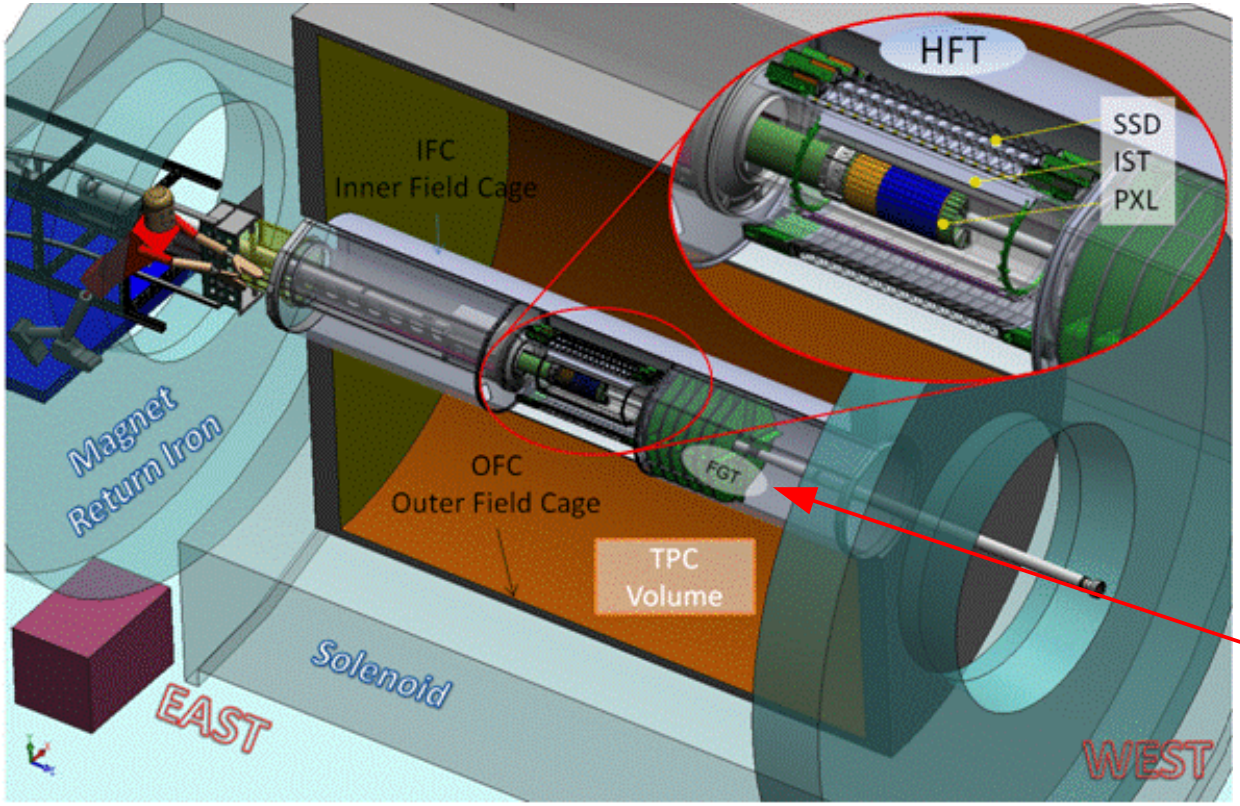
WBS 1.3
IST Overview

Gerrit van Nieuwenhuizen
MIT

IST presentation overview

- Detector overview
- CD-4 requirements and deliverables
- Technical description and design status
- Fabrication and testing
- Cost and basis of estimates
- Human resources
- Milestones and risk assessment

IST in Inner Detector Upgrade



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

HFT – Heavy Flavor Tracker

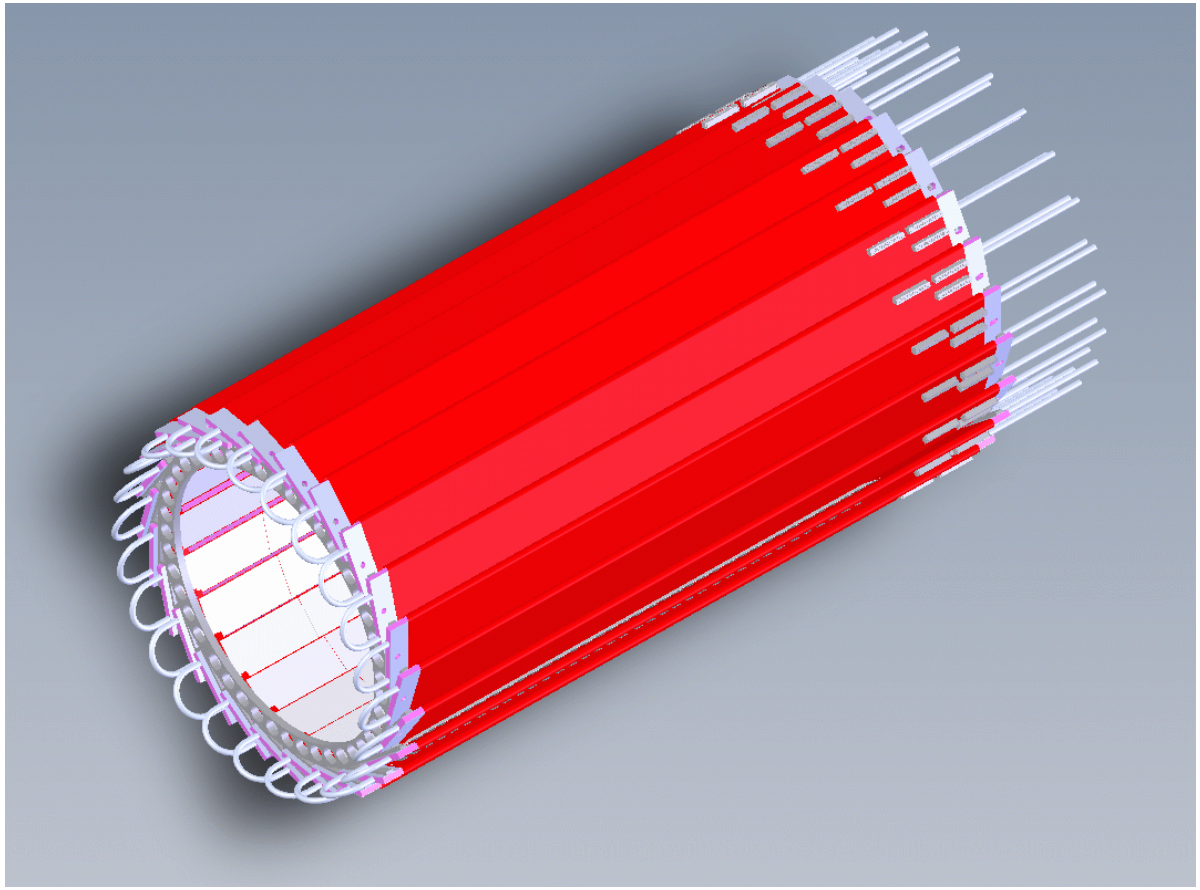
- SSD – Silicon Strip Detector
  - r = 22 cm
- **IST – Inner Silicon Tracker**
  - **r = 14 cm**
- PXL – Pixel Detector
  - r = 2.5, 8 cm

FGT – Forward GEM Tracker
Shares almost identical readout system with IST
Installation in CY2011

We track inward from the TPC with graded resolution:

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

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 CD-4 requirements

Low-level CD-4 key performance parameters:
experimentally demonstrated at Project Completion

4	Relative Stability of IST and SSD relative to PXL layer	< 300 μm	Survey during construction and assembly
7	Detector hit efficiency IST	> 95% from Signal, Noise better than 10:1	Low noise electronics, source and cosmic tests
8	Live channels for PXL and IST	> 85%	<1% dead silicon pads, redundancy, spares, care...
9	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 CD-4 deliverables

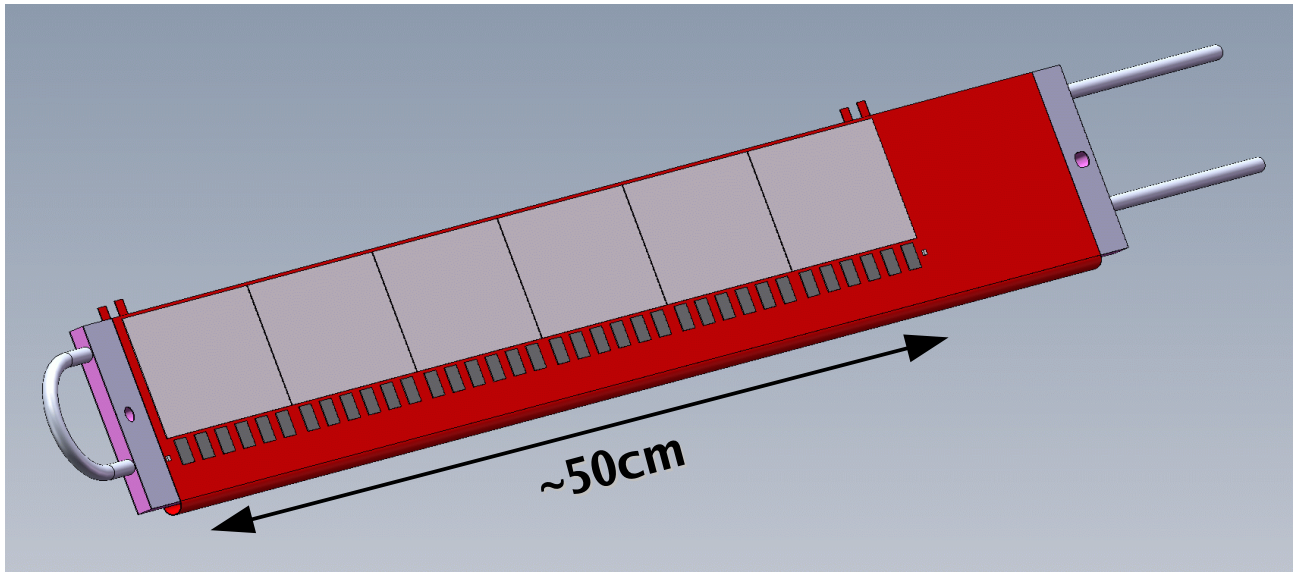
- 27 (24+3 spares) staves with six sensors per stave
- 24 IST staves installed on the Middle Support Cylinder
- Silicon bias voltage system for 24 staves
- Readout system for 24 staves
- Cabling and Cooling Services

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 ~10 kRad/year
- Be able to resolve 107ns beam bunches

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

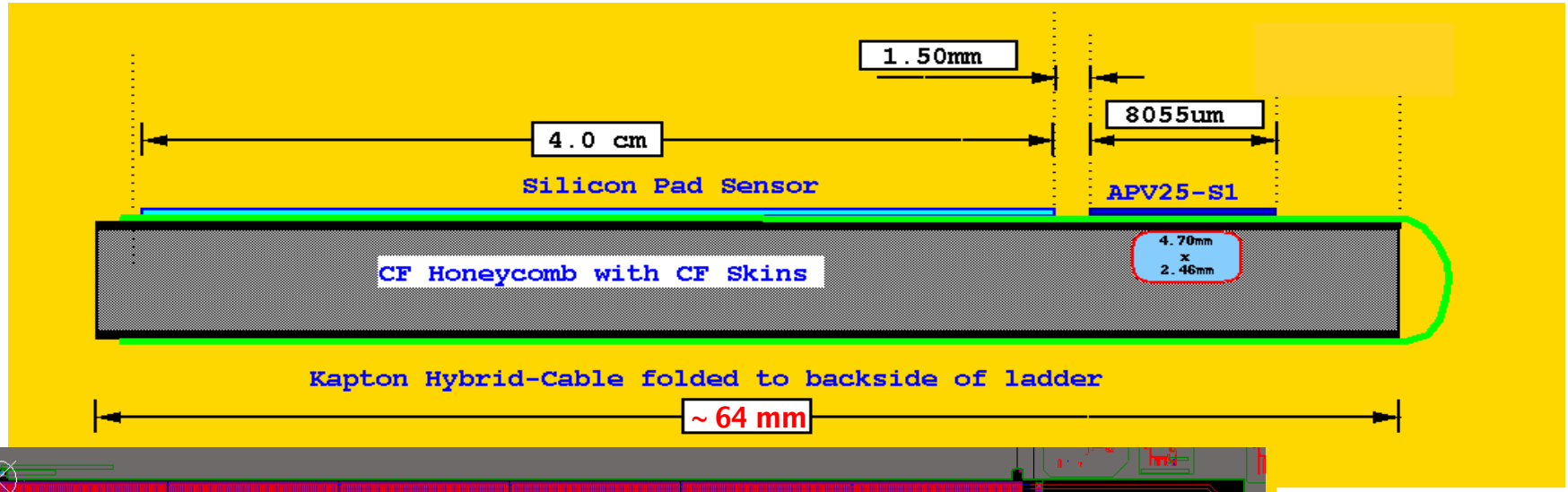
IST stave

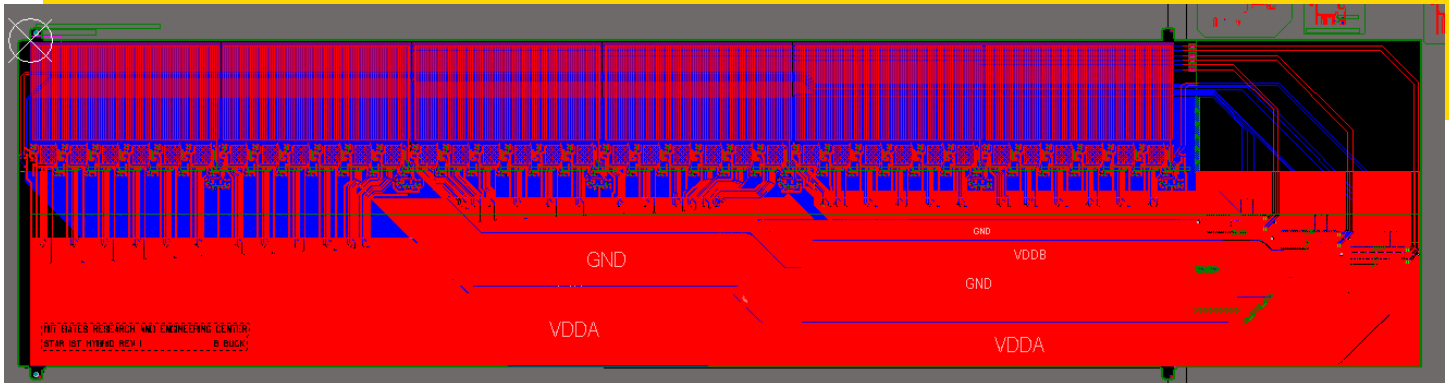


IST stave = carbon fiber ladder + cooling tubes
kapton flex hybrid + passive components
6 silicon pad sensors
3 x 12 APV25-S1 readout chips

Electrically divided in 3 units to reduce chance of failure of a full stave

IST ladder and hybrid





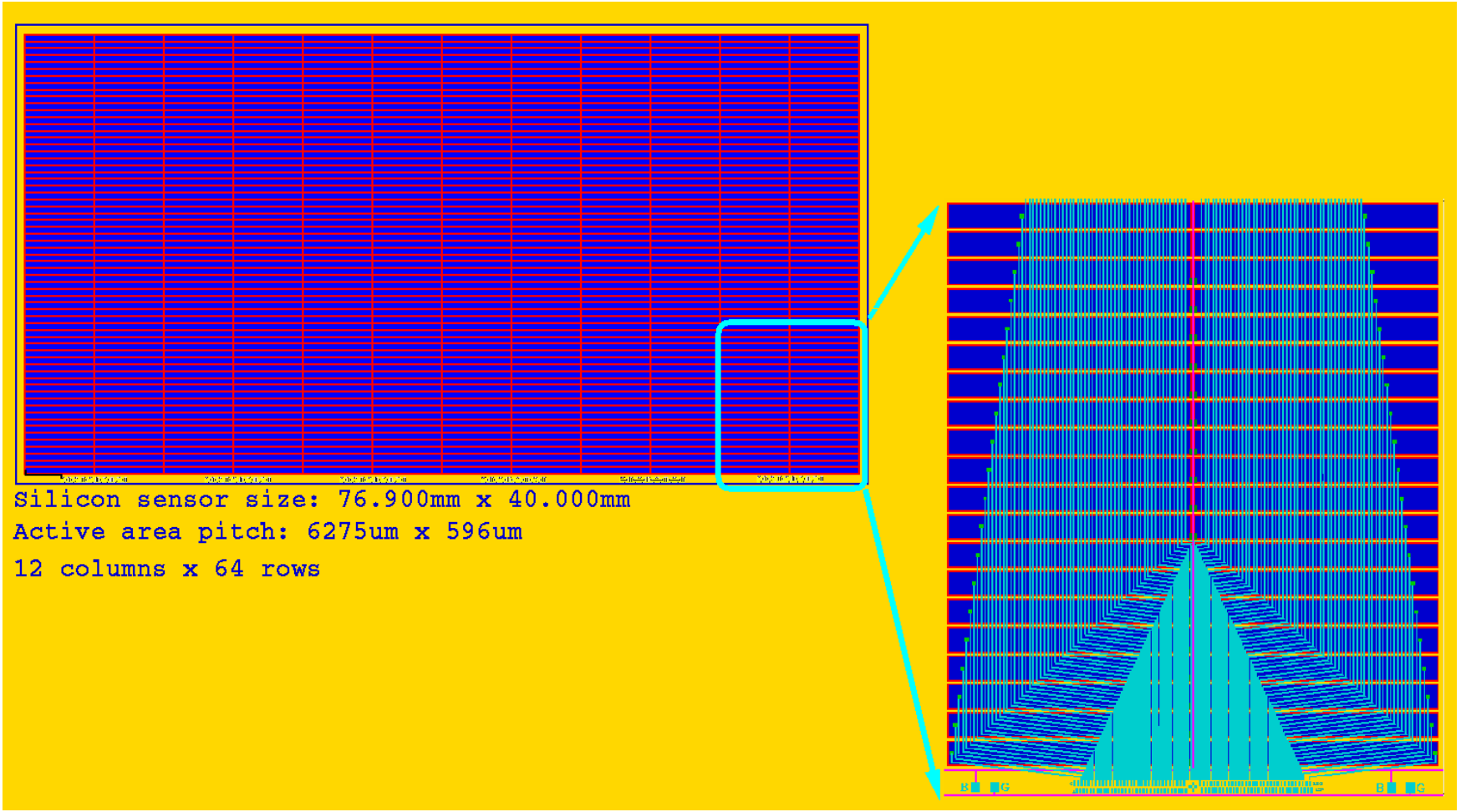
← 6 Sensors

← 36 APV25-S1

← cable, folds over to back

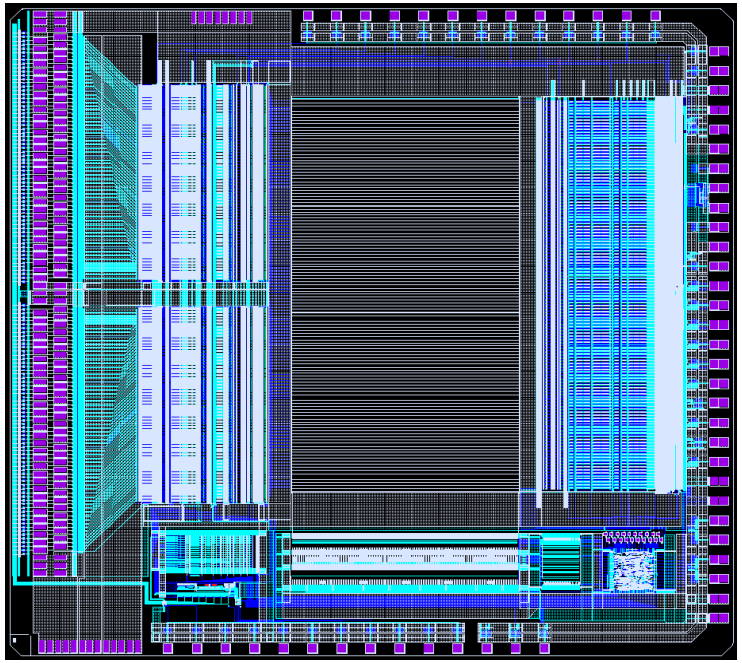
Design prototype ladder & hybrid finished, in production, ready in September

IST silicon pad sensor



Mask drawings approved, 8 prototypes expected in October

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

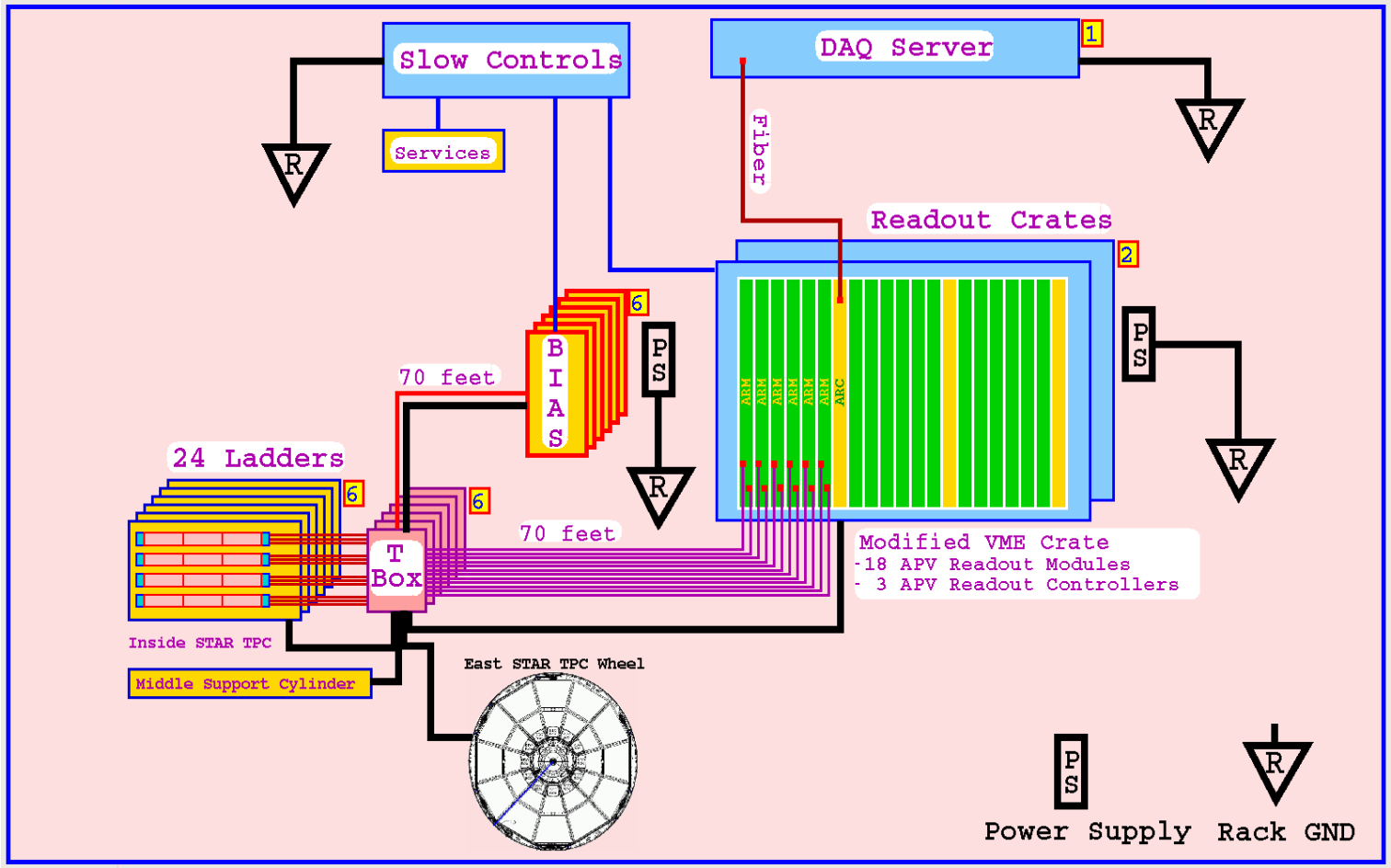
128 channels parallel sampling
40 MHz sampling rate
4 us analogue pipeline
< 30 us deadtime for 20 MHz 3-sample readout

Better than 15:1 signal to noise ratio

0.3 Watt per chip

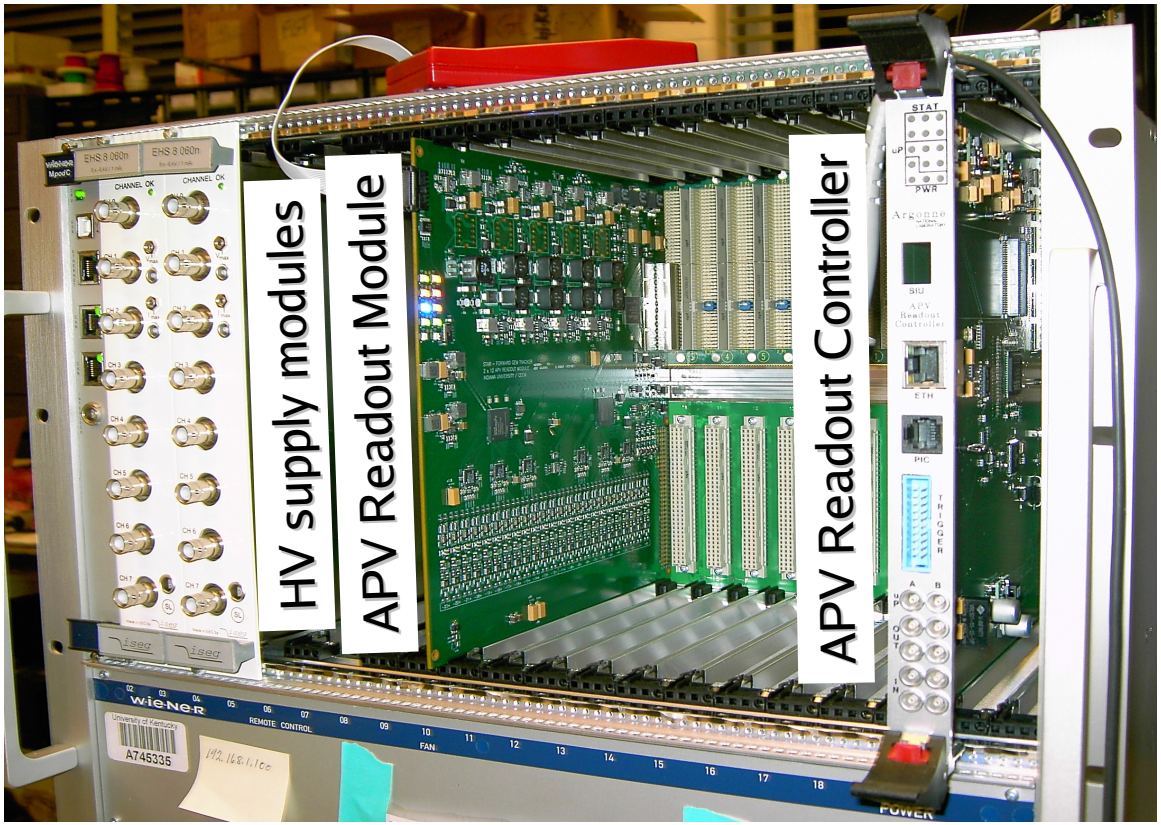
All chips have been procured

IST readout system



Layout 80% done, FGT as testbed

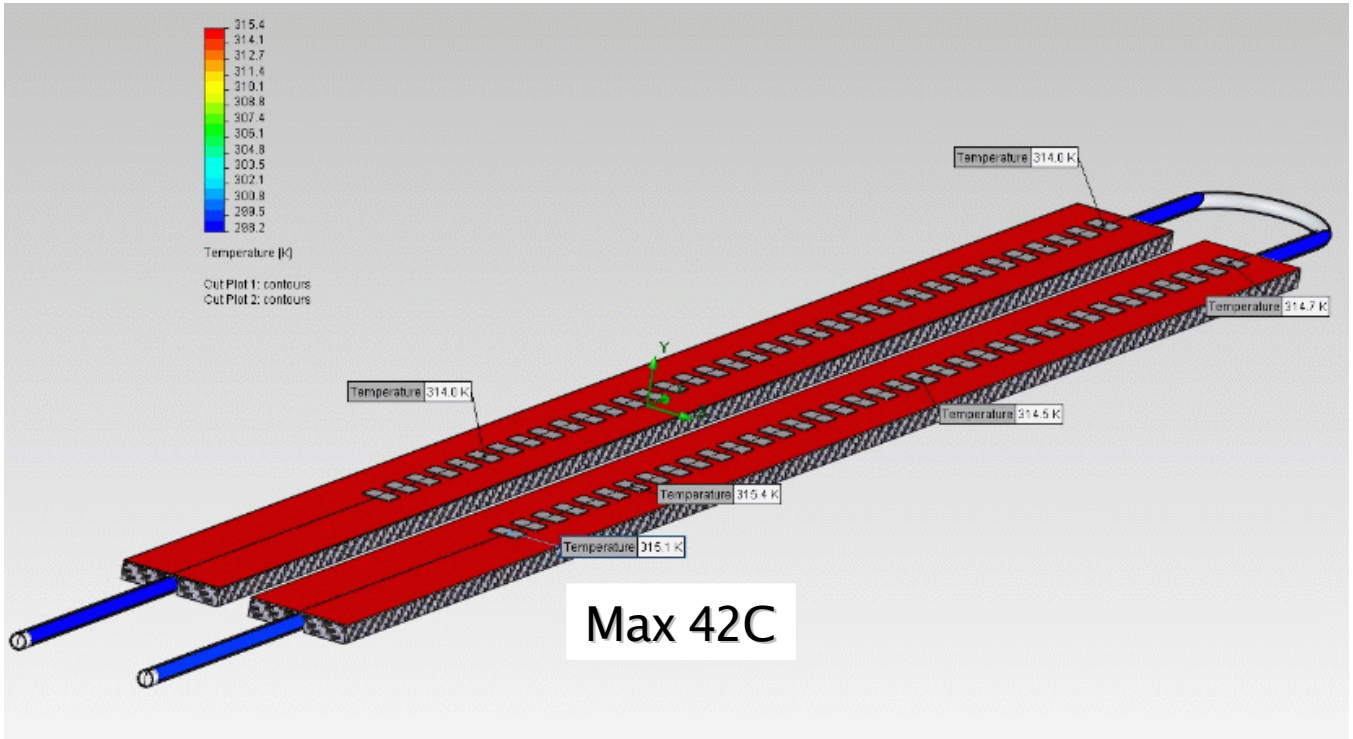
IST readout system



Currently being battle tested in FGT cosmic ray test setup

Design 90% done, ready for FGT installation in CY11

IST cooling



3M Novec 7200 fluorocarbon cooling fluid

Inlet 24C
(TPC oper.T)

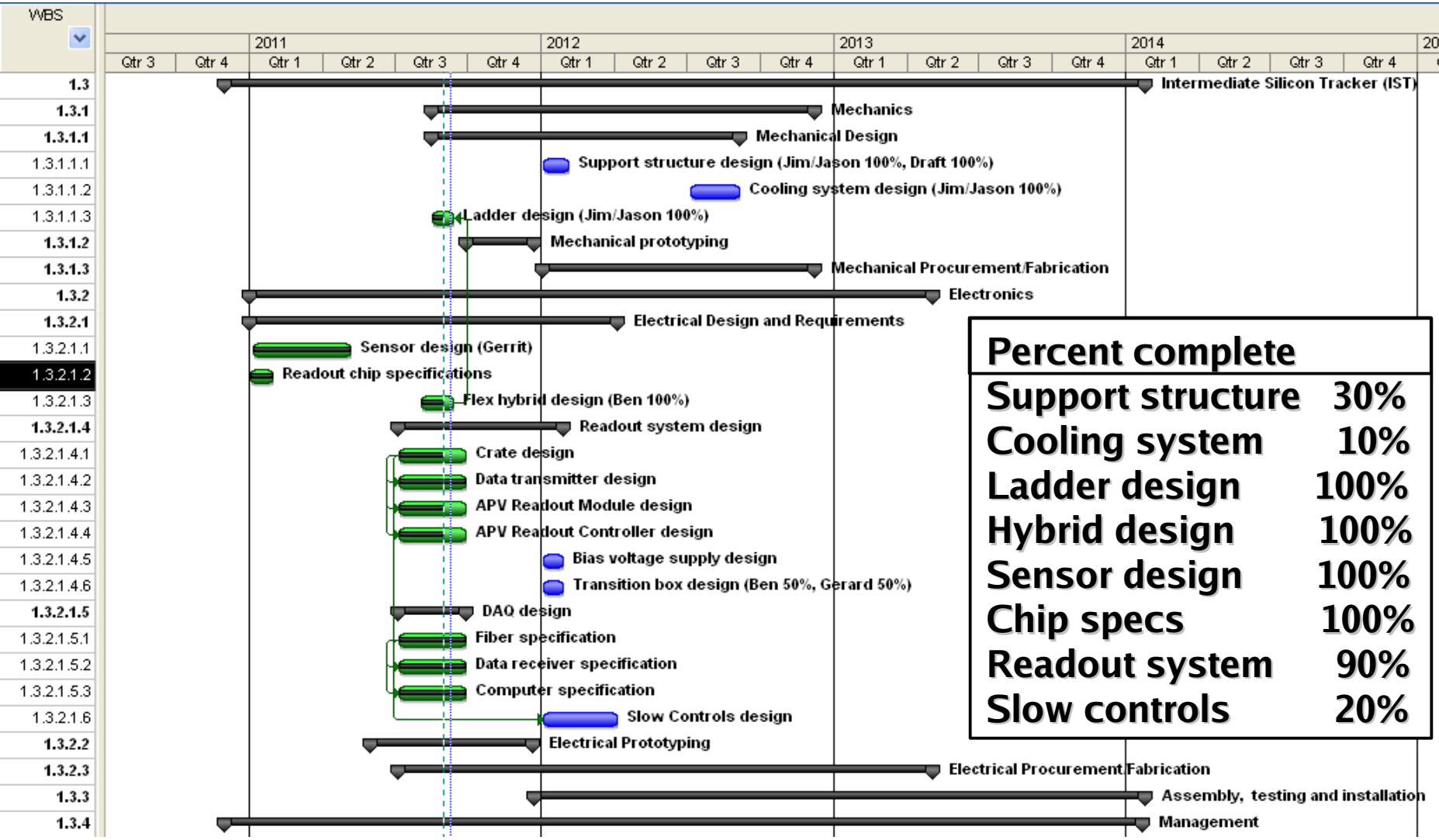
550mW/chip
(1.8 x nominal)

1 liter/min at 20psi

2 staves in series

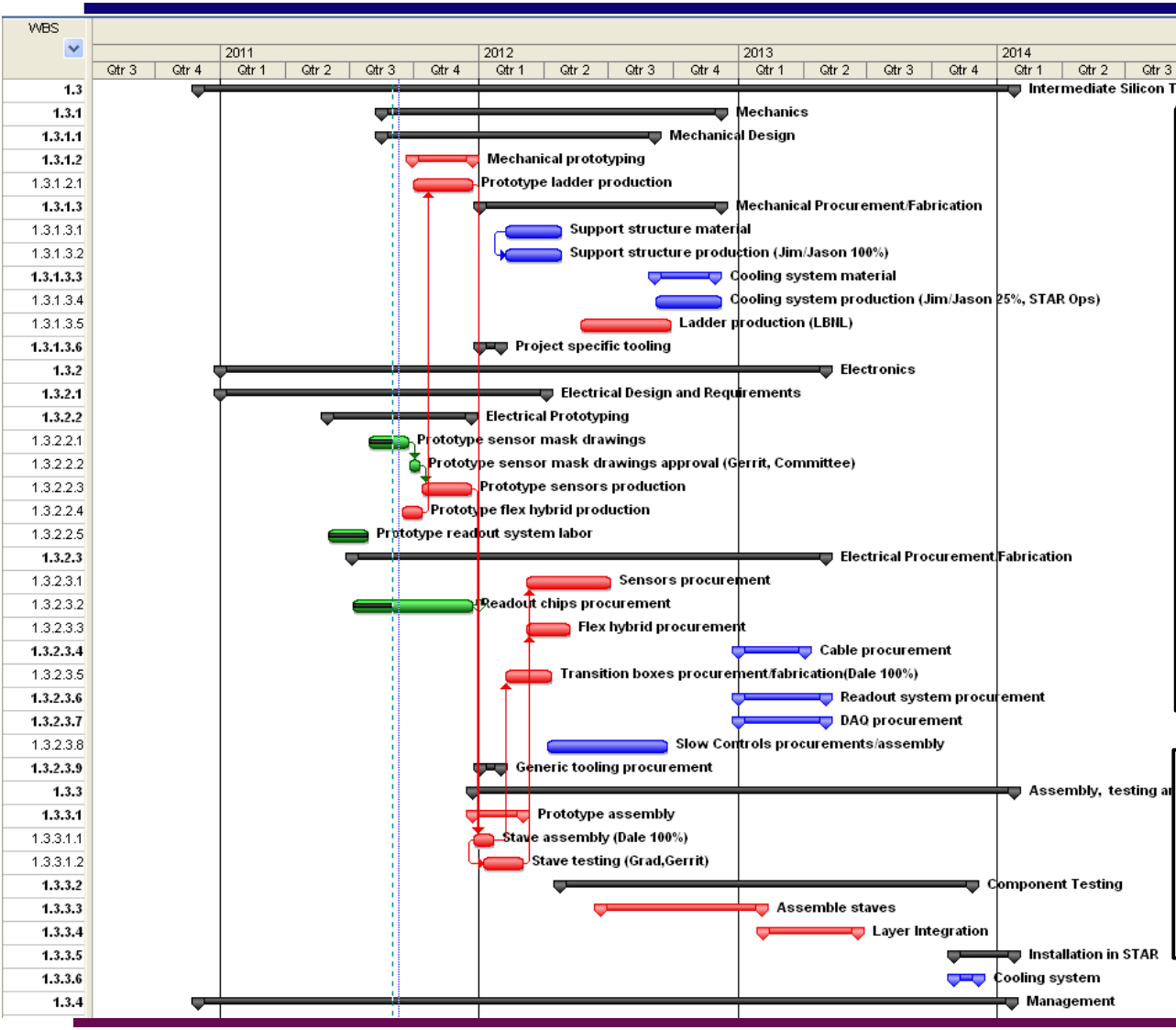
Simulations show 42C max at chips with 1.8x the nominal dissipation and no cooling via's through Kapton hybrid yet
Actual temperature will be lower

IST design status



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%

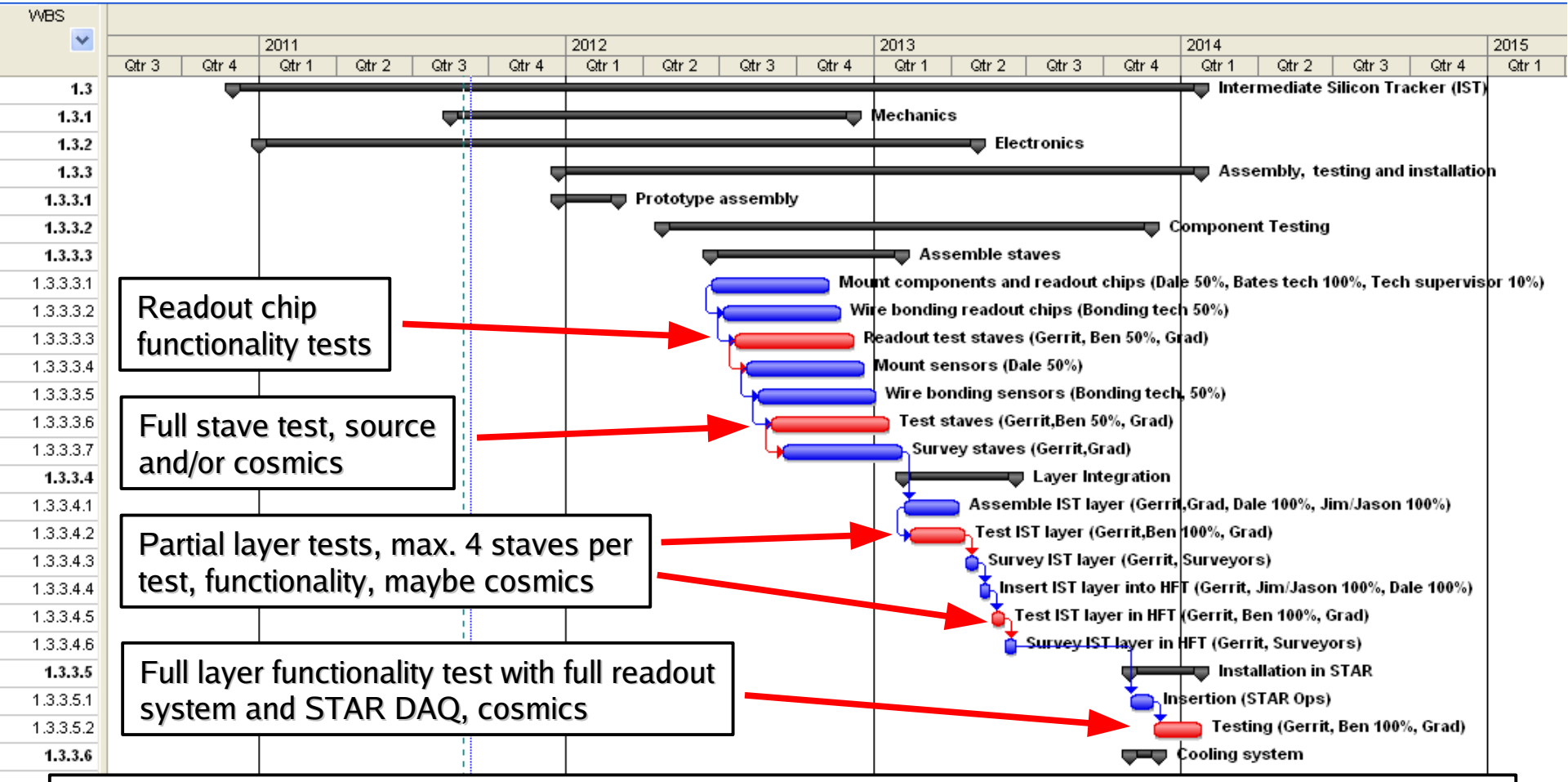
IST fabrication



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 tests



Schedule includes functionality tests in each step of the assembly process

IST cost by Level 3 WBS

WBS	Task Name	Cost ($K)
1.3	**Intermediate Silicon Tracker (IST)**	**2,480**
	MIT Scientist Contributed	-
1.3.1	Mechanics	599
1.3.2	Electronics	1,122
1.3.3	Assembly, testing and installation	759
1.3.4	Milestones	-

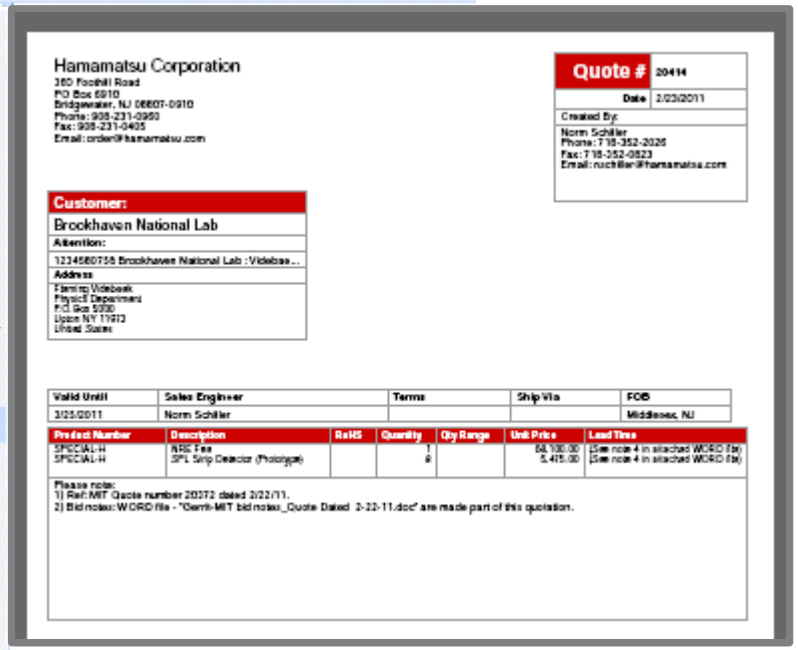
Largest cost item in 1.3.2 is the $450k sensor procurement

IST basis of estimates

EMC² documentum eRoom

My eRooms > Heavy Flavor Tracker > DOE CD 2/3 Review > Project Documents > Cost Basis > 1.3 IST

- Heavy Flavor Tracker
  - Contact List
  - DOE CD 2/3 Review
    - Agenda.docx
    - Dry Run Presentations and Documentation
    - Internal Review
    - Project Documents
      - Baseline Schedule
      - Components of Design
      - Cost Basis
        - 1.2. PXL
        - 1.3 IST
          - 1.3.1_Mechanics
          - 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.d
              - 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
          - 1.4 SSD



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 Videbeak
Physics Department
P.O. Box 5000
Upton NY 11973
United States

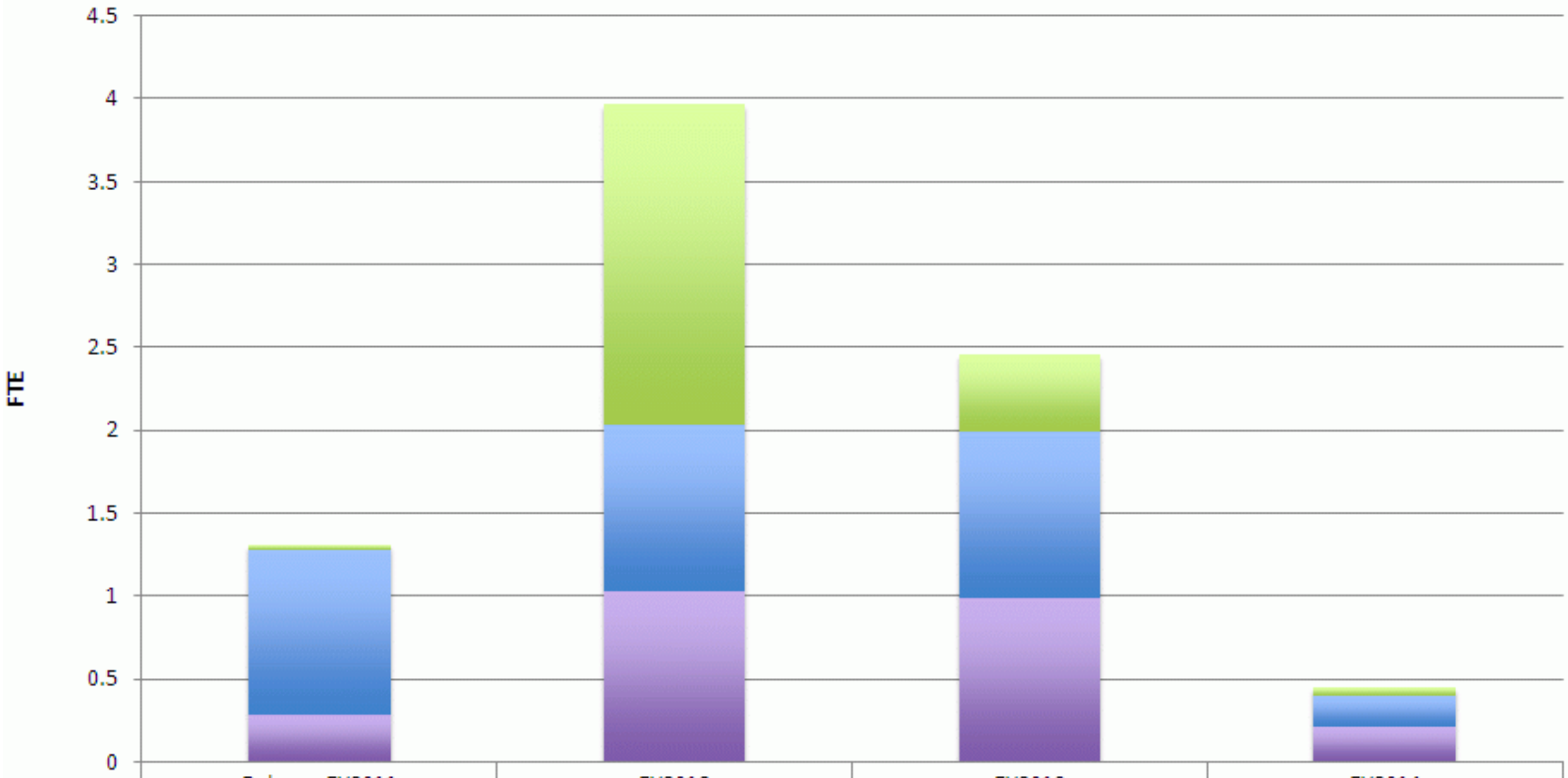
Valid Until	Sales Engineer	Terms	Ship Via	FOB
3/25/2011	Norm Schiller			Middlesex, NJ

Product Number	Description	RoHS	Quantity	Qty Range	Unit Price	Lead Time
SPECIAL-H	NRE Fee		1		68,100.00	(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 FTE per year



	Balance FY2011	FY2012	FY2013	FY2014
Technical	0.03	1.94	0.47	0.05
Scientific	1	1	1	0.19
Material				
Engineer	0.28	1.03	0.99	0.21

IST human resources

Name	Function	Affiliation	Expertise
Bernd Surrow	Physicist	MIT	Sub system manager
Gerrit van Nieuwenhuizen	Physicist	MIT	Detector development
Ben Buck	Electronics Engineer	MIT-Bates	Front End Electronics, Readout
Gerard Visser	Electronics Engineer	UICF	Readout, DAQ
Jim Kelsey	Mechanical Engineer	MIT-Bates	Support Structure, Cooling
Jason Bessuille	Mechanical Engineer	MIT-Bates	Support Structure, Cooling
Eric Anderssen	Mechanical Engineer	LBNL	Support Structure
Dale Ross	Technician	MIT-LNS	Assembly
TBD	Technician	MIT	Assembly
TBD	Technician	MIT/BNL	Wire Bonding
Don Pinelli	Technician	BNL	Wire Bonding

~9 FTE from 4 institutes for IST deliverables

IST milestones

Level	Milestone	Planned	Actual/Forecast
1	CD-0 Approve Mission Need		2/18/09 (A)
1	CD-1 Approve Alternative Selection and Cost Range		8/31/10 (A)
1	CD-2 Approve Performance Baseline	Q4FY11	Aug-11
1	CD-3 Approve Start of Fabrication	Q4FY11	Aug-11
1	CD-4 Approve Project Completion	Q2FY15	Jun-15
1.3	IST		
2	Sensor design Finished	Q1FY12	Jul-11
2	Prototype ladder tested	Q2FY12	Dec-11
2	Flex hybrid produced	Q3FY12	Feb-12
2	First staves produced	Q4FY12	Jun-12
2	Staves finalized	Q2FY13	Nov-12
2	Integrated into **HFT**	Q3FY13	Mar-13

First IST milestone met in June 2011

IST risk assessment

Part of the full IST risk table

WBS	WBS description	Description	Schedule Conseq.	Cost Impact ($K)	Severity	Mitigation Strategy
1.3.1.3.5	Ladders	Failure to produce all ladders in time	delay in assembly pipeline	none	low	scheduling slack
1.3.2.2.3	Prototype sensors	Failure to function according to specifications	delay in start production	Respin, $68k NRE + $44k prototypes	moderate	scheduling slack,reliable vendor
1.3.2.2.4	Flex hybrid prototype	Failure to function according to specifications	delay in start production	Respin, $15k	moderate	scheduling slack, less prototypes
1.3.2.3.1	Production sensors	Production problems	delay in assembly	none	low	reliable vendor, stage batch production
1.3.2.3.3	Production flex hybrid	Production problems	delay in assembly	none	low	scheduling slack by producing early
1.3.2.3.6	Readout system					Problems straightened out by FGT
1.3.3.3	Assemble staves	Assembly problems	delay in layer integration	increase in labor cost, $40k/mo	moderate	Establish conservative assembly pipeline
1.3.3.4	Layer Integration	Integration problems	delay in installation	increase in labor cost, $45k/mo	low	Scheduling slack, delay installation

All risks low to moderate, mitigation strategies in place

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 to moderate for all major project tasks and mitigation strategies are in place