Detector Production
WBS 1.1.4

James Fast

Fermilab

Detector Production Tasks

- Tasks involved
  - Fabrication of mechanical and electrical preproduction modules and staves
    - Mechanical module prototypes by 11/12/02
    - Mechanical stave prototypes 12/16/02
    - Electrical L1 module prototypes by 1/27/03
    - Electrical L2-5 module prototypes 2/18/03-4/15/03
    - Electrical stave prototypes 7/17/03
  - Fabrication of production modules for all layers
  - Assembly of L2-5 modules into staves
  - All testing required for Quality Assurance
    - Cecilia Gerber is managing electrical testing

L0 Modules

- Total of 144 modules to be installed
- Production rate of 2/day
  - Throughput of 1.6 good modules per day required
  - No CMM required for module assembly
  - Three sets of tooling will be fabricated
- Production start driven by hybrids
  - Flex and sensors available 2 months earlier
- Production duration 18+6 weeks, 3/22/04-9/7/04
  - ~3-5 week lag for first modules to get through assembly, testing and QA
  - ~6 week lag for final modules (repairs)

L1 Modules

- Total of 72 modules to be installed
- Production rate of 2/day
  - Throughput of 1.5 good modules per day required
  - Use Zeiss 500 in Lab C, Lab D CMMs are backup
  - Two fixtures; extra parts to allow higher rate
- Production start driven by hybrids
  - Sensors available 20 weeks earlier
- Production duration 10+6 weeks, 1/29/04-5/20/04
  - ~3-5 week lag for first modules to get through assembly, testing and QA
  - ~6 week lag for final modules (repairs)

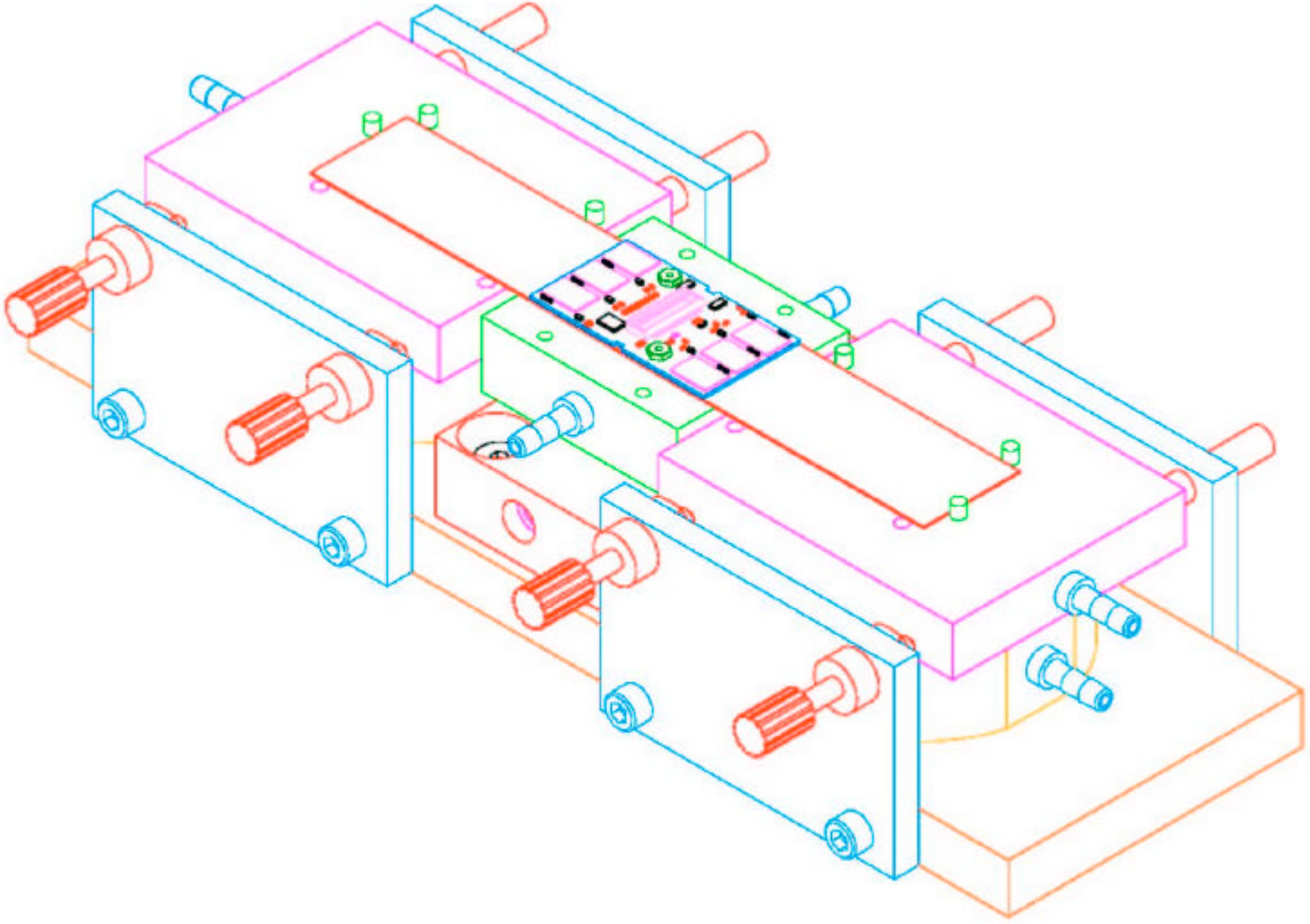
L2-L5 Modules

- Total of 672 modules to be installed, 800 built
- Production rate of 8/day
  - Throughput of 5.2 good modules per day required
  - Use 5 Zeiss CMMs in Lab D, Total of 8 fixtures
  - Tooling designed to allow for higher capacity per CMM in case of machine down time
- Production start driven by hybrids
- Production duration 12+6 weeks,
  - South Modules 3/16/04-7/23/04
  - North Modules 6/15/04-10/27/04
  - ~3-5 week lag for 1st modules to get through assembly, testing and QA
  - ~6 week lag for final modules (repairs)

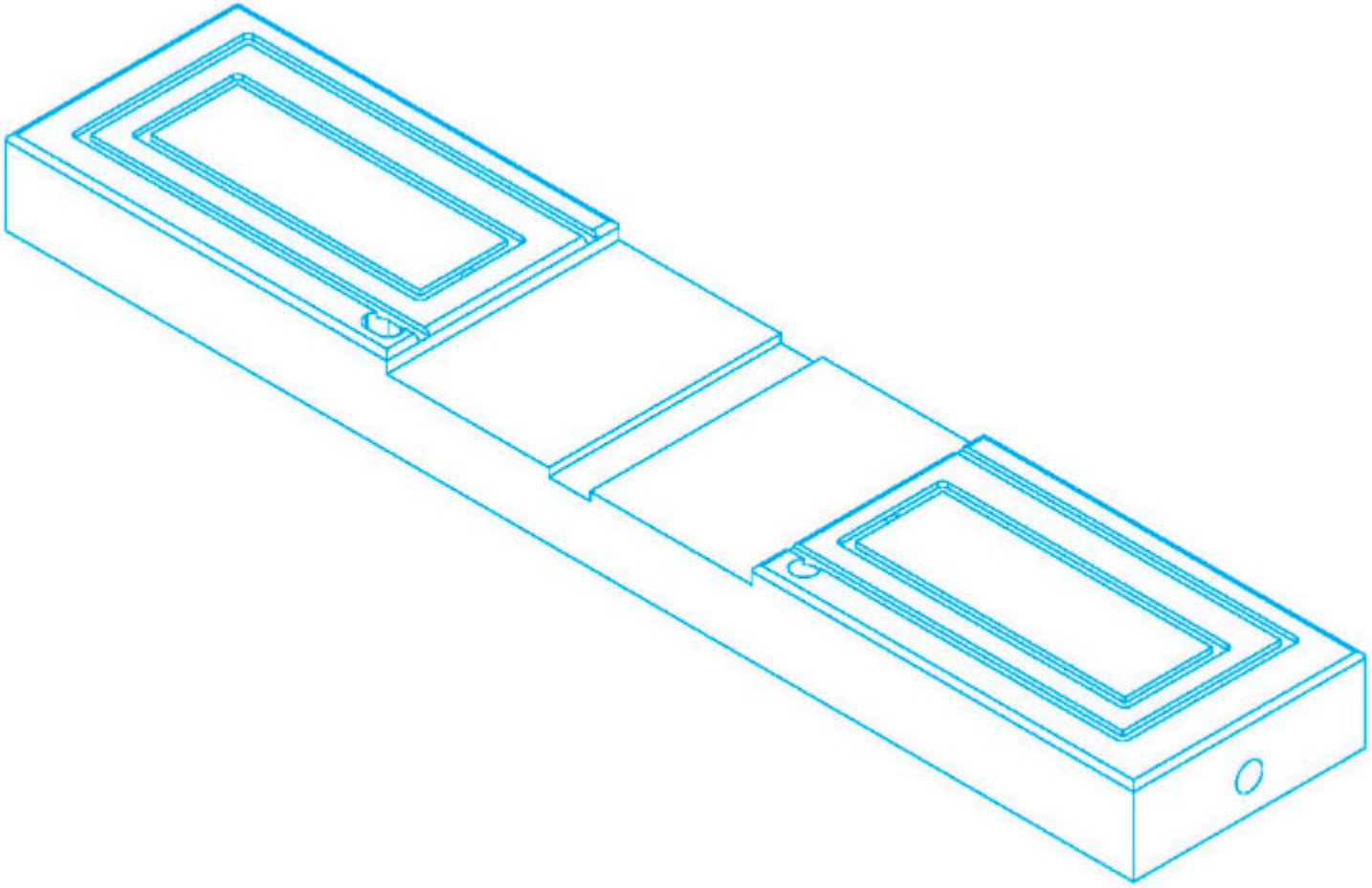
L1-L5 Module Tooling

- 6 flavors of fixture
  - L1 (160mm finished module length)
  - 20cm gang, 10-10A, 10-10S (200mm modules)
  - 20-20A, 20-20S (400mm modules)
- Alignment and Gluing
  - Precision alignment of sensor to sensor <5m
  - Alignment of hybrid to sensors to ~50m
- Module flipping
  - Backside HV connection from hybrid
  - Kapton HV insulation to isolate sensor from structure
  - Ground contact from hybrid for support structure
- Wirebonding
  - Axial and stereo can be bonded on same fixtures (4 types)
  - Reasonably flat (~50m) vacuum chucks up to 400mm long

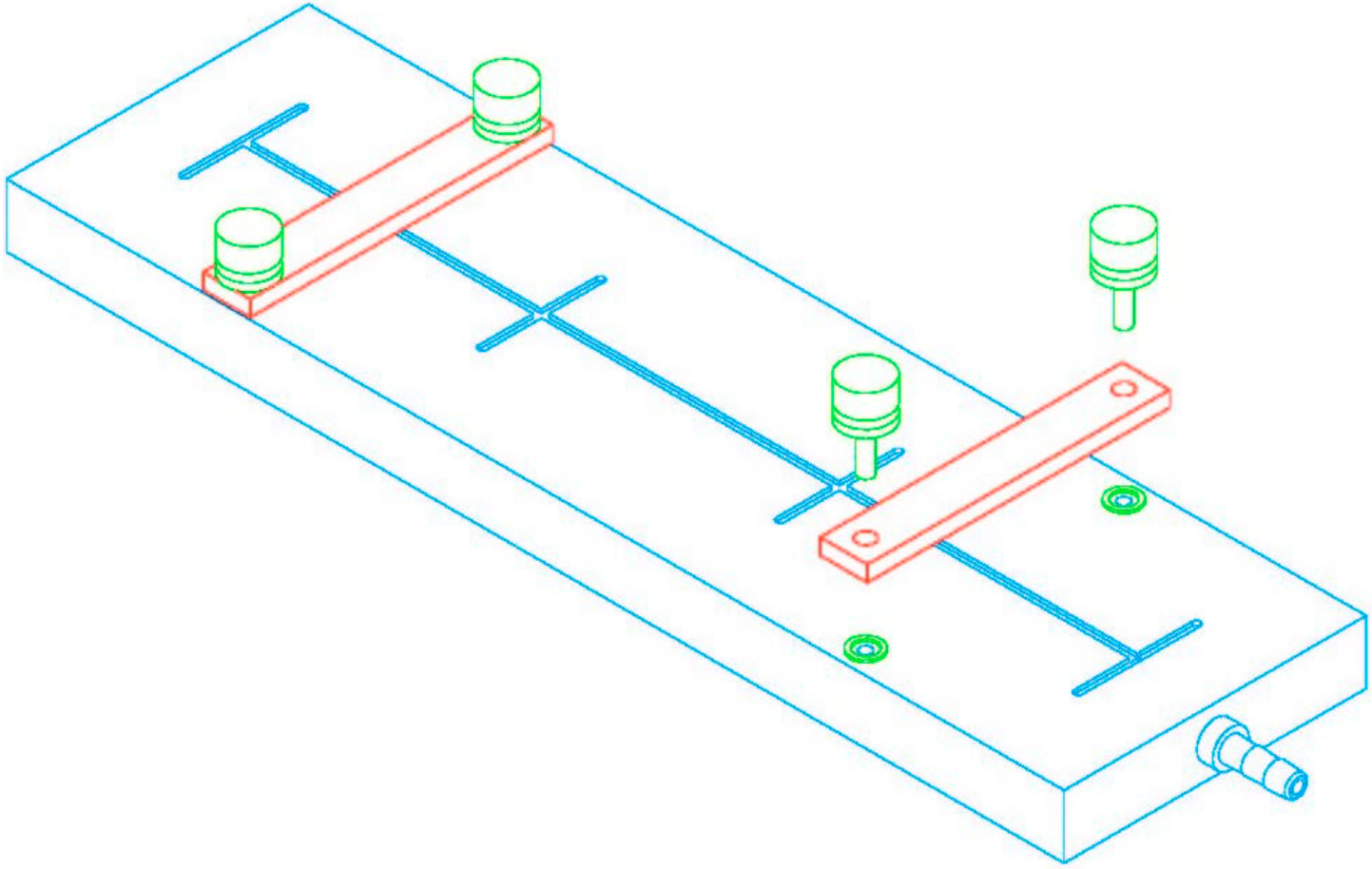
L1 Module Fixture



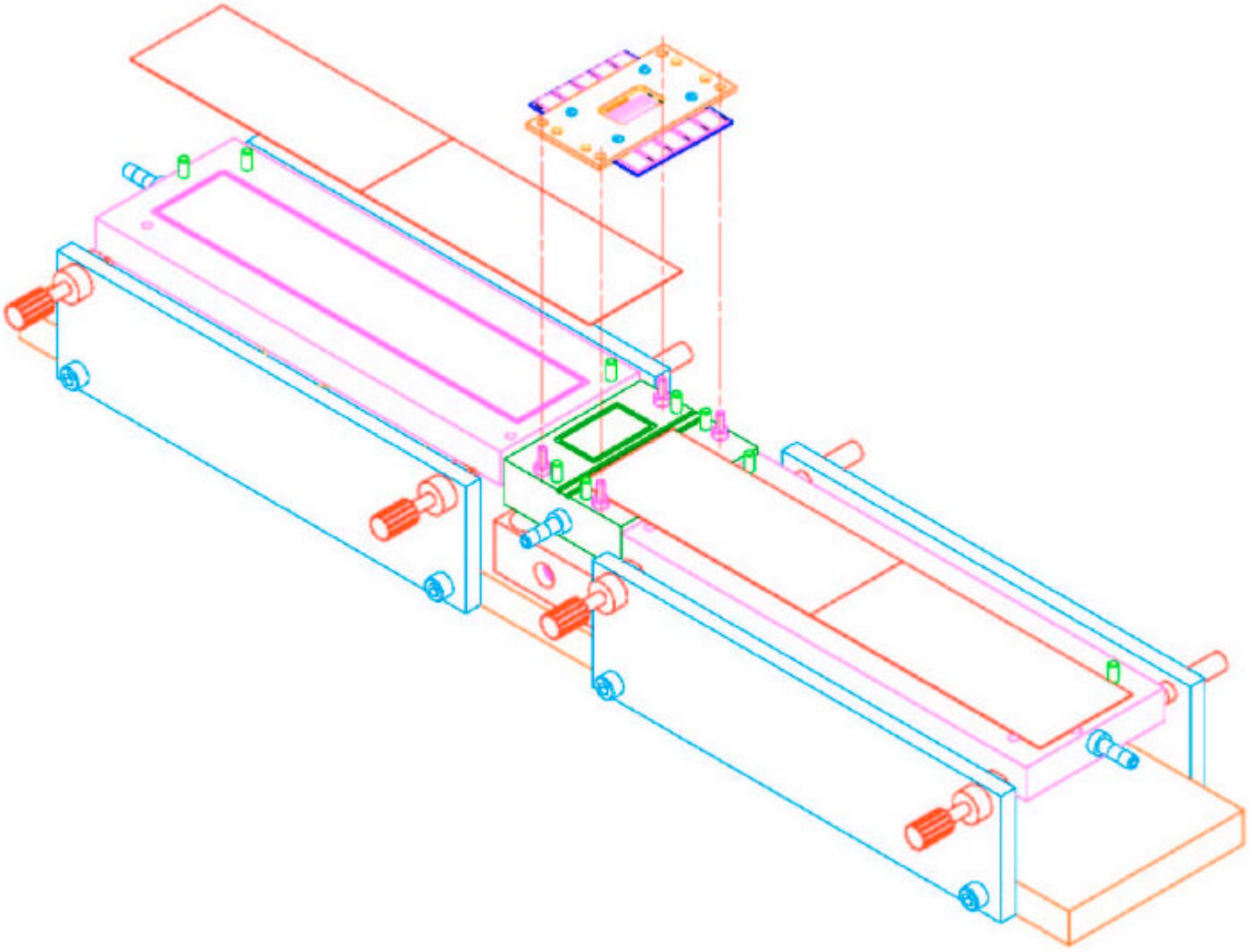
L1 Flipping Fixture



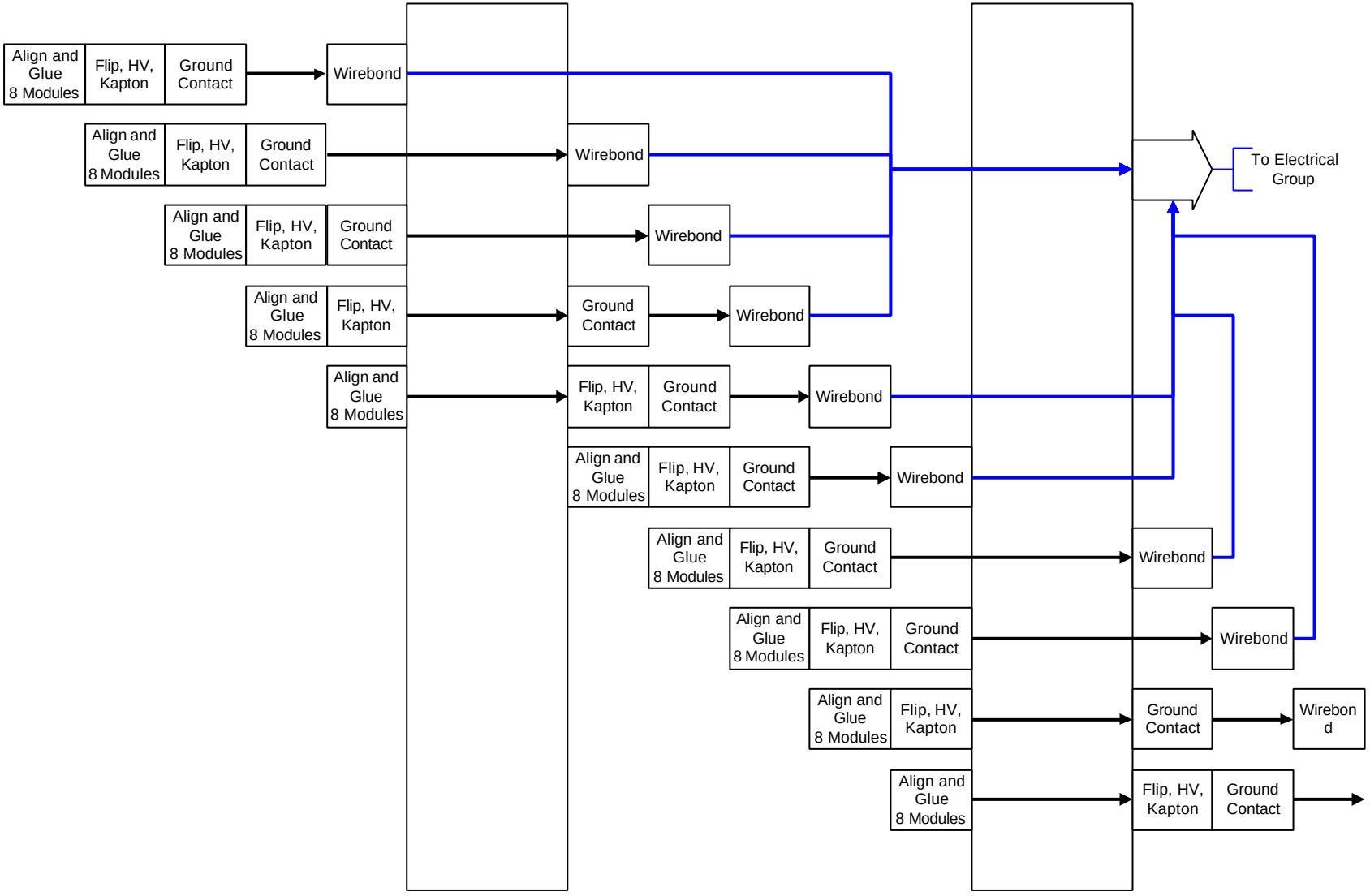
L1 Wirebonding Fixture



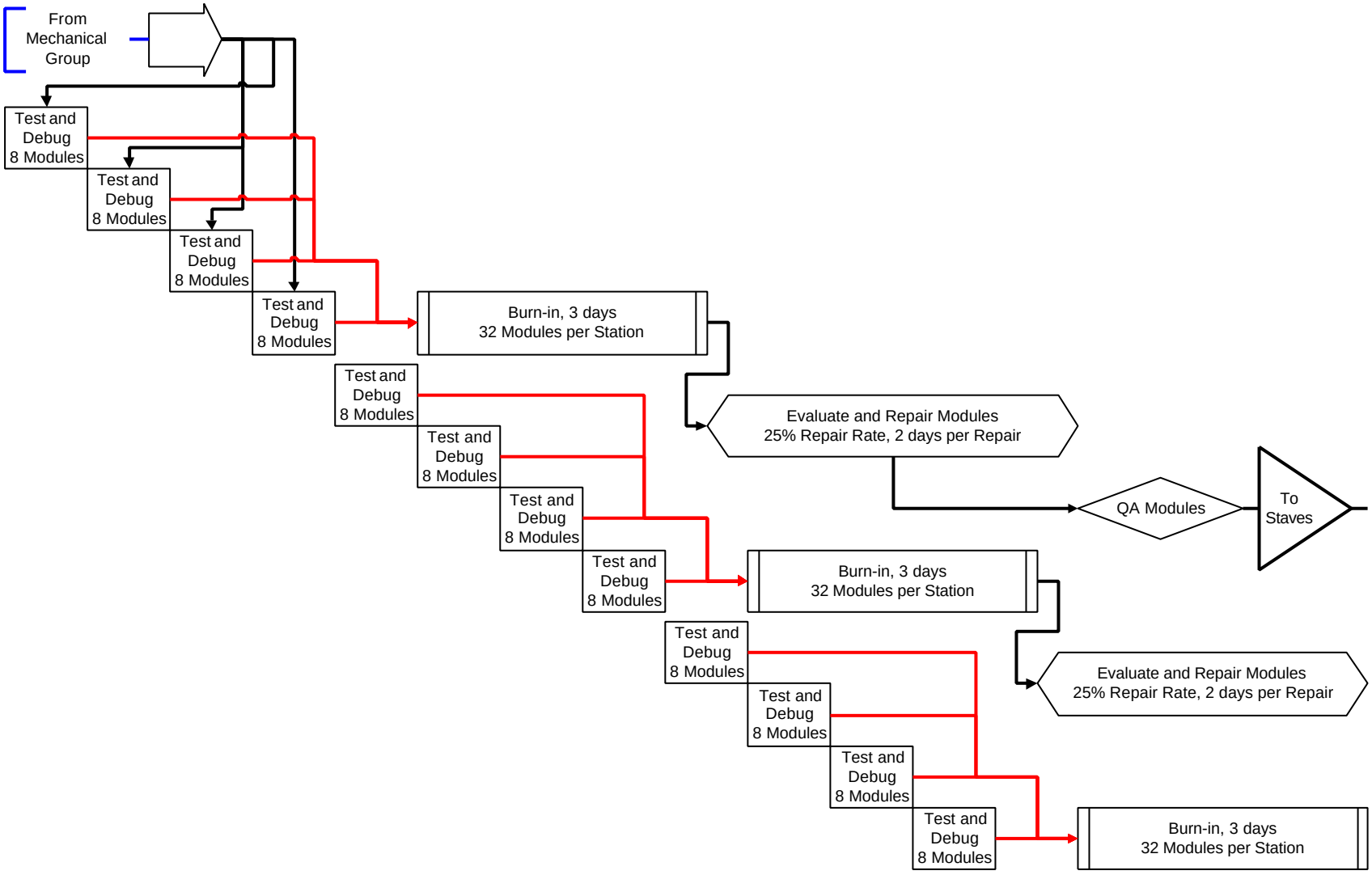
20-20 Axial Module Fixture



Module Production Flow I



Module Production Flow II



CMM Usage for Production

Week of	Z500 #1	Z500 #2	Z500 #3	Z500 #4	Z850-D	Z500-C	LK
07/18/03							
07/25/03	2X gang	2X gang	2X gang	2X gang			
08/01/03	2X gang	2X gang	2X gang	2X gang			
08/08/03	2X gang	2X gang	2X gang	2X gang			
08/15/03	2X gang	2X gang	2X gang	2X gang			
08/22/03	2X gang	2X gang	2X gang	2X gang			
08/29/03	2X gang	2X gang	2X gang	2X gang			
09/05/03	2X gang	2X gang	2X gang	2X gang			
09/12/03	2X gang	2X gang	2X gang	2X gang			
09/19/03	2X gang	2X gang	2X gang	2X gang			
09/26/03	2X gang	2X gang	2X gang	2X gang			
10/03/03	2X gang	2X gang	2X gang	2X gang			
10/10/03	2X gang	2X gang	2X gang	2X gang			
10/17/03							
10/24/03	2X gang	2X gang	2X gang	2X gang			
10/31/03	2X gang	2X gang	2X gang	2X gang			
11/07/03	2X gang	2X gang	2X gang	2X gang			
11/14/03	2X gang	2X gang	2X gang	2X gang			
11/21/03	2X gang	2X gang	2X gang	2X gang			
11/28/03	2X gang	2X gang	2X gang	2X gang			
12/05/03	2X gang	2X gang	2X gang	2X gang			
12/12/03	2X gang	2X gang	2X gang	2X gang			
12/19/03	2X gang	2X gang	2X gang	2X gang			
12/26/03	********** Holidays **********						
01/02/04	********** Holidays **********						
01/09/04	2X gang	2X gang	2X gang	2X gang			
01/16/04	2X gang	2X gang	2X gang	2X gang			
01/23/04	2X gang	2X gang	2X gang	2X gang			
01/30/04						2X L1	
02/06/04						2X L1	
02/13/04						2X L1	
02/20/04						2X L1	
02/27/04						2X L1	
03/05/04						2X L1	
03/12/04	2X 10-10A	2X 10-10S	1X 20-20A	1X 20-20A	2X 20-20S	2X L1	
03/19/04	2X 10-10A	2X 10-10S	1X 20-20A	1X 20-20A	2X 20-20S	2X L1	
03/26/04	2X 10-10A	2X 10-10S	1X 20-20A	1X 20-20A	2X 20-20S	2X L1	
04/02/04	2X 10-10A	2X 10-10S	1X 20-20A	1X 20-20A	2X 20-20S	2X L1	
04/09/04	2X 10-10A	2X 10-10S	1X 20-20A	1X 20-20A	2X 20-20S		
04/16/04	2X 10-10A	2X 10-10S	1X 20-20A	1X 20-20A	2X 20-20S		Mount L1S
04/23/04	2X 10-10A	2X 10-10S	1X 20-20A	1X 20-20A	2X 20-20S		Mount L1S
04/30/04	2X 10-10A	2X 10-10S	1X 20-20A	1X 20-20A	2X 20-20S		Mount L1S
05/07/04	2X 10-10A	2X 10-10S	1X 20-20A	1X 20-20A	2X 20-20S		Mount L1S
05/14/04	2X 10-10A	2X 10-10S	1X 20-20A	1X 20-20A	2X 20-20S		Mount L0S & L1S
05/21/04	2X 10-10A	2X 10-10S	1X 20-20A	1X 20-20A	2X 20-20S		Mount L0S & L1S
05/28/04	2X 10-10A	2X 10-10S	1X 20-20A	1X 20-20A	2X 20-20S		Mount L0S & L1S
06/04/04	2X 10-10A	2X 10-10S	1X 20-20A	1X 20-20A	2X 20-20S		Mount L0S & L1S
06/11/04							Mount L0S & L1S
06/18/04	2X 10-10A	2X 10-10S	1X 20-20A	1X 20-20A	2X 20-20S		Mount L0S & L1S
06/25/04	2X 10-10A	2X 10-10S	1X 20-20A	1X 20-20A	2X 20-20S		Mount L0S & L1S
07/02/04	2X 10-10A	2X 10-10S	1X 20-20A	1X 20-20A	2X 20-20S		Mount L0S & L1S
07/09/04	2X 10-10A	2X 10-10S	1X 20-20A	1X 20-20A	2X 20-20S		Mount L0S

Week of	Z500 #1	Z500 #2	Z500 #3	Z500 #4	Z850-D	Z500-C	LK	B&S	Z850-C
07/16/04	2X 10-10A	2X 10-10S	1X 20-20A	1X 20-20A	2X 20-20S		Mount L0S		
07/23/04	2X 10-10A	2X 10-10S	1X 20-20A	1X 20-20A	2X 20-20S		Mount L0S	2X Stereo Modules	2X Ax. Mod.
07/30/04	2X 10-10A	2X 10-10S	1X 20-20A	1X 20-20A	2X 20-20S		(L0S Testing)	2X St. Module + C-chan.	2X Ax. Mod.
08/06/04	2X 10-10A	2X 10-10S	1X 20-20A	1X 20-20A	2X 20-20S		(L0S Testing)	2X St. Module + C-chan.	2X Ax. Mod.
08/13/04	2X 10-10A	2X 10-10S	1X 20-20A	1X 20-20A	2X 20-20S		Mate L0S & L1S	2X St. Module + C-chan.	2X Ax. Mod.
08/20/04	2X 10-10A	2X 10-10S	1X 20-20A	1X 20-20A	2X 20-20S		Mount L0N & L1N	2X St. Module + C-chan.	2X Ax. Mod.
08/27/04	2X 10-10A	2X 10-10S	1X 20-20A	1X 20-20A	2X 20-20S		Mount L0N & L1N	2X St. Module + C-chan.	2X Ax. Mod.
09/03/04	2X 10-10A	2X 10-10S	1X 20-20A	1X 20-20A	2X 20-20S		Mount L0N & L1N	2X St. Module + C-chan.	2X Ax. Mod.
09/10/04	2X 10-10A	2X 10-10S	1X 20-20A	1X 20-20A	2X 20-20S		Mount L0N & L1N	2X St. Module + C-chan.	2X Ax. Mod.
09/17/04							Mount L0N & L1N	2X St. Module + C-chan.	2X Ax. Mod.
09/24/04							Mount L0N & L1N	2X St. Module + C-chan.	2X Ax. Mod.
10/01/04							Mount L0N & L1N	2X St. Module + C-chan.	2X Ax. Mod.
10/08/04							Mount L0N & L1N	2X St. Module + C-chan.	2X Ax. Mod.
10/15/04							Mount L0N & L1N	2X St. Module + C-chan.	2X Ax. Mod.
10/22/04							Mount L0N & L1N	2X C-chan.	
10/29/04							Mount L0N & L1N	2X Stereo Modules	2X Ax. Mod.
11/05/04							Mount L0N & L1N	2X St. Module + C-chan.	2X Ax. Mod.
11/12/04							(L0N & L1N Testing)	2X St. Module + C-chan.	2X Ax. Mod.
11/19/04							(L0N Testing)	2X St. Module + C-chan.	2X Ax. Mod.
11/26/04								2X St. Module + C-chan.	2X Ax. Mod.
12/03/04							Mate L0N & L1N	2X St. Module + C-chan.	2X Ax. Mod.
12/10/04							(L0N & L1N Testing)	2X St. Module + C-chan.	2X Ax. Mod.
12/17/04							(L0N & L1N Testing)	2X St. Module + C-chan.	2X Ax. Mod.
12/24/04	********** Holidays **********								
12/31/04	********** Holidays **********								
01/07/05								2X St. Module + C-chan.	2X Ax. Mod.
01/14/05								2X St. Module + C-chan.	2X Ax. Mod.
01/21/05								2X St. Module + C-chan.	2X Ax. Mod.
01/28/05								2X St. Module + C-chan.	2X Ax. Mod.
02/04/05								2X St. Module + C-chan.	2X Ax. Mod.
02/11/05								2X C-chan.	
02/18/05								(North Stave Testing)	
02/25/05								(North Stave Testing)	
03/04/05							Install South Staves	(North Stave Testing)	
03/11/05							Install South Staves	(North Stave Testing)	
03/18/05							Install South Staves	(North Stave Testing)	
03/25/05							Install South Staves	Install North Staves	
04/01/05							Install South Staves	Install North Staves	
04/08/05							(South Stave Testing)	Install North Staves	
04/15/05							(South Stave Testing)	Install North Staves	
04/22/05							(South Stave Testing)	Install North Staves	
04/29/05							Mate L0-1 to L2-5	(North Stave Testing)	
05/06/05							Mate L0-1 to L2-5	(North Stave Testing)	
05/13/05							Install Rad. Monitors	(North Stave Testing)	
05/20/05							Install Rad. Monitors	Mate L0-1 to L2-5	
05/27/05							**Final Tests**	Mate L0-1 to L2-5	
06/03/05							**Final Tests**	Install Rad. Monitors	
06/10/05							**South Complete**	**Final Tests**	
06/17/05							Prep for Shipping	**Final Tests**	
06/24/05							Prep for Shipping	**North Complete**	
07/01/05							Prep for Shipping	Prep for Shipping	
07/08/05								Prep for Shipping	
07/15/05								Prep for Shipping	
07/22/05							********* Ship to DAB *********		

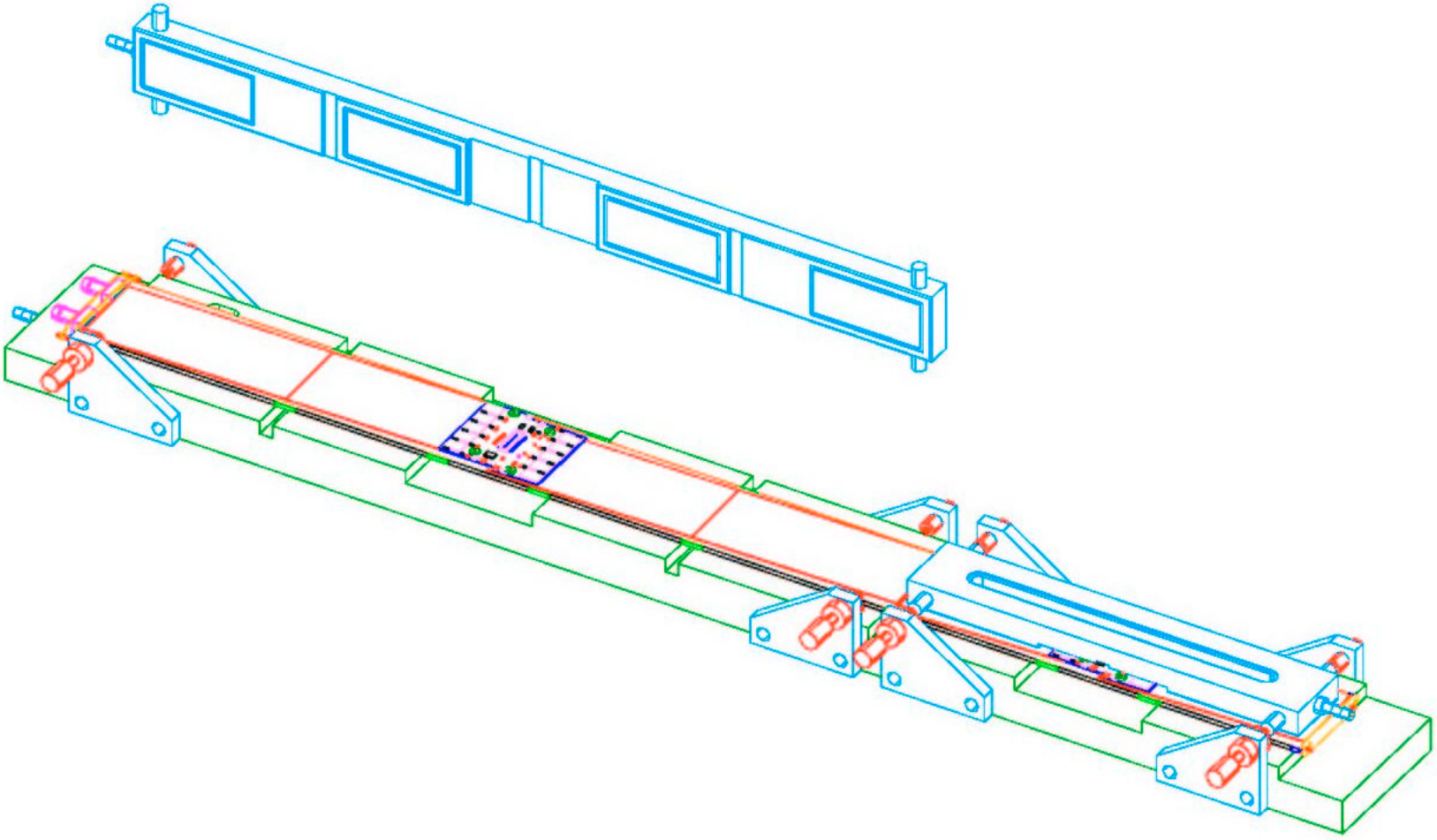
L2-5 Stave Assembly I

- Duration of 19.4 weeks, including electrical testing
  - South: 7/23/04-12/4/04
  - North: 10/27/04-3/25/05
- Day 1
  - Vacuum fixture, 600mm long, holds core flat
  - Two vacuum chucks hold axial modules flat and locate them to reference pins of stave core
- Day 2
  - CMM inspection of axial module locations
  - Stave core with axial modules is flipped
  - Two vacuum chucks hold stereo modules flat and locate them to reference pins of core
    - The same pins used for CMM reference to reduce alignment error between axial and stereo sides

L2-5 Stave Assembly II

- Day 3
  - CMM inspection of stereo module locations
  - Electrical testing of modules
  - Installation of C-channels (mechanical stiffeners for stave)
- Day 4
  - Final electrical testing
  - Final mechanical inspection
  - Certification for installation
- Small subset may be submitted to additional mechanical testing, e.g. deflection tests

L2-L5 Stave Assembly Fixture



L0-L1 Production Schedule

- L0 and L1 Module Assembly Run in Parallel
  - L0 Module Assembly 3/22/03-9/7/04
  - L1 Module Assembly 1/29/04-5/20/04
- Mounting of Module on Supports
  - L0 and L1 go in parallel
    - L0 South 5/7/04-7/19/04
    - L1 South 4/19/04-6/28/04
  - North follows South L0-L1 Mating
    - L0 North 8/24/04-11/2/04
    - L1 North 8/24/04-11/2/04
- L0-L1 Mating and Testing
  - South 8/17/04-9/7/04
  - North 12/3/04-12/23/04

L2-L5 Production Schedule I

- Ganging of sensors into 20cm readout segments precedes arrival of hybrids (complete 1/30/04)
- Parallel processing of modules for each stave set
  - South Modules (3/16/04-7/23/04)
  - North Modules (6/15/04-10/27/04)
- All South Stave modules completed before start of stave assembly
  - Human resource limitations drive this sequence
    - Electrical testing personnel: L2 hybrids, North modules, L0 north modules, L0 and L1 South module mounting concurrent
    - High level mechanical: Startup of L0 and L1 South module mounting concurrent

L2-L5 Production Schedule II

- Sequential assembly of staves
  - 6 weeks “overlap” is testing&repair of all staves
  - South Staves (7/23/04-12/4/04)
  - North Staves (10/27/04-3/25/05)
- All Staves completed prior to start of installation in cylinders
  - Driven by available CMM resources
    - B&S and Zeiss 850 completing North staves
    - LK completing L0-L1 subassemblies

Summary

- Module and Stave production schedules, including CMM usage, and interface between mechanical and electrical tasks, are well understood.
- The tooling design for modules is flexible so that we can easily increase production rate.
- Initial fixture designs are complete for L1-5 modules and nearly complete for staves.
- Initial module fixtures have been ordered.
- Initial stave fixtures to be ordered this month.
- On track for mechanical modules by 11/12 and mechanical staves by 12/16.