Silicon Tracker (WBS 8)

DOE-NSF Review

Joe Incandela, *University of California Santa Barbara*

US CMS Silicon Tracker Project Manager

June 5, 2002

Outline:

System overview, Status, and Technical Progress

Schedule and Cost Performance

Near term plans and Issues

Installation & Commissioning

Transition to Maintenance & Operation

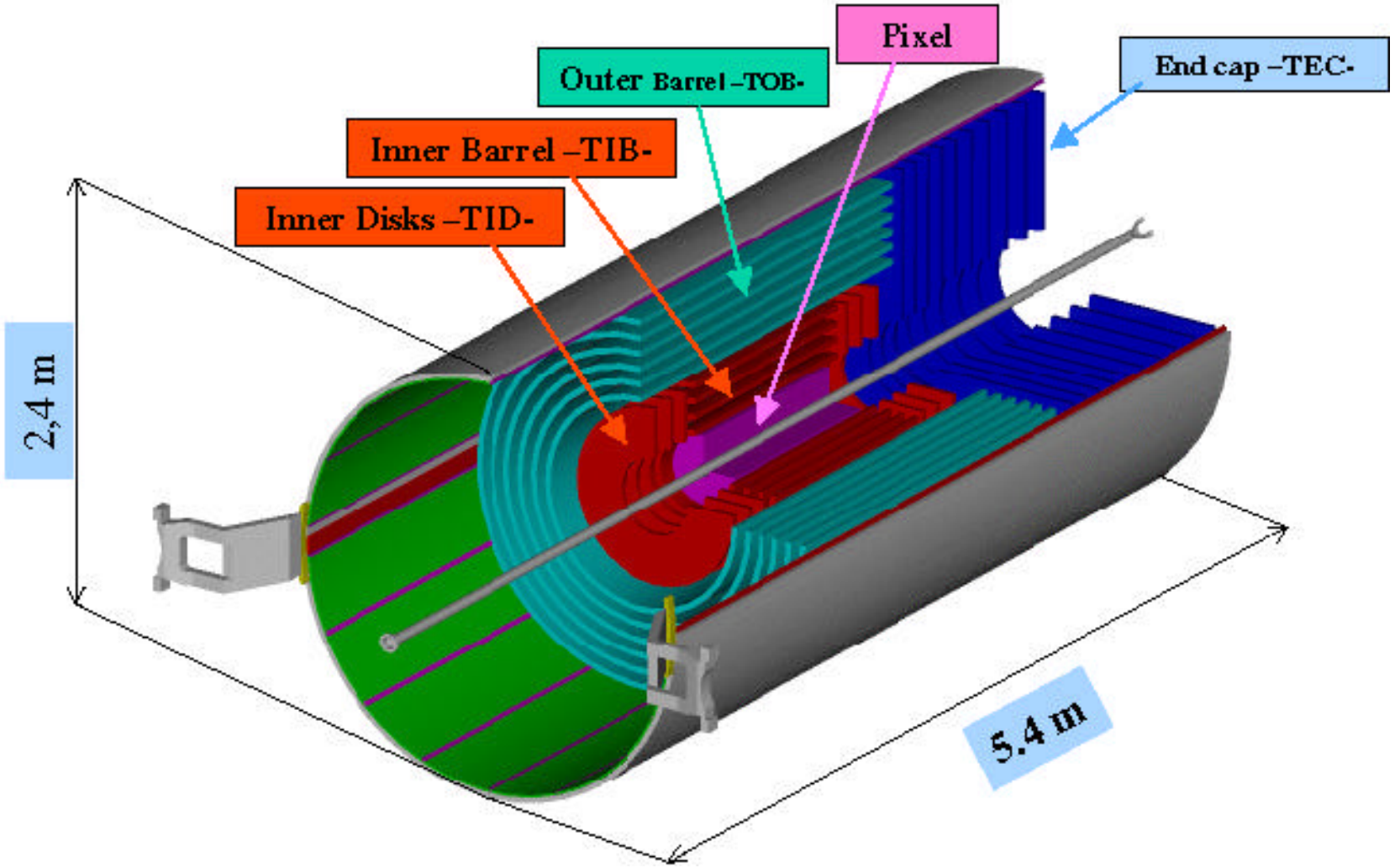
Summary

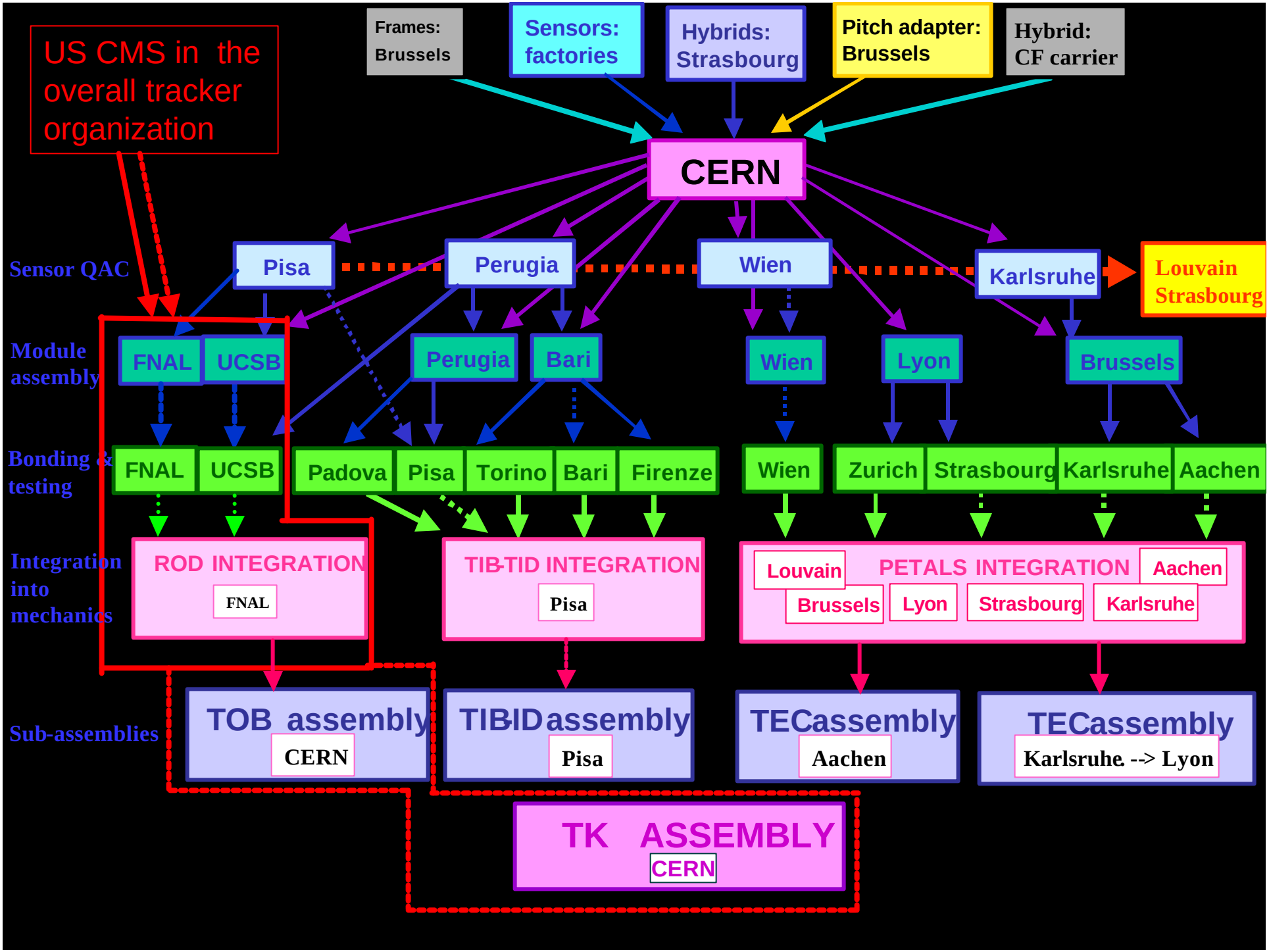
Si Tracker Group

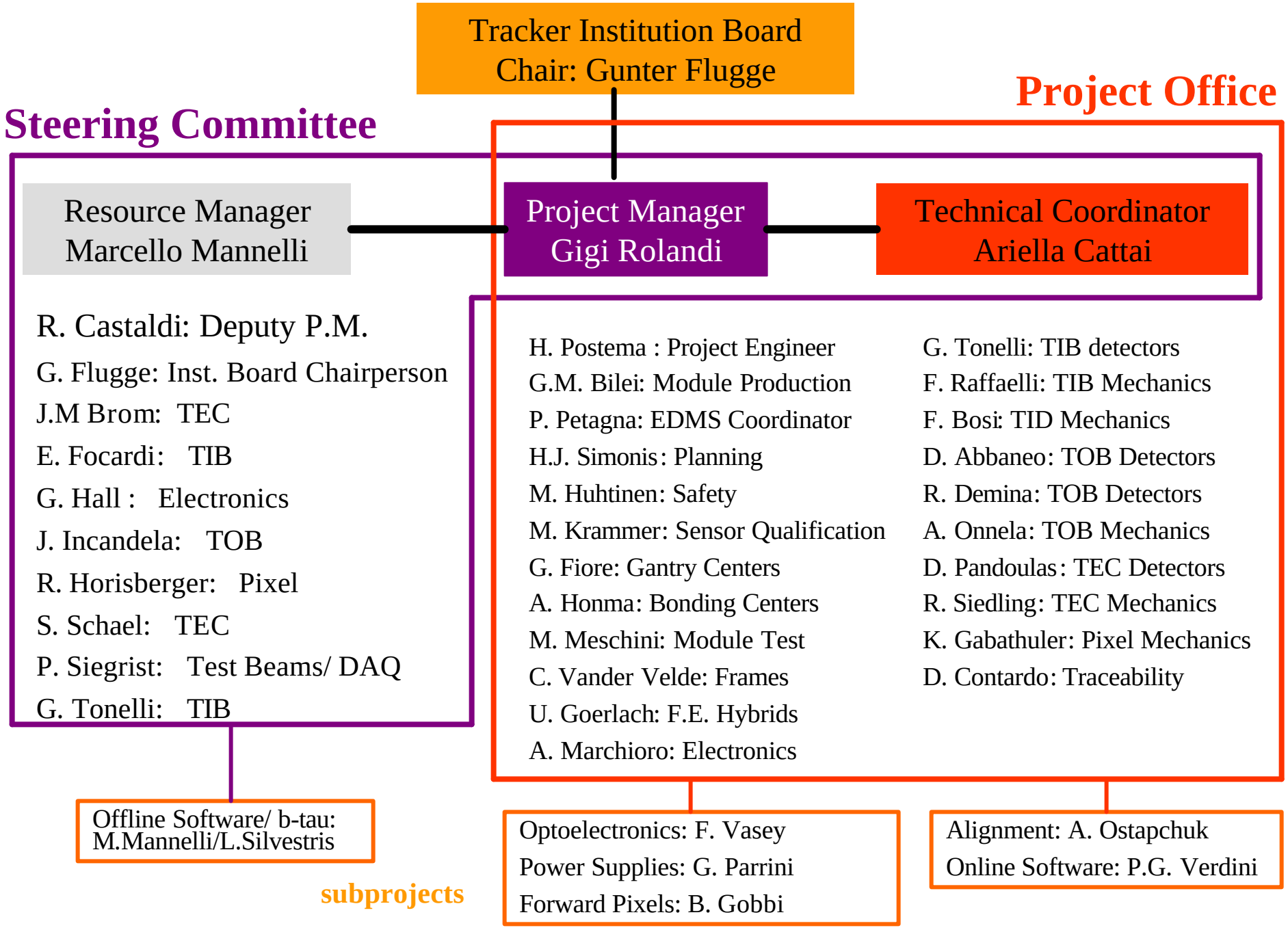
- Fermilab
  - B. Flaugher, R. Lipton, P. Rapidis, L. Spiegel, S. Tkaczyk
- Kansas State University
  - T.Bolton,R.Demina,W.kahl, S.Korjenevski, M.Kubantsev,W.Reay, R.Sidwell, N.Stanton
- Northwestern University
  - D. Buchholz
- Texas Tech University
  - A. Sill
- University of California, Riverside
  - Gail Hanson, *Gabriella Pasztor*
- University of California, Santa Barbara
  - *A. Affolder*, C.Campagnari, D. Hale, J.Incandela, *R. Taylor, D. White*
- University of Illinois, Chicago
  - *E. Chabalina*, C. Gerber
- University of Kansas
  - P. Baringer, A. Bean, *L. Christofek*, X. Zhao
- University of Rochester
  - *R. Eusebi, E. Halkiadakis*, A. Hocker, P. Tipton

Two new groups will support the UCSB production line and many *new faces*

CMS Tracker


Pixel
Outer Barrel –TOB-
End cap –TEC-
Inner Barrel –TIB-
Inner Disks –TID-
2,4 m
5,4 m

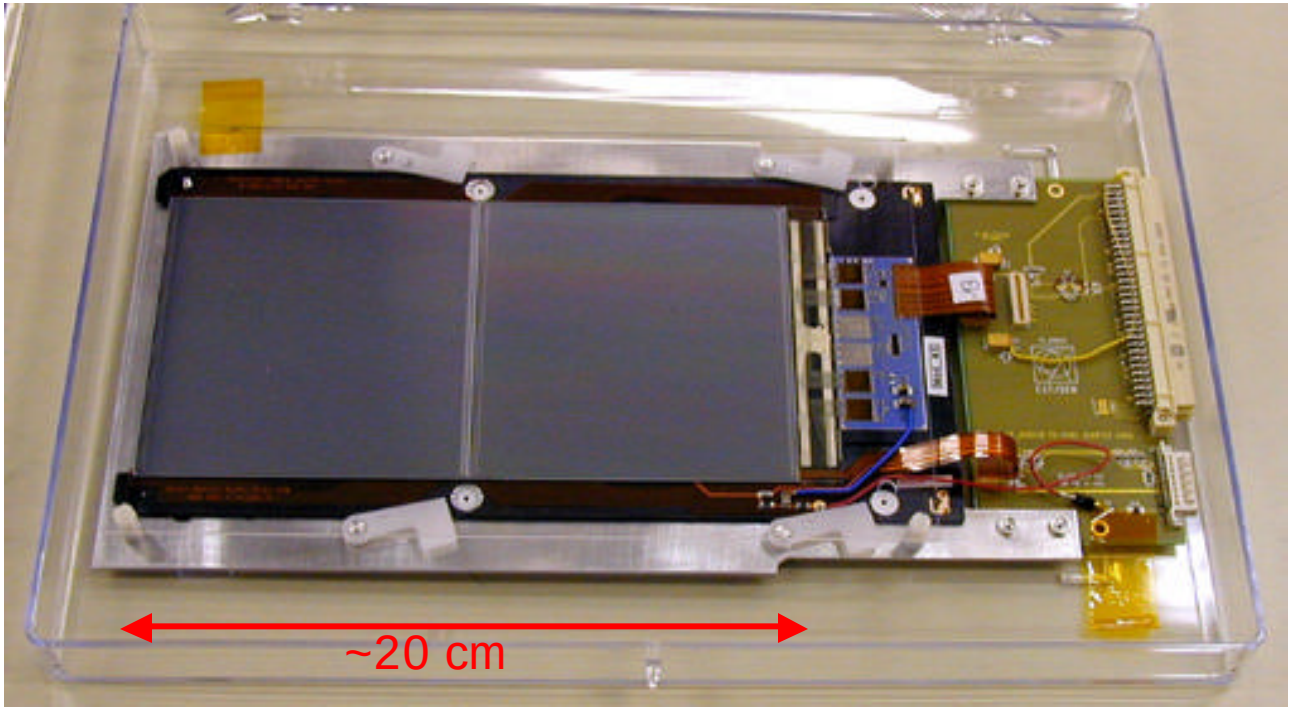

US CMS in the overall tracker organization
Frames: Brussels
Sensors: factories
Hybrids: Strasbourg
Pitch adapter: Brussels
Hybrid: CF carrier
CERN
Sensor QAC
Pisa
Perugia
Wien
Karlsruhe
Louvain Strasbourg
Module assembly
FNAL
UCSB
Perugia
Bari
Wien
Lyon
Brussels
Bonding & testing
FNAL
UCSB
Padova
Pisa
Torino
Bari
Firenze
Wien
Zurich
Strasbourg
Karlsruhe
Aachen
Integration into mechanics
ROD INTEGRATION
FNAL
TIB-TID INTEGRATION
Pisa
Louvain
PETALS INTEGRATION
Aachen
Brussels
Lyon
Strasbourg
Karlsruhe
Sub-assemblies
TOB assembly
CERN
TIB-TID assembly
Pisa
TEC assembly
Aachen
TEC assembly
Karlsruhe --> Lyon
TK ASSEMBLY
CERN


Tracker Institution Board
Chair: Gunter Flugge
Project Office
Steering Committee
Resource Manager
Marcello Mannelli
Project Manager
Gigi Rolandi
Technical Coordinator
Ariella Cattai
R. Castaldi: Deputy P.M.
G. Flugge: Inst. Board Chairperson
J.M Brom: TEC
E. Focardi: TIB
G. Hall : Electronics
J. Incandela: TOB
R. Horisberger: Pixel
S. Schael: TEC
P. Siegrist: Test Beams/ DAQ
G. Tonelli: TIB
H. Postema : Project Engineer
G.M. Bilei: Module Production
P. Petagna: EDMS Coordinator
H.J. Simonis: Planning
M. Huhtinen: Safety
M. Krammer: Sensor Qualification
G. Fiore: Gantry Centers
A. Honma: Bonding Centers
M. Meschini: Module Test
C. Vander Velde: Frames
U. Goerlach: F.E. Hybrids
A. Marchioro: Electronics
G. Tonelli: TIB detectors
F. Raffaelli: TIB Mechanics
F. Bosi: TID Mechanics
D. Abbaneo: TOB Detectors
R. Demina: TOB Detectors
A. Onnela: TOB Mechanics
D. Pandoulas: TEC Detectors
R. Siedling: TEC Mechanics
K. Gabathuler: Pixel Mechanics
D. Contardo: Traceability
Offline Software/ b-tau:
M.Mannelli/L.Silvestris
subprojects
Optoelectronics: F. Vasey
Power Supplies: G. Parrini
Forward Pixels: B. Gobbi
Alignment: A. Ostapchuk
Online Software: P.G. Verdini

TOB Geometry

Layer	Avg. radius	Modules / phi	Total # of modules	APV / det	Pitch phi	Pitch stereo	Total # of APVs
TOB1	610	42	504	4 + 4	183	183	4,032
TOB2	696	48	576	4 + 4	183	183	4,608
TOB3	782	54	648	4	183	-	2,592
TOB4	868	60	720	4	183	-	2,880
TOB5	965	66	792	6	122	-	4,752
TOB6	1080	74	888	6	122	-	5,328

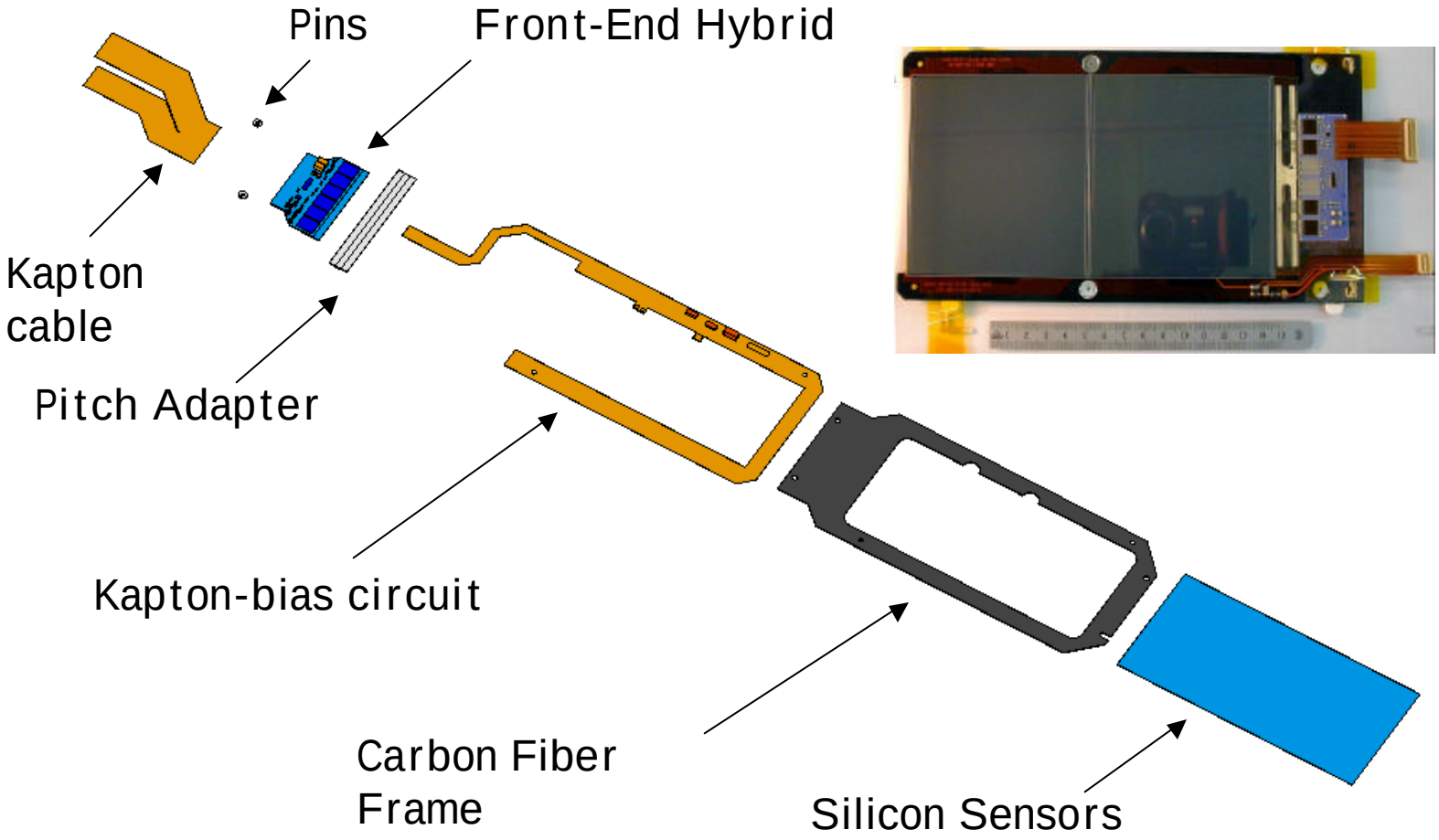
US Tasks



~6,000 Tracker Outer Barrel (TOB) modules

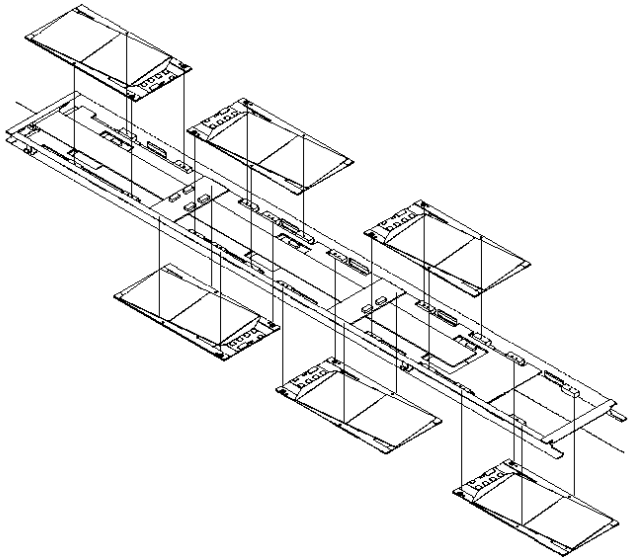
Current plan 2/3:1/3 constructed at FNAL:UCSB

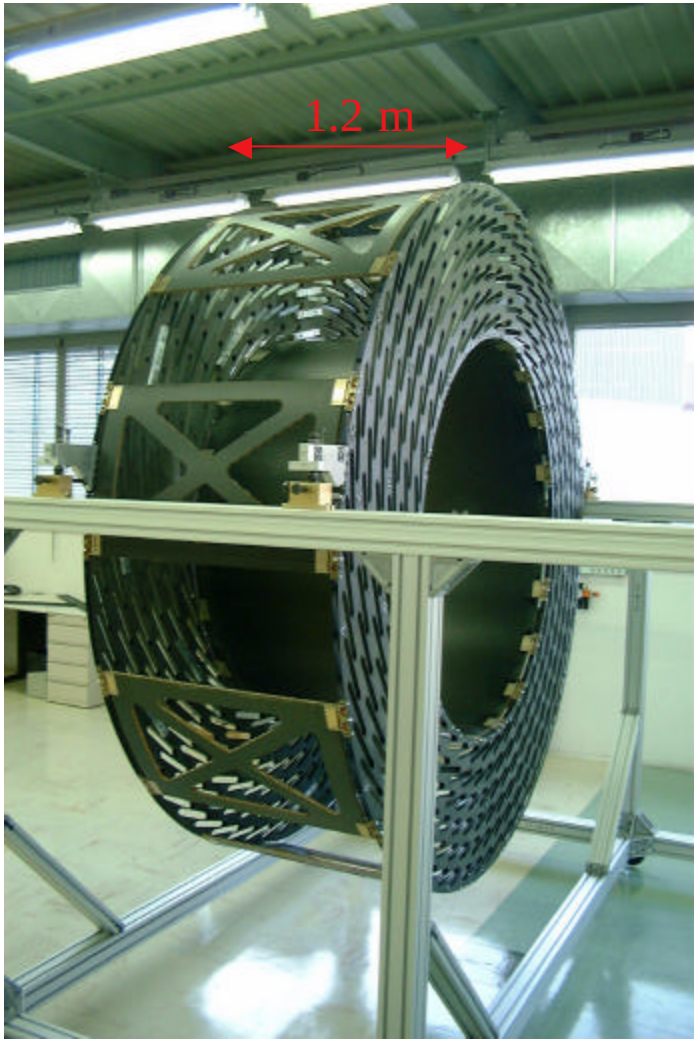
Module Components*



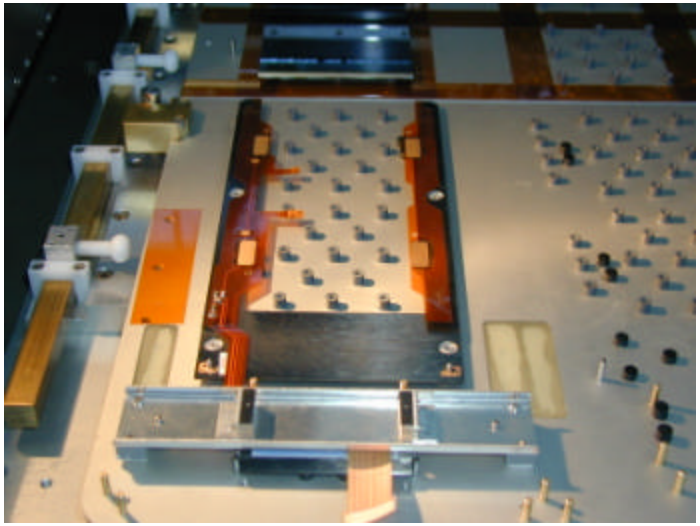
*All components procured by European groups

Rods & Wheels



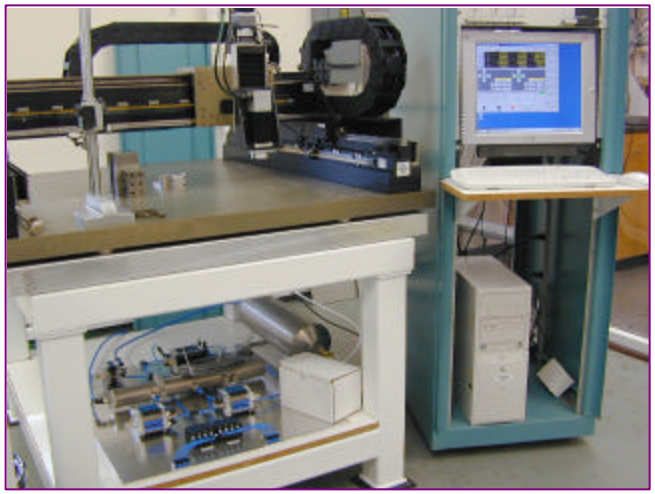


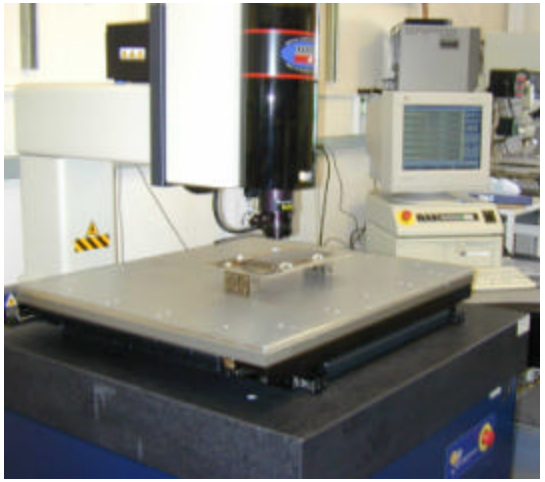
FNAL Production Center
(See talk by Lenny Spiegel)



- **FNAL pick and place gantry for automated module assembly**
  - **Made 7 very high quality pre-series TOB modules**
    - **All were reported to be fully functional in this month's test beam**
    - **Components in hand for more pre-series but…**
  - **Currently gantry down after move to final location in Lab D**

UCSB Production line

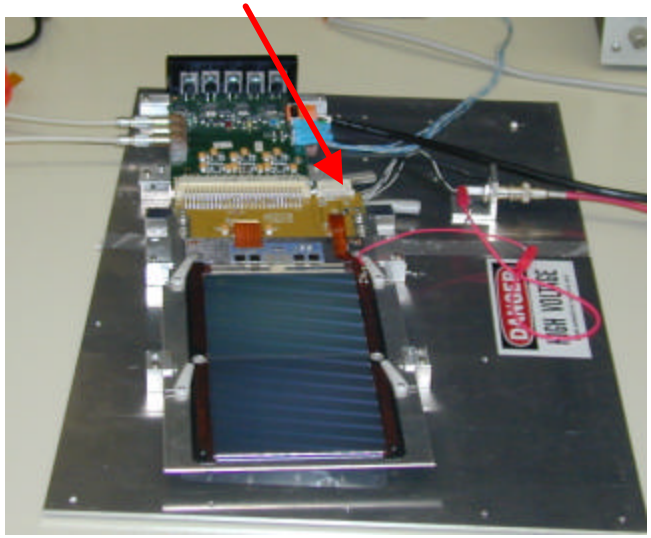




- **Significant progress.**
  - **Clean room expanded. K&S 8090 wirebonder now practicing on Babar modules. OGP functioning – for mechanical inspection of modules.**
  - **Gantry arrived in March, setup well underway.**
- **New post-docs**
  - **Russell Taylor (OPAL) – lead for mechanical assembly and wirebonding**
  - **Tony Affolder (CDF Silicon) – lead electronic testing**
- **New groups (UCR, and TTU) will support production line at UCSB.**

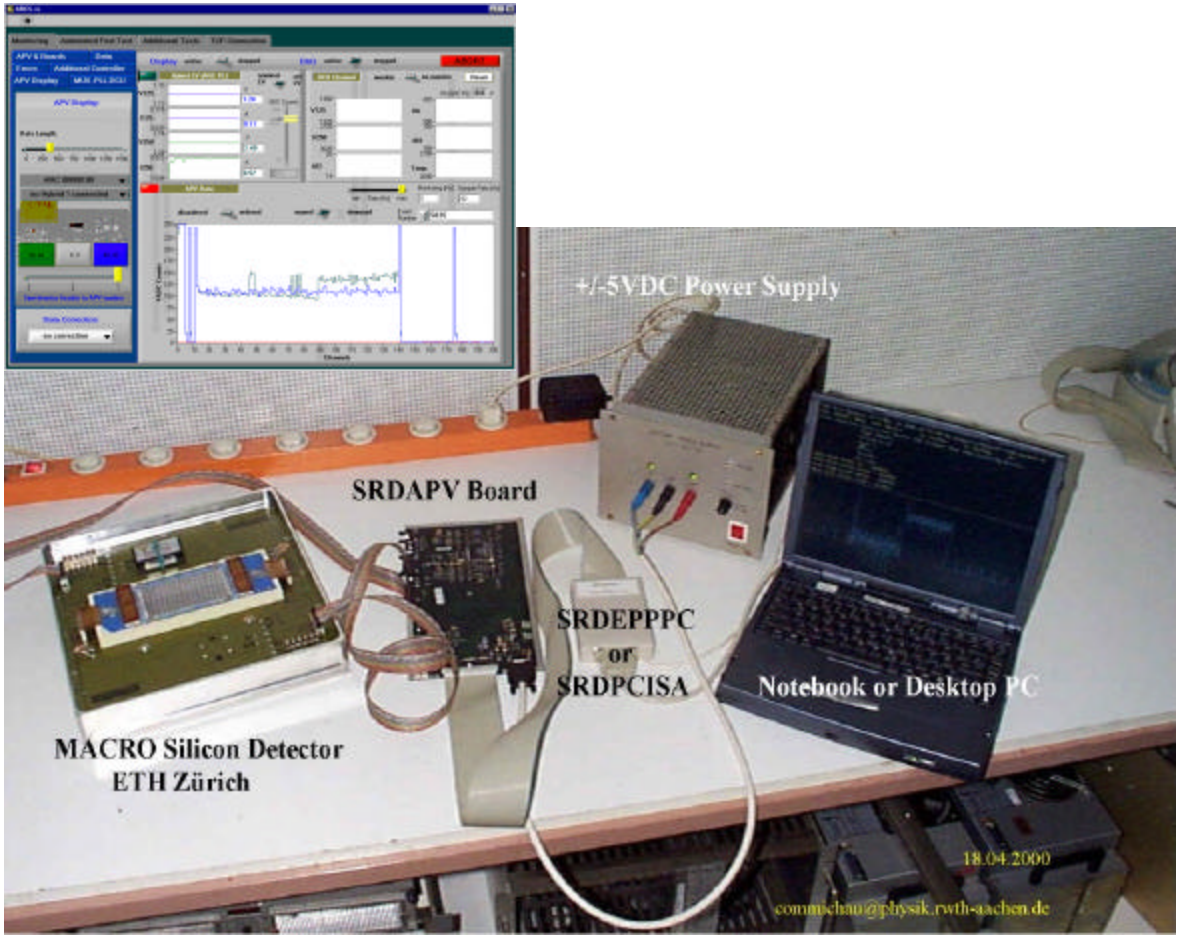
Test Stands
(see talk by Elizaveta Chabalina)

Functioning TOB module made at FNAL



ARCS* test stand now functioning at FNAL

- Fast testing and Burn-in of hybrids and modules



- We have 2 ARC stands and 2 full DAQ test stands
- We will receive 5 more ARC stands and 2 more full DAQ test stands
- We are fully trained in operation of these systems

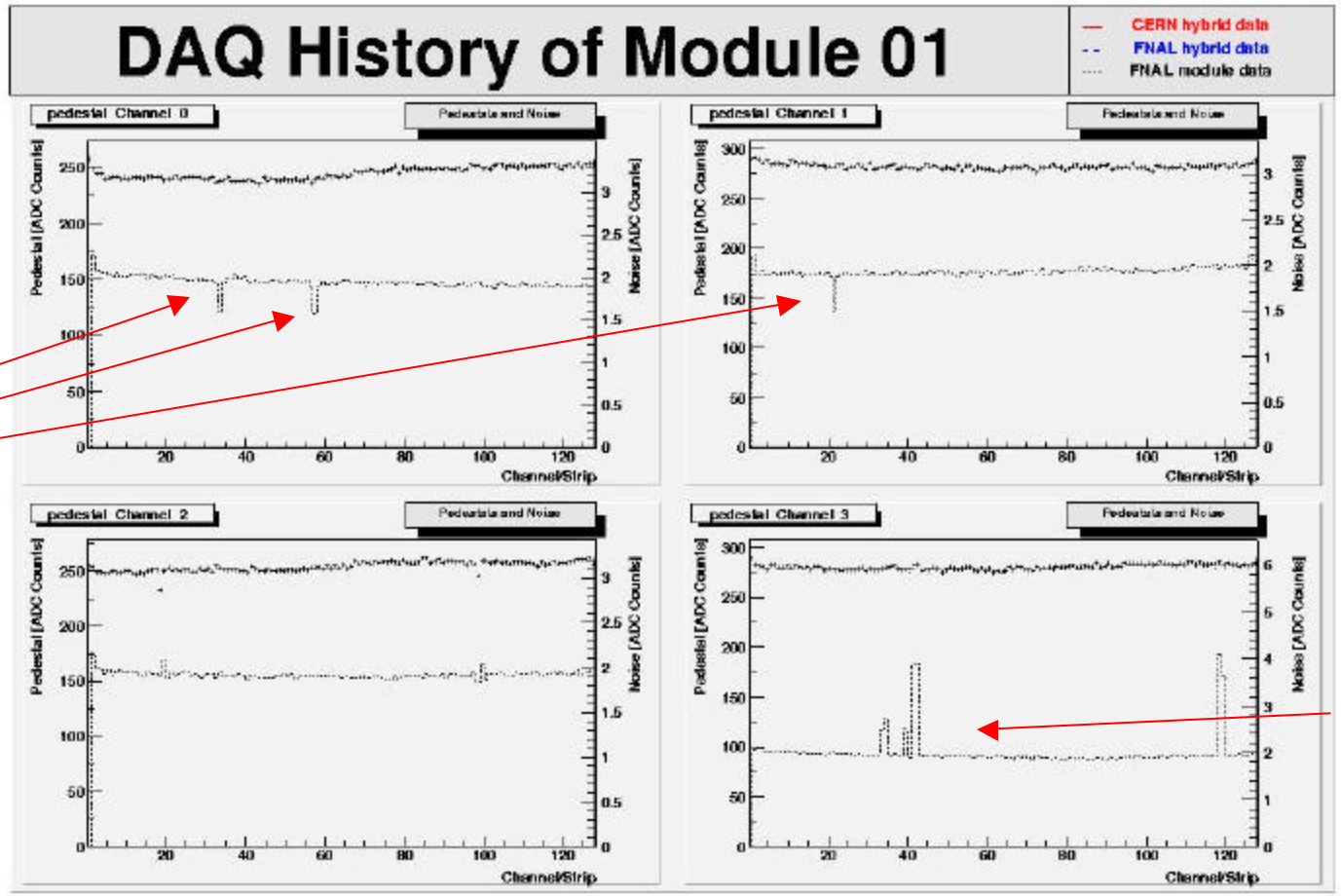
*APV Readout Controller Software

Test Results

Modules are tested after assembly at FNAL and again at CERN.

Pinholes*:

channels
33
57
405

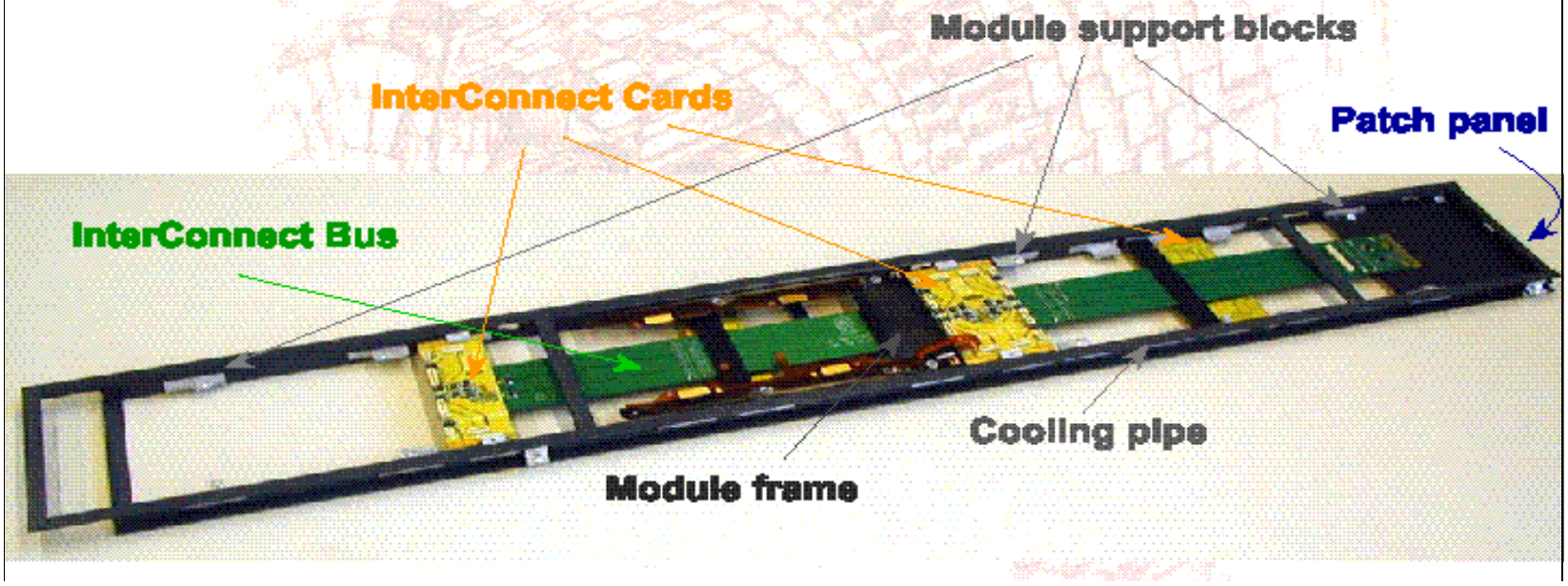


Noisy channels introduced by pitch adaptor

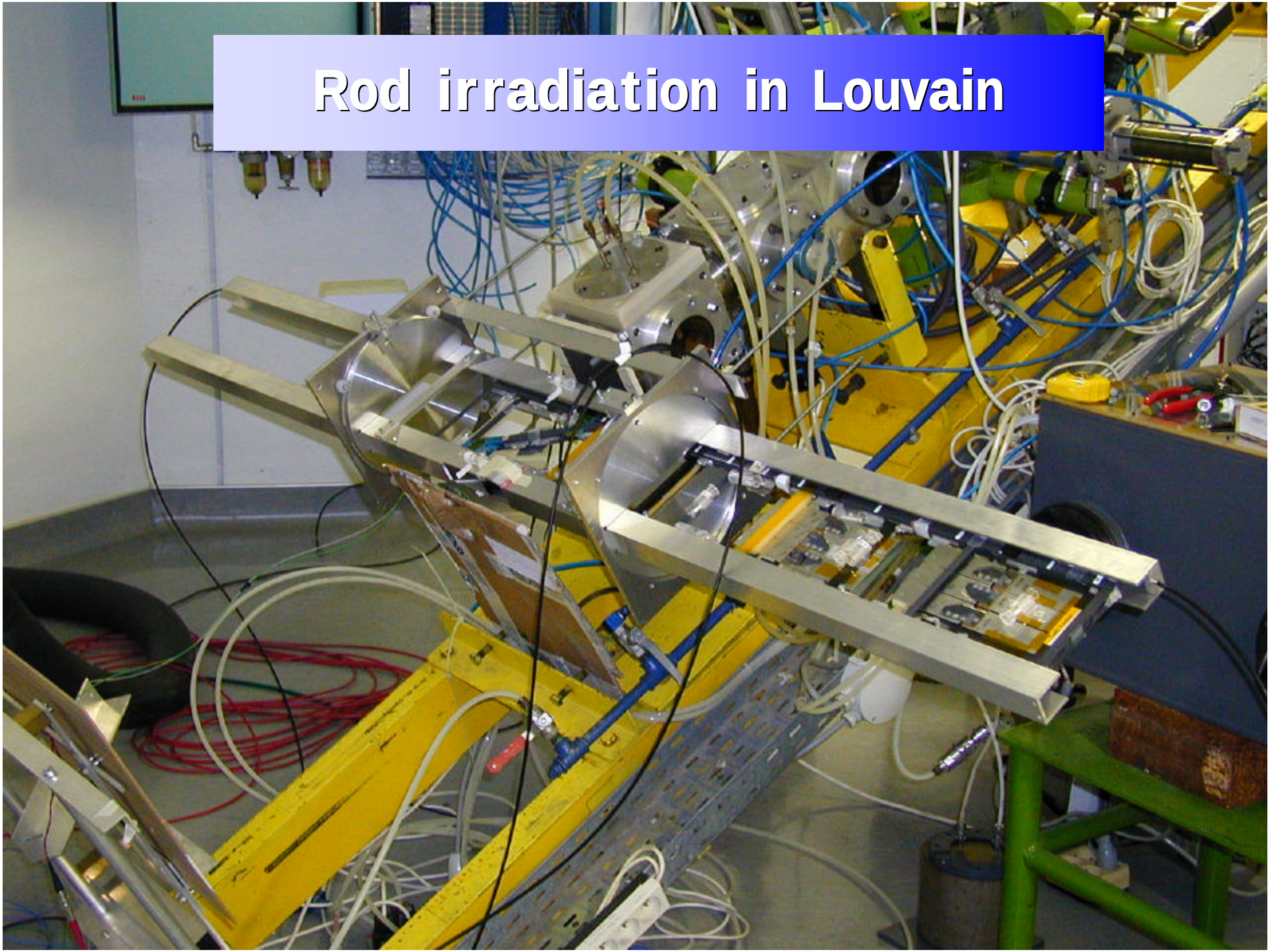
*Channels disconnected from readout due to pinholes show lower noise

Rods

- 6 (12) Modules per single (double) sided rod
- Preliminary tests complete
  - Interconnect bus and cards tested with 12 hybrids and associated opto-hybrids: definitive test of bus.
  - **Signals are very clean!**



Rod irradiation in Louvain



Delay: HIP's and Pinholes (see talk by Slawek Tkaczyk)

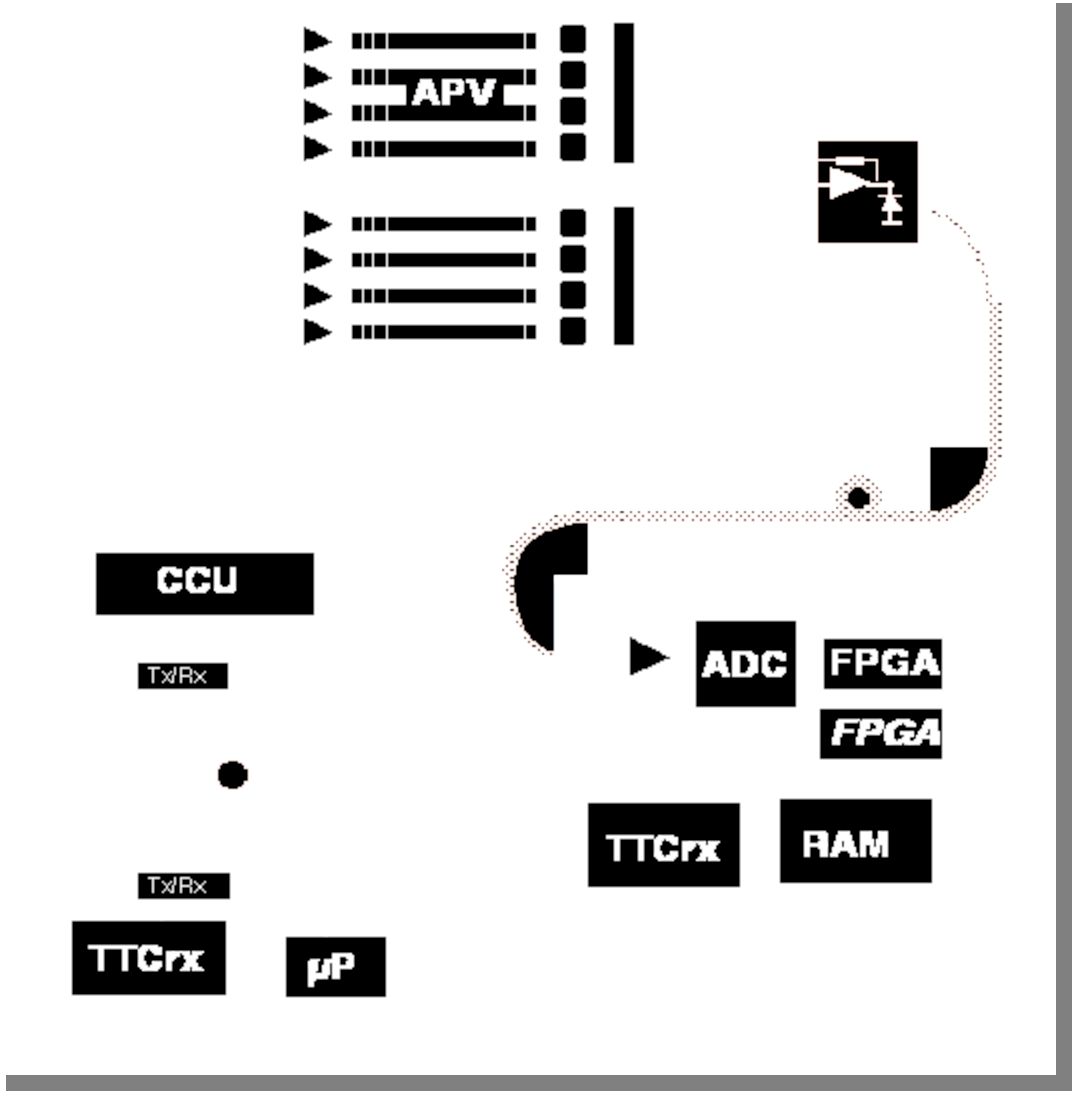
- **Read my HIPS: Highly Ionizing Particle–HIP (rare)**
  - **Due to nuclear interactions in the silicon**
  - **Big signal on a few strips, and can saturate all 128 channels of APV for ~200ns**

- **Pinhole**
  - **A short between metal and implant of strip coupled into APV Front end resulting in DC dark current into APV**
  - **Problematic when current is high and more than one pinhole present**

- **Solution (based on lab tests):**
  - **reduce bias resistor on the hybrid by a factor of 2.**
    - **minimizes rate of the effect to a negligible APV inefficiency**
    - **increases tolerable minimum number of pinholes to four**
    - **in cases where over 4 pinholes are present in APV during running - reduction of chip dynamic range (by switching the inverter off) can extend chip lifetime**

- **Other possible solutions studied include:**
  - **alternative sensor biasing schemes**
  - **redesign of the chip circuit (now ruled out)**

Tracker Readout System



Schedule Issues

Schedule.

- Hybrid schedule is the main issue but solutions appear to be in hand.
  - **We expect to have enough to start production this winter (current schedule)**
- FEDs.
  - **Initial models for testing of large quantities of FE hybrids and modules to be ready in late 2002.**
  - **Optical models for rod testing will be available 6/03.**
- Optical hybrids for assembly of modules into Rods will be available in 2002.
- Rod Assembly will wait for optical FEDs however.

Other items not expected to cause delays.

Status of Component Orders

- Sensors:
  - For the TOB, we will have a large supply arriving from ST starting this summer
- Frames: Orders starting this summer for fall
- Pitch Adapters: Will start with TOB 4 chip
- Optoelectronics: Tenders (4) finished and LOI sent for some contracts

- Central tube Thermal screen: in preparation
- TOB mechanics: one tender finished, one in preparation
- TIB/TID mechanics: in preparation
- TEC mechanics: procurement started

Not on critical path

*status as of ~3/1/02

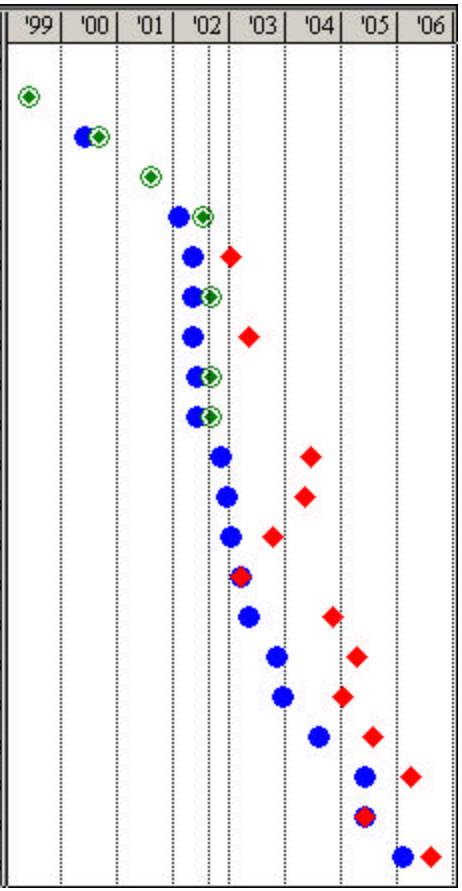
Current Tracker Schedule

Task Name	Start	Finish
Assembly of M200 at gantry	12/3/01	2/28/02
Pre-series sensors (ST)	2/7/02	5/20/02
Production sensors (ST)	5/7/02	12/23/03
Start delivery of TOB sensors to gantry centers		5/21/02
Frames production	7/1/02	9/3/04
Start delivery of TOB frames to gantry centers		7/22/02
Hybrids pre-production	2/11/02	4/1/02
Assembly 400 hybrids	6/19/02	9/10/02
Start delivery of 1st batch of 100 hybrids to gantry centers		4/15/02
Start delivery of 2nd batch of 250 hybrids to gantry centers		7/31/02
Start delivery of production hybrids to gantry centers		11/19/02
TOB Module Construction (J.I.)*	*1/5/03*	*3/1/05*
First 8 production FED delivered		6/1/03
Installation of TOB modules on rods	6/27/03	4/15/05
Installation of rods in mechanics	1/5/04	4/15/05
TOB complete		4/15/05

***Production likely to overlap CDF and D0 Run 2b projects at SiDet.**

US CMS
SiTrkr Milestones (v31)

System	Level?	CMS ID	Milestone	v31 Base	Current Start	Variance
			Silicon Tracker System (WBS 1.8)	**NA**	**Feb 28 '99**	**0 days**
SiTrkr	ML3	T-023	Deliver Front-End Chips for Prototype Construc	Feb 28 '99	Feb 28 '99	0 days
SiTrkr	ML2	T-1045	Tender for Sensors	Feb 29 '00	May 31 '00	66 days
SiTrkr	ML2	T-1026	Start Delivery of Front-End Chips	Apr 30 '01	Apr 30 '01	0 days
SiTrkr	ML2*	T-027	Begin Sensor Module Construction (for M200)	Oct 31 '01	Apr 1 '02	97 days
SiTrkr	ML2	T-1055	M200 Modules Ready for Installation	Jan 31 '02	Oct 1 '02	173 days
SiTrkr	ML2	T-1066	TOB: First Rod Ready	Jan 31 '02	May 22 '02	79 days
SiTrkr	ML2	T-1067	TOB: TOB Ready for Module Integration	Jan 31 '02	Jan 31 '03	250 days
SiTrkr	ML2	T-1068	First Assembled Rod Ready	Feb 28 '02	May 22 '02	59 days
SiTrkr	ML2	T-1069	Rod Ready for Burn-In	Feb 28 '02	May 22 '02	59 days
SiTrkr	ML2*	T-1070	25% of Rods Complete	Jul 31 '02	Mar 1 '04	390 days
SiTrkr	ML2	T-1056	1000 Modules Produced and Ready for Installat	Aug 31 '02	Feb 2 '04	347 days
SiTrkr	ML3	T-1071	Delivery TOB Disks and Panels to CERN	Sep 30 '02	Jul 1 '03	185 days
SiTrkr	ML2	T-1072	TOB Wheel Ready	Nov 30 '02	Nov 30 '02	0 days
SiTrkr	ML3	T-1073	50% of Rods Completed	Jan 31 '03	Aug 2 '04	379 days
SiTrkr	ML3	T-1075	75% of Rods Completed	Jul 31 '03	Jan 6 '05	352 days
SiTrkr	ML3	T-1076	50% of Rods Mounted into the Tracker Wheel	Aug 31 '03	Sep 30 '04	271 days
SiTrkr	ML2*	T-1077	Delivery of TOB to the Tracker	Apr 30 '04	Apr 15 '05	239 days
SiTrkr	ML2	T-013	Tracker Transported to SX5	Feb 28 '05	Dec 15 '05	208 days
SiTrkr	ML2	T-1101	Integrated Si Strip Tracker at SX5, Ready for Ins	Feb 28 '05	Feb 28 '05	0 days
SiTrkr	ML1	T-014	End Installation and Cabling of SiTrkr in UX5	Oct 31 '05	May 1 '06	120 days

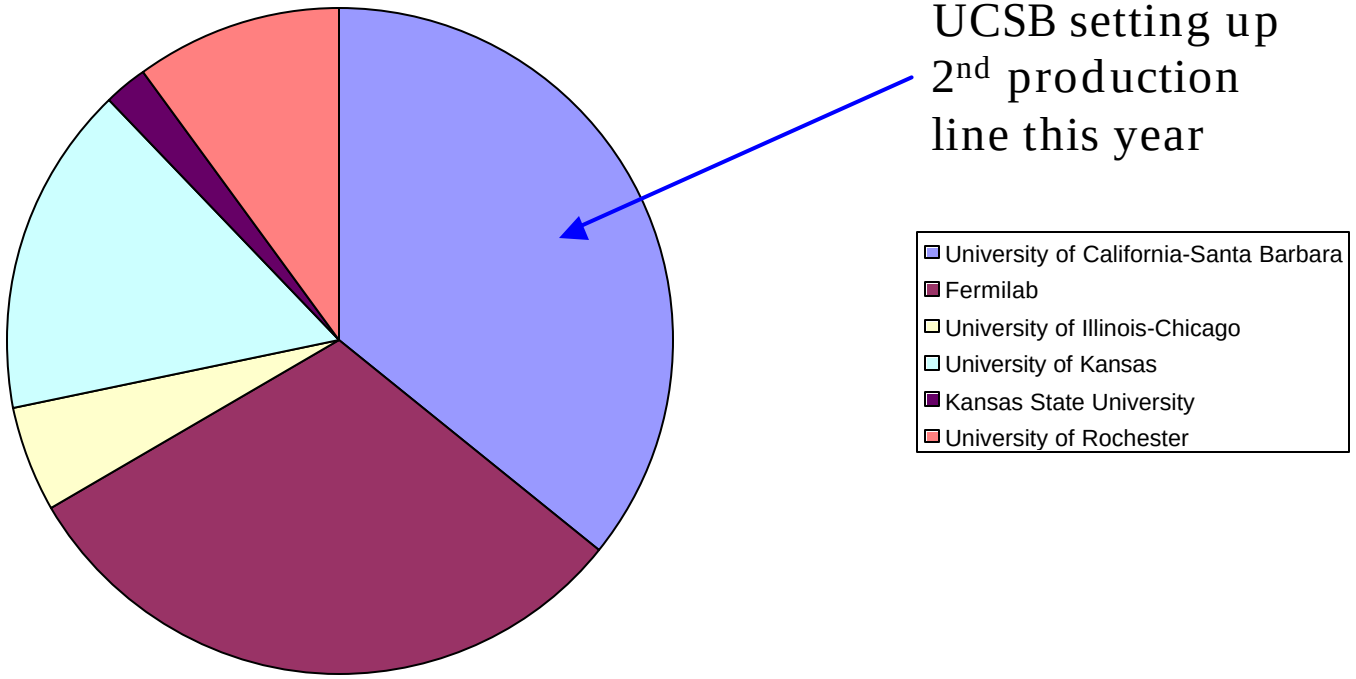


Cost Performance

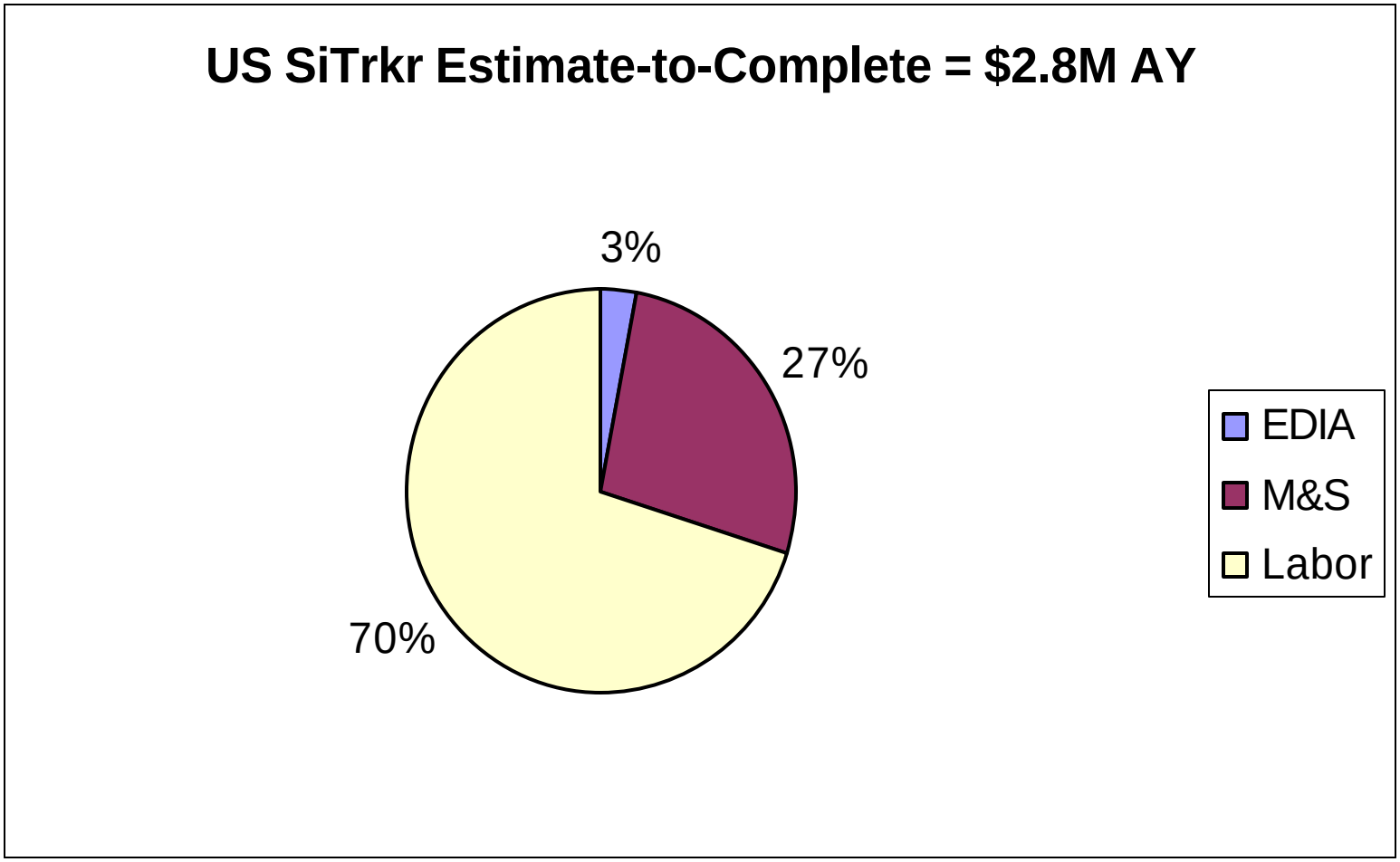
- Equipment
  - Completed purchases of most major eqpt items.
    - Gantry 1 – slightly over budget (~10%)
    - Gantry 2 – on budget
    - Wirebonder 1 – (5% over budget)
    - Wirebonder 2 – looking at used (40% below budget)
    - Test stands – as expected
- Setup costs
    - Gantry 1 – slightly over budget
    - Gantry 2 – no significant costs so far
- Production
    - No significant activity or costs so far...

US SiTrkr FY02 Planning

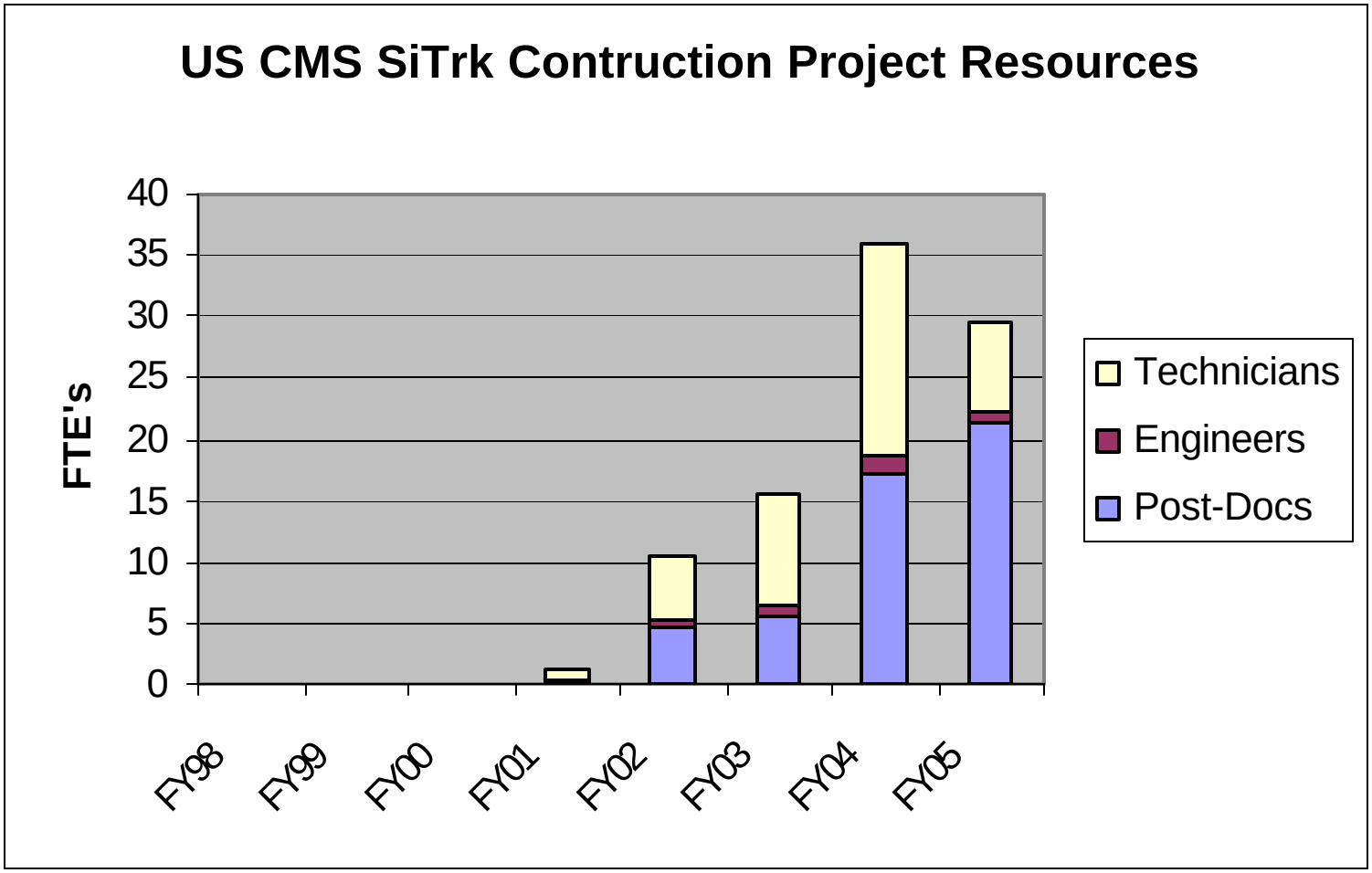
Silicon Tracker SOWs FY02 -- $1.3M



US SiTrkr Estimate-to-Complete



US SiTrkr Project Resources (FTE's)

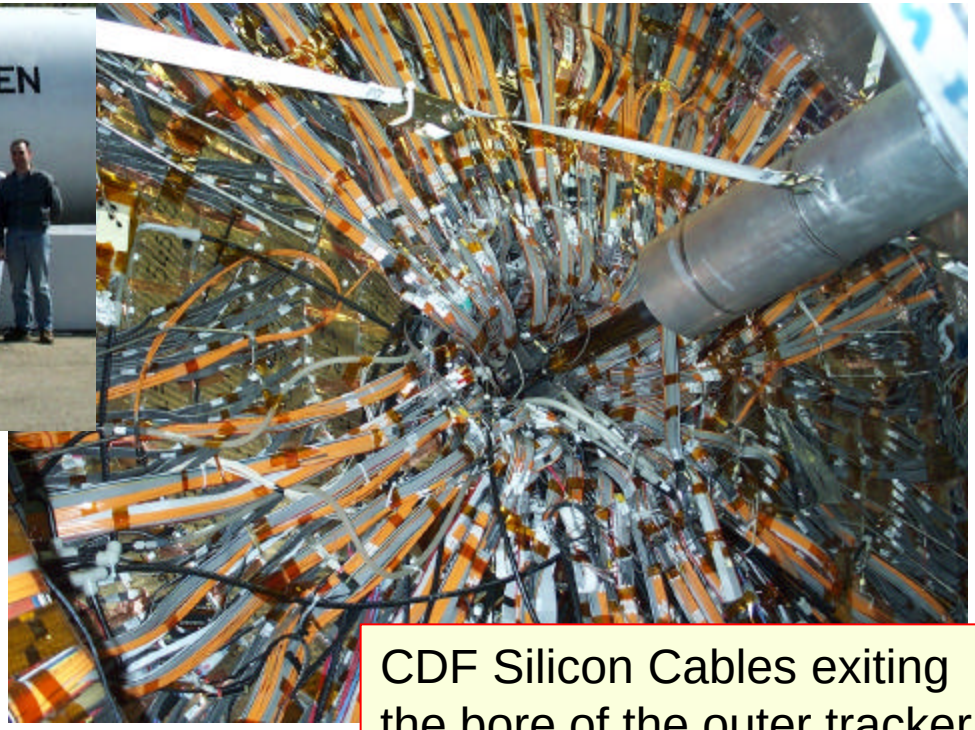


Project end & Transition to M&O

- **Our contribution to the installation and commissioning (I&C) and to the maintenance and operation (M&O) is important.**
  - **Installation/testing of rods in wheels (Jan 04 – April 05).**
    - **2-4 FTE Sr. Physicists, 7-10 Post-docs, students.**
      - **Testing modules on rods before installation.**
      - **Limited system tests/studies after installation.**
    - **1 FTE Engineer (base).**
      - **Rod & Module repairs, cooling system, mechanics.**
    - **Laboratory space and equipment for testing and repairs.**
  - **Starting in FY06 M&O support team must be in place.**
    - **We estimate 14 FTE post-docs/students at CERN together with continued engineering and technical support & associated M&S and operating costs for maintaining a small laboratory space for testing and repairs.**

CDF/DO Experience

CDF Silicon installation and operation group



CDF Silicon Cables exiting the bore of the outer tracker

- **CDF and D0 installation & operation**
  - **A very big job which takes many months and many people**
  - **Current operations requires 7-10 high level experts with backup of 10-15 additional operators and monitors**
- ***CMS Silicon is significantly larger most relevant measures***

Comment…

“ Our current commissioning effort is taking so long partially because of inadequate resources (both physicist and non-physicist). So, I would advise that for commissioning especially, you do not underestimate the need or overestimate the quality of resources available - ask for enough dedicated engineers to complement as many physicists as you can get.”

Chris Hill –

Co-leader

CDF Silicon Operations Group

Summary & Conclusions

- **Some components were delayed.**
  - **Technical concerns addressed.**
    - **No show stoppers.**
    - **Hybrid issues mainly related to cost appear to be rapidly converging on a solution**
  - **Production start late this year/early next.**
    - **Schedule appears to be holding well.**
    - **US group will be ready.**
- **Completion of project in Spring 2005.**
- **Based on CDF/D0 experience, significant resources will be needed for I&C and M&O.**