ITWG Topical Workshop

Management of Instrumentation Projects

19 to 21 May 2014

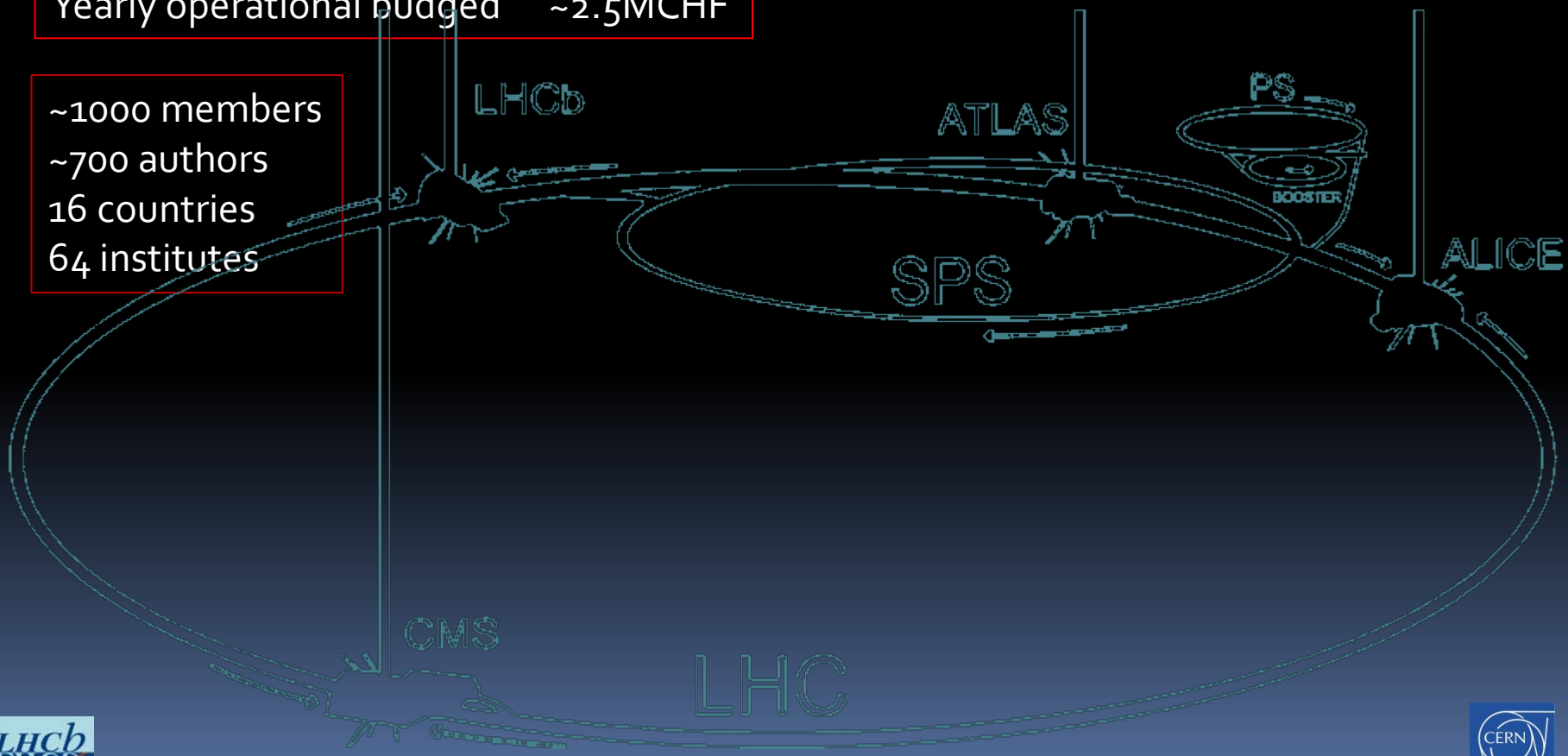
Rolf Lindner

From idea to realization of a HighEnergyPhysics experiment

The LHCb experiment at the LHC

Capital Investment:	75 MCHF
Yearly operational budged	~2.5MCHF

~1000 members
~700 authors
16 countries
64 institutes



The LHCb experiment

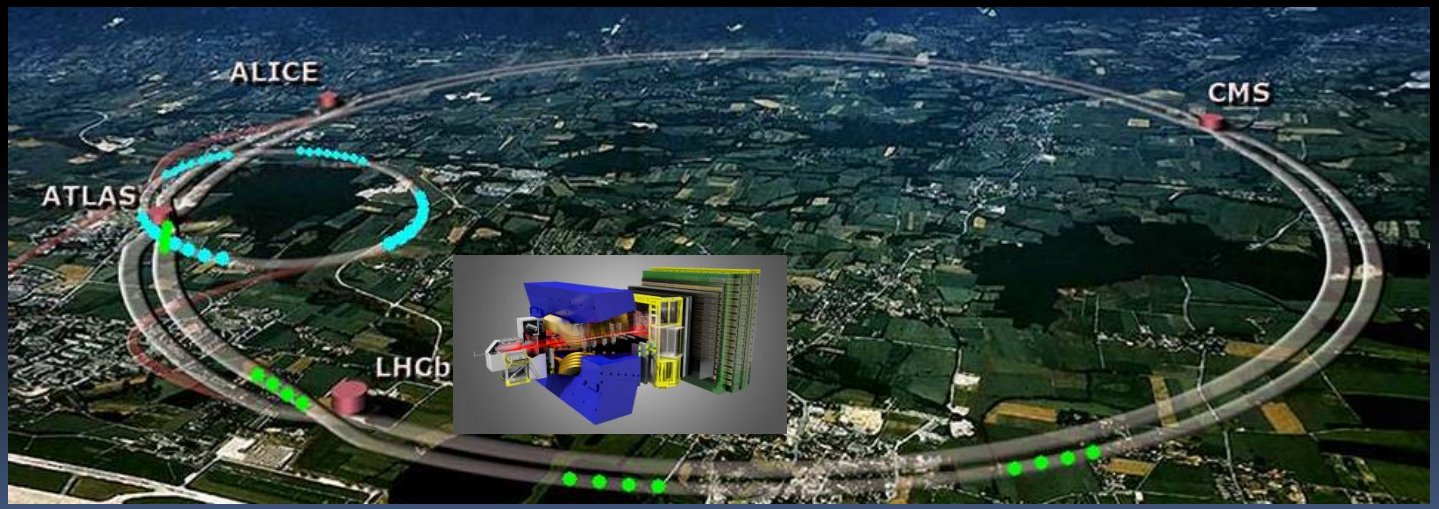
LHCb stands for Large Hadron Collider *beauty* experiment

- Specialized in *b physics*; *b hadrons* are heavy particles containing a *bottom (also named beauty)* quark

- Measuring parameters of CP violation.

  C for charge conjugation, which transforms a particle into its antiparticle, and P for parity, which creates the mirror image of a physical system. CP-symmetry -> laws of physics should be the same under C and then P transformation.

➢ Such studies can help to explain the Matter-Antimatter asymmetry of the Universe
➢ Search for 'New Physics'

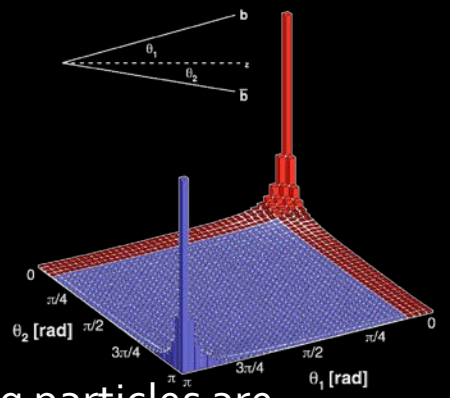


The experiment is located at the LHC at CERN, Geneva

How all started – *first idea*

In the late 1980' *CP violation* in the *B system* became a very 'hot' topic

A proposal was made to study this subject at the SPS Collider at CERN, 1989 *

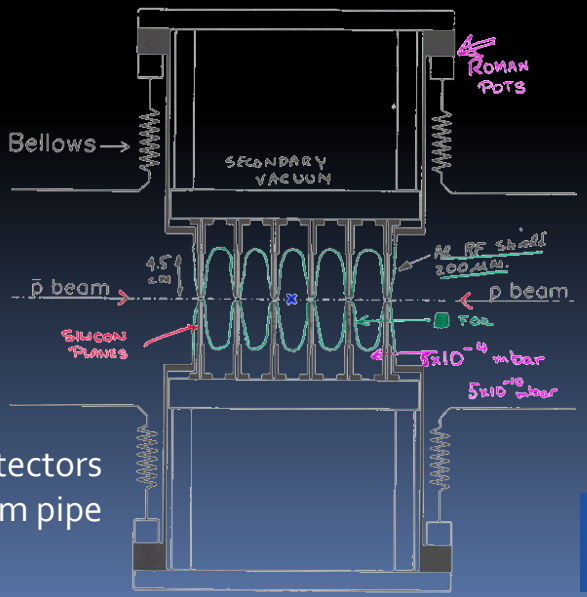


Two concepts

- very large B production in the forward direction
- use silicon detectors inside the beam pipe, where the colliding particles are kept

Proposal was not approved

but a successful test was made.



silicon detectors
inside the beam pipe

*Peter Schlein at all

How all started –the chance

Then, the LHC

In September 1989 the CERN DG, C. Rubbia, asked to organize a year's long study, with ~250 participants, whether and how a 17 TeV pp collider in the existing LEP tunnel could compete with the SSC. (Superconducting Super Collider)

The LHC project started at the ECFA Large Hadron Collider Workshop, Aachen, Germany, 4-9 Oct 1990.

Propose a *b physics* experiment at this collider

Different modes were possible:

- Collider
- Fixed Target, with extracted beam

Three groups of physicists submitted three Letters of Intent (LoI)

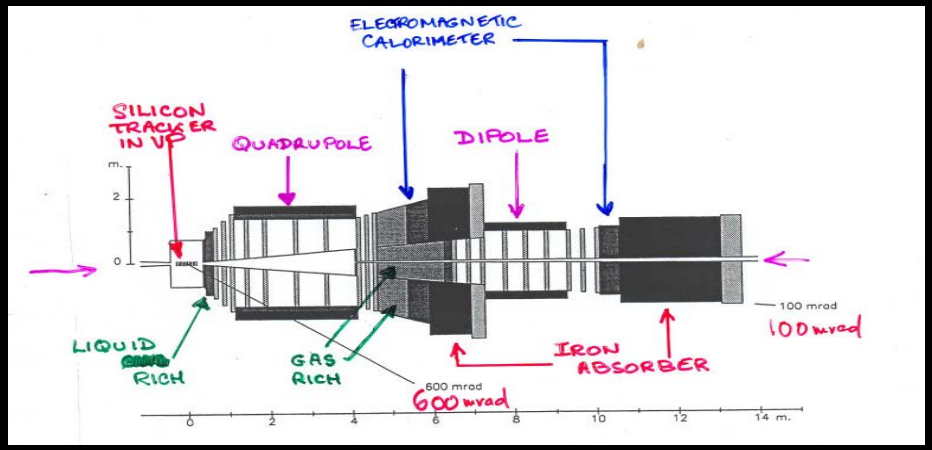
How all started – first proposal(s)

Three **Letters of Intent:** (1993)

- Design very similar (forward direction)
- Silicon Tracker close beam line

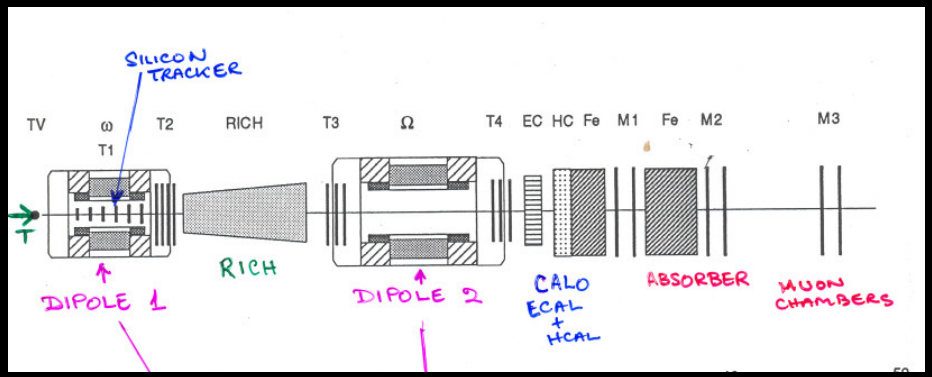
COBEX

collider mode



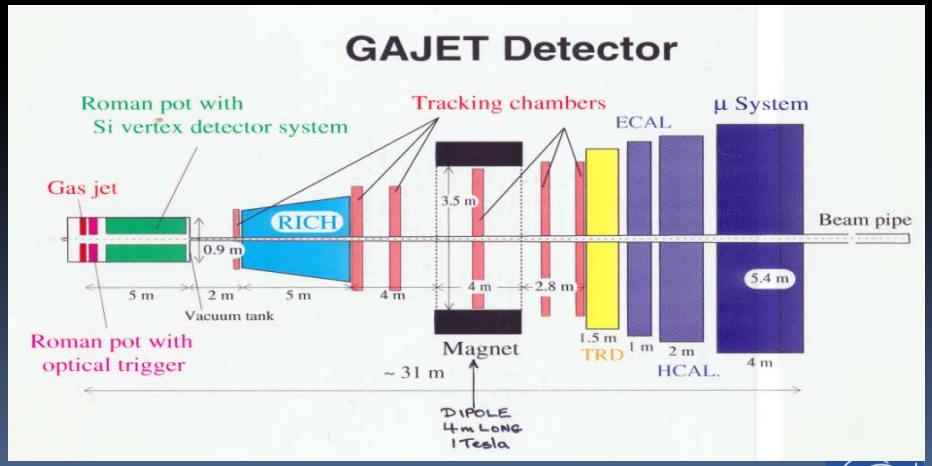
Large Hadron Beauty Factory

with beam extraction



Gajet

internal gas jet target



Taking shape –natural selection

The **LHCC, Larg Hadron Collider Committee.**

The LHCC was set up after the March 1992 meeting in Evian-les-Bains. Intensive interaction between the Committee and the Collaborations is required in order to converge on the detector designs, and to review the construction, installation and commissioning of the experiments. Like other experiment committees, the LHCC makes recommendations to the **CERN Research Board**.

As not all three proposal can be accepted at the LHC, the LHCC discussed the relative merits of the different approaches in spring 1994.

Conclusion (extracts), 8 June 1994:

- None of the collaborations has the necessary resources.
- Collider mode has the greater potential.
- Detector close to the beam is very desirable, but adequately optimized design of spectrometer does not exist yet.

The committee therefore encourages all participants from the three proposals to **join together** to prepare a new letter of intent for a new collider mode b experiment to be submitted to the LHCC.

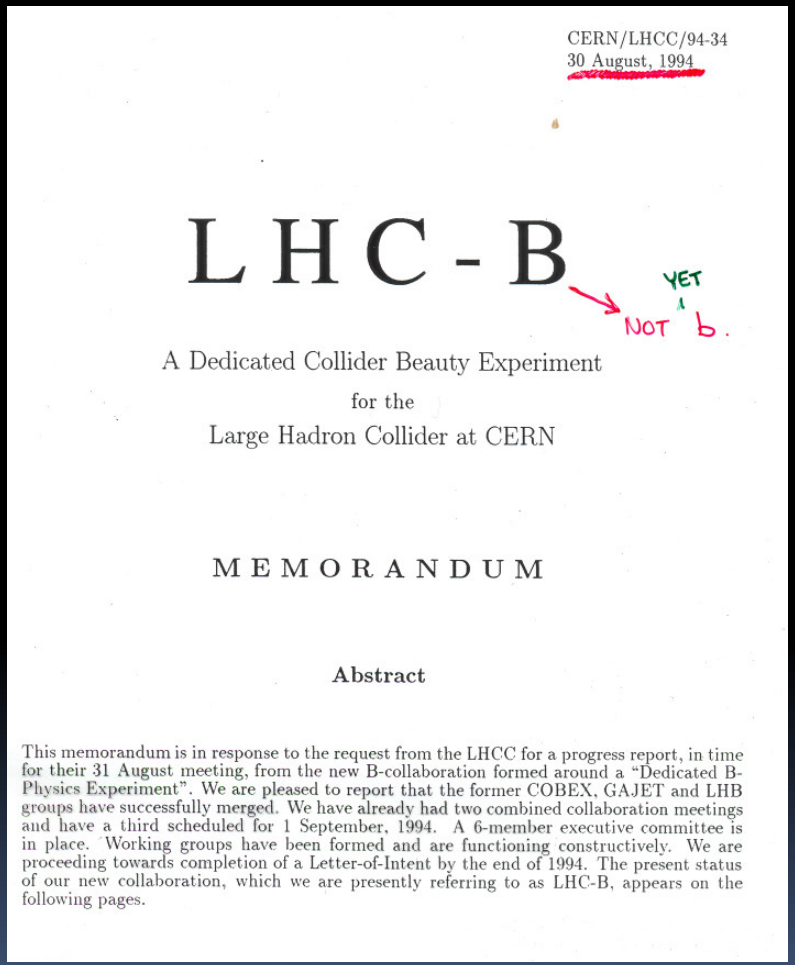
Taking shape –experiment is born

The three collaborations have decided to participate in a joint Letter of Intent.

The **Spokespersons** of the three original LoI's defined:

- An **Executive Committee** consisting of two members of each of the three former collaborations
- A **Collaboration Board** consisting of a senior representative of each of the major institutes

- A first joint meeting of the new collaboration was held in July 1994
  - New groups joined the collaboration
  - Preparation of a new **LoI** and a **Technical Proposal**
  - Forming working groups around the major subjects



CERN/LHCC/94-34
30 August, 1994

LHC-B

YET NOT b.

A Dedicated Collider Beauty Experiment
for the
Large Hadron Collider at CERN

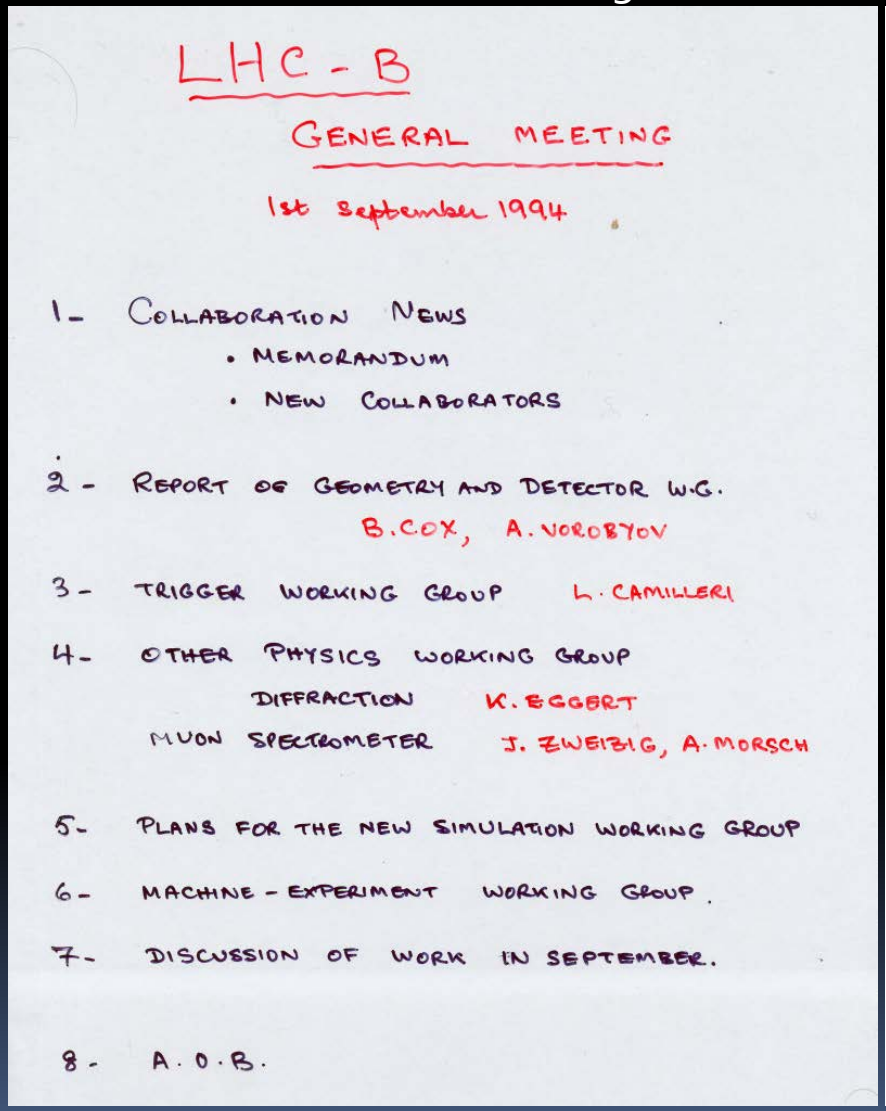
MEMORANDUM

Abstract

This memorandum is in response to the request from the LHCC for a progress report, in time for their 31 August meeting, from the new B-collaboration formed around a "Dedicated B-Physics Experiment". We are pleased to report that the former COBEX, GAJET and LHB groups have successfully merged. We have already had two combined collaboration meetings and have a third scheduled for 1 September, 1994. A 6-member executive committee is in place. Working groups have been formed and are functioning constructively. We are proceeding towards completion of a Letter-of-Intent by the end of 1994. The present status of our new collaboration, which we are presently referring to as LHC-B, appears on the following pages.

Taking shape -preparing for approval

One of the first meeting



LHC - B

GENERAL MEETING

1st September 1994

1- COLLABORATION NEWS
- MEMORANDUM
- NEW COLLABORATORS

2 - REPORT OF GEOMETRY AND DETECTOR W.G. B.COX, A.VOROBYOV

3 - TRIGGER WORKING GROUP L.CAMILLERI

4 - OTHER PHYSICS WORKING GROUP
DIFFRACTION K.EGGERT
MUON SPECTROMETER J. ZWEIBIG, A.MORSCH

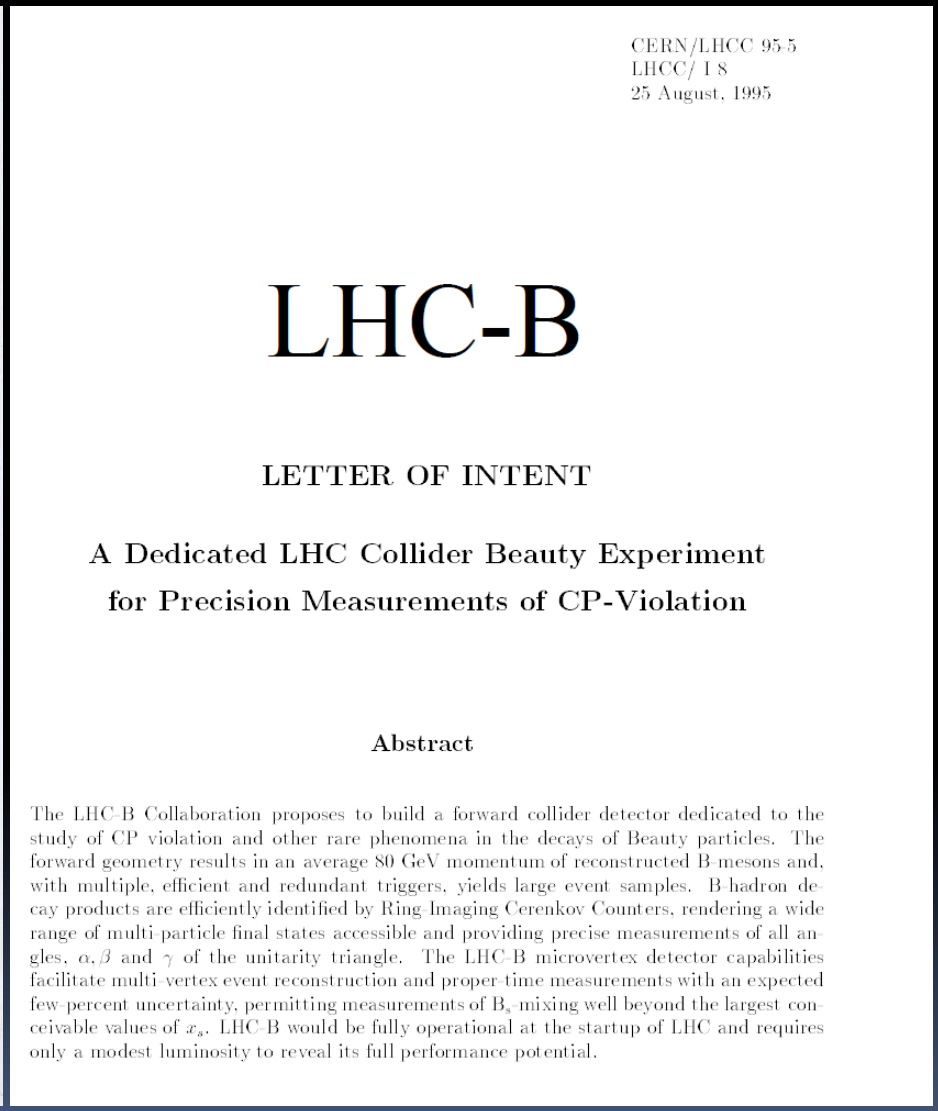
5 - PLANS FOR THE NEW SIMULATION WORKING GROUP

6 - MACHINE - EXPERIMENT WORKING GROUP.

7 - DISCUSSION OF WORK IN SEPTEMBER.

8 - A.O.B.

Letter of Intent



CERN/LHCC 95-5
LHCC/ I 8
25 August, 1995

LHC-B

LETTER OF INTENT

A Dedicated LHC Collider Beauty Experiment
for Precision Measurements of CP-Violation

Abstract

The LHC-B Collaboration proposes to build a forward collider detector dedicated to the study of CP violation and other rare phenomena in the decays of Beauty particles. The forward geometry results in an average 80 GeV momentum of reconstructed B-mesons and, with multiple, efficient and redundant triggers, yields large event samples. B hadron decay products are efficiently identified by Ring-Imaging Cerenkov Counters, rendering a wide range of multi-particle final states accessible and providing precise measurements of all angles, α, β and γ of the unitarity triangle. The LHC-B microvertex detector capabilities facilitate multi-vertex event reconstruction and proper-time measurements with an expected few-percent uncertainty, permitting measurements of B_s-mixing well beyond the largest conceivable values of x_s. LHC-B would be fully operational at the startup of LHC and requires only a modest luminosity to reveal its full performance potential.

Getting Approved –lines of decisions

Research Board

Chairperson: CERN Director General
Approval of Experiments at CERN
The Research Board receives the recommendations from all the CERN Experimental Committees, and takes decisions on them.

Recommends for approval

Approves the experiment

Large Hadron Collider Committee

review the construction, installation and commissioning of the experiments

Experiments submit

- LoI
- TP
- TDRs

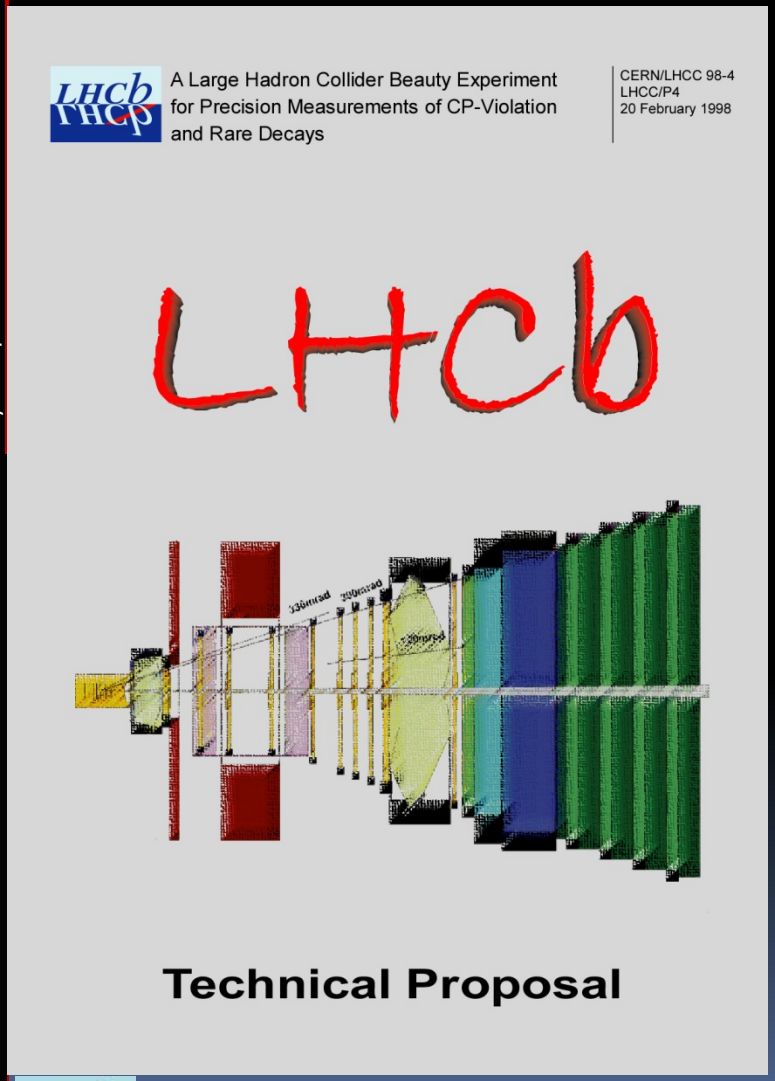
Reports 4x per year: Status of construction, installation, operation and analysis

LHCb collaboration

Getting Approved –*prepare the package*

The Technical Proposal:

Describes the physics case, the different sub systems and the project planning.



- Setting up the organization of the collaboration

  Institutes responsible for the detector construction -> **first LHCb Constitution**
- A **cost estimate of the full project** is given

  'CORE' cost for a Common Fund and Sub Systems
- Schedule
  - R&D work and prototype studies
  - Start of construction
  - Start of installation

Getting Approved – *agreement between all parties and financing*

Next step after the approval by the **CERN Research Board**:

Preparation of the

Memorandum of Understanding

Defines the programme of work to be carried out

- for the construction
- the distribution of charges
- responsibilities among parties

It set the organisational, managerial and financial guidelines to be followed by the Collaboration.

Before proceeding to the final construction phase, each sub system will be subject to a technical, financial, and personnel review, by the **Large Hardon Collider Committee**.

→ **Technical Design Reports** (TDRs)

Getting Approved –lines of decisions

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LHC Resources Review Boards

Chairperson: CERN Director for Research and Computing.
Comprises the representatives of each Experiment's Funding Agencies and the management of CERN and of each Experiment's Collaboration.

- reaching agreement on the MoU
- monitoring the Common Projects and the use of the Common Funds
- monitoring the general financial and manpower support
- reaching agreement on a maintenance and operation procedure and monitoring its functioning
- endorsing the annual construction and maintenance and operation budgets of the detector.

LHCb collaboration

The Implementation - Technical Design Reports (TDRs)

After choosing the hardware technology for each sub system a TDR has to be prepared and submitted to the LHCC.

The TDR describes the

- Requirements
- Layout
- Performance
- Technology

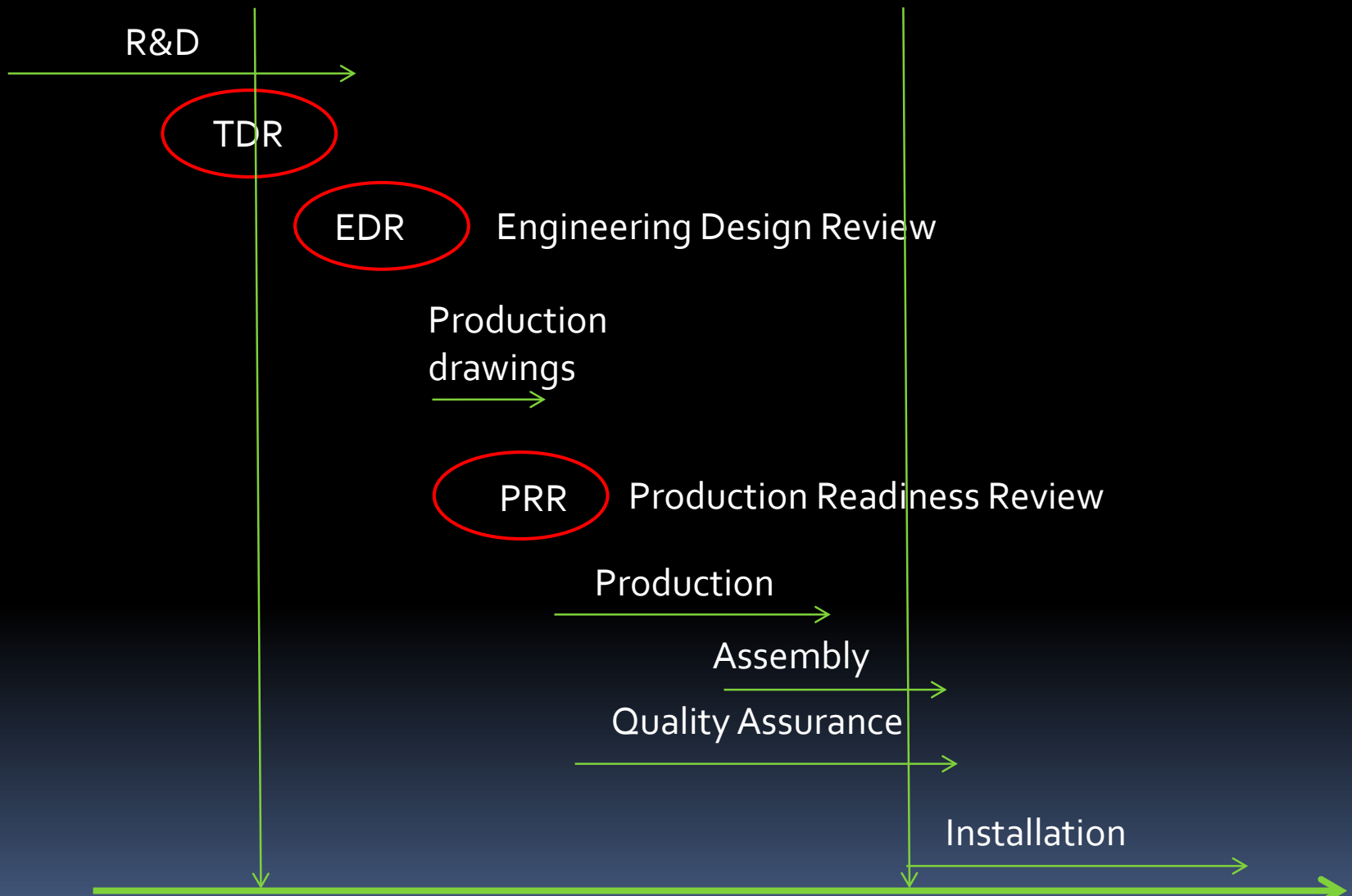
and contains the (sub) project organisation

- Participating institutes
- Responsibilities
- Schedule
- Cost & resources, including risk mitigation

Cost given in the TDRs

- only material
- personnel & general tooling is not part of it

The Implementation - General timeline for a sub (sub) project to follow



The Implementation – from R&D to operation

R&D phase

- Decision on technologies
- Test beams
- Working closely with Industry
  - Several companies
  - Iterative process
  - Improving technology (timing, radiation etc.)

Production

- Final Integration
- Define production centres
- Assembly sites
- Quality assurance
- Installation

Operation

- Commissioning
- Data Taking

for close monitoring: milestones

The Implementation –final structure of the collaboration

GLIMOS
Group Leader on Matters of Safety

Editorial Board

Speakers Bureau

Collaboration Board
Representatives from each collaborating institute
Collaboration chair : one of the representatives

Ultimate authority. All major decisions shall be approved.

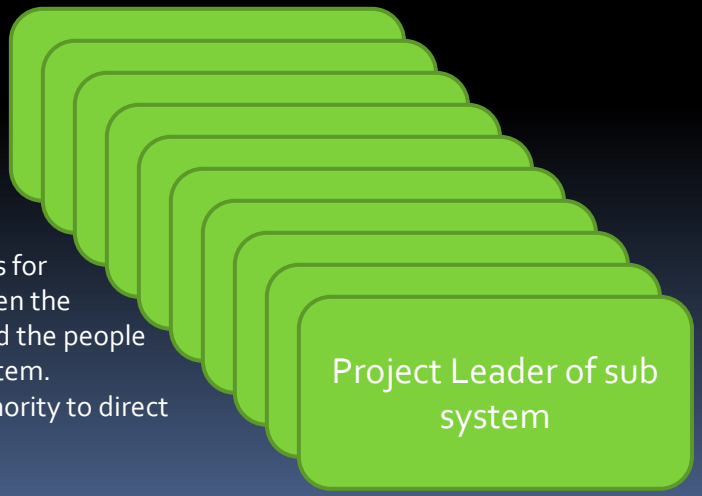
Management
Spokesperson + Deputy
Technical Coordinator, Resource Coordinator

executive body of the Collaboration. responsibility for managing the detector operation, upgrades, physics analysis.

Operation Planning Group
advisory body to the LHCb Management and ensures high quality data taking for physics analysis

Technical Board
advisory body to the Management, on all aspects of detector design, optimization, safety and cost.

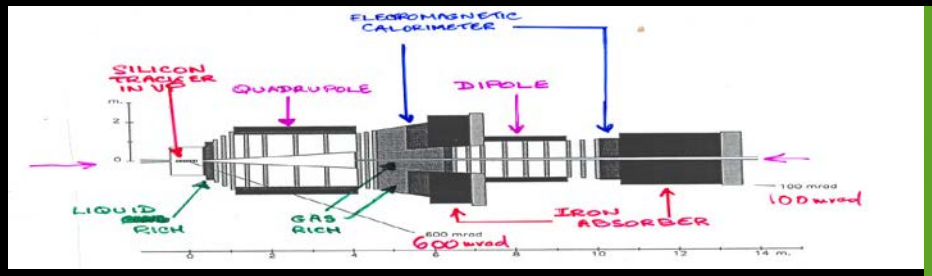
Physics Planning Group
advisory body to the Management and provides recommendations to ensure the best quality of the physics output

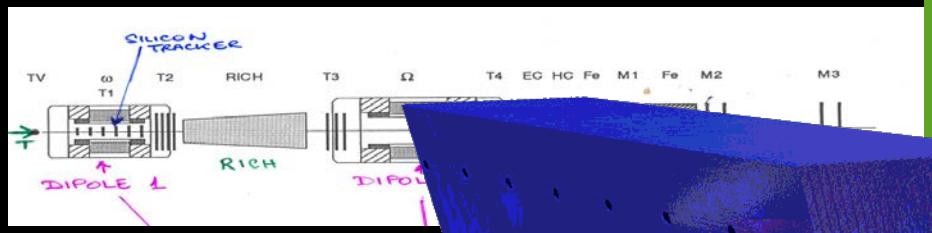


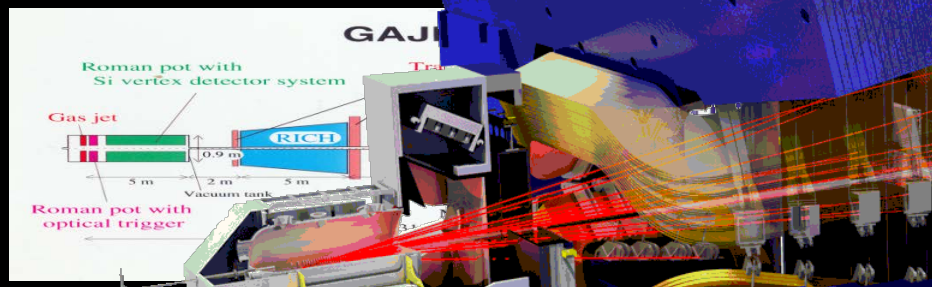
Formal contact persons for communication between the LHCb Management and the people working for the subsystem. Responsibility and authority to direct the work on that subsystem.

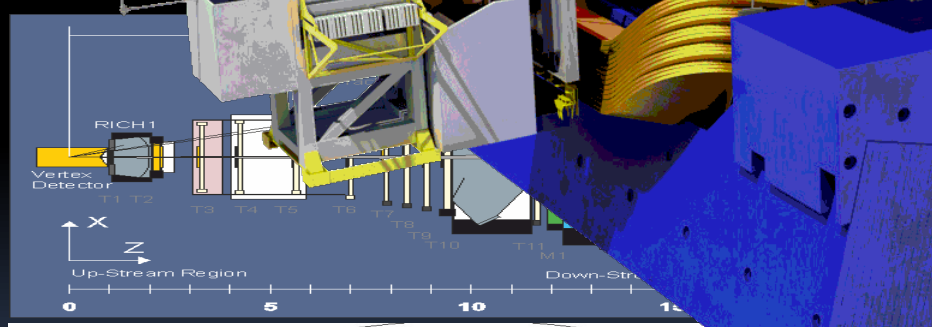
Coordinators
- Technical Coordinator
- Resources Coordinator
- Operation Coordinator
- Electronics Coordinator
- Physics Coordinator
- Run Coordinator
- LHC radiation and safety
- ECS Coordinator
- DAQ Coordinator
- Upgrade Coordinator
- LHC Contact
- Outreach Contact

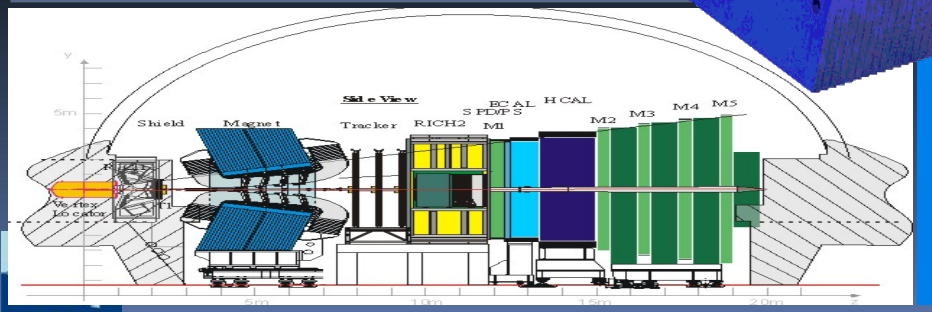
Implementation 2001-2008


ELECTROMAGNETIC CALORIMETER
SILICON TRACKER IN VP
QUADRUPOLE
DIPOLE
LIQUID RICH
GAS RICH
IRON ABSORBER
100 mrad
600 mrad


SILICON TRACKER
TV
T1
T2
RICH
T3
T4
EC
HC
Fe
M1
Fe
M2
M3
DIPOLE 1
RICH


Roman pot with
Si vertex detector system
Gas jet
RICH
0.9 m
5 m
2 m
5 m
Vacuum tank
Roman pot with
optical trigger


RICH1
Vertex
Detector
T1 T2
T3
T4 T5
T6
T7
T8
T9
T10
T11
M1
X
Z
Up-Stream Region
0
5
10


Side View
Shield
Magnet
Tracker
RICH2
S
PLPS
EC AL
M1
H CAL
M2
M3
M4
M5
5m
10m
15m
20m

1993

2003

Summary – a long way

- From first idea in 1989 to first data taking in 2010
-  21 years
- Many obstacles before final approval
- Structure of the experiment evolves with time
- Success of the project:
    1. Bright idea
    2. Well defined common goal
    3. Voluntary agreement at all levels
    4. Healthy mixture of experts
    5. Close collaboration between
        - ✓ Collaborating institutes
        - ✓ Industry
        - ✓ Funding agencies

Summary – time line

Late 1980's:	First thoughts for measuring CP violation in the B system, at the SPS. Publication with 21 authors
1989:	First proposal of experiment
1990:	Studies started for the Large Hadron Collider (LHC)
Early 1990's:	Three proposals to study this B physics at LHC
1993:	Three Letter of Intent ~100 authors, 33 institutes
1994:	Proposal to 'merge' all three proposals
1995:	LHCb gets structure, Letter of Intent for ONE B-experiment at LHC ~170 authors, 36 institutes
1998:	Submission of the Technical Proposal and Approval of the LHCb experiment by the CERN Research Board 336 authors, 42 institutes
2000:	First Technical Design Report (out of 11)
2005:	Last Technical Design Report
2002-2008:	Construction of LHCb sub systems
2008:	Commissioning started ~600 members, 48 institutes
2010:	Start of Data Taking
Now:	>1000 members, 700 authors, 64 institutes, 16 countries, >160 papers published