Reliably Cooling Accelerators

The Australian Synchrotron

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Lead Accelerator Operator

Reliably cooling Accelerators

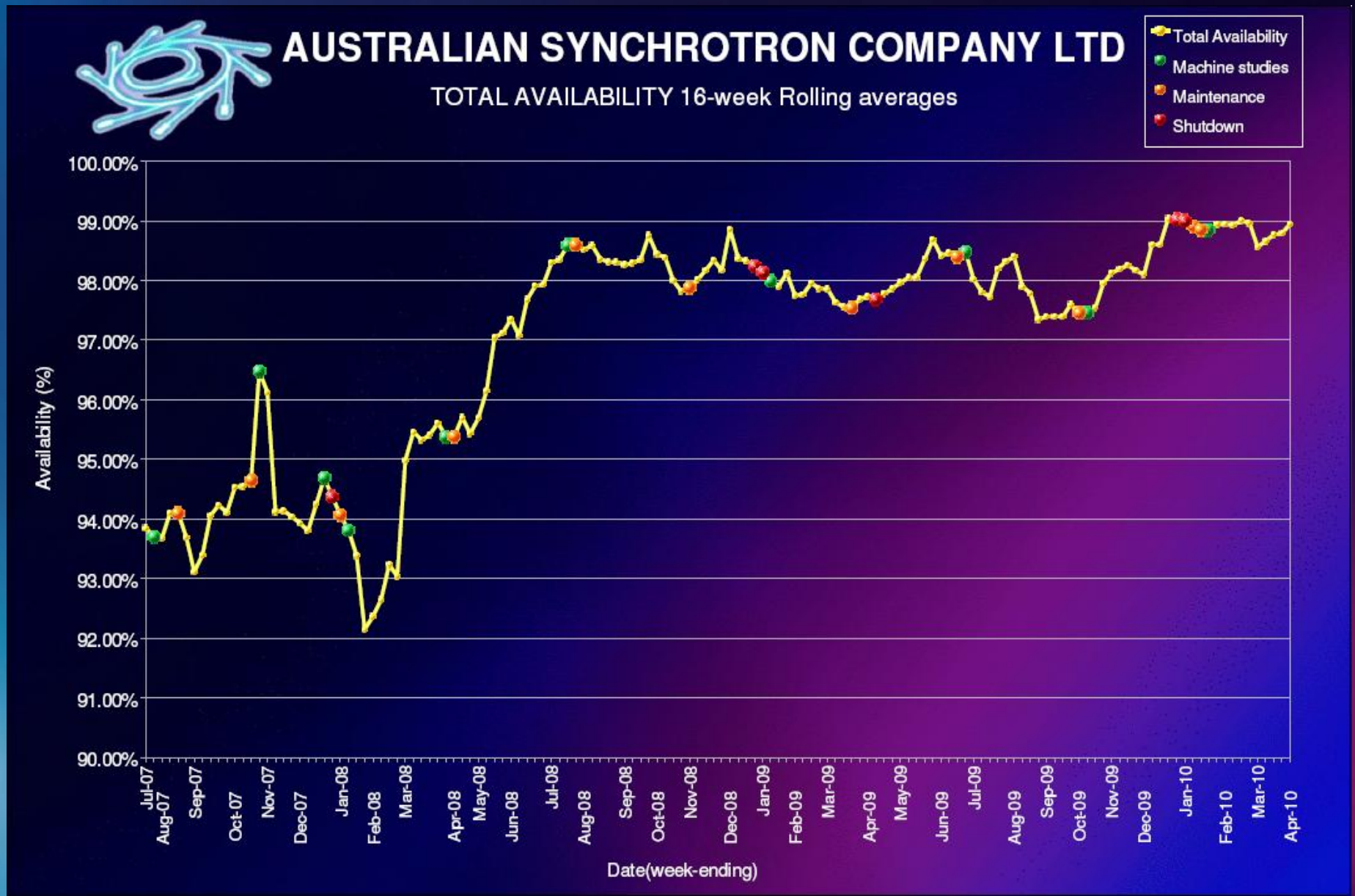
Its easy, just flow some cool water through whatever you wish to cool.

But

- If there is too little flow -> melt things
- If there is too much flow -> erode things
- If the pH is too low or too high -> corrode things
- If the oxygen level is too high -> oxidise things
- If the oxygen level is too low -> strip protective oxide layer
- If the temperature is not stable -> dimensional instabilities
- If temperature is too low or too high -> leaks
- If the conductivity is too high or too low -> corrosion

At the Australian Synchrotron we have tried to implement worlds best practise to eliminate, or at least minimise the disruption caused by cooling water problems.

Beam Availability during Scheduled User Time

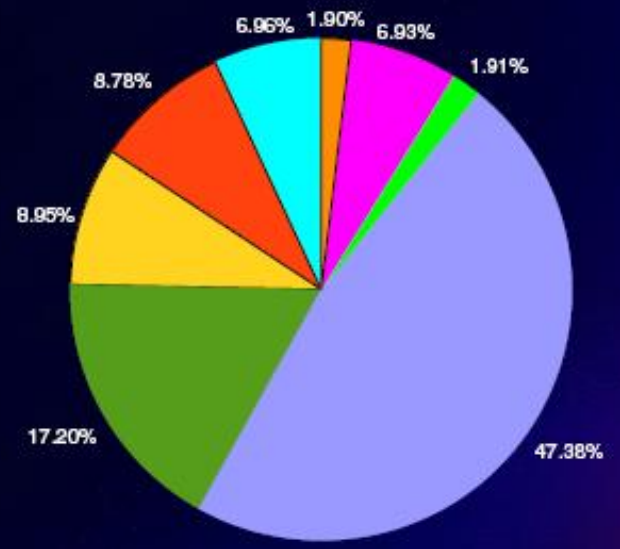


AUSTRALIAN SYNCHROTRON COMPANY LTD

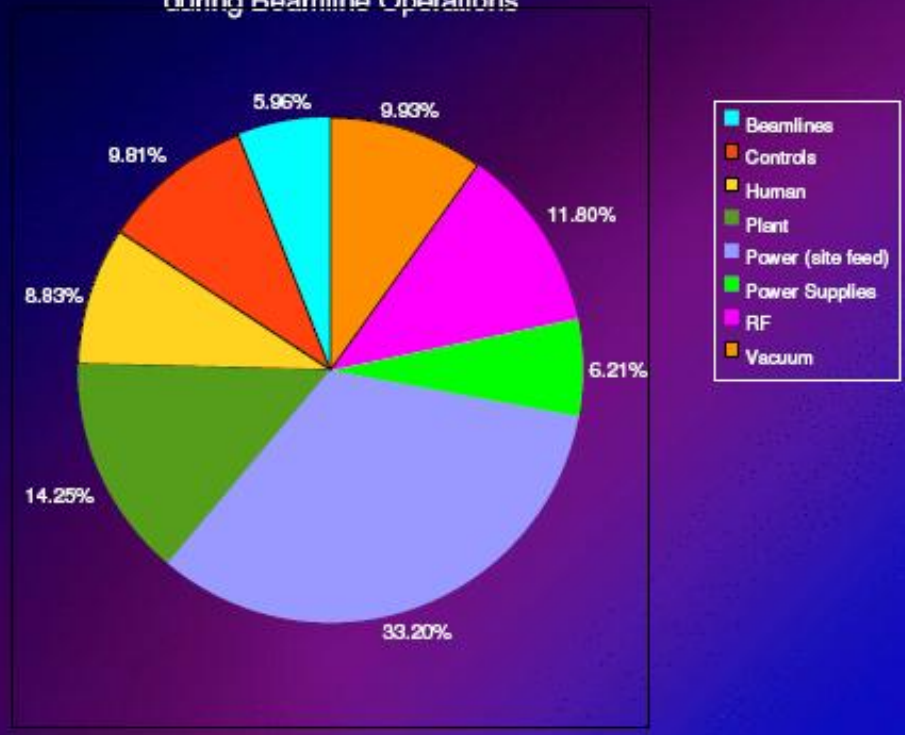
MTBF & MDT 16-week Rolling averages

AUSTRALIAN SYNCHROTRON COMPANY LTD

Percentage of total Downtime for Last 12 months during Beamline Operations



Percentage of total Downtime since beginning (Apr 07) during Beamline Operations



Melted HOM Damper in SRRF Cavity

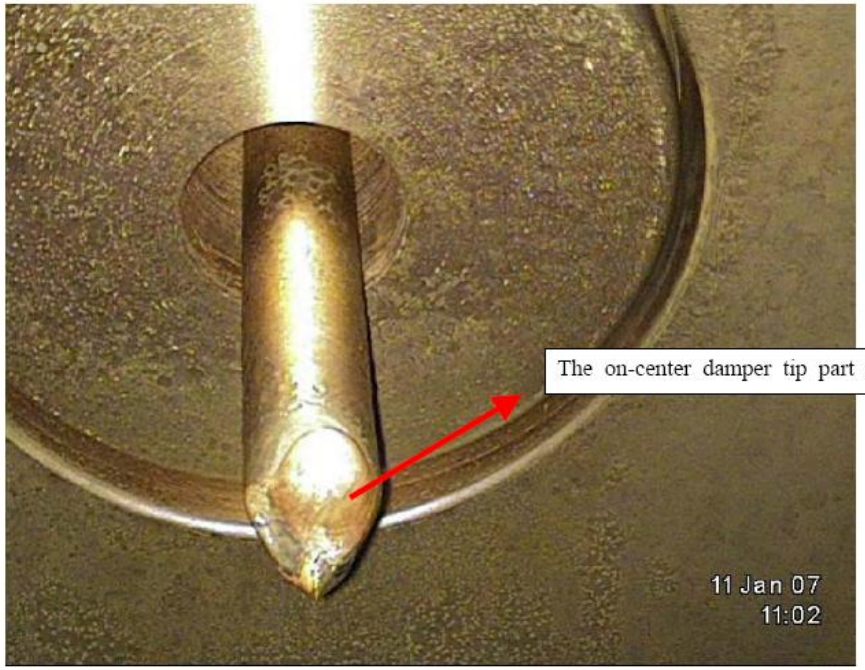


Fig. 2.4 (1) On-center damper copper sheath tip partial photograph

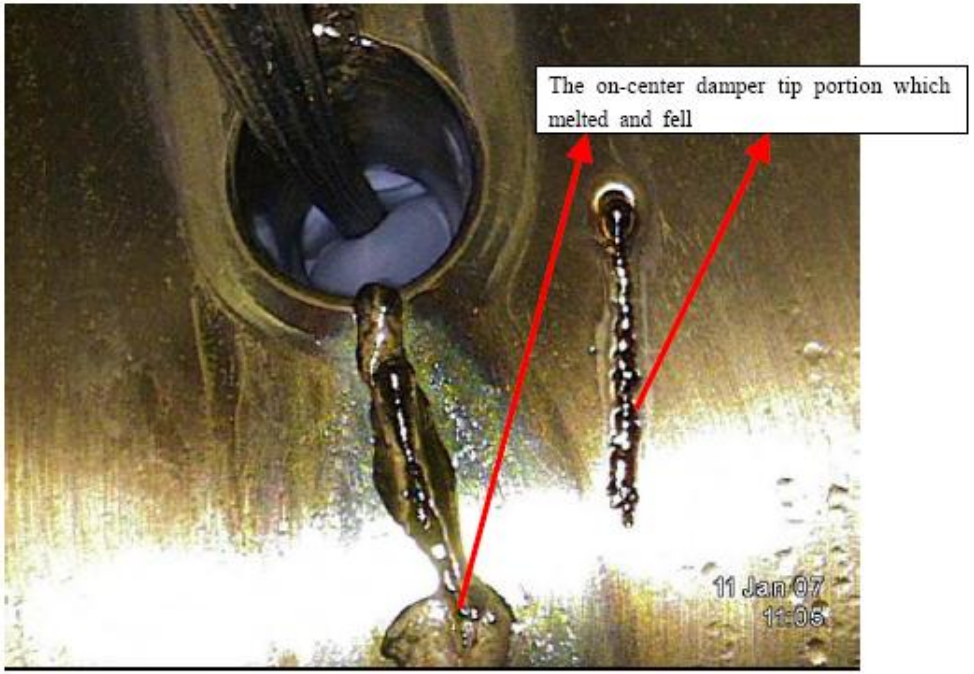
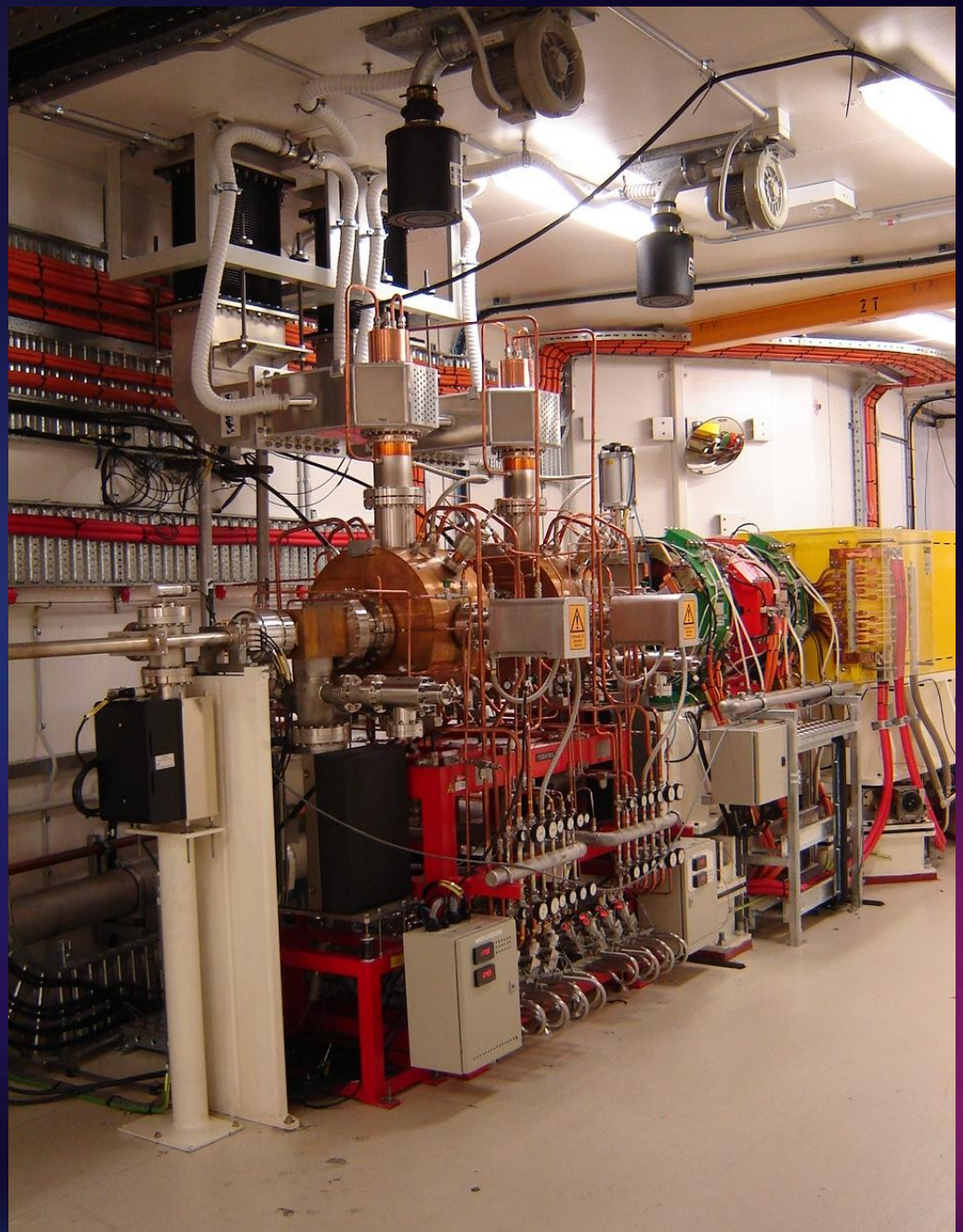
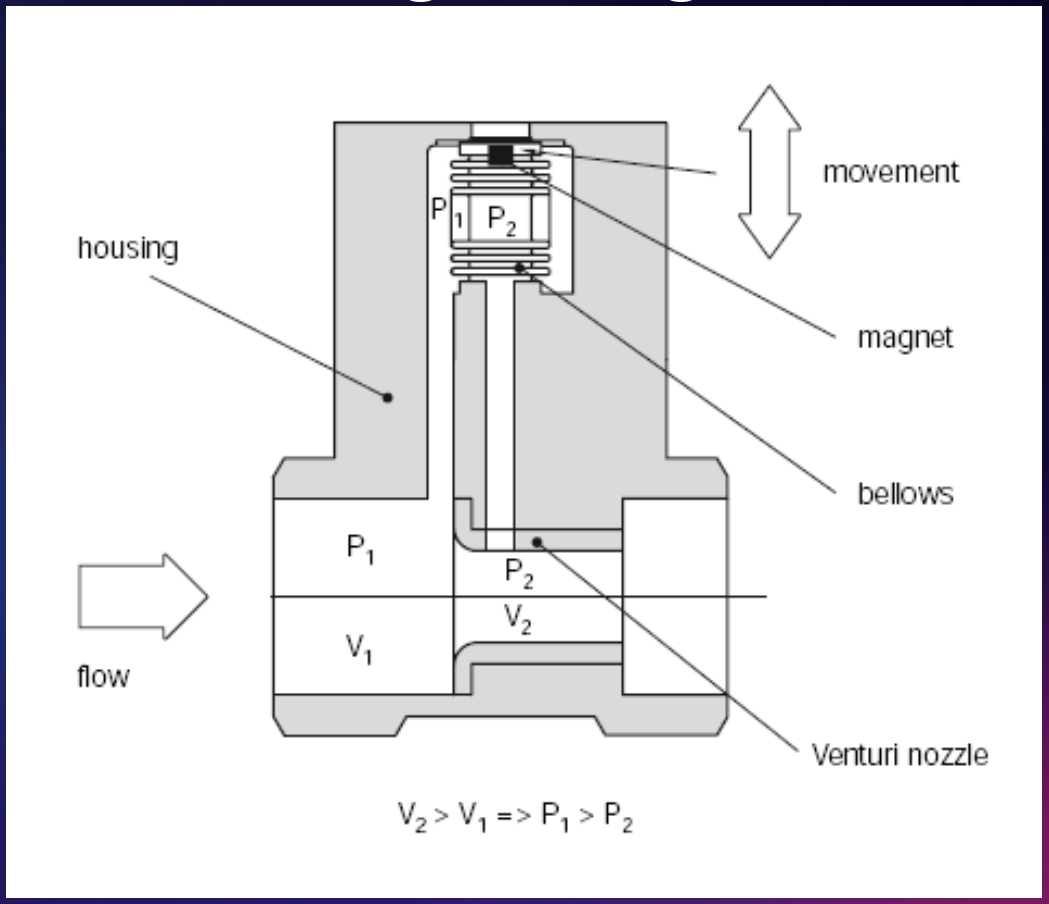


Fig. 2.4 (3) On-center damper tip portion (2) which melted and fell

Two of the SRRF cavities showing the extra flow meters added after the meltdown



Flow Meters used for Storage Ring LCW



Stainless Steel construction, no moving parts, remote digital readout
Differential Pressure with Hall effect monitor

Failure Modes of Flow meters

Have experienced greater than 20% failure rate

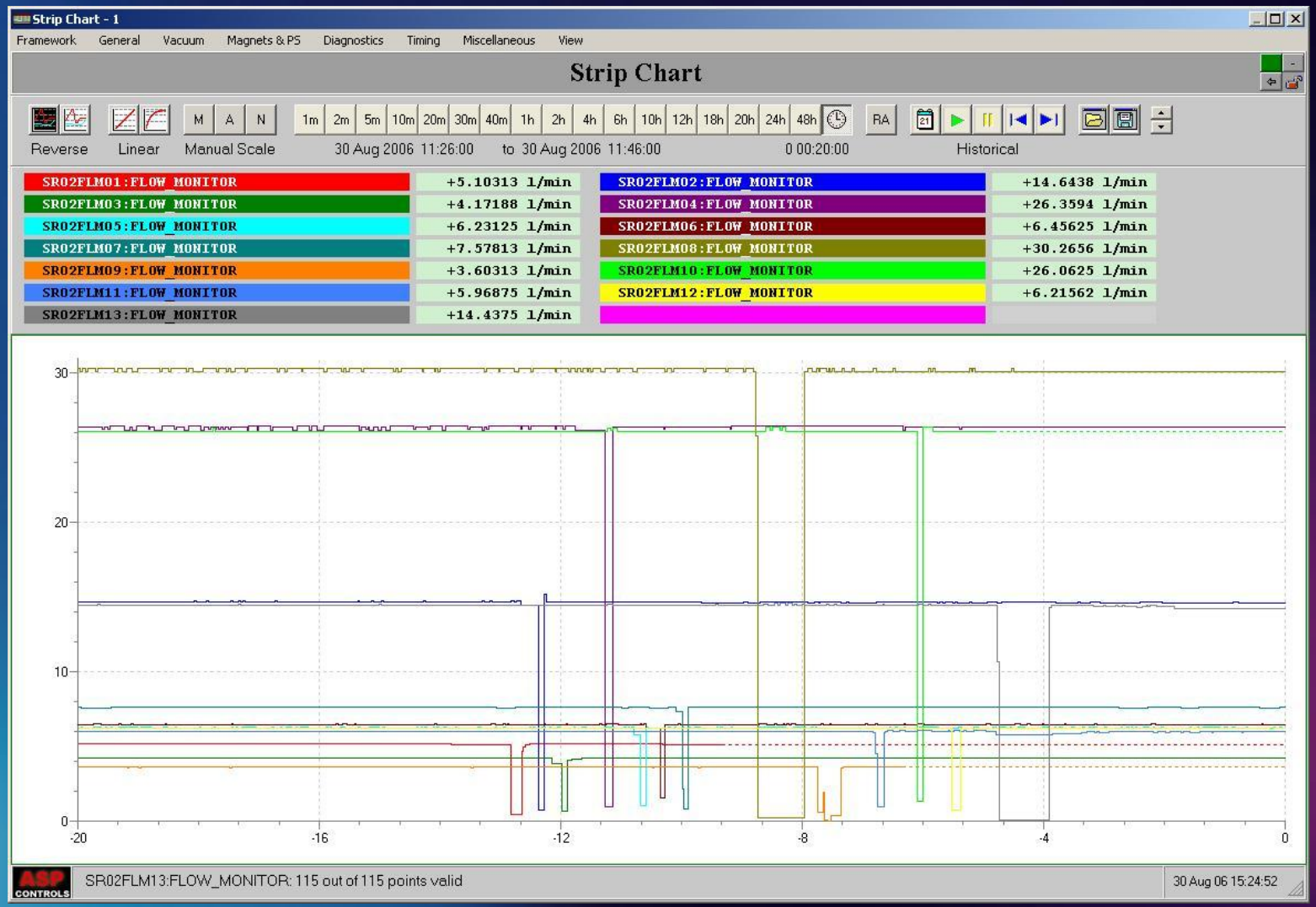
- PCB failure (change to non-Pb solder)
- Radiation Damage
- Magnet coming loose
- Earth leakage
- Failure to read Zero at zero flow
- High non-linearity
- Susceptibility to strong magnet fields

Better reliability if the meters are operated at flows near 50% flow range

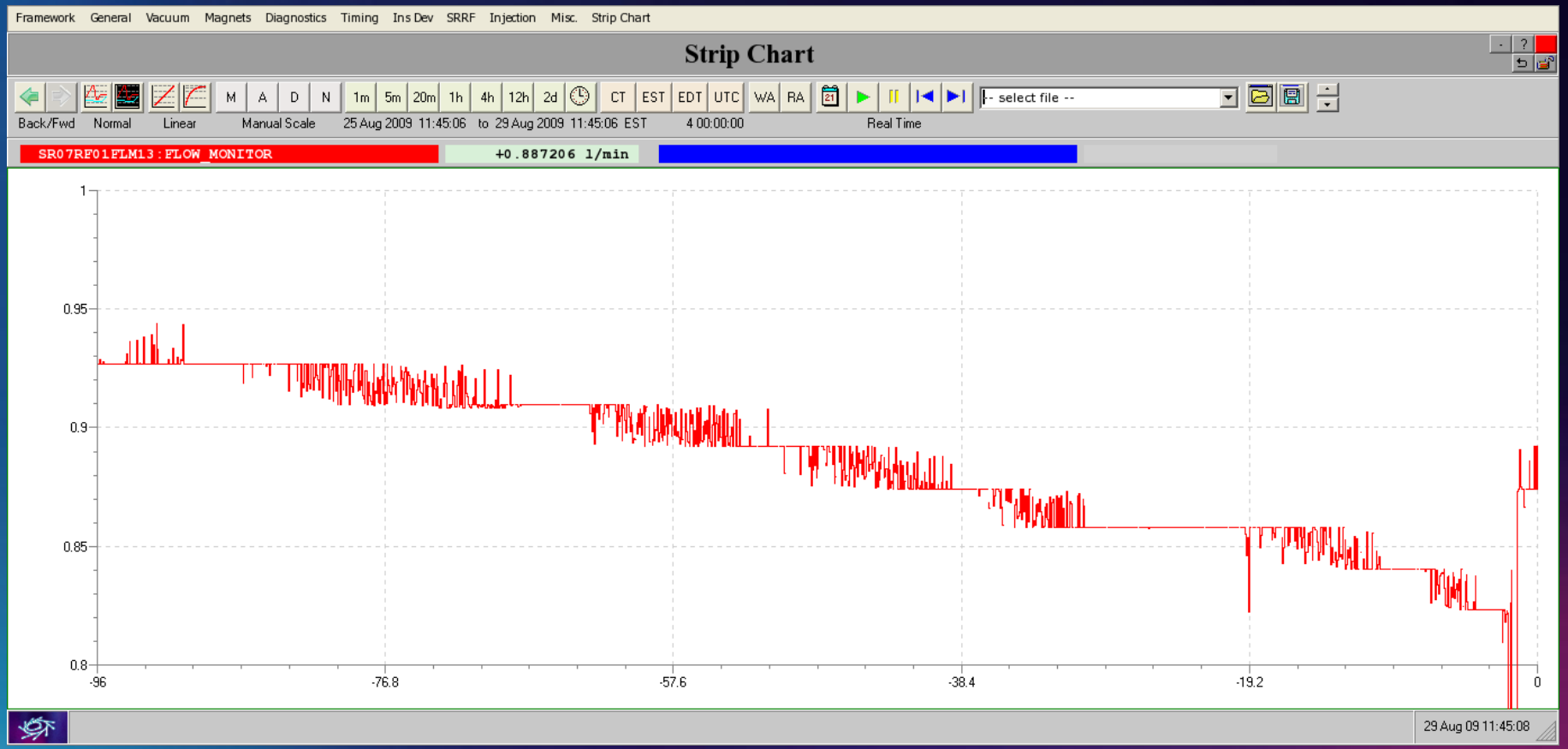
Also have ongoing problems with fouling of flow control valves

Required a simple and reliable way to test meters.

Testing Flow Meters by closing valves



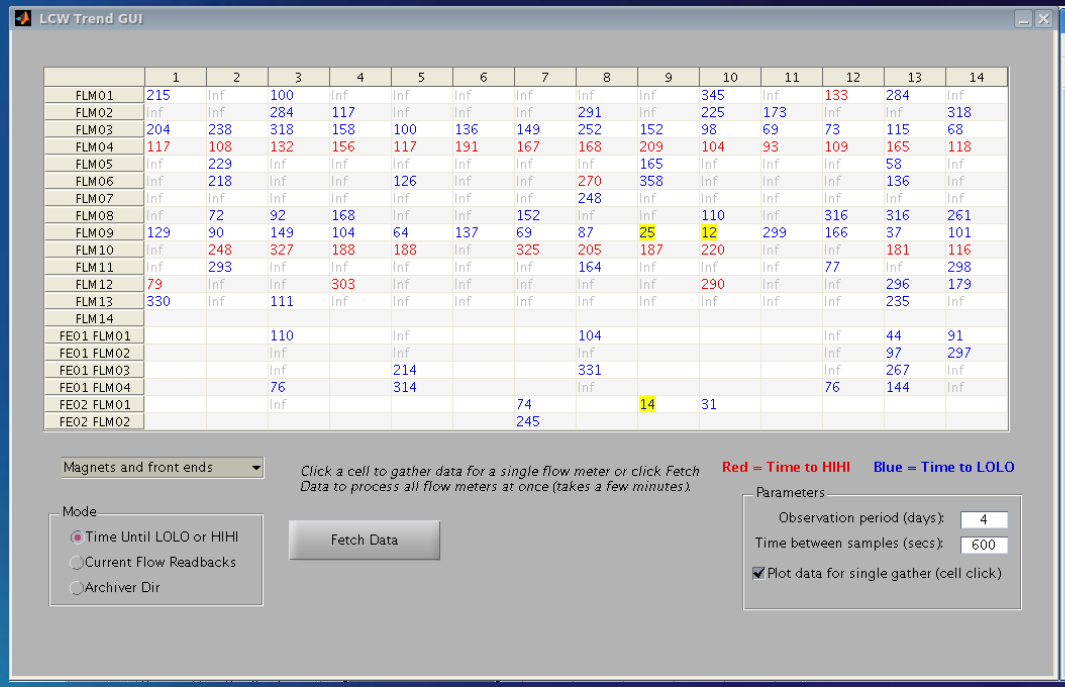
Drop in flow over a 4 day period



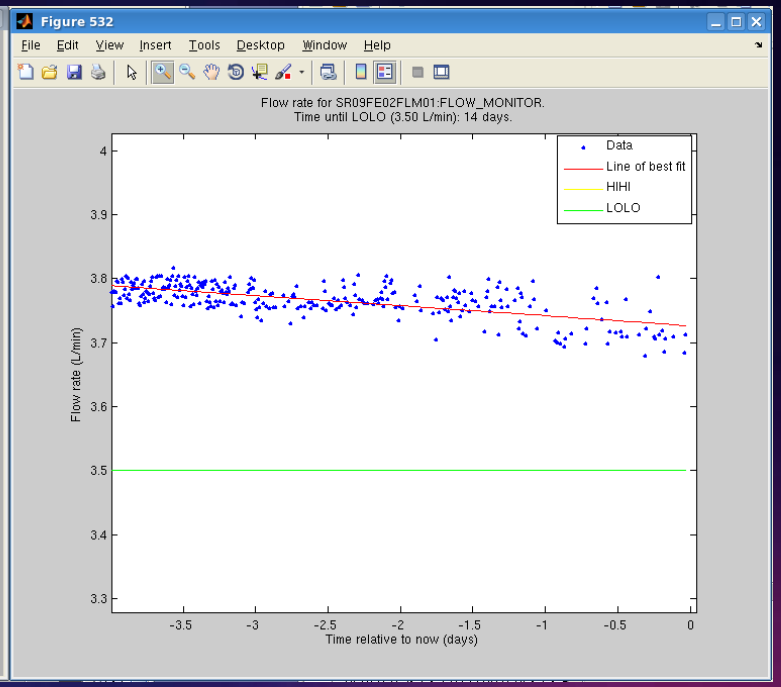
The trip point was 0.8 l/m

LCW Trend GUI

(matlab script accessing EPICS database)



	1	2	3	4	5	6	7	8	9	10	11	12	13	14
FLM01	215	Inf	100	Inf	Inf	Inf	Inf	Inf	Inf	345	Inf	133	284	Inf
FLM02	Inf	Inf	284	117	Inf	Inf	Inf	291	Inf	225	173	Inf	Inf	318
FLM03	204	238	318	158	100	136	149	252	152	98	69	73	115	68
FLM04	117	108	132	156	117	191	167	168	209	104	93	109	165	118
FLM05	Inf	229	Inf	Inf	Inf	Inf	Inf	Inf	165	Inf	Inf	Inf	58	Inf
FLM06	Inf	218	Inf	Inf	126	Inf	Inf	270	358	Inf	Inf	Inf	136	Inf
FLM07	Inf	Inf	Inf	Inf	Inf	Inf	Inf	248	Inf	Inf	Inf	Inf	Inf	Inf
FLM08	Inf	72	92	168	Inf	Inf	152	Inf	Inf	110	Inf	316	316	261
FLM09	129	90	149	104	64	137	69	87	25	12	299	166	37	101
FLM10	Inf	248	327	188	188	Inf	325	205	187	220	Inf	Inf	181	116
FLM11	Inf	293	Inf	Inf	Inf	Inf	Inf	164	Inf	Inf	Inf	77	Inf	298
FLM12	79	Inf	Inf	303	Inf	Inf	Inf	Inf	Inf	290	Inf	Inf	296	179
FLM13	330	Inf	111	Inf	Inf	Inf	Inf	Inf	Inf	Inf	Inf	Inf	235	Inf
FLM14														
FE01 FLM01			110		Inf			104				Inf	44	91
FE01 FLM02			Inf		Inf			Inf				Inf	97	297
FE01 FLM03			Inf		214			331				Inf	267	Inf
FE01 FLM04			76		314			Inf				76	144	Inf
FE02 FLM01			Inf				74		14	31				
FE02 FLM02							245							



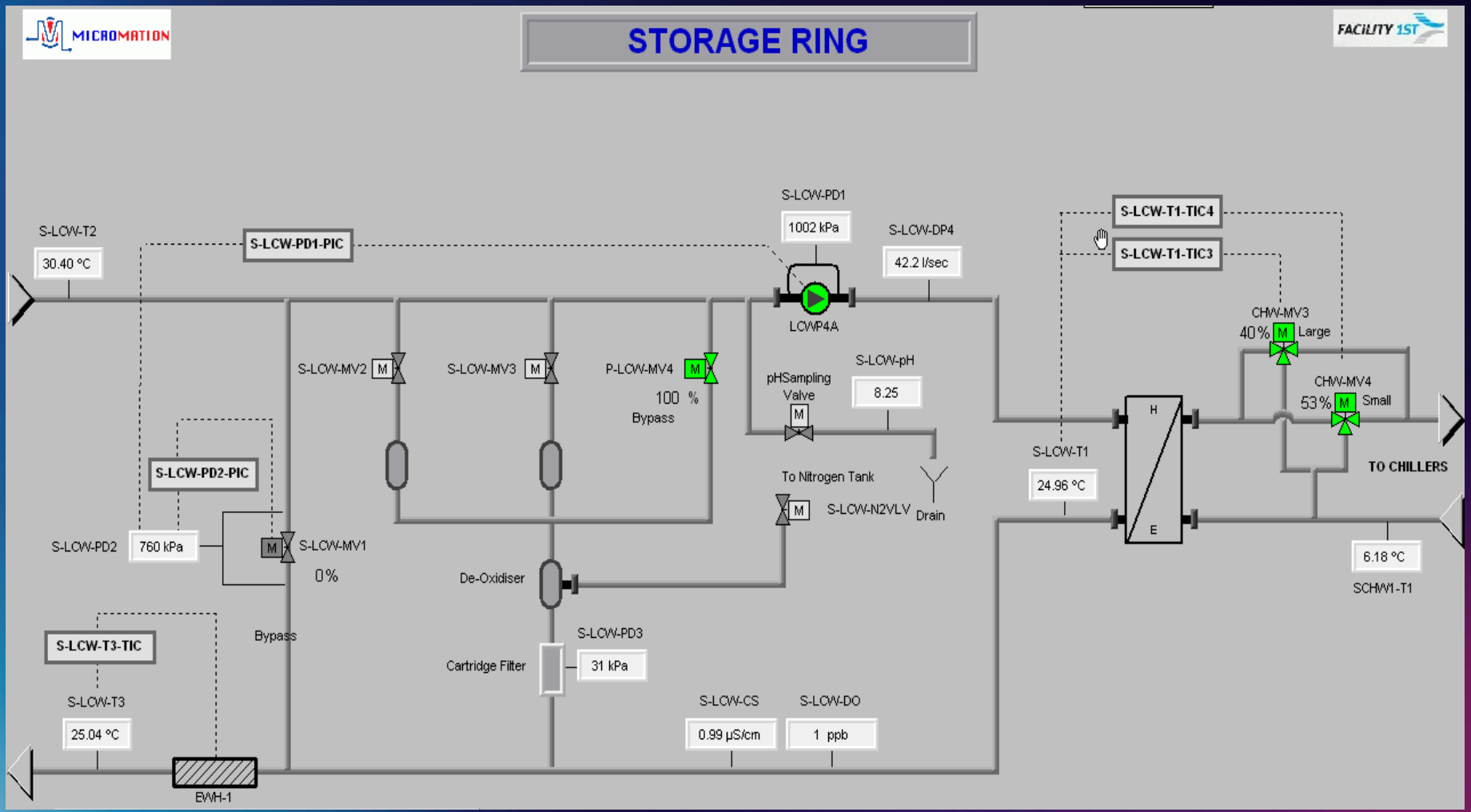
Select a duration and sampling interval

Fit a line and calculate time to LOLO or HIHI

Highlight those < 4 weeks

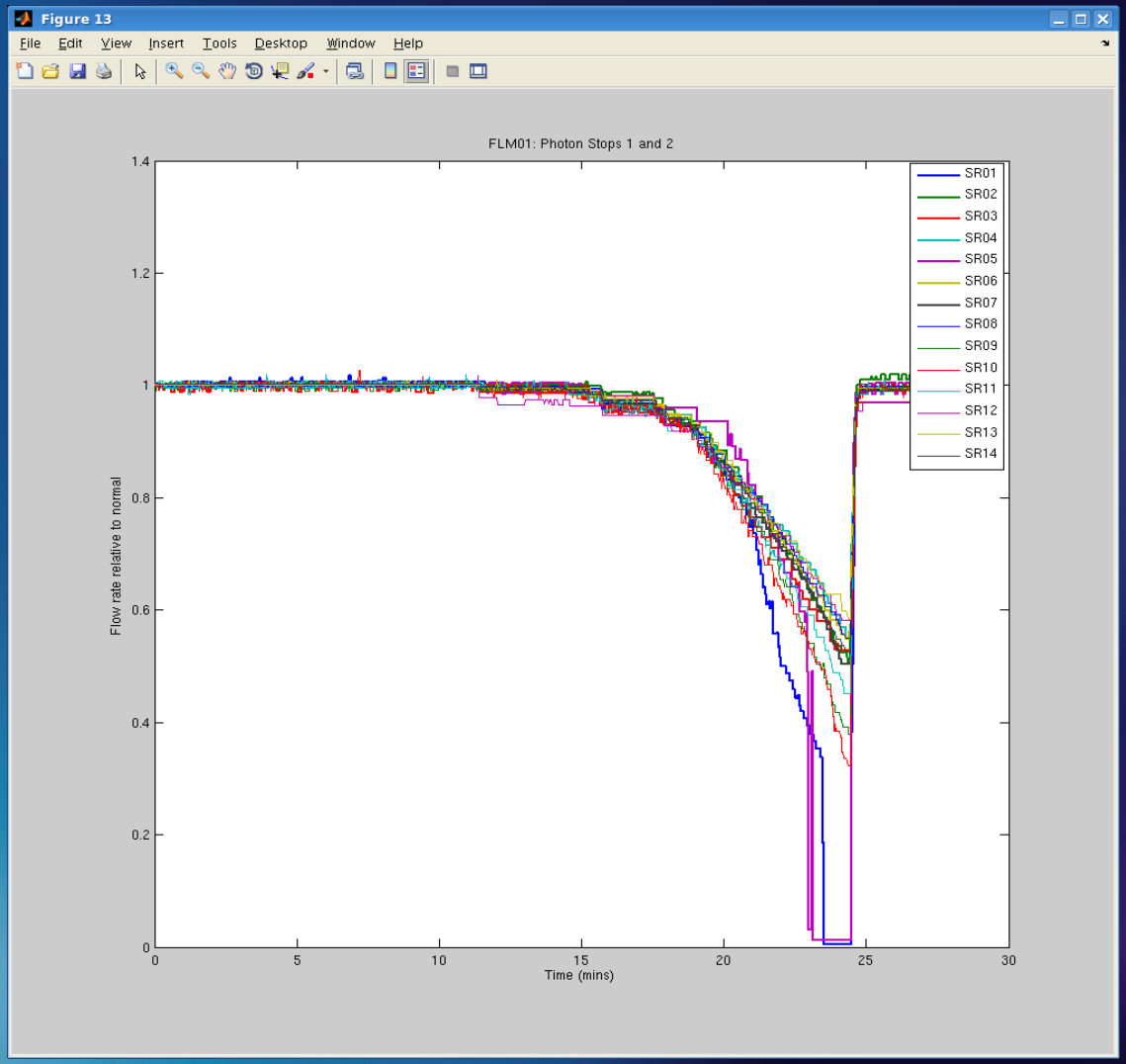
Click on an entry to graph trend

Storage Ring Low Conductivity Water Control



By changing the pressure (with no beam) it is possible to vary the flow

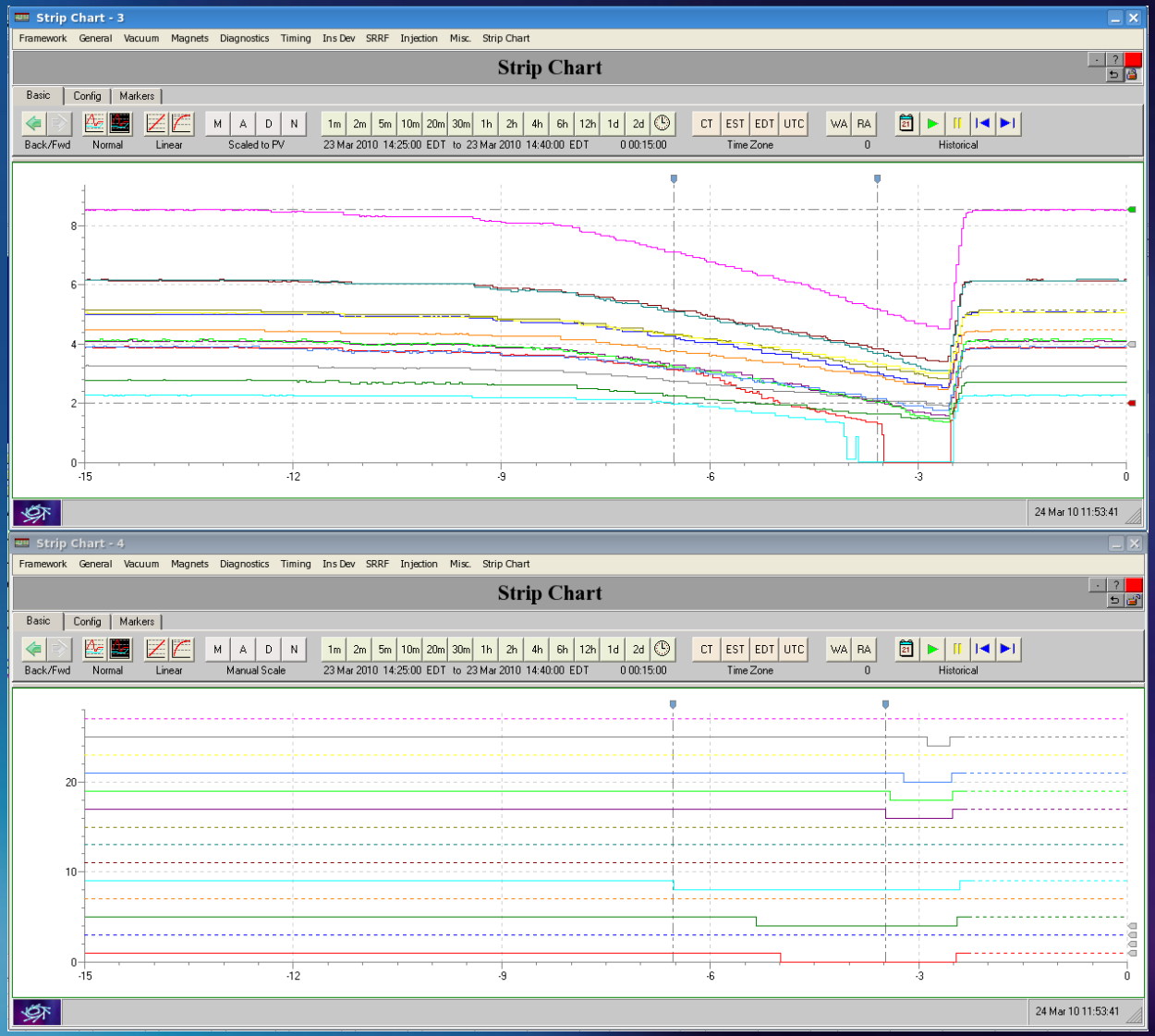
Photon Stop flow meters output as overall flow reduced



Note

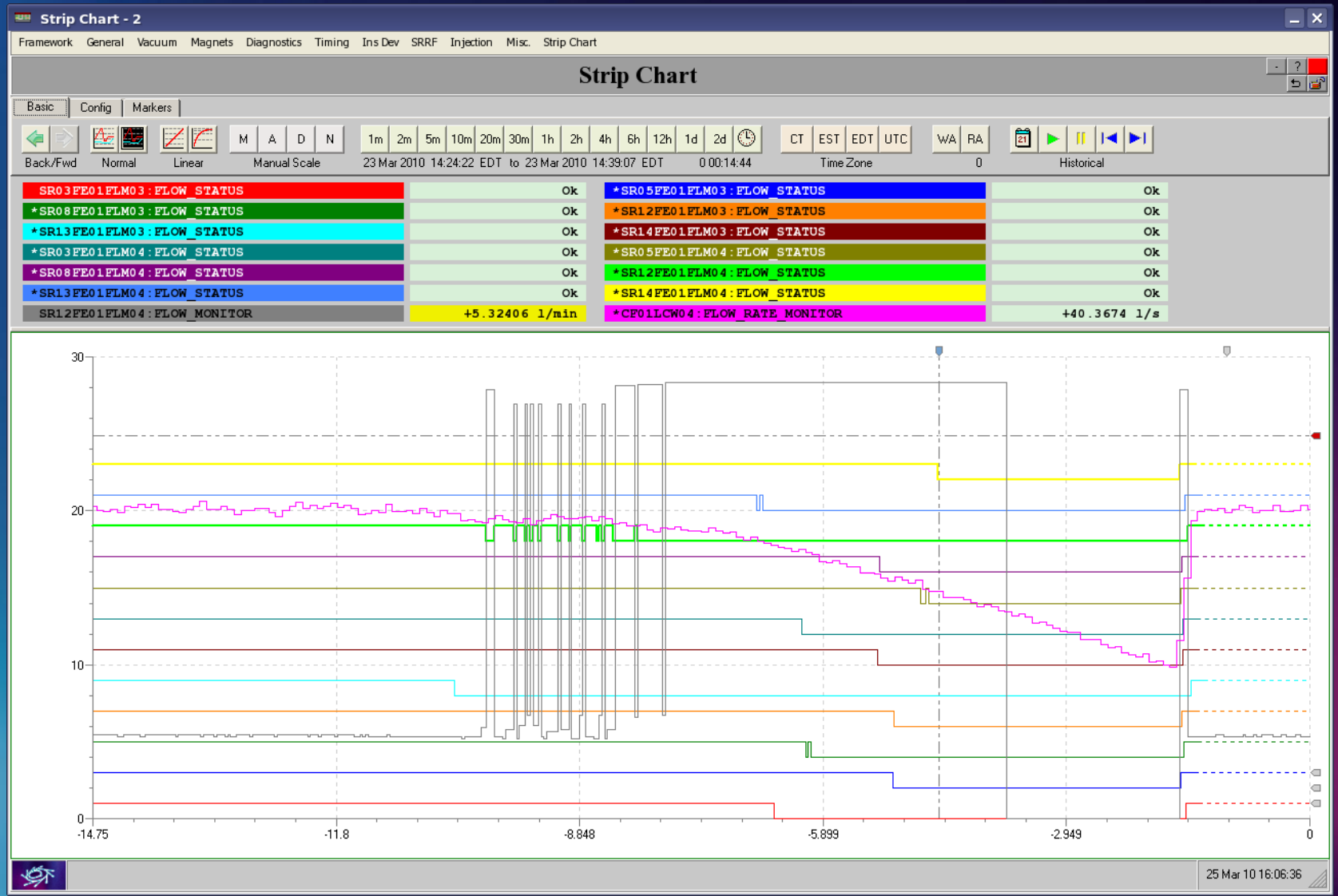
- SR01 deviates low
- SR12 deviates high then fails at 50%
- There is about a 30% variation between meters

Display of Flows and LOLO trip points



Display of bad LOLO trip point

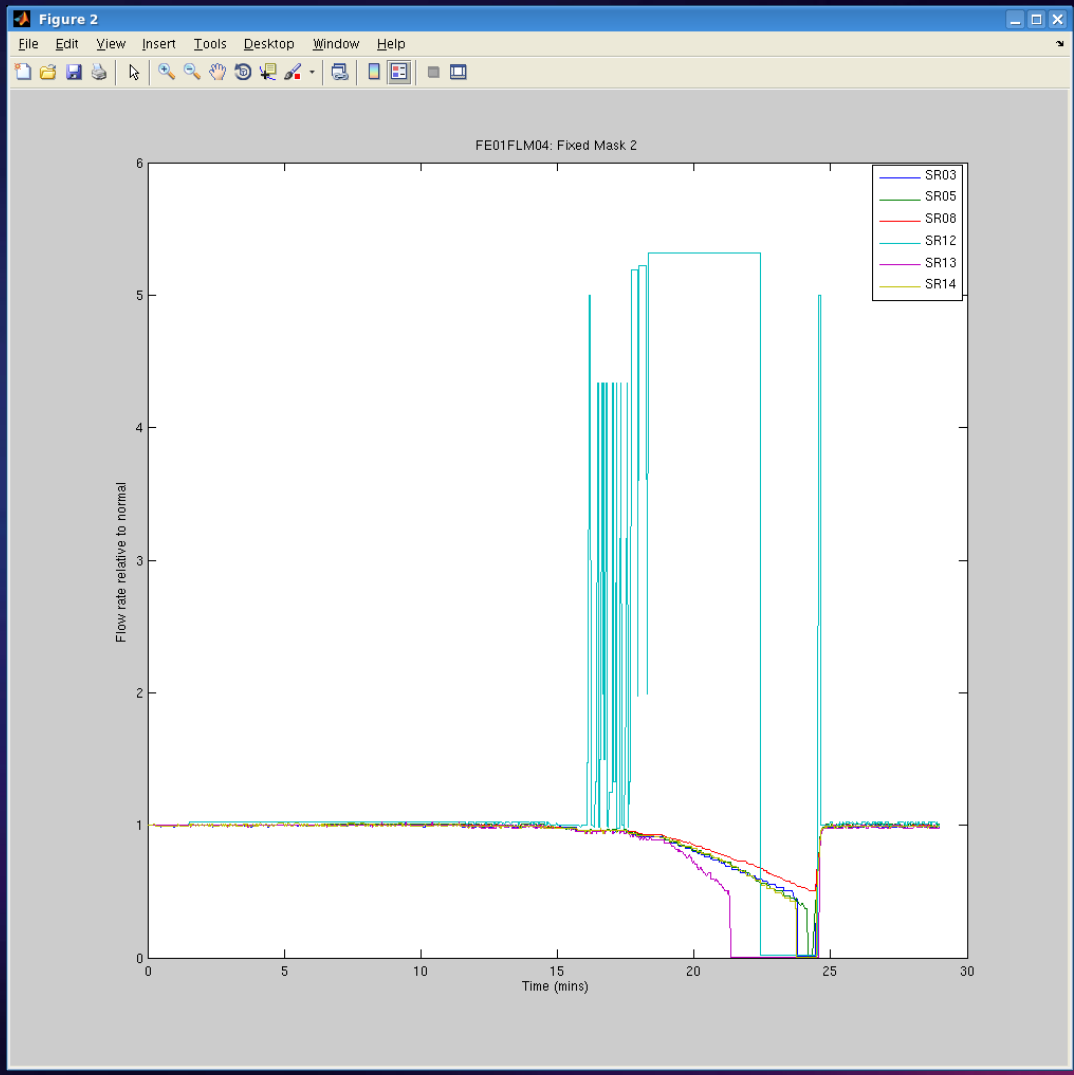
(SR12FE01FLM04:FLOW_STATUS)



Plot of Flow Meter showing bad behaviour

Two days after collecting the data, (before we had analysed it) we had a beam dump caused by an intermittent flow meter trip in Front End 12.

Looking back at the flow test data it was easy to identify the suspect meter.



Comparison of PLC set points and Observed Trip Points

The ID front end flow meters tripped at the values set in the PLCs.
(SR12FE01FLM02 didn't hit its LOLO setpoint. and SR12FE01FLM04 was bad)

	SR03	SR05	SR08	SR12	SR13	SR14
FE01FLM01	5.0\ 4.9	5.0\ 5.0	16.0\15.9	5.0\ 4.9	5.0\ 5.0	5.0\ 5.0
FE01FLM02	5.0\ 4.9	5.0\ 4.9	5.0\ 4.9	5.0\ NaN	5.0\ 4.9	5.0\ 4.9
FE01FLM03	16.0\16.0	16.0\15.9	16.0\16.0	6.0\15.8	16.0\15.9	16.0\16.0
FE01FLM04	5.0\ 5.0	5.0\ 4.9	16.0\15.8	5.0**26.6**	5.0\ 4.9	5.0\ 5.0

(PLC Trip Setpoint\Trip Value)

Injection System Flow Switches

Stainless Steel bodies

Springs and magnets exposed to LCW

Problems

Contamination

Plunger Sticking

Springs eroding

Magnets dissolving

Fouling of flow control valves

We will do similar testing of trip points of these switches.

Credit

Graham Harding for suggesting to vary the pump speed to vary the flows

Robbie Clarken for the Matlab scripts

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