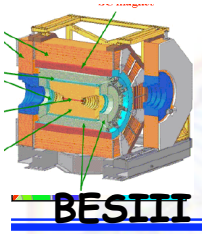
BESIII activities at LNF

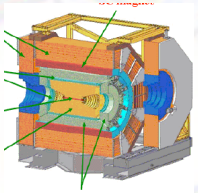
M.Bertani on behalf of the LNF group:

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

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



OUTLINE

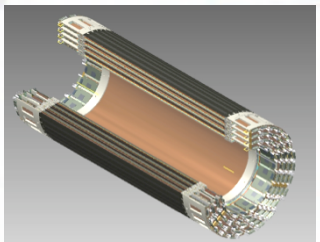


BESIII and BEPCII

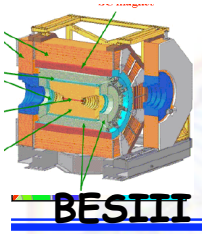
main physics goals

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

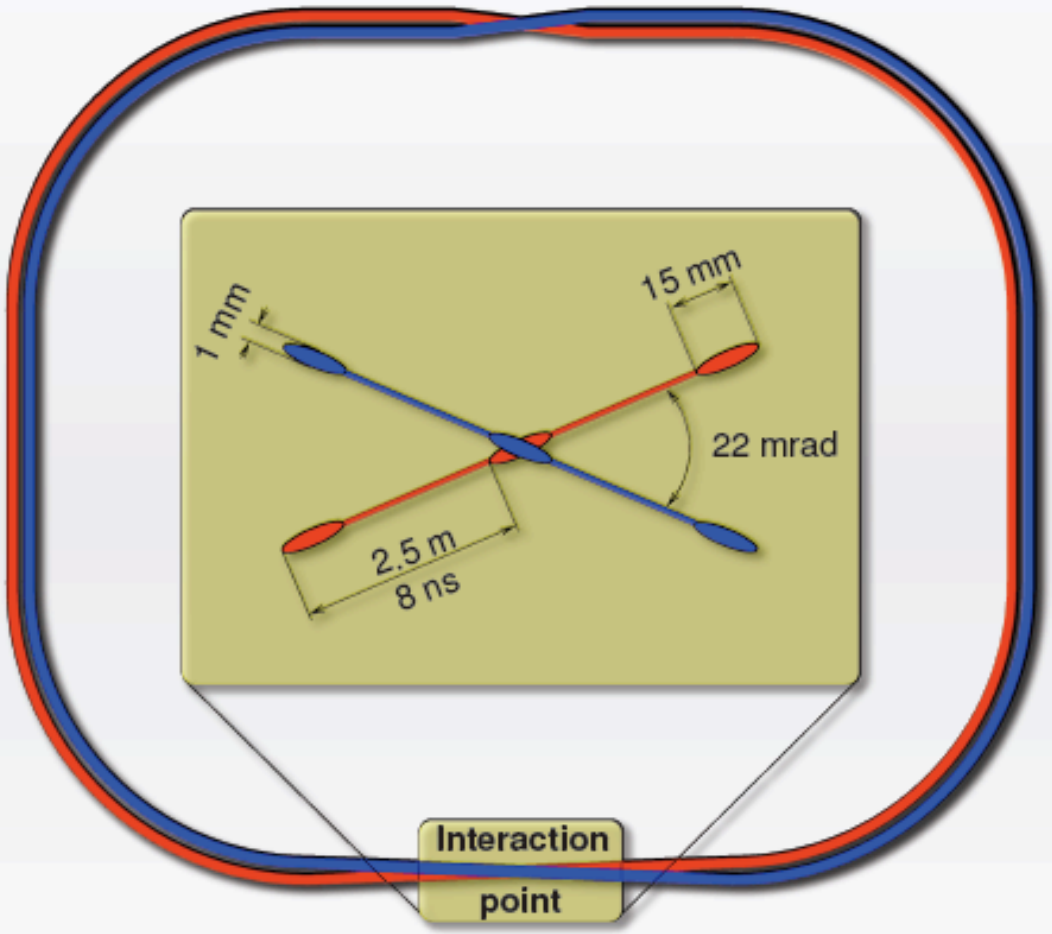
The Zero Degree Detector



Cylindrical GEM prototype proposal for upgrade of Inner MDC

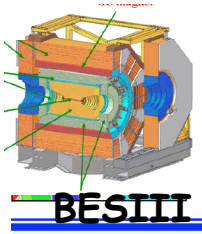


BEPCII: Beijing e^+e^- double ring collider



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

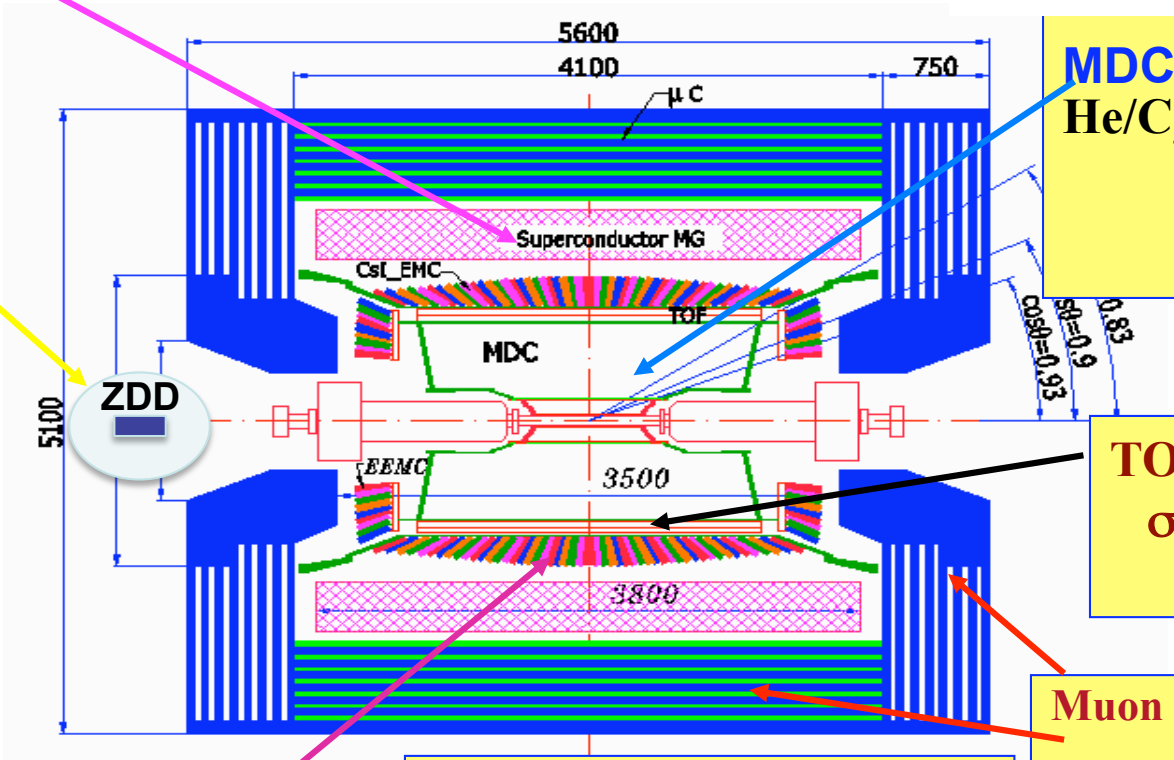


BESIII Detector

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

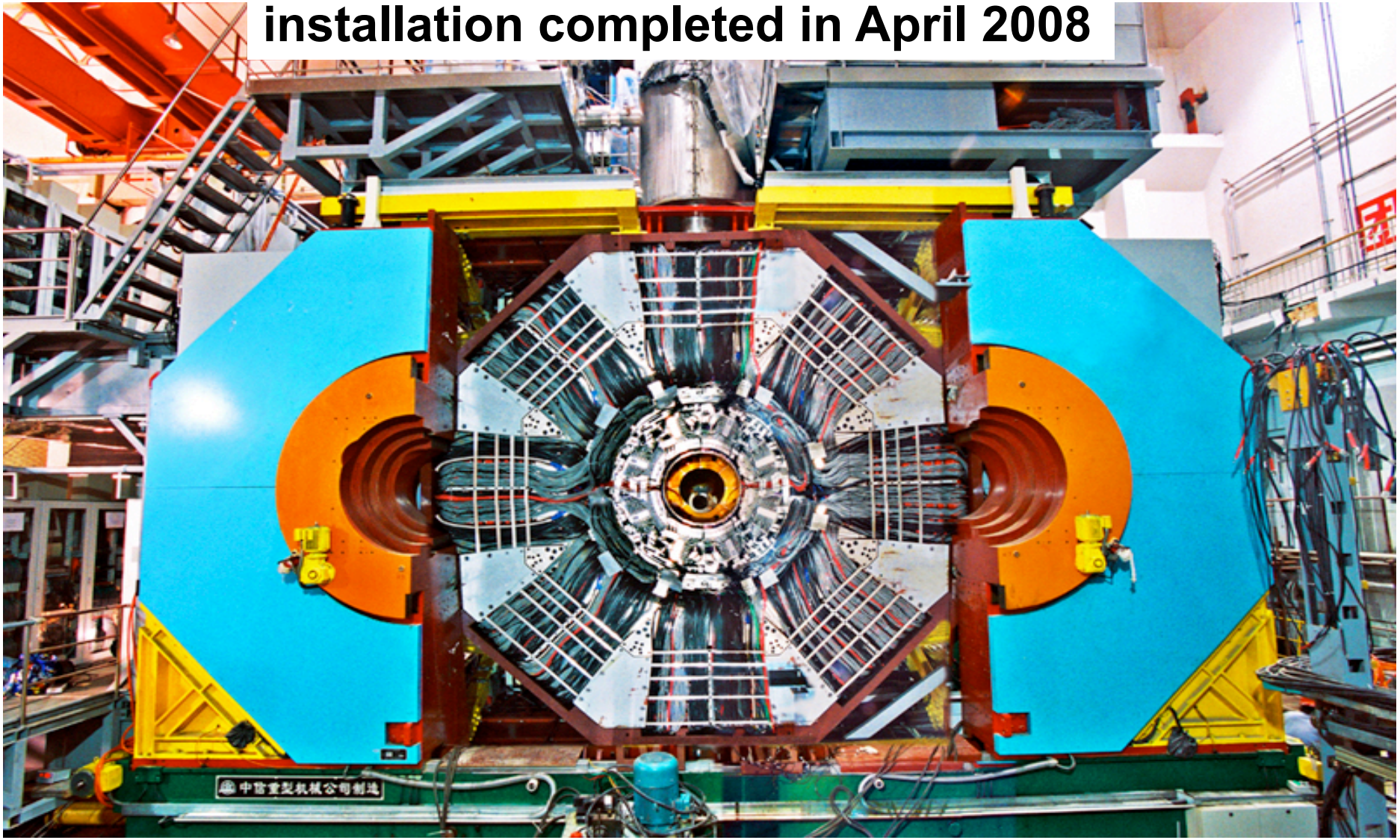
EMC: CsI crystal, 28 cm
ΔE/E = 2.5% @1 GeV
σz = 0.6 cm/√E

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.

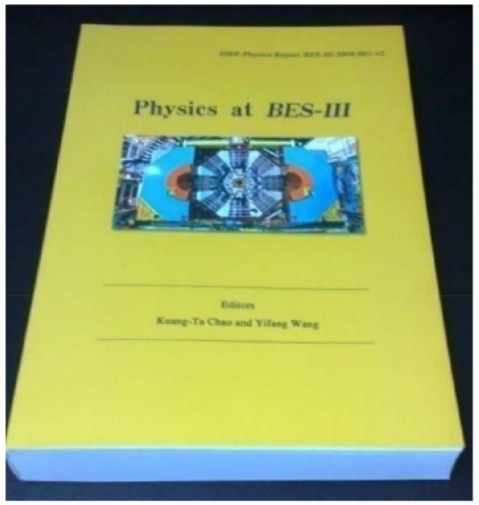
Beijing Spectrometer III (BESIII)

installation completed in April 2008



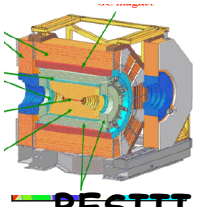
Physics in the tau-charm region

- **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: ρπ 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

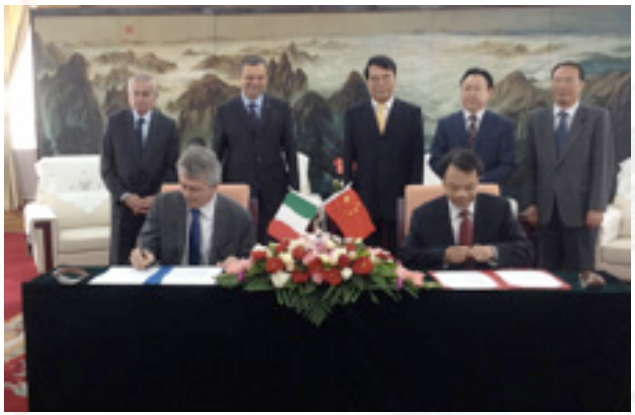


The Italian Collaboration at BESIII

- **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, Yadi Wang
  - LNF group in 2012-13: R. Baldini Ferroli, M.Bertani, A. Calcaterra, Y.Wang, A. Zallo (3FTE) M.Anelli (technical support, SSE)
- **Main physics interests**:
  - $e^+e^- \rightarrow$ BB (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/$\psi \rightarrow$ nn,pp (published), ψ' , ψ'' $\rightarrow$ nn,pp
- **Detector:**
  - **ZDD** construction and installation (summer 2011) of a mini-calorimeter in the forward region to detect ISR photons
  - 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

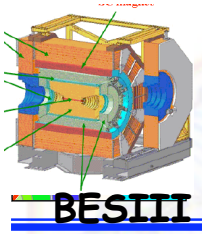


E' stato firmato nella mattina del 18 giugno a Pechino - la notte tra domenica e lunedì in Italia - l'accordo tra l'INFN e l'Istituto cinese per le alte energie (IHEP) per la realizzazione di una collaborazione tra le due strutture di ricerca scientifica. L'accordo - che è stato firmato nell'ambito del 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 fundings at the Italian ministery 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 BESIII
- **Nov 2008:** ~14M ψ(2S) events for detector calibration
- **2009:** **106M ψ(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 ψ(2S)**
  J/ψ: 1B eventi, lineshape,
  - 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 ψ(2S) ψ(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 spectroscopy)
additional ψ(3770), τ scan, R scan

Published Results

χ_{cJ} decays and transitions

1) Search for hadronic transition $\chi_{cJ} \to \eta_c \pi^+\pi^-$ and observation of $\chi cJ \to KK\pi\pi\pi$. [arXiv:1208.4805]
2) Measurement of χ_{cJ} decaying into $p\bar{p}\pi^-$ and $p\bar{p}\pi^-\pi^0$. [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 $\chi_{c2} \to \gamma\gamma$. 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 $\chi_{cJ} \to \pi^0\pi^0\pi^0\pi^0$. PRD83, 012006 (2011)

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

8) Search for η and η' Invisible Decays in $J/\psi \to \varphi\eta$ and $\varphi\eta'$. [arXiv.1209.2469]
9) Observation of $e^+e^- \to \eta J/\psi$ at center-of-mass energy $s^{1/2}$=4.009 GeV. [arXiv.1208.1857]
10) Evidence for $\eta c \to \gamma\gamma$ and Measurement of $J/\psi \to 3\gamma$. [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 $\psi' \to \gamma\eta c$. 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 $J/\psi \to \omega\eta\pi^+\pi^-$. 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 $\eta' \to \eta\pi^+\pi^-$. PRD83, 012003 (2011)

Published Results

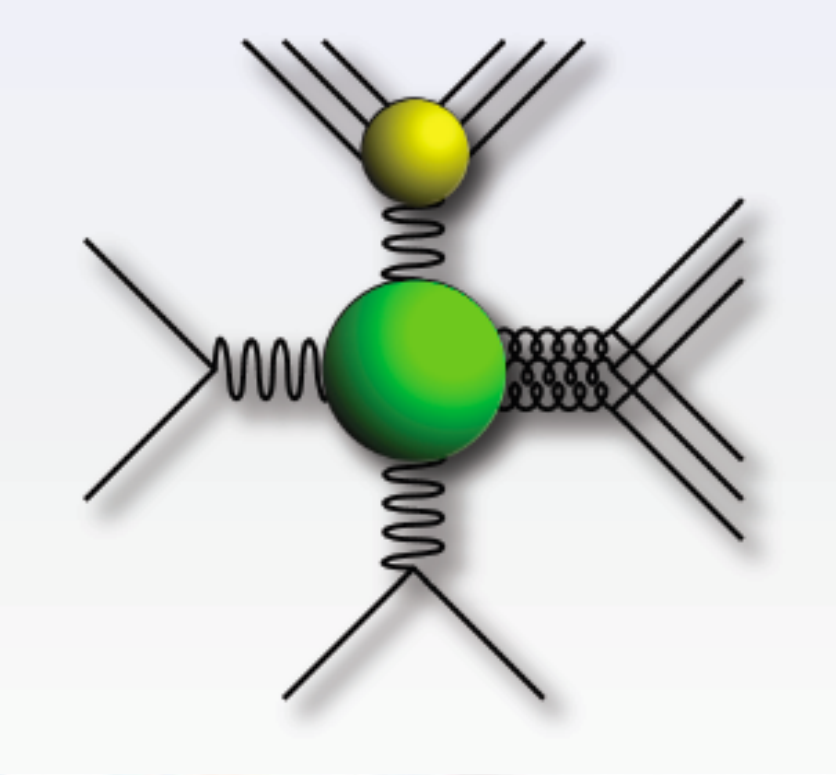
Decays of $c\bar{c}$ mesons

17) Measurement of χcJ decaying into $p\bar{p}\pi^-$ and $p\bar{p}\pi^-\pi^0$. [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/ψ→inclusive decays. [arXiv:1207.2865]
20) First observation of the M1 transition ψ(3686)→γηc(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 ψ(2S)→γχc2. PRD84, 092006 (2011)
26) Evidence for ψ' decays into $\gamma\pi^0$ and γη. PRL105 261801 (2010)

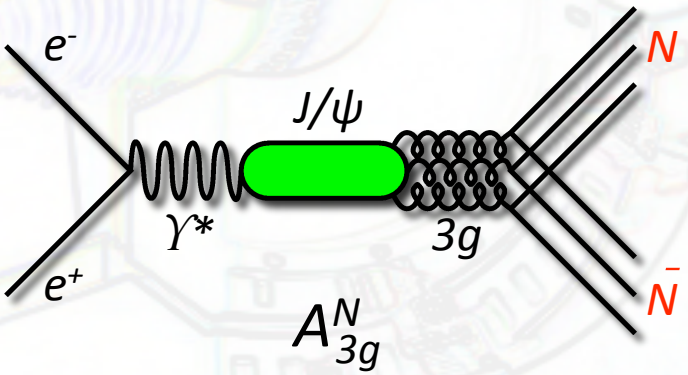
Scalar mesons and new states

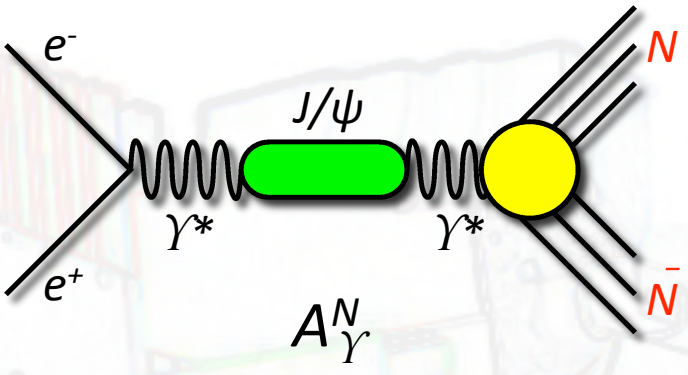
27) Search for a light Higgs-like boson A_0 in J/ψ radiative decays. PRD85 092012 (2012)
28) Study of $a_0^0(980)$–$f_0(980)$ mixing. PRD83, 032003 (2011)
29) Confirmation of the X(1835) and observation of the resonances X(2120) and X(2370) in $J/\psi \to \gamma\pi^+\pi^-\eta'$ PRL106, 072002 (2011)

J/ψ strong and e.m. amplitudes



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



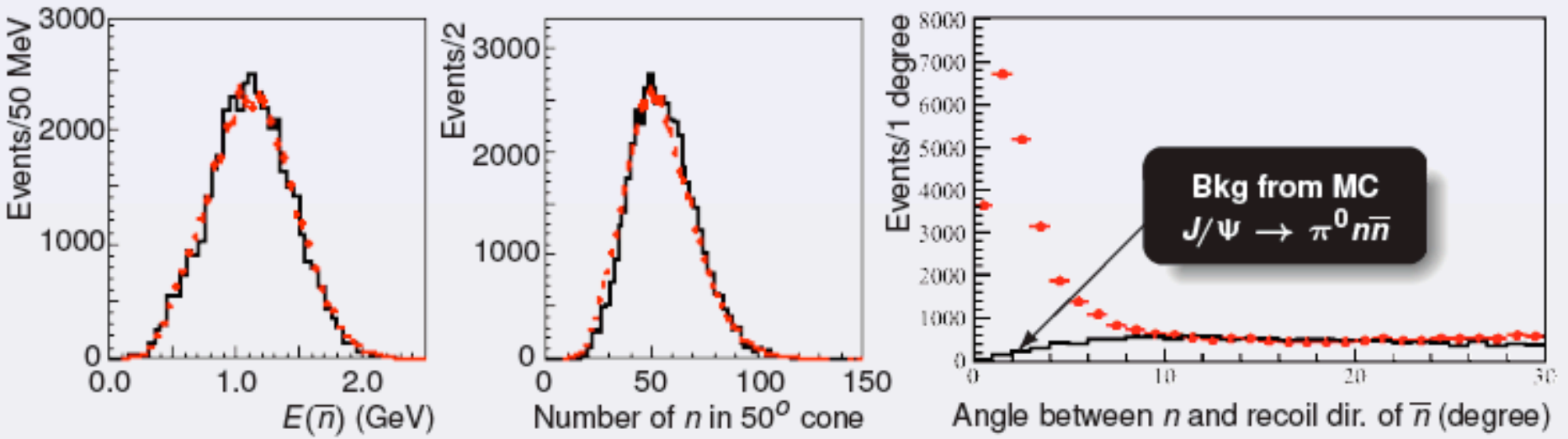


- The $J/\psi \to NN$ is a very good test of pQCD
- The 3 gluons in the OZI-violating strong amplitude just match the 3 qq pairs of NN final states
- dominant strong amplitude: $|A^N_{3g}| > |A^N_\gamma|$
- isospin symmetry $\Longrightarrow$ $|A^p_{3g}| = |A^n_{3g}|$
- $A^p_\gamma = -A^n_\gamma$ as magnetic 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:

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

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

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

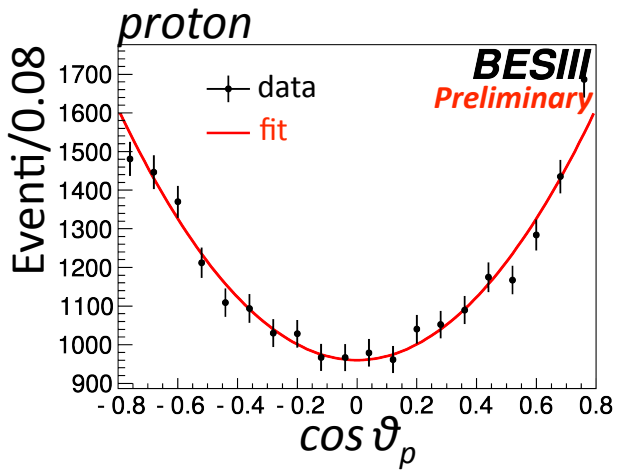
$A^N_{3g} \perp A^N_{\gamma}$ Large relative phase ~90° !

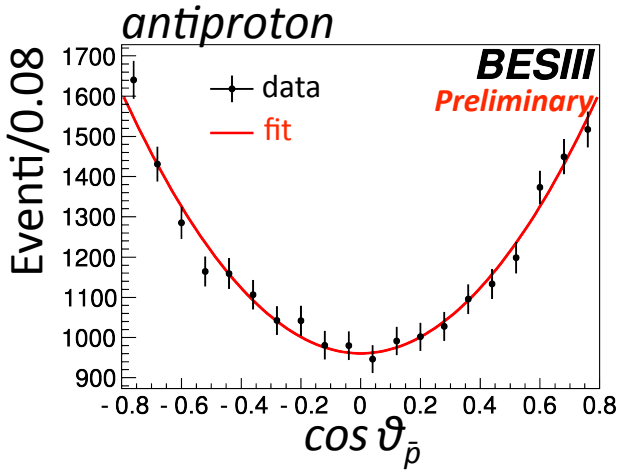
Work in progress at LNF/IHEP: $\psi' \to p\bar{p}$, $n\bar{n}$

- 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: $BR(\psi' \to p\bar{p}) = (2.76 \pm 0.12)\times10^{-4}$
- $\psi' \to n\bar{n}$ decay never observed

Proton and antiproton angular distribution



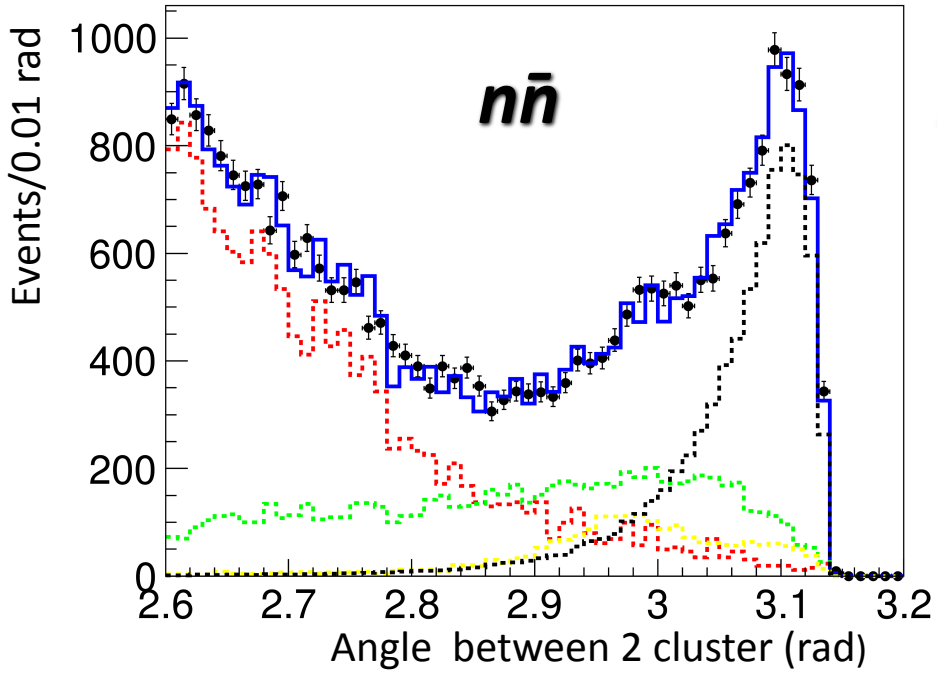


BESIII Preliminary

$BR(\psi' \to p\bar{p}) = (3.09 \pm 0.02 \pm 0.11)\times10^{-4}$

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

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



Bck contributions

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

Very Preliminary (stat. err. only):

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

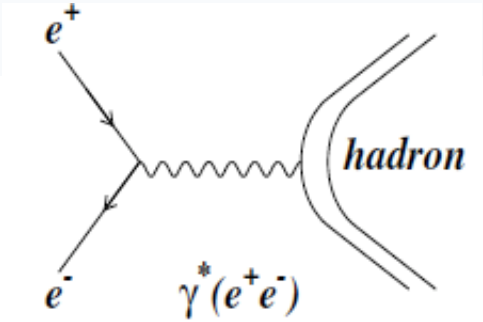
$$\frac{BR(J/\psi' \to p\bar{p})}{BR(J/\psi' \to n\bar{n})} \simeq 0.95 \pm 0.11$$

first measurement !

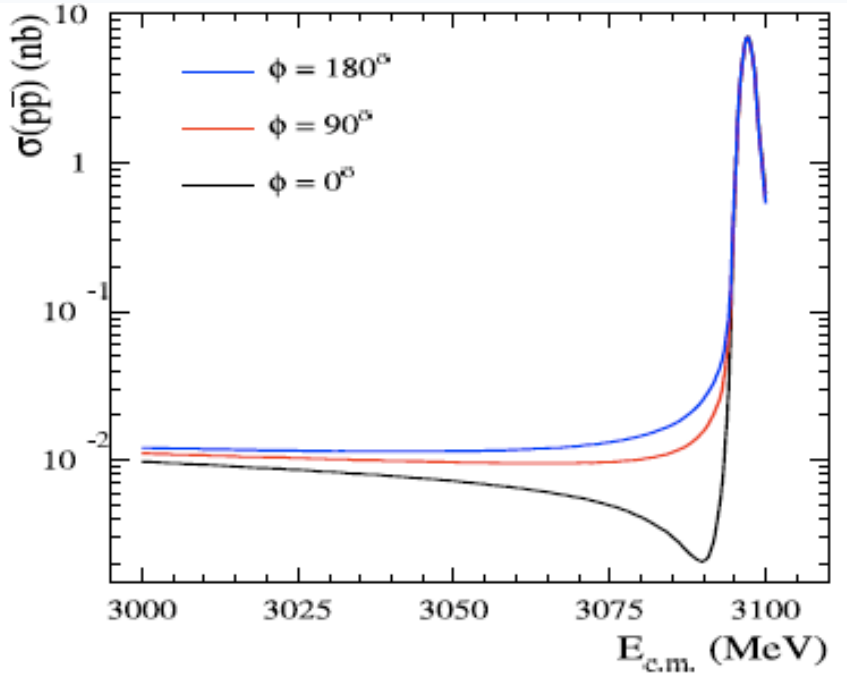
again a large phase between strong and e.m.amplitudes!

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

- So far experimentally: $\Phi_p \sim 90°$ → No interference, Im strong amplitude 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)

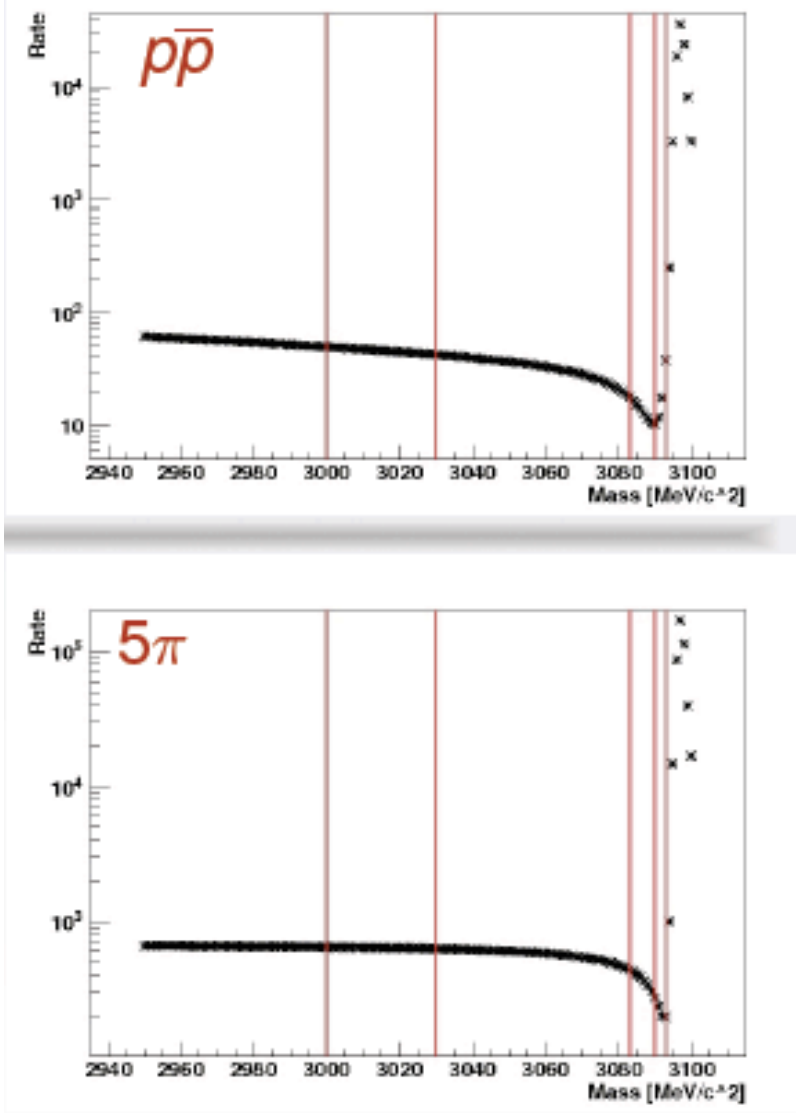


2012 data for J/ψ phase scan

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

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

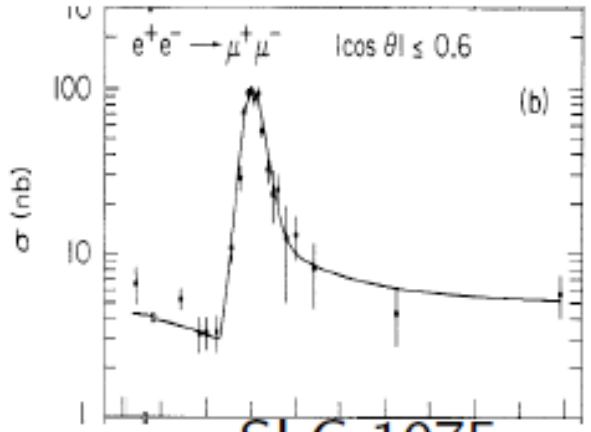
Energy requested [MeV]	Energy collected [MeV]	L_{int} [pb^{-1}]
3050	3046	14.0
3060	3056	14.0
3083	3086	16.5
3090	3085	14.0
3093	3088	14.0
3097	3097	79.6



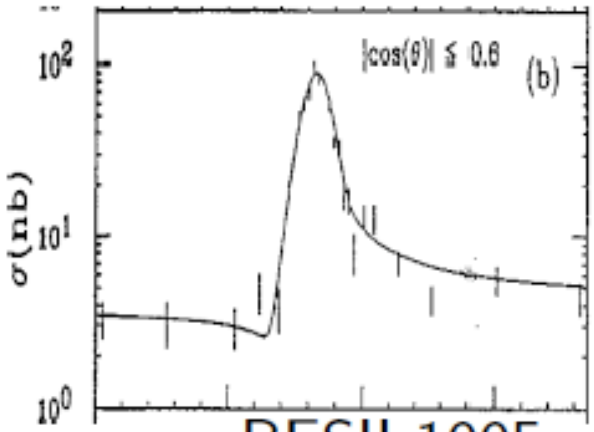
Proposed by the Italian group in 2010,
accepted by the BESIII collaboration,
data taken in may 2012,
analysis in progress at LNF and Turin

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

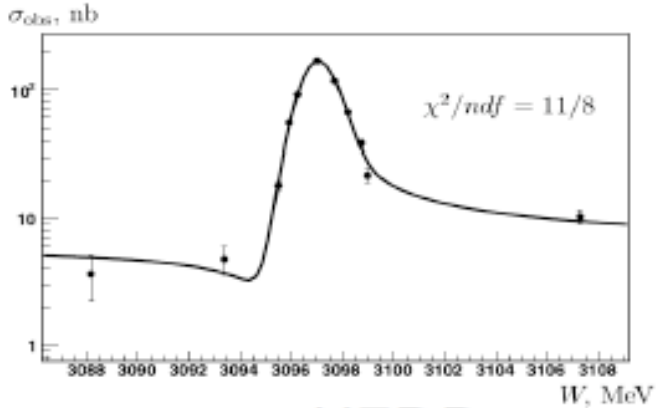
Interference pattern between *J/ψ* decay and the non-resonant decay amplitudes first observed at SLAC [PRL 33,1406] in 1975. Confirmed by BESII and KEDR



SLC 1975



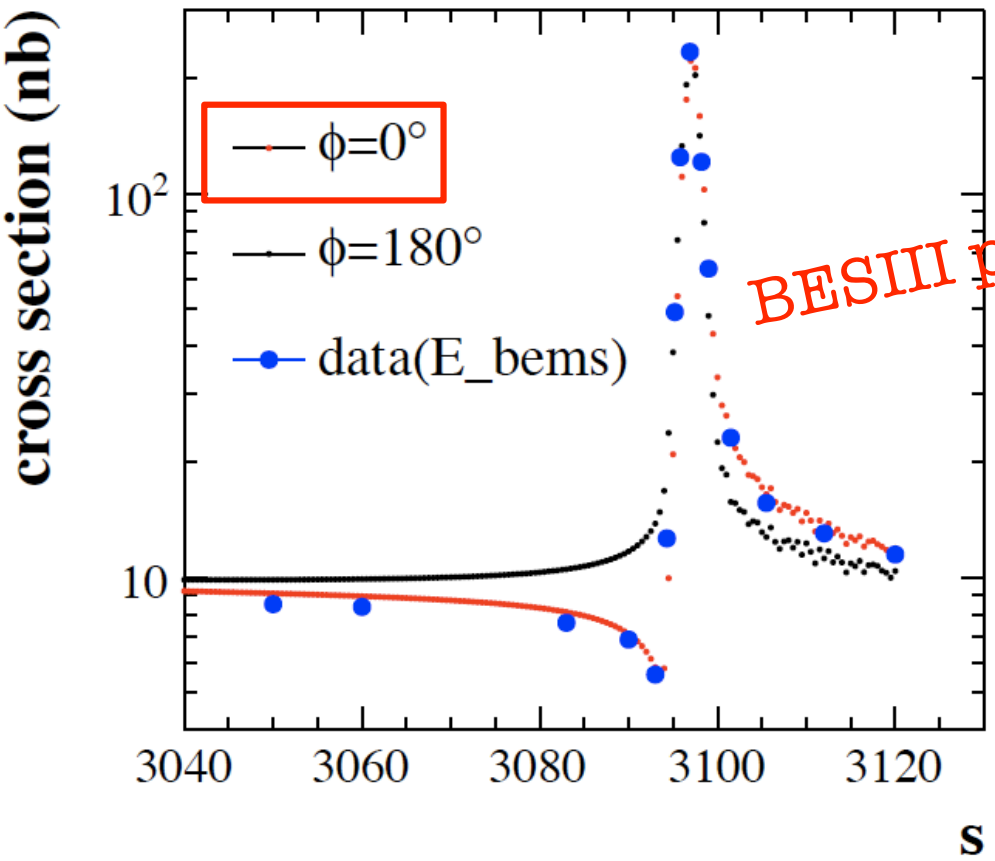
BESII 1995



KEDR

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

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

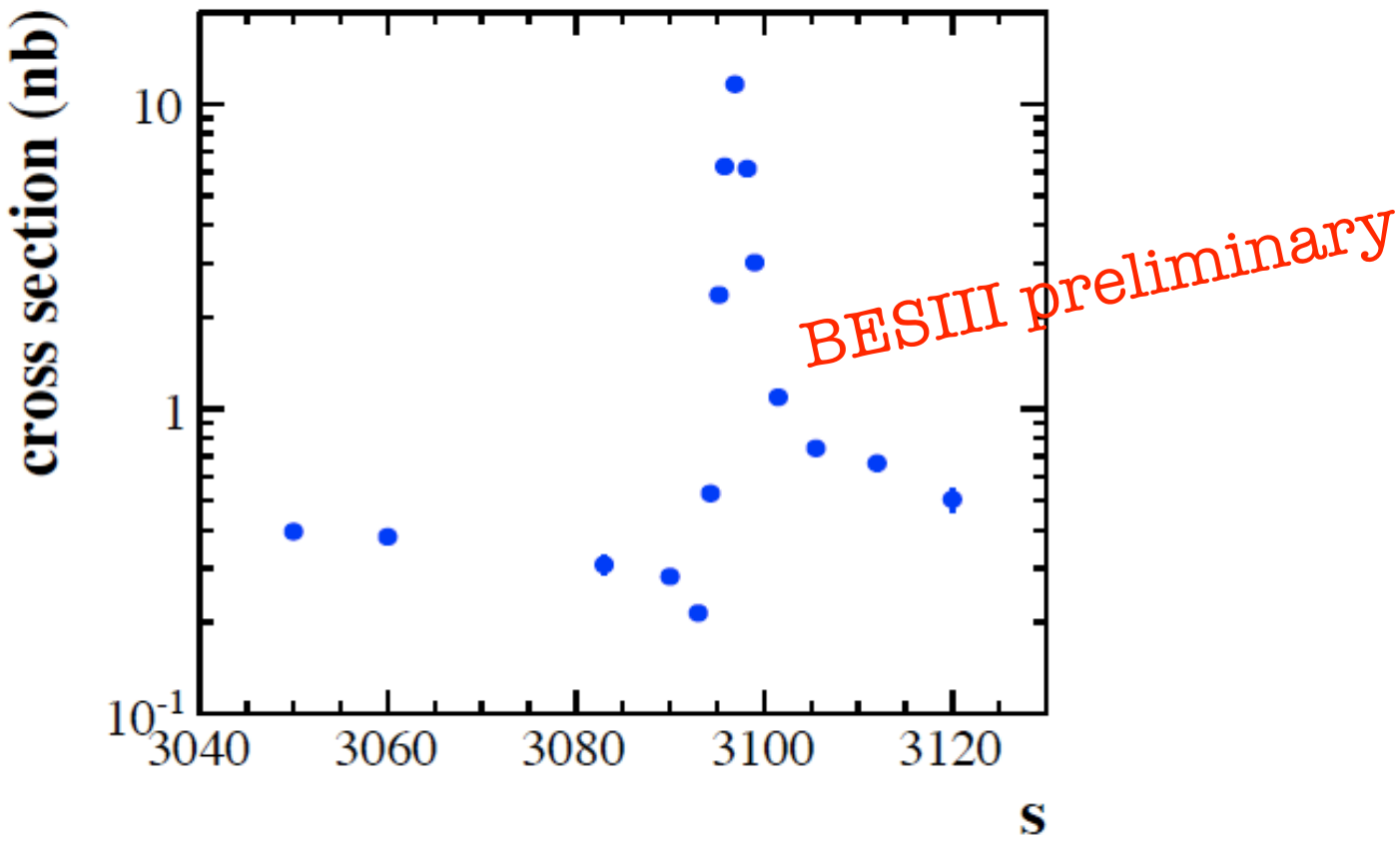


BESIII preliminary

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

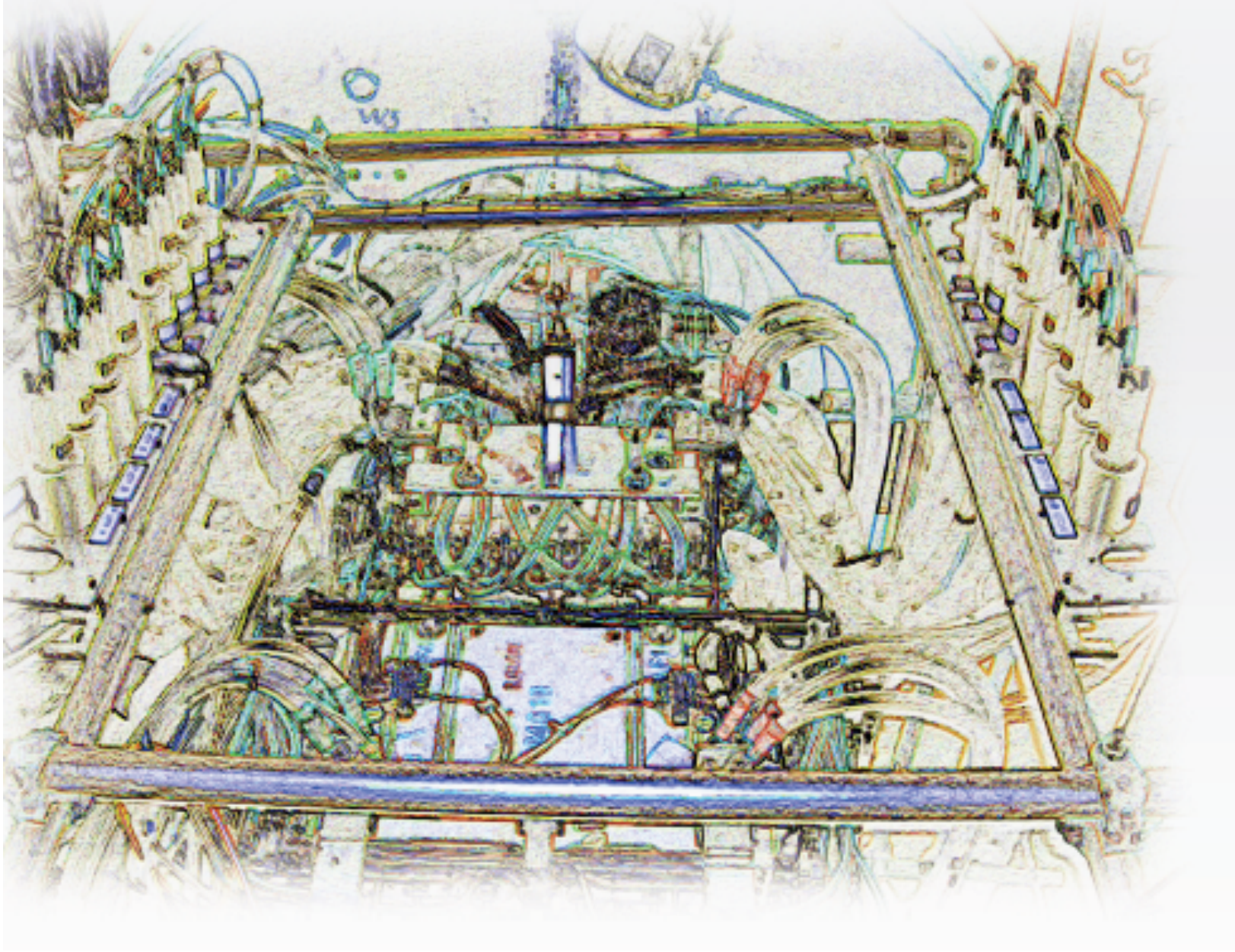
Preliminary BESIII results: $e^+e^- \to J/\psi \to \pi^+\pi^-\pi^+\pi^-$

- 2012 data set for J/psi lineshape

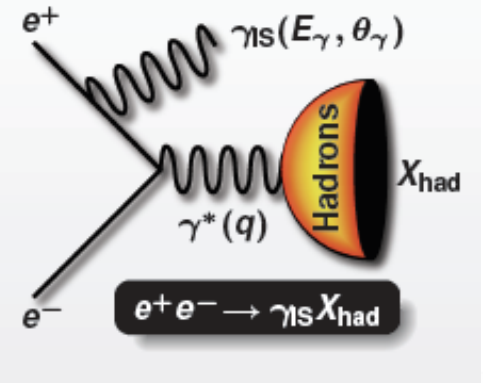


preliminary result consistent with ϕ=0°
as expected, as for $\mu^+\mu^-$

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

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

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

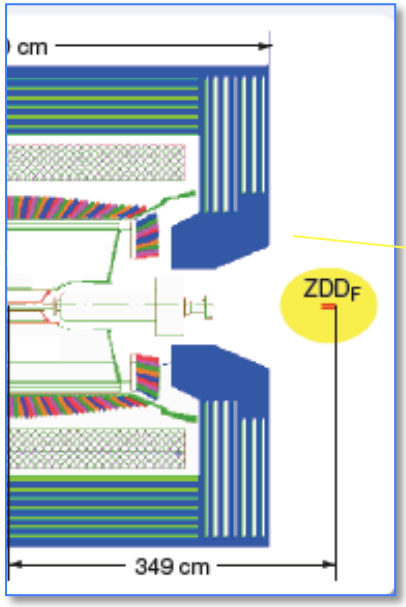
The ISR technique provides a unique tool to access threshold regions working at higher resonances:

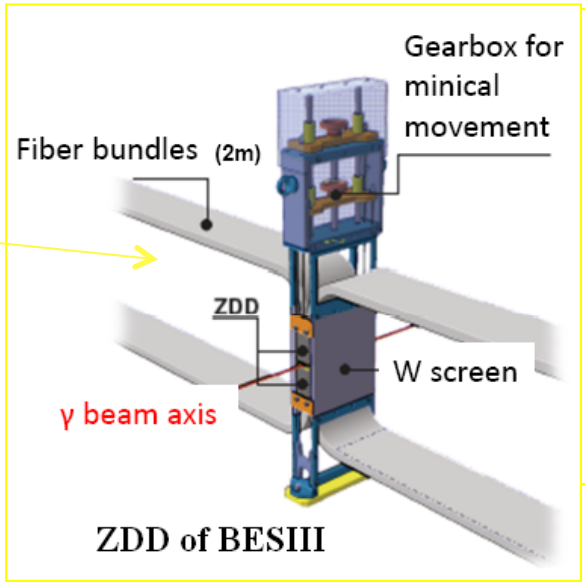
- all energies (q^2) at the same time → better control on systematics
- detect ISR photon → full X_{had} angular coverage

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

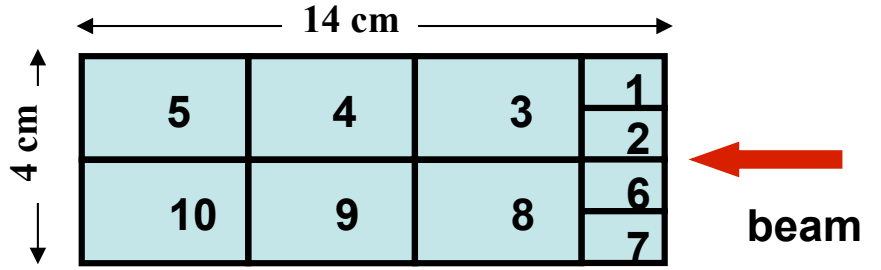




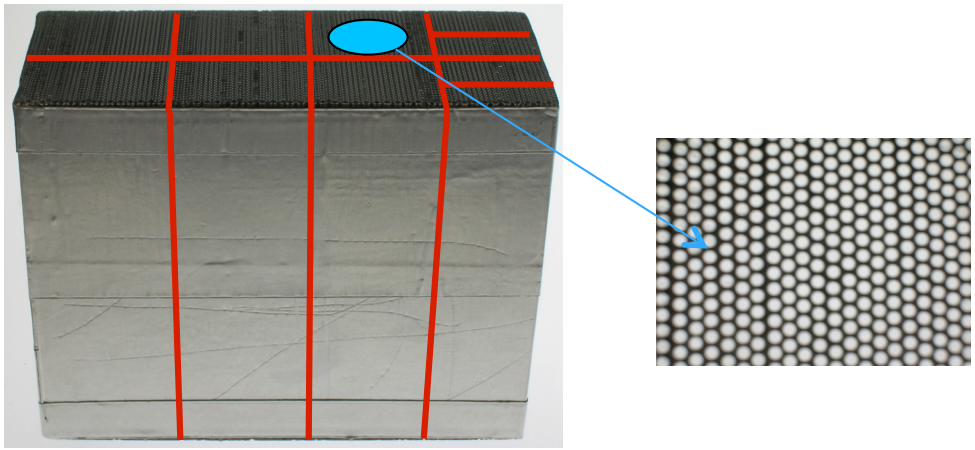
Pb/Sci.Fi Array a` la KLOE scintillating material 60% of total (in volume)

two modules (up and down the beam) dimensions:14×4×6cm^3

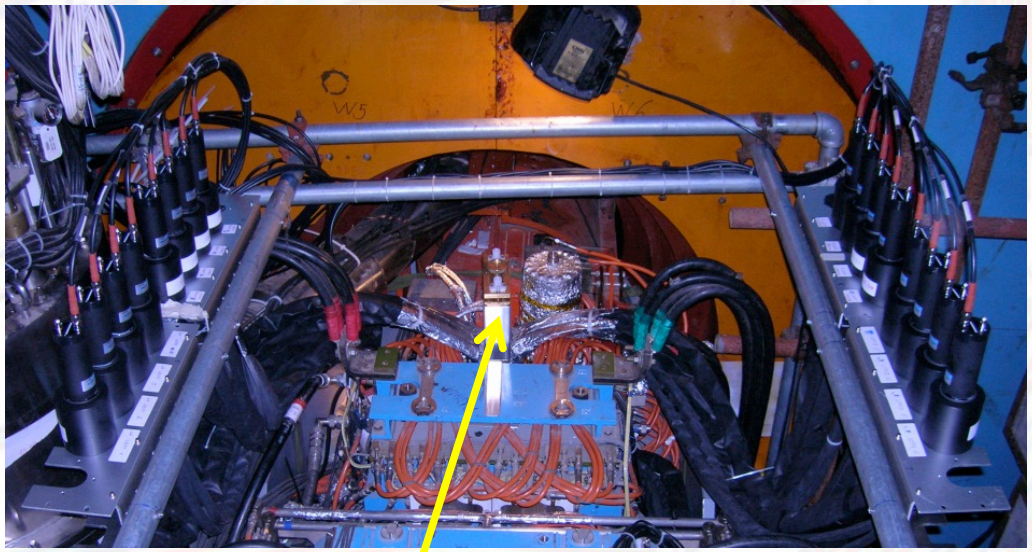
signal extracted and channeled to PM through bundles of clear optical fibers (2m long)

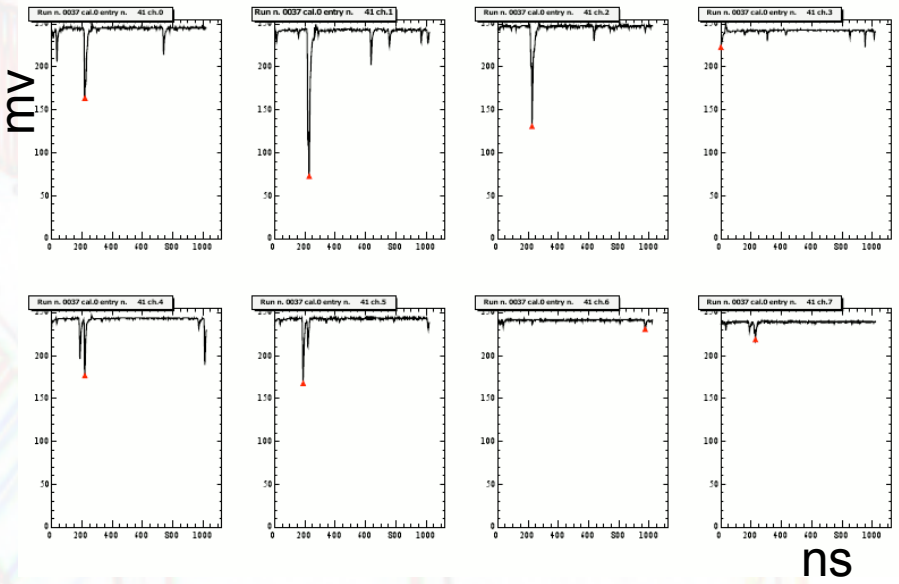


Each sector is sent to a PM, sectors 1&2 (6&7) are sent to the same PM (for now)



ZDD timeline

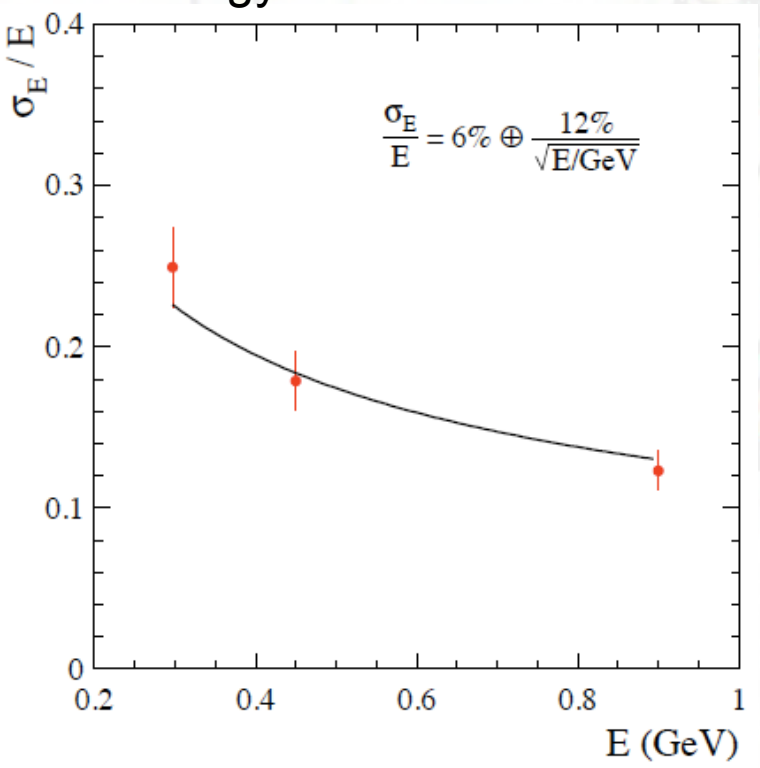




- 01/2011-06/2011: construction and assembling of the first ZDD station at LNF
- 06/2011-08/2011: tests with cosmic rays and BTF @ LNF: σ_E/E=12.4% @E=450MeV
- agosto 2011:shipping to Beijing and installation at BEPCII east side
- 2012: debugging with cosmics and on-line data @ BEPCII
  - worked as luminometer
  - data taken on stand-alone PC with L1 BESIII trigger
  - now is beeing inserted BESIII general DAQ system
- 2013: upgrade with scintillating strips for a better bck suppression

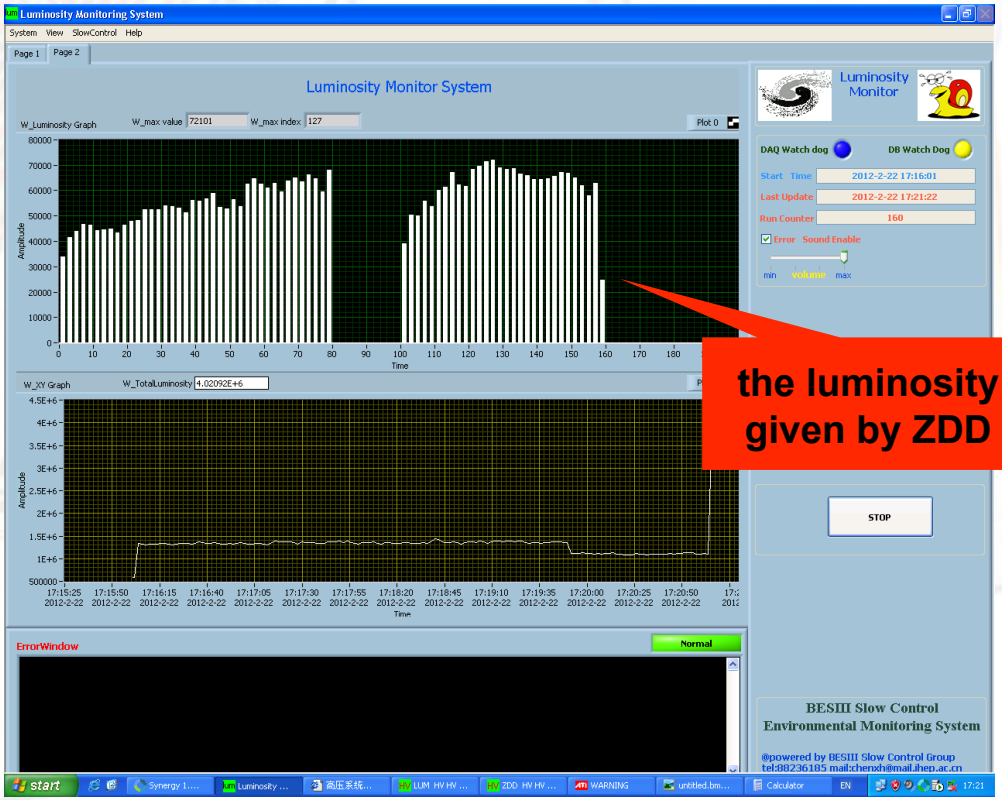
ZDD performances

energy resolution



zallo: 5.2%+6.8%/sqrt(E)?

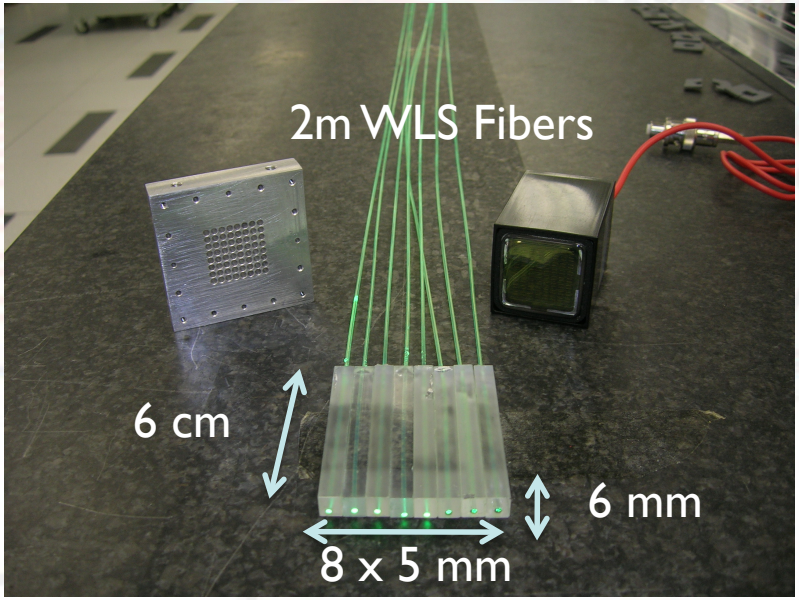
ZDD as a luminometer



ZDD upgrade at LNF

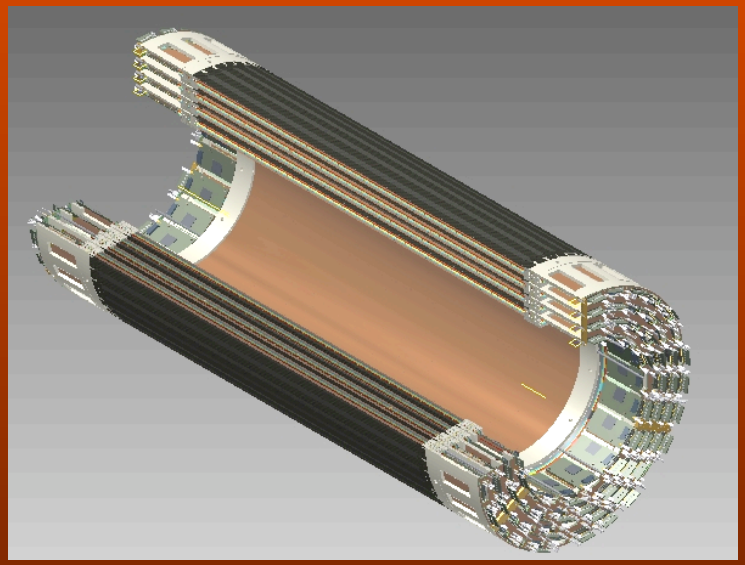
Upgrade of ZDD with thin layer of scintillator strips, signal brought out by fibers, 2m long

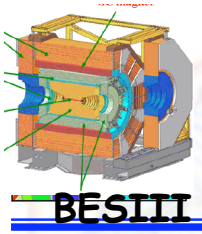
- Read out by MAPMT, FEE electronic worked out at LNF SEA
- To be put in front of ZDD to discriminate photons vs e^{+-} from beam-pipe conversion
- Activity co-financed by DTZ and other groups (LHCb, SuperB, Gr2) interested in this kind of tracking detector
- detector ready to be installed (2013), work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



CGEM PROPOSAL

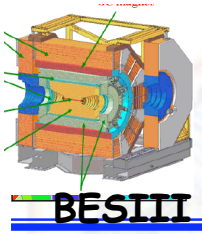
by the BESIII Italian Collaboration





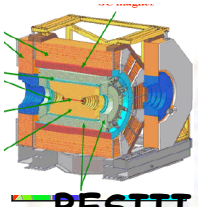
Inner Drift Chamber Upgrade

- MDC inner layers at BESIII are facing aging problems
- construct a new inner drift chamber (spare) from 2013
- The manifacture of a Cylindrical GEM, which fulfills many BESIII needs, is on going at LNF and will be installed in KLOE-2 by the end of this year
- Investigation of CGEM technology, based on KLOE2 expertise (thanks to G.Bencivenni) :
  - LNF and IHEP have asked MAEs financial support for an analog readout CGEM prototype: 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 ~ 1.5-2 year, including analog readout R&D



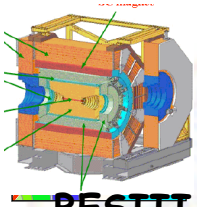
GEM detector features

- **flexible geometry** → arbitrary shape: rectangular, cylindrical …
- **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)



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
- CGEM upgrade proposal
- Many interesting physics analysis going on



spares

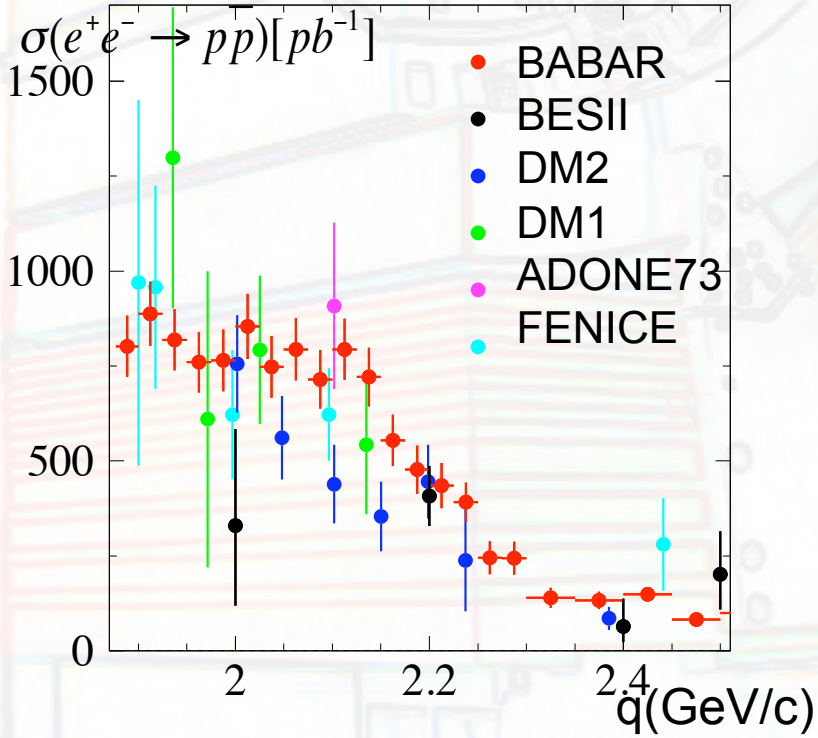
$e^+e^- \to p\bar{p}$

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:

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

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

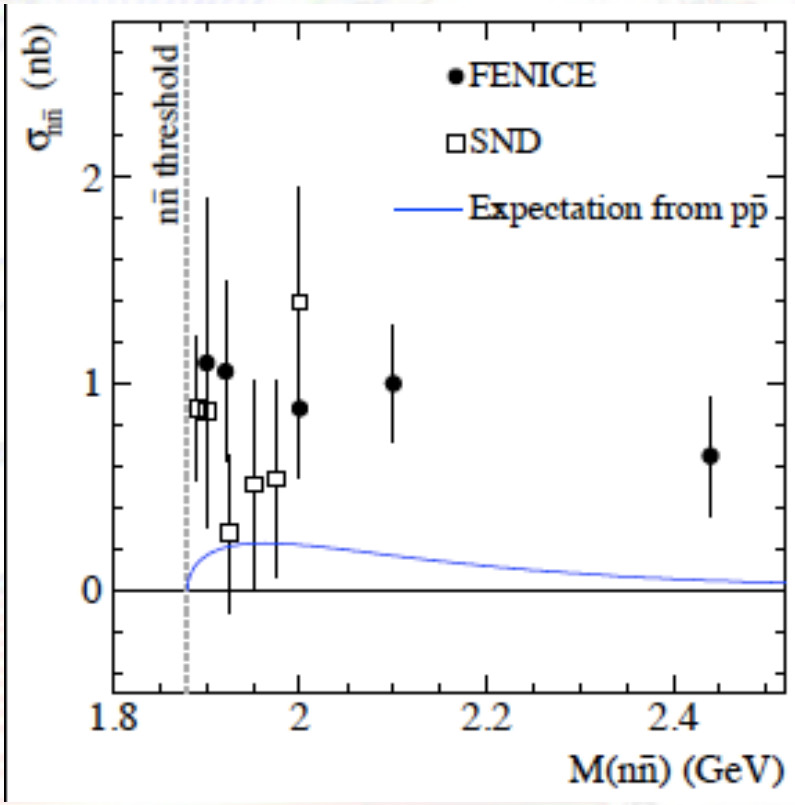
$\Downarrow$

$|G_p(4M^2_p)|=1$ 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)



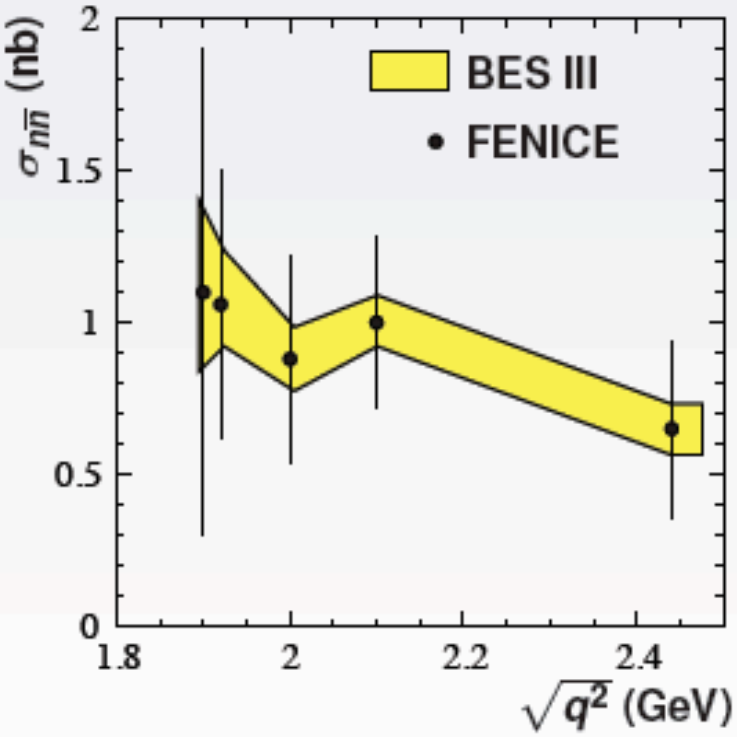
measured by FENICE, recently confirmed by SND

- **$\sigma(n\bar{n}) > \sigma(p\bar{p})$?**
- **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**

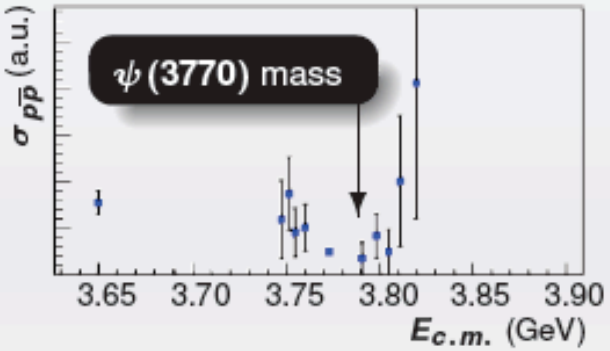
Expectations for $n\bar{n}$ $p\bar{p}$ at BESIII

- 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: $N_{n\bar{n}} \simeq 1000$ $N_{p\bar{p}} \simeq 2000$



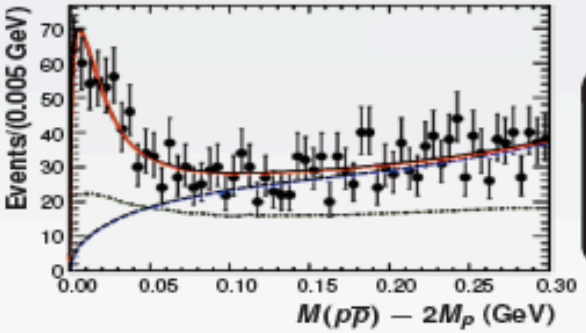
Other baryonic processes under investigation

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



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

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



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

- $e^+e^- \to \Sigma^+\Sigma^-$

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

Status of MDC(I)

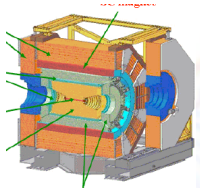
- Malter effects
  - In 24 Jan., we found the dark current in layer 4-8 becomes large abnormally
  - After lots of test and trial, we determined it caused by Malter effects, a aging problem of field wire
  - To separate the malter region, the HV of inner chamber are divided into several regions. But failed soon, since the malter region expanded too fast
  - To prevent the spread of Malter region, 5% CO2 gas was add to MDC. At same time, we're preparing the device for water vapor
  - CO2 failed once in large dark current, it took too long training time and the beam current is also limited
  - By the hard works of MDC and gas people, water vapor was added into MDC gas in April 1. The Malter effect has been cured successfully

Status of MDC(II)

- Noise: a headache problems since 2008, BESIII start running time
- Noise in outer chamber (long tracks): serious in region IV, close to east side of BESIII, lots improvement shielding and grounding. It controlled in 2010
- Noise in stepped chamber (short tracks): need ramp up/down AS, some improvement in 2011 by connect east BES door and low temperature pipe. In 2011 summer, the west BES door was connected to low temperature pipe. This type of noise disappeared by improving the grounding
- Noise in Inner chamber(inner tracks), it related to the electron beam. East endcap TOF had the same problem.
  - Monitor the number of inner tracks. If serious, ask machine people to knock out beam, reinject
  - In May 10, machine people decide to shield DCCT(which measure the beam current). Noise in inner chamber and east endcap TOF totally disappeared. This story happened in 1998

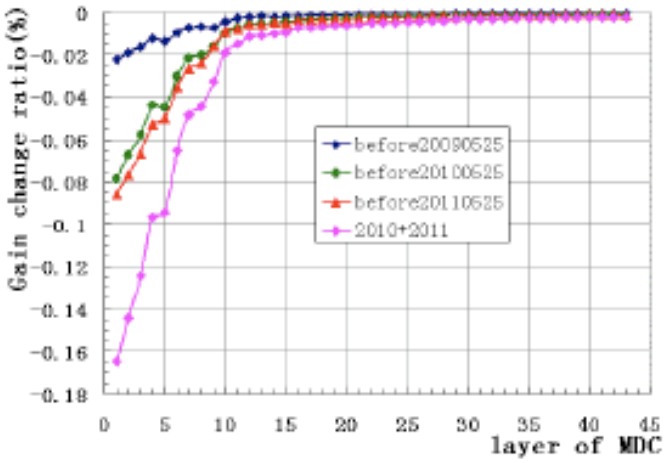
Status of MDC(III)

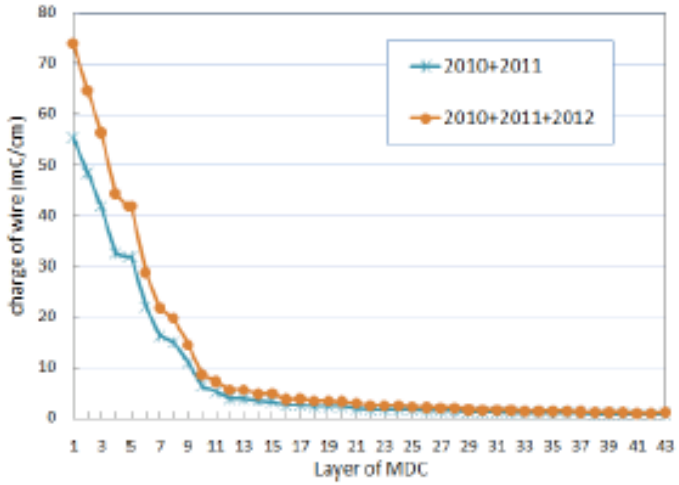
- Backgrounds: beam associated backgrounds become worse, compared with that in 2011.
- Noise and backgrounds to tracking software
  - Track quality will be worse if noise and backgrounds are serious
  - ~1%/track improvement should be expected
  - High luminosity → high beam current → more backgrounds, especially in small storage ring. it'll cause lots of troubles to tracking software. People should not expect too more to software
  - We believe that there is no big problem in BESIII tracking software. Any report on terrible difference (to CLEO), e.g., >30%, should be carefully reviewed in physics group.
  - We'd like to ask for to take several tens pb-1 psi(3770) data this year if possible, and welcome people to check the analysis efficiencies again.

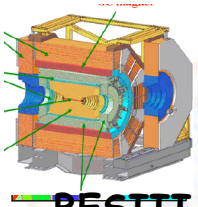


Aging effects of Inner MDC layers

- **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







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:** $93\%\ 4\pi$
- **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**

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

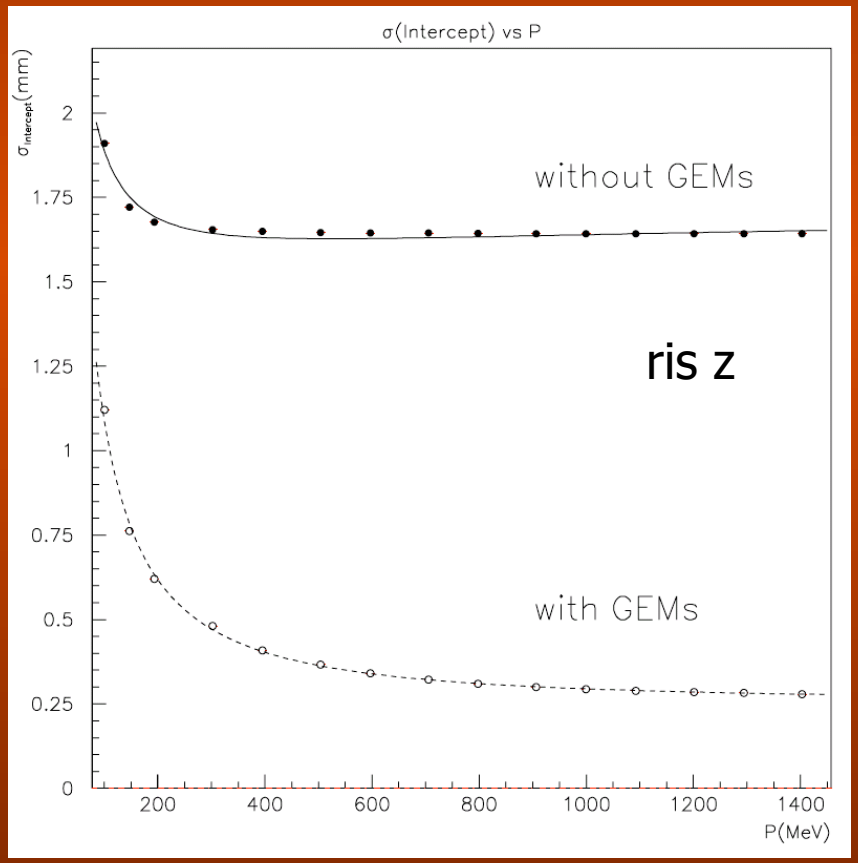
- The manifacture of a Cylindrical GEM, which fulfills many BESIII needs, is on going at LNF and will be installed in KLOE-2 by the end of this year

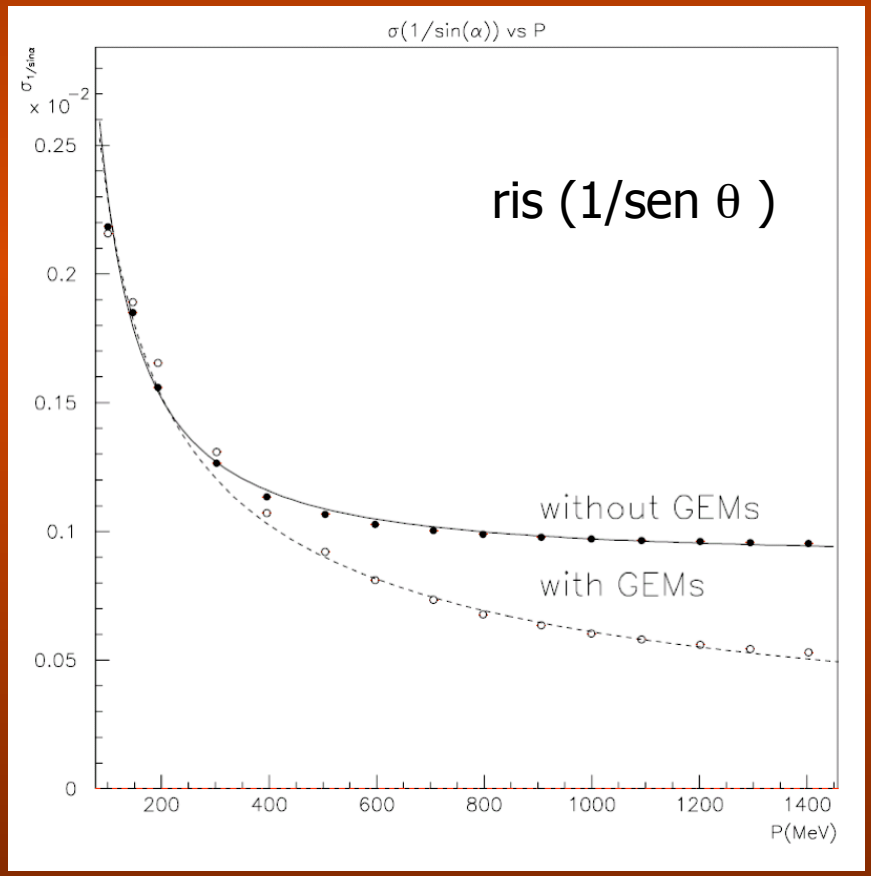
- BESIII inner chamber is a bit smaller
  - makes a Cylindrical GEM easier to be built,
  - enough space to allocate 4 triple-GEM,
  - equivalent to the present 8 layers of MDC,
  - much better vertex reconstruction
  - however, new construction tools are needed
  - more material (0.45 -> 1.5 % X_0):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

Resolutions Toy MC

Assuming:

- KLOE2 pitch (650 μm)
- Analog readout (extrapolated from COMPASS results)
  - σ_x ~ 130 μm
  - σ_z ~ 250- 300 μm





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 ~ 40⁰ (like KLOE2)

KLOE - IT dimensions

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

- KLOE2 CGEM cost, including tests and R&D ~ 7500 KRMB

  BESIII ~ 3000 KRMB
  - Construction Toolings (II) and others available
  - Molds ~ 600 K RMB (x 1/4 ?)
  - GEM ~ 900 KRMB
  - Readout ~ 1500 KRMB (Italy?)
- KLOE2 CGEM construction and R&D ~ 3 years

  BESIII ~ 1.5-2 year, including readout analog R&D
- INFN and IHEP have asked MAEs financial support for an analog readout CGEM prototype
- CGEM miniWorkshop October 25-26 in Frascati

  (LNF, Bari, BESIII, CMD2 , Rui De Oliveira)

Conclusions

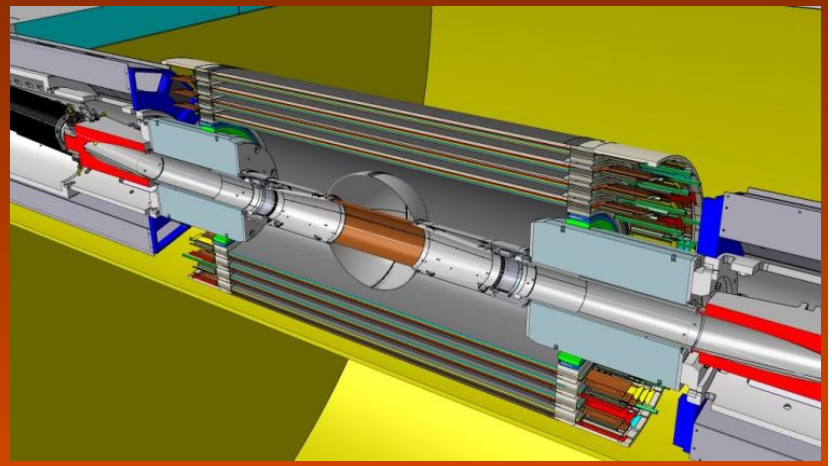
- CGEM could be a solution for a new Inner Tracker
- A relevant gain is achieved in the longitudinal view
- Transverse momentum resolution worsening should be at most 10 %
- Cost and time schedule rough estimation
- A dedicated workshop in October at LNF
- A prototype with analog readout is foreseen

In caso la proposta CGEM in BESIII fosse accettata dalla collaborazione, nel 2013 vorremmo costruire a LNF un piccolo prototipo planare (10x10cm^2) per R&D con lettura analogica

KLOE-2 Inner Tracker

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

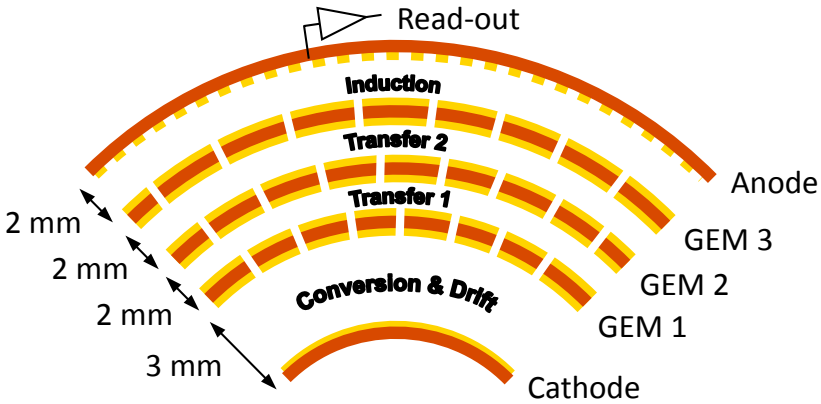
1. **$\sigma_{r\varphi} \sim 200$ μm and $\sigma_z \sim 350$μm**
2. **low material budget**: < 2% X_0



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

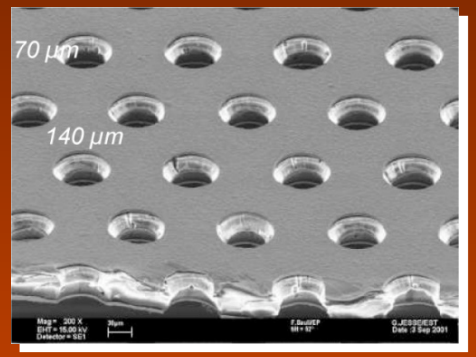
Cylindrical Triple GEM

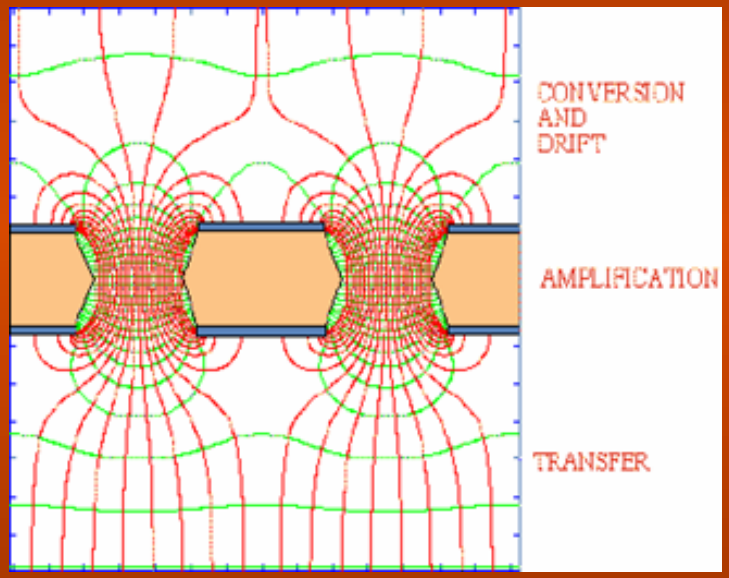


$K_S \rightarrow \pi^+ \pi^-$ vertex resolution **will improve of about a factor 3** from present **6mm**

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.

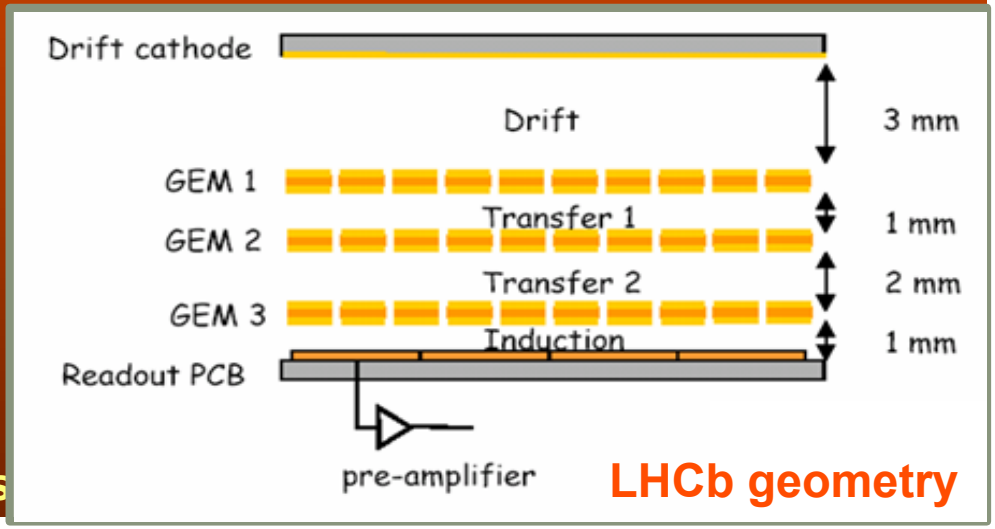




By applying 400-500 V between the two copper sides, an electric field as high as ~100 kV/cm is produced into the holes which act as multiplication channels for electrons produced in the gas by a ionizing particle.

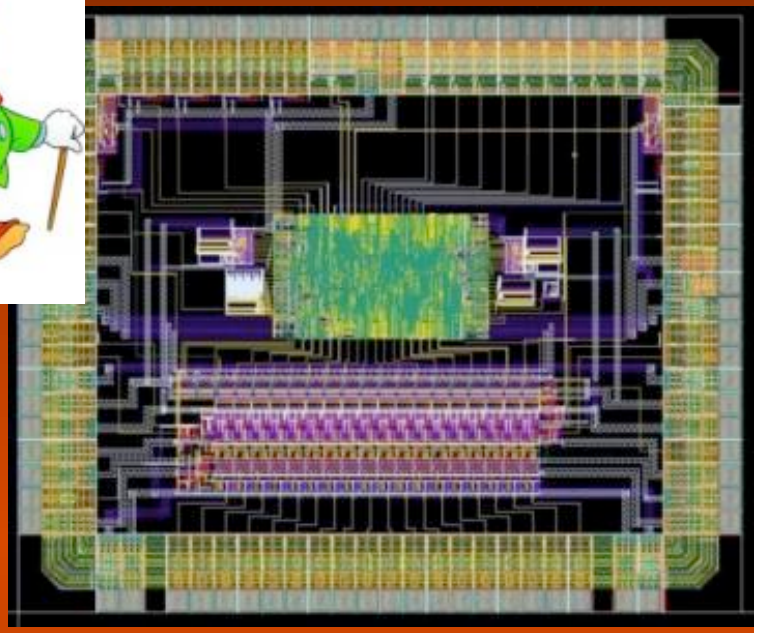
Gains up to 1000 can be easily reached with a single GEM foil. Higher gains (and/or safer working conditions) are usually obtained by cascading two or three GEM foils.

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



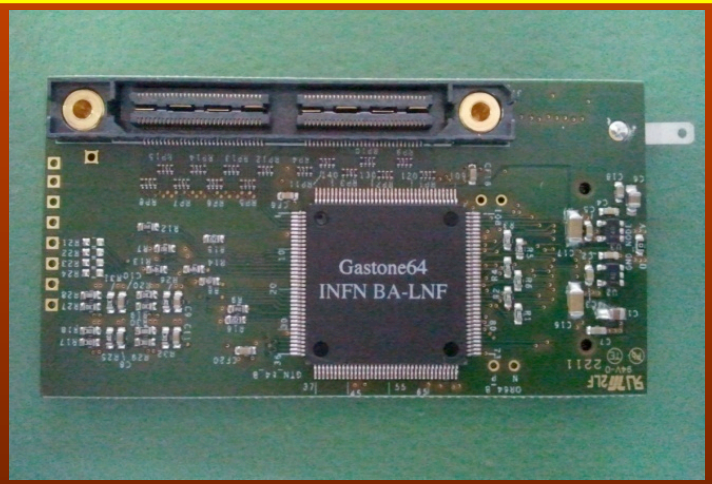
GASTONE: the IT dedicated FEE chip

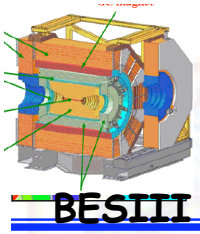
Sensitivity (pF)	20 mV/fC
Z_{IN}	400 Ω (low frequency)
C_{DET}	1 – 50 pF
Peaking time	90 – 200 ns (1-50 pF)
Noise (erms)	800 e^- + 40 e^-/pF
Channels/chip	64*
Readout	LVDS/Serial
Power consum.	≈ 0.6 mA/ch



- **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)

0.35 CMOS technology- no Rad-Hard





Preparazione ZDD per run 2012-2013

Perchè DAQ separato in 2011-2012?

- Mancanza di tempo:
  - ZDD installato agosto 2010, con ripartenza prevista a novembre
  - Test in cosmici settembre ottobre: hanno permesso di verificare l'hardware e di capire come usare il FlashADC: necessità di usare il controller CAEN ed il PC
  - Problemi di firmware su FADC CAEN V1721 risolti nei mesi successivi
- BESIII-DAQ disposto a integrare il V1721, ma solo dietro nostra ricetta "completa": disponibile ora, dopo "pratica" durante le collisioni

Lavori in corso per ZDD in DAQ globale

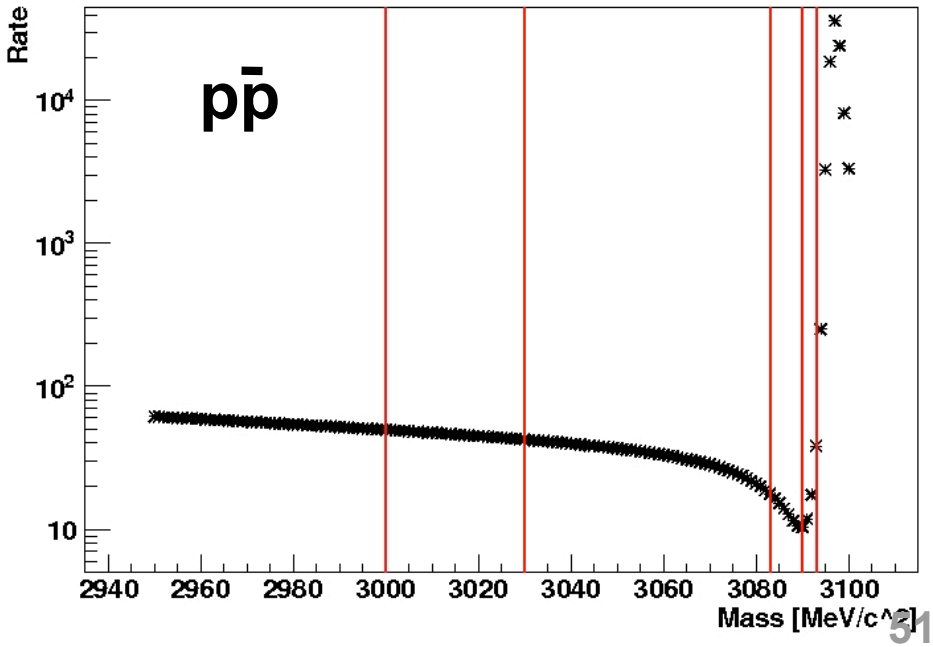
- moduli amplificazione/shaper per passaggio FEE NIM->VME
- Il gruppo DAQ di BESIII ha preso in carico l'inserimento dello ZDD in collaborazione con Sandro
  - Necessari 2 circuiti ausiliari di conversione dei segnali di trigger (CHK e FULL) da commissionare a SELF (URGENTE: richiesta aggiuntiva 2012)
  - interazione LNF e gruppo DAQ IHEP per far funzionare il tutto
- Due giovani cinesi per la manutenzione dello ZDD a IHEP !

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

- Exclusive scenario: could see interference effects

• e^+e^+ -> J/ψ -> pp, nn	NN	BR ~ 2.17×10^{-3}	σ_{cont}~ 11 pb, 5pb
• e^+e^- -> J/ψ -> ρπ	VP	BR ~ 1.69%	σ_{cont}~ 20 pb
• e^+e^- -> J/ψ -> $2(\pi^+\pi^-)\,\pi^0$		BR ~ 5.5%	σ_{cont}~ 500 pb

- max. interference simulation: 0°
  - 2 pts at low s:
    - fix the continuum
    - fix the slope
  - 2 pts at deep positions
  - 1 pt at resonance rise



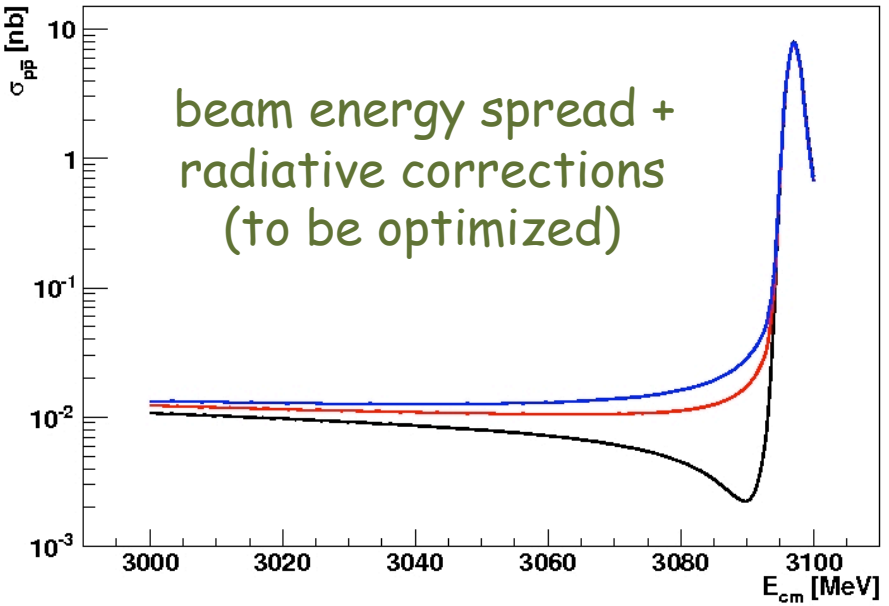
Simulated Yields for e^+e^--> $p\bar{p}$

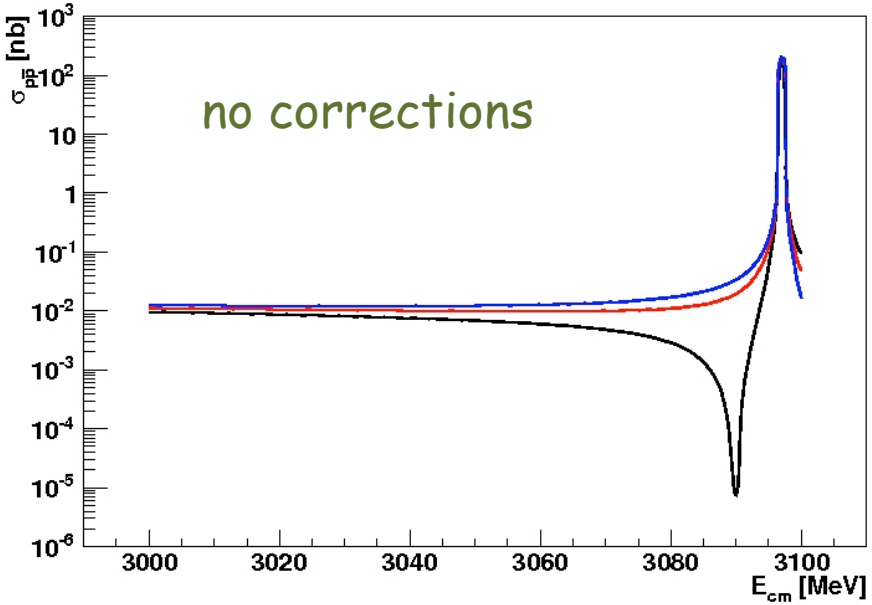
— $\Delta\varphi = 0°$

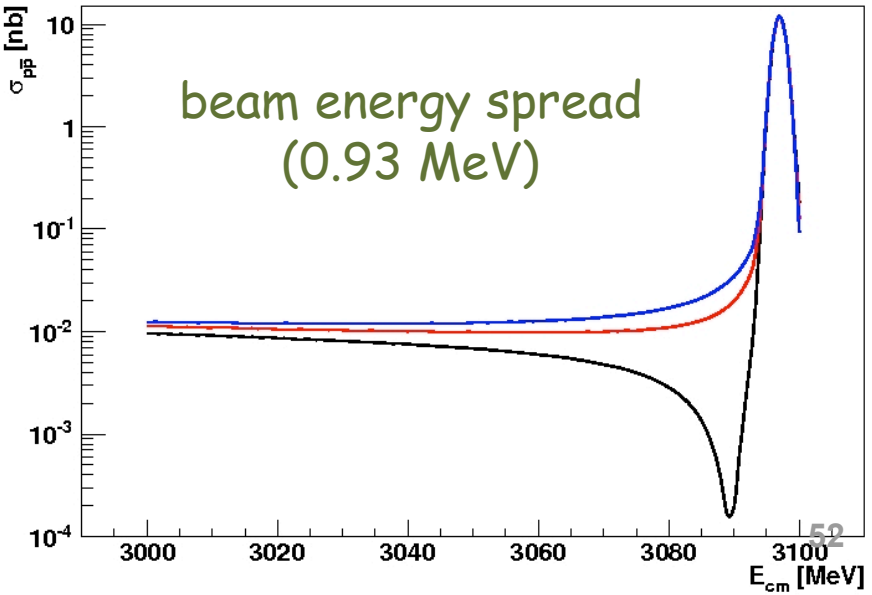
— $\Delta\varphi = 90°$

— $\Delta\varphi = 180°$

continuum reference
$\sigma \sim 11$ pb





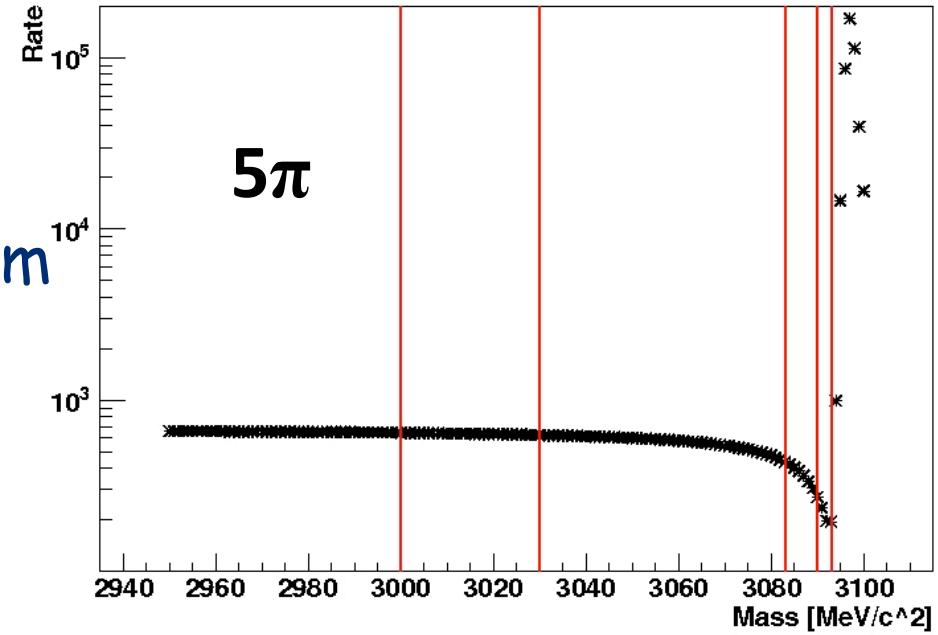


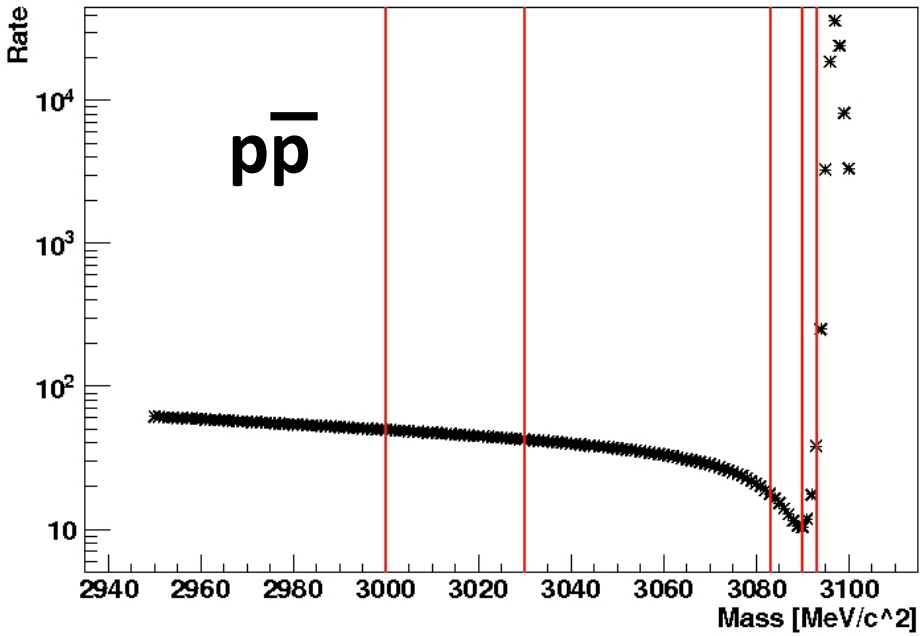
Scan energies selection

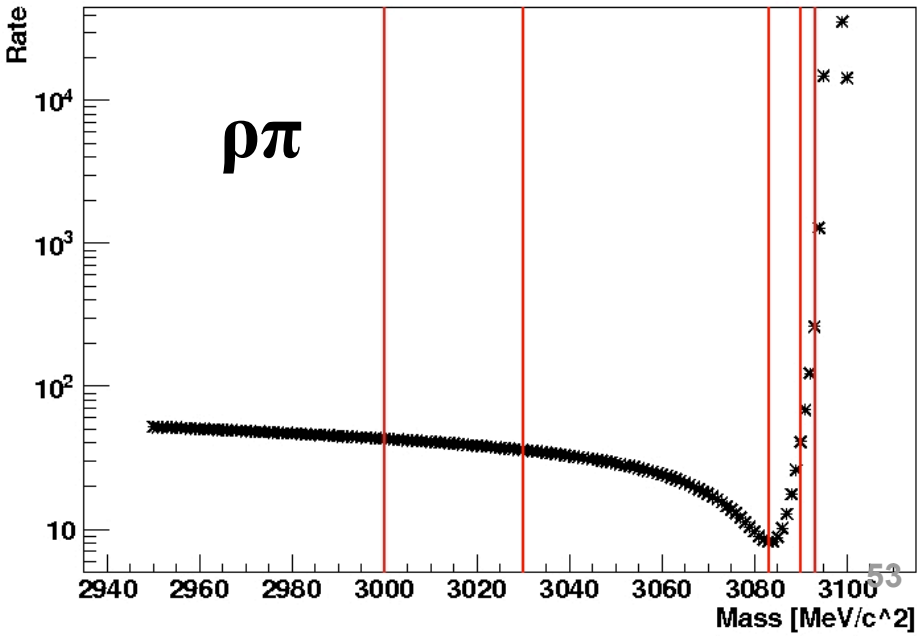
Depends on the process

Maximum interference: 0°

- 2 pts at low W
  - fix the continuum
  - fix the slope
- 2 pts at deep positions
- 1 pt Beginning of the BW







J/ψ phase scan

$p\bar{p}$

$\Delta\varphi = +90°$

3 parameters:

φ, σ_{cont} and B_{out}

σ_{cont} = 11 pb $B_{out} = 2.17\ 10^{-3}$

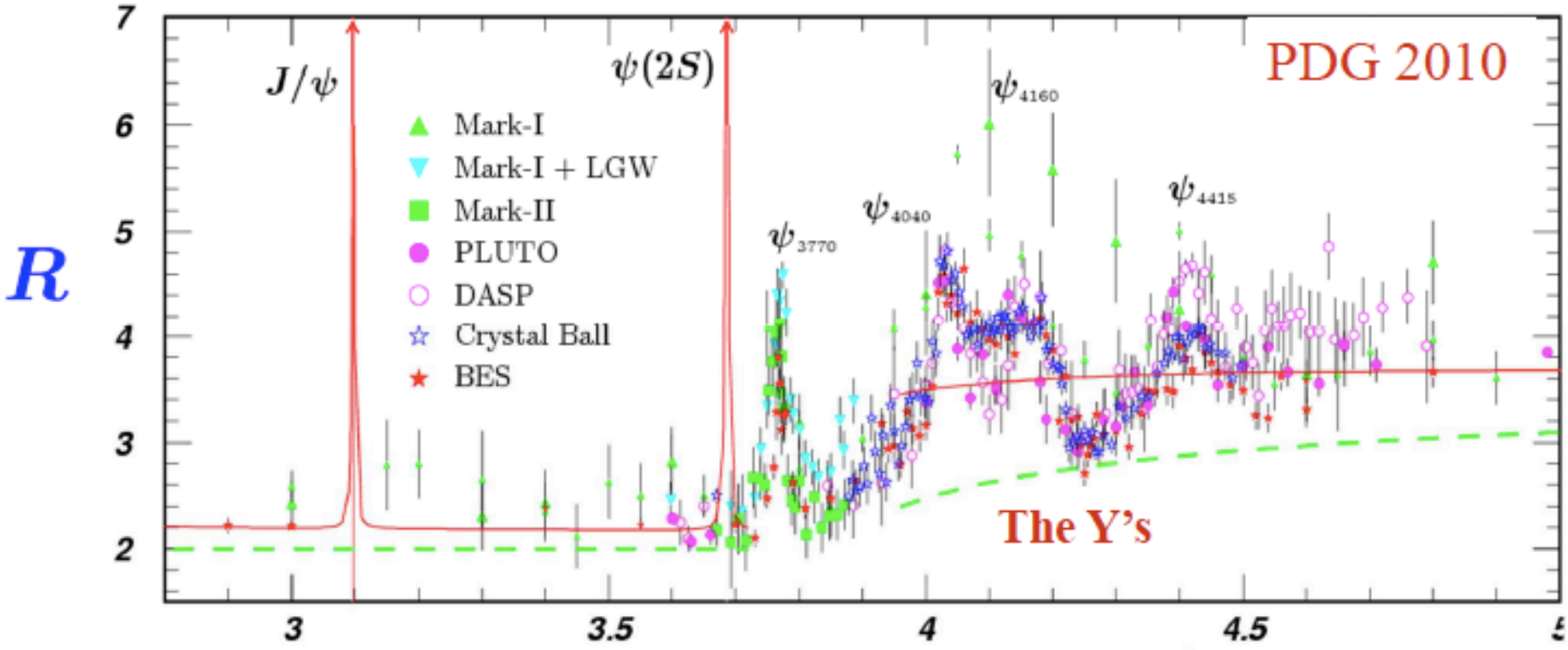
Points	Par	Inj. eff.	Δϕ [°]	Δσ [pb]	ΔB_{out}
5	3	0.7	29.3	1.3	$0.7\ 10^{-3}$
5	3	0.8	26.7	1.3	$0.7\ 10^{-3}$
6	3	0.8	6.1	0.9	$0.4\ 10^{-5}$
12	3	0.7	6.3	0.9	$0.7\ 10^{-4}$
12	3	0.8	5.9	0.9	$0.7\ 10^{-4}$

3 parameters: 3096.9 needed

(1 point more with high statistics)

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

Richieste alla CSN1
per la creazione di un sito di BESIII computing a Torino

- **WNs:**
  - CPU: **2000 HS06, costo standard GRID-INFN: 28 K€**

- **server/WNs:**
  - storage: **21TB netti, costo standard GRID-INFN: 7.5 K€**
  - server per SE: 2x8 cores xeon, FC: **4.5 K€**