

SMT Production Update & QCD/WZ group New results

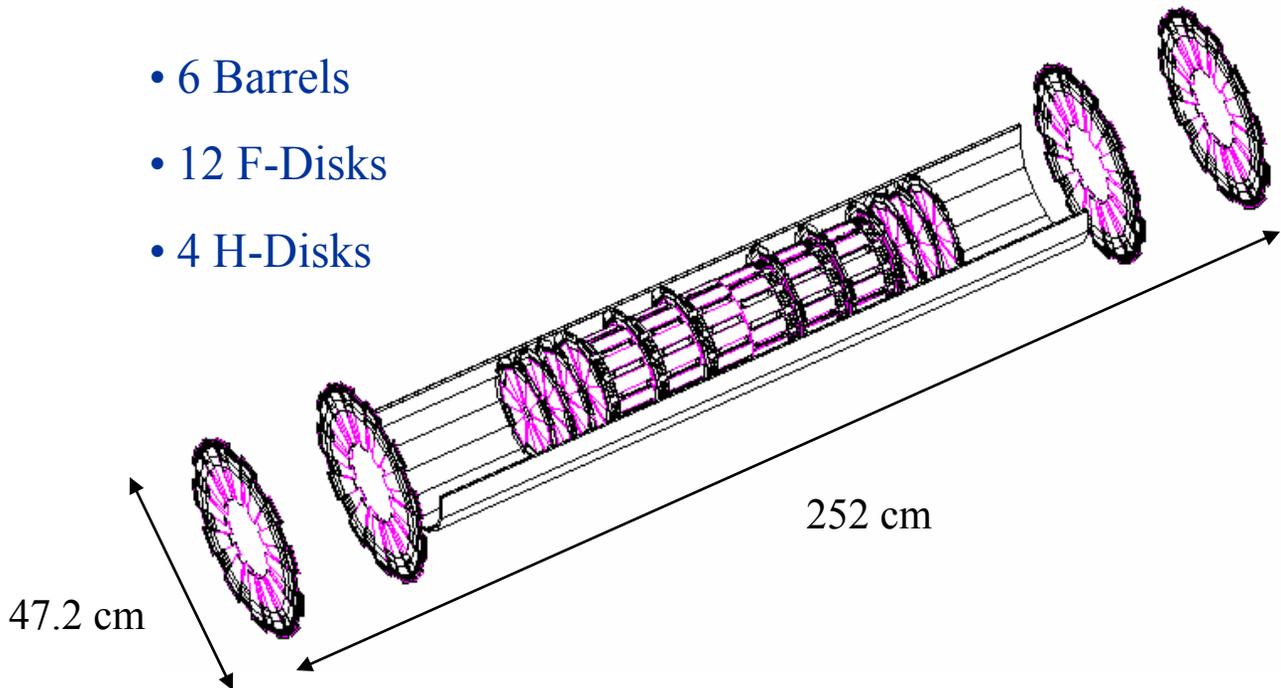
Cecilia Gerber
(Fermilab)

March 13, 1999

Silicon Microstrip Tracker

- Innermost system in D0 Run 2 detector
- Interspersed Barrel-Disk design
- Silicon tracking up to $\eta < 3$
- $\sim 800,000$ channels read out by SVX-IIe

- 6 Barrels
- 12 F-Disks
- 4 H-Disks



Barrel

- 72 3-Chip SS
- 216 9-Chip DS2deg
- 144 6-Chip DS90deg

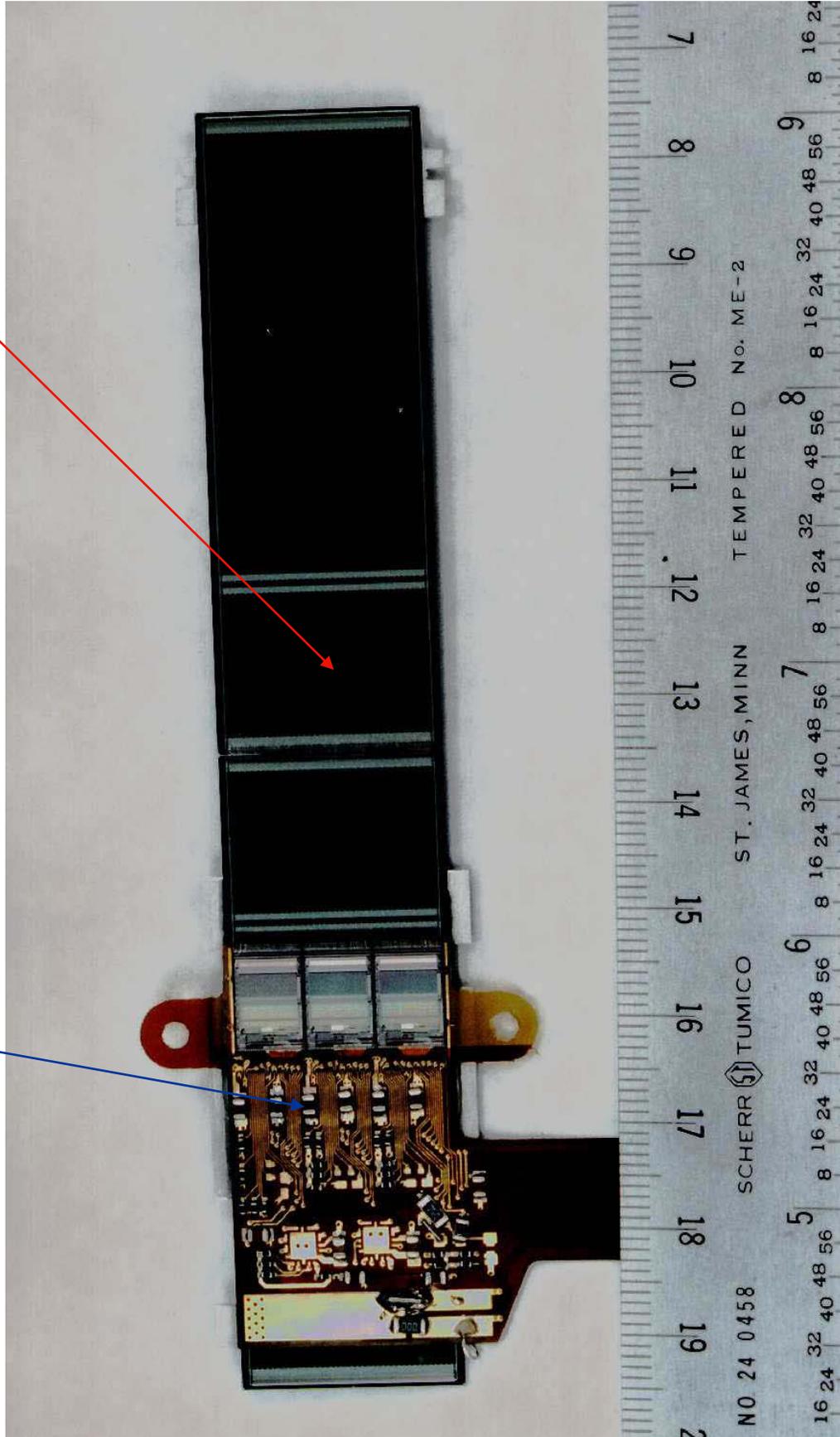
Disks

- 144 6+8-Chip DS 15deg
- 96x2 6-Chip SS

D-Zero Ladder

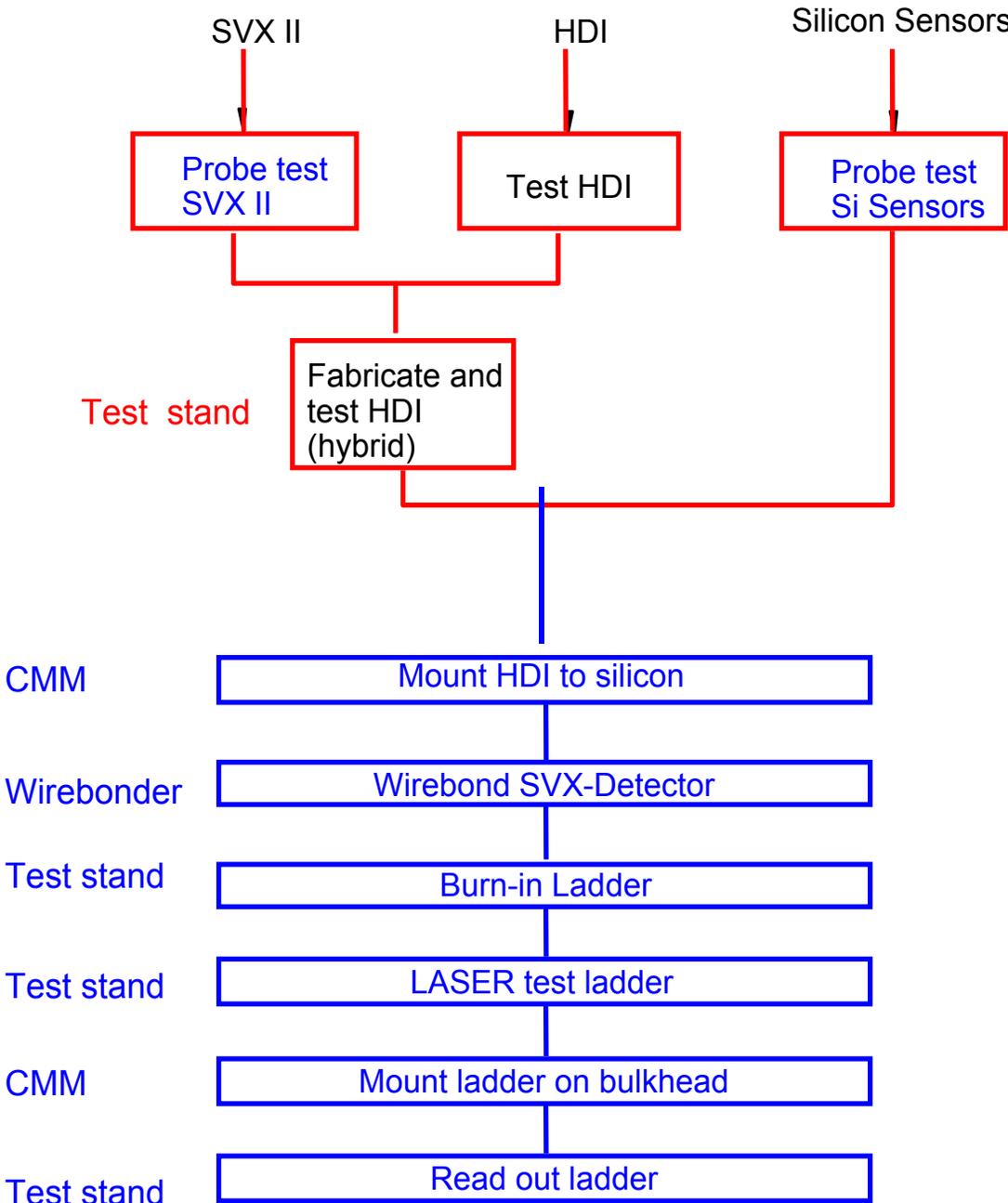
Silicon Sensor

HDI



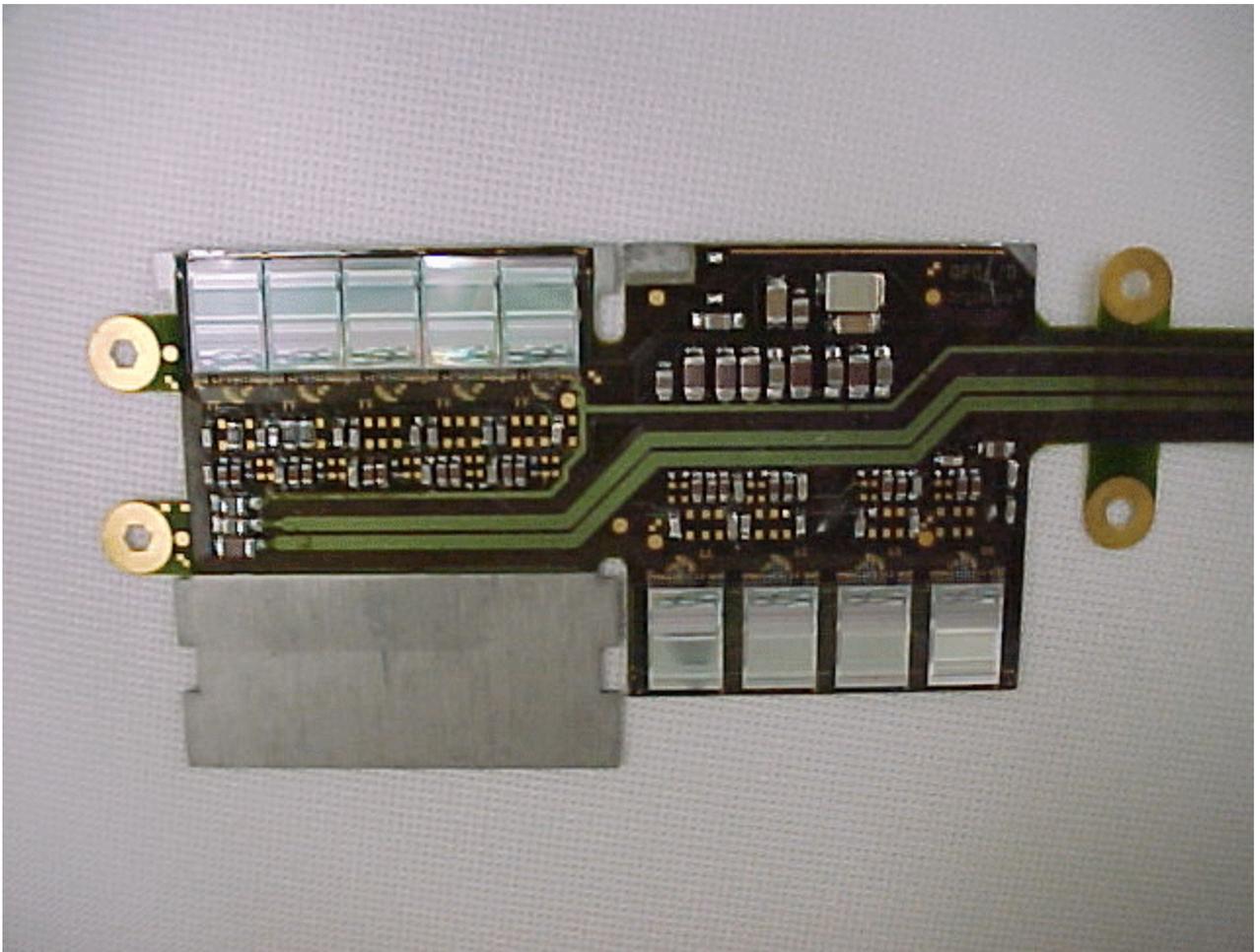
Ladder Fabrication

Ladder Fabrication



What is an HDI?

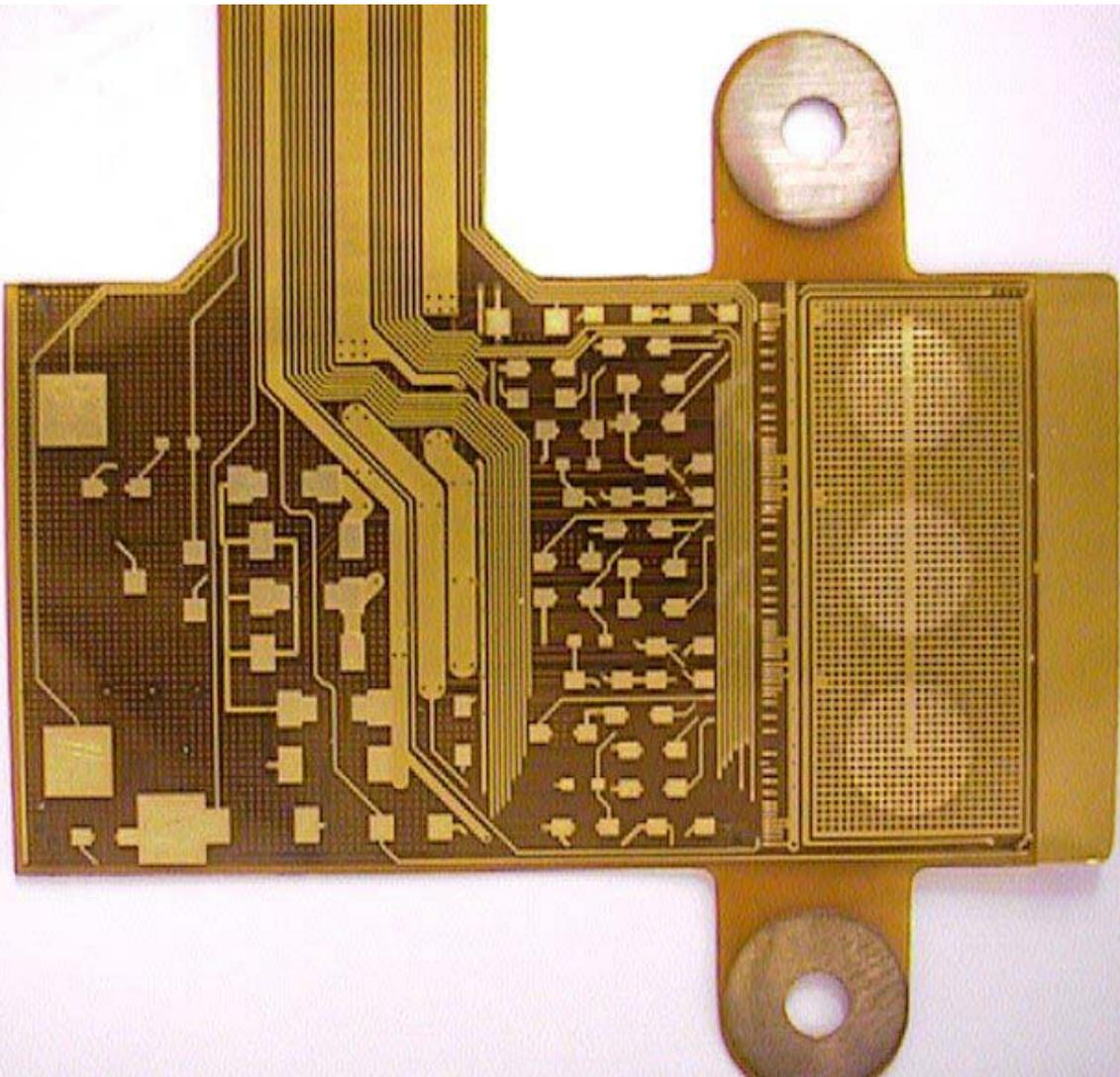
- High Density Interconnect flexible circuit
- Laminated to Be substrate. Mounted on Si sensors
- Carries SVX chips & passive components
- Integrated with thin flexible “pigtail” cable
- 9 Types (3 differ only in tail length)



How do we make an HDI?

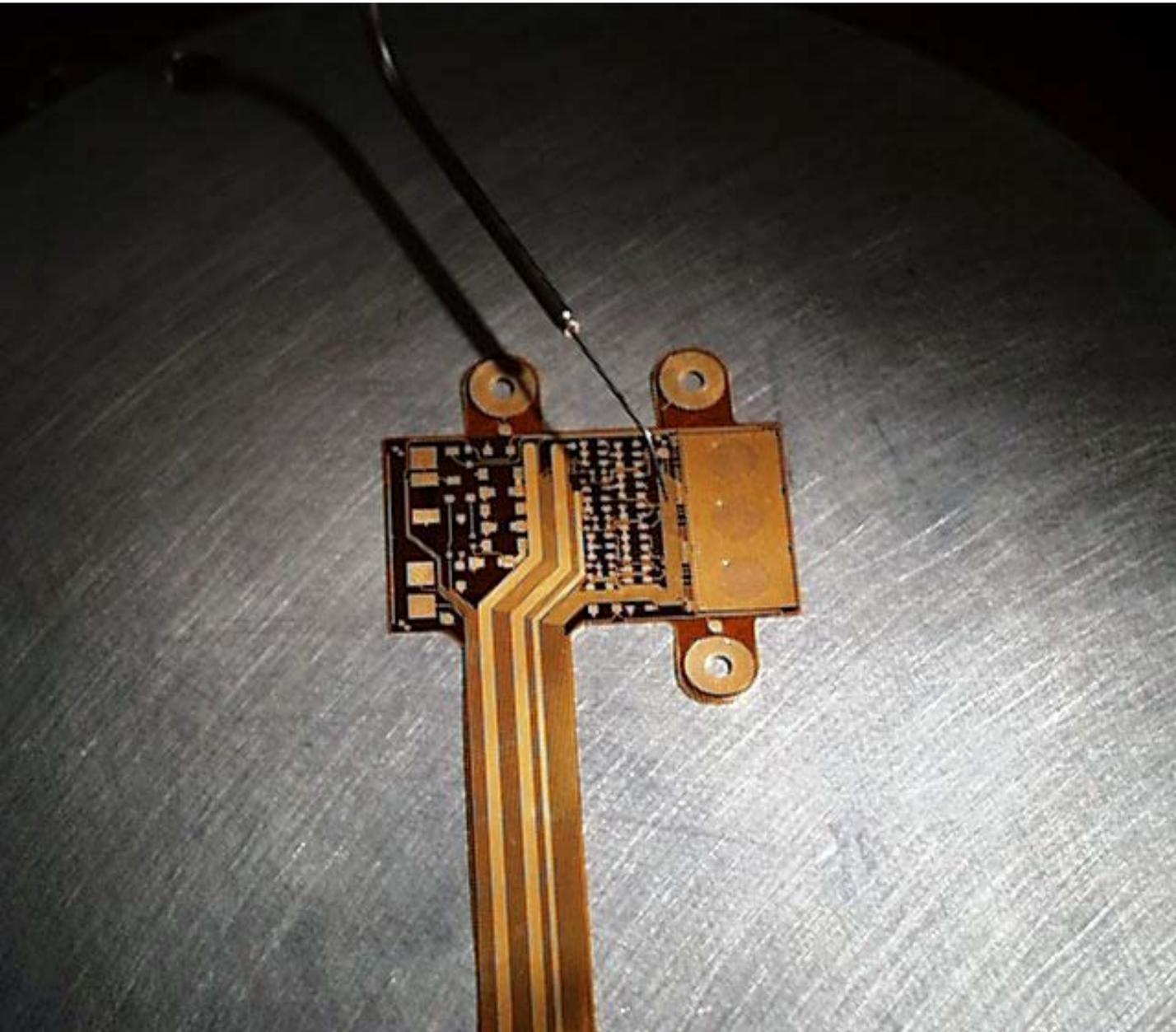
Step 1: Bare HDI

- Bare HDI from LPC, Dyconex, Allied Signal, ?, ...
 - 0.005 inch thick flex circuit (Kapton & Cu conductor layer)
 - 0.002 inch via diameter , more than 500 vias
 - 0.005 inch bond areas (plated with nickel and gold)



Testing of Bare HDIs

- Bare HDIs tested for shorts and continuity at FNAL & UCI using a wafer probe station.



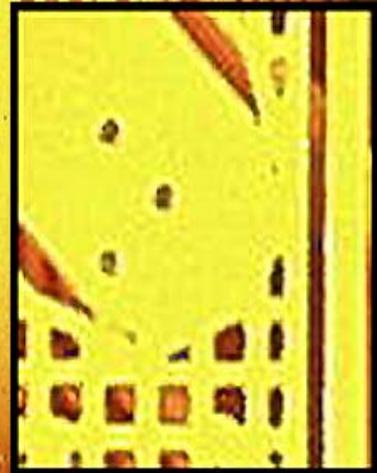
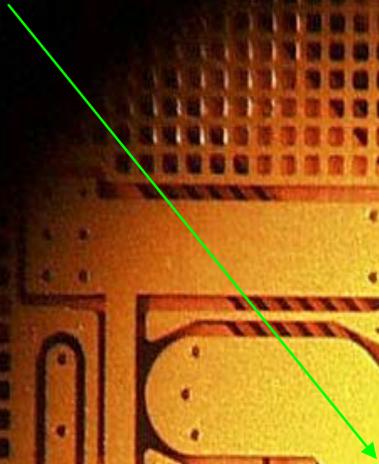
Bare HDI History

- 1996 - Prototype production and vendor search
- 1997 - Prototype HDIs from Litchfield Precision (LPC) used in test beam and pre-production ladders (40-60% yields)
- Production orders from LPC
 - Jan-Feb 1998 - order 3 types
 - March - receive type 3-Chip S - 40% yield
 - May - receive type 9-Chip L - *all fail*
 - August - visit company - no real answers
 - † order 9-Chip L from Dyconex (all work)
 - November - LPC will not produce future HDIs (deliver what is in the pipeline)
 - December - receive final LPC shipment:
~50 type 3-Chip L - *all needed to be "fixed"*

Got enough to start production (need 24 working HDIs from this type) Dec 1998.

Short between trace & ground

shorted trace



Bare HDI Status

- Dyconex HDIs work well but cost too much.
- Placed orders with Dyconex to maintain schedule
 - received 60 3-Chip short, 41 9-Chip long
 - ordered 65 9-Chip long, 20 6-Chip H
- Continue vendor qualification in parallel
 - Allied Signal (Bad quality, out of business)
 - Speedy Circuits (Delivered March 1st, 6-Chip F)
 - Graphic PLC (England) Did not send quote
 - QPI (Netherlands) (Placed test order, 25 8-Chip F)
 - Compunetics (Placed test order, 25 8-Chip F)

4 new types (6&8 Chips) still need to be made

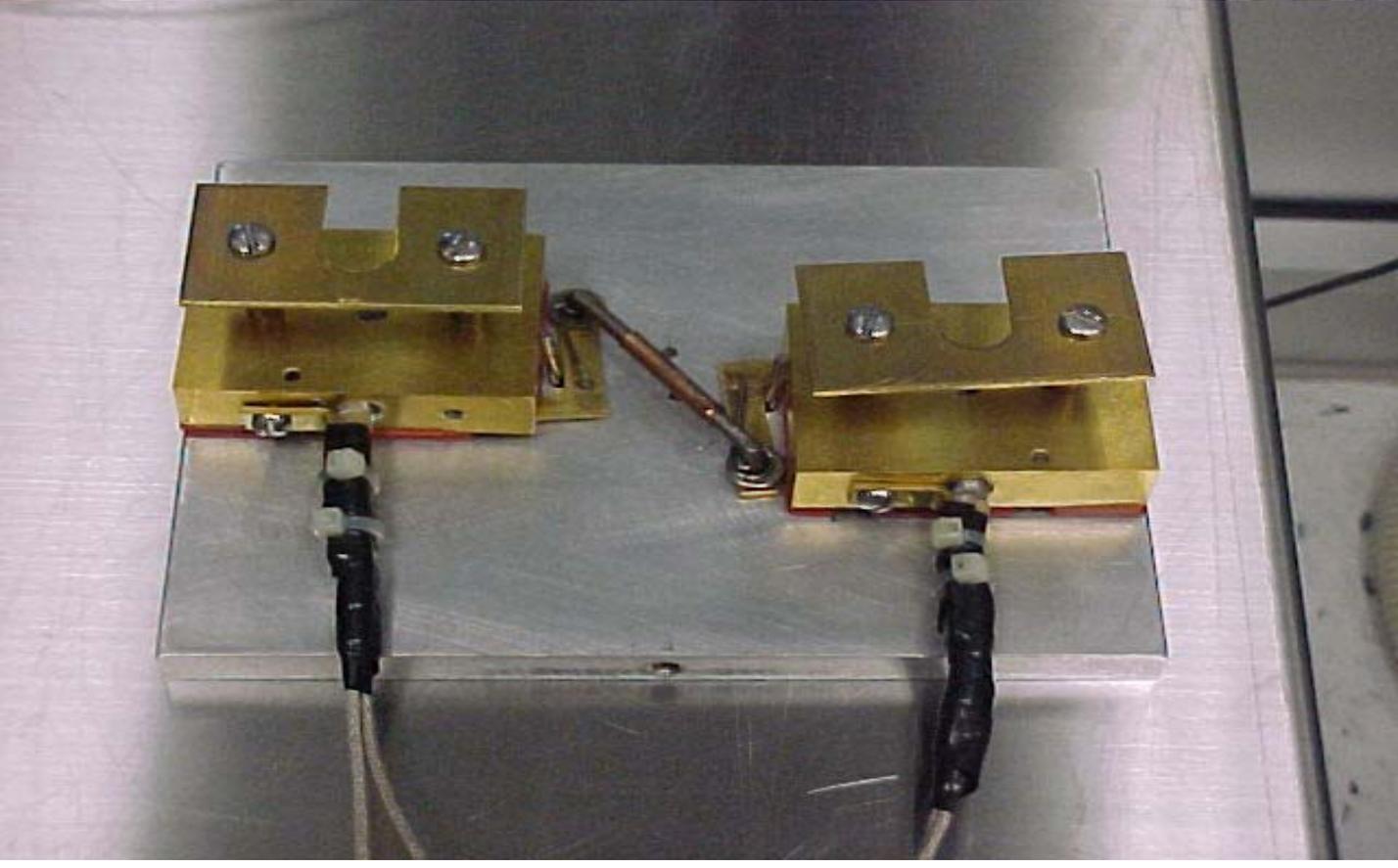
How do we make an HDI?

Step 2: mounting of components

- Bare HDIs are laminated on Be @ FNAL
 - Had problems with air bubbles trapped between Be and HDI which caused problems during wire bonding.
 - Solved by using a Bell Jar with controlled heat and pressure.
- Components and SVX chips are mounted on HDI & chips are wire bonded to HDIs
 - Pre-production tests at FNAL during 1997-1998
 - ⤴ Be warping, problems during wire bonding (yield ~ 20%)
 - HYTEL (First half of 1998)
 - ⤴ yield ~10% good HDI
 - PROMEX (Second half of 1998)
 - ⤴ yield of good HDIs ~ 80-90%

Finally had working HDIs (Jan '99)

Bell Jar setup for lamination



3-Chip HDI from Promex



How do we make an HDI?

Step 3: electrical tests

- HDIs are visually inspected and electrically tested at FNAL (yield ~ 80-90%)
- Good HDIs are burned-in for 12 hours
 - digital checks, pedestal, noise, gain and sparse readout
 - so far, yield 100%
- Good HDIs have their wire bonds encapsulated
 - problem with fumes of chosen encapsulant
 - looking into alternative products
- HDIs are burned in for 24 hours
 - so far, yield 100%

HDI ready to build a ladder

Ladder Construction & Testing

- Mechanical Assembly

- limited by number of fixtures and glue curing time

ladder type	needed	yield	total time
3-chip SS	72	10/week	7 weeks
9-chip DS	216	8-10/week	27 weeks
6-chip DS	144	8-10/week	18 weeks

- Wire bonding

- 15 minutes / chip, ~6000 chips to bond => 40 weeks
- 2 technicians assigned to D0 (should be 4 soon)

- Burn-in

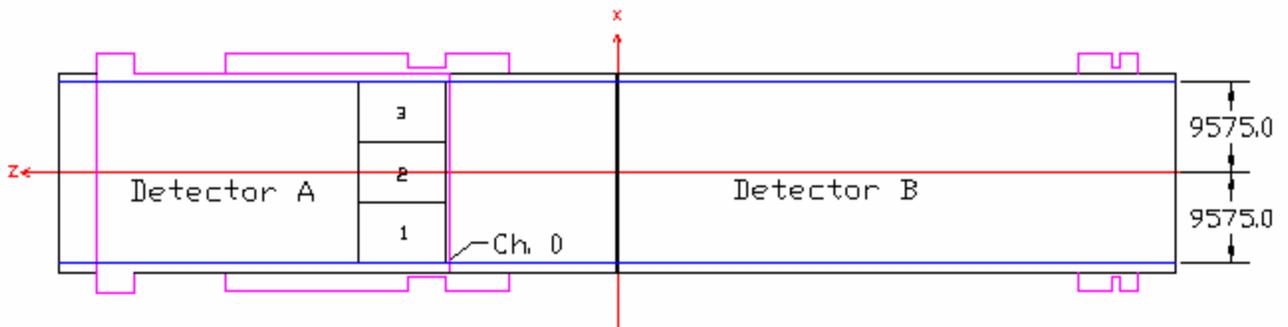
- 912 HDIs, 2days / HDI => 1800 days
- 672 detectors => 1300 days
 - ↑ Clearly will need to do burn-in in parallel

- Mounting of ladders on bulkheads

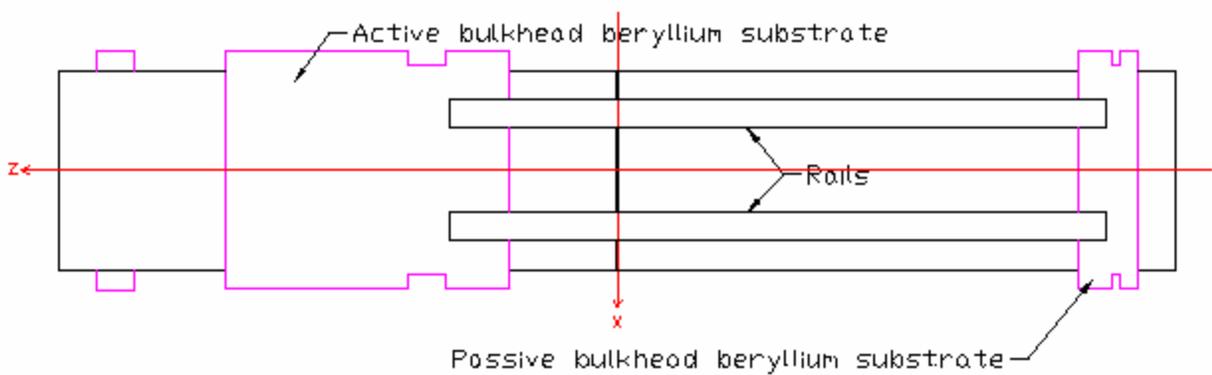
We DO NOT have all the pieces in hand yet

SS ladders (3-chip)

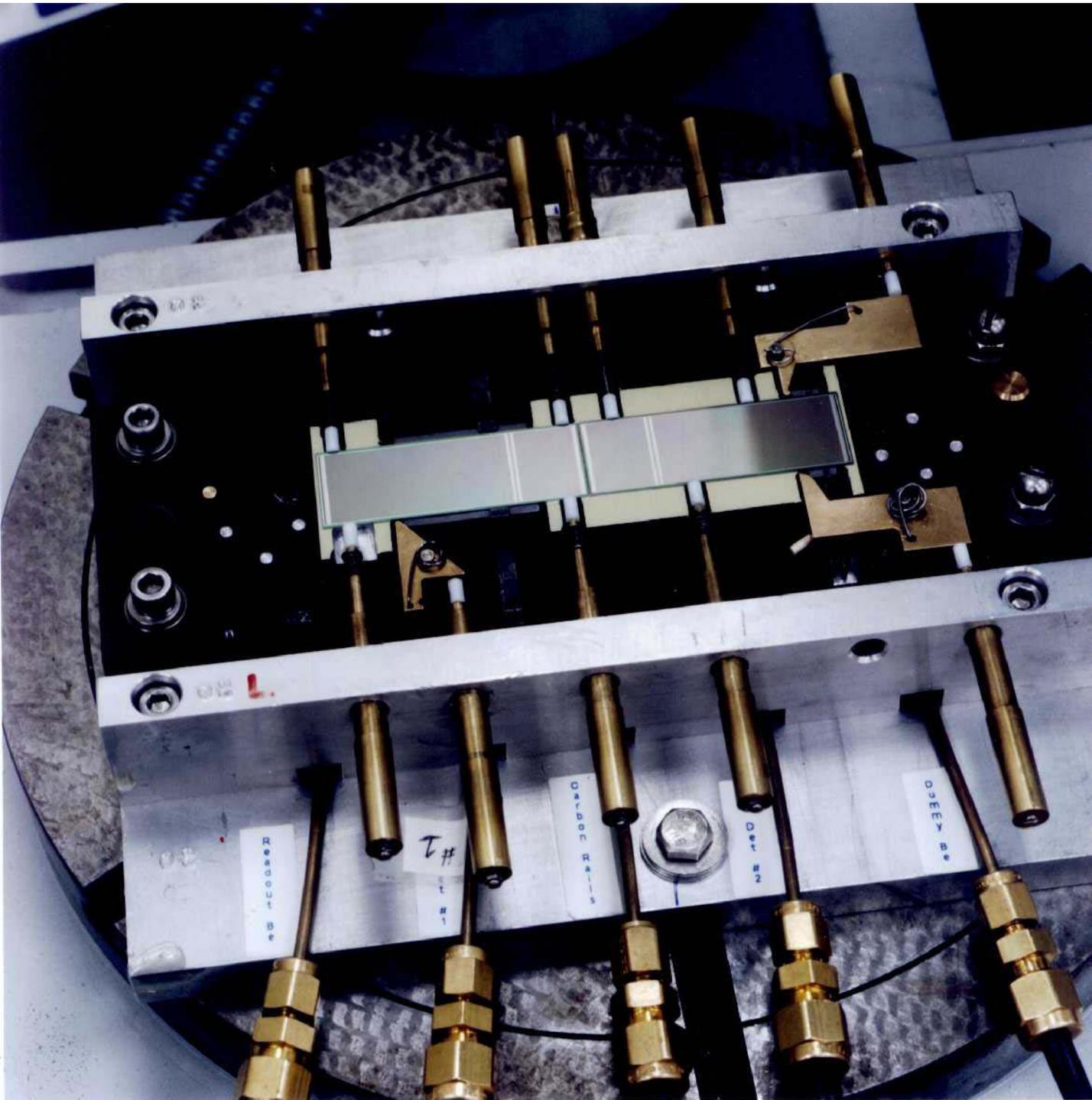
3-chip ladder top surface (p-side) (0 degree)



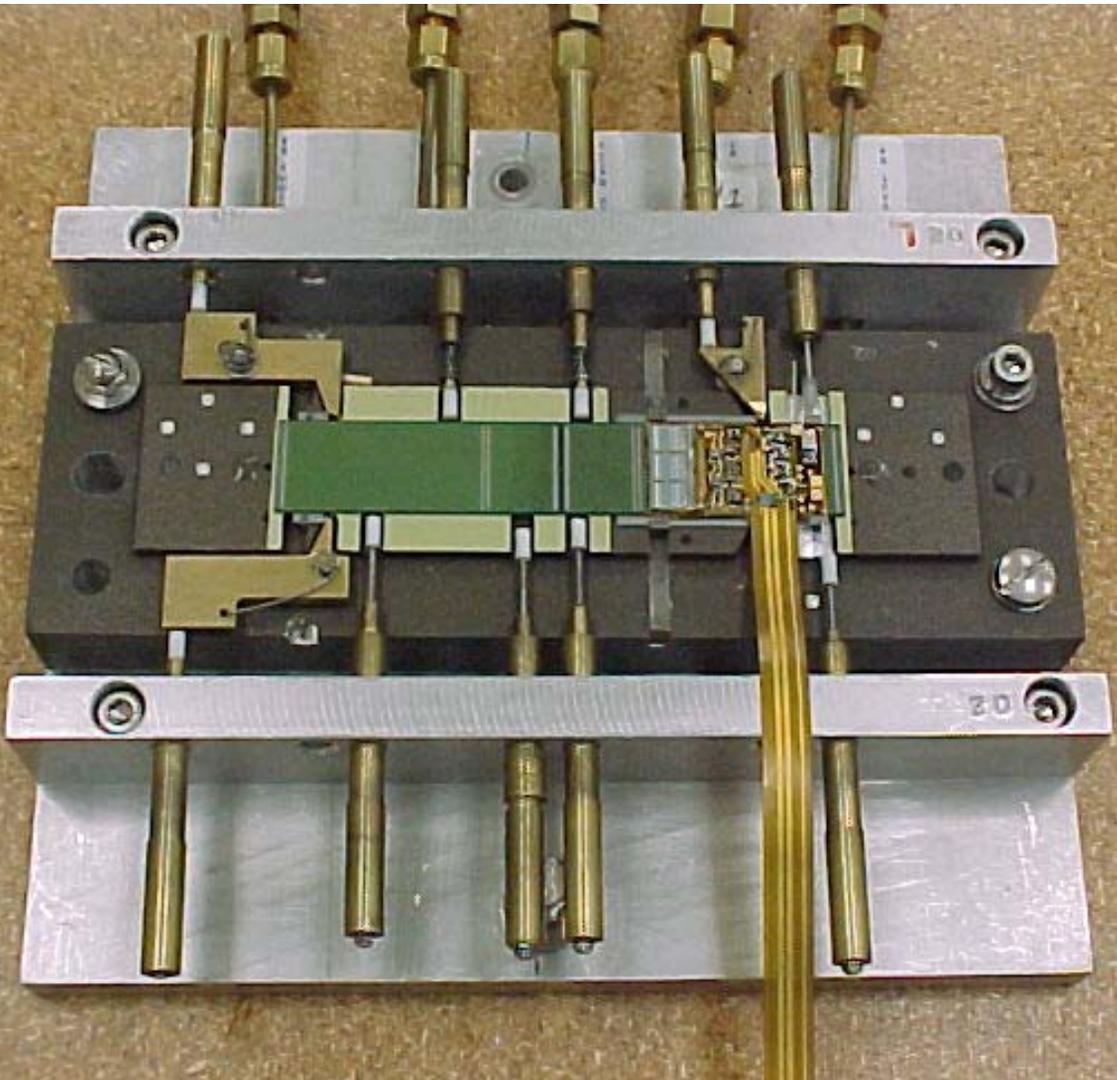
3-chip ladder bottom surface (n-side)



Ladder Assembly (1)



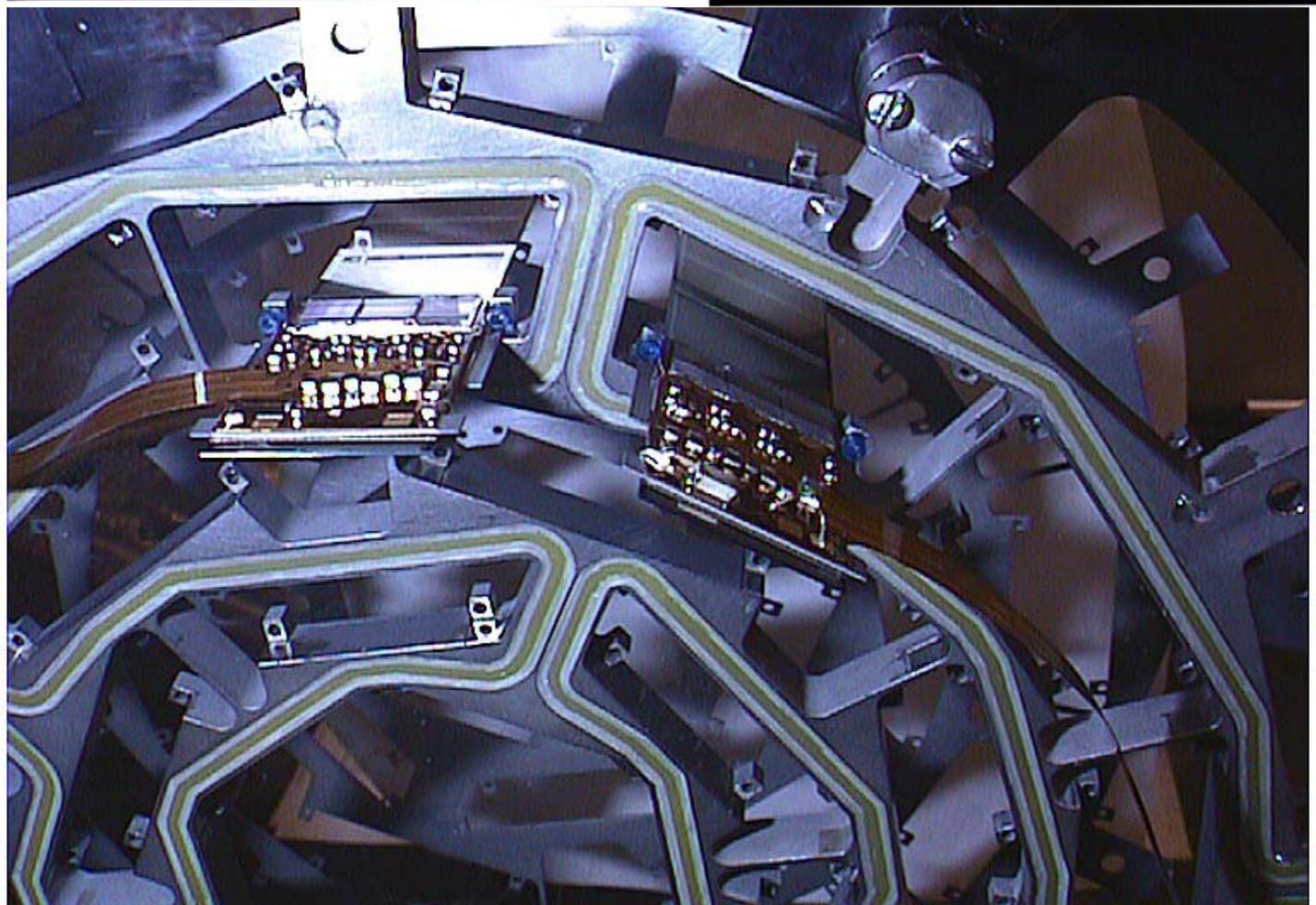
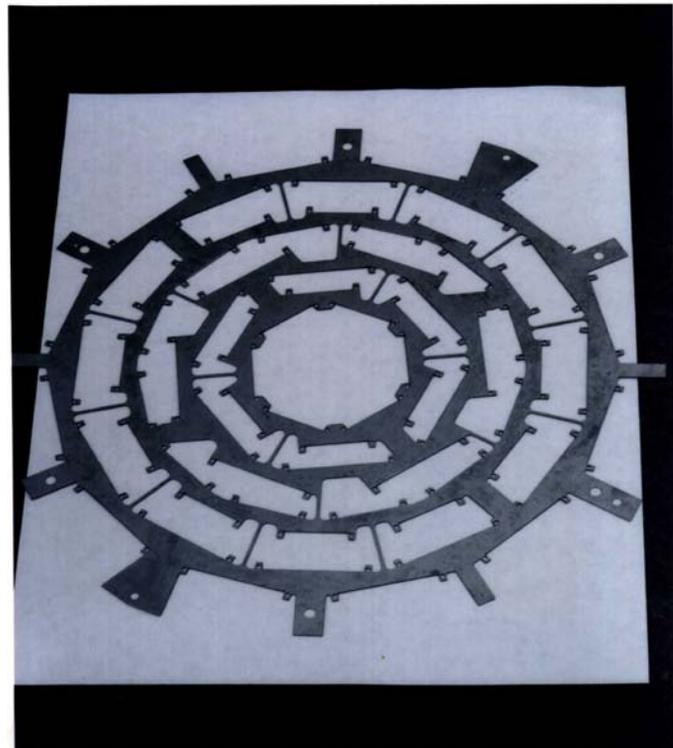
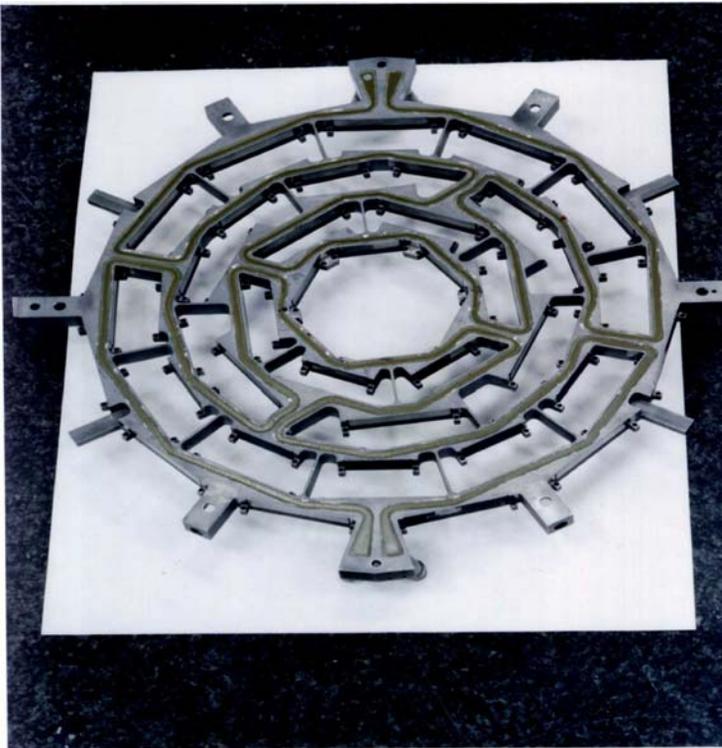
Ladder Assembly (2)



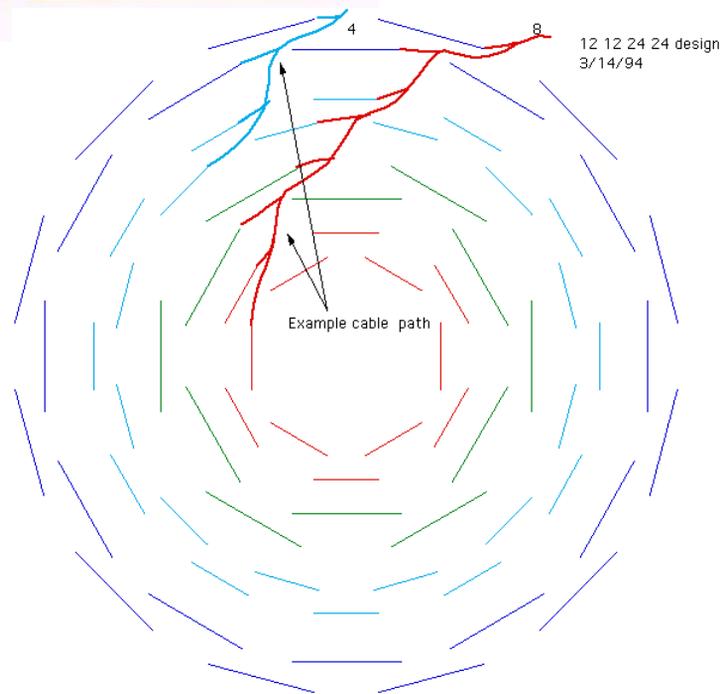
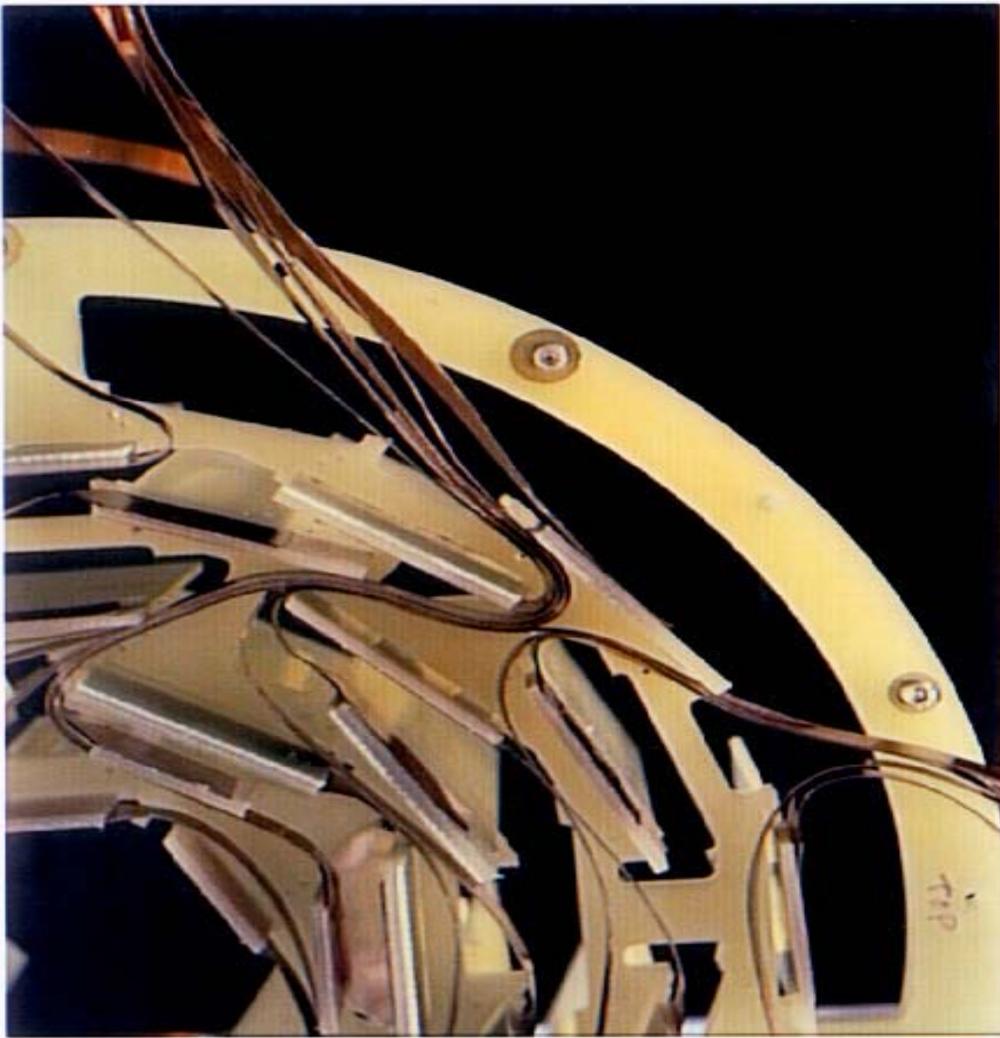
Zeiss machine



Ladders mounted on Be Bulkhead



Tail routing



3-Chip SS Ladders (72)

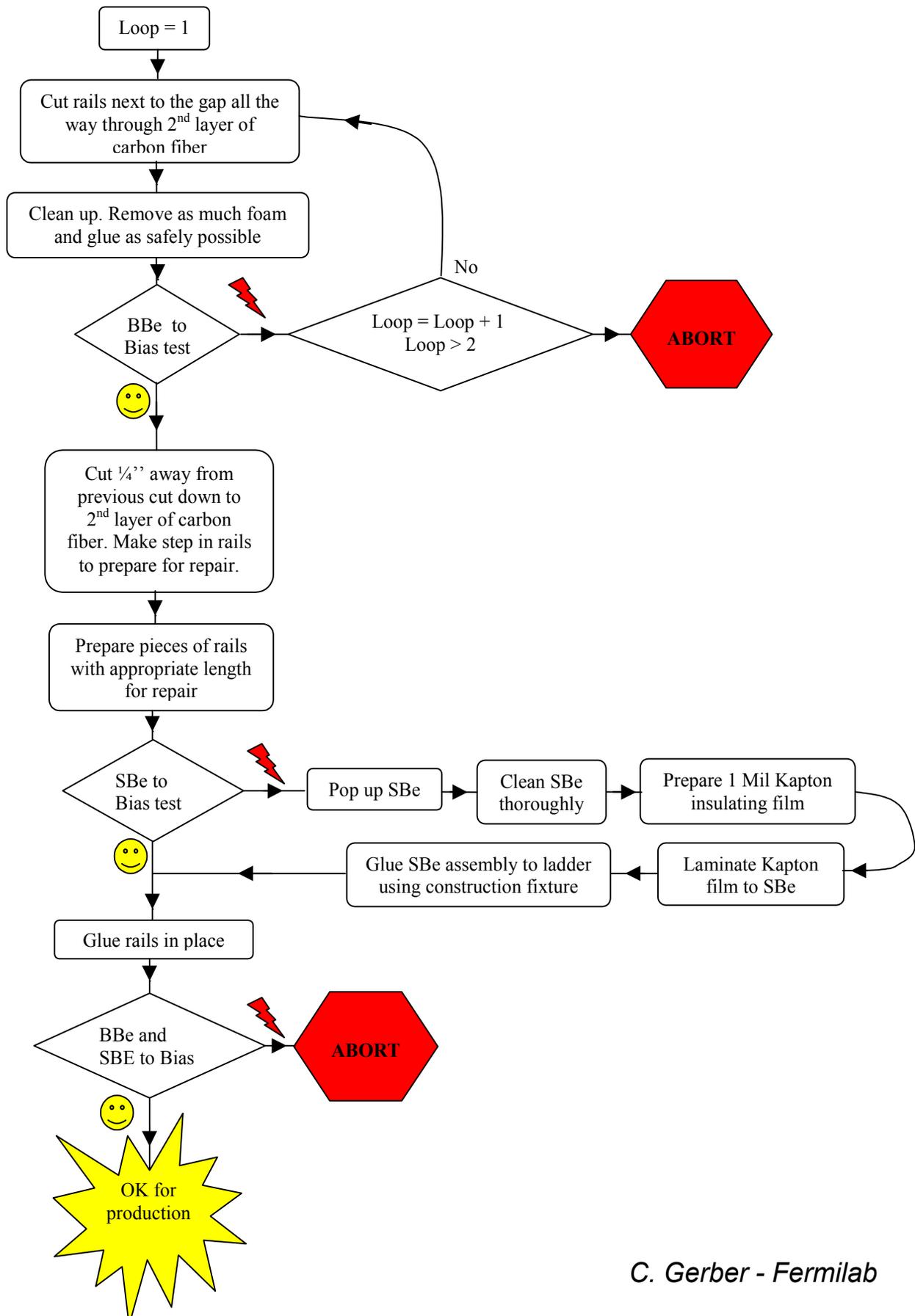
SENSORS

- All Silicon sensors on hand (need 72x2) and built into “mechanical” assemblies.
- BUT: most have problems
 - Silver epoxy “migration” shorted backplane-GND (50%)
 - Scratches, spots on pads, chipped edges (20%)
 - Silver epoxy on Si, missaligned rails (30%)
 - ↑ Have enough spare sensors to cover some shortfall
 - ↑ Need to order more Be pieces

HDI's

- **3351 3-Chip long (Need 24)**
 - Have 22 working HDIs, 10 ready to be send to Promex
 - ↑ should have all the bare HDIs we need.
- **3314 3-Chip short (Need 48)**
 - Have 36 ready to send to Promex, 24 waiting for Be pieces to be laminated
 - ↑ should have all the bare HDIs we need.

PROCEDURE FOR 3-CHIP LADDER FIX

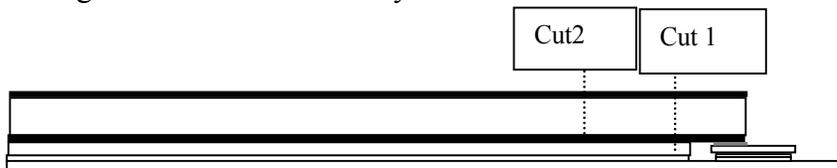


PROCEDURE TO FIX SHORTED 3-CHIP LADDERS

Schematic profile (not to scale) of a ladder (Small Beryllium piece side), rails on top:



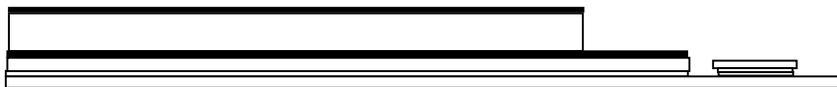
Cut 1 is to be performed 2mm away from the down to and through the 2nd carbon fiber layer. Cut 2 is to be performed 15mm from the end of the rail glued to the SBe piece down to and through the 2nd carbon fiber layer.



Once Cut 1 has been done, all rail debris and glue remnants on the SBe piece should be removed.



- If Resistance(SBe,BBe) NOT infinite ABORT for this ladder.
- If Resistance(SBe,BBe) infinite:
 - If ladder breaks down on BBe piece ABORT for this ladder.
 - If ladder does NOT break down on BBe piece, perform cut 2 to prepare ladder for rail fixing. Clean rail debris.



- If ladder breaks down on SBe piece, remove SBe with the help of a piece of Kapton film.



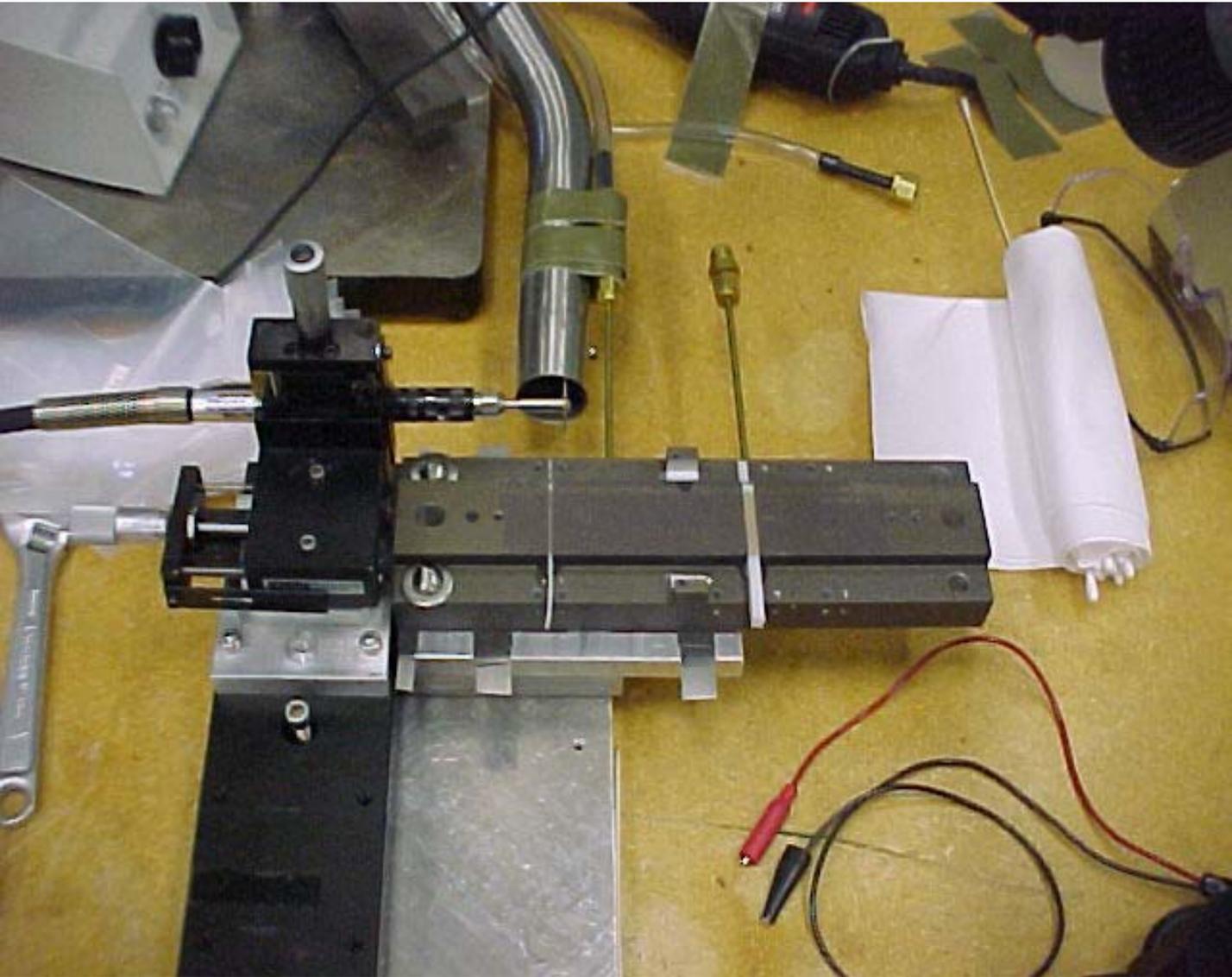
Clean thoroughly the SBe from its epoxy film and other glue remnants using dimethyl-acetone. Using room temperature epoxy and the ladder building fixture glue back the SBe and a piece of 1mil Kapton film slightly oversized in z w.r.t the SBe piece size.



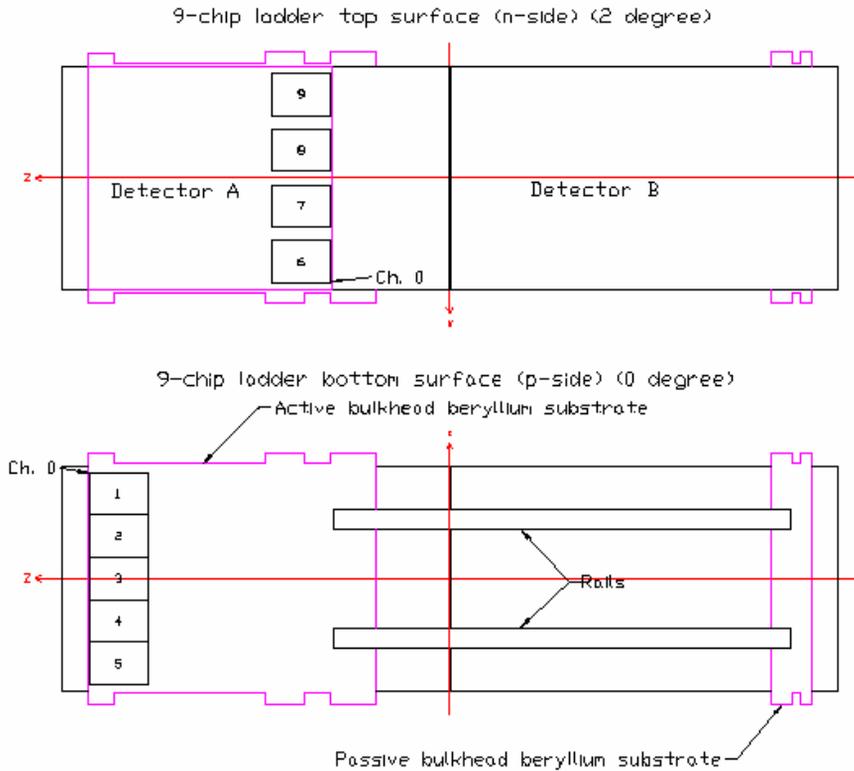
Glue with room temperature epoxy the complementary pieces of rails:



Setup for ladder repair



9-Chip DS2deg (216)



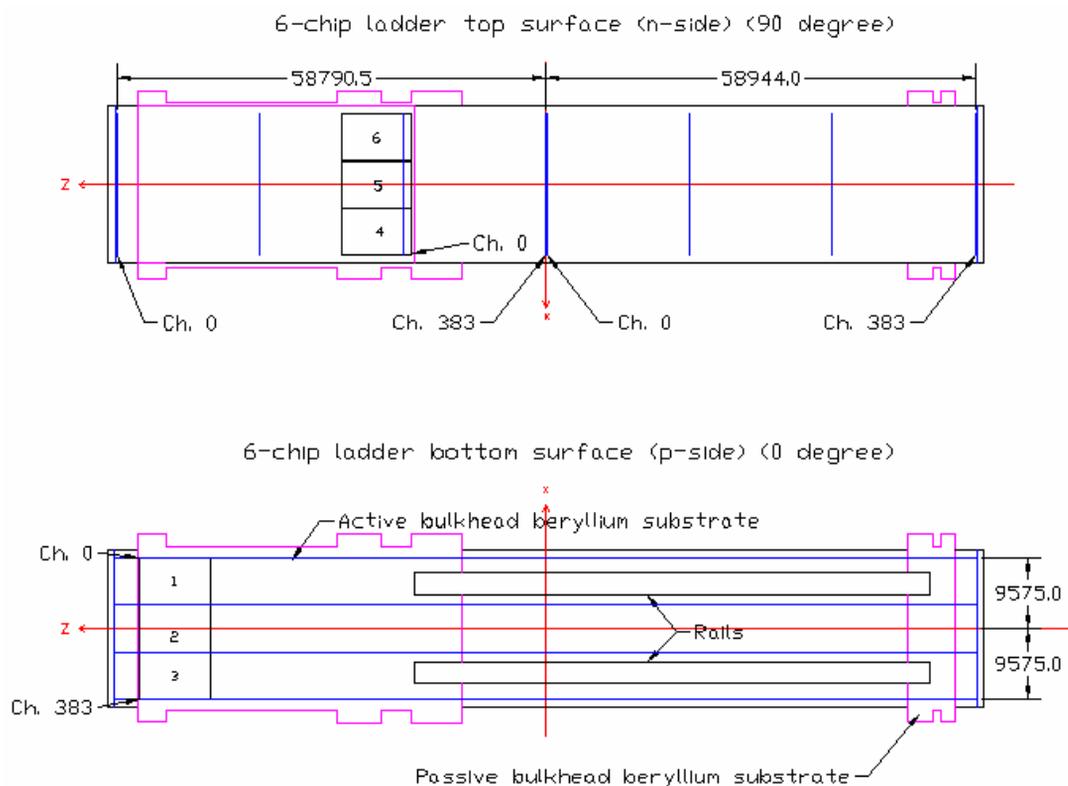
SENSORS

- Have ~130 detector grade sensors (need 216x2)
- in production at MICRON (~40/month)

HDI

- 3953 9-Chip long (Need 72)
 - Have 6 (+25+10), ordered 65 from Dyconex
 - ↑ should have all the bare HDIs we need.
- 3913 9-Chip short (Need 144)
 - out for bid

6-Chip DSDM90deg (144)



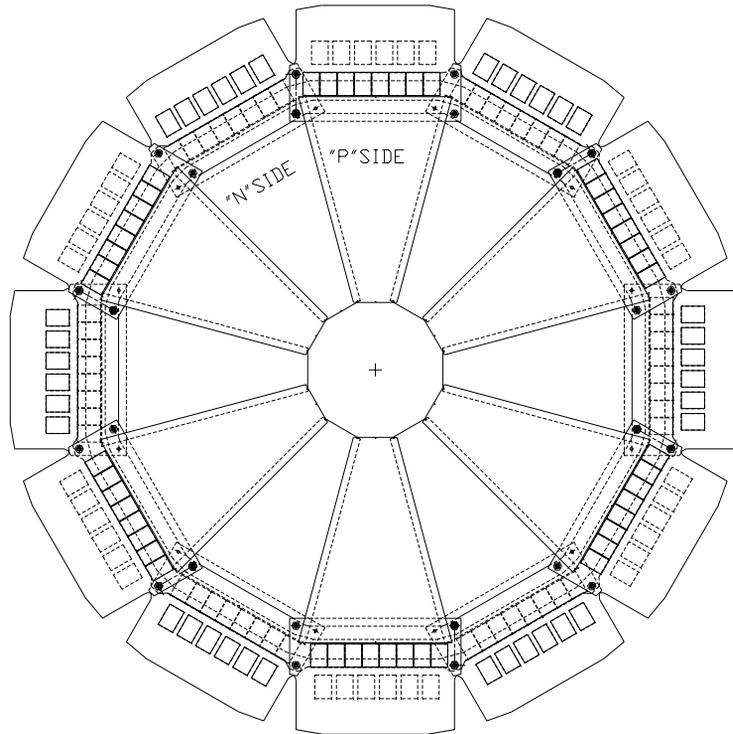
SENSORS

- Have ~ 5 detector grade sensors (need 144)
- MICRON visited Feb 99. Expect ~30 sensors/month.

HDI's

- Layout in process for 6-Chip long & short (need 48+96)

F-Disk wedges (144)



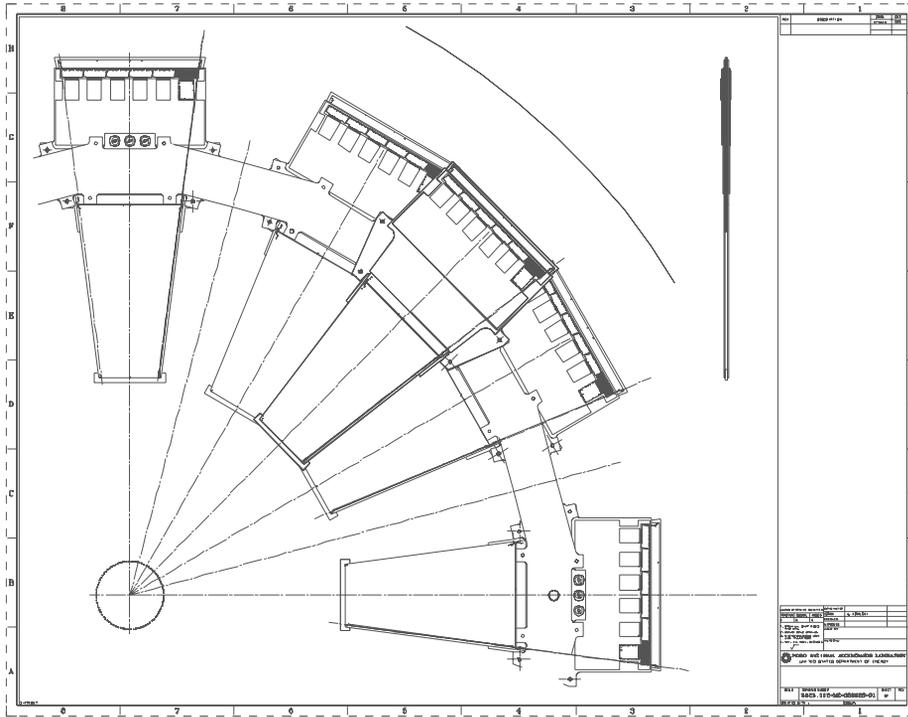
SENSORS

- Have ~20 detector grade sensors (need 144)
- Order split between MICRON(75) and Eusisys (100)

HDI's

- 4611 6-Chip (Need 144)
 - 20 received from Speedy Circuits on 3/3
- 4811 8-Chip (Need 144)
 - 25 ordered from both QPI & Compunetics, due 3/20

H-Disk wedges (96)



SENSORS

- Have ~ 60 detector grade sensors (need 96x4)
- Production is underway at ELMA (~ 50/month)

HDI's

- 7611 6-Chip (Need 192)
 - Ordered 20 from Dyconex, due 3/24

Conclusions

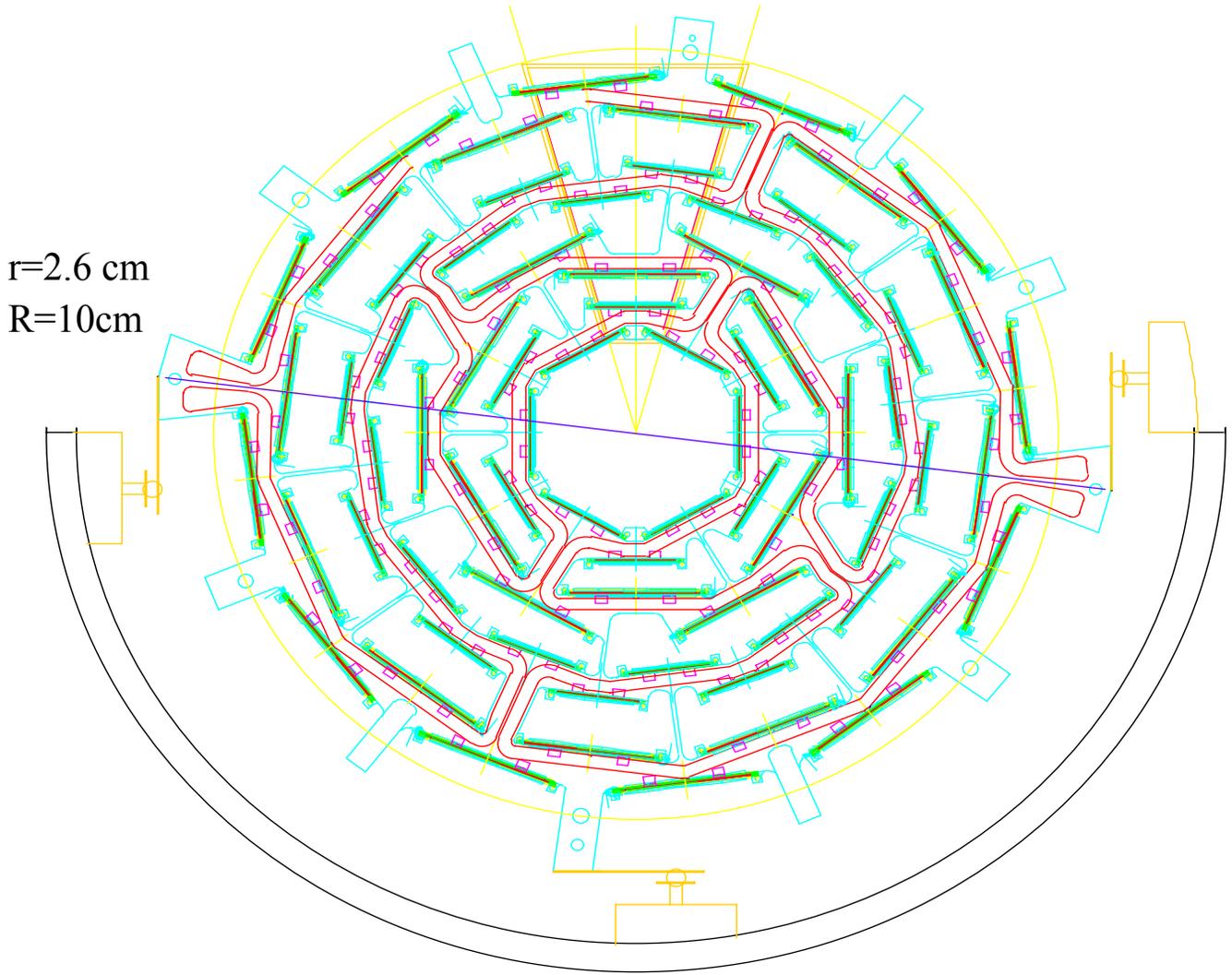
- *We are* in production.
- Know how to make working HDIs
 - but it costs us more \$\$ than expected
- First ladders being build
 - Facing first wire bonding issues
 - Need to refine ladder testing procedures
- Silicon sensors still a big worry...
will have to keep an eye on it
- Tight schedule but doable

Will need all the help we can get when
production ramps up!!!

What we need

	# HDIs	# Chips	# Detect.
Barrel			
3-C SS	72	216	72
6-C DS	144	864	144
9-C DS	216	1944	216
Sub-total	432	3024	432
F-Disks			
8-Chip	144	1152	
6-Chip	144	864	
Sub-total	288	2016	144
H-Disks			
6-Chip	192	1152	96
Total	912	6192	672

Barrel ladders



	B1&B6	B2-B5	
Layer 1	12 SS	12 DS90	} 72 SS (3-Chip) 144 DS90deg (6-Chip) 216 DS2deg (9-Chip)
Layer 2	12 DS2	12 DS2	
Layer 3	24 SS	24 DS90	
Layer 4	24 DS2	24 DS2	