

Cooling system
LV & HV and all that

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Minnesota

Low Voltage

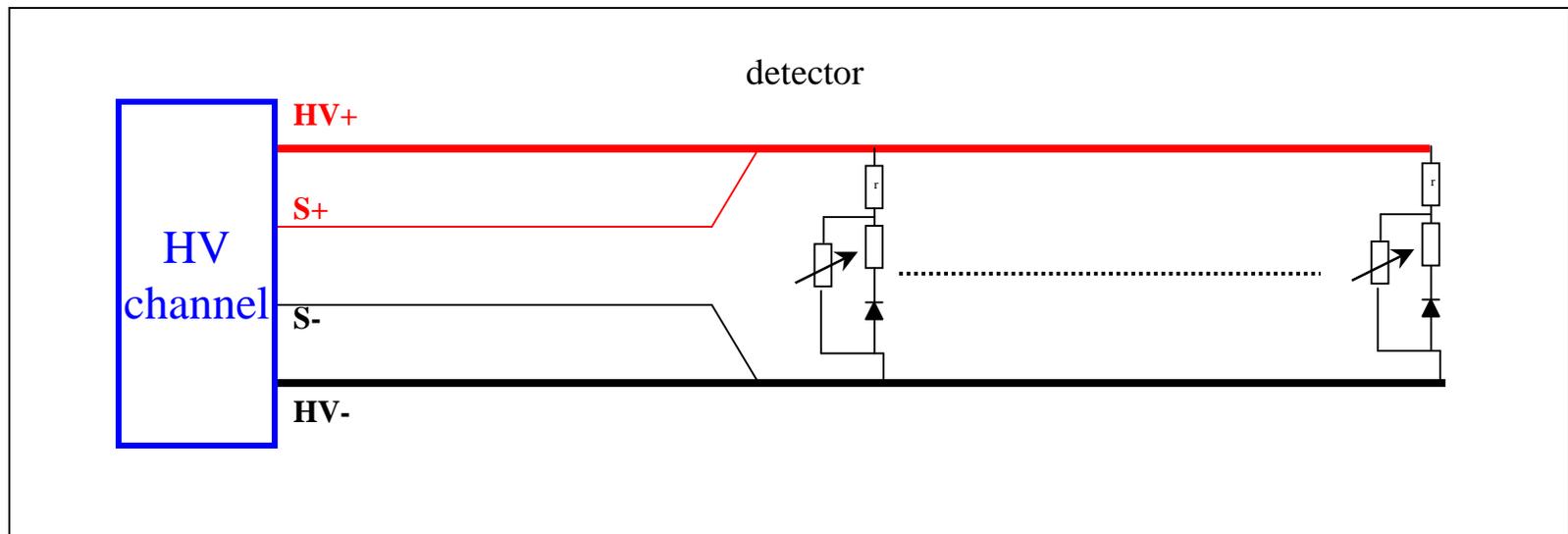
- **Basic parameters:**
 - 23808 modules.
 - Each module requires:
 - **3W (+2W) of low quality ($\leq 0.5V$ ripple) 12V For TE coolers.**
 - **3W of clean supply for readout electronics 3V.**
 - ~100 kW of clean power.
 - ~100 kW of 12V for TEC's.

Use commercial supplies for clean power.

Use cheap commercial (or home made) supplies for the TEC.

HV Architecture

- *The system is composed by 23808 APD modules.*
- *Each APD module draws ~50 nA.*
- *Variable resistor used to set required voltage for $M = 100$.*
- *Total current per module 0.5 μA .*



- *A single HV channel will bias 128 modules*
- *The channel can be floating with sense lines.*
- *Maximum HV required is 500 V*
- *A current monitor system allows to measure increase in APD dark current or short circuit event with a precision of about 100 nA*

Water Cooling

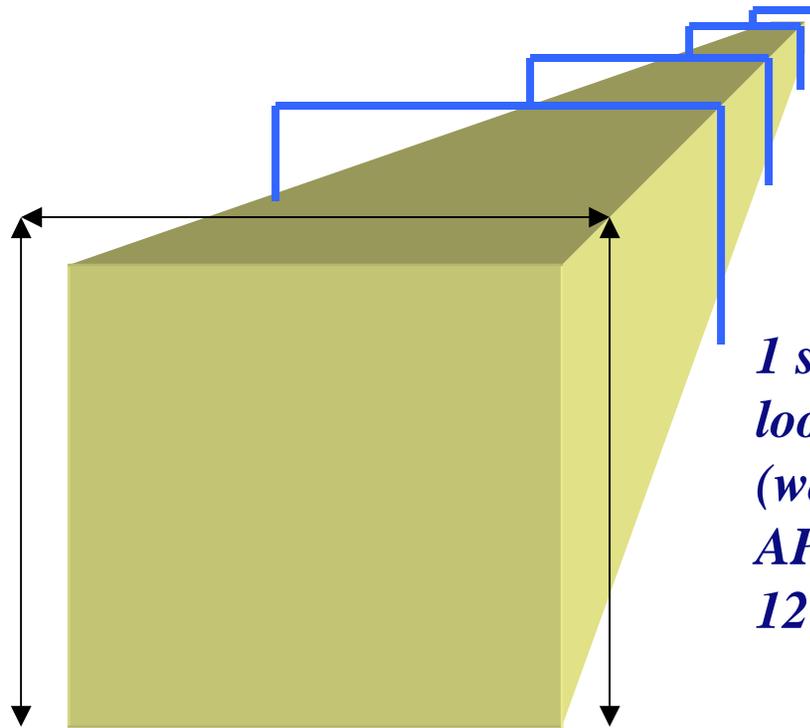
- *Requirements:*
 - 3W Heat extraction.
 - Water cooling, with a temp rise of 1° C.
 - Flow rate through cooling module
 - 7.17×10^{-4} litres/s = 0.04 gals/minute.
 - Flow water in horizontally to avoid large pressure drops.
 - On top of the detector 256 APD modules in one loop - 3.0 gallons/minute total.
 - 128 APD modules in one loop on the sides.
 - Use reverse return to balance flow.
 - Factor of five headroom in flow.
 - APD Module Water Flow Calculation

Cooling System Zones & Dimensions

4 primary cooling zones along the length of the detector supplied by chilled water at 48 °F supplied by FESS.

□ 3 zones of 8 sections + 1 zone of 7 sections.

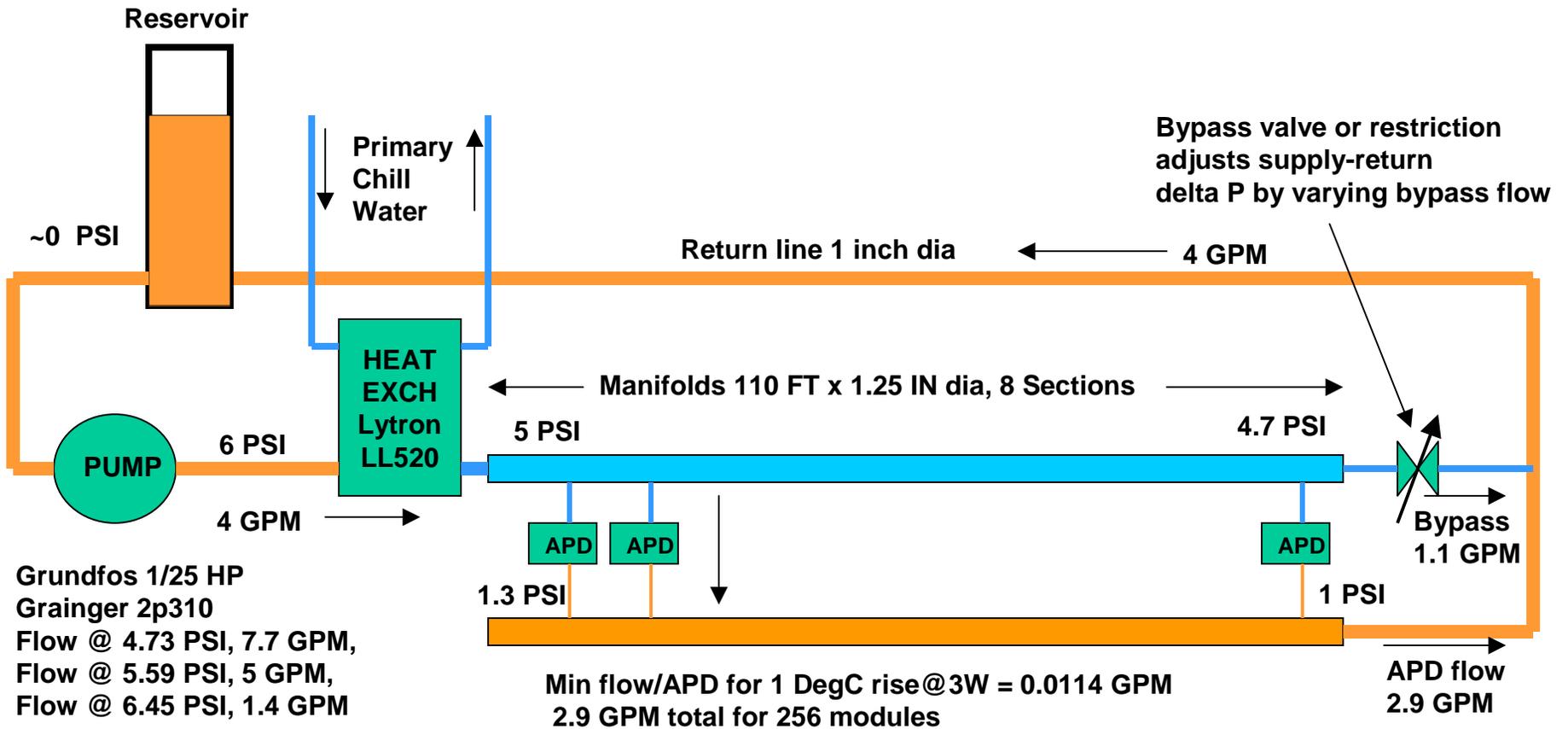
*12 rows
of detectors
each face*



*1 secondary cooling
loop per row, per zone,
(water from heat exch to
APDs)*

*12 row x 3 face x 4 zones
= 144 secondary loops*

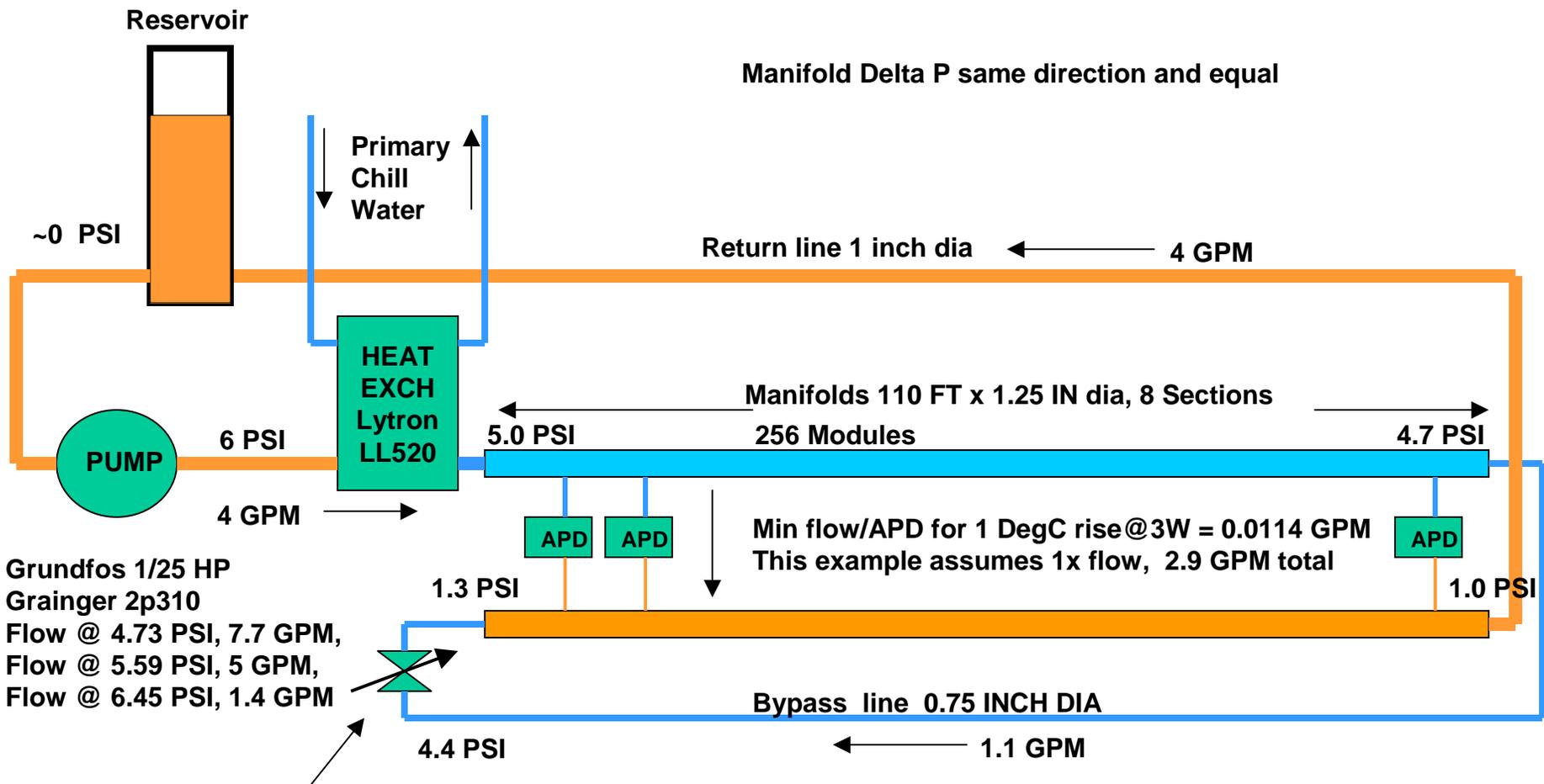
Reverse Return Manifold w/End Bypass Example



Manifold delta P same direction, but unequal due to bypass flow

This is our strawman design.

Mirror Reverse Return Manifold Example

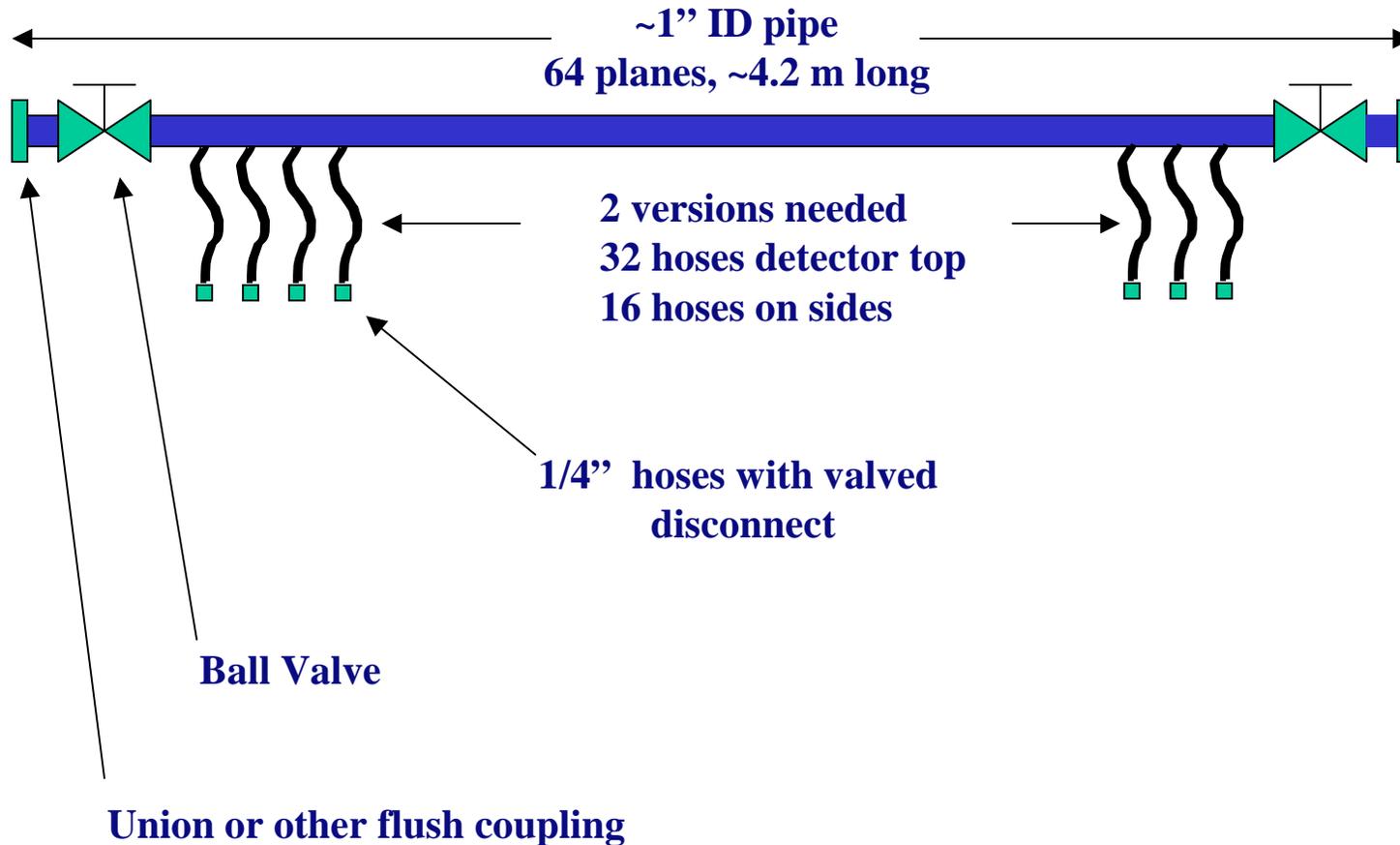


Grundfos 1/25 HP
Grainger 2p310
Flow @ 4.73 PSI, 7.7 GPM,
Flow @ 5.59 PSI, 5 GPM,
Flow @ 6.45 PSI, 1.4 GPM

Bypass valve or restriction
adjusts supply-return
delta P by varying bypass flow

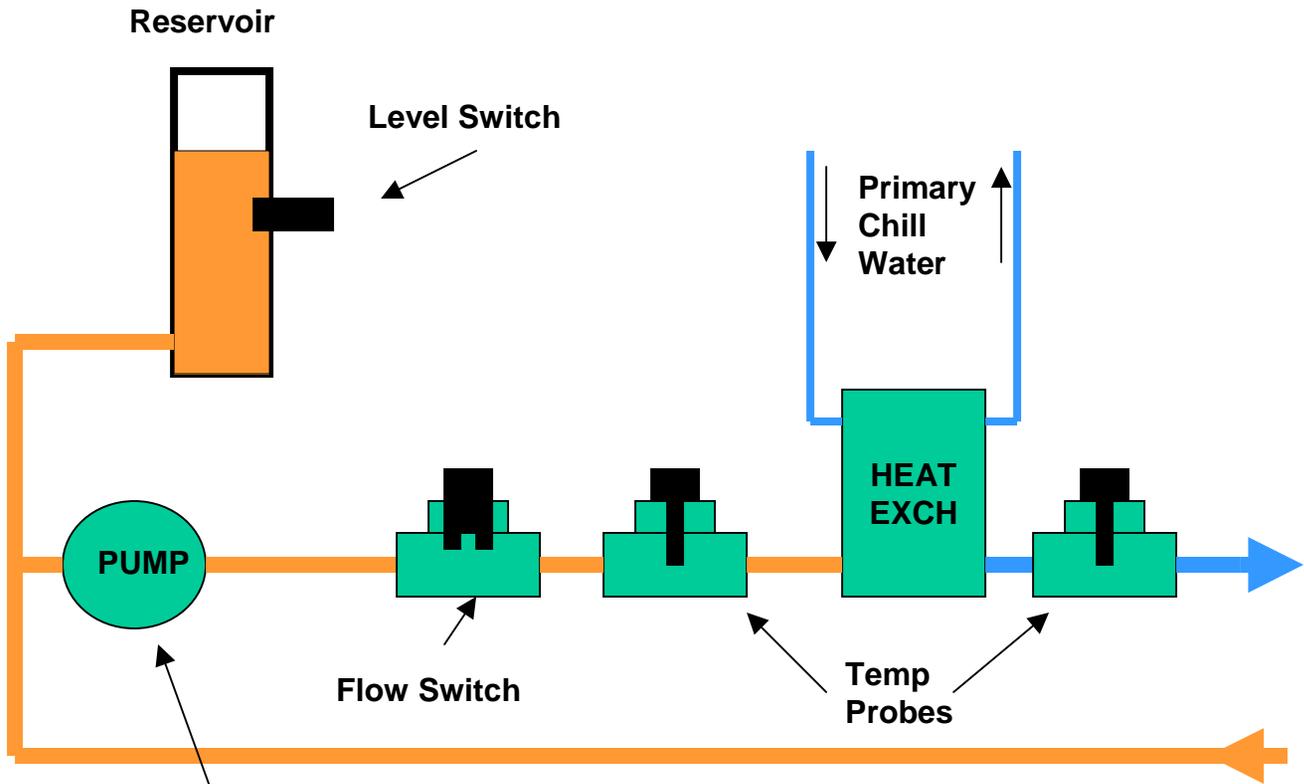
Pressure drops estimated with schedule 80 PVC using calculator found at:
<http://www.irrigationtutorials.com/formulas.htm#sec8>

NOVA Cooling Manifold Section



**Each manifold connects to 64 (32) modules on the top (side).
Connect eight manifolds together as the detector is built up.**

Secondary Cooling Loop Instrumentation



**Flow switch from
Omega catalog**



System Cost Cooling

Detector top, insulated manifold. Assuming 1 loop per row of APD modules:
 31 sections x 12 sensor rows x 2 per loop = 744 needed.

1	~1" x 12 ft pipe section with 32 hose barbs installed	\$200	\$200
2	ball valve	\$ 15	\$ 30
1	union(1/2 each end)	\$ 10	\$ 10
32	hose assembly with valved quick disconnect	\$ 15	\$ 480
?	pipe & tube insulation	\$	\$ 10
2	hours assembly/testing labor	\$ 50	\$100
Total Each			\$830

Detector sides, insulated manifold. Assuming 1 loop per row of APD modules:
 31 sections x 24 sensor rows x 2 per loop = 1488 needed.

1	~1" x 12 ft pipe section with 16 hose barbs installed	\$ 150	\$150
2	ball valve	\$ 15	\$ 30
1	union(1/2 each end)	\$ 10	\$ 10
16	hose assembly with valved quick disconnect	\$ 15	\$ 240
?	pipe & tube insulation	\$	\$ 10
1.5	hours assembly/testing labor	\$ 50	\$ 75
Total Each			\$ 515

Cost per Secondary Cooling Loop

SWAG cost estimate for loops on detector top, side loops a bit lower:

1	Pump 1/25hp bronze cast	\$ 150	\$ 150
1	Heat Exchanger (~LytronLL520)	\$ 200	\$ 200
16	Top manifold assembly	\$ 830	\$ 13280
1	Fluid Reservoir	\$ 50	\$ 50
1	Fluid level switch(float, capacitive, other)	\$ 80	\$ 80
2	Temp probes, RTD in welded SS fitting	\$ 50	\$ 100
1	Flow switch (~Omega FST-211-SPST)	\$ 160	\$ 160
1	Channel, motor controls, enclosure	\$ 200	\$ 200
6	Remote I/O channels(2 temp, 1flow, 1 level, 1 pump status, 1 pump control)	\$ 200	\$ 1200
x	Misc pipe, wire, cable	\$ 100	\$ 100
24	man-hours assembly: mount 8 manifold sections make 512 quick connects mount & connect pump & other components install wire duct, field wiring, fill, test etc.	\$ 50	\$ 1200
	Total		\$ 16720

Total manifold cost = 12 * 2 * 4 * \$17k = \$1.6M