A new STAR Silicon Tracker

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Workshop on STAR Near Term Upgrades
Yale, Jun. 16, 2004

Outline

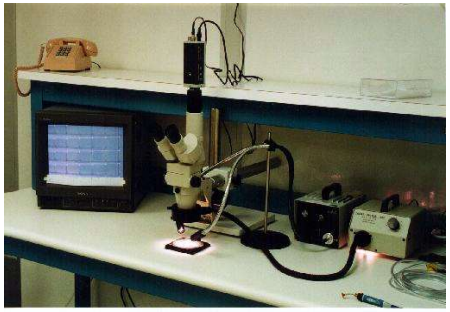
- Silicon capabilities at
  - The 'past'
  - The future in terms of resources for
- Rough sketch of a new tracker
  - Conceptual design
  - Cost estimate

Silicon Lab Infrastructure at MIT LNS

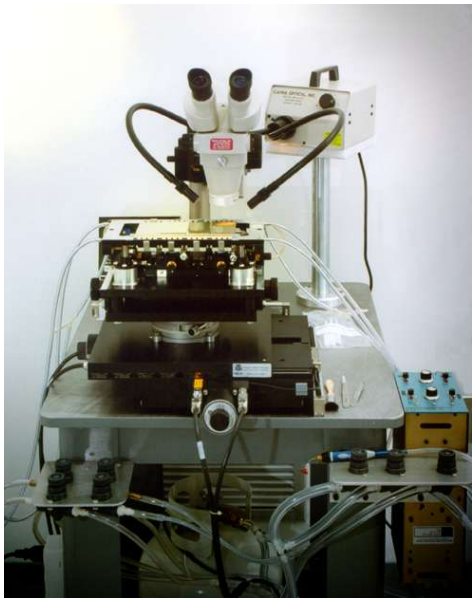
Laboratory for Nuclear Science

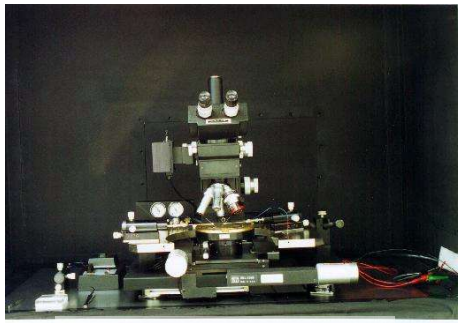
Hughes 2470-V bonder

Inspection stations



Gluing Station





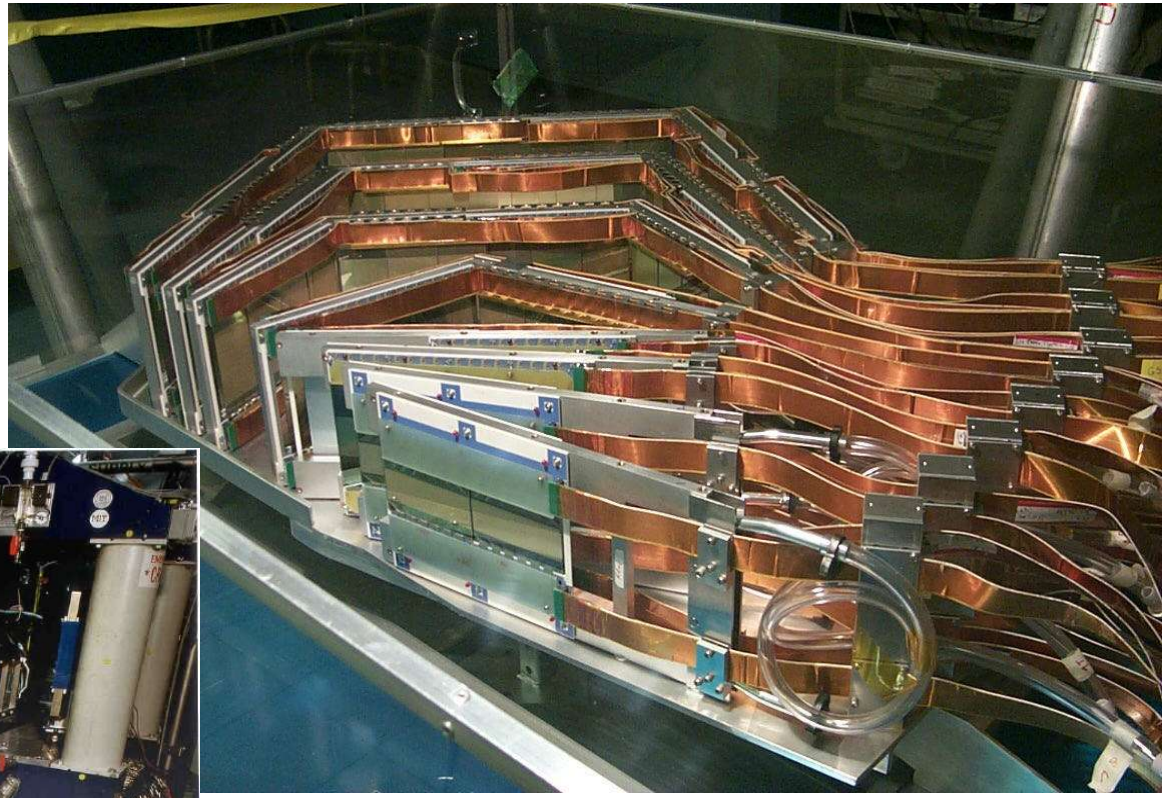
Probe Station

Clean Room

Survey Station

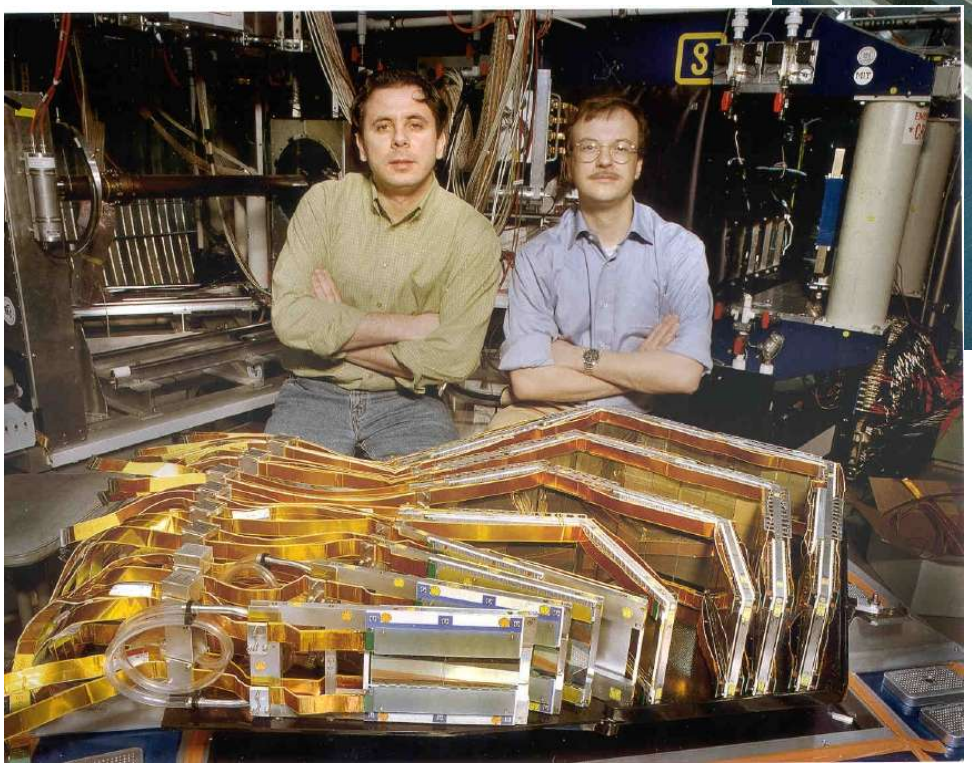
Source Test Stations

Two PHOBOS Spectrometer Arms



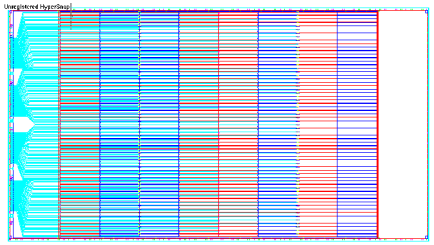
Negative Arm (1999)

Positive Arm (2001)

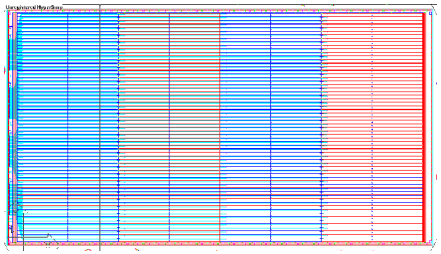


Light in the Tunnel, this is what it took

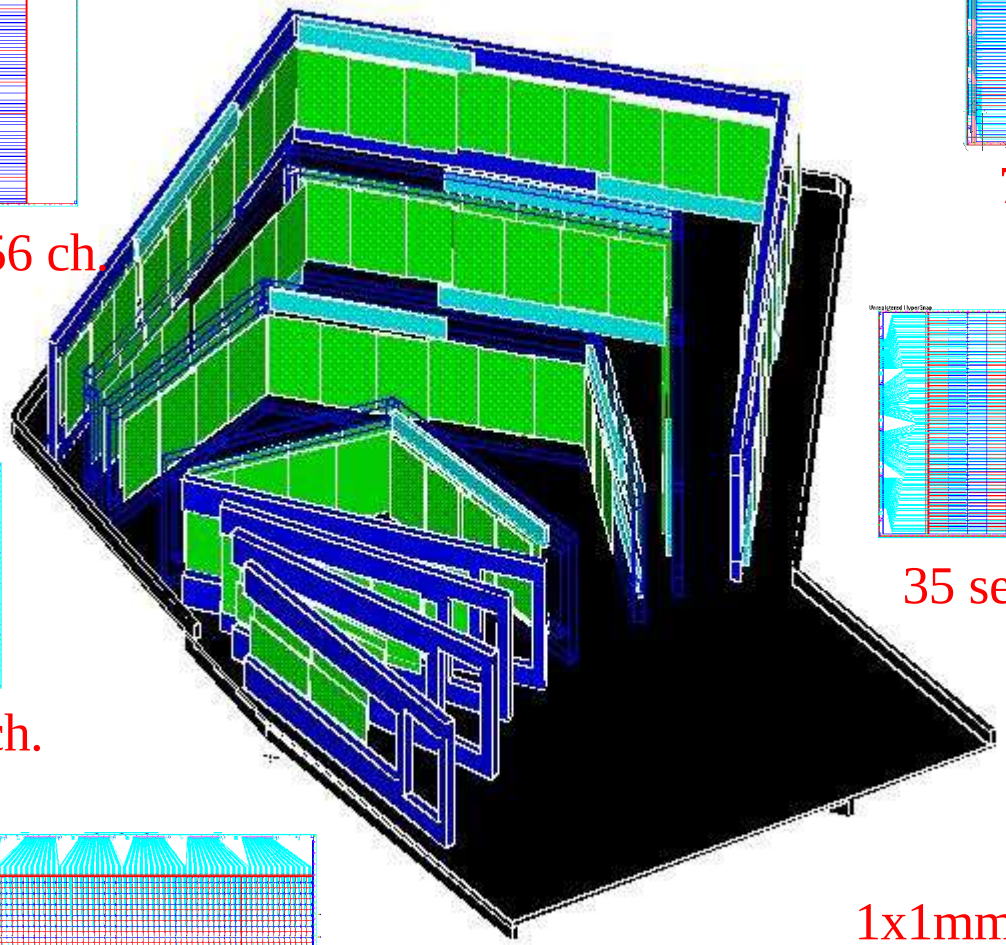
5 Sensor Types

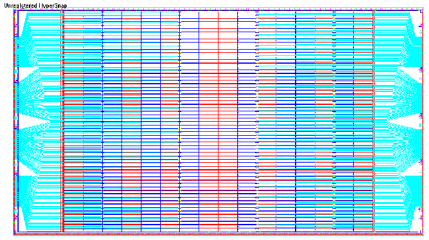


28 sensors x 256 ch.

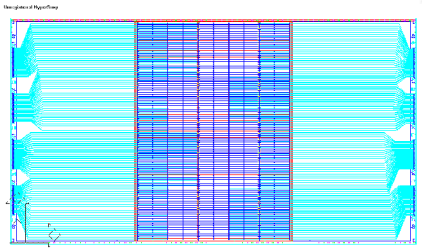


76 sensors x 256 ch

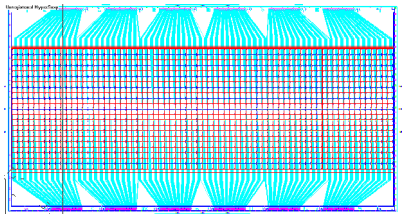




35 sensors x 512 ch.



21 sensors x 500 ch.

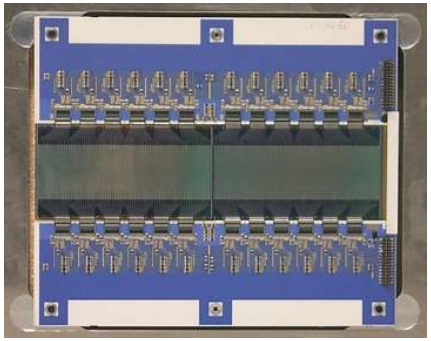


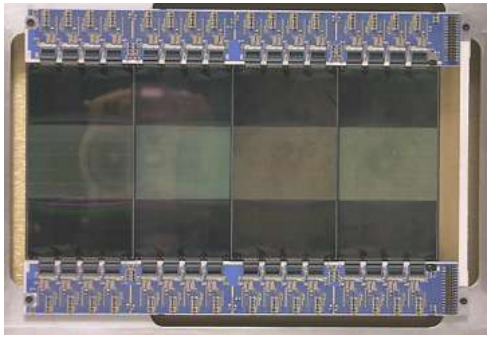
12 sensors x 1536 ch.

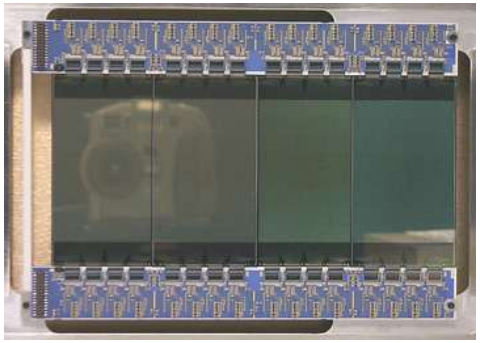
1x1mm to 0.7x19mm pads
73728 channels/arm

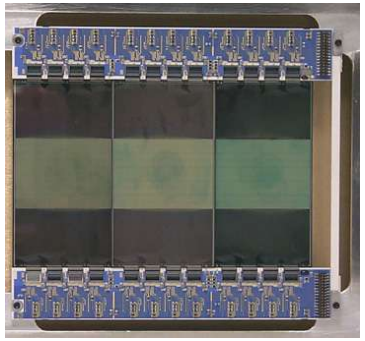
Total of 172 Sensors per Spectrometer Arm, mounted on.....

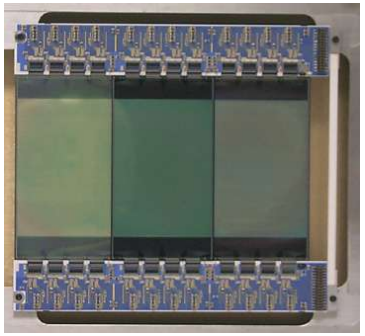
9 Module Types

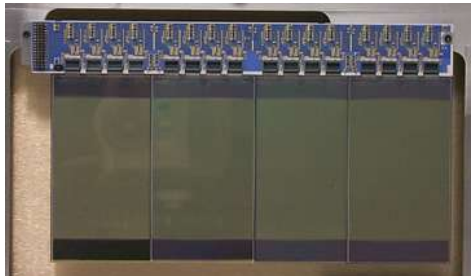
6* 

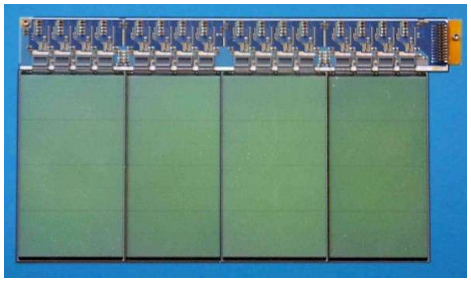
3* 

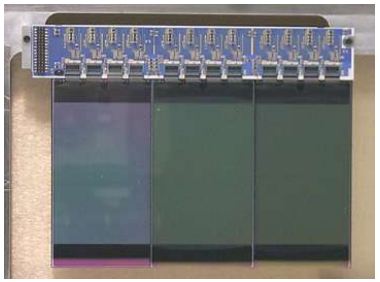
5* 

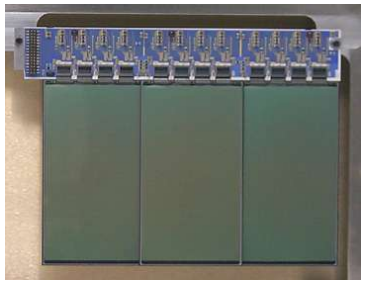
3* 

5* 

4* 

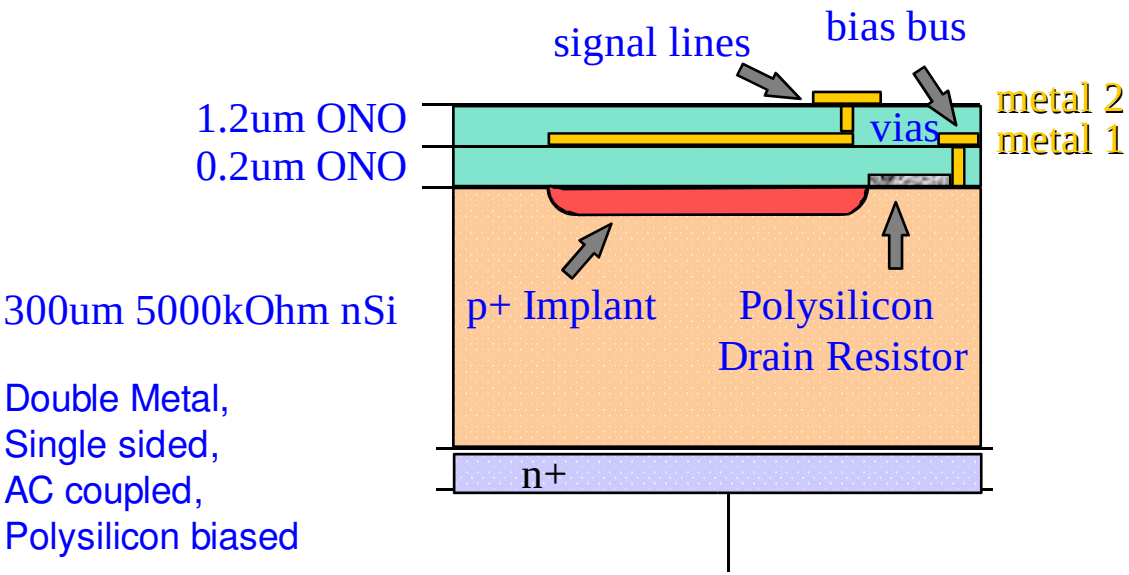
7* 

4* 

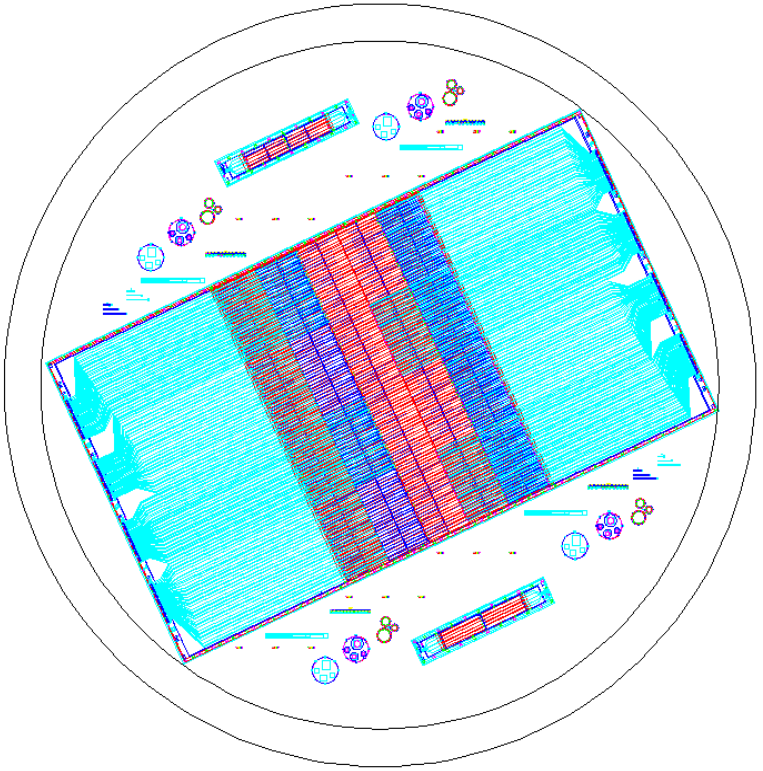
16* 

Total of 53 Modules per Spectrometer Arm

Silicon Sensor Testing: TestKeys



Double Metal,
Single sided,
AC coupled,
Polysilicon biased



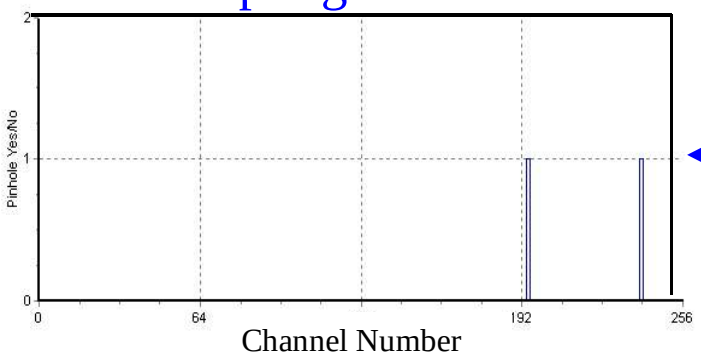
TestKeys

Thin ONO | Thick ONO | PN junction | Polysilicon

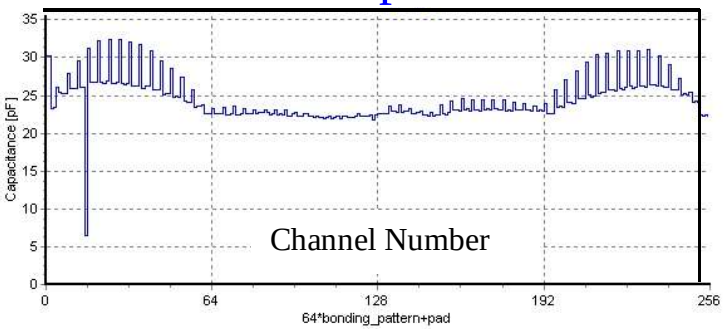
Testing Time negligible when compared to .....

Silicon Sensor Testing: Scans

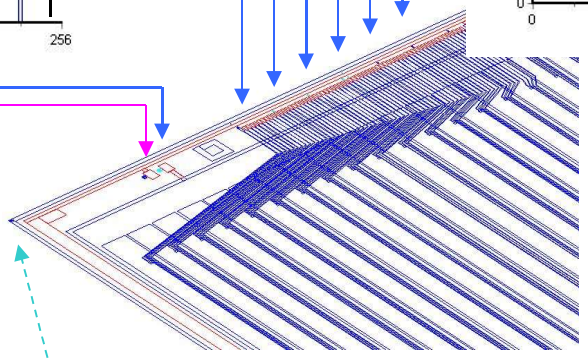
AC coupling Pinhole Scan



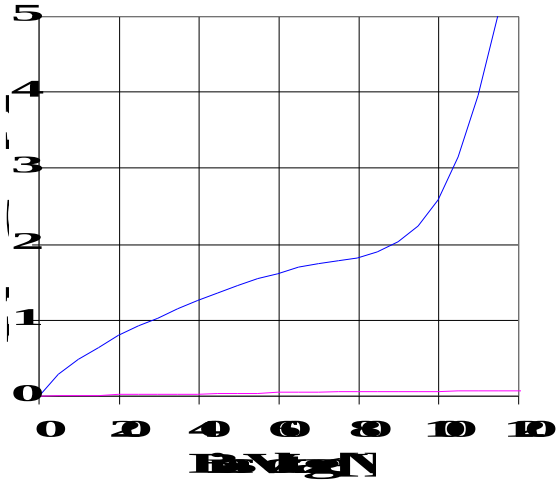
Sensor Pad Capacitance Scan

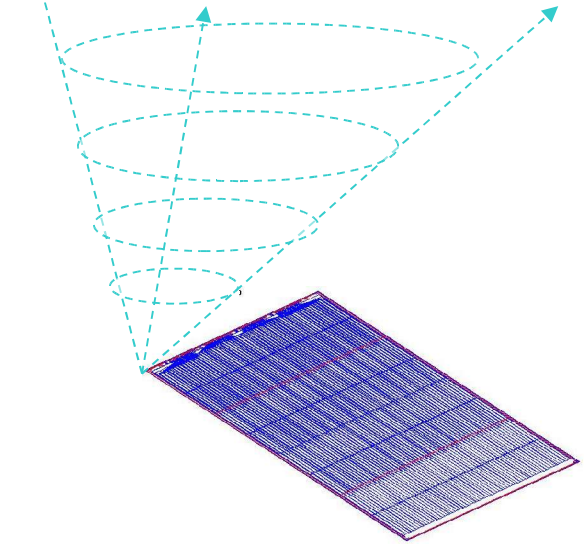


Automatic Probing

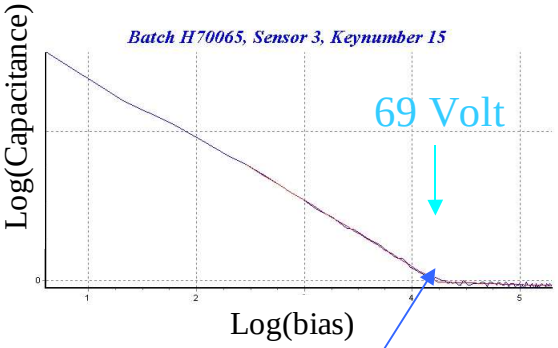


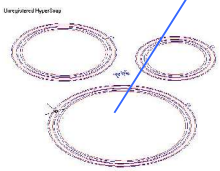
Leakage Currents





Full Depletion Voltage

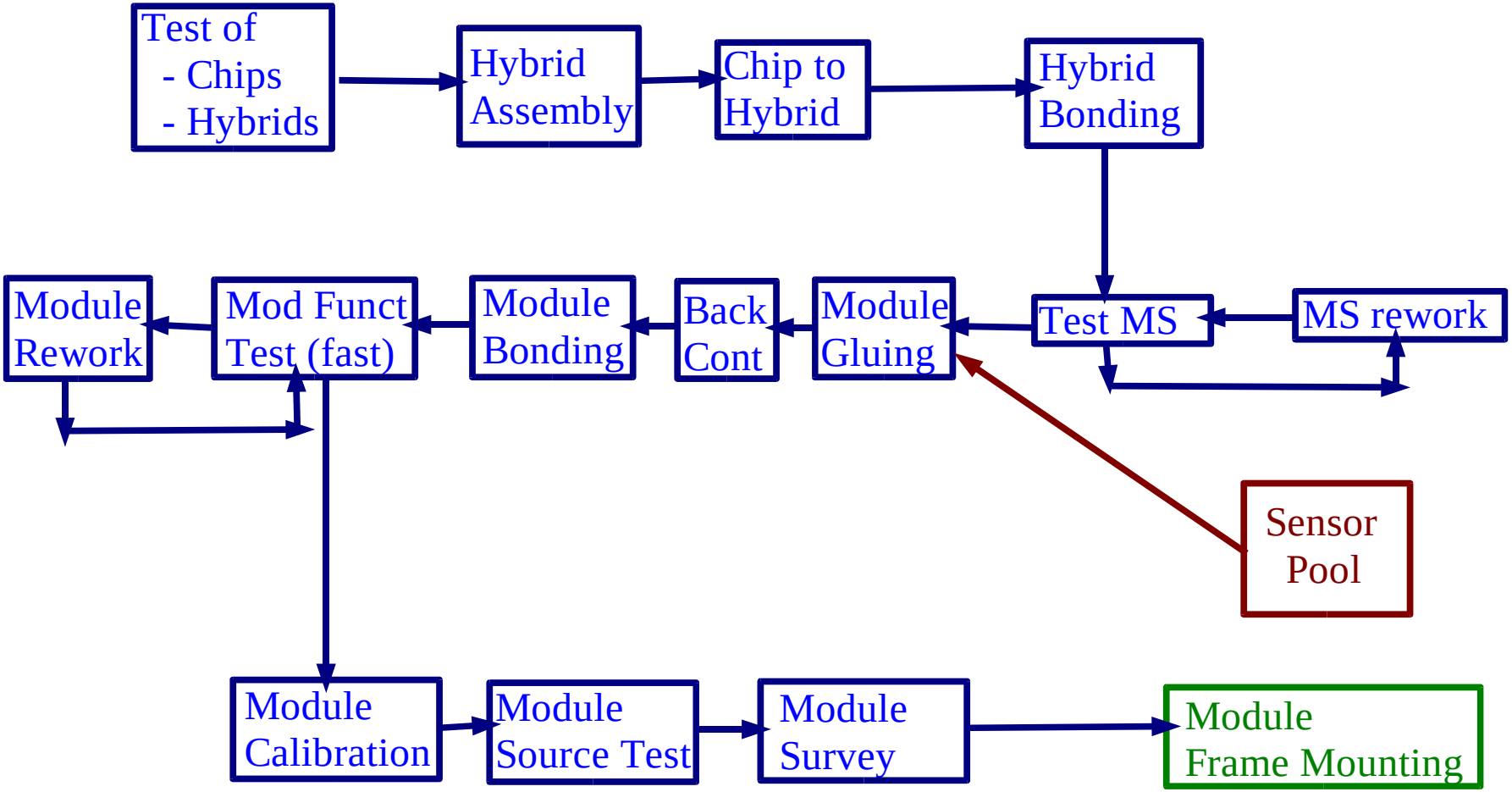




PN Testkey

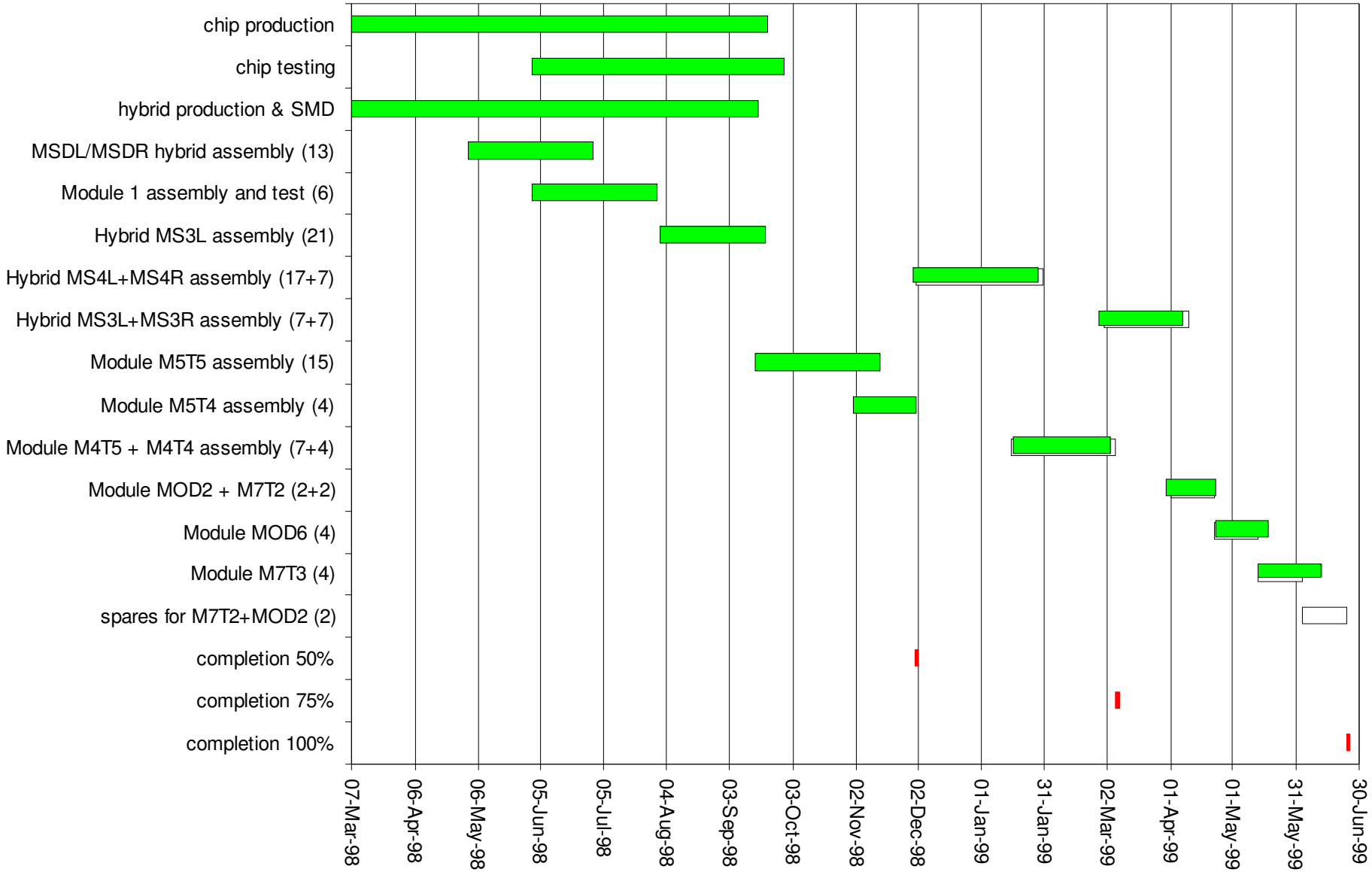
Each Scan takes about 10 seconds per Pad!

Module Assembly & Testing



That's a lot of work, how long did it take?.....

Time to Completion



Everything got build in a bit more than a year

STAR resources for a tracking upgrade

- Several institutions like to participate by providing available resources

ARGONNE NATIONAL LABORATORY

INDIANA UNIVERSITY CYCLOTRON FACILITY

BROOKHAVEN NATIONAL LABORATORY

BERKELEY LAB

YALE UNIVERSITY

UCLA

WAYNE STATE UNIVERSITY

USP Universidade de São Paulo BRASIL

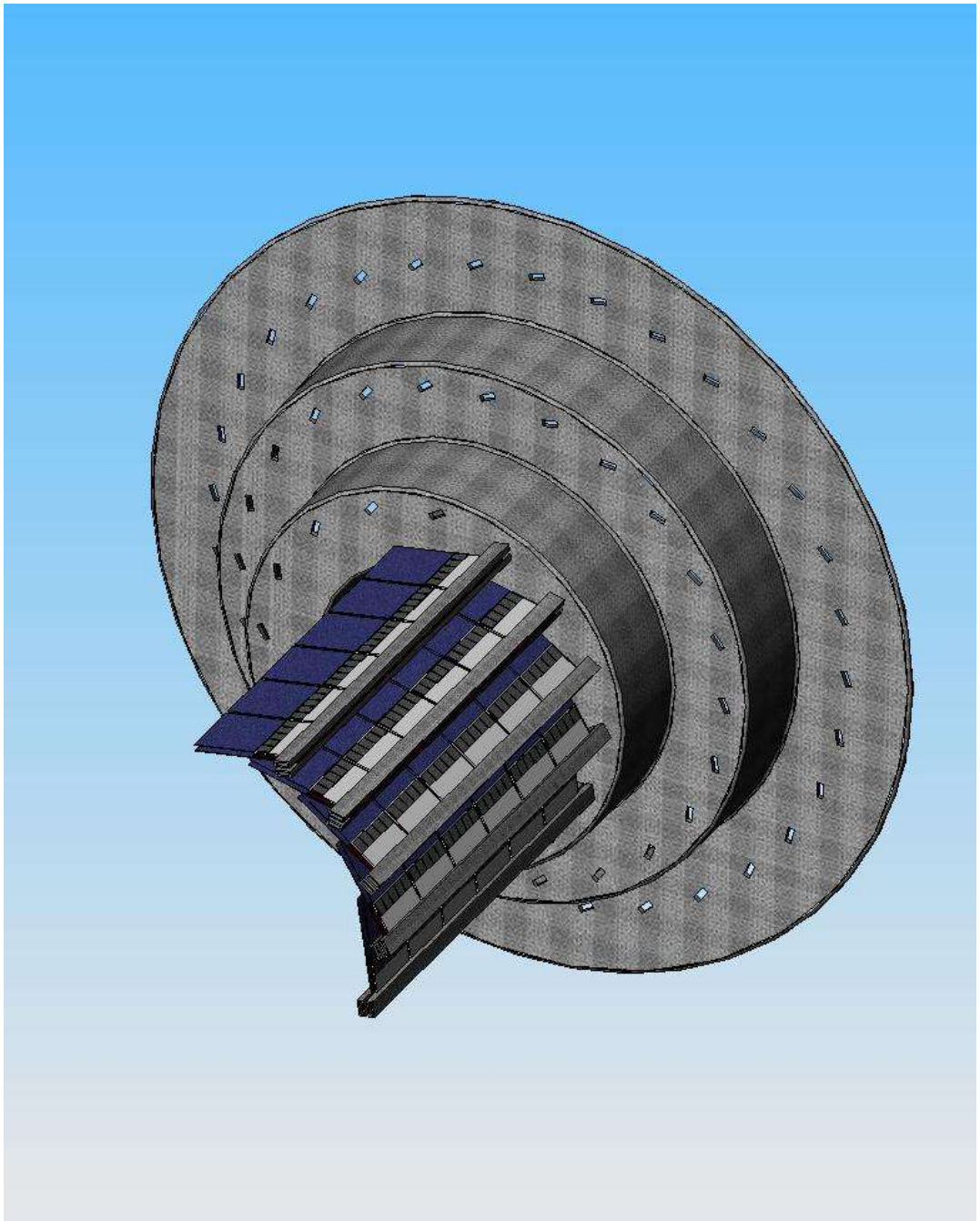
LNS LABORATORY FOR NUCLEAR SCIENCE

Massachusetts Institute of Technology Bates Linear Accelerator Center

Resources for a STAR inner tracker

- Infrastructure exists
  - Engineering/construction at Bates
  - Hybrid assembly/Testing at LNS
- Man power available at Massachusetts Institute of Technology Bates Linear Accelerator Center
  - 1 Mechanical engineer (CAD expert)
  - 2 Technicians
  - 2 Staff physicists
- Man power available at LNS Laboratory for Nuclear Science
  - 1 Technician (bonding expert)
  - 1 Postdoc and 2 grad students
  - 2 Principal research scientists
  - 1 Assistant professor of physics

Very Preliminary Design



Axial View

Si-Tracker Very Rough Estimates I

- Barrel Geometry
  - Radius = 100, 150, 200 mm
  - Length = 240, 360, 480 mm
- Let's assume strip sensors:
  - Size = 40x40 mm^2
  - Pitch = 50 um => 768 channels per sensor
  - 16, 24, 32 ladders => 72 total
- For 3 stereo layers gives a total of:
  - 1392 sensors
  - 1,069,056 channels
- Comparable to PHOBOS if we take much simpler design into account

Si-Tracker Very Rough Estimates II

- 1392 sensors a $1000 ==> M$ 1.4
- 6 128ch chips per sensor a $20 ==> M$ 0.2
- 1 hybrid per 3 sensors a $500 ==> M$ 0.25
- Say $0.5 to $1 per FEE channel ==> M$ 0.5-1.0
- Mechanical construction
- Low mass cables
- Cooling system
- Air handling system
- Slow controls
- Test setups / prototyping
- Survey

~ M$ 4

To be ready in 2008

- Avoid extensive R&D work
- Use conventional sensor technology
- Use off-the-shelf readout chips
  - For instance APV25-S1, used extensivily in CMS silicon and COMPASS triple GEM (both in STAR!)
- 'Steal' as much as possible
- Avoid time consuming design steps
  - One mechanical design for pixel detector and silicon tracker
  - DON'T try to stick the pixel detector in the SVT
    - Major work on the SVT, which is a very risky operation
    - After the pixel detector installation STAR needs a properly working tracker for high luminosity operation
      - The SVT will be an 'old' and 'slow' detector in 2008
    - It will suck up resources and will cause an unneccesary delay for the silicon tracker barrel and possibly also for the forward tracker

Inner Tracker Wrapup

- Many institutes have expressed intent to participate
- MIT/LNS/Bates
  - We have the facilities
  - We have experienced people
  - We will commit to
    - Design, building and testing of the ladders
    - Strongly participate in mechanics and installation
    - Strongly participate in calibration
    - Strongly participate in maintenance
  - We have proven to deliver (PHOBOS)
- Time needed to build 3(6) layer tracker modules
  - Assuming continuous delivery of parts
  - Assuming high sensor yield
  - 1 year
- We will work with the STAR management to write a realistic proposal (first preliminary version should be ready by the end of July 2004)