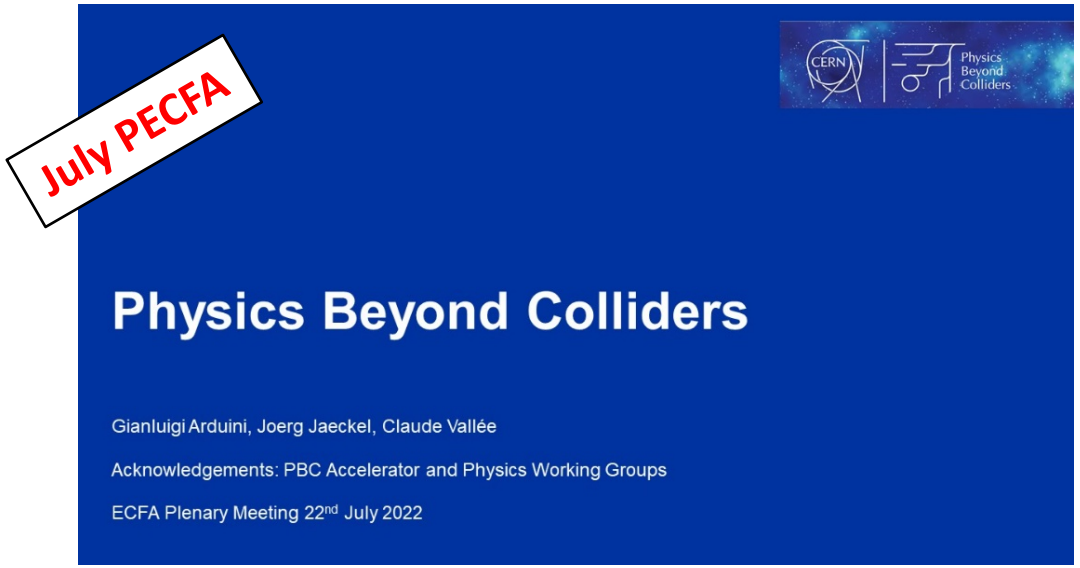
Plenary ECFA open meeting, CERN, November 18th 2022

SHORT UPDATE ON PHYSICS BEYOND COLLIDERS

C. Vallée on behalf of the PBC Coordination

Builds on the general PBC review given by G. Arduini in July PECFA meeting (link)



All details on recent progress presented at last week PBC annual workshop (indico)

Will focus here on matters of short term scrutiny:

ECN3 future, Forward Physics Facility, LHC Fixed Target, NA ions, R&D

ECN3 FUTURE: reminder

Two main configurations in competition for post-LS3 use of the unique ECN3 underground hall in North Area:

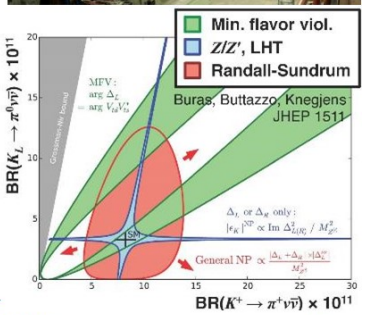
HIKE & SHADOWS vs SHiP

North Area High Intensity Beams HIKE

ULTRA-RARE K DECAYS $K \to \pi\nu\nu$ (BR~10^{-10})

HIKE (High Intensity Kaon Experiment):

- 1st phase: expansion of the NA62 K^+ programme at higher proton intensity with upgraded detector
- 2nd phase: K^0_L programme with significant modification of beamline and detector
- 1.2×10^{19} P.o.T./year required (6-fold increase)
- Programme complemented by the search for visible decays of Feebly-Interacting Particles (FIP) in Beam Dump mode on-axis (10^{18} P.o.T. to be collected during Run 3 with NA62)
- Expression of Interest (EoI) in preparation for SPSC



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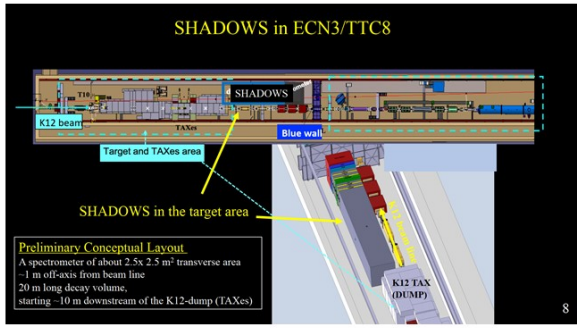
North Area High Intensity Beams SHADOWS

SHADOWS (Search for Hidden And Dark Objects With the SPS):

- Search for FIP visible decays in Beam Dump (BD) mode off-axis.
- Running in parallel to HIKE when operated in BD mode would increase acceptance at high mass
- Compact detector, standard spectrometer employing existing technologies
- Key challenge: background (reduced by operating off-axis)
- 1.2×10^{19} P.o.T./year required over 4 years



North Area High Intensity Beams: SHiP

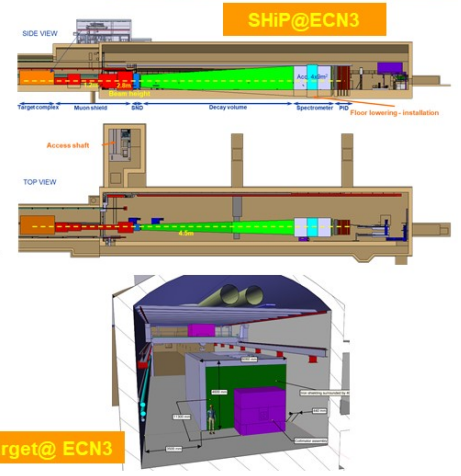
ECN3 most promising alternative location and less expensive:

- Existing extraction and primary transfer
- Surface buildings and space for services for experiment appear sufficient

Detailed analysis of background done in the 2019 CDS. Being revised for the ECN3 location

SHiP proposing a comprehensive investigation of the Hidden Sector in the O(GeV) domain

- 4×10^{19} P.o.T./year over 5 years



ECN3 FUTURE: latest news

Decision timeline agreed with Management and SPSC:

March 2023: decision for physics agnostic high-intensity facility (inclusion in next MTP):

- **Experiments LoI's successfully submitted to SPSC (CDS links to HIKE, SHADOWS, SHiP)**
- ***Critical input: accelerator document in preparation for end 2022 based on experiments requirements***

End 2023: decision for experimental programme

(assuming positive outcome of previous step)

- ***HIKE, SHADOWS and SHiP LoIs to be consolidated into proposals or with addenda:***
  - Coherent simulation tools/methods for background simulations
  - Details on detectors developments, schedules and costings
  - Updated collaboration support
- ***BSM physics reach of all projects to be compiled by FPC (FIPs) and BSM WG (Flavor) in worldwide context (incl. FPF)***
- ***Neutrino physics reach (SHADOWS/SHiP) to be addressed by QCD WG in worldwide context (incl. FPF)***

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Post-LS3 Experimental Options in ECN3

C. Ahdida, G. Arduini, K. Balazs, H. Bartosik, J. Bernhard, A. Boyarsky, J. Brod, M. Brugger, M. Calviani, A. Ceccucci, A. Crivellin, G. d'Ambrosio, B. Döbrich, M. Fraser, A. Golutvin, M. Gonzalez Alonso, E. Goudzovski, J. Jaeckel, R. Jacobsson, Y. Kadi, F. Kahlhöfer, M. Koval, G. Lanfranchi, C. Lazzeroni, K. Massri, M. Moulson, J. Osborne, M. Pospelov, Ch. Rembser, A. Rozanov, G. Ruggiero, G. Rumolo, Y. Soreq, T. Spadaro, C. Vallée (to be finalized).

Dedicated PBC note due by mid-2023

FORWARD PHYSICS FACILITY

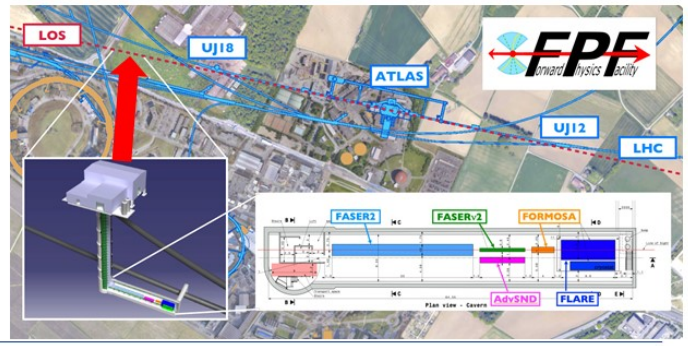
July PECFA

Long-Lived Particles @ LHC Forward Physics Facility

A new facility on LHC IP1 Line of Sight (like FASER@LHC)

Would take advantage of (so far unexploited) particles already produced in LHC collisions maximizing the physics output from the LHC (Very Weakly Interacting Particles, VHE ν physics, QCD/PDF)

Cavern hosting larger scale forward detectors in the HL-LHC era



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Recent news:

- Good progress in the conceptual design of the infrastructure and decoupling from LHC operation constraints
- Strong support from Snowmass HE group to HL-LHC auxiliary detectors
- LHCC statement in September recommending to further study the FPF in the global PBC context

Next step:

- LoI expected in 2023 with more details on detector technical aspects, physics specificity and Collaboration structure

LHC Fixed Target: reminder

Two configurations under study:

Internal gas targets @LHCb
for
Structure Functions and Spin physics

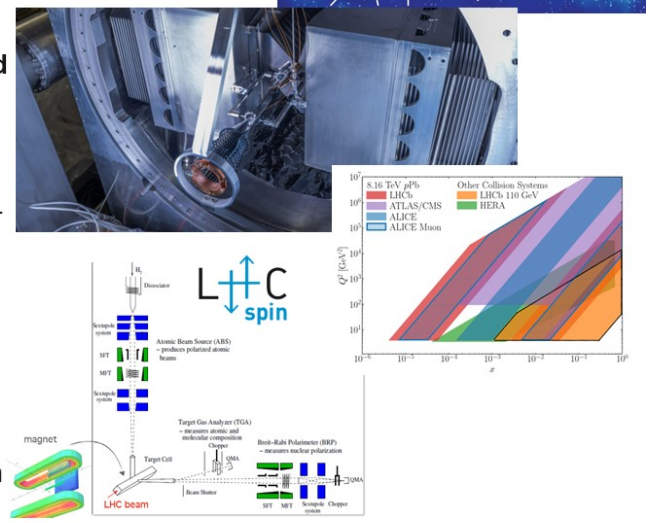
Crystal extraction + wire target @ALICE
and
double-crystal set-ups
for short-lived baryons MDM/EDM

LHC Fixed Target Gas targets

Gas storage cell (SMOG2) recently installed in front of the LHCb VELO ➔ LHC as FT machine with protons and ion beams (new kinematic range)

- Being commissioned (with Ne gas)➔ O(10-100) luminosity increase w.r.t. SMOG
- Possibility to inject different type of gases (Ar, He – other like Kr, Xe, O_2, N_2, H_2, D_2 being considered but require study of the impact on vacuum system)

Future development: polarized gas jet target or polarized gas storage cell ➔ open the LHC to spin physics!



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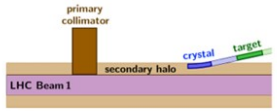
LHC Fixed target Crystals

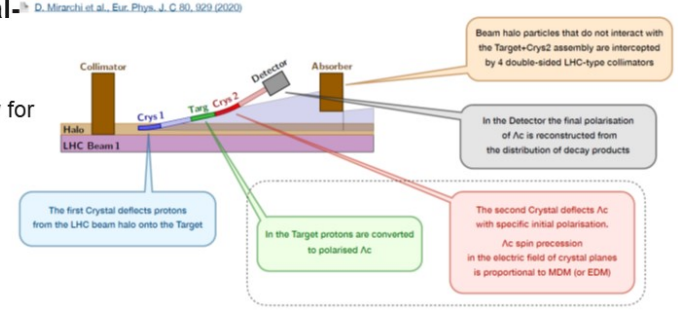
Extract the proton secondary halo by means of crystals for measurements of PDF (single crystal) or Magnetic and Electric Dipole moments of Λ_c^+ (double crystal)



A proof of principle experiment of crystal-assisted extraction of secondary halo is being designed for LHC LSS3. Aims:

- Experimental validation of channeling efficiency for long crystals @ O(TeV)
- Control/management of secondary halo
- Validate P.o.T. rate capability
- Measure background environment with a track/vertexing detector

D. Mirarchi et al., Eur. Phys. J. C 80, 929 (2020)



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LHC FIXED TARGET: latest news

Successful installation and very promising first operation of SMOG2 in LHCb

Feedback from coming year operation will be decisive
to assess the future full physics potential of gas targets at LHC

Very good progress in the design and preparation of crystal set-ups

WP definition and manpower requirements for the Proof of Principle
of a double crystal set-up at IR3 during run 3 expected in coming months

LoI for a full double crystal experiment in preparation

NA IONS

July PECFA

North Area Ions

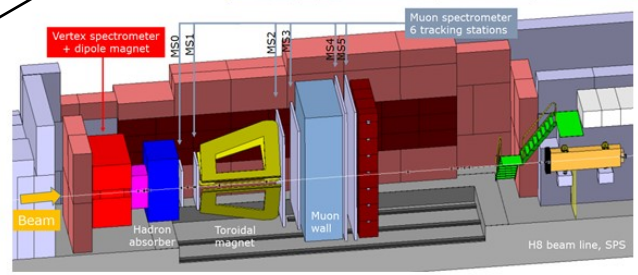
Pb Ions for NA60++ to measure the caloric curve of the QCD phase transition:

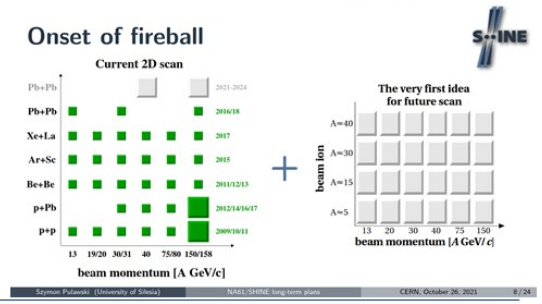
- Location found in H8 (EHN1)
- Support for integration and muon toroidal spectrometer design

NA61++ aiming to explore onset of fireball

- requires production and acceleration of lighter ions
- feasibility to be assessed.

Summary of requirements, conceptual feasibility expected performance, implications for accelerators, physics potential by mid 2023





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Ion beams requirements for the North Area Experiments post-LS3

R. Alemany Fernandez, G. Arduini, H. Bartosik, D. Boer, N. Charitonidis, M. Gazdzicki, J. Jaeckel, M. Kuich, J. Pawlowski, S. Pulawski, G. Rumolo, G. Schnell, E. Scomparin, G. Usai, C. Vallée (to be finalized)

NA60++ LoI being finalized for submission in a few weeks

NA61++ workshop on post-LS3 programme scheduled in December, post-LS3 LoI foreseen mid-2023

Accelerator working group set-up to address the implications of experiment requirements on ion sources and accelerator complex operation, also taking into account longer term LHC requirements

Dedicated PBC note in preparation for end 2023

R&D PROJECTS latest news

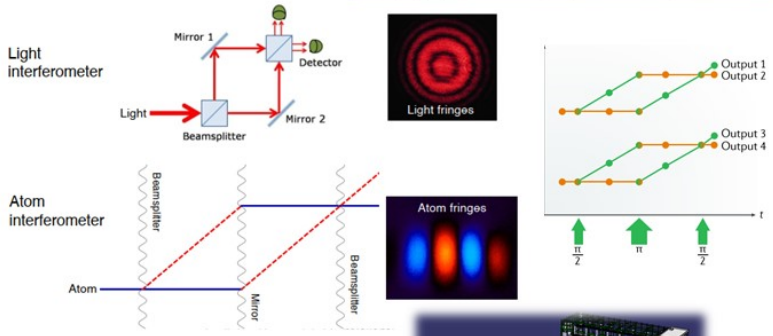
July PECFA

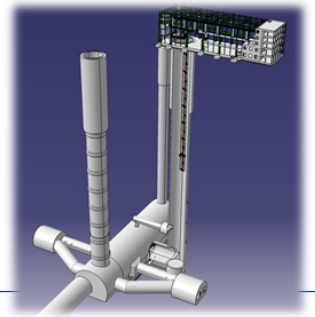
Technology/Quantum sensors

Technology know-how and experience available at CERN supporting the design of non-accelerator/accelerator experiments (one example):

AION (Atom Interferometer Observatory and Network) for mid-frequency gravitational waves and ultra-light Dark Matter detection

- Proof-of-Principle (10m) being built in UK
- Possible siting of a 100m setup in an LHC shaft (PX46) under investigation in PBC (Integration, RP & general safety, evaluation of EM interference -RF zone- and seismic noise /vibrations)





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Recent progress of VMB@CERN to converge into a SPSC proposal early 2023

AION100 technical report expected early 2023 as input to site decision

Exploration of synergies between ENUBET and NuTAG started for the design of novel ν-beams

Intense PBC WGs activity
in the coming months…

Hope for a positive impulse to significant new projects
from CERN decisions to come!