FPCP 2014, Marseille, 25-30 May 2014

Recent QCD measurements at flavour experiments

Thomas Latham

(on behalf of BaBar experiment)

27th May 2014

Overview

- Presenting results from several experiments
- Light hadron production in ISR at BaBar & Belle and implications for muon g-2
- Light hadron spectroscopy at BES III & BaBar
- B^+ meson production at ATLAS
- Λ_b baryon production at LHCb

lonelyplanet.com

Hadron production in e^+e^- collisions and implications for muon g–2

Motivation

- Magnetic moment:

$$\vec{\mu} = g \frac{e\hbar}{2mc} \vec{S}$$

- Expect g = 2 for fermions but QFT implies some deviation
- Muon anomaly: $a_\mu = (g-2)_\mu/2$

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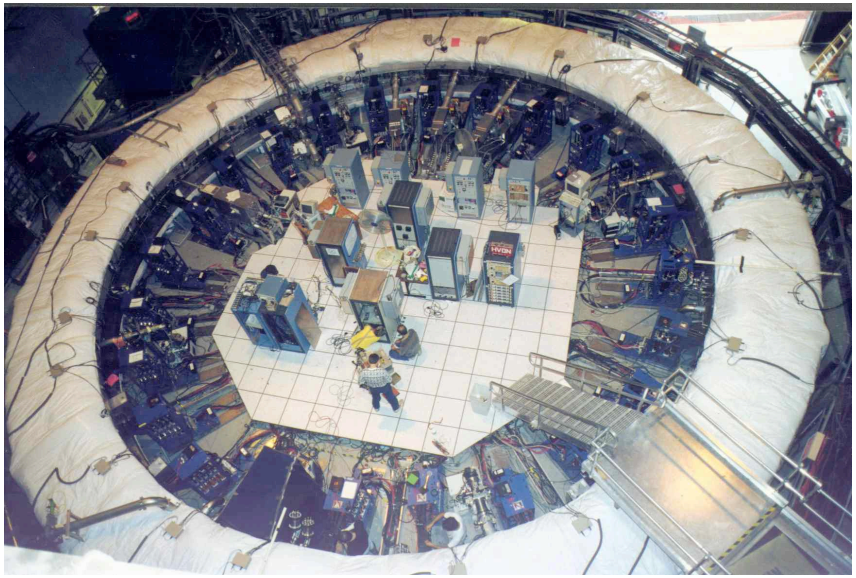

Source	Value	Uncertainty
Expt.	11 659 208.9	6.3

(units of 10^{-10})

- Measured by BNL E821 experiment
- PRD **73** 072003 (2006)

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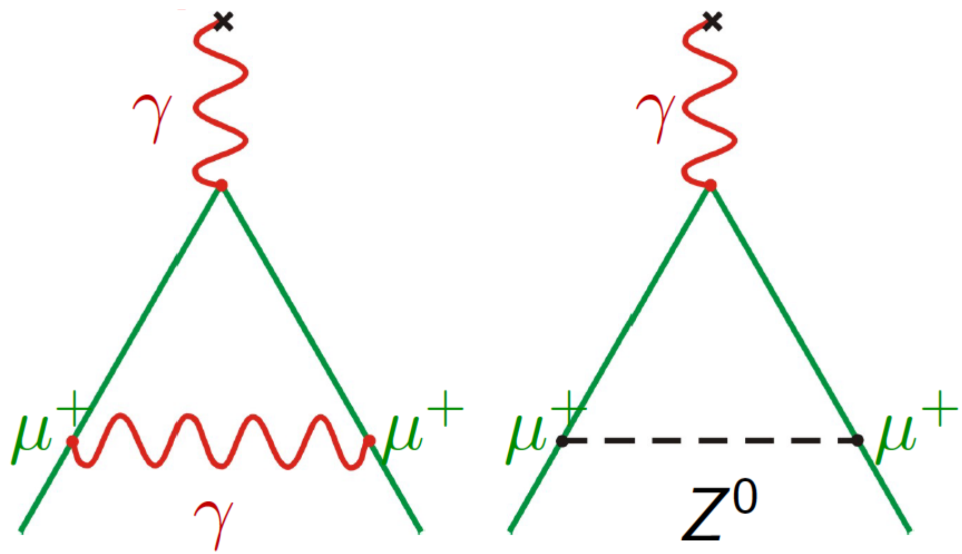
$$a_\mu^{\text{theory (SM)}} = \underline{a_\mu^{\text{QED}}} + \underline{a_\mu^{\text{weak}}} + a_\mu^{\text{had.}}$$



Source	Value	Uncertainty
Expt.	11 659 208.9	6.3
QED	11 658 471.895	0.008
Weak	15.4	0.2

(units of 10^{-10})

- PRL **109**, 111808 (2012)
- PRD **67**, 073006 (2003), Erratum-ibid. D**73**, 119901 (2006)
- JHEP 0211, 003 (2002)

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$$a_\mu^{\text{theory (SM)}} = a_\mu^{\text{QED}} + a_\mu^{\text{weak}} + a_\mu^{\text{had.}}$$

- Hadronic part
- Two main contributions:
  - Light-by-light (LBL)
  - Vacuum polarisation (VP)
- VP part dominates – will discuss this today

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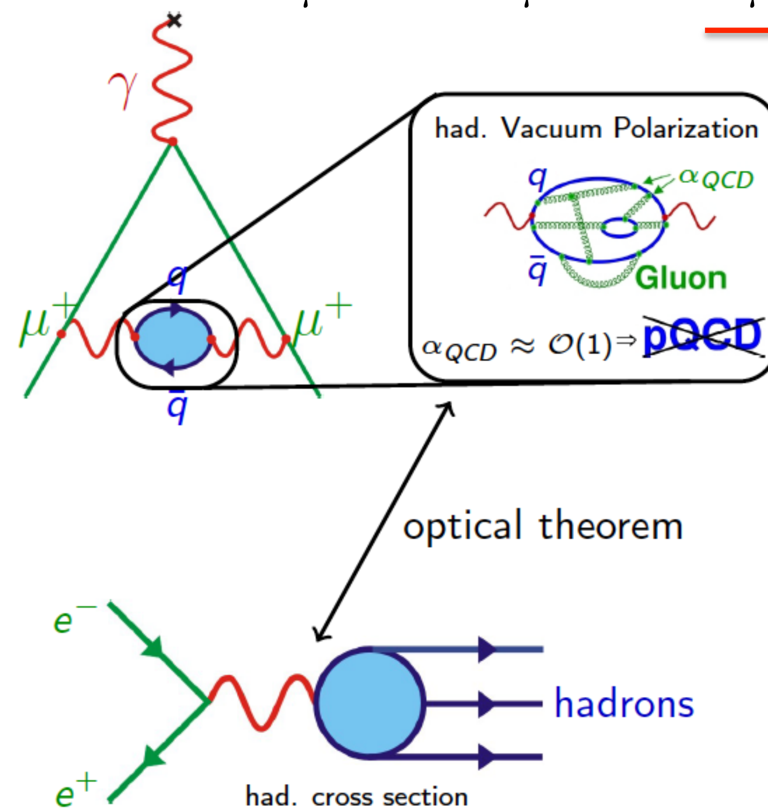

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Hadronic		

(units of 10^{-10})

- EPJ **C71** (2011) 1515, Erratum-ibid. **C72** (2012) 1874
- $a_\mu^{\text{VP, LO}} = 692.4 \pm 4.2$

Motivation

- Magnetic moment:

$$\vec{\mu} = g \frac{e\hbar}{2mc} \vec{S}$$

$$a_\mu^{\text{theory (SM)}} = a_\mu^{\text{QED}} + a_\mu^{\text{weak}} + a_\mu^{\text{had.}}$$

- Expect g = 2 for fermions but QFT implies some deviation
- Muon anomaly: $a_\mu = (g-2)_\mu/2$

$a_\mu^{exp} - a_\mu^{SM}$: 3.6σ difference

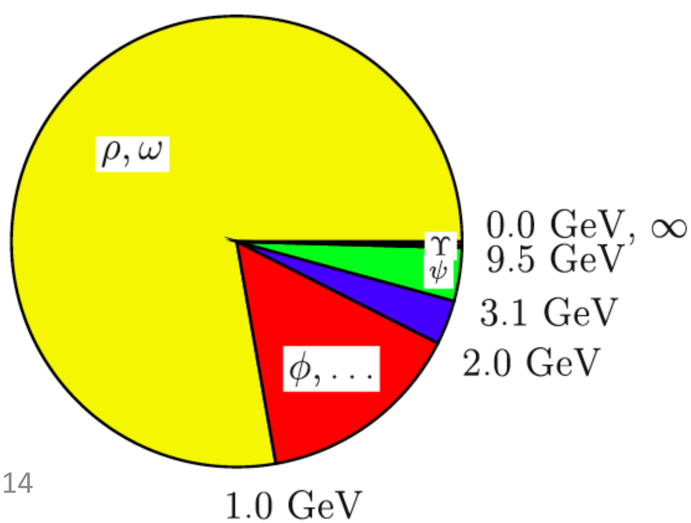
Source	Value	Uncertainty
Expt.	11 659 208.9	6.3
QED	11 658 471.895	0.008
Weak	15.4	0.2
Hadronic	693.0	4.9
BNL–SM	**28.7**	**8.0**

(units of 10^{-10})

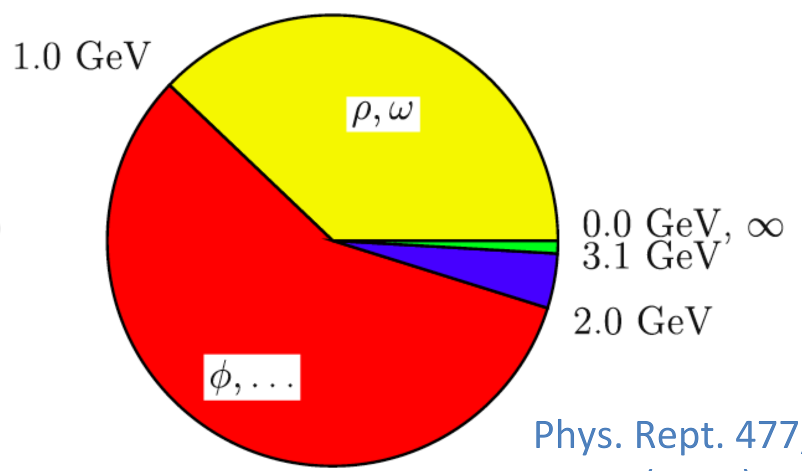
Motivation

- Dispersion relation: $$a_{\mu,\mathrm{LO}}^{\mathrm{had}} = \frac{1}{4\pi^3}\int_{m_{\pi^0}^2}^{\infty} ds\, K(s)\, \sigma_{\mathrm{had}}(s)$$
- $K(s) \sim 1/s$ & $\sigma(s) \sim 1/s$
- Integrand ~ $1/s^2$ ⇒ low energy v. important!
- $\pi^+\pi^-$, K^+K^-, $K_S K_L$, $2(\pi^+\pi^-)$, $\pi^+\pi^-\pi^0$, $\pi^+\pi^-\pi^0\pi^0$, etc. all crucial

Contribution to a_μ^{had}

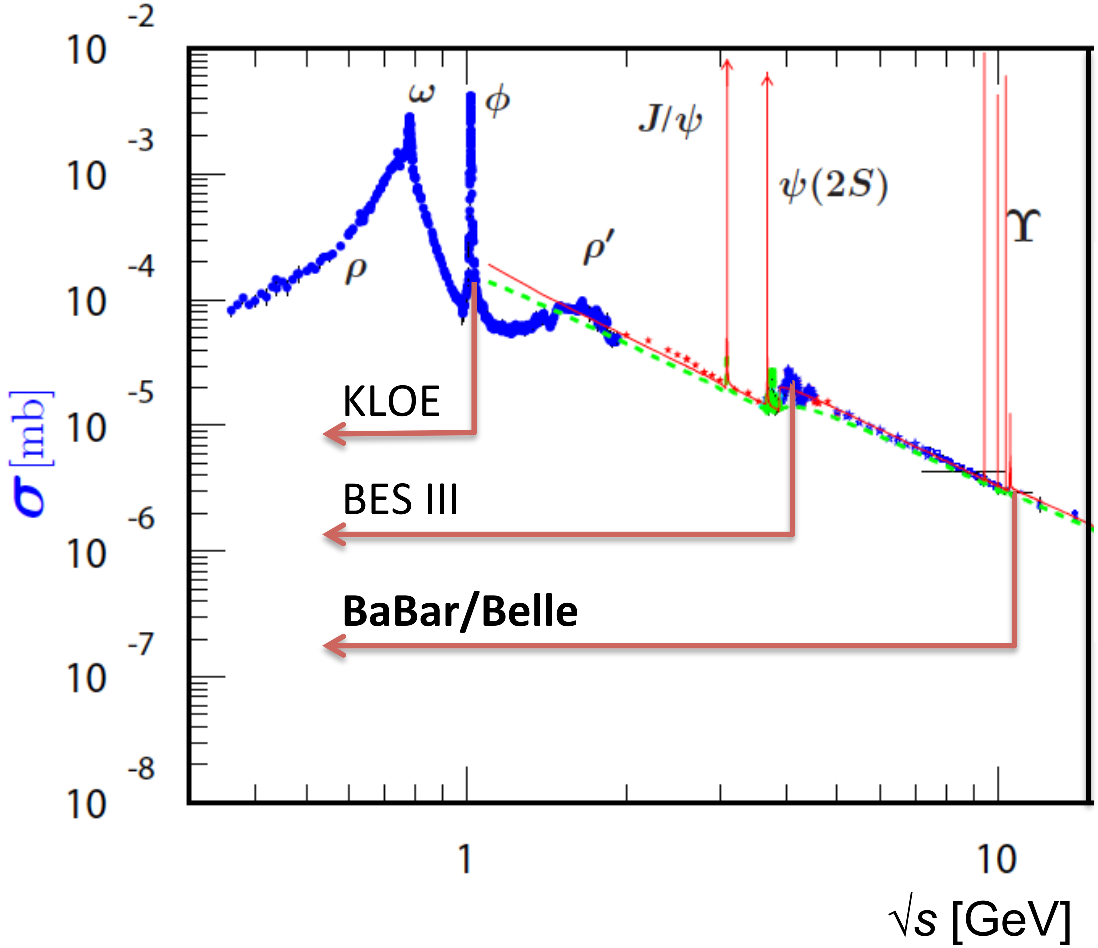


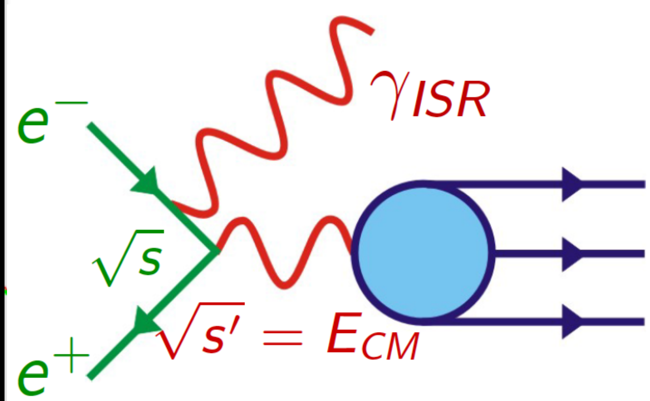
Contribution to uncertainty on a_μ^{had}



Phys. Rept. 477, 1-110 (2009)

ISR $e^+e^- \longrightarrow$ hadrons





B-factory ISR Programme

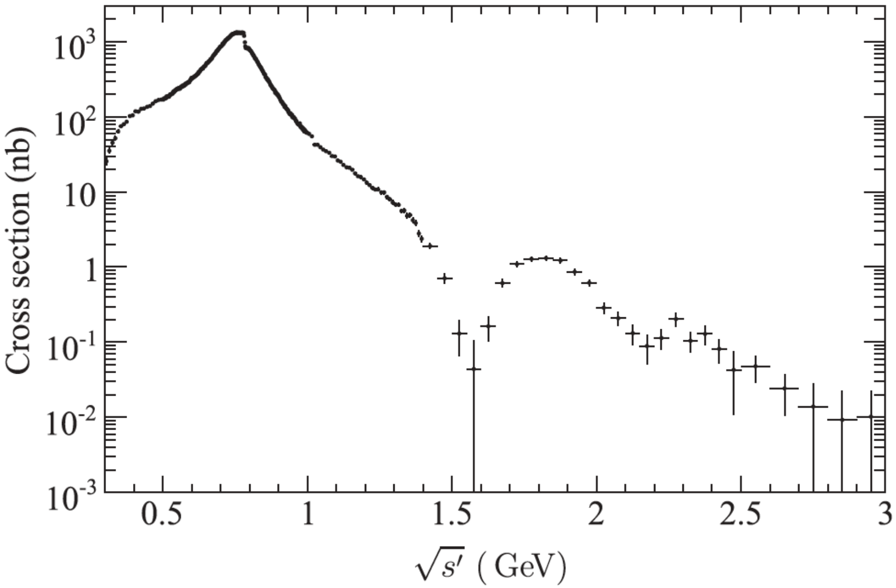
- BaBar has an extensive programme of ISR measurements, covering more than 25 light-hadron cross sections, with up to 5-body final states
  - Also many charm and charmonium measurements
- Bhabha veto system of Belle trigger hinders low multiplicity light-hadron measurements in ISR
  - But large charm and charmonium programme
  - Different system to be used at Belle 2
- Modes discussed today:

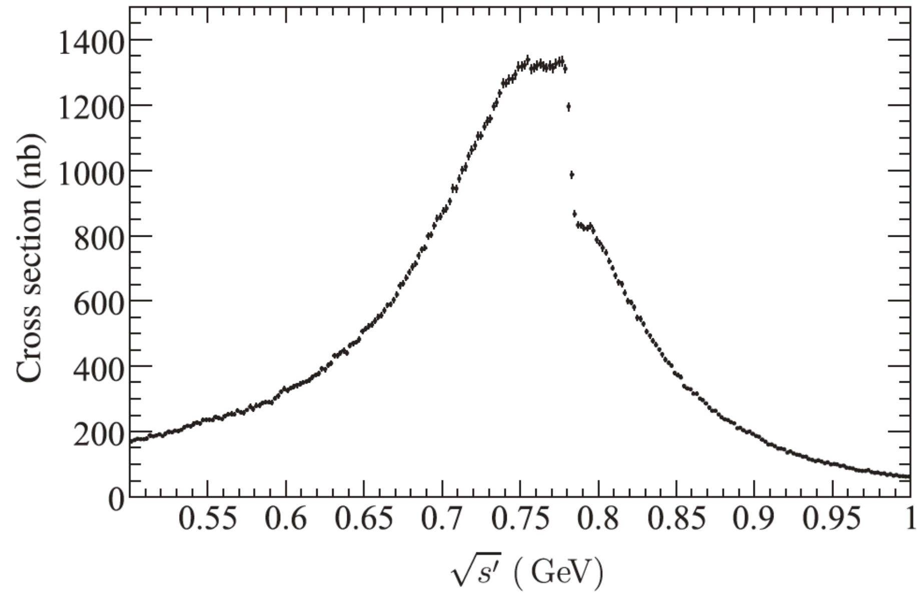
$e^+e^- \longrightarrow \pi^+\pi^-$	PRL 103, 231801 (2009), PRD 86, 032013 (2012)	BaBar
$e^+e^- \longrightarrow K^+K^-$	PRD 88, 032013 (2013)	BaBar
$e^+e^- \longrightarrow K_SK_L, K_SK_L\pi^+\pi^-, K_SK_S\pi^+\pi^-, K_SK_SK^+K^-$	PRD 89, 092002 (2014)	BaBar
$e^+e^- \longrightarrow \pi^+\pi^-\pi^0$	Preliminary	Belle

PRL 103, 231801 (2009)
PRD 86, 032013 (2012)

$\pi^+\pi^-$ cross section

Luminosity = 232 fb^{-1}

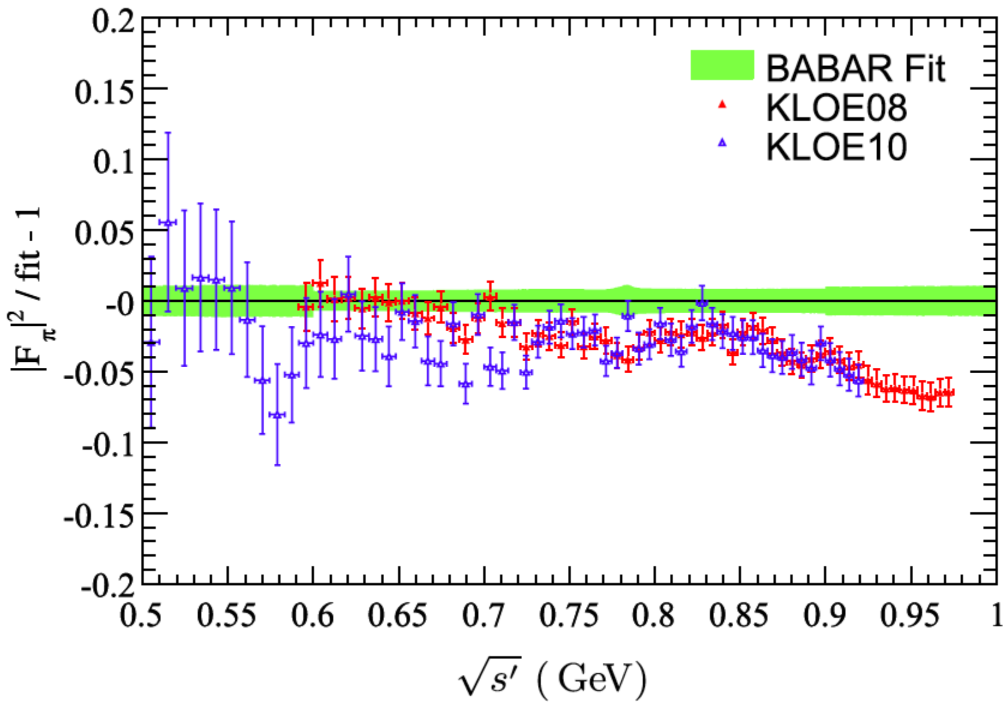




- Bare cross section including possible FSR
- Statistical + systematic uncertainty shown, systematic ~0.5%
- Dominated by $\rho(770)$ resonance
- Dip at 1.6 GeV likely due to interference between ρ' and ρ''
- Dip at 2.2 GeV may be due to even higher mass ρ state

PRL 103, 231801 (2009)
PRD 86, 032013 (2012)

$\pi^+\pi^-$ cross section



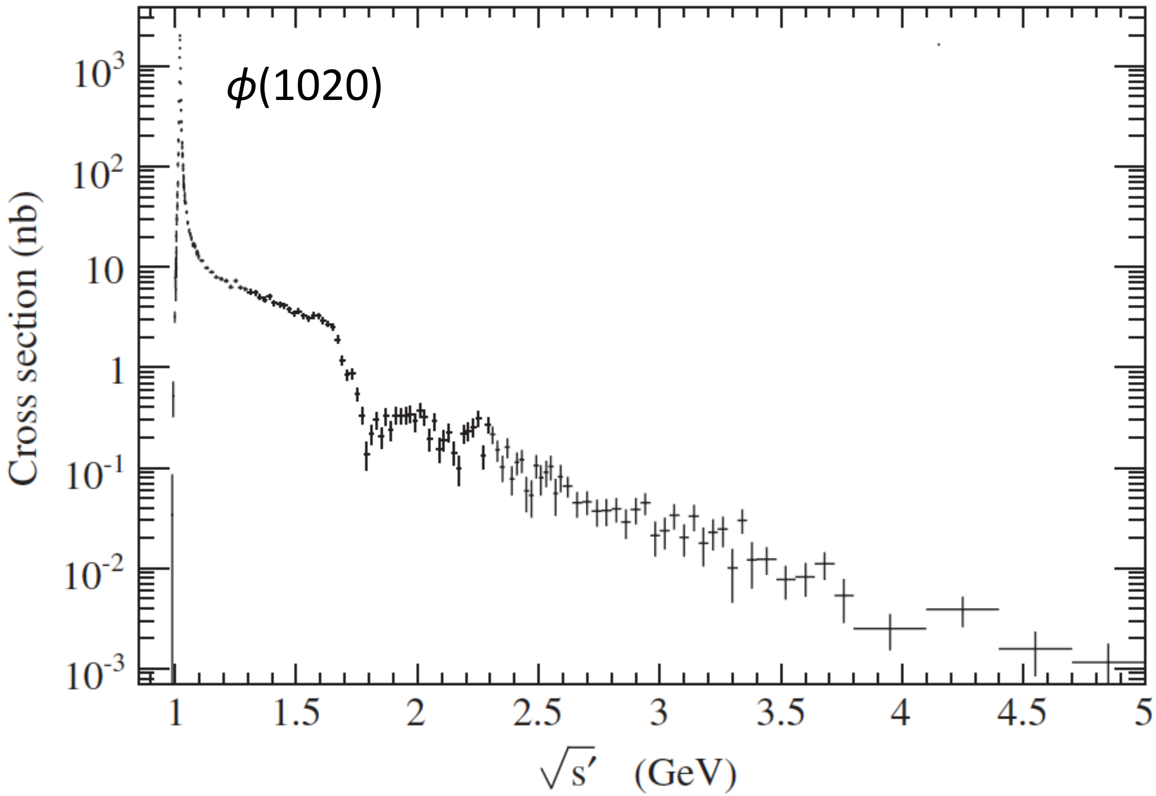
- Some disagreement between BaBar and KLOE
- In particular in region just above $\rho(770)$
- Need to resolve discrepancy – leads to increased uncertainty on a_μ^{had}

see e.g. [J. Phys. G**38** (2011) 085003]

PRD 88, 032013 (2013)

K^+K^- cross section

Luminosity = 232 fb^{-1}



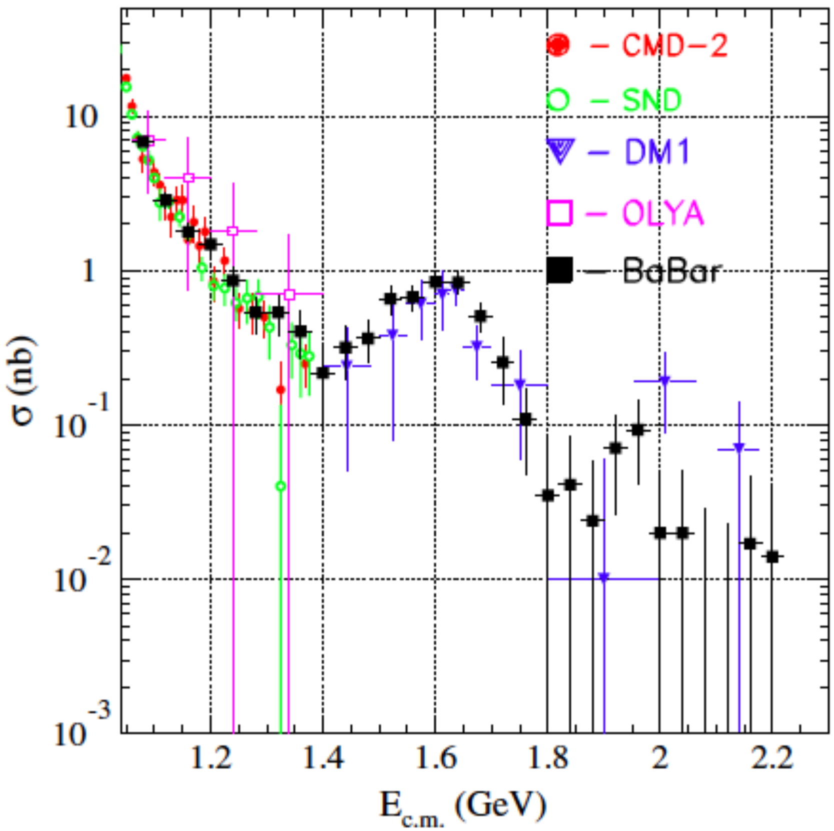
- Bare cross section including possible FSR
- Charmonium contributions removed
- Uncertainty of only 0.8% near peak

PRD 89, 092002 (2014)

$K_S K_L$ cross section

Luminosity = 469 fb^{-1}

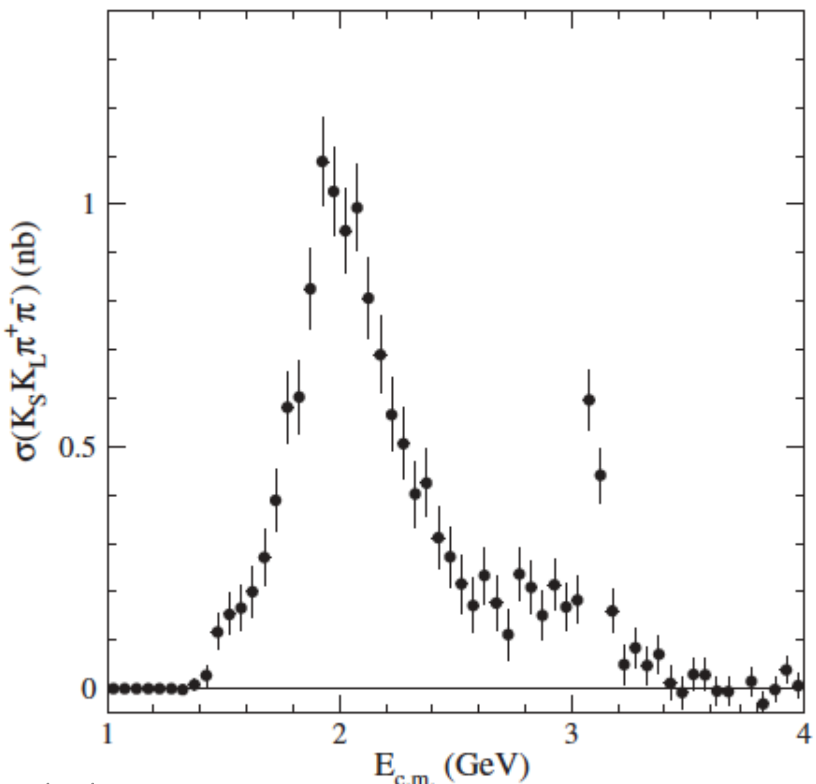
- Cross section measured on ϕ peak (1409 ± 55 nb) and in region above (right plot)
- In good agreement with previous experiments in both regions
- Comparable precision to CMD-2 and SND
- Better precision than other experiments

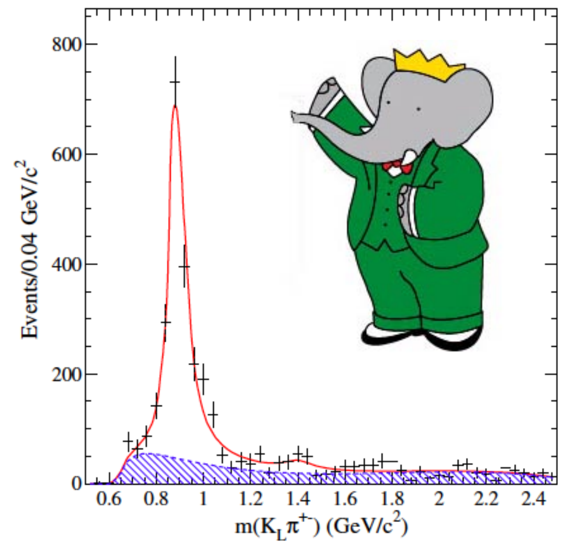


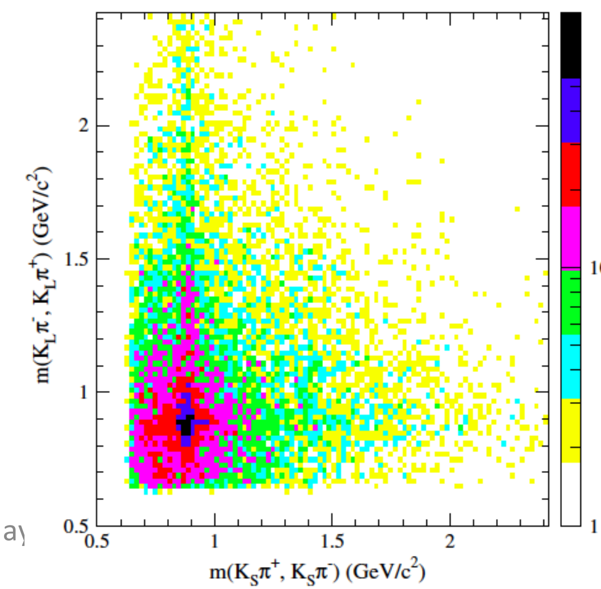
- Systematic uncertainties: 2.9% on ϕ peak, ~10% for > 0.5 nb, ~30% for < 0.5 nb
- Dominated by background subtraction procedure

$K_S K_L \pi^+ \pi^-$ cross section

- Only such measurement!
- Systematic uncertainty dominated by background subtraction
- ~10% at 2GeV, rising to ~30% at 1.5 and 3.0 GeV
- Dominated by $K^{*+} K^{*-}$

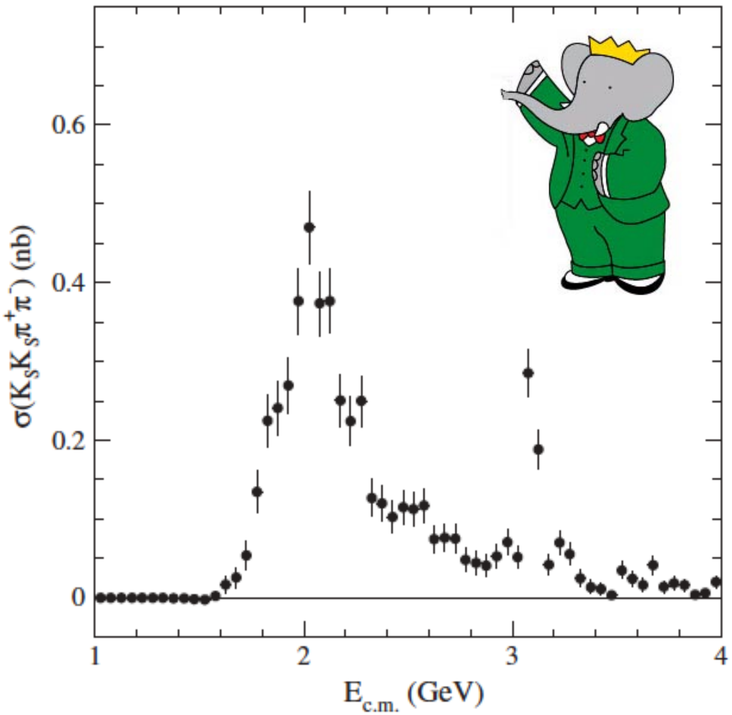


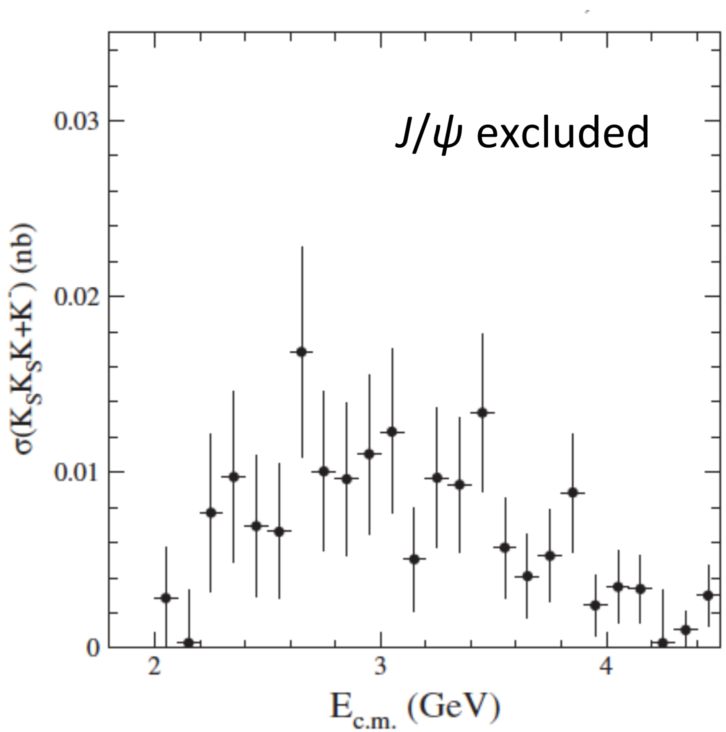




PRD 89, 092002 (2014)

$K_S K_S \pi^+\pi^-$ & $K_S K_S K^+K^-$ cross sections

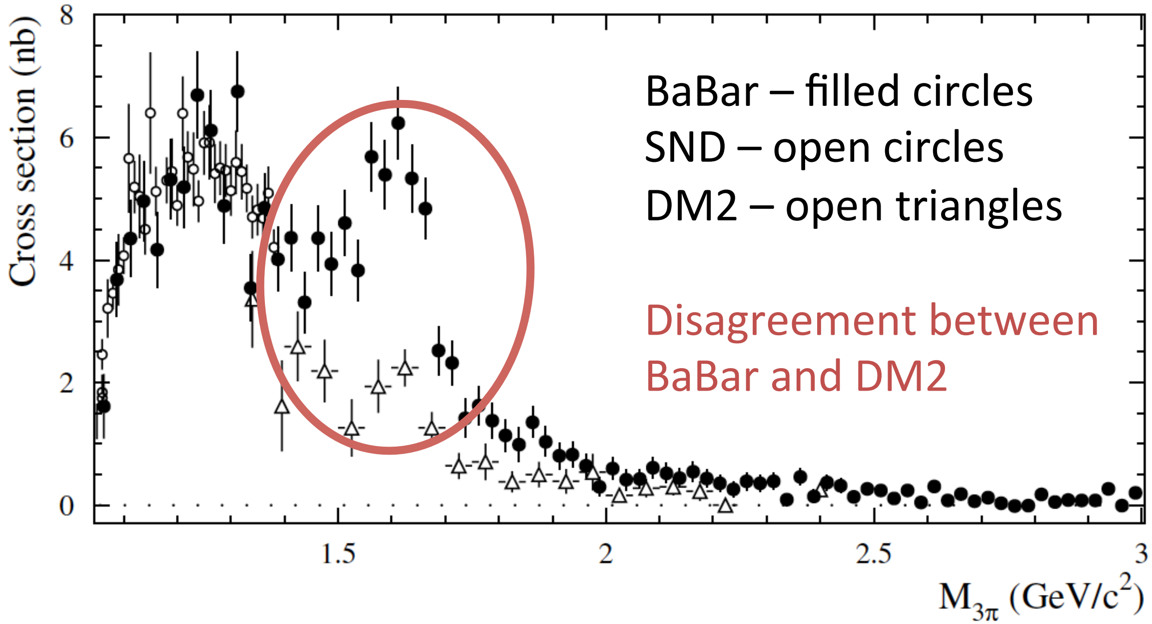




- Again, only existing measurements of these channels
- Systematic uncertainties range from ~5% in peak regions to 50-70% above 3 GeV
- Statistical uncertainties dominate the 4 kaon mode
- Dominant contributions to a_μ^{had} uncertainty now $\pi^+\pi^-\pi^0\pi^0$ – analysis in progress

$\pi^+\pi^-\pi^0$ cross section

BaBar 89 fb^{-1}: PRD **70**, 072004 (2004)

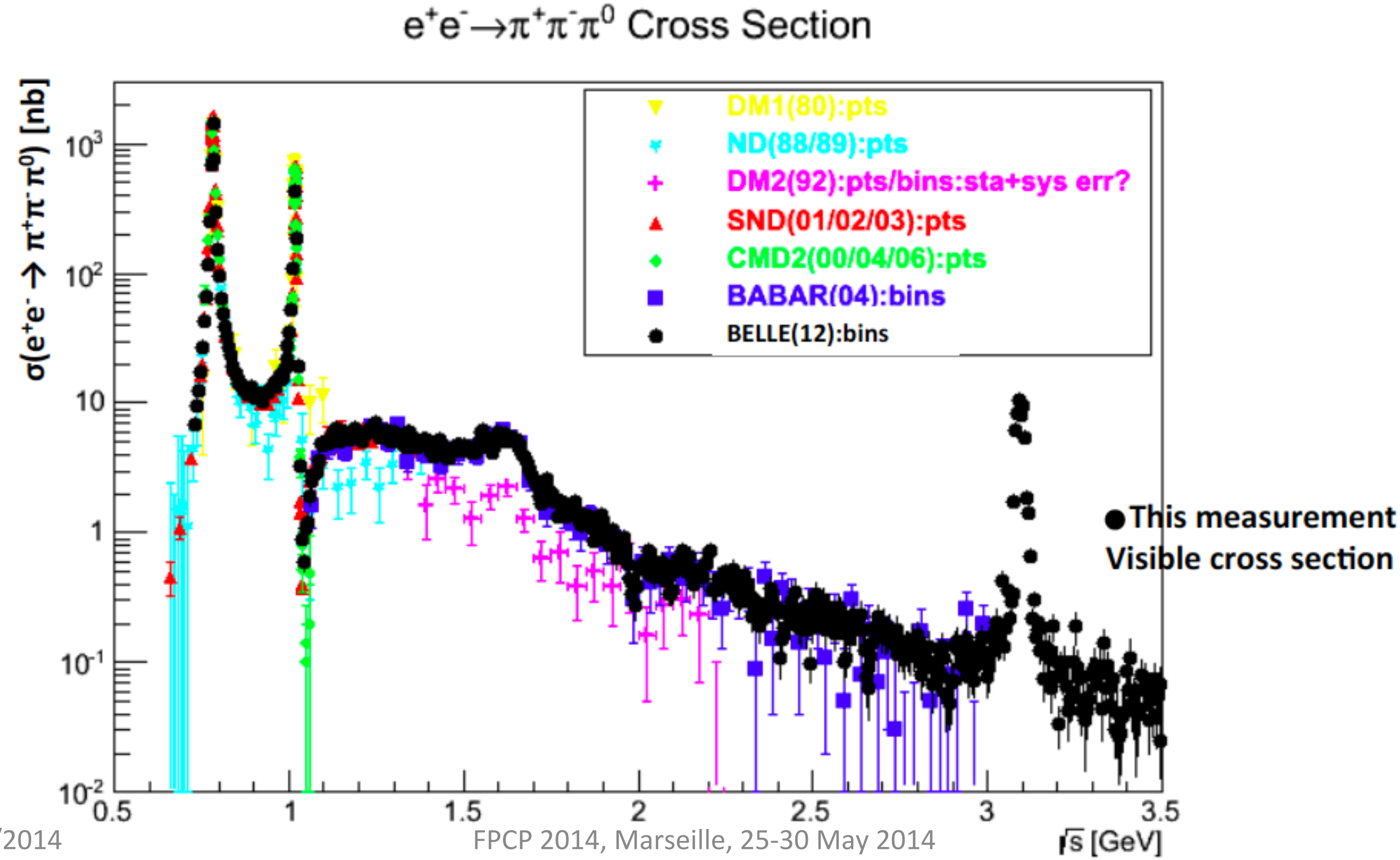


- Second largest contributor to a_μ^{had}
- Discrepancy in ω'-ω'' region needs to be resolved
- Preliminary Belle analysis using 526 fb^{-1} data sample

Talk by J. Crnkovic @ Tau2012

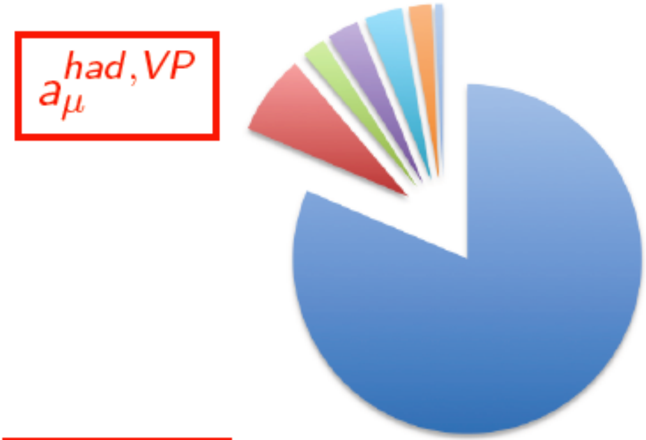
$\pi^+\pi^-\pi^0$ cross section

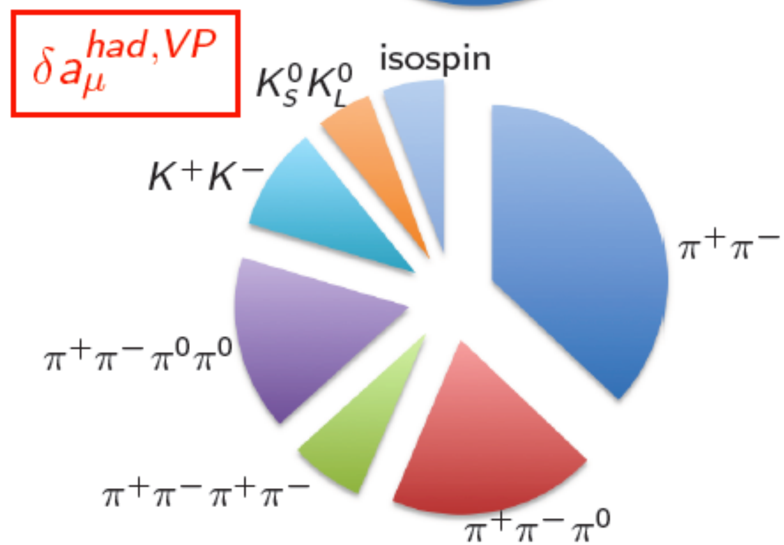
- Preliminary Belle results agree well with BaBar including region of ω' and ω''
- Systematic uncertainties still to be evaluated, hope for ~5% in peak regions



Summary of impact on g–2

- BaBar measurements of K^+K^- reduced uncertainty on that channel by factor 2.7
- Measurements of $\pi^+\pi^-\pi^+\pi^-$ by BaBar (not shown today) reduced uncertainty on that channel by 40%
- Effects of BaBar K_SK_L results still need to be evaluated
- Also for Belle $\pi^+\pi^-\pi^0$ once it is finalised
- BaBar analyses of $\pi^+\pi^-\pi^0\pi^0$ and $K_SK^{\pm}\pi^{\mp}\pi^0$ on-going





Data from EPJ C **71**, 1515 (2011)
Plots compiled by A. Hafner – many thanks!

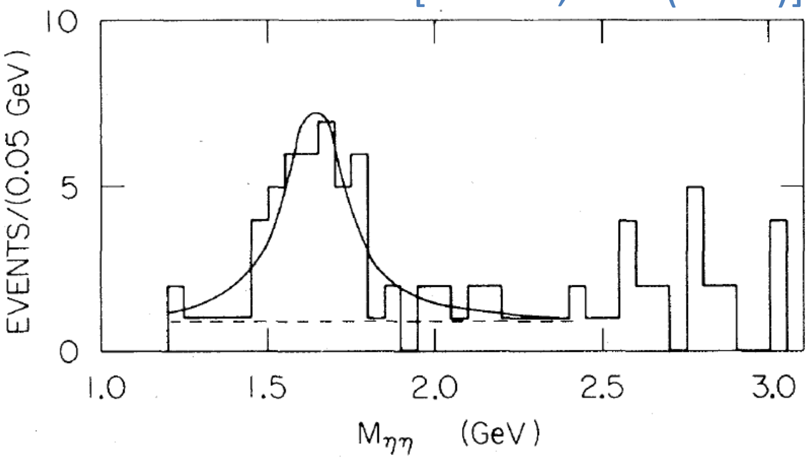
Light hadron spectroscopy

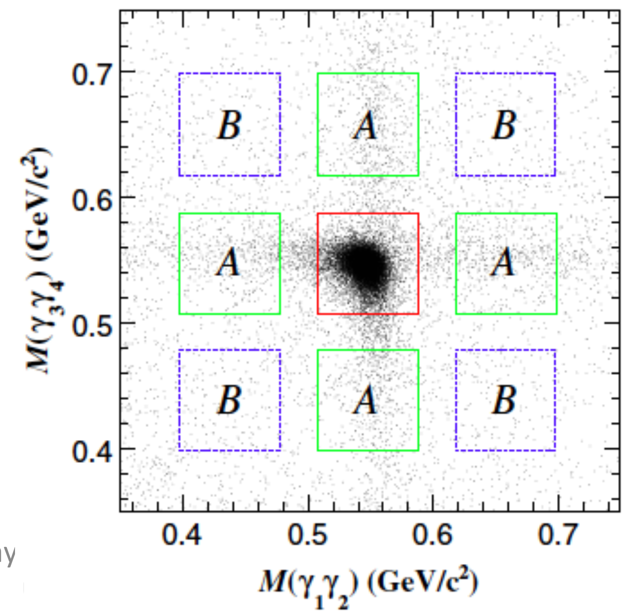
PRD 87, 092009 (2013)

Partial wave analysis of $J/\psi \longrightarrow \gamma\eta\eta$

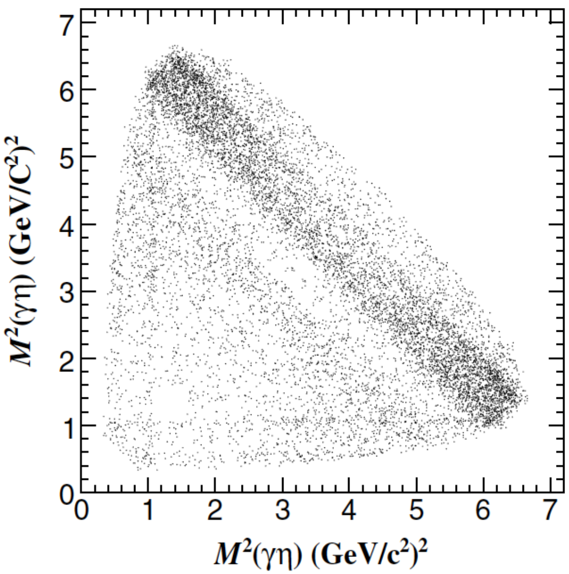
- First studied by Crystal Ball in early 1980's
- Extremely useful decay for studying I=0 scalar mesons, e.g. $f_0(1500)$, decaying to ηη
- And the corresponding tensor states, e.g. $f_2'(1525)$
- 5 photon final state

[PRL 48, 458 (1982)]

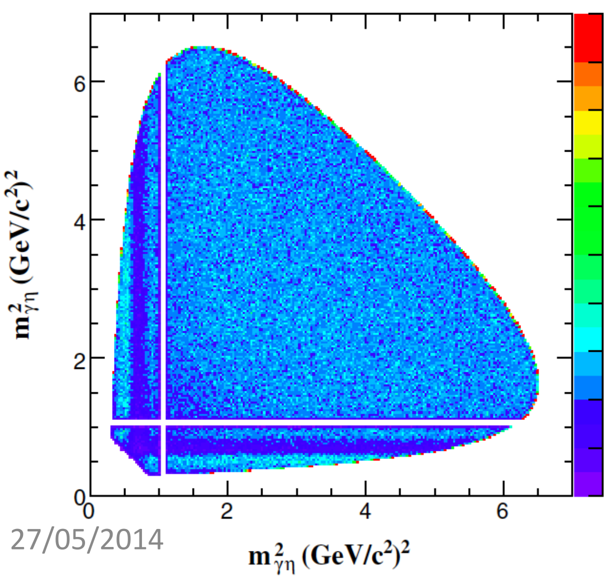


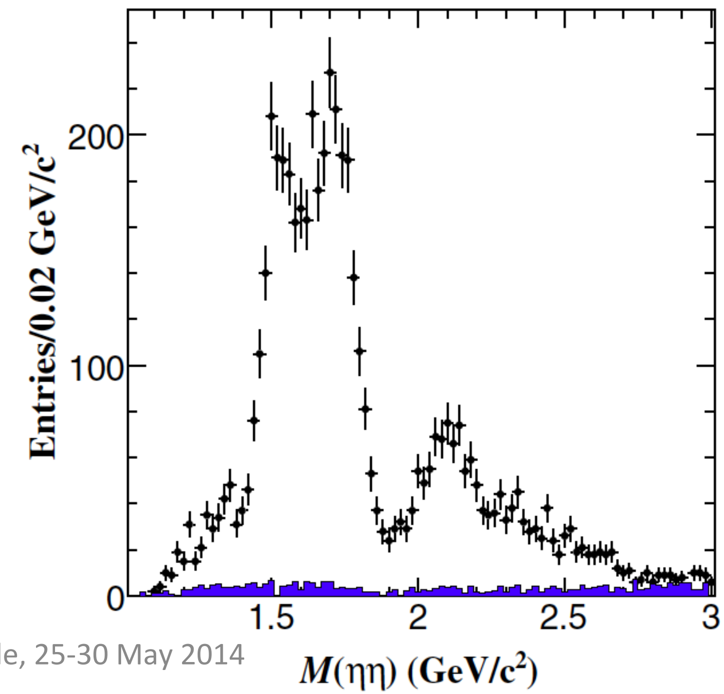


$J/\psi \longrightarrow \gamma\eta\eta$ PWA



- Dalitz plot of events in data sample (two entries per event)
- Contribution of $\phi\eta$ with $\phi \longrightarrow \gamma\eta$ is vetoed
- Effects from the tail are accounted for in amplitude model
- Efficiency variation over the Dalitz plot accounted for





PRD 87, 092009 (2013)

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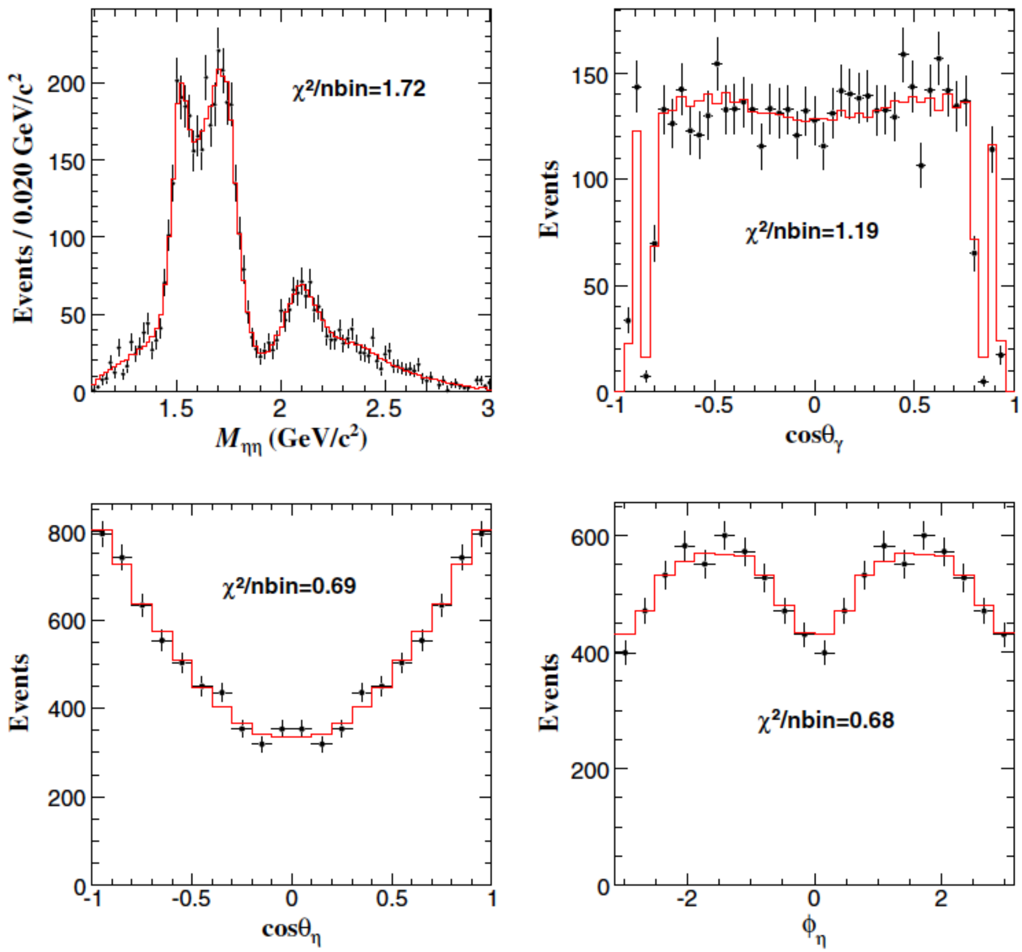


- Fit quality is good in all projections
- Dominant systematic uncertainties from background description and models with extra resonances

PRD 87, 092009 (2013)

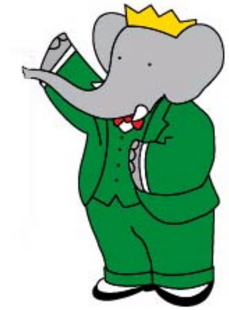
$J/\psi \longrightarrow \gamma\eta\eta$ PWA

- Best fit contains six resonances and a 0^{++} phase space component
- Resonance masses and widths are determined from performing iterative fits with the parameters fixed

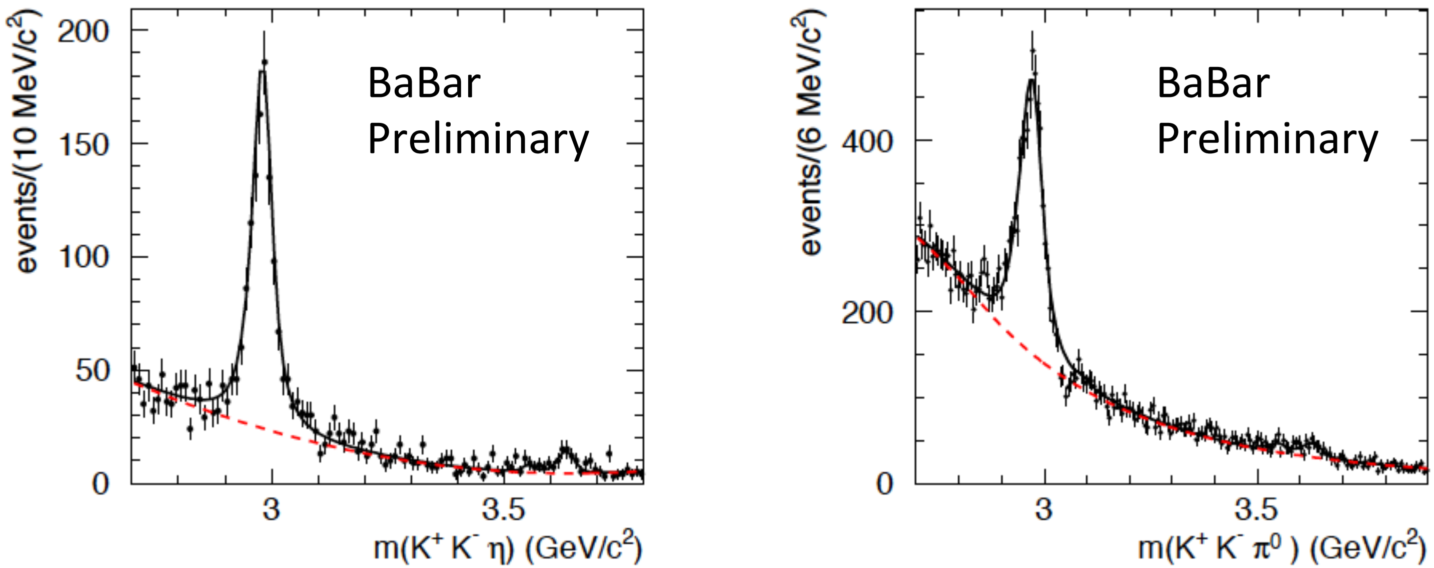
Resonance	Mass (MeV/c^2)	Width (MeV/c^2)	$\mathcal{B}(J/\psi \to \gamma X \to \gamma\eta\eta)$	Significance
$f_0(1500)$	1468^{+14+23}_{-15-74}	$136^{+41+28}_{-26-100}$	$(1.65^{+0.26+0.51}_{-0.31-1.40}) \times 10^{-5}$	8.2σ
$f_0(1710)$	$1759 \pm 6^{+14}_{-25}$	$172 \pm 10^{+32}_{-16}$	$(2.35^{+0.13+1.24}_{-0.11-0.74}) \times 10^{-4}$	25.0σ
$f_0(2100)$	$2081 \pm 13^{+24}_{-36}$	273^{+27+70}_{-24-23}	$(1.13^{+0.09+0.64}_{-0.10-0.28}) \times 10^{-4}$	13.9σ
$f_2'(1525)$	$1513 \pm 5^{+4}_{-10}$	75^{+12+16}_{-10-8}	$(3.42^{+0.43+1.37}_{-0.51-1.30}) \times 10^{-5}$	11.0σ
$f_2(1810)$	1822^{+29+66}_{-24-57}	$229^{+52+88}_{-42-155}$	$(5.40^{+0.60+3.42}_{-0.67-2.35}) \times 10^{-5}$	6.4σ
$f_2(2340)$	$2362^{+31+140}_{-30-63}$	$334^{+62+165}_{-54-100}$	$(5.60^{+0.62+2.37}_{-0.65-2.07}) \times 10^{-5}$	7.6σ

- No significant contributions seen from $f_0(1370)$, $f_0(1790)$ or $f_2(2010)$
- Relative contribution strengths give information to help resolve nature of the I=0 scalar and tensor resonances
- Dominance of $f_0(1710)$ and $f_0(2100)$ over $f_0(1500)$ consistent with recent lattice calculations [PRL 110, 021601 (2013)]

arXiv:1403.7501
Submitted to PRD



Dalitz plot analyses of $\eta_c \longrightarrow K^+K^-\eta$ and $K^+K^-\pi^0$

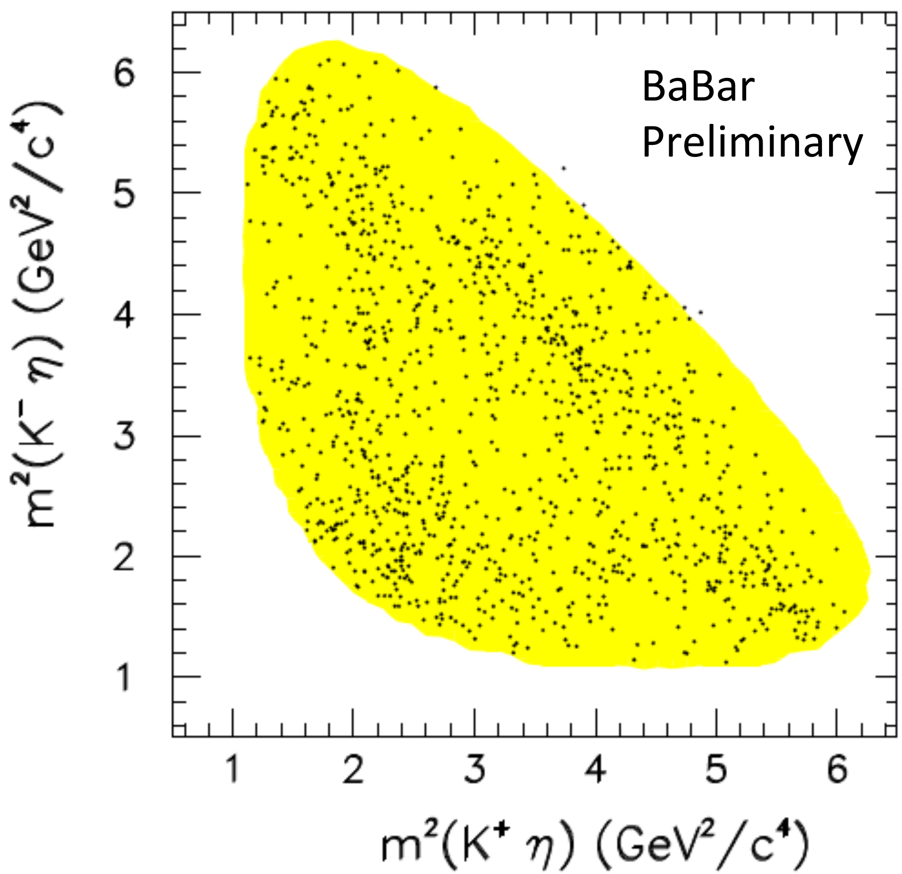


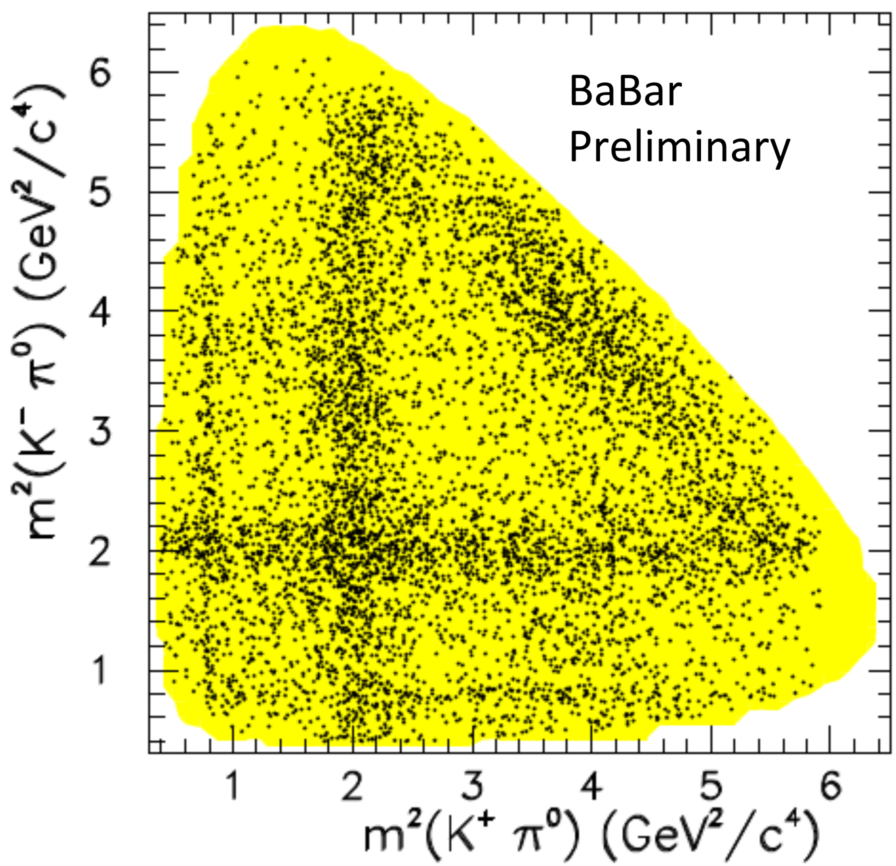
- Search for $K^+K^-\eta$ and $K^+K^-\pi^0$ in two-photon interactions
- First observation of $\eta_c \longrightarrow K^+K^-\eta$ (~1150) signal events and yield of ~4500 signal for $\eta_c \longrightarrow K^+K^-\pi^0$
- Also first evidence of $\eta_c(2S) \longrightarrow K^+K^-\eta$

arXiv:1403.7501
Submitted to PRD

DP analyses of $\eta_c \longrightarrow K^+K^-\eta/\pi^0$

Dalitz plot distributions of data events in the signal region





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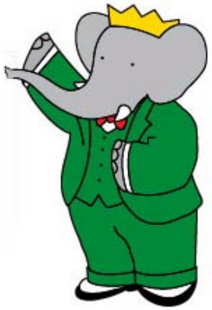
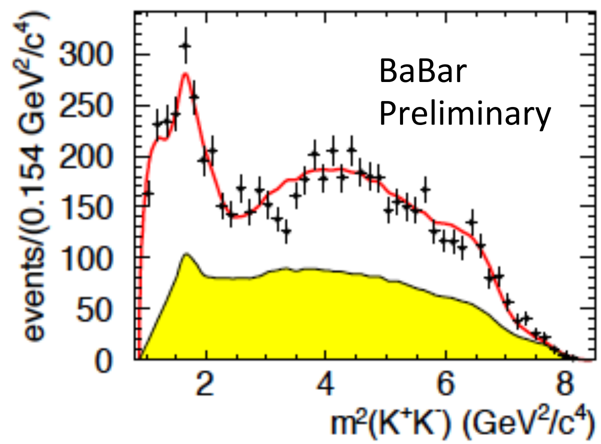
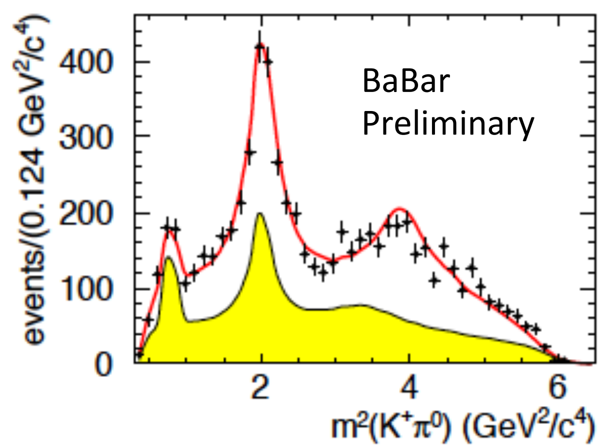


$\eta_c \longrightarrow K^+K^-\pi^0$

- Contributions from scalar and tensor *K** and I=1 *a* mesons plus a phase space nonresonant component
- Largest component is $K_0^*(1430)$

Final state	Fraction %	Phase (radians)
$K_0^*(1430)^+K^-$	$33.8 \pm 1.9 \pm 0.4$	$0.$
$K_0^*(1950)^+K^-$	$6.7 \pm 1.0 \pm 0.3$	$-0.67 \pm 0.07 \pm 0.03$
$a_0(980)\pi^0$	$1.9 \pm 0.1 \pm 0.2$	$0.38 \pm 0.24 \pm 0.02$
$a_0(1450)\pi^0$	$10.0 \pm 2.4 \pm 0.8$	$-2.4 \pm 0.05 \pm 0.03$
$a_2(1320)\pi^0$	$2.1 \pm 0.1 \pm 0.2$	$0.77 \pm 0.20 \pm 0.04$
$K_2^*(1430)^+K^-$	$6.8 \pm 1.4 \pm 0.3$	$-1.67 \pm 0.07 \pm 0.03$
NR	$24.4 \pm 2.5 \pm 0.6$	$1.49 \pm 0.07 \pm 0.03$
Sum	$85.8 \pm 3.6 \pm 1.2$	
χ^2/ν	$212/130$	





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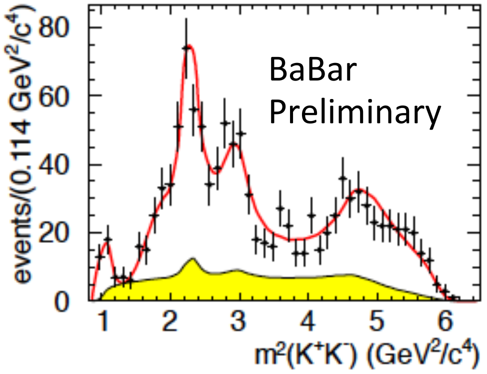
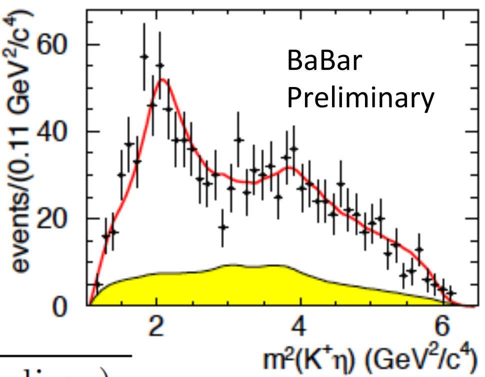
$\eta_c \longrightarrow K^+K^-\eta$



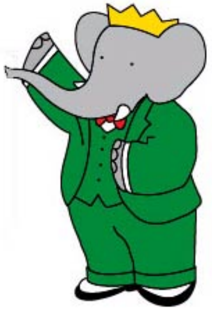


- Contributions from scalar K^* and scalar and tensor I=0 f mesons plus a phase space nonresonant component
- Largest component is $f_0(1500)$
- First observation of $K_0^*(1430)$ decaying to $K\eta$

$$\frac{\mathcal{B}(K_0^*(1430)\to\eta K)}{\mathcal{B}(K_0^*(1430)\to\pi K)} = 0.092 \pm 0.025^{+0.010}_{-0.025}$$

- Ratio can help understand mixing of pseudoscalar mesons
- Assuming a single mixing angle for singlet and octet, find $\theta_P = \left(3.1^{+3.3}_{-5.0}\right)^\circ$

Final state	Fraction %	Phase (radians)
$f_0(1500)\eta$	23.7 ± 7.0 ± 1.8	0.
$f_0(1710)\eta$	8.9 ± 3.2 ± 0.4	2.2 ± 0.3 ± 0.1
$K_0^*(1430)^+K^-$	16.4 ± 4.2 ± 1.0	2.3 ± 0.2 ± 0.1
$f_0(2200)\eta$	11.2 ± 2.8 ± 0.5	2.1 ± 0.3 ± 0.1
$K_0^*(1950)^+K^-$	2.1 ± 1.3 ± 0.2	-0.2 ± 0.4 ± 0.1
$f_2'(1525)\eta$	7.3 ± 3.8 ± 0.4	1.0 ± 0.1 ± 0.1
$f_0(1350)\eta$	5.0 ± 3.7 ± 0.5	0.9 ± 0.2 ± 0.1
$f_0(980)\eta$	10.4 ± 3.0 ± 0.5	-0.3 ± 0.3 ± 0.1
NR	15.5 ± 6.9 ± 1.0	-1.2 ± 0.4 ± 0.1
Sum	100.0 ± 11.2 ± 2.5	
χ^2/ν	87/65	



Heavy hadron production in pp collisions

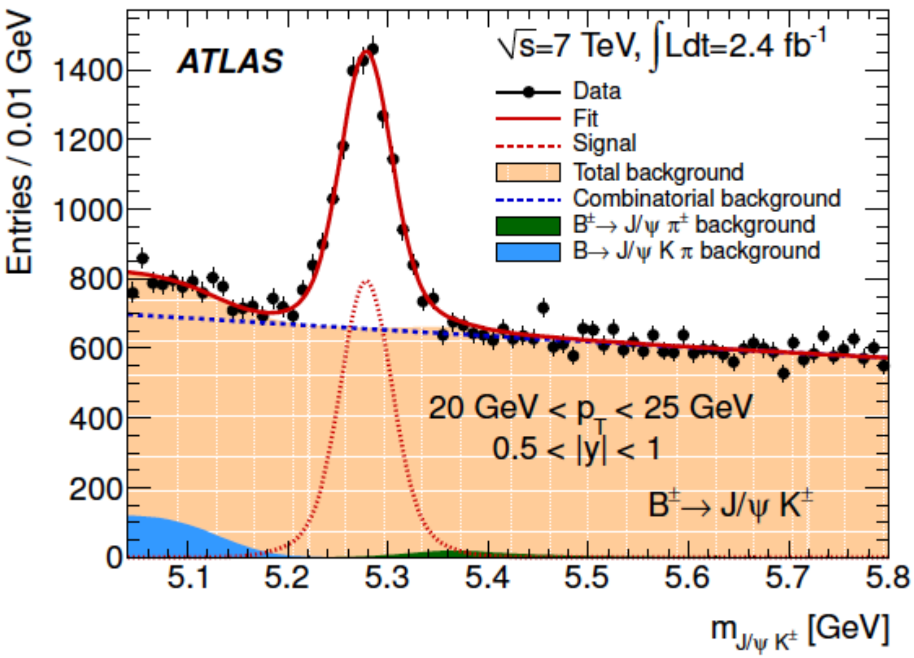
JHEP 10 (2013) 042

B^+ production cross section

- Important to make precise measurements of heavy quark production in hadronic collisions
- Compare with theoretical calculations to help improve models
- ATLAS collaboration measures B^+ meson cross section as function of p_T and rapidity (y)
- In ranges: $9 < p_T < 120$ GeV/c^2 and $|y| < 2.25$
- Complementary rapidity range to LHCb
- Analysis uses 2.4 fb^{-1} of $\sqrt{s} = 7$ TeV data

JHEP 10 (2013) 042

B^+ production cross section

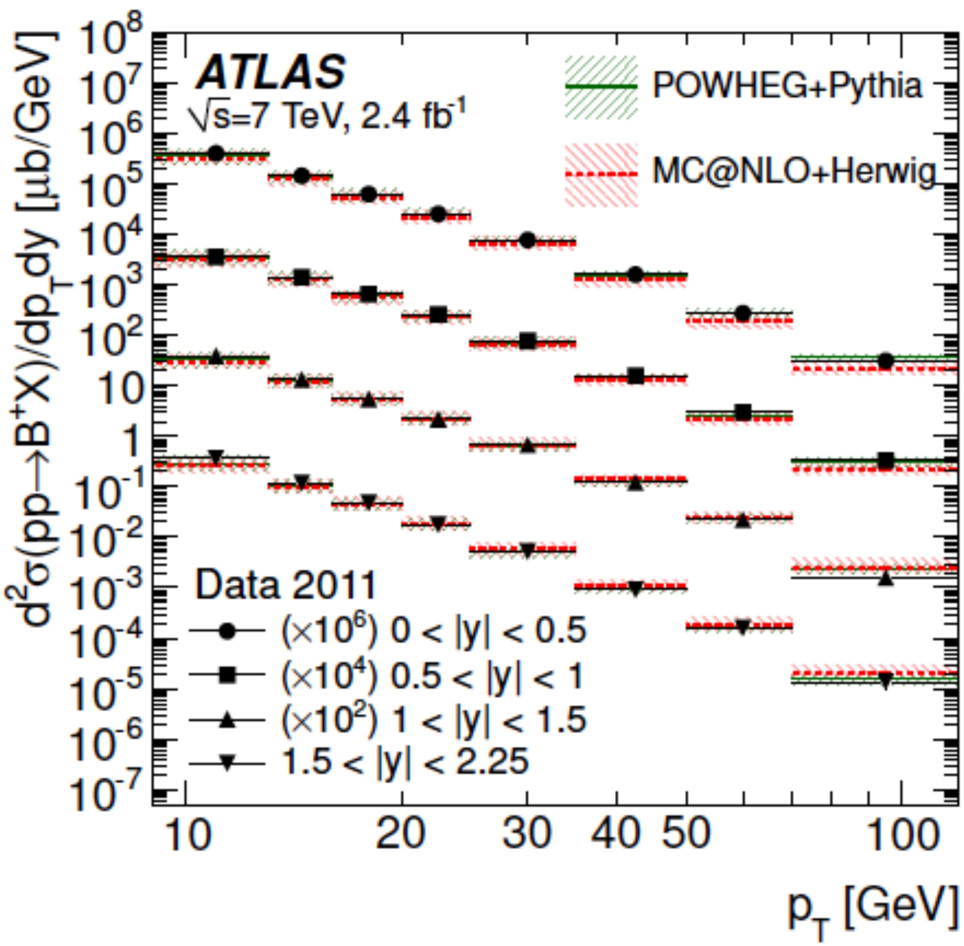


- Use decay B^+ to $J/\psi\ K^+$, with J/ψ to $\mu^+\mu^-$
- Invariant mass distribution of candidates shown on left
  - Only part of full p_T and y range shown in this example
- In total ~125000 signal candidates

- Detector acceptance and reconstruction efficiency taken into account as function of p_T and y
  - Largest variation with p_T
- Ratio of B^+ and B^- candidates found consistent with unity

JHEP 10 (2013) 042

B^+ production cross section



- Cross section shown as function of p_T for different rapidity bins
- Predictions from POWHEG and MC@NLO also shown
- Agreement with POWHEG is good over whole range
- MC@NLO predicts lower cross-section at low p_T and softer p_T spectrum for $|y| < 1$ and harder for $|y|>1$
- Good agreement also obtained with CMS results and with fixed order next-to-leading-logarithm calculations

LHCb-PAPER-2014-004
To be submitted to JHEP

Λ_b relative production rate

- Kinematic dependence of relative production rate of Λ_b and B^0 hadrons studied at LHCb
- Analysis uses 1fb^{-1} of 7 TeV data recorded in 2011
- Range of transverse momentum:

$$1.5 < p_\mathrm{T} < 40\ \mathrm{GeV}/c^2$$

- And pseudorapidity:

$$2 < \eta < 5$$

- Uses the hadronic decays:
  - $\Lambda_b \longrightarrow \Lambda_c^+ \pi^-$, with $\Lambda_c^+ \longrightarrow p\, K^- \pi^+$
  - $\bar{B}^0 \longrightarrow D^+ \pi^-$, with $D^+ \longrightarrow K^- \pi^+ \pi^+$

LHCb-PAPER-2014-004
To be submitted to JHEP

Λ_b relative production rate

- Determine ratio of efficiency corrected yields in bins of p_T and η:

$$\mathcal{R}(x) \equiv \frac{N_{\Lambda_b^0\to\Lambda_c^+\pi^-}(x)\,\epsilon_{\overline{B}^0\to D^+\pi^-}(x)}{N_{\overline{B}^0\to D^+\pi^-}(x)\,\epsilon_{\Lambda_b^0\to\Lambda_c^+\pi^-}(x)}$$

- Related to the ratio of production rates by:

$$\frac{f_{\Lambda_b^0}}{f_d}(x) = \frac{\mathcal{B}(\overline{B}^0\to D^+\pi^-)}{\mathcal{B}(\Lambda_b^0\to\Lambda_c^+\pi^-)}\frac{\mathcal{B}(D^+\to K^-\pi^+\pi^+)}{\mathcal{B}(\Lambda_c^+\to pK^-\pi^+)}\times\mathcal{R}(x)$$

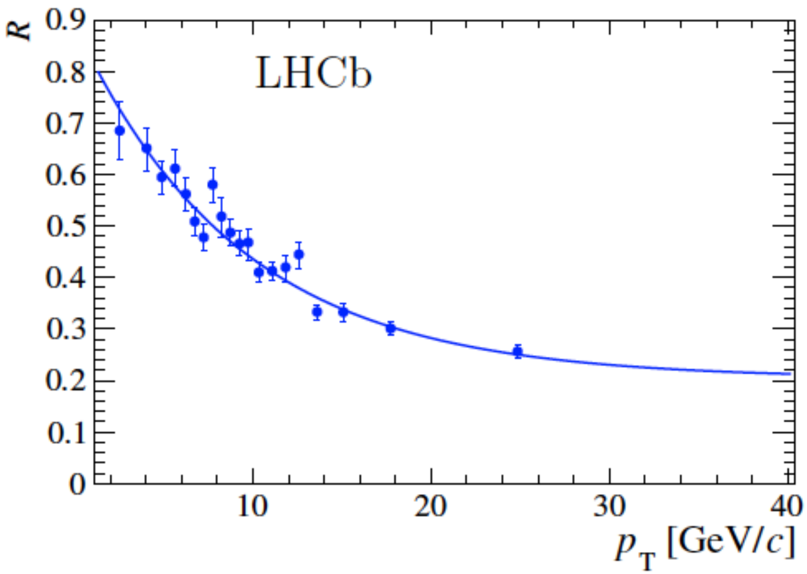
$$\equiv \mathcal{S}\times\mathcal{R}(x),$$

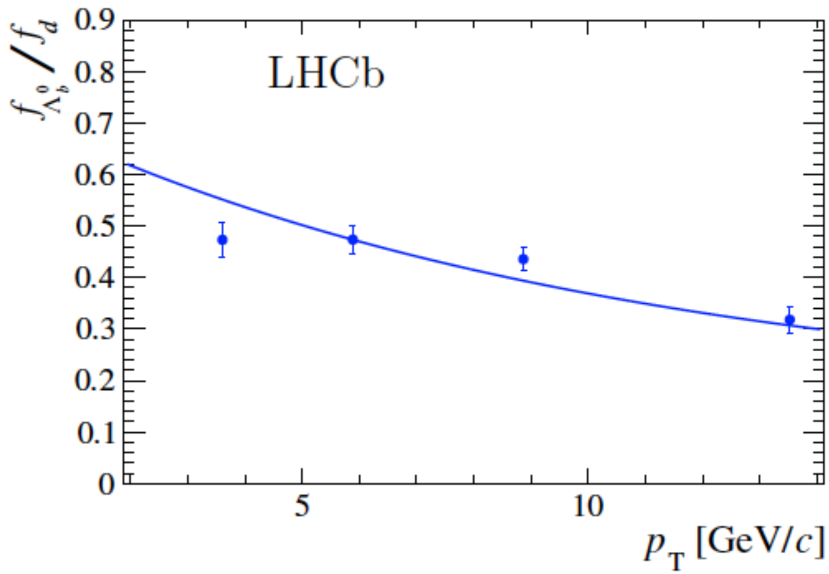
- Where S is a constant scale factor

LHCb-PAPER-2014-004
To be submitted to JHEP

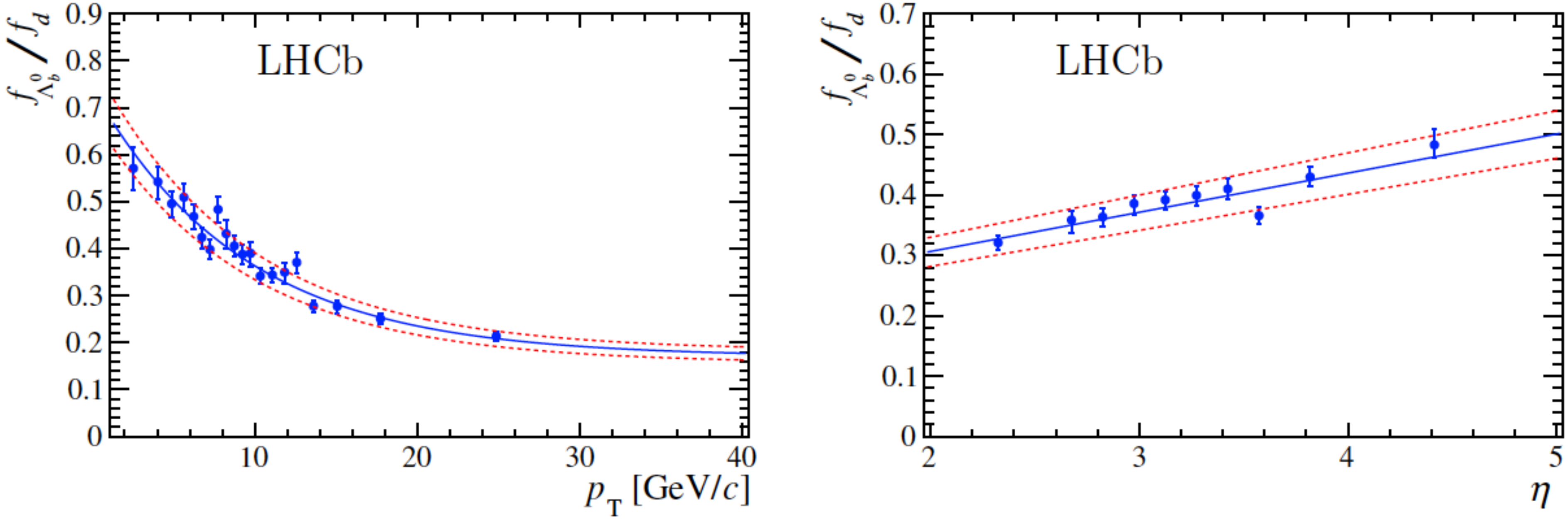
Λ_b relative production rate

- Fit exponential form to p_T distribution of *R*
- Can then determine *S* from fitting shape to previous data for f_{Λ_b}/f_d from semi-leptonic decays
- Provides translation from *R* to production ratio for η distribution as well





Λ_b relative production rate



- Also allows world's most precise determination of:

$$\mathcal{B}(\Lambda_b^0 \to \Lambda_c^+ \pi^-) = \left(4.30 \pm 0.03\ {}^{+0.12}_{-0.11} \pm 0.26 \pm 0.21\right) \times 10^{-3}$$

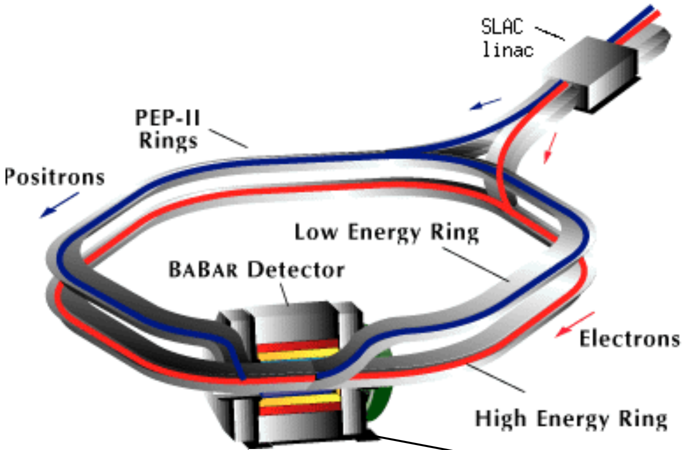
- Uncertainties are statistical, systematic, due to previous LHCb f_{Λ_b}/f_d measurement, and BF of $\bar{B}^0 \longrightarrow D^+\pi^-$
- Essential ingredient for measuring other Λ_b BFs

Summary

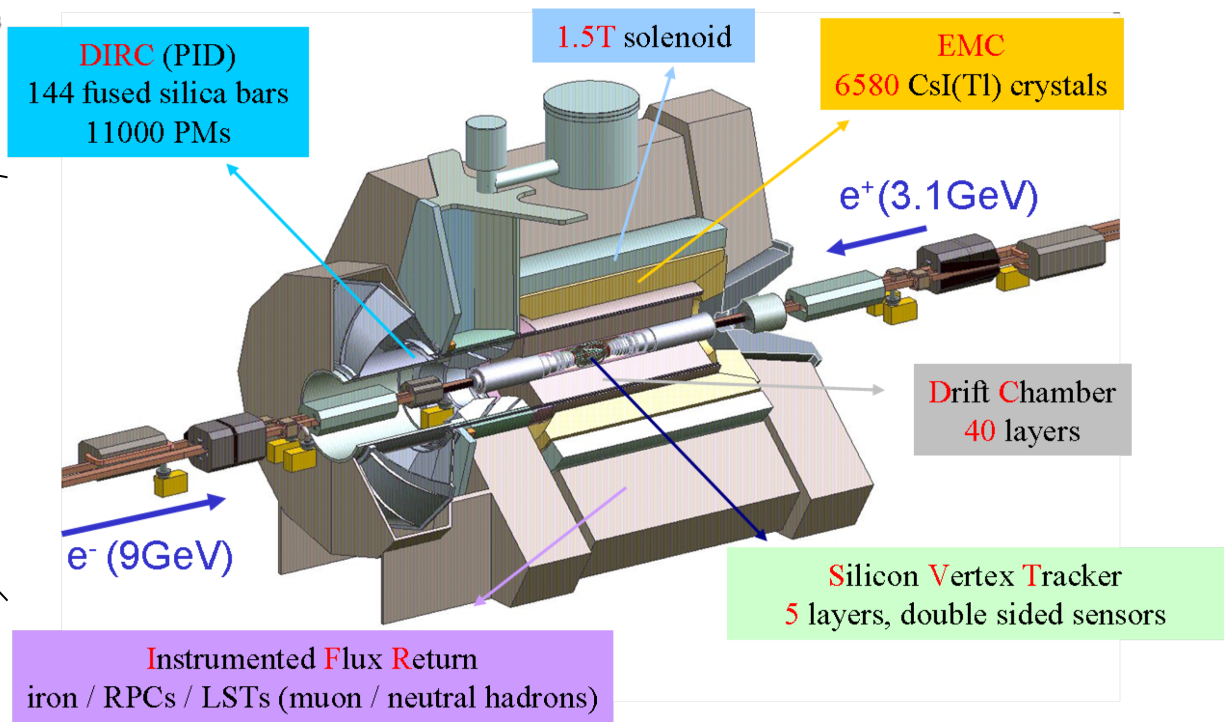
- Many exciting developments improving understanding of QCD and its role in $(g-2)_\mu$
- Other sophisticated studies of hadron production and spectroscopy
- These are taking place at flavour experiments and in heavy flavour studies at ATLAS & CMS
- Further refinements in the pipeline and new experiments to contribute in near future
- Stay tuned!

Backup Slides

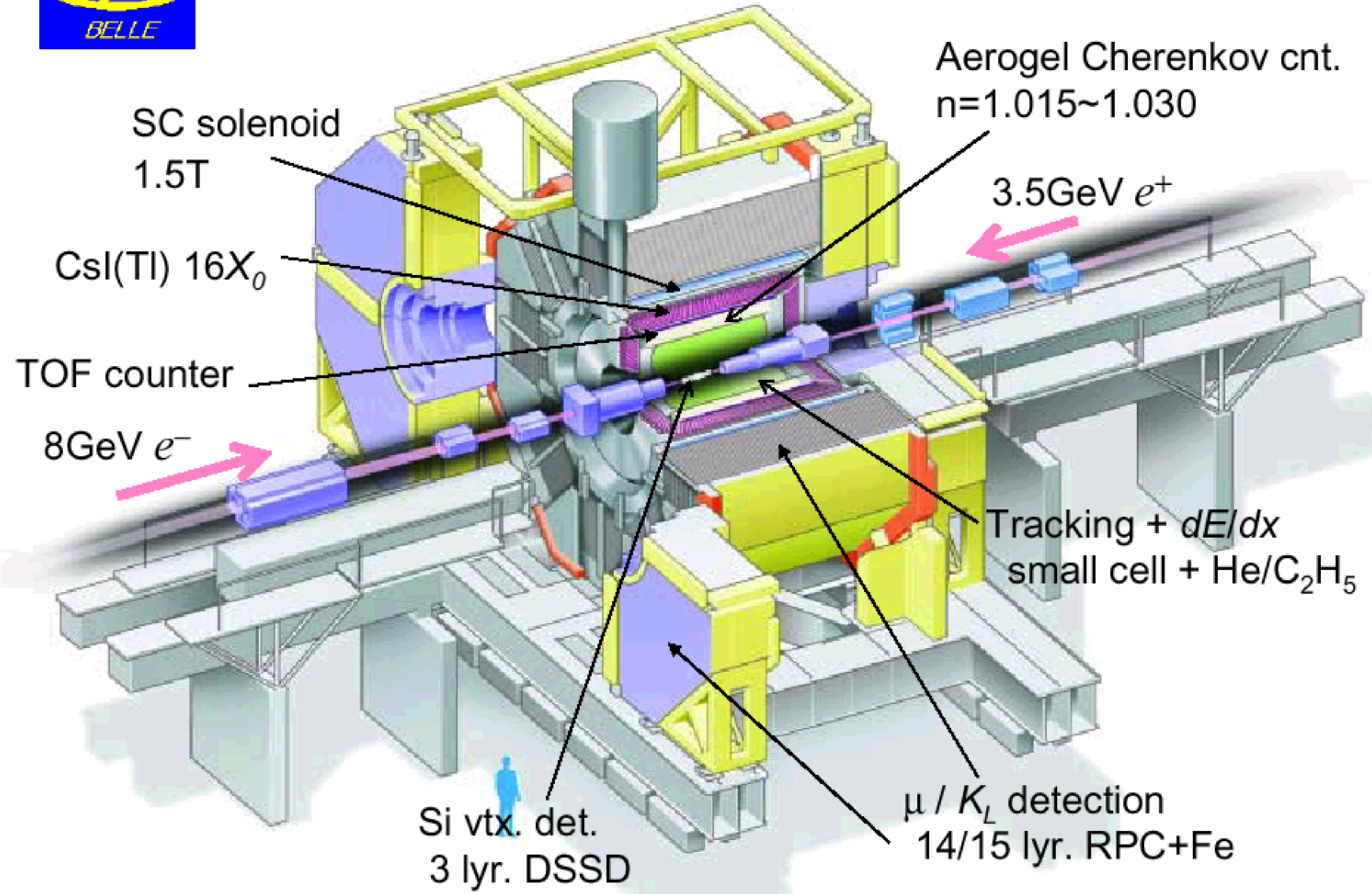
PEP-II and BaBar



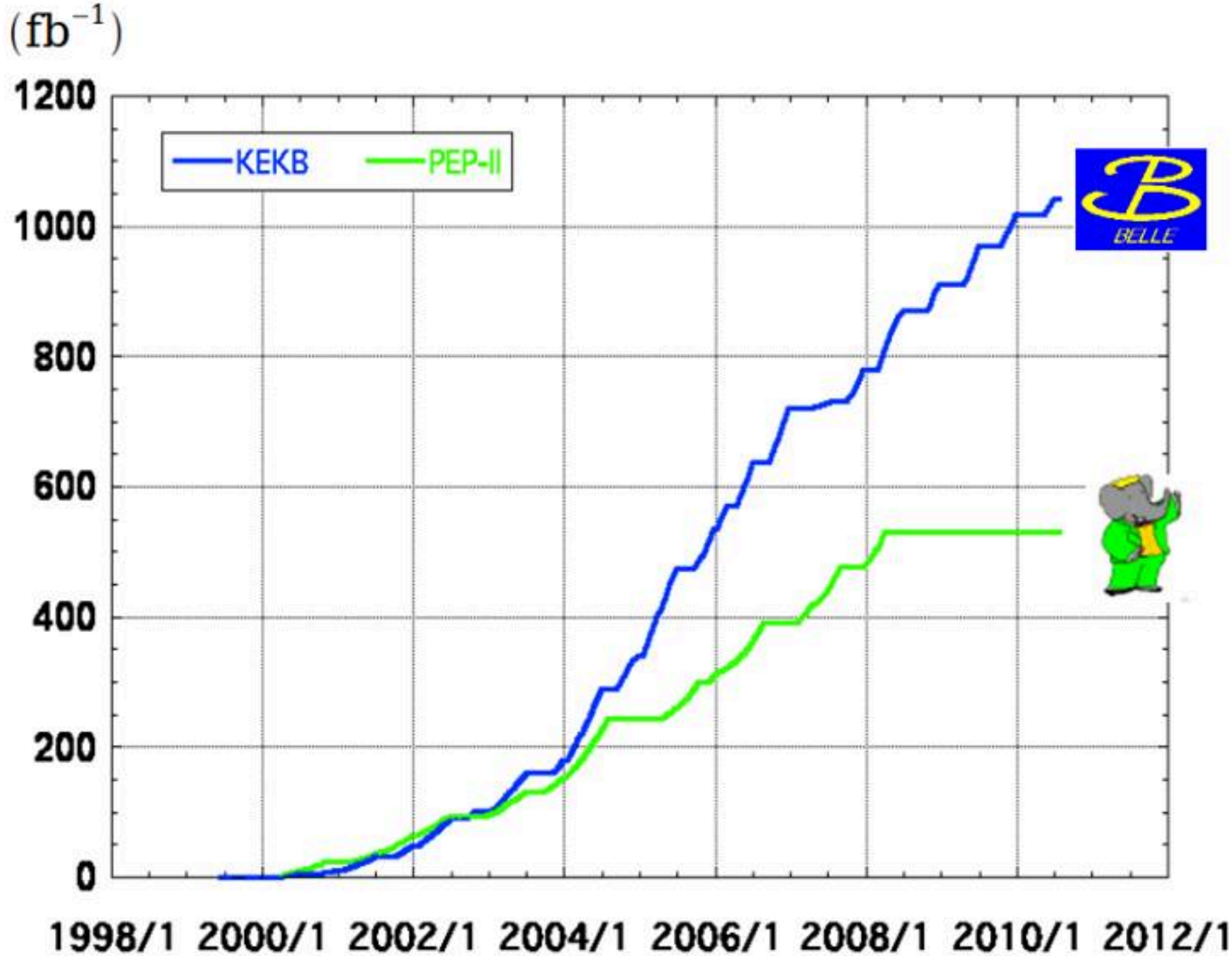
- PEP II/BaBar *B*-Factory located at SLAC National Accelerator Laboratory
- Collided beams of electrons and positrons with asymmetric energies



Belle Detector



Integrated luminosity of B factories



> 1 ab^{-1}

On resonance:

$\Upsilon(5S)$: 121 fb^{-1}

$\Upsilon(4S)$: 711 fb^{-1}

$\Upsilon(3S)$: 3 fb^{-1}

$\Upsilon(2S)$: 25 fb^{-1}

$\Upsilon(1S)$: 6 fb^{-1}

Off reson./scan:

~ 100 fb^{-1}

~ 550 fb^{-1}

On resonance:

$\Upsilon(4S)$: 433 fb^{-1}

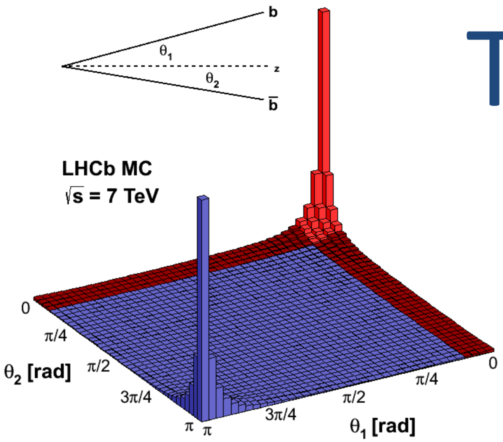
$\Upsilon(3S)$: 30 fb^{-1}

$\Upsilon(2S)$: 14 fb^{-1}

Off resonance:

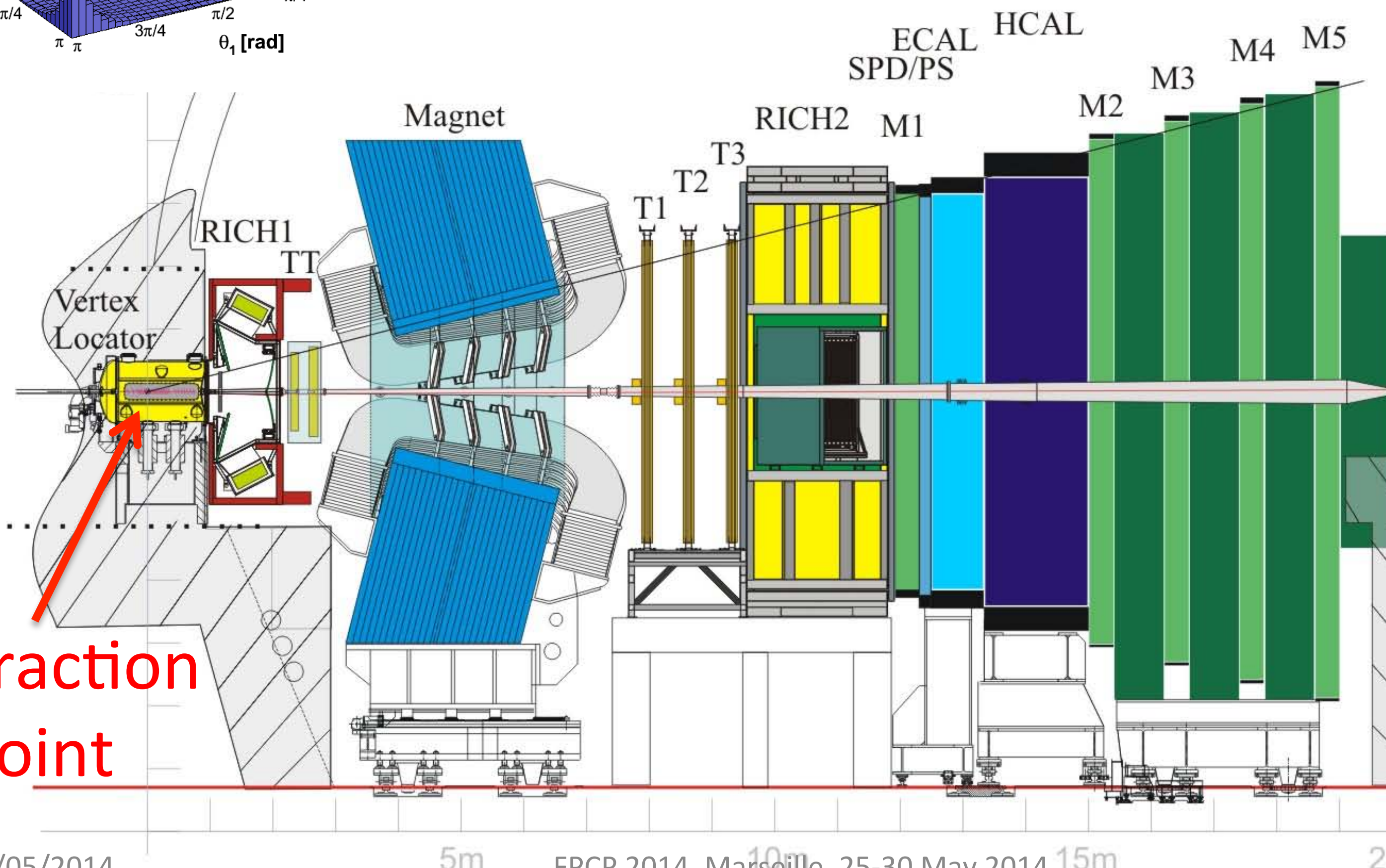
~ 54 fb^{-1}

The LHCb detector



LHCb $\sigma(pp \rightarrow H_b X) = (75 \pm 5 \pm 13)\ \mu b$

[Phys. Lett. B 694, 209-216 (2010)]



Approximate acceptance:
$2 < \eta < 5$

~4% of solid angle
~40% of heavy quarks

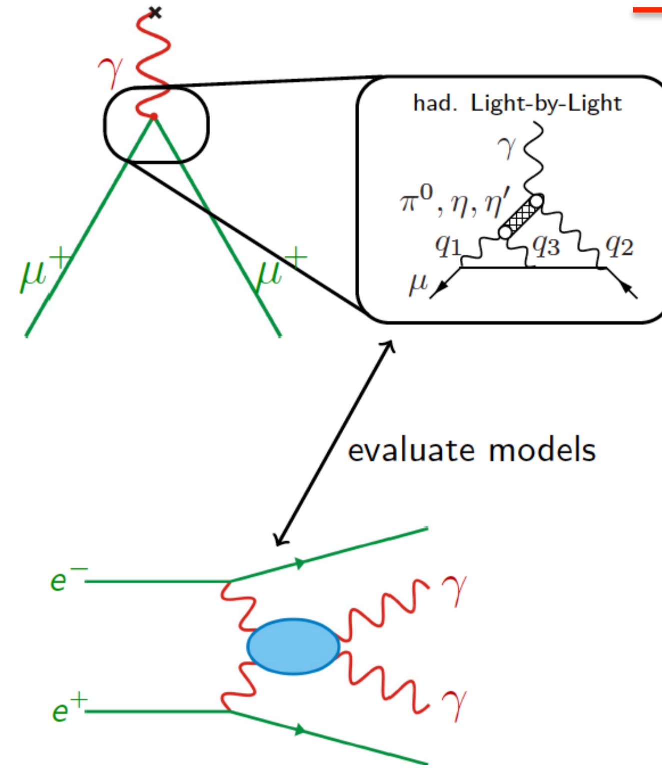
Motivation

- Magnetic moment:

$$\vec{\mu} = g\frac{e\hbar}{2mc}\vec{S}$$

- Expect g = 2 for fermions but QFT implies some deviation
- Muon anomaly: $a_\mu = (g-2)_\mu/2$

$$a_\mu^{\text{theory (SM)}} = a_\mu^{\text{QED}} + a_\mu^{\text{weak}} + a_\mu^{\text{had.}}$$



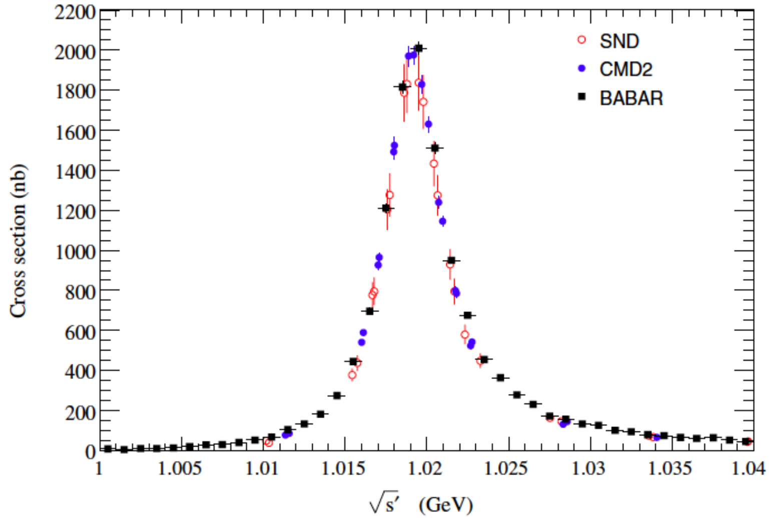
Source	Value	Uncertainty
Expt.	11 659 208.9	6.3
QED	11 658 471.895	0.008
Weak	15.4	0.2
Hadronic		

(units of 10^{-10})

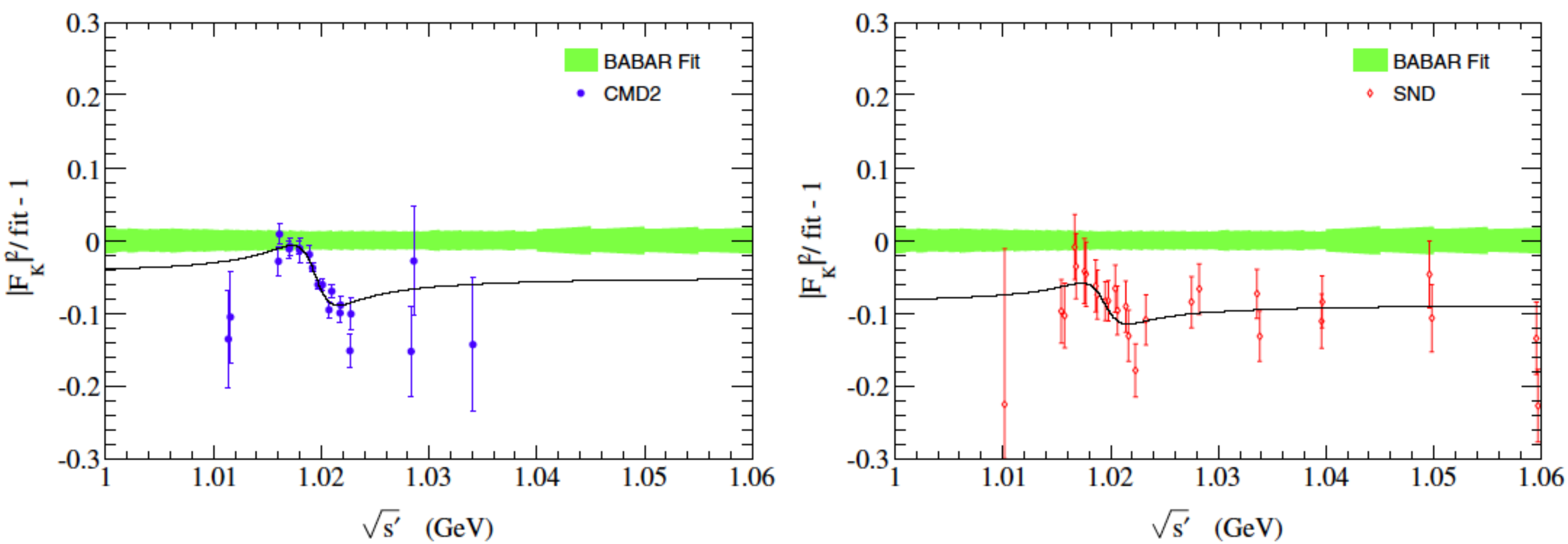
- arXiv:0901.0306 [hep-ph]
- **$a_\mu^{LBL} = 10.5 \pm 2.6$**

PRD 88, 032013 (2013)

K^+K^- cross section

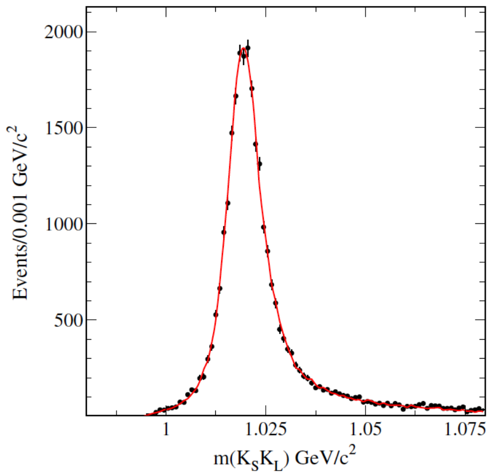


- Results in region of the phi peak consistent with previous results within calibration uncertainties



PRD 89, 092002 (2014)

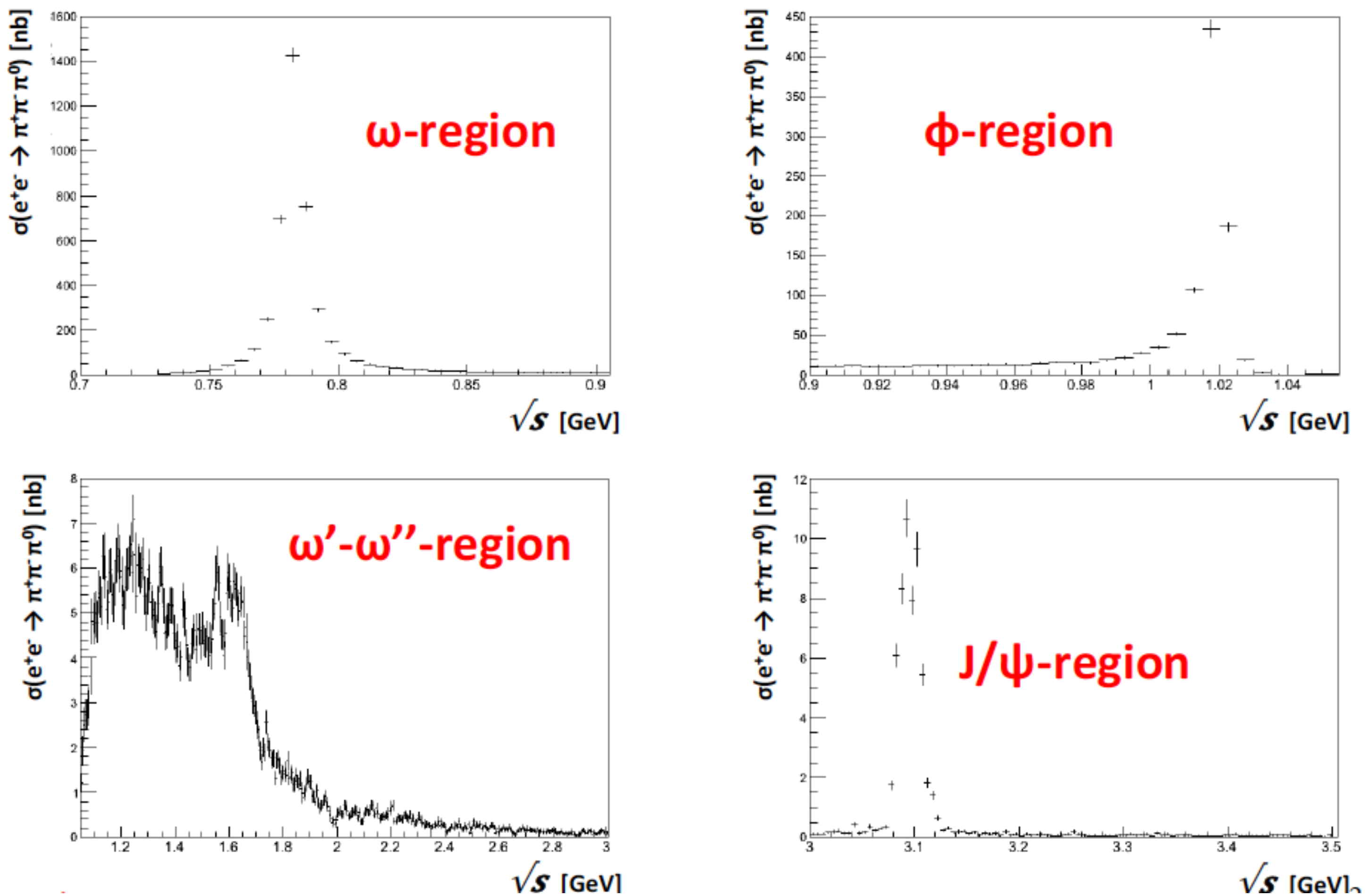
$K_S K_L$ cross section



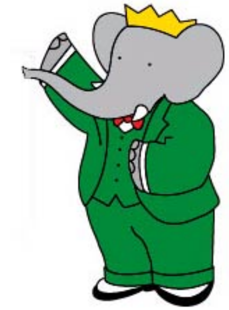
- Background subtracted data fitted to obtain cross section and parameters of phi peak
- Systematic uncertainty of 2.9%, dominated by the software background filter

	BABAR	CMD-2	PDG(2012)
σ_0	$1409 \pm 33 \pm 42 \pm 15\,\mathrm{nb}$	$1376 \pm 6 \pm 23\,\mathrm{nb}$	-
$m_\phi\,[\mathrm{MeV}/c^2]$	$1019.46 \pm 0.04 \pm 0.05 \pm 0.03$	$1019.48 \pm 0.01 \pm 0.03$	1019.46 ± 0.02
$\Gamma_\phi\,[\mathrm{MeV}]$	$4.205 \pm 0.103 \pm 0.050 \pm 0.045$	$4.280 \pm 0.033 \pm 0.025$	4.26 ± 0.04
$\Gamma_\phi^{ee}\mathcal{B}_{K_S^0 K_L^0}\,[\mathrm{keV}]$	$0.4200 \pm 0.0033 \pm 0.0122 \pm 0.0019$	-	-
$\Gamma_\phi^{ee}\,[\mathrm{keV}]$	$1.228 \pm 0.037 \pm 0.0140^{PDG}_{\mathcal{B}(\phi \to K_S^0 K_L^0)}$	$1.235 \pm 0.006 \pm 0.022$	1.27 ± 0.04
$\mathcal{B}_{ee}\mathcal{B}_{K_S^0 K_l^0} \cdot 10^4$	$0.986 \pm 0.030 \pm 0.009^{PDG}_{\Gamma_\phi}$	-	1.006 ± 0.016

$\pi^+\pi^-\pi^0$ cross section



arXiv:1403.7501
Submitted to PRD



Mixing angle θ_P

- Value found from ratio of $K^*_0(1430)$ decays to ηK and πK

$$\frac{\mathcal{B}(K_0^*(1430)\to\eta K)}{\mathcal{B}(K_0^*(1430)\to\pi K)} = 0.092 \pm 0.025^{+0.010}_{-0.025} \qquad \theta_P = \left(3.1^{+3.3}_{-5.0}\right)^\circ$$

- Quite different from many previous determinations, which find around −20°
- Possible explanation in [Int. J. Mod. Phys. **A15** (2000) 159-207], which suggests that two angles are needed θ_0 and θ_8
- Finds θ_8 around −20° and θ_0 around −9°
- This BaBar determination is consistent with the latter