Status of COSY

• COSY

• Experiments
  ANKE, WASA, TOF,
  PAX, EDM/JEDI

• Future

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Forschungszentrum Jülich

MesonNet Meeting Prag
17.-19. June 2013
COSY (cooler synchrotron, Forschungszentrum Jülich, Germany)
proton, deuteron: unpolarized, polarized
\( P \leq 3.7 \text{ GeV/c} \), cooling \( (e^-, \text{stochastic}) \)
intensity \( \leq 10^{11} \) stored particles, slow extraction \( (\leq 10^{10} \text{ part./s}) \)
ANKE

TOF

WASA

PAX: study of beam polarization by spin filtering

EDM: test measurements to develop a facility for measurements of electric dipole moments

FAIR weeks: detector tests
ANKE - Apparatus for Studies of Nucleon and Kaon Ejectiles

Internal magnetic spectrometer, C-type dipole, gap height 20 cm

Tracking detectors: scintillators, wire chambers, Si-telescope close to target

Cluster target, polarized atomic beam and storage cell
ANKE Physics Program

focus: spin dependence of NN interaction and pion production
→ detailed understanding of nuclear forces and reactions at intermediate energies

\[ d \, p \rightarrow \{pp\}_s n \] : sensitive to spin-spin term in \( np \rightarrow pn \) amplitude

\[ \bar{d} \, p \rightarrow \{pp\}_s n \]

\[ d \, p \rightarrow \{pp\}_s n \]

\[ \bar{d} \, p \rightarrow \{pp\}_s n \]

impulse approximation with SAID amplitudes

→ polarization data needed

tracking detectors: scintillators, wire chambers, EM calorimeter (CsI), Pellet target, thin wall SC magnet (1T)

close to $4\pi$ detection system for charged particles and photons
# Projects at WASA

<table>
<thead>
<tr>
<th>Decay Path</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>$\eta \rightarrow \pi^0 \pi^0 \pi^0 / \pi^+ \pi^- \pi^0$</td>
<td>Isospin breaking decay, sensitive to $m_u - m_d$ Dalitz plot parameters, $\pi\pi$ scattering parameter</td>
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<tr>
<td>$\rightarrow \pi^+ \pi^- \gamma$</td>
<td>Box anomaly</td>
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<tr>
<td>$\rightarrow \pi^+ \pi^- e^+e^-$</td>
<td>CP violation (virtual photon asymmetry)</td>
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<tr>
<td>$\rightarrow e^+ e^- e^+ e^-$</td>
<td>Transition form factor</td>
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<td>$\rightarrow e^+ e^-$</td>
<td>Physics beyond SM ($\text{BR} \sim 10^{-9}$)</td>
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<td>$\pi^0 \rightarrow e^+ e^-$</td>
<td>Physics beyond SM, discrepancy between KTEV data and theory</td>
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<tr>
<td>$\omega \rightarrow \pi^0 e^+ e^-$</td>
<td>Transition form factor, deviation from VMD prediction</td>
</tr>
<tr>
<td>$\rightarrow \pi^+ \pi^- \pi^0$</td>
<td>Triangle / box anomaly, fsi</td>
</tr>
<tr>
<td>$\rightarrow \pi^+ \pi^-$</td>
<td>$\rho - \omega$ interference</td>
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</table>

### ABC effect

\[ \vec{d}p \rightarrow d\pi^0\pi^0 + p_{\text{spectator}} \text{ and } \vec{d}p \rightarrow pn + p_{\text{spectator}} \]

### 3N dynamics

\[ dp \rightarrow ppn / ^3\text{He} \gamma / dp \gamma / dp \]
TOF – Time Of Flight Spectrometer

$\text{H}_2$ target

Ø 6 mm

tracking of charged particles
vertex reconstruction, delayed decays
→ event reconstruction from geometry / tof
neutral particle detection → missing mass,
neutron detector in forward direction
hyperon production

• **high statistics**
  (Dalitz plot analysis)
  p K⁺ Λ events:
  150k at 2.7 GeV/c
  120k at 2.95 GeV/c

• **polarization observables**
  polarized beam
  (≤70% polarization)
  self-analyzing weak decay
  Λ → p π⁻
  → Pₜ, Aₜ, Dₜₜ
The pKΛ – Dalitz plot

FSI
P(p-Λ) low

cusp
m_{pΛ} at NΣ threshold

Data 2010 (2.95 GeV/c)

N*(1720)
N*(1650)
Comparison of 2.7 GeV/c and 2.95 GeV/c Data

strong FSI (→ extraction of scattering length $\bar{a} = -1.28 \pm 0.11 \pm 0.3$)

N* strong at 2.95 GeV/c, weak at 2.7 GeV/c

pΣ cusp effect not visible at 2.7 GeV/c

2.95 GeV/c data: M. Röder,
2.7 GeV/c data: F. Hauenstein
edm test in storage rings

- Proposal 176 Stephenson, Lenisa
- Proposal 216 Lehrach, Rathmann, Pretz (JEDI collaboration)

if $P$ and $T$ ( = CP if CPT holds) are conserved electric dipole moment $\vec{d} = 0$

SM prediction: $d_n \sim 10^{-30}$ e cm
experiment: $d_n < 2.6 \cdot 10^{-26}$ e cm

measurement of $\vec{d} \rightarrow$ new sources of CP violation like strong CP violation

$$\frac{d \vec{S}}{dt} = \vec{d} \times \vec{E} + \vec{\mu} \times \vec{B} = \vec{\Omega} \times \vec{S}$$

radial electric field rotates the spin transverse polarization buildup sign for edm

one of the first steps: maximize spin coherence time
Sensitivity to Rule on Several New Models

from:
WE-Heraeus-Seminar
Bad Honnef, 4-6 July 2011
Storage ring EDM experiments: The
status of the proton EDM proposal
Yannis K. Semertzidis, BNL

Future

New Installations at COSY

2 MeV electron cooler presently installed
existing e-cooler: 25 keV – 100 keV
new e-cooler: → 2 MeV

sibirian snake → logitudinally polarized beam
installation end of 2013
Summary and Future of experimental activities

**ANKE**

- magnetic spectrometer
- large acceptance
- in forward direction
- precise momentum reconstruction
- polarized targets

**WASA**

- ~ $4\pi$ detector for charged particles and photons
- pellet target → high luminosities
- rare decay studies

**spin physics**

**Outlook**

- double polarization studies, including longitudinal spin (Sibirian snake)

**Future**

- FAIR weeks increase → FAIR related detector tests
- PANDA pre-assembly (beginning 2014, TOF area)
- PAX studies, TRIC experiment (time reversal invariance)
- EDM related activities → possible future of COSY/new ring

(data analysis)

**TOF**

- geometry spectrometer
- precise tracking
- reconstruction of delayed decays
- hyperon production

**strangeness**

- data taking stopped
- last test beam end 2013
- data analysis
- $\bar{p}p \rightarrow p K^+ \Lambda, \bar{p}d \rightarrow p p K^0 \Lambda$

**hadron physics activities stop end of 2014**
Summary and Future of experimental activities

**ANKE**
- Magnetic spectrometer
- Large acceptance in forward direction
- Precise momentum reconstruction
- Polarized targets
- Spin physics
- $\pi^0 \rightarrow e^+ e^- / \pi^0 \rightarrow e^+ e^- \gamma$
- (Physics beyond SM, dark matter)
- $d d \rightarrow \alpha \pi^0$ (Isospin violation)
- Data analysis
- Hadron physics activities stop end of 2014

**WASA**
- Double polarization studies, including longitudinal spin (Sibirian snake)

**TOF**
- TOF geometry spectrometer
- Precise tracking
- Reconstruction of delayed decays
- Hyperon production
- Data analysis
- $\bar{p}p \rightarrow p K^+ \Lambda, \bar{p}d \rightarrow p p K^0 \Lambda$

**Future**
- FAIR weeks increase → FAIR related detector tests
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Thank you for your attention!