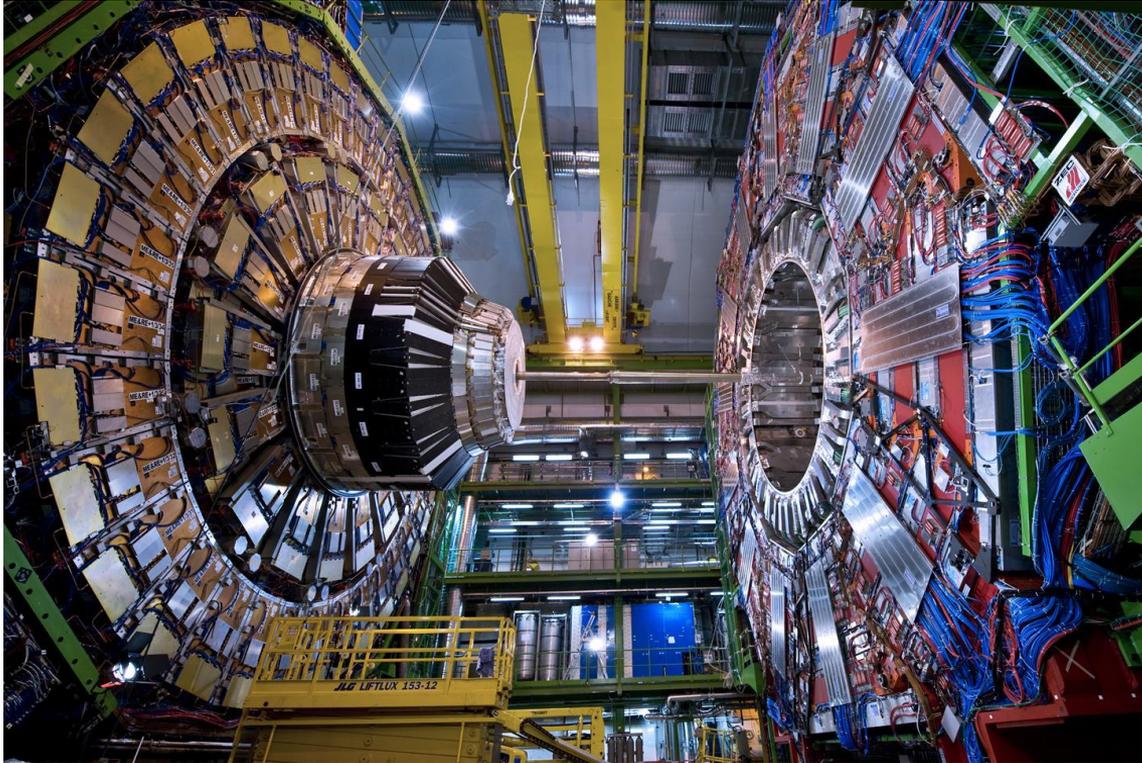


Memory Analysis of the CMS HCAL Online Software

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UM CERN REU 2014
August 7, 2014

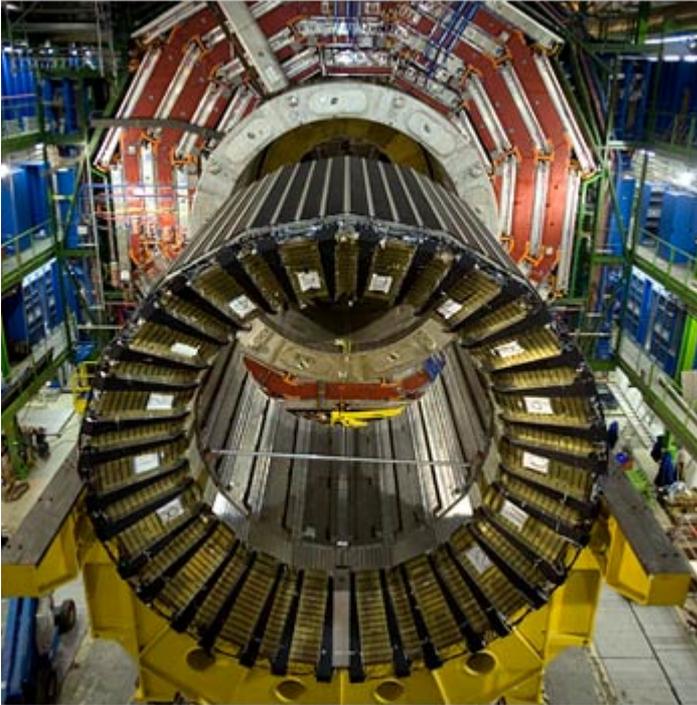


The Compact Muon Solenoid Detector



- One of 2 large general-purpose detectors on the LHC
- Participated in the Higgs boson discovery
- Looking for any kind of new physics: supersymmetry, dark matter, extra dimensions, etc.

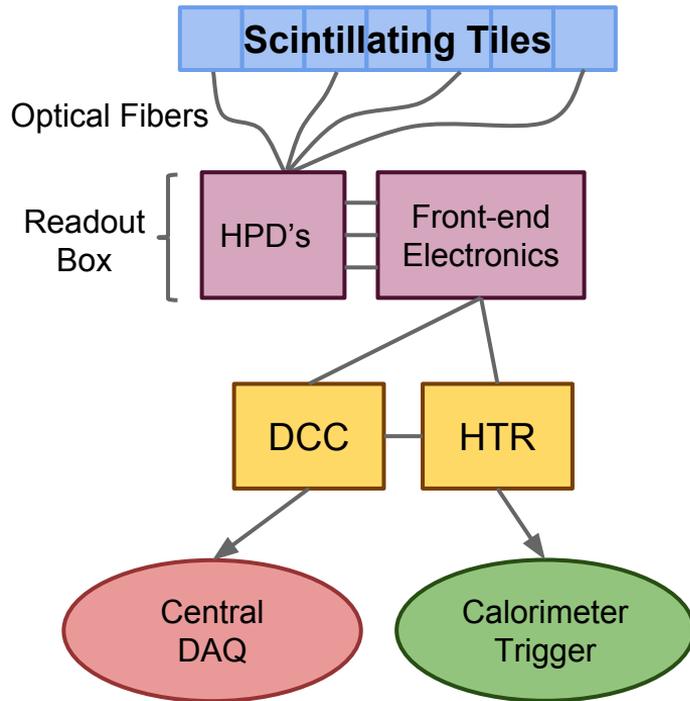
The Hadron Calorimeter (HCAL)



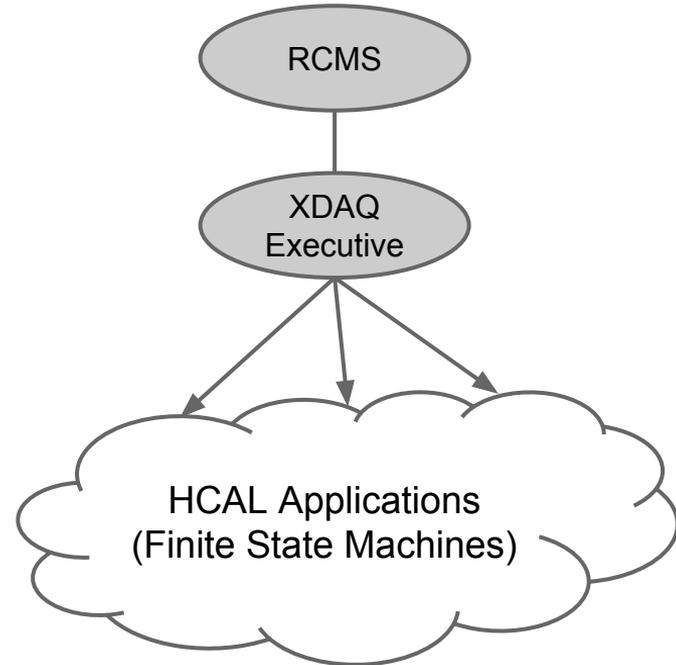
- Precisely measure the energies of any hadrons produced in the collisions
- Metal plates trigger particle showers
- Interactions with plastic scintillators produce light in proportion to particle energy

HCAL Detector Control System

(Very) Simplified Model of HCAL



Online Software



Analyzing the HCOS Memory Usage

- First step: run the XDAQ executive outside of RCMS
- Took a quite few weeks to get everything up and running without any errors (had to restart on different teststands a couple times).
- Next, push the applications through the various FSM states to find out which transitions cause memory leaks.
- As software is upgraded to run for longer periods of time, leaks will become a much bigger issue.

Analyzing the HCOS Memory Usage

- valgrind: Linux tool to monitor memory usage of C/C++ programs
- valgrind logs are ~20000 lines long. Wrote a Python script to parse through the logs and extract the relevant information.

Raw valgrind leak report:

```
7,168 bytes in 14 blocks are possibly lost in loss record 29,708 of 29,861
==18102==   at 0x4A076A5: operator new(unsigned long) (vg_replace_malloc.c:319)
==18102==   by 0x59EAC3F: xercesc_3_1::MemoryManagerImpl::allocate(unsigned long) (in /opt/xdaq/lib/libxerces-c-3.1.so)
==18102==   by 0x596D0BE: xercesc_3_1::XMLStringPool::XMLStringPool(unsigned int, xercesc_3_1::MemoryManager*) (in
/opt/xdaq/lib/libxerces-c-3.1.so)
==18102==   by 0x5993C6C: xercesc_3_1::DOMDocumentImpl::DOMDocumentImpl(unsigned short const*, unsigned short const*, xercesc_3_1::
DOMDocumentType*, xercesc_3_1::DOMI
mplementation*, xercesc_3_1::MemoryManager*) (in /opt/xdaq/lib/libxerces-c-3.1.so)
==18102==   by 0x59A06D3: xercesc_3_1::DOMImplementationImpl::createDocument(unsigned short const*, unsigned short const*, xercesc_3_1::
DOMDocumentType*,
xercesc_3_1::MemoryManager*) (in /opt/xdaq/lib/libxerces-c-3.1.so)
==18102==   by 0x62143DD: soap::SOAPMessage::SOAPMessage(soap::MessageFactory*) (in /opt/xdaq/lib/libsoap.so)
==18102==   by 0x623102E: soap::ver1_1::SOAPMessageImpl::SOAPMessageImpl(soap::MessageFactory*) (in /opt/xdaq/lib/libsoap.so)
==18102==   by 0x6231B31: soap::ver1_1::MessageFactoryImpl::createMessage() (in /opt/xdaq/lib/libsoap.so)
==18102==   by 0x622BD62: soap::createMessage() (in /opt/xdaq/lib/libsoap.so)
==18102==   by 0x2342A49A: hcal::super::StateVector::addApplication(xdaq::ApplicationDescriptor*) (in /home/daqowner/daq.12.0.1
/lib/libhcalSuperv.so)
==18102==   by 0x23436B57: hcalSupervisor::setup() (in /home/daqowner/daq.12.0.1/lib/libhcalSuperv.so)
==18102==   by 0x2343DAFF: hcalSupervisor::hcalSupervisor(xdaq::ApplicationStub*) (in /home/daqowner/daq.12.0.1/lib/libhcalSuperv.so)
```

Analyzing the HCOS Memory Usage

Record	Type	Bytes	Lowest level hcoss	Highest Level			
29859	PL	229376	hcal::super::StateVector::addApplication	hcalSupervisor::setup() (in /home/daqowner/daq.12.0.1/	0	Initialize	DL = Definitely Lost
29807	PL	28896	hcal::super::StateVector::addApplication	hcalSupervisor::hcalSupervisor(xdaq::ApplicationStub*)	0	Configure	IL = Indirectly Lost
29783	PL	16384	hcal::super::TriggerInterface::buildMessage	hcal::super::TriggerInterface::handleTrigger(xdaq::Appli	0	Start	PL = Possibly Lost
29779	PL	14336	hcal::super::StateVector::addApplication	executive::Application::Configure(xercesc_3_1::DOMNo	0	Stop	
29770	PL	12208	hcal::super::StateVector::addApplication	executive::Application::Configure(xercesc_3_1::DOMNo	0		
29723	PL	7168	hcal::super::StateVector::addApplication	hcalSupervisor::hcalSupervisor(xdaq::ApplicationStub*)	0		
29696	PL	4816	hcal::super::StateVector::addApplication	hcalSupervisor::instantiate(xdaq::ApplicationStub*) (in /h	0		
29687	PL	4096	ConfigurationDatabaseStandardXMLParser::parseMultiple	hcal::ConfigurationDatabase::getTTCrxPhase(std::string	1		
29663	DL	3584	hcalCrate::init	clone (in /lib64/libc-2.12.so)	1		
29502	PL	2064	hcal::super::TriggerInterface::buildMessage	hcalSupervisor::setup() (in /home/daqowner/daq.12.0.1/	0		
29499	PL	2048	ConfigurationDatabaseStandardXMLParser::parseMultiple	hcalHTRManager::init() (hcalHTRManager.cc:516)	1		
29498	PL	2048	ConfigurationDatabaseStandardXMLParser::parseMultiple	hcalHTRManager::init() (hcalHTRManager.cc:516)	1		
29497	PL	2048	ConfigurationDatabaseStandardXMLParser::parseMultiple	hcalHTRManager::init() (hcalHTRManager.cc:516)	1		
29496	PL	2048	ConfigurationDatabaseStandardXMLParser::parseMultiple	hcalHTRManager::init() (hcalHTRManager.cc:516)	1		
29495	PL	2048	ConfigurationDatabaseStandardXMLParser::parseMultiple	hcalHTRManager::init() (hcalHTRManager.cc:516)	1		
29494	PL	2048	ConfigurationDatabaseStandardXMLParser::parseMultiple	hcal::Application::steerInit(toolbox::task::WorkLoop*) (in	1		
29493	PL	2048	ConfigurationDatabaseStandardXMLParser::parseMultiple	hcalHTRManager::init() (hcalHTRManager.cc:516)	1		
29492	PL	2048	ConfigurationDatabaseStandardXMLParser::parseMultiple	hcalHTRManager::handleTTCrxPhase(hcal::Configurati	1		
29491	PL	2048	ConfigurationDatabaseStandardXMLParser::parseMultiple	hcalHTRManager::handleTTCrxPhase(hcal::Configurati	1		
29490	PL	2048	ConfigurationDatabaseStandardXMLParser::parseMultiple	hcalHTRManager::handleTTCrxPhase(hcal::Configurati	1		
29489	PL	2048	ConfigurationDatabaseStandardXMLParser::parseMultiple	hcalHTRManager::handleTTCrxPhase(hcal::Configurati	1		
29488	PL	2048	ConfigurationDatabaseStandardXMLParser::parseMultiple	hcalHTRManager::handleTTCrxPhase(hcal::Configurati	1		
29487	PL	2048	ConfigurationDatabaseStandardXMLParser::parseMultiple	hcalHTRManager::handleTTCrxPhase(hcal::Configurati	1		
29486	PL	2048	ConfigurationDatabaseStandardXMLParser::parseMultiple	hcalHTRManager::handleTTCrxPhase(hcal::Configurati	1		
29485	PL	2048	ConfigurationDatabaseStandardXMLParser::parseMultiple	hcal::Application::steerInit(toolbox::task::WorkLoop*) (in	1		

Analyzing the HCOS Memory Usage

- Look through the HCOS source code to attempt to find the source of the leaks, suggest fixes, etc.
- Found and eliminated some “false” leaks, and identified some potentially more problematic ones.
- Only really got to work on this part for the last week, so still many improvements to be made

Adventures!

