Project Report

Title		Version	Date
Front End Test Stand			
Duration	**Approved Budget**	**Project Type**	
3 years – 1 April 2012 – 31 March 2015	Total funding from SPD £2.57M (including £1.00M for university project grants) in addition ~4fte/year funded from ASTeC core funding	project	
Project Manager	**Sponsor**	**Department**	
Dr Juergen Pozimski	Charlotte Jamieson	Programme Department	

Project Description

The Front End Test Stand (FETS) is being constructed at Rutherford Appleton Laboratory by a collaboration of UK and Spanish institutes. It aims to demonstrate beam chopping of a high intensity H minus beam. Minimising beam loss and consequently activation will be important in future high power proton accelerators. Effective beam chopping plays a key role in this.
FETS was originally designed as a beam chopper test but the current proposal is to construct a generic test stand that could be used as for a variety of projects that require a high power proton driver.

The current experiment has been running since 2009 and extensive studies and modifications have been carried out allowing the experiment to approach the design specification of 0.25 π mm mrad normalised rms. FETS consists of an H- ion source, magnetic low energy beam transport, RFQ accelerator, medium energy beam transport and chopper line, and diagnostics.

Approved Funding Level

	12/13	13/14	14/15
STFC staff funded by ASTeC core budget (fte)	4	4	4
University staff[1] (£k)	331	336	336
Joint fellow (£k)	47	48	50
Funds transferred to ASTeC (£k)	552	516	354
Total funds available from PD (£k)	930	900	740

[1] Huddersfield, Imperial College, Royal Holloway, UCL and Warwick

Progress

The overall progress on FETS is good. After the delays caused by the refurbishment of R8 in spring and summer 2012 major progress has been made in R8 in preparation for the RFQ delivery. Cooling water installation is nearly finished, preparation for the RFQ delivery is on track as well as the high power RF setup. The radiation expected from the beam dumps has been calculated using experimental data. The radiation analyses showed that 0.5 m of concrete shielding is sufficient under the assumption that the 3 beam dumps as main radiations are surrounded locally by 10 cm of lead shielding. Work on laser safety is progressing well with the laser lab ready in April 2013, as well as other preparatory work. Considering that it was expected that the RFQ manufacturing would be finished at the start of the project a delay of 6 month was inherited with a further 3-6 month added due to unexpected difficulties in the final machining stage of the first RFQ quadrant. These difficulties have been resolved and machining is expected to continue after final inspection of the fist finished quadrant. While delays in some areas have prevented the collaboration to keep the capital spend at the expected level in the first half of the year measures have been taken to correct this in the second half. Taking the inherited delays into account the FETS project overall is on track and the overall status is green. As already discussed at the start of the grant a proposal to extend the FETS funding for 1 year to be submitted early 2014 seems now likely.

The progress on the ion source has been good over the last half year. While due to building works and repairs only a few hours of beam has been available until summer, since then a high availability for experiments on the LEBT has been reached. Based on the experience with the UV spectrometer from the University of Jyväskylä at FETS a new high resolution spectrometer has been purchased and tested. This will be part of an experimental setup that is under construction in the moment and will be used to develop the scaled “times2” ion source. Simulations of particle tracking with a new ion source code have been started with encouraging results. It is expected that these simulations will continue until late 2014 at a reduced level to allow for a direct comparison of simulations and the latest experimental results. While until recently the severe misalignment of the beam in respect to the expected beam axis at the RFQ entrance was rather badly understood recent experiments strongly indicate the cause of the problem. FETS is in discussion with Linac4 staff concerning this subject and it is expected that before the RFQ installation is complete this issue is solved. Measurements of space charge compensation in the FETS LEBT raised interest by CERN and ESS and discussion concerning collaborations on this field have been started.

All low level RF coupler are available as well as all auxiliary RFQ components (endflanges etc). The high power RF couplers are under development and will be manufactured in collaboration with ESS Bilbao. A delivery in time with the HP RF test in late summer 2013 is expected. Due to further unexpected problems in the final machining and QA the delivery of the first RFQ section is delayed. While the final machining of the first quadrant is finished all other quadrants will be machined to the last critical machining step until inspection of the first quadrant is complete. The delivery of all 16 section in this financial year is expected. Preparation of installation of the clean tent for alignment and low power RF testing are nearly finished and will be ready before the end of 2012. All handling and testing tools are available and tested. The high power RF setup is underway with the circulator moved to the klystron and circulator test in preparation. The high power RF setup is expected to be tested and operational before the end of this financial year. The revised plan for the RFQ now foresees first beam in the RFQ at the end of 2013.

Numerous simulations of CH structures have been performed as well as particle tracking simulations. While those results are very encouraging and would allow a doubling of the FETS energy within ~1.5 m of additional length with negligible emittance growth and comparable power consumption per unit length as the RFQ (peak power ~150 kW). As this work has lower priority

compared to the main aims of FETS final simulation results concerning the RF properties of the resonator are now expected with a slight delay for summer 2013 while particle tracking and cold model are still on track.

The mechanical design of the slow chopper nears completion the design for the fast chopper is delayed as new simulation results showed that a new design of a delay line design on a high ε_r substrate might deliver the required specifications at highly reduced cost and production time. Fully engineered designs for both choppers are now expected to be available mid 2013 with procurement for the slow chopper already started. The mechanical design of MEBT is progressing well. While design solutions are available for most beam line components two issues prevented us from finishing the designs. Simulations of the power density on the chopper beam dumps showed that in the present lattice design it might exclude the use of aluminium as beam dump material. Aluminium would be the preferred material for reasons of induced radiation and is used in the main beam dump at the end. Further engineering effort showed also that the positioning of beam diagnostics in the beam line will be difficult due to the density of the lattice. A new lattice has been proposed to address these issues and a rigorous comparison between both lattices is underway. A final decision on which lattice will be used is expected early 2013. As magnets, cavities, choppers and beam dumps will have the same design in both lattices the engineering designs for the MEBT should progress swiftly and is now expected to be finished and procurement started in mid 2013. The MEBT assembly will be delayed by 3-6 month.

Steady progress has been made on the beam diagnostics. Furthermore the position and specification of 5 toroids to be installed in the MEBT was defined and procurement started. At least for the alternative lattice the position of the 5 beam position monitors (BPM) has been defined and a preliminary design of BPM is available. Collaboration with CERN on this subject has been discussed as well as on the subject of laser based diagnostics. Due to problems with the Laser system (only 20% laser power) the 1 D profile measurements are delayed. The laser has been returned to the manufacturer in France for repair. Two options have been discussed for the further procedure on this field. In the first option the laser returns directly to RAL and measurements of 1D profiles will be performed or the laser will be shipped to CERN first to help with measurements at the LINAC4 test stand and returned in summer to RAL. Discussion with CERN on time schedules and procedures are underway.

The discussions with Siemens concerning the direct drive high power RF system are still ongoing. A collaboration agreement between Siemens and ISIS on the subject of solid state klystrons based on the new technology is being finalized and seems to be the logical first step in this direction. Due to the limited resources the work on the future of FETS work package is lower importance in the moment but will pick up as soon as the MEBT issues are resolved.

Milestones		Dates		
	Description	Planned	Expected	Complete
1.1	Detailed simulations of ion source plasma and comparison with experimental results	31/12/2012	31/03/2015	
2.1	RF couplers manufacture finished	30/06/2012	30/06/2013	
2.2	RFQ assembled and installed	30/06/2012	30/06/2013	
2.3	RFQ RF tests finished	30/09/2012	30/09/2013	
3.1	Detailed RF simulations of 324 MHz CH structure finished	30/06/2012	30/06/2013	
4.1	Fully engineered chopper design complete	30/09/2012	30/06/2013	

4.2	Mechanical design of MEBT finished	30/09/2012	30/06/2013	
5.1	Design of MEBT diagnostic finished	30/06/2012	30/03/2013	
5.4	1D-transversal beam profile system commissioned at FETS => Photodetachment demonstrated at RAL or in collaboration with CERN	30/09/2012	30/09/2013	
6.1	Report on advanced RF sources	30/09/2012	30/06/2013	

Financial Summary				
	Staff (SY)	Staff (£k)	Recurrent (£k)	Total (£k)
Planned Cost to Date	6.64	£355,239	£85,879	£441,136
Actual Cost to Date	5.34	£281,586	£73,309	£354,895
Planned Total Cost	25.71	£1.857,003	£442,460	£2.299,487
Current Estimate of Total Cost	25.71	£1.857,003	£442,460	£2.299,487
Approved Budget	25.71	£1.698,803	£353,969	£2.052,790

Project Issues/Active Risks		
	Issues/Risks identified	Proposed mitigation taken (or planned)

Key Milestones/Deliverables over the next Period		
	Milestone/Deliverable	Potential Issues/Concerns
1.2	Experimental determination of plasma parameters in the ion source by means of Langmuir probes, optical spectrometers and particle energy spectrometers.	New Lab will be available from Spring 2013
1.3	Design of upgraded 2X source	
2.4	First beam at the RFQ exit	Delay by ~ 9 month due to RFQ manufacture delay.
3.2	Particle tracking for CH linac finished	
4.3	Procurement of MEBT components	
4.4	Manufacture of chopper assemblies complete	

5.5	2D-transversal profile system and reconstruction operational at FETS	
6.2	IDR for a high power proton beam centre at RAL	