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 Ultravides d'aujourd'hui sur les installations complexes »
Institut Néel CNRS, Grenoble, 1er et 2 Décembre 2014

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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

Before bake out cycle

- Outgassing rate
- Residual Gas Analysis
- Leak tightness
- Functionality

After bake out cycle

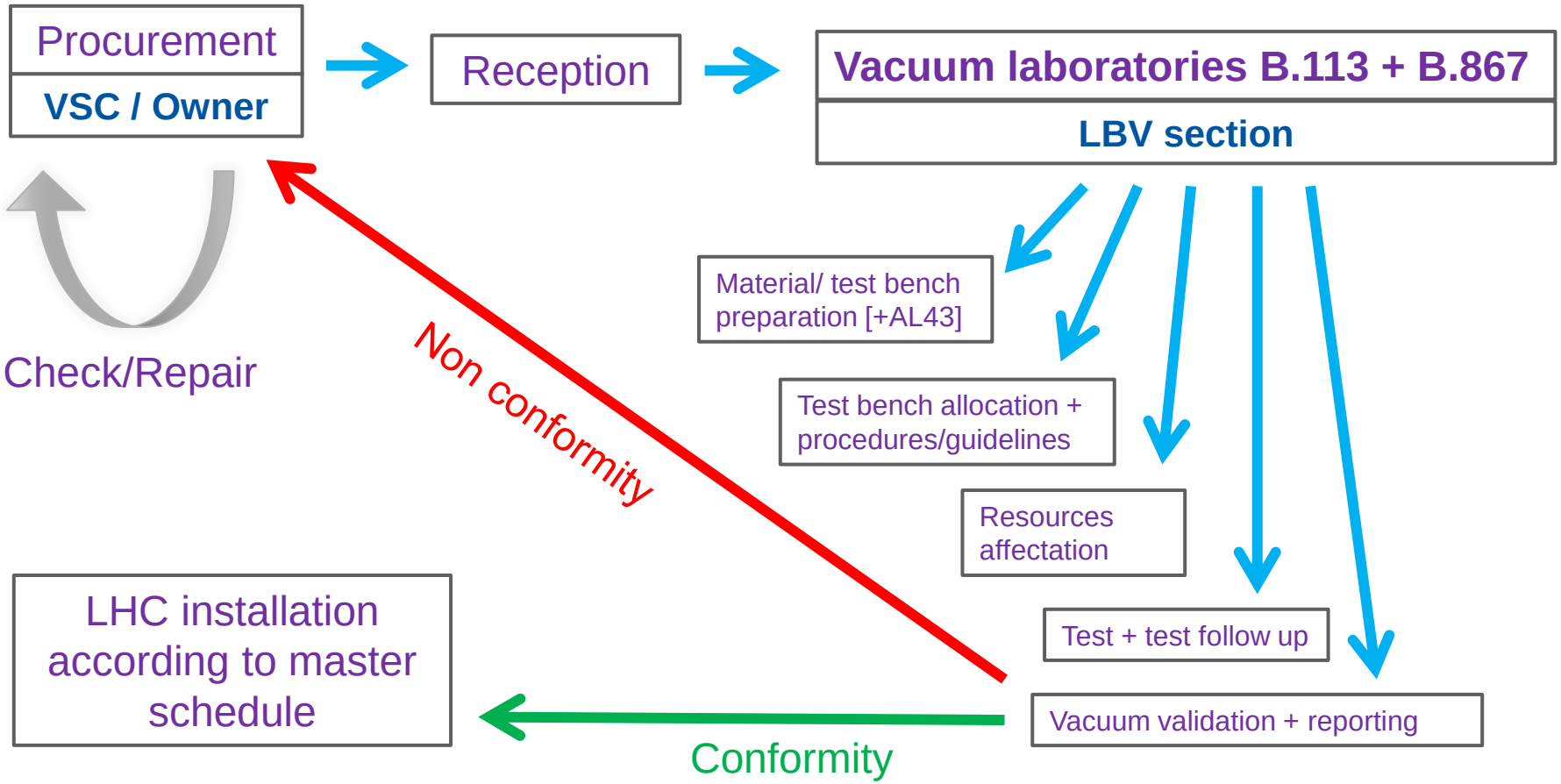
Parts tested

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

Gauges, valves, VPI, NEG cartridge…etc.

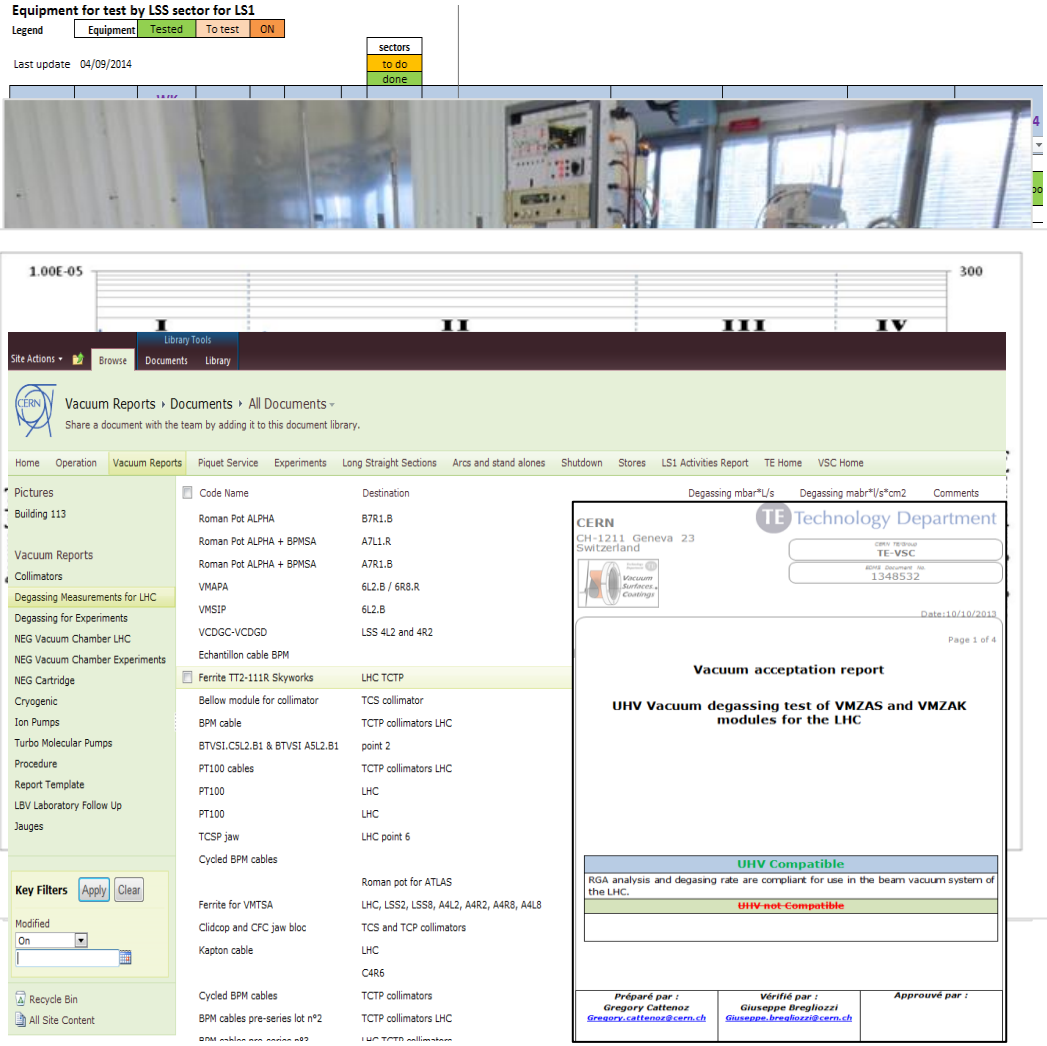
Organisation flux

Coordination : G. Cattenoz



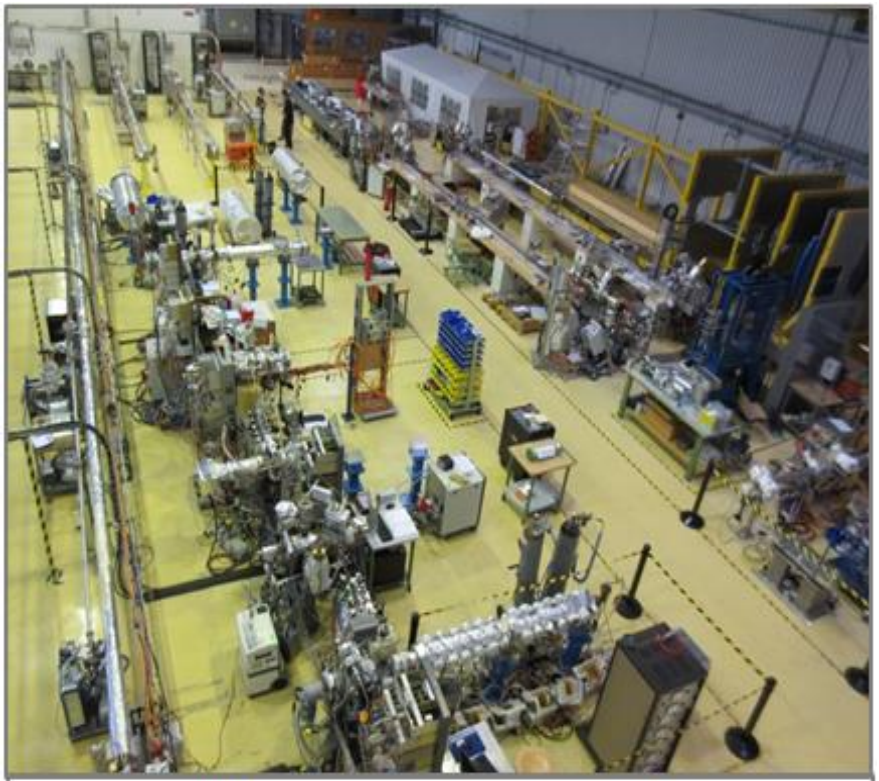
LS1 Vacuum validation: Noticeable activities

- **Scheduling:** Procurement Vs installation time
- **Coordination:** Staff
- **Laboratory work**
  - Reception + preparation
  - Bake-out cycle
  - Tests and validation
- **Official reporting : EDMS + LBV section web site**



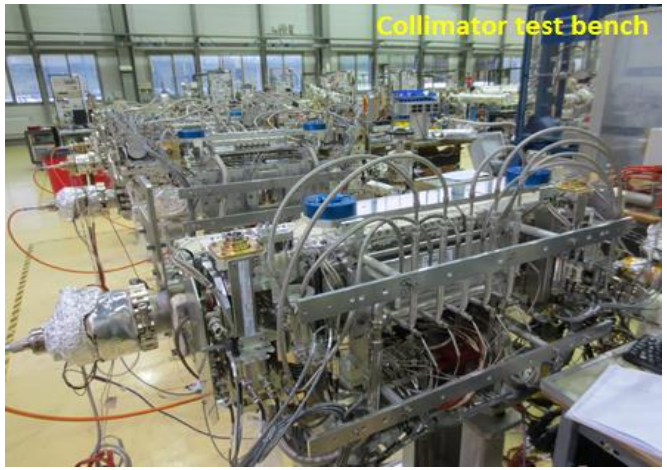
LS1 vacuum validation: Some numbers

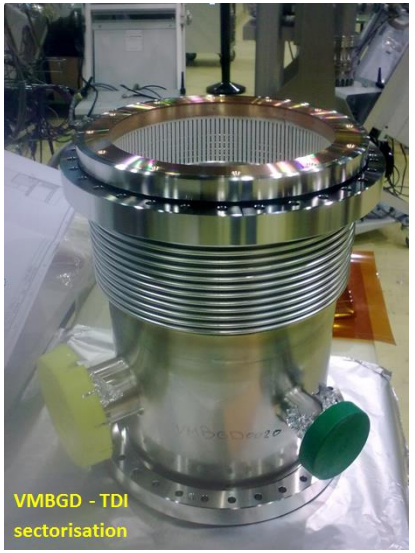
- **2 laboratories: active/non-active parts**
- **19 test benches: LHC + Experience**
- **18 months activity**
- **3 (+1) staff**



CERN vacuum laboratory B.113

Examples of tested parts





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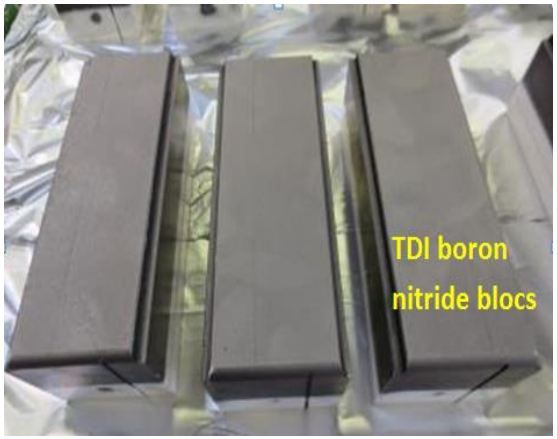
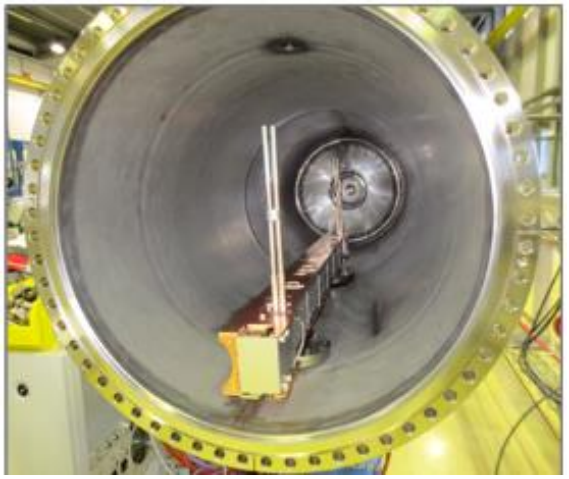
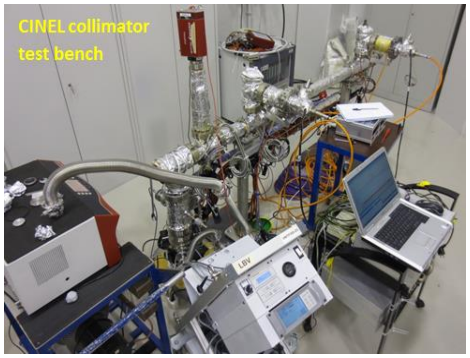
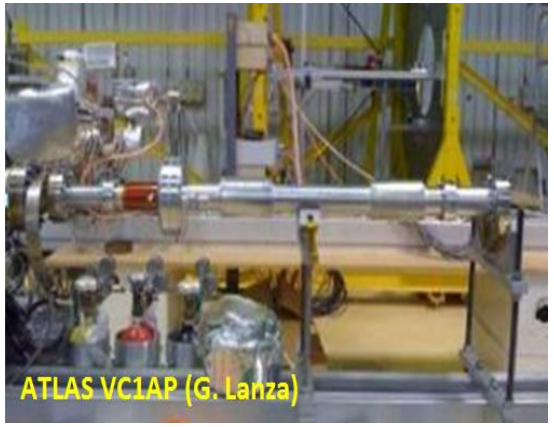








LHC Beam vacuum consideration

- Pressure requirements:

  LHC: Pmax ≈ 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

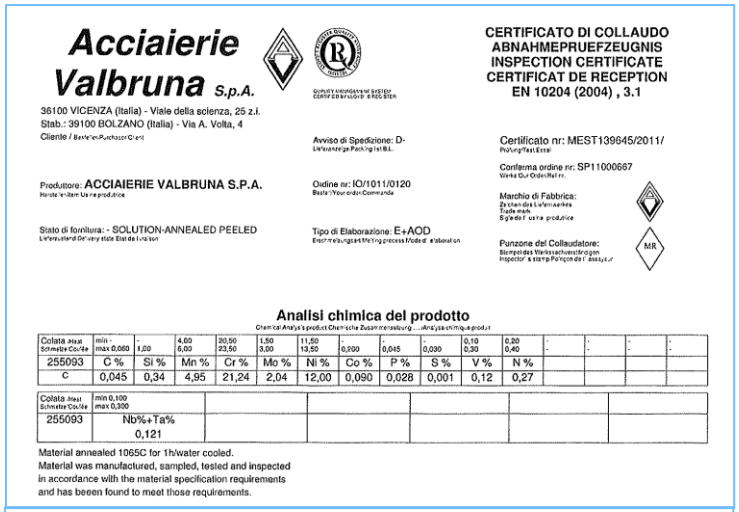
  Arcs and standalone: Cryo-pumping

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



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

Produttore: ACCIAIERIE VALBRUNA S.P.A.

Stato di fornitura: - SOLUTION-ANNEALED PEELED

Tipo di Elaborazione: E+AOD

Certificato nr: MEST139645/2011/

Conferma ordine nr: SP11000667

Ordine nr: IO/1011/0120

Marchio di Fabbrica:

Punzone del Collaudatore:

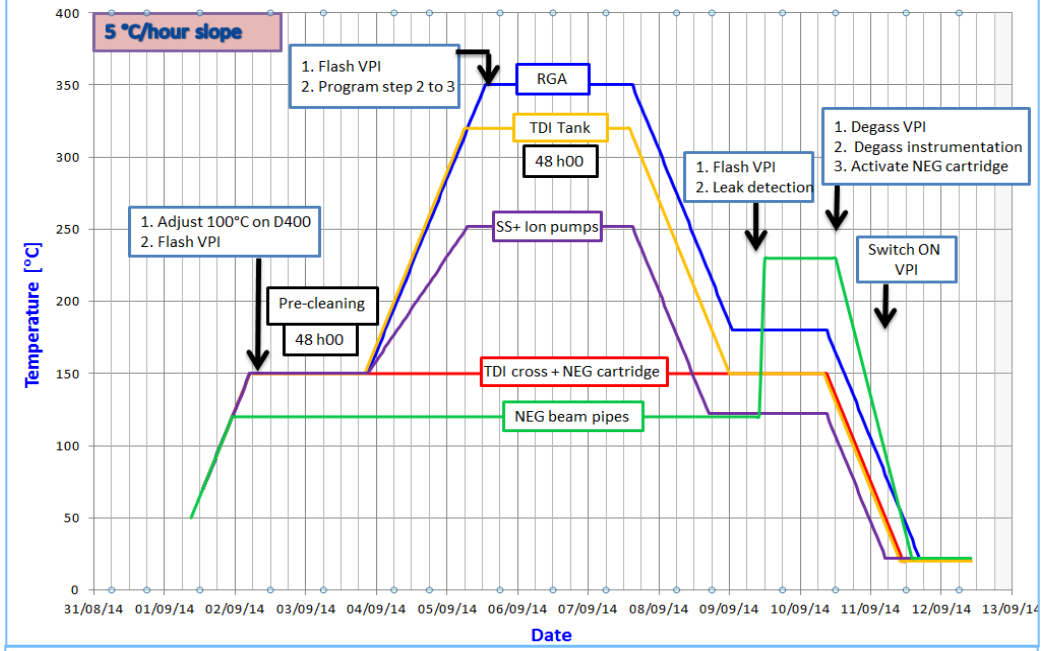
Analisi chimica del prodotto

Colata	C %	Si %	Mn %	Cr %	Mo %	Ni %	Co %	P %	S %	V %	N %
255093	0,045	0,34	4,95	21,24	2,04	12,00	0,090	0,028	0,001	0,12	0,27

Colata	Nb%+Ta%
255093	0,121

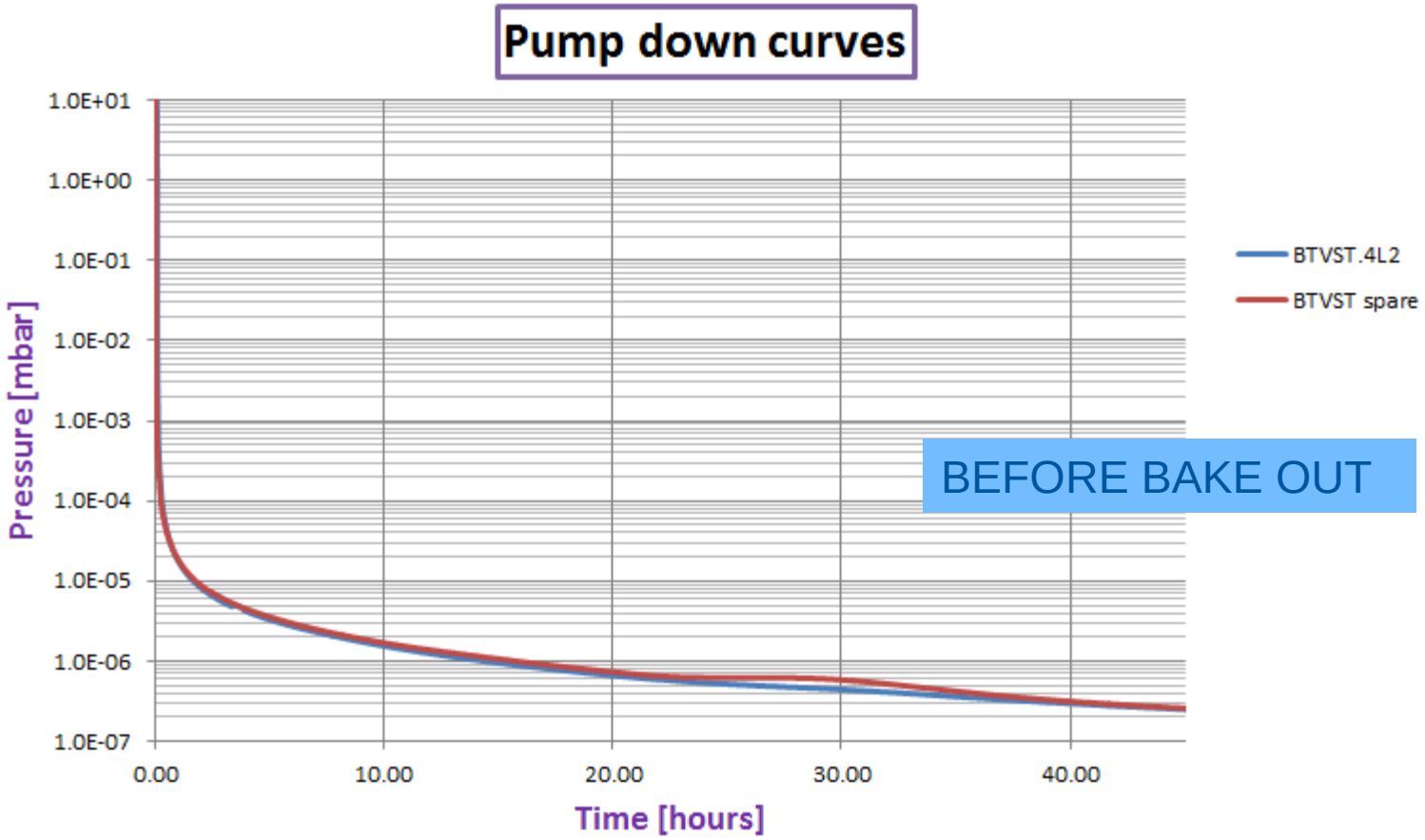
Material annealed 1065C for 1h/water cooled.
Material was manufactured, sampled, tested and inspected in accordance with the material specification requirements and has beeen found to meet those requirements.

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



Cycle d'étuvage du Target Dump Injection (TDI) equipment vide

Preliminary test: Pump down



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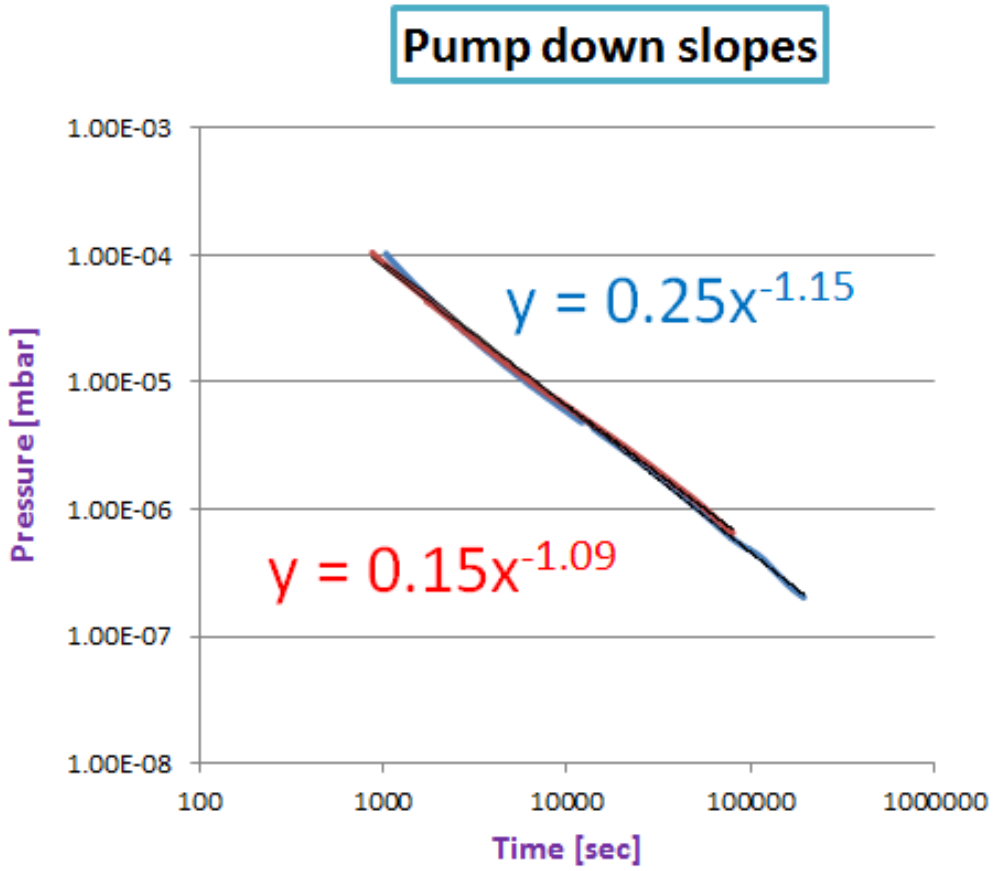
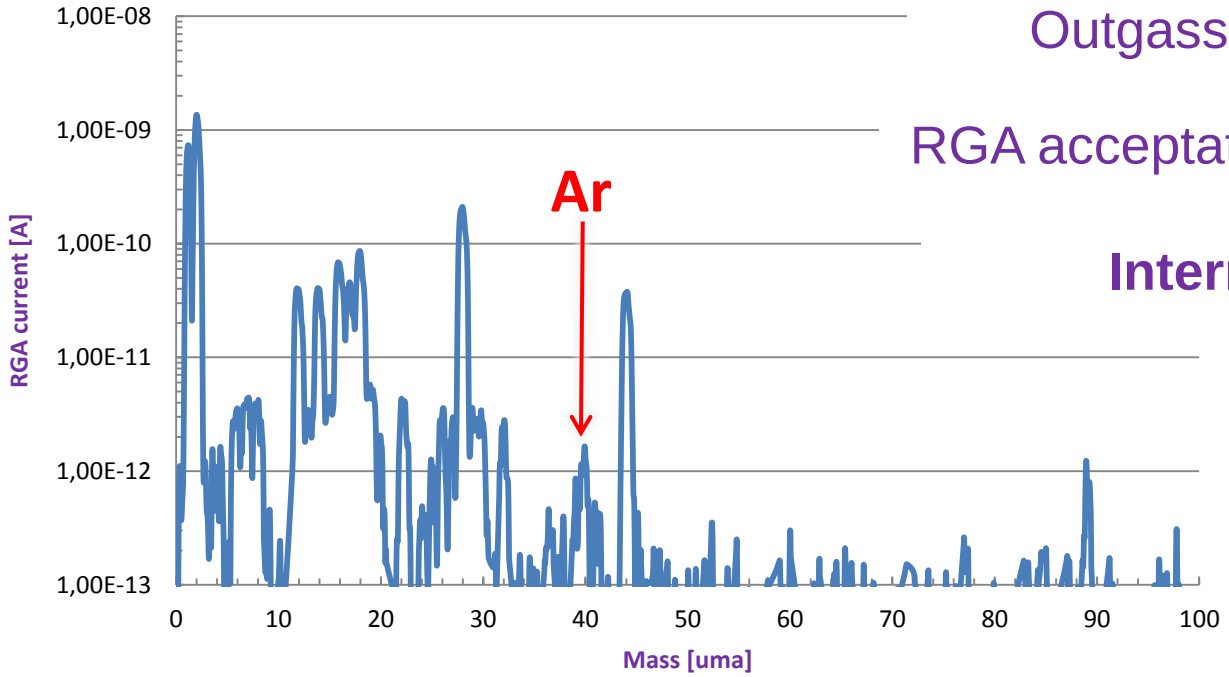


Diagnostic possible presence of contaminants or leak by comparison

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

Internal outgassing rate measurement 1/2



Externally leak tight

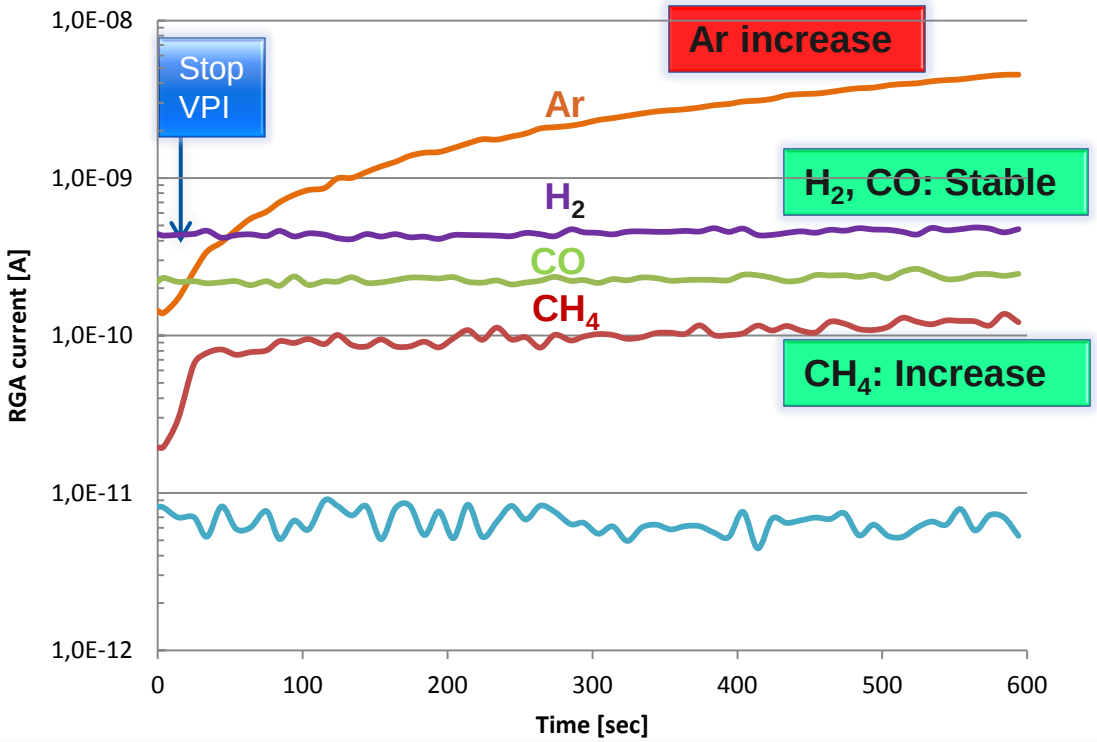
Outgassing rate

RGA acceptation 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 acceptation criteria 1/2

Based on collimator specifications (EDMS 1113402)

- Maximum total outgassing rate of 2.10^{-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

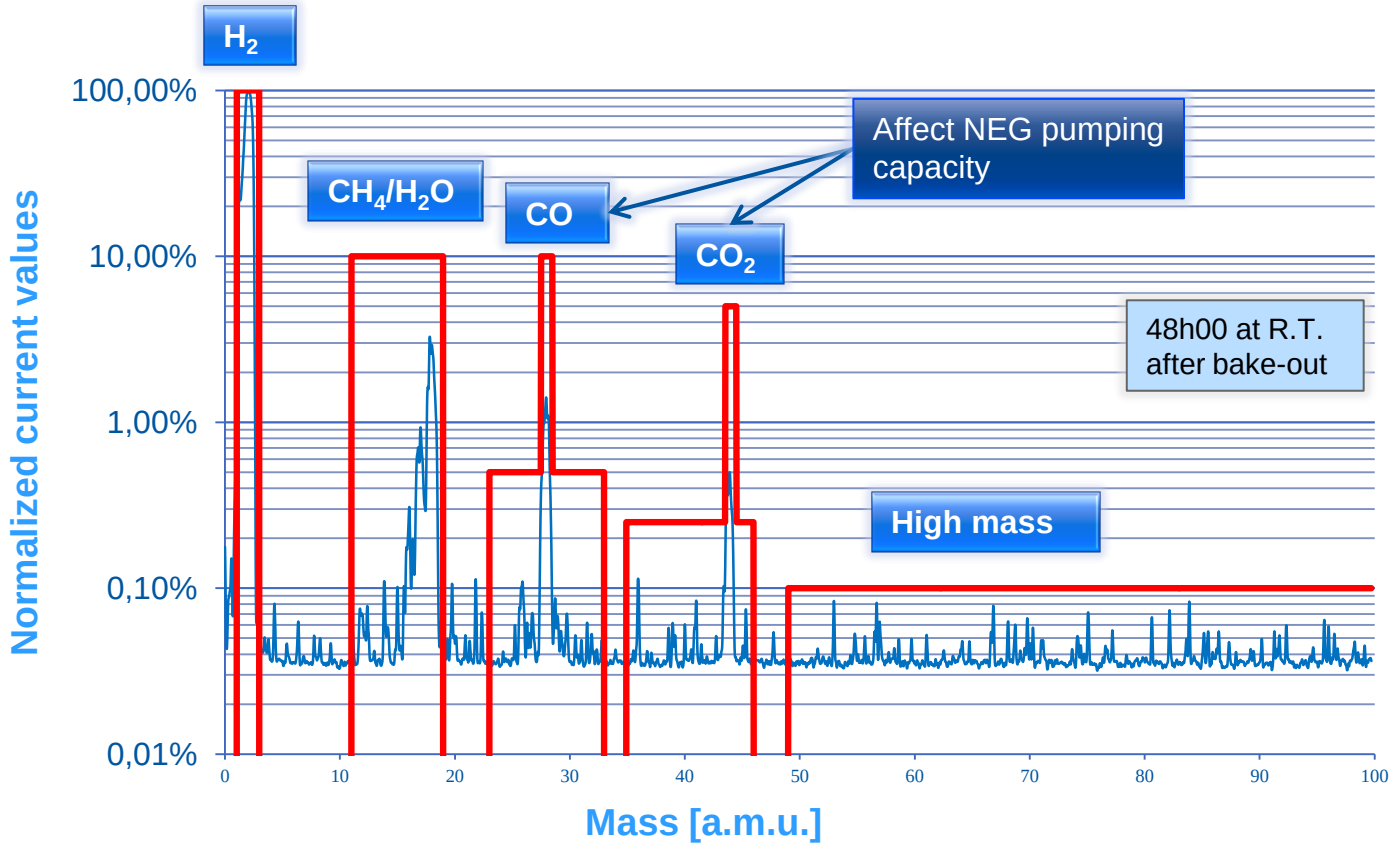
Affect vacuum performance

How?

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

RGA acceptation criteria 2/2

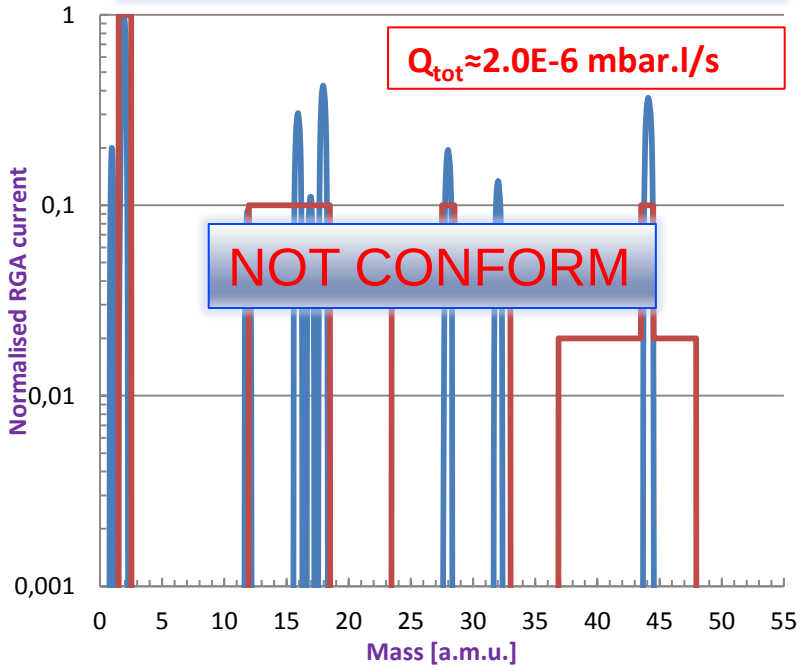
Normalised RGA currents to H_2 with defined acceptance limits



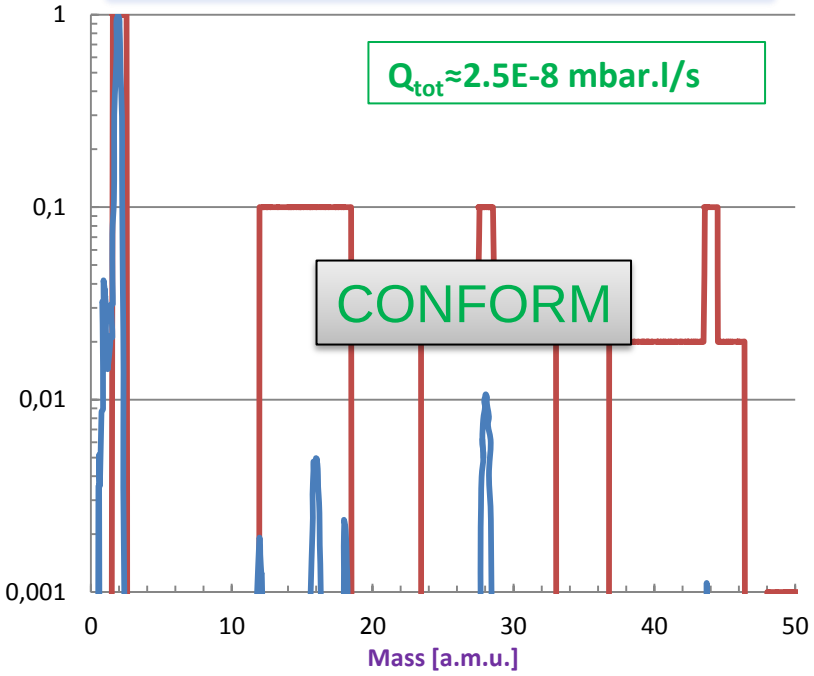
Example of XRPT stations

XRPT station: Critical bake-out

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

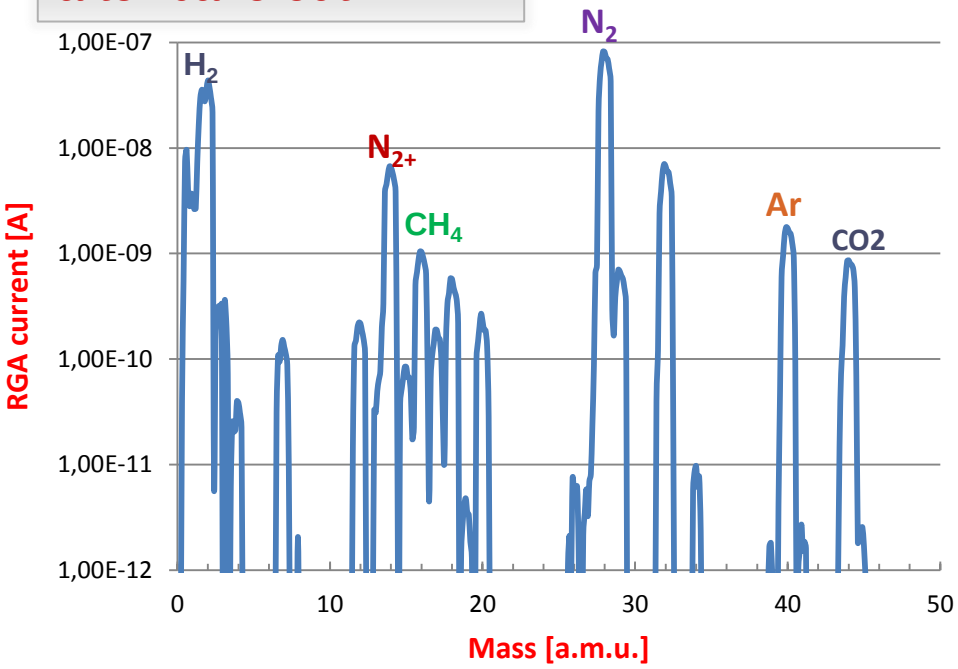


After 2nd bake-out
No external + no internal leak
Optimized bake out

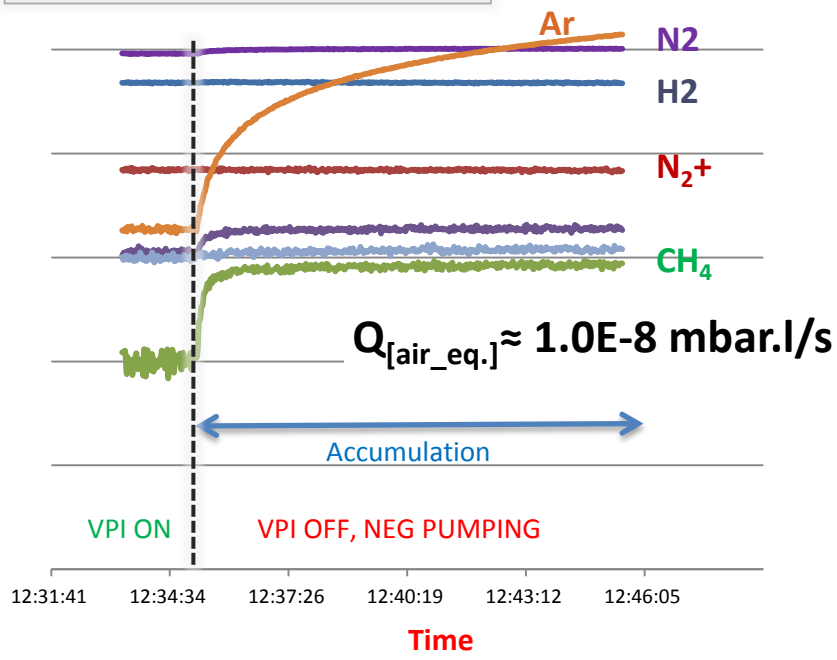


XRPT station: Leak on BPM

Air leak RGA spectra after bake out

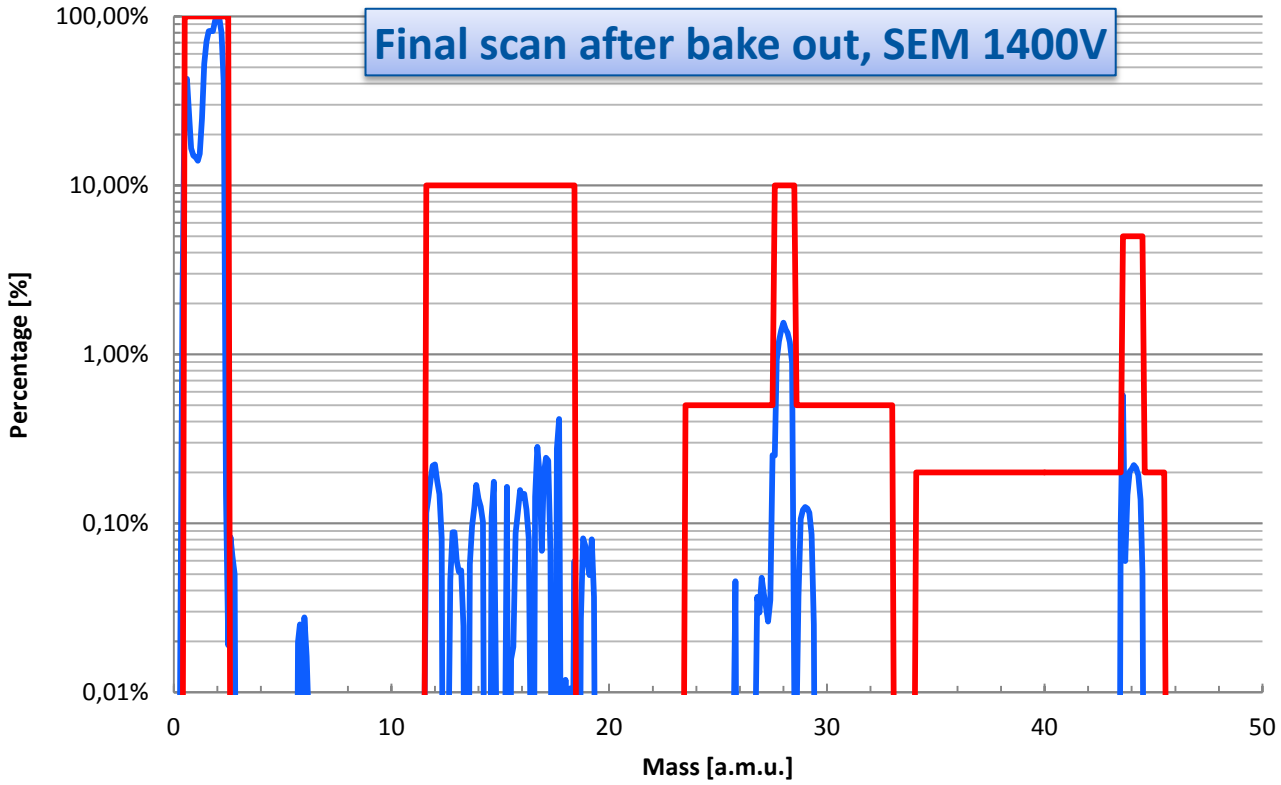


Leak flow estimation



XRPT station: Final results

Outgassing rate after bake out cycle at 250°C≈ $6{,}0.10^{-9}$ 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

} guarantee correct temperature regulation

- 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

In any circumstance, allow TIME for test!

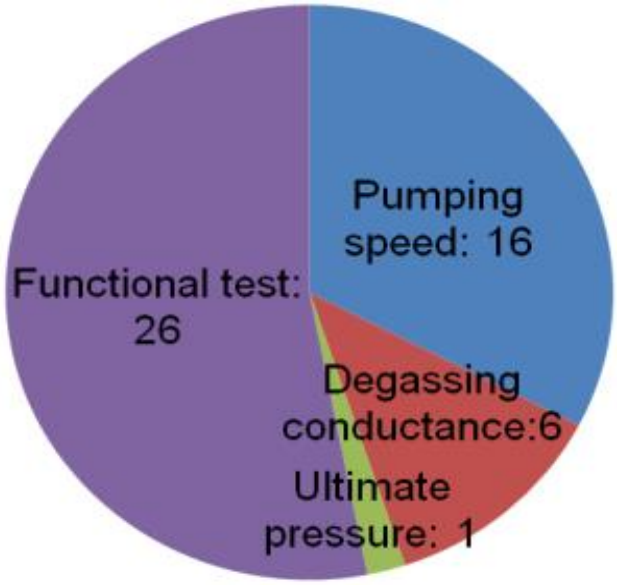
Conclusions

- 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]	$2.0.10^{-8}$	$3.0.10^{-8}$	$4.0.10^{-9}$	$1.5.10^{-8}$

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



Non-conformities distribution

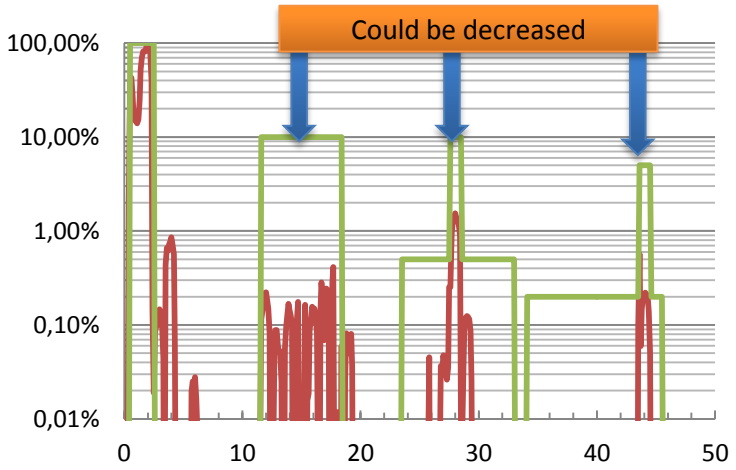
Outlook and further development

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


CERN