



C. Vallée, CERN, 21 Nov. 2017

Physics Beyond Colliders Annual Workshop

CERN, November 21-22, 2017

J. Jäckel, M. Lamont and C. Vallée

## INTRODUCTION TO THE WORKSHOP: Motivation/Events/Organisation/Resources/Deliverables

PBC: a Study Group mandated by the CERN Management to prepare the next European HEP strategy update (2019-20)

Excerpt from the PBC mandate:

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

Time scale: next 2 decades

[pbc.web.cern.ch](http://pbc.web.cern.ch)

# A MATTER OF GROWING INTEREST WITHIN THE COMMUNITY

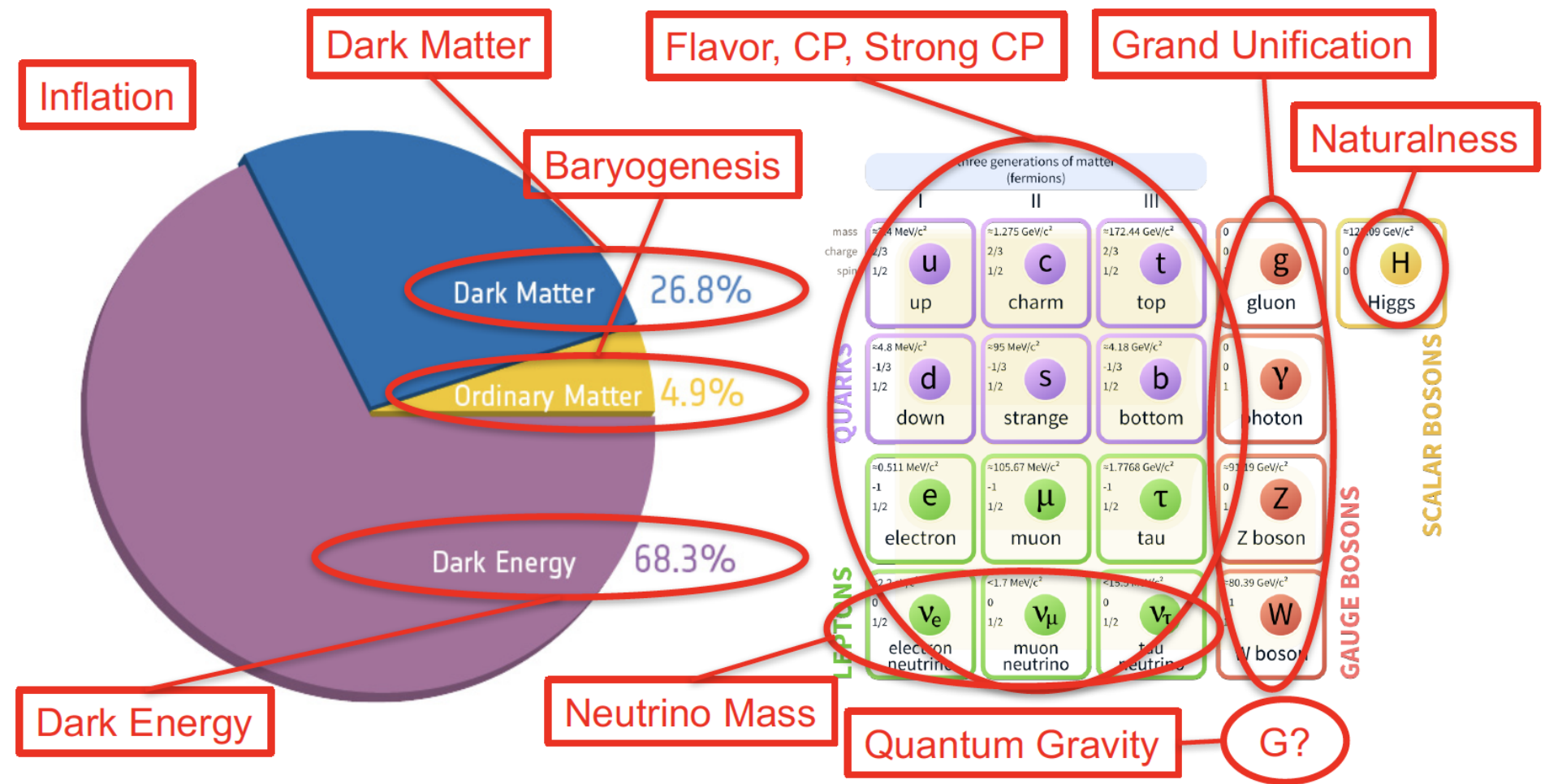
e.g. ICFA Seminar, 6-9 Nov. 2017, Ottawa

## Topics covered: large overlap with PBC study

- Neutrinos, double beta decay
- Dark matter: wimps, axions, dark photons...
- Nuclear theory, nuclear astrophysics,
- Ions, DIS, QCD
- Flavour
- Dipole moments
- Cosmology: CMB, dark energy
- Advanced accelerators, table-top experiments, quantum materials
- LHC, future colliders, technology

# OUTSTANDING PROBLEMS

- Actually, we have an embarrassment of riches: naturalness is just one of the many deep and interesting puzzles we have the privilege to think about



# STRONG ENCOURAGEMENTS TO BROADEN THE DOMAINS OF SEARCHES

ICFA SEMINAR



Timely to consider theoretical frameworks for broad classes of DM scenarios, and a search strategy that goes broad as well as deep - we do not yet know the answer!

Jonathan FENG

In particle theory, this is a time of great creativity, new ideas, and best of all, new proposals for experiments and connections to other fields (cosmology, astrophysics, nuclear physics, condensed matter, atomic physics, ...)

## PBC EVENTS

**KICK-OFF WORKSHOP, CERN, Sept. 6-7, 2016**

**> 300 registered participants, 3/4 from outside CERN**

**Call for abstracts → 33 abstracts submitted, 20 selected for presentation**

**1<sup>st</sup> GENERAL WORKING GROUP MEETING, CERN, March 1-2, 2017**

**Identification of main issues to be studied**

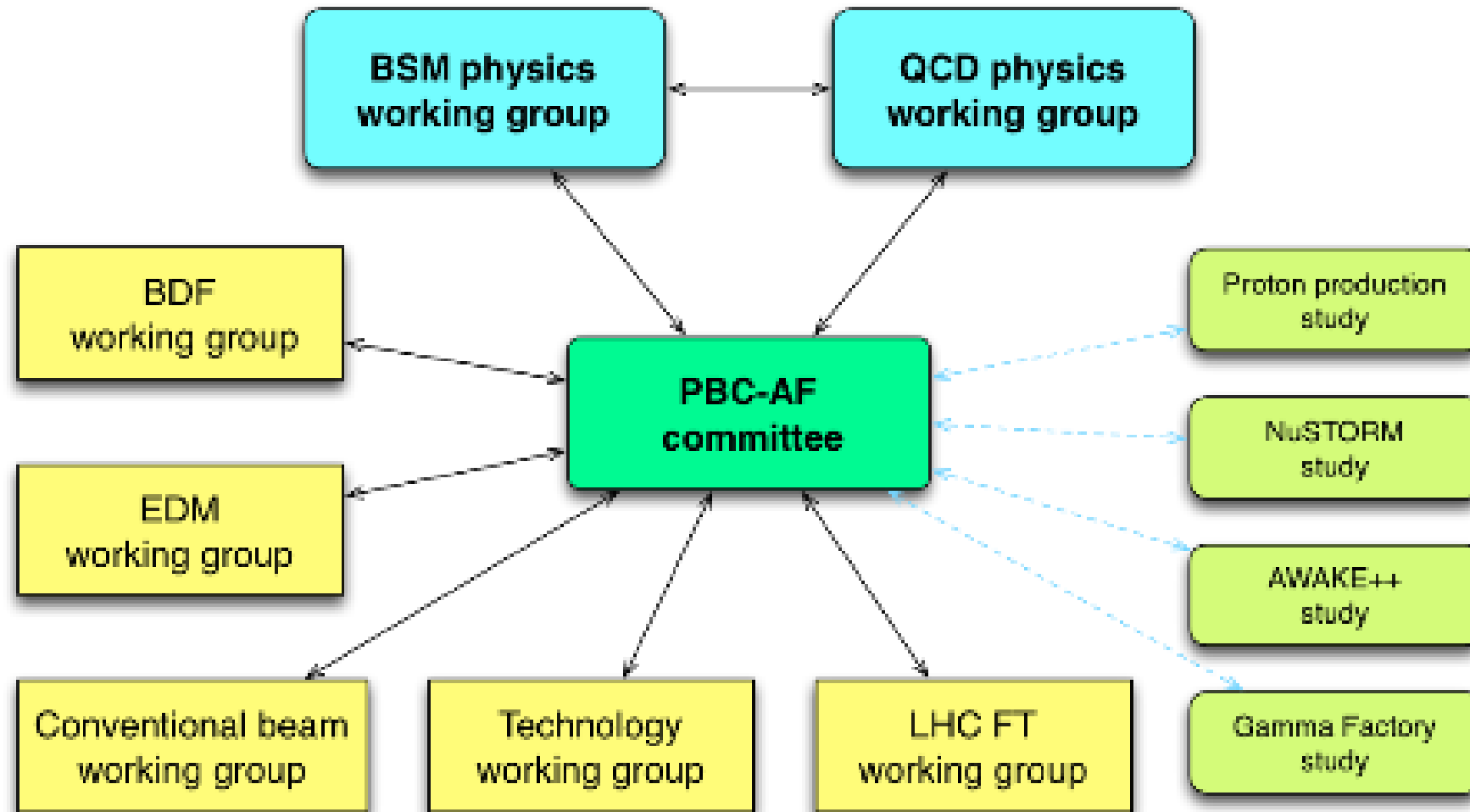
**FOLLOW-UP WORKSHOP, CERN, November 21-22, 2017**

**Agenda :**

**Working groups project reports**

**New call for abstracts → 10 abstracts submitted, 7 selected for presentation**

# PBC WORKING GROUP STRUCTURE



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

# PBC WORKING GROUP STRUCTURE

Conveners: C. Burrage, S. Rozanov, G. Ruoso

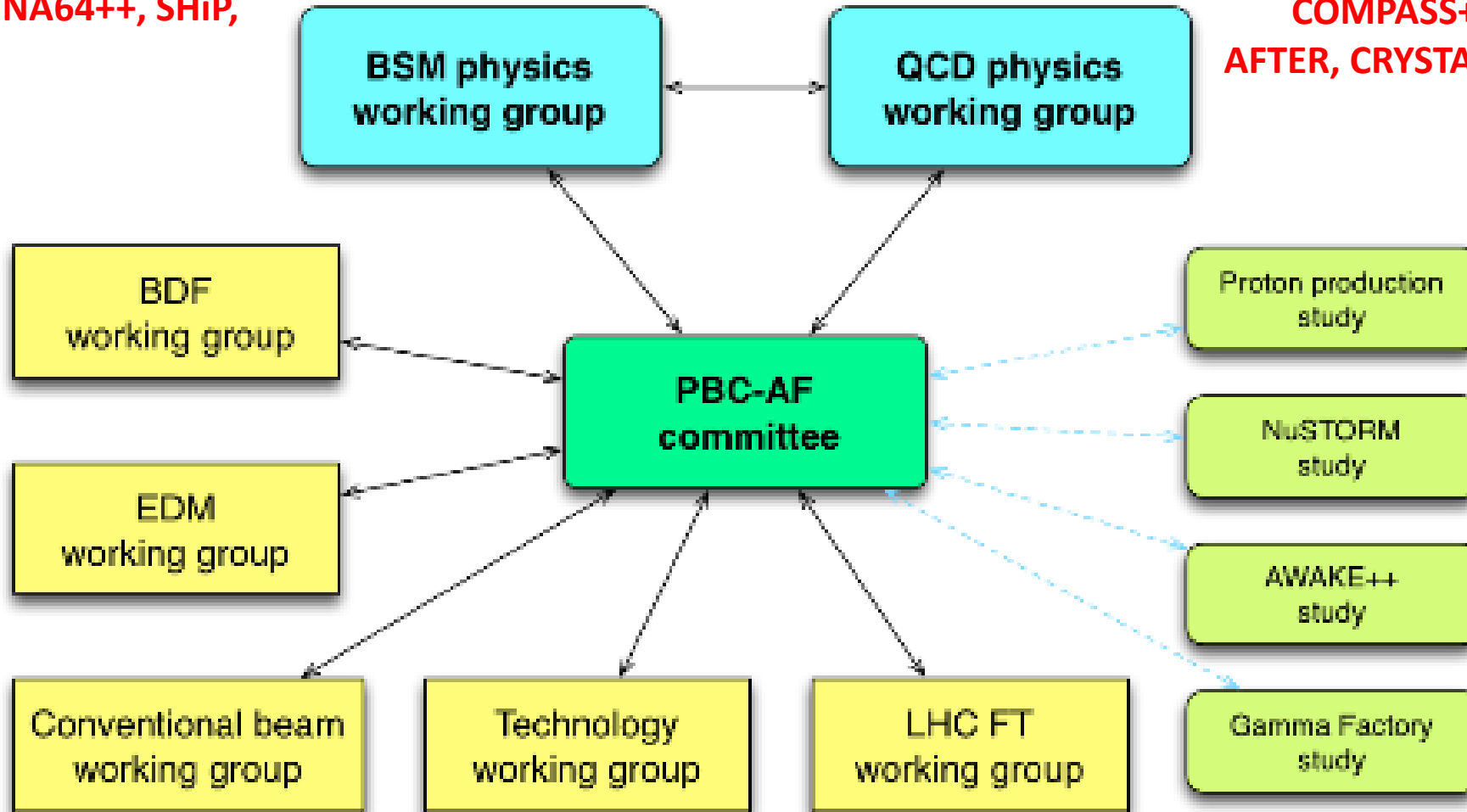
+ ext. experts + projects representatives:

NA62++, KLEVER, NA64++, SHiP,  
IAXO, LSW, EDM

Conveners: M. Diehl, J. Pawlowski, G. Schnell

+ ext. experts + projects representatives:

COMPASS++, MUonE, DIRAC++  
AFTER, CRYSTAL, LHCb-FT, ALICE-FT  
NA61++, NA60++



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# RESOURCES FOR ACCELERATOR ACTIVITIES

*PBC study now officially included in the CERN Mid Term Plan*

## 37. Physics Beyond Collider (PBC)

<b>Goals</b>	<p>Physics Beyond Colliders (PBC) is an exploratory study aimed at exploiting the full scientific potential of CERN's accelerator complex and its scientific infrastructure through projects complementary to the LHC, HL-LHC and other possible future colliders. These projects would target fundamental physics questions that are similar in spirit to those addressed by high-energy colliders, but that require different types of beams and experiments.</p> <p>A kick-off workshop was held in September 2016 identified a number of areas of interest. Following this meeting and consultation with the relevant communities, the study team has defined the structure and the main activities of the group and appointed conveners of thematic working groups. The scientific findings will be collected in a report to be delivered by the end of 2018. This document will also serve as input to the next update of the European Strategy for Particle Physics.</p> <p>Under the auspices of the PBC study are the feasibility studies for the SPS Beam Dump Facility (BDF). Resources for these studies were included in the 2016 MTP.</p>
<b>2018 targets</b>	<p>The key deliverable of the Physics Beyond Colliders study is a document summarizing the feasibility and science case of the options. This document is to be provided to the update of the European Strategy for Particle Physics, the process for which is scheduled to take place in 2019.</p>
<b>Future prospects &amp; longer term</b>	<p>The long-term vision for the exploitation of the accelerator complex is to be explored. Backed by strong physics case, initiatives pursued could provide a valuable to complement to CERN's collider program.</p>

- Resources have been assigned – our thanks to the directorate
- 12 fellows at present (9 with BDF) plus some material

***... + many contributions from external institutes associated to the projects***



# PBC DELIVERABLES

To be submitted end 2018 as input to the next European Particle Physics strategy update

## Guidelines for structure and content distributed to all participants

### STRUCTURE OF PBC DELIVERABLES

The following table describes the overall spirit, content and relationship of the documents expected at the term of the PBC study. The PBC working groups are in charge of defining the detailed structure and content of their own deliverables along these lines.

DOCUMENT	EDITORS	AUTHORS	CONTENT
<b>Main</b> (30-50 pages)	PBC coordinators	PBC WGs	Highlights of the physics case of the proposed PBC experiments at CERN, and how they can address it: <i>physics orientations in the worldwide landscape, uniqueness of CERN context, compatibility of projects, technical feasibility, timelines and financial implications.</i> The content of this document will be supported by the detailed information provided in the ancillary documents listed hereafter.
<b>BSM context</b>	BSM WG conveners	BSM WG + possible externals as appropriate	Worldwide BSM physics landscape with a focus on how the proposed PBC projects fit in term of theoretical motivation and experimental sensitivity: <i>overview of experimental physics processes (direct production modes, decay signatures, indirect searches...) reach in term of new particle types, masses and couplings; comparison and complementarity of their sensitivities via common simplified BSM models (e.g. accelerator WIMP searches vs recoil experiments via effective operator and simple mediator test models, helioscope and LSW searches vs EDM limits via axion-like particle models, p/d vs n EDM,...); indication of mass and coupling ranges favored by current observations (DM amount, experimental&amp;astrophysical hints, ...); general suggestions for possible extension of the PBC projects discovery reach.</i>
<b>QCD context</b>	QCD WG conveners	QCD WG + possible externals as appropriate	Worldwide QCD physics landscape with a focus on how the proposed PBC projects fit in term of theoretical motivation and experimental sensitivity: <i>QCD fundamental open questions and measurements of interest for other domains.</i>
<b>Experiments contributions</b>	Proponents	Proponents	Experiments contribute to the BSM and QCD context documents by providing their sensitivity curves within the commonly agreed models and assumptions for comparison with past, present and future experiments. ----- Documents are also expected from the Collaborations with a level of details matched to the maturity of their project: <i>physics motivation; expected sensitivity; detector layout; estimated timeline and cost; Collaboration structure.</i> NB: these documents stay under responsibility of the Collaborations and can be the basis for possible future consideration of the projects by the SPSC and LHCC.

<b>Complex Performance</b>	Complex study group	Complex study group	Injector complex performance after LIU: <i>proton delivery through the CERN accelerator complex in view of the potential provided by LIU; intensity limitations and possible mitigation; considerations on the optimization of the delivery rates.</i>
<b>BDF Comprehensive Design Study</b>	BDF WG	BDF WG	<b>Conceptual design of the Beam Dump Facility:</b> <i>complete technical feasibility studies, layout and performance from SPS extraction to experimental hall; siting and civil engineering; interconnection to the SHiP detector and to possible additional detectors; possible longer term use as a general high-intensity facility; construction schedule and costing.</i>
<b>EDM</b>	EDM WG	EDM Collab.	Fully developed feasibility study of the proton/deuteron EDM storage ring: <i>ring layout options; experimental aspects of the EDM measurement (e.g. systematics); initial civil engineering studies for a possible siting at CERN; timeline and cost estimate; collaboration structure.</i>
<b>Conventional Beams upgrades</b>	CB WG	CB WG	Description of the conventional beam upgrades associated to the proposed projects: <i>technical feasibility; schedule and cost; identification of potential areas of conflict between projects siting in available experimental halls.</i> Level of details to be matched to the available manpower for the studies, with a priority to implementations possible after LS2: <i>NA62++ beam dump, NA64++ and MUE muon beams, NA61++ higher intensity ion beam. Reliable estimates of the orders of magnitude of the costs of the COMPASS RF-separated beam and of the KLEVER K<sup>0</sup> beam are also needed.</i>
<b>LHC Fixed Target</b>	LHC-FT WG	LHC-FT WG	Study of the implementation of LHC internal fixed targets in the LHCb and ALICE areas: <i>technical description of the discussed options (gas targets with and without polarisation, crystals, etc...); estimation of the maximal luminosities achievable for each option, compatible with the experiments and LHC constraints.</i>
<b>Technology support</b>	Technology WG	Technology WG	Exploration and evaluation of possible technological contributions of CERN to non-accelerator projects possibly hosted elsewhere: <i>survey of suitable experimental initiatives and their connection to and potential benefit to and from CERN; description of identified initiatives and how their relation to the unique CERN expertise is facilitated.</i>
<b>AWAKE</b>	AWAKE study group	AWAKE study group	Exploratory study of possible applications of the AWAKE concept: <i>development of physics cases and experimental design; accelerator systems and realistic range of parameters; possible infrastructure and siting.</i>
<b>nuSTORM</b>	nuSTORM study group	nuSTORM study group	Updated broad outline of a possible nuSTORM implementation at CERN.
<b>γ Factory</b>	γ Factory study group	γ Factory study group	Exploratory study of the concept feasibility: <i>results of initial tests and extrapolated performance; elaboration on the corresponding physics reach.</i>

# PBC DELIVERABLES in short

One main overview document supplemented by :

## Accelerator documents:

Beam Dump Facility	:	Conceptual Design of the BDF
EDM ring	:	Fully developed feasibility study including preliminary costing
Conventional beams	:	Study beam upgrades for extended or new fixed target projects
LHC Fixed Target	:	Conceptual design of LHC internal crystal and gaseous targets
Technology	:	Evaluation of possible CERN contributions to non-acc. projects
Complex performance	:	Injector complex performance after LIU
AWAKE++	:	Exploratory study of possible applications of the AWAKE concept
NuSTORM	:	Updated broad outline of a possible implementation at CERN
Gamma Factory	:	Exploratory study of the concept feasibility

## BSM and QCD context documents with for each proposed project:

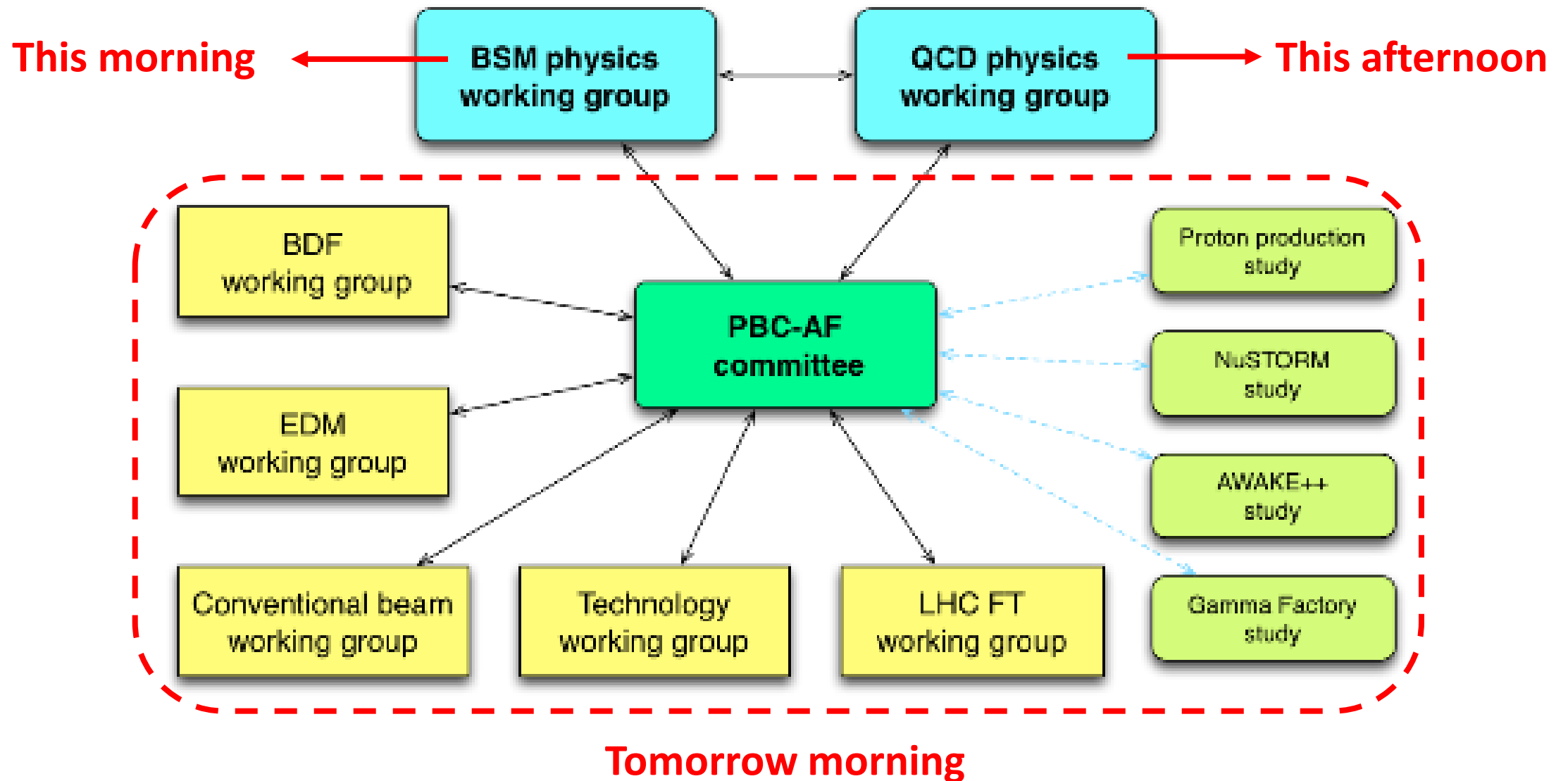
Evaluation of the physics case in the worldwide context

Possible further optimization of the detector

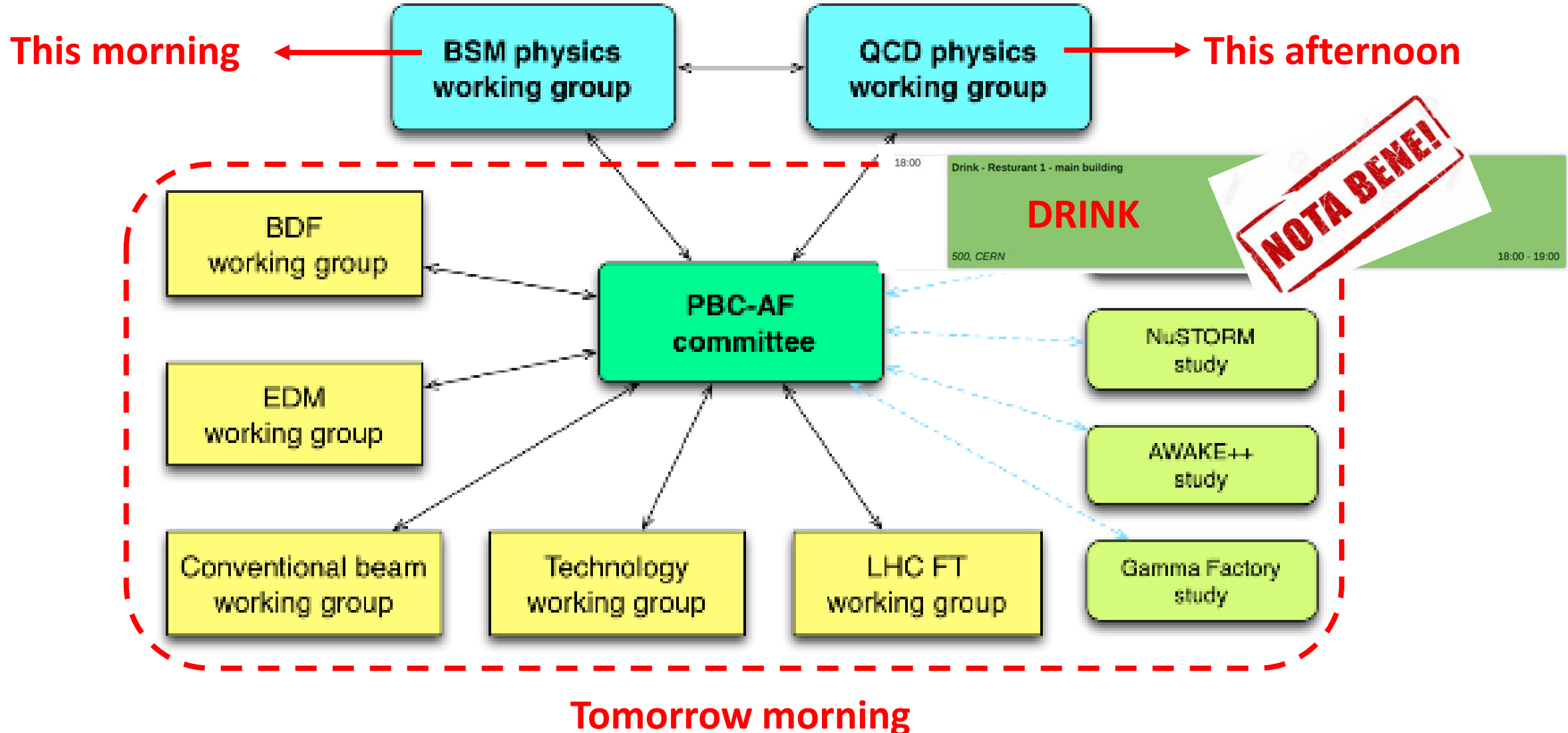
For new projects: investigation of the uniqueness of CERN siting

**NB: no arbitration between projects to be done by PBC !**

# THIS WORKSHOP: WORKING GROUP REPORTS



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# The “NEW IDEAS” SESSION TOMORROW AFTERNOON

14:00	<b>Light Dark Matter Searches with Carbon Nanotubes</b>	<i>Antonio Polosa</i>
	500-1-001 - Main Auditorium, CERN	14:00 - 14:15
	<b>A new experiment for axion-like particle search</b>	<i>Paolo Spagnolo</i>
	500-1-001 - Main Auditorium, CERN	14:15 - 14:30
	<b>Measuring vacuum magnetic birefringence with static high-field superconducting magnets</b>	<i>Guido Zavattini</i>
	500-1-001 - Main Auditorium, CERN	14:30 - 14:45
15:00	<b>Precision measurements in nuclear beta decay at ISOLDE</b>	<i>Martin Gonzalez-Alonso et al.</i>
	500-1-001 - Main Auditorium, CERN	14:45 - 15:10
	<b>Search for new physics via EDM of heavy and strange baryons at the LHC</b>	<i>Fernando Martinez Vidal</i>
	500-1-001 - Main Auditorium, CERN	15:10 - 15:30
	<b>Coffee</b>	
	500-1-001 - Main Auditorium, CERN	15:30 - 16:00
16:00	<b>Probing QED in the strong-field limit with the XFEL at DESY</b>	<i>Matthew Wing</i>
	500-1-001 - Main Auditorium, CERN	16:00 - 16:20
	<b>A possible implementation of an electron beam facility at CERN</b>	<i>Steinar Stapnes</i>
	500-1-001 - Main Auditorium, CERN	16:20 - 16:40
	<b>REDTOP: Rare Eta Decays with a TPC for Optical Photons</b>	<i>Roberto Carosi</i>
	500-1-001 - Main Auditorium, CERN	16:40 - 16:55
17:00	<b>Closeout</b>	
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**+ ahead of the BSM session:  
invited talk by P. Schuster  
on the physics potential  
of low-E e-LINACs**