

MICA

MITIGATE INSTABILITIES IN CIRCULAR ACCELERATORS

R. CIMINO NATIONAL RESPONSIBLE

A PROJECT INVOLVING LNF, INFN-NA & INFN-RMI

MICA: MOTIVATIONS

INFN has a longstanding tradition and a series of well developed competences on issues related to various aspects of the ongoing global effort in accelerator technology aiming to the reduction of collective effects in Circular Accelerators.

- LNF, Na, and Romal are collaborating with CERN and in international contests on issues aiming to optimize the performance of most of the existing and future circular colliders:
 - ❑ **HiLumi LHC**, which is the major funded upgrade to increase LHC luminosity by a factor of 10 beyond its design value. The project is co-funded by the EU and implies significant upgrades not only for LHC but for all the machines in the injection chain (LIU project).
 - ❑ **FCC (Future Circular Collider)**: INFN and University of Roma I are participating to the global effort (lead by CERN) to study a post-LHC particle accelerator in a worldwide context. The project is co-funded by the EU and it is exploring the potential of hadron and lepton circular colliders, considering the technology R&D programs that would be required to build them.

MICA: GOALS

- Predict the behaviour of these future accelerators in terms of beam stability due to the increase of beam intensity that could lead to undesirable collective effects, triggered by self-induced em fields, which may play an important role in the machine performance.
- Put together several competences available at INFN to fully qualify materials to be compliant to operational parameters of such future accelerators.
- Create an INFN network able to completely perform theoretical and experimental studies on collective effects.

MICA – GROUPS AND PEOPLE (LNF - ROMA I - NAPOLI)

@ LNF: FTE = 4.65 + 2.5 = 7.15 for a total of 13 participants.

Who	Role	Position	%	Additional resources (%) EuroCirCol
Roberto Cimino	National and Local resp.	I° researcher LNF	50	50
Rosanna Larciprete		I° researcher CNR & associate @ LNF	100	
Marica Biagini		Dir thech. LNF	10	
Catia Milardi		I° researcher LNF and DAFNE Resp.	10	
Susanna Guiducci		Dir Ric. LNF	10	
Mikhail Zobov		Dir thech. LNF	20	
Andrea Ghigo		Dir Ric. LNF and head of LNF acc group	10	
David Alesini		I° researcher LNF	15	
Antonio DiTrollo		Researcher, CNR & associate @ LNF	100	
Alessandro Drago		I° Tech. researcher LNF	40	
Marco Angelucci		postDoc EuroCircol		100
Luis Gonzalez		postDoc EuroCircol		100
Eliana La Francesca		Dottoranda RMI	100	
		TOTAL FTE	4.65	2.5

MICA – GROUPS AND PEOPLE (LNF - ROMA I - NAPOLI)

- **Roma I:** M. Migliorati (local responsible) - (total of about 2 FTE). Main activity: Study and simulations of coupling impedances and wake fields. Beam measurements at CERN. Study of collective effects and instabilities for FCC-ee, LIU and HL-LHC.
- **Napoli:** M. R. Masullo (local responsible) - (total of about 2 FTE). Main activity: Coupling impedance measurements with telescopic method, study and e.m. characterization of metamaterials for HOM damping, Amorphous Carbon (a-C) and other coating @ high frequency (hundred of GHz to THz).

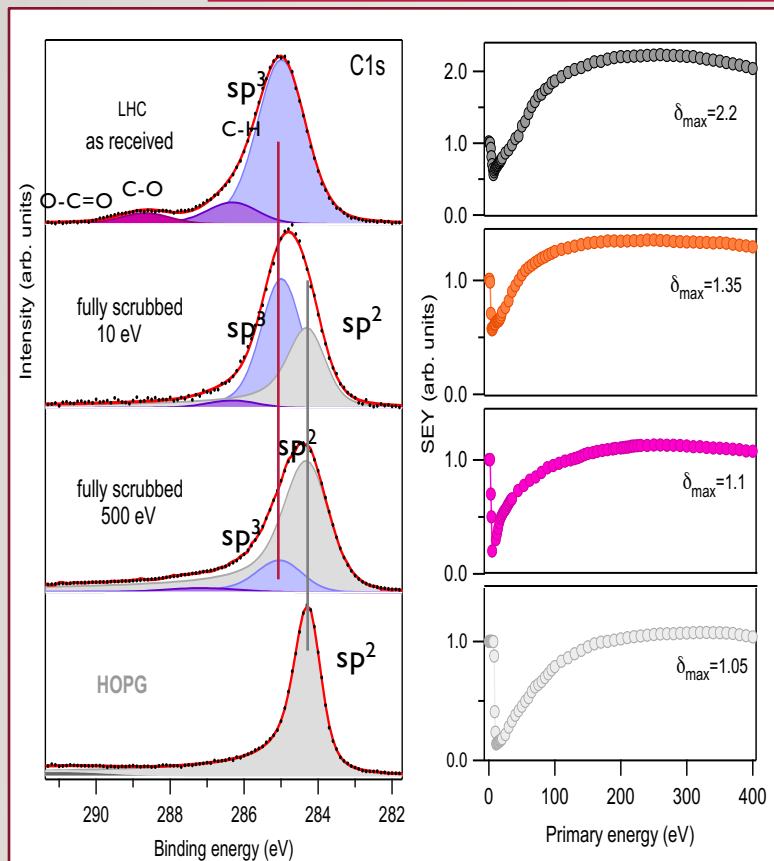
MICA IS ORGANIZED IN WP'S:

WP	TITLE	UNITS INVOLVED	RESPONSIBLE
WP1	Surface properties of Carbon and Cu Surfaces for HL-LHC	LNF-INFN CERN	R. Larciprete
WP2	Vacuum stability at FCC-hh	LNF-INFN CERN	R. Cimino
WP3	Synchrotron radiation material studies	LNF-INFN CERN	R. Cimino
WP4	Impedance simulations and beam dynamics studies	Rome I-INFN Na-INFN CERN	M. Migliorati
WP5	Impedance Study and measurements of materials in real condition	Na-INFN Salerno-INFN Rome I-INFN	M.R. Masullo
WP6	Feedbacks for FCC-ee	LNF-INFN CERN	A. Drago

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- The base line design of Hi Lumi – LHC propose to use amorphous Carbon (a-C) coatings held at temperature between 5 and 20 K to mitigate electron cloud issues.
- Cu surfaces in the standard LHC BS must be compatible with the higher luminosity.
- Cu and a-C films have to be validated at low temperatures and as a function of cryosorbed gas, ion, electron and photon bombardment.
- All surface properties (SEY, chemical modification by XPS, induced desorption, etc) needs to be studied at Low cryogenic Temperature and the XPS system needs a close cycle LT Manipulator.



The importance of XPS in the understanding of the scrubbing process has been demonstrated (IMCA project):

R Cimino, et al: *Phys. Rev. Lett.* **109** (2012) 064801.

R. Larciprete et al. *Phys. Rev. ST-AB*, **16** (2013) 011002.

D. R. Grosso, et al *Phys. Rev. ST-AB* **16**, 051003 (2013).

Rosanna Larciprete, et al *Applied Surface Science*, **328** (2015) p. 356.

The importance of LE-SEY in determining e-cloud issues has been demonstrated (also IMCA project):

R. Cimino et al: *Phys. Rev.Lett.* **93**, 014801 (2004).

R. Cimino, et al. *IEEE Transactions on Plasma Science*, vol.43, no.9, pp. 2954-2960, (2015).

R. Cimino et al. *Phys. Rev. ST-AB*, vol. **18**, pp. 051002-1, 051002 (2015).

- This WP will be symbiotic with LNF activity within EuroCirCol aiming to a better reach of the its tasks. (M Angelucci will work on this full time)
- Vacuum stability in the temperature range between 20 and 60 K, needs to be carefully studied for the various materials which are foreseen for FCC-hh.
- Temp. Programmed Desorbption (TPD) & XPS from small samples @LT.
- We need an optimized Mass spectrometer (and an LT manip. as for WP1) able to detect minimal amount of desorbed gasses from samples at LT during their fast warm-up or during Ion- el- (and eventually) photon- irradiation.
- We want to prove that SEY and LE-SEY can monitor adsorbate thermal stability versus temperature and versus irradiation.

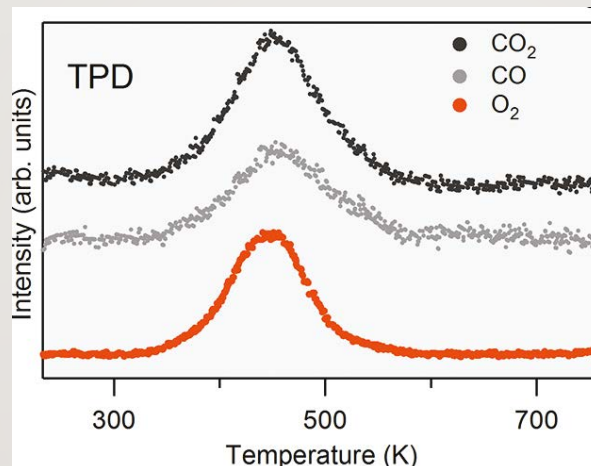
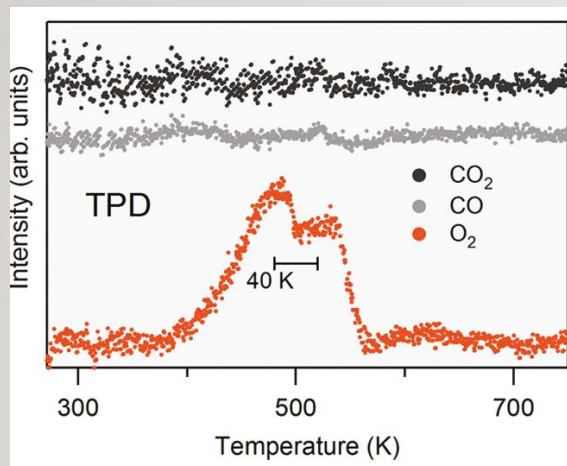
WP2

Vacuum stability at
FCC-hh

LNF-INFN
CERN

R. Cimino

O₂ on Graphene /Ir : $\theta = 0.03$ ML - $\theta = 0.25$ ML



The importance of TPD in desorption studies has been widely demonstrated:

A. Politano, ...R. Larciprete ACS Nano, 10 (2016) 4543-4549

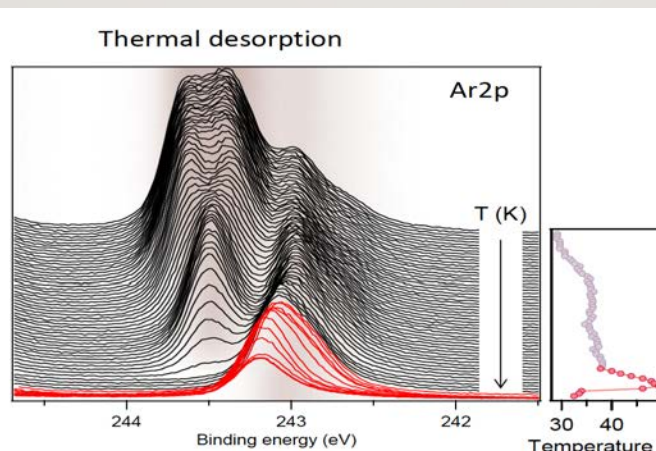
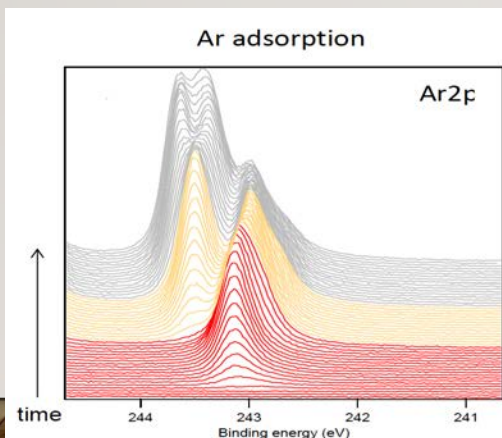
N.S. Faradzhev Chemical Physics Letters 415 (2005) 165-171

....

The importance of XPS in desorption study has been widely demonstrated:

R. Larciprete, et al J. Amer. Chem. Soc. 133 (2011) 17315-17321

....

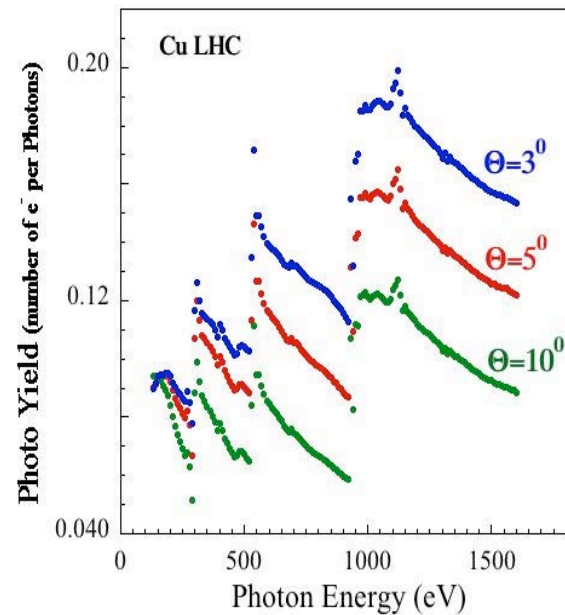
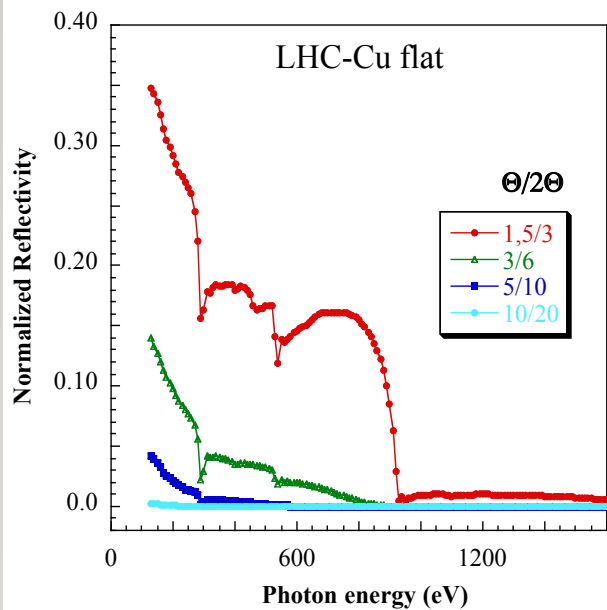


$p=6 \times 10^{-9}$ mbar
 $T=31$ K
4.15 L 15.6 min 0.26 L/min

Ar physisorption on GR/Ru(0001)

ti 04-7-2016

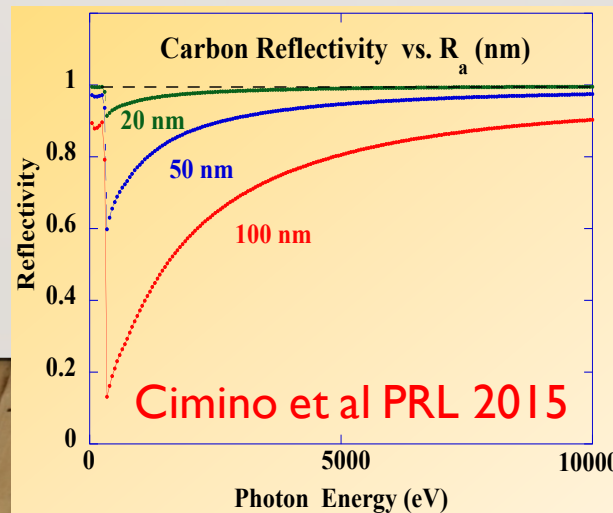
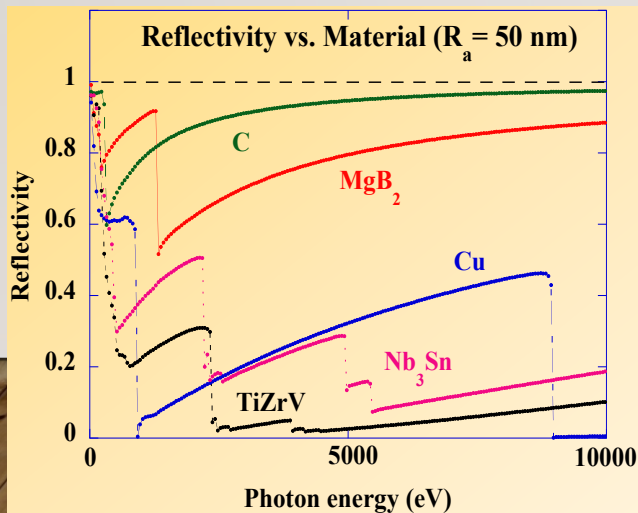
- All materials proposed and under study need validations in terms of their behavior under SR illumination with 3 different approaches:
1. At **ANKA** a set-up to study photo induced desorption will be installed and operated within EuroCirCol. (L. Gonzalez will work on this full time)
 2. At **Bessy2** we started a long term project to access SR the use of an 'ad hoc' developed at-wavelength reflectometry to measure **R and PY** which are essential ingredients to simulate collective effects in accelerators.
 3. Highly reflecting surfaces are proposed (PRL 2015) as a novel tool to deal with the very high SR induced heat load in FCC.



The importance of studying R and PY for instabilities issues has been demonstrated:

R. Cimino and Theo Demma: IJMPA (2014), 1430023

R. Cimino and F. Schäfers IPAC14
F. Dugan, et al: **Phys. Rev. ST-AB**, vol. 18, 040704, (2015).



The importance of Reflectivity to manage high SR heat load has been proposed:

R. Cimino, et al: **Phys. Rev. Lett.** 115, 264804 (2015).

WP4

**Impedance simulations
and beam dynamics
studies**

**Rome I-INFN
Na-INFN
CERN**

M. Migliorati

Main activity: Study and simulations of coupling impedances and wake fields. Beam measurements at CERN. Study of collective effects and instabilities for FCC-ee, LIU and HL-LHC.

See:

N. Biancacci, V. G. Vaccaro, E. Métral, B. Salvant, M. Migliorati, and L. Palumbo, “Impedance studies of 2D azimuthally symmetric devices of finite length”, **Phys. Rev. ST-AB**, 17, 021001 (2014).

M. Migliorati, L. Palumbo, “Multibunch and multiparticle simulation code with an alternative approach to wakefield effects”, **Phys. Rev. ST-AB**, 18, 031001 (2015).

N. Biancacci, V. G. Vaccaro, E. Métral, B. Salvant, M. Migliorati, and L. Palumbo “Impedance studies of 2D azimuthally symmetric devices of finite length” **Phys. Rev. ST-AB** 17, 049901 (2014).

M Migliorati is PI of a PRIN in collaboration with LNF and CNR which is partially overlapping with MICA activity.

WP5

**Impedance Study and
measurements of materials in
real condition**

**Na-INFN
Salerno-INFN
Rome I-INFN
CERN**

M.R. Masullo

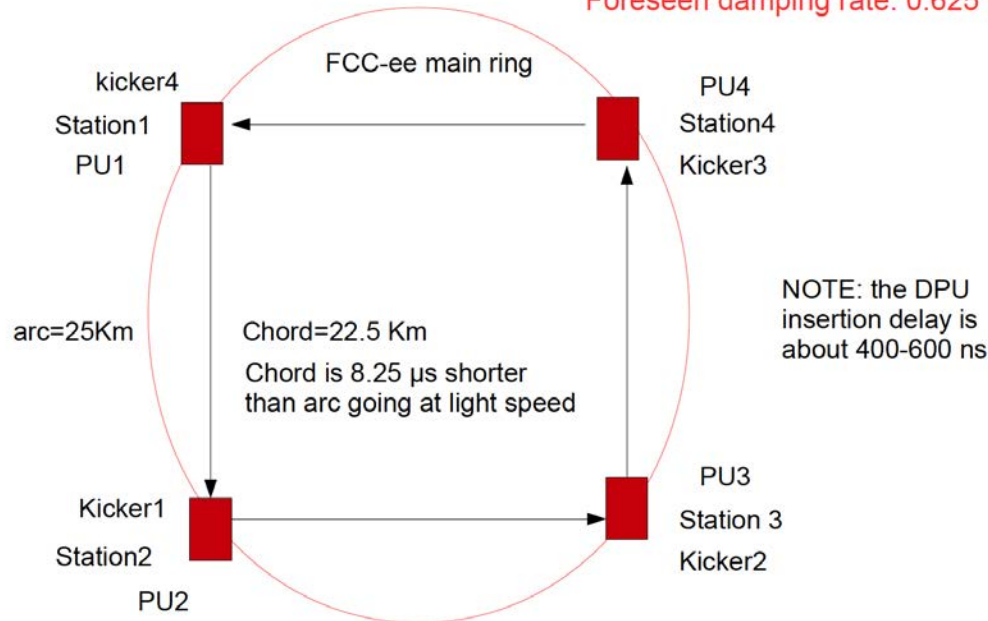
Main activity: Coupling impedance measurements with telescopic method, study and e.m. characterization of metamaterials for HOM damping, Amorphous Carbon (a-C) and other coating @ high frequency (hundred of GHz to THz).

See: A.D'Elia, M. R. Masullo and V. G. Vaccaro "High-accuracy measurements on biperiodical circuits", **Measurement Science and Technology**, 29, 9 (2015)

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- Goal of this work-package is to carry on R&D activities and evaluations on the bunch-by-bunch feedback systems mainly for the FCC-ee project.
 - The most critical and interesting point of this proposal is to consider the feasibility of a feedforward scheme versus the usual feedback approach. The feedforward scheme will give many advantages in terms of faster damping rates and smaller number of systems. At the same time this innovative approach asks for stronger technological R&D activities before the implementation.
 - A second, very important point is to evaluate how much power and how many systems are necessary for each feedback in base at the beam dynamics group simulations.

4 Feedforward systems (4 stations)

Foreseen damping rate: 0.625 turns



The importance of studying fast feedbacks for FCC – ee has been demonstrated:

A. Drago:invited talk at the FCC-week in April 2016, Rome.

<http://indico.cern.ch/event/438866/sessions/96520/#20160413>

A. Drago Physical Review Accelerators and Beams (PRAB); in preparation

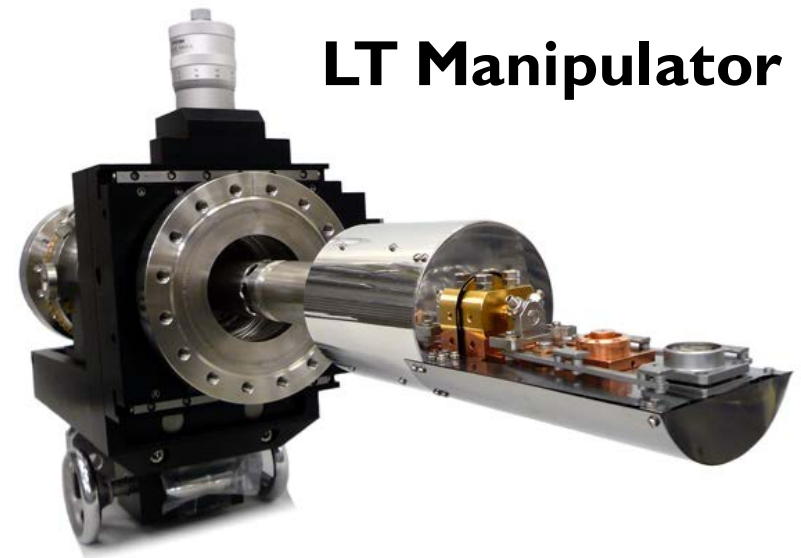
MICA @ LNF:

Requests to Comm.V (2017)

WP1 and WP2: Apparata & consumable & Mobility
Upgrade of the existing set up with a **LT Manipulator** and an optimised **Quadrupole**:

WP3: Consumable & Mobility
❖ To machine tests samples and perform experiments in EU.

WP6: Mobility
❖ To take part to relevant meetings on Feedbacks systems.



LT Manipulator

**High sensitivity
Quadrupole Mass
spectrometer**

MICA @ LNF:

Requests to LNF (2017)

- 1 mu mechanical workshop
- Support from “Servizio Fluidi” to improve water cooling system.
- Standard technical support from the DAΦNE-L Service team: as already foreseen for EuroCirCol approved project.
(A. Grilli, A. Raco, V. Tullio, V. Sciarra, M. Pietropaoli and G. Viviani)
- DAΦNE-L technical and scientific support to investigate potentialities to use SR at DAΦNE for such studies.