300mK Straps
Subsystem Development Plan

Draft

For approval

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Distribution list

Update history

Date	Version	Remarks
8/01/01	Draft 1.0	Creation of document

Table of Contents

1. Scope

This document describes the development plan for the FIRST/SPIRE 300mK straps subsystem.
It is a preliminary version, which will be updated as the design matures.

2. Documents

2.1. Applicable documents

	Title	Author	Reference	Date
AD1	300mK Straps Subsystem Specification Document	To be written		
AD2				
AD3				

2.2. Reference documents TBW

	Title	Author	Reference	Date
RD1	Instrument Requirements Document	B.M.Swinyard	SPIRE-RAL-PRJ-000034 Issue 0.30	May 2000
RD2	Instrument development plan	K.J.King		

2.3. Glossary TBW

AD Applicable Document	FS Flight Spare
ATC Astronomy Technology Centre	FTS Fourier Transform Spectrometer
BDA Bolometer Detector Array	
CBB Cryogenic Black Body	
	LAS Laboratoire d'Astronomie Spatiale
CDR Critical Design Review	MGSE Mechanical Ground Support Equipment
	MSSL Mullard Space Science Laboratory
CoG Centre of Gravity	NA Not Applicable
CQM Cryogenic Qualification Model	OGSE Optical Ground Support Equipment
DDR Detailed Design Review	PCAL Photometer CALibrator
	PFM ProtoFlight Model
DM Development Model	RAL Rutherford Appleton Laboratory
DRCU Digital Read-out and Control Unit	RD Reference Document
EGSE Electrical Ground Support Equipment	SCAL Spectrometer CALibrator
FIRST Far InfraRed Space Telescope	WE Warm Electronics
FPU Focal Plane Unit	

3. Subsystem Description

Updated sketches/drawings from JC/BW needed

The 300mK straps subsystem comprises all thermal straps between the ^{3}He cooler head and the BDAs, all supports for these straps (which should provide a high degree of thermal isolation from the 2K structure), and all light baffles (used where the straps go from a 4K environment to a 2K environment).
A conceptual design for the light baffles is shown in figure (1). These are used to prevent 4K radiation from entering the 2K boxes, and also provide thermally isolated mechanical suspension for the straps.

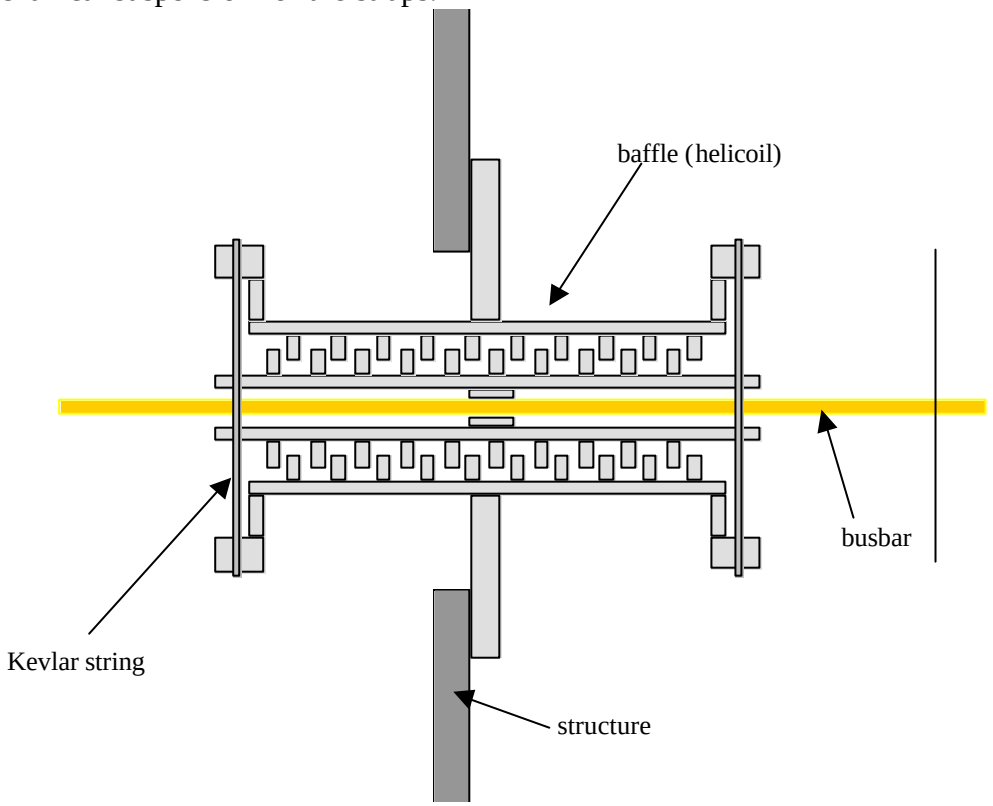

Figure 1

The conceptual design for the photometer straps is shown in figures (2) and (3). The photometer straps are suspended from the 2K structure, and run along the walls of the 2K photometer box. The suspension of these straps must provide excellent thermal isolation from the 2K structure, whilst retaining high mechanical strength.

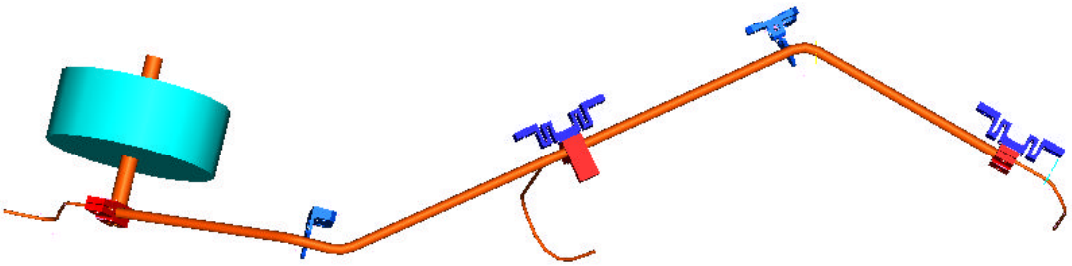

Figure 2

Updated drawing needed – Kevlar suspension

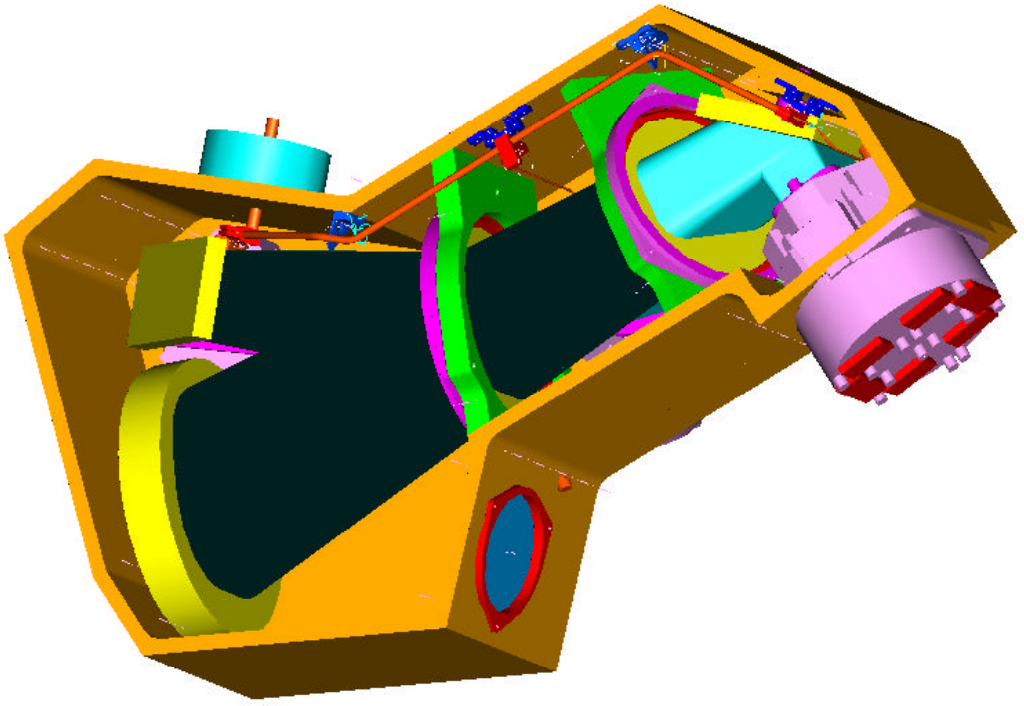

Figure 3

Updated drawing needed – Kevlar suspension

3.1. Block diagram

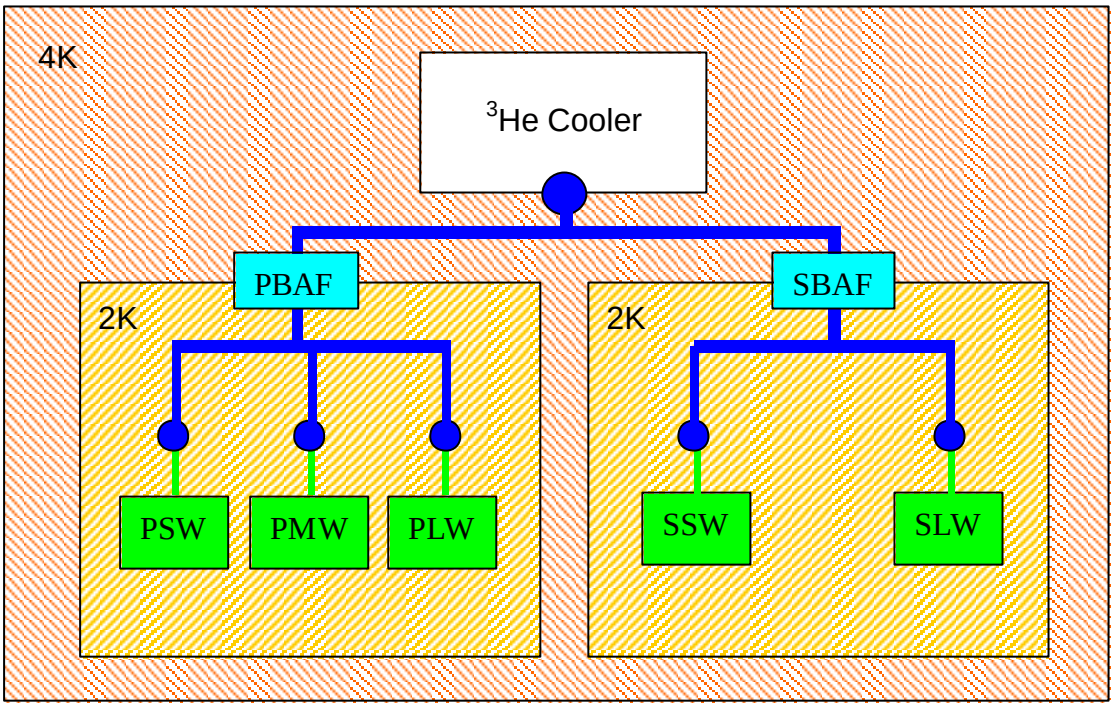

Figure 4 Block diagram of 300mK strap sub-system. The straps are shown in dark blue, thermal interfaces to other subsystems are shown as blue circles, and PBAF & SBAF are the photometer & spectrometer light baffles.

4. Organisation

This work package is largely shared between Cardiff and MSSL, with design input, in the form of thermal and optical modeling, from RAL.

Cardiff are responsible for:-

- Thermal testing
  - Thermal conductivity of prototype materials
  - Thermal interface study – to find optimal interface configuration.
  - Thermal testing of prototype 300mK system.
- Optical testing
  - Testing the performance of prototype stray light baffles.
- System design (thermal)

MSSL are responsible for:-

- System design (mechanical)
- Mechanical testing.
- Procurement & manufacture of the 300mK system for STM/CQM, PFM & FS.

RAL are responsible for:-

- Thermal modeling.
- Stray light analysis.
- Input from RAL will be used by Cardiff and MSSL in the preliminary design phase.

5. Deliverables

The current SPIRE model philosophy dictates that flight representative thermal straps are delivered for integration to the structure for STM testing. This STM structure will then become the CQM structure. It is proposed that the CQM structure is then refurbished for the flight spare, once received back from ESA. This would imply that only two 300mK strap models are necessary – one for the STM/CQM and FS, and one flight model. However, we are concerned about the thermal cycling and vibrations that the STM/CQM model will have been subjected to. High vibrational levels may cause creep of the proposed Kevlar support, as well as work-hardening of the straps. We have assumed the provision of a separate FS model, which may be integrated to the FS structure as a replacement for the STM/CQM system.

The concept of a deliverable needs clarification in this case. It is yet to be decided whether the 300mK strap system will be integrated to the structure at MSSL, prior to delivery to RAL, or whether the straps and structure will be delivered to RAL as separate entities, and integrated there (***Berend/Bruce – comments please – clean room facilities etc)***. If the straps are integrated at MSSL, then there is no deliverable from this work package to SPIRE (apart from documentation) – it becomes an internal milestone. Rather than deliverable dates, I have quoted "available for integration" dates in table (1).

Table 1 SPIRE deliverables for each instrument model

Deliverables to RAL*					
Model	**Description**	**Required date**	**Available for integration**	**Difference from flight model**	**Responsible Institute**
STM	300mK system	1/1/02 TBC	16/4/02	None	MSSL
CQM	300mK system	Not required			
PFM	300mK system	11/7/03	27/8/03	None	MSSL
FS	300mK system	Not required	22/10/03	None	MSSL
*Note, these may become "internal" deliverables if the straps are integrated to the structure at MSSL prior to delivery of the structure to RAL.					

Table 2 contains a list of "internal" deliverables. These are defined as deliverables between Cardiff and MSSL during the development, test and manufacture phases. These are not deliverable to SPIRE.

Table 2 Internal deliverables

Internal Deliverables				
Model	**Description**	**Required**	**Deliver to**	**Responsible**
LBP1	Prototype 1 light baffles (2 off)	11/4/01	Cardiff	MSSL
LBP2	Prototype 2 light baffles (2 off)	5/7/01	Cardiff	MSSL

6. Constraints

6.1. Technical constraints

The performance requirements for the 300mK straps are listed below, and are extracted from RD1.

6.1.1. 300mK strap performance requirements

Requirement ID	***Description***	***Value***
IRD-COOL-R01	Temperature at the detectors	The ^{3}He cooler , in conjunction with the associated 300mK architecture, shall maintain all BDAs at less than 310mK (goal – 300mK)
IRD-COOL-R02	Operating temperature control	Desirable to be able to vary the temperature of the detectors up to 320mK and below 300mK if this is permitted by the temperature drop across the thermal link.
IRD-COOL-R03	Temperature drop across thermal link between detectors and evaporator cold tip	Maximum of 20mK

6.2. System constraints

The system requirements for the 300mK straps are listed below, and are extracted from RD1.
Additional overall system constraints are:-

- SPIRE orbital lifetime – 4.25 years
- Volume envelope/strap routing = TBD

- Mass = 900g for the photometer straps – **this needs clarification – there is nothing in the mass budget for spectrometer straps – Colin has been informed**
- Vibration level =
- Shock level =
- Cleanliness =
- Transit loads =
- Storage =
- Bake-out temperature on AIV integration = 80°C for 48 hours

6.2.1. 300mK straps system requirements

There are no stated system requirements on the 300mK strap sub-system.

6.3. Calendar constraints

The major SPIRE project dates are (RD2):-

PDR	26/27 Jun 2000
DDR – Interface Review	28/29 Nov 2000
QMW Programme Review	16 Jan 2001
STM 300mK straps delivery to RAL	17 Jan 2002 TBC
CDR	3 Feb 2003
SPIRE CQM delivery to ESA	Apr 2003
PFM 300mK straps delivery to RAL	17 Jun 2003
SPIRE PFM delivery to ESA	1 Jul 2004
FS 300mK straps delivery to RAL	10 Sept 2003
SPIRE FS delivery to ESA	1 Jul 2005
FIRST launch	2007

7. Work Description

7.1. Model philosophy

The model philosophy is compliant with the revised SPIRE project model philosophy.

The following models will be produced:-

- Light baffle prototypes. Two generations of light baffles will be produced:-
  - LBP1 - The first generation will be designed with input from RAL (stray light analysis and thermal modeling) and built under MSSL responsibility. Three identical models of LBP1 will be built – two will be sent to Cardiff for optical and thermal tests, while one will stay at MSSL for mechanical tests.
  - LBP2 – after completion of tests on the LBP1 models, a two week period of re-design follows before the manufacture of three models of

LBP2 starts. The LBP2 models will also be tested in parallel, as for LBP1.

- Strap and suspension prototypes. Two strap and suspension prototypes will be built:-
  - CSTM – this is the Cold Strap Thermal Model. This will be built under Cardiff responsibility, and designed with input from RAL (thermal modeling). This model will be thermally representative of the 300mK strap system, replicating the thermal characteristics of all thermal paths in the final system. It will not be structurally representative, as it has to be tested in a cryostat with limited internal volume.
  - CSSM – this is the Cold Strap Structural Model. This will be designed and built under MSSL responsibility. CSSM will be structurally representative of the 300mK system, with, for instance, dummy masses to represent the light baffles.
- 300mK strap STM/CQM – Because of the high degree of risk associated with this development programme, in that the first overall system test will take place once the system is installed in the STM, two STM/CQM systems will be built. One will be left unassembled in component form as a back-up in the event of STM strap system failure. The STM models will be designed with information from the prototype testing, and a design review will be held on 23/1/02 (TBC). Manufacture of components will commence after this review and should be complete by 20/3/02. Manufacture and acquisition of these components is the responsibility of MSSL. Following assembly of the components, the 300mK system STM will be ready for integration to the structure by 18/4/02. The 300mK STM system will remain in the STM/CQM structure throughout the STM and CQM test campaigns.
- 300mK strap PFM – Manufacture of the PFM straps will commence after the CDR, under the responsibility of MSSL. These will be ready for integration in August 2003.
- 300mK strap FS – The present SPIRE model philosophy proposes refurbishing the CQM FPU for the FS. However, the 300mK straps in this system will have been subjected to all of the STM and CQM tests (thermal cycles, cold vibrations etc), and we are concerned that this will adversely affect the performance of the 300mK straps (work-hardening, Kevlar creep etc). Therefore, we will provide a replacement 300mK sub-system for CQM → FS refurbishment. This will be delivered to RAL in October 2003.

7.2. Preliminary design phase

The PDR freezes the technical specifications/requirements, while the interfaces are frozen at the interface review.

7.2.1. Materials testing

A dedicated ^{3}He cryostat has been assembled for thermal conductivity tests on candidate materials for the straps and supports. These tests will take place between January and March 2001, and include:-

- Thermal conductivity of Copper – nominally high purity (99.999%) Copper from Goodfellows – as a function of material treatment (level of annealing, Gold plating etc)
- Thermal conductivity of Kevlar, Vespel & Torlon – the materials to be tested will be from the proposed suppliers for the flight model (eg Goodfellows, DuPont). The Vespel and Torlon data will also be used for the SCAL development programme.

7.2.2. Interface study

The thermal test dewar will also be used to study the thermal impedance of different interface configurations, with the goal of finding the optimal configuration for thermal conductivity across interfaces. This is necessary to meet the 20mK thermal drop requirement (IRD-COOL-R03) between the detectors and the evaporator cold tip.

7.2.3. Modeling

A MathCad model has been produced for simple thermal/mechanical analysis of design concepts. The thermal analysis is compared to results from ThermXL (Alstom technology). This is used as the first step in the design process.
Detailed thermal analysis of candidate designs will then be carried out by RAL using ESATAN. Detailed mechanical FE analysis will be carried out at MSSL using the IDEAS Master Series CAD package.

7.2.4. Prototyping

Prototype light baffles and strap/suspension systems will be built, as detailed in section 7.1, in order to verify the design.

7.2.5. Testing

The prototype light baffles and straps will undergo the following tests (as a minimum):-

- Thermal tests (CSTM, LBP1(A&B), LBP2(A&B))
    - Thermal drop between evaporator cold tip and detector interface points (CSTM only)
    - Parasitic heat load from 2K to 300mK. The test dewar will, as a default, run with a 2K pumped Helium bath. This is because the whole 300mK system will only be suspended from 2K structure in SPIRE. This test will tell us about the efficacy of the thermal isolation of the strap supports, including the light baffles, which incorporate internal supports for the straps.

- Mechanical tests (CSSM, LBP1(C), LBP2(C))
  - Resonant frequency (warm)
  - Cold vibration (at RAL) - TBC

7.3. Procurement of long lead-time components

Once a preliminary design has evolved, long lead-time items will be procured.

Note – need to clarify CPP procedure & items

7.4. Detailed design phase

The detailed design of the STM/CQM straps will proceed in parallel with the prototype test campaign, with test results being used to modify the design.
The detailed design should therefore be available shortly after prototype component tests are complete.
A design review will be held in January 2002, which will freeze the STM/CQM design.

7.5. STM/CQM manufacture & test

The detailed design is presented at the Detailed Design Review. The DDR and 300mK strap design review must have happened before STM/CQM manufacture can begin.

STM/CQM manufacture takes place between January 2002 and March 2002.

There is no way of testing the performance of the whole, assembled STM/CQM 300mK system prior to integration to the structure. The first test of the performance of the whole system will therefore coincide with the STM tests. This obviously introduces an element of risk to the program. This will be minimized by rigorous testing of the prototype components (materials, interfaces, CSTM, CSSM, LBP1, LBP2).

The design verification tests (once incorporated in the STM structure) include:-

- Verification of the basic mechanical parameters (Mass, stiffness, resonance frequencies).
- Performance verification – thermal drop, parasitic heat load.
- Warm and cold vibrations.

After the 300mK strap STM/CQM delivery, the SPIRE STM is tested at project level. The STM structure and straps will then serve as the CQM structure and straps – i.e. they will be the same components used for STM testing.
The results of the qualification tests are to be presented at the SPIRE CDR, which is the start point of the PFM and FS manufacture.

Then, the SPIRE CQM is delivered to ESA for cryogenic tests of the FIRST FPU.

7.6. PFM & FS manufacture & test

Following the SPIRE CQM tests, some modifications may have to be implemented in the design.
The design changes are to be implemented in the flight design and be validated using the prototype components (CSSM, CSTM, LBP1, LBP2).
The 300mK strap PFM is then manufactured and undergoes acceptance tests.
The FS model is a duplicate of the PFM and is assembled after the PFM, although the components will be manufactured simultaneously. The FS model undergoes the acceptance tests after the PFM delivery.

7.7. Work flow

A cross-functional work flow diagram is shown in figures 5, 6 & 7. Figure 5 is the top level work flow, while figures 6 and 7 show more detail with regard to the strap and baffle prototyping phases.

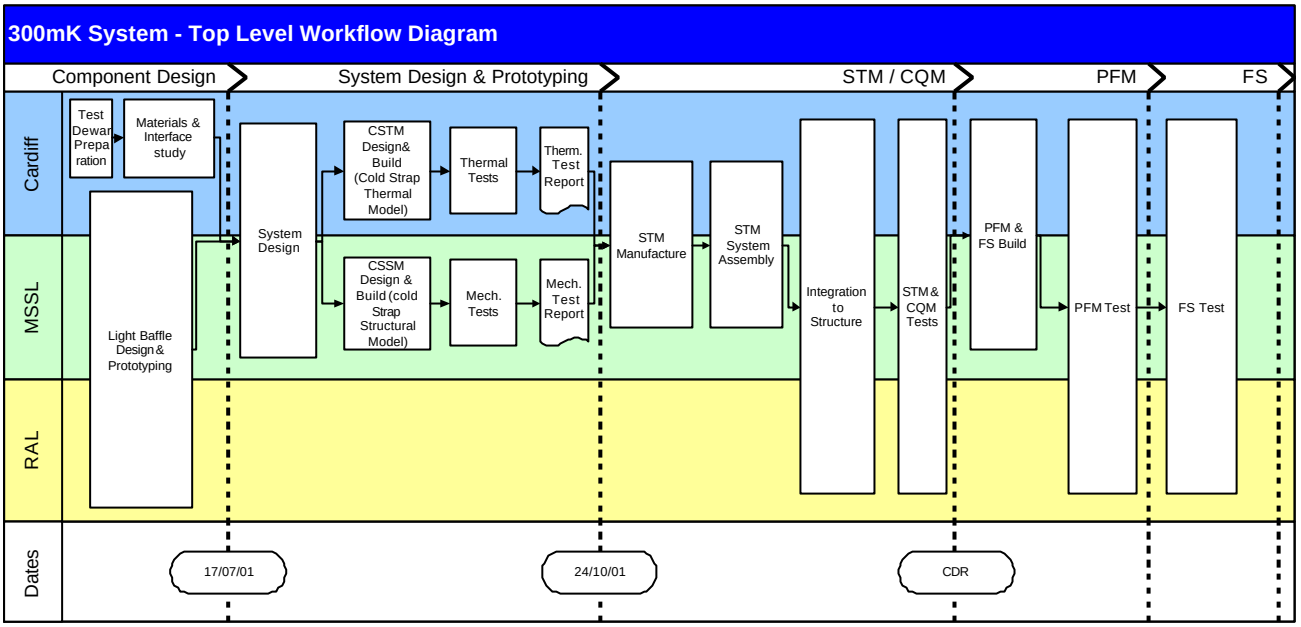

Figure 5 Top level workflow diagram

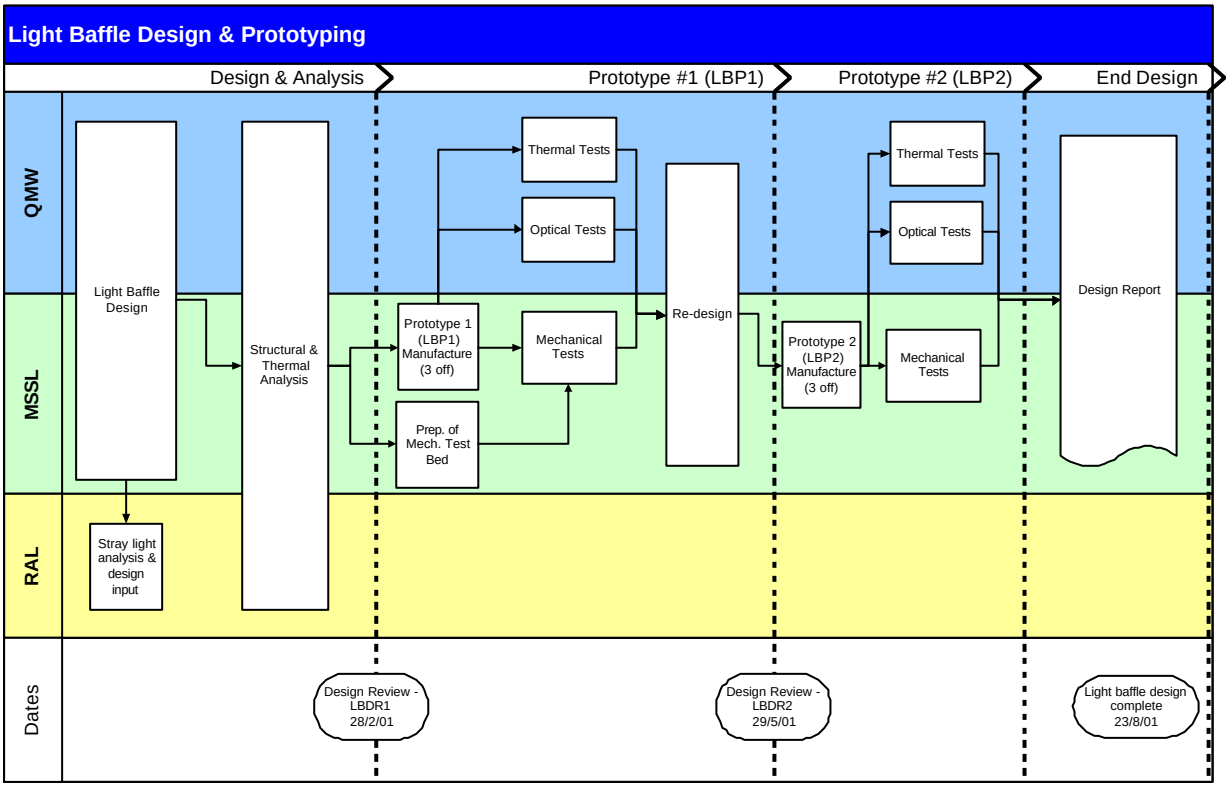

Figure 6 Detail of the light baffle prototyping phase

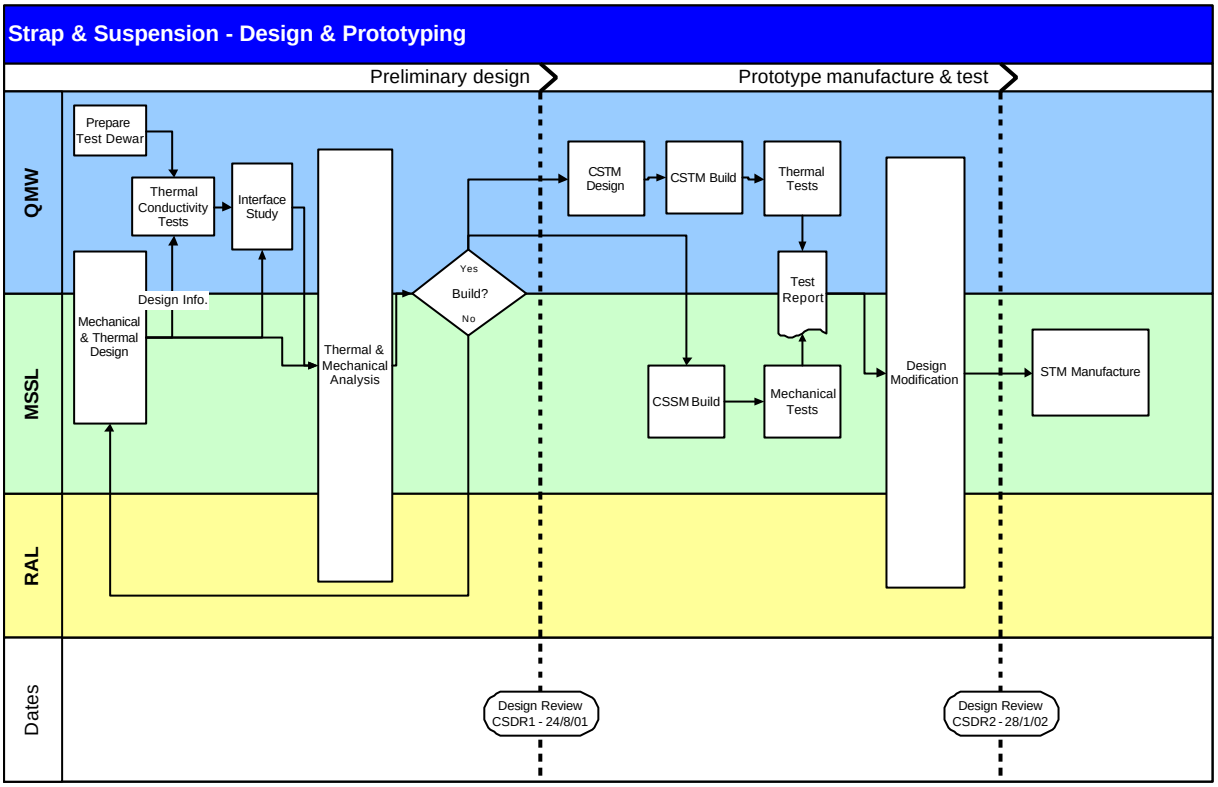

Figure 7 Detail of the strap and suspension prototyping phase

8. Risk analysis

Risk	Impact	Preventative Action	Notes
Damage during component assembly.	Development plan must be updated. Delivery dates may be delayed (margin has been built into schedule).	Clearly written & detailed integration plan.	Most likely damage would be bending (hence work-hardening) of straps, or damage to Kevlar suspension.
Failure during STM/CQM testing.	Major SPIRE schedule impact. Spare strap system will need to be assembled after failed system has been removed and analysed for failure mode.	Extensive testing of prototype components. Impact of failure will be minimized by the provision of spare components.	MSSL are working to make integration of the 300mK strap system as simple as possible.
Failure of test	TBD	Spare cryostat	This cryostat is a

cryostat		available at Cardiff	general lab. He-3 system – it could be used for strap testing in an emergency, with little modification.
Unavailability of main test team member	Moderate.	Other group members at Cardiff are/will be involved in the project.	One person is identified as responsible for the test plan at Cardiff, but other group members will be involved to such a level that they can replace the missing person.
Qualification failure	Development plan must be updated. Delivery dates may be delayed.	None.	
Limited staff resources	Development plan must be updated. Delivery dates may be delayed.	Recruitment of new staff.	Resource analysis has been completed. Two new PDRA positions have been created, of which 1.5 post-docs will be working on SPIRE.

9. Verification plan –To Be Updated

The verification plan must be compliant with the project verification plan [Refs – AD??, RD??].
300K vibrations are conducted at Cardiff - TBD
Cryovibrations are conducted at RAL under MSSL responsibility (TBC).
Vacuum cycles, soak cycles, thermal cycles are conducted at Cardiff.
Lifetime tests are conducted at Cardiff.
Performance tests are conducted at Cardiff.
In the table below,

X = a real test is conducted
A = an analysis is conducted
NA = Non applicable

	DM	STM/CQM	PFM	FS
Mass measurement	X	X	X	X
CoG measurement	X	X	X	X
Thermal drop measurement	X	A	A	A
Vibrations 300K	X	X		
Vibrations 4K	X	X	X	X
Thermal/Vacuum cycle	X	X	X	X
Accelerated lifetime (12,000 operations)	N/A	N/A	N/A	N/A
Radiation tolerance**	N/A	N/A	N/A	N/A
Microphonics	N/A	N/A	N/A	N/A
EMI / EMC	N/A	N/A	N/A	N/A

10. Development calendar & schedule

The major project milestones pertinent to the 300mK straps sub-system are:-

STM/CQM straps to RAL 01/01/02
PFM straps to RAL 11/07/03
FS straps to RAL not defined

Internal milestones and delivery dates are:-

ID	Milestone	Date	Status	Comment
306	GRTs from Lakeshore	25/1/01	Complete	
304	He-3 fridge shield ready	12/02/01	On schedule	
313	Test dewar ready	27/2/01	On schedule	
326	Design Review – LBDR1	28/2/02	On schedule	Light baffle DR1
328	LBP1 to Cardiff	12/4/01	On schedule	Light baffle prototype 1 (2 off)
322	Interface study complete	9/5/01	On schedule	
334	Design Review – LBDR2	29/5/01	On schedule	
336	LBP2 to Cardiff	11/7/01	On schedule	
340	Design report	2/8/01	On schedule	Light baffle design report
342	Light baffle design complete	23/8/01	On schedule	
347	Design review – CSDR1	24/8/01	On schedule	Cold strap design review 1
353	Cold strap prototypes – test report	10/12/01	On schedule	Report on CSSM and CSTM tests
357	STM design review – CSDR2	28/1/02	On schedule	
362	STM/CQM straps ready for integration	23/4/02	On schedule	

370	PFM straps ready for integration	3/9/03	On schedule	
374	FS straps ready for integration	03/09/03	On schedule	

ID	Task Name	Duration	Start	Finish	Resour	Predecessor
295	**300mK straps**	**847 days?**	**Fri 01/12/00**	**Mon 01/03/04**		
296	**STM/CQM 300mK system to RAL**	1 day?	Tue 01/01/02	Tue 01/01/02		
297	**PFM 300mK straps to RAL**	1 day?	Fri 11/07/03	Fri 11/07/03		
298	**FS 300mK straps to RAL**	1 day?	Mon 01/03/04	Mon 01/03/04		
299	**Design**	**281 days?**	**Fri 08/12/00**	**Fri 04/01/02**		
300	**Test dewar**	**47 days?**	**Fri 08/12/00**	**Mon 12/02/01**		
304	He-7 fridge shield ready	1 day?	Mon 12/02/01	Mon 12/02/01	ohnson	
306	GRTs from Lakeshore	5 days?	Thu 25/01/01	Wed 31/01/01		
313	Test dewar ready	1 day?	Tue 27/02/01	Tue 27/02/01		312
322	Interface study complete	1 day?	Wed 09/05/01	Wed 09/05/01		321
323	**Light baffle concept**	**136 days?**	**Wed 24/01/01**	**Wed 01/08/01**		
326	Design Review - LBDR1	1 day?	Wed 28/02/01	Wed 28/02/01		325
328	LBP1 to Cardiff (2 off)	3 days	Thu 12/04/01	Mon 16/04/01		327
334	Design Review - LBDR2	1 day?	Tue 29/05/01	Tue 29/05/01		333
336	LBP2 to Cardiff (2 off)	1 day?	Wed 11/07/01	Wed 11/07/01		335
340	Design report	1 wk	Thu 02/08/01	Wed 08/08/01	SL[50%]	323
342	Light baffle design complete	1 day?	Thu 23/08/01	Thu 23/08/01		341
343	**300mK system design**	**153 days?**	**Wed 09/05/01**	**Fri 07/12/01**		
346	Prototype light baffle design	1 day?	Thu 23/08/01	Thu 23/08/01		341,345
347	Design Review - CSDR1	1 day?	Fri 24/08/01	Fri 24/08/01		346
353	Cold strap prototypes - Test Report	2 wks	Mon 10/12/01	Fri 21/12/01	SL[50%]	343
355	**STM/CQM Manufacture**	**76 days?**	**Mon 07/01/02**	**Mon 22/04/02**		
357	STM design review - CSDR2	1 day?	Mon 28/01/02	Mon 28/01/02		356,353
361	**STM/CQM Integration & Test**	**276 days?**	**Tue 23/04/02**	**Tue 13/05/03**		
362	STM/CQM straps ready for integration	1 day?	Tue 23/04/02	Tue 23/04/02		360
367	**PFM manufacture**	**81 days?**	**Wed 14/05/03**	**Wed 03/09/03**		
370	PFM straps ready for integration	1 day?	Wed 03/09/03	Wed 03/09/03		369
371	**FS manufacture**	**121 days?**	**Wed 14/05/03**	**Wed 29/10/03**		
374	FS straps ready for integration	1 day?	Wed 29/10/03	Wed 29/10/03		373

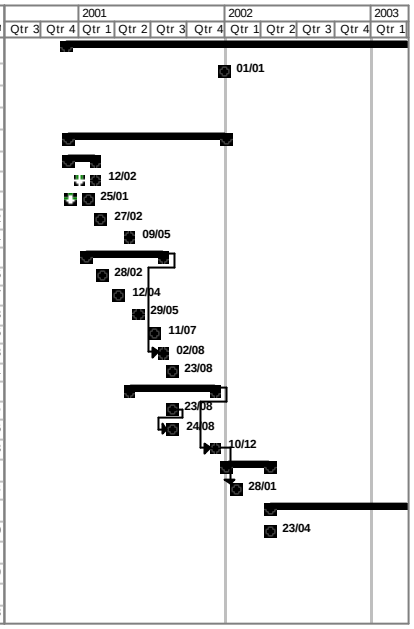

Figure 8 300mK strap sub-system milestones.

11. 300mK straps sub-system schedule

ID	Task Name	Duration	Start	Finish	Resour	Predecesso
295	**300mK straps**	**847 days?**	**Fri 01/12/00**	**Mon 01/03/04**		
296	**STM/CQM 300mK system to RAL**	1 day?	Tue 01/01/02	Tue 01/01/02		
297	**PFM 300mK straps to RAL**	1 day?	Fri 11/07/03	Fri 11/07/03		
298	**FS 300mK straps to RAL**	1 day?	Mon 01/03/04	Mon 01/03/04		
299	**Design**	**281 days?**	**Fri 08/12/00**	**Fri 04/01/02**		
300	**Test dewar**	**47 days?**	**Fri 08/12/00**	**Mon 12/02/01**		
301	Dewar stripout	1 day?	Fri 08/12/00	Fri 08/12/00		
302	Housekeeping wiring	5 days	Mon 11/12/00	Fri 15/12/00	o[20%]	301
303	He-10 fridge wiring	5 days	Mon 08/01/01	Fri 12/01/01	e[20%]	302
304	He-7 fridge shield ready	1 day?	Mon 12/02/01	Mon 12/02/01	ohnson	
305	Wire He-7 fridge	2 days	Thu 18/01/01	Fri 19/01/01	e[30%]	
306	GRTs from Lakeshore	5 days?	Thu 25/01/01	Wed 31/01/01		
307	Assemble & test DAQ system	5 days	Mon 15/01/01	Fri 19/01/01	e[20%]	
308	Acqn. Software	5 days?	Mon 22/01/01	Fri 26/01/01	e[20%]	307
309	Sample mounting hardware	1 wk	Mon 11/12/00	Fri 15/12/00	0%]	301
310	Housekeeping thermometry	5 days?	Mon 18/12/00	Fri 22/12/00	e[20%]	302
311	RF filters	1 day?	Mon 15/01/01	Mon 15/01/01	argrave	302,303
312	Margin	2 wks	Tue 13/02/01	Mon 26/02/01		300
313	Test dewar ready	1 day?	Tue 27/02/01	Tue 27/02/01		312
314	**Materials & thermal interface study**	**40 days**	**Wed 28/02/01**	**Tue 24/04/01**	**[50%]**	**313**
315	Cu	1 mon	Wed 28/02/01	Tue 27/03/01		
316	Al	1 mon	Wed 28/02/01	Tue 27/03/01		
317	Kevlar	1 mon	Wed 28/02/01	Tue 27/03/01		
318	Vespel	1 mon	Wed 28/02/01	Tue 27/03/01		
319	Torlon	1 mon	Wed 28/02/01	Tue 27/03/01		
320	Interface study	1 mon	Wed 28/03/01	Tue 24/04/01		317,318,319
321	Margin	2 wks	Wed 25/04/01	Tue 08/05/01		314
322	Interface study complete	1 day?	Wed 09/05/01	Wed 09/05/01		321
323	**Light baffle concept**	**136 days?**	**Wed 24/01/01**	**Wed 01/08/01**		
324	Detailed prototype design following Tony Richards gui	3 wks	Wed 24/01/01	Tue 13/02/01	20%]	
325	Structural/Thermal analysis	2 wks	Wed 14/02/01	Tue 27/02/01	MSSL	324
326	Design Review - LBDR1	1 day?	Wed 28/02/01	Wed 28/02/01		325
327	Prototype manufacture (LBP1 - 3off)	6 wks	Thu 01/03/01	Wed 11/04/01	MSSL	326
328	LBP1 to Cardiff (2 off)	3 days	Thu 12/04/01	Mon 16/04/01		327
329	Prep. of mech test bed	6 wks	Wed 28/02/01	Tue 10/04/01	MSSL	325
330	Thermal tests	4 wks	Tue 17/04/01	Mon 14/05/01	e[50%]	328
331	Optical tests (BACUS dewar)	4 wks	Tue 17/04/01	Mon 14/05/01	e[50%]	328
332	Mechanical tests	4 wks	Thu 12/04/01	Wed 09/05/01	MSSL	327,329
333	Revised design	2 wks	Tue 15/05/01	Mon 28/05/01	[30%]	330,331,332
334	Design Review - LBDR2	1 day?	Tue 29/05/01	Tue 29/05/01		333
335	2nd prototype manufacture (LBP2 - 3off)	6 wks	Wed 30/05/01	Tue 10/07/01	MSSL	334
336	LBP2 to Cardiff (2 off)	1 day?	Wed 11/07/01	Wed 11/07/01		335
337	Thermal tests	3 wks	Thu 12/07/01	Wed 01/08/01	e[50%]	336
338	Optical tests (BACUS dewar)	3 wks	Wed 11/07/01	Tue 31/07/01	e[50%]	335
339	Mechanical tests	3 wks	Wed 11/07/01	Tue 31/07/01	MSSL	335
340	Design report	1 wk	Thu 02/08/01	Wed 08/08/01	[50%]	323
341	Margin	2 wks	Thu 09/08/01	Wed 22/08/01		340
342	Light baffle design complete	1 day?	Thu 23/08/01	Thu 23/08/01		341
343	**300mK system design**	**153 days?**	**Wed 09/05/01**	**Fri 07/12/01**		
344	Preliminary strap design from MSSL	3 wks	Wed 09/05/01	Tue 29/05/01	MSSL	321
345	Approval by QMW (following thermal tests & analysis)	5 wks	Wed 30/05/01	Tue 03/07/01	[50%]	344
346	Prototype light baffle design	1 day?	Thu 23/08/01	Thu 23/08/01		341,345
347	Design Review - CSDR1	1 day?	Fri 24/08/01	Fri 24/08/01		346
348	Thermal prototype design (CSTM)	3 wks	Mon 27/08/01	Fri 14/09/01	0%]	347
349	Thermal Prototype Manufacture (CSTM)	6 wks	Mon 17/09/01	Fri 26/10/01	0%]	348
350	Thermal tests at QMW	6 wks	Mon 29/10/01	Fri 07/12/01	e[50%]	349
351	Mechanical Prototype manufacture (CSSM)	6 wks	Fri 24/08/01	Thu 04/10/01	MSSL	346,345
352	Mechanical tests at MSSL/RAL	6 wks	Fri 05/10/01	Thu 15/11/01	MSSL	351,329
353	Cold strap prototypes - Test Report	2 wks	Mon 10/12/01	Fri 21/12/01	[50%]	343
354	Margin	2 wks	Mon 24/12/01	Fri 04/01/02		353
355	**STM/CQM Manufacture**	**76 days?**	**Mon 07/01/02**	**Mon 22/04/02**		
356	STM design modifications	3 wks	Mon 07/01/02	Fri 25/01/02	0%]	354
357	STM design review - CSDR2	1 day?	Mon 28/01/02	Mon 28/01/02		356,353
358	STM/CQM manufacture	8 wks	Tue 29/01/02	Mon 25/03/02	MSSL	357
359	300mK STM system assembly	2 wks	Tue 26/03/02	Mon 08/04/02	SSL	358
360	Margin	2 wks	Tue 09/04/02	Mon 22/04/02		359
361	**STM/CQM Integration & Test**	**276 days?**	**Tue 23/04/02**	**Tue 13/05/03**		
362	STM/CQM straps ready for integration	1 day?	Tue 23/04/02	Tue 23/04/02		360
363	Integration to STM structure	4 wks	Wed 24/04/02	Tue 21/05/02	0%]	362
364	STM tests of CQM straps	6 mons	Wed 22/05/02	Tue 05/11/02		363
365	CQM tests	6 mons	Wed 06/11/02	Tue 22/04/03		364
366	Design modification	3 wks	Wed 23/04/03	Tue 13/05/03		2,365
367	**PFM manufacture**	**81 days?**	**Wed 14/05/03**	**Wed 03/09/03**		
368	PFM manufacture	10 wks	Wed 14/05/03	Tue 22/07/03		366
369	Acceptance Checks	6 wks	Wed 23/07/03	Tue 02/09/03		368
370	PFM straps ready for integration	1 day?	Wed 03/09/03	Wed 03/09/03		369
371	**FS manufacture**	**121 days?**	**Wed 14/05/03**	**Wed 29/10/03**		
372	FS manufacture	12 wks	Wed 14/05/03	Tue 05/08/03		366
373	Acceptance checks	12 wks	Wed 06/08/03	Tue 28/10/03		372
374	FS straps ready for integration	1 day?	Wed 29/10/03	Wed 29/10/03		373
375	**Documentation**	1 day?	Fri 01/12/00	Fri 01/12/00		

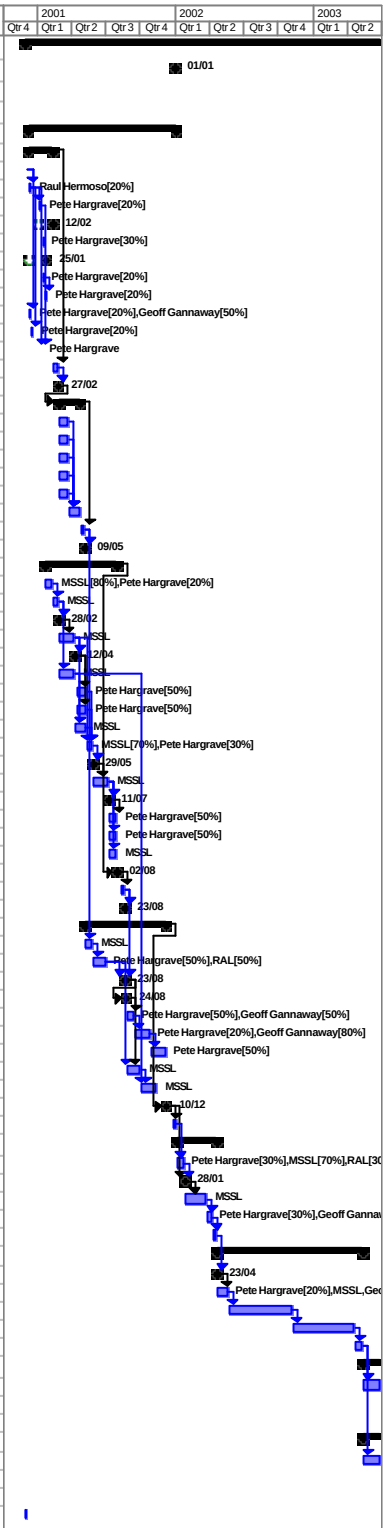

Figure 9 300mK strap schedule.