Status of fullSim PandaRoot studies in the Charmonium-like Exotics (CCE) PWG

(input to yesterday's PhysCom discussion, on a Panda phase-I paper)

Frank Nerling
GU Frankfurt, GSI Darmstadt

Possible fullSim results for a "phase-1" physics paper

- X(3872) energy scan
  - FullSim studies completed
  - ✓ Released
- X(3872) → $Z^{\pm}(3730)\pi^{-/+}$
  - FullSim studies started/ongoing
  - Nothing yet released (prod. numbers, summarised in IN)
- Zc(3900) production and decays into pbar d
  - FullSim studies started
  - On hold since a year, nothing yet released
- X(3872) → DDbar decays
  - FullSim studies started,1st presentation this meeting, Wed,
  - Status not yet known, nothing yet released

X(3872) energy scan

X(3872) Lineshape Study
and the new LHCb Measurement

PANDA CM Mainz

Charmonium Exotics Session

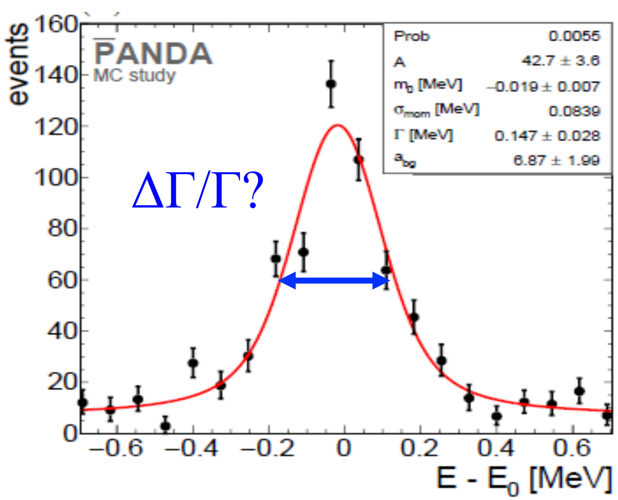
14. Sep. 16

K. Götzen, R. Kliemt, F. Nerling, K. Peters

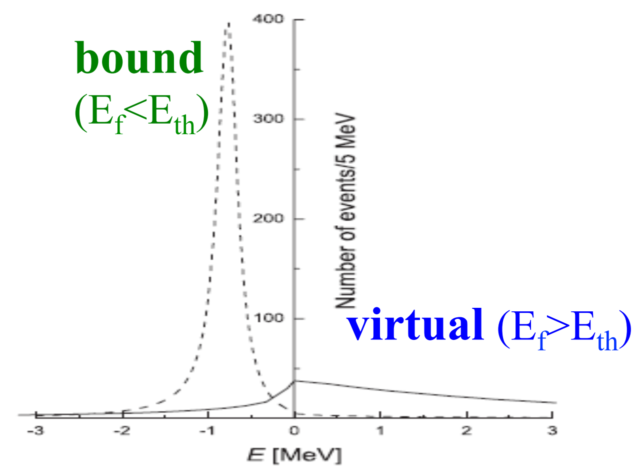
Reminder

- Nature of X(3872)
  - ➢ Need lineshape and width to clarify nature
- Approach at PANDA
  - ➢ Fine scan around nominal mass =>measurement of energy dependent cross-section
- Analysis goals
  - ➢ Sensitivity of Γ measurement (conventional BW)
  - ➢ Sensitivity for virtual/bound state (molecular picture)

a)



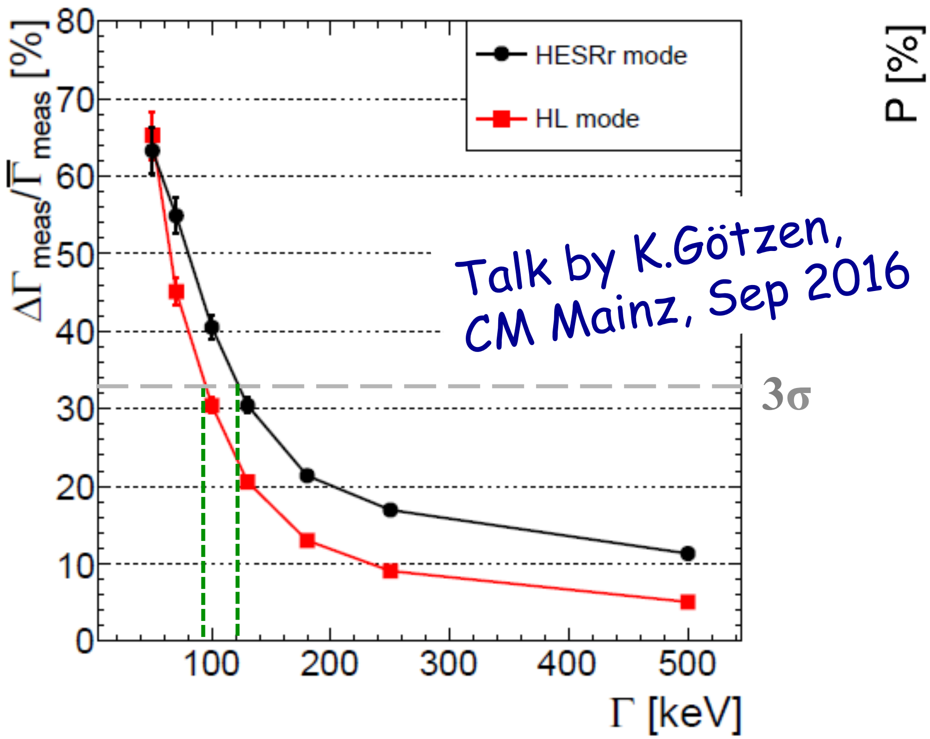
b)



Main results (σ = 50nb assumed)

- Achievable precision in measured BW width Γ
- Clarify nature by lineshape measurement (distinguish virtual/bound state)

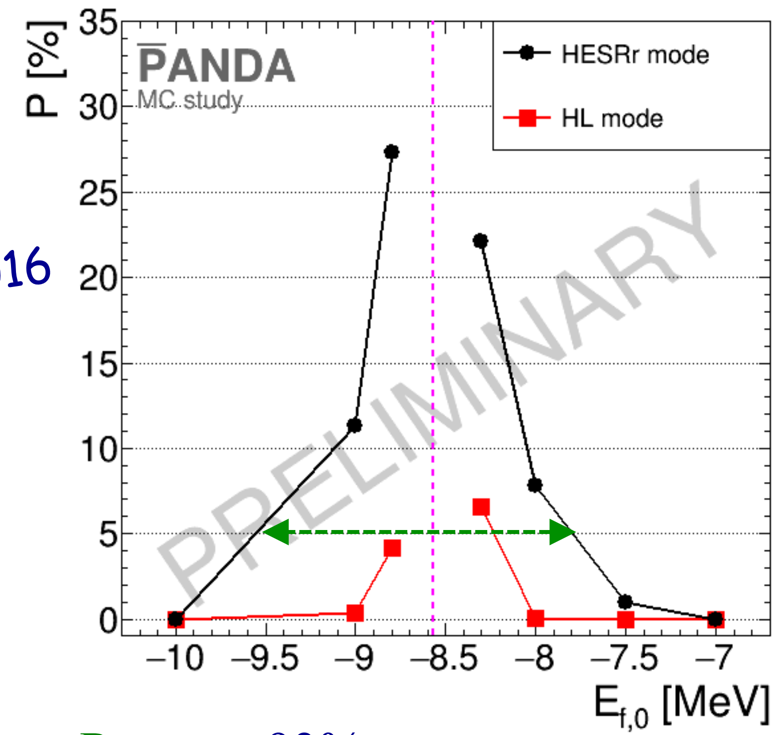
Sensitivity



$\Delta\Gamma/\Gamma$ =33% : Γ= 90 ... 120 keV

HL HESRr

P_{mis} X(3872) nature



P_{HL} > 93%

P_{HESRr} > 93% for $|E_f - E_{f,th}| \gtrsim 1$ MeV

[RN-QCD-2016-002]

$X(3872) \rightarrow Z^{\pm}(3730)\pi^{-/+}$


JÜLICH
FORSCHUNGSZENTRUM
Simulation of
$X(3872) \to Z^{\pm}(3730)\pi^{\mp}$
Transitions
L. Bianchi, Forschungszentrum Jülich
A. Blinov, NSU & BINP Novosibirsk
S. Lange, Uni Giessen
E. Prencipe, Forschungszentrum Jülich
P̄ANDA Collaboration Meeting #56
Bochum, Mar 2, 2016

Search for X → Z transitions at PANDA

Motivation

- Strong theoretical motivations for Z state at the DD threshold
  - Z near DD* threshold: Z(3900) (observed, BESIII)
  - Z near D*D* threshold: Z(4020) (observed, BESIII)
  - Z near DD threshold: never observed
    - Quantum numbers incompatible with $e^+ e^-$ production
- Transitions between exotic states
  - $Y(4260) \to Z(3900)^- \pi^+$ (observed, BESIII)
  - $Y(4260) \to X(3872)\,\gamma$ (observed, BESIII)
  - $X \to Z$ or $Z \to X$ still unobserved
- $\bar{\text{P}}$ANDA is a X(3872) factory
  - Belle 2: 7500 X(3872) in ~10 years
  - BESIII: ~250 X(3872)/year
  - $\bar{\text{P}}$ANDA: $[57000 \div 146000]$ X(3872)/day ($\mathcal{L} = 0.864\ \text{pb}^{-1}$/day)

$\Longrightarrow$ $\bar{\text{P}}$ANDA: unique capabilities for studying rare/suppressed processes involving X(3872)

Talk by S.Lange, CM Uppsala, Sep 2015
&
Talk by L.Bianchi, CM Bochum, March 2016

[IN-PRP-2015-004]

Search for X → Z transitions at PANDA

Strategy

Branching Ratio

$$N_{evt}/\text{day} = N_X/\text{day} \times \mathcal{B}(X \to Z\pi) \times \mathcal{B}(Z \to \chi_{c1}\pi) \times \mathcal{B}(\chi_{c1} \to J/\psi\gamma) \times \mathcal{B}(J/\psi \to \ell^+\ell^-)$$

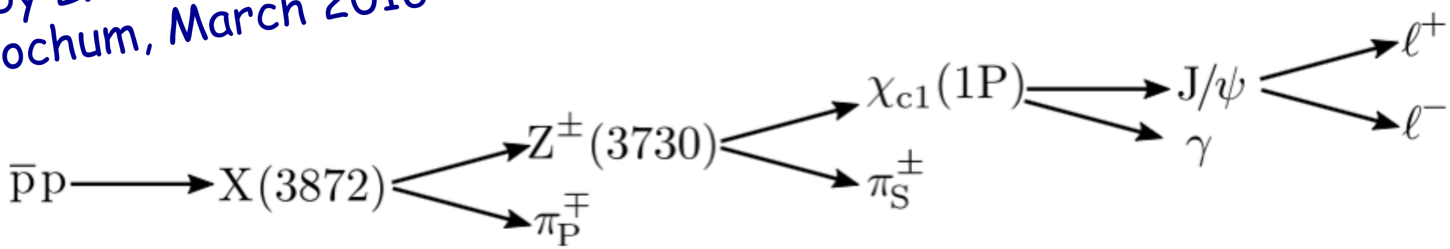
- $\mathcal{B}(\chi_{c1} \to J/\psi\gamma) = (33.9 \pm 1.2)\%$ (PDG)
- $\mathcal{B}(J/\psi \to \ell^+\ell^-) = 11.52\%$ (PDG)
- $\mathcal{B}(X \to Z\pi) \times \mathcal{B}(Z \to \chi_{c1}\pi) = \mathcal{B}_{unknown}$
- $N_{evt}/\text{day} = [2200 \div 5700] \times \mathcal{B}_{unknown}$

Talk by L.Bianchi, CM Bochum, Mar 2016

- Perform analysis
- Calculate minimum $\mathcal{B}_{unknown}$ for which we can get 5σ during data-taking period

Search for X → Z transitions at PANDA

Talk by L.Bianchi, CM Bochum, March 2016



π_P: π_{prompt} $\quad$ π_S: $\pi_{secondary}$

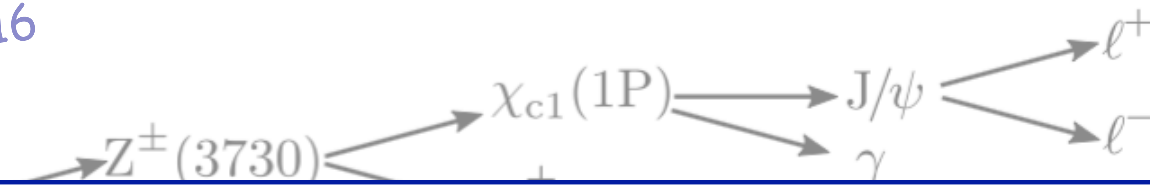
- 100k events, using `SimpleEvtGenRO`
- Using `pbarpSystem1` ($S = 1$) with $p_{\text{beam}} = 6.99102$ GeV/c
- PHSP decays
- All BR 1.0
- $Z^{\pm}(3730)$ model in EvtGen:

```
add p Particle Z(3730)- 99663302 3.73000e+00
5.0e-05 0 -3 0 0.0000000e+00 0
```

Work in progress,
Status report: CM GSI, Dec 2016

Search for X → Z transitions at PANDA

Talk by L.Bianchi,
CM Bochum, March 2016



- Study X to Z transitions in the X(3872) mass scan dataset
- First look at generator-level information with EvtGen
- Next step: simulation $\bar{p}p \to Z(3730)$ in PandaRoot
  - Release: `mar15` (improved MC matching of photons)
  - Re-use existing MC samples (and disk space!)
- Additional information:
  - Internal note IN-PRP-2015-004
  - Sören's talk at CM Uppsala: Slides

Updqate to fullSim
→ Ludovico's talk

```
add p Particle Z(3730)- 99663302 3.73000e+00
5.0e-05 0 -3 0 0.0000000e+00 0
```

Zc(3900) production and decays into pbar d

Zc(3900) production and decays into pbar d

Simulation of *Zc(3900)*-production and decays in $\bar{p}$-*d* collisions at PANDA

Alexander Blinov, BINP&NSU, Novosibirsk
Jens Sören Lange, Elisabetta Prencipe, FZ Jülich
PANDA LV C-meeting, Vienna, 01.12.2015

Talk by A.Blinov, CM Vienna, Dec 2015

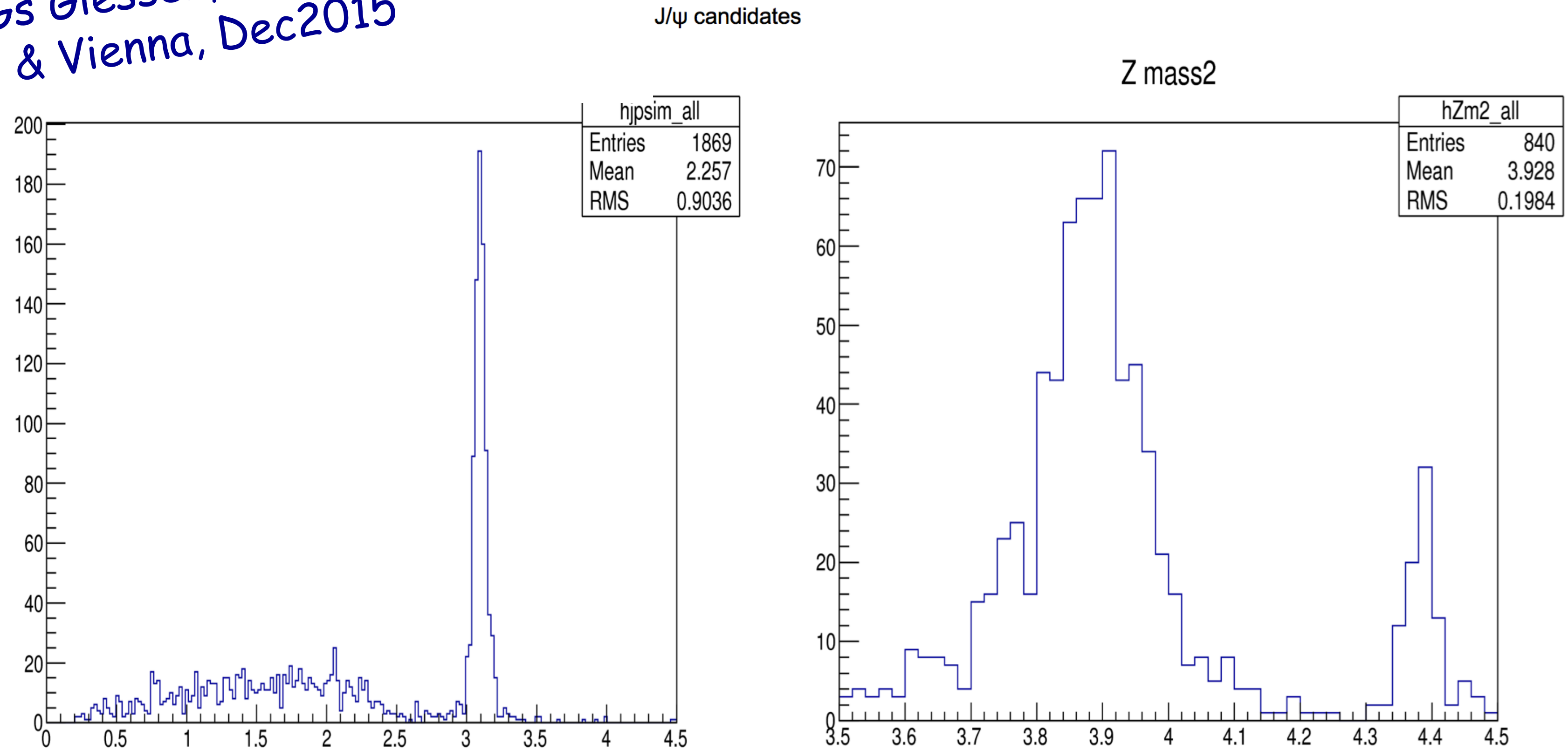
1. Status of *Z*-states,
2. *Zc*-coupling with nucleon-antinucleon channel,
3. *Zc*-production in $\bar{p}$-*d* collisions,
4. Reconstruction of $Z_c(3900) \longrightarrow \pi^- \, J/\psi \longrightarrow l^+l^-$,
5. Conclusions.

Another unique PANDA possibility: $\bar{p}d \rightarrow Z^- p$

Simulation of non-resonant p d⟶π- J/ψ⟶μ+μ-

Talk by A.Blinov,
PWGs Giessen, Dec 2014
& Vienna, Dec2015

Ppbar = 7.05 GeV/c, 1000 events



π J/ψ

J/ψ with track splitting

-> FullSim started

Another unique PANDA possibility: $\bar{p}d \rightarrow Z^- p$

Simulation of non-resonant p d⟶π- J/ψ⟶μ+μ-

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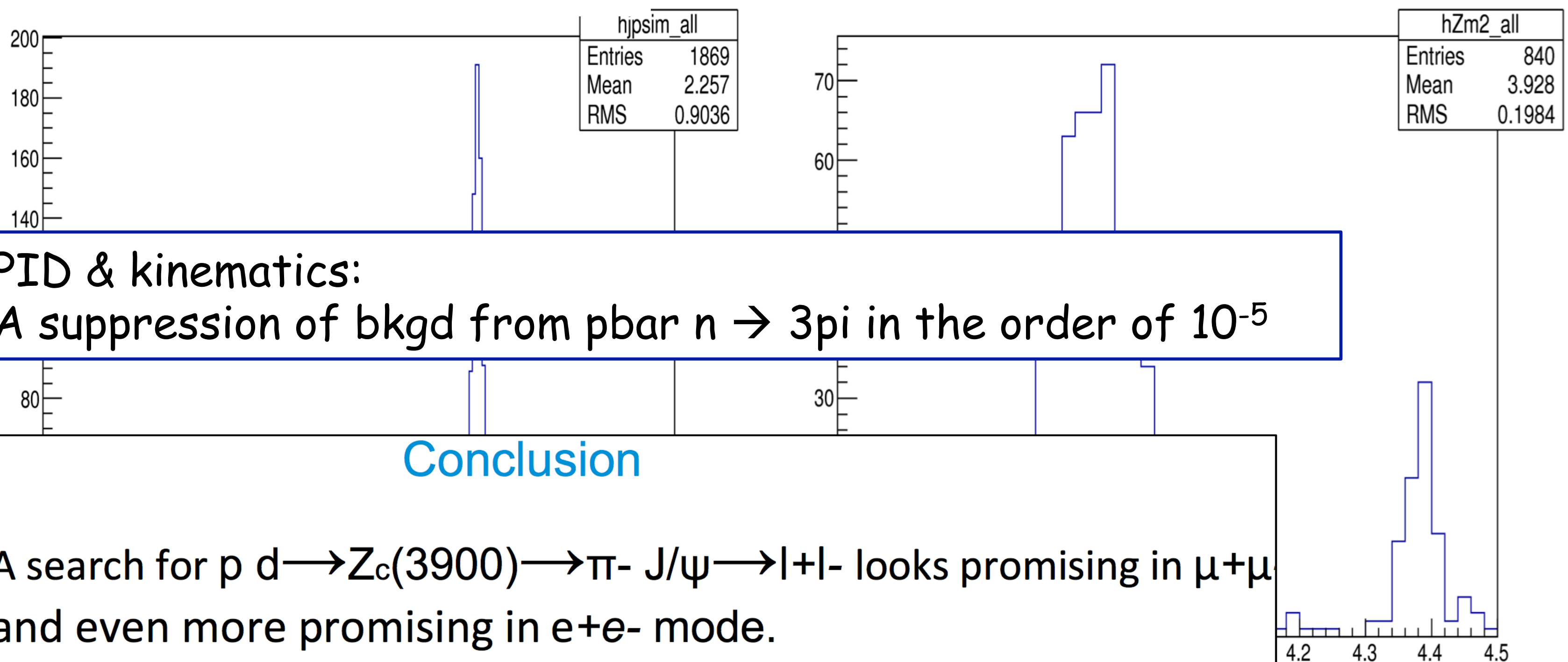


PID & kinematics:
A suppression of bkgd from pbar n → 3pi in the order of 10^{-5}

Conclusion

A search for p d⟶Z_c(3900)⟶π- J/ψ⟶l+l- looks promising in μ+μ
and even more promising in e+e- mode.

π J/ψ

J/ψ with track splitting

-> FullSim started

X(3872) → DDbar decays

Recent results on the full simulation of charmonium-like decays

A. Zinchenko, M.Barabanov,
A.Vodopianov

(VBLHEP, JINR, Dubna)

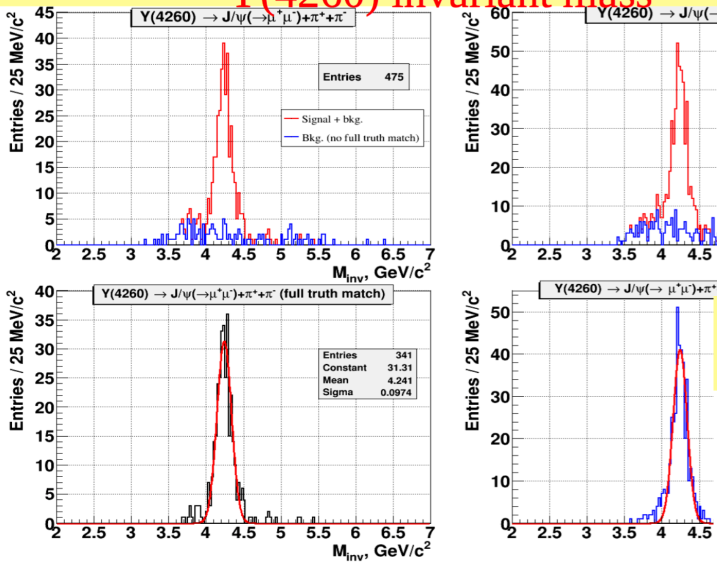
PANDA LVI Collaboration Meeting
29.02 – 4.03 2016
Ruhr-Universitat Bochum, Germany

FullSim PandaRoot studies

Y(4260) → J/ψ (→μ+μ-) π+π- reco

Y(4260) invariant mass

Talk by A.Zinchenko, CM Bochum, Mar 2016



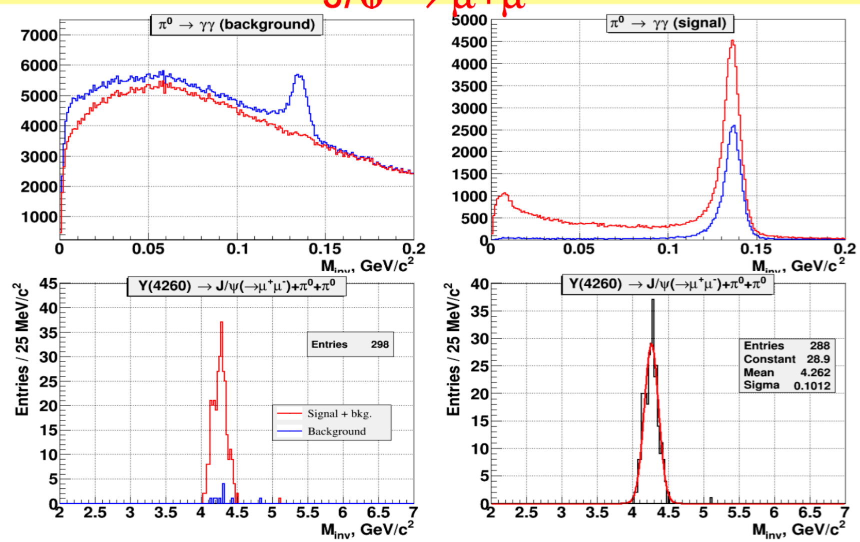
March 2015 Release

Now: Eff. = 439 / (30000

2-Mar-2016 A.Zinchenko

Y(4260) → J/ψ π⁰π⁰ reco

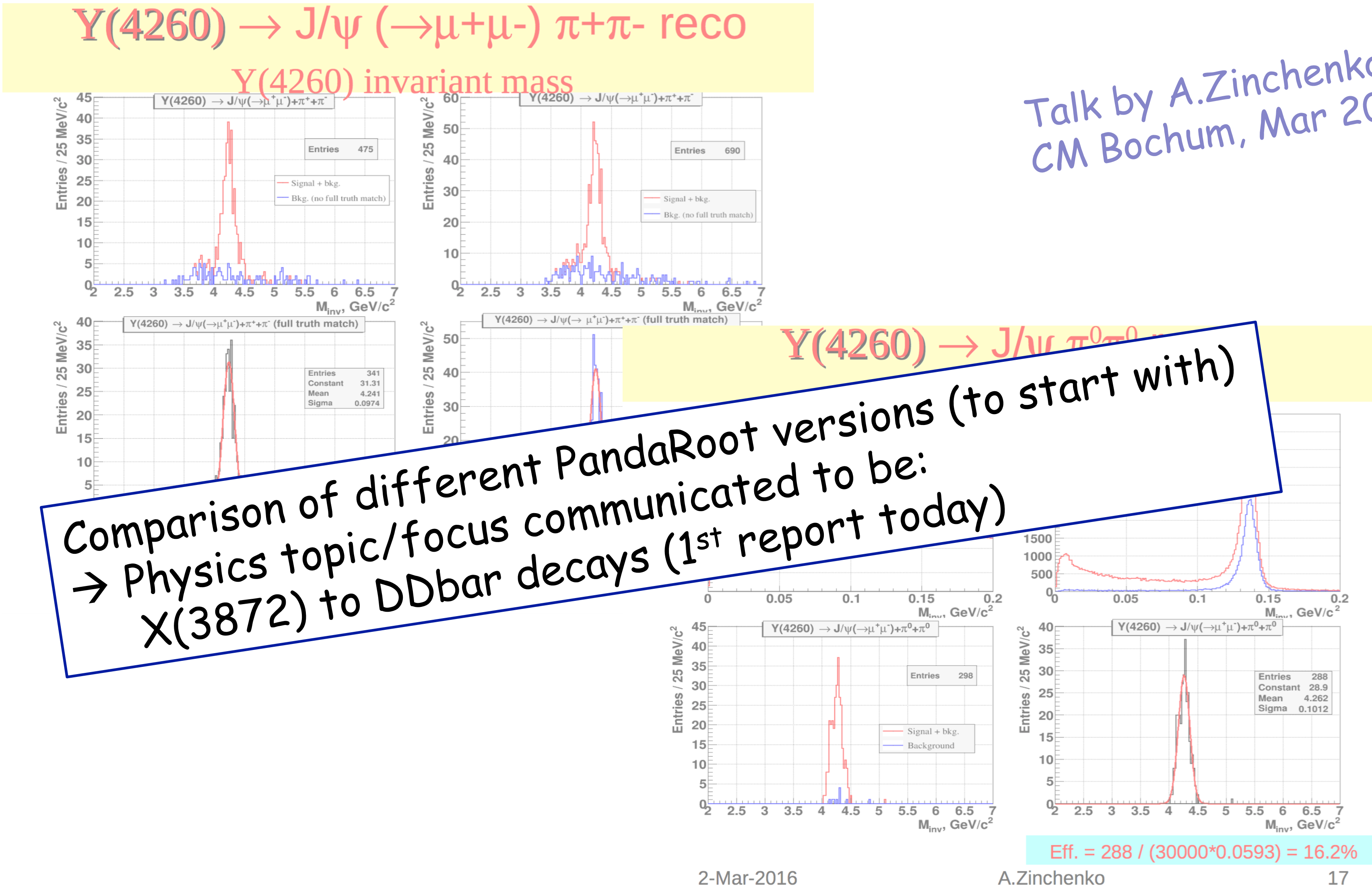
J/ψ → μ+μ-



Eff. = 288 / (30000*0.0593) = 16.2%

2-Mar-2016 A.Zinchenko 17

FullSim PandaRoot studies



Talk by A.Zinchenko, CM Bochum, Mar 2016

Comparison of different PandaRoot versions (to start with)

→ Physics topic/focus communicated to be: X(3872) to DDbar decays (1st report today)

Charmonium-like Exotics at PANDA in view of "phase-1" physics paper

- X(3872) energy scan
  - FullSim studies completed
  - ✓ Released

Material ready to go in:
a) exemplary proof of princple for E-Scan
b) concrete feasibility and performance study for X(3872)

- X(3872) → $Z^{\pm}(3730)\pi^{-/+}$
  - FullSim studies started/ongoing
  - Nothing yet released (prod. numbers checked, summarised IN)

Updated status this Wed
→ timelines (paper/Ludovico)

- Zc(3900) production and decays into pbar d
  - FullSim studies started
  - On hold since a year, nothing yet released

Update expected March CM 2017
→ At least possible to mention (qualitatively)

- X(3872) → DDbar decays
  - FullSim studies started,1st presentation this meeting, Wed,
  - Status not yet known, nothing yet released

→ First status report today

Charmonium-like Exotics at PANDA in view of "phase-1" paper -- Summary

Charmonium-like exotics at PANDA

- uniquely gluon-rich process: ppbar
  - → *high cross section for states with gluonic excitations / exotics*
- unique in precise measurement of widths
  - → *sub-MeV range, needed to understand X,Y,Z nature*
- unique in discovery potential for high spins:
  - → *no angular momentum barrier (and no restriction spin)*

=> Only PANDA will enable to explore complete multiplets and clarify nature of X,Y,Z

Possible Topics for Early Physics Beam

- X(3872) energy scan (results released)
- X(3872) → $Z^{\pm}(3730)\pi^{-/+}$ (under work)
- Zc(3900) production and decays into pbar d (on hold, to be resumed)
- X(3872) → DDbar decays (first studies started)

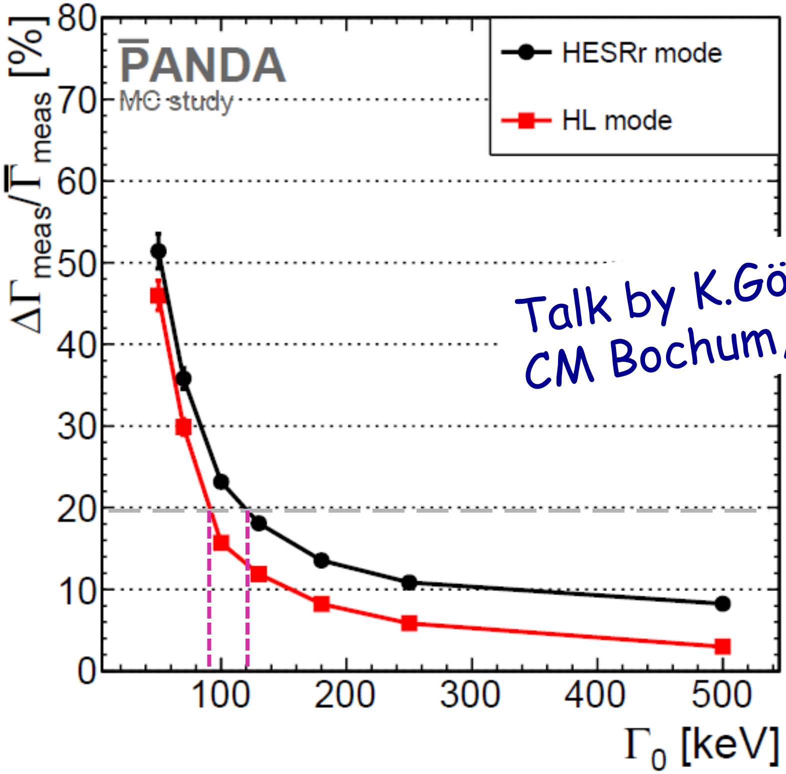
=> Depending on timeline, manpower/focus to be strengthened

Additional slides

Main results (σ = 100nb assumed)

- Achievable precision in measured BW width Γ
- Clarify nature by lineshape measurement (distinguish virtual/bound state)

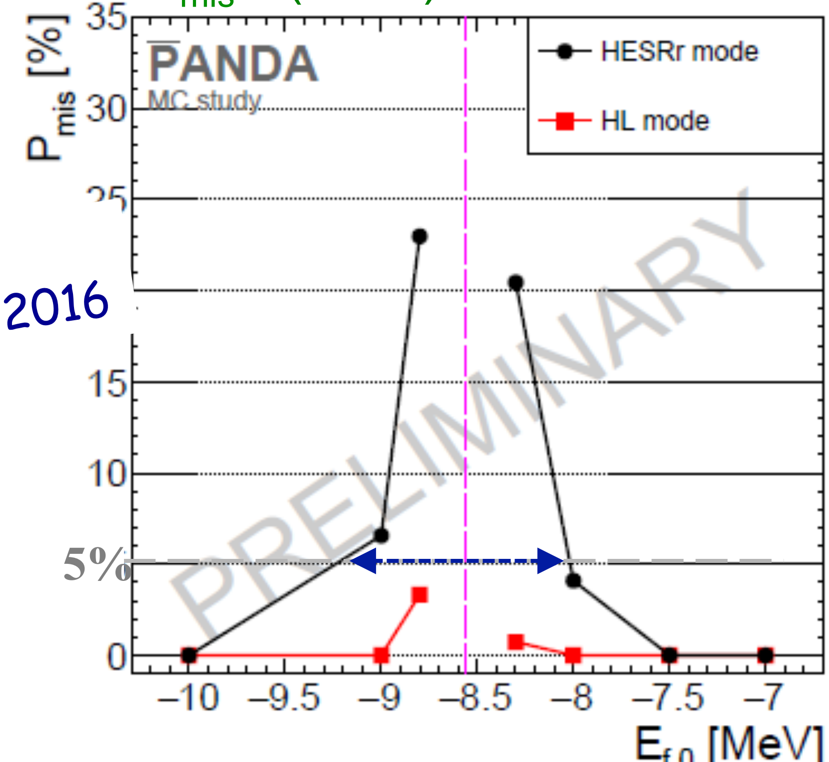
Sensitivity



$\Delta\Gamma/\Gamma$ =20% : Γ= 90 ... 120 keV

HL HESRr

P_{mis} X(3872) nature



P_{HL} > 95%

P_{HESRr} > 95% for $|E_f - E_{f,th}| \gtrsim 0.75$MeV

[RN-QCD-2016-002]

Rough estimate of stats

- X(3872) energy scan
  - 140 evts (on peak) / 1-2 days => 40 scan points x 2 days = 80 days

- X(3872) → DDbar decays
  - X → DDbar: In principle 10-20 x Xscan case, (90% / 5% = factor 20)
  - Nb of DDbar evts? Many individ.decays, with relatively small BR (~5%)

- X(3872) → $Z^{\pm}(3730)\pi^{-/+}$
  - $J^P = 0^+$ (I=1), X(3872) production: 50k – 145k, plus:
  - BR(Z→ $\chi_{c1}\pi$) =?, BR(X→ Zπ) ≤ 10% => 50-145k x 0,34 x 0,115

    = 2200 – 5700 x 0,10 x 0,xx => ≤ 220 -570 /day

    plus reco-effi ≤ 20% => 45 -100 /day

  Assume Xscan data, 30 points: rough estimate factor 1/3 => 15 -30 evts /day

  => 80 days = N_{Zrec}= 1200 -2500

Rough estimate of stats

- Zc(3900) production and decays into pbar d
  - Zc production not neccessarily suppressed (OZI argument, vs ccbar))
  - $W(P_N < P)$ = probability for neutron momenta < P

    => W(n) <= 200 MeV (90%)
  - Ecms = ~4 GeV: FWHM = 160 MeV => sigma = 60-70 MeV

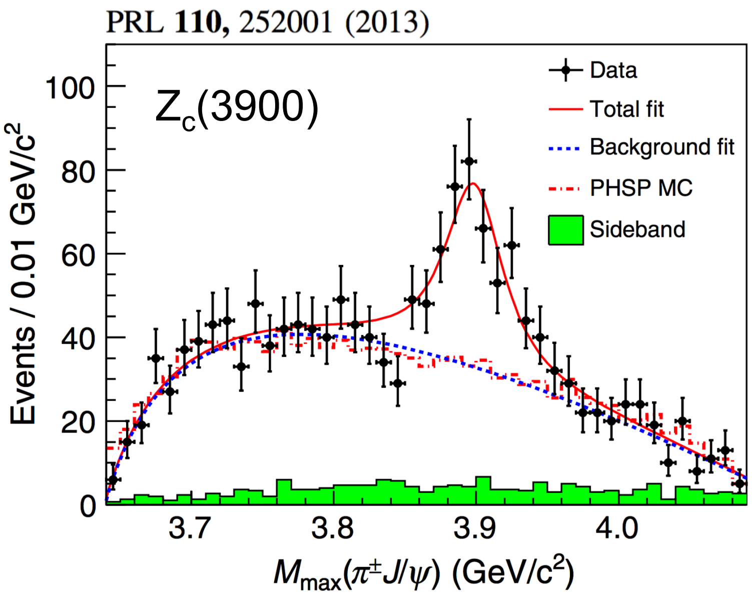
    => ppbar: sigma = 80 -180 keV (X scan)

    pbar d: sigma = 70 MeV => factor 1000 worse

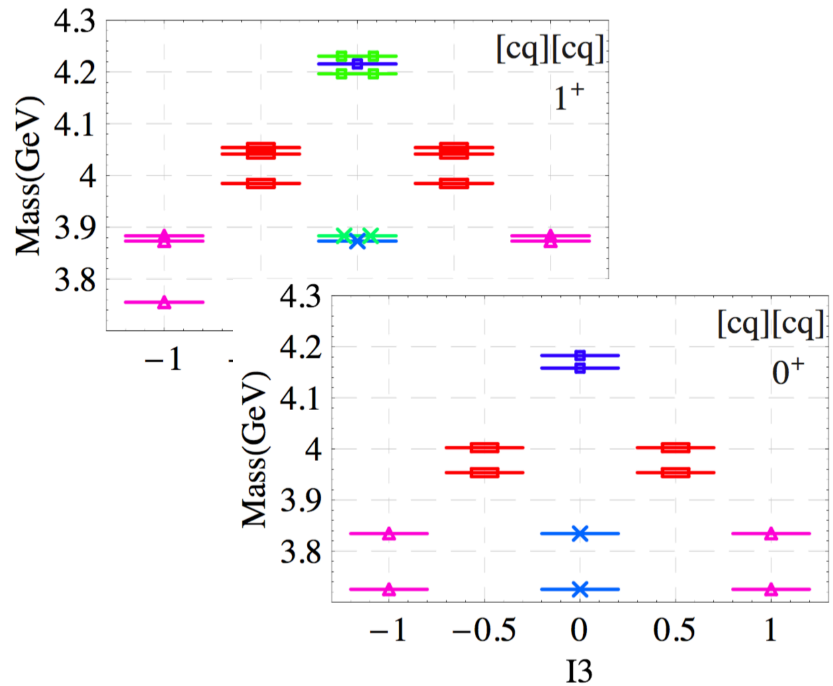
    but no recoils, need clever idea, anyhow:

    => NO energy scan really possible, but observation

Motivation



[N.Drenska et al., Riv. Nuovo Cim. 033 (2010) 633]



unexpected,
manifestly exotic!

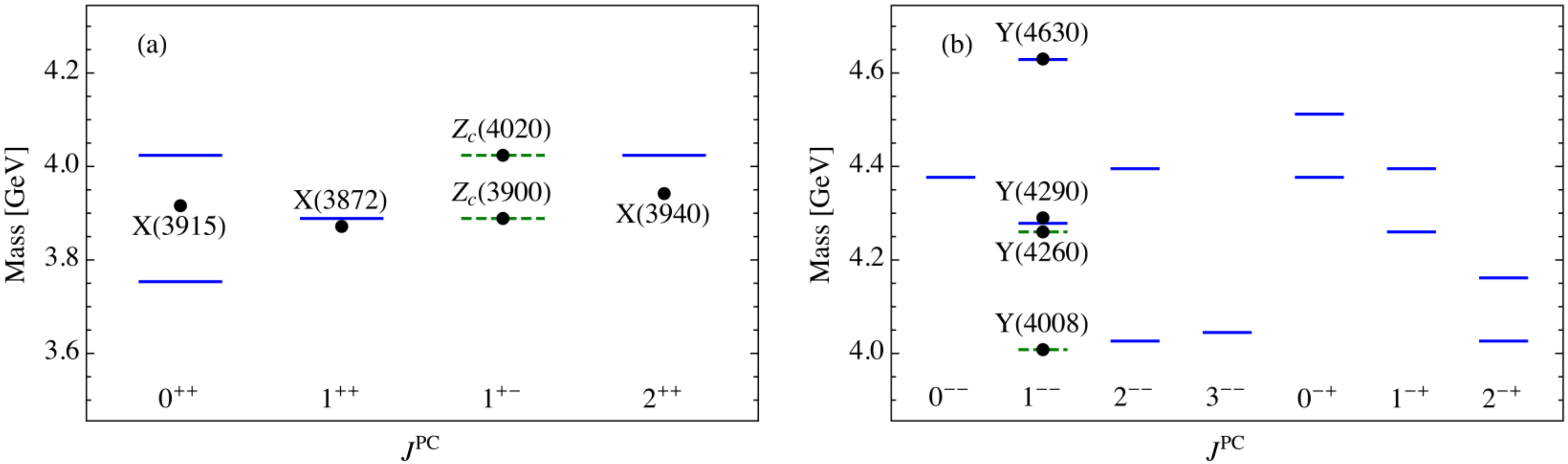
Complete multiplets to be observed?

→ *e.g.* 0^+, 1^+, 2^+, ... *spin partner states*

→ *further charmonia channels needed*

Further channels of interest – many, still in 2025? what counts for us most, uniqueness!

Cleven et al., arXiv:1505.01771



- Many more charged and neutral channels predicted than observed
  - 67 among 80 ground states still to be discouvered
- Only PANDA has discovery potential for high spin states *(angular momentum barrier)*
  - e.g. predicted J = 3 state
- Observation of complete multiplets needed to solve X,Y,Z puzzle

=> PANDA

[C.Hahnhart, GSI, May 2015]

"Old Released" results

Summary of "old released PANDA plots and results" – Meson spectroscopy

The PANDA Charmonium, Charmonium-like Exotics and Light Quark Meson Physics Working Groups

Editors:

E. Fioravanti[1], F. Nerling[2], and M. Pelizaeus[3]

[1]INFN Ferrara
[2]HIM, GSI Darmstadt
[3]Ruhr-Universitaet Bochum

November 19, 2015

Chapter 2

Charmonium-like Exotics

In the following sections, we summarise the results obtained from MC simulation studies performed in view of the feasibility of PANDA for spectroscopy of charmonium-like exotics, like the famous X,Y,Z states.

- Study for spin-exotic charmonium hybrid $\tilde{\eta}_{c1}$
  → *M.Pelizaeus*
- Study of X(3872) energy scan
  → *M.Galuska et al.*
- Study of Y(4260)
  → *E.Prencipe et al.*
- Study of Zc(4430) state
  → *M.Pelizaeus*

An internal PANDA note...

A proposal for Z state search and estimate of X, Y, Z production rates at $\overline{\mathrm{P}}$ANDA.

Alexander Blinov, Budker Institute of Nuclear Physics and Novosibirsk State University, Novosibirsk (Russia);
Martin Galuska, Justus-Liebig-Universität, Giessen (Germany);
Jens Sören Lange, Justus-Liebig-Universität, Giessen (Germany);
Elisabetta Prencipe, Forschungszentrum Jülich (Germany);
James Ritman, Forschungszentrum Jülich (Germany);

on behalf of the $\overline{\mathrm{P}}$ANDA charmonium-light exotics group.

Abstract

The $\overline{\mathrm{P}}$ANDA detector at FAIR (Facility for Antiproton and Ion Research) in Darmstadt (Germany) aims to conduct an antiproton-proton experiment with a very high rate capability, up to 10^7 interactions per second. In the past 12 years several unpredicted resonant states were observed. Prominent examples are the so-called Z charged states and their neutral partners, that were first observed at the Belle and BES III experiments two years ago. Some of them have recently been confirmed by LHCb. They have risen the interest in searching for further charmonium-like states. Measurements in $\bar{p}p$ annihilation are complementary to what has been achieved in this sector by e^+e^- colliders, and running experiments in pp collisions. In this short report, we present some extrapolations to understand the level of competitiveness of $\overline{\mathrm{P}}$ANDA, in the first day of data taking, assuming a luminosity $\mathcal{L} = 10^{31}$ cm^{-2} s^{-1}.

- $\bar{p}p \to X(3872) \to Z(3730)\pi$

Table 2: Summary of the expected X, Y, and Z production rates per day in $\overline{\mathrm{P}}$ANDA, assuming different detector luminosity ($\mathcal{L}$/pb^{-1}/day). The calculation is performed by multiplying luminosity and cross sections. The cross section upper limits are used in these calculations.

Resonance	$\mathcal{L} = 8.64$	$\mathcal{L} = 0.864$	$\mathcal{L} = 0.432$	Ref.
$X(3872)$	432000	43200	21600	[18]
$Y(4260)$	19000	1900	950	
$Z(3900)^+$	4050	405	202	[13]

CHARMONIUM PHYSICS WORKING GROUP

Elisa Fioravanti
INFN Ferrara

PANDA Collaboration Meeting, Nov 30 - Dec 04 2015, Vienna

Summary

- **Charmonium spectroscopy at PANDA:**

  - Precision measurements mandatory: e.g. branching fractions, masses and widths

- Scutiny Group merged proposals made by the various PWGs to a **two year early physics proposal**

  Charmonium spectroscopy:

  - 13 days at 5.55 GeV/c for χ_{c1} angular distribution studies
  - 36 days at 5.73 GeV/c for χ_{c2} angular distribution studies
  - 60 days at 5.61 GeV/c for h_c width measurement

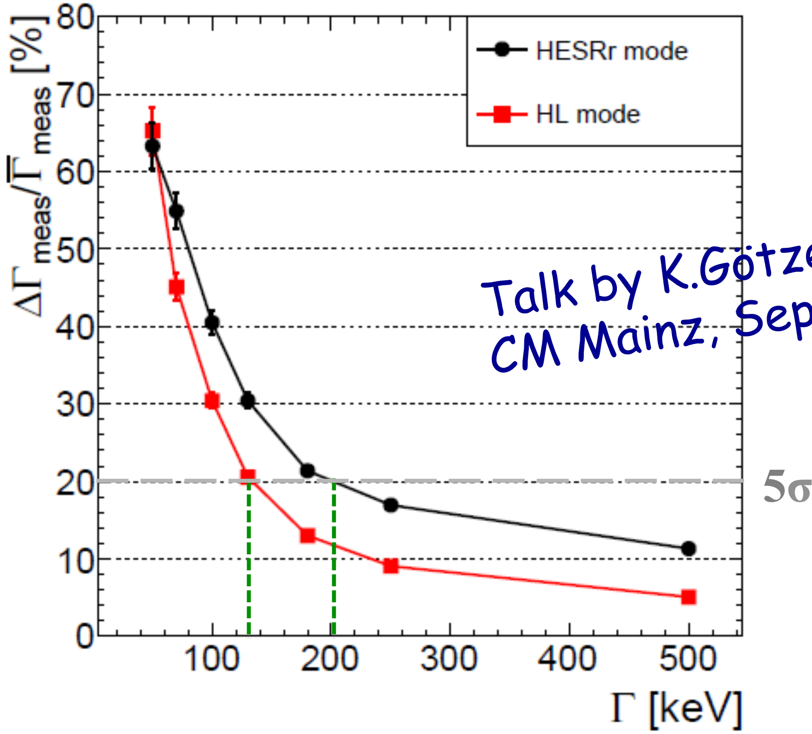
- **Future plans:**
  - Full simulation of the analysis done during the scrutiny process

- **Limited manpower:**
  - like in Charmonium-like Exotic and Light Mesons PWGs - Anyone is welcome!

Main results (σ = 50nb assumed)

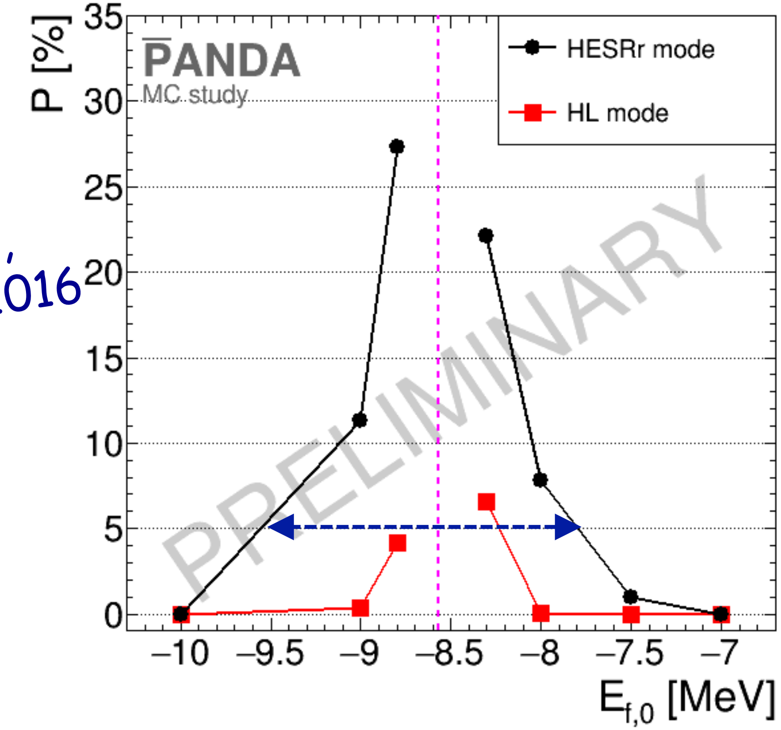
- Achievable precision in measured BW width Γ
- Clarify nature by lineshape measurement (distinguish virtual/bound state)

Sensitivity



Talk by K.Götzen, CM Mainz, Sep 2016

P_{mis} X(3872) nature



$\Delta\Gamma/\Gamma$ =20% : Γ= 130 ... 200 keV

HL HESRr

P_{HL} > 93%

P_{HESRr} > 93% for $|E_f - E_{f,th}| \gtrsim 1$ MeV

[RN-QCD-2016-002]

Search for X → Z transitions at PANDA

Talk by S.Lange,
CM Uppsala, Sep 2015

Open questions about Z states

- charged and neutral Z states → same mass ?
  [ccuu,ccdd] vs. [ccud]
- why are all the Z states observed above threshold ?
  (contradicts interpretation as molecules and CUSPs)
- transitions of XYZ states ?
  Y → Z, seen at BESIII (Y(4260) → Z(3900) π^+)
  Y → X, seen at BESIII (Y(4260) → X(3872) γ)
  → what about X → Z transistions?

Z near DD threshold	0+	never observed
Z near DD* threshold	1+	Z(3900)
Z near D*D* threshold	0+,1+,2+	Z(4020)

[IN-PRP-2015-004]

Search for X → Z transitions at PANDA

$$\bar{p}p \rightarrow X(3872) \rightarrow Z(3730)\pi$$

$X(3872) \rightarrow Z(3730)^0\pi^0$ (with L=1),

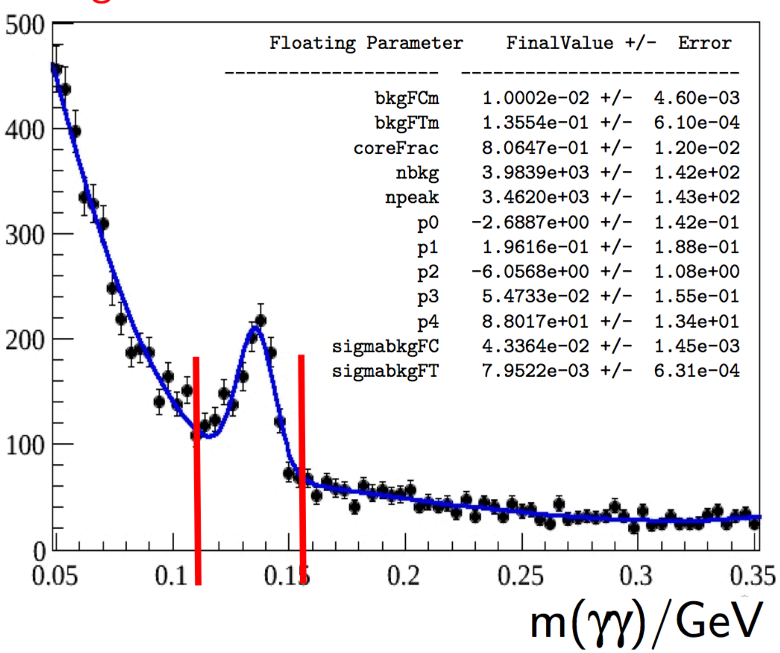
where $Z(3730)^0$ decays to $J/\psi\gamma$ and $\chi_{c1}\pi^0$

Also, possible charged $Z(3730)^+$ candidate, decaying to $\chi_{c1}\pi^+$,

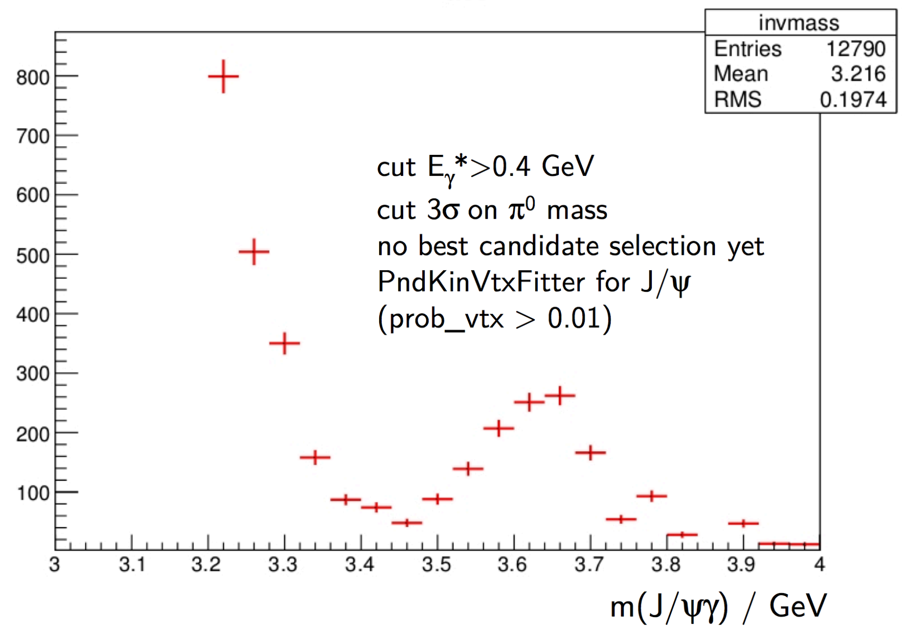
with subsequent $\chi_{c1} \rightarrow J/\psi\gamma$

Talk by S.Lange,
PWG Uppsala, June 2015

Signal MC

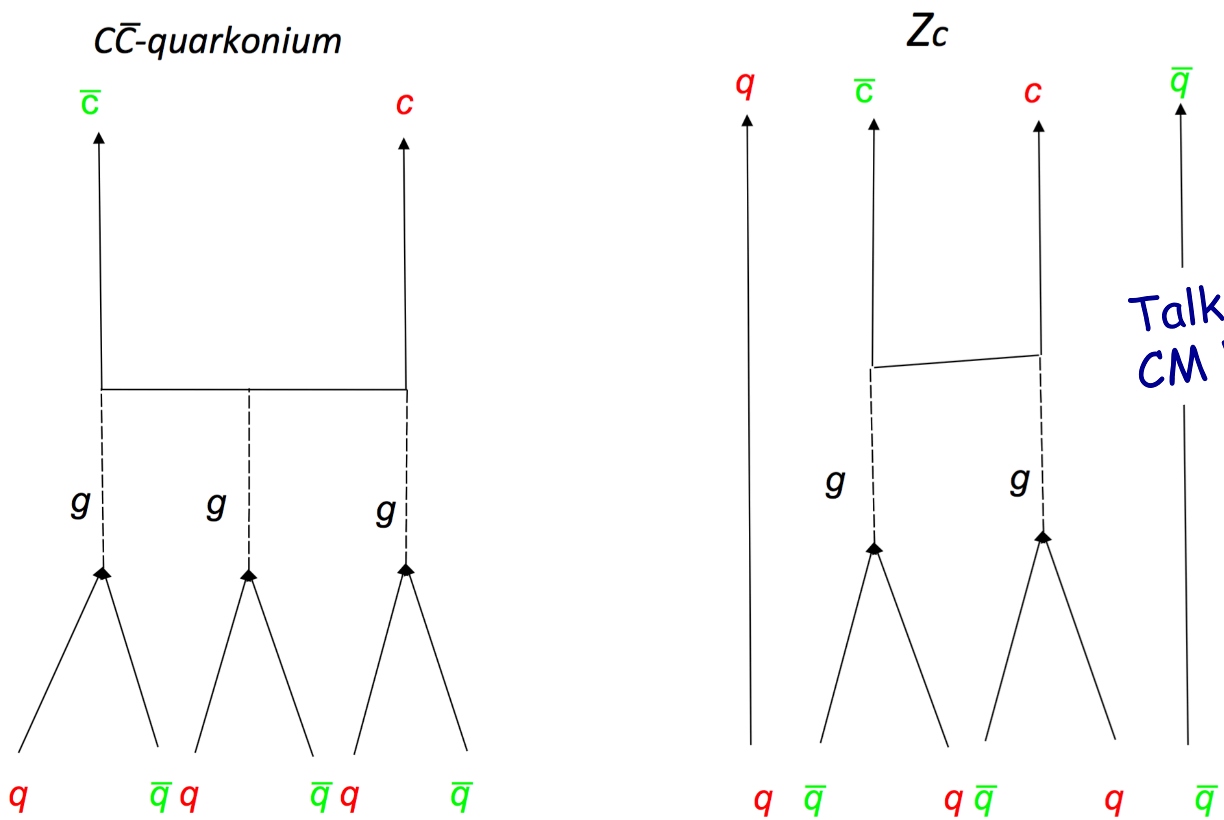


$Z^0(3730)$ Signal



Zc(3900) production and decays into pbar d

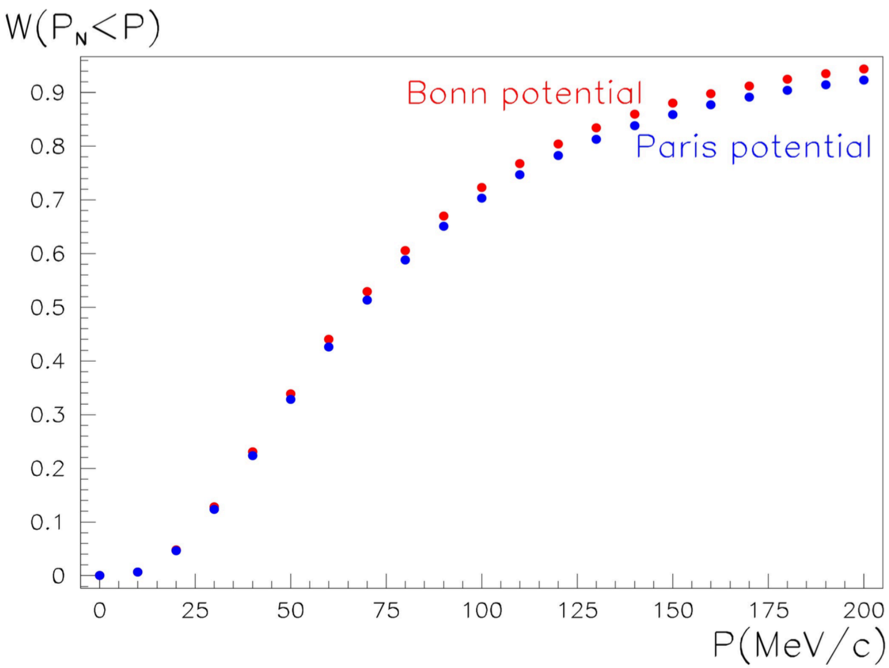
Couplings with nucleon-antinucleon channel: $c\bar{c}$ v.s. Zc



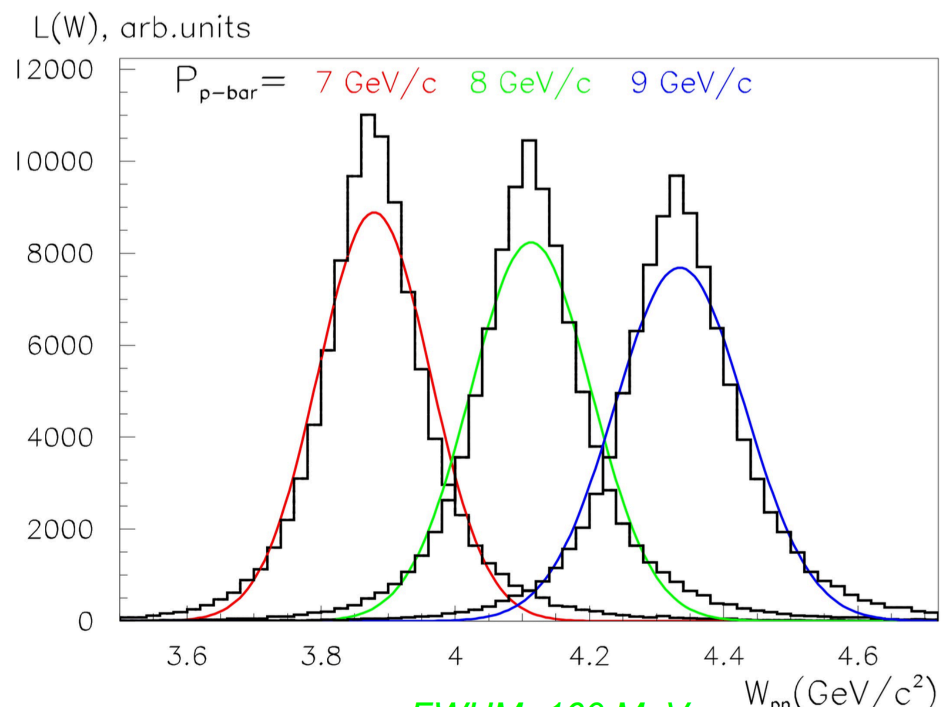
Talk by A.Blinov,
CM Vienna, Dec 2015

Zc(3900) production and decays into pbar d

Cumulative probability distribution of P_N in deuteron



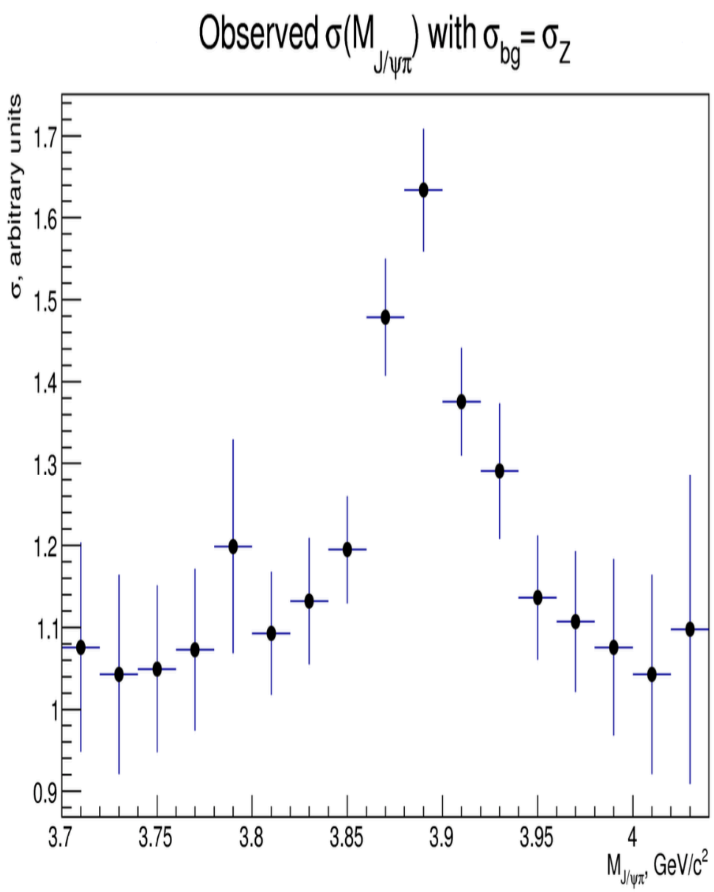
Talk by A.Blinov, CM Vienna, Dec 2015

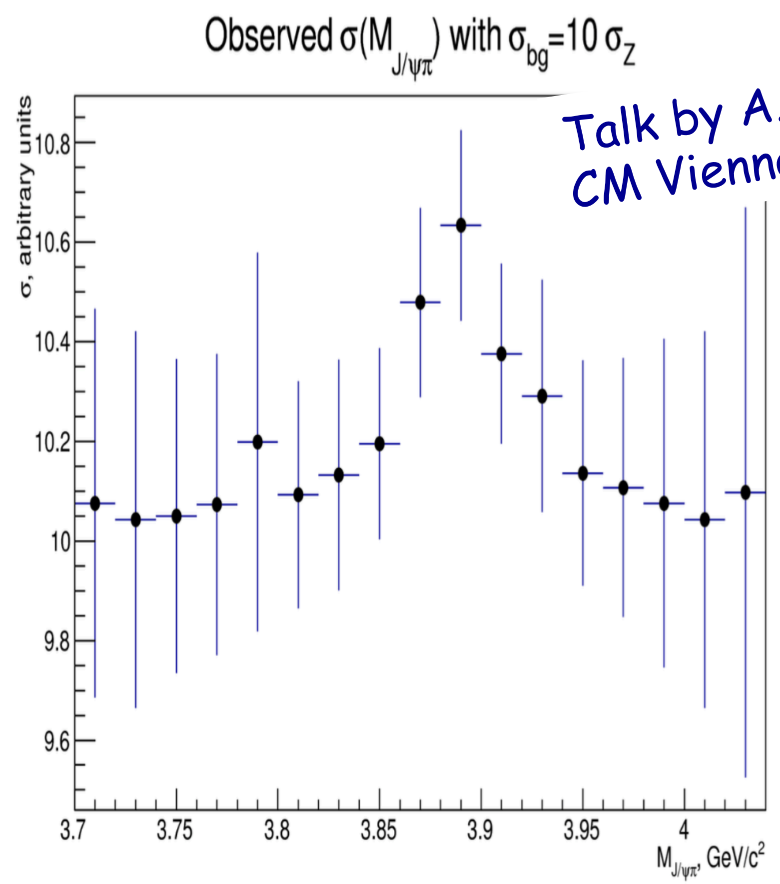


FWHM=160 MeV

Zc(3900) production and decays into pbar d

Simulation of Z-search with σ_{bg} / σ_z = 1 and 10

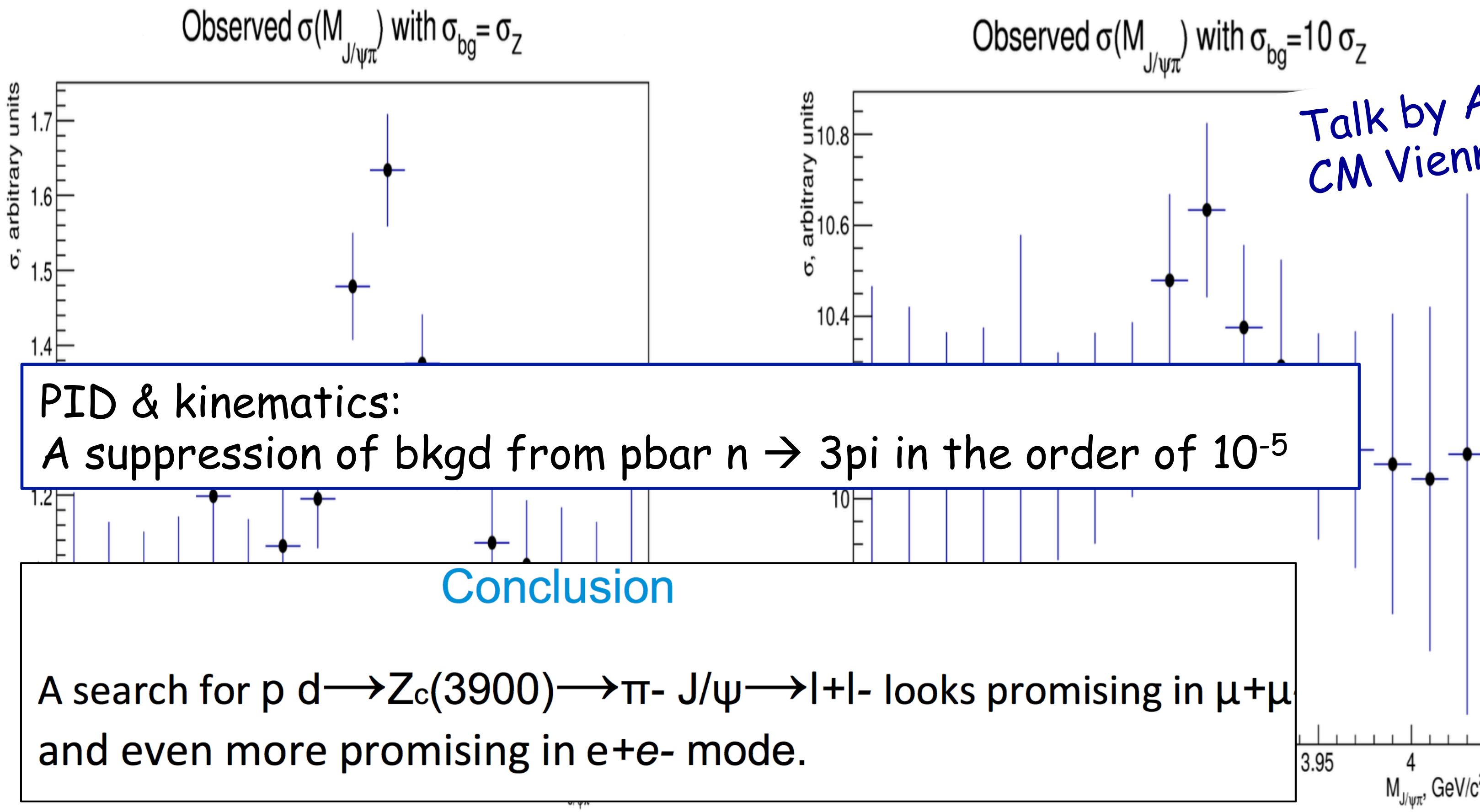




Talk by A.Blinov, CM Vienna, Dec 2[...]

Zc(3900) production and decays into pbar d

Simulation of Z-search with σ_{bg} / σ_Z = 1 and 10



Talk by A.Blinov, CM Vienna, Dec 2[...]

PID & kinematics:
A suppression of bkgd from pbar n → 3pi in the order of 10^{-5}

Conclusion

A search for p d⟶Z_c(3900)⟶π- J/ψ⟶l+l- looks promising in μ+μ[...]
and even more promising in e+e- mode.

Charmonium-like Exotics PWG

Who we are:

- Univ. Bochum
  - M.Pelizaeus
- GSI Darmstadt
  - K.Götzen, R.Kliemt, F.Nerling
- JINR Dubna
  - M.Barabanov, A.Luchinsky, A.Zinchenko
- INFN Ferrara
  - E.Fioravanti (on hold)
- Univ. Giessen
  - M.Galuska, S.Lange, tbc
- FZ Jülich
  - E.Prencipe, tbc (on hold for a few month)
- HI Mainz
  - T.Weber (left), others tbc
- BINP Novosibirsk
  - A.Blinov

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- BINP Novosibirsk
  - A.Blinov, tbc

Charmonium-like Exotics PWG

- Univ. Bochum
  - Study for spin-exotic charmonium hybrid η_{c1}, further channels (PANDA Phys. Perf. Report)
  - Very quick, first look to kinematics at PANDA for Zc(4430)
- GSI Darmstadt
  - Scrutiny studies for X,Y,Z (feasibilty for various charmonia and recoils)
  - X(3872) resonance energy scan (width, lineshapes)
- JNR Dubna
  - PandaRoot QA checks
  - EvtGen modelling for X(3872)
- INFN Ferrara
  - Scrutiny studies for X(3872)
- Univ. Giessen
  - X(3872) resonance energy scan (width)
  - Search for Zc(3730) at PANDA
- FZ Jülich
  - Y(4260) first studies (also Giessen)
  - Search for Zc(3730) at PANDA
- HI Mainz
  - X(3872) resonance energy scan (trial to extract lineshape, importance of precise lumi)
- BINP Novosibirsk
  - Study of pbar d → Z^- p, with additional recoil proton detector
  - Search for Zc(3730) at PANDA (also Jülich)

Activities, achievements so far

- PANDA Physics Performance Report
  - old analysis framework
  - among others dedicated studies for Charmonium-like exotics

- Scrutiny studies
  - fastSim studies (tuned to full sim)
  - for X,Y,Z production, various charmonia and recoils

- Dedicated X(3872) energy scan studies
  - pbarp → X(3872) → $J/\psi \pi^- \pi^+$ (J/ψ → e+e- and partly also mu+mu-)
  - 3 independent analyses (M.Galuska, T.Weber, K.Götzen)

    → *with different focus and levels of completeness,*

    cf. Master thesis, IN-REP-2015-005, Talks at last PWG meetings, respectively

- X,Y,Z production and proposal of a search for Z(3730) at PANDA
  - estimate of X,Y,Z states produced at PANDA
  - Search for X → Z transition (S.Lange, E.Prencipe, A.Blinov, ...)
  - Zc production on deuterim target: pd → Z^- p (A.Blinov)

Charmonium-like Exotics at PANDA

Charmonium-like exotics at PANDA

- uniquely gluon-rich process: ppbar
  → *high cross section for states with gluonic excitations / exotics*
- unique in precise measurement of widths
  → *sub-MeV range, needed to understand X,Y,Z nature*
- unique in discovery potential for high spins:
  → *no angular momentum barrier (and no restriction spin)*

Even topics for Early Physics Beam

- X(3872) energy scan
- Charmonium survey (incl. Zc, Hybrids)

=> **Only PANDA will enable to explore complete multiplets & clarify nature of X,Y,Z**

Manpower situation

- Only 3 full simulation studies focusing on physics "results"
  → *feasibility studies for scrutiny started to extend to fullSim*
- Many more channels to be updated, and also to be started
  → *new ideas and proposals of course welcome, also active analysts*

Future plans to enrich PANDA repertoire of unique PANDA physics:

- Prioritise work on channels, extend coverage of complete physics case
  → *full simulations with realistic background estimations*
  → *extension to include angular distributions (PWA)*
  → *go for more realistic generators (incl. charm)*
- Combine efforts as much as possible (CC, LQM, ,,,)
  → *data production, knowledge, ...*

=> **New manpower welcome!**

Short Summary of Results, FoMs

- Scrutiny studies: Feasibility for XYZ states at PANDA

[K .Götzen, R. Kliemt, F. Nerling]

$\sigma_s = 10\,\mathrm{nb}$, $E_{cms} = 5.5\,\mathrm{GeV}$, $1\mathrm{x}10^{32}$

10nb	L/cms			
E_cm	detopt	Full		
	mode	t [d]	S/B	Dal QA
5,5	etac(2Kpi0) 2pi	7,0	0,004	✓
	etac(2Kpi0) 2pi0	3,0	0,016	✓
	etac(2Kpi0) 2eta	9,4	0,20	✓
	etac(2Kpi0) 2K	1,4	0,079	✓
	etac(KsKpi) 2pi	3,7	0,11	✓
	etac(KsKpi) 2pi0	3,7	0,26	✓
	etac(KsKpi) 2eta	10	0,19	✓
	etac(KsKpi) 2K	2,8	0,69	✓
	Jpsi(2e) 2pi	0,8	2,6	✓
	Jpsi(2e) 2pi0	0,9	2,1	✓
	Jpsi(2e) 2eta	3,8	0,57	✓
	Jpsi(2e) 2K	0,7	2,7	✓
	Jpsi(2mu) 2pi	0,6	3,1	✓
	Jpsi(2mu) 2pi0	0,6	3,0	✓
	Jpsi(2mu) 2eta	2,3	0,82	✓
	Jpsi(2mu) 2K	0,5	3,8	✓

$\sigma_s = 1\,\mathrm{nb}$, $E_{cms} = 5.5\,\mathrm{GeV}$, $1\mathrm{x}10^{31}$

1nb	L/cms			
E_cm	detopt	Full		
	mode	t [d]	S/B	Dal QA
5,5	etac(2Kpi0) 2pi	701	0,000	✓
	etac(2Kpi0) 2pi0	291	0,002	✓
	etac(2Kpi0) 2eta	118	0,020	✓
	etac(2Kpi0) 2K	43	0,008	✓
	etac(KsKpi) 2pi	88	0,011	✓
	etac(KsKpi) 2pi0	37	0,026	✓
	etac(KsKpi) 2eta	133	0,019	✓
	etac(KsKpi) 2K	28	0,069	✓
	Jpsi(2e) 2pi	7,6	0,26	✓
	Jpsi(2e) 2pi0	9,2	0,21	✓
	Jpsi(2e) 2eta	38	0,057	✓
	Jpsi(2e) 2K	7,2	0,27	✓
	Jpsi(2mu) 2pi	6,3	0,31	✓
	Jpsi(2mu) 2pi0	6,4	0,30	✓
	Jpsi(2mu) 2eta	24	0,082	✓
	Jpsi(2mu) 2K	5,1	0,38	✓

Time QA (days)
green < 30 yellow < 365 red >= 365

S/B QA
green > 1 yellow > 0.1 red <= 0.1

Dal QA
ok < 1.5

Lineshapes for different E_f

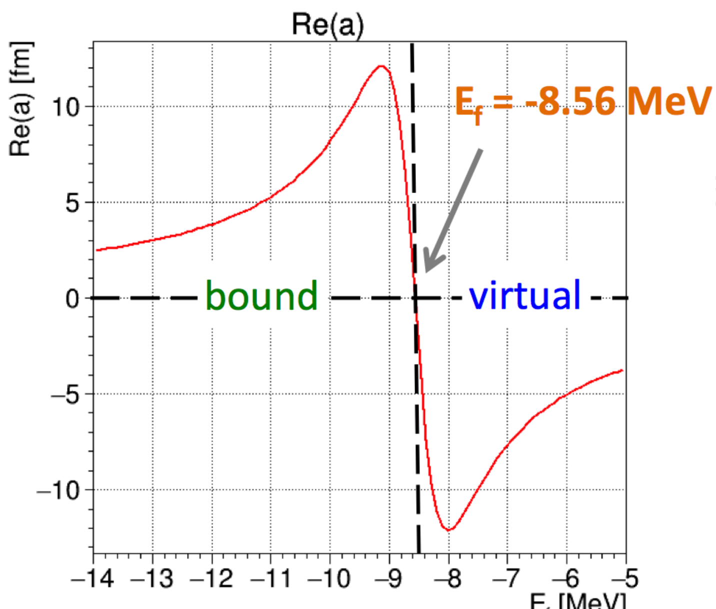
-> Talk by K. Götzen, PWGs 18th Nov & 1st Dec2015

Scattering length D^0D^{0*}:

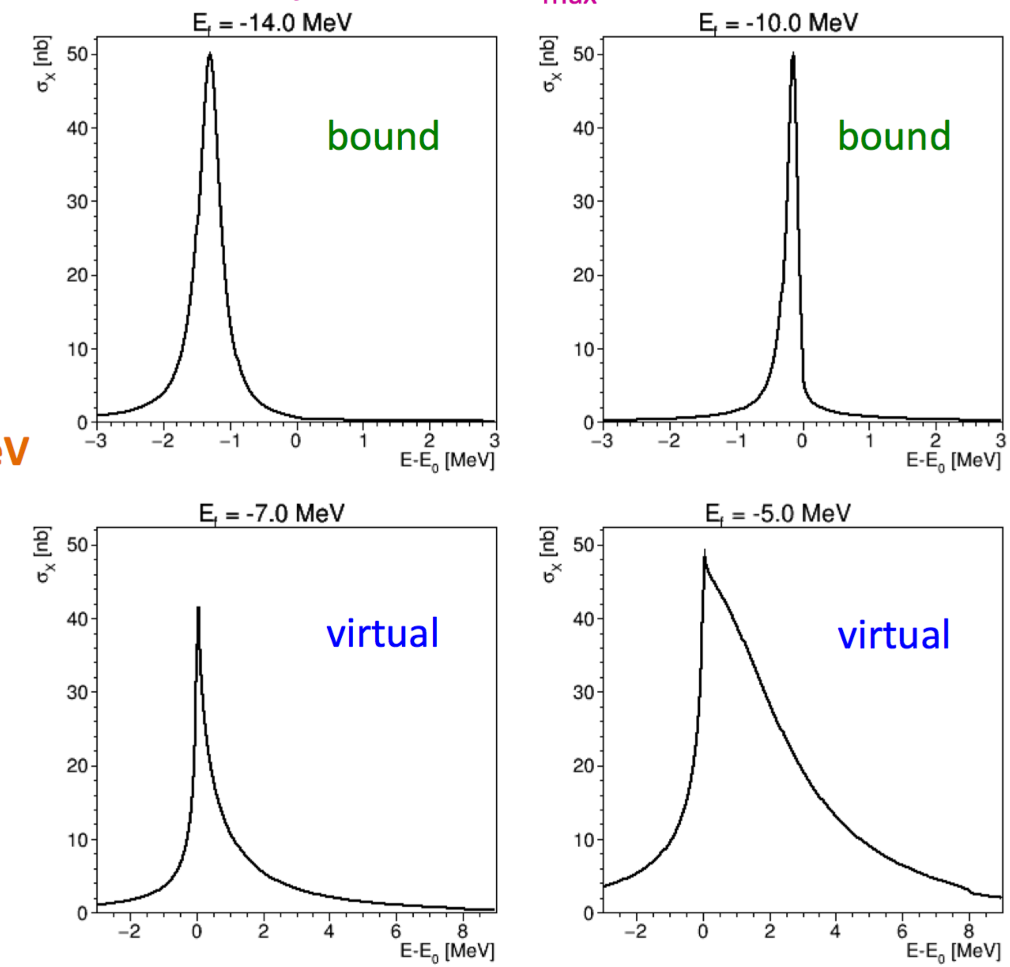
$$a = -\frac{\sqrt{2\mu_2\delta} + 2E_f/g + i\Gamma(0)/g}{(\sqrt{2\mu_2\delta} + 2E_f/g)^2 + \Gamma(0)^2/g^2}$$

Re(a) > 0 : bound state

Re(a) < 0 : virtual state



Always scaled to f_{max} = 50 nb here!

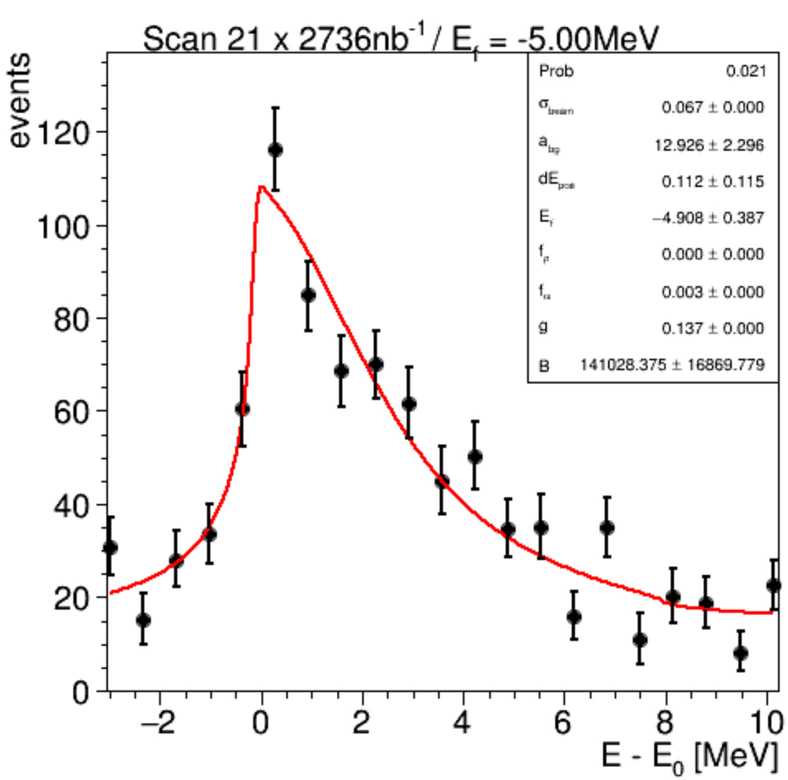


Scan Examples Molecule Lineshape

-> Talk by K. Götzen, PWGs 18th Nov & 1st Dec2015

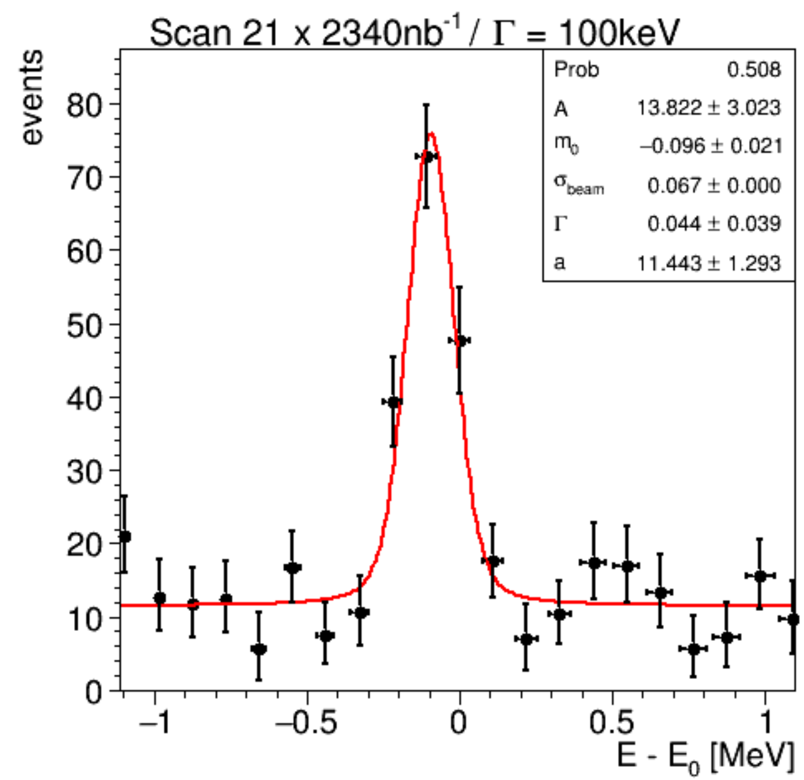
HR: 21 x 2 days

E_f = -5 MeV



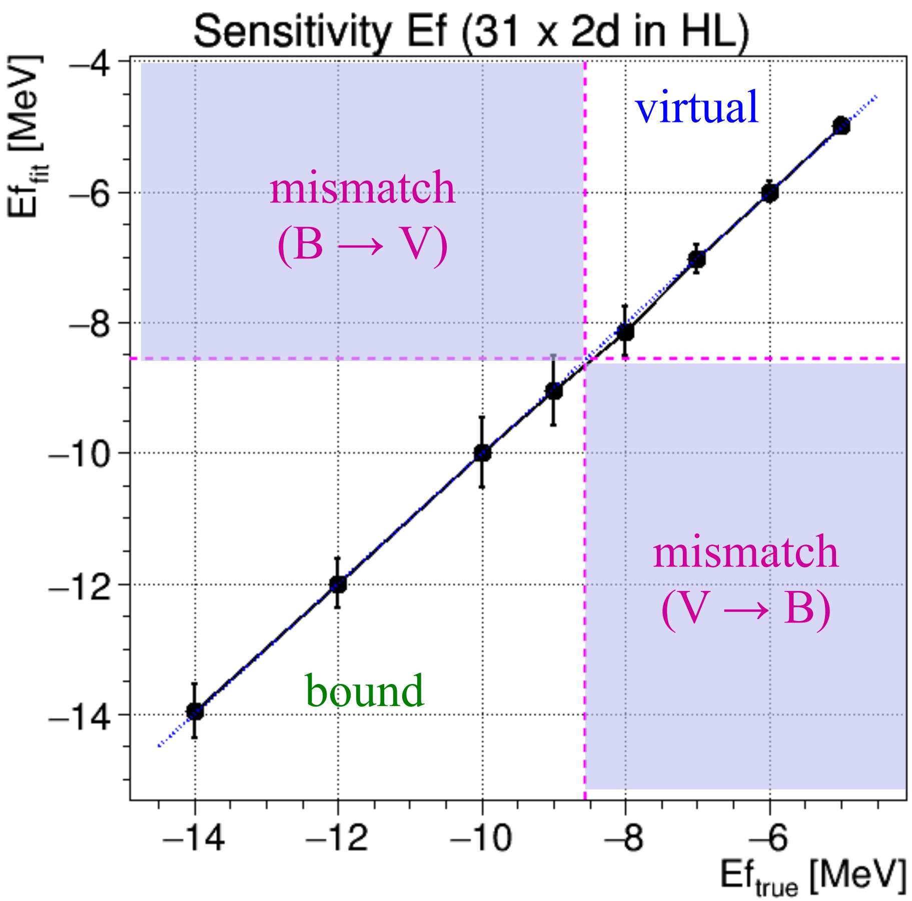
HESRr: 21 x 2 days

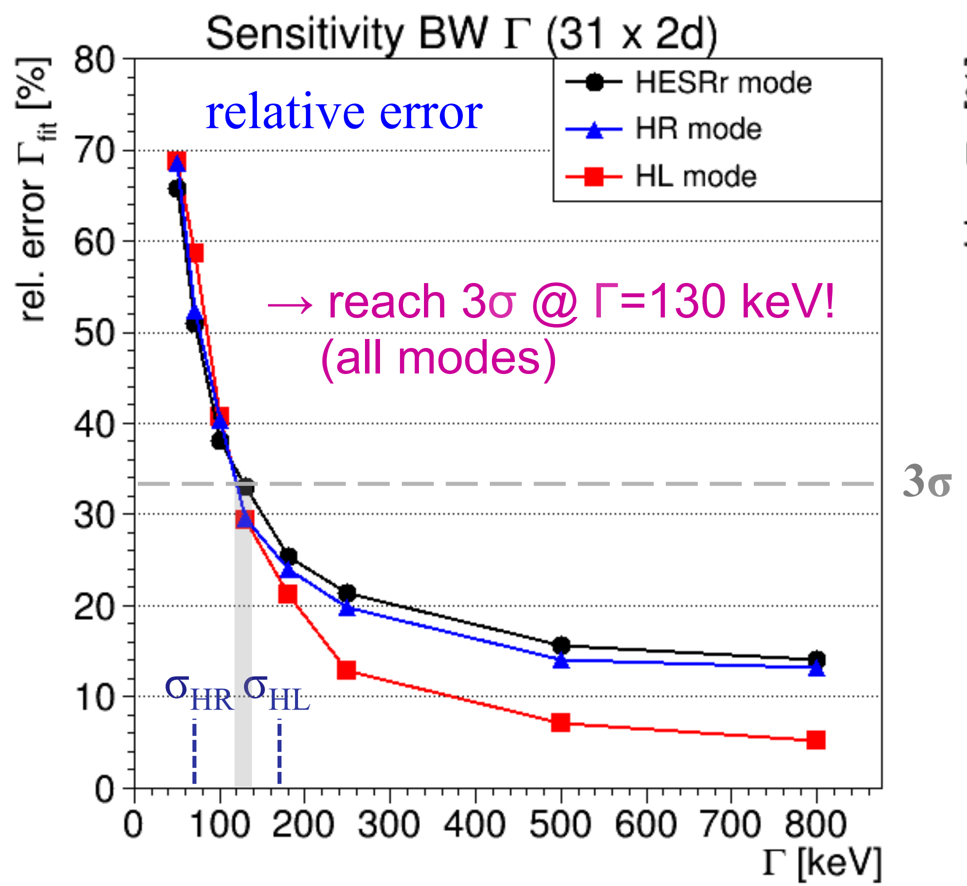
Γ = 100 keV



Scan Examples Molecule Lineshape

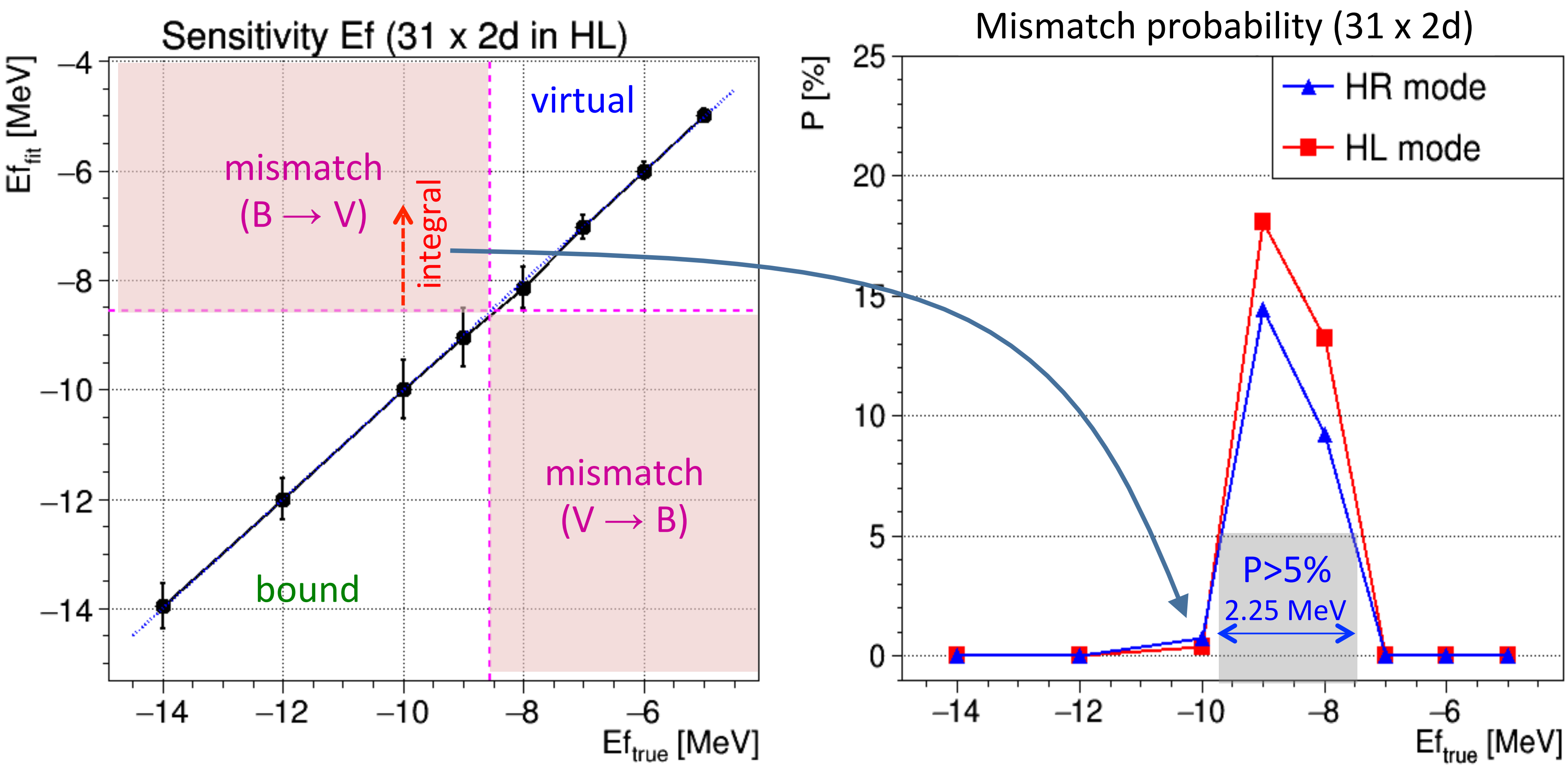
-> Talk by K. Götzen,
PWGs 18th Nov & 1st Dec2015





Sensitivities Molecule Lineshapes (31 x 2d)

- Extract standard deviation and bias from toy MC fits
- How well can virtual and bound state be distinguished?
- Uncertainty = $\sigma_{Gaussian}$ → Integrate in mismatch region



Our Focus: Charmonium-like Exotics

List of channels / charmonia (XYZ states):

- $J/\psi + X$, $J/\psi \rightarrow e^+e^- / \mu^+\mu^-$
- $\eta_c + X$, $\eta_c \rightarrow K^+K^-\pi^0 / K_s K^{+/-}\pi^{-/+}$

→ with **various recoils**: $X = \pi^-\pi^+, \pi^0\pi^0, \eta\eta$, KK

→ at **different energies**: E_{cms} = 4.5, 5.5 GeV

→ and the various **detector options** (1+5)

Scenarios proposed:

a) Nominal Set-up: 1,2,3,4,5
b) w/o Barrel EMC: 1,3,4,5
c) w/o FS: 1,2,3,4
d) w/o Disc DIRC: 1,2,3,5
e) w/o Barrel DIRC: 1,2,4,5
f) STT only: 2,3,4,5

Statistics: 1 M signal evts, 1000 M DPM bkgrd evts

see talk by K.Götzen → FastSim

FoM: Significance, S/B, Efficiency

- Time needed to achieve 5σ significance = S / sqrt(S+B) *(for the excl. pbarp system)*

$$Significance(t) = \sqrt{L \cdot t} \cdot \frac{\sigma_s \cdot \varepsilon_s \cdot f_{BR}}{\sqrt{\sigma_s \cdot \varepsilon_s \cdot f_{BR} + \sigma_b \cdot \varepsilon_b}}$$

- Signal to Bkgd $$S/B = \frac{\sigma_s \cdot \varepsilon_s \cdot f_{BR}}{\sigma_b \cdot \varepsilon_b}$$

- Signal Efficiency ε_s

"known"

σ_s = total signal cross-section	*(assumption)*
σ_b = total pbarp cross-section	*(known: 60mb)*
f_{BR} = BR factor for given decay	*(known)*
L = Luminosity	*(known for assumed lumi modes)*

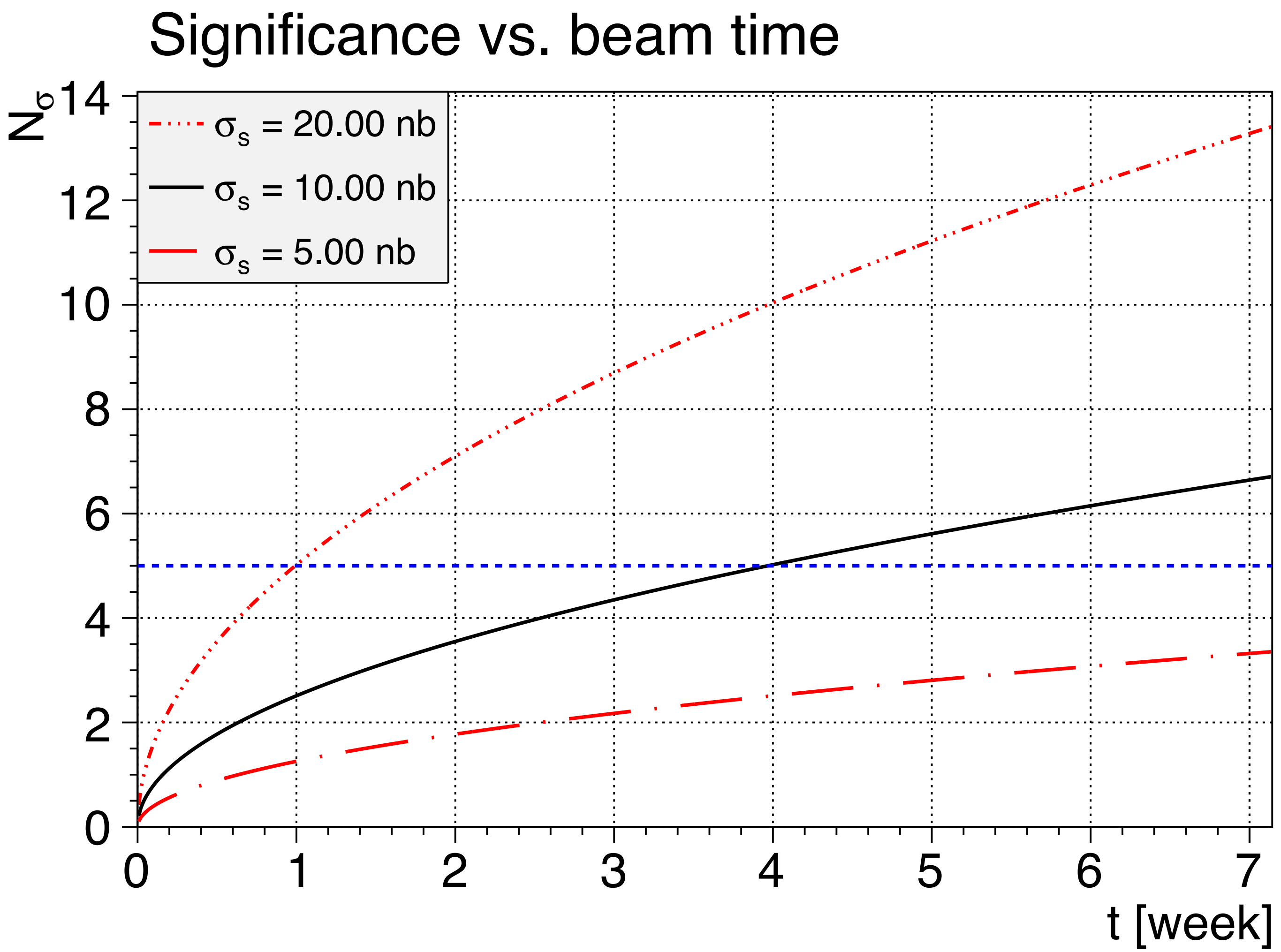
"input"

ε_s = reconstr. efficiency for signal evts.	*(measured from data)*
ε_b = reconstr. efficiency for bckgrd evts.	*(measured from data)*

Proposed FoM: Significance

Example: $\eta_c + \pi^-\pi^+ \rightarrow K^+K^-\pi^0 + \pi^-\pi^+$ at 4.5 GeV

σ_s = ~10 nb, σ_b = 60 mb
f_{BR} = 3.5 %, L = 2 x 10^{32}
ε_s = 22.6% , ε_b = 2.0 x 10^{-6}



Proposed FoM: Significance

Example: $\eta_c + \pi^-\pi^+ \rightarrow K^+K^-\pi^0 + \pi^-\pi^+$ at 4.5 GeV

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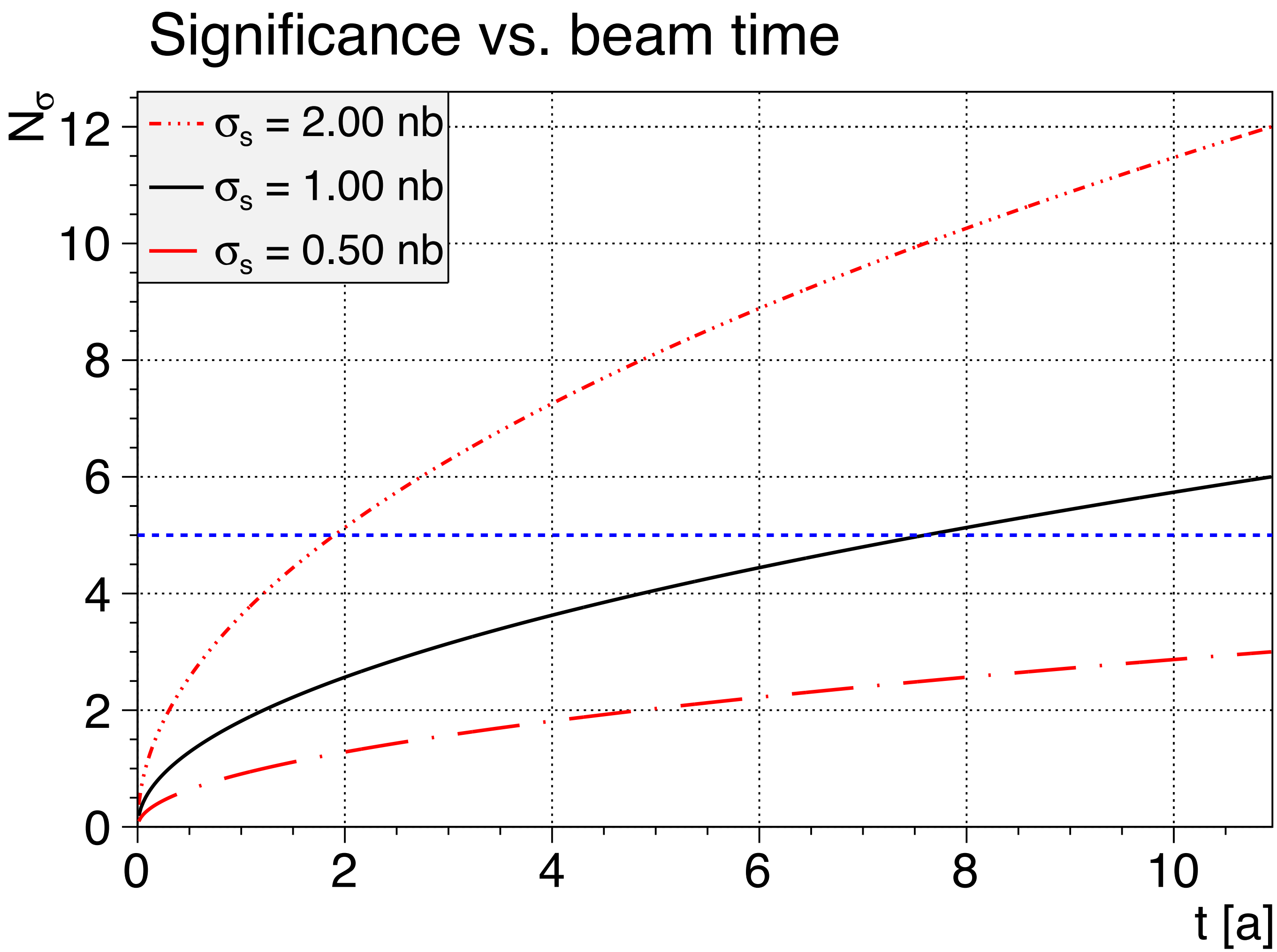

Overview & Summary Results FoMs

$\sigma_s = 1$ nb, $E_{cms} = 5.5$ GeV

1nb	L/cms	1,0E+32																	
E_cm	detopt	Full			No FS			No Emc Barrel			No Disc DIRC			No Barrel DIRC			STT only Tracking		
	mode	t [d]	S/B	Dal QA	t [d]	S/B	Dal QA	t [d]	S/B	Dal QA	t [d]	S/B	Dal QA	t [d]	S/B	Dal QA	t [d]	S/B	Dal QA
5,5	etac(2Kpi0) 2pi	701	0,000	✓	748	0,001	✓	1259	0,001	✓	1176	0,000	✓	1979	0,000	✓	16402	0,000	✓
	etac(2Kpi0) 2pi0	291	0,002	✓	342	0,005	✓	4928	0,001	✓	285	0,002	✓	273	0,002	✓	1249	0,001	✓
	etac(2Kpi0) 2eta	118	0,020	✓	893	0,008	✓	35472	0,001	✓	82	0,025	✓	243	0,008	✓	495	0,010	✓
	etac(2Kpi0) 2K	43	0,008	✓	27	0,073	✓	73	0,009	✓	315	0,003	✓	148	0,004	✓	297	0,013	✓
	etac(KsKpi) 2pi	88	0,011	✓	45	0,043	✓	87	0,012	✓	296	0,005	✓	222	0,009	✓	35452	0,001	✓
	etac(KsKpi) 2pi0	37	0,026	✓	91	0,023	✓	198	0,016	✗	61	0,032	✓	75	0,026	✓	991	0,007	✓
	etac(KsKpi) 2eta	133	0,019	✓	1759	0,005	✓	14200	0,002	✓	171	0,017	✓	133	0,019	✓	8878	0,002	✓
	etac(KsKpi) 2K	28	0,069	✓	41	0,047	✓	26	0,074	✓	79	0,025	✓	60	0,032	✓	8878	0,002	✓
	Jpsi(2e) 2pi	7,6	0,26	✓	14	0,16	✓	10	0,19	✓	7,8	0,25	✓	8,0	0,24	✓	57	0,034	✓
	Jpsi(2e) 2pi0	9,2	0,21	✓	19	0,10	✓	43	0,045	✗	9,3	0,21	✓	10	0,20	✓	24	0,082	✓
	Jpsi(2e) 2eta	38	0,057	✓	146	0,019	✓	1868	0,005	✗	37	0,058	✓	38	0,051	✓	109	0,021	✓
	Jpsi(2e) 2K	7,2	0,27	✓	10	0,20	✓	7,4	0,26	✓	7,2	0,27	✓	7,4	0,29	✓	67	0,029	✓
	Jpsi(2mu) 2pi	6,3	0,31	✓	10	0,094	✓	7,5	0,26	✓	7,9	0,24	✓	7,8	0,28	✓	50	0,039	✓
	Jpsi(2mu) 2pi0	6,4	0,30	✓	16	0,12	✗	31	0,063	✗	7,1	0,27	✓	7,2	0,27	✓	20	0,099	✓
	Jpsi(2mu) 2eta	24	0,082	✓	69	0,031	✓	732	0,009	✗	24	0,082	✓	24	0,082	✓	67	0,029	✓
	Jpsi(2mu) 2K	5,1	0,38	✓	6	0,31	✓	5,5	0,35	✓	5,3	0,37	✓	5,1	0,38	✓	49	0,040	✓

Time QA (days)
green < 30 yellow < 365 red >= 365

S/B QA
green > 1 yellow > 0.1 red <= 0.1

Dal QA
ok < 1.5

Overview & Summary Results FoMs

$\sigma_s = 10\,\text{nb},\ E_{cms} = 5.5\,\text{GeV}$

10nb	L/cms	1,0E+32																	
E_cm	detopt	Full			No FS			No Emc Barrel			No Disc DIRC			No Barrel DIRC			STT only Tracking		
	mode	t [d]	S/B	Dal QA	t [d]	S/B	Dal QA	t [d]	S/B	Dal QA	t [d]	S/B	Dal QA	t [d]	S/B	Dal QA	t [d]	S/B	Dal QA
5,5	etac(2Kpi0) 2pi	7,0	0,004	✓	7,5	0,008	✓	13	0,005	✓	12	0,003	✓	20,00	0,002	✓	164	0,002	✓
	etac(2Kpi0) 2pi0	3,0	0,016	✓	6,1	0,045	✓	50	0,014	✓	2,9	0,017	✓	2,8	0,016	✓	13	0,013	✓
	etac(2Kpi0) 2eta	9,4	0,20	✓	28	0,078	✓	358	0,012	✓	7,9	0,25	✓	7,9	0,082	✓	20	0,099	✓
	etac(2Kpi0) 2K	1,4	0,079	✓	2,6	0,73	✓	2,5	0,086	✓	3,2	0,025	✓	2,4	0,041	✓	15	0,13	✓
	etac(KsKpi) 2pi	3,7	0,11	✓	4,5	0,43	✓	4,1	0,12	✓	5,7	0,048	✓	7,5	0,086	✓	356	0,006	✓
	etac(KsKpi) 2pi0	3,7	0,26	✓	8,3	0,23	✓	12	0,16	✗	6,1	0,32	✓	7,5	0,26	✓	28	0,070	✓
	etac(KsKpi) 2eta	10	0,19	✓	37	0,053	✓	145	0,019	✓	11	0,17	✓	10,00	0,19	✓	91	0,023	✓
	etac(KsKpi) 2K	2,8	0,69	✓	4,1	0,47	✓	2,6	0,74	✓	7,7	0,25	✓	6,00	0,32	✓	91	0,023	✓
	Jpsi(2e) 2pi	0,8	2,6	✓	1,4	1,6	✓	1,0	1,9	✓	0,8	2,5	✓	0,8	2,4	✓	5,7	0,34	✓
	Jpsi(2e) 2pi0	0,9	2,1	✓	1,9	1,0	✓	4,3	0,44	✗	0,9	2,1	✓	0,9	2,0	✓	2,3	0,82	✓
	Jpsi(2e) 2eta	3,8	0,57	✓	11	0,19	✓	40	0,054	✗	3,7	0,58	✓	3,8	0,51	✓	9,1	0,21	✓
	Jpsi(2e) 2K	0,7	2,7	✓	1,0	2,0	✓	0,7	2,6	✓	0,7	2,7	✓	0,7	2,9	✓	6,7	0,29	✓
	Jpsi(2mu) 2pi	0,6	3,1	✓	1,0	0,94	✓	0,8	2,6	✓	0,8	2,4	✓	0,8	2,8	✓	5,0	0,39	✓
	Jpsi(2mu) 2pi0	0,6	3,0	✓	1,5	1,2	✗	3,1	0,63	✗	0,7	2,7	✓	0,7	2,7	✓	2,0	0,99	✓
	Jpsi(2mu) 2eta	2,3	0,82	✓	6,9	0,31	✓	25	0,086	✗	2,3	0,82	✓	2,3	0,82	✓	6,7	0,29	✓
	Jpsi(2mu) 2K	0,5	3,8	✓	0,6	3,1	✓	0,5	3,5	✓	0,5	3,7	✓	0,5	3,8	✓	4,9	0,40	✓

Time QA (days)
green < 30 yellow < 365 red >= 365

S/B QA
green > 1 yellow > 0.1 red <= 0.1

Dal QA
ok < 1.5

Overview & Summary Results FoMs

1nb	L/cms	1,0E+30														
E_cm	detopt	Full			No FS			No Emc Barrel			No Disc DIRC			STT only Tracking		
	mode	t [d]	S/B	Dal QA	t [d]	S/B	Dal QA	t [d]	S/B	Dal QA	t [d]	S/B	Dal QA	t [d]	S/B	Dal QA
4,5	etac(2Kpi0) 2pi	423239	0,0001	✓	466074	0,0001	✓	1E+06	0,0001	✓	559109	0,0001	✓	4E+06	0,0001	✓
	etac(2Kpi0) 2pi0	229605	0,0002	✓	367916	0,0003	✓	1E+07	0,0001	✓	252394	0,0002	✓	630019	0,0002	✓
	etac(KsKpi) 2pi	4530	0,043	✓	4295	0,045	✓	7273	0,018	✓	7349	0,026	✓	2E+06	0,001	✓
	etac(KsKpi) 2pi0	5802	0,033	✓	7349	0,026	✓	63539	0,009	✗	5421	0,036	✓	189516	0,003	✓
	J/psi(2e) 2pi	756	0,26	✓	1073	0,20	✓	1232	0,16	✓	750	0,26	✓	3991	0,048	✓
	J/psi(2e) 2pi0	911	0,21	✓	2036	0,095	✗	18151	0,016	✗	920	0,21	✓	1919	0,10	✓
	J/psi(2mu) 2pi	783	0,25	✓	1018	0,19	✓	808	0,24	✓	705	0,27	✓	3326	0,058	✓
	J/psi(2mu) 2pi0	715	0,27	✗	1523	0,13	✗	6047	0,032	✗	795	0,24	✗	1523	0,13	✓
5,5	etac(2Kpi0) 2pi	70136	0,0004	✓	74815	0,0008	✓	125854	0,0005	✓	117629	0,0003	✓	2E+06	0,0002	✓
	etac(2Kpi0) 2pi0	29140	0,002	✓	34175	0,005	✓	492784	0,001	✓	28460	0,002	✓	124882	0,001	✓
	etac(KsKpi) 2pi	8840	0,011	✓	4530	0,043	✓	8742	0,012	✓	29633	0,005	✓	4E+06	0,001	✓
	etac(KsKpi) 2pi0	3674	0,026	✓	9064	0,023	✓	19747	0,016	✗	6124	0,032	✓	99108	0,007	✓
	J/psi(2e) 2pi	756	0,26	✓	1367	0,16	✓	1003	0,19	✓	780	0,25	✓	5702	0,034	✓
	J/psi(2e) 2pi0	915	0,21	✓	1865	0,10	✓	4338	0,045	✗	933	0,21	✓	2348	0,082	✓
	J/psi(2mu) 2pi	628	0,31	✓	1023	0,094	✓	750	0,26	✓	789	0,24	✓	4989	0,039	✓
	J/psi(2mu) 2pi0	642	0,30	✓	1547	0,12	✗	3070	0,063	✗	705	0,27	✓	1956	0,099	✓

Time QA (days)
green < 30 yellow < 365 red >= 365

S/B QA
green > 1 yellow > 0.1 red <= 0.1

Overview & Summary Results FoMs

1nb	L/cms	1,0E+31														
E_cm	detopt	Full			No FS			No Emc Barrel			No Disc DIRC			STT only Tracking		
	mode	t [d]	S/B	Dal QA	t [d]	S/B	Dal QA	t [d]	S/B	Dal QA	t [d]	S/B	Dal QA	t [d]	S/B	Dal QA
4,5	etac(2Kpi0) 2pi	42324	0,0001	✓	46607	0,0001	✓	122059	0,0001	✓	55911	0,0001	✓	362845	0,0001	✓
	etac(2Kpi0) 2pi0	22961	0,0002	✓	36792	0,0003	✓	1E+06	0,0001	✓	25239	0,0002	✓	63002	0,0002	✓
	etac(KsKpi) 2pi	453	0,043	✓	430	0,045	✓	727	0,018	✓	735	0,026	✓	177361	0,001	✓
	etac(KsKpi) 2pi0	580	0,033	✓	735	0,026	✓	6354	0,009	✗	542	0,036	✓	18952	0,003	✓
	J/psi(2e) 2pi	76	0,26	✓	107	0,20	✓	123	0,16	✓	75	0,26	✓	399	0,048	✓
	J/psi(2e) 2pi0	91	0,21	✓	204	0,095	✗	1815	0,016	✗	92	0,21	✓	192	0,10	✓
	J/psi(2mu) 2pi	78	0,25	✓	102	0,19	✓	81	0,24	✓	71	0,27	✓	333	0,058	✓
	J/psi(2mu) 2pi0	72	0,27	✗	152	0,13	✗	605	0,032	✗	80	0,24	✗	152	0,13	✓
5,5	etac(2Kpi0) 2pi	7014	0,0004	✓	7482	0,0008	✓	12585	0,0005	✓	11763	0,0003	✓	164015	0,0002	✓
	etac(2Kpi0) 2pi0	2914	0,002	✓	3417	0,005	✓	49278	0,001	✓	2846	0,002	✓	12488	0,001	✓
	etac(KsKpi) 2pi	884	0,011	✓	453	0,043	✓	874	0,012	✓	2963	0,005	✓	354515	0,001	✓
	etac(KsKpi) 2pi0	367	0,026	✓	906	0,023	✓	1975	0,016	✗	612	0,032	✓	9911	0,007	✓
	J/psi(2e) 2pi	76	0,26	✓	137	0,16	✓	100	0,19	✓	78	0,25	✓	570	0,034	✓
	J/psi(2e) 2pi0	92	0,21	✓	187	0,10	✓	434	0,045	✗	93	0,21	✓	235	0,082	✓
	J/psi(2mu) 2pi	63	0,31	✓	102	0,094	✓	75	0,26	✓	79	0,24	✓	499	0,039	✓
	J/psi(2mu) 2pi0	64	0,30	✓	155	0,12	✗	307	0,063	✗	71	0,27	✓	196	0,099	✓

Time QA (days)
green < 30 yellow < 365 red >= 365

S/B QA
green > 1 yellow > 0.1 red <= 0.1

Overview & Summary Results FoMs

1nb	L/cms	1,0E+32														
E_cm	detopt	Full			No FS			No Emc Barrel			No Disc DIRC			STT only Tracking		
	mode	t [d]	S/B	Dal QA	t [d]	S/B	Dal QA	t [d]	S/B	Dal QA	t [d]	S/B	Dal QA	t [d]	S/B	Dal QA
4,5	etac(2Kpi0) 2pi	4232	0,0001	✓	4661	0,0001	✓	12206	0,0001	✓	5591	0,0001	✓	36285	0,0001	✓
	etac(2Kpi0) 2pi0	2296	0,0002	✓	3679	0,0003	✓	141744	0,0001	✓	2524	0,0002	✓	6300	0,0002	✓
	etac(KsKpi) 2pi	45	0,043	✓	43	0,045	✓	73	0,018	✓	74	0,026	✓	17736	0,001	✓
	etac(KsKpi) 2pi0	58	0,033	✓	74	0,026	✓	635	0,009	✗	54	0,036	✓	1895	0,003	✓
	J/psi(2e) 2pi	7,6	0,26	✓	10,7	0,20	✓	12,3	0,16	✓	7,5	0,26	✓	40	0,048	✓
	J/psi(2e) 2pi0	9,1	0,21	✓	20,4	0,095	✗	182	0,016	✗	9,2	0,21	✓	19,2	0,10	✓
	J/psi(2mu) 2pi	7,8	0,25	✓	10,2	0,19	✓	8,1	0,24	✓	7,1	0,27	✓	33	0,058	✓
	J/psi(2mu) 2pi0	7,2	0,27	✗	15,2	0,13	✗	61	0,032	✗	8,0	0,24	✗	15,2	0,13	✓
5,5	etac(2Kpi0) 2pi	701	0,0004	✓	748	0,0008	✓	1259	0,0005	✓	1176	0,0003	✓	16402	0,0002	✓
	etac(2Kpi0) 2pi0	291	0,002	✓	342	0,005	✓	4928	0,001	✓	285	0,002	✓	1249	0,001	✓
	etac(KsKpi) 2pi	88	0,011	✓	45	0,043	✓	87	0,012	✓	296	0,005	✓	35452	0,001	✓
	etac(KsKpi) 2pi0	37	0,026	✓	91	0,023	✓	198	0,016	✗	61	0,032	✓	991	0,007	✓
	J/psi(2e) 2pi	7,6	0,26	✓	13,7	0,16	✓	10,0	0,19	✓	7,8	0,25	✓	57	0,034	✓
	J/psi(2e) 2pi0	9,2	0,21	✓	18,6	0,10	✓	43	0,045	✗	9,3	0,21	✓	23,5	0,082	✓
	J/psi(2mu) 2pi	6,3	0,31	✓	10,2	0,094	✓	7,5	0,26	✓	7,9	0,24	✓	50	0,039	✓
	J/psi(2mu) 2pi0	6,4	0,30	✓	15,5	0,12	✗	31	0,063	✗	7,1	0,27	✓	19,6	0,099	✓

Time QA (days)
green < 30 yellow < 365 red >= 365

S/B QA
green > 1 yellow > 0.1 red <= 0.1

Overview & Summary Results FoMs

1nb	L/cms	2,0E+32														
E_cm	detopt	Full			No FS			No Emc Barrel			No Disc DIRC			STT only Tracking		
	mode	t [d]	S/B	Dal QA	t [d]	S/B	Dal QA	t [d]	S/B	Dal QA	t [d]	S/B	Dal QA	t [d]	S/B	Dal QA
4,5	etac(2Kpi0) 2pi	2116	0,0001	✓	2330	0,0001	✓	6103	0,0001	✓	2796	0,0001	✓	18142	0,0001	✓
	etac(2Kpi0) 2pi0	1148	0,0002	✓	1839,6	0,0003	✓	70872	0,0001	✓	1262	0,0002	✓	3150	0,0002	✓
	etac(KsKpi) 2pi	22,6	0,043	✓	21,5	0,045	✓	36	0,018	✓	37	0,026	✓	8868	0,001	✓
	etac(KsKpi) 2pi0	29,0	0,033	✓	37	0,026	✓	318	0,009	✗	27,1	0,036	✓	948	0,003	✓
	J/psi(2e) 2pi	3,8	0,26	✓	5,4	0,20	✓	6,2	0,16	✓	3,8	0,26	✓	20,0	0,048	✓
	J/psi(2e) 2pi0	4,6	0,21	✓	10,2	0,095	✗	91	0,016	✗	4,6	0,21	✓	9,6	0,10	✓
	J/psi(2mu) 2pi	3,9	0,25	✓	5,1	0,19	✓	4,0	0,24	✓	3,5	0,27	✓	16,6	0,058	✓
	J/psi(2mu) 2pi0	3,6	0,27	✗	7,6	0,13	✗	30	0,032	✗	4,0	0,24	✗	7,6	0,13	✓
5,5	etac(2Kpi0) 2pi	351	0,0004	✓	374	0,0008	✓	629	0,0005	✓	588	0,0003	✓	8201	0,0002	✓
	etac(2Kpi0) 2pi0	146	0,002	✓	171	0,005	✓	2464	0,001	✓	142	0,002	✓	624	0,001	✓
	etac(KsKpi) 2pi	44	0,011	✓	22,6	0,043	✓	44	0,012	✓	148	0,005	✓	17726	0,001	✓
	etac(KsKpi) 2pi0	18,4	0,026	✓	45	0,023	✓	99	0,016	✗	31	0,032	✓	496	0,007	✓
	J/psi(2e) 2pi	3,8	0,26	✓	6,8	0,16	✓	5,0	0,19	✓	3,9	0,25	✓	28,5	0,034	✓
	J/psi(2e) 2pi0	4,6	0,21	✓	9,3	0,10	✓	21,7	0,045	✗	4,7	0,21	✓	11,7	0,082	✓
	J/psi(2mu) 2pi	3,1	0,31	✓	5,1	0,094	✓	3,8	0,26	✓	3,9	0,24	✓	24,9	0,039	✓
	J/psi(2mu) 2pi0	3,2	0,30	✓	7,7	0,12	✗	15,4	0,063	✗	3,5	0,27	✓	9,8	0,099	✓

Time QA (days)
green < 30 yellow < 365 red >= 365

S/B QA
green > 1 yellow > 0.1 red <= 0.1

Overview & Summary Results FoMs

10nb	L/cms	1,0E+30														
E_cm	detopt	Full			No FS			No Emc Barrel			No Disc DIRC			STT only Tracking		
	mode	t [d]	S/B	Dal QA	t [d]	S/B	Dal QA	t [d]	S/B	Dal QA	t [d]	S/B	Dal QA	t [d]	S/B	Dal QA
4,5	etac(2Kpi0) 2pi	4237	0,001	✓	4666	0,001	✓	12217	0,001	✓	5595	0,001	✓	36314	0,001	✓
	etac(2Kpi0) 2pi0	2301	0,003	✓	3690	0,003	✓	141930	0,002	✓	2529	0,002	✓	6313	0,002	✓
	etac(KsKpi) 2pi	453	0,43	✓	430	0,45	✓	525	0,18	✓	735	0,26	✓	17922	0,012	✓
	etac(KsKpi) 2pi0	580	0,33	✓	735	0,26	✓	2205	0,088	✗	542	0,36	✓	2205	0,029	✓
	J/psi(2e) 2pi	76	2,6	✓	107	2,0	✓	123	1,6	✓	75	2,6	✓	399	0,48	✓
	J/psi(2e) 2pi0	91	2,1	✓	204	0,95	✗	1174	0,16	✗	92	2,1	✓	192	1,0	✓
	J/psi(2mu) 2pi	78	2,5	✓	102	1,9	✓	81	2,4	✓	71	2,7	✓	333	0,58	✓
	J/psi(2mu) 2pi0	72	2,7	✗	152	1,3	✗	605	0,32	✗	80	2,4	✗	152	1,3	✓
5,5	etac(2Kpi0) 2pi	704	0,004	✓	754	0,008	✓	1264	0,005	✓	1179	0,003	✓	16435	0,002	✓
	etac(2Kpi0) 2pi0	296	0,016	✓	612	0,045	✓	4990	0,014	✓	289	0,017	✓	1264	0,013	✓
	etac(KsKpi) 2pi	367	0,11	✓	453	0,43	✓	408	0,12	✓	570	0,048	✓	35638	0,006	✓
	etac(KsKpi) 2pi0	367	0,26	✓	827	0,23	✓	1225	0,16	✗	612	0,32	✓	2756	0,070	✓
	J/psi(2e) 2pi	76	2,6	✓	137	1,6	✓	100	1,9	✓	78	2,5	✓	570	0,34	✓
	J/psi(2e) 2pi0	92	2,1	✓	187	1,0	✓	434	0,44	✗	93	2,1	✓	235	0,82	✓
	J/psi(2mu) 2pi	63	3,1	✓	102	0,94	✓	75	2,6	✓	79	2,4	✓	499	0,39	✓
	J/psi(2mu) 2pi0	64	3,0	✓	155	1,2	✗	307	0,63	✗	71	2,7	✓	196	0,99	✓

Time QA (days)
green < 30 yellow < 365 red >= 365

S/B QA
green > 1 yellow > 0.1 red <= 0.1

Overview & Summary Results FoMs

10nb	L/cms	1,0E+31														
E_cm	detopt	Full			No FS			No Emc Barrel			No Disc DIRC			STT only Tracking		
	mode	t [d]	S/B	Dal QA	t [d]	S/B	Dal QA	t [d]	S/B	Dal QA	t [d]	S/B	Dal QA	t [d]	S/B	Dal QA
4,5	etac(2Kpi0) 2pi	424	0,001	✓	467	0,001	✓	1222	0,001	✓	560	0,001	✓	3631	0,001	✓
	etac(2Kpi0) 2pi0	230	0,003	✓	369	0,003	✓	14193	0,002	✓	253	0,002	✓	631	0,002	✓
	etac(KsKpi) 2pi	45	0,43	✓	43	0,45	✓	53	0,18	✓	74	0,26	✓	1792	0,01	✓
	etac(KsKpi) 2pi0	58	0,33	✓	74	0,26	✓	221	0,09	✗	54	0,36	✓	221	0,03	✓
	J/psi(2e) 2pi	7,6	2,6	✓	10,7	2,0	✓	12,3	1,6	✓	7,5	2,6	✓	40	0,48	✓
	J/psi(2e) 2pi0	9,1	2,1	✓	20,4	0,95	✗	117	0,16	✗	9,2	2,1	✓	19,2	1,0	✓
	J/psi(2mu) 2pi	7,8	2,5	✓	10,2	1,9	✓	8,1	2,4	✓	7,1	2,7	✓	33	0,58	✓
	J/psi(2mu) 2pi0	7,2	2,7	✗	15,2	1,3	✗	61	0,32	✗	8,0	2,4	✗	15,2	1,3	✓
5,5	etac(2Kpi0) 2pi	70	0,004	✓	75	0,008	✓	126	0,005	✓	118	0,003	✓	1644	0,002	✓
	etac(2Kpi0) 2pi0	29,5	0,016	✓	61	0,045	✓	499	0,014	✓	28,9	0,017	✓	126	0,013	✓
	etac(KsKpi) 2pi	37	0,11	✓	45	0,43	✓	41	0,12	✓	57	0,048	✓	3564	0,006	✓
	etac(KsKpi) 2pi0	37	0,26	✓	83	0,23	✓	123	0,16	✗	61	0,32	✓	276	0,070	✓
	J/psi(2e) 2pi	7,6	2,6	✓	13,7	1,6	✓	10,0	1,9	✓	7,8	2,5	✓	57	0,34	✓
	J/psi(2e) 2pi0	9,2	2,1	✓	18,6	1,0	✓	43	0,44	✗	9,3	2,1	✓	23,5	0,82	✓
	J/psi(2mu) 2pi	6,3	3,1	✓	10,2	0,94	✓	7,5	2,6	✓	7,9	2,4	✓	50	0,39	✓
	J/psi(2mu) 2pi0	6,4	3,0	✓	15,5	1,2	✗	31	0,63	✗	7,1	2,7	✓	19,6	0,99	✓

Time QA (days)
green < 30 yellow < 365 red >= 365

S/B QA
green > 1 yellow > 0.1 red <= 0.1

Overview & Summary Results FoMs

10nb	L/cms	1,0E+32														
E_cm	detopt	Full			No FS			No Emc Barrel			No Disc DIRC			STT only Tracking		
	mode	t [d]	S/B	Dal QA	t [d]	S/B	Dal QA	t [d]	S/B	Dal QA	t [d]	S/B	Dal QA	t [d]	S/B	Dal QA
4,5	etac(2Kpi0) 2pi	42	0,001	✓	47	0,001	✓	122	0,001	✓	56	0,001	✓	363	0,001	✓
	etac(2Kpi0) 2pi0	23,0	0,003	✓	37	0,003	✓	1419	0,002	✓	25,3	0,002	✓	63	0,002	✓
	etac(KsKpi) 2pi	4,5	0,43	✓	4,3	0,45	✓	5,2	0,18	✓	7,3	0,26	✓	179	0,01	✓
	etac(KsKpi) 2pi0	5,8	0,33	✓	7,3	0,26	✓	22,0	0,09	✗	5,4	0,36	✓	22,0	0,03	✓
	J/psi(2e) 2pi	0,8	2,6	✓	1,1	2,0	✓	1,2	1,6	✓	0,8	2,6	✓	4,0	0,48	✓
	J/psi(2e) 2pi0	0,9	2,1	✓	2,0	0,95	✗	11,7	0,16	✗	0,9	2,1	✓	1,9	1,0	✓
	J/psi(2mu) 2pi	0,8	2,5	✓	1,0	1,9	✓	0,8	2,4	✓	0,7	2,7	✓	3,3	0,58	✓
	J/psi(2mu) 2pi0	0,7	2,7	✗	1,5	1,3	✗	6,0	0,32	✗	0,8	2,4	✗	1,5	1,3	✓
5,5	etac(2Kpi0) 2pi	7,0	0,004	✓	7,5	0,008	✓	12,6	0,005	✓	11,8	0,003	✓	164	0,002	✓
	etac(2Kpi0) 2pi0	3,0	0,02	✓	6,1	0,05	✓	50	0,01	✓	2,9	0,02	✓	12,6	0,01	✓
	etac(KsKpi) 2pi	3,7	0,11	✓	4,5	0,43	✓	4,1	0,12	✓	5,7	0,05	✓	356	0,01	✓
	etac(KsKpi) 2pi0	3,7	0,26	✓	8,3	0,23	✓	12,2	0,16	✗	6,1	0,32	✓	27,6	0,07	✓
	J/psi(2e) 2pi	0,8	2,6	✓	1,4	1,6	✓	1,0	1,9	✓	0,8	2,5	✓	5,7	0,34	✓
	J/psi(2e) 2pi0	0,9	2,1	✓	1,9	1,0	✓	4,3	0,44	✗	0,9	2,1	✓	2,3	0,82	✓
	J/psi(2mu) 2pi	0,6	3,1	✓	1,0	0,94	✓	0,8	2,6	✓	0,8	2,4	✓	5,0	0,39	✓
	J/psi(2mu) 2pi0	0,6	3,0	✓	1,5	1,2	✗	3,1	0,63	✗	0,7	2,7	✓	2,0	0,99	✓

Time QA (days)
green < 30 yellow < 365 red >= 365

S/B QA
green > 1 yellow > 0.1 red <= 0.1

Overview & Summary Results FoMs

10nb	L/cms	2,0E+32														
E_cm	detopt	Full			No FS			No Emc Barrel			No Disc DIRC			STT only Tracking		
	mode	t [d]	S/B	Dal QA	t [d]	S/B	Dal QA	t [d]	S/B	Dal QA	t [d]	S/B	Dal QA	t [d]	S/B	Dal QA
4,5	etac(2Kpi0) 2pi	21,2	0,001	✓	23,3	0,001	✓	61	0,001	✓	28,0	0,001	✓	182	0,001	✓
	etac(2Kpi0) 2pi0	11,5	0,003	✓	18,5	0,003	✓	710	0,002	✓	12,6	0,002	✓	32	0,002	✓
	etac(KsKpi) 2pi	2,3	0,43	✓	2,1	0,45	✓	2,6	0,18	✓	3,7	0,26	✓	90	0,01	✓
	etac(KsKpi) 2pi0	2,9	0,33	✓	3,7	0,26	✓	11,0	0,09	✗	2,7	0,36	✓	11,0	0,03	✓
	J/psi(2e) 2pi	0,4	2,6	✓	0,5	2,0	✓	0,6	1,6	✓	0,4	2,6	✓	2,0	0,48	✓
	J/psi(2e) 2pi0	0,5	2,1	✓	1,0	0,95	✗	5,9	0,16	✗	0,5	2,1	✓	1,0	1,0	✓
	J/psi(2mu) 2pi	0,4	2,5	✓	0,5	1,9	✓	0,4	2,4	✓	0,4	2,7	✓	1,7	0,58	✓
	J/psi(2mu) 2pi0	0,4	2,7	✗	0,8	1,3	✗	3,0	0,32	✗	0,4	2,4	✗	0,8	1,3	✓
5,5	etac(2Kpi0) 2pi	3,5	0,004	✓	3,8	0,008	✓	6,3	0,005	✓	5,9	0,003	✓	82	0,002	✓
	etac(2Kpi0) 2pi0	1,5	0,02	✓	3,1	0,05	✓	24,9	0,01	✓	1,4	0,02	✓	6,3	0,01	✓
	etac(KsKpi) 2pi	1,8	0,11	✓	2,3	0,43	✓	2,0	0,12	✓	2,9	0,05	✓	178	0,01	✓
	etac(KsKpi) 2pi0	1,8	0,26	✓	4,1	0,23	✓	6,1	0,16	✗	3,1	0,32	✓	13,8	0,07	✓
	J/psi(2e) 2pi	0,4	2,6	✓	0,7	1,6	✓	0,5	1,9	✓	0,4	2,5	✓	2,9	0,34	✓
	J/psi(2e) 2pi0	0,5	2,1	✓	0,9	1,0	✓	2,2	0,44	✗	0,5	2,1	✓	1,2	0,82	✓
	J/psi(2mu) 2pi	0,3	3,1	✓	0,5	0,94	✓	0,4	2,6	✓	0,4	2,4	✓	2,5	0,39	✓
	J/psi(2mu) 2pi0	0,3	3,0	✓	0,8	1,2	✗	1,5	0,63	✗	0,4	2,7	✓	1,0	0,99	✓

Time QA (days)
green < 30 yellow < 365 red >= 365

S/B QA
green > 1 yellow > 0.1 red <= 0.1