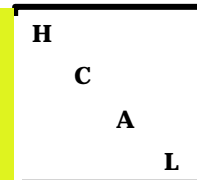




RBX SAFETY ISSUES



RBX Production Readiness Review

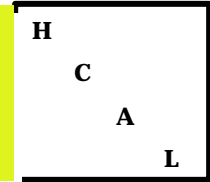
Safety Issues and Mitigations

John E. Elias

HCAL Electronics Coordinator



RBX HAZARDS



Low Voltage and Fire

- Each box requires
 - 18 amps at 6.5 volts
 - 26 amps at 4.5 volts

High Voltage

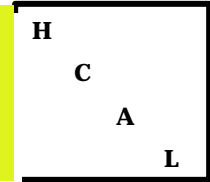
- HV System is capable of 15 kV

Optical Data Link Lasers

- VCSELs operate at 850 nm
 - not visible light
 - but focused well by the eye



Low Voltage and Fire - 1

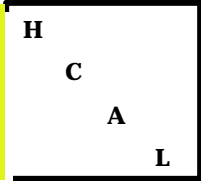


Wires from LV supply to the RBX (20m)

- Sized for ~1 Volt drop under normal conditions
- Can carry worst case fault current indefinitely without overheating
 - Example: 20 amps at 1 volt drop nominal
 - RBX ground fault at LV supply max. current gives power = $V \times I = 7.5V \times 26A = 195\text{ W}$ which is only 10 W per meter of wire
- Current limiting features built into the LV supply are adequate to mitigate the hazard

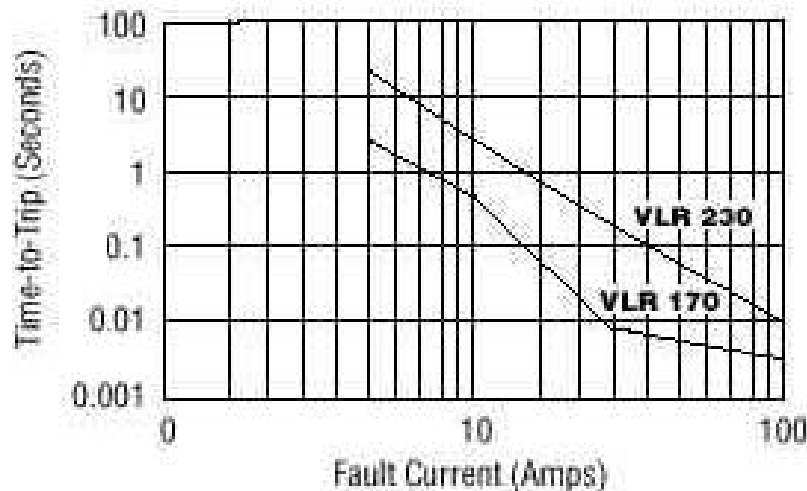


Low Voltage and Fire - 2



Readout Cards

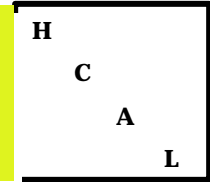
- Each card has access to the full power supply current via the backplane in event of a fault
- Mitigations
 - Current limiting feature in voltage regulators
 - PolyFuse protection at point of entry



Polymeric positive temperature coefficient device for overcurrent and overtemperature protection
Resettable – power down



Low Voltage and Fire - 3



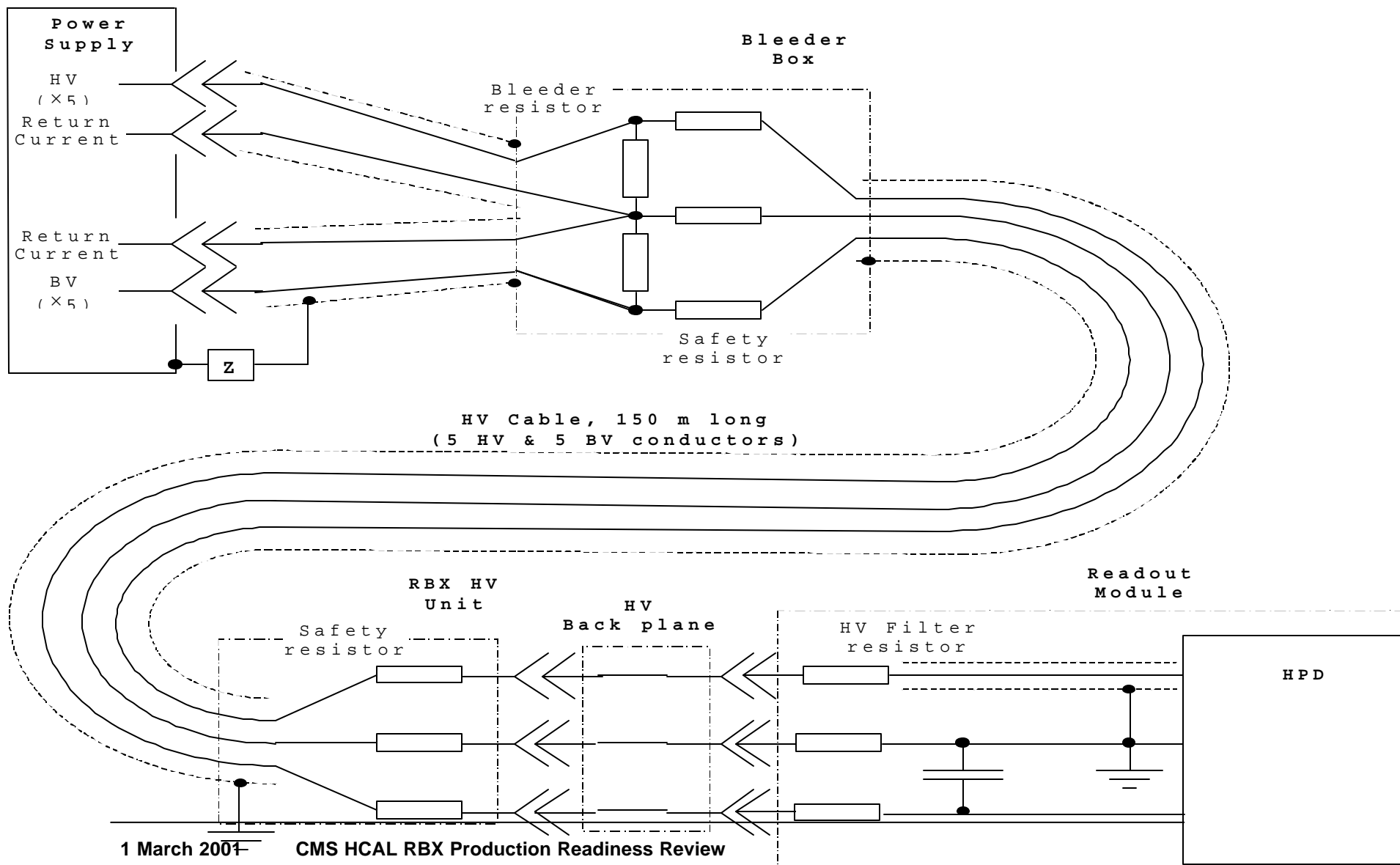
Sample Draw System Planned

- **Continuously monitors air sampling system for fumes and aerosols, “sniffers”**
 - Break detector into many monitor zones
- **Multi-level alarming**
 - Off normal – check into it
 - Seriously off normal – do something now
 - Corroboration by other system – fire alarm
- **Provision for automatic shutdown of the low voltage system**
 - Individual RBX basis
 - Entire half-barrel, end cap or HO basis



High Voltage - 1

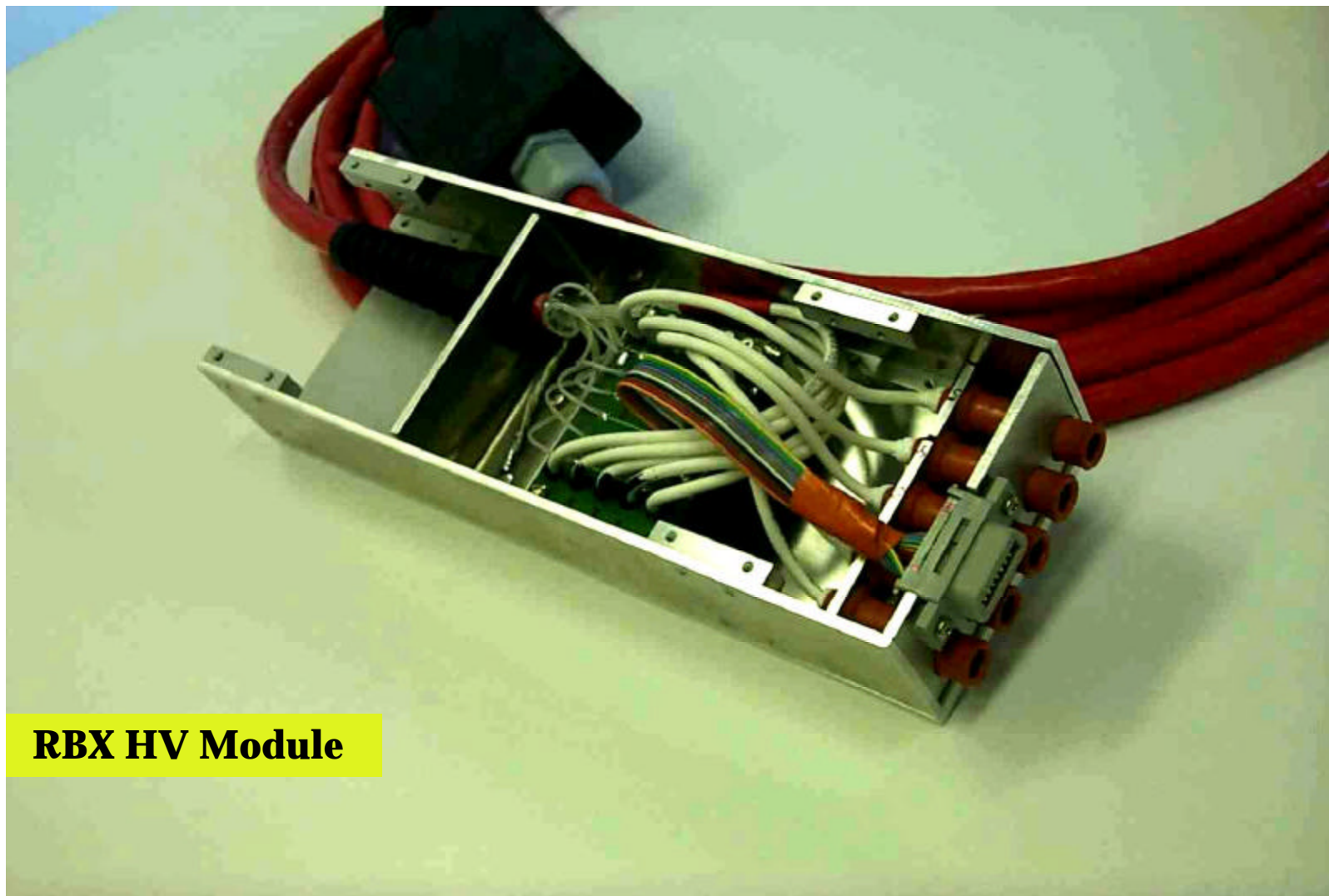
H
C
A
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High Voltage - 2

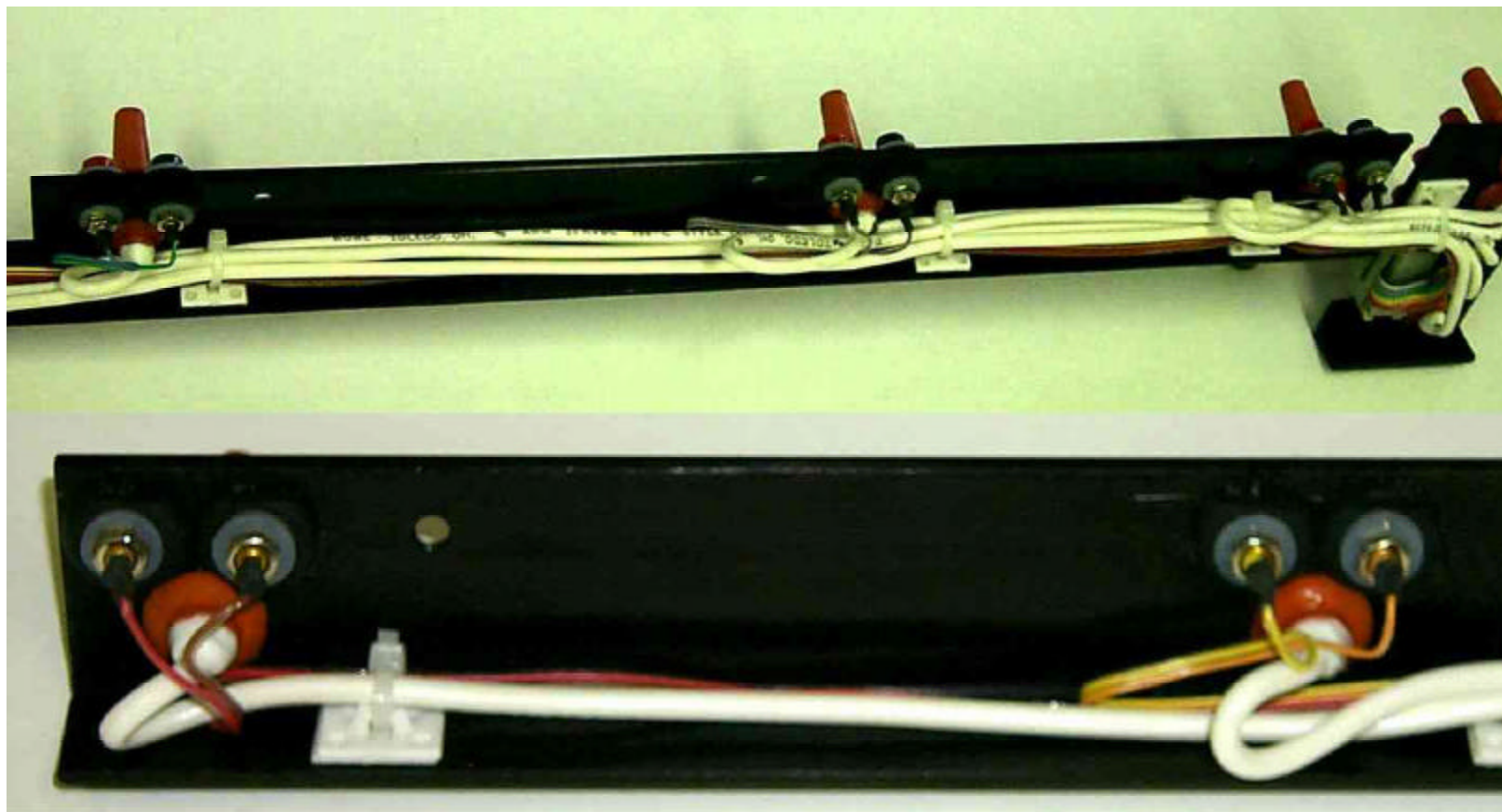
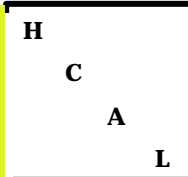
H
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RBX HV Module



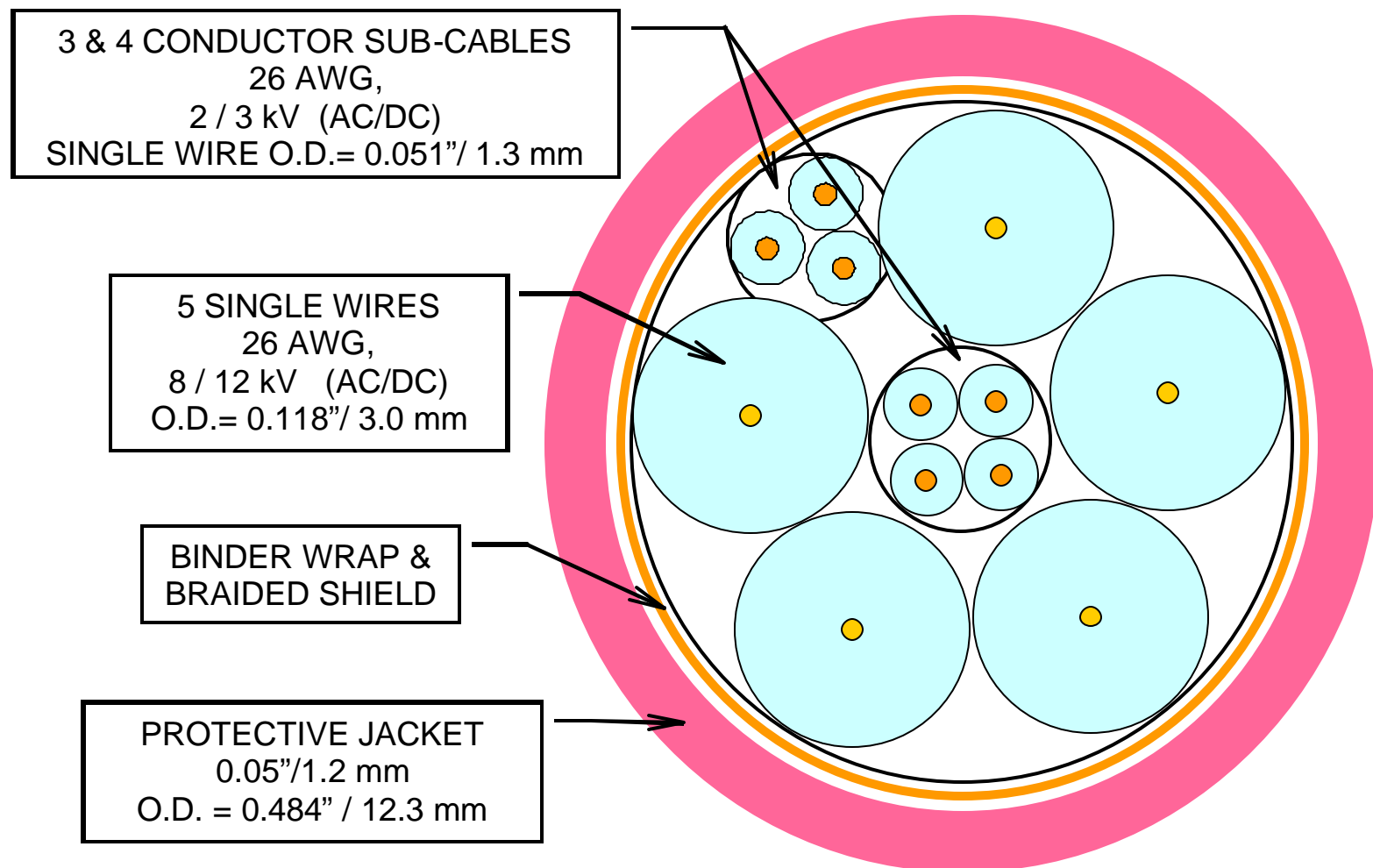
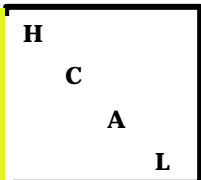
High Voltage - 3



RBX High Voltage Distributor (Backplane)

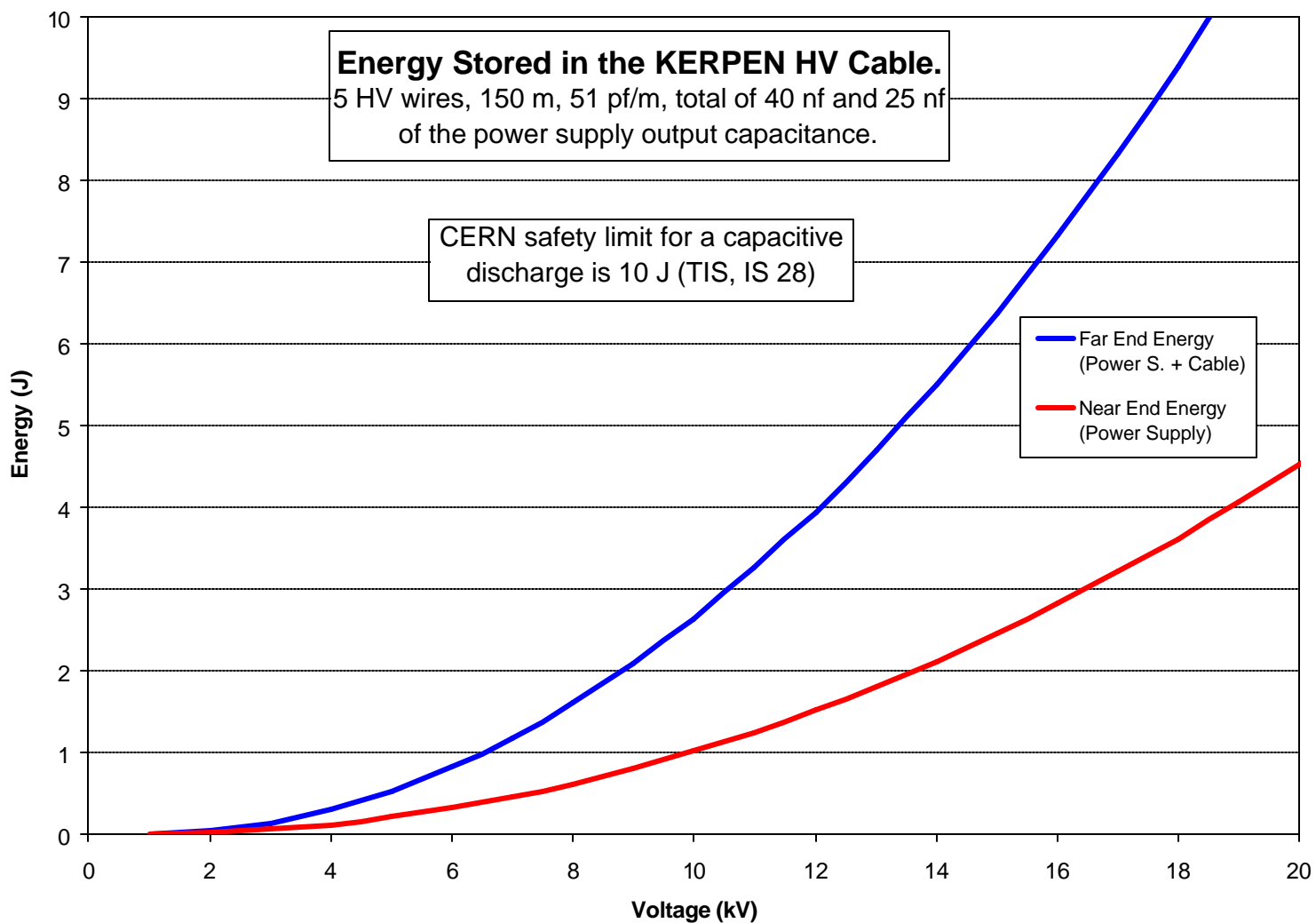
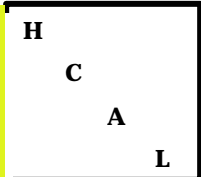


High Voltage - 4



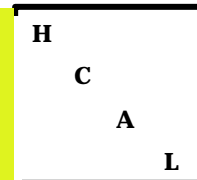


High Voltage - 5





High Voltage - 6

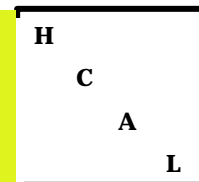


High Voltage Summary

- Connectors have deeply recessed contacts and are rated for 30 kV
- Safety resistor potted in series at RBX end of the cable limits maximum discharge current to 1 mamp per wire at 10 kV
- Stored energy in the cable (all five wires) is 6 Joules at the maximum supply voltage
- Maximum power supply current capability is 40 microamps
- A 250 meter length of cable has been held at 20 kV for one year (accelerated testing) with the leakage current unchanged at < 10 pamp



Laser Diode - 1



VCSELs drive the optical data links

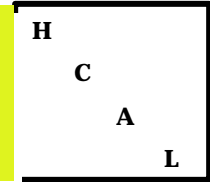
- Optical power is 1.8 mW typ.
- But the 850 nm light is not visible and this overrides the power consideration and makes it hazard class 3b “can cause eye injury in less than 0.25 sec”

	HFE4086-001	3 mm long 1 mm dia.
	Product Sheet	

- Glued to ~15 cm long connectorized fiber



Laser Diode - 2



Intrinsically eye-safe Strategy 1

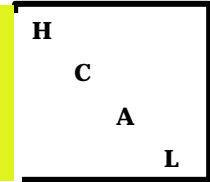
- **Glue a permanent attenuator in fiber pigtail to make the link intrinsically eye-safe at the front panel connector of the Readout Module**
 - Unknown – whether the light level at the receiver is adequate for good link performance
 - Known – the TTC optical links are intrinsically eye-safe and perform very well

Intrinsically eye-safe Strategy 2

- **Use a spring loaded shutter on the front panel connector of the Readout Module**
 - Unknown – whether shutters exist for ribbon connectors or a custom add-on is needed
 - Known – it will be costly



Laser Diode - 3



Eye-Safety on the workbench

- The laser and fiber pigtail are removable from the printed circuit board with two fasteners

Work to be Done

- Detailed power density analysis using the beam power profile versus angle
- Determination of the minimum safe distance between the fiber end and the eye surface

Commitment – intrinsically safe system

- Administrative procedures may still be needed but they are not the principal mitigation