

Vacuum Acceptance Tests for the UHV Room Temperature Vacuum System of the LHC during LS1

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on behalf of LBV section

TE-VSC seminar, 5/09/2014.



Outline

- Introduction
- Vacuum validation process overview
- RGA and internal outgassing criteria
- Noticeable results
- 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.



Vacuum validation process overview

Coordination: G. Cattenoz
Scheduling (proc., installation)

Laboratory work (LBV)

- 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

1.00E-05 300

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Code Name	Destination
<input type="checkbox"/> Roman Pot ALPHA	B7R1.B
<input type="checkbox"/> Roman Pot ALPHA + BPMSA	A7L1.R
<input type="checkbox"/> Roman Pot ALPHA + BPMSA	A7R1.B
<input type="checkbox"/> VMAPA	6L2.B / 6R8.R
<input type="checkbox"/> VMSIP	6L2.B
<input type="checkbox"/> VCDGC-VCDGD	LSS 4L2 and 4R2
<input type="checkbox"/> Echantillon cable BPM	
<input type="checkbox"/> Ferrite TT2-111R Skyworks	LHC TCTP
<input type="checkbox"/> Bellow module for collimator	TCS collimator
<input type="checkbox"/> BPM cable	TCTP collimators LHC
<input type="checkbox"/> BTVSI.CSL2.B1 & BTVSI.ASL2.B1	point 2
<input type="checkbox"/> PT100 cables	TCTP collimators LHC
<input type="checkbox"/> PT100	LHC
<input type="checkbox"/> PT100	LHC
<input type="checkbox"/> TCSP jaw	LHC point 6
<input type="checkbox"/> Cycled BPM cables	
<input type="checkbox"/> Roman pot for ATLAS	
<input type="checkbox"/> Ferrite for VM TSA	LHC, LSS2, LSS8, A4L2, A4R2, A4R8, A4L8
<input type="checkbox"/> Clidcop and CFC jaw bloc	TCS and TCP collimators
<input type="checkbox"/> Kapton cable	LHC
<input type="checkbox"/> C4R6	
<input type="checkbox"/> Cycled BPM cables	TCTP collimators
<input type="checkbox"/> BPM cables pre-series lot n°2	TCTP collimators LHC
<input type="checkbox"/> BPM cables pre-series n°3	LHC TCTP collimators

Key Filters

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EDMS document no.
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

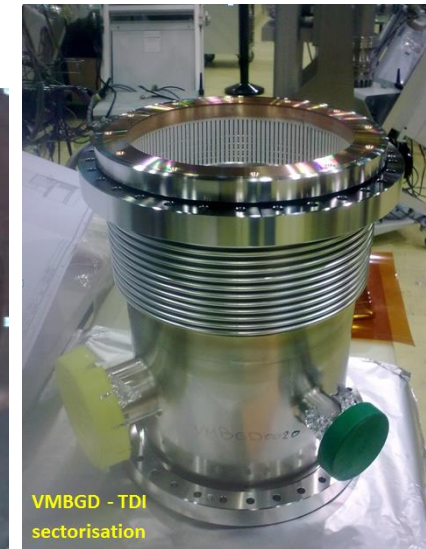
Préparé par : Gregory Cattenoz
Gregory.cattenoz@cern.ch

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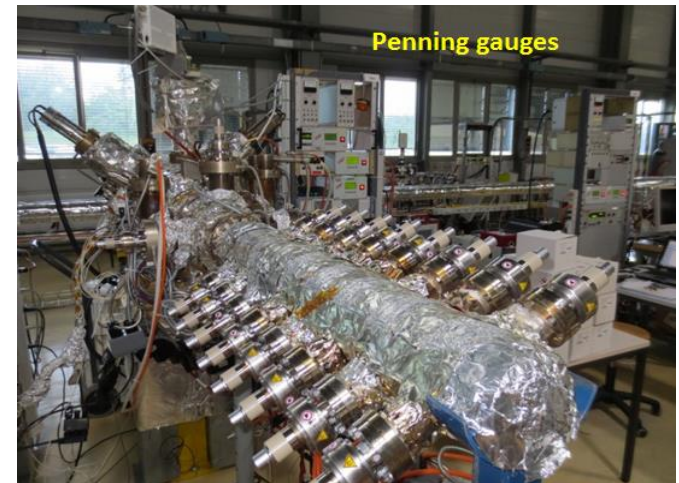
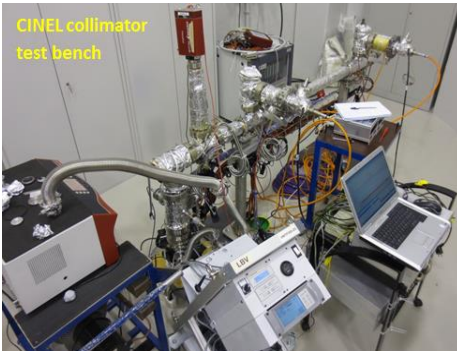
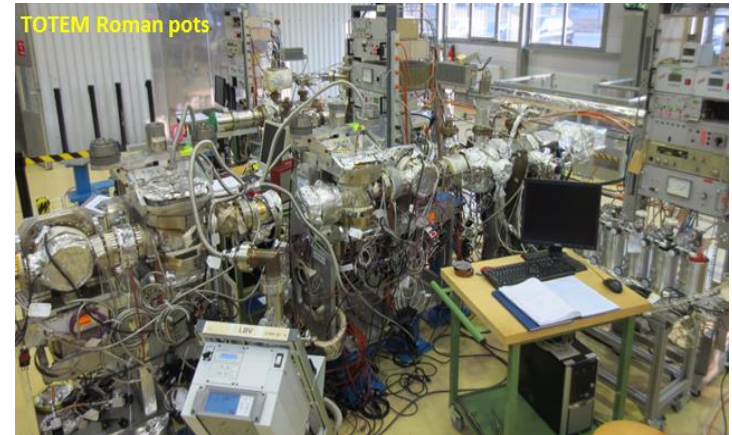
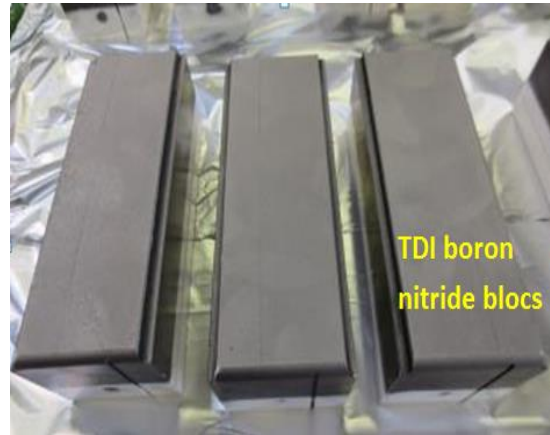
Approuvé par :



Examples of tested parts



Examples of tested parts



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: Need of controlled quantity and nature of residual species after bake out.

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

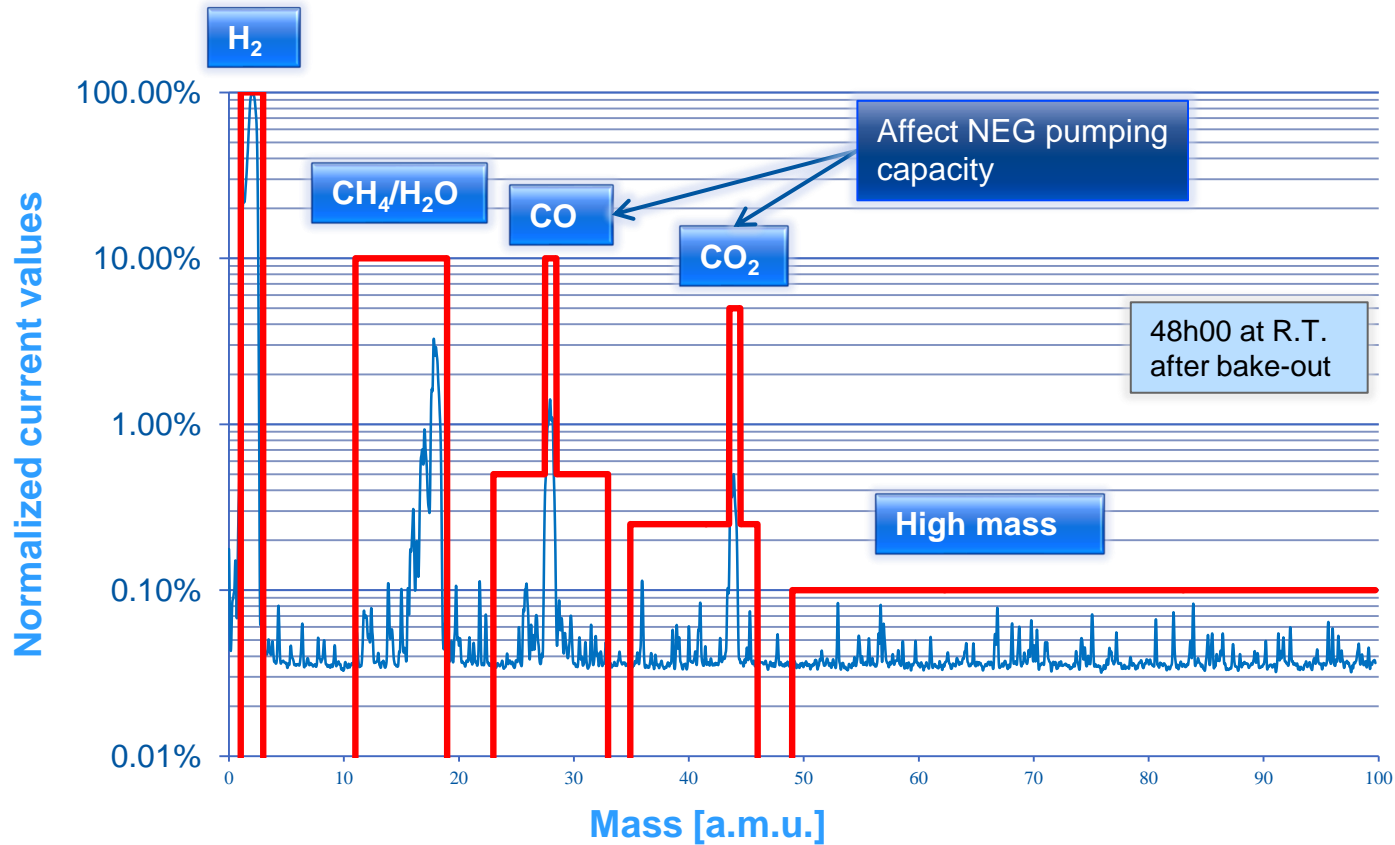
How?

- RGA currents normalized to H_2 : Gas not affecting the NEG performances
- Acceptation limits template applied to normalized RGA currents



RGA acceptance criteria 2/2

Normalised RGA currents to H₂ with defined acceptance limits



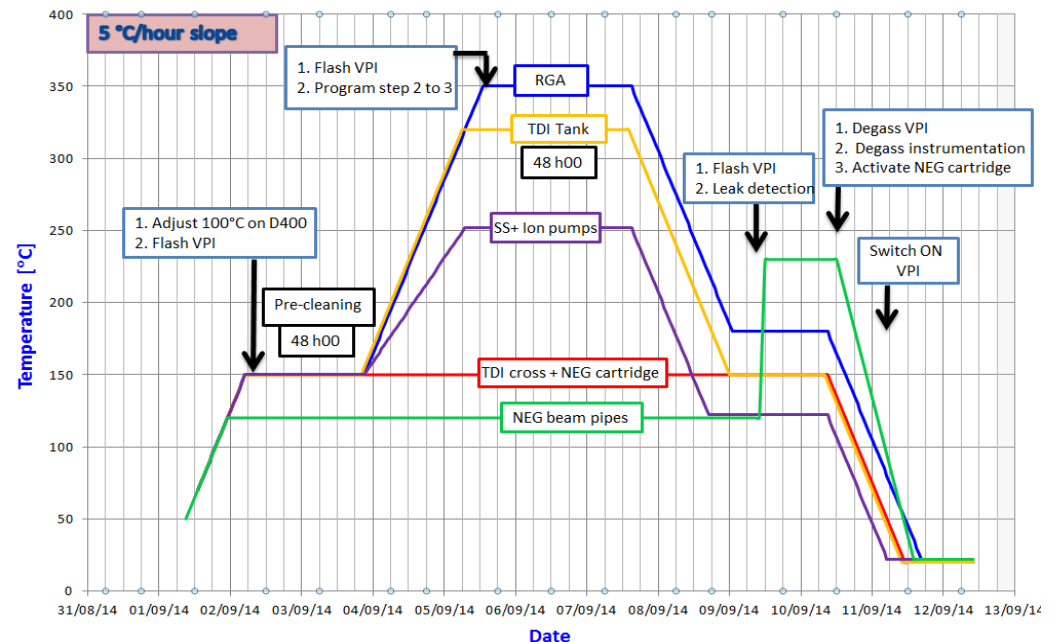
How to achieve vacuum performance?

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

Bakeout cycle TDI - Tunnel activation C4R8 - September 2014



Acciaierie Valbruna S.p.A.

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 Clienti / Kunden / Customers

Produttore: ACCIAIERIE VALBRUNA S.P.A.
 Hersteller / Fabricator

Stato di fornitura: - SOLUTION-ANNEALED PEELED
 Lieferzustand / Delivery state



Avviso di Spedizione: D
 Lieferfrist / Delivery date

Ordine nr: IO/1011/0120
 Bestellnummer / Order no.

Tipo di Elaborazione: E+AOD
 Herstellungsprozess / Production process

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

Certificato nr: MEST139945/2011/
 Prüfzeugnis Nr.

Confirma ordine nr: SP11000667
 Bestätigung / Confirmation

Marchio di Fabbrica:
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 Date mark
 Eigentümerversignatur

Funzione del Collaudatore:
 Beurteiler / Inspector
 Inspector / Inspizor / Inspektor

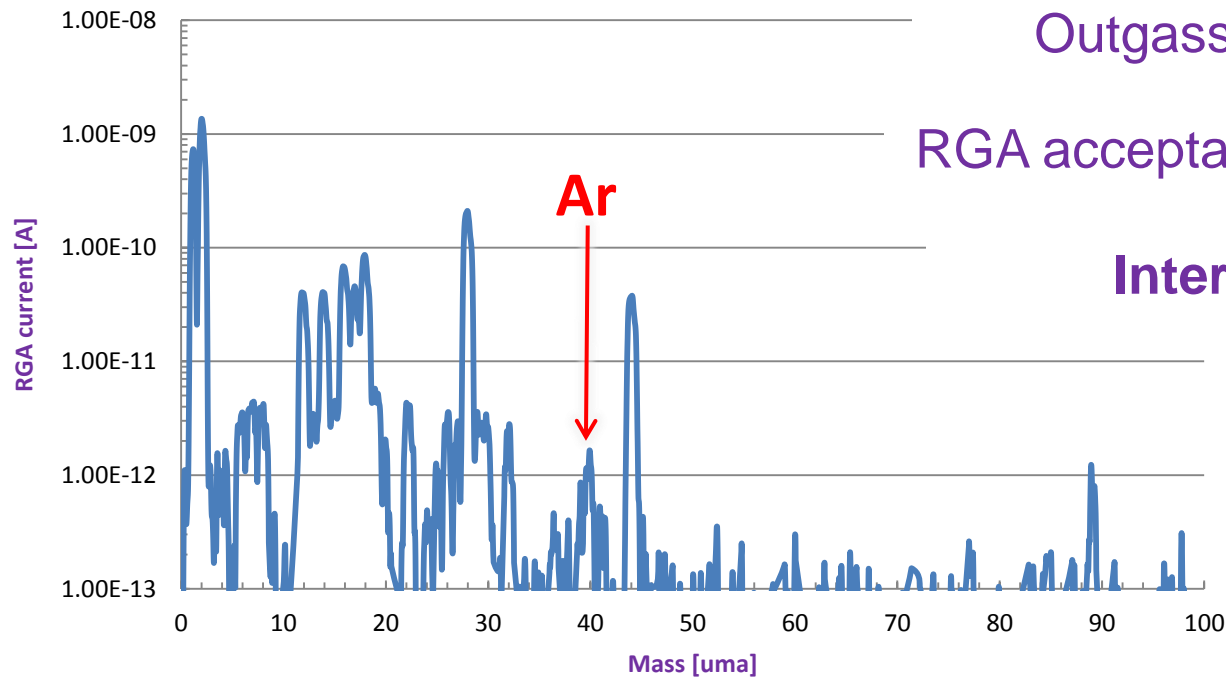
Analisi chimica del prodotto

Colata Heat		Chemical Analysis										
255093	255093	C %	Si %	Mn %	Cr %	Mo %	Ni %	Co %	P %	S %	V %	N %
min 0,005	max 1,00	4,00	0,00	20,00	1,00	11,00	0,00	0,045	0,030	0,10	0,30	-
0,045	0,34	4,95	21,24	2,04	12,00	0,090	0,028	0,001	0,12	0,27	-	-

Material annealed 1055C 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.



Internal outgassing rate measurement 1/2



Externally leak tight



Outgassing rate



RGA acceptance limit

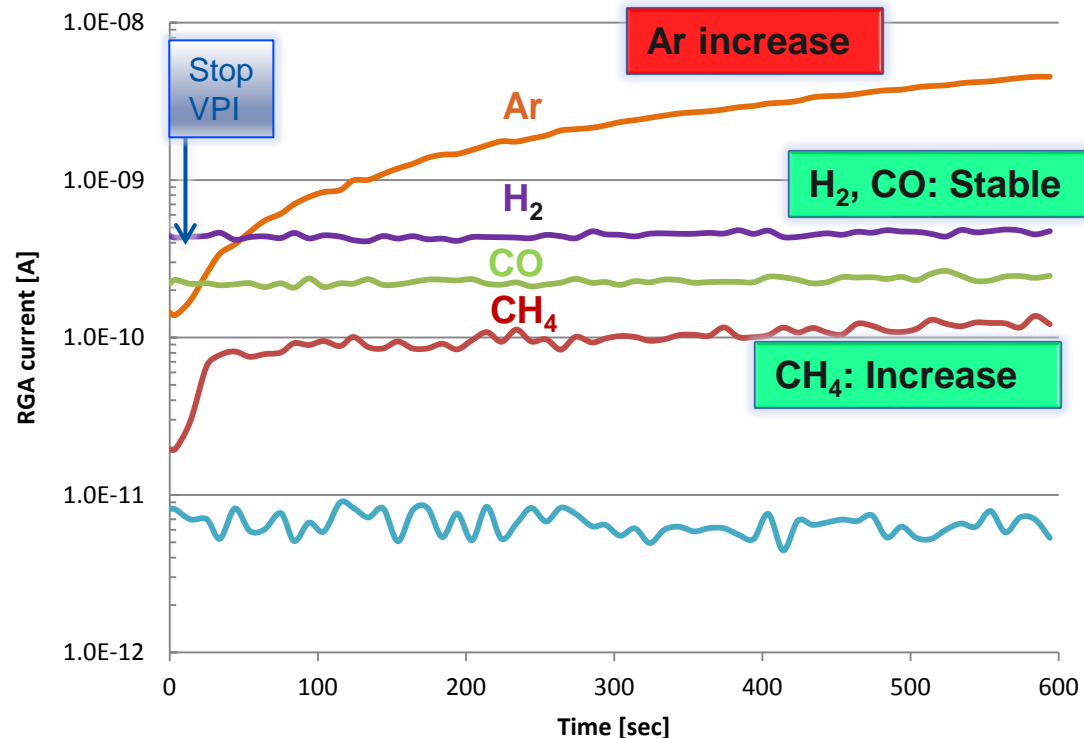


Internal leak



Internal outgassing rate measurement 2/2

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



Total outgassing rate quantification:
(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**

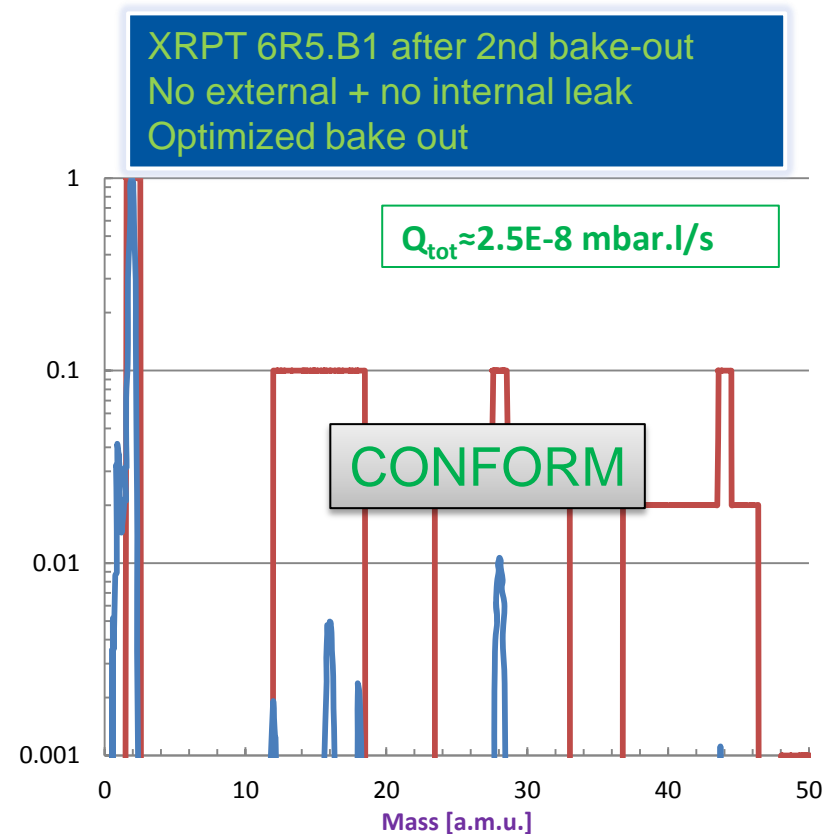
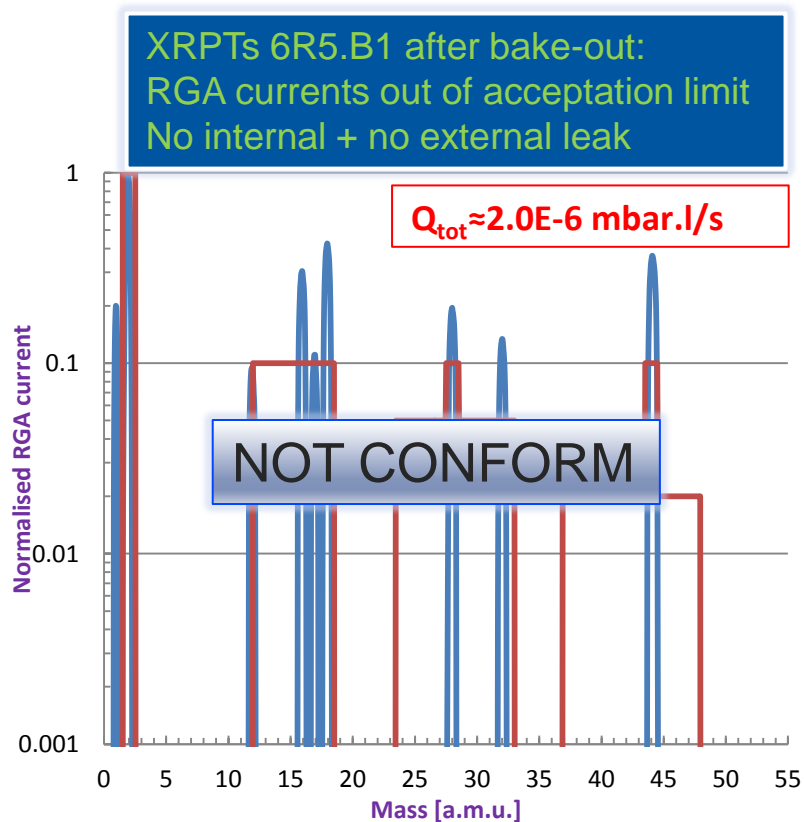
$Q_{[air_eq.]} < 5.10^{-9}$ mbar.l/s correspond to ≈ 1 m saturated NEG (80mm D.) every 150 days



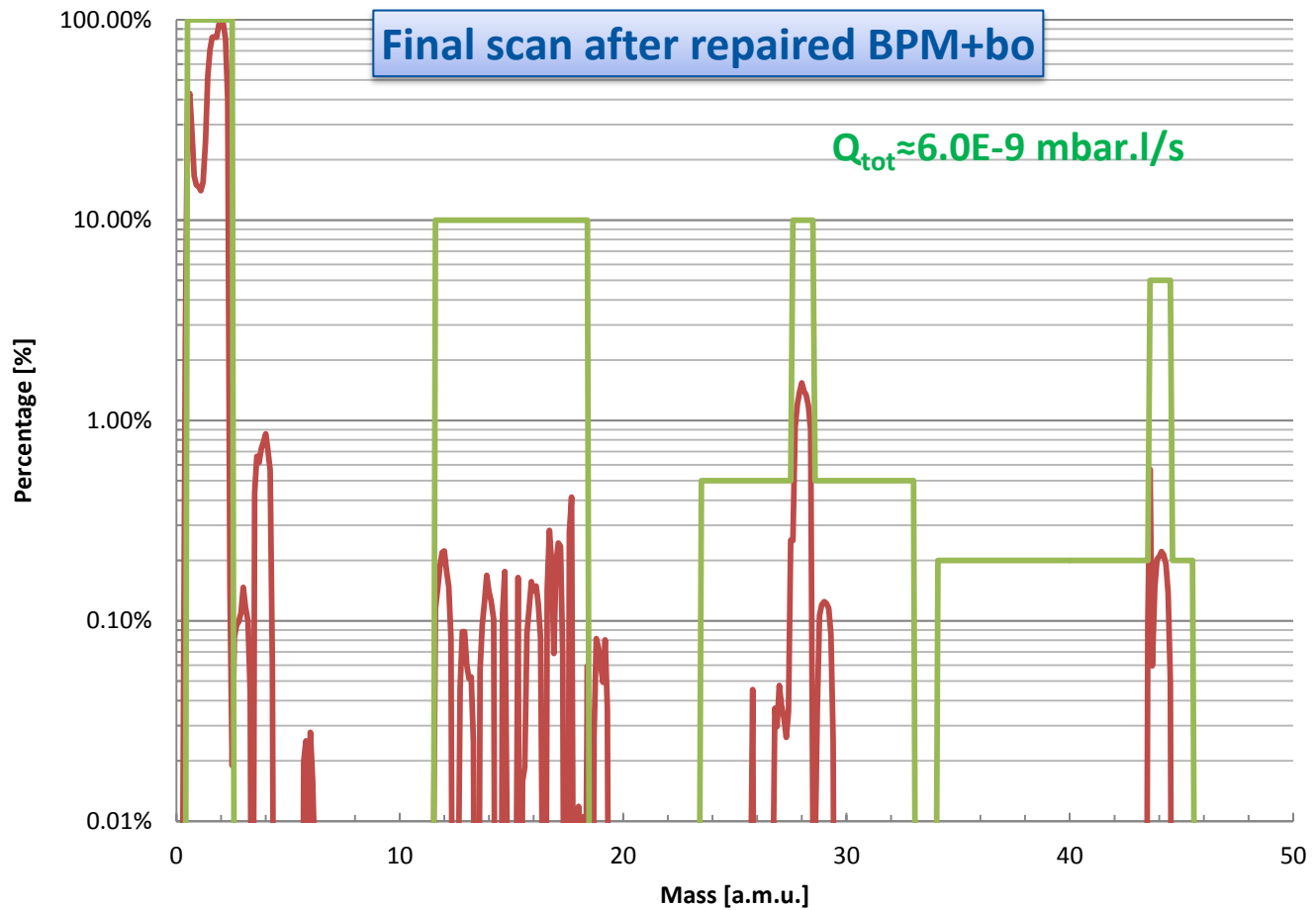
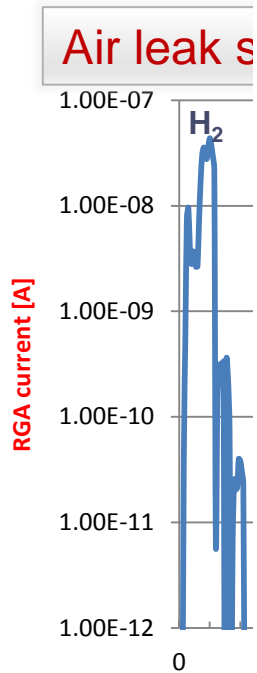
Example XRPT stations



Example XRPT stations: Critical bake-out



Example XRPT stations: Leak on BPM

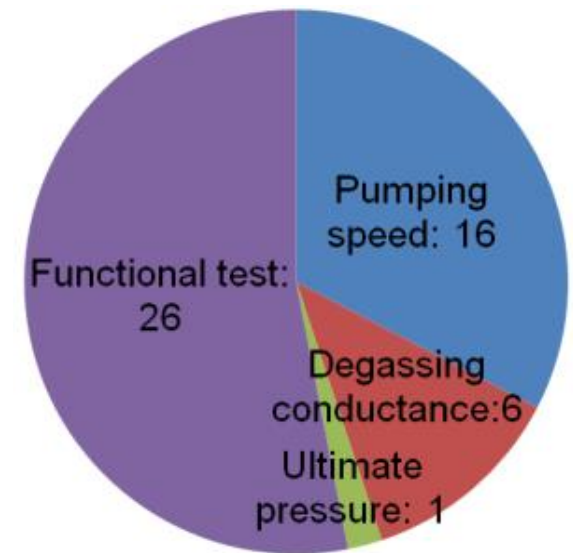


Conclusions

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

Equipment	XRPT	TCTP	BTV	VVS_MKI
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

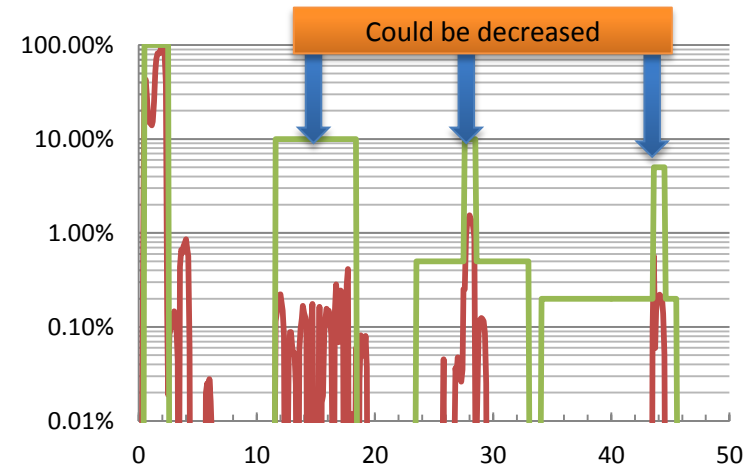
Outlook

General:

- Put in place tool for identification of components at reception
- Use of EDMS for report results acknowledgement
- Take part in the design/prototyping/fabrication phases

Measures:

- Review acceptance criteria
- Carry out sub-assembly test of complex system
- Regular zero measurement of test bench
- Recurrent RGA calibration



Thank you for your attention.

Questions and feedback.

