

Jefferson Lab Experience

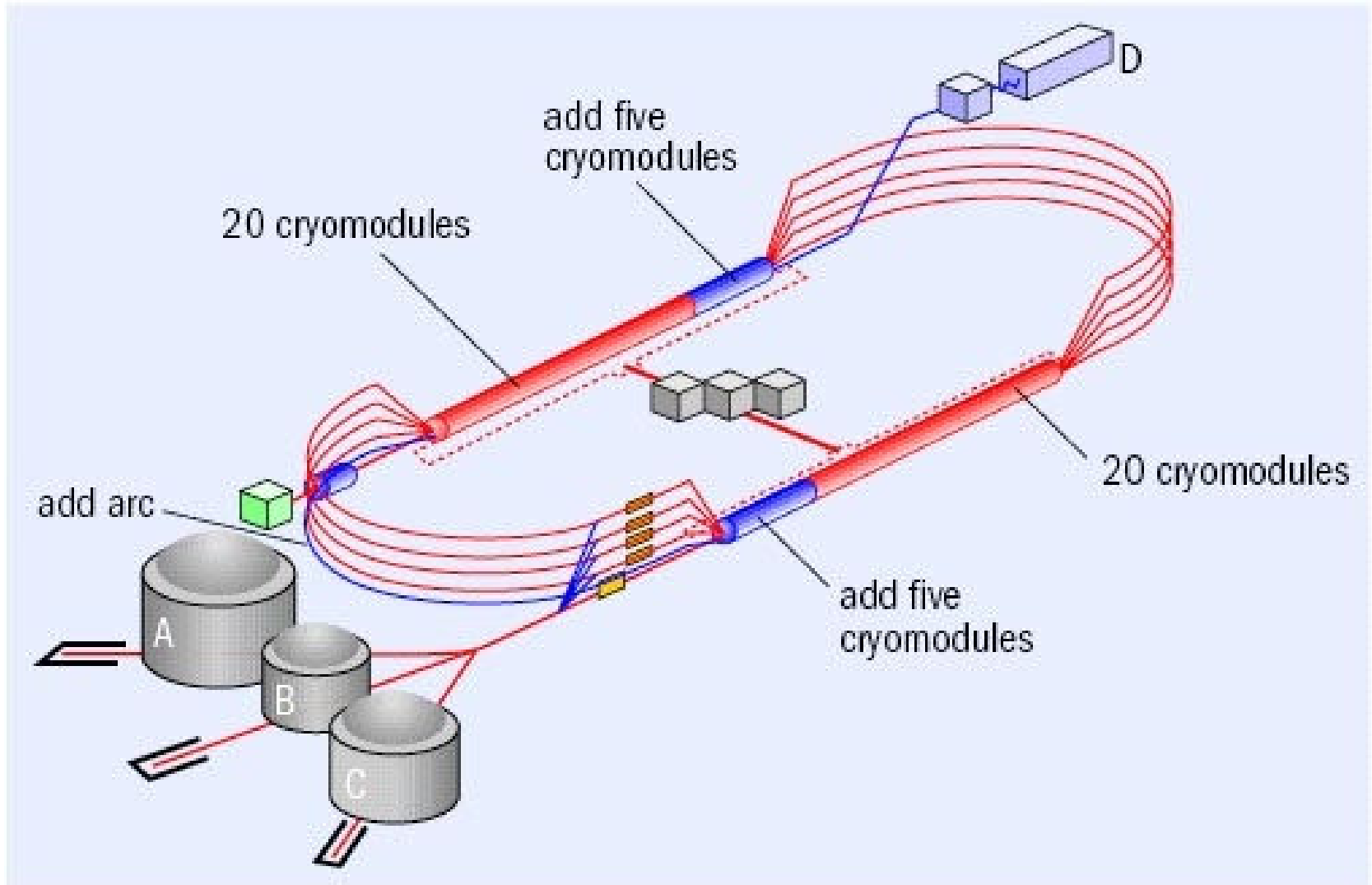
Joe Preble

Workshop on cryogenic and vacuum sectorisations of the SPL
November 9-10, 2009

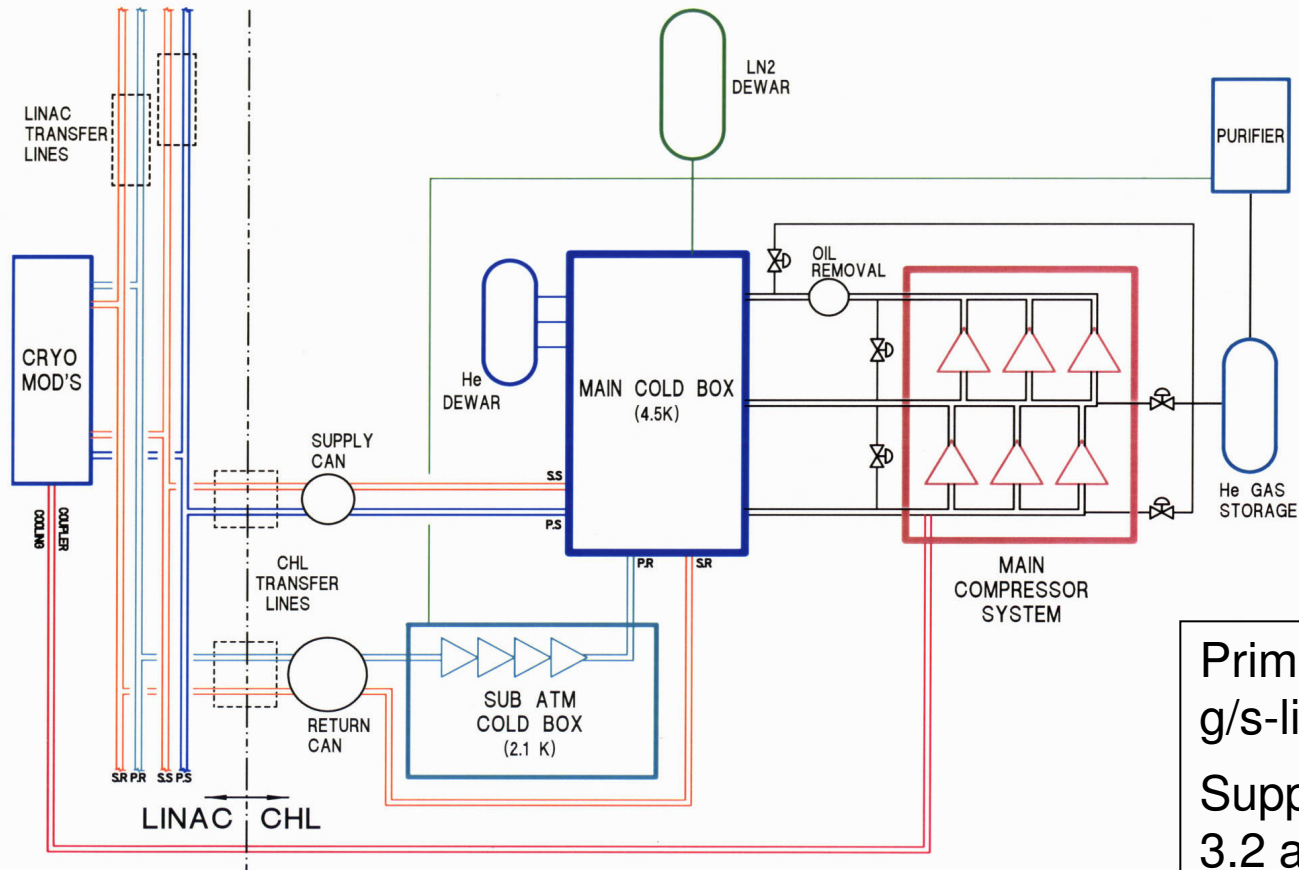
Outline: CEBAF cryogenic and vacuum system

- ❖ **Description**
- ❖ **Operating experience**
- ❖ **Configuration sensitivities**

Description



CHL System Schematic



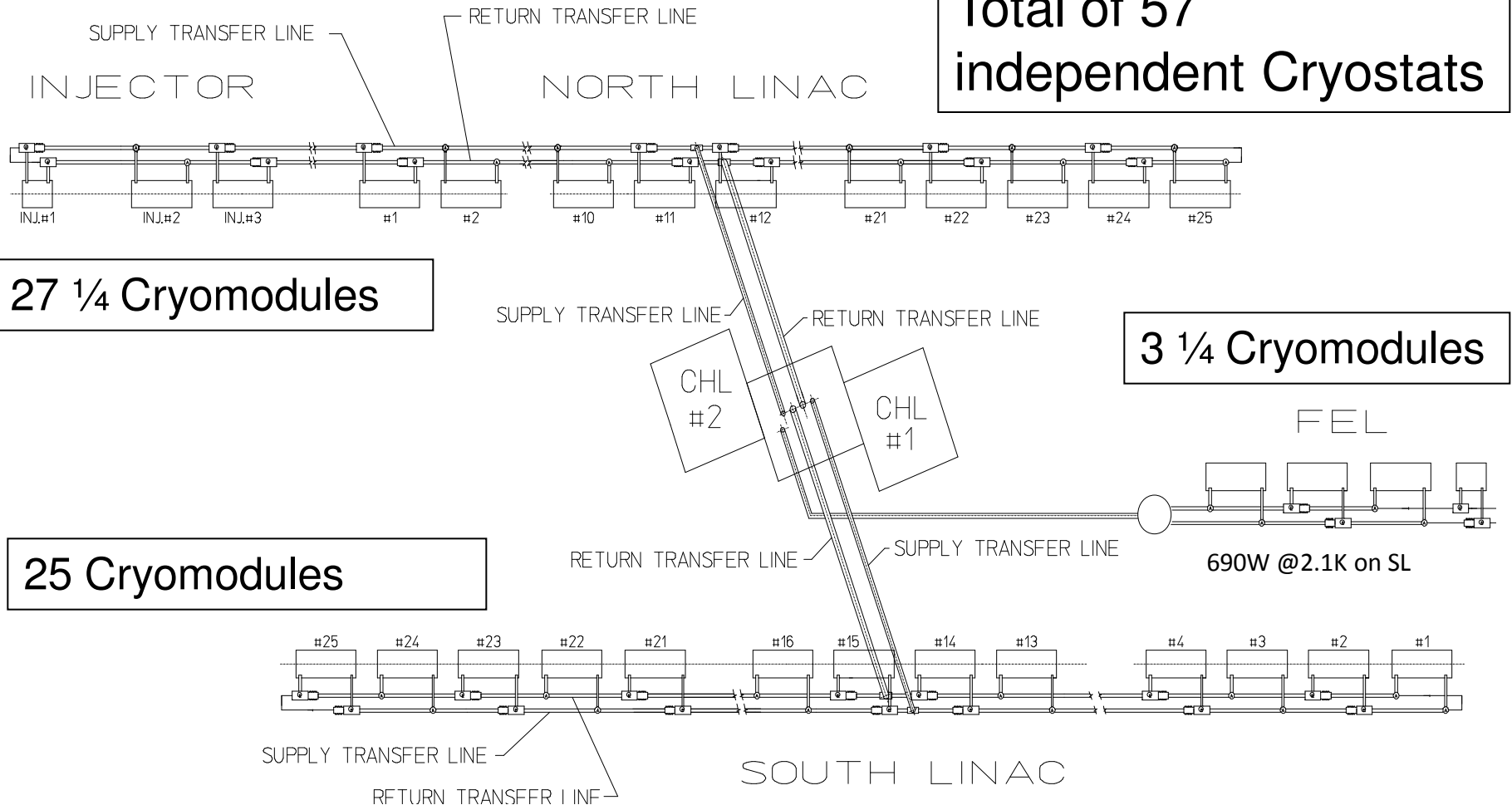
Primary Circuit ~180
g/s-linac (2 linacs)

Supply
3.2 atm
~3 K

Return
2.1 K

LINACs Configuration

Total of 57 independent Cryostats



27 ¼ Cryomodules

3 ¼ Cryomodules

25 Cryomodules

CHL Capacities

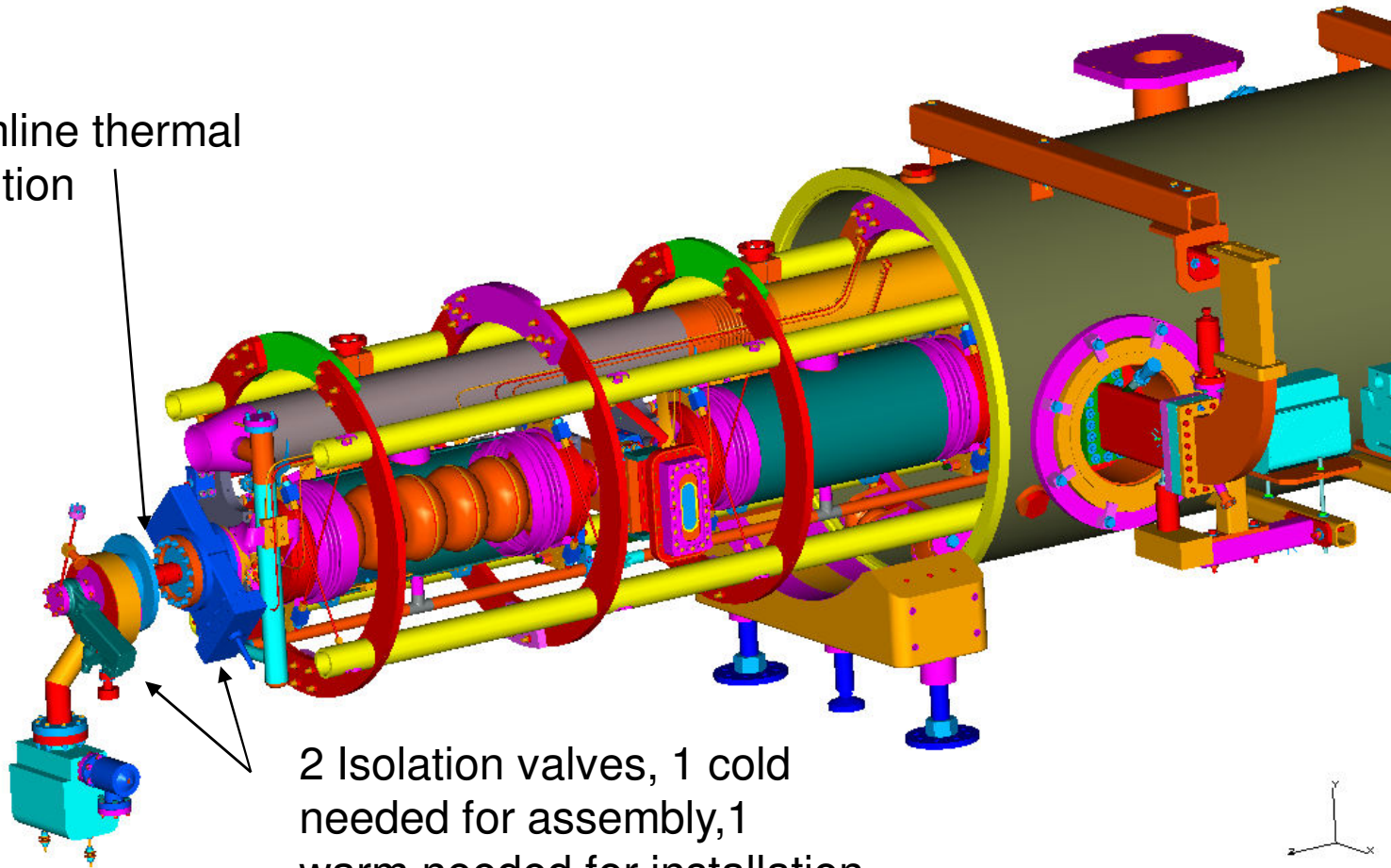
- **Current 6 GeV (CHL #1)**
 - Load: 4248W @ 2.1K, 11648 W @ 50K
 - Capacity: 4600W @2.1K, 12000W @ 50K
- **New 12 GeV (CHL #1 + new CHL#2)**
 - Load: 7400W @ 2.1K, 14650W @ 50K
 - Capacity: 9200W @ 2.1K, 24000W @ 50K

Cryomodule Description: 10 m pitch

- 8 cavities and power couplers
- 2 cryogenic circuits, 2K & 50K
- 4 U-tubes supplying cryogenics, 2 supply and 2 return
- 2 beamline warm to cold transition with isolation valves
- 3 independent vacuum systems, beamline, power coupler, and insulating vacuum
- ~1m warm beamline between cryomodules

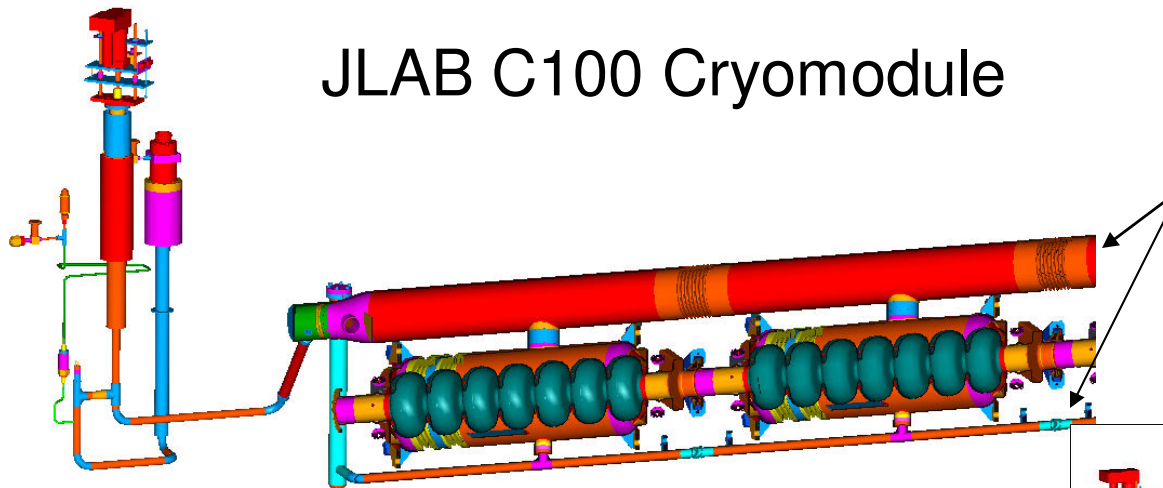
Cryomodule Description

Beamline thermal transition



2 Isolation valves, 1 cold needed for assembly, 1 warm needed for installation

Cryomodule Description: 2K circuit



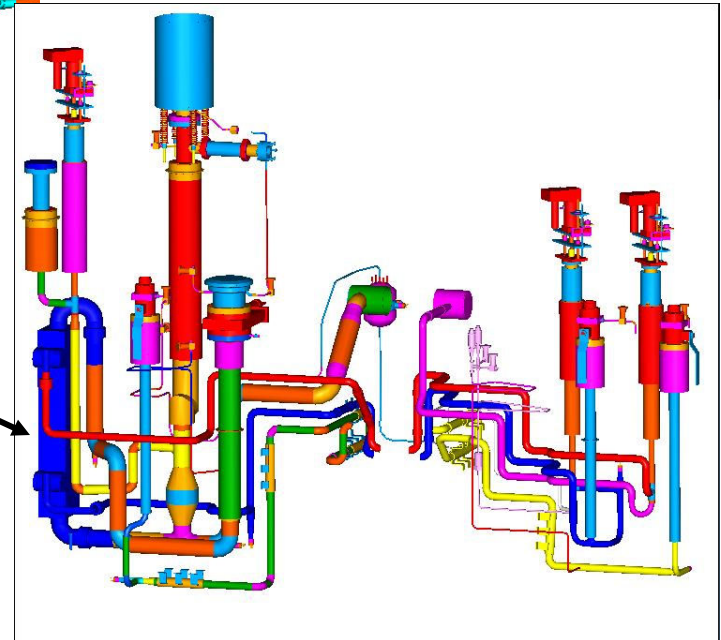
JLAB C100 Cryomodule

2 Headers

5" 1/2 filled with liquid
and 1" completely
filled with liquid

SNS End Cans

Return end includes
heat exchanger, real
improvement in design
over CEBAF CM

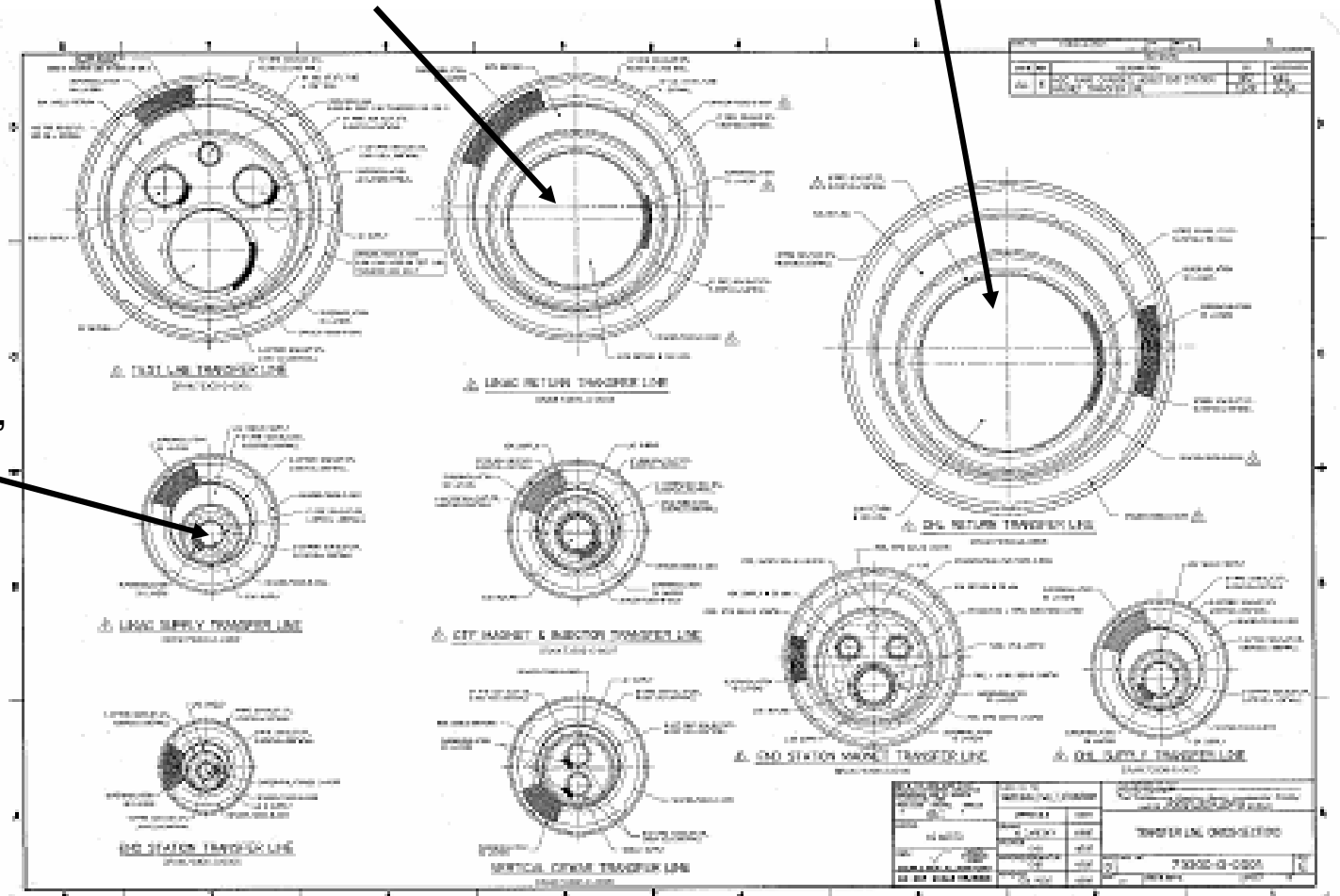


Transfer Line

LINAC 6" Return Line

CHL 8" Return Line

LINAC 1" Supply



Loads/Capacities: 6GeV/12GeV Breakdown

Unit Loads			6 GeV			12 GeV					
						North Linac			South Linac		
	2 K	50 K	#	2 K	50 K	#	2 K	50 K	#	2 K	50 K
Loads (#,W)											
Static											
Transfer Line	530	6360	1	530	7000	0.57	228	3990	0.43	302	3010
Original CMEs	16	110	42.25	676	4648	21.25	340	2448	20	320	2200
12 GeV CMEs	18	250				6	108	1250	5	90	1250
Dynamic											
Original CMEs	72	40	42.25	3042		21.25	1530	850	20	1440	800
12 GeV CM	250	50				6	1500	300	5	1250	250
Totals			42.25	4248	11648	25.25	3706	7988	29.25	3402	6710
Capacities (W)											
CHL#1 (W)				4600	12000		4600	12000			
% of Full Load				92%	97%		85%	67%			
CHL#2(W)										4600	12000
% of Full Load										77%	56%

Operational Experience

• Installation and commissioning

- Original installation and commissioning was completed in sections as we built cryomodules and cryo plant, injector first, ~ 1/2 first linac, ..., saving considerable amounts of time
- Remove and replace cryomodules with the linac cold
 - 3 days to remove a cryomodule and install a drift tube
 - ~week to replace a cryomodule and cool down to 2 K

• Maintenance activities

- Can include cryomodule work requiring a thermal cycle, ~week
- Response to loss of power, hurricanes in our case

Operational Experience

- Refurbishment program started after ~15 years of operations, remove 1 or 2 cryomodules and completely rework them, 10 over 3 years
 - Increased machine energy
 - Benefit from current processing technologies
 - replace o-rings, pumps, gauges, ...
- Upgrade
 - Add additional cryomodules over time
 - Cool down when wanted

Configuration Sensitivities

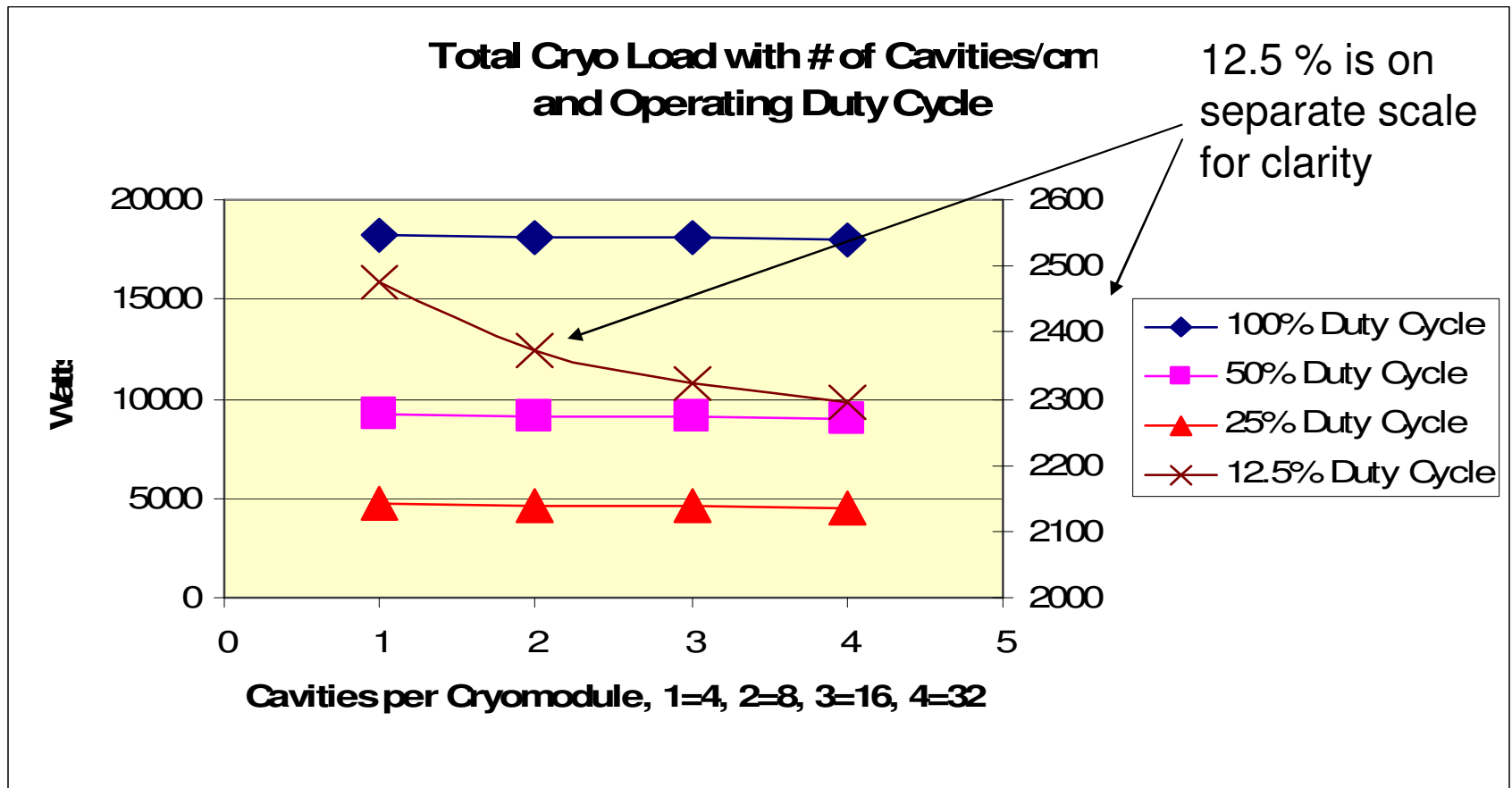
❖ Model LINAC performance based on SNS and CEBAF LINACs, Spreadsheet model available for discussion, sample below

length, m	ea				
cavity length in cm, m	1.3	5.2	10.4	20.8	41.6
quad length (every 4th cav)	0.8	0.0	0.8	1.6	3.2
Beamline transition, m	0.8	1.6	1.6	1.6	1.6
Total length per cm, m		6.8	12.8	24.0	46.4
Total cm length in linac, m		340.0	320.0	300.0	290.0
warm spacing between cm	1.0	50.0	25.0	12.5	6.3
Total linac length		390	345	313	296
Distribution costs		1470	1185	1013	926
Total Cost cm+dist		46470	44935	43513	42801

Configuration Sensitivities

❖ Duty Cycle determines cryo load

❖ # of cavities in a cryomodule has little effect on the cryo load



Configuration Sensitivities

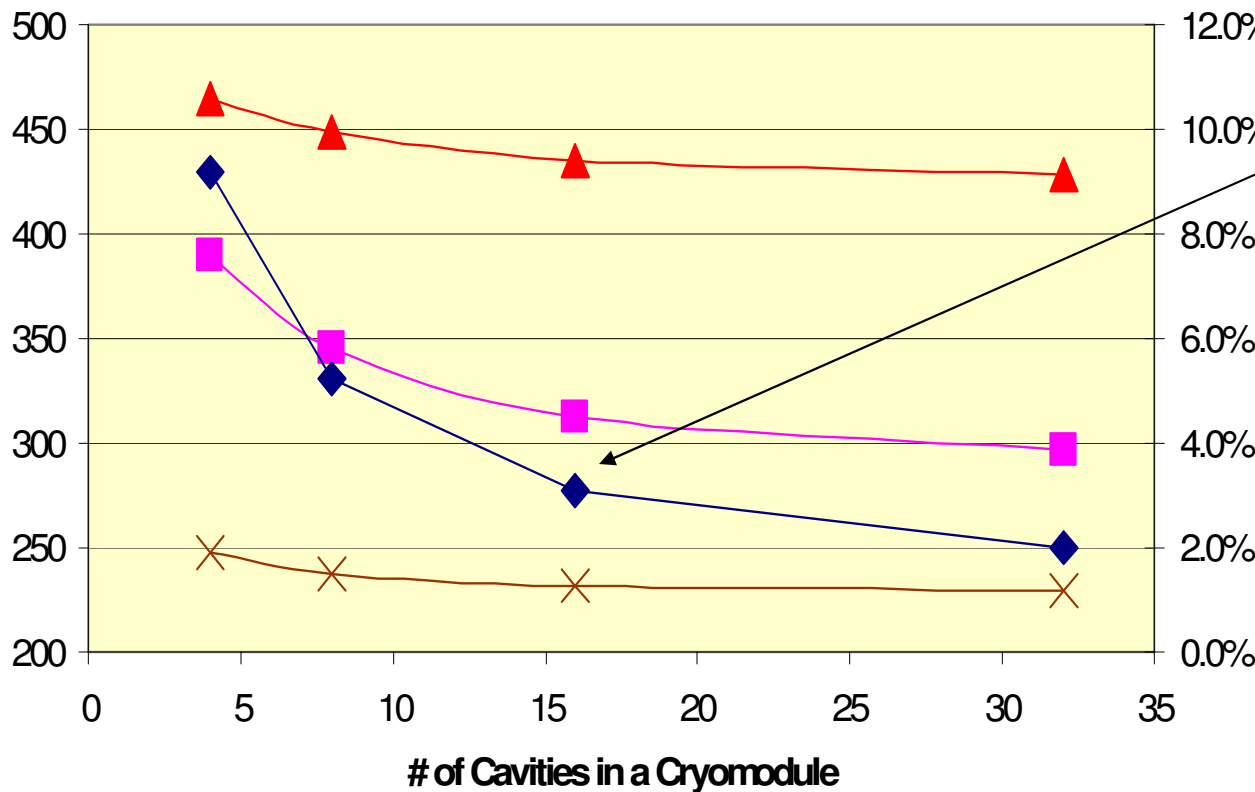
❖ Using 12.5 % Duty Cycle

Configuration Sensitivities

Costs 43-47 M\$

Watts 2.3-2.5 kW

Dist Sys % of Total
on second scale for
clarity, 2-9 %



- Length (m)
- ▲ Cost CM+ DIST (k\$/100)
- × 2K Watts/10
- ◆ Dist. Sys @ 12.5% Ops (%)