**Big Questions**

- What is the interplay of dynamical symmetry breaking, explicit symmetry breaking by the quark masses, and the chiral anomaly? How does it affect the dynamics of light mesons? What role do light meson (rescattering) dynamics play in heavy meson decays?
- What is the nature of the bound states of the strong force? When does the quark-antiquark picture of mesons break down? Are there exotic states like tetraquarks, molecules, hybrids, and glueballs and how do they interrelate?

**Physics Program of the Second Funding Period (2016 – 2019)**

**Light Mesons:**
- \( \eta, \omega \) and \( \eta' \) decays with A2 @ MAMI
  - Amplitude analysis \( \eta' \rightarrow 3\pi \)
  - Study decays \( \omega \rightarrow \eta \gamma \) and \( \omega \rightarrow \eta' e^+ e^- \)
- Light hadron dynamics in charmonium decays
  - Study difference between \( J/\psi \rightarrow \pi^+ \pi^- \pi^0 \) and \( \psi' \rightarrow \pi^+ \pi^- \pi^0 \) (pn puzzle)
  - Study effects of \( \pi \pi \) rescattering
  - Develop and test amplitude analysis methods across channels and with various models

**Effective Field Theory:**
- Description of anomalous processes in chiral EFT including vector mesons
  - Dirac constraint analysis
  - Investigation of various vector-meson approaches (vector, tensor, massive Yang-Mills formulation) to study VPP interactions
  - Development of power-counting scheme (complex-mass scheme)
- Quantum corrections to chiral anomaly
  - Investigation of more complex processes such as \( \eta^0 \rightarrow \pi^0 \gamma \) and \( \eta^0 \rightarrow \pi^- \gamma \)

**Heavy Mesons:**
- Global analysis of exotic charmonium states
  - Interrelationship of \( Y \) and \( Z^+ \) states
  - Simultaneous amplitude analysis of the channels \( Y \rightarrow J/\psi \pi^+ \pi^- \) and \( Y \rightarrow D \bar{D} \)
- Search for exotic charmonium isospin singlets
  - Isospin singlet decaying to \( J/\psi \eta \) to the \( Z^+ (3900) \) triplet
  - Isospin singlet decaying to \( \eta \eta' \)
- Search for exotic charm states
  - Inclusive analyses of the \( D \) and \( D^* \) recoil spectra

**Role within the CRC**

The duality between a better knowledge of the internal structure and the dynamics of hadrons and its relevance and impact in different fields is the central and connecting goal of the CRC1044. In this project the spectroscopy and dynamic investigations of light and heavy mesons connect the perturbative description of the strong interaction at high energies which describes the interaction in terms of quarks and gluons with the non-perturbative description at the low-energy regime where mesons and baryons are the degrees of freedom.