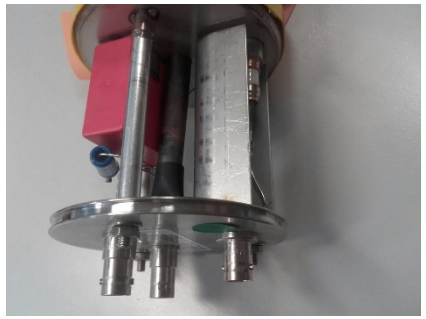
icBLM

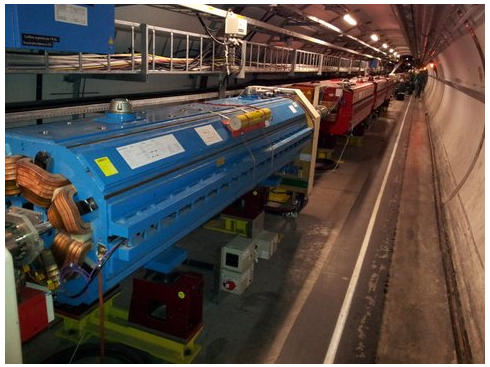
10/07/2017 Viatcheslav GRISHIN

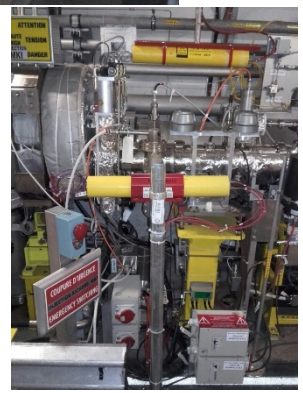
BLM Ionization Chamber



At the beginning of Run 2, BLM LHC system had 3929 monitors
3518 Ionization Chambers (IC), 108 LIC and 191 SEM

LINAC 2 had 5 IC
LINAC 4 installed 24 IC





~100 ICs in PS

BLM PSB system had 32 installed IC and 32FIC.

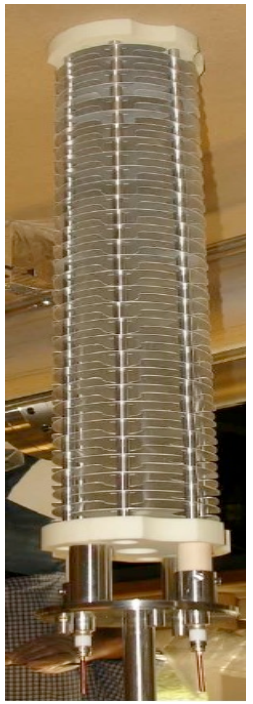
Design criteria and specification

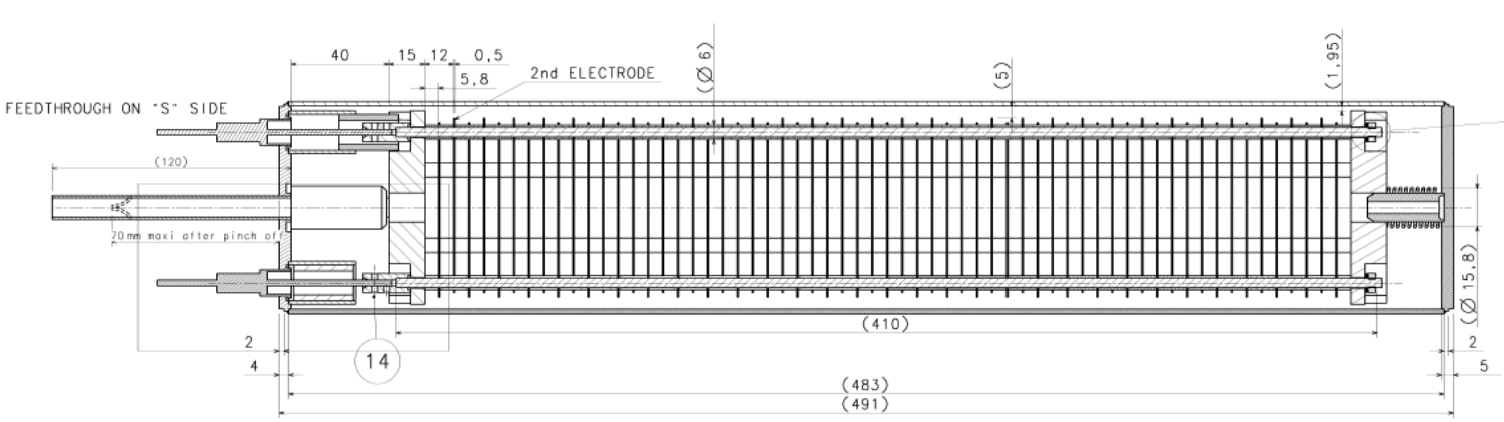
- The design of the LHC type beam loss monitors is based on the experience gained with the SPS BLMs, which have been in operation last 40 years.
- Signal speed and robustness against aging were the main design criteria.
- Ionization Chamber : parallel aluminum electrode plates separated 0.5 cm (for ESS 0.54).
- The detector is about 50 cm long (electrical and vacuum, active parts) with diameter of 9 cm, sensitive volume of 1.5 liter, insulated.
- Each monitor is permanently sealed inside a stainless-steel cylinder. The quality of the welding was a critical aspect during production.
- The chambers are filled with Nitrogen at 100 mbar overpressure.
- To avoid radiation aging (electronegative gases, organic compounds), up to 2.10^8 Gy in 20 years, production of the chambers followed strict UHV requirements and strict cleaning procedure.
- No gain variations are expected on the LHC BLMs for 20 years of operation.
- The chambers are operated at 1.5 kV and are equipped with low pass filter at the high voltage input.
- BLMs have been manufactured and tested at the Institute for the High Energy Physics (IHEP), Protvino, Russia, following their development at CERN.
- IHEP designed and built the UHV production stand.
- Due to the required dynamic range of 10^7,the leakage current of the monitors has to stay below 2 pA.
- Several tests during and after production were performed at IHEP and CERN. And high quality during the whole production period was achieved.

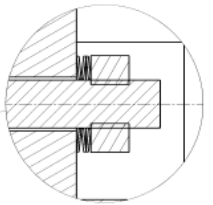
Detector description

- 61 circular parallel plate Al electrodes
- HV = 1500V
- 1.5 l N_2 gas (1.1 bar pressure)

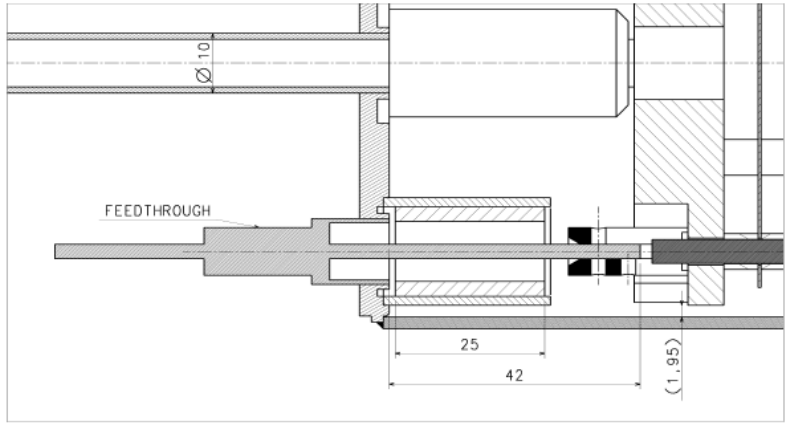
- Sensitivity: 5.26 x 10^{-5} C/Gy derived from
  - $\rho(N_2)$ = 1.2 kg/m^3
  - W = 34.8 MeV (avg energy for ionization)
- Dynamic range ($10^{7)}$ limited by:
  - Leakage current (1-2 pA)
  - Saturation effects (space charge)

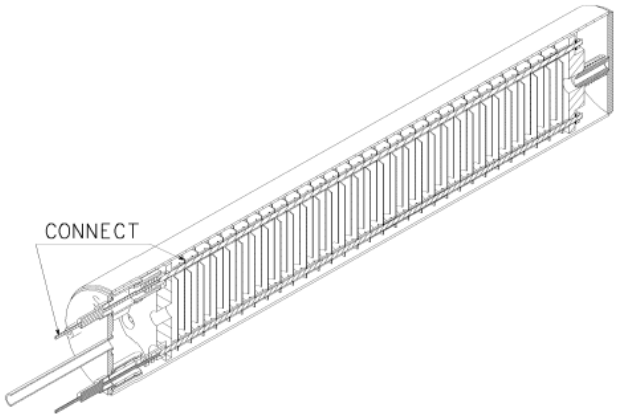


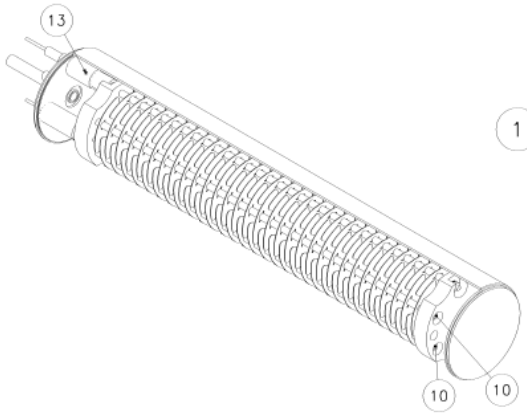


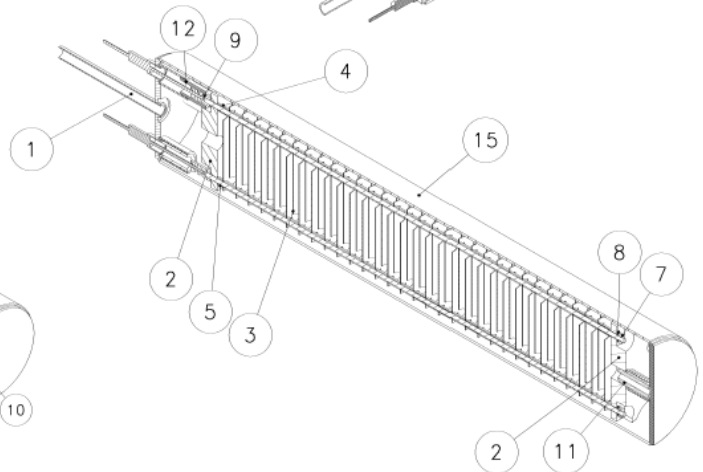


MOUNTING SEQUENCE
Tighten nut M4 (Item 7) to completely compress washers, then unscrew 1/4 turn









!!WARNING!!

CONNECT THE FEEDTHROUGH ON THE "S" SIDE WITH THE SECOND ELECTRODE

WELDING SPECIFICATIONS:
- THE WELDS MUST BE EXECUTED BY TIG WELDING
- WITHOUT FILLER MATERIAL
- UNDER ARGON SHIELDING
- WITH 100% PENETRATION

- LEAK TESTING REQUIREMENTS FOR ULTRA HIGH VACUUM COMPONENTS:
- CLEANING OF THE COMPONENTS BEFORE THE LEAK TEST: THE COMPONENT SHALL BE CLEANED IN ACCORDANCE WITH TECHNICAL NOTE 3DPS-ML TR-01.
- FOLLOWING PRESSURE TESTING AND FINAL CLEANING, THE COMPONENT SHALL BE LEAK TESTED AT ROOM TEMPERATURE WITH A SENSITIVITY < 10-10Pa.m3/s USING A CALIBRATED LEAK DETECTOR THE LEAK DETECTOR SHALL NOT SHOW ANY DEVIATION WHEN THE COMPONENT IS ENCLOSED IN A HELIUM FILLED ENVELOPE

Mass = 3.8 kg

1	MULTIPLE ELECTRODE BLM - EXTERNAL	15		LHCBLM...0040 TYPE A	
4	VIS S.T.6PC BT POINT.IN. 3X 3	14		Bossard BN618	
	VIS S.T.6PC BT POINT.IN. 3X 3				
2	Slotted screw M3x4	13	A2-ISO1580	Bossard BN652	
2	ALUMINA TUBE Ø 15/10	12	Al203	L=25mm	19.63.30
					128.9
1	COMPRESSION SPRING	11	1.4310	Ferroflex VD-180M-14	
4	TIGHTENERS M4 -	10		LHCBLM...0016 TYPEA-VARIANTE 1	
2	TIGHTENERS M4 -	9		LHCBLM...0016 TYPE B-VARIANTE 1	
18	SPRING WASHER Ø 8/4.2-0.2	8	1.4310	BOSSARD BN838	
6	LOCK NUT M4	7	A2	DIN 980V-BOSSARD BN5242	
1	BOTTOM COVER -	6		LHCBLM...0006-TYPE A	
6	ELECTRODE SPACERS -	5		LHCBLM...0007 TYPE C	
183	ELECTRODE SPACERS -	4		LHCBLM...0007-TYPE A	
61	ELECTRODE -	3		LHCBLM...0004 TYPE AI	
2	ALUMINE INSULATOR -	2		LHCBLM...0005	
1	COVER ASSEMBLY -	1		LHCBLM...0002-TYPE A	
PLANT	DESCRIPTION	POS	MAT.	OBSERVATIONS	REF.CERN
	ENS./ASS.			S.ENS./S.ASS.	

B	2015-11-16	G. FOFFANO	updated
A	2014-05-06	G. FOFFANO	updated (length part 15)

Beam Loss Monitor

MULTIPLE ELECTRODE BLM
WELDED VERSION ASSEMBLY

ECHELLE SCALE	1:1	
DES/DRA	G. FOFFANO	2014-05-06
CONTROLLED	R. PERRET	2021-12-06
RELEASED	E. HOLZER	2021-12-06
APPROVED	-	-

LHCBLM-...-0EA-M.05000.15007.0007200SPL
REMPLACE/REPLACES

RELEASED BY PROJECT ENGINEER | FOR SUPERVISION | TITRE | LHCBLM_0001 | SIZE A3 | SHEET

CERN: materials

Time of test					
Signal in pA					
N° disk					
N°1					
N°2					
N°3					
N°4					
N°5					
N°6	44	43	43	40	
N°7	485	381	322	268	
N°8	355	351	342	323	
3rd batch 2015					
Offset of picometer					
Signal in pA	-3.8	-0.5	-0.3		
HV = 1500 V					
N° disk					
N°2	7.8	7.3	6.0	4.2	3.2
N°3	14.0	9.2	6.3	4.2	2.6
N°4	10.7	7.6	5.5	3.7	2.8
27.01.2016, Vacuum lab (bat 112) , pict21&22					
3rd batch 2015					
HV = 1500 V					
Signal in pA					
N° disk					
N°1	2.8	2.4	2.0		
N°2	3.8	3.2	1.7		
N°3	1.0	1.7	1.3		
N°4	4.3	2.3	1.5		

Sub system	Company (2015)		
LHCBLM__0001 and LHCBLM__0009			
Material: tubes 1.4435 ss 88.9 x 2.0 x 6 mt	Nicormal(Germany)		
tube inox 316L 483x88.9x2.0 LHCBLM__0040, **IC**	Morfi (Greece)		
tube inox 316L 105x88.9x2 LHCBLM__0038	Morfi (Greece)		
AC, **IC**	Friatec (Germany)		
	Metalvin (Spain)		
BLM__0004 0.5X82,	ADM (France)	61	53200
007 type A	Ruprec(Portugal)		
007 type C	Ruprec(Portugal)		
0006	Morfi (Greece)		
__0006	Morfi (Greece)		
16			
her)	Morfi (Greece)		
0013)	Morfi (Greece)		
rroflex	Ferroflex (France)	1	872
n	Ceratec (Netherlands)		
electrical connections LHCBLM__0036			
external plate LHCBLM__0037, manufacture	Morfi (Greece)		
st steel sheet LHCBLM__0037, manufacture	NCP (Portugal)		
tube AlMgSi hard 4*7 L=60	Metallica (Swiss)		
in.steel.thr.rods A4 316 M4 L=85	Fournisseur EPI (France)		
BNC HT RRI Polystyrene SHV 5KV	Huber+Suhner (Swiss)	2	1743
BNC 50ohm, connecteur coaxial, femelle,RRI Polystyrene	Huber+Suhner (Swiss)	1	872
soldering lug, M4	CERN	1	872
soldering lug, BNC	CERN	1	872
wires (L=100, 1.5mm2)	CERN	0.15	130
tinned cupper wires, without insulation, D=0.91mm	CERN	0.1	10
Resistor 10Mohm ,1W	Etronics AG (Swiss)	1	900
Capacitor (0.47uF, 2000V)	WIMA(Germany)	1	900
shrinking tube	CERN	0.05	

High voltage 2000 V DC

Quantité 12 0 Pièces

TEST N° 1

Quantité = 120 pièces

Bonnes 42

Rebuts 78

TEST N° 2

Quantité = 78 pièces

Bonnes 13

Rebuts 65

TEST N° 3

Quantité = 65 pièces

Bonnes 42

Rebuts 23

RESULTAT FINAL

Bonnes 97 Pièces

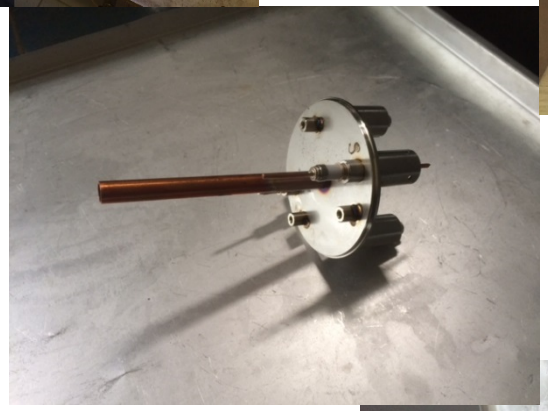
Rebuts 23 Pièces

	N	1100	1100
	N	50	50
	N	20	20
	N	4	4
Gant cuir souple/soudure	CERN	4	4
CERN shipping permission	Tom Wegelius (CERN+Swiss)		In progress
Protvino shipping permission	Expert - OK; new IHEP Director - change of doc		In progress
Gaine thermo jaune s halogenne	Srati (France)		OK

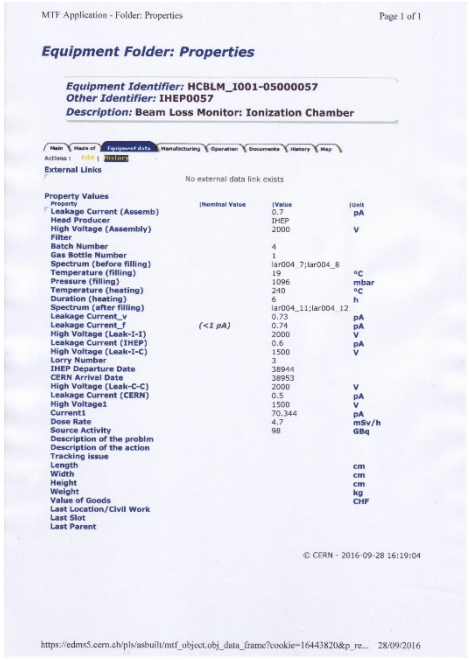
Protvino: vacuum stand

Heating of the chambers started after the pressure had reached 2 ·10−5 mbar. The temperature of the chambers was increased at a rate of 50 ◦C per hour and kept at 220 ◦C for 6 hours. Then, the heating was switched off and at about 100 ◦C and a pressure of 5 - 10·10−6 mbar the ion molecular pump was switched on and kept pumping during 20 hours to further reduce the pressure to a final value of 10−8 mbar before filling. Chambers were filled with 99.999% nitrogen at 1.1 bar at a temperature of 20 ◦C. After pinch-off (annealed Cu-tube) and removal of the chambers from the vacuum stand, the nitrogen is pumped from the stand during one hour (test of the tightness of all pinch-offs remaining on the stand). To control the purity of the nitrogen, the composition and residual gas pressure was measured. Analysis of the residual gas spectrum shows a typical spectrum for this type of vacuum stand and gives evidence of the absence of additional pollution from the nitrogen gas.

Protvino: Production



Protvino & CERN: database


MTF Application - Folder: Properties

Page 1 of 1

Equipment Folder: Properties

Equipment Identifier: HCBLM_I001-05000057
Other Identifier: IHEP0057
Description: Beam Loss Monitor: Ionization Chamber

External Links

No external data link exists

Property Values

Property	Nominal Value	Value	Unit
Leakage Current (Assemb)		0.7	pA
Head Producer		IHEP	
High Voltage (Assembly)		2000	V
Filter			
Batch Number		4	
Gas Bottle Number		1	
Spectrum (before filling)		lar004_7;lar004_8	
Temperature (filling)		19	°C
Pressure (filling)		1096	mbar
Temperature (heating)		240	°C
Duration (heating)		6	h
Spectrum (after filling)		lar004_11;lar004_12	
Leakage Current_v		0.73	pA
Leakage Current_f	(<1 pA)	0.74	pA
High Voltage (Leak-I-I)		2000	V
Leakage Current (IHEP)		0.6	pA
High Voltage (Leak-I-C)		1500	V
Lorry Number		3	
IHEP Departure Date		38944	
CERN Arrival Date		38953	
High Voltage (Leak-C-C)		2000	V
Leakage Current (CERN)		0.5	pA
High Voltage1		1500	V
Current1		70.344	pA
Dose Rate		4.7	mSv/h
Source Activity		98	GBq
Description of the problm			
Description of the action			
Tracking issue			
Length			cm
Width			cm
Height			cm
Weight			kg
Value of Goods			CHF
Last Location/Civil Work			
Last Slot			
Last Parent			

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MTF Application - Slot Folder: Main Info

Page 1 of 1

Slot Folder: Main Info

Slot Identifier: BLMQI.B6L5
Other Identifier: BLMQI.06L5.B1I30_MQML_XRP
Description: Beam Loss Monitor Type BLMQI

Slot main data

Type	BLM		
Status	Manufacturing		
Other Identifier	BLMQI.06L5.B1I30_MQML_XRP		
Parent slot			
Location	R532		
Slot details	Link to Layout DB		
MRC	B01		

Installation data

Item			
Equipment	HCBLM_I001-05000057	Dcum Start	13106.4706
		Dcum End	13106.4706

Navigation

Comments

Audit

Created on	2005-01-01	by	LHCHWCOM
Last modified on	2015-08-10	by	EDMS_MGR
EDMS owner	EDMSIMPORT	EDMS group	AB-BI-BLM-MTF

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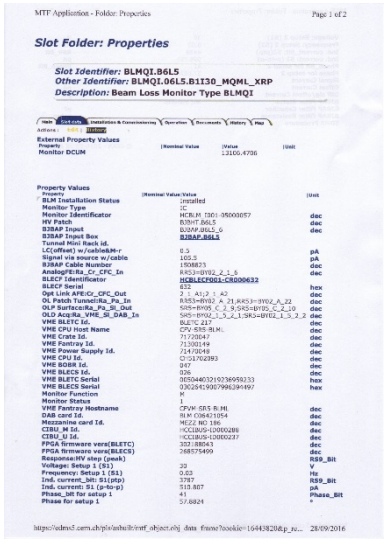
MTF Application - Folder: Properties

Page 1 of 2

Slot Folder: Properties

Slot Identifier: BLMQI.B6L5
Other Identifier: BLMQI.06L5.B1I30_MQML_XRP
Description: Beam Loss Monitor Type BLMQI

External Property Values

Property	Nominal Value	Value	Unit
Monitor DCUM		13106.4706	

Property Values

Property	Nominal Value	Value	Unit
BLM Installation Status		Installed	
Monitor Type		IC	
Monitor Identificator		HCBLM_I001-05000057	dec
HV Patch		B3HT.B6L5	dec
B3BAP Input		B3BAP.B6L5_G	dec
B3BAP Input Box		B3BAP.B6L5	
Tunnel Mini Rack id.			
LC(offset) w/cable&M-r		8.5	
Signal via source w/cable		105.5	pA
B3BAP Cable Number		1508823	dec
AnalogFE:Ba_Cr_CFC_In		RRS>BY02_2_1_6	dec
BLECP Identificator		HCBLECF001-CB000632	
BLECP Serial		632	hex
Opt Link APE:Cr_CFC_Out		2_1: A1;2_1: A2	dec
OL Patch Tunnel:Ra_Pa_In		RRS>BY02_A_21;RRS>BY02_A_22	dec
OLP Surface:Ra_Pa_SI_Out		SRS>BY05_C_2_9;SRS>BY05_C_2_10	dec
OLD Acq:Ra_VME_SI_DAB_In		SRS>BY02_1_5_2_1;SRS>BY02_1_5_2_2	dec
VME BLETC Id.		BLETC-217	dec
VME CPU Host Name		CPU-RSS-BLM-	dec
VME Crate Id.		7172067	dec
VME Fantray Id.		7130149	dec
VME Power Supply Id.		7147048	dec
VME CPU Id.		CH-5170293	dec
VME BOSR Id.		847	dec
VME BLECS Id.		025	dec
VME BLETC Serial		0E504403219238958233	hex
VME BLECS Serial		0302E419007996396497	hex
Monitor Function		M	
Monitor Status		1	
VME Fantray Hostname		CFVM-SBS-BLM1	dec
DAB card Id.		RAM C06421054	dec
Mezzanine card Id.		MEZZ MC 186	dec
CIBU_M Id.		HCCIBUS-I2000288	dec
CIBU_U Id.		HCCIBUS-I2000237	dec
FPGA firmware vers(BLETC)		3521180543	dec
FPGA firmware vers(BLECS)		268575499	dec
Response:HV step (peak)			RS9_Bit
Voltage: Setup 1 (S1)		39	V
Frequency: Setup 1 (S1)		0.03	Hz
Ind. current_bit: S1(ptp)		3787	RS9_Bit
Ind. current: S1 (p-to-p)		310.807	pA
Phase_bit for setup 1		41	Phase_Bit
Phase for setup 1		57.6824	°

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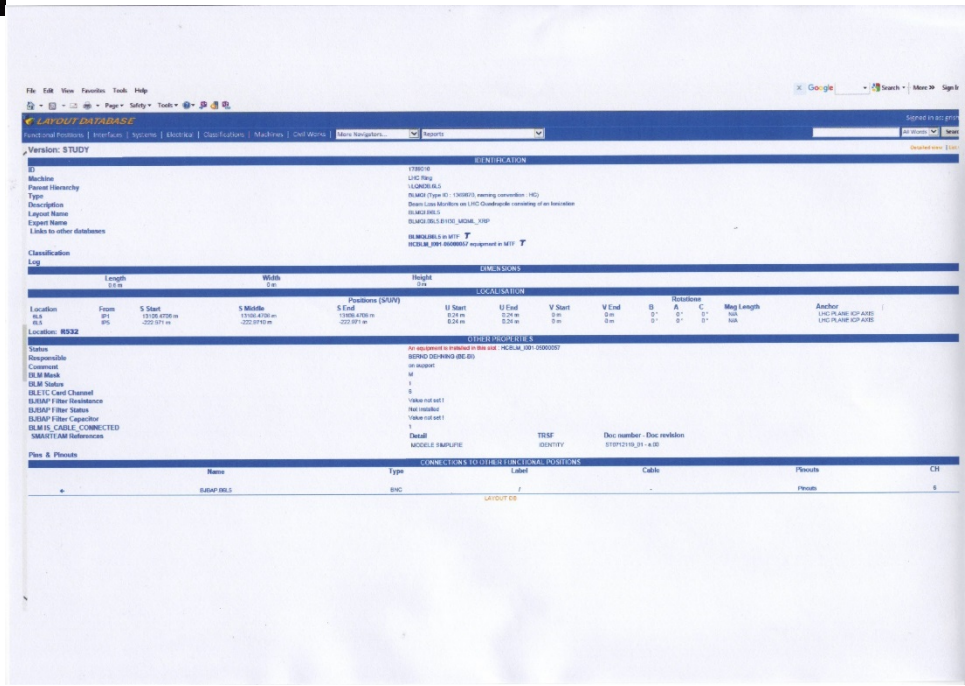

LAYOUT DATABASE

Version: STUDY

IDENTIFICATION

DIMENSIONS

LOCALISATION

Location: R532

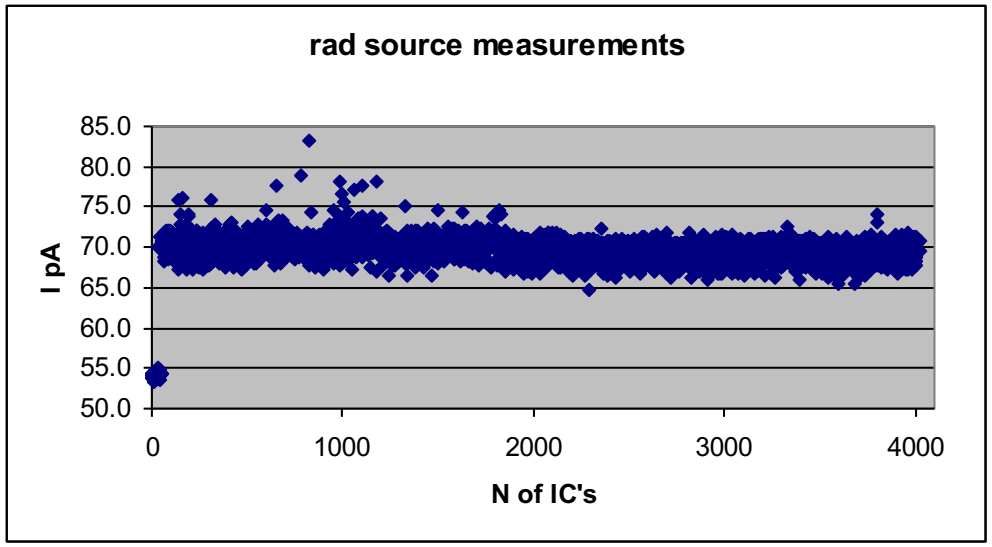
OTHER PROPERTIES

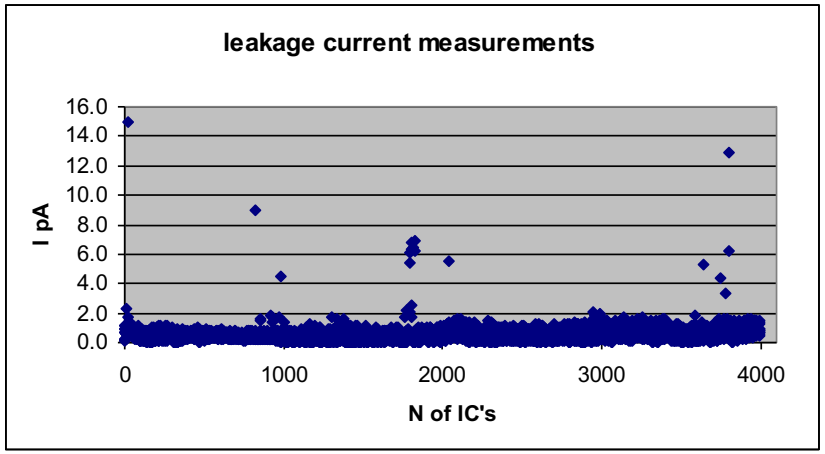
CONNECTIONS TO OTHER FUNCTIONAL POSITIONS

Acceptance test at CERN

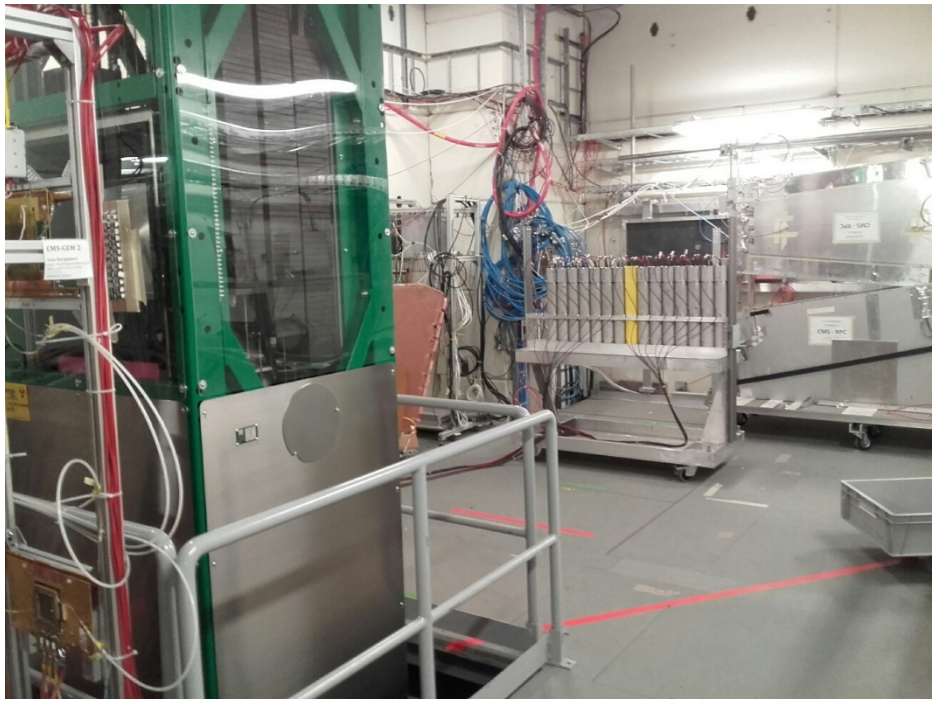
- After transport of the monitors to CERN by lorry, reception tests were performed at CERNs gamma irradiation facility (GIF in 2009 and GIF++ in 2017).
- For the IC they consisted of a) leakage current measurements and b) measurements of the signal induced by the radioactive source.
- For GIF the 15 monitors were placed in a special support at 1.4 m transverse to the flux of the radioactive source 137 Cs (98 GBq, 4.7 mSv/h), the geometry leading to a difference in flux of +/- 5% between the 15 monitors. T
- The measurements are recorded in the MTF equipment database. In 2019 out of 4259 IC arriving at CERN only 20 did not pass the reception tests.

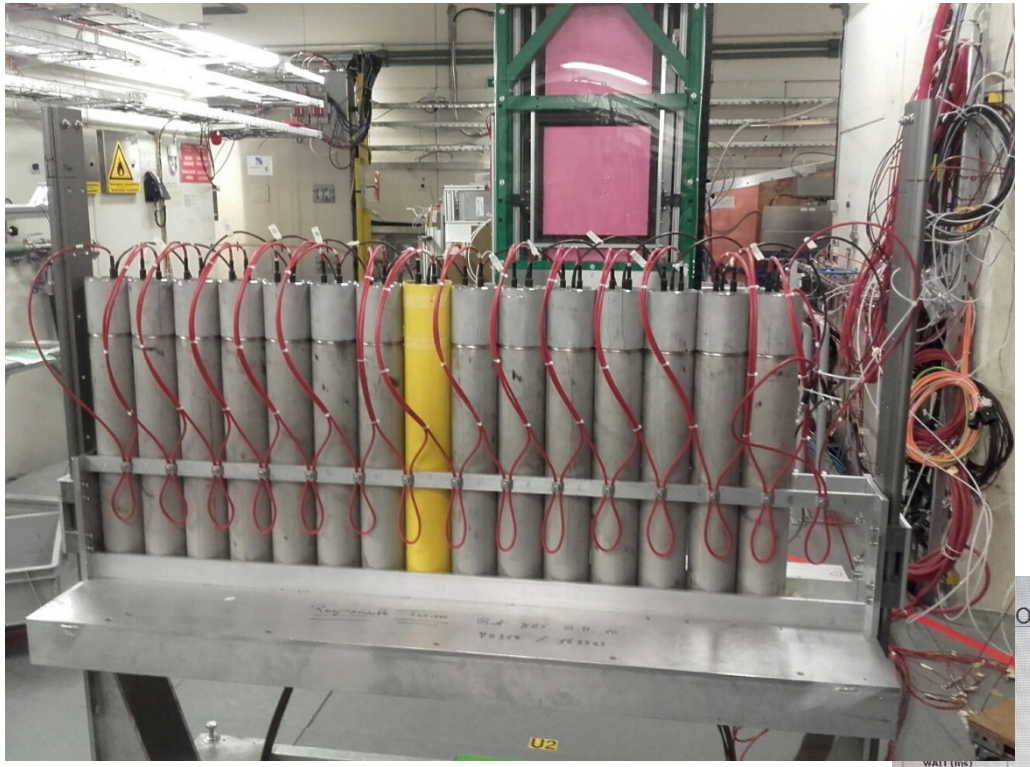
2009 test results

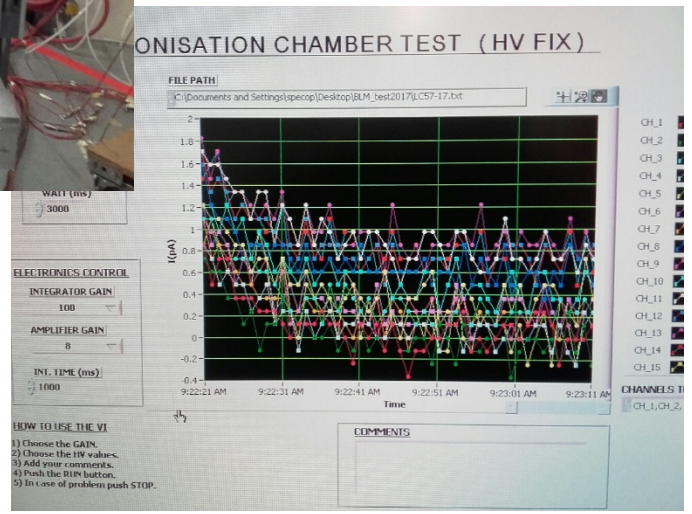


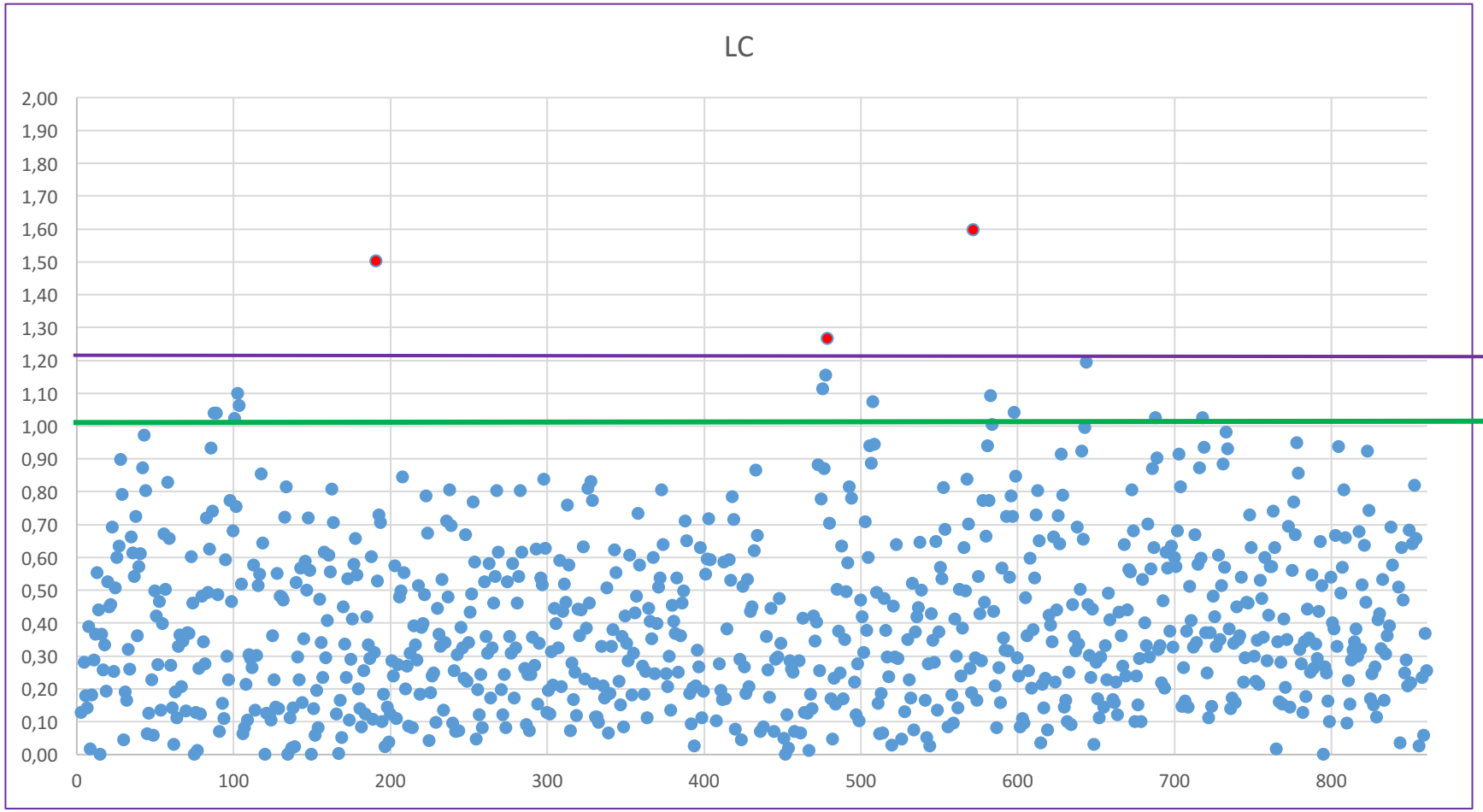


2017 GIF++ CERN acceptance test









830IC:

*8 ICs – well known assembly problems

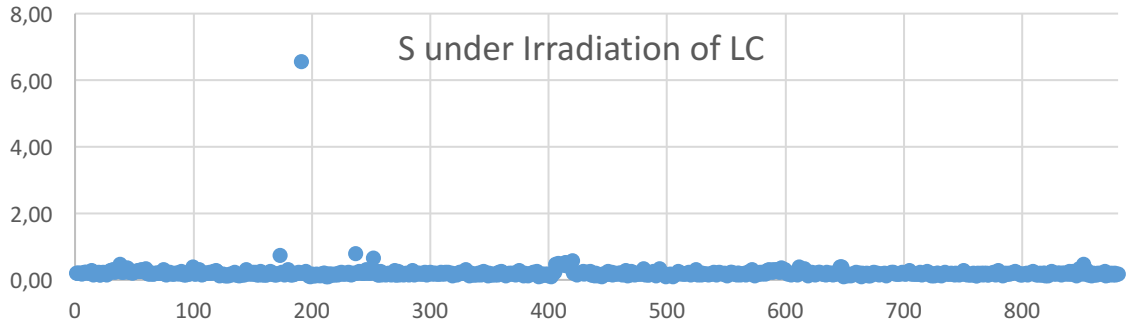
*822 ICs tested in 59 set-ups

*During all tests one “old” IC was at set up

3 ICs have big Leakage Current (it should be <1.0-1.2 pA)

799 ICs are accepted

+10 ICs will be checked and re-tested



CERN: Insulation and shipping

BLM at ESS

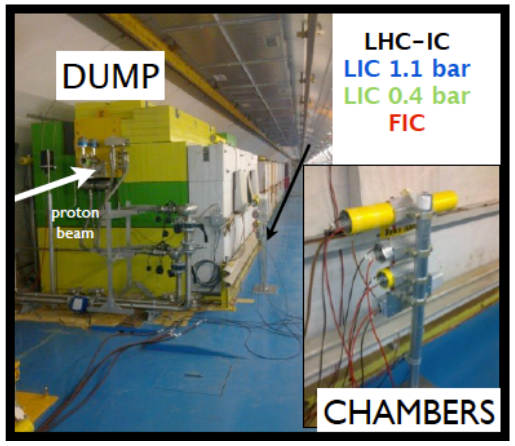
1. Arrival and visual inspection

2. Leakage current test

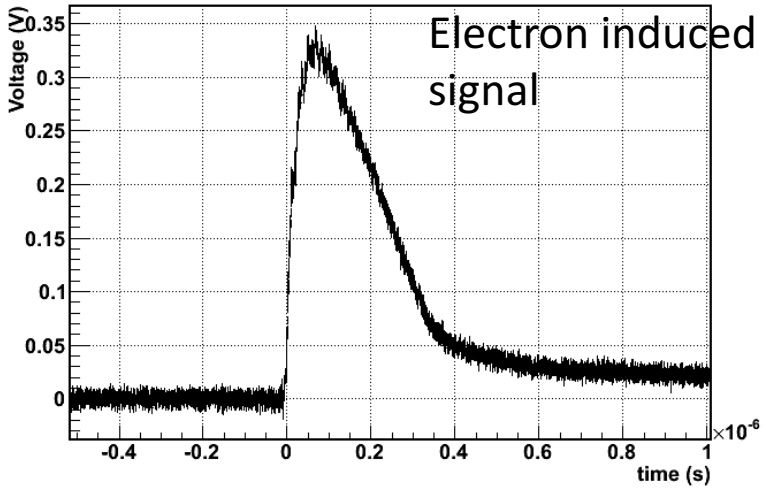
3. Radiation source calibration test

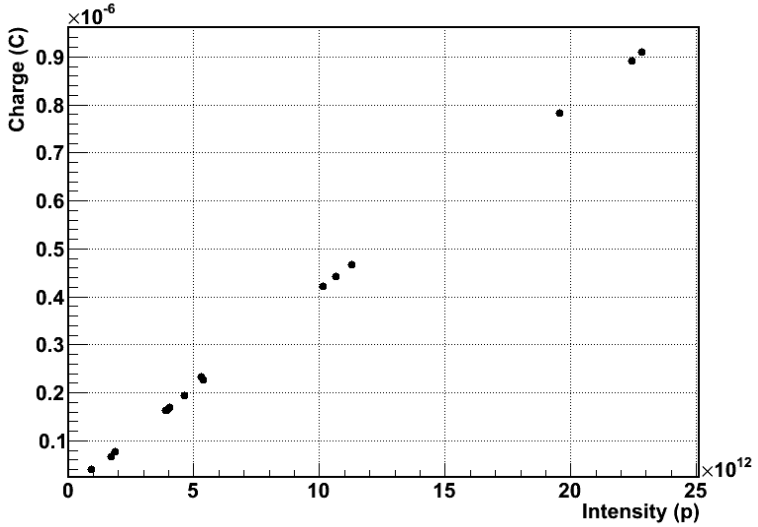
4. Radiation source test (before startup):
Placing a radioactive source (mobile irradiator) on the monitor and reading the induced signal by icBLM electronics, DB

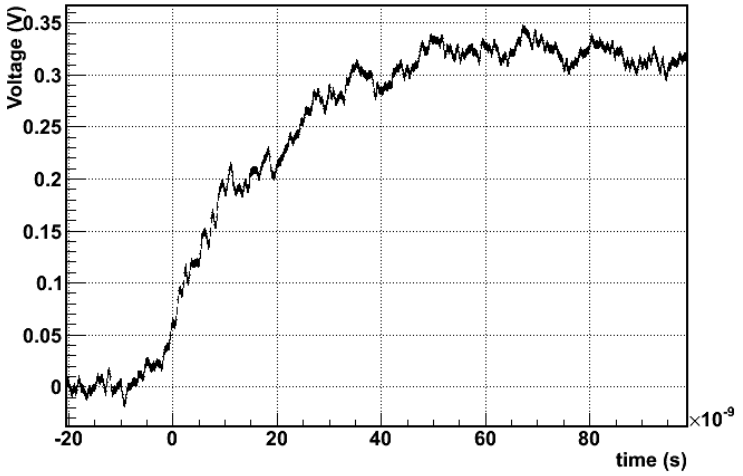
Detector performance at CERN



- Response to 1 ns pulsed (mixed radiation field. Protons onto dump)
- Raise time/FWHM ~40/200 ns
- Total (ion) charge collected in 300us
- Response linear with intensitv

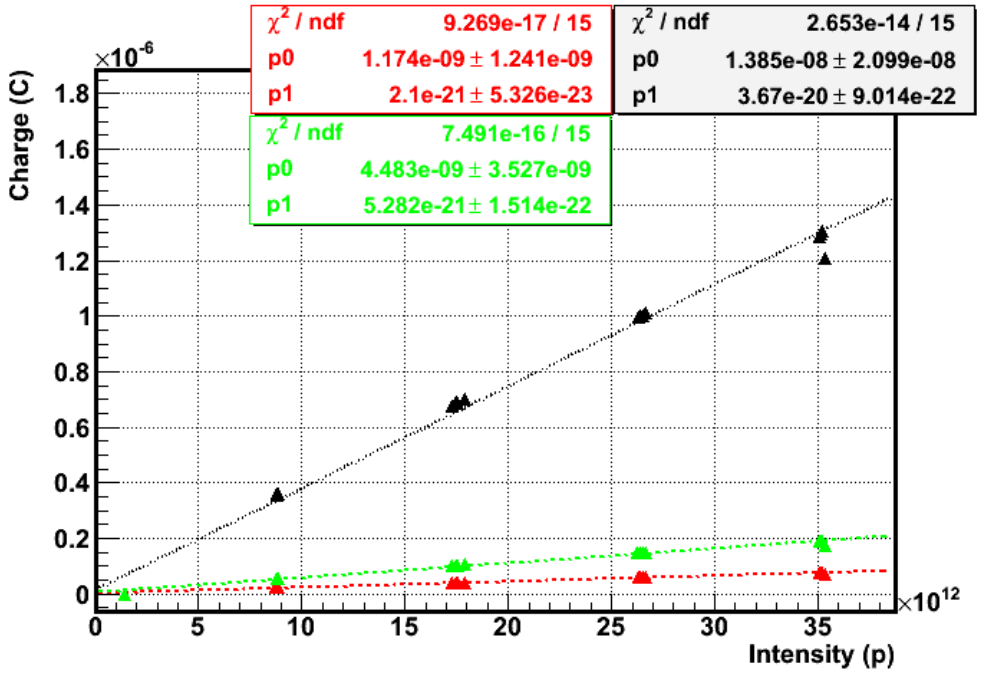


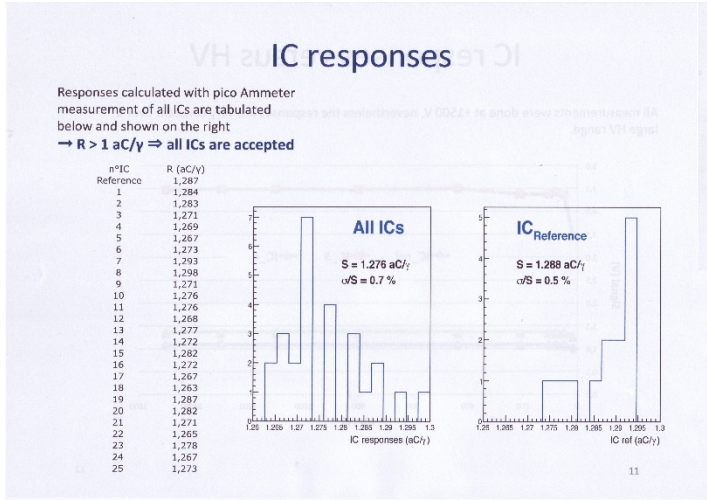


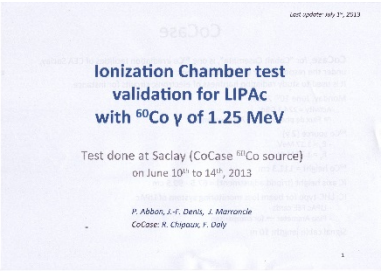


Ionization Chamber: CERN HRM and Saclay's test

plot of the integrated charge (over 40 us), Sep 2015 at HRM
black = IC, green = FIC, red =LIC



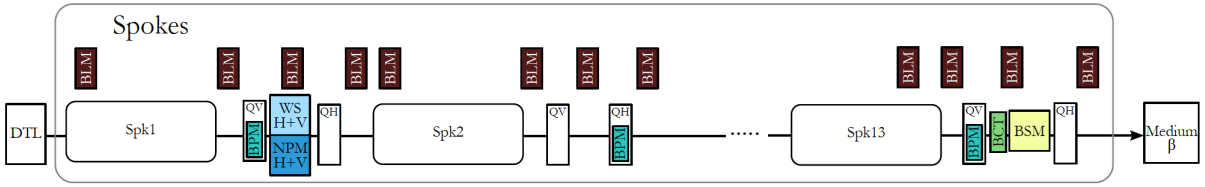




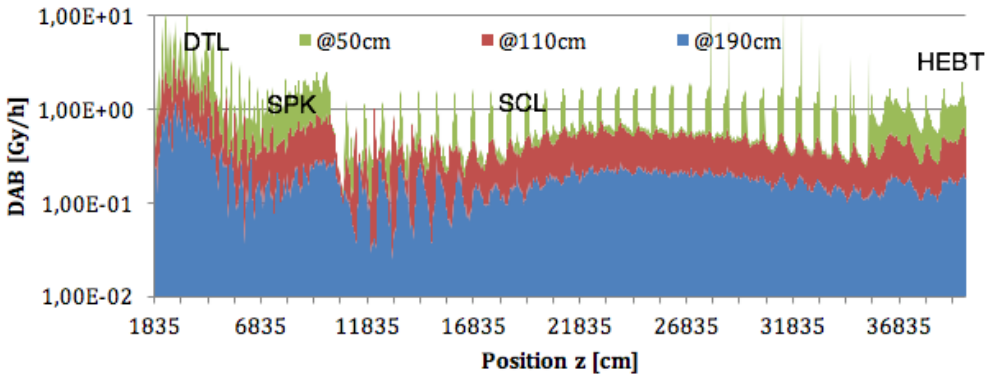
BLM at ESS linac

The number of ionization chambers deployed per LINAC section is summarized in the table

LINAC section	Number of ionization chambers	Comment
DTL	5	1 per Tank
Spokes	52	
Medium Beta	36	
High Beta	84	
HEBT	45	3 per q-pair
Dog leg	21	3 per q-pair
	2	1 per dipole
A2T	15	
Dump line	6	
Total	266	



icBLM detectors positions are chosen in accordance with maximum beam loss locations, and to minimize crosstalk. Because the ionization chambers are nearly point detectors, their location must be chosen to allow full coverage without blind spots.
For diagnostic use, the detector layout should also allow determination of the loss origin Operational and accidental losses are based on ESS-0044760:
“A guideline to operational and accidental absorbed dose rates in the ESS accelerator tunnel” by Lali Tchelidze.
Detectors will be installed outside cryostats and will have an option as mounting flexibility (mobile monitors).
Normal operational 1 W/m proton beam loss was considered.
This was derived from hands-on maintenance criteria for high intensity proton machines and was adopted at ESS as a maximum allowable operational beam loss.
The beam loss was simulated as a homogeneous uniform loss around and across the vacuum beam pipe, with a shallow angle.
Additionally, a full point beam loss was considered for 2 GeV on a vacuum beam pipe as an accidental beam loss.

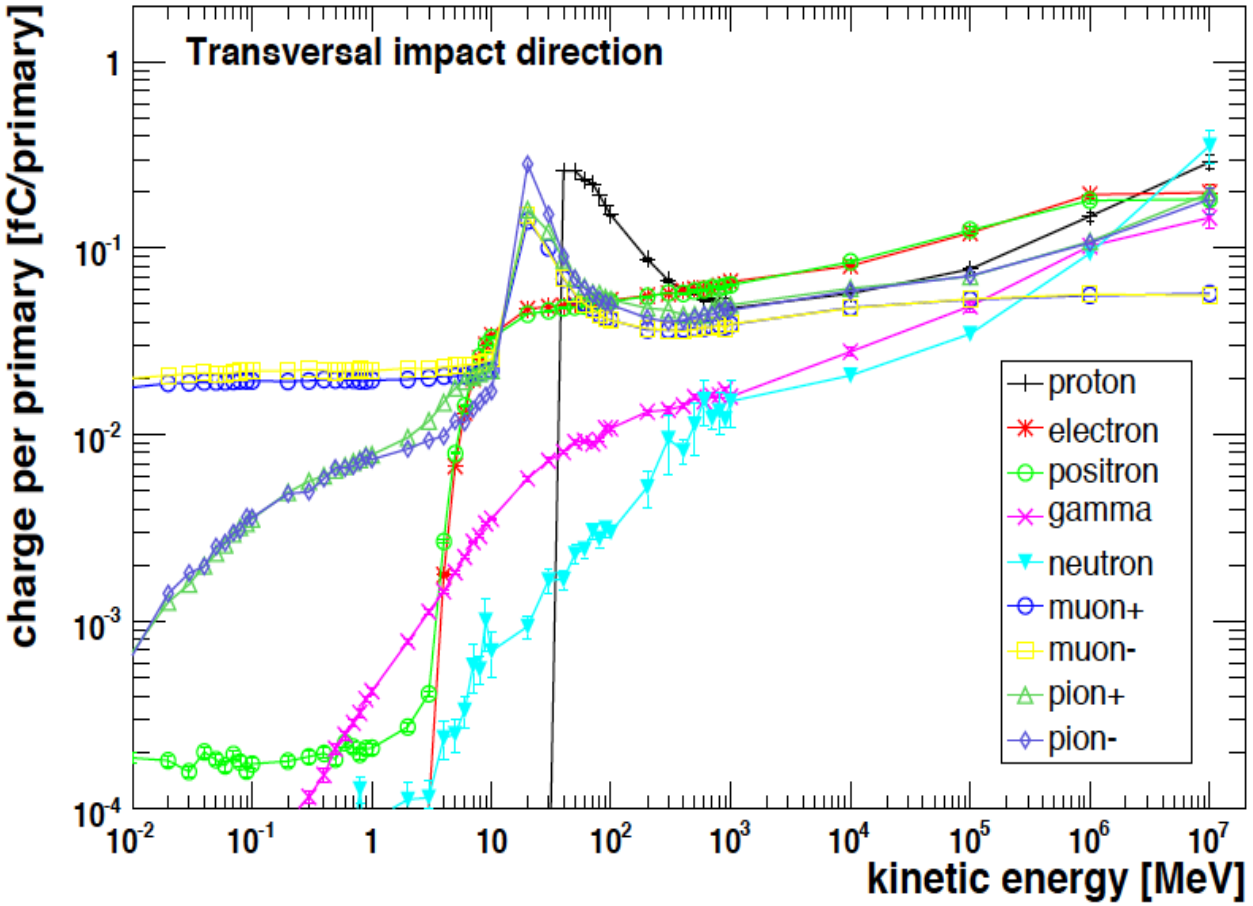


ESS SCL – icBLM

- Ionization chambers (ICs) developed for LCH BLM – primary BLMs in SCL
- Photon background due to the RF cavities must be taken into account when using ICs a linac
  - Bckg. mainly due to el. field emission from cavity walls, resulting in bremsstrahlung photons created on cavities/beam pipe materials.
  - Levels are difficult to predict numerically – they depend on the quality of cavities, operation conditions and time.
  - Energy spectra estimation: photons with energies up to tens of MeV can be expected.
  - Plan to asses this experimentally as well.
    - BLM tests in Uppsala (September 2017), Steve M.
    - Test in Saclay
    - Test in Los Alamos (November 2017)

- LHC IC sensitivity to photons:
  "cut off" at transversal photon and electron incidence ~2MeV (~30MeV for p and n)
- Background sampling and subtraction in the signal processing necessary.

ESS BLM



Name	Description
Leakage current	Less than 1-2 pA
Conversion factor	5.25 E-5 C/Gy
Energy Cut-off	*Protons, neutrons ~ 30 MeV *Electrons, photons ~ 2 MeV
Electron and Ion drift time	Electrons: 1/e fit of max is ~ 50 ns, all electrons collected is ~300ns Ions: 1/e fit of max is ~ 83 microsec, all ions collected is ~300 microsec
Dynamic range	Chamber's current is 10^7, in range ~50 pA to 0.5 mA