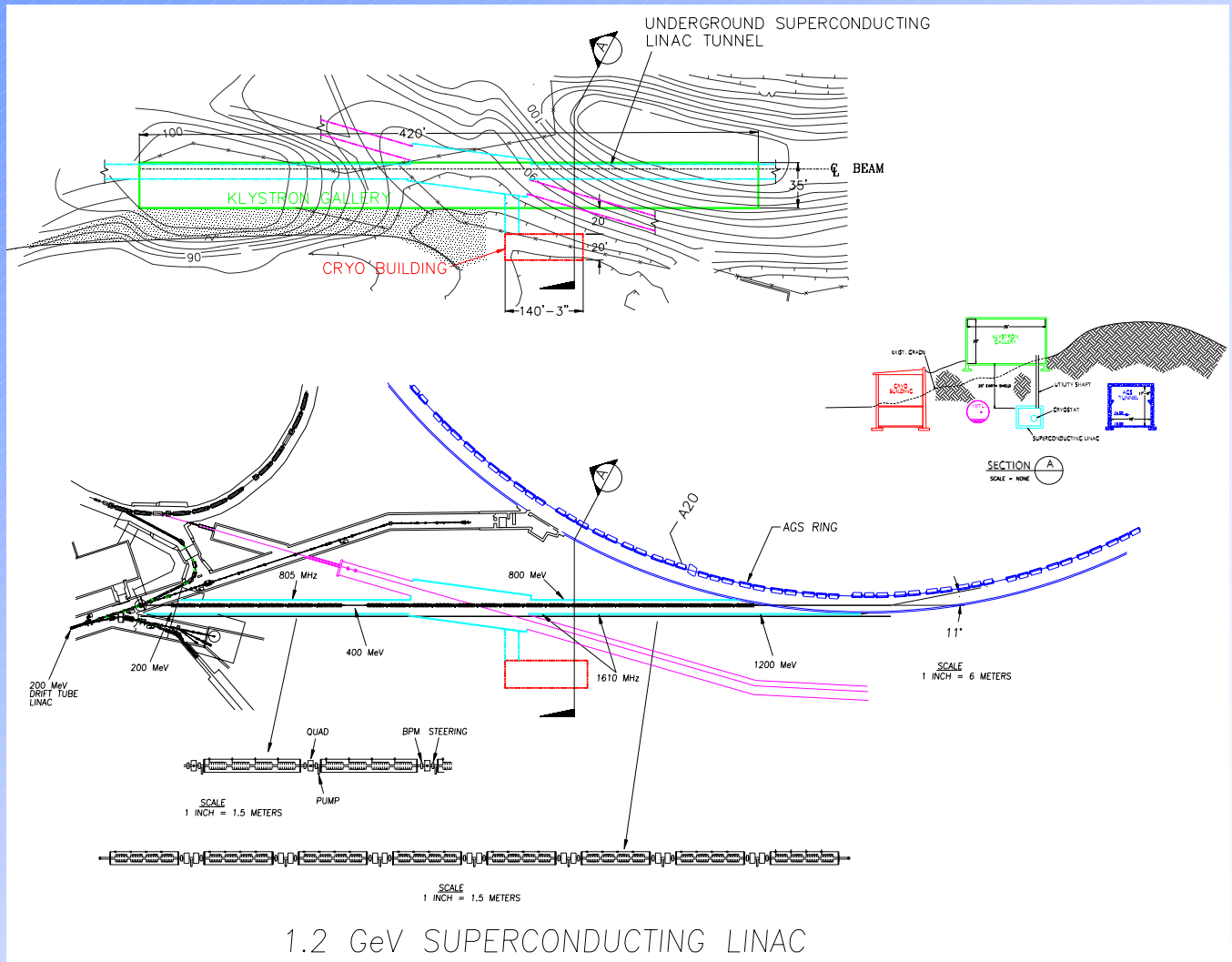
Cryogenic System for AGS SCL

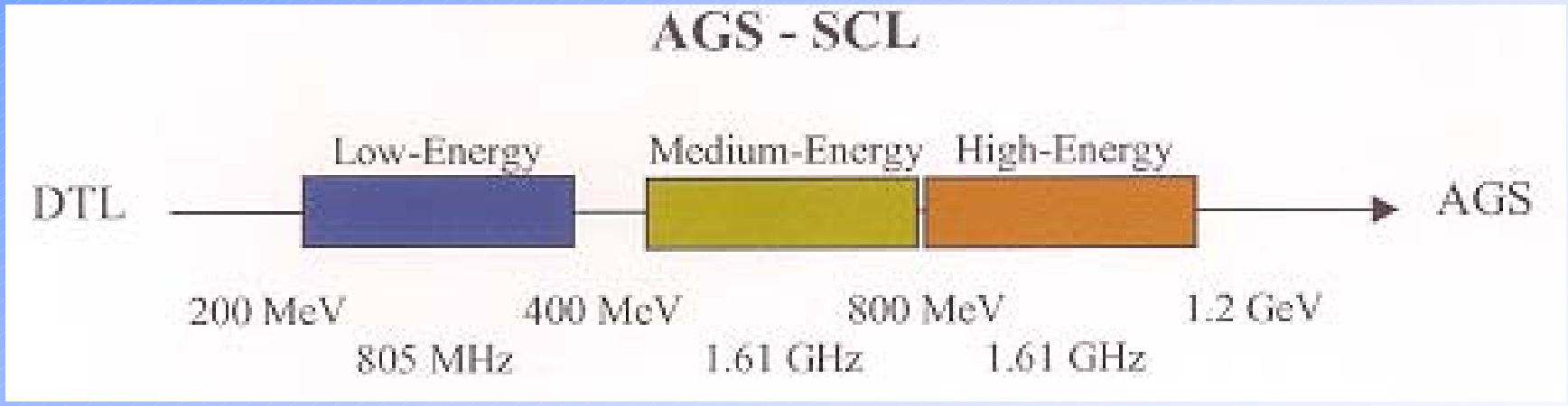
K. C. Wu
6/9/04

- Introduction
- RF Cavity
- Cryomodule
- Cooling System
- Heat Load
- Summary

Layout of AGS SCL

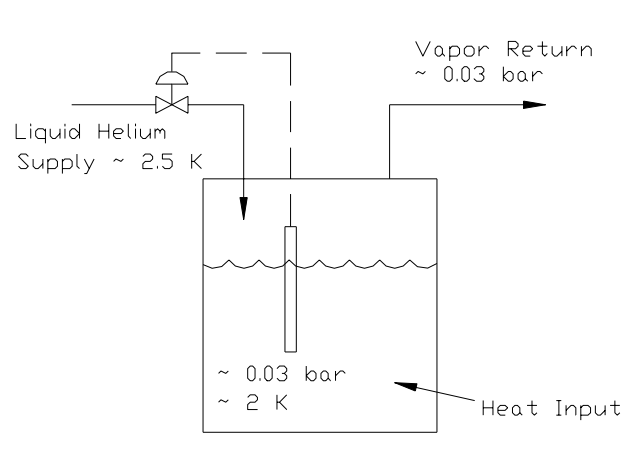


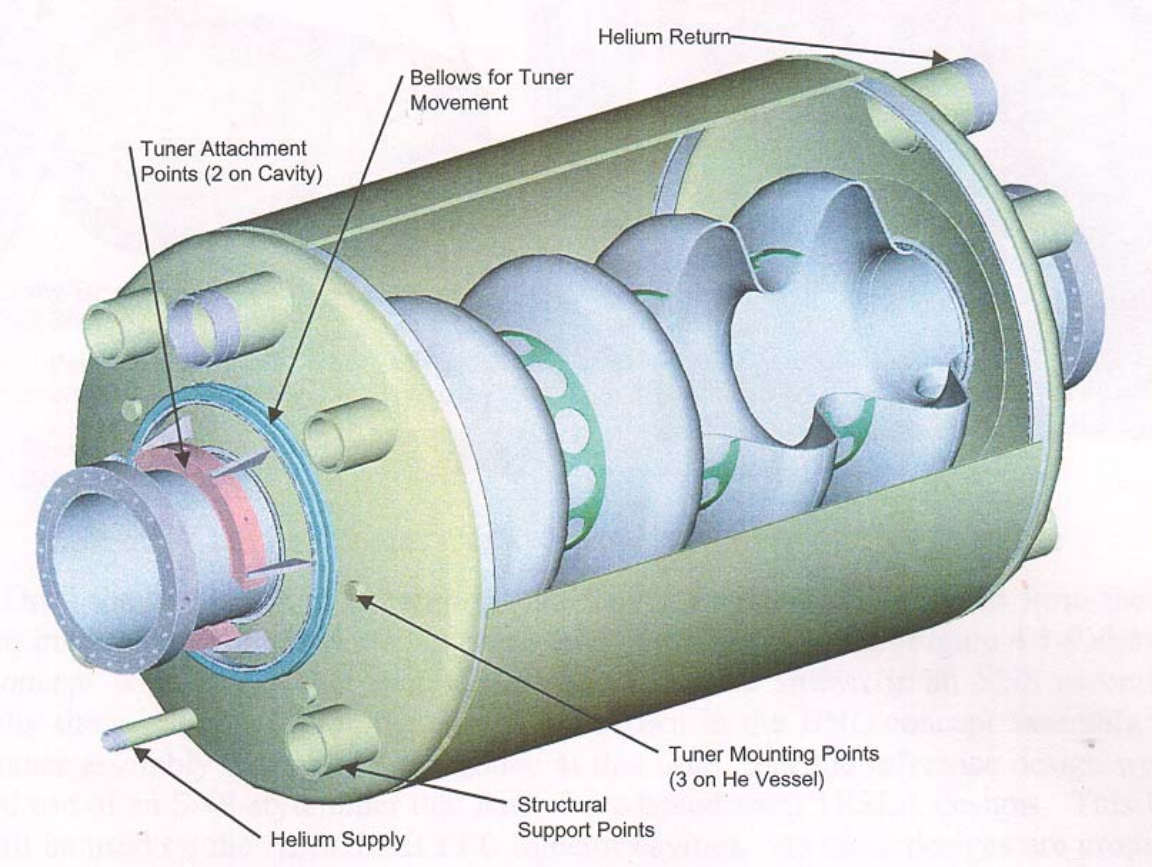
RF System for AGS-SCL



Helium Vessel for the RF Cavity

Cavities are immersed in liquid helium bath at ~ 2 K





Design Approach

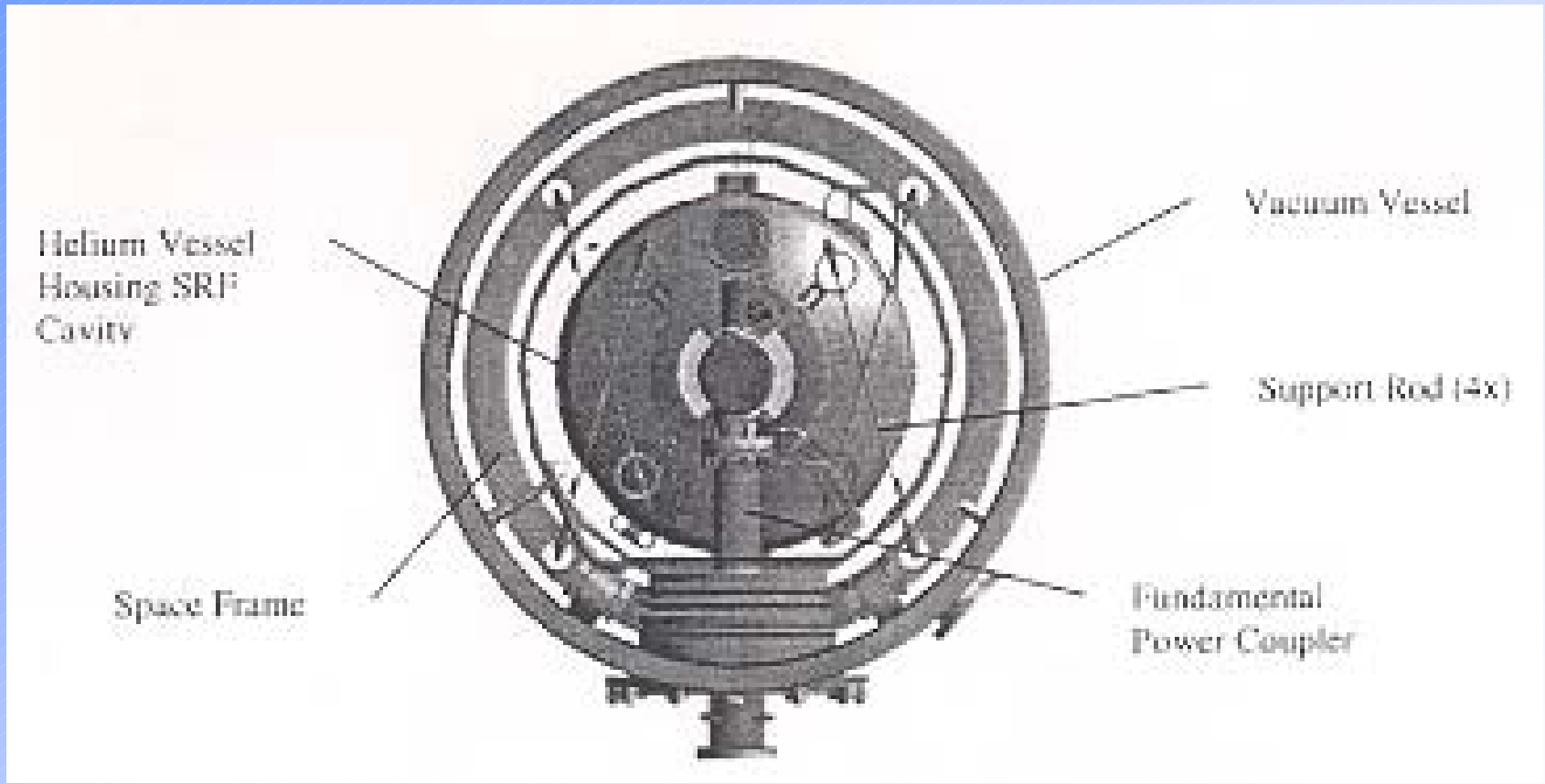
- Base on the "most matured" technology available today - SNS (derived from CEBAF, LHC, TESLA & KEK)
- Will review / revise design
  - as project evolves and detailed information becomes available, or
  - new RF system were developed

Cooling Requirements

- Three temperature levels:

  2 K - RF Cavity
  5 K - Power Coupler
  50 K - Heat Shield

Cross Section of SNS RF Cryomodule

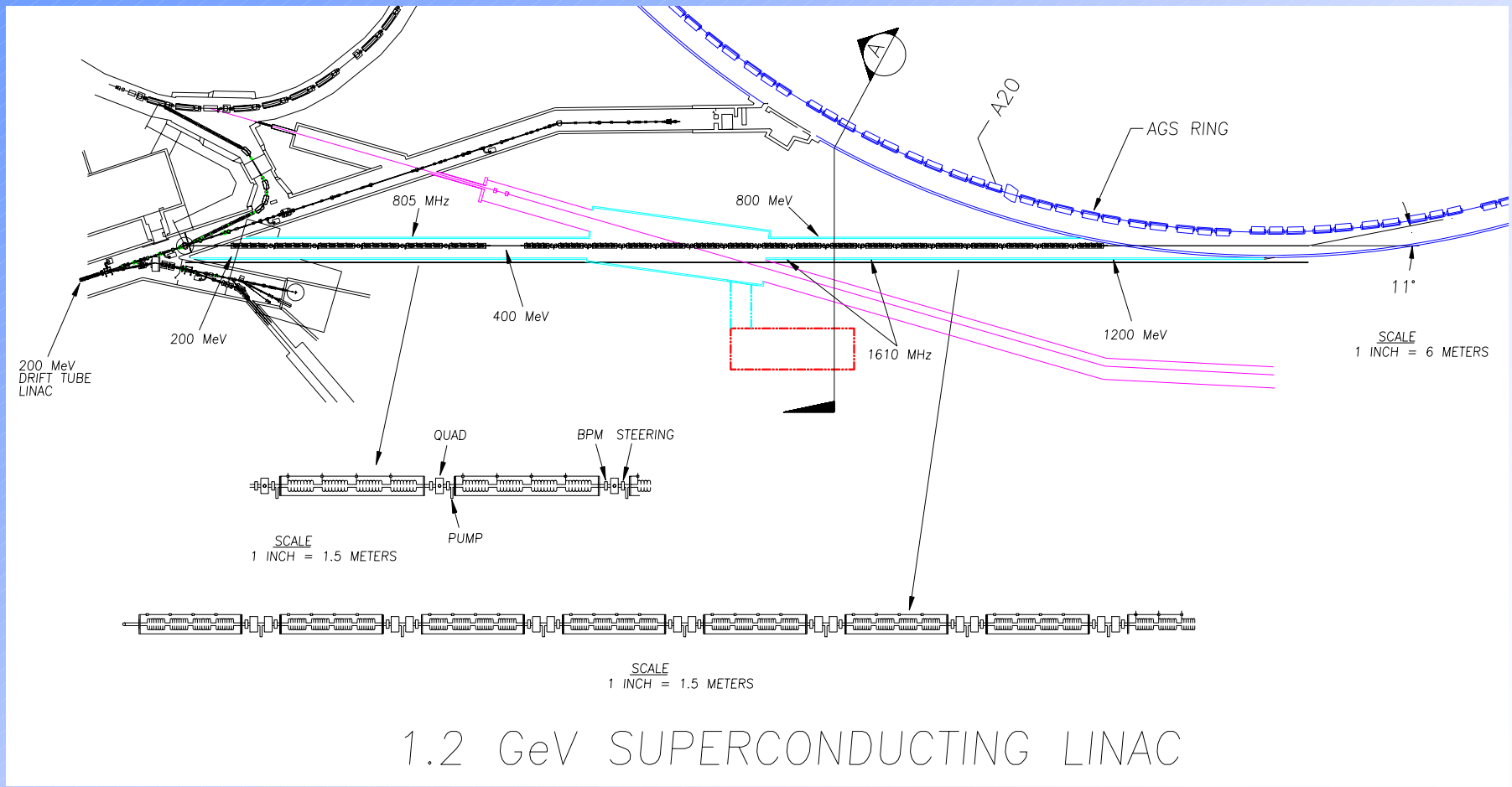


SCL Cryomodule

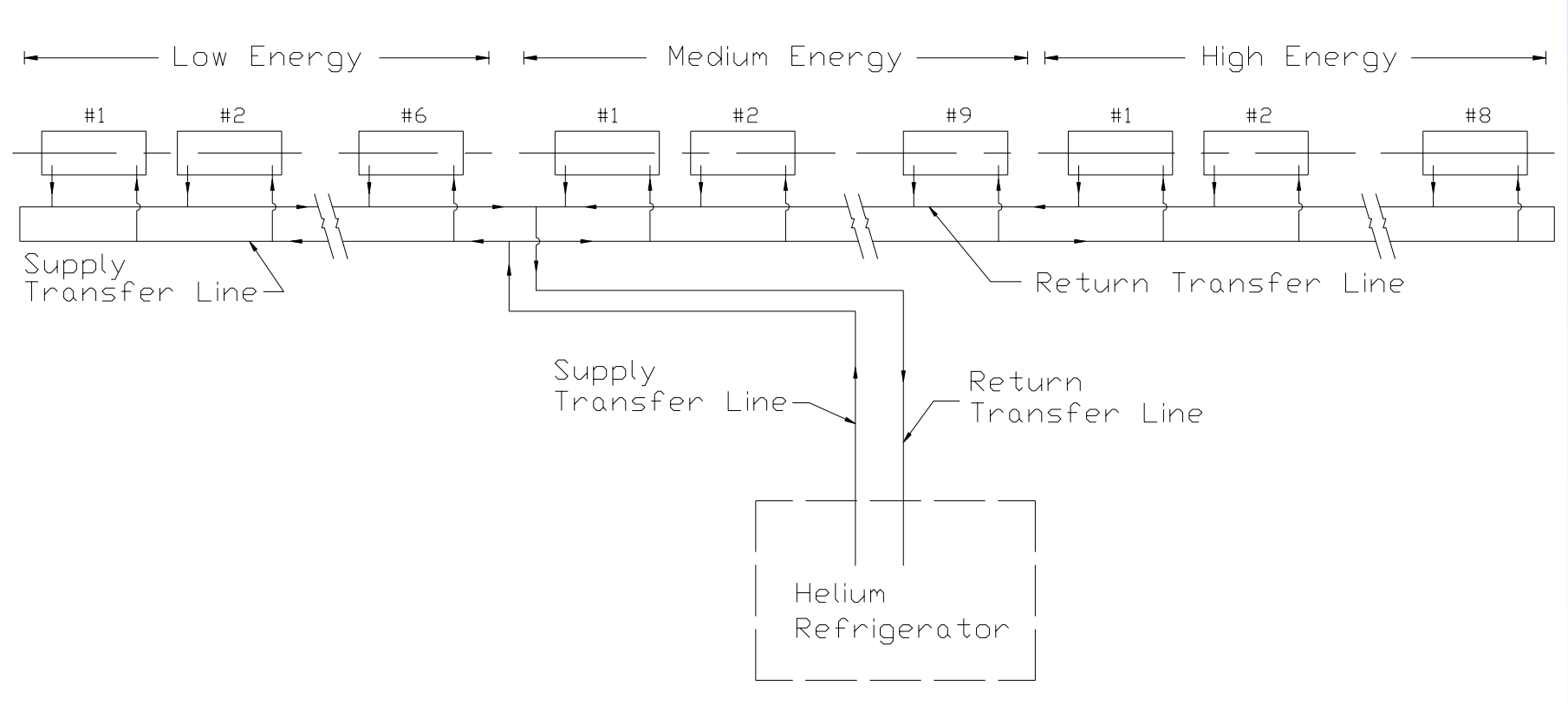
- 8 cells per cavity
- 4 cavities per module
- 120 m overall length in three sections for Low Energy, Medium Energy and High Energy

	L. E.	M.E.	H.E.
• No. of cryomodule	6	9	8
• Length - m	5.46	3.49	3.77

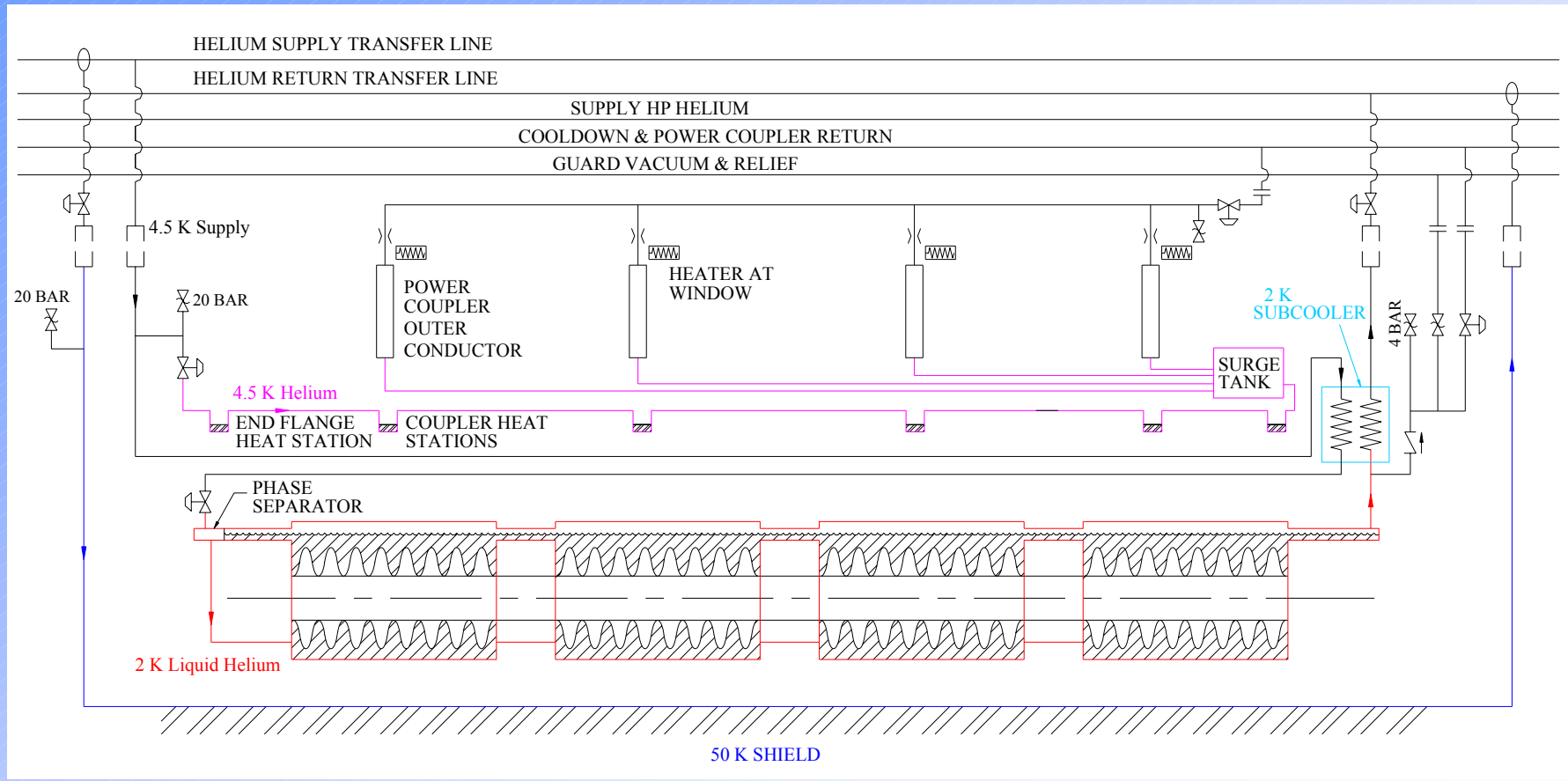
Layout of SCL



Cooling System for SCL (Parallel Cooling)



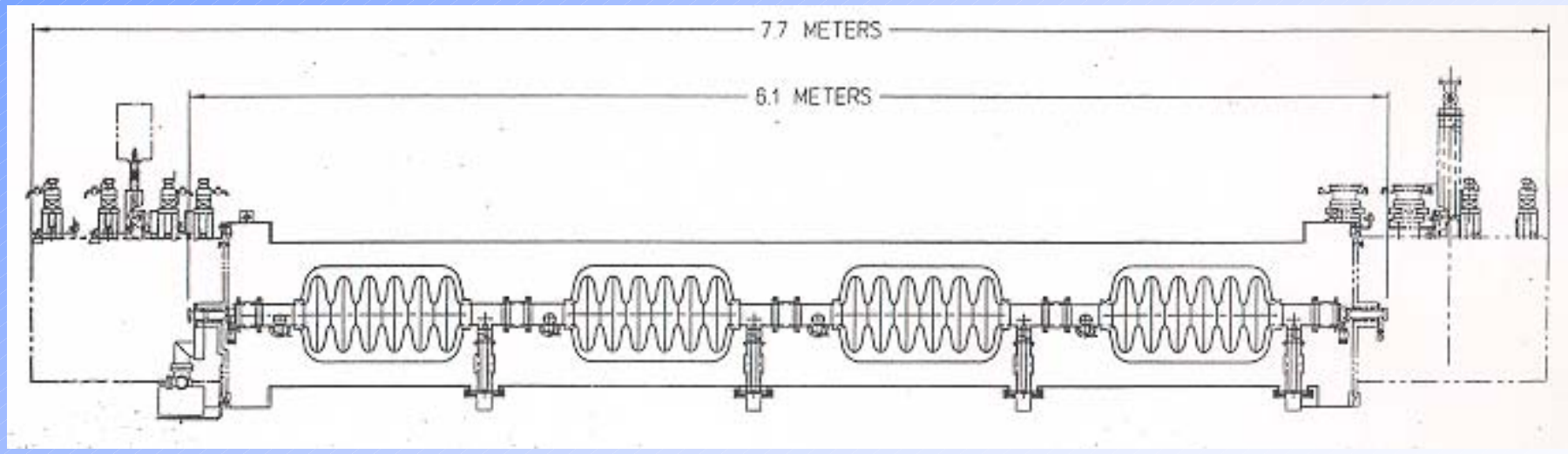
Cooling Scheme for a SCL Cryomodule



Helium Refrigerator, Transfer Line and End Box

- Helium Refrigerator -
  2 K, 5 K and 50 K cooling
- Transfer Line and Bayonet
- End Box
- Able to replace cryomodule while others are cold (no cutting or welding)

Side View of SNS High Beta Cryomodule with End Cans



Parameters and Heat Loads of a Cryomodule

	Low Energy	Medium Energy	High Energy
No. of cryomodule	6	9	8
No. of cavities per module	4	4	4
No. of cells per cavity	8	8	8
Length	5.46 m	3.49 m	3.77 m
2 K static heat load	28 W	28 W	28 W
2 K dynamic heat load	0.33 W	1.22 W	1.00 W
4.5 K static load for couplers	0.2 g/s	0.2 g/s	0.2 g/s
4.5 K dynamic load for couplers	0.1 g/s	0.1 g/s	0.1 g/s
Shield heat load	200 W	200 W	200 W

Cryogenic System Parameters

23 Cryomodules	Primary	Secondary	Shield
Temperature	2.1 K	4.5 K	35 – 55 K
Pressure	0.04 bar	3.0 bar	~ 4 bar
Static load	645 W	4.6 g/s	4,600 W
Dynamic load	21 W	2.3 g/s	-
Total load	666 W	6.9 g/s	4,600 W
Refrigerator Capacity	1,300 W	15 g/s	6,200 W
Margin	~ 100 %	~ 100 %	~ 35 %

Equivalent Capacity for Helium Refrigerator

- Capacity for AGS-SCL He refrigerator
  - 1300 W at 2 K
  - 15 g/s at 4.5 K (< = > 1500 W at 4.5 K)
  - 6200 W (35 – 55 K) (use mean temperature of 45 K)
  - Equivalent capacity at 2 K
    1300 + 0.44 x 1500 + 0.038 x 6200 ~ 2200 W (58% of SNS)

- Capacity for SNS He refrigerator
  - 2850 W at 2 K
  - 15 g/s at 4.5 K (< = > 1500 W at 4.5 K)
  - 8300 W (35 – 55 K) (use mean temperature of 45 K)
  - Equivalent capacity at 2 K
    2850 + 0.44 x 1500 + 0.038 x 8300 ~ 3825 W

Helium Refrigerator

- Will consist of a 4 K cold box and 2 K cold box
- Plant Size is ~ 58 % of SNS
- Power consumption ~ 60 % of SNS
- Plant Cost ~ (Comp. Power)$^{0.7}$
- Plant Cost for SCL ~ 70 % that of SNS
- Installed power 3 – 4 MW

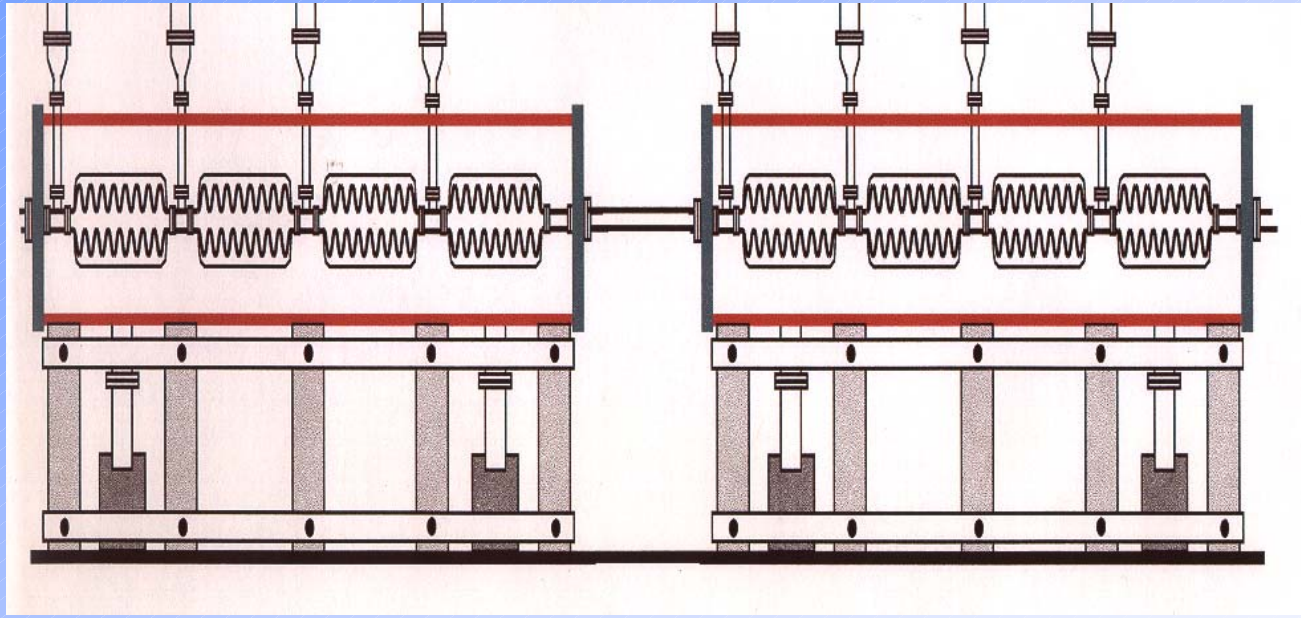
SCL Tunnel Size

- Similar to SNS -
  Cross section ~ 3 M x 4.3 M (10’ x 14’)
- Possible cost advantage with decreasing tunnel size?
- Coupler to be located on top position so that power feed can enter the tunnel above cryomodule

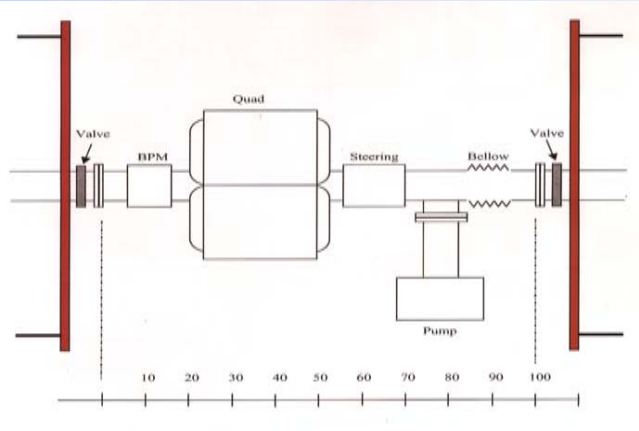
Issues Specific to AGS - SLC

- Available space between neighboring cryomodules. Amount of hardware to be installed – Quad, BPM, bellow and vacuum valves etc.
- 2 K – 1300 W helium refrigerator. Are there cold compressors available in this size?
- Layout of Helium Refrigerator
- Layout of Transfer Line
- Connection between refrigerator and feed point of the transfer line in tunnel
- Expect continuous operation. Plan for 75% duty cycle.
- Intent to keep SCL cold all the time similar to JLAB.

Side View of Two SCL RF Cryomodules



Typical "Warm" Components in Interconnect



Cost Estimation for SCL Cryogenic System

No Burden

(5/5/04)

		(M$ - 2004)
1.1.4	Cryogenic System	15.9
1.1.4.1	Helium Refrigerator Labor	1.5
1.1.4.2	Refrigeration System	8.4
1.1.4.3	Control, Refrigerator/ Cryomodule	1.7
1.1.4.4	Ancillary Equipment	1.2
1.1.4.5	Transfer Lines, Linac/ Distribution	3.1