

EDM – CERN PERSPECTIVE

Mike Lamont 8th March 2018

- What does CERN want/need from this process?
- Process status, schedule, deadlines, goals
- Manuscript preparation
- CERN tasks, site layout, etc.
- Outside funding initiatives (synergy grant?)

PBC mandate

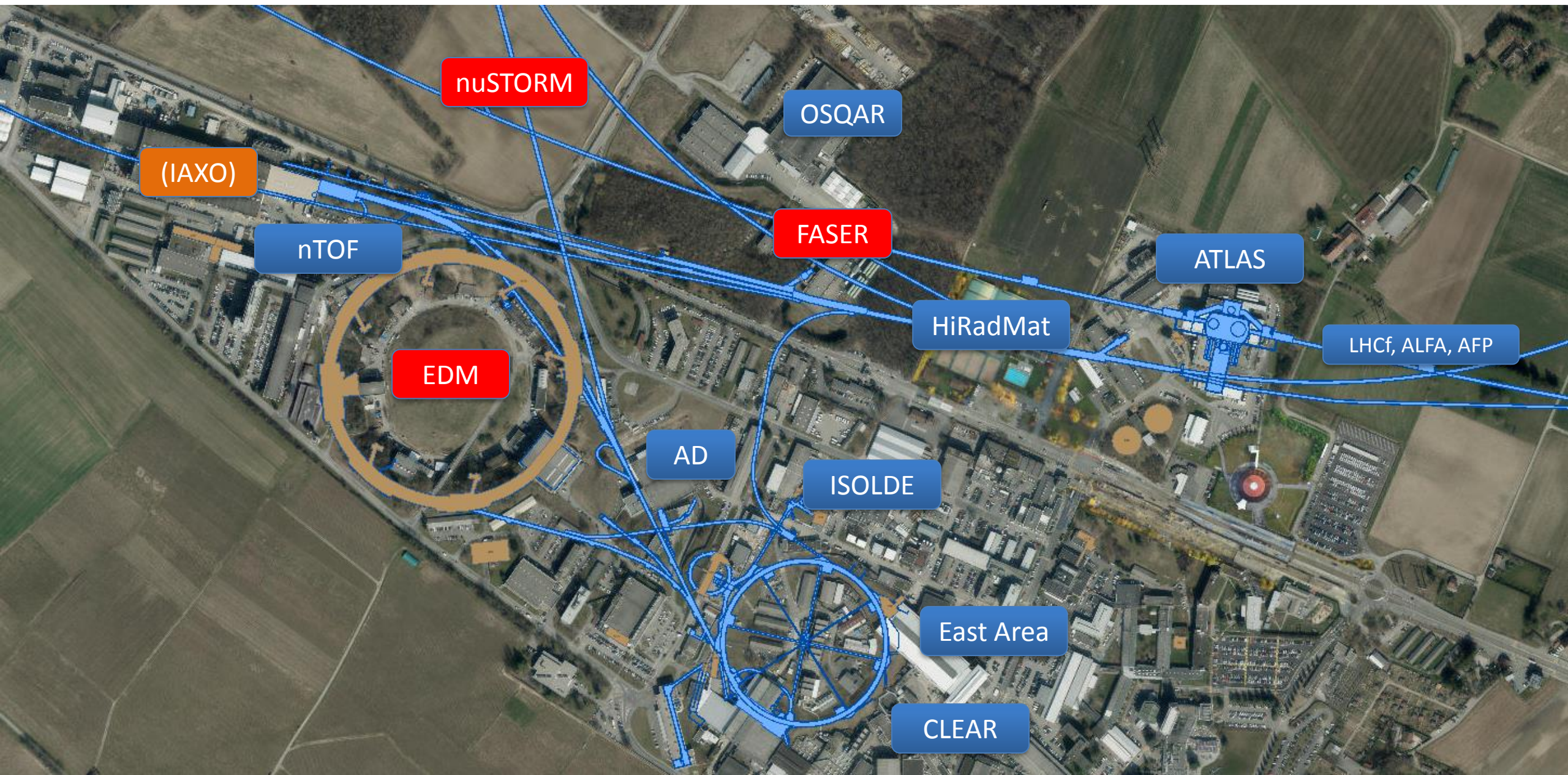
- CERN Management wishes to launch an **exploratory study** aimed at exploiting the full scientific potential of its accelerator complex and other scientific infrastructure through projects complementary to the LHC and HL-LHC and to possible future colliders (HE-LHC, CLIC, FCC).
- These projects would 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.
- This study should provide input for the future of CERN's scientific diversity programme, which today consists of several facilities and experiments at the Booster, PS and SPS, over the period until ~2040.
- Complementarity with similar initiatives elsewhere in the world should be sought, so as to optimize the resources of the discipline globally, create synergies with other laboratories and institutions, and attract the international community.

PBC - Scientific goal

- The main goal of the Study Group is to 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](#).
- These experiments would typically:
 - ...exploit the unique opportunities offered by CERN's accelerator complex and scientific infrastructure...
- Examples of physics objectives include searches for rare processes and very-weakly interacting particles, measurements of electric dipole moments, etc.

What has CERN got to offer?

- Existing accelerator complex and associated infrastructure
 - Wide range of beams, intensities, energies
- Technical expertise
 - Vacuum, magnets, power converters, RF, instrumentation, beam transfer, targets, cryogenics, accelerator physics, engineering...
- Experience
- Support
 - workshops, test facilities, engineering...
- Resources, size, and flexibility
 - Maximize performance of existing complex
 - Harness existing expertise and resources
 - New facilities exploiting existing complex
 - Novel exploitation of existing facilities



nuSTORM

OSQAR

(IAXO)

nTOF

EDM

FASER

ATLAS

LHCf, ALFA, AFP

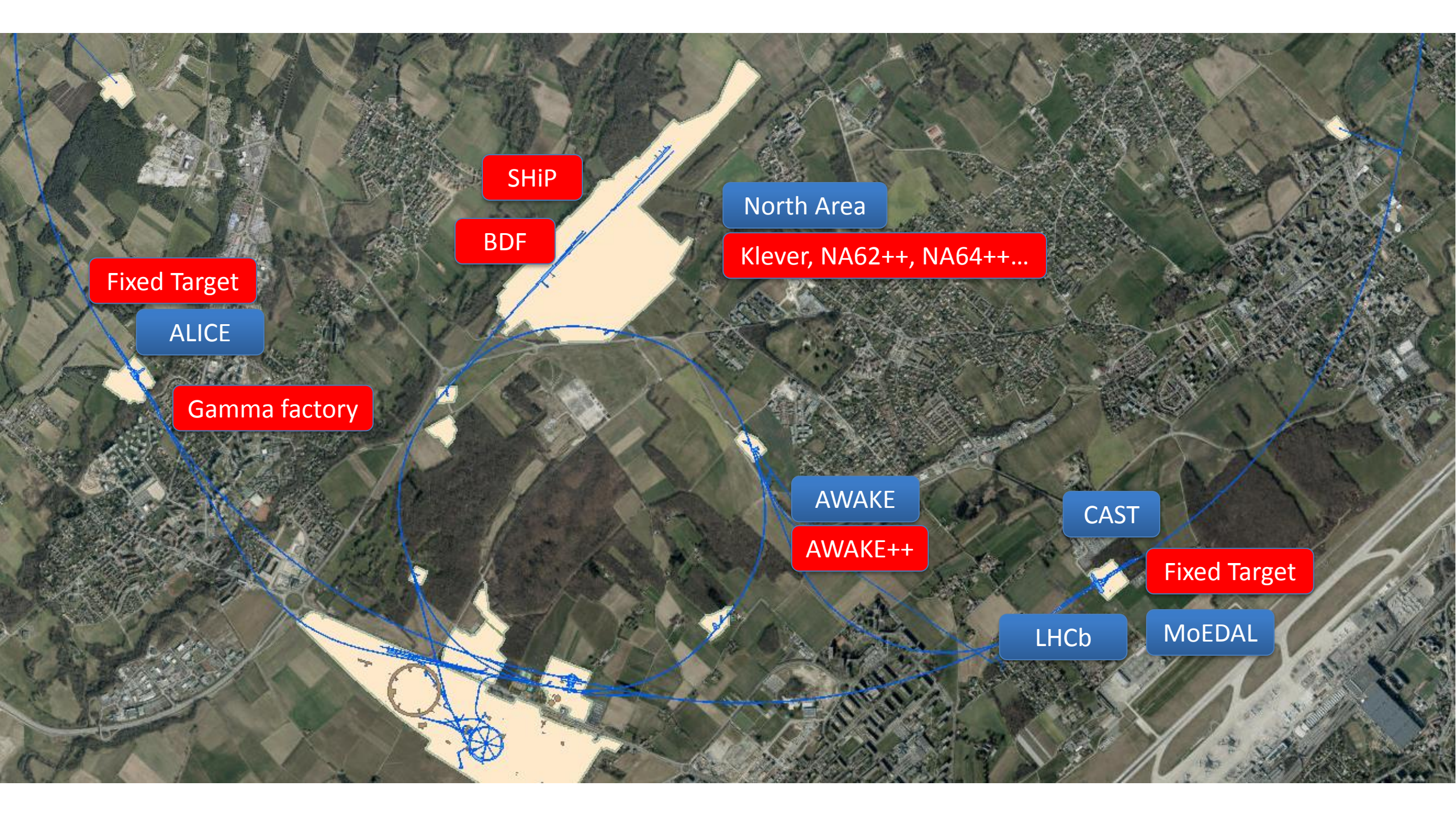
HiRadMat

AD

ISOLDE

East Area

CLEAR



SHiP

BDF

North Area

Klever, NA62++, NA64++...

Fixed Target

ALICE

Gamma factory

AWAKE

AWAKE++

CAST

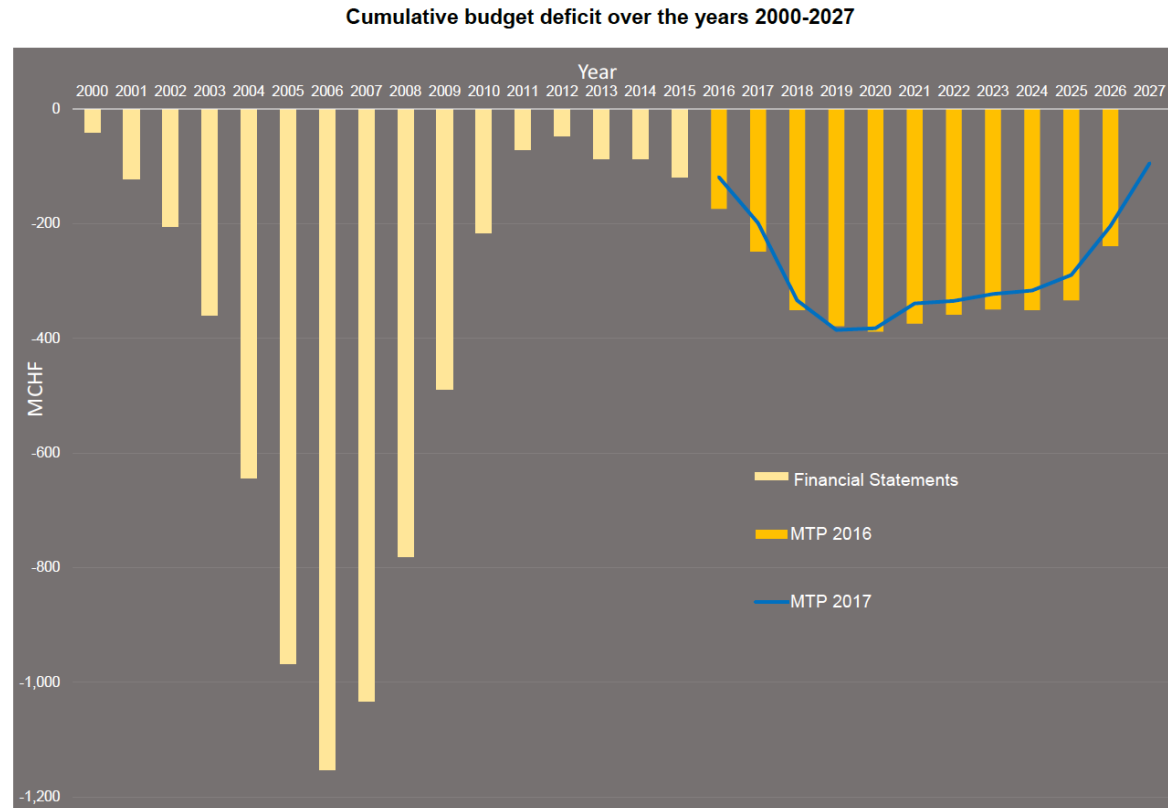
Fixed Target

MoEDAL

LHCb

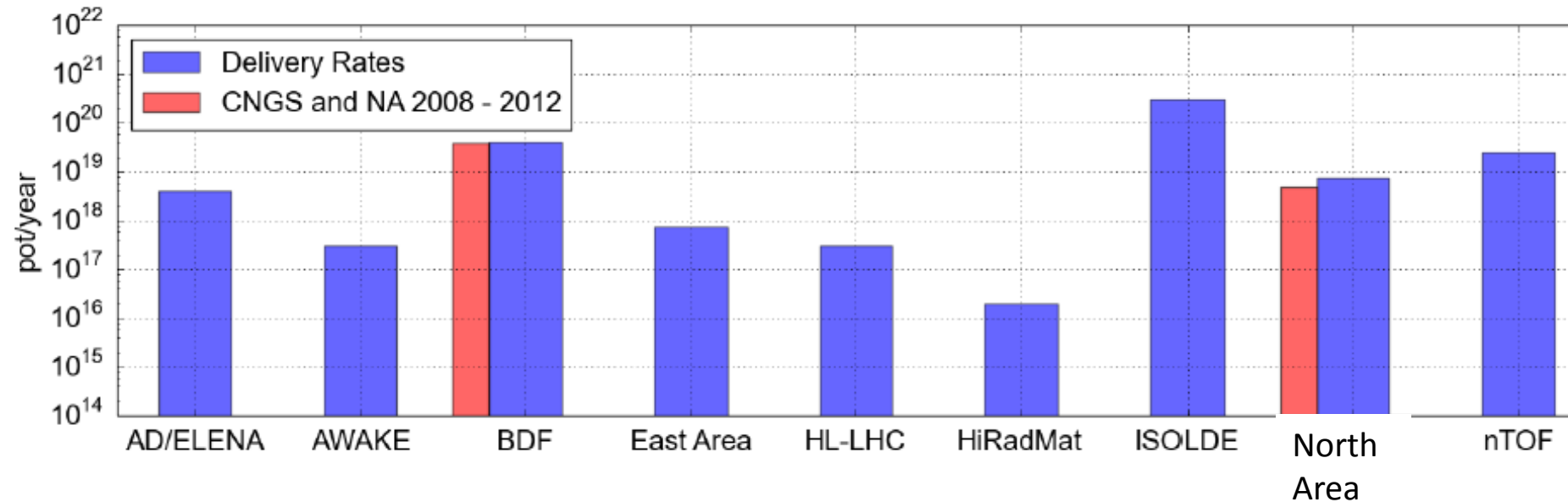
However...

- We're busy
- Not particularly acquisitive
- Little uncommitted money for the next 8 years or so



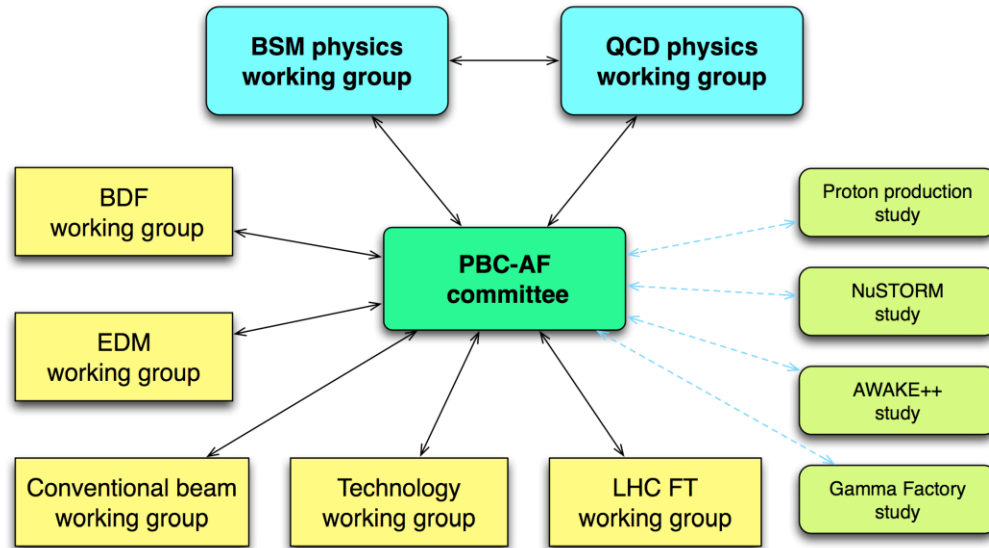
Complex already heavily solicited

- LHC will continue to dominate
- Diverse forward looking program already in place!



Nonetheless...

On the list at the moment



+ FASER, REDTOP, IAXO...

- Maximize performance of existing complex
- Harness existing expertise and resources
- New facilities exploiting existing complex
- Novel exploitation of existing facilities

- Studies clearly at different stages
- Nothing too radical - such as a new proton driver (SPL, PS2 etc.)
- Probably appropriate given the medium to long term priorities of the lab

All teams up and running

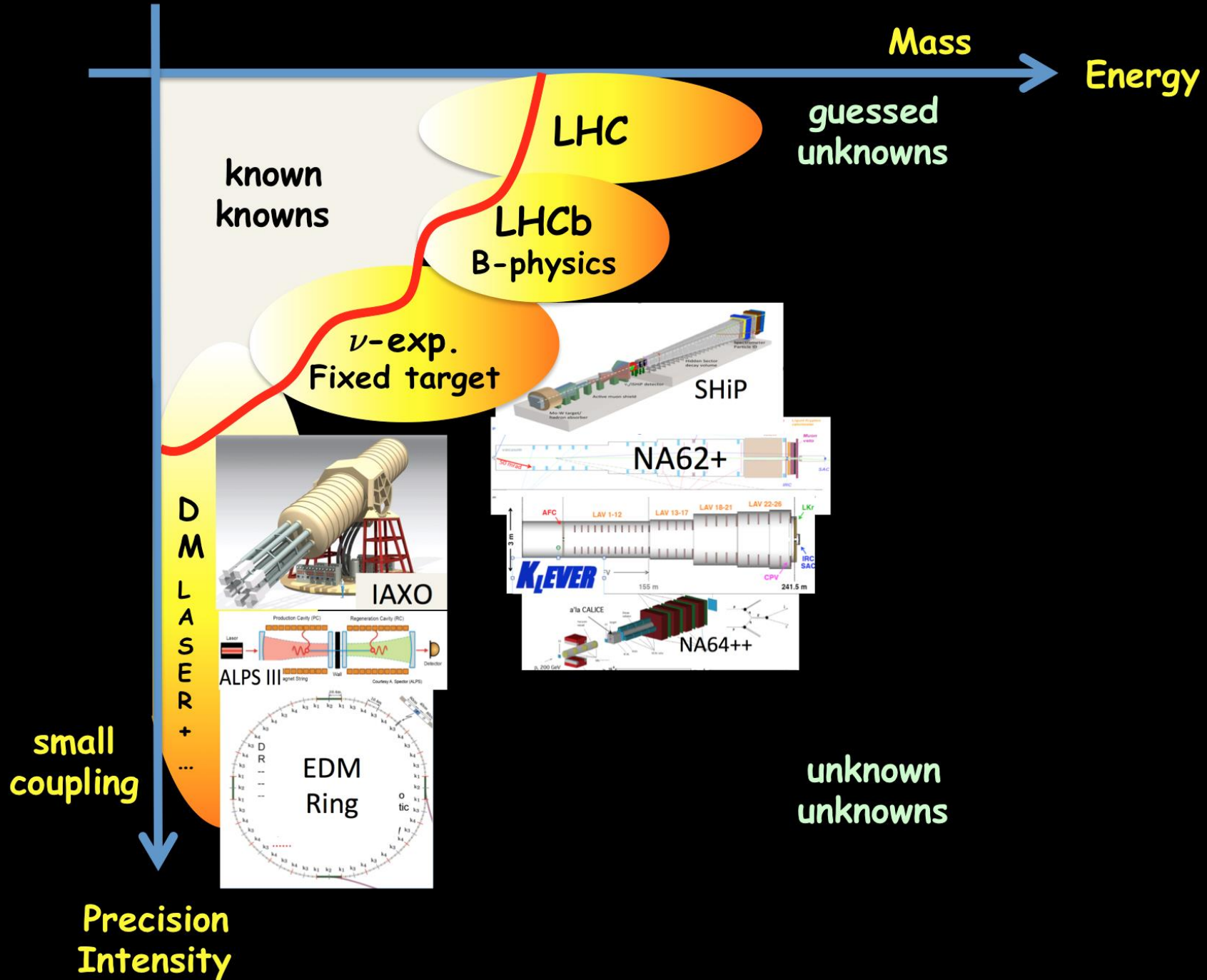
If you are prepared to accept meetings as measure of activity...

PBC-AF committee	7 events	➡
Beam Dump Facility	71 events	➡
Conventional beams	7 events	➡
EDM storage ring	11 events	➡
LHC fixed target	6 events	➡
nuSTORM	3 events	➡
Technology	5 events	➡
Physics with e-beams (AWAKE)	empty	➡
Physics with e-beams (SPS)	2 events	➡
Physics - BSM	8 events	➡
Physics - QCD	3 events	➡
FASER	1 event	➡

Input to ESPP update

Overall executive summaries plus:

Protons post LIU	Evaluation and proposals
Technology	Evaluation and proposals
BDF	Comprehensive design study
Conventional beams	Case dependent feasibility studies
LHC FT	Preliminary conceptual designs
EDM	Feasibility study
Gamma factory	Exploratory study
AWAKE++	Exploratory study
nuSTORM	Exploratory study



EDM - 2017

- 2011 BNL proposal
- Considerable effort by community as evidenced in the kickoff...
- NB Lebedev's evaluation
- CERN
 - Sketch possible implementation (beam delivery, siting etc.)
 - Components
 - Examine systematics

Working on the, perhaps naïve, assumption: it's tough but doable

Kickoff

- All-electric; E&B
- COSY - precursors
- Spin tracking, spin manipulation
- Polarized sources
- Beam control
- Deflectors
- Instrumentation – squids, BPMs
- Magnetic shielding; well defined procedures for cancellation of B-field components
- Polarimetry
- Simulations, lattice, analytic approach

Conclusion: convincing – development required but the pieces of the jigsaw are there.

Work package	Comments	Contributors	Coordination
Science case	<ul style="list-style-type: none"> • Up to date physics case for EDM • EDM landscape • Motivation for CP-EDM • Critical synthesis of storage ring systematics - can the experiment be done at the required sensitivity? 	KAIST/FZJ/CERN	Frederic Taubert (CERN) Themis Bowcock (Liverpool) In liason with Joerg Jaeckel (BSM WG lead)
Ring design	<ul style="list-style-type: none"> • All electric lattice • E/B lattice • Beam and spin dynamics • RF cavities 		Yannis Semertzidis (CAPP/IBS & KAIST)
Beam control	<ul style="list-style-type: none"> • Cooling • Feedbacks 		Joerg Pretz (FZJ)
Beam preparation	<ul style="list-style-type: none"> • Source, acceleration, injection, • Spin manipulation 	FZJ/CERN	Beam delivery: Christian Carli (CERN) Spin manipulation NN (FZJ)
Ring components (1)	<ul style="list-style-type: none"> • RF, • Vacuum... 	CERN	NN (CERN)
Ring components (2)	<ul style="list-style-type: none"> • Shielding, • Electrostatic deflectors, • ExB deflectors • Beam instrumentation (BPMs, SQUIDS...), • Beam and spin manipulators 	KAIST/FZJ/CERN	Frank Rathmann
Polarimetry	<ul style="list-style-type: none"> • Proton • Deuteron • Targets • Systematic errors 	FZJ	Edward Stephenson (Indiana U.)
Systematics	<ul style="list-style-type: none"> • Magnetic fields • Alignment • Electric fields • CW/CCW effects 	KAIST/FZJ/CERN	Yannis Semertzidis (CAPP/IBS & KAIST)
Siting at CERN	<ul style="list-style-type: none"> • Site • Civil engineering • Cost 	CERN	Mike Lamont (CERN)



Theory meeting
26th March



Jan



Christian



Questions arising...

- Systematics
 - In particular radial B-field – see Christian’s talk
- Simulations
 - Consistent handling of KE change in electric field?
- Focusing strength
 - Weak
 - “required mechanical accuracies of bending plates manufacturing, assembly and installation look too tight”
 - Strong (AG)
 - Reduced sensitivity to effect of Br on CW/CCW splitting
 - Strong focusing rules out 10^{-29} e.cm (?)
 - Back to weak?
- Is 10^{-29} e.cm credible?
- Do we need a prototype? If so what...
- Options: axions, ultra-weak focusing, frequency domain

Lessons

- Encouraging kick-off
- Took BNL proposal seriously
 - First reaction was to look at doing similar at CERN
 - Look at beam delivery, possible siting etc.
 - Cross-check of systematics analysis
- Bogged down in counter-proposals, systematics, options, trustworthiness of simulations...
- Despite the huge amount of effort – come to the conclusion that things are not mature as was first assumed

Prototype

- If we continue... a prototype of some sort would appear inevitable
- To test:
 - Shielding, b-field compensation
 - Components
 - Instrumentation
 - Measurement techniques
 - Control of systematics

Process status, schedule, deadlines, goals

- PBC schedule
 - WG meeting June
 - Close-out December
- Document delivery – December
 - Re-scope EDM for ESPP
 - At this stage imagine only a sketch of possible implementation at CERN/green field
- CERN prepared to participate in Synergy grant application
 - Envisaging prototype at Juelich

What does CERN want/need from this process?

- An informed statement of the present situation regarding the viability of building an EDM ring **at CERN or elsewhere** that can reach a competitive sensitivity
- A clear and concise exposition of the ring, measurement, realistic valuation of systematics and challenges pertaining
- Roadmap
 - Required R&D
 - Required prototyping
 - Resources – material and personnel

Proposed document

Executive summary plus...

1	Overview and motivation
2	Overview of pEDM experiment method - requirements
3	Ring design
4	Beam dynamics and control
5	Injection
6	Electric fields: deflectors, quads
7	Magnetic fields: shielding
8	Polarimetry
9	Instrumentation
10	RF, RF solenoids
11	Detailed measurement procedures
12	Systematics, challenges, mitigation
13	Prototype, options
14	Roadmap

Conclusions

- Huge amount of work out there in the EDM community
- However important questions still to be answered
- Feasibility study and possible roadmap to be presented to ESPP
- Prototype seems inevitable (if...)
 - Not at CERN is fine