

**SPIRE BSM**

**At MPIA : Oct 17, 2000**

ATC Ref: SPI-BSM-MHO-0705

RAL Ref: SPIRE-ATC-MHO-000705

# Beam Steering Mirror

UK ATC

Ian Pain

Brian Stobie

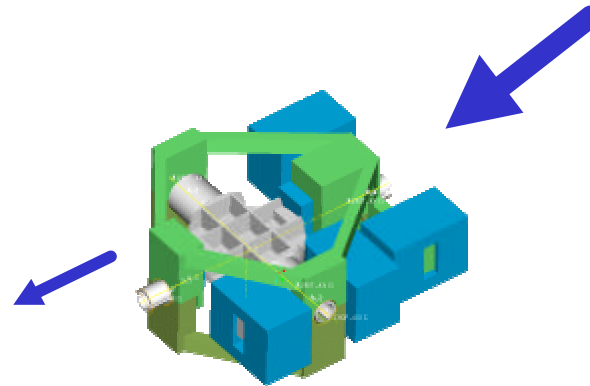
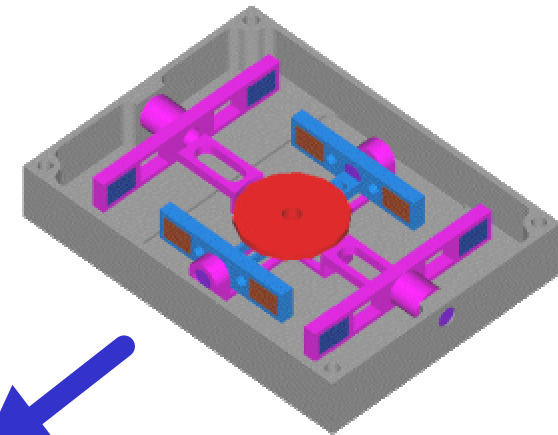
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## Beam Steering Mirror

- **Design Overview**
- **Review of Design Updates**
  - Requirements
  - Mechanism
  - Electronic
  - Control
- **Issues for resolution**
- **Development Plan**

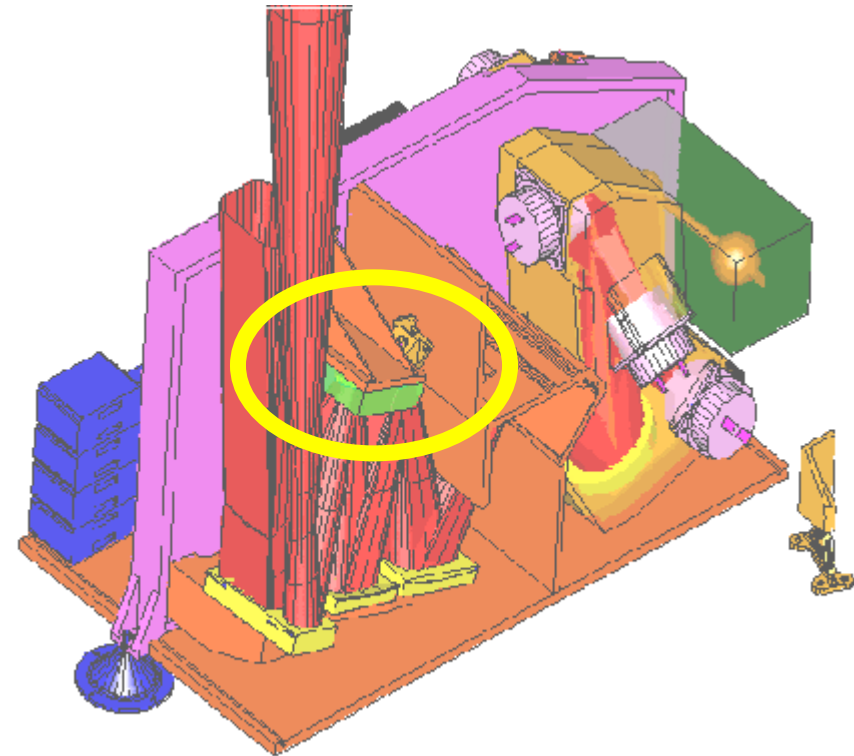


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## Design Overview

The BSM mechanism subsystem:

- Cryogenic Mechanism (BSMm)
- Structure (BSMs)
- Warm Electronics (BSMe)
- Mass Dummies (BSMd)



## **Requirements Update**

- Since the choice of horn arrays:
  - Reduced chopping speed requirement to 2 Hz
    - Risetime now 25 ms
    - chop angle +/- 2.5°
  - Reduced jiggling speed requirement to 0.5 Hz
    - Risetime now 100 ms
    - chop angle +/- 0.5°

## Design Update

### The cryogenic mechanism (BSMm).

Mechanical design refined: stiffer & lighter

Prototype build started.

### The structural interface (BSMs).

ATC now responsible for BSMs

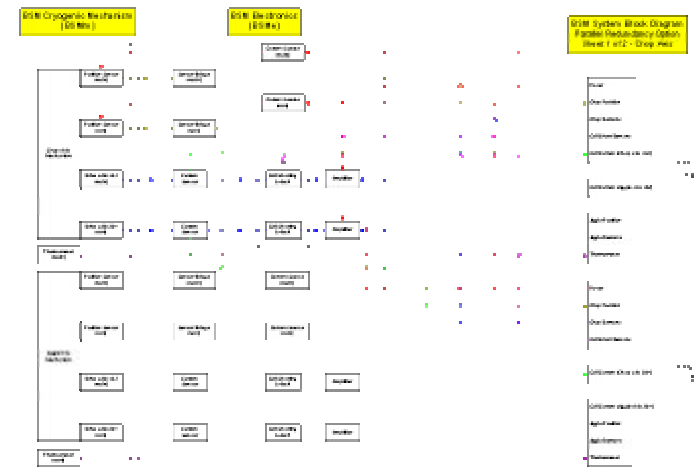
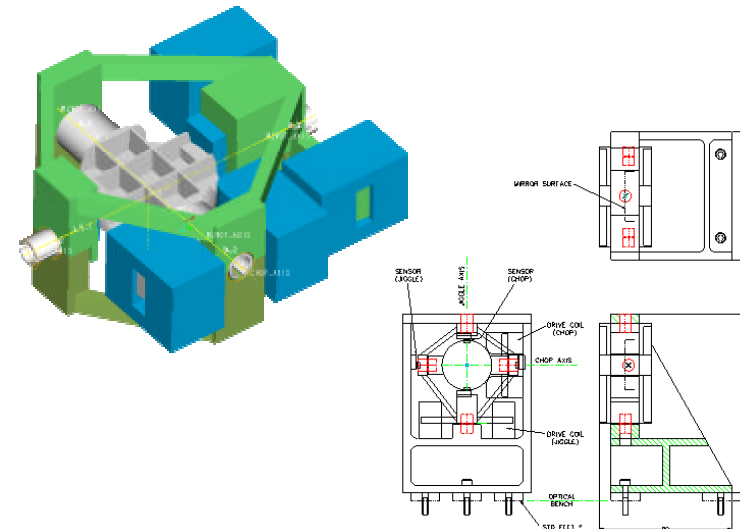
Concept design complete

### The warm electronics (BSMe)

Digital control selected

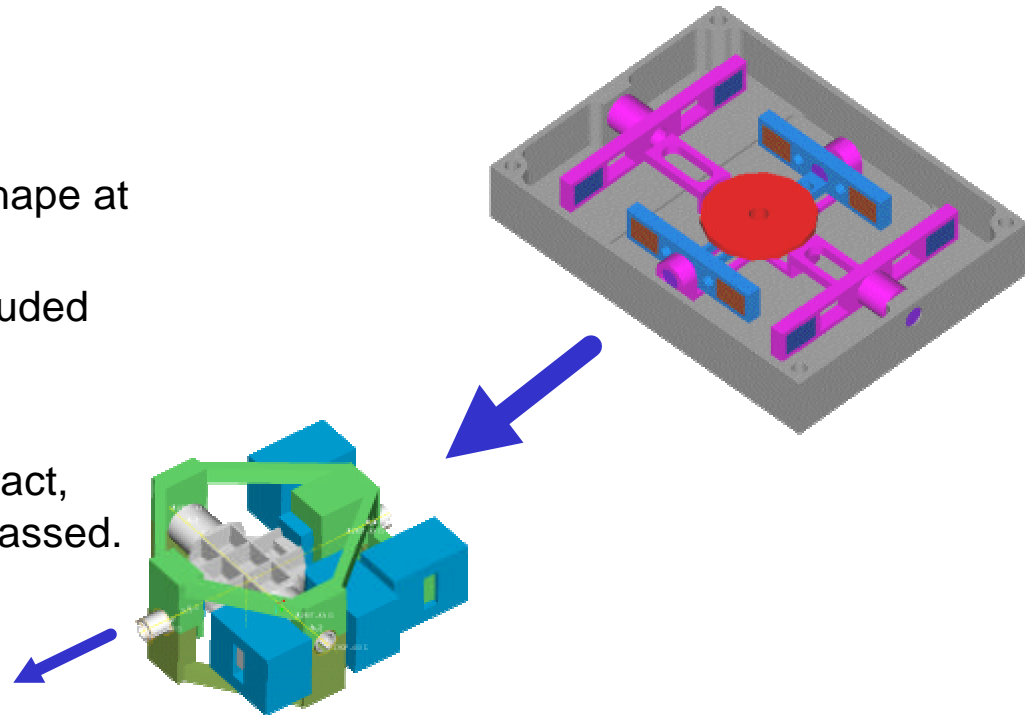
Parallel redundancy adopted (as SMEC)

Full Control design in progress



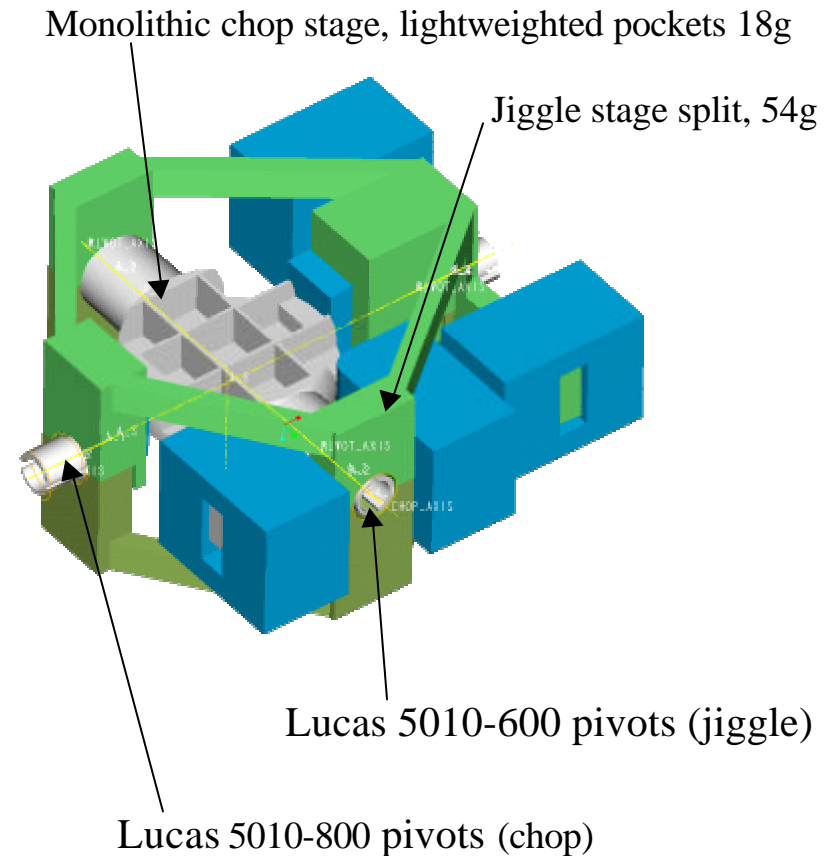
## Recent Accomplishments - BSM

- BSM
  - Delta PDR, Saclay
  - BSM noted as in good shape at PDR
  - Static sensor tests concluded
  - Single axis mechanical prototype manufactured
  - Alternate prototype contract, CDL Systems. “CoDR” passed.



## Cryogenic Mechanism (BSMm)

- **Al 6061 structure**
- **Motors**
  - design TBD (ISOPHOT or PACS)
- **Magneto-resistive sensors**
  - per ISOPHOT
- **Lucas flex pivots**
- **resonant frequencies:**
  - 23Hz (chop); 18 Hz (jiggle)
  - 1st parasitic resonance at 729 Hz.



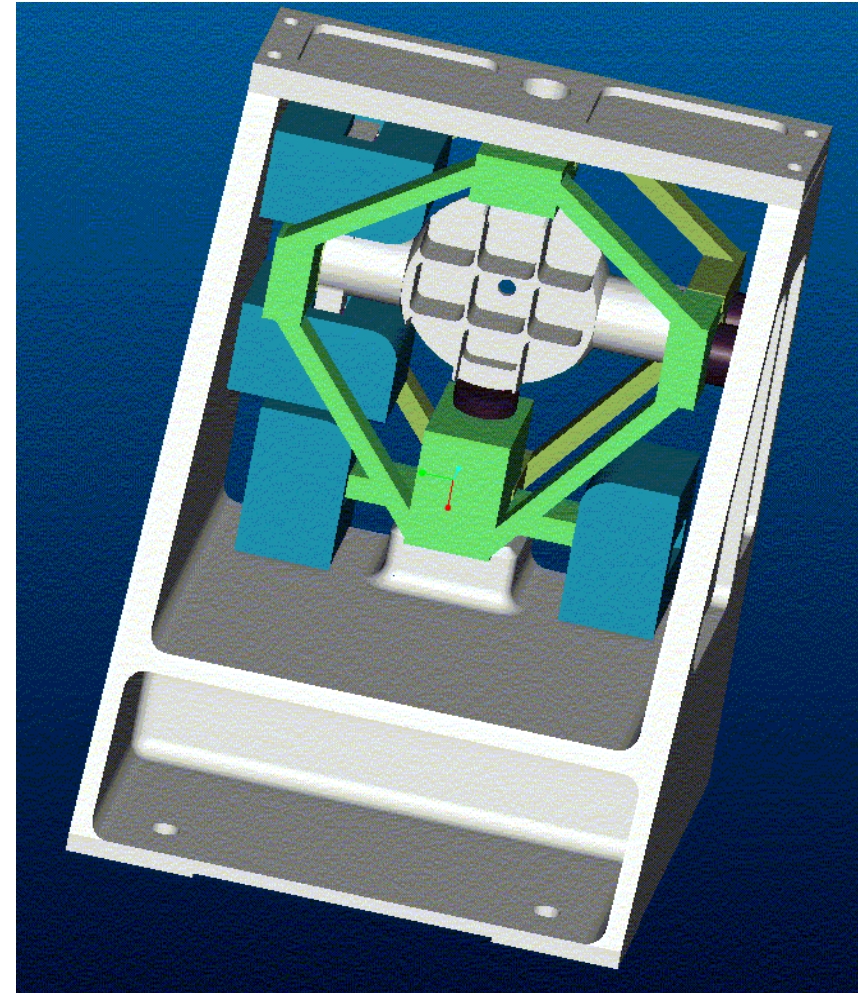
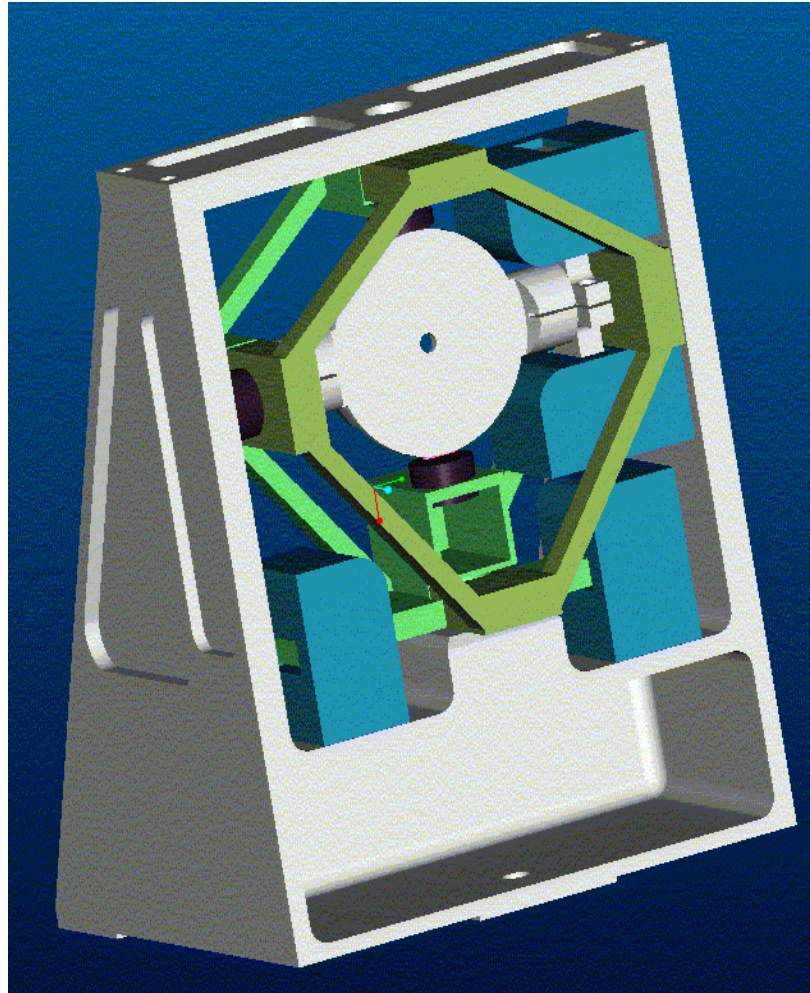
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## **Cryogenic Mechanism & Structure**



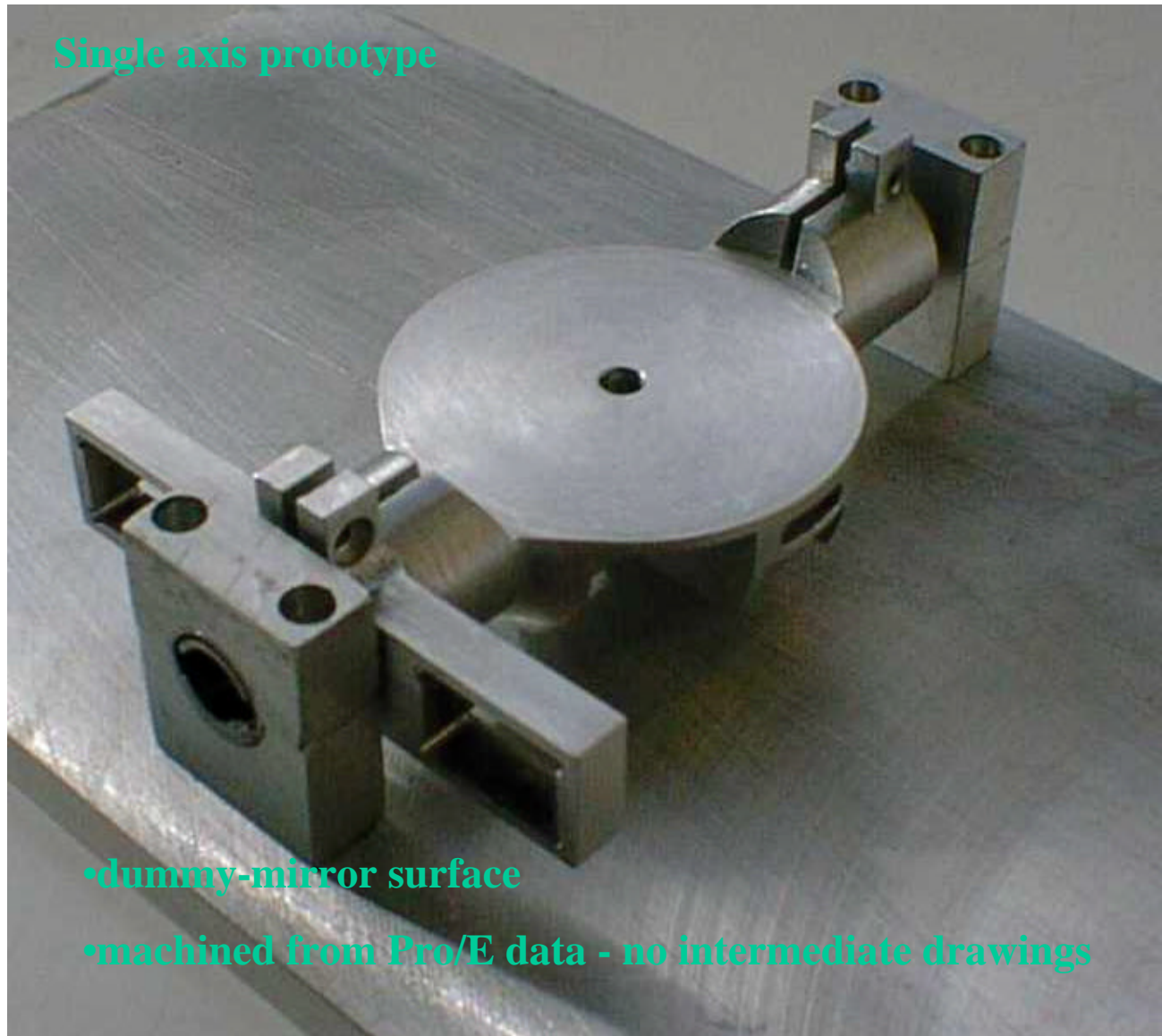
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Single axis prototype

-0705  
IO-000705

- dummy-mirror surface
- machined from Pro/E data - no intermediate drawings

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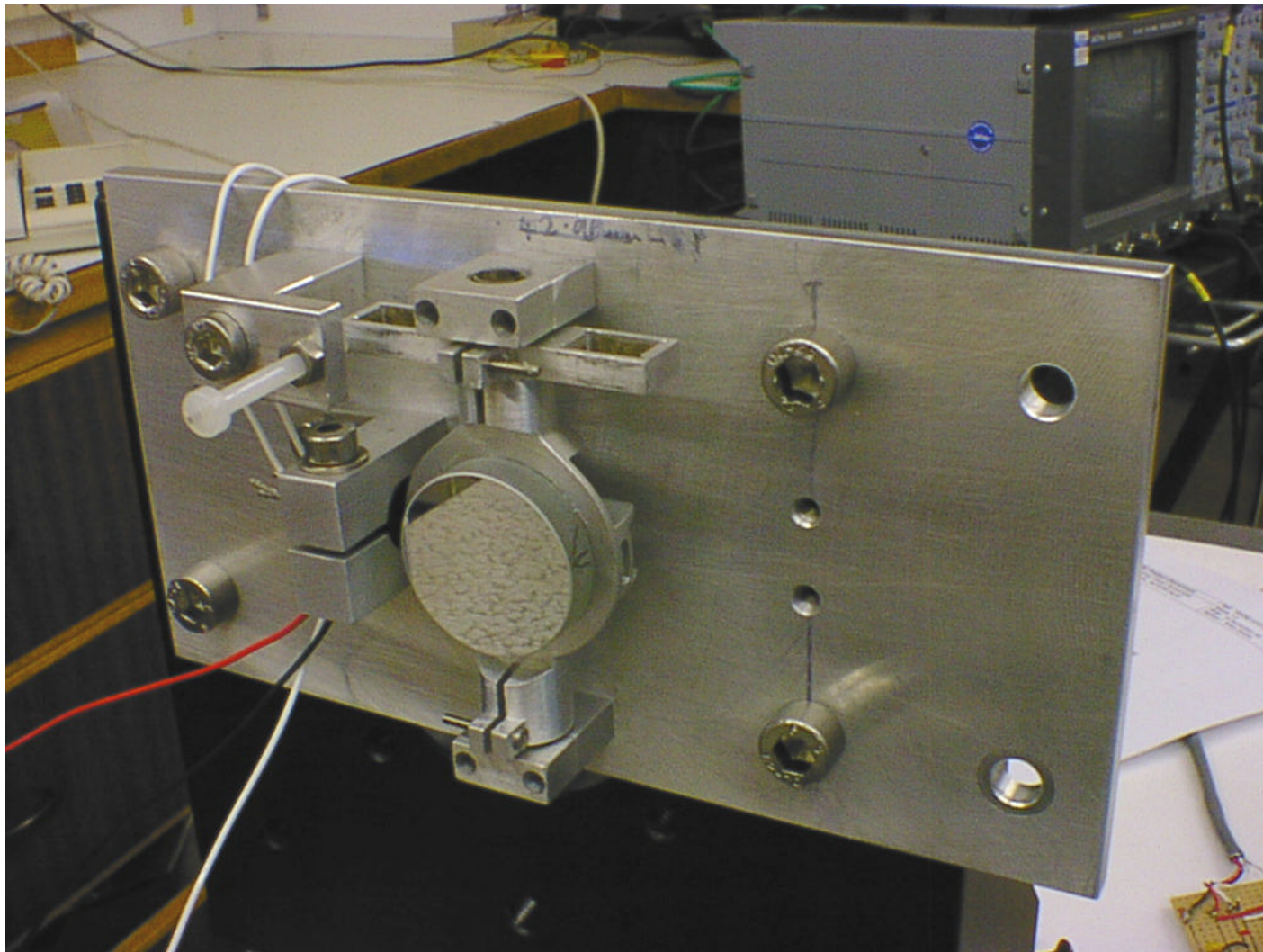
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## Sensor Tests

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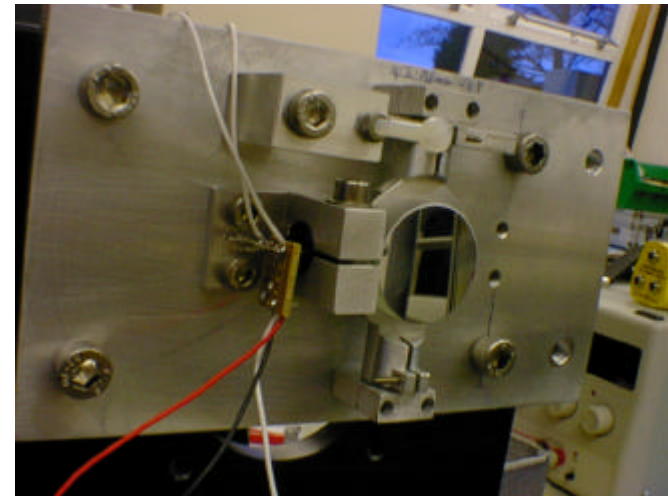
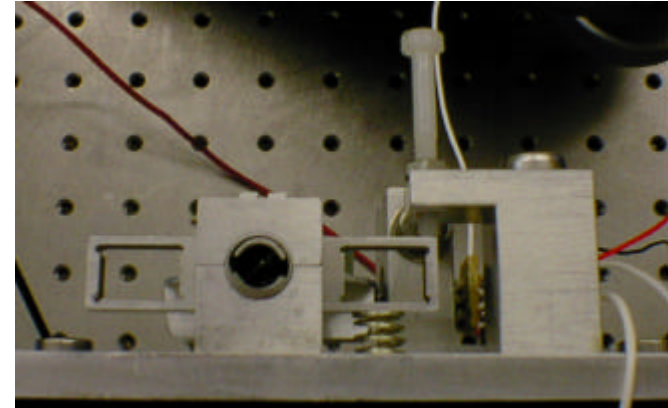
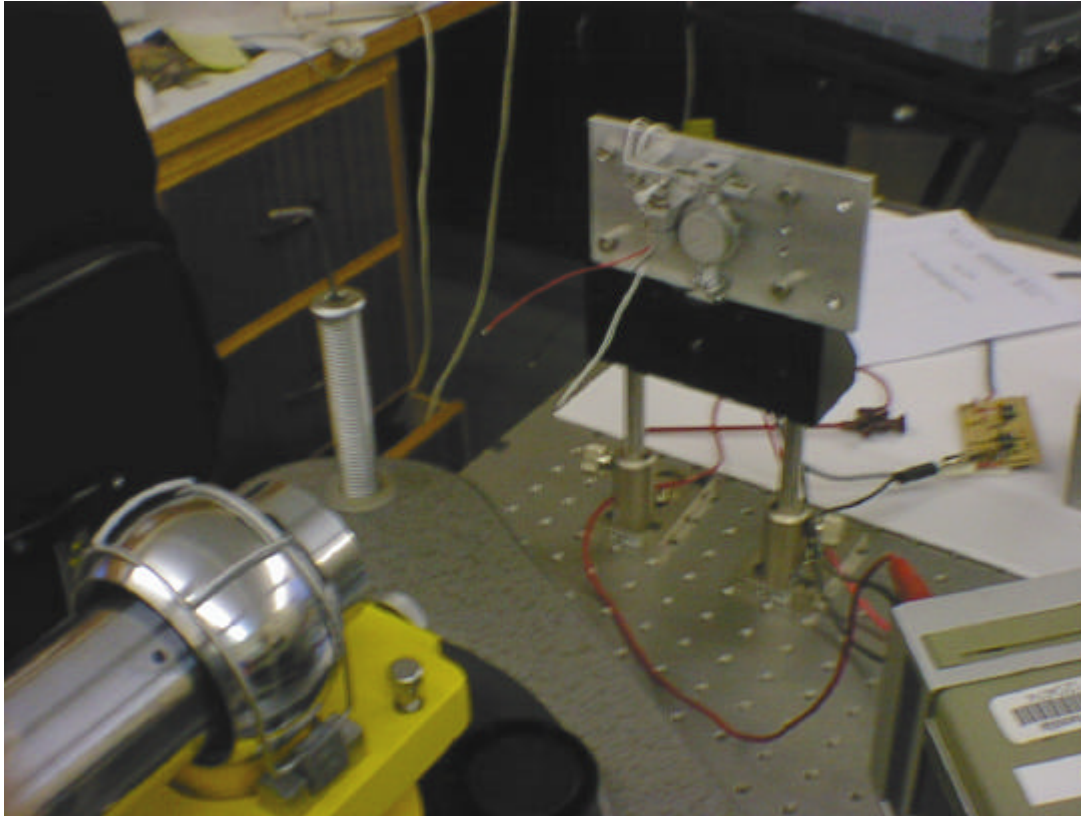
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## Sensor Tests

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RAL Ref: SPIRE-ATC-MHO-000705

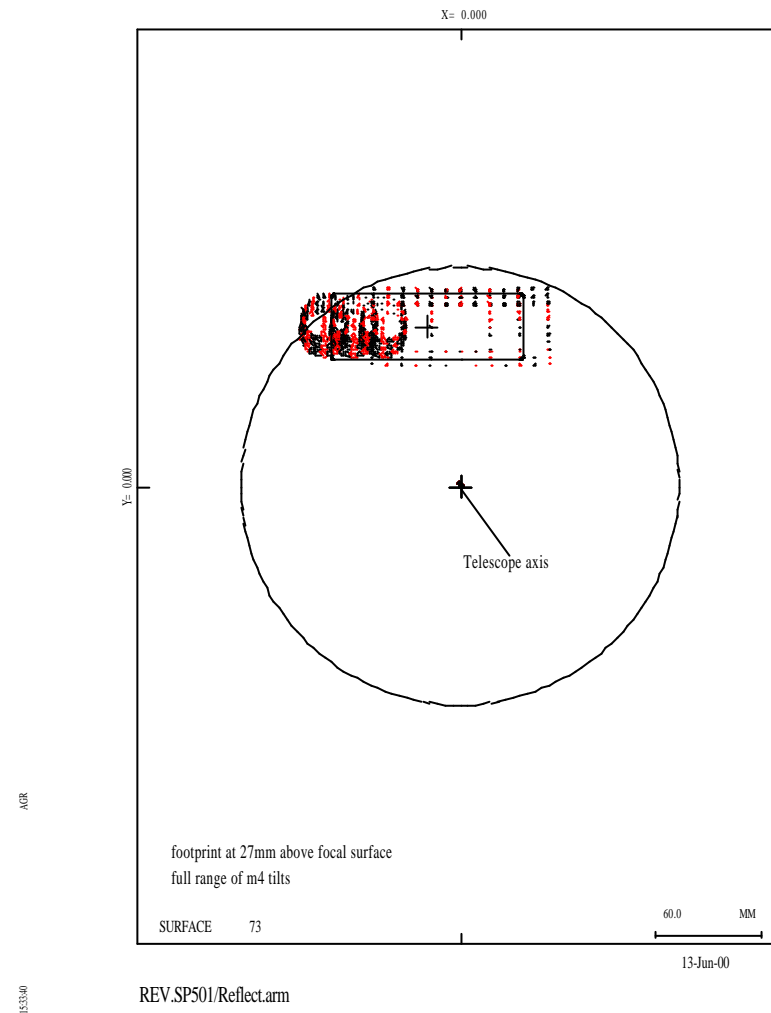


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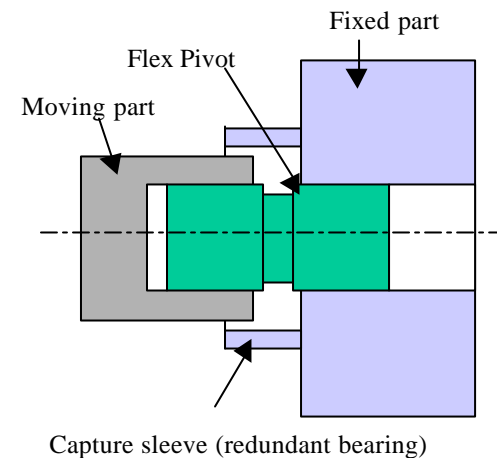
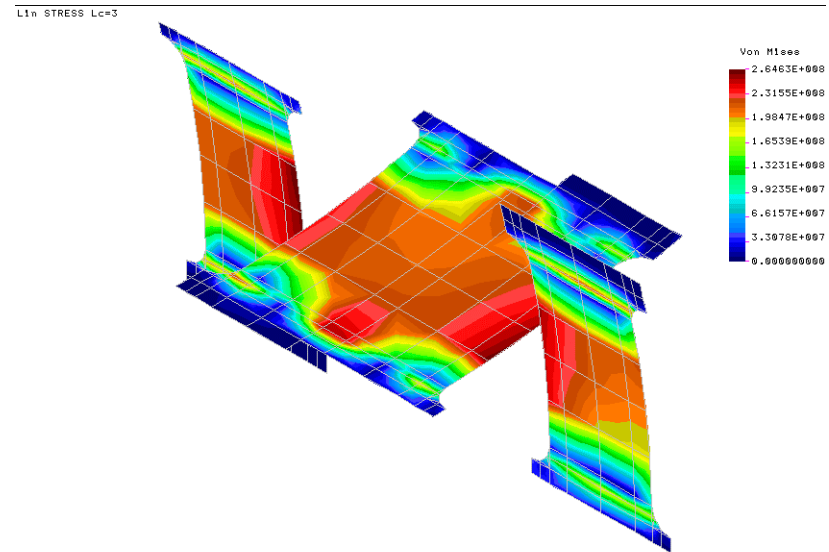
## BSMm - Launch Protection ?

- **Fail safe requirements?**
  - Scan mode :  $0.36^\circ$  of (0,0)
  - NOT at end of travel  
(Spectrometer unusable)
- **Baseline design**
  - launch “damper” - see BSMe
- **Physical Deployable End-stop?**
  - Extra protection vs risk of latch failure or flexure overconstraint.



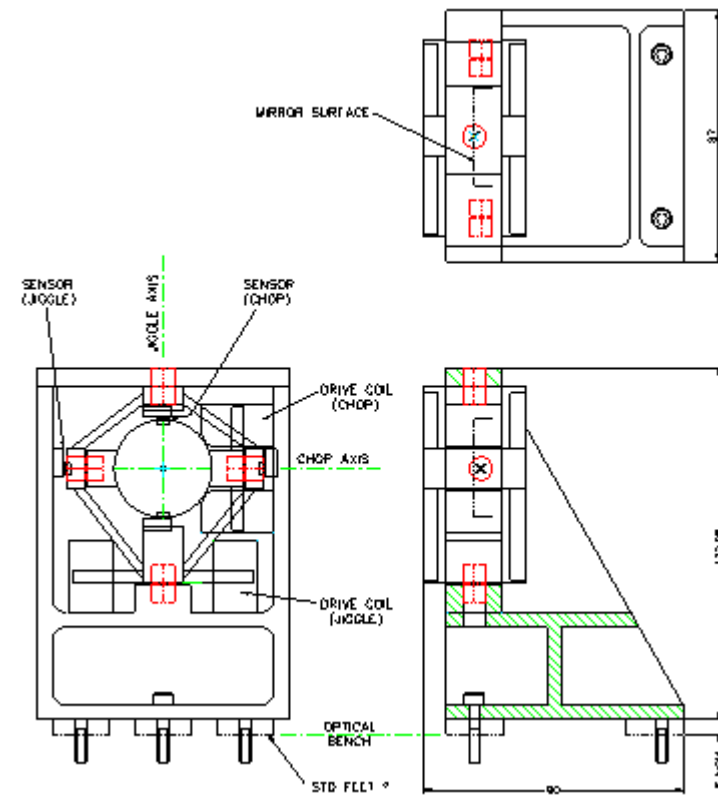
## BSMm - Flex pivots

- **Design for adequate reserve**
  - Inconel.
  - Initial FEA: reserve >3 (50g static load).
- **Redundant “bearings” ?**
  - preferred to physical latch (FMEA required).



## Structure (BSMs)

- Preliminary design
  - Lightweighting required
  - Calibrator mechanical interface TBD
  - Harness interface TBD



## **Electronics -BSMe**

- Redundancy architecture
- Magnetoresistive Sensors
- ISOPHOT-type motors - or similar
- Electronics Design : SMEC-type power amps, ISOPHOT-type current source and preamplifiers
- Control Design :
  - State feedback using observer and windowed integrator
  - Chop Axis Bandwidth ~ 100 Hz
  - Jiggle Axis Bandwidth ~ 75 Hz
  - Sinusoidal profile generator used for I/P's > 10% of max demand

## **BSM Control : Mechanism Parameters**

### CHOP :

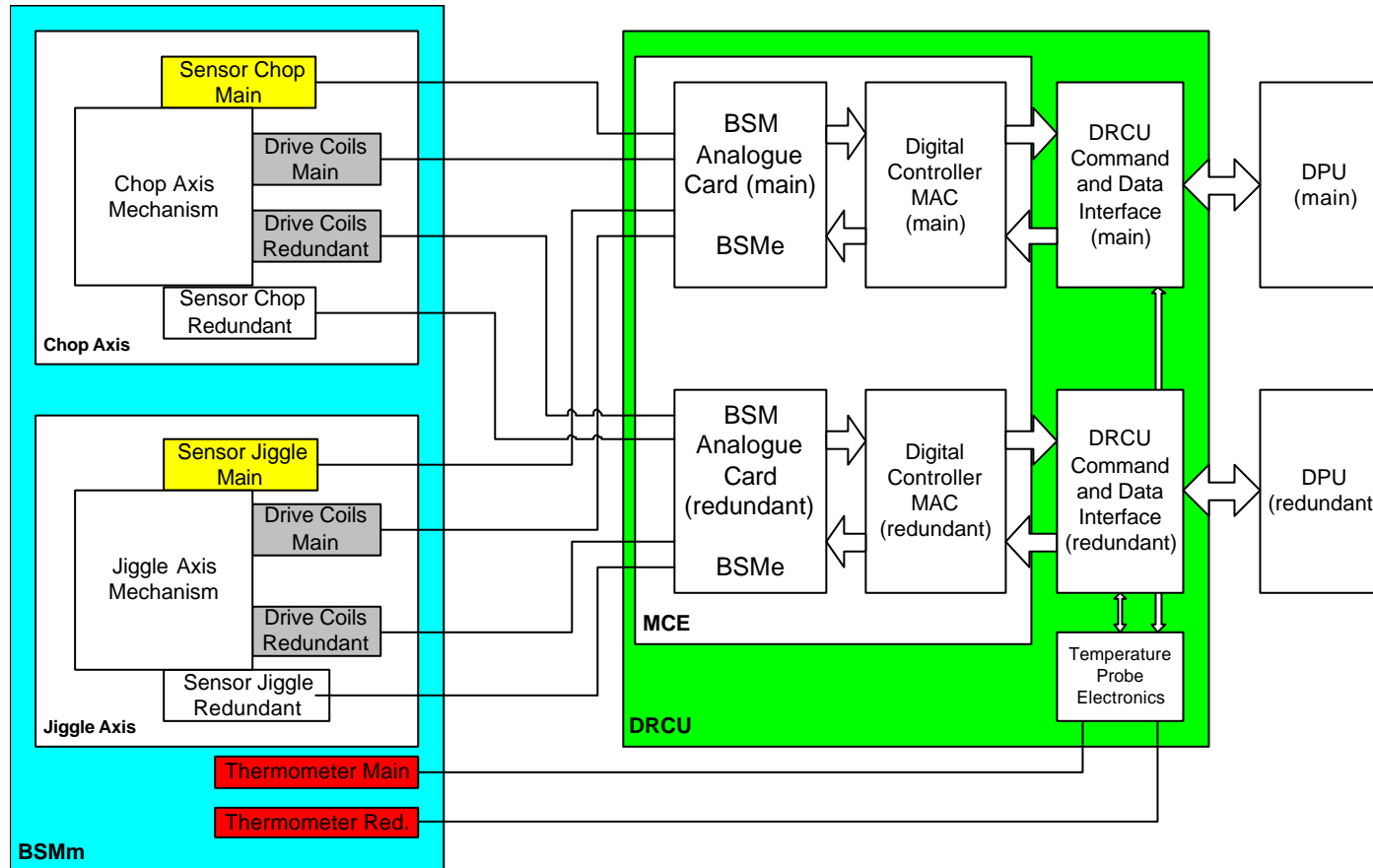
Axis moment of inertia	2.1e-6 kg.m <sup>2</sup>
Flex stiffness	0.047 N.m/rad
Flex damping	2.3e-5 N.m.s

### JIGGLE :

Axis moment of inertia	27.0e-6 kg.m <sup>2</sup>
Flex stiffness	0.37 N.m/rad
Flex damping	2.3e-5 N.m.s



### BSMe - Redundancy Architecture



## **BSMe - Position Sensors and Redundancy**

- **ISOPHOT-type magneto-resistive sensors**
- ( Infineon FP 210 L 100-22 )
- Stability tests underway at ATC.
  
- **Redundancy:**
  - Parallel redundant circuits, sensors and motors
  - Motor Current feedback
  - Broken flex joint control loop (different control structure or just new parameters)
  - Off-Line fault analysis to determine optimum corrections

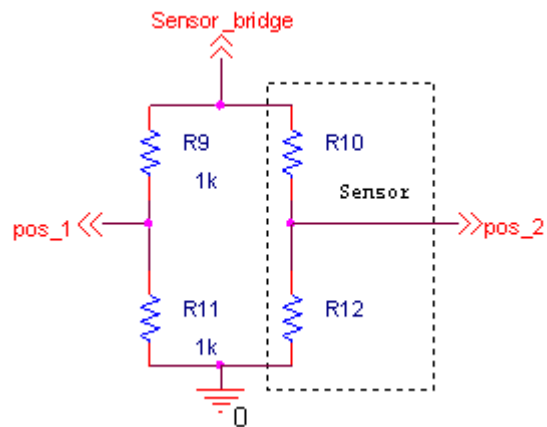
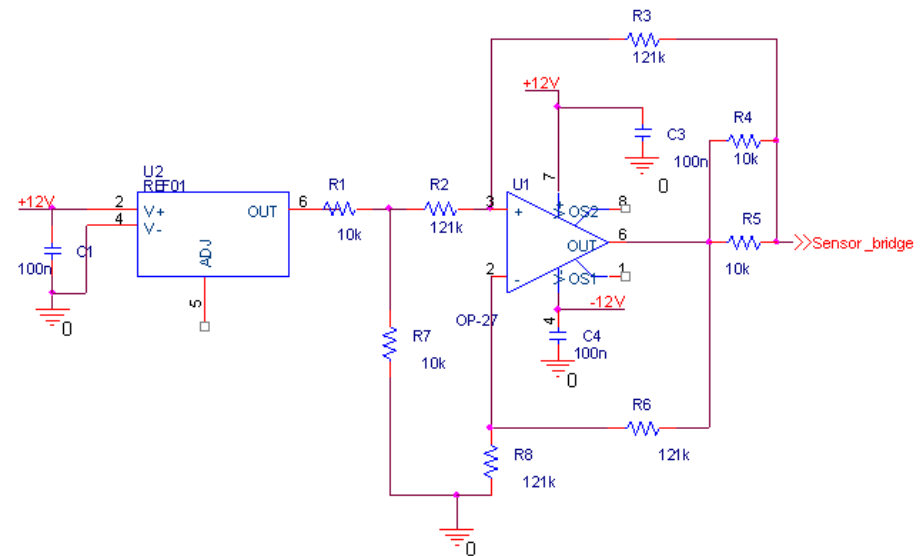
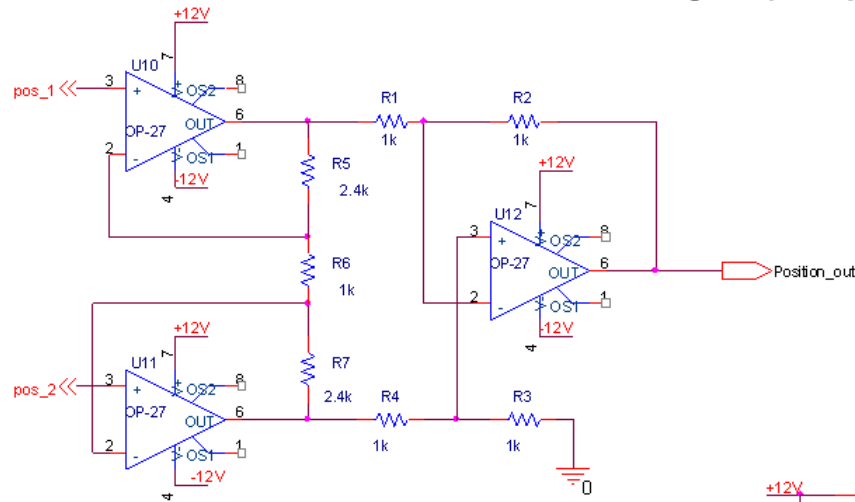
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## BSMe - sensors



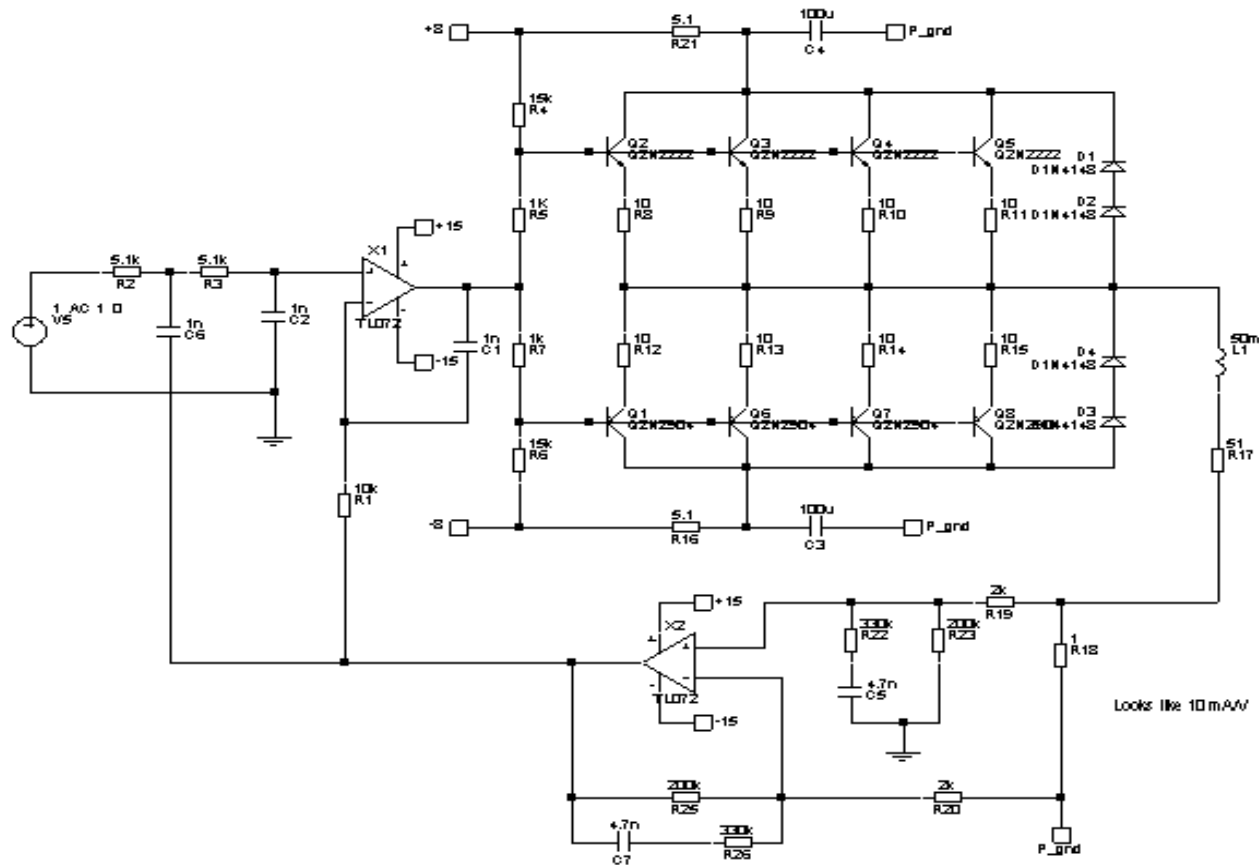
## Position sensor read-out circuits

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# BSMe - Power Amplifiers

- LAM SMEC design : need to minimise power dissipation, means low power supply voltage , and low slew rate

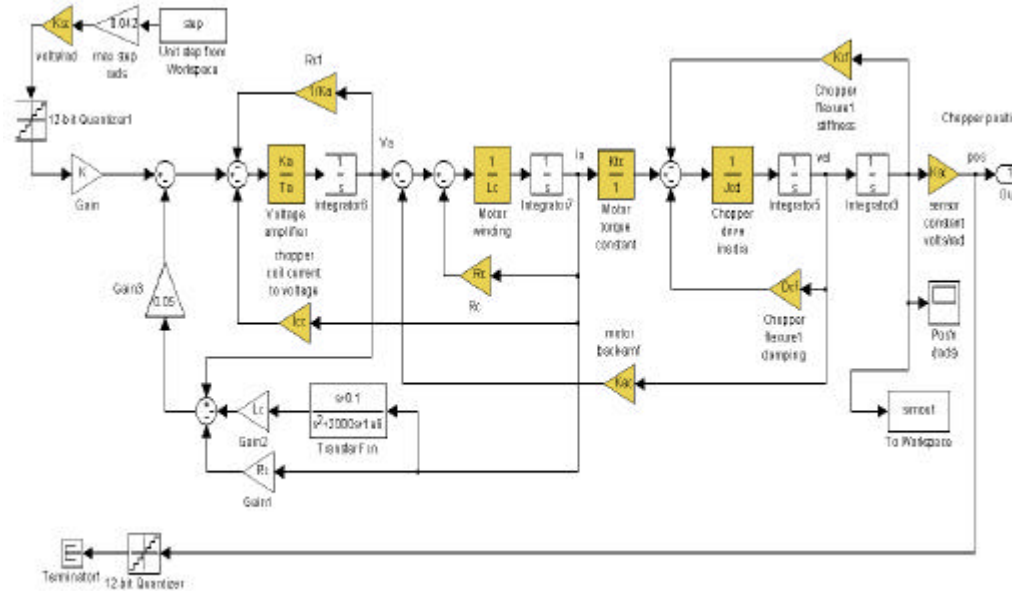


# SPIRE BSM

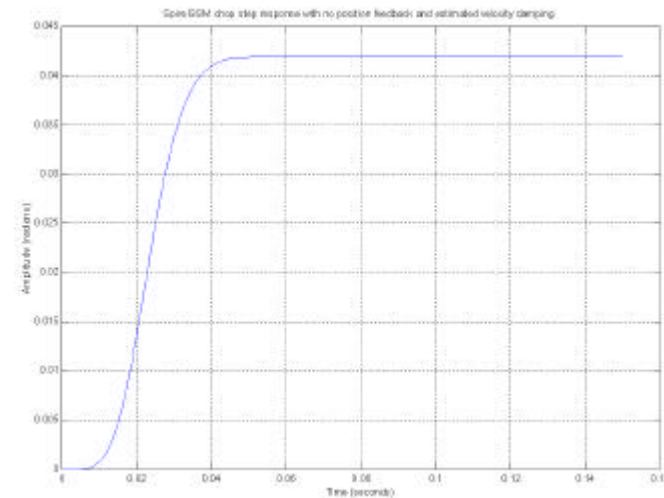
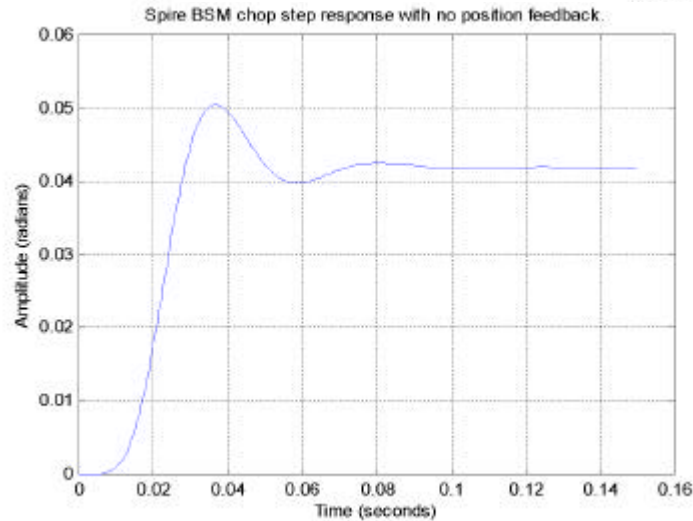
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ATC PI-BSM-MHO-0705  
PIRE-ATC-MHO-000705

BSMe - sensors  
... open loop?



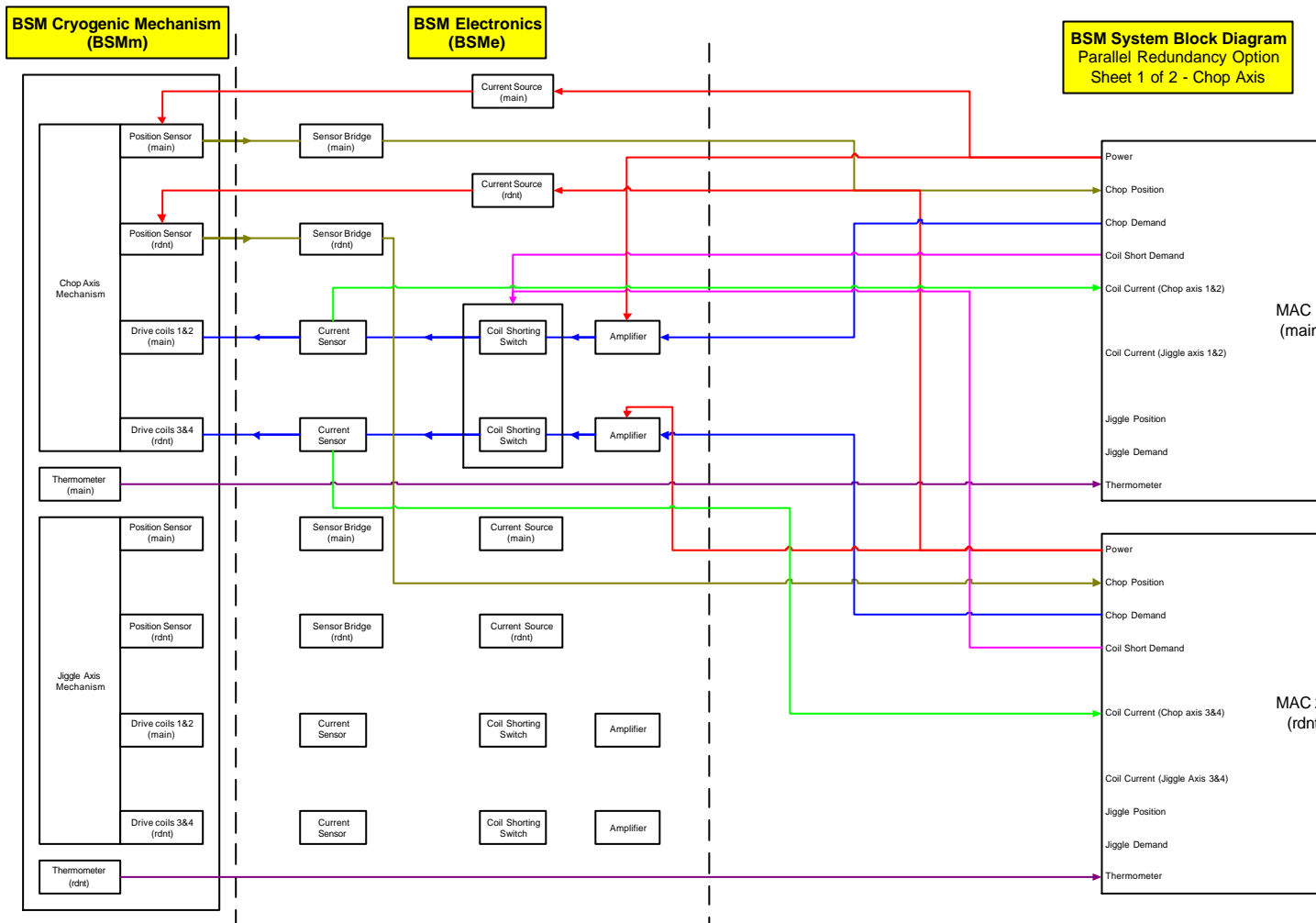
SPIRE Beam Steering Mirror chopper axis simplified dynamics with no position feedback and estimated velocity damping:  
spire\_chop\_mod@nofb.mdl



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## BSMe -Electronics Design



## **BSM development plan**

### Relevant documents:

- BSM Development Plan

- Workflow Diagram

- Project Plan

  - BSMe plans developed in liaison with LAM

  - Meets CQM delivery deadlines

### Immediate future:

- Prototyping phase underway

- Motor analysis & selection

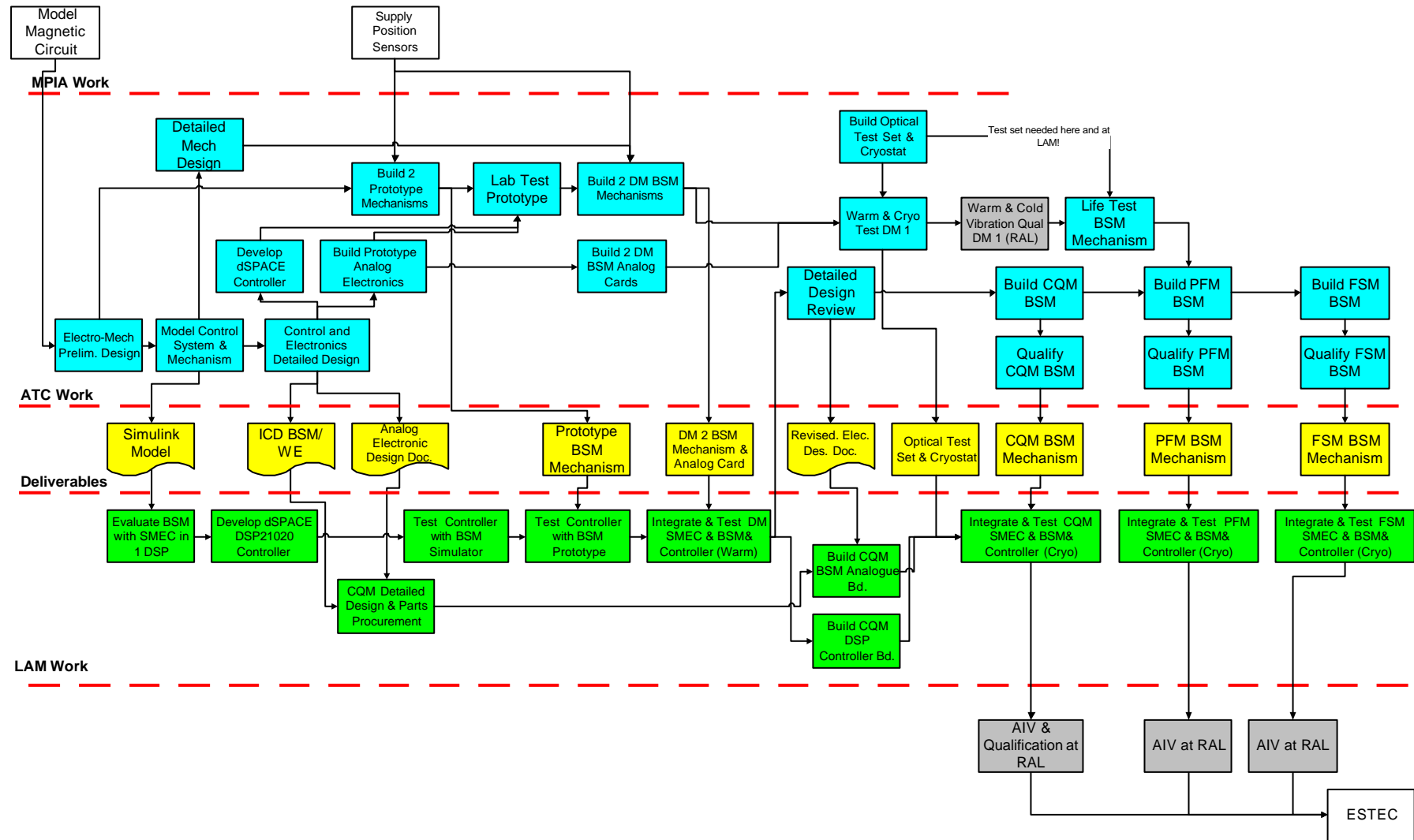
- Detailed design & FMEA.

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**BSM Development Work Flow V1.2**  
14/4/00



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## Costs & Milestones

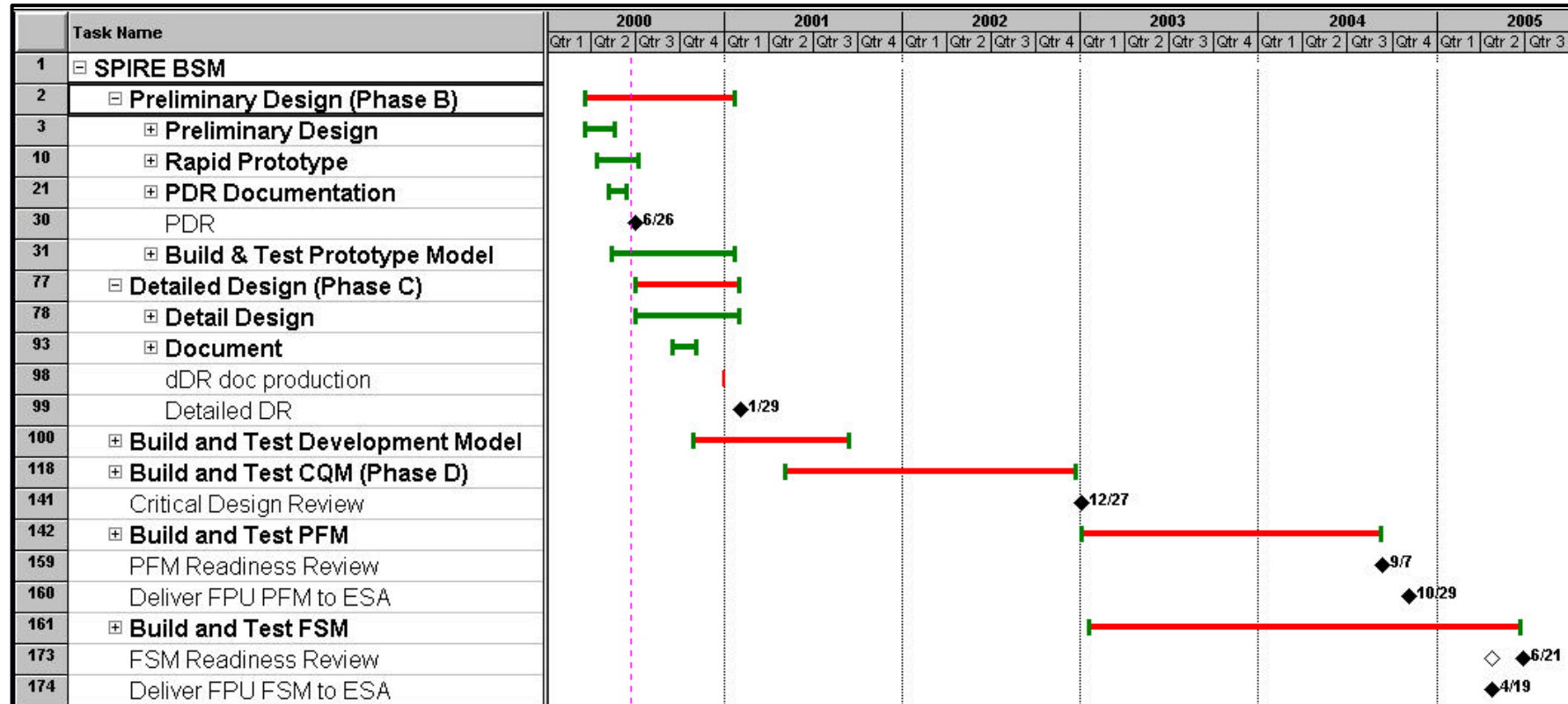
Milestone	Date@ Feb.00	Date @ Aug.00
Project Start Date	Sep.97	complete
PDR	Jul .99	complete
Delta PDR SPIRE	Apr.00	Complete
BSM Simulink Model Del'y to LAM ATC		Nov.00
BSM Analogue Board Design Del'y to LAM ATC		Aug.00
BSM Prototype2 Del'y to LAM ATC		Sep00(?)
BSM Analogue Board Detailed Design Del'y to LAM ATC		Jan.01
SMEC, BSM Detailed Design Review SPIRE	Sep.00	Jan.01
BSM DM2 Deliver to LAM ATC		Mar.01
CQM BSMm Del'y to LAM ATC	Jan.02	Jul.02
CQM BSMm Del'y to RAL ATC		Oct.02
BSM Design CDR SPIRE	Dec.02	Mar.03
System Design CDR SPIRE		Mar.03
CQM Del'y to ESA RAL Apr.03		
WE Critical Design Review SPIRE Mar.03		
PFM BSMm Del'y to LAM ATC	Jul.04	Jul.03
PFM BSMm Del'y to RAL LAM		Oct.03
PFM Del'y to ESA RAL	Nov.04	Jul.04
FS BSMm Del'y to LAM ATC		Jan.04
FS BSMm Del'y to RAL LAM	Jul.05	Nov.04
FS Available to ESA RAL		Jul.05
Launch	Jan.07	Jan.07

- **Cost Summary**

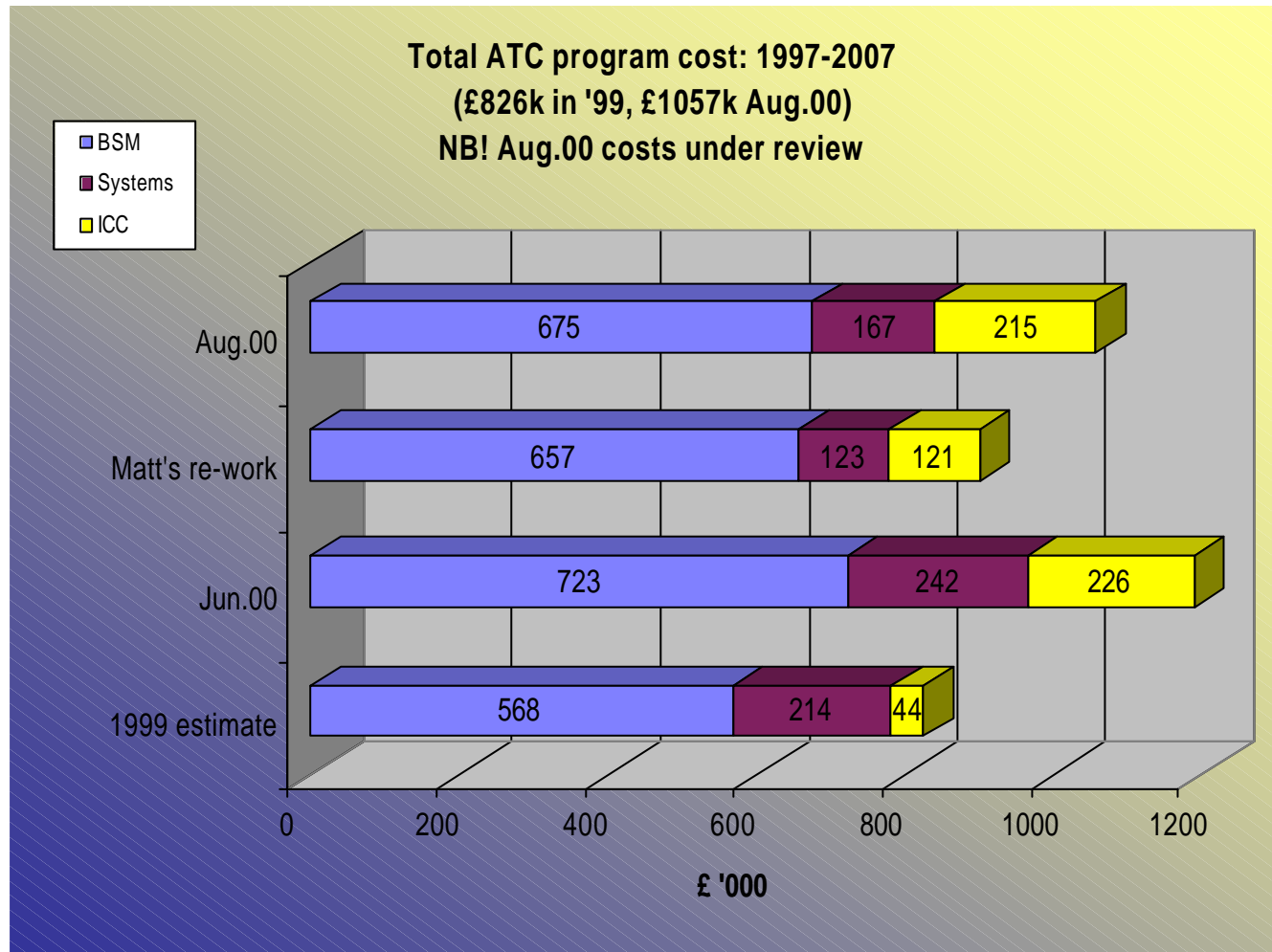
	Requisitions £k	Staff Effort DSY	Total Cost £k
Approved Feb.00	198.5	12.7	871
Projected Feb.00	209.8	10.7	749
Projected Aug.00	409	11.9	1057

Projected costs under review  
at UK consortium level

## BSM development plan (as presented at D-PDR)



# SPIRE Project Cost projections



## **UKATC SPIRE BSM Team**

Ian Pain - Project Manager & Engineer

Gillian Wright - Project Scientist

Brian Stobie - Control/Electronics Engineer

Richard Bennett - Mechanical Engineer

David Henry - Optical Engineer

Fay Hannon - Electronics Engineer