

## Cooling Connections Status Report: LBNL Effort

**February, 2002**

**N. Hartman, E. Anderssen, M. Gilchriese, F. Goozen, T. Johnson,  
T. Weber, J. Wirth**

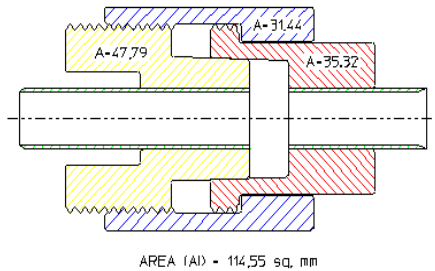
## Current Status

- **Second round of fittings made**
  - Fitting cross sections optimized for low mass
  - Indium and Luer Lock variants machined
  - Sector, exhaust, and capillary size fittings created
- **Laser welding in progress**
  - New fittings have been sent out for laser welding (exhaust and capillary)
  - Pre-production sector tubes (final bend shape) are being readied for welding
- **Capillary, type 0, and type 1 tubing being evaluated**
  - 4 mm ID, 8 mm ID, and two capillary tubing sizes have all been obtained in aluminum for testing
  - Preliminary capillary calculations have been made suggesting a capillary ID of ~0.8 mm
  - A more accurate model of capillary pressure drop (as well as plans to measure this) is in the works
- **Prototype u-tube constructed**
  - Prototype designed for flexibility in alignment
  - Frame length changed for u-tube clearance

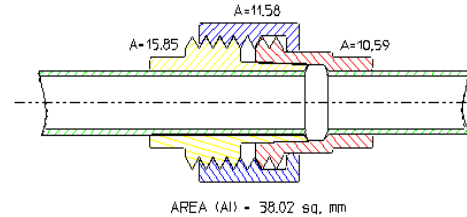
## Fitting Comparisons – Mass and X-Section

Fitting	Metal X-Area	T Al/fitting	T Plastic/fitting	T Ni,In,Cu/Fitting	% X0/fitting	# fittings	%X0
Luer Lock (Al) - Baseline	115	6.0E-05	0.0E+00	0.0E+00	0.08%	75	5.63%
Variseal (w/ centering ring)	40	2.4E-05	9.4E-07	0.0E+00	0.03%	75	2.27%
Variseal (w/o centering ring)	36	2.1E-05	9.4E-07	0.0E+00	0.03%	75	2.03%
Indium Fitting (Stave Size - CuNi)^	13	0.0E+00	0.0E+00	4.7E-06	0.02%	75	1.75%
<b>Reduced Mass Luer Lock</b>	41	1.6E-05	0.0E+00	0.0E+00	0.02%	75	1.51%
<b>Indium Fitting (Sector Size - Al)*</b>	36	1.3E-05	0.0E+00	3.1E-07	0.02%	75	1.32%

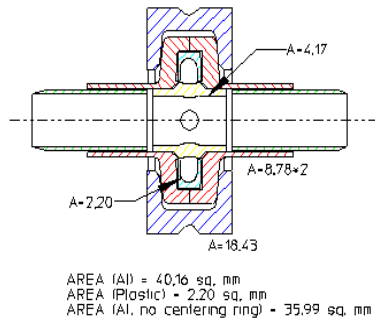
Fitting Volume Smeared over hoop at radius 210 mm, 50 mm long.



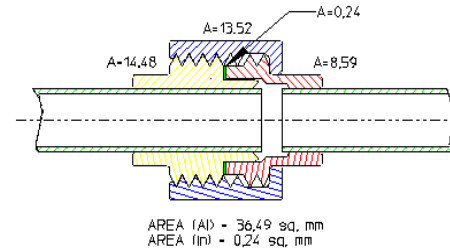
**Current Luer Design**



**"Reduced-Mass" Luer Design**

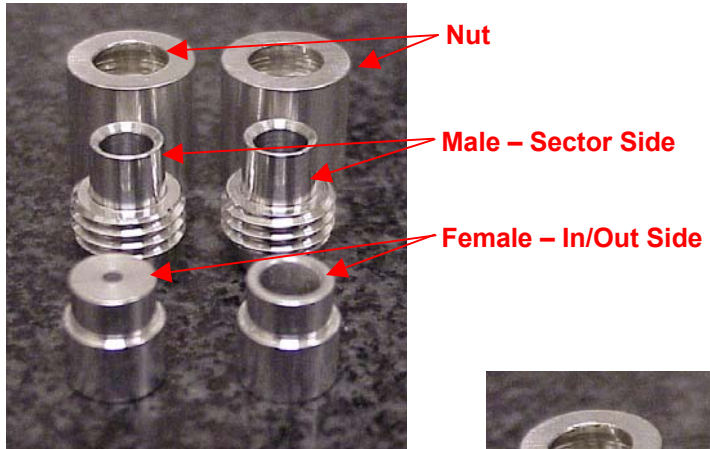


**Old Variseal Design**



**Sector Indium Design**

## “Reduced-Mass” Luer Fittings



Nut, Male, Female Fitting Pieces



Male and Female Pieces Assembled



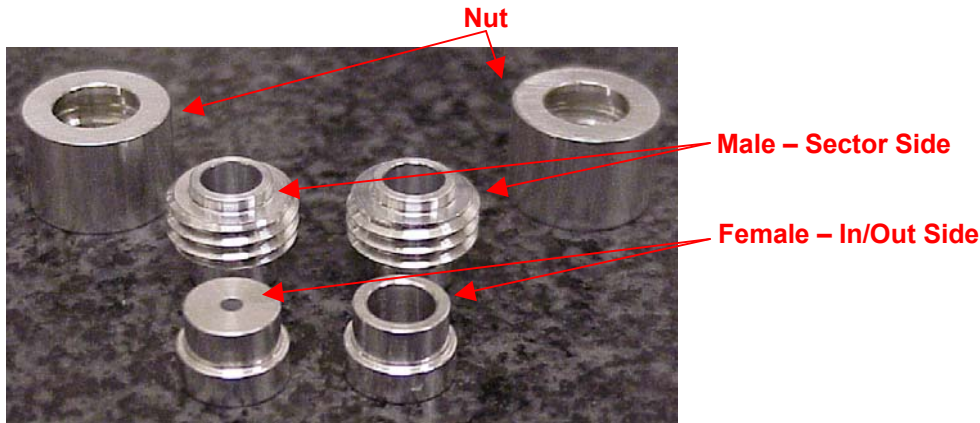
Sector Side - Assembled



In/Out Side - Assembled

# Pixel Detector

## Sector Indium Fittings



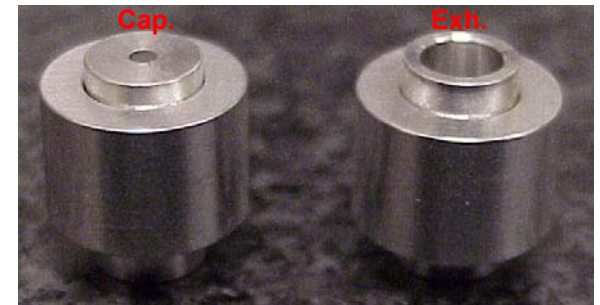
Nut, Male, Female Fitting Pieces



Male and Female  
Pieces Assembled  
(In Washer Not Shown)



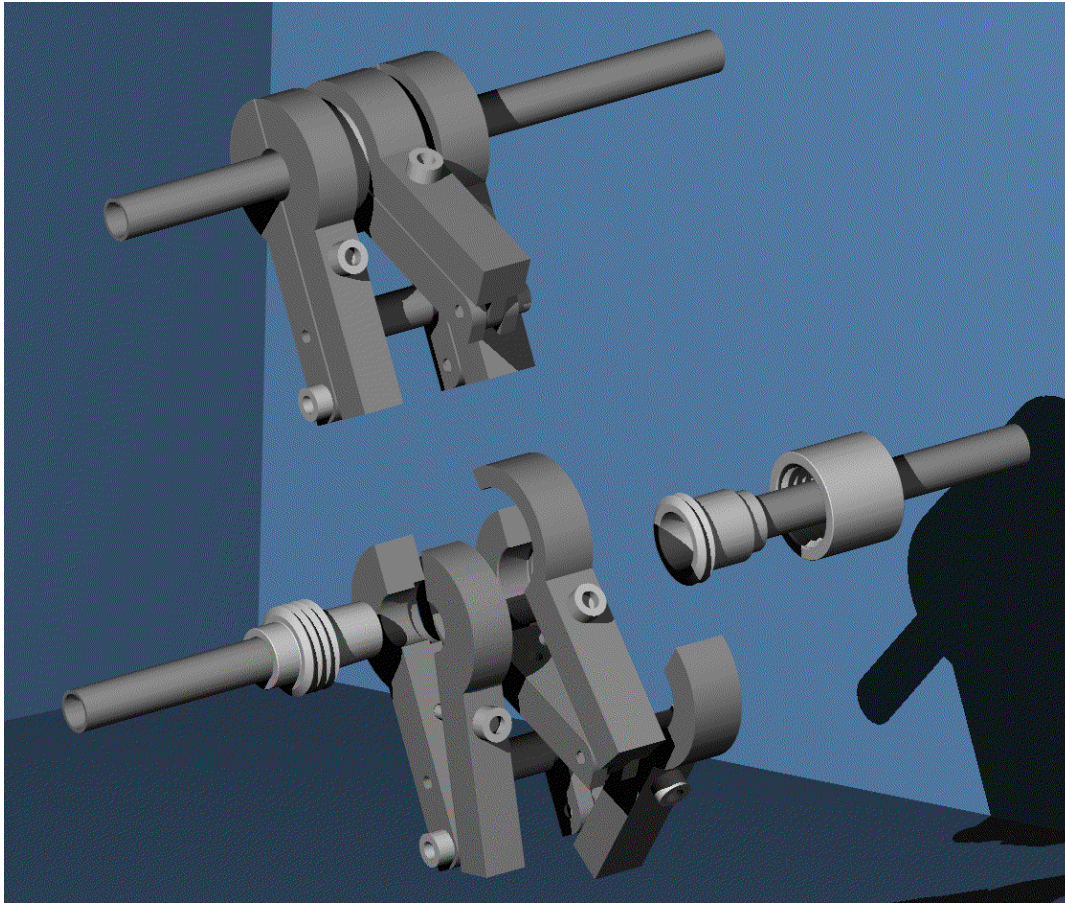
Sector Side - Assembled



In/Out Side - Assembled

# Pixel Detector

## Fitting Wrench



- Works with Luer and Indium Fittings
- Prevents differentially torquing the two joining tubes
- Provides for assembly as well as disassembly

## Fitting #'s Fabricated and Sent out for Welding

LUER:					INDIUM:				
Number Ordered:					Number Ordered:				
Fitting Tally	Sectors	U-tubes	Blanks	Totals	Fitting Tally	Sectors	U-tubes	Blanks	Totals
Male - Sector Bore	40			40	Male - Sector Bore	40			40
Male - Blanks			20	20	Male - Blanks			20	20
Female - Capillary	20			20	Female - Capillary	20			20
Female - Exhaust	20	20		40	Female - Exhaust	20	20		40
Female - Blanks			10	10	Female - Blanks			10	10
Nut - Exh/Sector	40	20	10	70	Nut - Exh/Sector	40	20	10	70
<b>Totals</b>	<b>120</b>	<b>40</b>	<b>40</b>	<b>200</b>	<b>Totals</b>	<b>120</b>	<b>40</b>	<b>40</b>	<b>200</b>

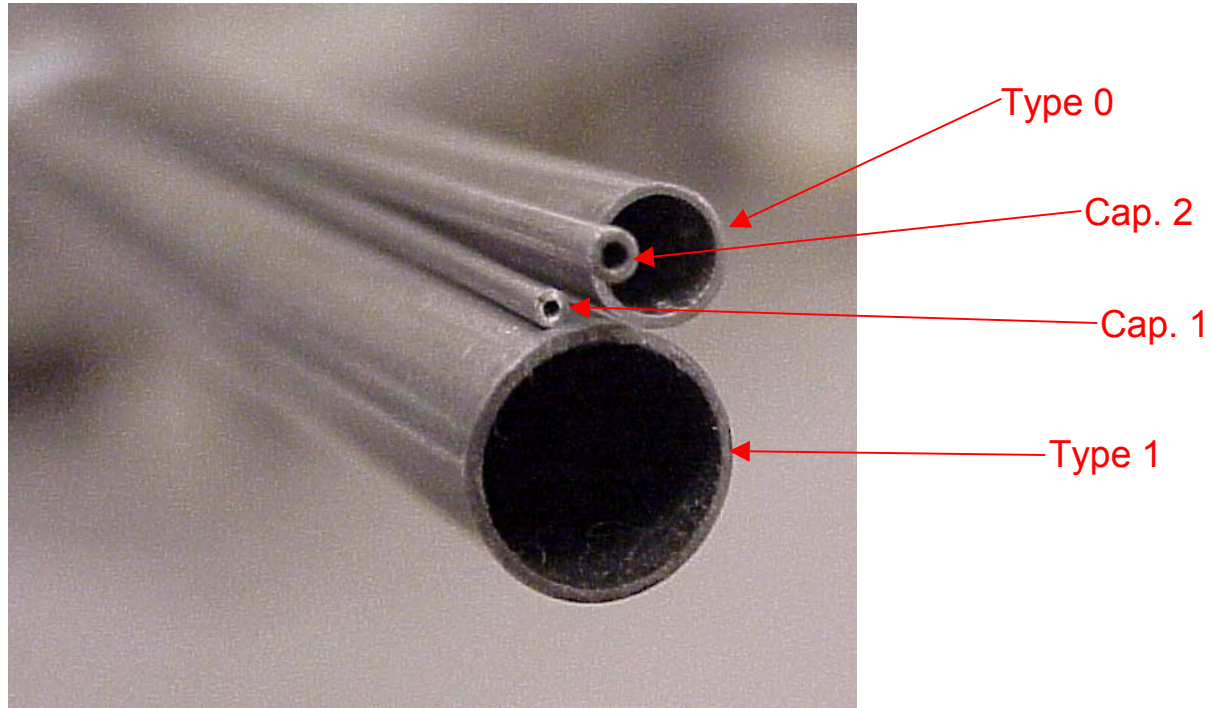
- **Samples sent out for welding**
  - Capillaries
    - 4 Luer 1.2 m long capillaries (Capillary 2 size)
    - 4 Indium 1.2 m long capillaries (Capillary 2 size)
  - Type 0 tubing
    - 4 Luer 2 m long type 0 tubes (longest available)
    - 4 Indium 2 m long type 0 tubes (longest available)
  - U-tubes
    - 3 Full Indium u-tubes (with trapped nuts)
    - 3 Full Luer u-tubes (with trapped nuts)

## Sector Pre-production Welding Plans

- **Delivery and Handling**
  - Each sector tube will be cleaned and mounted to a “carrier” plate
  - The fittings will be cleaned and assembled to nominal position on the carrier
  - The carrier/sector tube assembly will be dry-bagged and shipped to the laser weld vendor
- **Welding Setup**
  - The vendor will align a plate supplied by LBL to the welder’s worktable
    - Plate will have alignment pins corresponding to each sector outlet
  - Carrier plate will have two sets of alignment holes, one for each side of sector tube
    - Carrier plate will self align to fixture on welder’s worktable, in position for welding either side
  - Fitting height will be adjustable (within  $\sim 0.2$  mm) to suit most preferable weld geometry
- **Quality Assurance**
  - The sector tube’s welds will be inspected with an He leak detector to 10-7 Torr, without removing sector tube from carrier
  - Carrier and welded sector tube will be re-bagged and shipped back to LBL



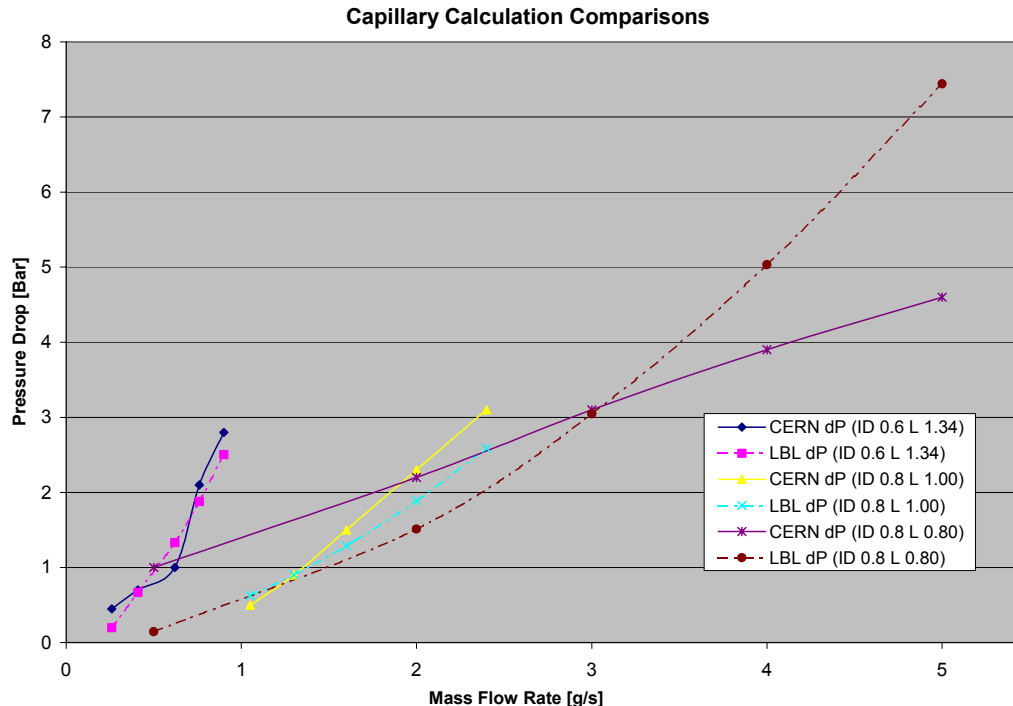
## Capillary, Type 0, and Type 1 Tubing



Tubing Type	Nominal ID [mm]	Actual ID [mm]	Actual OD [mm]	Wall [mm]
Capillary 1	-	0.48	1.19	0.36
Capillary 2	-	0.88	1.59	0.36
Type 0	4	4.05	4.76	0.36
Type 1	8	7.92	8.73	0.41

## Capillary Pressure Drop Calculations

- Model based on all liquid flow in capillary (simple pipe flow correlations)
- Results match CERN calculations fairly closely
- Student is now working on two phase solution, as well as developing methods to measure dP at LBL for QA/QC purposes (without evaporative cooling system present)



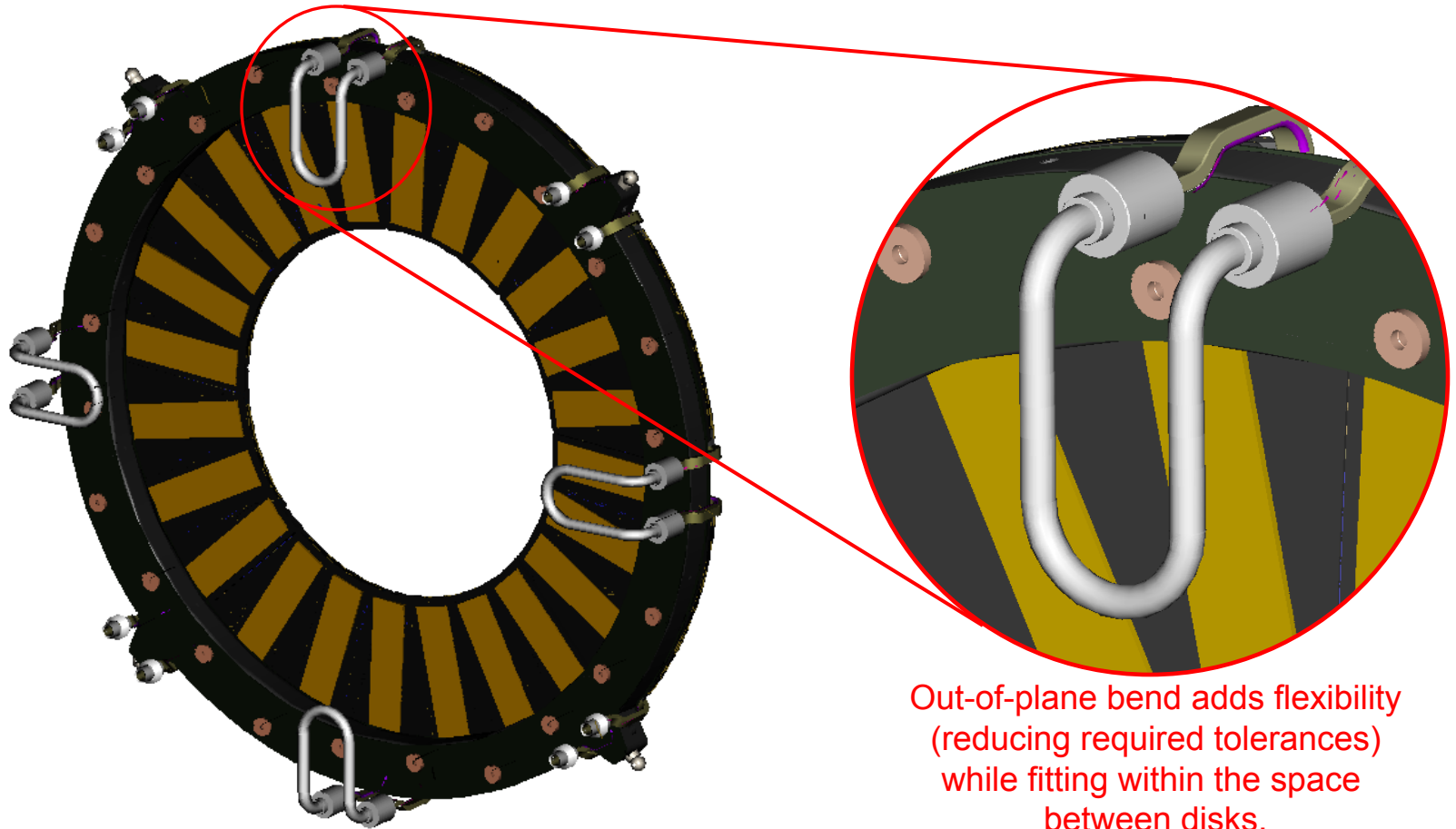
## Estimated Capillary Size Calculations

Pressure Drop (Bar) vs. Capillary Length, Flow Rate, and ID

Flow Rate [g/s]	Capillary ID [mm]					
	0.50	0.60	0.70	0.80	0.90	1.00
<b>Length 300</b>						
1.50	3.18	1.34	0.65	0.35	0.20	0.12
2.25	6.43	2.71	1.31	0.71	0.40	0.24
3.00	10.64	4.48	2.17	1.17	0.67	0.40
<b>Length 600</b>						
1.50	6.36	2.68	1.30	0.70	0.40	0.24
2.25	12.86	5.42	2.63	1.42	0.81	0.49
3.00	21.28	8.97	4.35	2.34	1.34	0.80
<b>Length 900</b>						
1.50	9.54	4.02	1.95	1.05	0.60	0.36
2.25	19.29	8.13	3.94	2.12	1.21	0.73
3.00	31.92	13.45	6.52	3.51	2.01	1.20
<b>Length 1200</b>						
1.50	12.72	5.36	2.60	1.40	0.80	0.48
2.25	25.72	10.84	5.26	2.83	1.62	0.97
3.00	42.56	17.93	8.70	4.68	2.68	1.61

- **Assumptions**
  - Flow rate up to 3 g/s
  - Capillary length of at least 0.6 m
  - Must not exceed dP of 3 bar in capillary
- **Colors denote unacceptable dP (orange), borderline dP (yellow), and safe dP (green)**
  - Target capillary size is somewhere in the range of ID 0.7 to 0.9 mm
  - This size most closely matches capillary “size 2”

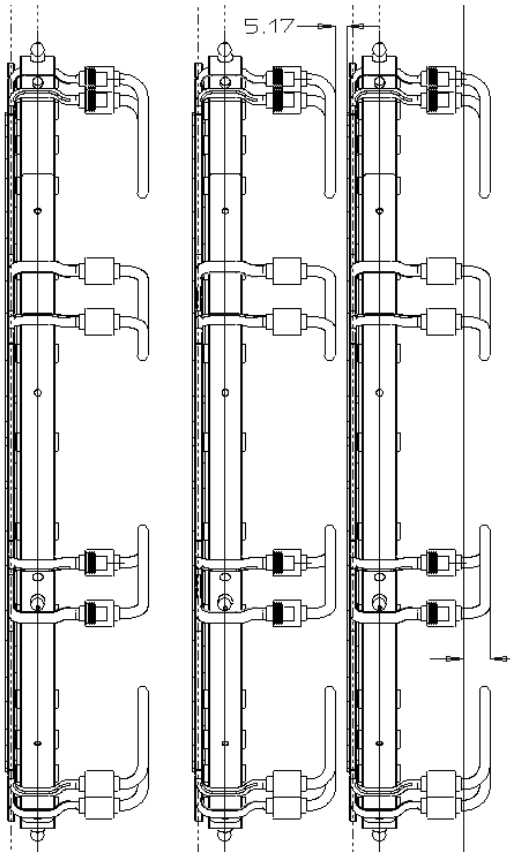
## U-tube Design



Sector Disk with U-tubes

Out-of-plane bend adds flexibility  
(reducing required tolerances)  
while fitting within the space  
between disks.

## U-tube Shape



Relative Disk Positions  
and Spacing



Bent U-tube (Using exhaust tubing)

## Upcoming Work

- **Testing of reduced mass luer and indium fittings**
  - Testing to be done in March
  - Still need to fabricate adapter pieces for welding up test samples
- **Sector pre-production welding**
  - Fabricate 10 sector tubes with Luer and Indium fittings
  - Verify weld QA and alignment system success (i.e. carriers and alignment plate)
- **Capillary testing**
  - Robustness tests
    - Bend/unbend repetitions
    - Pressure/leak testing (with swage lock connectors)
  - Verification of target pressure drop
    - Develop model of two phase flow
    - Devise method for measuring pressure drop in absence of evaporative cooling system
- **Full system prototype**
  - Complete cooling circuit prototype from pp1 to sector
  - All “real” fittings – all laser welded (including 4/8 mm tubes)
  - Completed sometime before next summer
  - Plans to test in Marseille with evaporative cooling plant