Perceiving the emergence of Hadron Mass through AMBER at CERN SPS

Perceiving the Emergence of Hadron Mass through AMBER@CERN

27 April to 30 April 2021
CERN, Geneve - Switzerland

Oleg Denisov on behalf of the Workshop Organizing Committee, CERN, 2021/04/27

It is a fifth workshop over past one and a half year

- Overview
- Timetable
- Committee
- Registration
- Contribution List
- Participant List
- Book of Abstracts
- Videoconference access
- Previous workshops
  - EHM workshop I
  - EHM workshop II
  - EHM workshop III
  - EHM workshop IV

Local Organizers

EHM-AMBER-2020-03...

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Attention: This follow-up workshop will take place by videoconference only.

Due to the health emergency related to the Coronavirus outbreak (COVID-19), this event is by videoconference only.

The origin of the bulk of visible mass in the Universe is still unknown. Contrasting to the massiveness of the proton, the pion appears as unnaturally light, although both are of composite nature. This dichotomy forms a key part of the conundrum of "Emergence of Hadron Mass". The mechanism responsible for the generation of mass is the dynamical breaking of the scale invariance in Quantum Chromodynamics; and measurements of parton distribution functions (PDFs) are sensitive to this effect and its corollaries.

PDFs can be experimentally accessed via deep inelastic scattering, by pion and kaon-induced Drell-Yan interactions, charmonium production at moderate energies and hadro-production of direct photons. Remarkable theoretical progress has been achieved during the last decade. The resulting predictions require confrontation with accurate experimental data, like those that would become available at the AMBER experiment, very recently proposed at CERN. The prospects opened by the AMBER proposal provide now the opportunity for reviewing the present theoretical understanding of the Emergence of Hadron Mass, in order to harden and extend the list of experimental observables accessible at AMBER.

This Theory Initiative will join theorists from high-energy nuclear and particle physics, in a dialogue with the experimentalists, addressing the origin of hadron masses. This workshop is a follow-up of those held in December 2019 (https://indico.cern.ch/event/868625/), March/April (https://indico.cern.ch/event/880248/), August (https://indico.cern.ch/event/940450/), and in November/December (https://indico.cern.ch/event/971469/). It is meant to continue a collaborative effort between the experimentalists proposing this new measurement campaign, the phenomenologists doing global data analyses for parton distributions, and hadron-structure theorists.

There stages process to investigate "validity" of the EHM phenomenon as a driving force of the AMBER QCD facility at CERN SPS:

1. "State of art" in Theory, "objects" to be studied in order to shed a light on the EHM mechanism(s)

2. Competition and complementarity: what is going on on the world-wide scale, other Lab's plans, AMBER uniqueness

3. Which kind of probes valid to study EHM phenomenon do we have in AMBER, most sensitive to EHM mechanisms processes, physics quantities (observables) we have to extract, precision, phase space coverage….

From now on we have to concentrate on point 3 as our intension is to submit AMBER Phase-II proposal in the beginning of 2022 and tight collaboration with theory colleagues is a must for success

Timetable, day 1

14:00	**Introductory talk**	*Oleg Denisov*	14:00 - 14:05
	Probing EHM with AMBER	*Craig Roberts*	14:05 - 14:40
	Charged proton-radius measurement	*Aleksei Dziuba*	14:40 - 15:05
15:00	**Antiproton cross-section measurements for Dark Matter search**	*Paolo Zuccon*	15:05 - 15:25
	Probing the pion's parton structure at AMBER	*Stephane Platchkov*	15:25 - 15:50
	Coffee break		15:50 - 16:00
16:00	**Probing the kaon' s parton structure at AMBER Phase-2**	*Vincent Andrieux*	16:00 - 16:30
	Measuring excitacion spectra in K pi pi final states with AMBER Phase-2	*Boris Grube*	16:30 - 16:55
17:00	**Measuring the Primakoff reaction and F_{K2pi} with AMBER phase-II**	*Andrii Maltsev*	16:55 - 17:15
	Can AMBER Phase-2 access the charge radius of pion or/and kaon?	*Jan Friedrich*	17:15 - 17:30
	Can AMBER Phase-2 access Moments of pion/kaon Distribution Amplitudes in Diffractive Scattering?	*Oleg Denisov*	17:30 - 17:45

BACK UP

AMBER – Proposal Phase-1

EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

CERN-SPSC-2019–022
SPSC-P-360
September 30, 2019

51 institutions, ~260 authors,
19 new institutions with respect to COMPASS (Majority from USA, also Germany, Italy, Russia etc.)

Proposal for Measurements at the M2 beam line of the CERN SPS

– Phase-1 –

COMPASS++*/AMBER†

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AMBER PHASE-1 (proposal submitted in Sep. 2019, approved in Dec. 2020)

Program	Physics Goals	Beam Energy [GeV]	Beam Intensity [s^{-1}]	Trigger Rate [kHz]	Beam Type	Target	Earliest start time, duration	Hardware additions
muon-proton elastic scattering	Precision proton-radius measurement	100	$4 \cdot 10^6$	100	$\mu^\pm$	high-pressure H2	2022 1 year	active TPC, SciFi trigger, silicon veto,
Hard exclusive reactions	GPD E	160	$2 \cdot 10^7$	10	$\mu^\pm$	$NH_3^\uparrow$	2022 2 years	recoil silicon, modified polarised target magnet
Input for Dark Matter Search	$\overline{p}$ production cross section	20-280	$5 \cdot 10^5$	25	p	LH2, LHe	2022 1 month	liquid helium target
$\overline{p}$-induced spectroscopy	Heavy quark exotics	12, 20	$5 \cdot 10^7$	25	$\overline{p}$	LH2	2022 2 years	target spectrometer: tracking, calorimetry
Drell-Yan	Pion PDFs	190	$7 \cdot 10^7$	25	$\pi^\pm$	C/W	2022 1-2 years	
Drell-Yan (RF)	Kaon PDFs & Nucleon TMDs	~100	10^8	25-50	$K^\pm, \overline{p}$	$NH_3^\uparrow$, C/W	2026 2-3 years	"active absorber", vertex detector
Primakoff (RF)	Kaon polarisa-bility & pion life time	~100	$5 \cdot 10^6$	> 10	K^-	Ni	non-exclusive 2026 1 year	
Prompt Photons (RF)	Meson gluon PDFs	$\geq$ 100	$5 \cdot 10^6$	10-100	$K^\pm$ $\pi^\pm$	LH2, Ni	non-exclusive 2026 1-2 years	hodoscope
K-induced Spectroscopy (RF)	High-precision strange-meson spectrum	50-100	$5 \cdot 10^6$	25	K^-	LH2	2026 1 year	recoil TOF, forward PID
Vector mesons (RF)	Spin Density Matrix Elements	50-100	$5 \cdot 10^6$	10-100	$K^\pm, \pi^\pm$	from H to Pb	2026 1 year	

Table 2: Requirements for future programmes at the M2 beam line after 2021. Muon beams are in blue, conventional hadron beams in green, and RF-separated hadron beams in red.

PHASE-1

Conventional hadron and muon beams

2022 ➔ 2027

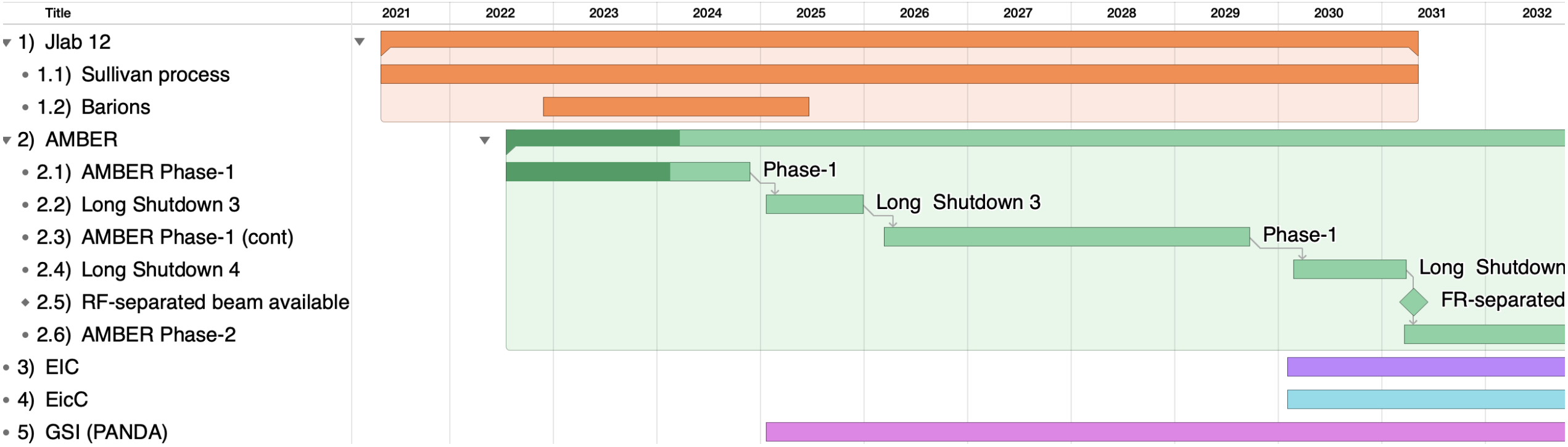
PHASE-2

Conventional and RF-separated Hadron/Hadron and muon beam

2029 and beyond

AMBER – Phase - 1
Running plan

We will start AMBER Phase-1 program with proton radius measurement, then antimatter production cross-section and Drell-Yan:
PRM: 2022-2023
AMP: 2023-2024
Drell-Yan: starting 2024



EHM through experimental studies