Summary of Technological and Inter-disciplinary research (CSN5) at LNF

S. Dell'Agnello
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Frascati, November 20, 2012

Outline

- Intro (brief, 1 slide)
- CSN5-LNF manpower and funding for 2013
- Summary of selection of experiments
  - More details (and if required more experiments) in later closed session w/referees

2013 News and budget

INFN LNF CSN5

- Merge with CSN5 experiments with NTA
- Emphasis on external funds continues
  - 4th visit by President at Sep. meeting
- Budget 2013 = CSN5 + NTA + INFN-Med ~ 5 M€
- CSN5 'EU-style' Calls under discussion
- New CSN5 'PRIN-style' call ~ready for 2013
  - Extra funds by GE

CSN5-LNF manpower for 2013

INFN LNF CSN5

66.7 FTE
out of

SEZIONE	NOME COGNOME	TIPO	CONTRATTO	QUALIFICA	RICERCATORI	TECNOLOGI	TOT. PERS.	FTE
!CHAOS					1	2	3	1.0
3L-2D					2	2	4	1.3
BEAM4FUSION					2	2	4	1.7
ETRUSCO-GMES					10	7	17	13.3
I-FCX					4	2	6	1.4
MANESCO					8	1	9	4.0
NESCOFI@BTF					2	5	7	3.0
NEXTARCH					6	2	8	1.8
NORCIA					7	3	10	4.0
NTA-ELI					2	7	9	1.3
NTA-EUROFEL					2	3	5	0.9
NTA-ILC						1	1	0.1
NTA-IMCA					12	1	13	7.2
NTA-LC					3	6	9	1.8
NTA-PLASMONX						2	2	0.5
NTA-SL-COMB					5	9	14	3.1
NTA-SL-EXIN					3	7	10	2.1
NTA-SL-G-RESIST					3	1	4	1.1
NTA-SL-POSSO					4	1	5	2.5
NTA-SL-THOMSON					4	7	11	2.3
NTA-SUPERB					6	9	15	4.3
ODRI2D					1	2	3	1.1
RDH					4	2	6	1.2
SLEAR					6		6	3.5
SL_FEMTOTERA					5	1	6	1.6
SPACEWEATHER					1	3	4	0.6

LNF funding for 2013

INFN LNF CSN5

Esper. & Suf.	MI				CON				SEM				TRA				PUB				MAN				INV				APP				LIC-SW				SPSERVIZI				TOTALE			
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I-FCX	14.0 0.0				25.0 0.0								1.0 0.0												70.0 0.0				5.0 0.0												115			0
NESCOFI@BTF	27.0 4.5	2.0			31.5 21.5								8.0 1.5												19.5 18.0												16.0 4.0				102 49.5	2.0		0
NEXTARCH.DTZ	4.0 0.0				10.0 0.0			2.0																	16.0 1.0			1.0													30 1.0			3
NORCIA	19.0 10.0				124.0 56.0								3.0 0.0												26.0 8.0								8.0 1.0								180 75.0			0
NTA-IMCA	45.0 20.0				27.0 12.0																5.0 0.0				27.0 0.0				41.0 41.0				1.0 1.0								146 74.0			0
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NTA-SL-COMB	10.0 2.5				10.0 7.0																				50.0 30.0								5.0 1.5								75 41.0			0
NTA-SL-EXIN	9.0 2.5				20.0 8.0																								180.0 0.0	95.0											209 10.5	95.0		0
NTA-SL-G-RESIST	4.0 0.0				7.0 0.0																				4.5 0.0				35.5 0.0												51			0
NTA-SL-POSSO	18.0 0.0				5.0 0.0																				73.0 0.0				19.0 0.0	19.0											115	19.0		0
NTA-SL-THOMSON	9.0 4.0	6.0			5.0 0.0																				1.0 0.0				25.0 0.0				1.5 1.0								41.5 5.0	6.0		0
NTA-SUPERB	70.0 0.0				26.0 0.0																				85.0 0.0												4.0 0.0				185			0
ODRI2D	1.5 1.5												1.0 1.0												34.0 34.0																36.5 36.5			0
RDH	14.0 4.5	3.0			8.0 0.0	4.5							2.0 0.0	1.0																											24 4.5	8.5		0
SL_FEMTOTERA	6.0 2.0				10.0 6.0																				30.0 0.0				15.0 15.0												61 23.0			0
SPACEWEATHER	6.0 0.0				8.0 3.0																																				14 3.0			0
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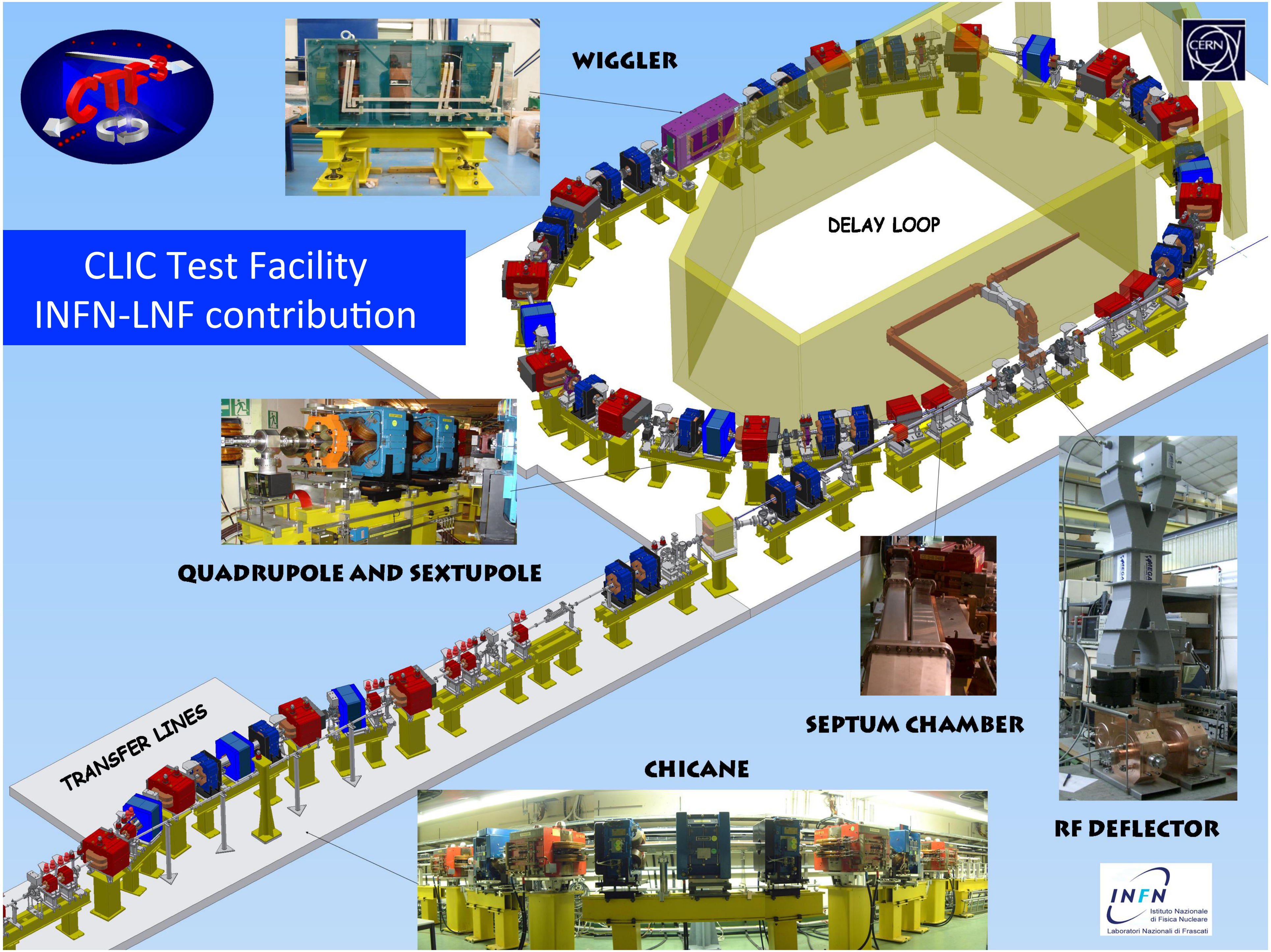
				102.0				240.0				1.0				8.5				0.0				0.5				146.5				236.0				29.0				6.0				769.5

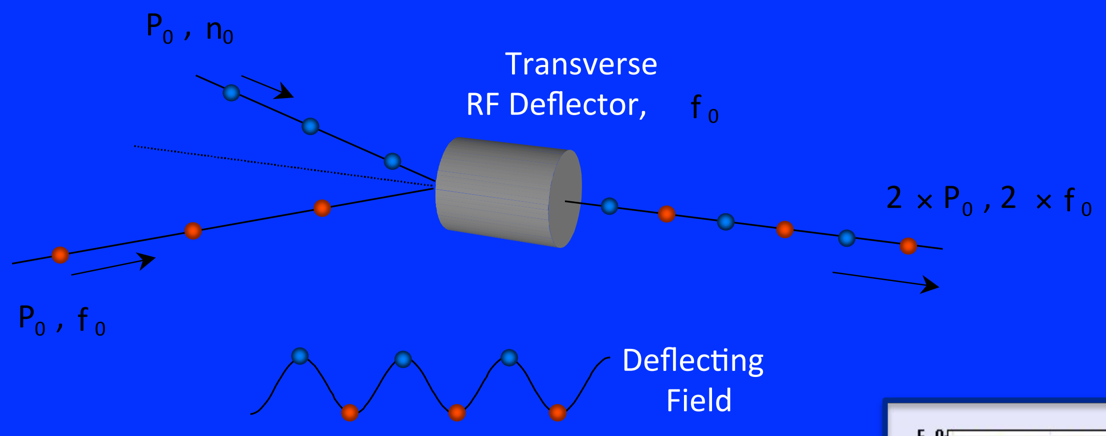
769.5 k€

(~100 k€ in 2012)


CLIC Test Facility
INFN-LNF contribution
WIGGLER
DELAY LOOP
QUADRUPOLE AND SEXTUPOLE
SEPTUM CHAMBER
CHICANE
RF DEFLECTOR
TRANSFER LINES
CERN
INFN
Istituto Nazionale
di Fisica Nucleare
Laboratori Nazionali di Frascati

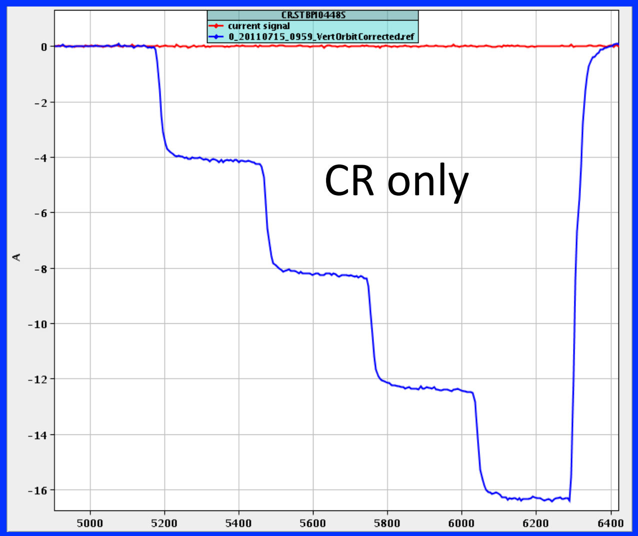
CLIC

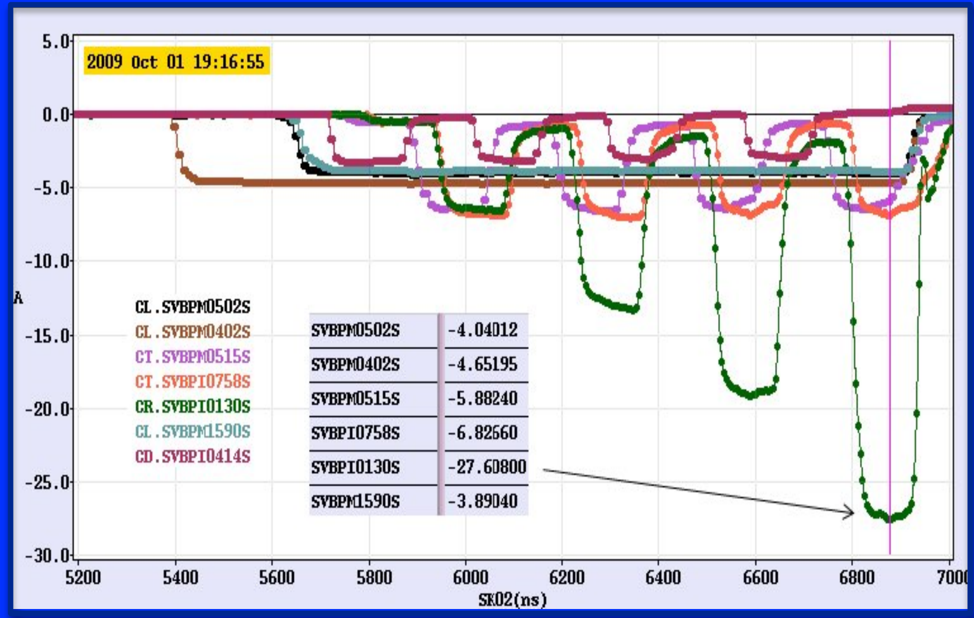
CTF3 Achievements – Drive Beam Generation



Beam recombination

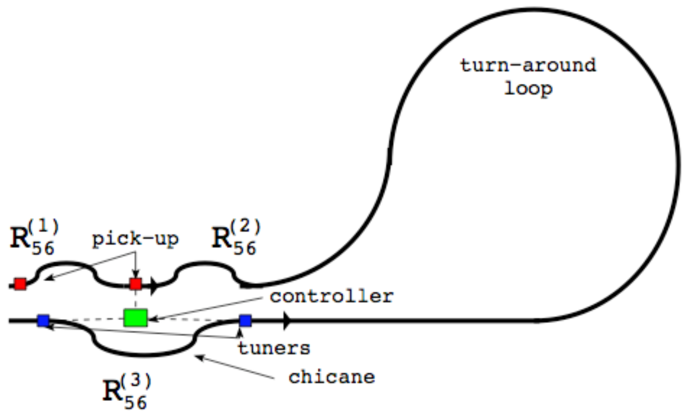
- Factor 8 recombination by RF deflector injection
- COMBINER RING: SUBSTANTIAL LNF CONTRIBUTION

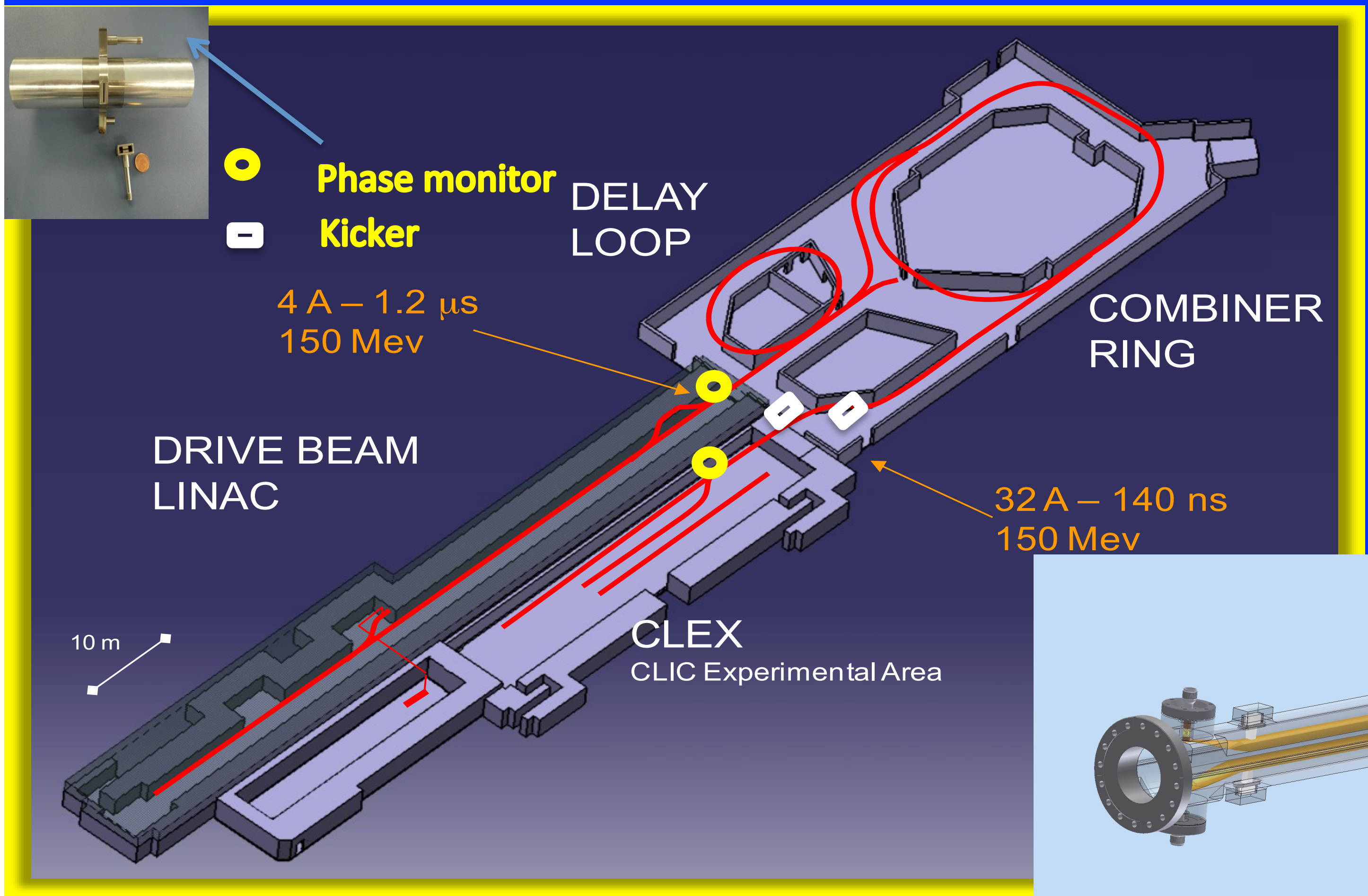




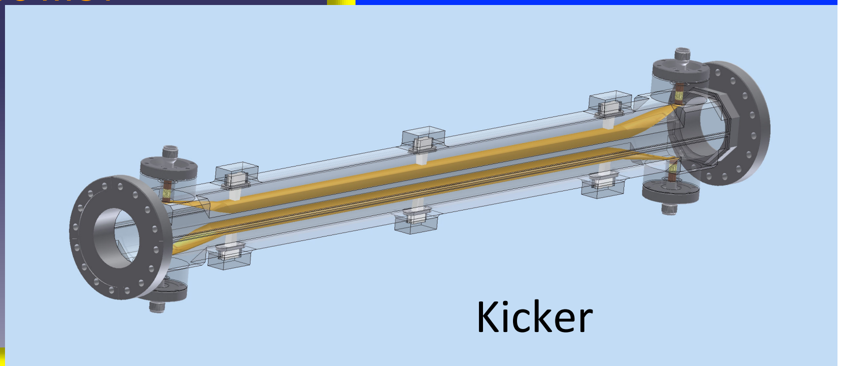
Feed-forward experiment in CLIC Test Facility CTF3

Drive Beam phase measurement and correction in CLIC turn around (CURRENT WORK, FUND BY NTA, C5+FP7)





Transverse orbit distortion in the transfer line change the longitudinal path length -> the beam phase



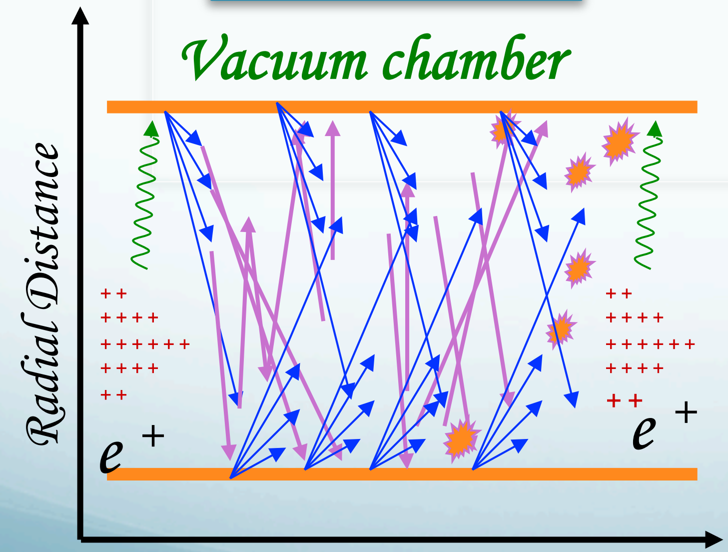
NTA- IMCA (Innovative Material and Coatings for Accelerators)

R. Cimino, R. Flammini, M. Commisso, D.R. Grosso and R. Larciprete

Development and Characterization of Accelerator's new Material and Coatings for e-cloud and single beam instabilities mitigation @ LNF.

Thanks to : DAΦNE-L; LNF acc. Group,CERN, SLAC, ANKA, DESY, Cornell, RICH, SuperB, SuperKEKB….

The Problem

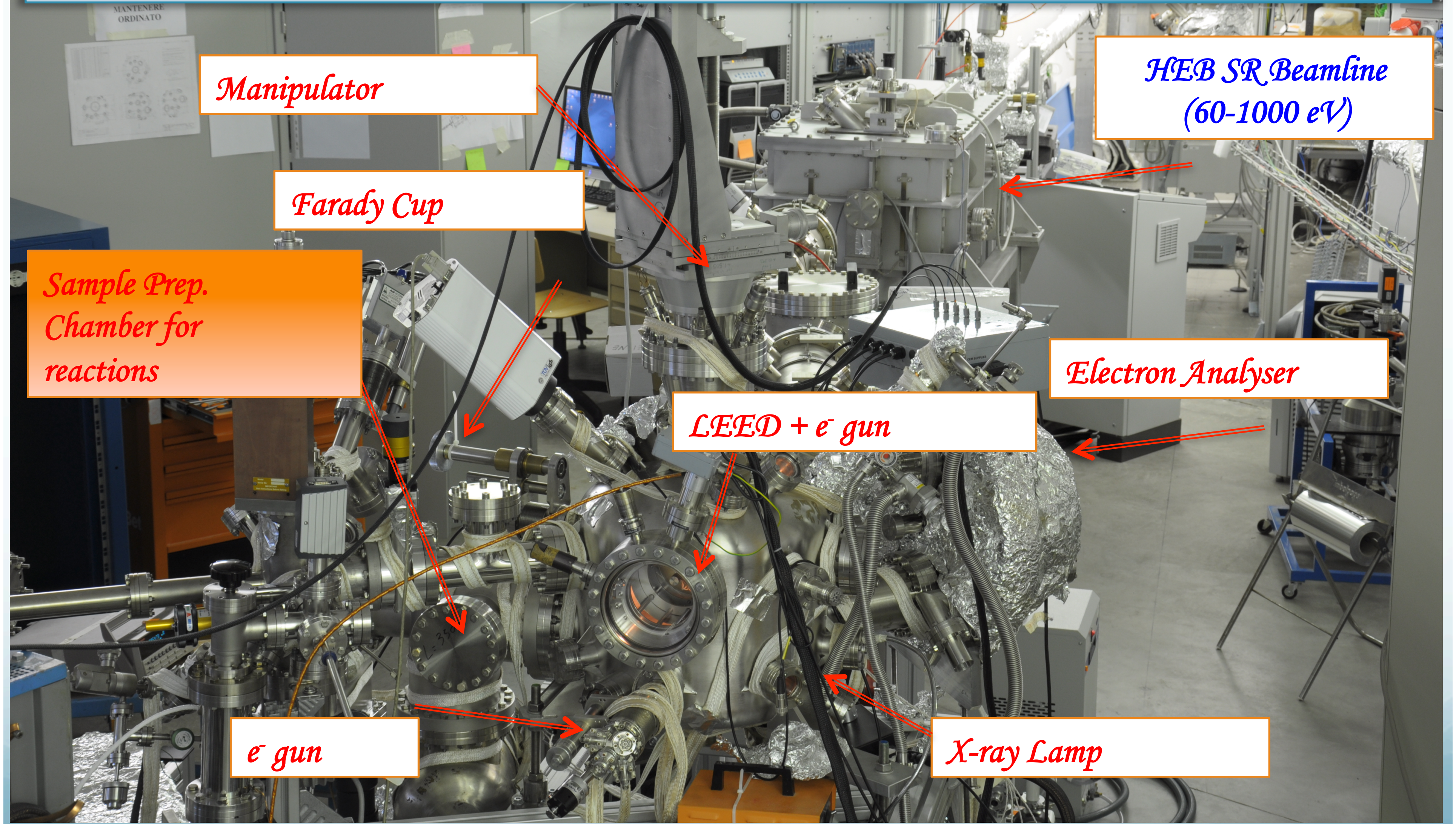


The accelerated particle beam produces SR and/or e^- that, by hitting the accelerator's walls can be reflected (R), generate photo-e^- (PY) or secondary-e^- (SEY).

The e^- can interact with the beam and :

1) Cause single bunch instabilities (driven by R and PY)
2) Multiply, (driven by SEY) inducing extra-heat load, gas desorption , and affecting machine performance.

We set up and are working on two Surface Science "state of the art" systems to study, produce and test low SEY films @ Daϕne Light Laboratory



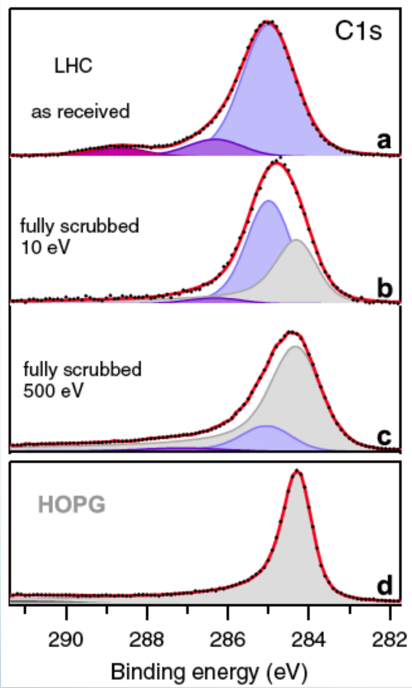
Activity of the LNF Material Science Laboratory

- *Our Laboratory is becoming an internationally recognized reference Lab for material science analysis and tests of relevance for e-cloud studies.*
- *We are studying (in collaboration with international labs):*
- *CERN- LHC (Dipole chamber) Cu Samples*
- *CERN – SPS SS and a-C Coatings*
- *Al from DAFNE and PETRA 3 (DESY)*
- *Stainless Steal (from RICH, Brookhaven)*
- *TiN "test" samples produced at LNF and from PEP*

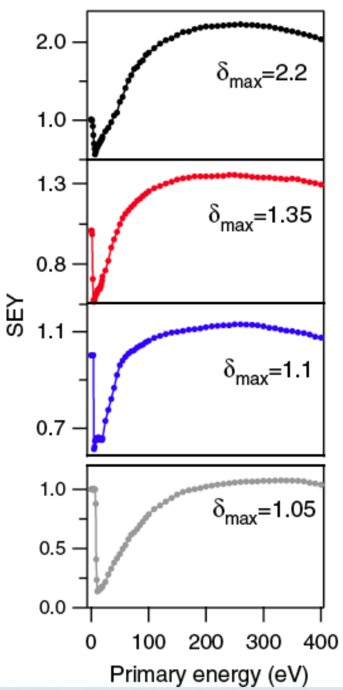
… and we are learning a lot!!!

- ✓ *We measure and feed material parameters (R, PY, and SEY) into simulations.*
- ✓ *Understand their profound nature to:*
- ✓ *Optimize chemical (mechanical) process to reduce their detrimental influence on beam.*
- ✓ *Search for new material / coatings with intrinsically "good" parameters.*

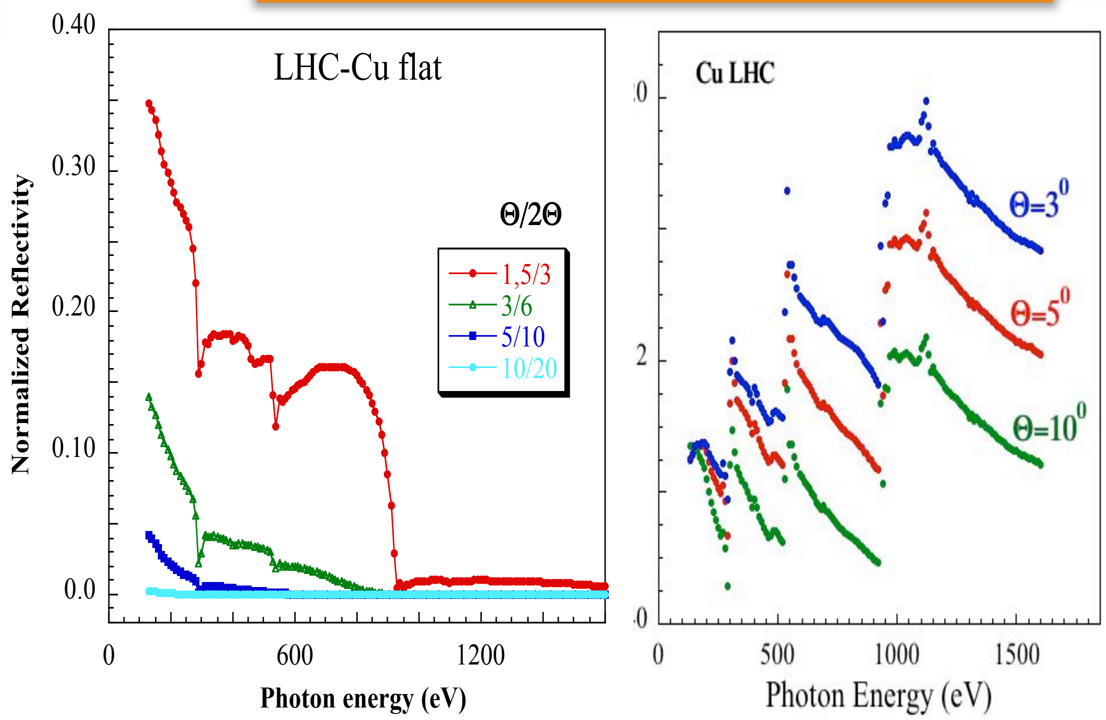
XPS



SEY



SR Reflectivity and PY (@BESSY-II)



Some recent results:

PRL **109,** 064801 (2012) PHYSICAL REVIEW LETTERS week ending 10 AUGUST 2012

Nature of the Decrease of the Secondary-Electron Yield by Electron Bombardment and its Energy Dependence

R. Cimino,[1] M. Commisso,[1] D. R. Grosso,[1] T. Demma,[2] V. Baglin,[3] R. Flammini,[1,4] and R. Larciprete[1,5]

IPAC 11 proceedings and submitted to Phys. Rev. Special topics:

Effect of the surface processing on the secondary electron yield of Al samples

D. R. Grosso[1], M. Commisso[1], and R. Cimino[1], R. Larciprete[1,2*], R. Flammini[1,3], R. Wanzenberg[4]

ECLOUD-12 proceeding and submitted to Phys. Rev. Special Topics

Secondary electron yield of Cu technical surfaces: dependence on electron irradiation

R. Larciprete, D.R. Grosso, M. Commisso, R. Flammini,2 and R. Cimino

ECLOUD-12 proceeding and to be submitted to Phys. Rev. Special Topics

Soft X-ray reflectivity: from quasi-perfect mirrors to accelerator walls

F. Schäfers and R. Cimino

Presented @ ECLOUD-12

Effects of the low energy electron irradiation of TiN samples studied by photoelectron spectroscopy

R. Cimino, M. Commisso,D.R. Grosso, R. Flammini, and R. Larciprete

In prepartion:

Surface analysis and secondary electron yield of 316N stainless steel samples from RHIC

M.S. Kurta, D.R.Grosso, R.Larciprete, R. Cimino, A.A. Volinsky, M. Blaskiewicz, W. Fischer

ECLOUD12 sheds light on electron clouds

INTERNATIONAL JOURNAL OF HIGH-ENERGY PHYSICS
CERNCOURIER
VOLUME 52 NUMBER 7 SEPTEMBER 2012

A recent workshop reviewed the latest experiences with the phenomenon of electron clouds at the LHC and other accelerators.

Electron clouds – abundantly generated in accelerator vacuum chambers by residual-gas ionization, photoemission and secondary emission – can affect the operation and performance of hadron and lepton accelerators in a variety of ways. They can induce increases in vacuum pressure, beam instabilities, beam losses, emittance growth, reductions in the beam lifetime or additional heat loads on a (cold) chamber wall. They have recently regained some prominence: since autumn 2010, all of these effects have been observed during beam commissioning of the LHC.

Electron clouds were recognized as a potential problem for the LHC in the mid-1990s (*CERN Courier* July/August 1999 p29) and the first workshop to focus on the phenomenon was held at CERN in 2002 (*CERN Courier* July/August 2002 p15). Ten years later, the fifth electron-cloud workshop has taken place, again in Europe. More than 60 physicists and engineers from around the world gathered at La Biodola, Elba, on 5–8 June to discuss the state of the art and review recent electron-cloud experience.

Valuable test beds

Many electron-cloud signatures have been recorded and a great deal of data accumulated, not only at the LHC but also at the CESR Damping Ring Test Accelerator (CesrTA) at Cornell, DAΦNE at Frascati, the Japan Proton Research Complex (J-PARC) and PETRA III at DESY. These machines all serve as valuable test beds for simulations of electron-cloud build-up, instabilities and heat load, as well as for new diagnostics methods. The latter include measurements of synchronous phase-shift and cryoeffects at the LHC, as well as microwave transmission, coded-aperture images and time-resolved shielded pick-ups at CesrTA. The impressive resemblance between simulation and measurement suggests that the existing electron-cloud models correctly describe the phenomenon. The workshop also analysed the means of mitigating electron-cloud effects that are proposed for future projects, such as the High-Luminosity LHC, SuperKEKB in Japan, SuperB in Italy, Project-X in the US, the upgrade of the ISIS machine in the UK and the International Linear Collider (ILC).

An international advisory committee had assembled an exceptional programme for ECLOUD12. As a novel feature for the series, members of the spacecraft community participated includi[...] aerospa[...] ogy, the [...] Polytec[...] space su[...] in accel[...] termeas[...] through[...] satellite[...] perform[...] Intrigui[...] emissio[...] lyse ele[...] constru[...] emission[...] ures for[...] ings and[...] ECLOU[...] involved[...] at this m[...] emission[...] first app[...] at the Un[...] effects i[...]

Severa[...] first time[...] from Cornell, for photon tracking, modelling surface properties and 3D geometries; OSMOSEE from Onera, to compute the secondary-emission yield, including at low primary energies; PyECLOUD from CERN, to perform improved and faster build-up simulations; the latest version of WARP-POSINST from Lawrence Berkeley National Laboratory, which allows for self-consistent simulations that combine build-up, instability and emittance growth, and is used to study beam-cloud behaviour over hundreds of turns through the Super Proton Synchrotron (SPS); and BI-RME/ECLOUD from a ▷

Several powerful new simulation codes were presented for the first time at ECLOUD12.

chairs of ECLOUD12

Roberto Cimino, LNF/INFN
and
Frank Zimmermann, CERN

3L_2D

- Time Resolved e+/e- Light in 2-Dimension
- Goal of this proposal is to built an innovative dedicated 2D diagnostic tool to study bunch-by-bunch transverse instabilities using the mid-infrared light emitted by synchrotron acceleration from bending magnets
- Main focus is to take data from DAFNE & SuperB positron beam to study parasitic e-cloud behavior and other 2D instabilities
- Proposal by: Alessandro Drago (LNF-DA), Augusto Marcelli (LNF-DR), Mariangela Cestelli Guidi (LNF-DR), Emanuele Pace (Univ.Firenze), Alessio Bocci (CNA - University of Seville, Spain)

Parasitic electron clouds make instabilities on positive charged beams in circular accelerators. These effects and the mitigation techniques can be experimentally evaluated by using bunch-by-bunch and turn-by-turn acquisition systems as reported in the side paper (BIW 2012)

To mitigate and to control e-clouds, in DAFNE different strategies have been implemented:

a) powerful bunch-by-bunch feedback systems

b) solenoids in straight section

c) clearing electrodes in wiggler&bending magnets

We use also several techniques to carefully compare and analyze the beam behavior

From the BIW12 paper, four methods are used to evaluate clearing electrode and solenoid performance:

1) SLM - standard Synchrotron Light Monitor (not bunch-by-bunch) to estimate vertical and horizontal beam dimension and shape

2) FFT Spectrum analyzer to evaluate beam fractional tune shift

3) Beam instability grow rates made by using bunch-by-bunch feedback (in horizontal / vertical planes) with its capability to stop damping action.

4) Betatron fractional tune spreads measured by using bunch-by-bunch feedback system only as recording tool (i.e. in parasitic way)

MITIGATION AND CONTROL OF INSTABILITIES IN DAFNE POSITRON RING*

Alessandro Drago, David Alesini, Theo Demma, Alessandro Gallo, Susanna Guiducci, Catia Milardi, Pantaleo Raimondi, Mikhail Zobov
Istituto Nazionale di Fisica, Nucleare Laboratori Nazionali di Frascati, Frascati, Italy

Abstract

The positron beam in the DAFNE e+/e- collider has always been suffering from strong e-cloud instabilities. In order to cope with them, several approaches have been adopted along the years: flexible and powerful bunch-by-bunch feedback systems, solenoids around the straight sections of the vacuum chamber and, in the last runs, e-cloud clearing electrodes inside the bending and wiggler magnets. Of course classic diagnostics tools have been used to evaluate the effectiveness of the adopted measures and the correct setup of the devices, in order to acquire total beam and bunch-by-bunch currents, to plot in real time synchrotron and betatron instabilities, to verify the vertical beam size enlargement in collision and out of collision. Besides, to evaluate the efficacy of the solenoids and of the clearing electrodes versus the instability speed, the more powerful tools have been the special diagnostics routines making use of the bunch-by-bunch feedback systems to quickly compute the growth rate instabilities and the bunch-by-bunch tune spread in different beam conditions.

INTRODUCTION

In the DAFNE e+/e- collider [1-2], in operation since 1997, the positron beam has always been suffering from strong instabilities [3] mainly due to parasitic e- clouds. In order to cope with them, several approaches have been adopted along the years: flexible and powerful bunch-by-bunch transverse feedback systems, solenoids around the straight sections of the vacuum chamber and, in the last runs, e-cloud clearing electrodes.

Metallic electrodes have been designed to absorb the photo-electrons in the DAFNE positron ring. They have been inserted in the wiggler and bending magnet vacuum chambers and have been connected to external voltage generators.

The dipole electrodes have a length of 1.4 or 1.6 m depending on the considered arc, while the wiggler ones are 1.4 m long. They have a width of 50 mm and a thickness of 1.5 mm.

The electrodes have been made in copper and have a distance of 0.5 mm from the vacuum pipe. This small distance has been chosen to reduce the beam coupling impedance of the devices. The distance is guaranteed by special ceramic supports made in SHAPAL and distributed along the electrodes.

The distance of the electrodes from the beam axis is 8 mm in the wigglers and 25 mm in the bending magnets.

Analytical calculations and electromagnetic simulations have been done to estimate the power released from the beam to the electrodes. We expect a maximum temperature increase of the order of 100°C with a 2A beam for the wiggler electrodes. This temperature increase has been considered acceptable since the electrodes have been heated up to this level without damage and also because it is in the range of operation of all the components (SHAPAL and feedthroughs).

The electrodes are connected to external generators and have been tested (with the beam) applying dc voltages up to 250 V.

RF measurements have been also done to precisely measure the resonant frequencies of the electrodes modes.

RF measurements have been performed before and after the electrode installation by using a network analyzer. We have done two types of measurements: reflection coefficient at the feedthrough port and transmission coefficient between one BPM near to the strip and the feedthrough. In both cases it was possible to measure the resonant frequencies of the stripline modes.

The electrode impedance consists of two contributions: resistive wall impedance due to a finite conductivity of the electrode and stripline impedance due to the gap created between the electrode and the vacuum chamber wall.

The estimated low frequency broadband impedance of the electrode Z/n is about 0.005 Ohm that should give a small contribution to the total ring impedance.

Figure 1: The beam horizontal frequency shift caused by turning off all the 12 electrodes is ~20KHz, that corresponds to a difference in the horizontal tune of ~0.0065.

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MEASUREMENTS ON e+ BEAM

Looking at the effect on the positron beam, measures have been carried on by using a synchrotron light monitor, a FFT spectrum analyzer, and the bunch-by-bunch horizontal and vertical feedback systems.

As shown in Fig. 1, a FFT analyzer (Tektronix RSA3303A) is used to study the beam frequency response from a button pickup. A horizontal frequency shift is evident by turning off all the clearing electrodes. The frequency difference is ~20 KHz corresponding to a difference in the horizontal tune of ~0.0065. Frequency and betatron tune grow up when the electrodes go off. This kind of measure does not separate the signal for each bunch, plotting the response in frequency of the whole beam behavior.

In Fig. 2 a plot from the SLM is shown: turning off progressively the electrodes, a vertical enlargement is evident on the SLM. The beam vertical size goes from 110 to 145 μm. These data are not recorded by a gated camera so they are not a bunch by bunch measure. Furthermore in this measure as well as in the following ones, the positron beam is not colliding with the electron beam.

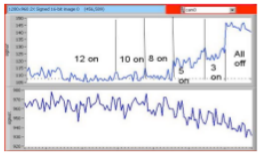


Figure 2: Vertical beam size enlargement due to the clearing electrodes progressive turning off: the beam vertical size goes from 110 to 145 μm.

In DAFNE it is possible to acquire bunch by bunch data using the feedback systems designed to damp the coupled bunch instabilities. The bunch-by-bunch feedback has been developed in 1992-96 by a large collaboration of SLAC, LNF, ALS-Berkeley, [4], [5], and, in the latest upgrade, KEK [6], and it has shown powerful diagnostics capabilities [7-9]. In the first design was implemented only for longitudinal damping, then, in the following upgrades, also as transverse feedback. Recently a new upgrade including 12 bits analogue conversion (it was done previously by 8 bits) has been installed at DAFNE [10] for damping transverse instabilities. The feedback has been used in order to produce horizontal instability growth rate measurements versus beam currents (as shown in Fig. 3) testing the performance of the e-cloud clearing electrodes at different voltages.

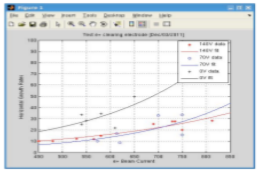


Figure 3: Horizontal instability growth rates (ms-1) versus beam current (mA). Measures done by using the bunch-by-bunch feedback at different voltages applied to the clearing electrodes.

Growth rates (in ms-1) have been measured comparing no voltage with 70V and 140V. In Fig. 3 the effectiveness of the electrodes is evident. After many tests on the reliability with high beam currents, the voltages applied to the electrodes have been increased to 200V (in dipoles) and 250V (in the wiggler magnets).

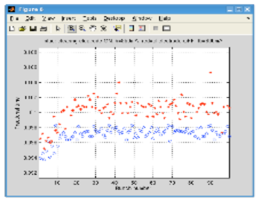
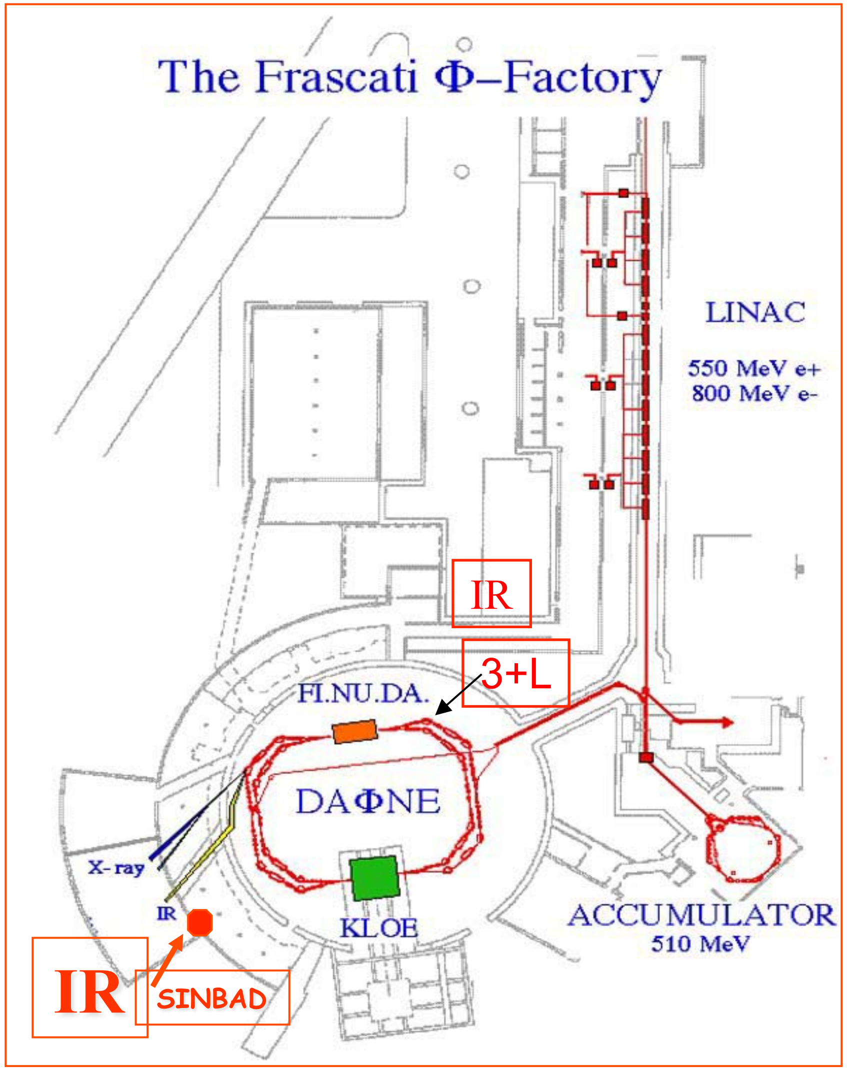


Figure 4: Horizontal fractional tune versus bunch number measured by the bunch-by-bunch feedback system acquiring and averaging 12 M samples of data. Turning off the electrodes in 4 wigglers and 2 dipoles, the horizontal tune goes up.

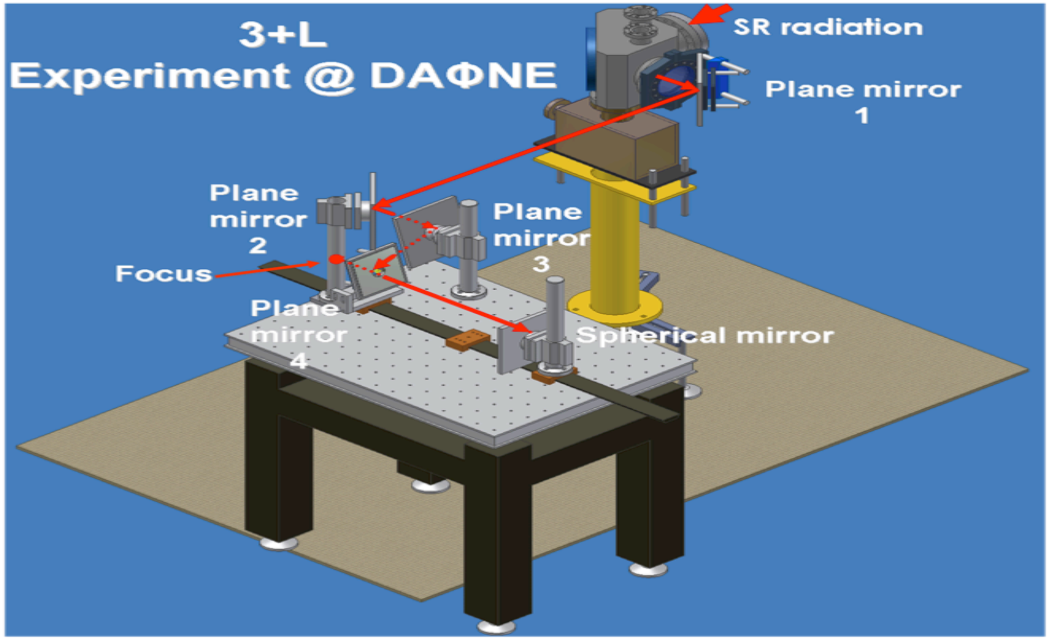
By using the new version of the feedback based on Xilinx Virtex-5 FPGA, up to 12 Msamples can be stored in the chip memory. After recording the longest tracks, data are downloaded to the server where they are

ISBN 978-3-95450-121-2

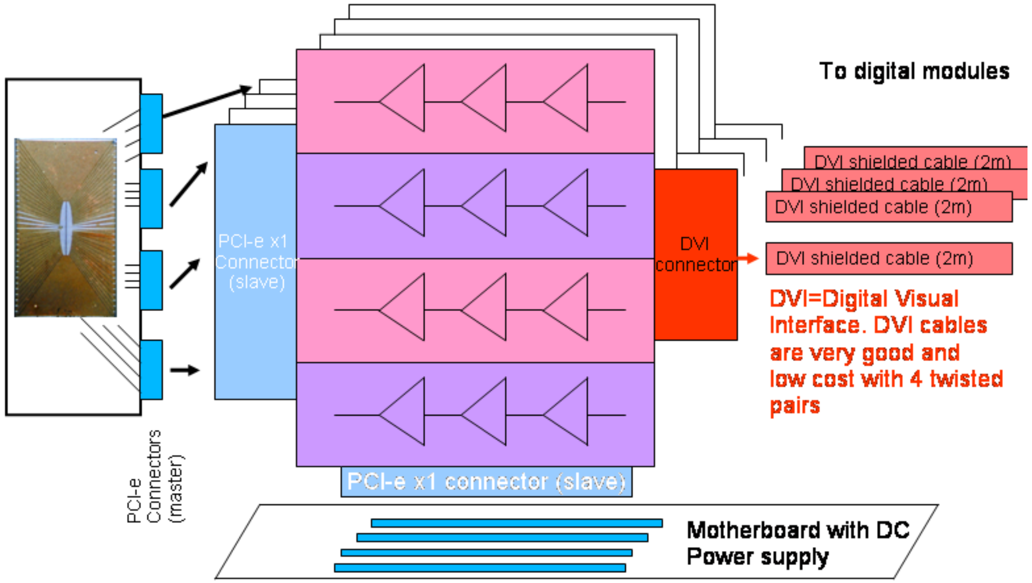
DAFNE infrared beamlines



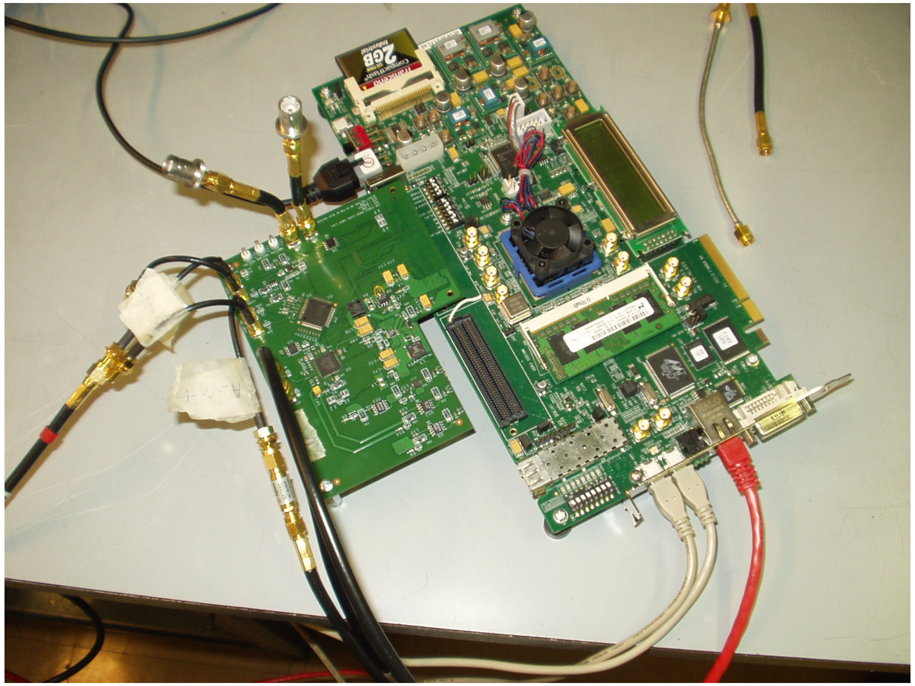
A new data acquisition system based on Infrared array detector is going to be built

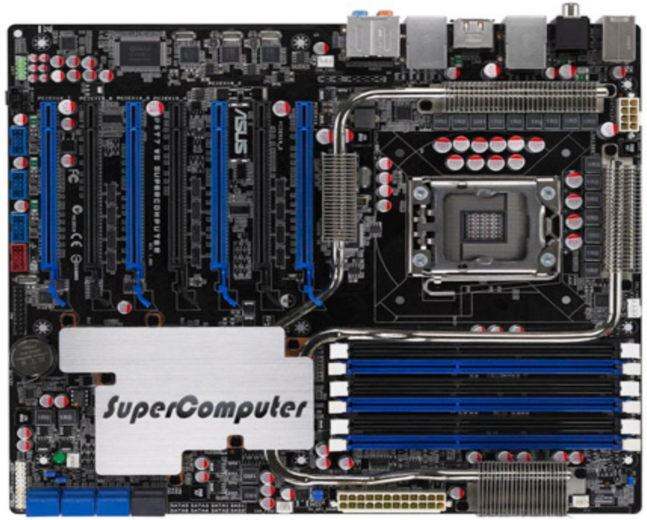


Project of a new, modular analog front end based on four channels amplification (G=52dB each) modules replicated by four ➔ in total 16 pixels



From digital acquisition point of view, this FPGA-based ML605 board by Xilinx **has been tested**. It has a custom 14-bit ADC/DAC mezzanine board with FMC interface. The system has been **used in May 2012 to acquire DAFNE e+ beam data from a BPM.**





Low-cost pc motherboard that can accept 7 PCI-express boards on the bus and can be used as main processing unit

TIMING MODULE

a 14 channels data acquisition system that works in parallel needs an efficient clock and trigger management. A custom module with functionality of distributing and timing the 14 DAS has to be designed & built. The goal is to be able to de-skew individually the sampling frequency for each channels and also to interface the start acquisition trigger. If programmed adequately, this module can also make the data acquisition for both longitudinal and transverse signal detection.

NORCIA

NOvel Researches Challenges In Accelerators

(Responsabile B. Spataro)

New technologies are necessary to achieve the multi-TeV energies required by the next linear e^+/e^- colliders, ν's facilities, x-ray FELs, etc.

The present proposal is devoted to the R&D of key components of the next generation of accelerators

- **RF cavities**
  Multi-TeV linear colliders require RF high-frequency and high-power with accelerated gradients >120 MeV/m

NORCIA EXPERIMENT

High Gradient Accelerator Sections
INFN/LNF, INFN/LNL, Universita' Sapienza;
Universita' di Catania/CNR;
Universita' di Camerino, SLAC, KEK & UCLA

INFN/LNF : B. Spataro, M. Zobov, D. Alesini, M. Ferrario, G. Gatti, A. Marcelli, D. Di Gioacchino
INFN/LNL : V. Rigato
Universita' Sapienza/INFN : M. Migliorati, A. Mostacci, L. Palumbo
Universita' di Catania/CNR : M.G. Grimaldi, L. Romano, F. Ruffino
Universita' di Camerino: R. Gunnella

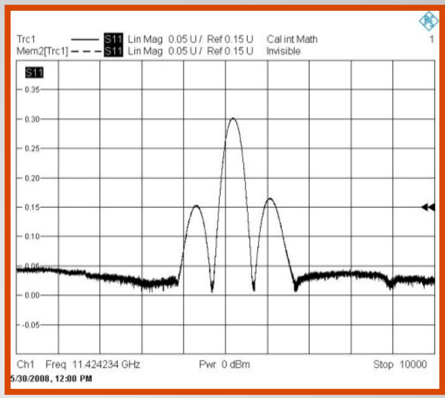
Diamond (U.K.) : G. Cibin
DESY (D) : A. Ricci
UCLA (USA) : J. Rosenzweig
KEK (J) : Y. Higashi
SLAC (USA) : V. Dolgashev, S. Tantawi, D. Yeremian

HGAS

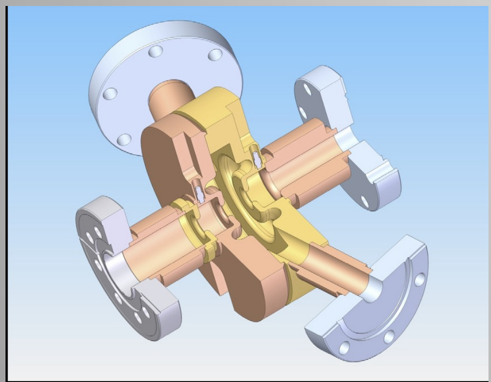
High Gradient Accelerator Sections at 11.424 GHz

LNF – LNL - Universita' Sapienza – Universita' Camerino - UCLA – SLAC – KEK

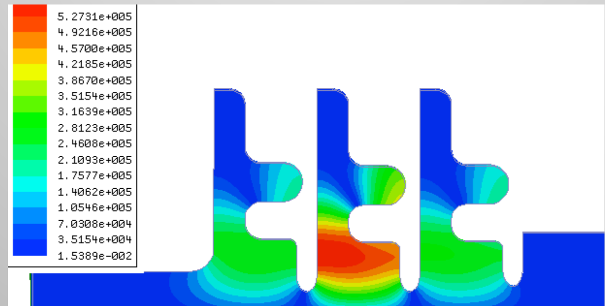
R&D of Three cells SW typical structures



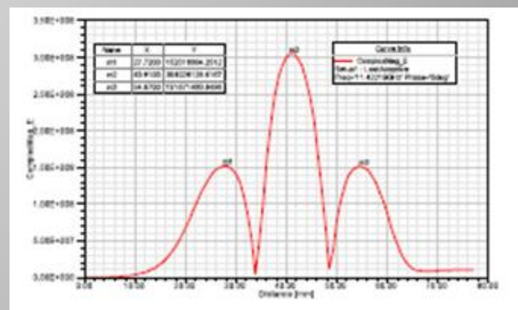
Copper model and longitudinal electric field profile of the operating mode



Triple choke solid model



Field distribution



Longitudinal electric field profile of the operating mode

X-band device realisation issue

Guidelines:

How to improve the high power performance (e.g. discharge rate) ?

- using materials with higher fusion temperature; → R&D of materials
- avoiding the device heating at high temperature as done in conventional brazing → R&D on fabrication techniques

R&D of material →

- Sintered molybdenum (bulk)

R&D on fabrication techniques →

- Electroforming
- Soft Bonding
- Mo sputtering on Cu
- EBW (Electron Beam Welding)

Activities status and 2013 plan

X-band structure e.m. designs have been completed for standard 3-cells structure, triple choke-cavity & dual mode cavities.

Technological activity to be carried out:

a) R&D of the sputtering method,

b) soft bonding, new alloys, Electron Beam Welding (EBW) on samples SLAC, KEK, University of Catania/CNR and INFN-LNL collaborations;

c) Studies of a 3-cell standard prototype (combination of soft brazing-electroplating Mo sputtering, etc..) made of Cu and Cu/Zr - SLAC-KEK collaborations;

d) Studies of Cu electro-deposition on stainless steel irises;

e) Construction of three electroformed standard SW structures (SLAC-KEK collaborations): standard 3-cells structures in Ni, Cu and Cu/stainless steel irises with electroforming process;

f) Triple choke wave cavity realization with the electroforming process (SLAC-KEK-LNF-LNL University Roma Sapienza);

g) Power tests at SLAC *(already partially carried out) in the framework of the INFN/SLAC MoU.*

ODRI 2D
2 Dimensional Optical Diffraction Radiation Interference

TO BE USED AS TRANSVERSE BEAM DIAGNOSTICS FOR HIGH INTENSITY ELECTRON BEAMS AT HIGH REP. RATES

2013 – 2015

Coordinatore nazionale: A. Cianchi (Roma 2)

Sezioni partecipanti:

LNF (M. Castellano, E. Chiadroni, D. Di Giovenale, R. Pompili)

Roma Tor Vergata (A. Cianchi, L. Catani, S. Tazzari)

Collaborazione:

FLASH @ DESY Hamburg (V. Balandin, N. Golubeva, K. Honkavaara, G. Kube)

MOTIVATION

- For linear colliders (ILC), linac-driven FEL sources (XFEL), advanced radiation sources (Compton x-rays)
  - Small transverse beam size ($\approx$ 10 μm)
- High energy, high charge density, high repetition rate beams require non-invasive diagnostics
  - Optical Diffraction Radiation as transverse diagnostics
    - Position, angular divergence, transverse dimensions => emittance
  - All other intercepting devices are easily damaged or destroyed from these type of beams
  - Even more desirable after recent observations of Coherent Optical Transition Radiation in linac-driven FELs.

DR THEORY

- DR generation via interaction between the EM fields of the moving charge, moving through a slit of aperture a, and the conducting screen
- extension of EM field of a relativistic particle is flat circle
  - Radius $\gamma\lambda/2\pi$
- radiation intensity scales proportional to $|E|^2$

$$I \propto e^{-\frac{a}{h_{imp}}} \quad \text{with} \quad h_{imp} = \frac{\gamma\lambda}{2\pi}$$

- dependency on impact parameter

$a >> h_{imp}$: no radiation

$a \cong h_{imp}$: DR

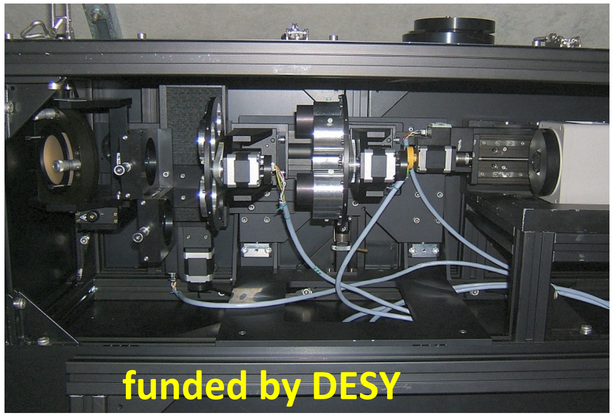
$a << h_{imp}$: TR

- excellent candidate to measure beam parameters **parasitically**

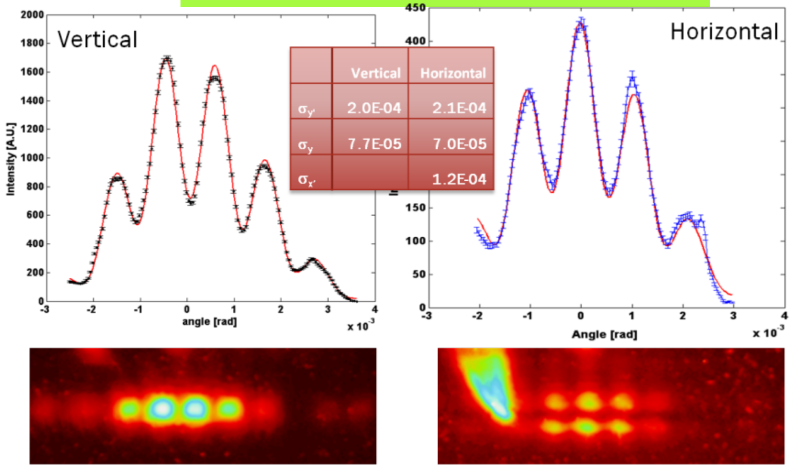
ODRI ACHIEVEMENTS IN 2010-2012

We have demonstrated that **ODRI effect can be successfully used as reliable non intercepting technique** able **to measure** the beam size with the accuracy needed to estimate **the emittance** via quadrupole scan technique.

2010: New target holder and screens, and new optical system

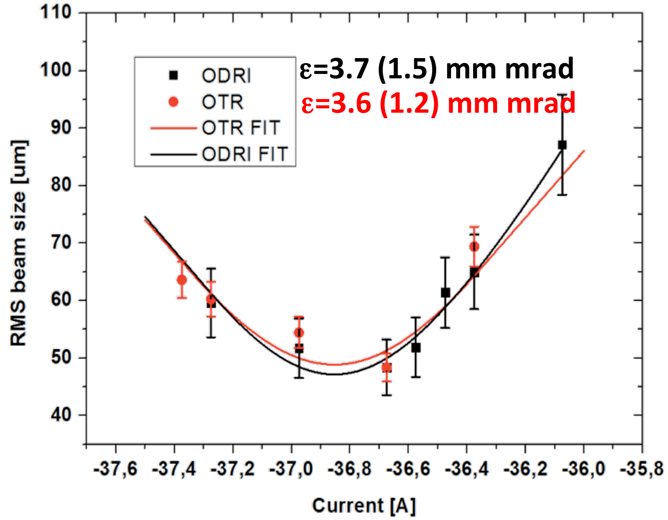


2011: Characterization of the round beam => Horizontal and vertical ODRI polarization



	Vertical	Horizontal
$\sigma_{y'}$	2.0E-04	2.1E-04
σ_y	7.7E-05	7.0E-05
$\sigma_{x'}$		1.2E-04

2012: First non-intercepting emittance measurement in the vertical plane



Despite of the total error in the measurement the agreement, for both the emittance results and the shape of the curve of the quadrupole scans, are really excellent.

M. Castellano, E. Chiadroni, A. Cianchi, *Phase Control Effects in Optical Diffraction Radiation from a Slit,* NIM **A 614**, 163 - 168 (2010).

E. Chiadroni et al., *New Experimental Results with Optical Diffraction Radiation Diagnostics*, International Journal of Modern Physics A Vol. **25**, Supplement 1 (2010) 189.

A. Cianchi et al., *Non-intercepting electron beam size monitor using optical diffraction radiation interference,* PRST-AB **14** 102803 (2011).

E. Chiadroni et al., *Effect of transverse electron beam size on transition radiation angular distribution,* NIM A **673**, 56-63 (2012).

A. Cianchi et al., *Non-intercepting diagnostic for high brightness electron beams using Optical Diffraction Radiation Interference (ODRI),* Journal of Physics: Conference Series **357** (2012) 012019.

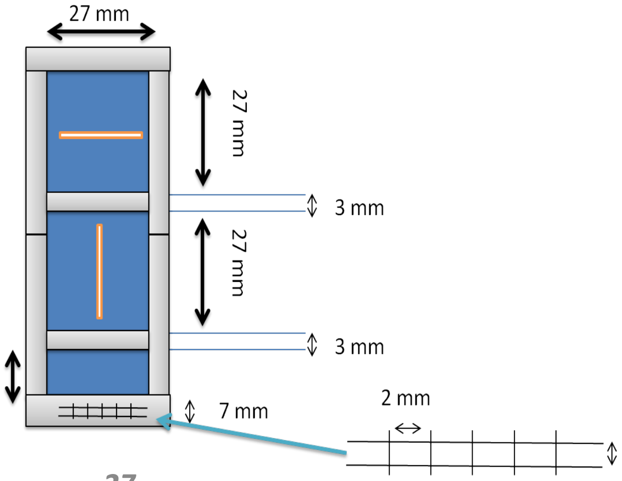
ODRI2D (2013-2015)

In the framework of ODRI we succeeded in performing for the first time a non intercepting quadrupole scan measurement to determine vertical emittance
➔ We propose an experiment called **ODRI2D** to determine the **transverse emittance**, i.e. **both horizontal and vertical**.

- The bypass is going to be dismounted
  - a dedicated vacuum chamber were reserved on the FLASH2 main line after the variable gap undulator
  - the same optical setup will be used, but mounted vertically, due to technical reasons
- DESY, whose strong interest is demonstrated by allowing to move our experiment from the bypass to the main line, will provide
  - technical support for drawings, installations, movements
  - hardware (optical system)
  - simulations of electron beam optics upstream from ODRI2D setup

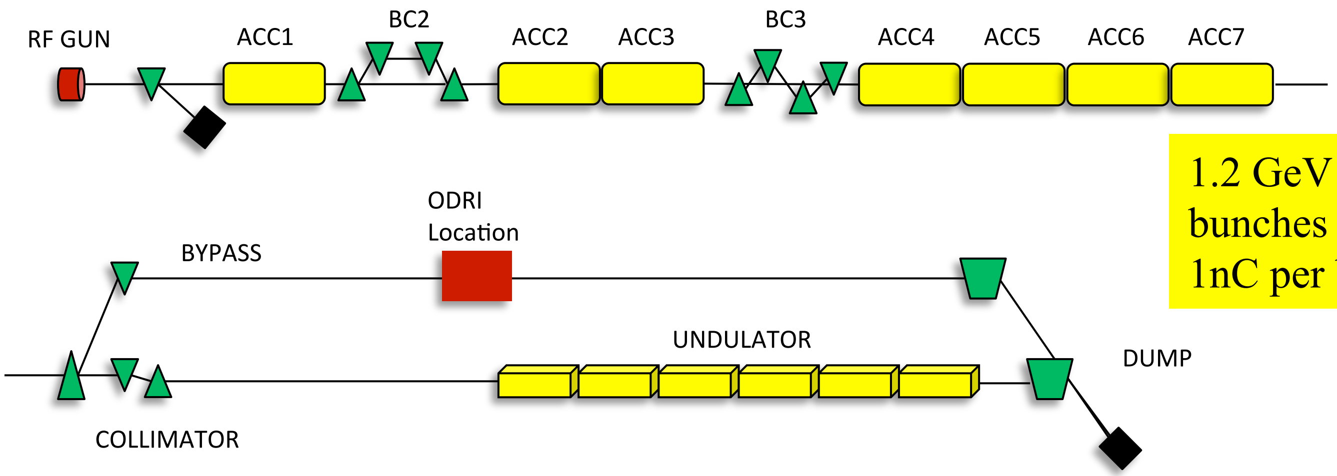
Scientific Motivation

- Investigate the horizontal plane (SR plays different roles in the two planes) to measure also horizontal emittance
  - improvement of the system: two slits, one horizontal and one vertical to measure both vertical and horizontal emittance
- Investigate the contribution and the effects of coherent emission due to microbunching within the electron beam, i.e. Coherent Optical Diffraction Radiation Interference (CODRI)
  - the new chamber is downstream from the FLASH2 undulator
- Investigate different regimes, e.g. near field imaging



ODRI ACTIVITY

Optical Diffraction Radiation angular distribution depends on beam transverse size and angular divergence => a non intercepting emittance measurement become feasible



1.2 GeV beam energy, up to 30 bunches in the bunch train (up to 1nC per bunch), 10 Hz rep rate

M. Castellano, *A New Non Intercepting Beam size Diagnostics Using Diffraction Radiation from a Slit*, NIM **A 394**, 275, (1997).

E. Chiadroni et al., *Non-intercepting electron beam transverse diagnostics with optical diffraction radiation at the DESY FLASH facility,* NIM **B 266** (2008) 3789–3796.

E. Chiadroni, M. Castellano, A. Cianchi, *Diffraction as Ultra-High Intensity Electron Beams Non-Intercepting Diagnostics,* Il Nuovo Cimento **32 C,** N. 03-04 (2009).

M. Castellano, E. Chiadroni, A. Cianchi, *Phase Control Effects in Optical Diffraction Radiation from a Slit,* NIM **A 614**, 163 - 168 (2010).

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A. Cianchi et al., *Non-intercepting diagnostic for high brightness electron beams using Optical Diffraction Radiation Interference (ODRI),* Journal of Physics: Conference Series **357** (2012) 012019.

NESCOFI@BTF

NEutron Spectrometry in COmplex FIelds

http://www.lnf.infn.it/acceleratori/public/nescofi/

(2011-2013) DEVELOPMENT OF INSTRUMENTATION FOR THE SPECTROMETRIC CHARACTERIZATION OVER A LARGE ENERGY RANGE (10^{-8}-10^{2} MeV) OF PULSED, HIGH-INTENSITY NEUTRON FIELDS

R. Bedogni (resp. LNF e nazionale) 80%, D. Bortot (80%), B. Buonomo (20%), A. Esposito (40%), G. Mazzitelli (30%), L. Quintieri (10%), A. Gentile (40%)
INFN-LNF

M.V. Introini (30%), A. Pola (30%)
INFN-Milano e Dip. di Energia Politecnico di Milano

J.M. Gomez-Ros (40%)
CIEMAT, Madrid - Associato LNF

Scientific highlights

Developing innovative neutron sensitive instruments for the spectrometric and dosimetric characterization of neutron fields, intentionally produced or present as parasitic effects, in particle accelerators used in **industry, research and medical fields**.

These neutron fields:

- range in energy from thermal (1E-8 MeV) to tens or hundreds MeV;
- range in fluce rate from few tens up to 10^5 cm^{-2} s^{-1}
- are accompanied by other particles (photons, high-E hadrons)
- Have pulsed structure

(1) Fast neutron irradiation

TRIUMF, LANSCE, TSL (ANITA), ISIS, **ESS**: dedicate neutron lines for material science, chip irradiation (electronics, avionics, aerospace) and radiation damage.

Neturon spectra are generally known by simulation only. Measurements performed in limited energy regions only. A large interest exists for broad-energy, on-line spectrometry that would allow

- estimating field pertutbation due to irradiated objects,
- evaluate the importance of room-return for different user positions;
- prevent beam alterations due to change in energy or space characteristics of primary beam.

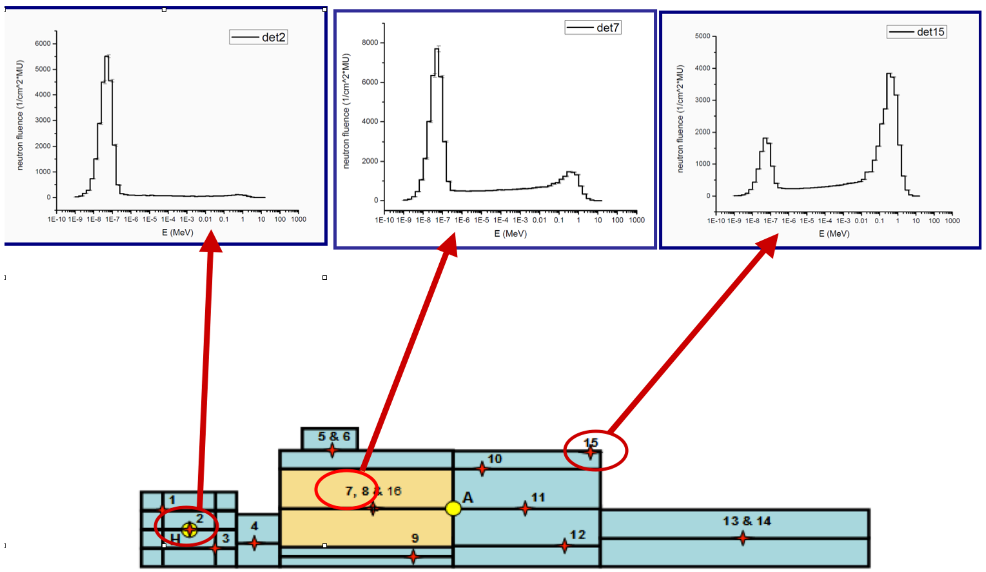
Scientific highlights

(2) Medical field

Modern radiotherapy techniques (including hadron-therapy) dramatically improved lifespan and life quality of patients. In parallel the interest for secondary cancers is increasing. **A significant fraction of secondary cancers is estimated to come from parasitic neutrons.**

The **medical physics** community is seeking on-line instruments to provide neutron-related field and dosimetric quantities in broad ranges of Energy (10^{-8} - 10^{2} MeV) and flux (10^{2}-10^{4} cm^{-2} s^{-1})

NESCOFI products may be immediately applied in the field of in-vivo (in-phantom) verification of simulated neutron quantities during radiotherapy (collaboration with Sevilla University)



NESCOFI's philosophy

To date, the Bonner Sphere spectrometer is the only existing device having the capability to simultaneously determine all energy components.
Disadvantage: need to sequentially expose the spheres.

NESCOFI goal is to provide real-time spectrometers to simultaneously provide all energy components (and their variation with time) in a single irradiation,
exploiting the same principle of Bonner Spheres (detection of moderated neutrons) but in a single moderator embedding multiple thermal neutron detectors.

General planning

Build TWO types of spectrometers for different field geometries:

$(SP)^2$ **SP**herical-**Sp**ectrometer: measure the total spectrum independently from direction distribution

CYSP **CY**lindrical-**SP**ectrometer: determine the spectrum from a preferred direction (typ. from a target. Allows eliminating room return)

For each geometry: Identify suitable Active Thermal Neutron Detectors (ATND) to produce a low-rate & a high-rate version.

2011	**MC Design of the geometries and test with passive detectors (Dy-foils)**
2012	**Identify suitable ATND**
2013	**Build and calibrate final spectrometers**

ETRUSCO-GMES @ SCF_LAB:

R&D on laser-based Geometrodynamics applied to Galileo (ESA contract), IRNSS (ISRO contract) & GMES (It. Ministry of Defense contr.)

SCF_LAB

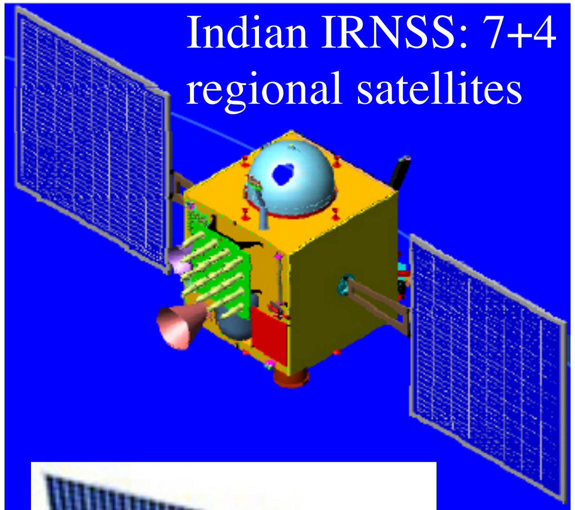
Satellite/Lunar/GNSS laser ranging and altimetry **C**haracterization **F**acilities' **LAB**oratory

Simone Dell'Agnello for the SCF_LAB Team

Italian National Institute for Nuclear Physics, Laboratori Nazionali di Frascati (INFN-LNF), Via Enrico Fermi 40, Frascati (Rome), 00044, Italy

Global Navigation Satellite System (GNSS):

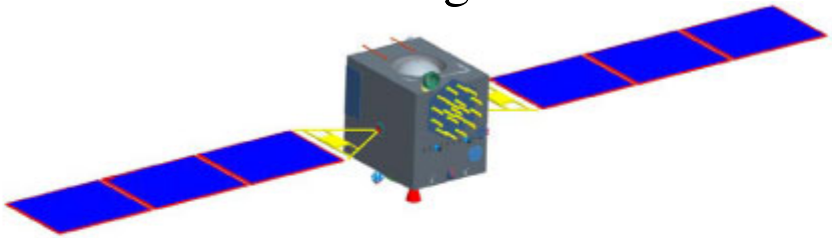
~100 satellites with laser retroreflectors (CCRs)



European Galileo:
30 satellites

Russian GLONASS:
24 global satellites

Chinese COMPASS:
20 global and 5
regional satellites



Galileo implementation plan

2 IOV satellites
launched Oct. 2011
2 IOV satellites
launched Oct. 2012

ETRUSCO-IRNSS (ISRO-INFN project)

80k€ co-funded Research Contract:
5 months tests
7 months science collaboration.

GOVERNMENT OF INDIA
DEPARTMENT OF SPACE
LEOS - ISRO
1st CROSS, 1st STAGE, PEENYA INDUSTRIAL ESTATE, BANGALORE 560058
PURCHASE

Ph No: 080-28398836
Fax 080-28391964

Date :28/11/2011

INVITATION TO TENDER

Our Ref No : LEAO **2011-000261-01**
Tender Due: 16:00 **Hrs ISTon** 12/12/2011

M/s I00464
INSTITATO NAZIONALE DI FISICA NUCLEARE (INFN)
VIA ENRICO FERMI, 40-00044
FRASCATI (ROME)
ITALY
Ph: 00 39 0694031 Fx: -

Dear Sirs,

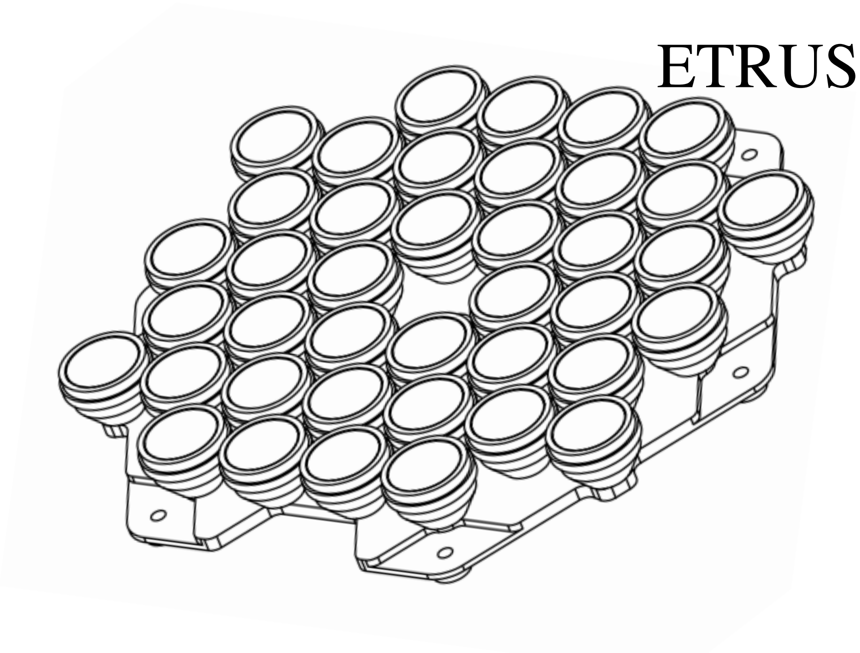
Please submit your sealed quotation , in the Tender Form enclosed here along with the descriptive catalogues / pamphlets /literature ,superscribed with Our Ref.No. and Due Date for the supply of the following items as per the terms & conditions mentioned in Annexure(Form No: ENCLOSED)

S.No.	Description of Items with Specifications	Unit	Quantity
1	FAR FIELD DIFFRATION PATTERN(FFDP)CHARACTERIZATION OF CORNER CUBE RETRO REFLECTOR ASSEMBLY IN THE SPACE CLIMATE CONDITIONS AS PER ENCLOSED RFP SPECIFICATIONS	set	1

DELIVERY AT:	LEOS-STORES
MODE OF DESPATCH	BY ROAD
DUTY EXEMPTIONS	WE ARE EXEMPTED FROM PAYMENT OF CUSTOM DUTY/ EXCISE DUTY.
SPECIAL INSTRUCTIONS	NIL
SPECIFIC TERMS	ENCLOSED

S.SUBRAMANYA
PURCHASE OFFICER
For and on behalf of the President of India
The Purchaser

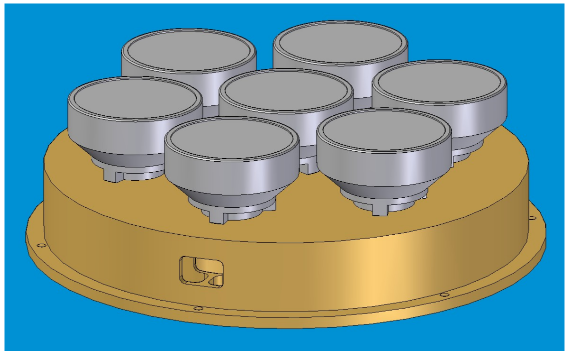
ETRUSCO-IRNSS, ETRUSCO- IOV

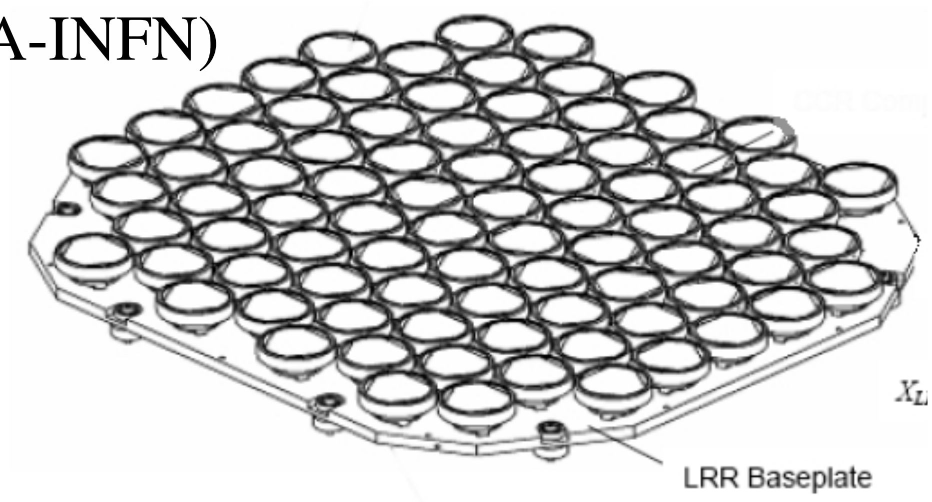


ETRUSCO-IRNSS (ISRO-INFN)

All arrays will **need large laser beam/ optical window** to test several, or all, reflectors at once

ETRUSCO-IOV (ESA-INFN)





GMES: from ESA Bulletin Feb. 2012

→ GLOBAL MONITORING FOR ENVIRONMENT AND SECURITY

GMES Space Component getting ready for operations

Monitoring of Environment with Galileo ("SatNav") and

Synthetic Aperture Radar (SAR)

SAR: Italy's CosmoSkyMed (CSK) and ESA's Sentinel-1

Next to Galileo, Global Monitoring for Environment and Security (GMES) is one of the two European Union flagship programmes in space, and another example of how space policy can contribute to improving European citizens' lives.

While the future of Galileo is secured through the EC's proposal to provide sufficient operational funding within the general budget of the EU, the long-term future of GMES has yet to be secured. Unexpectedly, last year the EC proposed to finance GMES outside the EU Multi-Annual Financial Framework (MFF), which covers the period 2014–20, suggesting instead to organise the required funding through a new intergovernmental mechanism.

In the GMES Space Component, the Sentinels and ground segment are currently in the final stages of their development and are getting ready for launch from 2013 onwards. Pre-operational data delivery from existing national and third party missions is well under way. What is most urgently needed now is securing the operational funds and consolidating the governance including Sentinel ownership and data policy.

G-CALIMES

- Continuation, enhancement and major extension of ETRUSCO/ETRUSCO-2 program with development of fundamental geometrodynamics networks in Earth and Space for
  - **Galileo**, and other **GNSS** (SatNav)
  - **GMES**: satellites for Global Monitoring for Environment and Security

New goal of ETRUSCO-GMES

Unify observations of Galileo & Cosmo constellations, through absolute laser inter-calibrations in Earth & Space

"GMES will provide us with crucial imagery and data on the environment, which will enable us to understand better and mitigate climate change. It will also make our agriculture and fishery more efficient. This in turn will guarantee better food quality and food security. It will also be of great help in crisis response in emergency situations during natural or manmade disasters."

J.M. Barroso, President of the European Commission, November 2011

Who are the users of GMES?

Based on global observations, GMES services, developed in close collaboration with users, will provide essential information in three Earth-system domains (atmosphere, marine and land) and three cross-cutting domains (emergency management, security and climate change).

These services, once operational, will provide standardised multi-purpose information common to a broad range of EU policy-relevant application areas:

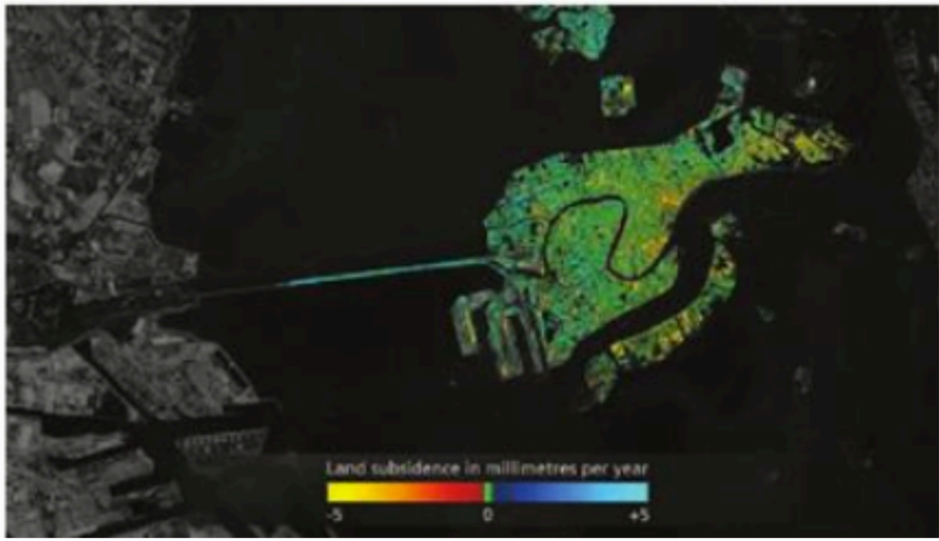
- GMES Marine Monitoring Service: focused on areas such as marine safety and transport, oil spill monitoring, water quality, weather forecasting and the polar environment.

European Union Satellite Centre), private business and individual citizens. A large variety of commercial industry segments will also benefit through the development and provision of operational geo-services.

At a regional level, GMES is already used to monitor air quality, map coastlines, regional areas and urban expansion and to manage marine and agricultural resources. GMES also plays a key role in disaster management and prevention.

On air quality, for instance, GMES currently provides daily (three-day) air quality forecasts and historical records of key industrial pollutants such as ozone, nitrogen dioxide, sulphur dioxide and aerosols for the major cities and regions of Europe. The forecasts form the basis for the management of health risks of citizens suffering from asthma or other symptoms. The

From ESA Bulletin Feb. 2012



← Very high resolution map of land subsidence in Venice (mm/year), with data collected from May 2008 to April 2010 showing over 1.5 million point measurements (ESA/DLR)

CSN5-LNF manpower for 2013

66.7 FTE
out of

SEZIONE	NOME COGNOME	TIPO	CONTRATTO	QUALIFICA	RICERCATORI	TECNOLOGI	TOT. PERS.	FTE
!CHAOS					1	2	3	1.0
3L-2D					2	2	4	1.3
BEAM4FUSION					2	2	4	1.7
ETRUSCO-GMES					10	7	17	13.3
I-FCX					4	2	6	1.4
MANESCO					8	1	9	4.0
NESCOFI@BTF					2	5	7	3.0
NEXTARCH					6	2	8	1.8
NORCIA					7	3	10	4.0
NTA-ELI					2	7	9	1.3
NTA-EUROFEL					2	3	5	0.9
NTA-ILC						1	1	0.1
NTA-IMCA					12	1	13	7.2
NTA-LC					3	6	9	1.8
NTA-PLASMONX						2	2	0.5
NTA-SL-COMB					5	9	14	3.1
NTA-SL-EXIN					3	7	10	2.1
NTA-SL-G-RESIST					3	1	4	1.1
NTA-SL-POSSO					4	1	5	2.5
NTA-SL-THOMSON					4	7	11	2.3
NTA-SUPERB					6	9	15	4.3
ODRI2D					1	2	3	1.1
RDH					4	2	6	1.2
SLEAR					6		6	3.5
SL_FEMTOTERA					5	1	6	1.6
SPACEWEATHER					1	3	4	0.6