



BACnet etc...

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Outline

- Context (ISAC Controls)
- PLCs
- Linde Cryo-Systems
- Building Controls (Delta Controls)


TRIUMF / ISAC

two loosely coupled machines

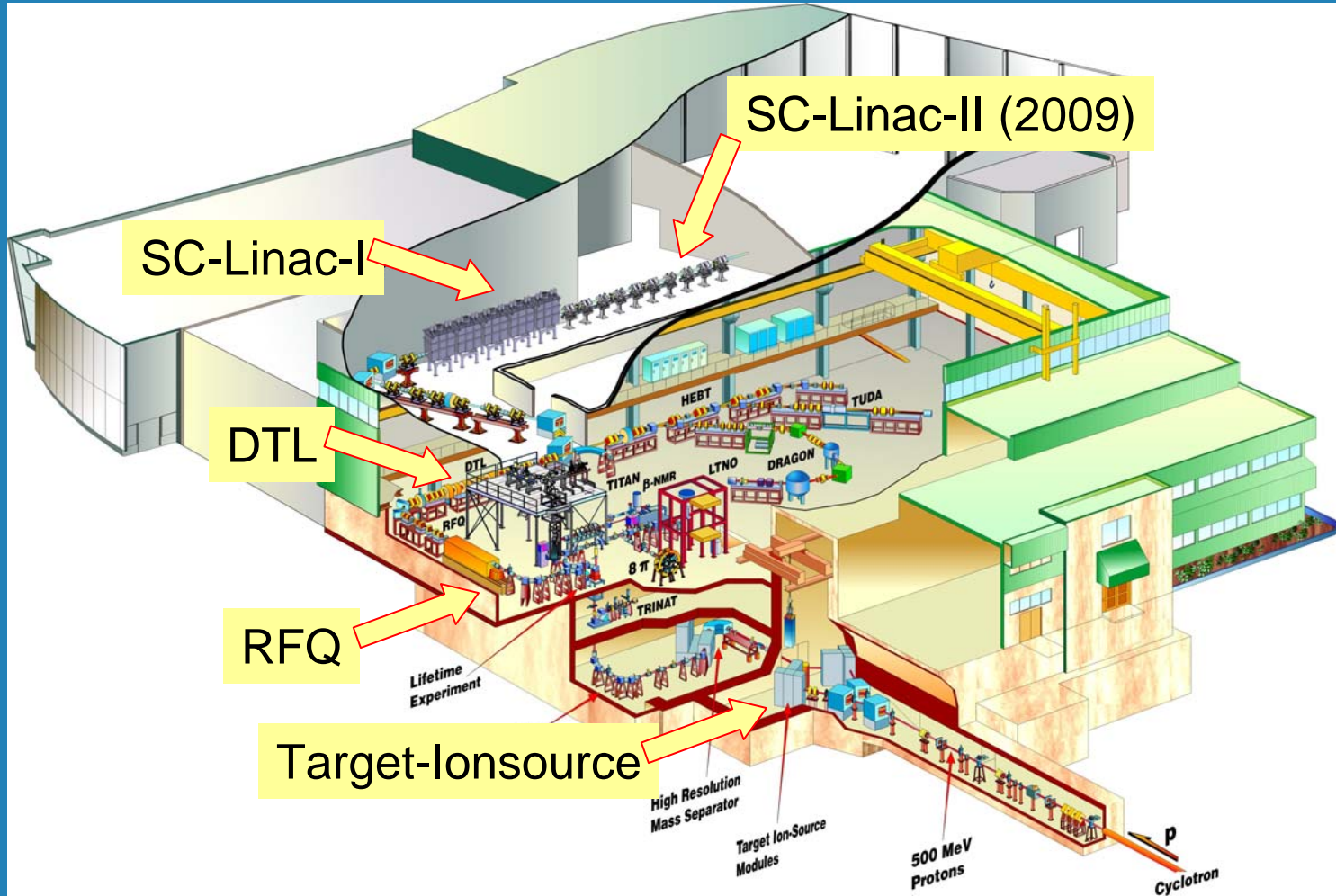
- TRIUMF H⁻ Cyclotron
 - Ø 500 MeV, 300µA protons
 - Ø Home-made controls (CAMAC, OpenVMS)

not my problem



- ISAC Radioactive Beam Facility
 - Ø Uses up to 100µA protons from cyclotron
 - Ø accelerates beams of short lived isotopes (> 100 msec)
 - Ø 4.5 MeV/u (2009: 6.5 MeV/u)
 - Ø  EPICS controls

ISAC Radioactive Beam Facility



ISAC Control System

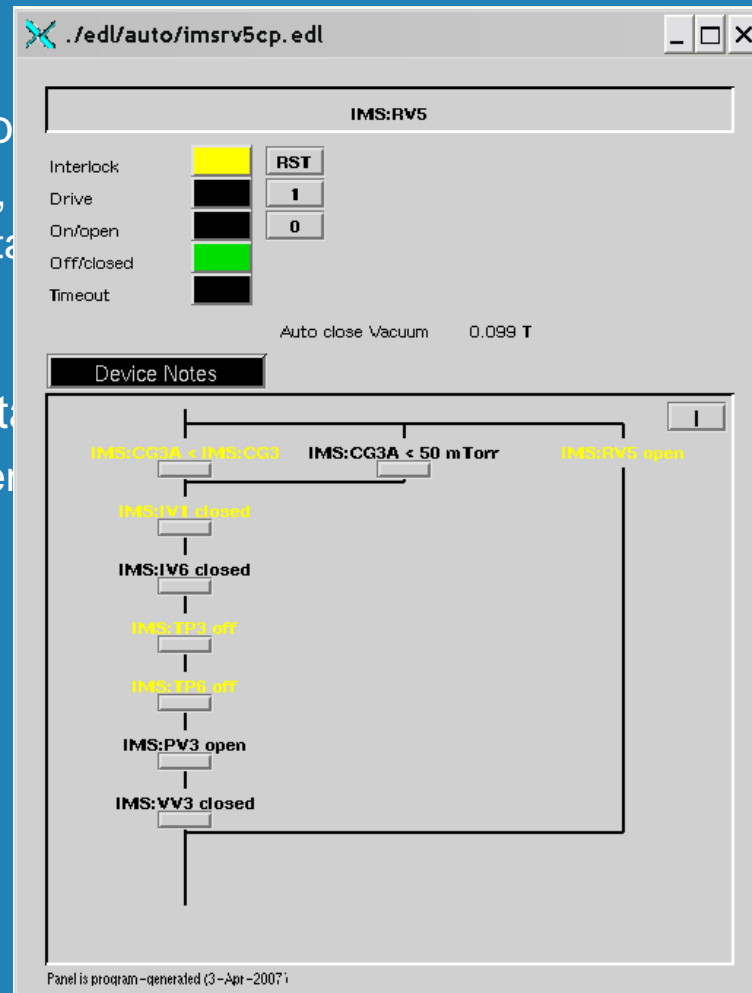
- 3000 Devices
- Beam Optics → CANbus out of VME
- Beam Diagnostics → VME
- Vacuum, Ion sources → PLC
- ~13000 I/O channels
 - Ø 9000 digital
 - Ø 3500 analog
 - Ø 70 motors
- 34 IOCs (Motorola MVME162, PC104, Pentium)
vxWorks(26), Linux(3), WindowsXP(5)
~ 90000 EPICS records
- 14 PLC systems (Modicon (13), Siemens(1), supervised by EPICS)
- 9 RF control systems (Windows98/XP - supervised by EPICS)
- Building control system (BACnet - monitored by EPICS)

PLCs

- Extensive use of Modicon PLCs (Group Schneider)
 - Ø Vacuum Systems
 - Ø Ion Sources
 - Ø RF Amplifiers
- Quantum Series
- Momentum Series
 - Ø Momentum I/O
 - Ø Advantys I/O
- Integration with EPICS:
Modbus/TCP → modtcp device support
 - Ø 10 years old → modbusTCP (Mark Rivers, Chicago)

ISAC PLC Tools

- Generate Edm device control panel
 - ∅ Guarantee that operator sees, in the PLC and their current state
- Verify PLC interlock implementation
 - ∅ Guarantee that interlock implementation



Linde Cryo-Systems

- ISAC-II LINDE He Liquefier System
 - Ø Cools 20 superconducting cavities and 5 superconducting solenoids
 - Ø 2nd system October 2007
- Standard Linde controls: Siemens S7-400 PLC
 - Ø control via touch panel
 - Ø Had tried to get Modicon @#%!
- Integration with EPICS
 - Ø Simatic CPE 443 TCP/IP module
 - Ø Use Siemens fetch/write protocol
 - add fetch/write support to modtcp → plctcp
 - Ø Initially read-only
- Experience with Linde:
 - Ø limited controls knowledge
 - Ø cumbersome to get information

ISAC Building Controls

- Controls:
 - Ø Heating, air conditioning
 - Ø Non-radioactive water systems
 - Ø Air-pressure zoning, nuclear exhaust
 - Ø Oxygen sensors
- Required:
 - Ø integration with EPICS control system
 - Ø Monitoring and alarms on operator consoles
 - Ø read-only
- Communication difficulties
 - Ø within TRIUMF
 - Ø with Consulting Architects
 - Ø with Controls Providers (Delta Controls)

Delta Controls - BACnet

- We asked for open TCP/IP standard
- We got BACnet-ethernet
- System as delivered
 - Ø Separate ethernet
 - Ø OrcaView console
 - ô Windows
 - ô No integration
 - ô No archiving
 - ô Unstable

BACnet

- **B**uilding **A**utomation **C**ontrols **net**work
- ANSI/ASHREA Standard 135-2001
- Open standard network protocol for interconnection of building control components
- Includes the use of ethernet for physical and datalink layer
- Structured as hierarchy of devices, objects, properties
- 550 pages

BACnet vs EPICS

- Many BACnet Objects have corresponding EPICS records
BACNET Object properties <<>> EPICS record fields

<i>BACnet Object Type</i>	<i>EPICS Record Type</i>
Analog Input	ai
Analog Output	ao
Analog Value	ai / ao
Binary Input	bi
Binary Output	bo
Binary Value	bi / bo
Multi-state Input	mbbi
Multi-state Output	mbbo

BACNET – Integration with EPICS

- Disclaimer / Credits:

- Ø All work was done by Rod Nussbaumer (bomr@triumf.ca)

BACNET Support for EPICS, R.Nussbaumer, G.Waters, ICALEPCS05, Geneva

- Ø My contribution



ISAC EPICS – BACnet Gateway

- Open source bacnet4linux drivers (Linux)
(<http://sourceforge.net/projects/bacnet4linux>)
 - Ø discovery of BACnet Objects (broadcast)
 - Ø subscribe to real-time data
 - Ø HTTP Server
 - Ø debugging console on Linux
- We added
 - Ø bug-fixes (fed back to sourceforge)
 - Ø functionality to web-interface
 - ô Display object properties
 - Ø debugging functionality

BACnet stack HTTP server

BACnet

Thu Apr 19 10:10:53 2007

Device Address	Device Name
100	ISAC2 PENTHOUSE
101	V1-01 RM121
102	V1-02 RM131
103	V1-03 RM132
104	V1-04 RM133
105	V1-05 RM134
106	V1-06 RM135
107	V1-07 RM136
108	V1-08 RM137
109	V1-09 RM138
110	V1-10 RM139
111	V1-11 RM140
112	V1-12 RM158
113	V1-13 RM157

Device	Vendor	SNET	SADR	IP
101 - V1-01 RM121	0	20001	01:00:00:00:00:00	

Monitoring 4 / 1 objects in Device 101.

Object Type	Instance	Value	Object Name
Analog Input Objects (Type 0)			
Analog Input	1	22.9 degrees-celsius	V1-01_Room Temperature
Analog Input	2	21.9 degrees-celsius	V1-01_RoomSetpointinput
Analog Input	4	98.6 percent	V1-01_Damper Feedback
Analog Input	5	299 liters-per-second	V1-01_Airflow

Server Status

Device List



ISAC EPICS – BACnet Gateway

- **Discovery**

- Ø BACnet stack in discovery mode
- Ø Export of discovered Object hierarchy >> XML
6000 BACnet objects

- **Object Tree Pruning Tool**

- Ø Reduce to operator interest (400 objects)
- Ø Generate pruned XML file
- Ø Generate EPICS database
- Ø Generate Operator Display Panels for Edm (use EdlBuild Perl library)

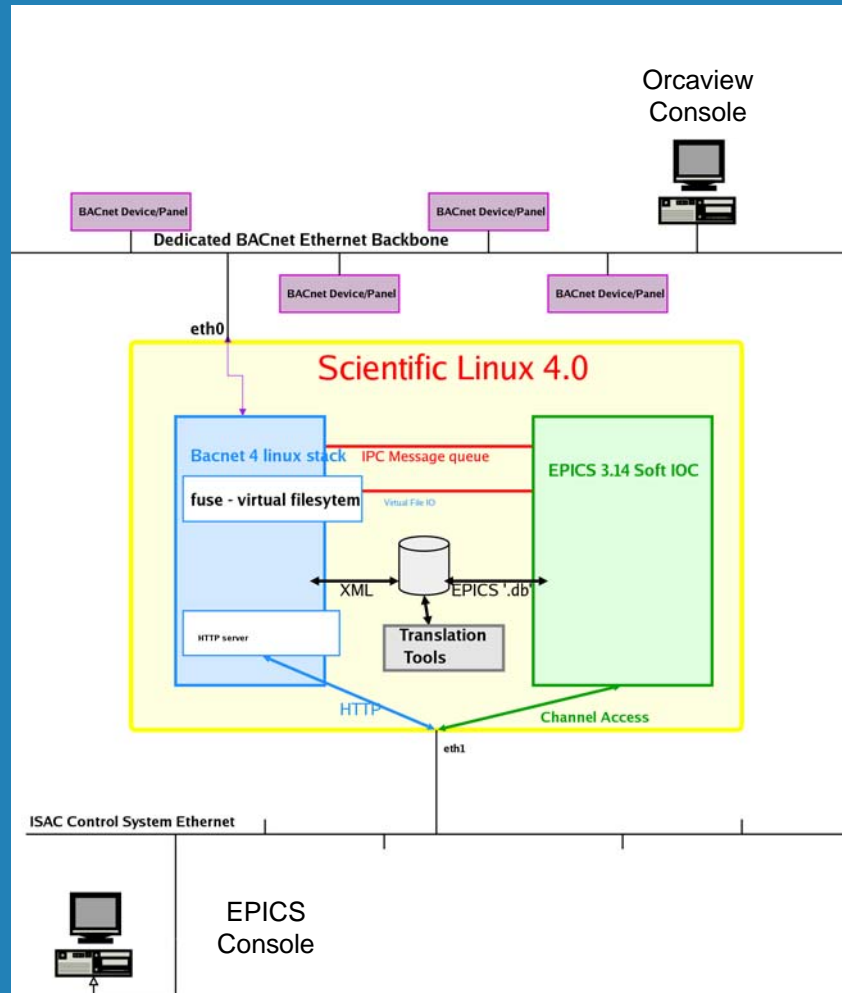
- **BACnet IOC**

- Ø BACnet stack in import mode
 - Import pruned XML
 - reduce startup from 40 min to < 5 seconds
- Ø Linux based soft IOC
- Ø Record Init: use open source fuse (file system in user space)
- Ø PV Monitors: BACnet stack → *IPC Message Queue* → device support

ISAC EPICS – BACnet Gateway

- **Alarms**
 - Ø manually configured in the EPICS database
 - Ø No 1-1 correspondence to BACnet alarm objects
- **Synoptic displays**
 - Ø delegated to operations group

ISAC EPICS – BACnet Gateway



Operator display panels

./ed/ibcs_menu.edl

Device 100-120 Device 121-199 Device 200-299 Device 300-399

IBCS Diag.

/usr1/isac2/edl/ibcs... /usr1/isac2/edl/ibcs_dev301.edl

V1-01 RM121

[IBCS:101:AI:1] V1-01_Room Temperature 24.734 deq-C	[IBCS:101:AI:2] V1-01_RoomSetpointinput 21.925 deq-C	[IBCS:101:AI:4] V1-01_Damper Feedback 98.604 %	[IBCS:101:AI:5] V1-01_Airflow 295.526 liters/
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V1-06 RM135

[IBCS:106:AI:1] V1-06_Room Temperature 23.998 deq-C	[IBCS:106:AI:2] V1-06_RoomSetpointinput 22.174 deq-C	[IBCS:106:AI:4] V1-06_Damper Feedback 98.486 %	[IBCS:106:AI:5] V1-06_Airflow 74.373 liters/
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CHILLER/CT1

[IBCS:301:AI:4] ISAC1_CHIL1_COND_P20A 2.958 amperes	[IBCS:301:BI:9] ISAC1_CHIL1_CHW_FLOW ON
[IBCS:301:AI:6] ISAC1_CHIL1_CHW_P21A 9.032 amperes	[IBCS:301:BI:10] ISAC1_CT1B_AL OFF
[IBCS:301:AI:7] ISAC1_CHIL1_CHW_P22A 9.187 amperes	[IBCS:301:BI:11] ISAC1_CHIL1_EVAP_FLOW ON
[IBCS:301:AI:8] ISAC1_CHIL1_CHWST 7.918 deq-C	[IBCS:301:BO:5] ISAC1_CHIL1_ENABLE ON
[IBCS:301:AI:12] ISAC1_CT_P1A 9.737 amperes	[IBCS:301:BO:6] ISAC1_CHIL1_CHW_P21C ON
[IBCS:301:AI:13] ISAC1_CT_P2A 0.163 amperes	[IBCS:301:BO:7] ISAC1_CHIL1_CHW_P22C ON
[IBCS:301:AI:14] ISAC1_CT_RAW_CWST 22.176 deq-C	[IBCS:301:BO:11] ISAC1_CT_P1C ON
[IBCS:301:AO:8] ISAC1_CHIL1_RESET 0.000 %	[IBCS:301:BO:12] ISAC1_CHIL1_COND_P20C ON
[IBCS:301:AO:14] ISAC1_CT1A_SPD_C 46.852 %	[IBCS:301:BO:13] ISAC1_CT_P2C OFF



BACnet Summary

- Status
 - ∅ Have a working monitoring system
 - ∅ Reliable integration
 - ∅ Took much longer than expected
 - ∅ Some intra-TRIUMF communication problems remain
- Future
 - ∅ Bacnet4linux stack is “dead”
 - ∅ If we had time
 - ô discover alarms
 - ô new sourceforge library
 - ô ASN.1 compilers
 - ô (*Abstract Syntax Notation*)
 - ∅ We may never upgrade to write operations