LLO Y arm Leak Localization Results

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Summary The accumulations and valve modulations made in June and July 2013 have been analyzed. The highest probability solution at the current level of sensitivity is a single leak of 4.2 x 10^{-5} torr liters/sec located at 1930 +- 50 meters from the LVEA tube end. The uncertainty embraces the mid building and the gate valve. Improvements in the analysis and data collection have been made: amu5 is used to correct for offsets in the RGA (07/13) data, the temperature has been determined from the amu2 outgassing and the new model of the beamtube includes the effect of the baffles which reduces the pumping speed of the tube by 0.74. The correction for the baffles brings the accumulation and valve modulation methods into better agreement for the leak positions. The methods are still dominated by systematic errors as the random errors are a few meters. Work is progressing on using the entire pressure time series for the localization, see **Figures 3** and **4.**

Data

Table 1 Localizations and technique

type of measurement	date	# of leaks	results xlk, qlk	notes
valve modulation	07/25/13	1	1951+-13m	χ^2 min lvea,yend,mid
valve modulation	07/25/13	1	1938+-21m	deterministic lvea,yend **Fig 1** and **3**
valve modultion	07/25/13	2	1932+-20m 2.1x10^{-6} 1952+-20m 4.0x10^{-5}	χ^2 min lvew,yend,mid **Fig 1** and **3**
accumulation #2	07/25/13	1	1890+-50m	deterministic lvea,yend
accumulation #1	07/23/13	1	1991+-40m	deterministic lvea,yend
accumulation	06/04/13	1	1932+-52m	deterministic lvea,yend
valve modulation	06/04/13	1	1903+-30m	χ^2 min and offset mid fit lvea,yend,mid **Fig 2**
valve modulation	06/04/13	2	1825 -> 1900m	χ^2 min and offset mid fit lvea,yend,mid **Fig 2**

χ^2 surfaces

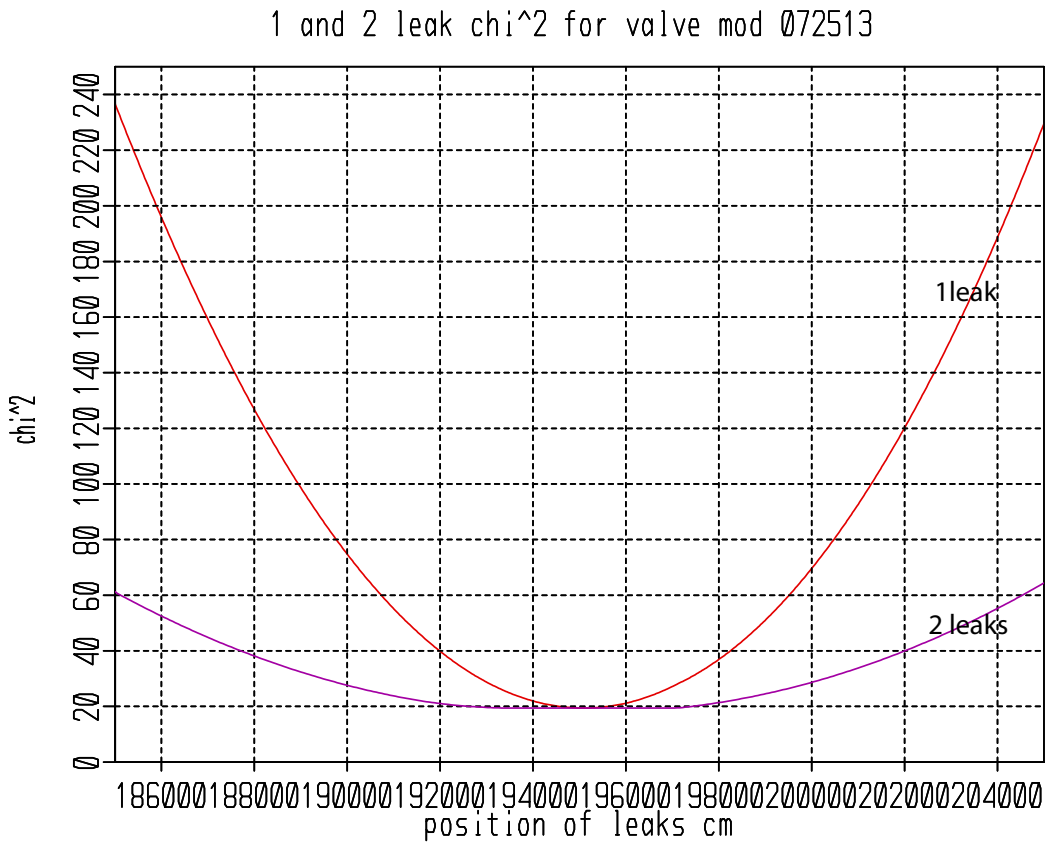

Figure 1 χ^2 plots for one and two leak models to the data from the valve modulation on 072513. The data was the best we have taken with only corrections for temperature variations needed. The RGA offsets were measured using amu5 as the reference. The model with 1 leak gives the same χ^2 as the one with two leaks. There is a solution for two leaks with one leak very much smaller than the other. The broadening of the χ^2 curve embraces the small leak which implies that the two leak solution is not useful and is probably not correct at this level of sensitivity.

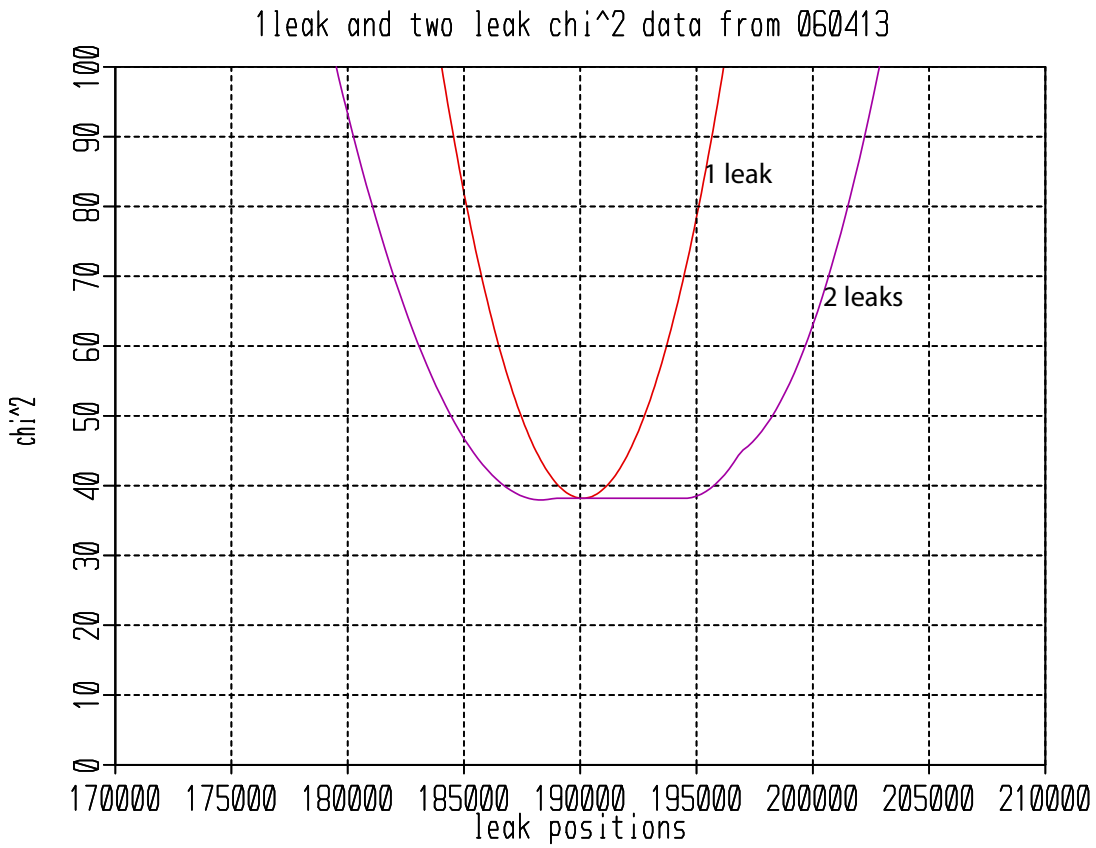

Figure 2 χ^2 for one and two leak models to the data from the valve modulation of 060413. The data has been corrected for an offset of -1.7 x 10^{-9} torr in RGA data at the mid building, The offset was determined by minimizing χ^2. The data is much less trustworthy than that of **Figure 1** as the two leak fit is sensitive to the offset . With a small change of the offset solution, the two leak model fit flattens to have no solution for a second leak. Again, the data is best fit by a single leak.

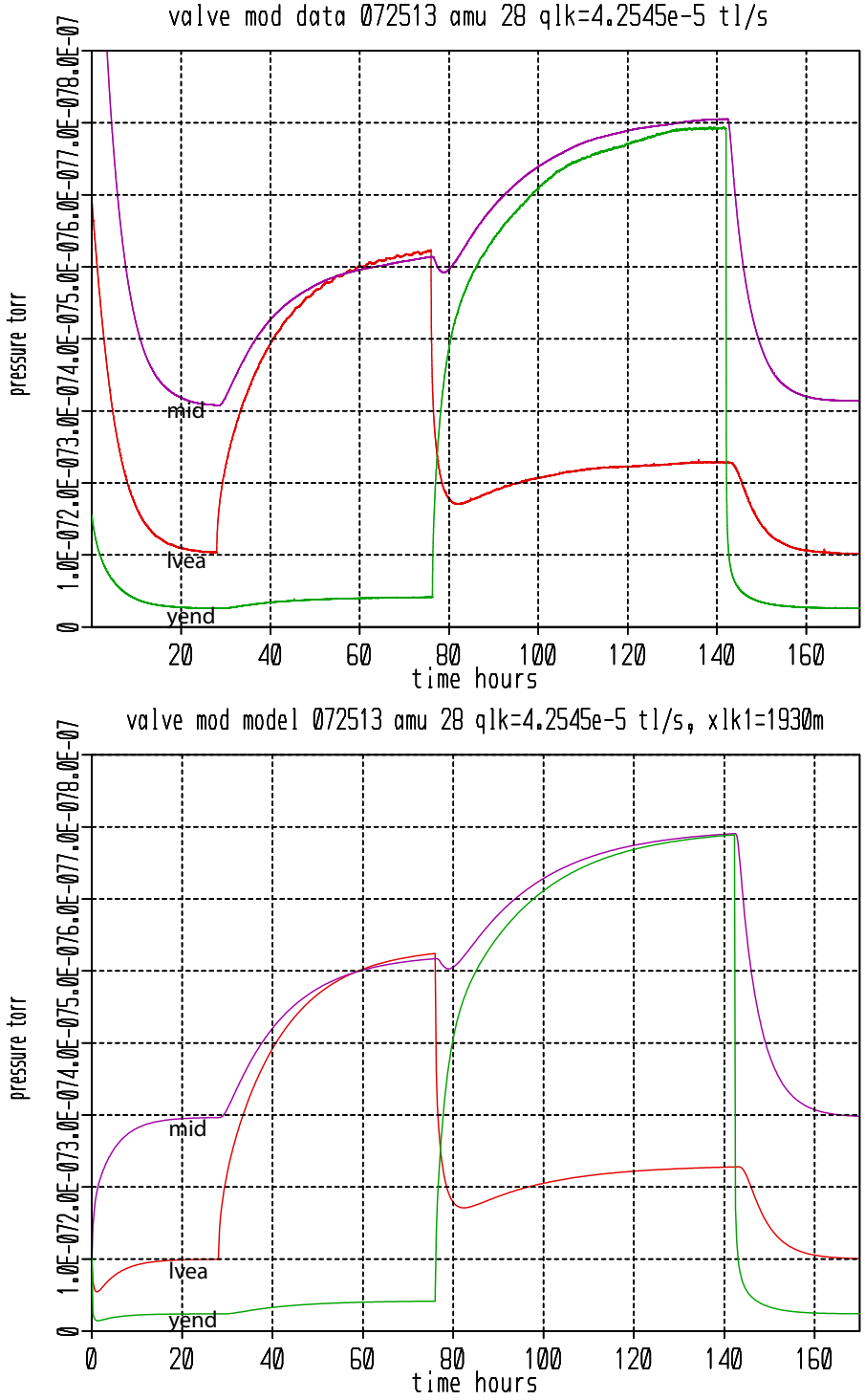

Figure 3 Top figure is the amu28 pressure data as a function of time at the LVEA, mid and yend RGAs while the lower figure is the result of a finite element diffusion model with the same times for the valve modulations and a single leak of 4.25×10^{-5} torr liters/sec at 1930m. The model after 20 hours in the lower figure corresponds moderately well with the actual data above. In the data fitting for the leak location, the yend data was adjusted for the temperature variation between 100 to 140 hours. The corrected data has the pressure in the mid and yend RGA come together as in the model. The ability to χ^2 minimum fit the entire pressure time series to the model is being programmed. An important finding has been that the baffles in the tube reduce the pumping speed of the tube to 0.74 of the standard estimate for a straight long tube. A simple model of the tube in series with apertures given by the number of baffles gives a similar result

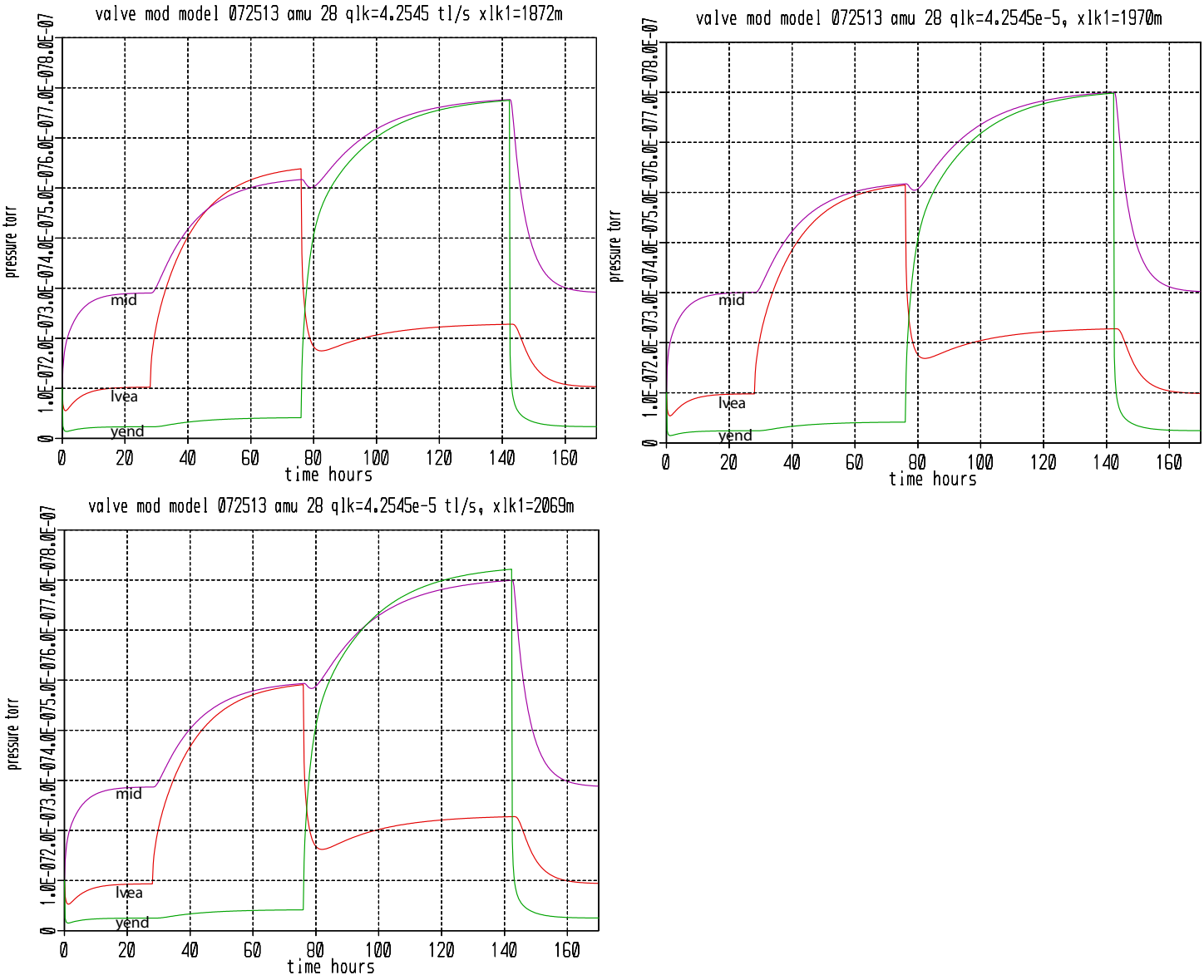

Figure 4 Finite element model for three different leak locations near middle of the tube.

Table 2 Derivatives dp/dxlk torr/meter at the plateaus in the valve modulation

Pump on lvea yend	lvea	mid	yend
1 1	-4.58×10^{-11}	-4.55×10^{-11} 1.05×10^{-10}	$8.30e10^{-12}$
0 1	-2.42×10^{-10}	3.05×10^{-12} -2.40×10^{-10}	2.74×10^{-13}
1 0	-1.71×10^{-12}	-6.44×10^{-12} 2.39×10^{-10}	2.38×10^{-10}

Double entry in mid is due to slope discontinuity when xlk=position of RGA