising filters. Sample preparation and support laboratories such as biology support labs, sample alignment and characterisation facilities.
The CPT has formed a task group on *Site layout and common infrastructure* where this task is a part of. The task leader of the CPT task group is Andreas Wischnewski.

6) Non-neutron scattering applications

It is to evaluate the potentials of ESS for applications other than neutron scattering: fundamental physics, nuclear physics, muon-resonance, radiography, tomography, irradiation, etc.
It has been agreed on to form working parties to address to these questions. Convenor for fundamental physics is H. Rauch, Atominstitut, Austria, for muon-resonance R. Cywinski, Uni Edinburgh, England. Additional convenors will be contacted. On January 31, 2002 preliminary results have to be ready for a first round of discussion. On May 20, 2002 the final report will be compiled.

ESS Instrumentation Office

Will take care of the information flow within ITG, organize next ITG meeting March 18.-19. 2002 in Grenoble, France. Prepare and editing of reference instrument suite report to be presented at SAC meeting March 15.-17. 2002 in Paris, France, and presentation at the ESS European User Meeting May 15.-17 2002 in Bonn, Germany.
Document all activities and maintain ESS ITG webside.

MoU Institutes

Instrument R&D needs (components, methods, data analysis) as identified by ITG (see 2)) and in enhanced interaction with the user community should be carried out in agreement with interested MoUs.
Examples of areas of activity as outline above are: (a1) Choppers i.e. T0 choppers – 100Hz running, low transmission, (a2) Disk and pulse shaping choppers, (b) Detectors i.e. high count-rates, low γ sensitivity, position sensitivity, high stability, (c) Data Acquisition Electronics, (d) Instrument Control Software, (e) Data Visualisation software, (f) Polarisation, (g) Neutron Optics and Guides, (h) Shielding and guid,e (i) Instrument prototyping.
Core Working Groups will be formed to focus on specific areas as outlined above in 3), 4) and 6), to establish development work that is currently underway within the European community, and to pursue research and development programmes as identified above.

Data acquisition, visualisation and evaluation will be of decisive importance. It will become essential to add detector development to the ESS core activities by about 2004 and beyond. There is no doubt about the availability of the required computing hardware, and we have to be conscious of the huge potentials and needs in software development. It is important to prospect the new opportunities rapidly developing information technology will offer for smart data collection, evaluation and interpretation, both in terms of speed and depth. This has to be part of the ESS vision in instrumentation.

Responsibility

The ESS Task Leader Ferenc Mezei for Instrumentation is responsible for carrying out those work packages correctly, which have no shared responsibility. For work packages with shared responsibility, the responsibility is given within the work package itself.

Milestones

Milestone	Time	Status
First evaluation of source and moderator performance (Core activity)		
	December 31, 2000	Finished
Generic instrument performance (Core activity)		
	April 20, 2001	Finished
(1) Reference instrument suite (Core activity)		
Planned to provide a draft on this topic by	April 20, 2002	Ongoing
(2) Identify instrument R&D needs (Core and Necessary activities)		
Start of (a) and (b) , see Description	December 31, 2001	Quiet
Neutron Spin Echo Spectroscopy workshop	October, 2000	Finished
Moderator workshop	March, 2001	Finished
Detector workshop	June, 2001	Finished
(3) Research and Development as identified in (2) (Core, Necessary and Relevant activity)		
Core Working Group established	October 31, 2001	Ongoing
Framework for the development programme will be established	December 31, 2001	Quiet
(4) Optimisation of Moderators for instrument suite (Core activity)		
A reference choice of moderators will be defined	December 31, 2002	Ongoing
(5) Definition and Costing of infrastructure (Core activity)		
	December 31, 2002	Quiet
(6) Non-neutron scattering applications (Core activity)		
Forming of working parties	September 30, 2001	Ongoing
Preliminary results are ready for a first round of discussion	January 31, 2002	Quiet
Final report compiled	May 20, 2002	Quiet

Available and required capital cost for Instrumentation Group

Capital cost resources for Instrument Group:

Activity as defined by WP	Available/Required capital cost for the second half of **2001** (K?)	Available/Required capital cost **2002** (K?)	Available/Required capital cost for the first half of **2003** (K?)	Available/Required capital cost **2001-2003** (K?)	Priority and results available by
Instrumentation Group Administration	0 / 2	0 / 4	0 / 2	0 / 8	Core
Non-neutron scattering applications	0 / 2	0 / 4	0 / 2	0 / 8	Core
Identify instrument R&D needs	0 / 2	0 / 4	0 / 2	0 / 8	Core
Research and Development as identified in *Identify instrument R&D needs*	0 / 2	0 / 4	0 / 2	0 / 8	Necessary
Reference instrument suite	0 / 2	0 / 4	0 / 2	0 / 8	Core
Optimisation of Moderators for instrument suite	0 / 2	0 / 4	0 / 2	0 / 8	Core
Total available / required	0 / 12	0 / 24	0 / 12	0 / 48	
Grand partner contrib. to capital cost of task (kEUR)	0	0	0	0	
Grand capital cost requirements of task (kEUR)	12	24	12	48	