Development and UHV testing of LN_2 cooled Titanium Sublimation Pump

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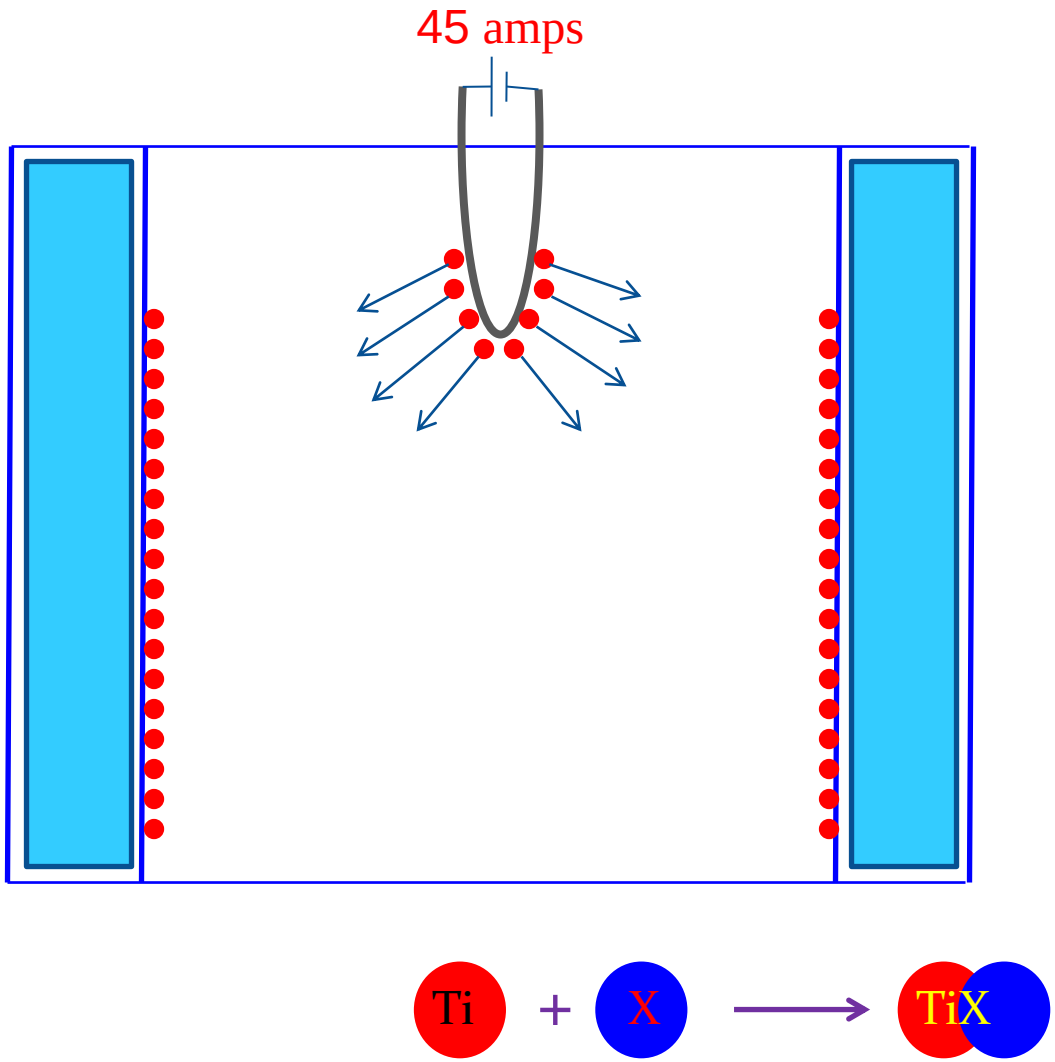
Working Principal:

The Titanium sublimation pump works on the principle that atomically-clean titanium is extremely reactive .

Titanium is sublimated by passing high current approx. 45 amperes current through Ø2.1 mm filaments, forms an active layer of Titanium on chamber walls.

TSP provides high pumping speed in UHV regions for active gasses like H_2, N_2 and CO etc.

Pumping Speed of TSP can be increased by cooling the Titanium deposited film, due to increase in sticking coefficient.


45 amps
Ti
+
X
TiX

Advantages of TSP:

- Simple in construction.
- Low initial and operating cost.
- Simple in operation.
- Pumping Speed independent of pressure in UHV region.

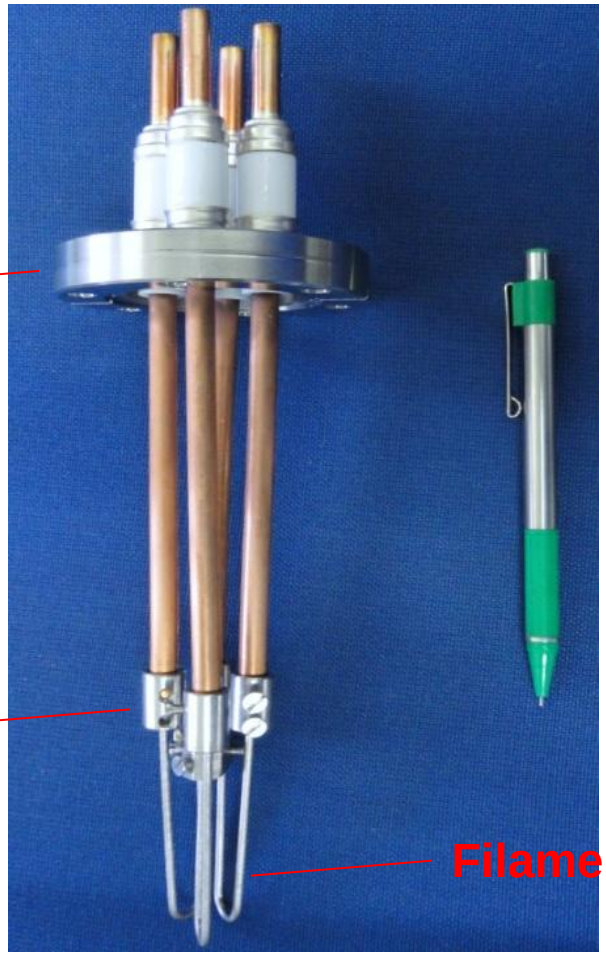
Limitations of TSP:

- Low throughput.
- More effective in UHV region only.
- No pumping for inert gases.

Construction of TSP:

High Current Feed-through DN 40 CF

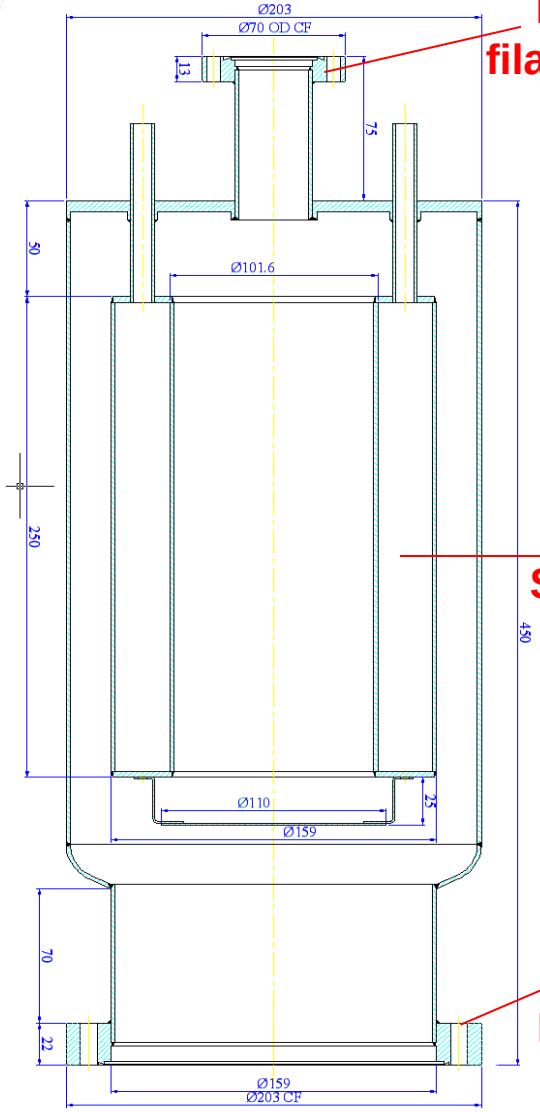
SS Connector



Filament:

- (Ti -85 %, Mo-15%)
- Diameter - 2.1 mm
- Resistance 35 mΩ

1. Filament Cartridge



DN 40 CF for filament cartridge

LN2 Shroud

DN 160CF for Pump connection

2. TSP Body

Design details:

Mechanical Design:

- Vacuum Chamber (Cylindrical), as per Guidelines given by ASME Section VIII, Div-1.
- Material – SS 304L/316L, Standard available pipes & CF flanges used.
- Fabrication – Machining with precision Lathe.
  - TIG welding Process with vacuum facing weld joints were preferred.
  - Forming operation used to form Torispherical dished end.

Titanium Sublimation Pump:

- Titanium film quoted area – approx. 250 cm^2
- LN_2 Shroud – 1.9 litres capacity, provides approx. 2000 cm^2 cooled surface area.

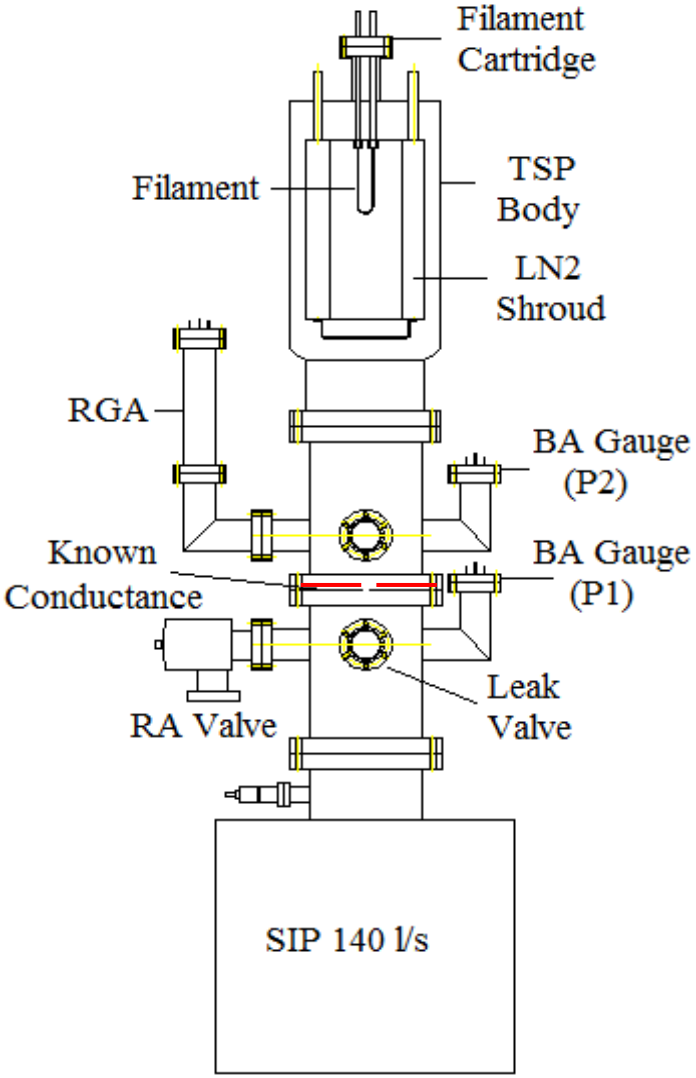
Cleaning Procedure:

- **Chemical Cleaning:**
  - Ultrasonic Cleaning with TCE
  - Vapour degreasing with TCE
  - Chemical Cleaning
  - Electro polishing
  - Vacuum Degassing

Leak Detection:

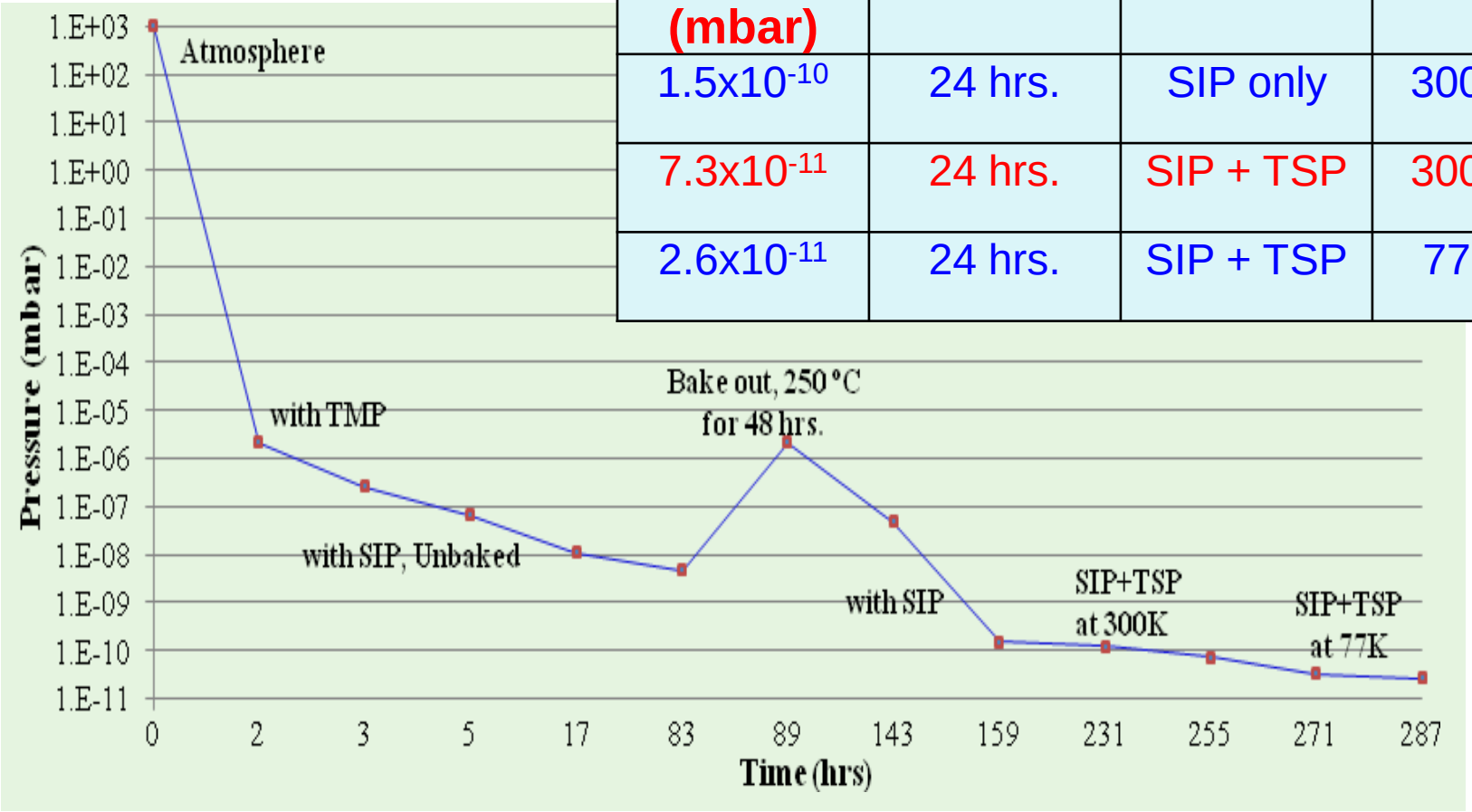
- Leak Detection of TSP body with HMSLD < $1x10^{-10}$ mbar-l/s

Test Setup


Filament Cartridge
Filament
TSP Body
LN2 Shroud
RGA
BA Gauge (P2)
Known Conductance
BA Gauge (P1)
Leak Valve
RA Valve
SIP 140 l/s

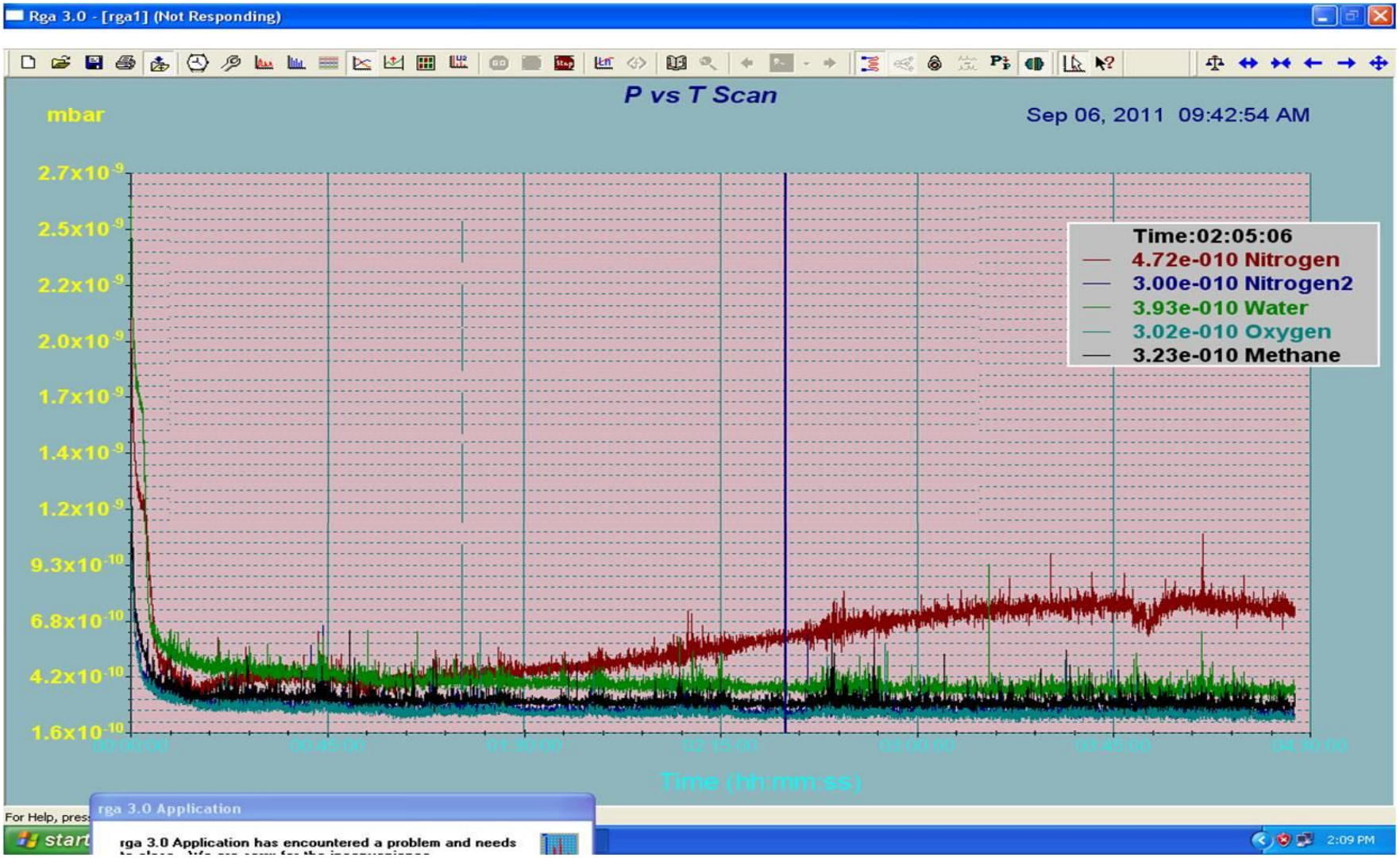
UHV Testing:

Ultimate Pressure (mbar)	Time duration	Pump used	Temp.
1.5×10^{-10}	24 hrs.	SIP only	300 K
7.3×10^{-11}	24 hrs.	SIP + TSP	300 K
2.6×10^{-11}	24 hrs.	SIP + TSP	77 K

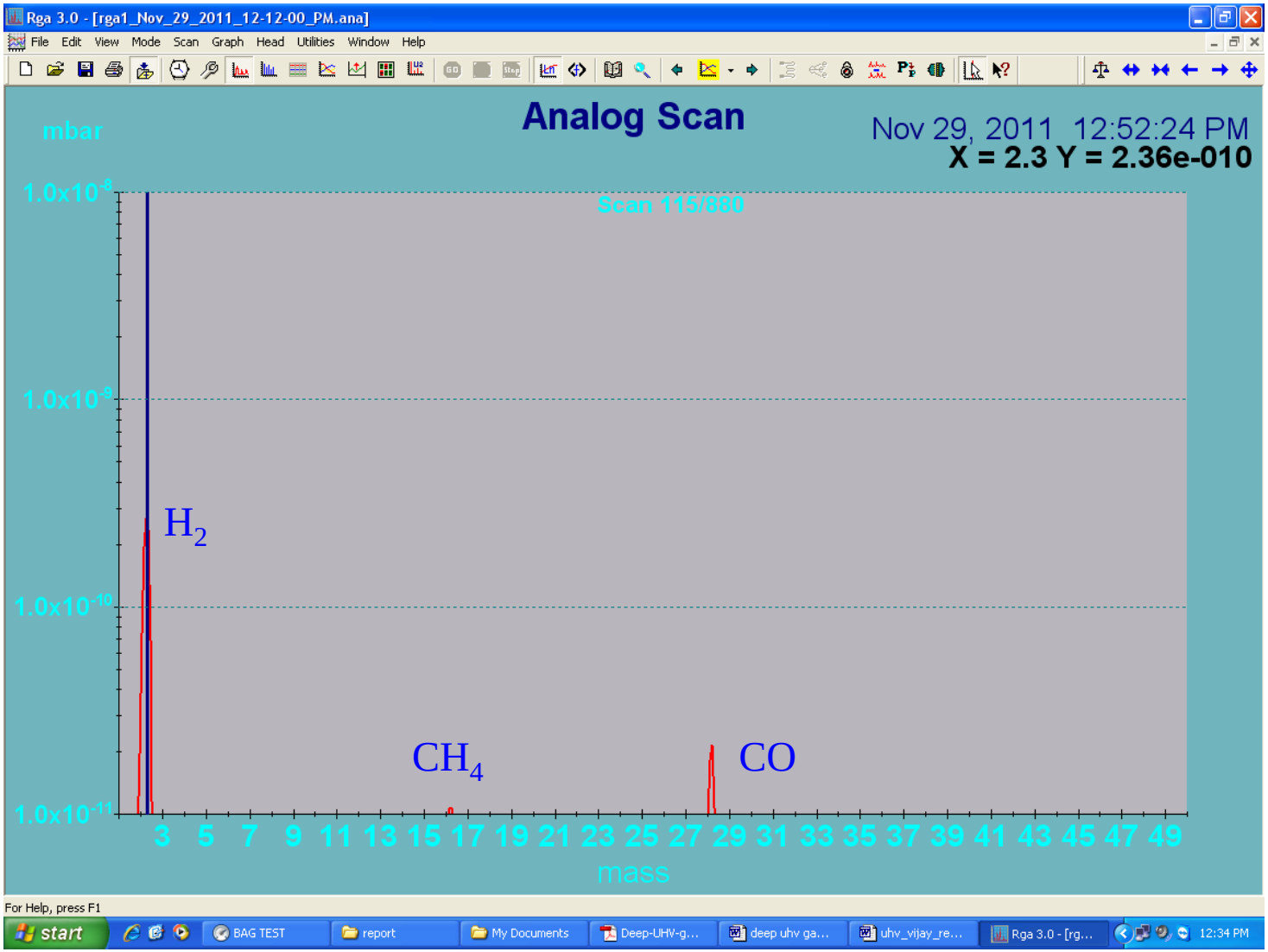


Pump down curve of the test setup

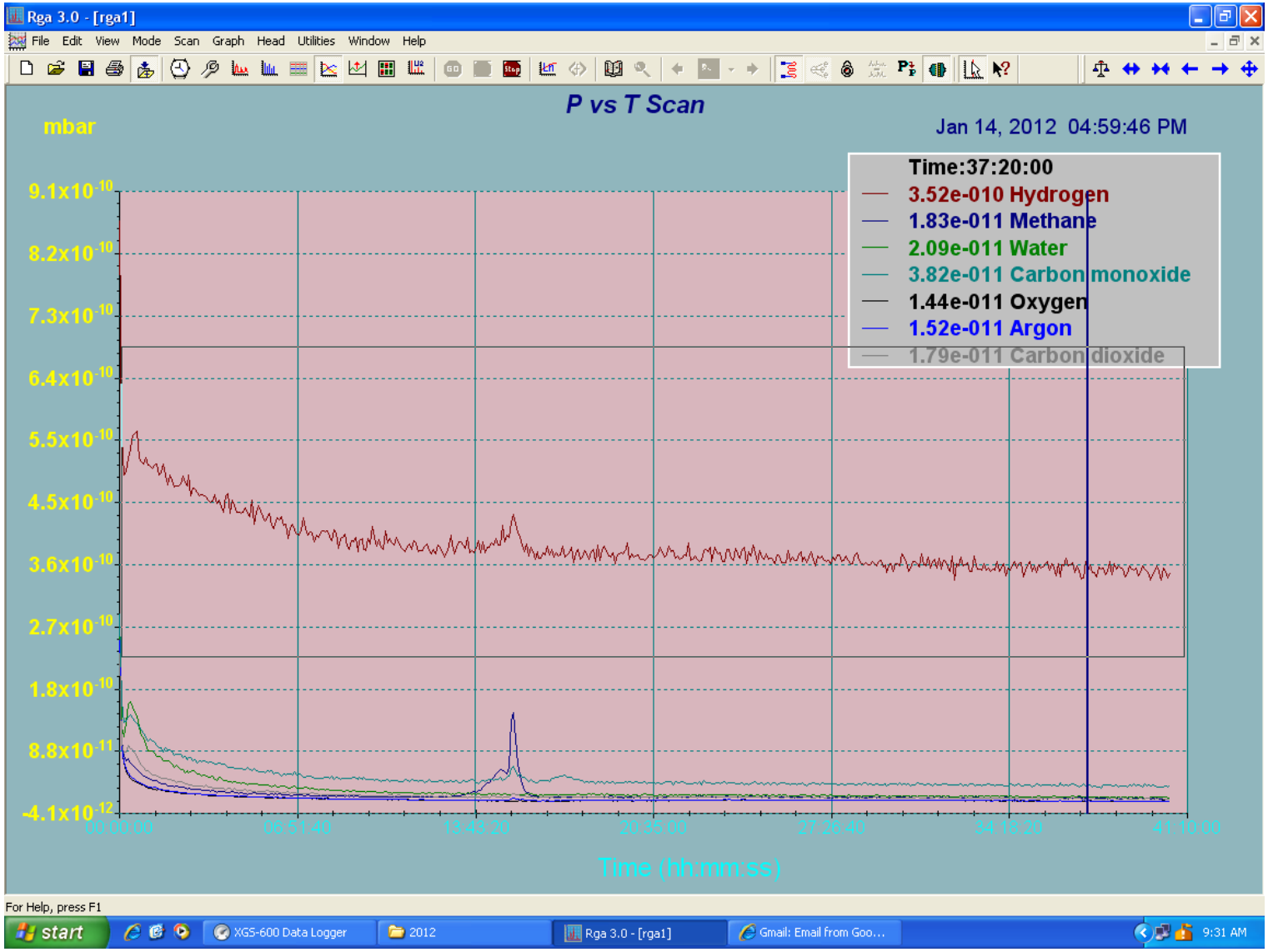
Residual Gas Spectrum in unbaked condition at 77K



Partial Pressure of gasses post bake-out condition 77K



Residual Gas Spectrum in baked condition at 77K



Pumping Speed Measurement:

- Known conductance method (AVS 4.1)
- Pumping Speed Measured for N_2, H_2 & CO at 300 K & 77 K

$$S = C \times [(P_1/P_2)-1]$$

Where:

S – Pumping speed (l/s)

C – Known conductance (l/s)

(9.66 l/s for N_2 at 20 ^oC)

P_1 – Pressure gas purging side (mbar)

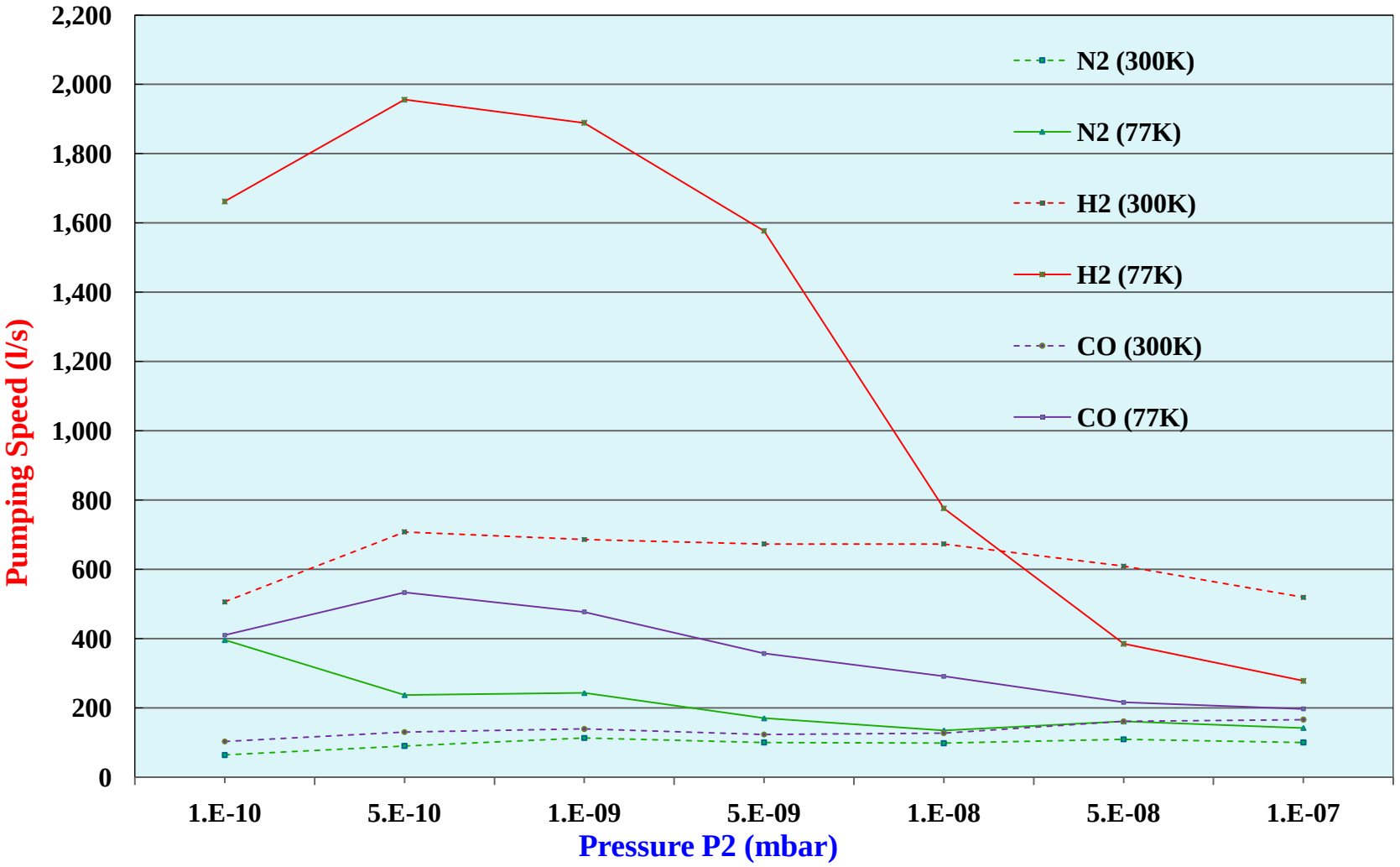
P_2 – Pressure TSP side (mbar)

- Pure N_2 purged by boiling of liquid Nitrogen.
- H_2 & CO purged from high purity gas cylinder.

Pumping Speed Measurement:

S. No.	Pressure P_2 (mbar)	Pumping Speed for N_2 (l/s)		Pumping Speed for H_2 (l/s)		Pumping Speed for CO (l/s)	
		300 K	77 K	300 K	77 K	300 K	77 K
1.	$1x10^{-10}$	64	396	506	1662	103	410
2.	$5x10^{-10}$	90	237	708	1956	130	533
3.	$1x10^{-9}$	113	243	686	1889	139	477
4.	$5x10^{-9}$	100	170	673	1577	123	357
5.	$1x10^{-8}$	98	135	673	776	127	291
6.	$5x10^{-8}$	109	161	609	385	161	216
7.	$1x10^{-7}$	100	142	519	278	166	197

Graph of Pumping Speed v/s Pressure



Conclusion

A LN_2 cooled Titanium Sublimation Pump was successfully developed specified design parameters were obtained and an ultimate vacuum of 2.6×10^{-11} mbar was achieved within reasonable time. The TSP has been characterised for its pumping speed with N_2, H_2 and CO at 300 K as well as at 77K successfully.

Thanks!!!
for your attention