STATUS AND ACTIVITIES

M.Bertani for the LNF BESIII group:

M.Anelli (tecn.),R. Baldini Ferroli (ass)
M. Bertani, A.Calcaterra, J.Dong (ihep),
G.Felici, G.Morello, S.Pacetti (Perugia),
P.Patteri, E. Tskhadadze (Dubna,FAI fellowship)
A.Zallo (guest)

and in collaboration with:

LNF SPAS: S. Cerioni,
LNF SEA: M. Gatta,
LNF (div. acc.): M. Paris, F. Putino

INFN-ROMA1 A. Pelosi(tec.), M.Capodiferro(tec.)
BESIII TO&FE&PG groups

OUTLOOK

- BESIII @ BEPCII
- PHYSICS ANALYSIS AND PROPOSALS BY ITALIAN TEAM
- CYLINDRIC GEM INNER TRACKER:
  - THE PROJECT & THE TEAM
  - STATUS OF CONSTRUCTION
  - TEST BEAM AT CERN
  - THE PLAN
- ZDD STATUS
- SUMMARY

BESIII/BEPCII current status

BESIII experiment at the τ-charm factory

BEPC-II, Beijing e+e- collider @ IHEP

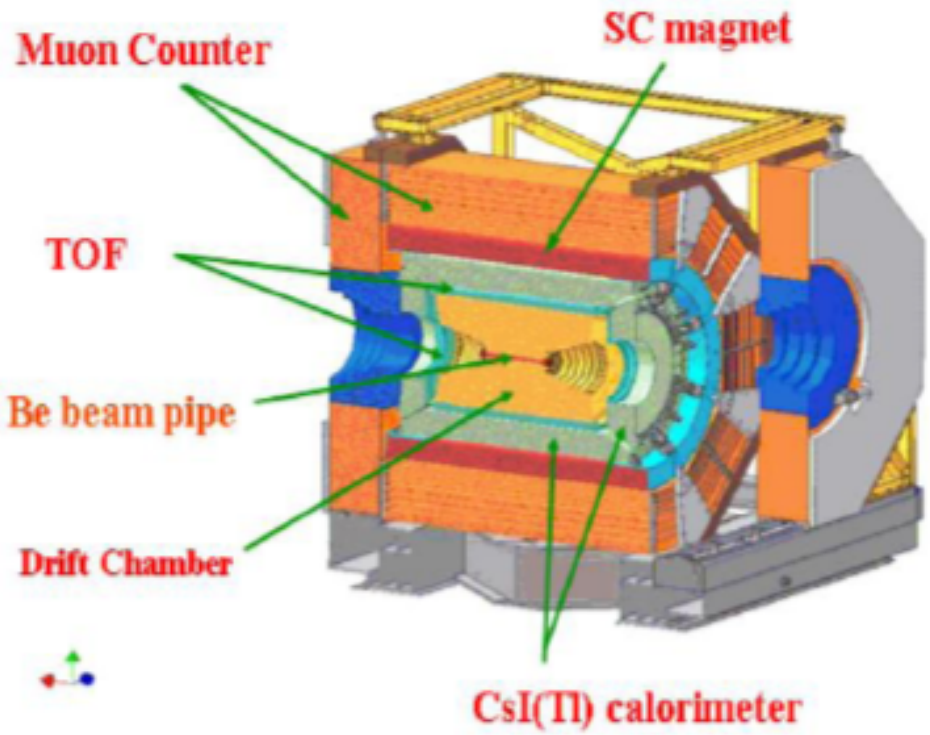
c.m. energy range: 2 GeV- 4.6 GeV.

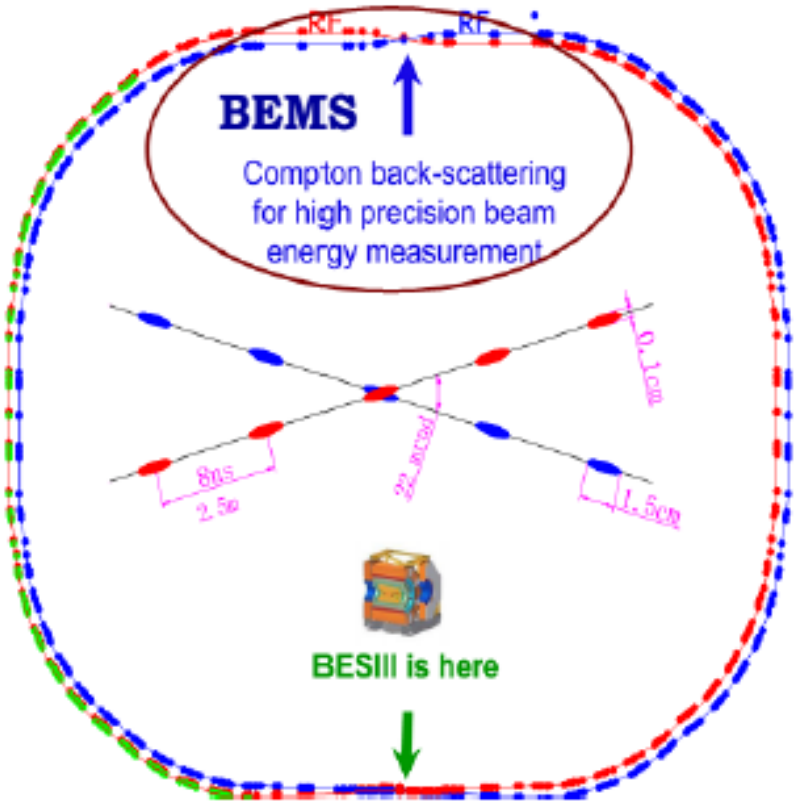
BESIII & BEPCII

E_{cm}: 2.0 – 4.6 GeV.

Excellent tracking: $\delta p/p = 0.5\%$ @1GeV
dE/dx=6%

Peak Luminosity **achieved**:
0.85×10^{33} cm^{-2}s^{-1}





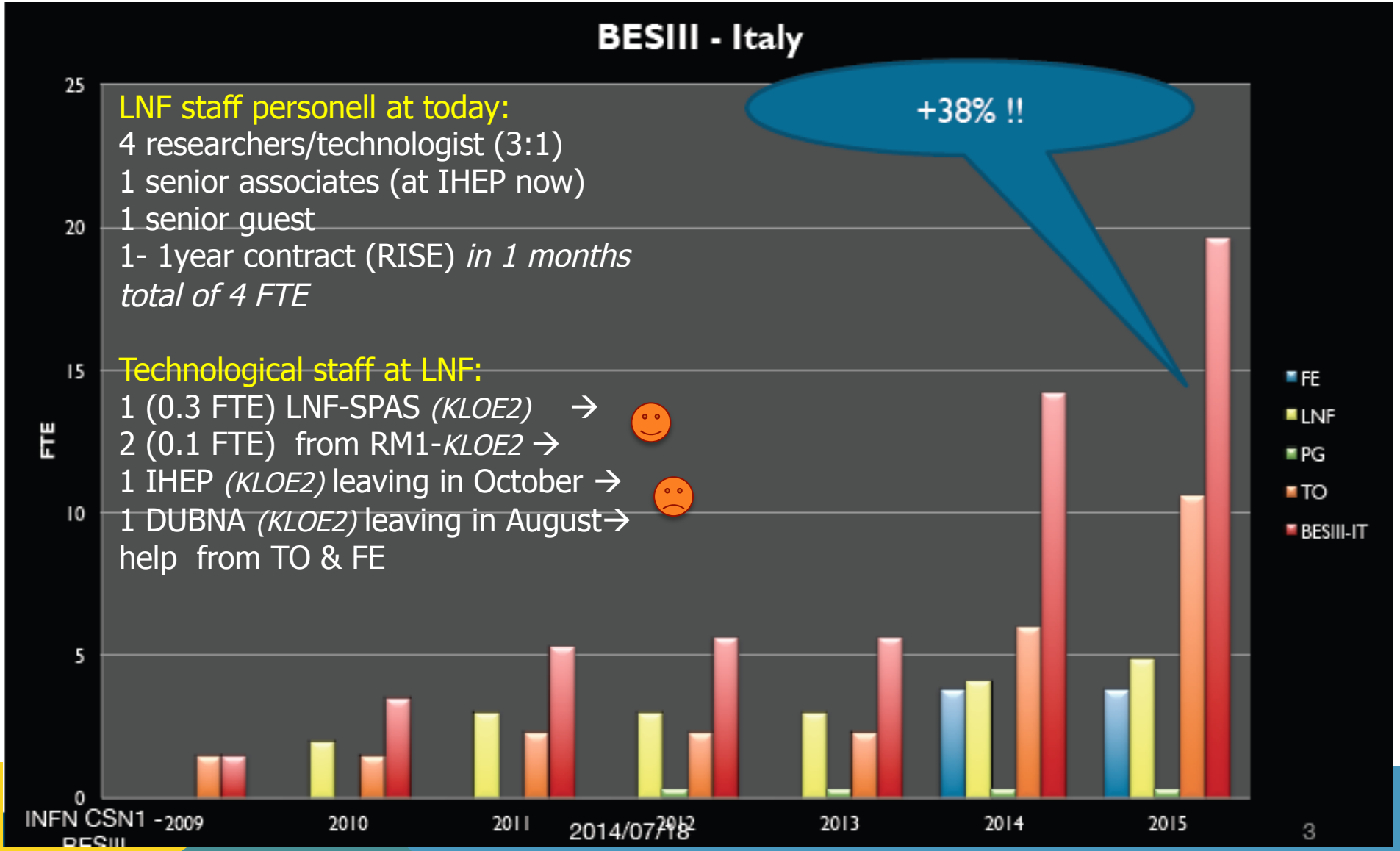
Shower reconstruction: $\Delta E/E = 2.5\%$ @1 GeV
$\sigma_{\varphi,z} = 0.5\sim0.7$ cm/$\sqrt{E}$

Optimal energy **1.89 GeV**

BESIII实验是以高能所为基地的大型国际合作实验

BESIII 国际合作组

THE INFN BESIII GROUP

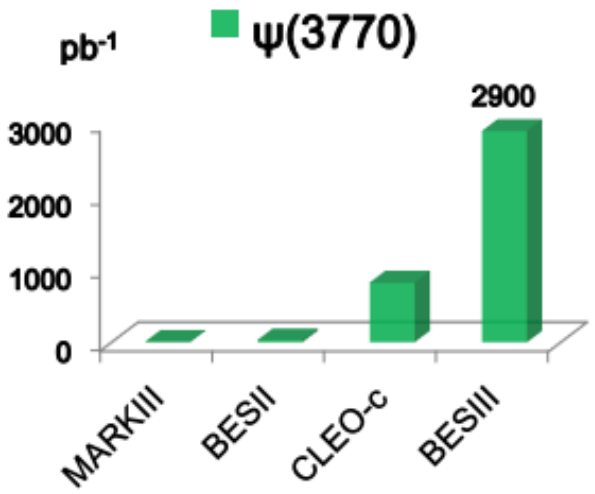


as presented to CSN1 last September

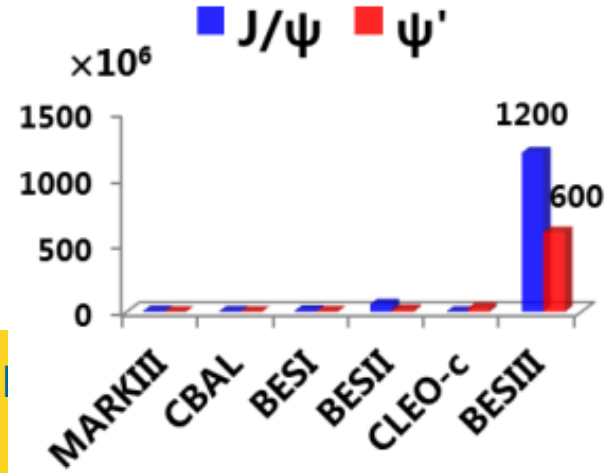
BESIII DATASET FROM 2009-TODAY

2.9 fb^{-1} / 20 fb^{-1}

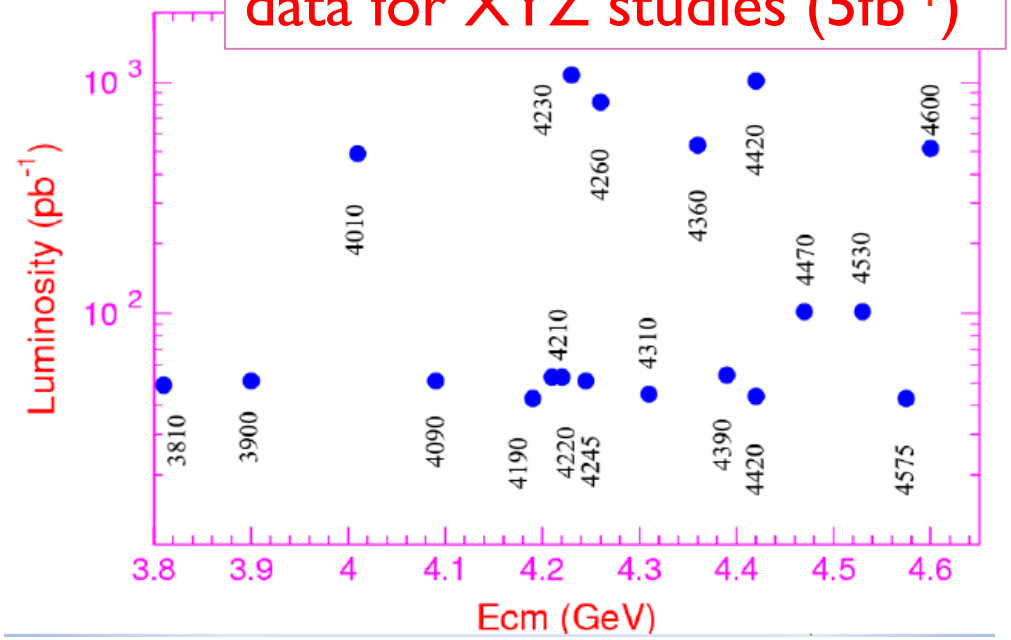
0.6 B / 3 B (106 M)



1.3 B / 10 B (225 M)



data for XYZ studies (5fb^{-1})



+ 104 energy points between 3.85 and 4.59 GeV (XYZ)
+ 20 energy points between 2.0 and 3.1 GeV *(just finished)*
for RQD and hyp form factors/xsections at @ threshold
+ Y(2175) *ongoing*
Direct production of 1^{--} states studied with world's largest scan dataset

the world's largest scan dataset of J/ψ ψ(2S) ψ(3770)
XYZ states
R-QCD studies
will run at least 8 more years !

PHYSICS HIGHLIGHTS

Scientists discover first tetraquark particle

See also Science & Space / Particle Physics

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Archive > Volume 498 > Issue 7454 > News > Article

NATURE | NEWS

عربي

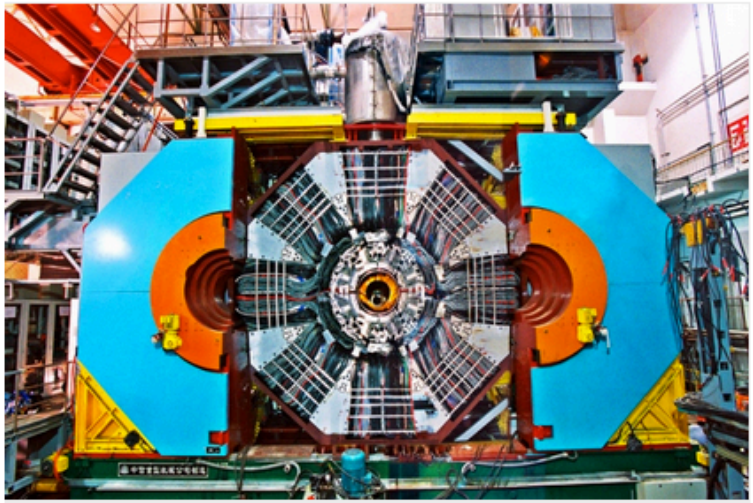
Quark quartet opens fresh vista on matter

First particle containing four quarks is confirmed.

Devin Powell

18 June 2013

PDF | Rights & Permissions



IHEP

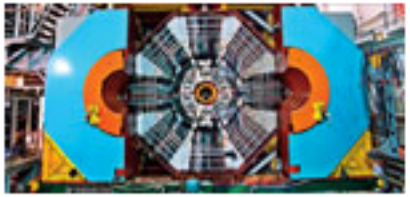
The BESIII detector in China is one of two experiments to detect four-quark particles.

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

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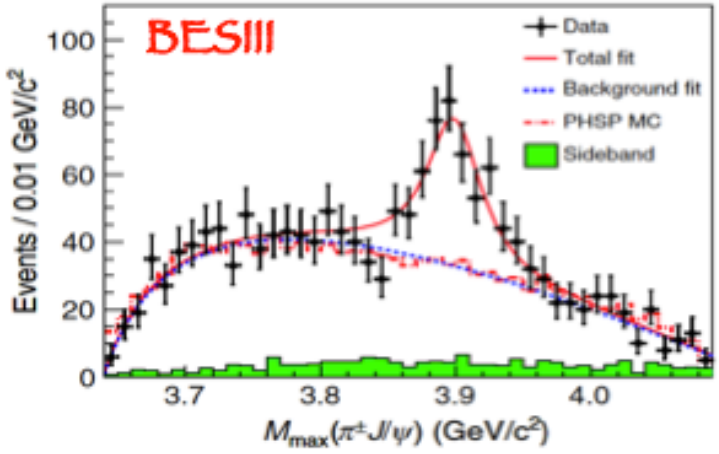
1. Beijing smog contains witches' brew of microbes
   Nature | 31 January 2014
2. Biologists make first mouse model for MERS
   Nature | 30 January 2014
3. Brain responds to tiniest speech details
   Nature | 30 January 2014



PHYSICS HIGHLIGHTS

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NATURE | NEWS

عربي

Quark quartet opens f

First particle containing four quarks

Devin Powell

18 June 2013

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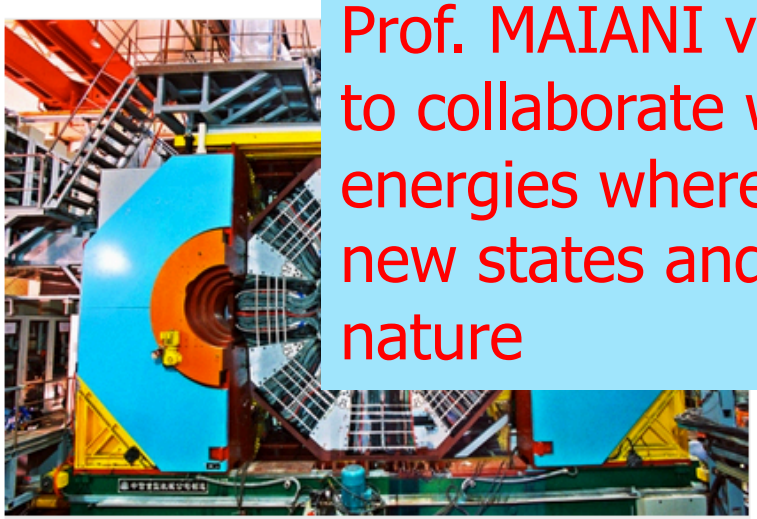


IHEP

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

Scientists discover first tetraquark particle

See also Science & Space / Particle Physics

Share

CERN COURIER

particle

BESIII spectrometer

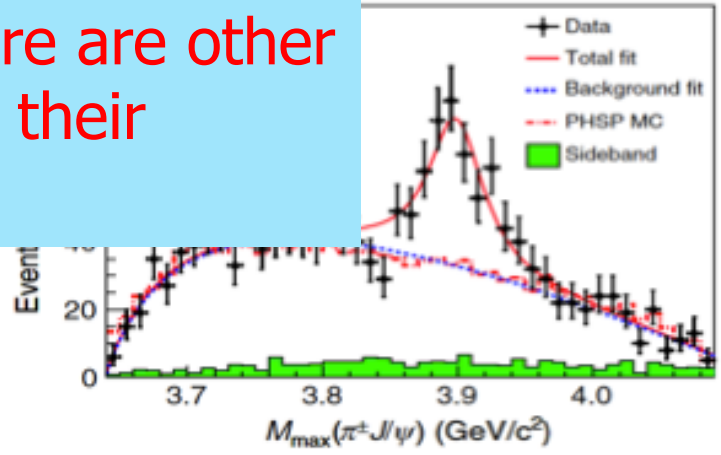
Z_c^{+-} (3900) and its neutral partner discoverd at BESIII and many more new states ! Tetraquark ?!

Prof. MAIANI visiting IHEP in this days to collaborate with BESIII group to find energies where may be there are other new states and understand their nature

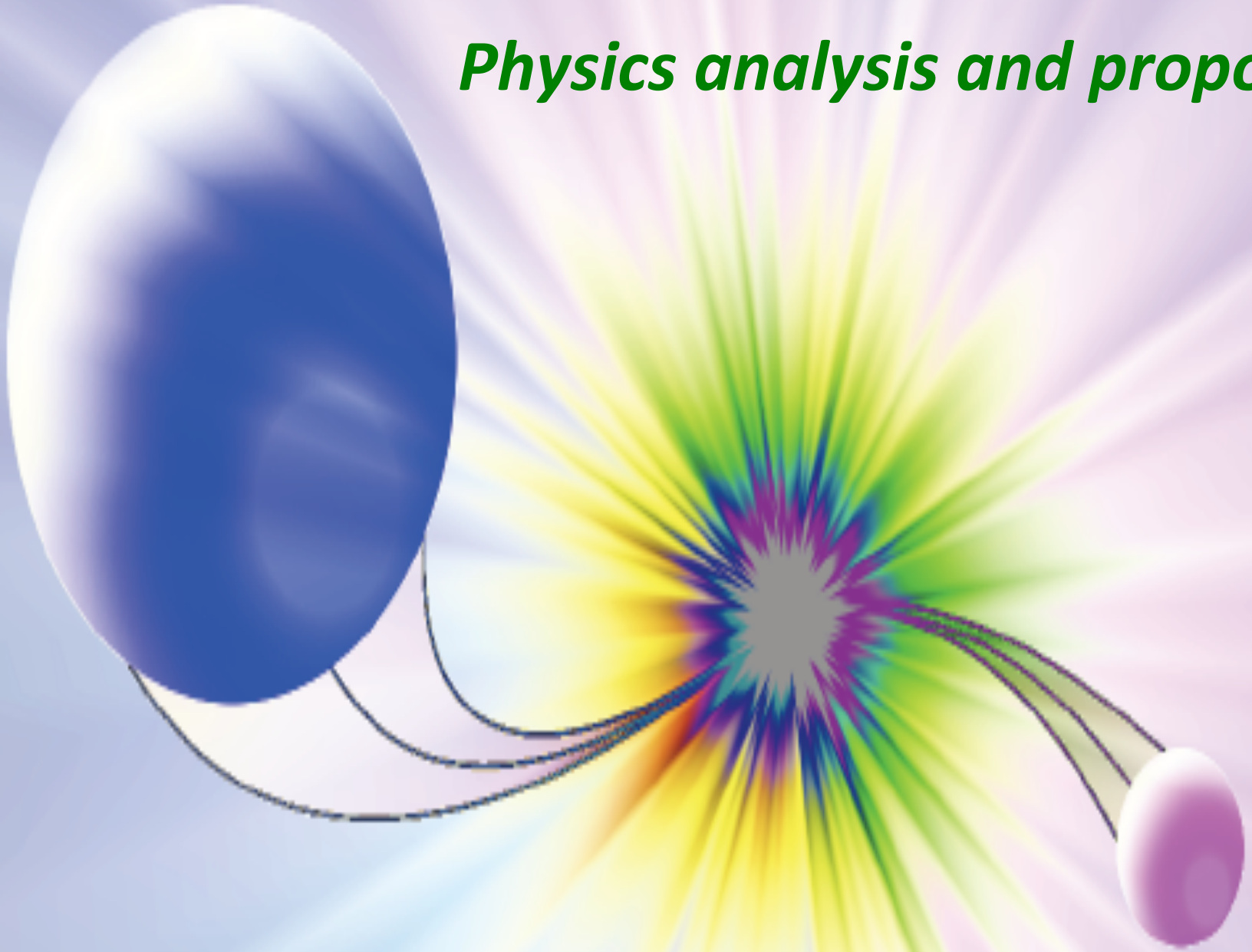
of microbes
Nature | 31 January 2014

2. Biologists make first mouse model for MERS
Nature | 30 January 2014

3. Brain responds to tiniest speech details
Nature | 30 January 2014



Physics analysis and proposals



PHYSICS ANALYSES AND PROPOSALS FROM LNF-TO-FE TEAM

- Br ($J/\psi \rightarrow n\bar{n}$, $p\bar{p}$) *published 2012*
- Br ($\psi' \rightarrow n\bar{n}$, $p\bar{p}$) *advanced draft stage*
- J/ψ c.m. scan (16 points) for e.m. and strong decay amplitude phase measurement
  - $e^+e^- \rightarrow J/\psi \rightarrow \mu^+\mu^-$, $\pi^+\pi^-$, $\pi^+\pi^-\pi^0$, $\pi^+\pi^-\pi^+\pi^-$, $p\bar{p}$, $K^+\bar{K}^-$, $\Lambda\bar{\Lambda}$, $\Sigma\Sigma$, $K^0_S\bar{K}^0_L$
    advanced draft stage / internal referee review
    first measurement of this kind

- proposal: ψ' scan for e.m. and strong decay amplitude measurement *approved*

- proposal: baryons and hyperons cross sections at threshold,
  data partly already taken in this run

- measurement of Collins asymmetry in inclusive production of pion pairs
advanced draft stage

J/ψ Strong and Electromagnetic Decay Amplitudes

Resonant contributions

$\Gamma_{J/\psi} \sim 93KeV \rightarrow pQCD$

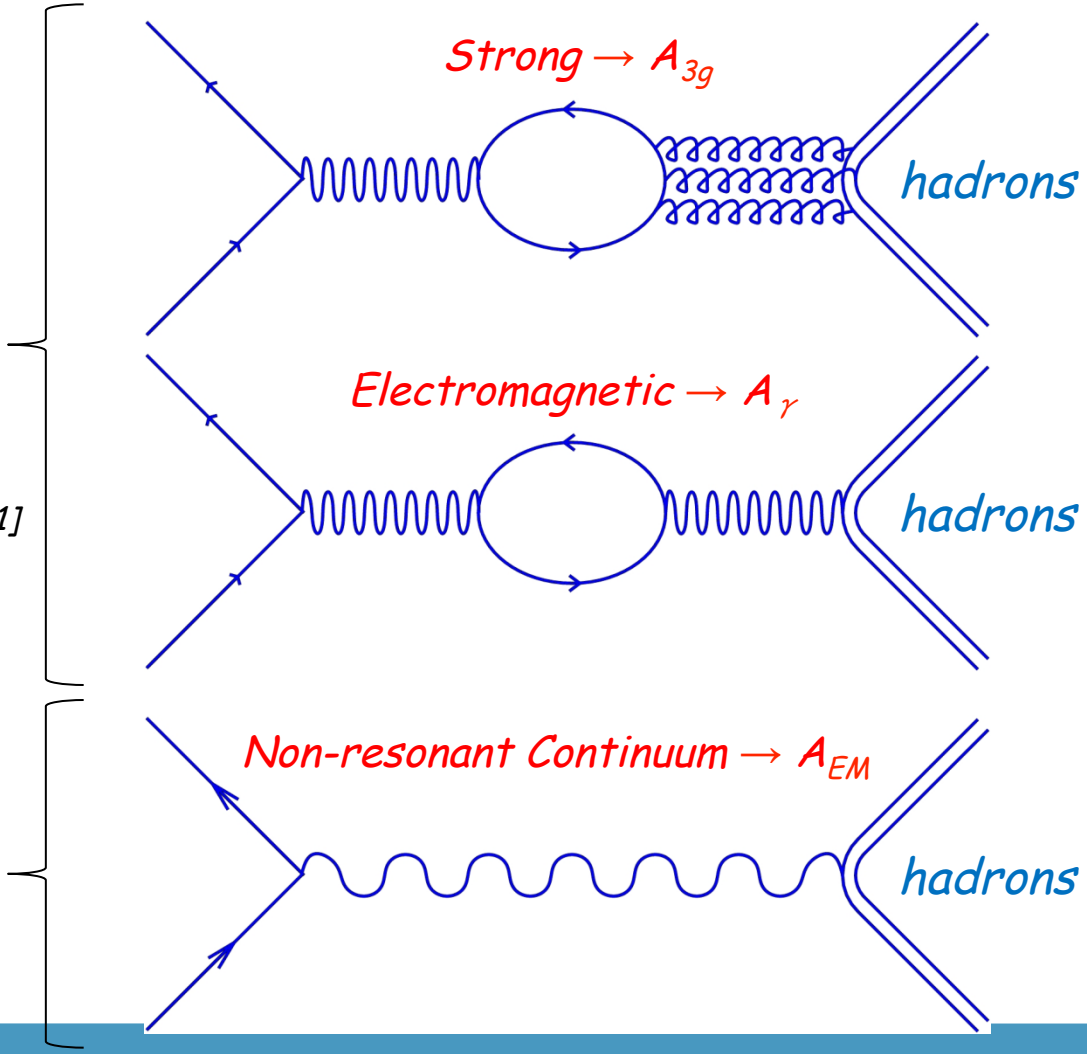
pQCD: all amplitudes are real [1,2]

Maximum interference -> $\Phi_p \sim 10°$ [1]

Non-resonant continuum

pQCD regime

$A_{EM} \in \Re$



[1] J. Bolz and P. Kroll, WU B 95-35.
[2] S.J. Brodsky, G.P. Lepage, S.F. Tuan, Phys. Rev. Lett. 59, 621 (1987).

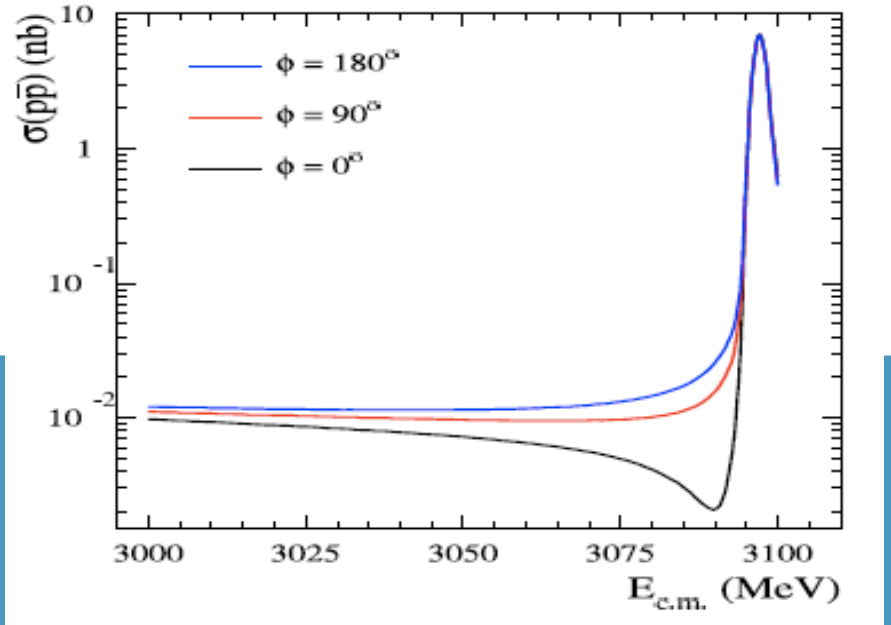
J/ψ Strong and Electromagnetic Decay Amplitudes

- If both A_{3g} and $A_{\gamma\ are}$ real, they must interfere ($\Phi_p \sim 0°/180°$)
- So far, experimentally (model dependent results) $\Phi_p \sim 90°$ → Imaginary strong amplitudes hard to explain!

$$\frac{Br(J/\psi \to p\bar{p})}{Br(J/\psi \to n\bar{n})} = \frac{(2.112 \pm 0.004 \pm 0.031) \times 10^{-3}}{(2.07 \pm 0.01 \pm 0.17) \times 10^{-3}} \sim 1 \rightarrow \phi \sim 90°.$$

PHYSICAL REVIEW D 86, 032014 (2012), BES-III result No interference!

- Model independent test: look for interference pattern between the resonant amplitude and the non-resonant continuum through a c.m. energy scan around and at the J/ψ peak



J/ψ Strong and Electromagnetic Decay Amplitudes

Investigated Processes at BESIII (LNF-PG, TO, FE, IHEP)

➢Exclusive scenario: could see interference effects

- $e^+e^+ \to J/\psi \to \mu^+\mu^-$
- $e^+e^- \to J/\psi \to \pi^+\pi^-\pi^+\pi^-$
- $e^+e^- \to J/\psi \to \pi^+\pi^-\pi^0$, $2(\pi^+\pi^-)\pi^0$
- $e^+e^+ \to J/\psi \to p\bar{p}$
- $e^+e^+ \to J/\psi \to K^+K^-$, $\Lambda\bar{\Lambda}$, $\Sigma\bar{\Sigma}$, $K^0_S\bar{K}^0_L$

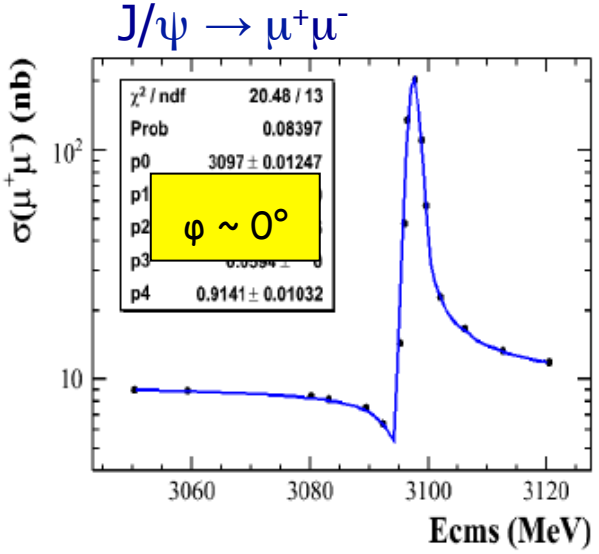
E.M. processes : full interference expected

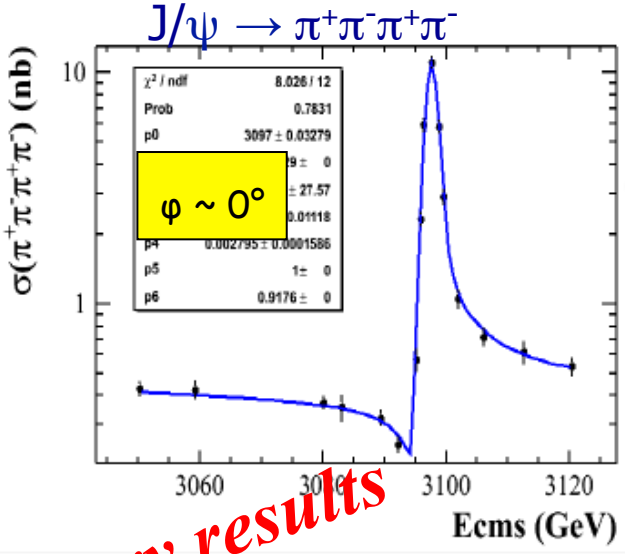
Preliminary results
Analysis completed, memo under referee committee review

Very preliminary results
Analysis in good progress preparing memo

➢Data taken at 16 points below, at and above J/ψ peak, after Italian team proposal to BESIII Collaboration

J/ψ Strong and Electromagnetic Decay Amplitudes preliminary results

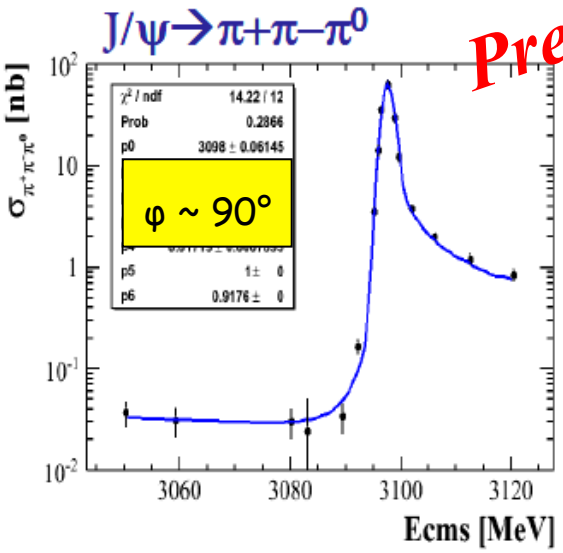


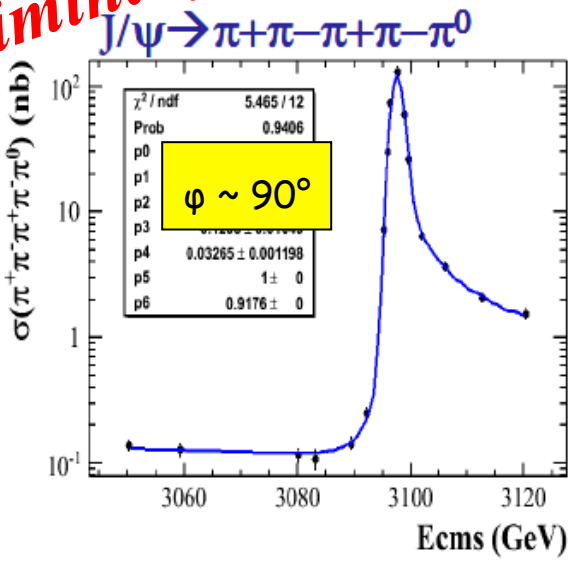


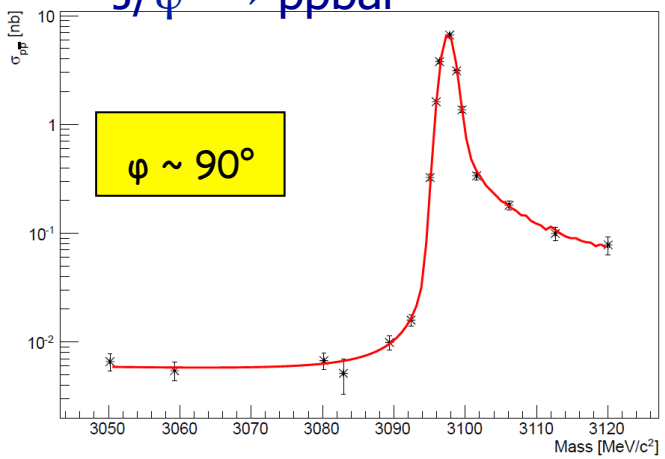
Interference observed between A_γ and A_c as expected

No interference observed between A_{strong} and A_c for 3π and 5π and ppbar, confirming $J/\psi \to ppbar, nnbar$ BESIII result

Preliminary results







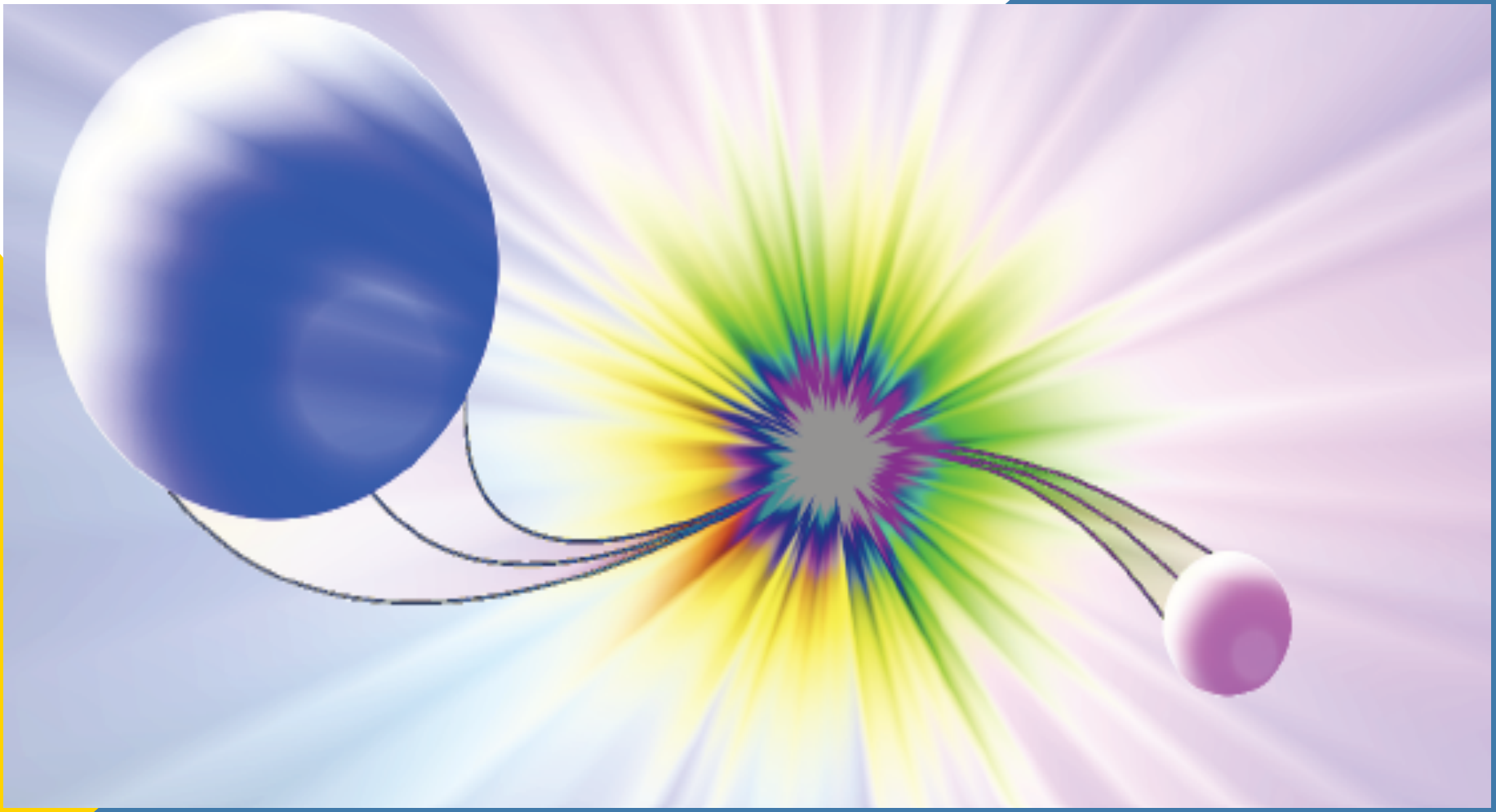
OTHER VECTOR CHARMONIUM PHASES ?

- **ψ'(3686)** controversial: BESIII measurement of $\psi' \to p\bar{p}, n\bar{n} \to \varphi \sim 50°$
  from $\psi' \to$ VP decays $\to \varphi \sim 180°$
  from $\psi' \to$ PP decays $\to \varphi \sim 90°$
- **ψ"(3770)**: Present data suggests: $\varphi \sim -90°$

- ***If the relative phase between vector charmonium E.M. and strong amplitude is different from 0°, something important is lacking in the present charmonium description:***
  - A model of quarkonium OZI breaking decay developed to justify the anomalous phase.
  - kkbar anomalalous phase related to G-parity violation ?

Proposed by Italian group a data taking scan below, at and above the ψ' peak to directly measure the phase.
Approved by the Collaboration to be taken in 2016 run

Baryon-Antibarion cross sections



UNEXPECTED BEHAVIOUR OF BARYON-ANTIBARYON AT THRESHOLD?

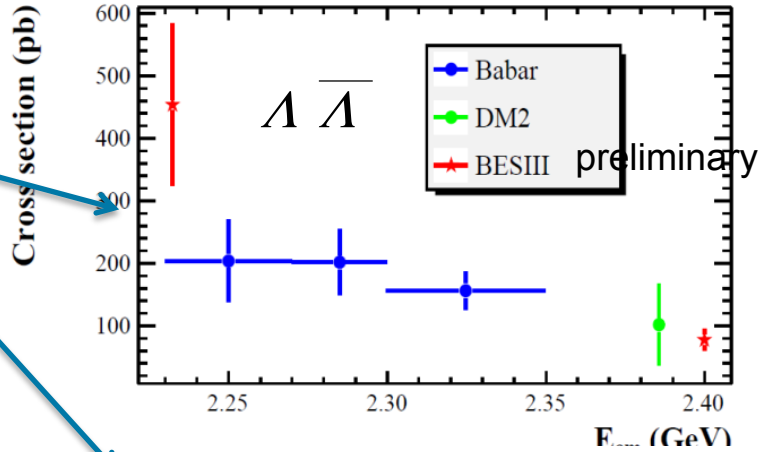
Theory prediction for neutral baryons

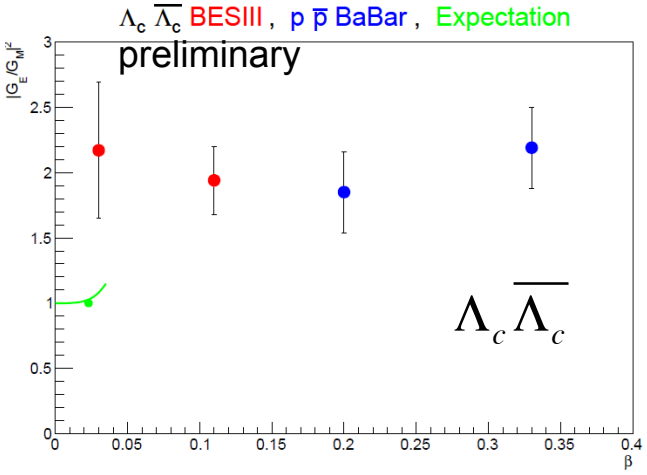
$$\sigma_{\Lambda\bar{\Lambda}} = \frac{2\pi\alpha^2}{W^2}\beta G_{eff}^2(W^2)$$

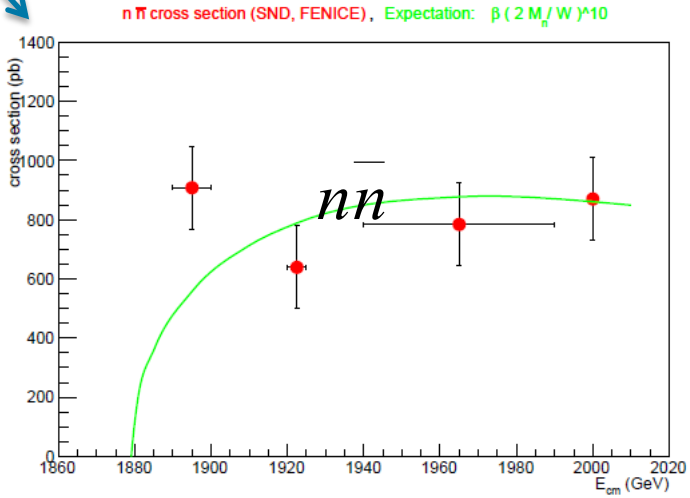
Cross section vanishes as the velocity

$$\beta = (1 - 4M_\Lambda^2/W^2)^{1/2}$$

when: $W^2 \longrightarrow 4M_\Lambda^2$.





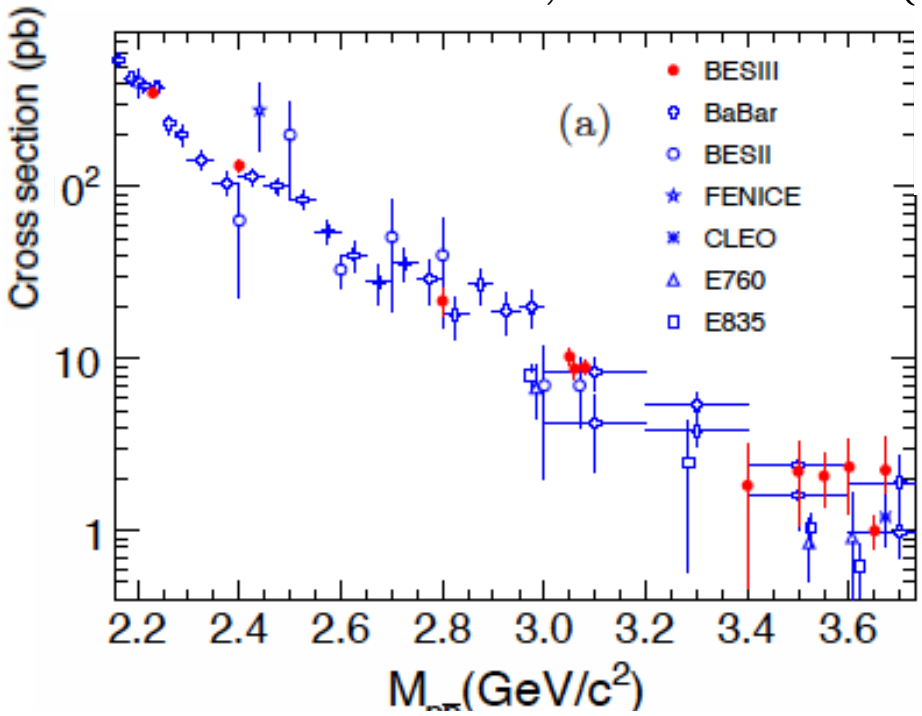


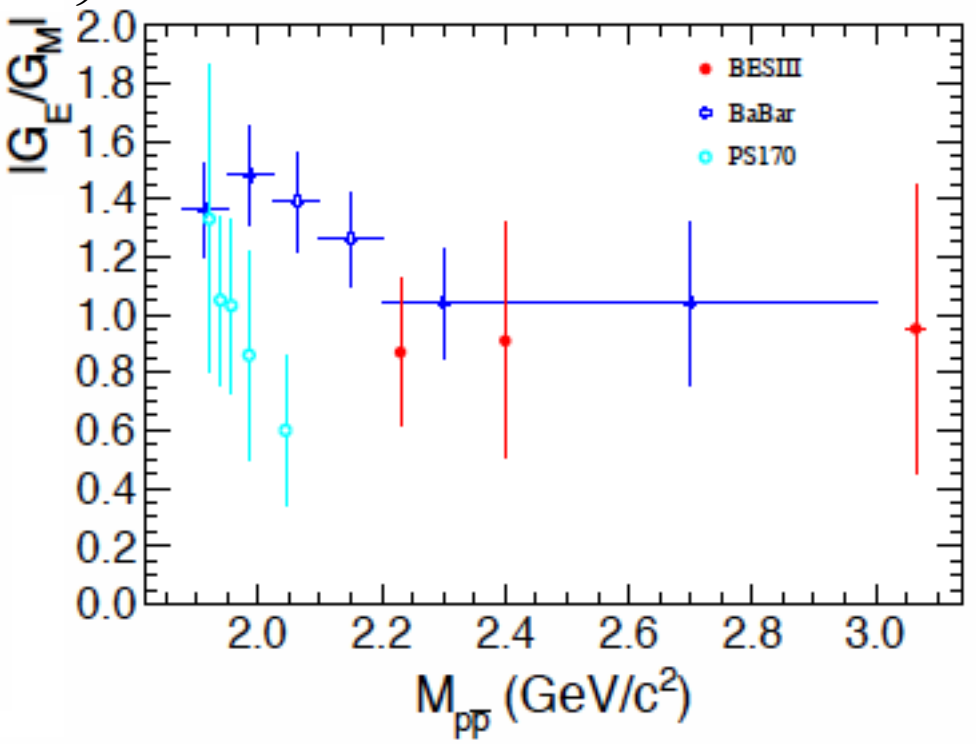
- First measurement of $\Lambda\ \bar{\Lambda}$ at threshold, BESIII result preliminary *Italian group proposal*
- We requested more data for $\Lambda_c\bar{\Lambda}_c$ at W=4575MeV at threshold to improve Ge/Gm error

- Neutral baryons: hints of non-zero cross section at threshold |G|=1
- Charged baryons: hints of non-isotropic cross section at threshold → |Ge/Gm| # 1
- Unexpected D-wave contribution at threshold?

BESIII PROTON FORM FACTOR MEASUREMENT

submitted to P.R.D, arXiv:1504.02680(2015)





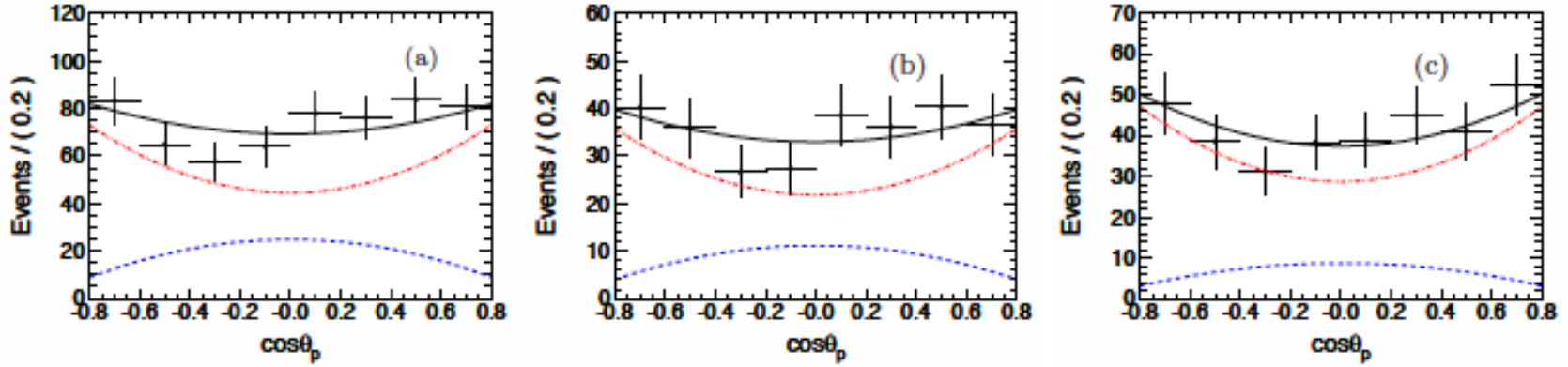


FIG. 6. Efficiency corrected distributions of $\cos\theta_p$ and fit results for data at c.m. energies (a) 2232.4, (b) 2400.0 MeV and (c) a combined sample with c.m. energy at 3050.0, 3060.0 and 3080.0 MeV. The dots with error bars represent data. The solid line (black) represents the overall fit result. The dashed line (in blue) shows the contribution of the magnetic FF and the dot-dashed line (in red) of the electric FF.

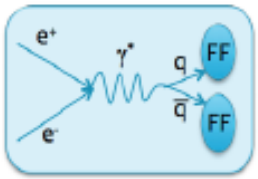
DIS 2015 - XXIII International workshop on
Deep-Inelastic Scattering and Related Subjects

Measurement of Collins asymmetry in inclusive production of pion pairs at BESIII

Garzia I. [a], Guan Y. [b]
[a]INFN-Sezione di Ferrara
[b]Institute of High Energy Physics
On behalf of the BESIII Collaboration

Take advantage of the experience gained on the BaBar experiment to begin a new fruitful collaboration between Italian and Chinese groups.

Collins Fragmentation Functions at BESIII



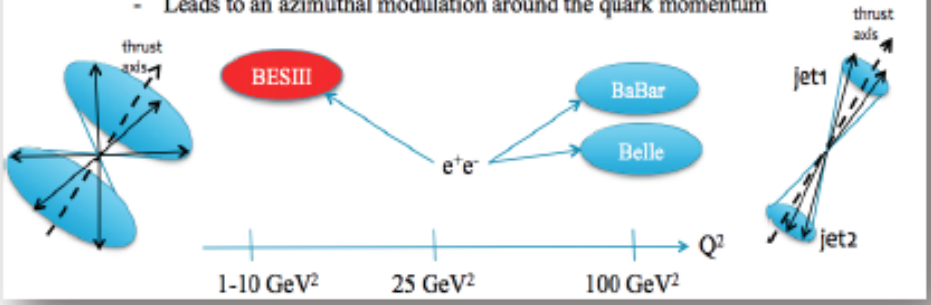
Collins FF ⊗ Collins FF

Unpolarized FF — Polarized FF

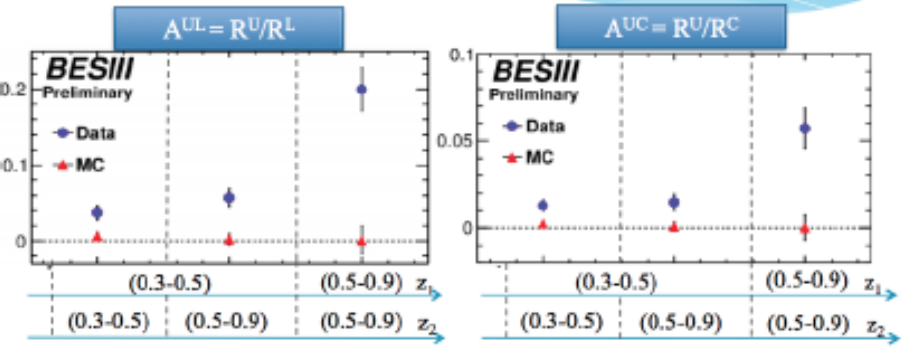
$$D_{hq^\uparrow}(z, P_{h\perp}) = D_1^q(z, P_{h\perp}^2) + H_1^{\perp q}(z, P_{h\perp}^2)\frac{(\hat{\mathbf{k}} \times \mathbf{P}_{h\perp}) \cdot \mathbf{S}_q}{z M_h}$$

J. Collins, Nucl. Phys. B396, 161 (1993)

Fragmentation of a transversely polarized quark into a spinless hadron h:
- Depends on the hadron fractional energy $z=2E_h/\sqrt{s}$ and $P_{h\perp}$
- Leads to an azimuthal modulation around the quark momentum



Data/MC comparisons



Non zero A^{UL} and A^{UC} asymmetries
- Preliminary results: statistical uncertainties only
- Asymmetry measured in the MC sample consistent with zero in each bin of z: detector effects cancel with the double ratio

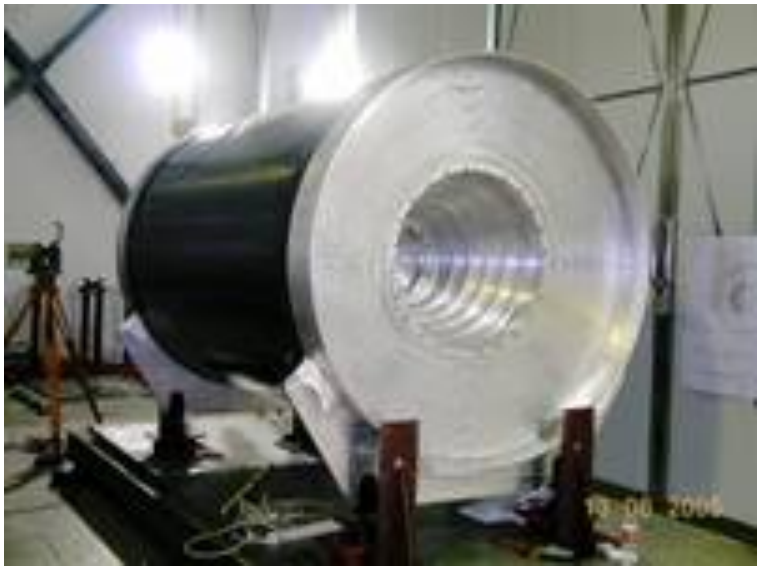
Preliminary result has been presented to the Spin2014 conference (in Beijing) and the final paper is expected to be submitted in 2015

THE CGEM INNER TRACKER STATUS

The BESIII Cylindrical GEM-IT:

- innovations and peculiarities
- construction of the cylindrical layer
- Team , Project & Schedule
- planar prototype:
  - test setup @ LNF
  - CERN test beam

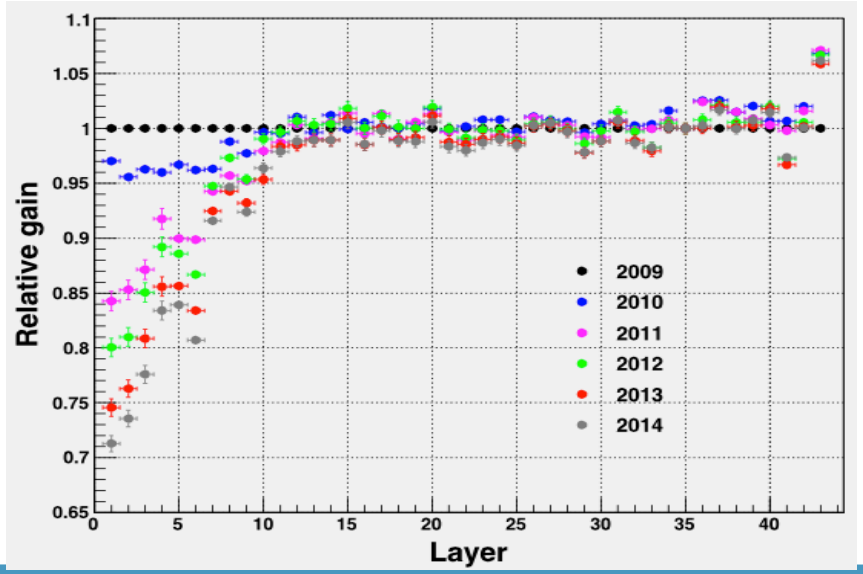
THE MULTILAYER DRIFT CHAMBER INNER TRACKER



- MDC performs momentum and dE/dx measurement for charged particle identification.
- Spatial resolution is 130 μ m in r-φ plane) and 2 mm in the z-coordinate.
- Inner and Outer MDC are two separate chambers sharing the same gas volume.

The increases of the luminosity is speeding up the aging the the inner tracker (IT).

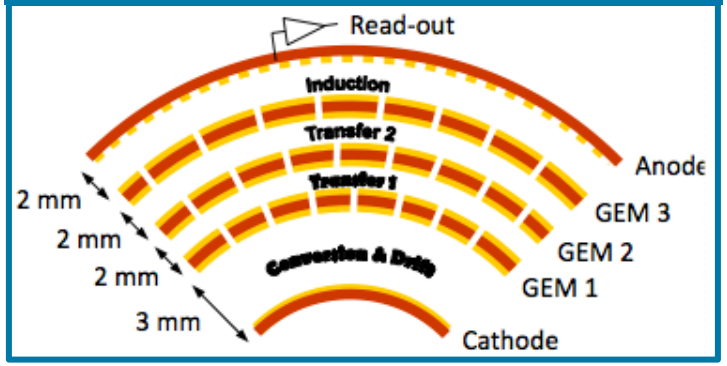
The gain of the innermost layers is decreasing of about 4% per year of data taking.



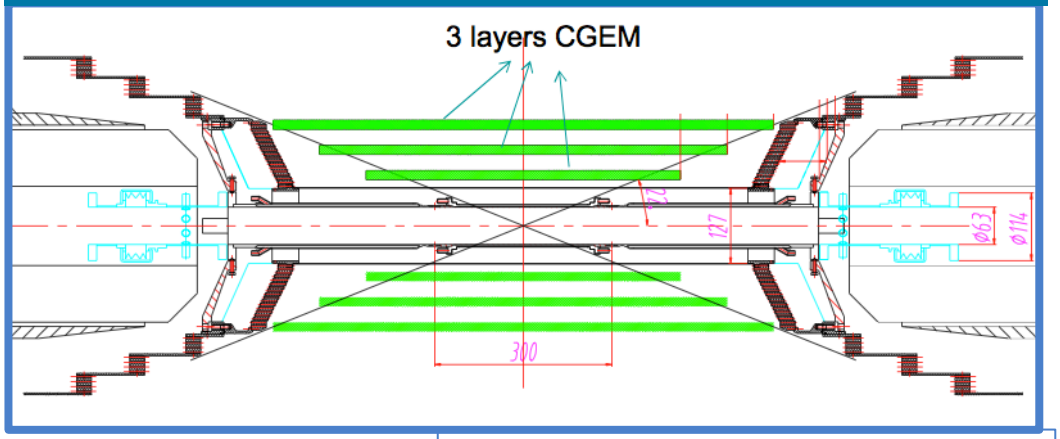
BESIII will run at least up to 2024→ a replacement is needed

THE CGEM-IT

A cylindrical triple GEM



Three layers of CGEM for BESIII



- Three active layers
- Active area
  - L1 length 532 mm
  - L2 length: 690 mm
  - L3 length: 847 mm
- Inner radius: 78 mm
- Outer radius: 178 mm

Requirements

Rate capability: ~10 KHz/cm^2

Spatial resolution: σ_{xy} =~100μm : σ_z=~1mm

Momentum resolution (INNER+MDC): σ_{pt}/P_t =~0.5% @1GeV

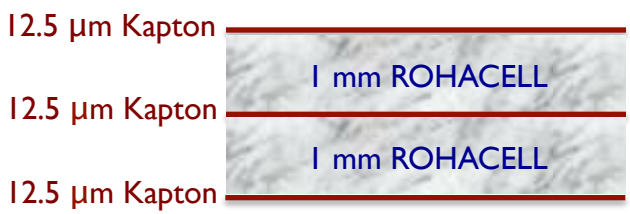
Efficiency = ~98%

Material budget ≤ 1.5% all layers

Coverage: 93% 4π

BESIII IT DESIGN VS KLOE IT DESIGN: INNOVATIONS

- rohacell (structure instead of honeycomb+carbon fiber) used to give mechanical rigidity
- anode design: XV readout with jagged-strip layout to decrease parasitic capacitance
  X 570μm strips,V 170μm stereo (31°-33°-47°) strips, 650μm pitch wide
- analog readout to achieve the required spatial resolution with a limited number of channels (charge centroid)

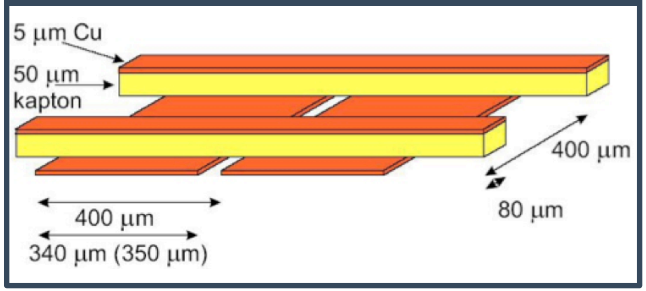


cathode foil wrapped on the rohacell

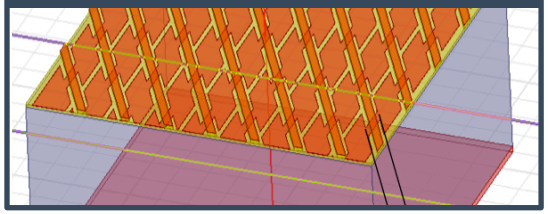
	BESIII	KLOE-2
# of X_0 for 1 layer	0.33	0.49
# of X_0 for 3 layers	0.99	1.47

KLOE strips implemented on KAPTON multilayer PCB

COMPASS structure



JAGGED structure
≈ 30% inter-strip capacitance reduction (simulation)



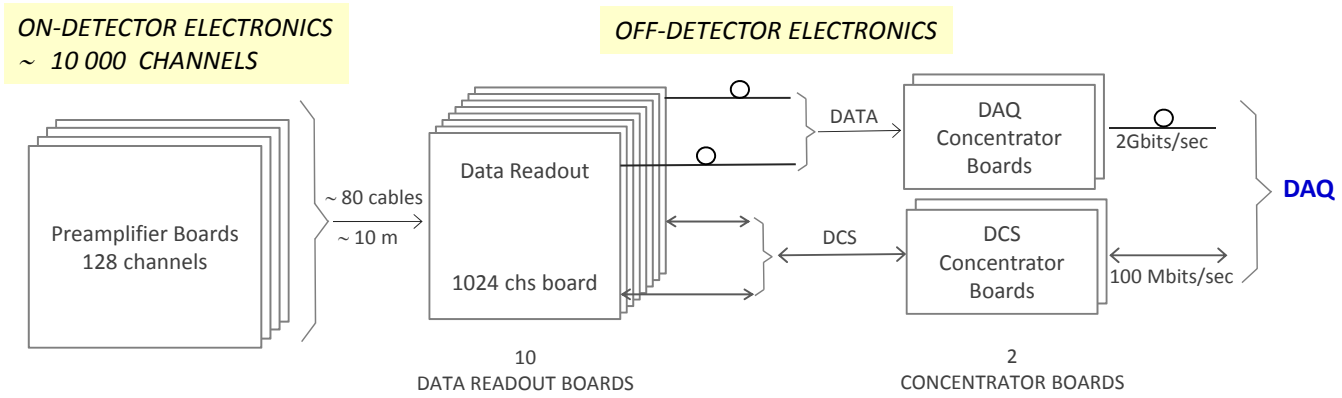
FRONT END ELECTRONICS

GOALS

- Spatial Resolution ≤ 100 μ m
- Time Resolution ≈ 1 ns
- Dead time (shaping + analog-to-digital conversion) ≤ 1 μ s to limit pile-up probability at a few %

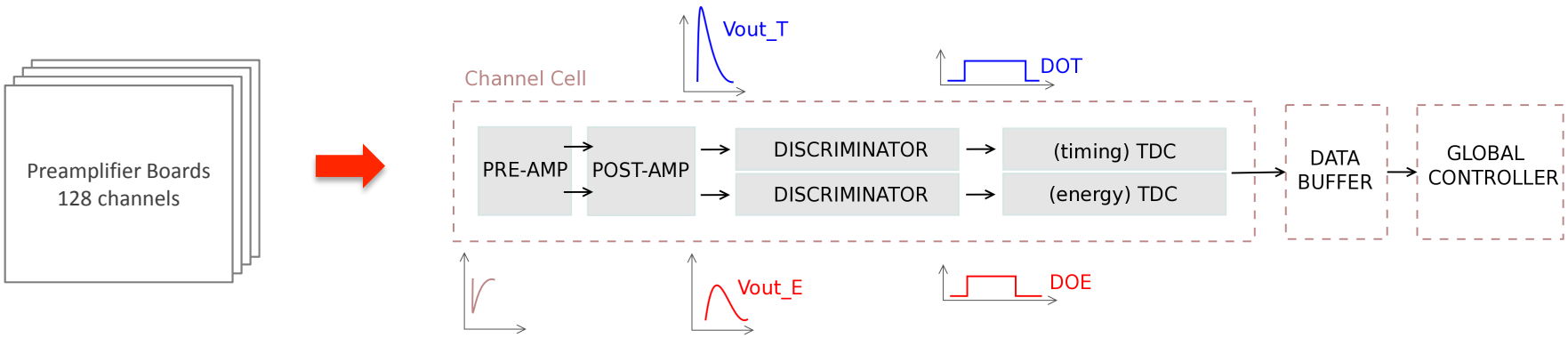
ANALOG READOUT WILL BE USED TO MEASURE STRIP CHARGE

- Charge centroid measurements → improve spatial resolution (with respect to the ≈ pitch/$\sqrt{12}$ of the digital ones).
- Two thresholds: on single strip and on total charge → better S/N
- Moderate strips pitch (650 µm) → reduced number of channels (≈ 10 kchs)
- 6-8 bits of fast digitization for each channel required → new ASIC development



Preamplifier boards located on the detector preserve S/N ratio
Data Readout Boards and Concentrator Boards
as close as possible to the detector

PREAMPLIFIER BOARDS (TO)

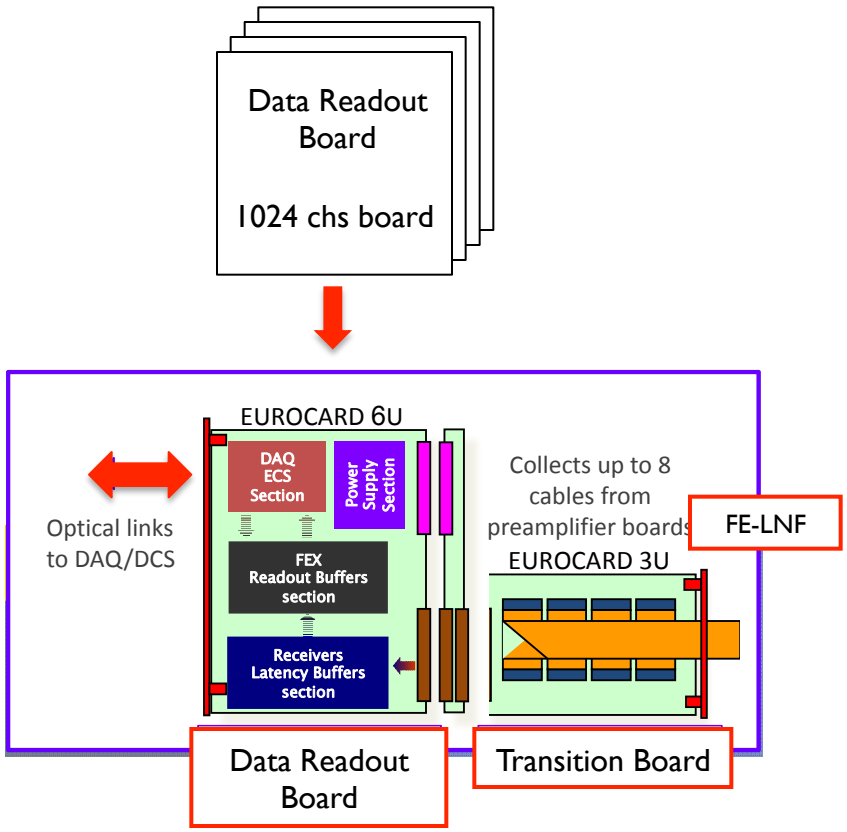


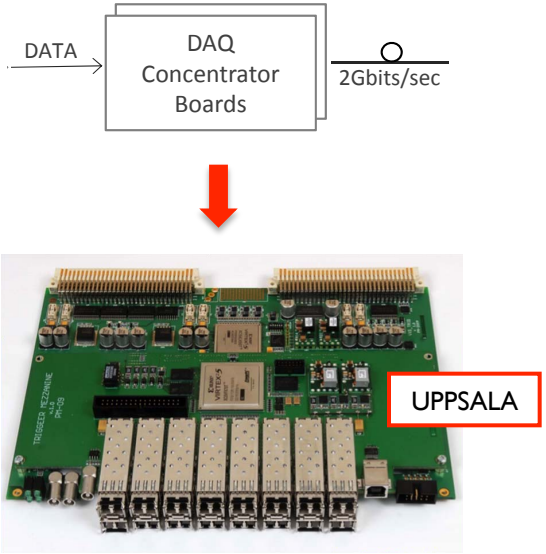
DESIGN INFERRED FROM TOFPET ASIC (development for medical applications – TO)

- Time and Charge measurements by TDCs
- Time over Threshold (ToT) charge measurement
- Double threshold discrimination
- Time resolution ≤ 1ns
- Energy resolution ≤ 0.5 fC
- Technology UMC 110 nm (CGEM)
- Two ASICs per preamplifier board
- ≈ 80 boards

ASIC (from TOFPET development)
64 channels
0.5 – 60 fC Input Charge
$C_{IN\ MAX} \approx 100$ pF
≈ 60 kHz average input rate

DATA READOUT (FE-LNF) & CONCENTRATOR (UPPSALA) BOARDS



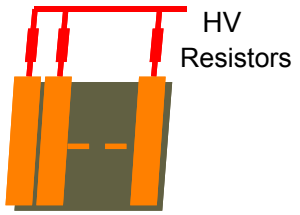


Readout Boards must match the ASICs data driven architecture with BES DAQ based on L1 trigger and 6.4 (nominal) latency time

10 Data Readout Boards
1024 channels/board

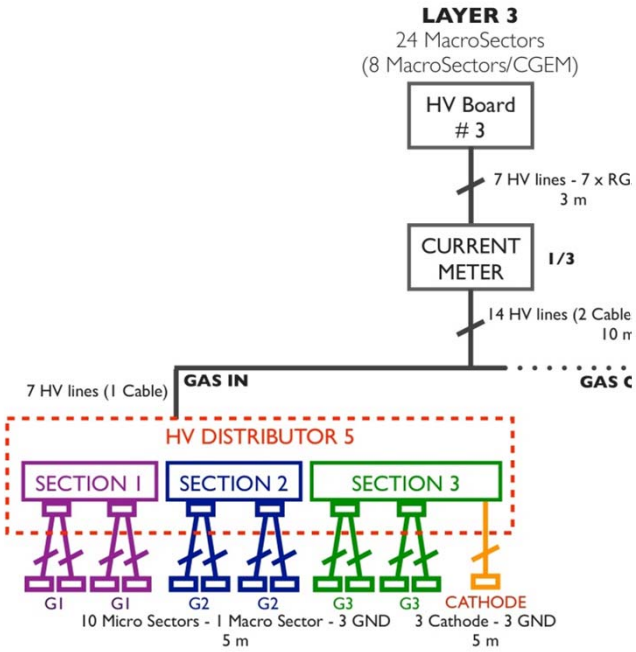
2 Concentrator Board
5000 channels/board

HV DISTRIBUTION (LNF)

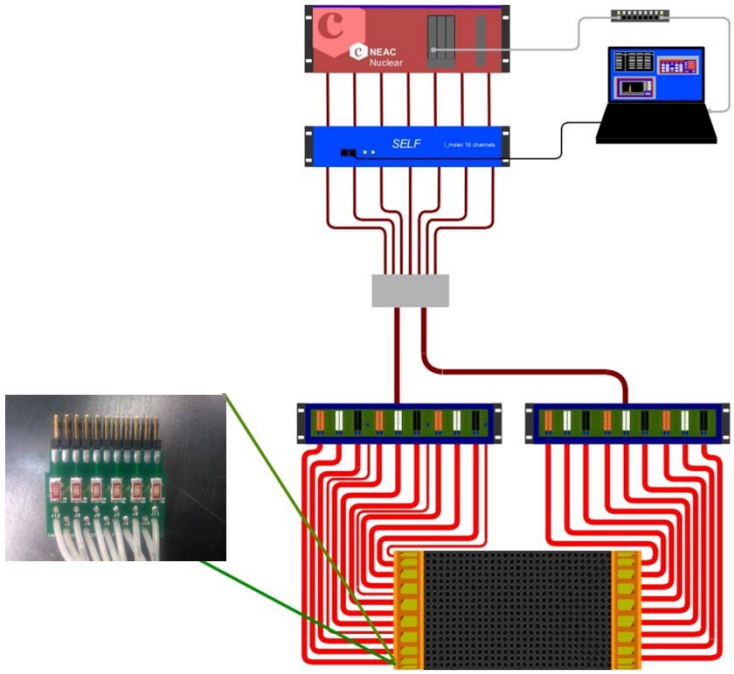


10 HV micro-sectors

Internal CGEM μ-sectors
(discharge protection)



LAYER 3 HV Distribution Chain



Single Layer Distribution Block Diagram

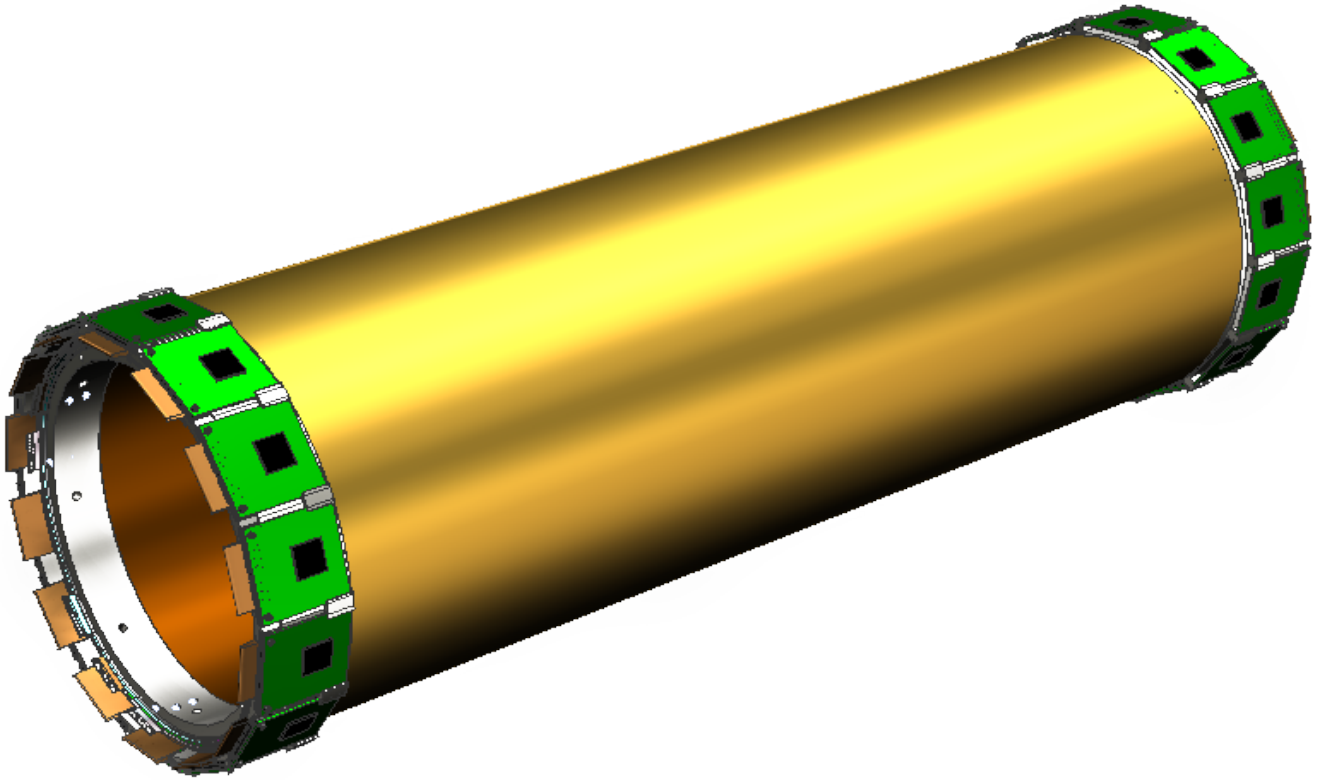
HV DISTRIBUTION SYSTEM

6 Distribution Boxes (2 boxes x layer)

2, 4, 6 Macro-Sectors per side

20, 40, 60 micro-sectors per side

TOWARD THE CONSTRUCTION OF THE FIRST CYLINDRICAL LAYER



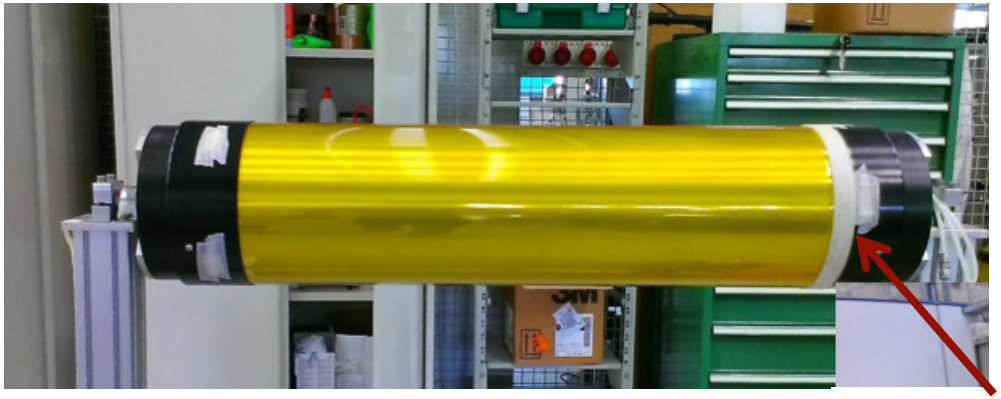
CGEM Construction Tools

consttruction and assembling procedures inherited by KLOE2 experience

- Assembling of the cylinders is performed vertically → A dedicated machine has been designed and realized for KLOE2 by INFN-RM1 technical staff now beeing modify to host BESIII cylinders by same technical staff, thanks to RM1-INFN workshop.
- Axial alignment has a precision of 0.1mm/1.5m.
- The structure can rotate by 180° around its central horizontal axis one into the other.

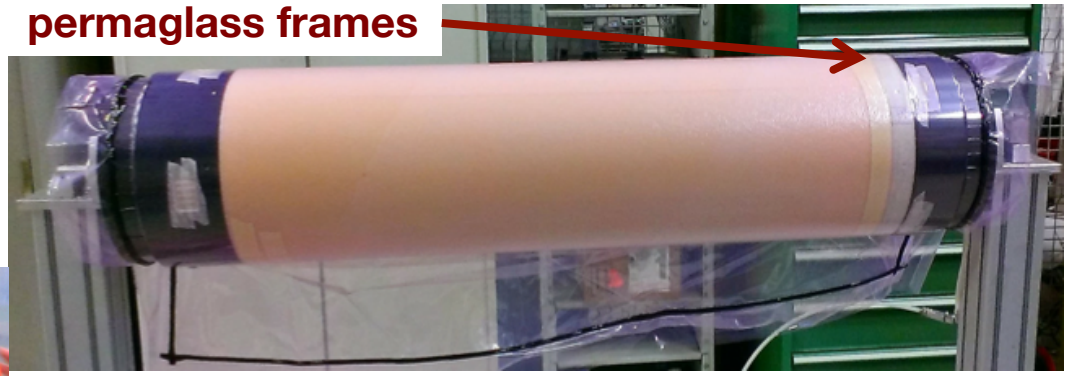
To obtain cylindrical electrodes the foils are wrapped around molds, one mold for each of the 5 electrodes.

Cathode construction (FE)



- 12.5 micron kapton foil around the aluminum mold; that is the most critical part.

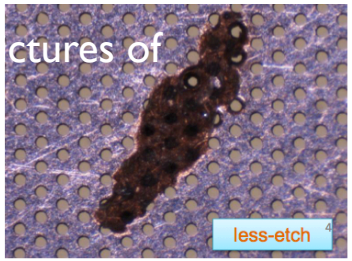
permaglass frames

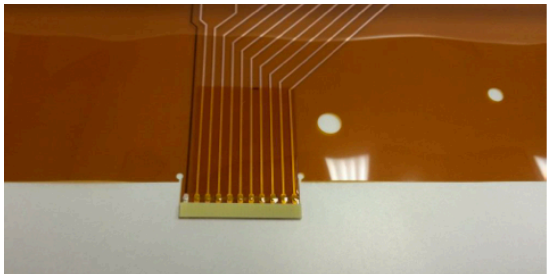


- the Rohacell plane is glued under vacuum on the kapton.

- the Rohacell plane is machined with a high precision milling machine.

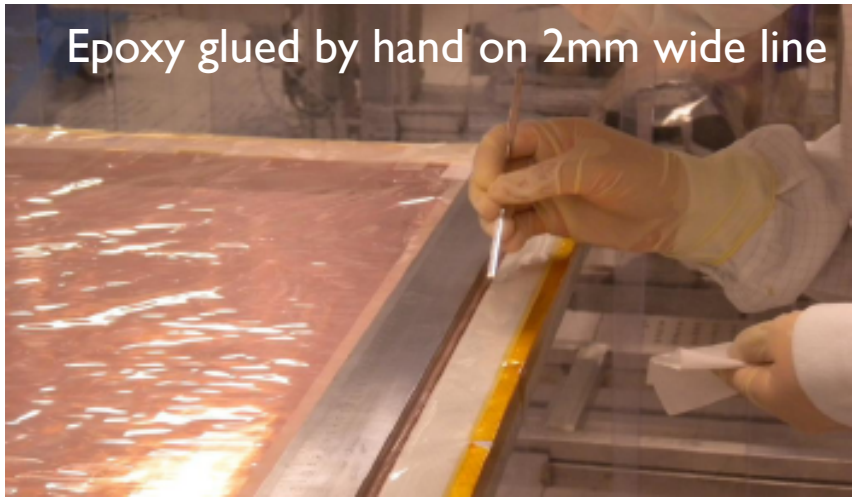
GEM testing and planar gluing (LNF)

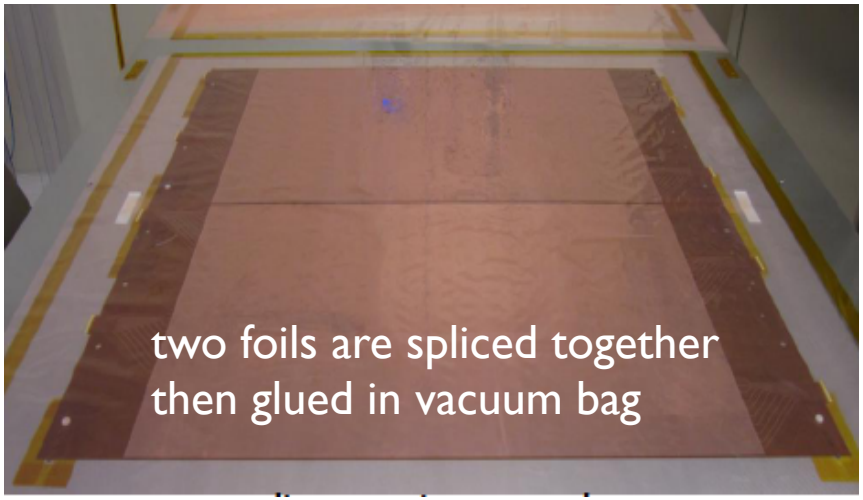




GEM production HV quality test.
After visual inspection , HV test:

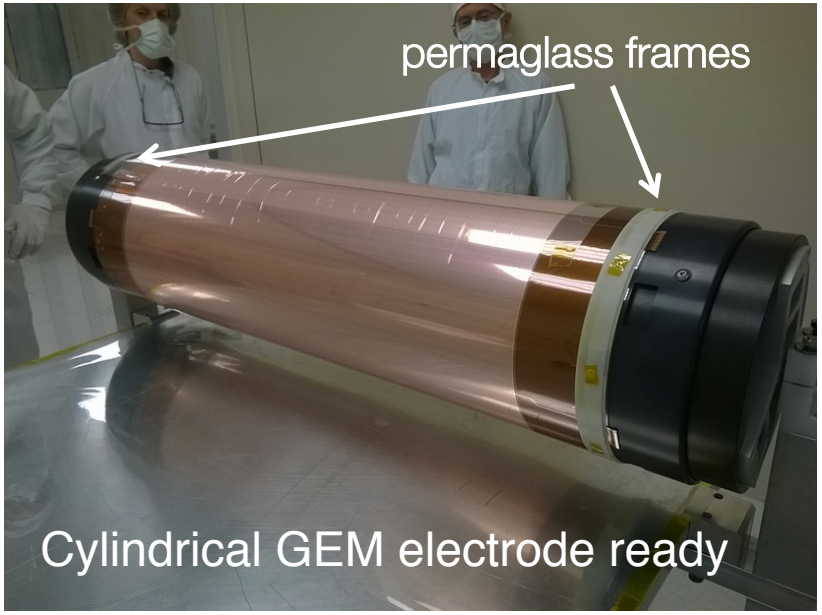
- <1 nA @ 600 V
- <2 discharges/30mins



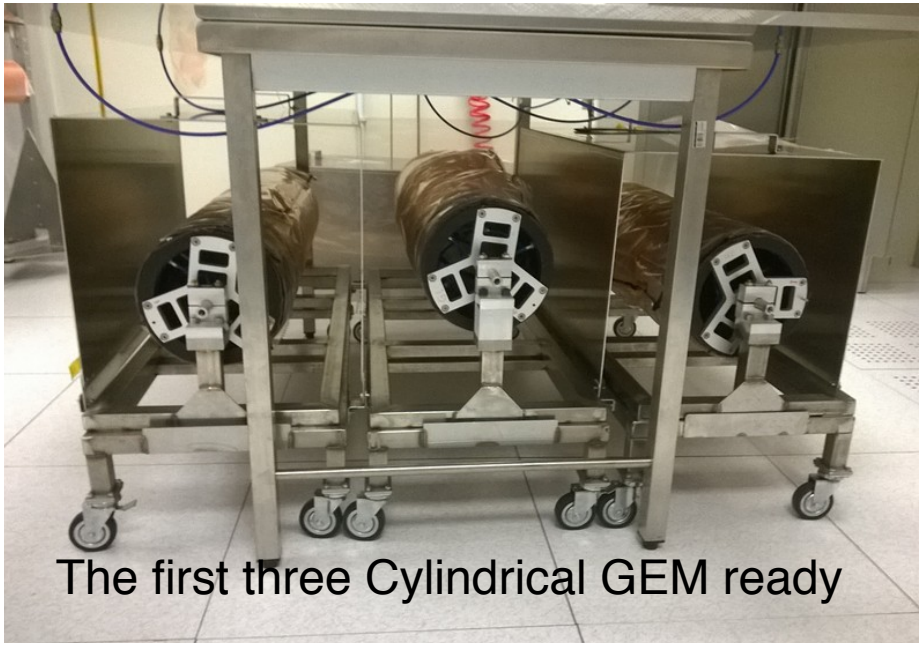


Cylindrical GEM assembly (LNF)

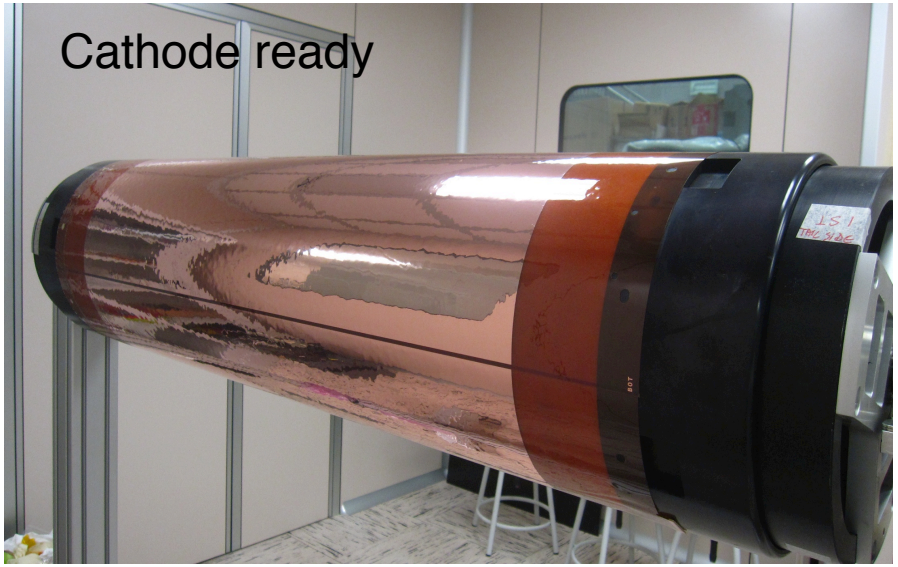
- GEM cylindrical assembly in the INFN-LNF clean room
- The three CGEM cylinder for the first layer are ready on their molds in LNF.
- Cathode is ready in Ferrara
- Plan to move to the vertical assembly this summer.



Cylindrical GEM assembly (LNF)



The first three Cylindrical GEM ready



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- The three CGEM cylinder for the first layer are ready on they molds in LNF.
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- Plan to move to the vertical assembly next summer.

CGEM: The Team,
Project status and schedule

The CGEM team

The INFN group is leading the development of the CGEM-IT

- Together with INFN (LNF-PG, Ferrara, and Turin) and IHEP,
- Mainz and Uppsala are officially part of the project.

- Sharing of responsibilities:

  - INFN: design and construction of the detector and electronics
  - IHEP: gas system, slow control and all the software developments needed to readout and integrate the detector into the DAQ
  - Mainz: high voltage system and participation to the ASIC foundry cost.
  - Uppsala: data concentrator

June 2014: Conceptual Design Report

1. Introduction
   1. The present BESIII Inner Tracker
   2. Luminosity Issues
      1. Present and expected backgrounds
   3. Inner Tracker Upgrade Requirements
2. Detector design
   1. Operating principle of a triple Cylindrical GEM detector
      1. The KLOE2 Inner Tracker: know-how and first results
   2. BESIII CGEM innovations
      1. Rohacell
      2. Anode design
      3. Analog vs. digital, expectations and measurements
3. The BESIII CGEM-IT
   1. CGEM-IT vs DC-IT
   2. Mechanical Design
   3. Tooling and Construction
4. Simulation of Cylindrical GEM Inner Track
   1. Parametric Simulations (Liang)
   2. CGEM-IT full Offline Reconstruction
      1. Pattern Recognition
      2. Tracking
      3. Acceptance, Resolutions and Reconstruction Efficiencies
   3. Monte Carlo simulation results
      1. Physics Benchmark
5. Front End Electronics
   5. Requirements
      5. Power Consumption
   6. System Block Description
   7. On-Detector Electronics
      5. ASIC
   8. Off-Detector Electronics
6. DAQ and Trigger
   5. Requirements
   6. Dead time and bandwidth
   7. Possible second level trigger future upgrades
   8. Storage
7. Integration of the CGEM-IT with the Spectrometer
   5. Mechanical design
      5. Interfacing with beam pipe
      6. Interfacing with Outer DC
   6. Power Dissipation and Cooling
   7. Gas Systems
   8. HV Systems
   9. Slow Controls
8. Money, manpower, schedule, task subdivision…..

Approved by BESIII Executive Board on July 2014

June 20 … Report

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      3. Acceptance, Resoluti…
   3. Monte Carlo simulation re…
      1. Physics Benchmark

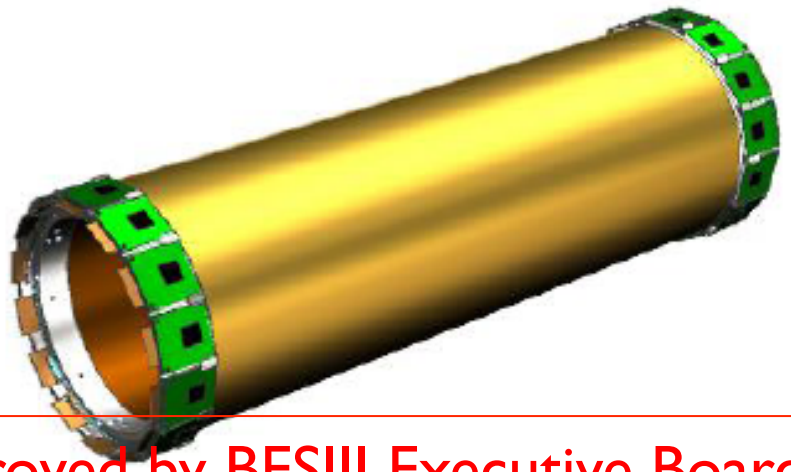
Conceptual Design Report

BESIII Cylindrical GEM Inner Tracker

BESIII Collaboration

July 3rd, 2014

Ver. 1.0.1



…ics

…onsumption
…Description
…Electronics

…Electronics

…l bandwidth
…d level trigger future upgrades

…CGEM-IT with the Spectrometer
…sign
…ng with beam pipe
…ng with Outer DC
…tion and Cooling

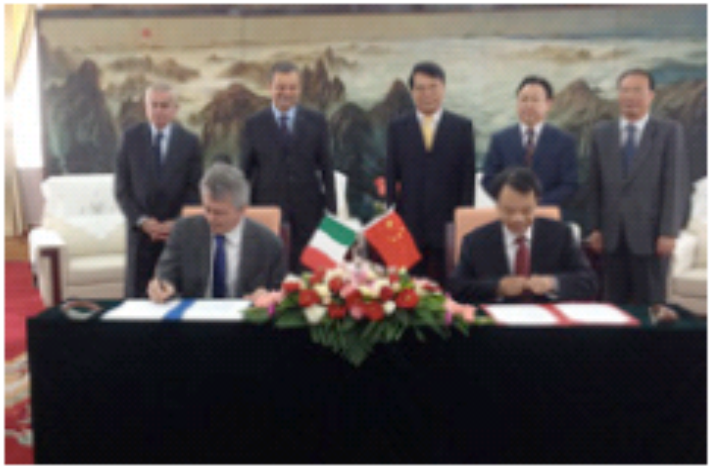
…; schedule, task subdivision…..

Approved by BESIII Executive Board on July 2014

External fundings

INFN-MAE-IHEP 2013-2015 CGEM PROJECT

- Design, construction and test of a CGEM prototype with analog readout, to be used as the first layer of a new CGEM IT for BESIII,
- Recognized as a Great Relevance Project within the Executive Program for Scientific and Technological Cooperation between Italy and P.R.C. for 2013-2015.
- total budget ≈ 360.0K€



Horizon 2020 MSCA RISE (Research and Innovative Staff Exchange) 2014

Proposal Evaluation Form

	EUROPEAN COMMISSION Horizon 2020 - Research and Innovation Framework Programme	Evaluation Summary Report

Call:	H2020-MSCA-RISE-2014
Funding scheme:	Marie Skłodowska-Curie Research and Innovation Staff Exchange (RISE)
Proposal number:	645664
Proposal acronym:	BESIIICGEM
Duration (months):	48
Proposal title:	An innovative Cylindrical Gas Electron Multiplier Inner Tracker for the BESIII Spectrometer

Criterion 1 - Excellence (weight 50%)

Score: **4.40** (Threshold: 0.00/5.00 , Weight: 50.00%)

Project Schedule

commissioning and data taking

installation

QC and test

complete construction

begin detector construction

finalize the detector design

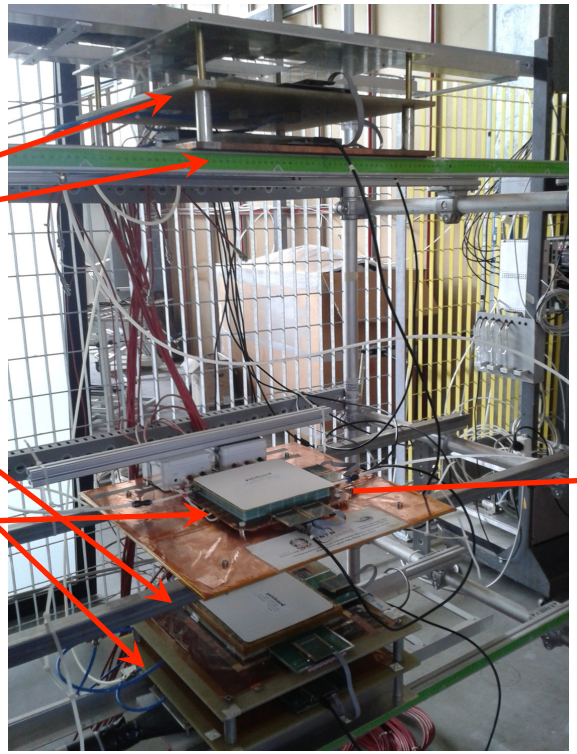
R&D and simulation for detector design

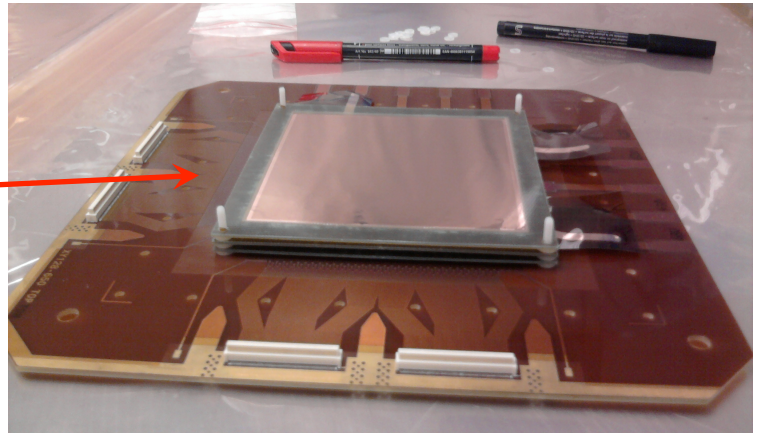
PLANAR DETECTOR TEST PROTOTYPE

THE PLANAR PROTOTYPE & THE TEST BEAM AREA @ LNF

4 KLOE tracking chambers

The BESIII-(COMPASS-)type test chamber





Cosmic telescope setup @ LNF :

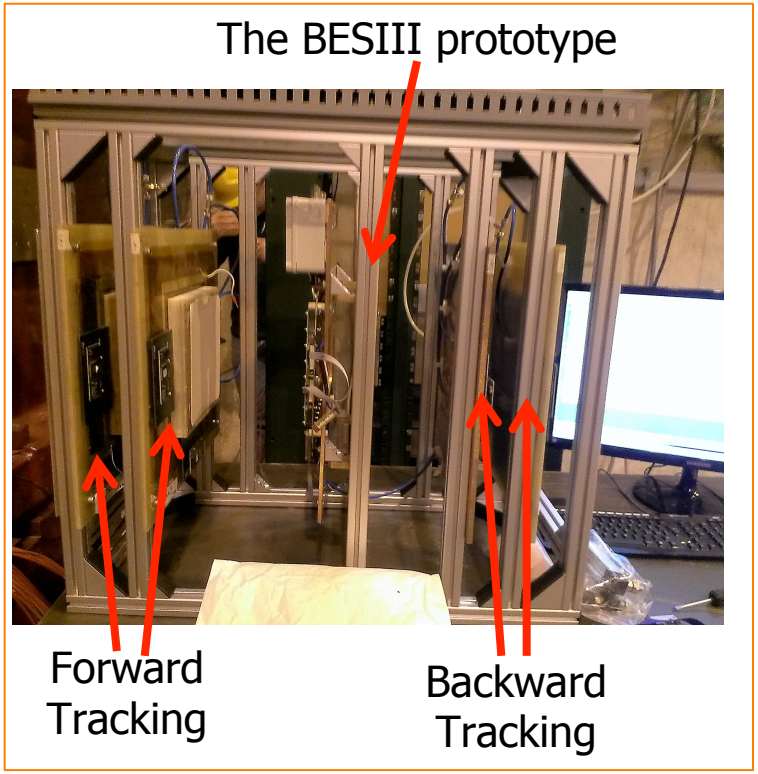
New BESIII test chamber (10x10 cm^2) compass-like.

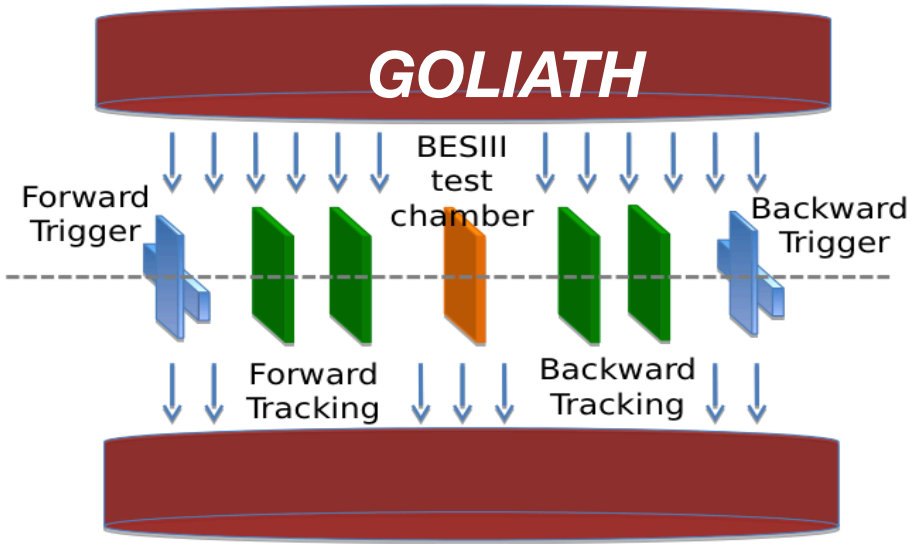
4 KLOE-type planar chambers (Thanks to KLOE2 people) X-Y ortogonal views

The new BESIII-type planar (10x10 cm) test chamber:
X- and Y-strip planes
128 strips/plane
read out by 2 APV25 chips, yielding 128 charge values, for 27 time samples (25 ns apart)

CERN SPS TEST BEAM

Planar prototype tested at CERN SPS beam last December to test a planar prototype inside a magnetic field.





- validate analogue readout
- validate Garfield simulation
- test different gas and geometry configurations
- test 3mm and 5mm gap

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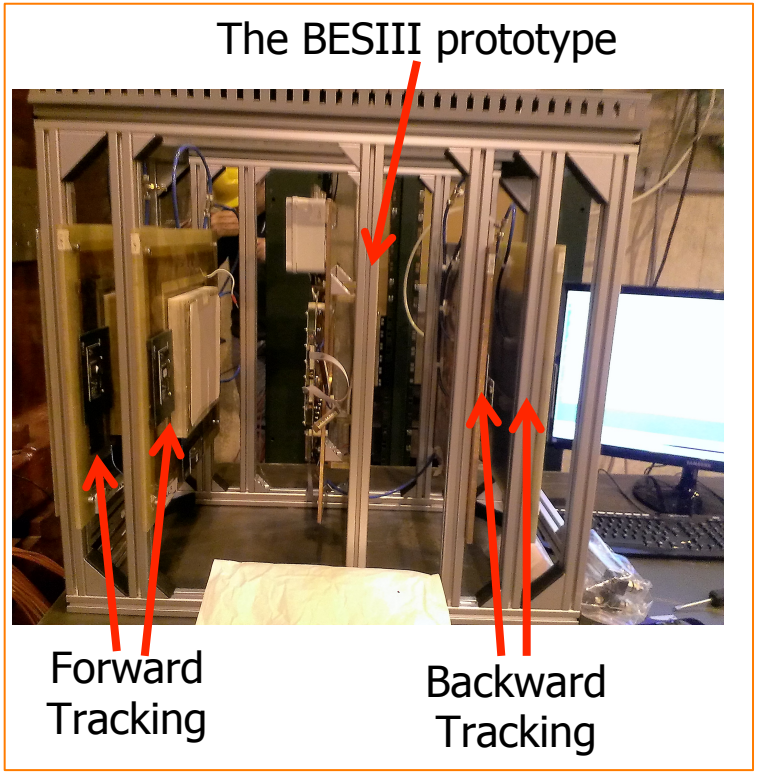
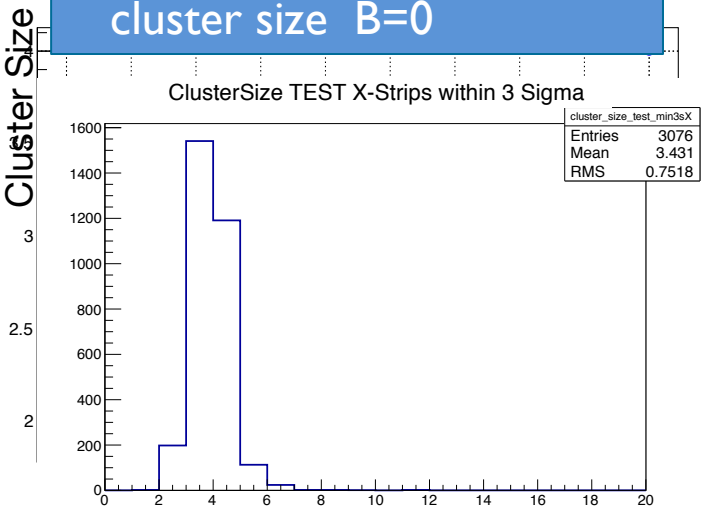


- validate analogue readout
- validate Garfield simulation
- test different gas and geometry configurations
- test 3mm and 5mm gap

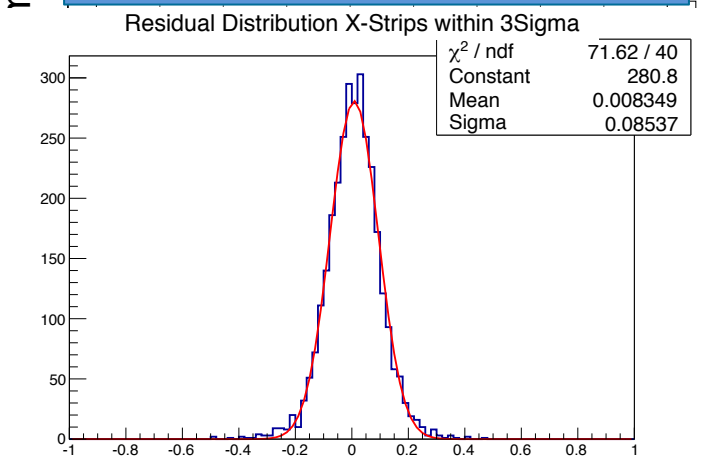
TEST BEAM PRELIMINARY RESULTS B=0

gas mixture: Ar/Isobutane (90/10)

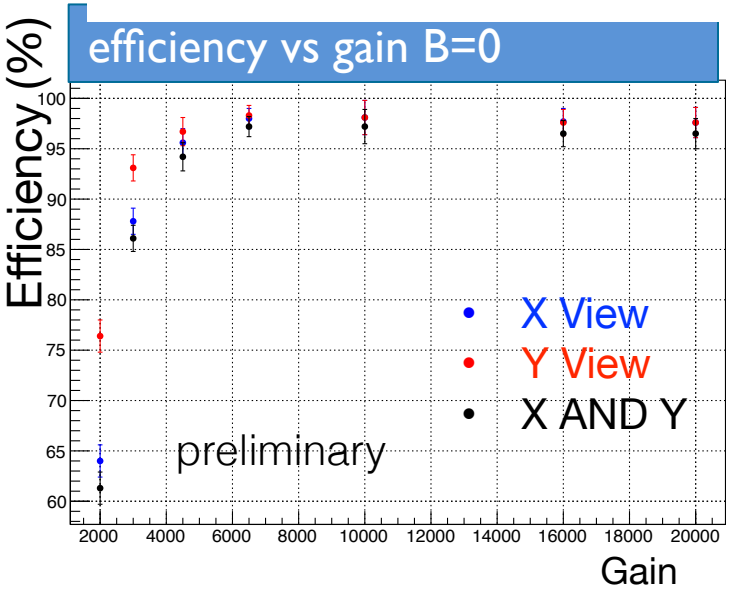
cluster size B=0



spatial resolution B=0



efficiency vs gain B=0



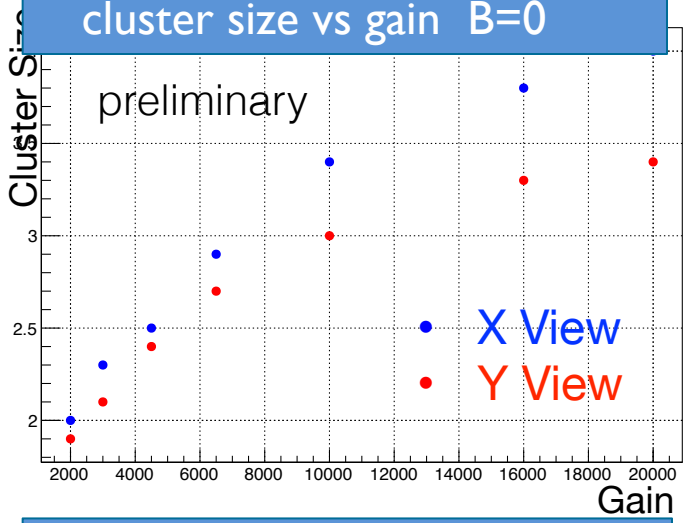
With Ar/Isob (90/10) gas mixture, 650 μm strip pitch, 3mm gap, B=0 :

- Efficiency plateau starts @ gain≈6000.
- Efficiency for 2 dimensional clusters ~97%
- σ≈ 90 μm

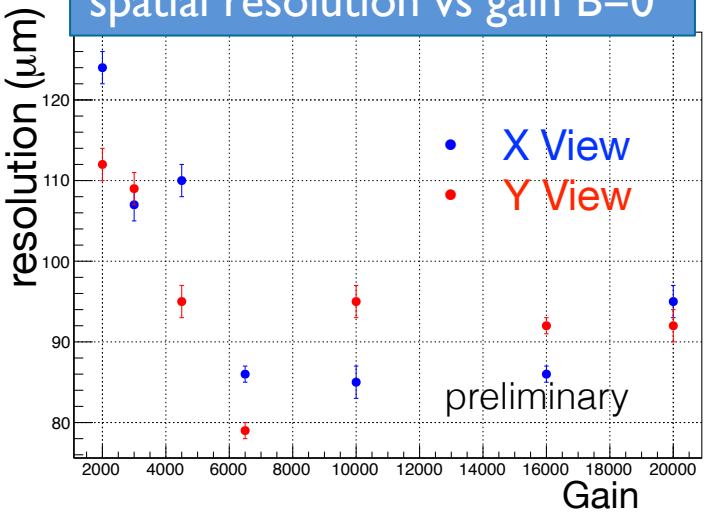
TEST BEAM PRELIMINARY RESULTS B=0

gas mixture: Ar/Isobutane (90/10)

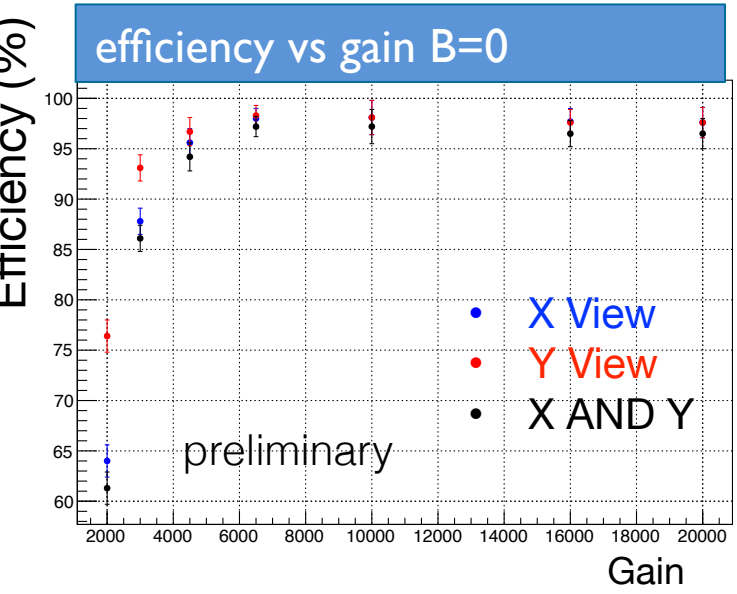
cluster size vs gain B=0



spatial resolution vs gain B=0



efficiency vs gain B=0

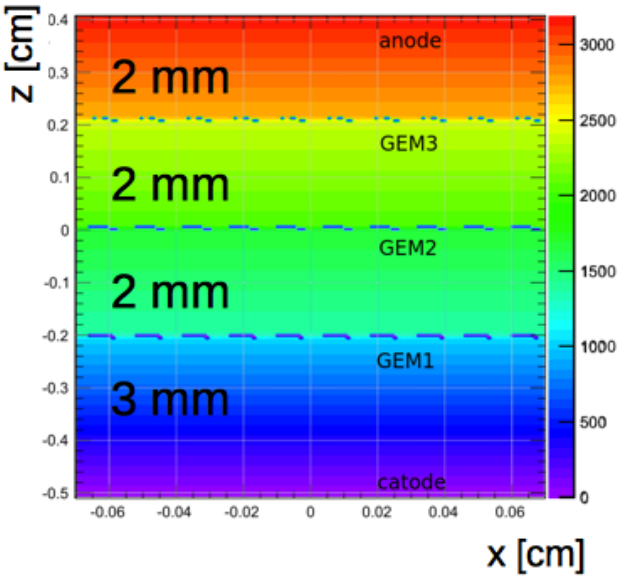


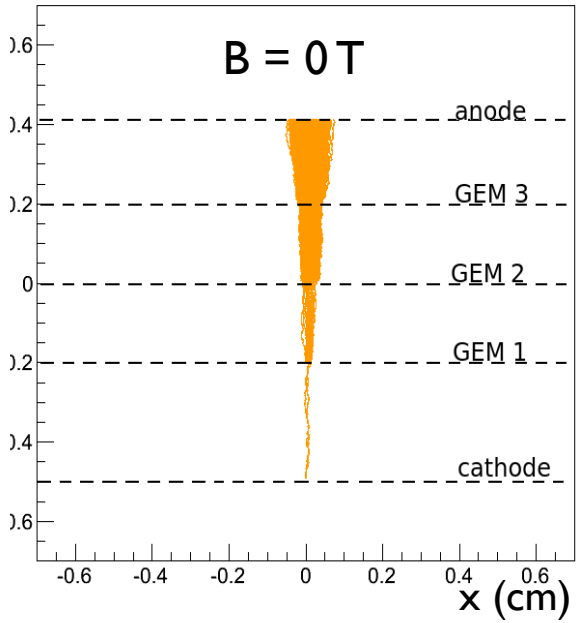
With Ar/Isob (90/10) gas mixture, 650 μm strip pitch, 3mm gap, B=0 :

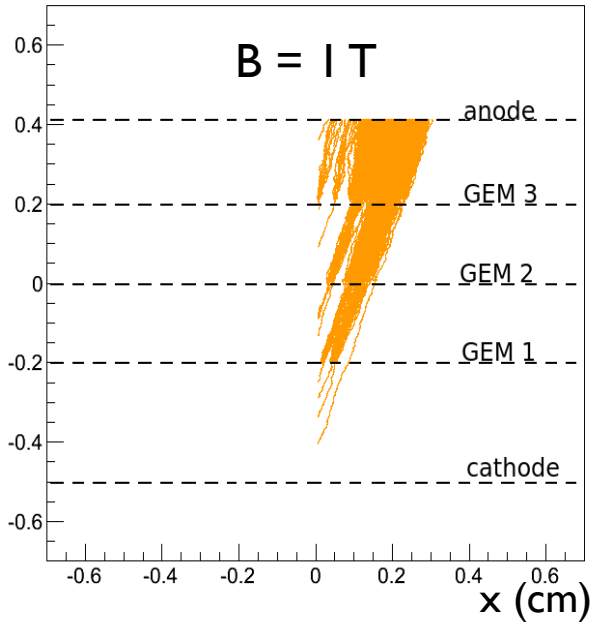
- Efficiency plateau starts @ gain≈6000.
- Efficiency for 2 dimensional clusters ~97%
- $\sigma \approx 90$ μm

Effect of the magnetic field on the electron avalanche

- The effect of the magnetic filed to the electron avalanche has been studied with a Garfield simulation.





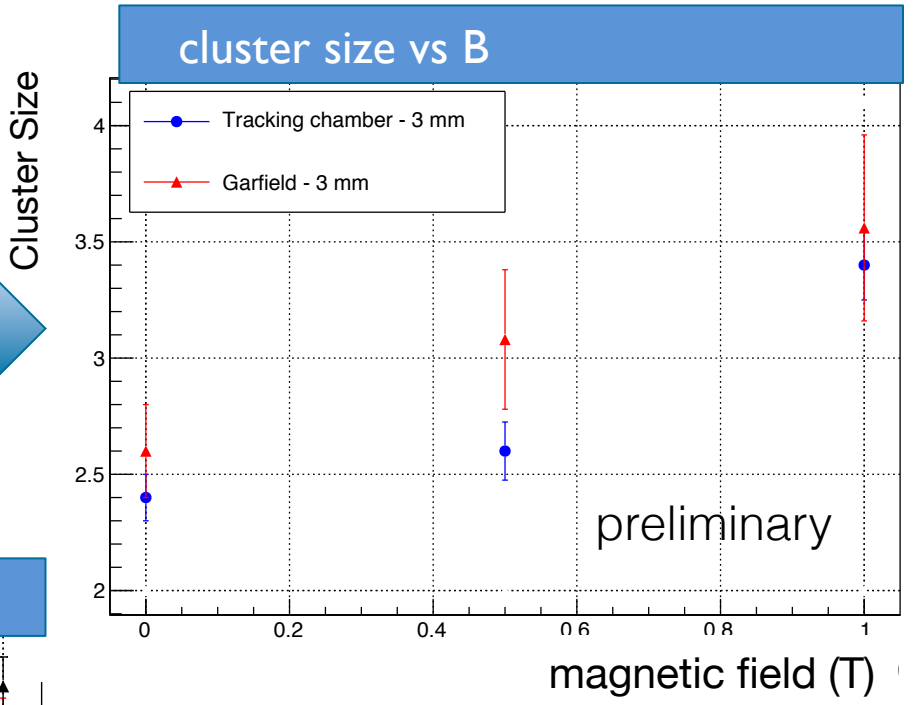


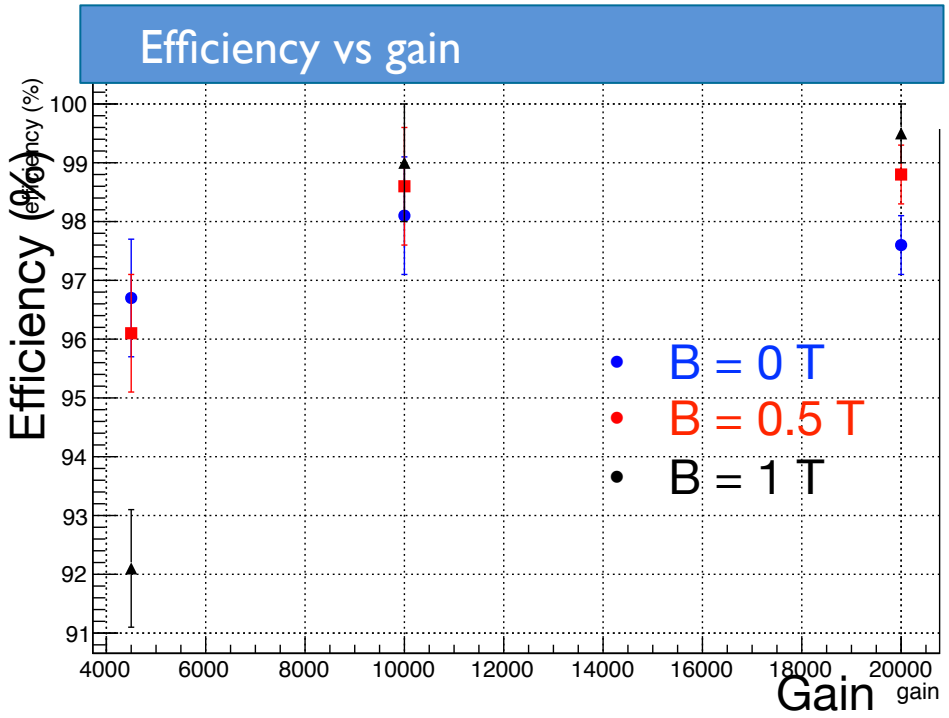
- The Lorentz force displaces the electron avalanche
- In addition the B field produces a broadening of the charge distribution at the anode.

PRELIMINARY RESULTS WITH B FIELD

gas mixture: Ar/Isobutane (90/10)

- Effect of B field on cluster multiplicity and comparison with Monte Carlo simulation.
- work in progress for resolution

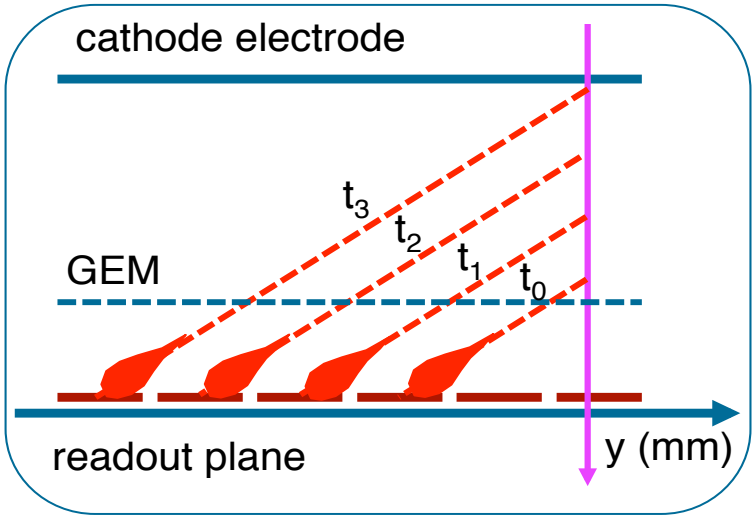




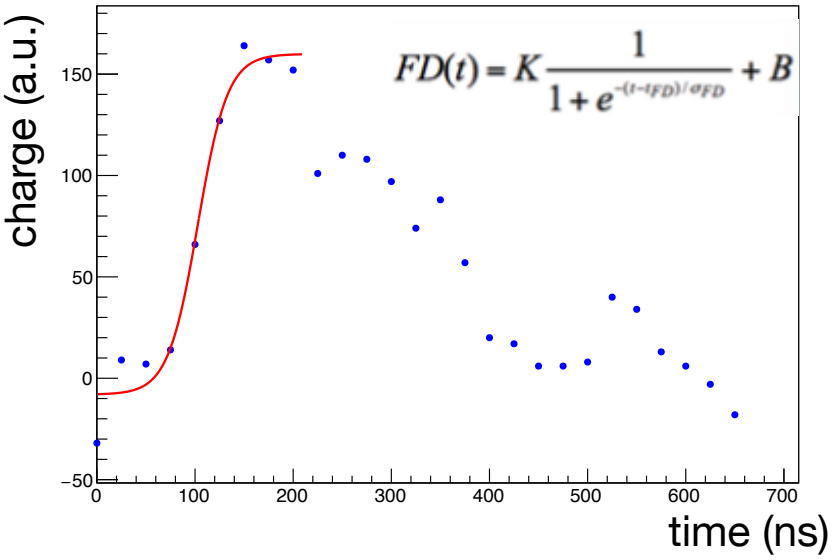
- No effect of magnetic field on tracking efficiency.

Exploring the GEM technology potentialities: μTPC readout

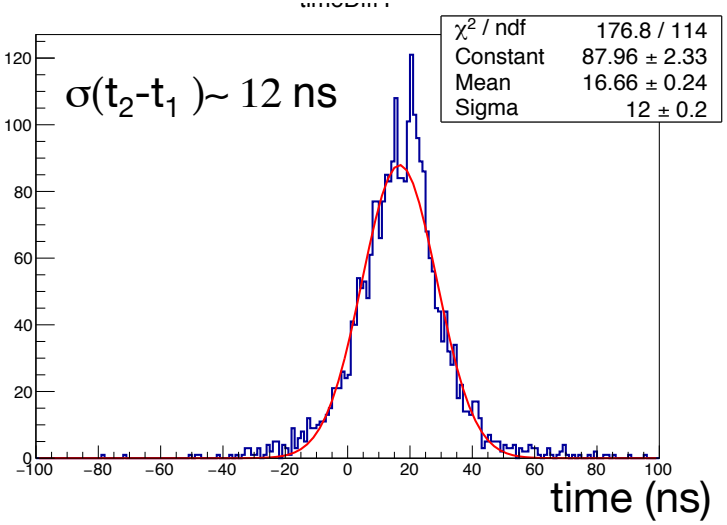
- The time information can be used to improve the spatial resolution with B field.
- Time information can be extracted from the sampling of the APV signal.



Fit to the charge samples to extract the drift time

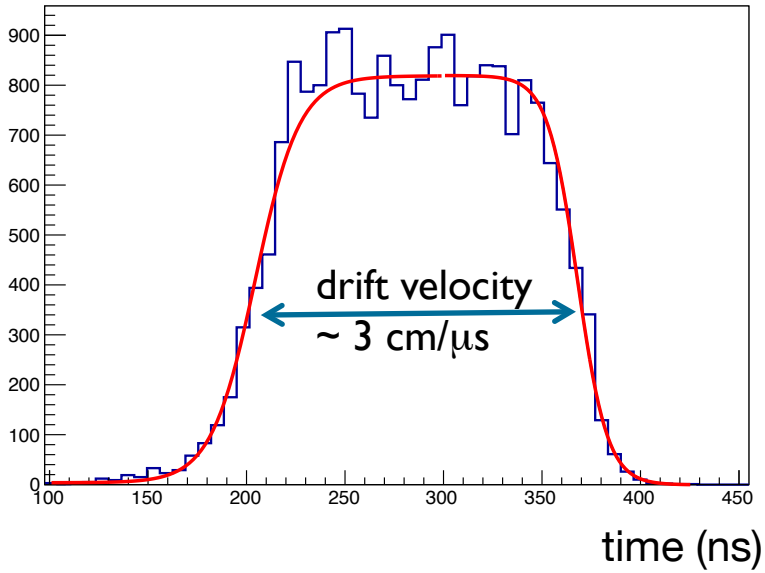


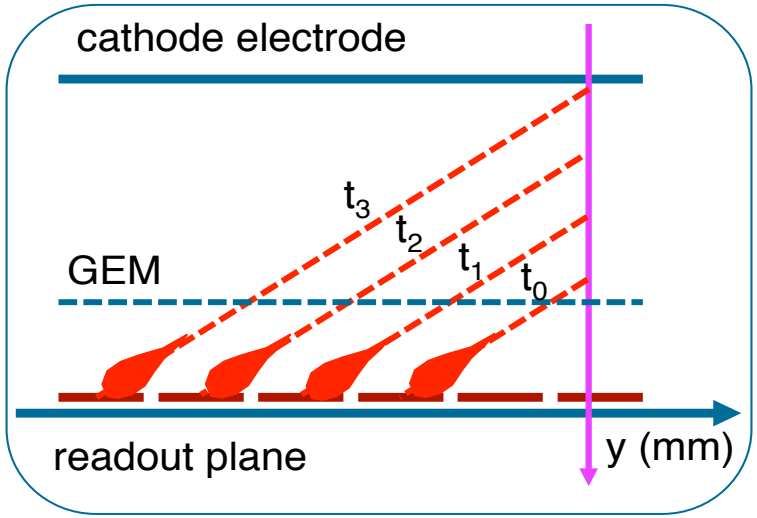
difference from t_2 and t_1



μTPC readout feasibility study

Hit Time distribution for all clusters with 1 T magnetic field

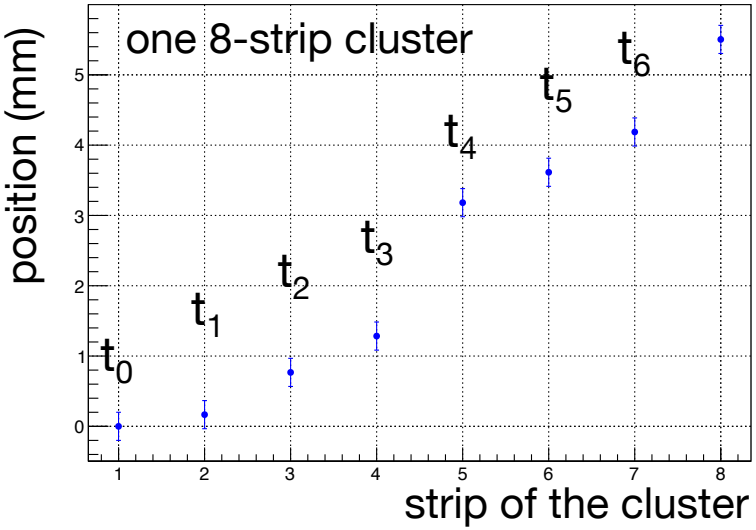




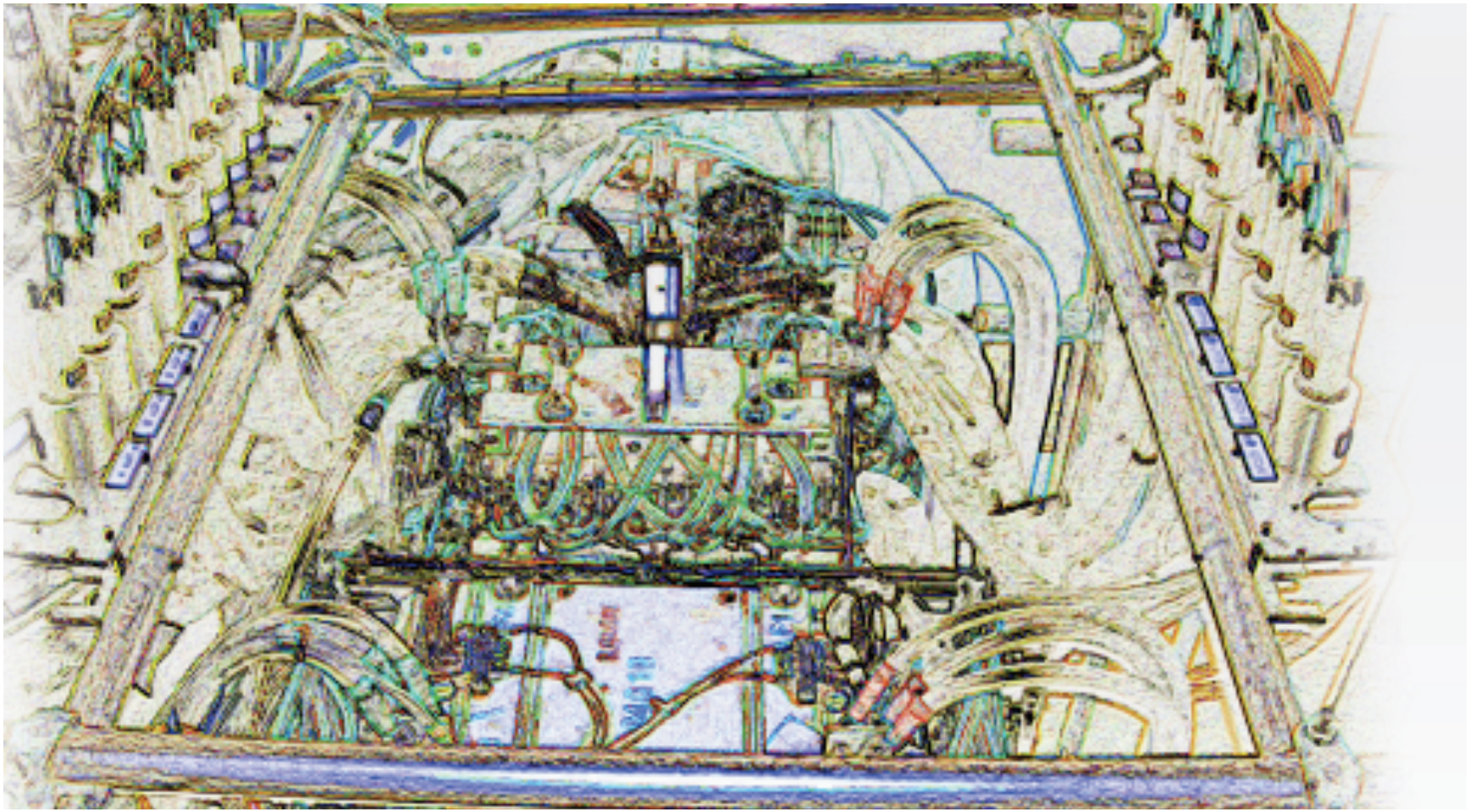
- The electron drift velocity can be extracted by the hit time distribution and it's consistent with simulations.

- The track can be reconstructed from the drift velocity measurement.

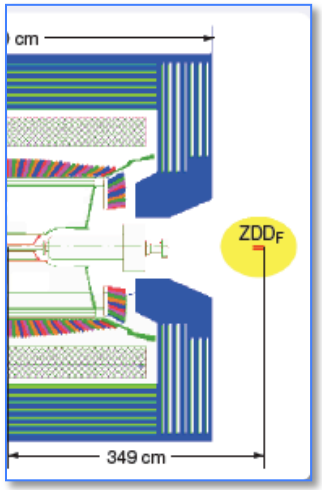
one track reconstruction in a 5 mm gap

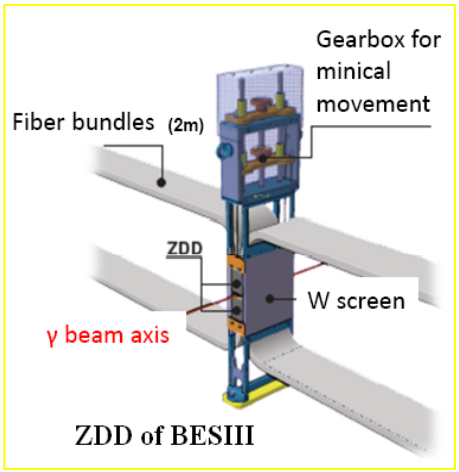


ZDD STATUS

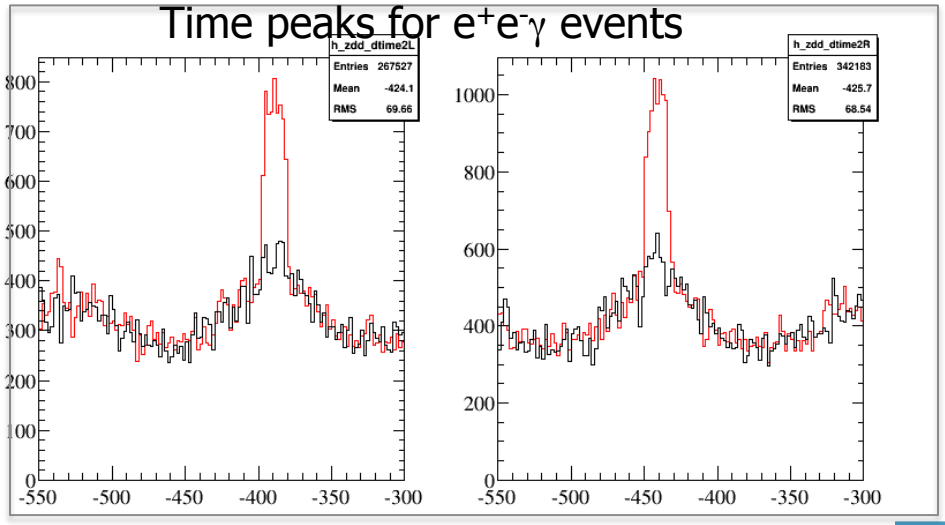


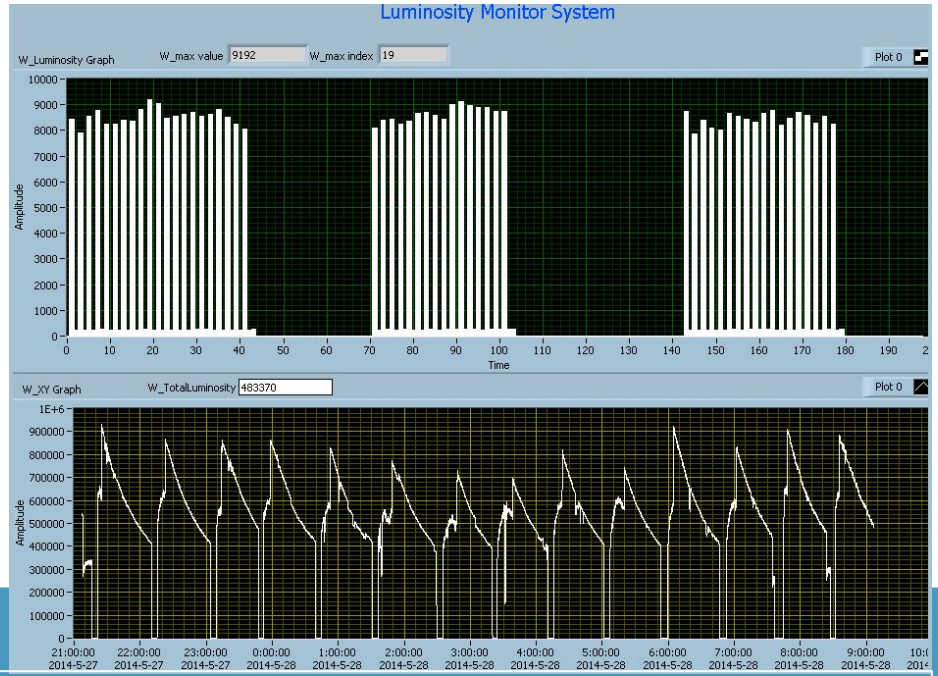
ZDD STATUS





- *Pb/Sci.Fi Array a` la KLOE scintillating material 60% of total (in volume)*
- *two modules (up and down the beam) dimensions:14×4×6cm^3*
- *signal extracted and channeled to PM through bundles of clear optical fibers (2m long)*





Is perfectly working as luminosity monitor !

SUMMARY AND CONCLUSIONS

- **BEPCII is running smoothly from 2.1 to 4.6 GeV since 2009**
- **Many new unexpected results both at high and low energies**
- **New CGEM-IT beeing developed**
- **Successfull physical proposals by Italian group**
- **Joined IHEP-INFN Annual Cooperative Meeting on May 15**
  - **Congratulations by Y.Wang to the Italian team for the valuable contributions to BESIII**
  - **Prof. Maiani visiting IHEP now, congratulates for XYZ results,**
    giving suggestions where to look for new states !

An IHEP-INFN Fellowship Program

Rinaldo Baldini, Lijun Guo, Marco Maggiora

A flexible Fellowship Program

- **IHEP-INFN Fellowship Program:**
  - flexible to cope dynamically with existing research challeng
  - flexible to catch new opportunities
  - jointly agreed amendments may occour at any time
- **every year IHEP and INFN agree on:**
  - which Collaboration(s) may have access to the Fellowship P
  - the composition of the Selection Committee(s)
  - the exact number of the positions available, the baseline beir two annuities per year per Collaboration
- **strengthening I2JL with a Common Fund:**
  - set within I2JL to support the program
  - funded by IHEP and INFN with 400kCNY each, 800kCNY per year, per Collaboration

Baseline

- **it's a joint program:**
  - shared financial effort: 50%-50%!
- **two annuities (24 months) available each year per Collaboration:**
  - 1y + 1y positions available each year, or
  - 1y position available each year and 2y position available every 2y
  - each position can be renewed up to a total of 3y
- **characteristics:**
  - reserved for Italian Post Doctoral Researchers (PhD is required)
  - positions provided by IHEP
  - funded by the Common Fund
  - P.R.C. laws and regulations apply
  - gross salary: 400kCNY/y, ~ 57k€/y
  - net salary (current P.R.C. taxation): ~ 330 kCNY/y (~ 47k€/y, ~ 3.9k€/m)
  - housing assistance from IHEP

THE LNF GROUP

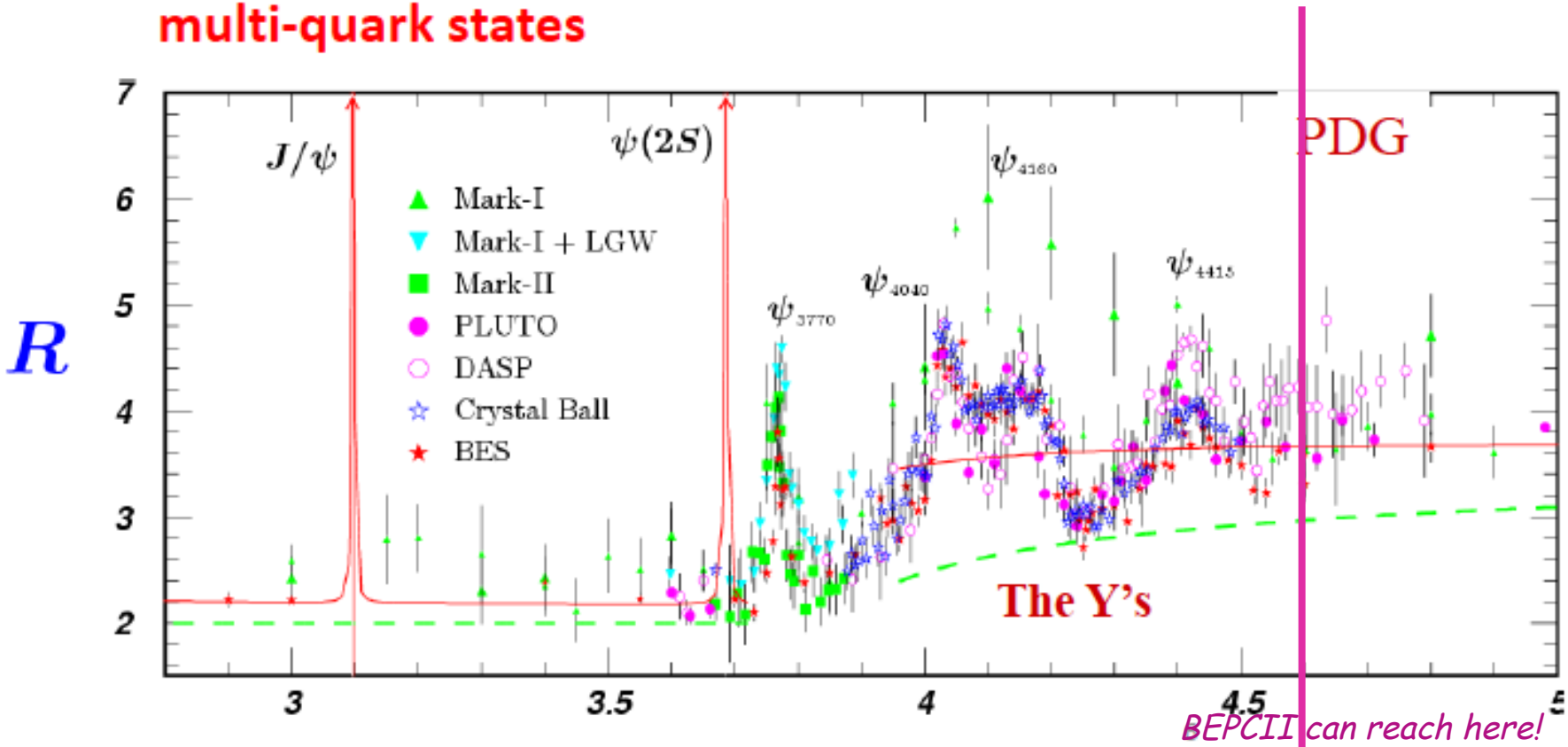
LNF staff personell at today:
4 researchers/technolgist *(KLOE2)* (3:1)
1 senior associates (at IHEP now)
1 senior guest
1- 1year contract *in 1 months*
total of 4 FTE

Technical staff at LNF:
1 (0.3 FTE) LNF-SPAS *(KLOE2)* → 
2 (0.1 FTE) RM1 from RM1-*KLOE2* → 
1 IHEP *(KLOE2)* leaving in October → 
1 DUBNA *(KLOE2)* leaving in August→ 
1-2 (0.1 FTE) from TO

SOME MORE INFORMATION

THE BESIII ENERGY REGION 2 - 4.6 GEV

- Rich of **resonances:** charmonia and charmed mesons
- **Threshold** characteristics (pairs of τ, D, D_s, ...)
- **Transition between** smooth and resonances, perturbative and non-perturbative QCD
- Energy location of the **new hadrons: glueballs, hybrids, multi-quark states**



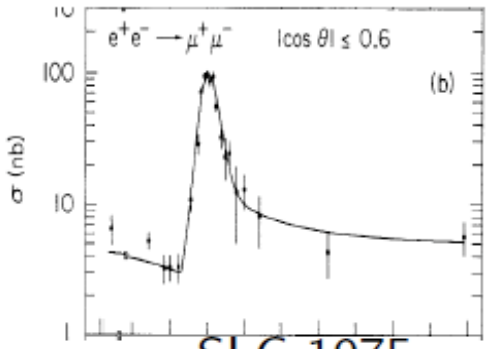
BESIII data taking status & plan

	Previous data	BESIII present & future	Goal
J/ψ	BESII 58M	1.2 B 20* BESII	10 B
ψ'	CLEO: 28 M	0.5 B 20* CLEOc	3B
ψ''	CLEO: 0.8/fb	2.9/fb 3.5*CLEOc	20 /fb
Above open charm threshold	CLEO: 0.6/fb @ ψ(4160)	0.5/fb @ ψ(4040) 2.3/fb@~4260, 0.5/fb@4360 0.5/fb@4600, 1/fb@4420	5-10 /fb
R scan & Tau	BESII	3.8-4.6 GeV at 105 energy points 2.0-3.1 GeV at 20 energy points	
Y(2175)		100 pb^{-1} (taking data now)	
ψ(4170)		3 fb^{-1} (next run)	

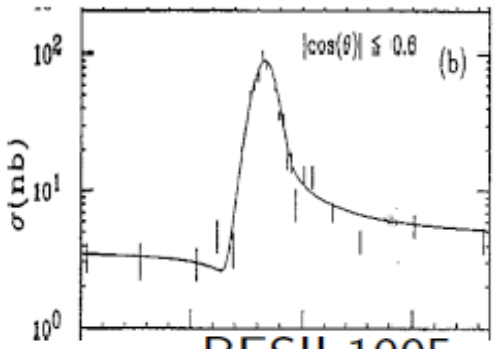
Peak luminosity achieved 8.5 $\times 10^{32}$ cm^{-2} s^{-1}

Interference in $e^+e^- \rightarrow J/\psi \rightarrow \mu^+\mu^-$

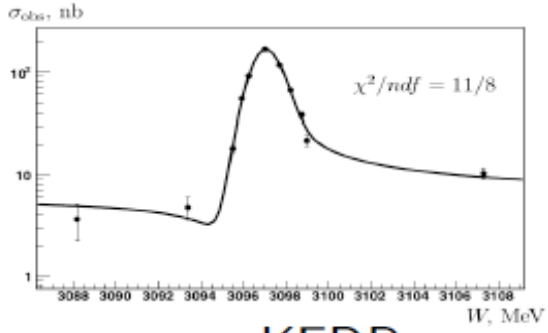
Interference pattern between J/ψ decay and the non-resonant decay amplitudes first observed at SLAC [PRL 33,1406] in 1975. Confirmed by BESII and KEDR



SLC 1975

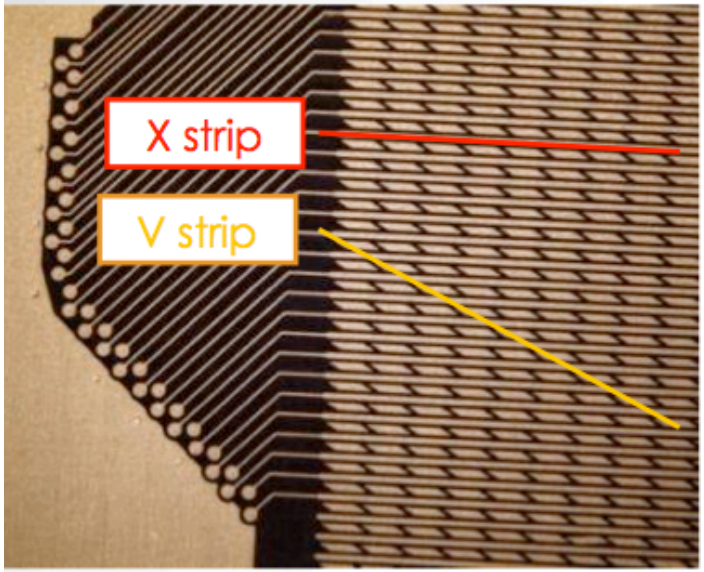


BESII 1995



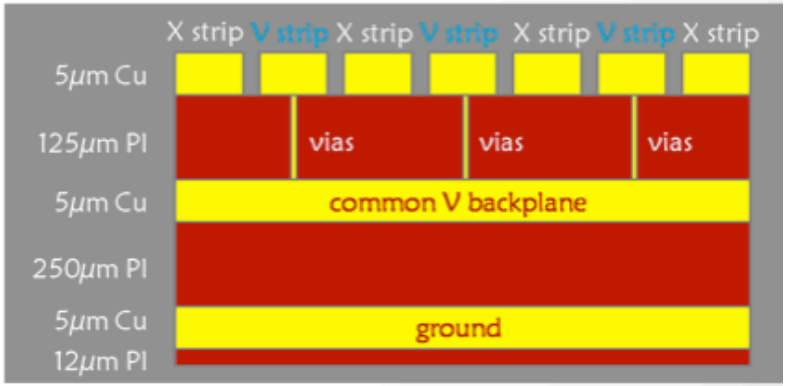
KEDR

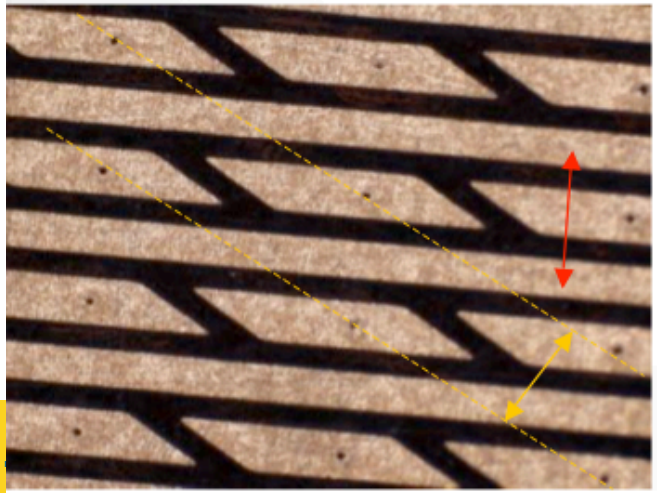
THE KLOE-2 ANODE DESIGN



Readout plane is realized at CERN TE-MPE-EM
It is a kapton/copper multilayer flexible circuit
Provides 2-dimensional readout with XV strips on the same plane

- X are realized as longitudinal strips
- V are realized by connection of pad through conductive holes and a common backplane
- Pitch is 650 μm for both





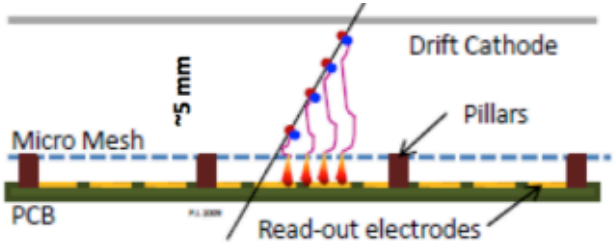
X pitch 650μm → X res 190μm

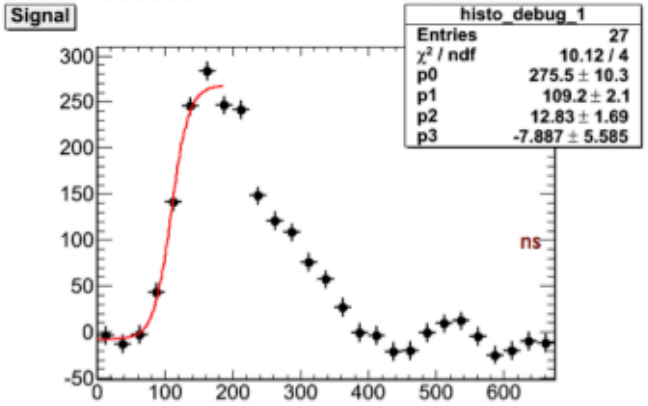
V pitch 650μm → Y res 350μm

25/10/2012 • 17

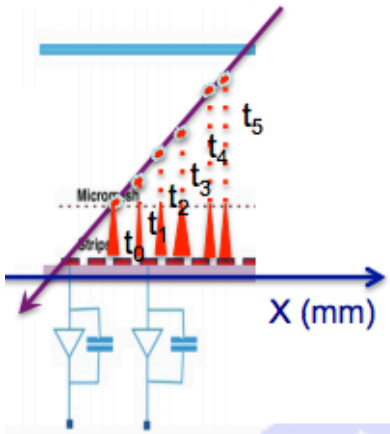
An alternative solution: uTPC

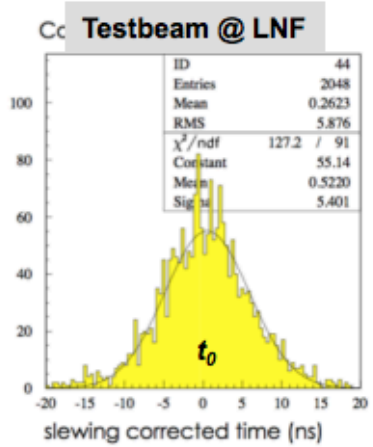
uTPC

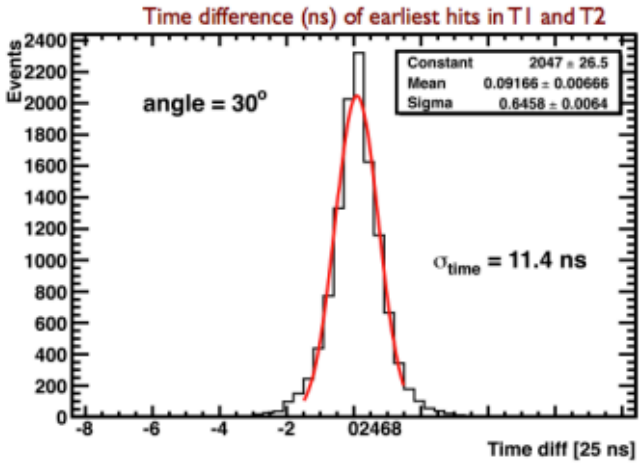




- For the uTPC mode operation a good time resolution on single hit O(<10ns) is crucial
- APV samples signal at 25ns
- Time extracted by fitting the binned signal shape with a FD function → σ_t = 11-12 ns
- Take the first hit from T1 ant T2 and compute Dt = t1-t2
- Intrinsically MM can do much better
  - TB at BTF: σ_t = 6 ns

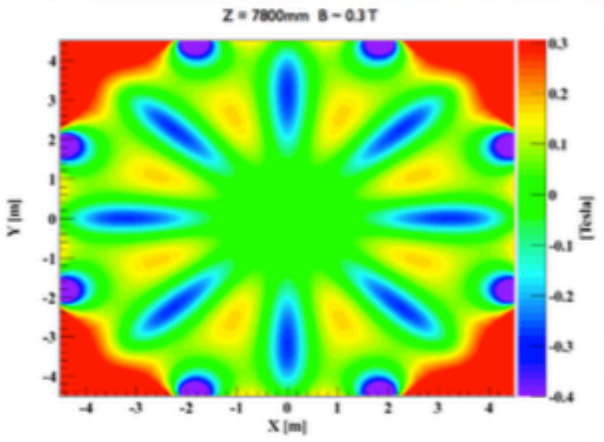




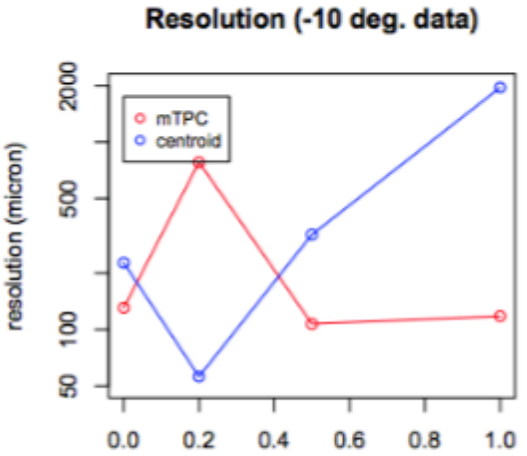


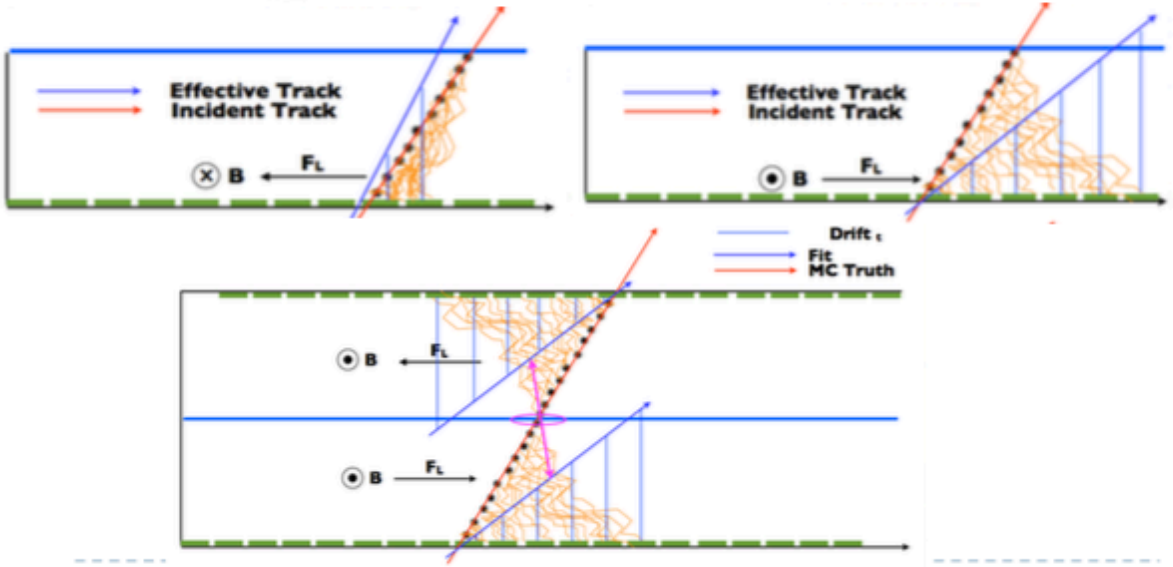
ATLAS test

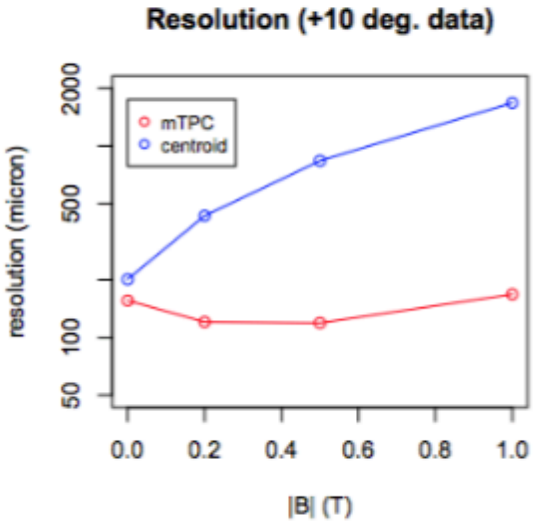
MM in Magnetic field



- Large variation of magnetic field inside the wheel (B up to 0.3T)
- Simulation validated with beam test in magnetic field up to 1T
- Resolution (combining uTPC and centroid) not substantially degraded
- Systematics can be corrected with the back-to-back configuration



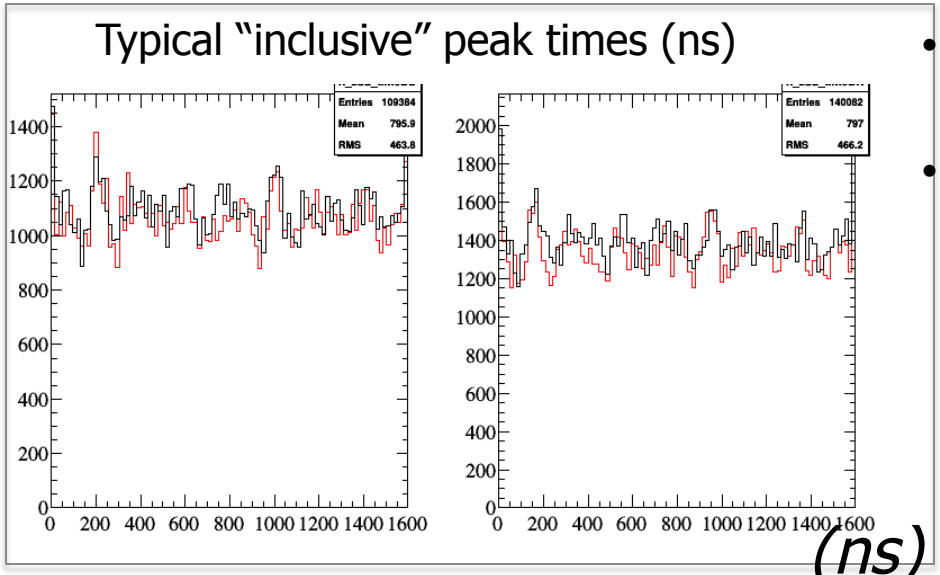


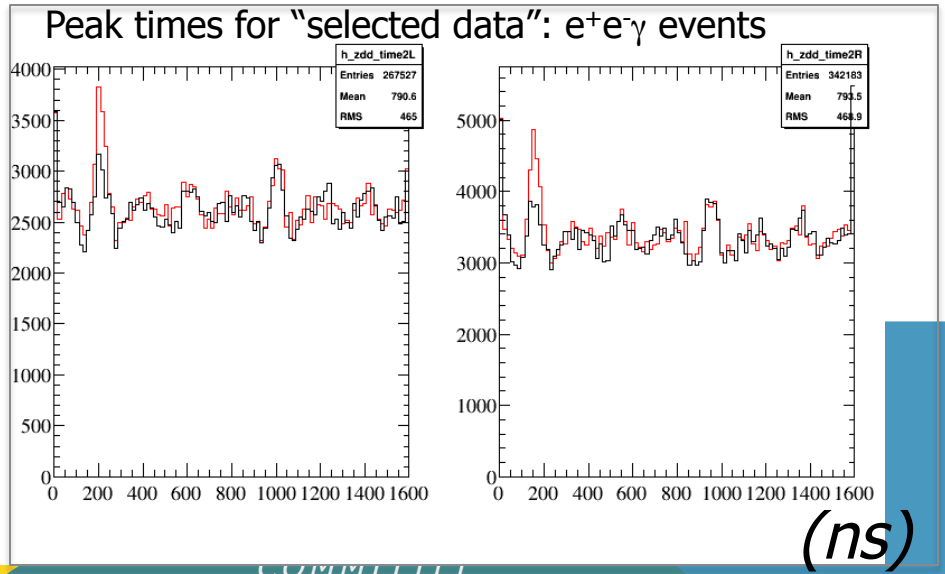


ZDD STATUS

- *designed in Frascati in 2010 to detect ISR photons at low angle and measure luminosity*
- *In 2011:built, tested at LNF and installed at BEPCII*
  - *–Not ready for integration in BESIII DAQ in 2011-2012*
- *Start of real BESIII data taking in 2012-2013*
  - *–DAQ errors! Data compression buggy, and also too slow*
- *An upgrade was designed, built and installed in 2013*
  - *–New preamps in VME instead of NIM, "segmentation" strips*
  - *–DAQ problems persisted also in 2013-2014*
  - *–Data taking window too large for processor speed wrt L1* rate*
  - *–Latest CAEN firmware not buggy but still too slow*
- *ZDD signal finally identified in spring-summer 2014*
  - *Is in the data stream of BESIII*
  - *Data on tape*
- *Since 2012 is working as Luminomiter of BEPCII*

ZDD SIGNAL TIMING



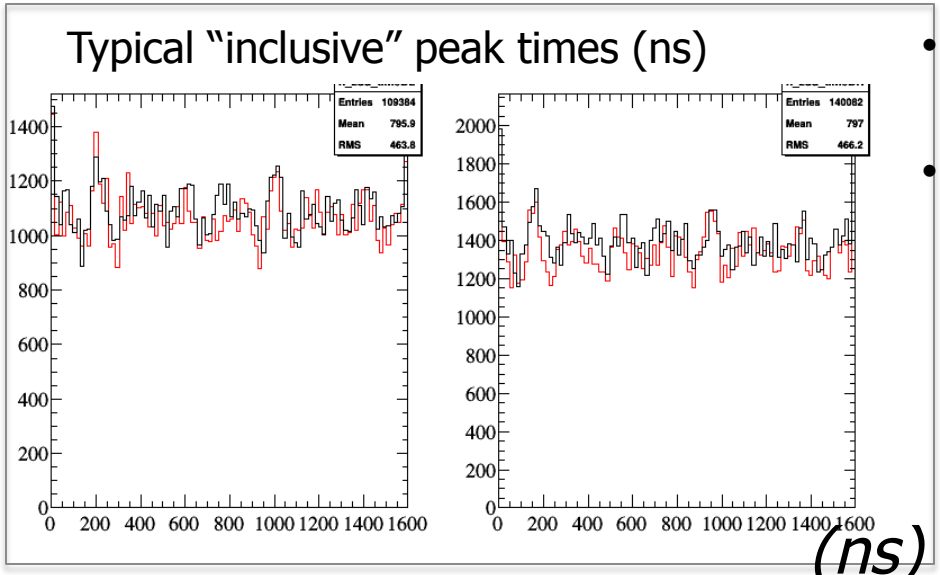


- *ZDD sensitive to most of BEBCII beam crossing, high background!*
- *If we plot "everything" there is no ZDD signal*

Plot "selected data" in BESIII: $e^+e^-\gamma$ events

- *2 charged tracks, total charge 0*
- *Less than 10 neutrals*
- *$E(e^+) > 0.6$ GeV/c^2 and $E(e^-) > 0.6$ GeV/c^2*
- *A successful vertex fit*
- *A "strong" missing photon: E_{miss}>0.4 GeV*
- *A low polar emission angle: $|\cos(\theta_\gamma)| > 0.98$*

ZDD SIGNAL TIMING



- *ZDD sensitive to most of BEBCII beam crossing, high background!*
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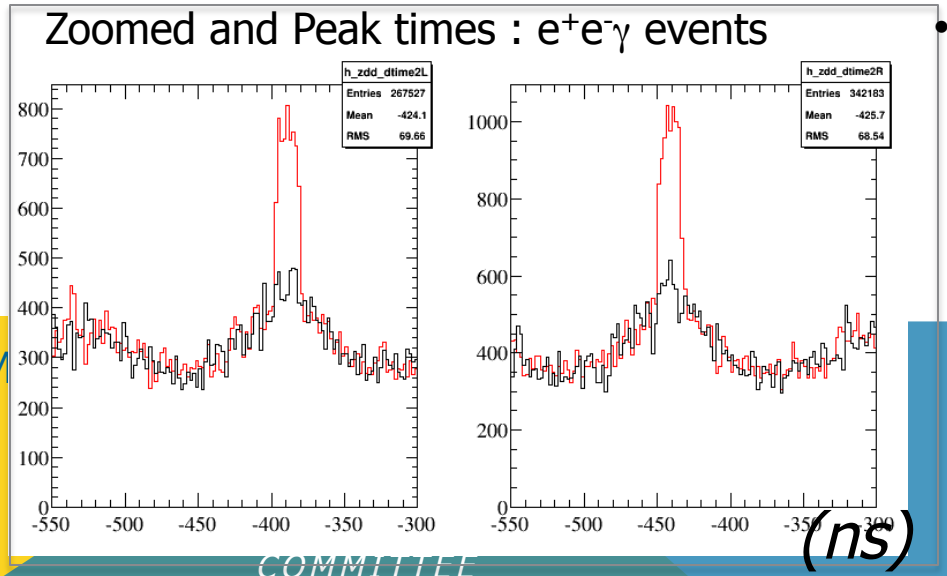


- *Plot "selected data" in BESIII: $e^+e^-\gamma$ events*
  - *two clear correlated peaks on top and bottom modules*

RISE DETAILS

EUROPEAN COMMISSION

Horizon 2020 - Research and Innovation Framework Programme

Evaluation Summary Report

Call:	H2020-MSCA-RISE-2014
Funding scheme:	Marie Skłodowska-Curie Research and Innovation Staff Exchange (RISE)
Proposal number:	645664
Proposal acronym:	BESIIICGEM
Duration (months):	48
Proposal title:	An innovative Cylindrical Gas Electron Multiplier Inner Tracker for the BESIII Spectrometer
Activity:	PHY

N.	Proposer name	Country	Total Cost	%	Grant Requested	%
1	ISTITUTO NAZIONALE DI FISICA NUCLEARE	IT	657,000	37.73%	657,000	43.84%
2	JOHANNES GUTENBERG UNIVERSITAET MAINZ	DE	670,500	38.50%	670,500	44.74%
3	UPPSALA UNIVERSITET	SE	171,000	9.82%	171,000	11.41%
4	INSTITUTE OF HIGH ENERGY PHYSICS CHINESE ACADEMY OF SCIENCES	CN	243,000	13.95%	0	0.00%
	Total:		1,741,500		1,498,500	

Evaluation Summary Report

Evaluation Result

Participant Number	Organisation Short Name	Country	Academic	Number of secondments	Person-months	Estimated budget support (whole duration of the project)				Requested EU contribution/€
						Staff member costs	Research, training and networking costs	Management and indirect costs	Total	
1	INFN	IT	yes	111	146	292 000	262 800	102 200	657 000	657 000
2	JGU-Mainz	DE	yes	97	149	298 000	268 200	104 300	670 500	670 500
3	UUppsala	SE	yes	25	38	76 000	68 400	26 600	171 000	171 000
4	IHEP	CN	yes	13	54	108 000	97 200	37 800	243 000	0
Total				246	387	774 000	696 600	270 900	1 741 500	1 498 500

Participant number *(as table §A.2)*	**Partnership Member**	**Legal Entity Short Name**	**Academic (Y/N)**	**Country**
	Beneficiaries			
1	Marco Maggiora	INFN	Y	IT
2	Frank Maas	JGU-Mainz	Y	DE
3	Tord Johansson	UUppsala	Y	SE
	Partner Organisations			
4	Xiaoyan Shen	IHEP	Y	CN

Package No		Training, Management, Communication, Dissemination…)	person-months involved	Month	
1	CGEM design	Research, Training	16	1	24
2	CGEM construction	Research, Training	62	1	48
3	CGEM electronics	Research, Training	74	1	48
4	Data simulation and analysis	Research, Training	229	1	48
5	Data challenge	Research, Training	2	1	48
6	Outreach	Training, Dissemination	0	1	48
7	Management	Communication, Management	4	1	48

budget is entirely built up on researcher's secondment periods in P.R.C.

1 secondment person month = 4500 €

Formally: 4500€ =

- 2000 (researcher's salary top-up)
- 1800 (research costs)
- 700 (management costs)

However: no budget accounting is required, but only secondments accounting !

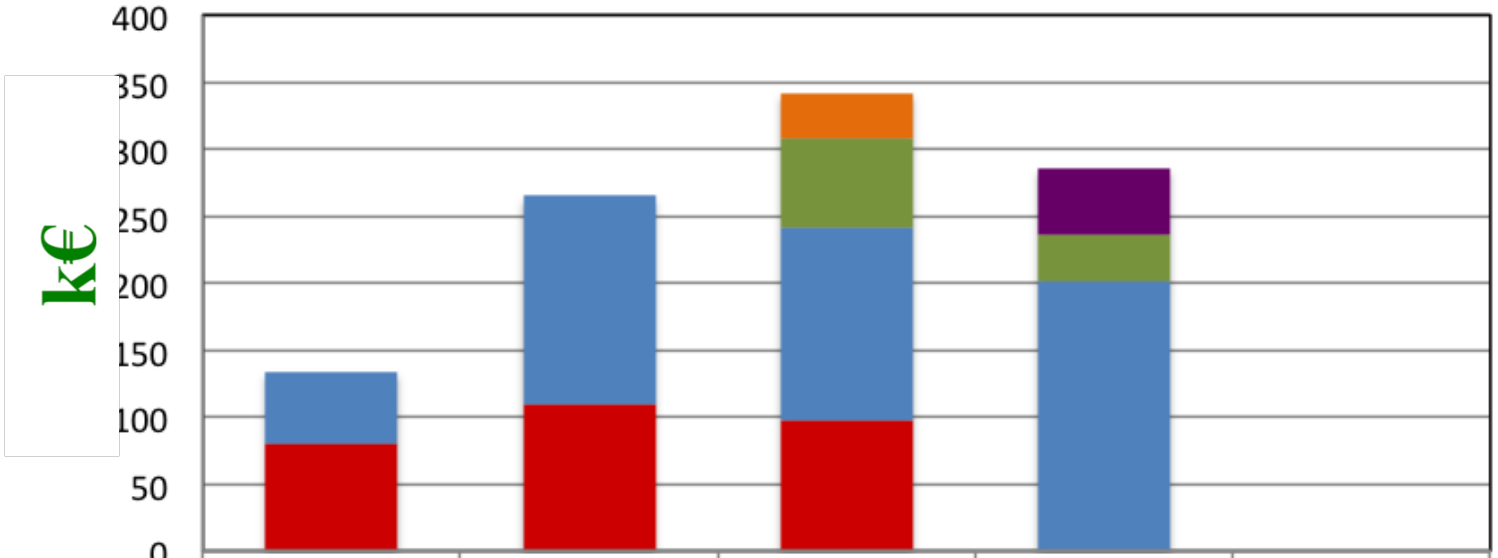
i.e. Only proofs of the secondments travels and activity shall be provided.

Budget can be used freely according to internal project rules.

Financial cooperation EU - IHEP

The full construction cost for the full CGEM-IT is **about 1 M€**

(not including manpower, integration and installation)



	2013	2014	2015	2016	2017
Uppsala	0	0	34	0	0
IHEP	0	0	0	50	0
HI Mainz	0	0	66	34	0
INFN	54	155	144	202	0
INFN-MAE-MOST	80	110	98	0	0

Observation of a charmonium like structure: $Z_c(3900)^{\pm}$

- 2013: 515 pb^{-1} @ 4260 MeV

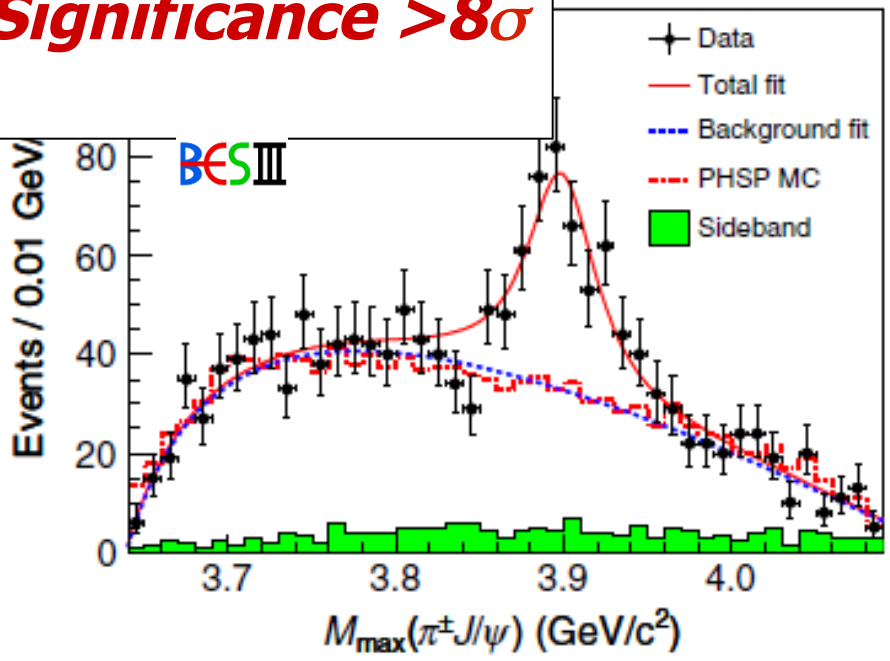
PRL 110, 252001

- $e^+e^- \rightarrow \pi^+\pi^- J/\psi$
- Dominant background $e^+e^- \rightarrow \pi^+\pi^-\pi^+\pi^-$
- J/ψ signal: [3.08,3.12] GeV
- J/ψ sideband: [3.0,3.06] GeV or [3.14,3.20] GeV
- Structure seen: $Z_c(3900)^{\pm} \rightarrow \pi^{\pm} J/\psi$

BESIII: e^+e^- -> $\pi^+\pi^- J/\psi$ @ 4.26 GeV

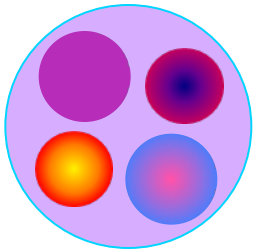
PRL 110, 252001

Significance >8σ



$Z_c(3900)^{\pm}$

- Couples to cc
- Has electric charge
- At least 4-quarks
- What is its nature?

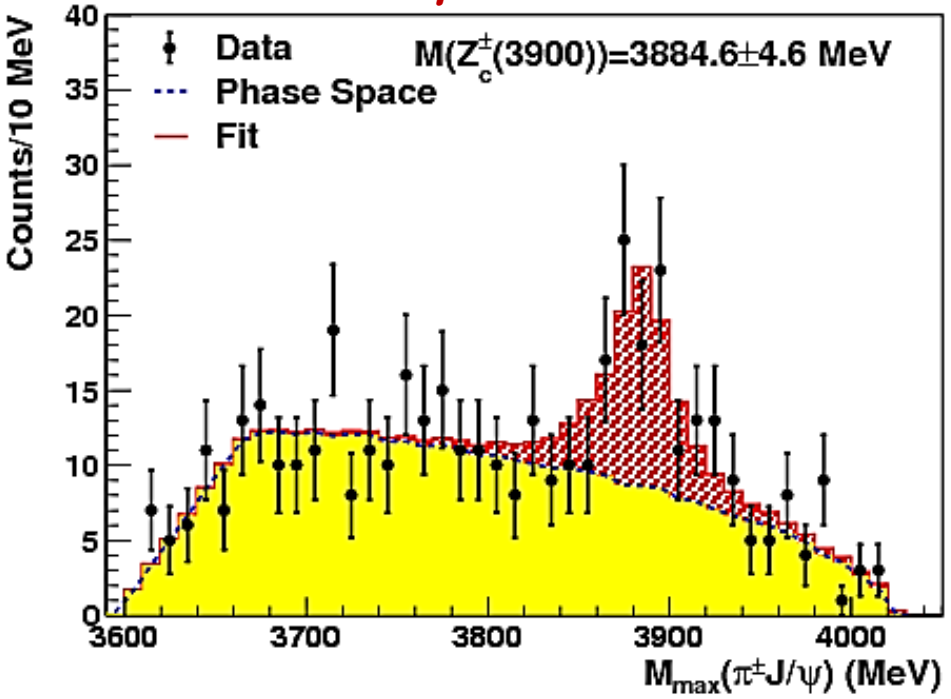


- S-wave Breit-Wigner with efficiency correction
- Mass = (3899.0±3.6±4.9) MeV
- Width = (46±10±20) MeV
- Fraction = (21.5±3.3±7.5)%

BESIII: e^+e^- -> $\pi^+\pi^- J/\psi$ @ 4.26 GeV

K. Seth & co. @ 4.170 GeV

hep-ex:1304.3036

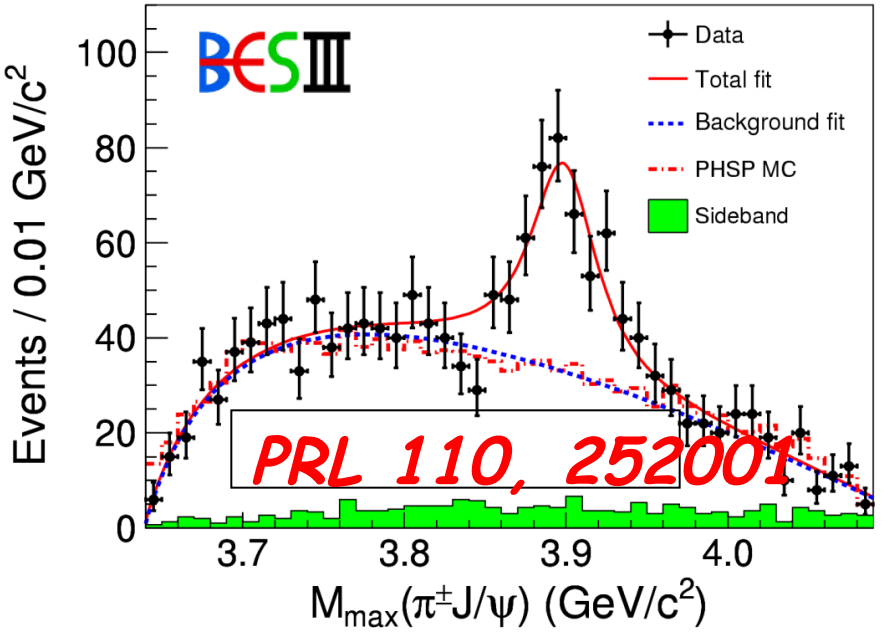


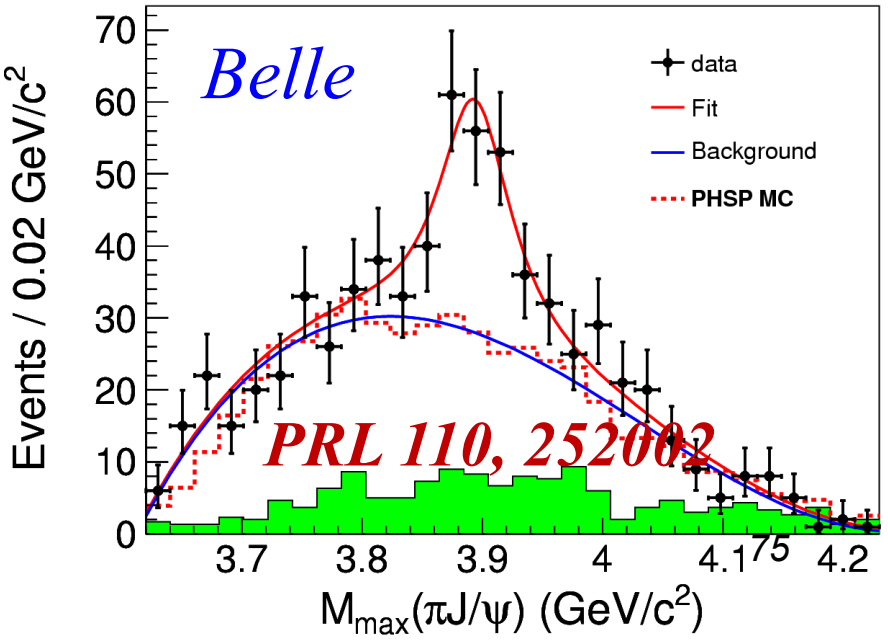
$M = (3885 \pm 5 \pm 1)\ MeV/c^2$

$\Gamma = (34 \pm 12 \pm 4)\ MeV/c^2$

81±20 events

6.1σ

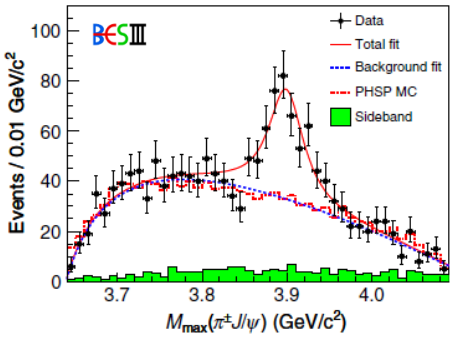




BESIII: Z_c Results

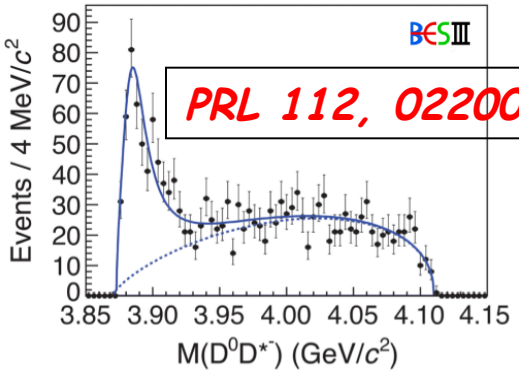
PRL 110, 252001

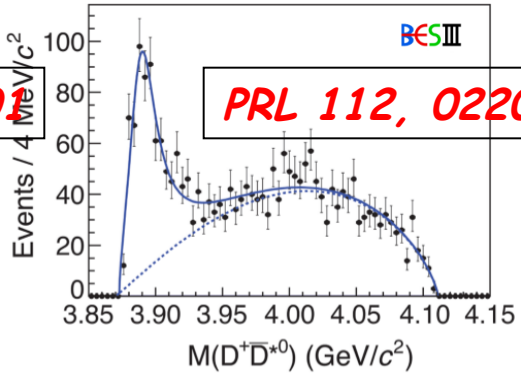
$e^+e^- \to \pi^+\pi^- J/\psi$ @ 4.26 GeV



PRL 112, 022001

$e^+e^- \to \pi^-(D\bar{D}^*)^+ + c.c.$ @ 4.26 GeV



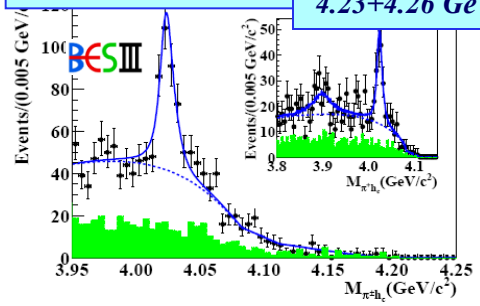


PRL 111, 242001

$e^+e^- \to \pi^+\pi^- h_c$ @ 4.23,4.26,4.36 GeV

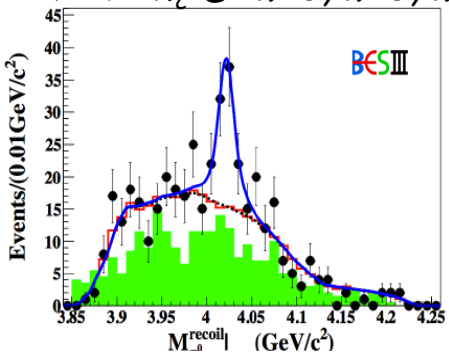
4.23+4.26+4.36 GeV

4.23+4.26 GeV



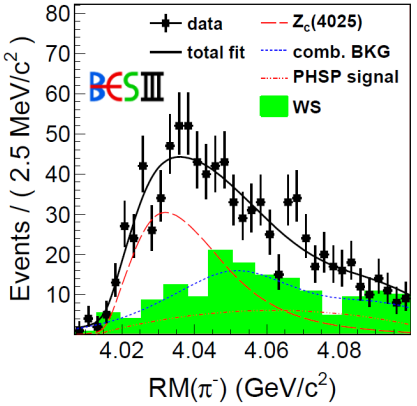
PRL 113, 212002

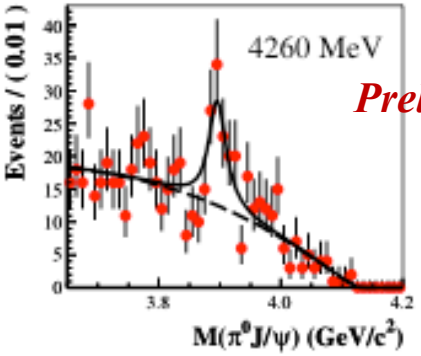
$e^+e^- \to \pi^0\pi^0 h_c$ @ 4.23,4.26,4.36 GeV



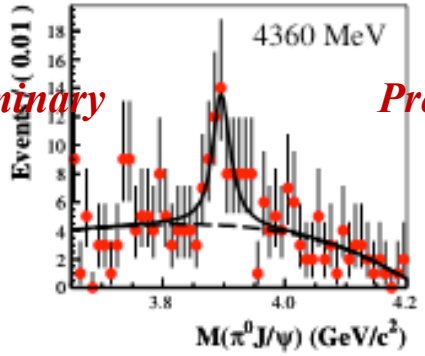
PRL 112, 132001

$e^+e^- \to \pi^+(D^*\bar{D}^*)^\pm + c.c.$ @ 4.26 GeV

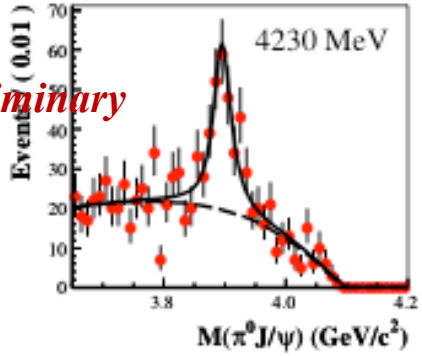




Preliminary



Preliminary



$e^+e^- \to \pi^0\pi^0 J/\psi$ @ 4.23,4.26,4.36 GeV

76

Above 4 GeV

- *The observed charmonium-like states Y(4260), Y(4360), and Y(4660) can not interpreted as conventional charmoniums.*
- *New decay modes searching and the line shape measurement is useful for understanding the nature of these Y-states.*
- *Hadronic transitions (by an η or π^0) to lower charmonia like J/ψ are regarded as sensitive probes to study the properties of these Y-states.*
- *Nature of these Y-states:*

  hybrids ?

  tetraquarks?

  hadro-charmonium?

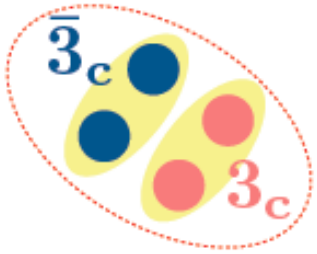
  hadronic molecule?

Models for X Y Z mesons

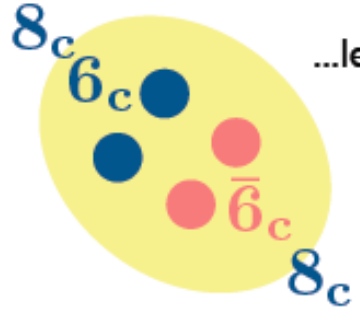
see e.g. M.Cleven, F.K.Guo, C.Hanhart, Q.Wang and Q.Zhao, arXiv:1505.01771 and refs. therein

courtesy of A. Polosa

(R=1 fm)



a compact `tetraquark'



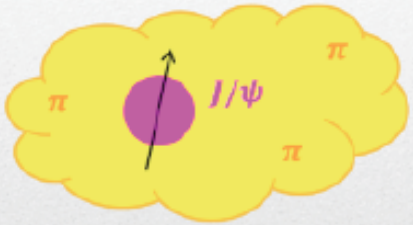
...less bound

the 'hybrid' option

Hadro-charmonium

X.Li, M.B.Voloshin, Mod. Phys. Lett. **29**(2014) 12, 1450060 and refs. therein

Voloshin arXiv:1304.0380



A $c\bar{c}$ state surrounded by light matter

Decay into $\eta_c\,\rho$ forbidden by HQSS

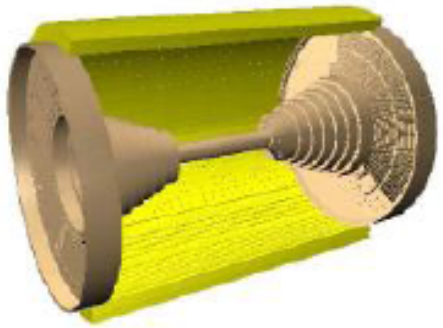
quark (heavy or light)

antiquark

gluon

BESIII Detector

MDC

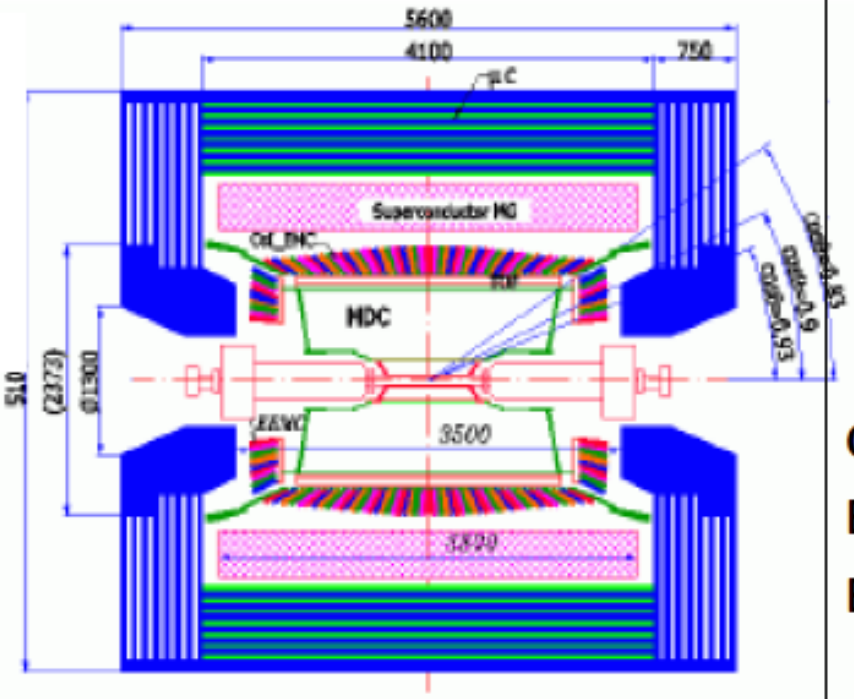


R inner: 63mm ;

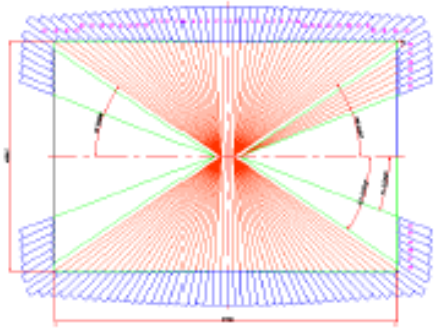
R outer: 810mm

Length: 2582 mm

Layers: 43



CsI(Tl) EMC



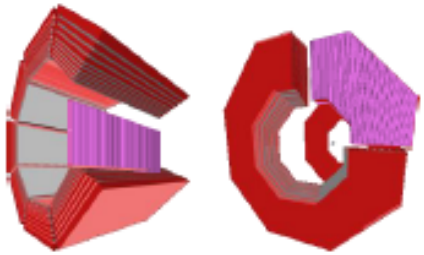
Crystals: 28 cm(15 X_0)

Barrel: $|\cos\theta|<0.83$

Endcap:

$0.85 < |\cos\theta| < 0.93$

RPC MUC



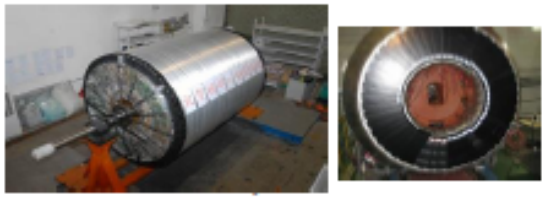
BMUC: 9 layers – 72 modules

EMUC: 8 layers – 64 modules

TOF

BTOF: two layers

ETOF: 48 crys. for each



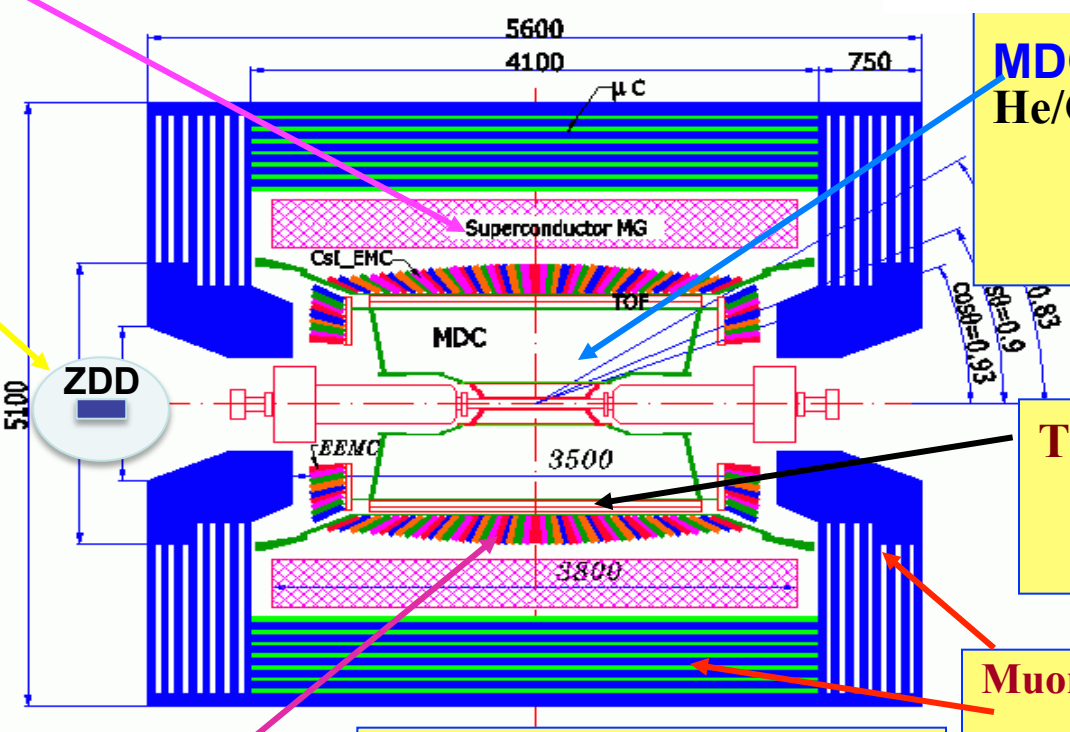
BESIII Detector

[NIM A614 (2010)345]

BESIII detector: all new !

CsI calorimeter
Precision tracking
Time-of-flight + dE/dx PID

Magnet: 1 T Super conducting



MDC: small cell & Gas:
He/C_3H_8 (60/40), 43 layers
σ_{xy}=130 μm
σ_p/p = 0.5% @1GeV
dE/dx=6%

Zero Degree Detector new (2011)

TOF:
σ_T = 100 ps Barrel
110 ps Endcap

Muon ID: 9 layers RPC
8 layers for endcap

EMC: CsI crystal, 28 cm
ΔE/E = 2.5% @1 GeV
σz = 0.6 cm/√E

Data Acquisition:
Event rate = 4 kHz
Total data volume ~ 50 MB/s

The detector is hermetic for neutral and charged particle with excellent resolution, PID, and large coverage.