Results on the FCC-hh Beam Screen prototype at the Karlsruhe Research Accelerator

L.A. Gonzalez,[1, 2]
M. Gil Costa,[3, 2] P. Chiggiato,[2] V. Baglin,[2] C. Garion,[2] R.Kersevan,[2] S. Casalbuoni,[4] E. Huttel,[4] I. Bellafont[2,5] and F. Perez[5]

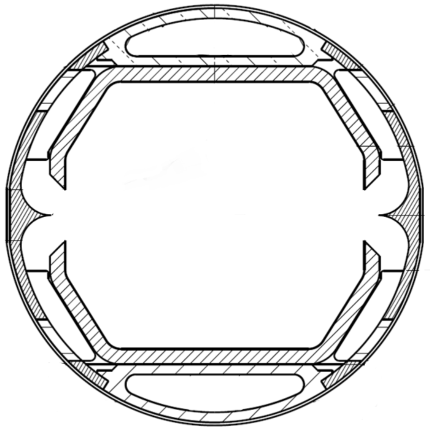
1 INFN Istituto Nazionale di Fisica Nucleare Laboratori Nazionali di Frascati

2 CERN

3 Ciemat

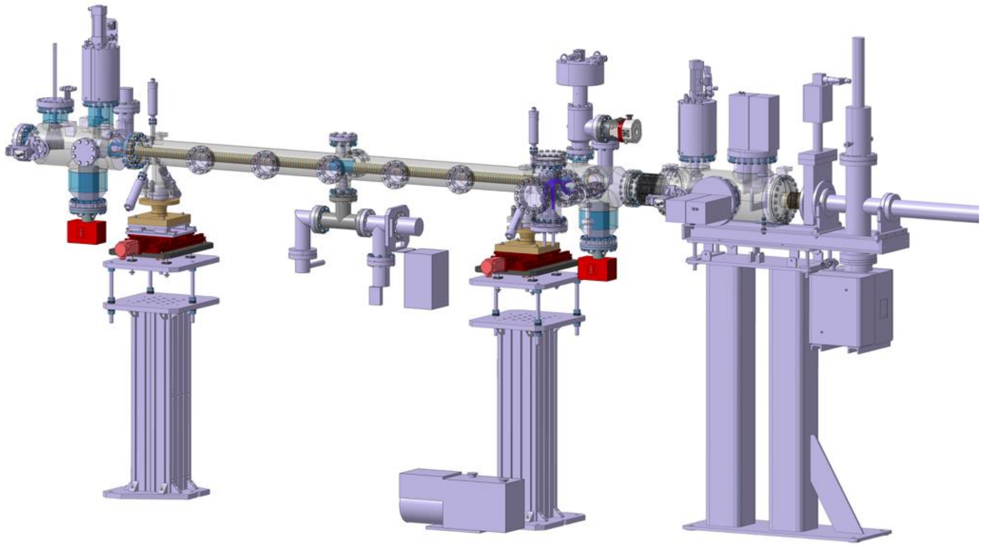
4 KIT Karlsruhe Institute of Technology

5 ALBA

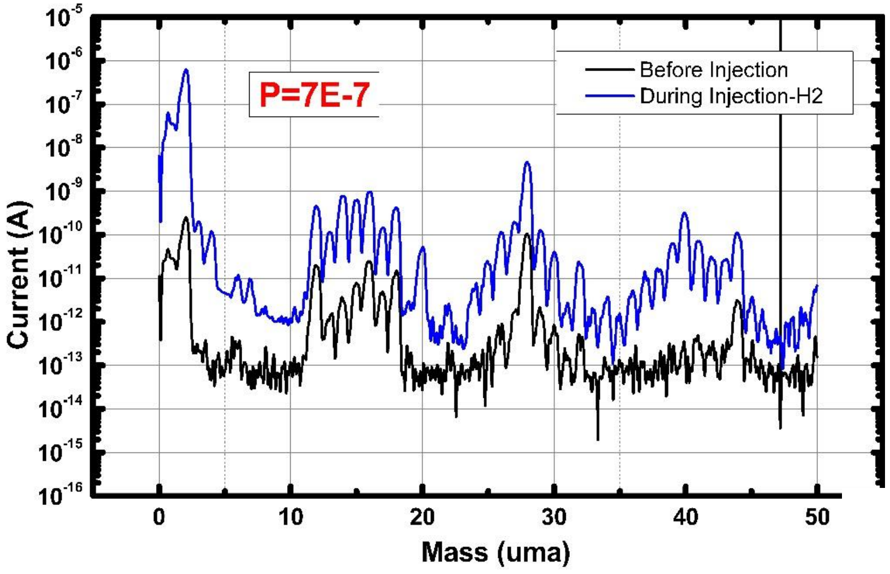


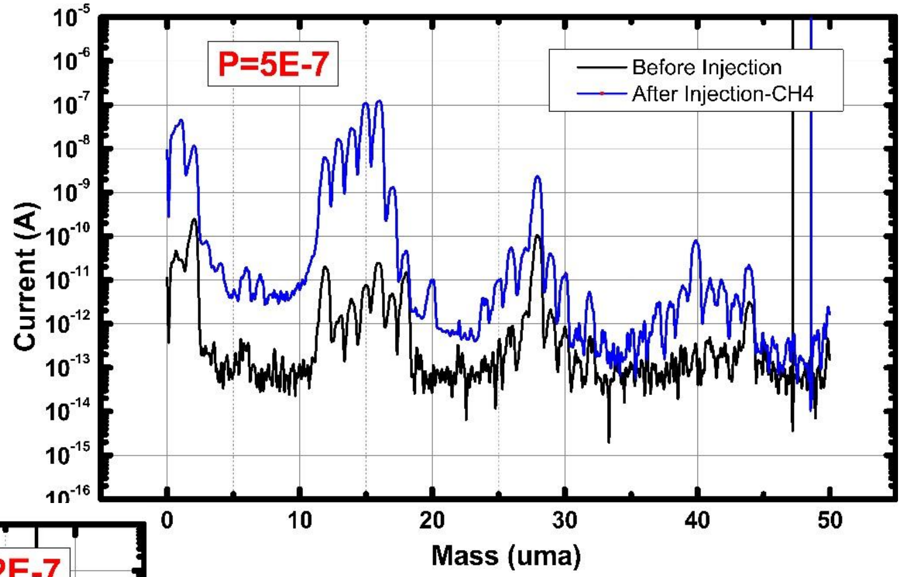
EuroCirCol
A key to New Physics

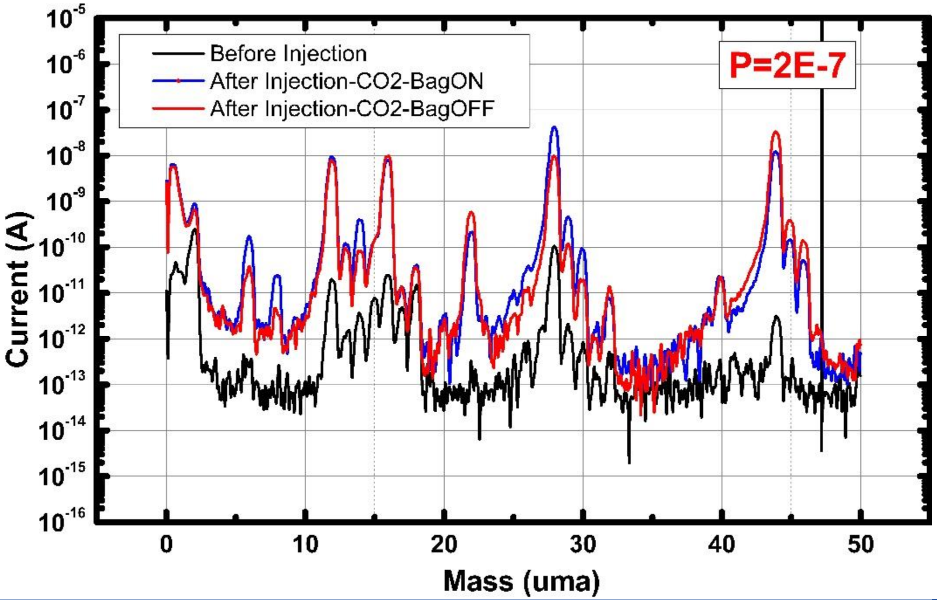
Task4.6: Measurements on cryogenic beam vacuum system prototype



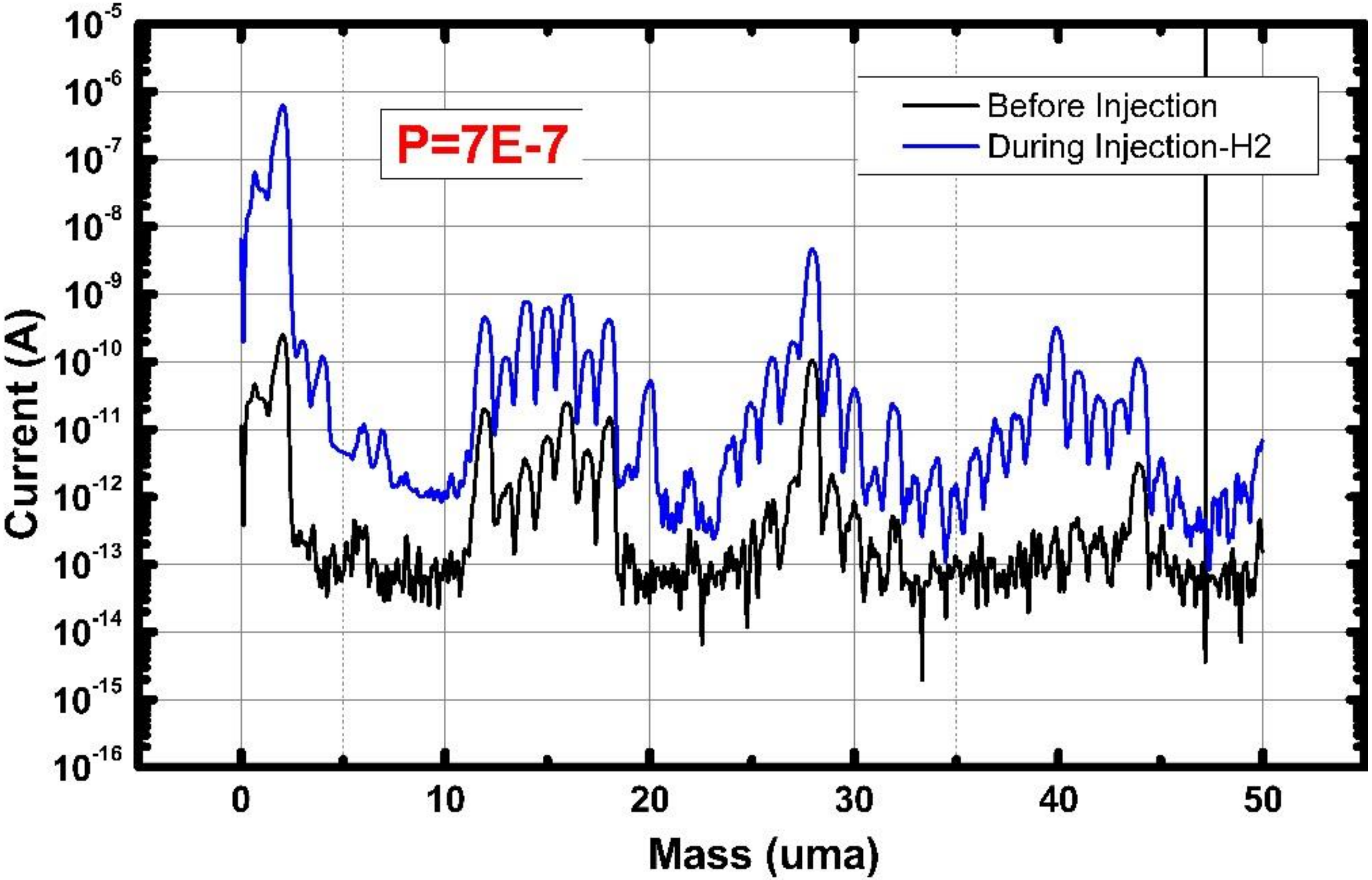
RGA CALIBRATION



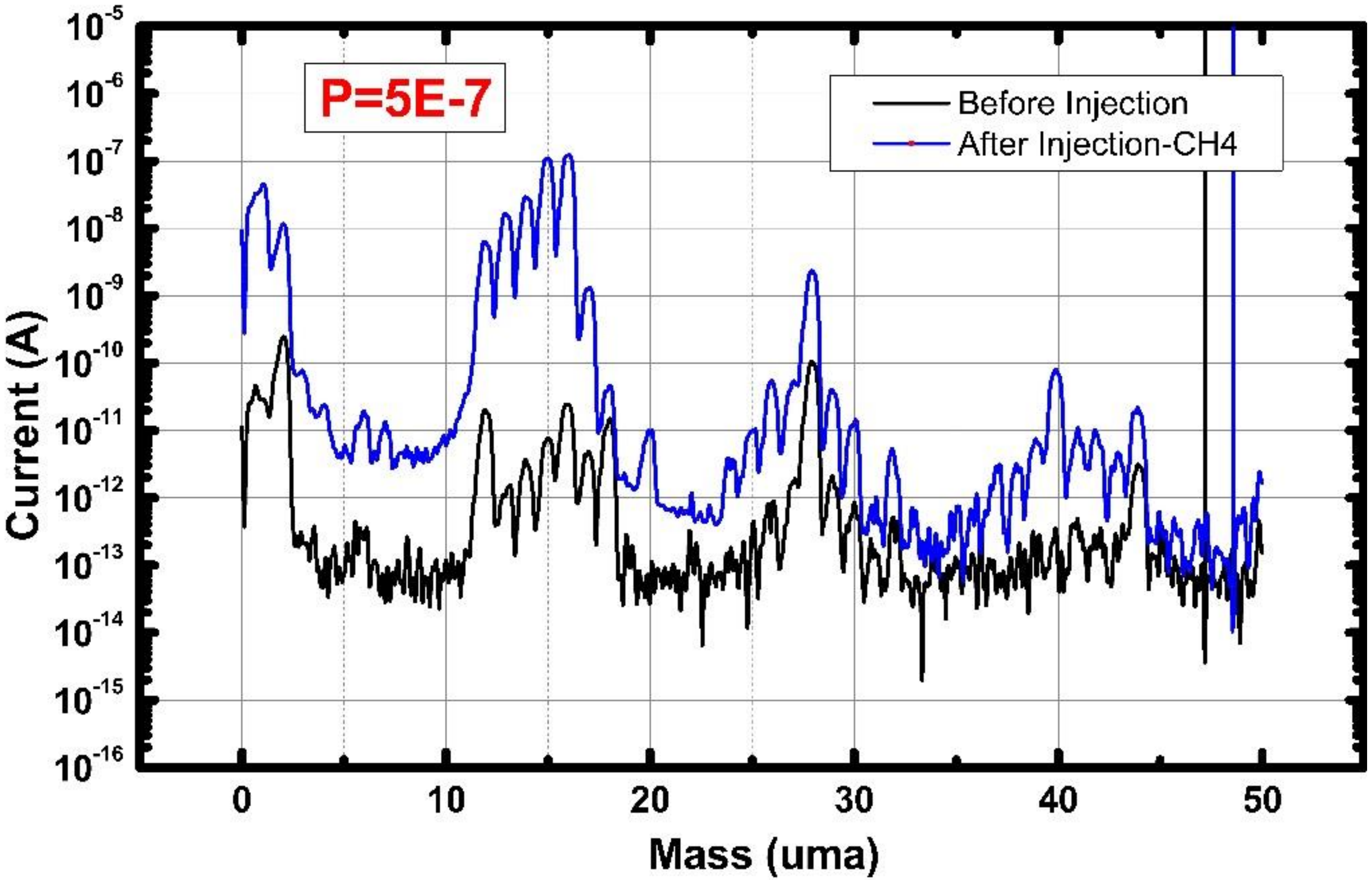




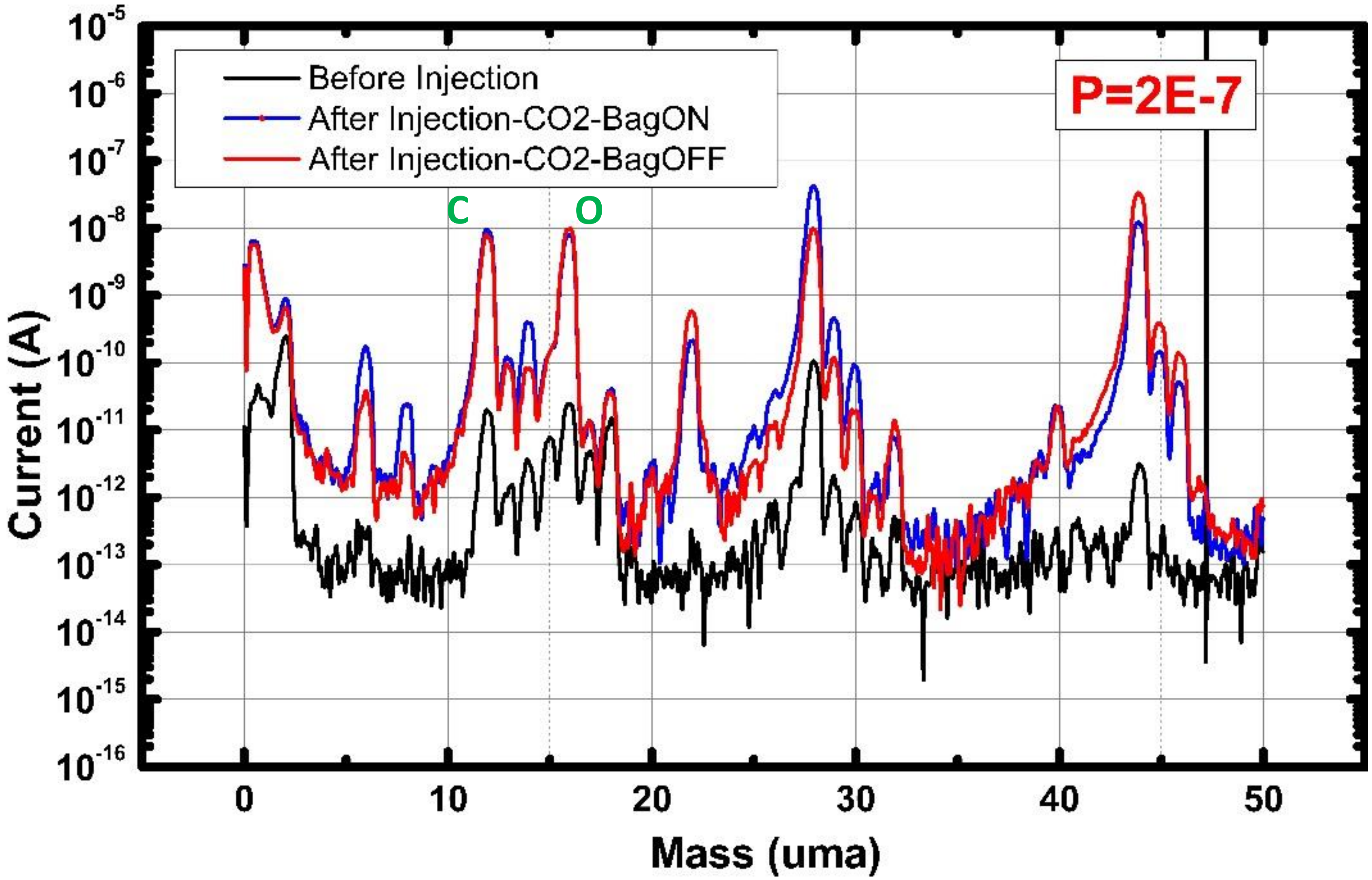
RGA CALIBRATION



RGA CALIBRATION



RGA CALIBRATION



IPAC Proceeding

RESULTS ON THE FCC-hh BEAM SCREEN AT THE KIT ELECTRON STORAGE RING KARA

L. A. Gonzalez*[1], LNF-INFN, [00044] Frascati (Rome), Italy
M. Gil-Costa[1], Ciemat, [280XX] Madrid, Spain
I.Bellafont[1], ALBA, [280XX] Barcelona, Spain
V. Baglin, CERN, [1211] Geneva, Switzerland
S. Casalbuoni, IBPT-KIT, [76131] Karlsruhe, Germany
P. Chiggiato, CERN, [1211] Geneva, Switzerland
C. Garion, CERN, [1211] Geneva, Switzerland
E. Huttel, IBPT-KIT, [76131] Karlsruhe, Germany
R, Kersevan, CERN, [1211] Geneva, Switzerland
F.Perez, ALBA, [280XX] Barcelona, Spain
[1]also at CERN, [1211] Geneva, Switzerland

Abstract

In the framework of the EuroCirCol collaboration* (work package 4 "Cryogenic Beam Vacuum System"), the fabrication of 3 FCC-hh beam-screen (BS) prototypes has been carried out with the aim of testing them at room temperature on the Karlsruhe Institute of Technology (KIT) 2.5 GeV electron storage ring KARA (KArlsruhe Research Accelerator) light source. The 3 BS prototypes will be tested on a beamline installed by the collaboration, named as BEam Screen TEstbench EXperiment (BESTEX). KARA has been chosen because its synchrotron radiation (SR) spectrum, photon flux and power, match the one foreseen for the 50+50 TeV FCC-hh proton collider. Each of the 3 BS prototypes, 2 m in length, implement a different design feature: 1) baseline design (BD), with electro-deposited copper and no electron-cloud (EC) mitigation features; 2) BD with set of distributed cold-sprayed anti-EC clearing electrodes; 3) BD with laser-ablated anti-EC surface texturing. We present here the results obtained so far at BESTEX and the comparison with extensive montecarlo simulations of the expected outgassing behavior under synchrotron radiation.

INTRODUCTION

The Future Circular hadron Collider (FCC-hh) is a proposed successor of the LHC which aims to provide hadron collision at a center of mass of 100TeV. Proton beams travelling through FCC-hh´s arcs would originate unprecedented levels of Synchrotron Radiation (SR). A comparison between the main SR related parameters of LHC and FCC-hh is shown in Table 1.As SR is known to be at the origin of many beam detrimental effects,* a novel shaped beam screen (BS) is being designed to minimize the SR related photo desorption, photoelectron electron generation and heat load effects at FCC-hh.

Table 1: Comparison between LHC and FCC-hh SR.

	LHC	FCChh	BESTEX
SR Power [W/m]	0.2	32	32
SR Flux* [ph/m/s]	$4.2\cdot10^{16}$	$1.5\cdot10^{17}$	$4.85\cdot10^{16}$
Critical E [eV]	44.2	$4.3\cdot10^{3}$	$4.3\cdot10^{3}$
Glancing Angle [mrad]		< 2	18

*Photon Energy above 4eV at nominal operation

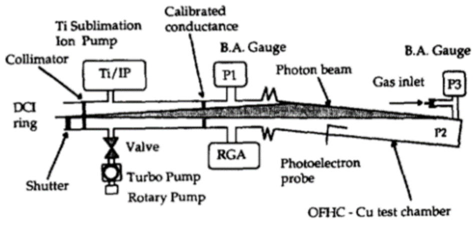
3 FCC-hh BS prototypes have been manufactured according to the current BS baseline designs (BD) and are being tested at the BEam Screen Testbench EXperiment (BESTEX) installed in the 2.5 GeV electron storage ring KARA (KArlsruhe Research Accelerator) light source at the Karlsruhe Institute of Technology (KIT). KARA has been chosen due to its similarities with FCC-hh in terms of SR spectrum, photon flux and power*. The experimental results obtained at BESTEX have been compared to intensive montecarlo calculations in order to to benchmark the validity of the simulations and improve the considerations taken into account.

EXPERIMENTAL DETAILS

Experimental Setup

BESTEX in an experimental instrument that allows to study SR induced effects on non-leak tight tubular samples under ultra high vacuum (UHV).

A schematic layout of BESTEX is presented in Fig. X. SR can be collimated both vertically and horizontally before impinging on the 2 m long test sample which can be pivoted about a vertical axis so as to be able to irradiate at any required glacing angle. To perform the experiments presented in this paper, the collimation aperture was chosen so that the sample is irradiated along 1.8 m of its inner inner wall,



depositing a total power density of 32W/m as it is foreseen at FCC-hh arcs. Under this constraints SR impinges the sample at a main glacing angle of 18mrad. Table X shows a comparison between the SR parameters at BESTEX and FCC-hh.

Calibrated vacuum Bayard Alpert Gauges (BAG) are strategically placed along the system upstream (*Back BAG*), downstream (*front BAG*) and in the middle point (*Middle BAG*) of the test bench. The latter, together with a calibrated residual gas analyzer (RGA), allow to measure photodesorption yields from the inner part of the sample under study by using a chimney connection as depicted in Fig. X.

A water-cooled photon absorber is placed at the back end of the setup. The absorber is equipped with an insulated electrode on which a positive voltage bias can be applied so as to collect the photo-electrons generated on the photon absorber itself.

Samples

Two main baseline designs (BD1 and BD2) have been developed for the FCC-hh BS as its properties have been under constant optimization. Briefly, both designs implement a main chamber (MC) and an antechamber (AC) separated by a slot aperture at the BSs ecuatorial plane, through which SR would pass. Placed in the AC, in order to cope with the SR Main chamber-antechamber-tip. More detailed description of these two designs can be found elsewhere*

The results presented in this paper correspond to 2 FCC-hh beam screen prototypes labeled as BS1 and BS2 and manufactured according to BD1. BS2 counts also with an anti-EC isolated clearing electrode, implemented by means of cold sprayed techniques*, at the primary chamber of the BS.

Before insertion into BESTEX, the samples were cleaned following standard UHV procedures. Then, after installation, bake out cycles of 24h at 150°C were performed, in order to remain within vacuum pressure limits required to operate at KARA.

The samples were irradiated in four geometrical configurations as shown in Fig X. Each configuration resembles a different scenario of FCC-hh operation i.e. normal operation (CFG1in Fig.X), ramp up during beam injection (CFG2 and CFG3 in Fig.X) and missaligment (CFG4 in Fig X). The samples were aligned with respect the KARAs e⁻ beam plane so as to irradiate the intended area with an accuracy of 100µm.

RESULTS

The log-log plots presented in Fig. X show the evolution of the pressure normalized to the KARA´s e⁻beam current as a function of the accumulated dose during irradiation of BS1 and BS2. For clarity reasons, only the results corresponding to *Middle BAG* are presented. At low photon doses, the normalized pressure during irradiation of BS2 is about 2 orders of magnitude higher than for BS1. This effect is ascribed to the presence of the clearing electrode in BS2, indicating that a large amount of photons are reflected back to the primary chamber after direct irradiation on the reflectors tip. As the photon dose increases, the normalized pressure decreases linearly with a slope of -0.5 and -0.9 for BS1 and BS2 respectively.

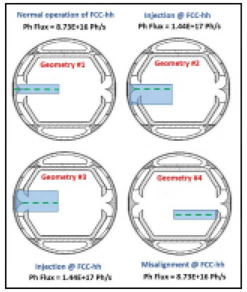


Figure 2: Configurations.

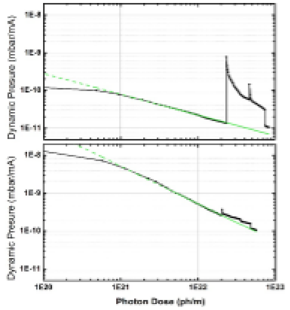


Figure 3: Dynamic pressures.

In the transition from CFG1 to CFG2, the photon flux is incremented in a X% irradiating areas which had not receive direct photons before. As a result, a pressure rise up to ~XX mbar/mA can be observed for both BS1 and BS2. As the photon dose increases at CFG2 the vacuum rapidly recovers to values in the range of 10^{-11} mbar/mA for BS1, while in the case of BS2 it remains above 10^{-10} mbar/mA. After irradiation in CFG3 the changes in the dynamic pressure are negligible for both samples indicating a pre conditioning of the newly irradiated region was performed during previous configurations.

Table 1: Margin Specifications

	3Ah		9.5 Ah	
	Exp	Cal	Exp	Calc
Middle (mbar)	5.7E-9	6.3E-9	3.0E-9	3.3E-9
Front (mbar)	2.9E-9	2.9E-9	2.0E-9	1.6E-9
Back (mbar)	2.0E-9	2.8E-9	1.0E-9	1.4E-9

Table X shows a comparison between experimental results and calculations performed on the pressure evolution of BESTEX at two different photon doses, namely 3Ah and 9 Ah

The experimental of the dynamic pressure at BESTEX obtained at BESTEX have been compared to intensive montecarlo calculations

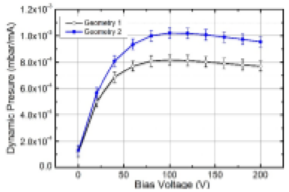


Figure 1: Results Clearing electrode

CONCLUSIONS

ACKNOWLEDGEMENTS

BIBLIOGRAPHY

Thank you