Charmonium-like exotics (CCE) Physics Working Group

Frank Nerling
Helmholtz Institute Mainz, GSI Darmstadt

Charmonium-like Exotics PWG

- New structure, three Physics Working Groups since 2014
  - Charmonium
  - Charmonium-like Exotics
  - Light Quark Mesons
- Regular joint meetings (JourFix: Wed, 10h30)
  - Large overlap in activities and interests
- Manpower situation
  - Participation in the joint meetings: 5-10 people
  - Merely 3-4 analysts actively involved during scrutiny process in 2014
  - At present: 3 active physics analysis (fullSim, pandaRoot)

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, tbc
- INFN Ferrara
  - E.Fioravanti
- Univ. Giessen
  - M.Galuska, S.Lange, tbc
- FZ Jülich
  - E.Prencipe, tbc
- HI Mainz
  - T.Weber, tbc
- 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

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  - 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
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Activities, achievements so far

- PANDA Physics Performance Report
  - ➢ quite some work went in
  - ➢ not up-to-date anymore
  - ➢ not sufficient anymore
  - ➢ need an update (Physics Book)

<u>And therefore:</u>

→ detailed, dedicated pandaRoot simulation studies with a reasonable detector description to be conclusive!

→ take into account recent news, facts and measurements

FAIR/PANDA/Physics Book i

Physics Performance Report for:

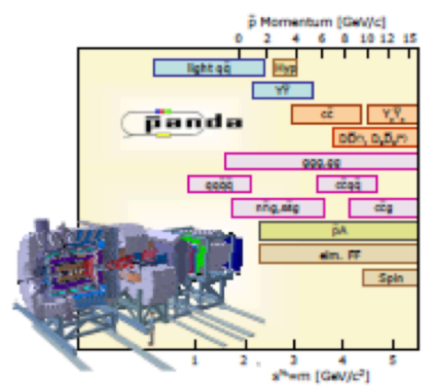
$\overline{\text{P}}$ANDA

(AntiProton Annihilations at Darmstadt)

Strong Interaction Studies with Antiprotons

$\overline{\text{P}}$ANDA Collaboration

To study fundamental questions of hadron and nuclear physics in interactions of antiprotons with nucleons and nuclei, the universal $\overline{\text{P}}$ANDA detector will be build. Gluonic excitations, the physics of strange and charm quarks and nucleon structure studies will be performed with unprecedented accuracy thereby allowing high-precision tests of the strong interaction. The proposed $\overline{\text{P}}$ANDA detector is a state-of-the-art internal target detector at the HESR at FAIR allowing the detection and identification of neutral and charged particles generated within the relevant angular and energy range.
This report presents a summary of the physics accessible at $\overline{\text{P}}$ANDA and what performance can be expected.



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Short Summary of Results, FoMs

- Scrutiny studies: Feasibility for XYZ states at PANDA [K .Götzen, R. Kliemt, F. Nerling]

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

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	✓

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

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

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Knowns and missings on the X(3872)

Already known:

- Observed by 7 experiments
- Observed in 5 decay channels
- Quantum numbers $J^{PC}=1^{++}$
  charmonium potential model: χ_{c1}'
  → *predicted mass ≥ 50 MeV larger*
  [Barnes, Godfry, Swanson, Phys. Rev. D72 (2005) 054026]
- Not produced in $e^+e^- \rightarrow \gamma^* \rightarrow X(3872)$
  ($e^+e^- \rightarrow \gamma^*\gamma^* \rightarrow X(3872)$ possible but suppressed)

Important knowledge missing & needed:

- Width, only upper limit (BelleI): $\Gamma < 1.2\,\mathrm{MeV}$

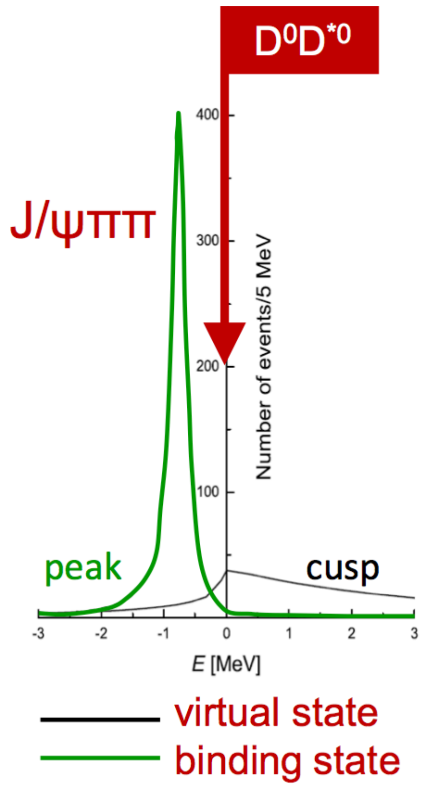
  → *prediction for pure charmonium state χ_{c1}':*
  $\Gamma = 40\,keV$
  [G.Y. Chen, J.P. Ma, Phys. ReV. D77 (2008) 034019]

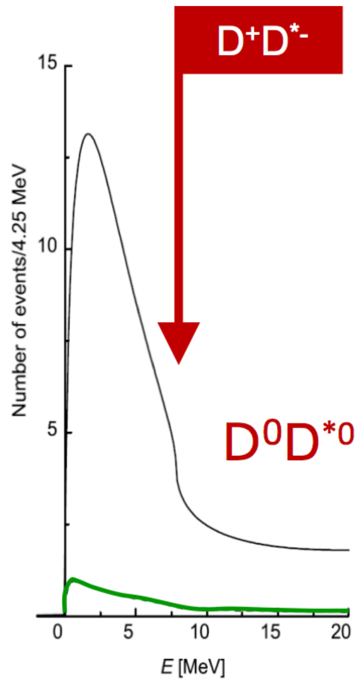
  → *prediction for molecule, must be larger than width of D*:*
  $\Gamma > 82.3 \pm 1.2 \pm 1.4\,keV$
  [E.Braaten, Phys. Rev. D77 (2008) 034019]

=> precise (sub-MeV) measurement of the width of the X(3872), indeed needed the lineshape!

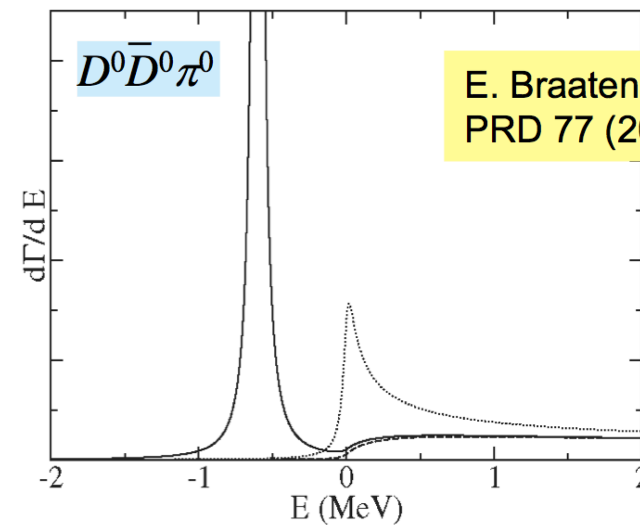
How PANDA can contribute: Study lineshapes

- Panda: Neutral & charged, e.g. $J/\psi\pi^-\pi^+$, $J/\psi\pi^0\pi^0$, $\chi_c\gamma\rightarrow J/\psi\gamma\gamma$, $J/\psi\gamma$, $J/\psi\eta$, $\eta_c\gamma$, ...
- Direct formation in $\bar{p}p$ → *lineshapes*
- Example: X(3872)





C. Hanhart *et al.*,
PRD 76 (2007) 034007



E. Braaten, M. Lu,
PRD 77 (2008) 014029

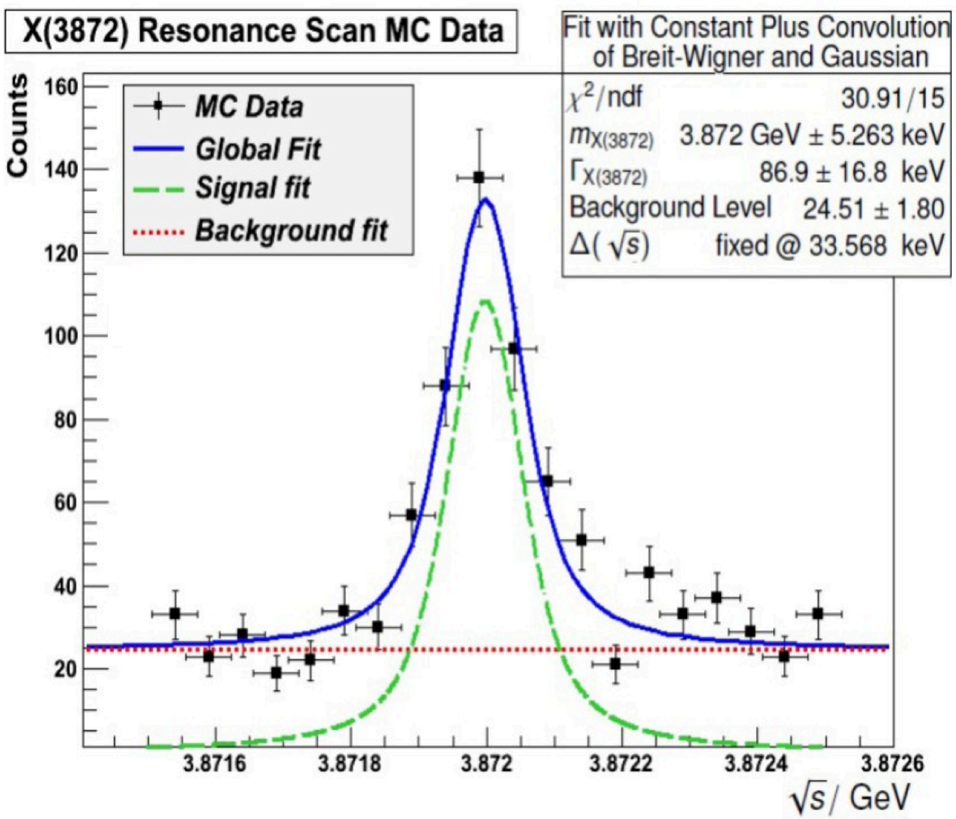
Compare lineshapes
in different final states

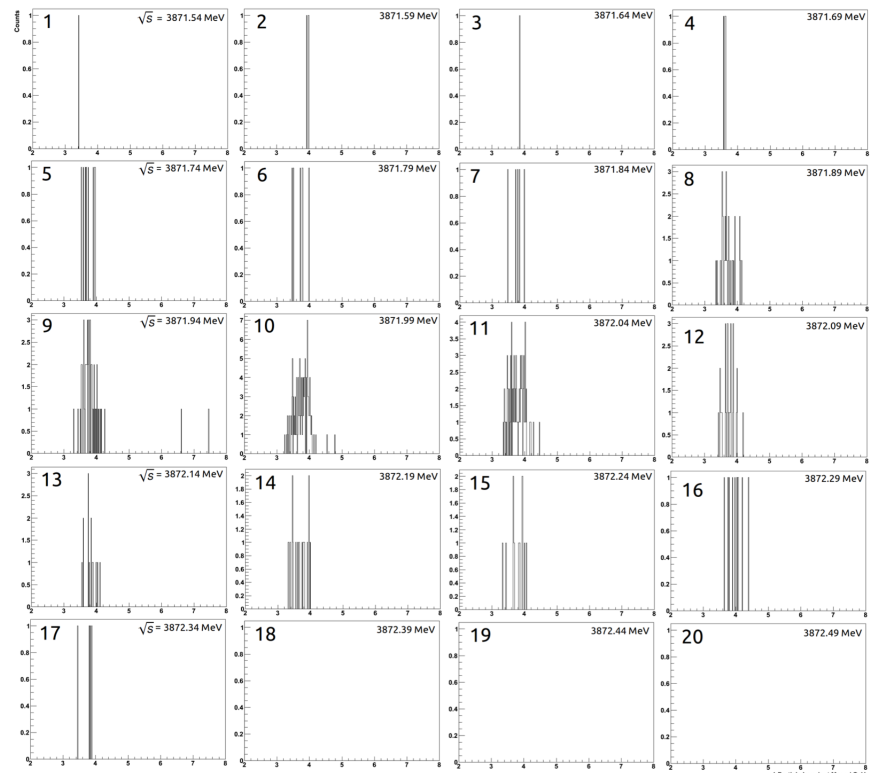
X(3872) – released result

- Upper limit on branching ratio by LHCb:

  $BR(X \to \bar{p}p) < 0.002 * BR(X \to J/\psi \pi^- \pi^+)$ → $\Gamma < 1.2$ MeV   EPJ C73 (2013) 2462

- And $BR(X \to J/\psi \pi^- \pi^+) > 0.026$ (PDG 12) => $\sigma(\bar{p}p \to X(3872)) < 67$ nb





- Here: Assume σ = 50 nb, Luminosity: 2×10^{31} $cm^{-2}s^{-1}$
- Measurement of Γ=100 keV with 20% relative error

[M.Galuska, Master thesis]

Lineshapes for different E_f

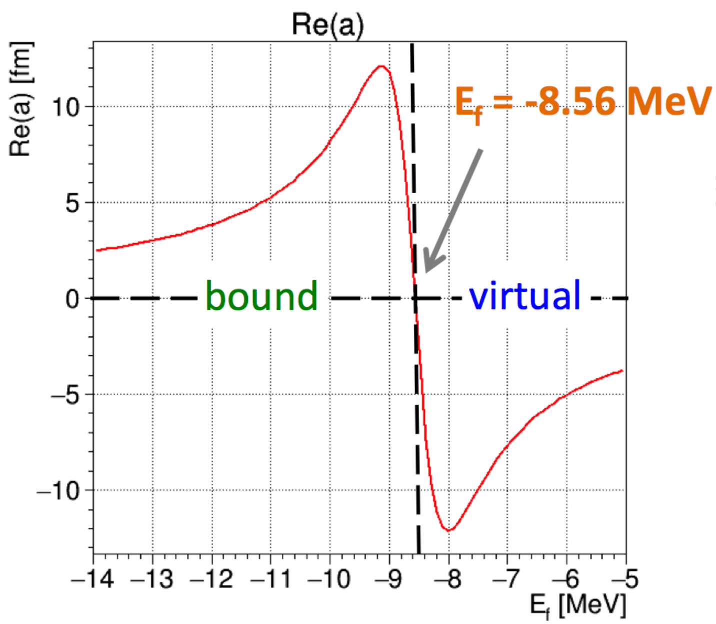
-> Talk by K. Götzen, PWGs 18th Nov & 1st Dec2015

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

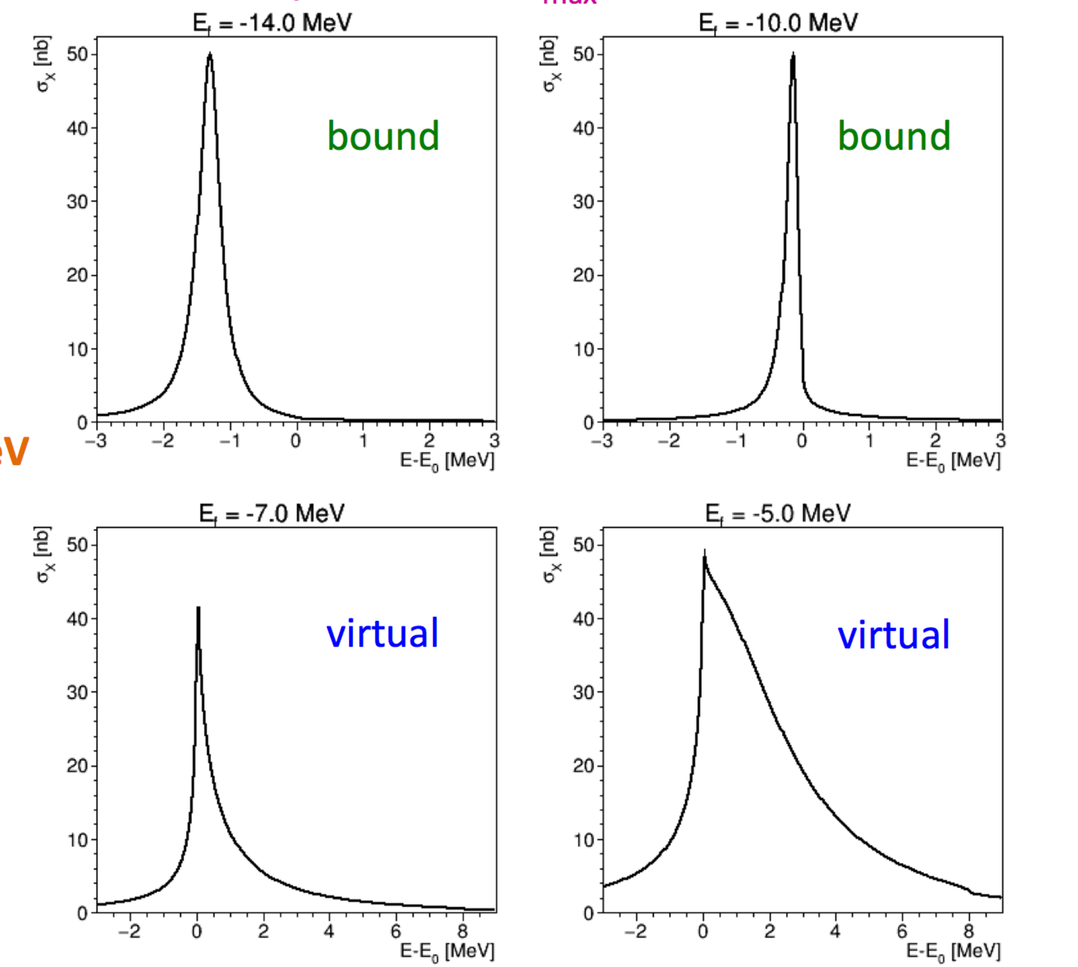
$$a = -\frac{\sqrt{2\mu_2\delta} + 2E_f/g + i\Gamma(0)/g}{(\sqrt{2\mu_2\delta} + 2E_f/g)^2 + \Gamma(0)^2/g^2}$$

Re(a) > 0 : bound state

Re(a) < 0 : virtual state



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

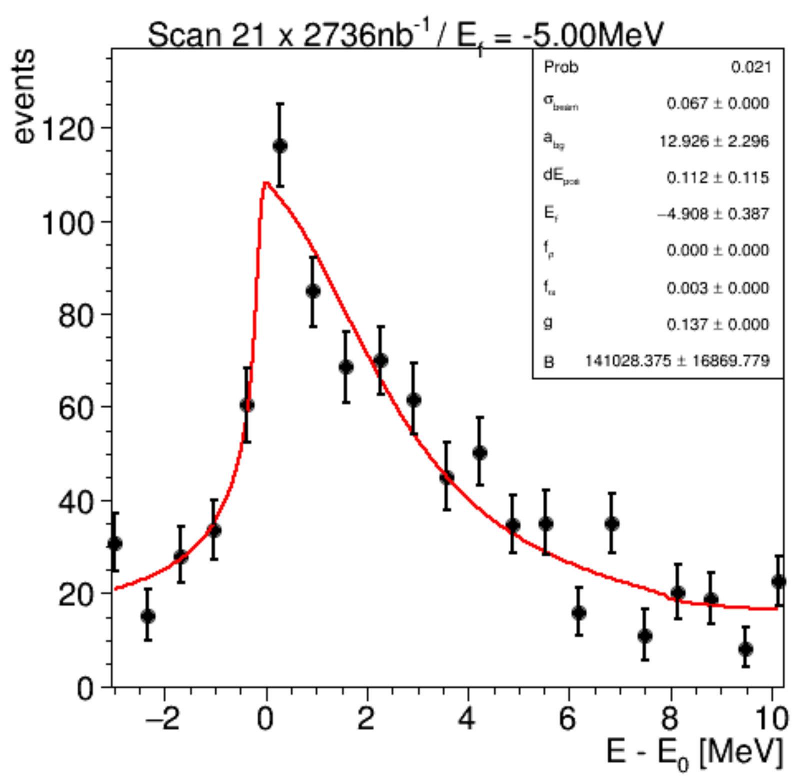


Scan Examples Molecule Lineshape

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

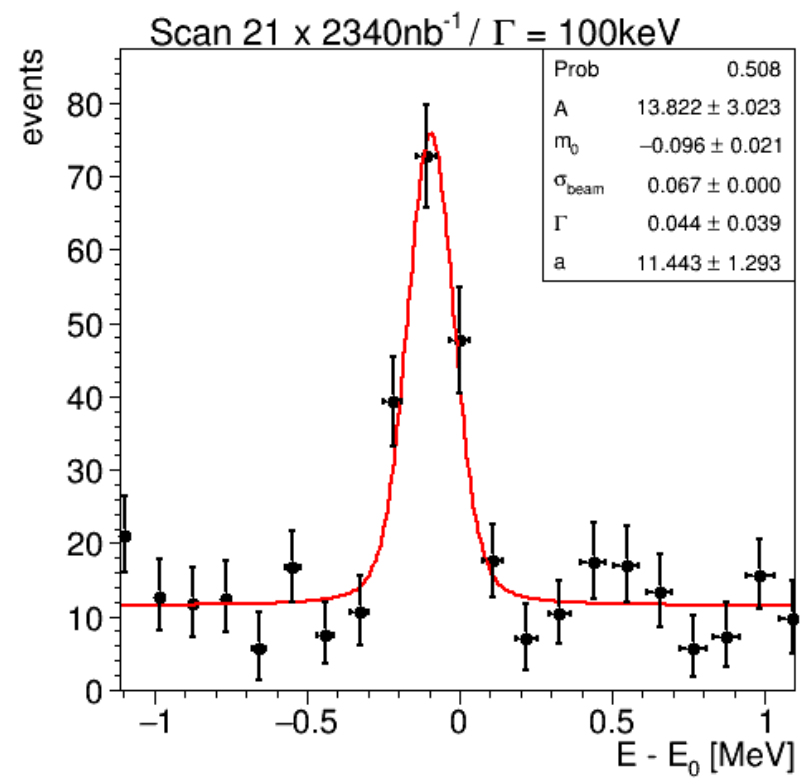
HR: 21 x 2 days

E_f = -5 MeV



HESRr: 21 x 2 days

Γ = 100 keV



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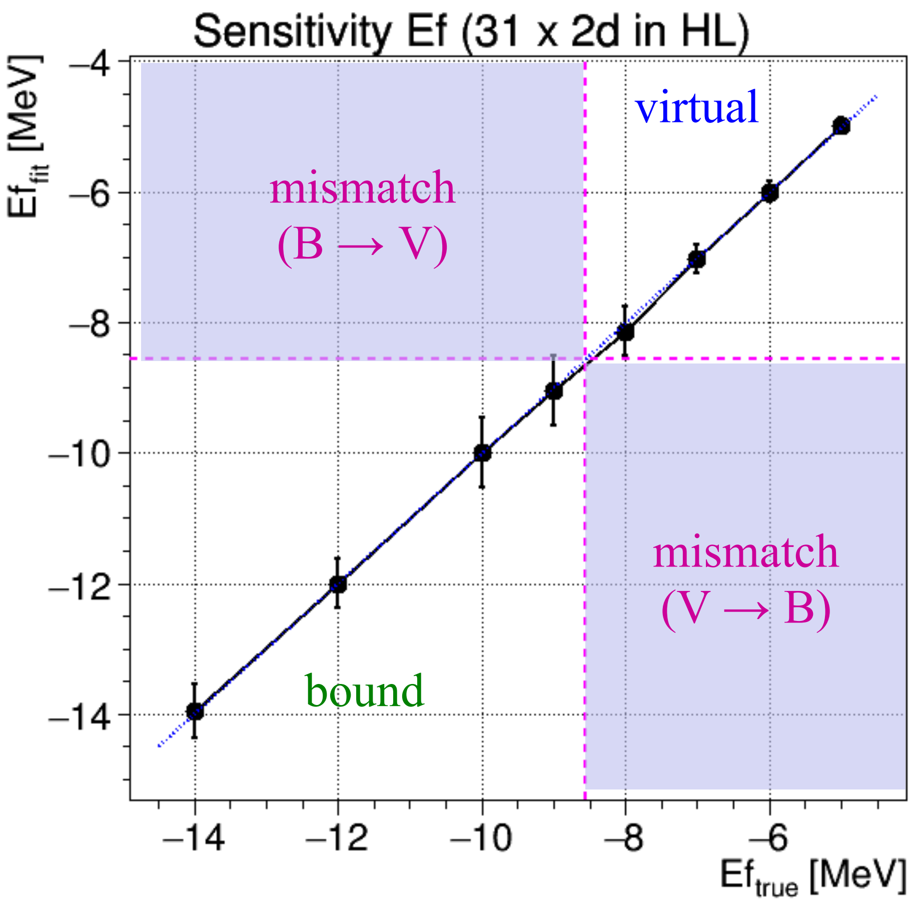

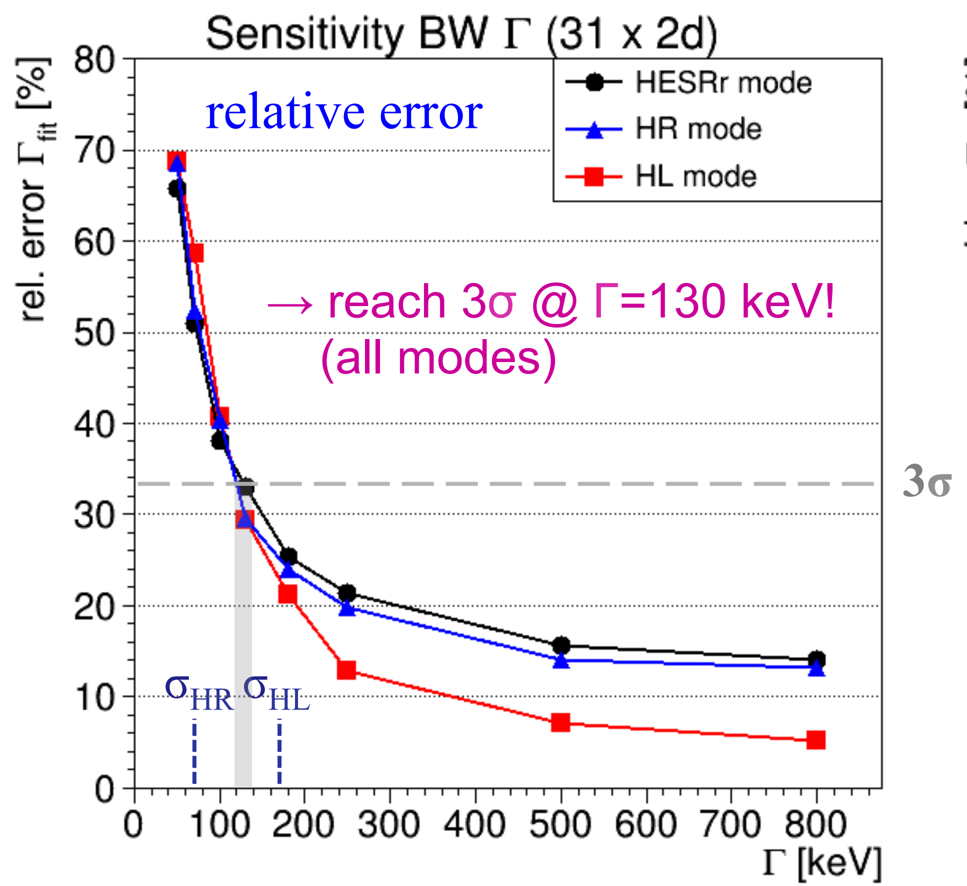

Activities, achievements so far

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

- Scrutiny studies
  - fastSim studies (tuned to full sim)
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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)

Search for X → Z transitions at PANDA

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

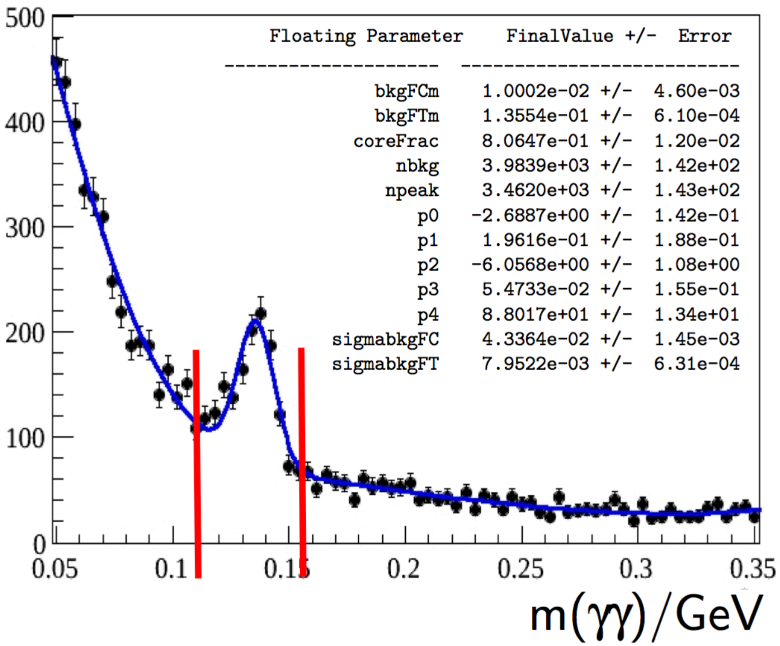
$$X(3872) \rightarrow Z(3730)^0\pi^0 \text{ (with L=1)},$$

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

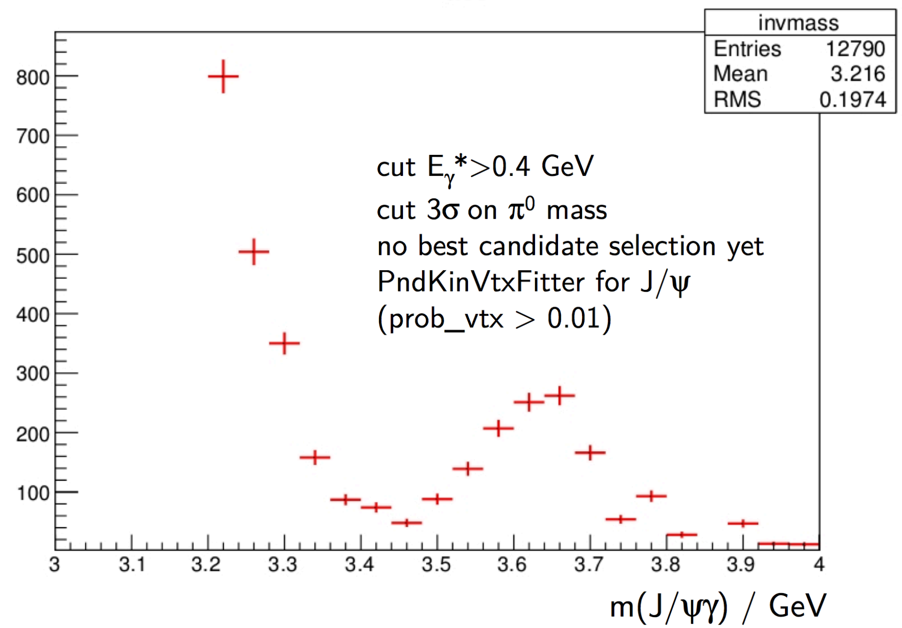
Also, possible charged $Z(3730)^+$ candidate, decaying to $\chi_{c1}\pi^+$, with subsequent $\chi_{c1} \rightarrow J/\psi\gamma$

Talk by S.Lange,
PWG Uppsala, June 2015

Signal MC



$Z^0(3730)$ Signal



An internal PANDA note...

A proposal for Z state search and estimate of X, Y, Z production rates at $\overline{\text{P}}$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 $\overline{\text{P}}$ANDA charmonium-light exotics group.

Abstract

The $\overline{\text{P}}$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 $\overline{\text{P}}$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 $\overline{\text{P}}$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.

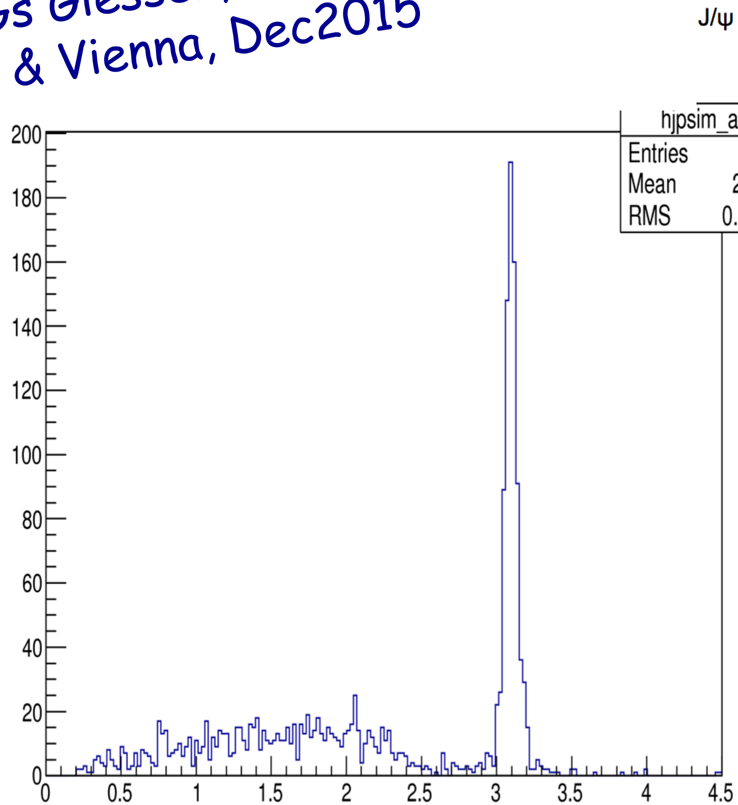
Resonance	$\mathcal{L} = 8.64$	$\mathcal{L} = 0.864$	$\mathcal{L} = 0.432$	Ref.
$X(3872)$	432000	43200	21600	[18]
$Y(4260)$	19000	1900	950	
$Z(3900)^+$	4050	405	202	[13]

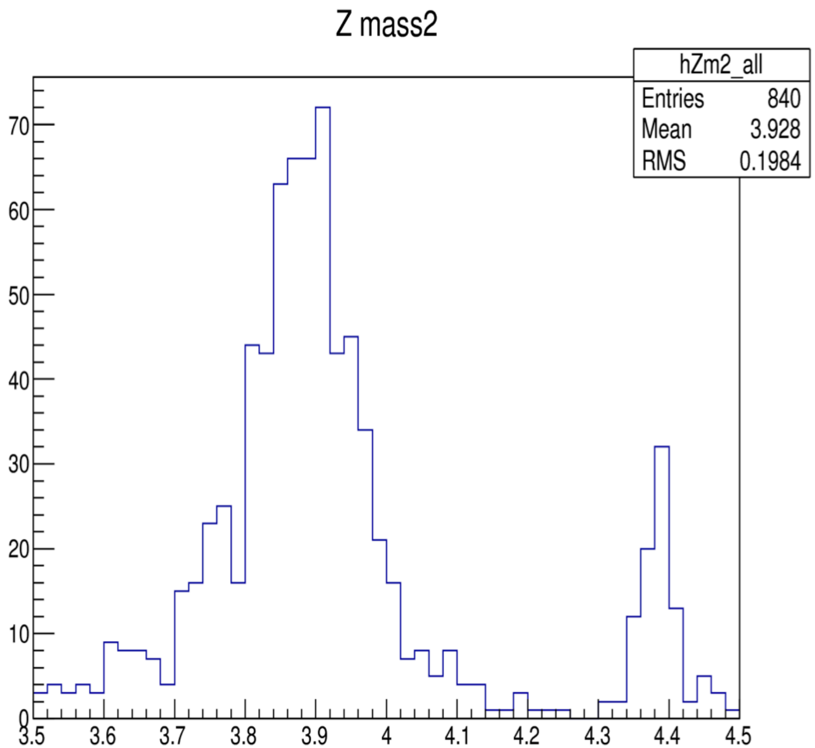
Another unique PANDA possibility: $\bar{p}d \rightarrow Z^- p$

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

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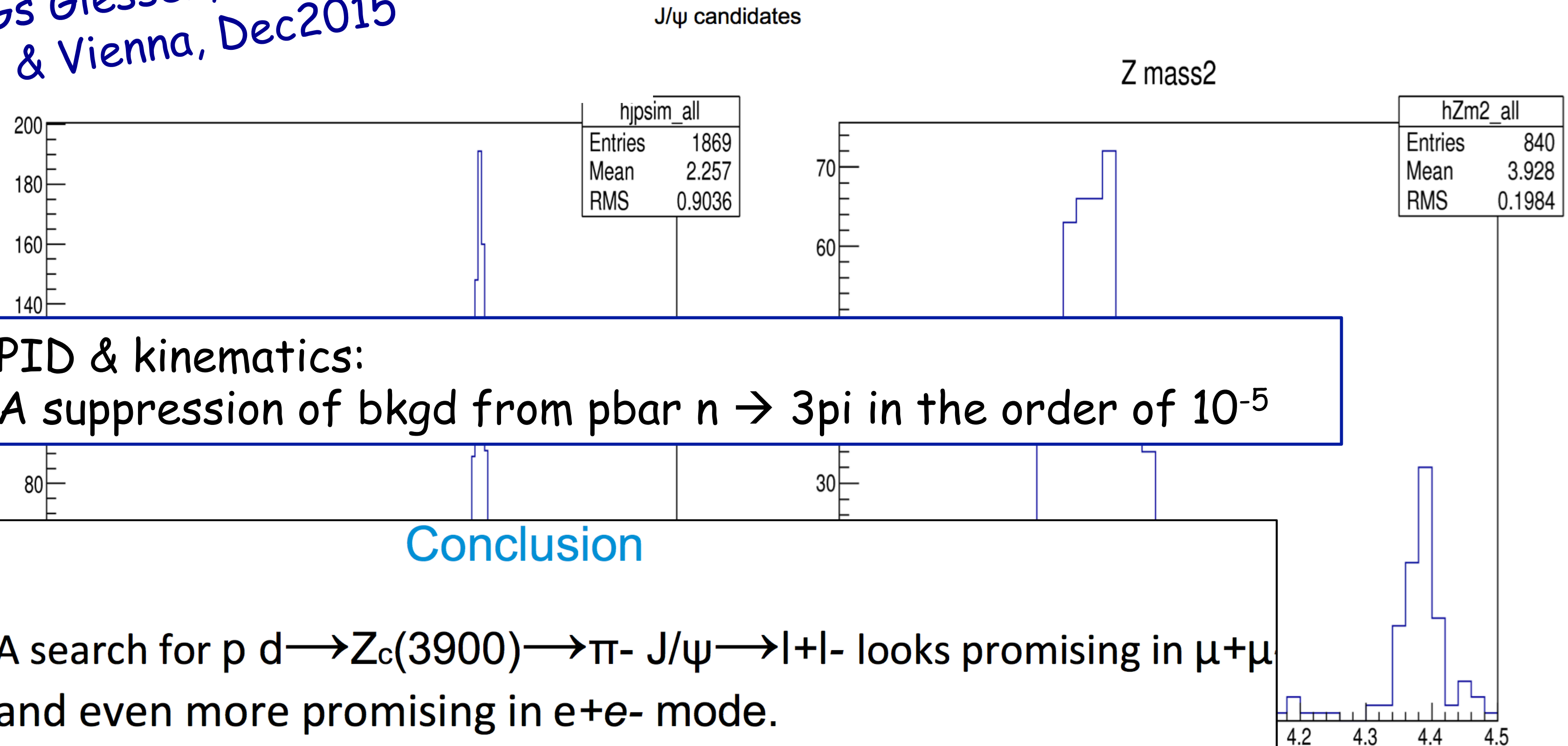


PID & kinematics:
A suppression of bkgd from pbar n → 3pi in the order of 10^{-5}

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.

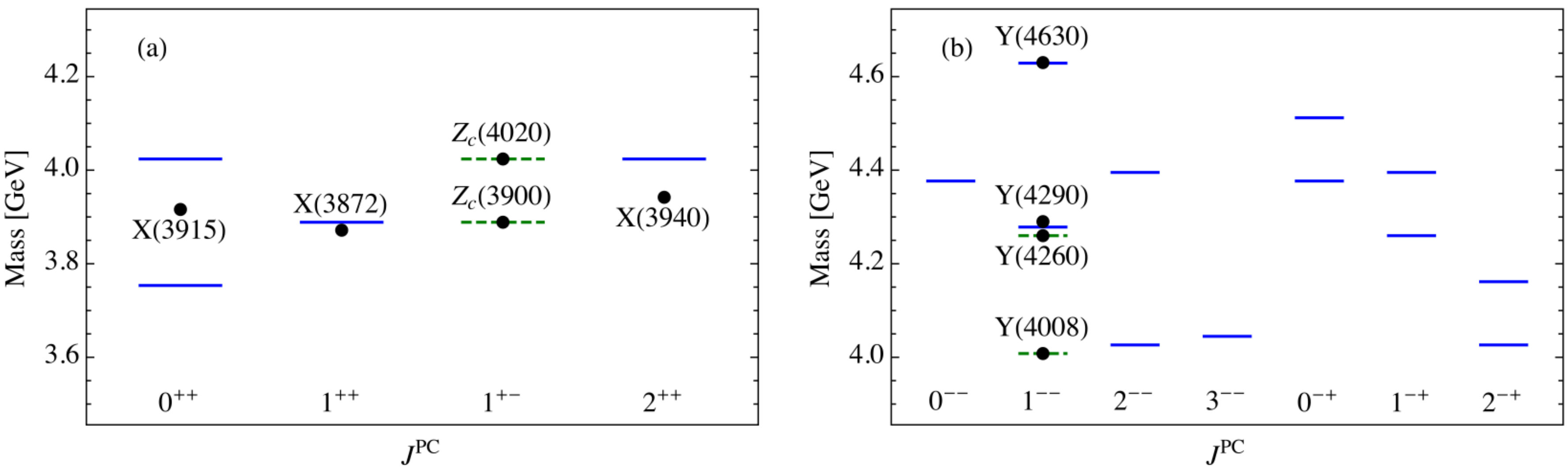
π J/ψ

J/ψ with track splitting

-> FullSim started

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]

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

Charmonium-like Exotics at PANDA

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*

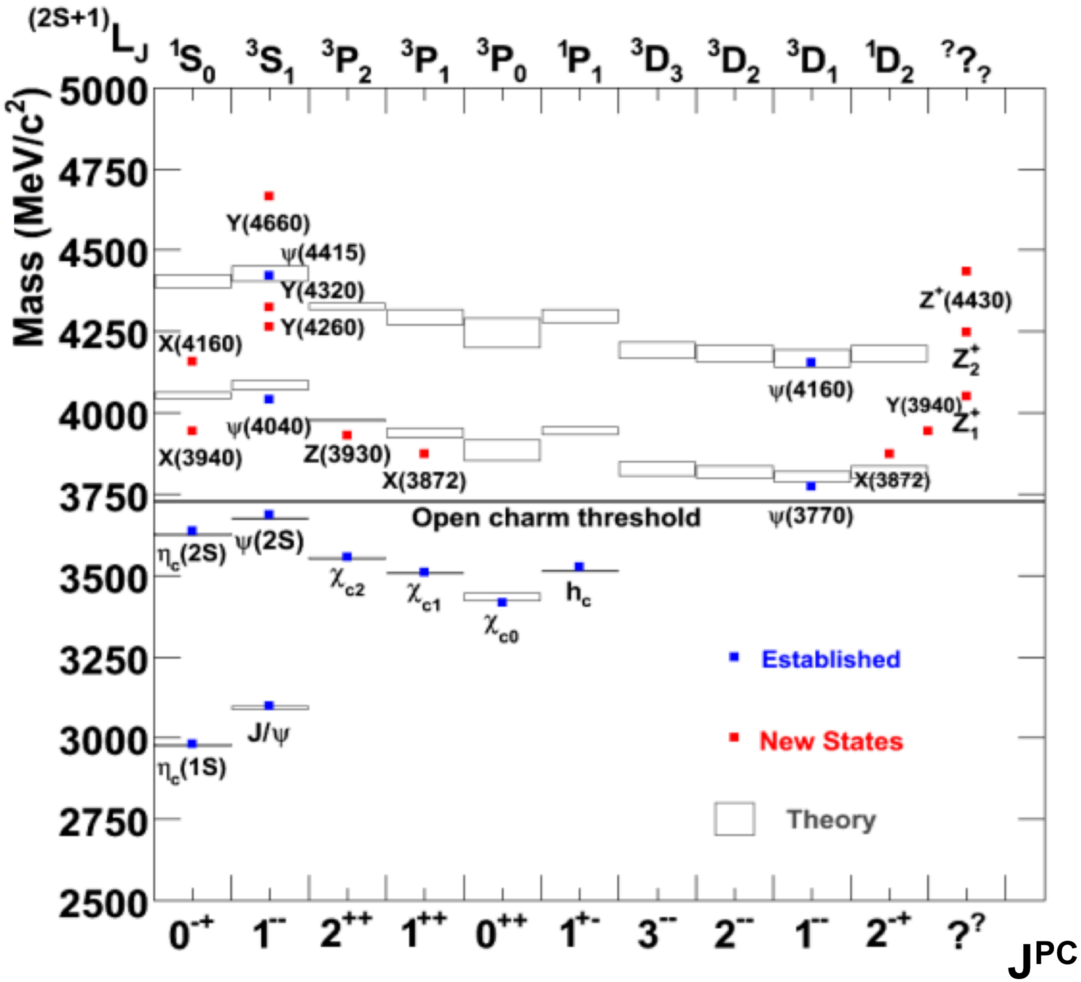
Future plans to enrich PANDA repertoire of unique PANDA physics:

- 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!**

Additional slides

Charmonium(-like) Spectrum



- Since 2003 charmonium-like spectrum found richer as expected
- Observation of states that do not fit theoretical models/predictions
- The case of the X(3872):
  - isospin violating, very narrow
  - quantum numbers known (1^{++}, LHCb)
  - width unclear

  → *nature not yet clear..*

  needed: measurement of width
- X,Y,Z states:
  - some need still confirmation
  - masses poorly known
  - statistics poor, nature unclear:

    Molecules, tetraquarks, hybrids, ..?

    Z_c(3900): First order exotic?

"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:

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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*

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*
- A recent internal notes on behalf of the PWG
  → *good discipline in documenting and following new rules*

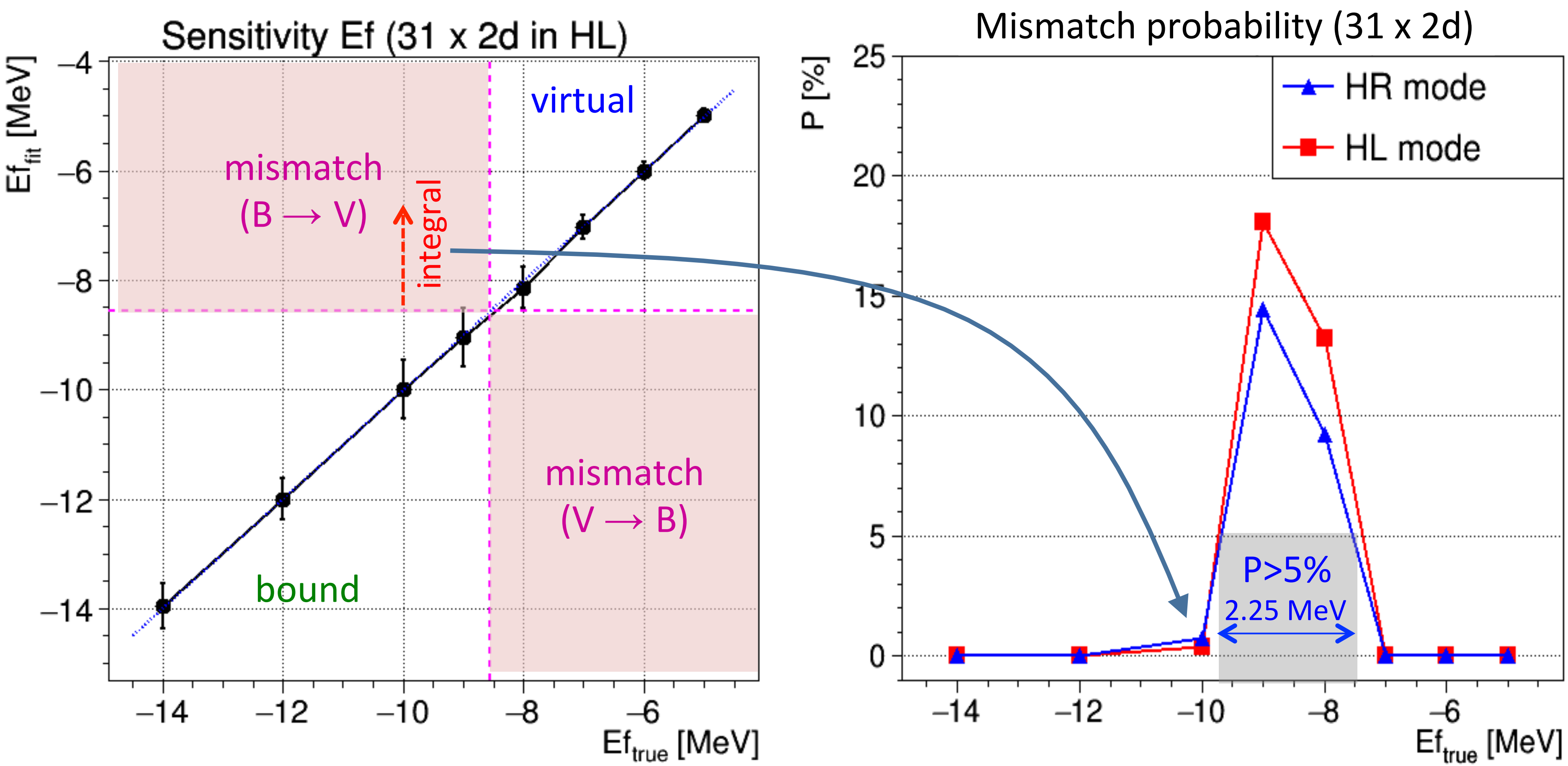
Future plans to enrich PANDA repertoire of unique PANDA physics:

- 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!**

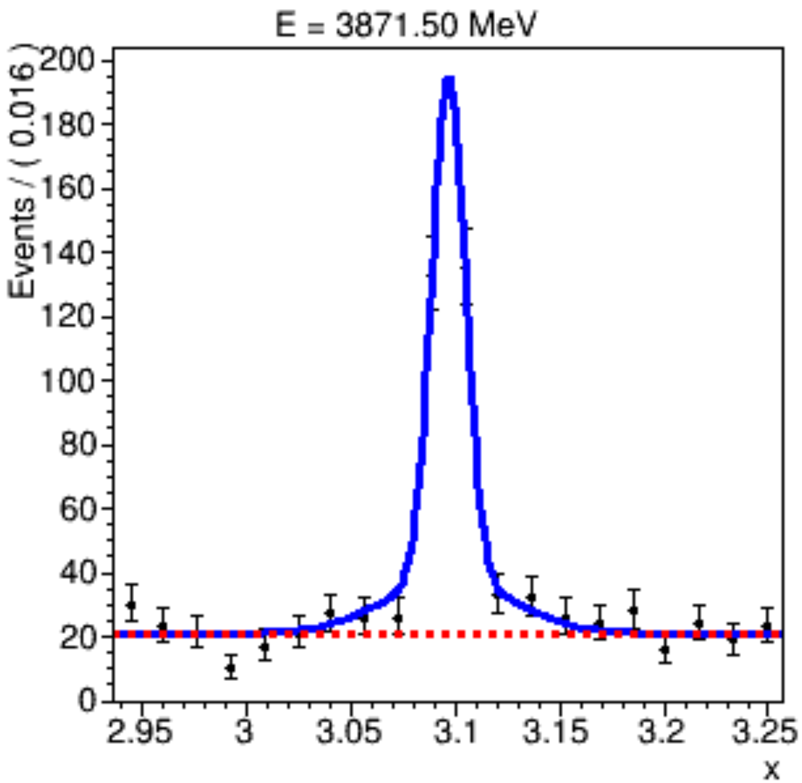
Sensitivities Molecule Lineshapes (31 x 2d)

- 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

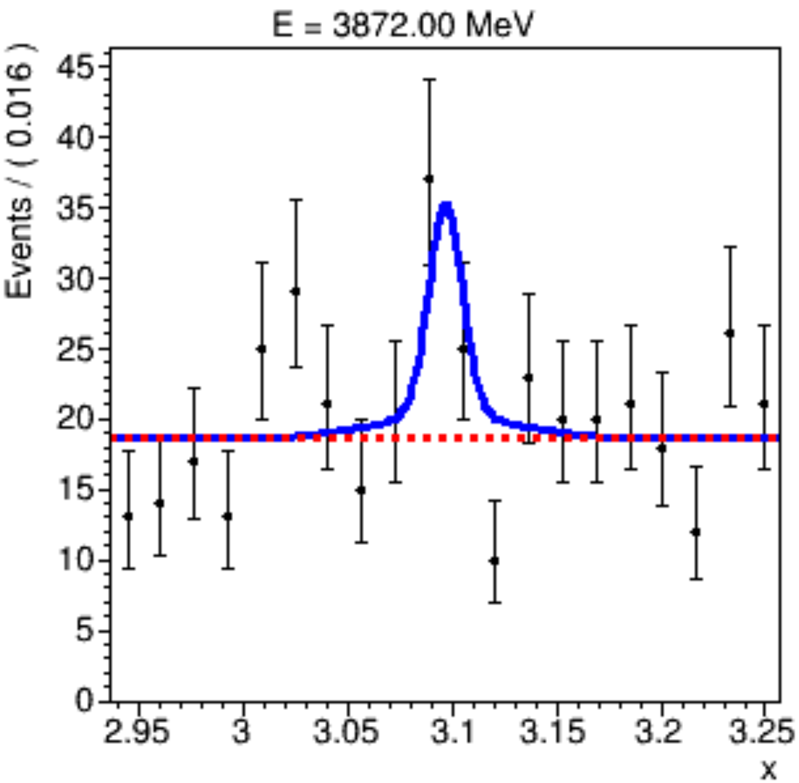


Generated J/ψ Plots Examples

- Signal pdf like in true reco; background flat
- Scaled bkg efficiency ROI → full window width (x 4)



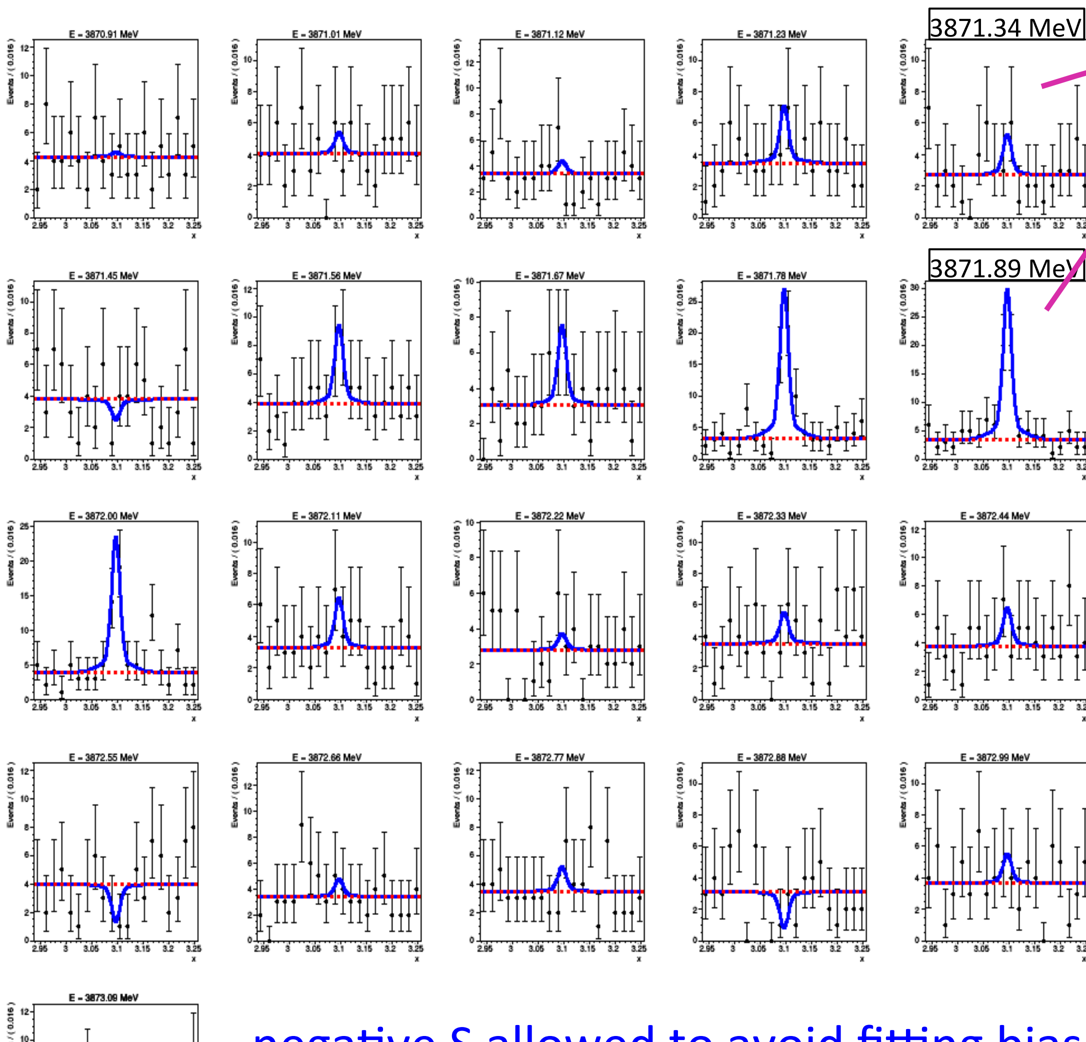
$S = 275.8\ ^{+16.8}_{-16.7}$

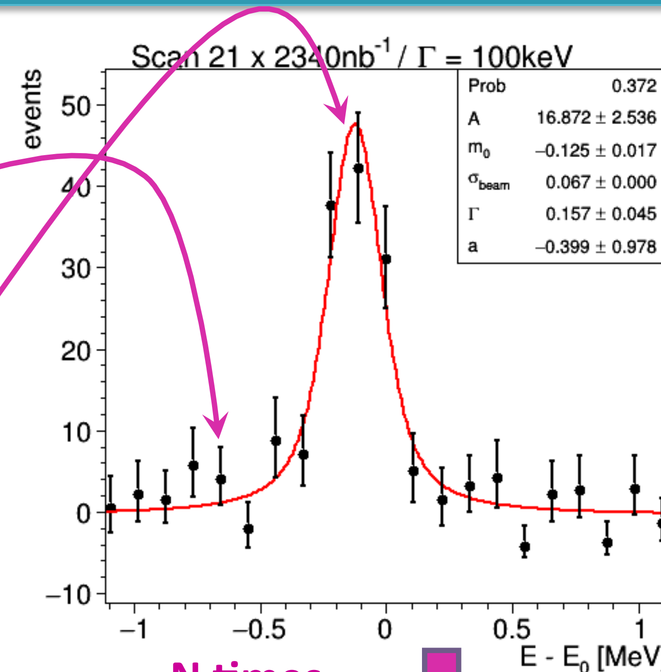


$S = 26.1\ ^{+9.7}_{-9.0}$

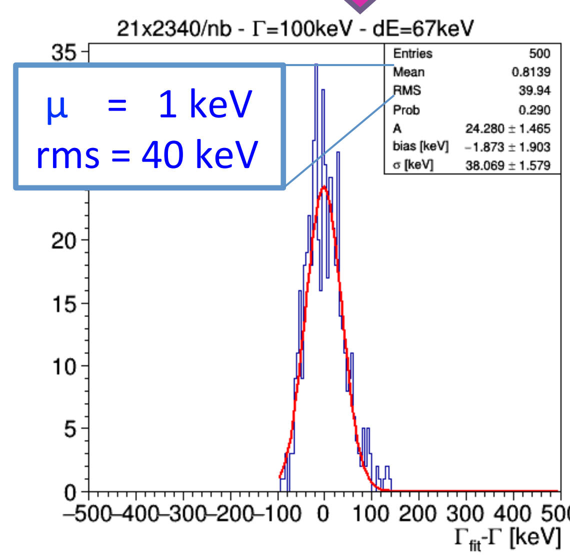
Illustration for Scan

BW, 21 x 2d in HESRr mode





N times ...



negative S allowed to avoid fitting bias

Our Focus: Charmonium-like Exotics

List of channels / charmonia (XYZ states):

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

→ 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)*

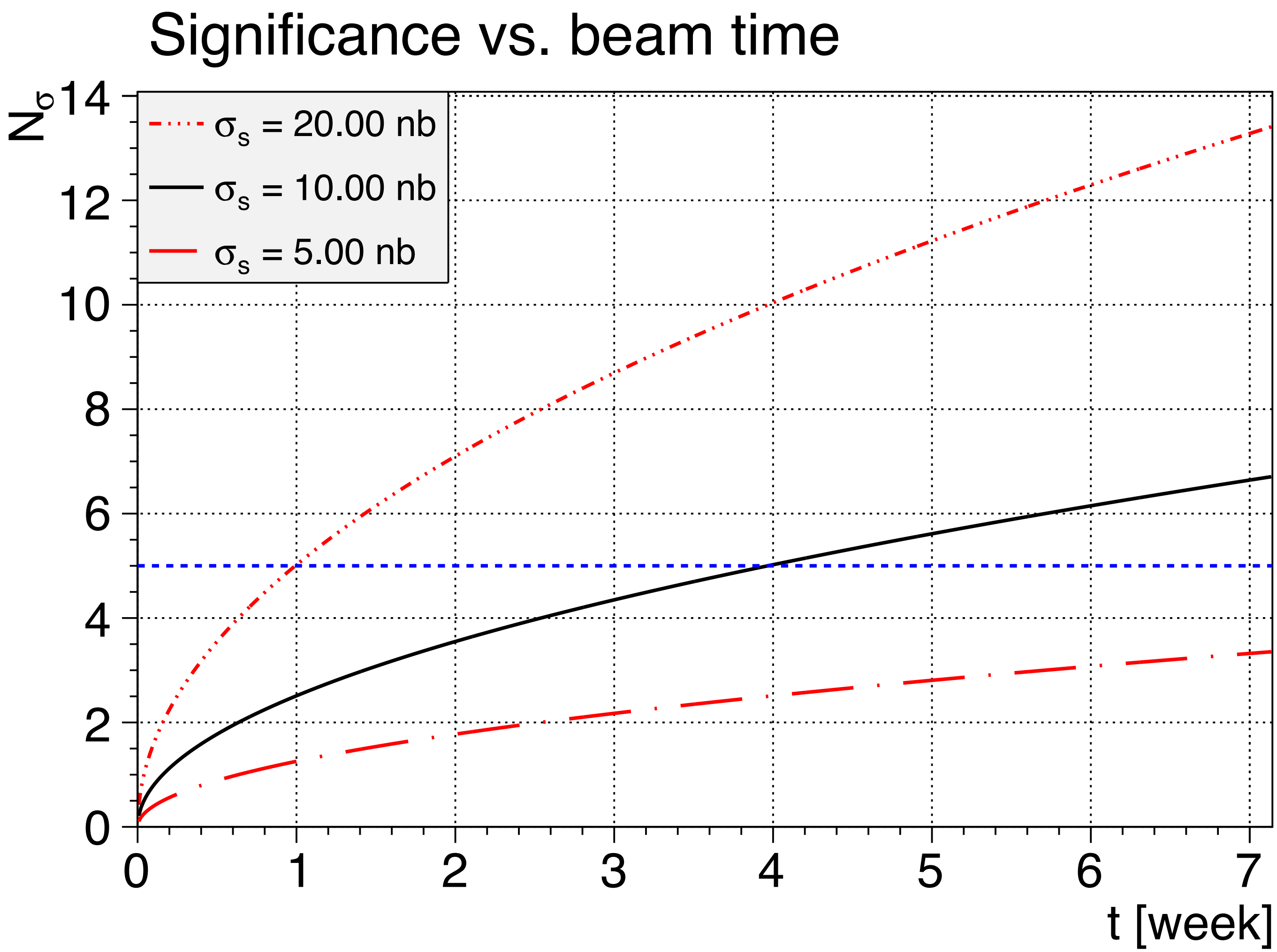
"input":

- 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

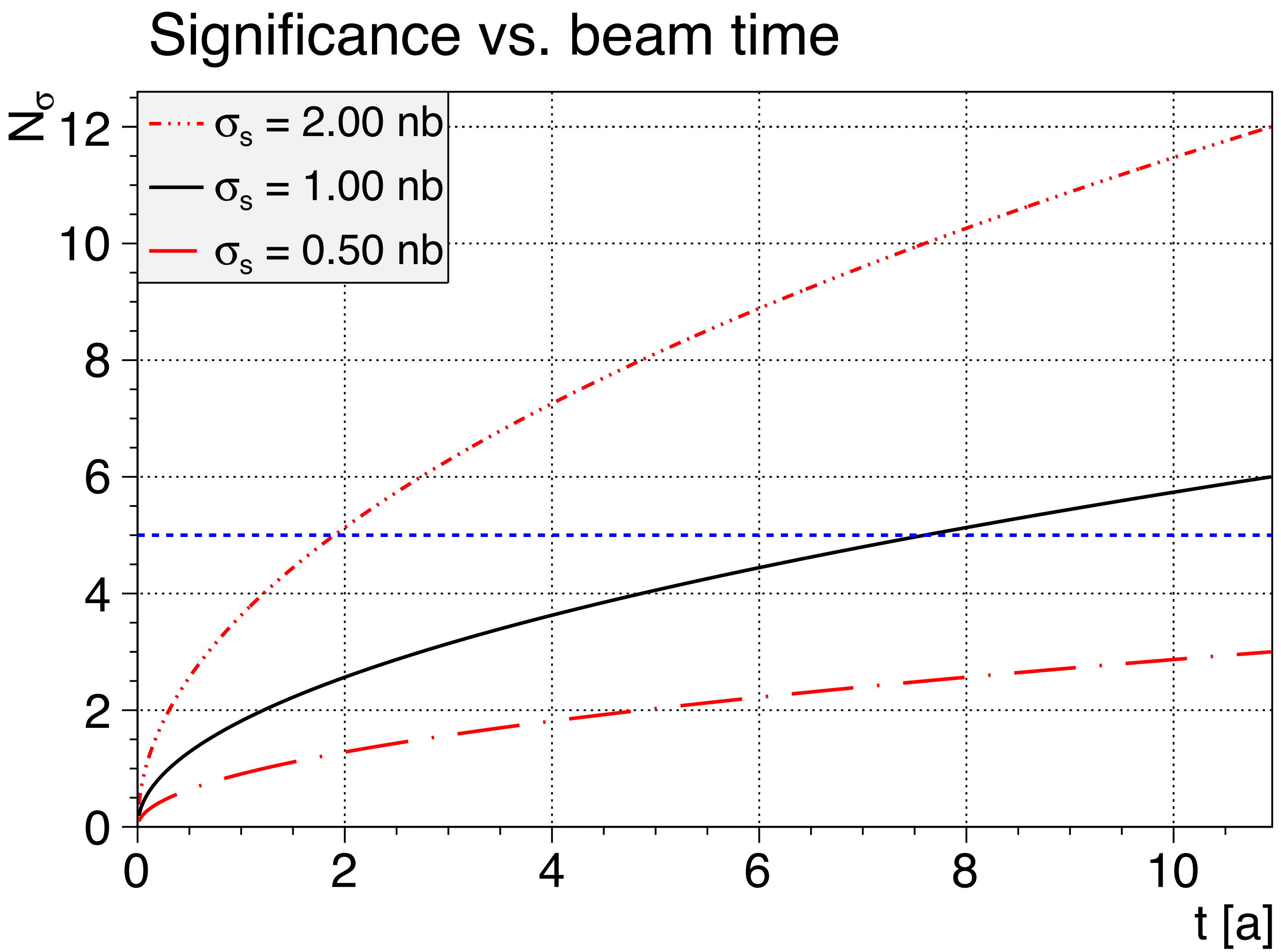
σ_s = ~10 nb, σ_b = 60 mb
f_{BR} = 3.5 %, L = 2 x 10^{32}
ε_s = 22.6% , ε_b = 2.0 x 10^{-6}



Proposed FoM: Significance

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

σ_s = ~1 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}



Overview & Summary Results FoMs

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

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

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)