

Validation de systèmes à vide pour le grand arrêt numéro 1 du LHC

Gregory CATTENOZ,

CERN, TE-VSC group, on behalf of LHC Beam Vacuum section

Journées thématiques : « Problématiques Ultravioletes
d'aujourd'hui sur les installations complexes »

Institut Néel CNRS, Grenoble, 1er et 2 Décembre 2014



Outline

- Introduction
- Presentation of the vacuum validation process
- LHC beam vacuum consideration
- 3 tests overview:
 - Pump down
 - Residual Gas Analysis
 - Internal leak rate measure
- Example of the Totem roman pot detector
- Conclusion and outlook



Introduction

Vacuum baseline:

VACUUM VALIDATION → LHC BEAM VACUUM INSTALLATION

Measure and verification of vacuum performance

- Functionality
 - Leak tightness
 - Outgassing rate
 - Residual Gas Analysis
 - Leak tightness
 - Functionality
- } Before bake out cycle
- } After bake out cycle

Parts tested

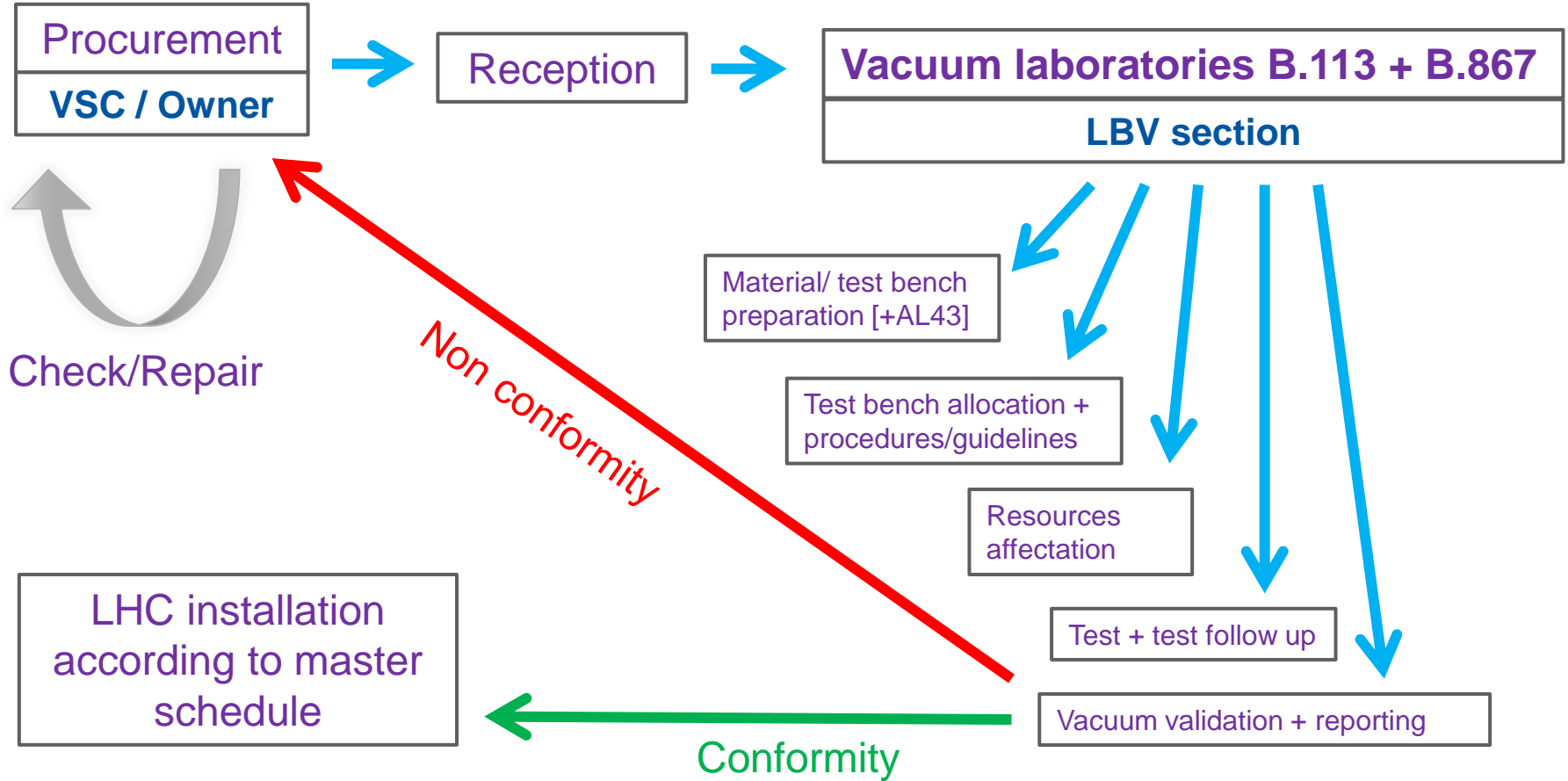
Instruments: TCTP collimators, MKI, Roman pots,...etc.

Gauges, valves, VPI, NEG cartridge...etc.



Organisation flux

Coordination : G. Cattenoz



LS1 Vacuum validation: Noticeable activities

➤ **Scheduling:** Procurement Vs installation time

➤ **Coordination:** Staff

➤ **Laboratory work**

- Reception + preparation
- Bake-out cycle
- Tests and validation

➤ **Official reporting : EDMS + LBV section web site**

Equipment for test by LSS sector for LS1

Legend Equipment Tested To test ON

Last update 04/09/2014

sectors
to do
done



1.00E-05 300

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Code Name	Destination
Roman Pot ALPHA	B7R1.B
Roman Pot ALPHA + BPMSA	A7L1.R
Roman Pot ALPHA + BPMSA	A7R1.B
VMAPA	6L2.B / 6R8.R
VNSIP	6L2.B
VCDGC-VCDGD	LSS 4L2 and 4R2
Echantillon cable BPM	
<input checked="" type="checkbox"/> Ferrite TT2-111R.Skyworks	LHC TCTP
Bellow module for collimator	TCS collimator
BPM cable	TCTP collimators LHC
BTVSI.C5L2.B1 & BTVSI ASL2.B1	point 2
PT100 cables	TCTP collimators LHC
PT100	LHC
PT100	LHC
TCSP jaw	LHC point 6
Cycled BPM cables	
	Roman pot for ATLAS
Ferrite for VM TSA	LHC, LSS2, LSS8, A4L2, A4R2, A4R8, A4L8
Clicop and CFC jaw bloc	TCS and TCP collimators
Kapton cable	LHC
	C4R6
Cycled BPM cables	TCTP collimators
BPM cables pre-series lot n°2	TCTP collimators LHC
BPM cables pre-series lot n°3	LHC TCTP collimators

Key Filters Apply Clear

Modified On

Recycle Bin All Site Content

Degassing mbar³/s Degassing mabr³/s*cm2 Comments

CERN CH-1211 Geneva 23 Switzerland
TE Technology Department
TE-VSC
1348532
Date:10/10/2013
Page 1 of 4

Vacuum acceptance report
UHV Vacuum degassing test of VMZAS and VMZAK modules for the LHC

UHV Compatible
RGA analysis and degassing rate are compliant for use in the beam vacuum system of the LHC.

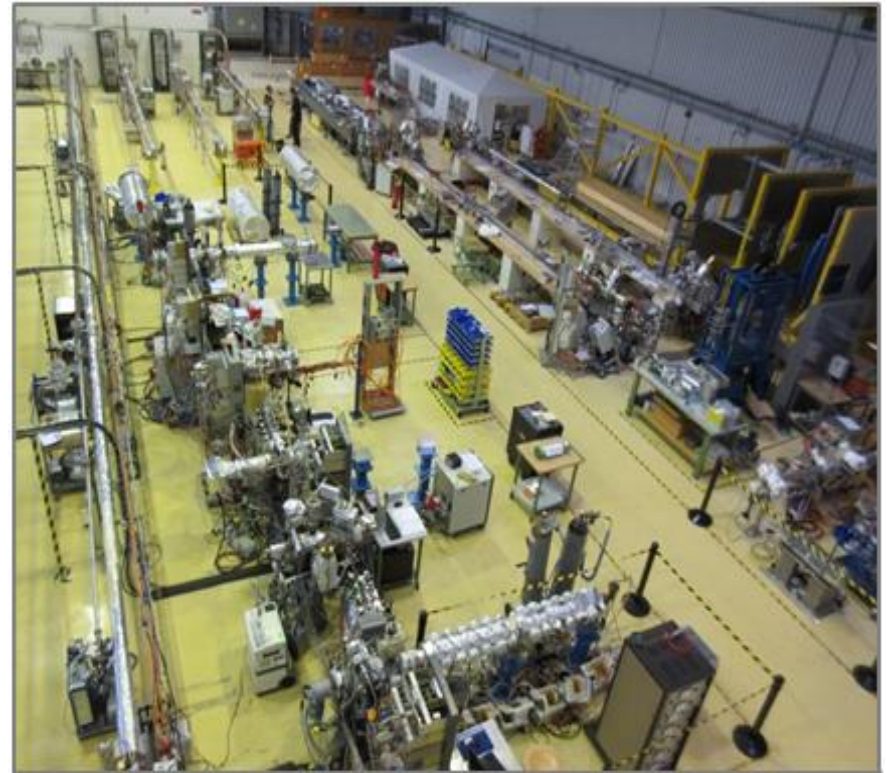
UHV not Compatible

Préparé par : Gregory Cattenoz
Vérfié par : Giuseppe Bregliozzi
Approuvé par :



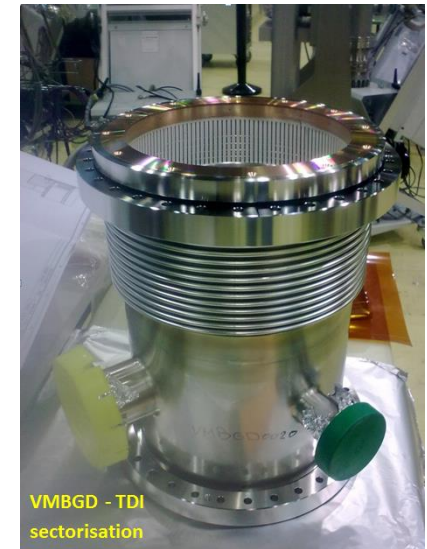
LS1 vacuum validation: Some numbers

- **2 laboratories: active/non-active parts**
- **19 test benches: LHC + Experience**
- **18 months activity**
- **3 (+1) staff**

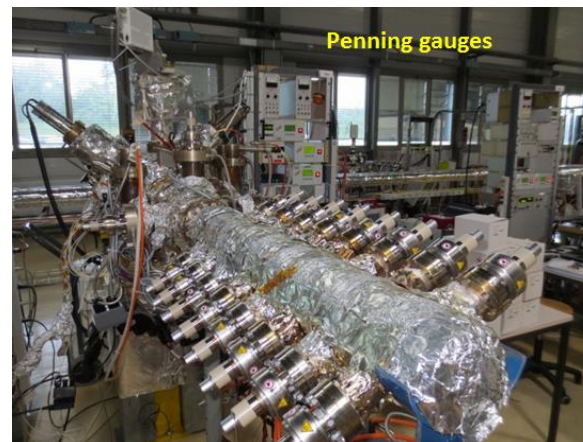
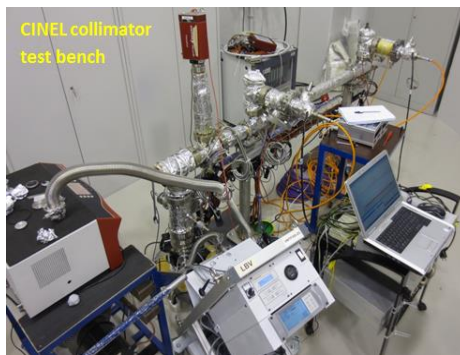
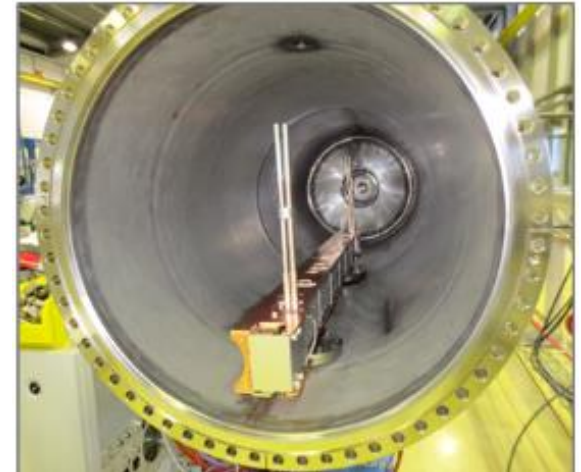
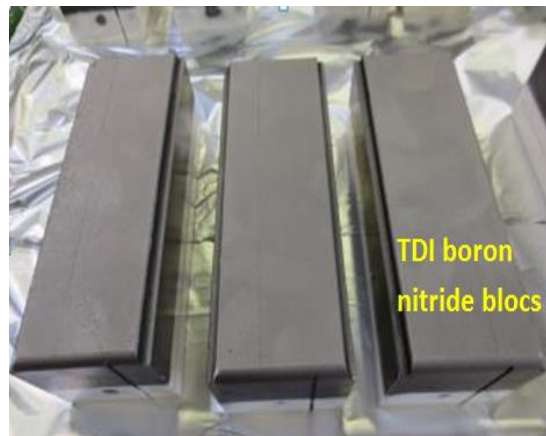


CERN vacuum laboratory B.113

Examples of tested parts



Examples of tested parts



LHC Beam vacuum consideration

- Pressure requirements:

LHC: $P_{\max} \approx 10^{-8}$ mbar - 100h beam life time operation

Experiments: $10^{-10}/10^{-11}$ mbar - reduced background

- Pumping characteristics

Room temperature vacuum sectors

VPI: every 28m - CH_4

NEG: coating/strip/cartridge - H_2 , CO , CO_2

Arcs and standalone: Cryo-pumping

Rely on NEG pumping → Localized outgassing rate: Necessity to control quantity and nature of residual species after bake out.

How to achieve vacuum performance?

1. UHV clean, vacuum treated parts
2. Tested/known sub-components
3. Test bench zero reference
4. Controlled bake-out: Instrumentation, cold point, cycle



Vacuum-fired ferrite (TT2-111R / Transtech)
@ 1000°C/24h00
→ TCTP + XRPT

Acciaierie Valbruna S.p.A.
36100 VICENZA (Italia) - Viale della scienza, 25 z.i.
Stab.: 39100 BOLZANO (Italia) - Via A. Volta, 4
Cliente / Kunde / Client: C-est

Prodotto: ACCIAIERIE VALBRUNA S.P.A.
Rolle / Rollen / Role: produit

Stato di fornitura: SOLUTION-ANNEALED PEELED
Livraison / Lieferung / Delivery: état de livraison

CERTIFICATO DI COLLAUDO
ABNAHMEPRUEFZEUGNIS
INSPECTION CERTIFICATE
CERTIFICAT DE RECEPTION
EN 10204 (2004) , 3.1

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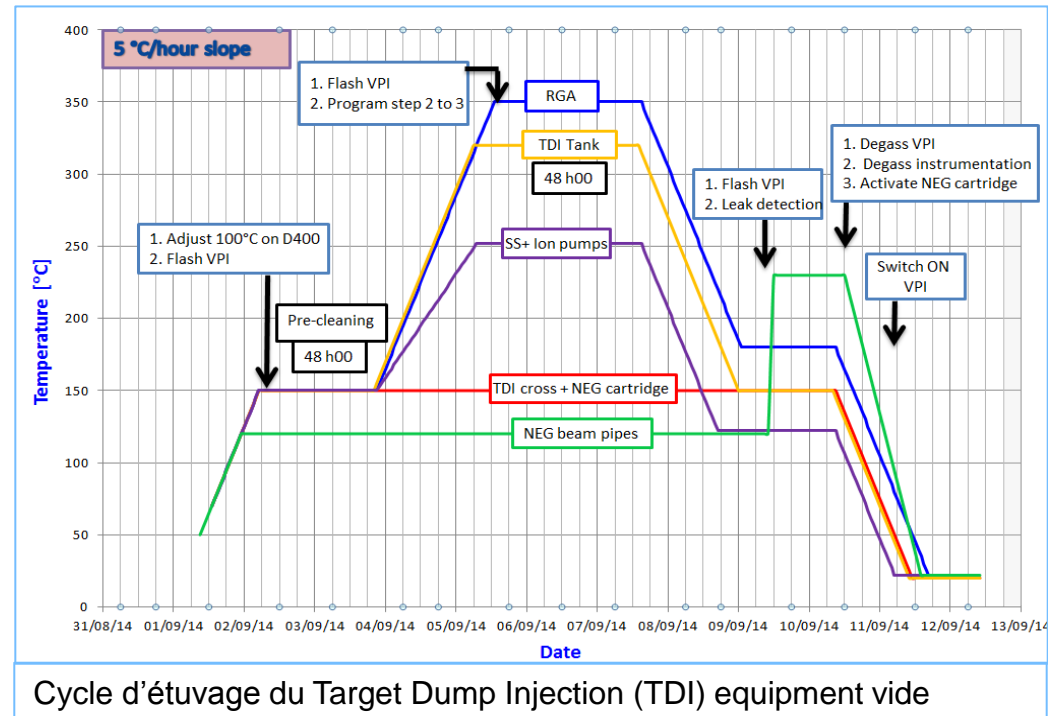
Analisi chimica del prodotto
Chemical Analysis product / Chemische Zusammensetzung... / Analyse chimique produit

Colata steel Schmelze/Steel Casta	min	0,050	1,20	4,00	20,90	0,90	1,50	11,50	0,030	0,10	0,20	-	-	-	-	-	-
255093	C %	Si %	Mn %	Cr %	Mo %	Ni %	Co %	P %	S %	V %	N %	-	-	-	-	-	-
C	0,045	0,34	4,95	21,24	2,04	12,00	0,090	0,028	0,001	0,12	0,27	-	-	-	-	-	-

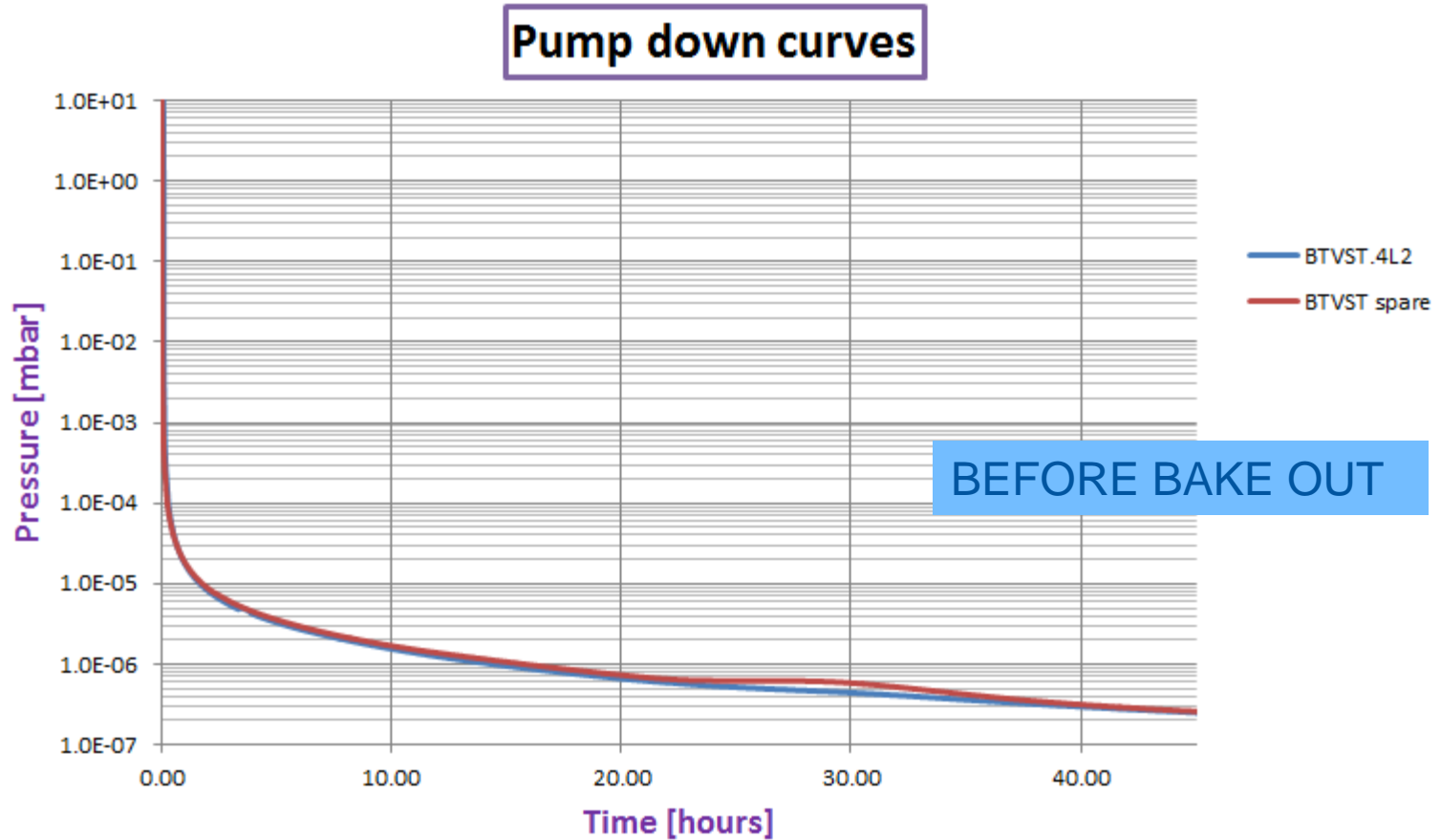
Colata steel Schmelze/Steel Casta	min	0,100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
255093	Nb%+Ta%	0,121	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Material annealed 1065C for 1h/water cooled.
Material was manufactured, sampled, tested and inspected
in accordance with the material specification requirements
and has been found to meet those requirements.

Certificat de coulée acier inox pour fabrication
cable BPM (TMS)

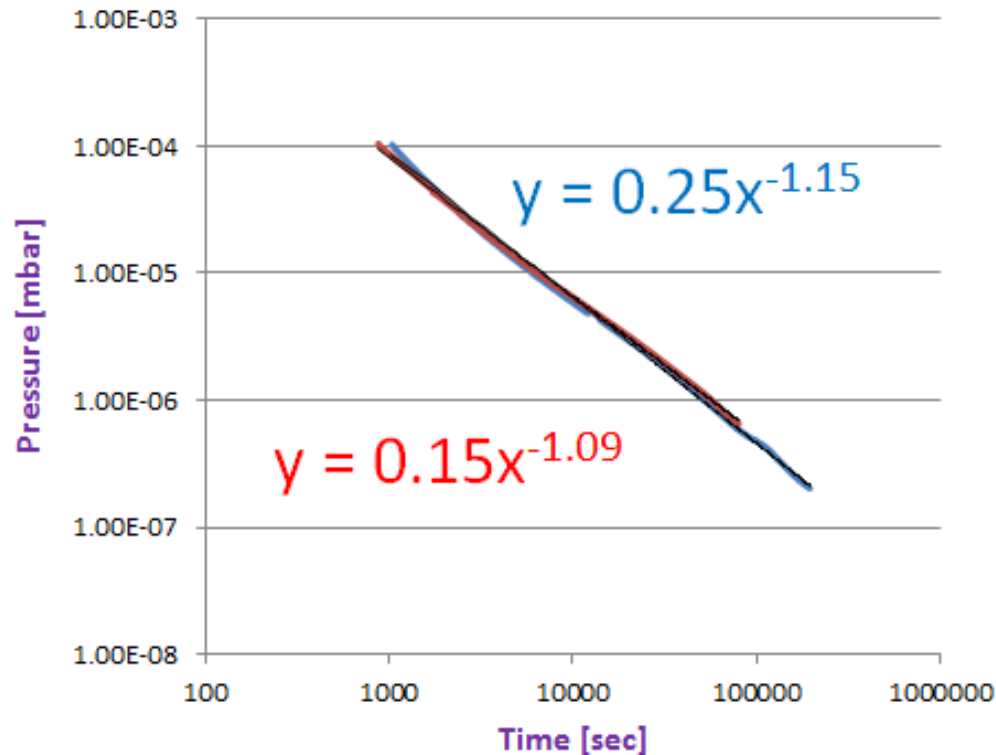


Preliminary test: Pump down



Preliminary test: Pump down

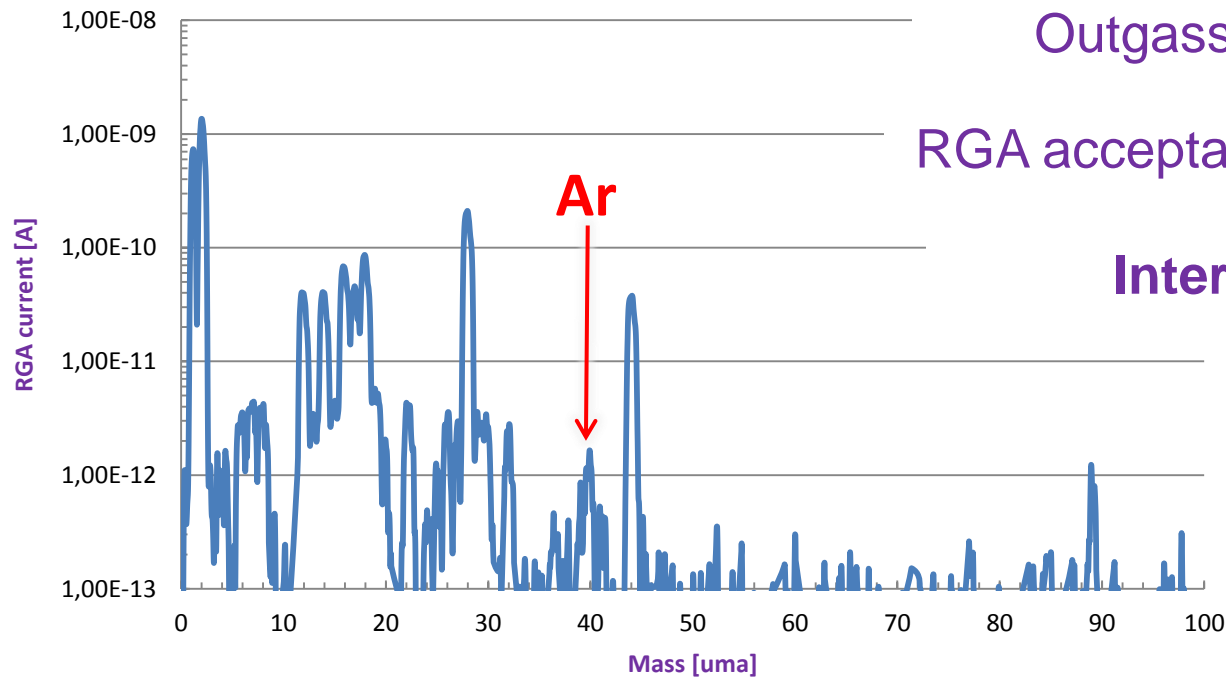
Pump down slopes



Diagnostic possible presence of contaminants or leak by comparison

Metallic substrate: P(t) fitted with 1/t equation

Internal outgassing rate measurement 1/2



Externally leak tight



Outgassing rate



RGA acceptance limit

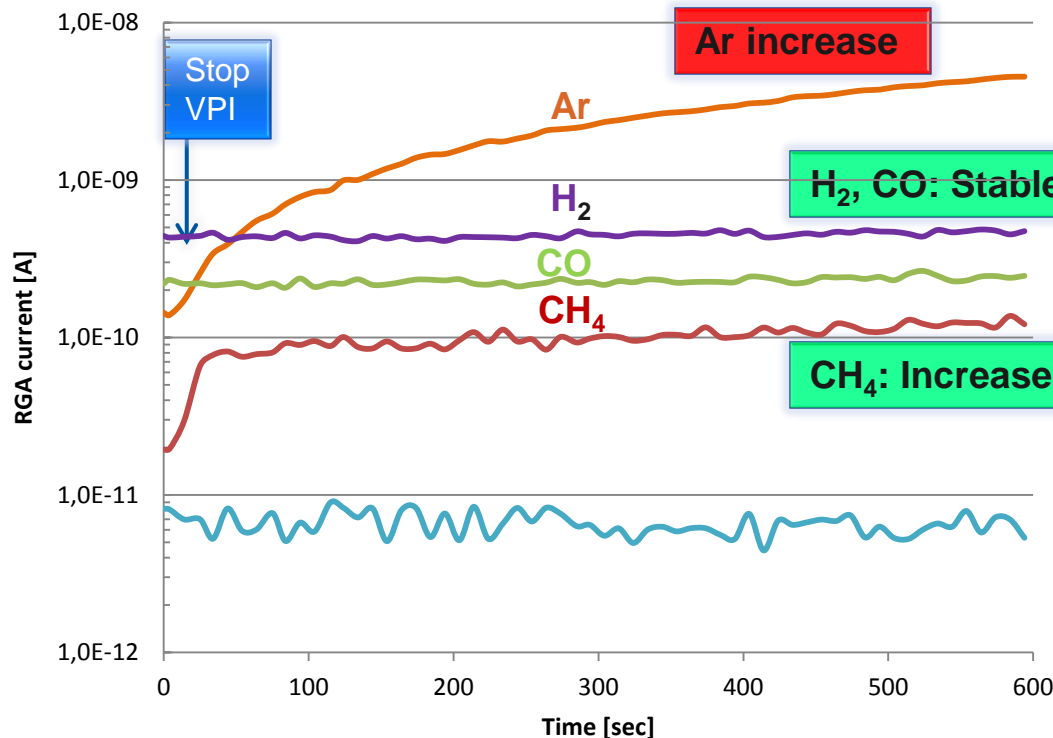


Internal leak



Internal outgassing rate measurement 2/2

Procedure could be applied in case of active NEG present in the system



Method:

(G. Bregliozzi – «Procedure for the leak detection of an LSS vacuum sector after NEG activation»)

$$Q = (P \times V) / t$$

Pressure rise (total - SVT)

Volume accumulated

time accumulate (10min)

2. Argon outgassing : Contribution ratio (RGA current spectra)
3. Air equivalent internal leak rate estimation

$Q_{[air_eq.]} < 5.10^{-9}$ mbar.l/s correspond to ≈ 1 m saturated NEG (80mm D.) every 150 days



RGA acceptance criteria 1/2

Based on collimator specifications (EDMS 1113402)

- Maximum total outgassing rate of $2 \cdot 10^{-7}$ mbar.l/s after bake out
- Presence of known residual gas in well-defined limits

Why?

- Control absence of contaminants + air leaks
- Verify partial pressure composition after bake out

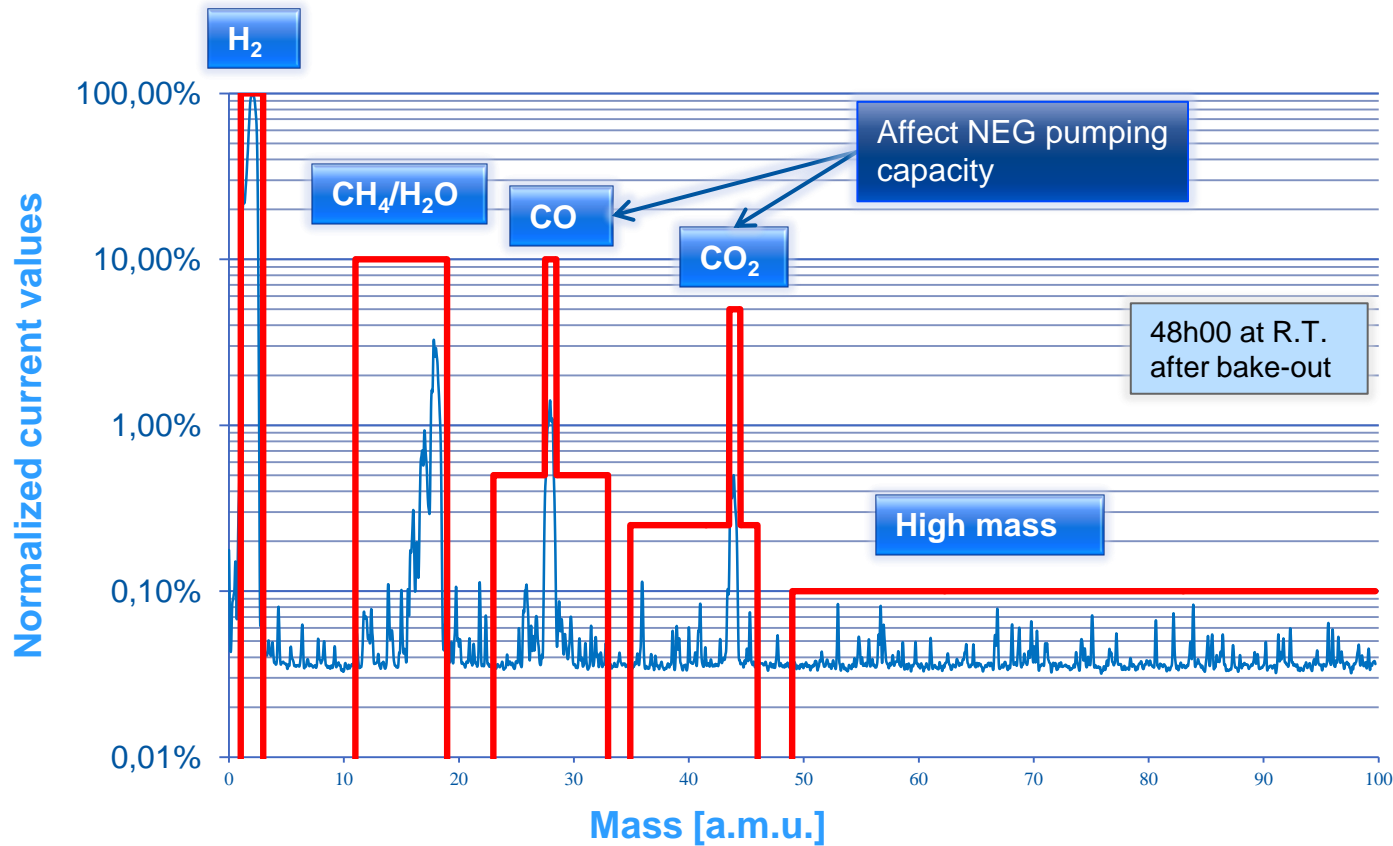
Affect vacuum performance

How?

- RGA currents normalized to H_2 : Dominant gas but not affecting NEG performance
- Acceptation limits template applied to normalized RGA currents

RGA acceptance criteria 2/2

Normalised RGA currents to H₂ with defined acceptance limits

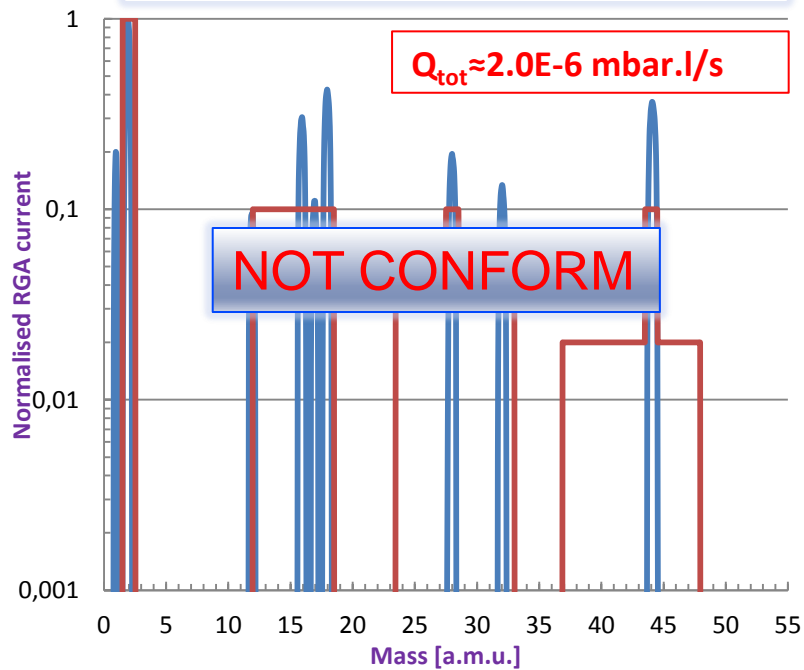


Example of XRPT stations

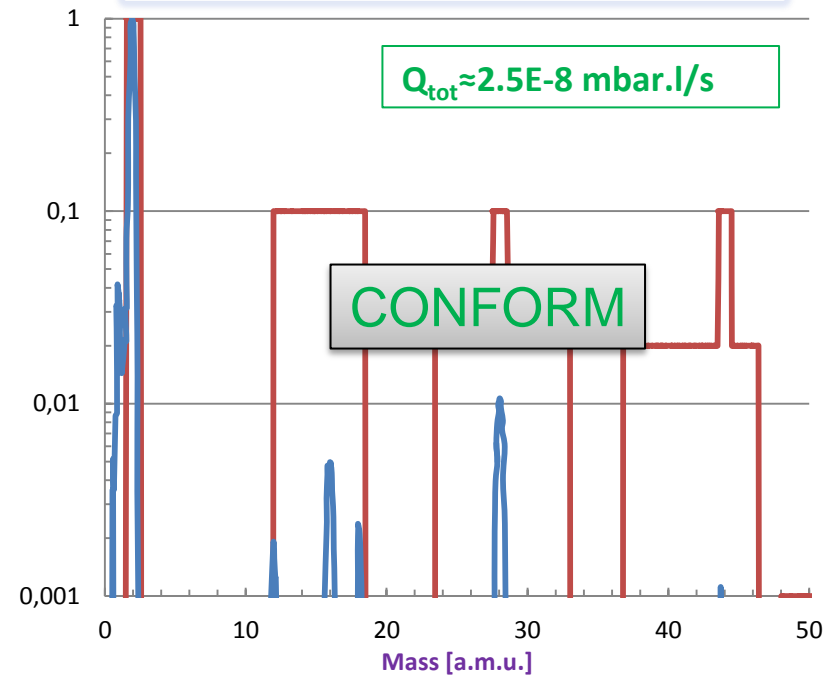


XRPT station: Critical bake-out

After 1st bake-out:
RGA currents out of acceptance limit
No internal + no external leak

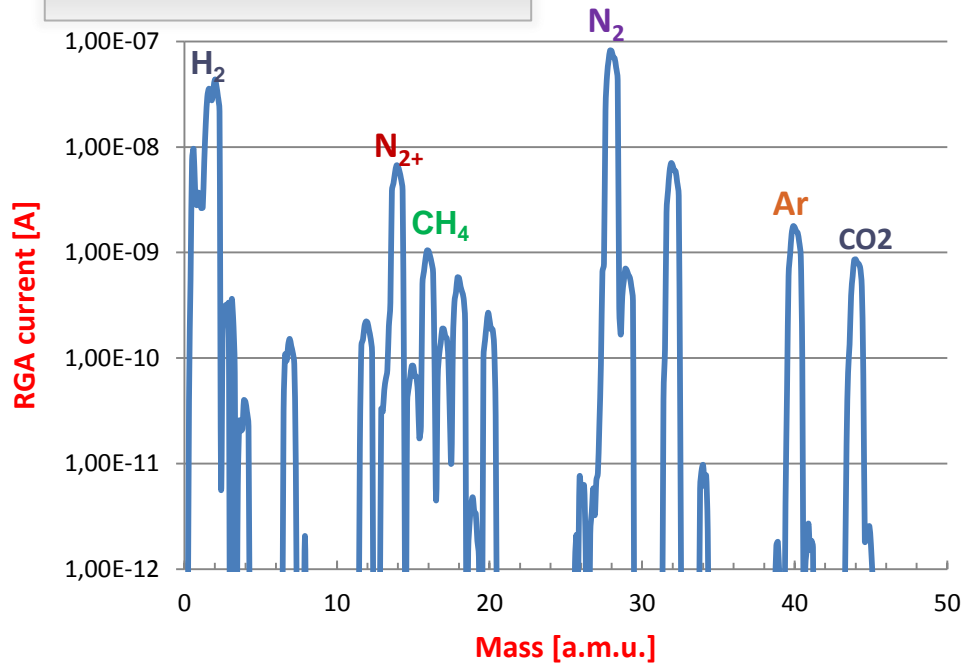


After 2nd bake-out
No external + no internal leak
Optimized bake out

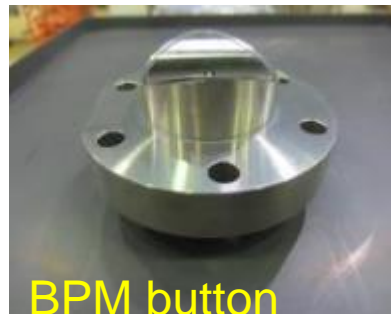
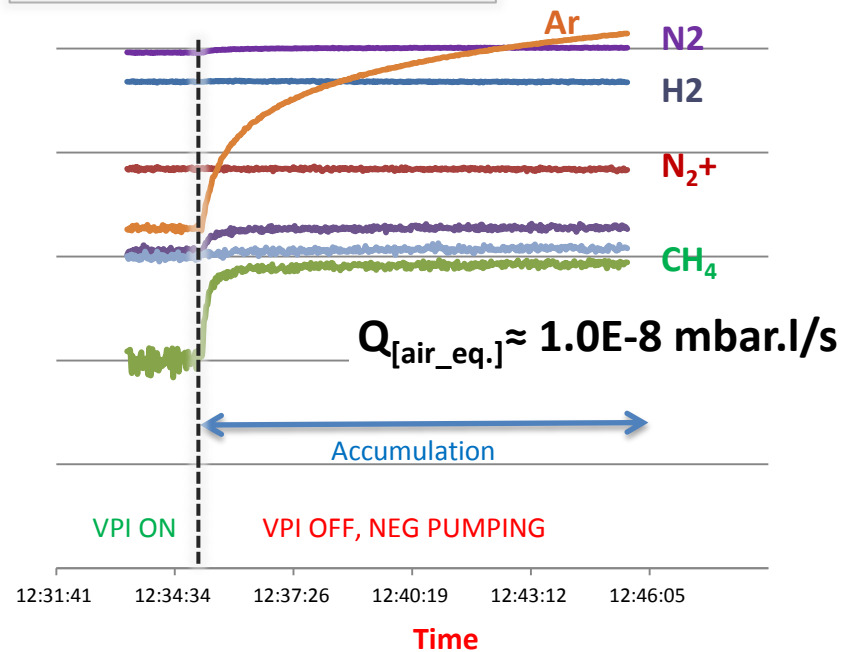


XRPT station: Leak on BPM

Air leak RGA spectra after bake out

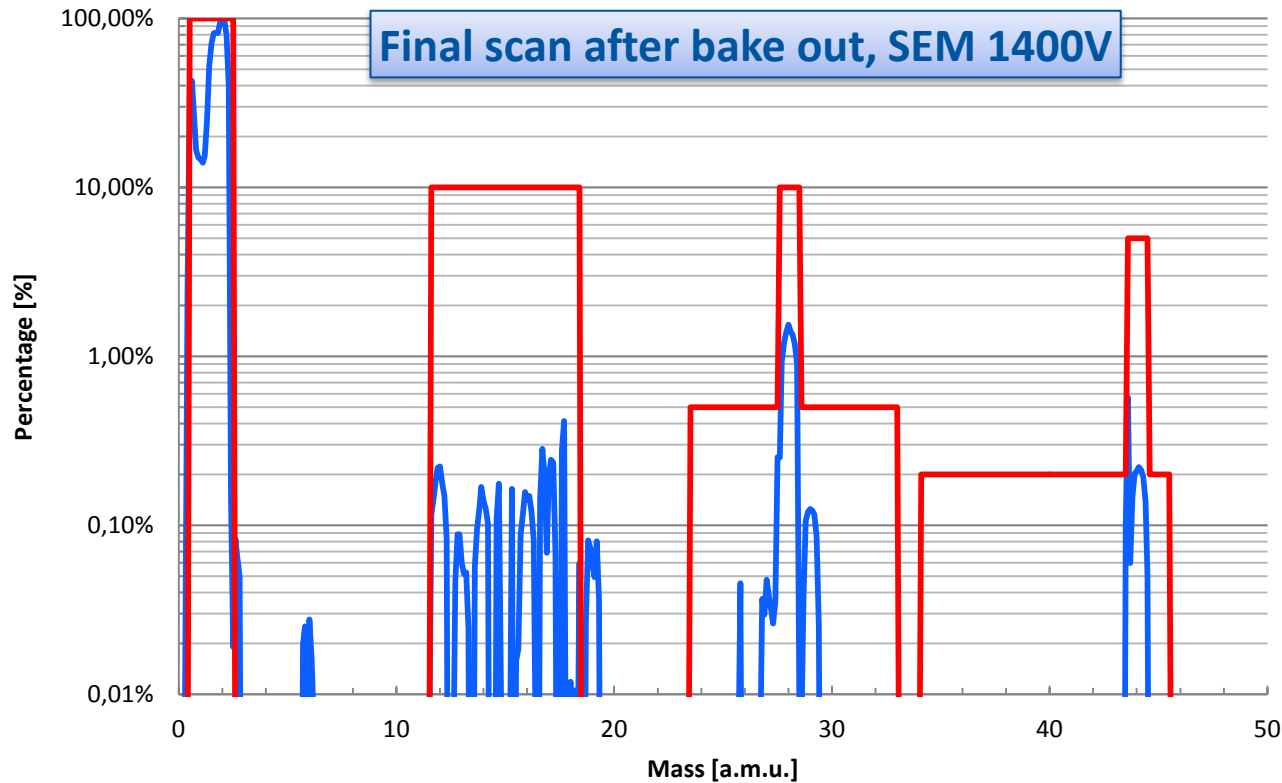


Leak flow estimation



XRPT station: Final results

Outgassing rate after bake out cycle at $250^{\circ}\text{C} \approx 6,0 \cdot 10^{-9}$ mbar.l/s.



XRPT: Conclusion based on LS1 experience

For bake out, ensure: (can not be neglected)

- Proper positioning of:
 - Regulating thermocouple
 - Appropriate heating element
 - No cold point
 - Correct operation → Regular check to 50°C, 100°C, until maximum temperature
 - Removal of equipment, always after bake out cycle, to enable helium leak test
- } guarantee correct temperature regulation

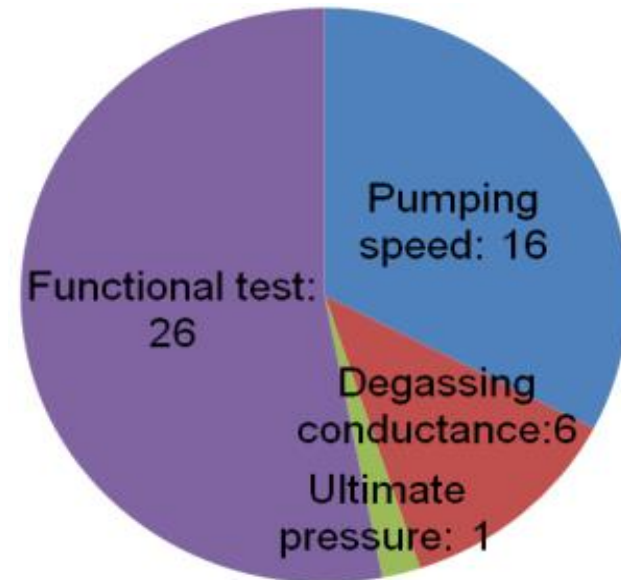
In any circumstance, allow TIME for test!

Conclusions

- All parts tested before installation
→ **RESPECTED BASELINE**
- Overall 1200 parts tested

Equipment	XRPT	Collimator	Beam instrument BTV	Sector valve (MKI)
Average Q_tot. measured [mbar.l/s]	$2.0 \cdot 10^{-8}$	$3.0 \cdot 10^{-8}$	$4.0 \cdot 10^{-9}$	$1.5 \cdot 10^{-8}$

- About 5% non conformity:
TCSP, BQSV.5R4, BWS.5R4, TDI blocs, insert, VPIAN



Non-conformities distribution

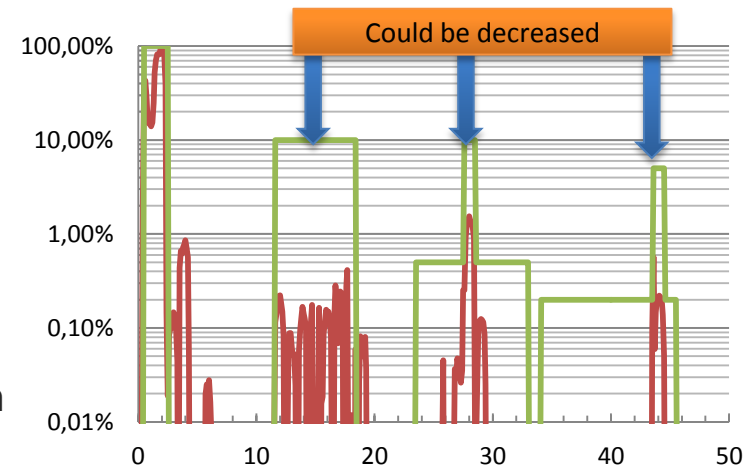
Outlook and further development

General/logistics:

- Put in place tool to identify components at reception
- Use of EDMS as tool for report results acknowledgement
- Take part in the conceptual phase, prototyping and follow fabrication of critical component

Measures:

- Review acceptance criteria
- Allow time to carry out sub-assembly test of complete system (i.e. Roman pot)
- Perform regular zero measurement of test bench
- Operate recurrent RGA calibration



More details on this subject

Proceedings of IPAC2014, Dresden, Germany

WEPME041

VACUUM ACCEPTANCE TESTS FOR THE UHV ROOM TEMPERATURE VACUUM SYSTEM OF THE LHC DURING LS1

G. Cattenoz, V. Baglin, G. Bregliozzi, D. Calegari, J. Gallagher, A. Marraffa, and P. Chiggiato
European Organization for Nuclear Research, CERN, 1211 Geneva 23, Switzerland



Thank you for your attention



