TDIS Review: Vacuum considerations

Outline:

1) Vacuum requirements for the LHC & Materials outgassing results
2) VSC Actions following TDI main pressure increase during Run1
3) TDIS vacuum system proposition & Possible sectorization
4) Conclusions

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01/12/2016

Vacuum Requirements for Collimators: After bake out

1) Materials used in the collimators:
   a) All materials shall be qualified regarding their outgassing: **< 10^{-12} mbar·l/s·cm^2**
   b) All trapped volumes shall be avoided as well as contact between large surfaces

2) Pumping Speed:
   a) Effective pumping speed is limited at 20 l/s by the space available or the conductance of the surrounding vacuum chambers
   b) In order to be able to achieve the required static pressure of $5 \cdot 10^{-9}$ mbar the total flux of the collimator should not exceed **≈ $1 \cdot 10^{-7}$ mbar·l/s**

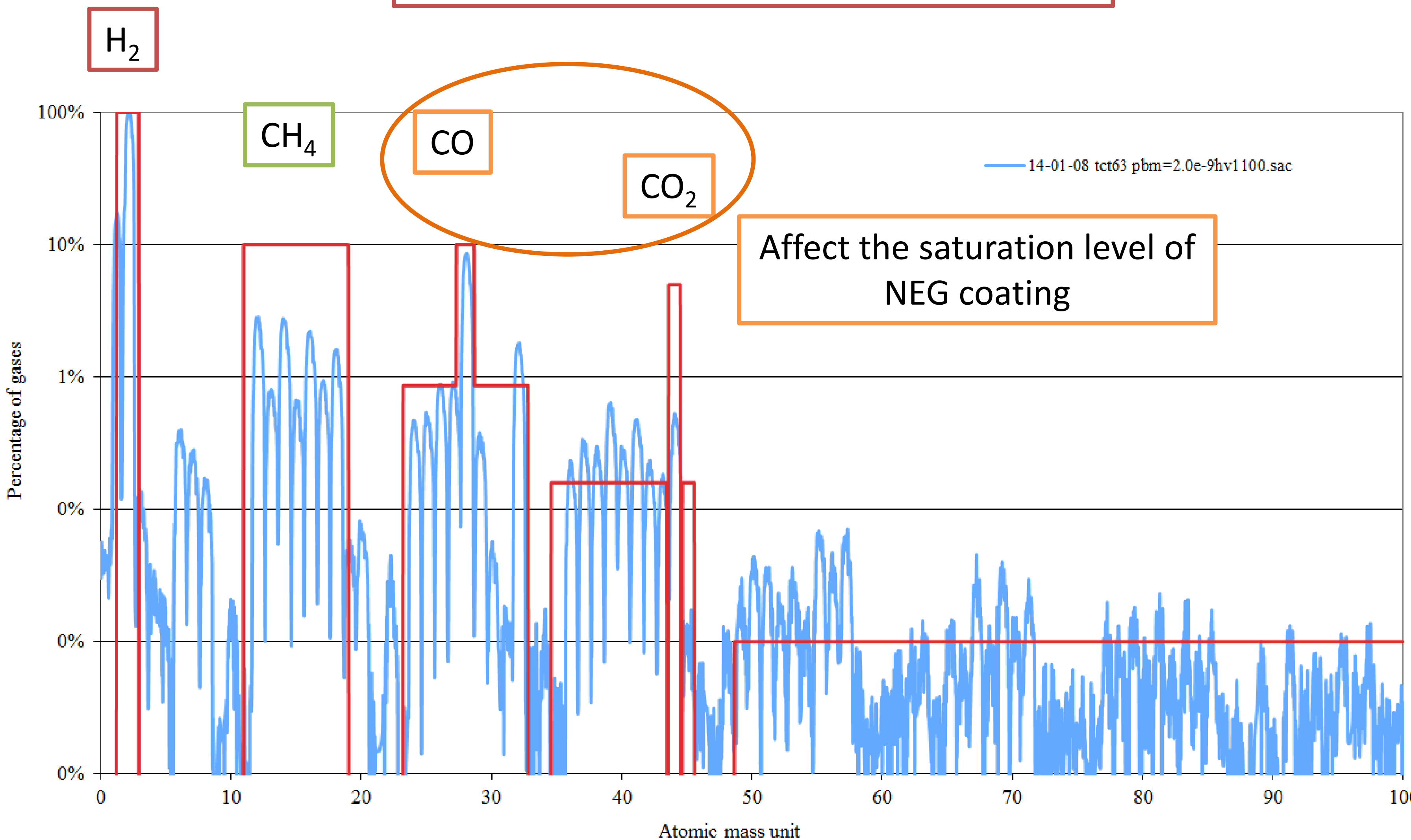
"As an indication, the allowed outgassing flux of the secondary collimator (based on the existing draft design) will be exceeded if assuming an operating temperature below 50°C and 200 cm^2 of graphite jaws with a local overheating (50°C < T < 100°C)"

"Any deviation from this total outgassing flux or from the operating temperature,….,imply an additional pumping speed to ensure the required gas density profile and the **vacuum stability**"

From EDMS 428155

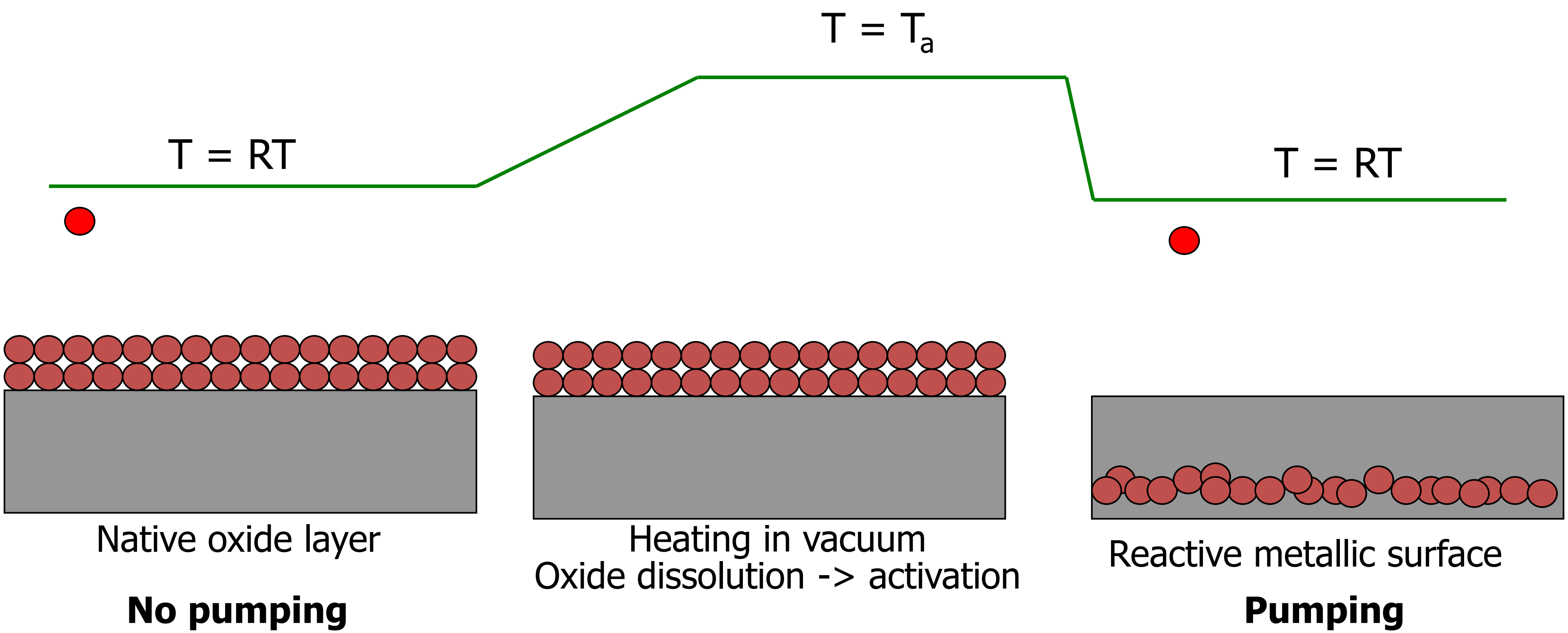
Vacuum Requirements for Collimators after Bake Out
Accepted Gases Species

Maximum total outgassing **≈ 1·10^{-7} mbar·l/s**



NEG Alloy: Pumping Mechanism

A NEG material is a metallic alloy that can pump most of the gases present in a vacuum system after thermal dissolution of its native oxide layer (activation process).



NEGs do not pump hydro-carbon at room temperature and rare gases.

NEG Pumping Mechanism

H_2:

- Diffuses into the getter bulk even at room temperature,
- Small quantities of H_2 do not affect the pumping of other gases.

CO & CO_2:

- Molecules chemically absorbed on the getter surface
- No Diffusion in the bulk and affect the pumping speed of all the other gases,
- CO capacity ≈ $5 \cdot 10^{14}$ molecules/cm^2

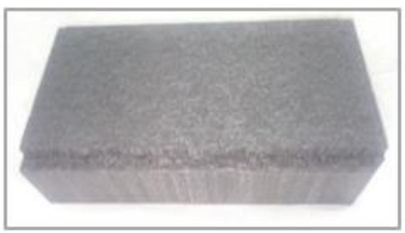
N_2:

- No Diffusion in the bulk and the absorption takes place underneath the first monolayer of the surface,
- Six adsorption sites to pump a single N_2 molecule,
- N_2 capacity ≈ about 7 times lower than for CO
- Do not affect the pumping speed of CO

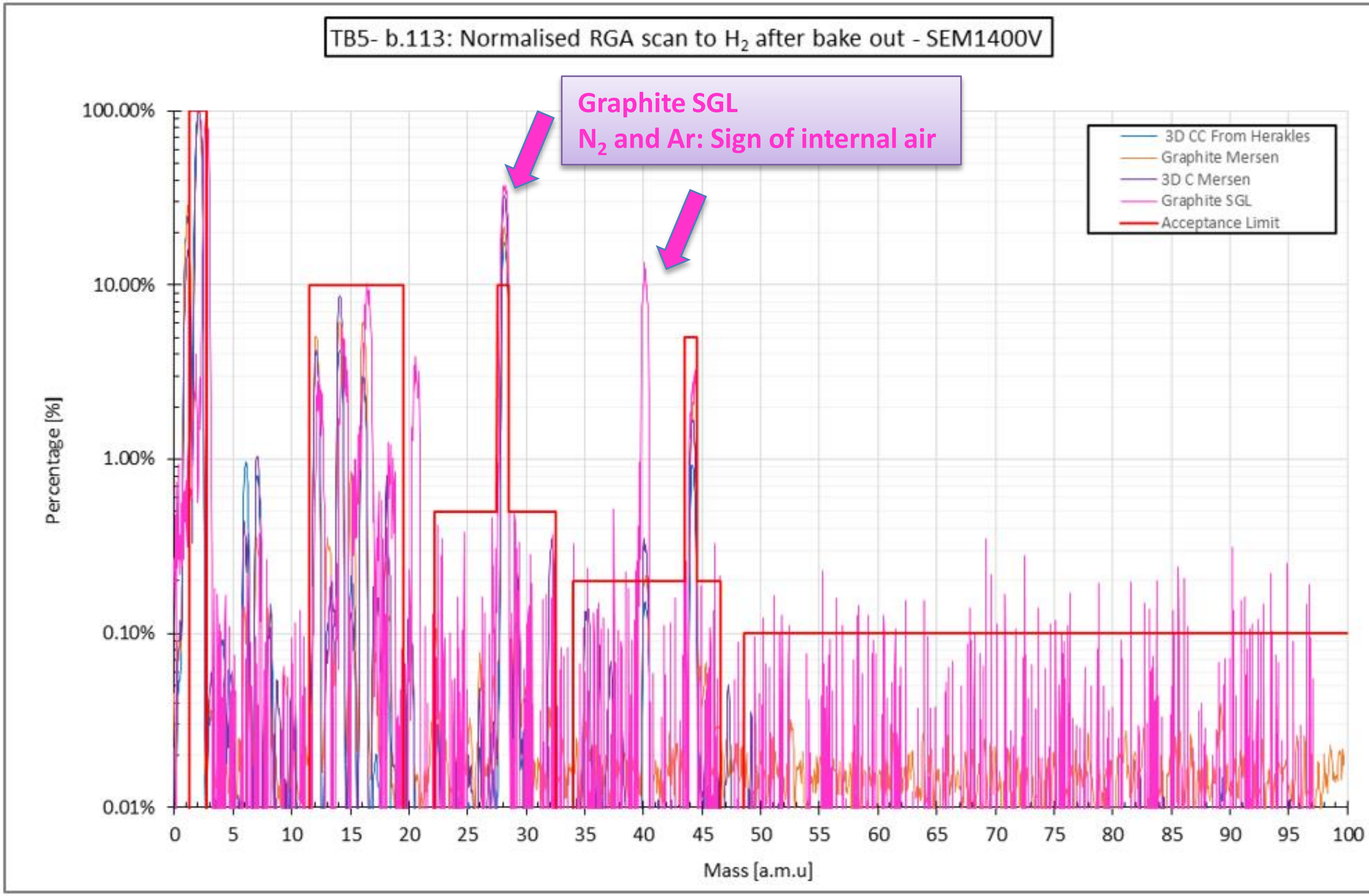
O_2 & H_2O:

- The capacity of NEG for O_2 and H_2O is estimated around 10 times larger than for CO

Materials Outgassing: Possible candidates

Used name	3D CC HERAKLES	Graphite MERSEN	3D CC MERSEN	Graphite SGL
Material	Carbon-carbon	Graphite	Carbon-carbon	Graphite
Supplier	HERAKLES	MERSEN	MERSEN	SGL
Model	SEPCARB®Wrapping Process	2123PT	A412	R7550P5D
				

New Materials: RGA Analysis after bake out



New materials: Baked and unbaked system

Material	Outgassing rate Baked [mbar·l/s cm²]	RGA Baked	Outgassing rate Unbaked [mbar·l/s cm²]	RGA Unbaked	
				< 50 amu	> 50 amu
3d CC Heracles	$\approx 9.0 \cdot 10^{-12}$ ✓	✓	$\approx 2.3 \cdot 10^{-8}$ ✗	✗	✓
Graphite Mersen	$\approx 2.5 \cdot 10^{-12}$ ✓	✓	$\approx 2.3 \cdot 10^{-9}$ ✓	✓	✓
3d CC Mersen	$\approx 3.5 \cdot 10^{-11}$ ✗	✓	$\approx 2.9 \cdot 10^{-8}$ ✗	✓	✓
Graphite SGL	**$\approx 5.0 \cdot 10^{-13}$** ✓	✗	**$\approx 6.5 \cdot 10^{-10}$** ✓	✓	✗

Graphite SGL

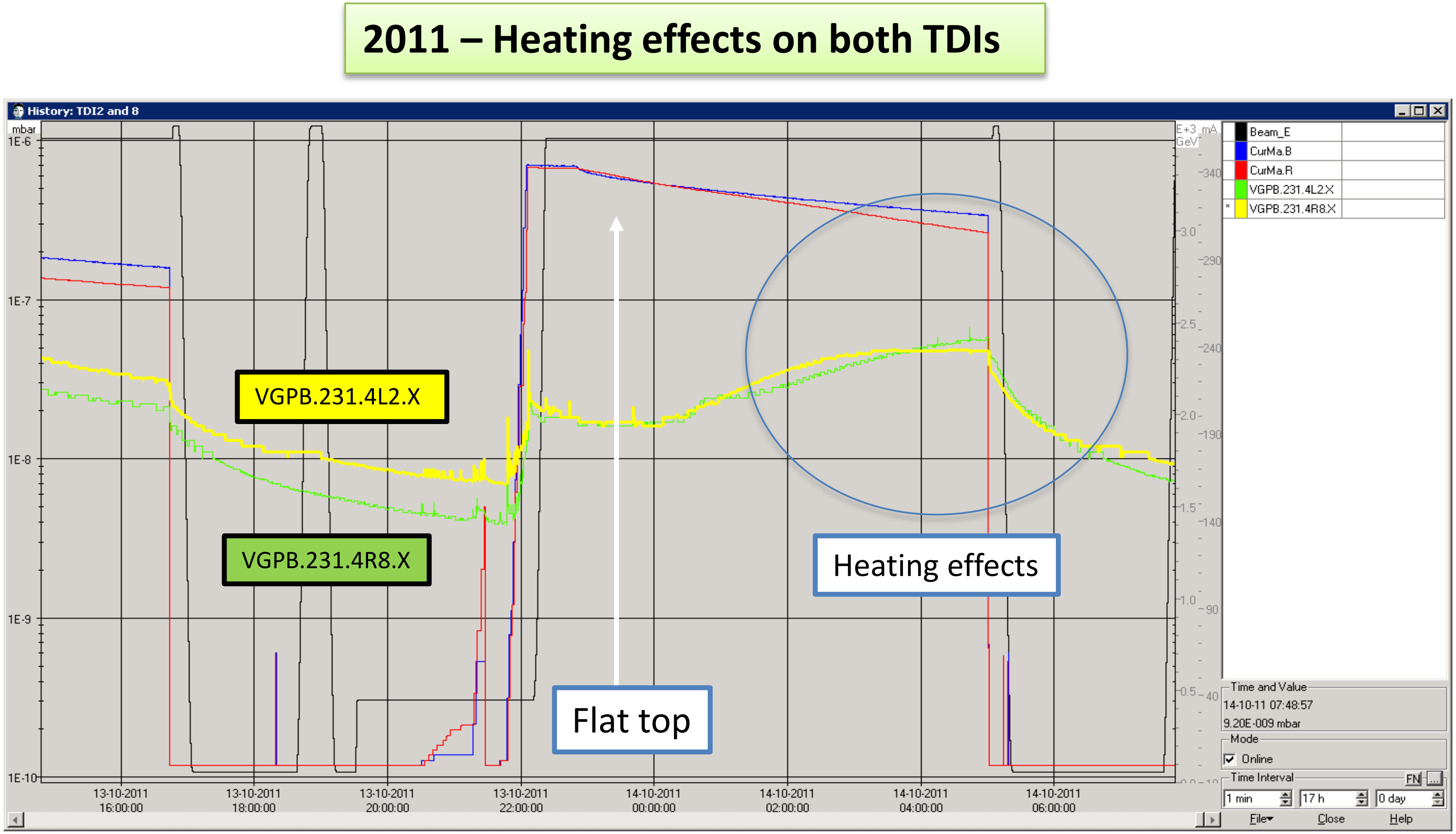
Total surface for the first 2 modules $\approx 1.7 \cdot 10^{4}$ cm²

Expected total outgassing $\approx 1 \cdot 10^{-8}$ [mbar·l/s]

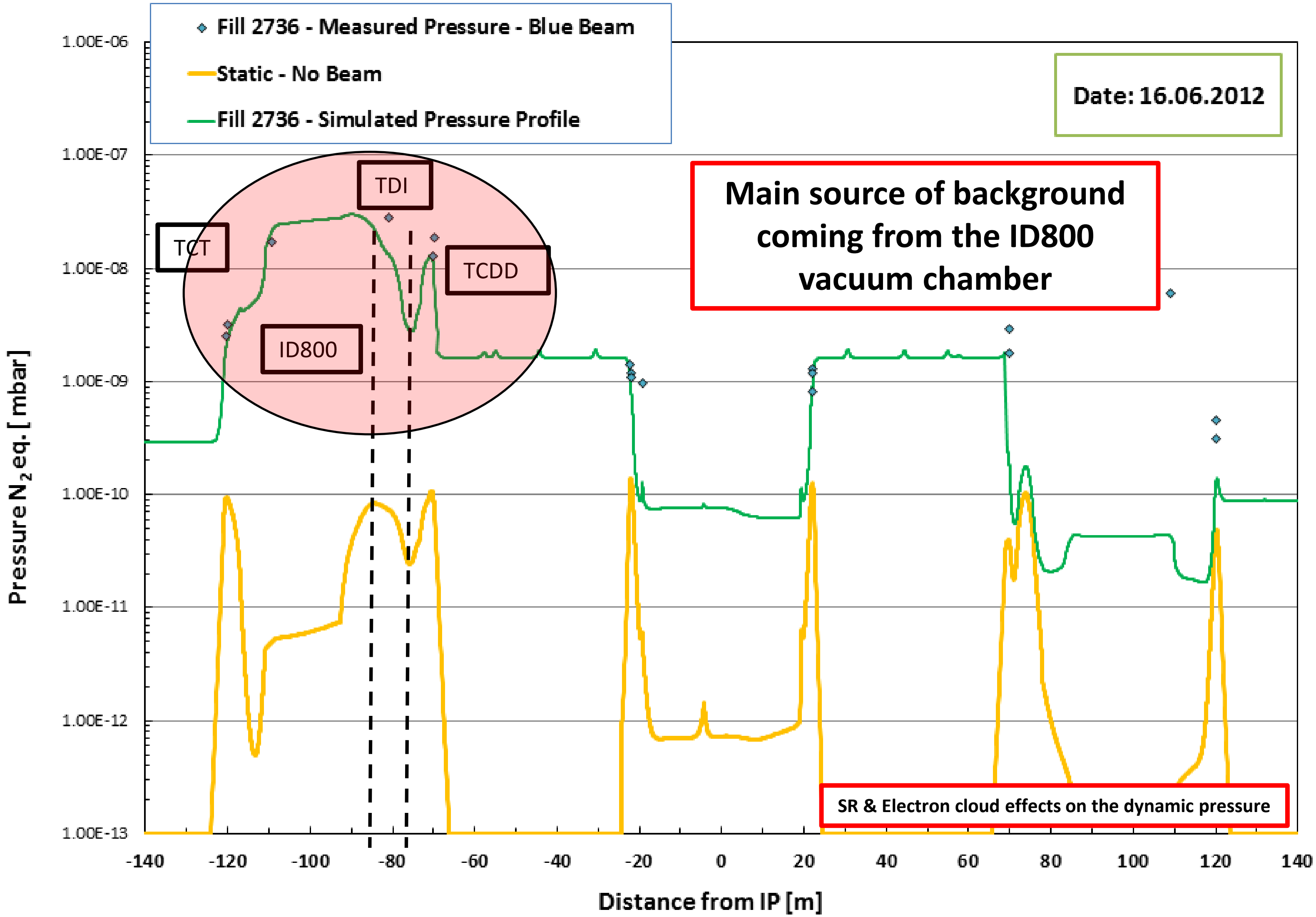
Results for RT working condition. Any deviation must be analysed and accepted

Overview of main pressure increase during Run1 & Run2

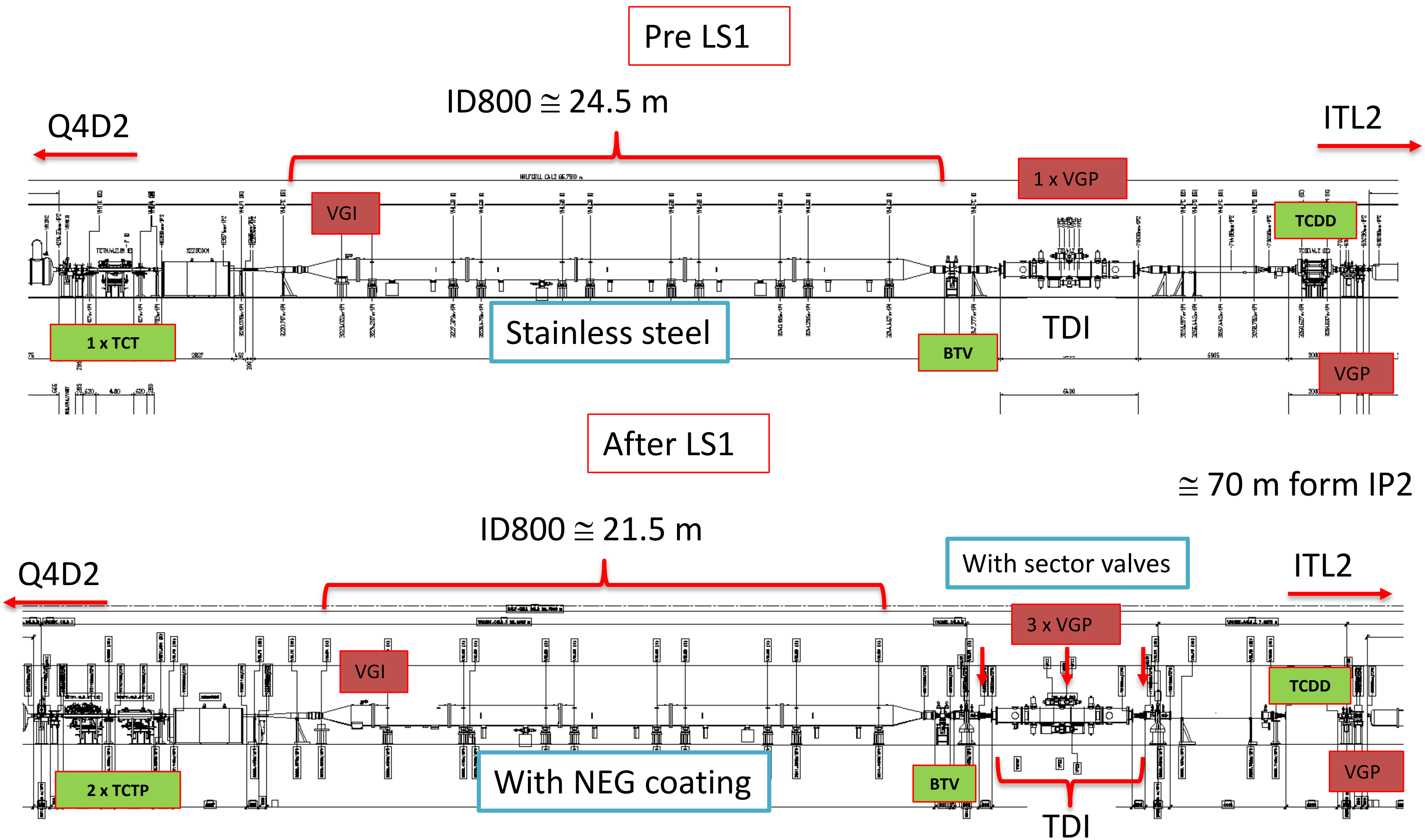
TDI during Run1: Heating effects



TDI Pressure evolution during Run1



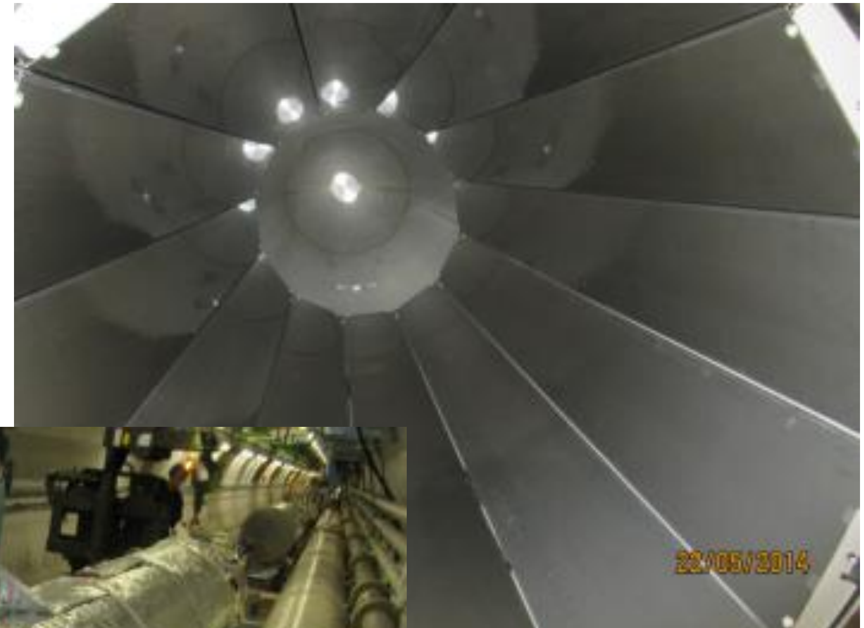
Layout upgrade in LSS2 during LS1



ID800 Upgrade

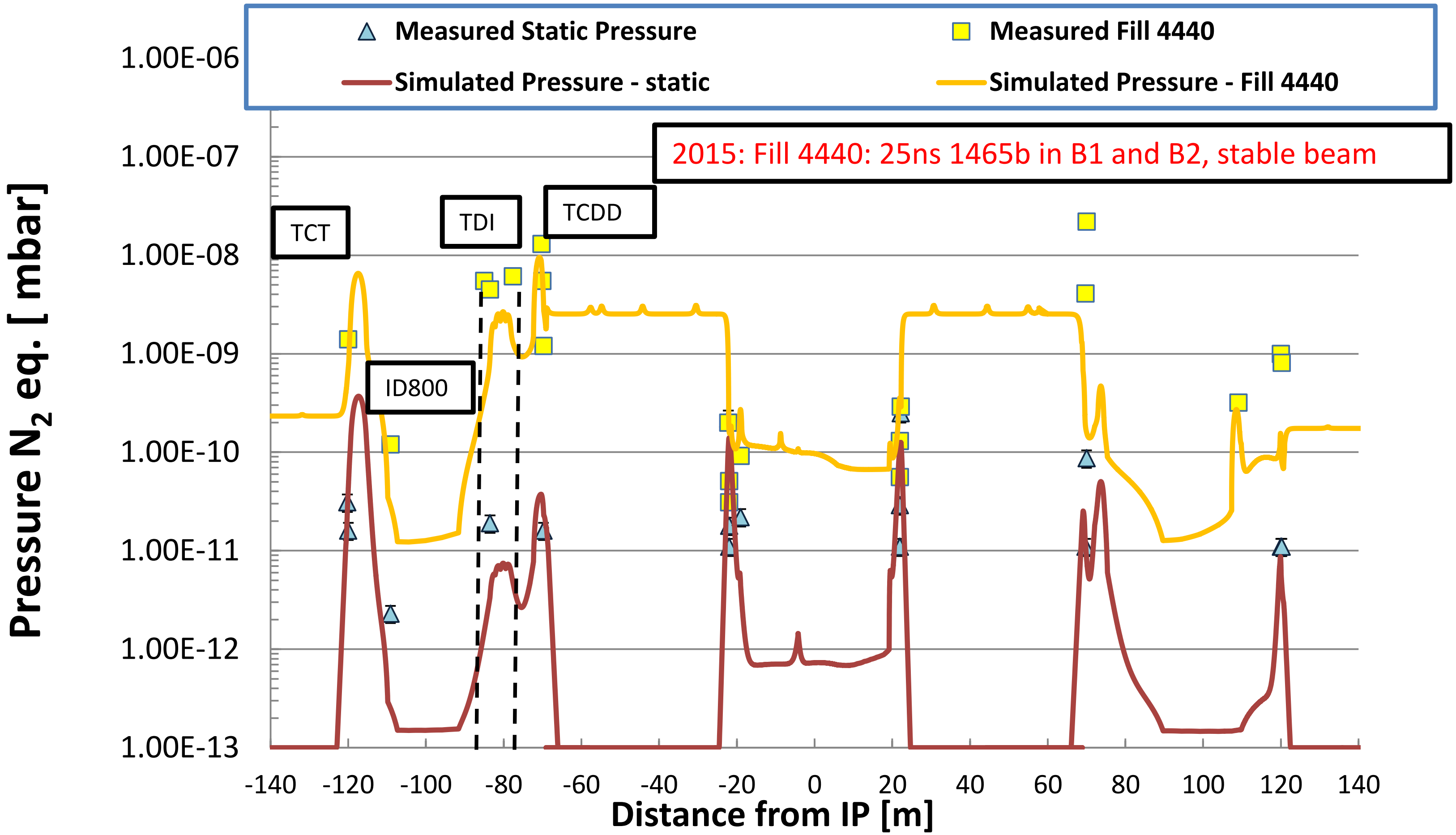
For operation with protons beam

- ID 800 upgrade :
  - **NEG coated liners along ID800**



E.Page & V.Baglin

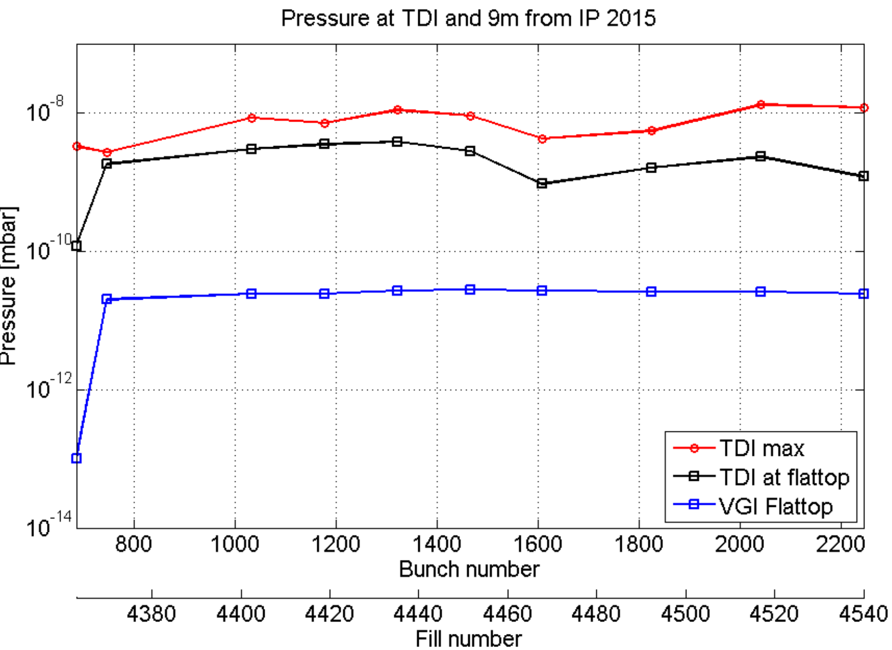
Static/Dynamic pressure after LS1



Pressure for TDI2 and 9m from IP2

2015

14/09/2015 05/10/2015 28/10/2015



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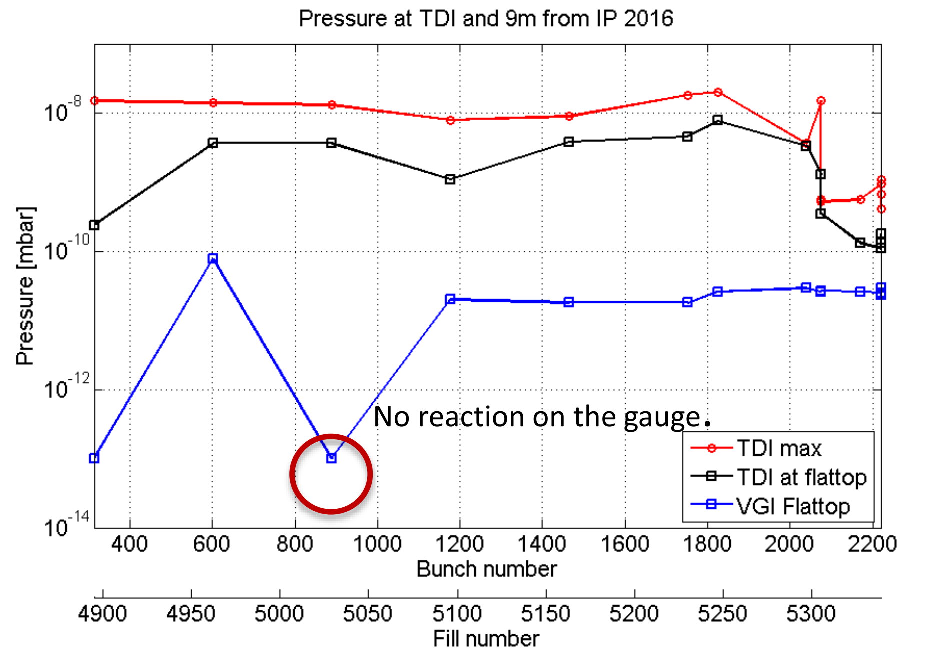
2016

08/05/2016 28/05/2015 26/09/2015



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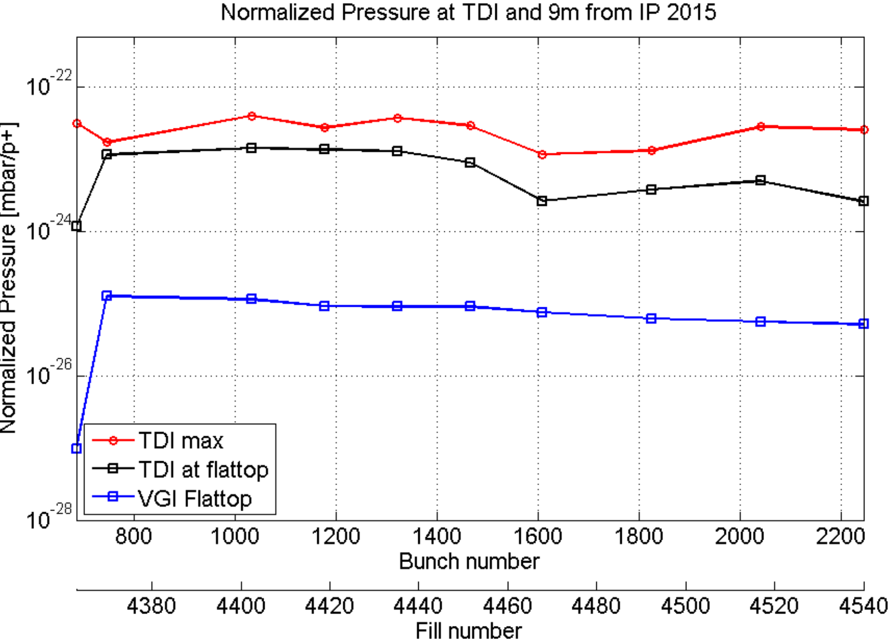
Lower bunch intensity

Normalized Pressure for TDI2 and 9m from IP2

2015

14/09/2015 05/10/2015 28/10/2015



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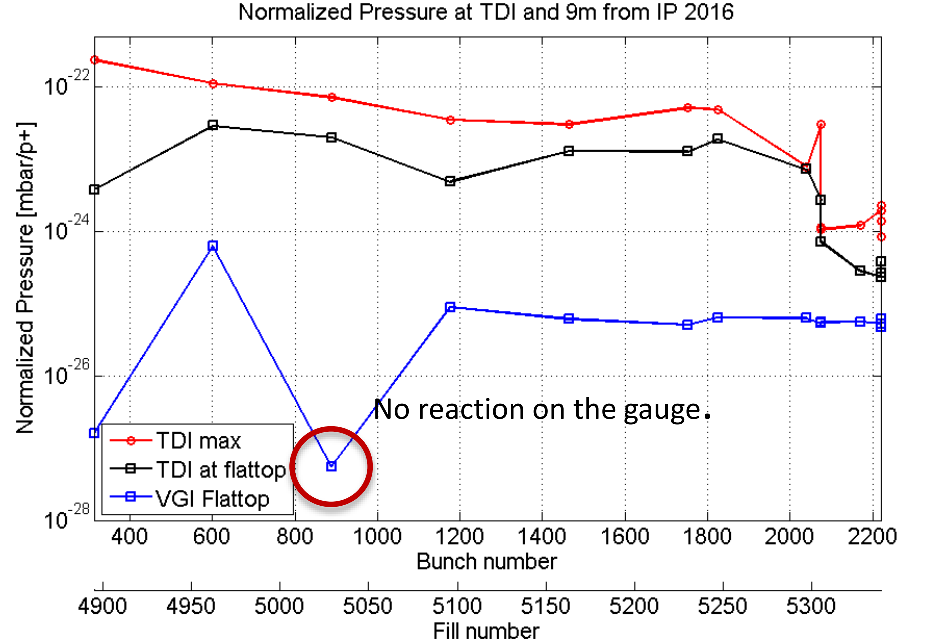
2016

08/05/2016 28/05/2015 26/09/2015



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Lower bunch intensity

Vacuum system for the new TDIS
&
Proposed layout

Vacuum System Upgrade: Old NEG Cartridge

CapaciTorr from SAES Getter

St172® porous sintered getter
Zr 70% V 24,6% Fe 5,4%

	D2000
H_2 (l/s)	2000
O_2 (l/s)	2000
CO (l/s)	1100
N_2 (l/s)	800
H_2 capacity (Torr.l)	2250
CO capacity (Torr.l)	5
CO total (Torr.l)	2000
Flange	CF100-CF150
Weight (kg)	2-3
Total lenght from the flange (cm)	19.5

During the bake out cycles high outgassing coming from the TDI tanks decrease the lifetime and the sorption capacity of this NEG cartridge

Vacuum System Upgrade: New NEG Cartridge

HV ZAO NEG Cartridge always from SAES Getter

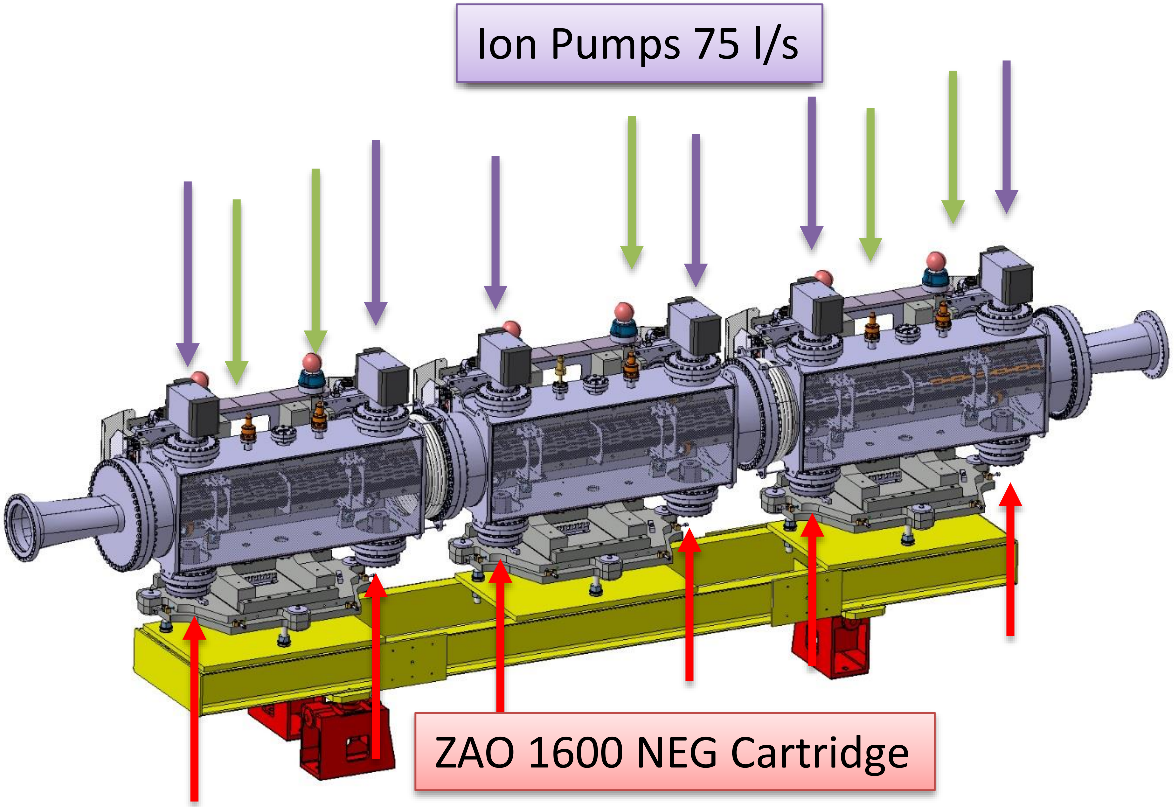
New Alloy ZAO
Ti-Zr-V-Al

- Highly porous sintered disks.
- High pumping performance in the high vacuum (HV) regime (i.e. $10^{-7} – 10^{-9}$ mbar range) for all getterable gases
- The getter cartridge can operate at moderate temperature ≈ 200 °C (Typical of the bake out cycle)
- Due to the high gas sorption capacity, the pump can cope with large air leakages or sudden gas release.

	Capacitorr D2000	ZAO HV 1600
H_2 [l/s]	2000	1700
O_2 [l/s]	2000	800
CO [l/s]	1100	620
N_2 [l/s]	800	470
H_2 Capacity per activation cycle [Torr·l]	2250	13800
CO Capacity per activation cycle [Torr·l]	5	160
CO Total lifetime [Torr·l]	2000	>20 cycles

Gain in robustness and pumping capacity

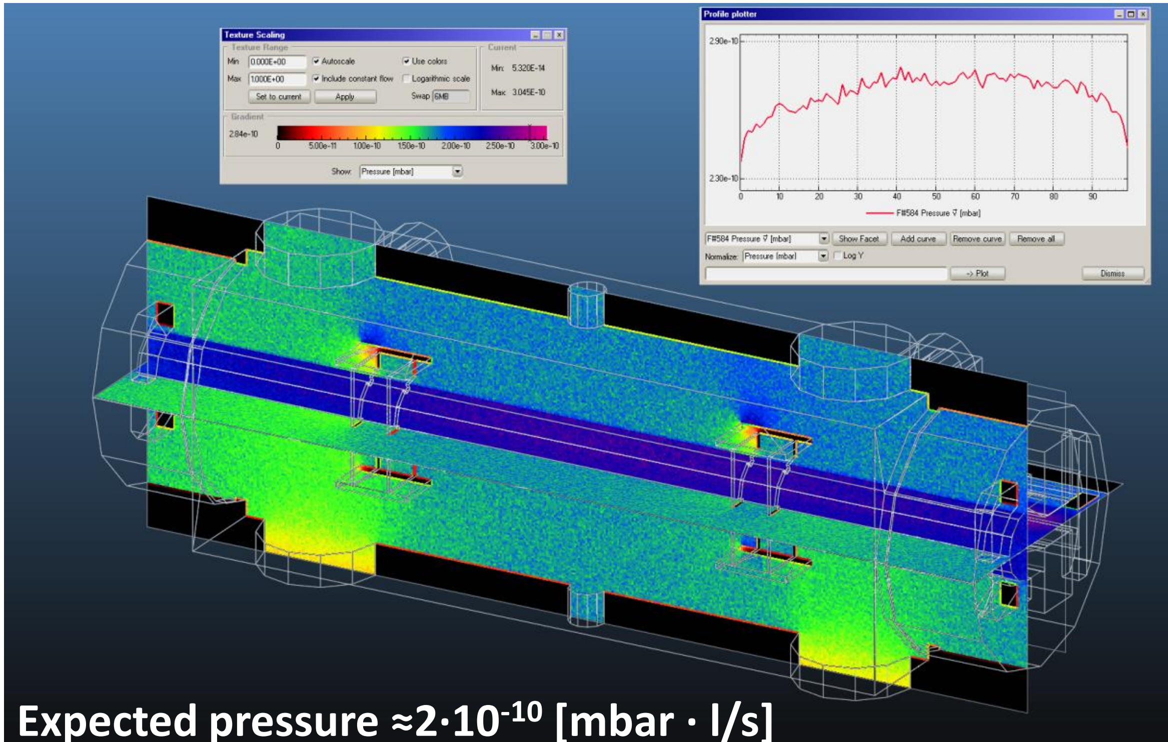
Overview of the proposed TDIS vacuum system

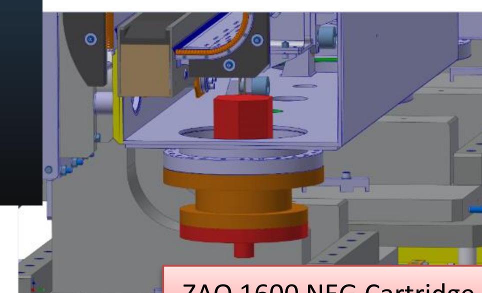


- Gauges & Pumps redundancy
- Small ion pumps to easier the installation without loosing performances
- Upgrade of the NEG cartridge to cope with high outgassing: passive element, no need of power.
- Remotely connected to SCADA application for possible regeneration during TS

	Ion Pumps [l/s]	NEG Cartridges H_2 [l/s]	NEG Cartridges N_2 [l/s]
Actual TDI	4 x 400	2 x 2000	2 x 800
TDIS	6 x 75	6 x 1700	6 x 470
Difference	-750	+ 6000	+1220

Expected pressure: Case of 1 tank



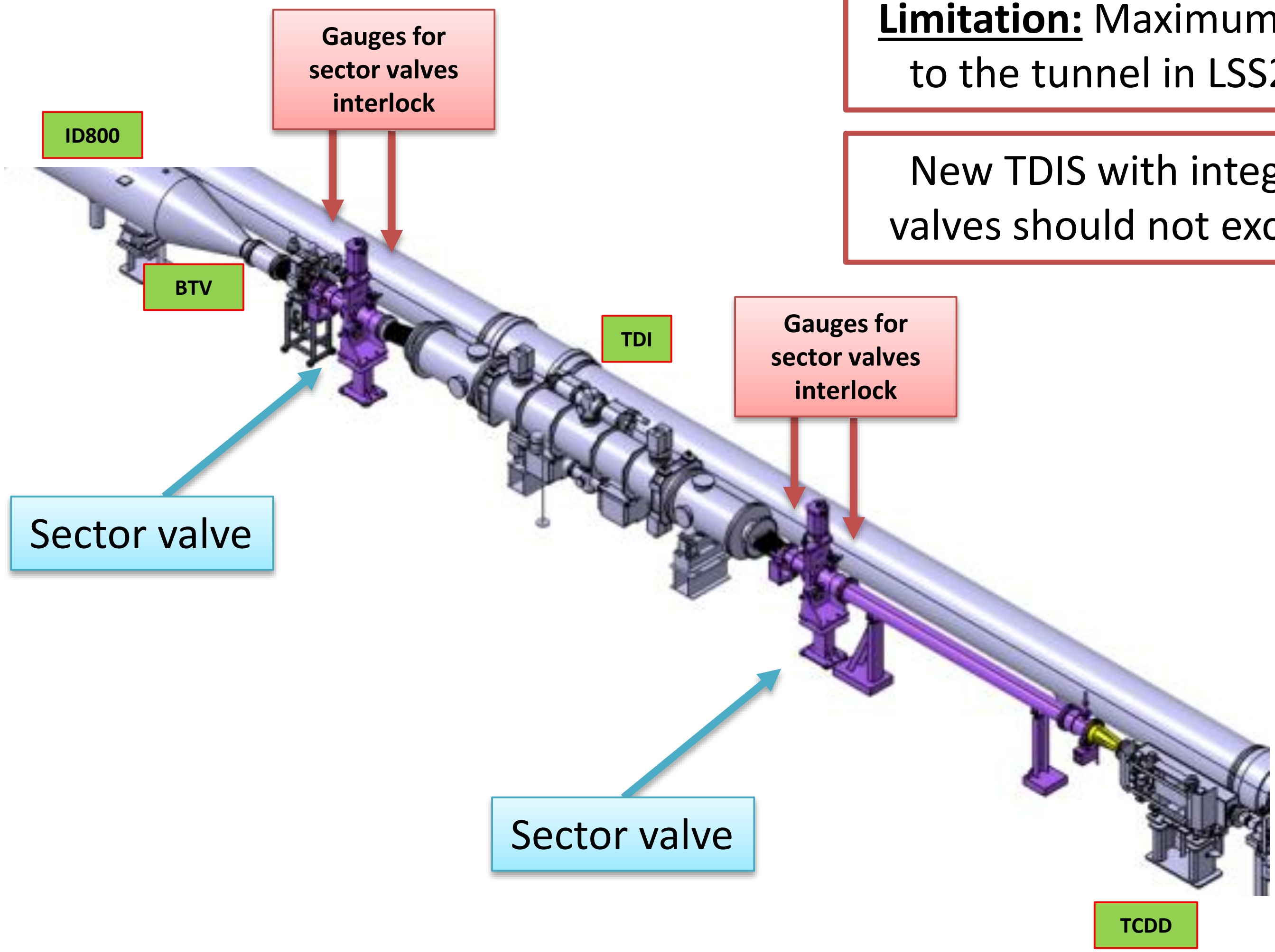


ZAO 1600 NEG Cartridge

Static pressure evolution

Maximum outgassing rate uniformly distributed on the jaws: $2 \cdot 10^{-7}$ [mbar·l/s]

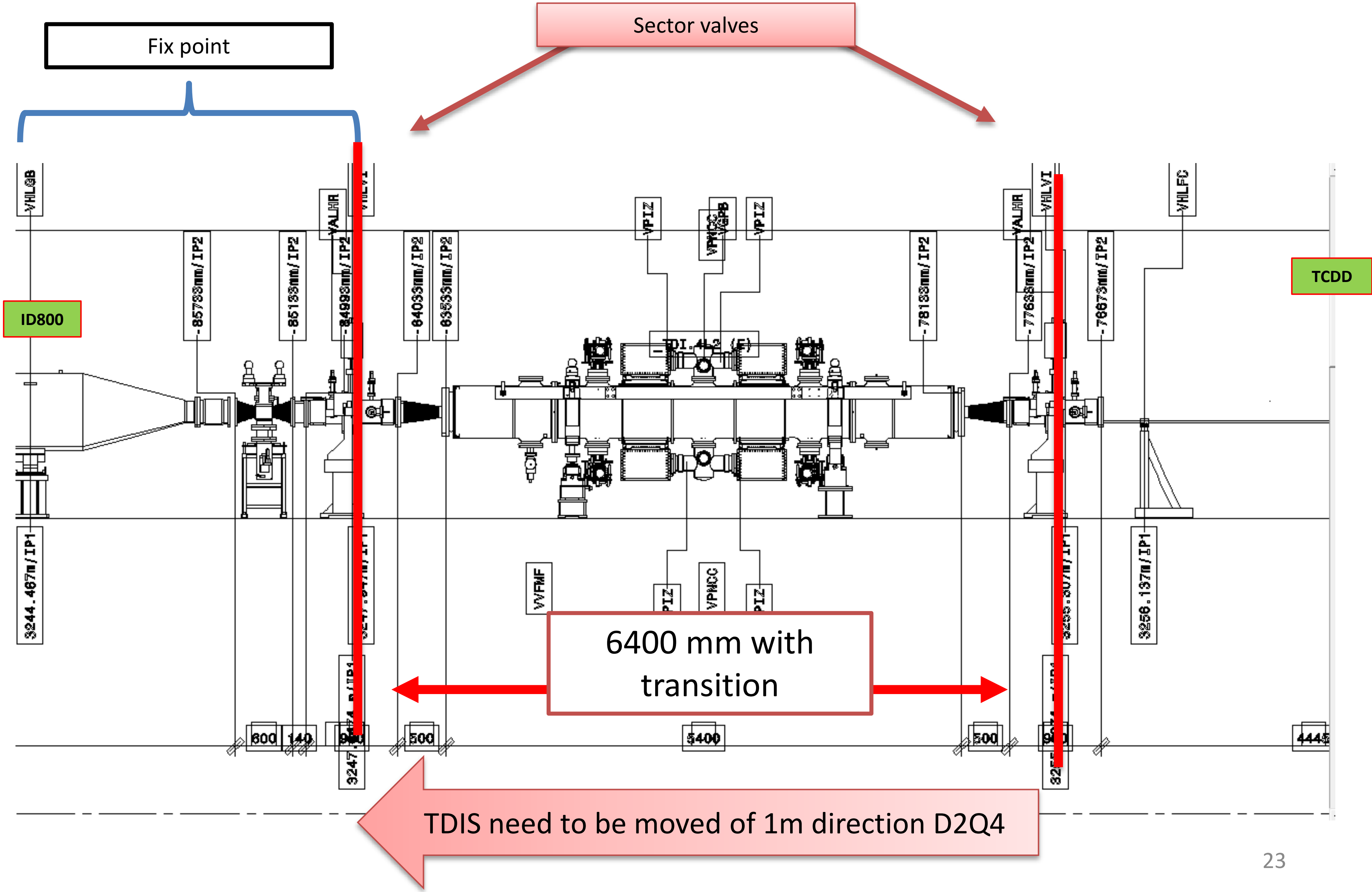
Present Sectorization



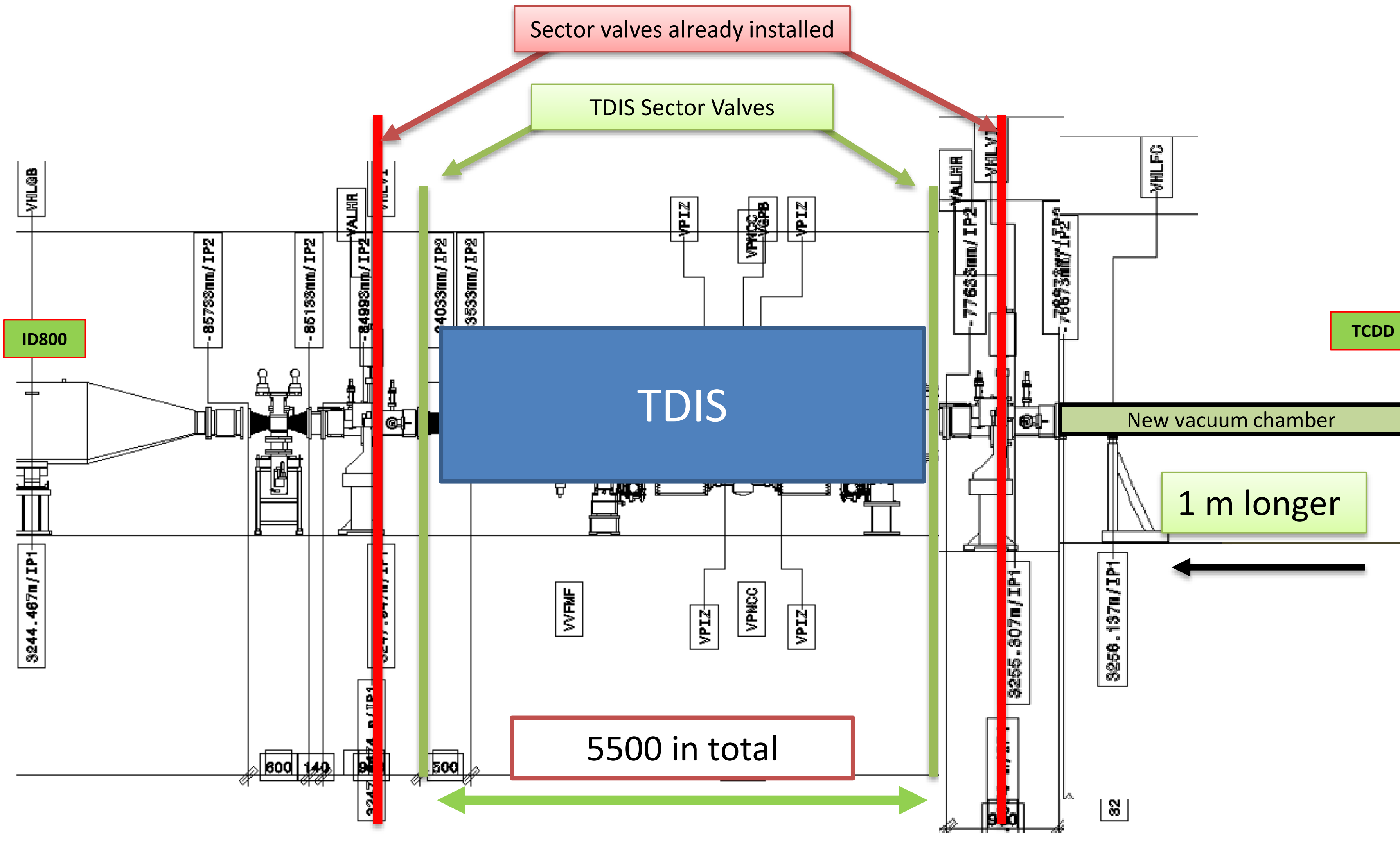
Limitation: Maximum access length to the tunnel in LSS2 is 5500mm

New TDIS with integrated sector valves should not exceed 5500mm

New position of the TDIS



Proposed sectorization



Pros & Cons for the sectorization

CONS

- Cost of the sector valves: ≈ 60 kCHF per unit – Need of 10 VVS for a total of 600 kCHF!
- Integration of the sector valves in the table of the TDIS: about 150 Kg for each valve
- Length limitation to 5500 mm
- New cabling, new components for the new small vac sector

PROS

- Limit time and radiation of personnel in case of exchange
- The exchange could be done over a Technical stop: 5 days

Summary

- **TDIS Upgrade:**
  - SGL Graphite blocks with low outgassing rate even if still traces of air: N_2 and Ar.
    - ➢ For the first 2 modules ≈$1.7 \cdot 10^4$ cm^2 → ≈ $1 \cdot 10^{-8}$ [mbar·l/s]
    - ➢ Expected pressure after bake out ≈ $5 \cdot 10^{-11}$ mbar
    - ➢ Expected pressure with beams < $1 \cdot 10^{-8}$ mbar
  - Robust new pumping scheme with redundancy for both gauges and pumps
  - Vacuum sectorization is highly recommended: ALARA consideration and possibility to exchange the tank within a TS

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