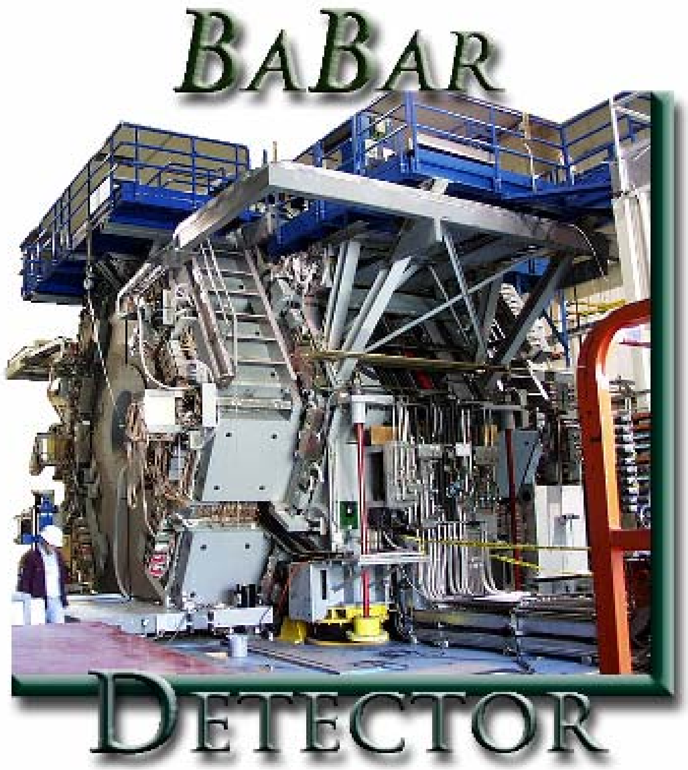
BaBar Transition

Services and Mechanical



- Collaboration post-operations planning: analysis, computing, manpower (brief).
- BaBar Detector Rampdown
  - Detector Description
  - Assets
  - Minimal Maintenance State:
    - Rampdown (FY2009)
      - Plan, manpower, costs
    - Assets preservation in the MMS (FY2009-FY2014)
      - Plan, manpower, costs
  - Collaboration involvement in the MMS

BaBar Collaboration: Post-Ops

- Shape of the collaboration after end of data-taking:
  - Intense analysis period extends 2-3 years after the end of data-taking on September 30, 2008.
    - There is a set of high priority analyses to be completed as soon as possible after end of data-taking.

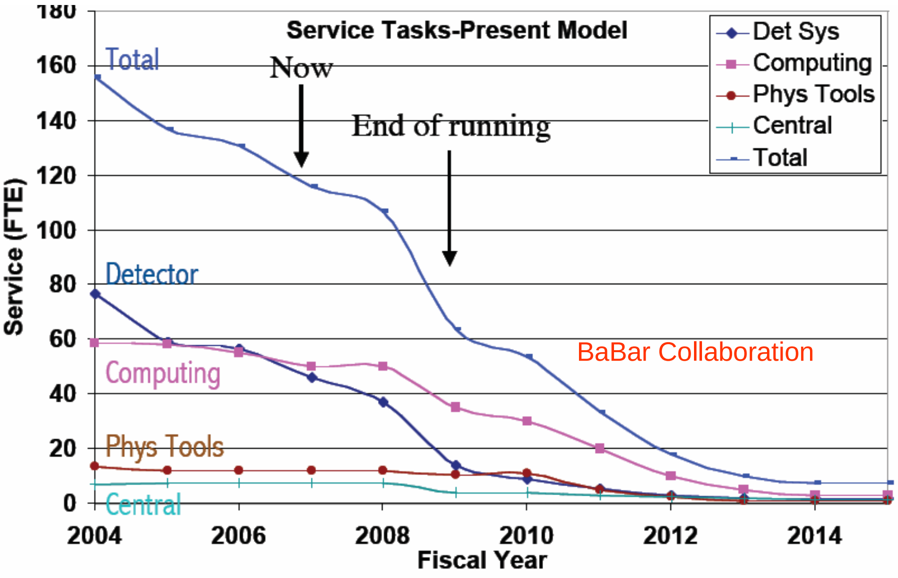
Table 1. High-priority BABAR physics topics to be published during the initial intense analysis period within 1-2 years of the end of data taking.

Charmless:
$\sin 2\beta$ in $b \to s$ penguin: $K^0 + (\eta',\ K^+K^-,\ K^0_S K^0_S,\ \pi^0, f_0,\ \rho,\ \omega,\ \pi^0\pi^0)$
BFs of color-suppressed decays for SU(3) limits: $B \to \eta'\pi^0,\ \eta\pi^0,\ \eta'\eta,\ \eta'\eta', \eta\eta)$
2-body (TD, BFs, $\mathcal{A}_{ch}$): $\pi\pi$ (also TD for α), $K\pi,\ KK$
Dalitz plots: $3\pi,\ K\pi\pi,\ 3K$
VV decays (BFs, $\mathcal{A}_{ch}$, polarization): $\rho\rho$ (also TD for α), $\phi K^*,\ \rho K^*,\ \omega\rho,\ \omega K^*$
Direct CP: $\rho^0 K^+,\ \eta K^+,\ \ldots$
$B \to$ Charmonium $+X$:
$\sin 2\beta$ with $B \to c\bar{c}K^0$, $\cos 2\beta$ with $B \to J/\psi K^*$
Measurements of γ:
$B \to DK$ (Dalitz,GLW,ADS), $D^{(*)0}K^{(*)0},\ D^{(*)}\pi,\ D^{(*)}\rho$
B semileptonic:
V_{ub} with both inclusive and exclusive $b \to X_u \ell\nu$
Radiative B decays:
inclusive and exclusive $b \to s\gamma,\ b \to d\gamma$ (BFs, $\mathcal{A}_{ch}$), $B \to K^*\gamma$ TD
Rare B decays:
inclusive and exclusive $b \to s\ell\ell$ (BFs, A_{FB}), $B \to K^{(*)}\nu\bar{\nu}$
B leptonic decays:
$B \to \ell\nu(\gamma),\ B \to \ell\ell$
LFV in τ decays:
$\tau \to \ell + (\ell\ell,\ \gamma,\ \pi^0,\ \eta,\ \eta',\ K^0_S,\ \ldots)$
Rare charm decays:
$D \to \ell\ell$, FCNC in D decays
D mixing and CPV:
Mixing ($D^0 \to K\pi,\ K\pi\pi,\ K3\pi$); CPV ($KK,\ \phi K^0_S,\ K^0_S\pi^0$)

Key physics topics cover the full range of CP violation and rare decays in beauty, charm and tau physics

BaBar Collaboration: Post-Ops

- Shape of the collaboration after end of data-taking:
  - Intense analysis period extends 2-3 years after the end of data-taking on September 30, 2008.
    - Collaboration manpower, obtained by a survey (80% response) of institutional principal investigators during this period is expected to be adequate to the task



Estimated Needs

Region	Returns	Institutions			Members "short" (2006)		
		2006	"short"	"long"	Academics	RAs+Staff	Students
Canada	100%	4	4	2-3	9 (10)	2 (5)	12 (8)
France	80%	5	4-5	3-4	13 (13)	6 (17)	5 (11)
Germany	100%	6	5	3	6 (7)	3 (8)	8 (16)
Italy	67%	12	8-11	5-8	18 (27)	25 (42)	9 (19)
UK	80%	10	7	2	14 (23)	8 (19)	8 (21)
US(West)	80%	15	11-13	3-5	16 (38)	11 (25)	18 (28)
US(East)	68%	19	11-15	5-10	23 (37)	17 (27)	21 (35)
Other	75%	4	2-3	1	6 (7)	6 (9)	8 (8)
Total	80%	75	52-63	24-36	105 (162)	78 (152)	89 (146)

Estimated available manpower

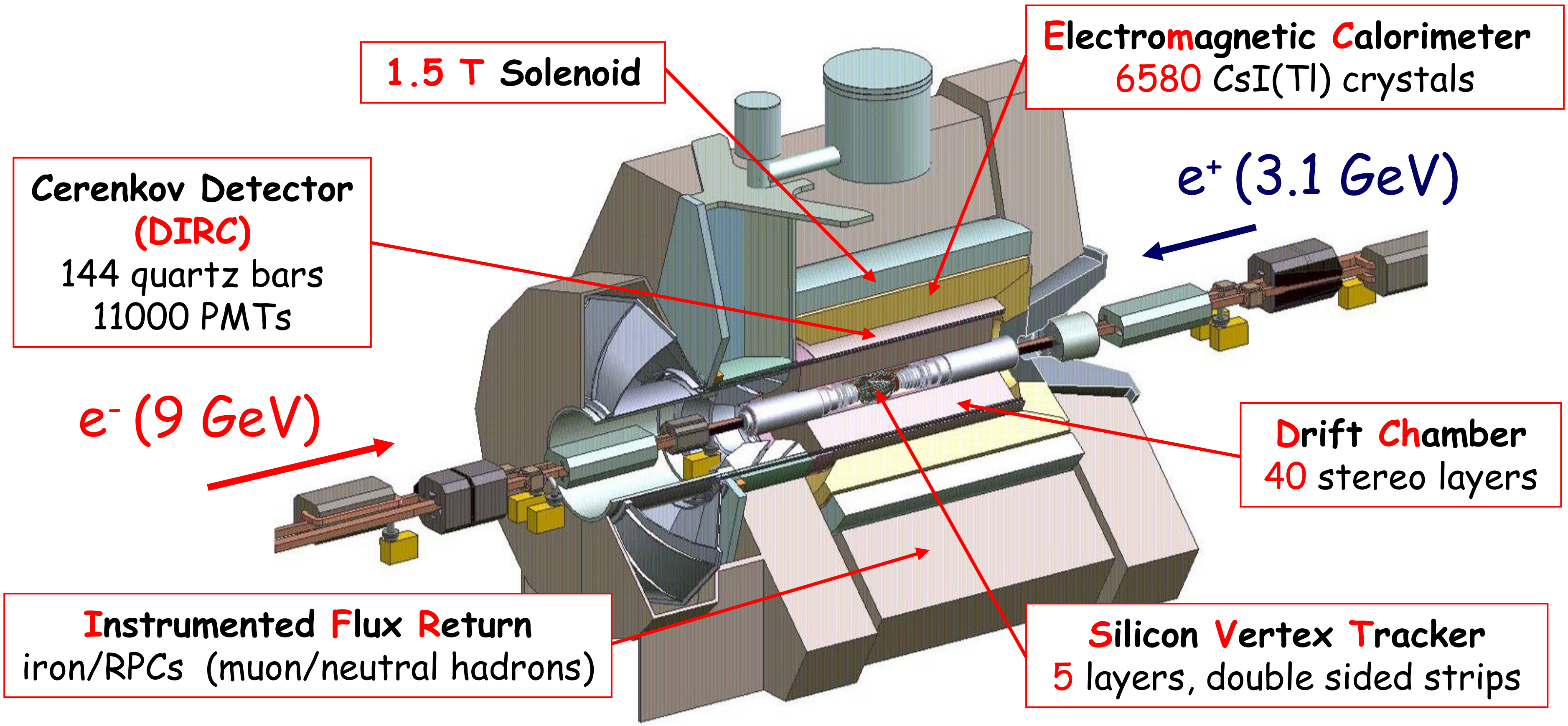
BaBar Collaboration: Post-Ops

- Computing plans:
  - Three phases:
    - Intense analysis period (up to three years)
    - Ramp-down (about two additional years)
      - Includes more challenging analyses, systematics limited analyses which require more effort to bring to a close.
    - Archival storage
  - Plan assumes full reconstruction of the Run 1-6 data in parallel with, but lagging, the Run 7 processing, with goal of full uniform data set readiness for summer 2009 conferences. Final decision on full reco Fall 07.

Table 2. Requirements for new CPU and disk hardware in a model where reprocessing of Runs 1-6 occurs in parallel with initial processing of Run 7 data. Note that the requirements in FY09-FY11 are driven entirely by retirements of existing equipment.

	FY07	FY08	FY09	FY10	FY11
CPU requirement at SLAC [kSI2K units]					
New CPU capacity	1200	2600	0	-1200	0
Total installed SLAC capacity	5200	7800	7800	6600	6600
Replacement CPU	1000	1300	1950	750	1650
Total CPU requirement	2200	3900	1950	-450	1650
Disk requirement at SLAC [Tbytes]					
New disk capacity	60	270	0	-50	0
Total installed SLAC capacity	557	827	827	777	777
Replacement disk	124	139	207	157	194
Total disk requirement	184	409	207	107	194

BaBar Detector



SVT:	97% efficiency, 15 μm z hit resolution (inner layers, perp. tracks)
SVT+DCH:	$\sigma(p_T)/p_T = 0.13\ \% \times p_T + 0.45\ \%$
DIRC:	K-π separation 4.2σ @ 3.0 GeV/c → >3.0σ @ 4.0 GeV/c
EMC:	$\sigma_E/E = 2.3\ \% \cdot E^{-1/4} \oplus 1.9\ \%$

BaBar Detector

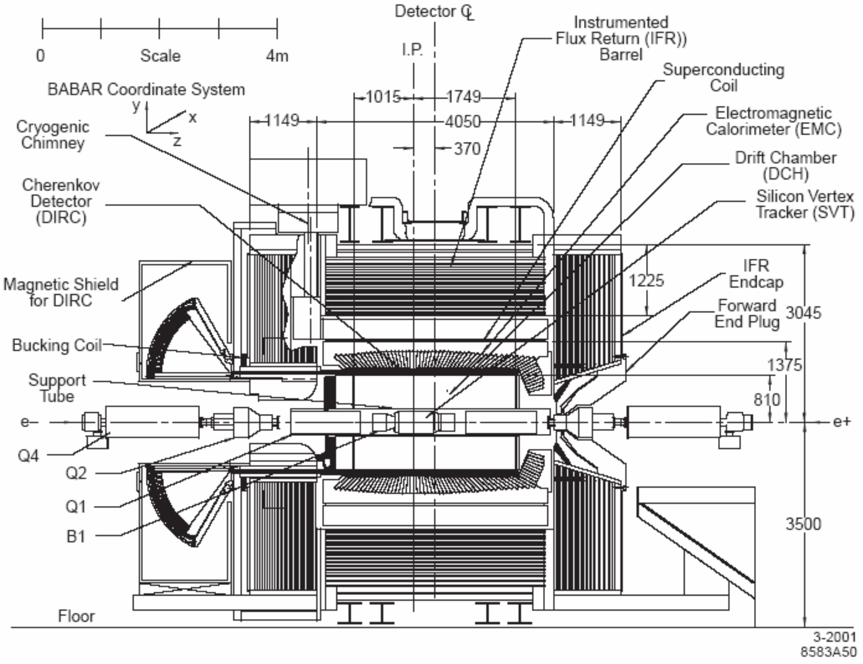


Figure 1. *BABAR* detector longitudinal section.

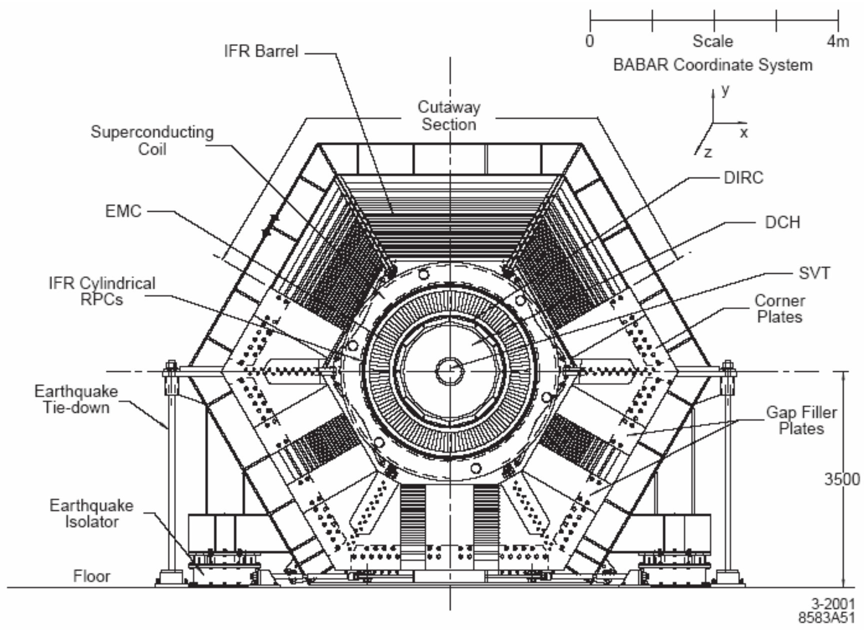
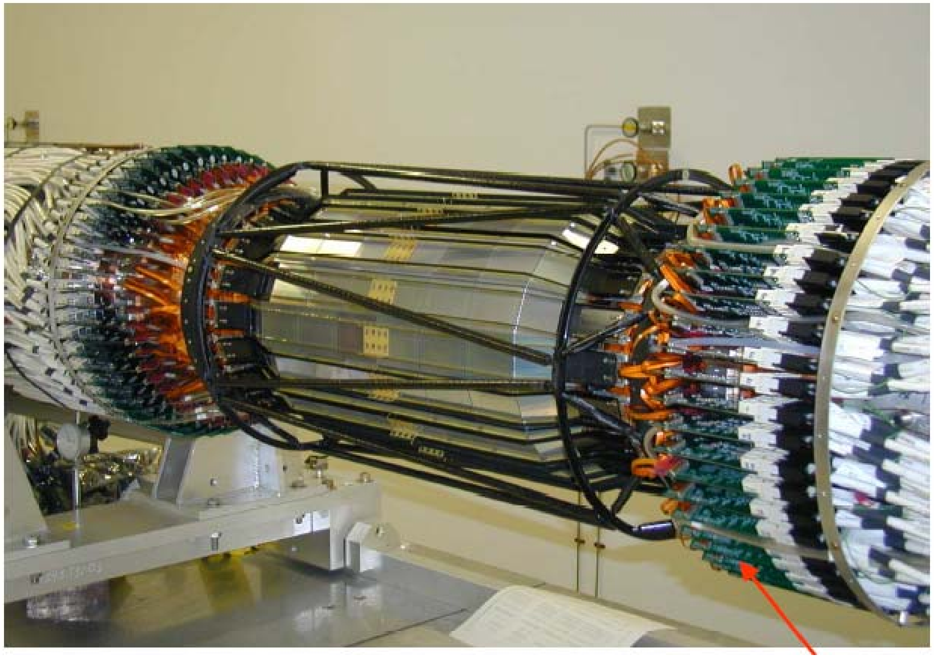


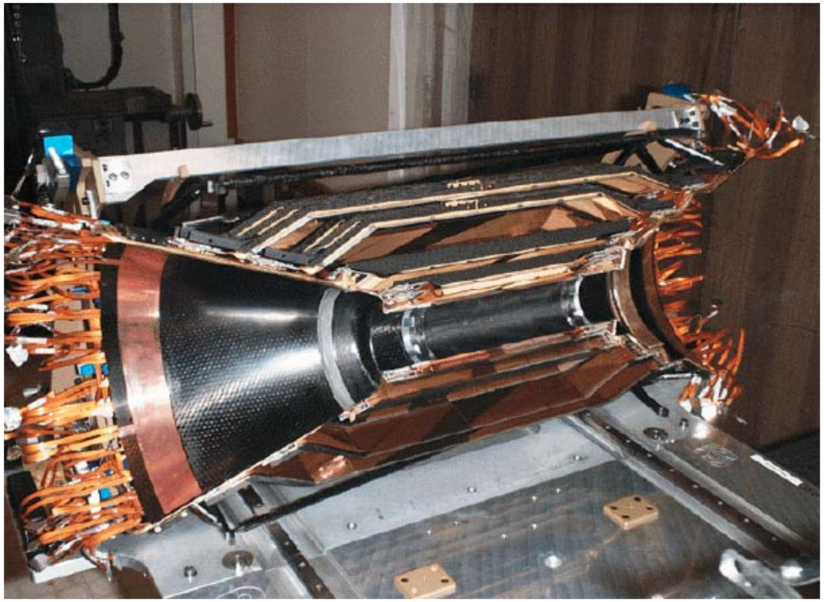
Figure 2. *BABAR* detector end view.

Details can be found in NIM A479 (2002) 1-116.

Silicon Vertex Detector

- SVT is located inside the IP machine element support tube.





Silicon Vertex Detector

- SVT has 5 double-sided layers providing z and φ readout. There are 6,6,6,16 and 18 modules in each later. ~150K channels in 208 read-out sections.

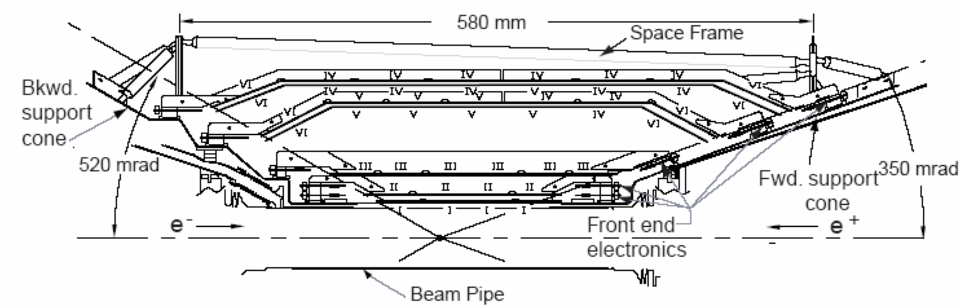
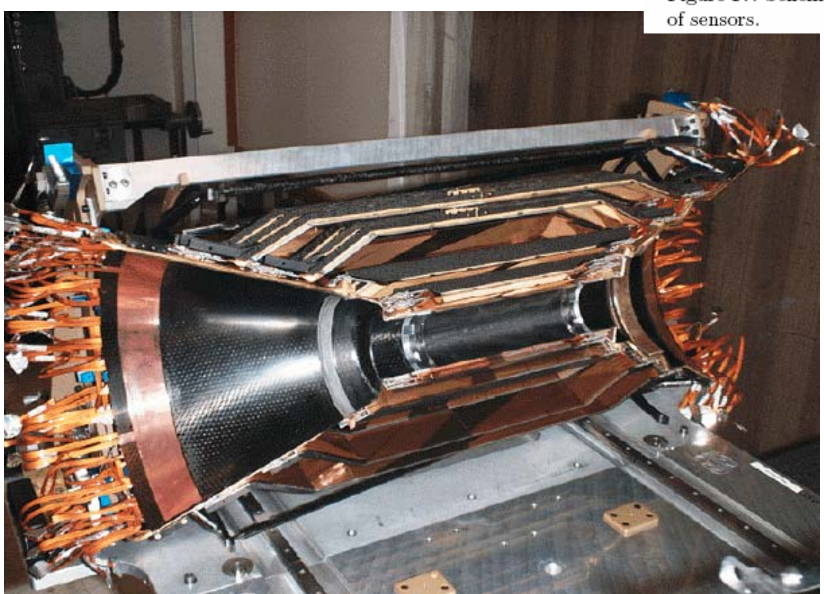


Figure 17. Schematic view of SVT: longitudinal section. The roman numerals label the six different types of sensors.



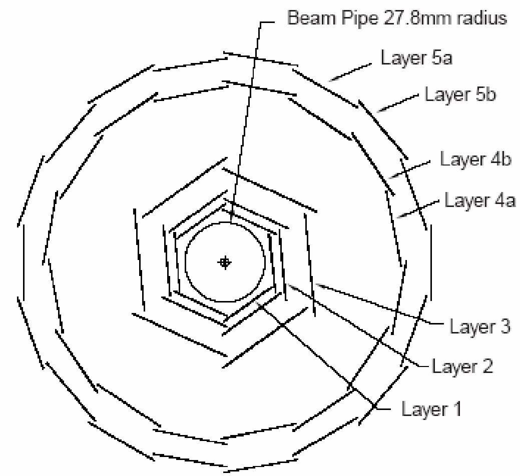


Figure 18. Schematic view of SVT: tranverse section.

Silicon Vertex Detector

- Type inversion has occurred/will occur on many chips due to radiation dose during BaBar's operational life.
- Radiation damage to components in the horizontal plane.
- Read-out: matching cards in the support tube, power supplies and next level of read-out atop the detector and on mezzanine, final stage of readout (ROM) in Electronics Hut
- Services: humidity controlled air; water cooling system (dual system fed from front and read; includes pumps, chillers, and their backups)
- During Transition to MMS: electronics will be turned off and locked out; humidification will be turned off, leaving dry air on; cooling system will be drained and dried out.
- During MMS, dry air flow will be maintained.
- Reduced monitoring system checking air status.

Drift Chamber

- Drift Chamber: charged particle tracker consists of 7104 small drift cells arranged in 40 cylindrical layers which form ten superlayers, 4 axial, and 6 stereo.

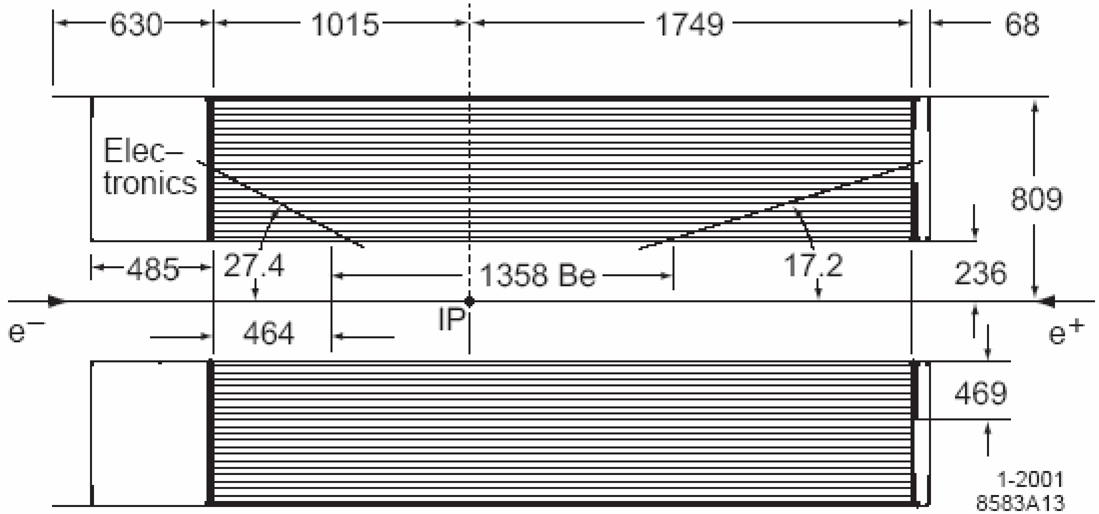


Figure 28. Longitudinal section of the DCH with principal dimensions; the chamber center is offset by 370 mm from the interaction point (IP).

Drift Chamber

- Front end electronics packages are mounted at the aft end of the drift chamber. There is a single low voltage power supply located in the Electronics Hut (EH), along with high voltage supplies for the wires.

Table 9
The DCH superlayer (SL) structure, specifying the number of cells per layer, radius of the innermost sense wire layer, the cell widths, and wire stereo angles, which vary over the four layers in a superlayer as indicated. The radii and widths are specified at the mid-length of the chamber.

SL	# of Cells	Radius (mm)	Width (mm)	Angle (mrad)
1	96	260.4	17.0-19.4	0
2	112	312.4	17.5-19.5	45-50
3	128	363.4	17.8-19.6	-(52-57)
4	144	422.7	18.4-20.0	0
5	176	476.6	16.9-18.2	56-60
6	192	526.1	17.2-18.3	-(63-57)
7	208	585.4	17.7-18.8	0
8	224	636.7	17.8-18.8	65-69
9	240	688.0	18.0-18.9	-(72-76)
10	256	747.2	18.3-19.2	0

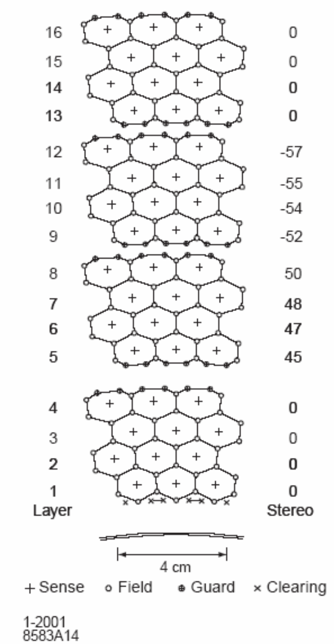


Figure 31. Schematic layout of drift cells for the four innermost superlayers. Lines have been added between field wires to aid in visualization of the cell boundaries. The numbers on the right side give the stereo angles (mrad) of sense wires in each layer. The 1 mm-thick beryllium inner wall is shown inside of the first layer.

Drift Chamber

- The DCH is mounted in the DIRC support tube.
- The DCH uses an 80:20 helium:isobutane mix provided at slight overpressure by a gas mixing system that recirculates and scrubs gas in the DCH every 6 hours, adding a full volume of makeup gas every day-and-a-half. Nitrogen is flushed between the bulkheads and endplates.

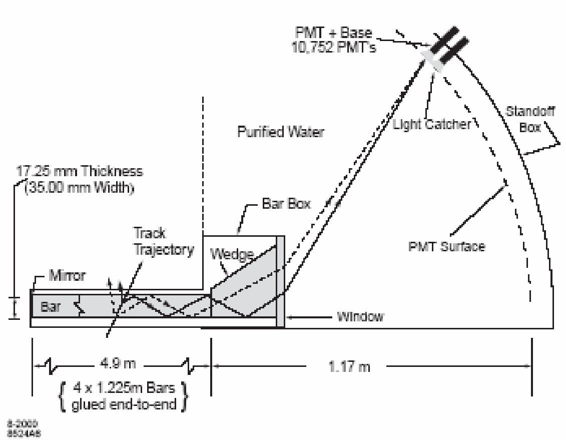
Drift Chamber

- Rest state during accelerator downs:
  - Chamber gas: Helium. Bulkhead flush gas: dry air (PRCS issue).
  - Front end electronics: off.
  - Power supplies: LV off, locked out. HV off, supply locked off.
  - Chiller and cooling water flow off.
- Minimal maintenance state:
  - Chamber gas: nitrogen (will investigate dry air). Bulkhead flush: dry air.
  - Front end electronics: off.
  - Power supplies: LV off, locked out. HV off, supply locked off.
  - Chiller and cooling water flow off, dried.
  - Reduced monitoring system checks gas flow and pressure, voltage.

DIRC

- Particle identification system: ring imaging Cherenkov detector that provides pi/K identification from pi threshold to 4.2GeV/c.
- Radiator is synthetic fused silica in the form of long, thin bars with rectangular cross-section. Radiator acts as light pipe too (total internal reflection). The material was chosen for its resistance to radiation, long attenuation length, large index of refraction, excellent optical finishing properties. The 144 bars are collected together in groups of 12 in hermetically sealed bar boxes. The bars are a unique resource.
- The bar boxes are cantilevered off the IFR barrel in a central support tube that is necessarily thin which is attached to the strong support tube (see figure next transparency).
- The Cherenkov photons emerge from the bars into a water filled expansion region, the Stand-Off Box. The SOB is instrumented with ~11000 phototubes whose faces are exposed to water.
- High voltage distribution and front end readout electronics are attached around the SOB.

DIRC



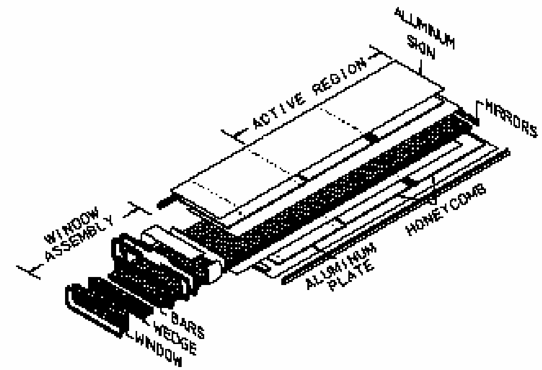


Figure 50. Schematics of the DIRC bar box assembly.

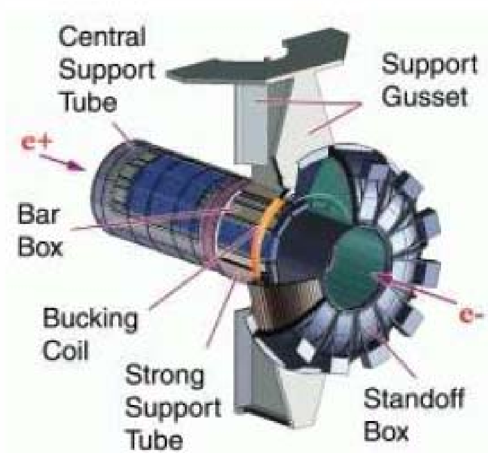


Figure 49. Exploded view of the DIRC mechanical support structure. The steel magnetic shield is not shown.

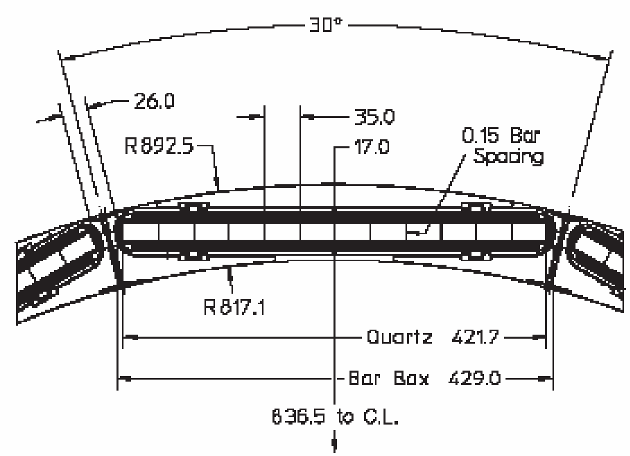


Figure 52. Transverse section of the nominal DIRC bar box imbedded in the CST. All dimensions are given in mm.

DIRC

- Rest state during accelerator downs:
  - Electronics off. Low voltage off. High voltage off.
  - Nitrogen flow to the bar boxes on to maintain dry atmosphere needed for bar surface.
  - SOB full of pure water; SOB water purification system running.
- Minimal maintenance state:
  - Electronics off. Low voltage off. High voltage off.
  - Water chiller for electronics off and system drained.
  - Nitrogen flow to bar boxes on to maintain dry atmosphere needed for bar surface.
  - SOB emptied, dried. Purification system off. *
  - Reduced monitoring system checks bar box humidity.

    - * Purification system may be left on to preserve functionality. TBD.

EMC

- Electromagnetic Calorimeter: measures energy deposited by particles interacting in the device. Principal goal is to measure photon energies; aids in identification of charged particles (hadron-electron separation, muon ID); provides some neutral hadron ID.
- Consists of 6580 ~4kg CsI(Tl) crystals read out with two photodiodes each. CsI(Tl) is mildly hygroscopic. Crystal/diode glue joint is secure over a limited thermal range. Crystals are suspended in carbon-fiber support structures mounted in the calorimeter support structures. ~$20M asset.
- Calorimeter is in two parts: barrel portion (most of crystals) and forward endcap, suspended from the steel flux return.
- Cooling for barrel power-hungry readout electronics is water cooling the support structure. Cooling for barrel preamps located at the back of each crystal is fluorinert. All endcap cooling is fluorinert. Fluorinert cooling maintains constant temperature for the diode-crystal glue joint. Extensive cooling plant. Nitrogen flush system to maintain dry environment.
- Final read-out electronics in EH. Large contingent of ROMs and VME crates, and power supplies.
- Calibration systems include radioactive source system (DT generator) and light pulser.

EMC

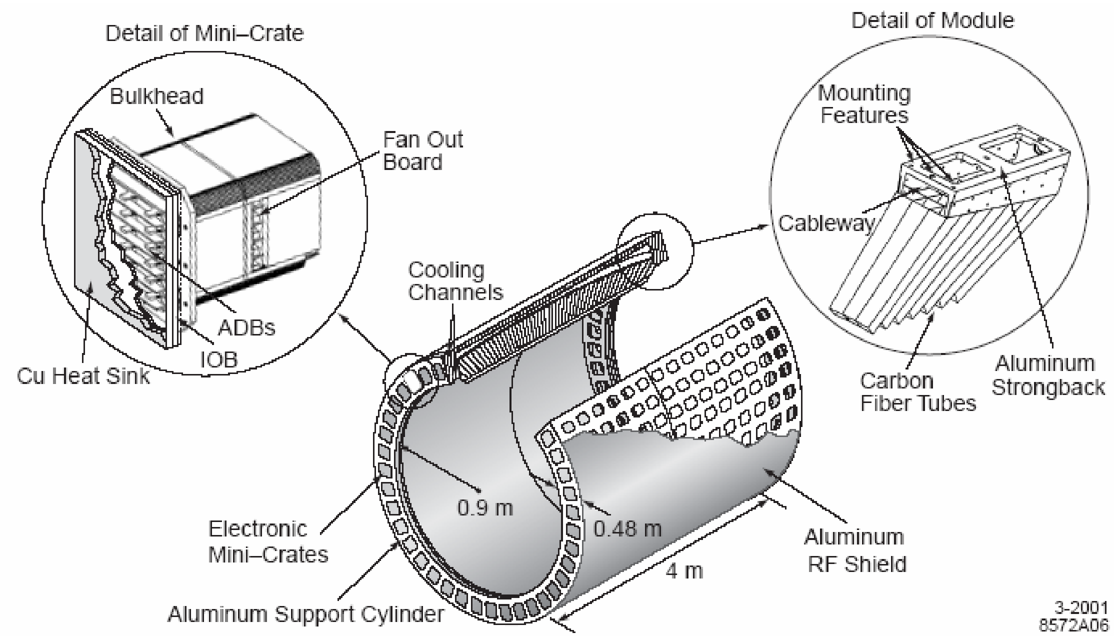


Figure 63. The EMC barrel support structure, with details on the modules and electronics crates (not to scale).

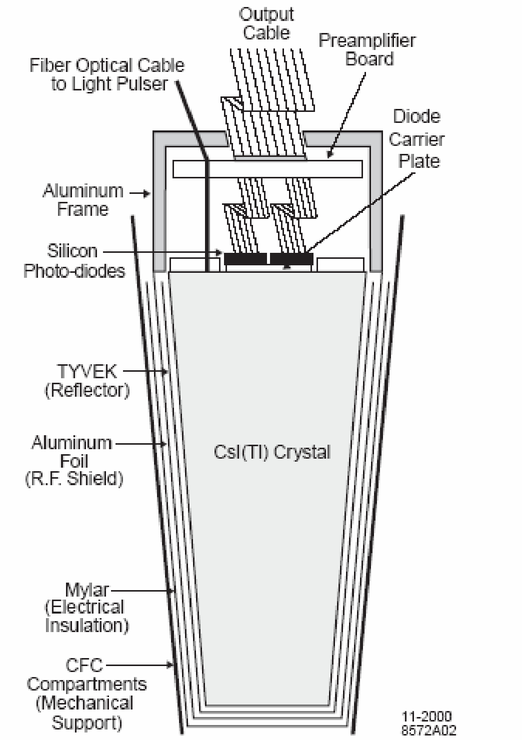
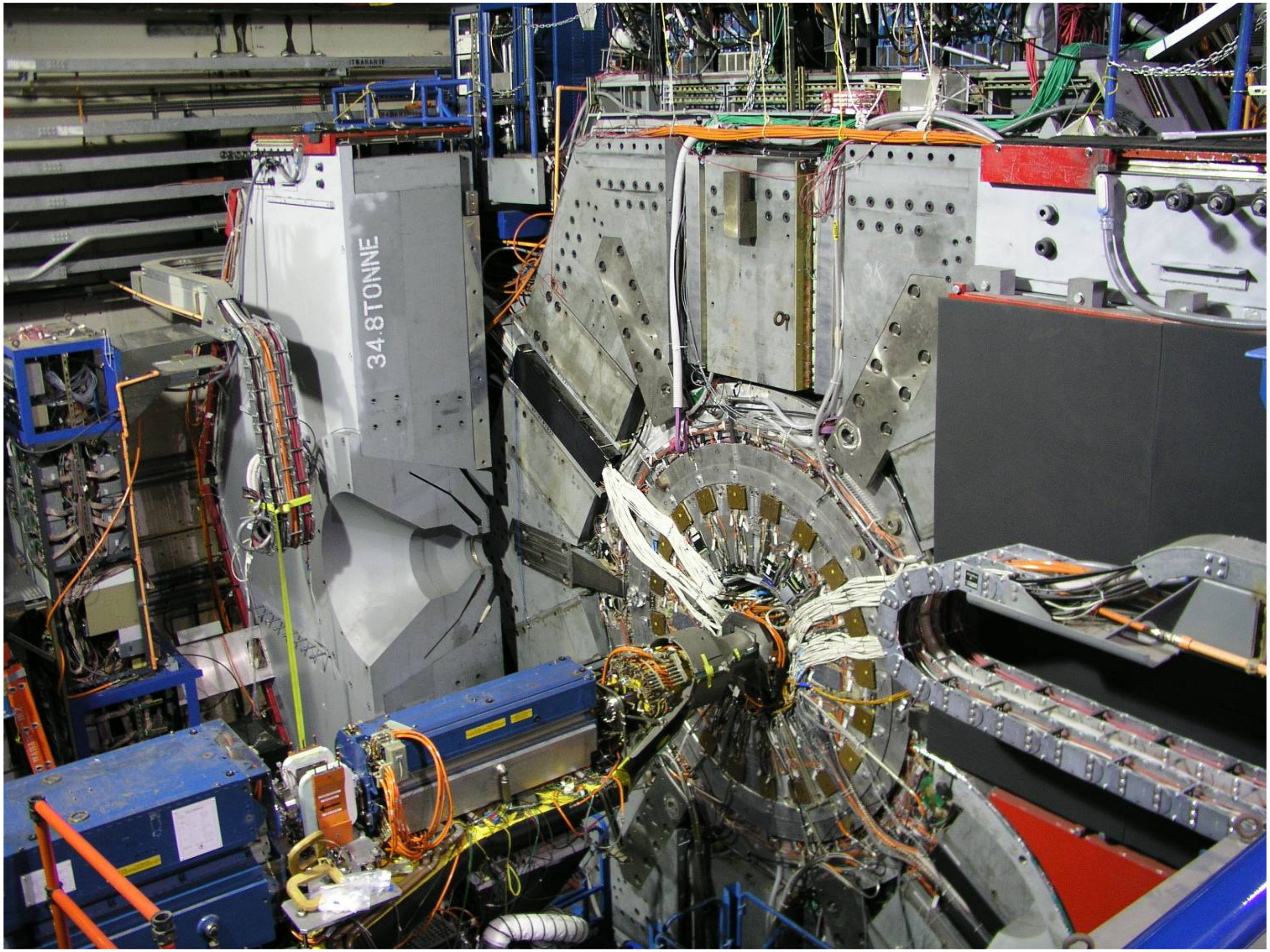


Figure 62. A schematic of the wrapped CsI(Tl) crystal and the front-end readout package mounted on the rear face. Also indicated is the tapered, trapezoidal CFC compartment, which is open at the front. This drawing is not to scale.

EMC



EMC

- Rest state during accelerator downs:
  - Electronics off.
  - Nitrogen flow on to maintain dry environment.
  - Water flow on, de-ionizer on. Required to avoid corrosion from standing water in system (aluminum used in barrel structure has high Cu content; stagnant water corrodes the structure).
  - Fluorinert cooling on, to maintain constant temperature for the photodiode-crystal glue joint.
- Minimal maintenance state:
  - Electronics off.
  - Nitrogen flow on to maintain dry environment.
  - Water flow off. System drained. Barrel cooling channels dried out to prevent corrosion of structure.
  - Fluorinert cooling on, to maintain constant temperature for the glue joint.
  - Reduced monitoring system will check humidity, crystal temperatures, fluorinert chiller operational status (temp out, temp in).
  - Source system fluorinert (fluid irrradiated by DT generator for 6.1 MeV calibration photons) will be drained. DT generator transferred to Radiation Physics.

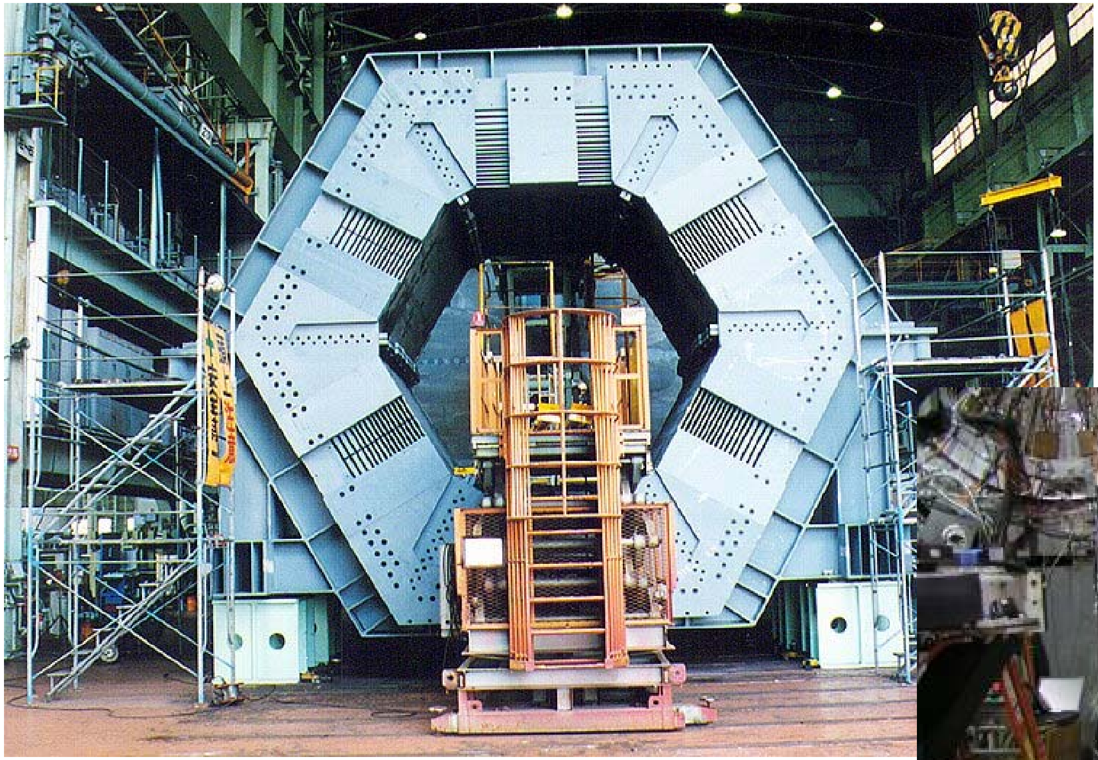
EMC: Glue Joint Fragility

- Crystal-photodiode glue joints (127) were tested before calorimeter construction through 40 8-hour cycles of +/- 4C and 120 12 hour cycles of +/- 5C. No joints failed.
- While the endcap calorimeter was being prepared for installation, assembly area cooling failed on a hot day. A temperature excursion of +10C was measured. Several glue joints failed in several modules, leading to the temperature maintenance requirement for the calorimeter.

IFR

- Instrumented Flux Return consists of two systems: Limited Streamer Tubes in the barrel, installed in 2004 and 2006, and Resistive Plate Chambers in the forward and backward endcaps.
- LSTs: twelve layers of modules in 6 sextants. Six layers of brass installed in gaps formerly occupied by PRCs (increase interaction lengths). These detectors are expected to have minimal aging at the time of cessation of B-Factory operations.
- RPCs: Forward endcap: 16 layers of chambers (192 gaps), 4 in double modules, with 5 layers of brass; these chambers are being aged by backgrounds. Backward endcap: 18 layers of modules (216 gaps) from the initial construction of the detector; the majority of these chambers are in bad shape.
- Gas mixing systems provide mixes for LSTs, RPCs, and avalanche mode RPCs.

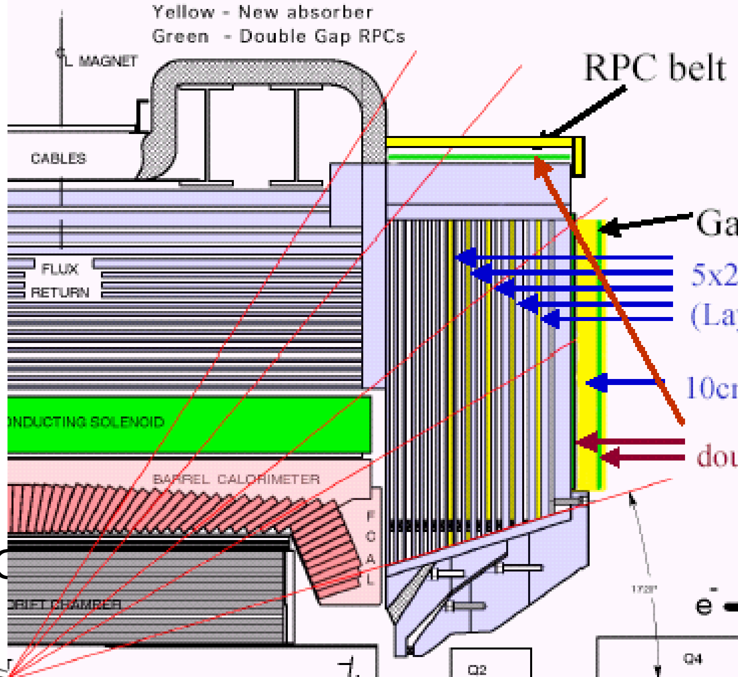
IFR: LSTs



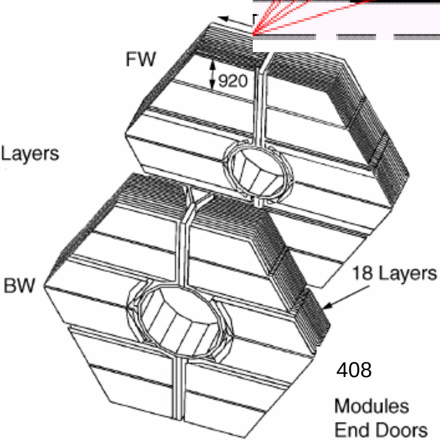
Barrel Flux Return Steel

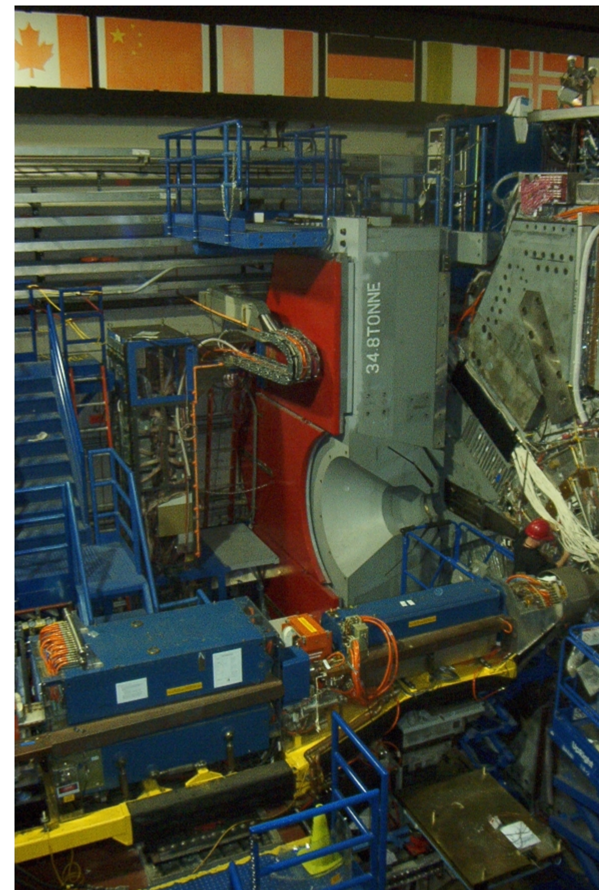
LST Installation

IFR: RPCs



Endcap C





IFR: Gas System

Gas Shack

IFR gas mixing racks

IFR

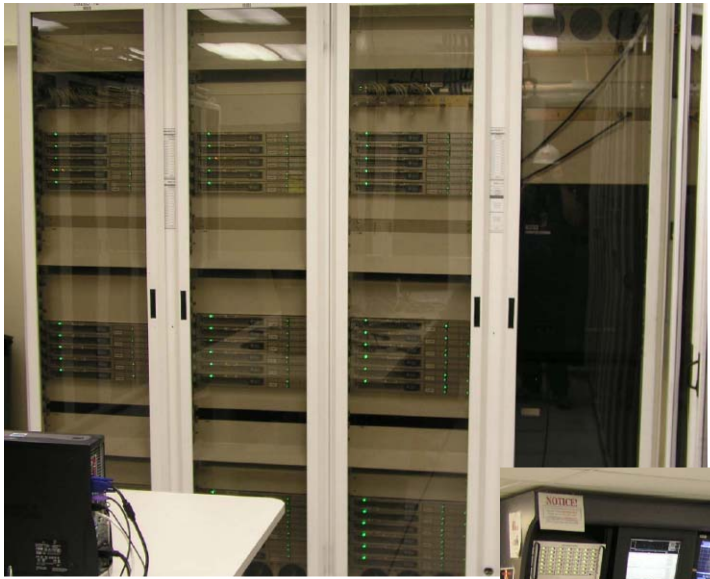
- Rest state during accelerator downs:
  - LSTs:
    - Electronics off. Gas flow on. HV on (conditioning). Cooling only used to keep barrel temperature constant.
  - RPCs:
    - Electronics off. Gas flow typically off. HV off. Water cooling off.
- Minimal maintenance state:
  - LSTs:
    - Electronics off. Gas changed to nitrogen(off). HV off. Cooling off.
  - RPCs:
    - Electronics off. Gas changed to nitrogen(wet) or off. HV off. Colling off.
  - Monitoring: gas flow.

Trigger & DAQ

- The trigger, with it’s custom Level 1 electronics using inputs from the DCH and EMC, resides in VME crates in water cooled racks in the Electronics Hut. The ROM level DAQ electronics is also found in VME crates in the EH racks, as is the switching units for event building. The balance of the online equipment is in the alcove adjacent to the control room. The EH heat exchanger is located on the roof of the EH.

Trigger & DAQ

EH top deck



L3 farm & switches

Control Room

ROMs & L1

Trigger and DAQ

- In MMS, both will be off, as will be the online farm. EH cooling may need to be on, though with a minimal monitoring system the heat load may be low enough so that the IR2 general chiller plant will not need to be operated. A UPS system will be needed for the MMS monitoring. See Luitz talk for details.

Magnet

- The magnet system is composed of:
  - Superconducting coil in its cryostat, with current leads. This is an asset with long term value.
  - Power supply for the magnet.
  - Cryogen system: pumps, liquifier, dewars and controls. Has long term value, though will be almost two decades old.
  - Flux return steel (IFR). Has potential long term value.
- Asset preservation in the MMS:
  - Power supply off.
  - Cold mass warmed to room temperature.
  - Cryo plant drained and mothballed.
  - Vacuum pumps on to maintain vacuum.
  - Monitoring system maintained to watch vacuum and cold mass status (strain gauges, etc.)

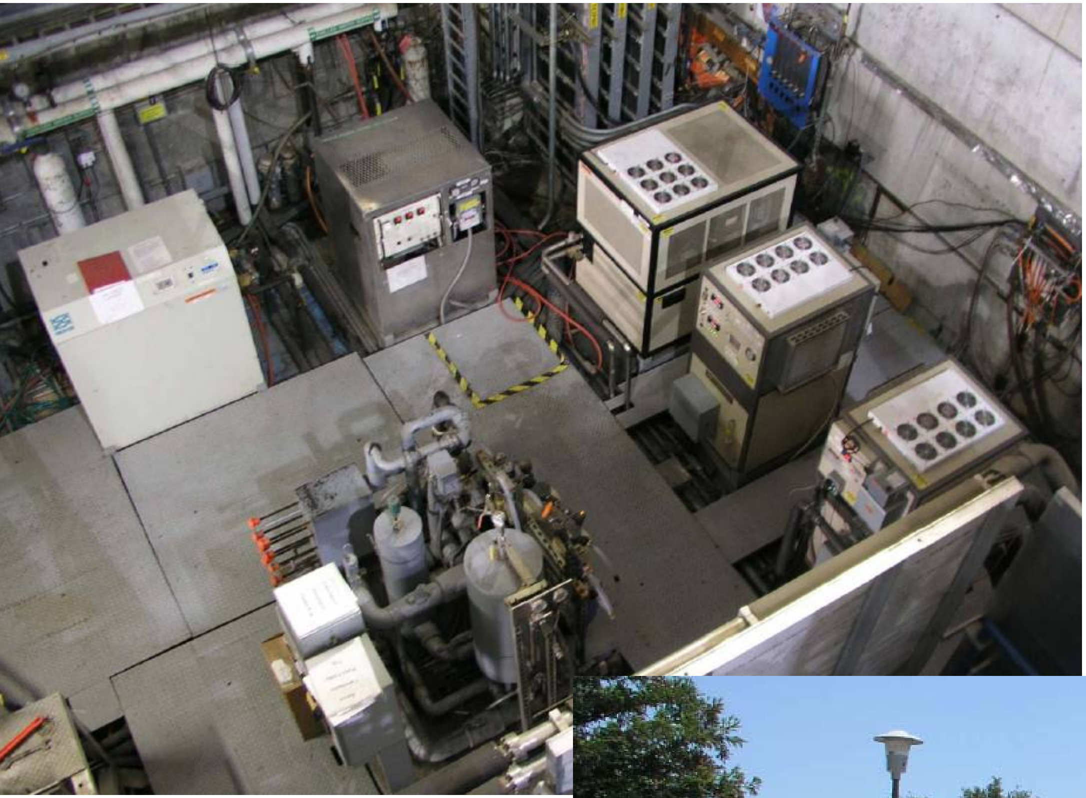
Cryo Plant

IR2 portion of plant. The balance of the complex is in the Research Yard.

IR2 Complex

- Limited power will be needed to support the monitoring of the detector in the MMS. There will be limited use of the gas shack to supply nitrogen for the detector rest state. Assuming the thermal load of the EH is low enough, the main chiller pad will not be critical to operations. Much of the detector (technical) chiller plant will not be active.

IR2 Complex



BaBar Chiller Pad

Central chiller pad

IR2 complex

Summary of MMS Detector

System	Front-end electronics	Power supplies	Gas	Cooling	Other utilities
SVT	Off	Off	dry air	off, drained	
DCH	Off	Off	dry nitrogen	off	
DRC	Off	Off	dry nitrogen	off, empty	SOB drained, purification system off
EMC	Off	Off	dry nitrogen	fluorinert circulating	water system drained and dried; source system drained
IFR-RPC	Off	Off	dry nitrogen	off, drained	
IFR-LST	Off	Off	dry nitrogen	off, drained	
Trigger	Off	Off	n/a	n/a	
DAQ	Off	Off	n/a	n/a	
Online farm	Off	Off	n/a	n/a	
Safety systems/monitoring/UPS	On	On	n/a	EH cooling on	UPS maintained
Infrastructure	n/a	n/a	n/a	EH cooling on	UPS maintained
Magnet	On	Off	n/a	n/a	vacuum pumps on
IR2 complex	n/a	On	On	On	gas shack limited use

Rampdown to MMS

- The rampdown to the Minimum Maintenance State is very close in scope, for most subsystems, to moving to the rest state during yearly down times (a process that requires a couple of days). The principal differences are:
  - Draining of cooling fluids (expect completion in a couple of months)
  - Modifying gas systems to allow more extensive use of nitrogen or dry air (expect completion in a couple of months)
  - Development of a stand-alone slow control system (see Luitz talk)

Schedule for Rampdown

ID	Task Name	Duration
1	**BABAR transition to MMS**	**34 wks**
2	Drain & dry all cooling systems	10 wks
3	Cooling systems drained	0 wks
4	Develop standalone slow controls	26 wks
5	Standalone slow controls deployed	0 wks
6	BABAR transition complete	0 wks
7	**PEP-II transition to MMS**	**82 wks**
8	Secure electrical hazards	26 wks
9	Electrical hazards secure	0 wks
10	Secure mechnical hazards	10 wks
11	Mechanical hazards secured	0 wks
12	Drain & dry magnets	52 wks
13	Magnets drained	0 wks
14	Drain & dry vacuum cooling systems	52 wks
15	Vacuum cooling drained	0 wks
16	Vent & secure vacuum system	10 wks
17	Vacuum system secured	0 wks
18	Drain & secure RF systems	26 wks
19	RF systems secured	0 wks
20	PEP-II transition complete	0 wks

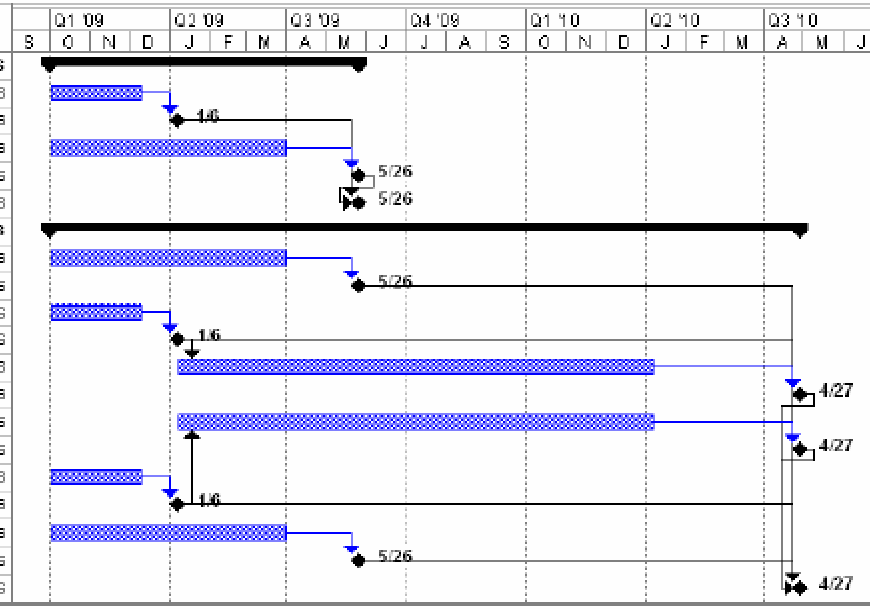


Figure 2. Summary of tasks and milestones for the BABAR and PEP-II transition to a minimal maintenance state (MMS).

Manpower

- The experiment has several technicians who are responsible for system repairs. These folks, along with some help from CEF (conventional and experimental facilities) department who have maintained parts of the chiller system, will implement the transition to the MMS, with the help of system physicists. The manpower involved in this activity adds up to 2.2 FTEs of technician, engineer, and .7 FTE of physicist effort, including the Operations Manager, Technical Coordinator and System Managers.
- Once in the MMS, it is expected that a small fraction of several key technicians and physicists will be needed to perform inspections of the detector and respond to any alarms raised by the robust minimal monitoring system. In addition, routine maintenance of the VESDA fire early warning system, the crane, lights, and UPS system will be needed.

Cost

- M&S includes fluids and gases needed to maintain the detector as well as items needed for repairs of the systems for the MMS.

Table 7. Budget projections for BABAR detector transition and minimal maintenance. A 4% salary escalation is assumed, but no inflation for M&S. The transition tasks occur in FY09.

	FY09		FY10		FY11	
	FTE	**Budget [k$]**	**FTE**	**Budget [k$]**	**FTE**	**Budget [k$]**
PPA Labor	2.1	440	0.6	120	0.6	125
Operations Directorate Labor	0.9	150	0.4	90	0.4	90
M&S		100		80		80
Total		690		290		295

MMS Alternative Considerations

- The Collaboration considered two models for the MMS, the one adapted (described above), and one which would allow limited calibrations and cosmic ray running. This would have required a more complex online system which would have required more professional effort to maintain. It would also have required restoration of the detector from a deep rest state to operations, and return to the MMS deep rest state. This would have been very costly in terms of manpower for a perhaps marginal insurance policy. (Keeping the detector in a state of higher readiness, another alternative, would incur greater cost both in manpower and M&S, so would be less acceptable). The most prudent choice, the MMS as described above, where the detector assets are preserved, but no more, was chosen.

Asset Security

- While BaBar is running, 24x7 shift personnel provide limited security monitoring. Now that all upgrades are complete, and operations at IR2 are routine, manpower at IR2 has been reduced. In order to limit stray personnel in IR2 and to control work performed in Bldg 620, as well as provide levels of security expected for computing systems, card locks have been investigated for buildings of the IR2 complex, the EH and the computing alcove. Implementation of a robust system is anticipated during the coming year. This system will need to provide a first line of defense in protecting BaBar assets when the MMS has been established.

Asset Security

- During the MMS, the detector end doors as well as DIRC plug will protect the key detector assets. The possible adaption of the PEPII PPS apparatus, once it is disconnected from the global PPS system, as a form of access control to the detector and accelerator, will be investigated before cessation of operations.

Asset Security

Detector Closed

PPS entry

Collaboration Involvement in MMS

- The BaBar Collaboration proposes to continue to hold responsibility for the detector through the end of calendar 2010. The BaBar community is interested in re-use of the detector components as part of a SuperB project. This was broached to the International Finance Committee in July, with expectation of a decision in January. If the IFC agrees to the proposal, the Collaboration would oversee the transition to the MMS, and the Operating Common Fund cover M&S and non-physicist personnel though this period.