BESIII

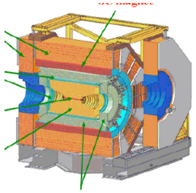
BESIII activities at LNF

M.Bertani on behalf of the LNF group:

M.Anelli ,R. Baldini Ferroli, M.Bertani, A. Calcaterra, Y.D. Wang, A. Zallo

45th LNF Scientific Committee,
Frascati, November 20th, 2012

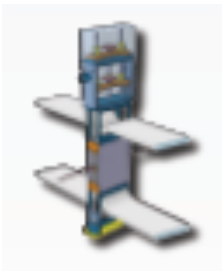
OUTLINE



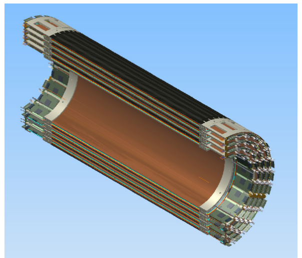
BESIII and BEPCII

main physics goals

The Italian collaboration interests: ISR physics, J/ψ phase measurement, ψ' s→ $n\bar{n}$, $p\bar{p}$

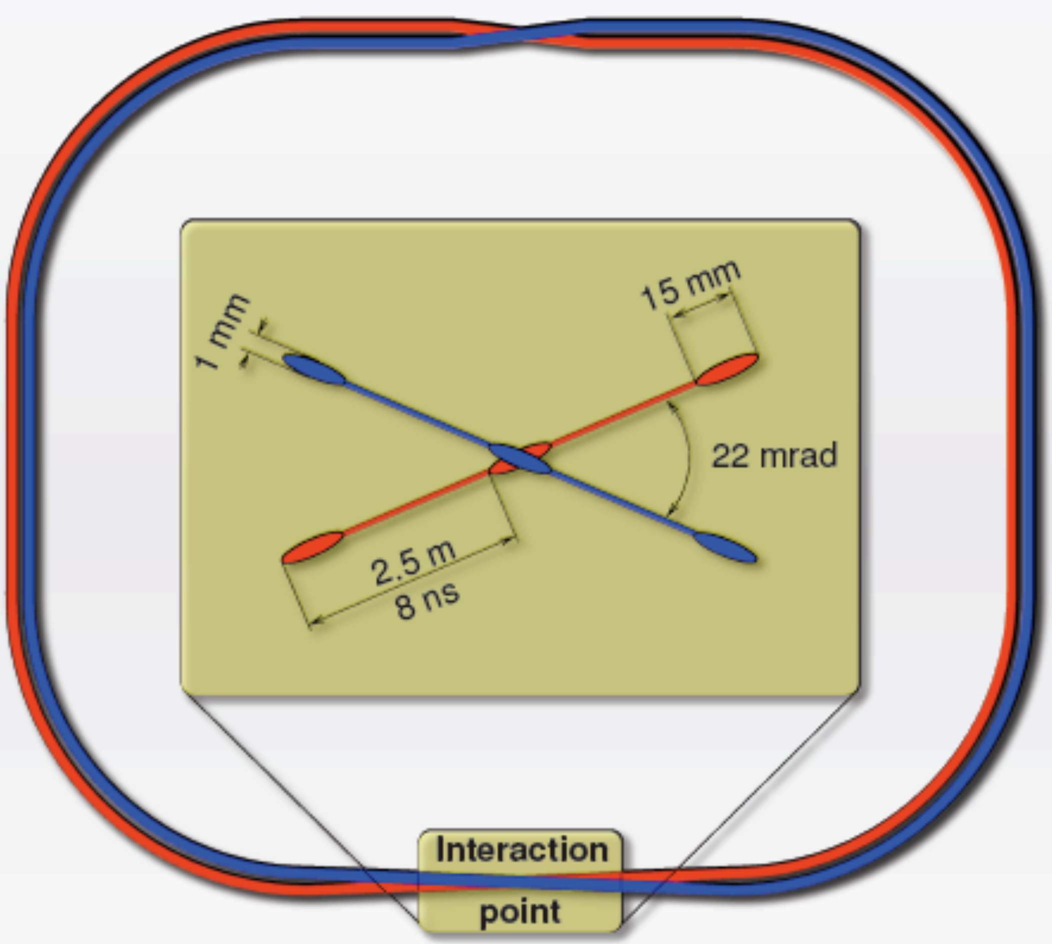


The Zero Degree Detector



Cylindrical GEM proposal
for upgrade of BESIII Inner MDC

BEPCII: Beijing e^+e^- double ring collider



Design Features

- Beam energy: **1.0 - 2.3** GeV
- Crossing angle: **22** mrad
- **Luminosity: 10^{33} cm^{-2}s^{-1}**
- **Optimum energy: 1.89 GeV**
- Energy spread: **5.16×10^{-4}**
- Number of bunches: **93**
- Bunch length: **15** mm
- Total current: **0.91** A
- Circumference: **240** m

BESIII Detector

[NIM A614 (2010)345]

BESIII detector: all new !

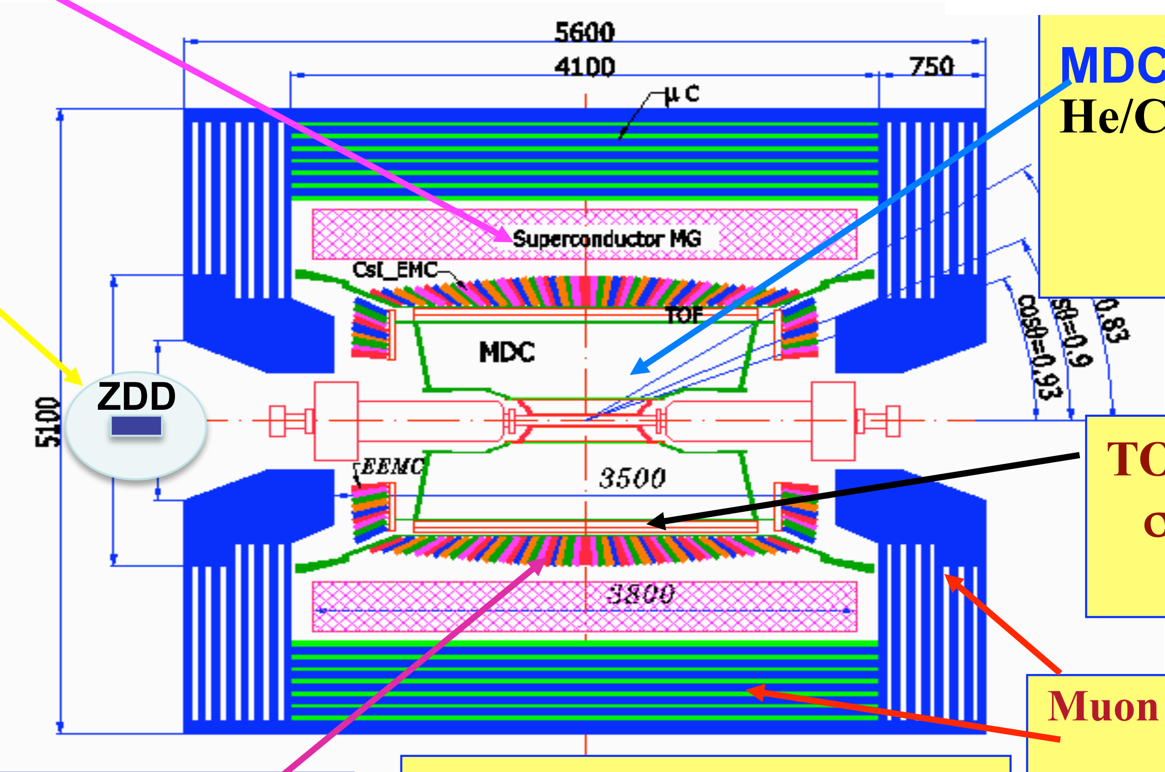
CsI calorimeter

Precision tracking

Time-of-flight + dE/dx PID

Magnet: 1 T Super conducting

Zero Degree Detector new (2011)



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%

TOF:

σ_T = 100 ps Barrel

110 ps Endcap

Muon ID: 9 layers RPC

8 layers for endcap

EMC: CsI crystal, 28 cm

$\Delta E/E$ = 2.5% @1 GeV

σz = 0.6 cm/$\sqrt{E}$

Data Acquisition:

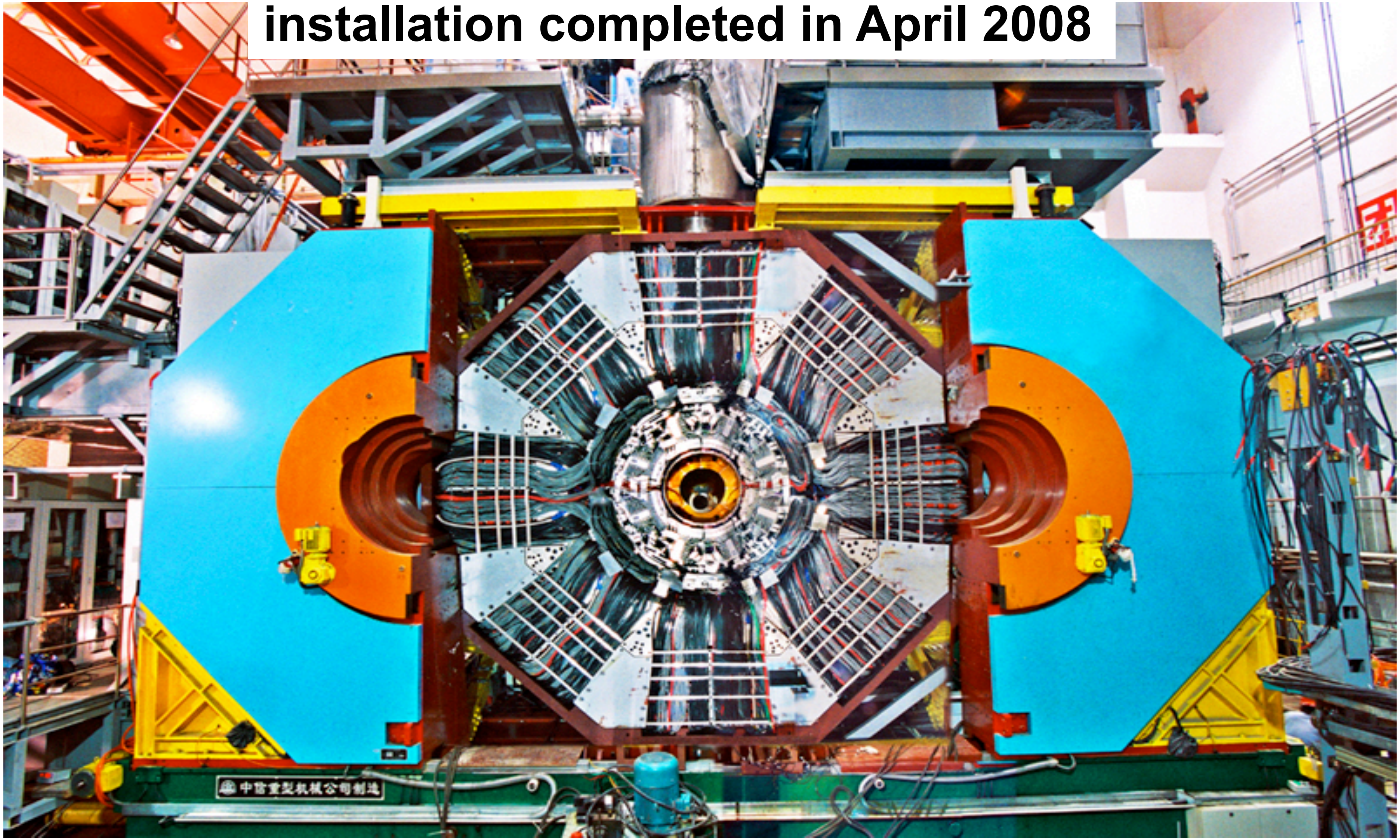
Event rate = 4 kHz

Total data volume ~ 50 MB/s

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

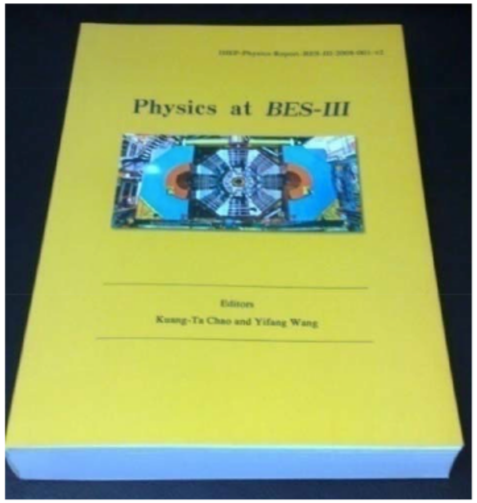
Beijing Spectrometer III (BESIII)

installation completed in April 2008



Physics in the tau-charm region

- **Light hadron physics**
  - Spectroscopy: normal and exotic hadrons **QCD**
  - How quarks form hadron ? **non-pQCD**
  - Baryon e.m. form factors
- **Charm physics**
  - Full spectra CKM matrix elements → **SM and beyond**
  - $D\bar{D}$ mixing and CPV →**SM and beyond**
- **Charmonium physics**
  - Spectroscopy and transition →**pQCD & non-pQCD**
  - New states above open charm thresholds →**exotic hadrons?**
  - pQCD: $\rho\pi$ puzzle → a probe to **non-pQCD or?**
- **Tau physics and QCD**
  - Precision measurement of the tau mass and R measurement
- **Search for rare and forbidden decays**



arXiv: 0809.1869

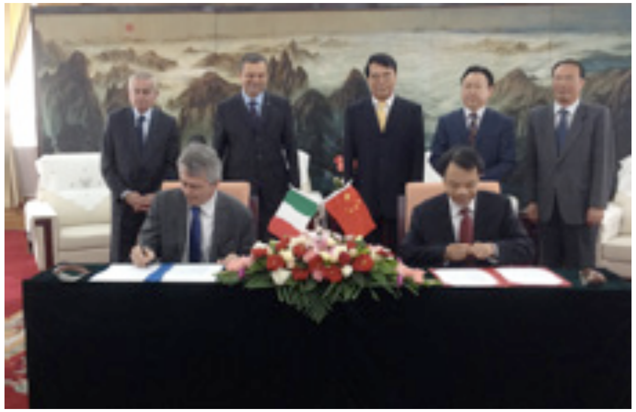
Precision tests of SM and search for new physics

The Italian Collaboration at BESIII

- **2009**:INFN Laboratori Nazionali di Frascati, Perugia University/INFN and Torino University/INFN groups joined BESIII
  - Since then three IHEP young colleagues spent some months at LNF collaborating in analysis and detector development
  - One-year INFN post doc fellowship at LNF from IHEP: Yadi Wang just started
  - LNF group in 2012-13: R. Baldini Ferroli, M.Bertani, A. Calcaterra, Y.D.Wang, A. Zallo (3FTE) M.Anelli (technical support, SSE)
- **Main physics interests**:
  - $e^+e^- \to B\bar{B}$ (B=n,p, Σ,Λ) via energy scan and ISR technique:
    - High statistics cross section measurements
    - Threshold effects and time-like form factors
  - J/ψ phase between strong and e.m. decay measurement
  - $J/\psi \to n\bar{n}, p\bar{p}$ (published), ψ', $\psi'' \to n\bar{n}, p\bar{p}$
- **Detector:**
  - **ZDD** construction and installation (summer 2011) of a mini-calorimeter in the forward region to detect ISR photons as well as a luminometer
  - Proposal of an upgrade of Inner Drift Chamber with **CGEM** technology
- **Computing in Turin**: off-site computing farm, doxigen documentation, multi access BESIII DataBase replica, proposal for a GRID computing site

IHEP-INFN collaboration

FIRMATO L'ACCORDO DI PECHINO
Lunedì 18 Giugno 2012 10:00



E' stato firmato nella mattina del 18 giugno a Pechino - la notte tra domenica e lunedì in Italia - l'accordo tra l'INFN e l'Istituto cinese per le alte energie (IHEP) per la realizzazione di una collaborazione tra le due strutture di ricerca scientifica. L'accordo - che è stato firmato nell'ambito del viaggio del ministro Profumo in Cina - riguarda sia la ricerca che la formazione dei giovani. In particolare, l'insieme delle collaborazioni tra INFN e IHEP si configurerà coma un vero e proprio istituto di ricerca virtule unificato.

- **Agreement of scientific cooperation for the establishment of a joint laboratory *"INFN-IHEP JointLab (I2JL)"* in the physics sectors of particle, astroparticle, detector and computing development as well as young researchers formation**
- **We have applied for funding at the Italian and Chinese ministries of foreign affairs in the framework of the Italy-China collaboration to build a prototype of a cylindrical GEM with analog readout, eventually being the first layer of a new inner tracker in BESIII.**
- ***October 2012: CGEM workshop at LNF with Chinese collaborators , Kloe-2 experts and R.Oliveira, Cern***

BESIII timeline

- **July 19, 2008:** first e^+e^- collision event in BESIII
- **Nov 2008:** ~14M $\psi(2S)$ events for detector calibration
- **2009:** **106M $\psi(2S)$ 4xCLEOc**
  225M J/ψ 4xBESII
- **2010-11:** **2.9 fb^{-1} ψ (3770) 3.5xCLEOc**
- **2011:** **0.5 fb^{-1} @4.01GeV** (D_s, XYZ)
- **2012:** **0.4B $\psi(2S)$**
  J/ψ: 1B events, lineshape fine scan,
  scan for J/ψ phase measurement, 14pb^{-1}/point, tot 5 points
  - R scan @ **2.4, 2.8, 3.4 GeV**

the world's largest set of
J/ψ $\psi(2S)$ $\psi(3770)$
and still growing!

- **Peak luminosity: 6.5x10^{32} $cm^{-2}s^{-1}$ @ 3770MeV**

next run: Dec. 2012 - June 2013
foreseen luminosity : 7-8x10^{32} $cm^{-2}s^{-1}$ @ 3770MeV
Ecm=4.26, 4.36 (XYZ meson spectroscopy)
additional $\psi(3770)$, τ scan, R scan

Published Results

χ_{cJ} decays and transitions

1) Search for hadronic transition $\chi_{cJ}\rightarrow\eta_c\pi^+\pi^-$ and observation of $\chi cJ\rightarrow K\bar{K}\pi\pi\pi$. [arXiv:1208.4805]
2) Measurement of χ_{cJ} decaying into $p\bar{n}\pi^-$ and $p\bar{n}\pi^-\pi^0$. [arXiv:1208.3721]
3) Observation of χ_{cJ} Decays to $\Lambda\bar{\Lambda}\pi^+\pi^-$. PRD86, 052004 (2012)
4) Two-photon widths of the $\chi_{c0,2}$ states and helicity analysis for $\chi_{c2}\rightarrow\gamma\gamma$. PRD85, 112008 (2012)
5) Observation of χ_{c1} decays into vector meson pairs $\varphi\varphi$, $\omega\omega$, and $\omega\varphi$. PRL107, 092001 (2011)
6) Study of χ_{cJ} radiative decays into a vector meson. PRD83, 112005 (2011)
7) First Observation of the Decays $\chi_{cJ}\rightarrow\pi^0\pi^0\pi^0\pi^0$. PRD83, 012006 (2011)

Studies of η, η' , $\eta(1405)$, η_c and η_c'mesons

8) Search for η and η' Invisible Decays in $J/\psi\rightarrow\varphi\eta$ and $\varphi\eta'$. [arXiv.1209.2469]
9) Observation of $e^+e^-\rightarrow\eta J/\psi$ at center-of-mass energy $s^{1/2}$=4.009 GeV. [arXiv.1208.1857]
10) Evidence for $\eta c\rightarrow\gamma\gamma$ and Measurement of $J/\psi\rightarrow3\gamma$. [arXiv.1208.1461]
11) First observation of $\eta(1405)$ decays into $f^0(980)\pi^0$. PRL108,182001 (2012)
12) Measurements of the mass and width of the ηc using $\psi'\rightarrow\gamma\eta c$. PRL108, 222002 (2012)
13) Search for $\eta'c$ decays into vector meson pairs. PRD84, 091102 (2011)
14) $\eta\pi^+\pi^-$ Resonant Structure around 1.8 GeV/c^2 and $\eta(1405)$ in $J/\psi\rightarrow\omega\eta\pi^+\pi^-$. PRL107, 182001 (2011)
15) Search for CP and P violating pseudoscalar decays into $\pi\pi$. PRD84, 032006 (2011)
16) Measurement of the Matrix Element for the Decay $\eta'\rightarrow\eta\pi^+\pi^-$. PRD83, 012003 (2011)

Published Results

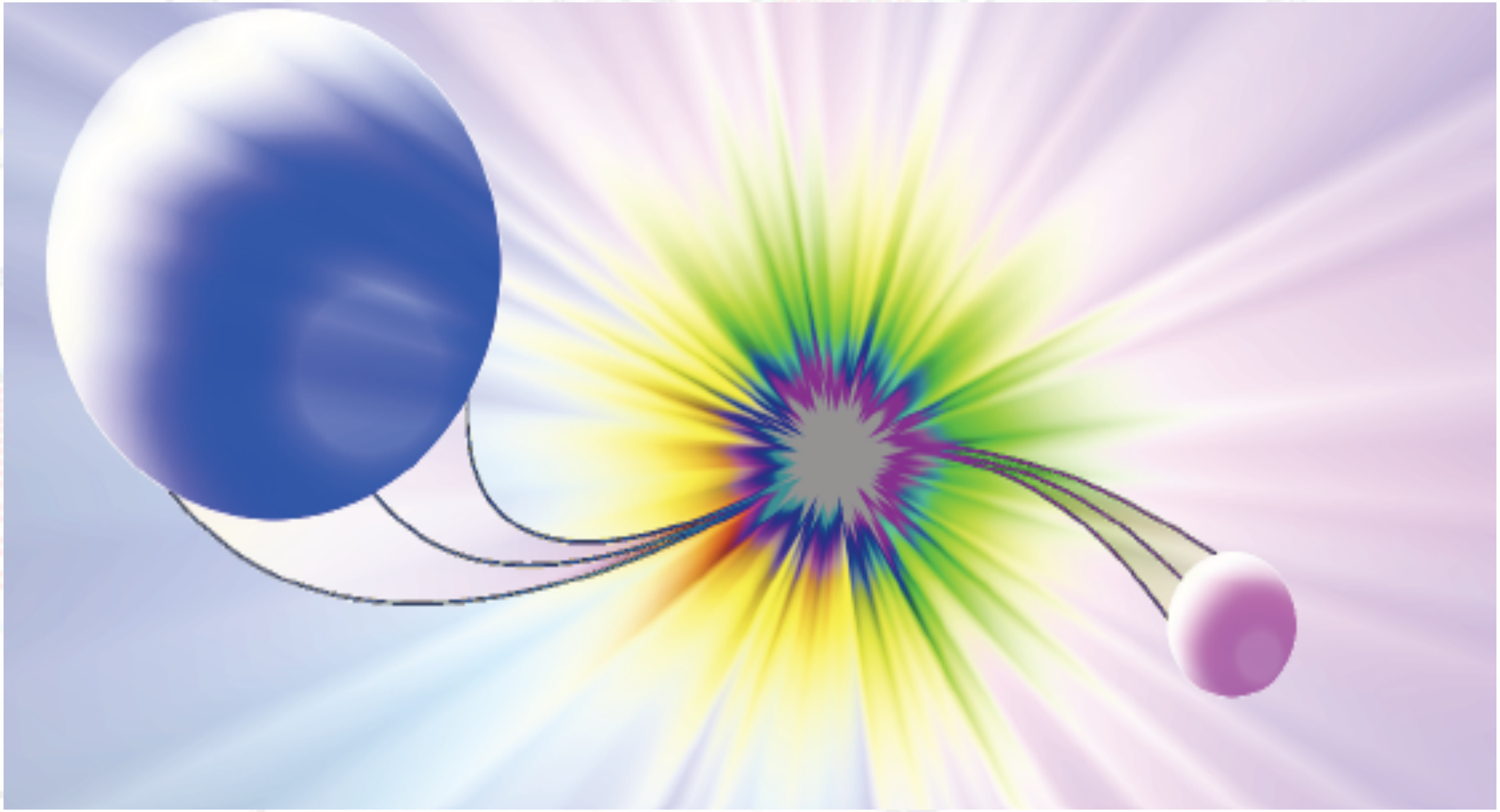
Decays of $c\bar{c}$ mesons

17) Measurement of χcJ decaying into $p\bar{n}\pi^-$ and $p\bar{n}\pi^-\pi^0$. [arXiv:1208.2320]
18) First observation of the isospin violating decay $J/\psi \to \Lambda\bar{\Sigma}_0$+c.c.. PRD86, 032008 (2012)
19) Determination of the number of J/ψ events with $J/\psi \to$inclusive decays. [arXiv:1207.2865]
20) First observation of the M1 transition $\psi(3686) \to \gamma\eta c(2S)$. PRL109, 042003 (2012)
21) Study of $J/\psi \to p\bar{p}$ and $J/\psi \to n\bar{n}$ [arXiv:1205.1036] PRD86 (5), 032014 (2012)
22) Evidence for the Direct Two-Photon Transition from ψ' to J/ψ. [arXiv:1204.0246]
23) Precision measurement of the branching fractions of $J/\psi \to \pi^+\pi^-\pi^0$ and $\psi' \to \pi^+\pi^-\pi^0$. PLB710, 594 (2012)
24) Spin-Parity Analysis of $p\bar{p}$ Mass Threshold Structure in J/ψ and ψ' Radiative Decays. PRL108 112003 (2012)
25) Higher-order multipole amplitude measurement in $\psi(2S) \to \gamma\chi c2$. PRD84, 092006 (2011)
26) Evidence for ψ' decays into $\gamma\pi^0$ and $\gamma\eta$. PRL105 261801 (2010)

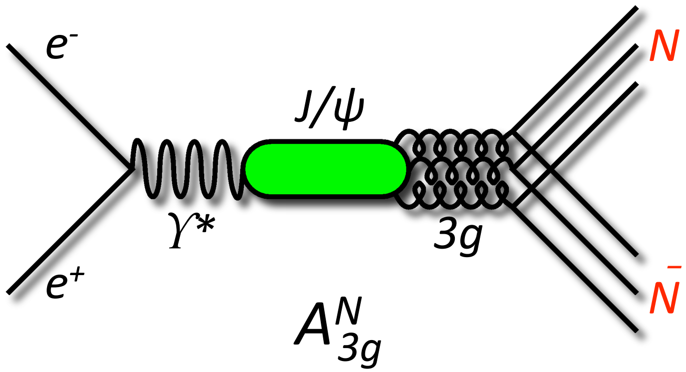
Scalar mesons and new states

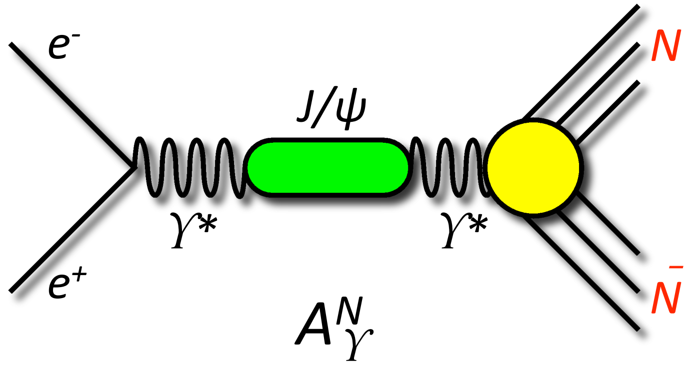
27) Search for a light Higgs-like boson A_0 in J/ψ radiative decays. PRD85 092012 (2012)
28) Study of $a_0^0(980)$–$f_0(980)$ mixing. PRD83, 032003 (2011)
29) Confirmation of the X(1835) and observation of the resonances X(2120) and X(2370) in $J/\psi \to \gamma\pi^+\pi^-\eta'$ PRL106, 072002 (2011)

J/ψ strong and e.m. amplitudes



Measurement of $J/\psi \to p\bar{p}$, $n\bar{n}$



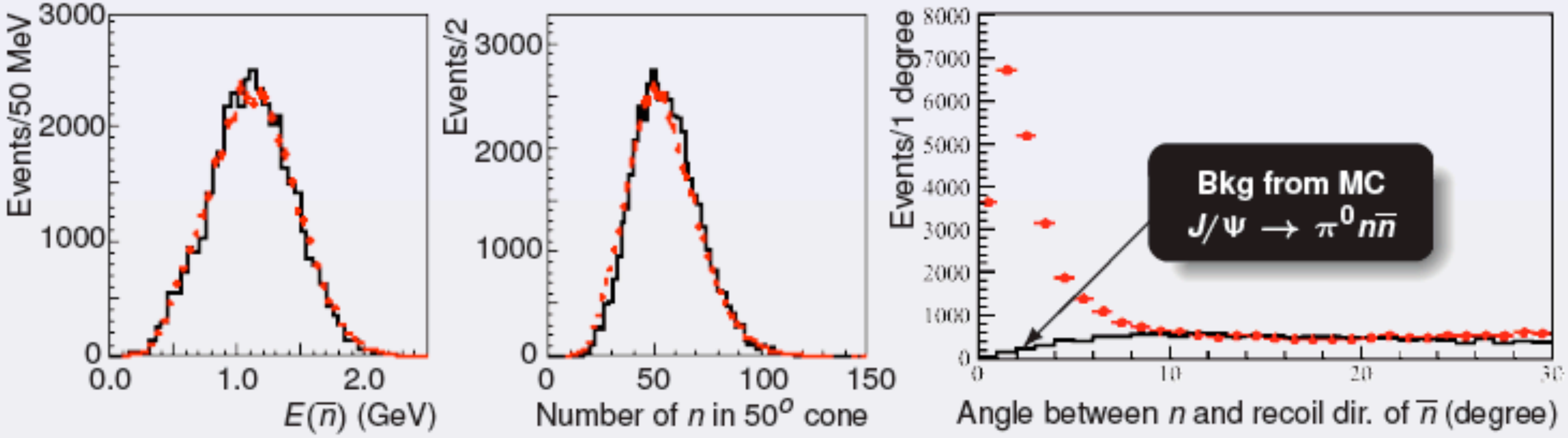


- The $J/\psi \to N\bar{N}$ is a very good test of pQCD
- The 3 gluons in the OZI-violating strong amplitude just match the 3 qq pairs of NN final states
- dominant strong amplitude: $|A^N_{3g}| > |A^N_\gamma|$
- isospin symmetry $\Longrightarrow$ $|A^p_{3g}| \simeq |A^n_{3g}|$
- A^p_γ and A^n_γ have opposite sign just as magnetic moments
- assuming pQCD: strong and e.m. amplitudes are Real $\Longrightarrow$ maximum interference and:

$$R = \frac{BR(J/\psi \to p\bar{p})}{BR(J/\psi \to n\bar{n})} = \left| \frac{A^p_{3g} + A^p_\gamma}{A^n_{3g} + A^n_\gamma} \right|^2 \simeq 2$$

BESIII results: $J/\psi \to p\bar{p}, n\bar{n}$ [PRD86 (5), 032014 (2012)]

$n\bar{n}$ identification



Recent BESIII results @LNF:

$BR(J/\psi \to p\bar{p}) = (2.112 \pm 0.004 \pm 0.027)\times 10^{-3}$

$BR(J/\psi \to n\bar{n}) = (2.07 \pm 0.01 \pm 0.14)\times 10^{-3}$

published: PRD86 (5), 032014 (2012)

PDG:

$BR(J/\psi \to p\bar{p}) = (2.17 \pm 0.07)\times 10^{-3}$

$BR(J/\psi \to n\bar{n}) = (2.2 \pm 0.4)\times 10^{-3}$

$BR(J/\psi \to p\bar{p}) \sim BR(J/\psi \to n\bar{n})$:

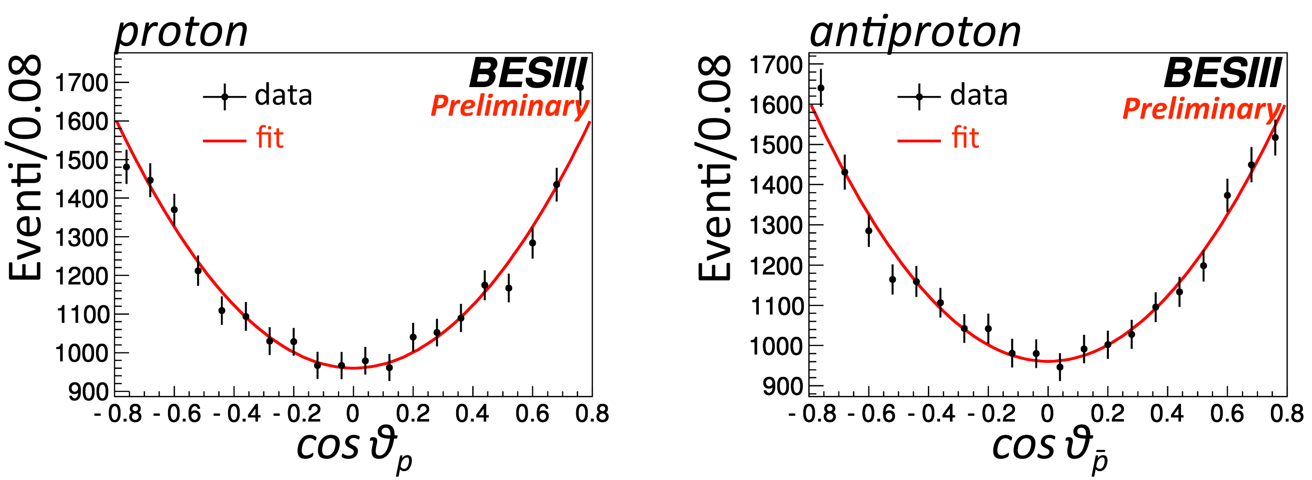
$A^N_{3g} \perp A^N_\gamma$ Large relative phase ~90° !

Work in progress at LNF/IHEP: $\psi' \to p\bar{p}$, $n\bar{n}$

- B^N_{3g} and B^N_γ relative phase is consistent with zero [Suzuki, PRD63, 054021 (2001)]
- Theoretically no differences between J/ψ and $\psi' \Longrightarrow B^N_{3g} \perp B^N_\gamma$ [Gerard, Weyers, PLB462 324 (1999)]
- $N\bar{N}$ angular distribution is $\propto (1+\alpha \cos^2\vartheta)$
  - $\alpha = 1$ helicity conservation (pQCD)
  - $\alpha < 1$ may imply isospin violation effects [Claudson, Glashow, Wise, PRD25, 1345 (1982)]

- PDG: $BR(\psi' \to p\bar{p}) = (2.76 \pm 0.12)\times 10^{-4}$
- $\psi' \to n\bar{n}$ decay never observed

Proton and antiproton angular distribution

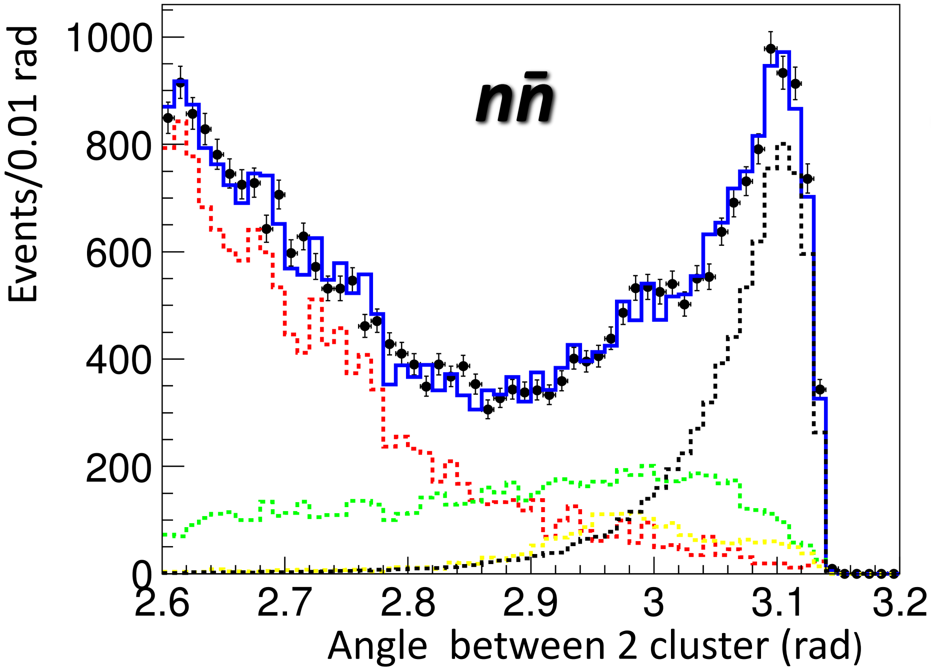


BESIII Preliminary

$BR(\psi' \to p\bar{p}) = (3.09 \pm 0.02 \pm 0.11)\times 10^{-4}$

$\alpha = 1.06 \pm 0.06 \pm 0.01$

Work in progress at LNF/IHEP: $\psi' \to p\bar{p}$, $n\bar{n}$



Bck contributions

- $\psi' \to n\bar{n}$
- Continuum data
- MC inclusive
- $\psi' \to \gamma\chi_{cJ}, \chi_{cJ} \to n\bar{n}$
- Total

Very Preliminary (stat. err. only):

$BR(\psi' \to n\bar{n}) = (3.24 \pm 0.03) \times 10^{-4}$

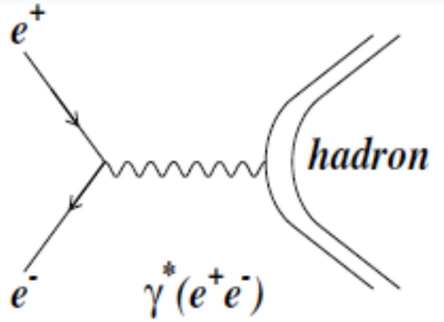
$$\frac{BR(J/\psi' \to p\bar{p})}{BR(J/\psi' \to n\bar{n})} \simeq 0.95 \pm 0.11$$

first measurement !

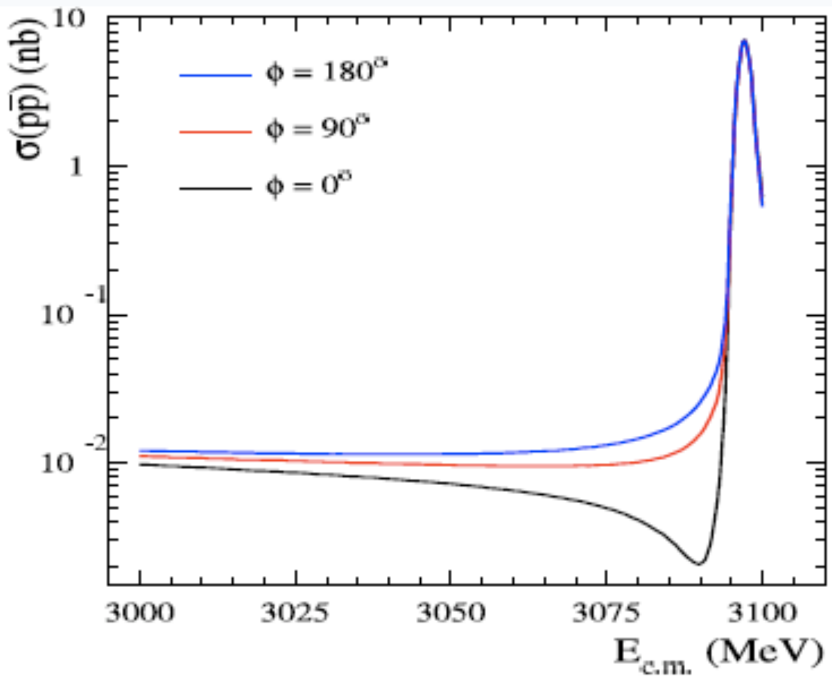
again suggesting a large phase between strong and e.m. amplitudes!

A model independent way to measure the phase between strong and e.m. decay amplitudes

- So far experimentally: $\Phi_p \sim 90°$ → Imaginary strong amplitudes hard to explain but results are model dependent
- Model independent test: look for interference pattern between the resonant amplitude and the non resonant continuum through a c.m. energy scan, i.e. out of *J/ψ* peak



- *No interference:* $\Phi_p \sim 90°$, (Imaginary strong amplitude!)
- Maximum interference: $\Phi_p \sim 0°$, 180° (Real strong amplitude)

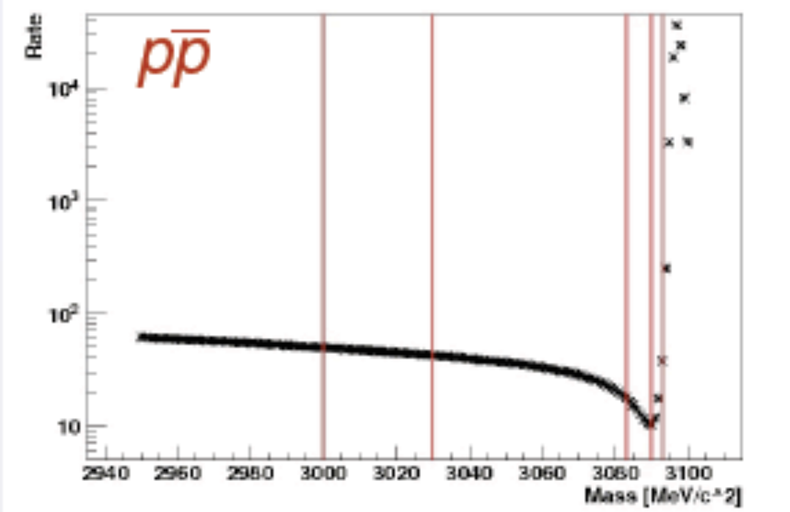


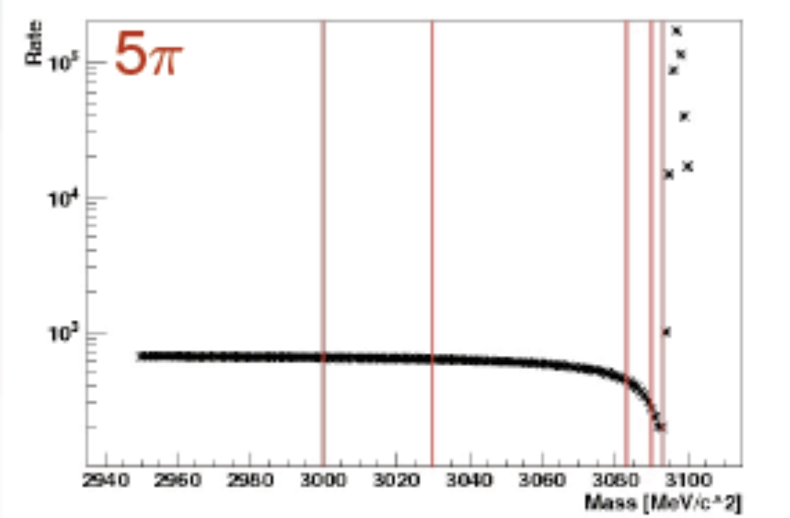
Data taking plan for J/ψ phase scan (MC)

Energy selection depends on the process:
max. interference: 0°

- 2 pts at low s:
  - fix the continuum
  - fix the slope
- 2 pts at deep positions
- 1 pt at resonance rise

Energy requested [MeV]	Energy collected [MeV]	L_{int} [pb^{-1}]
3050	3046	14.0
3060	3056	14.0
3083	3086	16.5
3090	3085	14.0
3093	3088	14.0
3097	3097	79.6

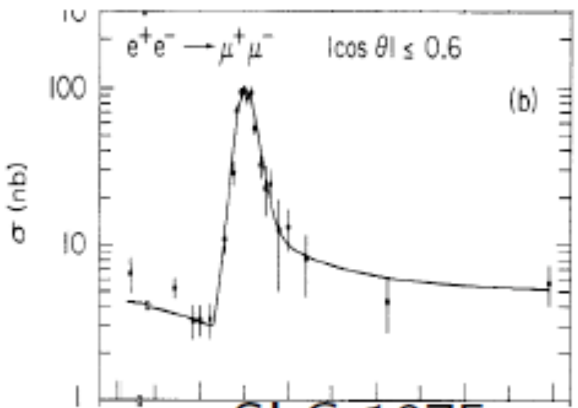




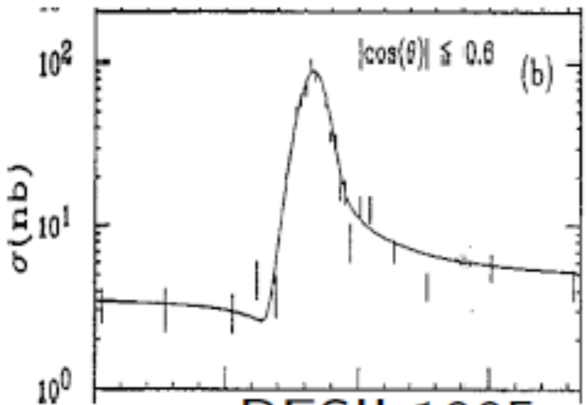
Proposed by the Italian group in 2010, accepted by the BESIII collaboration, data taken in may 2012,
analysis in progress at LNF and Turin

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

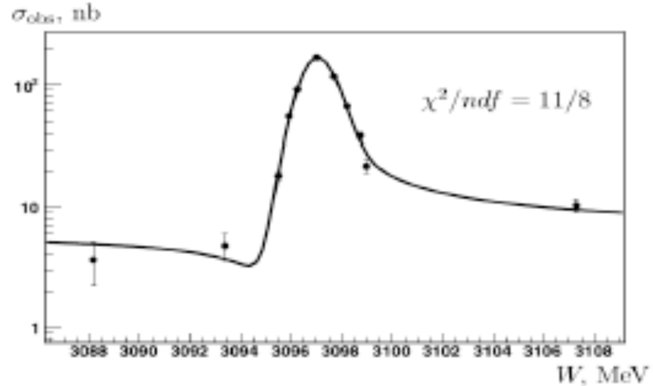
Interference pattern between *J/ψ* decay and the non-resonant decay amplitudes first observed at SLAC [PRL 33,1406] in 1975. Confirmed by BESII and KEDR



SLC 1975



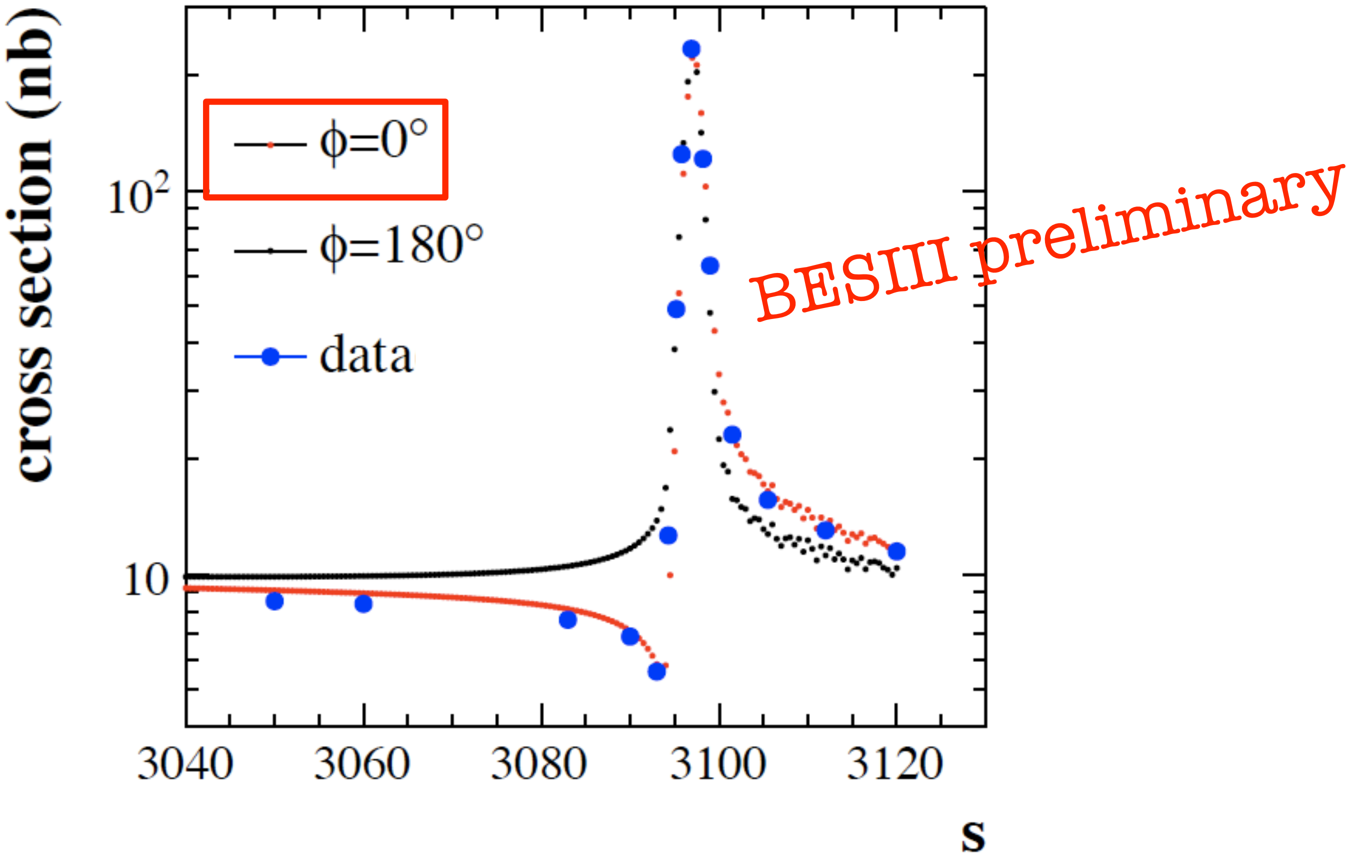
BESII 1995



KEDR

Preliminary BESIII results: $e^+e^- \longrightarrow J/\psi \longrightarrow \mu^+\mu^-$

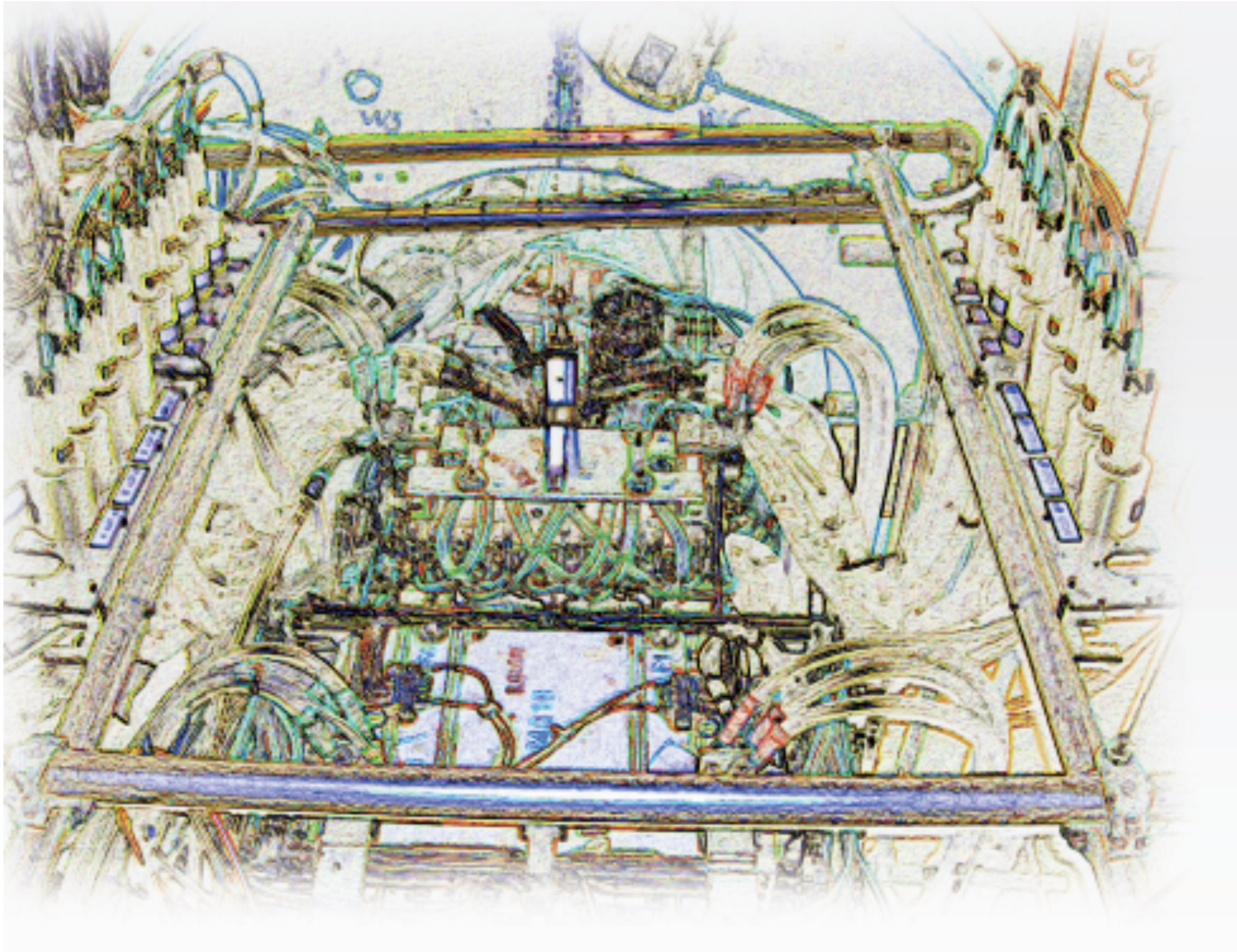
- 2012 data set for J/ψ lineshape
- red and black lines are MC simulations



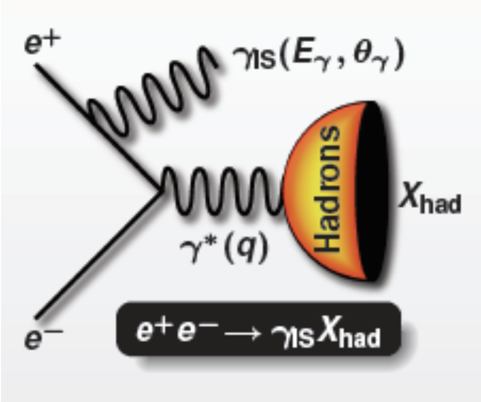
preliminary result consistent with ϕ=0° as expected for $\mu^+\mu^-$

other channels under study

Zero Degree Detector at BESIII



Physics Motivations: Initial State Radiation



◎Existing results, mainly from BABAR (ISR) show interesting and unexpected behaviors expecially at threshold for $e^+e^- \rightarrow p\bar{p}$, $e^+e^- \rightarrow \Lambda\bar{\Lambda}$

◎Only one measurement by FENICE (energy scan) for $e^+e^- \rightarrow n\bar{n}$ SND confirms FENICE

Physical limits in reaching threshold of many of these channels via energy scan (stable hadrons produced at rest cannot be detected)

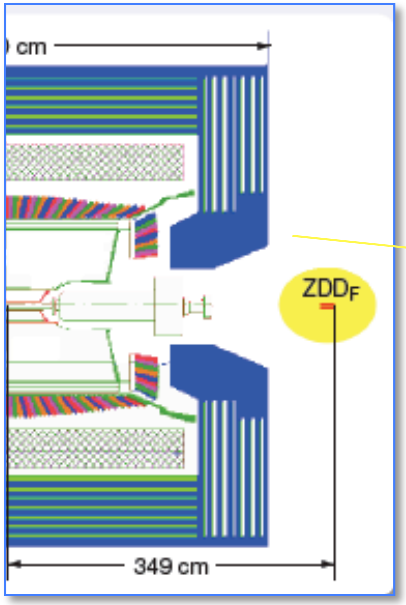
The ISR technique provides a unique tool to access threshold regions working at higher resonances:

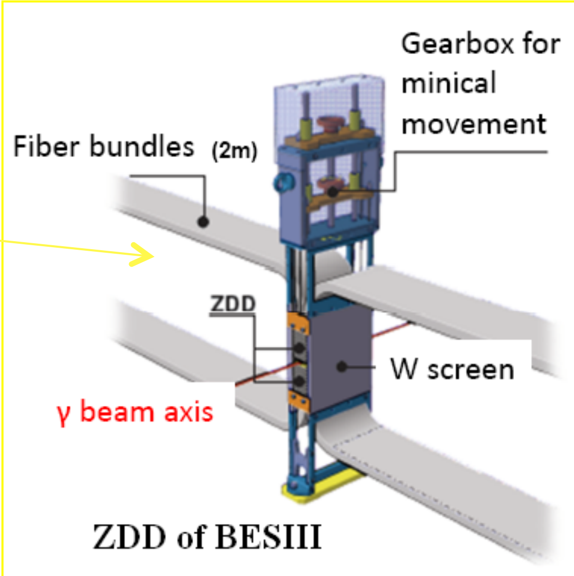
- all energies (q^2) at the same time → better control on systematics
- detect ISR photon → full X_{had} angular coverage

A Zero Degree radiative photon tagger (ZDD) installed at 3.5m from IP:

- to detect ISR photons peaked at small angle
- to suppress background from π^0 and γ_{FS}
- it also measures luminosity

ZDD: structure module and segmentation

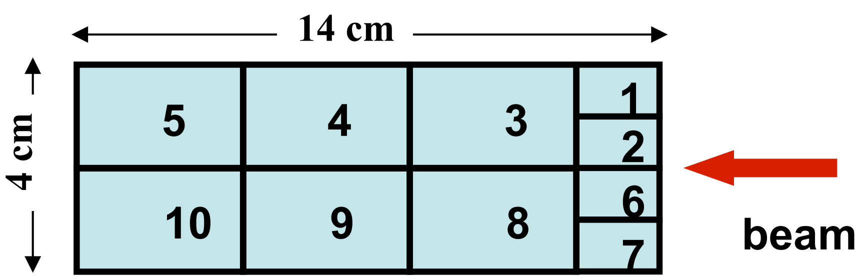




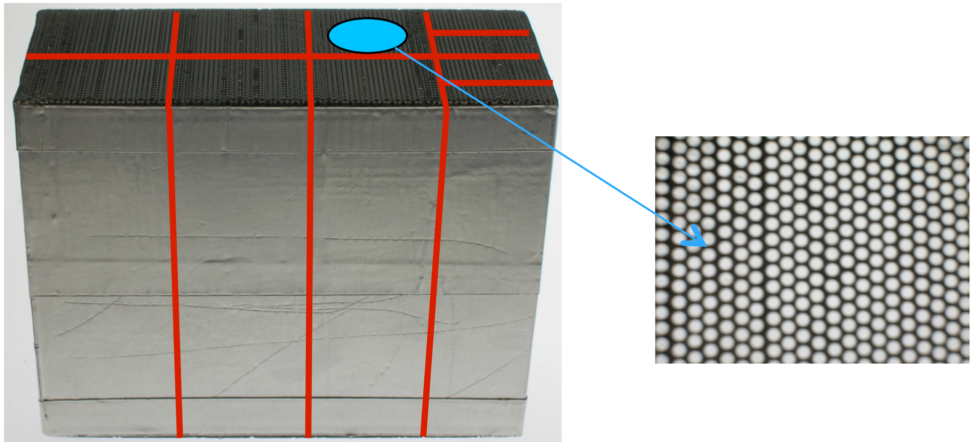
Pb/Sci.Fi Array a` la KLOE scintillating material 60% of total (in volume)

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)

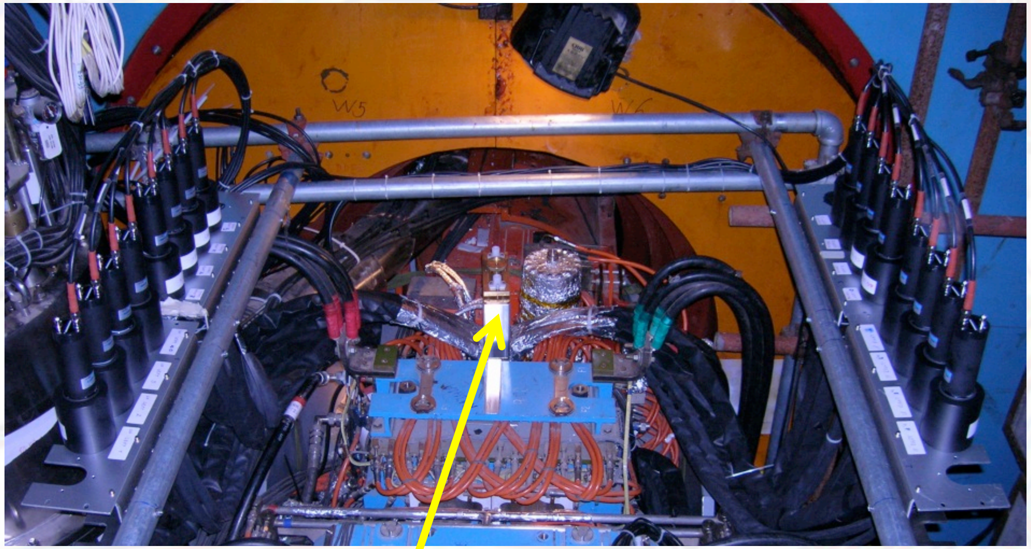


Each sector is sent to a PM, sectors 1&2 (6&7) are sent to the same PM (for now)

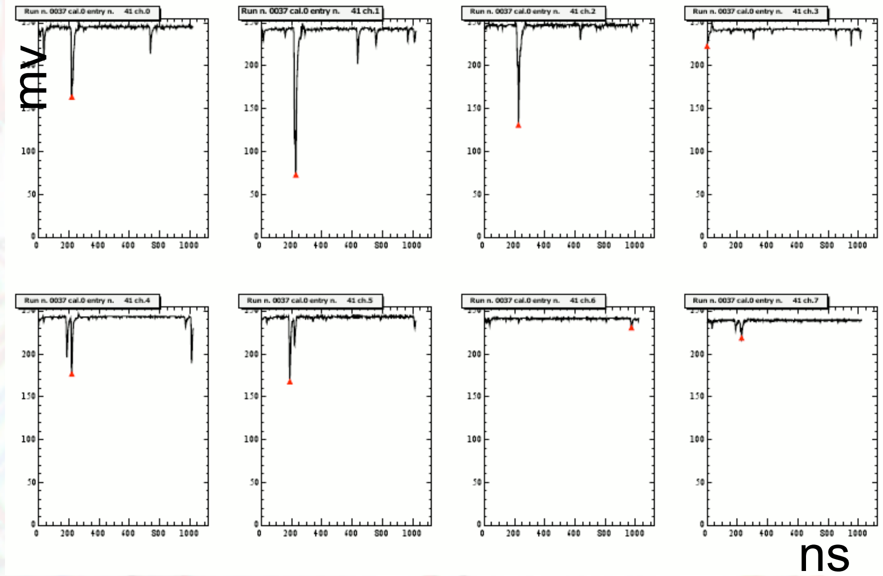


BESIII

ZDD timeline

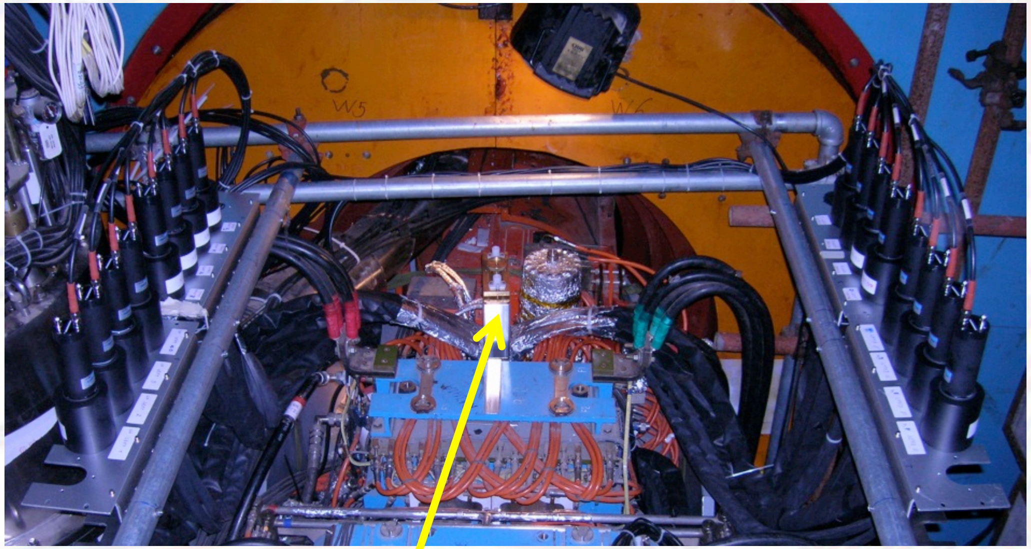


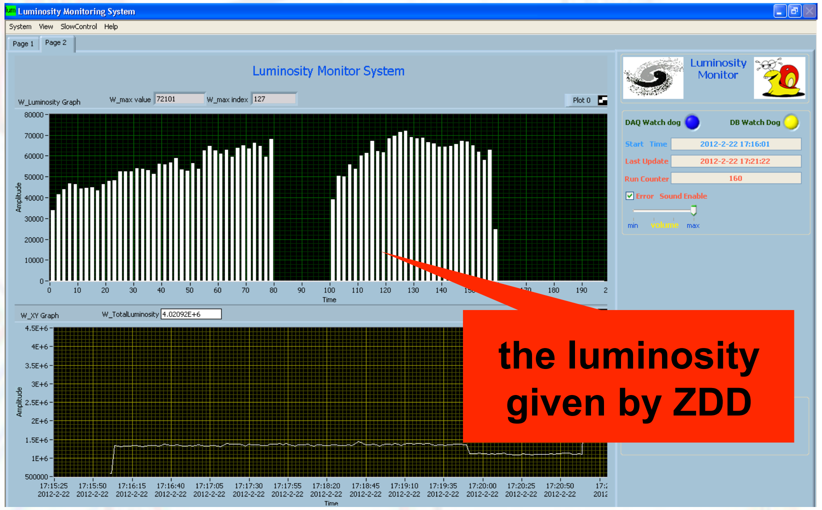
event in collision



- •01/2011-06/2011: construction and assembling of the first ZDD station at LNF
- •06/2011-08/2011: tests with cosmic rays and BTF @ LNF: σ_E/E=12.4% @E=450MeV
- •August 2011:shipping to Beijing and installation at BEPCII east side
- •2011-12: debugging with cosmics and on-line data @ BEPCII
  - worked as luminometer
  - data taken on stand-alone PC with L1 BESIII trigger
  - now is being inserted into BESIII general DAQ system
- •2013: upgrade with scintillating strips to improve energy resolution

ZDD timeline and status





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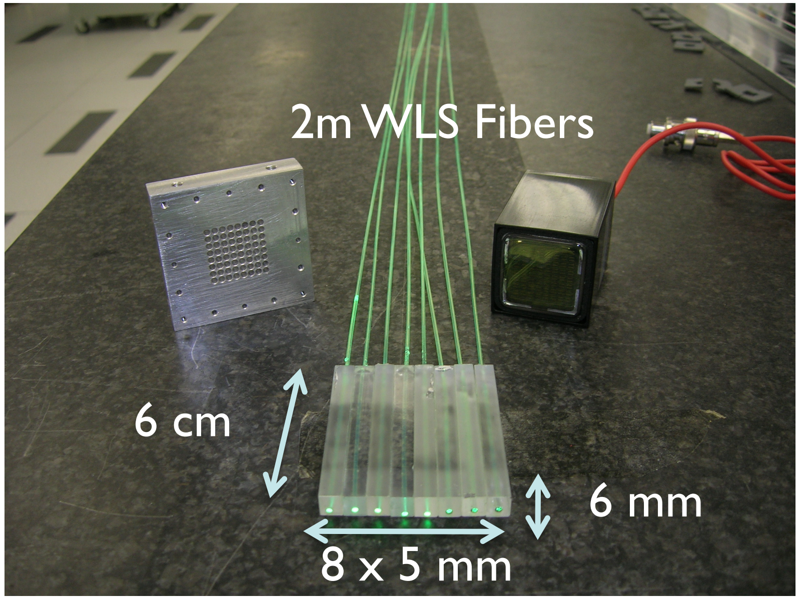
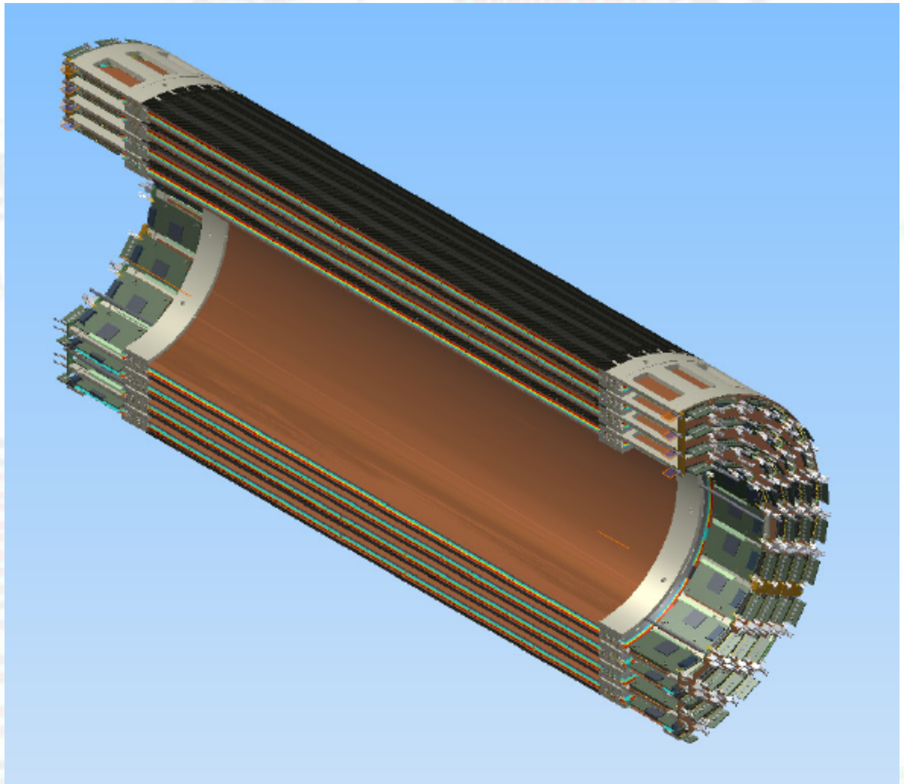
ZDD upgrade at LNF

Upgrade of ZDD with thin layer of scintillator strips, signal brought out by fibers, 2m long

- Read out by MAPMT, FEE electronic worked out at LNF SEA
- To be put in front of ZDD to discriminate photons vs e^{+-} from beam-pipe conversion
- Activity co-financed by DTZ and other groups (LHCb, SuperB, Gr2) interested in this kind of tracking detector
- detector ready to be installed (2013), work in progress for FEE @LNF SEA



CGEM proposal



by the BESIII Italian Collaboration

Inner Drift Chamber Upgrade

- MDC inner layers at BESIII are facing aging problems.
  BESIII will construct a new inner drift chamber starting 2013
  but with increasing luminosity → will have the same problem soon
- Investigating CGEM technology, based on KLOE2 expertise (thanks to G.Bencivenni) :
  - LNF and IHEP have asked Foreign Ministries financial support for a CGEM prototype with analog readout: a global funding request of 120Keuro
  - CGEM miniWorkshop held October 25-26 in Frascati (LNF, Bari, BESIII, CMD2 , Rui De Oliveira)
  - asked GR1 for a small planar (10x10cm^2) prototype to start testing analog readout in LNF during 2013
- KLOE2 CGEM construction and R&D ~ 3 years
  BESIII ~ 2 years

BESIII

Conclusions

- **BESIII is running successfully**
- **Very fruitful Italian-Chinese collaboration**
- **ZDD detector designed, built in LNF, installed at BEPCII in record time, now ready to take data with BESIII**
- **Many interesting physics analyses going on and new ones to start**
- **CGEM upgrade proposal**

We encourage our colleagues to join us in BESIIII enterprise

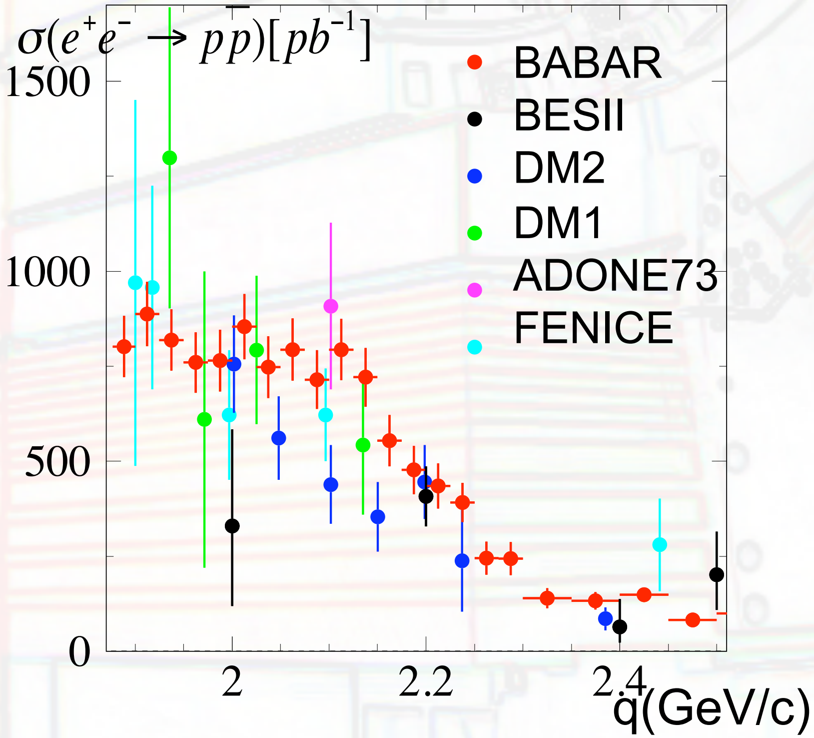
spares

$e^+e^- \to p\bar{p}$

EPJA39, 316

$$\sigma(e^+e^- \to p\bar{p}) = \frac{4\pi\ \alpha^2 \beta_p C}{3q^2}\left[|G_M|^2 + \frac{2M_p^2}{q^2}|G_E|^2\right]$$

Coulomb factor: $C \underset{\beta_p \to 0}{\sim} \left(\frac{\pi\alpha}{\beta_p}\right)$



At threshold:

$$\sigma(e^+e^- \to p\bar{p})(4M_p^2) = \frac{\pi\ \alpha^3\ \cancel{\beta_p}}{2M_p^2\ \cancel{\beta_p}}|G^p(4M_p^2)|^2$$

$$\sigma(e^+e^- \to p\bar{p})(4M_p^2) = 850\,|G^p(4M_p^2)|^2\ pb$$

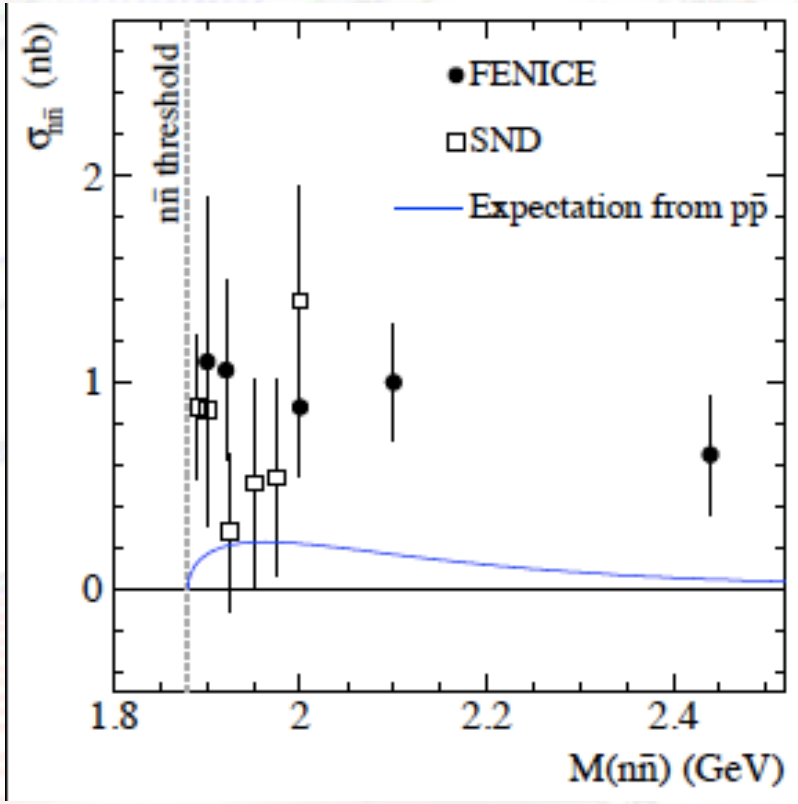
$\Downarrow$

$|G_p(4M^2_p)|=1$
as pointlike fermion pairs !

Using ISR technique with only few fb^{-1} of integrated luminosity BESIII can easily achieve the BABAR statistics

$e^+e^- \to n\bar{n}$

Nucl.Phys. B517,3 (1998)

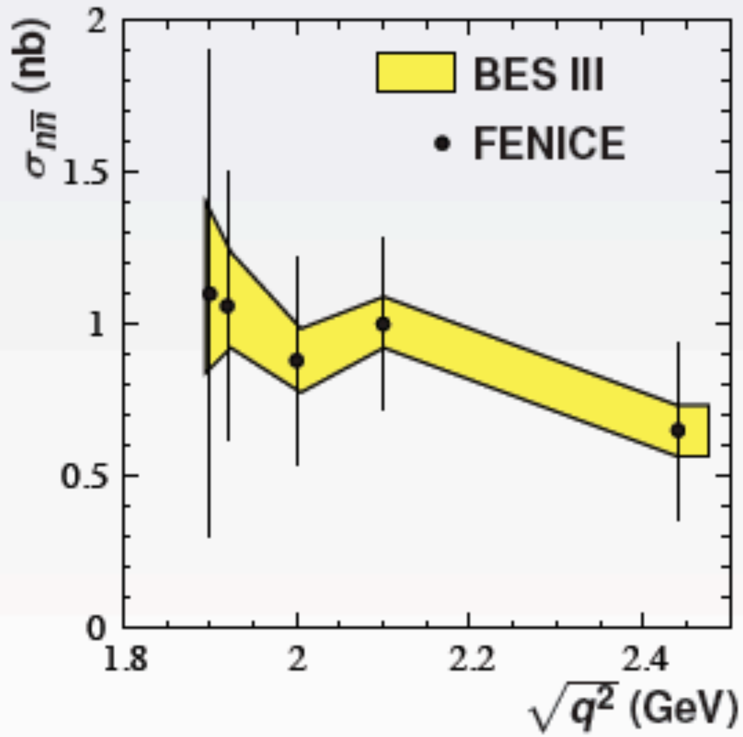


measured by FENICE, recently confirmed by SND
- $\sigma(n\bar{n}) > \sigma(p\bar{p})$?
- Not zero at threshold?

- BESIII has the unique possibility to measure this cross section
- No other experiments at present and in near future will be able to perform such a measurement

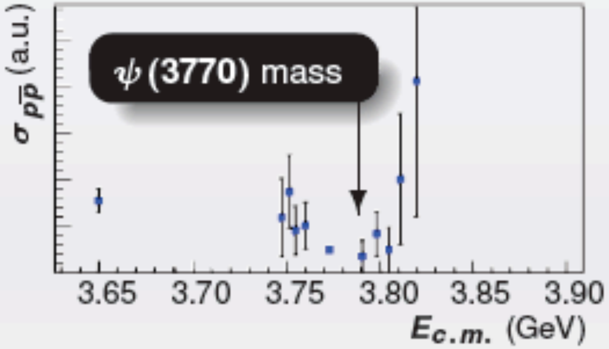
Expectations for $n\bar{n}$ $p\bar{p}$ at BESIII

- One year of data taking: $T = 1.5 \times 10^7$ s
- Average luminosity: $\overline{\mathcal{L}} = 3 \times 10^{32}\ \mathrm{cm}^{-2}\mathrm{s}^{-1}$
- Center of mass energy: $E_{c.m.} = 3.77$ GeV
- Detection efficiences: $\epsilon_{n\bar{n}} = 0.4$ $\epsilon_{p\bar{p}} = 0.8$
- Number of events: $N_{n\bar{n}} \simeq 1000$ $N_{p\bar{p}} \simeq 2000$



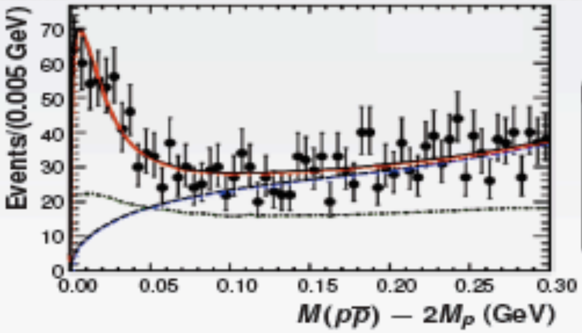
Other baryonic processes under investigation

- $\psi(3770) \rightarrow (p\bar{p}), n\bar{n}$



- Dip in $p\bar{p}$: continuum/resonance interference
- Negative neutron time-like FF
  $\Rightarrow$ peak in $n\bar{n}$ cross section
- $B(\psi(3770) \rightarrow p\bar{p}) - B(\psi(3770) \rightarrow n\bar{n})$:
  neutron time-like FF at $q^2 = 16$ GeV^2
  (space-like neutron FF masured only up to $q^2 = -4$ GeV^2)

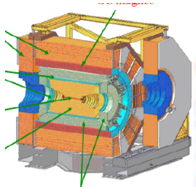
- $J/\psi \rightarrow \gamma n\bar{n}$



- Unexpected enhancement at small $p\bar{p}$ invariant masses
- No Coulomb enhancement

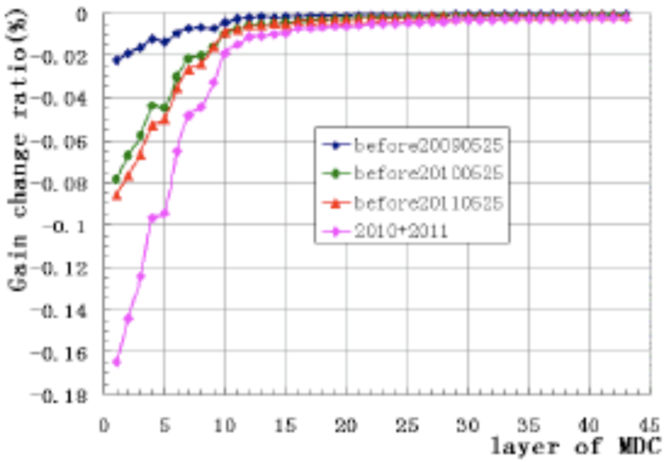
- $e^+e^- \rightarrow \Sigma^+\Sigma^-$

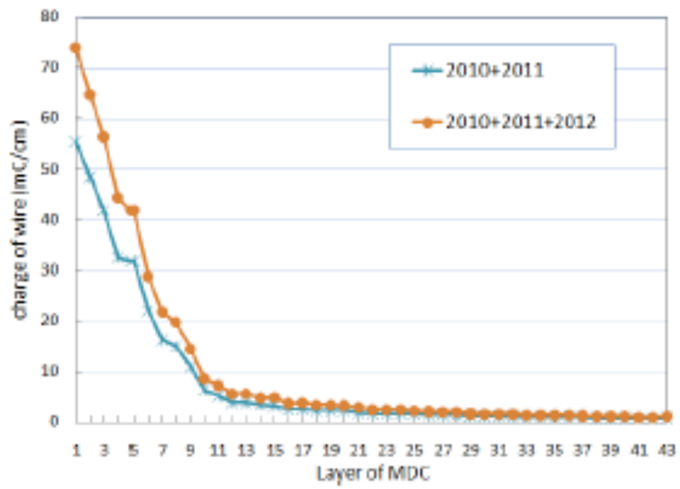
- Never measured
- At threshold expected like $p\bar{p}$: step and FF = 1



Aging effects of Inner MDC layers

- **field wires: Malter effect**
  - **Non-stopped discharge up to some μA/wire, possible large area damage to detector**
  - **Water vapor about 2000ppm @ 22 °C has been added, no Malter effect again. But, long term operation needs investigation.**
- **sense wires**
  - **2009 — 2011, gain degraded for the 1st 5 layers: 10% —15%**
  - **The accumulated charge of the sense wire on the first layer is 74mC/cm ≈ the specification of BESIII design for 5 full-year running**





BESIII

Requirements for Inner Chamber upgrade

- **Rating capability:** $\sim 10^4$ Hz/cm^2
- **Spatial resolution:** $\sigma_{xy} \sim 100\mu m$; $\sigma_z \sim 1mm$;
- **Momentum resolution:** $\sigma_{pt}/p_t \sim 0.5\%$ @1GeV;
- **Efficiency:** $\varepsilon \sim 98\%$
- **Material budget:** $< 1.5\%$ all layers
- **Coverage:** 93% 4π
- **Operation duration:** ~ 5 years

Possible options:

- **CGEM:** based on KLOE-2 technology, collaboration between Italian and Chinese groups
- **Monolithic pixels:** CPS developed by IPHC in Strasburg

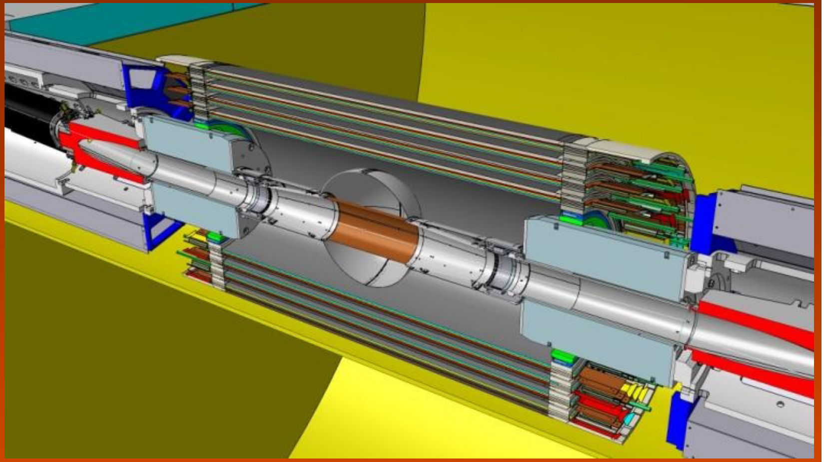
GEM detector features

- **flexible geometry**
- **ultra-light structure →** very low material budget: <0.5% X0/chamber
- **gas multiplication separated from readout stage →** arbitrary readout pattern: pad, strips (XY, UV), mixed …
- **high rate capability:** >50 MHz/cm2
- **high safe gains:** > 10^4
- **high reliability:** low discharge, $P_d < 10^{-12}$ per incoming particle
- **rad hard:** up to 2.2 C/cm^2 integrated over the whole active area without permanent damages (corresponding to 10 years of operation at LHCb1)
- **high spatial resolution:** down to 60μm (COMPASS with analog readout **Nucl.Phys.Proc.Suppl. 125 (2003) 368-373**)
- **good time resolution:** down to 3 ns (with CF_4)

KLOE-2 Inner Tracker

To improve vertex reconstruction of **K_s , η and η'** and **K_s- K_L interference measurements:**

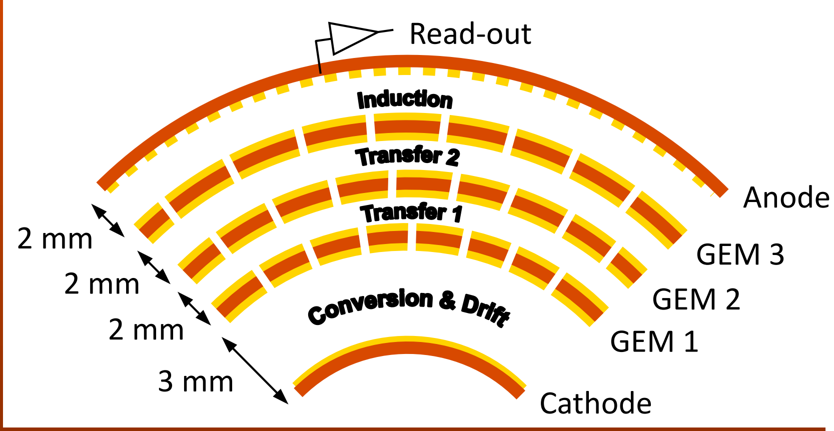
1. **$\sigma_{r\varphi} \sim 200$ μm and $\sigma_z \sim 350$μm**
2. **low material budget**: < 2% X_0



Cylindrical GEM detector is the adopted solution

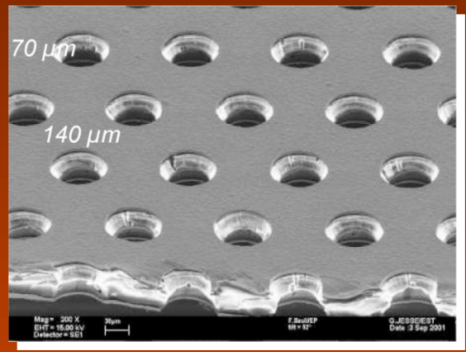
- **4 CGEM** layers :from IP to DC Inner wall
- **700 mm** active length
- **XV strips-pads readout (~40° stereo angle)**
- **<2%X_0** total radiation length in the active region

Cylindrical Triple GEM

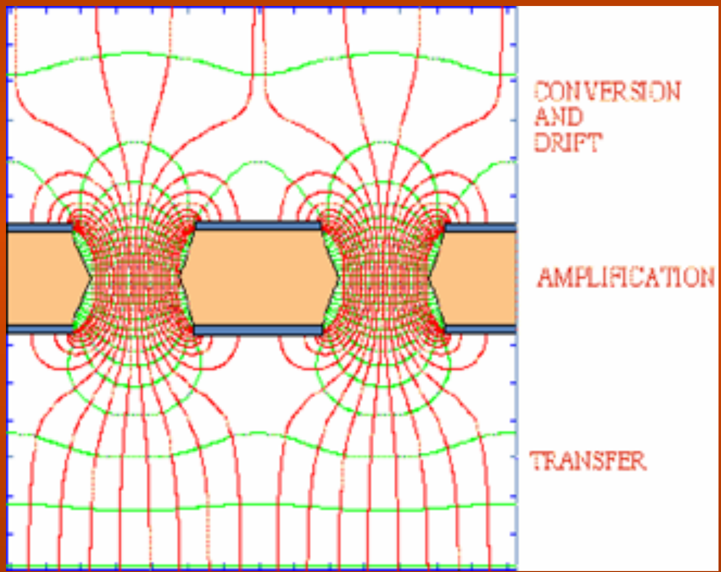


$K_S \rightarrow \pi^+ \pi^-$ vertex resolution **will improve of about a factor 3** from present **6mm**

GEM: principle of operation



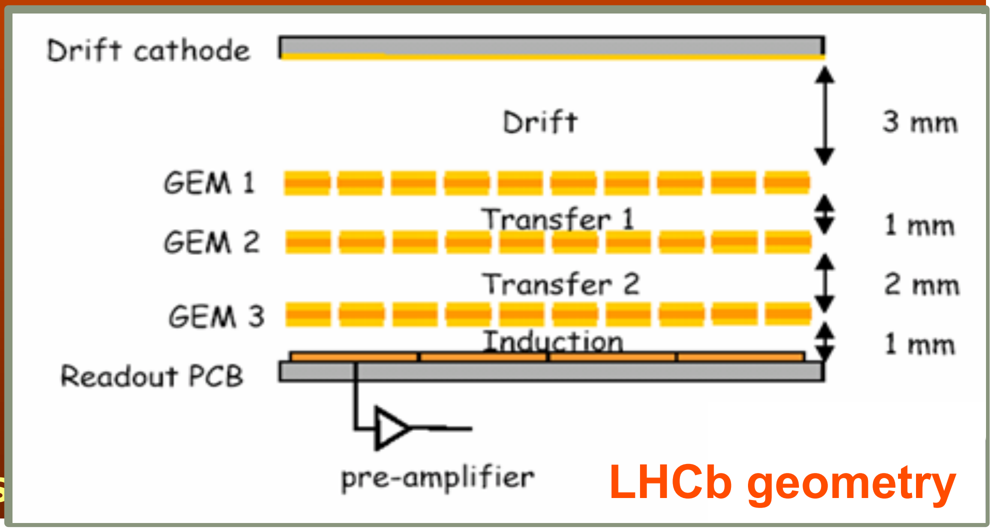
The GEM (Gas Electron Multiplier) [F.Sauli, NIM A386 (1997) 531] is a thin (50 μm) metal coated by a kapton foil perforated by a high density of holes (70 μm diameter, pitch of 140 μm) → standard photo-lithographic technology.



By applying 400-500 V between the two copper sides, an electric field as high as ~100 kV/cm is produced into the holes which act as multiplication channels for electrons produced in the gas by a ionizing particle.

Gains up to 1000 can be easily reached with a single GEM foil. Higher gains (and/or safer working conditions) are usually obtained by cascading two or three GEM foils.

A Triple-GEM detector is built by inserting three GEM foils between two planar electrodes, which act as the cathode and the anode.



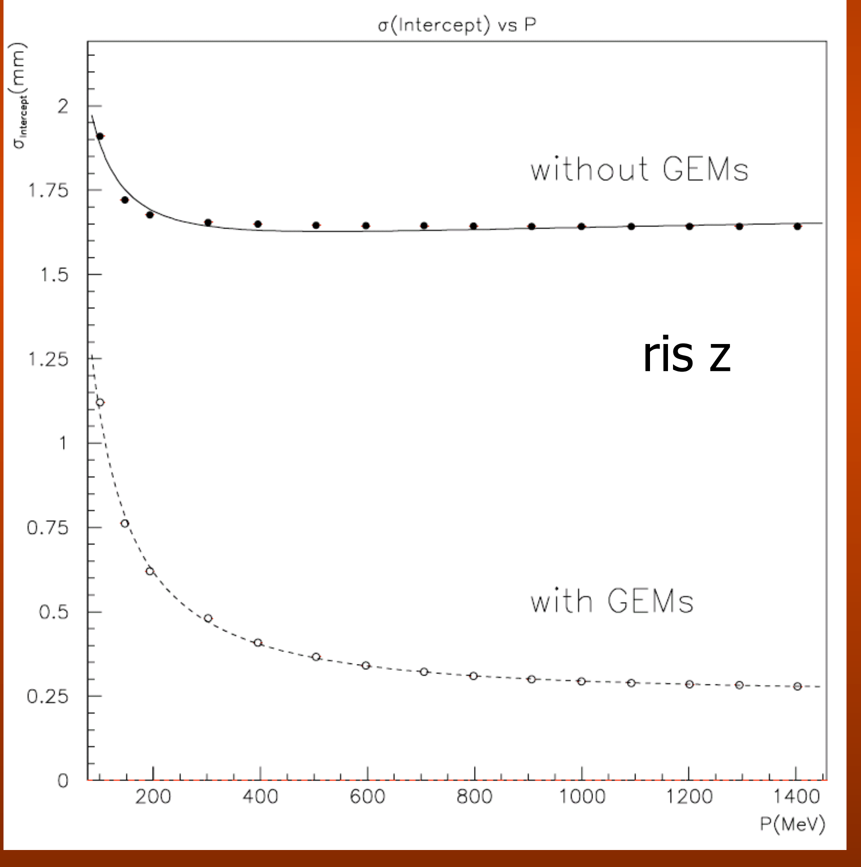
A Cylindrical GEM at BESIII
in case a new inner chamber is needed ?

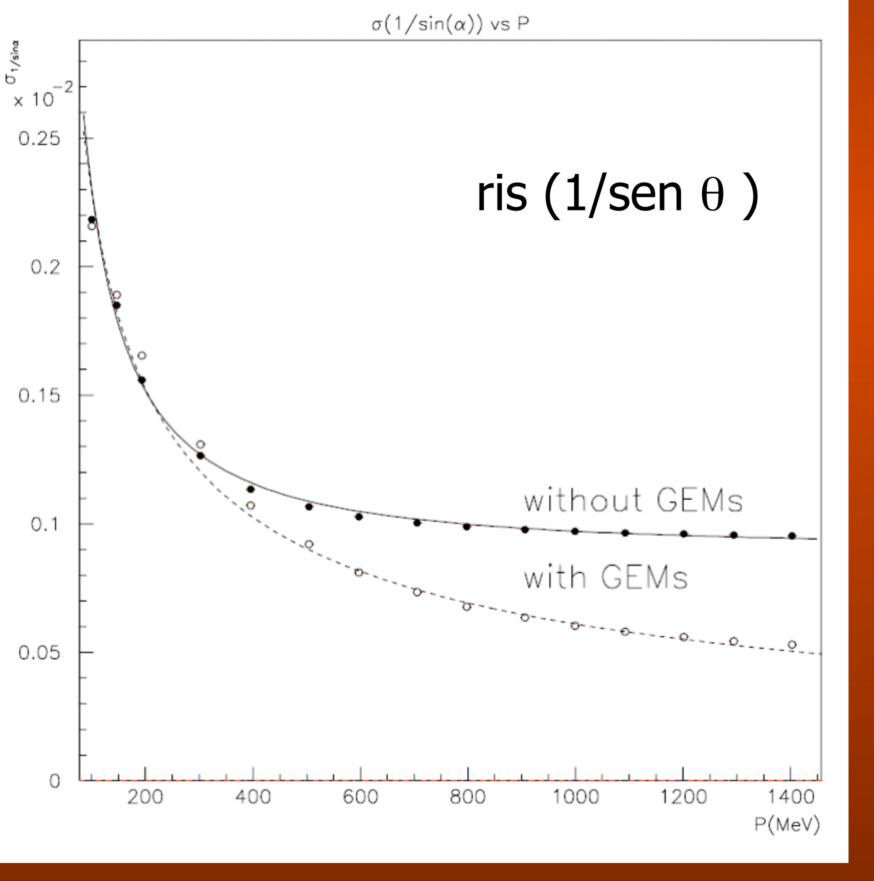
- Cylindrical GEM will be installed in KLOE-2 by the end of this year

- BESIII inner chamber is a bit smaller
  - makes a Cylindrical GEM easier to be built,
  - enough space to allocate 4 triple-GEM,
  - equivalent to the present 8 layers of MDC,
  - much better vertex reconstruction
  - however, new construction tools are needed
  - more material (0.45 -> 1.5 % X_0): P resolution under evaluation
  - Expertise from KLOE2 and CERN

Resolutions Toy MC

Assuming:
- KLOE2 pitch (650 μm)
- Analog readout (extrapolated from COMPASS results)
  - $\sigma_x \sim 130\ \mu m$
  - $\sigma_z \sim 250\text{-}300\ \mu m$





BESIII GEM
possible geometrical parameters

ayer	Int.diam (mm)	Length (mm)	Foils
1	126		1
2	192		2
3	258		2
4	324	870	2

N. strips ~ 20000 (KLOE2 ~ 30000)

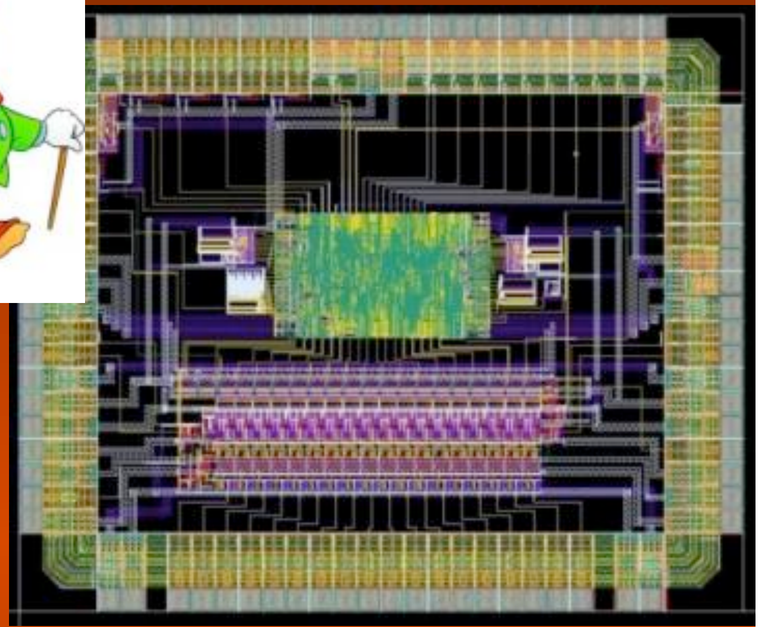
Stereo angle ~ 40^0 (like KLOE2)

KLOE - IT dimensions

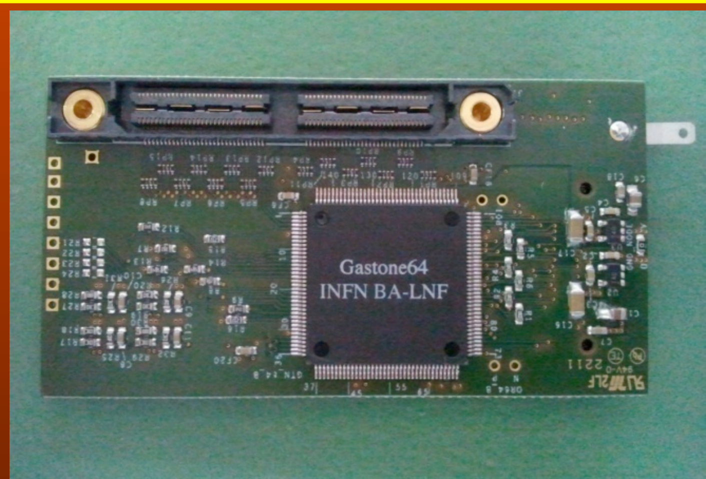
	Ext diam (mm)	Int diam (mm)
Layer 1	290	244
Layer2	340	294
Layer3	390	344
Layer4	440	394

GASTONE: the IT dedicated FEE chip

Sensitivity (pF)	20 mV/fC
Z_{IN}	400 Ω (low frequency)
C_{DET}	1 – 50 pF
Peaking time	90 – 200 ns (1-50 pF)
Noise (erms)	800 e^- + 40 e^-/pF
Channels/chip	64*
Readout	LVDS/Serial
Power consum.	≈ 0.6 mA/ch



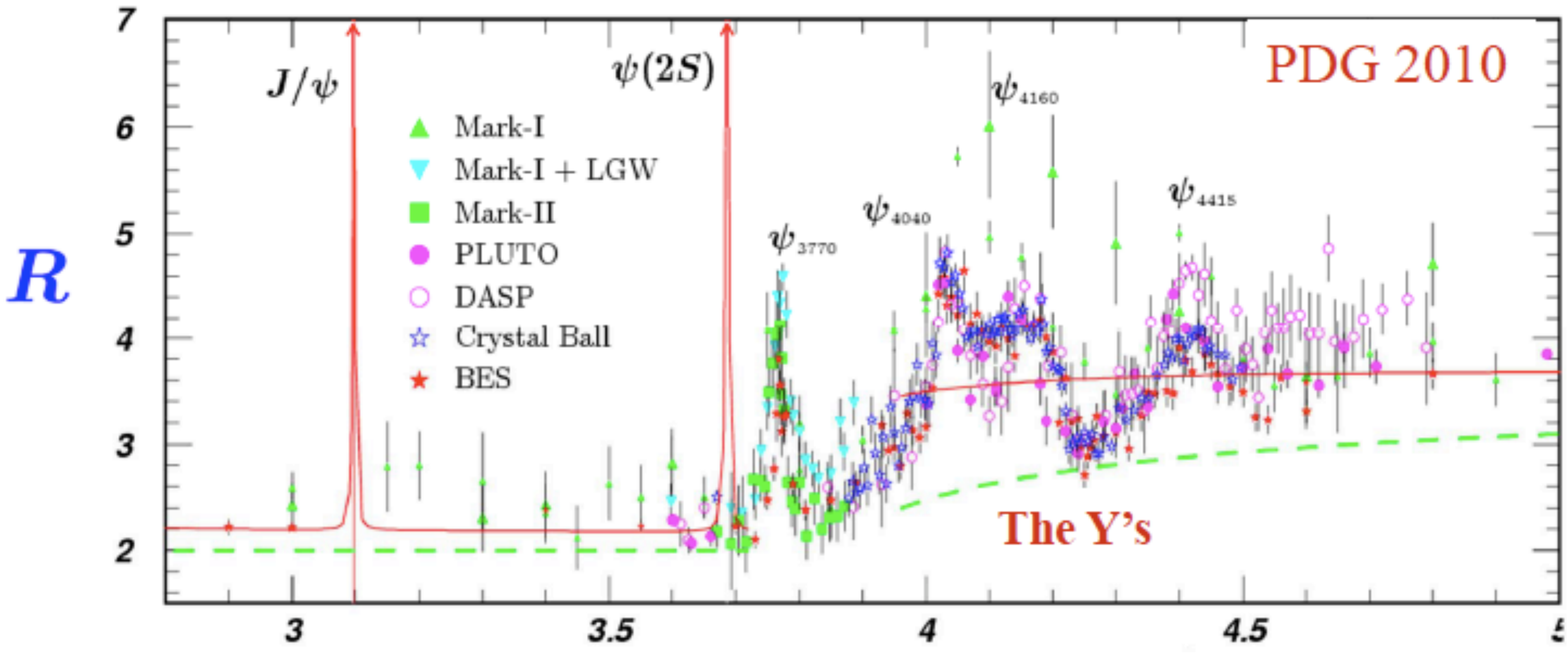
0.35 CMOS technology- no Rad-Hard



- **Mixed analog-digital circuit** (KLOE-2 dedicated);
- **Low input equivalent noise**, **low power consumption** and **high integrated chip;**
- 4 blocks:
  - **charge sensitive preamplifier**
  - **shaper**
  - **leading-edge discriminator** (prog. thr.)
  - **monostable** (stretch digital signal to match the trigger timing of the experiment)

Features of the BEPC Energy Region

- 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: glueballs, exotic states and hybrids



BESIII computing in Italy today

- **Italian mirror BES3 DB @ TO:** online since 09/2010
- **Italian BESIII computing farm @ TO (SLC 5.6/64):**
  - WN: 64 cores Xeon 2.13/2.53GHz; servers: DB 8 cores; open access (SSH) 8 cores
  - storage: 12TB NFS/ISCSI
  - activities: J/Ψ phase studies; BOSS analysis $e^+e^- \rightarrow p$ pbar, n nbar
- **BOSS framework full documentation @ TO (single worldwide):**
  - doxygen updated to BOSS 6.6.2, hosted by TO INFN central web server:
    - http://bes3.to.infn.it/BESIII_Doxygen_Documentation.html
- **BOSS 6.6.2 released:**
  - validation in progress