



| The European Synchrotron

UHV-leakage problems on BPM-buttons for EBS

Friederike EWALD

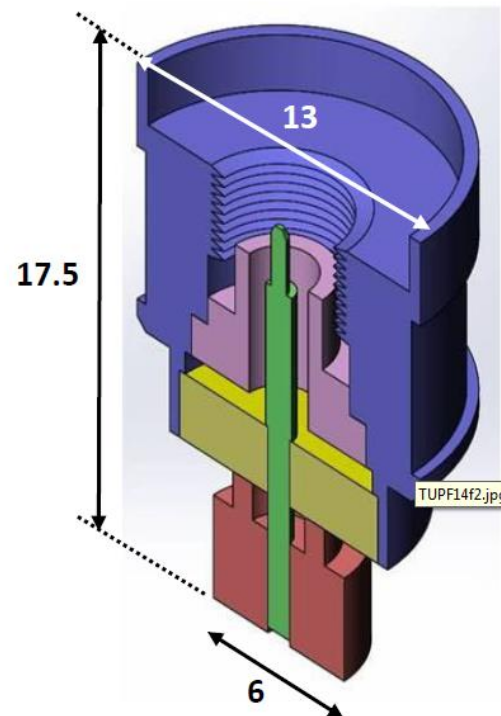
on behalf of the Diagnostics Group



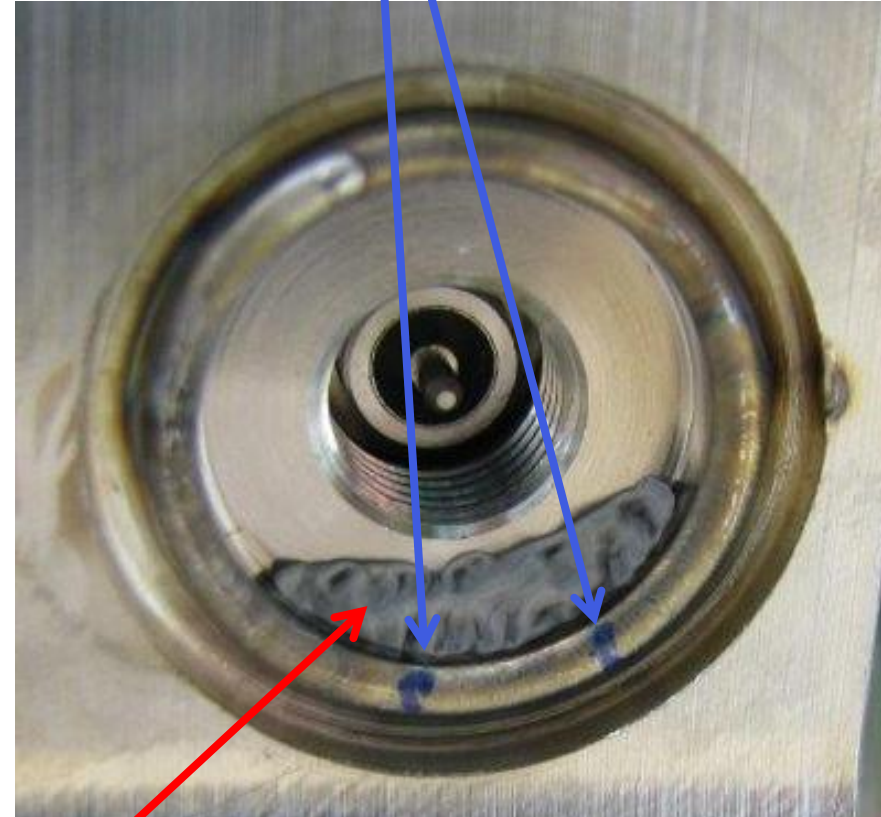
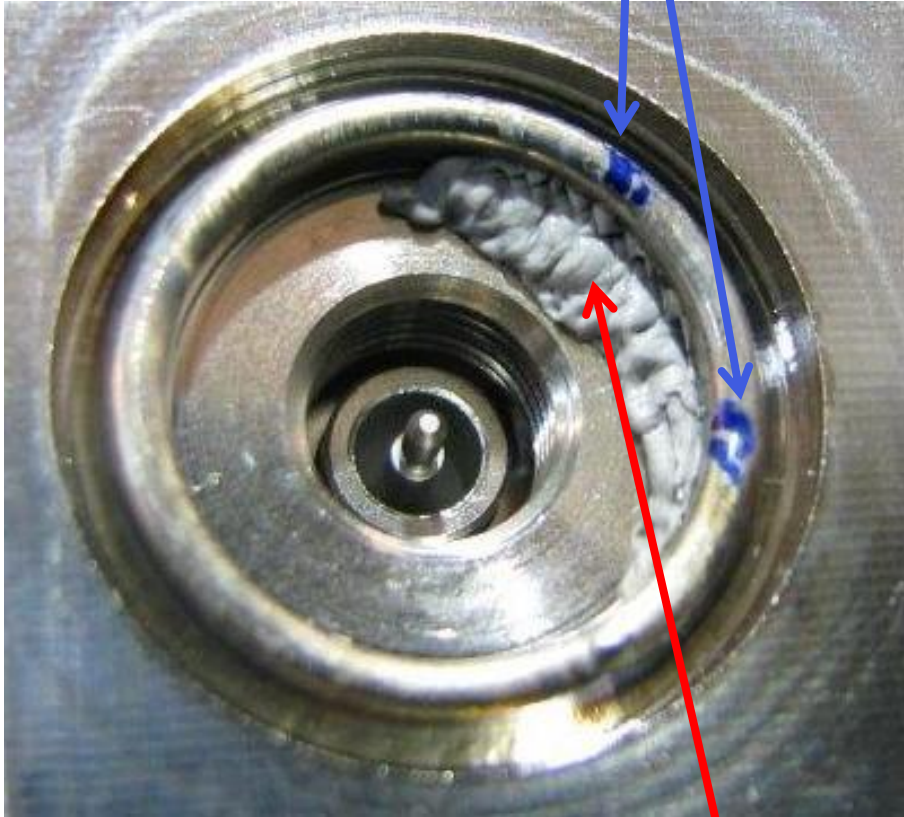
DEELS Workshop @ Diamond Light Source

18 -19 April 2018

- ☉ Vacuum leaks discovered after welding of BPM buttons into vacuum chambers end of 2016 (~ 25 % leaking units)



Leaks roughly located close to the welding

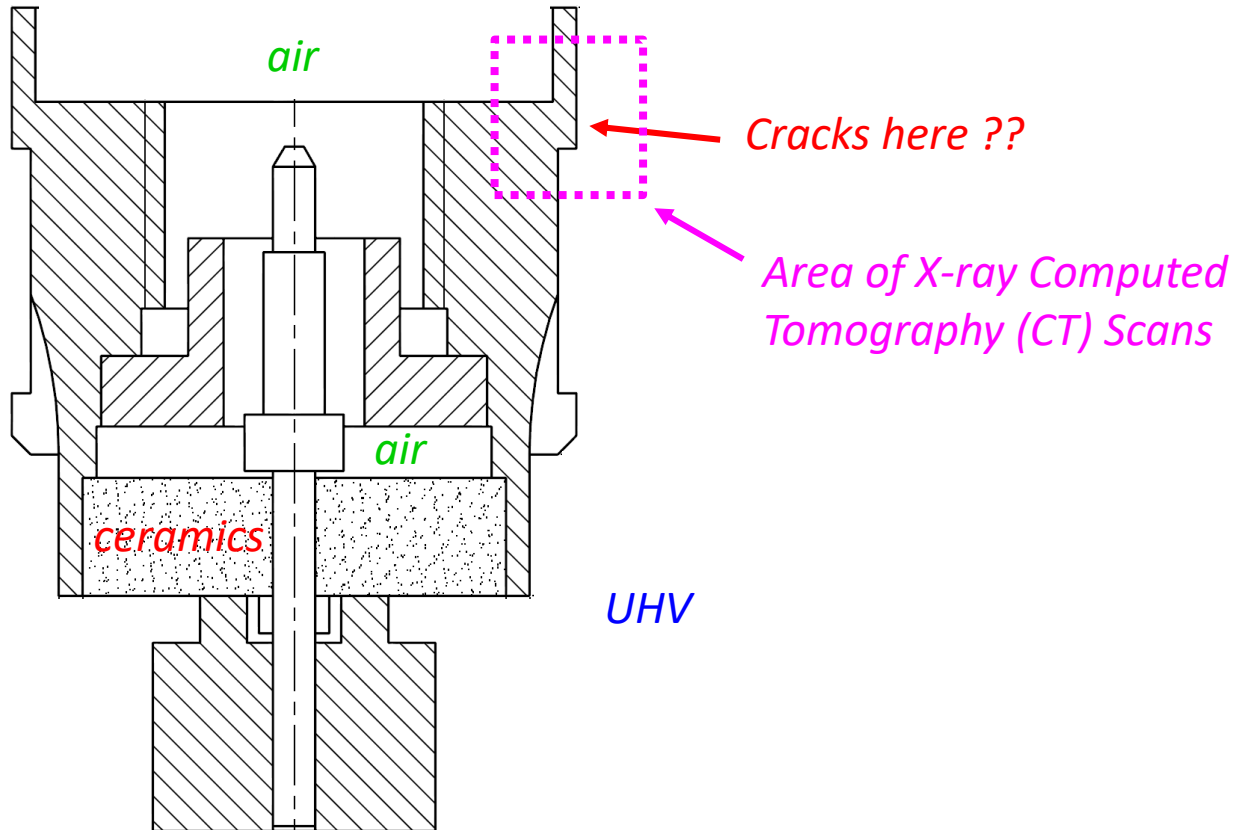


Wax applied in the corner between welding lip and main body :

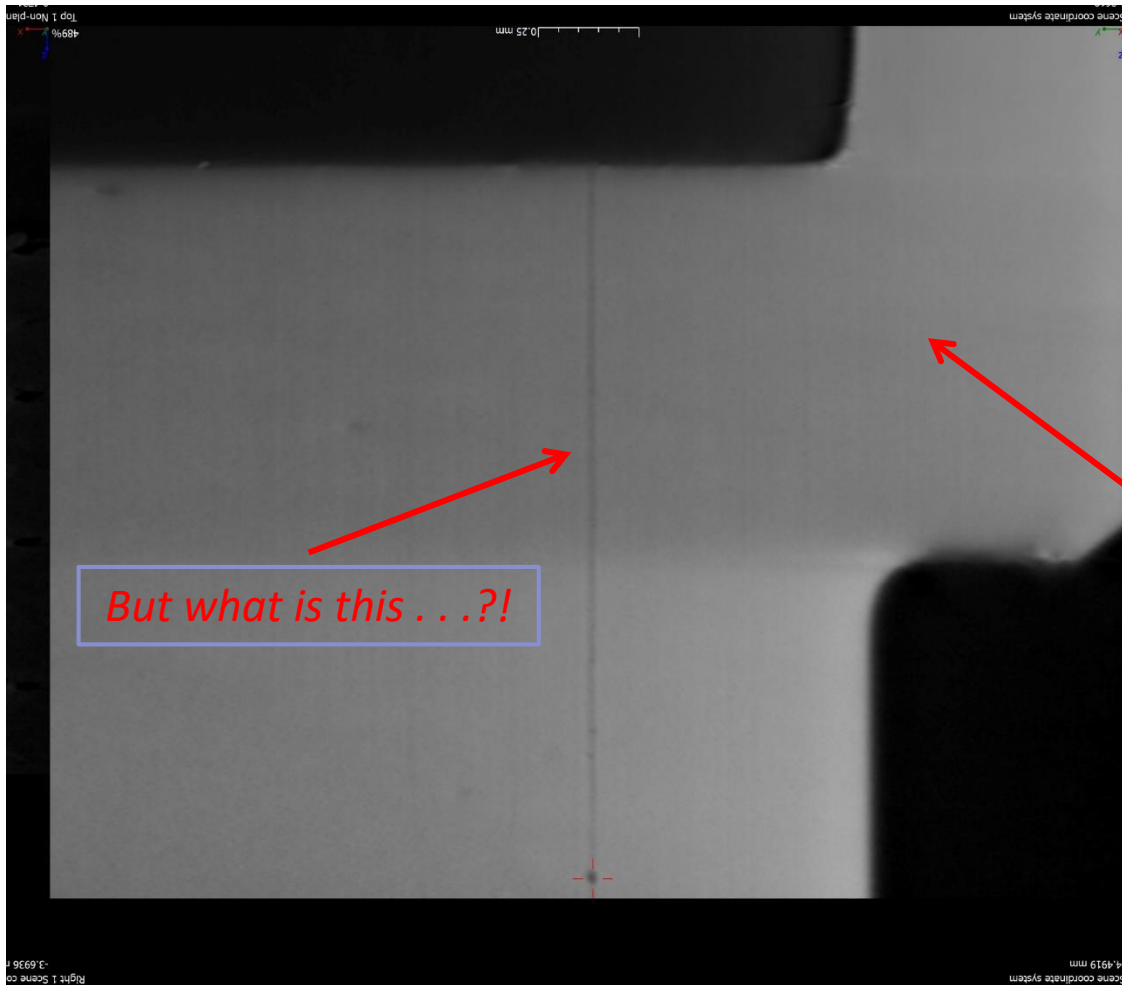
→ The leak is stopped !

→ The welding is OK !

1st Suspicion: Cracks in the welding lip due to mechanical stress

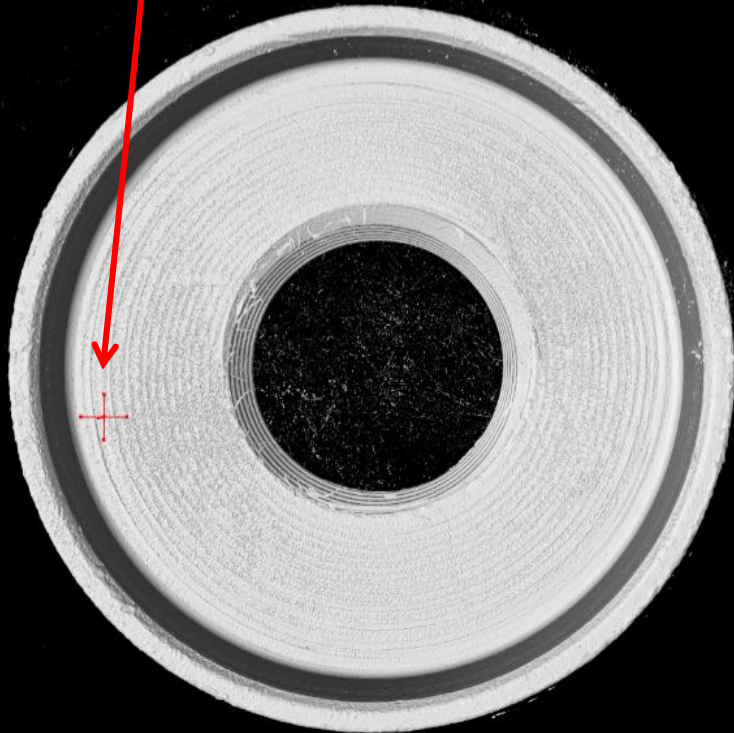


X-ray Computed Tomography done @ ESRF on a leaking button

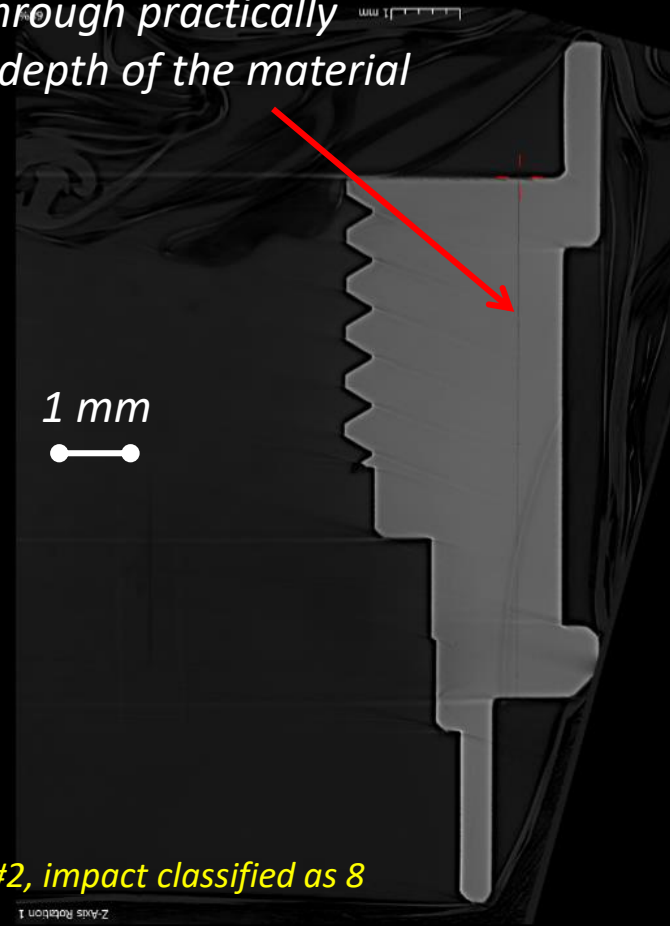


*Specialised Beamlines for X-ray tomography @ ESRF: ID10 & BM05
(Paul Tafforeau)*

Leak position located with He-leak test

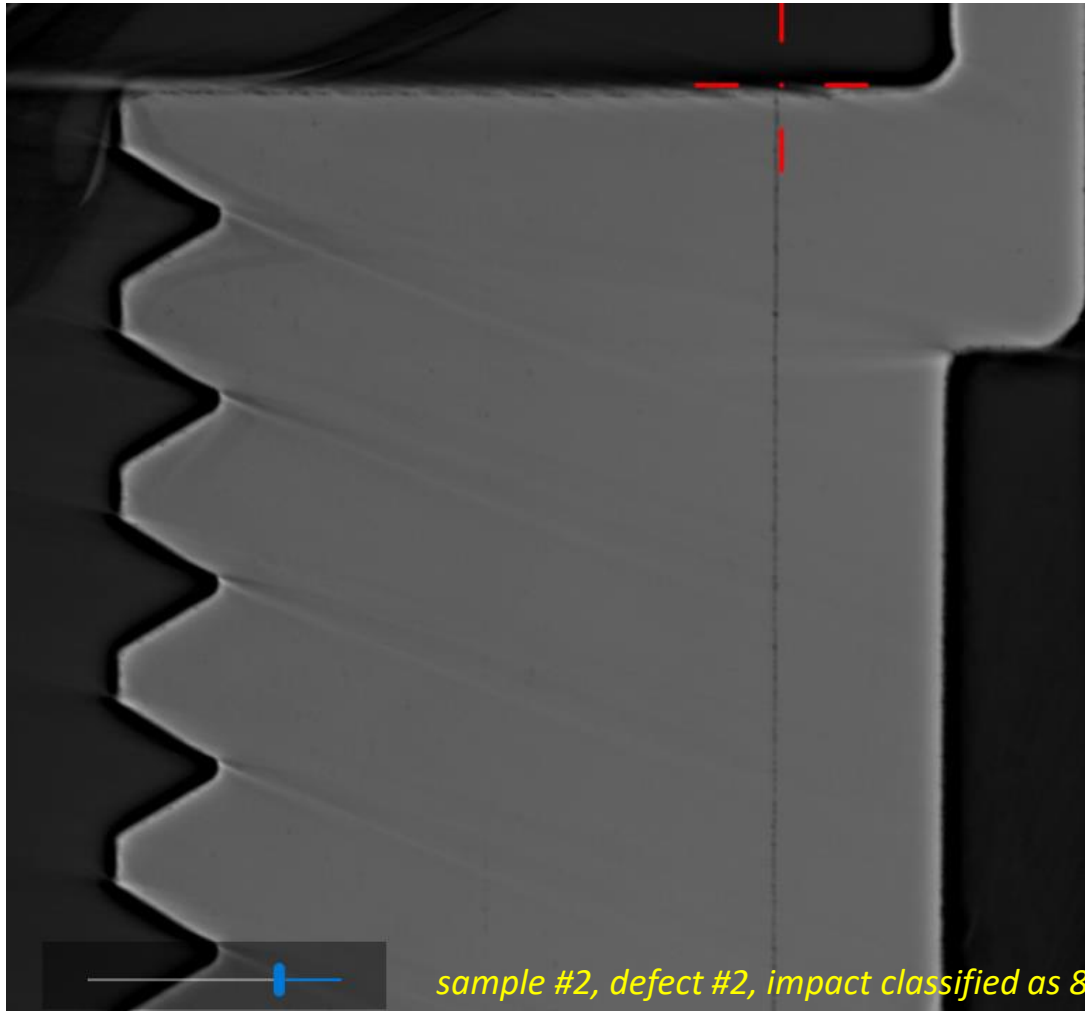


Channel / pipe of large diameter, going through practically the full depth of the material

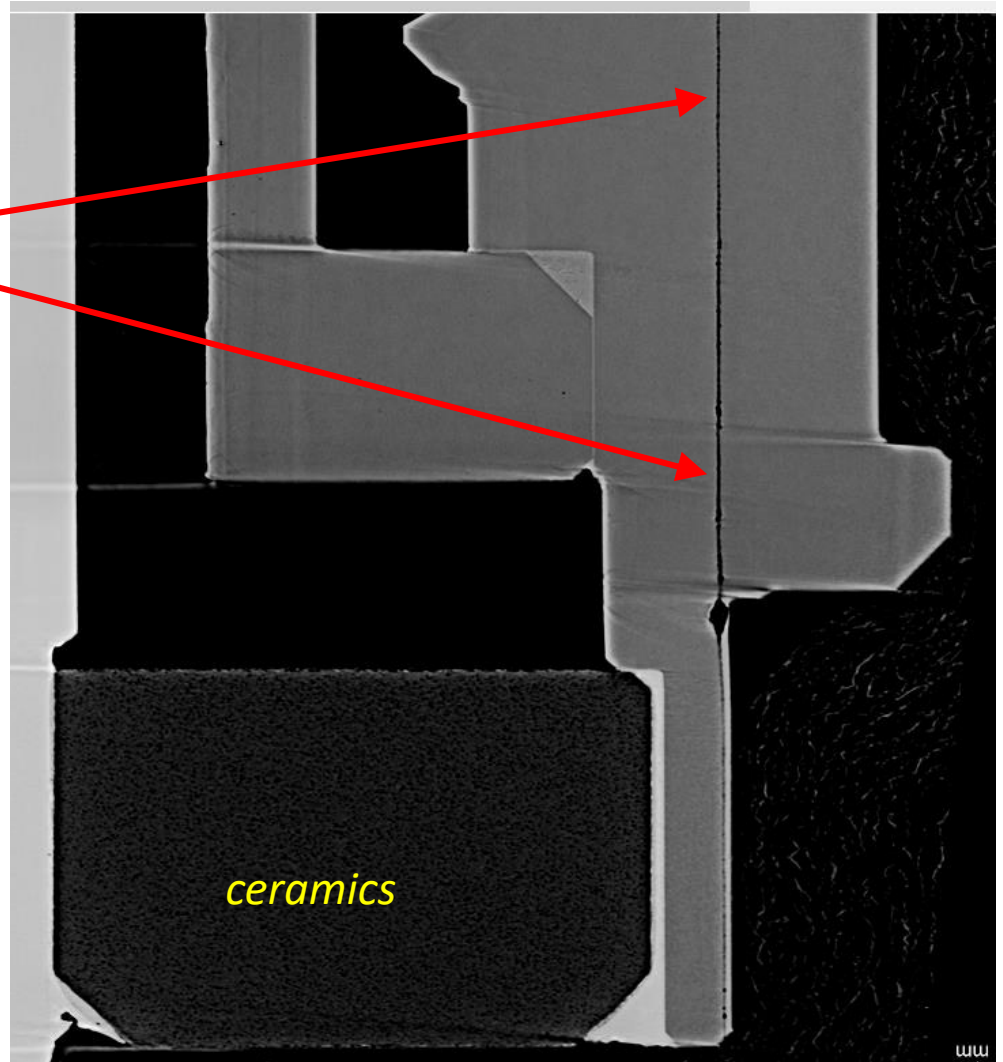


sample #2, defect #2, impact classified as 8

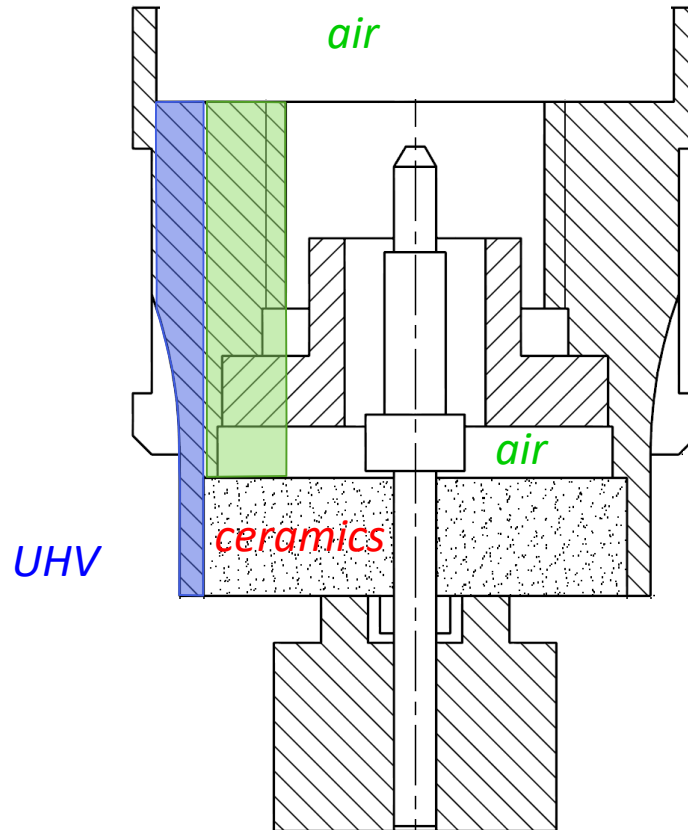
Zoom: Channel is an alignment of small “bubbles”



The channel passes through the full depth of the steel outer-body



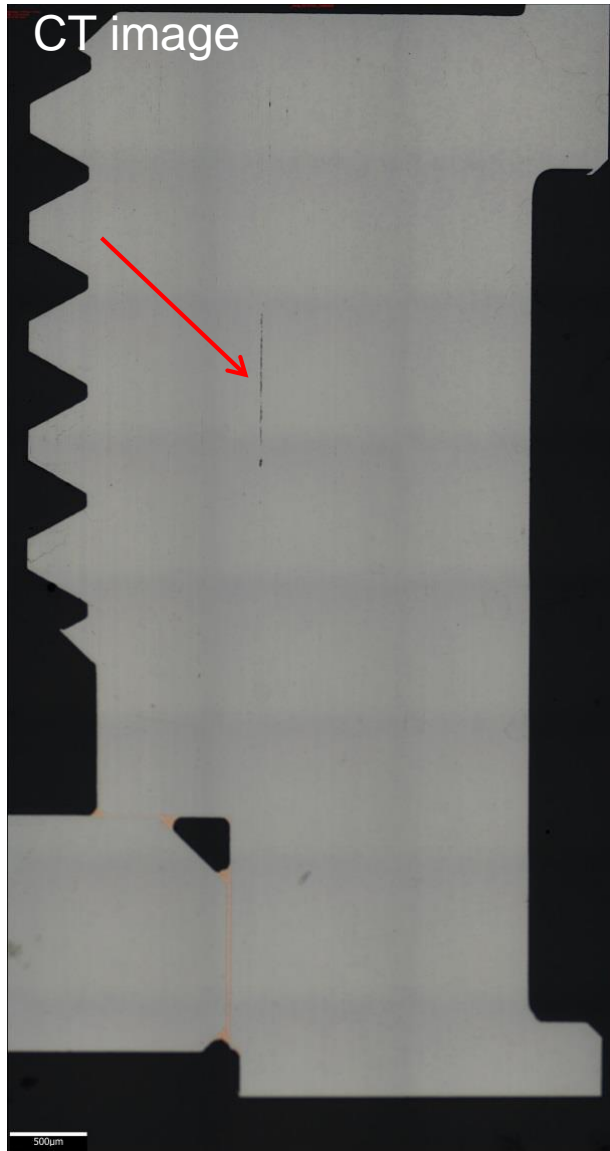
The “crack theory” is cancelled ; channel-like bulk defects create the leaks

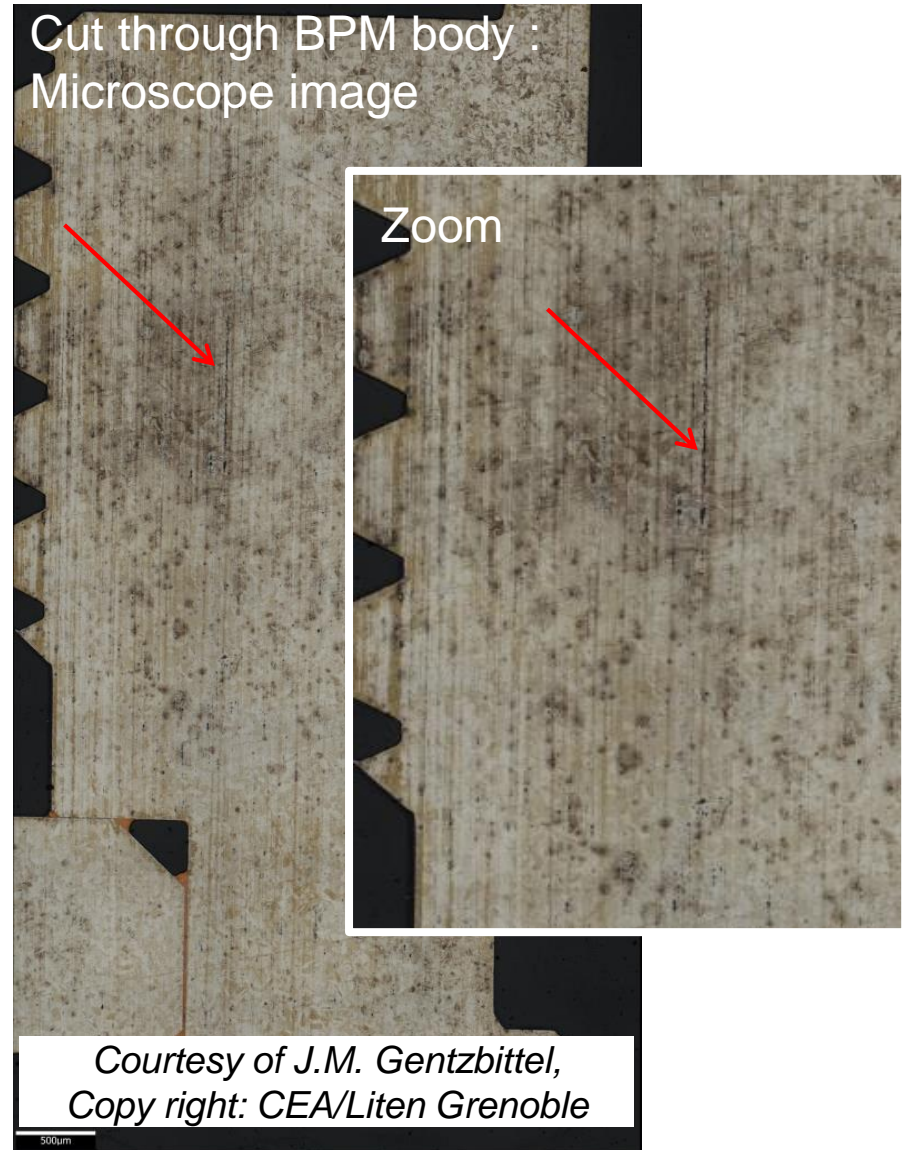
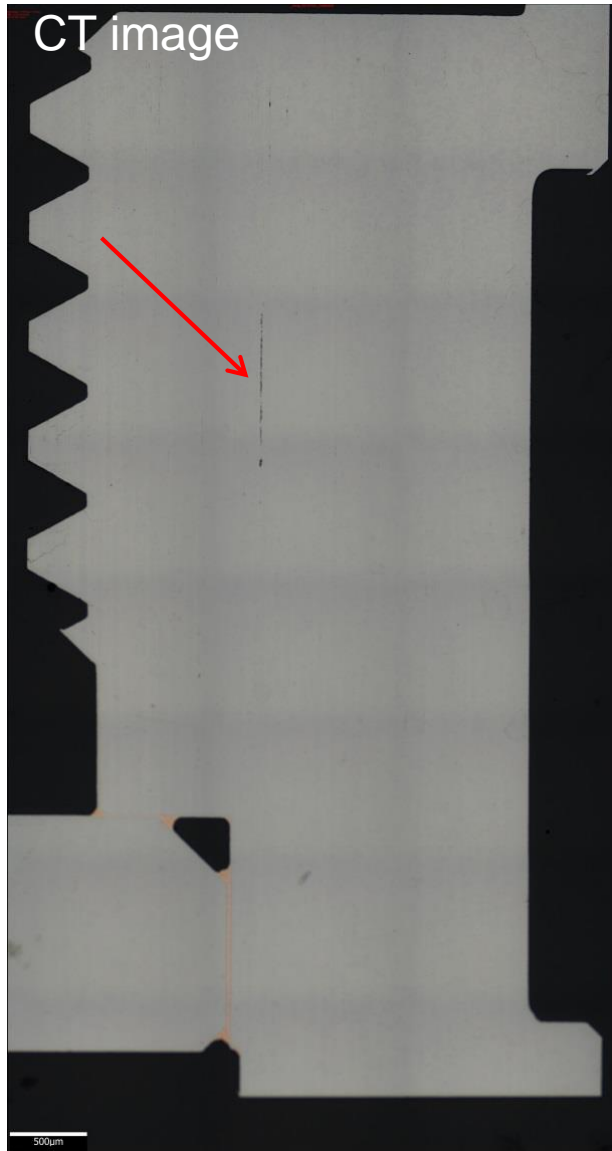


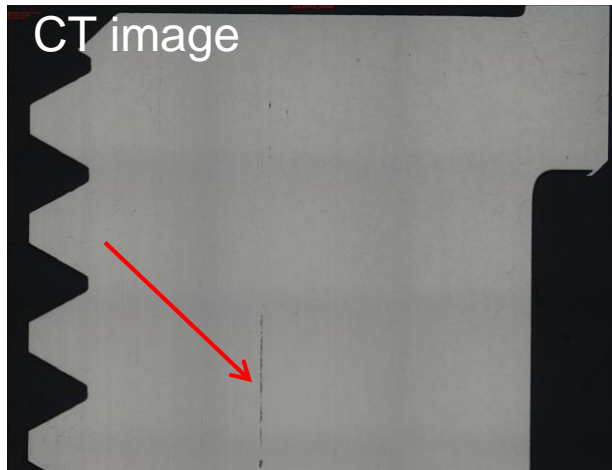
~~cracks here ??~~ → No.

Bulk defects lead to UHV leaks
ONLY in the blue area,
NOT in the green area (not connecting
with UHV)

- ☉ *Vacuum leaks discovered after welding of BPM buttons into vacuum chambers end of 2016 (~ 25 % leaking units)*
- ☉ *CT-scans : Correlation Leak \leftrightarrow Channels in bulk is confirmed*
- ☉ *~ 10% of buttons are rejected following the CT analysis ; rejection criterion: continuous channel in the “blue” region*
- ☉ *BUT : still leaks detected (just lower leak rates)*
- ☉ *→ Complementary metallurgical analysis*
 - reveals even more and thinner channels than seen by tomography !*

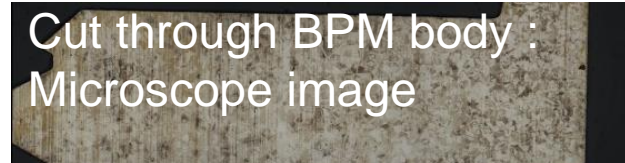
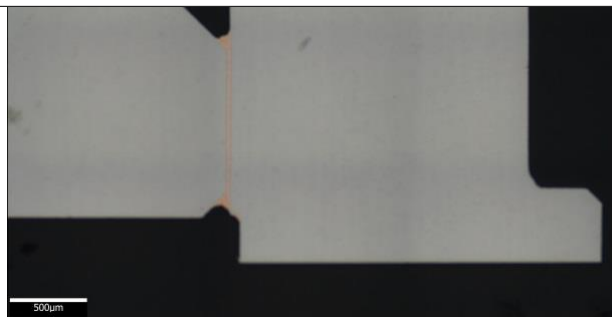






The used steel is even more porous than believed from X-ray CT images !

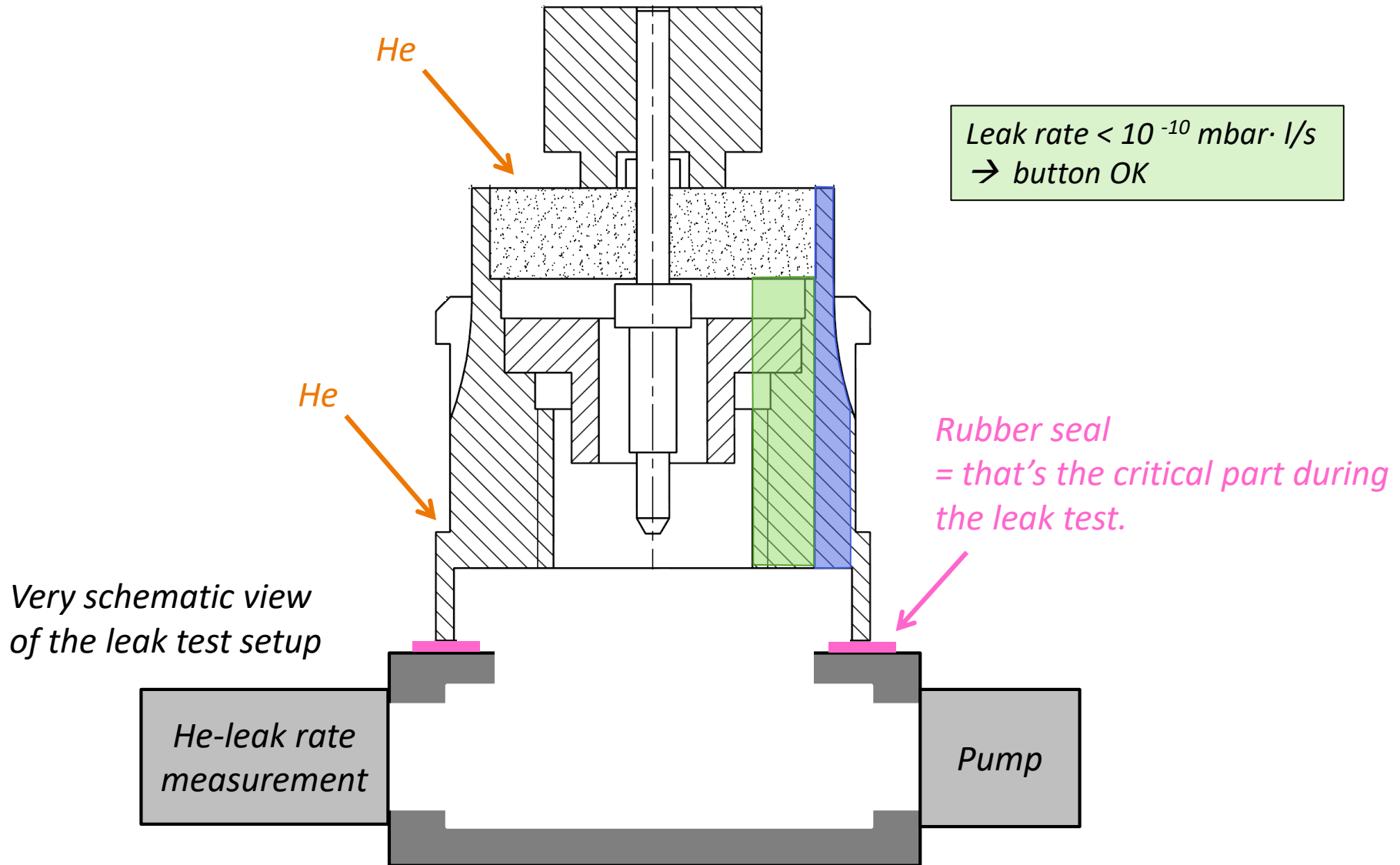
Channels are formed by alignment of small voids of less than 10 um diameter.



*Courtesy of J.M. Gentzbittel,
Copy right: CEA/Liten Grenoble*

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- ☉ *→ Complementary metallurgical analysis*
→ reveals even more and thinner channels than seen by CT !
- ☉ *Leak test for individual buttons developed → eliminate ALL LEAKING buttons.*

He-leak-test done on each individual BPM button !



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- ☉ ~ 10 % of buttons are rejected following the CT analysis
- ☉ BUT : still leaks detected (just lower leak rates)
- ☉ → Complementary metallurgical analysis
→ reveals even more and thinner channels than seen by CT !
- ☉ Leak test for individual buttons developed → eliminate ALL LEAKING buttons.
- ☉ Purchase of additional buttons to fill-up the stock (2017 & 2018)
 - ✓ Careful choice of the steel (samples checked with CT) -> OK
 - ✓ Check finished buttons by CT scans -> OK
 - ✓ Leak test -> OK

Check steel quality on paper, with CT scans and with microscopic analysis

Usine producteur/Hersteller/Manufacturer
 Ugine
 Avenue Paul Girod - CS
 90100
 73403 Ugine Cedex
 France

**CERTIFICAT DE RECEPTION 3.1
 INSPECTION CERTIFICATE 3.1
 ABNAHMEPRUEFZEUGNIS 3.1**

UGITECH
 Providing special steel solutions

EN 10204 / 3.1

N° lot MM / Chargen / Batch
 1715TS0400

Marque d'usine
 Herstellerzeichen
 Supplier's Mark

Poligon de l'expert
 Prüfstempel
 Inspector's stamp

IQ

Produit
 Erzeugnisform
 UGIPIURE 4307Q BARRE RECTIFIEE POLIE HYPERTREMPÉ DÉF. À FROID H9 RONDI(E) 16,000MM L
 ONG. 3,000M + 50,000MM -0,000MM
 UGIPIURE 4307Q BARRE RECTIFIEE POLIE HYPERTREMPÉ DÉF. À FROID H9 RONDI(E) 16,000MM LONG. 3,000M
 UGIPIURE 4307Q STAB GESCHLIFFEN POLIERT ABGESCHRECKT KALTVERFORMT H9 RUND 16,000MM LONG. 3,000M

Specification client / Kundenspezifikation / Customer's specification
 4307 QHP HY 2G AERO 0 27/01/2018

Nombre Stueckzahl Pieces Nbr	Profil Profille Shape	Dimension Ausmessung Dimension	Longueur Laenge Length	Poids Gewicht Weight
18	RO	16,000 MM 21-1	3,000	10 KG

Mode d'élaboration Erשמלזungsart Melting process	N° prélevement Probenummer Test number	Demandé / Vorschritt / Required	% C	% Si	% Mn	% Ni	% CR	% MO	% CU	% S
ERAF +AOD + CC + ESR 38	DRS6	Min	0,0300	1,0000	2,0000	10,0000	19,0000	0,5000	0,7500	0,0250
		Max	0,0190	0,4610	1,6030	9,6400	18,6330	0,2240	0,0490	0,0002

Signature: *pat 30/12*

Ugine le 08.06.2017
 L'inspecteur Qualité
 Der Qualitätsprüfer

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 4307 QHP HY 2G AERO 0 27/01/2018

Limite d'élasticité Yield Strength 0,2 %	RM Zugfestigkeit Tensile	Alongement Bruchdehnung Elongation	Striction Bruchminderung Red area	Dureté-Haerte-Hardness
207	517	45	50	140
210	640	45	50	215
432	630	51	80	201
415	627	52	78	

Corrosion intercrystalline suivant ISO 3651-2 & ASTM A262 PRACTICE E : CONFORME
 TAILLE DE GRAIN SUIVANT ASTM E112 (>= 3) = 3 - 5
 INCLUSIONS NON METALLIQUES SUIVANT ASTM E45/A :
 INCLUSIONS DE TYPE : A FINE = <1 ; A EPAISSE = <1
 INCLUSIONS DE TYPE : B FINE = 1 ; B EPAISSE = <1
 INCLUSIONS DE TYPE : C FINE = 1 ; C EPAISSE = <1
 INCLUSIONS DE TYPE : D FINE = 1,5 ; D EPAISSE = 1
 FERRITE <= 8%
 MACROSTRUCTURE SUIVANT ASTM A604 CONFORME
 MICRO TEST STRUCTURE OK
 CONTROLE PAR COURANT DE FOUCAULT 100 % - EN 10277 -1 CL.3 : CONFORME
 ULTRASON SUIVANT IGC 04.25.1158 CL. A : CONFORME - METHODE NON QUALIFIEE SUR 50 MM EN EXTREMITES
 CONTROLE ANTI-MELANGE : CONFORME

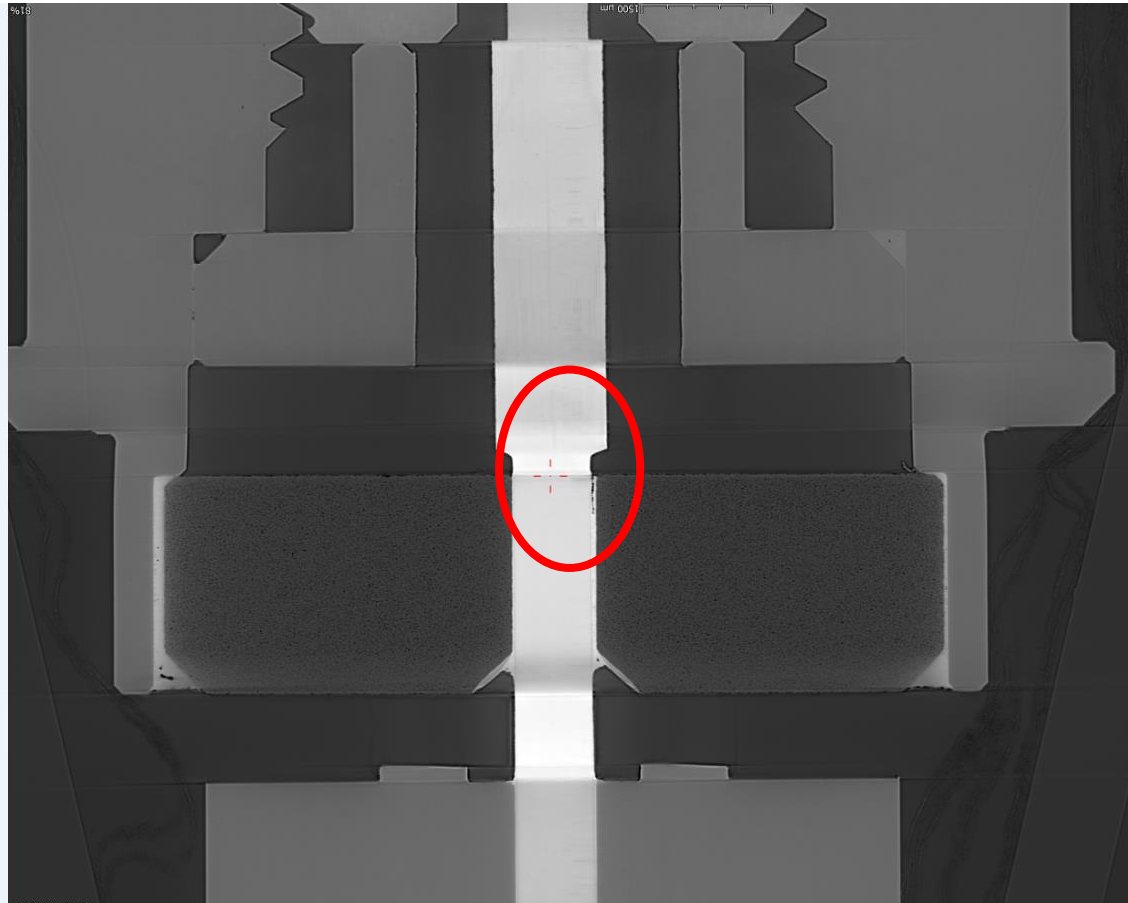
Signature: *M. PETT*

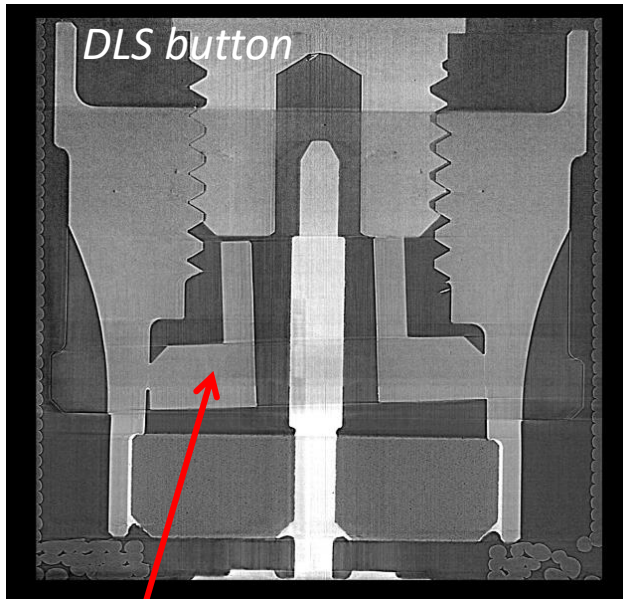
Ugine le 08.06.2017
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Information on material composition, inclusions, grain size, etc.
 BUT NO information about the shape of the inclusions → e.g. channels, ... !

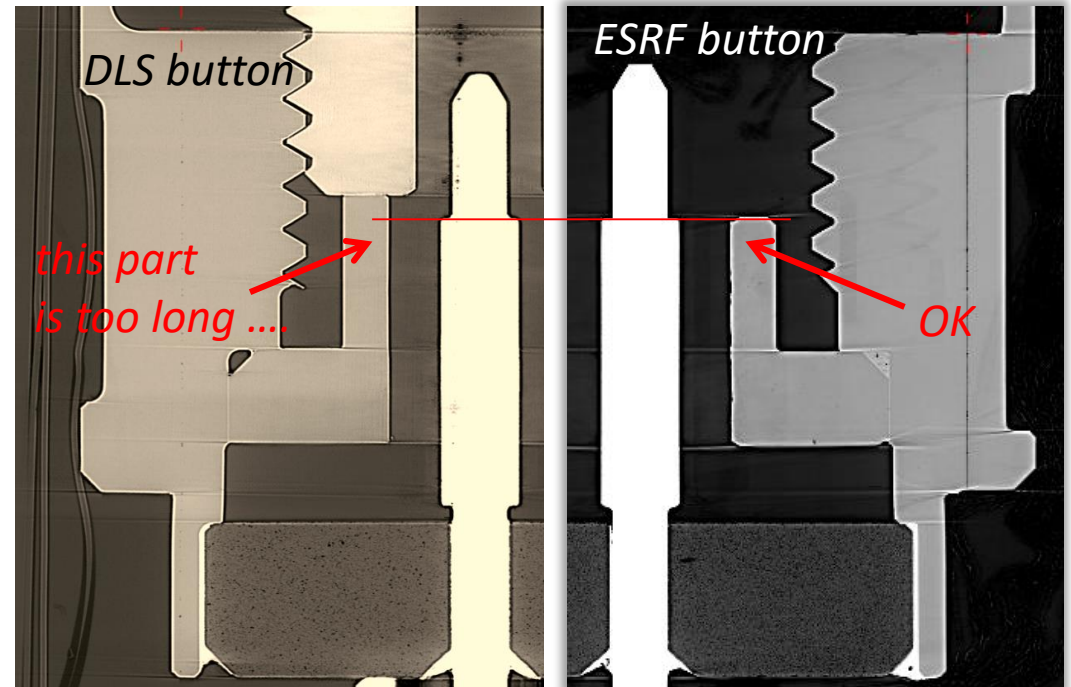
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- ⊗ *CT scans reveal also some misalignment issues of the button assembly*

*The CT scans can reveal problems with the brazing
But we had NO issues due to bad brazing !*

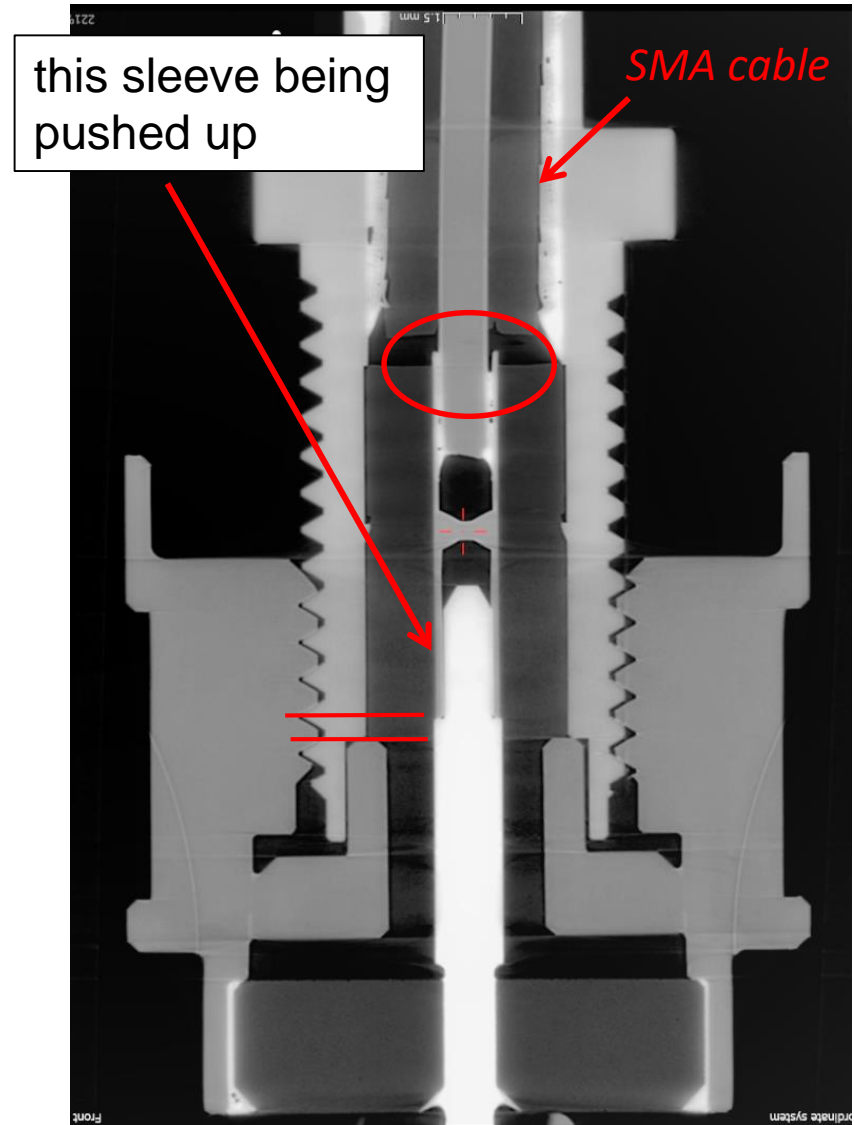
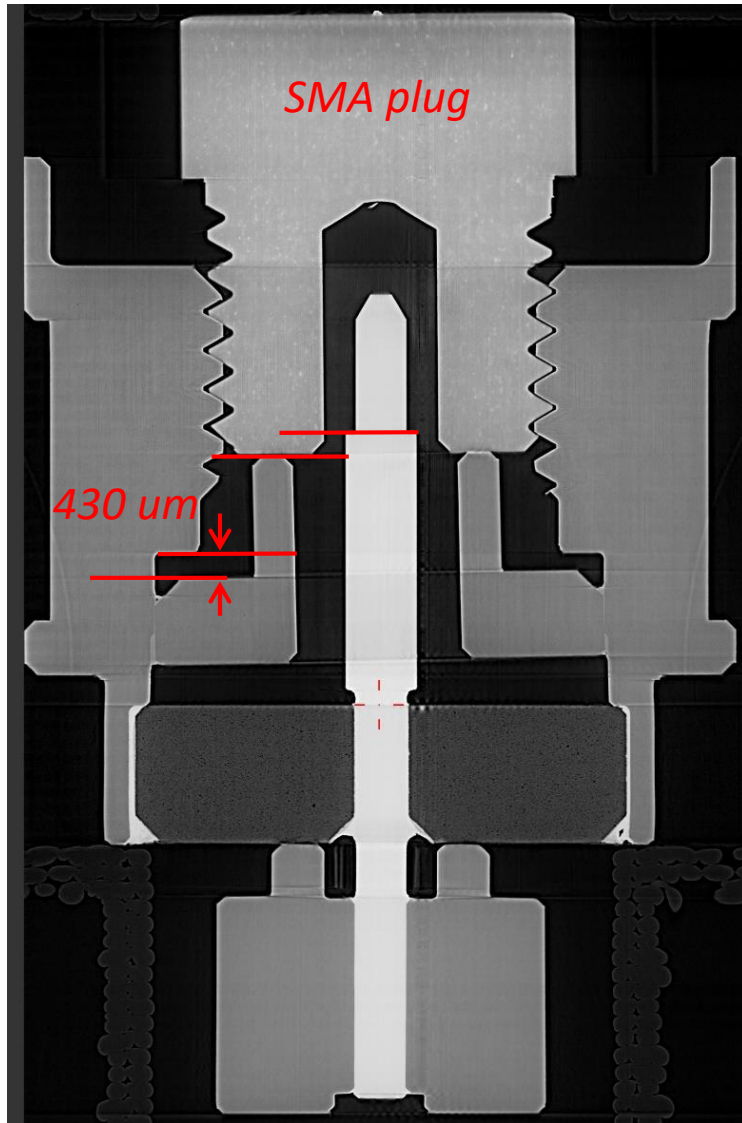




This part not completely inserted and oblique

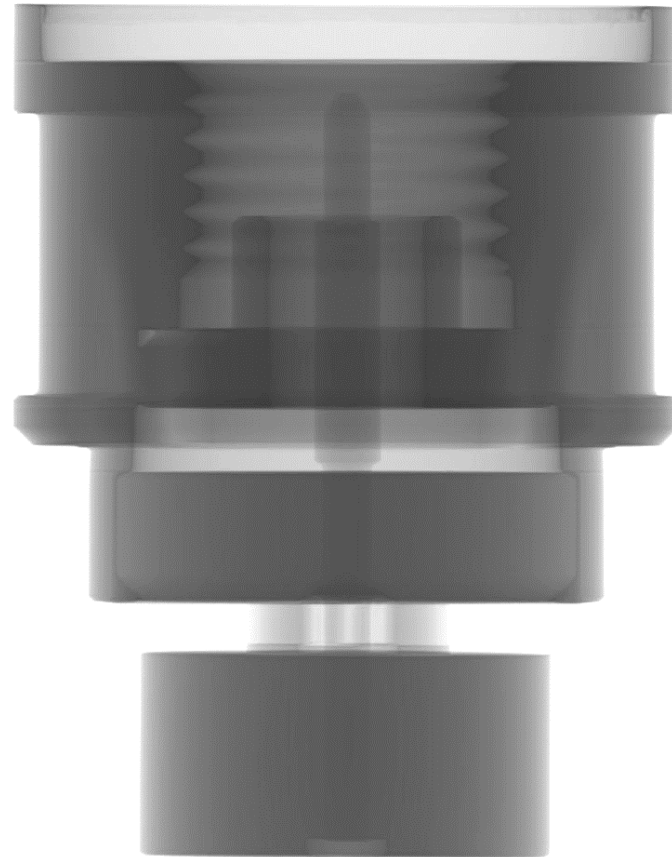


Zoo of Curiosities: Misplaced end stop for SMA connector (only 3 out of 250)



- ☉ *Leaks on the BPM buttons appeared (of course...) **WHERE WE DIDN'T EXPECT THEM**: in the bulk steel due to bad steel quality !*
- ☉ *The leak problem is now understood and under control.
For any further purchase of BPM buttons or other critical UHV equipment :
DON'T TRUST the manufacturer for purchasing the raw material:
→ Check at least the material quality certificate
→ Check if possible the quality by CT and more classic metallurgic techniques.*
- ☉ *Even if the buttons look nice from outside, CT scans reveal also some misalignment of the button assembly.*
- ☉ *Beamlines can provide valuable help using their various and powerful techniques to analyse material and structure properties.
→ Very good collaboration with Paul Tafforeau from ID19/BM05 who spend and enormous amount of time doing the scan and analysing the data !*

Thank you for your attention



Courtesy of Paul Tafforeau