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DES Filter-Changer Mechanism Fabrication, Assembly, and Test

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Overview



- Requirements
- Design Overview
- Component Fabrication
- FCM Assembly
- Filter Cell & FCM Testing
- Current Schedule and Costs
- Ongoing & Upcoming Work



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Requirements: DES Filter-Changer Mechanism



- Verification matrix

Requirement Number	Requirement Description	Requirement	Taken From	How Verified
1	Charged particle events	0.01 events cm ⁻² sec ⁻¹	DES-doc-1118	I
2	Orientation vs. performance	All orientations	DES-doc-1118	T
3	Survey conditions vs. performance	All conditions	DES-doc-1118	A
4	Filter deployment precision	0.5 mm (max.)	DES-doc-1118	T
5	Filter thickness	< or = 15 mm	DES-doc-1118	I
6	Number of filters / filter capacity	8	DES-doc-1118	I
7	Stow or deploy time	5 sec (max.)	DES-doc-1118	T
8	Stow sequence	Serial	DES-doc-1118	T
9	Reliability	MTBF > 100,000 cycles	DES-doc-1118	I/A
10	Thermal environment	-5 deg C / + 27 deg C	DES-doc-1118	A
11	Earthquake environment	0.65X weight	DES-doc-1118	A

Key
A = Analysis
I = Inspection
T = Test

- Filter cell function verified in sub-assembly thermal cycle test
- Mechanism function verified in cassette level acceptance tests
- Controller function verified in full assembly level acceptance test



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Design Overview: Filter-Changer Mechanism Assembly



- Current filter-changer mechanism (FCM) assembly design
 - Provides positions for eight (8) filters of maximum thickness of 15 mm
 - Consists of four (4) stacked cassette mechanism sub-assemblies
 - Air cylinders stow/deploy filters out/in of active position
 - Two per cassette (eight total)
 - Integral air cushions at end of travel to absorb energy of motion
 - Integral needle valves for safety and speed control
 - Toggling solenoid control valves operate cylinders
 - Power off except to change state
 - Driven by electronic control system
 - Cylinder mounted switches sense filter position states
 - Two per cylinder (16 total)



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Design Overview: Filter-Changer Mechanism Assembly



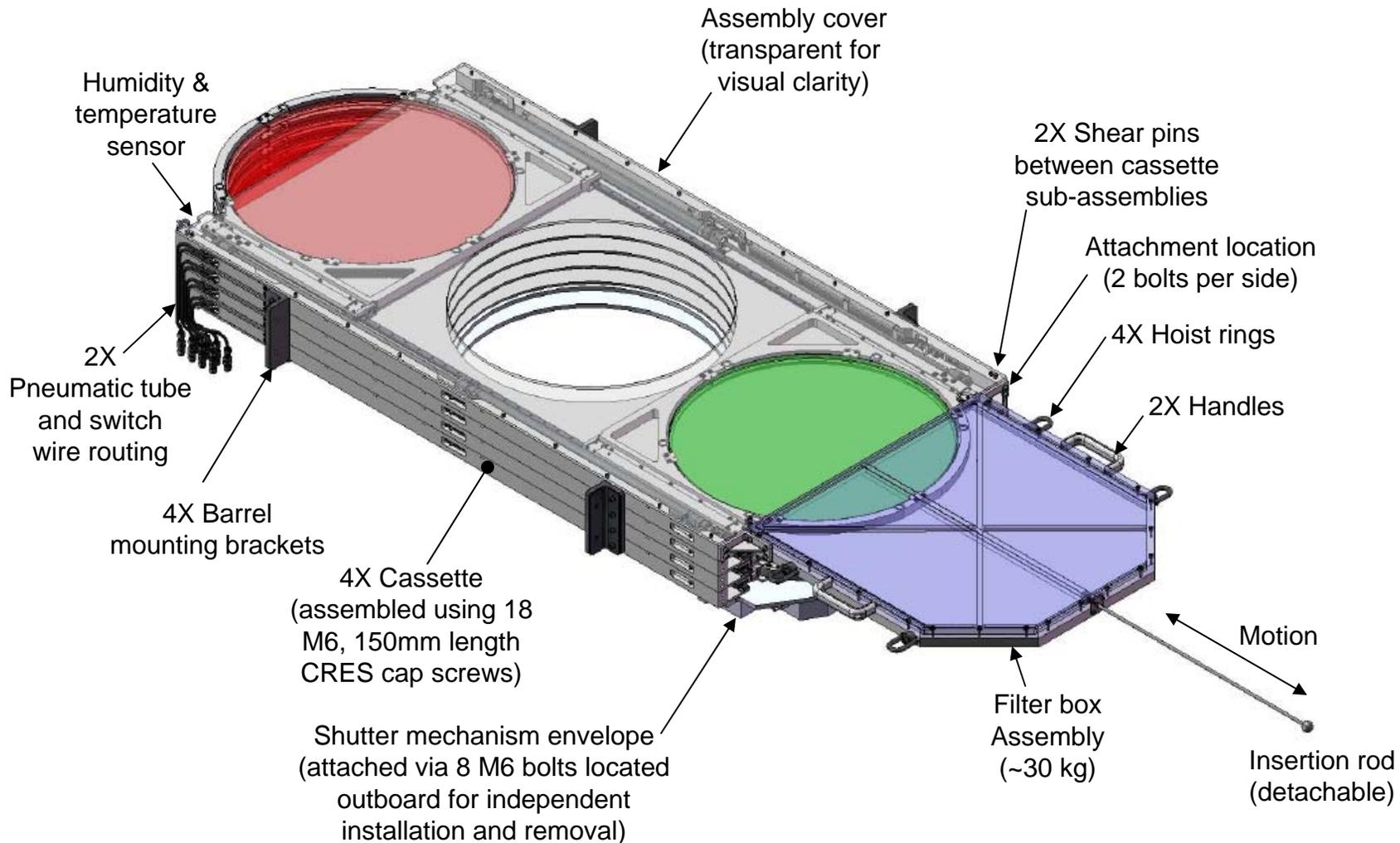
- **Cassette sub-assembly physical parameters**
 - Dimensions
 - 2000 mm wide X 871 mm tall X 40.5 mm thick
 - Mass (weight)
 - Estimated (including two filters) at 64.6 kg (142.5 lb)

- **FCM assembly physical parameters**
 - Envelope dimensions
 - 2000 mm wide X 900 mm tall X 232 thick
 - Includes shutter
 - Mass (weight)
 - Estimated (with eight filters) at 325 kg (720 lb)
 - Includes shutter and mounting hardware



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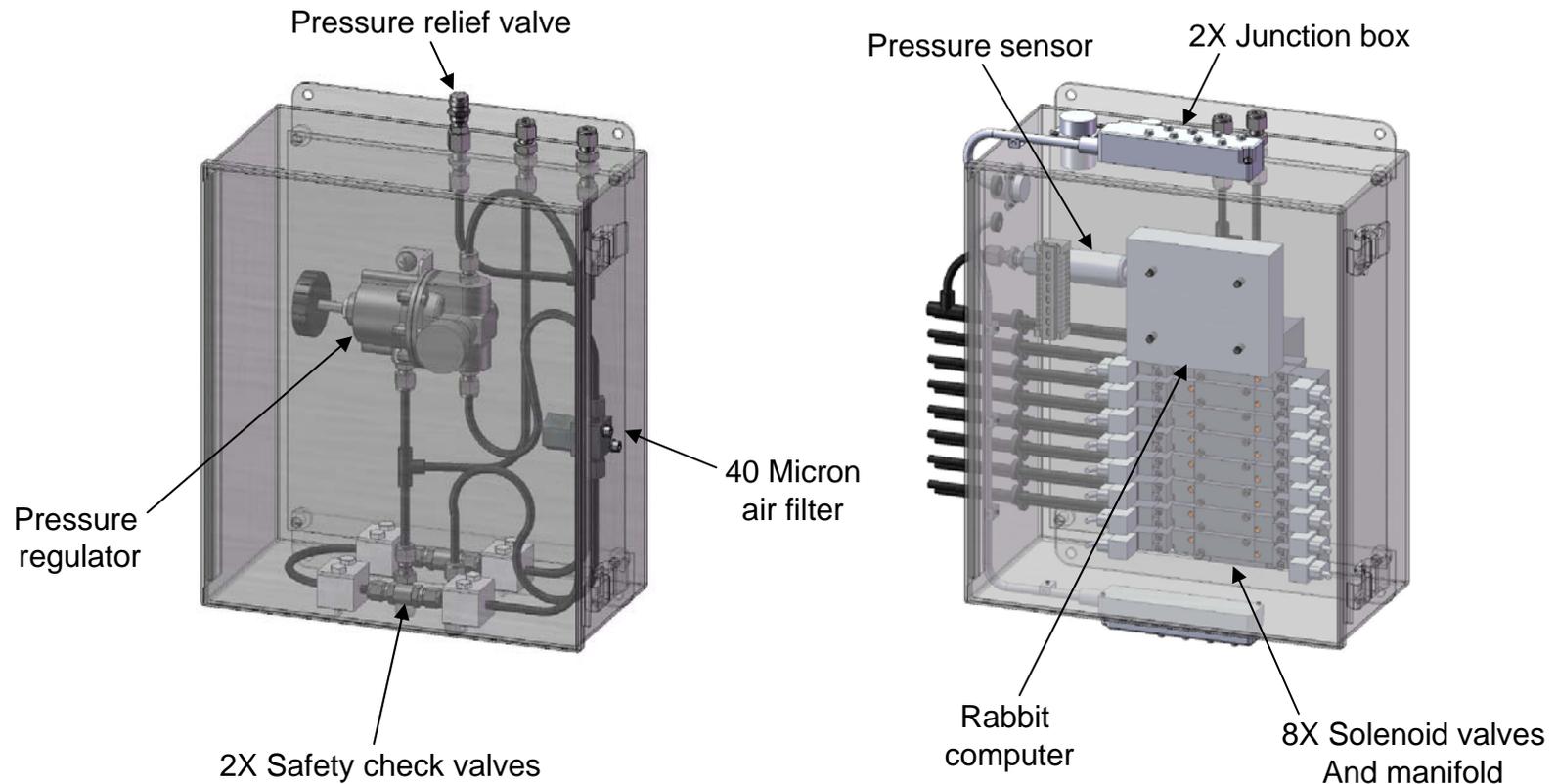
Design Overview: Filter-Changer Mechanism Assembly





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Design Overview: Pneumatic Controls



1X Air distribution box assembly

1X Solenoid box assembly



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Design Overview: Electronic Controls



- Controller: Rabbit BL2100 single board computer
 - Ethernet TCP/IP port for command control
 - Power requirements 24Vdc, Avg Power 6W, Pk Power 8.5W
 - Firmware controls filter position and prevents collisions
 - Has all digital and analog I/O necessary to control and monitor filter position
 - Digital output -16 (16 req'd) – 24V to drive solenoid valves directly
 - Digital inputs - 24 (16 req'd) – Monitor filter position switches
 - Analog inputs – 14 (3 req'd) – +/- 10V range 12 bit resolution
 - Valve air supply line pressure
 - Filter enclosure humidity
 - Filter enclosure temperature
 - Controller mounted to inside lid surface of solenoid box



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Component Fabrication



- Piece parts for the first filter-changer mechanism cassette are currently being fabricated by Leonard Machine Tool Systems (LMTS) in Warren, MI



Base plate fabrication



Machined filter frame



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Component Fabrication



- Current issues:
 - 7075-T7351 Al is stress relieved per Aluminum Standards and Data, however residual stresses are possible due to non-symmetric machining
 - Preliminary measurements of base plate show a ~1 mm bow, which exceeds the flatness requirement of 0.254 mm
 - Visual inspection of filter cages shows a non-flat 'spring' upwards of ~3 mm, which exceeds the flatness requirement of 0.1 mm
- Options:
 1. Attempt to relieve residual stresses in base plate by cryogenically heat-treat freezing parts to -300 deg F
 - Pros: inexpensive to try; Cons: may not work
 2. Re-machine bowed parts using a more complex process to achieve flatness
 - Heat-treat freeze to further stabilize metal
 - Rough machine leaving as little metal as possible for finish machining
 - Heat-treat freeze to stabilize metal
 - Finish machine
 - Pros: better chance of success; Cons: costly in terms of schedule



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FCM Assembly



- First cassette will be assembled in the Physics Dept.
 - All purchased components in-house
 - Filter blank in-house
 - Assembly tools procured
 - Work benches delivered
- Pneumatics control boxes will be assembled at SPRL
 - Includes fabrication and integration of microcontroller for system actuation
 - All purchased components in-house
 - Band switches must be exchanged due to LED
 - Completed assemblies will be transferred to central campus for integration

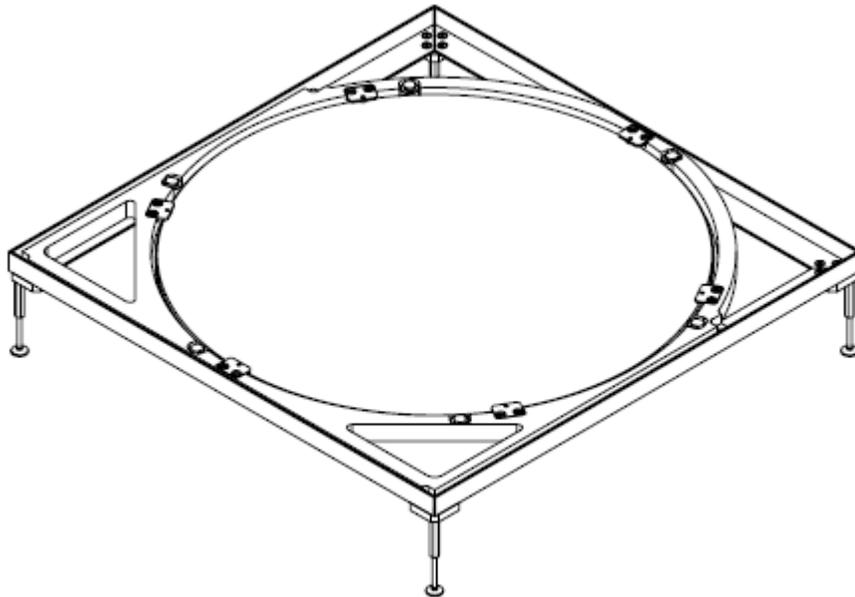


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Filter Cell & FCM Testing



- Filter cell thermal cycling will be performed in SPRL thermal test chamber per FCM Test Plan #119-0057



Thermal test fixture

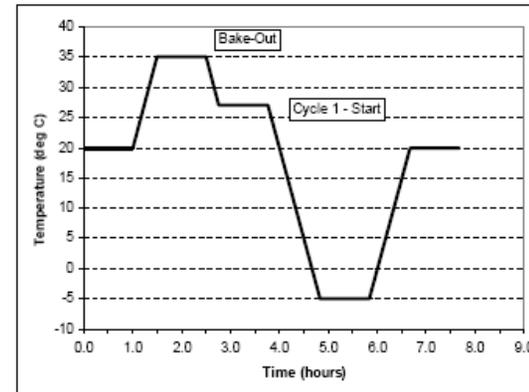


Figure 1: Filter cell assembly time-temperature profile for thermal cycle test

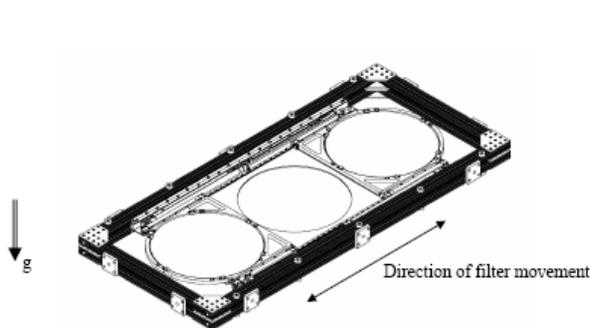


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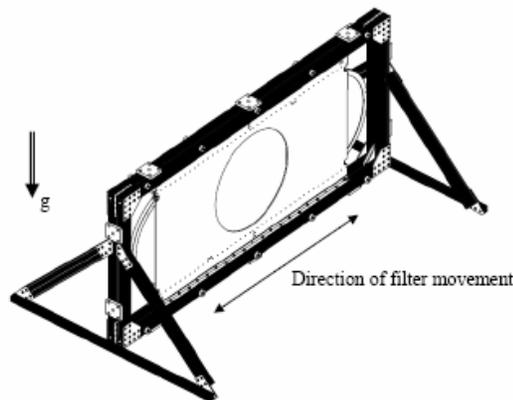
Filter Cell & FCM Testing



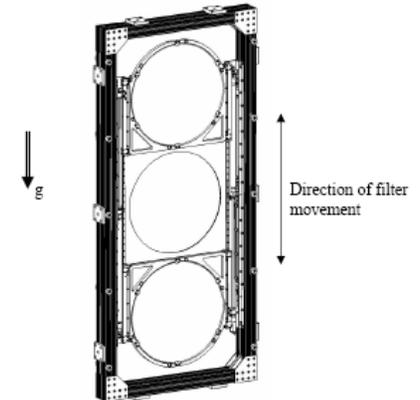
- First FCM cassette will be acceptance tested to verify function per FCM Test Procedure #119-0058
 - Filter deployment repeatability measurements
 - Deploy / stow time measurements
 - Orientation versus performance measurements



Configurations 1 & 2



Configuration 3



Configuration 4



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Filter Cell & FCM Testing



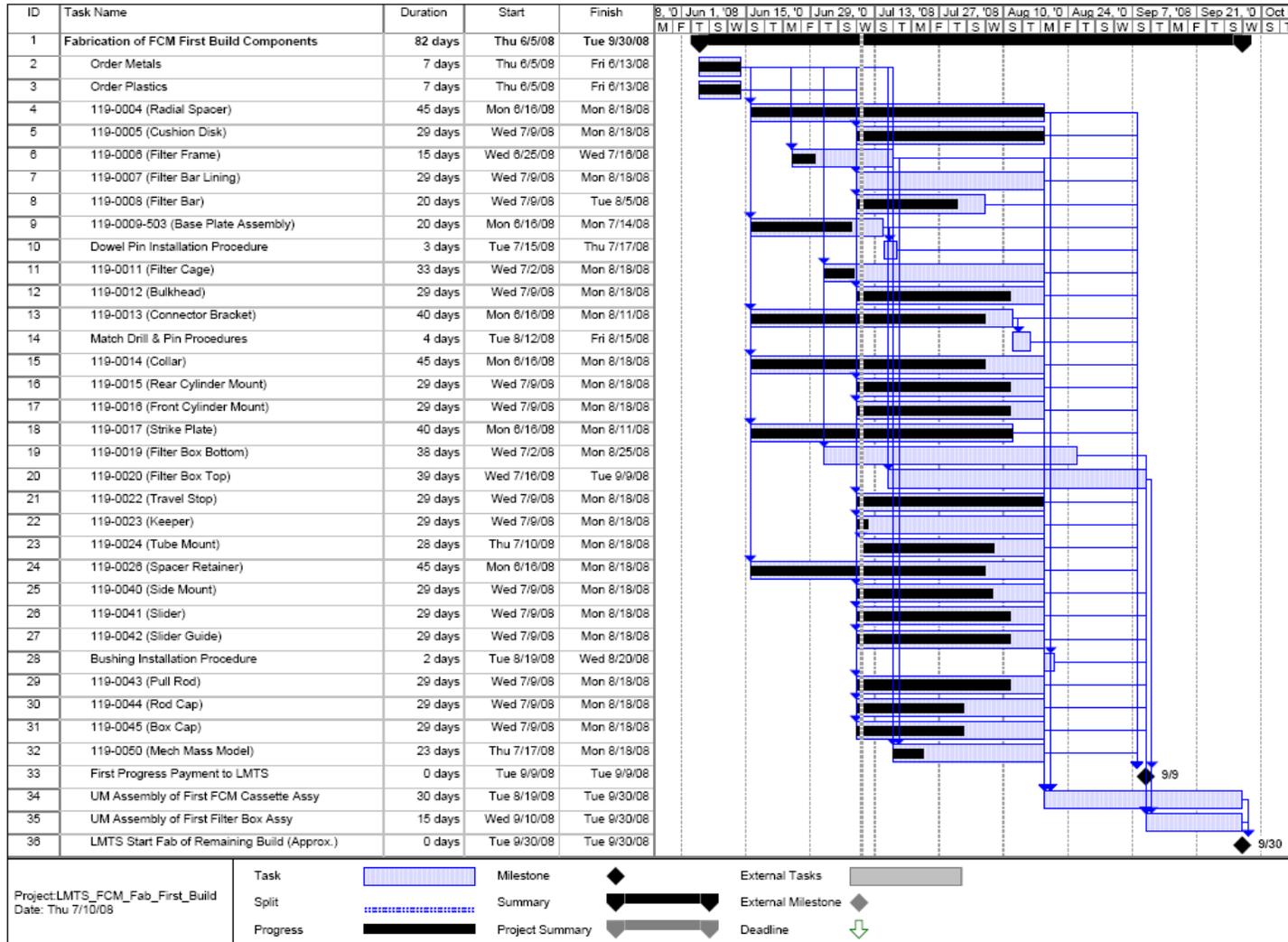
- Full FCM will be tested to verify controller performance per FCM Controller Test Procedure #119-0066
- Post-testing: shutter interface to the FCM assembly will be verified at UM prior to shipping to FNAL
- Filter-changer mechanism assembly and shutter assembly will be shipped separately
- Individual filters will be separately secured for shipping and handling



Current Schedule and Costs



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Current Schedule and Costs



- Current costs to date:
 - \$232K committed to LMTS for machined parts
 - Four cassette assemblies
 - One filter box assembly
 - Two mechanical mass models
 - Four barrel mounts
 - \$30K spent on purchased parts
 - Filter blank
 - Machine components for FCM
 - Tools for assembly
 - Workbenches
 - FCM acceptance test fixture components
 - Total cost to date = \$262K



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Ongoing & Upcoming Work



- Resolve current fabrication issues related to component flatness
- Assembly of first FCM cassette assembly, pneumatics box assemblies, and controller
- Finalizing FCM Test Procedure #119-0058
- Begin design of FCM installation fixture
 - Trip required to CTIO in conjunction with FNAL in Oct./Sept. '08