sPHENIX Director's Review

Robert Pisani
Physics Associate, BNL

August 2-4, 2017

BNL

TPC Support Systems Scope

From the WBS Definitions

- 1.2.7 **TPC Support Systems** TECHNICAL SCOPE: CONTAINS ALL TASKS WHICH ARE REQUIRED TO PROVIDE NECESSARY SUPPORT SYSTEMS FOR THE TPC: LASER, GAS, COOLING SYSTEM. WORK STATEMENT: PROVIDE ALL PARTS TO SUPPORT TPC OPERATION.
  - **1.2.7.1 TPC Laser System** TECHNICAL SCOPE: THIS ITEM CONTAINS ALL TASKS WHICH ARE REQUIRED TO IDENTITY COMPONENTS FOR THE TPC LASER CALIBRATION SYSTEM AND PROCURE AND CONSTRUCT THE ELEMENTS OF THE SYSTEM. WORK STATEMENT: PROVIDE ALL PARTS TO PRODUCE THE LASER CALIBRATION SYSTEM AND ASSEMBLE/INSTALL ALL PARTS.
  - **1.2.7.2 TPC Gas System** TECHNICAL SCOPE: THIS ITEM CONTAINS ALL TASKS WHICH ARE REQUIRED TO IDENTITY COMPONENTS FOR THE TPC GAS SYSTEM AND PROCURE AND CONSTRUCT THE ELEMENTS OF THE SYSTEM. WORK STATEMENT: PROVIDE ALL PARTS TO PRODUCE THE GAS SYSTEM AND ASSEMBLE/INSTALL ALL PARTS.
  - **1.2.7.3 TPC Cooling System** TECHNICAL SCOPE: THIS ITEM CONTAINS ALL TASKS WHICH ARE REQUIRED TO IDENTITY COMPONENTS FOR THE TPC GAS SYSTEM AND PROCURE AND CONSTRUCT THE ELEMENTS OF THE SYSTEM. WORK STATEMENT: PROVIDE ALL PARTS TO PRODUCE THE GAS SYSTEM AND ASSEMBLE/INSTALL ALL PARTS.

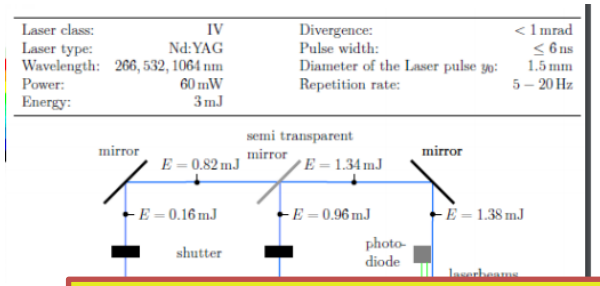
sPHENIX Detector
Relativistic Heavy Ion Collider
BASIS of ESTIMATE (BoE)

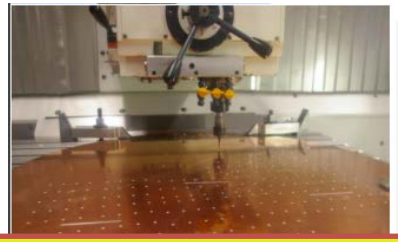
L2 Project Name	L2 WBS Number	L3 Project Name (Control Account)	L3 WBS Number
Time Projection Chamber	1.2	TPC Support Services	1.2.7

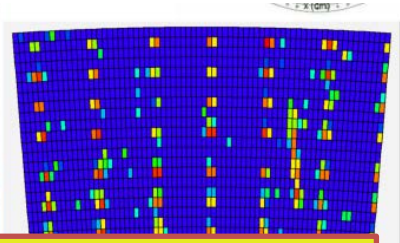
Work Package Name	WBS Number	Basis of Estimate Link
TPC Laser System	1.2.7.1	Laser-Summary
TPC Gas System	1.2.7.2	Gas-Summary
TPC Cooling System	1.2.7.3	Cooling-Summary

Laser System Technical Design Drivers

•A Laser System(1.2.7.1)- Lasers can be used to produce ionization in the TPC volume that provides both a source of signals and a calibration. This includes pattern applied to the central membrane (STAR) as well as direct laser transmission through the gas (STAR and ALICE). In the case of STAR and ALICE, the lasers going through the gas are directed via fibers and mirror bundles to criss-cross planes at several Z locations. The fiber bundles take radial space that both STAR and ALICE can afford. Due to the small size, sPHENIX cannot afford to have a bundle running along Z. Therefore we shall use two solutions to laser calibration. First, we will shine diffuse laser light onto the patterned centralmembrane. Second, we will allow for angled\tranjectories of laser light emanating from between the modules traveling at various angles through the gas. While not ideal it is a better solution than losing radial space.

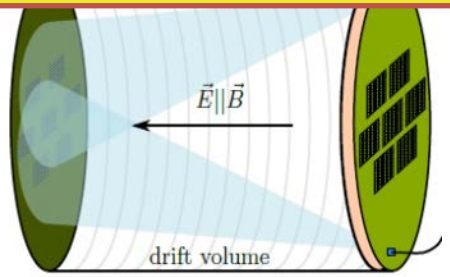






cathode with alumina dots

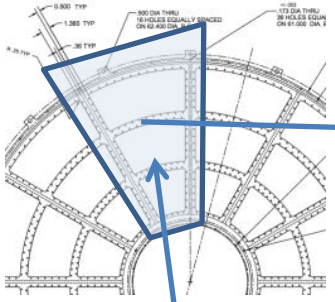
Place Holder



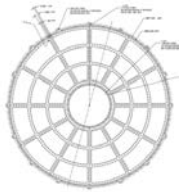
Cooling System Technical Design Drivers

•A Cooling System(1.2.7.3)- Cooling system need to be designed to remove 12kWatts of heat from the TPC Fee's which are located on the end caps of the TPC in side the SPhenix magnet. System to be operated below atmospheric pressure to prevent coolant leaks.

Segment system along the 12 sectors and remove 500 watts from each

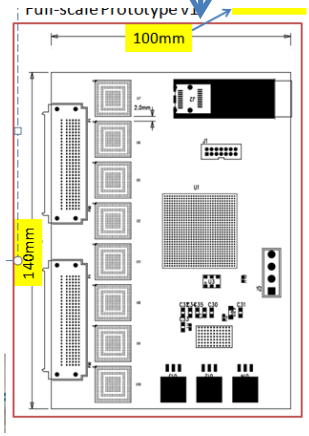


300 Fee Cards per End Cap:
Inner: 5/Module
Middle: 8/Module
Outer: 12/Module



Take heat out with chillers

Chilled water sent to TPC



Heat Source

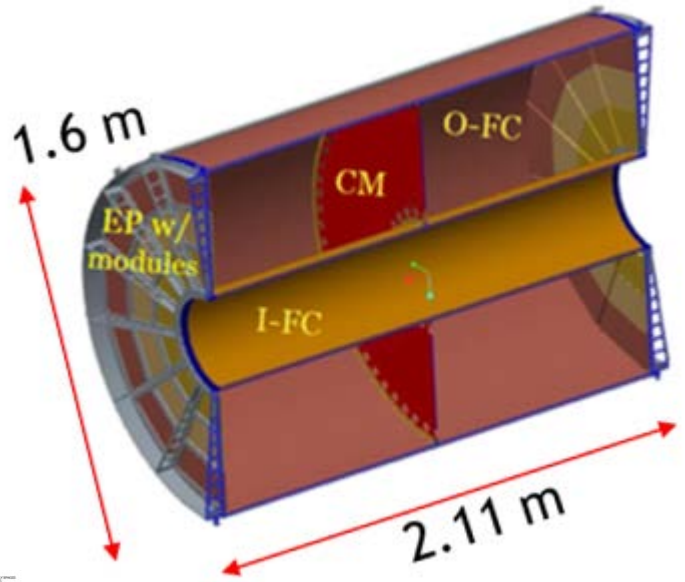
Cooling system must be thermally coupled to the Fee Board

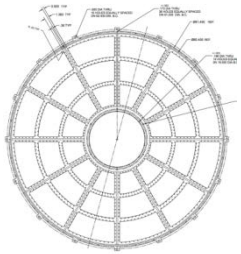
FEE estimated max ~20 watts per board

The Gas System Design Drivers

TPC Gas System Requirements

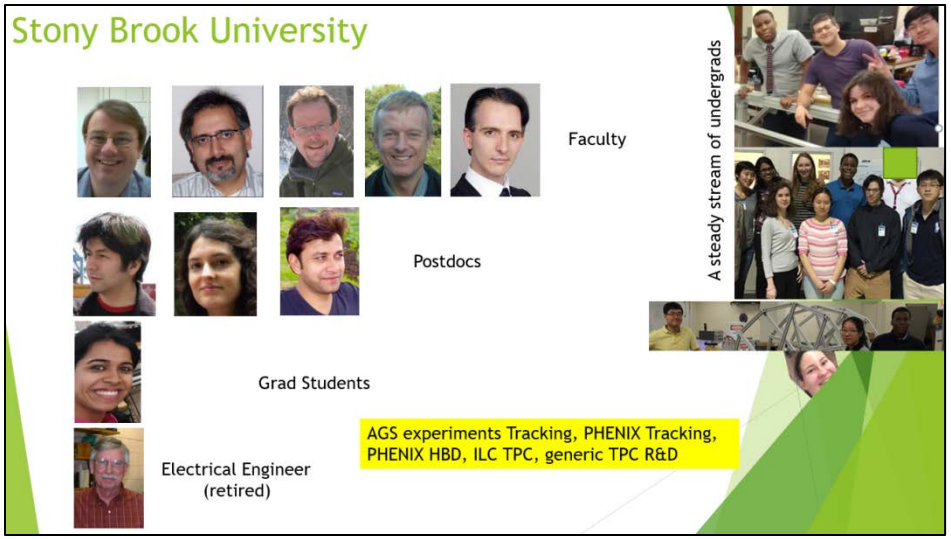
- •Neon based gas mixture
- •6 turnover a day
- •4000 liter volume
- •Slight overpressure above atmosphere
- •Compensate for changes in barometric pressure
- •High purity system
- •Recirculation required ($)
- •Remote monitoring
- •Alarming

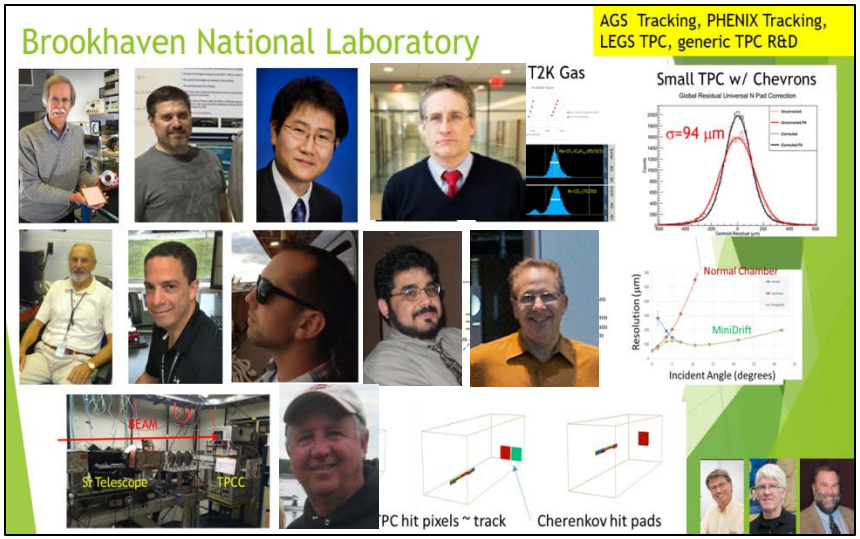


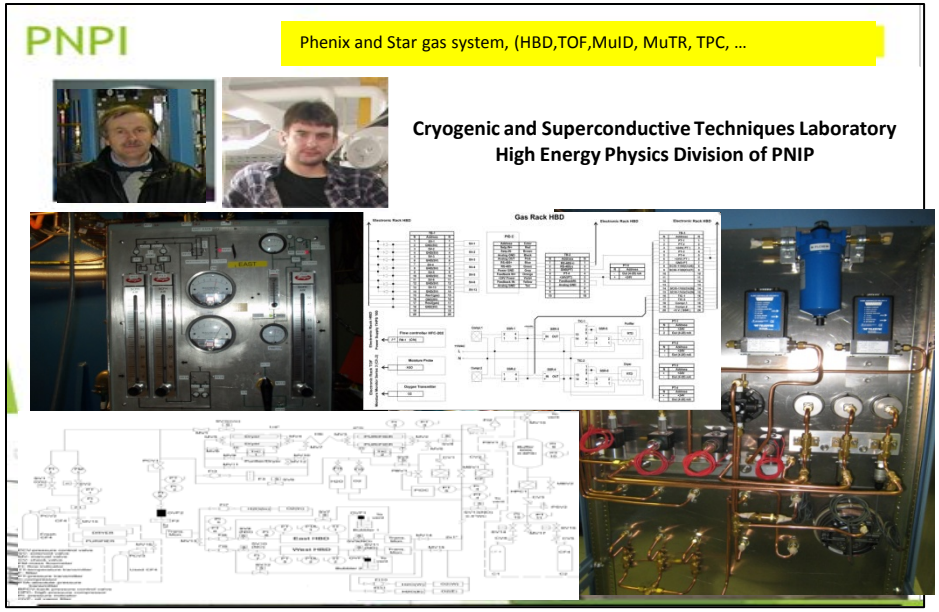


•A Gas System (1.2.7.2)--- High purity re-circulations system for a Ne based operating gas. System need to be operated at constant atmospheric pressure (0.5”w.c.) while turning over the gas volume (4000 liters) six times over 24hrs.

Subsystem Collaborators





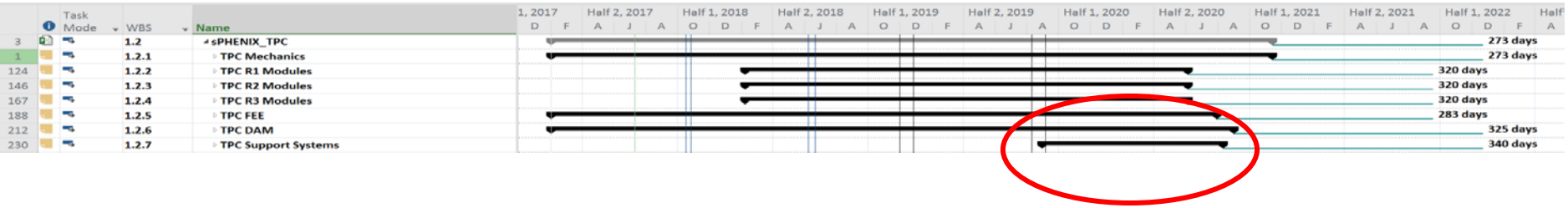


Some Key Personnel:

- Paul Giannotti – Principal Electrical Engineer (BNL)+20 Monitoring and alarms system experience.
- Don Lynch-- Chief Engineer (BNL)15 yrs thermal engineering experience, 20 yrs mechanical experience with BNL
- Robert Pisani—Physic Associate (BNL) 20+ years of gas systems and 10+ cooling systems experience.
- Carter Biggs --Sr Tech 20+ experience with technical support gas and cooling systems
- Dr. Leonid Kotchenda Sr Scientist (PNPI_20+ experience with gas system
- Dr. Peter Kravtsov Sr Scientist (PNIP)20+ experience with Gas systems
- Tom Hemmick Sr Scientist (SUNY SB) 20+ years gas detector experience
- Bob Azmoun Physics Associate +15 yrs experience gas detectors
- Sean Stoll Physics Associates +25 yr experience detectors and lasers.

Schedule Milestones

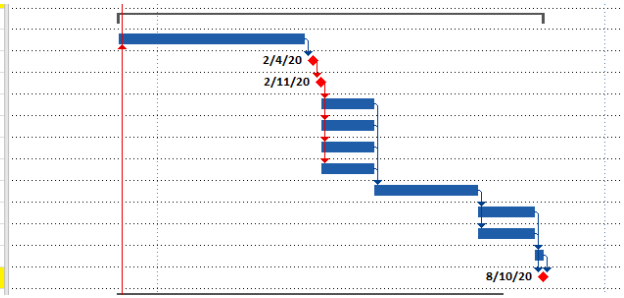
- Gas system
  - Design Winter 2019
  - Safety & Design Review Feb 2020
  - Procurement of parts Spring 2020
  - Assembly of system Summer 2020
  - System Complete August 2020
- Cooling System
  - Design Winter 2019
  - Safety & Design Review January 2020
  - Procurement of parts Winter/Spring 2020
  - Assembly of system Spring 2020
  - System Complete July 2020
- Laser system
  - Design Fall 2019
  - Safety & Design Review November 2019
  - Procurement Assembly of system Winter 2019/2020
  - Assembly of system Spring 2020
  - System Complete June 2020



Basis of Estimate and Resource-Loaded Schedule

Gas System

243	1.2.7.2	TPC Gas System	235 days	Fri 8/30/19	Mon 8/10/20	
244	1.2.7.2.1	Design TPC Gas Handling System	100 days	Fri 8/30/19	Tue 1/28/20	279
245	1.2.7.2.2	TPC Gas System Safety Review	0 days	Tue 2/4/20	Tue 2/4/20	244FS+5 days
246	1.2.7.2.3	TPC Gas System Design Review	0 days	Tue 2/11/20	Tue 2/11/20	245FS+5 days
247	1.2.7.2.4	Procure TPC Gas System mass flow meters	30 days	Wed 2/12/20	Wed 3/25/20	246
248	1.2.7.2.5	Procure TPC Gas System Analyzers (2 for redundancy)	30 days	Wed 2/12/20	Wed 3/25/20	246
249	1.2.7.2.6	Procure TPC Gas System scrubbers	30 days	Wed 2/12/20	Wed 3/25/20	246
250	1.2.7.2.7	Procure TPC Gas System oxygen and water sensors	30 days	Wed 2/12/20	Wed 3/25/20	246
251	1.2.7.2.8	Assemble TPC Gas System controls	60 days	Thu 3/26/20	Thu 6/18/20	247,248,249,250
252	1.2.7.2.9	Set up TPC Gas System computer control	30 days	Fri 6/19/20	Mon 8/3/20	251
253	1.2.7.2.10	Assemble and Plumb TPC Gas System	30 days	Fri 6/19/20	Mon 8/3/20	251
254	1.2.7.2.11	Install and Test TPC Gas System Interlocks	5 days	Tue 8/4/20	Mon 8/10/20	252
255	1.2.7.2.12	TPC Gas System Complete	0 days	Mon 8/10/20	Mon 8/10/20	254,253



The gas system cost is $109k before contingency and $135k after contingency.

Manufacturer quotes are either assessed as 20% or 25% contingency based upon past experience with long term price stability. All other items carry 40% contingency.

Components and Hardware

TPC Gas System mass flow meters					$9,475
	Mass Flow controllers		$4,500		Quote
	Power supply		$3,975		Web
	Cables		$500		web
	Mounting Hardware		$500		estimate
			$9,475	Pending	Experience
TPC Gas System Analyzers (2 for redundancy)					$29,750
	CH4 Analyzer		$14,000		past quote
	Iso Analyzer		$14,000		past quote
	Cables		$300		web
	Cabinet		$500		
	Mounting hardware		$500		estimate
	Fittings/tuning		$450		
			$29,750	Pending	Experience
TPC Gas System scrubbers					$8,670
	Filter Housing (Custom)		$5,000	experience	
	Catalyst		$600	past quote	
	Molecular sieves		$300	past quote	
	Heater and temp controller	OMEGA	$650	estimate	
	Fittings	Swagelok	$120		
			$6,670	Pending	Experience
TPC Gas System oxygen and water sensors					$11,500
	H2O analyzers		$7,000		web
	O2 Analyzers		$3,000		experience
	Cables		$1,200		quote
	Fitting/tubing		$300		
			$11,500	Pending	Experience
PC Gas System computer control					$51,730
	Procure Electronics Design	CSINO/PNPI (Russian Collaborat	$7,000		Past Cost
	Procure Design for Control Software	CSINO/PNPI (Russian Collaborat	$3,300		Past Cost
	Procure Gas system Electronic Crate	Allied	$1,000		Past Cost
	Procure Electronics Modules	CSino	$3,600		past cost
	Procure Hardware for electronics (Cabels,terms	Various	$2,600		Estimate
	Procure Gas System Control PC	Dell	$800		Web Quote
	Procure Power supplies	Omega	$1,200		estimate
	Procure Mounting hardware	McMaster	$200		estimate
	Procure Al Panels	McMaster	$340		estimate
	Procure Electronics Rack	Allied	$535		web quote
	Procure Stainless compression fittings	Swagelok	$6,500		old order
	Procure Stainless Tubing	Swagelok/Mcmaster	$3,400		old order
	Procure Monitoring instrumentation	Dwyer	$6,500		part order
	Procure Electronic Pressure Controller	Tescom	$2,400		web quote
	Procure Compressors (2)	Aid Dimensions	$4,000		past quote
	Procure Stainless Solenoids	Parker	$3,600		estimate
	Procure Stainless Valves	Swagelok	$3,500		estimate
	Procure AL Panels	McMaster	$520		web quote
	Procure Mounting hardware	McMaster	$400		estimate
	Procure Electronics Rack	Allied	$535		Web Quote
			$51,730	Pending	Experience

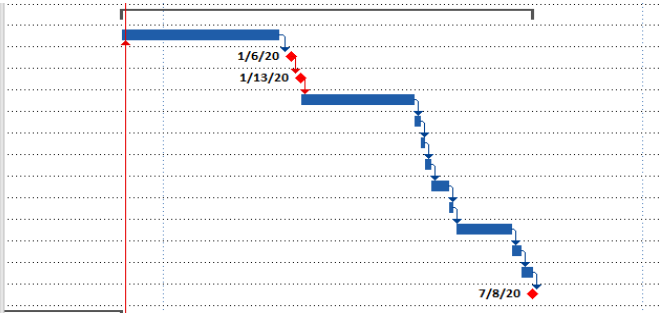
Estimated Labor

Aquire final quotes	Engineer	60	100%	60
Place orders	engineer	40	100%	40
Verify parts	Tech	80	100%	80
Design Gas system	Engineer	120	100%	120
Design interlocks	engineer	40	100%	40
Design interior manifolding (on endcap)	engineer/designer	20	200%	40
Asseble Electronics Rack	Engineer/Tech	80	200%	160
Install Flowmeters	Tech	8	100%	8
Install Filters	Tech	8	100%	8
Install Scrubbers	Tech	16	100%	16
Install Analizers	Tech	8	100%	8
Instrument control Racks	tech	24	100%	24
Hookup electronics	Engineer/Tech	80	200%	160
Instrument gas rack	engineer/tech	120	150%	180
Run Lines to IR	tech	80	200%	160
Test lines to IR	Tech	16	100%	16
Plumb gas rack	Tech	80	100%	80
Test Gas racks for leaks	Teck/Engineer	16	200%	32
Assemble IR manigolds	tech	80	100%	80
Test IR Manifolds	tech	8	100%	8
Plumb IR Manifolds	Tech	20	200%	40
Install detector plumbing(Manifold to Detector)	tech	40	200%	80
Test gas rack	Engineer/Tech	40	200%	80
Install Monitoring instrumentation in IR	Engineer/Tech	60	200%	120
				0
Commision system	engineer/tech	80	200%	160

Basis of Estimate and Resource-Loaded Schedule

Cooling System

256	1.2.7.3	TPC Cooling System	212 days	Fri 8/30/19	Wed 7/8/20	
257	1.2.7.3.1	Design TPC Cooling System	80 days	Fri 8/30/19	Fri 12/27/19	279
258	1.2.7.3.2	TPC Cooling System Safety Review	0 days	Mon 1/6/20	Mon 1/6/20	257FS+5 days
259	1.2.7.3.3	TPC Cooling System Design Review	0 days	Mon 1/13/20	Mon 1/13/20	258FS+5 days
260	1.2.7.3.4	Procure TPC Cooling Sys tem equipment(pumps,heat	60 days	Tue 1/14/20	Wed 4/8/20	259
261	1.2.7.3.5	Install TPC Cooling System pumps	3 days	Thu 4/9/20	Mon 4/13/20	260
262	1.2.7.3.6	Install TPC Cooling System heat exchanger	3 days	Tue 4/14/20	Thu 4/16/20	261
263	1.2.7.3.7	Install TPC Cooling System PH control	3 days	Fri 4/17/20	Tue 4/21/20	262
264	1.2.7.3.8	Install TPC Cooling System end cap manifolds	10 days	Wed 4/22/20	Tue 5/5/20	263
265	1.2.7.3.9	Install TPC Cooling System tanks	3 days	Wed 5/6/20	Fri 5/8/20	264
266	1.2.7.3.10	Install TPC Cooling System plumbing	30 days	Mon 5/11/20	Mon 6/22/20	265
267	1.2.7.3.11	Set up TPC Cooling System computer controls	5 days	Tue 6/23/20	Mon 6/29/20	266
268	1.2.7.3.12	Set up and Test TPC Cooling System interlocks	5 days	Tue 6/30/20	Wed 7/8/20	267
269	1.2.7.3.13	TPC Cooling System Complete	0 days	Wed 7/8/20	Wed 7/8/20	268



The cost before contingency is $138k and after contingency is $165k

Manufacturer quotes are either assessed as 20% or 25% contingency based upon past experience with long term price stability. All other items carry 40% contingency.

Components and Hardware

			File Name	
quipment(pumps,heat exchanger, PH control, manifolds, tanks...)				
Chillers watt 10C(3)	Thermo Scientific Merlin	$29,100	TPCMerlin	Quote
Deionizing filters (2)	McMaster	$1,644	TPCFilter_Switch	web Quote
Particle filters (2)	McMaster	$720	TPCFilter_Switch	web Quote
Valving for Chiller Switchover	McMaster	$610	TPCFilter_Switch	Web Quote
SS Manifolds (8) 6 port	Mcmaster	$1,110	TPCmanifold	web quote
Hardware (panel, brackets, mnts)	Mcmaster	$1,500		estimate
Flowmeter 24(SS) water	Dwyer	$1,230	TPCDwyer	web Quote
Compression fittings SS (various)	Swagelok	$3,550	TPC_Compression	Quote + experience
Bypas/filtering Valving at detector	McMaster	$1,550	TPCvalving	web Quote
Pressure gauges (16)	Dwyer	$450	TPCGauge	Web Quote
Manifold valving (24)	Swagelok	$1,575	TPCMetering	web Quote
FlexHose to Manifolds 8	Bannor Industries	$1,600		Estimate from past
1 1/4" thin walled SS Lines	Mcmaster	$1,200	TPCtubing	old Quote x inflation
1" SS Thin walled Lines	McMaster	$1,250	TPCtubing	old Quote x inflation
5/16" SS Coil (0.250 ID Min)	McMaster	$1,200	TPCtubcoil	web quote
SS Pipe fittings	Mcmaster	$1,000		experience
1 1/4" Braided lines (316 SS)	McMaster	$1,000	tpchose	web quote
Poly lines to detector (Various)	MSC	$924	TPCpolyhose	web Quote
House Water Manifolding (brass)	McMaster	$1,097	TPCwater	Web Quote
Pressure Transmitters (8 min)	Dwyer	$1,625	TPCpressureTran	quote
Transmitting Flowmeters (SS 1") (8)	Mcmaster	$2,050	TPCFlowTran	Web Quote
RTDs (8)	Omega	$550	TPCrtd	Web Quote
RTD transmitter+local read (7)	Omega	$2,986	TPCrtd	Web Quote
Electronic hardware	various	$1,750		estimate
House water Monitor (pressure)	Various	$1,200		Web Quote
Presure Relief Valves 1" (2) SS	Mcmaster	$882	TPCrelief	web quote
		$63,353		

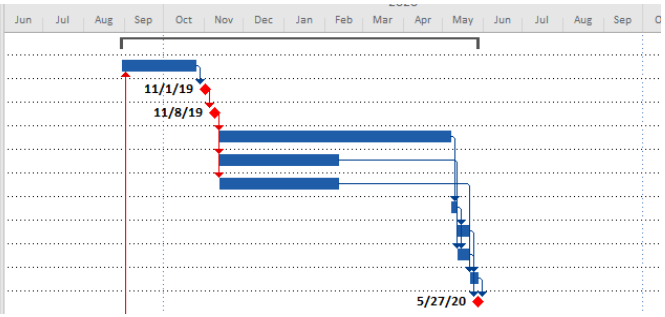
Estimated Labor

g				
Design Cooling system	Engineer/tech	120	200%	240
Layout Pipe loops and locations	Designer/engineer	80	125%	100
Design Manifolds	Engineer/tech	80	100%	80
Design Cold Plate	Engineer/tech	80	150%	120
Design Cold Plate manifolding	enginer/designer	80	150%	120
Get final Quotes	Engineer/tech	80	200%	160
Place Orders	Engineer/tech	40	100%	40
Verify parts	Engineer/tech	80	200%	160
Test cold plates (600)	Tech	1200	100%	1200
Build Filter system/test	Tech	40	200%	80
Build Manifolds/test	Tech	40	200%	80
Install Chillers	Tech	80	200%	160
Install Supply/Return Lines	tech	40	200%	80
Install Manifolds	tech	80	200%	160
Instrument Monitoring	engineer/tech	80	150%	120
Test Chillers	engineer	20	100%	20
Test Loop to Manifolds W	engineer	40	100%	40
Test Interlocks	engineer	20	100%	20
Install lines to detector	tech	120	200%	240
Commision Cooling system	engineer/tech	40	200%	80
				0
Install interior manifold	tech	160	200%	320
Install Cold Plates to electronics	tech	1200	100%	1200
Make final connections	tech/engineer	512	150%	768
Test completed manifold (interior)	tech	150	100%	150
Set up testing system	engineer/tech	80	100%	80
ks and Safety System				
Design Safety interlocks	Engineer	80	200%	160
Design Monitoring system	Engineer	80	200%	160
Instrument interlocks to system	engineer/tech	120	150%	180
Commission system	engineer/tech	80	200%	160

Basis of Estimate and Resource-Loaded Schedule

Laser System

	WBS	Task Name	Duration	Start	Finish	Predecessors
231	**1.2.7.1**	**TPC Laser System**	**184 days**	**Fri 8/30/19**	**Wed 5/27/20**	
232	1.2.7.1.1	Design TPC Laser System	40 days	Fri 8/30/19	Fri 10/25/19	279
233	1.2.7.1.2	TPC Laser System Safety Review	0 days	Fri 11/1/19	Fri 11/1/19	232FS+5 days
234	1.2.7.1.3	TPC Laser System Design Review	0 days	Fri 11/8/19	Fri 11/8/19	233FS+5 days
235	1.2.7.1.4	Procure TPC laser(s)	120 days	Tue 11/12/19	Wed 5/6/20	234
236	1.2.7.1.5	Procure TPC optics with mirrors	60 days	Tue 11/12/19	Tue 2/11/20	234
237	1.2.7.1.6	Procure TPC mirror bundles with supports	60 days	Tue 11/12/19	Tue 2/11/20	234
238	1.2.7.1.7	Install TPC lasers	3 days	Thu 5/7/20	Mon 5/11/20	235
239	1.2.7.1.8	Install TPC Laser safety interlocks	8 days	Tue 5/12/20	Thu 5/21/20	238
240	1.2.7.1.9	Install TPC Laser optics with mounts	8 days	Tue 5/12/20	Thu 5/21/20	236,238
241	1.2.7.1.10	Install TPC mirror bundles and supports	3 days	Fri 5/22/20	Wed 5/27/20	240,237
242	1.2.7.1.11	TPC Laser System Complete	0 days	Wed 5/27/20	Wed 5/27/20	241,239



The full cost of the laser system is $144k before contingency and $186k after contingency.

Manufacturer quotes are either assessed as 20% or 25% contingency based upon past experience with long term price stability. All other items carry 40% contingency.

Components and Hardware

WBS	Description	Item	Vendor	Total	Status	Basis of Estimate	Contingency	Item Contingency	Wt Contingency	Total	Contingency	Total w/ Contingency	Grand Total	Grand Total w/ Contingency
1.2.7.1	TPC Laser System												$144,177	$186,412
1.2.7.1.2	Procure TPC laser(s)								0.2	$77,177	$15,435	$92,612		
		Laser	Newport	$77,177	Pending	Manufacturer Quote	0.2	$15,435.40						
1.2.7.1.3	Procure TPC optics with mirrors								0.4	$50,000	$20,000	$70,000		
				$50,000	Pending	Experience	0.4	$20,000						
1.2.7.1.4	Procure													
1.2.7.1.6	Design													

Place Holder

Cost Drivers

- Gas system
  - Purifier system—$10k
  - Gas Analyzers- $41k
  - Stainless Steel $18k
  - Controller $10k
  - Monitoring instrumentation $10k

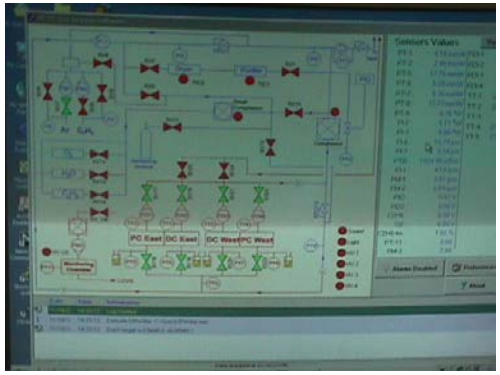
- Laser system
  - Laser—$77k
  - Fibers- $41k
  - Optics $18k

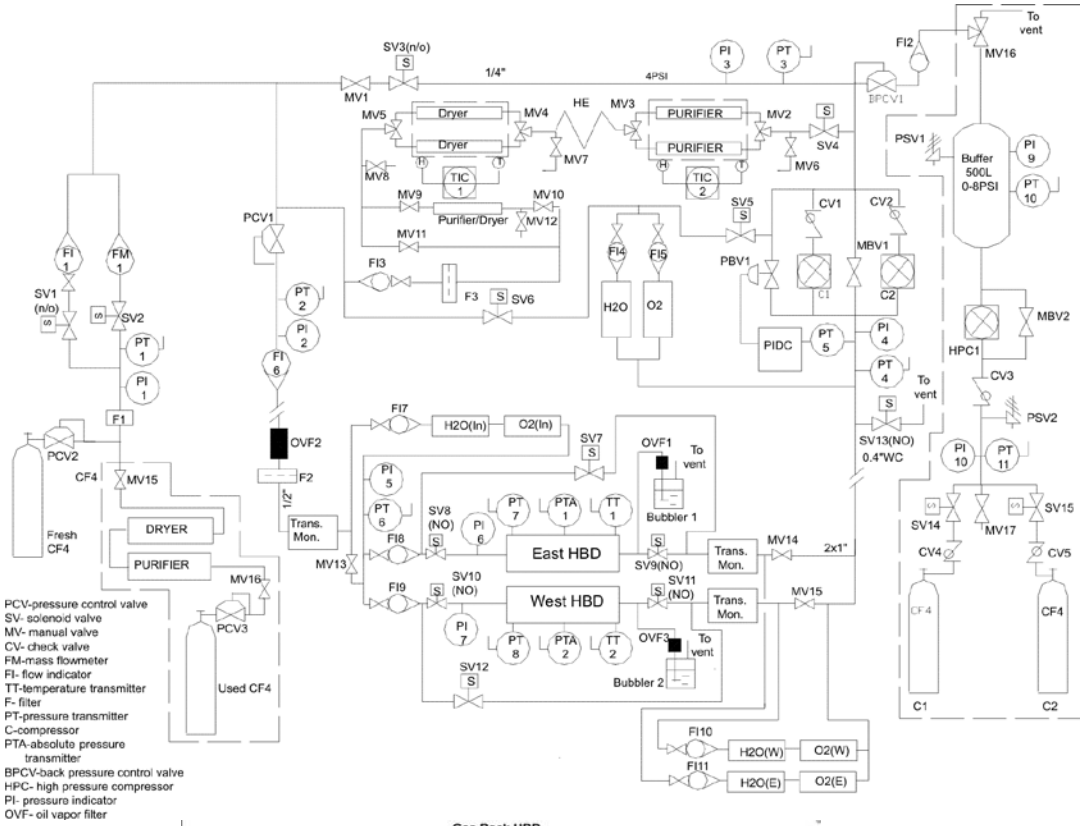
- **Cooling system**
  - Negative pressure unit $15k
  - Chillers $29k
  - Monitoring instrumentation -$13k
  - Interface to FEE inside magnet--$60k

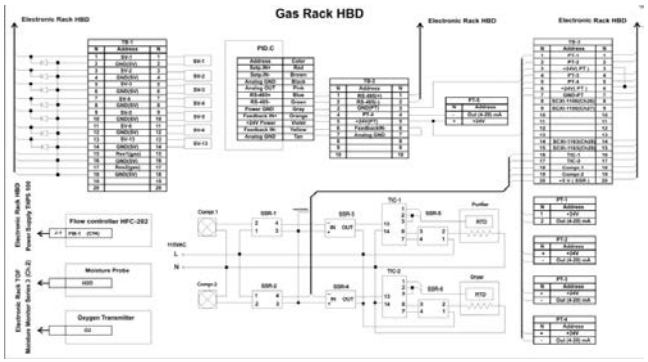
The Gas System Status

TPC Gas System

- Based on PHENIX HBD gas system designs
- Ne mixture (Ne/CF4/iC4H10; 95:3:2)
- Flowrate ~1m3/hr
- 1-2mBar (~0.5"w.c.) above atmosphere to +/- 1/8" w.c.
- Closed loop recirculation
- Analyzers to monitor mixture and impurities
- In line purifiers
- High purity system-all stainless
- PC Controlled
- Fully alarmed



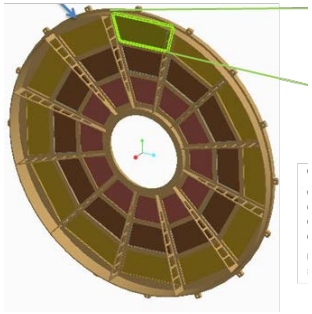


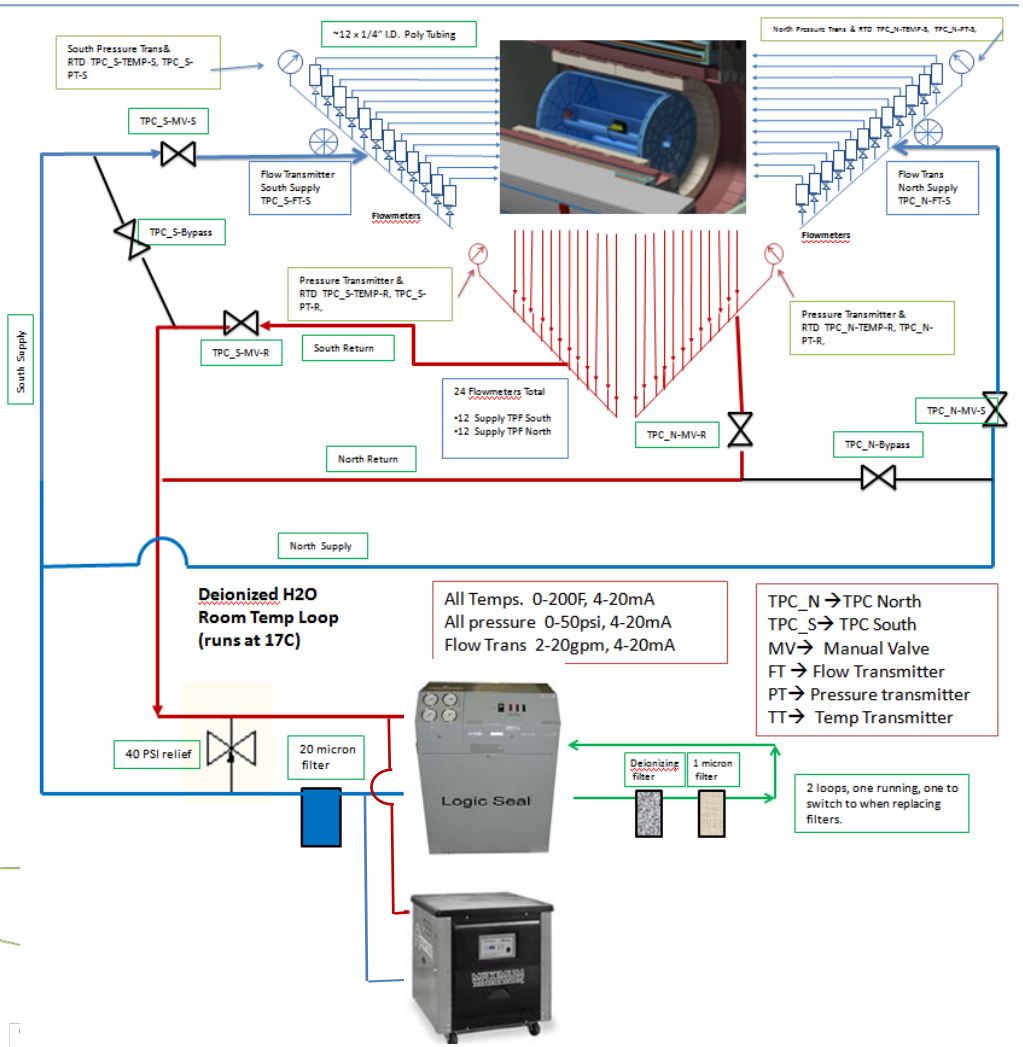


The Cooling System Status

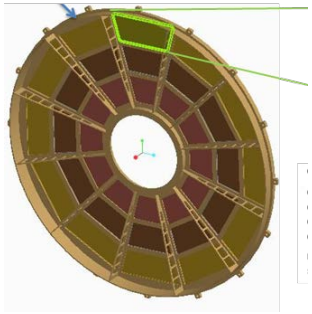
TPC Gas System

- •Based on the PHENIX VTX/FVTX cooling system
- •Negative Pressure Loop
- •Modified for flow rate and load, and segmentation
- •Water based coolant
- •Closed loop
- •Purifier loops built in
- •Monitored and alarmed
- •24 channel system divided North and South
- •Redundancy built into the system.
- •Total heat removed 12kWatt





The Laser System Status



Place Holder

Summary

Gas System

- PHENIX hosted many high purity gas systems (HBD detector, RPC, TOF, DC, PC, RICH,Mutr, Muid). The TPC detector's needs are rather similar to the HBD ultra high purity system (even less stringent) and so we feel it is conservative to use the HBD system as a cost basic.
- The system will be designed with all stainless plumbing for highest purity and ample contamination monitoring. It is very similar to the PHENIX HBD system, whose purity and flow rates are beyond the needs of the TPC.
- We have highly experienced people collaborating on this. Many with 15 to 20+ years experience.
- The gas system cost is $109k before contingency and $135k after contingency. (From BOE & RLS)

Cooling System

- Our heat load is dominated by the SAMPA chips on the FEE and is thereby well understood, allowing for reasonable accuracy on the cost estimation. The heat load is significant enough that liquid cooling is required since gas cooling will be insufficient.
- The cost basis uses is extrapolated using similar systems found in the PHENIX VTX/FVTX Cooling System
- We have a skilled set of people collaborating on this with 10 to 15 years experiences.
- The cost before contingency is $138k and after contingency is $165k.

Laser System

- We will base the calibration system on the STAR and Alice laser calibration systems
- The full cost of the laser system is $144k before contingency and $186k after contingency.
- We have a skilled set of people collaboration and department with 10 to 15 years experiences.

Back Up