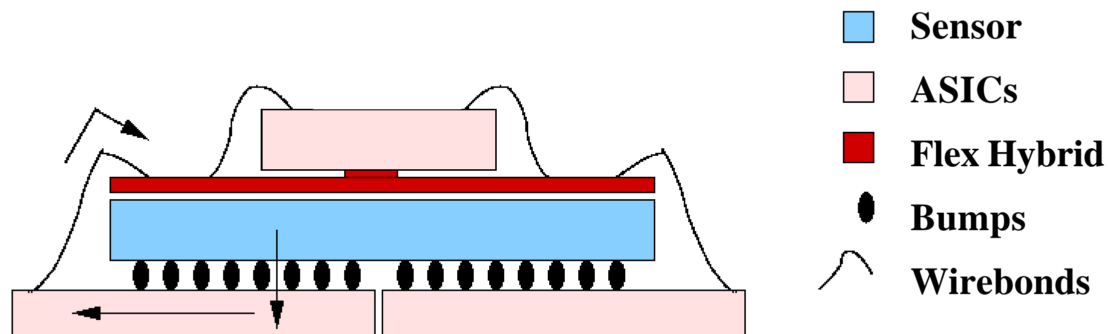
Hybrids
WBS 1.1.1.4
&
Module Assembly
WBS 1.1.1.5

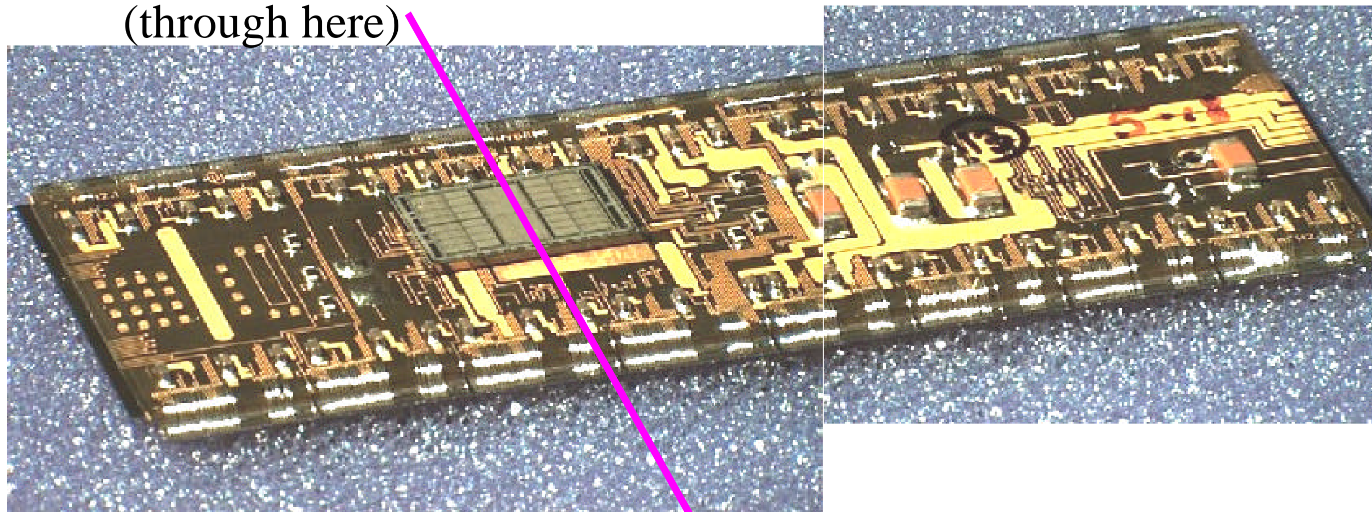
M. Garcia-Sciveres

LBNL

The Pixel Module



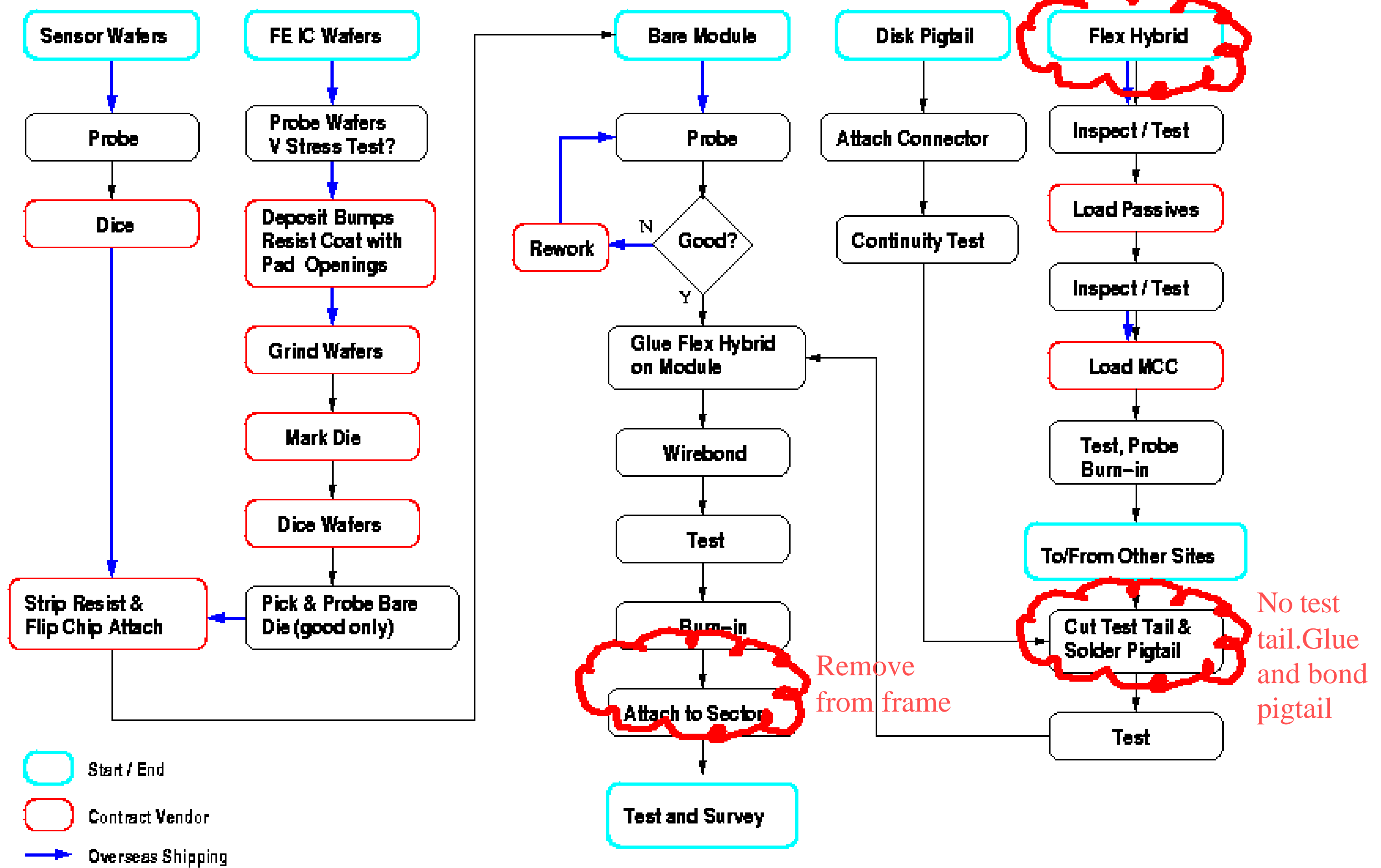
Schematic Cross Section
(through here)



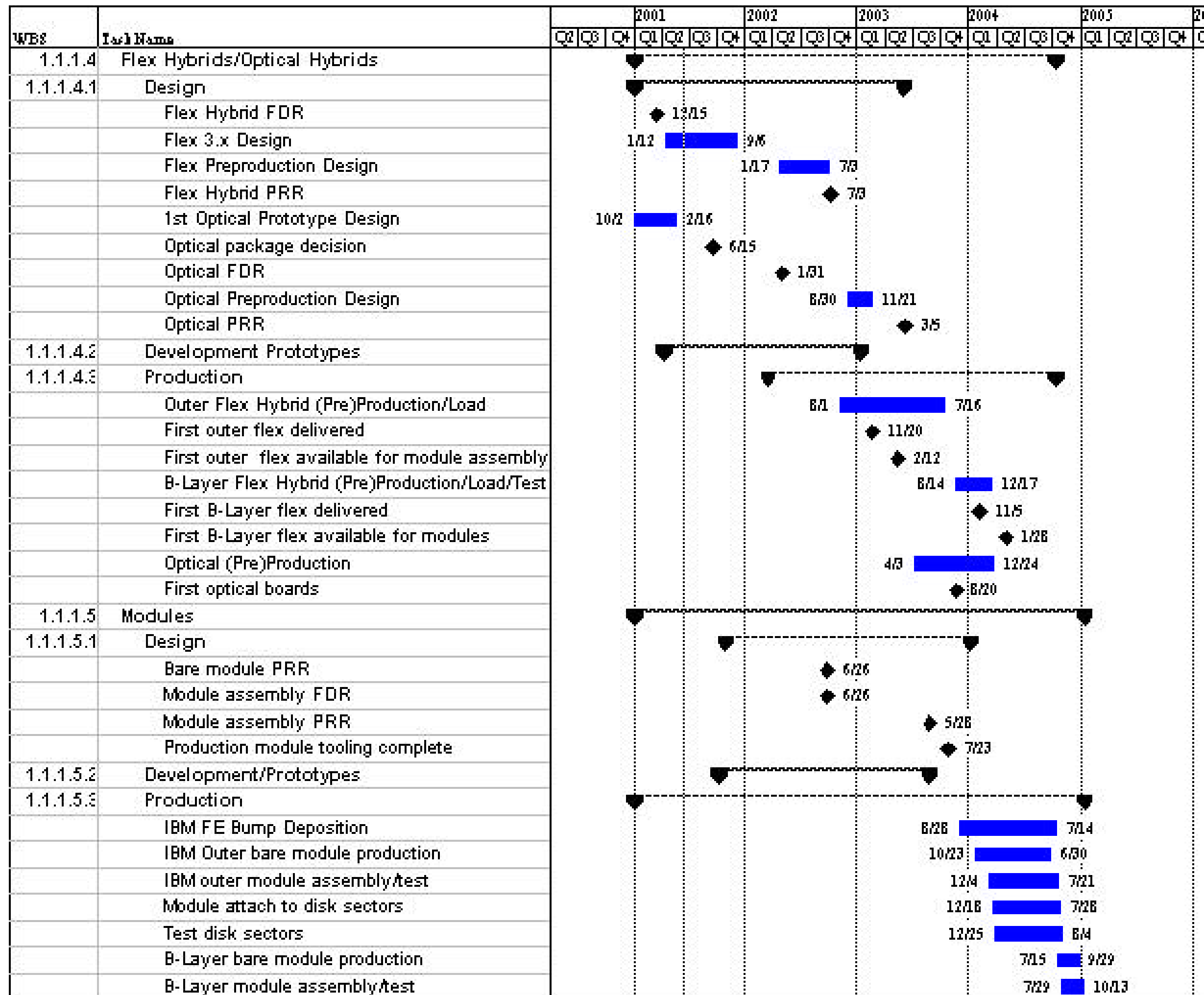
- All modules are identical (barrel and disks)
- “Pigtails” of different varieties are attached in assembly depending on use location

Module Production

COMPONENTS	US RESPONSIBILITY	INSTITUTIONS
Bumped 8” FE Wafers	Probe Thin and Dice	LBNL
Sensors	Probe	New Mexico, Oklahoma
Bare modules	Probe (no flip-chip in US)	LBNL
Flex Hybrids	Fabricate Component load & Test Load MCC chip & test	Oklahoma Oklahoma, Albany Oklahoma, Albany
Full Modules	Assemble, Wirebond, Test, Burn-In	LBNL TBD
Disk Pigtails	Fabricate, Test, Assemble	LBNL


U.S. Atlas Pixel Module Assembly Flow, Nov. 2, 2000
Support frame w/ flex hybrid
Sensor Wafers
Probe
Dice
Strip Resist &
Flip Chip Attach
FE IC Wafers
Probe Wafers
V Stress Test?
Deposit Bumps
Resist Coat with
Pad Openings
Grind Wafers
Mark Die
Dice Wafers
Pick & Probe Bare
Die (good only)
Bare Module
Probe
Rework
N
Good?
Y
Glue Flex Hybrid
on Module
Wirebond
Test
Burn-in
Attach to Sector
Test and Survey
Remove from frame
Disk Pigtail
Attach Connector
Continuity Test
Flex Hybrid
Inspect / Test
Load Passives
Inspect / Test
Load MCC
Test, Probe
Burn-in
To/From Other Sites
Cut Test Tail &
Solder Pigtail
Test
No test tail.Glue and bond pigtail
Start / End
Contract Vendor
Overseas Shipping

1.1.1.4 & 1.1.1.5 Schedule Summary



Flex Hybrids

- Development has so far gone through **two design cycles**
- Version **1.x** (x=0,1,3,4)
  - 80 Fabricated by CERN and Compunetics between 1998 and 1999.
  - Used to make “proof of principle” working modules with rad-soft electronics
- Version **2.x** (x=1,2)
  - 150 Fabricated by CERN and Compunetics in 2000
  - Detailed performance characterization & system tests have not been possible due to lack of rad-hard electronics
  - Used to debug manufacturing & assembly process & to investigate mass production issues.
- **F**inal **D**esign **R**eview during December ’00 Pixel Week
  - “Early” in design terms to derive max. technical benefit

Flex Hybrids (continued)

- Goals for Version 3 Flex design (in progress):
  - **Qualify more vendors**
    - Increasing ease of manufacture through interaction with designs of new FE chip and services.
  - **Test bed for first IBM FE chip run (FE-I) – to submit July 01**
    - Accelerating design cycle and avoiding un-proven features so hybrids will be ready ahead of FE-I delivery
    - Making compatible with existing (obsolete) controller chip
  - **Compatible with mass assembly, testing, and handling**
    - Apply lessons learned from V2.x prototypes
  - **Address system integration**
    - Work closely with parallel development of service connections
- Preliminary layout to be ready for bidding in April
- Expected fabrication June-Aug. 2001.

WBS 1.1.1.4 Funding Profile

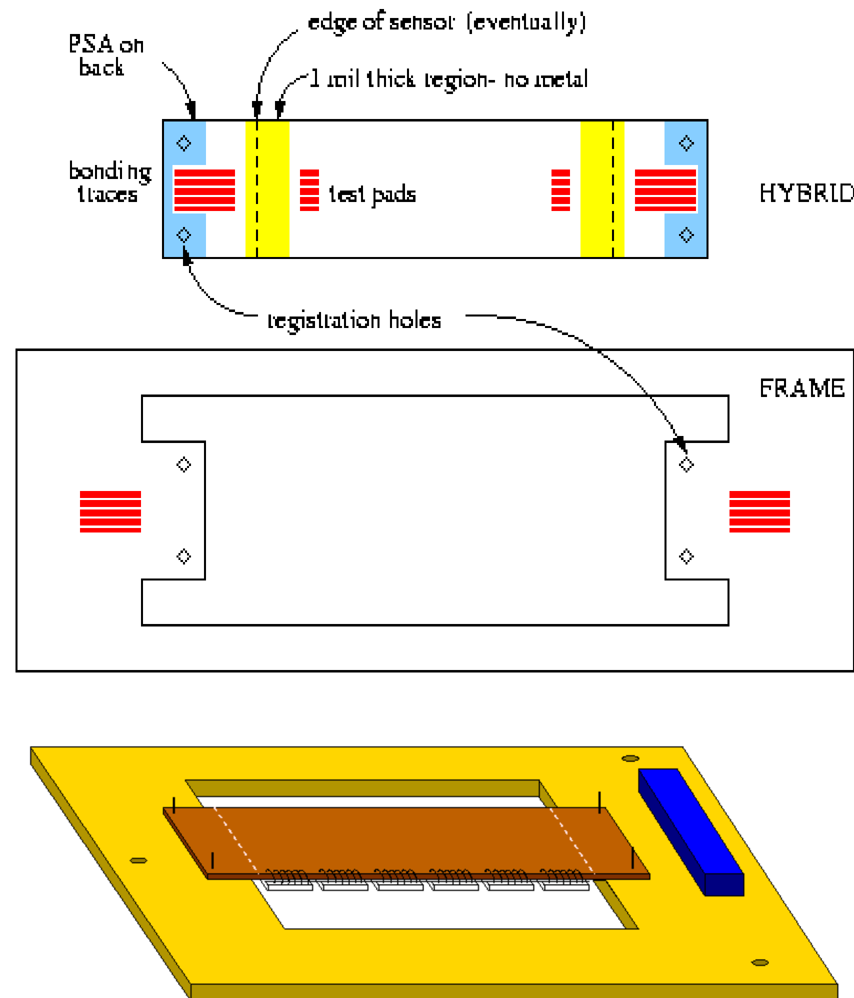
U.S. ATLAS E.T.C.
WBS Profile Estimates

Funding Source: All **Funding Type:** Project

WBS Number	Description	FY 99 (k$)	FY 00 (k$)	FY 01 (k$)	FY 02 (k$)	FY 03 (k$)	FY 04 (k$)	FY 05 (k$)	Total (k$)
1.1.1.4	**Flex Hybrids/Optical Hybrids**	**0**	**0**	**110**	**138**	**273**	**4**	**0**	**525**
1.1.1.4.1	Design/Engineering	0	0	18	50	9	0	0	77
1.1.1.4.1.1	Prototype design	0	0	18	0	0	0	0	18
1.1.1.4.1.2	Production design	0	0	0	50	9	0	0	59
1.1.1.4.2	Development and Prototypes	0	0	92	62	0	0	0	154
1.1.1.4.2.1	Flex hybrids	0	0	35	10	0	0	0	45
1.1.1.4.2.2	Optical prototypes	0	0	41	41	0	0	0	82
1.1.1.4.2.3	Pigtails prototypes	0	0	16	11	0	0	0	27
1.1.1.4.3	Production	0	0	0	26	264	4	0	294
1.1.1.4.3.1	Flex hybrid	0	0	0	16	158	1	0	175
1.1.1.4.3.2	Pigtails	0	0	0	0	33	0	0	33
1.1.1.4.3.3	Optical hybrids	0	0	0	10	73	3	0	86

Carrier Frame

- New development for Flex V.3
- Needed for reliable mass production, handling, & shipping of hybrids & modules
- Based on module assembly and test experience with Flex V.2

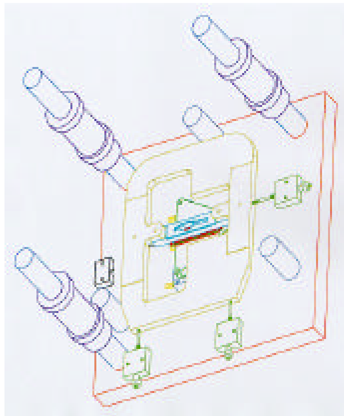
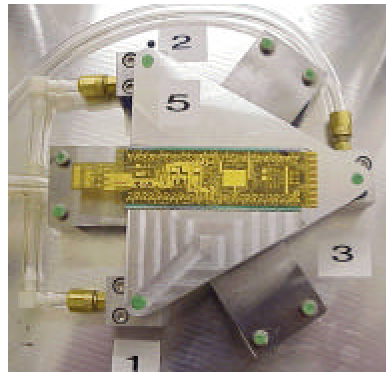


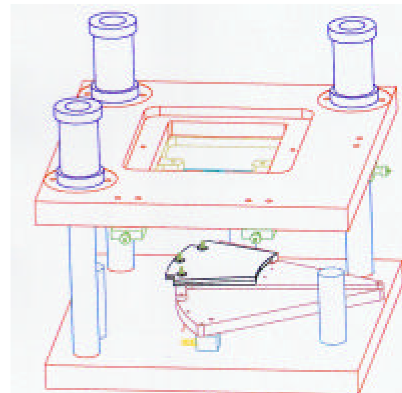
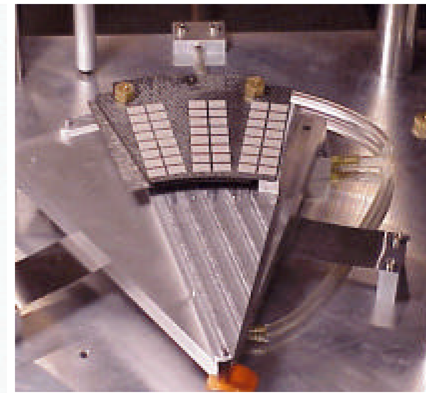
Pre-Production Module Work

		Parts Used
Validate Design	Electrical	**"Hot" Modules**
	Envelope	Mechanical Dummies
Debug Production Process	Assembly	Mechanical Dummies
	Handling	Mechanical Dummies
	Test	———

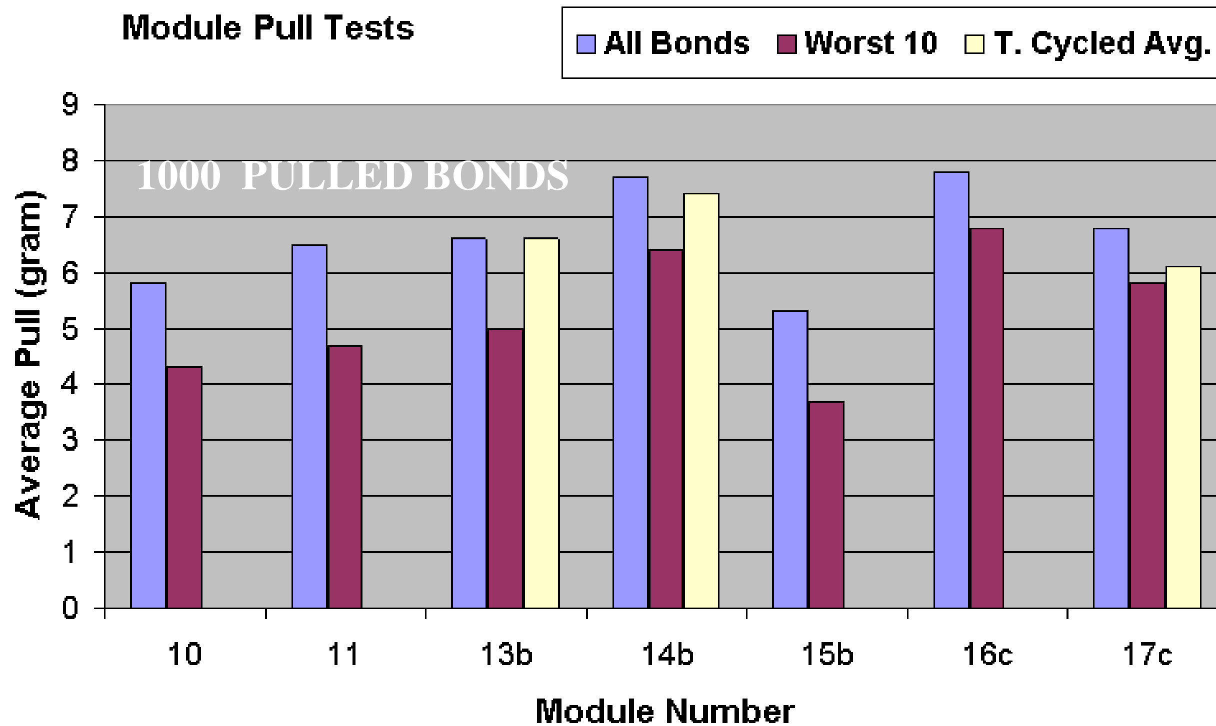
Modules Produced To Date in FY01

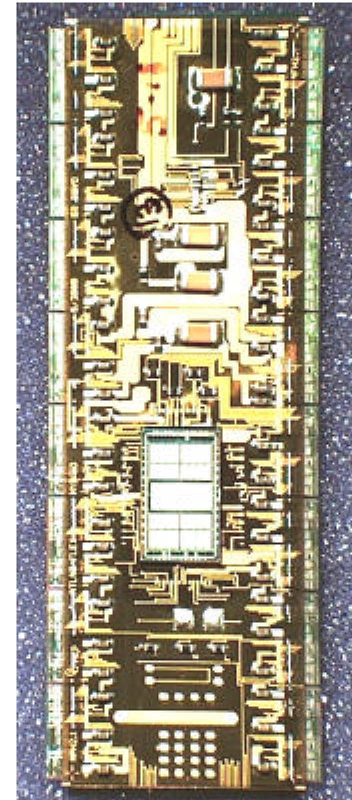
- 23 Mechanical Dummies
- 1 Hot Module (limited by FE chip availability)
- All Use Version 2 Flex Hybrid
- Built by Operators on Version 1 Production Tooling following assembly line procedures

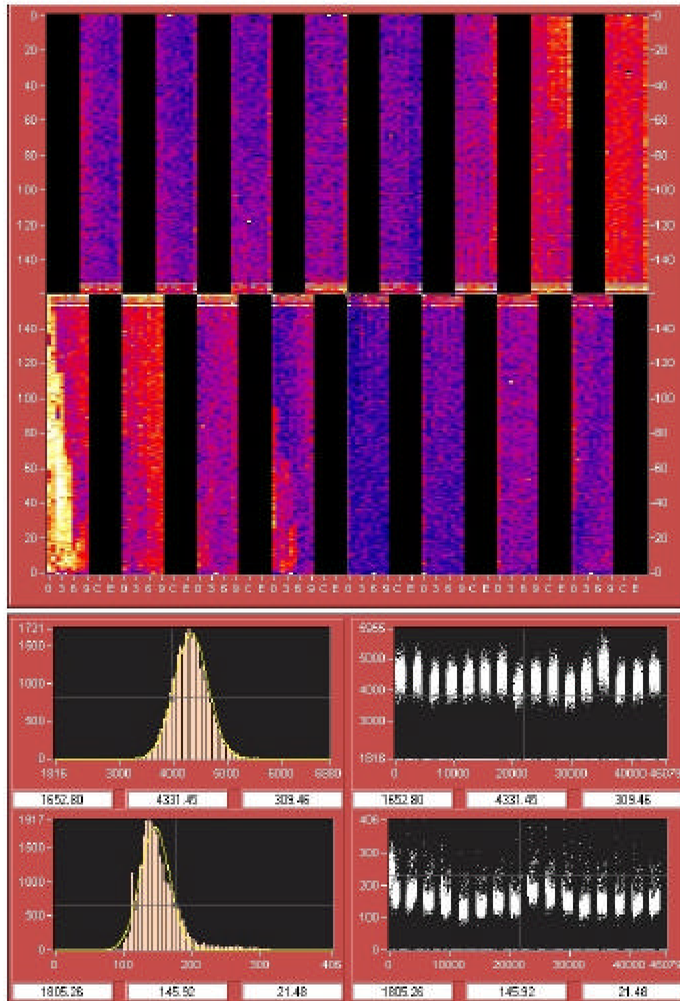
Mechanical Dummy Results

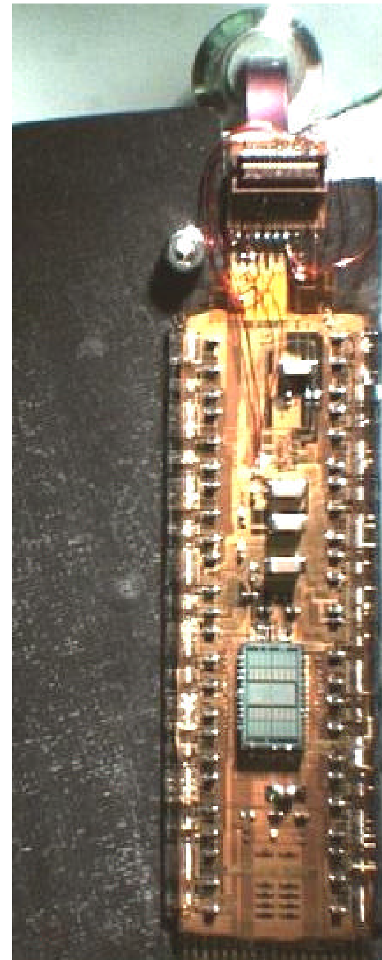




- Assembly tooling works
- Automatic wirebonding is feasible
- Adhesion and uniformity need improvement for production => better metalization
- Hybrids are fragile => need frame to control handling

FY01 "Hot" Module Results





- Full digital funtionality
- Excessive IR drops => need better metalization
- Analog performance needs more study. 150e^{-} noise achieved but dependence on supply voltages not understood.
- Flex Circuitry is fragile => No tabs or soldered pigtail. Use Frame for test connections.

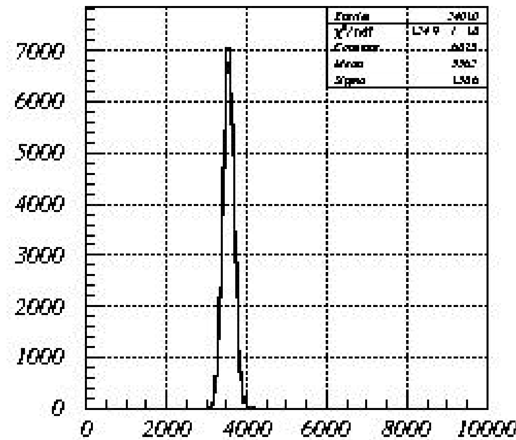
Global Summary of Hot Module Tests

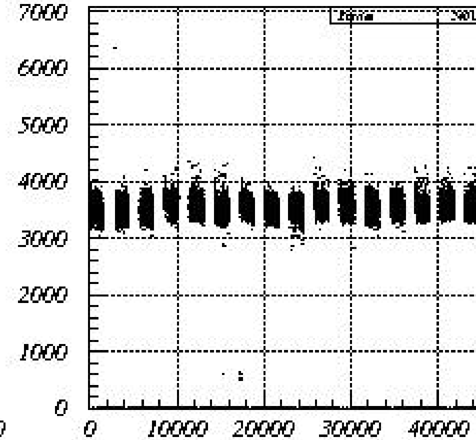
- First full modules operated in 1998
  - Rad-soft FE chips
  - Assemblies bump-bonded by Boeing
  - Version 1 Flex hybrid on support card
  - Full digital functionality. Some coherent noise issues.
- Hot modules with various bump technology and sensor combinations tested in 1999
  - Still Rad-soft electronics
  - "Ideal" analog performance achieved
  - Many assembly problems identified
- In 2000 fewer hot modules built due to lack of FE chips
  - Aim of electrical test is to validate assembly and hybrids
- To do once FE-I chips are available
  - Reproduce "ideal" performance with new chips and new flex hybrids
  - Move on to multi-module system tests

“Ideal” Module Performance

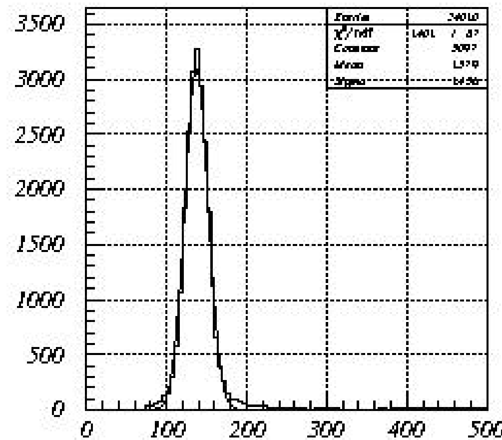
LBL4 (M1): FPDACs tuned, TDACs tuned, THBDACs tuned, MCC concurrent mode

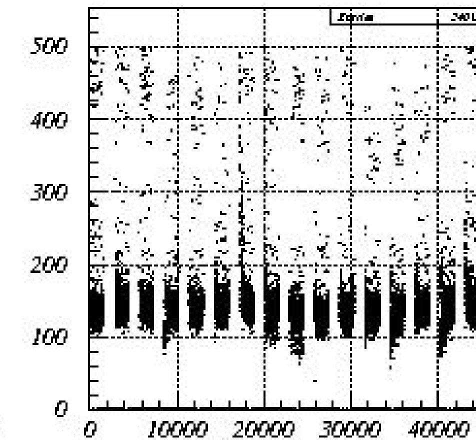
Threshold
s = 139e^{-}





ENC = 138e^{-}





Mechanical Dummy Program

- The 23 FY01 modules have no bumps- FE chips are glued to blank silicon
- Fabrication of 8” FE chip dummy wafers and 4” sensor dummies is under way – Expected delivery Apr. 5
- Enough parts for 300 bump-bonded dummies to test:
  - Thinning of bumped 8” wafers
  - Rate capability of flip-chip vendors
  - Electrical continuity of bumps through module assembly
  - Uniformity and rate of production line module assembly
- Will use remaining V.2 flex and assemble modules with V.3 flex ahead of FE-I delivery.
- Assembly period Jun. – Nov. 2001

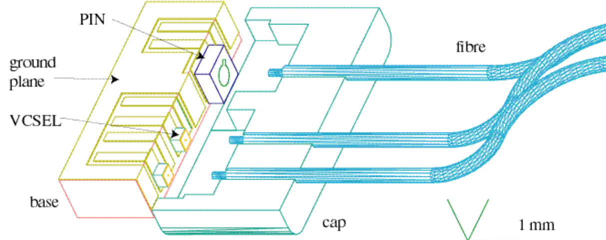
WBS 1.1.1.5 Funding Profile

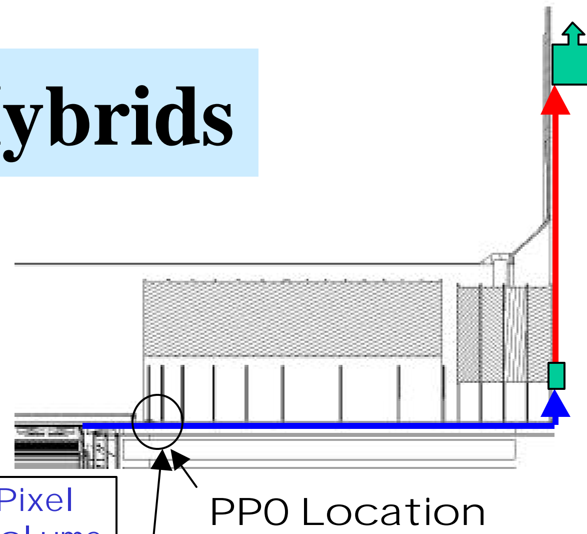
Funding Source: All **Funding Type:** Project

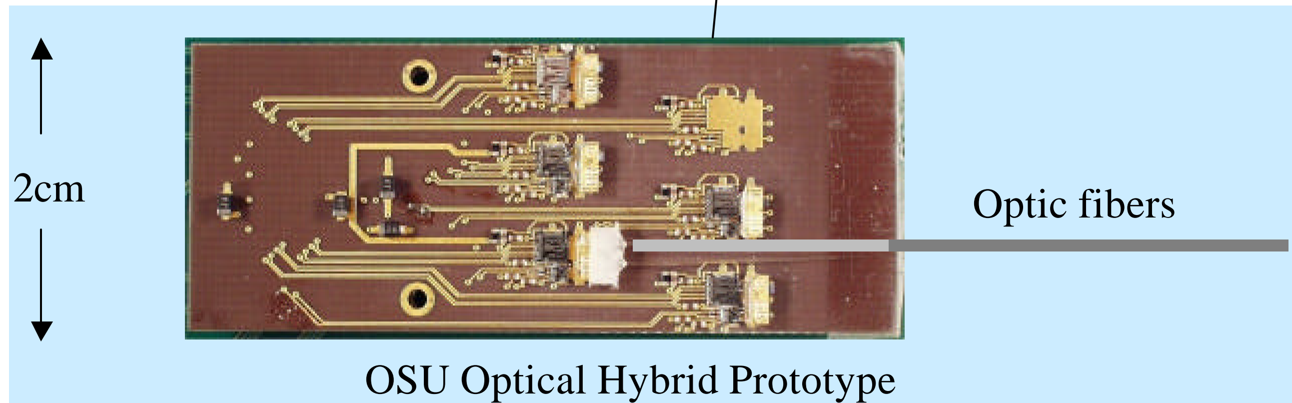
WBS Number	Description	FY 99 (k$)	FY 00 (k$)	FY 01 (k$)	FY 02 (k$)	FY 03 (k$)	FY 04 (k$)	FY 05 (k$)	Total (k$)
1.1.1.5	Module Assembly/Test	0	0	159	244	330	190	0	924
1.1.1.5.1	Design/Engineering	0	0	79	47	0	0	0	126
1.1.1.5.1.1	Prototype Design	0	0	0	0	0	0	0	0
1.1.1.5.1.2	Production Design	0	0	0	0	0	0	0	0
1.1.1.5.1.3	Testing Design	0	0	79	47	0	0	0	126
1.1.1.5.2	Development and Prototypes	0	0	80	135	46	0	0	261
1.1.1.5.2.1	X-ray Inspection	0	0	6	6	6	0	0	17
1.1.1.5.2.2	Wafer Thinning	0	0	0	0	0	0	0	1
1.1.1.5.2.3	Wafer Dicing and Die Sort	0	0	1	3	2	0	0	6
1.1.1.5.2.4	Dummy wafers	0	0	15	13	0	0	0	28
1.1.1.5.2.5	Module Assembly and	0	0	54	83	30	0	0	166
1.1.1.5.2.6	Module Attachment	0	0	5	30	8	0	0	43
1.1.1.5.3	Production	0	0	0	61	285	190	0	536
1.1.1.5.3.1	IC Wafer Thinning	0	0	0	0	2	2	0	3
1.1.1.5.3.2	Dicing of IC Wafers	0	0	0	0	12	12	0	25
1.1.1.5.3.3	IC Die Sort	0	0	0	0	0	0	0	0
1.1.1.5.3.4	Module Assembly	0	0	0	17	108	48	0	173
1.1.1.5.3.5	Module Testing	0	0	0	45	113	51	0	209
1.1.1.5.3.6	Module Attachment	0	0	0	0	12	39	0	51
1.1.1.5.3.7	Sector Electrical Testing	0	0	0	0	25	35	0	60
1.1.1.5.3.8	Production database	0	0	0	0	12	3	0	16

Optical Hybrids

OSU Optical Package (6 per hybrid)

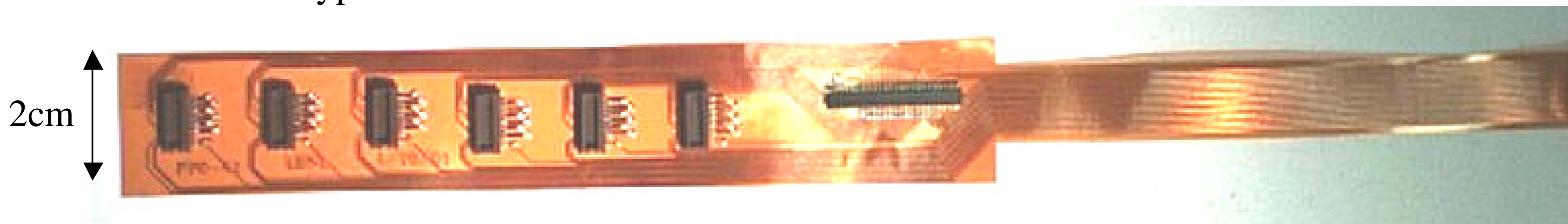






OSU Optical Hybrid Prototype

PP0 Printed Flex Prototype



Optical Hybrids (continued)

- US to produce and test optical hybrids for disks
- Parallel Hybrid development in progress at Ohio State and Wuppertal
- Parallel optical package development at Ohio State and Taiwan
- Choice of a baseline optical package scheduled for June 01
- First full hybrid p^+ irradiations scheduled for April 2001
- Initial γ irradiations of optical packages done in FY00

Conclsions

- Flex Hybrids on track towards production design.
- Issues being addressed: more vendors, FE-I schedule, service integration, production assembly, handling and testing.
- Module production being addressed with mechanical dummy program ahead of availability of final electronics.
  - Mechanical integration and manufacturing issues should not depend on details of readout chip.
- It is understood that design choices made now are contingent on results of system tests with final electronics.
- Optical hybrids designs advancing toward baseline selection date of June 2001.