Review of NF-IDS Targets Work Programme Status

C. Densham, RAL, 17 November 2009

EUROnu WP3 (selected)

Del. No.	**Deliverable name**	**Estimated staff months**	**Delivery dd-mm-yyyy**
D18	[…] Evaluation of reference design for spent proton-beam handling system, including a performance analysis. Recommendation of reference design	56 [part]	31-11-2011

IDS-NF Target system

Del. No.	**Deliverable name**	**Estimated staff months**	**Delivery dd-mm-yyyy**
	The target task encompasses the liquid-mercury-jet delivery and recirculation system; the proton-beam/mercury jet interaction region; the collection of nested solenoids that collects the pions and produces a pion beam with a large energy spread in three 2 ns bursts		
CDR	Seminal? (Immaculate?) Conceptual Design Review – the ‘start of the engineering’		10-04-2009!!
IDR	Cost estimate at 50-75% level		31-03-2011

Neutrino Factory Target System Work Programme

4.1 Baseline liquid mercury target and beam dump	Suggested involvement / responsibility	Status
4.2 Make statement of IDS-NF baseline specifications		done
4.3 Evaluate mercury handling infrastructure requirements, in particular revisions from Study2		
4.3.1 Evaluate costing in light of IDS-NF scenario revisions incorporating actual costs of SNS and JSNS and other relevant facilities, involving estimating:	ORNL? FNAL	
a) Active volume of target station		?
b) Mass and cost of steel and concrete shielding		?
c) Cost of solenoid system		?
d) Cost of civil engineering, building and services		?
e) Cost of mercury system		?
f) Cost of remote handling systems including shielding required		?
g) Any other significant costs		?
4.3.2 Beam window study	CJD, MR, MDF (RAL)	Just starting
4.3.3 Incorporate HARP data into MARS/FLUKA/GEANT4 simulations	NM,GC	Underway?
4.3.4 Pion/muon acceptance studies	HK, SB (RAL), JB (Warwick), GS	?
4.3.5 Continue analysis of MERIT data on proton beam/liquid metal jet interactions	HK (BNL), KM (Princeton) GS (Sheffield)	Done?
4.3.6 Extend MERIT MHD simulations	RS	Done?

4.3.7	Mercury nozzle studies	RE(RAL), HK	Just starting?
4.3.8	Mercury erosion experiments for bore & nozzle	VG?	?
4.3.9	Baseline liquid mercury beam dump, decay solenoid and shielding system studies including:	CJD, TD, OC, PL (RAL), VG(ORNL)	
a)	Beam interactions with liquid beam dump, options for mitigation of splashing, erosion etc	TD	Stalled
b)	CFD studies of mercury jet interactions (splash) with dump & containment	TD	Stalled
c)	Studies of irradiation, heat loads and cooling of decay solenoid	JB, PL	Underway
d)	Heat loads and cooling of shielding	PL	Stalled
e)	Solenoid system engineering, magnetic loads	PL	Stalled
4.3.10	Develop engineering layouts for target station including:	ORNL/FNAL/RAL	
a)	Mercury handling and recirculation system	VG	Underway
b)	Beam windows + remote maintenance	CJD, MR	Not started
c)	Integration of mercury jet with capture solenoid, containment and shielding including concepts for remote maintenance	VG	Underway?
d)	Integration of beam dump with decay solenoid, containment and shielding including concepts for remote maintenance	VG	Underway
Material compatibility with Hg		?	?

Cost models = generic for SB, NF, Eurisol

4.4	**Alternative target technologies (I) re-circulating solid tungsten target**	Suggested involvement / responsibility	Status
4.4.1	Interpretation of RAL off-line shock tests (VISAR data?)	JRJB (RAL), GS (Sheffield)	Done
4.4.2	On-line tungsten experiments (ISIS? BNL? ISOLDE?)	JRJB (RAL)?	Stalled?
4.4.3	Conceptual design for a horizontal axis spokeless solid-target wheel:	JRJB	Ongoing
	a) Radiation or water cooling		
	b) Drive & support system		
	c) Beam window integration (or no beam windows)		

4.2.4 Optimisation of 'Helmholtz' type geometry with the goal of minimizing the field dip in the target region.	JB	Ongoing
4.2.5 Develop a conceptual structure design for the Helmholtz magnet, which provides an entry/exit route for a solid target.	PL	No
4.2.6 Develop concept for beam dump within solenoid coils	?	
4.2.7 Remote dump: investigate the possibility to engineer the solenoid coils in such a way to let the beam pass through a "gap" to reach a remote beam dump.	SB (RAL)?	
a) Study heating of coils & shielding due to disrupted beam	?	
4.2.8 Investigate factors affecting the (huge) inter-coil forces, and how to reduce/handle these.	PL (RAL)	No
4.2.9 Estimate active volume of system and cost implications for TS shielding	?	
4.2.10 Investigate remote handling concepts and cost implications	RE	Started?

4.3 Alternative target technologies (II) flowing tungsten powder		
4.3.1 Agreed comparison of pion capture efficiency for reduced density powdered target with optimised system including accelerator and target geometry.	JB (Warwick)	
4.3.1 Carry out tungsten powder handling and erosion tests using RAL test plant.	CJD, OC, PL	Ongoing
4.3.2 Develop concepts for integration with capture solenoid, proton beam entry and exit windows of (i) open powder jet and (ii) contained powder jet	CJD, OC, PL	Ongoing
4.3.3 Develop and investigate concept for beam dump – stopping target?	CJD, OC, PL, JB	Starting?
4.3.4 Investigate concept for remote beam dump involving gap in capture/decay solenoid system	CJD, OC, PL, TD, SB (RAL) GS (Sheffield), JB (Warwick)	Remove?
4.3.5 Develop concept for complete powder target recirculation system	CJD, OC, PL (RAL)	
4.3.6 Estimate active volume of system and cost implications for TS shielding	CJD, OC, PL (RAL)	
4.3.7 Investigate remote handling concepts and cost implications	CJD, OC, PL (RAL)	
4.3.8 Powder jet density measurements	CJD, OC (RAL), GS (Sheffield)	
4.3.9 On-line shock test of tungsten powder in helium at CERN?	CJD, IE	

Glossary of contributors

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Selection criteria for choice of target technology for a Neutrino Factory and a Superbeam

	Criteria	Driving factors	Inputs & Issues	Inputs & Issues

			(Nufact)	**(Superbeam)**
1.	Performance (I) Pion production and capture efficiency	i. Material Z ii. Beam-target interaction geometry	High Z favoured	Target diameter and performance as function of material Z
2.	Performance (II) Proton beam parameter limits (energy, power, pulse structure)		Baseline accelerator parameters 4 MW, 10±5 GeV	Baseline accelerator parameters SPL: 4 MW, 3-5 GeV CERN PS2: ? MW, 30-50 GeV
3.	Performance (III) Engineering practicality, reliability	i. Integration with capture system ii. Integration with beam window iii. Integration with Beam Dump iv. Time to repair/replace target system, Remote Handling complexity v. Maintenance intervals vi. Failure scenarios & consequences of target failure	i. Integration with capture solenoid ii. Near or far dump?	i. Magnetic horn outline design geometry & target location ii. Far dump?
4.	Cost	i. Target system active volume – civil engineering,	Need cost models: SNS, JSNS costs	Need cost models: T2K costs

		shielding and building costs ii. Remote handling complexity iii. Target replacement and disposal cost iv. Target replacement and disposal frequency		
5.	R&D requirements (I) Off-line	i. Feasibility, reliability ii. Time and investment	i. MERIT@ORNL ii. RAL shock tests iii. RAL powder jet plant	
6.	R&D requirements (II) On-line	i. beam interactions with materials ii. radiation damage iii. radiochemistry	Need to use existing facilities: MERIT data, SPS@CERN? AP-0@FNAL? SNS, JSNS, BNL	Need to use existing facilities: T2K, BNL, SPS@CERN? AP-0@FNAL?
7.	Regulatory, safety, environmental issues	i. Liquid metal, solid, powder ii. Site	SNS, J-SNS, Eurisol experience	SNS, J-SNS, Eurisol experience

2 Basis of Cost Estimate

In order to achieve the stated requirement of a cost estimate to 50-75%, it will be necessary to:

1. Determine the scope of the costing and division of responsibilities with the rest of the facility, e.g.

   a. Scope: build only; build and operate; or build, operate and decommission
   b. Required lifetime of facility (20 years?)
   c. Envelope definitions with proton driver and muon front end
   d. Level of detail required for civil engineering specifications etc
   e. Regulatory issues and costs – site specific
2. State basis of estimate with reference to above scope
   a. statement of assumptions, effect of location, existing infrastructure etc.
   b. use of previous studies and facility costs e.g. SNS, J-SNS
3. Determine cost model
   a. Pricing model for civil engineering, building, materials, construction, installation and commissioning
   b. Shared infrastructure costs
   c. Costing of institute staff
4. Assess uncertainties, contingency
   a. Technical risks and cost implications
5. Cost implications for alternative target and beam dump technologies