EHM – V Workshop: Round-table discussion April 30, 2021

(AMBER experimentalist's) **Goal of the Round Table Discussion:**

How to convince the referees for the Phase-2 proposal that AMBER will indeed be capable to "Perceive the Emergence of Hadron Mass"?

What do we need to produce a sound and convincing Phase-2 proposal?

1) A list of fundamental Science Questions related to "AMBER vs. EHM";

2) A convincing experimental concept proving that the combination of AMBER's flexible beam/target/detector options with the envisaged high-energy, high-intensity (RF-separated) charged-kaon and antiproton beams at CERN will become a unique facility (!) to study EHM;

3) Convincing projections showing that acceptance, kinematic range and attainable precision (estimates for statistical and systematic uncertainties) are sufficient to give answers to (at least some of) the AMBER Phase-2 Science Questions.

This can be achieved only by continuing, and intensifying, the fruitful cooperation between phenomenology, theory and experiment. (NOTE: EHM-VI planned for Sept./Oct. 2021)

AMBER Science Questions (as of April 30, 2021)

1. **Parton Structure of Nambu-Goldstone Bosons:**
   To be measured: Pion and Kaon Distribution Functions (PDFs) – valence, sea and glue -- provide the first charts of the internal structure of Nature's most fundamental Nambu-Goldstone bosons.
   AMBER challenge: Deliver unique (World-beating) precision data whose intelligent analysis by phenomenologists and theorists will deliver the long-sought charts of pion and kaon structure;
2. **Spectra of unstable states, including those with strangeness:**
   To be measured: Spectra of unstable states, including those with strangeness.
   AMBER challenge: Measure entire array of excited states on pion and kaon trajectories reaching to masses of 2 GeV (and higher?);
3. **Size of Nambu Goldstone Bosons:**
   To be measured: Pion and kaon charge radii (exp. feasibility to be shown!).
   AMBER challenge: Can precise measurements of pion and kaon radii reveal the compositeness (confinement) scale for (near) Nambu-Goldstone bosons?
4. **Wave Functions of Nambu Goldstone Bosons:**
   To be measured: Pion and kaon distribution amplitudes (DAs) (exp. feasibility to be shown!)
   DAs are the nearest thing in quantum field theory to a Schrödinger wave function; consequently, they are fundamental to understanding pion and kaon structure.
   AMBER challenge: Can signature features of interference between EHM and Higgs-Boson mass generation, which are manifest in low-order Mellin moments of the DAs, be probed experimentally?

Proposed structure of the Round-Table discussion

Separate discussions on Science Questions 1, 2 and 3+4

Each discussion round is opened by short "Resume presentations“ of the Phase-2 related key presentations given during the EHM – V workshop.

Discussion round #1: "Parton structure of pion and kaon":
- St. Plachkov: Experimental aspects of AMBER Phase-1 studies of the pion's parton structure
- V. Andrieux: Experimental aspects of AMBER Phase-2 studies of the kaon's parton structure
- A.Maltsev: Measuring the Primakoff reaction and F_{K2pi} with AMBER Phase-2

Discussion round #2: "Spectra of unstable states, including those with strangeness":
- B. Grube: Experimental aspects of studying spectra of unstable states

Discussion round #3: "Meson charge radii and meson DAs“:
- J. Friedrich: Can AMBER access the charge radius of pion & kaon?
- O. Denisov: Can AMBER access DA moments in diffractive scattering?

General discussion (if appropriate)

Approved Phase-1 and envisaged Phase-2 Measurements of AMBER@CERN

Cat.	Beam	E/GeV	Target	Process	Measurement of	When	Status	EHM connection	exp. sensitivity
1 A	muon	100	proton	elastic	proton ch. radius	>=2022	test appr.	confinement	precision meas.
1 B	proton	190	p, ^4He	inclusive	p_bar x-sect.	>=2022	approved	indirect	ok
1 C	pion	190	Carbon	DY	pion's val.+sea cont.	<|>LS3	approved	pion's val.+sea DFs	ok
1 D	pion	190	Carbon	J/psi	pion's gluon content	<|>LS3	approved	pion's gluon DF	ok
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2 A	kaon RF	80-120	Carbon	DY	kaon's val+sea DFs	>LS4	in LoI	kaon's quark DFs	ok
2 B	kaon RF	80-120	Carbon	J/psi	kaon's gluon content	>LS4	in LoI	kaon's gluon DF	ok
2 C	kaon RF	100	proton	prompt photons	kaon's gluon content	>LS4	in LoI	kaon's gluon DF	ok(?)
2 D	pion	100	proton	prompt photons	pion's gluon content	>LS4	in LoI	pion's gluon DF	check!
2 E	kaon RF	50-70	proton	various	excitation spectra	>LS4	In LoI	DCSB	new PDG data
2 F	kaon RF	100-120	high-Z	kaon Compton	kaon polarizability	>LS4	In LoI	DCSB,confinement	confirm!
2 G	pion	190	high-Z	isolated pi0	pi0 lifetime (direct m.)	>LS4	In LoI	chiral anomaly	must be high pr.
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2 H	pion	?	?	?	pion charge radius	<LS4??	new idea	confinement	feasible?
2 I	pion	?	?	pion diffr.scatt.	few-pion final state	<LS4??	new idea	pion DA moments	to investigate
2 J	kaon RF	?	?	?	kaon charge radius	>LS4	new idea	confinement	feasible?
2 K	kaon RF	?	?	kaon diffr.scatt.	K+few-pion FS	>LS4	new idea	kaon DA moments	to investigate
2 L	kaon RF	?	high-Z	gamma K pi pi	F_{K2pi}	>LS4	new idea	chiral anomaly	complic. theory

Phase-1: before and after LS3;
Phase-2: before (?) and after LS4.

LS3: 2025-2026 (?)
LS4: 2030 (?)