

X Y Z states @ \bar{P} ANDA

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

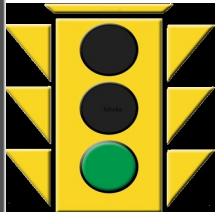
July 1th, 2015 | Elisabetta Prencipe, Forschungszentrum Jülich | Discussion on XYZ states

Preface

Goals of this talk:

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

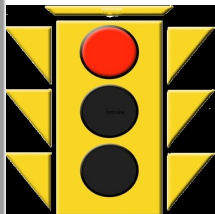
Markers:



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 performed
- New ideas how to look for Z states are explained
- Discussion on future plans



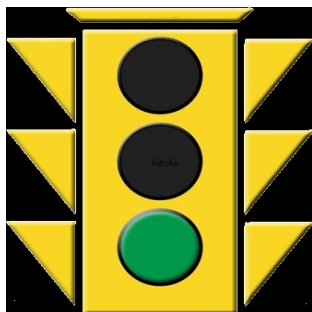
X(3872)

- QWG 2011. Martin's work is shown ([pandaroot rev-8466](#))
- > 20 proceedings written and published since 2011, in PANDA (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

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

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 $\bar{P}ANDA$ 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

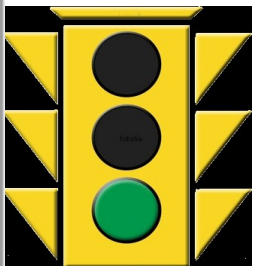
Input Parameters for Simulation of X(3872) Resonance Scan at PANDA

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



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

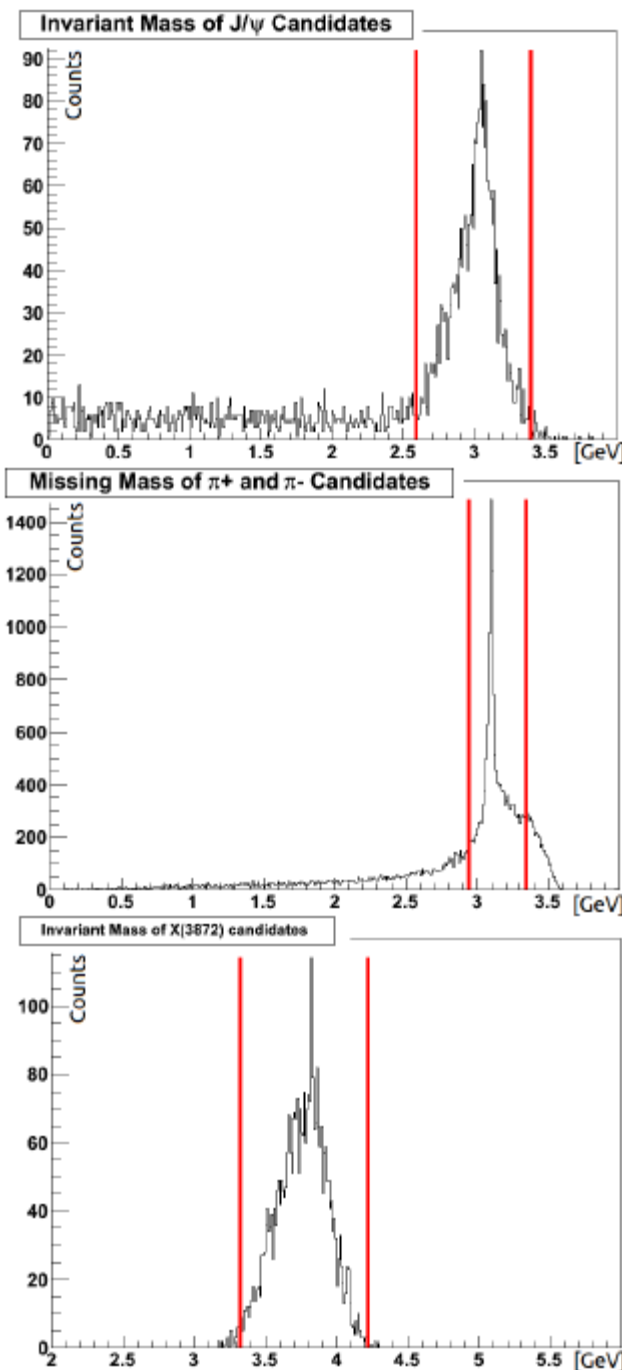
[†] K. Nakamura et al. (PDG) J. Phys. G37, 075021 (2010)



Reconstruction Procedure

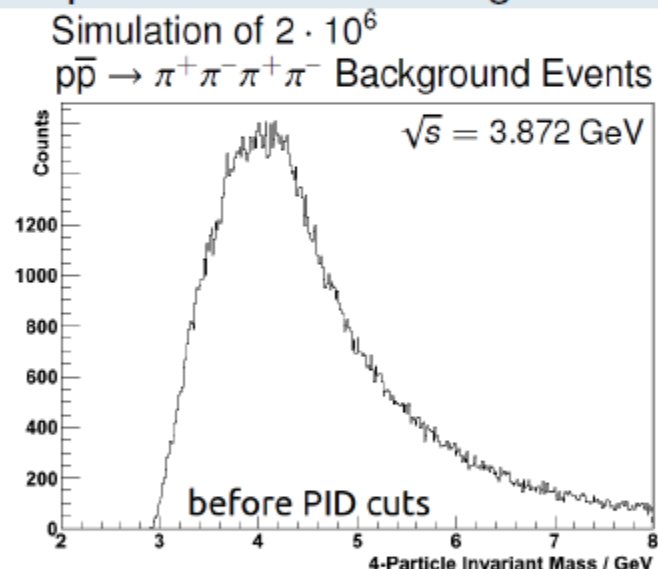
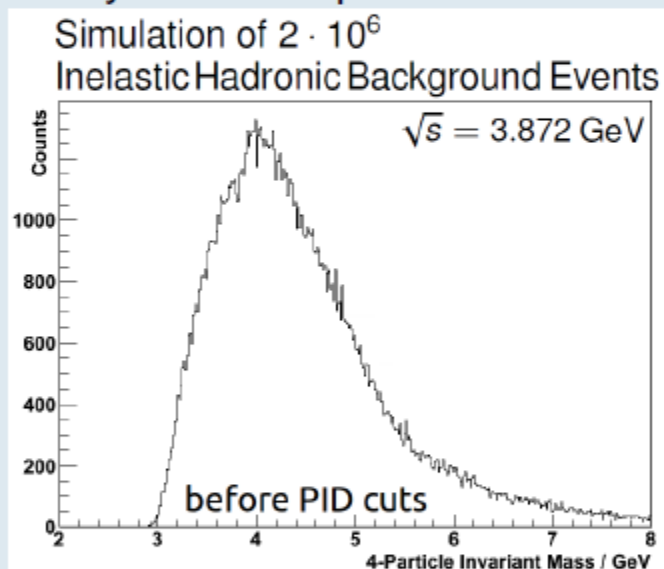
- 1 Apply PID cuts.
- 2 Cut on invariant mass of all e^+e^- candidates.
→ J/ψ candidates.
- 3 Cut on missing mass of all $\pi^+\pi^-$ candidates.
- 4 Cut on invariant mass of $e^+e^-\pi^+\pi^-$ candidates.
→ X(3872) candidates.
→ Signal counts for scan point.

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



Study of Background Processes

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



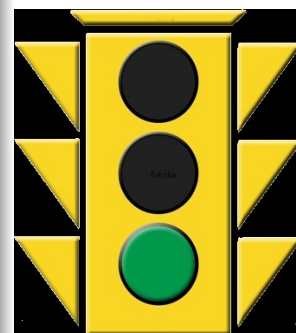
- After PID cuts: No fake signals observed.
- Investigation of larger sample sizes will follow.

* G. Y. Chen, J. P. Ma, Phys. Rev. D77(2008)097501

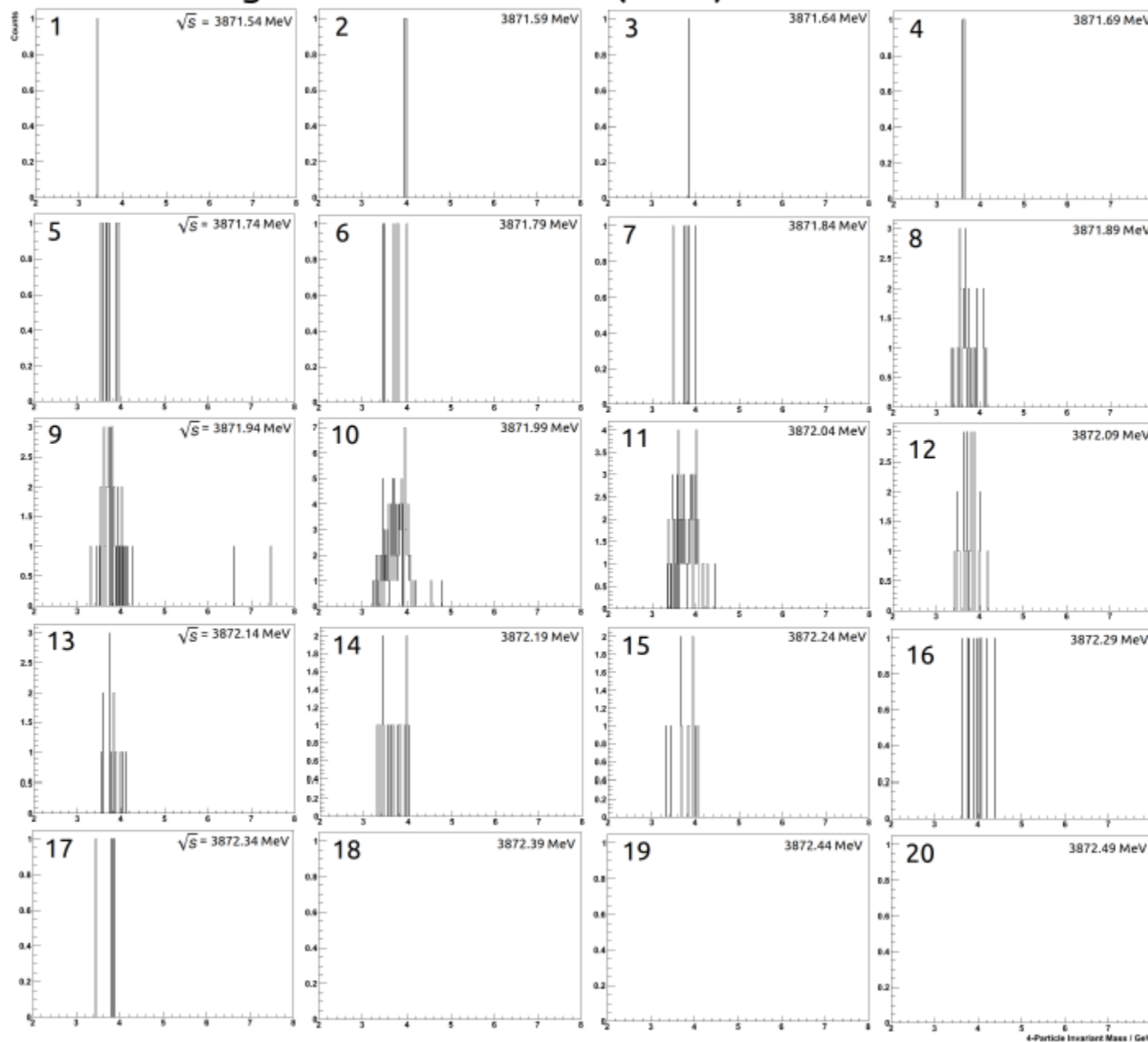
† K. Nakamura et al. (PDG) J. Phys. G37, 075021 (2010)

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

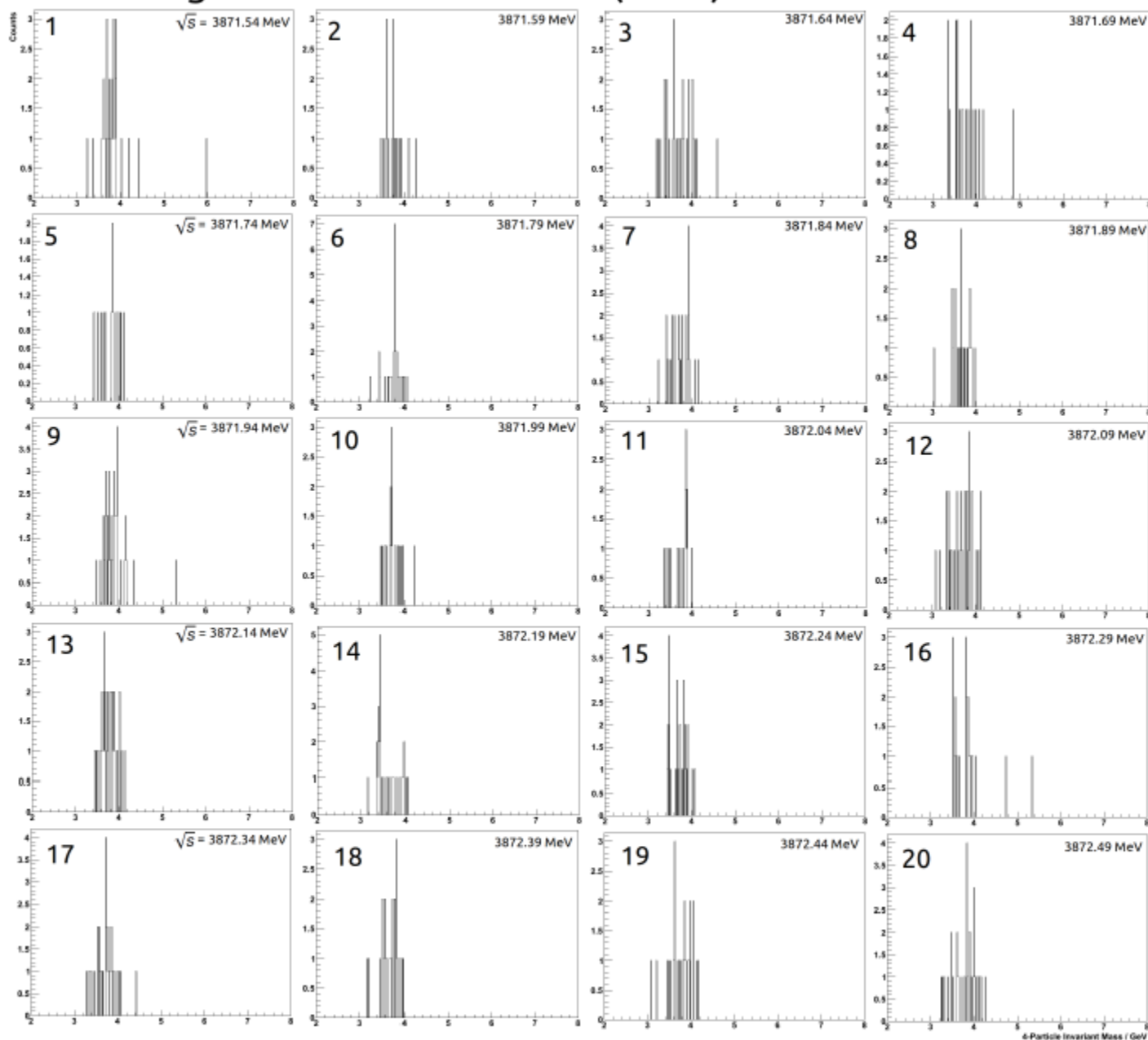
⊥ V. Uzhinsky, A. Galoyan, hep-ph/0212369



Signal Simulation for X(3872) Resonance Scan

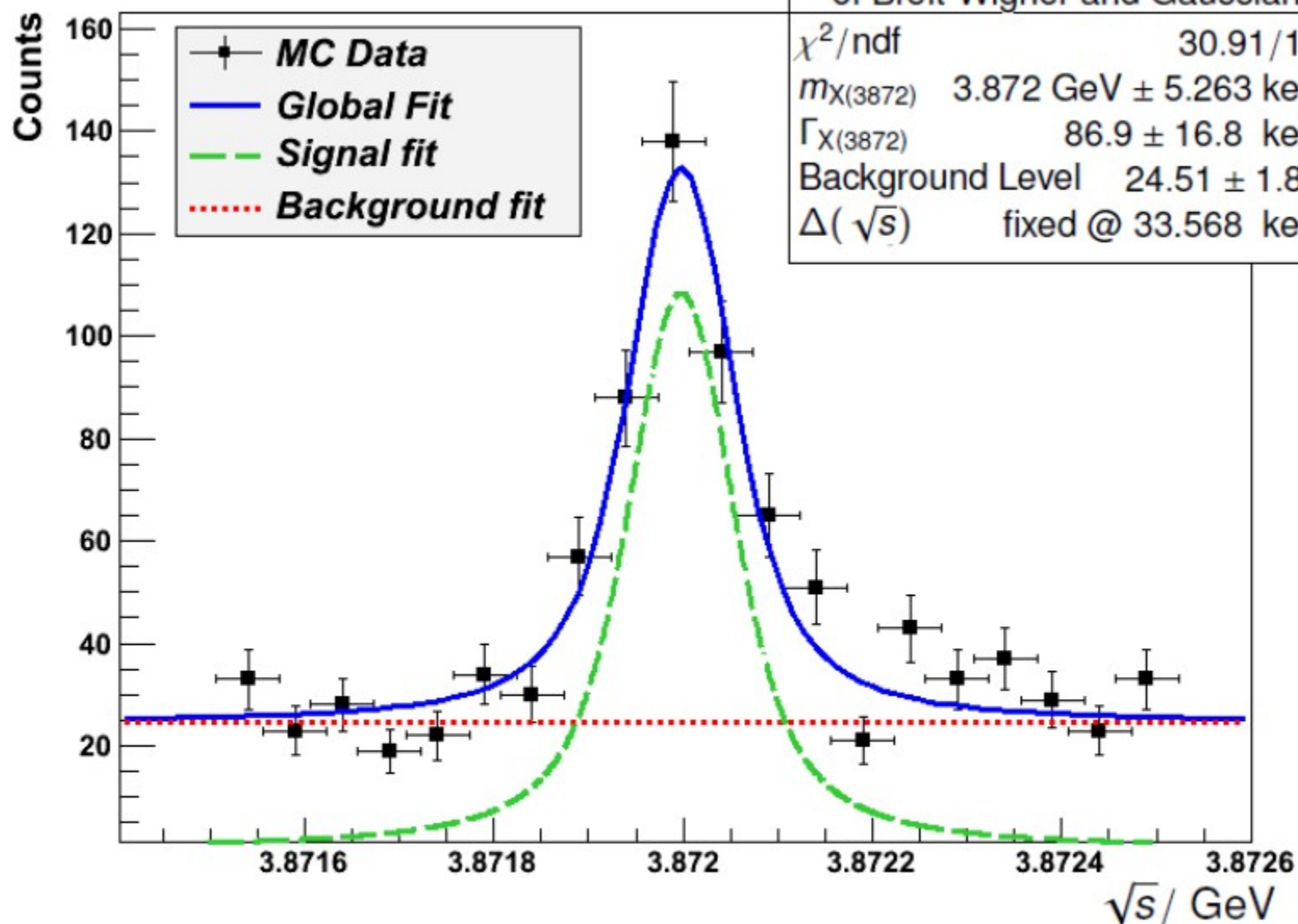


Background Simulation for X(3872) Resonance Scan



X(3872) Resonance Scan MC Data

Fit with Constant Plus Convolution of Breit-Wigner and Gaussian

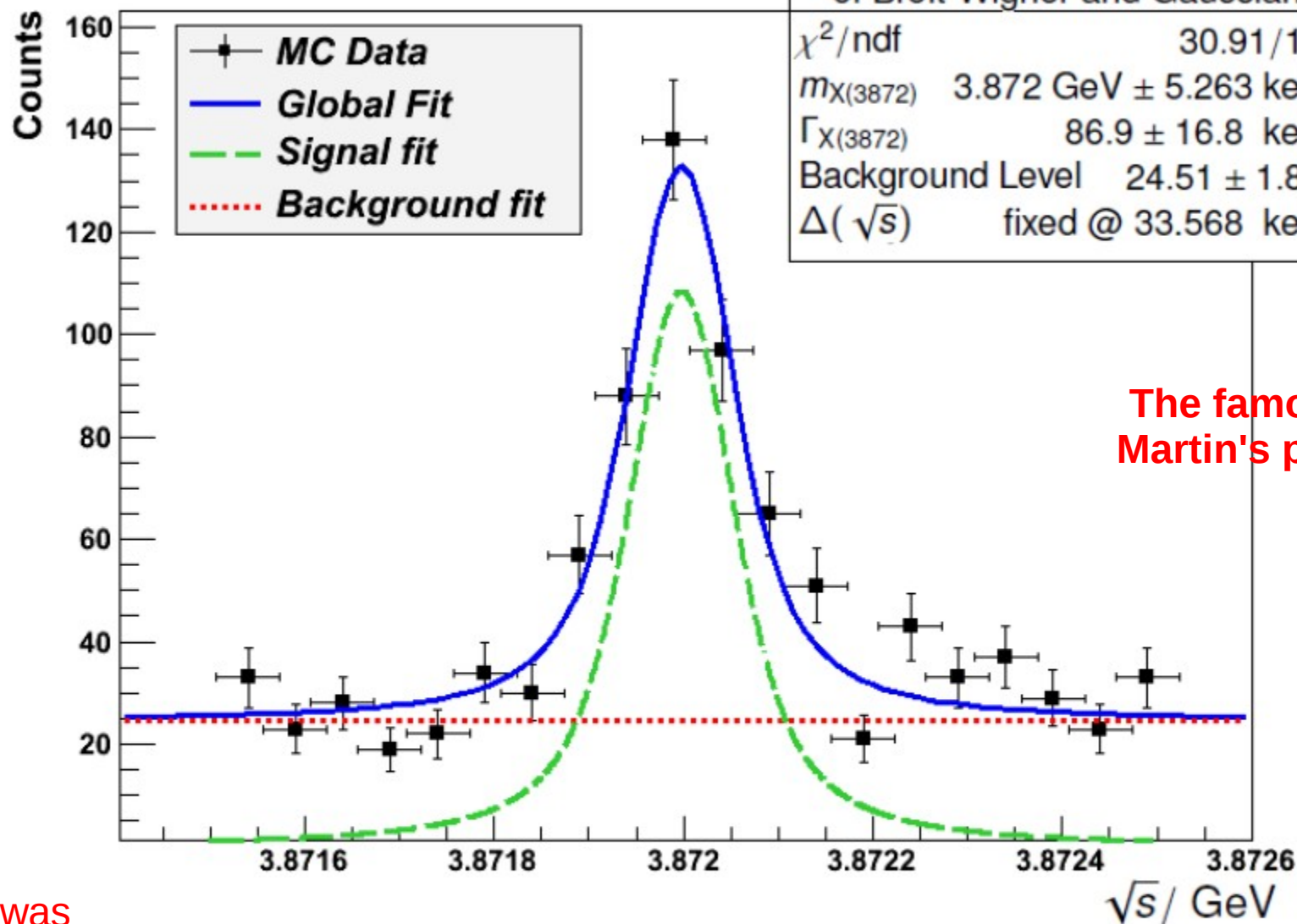


Reconstructed width $\Gamma_{X(3872)}$ is consistent with input width of 100 keV.*

*Results are preliminary. Only statistical errors are shown.

X(3872) Resonance Scan MC Data

Fit with Constant Plus Convolution of Breit-Wigner and Gaussian



The famous
Martin's plot!



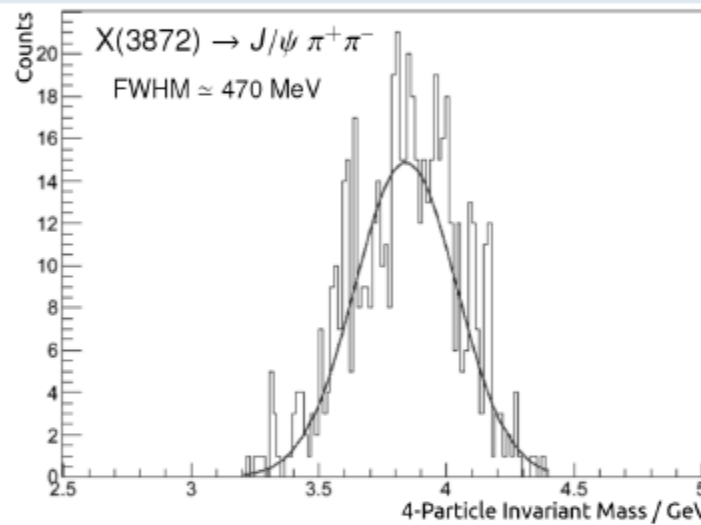
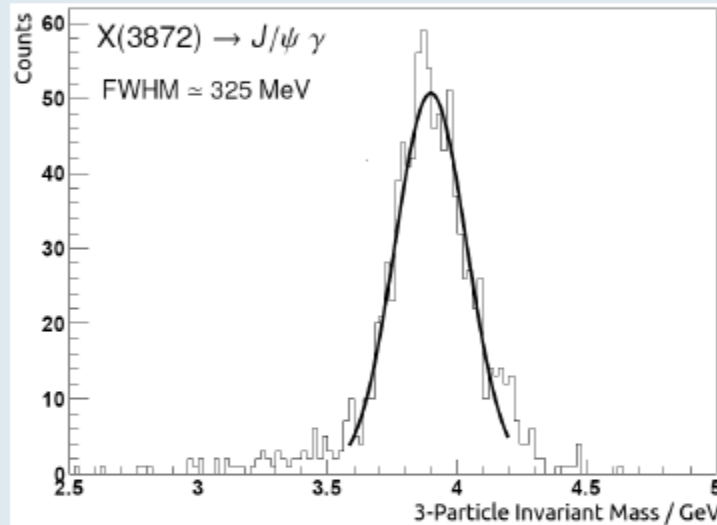
It was
2011!!

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

*Results are preliminary. Only statistical errors are shown.

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

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



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

* 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 $\bar{\text{P}}\text{ANDA}$

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

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 $\bar{\text{P}}\text{ANDA}$ collaboration

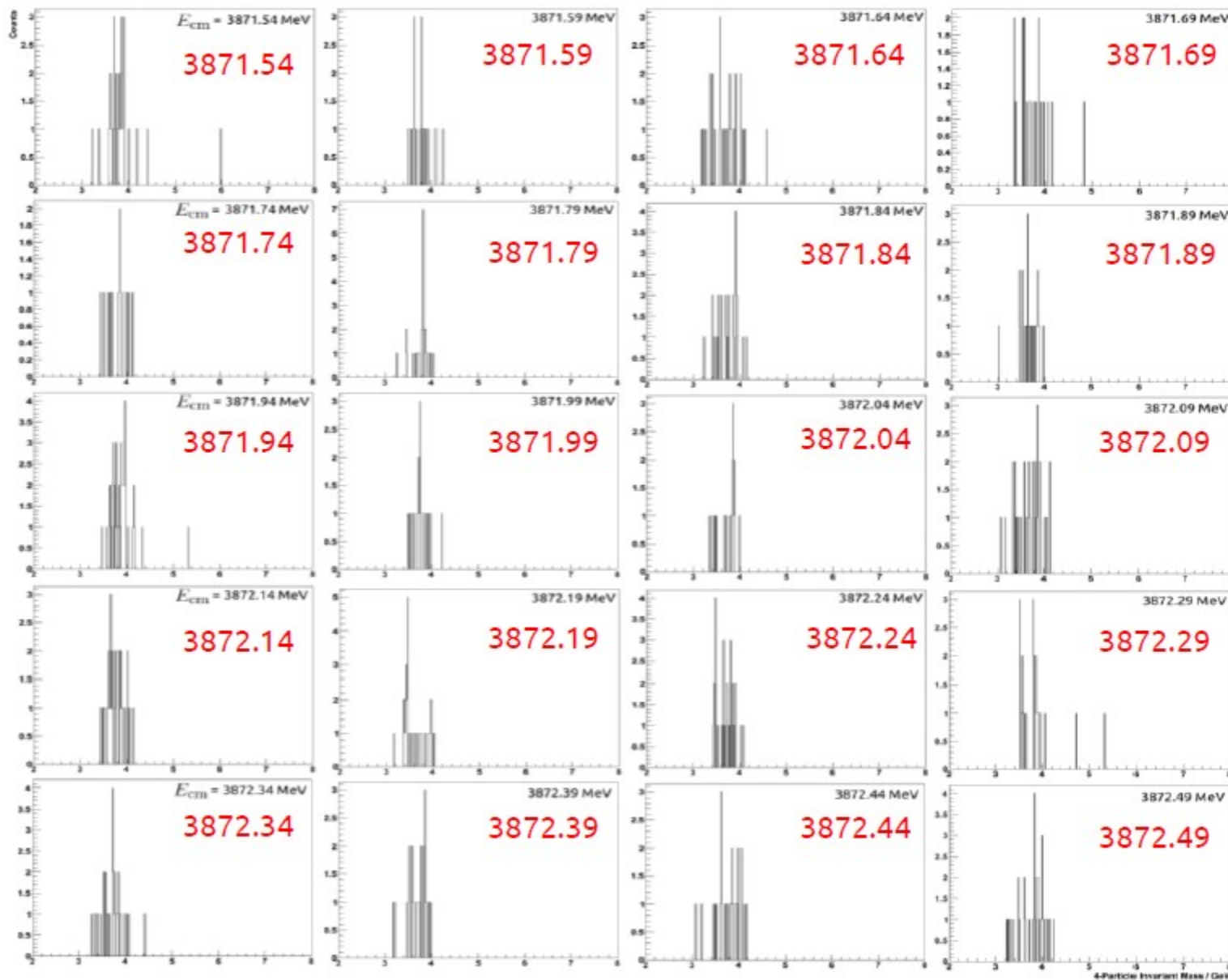


This talk - only MC



Bundesministerium
für Bildung
und Forschung

Example: Resonance Scan of $X(3872) \rightarrow J/\psi \pi^+ \pi^-$



How do we know cross sections @ $\overline{\text{PANDA}}$?

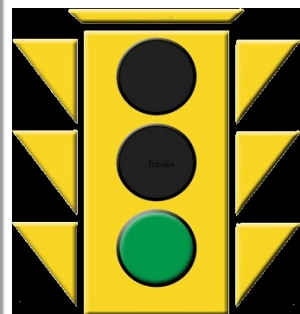
→ Detailed balance

Production @ Panda

$$\begin{aligned}
 \sigma[p\bar{p} \rightarrow X(3872)] &= \sigma_{BW}[p\bar{p} \rightarrow X(3872) \rightarrow \text{all}](m_{X(3872)}) \\
 &= \frac{(2J+1) \cdot 4\pi}{m_{X(3872)}^2 - 4m_p^2} \cdot \frac{\mathcal{B}(X(3872) \rightarrow p\bar{p}) \cdot \overbrace{\mathcal{B}(X(3872) \rightarrow f)}^{=1} \cdot \Gamma_{X(3872)}^2}{\underbrace{4(m_{X(3872)} - m_{X(3872)})^2}_{=0} + \Gamma_{X(3872)}^2} \\
 &\stackrel{(J=1)}{=} \frac{3 \cdot 4\pi}{m_{X(3872)}^2 - 4m_p^2} \cdot \mathcal{B}(X(3872) \rightarrow p\bar{p})
 \end{aligned}$$

Decay

@ Belle, BaBar, Bes3, LHCb



Cross section estimates from detailed balance

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

Res. R	J	Mass m [MeV]	$\mathcal{B}(R \rightarrow \bar{p}p)$	$\sigma_{[\bar{p}p \rightarrow R]}^{\text{peak}} \pm \text{err. fr. } \mathcal{B}(R \rightarrow \bar{p}p) \pm \text{err. fr. } m_R$
$J/\psi(1S)$	1	3096.916 ± 0.011	$(2.17 \pm 0.07) \cdot 10^{-3}$	$5.25 \pm 0.17 \pm 0.00 \mu\text{b}$
$\psi(2S)$	1	$3686.109^{+0.012}_{-0.014}$	$(2.76 \pm 0.12) \cdot 10^{-4}$	$402 \pm 18 \pm 4 \text{ nb}$
$\eta_c(1S)$	0	2981.0 ± 1.1	$(1.41 \pm 0.17) \cdot 10^{-3}$	$1.29 \pm 0.16 \pm 0.00 \mu\text{b}$
$\eta_c(1S)$	0	2981.0 ± 1.1	$(1.32 \pm 0.19) \cdot 10^{-3}$	$1.21 \pm 0.17 \pm 0.00 \mu\text{b}$
$\eta_c(2S)$	0	3638.9 ± 1.3	$(1.85 \pm 1.26) \cdot 10^{-4}$	$93 \pm 63 \pm 0 \text{ nb}$
$\eta_c(2S)$	0	3638.9 ± 1.3	$(3.12 \pm 1.65) \cdot 10^{-4}$	$< 157 \pm 83 \pm 0 \text{ nb (95\% CL)}$
$\chi_{c0}(1P)$	0	3414.75 ± 0.31	$(2.23 \pm 0.13) \cdot 10^{-4}$	$134.1 \pm 7.8 \pm 0 \text{ nb}$
$h_c(1P)$	1	3525.41 ± 0.16	$(8.95 \pm 5.21) \cdot 10^{-4}$	$1.47 \pm 0.86 \pm 0 \mu\text{b}$
$h_c(1P)$	1	3525.41 ± 0.16	$(1.68 \pm 0.05) \cdot 10^{-3}$	$< 2776 \pm 87 \pm 0 \text{ nb (95\% CL)}$
$X(3872)$	1	3871.68 ± 0.17	$(5.31 \pm 0.00) \cdot 10^{-4}$	$< 68.0 \pm 4.0 \pm 0.0 \text{ nb (95\% CL)}$
$X(3915)$?	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)



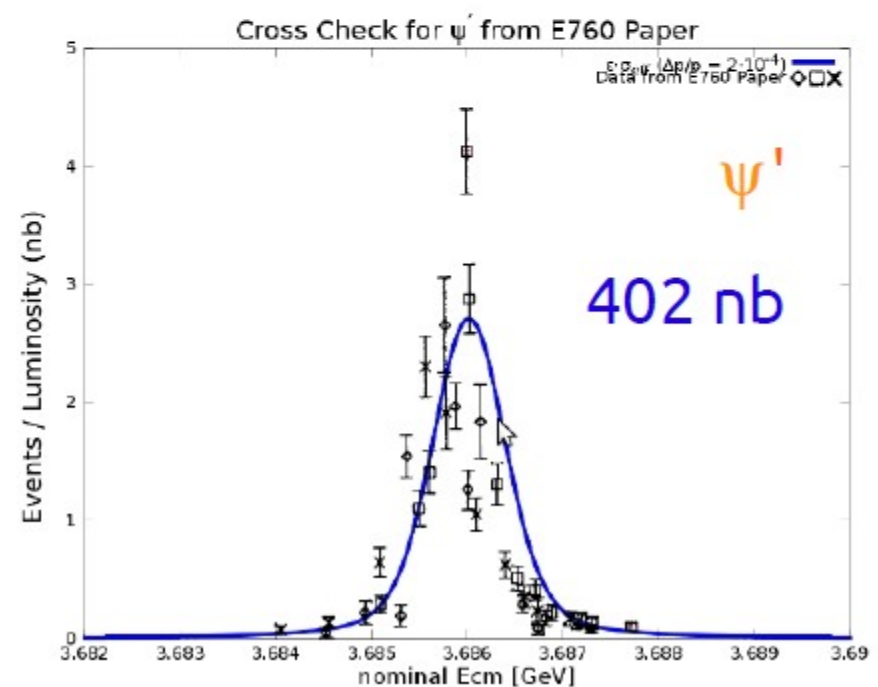
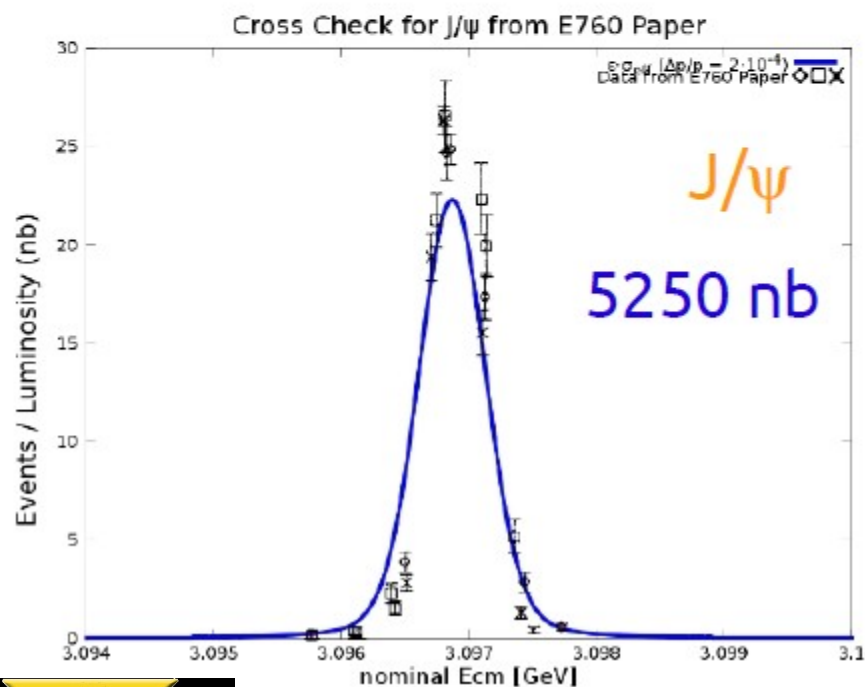
Check of cross section, derived from detailed balance

(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 PANDA?

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

L = luminosity

σ = cross section

ε = reco. efficiency

BR_i = branching fraction of secondary decays

LUMINOSITY

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

duty factor 50%

$$\begin{aligned}
 \mathcal{L}_{\text{int}} &= \frac{\int \mathcal{L} \cdot \alpha \, dt}{1 \text{ day}} = \boxed{2 \cdot 10^{31} \text{ cm}^{-2} \cdot 1 \text{ s}^{-1}} \cdot \frac{1}{2} \cdot \frac{60 \text{ s}}{1 \text{ min}} \cdot \frac{60 \text{ min}}{1 \text{ h}} \cdot \frac{24 \text{ h}}{1 \text{ day}} \\
 &= 10^{31} \cdot (10^{-2})^{-2} \text{ m}^{-2} \cdot \underbrace{\frac{60}{1} \cdot \frac{60}{1} \cdot \frac{24}{1 \text{ day}}}_{8.64 \cdot 10^4 / \text{day}} \\
 &= 8.64 \cdot 10^{39} \cdot \frac{10^{-12} \cdot 10^{-28}}{10^{-12} \cdot \underbrace{10^{-28} \text{ m}^2}_{1 \text{ b} = 10^{-28} \text{ m}^2}} \text{ per day} \\
 &= 8.64 \cdot \frac{10^{-1}}{1 \text{ pb}} \text{ per day} = 0.864 \text{ pb}^{-1} \text{ per day}
 \end{aligned}$$

CROSS SECTION

—————▶ Detailed balance, see slide 17-18

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

2011: $\sum_i BR_i(X(3872) \rightarrow \text{known measured decay channels}) = 10\%$

2014: $\sum_i BR_i(X(3872) \rightarrow \text{known measured decay channels}) = 3\% \div 8\%$

- 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 \Rightarrow 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 \(2014\)](#)
 \rightarrow Nuclear Physics B, proceedings of conferences**

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

from detailed balance

$$\rightarrow \sigma \leq 4370 \text{ nb}$$

due to high upper limit

$$\mathcal{B}(Y(4260) \rightarrow \overline{p}p) / \mathcal{B}(Y(4260) \rightarrow J/\psi \pi^+ \pi^-) < 0.13 \text{ (90\% C.L.)}$$

BaBar, Phys. Rev. D73(2006)012005

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

$$\sigma = 1.9 \pm 0.2 \text{ nb} \quad (\mathcal{L} = 2 \times 10^{32} \text{ cm}^{-2} \text{ s}^{-1}, \text{ planned})$$

\overline{P} ANDA is $Y(4260)$ mini-„factory“ $\rightarrow 16.400$ events per 1 day

Comparison to BESIII

$$\sigma = 62.9 \pm 1.9 \pm 3.7 \text{ pb} \quad (\mathcal{L} = 5.3 \times 10^{32} \text{ cm}^{-2} \text{ s}^{-1}, \text{ achieved})$$

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 $\mathcal{B}(Y(4260) \rightarrow J/\psi \pi^+ \pi^-) = 100\%$



What can \bar{P} ANDA do?

Search for rare decay $Y(4260) \rightarrow e^+ e^-$

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

Limit from coupling to initial state

$$\mathcal{B}(J/\psi\pi^+\pi^-) \times \mathcal{B}(e^+ e^-) = (7.5 \pm 0.9 \pm 0.8) \text{ eV}$$

BaBar, arXiv:0808.1543

Partial width of the order „eV“

of a state which is $\Gamma \sim 100 \text{ MeV}$ total width

→ factor $\geq 10^7$ suppressed

Test if annihilation (wavefunction at $r=0$) suppressed

- if $[c\bar{c}]_8g$ hybrid, minimum of hybrid potential Π_u not centered

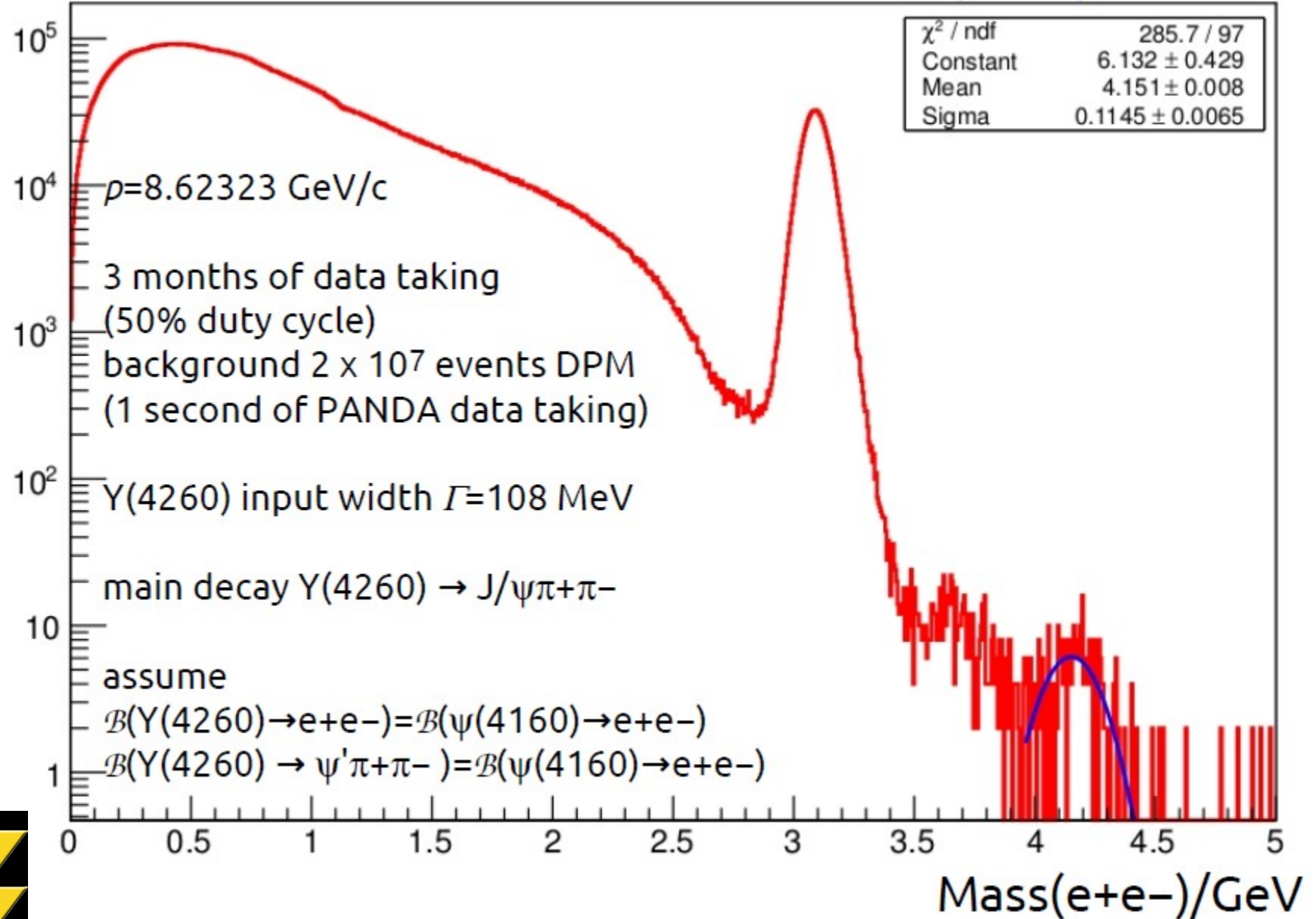
→ talk by E. Braaten, Saturday, 12:00

- enhanced long-range wavefunction, if $\bar{D}D_1(2420)$ molecule ?



Search for $Y(4260) \rightarrow e^+e^-$

PANDA preliminary



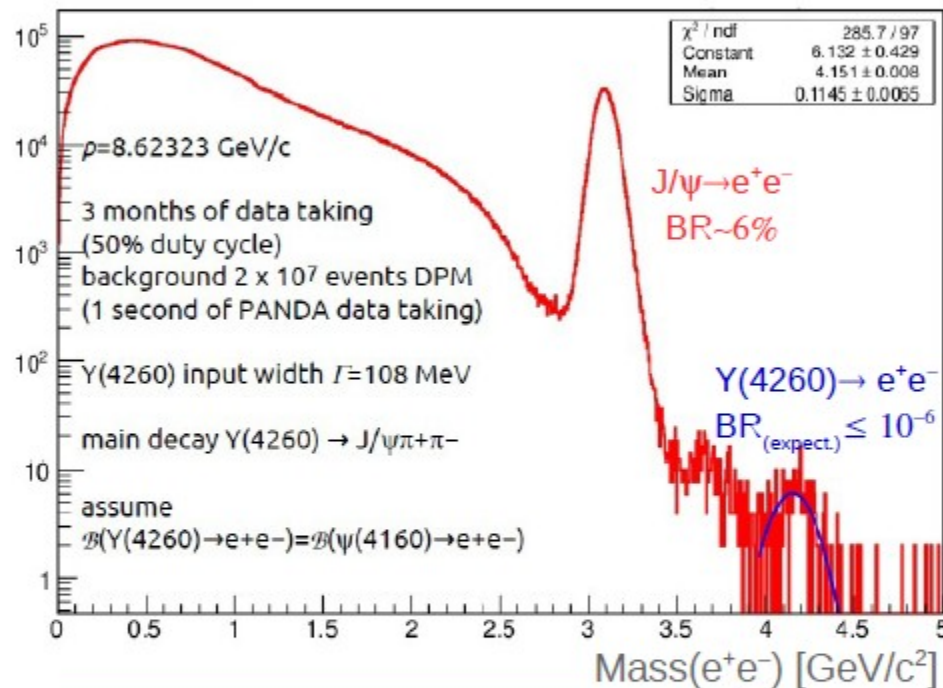


Status and Perspectives for $\bar{\text{P}}\text{ANDA}$ @ FAIR

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

Challenge: interference effect in rare decays

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

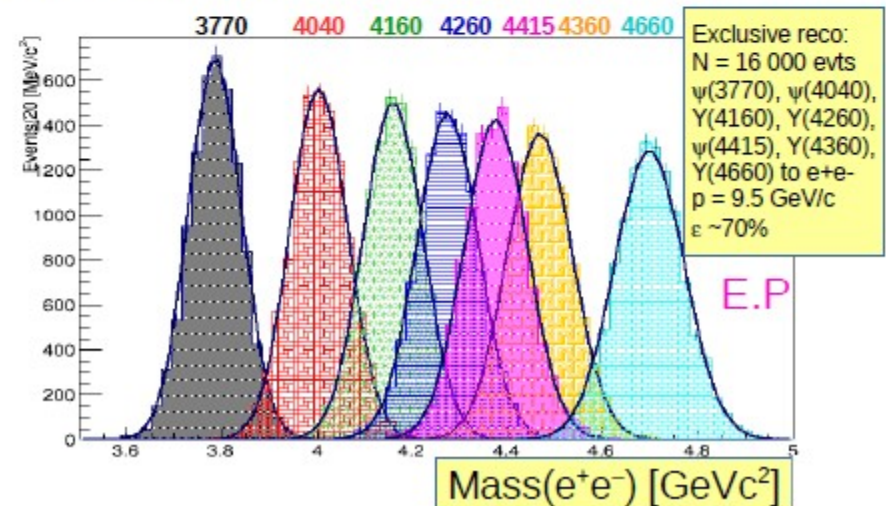


PDG	BR($\psi \rightarrow e^+e^-$)	Γ/MeV
$\psi(3770)$	$(9.6 \pm 0.7) \times 10^{-6}$	27.2 ± 1.0
$\psi(4040)$	$(1.07 \pm 0.16) \times 10^{-5}$	80 ± 10
$\psi(4160)$	$(8.1 \pm 0.9) \times 10^{-6}$	103 ± 8
$\psi(4415)$	$(9.4 \pm 3.2) \times 10^{-6}$	62 ± 20

Pandaroot-scrut14

E. Prencipe

- PANDA: *mini-Y*(4260) factory.
Expected ~ 16000 Y/day (high lum. mode)
- $Y(4260) \rightarrow e^+e^-$ not observed, yet:
limit from coupling to initial state
 $\mathcal{B}(J/\psi \pi^+ \pi^-) \times \mathcal{B}(e^+e^-) = (9.2 \pm 0.8) \text{ eV}$
BaBar, PRD 86 (2012) 051102
- Overpopulated 1^- Charmonium spectrum
- In PANDA possibility to study very rare decays: $Y(4260) \rightarrow e^+e^-$ would be an absolute measurement
- 1^- states are large: they can interfere



ICHEP Conference, 2-9 July .2014
arXiv:1410.5201 (2014)

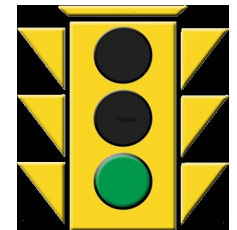
Then, \bar{P} ANDA numbers published on $Y(4260)$ are:

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 \Rightarrow **official**





PANDA is:

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

- BES III : Phys. Rev. Lett. 110 (2013) 252001
Observation of a Charged Charmoniumlike Structure
in $e^+e^- \rightarrow \pi^+\pi^- J/\psi$ at $\sqrt{s}=4.26$ GeV



$$\frac{\sigma(e^+e^- \rightarrow \pi^\pm Z_c(3900)^\mp \rightarrow \pi^+\pi^- J/\psi)}{\sigma(e^+e^- \rightarrow \pi^+\pi^- J/\psi)} = (21.5 \pm 3.3 \pm 7.5)\%$$



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

- BES III : Phys. Rev. Lett. 112 (2014) 092001
Observation of $e^+e^- \rightarrow \gamma X(3872)$ at BESIII



Observed transition $Y(4260) \rightarrow \gamma X(3872)$
 $\sigma(e^+e^- \rightarrow \gamma X(3872)) B(X(3872) \rightarrow \pi\pi J/\psi)$
 < 0.11 pb @ $\sqrt{s} = 4.26$ GeV



Use PANDA data set collected @ Y(4260) energy

Expectation in PANDA @ $L = 10^{31}$:



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



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

How? 30

Table 1: Summary of the observed Z resonant structures

Resonance	Mass [MeV/c ²]	Width [MeV]	Decay	J ^P
$Z(4430)^+$	$4433 \pm 4(\text{stat}) \pm 2(\text{syst})$	$45^{+18}_{-13}(\text{stat})^{+30}_{-13}(\text{syst})$	$\psi(2S)\pi^+$	[1]
$Z_c(3900)^+$	$3899.0 \pm 3.6(\text{stat}) \pm 4.9(\text{syst})$	$46 \pm 10(\text{stat}) \pm 20(\text{syst})$	$J/\psi\pi^+, D^0 D^{*-}$	[2]
$Z_c(3900)^0$	$3894.8 \pm 2.3(\text{stat})$	$29.6 \pm 8.2(\text{stat})$	$J/\psi\pi^0$	[3]
$Z_c(4020)^+$	$4022.9 \pm 0.8(\text{stat}) \pm 2.7(\text{syst})$	$7.9 \pm 2.7(\text{stat}) \pm 2.6(\text{syst})$	$h_c\pi^+$	[4]
$Z_c(4020)^0$	$4023.6 \pm 2.2(\text{stat}) \pm 3.9(\text{syst})$	-	$h_c\pi^0$	[5]
$Z_c(3885)^+$	$3883.9 \pm 1.5(\text{stat}) \pm 4.2(\text{syst})$	$24.8 \pm 3.3(\text{stat}) \pm 11.0(\text{syst})$	$D^+ \bar{D}^{*0}$	1 ⁺ [6]
$Z_c(4025)^+$	$4026.3 \pm 2.6(\text{stat}) \pm 3.7(\text{syst})$	$24.8 \pm 5.6(\text{stat}) \pm 7.7(\text{syst})$	$D^{*+} \bar{D}^*$	[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 ($m_Z \sim 3730 \text{ MeV}/c^2$)

$X(3872) \rightarrow Z(3730)\pi$ transition kinematically allowed
 \rightarrow suppressed at e^+e^- colliders

- Proposal @ PANDA:

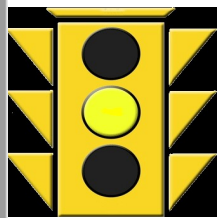
$$\bar{p}p \rightarrow Z(3730)^0\pi^0, \quad Z(3730)^0 \rightarrow J/\psi\gamma,$$

$$\bar{p}p \rightarrow Z(3730)^0\pi^0, \quad Z(3730)^0 \rightarrow \chi_{c1}\pi^0,$$

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



Unique for
PANDA!



How are calculations performed?

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

	Resonance	n. with $\mathcal{L}= 2 \times 10^{32}$	n. with $\mathcal{L}= 2 \times 10^{31}$	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].

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

$$N_Z = N_Y * 21.5\% \text{ [13]}$$



Resonance	n. with $\mathcal{L} = 2 \times 10^{32}$	n. with $\mathcal{L} = 2 \times 10^{31}$	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.

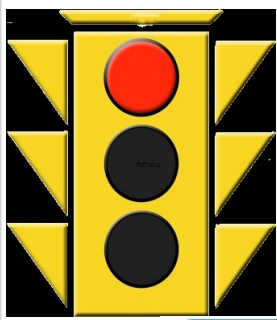
[20] S. Lange *et al.*, arXiv:1311.7597 (2013) [hep-ex].

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

(*) $N = \mathcal{L} * \sigma * \epsilon * BR_i = 50 \text{ nb} * \mathcal{L} * \epsilon * BR_i$. $BR(J/\psi \rightarrow e^+e^-) = 0.06$; $BR(X(3872)) = 0.1$; $\epsilon = 27\%$

A full sim. analysis is performed for $X(3872)$, but no forward spectrometer is included in this old simulation ($\rightarrow 2011$). 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 $p\bar{p}$

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

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

Comparison With Assumptions in Previous Work

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

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

The current values are

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

Software upgrade,
different input values



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

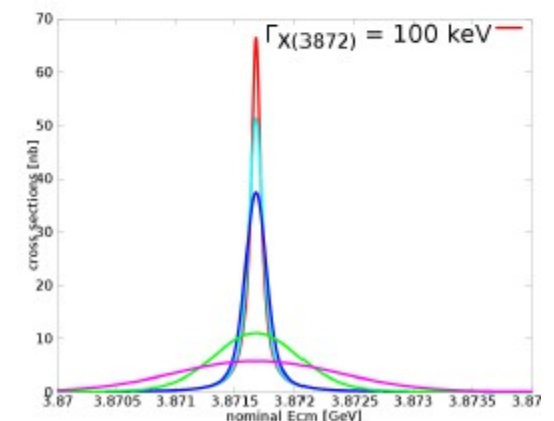
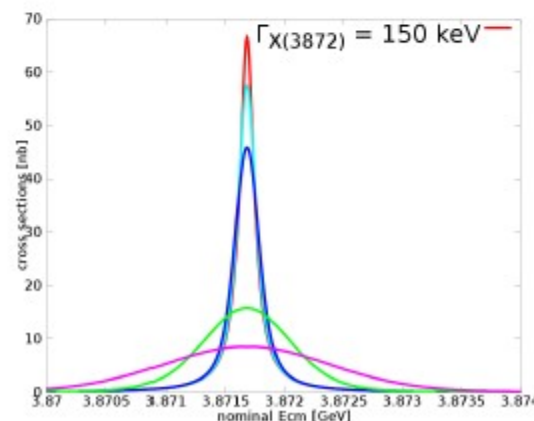
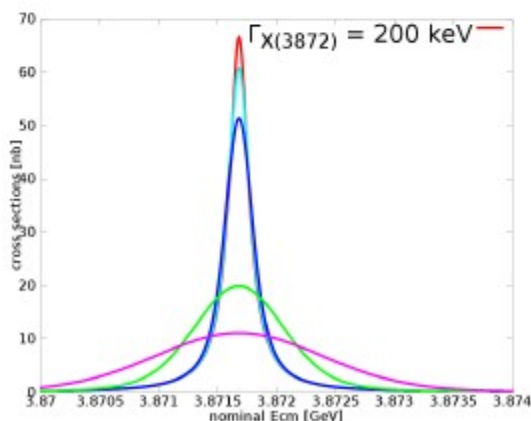
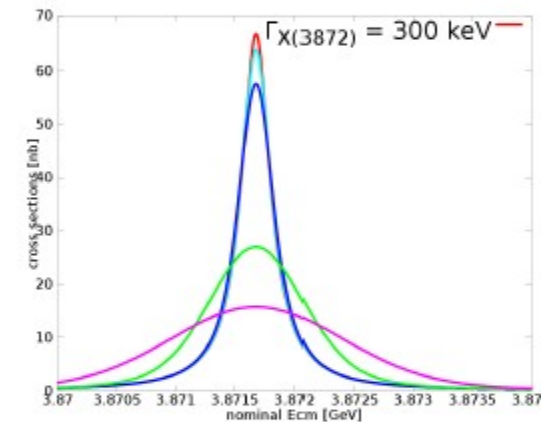
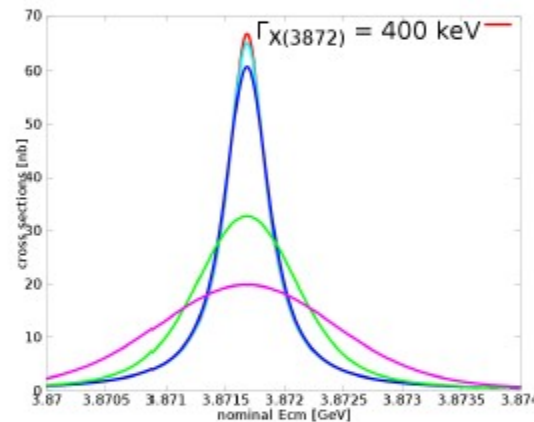
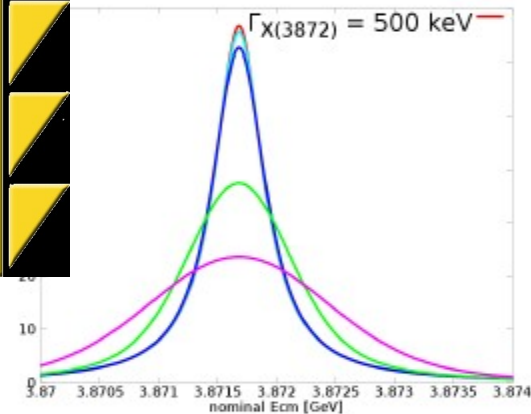
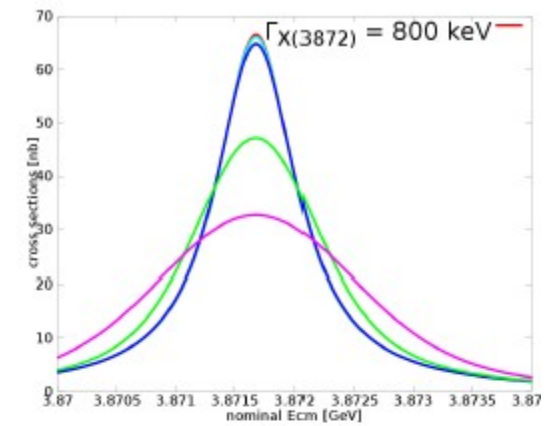
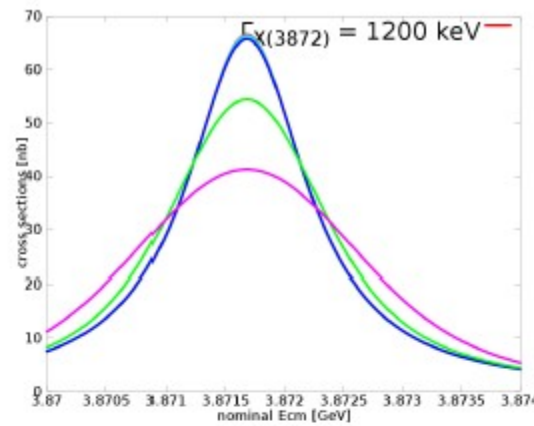
[phb09] The PANDA Collaboration: Physics Book (2009)

[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 $\Gamma_{\chi(3872)}$

σ_{BW} (Breit Wigner)	Red
$\sigma_{\text{eff}} (\Delta p/p = 2 \cdot 10^{-5})$	Cyan
$\sigma_{\text{eff}} (\Delta p/p = 4 \cdot 10^{-5})$	Blue
$\sigma_{\text{eff}} (\Delta p/p = 2 \cdot 10^{-4})$	Green
$\sigma_{\text{eff}} (\Delta p/p = 4 \cdot 10^{-4})$	Magenta



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

High Luminosity

Beam Mom [GeV/c]	cms Energy [GeV/c ²]	Cross Section [mb]*	Average Luminosity [cm ⁻² s ⁻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/c ²]	Cross Section [mb]*	Average Luminosity [cm ⁻² s ⁻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://lpxndwww.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

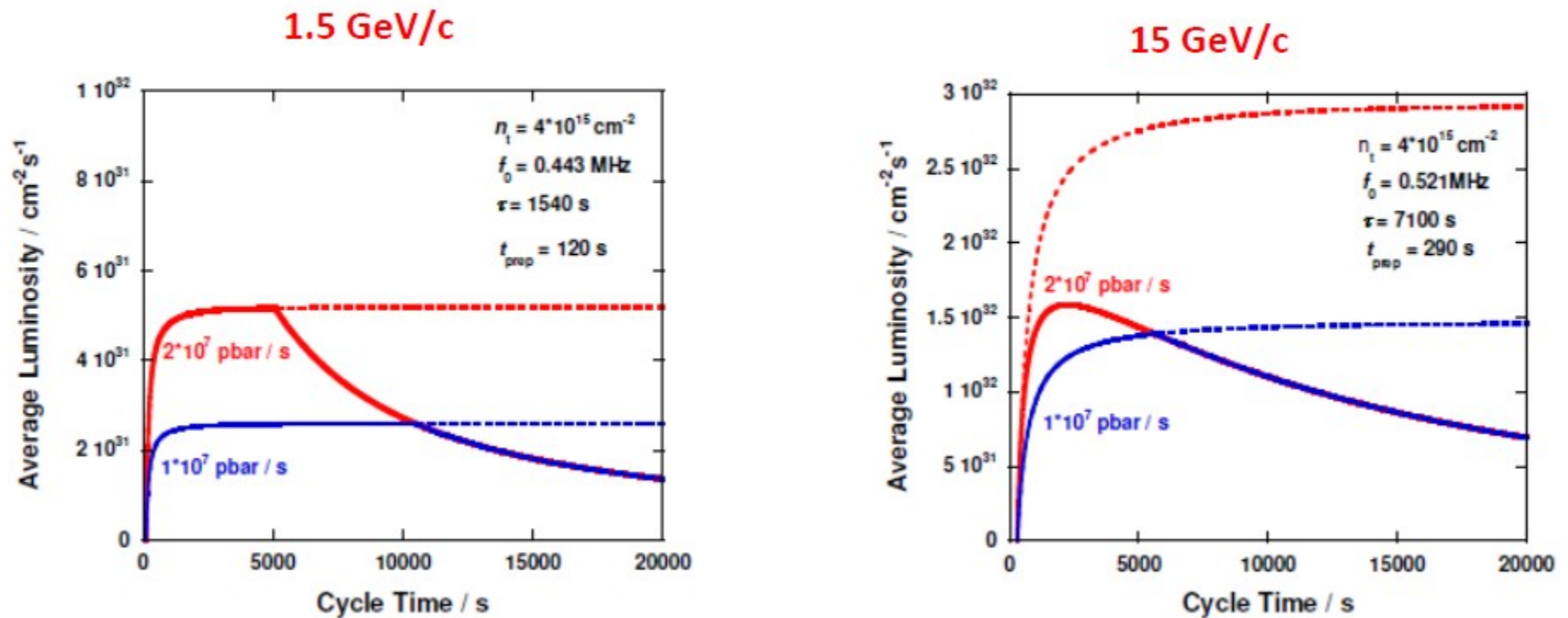


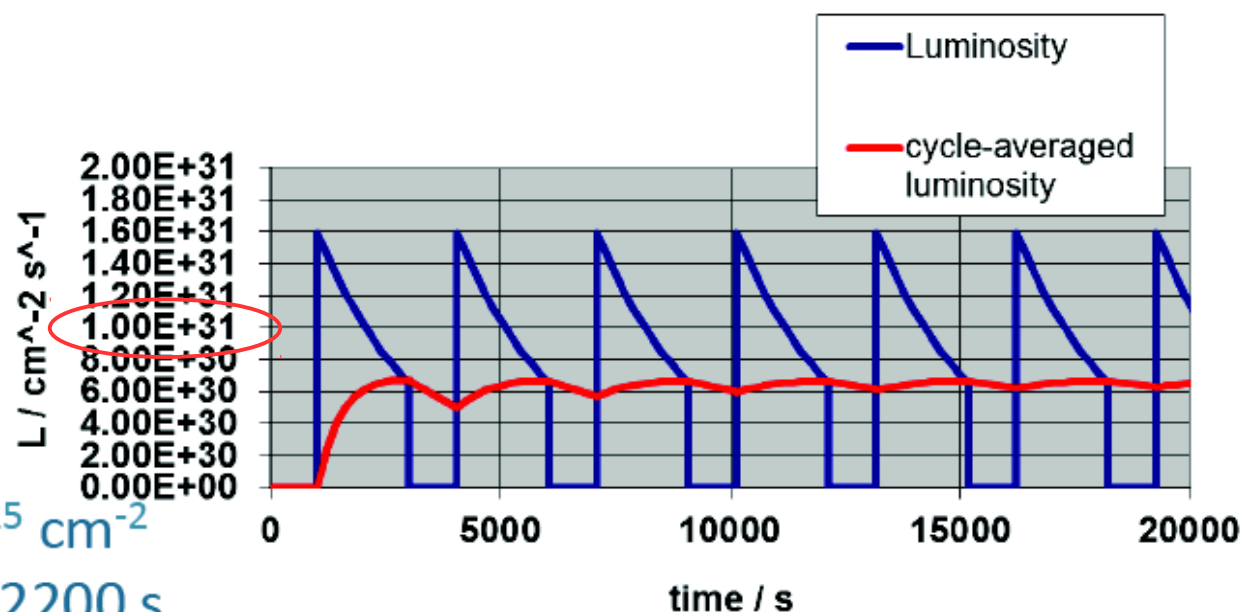
Figure 2.15: The maximum number of particles is limited to 10^{11} (solid line), and unlimited (dashed lines).

Low luminosity

$p = 1.5 \text{ GeV/c}$

target thickness = $4 \cdot 10^{15} \text{ cm}^{-2}$

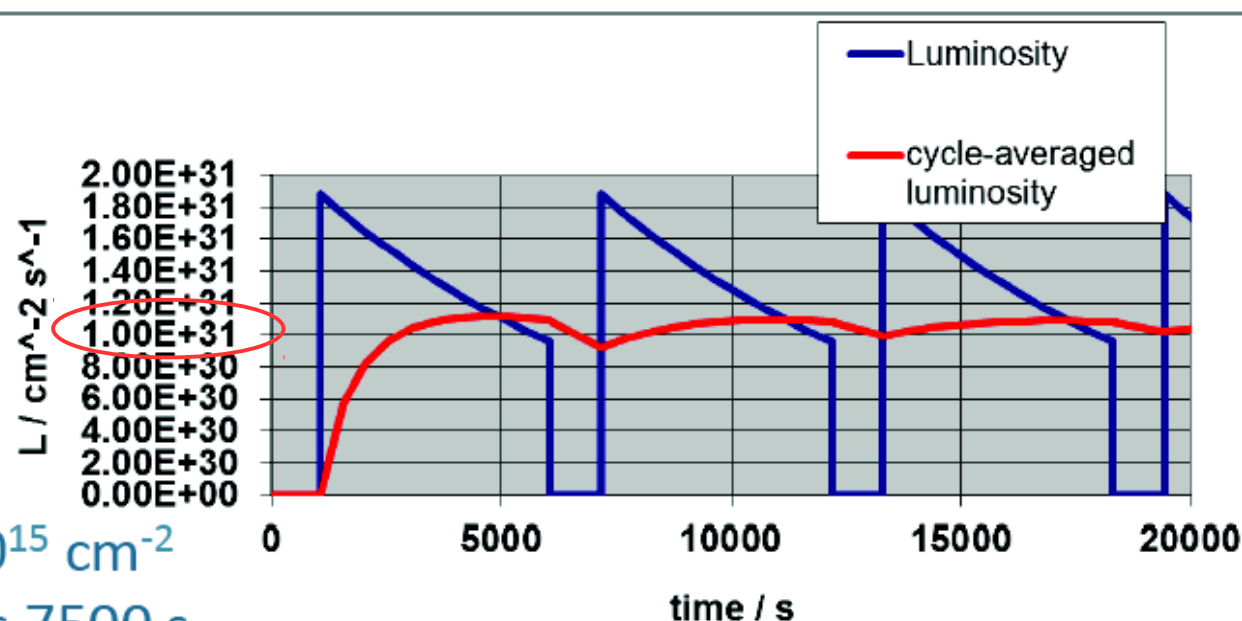
→ 1/e-beam lifetime is 2200 s



$p = 15 \text{ GeV/c}$

target thickness = $4 \cdot 10^{15} \text{ cm}^{-2}$

→ 1/e-beam lifetime is 7500 s



Dieter Prasuhn

11.12.2014

<https://indico.gsi.de/getFile.py/access?contribId=24&sessionId=7&resId=0&materialId=slides&confId=2366>

Some points of discussion, today:

- We have approved results for X(3872), and Y(4260). **Green light** !
- Extrapolations to $L = 10^{31} \text{ cm}^{-2} \text{ s}^{-1} \rightarrow 0.432 \text{ pb}^{-1}/\text{day}$ 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) \Rightarrow 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.....