Daya Bay RPC Gas System:
Design Report & Budget Estimate

Changguo Lu, Kirk McDonald

Princeton University

(July 28, 2007)

Outline

- Introduction
- Main gas system design parameters
- Gas mixing system
- Gas distribution and digital bubbler system
- Gas safety system
- Slow control system
- Location of gas system at experimental hall
- Conclusion

Introduction

The Daya Bay RPC gas system design is based on the BaBar and BELLE gas systems:

-- Gas mixing via mass flow control units.

-- Gas distribution to the RPCs through simple “flow resistors”.

-- Output flow from each chamber separately monitored by a low-cost electronic bubbler.

-- Separate gas safety system.

Major Gas System Design Parameters

We may use the OPERA RPC gas mix (for lower voltage operation): Ar/R134A/Isobutane/SF6 (75.4/20/4/0.6).

Gas flow rate is 1 volume change/day (~ 6 m^3/day).

Each detector hall has its own gas mixing/distribution system.

Each gas mixer feeds 7 or 12 gas distribution panels (“branches”).

Each gas distribution panel feeds 16 “sub-branches”.

Each “sub-branch” feeds 4 RPCs.

The output flow of each sub-branch is monitored by an electronic bubbler.

Gas volume/branch = 0.016 m^3, 1 volume/day = 0.2 cm^3/sec.

… Major Gas System Design Parameters

Far Hall:

Area of RPCs = 18 x 18 m^2,

Total number of RPCs = 648,

Total gas volume = 2.8 m^3,

Total number of gas distribution panels = 12.

Near Hall:

Area of RPCs = 12 x 18 m^2,

Total number of RPCs = 432,

Total gas volume = 1.73 m^3,

Total number of gas distribution panels = 7.

1 Far hall + 2 near halls:

Total number of gas distribution panels 12+14 = 26.

Main Panels of the Gas System Rack

(1) Gas safety interlock panel, it displays actual gas flow rates for four gas components, it also shows interlock status.

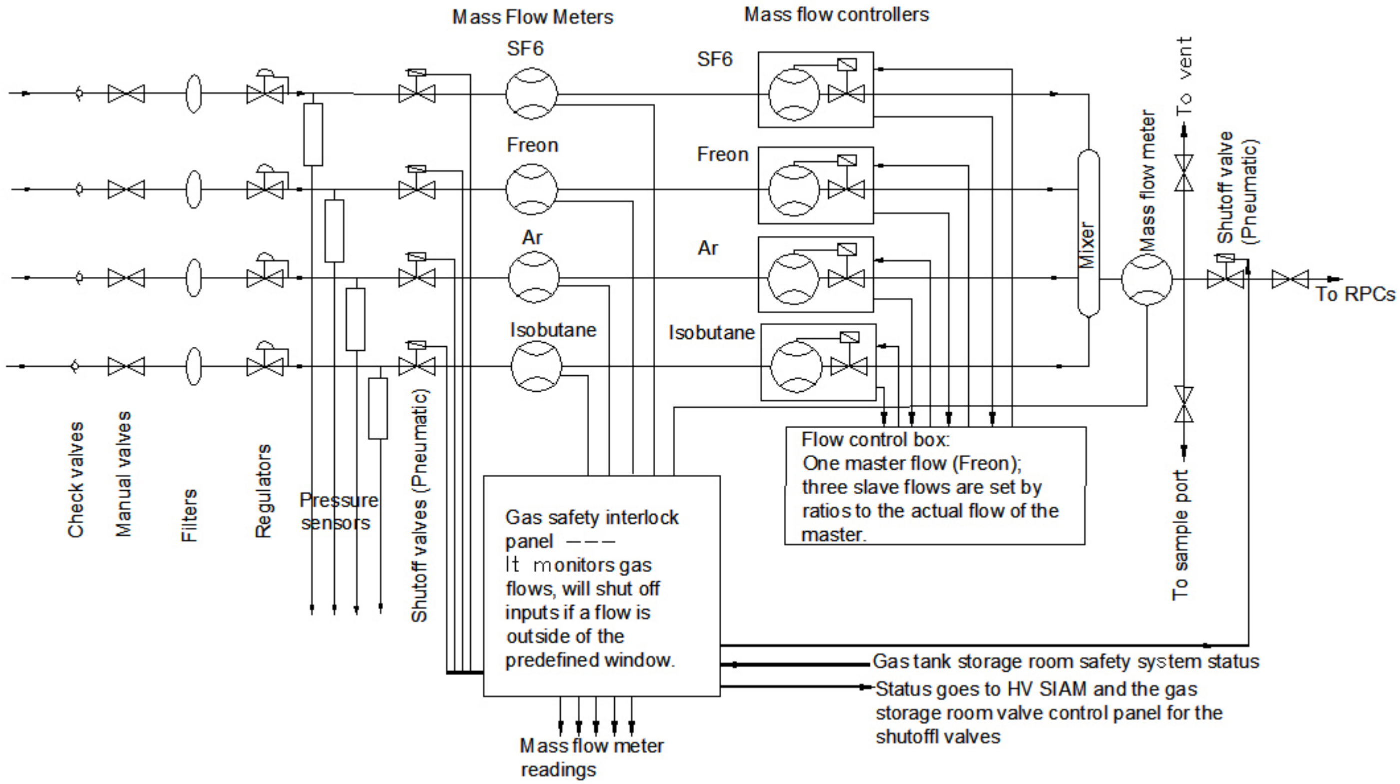
(2) Control panel of the gas valves in the gas storage room; it is also connected to the HAD sensor's safety rack. In case of HAD sensor alarming it closes the valves.

(3) Gas flow control box. It sets the gas flow rate and the mixing ratios for all four gases.

(4) Gas pressure monitor. It shows the gas pressure at the inlet side. It also monitors a pressure sensitive switch looking at the isobutane. This switch can turn off the system in case of too low isobutane pressure.

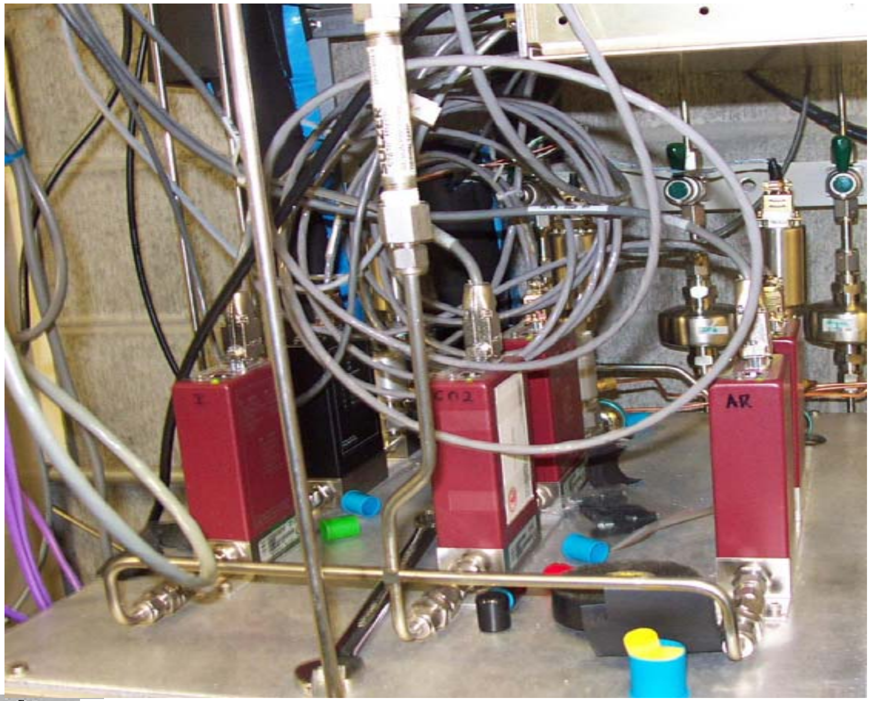
Gas Mixing System

We have incorporated the BaBar RPC/LST gas system experience and Daya Bay RPC system's requirement to design our own gas system.



... Gas Mixing System

We are considering two options: a conventional gas mixing system panel, and a new breed of Integrated Gas System (IGS).



Conventional gas system panel.

IGS Gas system panel

Gas-Mixing System Cost Estimate

Subsystem		Item	Specs	Price/unit	# of unit	Cost/item	Subsystem cost	# of subsystem	Total cost ($)
Gas mixing Rack							24350	3	73050
	Components								
		1479 Mass Flow Controller (Ar)	Full range 3.0 SLM	1503	1	1503			
		1479 Mass Flow Controller (R134A)	Full range 5.0 SLM	1503	1	1503			
		1479 Mass Flow Controller (Isobutane)	Full range 1.0 SLM	1503	1	1503			
		1479 Mass Flow Controller (SF6)	Full range 0.2 SLM	1503	1	1503			
		179A Mass Flow Meter (Ar)	Full range 3.0 SLM	983	1	983			
		179A Mass Flow Meter (R134A)	Full range 5.0 SLM	983	1	983			
		179A Mass Flow Meter (Isobutane)	Full range 1.0 SLM	983	1	983			
		179A Mass Flow Meter (SF6)	Full range 0.2 SLM	983	1	983			
		Gas Pressure Sensor	Type 890 single-ended, absolute	556	4	2224			
		247D four channel Power Supply/Readout		1482	1	1482			
		Line gas regulator		400	4	1600			
		Line gas filter		200	4	800			
		Manual shutoff valve		150	4	600			
		Solenoid shutoff valve		150	4	600			
		Gas mixer		600	1	600			
		Gas regulator for gas tank		400	4	1600			
		Valve power supply		100	1	100			
		Line check valves		150	4	600			
	Rack construction								
		Labor cost				3250			
		Fittings & S.S. tubing ($8/ft)				750			
		Rack		200	1	200			

$73,050

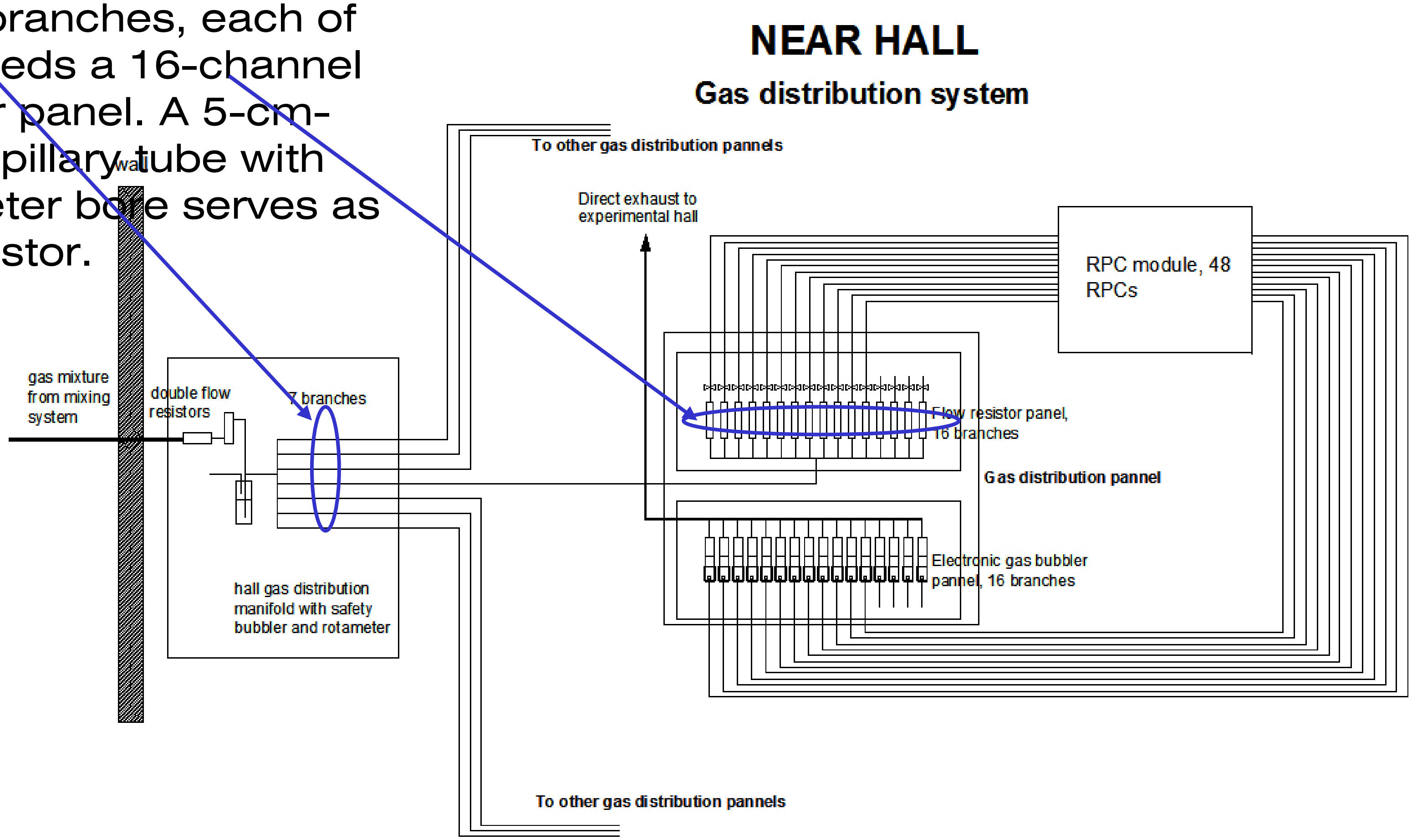
Gas Distribution/Bubbler System

The gas mixture needs to be distributed to every RPC in an experimental hall. The design goal:

- Uniformly distribute the gas mixture to every RPC in the system;
- Divide the entire RPC system in one experimental hall into several panels/branches, of which each will be further split to 16 sub-branches. In case of a leak in one sub-branch. the rest of the system should not be affected;
- Connect the RPCs in the same sub-branch in parallel, not in series, to prevent gas contaminants produced in upstream chambers from polluting the down stream chambers;
- Monitor the gas flow at the end of each sub-branch to check for leaky RPCs.

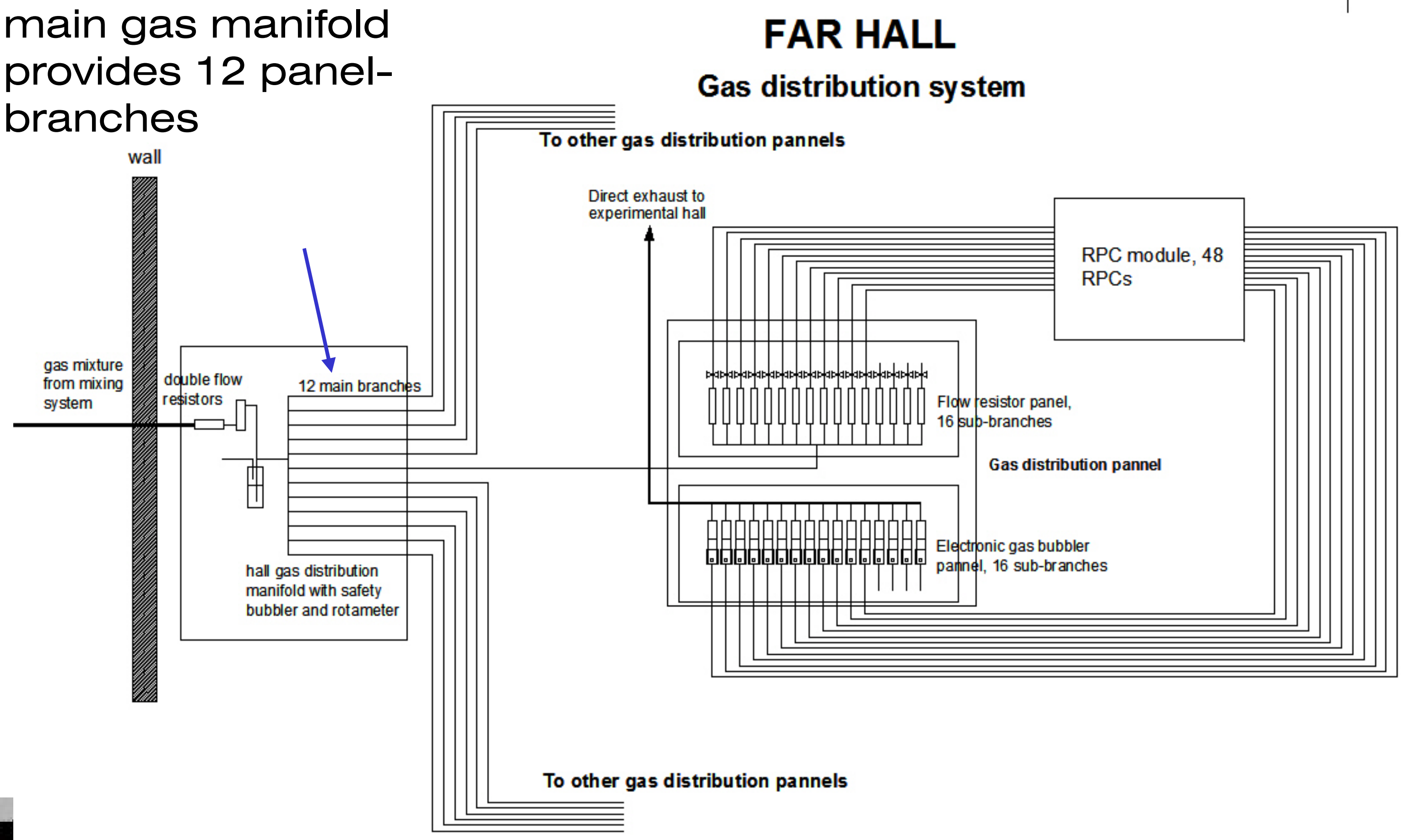
... Gas Distribution/Bubbler System

The main gas manifold provides 7 branches, each of which will feeds a 16-channel flow-resistor panel. A 5-cm-long S.S. capillary tube with 0.01” diameter bore serves as the flow resistor.



… Gas Distribution/Bubbler System

In Far Hall the main gas manifold provides 12 panel-branches



... Gas Distribution/Bubbler System

Each flow resistor provides gas mixture to 4 RPCs.

To simplify the gas tubing interconnection these 4 RPCs are connected in series (rather than in parallel).

The gas outlet from this sub-branch will return to a digital bubbler panel that can count the rate of the output bubbles, thereby recording the returning gas flow rate.

Budget Estimate: Gas Distribution/Bubbler System

				hour	cost/hour	cost($)	Total cost
Gas digital bubbler and flow resistor panels							83156.06
	Panel hardware cost (26 panels)						
		Bubbler & flow resistor panels				9827	
		Labor cost	(Sr-Tech)	480	90	43200	
	Electronics hardware cost						
		Readout PCB				2,586.00	
		Bubbler PCB				1,065.60	
		Cable				1,377.46	
	Electronics labor cost (PCB design and assemble)						
		Readout	(Sr-Tech)	80	90	7200	
		Bubbler	(Sr-Tech)	120	90	10800	
		Cable	(Sr-Tech)	40	90	3600	
		firmware design	(Grad-Student)	1 month		3500	

$83,156

Gas Safety System

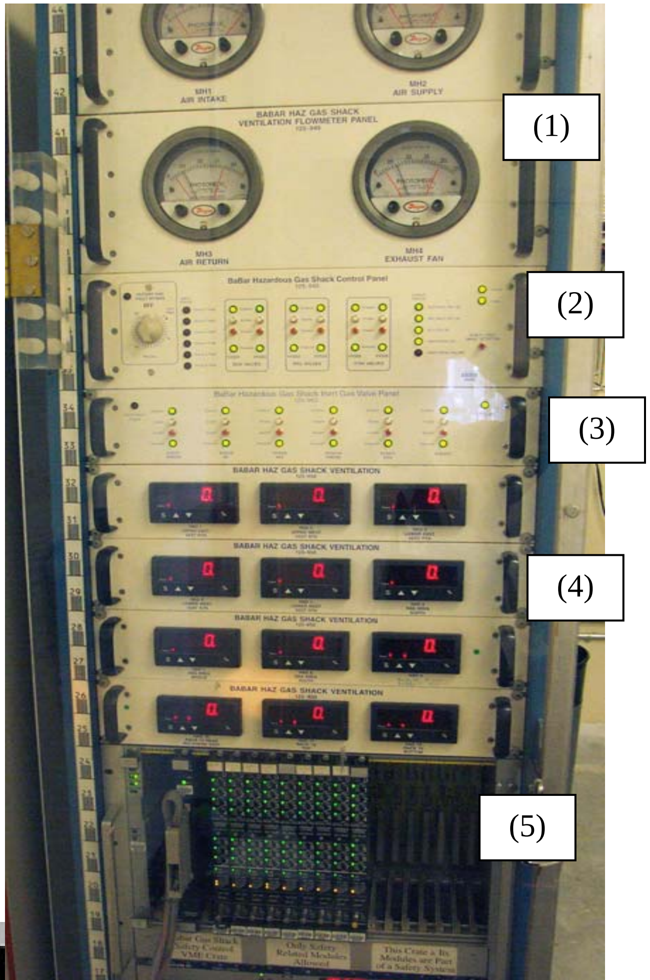
We suggest using the hazardous atmosphere detection (HAD) system for BaBar as the model for our Daya Bay safety system.

All HAD sensors are connected to display/controllers on the HAD control panel.

We use VME Summary Interlock and Alarm Module (SIAM) as the interface of its gas safety hardware system to the slow control system. The SIAM is a VME compatible module which can generate an output signal (trip) based on the latched state of eight input conditions (faults). Several modules can be daisy-chained to form a larger set of input conditions.

Since the gas safety system requires effort from several different institutions and subsystems, its final design is pending further collaboration-wide discussion.

Gas Safety System – BaBar



BaBar gas safety display/interlock panel.

(1) Ventilation flowmeter panel;

(2) Gas storage room hazardous gas control panel ;

(3) Inert gas valve panel;

(4) HAD sensor display/control panels;

(5) SIAM modules.

Cost of BaBar Gas Safety System

Since we haven't decided on our gas safety system, as a reference we show the BaBar gas safety system cost estimate:

					Total(k$)
Safety System					55.3
	Photohelics (6*250)			1.5	
	HAD sensors (8*1400)			11.2	
	SIAMS (7*1200)			8.4	
	Shutoff Solenoids (6*300?)			1.8	
	VME crate			5	
	Newports (8*300)			2.4	
	Control Chassis			5	
	Engineering			20	

$55.3k

Slow Control for the Gas System

To be monitored and controlled for the RPC gas system:

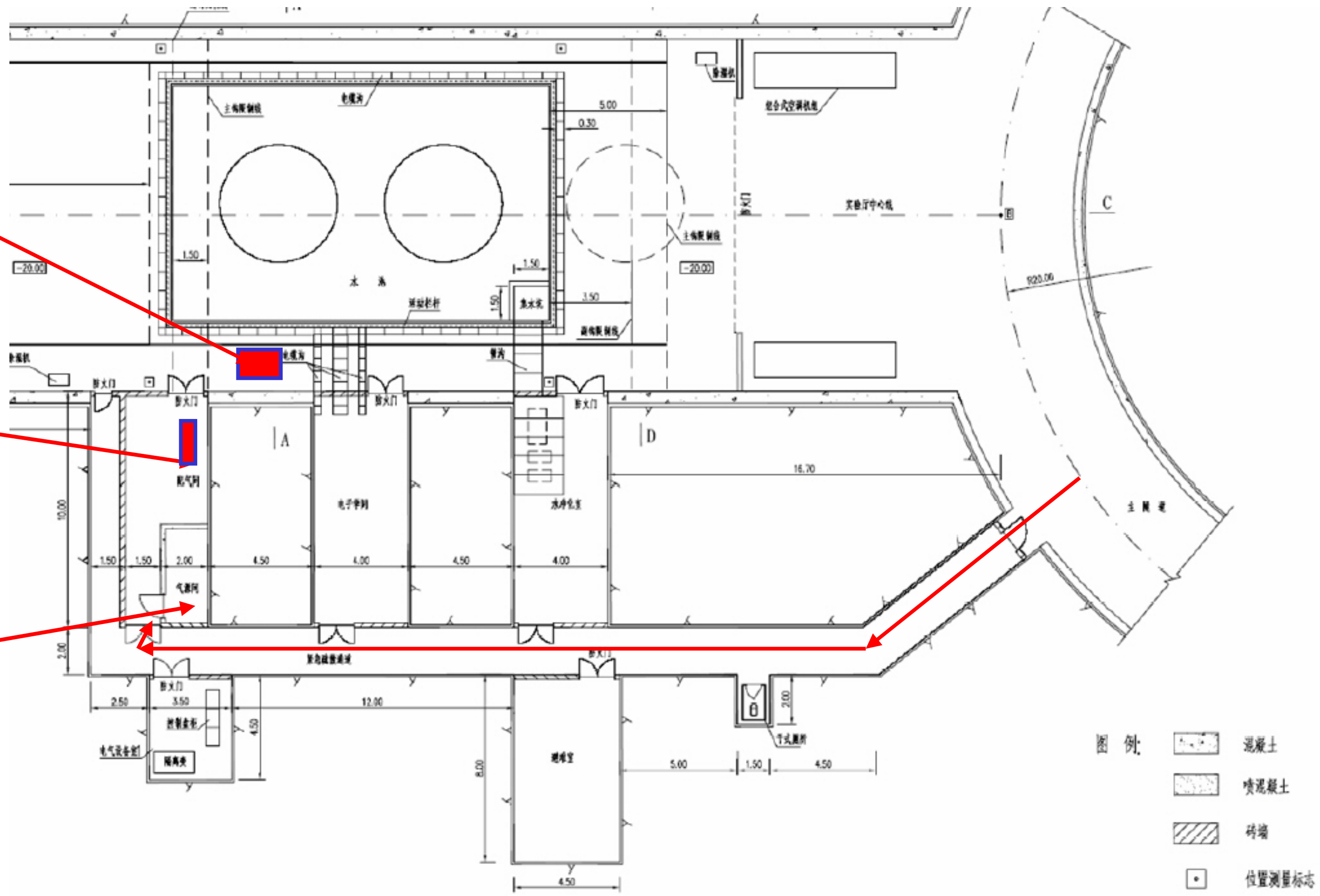
- Gas flow rate for all three (or four) components and the total flow rate for the gas mixture;
- Gas bubbling rate for every sub-branches to ensure no RPC is leaking;
- Pressure of the gas supply lines to avoid running out of the gas without notice;
- Ventilation air flow rate monitoring;
- HAD sensors monitoring;
- Gas tank storage room temperature monitoring.

Location of the Gas System in the Daya Bay Near Hall

Gas distribution/ digital bubbler system

Gas mixing system

Gas cylinders



Summary of Cost Estimate

3 sets of gas mixing systems: $73,050 (Daya Bay)

3 sets of gas distribution/bubbler systems: $83,156 (Daya Bay)

3 sets of gas safety systems: $55,300 (BaBar, ?)

(The installation of gas pipe from gas system room to experimental hall is IHEP's task, not included here.)

Total cost = $211,056

Add 20% contingency = $253,807

Add additional shipping and travel cost, looks OK for the budget of $320k, which is reserved for RPC gas system in Daya Bay project.