Summary of technological and interdisciplinary research activities (INFN-CSN5) at LNF/Cosenza (CS)

Simone Dell'Agnello, CSN5-LNF Coordinator

47th Meeting of the INFN-LNF Scientific Committee
Nov 14, 2013

Outline

- CSN5 R&D Areas
- CSN5 Experiments
- Summary of CSN5 Experiment Highlights
- MIUR funding for “Progetti Premiali”
- Conclusions

CSN5-LNF R&D Areas (I)

- **Accelerators and related technologies**
  - Mainstream activity at LNF
  - CSN5-LNF not = LNF Accelerator Division (AD) !!
  - Institutional/international AD activities (DAFNE, SPARC_LAB, DAFNE-LIGHT, BTF, etc.) managed by other and higher entities, with additional funds
  - Strategy of CSN5-LNF experiments: R&D integrated, synergetic with AD, providing important support and stimulus to current and future AD activities, also for other Accelerator Labs in which INFN is involved (CERN, etc.)
  - **Experiments = 11, FTE = 26**

CSN5-LNF R&D Areas (II)

- **Detectors and Electronics**
  - **Experiments = 3, FTE = 5.5**
    - Neutron calibration and metrology facility (NEURAPID); **FTE = 2.1**
    - Hybrid detectors for neutrons (HYDE, Cosenza); **FTE = 1.3**
    - GEM applications to plasma diagnostics & neutron detection (BEAM4FUSION); **FTE = 2.1**
  - Strategy:
    - Neutron detection and metrology (also towards IRIDE applications on neutrons; see workshop http://agenda.infn.it/event/IRIDE_Neutroni)

CSN5-LNF R&D Areas (III)

- **Interdisciplinary physics**
  - **Experiments = 2, FTE = 10.8**
    - Hadrotherapy (RDH); **FTE = 2.2**
    - Satellite laser ranging R&D for Galileo & Earth Observation (ETRUSCO-GMES); **FTE = 8.6**
      - Lunar R&D now CSN2 Experiment (MoonLIGHT-2)
      - SCF_Lab has 8.6 FTE in CSN5 and 8 FTE in CSN2
  - Strategy:
    - RDH: large-scale, mainstream INFN-led collaboration
    - SCF_Lab: characterize laser ranging/altimetry for GNSS, Earth Observation (EO), fundamental gravity. Target EU Flagship programs Galileo and Copernicus/GMES (EO)

R&Ds with "National" LNF Coordinator

CSN5 Experiment	R&D Area	National Coord.	FTE
NTA-SL-COMB	SPARC	M. Ferrario	3.0
NTA-SL-EXIN	SPARC	G. Di Pirro	2.5
NTA-SL-THOMSON	SPARC	C. Vaccarezza	6.5
NTA-IMCA	Acceler.	R. Cimino/R. Larciprete	2.0
3L_2D	Acceler.	A. Drago	1.3
NORCIA	Acceler.	G. Gatti/B. Spataro	4.0
ETRUSCO-GMES	Interdisc./ SCF_Lab	S. Dell'Agnello	8.6
NEURAPID (New)	Detec/Electr.	R. Bedogni	2.1
!CHAOS_14 (New)	Acceler.	A. Stecchi	3.1
PostD (MIUR Grant, New)	Acceler.	E. Chiadroni	1
PostD (CSN5 Grant, New)	***On-going selection, hopefully LNF will get one***		

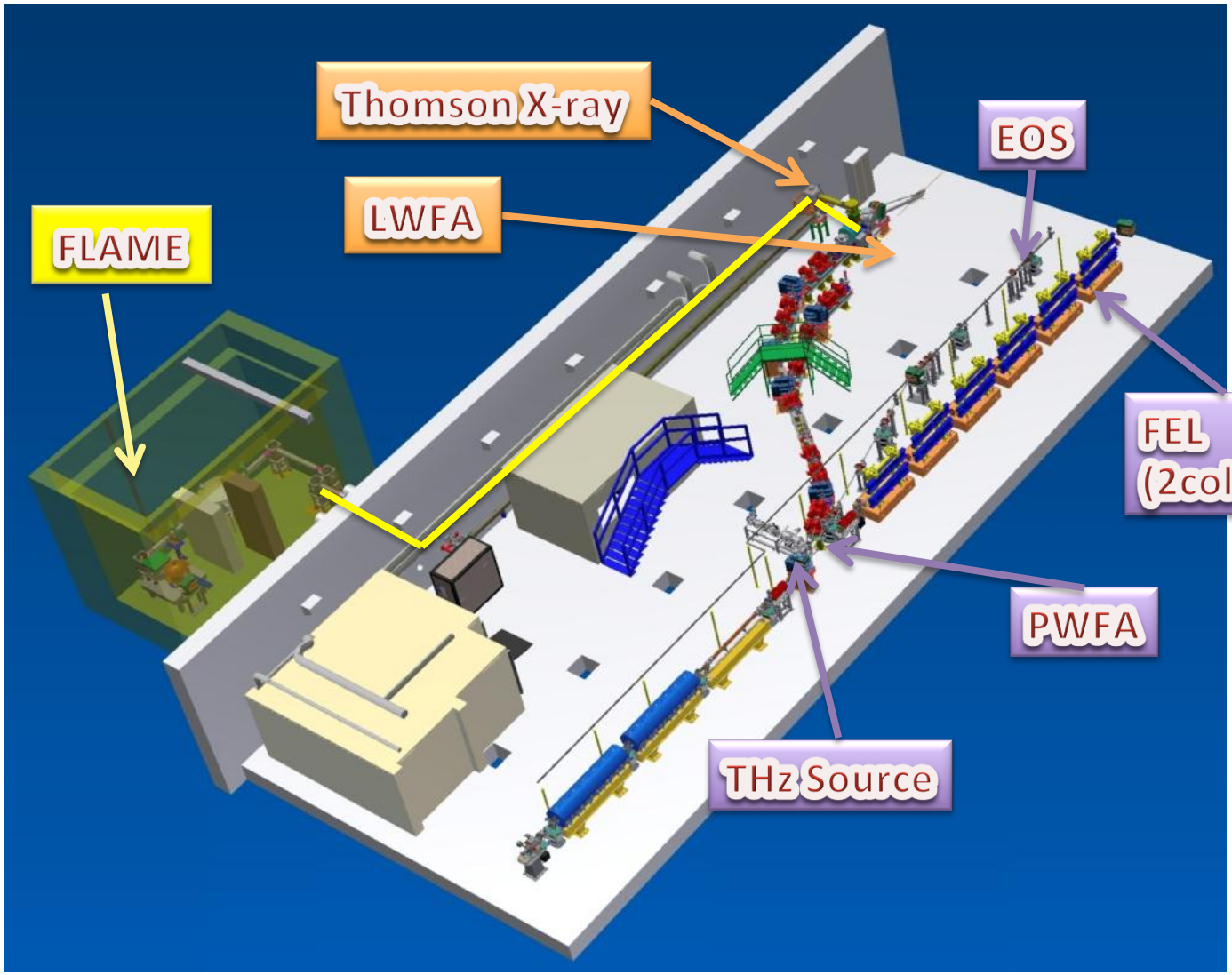
R&Ds with "Local" LNF/CS Coordinator

CSN5 Experiment	R&D Area	Local Coord.	FTE
RDH	Interdiscipl./ Hadrotherapy	E. Spiriti	2.2
HYDE	Detect/Electr	A. Mastroberardino (CS)	1.3
SL-FEMTOTERA	SPARC	E. Chiadroni	1.4
ODRI2D	Acceler.	E. Chiadoni	1.2
BEAM4FUSION	Acceler./ Detec/Electr	F. Murtas	2.1

Total FTE on CSN5-LNF/CS Experiments = 42.7

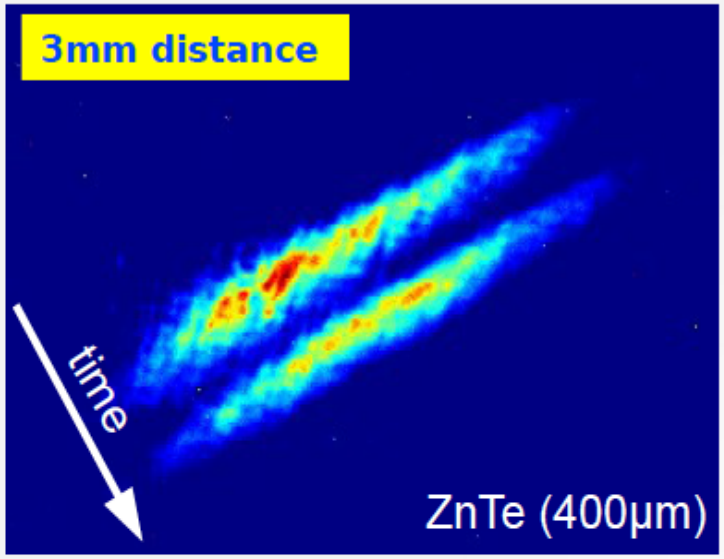
NTA-SL-COMB

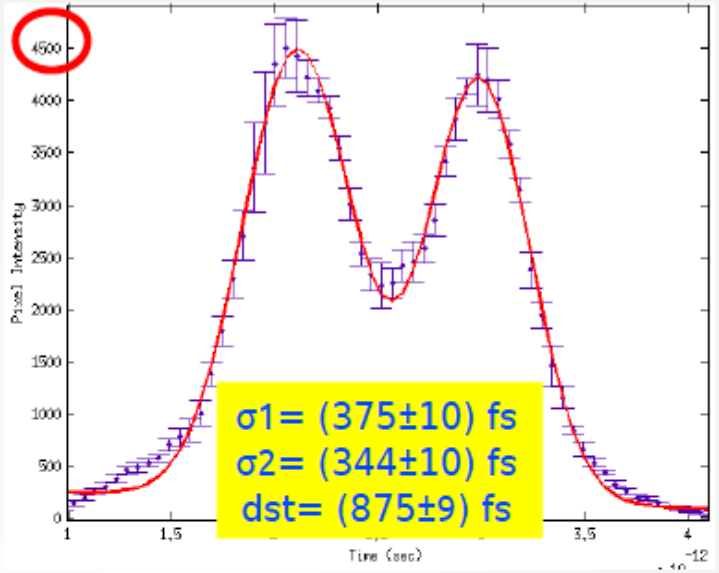
Massimo.Ferrario@LNF.INFN.IT



EOS = Electro-Optical Sampling

Single shot EOS signals





NTA-SL-EXIN (G. Di Pirro et al)

Electron beamlines

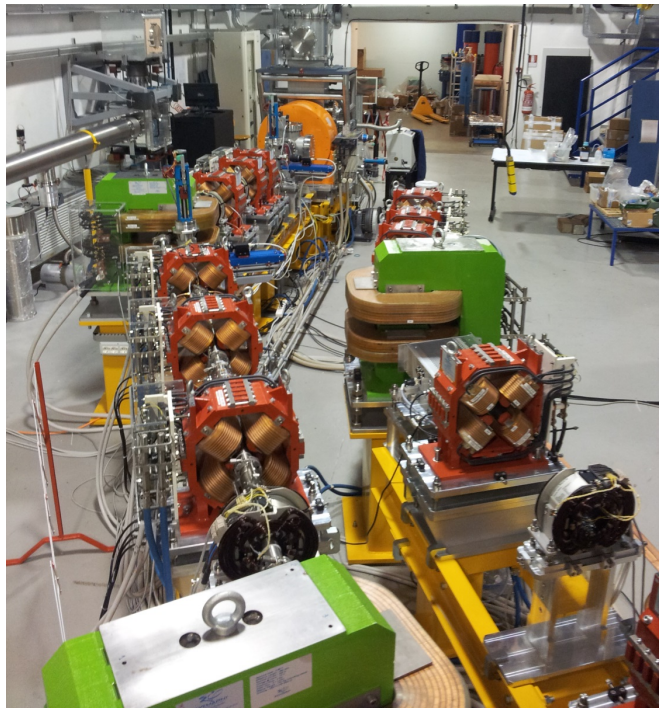
S
P
A
R
C
Hall
update

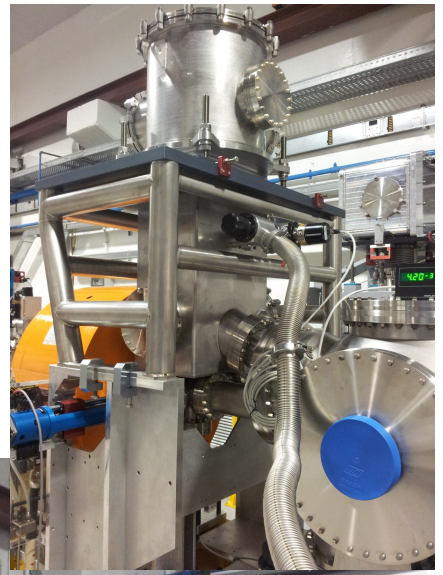
External Injection: Milestones 2014

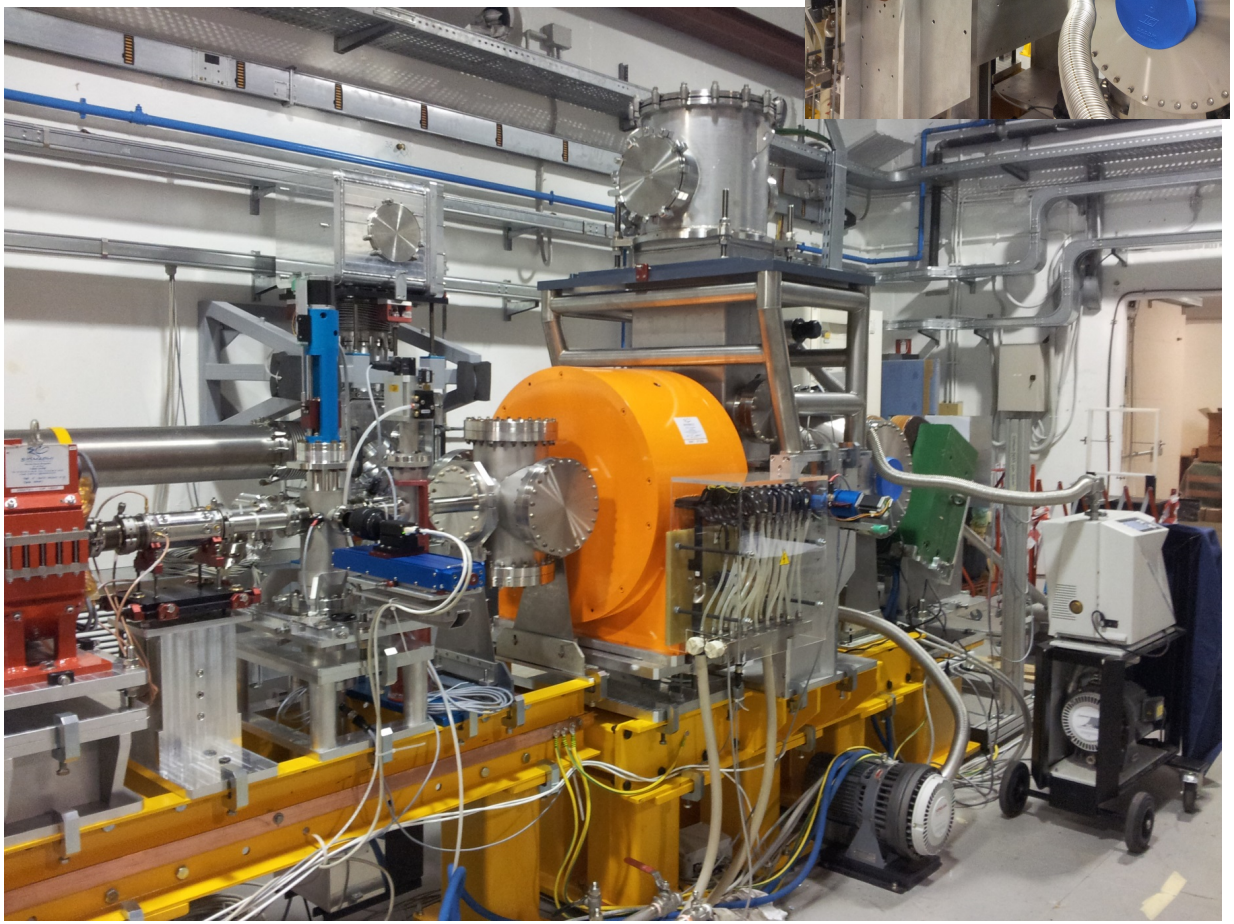
- **Complete Simulations for injection and acceleration in capillary**
- **Design electron diagnostic**
- **Design and implementation of the capillary holder (June 2014)**
- **Complete Design of Interaction Chamber and ready for installation (Dec 2014)**

NTA-SL-THOMSON

C. Vaccarezza et al







FORESEEN ACTIVITIES FOR 2014

After the completion of 2013 program (characterization X-ray beam and imaging performances both in absorption and in phase contrast at low energy):

- X-ray source characterization at higher energies up 500 keV
- Electron phase space studies before and after the Compton scattering for quantum model benchmark

NTA-IMCA (since 2011)

(Innovative Material and Coatings for Accelerators)

R. Cimino, A. Balerna, E. Bernieri, R. Larciprete

Laboratori Nazionali di Frascati

I. Masullo, V. Vaccaro et al

INFN- Na

S. Petracca, A. Stabile, et al

INFN Salerno e Università del Sannio

International collaborations:

CERN, SLAC, ANKA, DESY, Cornell, RICH, SuperKEKB.

2014 Activity

Identification, validation of materials (LNF) and their impedence analysis (Napoli, Salerno) with respect to their behavion for e-cloud effects

Activity in support of CSN1 (UA9 Experiment)

- *Validation of impedance and e-cloud compatibility of collimators funded in CSN1 to be used at LHC*

Activity for LHC and LHC High Lumi:

- *LHC run at 25 nsec. Need to solve e-cloud problems related to: efficiency of cold "scrubbing" both in dipoles (Cu) and in SPS (SS) ; behaviors of ceramic Kickers; detailed analysis of SEY at low energy*
- *High Lumi upgrade : need to control "single bunch instabilities" with accurate measurements of PEY and R*

NORCIA

NOvel **R**esearches **C**hallenges **I**n **A**ccelerators

(*Responsible:* G. Gatti/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 project is dedicated to the R&D of key components for existing accelerators and for next generation of accelerators

RF cavities

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

***FIRB2012**: Project of research funded by the Italian Government (March 2013-March 2016)*

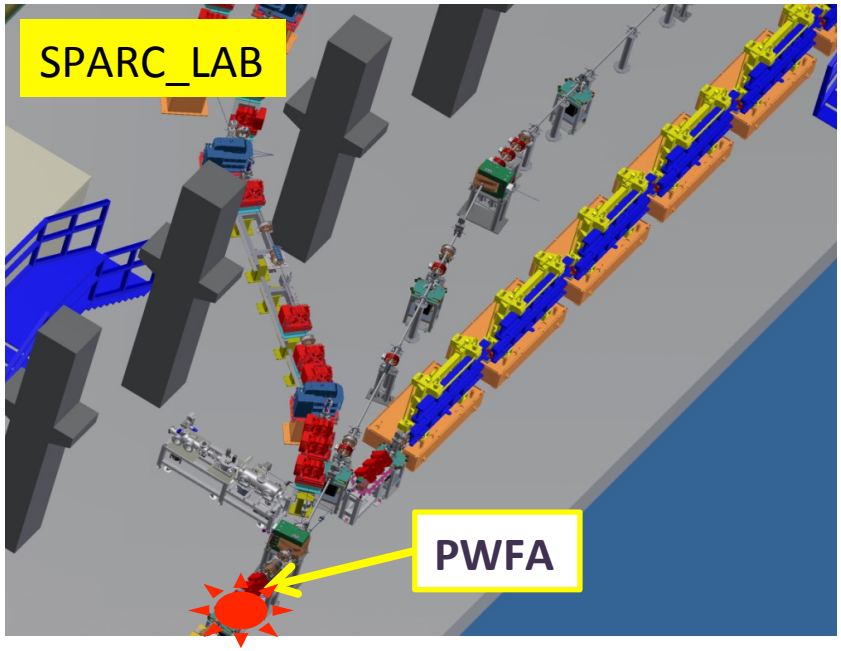
Enrica Chiadroni

Generation of high brightness electron beams from plasma-based accelerators

External injection of electrons to be accelerated in the plasma (Particle-driven Plasma WakeField Acceleration)

- Single bunch or comb beam
- Ramped bunch train
  - Bunch length < 100 fs
  - 200 pC
  - ε_n = 1 mm mrad

The main issue is on the quality of the accelerated electron beam, in terms of peak current, emittance, energy spread, stability, repeatability, for future applications, e.g. FELs, multi-staging compact colliders, advanced radiation sources



3L_2D
(A. Drago et al)

- Time Resolved e+/e- Light in 2-Dimension
- Built **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 positron beam to study parasitic e-cloud behavior
- Test/data taking in DAFNE e- ring and other storage rings foreseen to evaluate 2D instabilities and the detector performance

NEURAPID: NEUtron RAPId Diagnostics

Roberto Bedogni et al **(INFN-LNF, INFN-Milano)**

First Generation

NESCOFI@BTF (2011-2013), detectors for neutron spectra in real time from eV to GeV:
CYSP (Cylindrical spectrometer) e **SP²** (spherical spectrometer)

CYSP

- 8 detectors of thermal neutron in eV-GeV in given direction
- Emissions from targets as a function of emission angle

SP²

- 31 detectors of thermal neutron in eV-GeV, omindirectional
- Radioprotection
- Area monitoring

Mission

New generation neutron detectors for:

- **Very high sensitivity**
- **Rapid acquisition dynamics**
- **Response directionalty**

Applications

(i) LASER-BASED neutron production

(single shots of duration ~fs and instantaneous powers ~TW)

Diagnostics (application A1)

Radioprotection/area monitoring (applic. A2)

(ii) COSMIC RAYS MEASUREMENTS (applicazione A3)

Ground Level Enhancement

Radioprotection of astronauts

Deliverables

CYSP-one: CYSP, capable of working in pulsed mode or space mode (applic. A1 e A3)

SPEEDY: spheric, for Area Monitor (simplification of SP^2) for dosimetry and radioprection at pulsed facilities (applic A2)

LATND *(**L**arge **A**rea **T**hermal **N**eutron **D**etectors)*. Detectors x10 more sensitive SP^2 CYSP

ETHERNES *(**E**xtended **THER**mal **NE**utron **S**ource)*
New LNF facility for **metrology measurement**

Flux: 500 cm^{-2} s^{-1} uniform over 20 cm x 20 cm. Source: Am-Be da 2.7, moderator of 1 tonn. polyethilene

Test & calibration of new thermal neutron detectors of large area (LATND, ~ tens cm^2)

Only existing such facility is in UK, access is by payment

ETHERNES: radioprotection, users of future IRIDE-neutrons or similar facilities, detectors for nuclear fusion (BEAM4FUSION), applications of neutron activation, scattering, electronics chip irradiation.

INFN
Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati

BEAM4FUSION and INFN-E Activity

F.Murtas (INFN-LNF & CERN)

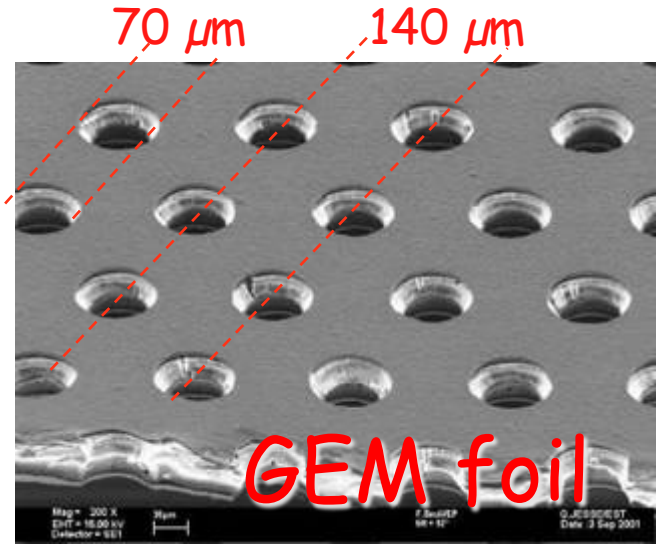
Triple GEM detectors : application on plasma diagnostics and neutron detection.

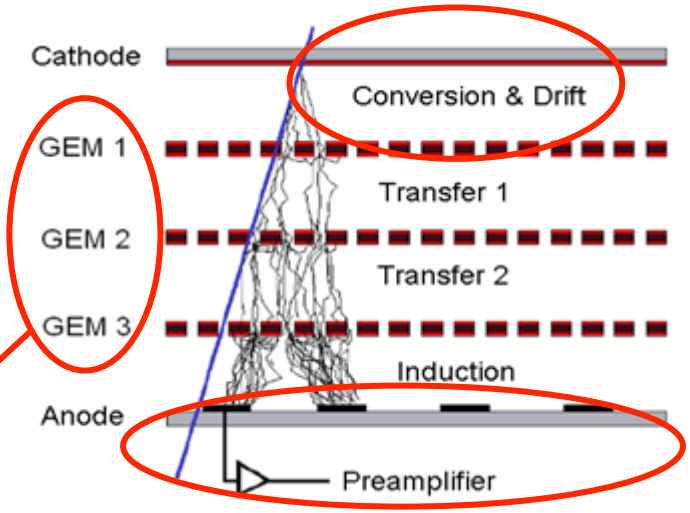
A.Balla, G.Claps, G.Corradi, G.Croci, A.Pietropaolo, S.Puddu, L.Quintieri, D.Raspino, D.Tagnani

A triple GEM Chamber

A Gas Electron Multiplier (F.Sauli, NIM A386 531) is made by 50 μm thick kapton foil, copper clad on each side and perforated by an high surface-density of bi-conical channels;

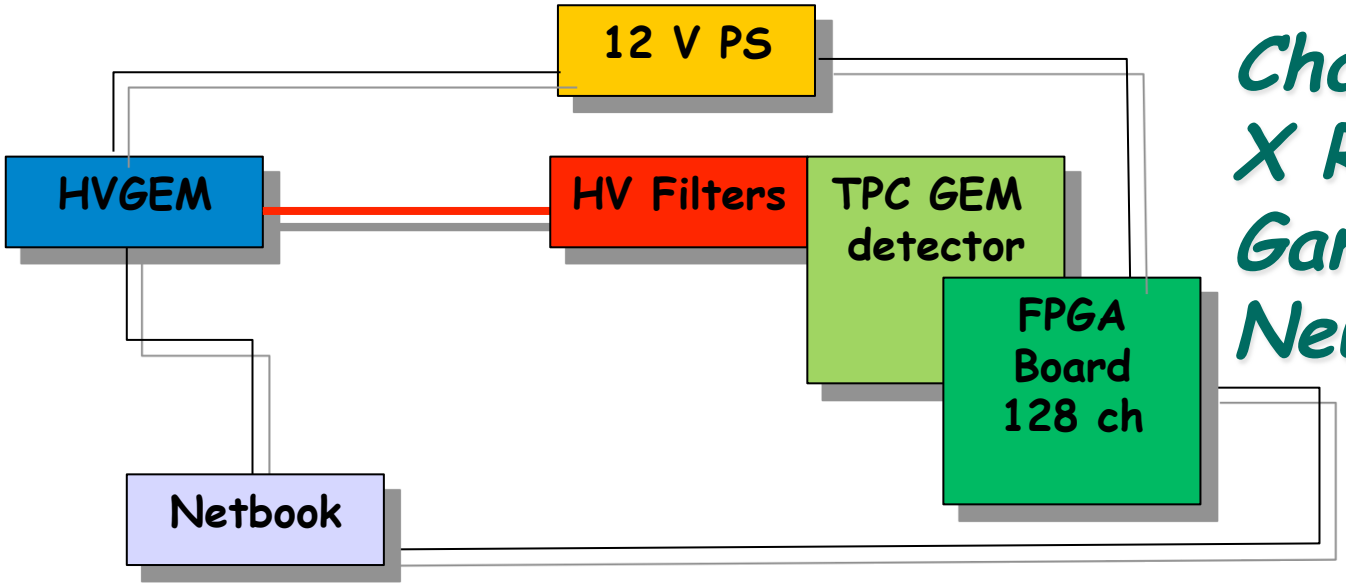
Several triple GEM chambers have been built in Frascati since 2001 (LHCb, Dafne Upgrade, KLOE2, UA9, IMAGEM, GEMINI, AIDA/BTF …





Working with different levels of gain it is possible to obtain high level of gamma-neutron discrimination

A triple GEM detector system



Charged particles
X Ray
Gamma Ray
Neutrons

Applications in:
Medical diagnostics and tumor treatment
Industrial materials
Nuclear plants: fission and fusion
Neutron Spallation Source

Main Characteristics

The main characteristics are :
- Extended dynamic range (from single particle up to 10^8 partcles cm^{-2} s^{-1})
- Good time resolution (5 ns)
- Good spatial resolution (200 μm)
- Radiation hardness (2C/cm^2)

Thanks to these characteristics a GEM detector can be used for:
- plasma imaging for fusion reactors (tokamak) neutron and X rays,
- diagnostics for beam particles (high energy physics)
- detectors for fast and thermal neutrons ,
- medical applications (diagnostics eand therapy):
    - medical diagnostics medicale in gamma theray;
    - medical diagnostics in hadro therapy;
    - steress diagnostics in industrial applications;
- environment monitoring;

Summary

- ✓ The triple GEM tecnology is very relayable and usefull for different applications in different science and technology fields
- ✓ With different pads configuration and drift, different spatial resolutions can be obtained, up to 80 micron.
- ✓ In Frascati we develope a compact and complete system
- ✓ The FPGA based Mather Board semplifies the Data Acquisition and the HVGEM allow a very fine tuning of the detector; their power supply can be provided by a simple portable swicth power pack
- ✓ Two GEM monitor has been insitalled in two TOKAMAKS, Frascati and Cadarache, for neutrons and X ray respectivelly
- ✓ Recently very good results have been obtained at RAL (ISIS) for the neutron beam monitor
- ✓ Developments are in progress regarding high flux thermal neutron measurements and high efficiency detection (He3 replacement)

SCF_Lab

Satellite/Lunar/GNSS
laser ranging and altimetry
Characterization **F**acilities **Lab**oratory

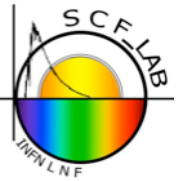
R&D and Services on laser retroreflector-based Geometrodynamics for Fundamental Gravity, GNSS, Copernicus/GMES, Earth Observation

External funds:

3.5 M€ in ~10 years

7 projects: ASI × 4, ESA, Ministry of Defence, Indian Space Research Organization

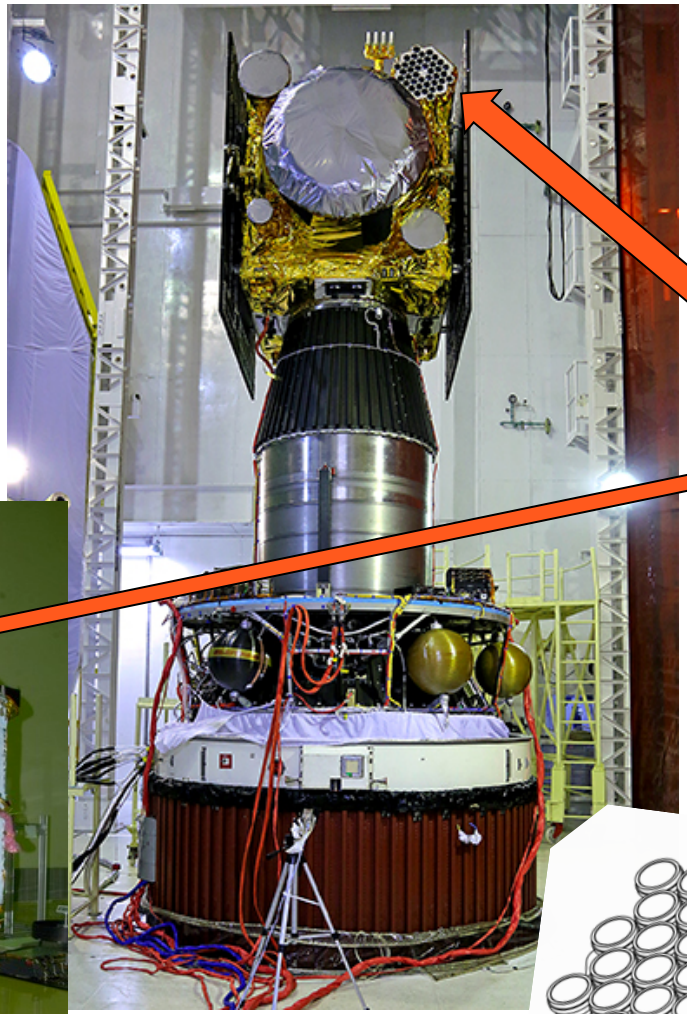
G-CALIMES: **Defense-INFN** Contract



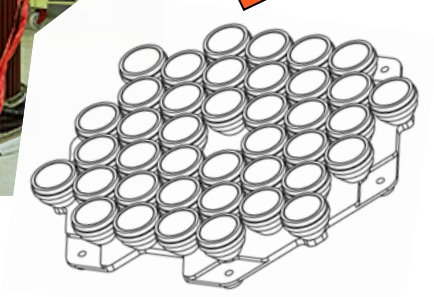
- **1.2 M€, on-going, 2.5 years**
- Continuation and extension of R&D for Galileo (ETRUSCO) to GMES and EO (Earth Observation)
  - Development of Galileo/radar/laser retroreflector positioning networks in Earth and Space for
    - **GMES**: Global Monitoring for Environment and Security
    - Galileo-Cosmo-skymed Absolute Laser Intercalibration
    - **Galileo**, and other **GNSS** (GPS, GLONASS, COMPASS, QZSS)

ISRO-INFN Contract for SCF-Test of IRNSS

(ETRUSCO-IRNSS project, ongoing, 1 year, 80 k€)



Laser Reflector Array



HYDE

HYbrid DEtectors for neutrons

2012-2014

LNL-PD/TN
Gruppo Coll. Cosenza
(Frascati)

Production of hybrid scintillator-3D silicon detectors for the detection of fast and thermal neutrons

FTE for Cosenza Group (linked to LNF) 2013

Person	Role	FTE
Anna Mastrobernardino	RU	30% (Resp Loc)
Marco Schioppa	PA	10%
Giancarlo Susinno	PE	30%
Antonio Policicchio	Ass.	30%
Daniela Salvatore	Ass.	30%
Francesco Pellegrino	TC	50%
Total FTE		**1.30**

Competitively-awarded Projects with additional funds from Ministry of Research (MIUR) synergetic with CSN5-LNF R&D (***Progetti Premiali***)

Project name	**R&D Area**	**Funding**
SPARC_ LAB Upgrades	SPARC_LAB	5.611 M€
Laser Ranging to Galileo	SCF_Lab	0.916 M€ (ASI!)
!CHAOS: a “cloud of controls:	Accelerators	0.591 M€

Under consideration for approval by Parliament Committees, 2° iteration

Conclusions

- 16 Experiments on:
  - Accelerators (11), Detector/Electronics (3), Interdisciplinary Physics (2), 42.3 FTE
- Defined strategies:
  - Support/stimulus to DA
  - New detectors for neutron applications
  - Hadrotherary and Flagship Space applications
- Busy year for CSN5: no more NTA, competitive R&D 'Calls' and R&D 'PostDoc Grants' for youths
- Good harmonization and synergism in progress or personnel and resources in the framework of CSN5