# WBS 1.3
# IST Overview

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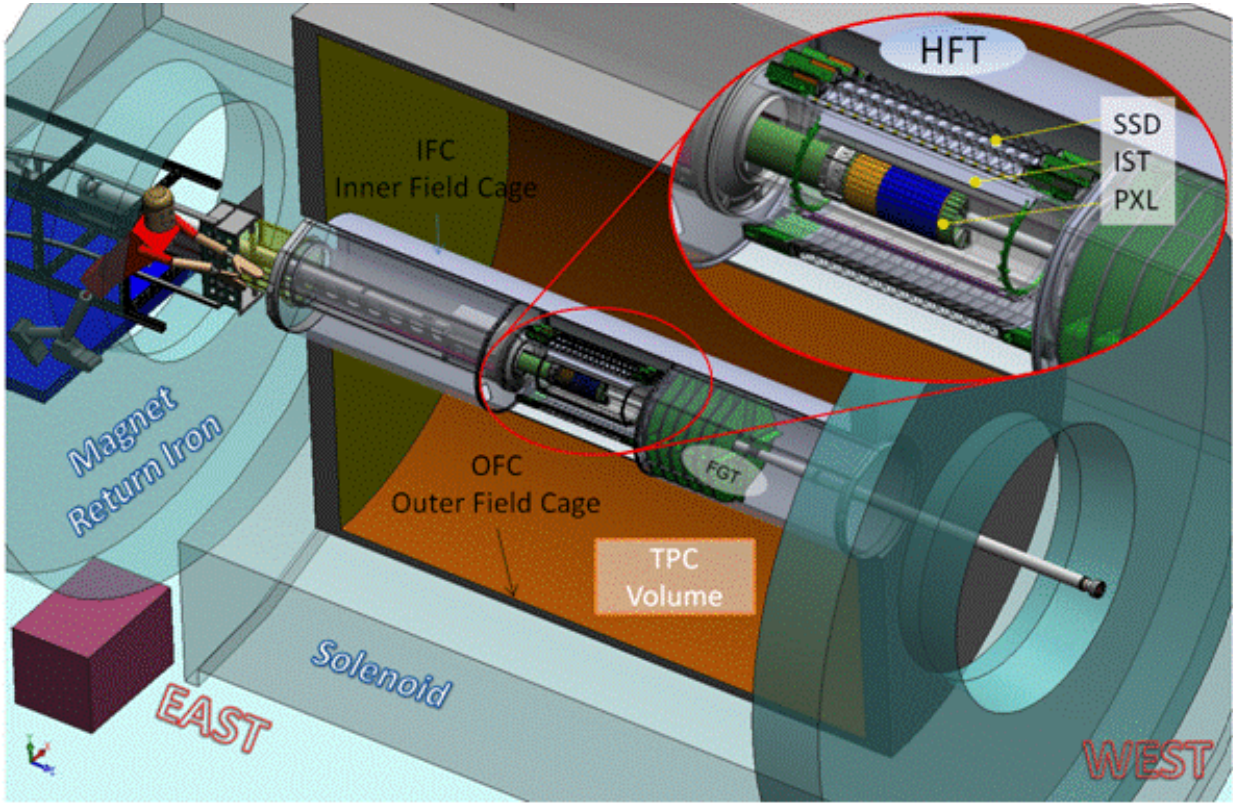
MIT

# IST talk overview

- Requirements
- Detector overview
- Status and plans
  - Design status
  - Fabrication Plan
  - System testing
- Cost and Schedule
- Basis of estimates
- Resources
- Risk Assessment

# IST in Inner Detector Upgrade




TPC – Time Projection Chamber (main tracking detector in STAR)

*HFT – Heavy Flavor Tracker*

- SSD – Silicon Strip Detector
  - r = 22 cm
- IST – Inner Silicon Tracker
  - r = 14 cm
- PXL – Pixel Detector
  - r = 2.5, 8 cm

We track inward from the TPC with graded resolution:

TPC → ~1mm → SSD → ~300μm → IST → ~250μm → PXL → <30μm → vertex

# IST CD-4 requirements

| | | |
|---|---|---|
| 3 Internal alignment IST and SSD | < 300 µm | Survey during construction and assembly |
| 6 Detector hit efficiency IST | > 96% with 98% purity | Low noise electronics, source and cosmic tests |
| 7 Live channels for PXL and IST | > 95% | <1% dead silicon pads, redundancy, spares, care... |
| 8 PXL and IST Readout speed and dead time | < 5% additional dead time @ 500 Hz average trigger rate and simulated occupancy | APV25-S1 readout time ~10-30us, fully parallel, appropriate buffering |

How to state this?

Replace by S/N?

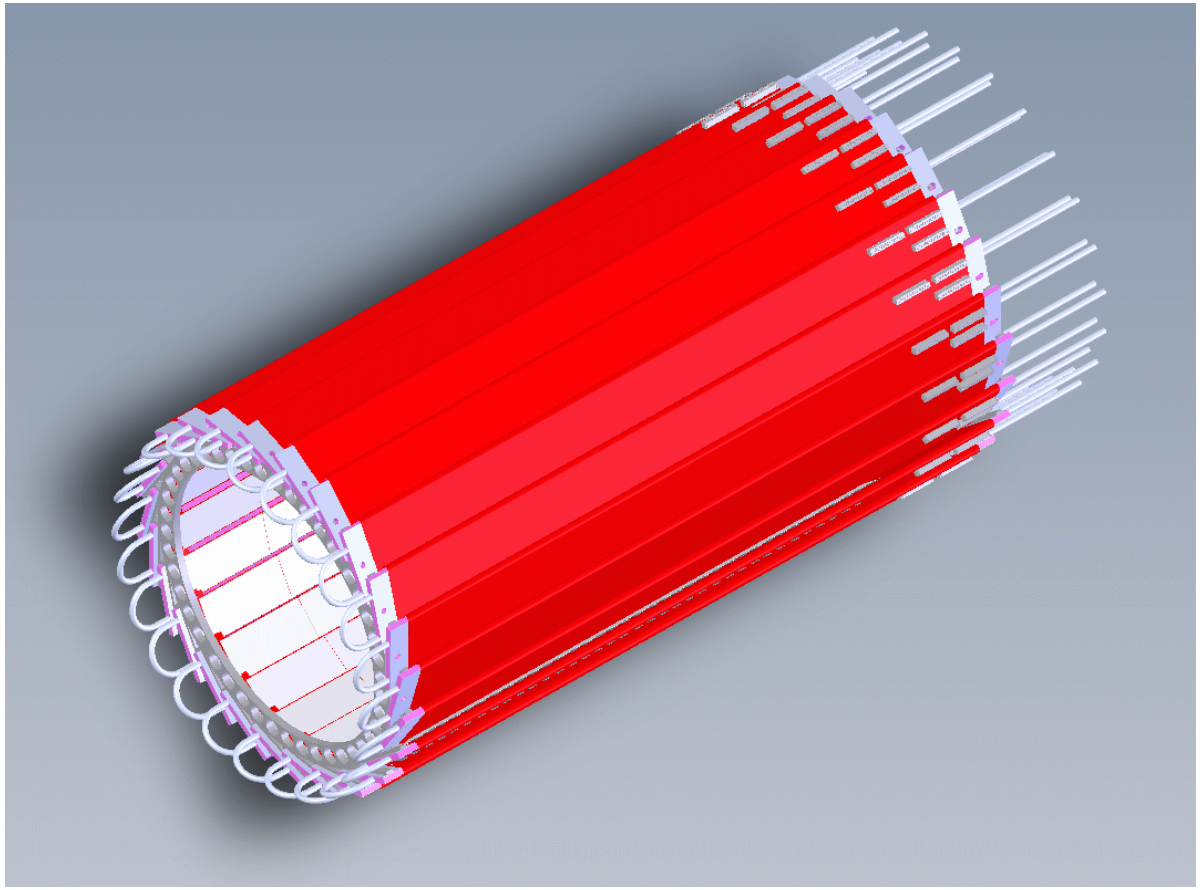
**Design meets these requirements**

# IST additional requirements

- Resolution of ~200μm (?) in r-Φ to provide required pointing resolution of 250μm (?) to PXL
- <1.5% Xo to limit multiple scattering and to minimize the impact on mid-rapidity physics
- Radiation hard for 10 years of 30 kRad/year
- Be able to resolve 107ns beam bunches

Careful choice of light weight materials, high-res. sensors and fast readout system

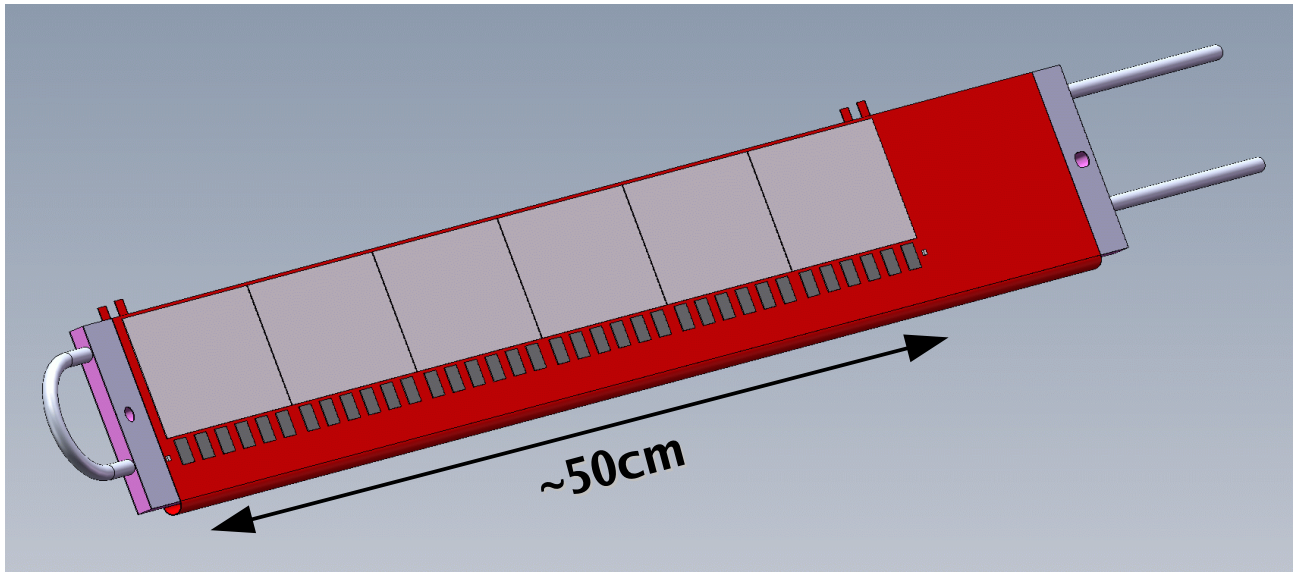
# IST overview



| | |
|---|---|
| Radius | 14cm |
| Length | 50cm |
| $\phi$-Coverage | $2\pi$ |
| $\lvert\eta\rvert$-Coverage | $\leq 1.2$ |
| Number of ladders | 24 |
| Number of hybrids | 24 |
| Number of sensors | 144 |
| Number of readout chips | 864 |
| Number of channels | 110592 |
| R-$\phi$ resolution | 172μm |
| Z resolution | 1811μm |
| Z pad size | 6000μm |
| R-$\phi$ pad size | 600μm |

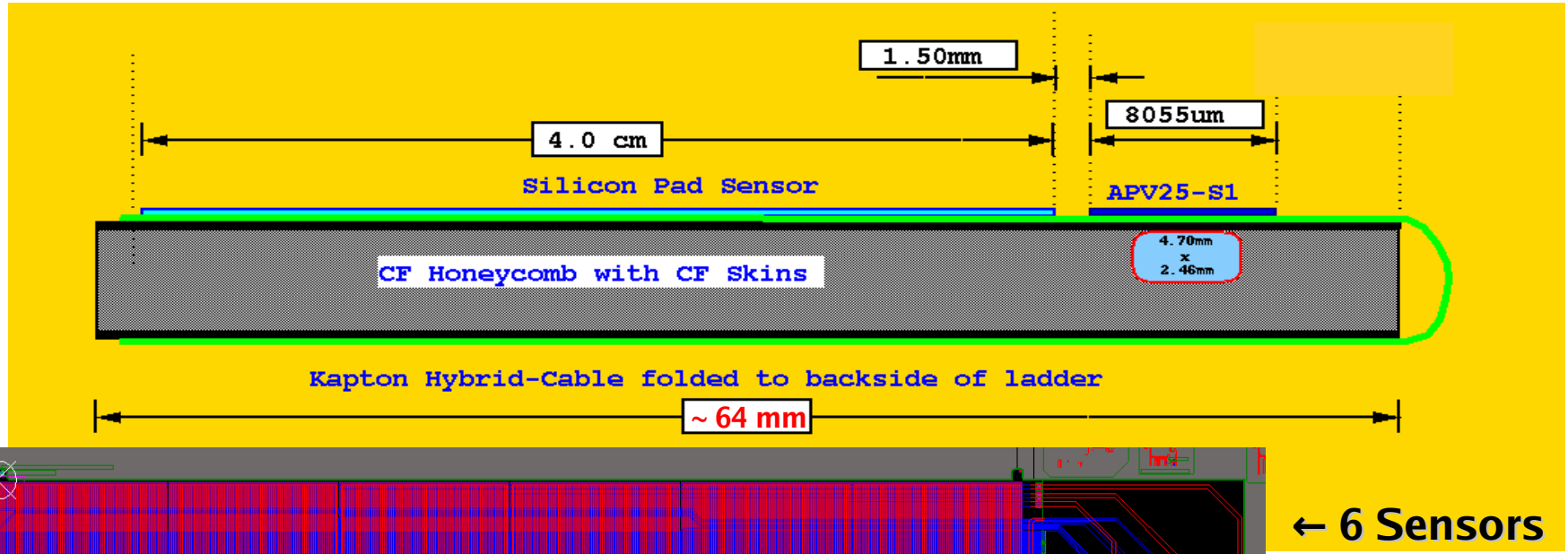
IST makes use of established technologies

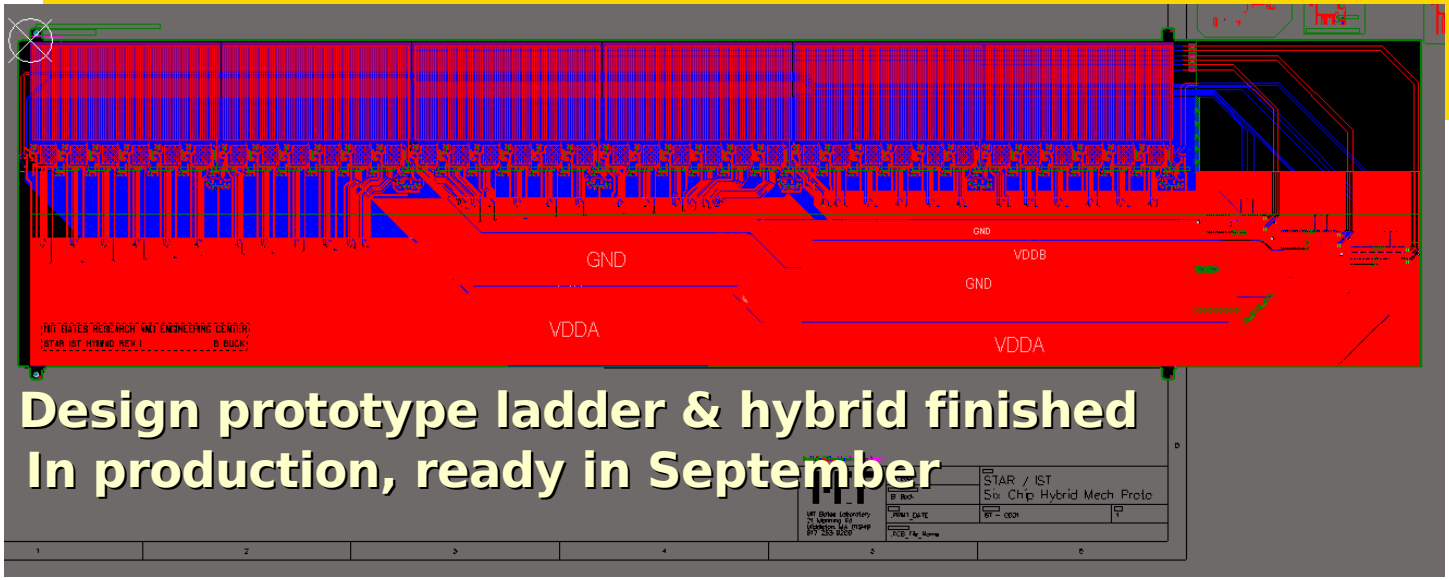
# IST stave




**IST stave = carbon fiber ladder + cooling tubes**
**kapton flex hybrid + passive components**
**6 silicon pad sensors**
**3 x 12 APV25-S1 readout chips**
**electrically divided in 3 units to reduce chance of failure of a full stave**

# IST ladder and hybrid



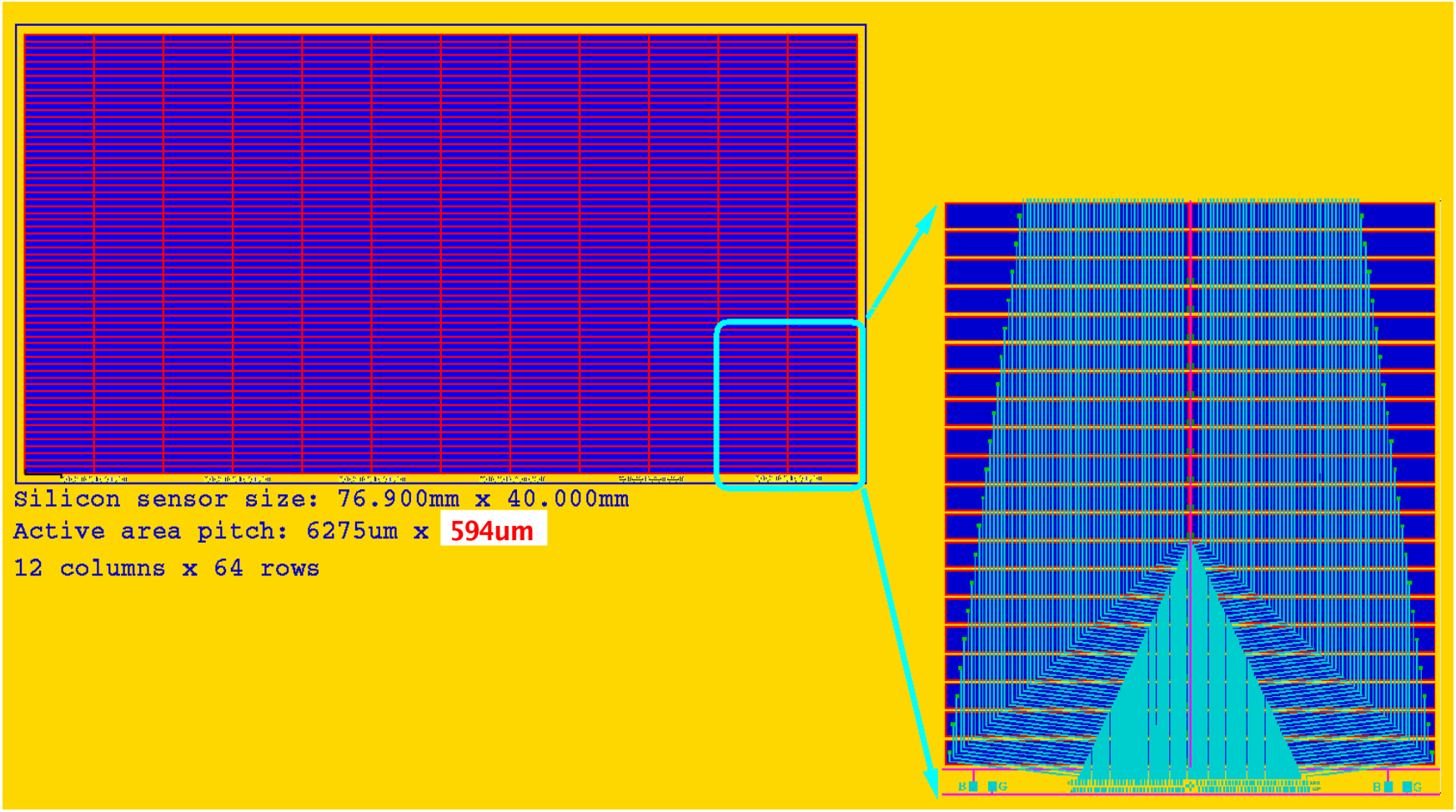

← 6 Sensors

← 36 APV25-S1

← cable, folds over to back

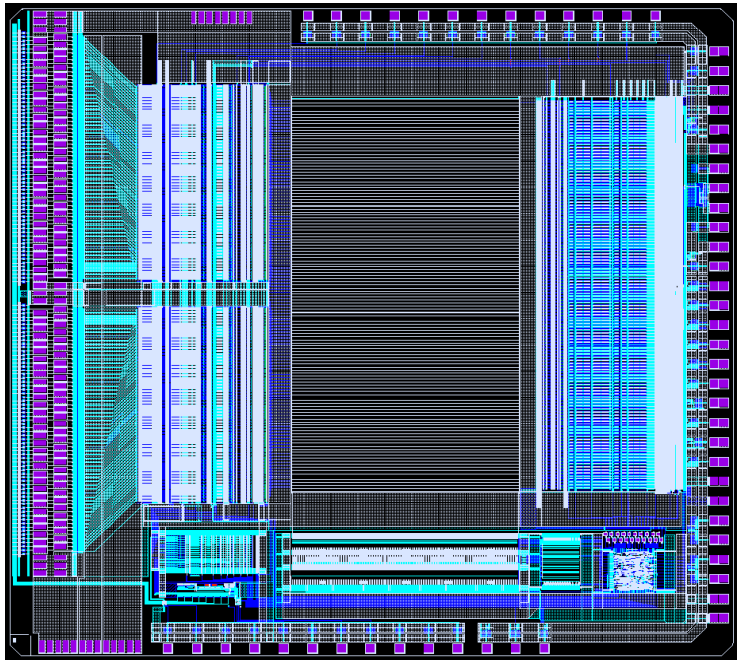
**Design prototype ladder & hybrid finished**
**In production, ready in September**

# IST silicon pad sensor




Mask drawings approved, 8 prototypes expected in September

# IST readout chip



**APV25-S1**

STAR use: - IST
- FGT
- pp2pp

Developed for CMS
(75,000 used in tracker)
(used in COMPASS for triple GEM)

0.25 um CMOS
Radiation hard

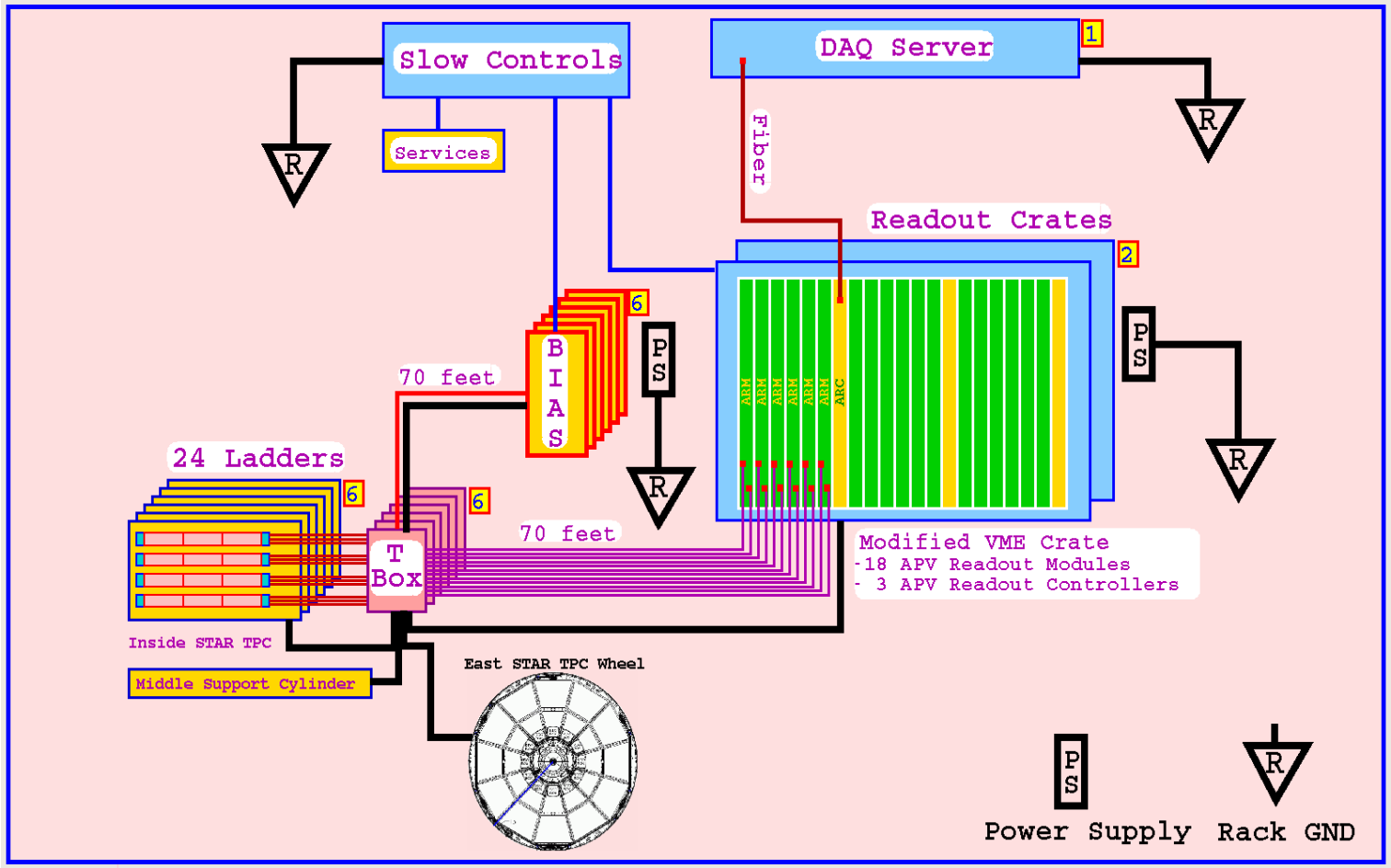
128 channels parallel sampling
40 MHz sampling rate
4 us analogue pipeline
< 30 us deadtime for 20 MHz 3-sample readout

11:1 signal to noise ratio

0.3 Watt per chip

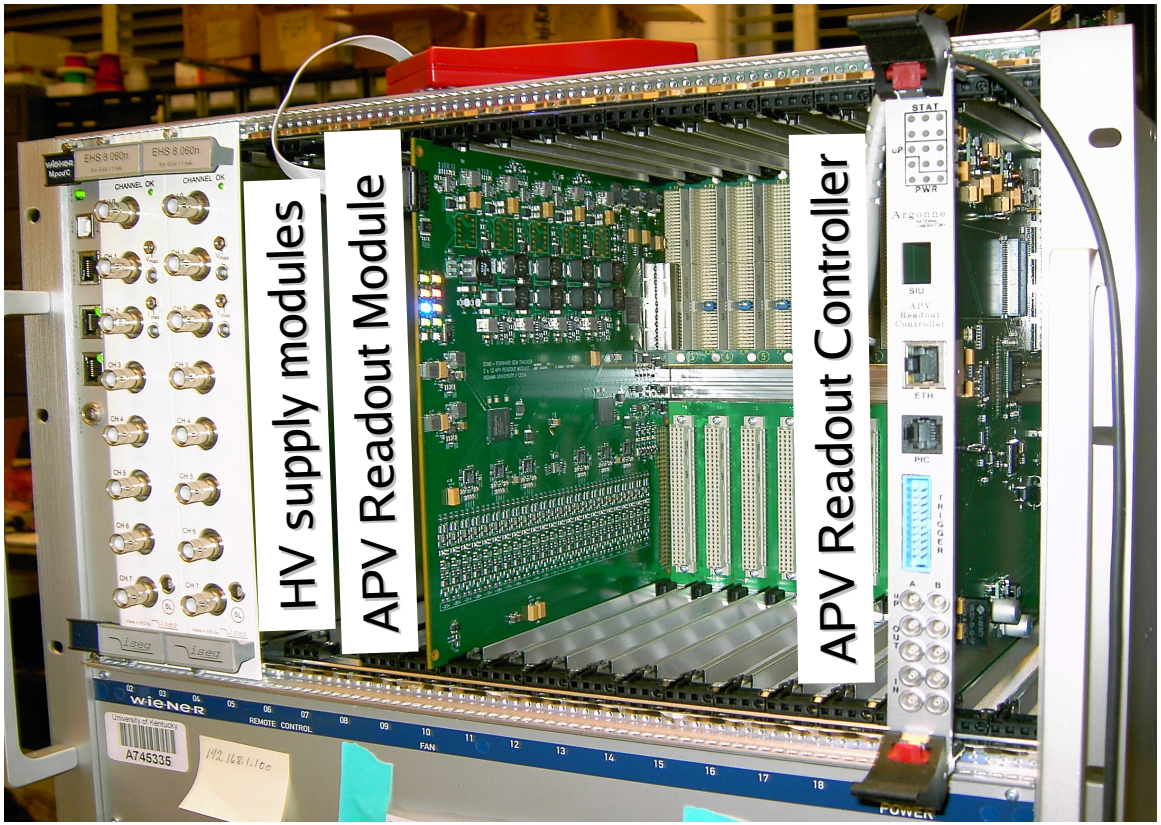
**All chips have been procured**

# IST readout system layout




Layout 80% done, FGT as testbed

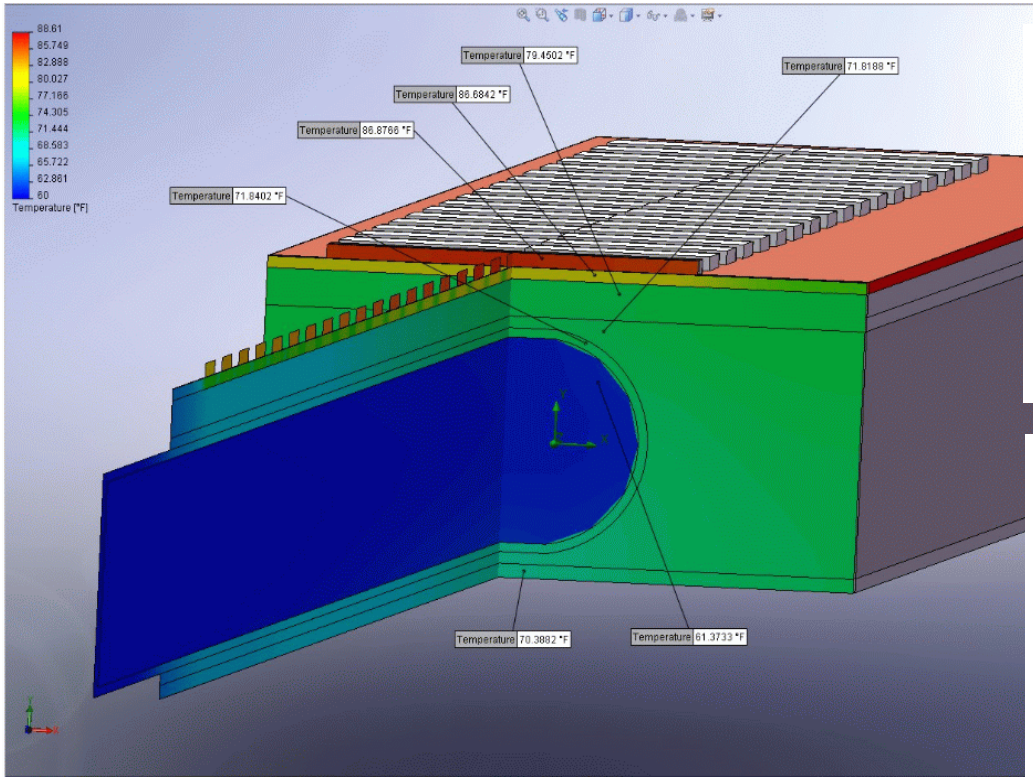
# IST readout system




Currently being battle tested in cosmic ray test setup

Design 90% done, ready for FGT installation in FY12

# IST cooling

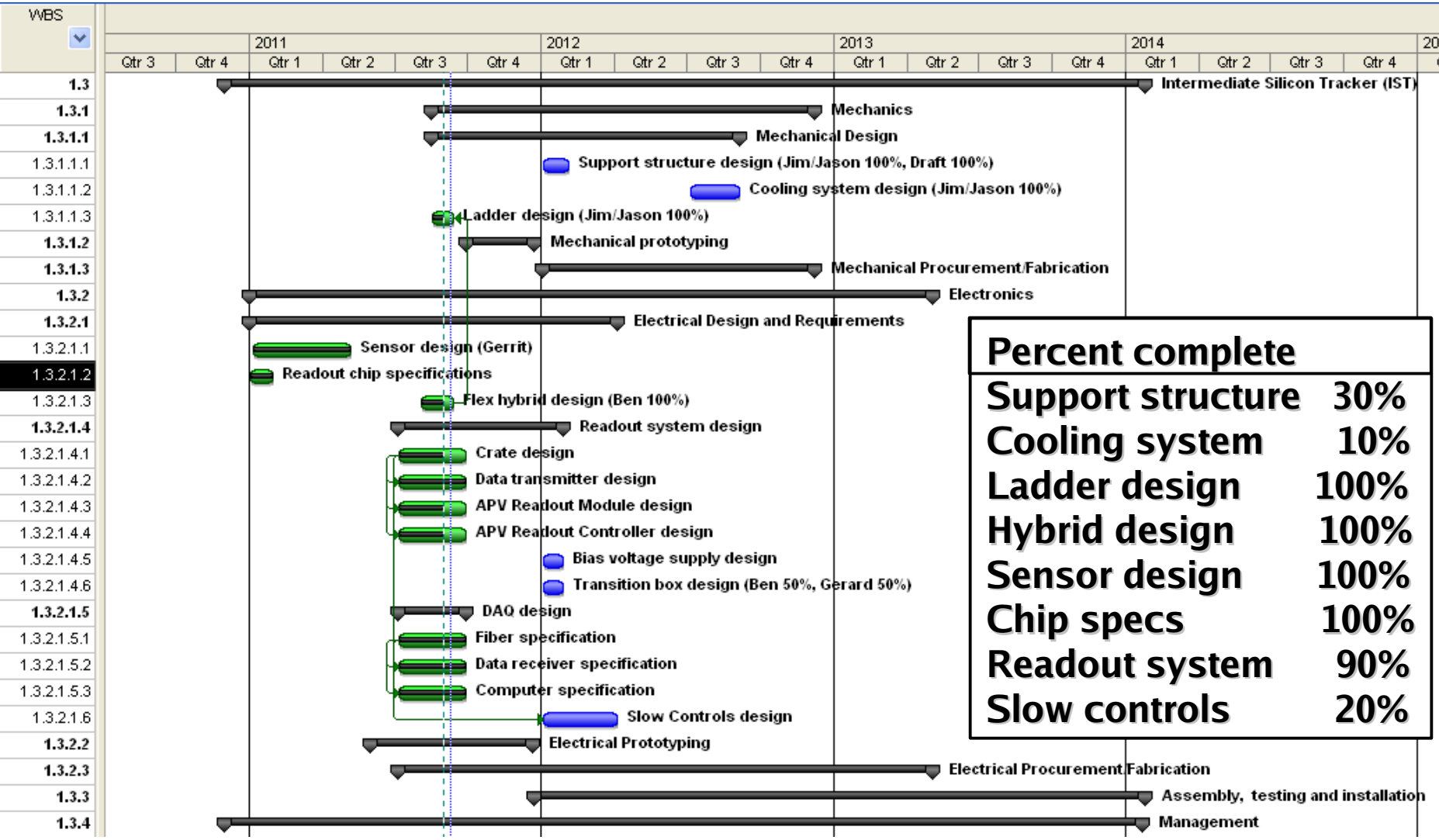



| | |
|---|---|
| Maximum readout chip temperature | 35°C |
| Cooling fluid velocity | 0.3-3 m/s |
| Maximum pressure | 0.2MPa |
| Cooling fluid inlet temperature | 24°C |

| | |
|---|---|
| Cooling fluid | 3M Novec 7200 |
| Cooling fluid | 1m/s |
| Maximum pressure | 0.14MPa |
| Calculated maximum temperature of readout chip | 34.9°C |

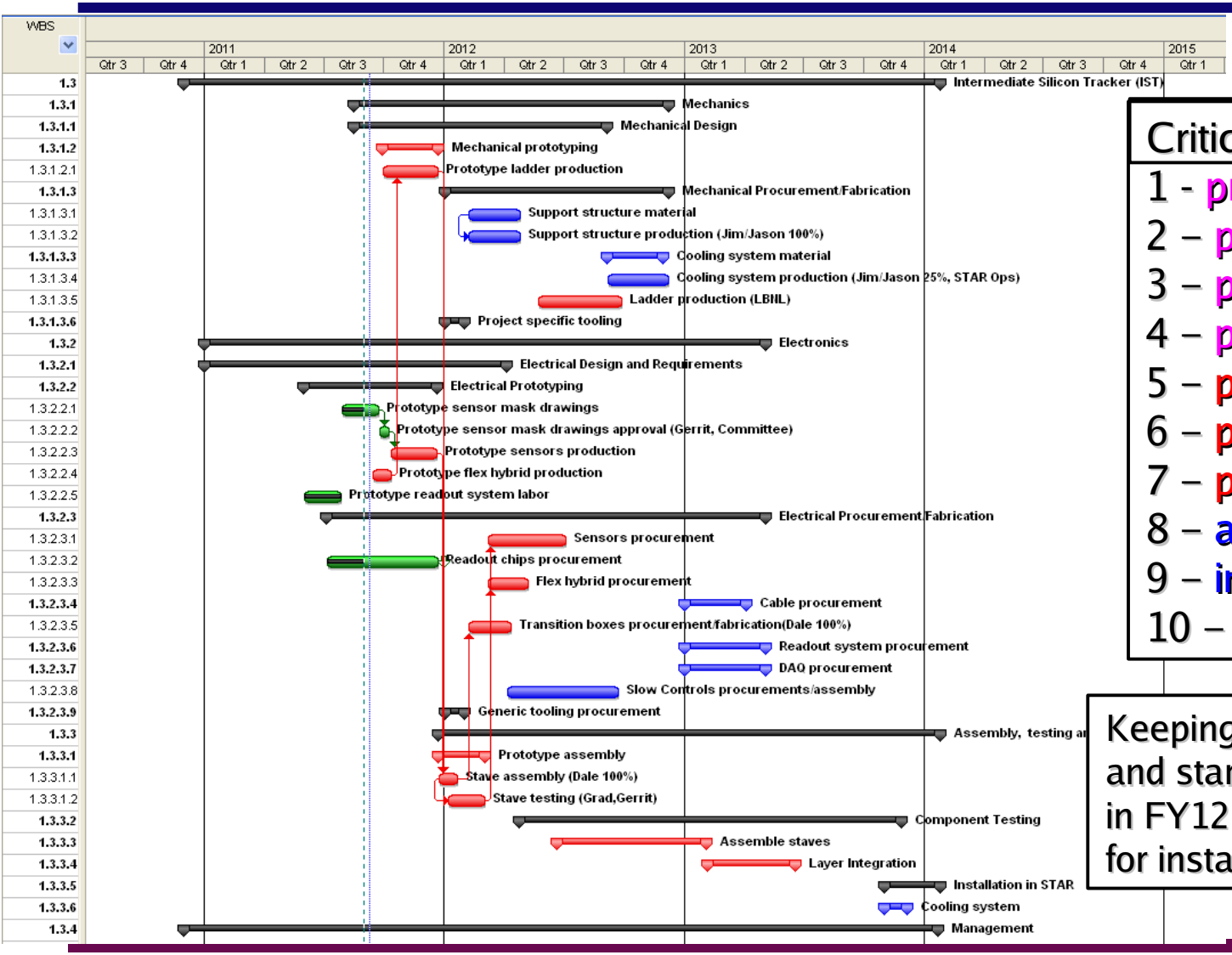
- Fluorocarbon fluid based cooling
- Simulations show proper cooling for one stave and possible daisy chaining of staves

# IST design status summary




| Percent complete | |
|---|---|
| Support structure | 30% |
| Cooling system | 10% |
| Ladder design | 100% |
| Hybrid design | 100% |
| Sensor design | 100% |
| Chip specs | 100% |
| Readout system | 90% |
| Slow controls | 20% |

# IST fabrication plan

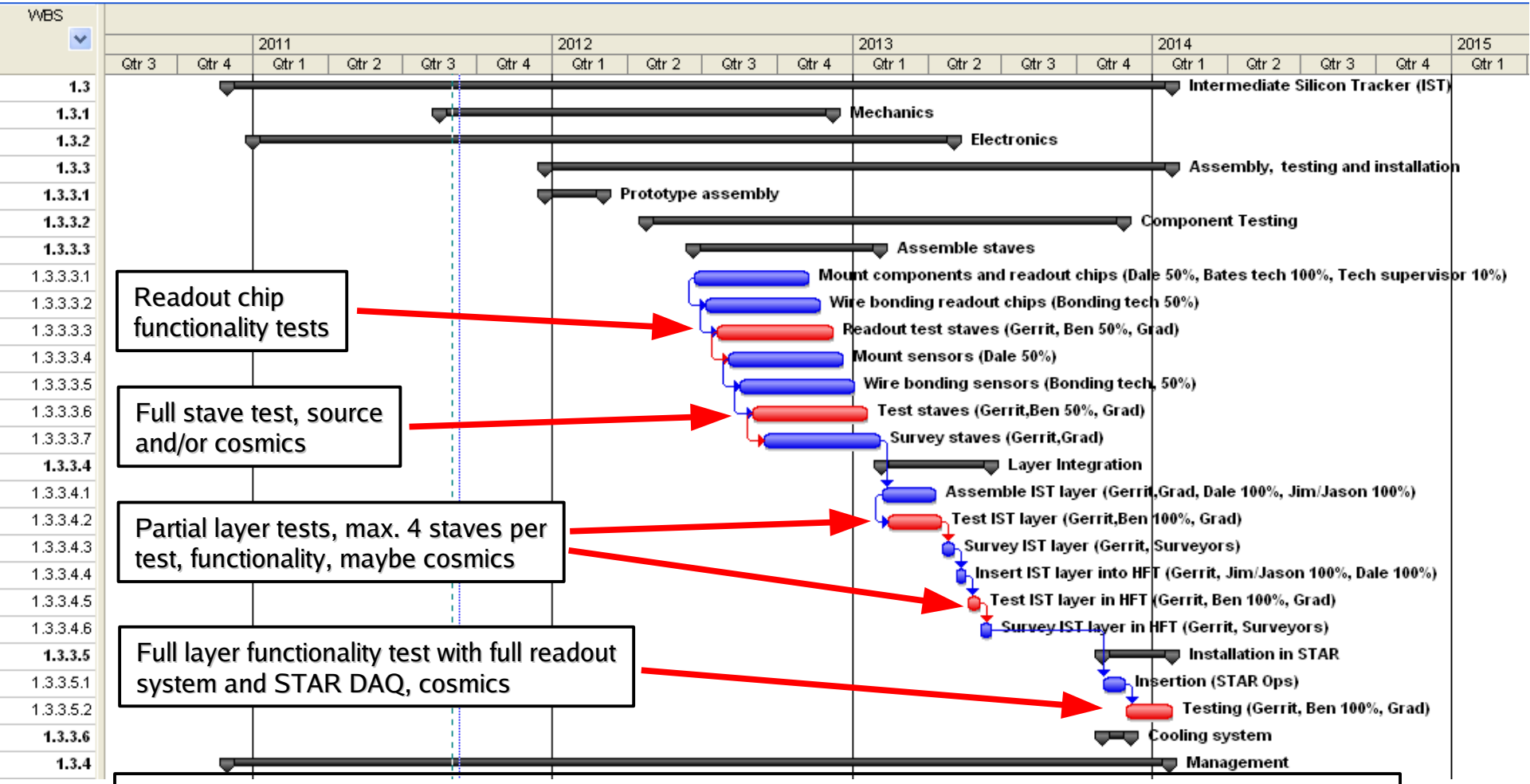



Critical steps:

1 - prototype sensors
2 – prototype hybrids
3 – prototype ladders
4 – prototype stave
5 – produce sensors
6 – produce hybrids
7 – produce ladders
8 – assemble staves
9 – integrate layer
10 – install in STAR

Keeping 5,6 and 7 in FY12 and starting assembling staves in FY12 is crucial to be ready for installation RUN 14

# IST system test(s)




Schedule includes functionality tests in each step of the assembly process

# IST cost by Level 3 WBS

| WBS | Name | Cost ($K) |
|---|---|---|
| 1.3 | Intermediate Silicon Tracker (IST) | 2,533.65 |
| 1.3.1 | Mechanics | 599.02 |
| 1.3.2 | Electronics | 1,110.69 |
| 1.3.3 | Assembly, testing and installation | 757.88 |
| 1.3.4 | Management | 66.06 |

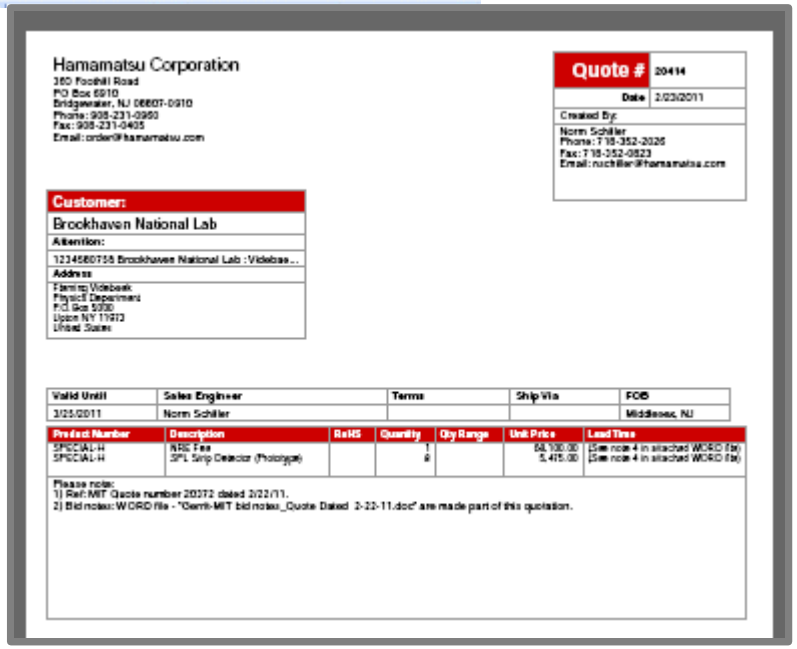
Budget pretty much equally divided between 1.3.1, 1.3.2 and 1.3.3 when not taking the $450k silicon sensors into account

# IST basis of estimates

documentum eRoom

My eRooms > Heavy Flavor Tracker > DOE CD 2/3 Review > Project Documents > Reference Material

- Reference Material
  - 1.1_Management_supporting_documents
  - 1.2_Pixel_Detector_(PXL)_supporting_documents
  - 1.3_Intermediate_Silicon_Tracker_(IST)_supporting_documents
    - 1.3.1_Mechanics
      - 1.3.1.1_Mechanical_Design
      - 1.3.1.2_Mechanical_Procurement_Fabrication
        - 1.3.1.2.8_ProductionLadderPrice.txt
      - 1.3.1.3_Mechanical_Prototyping
        - 1.3.1.3_Ladder_Prototype.txt
    - 1.3.2_Electronics
      - 1.3.2.1_Electrical_Design_and_Requirements
      - 1.3.2.2_Electrical_Prototyping
        - 1.3.2.2.1_PrleiminaryQuote_30Jul2010.txt
        - 1.3.2.2.1_Sensor_Quote_Hamamatsu_23Feb2011.pdf
        - 1.3.2.2.1_Sensor_Quote_Hamamatsu_Notes_23Feb2011.doc
        - 1.3.2.2.2_PrleiminaryQuote_30Jul2010.txt
        - 1.3.2.2.3_IST_protohybrid_quote_FPC_08Feb2011.pdf
        - 1.3.2.2.3_IST_protohybrid_quote_Vulcan_09Feb2011.pdf
      - 1.3.2.3_Electrical_Procurement_Fabrication
    - 1.3.3_Assembly_Testing_Installation
    - 1.3.4_Management
  - 1.4_Silicon_Strip_Detector_(SSD)_supporting_documents
  - 1.5_Integration_and_Global_Supports_supporting_documentation
  - 1.6_Software_supporting_documentation



Hamamatsu Corporation
360 Foothill Road
PO Box 6910
Bridgewater, NJ 08807-0910
Phone: 908-231-0960
Fax: 908-231-0405
Email: order@hamamatsu.com

Quote # 20414
Date 2/23/2011
Created By:
Norm Schiller
Phone: 718-352-2026
Fax: 718-352-0823
Email: nschiller@hamamatsu.com

Customer:
Brookhaven National Lab
Attention:
1234560756 Brookhaven National Lab : Videbae...
Address
Fermilab Videbaek
Physics Department
P.O. Box 5000
Upton NY 11973
United States

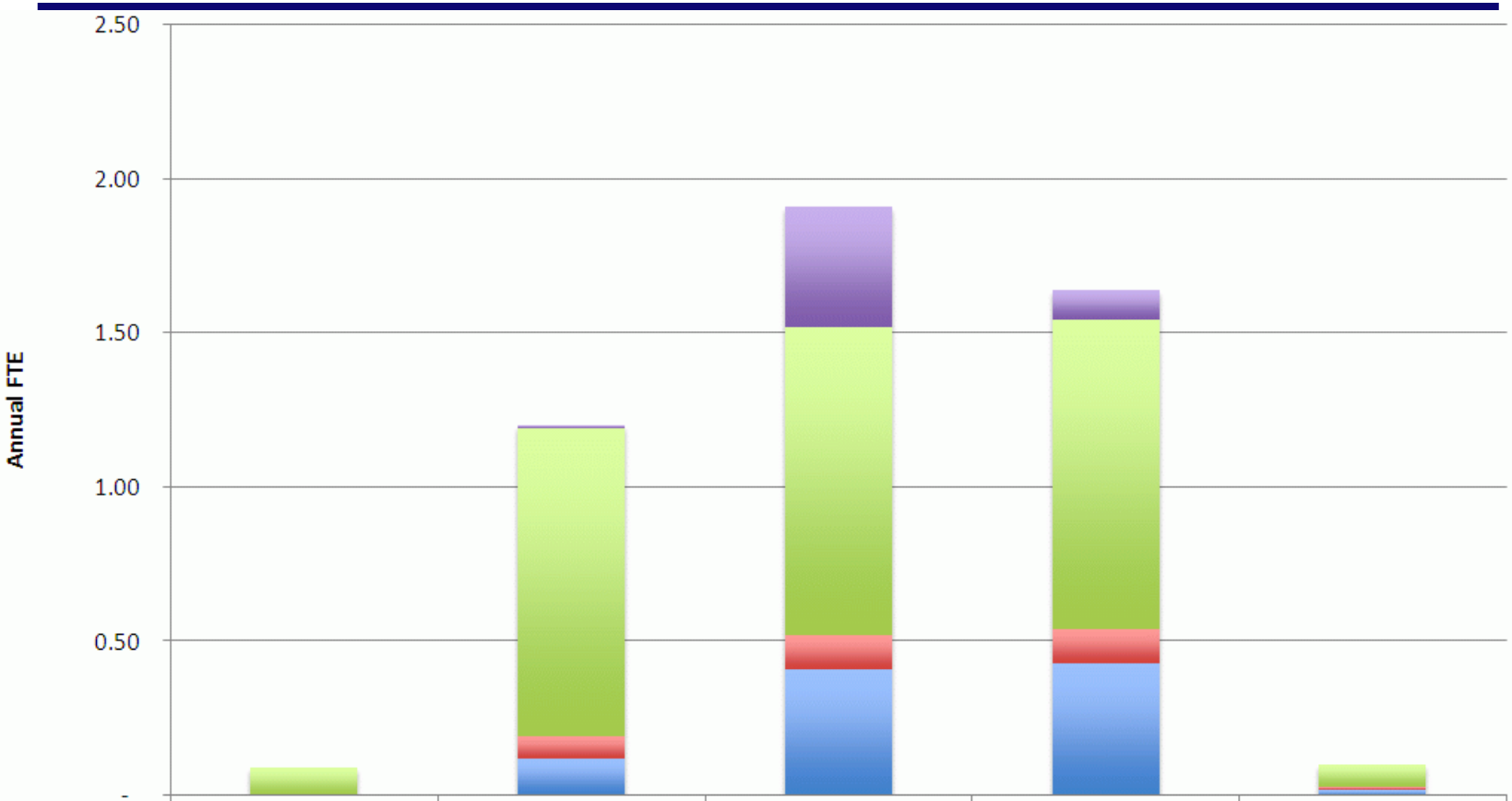
| Valid Until | Sales Engineer | Terms | Ship Via | FOB |
|---|---|---|---|---|
| 3/25/2011 | Norm Schiller | | | Middlesex, NJ |

| Product Number | Description | RoHS | Quantity | Qty Range | Unit Price | Lead Time |
|---|---|---|---|---|---|---|
| SPECIAL-H | NRE Fee | | 1 | | 64,100.00 | (See note 4 in attached WORD file) |
| SPECIAL-H | SPL Strip Detector (Prototype) | | 6 | | 5,415.00 | (See note 4 in attached WORD file) |

Please note:
1) Ref: MIT Quote number 20372 dated 2/22/11.
2) Bid notes: WORD file - "Gerrit-MIT bid notes_Quote Dated 2-22-11.doc" are made part of this quotation.

Estimates:
- quotations or catalog prices
- engineer or physicist estimates based on previous experiences and with appropriate contingencies

# IST resources at MIT




| | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|
| Technical | - | 0.01 | 0.39 | 0.10 | - |
| Scientific | 0.09 | 1.00 | 1.00 | 1.00 | 0.07 |
| PM Support | - | 0.07 | 0.11 | 0.11 | 0.01 |
| Engineer | - | 0.12 | 0.41 | 0.43 | 0.02 |

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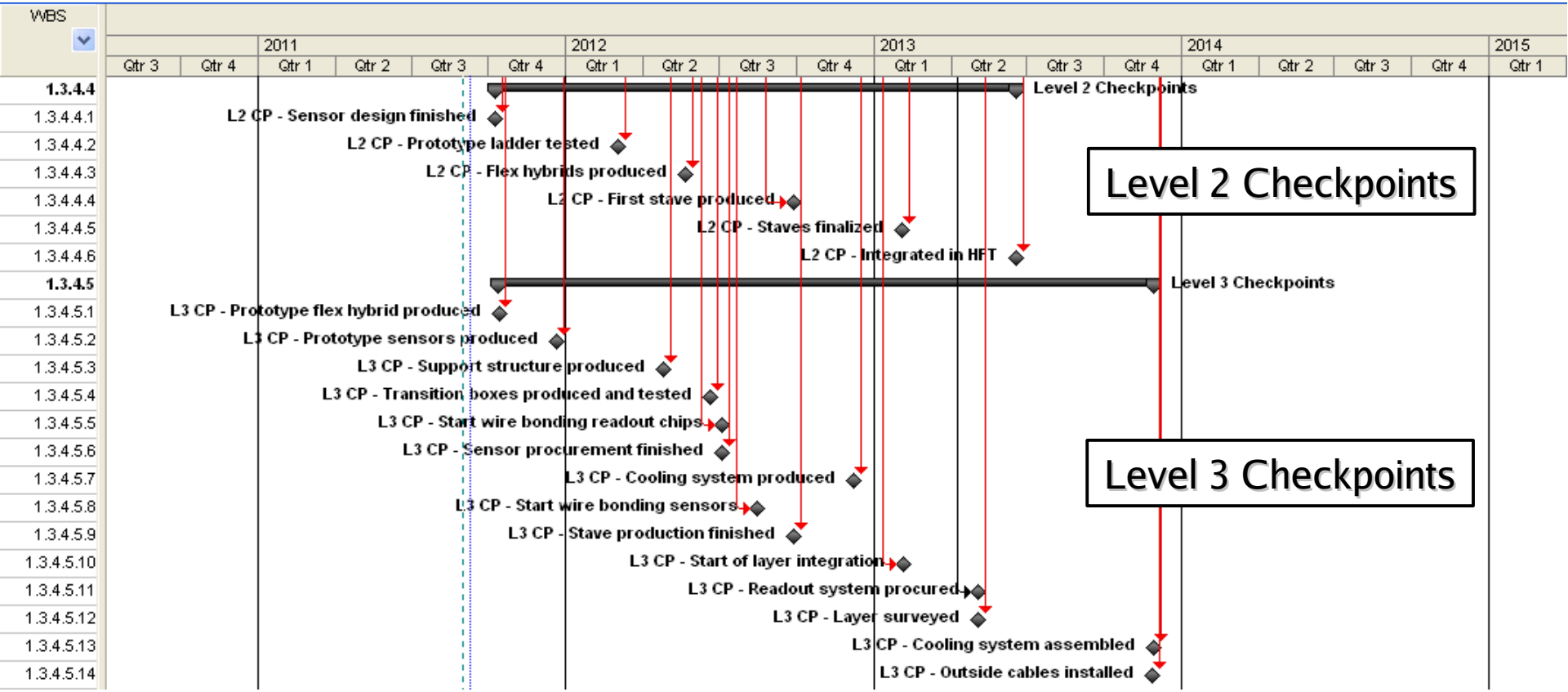
# IST milestones

| Level | Milestone | Planned | Actual/Forecast |
|---|---|---|---|
| 1 | CD-0 Approve Mission Need | | 2/18/2009 (A) |
| 1 | CD-1 Approve Alternative Selection and Cost Range | | 8/31/2010 (A) |
| 1 | CD-2 Approve Performance Baseline | Aug-11 | Aug-11 |
| 1 | CD-3 Approve Start of Fabrication | Aug-11 | Aug-11 |
| 1 | CD-4 Approve Project Completion | Mar-15 | Mar-15 |
| 1.3 | IST | | |
| 2 | Sensor design Finished | Oct-11 | Jul-11 |
| 2 | Prototype ladder tested | Mar-12 | Dec-11 |
| 2 | Flex hybrid produced | Jun-12 | Feb-12 |
| 2 | First staves produced | Sep-12 | Jun-12 |
| 2 | Staves finalized | Feb-13 | Nov-12 |
| 2 | Integrated into HFT | Jun-13 | Mar-13 |

# IST control checkpoints




L2 and L3 CP's reported against L2 and L3 Milestones monthly to PM

# IST risk assessment

| WBS description | Description | Technical Conseq. | Schedule Conseq. | Cost Impact ($K) | Type of Risk | Impact | Probability | Severity | Mitigation Strategy |
|---|---|---|---|---|---|---|---|---|---|
| Intermediate Silicon Tracker | | | | | | | | | |
| Support structure | More than one iteration to meet requirements | none | possible delay | none | schedule | low | low | I low | scheduling slack |
| Ladders | Failure to produce all ladders in time | none | delay in assembly pipeline | none | schedule | moderate | low | I low | scheduling slack |
| Sensor drawings and masks | Design problems leading to multiple iterations | none | delay in prototype production | none | schedule | low | low | I low | scheduling slack |
| Prototype sensors | Failure to function according to specifications | none | delay in start full production | $80k NRE + $[illegible] prototypes | cost/schedule | moderate | low | I low | scheduling slack,reliable vendor |
| Flex hybrid | Failure to function according to specifications | none | delay in full production | $5[illegible] | cost/schedule | low | low | I low | scheduling slack, less prototypes |
| Sensors | Production problems | none | delay in assembly | none | schedule | moderate | low | I low | reliable vendor, stage batch production |
| Flex hybrid | Production problems | none | delay in assembly | none | schedule | moderate | low | I low | scheduling slack by producing early |
| Signal cables inside field cage | Production problems | none | delay in installation | none | schedule | low | low | I low | conservative design, produce early |
| Signal cables outside field cage | Production problems | none | delay in installation | none | schedule | low | low | I low | conservative design, produce early |
| Bias voltage cables outside field cage | Production problems | none | delay in installation | none | schedule | low | low | I low | conservative design, produce early |
| Transition boxes | Fabrication problems | none | delay in installation | none | schedule | low | low | I low | conservative design, produce early |
| Readout system | | | | | | | | | Problems straightened out by FGT |
| DAQ | | | | | | | | | Problems straightened out by FGT |
| Assemble modules | Assembly problems | none | delay in assembling staves | increase in labor cost, $20k/mo | cost/schedule | moderate | low | I low | Establish conservative assembly pipeline |
| Assemble staves | Assembly problems | none | delay in layer integration | increase in labor cost, $20k/mo | cost/schedule | moderate | low | I low | Establish conservative assembly pipeline |
| Layer Integration | Integration problems | none | delay in installation | none | schedule | moderate | low | I low | delay installation |
| Cooling system | Assembly problems | none | delay in installation | parts and labor | cost/schedule | low | low | I low | assemble early |

Sorry, will take bit more time

# Summary

- IST meets the CD-4 requirements and the additional experimental requirements
- Design is about 90% finished
- Fabrication plan can be executed successfully provided that the FY2012 production schedule is followed carefully
- Functionality tests are included in each step of the assembly process
- Budget is based on quotes and realistic estimates
- Resources are sufficient to meet the milestones
- The risk severity is low for all major project tasks and mitigation strategies are in place

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