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X Y Z states @ P̄ANDA

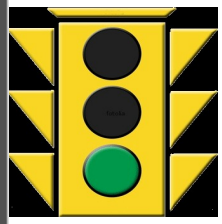
Summary on behalf of A. Blinov, M. Galuska, S. Lange, E. Prencipe, S. Spataro

Preface

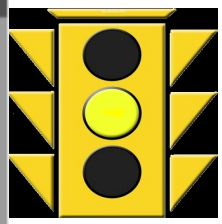
Goals of this talk:

- Discussion on the X(3872)
- Discussion on the Y(4260)
- Show extrapolations on Z(3900), from Y(4260)

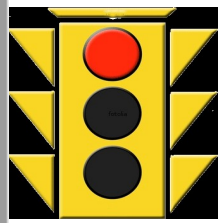
Markers:



Approved, reviewed, published



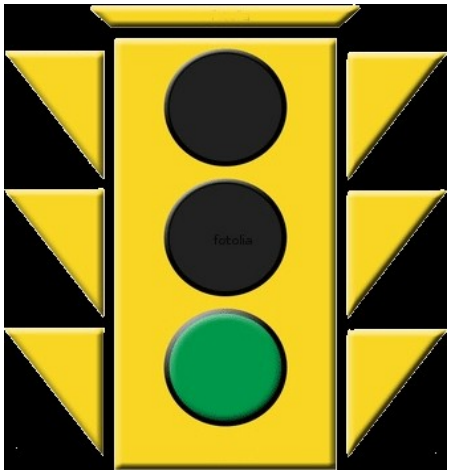
Approved, reviewed, published, and extrapolated to different luminosity



Not approved, under discussion during this meeting

Introduction

- Approved results on X(3872) and Y(4260) are shown
- Formulas on how calculations are preformed
- New ideas how to look for Z states are explained
- Discussion on future plans



X(3872)

- QWG 2011. Martin's work is shown (pandaroot rev-8466)
- > 20 proceedings written and published since 2011, in $\bar{P}$ANDA (EPJ, Nucl. Phys. B proc. of conf. Pos-Sissa,..)

- Official reference to refer to:

  M. Galuska et al., PoS (Bormio 2012) 018.

- No release note exists, because it is a work done 4 years ago. Informations are taken from the conference proceedings

Bundesministerium für Bildung und Forschung

JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

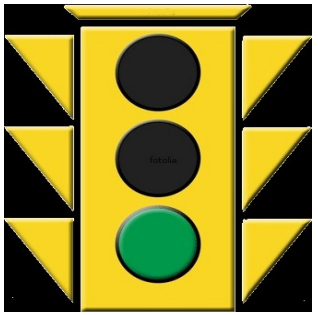
panda

HIC for FAIR
Helmholtz International Center

Simulation Results for a Resonance Scan of the X(3872) at $\overline{\text{P}}$ANDA *

8th International Workshop on Heavy Quarkonium 2011, GSI Darmstadt

Martin J. Galuska†, Svende A. Braun, Wolfgang Kühn,
J. Sören Lange and Björn Spruck for the $\overline{\text{P}}$ANDA Collaboration



II. Physikalisches Institut, JLU Gießen

October, 5th 2011

Slides 4-12:
Courtesy of M. Galuska
from QWG2011

*This work was supported in part by BMBF (06GI9107I) and HICforFAIR.

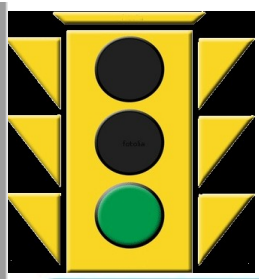
†Martin.J.Galuska@physik.uni-giessen.de

Input Parameters for Simulation of X(3872) Resonance Scan at $\overline{\text{P}}$ANDA

Mass $m_{X(3872)}$	3.872 GeV
Width $\Gamma_{X(3872)}$	100 keV
Production	$p\bar{p} \to X(3872)$ ($\sigma_{BW} = 50$ nb)*
Decay	$X(3872) \to J/\psi\, \pi^+\pi^-$ (BR $= 0.1$)
Subsequent Decay	$J/\psi \to e^+e^-$ (BR $= 0.06$)†
Time Requirement	$20 \cdot 2$ days
Accelerator duty factor	50%
Luminosity	0.864 pb^{-1}/day
HESR	High resolution mode
p_{beam} distribution	Gaussian, rms $\simeq 2 \cdot 10^{-5} \cdot p_{beam}$
$\sqrt{s}$ distribution	Gaussian, rms $\simeq$ 33.6 keV

*Corresponds to: BR(X(3872) $\to p\bar{p}$) $\simeq 3.9 \cdot 10^{-5}$

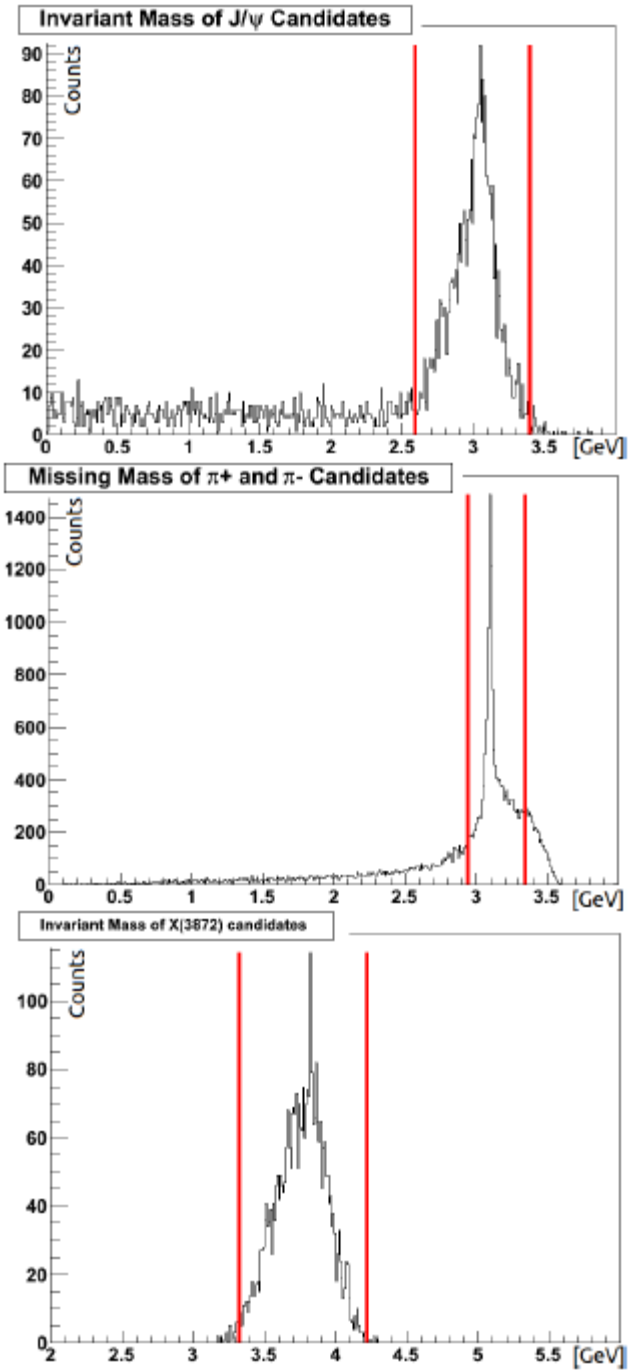
†K. Nakamura et al. (PDG) J. Phys. G37, 075021 (2010)



Reconstruction Procedure

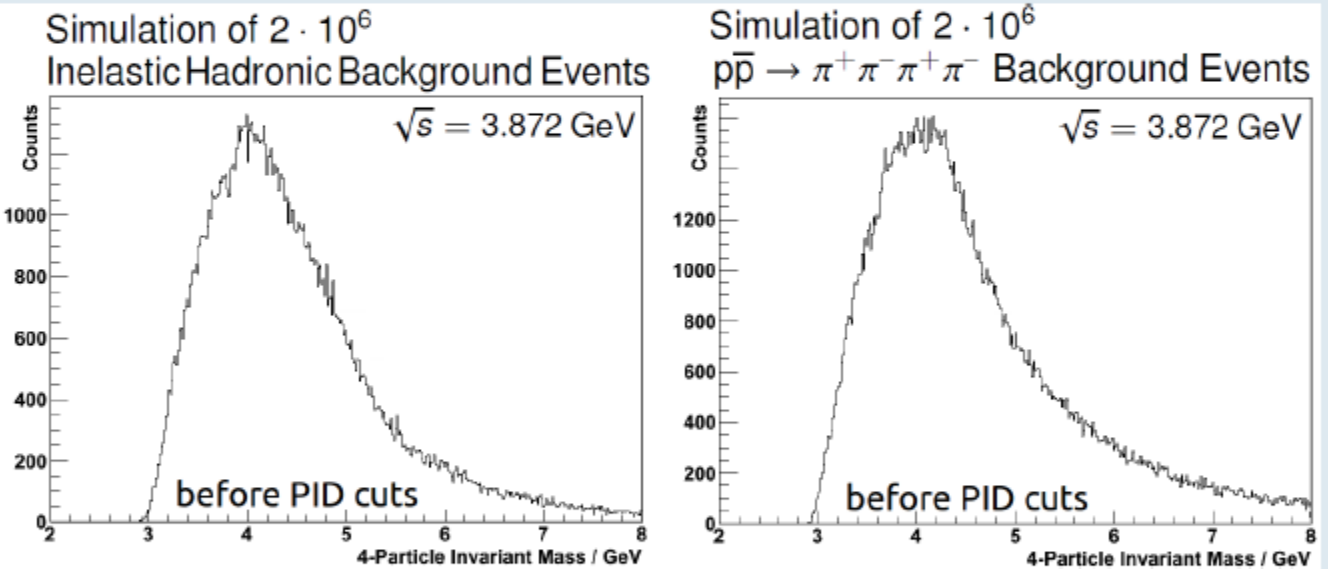
1. Apply PID cuts.
2. Cut on invariant mass of all e^+e^- candidates.
   → J/ψ candidates.
3. Cut on missing mass of all $\pi^+\pi^-$ candidates.
4. Cut on invariant mass of $e^+e^-\pi^+\pi^-$ candidates.
   → X(3872) candidates.
   → Signal counts for scan point.

Plots are shown for simulation of $p\bar{p} \to X(3872)$ signal events at $\sqrt{s} = 3.872$ GeV with subsequent $X(3872) \to J/\psi\,\pi^+\pi^-$ and $J/\psi \to e^+e^-$ decays.



Study of Background Processes

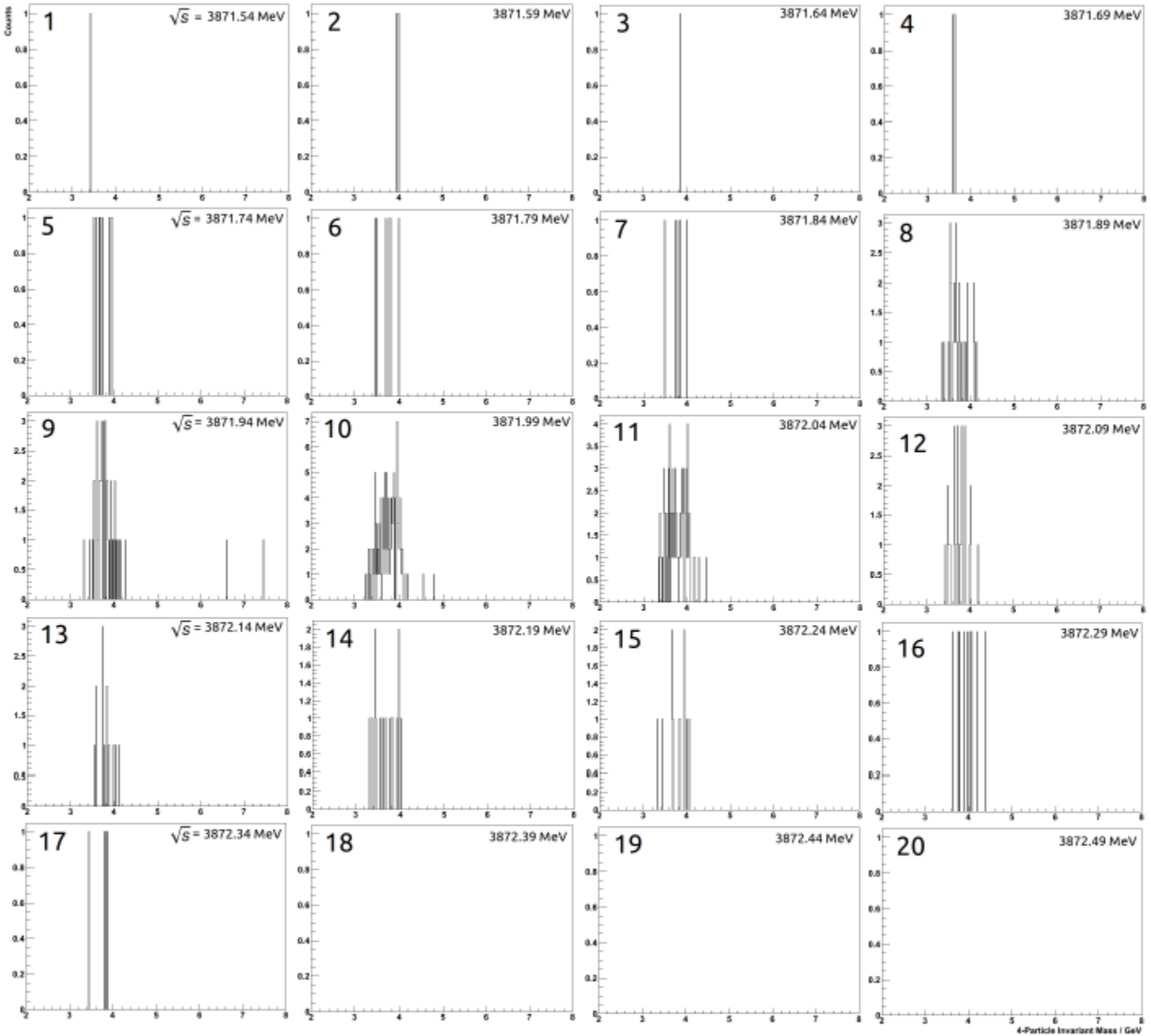
- Direct process $\sigma(p\bar{p} \to J/\psi\, \pi^+\pi^-) = 1.2$ nb* for $\sqrt{s} \simeq m_{X(3872)}$.
- All other processes assumed to be suppressible with PID
  - $\sigma_{\text{inelastic}} \simeq 45$ mb†
  - $\sigma(p\bar{p} \to \pi^+\pi^-\pi^+\pi^-) \simeq 50\ \mu$b‡
  - Study of events produced with dual parton model based generator⊥



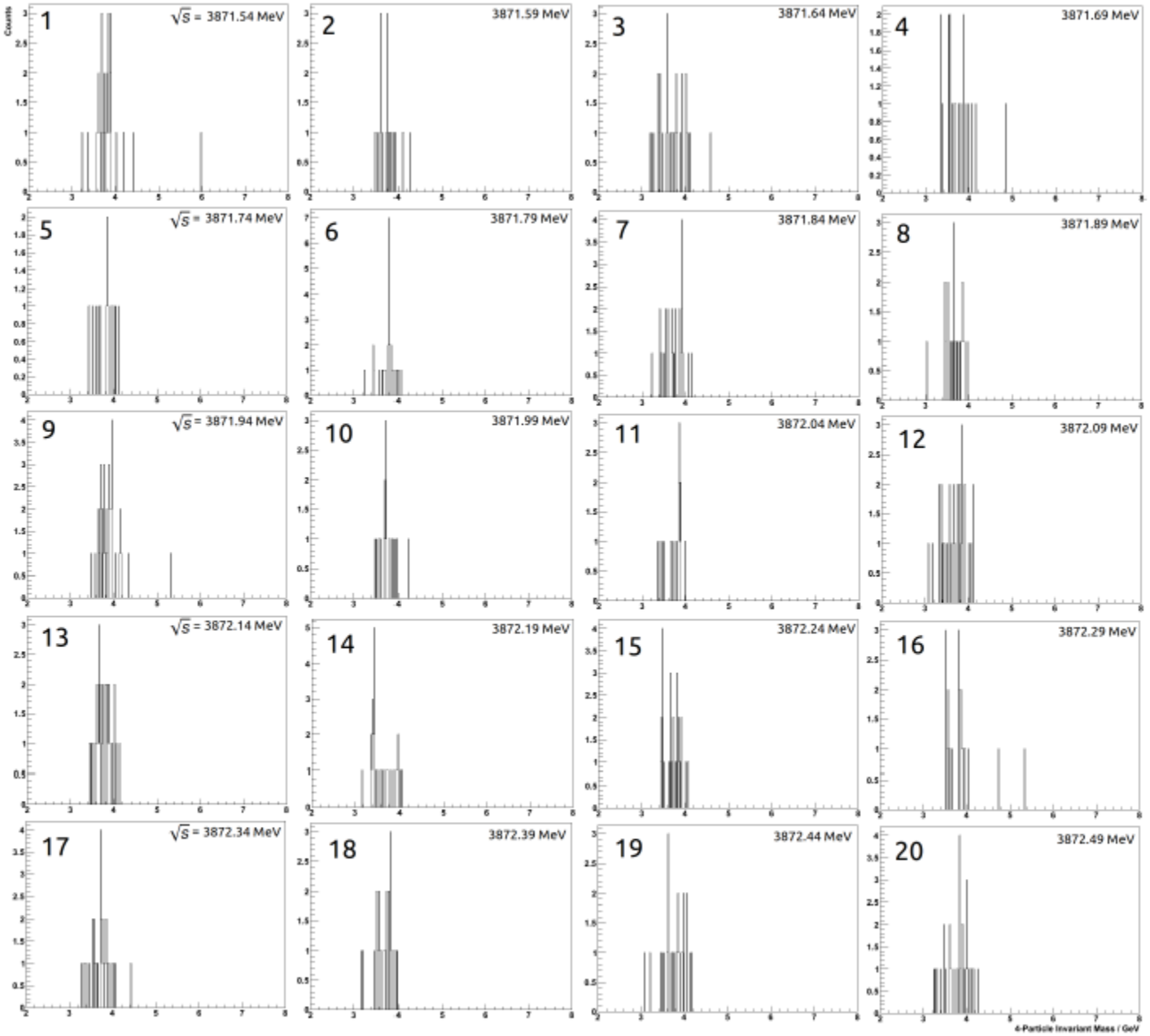
- After PID cuts: No fake signals observed.
- Investigation of larger sample sizes will follow.

* G. Y. Chen, J. P. Ma, Phys. Rev. D77(2008)097501
† K. Nakamura et al. (PDG) J. Phys. G37, 075021 (2010)
‡ V. Flaminio et al. (Compilation of Cross-Sections) CERN-HERA-79-03 (1979)
⊥ V. Uzhinsky, A. Galoyan, hep-ph/0212369

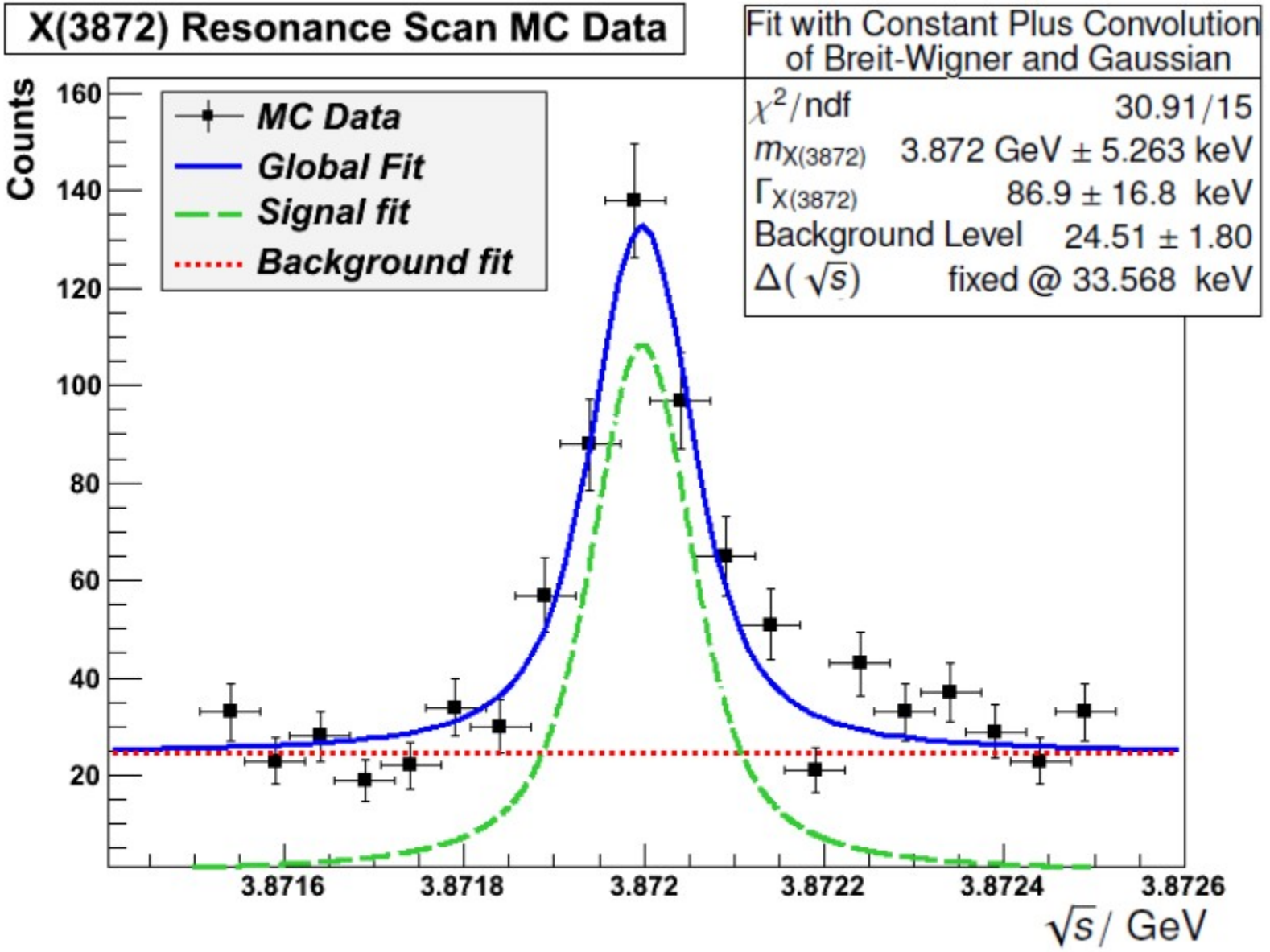
Signal Simulation for X(3872) Resonance Scan



Background Simulation for X(3872) Resonance Scan



X(3872) Resonance Scan MC Data

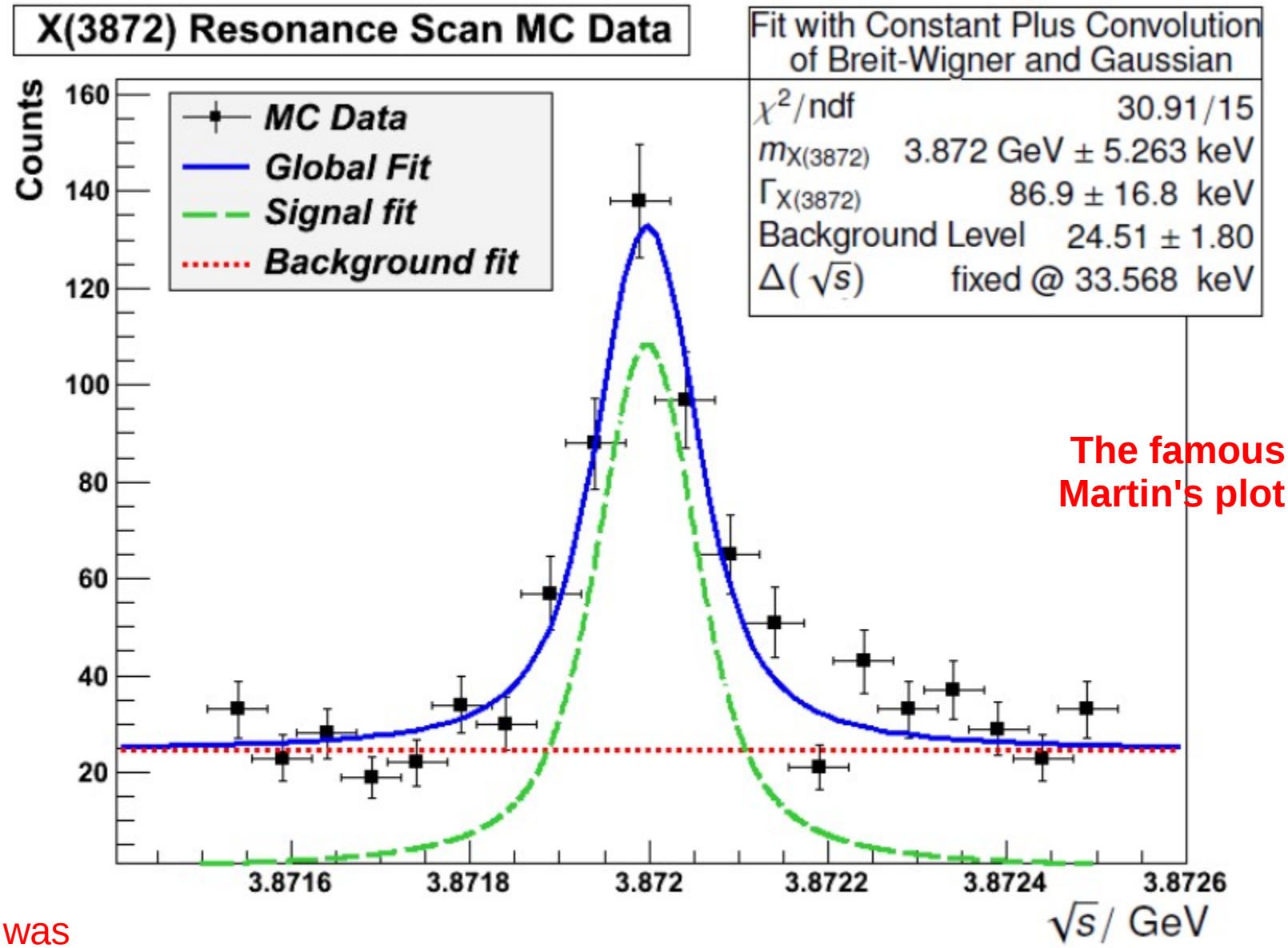


Fit with Constant Plus Convolution of Breit-Wigner and Gaussian

χ^2/ndf	30.91/15
$m_{X(3872)}$	3.872 GeV ± 5.263 keV
$\Gamma_{X(3872)}$	86.9 ± 16.8 keV
Background Level	24.51 ± 1.80
$\Delta(\sqrt{s})$	fixed @ 33.568 keV

Reconstructed width $\Gamma_{X(3872)}$ is consistent with input width of 100 keV.*

*Results are preliminary. Only statistical errors are shown.



The famous Martin's plot!

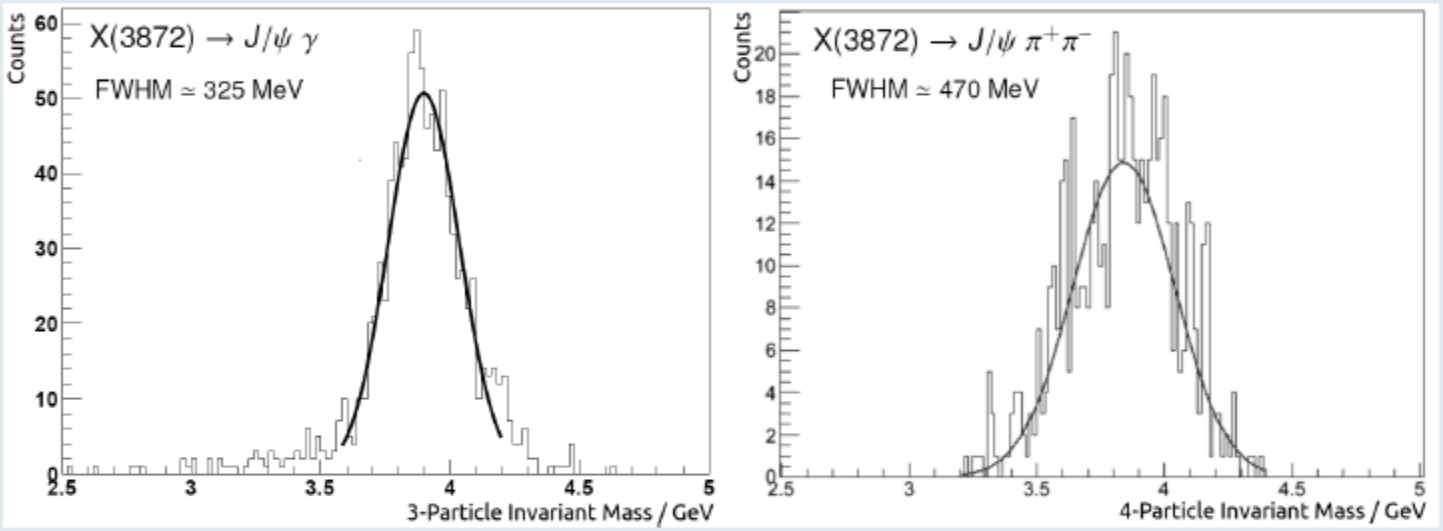
It was 2011!!

Reconstructed width $\Gamma_{X(3872)}$ is consistent with input width of 100 keV.*

*Results are preliminary. Only statistical errors are shown.

Comparison of X(3872) → $J/\psi\,\gamma$ and X(3872) → $J/\psi\,\pi^+\pi^-$

- $9 \cdot \mathrm{BR}(\mathrm{X}(3872) \to J/\psi\,\gamma) \simeq \mathrm{BR}(\mathrm{X}(3872) \to J/\psi\,\pi^+\pi^-)^*$
- Efficiency before PID: $\varepsilon(J/\psi\,\gamma) \simeq \varepsilon^2_{\mathrm{track}} \cdot \varepsilon_\gamma \leftrightarrow \varepsilon(J/\psi\,\pi^+\pi^-) \simeq \varepsilon^4_{\mathrm{track}}$
- Mass resolution: 325 MeV ↔ 470 MeV



- Main background: $p\bar{p} \to \pi^+\pi^-\pi^0$ ($\sigma \simeq 70\ \mu b^\dagger$) with misidentified $\pi^\pm$ and one γ from $\pi^0 \to \gamma\gamma$ lost in beampipe.
- Background analysis will show whether X(3872) → $J/\psi\,\gamma$ might be favorable for $\overline{\mathrm{P}}$ANDA.

* Derived from product branching fractions of *B*-decays.

† V. Flaminio et al. (Compilation of Cross-Sections) CERN-HERA-79-03 (1979)

...more on the X(3872) in $\bar{P}$ANDA:

S. Lange et al., arXiV:1311.7597 (2013) [hep-ex]

- Proceedings of the CHARM2013 conference
- Reviewed by P. Gianotti, approved, and submitted (2013)
- No X(3872) simulation update

Slide 15-18; 21-23 from CHARM2013

Status and Plan of $\overline{\text{P}}$ANDA

New Studies of XYZ at $\overline{\text{P}}$ANDA

S. Lange, M. Galuska, S. Reiter *(University Giessen)*
E. Prencipe *(FZ Jülich)*
S. Spataro *(University and INFN Torino)*

CHARM 2013, 08/31-09/04/2013, Manchester, UK
on behalf of the $\overline{\text{P}}$ANDA collaboration

This talk - only MC

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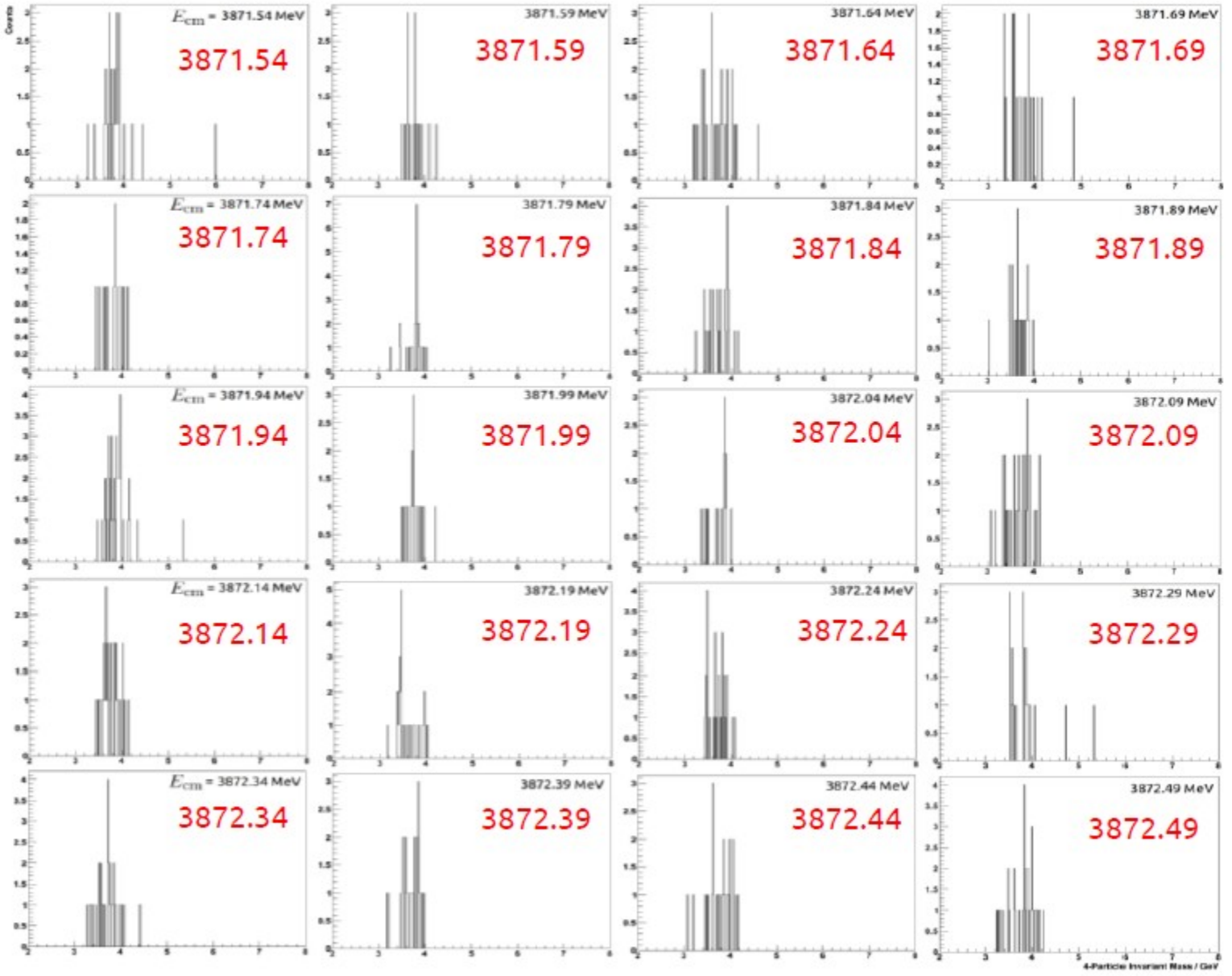
Example: Resonance Scan of X(3872) → J/ψ π+π−



How do we know cross sections @ $\overline{\text{P}}$ANDA ?
→ Detailed balance

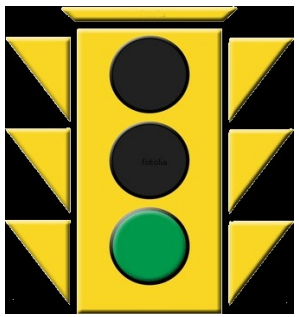
Production
@ Panda

$$\sigma[p\bar{p} \to X(3872)] = \sigma_{BW}[p\bar{p} \to X(3872) \to \text{all}](m_{X(3872)})$$

$$= \frac{(2J+1)\cdot 4\pi}{m^2_{X(3872)} - 4m_p^2} \cdot \frac{\mathcal{B}(X(3872) \to p\bar{p}) \cdot \overbrace{\mathcal{B}(X(3872) \to f)}^{=1} \cdot \Gamma^2_{X(3872)}}{\underbrace{4(m_{X(3872)} - m_{X(3872)})^2}_{=0} + \Gamma^2_{X(3872)}}$$

$$\overset{(J=1)}{=} \frac{3\cdot 4\pi}{m^2_{X(3872)} - 4m_p^2} \cdot \mathcal{B}(X(3872) \to p\bar{p})$$

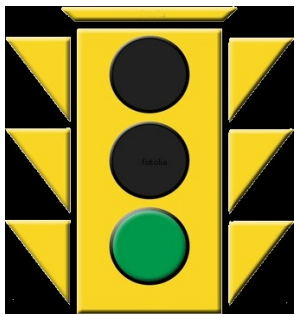
Decay
@ Belle, BaBar, Bes3, LHCb



Cross section estimates from detailed balance

Table: Peak cross sections $\sigma^{\text{peak}}_{[\bar{p}p\to R]}$ for $\bar{p}p \to R$ assuming Breit Wigner distributions with constant small width Γ_R.

Res. R	J	Mass m [MeV]	$\mathcal{B}(R \to \bar{p}p)$	$\sigma^{\text{peak}}_{[\bar{p}p\to R]}$ ±err. fr. $\mathcal{B}(R \to \bar{p}p)$± err. fr. m_R
$J/\psi(1S)$	1	3096.916 ± 0.011	$(2.17 \pm 0.07) \cdot 10^{-3}$	$5.25 \pm 0.17 \pm 0.00\ \mu$b
$\psi(2S)$	1	$3686.109^{+0.012}_{-0.014}$	$(2.76 \pm 0.12) \cdot 10^{-4}$	$402 \pm 18 \pm 4$ nb
$\eta_c(1S)$	0	2981.0 ± 1.1	$(1.41 \pm 0.17) \cdot 10^{-3}$	$1.29 \pm 0.16 \pm 0.00\ \mu$b
$\eta_c(1S)$	0	2981.0 ± 1.1	$(1.32 \pm 0.19) \cdot 10^{-3}$	$1.21 \pm 0.17 \pm 0.00\ \mu$b
$\eta_c(2S)$	0	3638.9 ± 1.3	$(1.85 \pm 1.26) \cdot 10^{-4}$	$93 \pm 63 \pm 0$ nb
$\eta_c(2S)$	0	3638.9 ± 1.3	$(3.12 \pm 1.65) \cdot 10^{-4}$	$< 157 \pm 83 \pm 0$ nb (95% CL)
$\chi_{c0}(1P)$	0	3414.75 ± 0.31	$(2.23 \pm 0.13) \cdot 10^{-4}$	$134.1 \pm 7.8 \pm 0$ nb
$h_c(1P)$	1	3525.41 ± 0.16	$(8.95 \pm 5.21) \cdot 10^{-4}$	$1.47 \pm 0.86 \pm 0\ \mu$b
$h_c(1P)$	1	3525.41 ± 0.16	$(1.68 \pm 0.05) \cdot 10^{-3}$	$< 2776 \pm 87 \pm 0$ nb (95% CL)
$X(3872)$	1	3871.68 ± 0.17	$(5.31 \pm 0.00) \cdot 10^{-4}$	$< 68.0 \pm 4.0 \pm 0.0$ nb (95% CL)
$X(3915)$	?	3917.5 ± 2.7	$(27 \pm 10) \cdot 10^{-3}$	not isolated



from PDG
from LHCb, arXiv:1303.7133 [hep-ex]
from combination of both (product branching fractions)

CHARM2013, arXiV:1311.7597

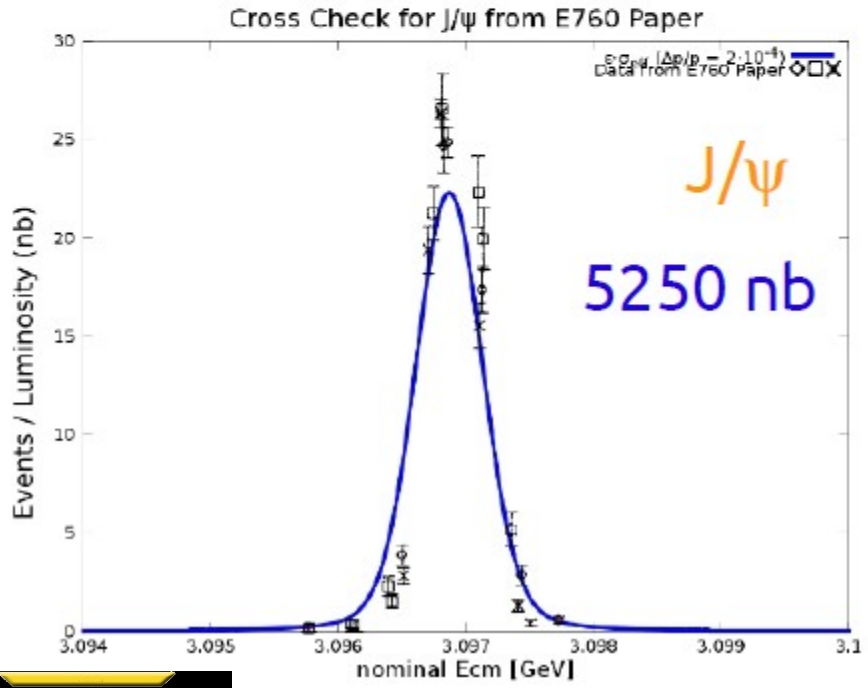
Check of cross section, derived from detailed balance

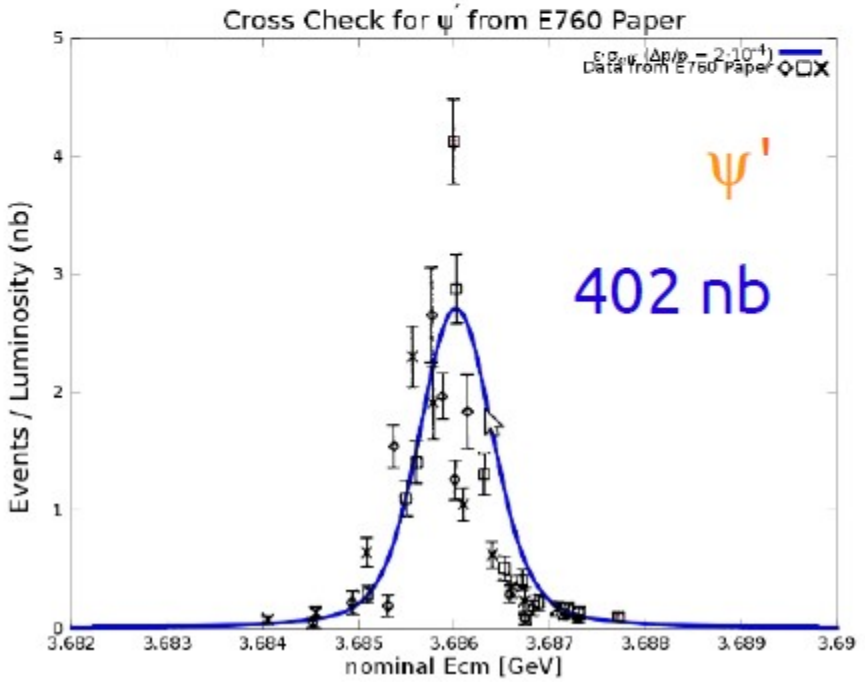
(blue line)

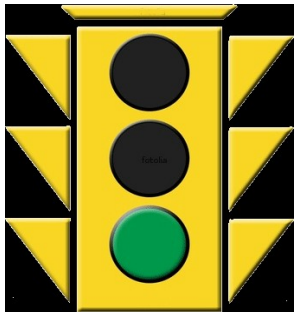
with direct measurement of J/ψ, ψ'

E760, Phys. Rev. D47(1993)772

(data points)







How many X(3872) do we expect in $\bar{P}$ANDA?

$$N = L * \sigma * \varepsilon * BR_i$$

L = luminosity
σ = cross section
ε = reco. efficiency
BR_i = branching fraction of secondary decays

LUMINOSITY

Example of calculation with luminosity = $2 * 10^{31}\ cm^{-2}\ s^{-1}$

duty factor 50%

$$\mathcal{L}_{\text{int}} = \frac{\int \mathcal{L} \cdot \alpha \ \mathrm{dt}}{1\ \text{day}} = \boxed{2 \cdot 10^{31}\ \text{cm}^{-2} \cdot 1\ \text{s}^{-1}} \cdot \frac{1}{2} \cdot \frac{60\ \text{s}}{1\ \text{min}} \cdot \frac{60\ \text{min}}{1\ \text{h}} \cdot \frac{24\ \text{h}}{1\ \text{day}}$$

$$= 10^{31} \cdot (10^{-2})^{-2}\ \text{m}^{-2} \cdot \underbrace{\frac{60}{1} \cdot \frac{60}{1} \cdot \frac{24}{1\ \text{day}}}_{8.64 \cdot 10^4/\text{day}}$$

$$= 8.64 \cdot 10^{39} \cdot \frac{10^{-12} \cdot 10^{-28}}{10^{-12} \cdot \underbrace{10^{-28}\ \text{m}^2}_{1\ \text{b}=10^{-28}\ \text{m}^2}}\ \text{per day}$$

$$= 8.64 \cdot \frac{10^{-1}}{1\ \text{pb}}\ \text{per day} = 0.864\ \text{pb}^{-1}\ \text{per day}$$

CROSS SECTION ⟶ Detailed balance, see slide 17-18

- Question: how the BR(X(3872)) was evaluated?

2011: $\sum_i$ BR$_i$(X(3872) → known measured decay channels) = 10%

2014: $\sum_i$ BR$_i$(X(3872) → known measured decay channels) = 3% ÷ 8%

- In all approved PANDA talks/proceedings, BR = 0.1
- All tables and plots since 2011 until May 2015 are consistent with BR = 0.1

$\sim 700\ X(3872)$ events/day in high luminosiy mode

70 events/day in high resolution mode

- In 2011 only the PANDA central tracker software was implemented.
- In 2015 we still do not have a realistic FTS implemented. Only ideal FTS.
- In 2015 the time-based simulation is work in progress.
- A duty factor 50% is always included in the PANDA calculations.
- I am not aware of other X(3872) simulations ongoing and approved since 2011.
- The numbers of the above published proceedings are the **official** X(3872) ones

Y(4260) and the Y-family

- Presented for the first time at CHARM2013
- Second talk with these informations at ICHEP2014
- Proceedings reviewed and submitted ⇒ approved
- No release note exists, because it is a work done in 2013-2014 (before PubCom rules apply)
- Informations are taken from the proceedings
- Official reference to refer to:

CHARM2013, S. Lange et al., arXiV:1311.7597

ICHEP2014, E. Prencipe et al., arXiv:1410.5201 (2014)
→Nuclear Physics B, proceedings of conferences

Cross section of Y(4260) at $\overline{\text{P}}$ANDA

from detailed balance
→ σ≤4370 nb
due to high upper limit
$\mathcal{B}$(Y(4260) → $\bar{p}p$) / $\mathcal{B}$ (Y(4260) → J/ψπ+π−) < 0.13 (90% C.L.)
BaBar, Phys. Rev. D73(2006)012005

Better approach: scaling $\mathcal{B}(Y(4260) \to \bar{p}p) = \mathcal{B}(J/\psi \to \bar{p}p) \times \frac{\Gamma(J/\psi)}{\Gamma(Y(4260)}$

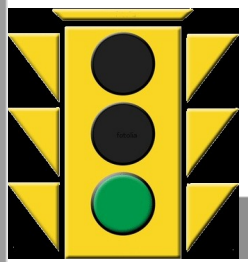
σ=1.9±0.2 nb ($\mathcal{L}$=2 x 10^{32} cm^{-2} s^{-1}, planned)
$\overline{\text{P}}$ANDA is Y(4260) mini-„factory“ → 16.400 events per 1 day

Comparison to BESIII

σ=62.9±1.9±3.7 pb ($\mathcal{L}$=5.3 x 10^{32} cm^{-2} s^{-1}, achieved)
Phys. Rev. Lett. 110, 252001 (2013)

Comparison to Belle II

- Y(4260) in *B* decays never observed
- in ISR ≤30.000 events in 50 ab^{-1} (≥8 years)
  assuming $\mathcal{B}$(Y(4260) → J/ψπ+π−)=100%



What can $\bar{P}$ANDA do?

Search for rare decay Y(4260) → e+ e−

Not observed yet, although $J^{PC}=1^{--}$

Limit from coupling to initial state

$\mathcal{B}(J/\psi\pi^+\pi^-) \times \mathcal{B}(e^+ e^-) = (7.5\pm0.9\pm0.8)$ eV

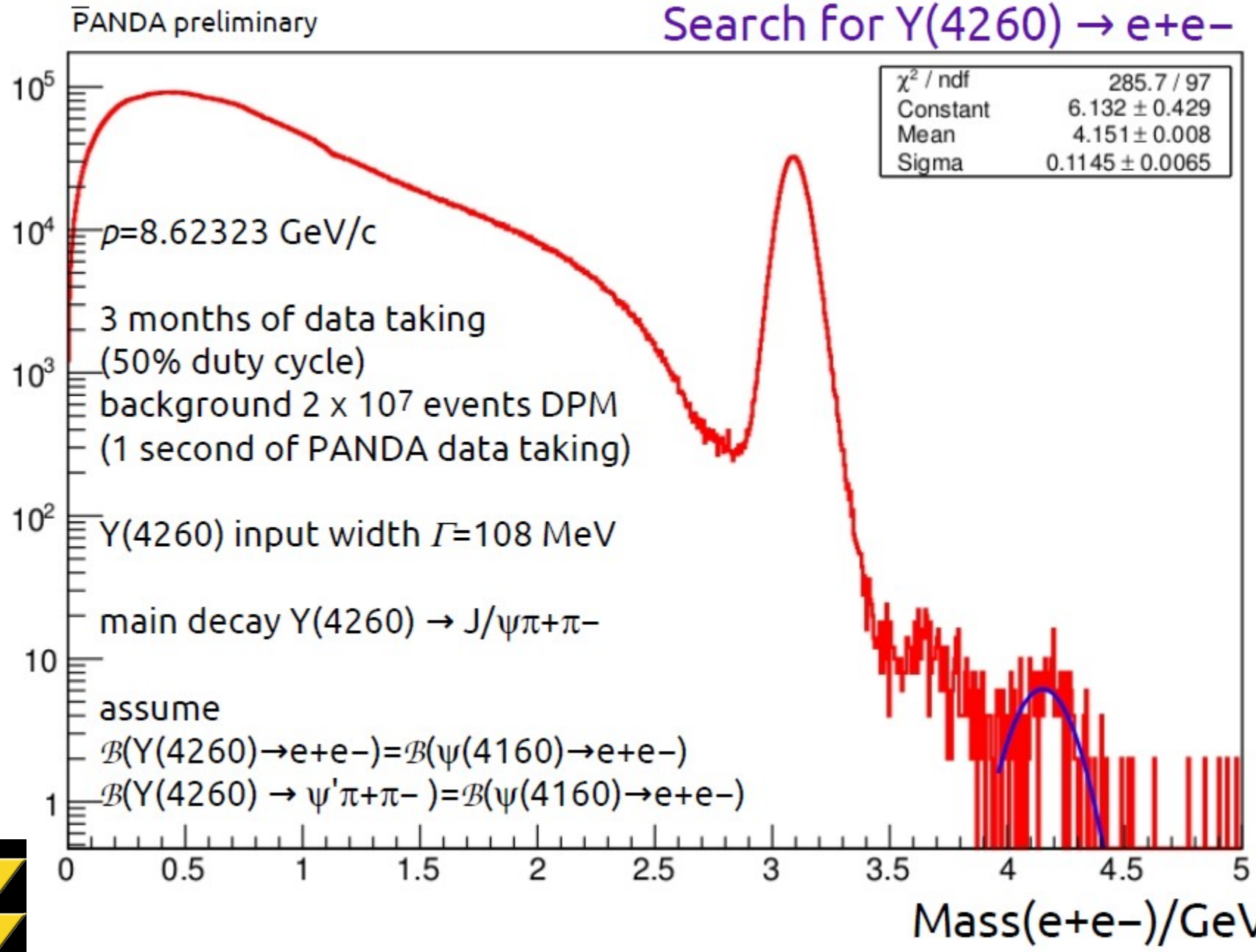
BaBar, arXiv:0808.1543

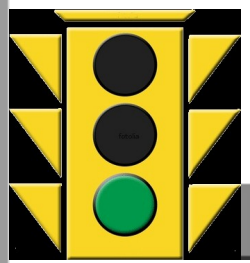
Partial width of the order „eV“
of a state which is Γ~100 MeV total width
→ factor $\geq 10^7$ suppressed

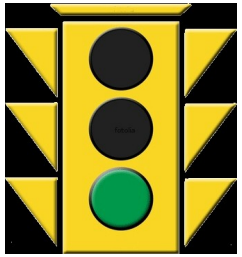
Test if annihilation (wavefunction at r=0) suppressed

- if $[c\bar{c}]_8 g$ hybrid, minimum of hybrid potential Π_u not centered
  → talk by E. Braaten, Saturday, 12:00
- enhanced long-range wavefunction, if $\bar{D}D_1(2420)$ molecule ?

Search for Y(4260) → e+e−







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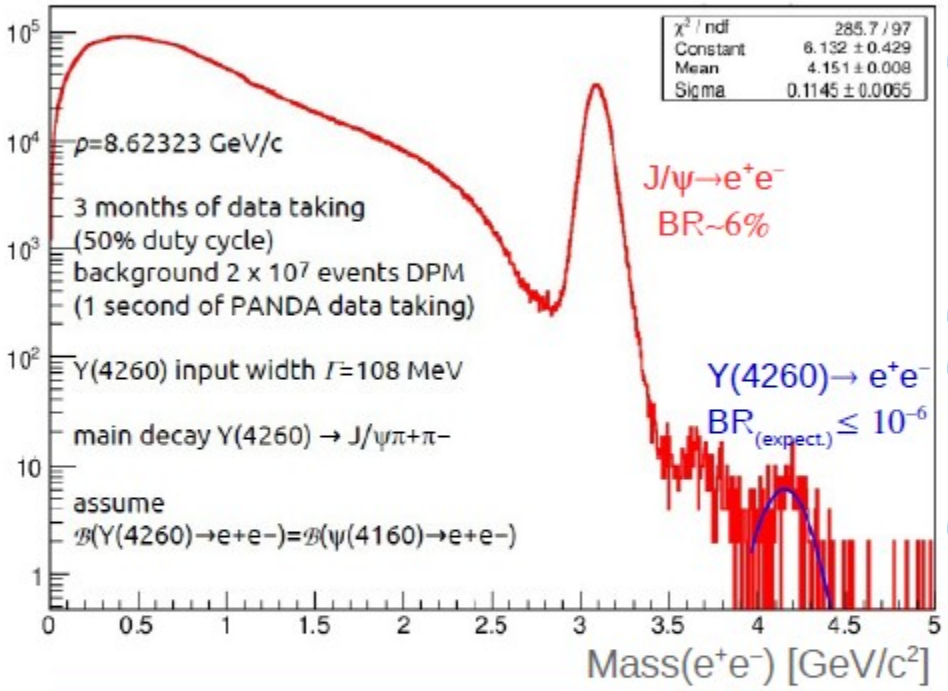
Status and Perspectives for $\overline{\text{P}}$ANDA @ FAIR

July 3rd, 2014 | Elisabetta Prencipe, Forschungszentrum Jülich | ICHEP 2014 – Valencia (Spain)

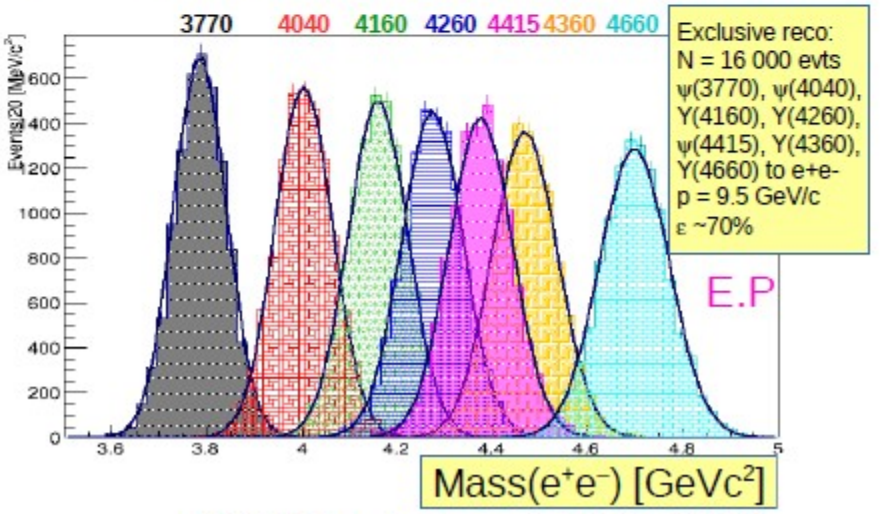
Challenge: interference effect in rare decays

- $\overline{p}p \rightarrow$Y(vector state), Y$\rightarrow e^+e^-$



PDG	BR($\psi \rightarrow e^+e^-$)	Γ/MeV
ψ(3770)	$(9.6\pm 0.7)\times10^{-6}$	27.2±1.0
ψ(4040)	$(1.07\pm 0.16)\times10^{-5}$	80±10
ψ(4160)	$(8.1\pm 0.9)\times10^{-6}$	103±8
ψ(4415)	$(9.4\pm 3.2)\times10^{-6}$	62±20

- $\overline{\text{P}}$ANDA: *mini*-Y(4260) factory.
  Expected ~16000 Y/day (high lum. mode)
- Y(4260) → e^+e^- not observed, yet:
  limit from coupling to initial state
  $\mathcal{B}(J/\psi\pi^+\pi^-) \times \mathcal{B}(e^+e^-) = (9.2\pm0.8)$ eV
  BaBar, PRD 86 (2012) 051102
- Overpopulated 1^- Charmonium spectrum
- In $\overline{\text{P}}$ANDA possibility to study very rare decays: Y(4260) $\rightarrow e^+e^-$ would be an absolute measurement
- 1^- states are large: they can interfere



Pandaroot-scrut14

E. Prencipe

ICHEP Conference, 2-9 July .2014

arXiv:1410.5201 (2014)

Then, $\bar{P}$ANDA numbers published on Y(4260) are:

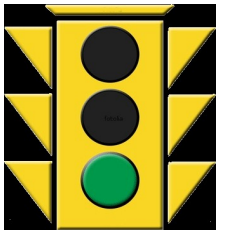
16400 $Y(4260)$ events per day are expected in high luminosity mode

1640 $Y(4260)$ events per day are expected in high resolution mode

We assume 100% total Y(4260) decay rate

Additional reference: Martin's talk @ Sept2013 Panda coll. meeting

These are the approved and published Y(4260) numbers ⇨ **official**



arXiV:1311.7597[hep-ex] CHARM13
arXiv:1410.5201 [hep-ex] ICHEP14

JÜLICH FORSCHUNGSZENTRUM

$\overline{\text{P}}$ANDA is:

- mini-Y(4260) factory:
- 16400 prod. evt/day expected @ L = 2 x 10^{32}
- extrapolation @ L = 10^{31} : 820 Y(4260)/day

- BES III : Phys. Rev. Lett. 110 (2013) 252001

Observation of a Charged Charmoniumlike Structure in $e^+e^- \to \pi^+\pi^- J/\psi$ at $s\sqrt{}$=4.26 GeV

$$\frac{\sigma(e^+e^- \to \pi^\pm Z_c(3900)^\mp \to \pi^+\pi^- J/\psi)}{\sigma(e^+e^- \to \pi^+\pi^- J/\psi)} = (21.5\pm3.3\pm7.5)\%$$

- mini-X(3872) factory:
- 432k prod. evt/day expected @ L = 2 x 10^{32}
- extrapolation @ L = 10^{31} : 21600 X(3872)/day

- BES III : Phys. Rev. Lett. 112 (2014) 092001

Observation of $e^+e^- \to \gamma X(3872)$ at BESIII

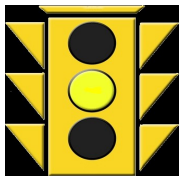
Observed transition Y(4260) $\to \gamma$ X(3872)

$$\frac{\sigma(e^+e^- \to \gamma X(3872))B(X(3872 \to \pi\pi J/\psi)}{\sigma(e^+e^- \to \pi^+\pi^- J/\psi)} = 0.52\%$$

@4.26 GeV

Use $\overline{\text{P}}$ANDA data set collected @ Y(4260) energy

Expectation in $\overline{\text{P}}$ANDA @ L = 10^{31} :



1) 176 $Z_c(3900)$/day, $Z_c(3900) \to \pi J/\psi$

2) Study transition X(3872)$\to Z\pi$

How?

Table 1: Summary of the observed Z resonant structures

Resonance	Mass [MeV/c^2]	Width [MeV]	Decay	J^P	
$Z(4430)^+$	$4433\pm4(\text{stat})\pm2(\text{syst})$	$45^{+18}_{-13}(\text{stat})^{+30}_{-13}(\text{syst})$	$\psi(2S)\pi^+$		[1]
$Z_c(3900)^+$	$3899.0\pm3.6(\text{stat})\pm4.9(\text{syst})$	$46\pm10(\text{stat})\pm20(\text{syst})$	$J/\psi\pi^+$, D^0D^{*-}		[2]
$Z_c(3900)^0$	$3894.8\pm2.3(\text{stat})$	$29.6\pm8.2(\text{stat})$	$J/\psi\pi^0$		[3]
$Z_c(4020)^+$	$4022.9\pm0.8(\text{stat})\pm2.7(\text{syst})$	$7.9\pm2.7(\text{stat})\pm2.6(\text{syst})$	$h_c\pi^+$		[4]
$Z_c(4020)^0$	$4023.6\pm2.2(\text{stat})\pm3.9(\text{syst})$	-	$h_c\pi^0$		[5]
$Z_c(3885)^+$	$3883.9\pm1.5(\text{stat})\pm4.2(\text{syst})$	$24.8\pm3.3(\text{stat})\pm11.0(\text{syst})$	$D^+\bar{D}^{*0}$	1^+	[6]
$Z_c(4025)^+$	$4026.3\pm2.6(\text{stat})\pm3.7(\text{syst})$	$24.8\pm5.6(\text{stat})\pm7.7(\text{syst})$	$D^{*+}\bar{D}^*$		[7]

[1] PRL 100(2008)142001; [2] PRL 110(2013)252001; [3] PLB 727(2013)366; [4] arXiV:1309.1806; [5] ICHEP2014; [6] PRL 112(2014)022001; [7] PRL 112(2014)132001.

- Reasonably expected Z states near $\bar{D}D$ threshold, never observed ($m_z \sim 3730$ MeV/c^2)

  X(3872)→ Z(3730)π transition kinematically allowed

  → suppressed at e^+e^- colliders

- Proposal @ $\bar{P}$ANDA:

$$\bar{p}p \to Z(3730)^0\pi^0\ ,\ Z(3730)^0 \to J/\psi\gamma,$$
$$\bar{p}p \to Z(3730)^0\pi^0\ ,\ Z(3730)^0 \to \chi_{c1}\pi^0,$$
$$\bar{p}p \to Z(3730)^+\pi^-\ ,\ Z(3730)^+ \to \chi_{c1}\pi^+, \text{ with } \chi_{c1} \to J/\psi\gamma$$

Unique for $\bar{P}$ANDA!

How are calculations performed?

Table 2: Summary of the expected X, Y, and Z production rates per day in $\overline{\mathrm{P}}$ANDA, assuming different detector luminosity ($\mathcal{L}/(\mathrm{cm}^{-2}\ \mathrm{s}^{-1})$). The calculation is performed by multiplying luminosity, cross section and a detector duty factor of 50%.

Resonance	n. with $\mathcal{L}= 2\times10^{32}$	n. with $\mathcal{L}= 2\times10^{31}$	n. with $\mathcal{L}= 10^{31}$	Ref.
$X(3872)$	432000	43200	21600	[20]
$Y(4260)$	16400	1640	820	[20, 21]
$Z(3900)^+$	3526	353	176	[13, 20, 21]

[13] M. Ablikim *et al.* (BESIII), Phys. Rev. Lett. 110 (2013) 252001.

[19] M. Galuska *et al.*, PoS (Bormio 2013) 023.

[20] S. Lange *et al.*, arXiV:1311.7597 (2013) [hep-ex].

[21] E. Prencipe *et al.*, arXiv:1410.5201 (2014) [hep-ex].

$N = \mathscr{L} * \sigma *$ duty factor 50%

$N_Z = N_Y * 21.5\%$ [13]

Resonance	n. with $\mathcal{L}= 2\times10^{32}$	n. with $\mathcal{L}= 2\times10^{31}$	n. with $\mathcal{L}= 10^{31}$	Ref.
$X(3872)$	700 (*)	70 (*)	35 (*)	[19, 20]
$Y(4260)$ (**)	16400	1640	820	[20, 21]
$Z(3900)^+$ (**)	3526	353	176	[13, 20, 21]

[13] M. Ablikim *et al.* (BESIII), Phys. Rev. Lett. 110 (2013) 252001.

[19] M. Galuska *et al.*, PoS (Bormio 2013) 023.

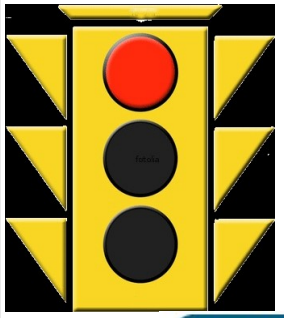
[20] S. Lange *et al.*, arXiV:1311.7597 (2013) [hep-ex].

[21] E. Prencipe *et al.*, arXiv:1410.5201 (2014) [hep-ex].

(*) **N = $\mathcal{L}$ * σ *ε * BR$_i$** = 50 nb $*\mathcal{L}$ * ε * BR$_i$. BR(J/ψ →e^+e^-) = 0.06; BR (X(3872))=0.1; ε = 27%

A full sim. analysis is performed for X(3872), but no forward spectrometer is included in this old simulation (→2011). Higher N is expected when the analysis will be done again (mar15?)

(**) Only produced events. Analysis note is still not available to quote reconstructed events.



Note: Martin is at the end of his PhD thesis time. A note on X(3872) will be documented later on. From his talk at the Coll meeting (2013):

Tightest Upper Limit for X(3872) Peak Production Cross Section in $p\bar{p}$

$$\sigma^{\text{peak}}_{[p\bar{p}\to X(3872)]} \overset{(J=1)}{<} \frac{3\cdot 4\pi}{m_{X(3872)}{}^2 - 4m_p^2}\cdot 2.0\cdot 10^{-3}\cdot 2.6\cdot 10^{-2} = 66.6 \pm 6.7 \text{ nb}$$

using $\mathcal{B}(B^+ \to X(3872)K^+ \to p\bar{p}K^+)$ the result is 68.0 ± 4.0 nb

Comparison With Assumptions in Previous Work

Resonance Scan with $\sigma^{\text{peak}}_{[p\bar{p}\to X(3872)]} = 50$ nb and $\Gamma_{X(3872)} = 100$ keV was shown to be feasible [gal11] with

2011
- $\mathcal{B}(X(3872) \to J/\psi\pi^+\pi^-) = 10\%$ (estimated)
- $\Delta p_{\text{beam}}/p_{\text{beam}} \leq \mathbf{2}\cdot 10^{-5}$ [phb09]
- Luminosity $\mathcal{L} = 2\cdot 10^{31}$ cm^{-2} s^{-1} [phb09]

The current values are

2013
- $\mathcal{B}(X(3872) \to J/\psi\pi^+\pi^-) > 2.6\%$ [pdg12]
- $\Delta p_{\text{beam}}/p_{\text{beam}} \leq \mathbf{4}\cdot 10^{-5}$ [stt12]
- **Peak** Luminosity $\mathcal{L} = 2\cdot 10^{31}$ cm^{-2} s^{-1} [stt12]

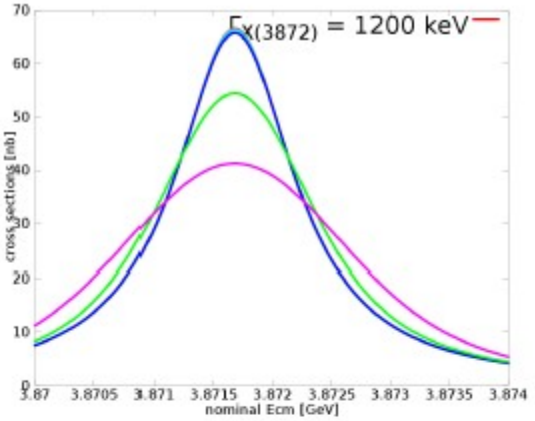
Software upgrade, different input values

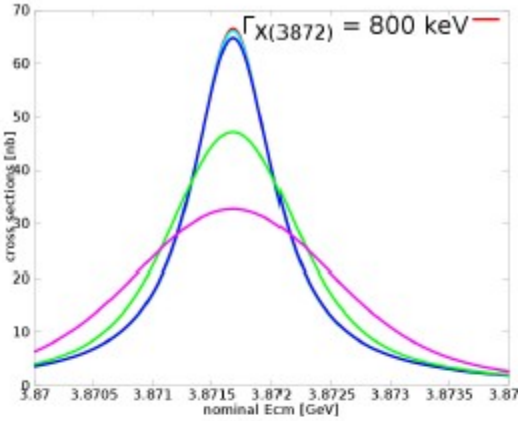
higher reco. X(3872) statistics, but nothing approved right now

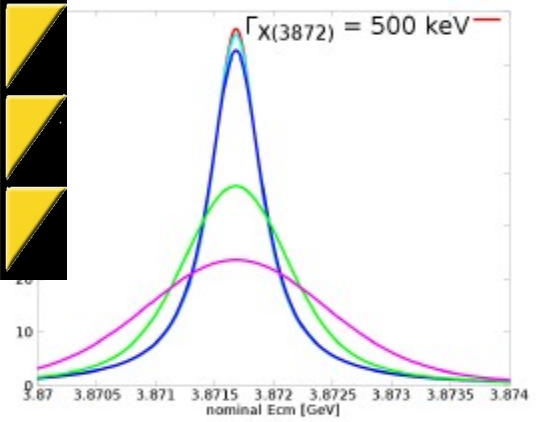
[phb09] The PANDA Collaboration: Physics Book (2009)
[stt12] The PANDA Collaboration: STT TDR (2012)
[gal11] M. J. Galuska, J. S. Lange: Talk at QWG (2011)

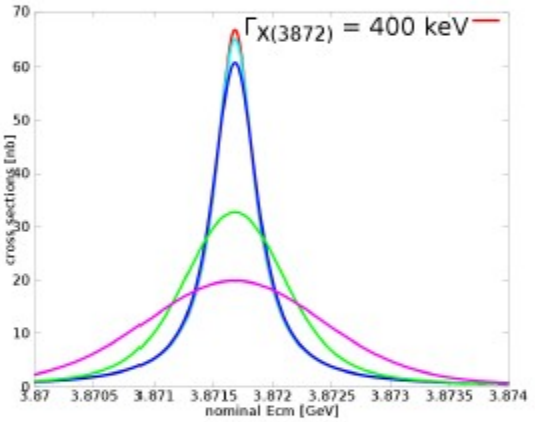
True and effective cross sections for different total widths $\Gamma_{X(3872)}$

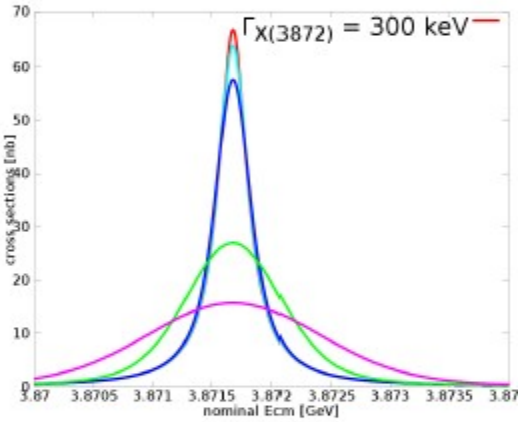
σ_{BW} (Breit Wigner)
σ_{eff} ($\Delta p/p = 2 \cdot 10^{-5}$)
σ_{eff} ($\Delta p/p = 4 \cdot 10^{-5}$)
σ_{eff} ($\Delta p/p = 2 \cdot 10^{-4}$)
σ_{eff} ($\Delta p/p = 4 \cdot 10^{-4}$)

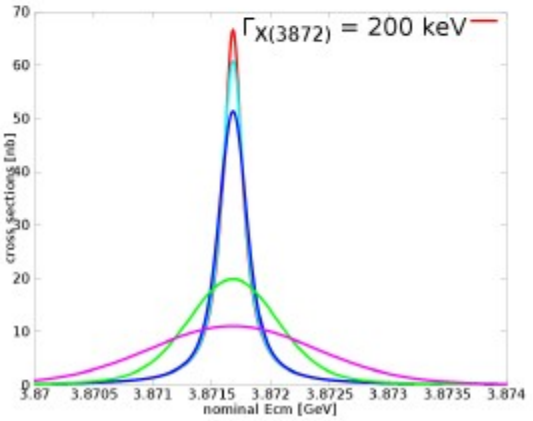


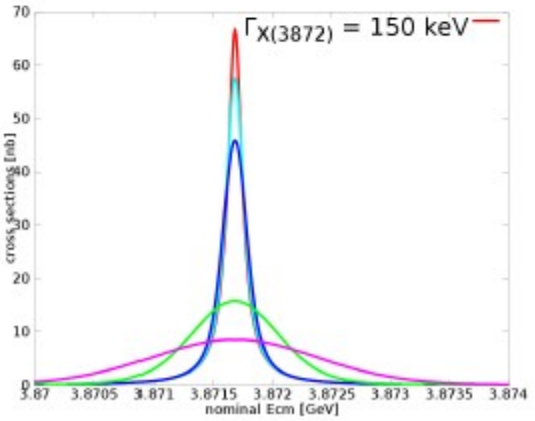


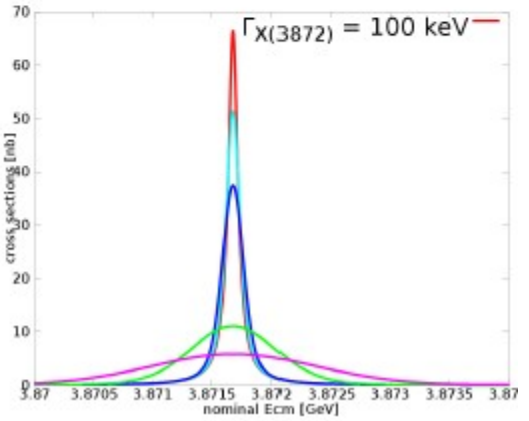












What does it mean high luminosity mode, high resolution mode, low luminosity mode?

High Luminosity				
Beam Mom [GeV/c]	cms Energy [GeV/c2]	Cross Section [mb]*	Average Luminosity [cm-2s-1]**	Interaction Rate [MHz]
1,50	2,25	100,26	5,0E+31	5,01
4,06	3,09	65,80		
8,90	4,31	57,51		
11,91	4,92	51,70		
15,00	5,47	51,00	1,6E+32	8,16

Low Luminosity				
Beam Mom [GeV/c]	cms Energy [GeV/c2]	Cross Section [mb]*	Average Luminosity [cm-2s-1]***	Interaction Rate [MHz]
1,50	2,25	100,26	7,0E+30	0,70
4,06	3,09	65,80		
8,90	4,31	57,51		
11,91	4,92	51,70		
15,00	5,47	51,00	1,1E+31	0,56

* http://lxpndwww.gsi.de/pbarx/showdata.php?chan=1000
** Panda Physics Performance Report page 29 Figure 2.15
*** https://indico.gsi.de/getFile.py/access?contribId=24&sessionId=7&resId=0&materialId=slides&confId=2366

Panda Physics Performance Report page 29 Figure 2.15

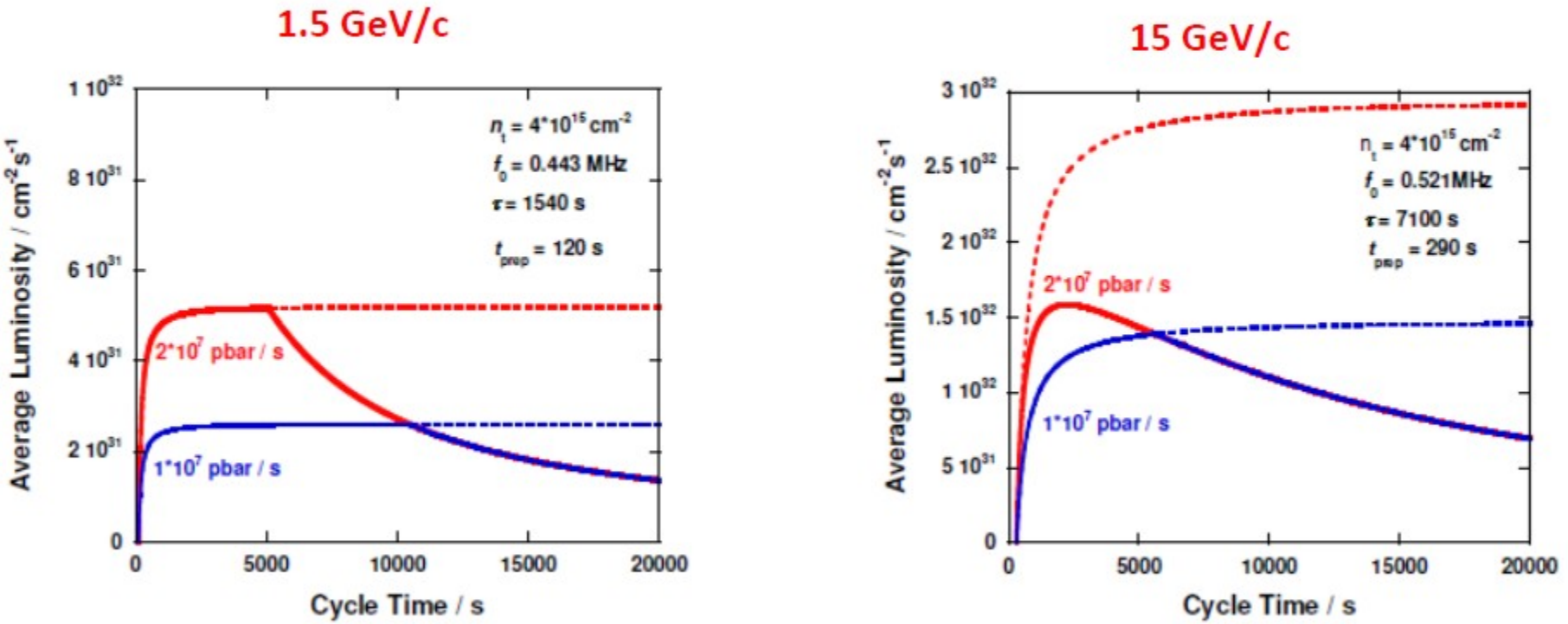
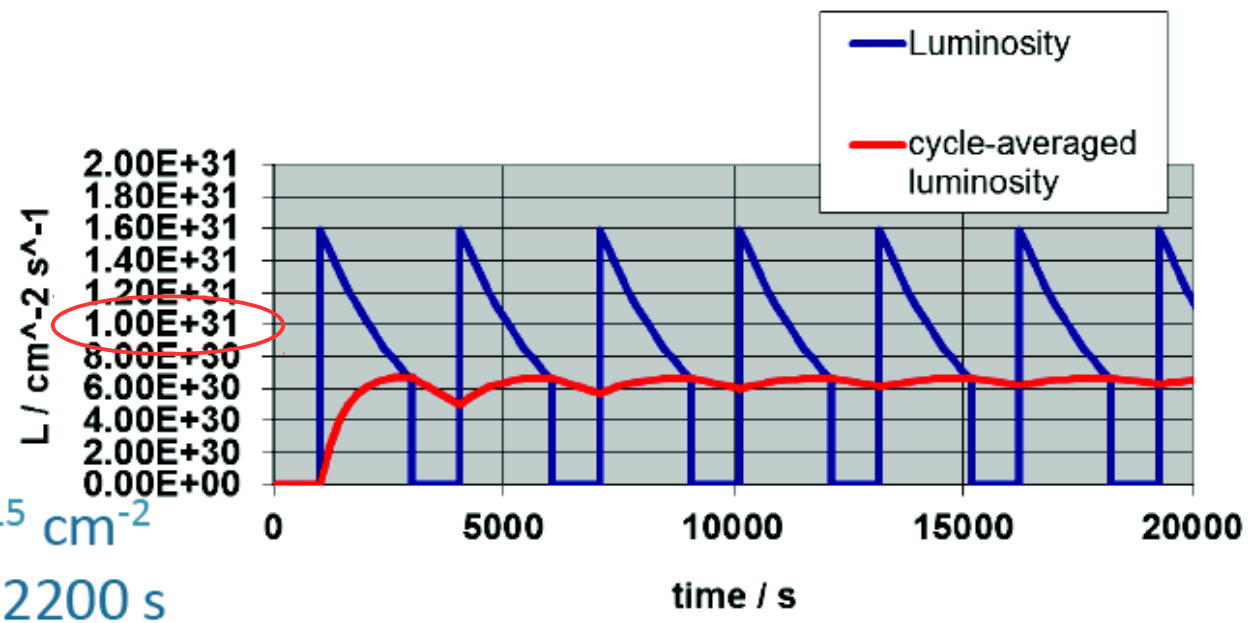
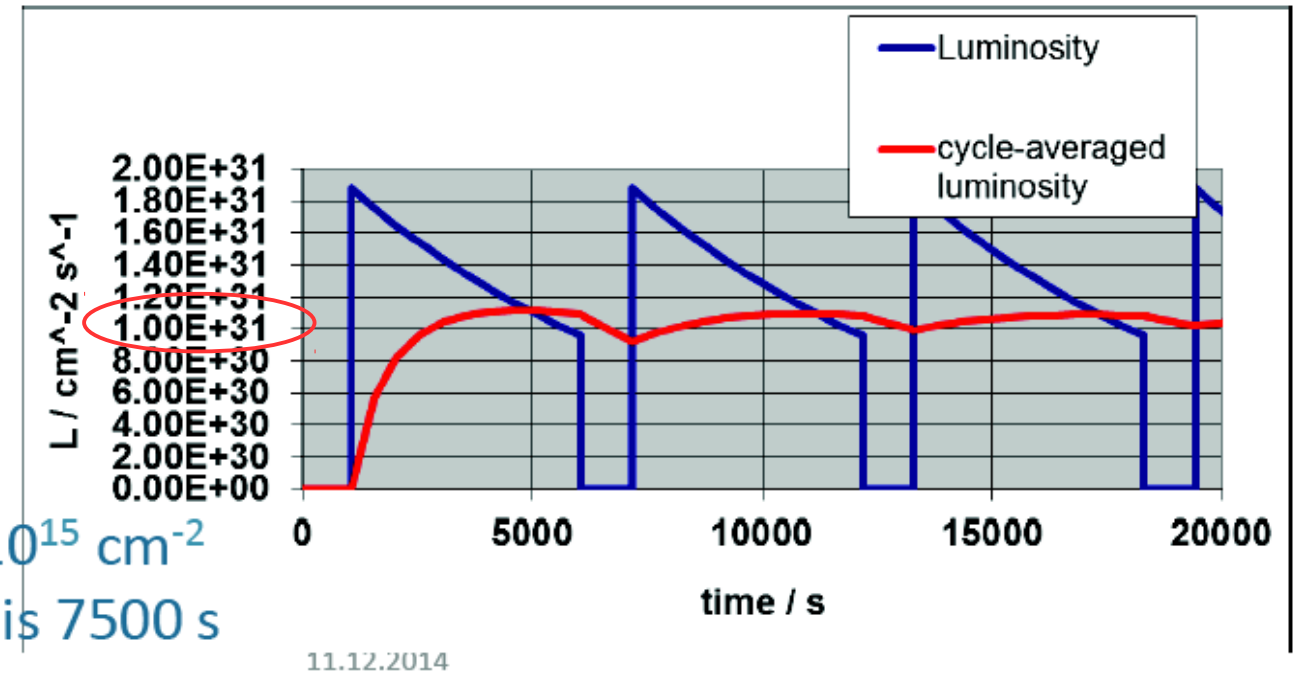


Figure 2.15: The maximum number of particles is limited to 10^{11} (solid line), and unlimited (dashed lines).

Low luminosity



p = 1.5 GeV/c
target thickness = $4*10^{15}$ cm^{-2}
➔ 1/e-beam lifetime is 2200 s



p = 15 GeV/c
target thickness = $4*10^{15}$ cm^{-2}
➔ 1/e-beam lifetime is 7500 s

Some points of discussion, today:

- We have approved results for X(3872), and Y(4260). Green light !
- Extrapolations to L = 10^{31} cm^{-2} s^{-1} → 0.432 pb^{-1}/day have been shown.
  Are we going to update the published results? To what/how? No clue.
  Who is willing to work on the new simulations, then?
  No release note, no update (new PubCom rules)!

Which luminosity shall we use to perform calculations and show results, from now?

- Proposed Z state search: do we switch on the green light ?
- My question: simulation on Z(3730) ⇒ need to use a code in /development/.
  Am I authorized to proceed with the new emc-code?
- My request: can I get 2-3 Tb disk space on Prometheus, for this simulation?

Thank you for your kind attention!

My special thanks to Alexander, Martin, Sören and Stefano,
with whom I've been working on X Y Z states,
for the useful discussion, great cooperation,
and extremely valuable effort.

Time for questions.....