Running the PEP-II LLRF Hardware for the last Decade

Experiences and Lessons Learned

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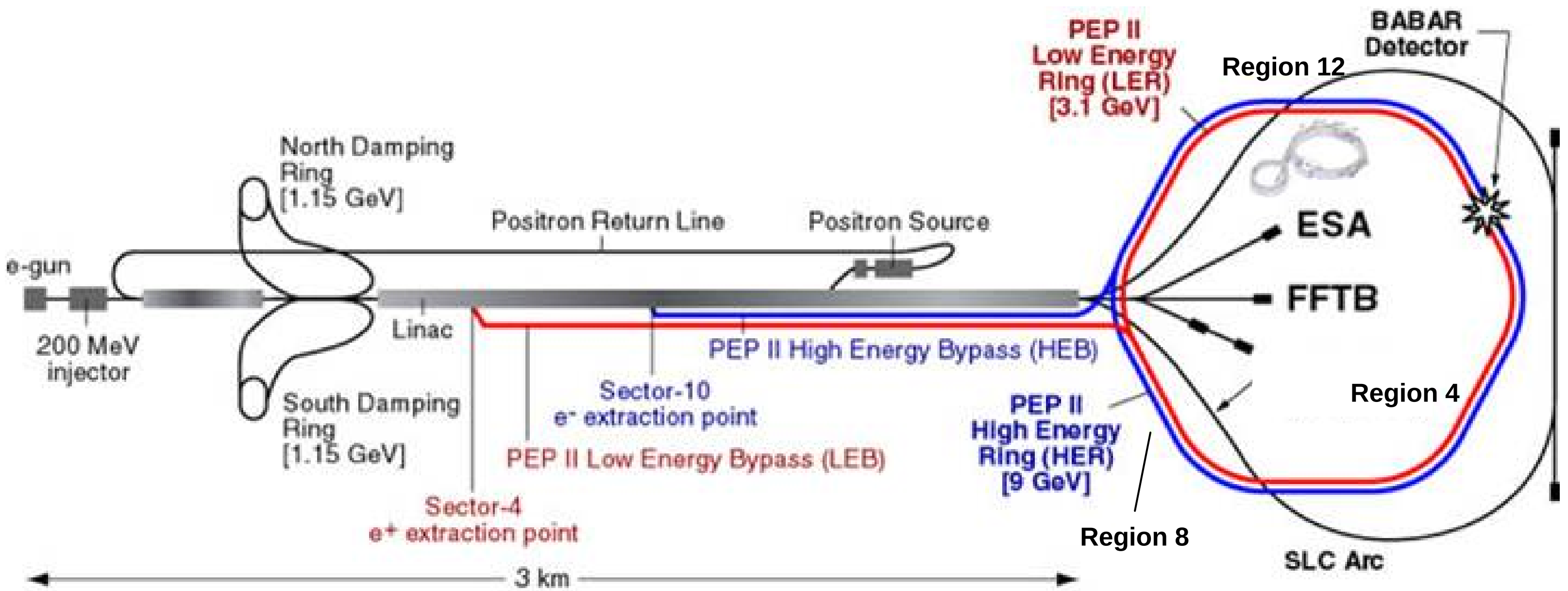
Introduction

→ This talk focuses on some of the experiences we have had in running the PEP-II LLRF System, specifically in operating, maintaining and upgrading the LLRF VXI Hardware and how we solved them.

- PEP-II was commissioned in 1997 (which means that the HW was designed in '93 – '96)
  - Did not have a spares budget for more modules or components
- Over the last decade we have:
  - Had component failures
  - Faced component obsolescence issues
  - Had several upgrade challenges (some pathological cases)
  - Discovered that even COTS (Commercial Off The Shelf –or- Crummy Old Technology that Stinks) HW was not a simple matter of plug & play

Some examples follow….

The SLAC Accelerator Complex



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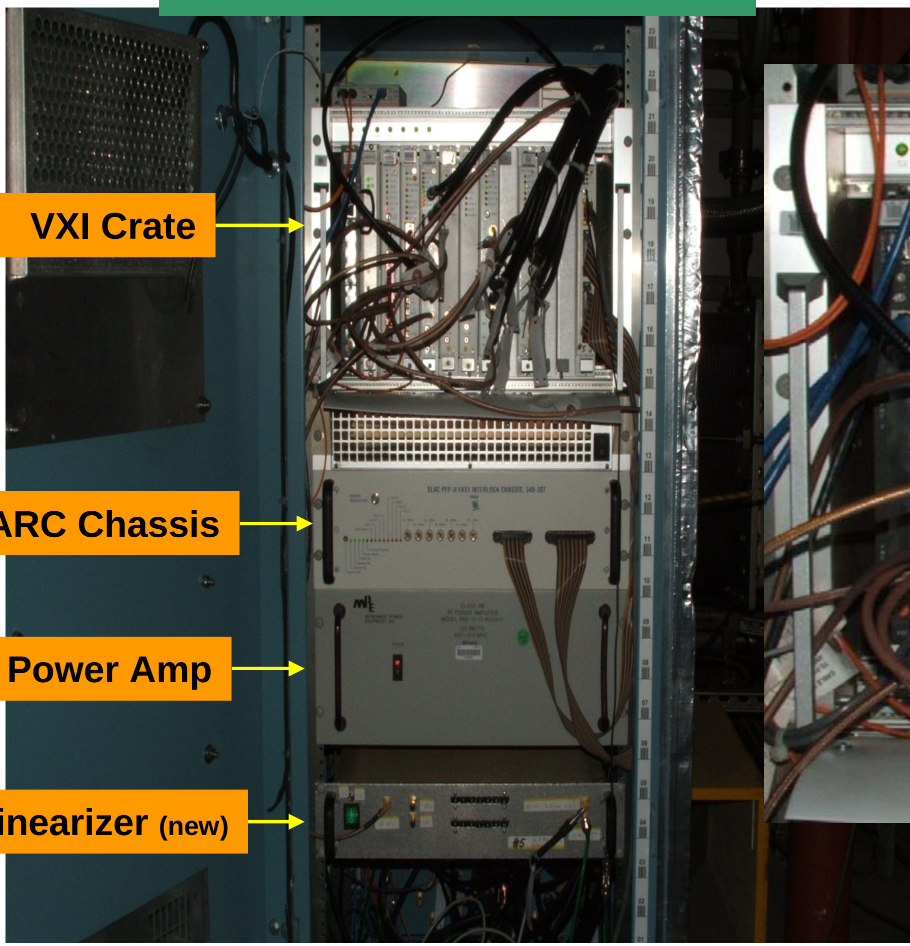
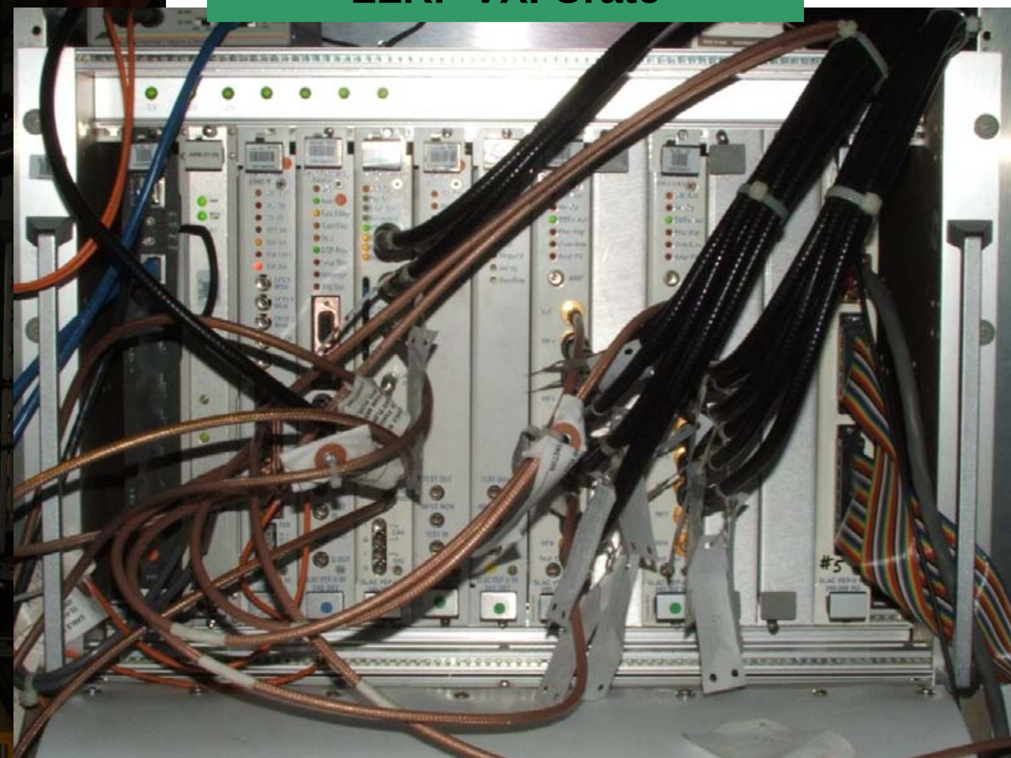
PEP-II Low Level RF System

LLRF Hardware

LLRF Electronics Rack



LLRF VXI Crate



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Component Failures

VXI LLRF Clock Module: *RF Amplifier Deaths*

- Found that after nearly 7 years of continuous operation, the Mini-Circuits MAR-6 RF Amplifiers in the clock started dying: would lose RF power. Started with one module, then others followed
- Design used them in normal operating region (Manufacturer's MTBF: 2200 years w/ case @ 85deg C) / Operating in clock's heater enclosure @ 50 deg C

Solution:

- Found replacement device: Sirenza Semi SGA-2386 / lifetime: 80K hrs @ 150 deg C
- Upgraded all modules with new amplifiers
- Have been running for 3 yrs w/o failures so far

The Amplifiers

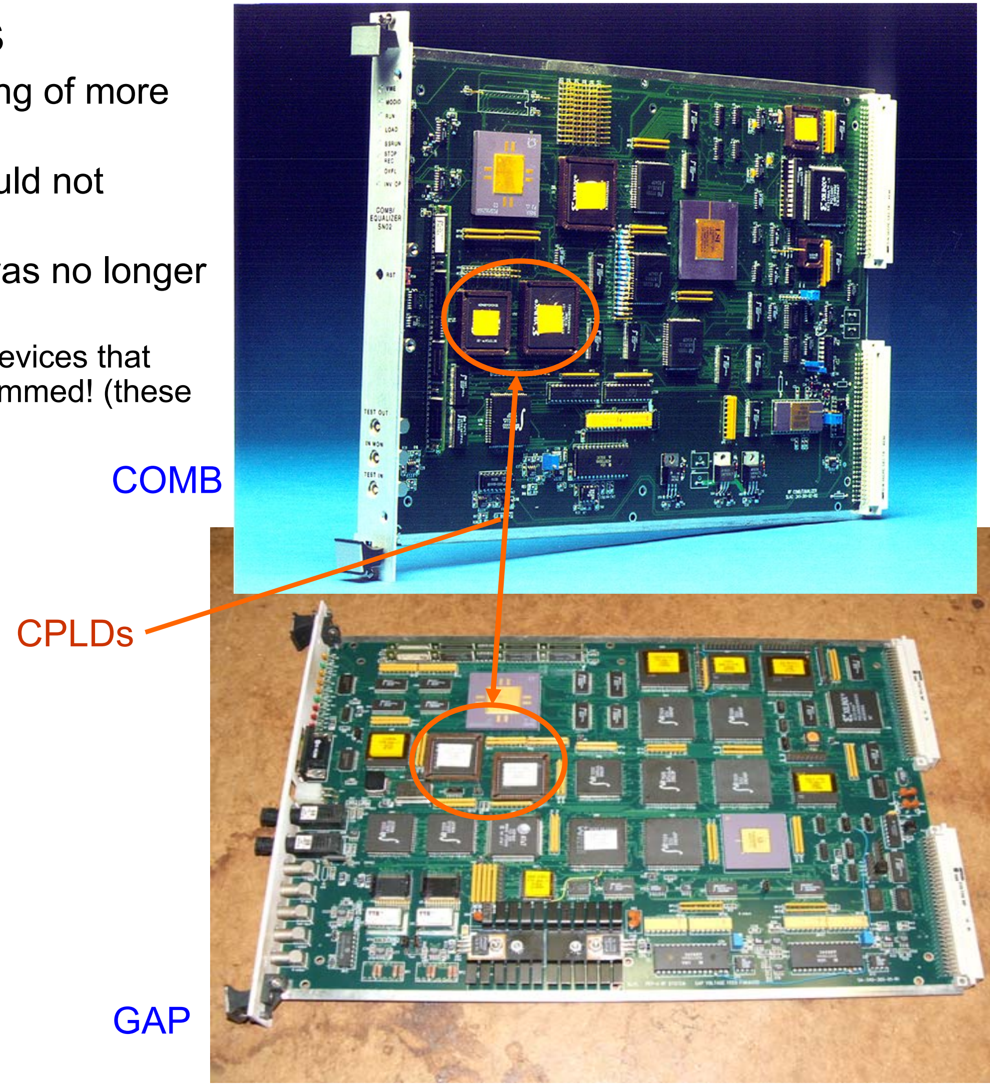
Upgrade Issues / Component Obsolescence

VXI LLRF COMB & GAP Modules

- Wanted to build more for planned adding of more RF Stations to PEP LER & HER
- Time, money and resource limited / could not redesign whole modules at the time
- Discovered the Xilinx XC7372 CPLD was no longer available:
  - Tried the “grey” market: we got “new” devices that turned out to have already been programmed! (these are one-time programmable)

Solution:

- Designed a carrier board that held an Altera 7000S-series CPLD that soldered into the XC7372 footprint
- Issues:
  - Finding & then converting old CPLD designs written in ABEL, PALasm & schematic to VHDL (reverse-engineering, etc.)
  - Altera CPLD was too fast! Had to use lower speed-grade part to meet timing

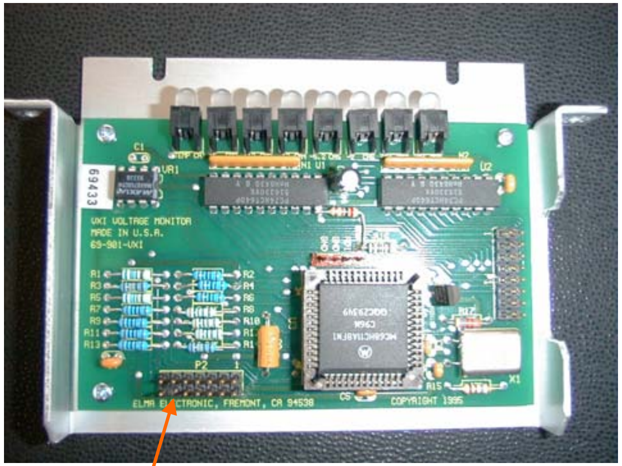


Even COTS HW Has Problems 1

ELMA VXI Crates

Bought new ELMA VXI Crates for additional stations / When all the modules were installed, the Allen-Bradley serial interface controller would not work.

- Problem was traced down to an “improvement” in the crate: mfr added a special monitor board that sensed the voltages and temperature, if there was a problem it would drive some VME signals / Old crates had comparator board that drove LEDs
  - Issue was that they had a long ribbon cable with only one Gnd between the backplane & monitor board / when one of our boards booted, the radiated EMI generated glitches on that cable, and the monitor reacted by driving VME_SYSFAIL* low, which made the Allen-Bradley go offline

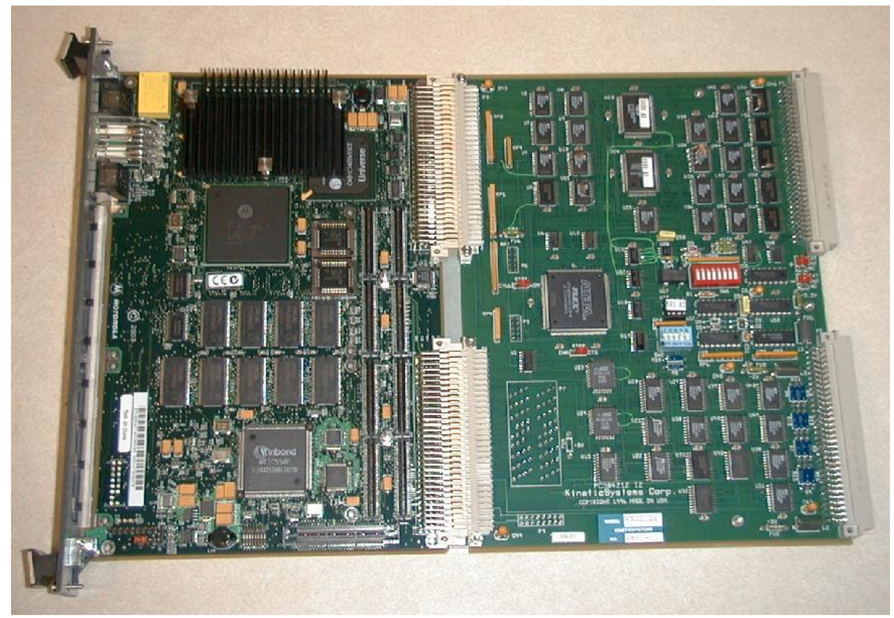


Solution:

Brute force: cut off ACFAIL* pin on the monitor board

Even COTS HW Has Problems 2

- VXI Computer Upgrade
  - Upgraded to the Kinetic Systems V152. This is a 350MHz MPC750 with 256MB of memory. This is a significant increase over the old 40MHz 68040 CPUs
  - Board did not work out-of-box
  - This module required extensive HW & SW design mods to it (done by us) as well as mods to all LLRF boards VXI interface in order to work in our systems. SW drivers had to be re-written
  - Result was CPU loading was reduced from 95% → <10%



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Component Obsolescence

→ What we're up against

Consumer electronics market: (drives component manufacture)

Average lifetimes (debatable) of consumer electronic devices:
(replaced by either upgrades or attrition)

iPOD:	2-3 Years
Cell Phone:	2-4 years
DVD Player:	4-5 years
Personal Computer:	2-4 years
The list goes on….	

(data source CNN.com article)

Will that fantastic FPGA be around in 10 years? Or even 5 years? What can we do about this? Buy enough for the lifetime of the project?

Conclusion

- What we did:
  - Obsolete Components:
    - Market sweep: www.findchips.com / parts brokers (our very resourceful purchasing agent)
    - Lifetime buys – nice idea, but…
    - Grey market: get what you pay for
    - Building our own carrier boards / buy www.arieselec.com where we could
    - Re-design board when possible (money/time/resources permitting)
- Lessons Learned:
  - Even buying the "same" thing doesn't mean it's the same
  - Follow standards
  - Need excellent documentation
  - Need some sane version control
  - Have some level of design standardization both in the HW and the development process
  - Sustaining engineering is a full-time job
  - Stuff happens

I'm sure you've all had similar experiences…

Question

→ Faced with seemingly accelerating component obsolescence trends, and our conflicting need to design machines with multi-decade lifetimes, how do/can we:

- Create future-proof architectures/designs
- Plan for the future
- Decide where to draw the line regarding part selections, etc.

Is every machine's requirements different?

Is this really an issue?

Any ideas?

Discuss…

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