

ILC Electronics Manufacturing Opportunities

Linear Collider Industrial Forum of
America (LFCOA)

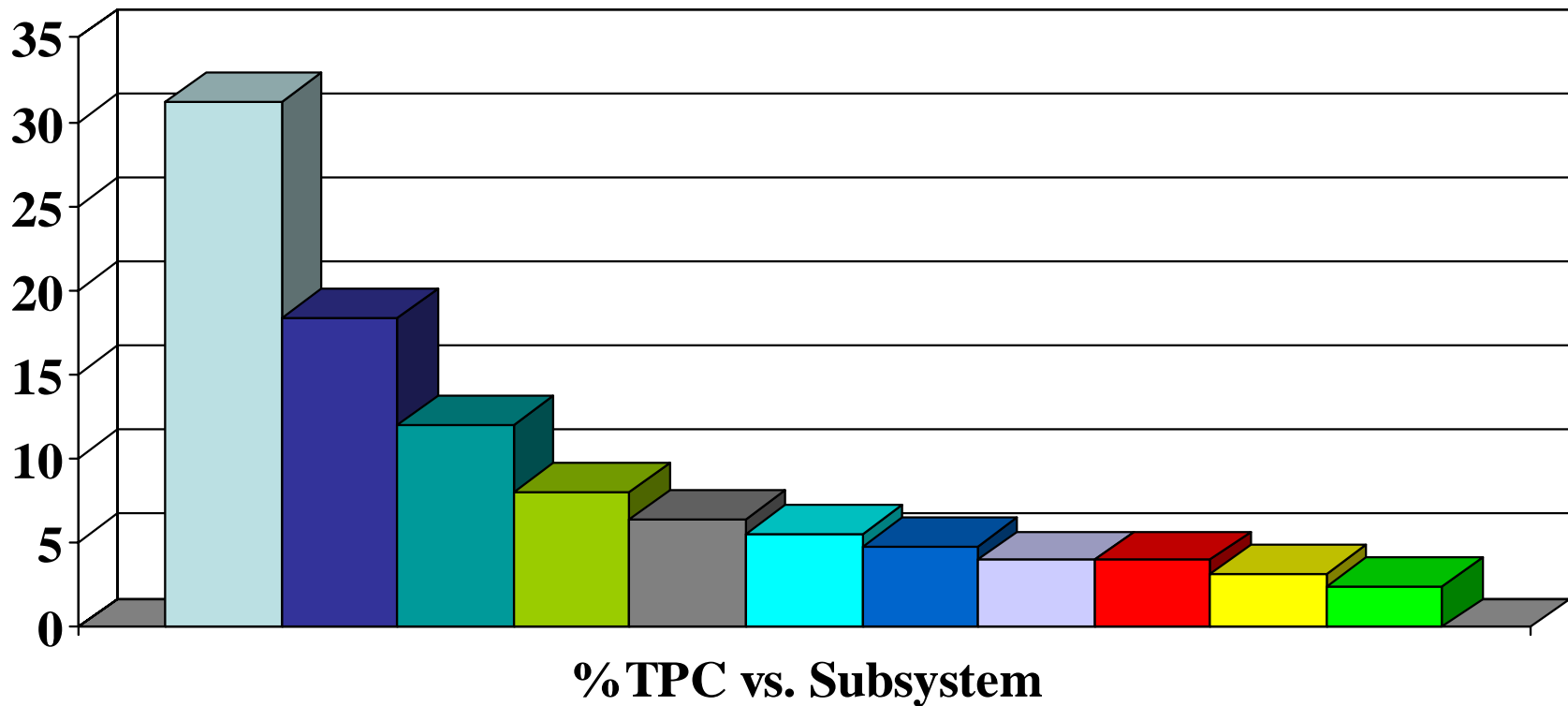
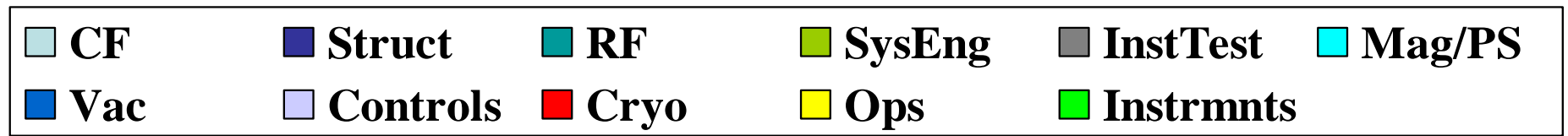
SLAC, May 1-2, 2006

Ray Larsen

Outline

- I. Power Electronics
 - Modulators (Manufacturing Models)
 - Power Supplies
- II. Controls & Instrumentation
- III. Laser Systems

Subsystem Relative Costs (From US Study)



I. Power Electronics

- Modulators
 - Total Qty ~ 700; Est. Cost ~4% TPC
 - Baseline: TESLA/FNAL.
 - Alternates: Marx (in R&D & 3 Phase I SBIRs); SNS-LANL; DTI Direct Switch (prototype due at SLAC early '07)
 - Goal: Evaluate ACD's, down-select by June 2007.
- Power Supplies
 - Total Qty all types ~20,000; Est. Cost ~2% TPC?? (USLCOS est.)
 - Baseline: New modular n/N designs for high availability
- *Note: All electronics designed for high systems availability (up-time)*

Manufacturing Comparison

- TESLA Baseline Design:
 - **Large capacitor banks in cabinets, point-to-point interconnects, separate charging source at 10KV DC, separate redundant discharge switch, separate oil-filled step-up transformer. Total of each unit ~700.**
 - **Preferred:**
 - Contract build-to-spec or build-to-print & deliver 700 fully tested units; schedule to install with minimal further testing; provide testers to mfgs.
 - **Alternate:**
 - Subcontract major subassemblies & factory testing; assemble full units & test on-site. More on-site storage, test facilities required.

- MARX ACD
 - **14 identical modules/unit, 2 power converter modules**
 - **Total boards = 9,800 for 700 units**
 - **60% Parts cost in IGBT switch sub-modules**
 - **Total IGBT sub-modules =10 per module, 98,000 for 700 units**
 - **Mounts in sealed box with air-water heat exchanger**
 - **Preferred:**
 - Contract for fully assembled factory tested units; provide testers to mfgs.
 - **Alternate:**
 - Subcontract all subassemblies to PC board industry; subcontract board testing; final assembly in enclosure & testing on site. More storage; test space on site.



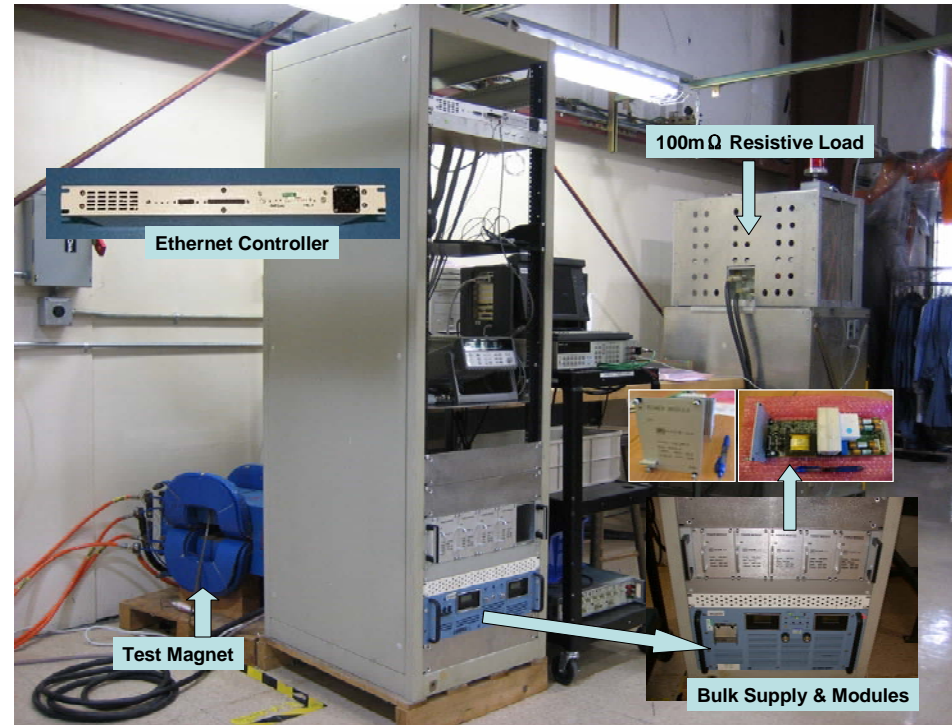
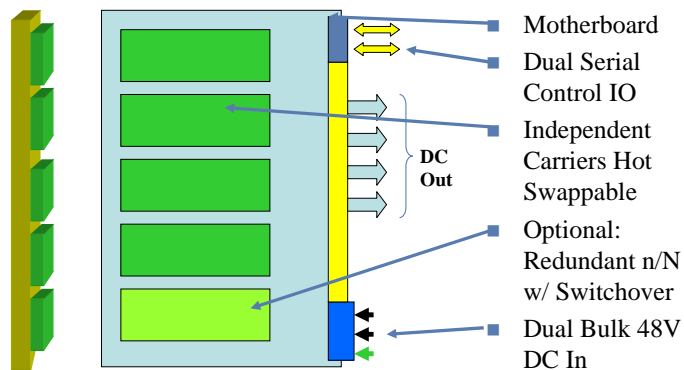
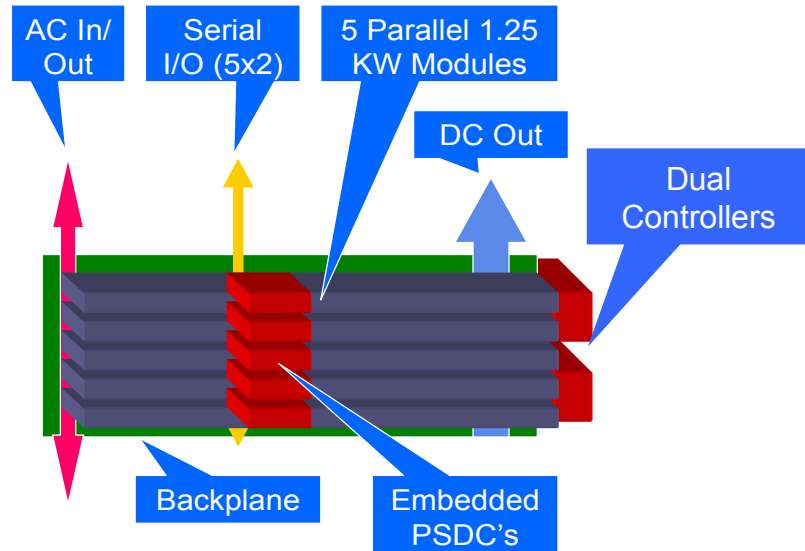
FNAL Modulator at TTF



Power Supplies

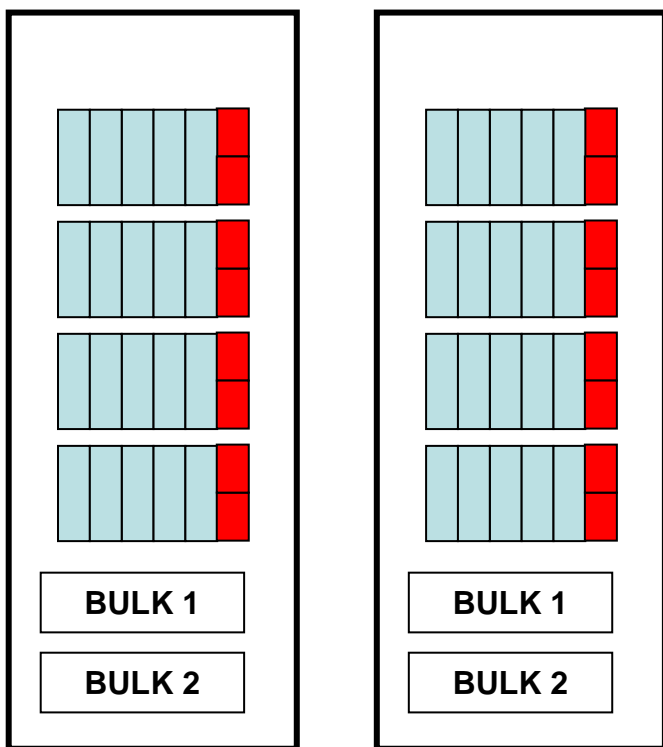
- Total Quantities
 - **LGPS 1/n redundant supplies: ~9000 (>1kW-multi kW)**
 - **Modular n-channel supplies: ~10,000 channels**
 - **Cryogenic modular supplies: ~1600**
- High Availability
 - **1/n Modular Designs where PS module failure will not interrupt machine; ideally hot swap to repair while running.**
- Apply to:
 - **KW to 100KW single load or magnet string supplies**
 - **Multi-channel Corrector supplies**
 - **Cryogenic magnet supplies**
- Prototype Tests
 - **Commercial modules successfully tested in 3/4 and 4/5 designs; hot swap feasible**
 - **Dual controller shown to be needed for 99% full ILC system availability**
- Goals for '07-08
 - **Demonstrate technical feasibility, cost viability full prototype w/ redundant sub-modules, bulk, controllers.**
 - **Demonstrate 40-unit basic system at ATF2.**

HA PS Concepts – Quads, Correctors, LGPS



- Prototype Test Setup 3/4, 4/5 Tests
- Resistive, Magnet Loads
- Single Bulk, Ethernet Controller
- Demonstrated recovery in <200 msec

System Configuration



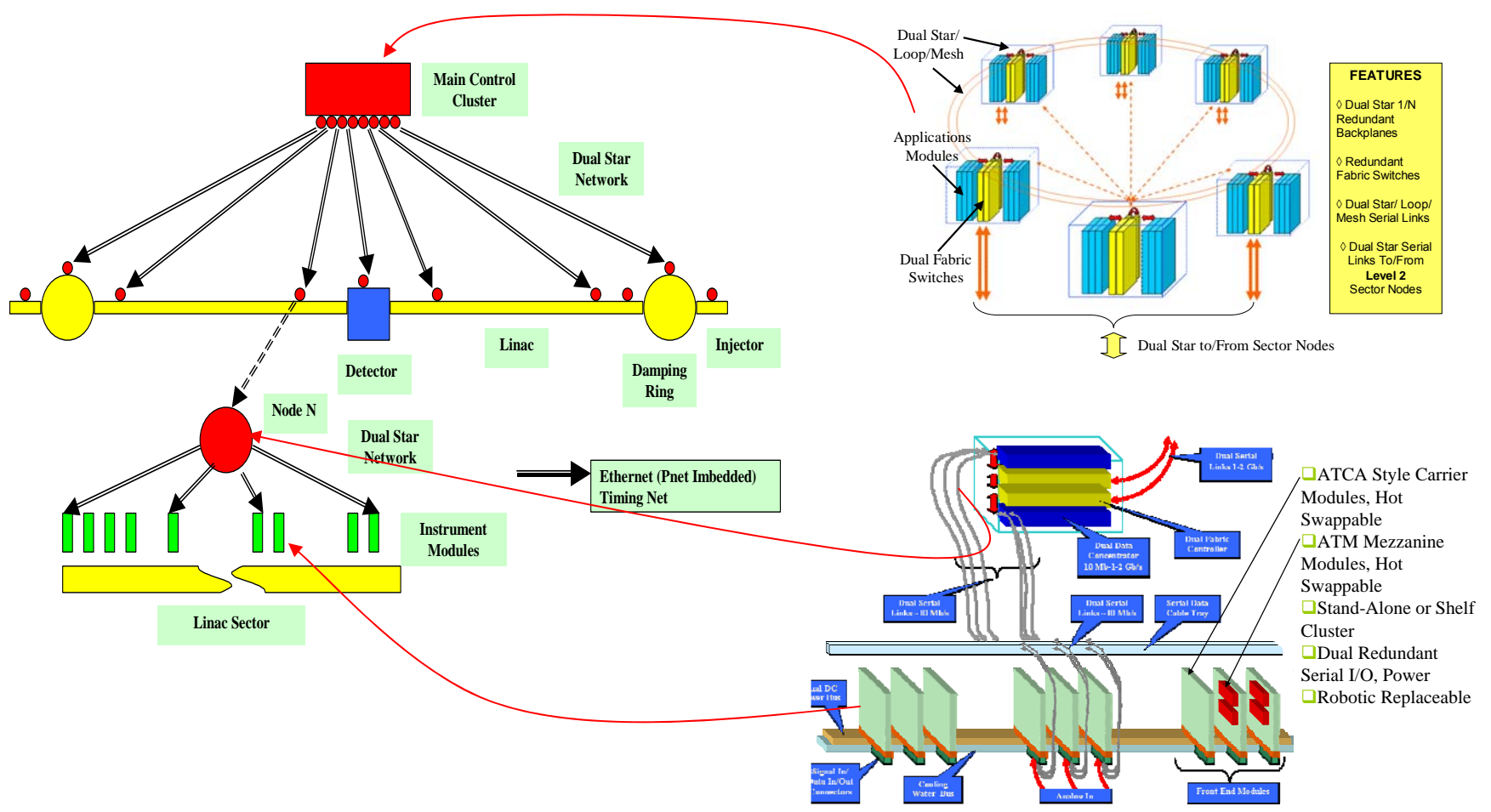
- N/n Modular PS
- Dual Controllers
- Dual Bulks
- Ethernet IO Star
- All Hot swappable

PS Manufacturing

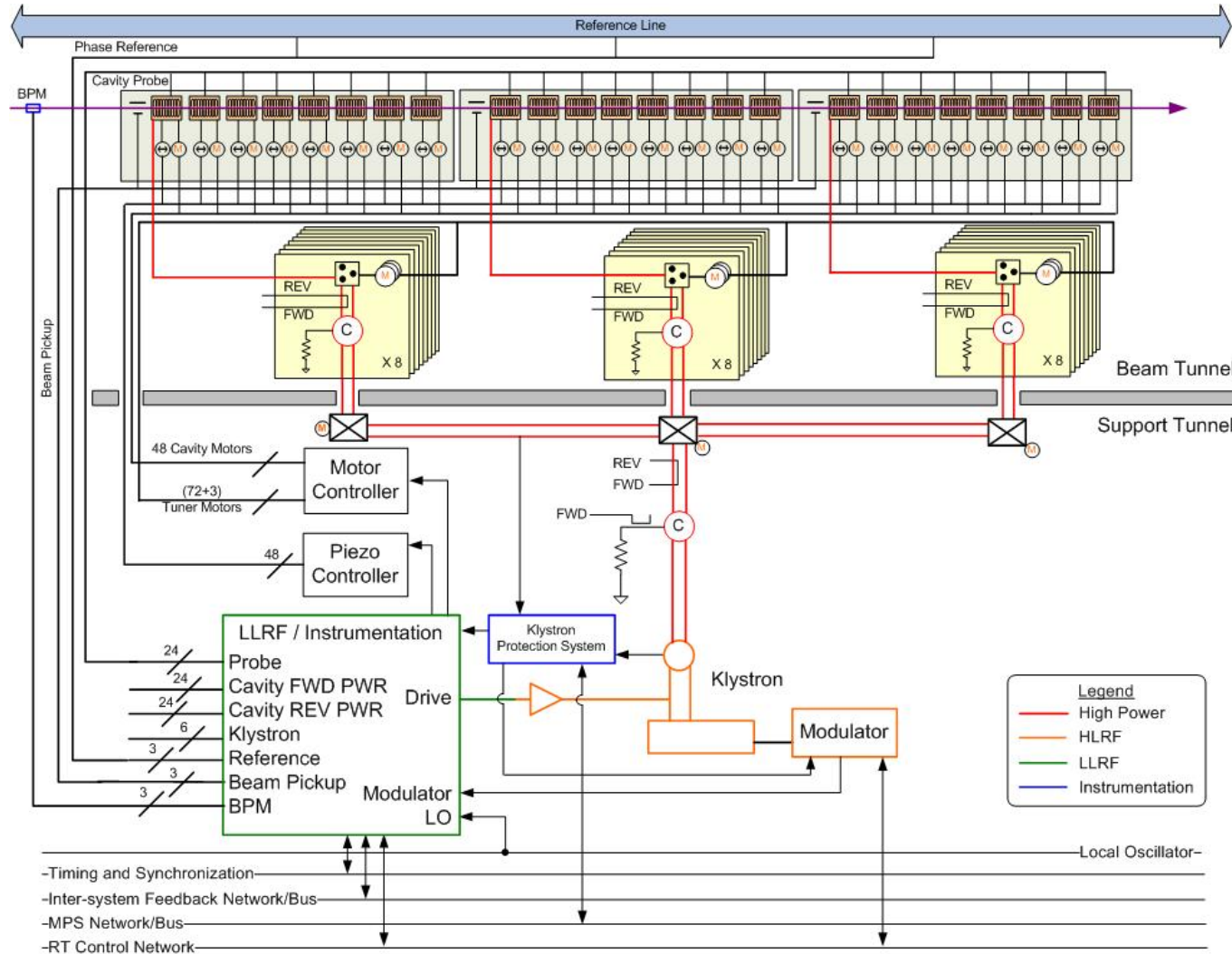
- Assume 1/N modular redundant supplies for any unit that would stop operation
- Main Linac
 - **Cold Quads, Correctors every 36m**
 - **Current sources of ~30-100A @ few volts**
 - **Small low power dissipation units w/ quench protection**
- Injectors, Damping Rings, Beam Delivery
 - **Warm magnets, higher power quads & correctors, many low power units in positron transport line & Beam Delivery areas**
- Total numbers (approx.)

– Modular supplies	9,000
– Dual bulk supplies	2,250
– Dual Controllers	18,000
– Sub-modules	36-45,000 (3 of 4, 4 of 5)
– Diagnostic cards/hybrids	45,000
– Dual Corrector channels	10,000
- Manufacturing
 - **Purchase all supplies, controllers to specification or to print.**
 - **Contract rack systems, acceptance tested at factory**

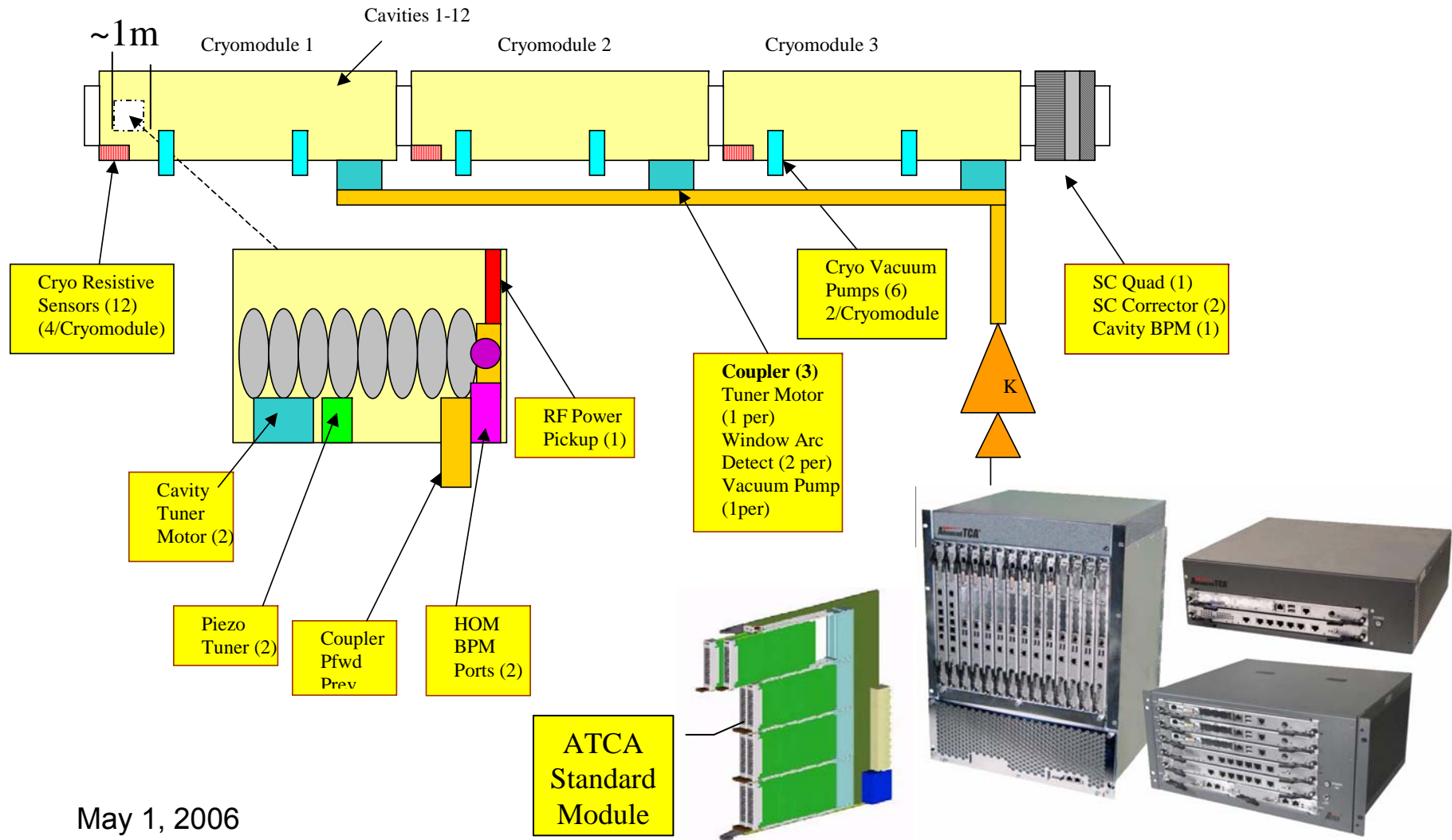
II. Controls & Instruments Architecture



Low Level RF System BD (36m)



ILC Linac Instrumentation (36m)



May 1, 2006

ML Controls & LLRF Parts List

- Main Linac + Injection + RTML (18,000 SRF Cavities)
 - Instrument & Power Support Racks (8/Sta) 4,800
 - Controls Sector Node Crates: 700
 - Central Control & Other Area Crates: 300
 - Beam position XY channels: 700
 - Low Level RF Crates: 1,400
 - LLRF Modules (2 10-brd crates/Kly.) 48,000
 - LLRF Sub-Modules, 4/brd 192,000
 - Vacuum pump drivers: 4,200
 - Cryo magnet channels: 2,100
 - Tuner motors & drivers: 54,000
 - Piezo tuners & drivers: 36,000
 - Networks 1,400
 - Dual Star Gigabit Ethernet 700
 - Dual Star timing & trigger reference 700
 - Etc.
- Manufacturing Model
 - Commercial racks, crates, IOC computers, switches, industrial drivers
 - Instrumentation modules - build to specs/print all high quantities

Controls & Instruments Manufacturing

- Controls & Instruments Est. $4+2.5=6.5\%$ of TPC.
- Controls
 - Propose all controls on HA platform.
 - Commercial open standard ATCA under study as candidate.
 - Modules, hardware, base software – COTS and commercial contracts from standard suppliers.
 - Custom design necessary for some data switching, fast timing modules; commercial manufacture.
 - Total modules est. ~4,000
 - Ethernet & Timing fiber plants substantial cost item.
 - HA software engineering major cost
- Instrumentation
 - New Serial Communications Standard Packaging system required.
 - Use ATCA HA packaging concepts where cost-viable
 - Some custom design necessary
 - Assume no electronics in beam tunnel, prefab cable plant from industry.

III. Laser Systems [A. Brachmann, M. Ross]

- 1. Source Lasers
 - Basic challenge: Amplification of a 3 MHz pulse train to μJ levels.
 - Initial laser system based on Ti:Sapphire (wavelength driven by bandgap of GaAs photocathodes).
 - Future source upgrades will require other amplifier medium (driven by photocathode development, e.g. Laser systems in the 400 nm wavelength range for GaN based photocathode's).
 - Multiple laser systems needed for multiple sources and source/photocathode R&D
- 2. Diagnostics Laser Systems
 - Example laser wires: Similar pulse train structure as source, UV wavelengths desired for small spot-size measurements.
 - Average power requirements are MW – GW and pico-second micro-pulses.
- 3. Anticipated average cost per laser system is 500 k\$ - 1M\$
 - Approx 16 diagnostic laser systems, 25 total high power laser systems in ILC (M. Ross)