



ISL Cooling Leak

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All Experimenters Meeting

May 19, 2007

- The Problem
- Overview of CDF Silicon and Cooling
- Leak history and initial investigation
- Plan for investigation, repair and operation

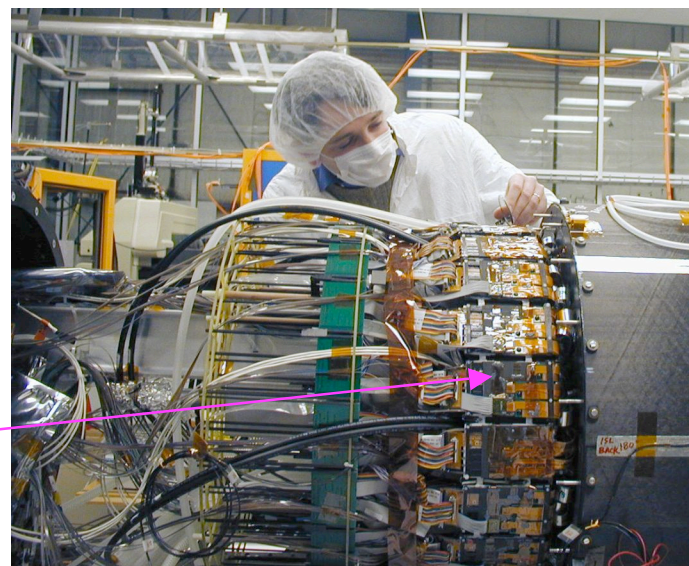
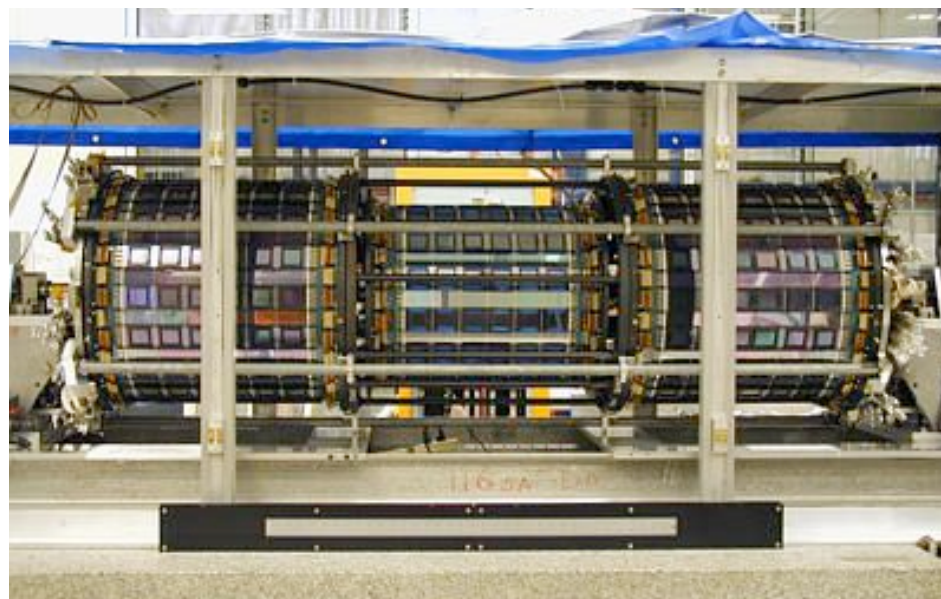
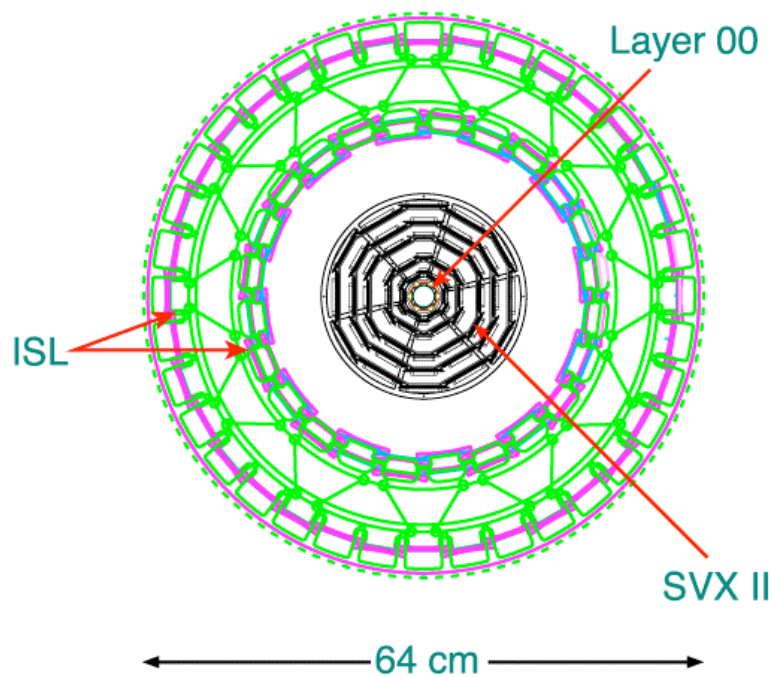


The Problem

- Leak in cooling for Intermediate Silicon Layers (ISL) and Layer 00 Port Cards
 - Affects readout for 1/2 of ISL and 1/2 of L00
 - Leak isolated to aluminum manifold on detector
 - Hole observed in the manifold
- Can't cool portcards to readout east ISL
- Can still run SVX
- Developing plan to run L00 w/o flow through the line
- Developing repair plan for the August shutdown



CDF Silicon Detectors





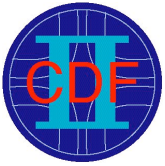
CDF Silicon Detector (cont)

- Five Layer SVX is core of system
 - B-tagging
 - Lifetime measurements
 - Silicon vertex triggers use SVX alone
- Layer 00
 - Improve vertex (eg B-tag) with point at beam pipe
- ISL
 - Not required for good B-tagging
 - High Lum point to help connect COT and SVX
 - High eta ($|\eta| < 2$) tracking for forward electrons

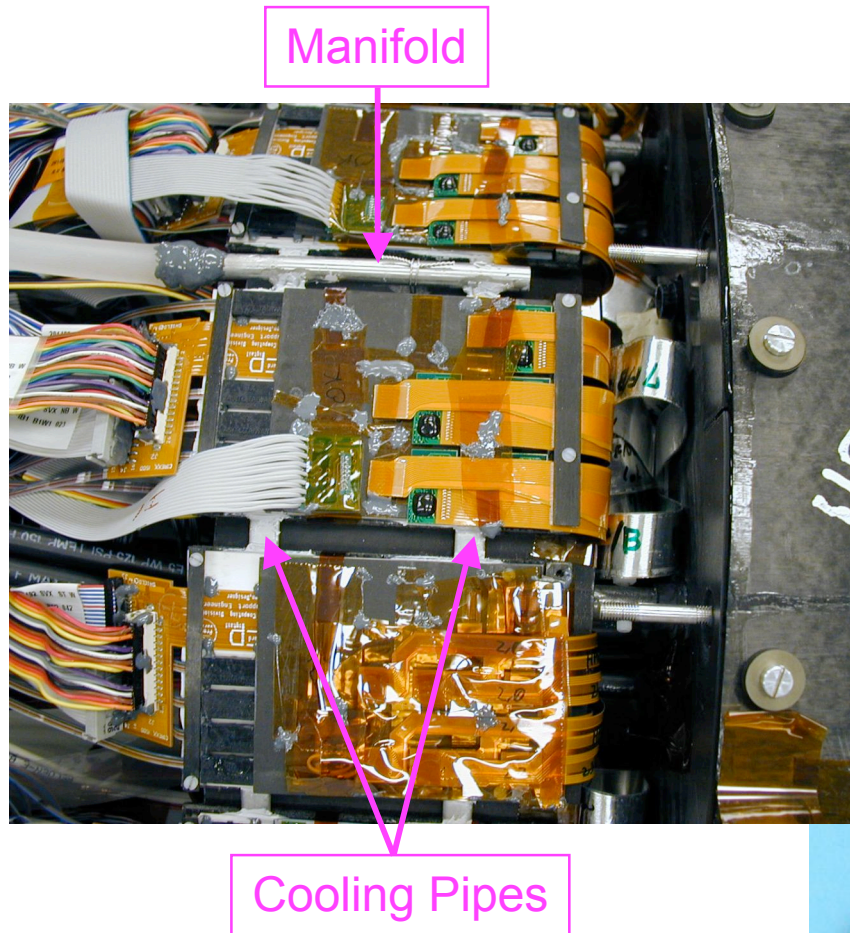


Silicon Cooling Systems

- Cool sensors, readout electronics on detector (SVX chips) and nearby readout electronics (Portcards)
- SVX and ISL have independent cooling systems using water and ethylene glycol for coolant
 - SVX (-10°C)
 - ISL (+6°C) - includes L00 and portcards for all 3 detectors
 - Need to keep SVX colder to reduce impact of radiation damage
- Each system broken into 10 cooling circuits on face of central detector with separate electronic control valves
 - From control valves cooling lines follow COT/Silicon cables to COT face
- Operated sub-atmospheric: leak sucks air into system rather than pushing coolant onto detector or electronics



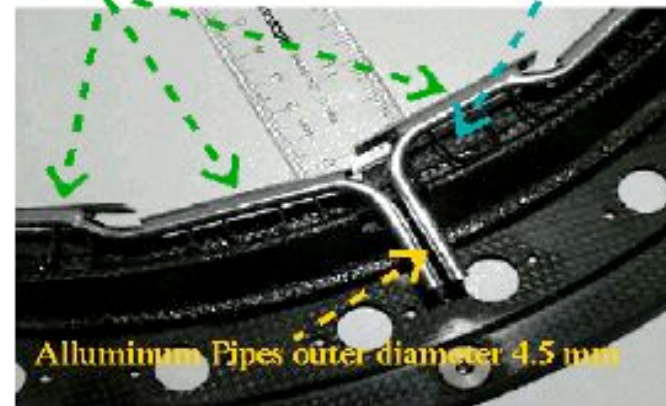
Silicon Cooling (cont)



Space Frame Cooling System

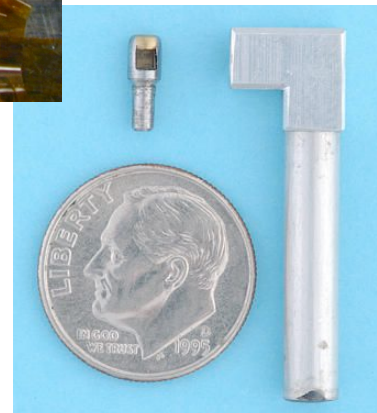
Beryllium Ledges

Carbon Fiber Ribbon



Maximum of 9 ladders in one cooling channel
 $\Delta T(\text{IN-OUT}) \sim 1^\circ\text{C}$

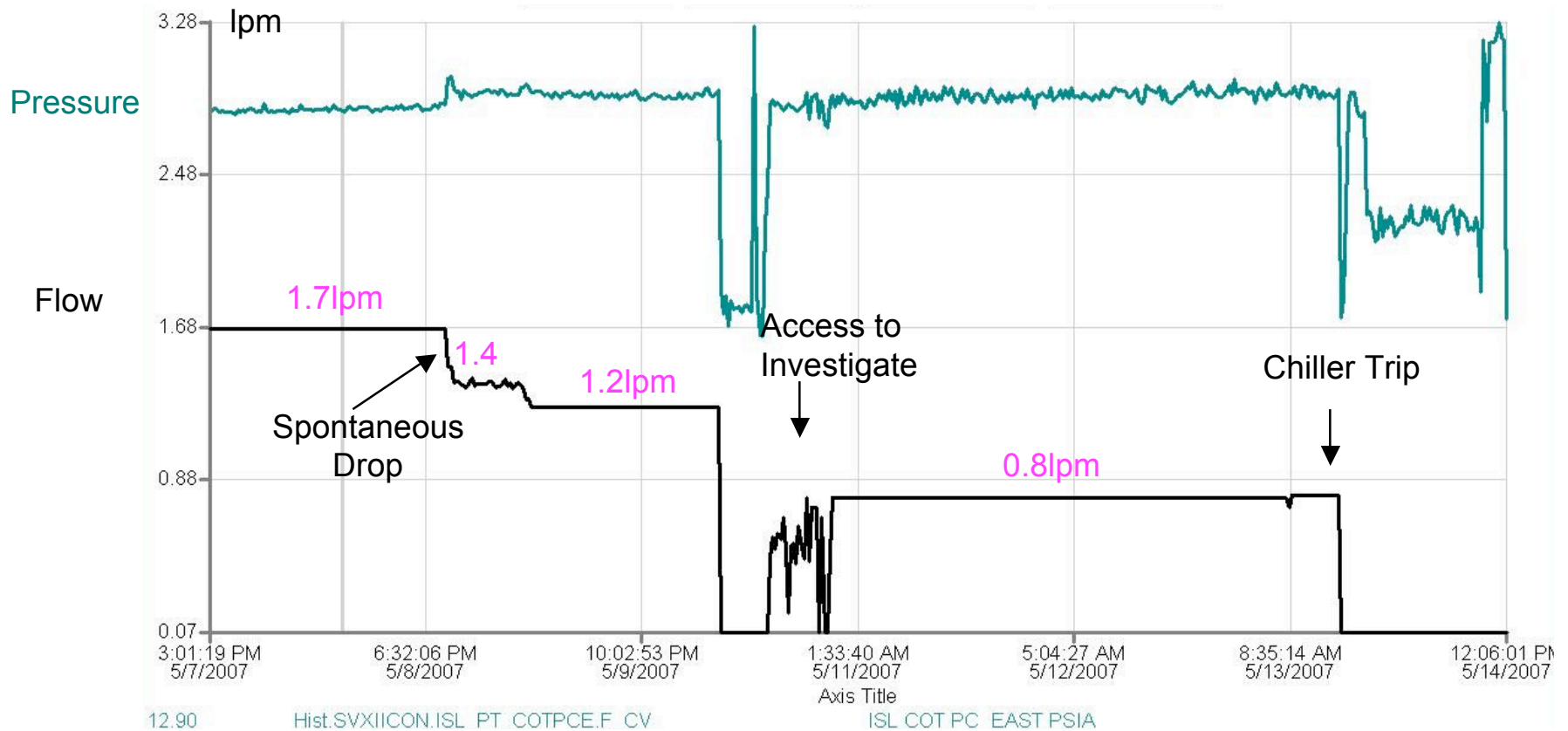
coolant flowing in aluminum tubes attached to beryllium ledges mounted on space frame





The Leak

- May 8-13 flow in East ISL/L00 portcard circuit dropped from 1.7 lpm (nominal) to 0.0 lpm:





Leak Investigation (1)

- May 10 - access to investigate flow
 - Tests indicate air leak in circuit
 - Flow drops after access
 - Start planning for access(es) to investigate
- May 14 - access to investigate leak
 - Not in valves on outside of detector
 - Leak is inside of plug calorimeter
 - **Need access to COT face**
- May 16 - pull east plug calorimeter and access COT face



Leak investigation (2)

- Access Wednesday May 16:
 - Open east plug calorimeter
 - Access COT face and Silicon cooling lines
- Further isolate (and we hoped fix) leak
 - Ruled out leak in junctions or tubing on the COT face
 - Leak inside silicon N₂ inerting volume (cold)
 - Using catheters with balloon and line to apply pressure, isolated leak to manifold for cooling ISL (L00) portcards





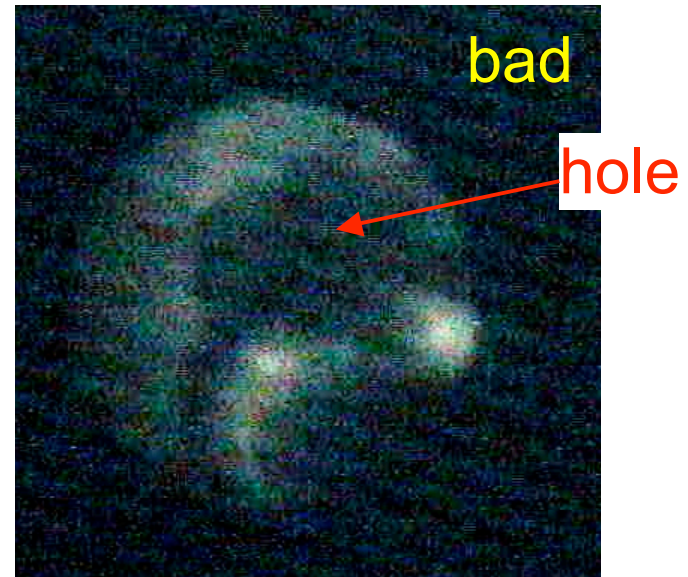
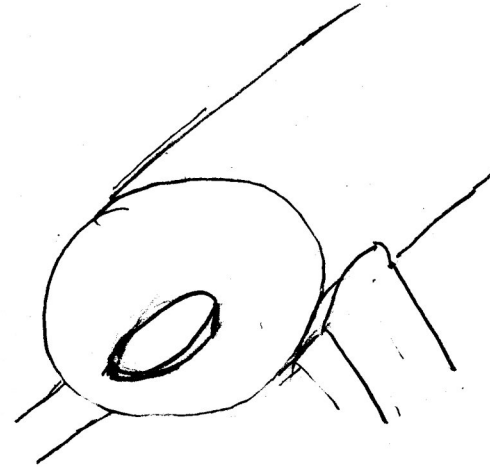
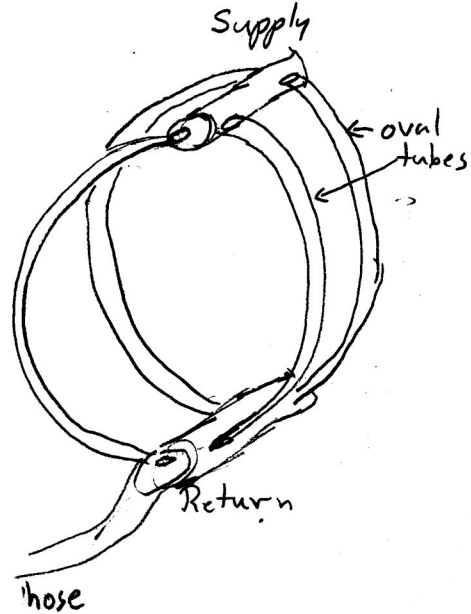
Leak investigation (3)

- Used boroscope to examine manifolds
 - Signs of erosion and/or corrosion at 2 locations on supply manifold and 2 locations in return manifold
 - Experts are convinced there is a hole at one of these locations on supply manifold





Boroscope pictures





Cause of the leak

- Visual evidence suggests erosive and/or corrosive process
- Possibility of corrosion due to recent experience of acidic coolant
 - Coolant became ionized during 2006 shutdown (see All Expt talk by Mary Convery March 19)
 - Recognized as acid (pH=2.2) in mid-March 2007
 - Drained and flushed April 3 (pH=2.9)
 - Rapid de-ionization May 10 (pH=4.7)
 - No significant Aluminum seen in coolant samples (Aug '06 and March '07)
- Possibility of erosion due turbulence in region of damage due to cooling tubes protruding into manifolds
- Exact cause not yet established - need to keep open minds during investigation



Establish Task Force

- Four major objectives:
 - Determine short term operating configuration
 - Determine probable cause of leak
 - Evaluate risk of future leaks in this and other components of system
 - Develop repair technique
- Follow all in parallel:
 - Need answers/plans in about 1 month to execute repair during summer shutdown
 - Repair completed during summer shutdown
 - Areas of future risk addressed before end of shutdown



Task Force

- **Composition**
 - Core of experts on CDF and at lab
 - Current and former members of Silicon Detector Group
 - Experts on CDF and within PPD who solved blocked ISL cooling lines in 2002
 - Seek help from experts other departments and divisions
 - Look for outside expertise, for example:
 - Chemical consultants
 - Other HEP laboratories
- **Report to CDF Detector Operations**
 - We will report results to laboratory



Task Force Work

1) Short Term Operation:

- Develop configuration for system until repair is completed
 - 11 weeks of operation until summer shutdown
 - At 30pb⁻¹/week would represent ~10% of total dataset
- Operate SVX
- Try to operate full L00 w/o flow through portcard cooling loop
- Operate West ISL if no thermal/mechanical issues
- **Evaluating risks**
 - Unusual operational configuration
 - Timescale for decision 1-2 weeks



Task Force Work (2)

2) Determining Probable Cause:

- Acidic coolant:

- Effects on specific materials: aluminum alloys, stainless, etc
- Consult with AD on past leak problems and outside consultants

- Erosion: Model flow of manifold

- May not have definitive cause:

- Need to understand impact of all likely causes for repair and vulnerability analysis



Task Force Work (3)

3) Evaluating Future Risk

- Determine if other components were damaged
- Complete analysis of design and construction
- Include risks for SVX cooling system

4) Repair

- Already developing ideas for repair
 - Most involve epoxy from inside
- Develop repair technique on a mockup of system



Summary

- Cooling leak for east ISL/Layer 00 port card electronics
 - Leak isolated to aluminum manifold on detector
 - Hole observed in the manifold
- Currently running detector with SVX but w/o L00 and ISL
 - All triggers working (including secondary vertex)
 - Full physics program operational
- Task force started:
 - Short term plan to run L00 and 1/2 ISL
 - Establishing probable cause
 - Evaluating vulnerabilities
 - Planning repair for the August shutdown
- We will fix the leak and have a fully operational detector by the end of the Shutdown



Backup Slides



Sample List of Questions

- Cause:
 - Acidic coolant:
 - Does chemical analysis cover all possible aluminum content? Would it all be dissolved? Could some be trapped by filters? Are there compounds that the tests are insensitive too? What is the reliability of the tests?
 - What actually caused the acid? If bacteria, what happened to it? What acids were there?
 - Could bacteria have attacked the weld/Aluminum
 - What was the pH in Aug 2006?
 - What is the history of conductivity before, during and after each shutdown?
 - Erosion
 - Is it possible for turbulence to cause the erosion? Was the manifold constructed as designed?
 - Is a combination of erosion and corrosion possible?
 - Mechanical defect? Cracks started during assembly? Mechanical stress?
 - What made the joints dark? Growth of a foreign material on the joint?
- Vulnerability:
 - Are the west portcard rings damaged?
 - What about the SVX portcards?
 - Are the ISL and L00 sensor cooling tubes damaged?
 - Was the same Al alloy used at all locations?
 - If acid is the problem, what is the safe range?
 - What is the construction of the SVX portcard ring?
- Repair:
 - Can we put epoxy from inside and outside?
 - Can we take junction cards out of the way?
 - Can we block leak with catheter to check for other leaks?
 - Is there a safe material to coat the full inner surface?
- Short term operation:
 - Will ISL frame be affected by differential heating if only 1/2 is powered?
 - Can the L00 DOIMs work with no cooling flow?
 - Could we flow cold dry nitrogen to portcards to operate L00?