WBS 1.3 IST

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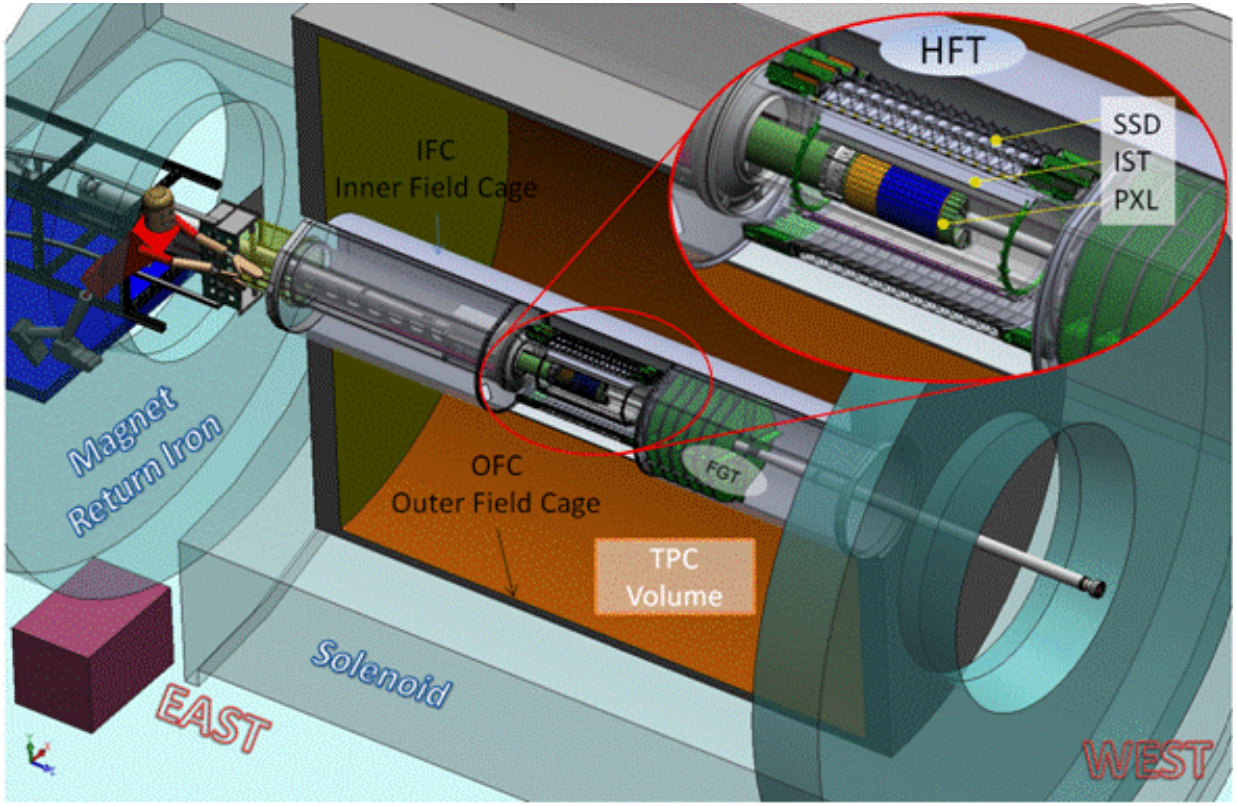
MIT

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

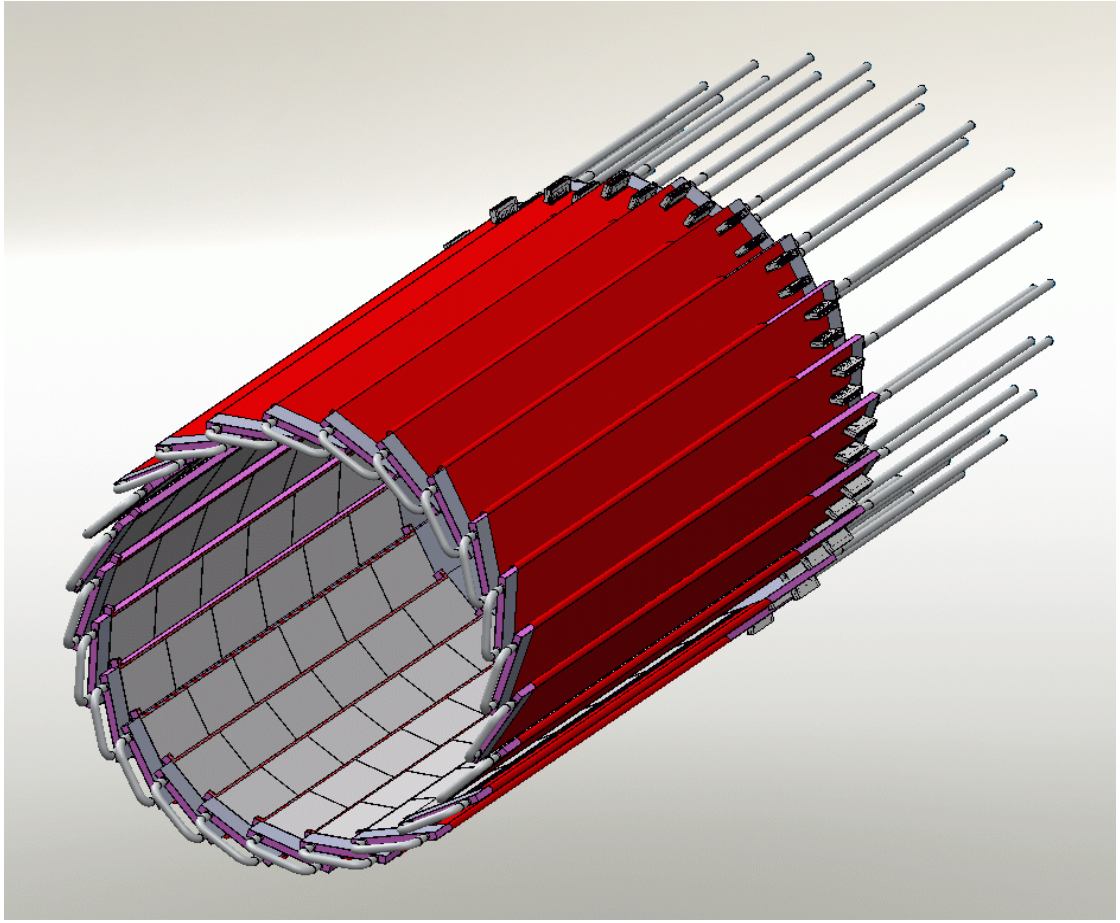
Design meets these requirements

IST additional requirements

- Resolution of ~200μm in r-Φ to provide required pointing resolution 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

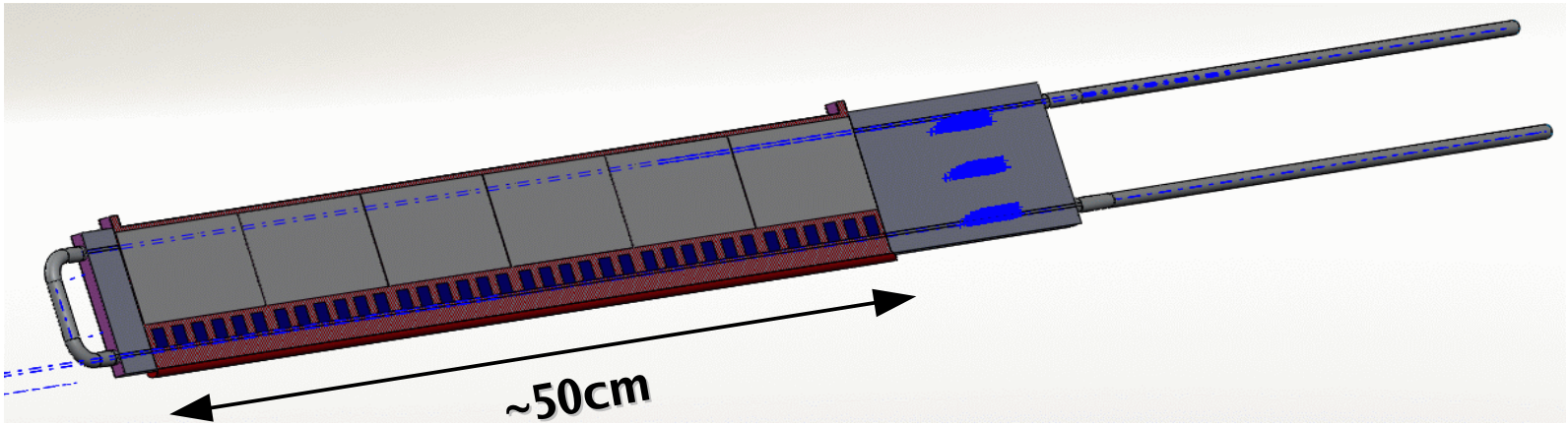
IST overview



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

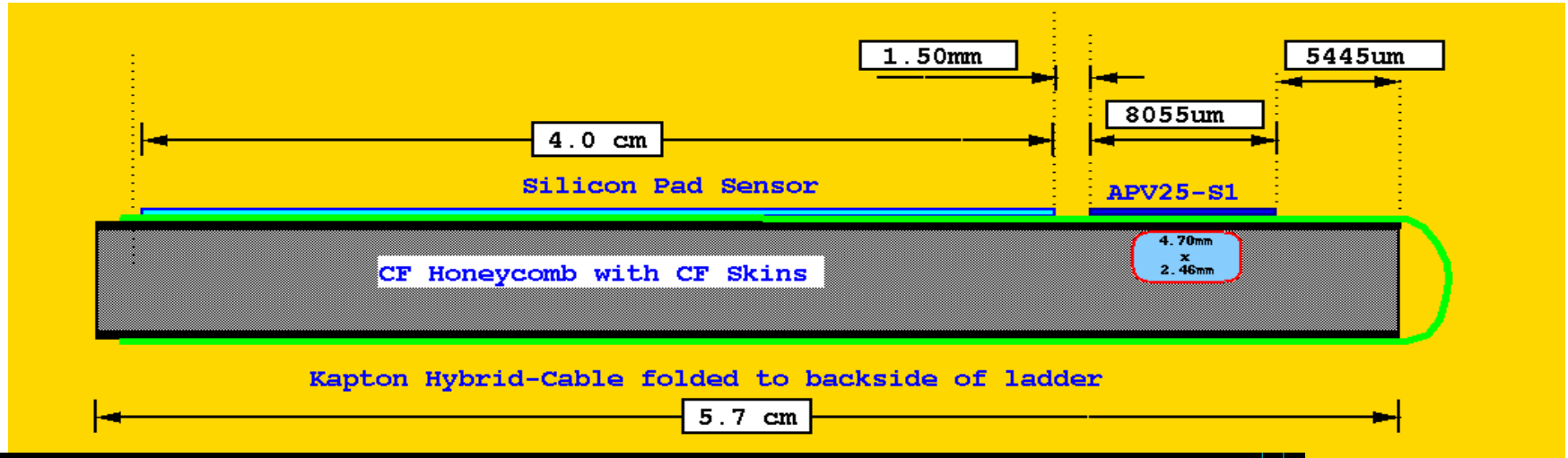
IST makes use of established technologies

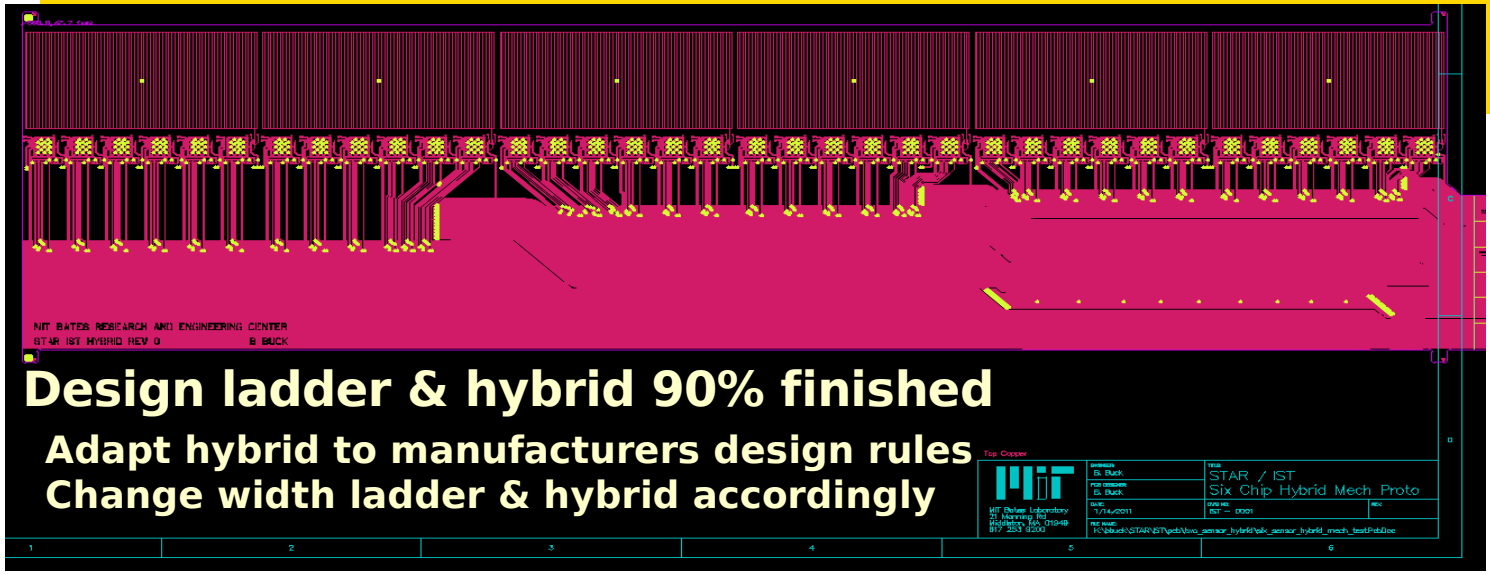
IST stave



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

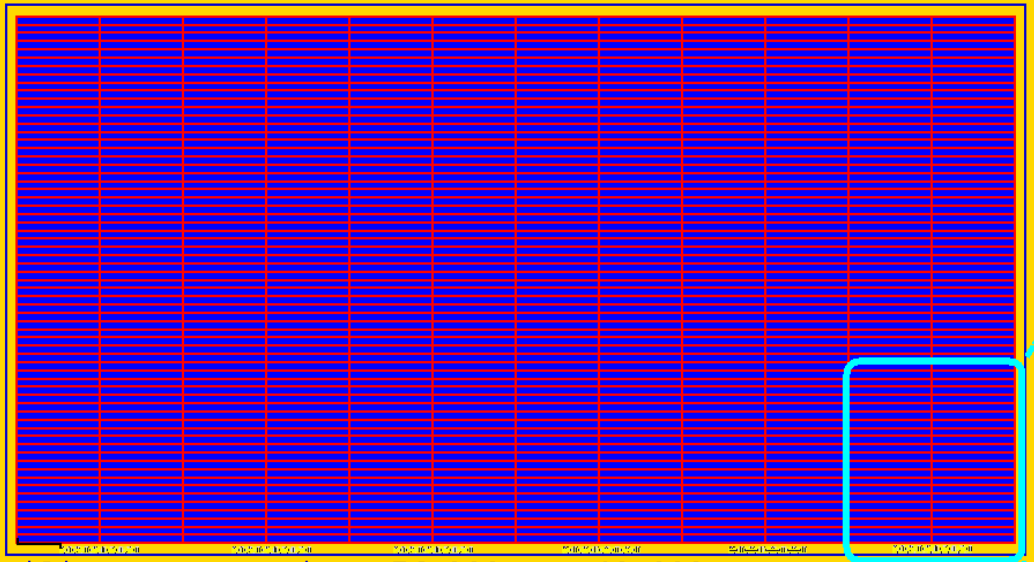
← 36 APV25-S1

← cable, folds over to back

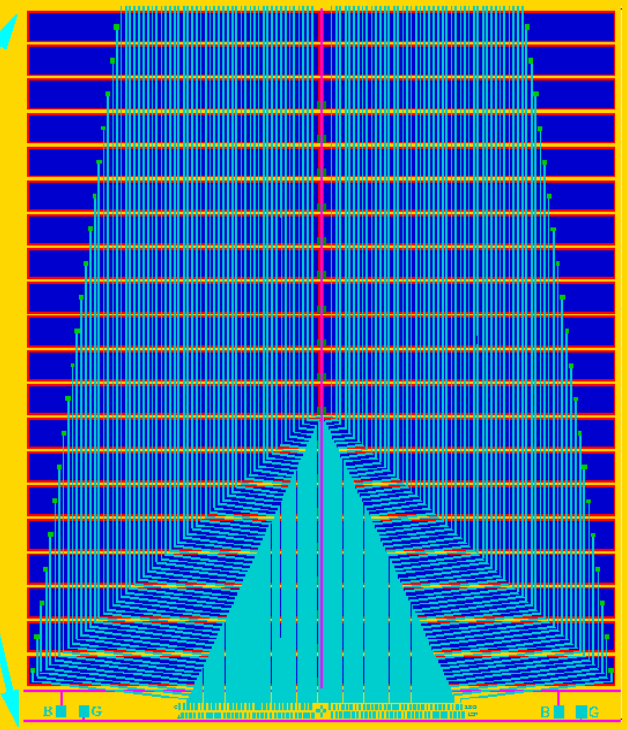
Design ladder & hybrid 90% finished

Adapt hybrid to manufacturers design rules
Change width ladder & hybrid accordingly

IST silicon pad sensor



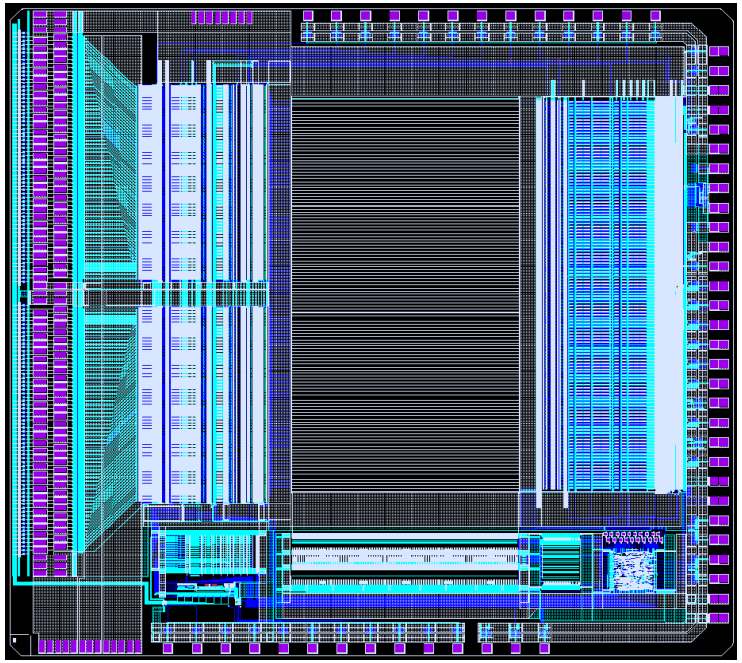
Silicon sensor size: 76.900mm x 40.000mm
Active area pitch: 6275um x 596um
12 columns x 64 rows



Design 80% finished
- layout of sensors finalized
- prototype mask drawings to be done

Procurement of sensor prototype in progress

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

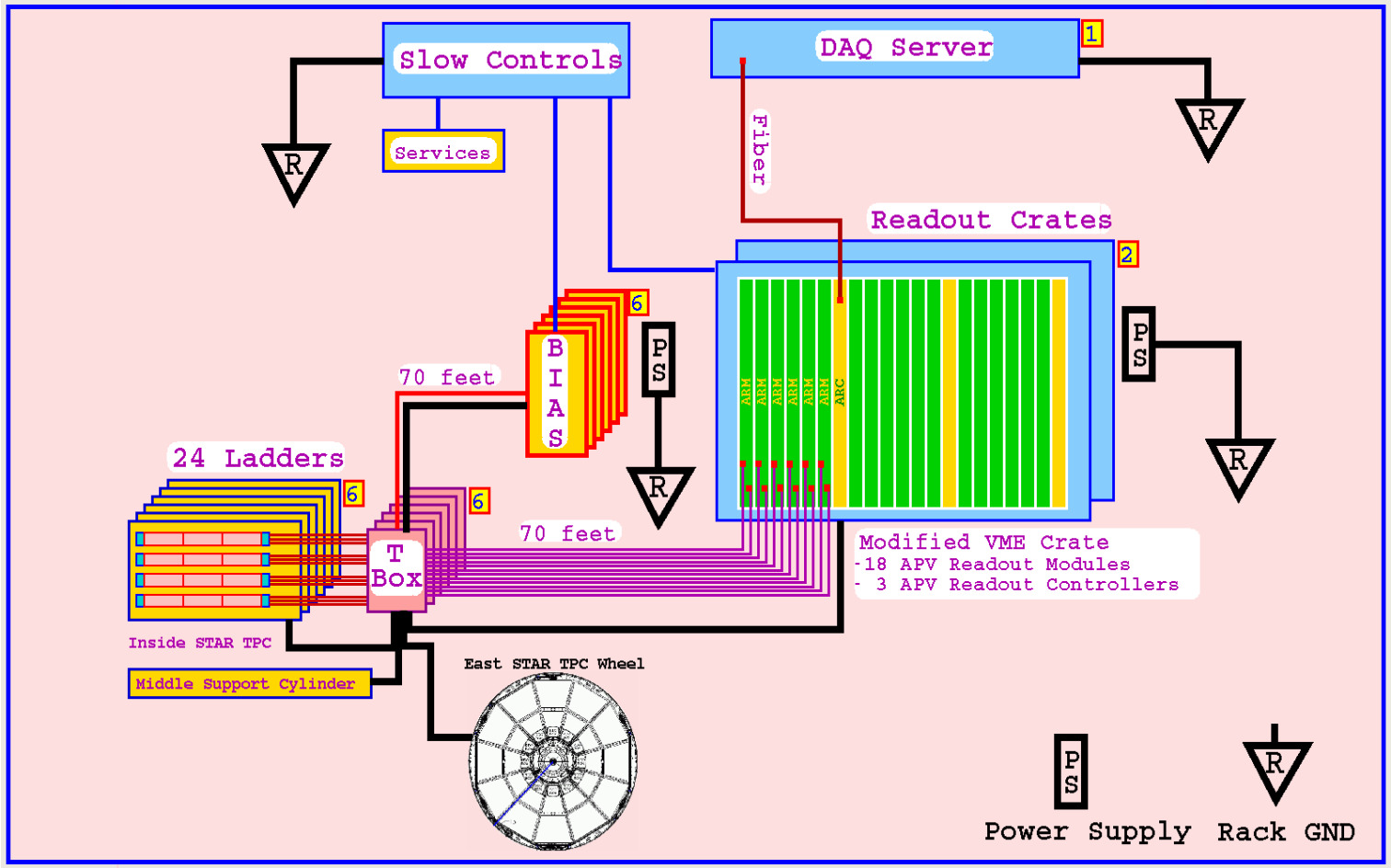
128 channels parallel sampling
40 MHz sampling rate
4 us analogue pipeline
< 30 us deadtime for 20 MHz 3-sample readout

11:1 signal to noise ratio

0.3 Watt per chip

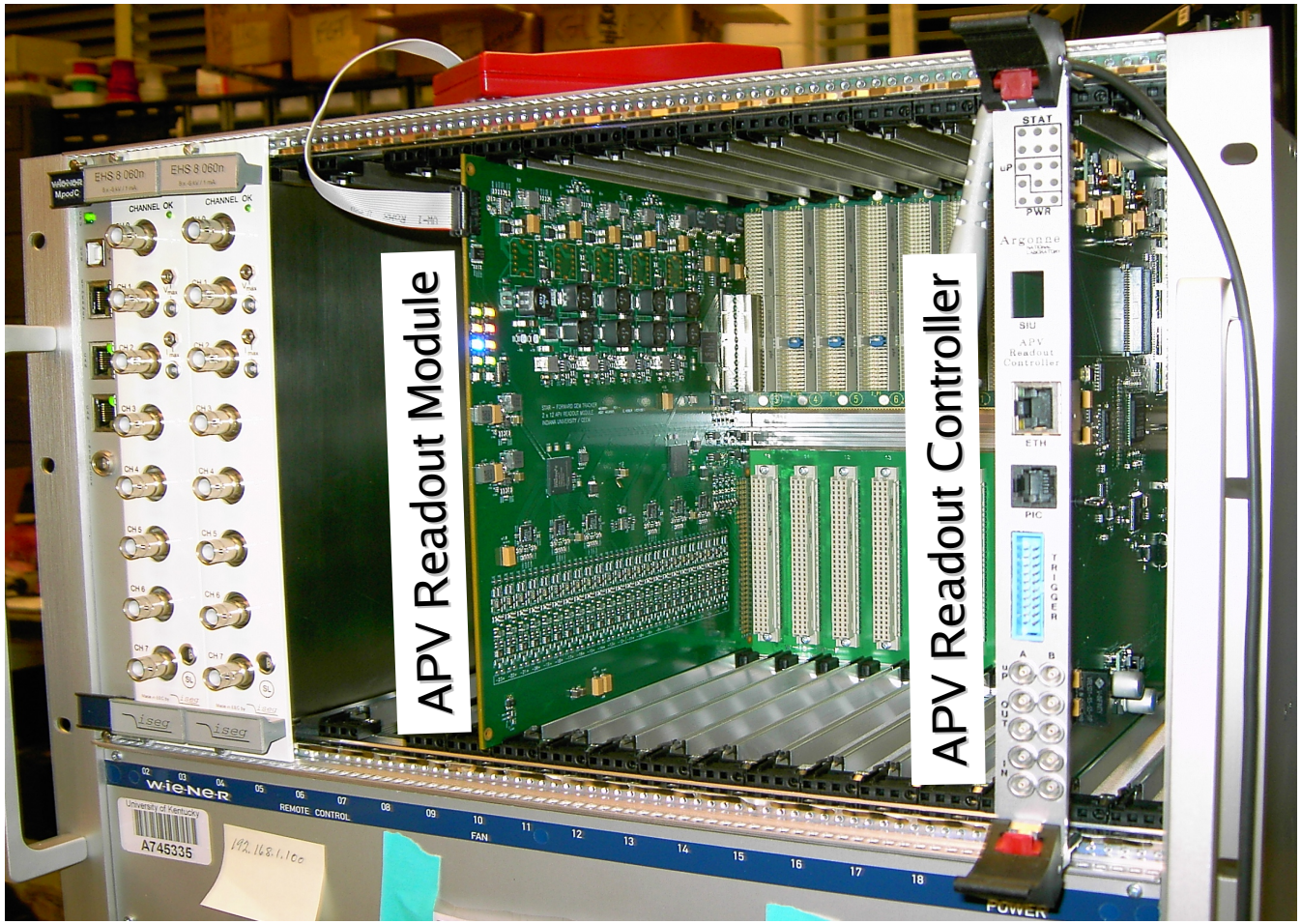
All chips have been procured

IST readout system layout



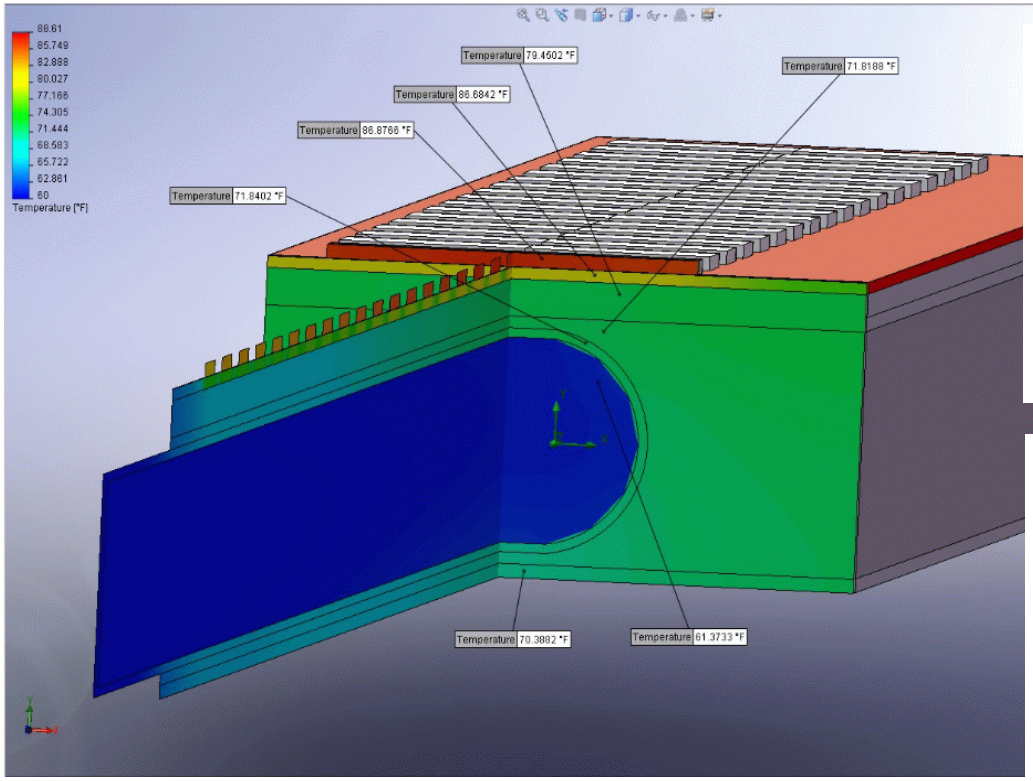
Layout 80% done, FGT as testbed

IST readout system



Design 90% done, ready for FGT installation in FY12

IST cooling

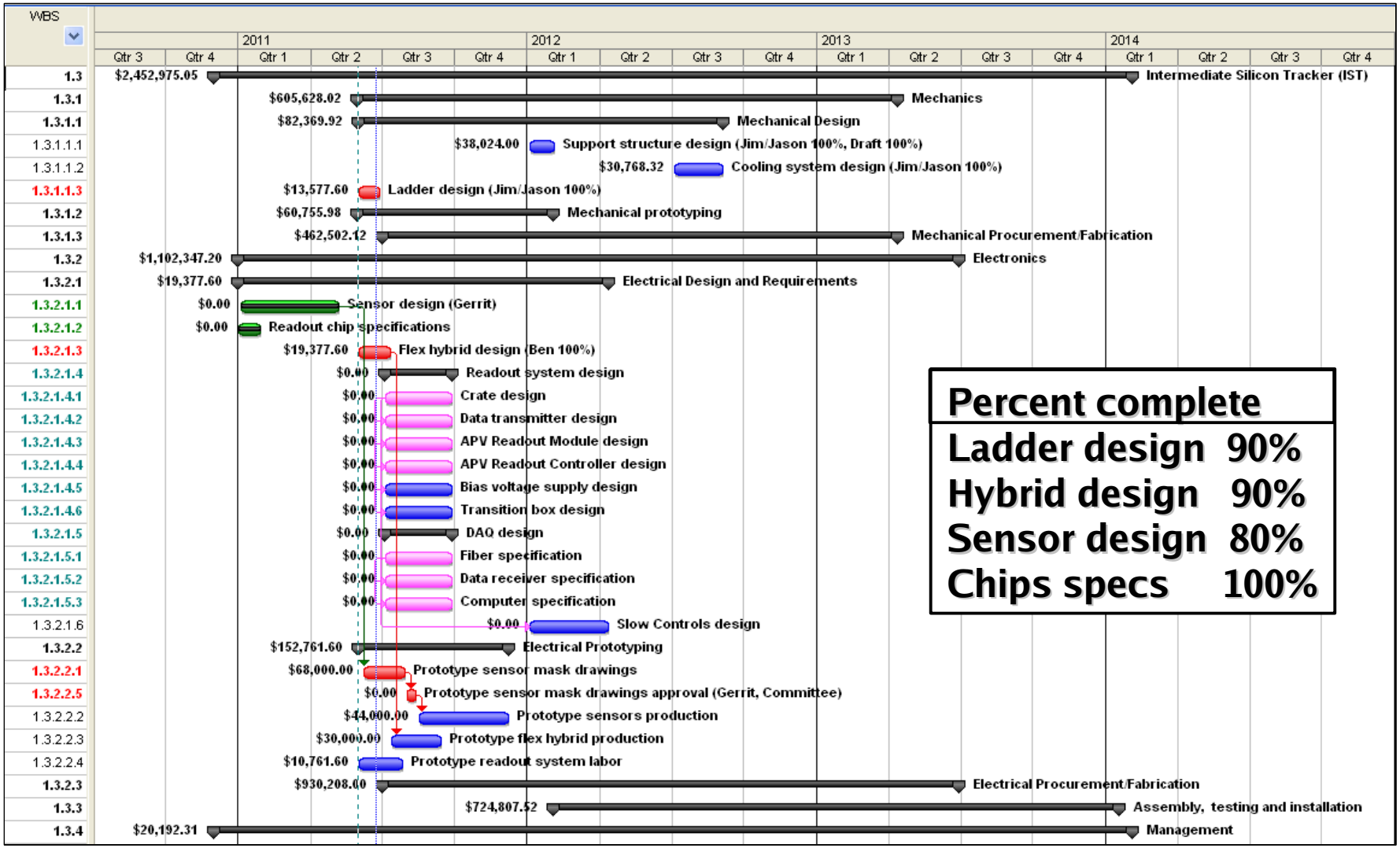


Maximum readout chip temperature	35°C
Cooling fluid velocity	0.3-3 m/s
Maximum pressure	0.2MPa
Cooling fluid inlet temperature	24°C

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

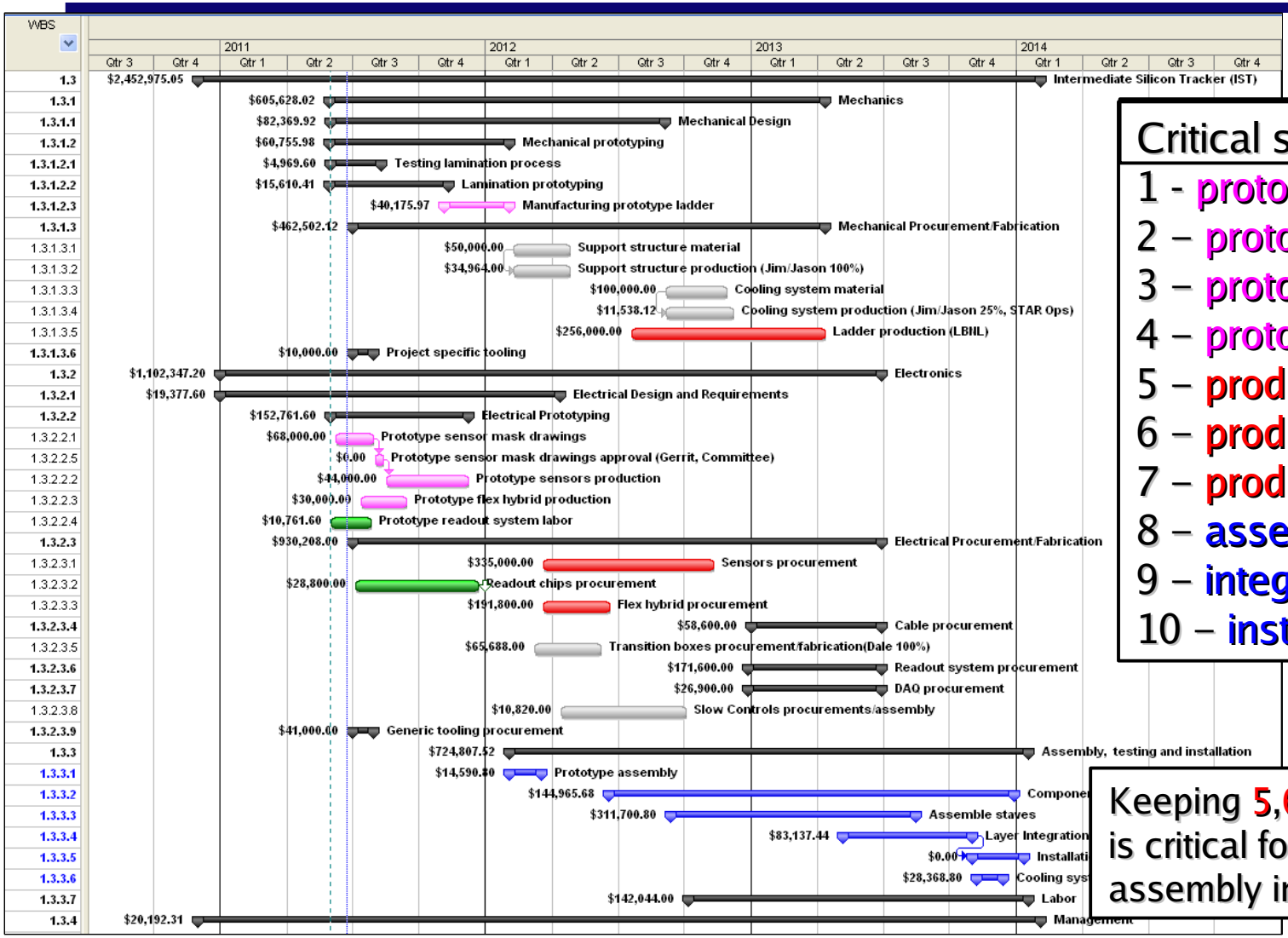
- Fluorocarbon fluid based cooling
- Simulations show proper cooling for one stave and possible daisy chaining of staves

IST design status summary



Percent complete	
Ladder design	90%
Hybrid design	90%
Sensor design	80%
Chips specs	100%

IST fabrication plan

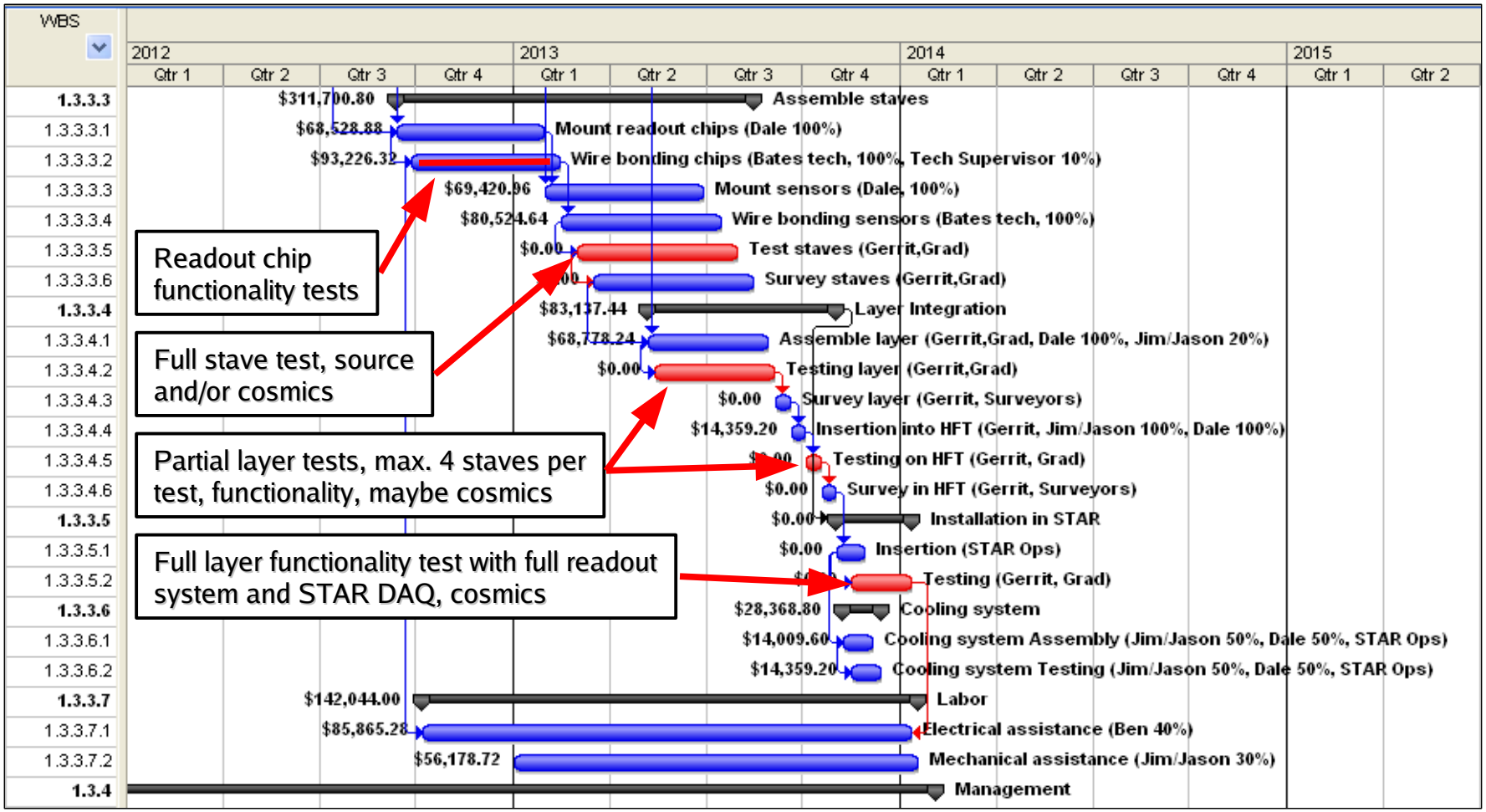


Critical steps:

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 FY2012 is critical for successful assembly in FY2013

IST system test(s)



Schedule includes functionality tests in each step of the assembly process

IST cost by Level 3 WBS

WBS	Name	Cost	Duration	Start	Finish
1.3	**Intermediate Silicon Tracker (IST)**	**$2,452,132.70**	**783 days**	**8/31/10**	**10/17/13**
	MIT Scientist Contributed	$0.00		8/31/10	10/17/13
1.3.1	Mechanics	$605,628.02	464 days	3/1/11	1/10/13
1.3.2	Electronics	$1,102,347.20	619 days	10/1/10	3/29/13
1.3.3	Assembly, testing and installation	$724,823.52	485 days	11/3/11	10/17/13
1.3.4	Management	$19,333.96	780 days	8/31/10	10/14/13

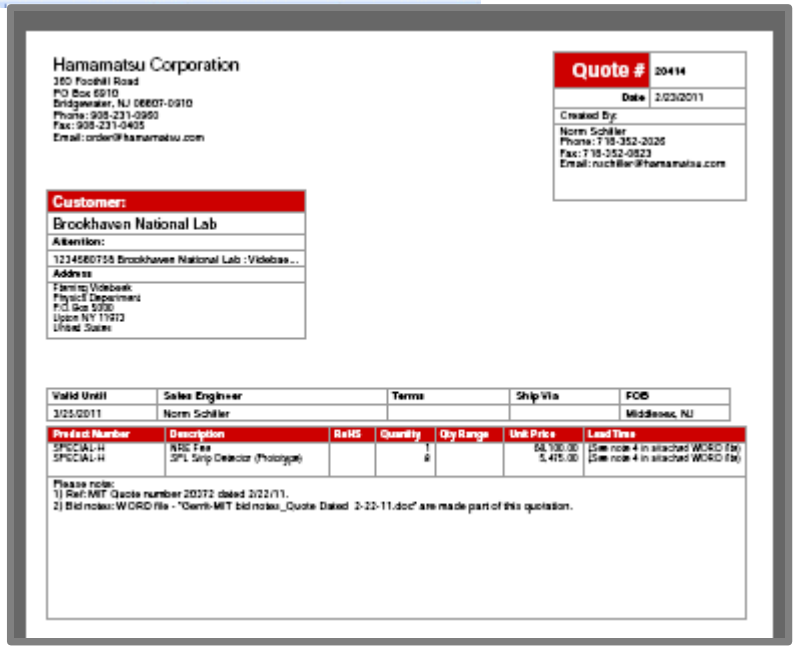
Budget pretty much equally divided between 1.3.1, 1.3.2 and 1.3.3 when not taking the $450k silicon sensors into account

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



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360 Foothill Road
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Quote # 20414
Date 2/23/2011
Created By:
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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

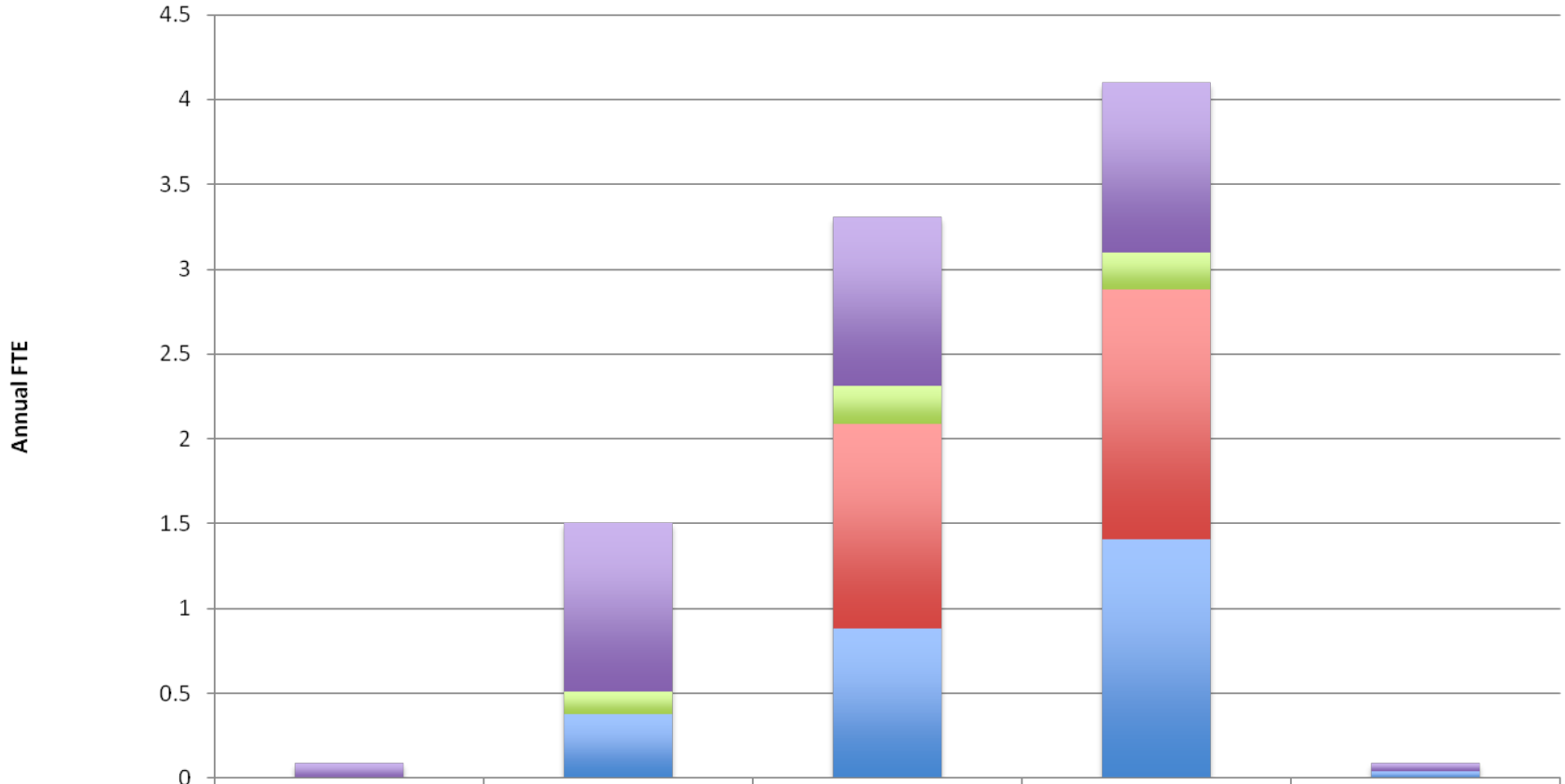
Valid Until	Sales Engineer	Terms	Ship Via	FOB
3/25/2011	Norm Schiller			Middlesex, NJ

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

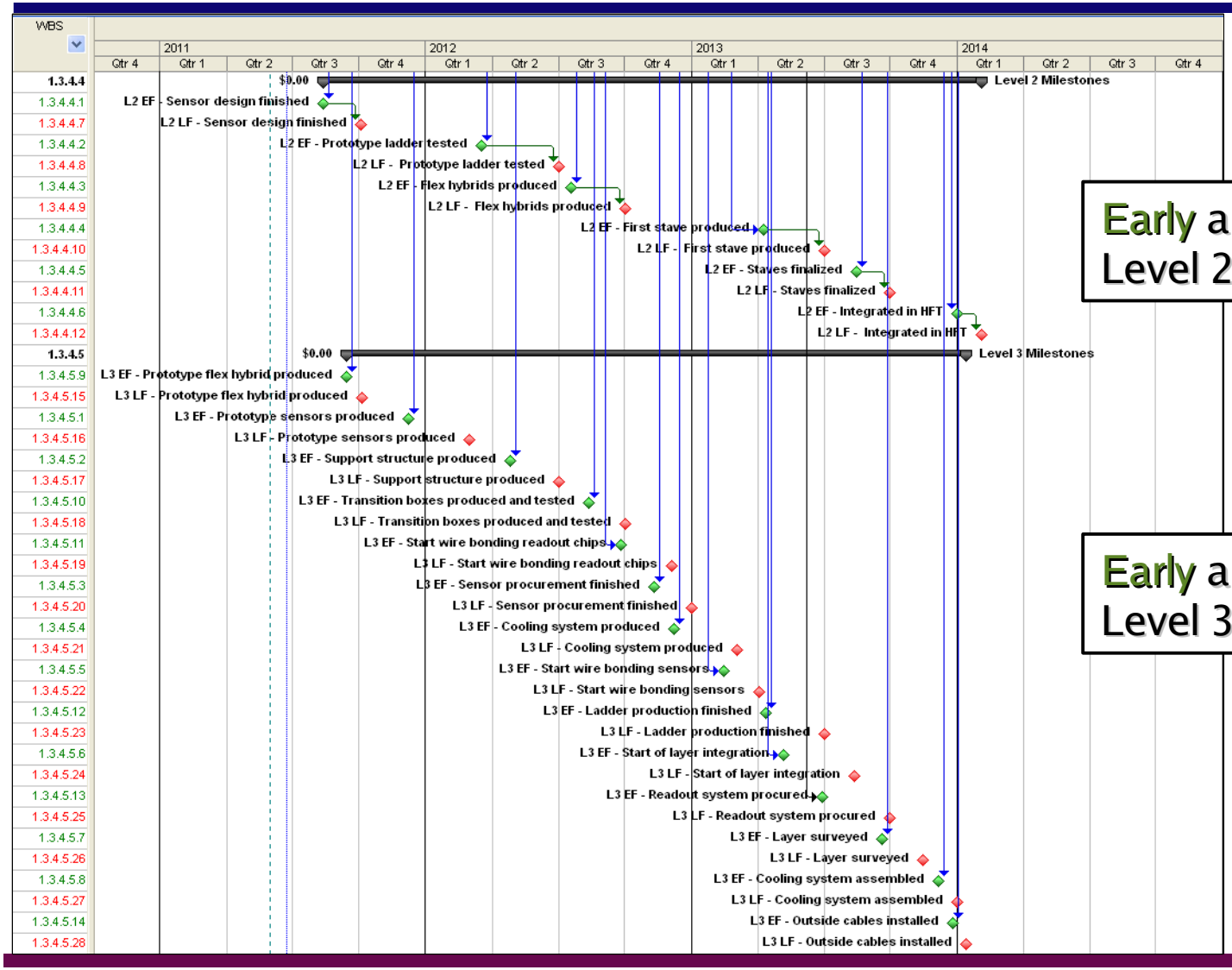


	2010	2011	2012	2013	2014
MIT Scientist	0.09	1.00	1.00	1.00	0.05
MIT PM Support	0	0.13	0.22	0.22	0
MIT Technical	0	0	1.21	1.47	0
MIT Engineer	0	0.38	0.88	1.41	0.04

IST milestones

Lvl	Milestone	Early Finish	Late Finish	Actual
1	CD-0 Approve Mission Need			Q2FY09 (A)
1	CD-1 Approve Alternative Selection and Cost Range			Q4FY10 (A)
1	CD-2 Approve Performance Baseline		Q3FY11	
1	CD-3 Approve Start of Fabrication		Q3FY11	
2	IST - Sensor design Finished	Q3FY11	Q4FY11	
2	IST - Prototype ladder tested	Q1FY12	Q3FY12	
2	IST - Flex hybrid produced	Q3FY12	Q4FY12	
2	IST - First staves produced	Q2FY13	Q4FY13	
2	IST - Staves finalized	Q3FY13	Q4FY13	
2	IST Integrated into HFT	Q1FY14	Q1FY14	
2	HFT Installed and Integrated into STAR	Q1FY14	Q1FY15	
1	CD-4 Approve Project Completion	Q1FY14	Q2FY15	

IST milestones control



Early and Late Finish
Level 2 Milestones

Early and Late Finish
Level 3 Milestones

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 + $32k prototypes	cost/schedule	moderate	low	I low	scheduling slack,reliable vendor
Flex hybrid	Failure to function according to specifications	none	delay in full production	$5k	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

Summary

- IST meets the CD-4 requirements and the additional experimental requirements
- Design is 80-90% 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