BACnet etc…

R. Keitel
Epics Collaboration Meeting, Hamburg
25-Apr-2007

Outline

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

TRIUMF ISAC

TRIUMF / ISAC
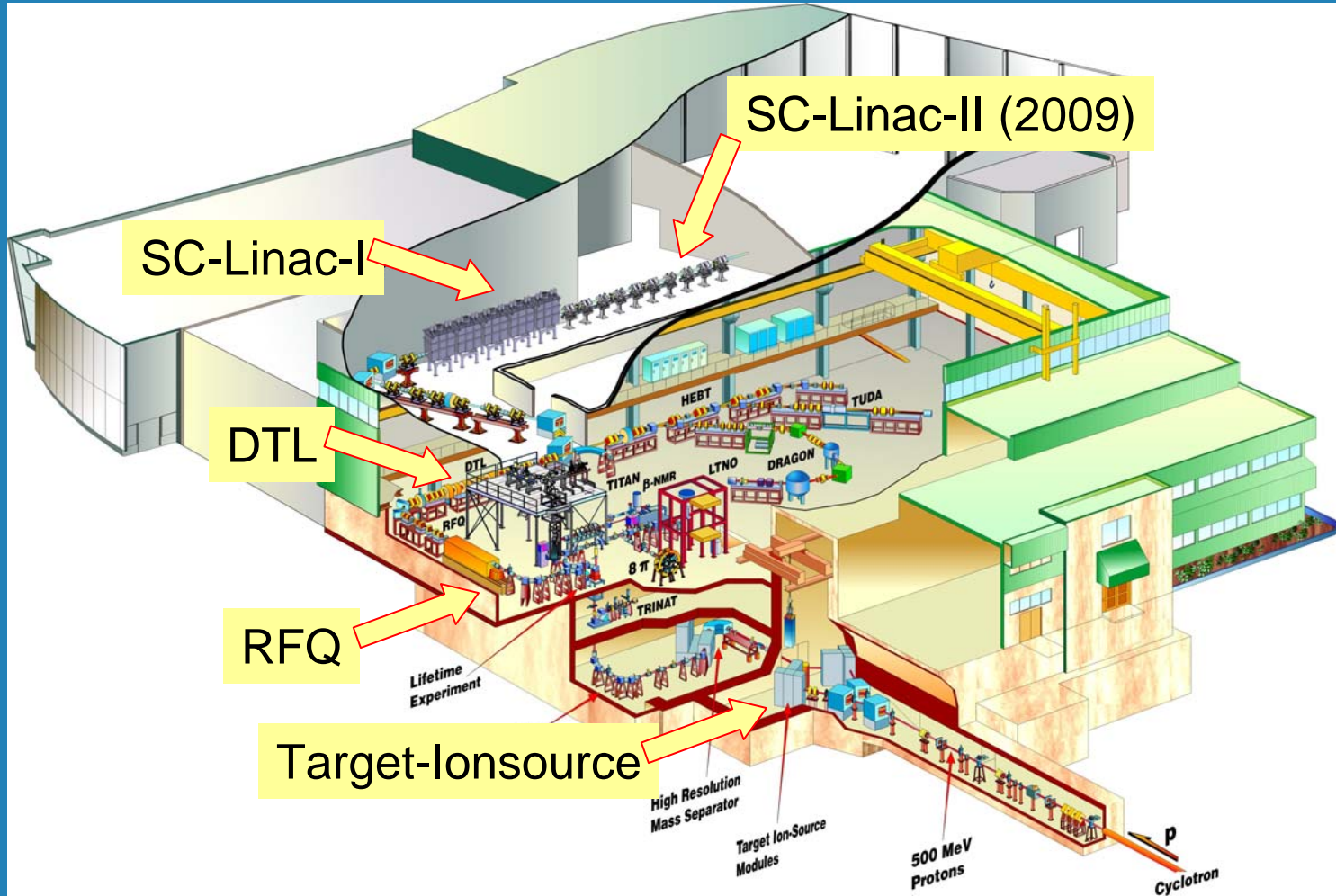## two loosely coupled machines

- 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

TRIUMF **ISAC**

ISAC Radioactive Beam Facility
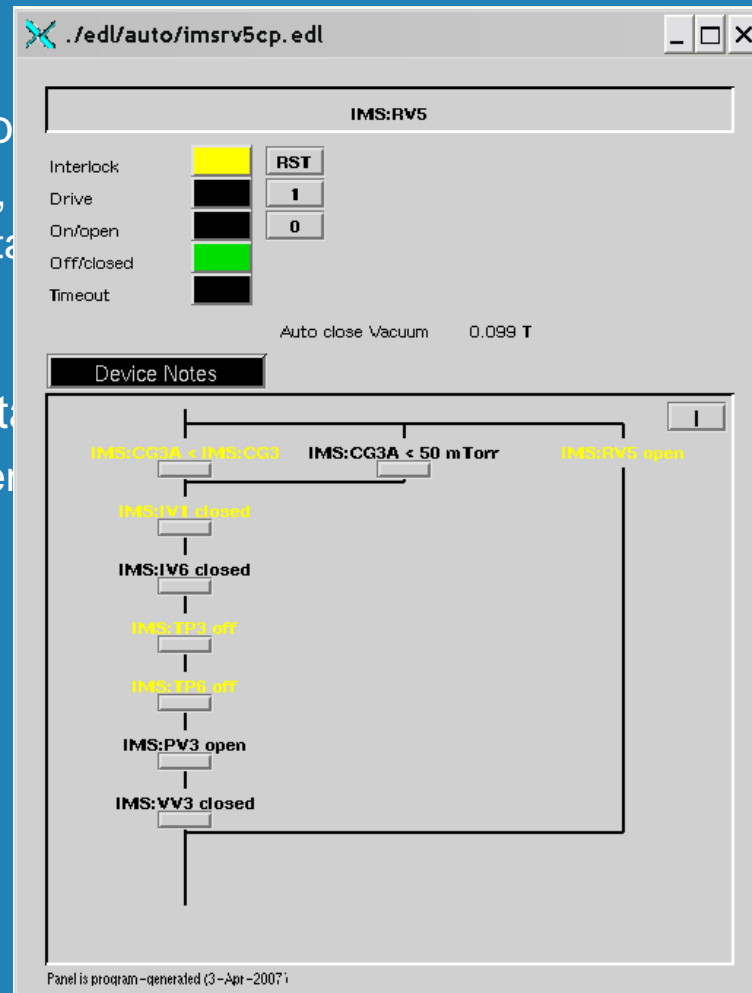
ISAC Control System

- 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)

TRIUMF
ISAC

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)

TRIUMF ISAC

ISAC PLC Tools

- Generate Edm device control p
    - Ø Guarantee that operator sees, in the PLC and their current sta

- Verify PLC interlock implement
    - Ø Guarantee that interlock imple

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

TRIUMF ISAC

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)

TRIUMF

ISAC

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

TRIUMF
ISAC

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

TRIUMF ISAC

BACnet vs EPICS

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

BACnet Object Type	EPICS Record Type
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

TRIUMF ISAC

BACnet stack HTTP server

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
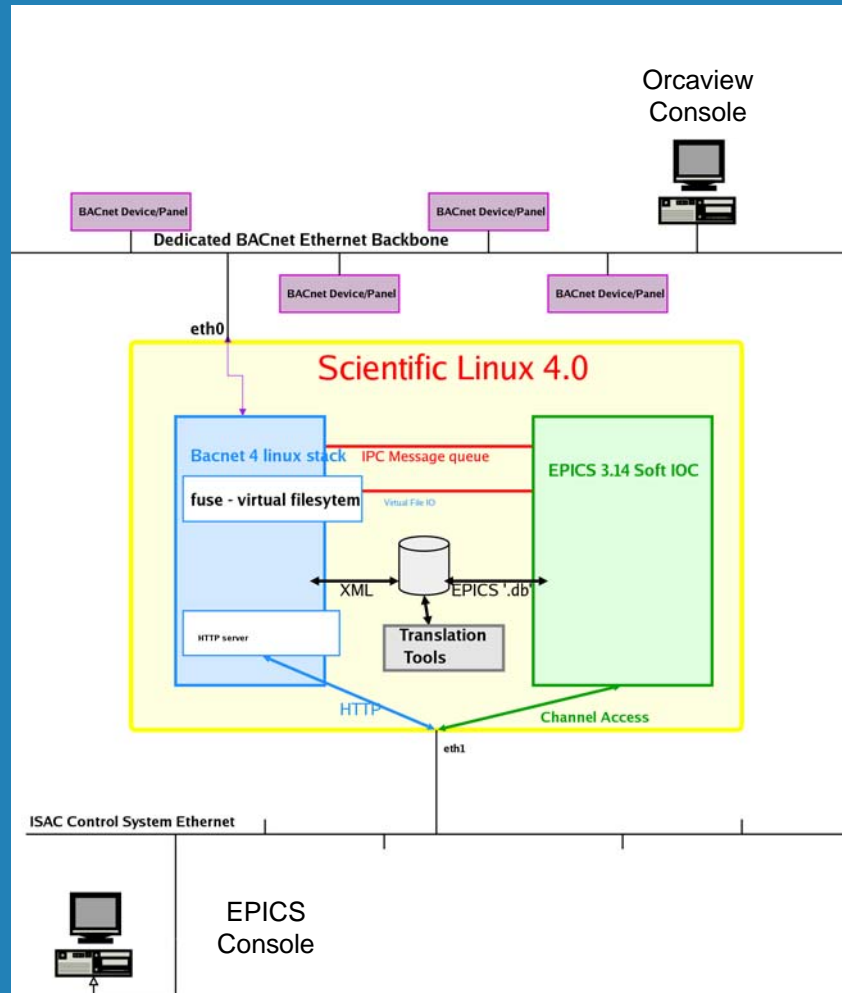 - Ø Generate Operator Display Panels for Edm (use EdlBuild Perl library)

- **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

TRIUMF ISAC

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

TRIUMF
ISAC

ISAC EPICS – BACnet Gateway

Operator display panels

BACnet Summary

- Status
  - Ø Have a working monitoring system
  - Ø Reliable integration
  - Ø Took much longer than expected
  - Ø Some intra-TRIUMF communication problems remain

- Future
  - Ø Bacnet4linux stack is "dead"
  - Ø If we had time
    - ô discover alarms
    - ô new sourceforge library
    - ô ASN.1 compilers
    - ô *(Abstract Syntax Notation)*
  - Ø We may never upgrade to write operations

TRIUMF **ISAC**