

Application to the RD5I

G. Cibinetto

on behalf of the **BESIII** INFN
Ferrara group



Outline

- Presentation of the group
- The BESIII experiment
- Our involvement in MPGD activities

The BESIII Ferrara group

- The group is composed by people from University of Ferrara and INFN
- Physicists:
 - Diego Bettoni (research director, INFN)
 - Mauro Savrié (Faculty, UNIFE)
 - Gianluigi Cibinetto (researcher, INFN)
 - Elisa Fioravanti (Post Doc. INFN)
 - Isabella Garzia (Post Doc INFN)
 - Giulio Mezzadri (PhD UNIFE)
 - + undergraduate students from UNIFE
 - **+ the support of engineers and technicians of the mechanics and electronics workshops.**
- We have wide background in data analysis and particle detectors
 - Analysis on hadron physics (charmonium spectroscopy, form factors, hadron structure, ...)
 - Previous collaborations: E760/E835 (Fermilab), NA48 (CERN), BaBar (SLAC), LHCb (CERN).



Data analysis

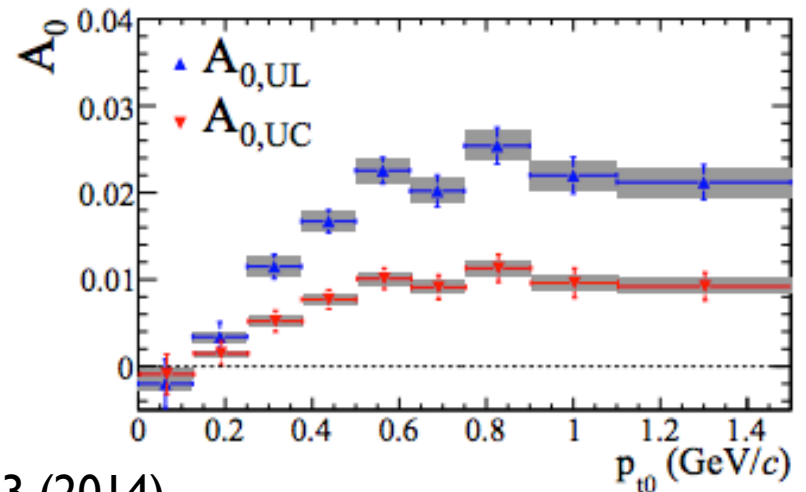
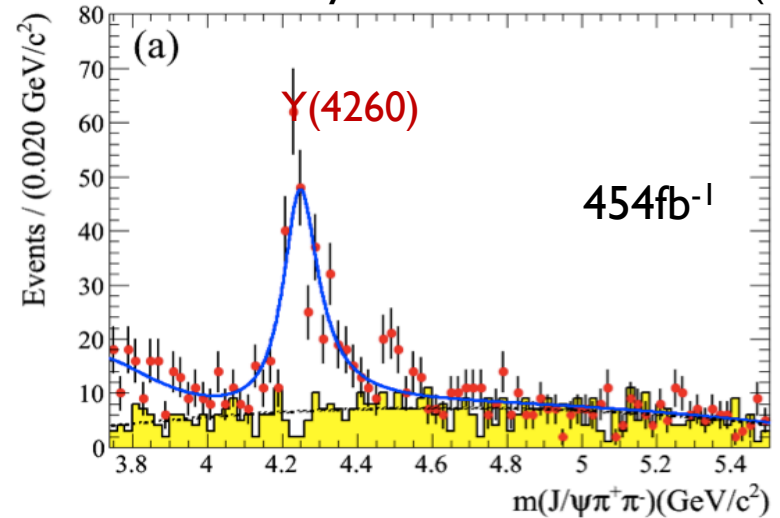
Measurement the J/ψ $p+p^-$ mass spectrum at BABAR and measurement of the $Y(4260)$ mass and width.

$$\begin{aligned} \text{Mass}(Y(4260)) &= 4244 \pm 5 \pm 4 \text{ MeV}/c^2 \\ \Gamma(Y(4260)) &= 114^{+16}_{-15} \pm 7 \text{ MeV} \\ \Gamma_{e^+e^-} X B(J/\psi \pi^+ \pi^-) &= 9.2 \pm 0.8 \pm 0.7 \text{ eV} \end{aligned}$$

Measurement of Collins asymmetries in inclusive production of charged pion pairs in e^+e^- annihilation at BABAR.

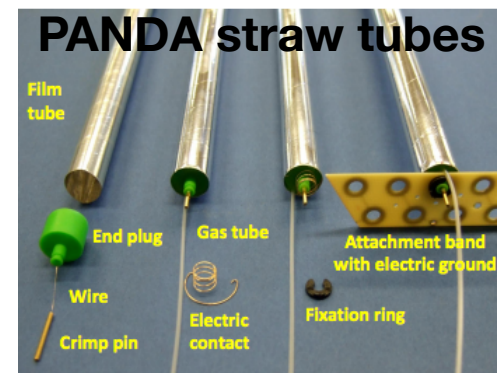
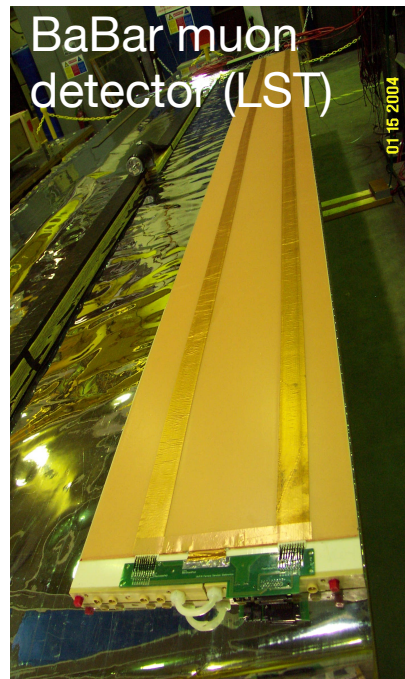
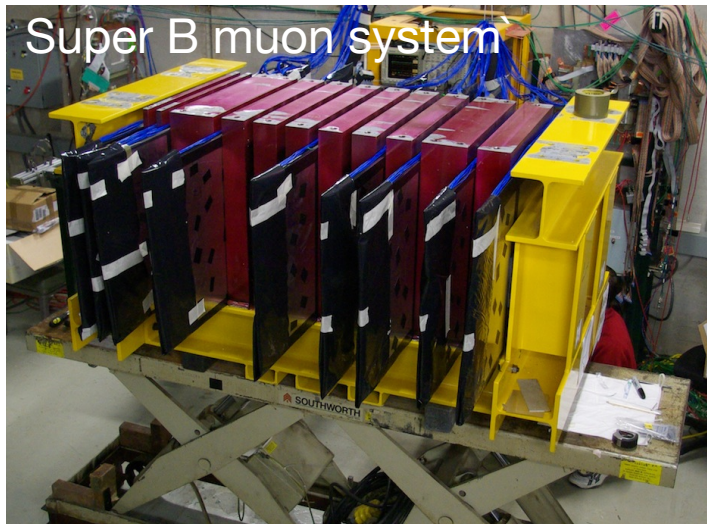
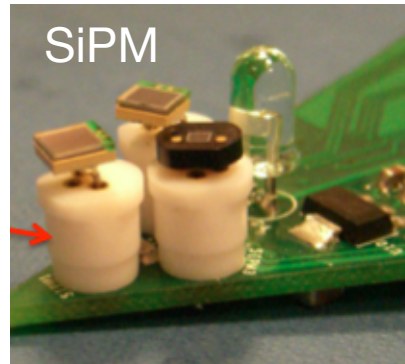
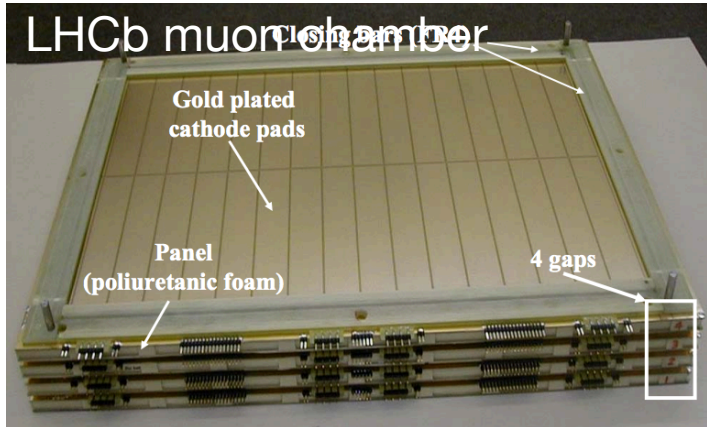
studying $e^+e^- \rightarrow q\bar{q} \rightarrow h_1 h_2 X$

Phys. Rev. D 86, 051102 (2012)



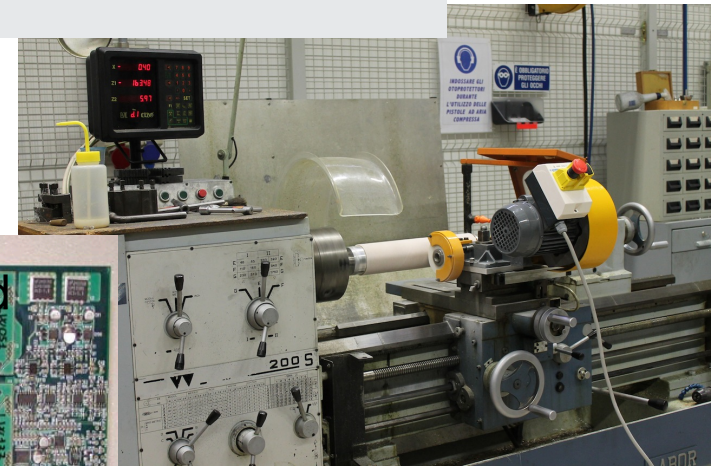
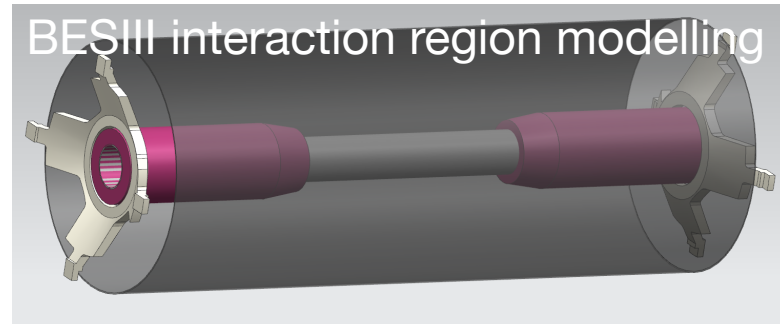
Phys. Rev. D 90, 052003 (2014)

Broad experience in particle detectors



Ferrara University and INFN Infrastructures

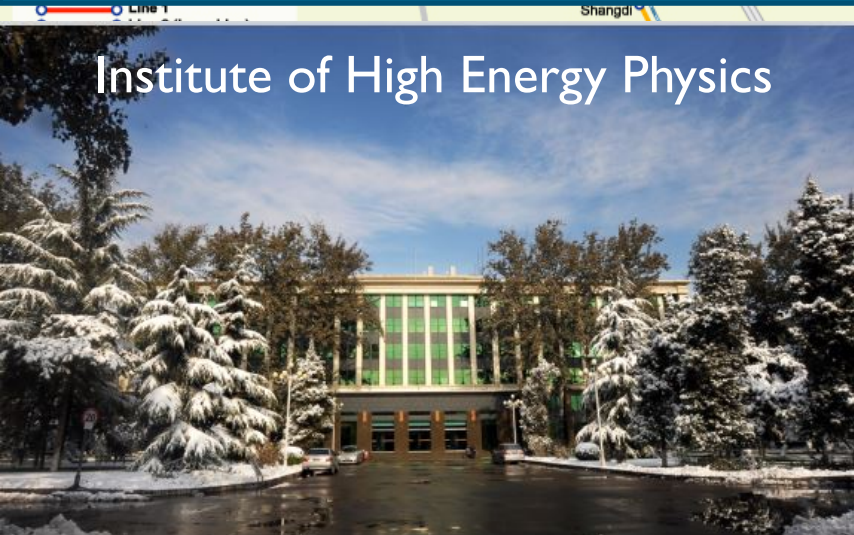
- Mechanics department, composed by engineers and technicians, provides expertise and manpower for detector design.
- The mechanical workshop provides support for the construction.
- Electronics department with large experience in the development of FEE for HEP experiments.
- INFN Ferrara has also a clean room for the assembly of detector prototypes.



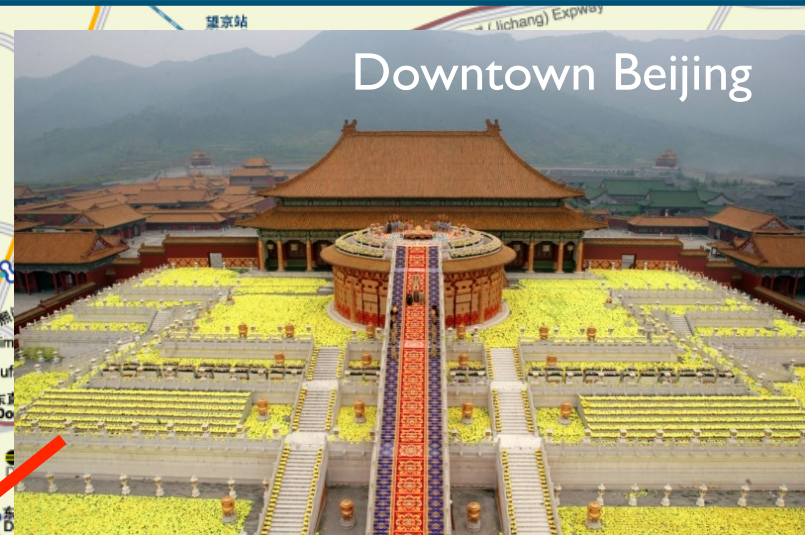
The BESIII experiment

BES-III (Beijing Spectrometer III) is τ -charm factory located at the Beijing e^+e^- collider BEPC-II working in the energy range from 2 GeV to 4.6 GeV.

Institute of High Energy Physics



Downtown Beijing



Very rich physics program: Charm, charmonium and exotic states spectroscopy, light hadrons, F.F., τ physics. BESIII has the world largest J/ψ and $\psi(2S)$ dataset.

The BESIII collaboration

53 institutions, more than 400 physicists

USA

Carnegie Mellon University, Indiana University, University of Hawaii, University of Minnesota, University of Rochester.



Germany

Bochum University, GSI Darmstadt, Helmholtz Institute Mainz, Johannes Gutenberg University of Mainz, Universitaet Giessen



Sweden

Uppsala University



Nederland

KVI/University of Groningen



Italy

Ferrara University, Laboratori Nazionali di Frascati, University of Turin, Perugia



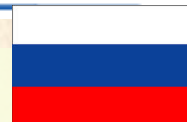
Turkey

Turkish Accelerator Center Particle Factory Group



Russia

Budker Institute of Nuclear Physics, Joint Institute for Nuclear Research



Japan

Tokyo University



China

31 institutions

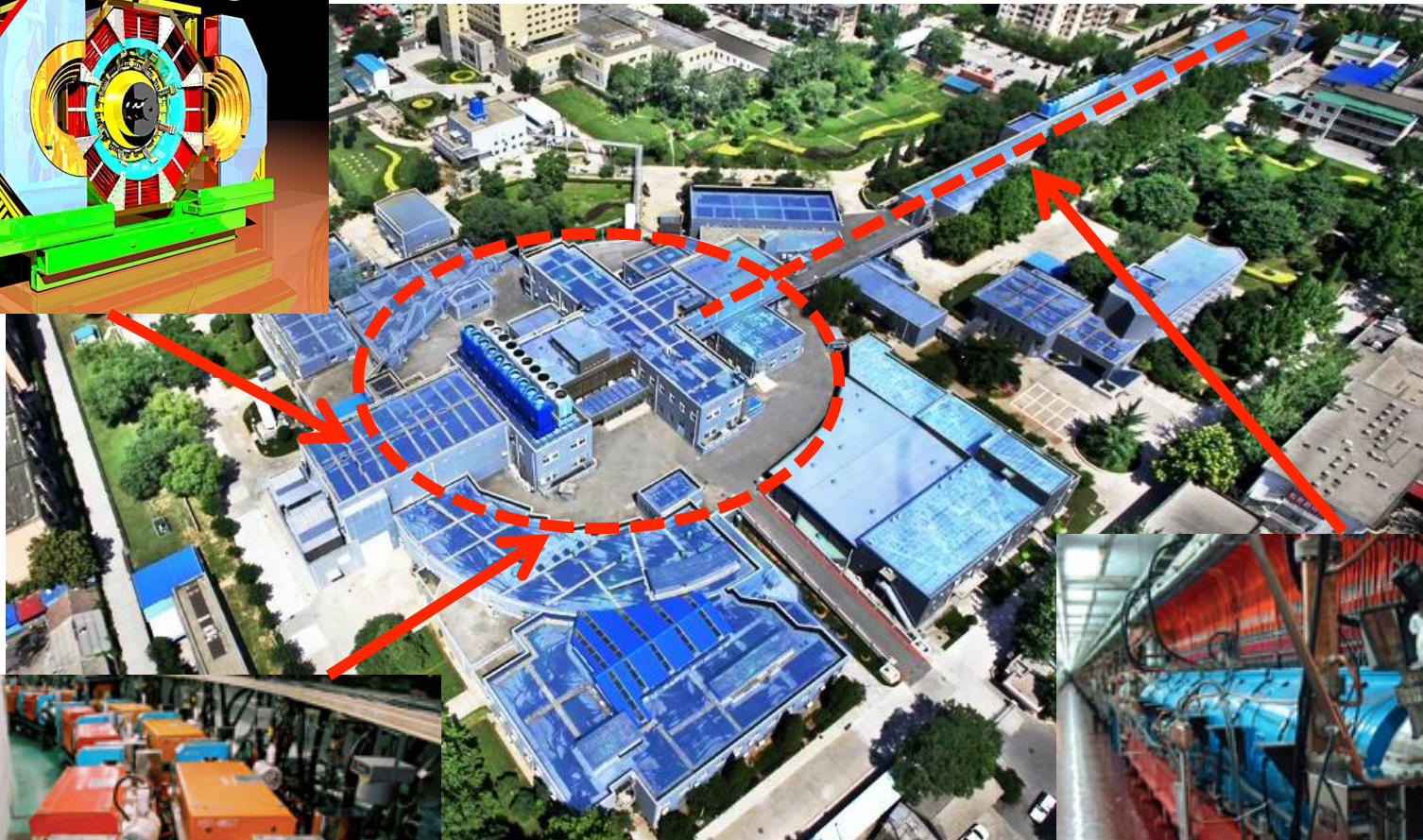
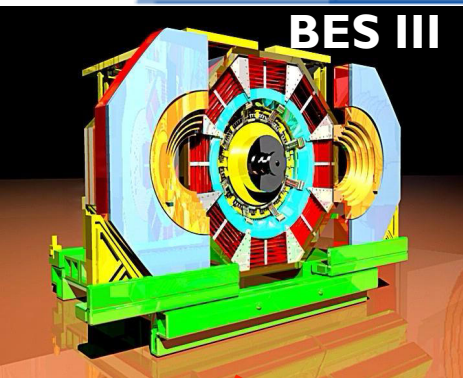


Pakistan

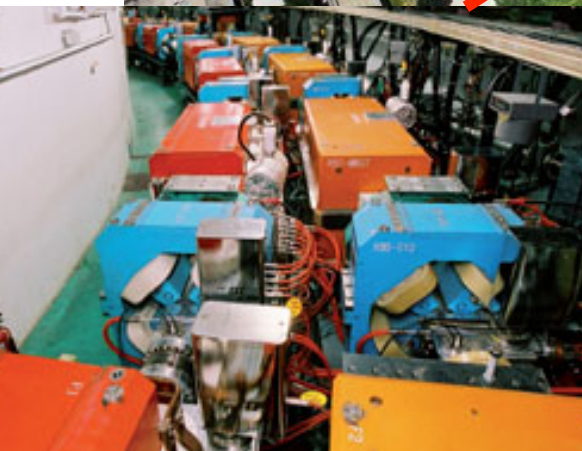
Institute of Information Technology, University of the Punjab.



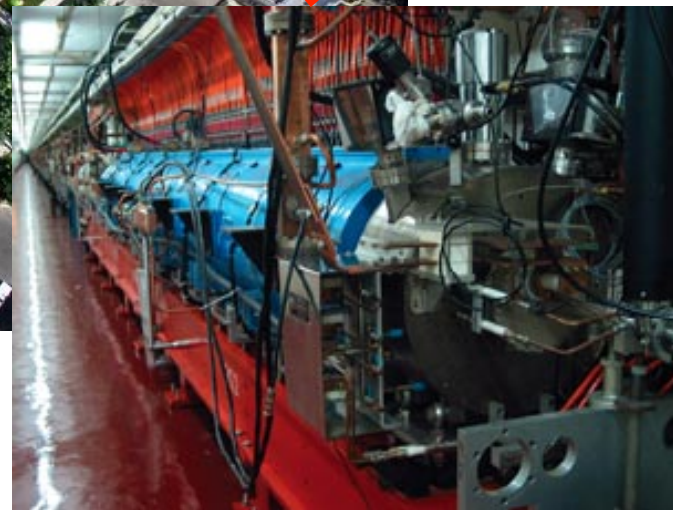
BEPCII at IHEP



LINAC



BEPC-II



The BESIII detector

- Multi-purpose magnetic spectrometer with 93% of 4π angular coverage.
- Our group is committed to data analysis and to hardware upgrade of the inner tracker.

Multilayer drift chamber

Time-of-flight

CsI electromagnetic calorimeter

1 Tesla
superconducting
solenoid

RPC muon system

Exotic spectroscopy



NATURE | NEWS

عربي

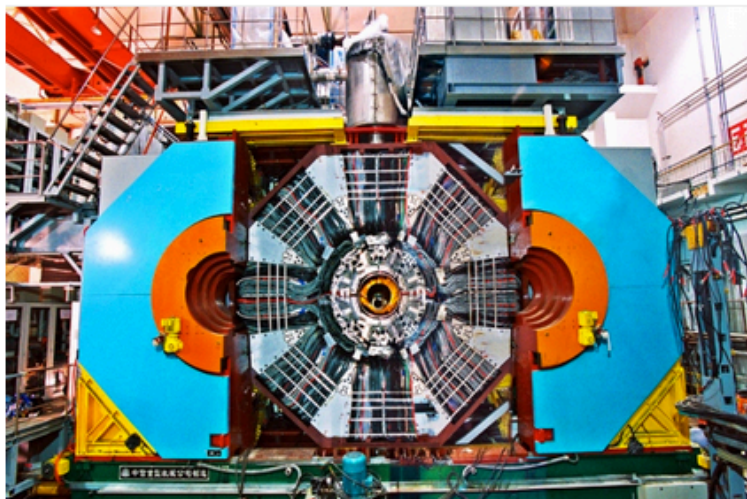
Quark quartet opens fresh vista on matter

First particle containing four quarks is confirmed.

Devin Powell

18 June 2013

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The BESIII detector in China is one of two experiments to detect four-quark particles.

IHEP

CERN COURIER

Apr 26, 2013

BESIII observes new mystery particle

In a striking and unexpected observation from new studies aimed at an understanding of the anomalous $Y(4260)$ particle, the international team that operates the Beijing



BESIII spectrometer

alert

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SCIENCE COMMUNICATION

Submit today!

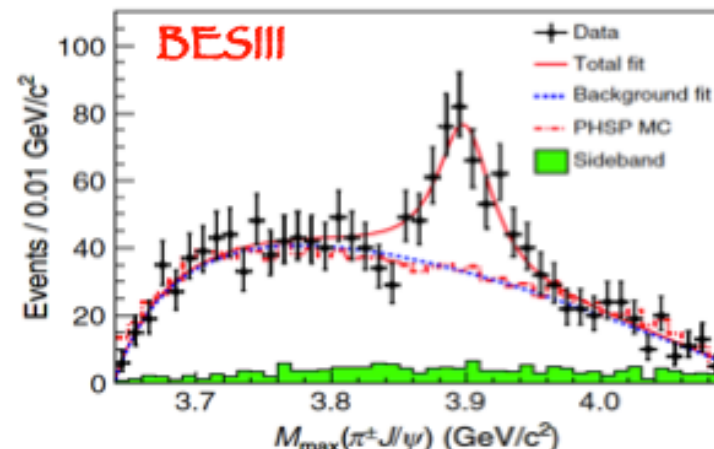
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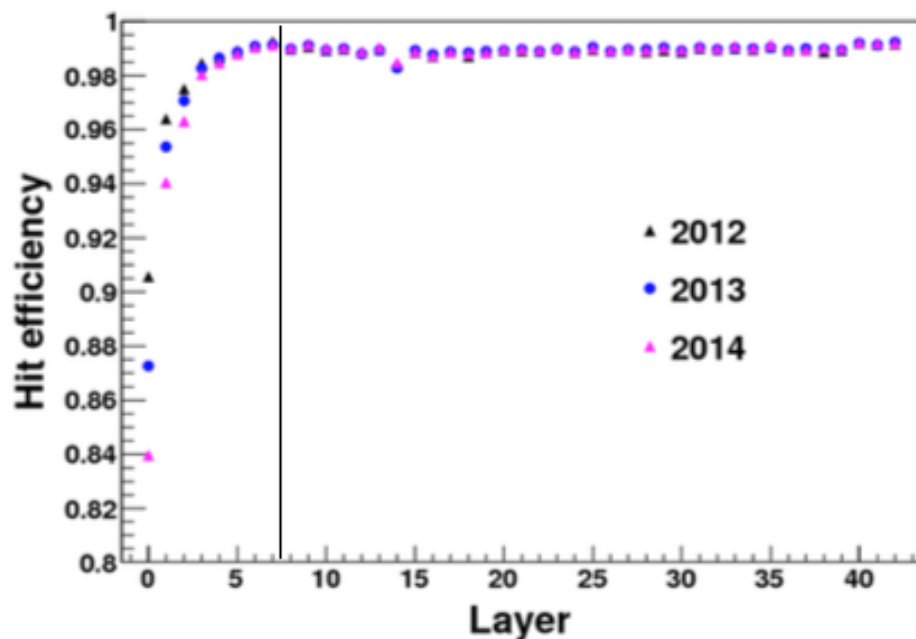
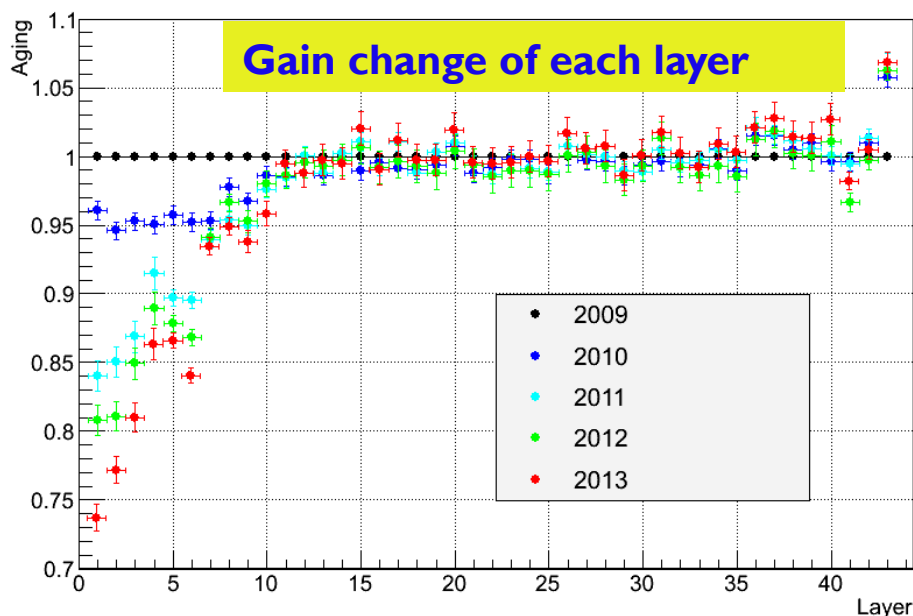
Emailed

1. Beijing smog contains witches' brew of microbes
Nature | 31 January 2014
2. Biologists make first mouse model for MERS
Nature | 30 January 2014
3. Brain responds to tiniest speech details
Nature | 30 January 2014



Drift chamber aging

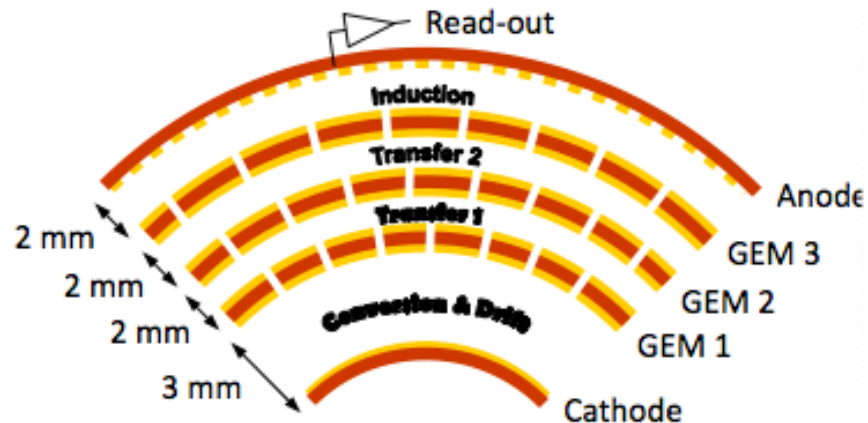
Due to beam background and luminosity increase, the inner chamber of the MDC shows ageing effect.



- Compared with 2009, now the gas gains of first 5 layers decrease about 26% — 14%
- The gains of the first 10 layers have an obvious decrease
- The gains of the layers in the outer chamber have nearly no change

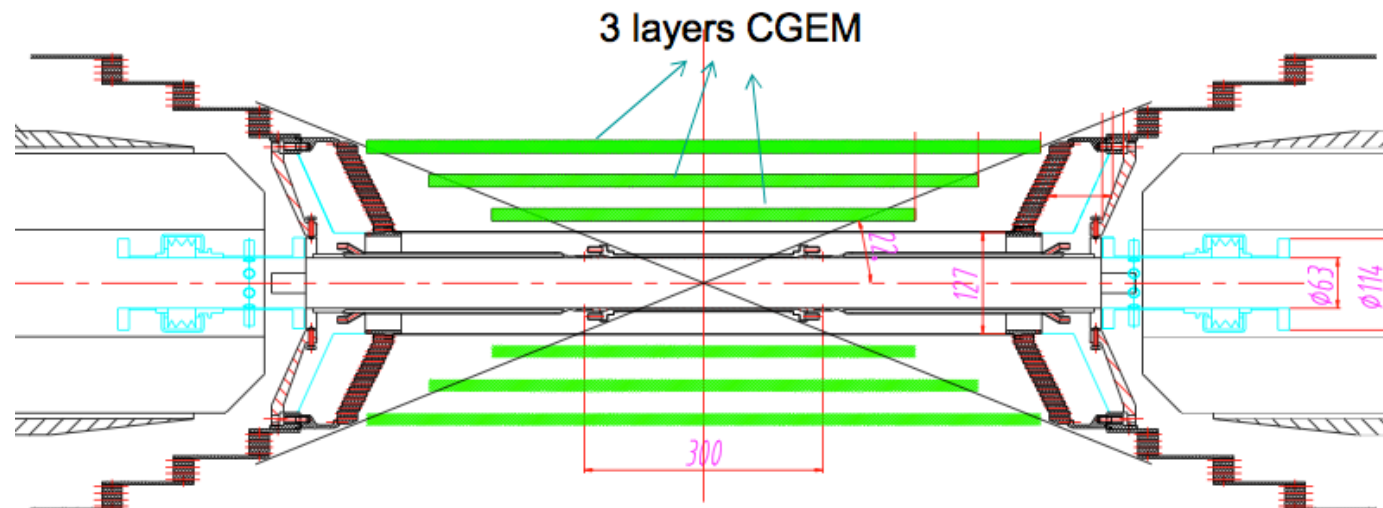
A new CGEM based Inner Tracker

A cylindrical triple GEM



Requirements

- Rate capability: $\sim 10^4$ Hz/cm²
- Spatial resolution: $\sigma_{xy} \sim 100 \mu\text{m}$: $\sigma_z \sim 1 \text{ mm}$
- Momentum resolution: $\sigma_{pt}/P_t \sim 0.5\%$ @1GeV
- Efficiency = $\sim 98\%$
- Material budget $\leq 1.5\%$ all layers
- Coverage: 93% 4 π
- Operation duration ~ 5 years



The project has been recognized as a Significant Research Project within the Executive Program for Scientific and Technological Cooperation between Italy and P.R.C.

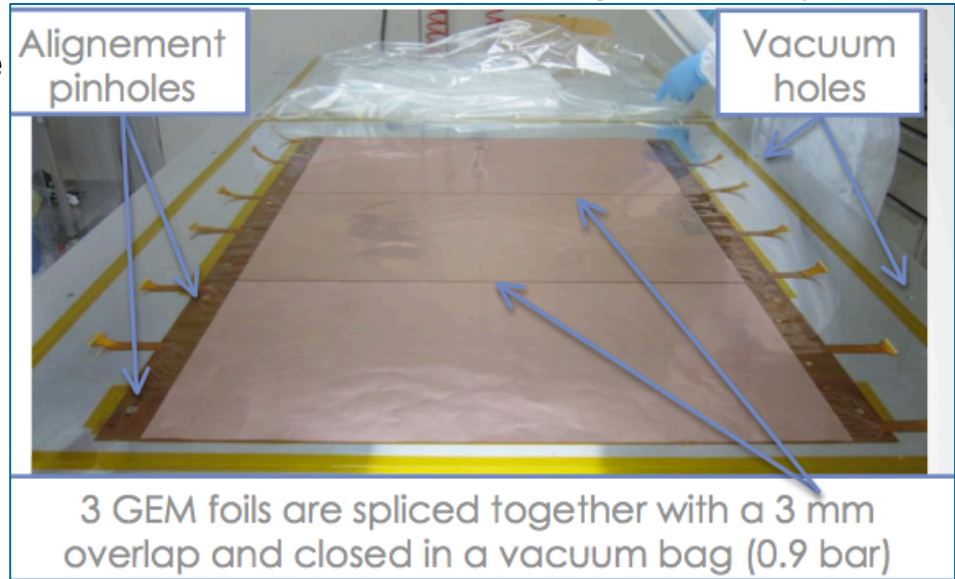
and recently selected as one of the project funded by the European Commission within the call H2020-MSCA-RISE-2014.

CGEM construction technique

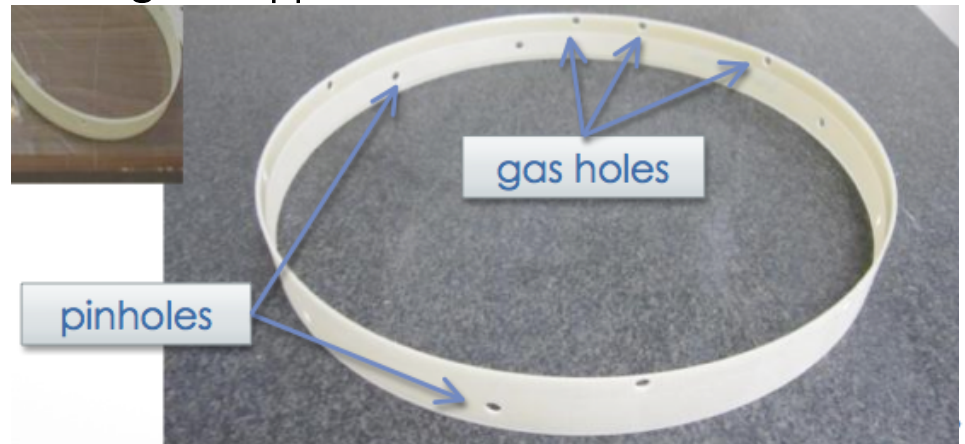
To obtain cylindrical electrodes the foils are wrapped around molds, there is one mold for each of the 5 electrodes.



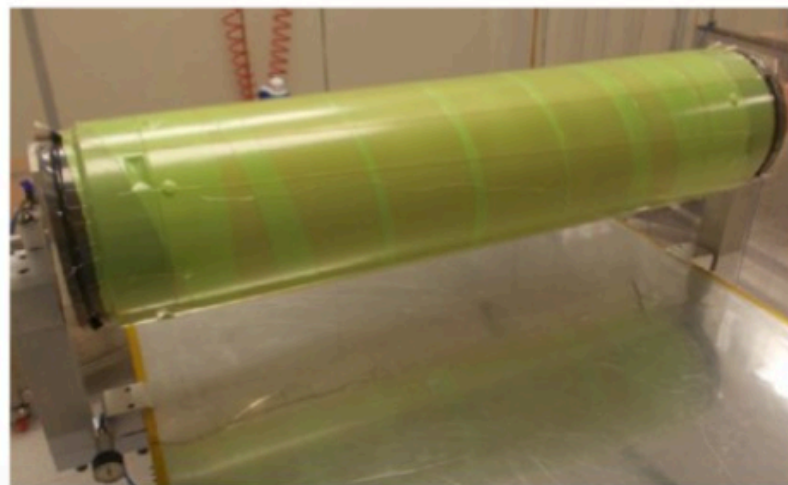
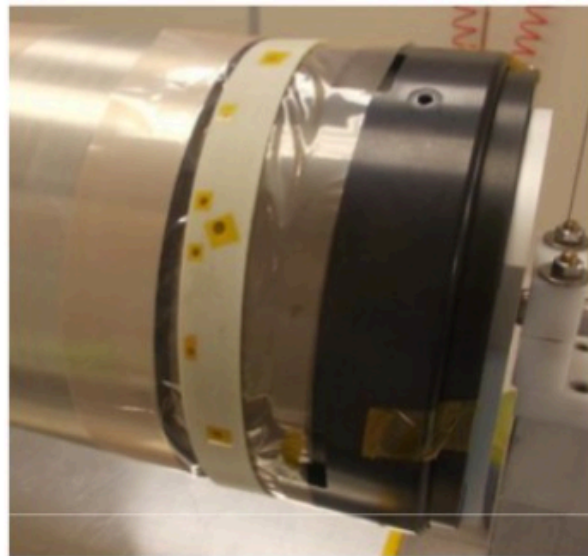
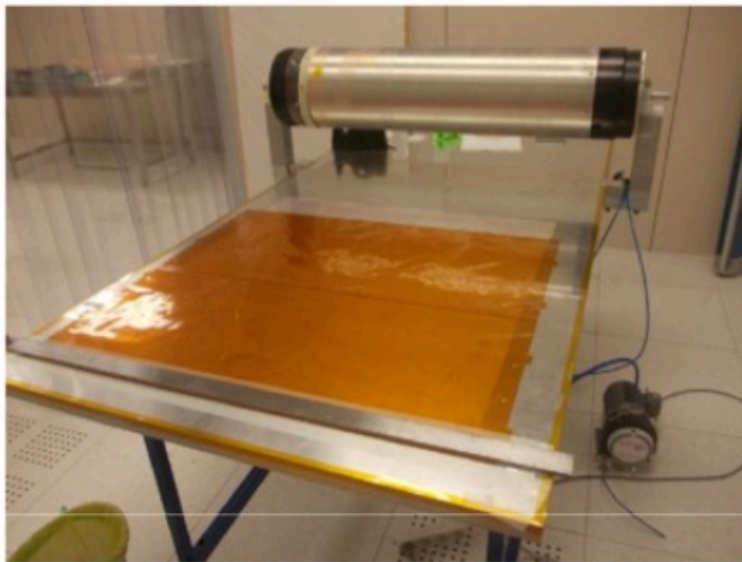
The electrode foils are first glued on a plane



Fiberglass supports are outside the active area

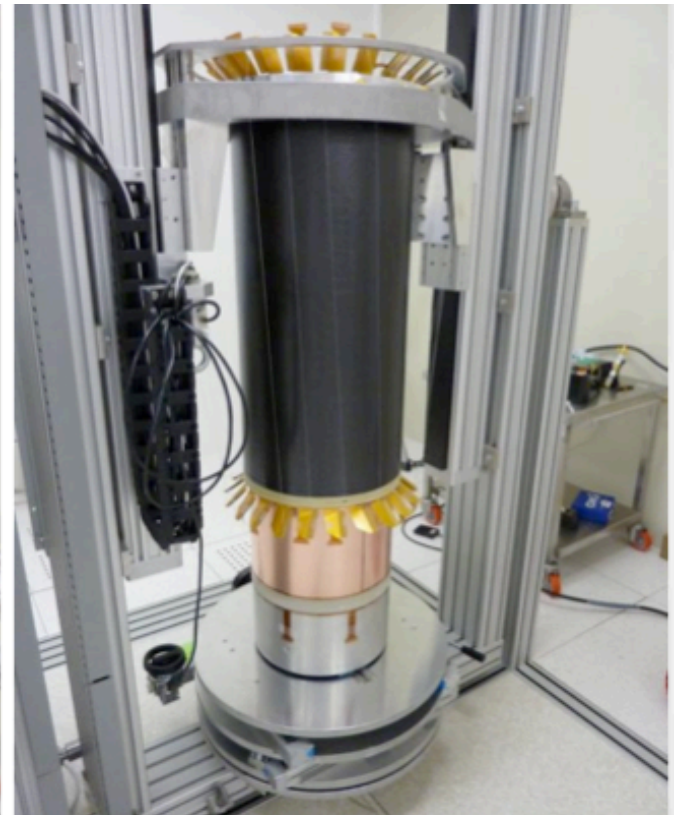
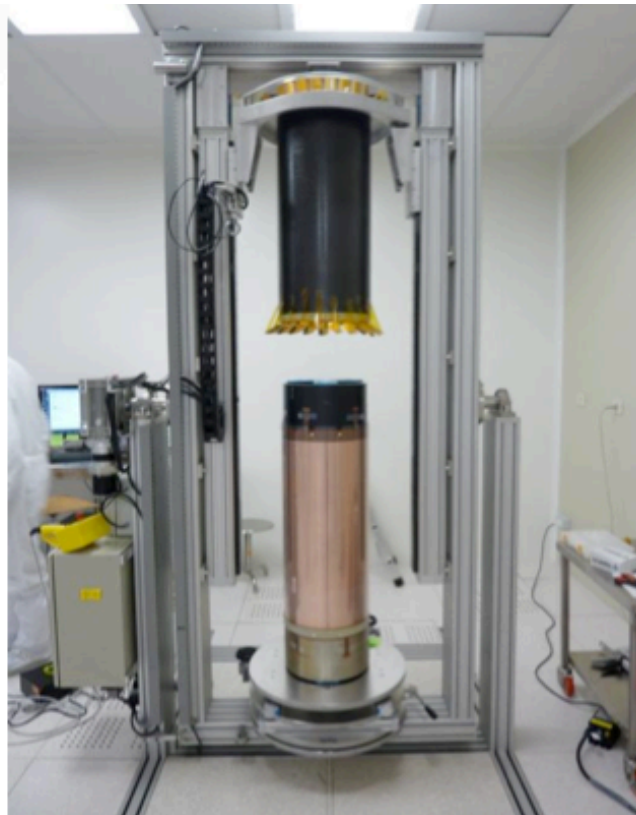


BESIII cylindrical gluing test



The KLOE-2 assembly technique

- A dedicated assembling machine has been designed and realized to perform the insertion of the electrodes.
- Axial alignment has a precision of 0.1mm/1.5m.
- The structure can rotate by 180° around its central horizontal axis.



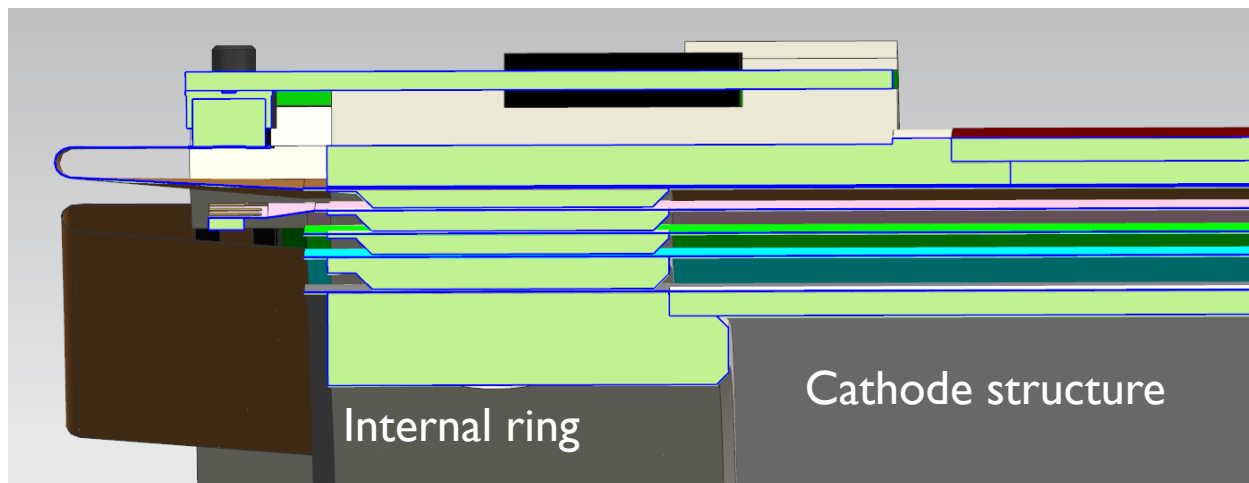
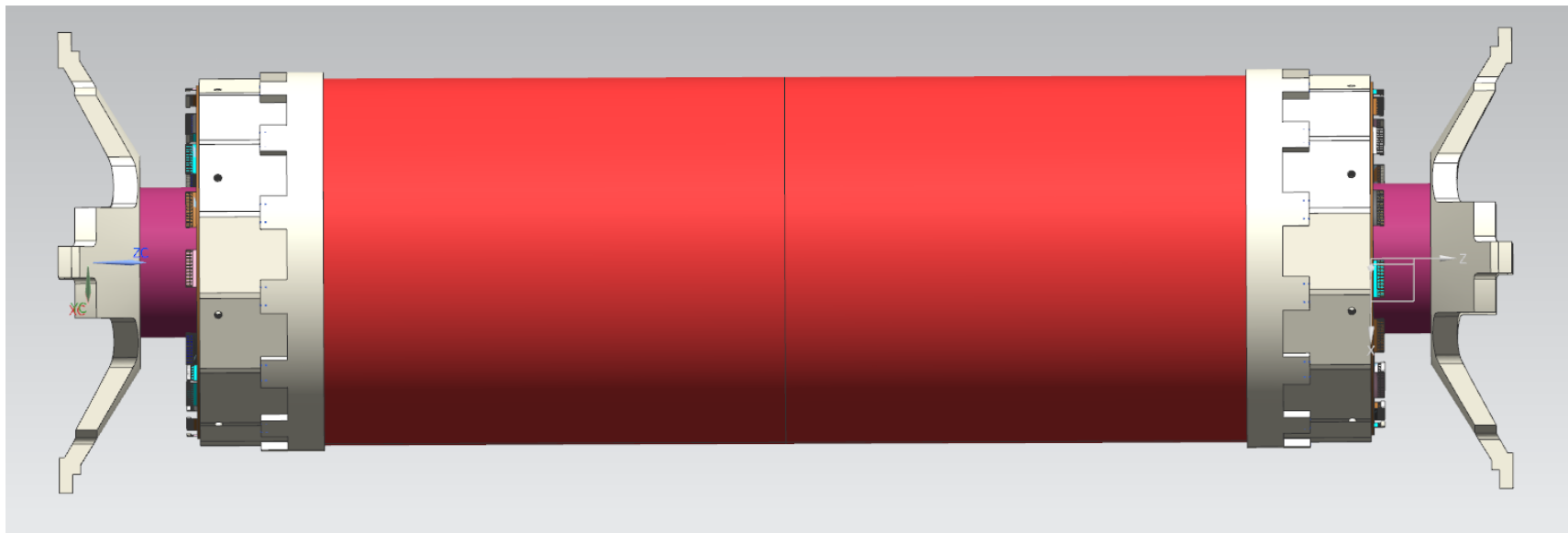
Peculiarities of the BESIII design

- Rohacell-based mechanical structure (about 1 % of X_0 for the complete CGEM-IT).
- Compass-like anode readout with jagged strip layout to reduce the inter-strip capacitance.
- Analogue readout inside high intensity magnetic field. A custom ASIC board will perform the charge measurement with TOT technique.

Ferrara contribution to the CGEM-IT

- Mechanical design
- Cathodes and anodes assembly
- Background studies
- Maxwell and Garfield simulations
- R&D and Beam test (preparation and data analysis)
- Development of tracking algorithms.

Detector mechanical design



The Ferrara group is responsible for the mechanical design of the detector, construction tooling and supporting structures.

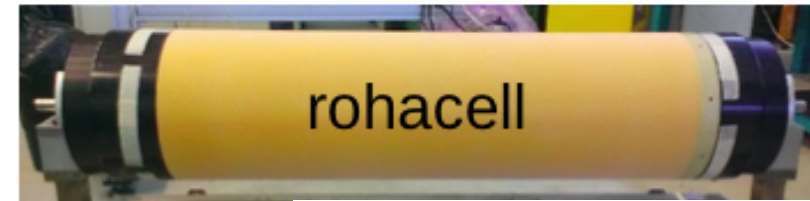
Cathode and anode construction



The mechanical structure of the anodes and the cathodes are assembled in Ferrara.

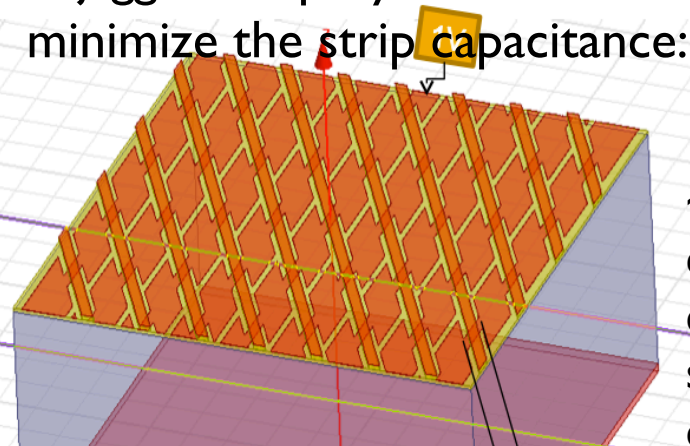
A sandwich of Kapton and Rohacell is used both for cathodes (2 mm) and anodes (4 mm) cylinders.

Test performed successfully.

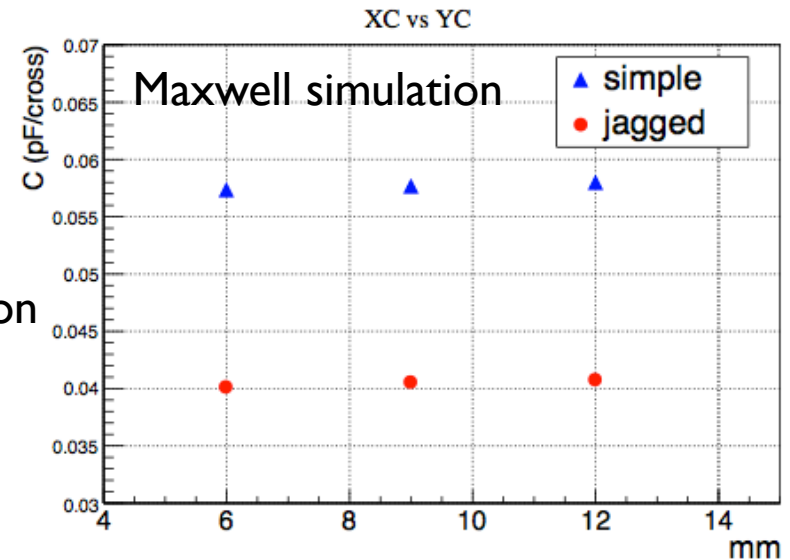


Maxwell and Garfield simulations

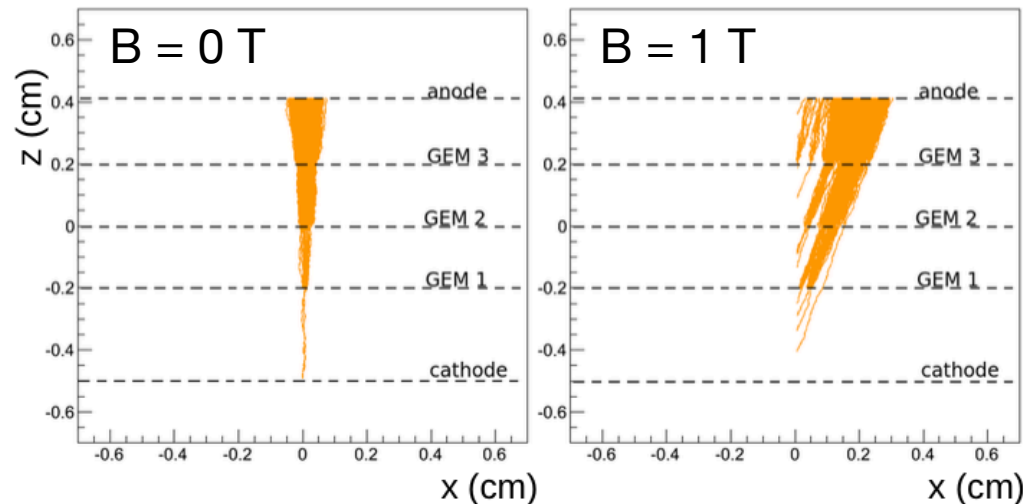
A jagged-strip layout has been studied to minimize the strip capacitance:



~30% inter-strip capacitance reduction compared to the standard strip configuration



Garfield simulation

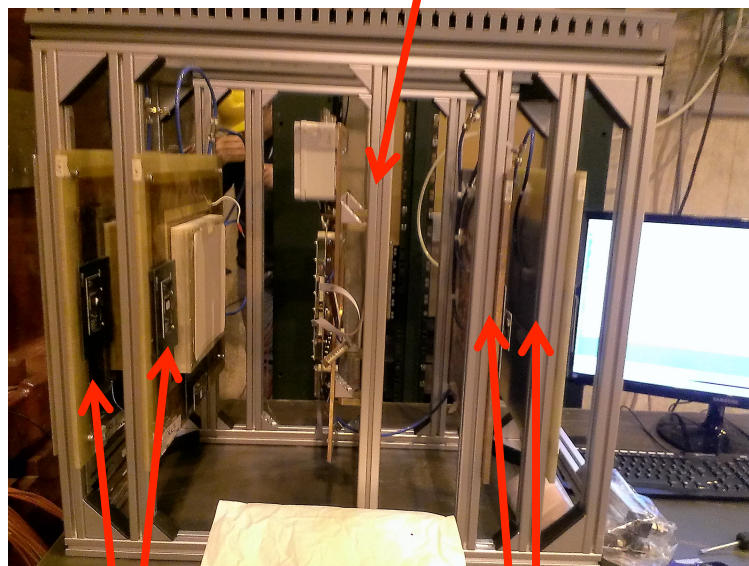


Garfield simulation has been deployed to extract information for the hit digitization.

BESIII setup

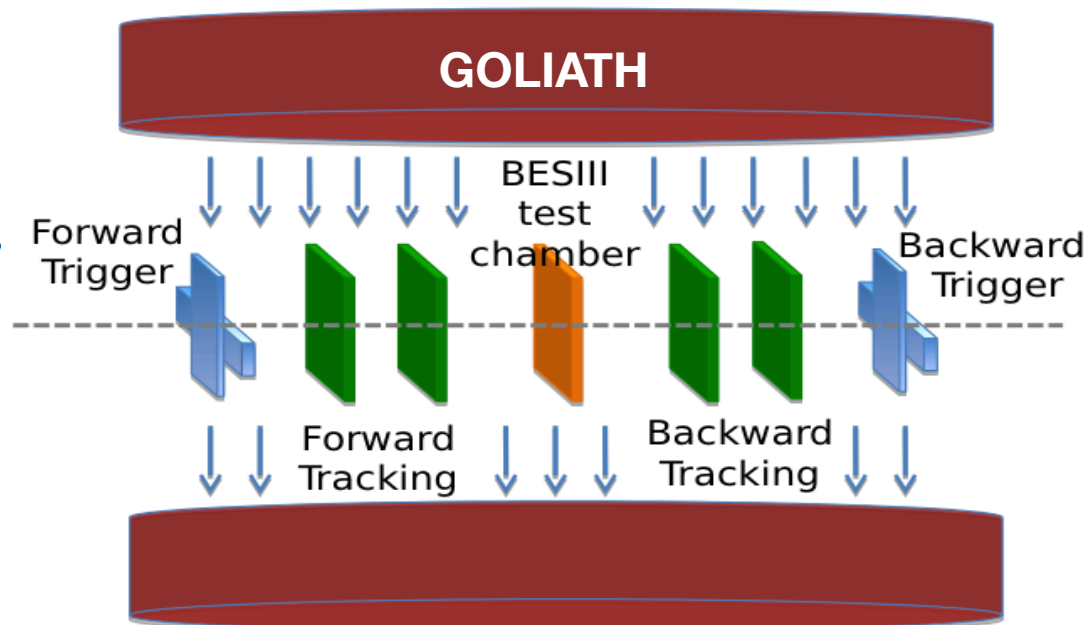
We performed a beam test last December to test a planar prototype inside a magnetic field.

The BESIII prototype

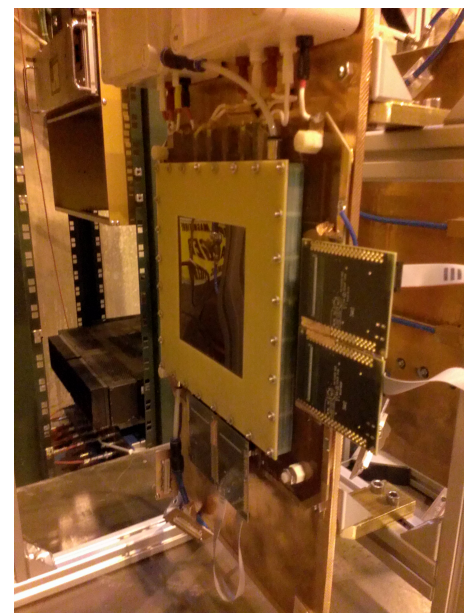


Forward Tracking

Backward Tracking

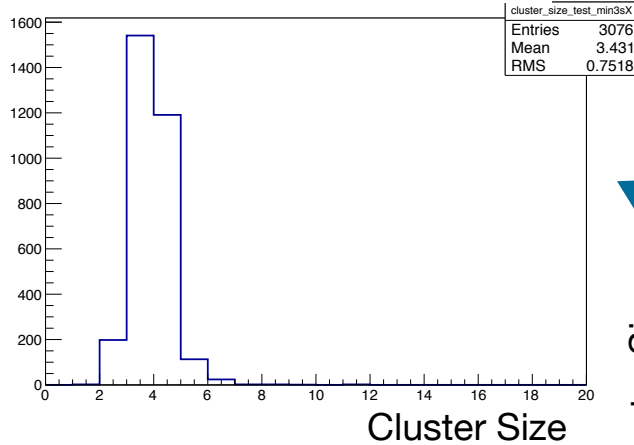


- validate analogue readout
- validate Garfield simulation
- test different gas and geometry configurations

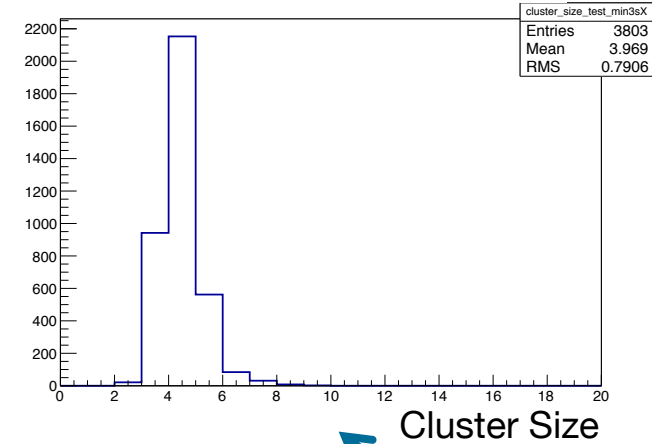


Cluster Size (no B field)

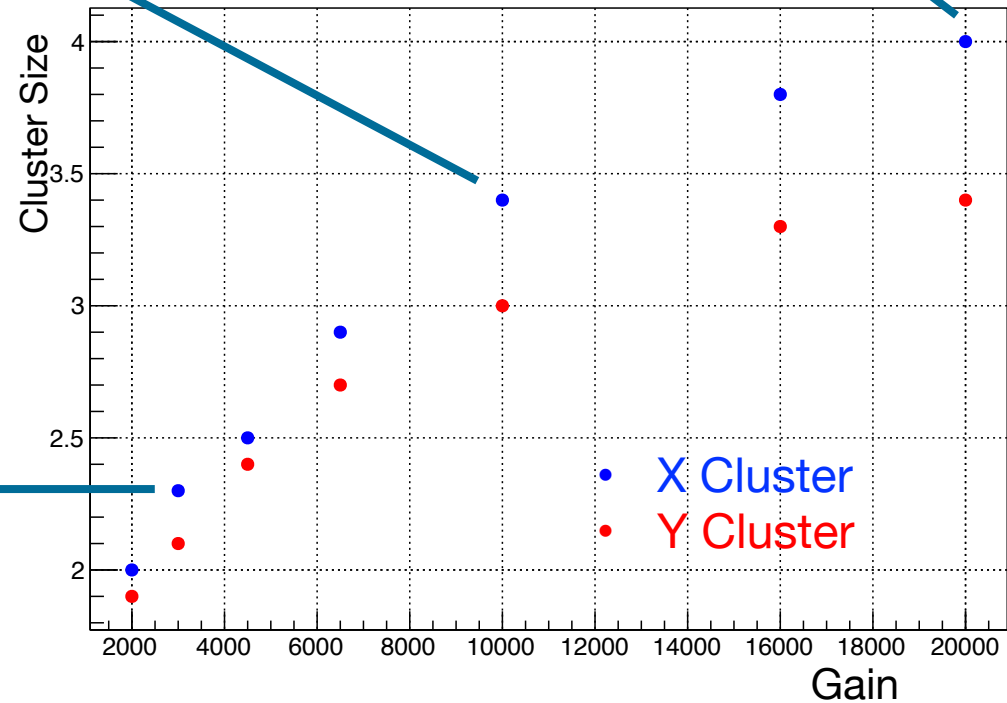
ClusterSize TEST X-Strips within 3 Sigma



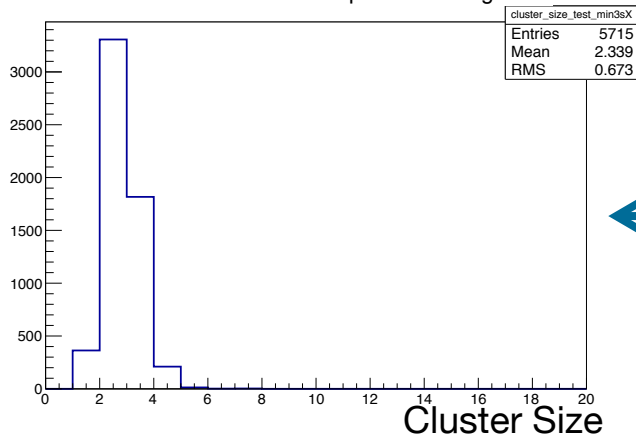
ClusterSize TEST X-Strips within 3 Sigma



Cluster Size vs gain (V)

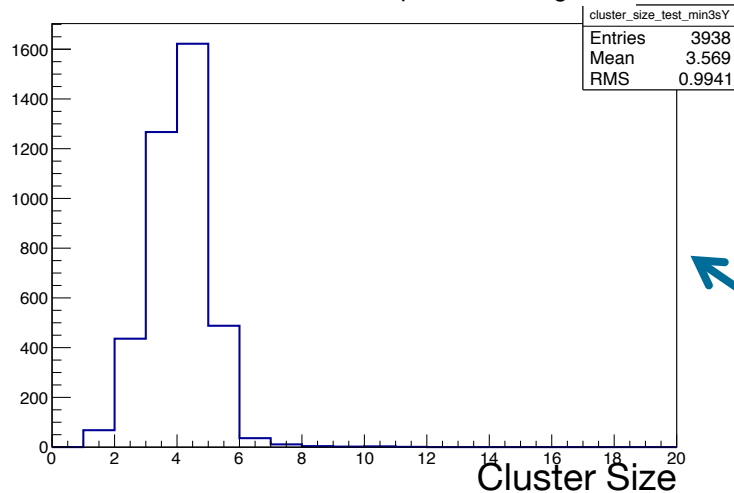


ClusterSize TEST X-Strips within 3 Sigma

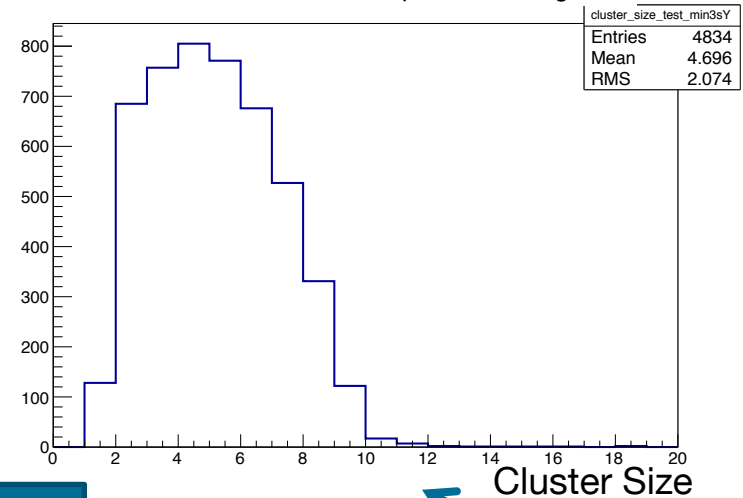


Cluster Size vs B field

ClusterSize TEST Y-Strips within 3 Sigma

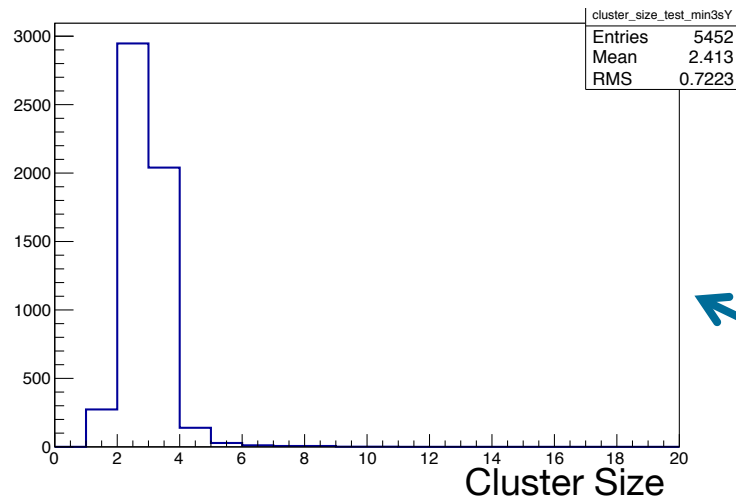
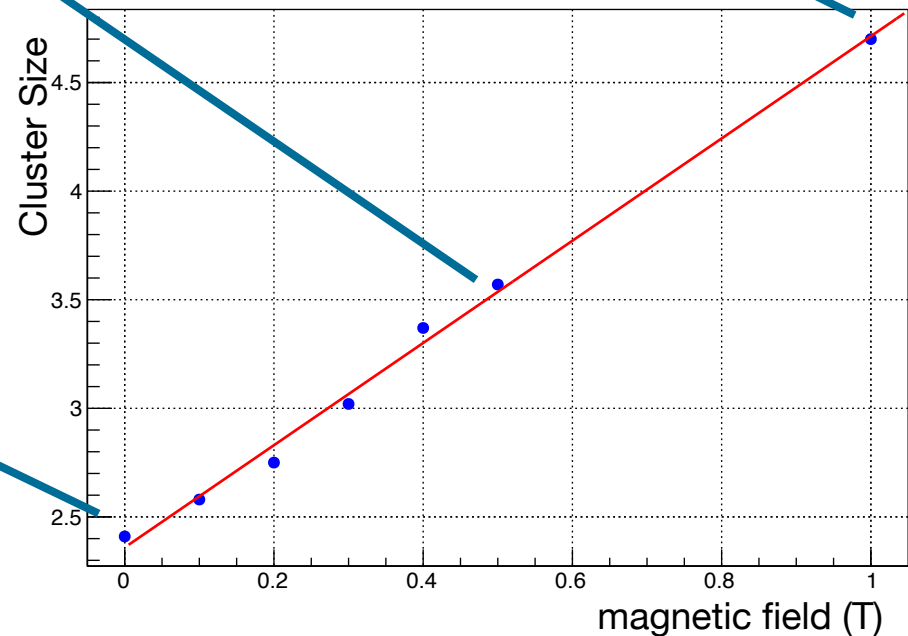


ClusterSize TEST Y-Strips within 3 Sigma



Gain = 4.5 k

Cluster Size vs B field (T)

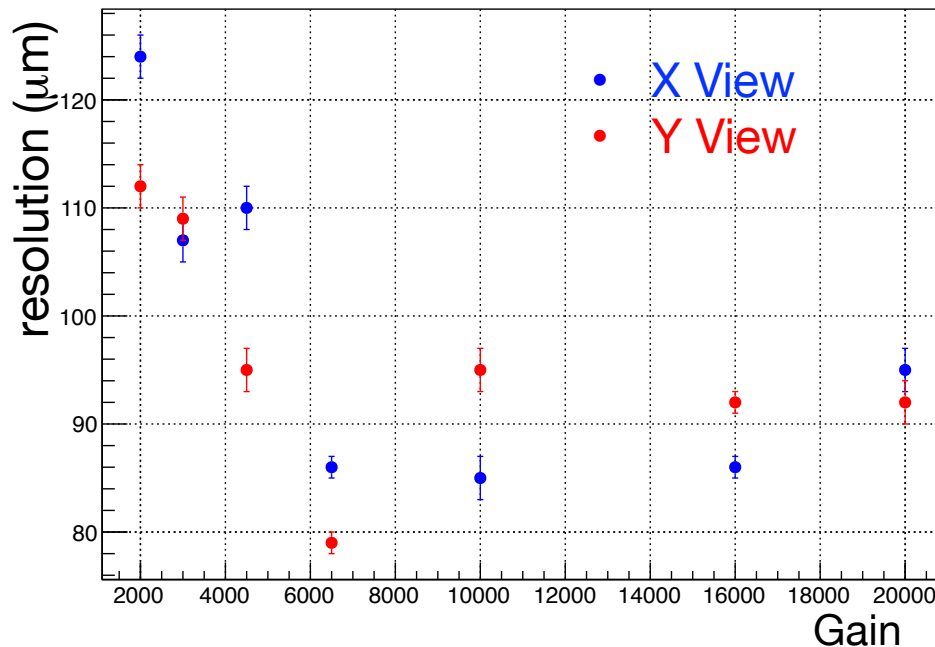


Efficiency and spatial resolution (no B field)

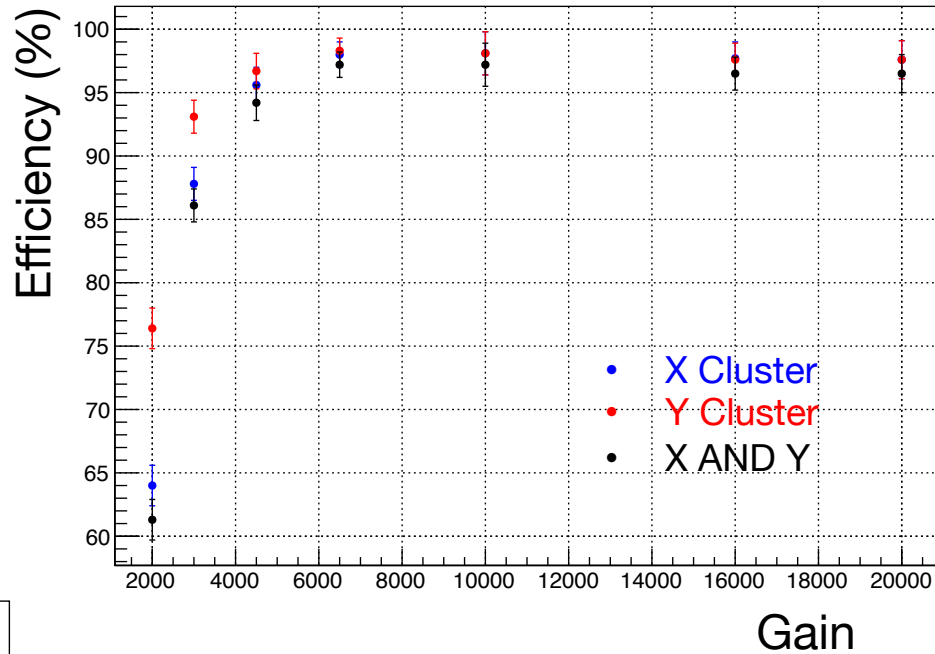
The efficiency plateau starts at about a gain of 6000.

Efficiency for 2 dimensional clusters
~97%.

Spatial resolution (micron) vs gain (V)



Efficiency (%) vs gain (V)



With 650 μm strip pitch we achieved about 90 μm of spatial resolution without magnetic field and Ar/Isob (90/10).

Studies with magnetic field ongoing.

Need for a new beam test to complete our measurements.

Summary and conclusions

- The BESIII Ferrara (University and INFN) group has broad experience in data analysis and detector development for HEP experiments.
- It's one of the leading player of the CGEM-IT project with responsibilities in the:
 - mechanical design and construction;
 - R&D and simulations for detector optimization
 - project coordination
- Our present and near future is the development of a cylindrical GEM inner tracker for the BESIII experiment, therefore we find straight forward apply to the RD51.