Physics Beyond Colliders annual workshop
CERN, 25-27 March 2024

The CERN PBC Study Group: short overview of past results and current focus

Gianluigi Arduini, Joerg Jaeckel, Gunar Schnell and Claude Vallée

PBC Phases 1 and 2
Phase 1 outcome
Phase 2 achievements
Current focus: this workshop

PBC Phase 1 (2016-2020)

Mandate:

"Explore the opportunities offered by the CERN accelerator complex and infrastructure to address some of today's outstanding questions in particle physics through experiments complementary to high-energy colliders and other initiatives in the world."

PBC Phase 2 (since 2020)

EPPSU recommendations → mandate enhanced with:

- *Increase synergies with cosmology, astroparticle, nuclear and atomic physics*
- *Strengthen collaboration of CERN with large National Laboratories*
- *Act as central forum of exchanges between theorists and experimentalists*

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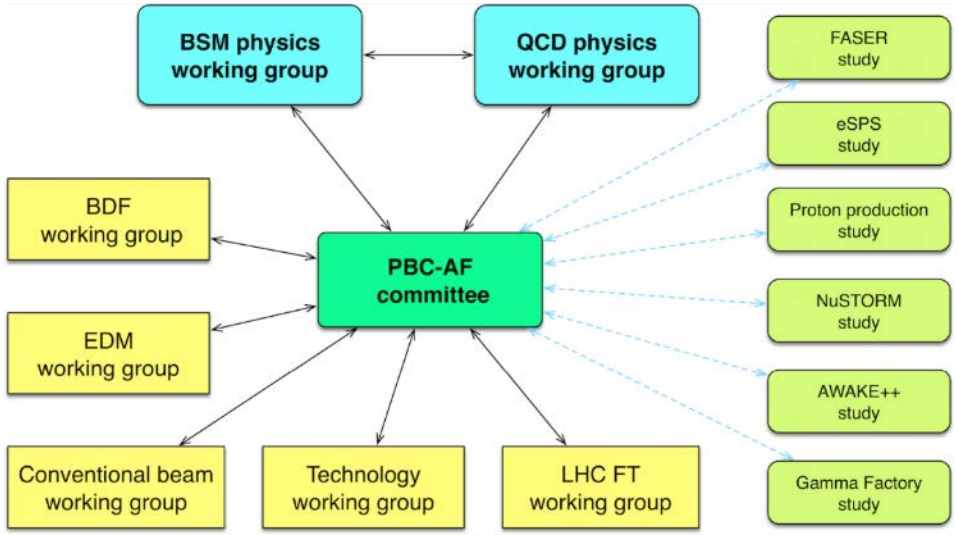

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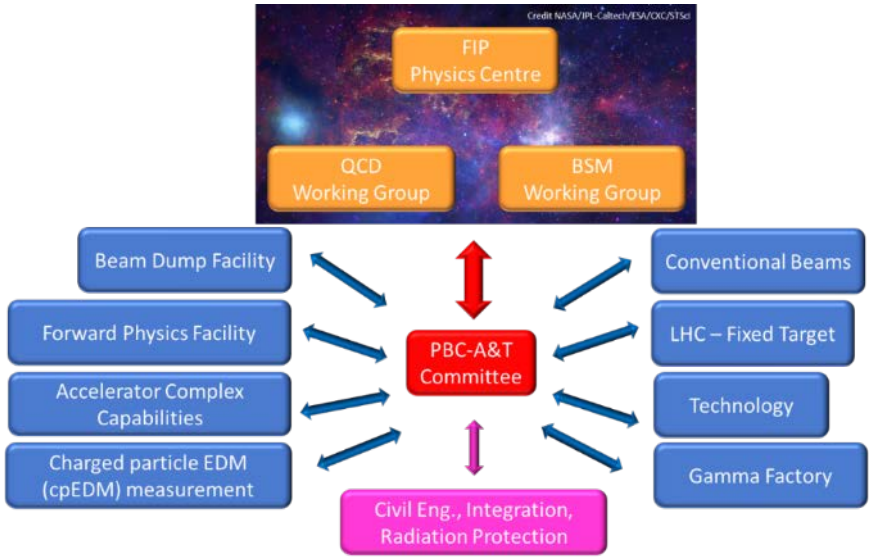

~100 core members in the Working Groups

Organisation and follow-up of activities documented on http://pbc.web.cern.ch/

PBC Phase 1 (2016-2020)

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"Explore the opportunities offered by the CERN accelerator complex and infrastructure to address some of today's outstanding questions in particle physics through experiments complementary to high-energy colliders and other initiatives in the world."

Kick-off workshop: September 2016

Annual workshop: November 2017

Annual workshop: January 2019

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Post-EPPSU relaunch workshop: March 2021

Annual workshop: November 2022

+ FIPs workshops in 2020 and 2022

This annual workshop: March 2024

PBC Phase 1 (2016-2020)

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Deliverables to EPPSU:

PBC Summary Report: arXiv:1902.00260

PBC BSM Report: arXiv:1901.09966

PBC QCD Report: arXiv:1901.04482

PBC Accelerator Reports:

http://cds.cern.ch/collection/PBC%20Reports?ln=en

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NB: evolution of projects

+ new EPPSU to come

→ now time to again update the PBC mandate ?

PBC Phase 1: CERN PROJECTS LANDSCAPE

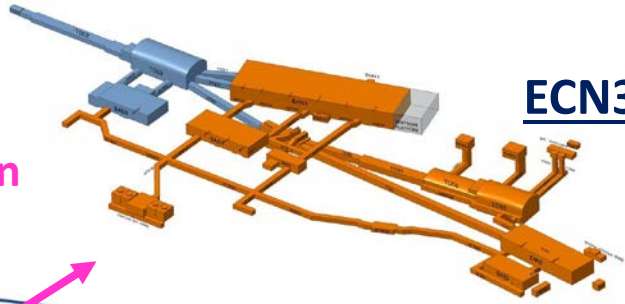
LHC-FT: SMOG2, LHCSpin, 2-Crystals

LHC-LLP:

- Forward: FASER
- Large angle: MATHUSLA, CODEXb, MilliQan

+ Gamma Factory

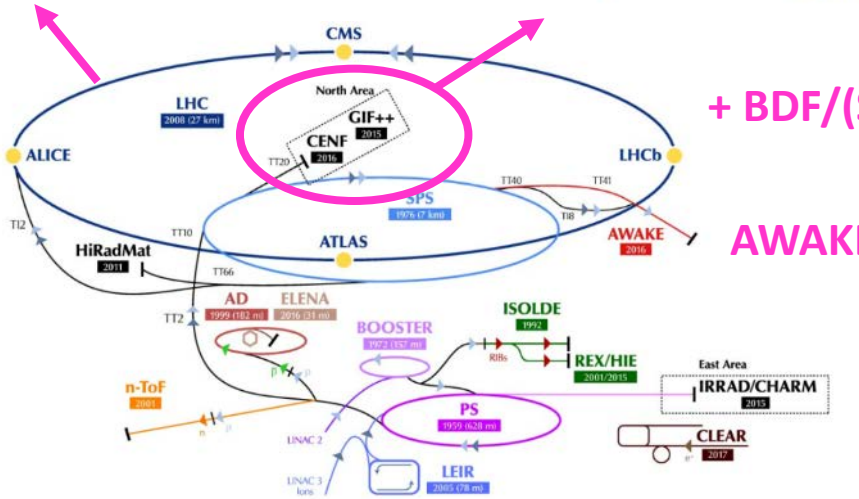
EHN1: NA61++, NA64++ (e,h)



ECN3: NA62-BD, KLEVER, NA60++, DIRAC++

EHN2: COMPASS++, NA64(μ), MUonE

+ BDF/(SHiP, TauFV)



AWAKE++

Non-accelerator:

IAXO (CAST++)
JURA (OSQAR++)
VMB@CERN
…

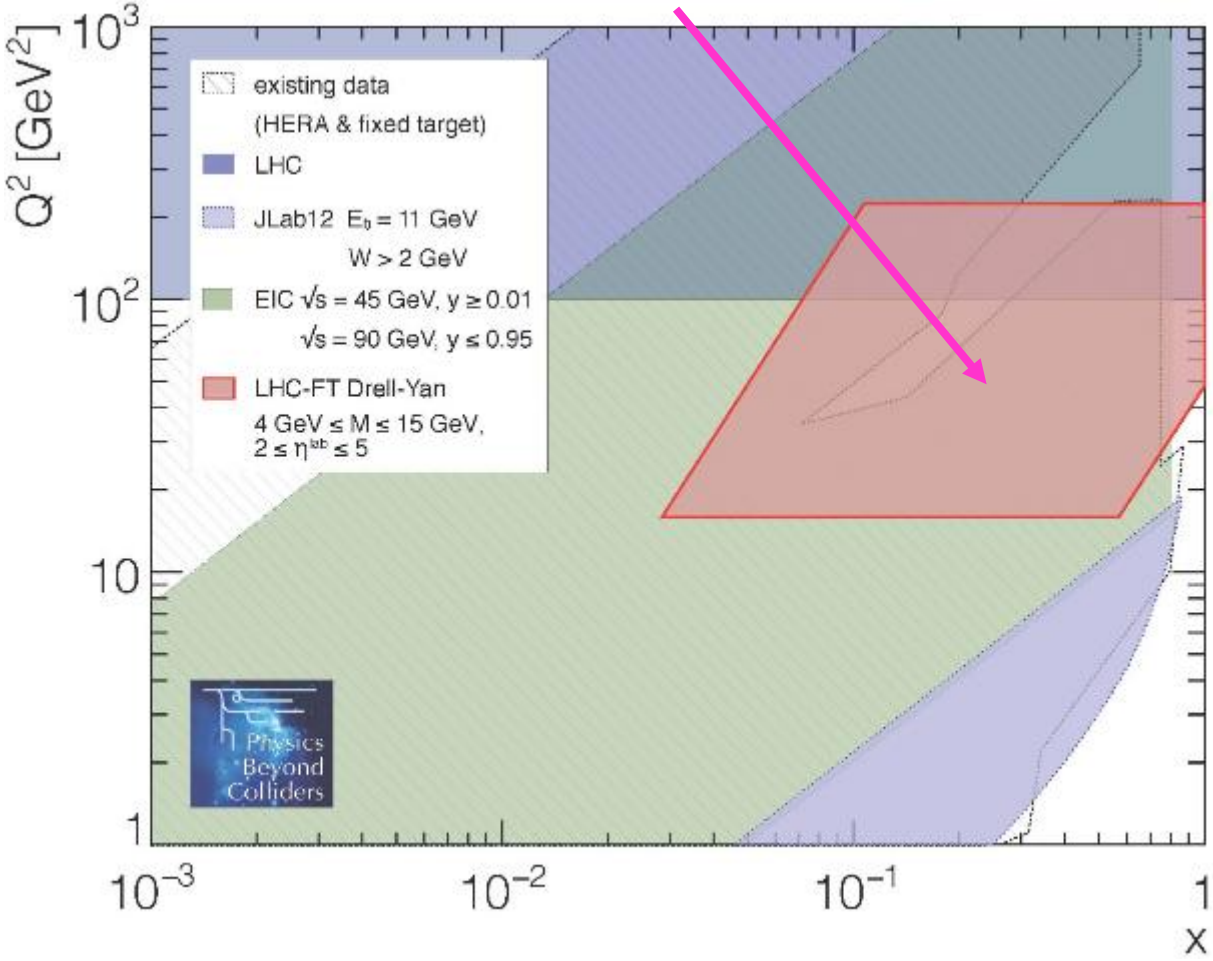
Low Energy:

Proton EDM ring
REDTOP@PS
LDMX@eSPS
nuSTORM

PBC Phase 1: global QCD landscape

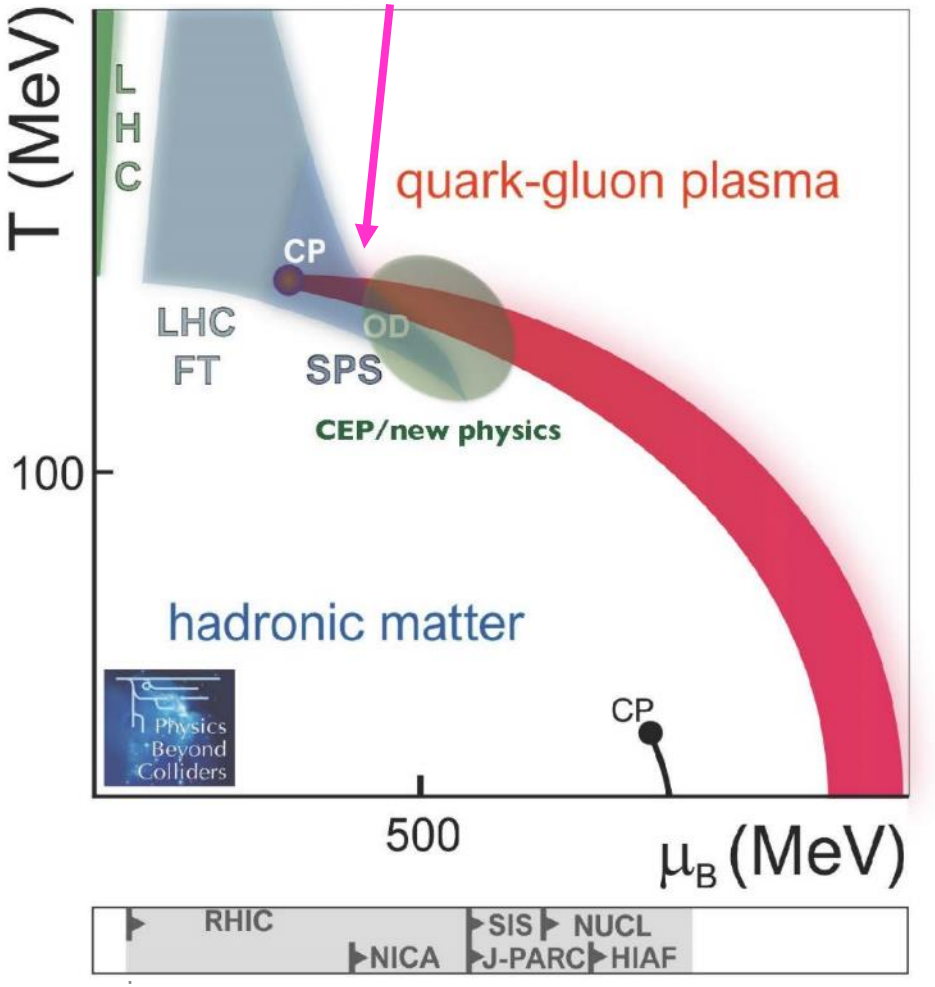
Structure Functions

Unique reach of LHC-Fixed Target with high statistics at high-x / high Q^2



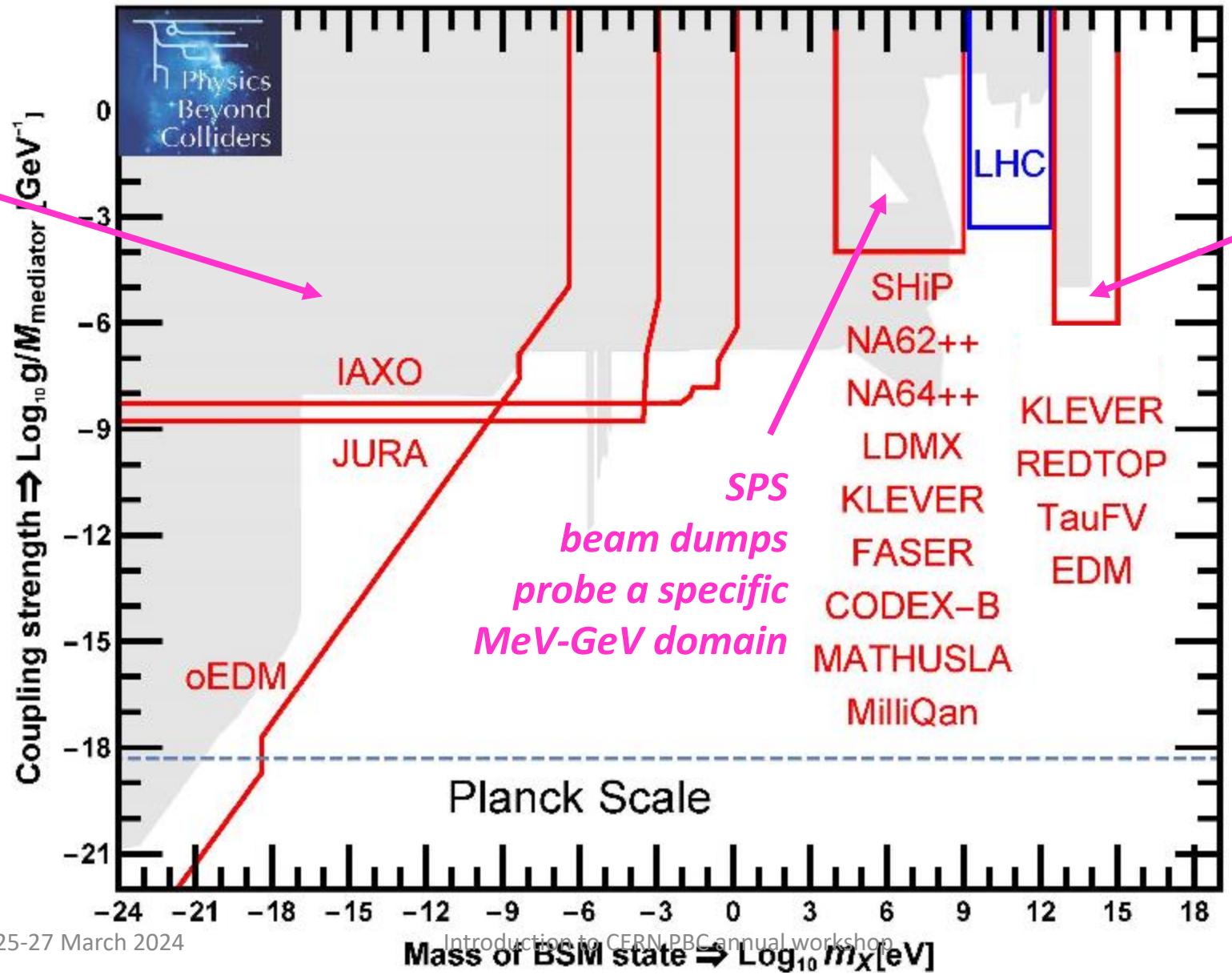
QCD Phase Transition

Unique reach of LHC-FT & SPS in transition region to high-μ_B



PBC Phase 1: global BSM landscape

EDM & non-accelerator projects cover the very low-mass domain

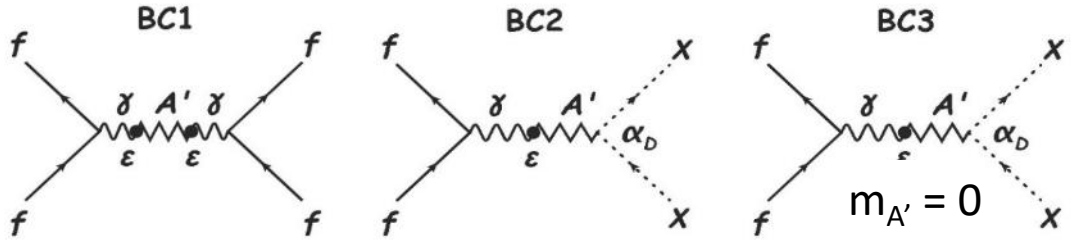


Precision & rare processes experiments extend reach of high-E colliders

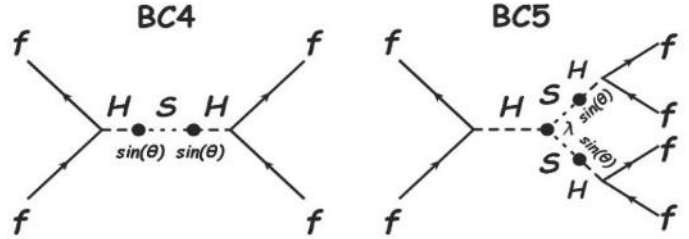
A highlight of PBC Phase 1 for EPPSU:

definition and wide acceptation of hidden sector benchmark models to compare reach of projects under same assumptions

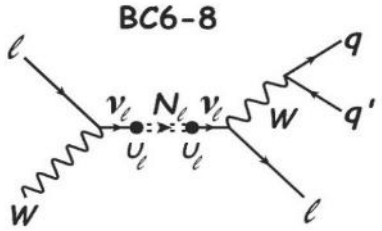
Dark Photons and Dark Matter



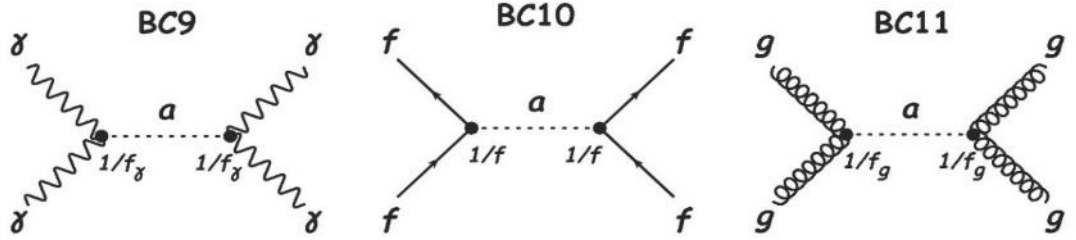
Dark Scalars



Heavy Neutral Leptons



Axion-Like Particles



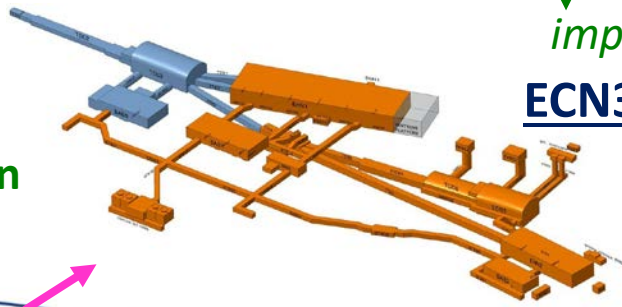
PBC Phase 1: PROJECTS FATE AFTER EPPSU

LHC-FT: **SMOG2, LHCSpin, 2-Crystals**
study cont'd

LHC-LLP:
- Forward: **FASER**
- Large angle: **MATHUSLA, CODEXb, MilliQan**

implemented
study cont'd

+ Gamma Factory
study cont'd

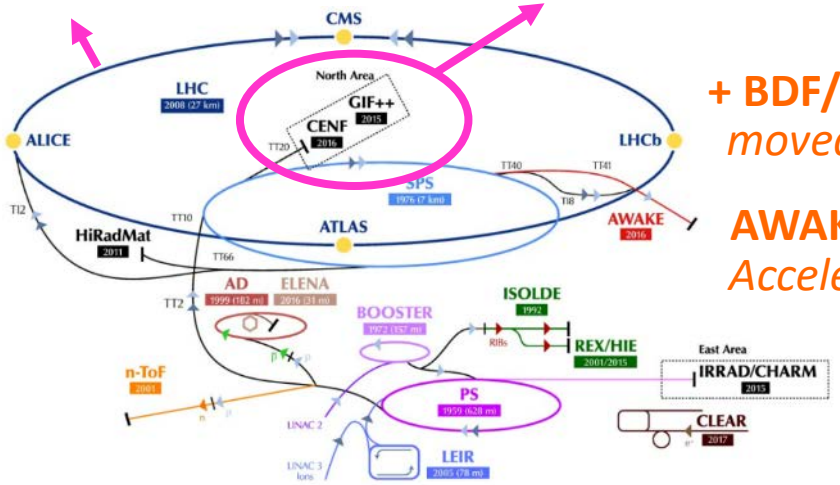


EHN1: **NA61++, NA64++(e)**
implemented

moved to EHN1

ECN3: **NA62-BD, KLEVER, NA60++, DIRAC++**
study cont'd *given up*

EHN2: **COMPASS++, NA64(μ), MUonE**
under SPSC for run 3



+ BDF/(SHiP, TauFV)
moved to ECN3, study cont'd

AWAKE++
Accelerator R&D under SPSC, experiment study on hold

Non-accelerator:

IAXO (CAST++) → *babyIAXO in preparation at DESY*
JURA (OSQAR++) → *on hold at CERN,*
a 2nd-generation project (ALPS-2) ongoing at DESY
VMB@CERN → *study cont'd*

Low Energy:

Proton EDM ring → *study cont'd under Juelich lead*
REDTOP@PS → *redirected to FNAL*
LDMX@eSPS → *on hold at CERN, LDMX ongoing at SLAC*
nuSTORM → *on hold at CERN*

PBC Phase 2: CERN PROJECTS LANDSCAPE AFTER EPPSU

LHC-FT: LHCSpin, 2-Crystals

LHC-LLP:

- Forward: Forward Physics Facility (FASER2, FASERnu, advSND, FORMOSA, FLARE)
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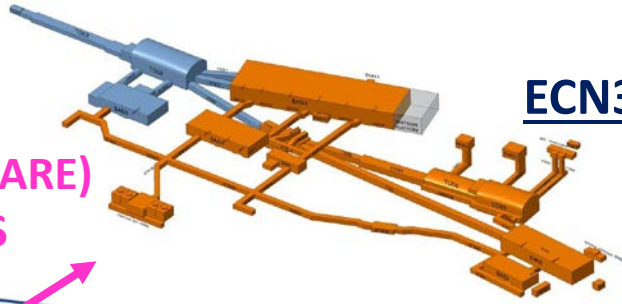
+ Gamma Factory (PoP@SPS)

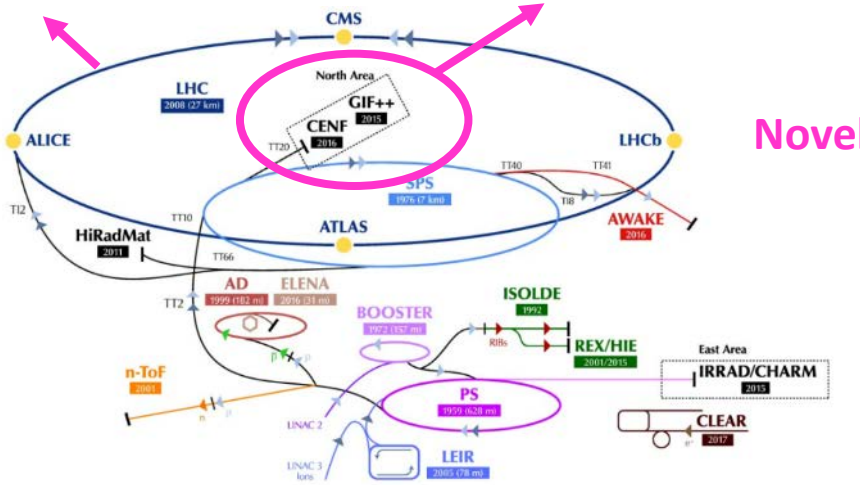
EHN1: NA61++, NA60++, NA64++ (e,h)



ECN3: HIKE/SHADOWS, BDF/SHiP

EHN2: AMBER-Phase 2, NA64++(μ)

Novel neutrino beams (ENUBET/NuTag) for SBL&LBL



Non-accelerator:

AION-100
ALPs cavities
Quantum sensors
…

Low Energy:

Proton EDM ring

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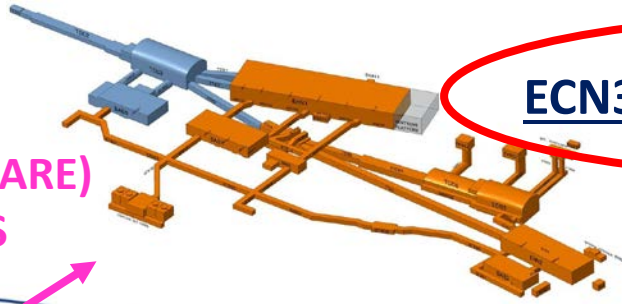

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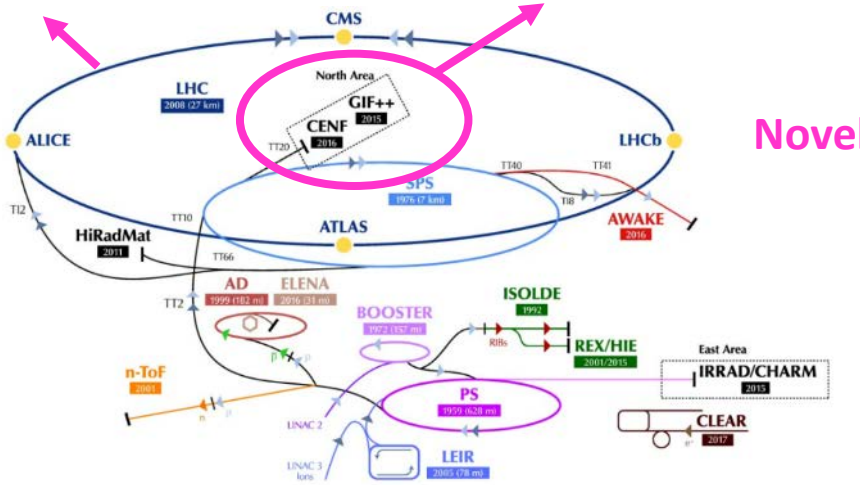

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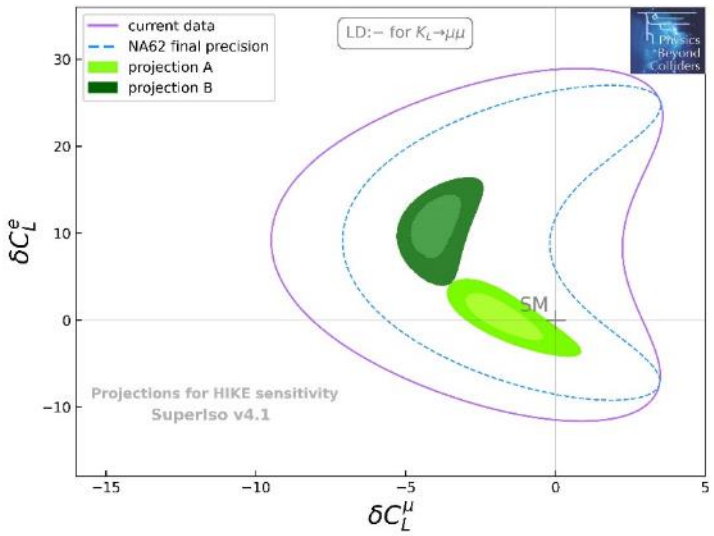
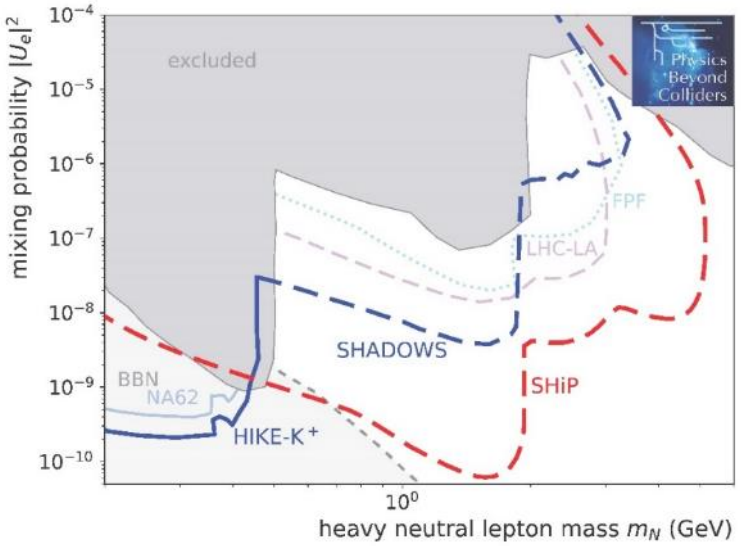
PBC Phase 2: ECN3 FUTURE

Two years of intensive PBC studies with BDF/SHiP and HIKE/SHADOWS
to prepare the proposals and inform the CERN Committees and Management decision
Comprehensive summary in PBC report: "Post-LS3 Experimental Options in ECN3" arXiv:2310.17726

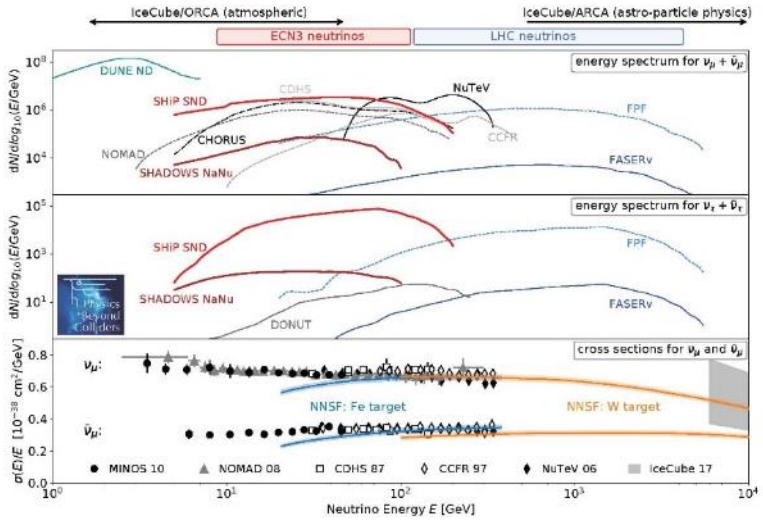
Kaon physics



FIPs (BC6 HNLs)



Neutrinos



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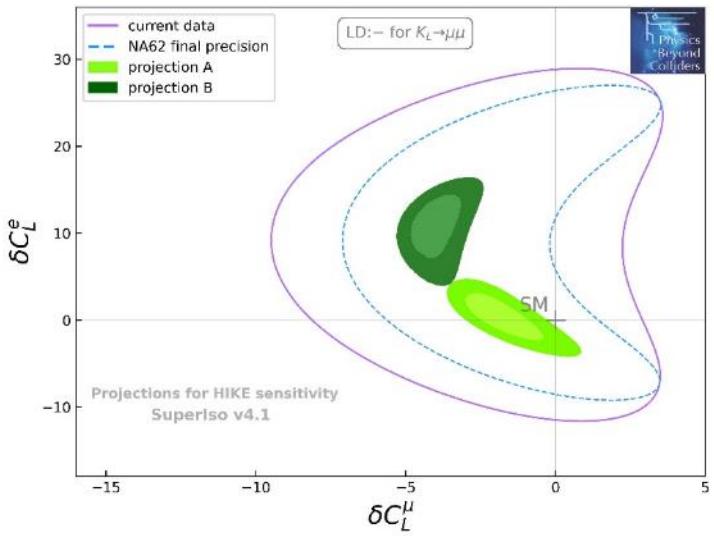

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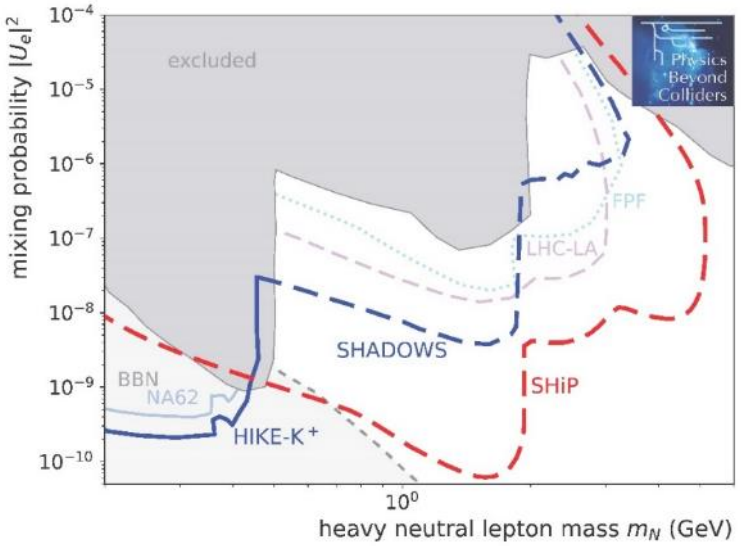

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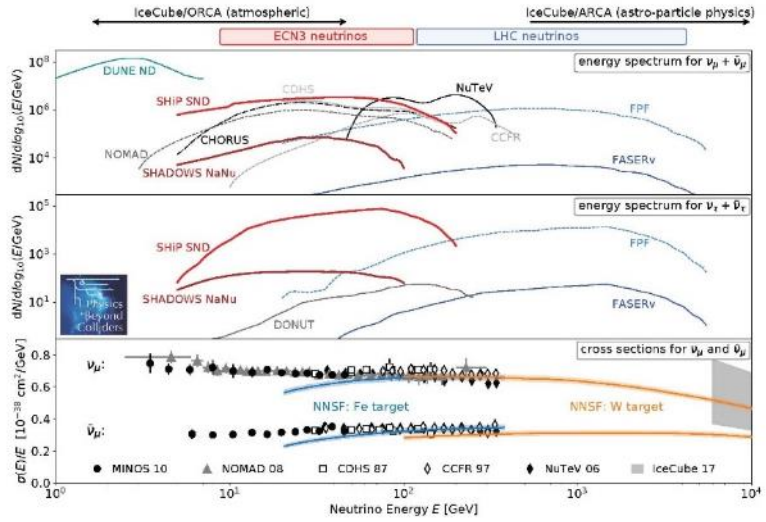

BDF/SHiP proposal endorsed by Research Board on March 6th

Discussions ongoing for inclusion in Medium-Term Plan to be approved by Council

Project now under SPSC review → no presentation at this workshop

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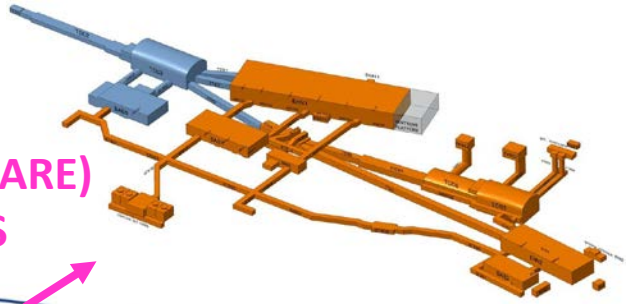
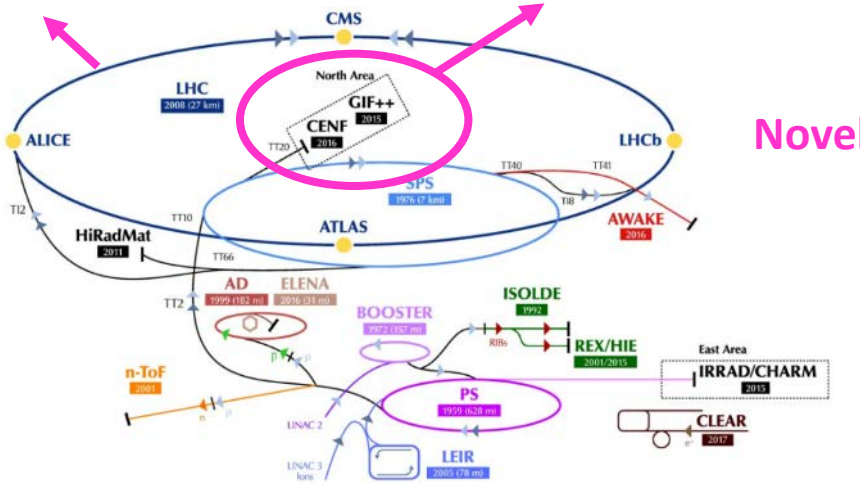


EHN2: AMBER-Phase 2, NA64++(μ)

Novel neutrino beams (ENUBET/NuTag) for SBL&LBL



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Quantum sensors
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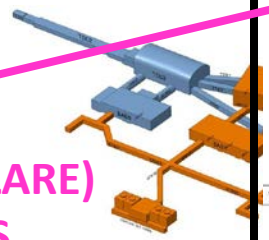

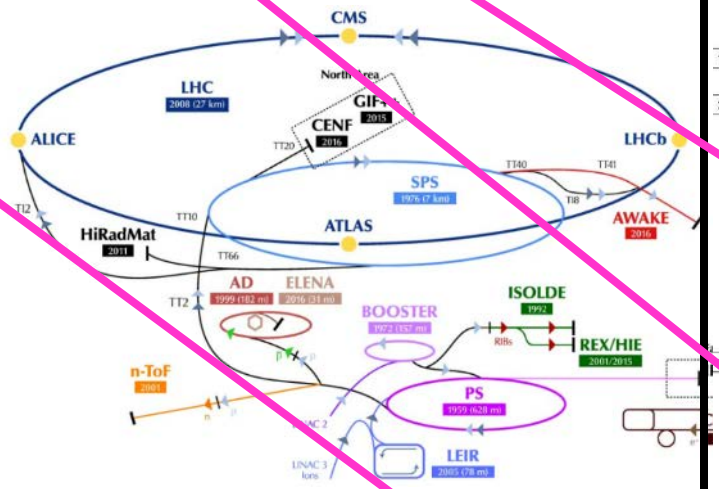

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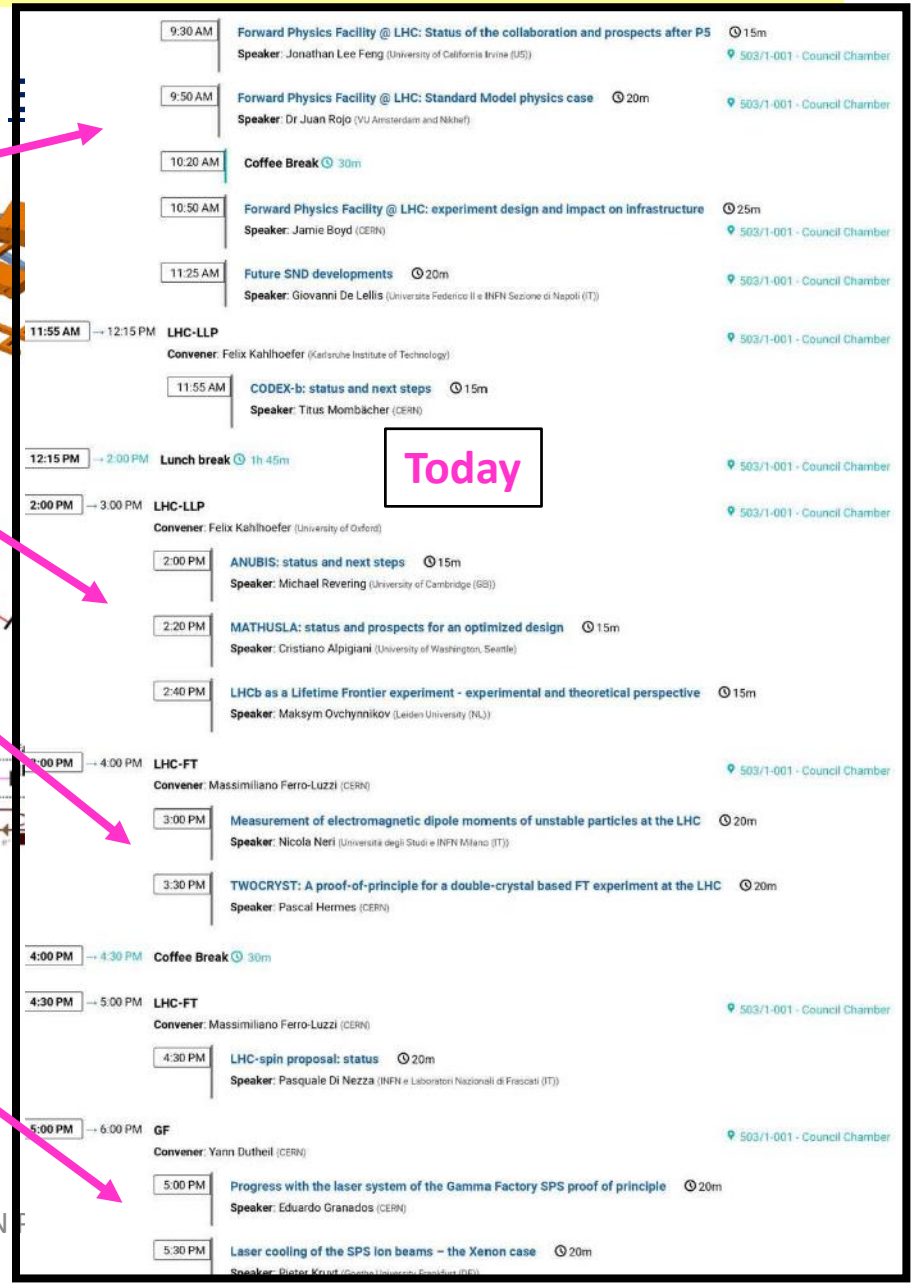


PBC Phase 2: CERN PROJECTS CURRENT LANDSCAPE

Tomorrow

8:45 AM → 12:15 PM **North Area** — 503/1-001 - Council Chamber
Convener: Gunar Schnell

- 8:45 AM — **Ion beams in the North Area: NA60++** 20m
  Speaker: Gianluca Usai (Universita e INFN, Cagliari (IT))
- 9:15 AM — **Ion beams in the North Area: NA61++** 20m
  Speaker: Maja Mackowiak-Pawlowska (Warsaw University of Technology (PL))
- 9:45 AM — **Physics potential of the NA ion programme** 20m
  Speaker: Tetyana Galatyuk
- 10:15 AM — **Coffee Break** 30m
- 10:45 AM — **Status of the feasibility studies: Pb and light ion beams in the accelerators and experimental area** 20m
  Speaker: Reyes Alemany Fernandez (CERN)
- 11:15 AM — **Monitored and tagged neutrino beam (ENUBET/NuTag)** 20m
  Speaker: Francesco Terranova (Universita & INFN, Milano-Bicocca (IT))
- 11:45 AM — **Beam line designs for ENUBET/NuTag** 20m
  Speaker: Marc Andre Jebramcik (CERN)

12:15 PM → 2:00 PM **Lunch Break** 1h 45m

2:00 PM → 3:30 PM **North Area** — 503/1-001 - Council Chamber
Convener: Johannes Bernhard (CERN)

- 2:00 PM — **NA64 programme post LS3** 20m
  Speaker: Paolo Crivelli (ETH Zurich (CH))
- 2:30 PM — **AMBER programme post LS3** 20m
  Speaker: Dr Bjorn Seitz (University of Glasgow (GB))
- 3:00 PM — **Beam options at the M2 beam line** 20m
  Speaker: Fabian Metzger (CERN, HISKP, University of Bonn (DE))

3:30 PM → 4:00 PM **Coffee Break** 30m

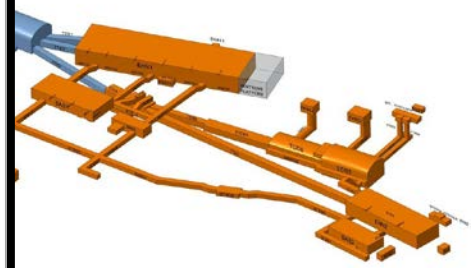
4:00 PM → 5:00 PM **AD** — 503/1-001 - Council Chamber
Convener: Gianluigi Arduini (CERN)

- 4:00 PM — **AD/ELENA facility: status and prospects** 20m
  Speaker: Davide Gamba (CERN)
- 4:30 PM — **New physics proposals at the AD** 20m
  Speaker: Prof. Stefan Ulmer (remote) (HHU Düsseldorf / RIKEN)

5:00 PM → 5:30 PM **ISOLDE** — 503/1-001 - Council Chamber
Convener: Gianluigi Arduini (CERN)

- 5:00 PM — **Beyond Standard Model Experiments at ISOLDE** 20m
  Speaker: Magdalena Kowalska (CERN)

EHN1: NA61++, NA60++, NA64++ (e,h)



EHN2: AMBER-Phase 2, NA64++(μ)

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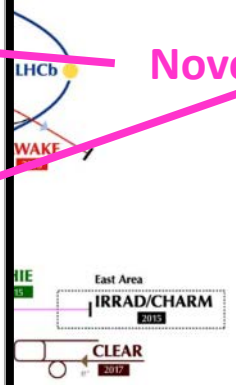

Low Energy:
Proton EDM ring

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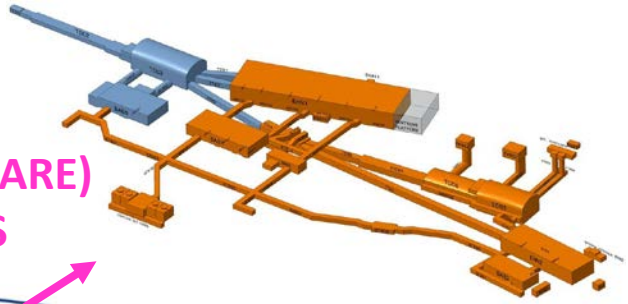

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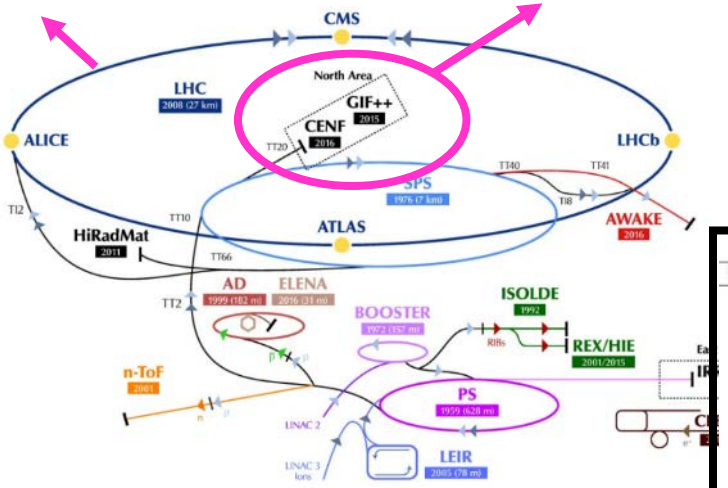

Non-accelerator:

AION-100
ALPs cavities
Quantum sensors
…

Wednesday

10:30 AM → 12:30 PM **TECH** — 503/1-001 - Council Chamber
Convener: Sergio Calatroni (CERN)

- 10:30 AM — Technology WG activities: status and plans — 20m — Speaker: Sergio Calatroni (CERN)
- 11:00 AM — Status of AION-10 and future prospects — 20m — Speaker: Oliver Buchmuller (Imperial College (GB))
- 11:30 AM — Axion searches: RADES — 20m — Speaker: Babette Dobrich (Max Planck Society (DE))
- 12:00 PM — Axion searches: FLASH — 15m — Speaker: Claudio Gatti (INFN e Laboratori Nazionali di Frascati (IT))

12:30 PM → 2:00 PM **Lunch Break** 1h 30m

2:00 PM → 2:30 PM **TECH** — 503/1-001 - Council Chamber
Convener: Sergio Calatroni (CERN)

- 2:00 PM — Axion searches: Heterodyne Detection — 20m — Speaker: Raffaele D'Agnolo (CEA IPhT Saclay)

PBC Phase 2: CERN PROJECTS CURRENT LANDSCAPE

LHC-FT: LHCSpin, 2-Cry + (e,h)

LHC-LLP:

- Forward: Forward P
  (FASER2, FASERnu, a
- Large angle: MATHU

ER-Phase 2, NA64++(μ)

+ Gamma Factory
(PoP@SPS)

ET/NuTag) for SBL&LBL

Non-accelerator:

AION-100
ALPs cavities
Quantum sensors
…

Wednesday

9:00 AM → 10:00 AM **Future prospects** — 503/1-001 - Council Chamber
Convener: Yannis Papaphilippou (CERN)

- 9:00 AM **Performance of the injectors after LIU: status and prospects** 20m
  Speaker: Tirsi Prebibaj (CERN)
- 9:30 AM **The FCC-ee injector scheme** 20m
  Speaker: Hannes Bartosik (CERN)

2:30 PM → 3:20 PM **New Ideas** — 503/1-001 - Council Chamber
Convener: Joerg Jaeckel (Institut fuer theoretische Physik, Heidelberg University)

- 2:30 PM **Measurement of the gravitational field of the LHC beam** 20m
  Speaker: Prof. Daniel Braun
- 3:00 PM **FAMU** 15m
  Speaker: Maurizio Bonesini (Universita & INFN, Milano-Bicocca (IT))

3:20 PM → 3:50 PM **Coffee Break** 30m

3:50 PM → 4:50 PM **General Overview** — 503/1-001 - Council Chamber
Convener: Joerg Jaeckel (Institut fuer theoretische Physik, Heidelberg University)

- 3:50 PM **Outcome of P5 and implications for PBC projects** 20m
  Speaker: Philip Schuster
- 4:20 PM **PBC BSM physics vision** 20m
  Speaker: Felix Kahlhoefer (Karlsruhe Institute of Technology)

4:50 PM → 5:40 PM **Closing** — 503/1-001 - Council Chamber
Conveners: Gianluigi Arduini (CERN), Joerg Jaeckel (Institut fuer theoretische Physik, Heidelberg University), Gunar Schnell, Claude Vallee (Centre de Physique des Particules de Marseille)

- 4:50 PM **Wrap-up and closing remarks** 20m
  Speakers: Claude Vallee (Centre de Physique des Particules de Marseille), Gianluigi Arduini (CERN), Gunar Schnell, Joerg Jaeckel (ITP Heidelberg)
- 5:10 PM **Discussion** 30m

… and do not forget:

We meet altogether this evening at 18:00 for a drink!

My very last slide…

…as PBC co-coordinator

A big thank to all of you
for years of exciting exchanges around so many nice projects!

Let me wish the best for the future
to Gunar, Joerg and Gianluigi, as well as to all PBC projects!

HAVE A NICE WORKSHOP!