Materials for BLMs

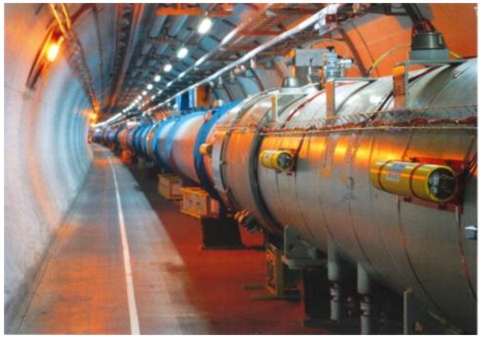
Viatcheslav (Slava) Grishin on behalf of CERN (BI-BL section) and IHEP (Protvino)

Materials and Engineering Technologies for Particle Accelerator Beam Diagnostic Instruments, June 23 2021

Outline

- Introduction
- Crucial points
- The flow diagram
- Materials
- Quality issues
- Conclusion

Introduction



The LHC accelerator beams store an unprecendented amount of energy. If even a small fraction of this beam deviates from the correct orbit, it may induce a quench in the superconductive magnets and/or cause physical damage to system components. The beam loss monitoring system is key to protecting the machine against dangerous beam losses.

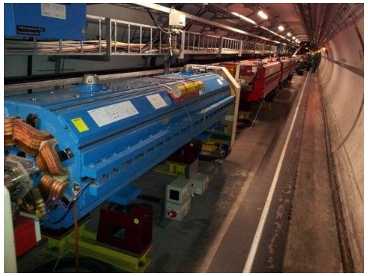
More then 5000 BLM detectors have been produced in a collaboration between CERN and IHEP, Protvino.

In the 16 years of collaboration, CERN and IHEP developed several types of BLM detectors and IHEP manufactured them using industry-produced components.

Beam Loss Monitors

5080 Ionization chambers
378 Secondary emission monitors
300 Little ionization chambers
50 Flat ionization chambers
6 prototypes of proportional chamber

LHC



+BNL
+CEBAF
+ IHEP, Protvino
+ INR, Moscow
+

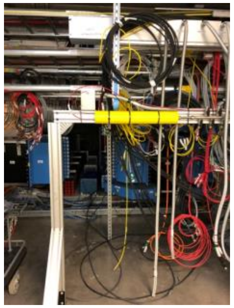
PS

PSB.

After LS3, all CERN accelerators and transfer lines will be equipped with BLM detectors produced by the CERN-IHEP, Protvino collaboration. Literally, every 10 meters in the whole accelerator complex, from LINAC4 to LHC, there will be a bright yellow tube.

LIPAC (for Ifmif-Eveda)

ESS



GSI

Requests for future BLM production::

- ~1000 for SPS
- ~200 FRIB
- ~300 IMP
- GSI
- ESS
- Other institutes interests

Crucial points

- Design
- The collaboration between CERN and IHEP, Protvino
- The requirements, prototypes, continuous materials checks, production schedule, tests before, during, after production, installation, the control of detector performance
- Complexity: No compromise on details, high focus on QA

Design

EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH
CERN — SL DIVISION

CERN SL-99-042 BI

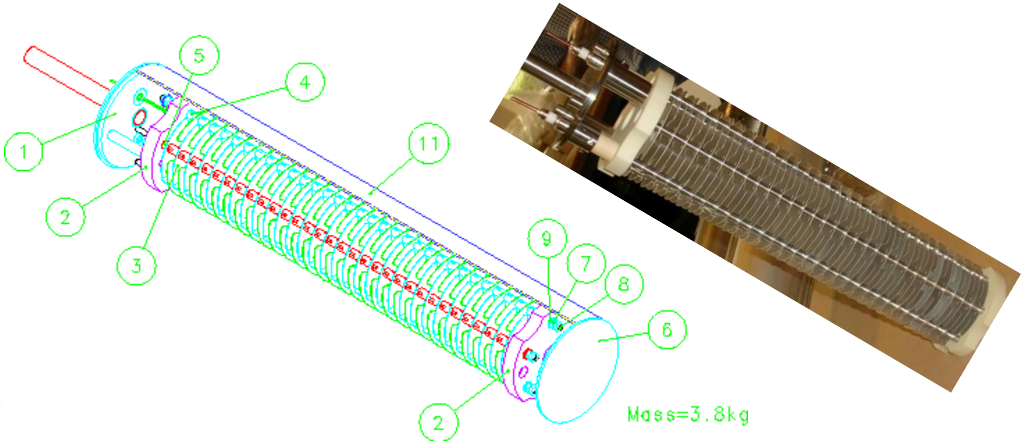
COMPARATIVE TEST RESULTS OF VARIOUS BEAM LOSS MONITORS IN PREPARATION FOR LHC

Bosser, J.; Ferioli, G.
CERN – Geneva - CH

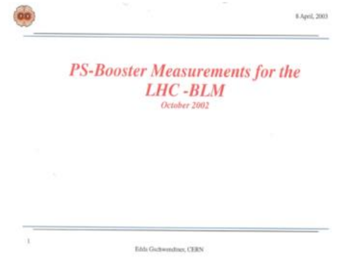
Abstract

Beam loss detectors will play an important role in the protection of the superconducting LHC magnets.
Different types of detectors have been tested in the SPS ring and secondary beam lines with a view to their possible use for this application.
This paper describes the measurements made with: microcalorimeters at cryogenic temperatures, PIN diodes, ionisation chambers, scintillators, and ACEMs.
Measurements made using proton beams showing their relative sensitivities, linearities in counting or analog mode and minimum detection level will be presented.

Presented at DIPAC
Chester – 16-18 May 1999



Bias Voltage low-pass filter
The connector's insulating material chosen to resist to a TID up to 10 MGy.

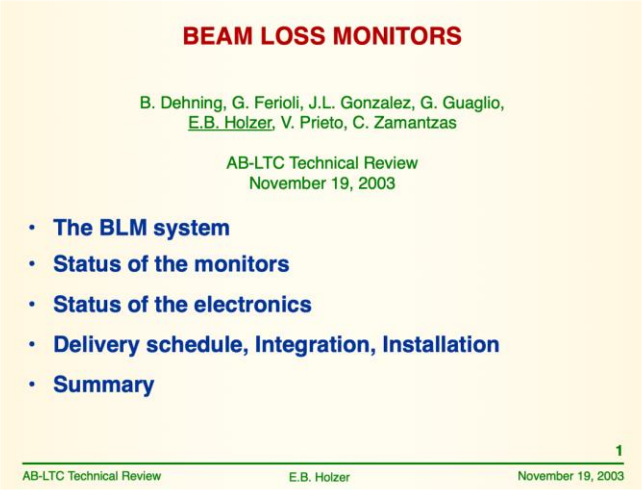


8 April, 2003

PS-Booster Measurements for the LHC -BLM
October 2002

1

Edda Gschwendtner, CERN



BEAM LOSS MONITORS

B. Dehning, G. Ferioli, J.L. Gonzalez, G. Guaglio,
E.B. Holzer, V. Prieto, C. Zamantzas

AB-LTC Technical Review
November 19, 2003

- **The BLM system**
- **Status of the monitors**
- **Status of the electronics**
- **Delivery schedule, Integration, Installation**
- **Summary**

1

AB-LTC Technical Review E.B. Holzer November 19, 2003

The LHC beam loss monitoring system's data acquisition card

B. Dehning [a], E.Effinger [a], J. Emery [a], G. Ferioli [a], G. Gauglio [b], C. Zamantzas [a]

[a] CERN, 1211 Geneva 23, Switzerland
[b] MEMC, 28100 Novara, Italy

ewald.effinger@cern.ch

Abstract

The beam loss monitoring (BLM) system [1] of the LHC is one of the most critical elements for the protection of the LHC. It must prevent the super conducting magnets from quenches and the machine components from damages, caused by beam losses. Ionization chambers and secondary emission based beam loss detectors are used on several locations around the ring. The sensors are producing a signal current, which is related to the losses. This current will be measured by a tunnel electronic, which acquires, digitizes and transmits the data via an optical link to the surface electronic. The so called threshold comparator (TC) [2] collects, analyzes and compares the data with threshold table. It also gives a dump signal through the combiner card to the beam inter lock system (BIC).

The usage of the system, for protection and tuning of the LHC and the scale of the LHC, imposed exceptional specification of the dynamic range and radiation tolerance. The input current dynamic range should allow measurements between 10pA and 1mA and it should also be protected to very high pulse of 1.5kV and its corresponding current. To cover this range, a current to frequency converter (CFC) is used in the tunnel card, which produces an output frequency of 0.05Hz at 10pA, and 5MHz at 1mA. In addition to the output frequency, the integrator output voltage is measured with a 12bit ADC to improve the resolution.

The location of the CFC card next to the detector imposes the placement of the card in the LHC tunnel, exposing the card to radiation. The radiation tolerance was defined by assuming a 20 year operation period corresponding to 400Gy. A mixture of radiation tolerant Asics from the microelectronic group at CERN, and standard component was chosen to cope with these requirements.

host the PowerPC, a combiner card, and two timing-cards. The PowerPC collects the running sum values of the TC, and sends it to a database. The combiner card has a hardwired link to the BIC, which transmits the beam dump signal to kicker magnets.

A. Specification of the data acquisition card

The exposition to radiation leads to the requirement of a tolerance of a maximum of 400Gy integrated dose for 20 years LHC life-time. For the system and the performed tests a maximum value of 500Gy was chosen to ensure a safety margin.

The employment of the system for the LHC protection requires a high reliability of the CFC card. To achieve a reliability level SIL3 [3] (10^{-7} to 10^{-8} failure/h) of the system, several different test modes, status information, protection circuits and a redundant data transmission are implemented. For the verification, different tests have been performed, like irradiation, temperature and burn-in test. An additional test in magnetic field was included.

Table 1: Specifications requirements

Current measuring range	2.5pA	1mA
Error down to 10pA	-50%	+100%
Error down to 1nA	-25%	+25%
Maximal input current	561mA	
Input voltage peak	1500V @ 100us	
Radiation	500Gy in 20yr	
Digital supply	+ 2.5V	
Analogue supply	+/- 5V	
HV monitor input	0V	+5V

The collaboration CERN-IHEP,Protvino


INTERNATIONAL JOURNAL OF HIGH-ENERGY PHYSICS

CERN COURIER

VOLUME 47 NUMBER 8 OCTOBER 2007

Astronomy c

ACCELERATORS

NEWS

LHC NEWS

IHEP and CERN collaborate well on beam-loss monitors

Detector head assembly required multiple labs:

DG Technology (Italy)
AeroVac(UK)
Alca (Italy)
IHEP, Protvino (Russia)
CERN prototypes

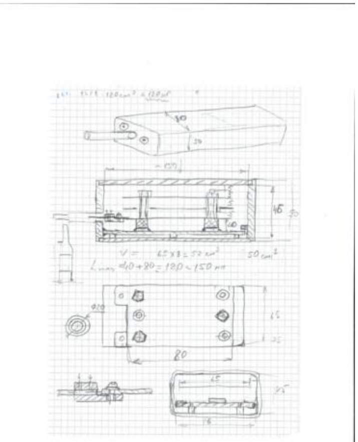
The quality issues, productions schedule…

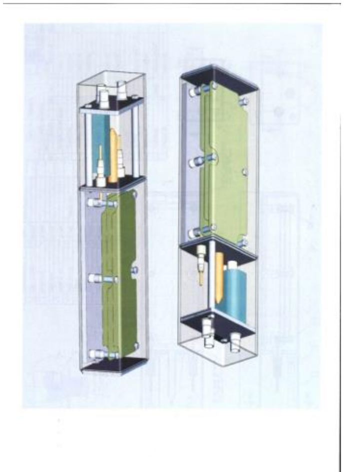
Meeting at CERN in September 2005 : R.Garoby, R.Jones, J-J.Gras, B.Dehning
A.Sytin, V.Grishin,
Ph. Bryant (LHC)

decided to establish the CERN-BL/IHEP-Protvino collaboration for whole chain , including the materails, prototypes, production, tests, installation.

To support the investigations of the LHC limitation and anticipate other possible similar future problems, we have produced **the proportional chamber**. The PC has the same outside geometry as IC but the sensitivity is 10- 100 times higher in comparison to the existing LHC IC.

- **LIC** type has been designed for lower sensitivity with respect to standard IC
- **FIC** type has been designed for space restrictions (PS Booster installation between beam pipes)





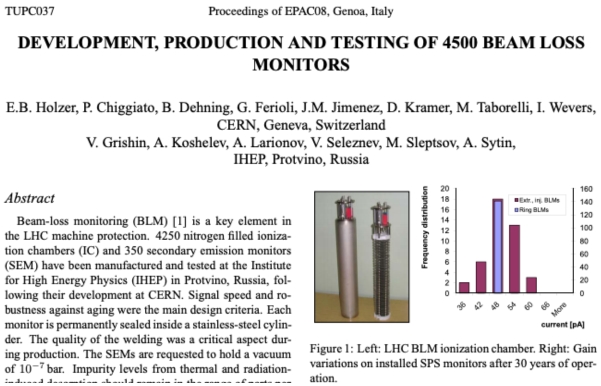
Production schedule


10. 03. 2006

Wednesday **5th December 2007**, 16:30

Meyrin Restaurant II

Dear colleagues,
the production of the beam loss monitors for the LHC in IHEP, Protvino
came last month to an end. **Over 1.5 million pieces were shipped to IHEP to produce 4250 gas filled ionisation chambers and 350 UHV treated secondary emission monitors.**
In the meantime all monitors arrived at CERN and most of them were source tested or beam tested.
About two third of the monitors are now installed by a team from IHEP


TUPC037 Proceedings of EPAC08, Genoa, Italy

DEVELOPMENT, PRODUCTION AND TESTING OF 4500 BEAM LOSS MONITORS

E.B. Holzer, P. Chiggiato, B. Dehning, G. Ferioli, J.M. Jimenez, D. Kramer, M. Taborelli, I. Wevers,
CERN, Geneva, Switzerland
V. Grishin, A. Koshelev, A. Larionov, V. Seleznev, M. Sleptsov, A. Sytin,
IHEP, Protvino, Russia

Abstract

Beam-loss monitoring (BLM) [1] is a key element in the LHC machine protection. 4250 nitrogen filled ionization chambers (IC) and 350 secondary emission monitors (SEM) have been manufactured and tested at the Institute for High Energy Physics (IHEP) in Protvino, Russia, following their development at CERN. Signal speed and robustness against aging were the main design criteria. Each monitor is permanently sealed inside a stainless-steel cylinder. The quality of the welding was a critical aspect during production. The SEMs are requested to hold a vacuum of 10^{-7} bar. Impurity levels from thermal and radiation-

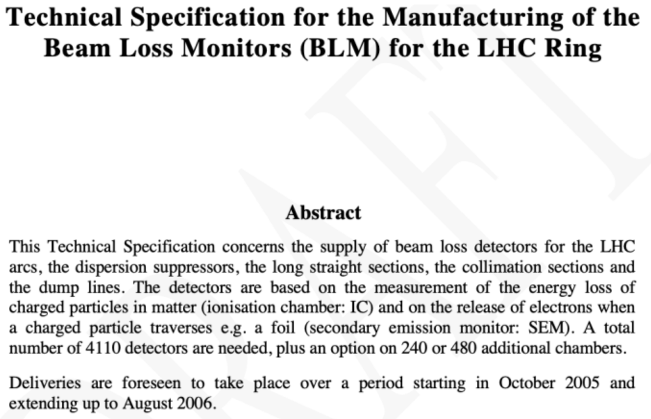
Figure 1: Left: LHC BLM ionization chamber. Right: Gain variations on installed SPS monitors after 30 years of operation.

The requirements

The total ionizing dose on the detectors over 20 years of LHC operation was estimated at 2 × 10^8 Gy in the collimation regions and 2 × 10^4 Gy at other locations. The radiation hardness depends mainly on the ceramics, connectors and feedthroughs.

To reduce radiation aging effects, production of the chamber components included a strict production and ultrahigh vacuum cleaning procedures. As a result, impurity levels from thermal and radiation-induced desorption should remain in the range of parts per million.

In addition, the required resistivity of the ceramics must be ensured also in air. The detectors have to operate (long enough) even in case of a leak which leads to air (and water) contamination in the inside of the chamber. Time and humidity dependence of the resistivity of the ceramics would lead to a reduced signal which would not be possible to be diagnosed without close inspection the LHC tunnel. This could pose a serious reliability problem for BLM systems.

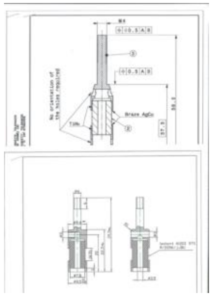


Technical Specification for the Manufacturing of the Beam Loss Monitors (BLM) for the LHC Ring

Abstract

This Technical Specification concerns the supply of beam loss detectors for the LHC arcs, the dispersion suppressors, the long straight sections, the collimation sections and the dump lines. The detectors are based on the measurement of the energy loss of charged particles in matter (ionisation chamber: IC) and on the release of electrons when a charged particle traverses e.g. a foil (secondary emission monitor: SEM). A total number of 4110 detectors are needed, plus an option on 240 or 480 additional chambers.

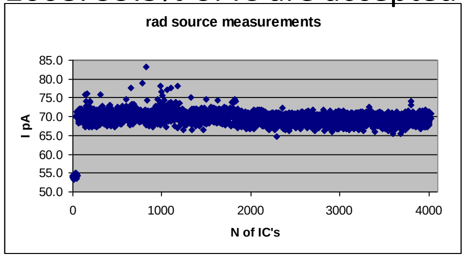
Deliveries are foreseen to take place over a period starting in October 2005 and extending up to August 2006.



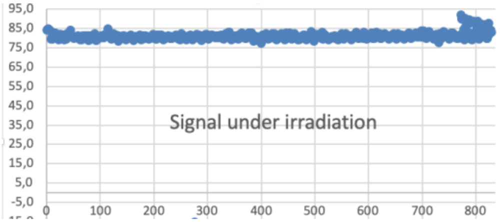
Ceramic: High Purity Alumina 97%
Metallic parts: DP1
No any treatment after brazing
The ceramics isn't glazed
The ceramics are not be touched or treated or cleaned in any way after baking
The control of the dimensions

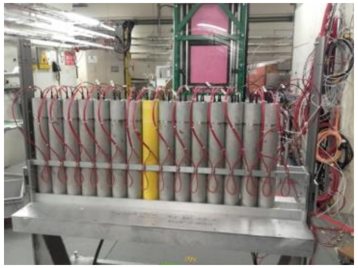
The acceptance tests

2008: 99.5% of IC are accepted

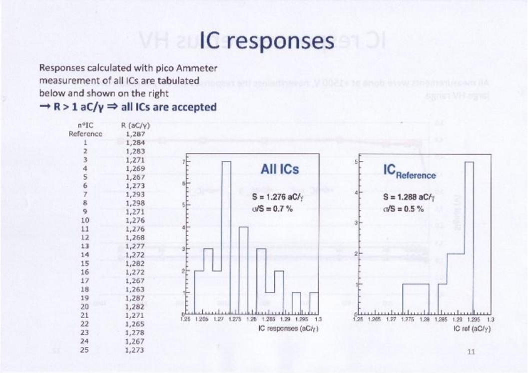


2017: 97 % of IC are accepted





One of the reasons for high (out of specs) signal is the migration of water and other nasty things from the ceramics.

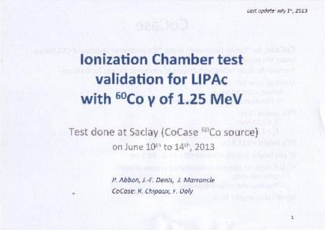


IC responses

Responses calculated with pico Ammeter measurement of all ICs are tabulated below and shown on the right

→ R > 1 aC/γ ⇒ all ICs are accepted

n°IC	R (aC/γ)
Reference	1,287
1	1,284
2	1,283
3	1,271
4	1,269
5	1,267
6	1,273
7	1,293
8	1,298
9	1,271
10	1,276
11	1,276
12	1,268
13	1,277
14	1,272
15	1,282
16	1,272
17	1,267
18	1,263
19	1,287
20	1,282
21	1,271
22	1,265
23	1,278
24	1,267
25	1,273



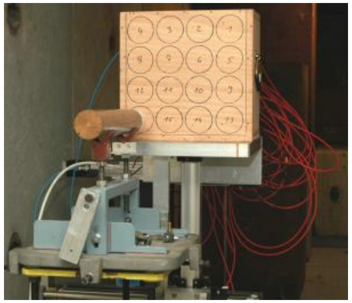
Last update: July 1st, 2013

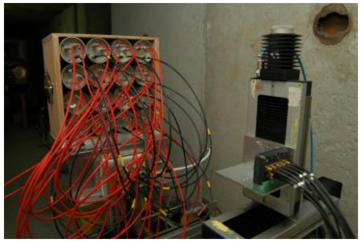
Ionization Chamber test validation for LIPAc with ^{60}Co γ of 1.25 MeV

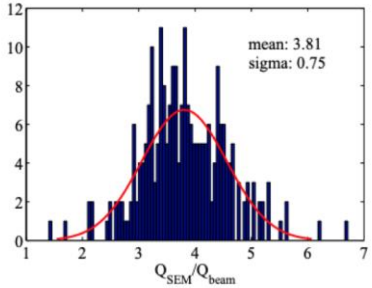
Test done at Saclay (CoCase ^{60}Co source)
on June 10th to 14th, 2013

P. Abbon, J.-F. Denis, J. Marroncle
CoCase: R. Chipaux, F. Daly

SEM

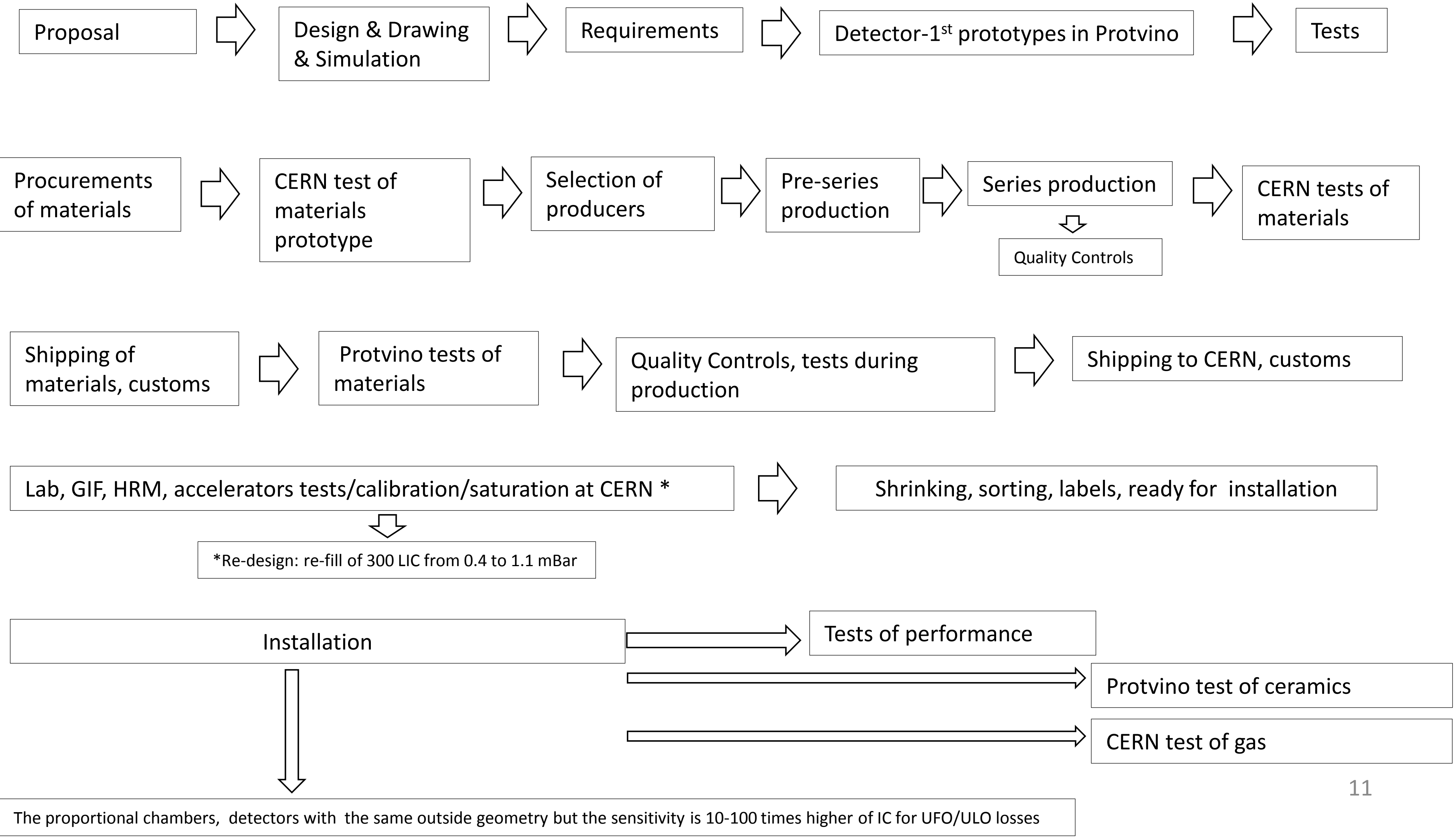






Calibration of 250 SEM detectors in a mixed radiation field corrected for systematic position errors.

The flow diagram



Proposal

Design & Drawing & Simulation

Requirements

Detector-1st prototypes in Protvino

Tests

Procurements of materials

CERN test of materials prototype

Selection of producers

Pre-series production

Series production

Quality Controls

CERN tests of materials

Shipping of materials, customs

Protvino tests of materials

Quality Controls, tests during production

Shipping to CERN, customs

Lab, GIF, HRM, accelerators tests/calibration/saturation at CERN *

*Re-design: re-fill of 300 LIC from 0.4 to 1.1 mBar

Shrinking, sorting, labels, ready for installation

Installation

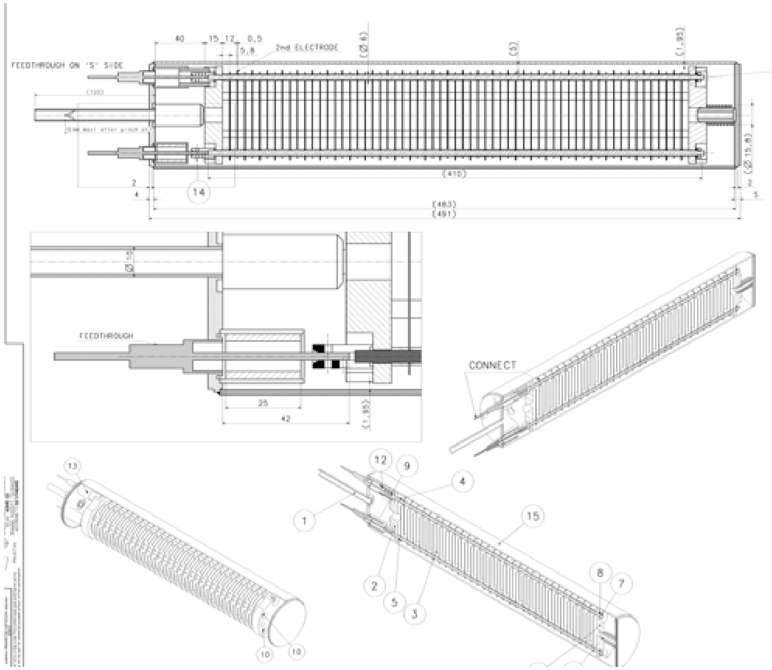
Tests of performance

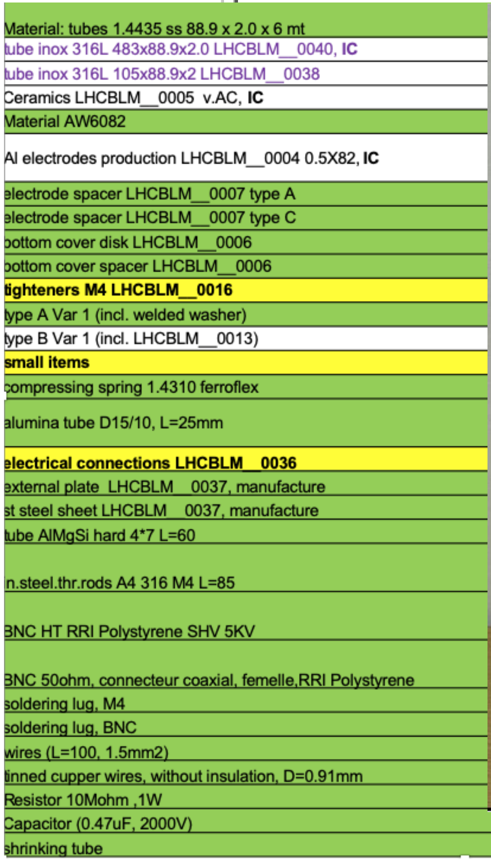
Protvino test of ceramics

CERN test of gas

The proportional chambers, detectors with the same outside geometry but the sensitivity is 10-100 times higher of IC for UFO/ULO losses

Materials:
industry-produced components

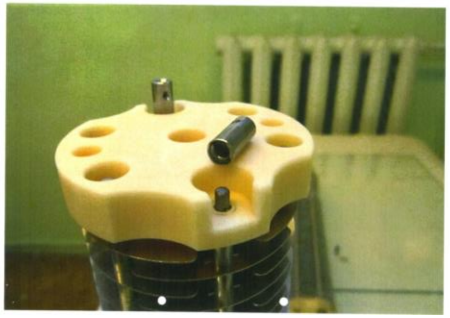


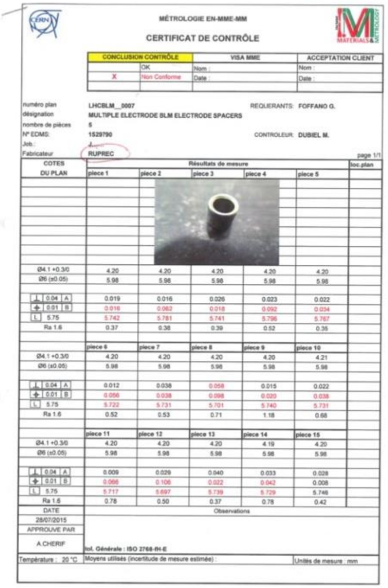


Material: tubes 1.4435 ss 88.9 x 2.0 x 6 mt
tube inox 316L 483x88.9x2.0 LHCBLM__0040, **IC**
tube inox 316L 105x88.9x2 LHCBLM__0038
Ceramics LHCBLM__0005 v.AC, **IC**
Material AW6082
Al electrodes production LHCBLM__0004 0.5X82, **IC**
electrode spacer LHCBLM__0007 type A
electrode spacer LHCBLM__0007 type C
bottom cover disk LHCBLM__0006
bottom cover spacer LHCBLM__0006
tighteners M4 LHCBLM__0016
type A Var 1 (incl. welded washer)
type B Var 1 (incl. LHCBLM__0013)
small items
compressing spring 1.4310 ferroflex
alumina tube D15/10, L=25mm
electrical connections LHCBLM__0036
external plate LHCBLM__0037, manufacture
st steel sheet LHCBLM__0037, manufacture
tube AlMgSi hard 4*7 L=60
n.steel.thr.rods A4 316 M4 L=85
BNC HT RRI Polystyrene SHV 5KV
BNC 50ohm, connecteur coaxial, femelle,RRI Polystyrene
soldering lug, M4
soldering lug, BNC
wires (L=100, 1.5mm2)
tinned cupper wires, without insulation, D=0.91mm
Resistor 10Mohm ,1W
Capacitor (0.47uF, 2000V)
shrinking tube

Careful selection of manufacturing companies necessary to reduce later issues.

1^{st} type of issues





MÉTROLOGIE EN-MME-MM

CERTIFICAT DE CONTRÔLE

CONCLUSION CONTRÔLE		VISA MME	ACCEPTATION CLIENT
	OK	Nom :	Nom :
X	Non Conforme	Date :	Date :

numéro plan: LHCBLM__0007

REQUERANTS: FOFFANO G.

désignation: MULTIPLE ELECTRODE BLM ELECTRODE SPACERS

nombre de pièces: 5

N° EDMS: 1529790

CONTROLEUR: DUBIEL M.

Job: J...

Fabricateur: RUPREC

page 1/1

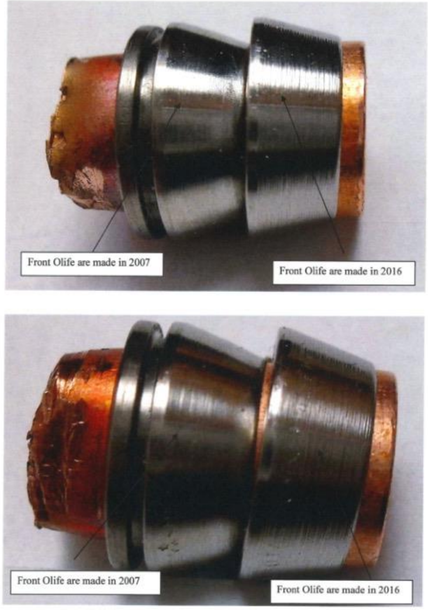
COTES DU PLAN	Résultats de mesure					loc.plan
	piece 1	piece 2	piece 3	piece 4	piece 5	
Ø4.1 +0.3/0	4.20	4.20	4.20	4.20	4.20	
Ø6 (±0.05)	5.98	5.98	5.98	5.98	5.98	
⊥ 0.04 A	0.019	0.016	0.026	0.023	0.022	
⌖ 0.01 B	0.016	0.062	0.018	0.092	0.034	
L 5.75	5.742	5.781	5.741	5.796	5.767	
Ra 1.6	0.37	0.38	0.39	0.52	0.35	
	piece 6	piece 7	piece 8	piece 9	piece 10	
Ø4.1 +0.3/0	4.20	4.20	4.20	4.20	4.21	
Ø6 (±0.05)	5.98	5.98	5.98	5.98	5.98	
⊥ 0.04 A	0.012	0.038	0.058	0.015	0.022	
⌖ 0.01 B	0.056	0.038	0.098	0.020	0.038	
L 5.75	5.722	5.731	5.701	5.740	5.731	
Ra 1.6	0.52	0.53	0.71	1.18	0.68	
	piece 11	piece 12	piece 13	piece 14	piece 15	
Ø4.1 +0.3/0	4.20	4.20	4.20	4.19	4.20	
Ø6 (±0.05)	5.98	5.98	5.98	5.98	5.98	
⊥ 0.04 A	0.009	0.029	0.040	0.033	0.028	
⌖ 0.01 B	0.066	0.106	0.022	0.042	0.008	
L 5.75	5.717	5.697	5.739	5.729	5.746	
Ra 1.6	0.78	0.50	0.37	0.78	0.42	

DATE	Observations
28/07/2015	
APPROUVE PAR	
A.CHERIF	tol. Générale : ISO 2768-fH-E

Température : 20 °C

Moyens utilisés (incertitude de mesure estimée) :

Unités de mesure : mm

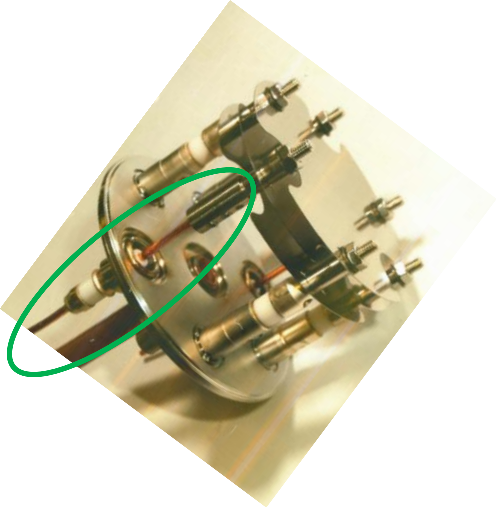


Comparison of roughness

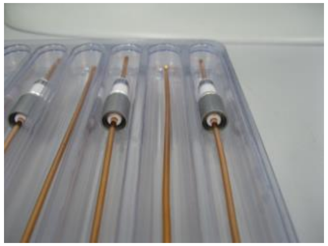
2nd type

UHV current feed through

- glazing of the ceramics on both sides, including the vacuum side
- outside: stainless steel
- current lead: copper
- leak rate: <10^{-10} mbar l/s
- UHV application.
- not outgas.
- withstand baking at 300 C.



Feedthroughs testing is done at CERN after reception and in IHEP just before chambers assembly. The acceptance criteria for leakage current is set below 1 pA in air at 2000 V.



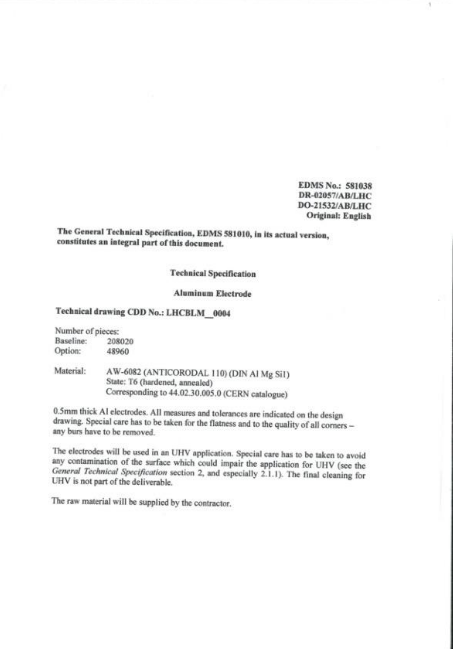
Only 15 out of 1700 feedthroughs were not accepted.

Electrodes

- no burr
- the flatness
- no edge curvature
- no surface scratches
- no oil
- large number

2 types of FIC electrode plates from st steel 316L and Al by 2 different technologies: water and laser.
In both cases we have the burrs, but in case of laser cutting the burrs are more smaller that water cutting plate.

The flatness in both case is good.



EDMS No.: 581038
DR-02057/AB/LHC
DO-21532/AB/LHC
Original: English

The General Technical Specification, EDMS 581010, in its actual version, constitutes an integral part of this document.

Technical Specification

Aluminum Electrode

Technical drawing CDD No.: LHCBLM_0004

Number of pieces:
Baseline: 208020
Option: 48960

Material: AW-6082 (ANTICORODAL 110) (DIN Al Mg Si1)
State: T6 (hardened, annealed)
Corresponding to 44.02.30.005.0 (CERN catalogue)

0.5mm thick Al electrodes. All measures and tolerances are indicated on the design drawing. Special care has to be taken for the flatness and to the quality of all corners – any burs have to be removed.

The electrodes will be used in an UHV application. Special care has to be taken to avoid any contamination of the surface which could impair the application for UHV (see the *General Technical Specification* section 2, and especially 2.1.1). The final cleaning for UHV is not part of the deliverable.

The raw material will be supplied by the contractor.

The defects of the metal drops adhering to the surface, trace from the laser on the edge of some plates, a small notch.

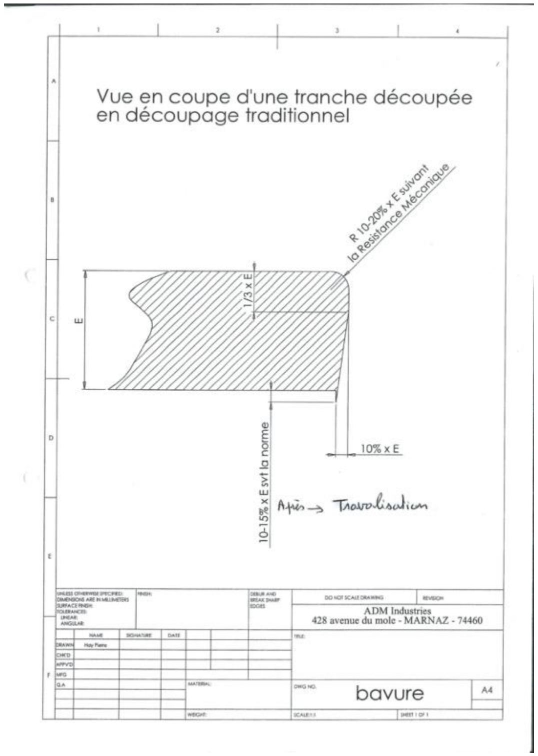
The Dutreive SAS, a company from Haut Savoie, which has produced for us ~ 300 000 Al elect by stamp, has closed. We have found a similar company (ADM Industrie) following the advice of Mr Dutreive (owner of old company).

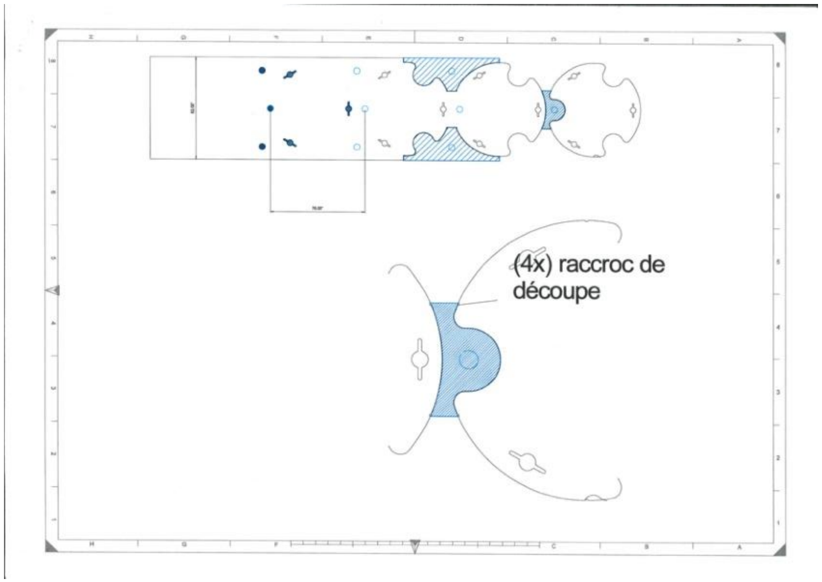
Electrodes

Qualite <qualite@adm-industrie.com>
20.05.2016
ADM electrodes : status 04/05/2016

We checked **flatness** after the deburring .
We can’t obtain parts without deformation <= 0.01mm
We don’t make the deburring.

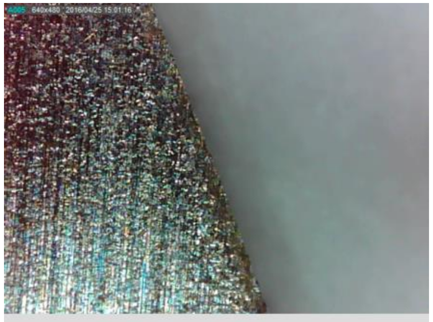
We propose you the parts, without deburring, and remove the price without this operation.



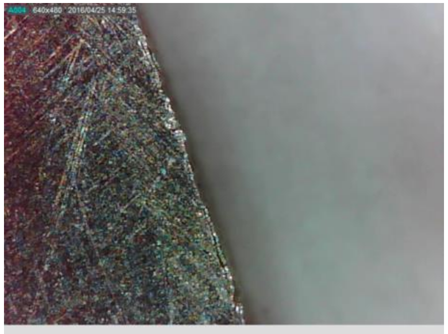


Electrodes

Dutrieve company, 2006
0.0 burr (bavure) and less curvature



ADM company, 2017

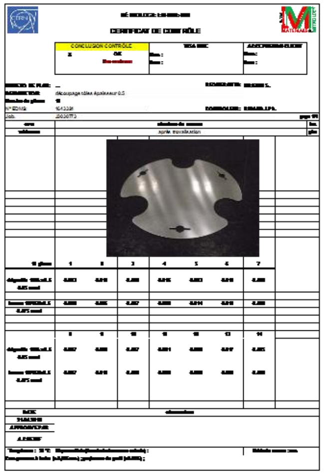


ADM:

* The results of metrology check of burr and edge shaping (in ideal should 0.000): the burrs less than 1.5 % (to 0.54 mm thickness) and in absolute in most of cases <0.01 mm for 0.54 thickness.

* oil, which needs for stamp. ADM cannot make the additional cleaning.

* To keep the flatness after stamping: the ADM worker manually put the electrodes in box. The standard procedure is to the details automatically falling down to box after stamping

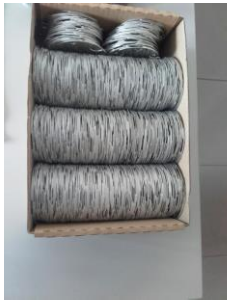


CERTIFICAT DE CONTRÔLE

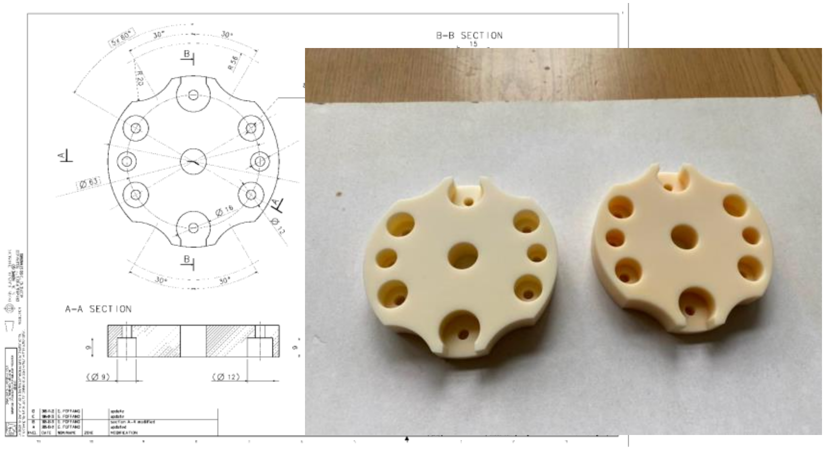
CONCLUSION CONTRÔLE

OK

découpage tôles épaisseur 0.5



Ceramics insulator



The dynamic range of an ionization chamber is defined by its lowest and highest current signals. It is limited by leakage current through the **ceramics insulator**, which should be less than 1 pA for lowest signals.

The electric resistivity at 3000 V in air has to stay below 1 pA .
Surface currents caused by air humidity above this value are not acceptable.

In 4250 IC, ceramics insulators are from SCT, France. No degradation has been observed over years of operation at LHC.

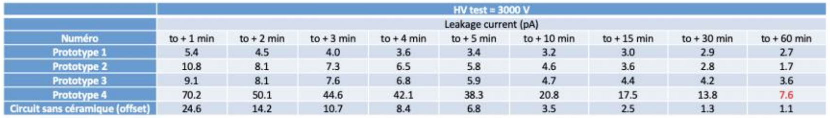
In last 830 IC, ceramics insulators are from Friatec, Germany.

Various investigations on the ceramic insulators include vacuum, chemical, electrical, cleaning, and heating tests. Some of these tests (e.g. heating and cleaning) leads to improved quality of the ceramics from Friatec.

Ceramics insulator

4 pcs. of insulators (= Al 99.5 amples; ”red” ceramics) were delivered in November 2014

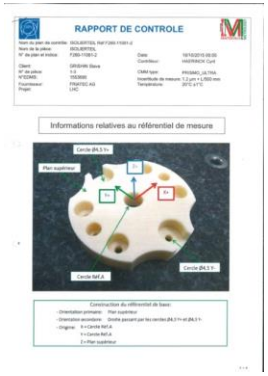
Test of 4 ceramic prototypes from Friatec (09/01/2015)



	HV test = 3000 V								
	Leakage current (pA)								
Numéro	to + 1 min	to + 2 min	to + 3 min	to + 4 min	to + 5 min	to + 10 min	to + 15 min	to + 30 min	to + 60 min
Prototype 1	5.4	4.5	4.0	3.6	3.4	3.2	3.0	2.9	2.7
Prototype 2	10.8	8.1	7.3	6.5	5.8	4.6	3.6	2.8	1.7
Prototype 3	9.1	8.1	7.6	6.8	5.9	4.7	4.4	4.2	3.6
Prototype 4	70.2	50.1	44.6	42.1	38.3	20.8	17.5	13.8	7.6
Circuit sans céramique (offset)	24.6	14.2	10.7	8.4	6.8	3.5	2.5	1.3	1.1

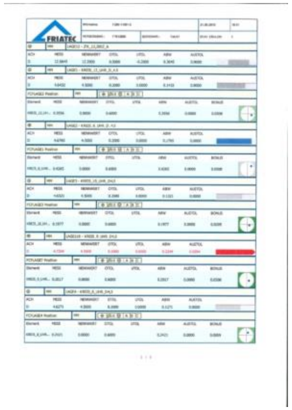
Number #1 is ceramic disk , which I have touched by hand when I've checked the dimensions, it was taken out from original Friatec box long time before the test (but stay in plastic bag).
Numbers #2-4 was taken out from Friatec box just before tests.

The metrology: the dimensions are OK.



RAPPORT DE CONTROLE

Informations relatives au référentiel de mesure



1st batch of ”red” (or ivory) ceramics was delivered around October 2015.

HV test = 2000 V						
	2 point measuements Δ =63 mm			2 point measuements Δ = 32 mm		
N° Box/N° Pièce	to + 1 min	to + 3 min	to + 5 min	to + 1 min	to + 3 min	to + 5 min
1/1	353	295	288	393	409	430
1/2	210	204	201	295	284	281
1/3	116	123	129	255	266	274
1/4	1.8	1.7	2.2	6.7	6.3	7.8
2/1	445	396	379	374	352	345
2/2	167	173	169	174	165	150.6
2/3	1147	1065	1094	731	716	684
2/4	724	708	694	854	895	892
Mesure avec 3 points en étoile - reprise 2 céramiques						
N° Box/N° Pièce	to + 1 min	to + 3 min	to + 5 min	to + 10 min	to + 15 min	to + 20 min
1/3	288	216	182	191	195	207
1/4	132	88	85	91	112	126

30% of those ceramics cannot be accepted

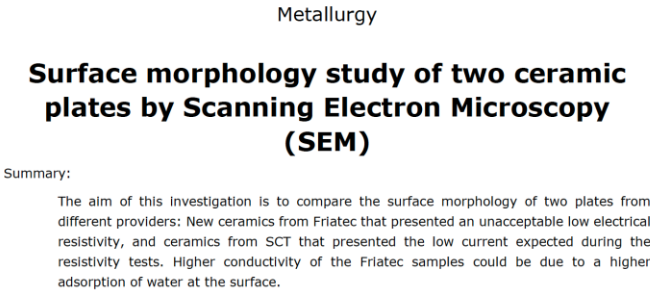
Tests of 1st series

We received in one week ~500 pcs, tested and asked a halt in the production.

Test le 26 octobre 2015								
HV = 2000 V								
	to + 15 sec	to + 30 sec	to + 1 min	to + 3 min	to + 5 min	to + 10 min	to + 15 min	to + 20 min
Boîte 5 - 1ère livraison	417	332	302	261	257			
Boîte 5 - 1ère livraison	1824	1630	1582	1471		Après cleaning + etching +cleaning		
Without cleaning to compare								
OLD (SCT16) céramique	4	-1	0.9	0.1				
Prototype n°4	142	91	65	47	32			23

The heating improved the resistivity, but not enough.
The etching is dramatically bad for properties.
The cleaning and etching did not improve the properties.

The surface differences of SCT and Friatec ceramics are visible with electronic scope (atomic level).



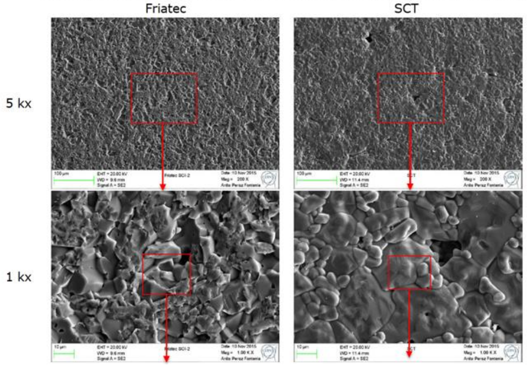
Metallurgy

Surface morphology study of two ceramic plates by Scanning Electron Microscopy (SEM)

Summary:

The aim of this investigation is to compare the surface morphology of two plates from different providers: New ceramics from Friatec that presented an unacceptable low electrical resistivity, and ceramics from SCT that presented the low current expected during the resistivity tests. Higher conductivity of the Friatec samples could be due to a higher adsorption of water at the surface.

Representative images of the surface topography of both samples is shown in Figure 2.



Test of the resistivity in vacuum oven with heating to 150-200 C.

Xray of 8 ceramics insulators before clean+etching : Ni and Cu on surface for 1 ceramic disk

Tests of 1st series

Friatec:

The problem isn’t caused by **the material resistivity of our ceramics, but by the surface resistivity.**

Two assumptions why this problem happens:

1. It may be that the morphology of our ceramic surface (it is grinded) in combination with carbon impurities or water causes problems, so an oxidizing heat treatment may help.
2. Oxygen defects in the surface layer may play a role, so an aging process under UV light may help.

The results of our investigation, the production of ”white” ceramics

Other issue

1) A quantity of 496 pieces of insulators (= series; ”white” ceramics) was delivered by us between January and February 2016.

2) The ceramics type 2015 (“red”) baked in CERN is acceptable.

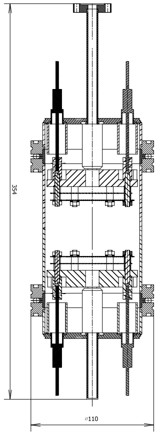
Tests at IHEP, Protvino

After annealing the ceramics are acceptable but very important is the ageing effects.

On the vacuum stand, we heat the ceramics during 22h with pumping out and there is no water vapor (we control the spectra) until nitrogen filled (the partial pressure was not recorded by the analyzer below 10^{-11} mbar).
After filling, the level of water vapor in the stand is 10^{-8} mbar (this is water vapor from pure nitrogen), the value is almost two orders of magnitude less than the specification requires (10^{-6} mbar).

in the event of accidental leaks (damage to the current lead or corrosion of the pich off of a copper tube, etc.), the leakage current can increase .

Proposal test of the ceramics on stand



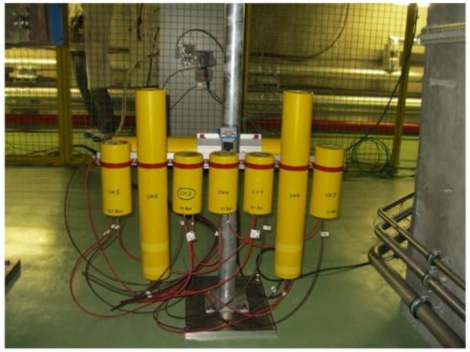
	Leakage current							
	SCT 1	SCT 2	Firatec 1	Firatec 2	Firatec 3	Firatec 4	Firatec 5	Firatec 6
13.03.2020	<1 pA	<1 pA	7 pA	7 pA	40 pA	9 pA	1311 pA	10 pA
25.01.2021	<1 pA	<1 pA	<1 pA	<1 pA	2 pA	2.5 pA	1234 pA	5 pA

Conclusion

For a successful production the following were necessary:

- production of prototypes
- thorough company selection, including on-site visits
- when large number of items: pre-series
- control each production/material process steps
- continuous material delivery checks
- the collaboration CERN-IHEP,Protvino with feedback
- test of materials, detector's performance after installation
- support of the vaccuum production stand in operational conditions
- build a team and maintain experienced experts

Thank you for your attention



Acknowledgements

B. Dehning, E.B. Holzer, G.Ferioli

CERN team:

C.Chery, Ch.Vuitton, C.Zamantzas, E.Effinger, R.Tissier, I.Savu, E.Nebot, J-M.Malzacker, M.Stockner, J.Emery, D.Kramer and many others

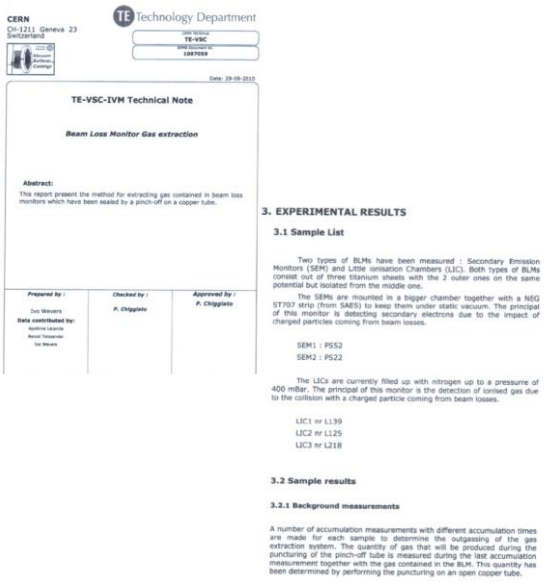
IHEP,Protvino team:

V. Seleznev, A.Larionov, A.Koshelev, M.Sleptsov, N.Tyurin, A.Sytin and many others

Back up slides

Production tests : leaks, gas, vacuum,cleaning

CERN test of the filling gas.



CERN
CH-1211 Geneva 23
Switzerland

Technology Department

TE-VSC

1097059

Date: 29-09-2010

TE-VSC-IVM Technical Note

Beam Loss Monitor Gas extraction

Abstract:
This report present the method for extracting gas contained in beam loss monitors which have been sealed by a pinch-off on a copper tube.

Prepared by :	*Checked by :*	*Approved by :*
Ivo Wevers **Data contributed by:**	*P. Chiggiato*	*P. Chiggiato*

3. EXPERIMENTAL RESULTS

3.1 Sample List

Two types of BLMs have been measured : Secondary Emission Monitors (SEM) and Little ionisation Chambers (LIC). Both types of BLMs consist out of three titanium sheets with the 2 outer ones on the same potential but isolated from the middle one.

The SEMs are mounted in a bigger chamber together with a NEG ST707 strip (from SAES) to keep them under static vacuum. The principal of this monitor is detecting secondary electrons due to the impact of charged particles coming from beam losses.

SEM1 : PS52
SEM2 : PS22

The LICs are currently filled up with nitrogen up to a pressure of 400 mBar. The principal of this monitor is the detection of ionised gas due to the collision with a charged particle coming from beam losses.

LIC1 nr L139
LIC2 nr L125
LIC3 nr L218

3.2 Sample results

3.2.1 Background measurements

A number of accumulation measurements with different accumulation times are made for each sample to determine the outgassing of the gas extraction system. The quantity of gas that will be produced during the puncturing of the pinch-off tube is measured during the last accumulation measurement together with the gas contained in the BLM. This quantity has been determined by performing the puncturing on an open copper tube.

Standartized test samples from Protvino analysed at CERN periodically helped to check the cleaning performance.

TE-VSC-SCC
(Surface Analysis)

X-ray photoelectron spectroscopy (XPS) report

Client: Slava Grishin	**Tel.:**
Job No.: 2555_2558-XPS-TE-VSC-SCC-2010-09-14	
Job opened by: M.Menai	**Date:** 2011-09-14

Number of samples: 10
Sample codification: 2555, 2558
2555-1: Cleaning test on stainless steel
2555-2: Cleaning test on stainless steel
2555-3: Cleaning test on stainless steel
2555-4: Cleaning test on stainless steel
2555-5: Cleaning test on stainless steel

2558-1: Cleaning test on Al
2558-2: Cleaning test on Al
2558-3: Cleaning test on Al
2558-4: Cleaning test on Al
2558-5: Cleaning test on Al

Nature of samples: Aluminium and stainless steel cleaning test samples previously contaminated at CERN with standard contamination. Protvino, BLM 29-08-2011.

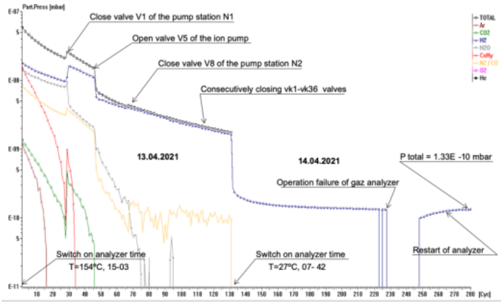
Sample storage: air, in aluminium foil and plastic bag

Aim of analysis: check the surface cleanliness for UHV applications

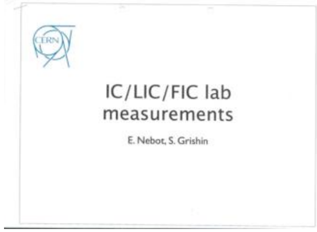
Page 1 out 3

XPS-report 2555_2558-TE-VSC-SCC-2010-09-14

The Protvino’s monitoring of the vacuum and the purity of the filling gas, which is very important due to this is the only component in the IC which is not remotely monitored.

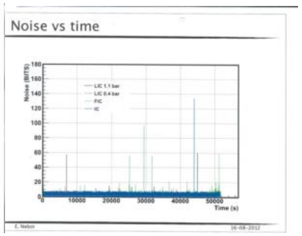


Prototype tests



IC/LIC/FIC lab measurements

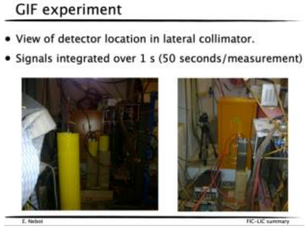
E. Nebot, S. Grishin



Noise vs time

E. Nebot

16-08-2012

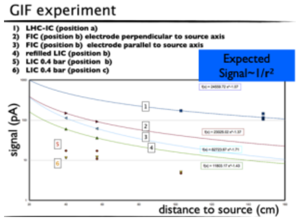


GIF experiment

- View of detector location in lateral collimator.
- Signals integrated over 1 s (50 seconds/measurement)

E. Nebot

FIC-LIC summary

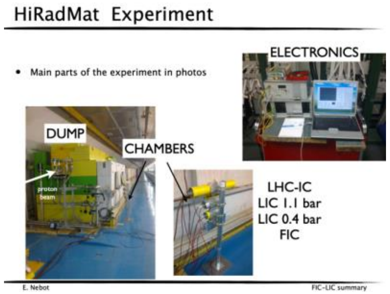


GIF experiment

1) LHC-IC (position a)
2) FIC (position b) electrode perpendicular to source axis
3) FIC (position b) electrode parallel to source axis
4) refilled LIC (position b)
5) LIC 0.4 bar (position b)
6) LIC 0.4 bar (position c)

Expected Signal~1/r²

FIC/LIC PSB DUMP
First Results

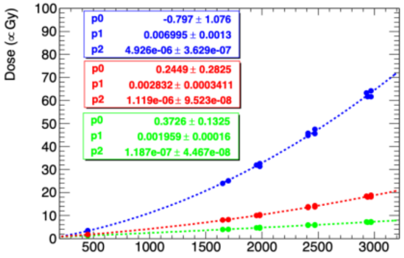


HiRadMat Experiment

- Main parts of the experiment in photos

E. Nebot

FIC-LIC summary



HiRadMat Technical Board recommendations for 2021 experiment HRMT55 – BLM:
The HiRadMat TB approves the BLM3 experiment for beam time.

From 2020 the application to the ARIES TA programme has been registered with the TA Project Identifier: **ARIES-CERN-HiRadMat-2020-01**

This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under Grant Agreement No 730871.