Ministero degli Affari Esteri
e della Cooperazione Internazionale

Grande Rilevanza

Cina
Physics and Astrophysics with particular reference to quantum technology and dark matter

Attenzione! Domanda ancora in bozza

Identificativo	***

Elementi generali

Area di ricerca	**Physics and Astrophysics with particular reference to quantum technology and dark matter**
Titolo (in Italiano)	**Progettazione, Industrializzazione e Produzione di un innovativo Micro Pattern Gas Detector (MPGD) basato sulla tecnologia micro-RWELL**
Titolo (in altra lingua)	**Design, Industrialization and Production of an innovative Micro Pattern Gas Detector (MPGD) based on the micro-RWELL technology**
Parola chiave #1	**MPGD**
Parola chiave #2	**micro-RWELL**
Parola chiave #3	**CepC**

Ente proponente italiano

Struttura	**Istituto Nazionale di Fisica Nucleare (INFN)**
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Ente pubblico	**Sì**
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IBAN	**IT22Q0200839105000401277684**
Banca	**UNICREDIT FRASCATI INFN**

Responsabile scientifico italiano

Titolo	**Dr.**
Cognome	**BENCIVENNI**
Nome	**GIOVANNI**
Qualifica	**Primo Ricercatore**
Indirizzo	**VIA ENRICO FERMI 40**
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C.V.

1983-1992:Responsible for the test of HCAL PSTs of the ALEPH experiment at LEP and the construction of the Muon Chambers of the experiment.
1990-1993:I introduced the concept of Glass Spark Counter (GSC) and I was PI of two projects funded by the INFN Agency, “Commissione Nazionale V”, for the R&D on GSC.
1994-2000:Responsible for the design and construction of the large KLOE Drift Chamber.
1999-2000:I participated in the proposal of MONOLITH for the detection of the atmospheric neutrino oscillations at the LNGS.
2000-2009:Responsible of the LNF-GEM group for the R&D, design, and construction of the GEM detectors for the Muon apparatus of LHCb.
2007-2014:I have introduced the new concept of Cylindrical-GEM (CGEM) detector, being responsible of the KLOE-IT group activities for the R&D and construction of the CGEM for the KLOE.
2008-present:LNF-group Supervisor in the RD51 Collaboration for the R&D on Micro-Pattern Gas Detector (MPGD).
2010-2015:Member of the RD51 Management Board.
2009-2011:LNF group Coordinator for the EU project “Joint-GEM: Ultra-light and ultra-large tracking systems based on GEM technology” in the framework of the “FP7–Hadron Physics 2”.
2010-2012:LNF group Coordinator of the project MIUR PRIN-2008, for the “Development of an ultra-light, full-sensitive vertex detector based on the innovative concept of Cylindrical-GEM”.
2012-2014:LNF group Coordinator in the EU project “Joint- GEM2:Engineering of ultra-light and ultra-large tracking systems based on GEM technology” in the framework of the “FP7-Hadron Physics 3”.
2014:I have introduced a novel MPGD, the micro-ResistiveWELL.
2015-2018:In collaboration with several INFN groups I have submitted to the Commissione Scientifica Nazionale V the proposal for project “MPGD_NEXT”. Supervisor of the WP1, devoted to the “Development of novel MPGD architectures”.
2015-2019:LNF group Coordinator in the EU project AIDA2020 for the “Development of a compact, spark-protected, single amplification-stage MPGD".

Pubblicazioni

1.Glass Electrode Spark counters and their use in low energy e.m. calorimeters, G. Bencivenni et al., Nucl. Instr. and Meth. A315 (1992) 507-512.
2.The kloe drift chamber construction, G. Bencivenni et al., Nucl. Instr. and Meth. A419 (1998) 320-325.
3.High-rate particle triggering with triple-GEM detector, M. Alfonsi, G. Bencivenni et al., Nucl. Instr. and Meth. A 518 (2004) 106-112.
4.An ultra-light cylindrical-GEM detector as inner tracker AT KLOE-2, G. Bencivenni, D.Domenici, Nucl. Instr. and Meth. A581 (2007) 221-224.
5.The micro-Resistive WELL detector: a compact spark-protected single amplification-stage MPGD, G. Bencivenni, et al., 2015_JINST_10_P02008.

Membri gruppo di ricerca italiano

Cognome	Nome	Qualifica
Bencivenni	**Giovanni**	**Primo Ricercatore**
Cibinetto	**Gianluigi**	**Ricercatore**
Giacomelli	**Paolo**	**Primo Ricercatore**
Ranieri	**Antonio**	**Dirigente di Ricerca**
Bedeschi	**Franco**	**Dirigente di Ricerca**
Maggiora	**Marco**	**Professore Associato**

Ente proponente straniero

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Indirizzo	**No.96, JinZhai Road Baohe District,Hefei,Anhui, 230026,P.R.China**
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Ente pubblico	**Sì**

Responsabile scientifico straniero

Cognome	**Liu**
Nome	**Jianbei**
Qualifica	**Professor**
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C.V.

2000-2005 Ph.D. in High Energy Physics, The Institute of High Energy Physics, Chinese Academy of Sciences
1996-2000 Bachelor in Physics, Tsinghua University, China
Research Experience
2012-present Professor, ATLAS physics and MPGD R&D, USTC
2007-2012 Postdoctoral Research Fellow, ATLAS muon spectrometer and ATLAS physics, University of Michigan
2005-2007 Post-doc, BESIII drift chamber R&D and construction, The Institute of High Energy Physics, Chinese Academy of Sciences

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Pubblicazioni

1 - "Evidence for Electroweak Production of W±W±jj in pp Collisions at sqrt(s) = 8 TeV with the ATLAS Detector", Phys. Rev. Lett. 113, 141803(2014).
2 - "Measurement of the WW cross section in sqrt(s) = 7 TeV pp collisions with the ATLAS detector and limits on anomalous gauge couplings", P.L.B, 712(2012)289.
3 - "Measurement of the transverse momentum distribution of Z/g* bosons in proton-proton collisions at sqrt(s)=7 TeV with the ATLAS detector", P.L.B 705(2011)415.
4 - "Commissioning of the ALTAS Muon Spectrometer with Cosmic Rays", The ATLAS Collaboration, EPJC 70(2010)875.
5 - "A Beam Test of a Prototype of the BESIII Drift Chamber in Magnetic Field", J.B. Liu et al., Nucl. Instr. Meth. A 557(2006)436.

Membri gruppo di ricerca straniero

Cognome	Nome	Qualifica
Liu	**Janbei**	**Professore Ordinario**
Li	**Liang**	**Professore Ordinario**
Li	**Gang**	**Professore Ordinario**
Xu	**Yin**	**Professore Ordinario**

Descrizione delle attività in programma

Sintesi

The Chinese electron positron Collider (CepC, [1]) will provide unprecedented precision measurements of many electroweak quantities. Being the QCD background rather low, CepC will provide measurements highly complementary to those obtainable at hadronic colliders. These high precision measurements open the searches for very small deviations from Standard Model predictions that might be signs of new physics, i.e. Dark Matter. For this purpose it is of outmost importance that the detector, placed in one of the collision points of CepC, has the best possible muon detection system, since many of the measurements involve leptons, and more specifically muons, in the final state.
The object of the project is to develop a new gas detector, the micro-Resistive WELL (micro-RWELL [2,3]): a compact, spark-protected, single amplification stage Micro-Pattern Gas Detector (MPGD). The new technology exploits several solutions and improvements achieved in the last years for MPGDs. This detector is extremely simple to be assembled and does not require complex and time-consuming assembly making possible the engineering of the detector and leading to a technological transfer to private industries.
The project is of extreme interest for possible uses in CepC muon system improving its performance with respect to the current RPC-based design.
Key points of the technology are the scalability and production of large-area, high-performing detectors with industrial processes, that can lower the costs, and the mechanical flexibility that allows to adapt the micro-RWELL design to different geometries and applications. The project aims to prove these characteristics by developing and testing a large area planar prototype and a cylindrical prototype of micro-RWELL.
Those prototypes will reach their full potential when instrumented with the final ASIC currently under design for BESIII and thanks to the use of a new algorithm for treatment of analogic data, the "micro-TPC mode".

Obiettivi

This project aims to investigate detectors expanding beyond the present MPGD technology, and to develop (also for CepC and FCC) a new generation of detectors, based on the micro-RWELL scheme. This scheme, firstly proposed in LNF, has all the useful characteristics of present-day MPGDs, but is easier to build, more robust from the point of view of gas discharges (a problem common to all MPGDs) and has much lower cost per unit area.
The amplification stage of the detector, realized with a structure similar to a GEM foil, is embedded through a resistive layer with the readout board. The resistive layer (0.1 - 0.2 µm thick) is realized with DLC (Diamond Like Carbon) dry sputtering. The resistive coating is deposited on one side of the Kapton foil (50 µm thick), where the copper layer (5 µm) has been previously removed by chemical etching. The required surface resistivity, typically ranging from few tens to hundreds MOhm/square, is clearly a crucial parameter that must be optimized as a function of the required detector performance, such as rate capability, charge spread on the readout electrodes, spark amplitude quenching and maximum achievable gain. A cathode electrode, defining the gas conversion-drift gap, completes the detector mechanics.
The target performance for this detection technology are:
- spatial resolutions < 100 microns
- time resolution < 5 ns
- rate capability up to 50 kHz/cm2
- efficiency ~98%

The readout electronics of the proposed micro-RWELL prototype will be developed, starting from the electronics under design for the CGEM-IT in BESIII. In general, wide adoption of analog electronics for high energy physics experiment, combined with excellence of algorithms used to reconstruct the data, will definitely have great impact on industry, leading to very large orders, because future detectors in this field will have millions of channels.

Metodologia prevista

1. Detector development
The micro-RWELL exploits both rigid and flexible technologies:
- inherits and improves the GEM amplifying scheme with the peculiarity of a well defined amplifying gap, but ensuring higher and more uniform gain, with no transfer gap which non-uniformity can affect the detector gain;
- inherits the MicroMegas (MM) resistive readout scheme that allows a strong suppression of the amplitude of the discharges.
In a micro-RWELL the electron charge produced into the wells is totally and promptly collected onto the readout plane through the resistive layer, generating a fast electronic signal (O(100ps)). In addition, also ionic components contribute to the signal formation. Gain is strongly correlated with the shape and the geometric parameters of the well and the thickness of the Kapton foil providing the detector amplification stage.
Introducing a high resistivity layer between the amplification stage and the readout reduces the capability to stand very high particle fluxes: the larger is the radiation rate, the higher is the avalanche current drawn through the resistive layer and hence the larger is the drop of the amplifying voltage corresponding to a local decrease of the gain of the device. A suitable optimization of the value of surface resistivity and the introduction of a proper current evacuation scheme, providing the grounding of the resistive layer, should ensure high gain uniformity up to particle fluxes of the order of few MHz/cm2.
An accurate simulation of the detector is needed to investigate the output signal as a function of the relevant parameters (i.e. surface resistance).
The physical processes developing inside the detector will be simulated with GARFIELD. The goal is to provide the software infrastructure needed to predict detector performance, in terms of gain, efficiency and time resolution, in various conditions of geometry and gas used.

2. Frontend electronics
In BESIII Inner tracker upgrade, an innovative readout of GEM signals is being pursued, using Time to Digital Converters (TDC) to extract both the arrival time of the hit and the integrated charge, by working mostly in the time domain. The chip [4] has modularity of 64 independent channels and can accommodate a wide range of input capacitance, up to 100pF. UMC technology (0.11um) will be used as baseline for the ASIC development. Each channel features a front-end amplifier, optimized for the GEM detector, and a low-power TDC. The first version of the chip is currently under test with the BESIII CGEM detector prototype.

3. Reconstruction algorithms
The main goal is providing a stable space resolution in the range 100-150um, for non-orthogonal tracks and/or in presence of a high magnetic field (up to 1T), by combining charge-centroid and micro-TPC mode.
The combination of these methods have been successfully implemented for the analysis of the data taken with BESIII GEM prototypes achieving the unprecedented space resolution of ~190 µm in a 1T magnetic field for different angles of incident particles [5].

The project will develop with the following time scheme and task sharing ("m" stands for the month of the project) :

1. detector simulation (INFN,IHEP,NKU); m1-12.
2. detector design (INFN,USTC,SJTU); m1-12.
3. optimization and industrialization of the production processes (INFN); m1-18.
4. prototype characterization (INFN,IHEP,NKU); m12-24.
5. integration of the front-end electronics (INFN); m6-24.
6. development of reconstruction algorithms (INFN,IHEP,SJTU); m6-30.
7. production and test with beam of large area prototypes to prove scalability of technology and cylindrical micro-RWELL reusing the BESIII CGEM assembly tooling to prove the capability of the technology to be adapted to different geometry configurations and used as inner tracker in collider experiments. (INFN,USTC,SJTU,IHEP,NKU); m24-36.

Risorse finanziarie e umane di entrambi i Paesi

INFN-Ba: A. Ranieri et al (T1,T2,T4,T7 tasks).
INFN-Bo: P. Giacomelli et al (T2,T3,T4,T7 tasks).
INFN-Fe: G. Cibinetto et al (T2,T4,T5,T6,T7 tasks).
INFN-LNF: G. Bencivenni et al (T2,T3,T4,T7 tasks)
INFN-Pi: F. Bedeschi et al (T7)
INFN-To: M. Maggiora et al (T5,T6,T7 tasks)
&
SJTU: Liang Li (T2,T4,T6,T7 tasks)
IHEP: Gang Li (T1,T6,T7 tasks)
USTC: Jianbei Liu (T2,T4,T7 tasks)
NKU: Yin Xu (T1,T7 tasks)

Financial resources

from Italy: INFN will contribute to the project with E 150000 worktime value from staff personnel, E 20000 of travel expenses and E 20000 for consumables.

from PRC: the Chinese groups have applied with the same project to the NSFC for a contribution of CNY 1.5M about

Risultati attesi

This innovative detector aims to fulfill the following main requirements: effective spark quenching at large gain, compactness and high construction simplicity for large area covering as well as high space and time resolution in order to satisfy tracking and triggering

requirements in frontier HEP experiments at the future hadron and electron Colliders (HL-LHC, FCC, CepC) to search for Dark Matter candidates using leptons.
From this program we expect that the micro-RWELL has the same good characteristics than GEM detectors, but with improved reliability and ease of use.
The test of the two final detector prototypes, one planar with the large area and the other cylindrical, will prove the scalability and the flexibility of the detection technology that can be employed also for applications beyond the high-energy physics, such as X-ray and neutron imaging in industrial and medical application and homeland security.
The final results will be obtained by means of beam tests that will be performed with muons and pions (CERN and PSI). Both prototypes are expected to meet the target performance of spatial resolutions (< 100 microns), time resolution (< 5 ns), rate capability (up to 50 kHz/cm2) and efficiency (~98%).
The prototypes are expected also to show the performance homogeneity on a large scale, independently on the geometrical shape of the detector, and the possibility to easily operate a large number of channels.
Thanks to the micro-TPC cluster reconstruction the micro-RWELL prototypes are expected to maintain the same performance also in presence of a strong magnetic field, and that is of paramount importance for high energy physics magnetic spectrometers.
Besides the development of the innovative technology, the engineering and industrialization of micro-RWELL is one of the most important goals of the project: we expect to be able to begin a technology transfer of the manufacturing process to industrial partners.

Collaborazioni

A distinctive advantage of the proposed technology is that the detector does not require complex and time-consuming assembly procedures (neither stretching nor gluing), and is definitely much simpler than many other existing MPGDs, such as GEMs or MMs. Being composed of only two main components, the cathode and anode PCBs, the detector is extremely simple to be assembled.
The engineering of the detector essentially coincides with the technological transfer of the manufacturing process of the anode PCB to suitable industrial partners. The main advantage of this technology with respect to other MPGDs (such as GEM or MM) is that in principle most of the manufacturing steps are already available by a typical company working on multi-layer rigid and flexible PCB. In particular for the anode PCB manufacturing, apart from the DLC coating and the etching of the holes on the thin polyimide foil, the technology and the know-how are already available at the ELTOS Company (an Italian company located in the industrial area around Arezzo, specialized in rigid PCB).
While the DLC dry sputtering will probably still be performed by a specialized external company (at the moment this is done by a Japanese firm), the polyimide etching to realize the micro-hole pattern, currently in the hand of the PCB-Workshop of CERN, will be object of a technological transfer to any industrial partner.
The micro-RWELL technology could also be a much better option to cope with the more stringent requirements introduced in future experimental scenarios foreseen in the next generation particle accelerators, as CepC or FCC.
The collaboration with the BESIII experiment (at IHEP Beijing) will allow to save money by using infrastructure used for the development of the cylindrical GEM tracker, expensive tooling (e.g. ~30 kE for the aluminum molds for the cylindrical micro-RWell) and the design of the ASIC chip.

Bibliografia

[1] CEPC-SppC Preliminary Conceptual Design Report Volume I - Physics & Detector, Muhammd Ahmad et al., IHEP-CEPC-DR-2015-01, http://cepc.ihep.ac.cn/preCDR/main_preCDR.pdf
[2] The micro-Resistive WELL detector: a compact spark-protected single amplification-stage MPGD, G. Bencivenni, et al., 2015_JINST_10_P02008.
[3] Performance of micro-RWELL detector vs resistivity of the resistive stage, G.Bencivenni et al., submitted to Nucl. Instr. and Meth. A – NIMA-D17-00488.
[4] A custom readout electronics for the BESIII CGEM detector, M. Da Rocha Rolo et al., arXiv:1706.02267, submitted to JINST.
[5] The Cylindrical GEM Inner Tracker of the BESIII experiment: prototype test beam results, L. Lavezzi et al, arXiv:1706.02428, submitted to JINST.

PIANO ECONOMICO - FINANZIARIO

TABELLA 1: PREVENTIVO				
DESCRIZIONE	Numero	Importo unitario (€)	Totale (€)	
a. Viaggi e soggiorni ricercatori stranieri in Italia	4	2.500	10.000	
b. Viaggi e soggiorni ricercatori italiani all'estero	10	2.500	25.000	
c. Prestazioni professionali e/o di terzi	0	0	0	
d. Contratti per personale non strutturato	5	23.500	117.500	
e. Partecipazione a/ Organizzazione di workshops			10.000	
f. Pubblicazioni o altre forme di disseminazione			3.000	
g. Materiale consumabile			115.000	
h. Materiale inventariabile (max10% di TOTALE COSTI)			0	0,00%
i. Altro			0	
SUBTOTALE COSTI			**280.500**	
j. Costi per personale strutturato (min 30% - max 45% di TOTALE COSTI)			150.000	32,22%
k. Costi indiretti (max10% della somma SUBTOTALE COSTI + voce j.)			35.000	8,13%
TOTALE COSTI			**465.500**	

TABELLA 2: FONTI DI FINANZIAMENTO		
DESCRIZIONE	IMPORTO (€)	%
A. Cofinanziamento Ente Proponente	185.000	39,74%
B. Cofinanziamento richiesto al MAECI	240.500	51,66%
C. Cofinanziamento Ente estero	0	0,00%
D. Eventuale cofinanziamento altro	40.000	8,59%
TOTALE FINANZIAMENTI	**465.500**	

Specificare su quali voci della Tabella 1 sarà attribuito il cofinanziamento alle voci C. e D. della Tabella 2

The INFN CSNI will contribute with E 20000 of travel expenses and E 20000 for consumables through the budget assigned to the experiments BESIII, CMS, RD_FA and RD51.

In addition the Chinese groups have applied to the NSFC for a contribution of CNY 1.5M about E 210000.

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(1) Elenco materiale consumabile

Consumables	cost
consumables for lab activities	12000
raw material for prototype construction (DLC, kapton)	15000
small prototype	25000
meccanica per Test Beam	3000
PCB per chip ASIC	15000
Readout Card per lettura ASIC	10000
large area prototype	20000
cylindrical prototype	15000
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Total	115000

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(2) Elenco materiale inventariabile

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(3) Elenco altre spese
