Communications, common PWG session:
Light Mesons (LM), Charmonium (CC) and Charmonium-like Exotics (CCE)

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Outline

- Publication / release issues
- Ongoing analyses
- Day-one and phase-one programme
  → *JSFC request (5 page paper and presentation*)

Publication / release issues

Phase One Paper

- Drafting ongoing, see report by physics coordinators
  - CCE: Xscan P1 → *delivered from our side*
  - CC, LM physics cases P1 → *delivered from our side*

Dedicated X(3872) scan paper (CCE)

- Precision energy scan measurements using the example X(3872)
  - ✓ Extension and completion of release
    - *Parameter space extended, and*
    - *Systematics estimated and included*
  - ✓ Presented and discussed in PWG
  - ✓ Release Note draft circulated within PWG
  - ✓ Review Committee formed by PubCom:
    - *M. Fritsch (chair)*
    - *J. Meschendorp (replacing K.Schoenning, representing PubCom)*

→ Collaboration wide talk: Plenary talk on Fri by Klaus Goetzen et al.

Publication / release issues

Phase One Paper

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  - ➢ CCE: Xscan P1 → *delivered from our side*
  - ➢ CC, LM physics cases P1 → *delivered from our side*

Dedicated X(3872) scan paper (CCE)

- Precision energy scan measure

Status as of today:
+ Analysis (note) approved by RC
+ Journal paper draft written, handed in to RC >2 weeks ago
+ Panda authorslist, EPJ style centrally provided (Udo)

--> Goal: Submission to EPJ soon (in time for P1 paper & LHCb update)
--> Appetizer for CWR, next slides

ubCom.

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Publication / release issues

Phase One Paper

- Drafting ongoing, see report by ...
  - CCE: X...
  - CC, LM...

Status as of today:
+ TAG members involved since Stockholm meeting
+ Editing work Johan & Karin
=> **Release to collaboration soon ("in Nov")**

Dedicated X(38..) scan paper (CCE)

- Precision energy sc...

Status as of today:
+ Analysis (note) approved by RC
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--> Goal: Submission to EPJ soon (in time for P1 paper & LHCb update)
--> Appetizer for CWR, next slides
=> **Commenting phase RC mostly finished, CWR soon (hope next week)**

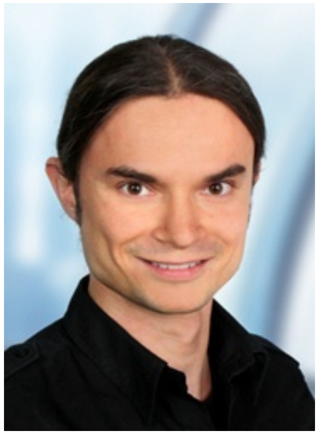
  - *J. Meschendorp (replacing K.Schoenning, representing PubCom)*

→ Collaboration wide talk: Plenary talk on Fri by Klaus Goetzen et al.

Ongoing Analyses

CCE ctnd:

- ppbar → $\tilde{\eta}_{c1}\eta$, with $\tilde{\eta}_{c1}$ → $\chi_{c1}\,\pi^0\,\pi^0$ (Markus Moritz, U Giessen)
  - Charmonium hybrid state
  - Studied for old performance report and fastSim (MP)
    - *A good channel showing importance of fully equipped EMC*
  - FullSim studies started
    (inline with needs of extending the fastSim studies to fullSim)
  - First status report today



New active analyst on a CCE channel:
→ Welcome, Markus!

Ongoing Analyses

CCE ctnd:

- ppbar → $\tilde{\eta}_{c1}\eta$, with $\tilde{\eta}_{c1}$ → $\chi_{c1}\ \pi^0\ \pi^0$ (Christian Will, U Giessen)
- EMC Reconstruction, split-offs/clustering (Aaron Kripkol, U Giessen)
  - ➢ Charmonium hybrid state
  - ➢ A good channel showing importance of fully equipped EMC
  - ➢ First status reports at PWG two weeks ago & this CM

New active analysts on a CCE channel:
→ Welcome, Aaron & Christian!

Day-1, Phase-1/2 input from Conveners

Physics line	P1/2	D1 kick-off	International competition
Light-meson spectroscopy	• Search for glueballs, such as tensor glueball (P1, P2). • Search for meson-like states, such as molecular candidates, $a_1(1420)$, tetraquarks, $\phi(2170)$, etc. (P1, P2).	• $\bar{p}p \to \phi\phi(\pi^0)$ (e.g. final states with charged tracks) at ~1.64 GeV/c (~1 μb xsec) and ~4 GeV/c. • *Beyond the state-of-the-art*: PANDA builds on at-rest annihilations at LEAR with possibilities to access other spin-parity states via in-flight reactions. Even in the first few hours at D1, PANDA will exceed statistics of JETSET. JETSET did not use magnetic spectrometer. PANDA will have a ~4pi acceptance for charged tracks, which is essential for an unambiguous PWA. • *Scientific output*: first PWA case study with potential sensitivity to observe new exotic states in a relatively simple final state.	• *BESIII*: expected to collect 10B J/psi decays for light-meson studies. Production branching fractions are at best 10^{-3}. PANDA will be able in some cases to collect significantly more data than BESIII. The spin-parity of initial state in e+e- puts severe restrictions to access resonances. PANDA will be complementary on this aspect. • *COMPASS/GLUE-X*: complementary by probe. COMPASS exploits central production as mechanism to produce exotics. • In general, LEAR has demonstrated that antiprotons have a strong potential to discover exotic states, such as demonstrated by the strong gluon component of the f0(1500) and other states.
Hyperon spectroscopy	• Baryon spectroscopy with strangeness d.o.f.: Ξ (|S|=2) (P1, P2) and Ω (|S|=3) (P2). • Search for exotic baryonic states (pentaquarks, dibaryons) (P1, P2).	• $\bar{p}p \to \bar{\Xi}\Xi^{(*)}$ at ~4 GeV/c. • *Proof-of-principle*: spectroscopy of Ξ(1320, 1530, 1620, 1690) via recoil-mass analysis (missing-mass studies). • *Scientific output*: existence of narrow (width ~20 MeV) states, such as the 1620. Note that these studies are complementary to the hyperon dynamic studies.	• *JPARC*: production of |S|=1, 2 baryons with kaon beams and gamma spectroscopy. PANDA has a complementary initial state which is likely advantageous compared to kaon-nucleon system. PANDA will be able to extend to |S|=3 sector. JPARC focuses primarily on inclusive studies (missing mass). PANDA will within its P1 program perform exclusive measurements. • *JLAB (CLAS/GLUE-X)*: baryon spectroscopy using tagged photons. PANDA has a complementary probe that could be sensitive to states that do not couple strongly to photons. In general, production cross sections of |S|=2 states are very small with photons with respect to antiprotons used by PANDA (factor 10^{-2}-10^{-3} smaller). • *COMPASS: In principle* has the possibility to look for Ξ states, no competition though.
Hyperon dynamics	• Production of $\bar{Y}Y$ pairs $Y=\Lambda, \Xi$ (P1, P2) $Y=\Omega, \Lambda_c$ (P2): strangeness dynamics in few-body systems. • Spin d.o.f. in $\bar{\Lambda}\Lambda$, $\bar{\Xi}\Xi$ (P1, P2) $\bar{\Omega}\Omega$, $\bar{\Lambda}_c\Lambda_c$ (P2) production and decay.	• $\bar{p}p \to \bar{\Lambda}\Lambda$ and $\bar{\Xi}\Xi$ at ~1.64 GeV/c and ~4 GeV/c. • *Beyond the state-of-the-art*: reproduction LEAR polarization data at 1.64 GeV/c. Typical one day measurement with the luminosity indicated for D1. Unique measurements of |S|=1 and |S|=2 hyperons at 4 GeV/c. • *Scientific output*: first polarization data at energies beyond LEAR. Unique: $\bar{p}p \to \bar{\Xi}\Xi$, first time observation, extending studies from |S|=1 to |S|=2 domain.	• No competition and unambiguously extending the earlier studies done at LEAR.
Hidden/open-charm spectroscopy	• Line-shape study of narrow hidden-charm states, such as the X(3872) (P1, P2). • Discovery of XYZ states, such as Z(3730) (P1, P2) • Search for high-spin charmonium states (P1, P2). • Production xsecs of open-charm mesons/baryons, such as $D_{(s)}\bar{D}_{(s)}$ (P1, P2). • Open-charm spectroscopy: heavy-light system, complementary to hidden-charm systems; width measurements of D_s* resonances, etc. (P2).	• $\bar{p}p \to J/\psi$ at ~4 GeV/c, line-shape studies. Note: $B(J/\psi \to \bar{p}p) = 2\times10^{-3}$, e.g. large compared to any other known charmonium states. • Z-states searches, possibly in $\bar{p}n$. Z states can easily be selected using charged tracks (J/ψ pi+/-) and J/ψ identification for trigger purposes. Competition, LHCb, BelleII. PANDA is unique in its production mechanism, which could be advantageous. • Open-charm production mechanism in $\bar{p}p \to \bar{D}D, \Lambda_c\bar{\Lambda}_c$. Note that production cross section can be order of few hundred nanobarns. First measurements could be done, which is also needed for next generation open-charm spectroscopy studies. No competition. • *Proof-of-principle*: energy-scan capabilities and performances. • *Scientific output*: Discovery potential for higher-mass Z-states with confirmation of lower-lying ones. First production cross section measurements of open-charm pairs in $\bar{p}p$.	• *BESIII*: PANDA has a complementary probe: different production mechanism of hidden-charm states with higher center-of-mass energy and a sensitivity to high spin states. Access to the line shape of (narrow) states beyond J^{PC}=1− can only be probed with unprecedented resolution with PANDA. BESIII cannot produce directly charged Z-states in e+e-. PANDA can produce these states directly and, thereby, is capable to reach higher masses (no recoil necessary). • *LHCb*: LHCb exploits decays of bottom-rich hadrons to probe hidden-harm states. For the complementarity of PANDA, see item BESIII, excluding the higher center-of-mass energy argument. • *BELLEII*: see LHCb • *General*: PANDA is undoubtfully complementary compared to his competitors. Note that the production

EM form factors	• Time-like formfactors ($\|G_E\|$, $\|G_M\|$) of the proton in e^+e^- (P1, P2) and $\mu^+\mu^-$ (P1,P2) • Time-like formfactors in the unphysical region; phase between G_E and G_M (P1,P2) • Hard exclusive processes, e.g. GDAs (P2)	• $\bar{p}p \to l^+l^-(\pi^0)$ at ~1.64 GeV/c. • *Proof-of-principle*: demonstrate feasibility to suppress background to identify e.m. probes. Multi-pion channels are important as input to setup analysis tools (generators etc.) for building up the EMFF program. No competition. • *Scientific output*: first identification of $\mu^+\mu^-$ and $e^+e^-\pi^0$ channels in $\bar{p}p$. Construct extensive database on multi-pion production in $\bar{p}p$ as input to QCD calculations.	• *BESIII*: time-like EMFF studies in $e^+e^- \to \bar{p}p$ (and other hadron and antihadrons in the final-state). PANDA has the unique capability to use the $\mu^+\mu^-$ to study the proton form factors. The radiative corrections in the case of $\mu^+\mu^-$ are different, hence complementary, and the additional di-muon channel is a test of the lepton universality with respect to EMFF with the potential to shed light on the proton radius problem. With an additional pion, PANDA is the only experiment that can provide data in the unphysical regime.
Hadrons in nuclei	• $\bar{Y}N$ potential via $\bar{Y}Y$ pair production (P1, P2) • Mass and width measurements of hidden-charm vector mesons in-medium (P2) • Nuclear color transparency (P2) • ΔΔ component in deuteron (P1) • Hyperatoms (P1) and |S|=2 hypernuclei (P2)	• Studies of $\bar{\Lambda}A$ potential in $\bar{p}A$ at 1.64 GeV/c via measurements (transverse) momentum correlations. |S|=1 hyperons (Λ, Σ) as well as |S|=2 hyperons (Ξ) can be studied at D1. Typically 1 week at 10^{30} luminosity sufficient. Cluster jet target works fine. • *Uniqueness*: The exclusive production of hyperon-antihyperon pairs close to their production threshold in pbar- nucleus collisions offers a unique and hitherto unexplored opportunity to elucidate the behaviour of antihyperons in nuclei under well controlled conditions. • *Relevance*: PANDA will provide benchmark data to test theoretical concepts used to describe the dynamics of (anti)hyperons in high-energy heavy-ion collisions. • *Outlook*: The method of transverse momentum correlations can be extended to each hadron–antihadron pair produced exclusively in pbar-A interactions. It may does open the door to |S|=3 nuclear physics by the study of Omegabar-Omega pairs and even to charmed hadrons in nuclei. D1 study would be an important step for hyperatom/nuclei program of PANDA. • *Scientific output*: First measurements of cross sections and momentum correlations of anti-hyperon production in $\bar{p}A$ with large sensitivity to study $\bar{\Lambda}A$ potential.	• No competition.

Several PhysCom discussions Sep/Oct,
Input, outcome compiled by Johan

5-Page Paper requested by JSC

Scientific Strategy for Day-1 of PANDA

Draft 2, October 19, 2018 / ~~October 25, 2018~~

- **5 pages, 3 Figs.**
- **Outline: Scientific Strategy for Day-1 of PANDA**

- PANDA@HESR - A worldwide unique facility for antiprotons
- MSV0-3 plans of PANDA (Phase-1 and -2)
  - Hadron spectroscopy
  - Hyperon Physics
  - Proton structure
  - Strange Hadrons in nuclei
- Day-1 PANDA Detector setup
- The Day-1 case
  - Flagship studie
  - Feasibility studies with discovery potential
  - Development of novel techniques
- Phase-0
- PANDA physics in perspective

More details, see Johan's talk, also dedicated talk by Klaus

Summary

- Only a few analyses ongoing, or rather "ongoing" ....
  - Two new members of PWG, CCE (Giessen)
- One released result progressing to a dedicated journal publication
  - X(3872) energy scan
  - EPJ paper draft written, under review in RC
  - Collaboration wide review soon
- Need more channels being analysed in fullSim
  - Also, better coverage of the our 3 physics topics, improving ...
  - Key channels and results to be worked out
- CCE SubTask Force with theorists successfully launched
  - Prioritised list of channels with dedicated input from theory
  - Expect first related report at the June CM → *update next CM*