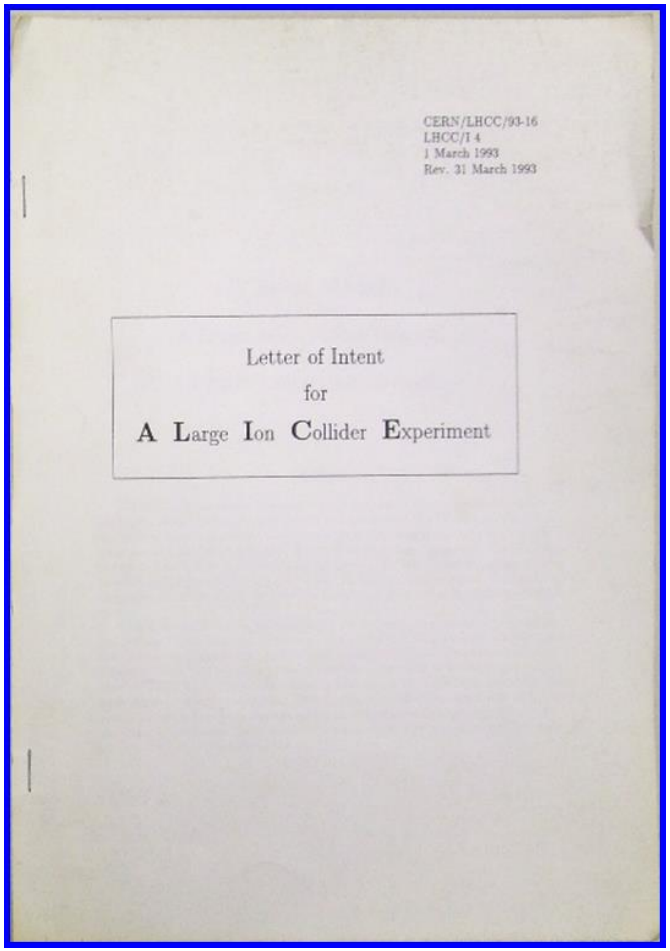
The making of . . . *1990 - 2009*

ALICE

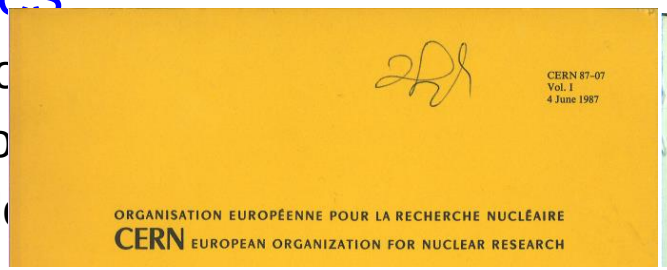
A Large Ion Collider Experiment

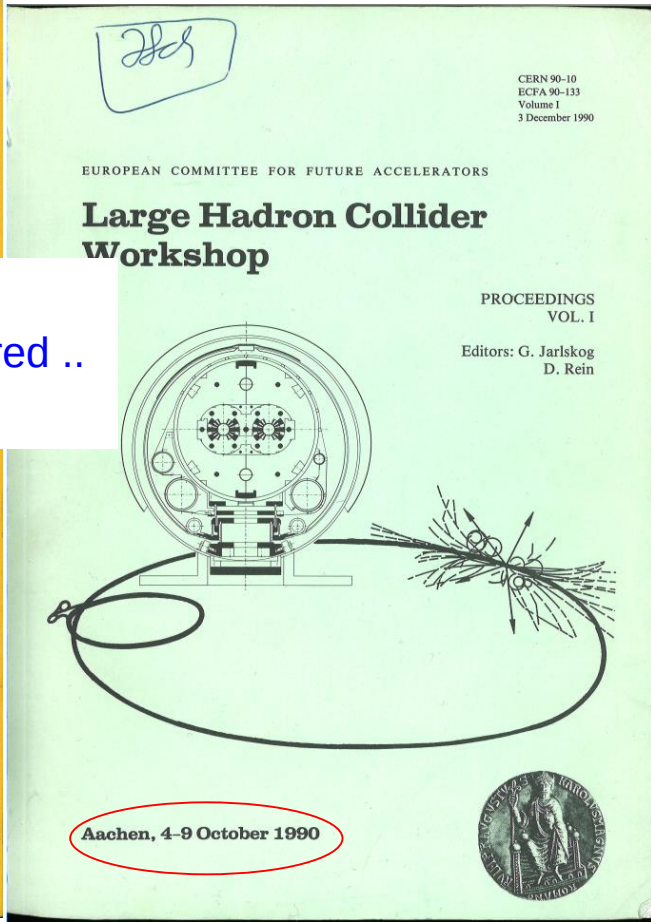


ALICE LoI
1 March 1993
Rev: 31 March 1993

The Making of ALICE

- Pre-History
  - ⇨ **1984**: Large **Hadron-Collider** discussed — Lausanne: pp machine in LEP tunnel
  - ⇨ **1986:** start of "Heavy" Ion Physics — Light ions, ^{16}O and ^{32}S at SPS/AGS
  - ⇨ **1987:** first mention of LHC as **Large-Hadron** Collider — La Thuile (large hadron = ^{208}Pb)
- Conceptual Studies
  - ⇨ **1990:** RHIC approved fo
    - ✪ call for experiments Lo
  - ⇨ **1990: First ideas** develo

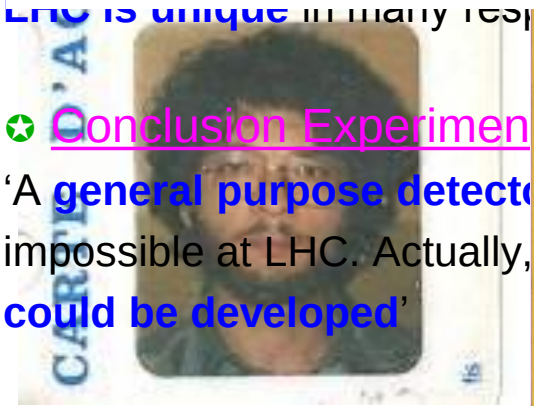




.. LHC is also capable as a collider for heavy ions ..

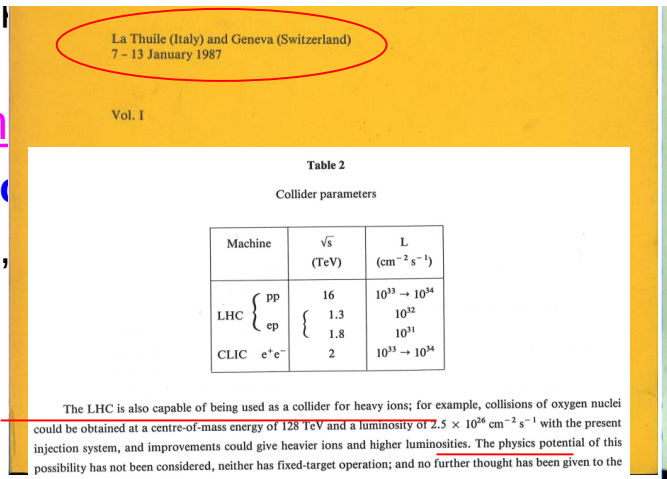
The physics potential of this possibility has not been considered ..

(~ 4 months after the very first ^{16}O ion beam in SPS !!)



- ✪ Conclusion Experimen

'A **general purpose detecto** impossible at LHC. Actually, **could be developed**'



First "ALICE" meeting, 27 years ago..

Conception of ALICE

Minutes of the 1st meeting on heavy ion / pp min. bias physics at LHC

The following is a short summary of the presentations and discussions taking place during the first meeting on a Heavy-Ion-Experiment at LHC held on Thursday, 13.12 1990 at CERN. The intention of this meeting was to initiate a serious experimental effort towards a heavy ion detector capable of measuring ultra-relativistic heav ... s attended by over 60 physicists. Copies of the transparencies and other related material will be send to the participants as annex to these minutes by mail.

attended by over 60 physicists

experimental areas will be finalized by end '91

- The design of the experimental areas will be finalized by end '91. The overall lay-out of an experiment should exist by then, if the caverns are to be built ... as well as the need for a Letter of Intent by end ... schedule of the LHC, i.e. even if the start of physics operation, presently foreseen for 1998, should slip somewhat, the extra time will be used to stretch the construction schedule of the machine (and the detectors) rather then to delay the start of construction

start of physics operation foreseen for 1998

.. should it slip, we stretch the construction schedule ..

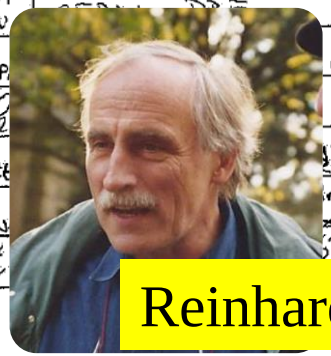
Some 'Founding Parents'

List of Participants

Name	E-Mail adress
TSERRUYA ITZHAK	FNTSRUYA at WEIZMANN
BROCKMANN, R	BROCKMAN @VXCERN
PAIC GUY	PAIC CERNVM
NAPPI E.	NPPI @ VXCERN
HECK, W.	HECK @ CERNVM
PANAGIOTOU, A.D	FAX: 00-30-7228:981
P. SEYBOTH	PXS at DM@HE
V. ECKARDT	VOE DM@HP
W. GEIST	GEIS CERN
W. Ochs	WWO DM@M
A.L.S. ANGELIS	ANGE @ CE
A. VOLTE	VOL @FRC
GIRONE M.	GIRON CERNV
A. PALANO	PAL @CE
D. Jouan	Joua @FRC
C. GERSCHEL	GERS @ FRC
P. GORODETZKY	GOR @FR
H.R Schmidt	SCHMIDT @VXWAPU
C. RACCA	RACCA @ FRCP
A. Sandoval	SANDO @ CER
R. Stock	your handwr
A. ROMANA	NABS @ FRCPN
H.J. SPECHT	Specht @dapnyv


Guy


Lodovico


Reinhard


Hans

Name	E-M adres
G. VASSILIADIS	SPNG
Aden Sher	FNSH @W
L. Leistam	UKCE LEIS
D. BIANDT	BRA @C
U. Goerlach	GO @
H. BEDJIDIAN	BE @A
J. CONTADOU	CONT @FR
J.Y. OLLITRAULT	OLL @ FR
[illegible] FRANZ	FRANZ @VXWA80
[illegible] RICCATI	RICCATI @CERNVM
PAOLO GIUBELLINO	PAOLO @ CERNVM
LUCIANO RAMELLO	RAMELLO @ CERNVM
PIERGIORGIO CERELLO	CERELLO @CERNVM
QUEBERT Jean	QUEBERT @ FRCPN11
LAUTRIDOU. Pascal	LAUTRIDO @ FRCPN11
BOUCHENEB Narrimane	BOUCHENE @ FRCPN11
TULLIO BRESSANI	VXOXCØ:: BRESSANI
SIMONETTA MARCELLO	VXOXCØ::

CERN PPE

TORINO INFN

INFN TORINO VIA P.GIURIA 1

TORINO UNIVERSITY VIA P.GIURIA 1

INFN TORINO VIA P. GIURIA 1,

CEN Bordeaux Le Haut Vigneau

CEN Bordeaux - Le Haut Vigneau

CEN Bordeaux - Le Haut-Vigneau

INFN - SEZ. DI VIA P GIURIA 1

INFN - SEZ. DI GIURIA 1

CERN

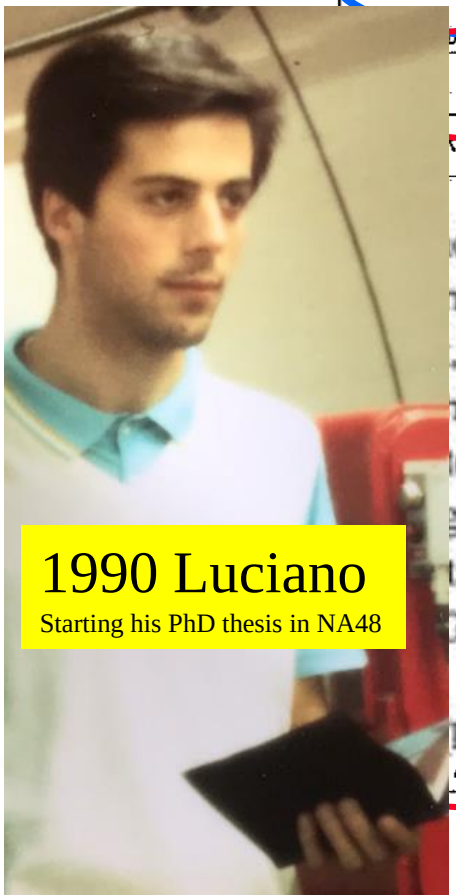

Lars


Paolo


Louis

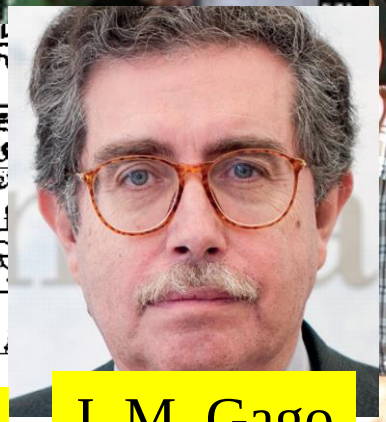
Emanuele

Hans & JS



1990 Luciano

Starting his PhD thesis in NA48



J. M. Gago

Chris

Peter

Re: 'proto-collaboration' for heavy ion physics at the LHC
meeting at CERN on 29th October 1991

Birth of ALICE :
HIPC=
"Heavy Ion Proto Collaboration"

Dear Colleague,

As you can see from the accompanying letters by C. Rubbia and W. Hoogland, the preparations for the LHC project at CERN have started in a major way. Prospective users are invited to express their interest and present their current ideas about

A meeting .. with representatives from all Institutions interested

To meet the overall time schedule of the LHC (oral expression of interest March '92, LOI end '92, start of experimentation > '98), the interested community needs to strengthen and concentrate its efforts in order to present a viable and credible concept in less then 6 months from now. **To this end, a meeting will be organized at CERN on 29 October 1991, to which representatives are invited from all institu**tions at the LHC. If your group is considering to

.. form a "proto-collaboration" .. establish formal structures

ion detector. It is expected, that in the course of the meeting we will form a common platform of the heavy ion community ('proto-collaboration') and establish a formal structure, which should enable us to converge towards a Letter of Intent by end '92. Depending on the interest, it is conceivable that we could follow up in parallel the different options mentioned above and present our conclusions about the most promising strategies at the March LHC meeting.

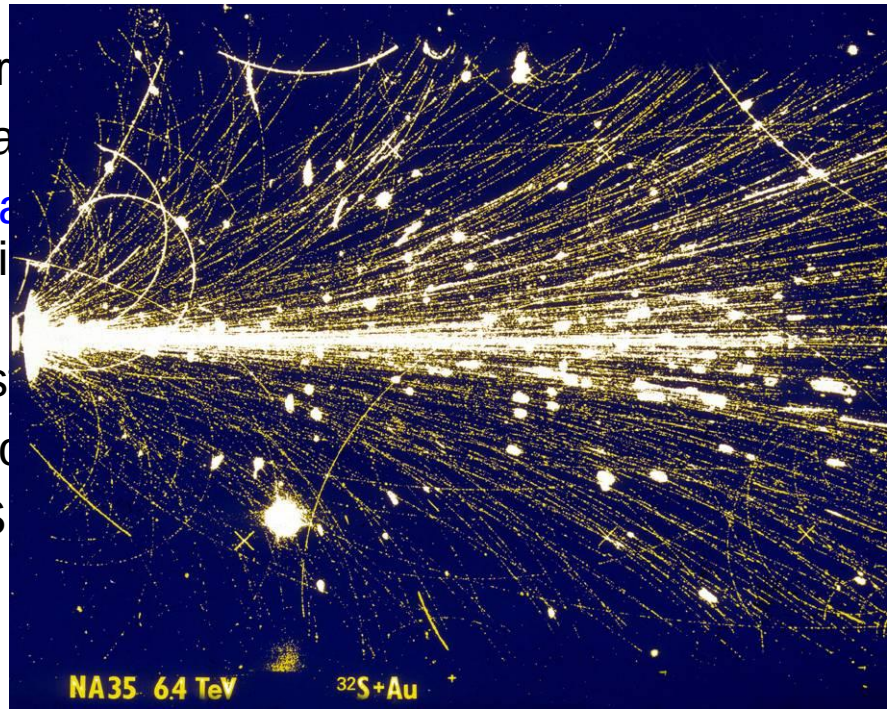
thoroughly enthusiastic & totally clueless

The ABERDEEN: Distribution list for Memorandum by W. Hoogland:

N. Belyaev (Kurchatov Inst. Moscow), R. Bock (GSI Darmstadt), B. Dolgoshein (Moscow Eng. Phys. Inst.), H. Enyo (Kyoto), J. Gago (LIP Lisbon), B. Ghidini (Bari), J. Gosset (CRN Saclay), K. Gulamov (Tashkent Inst. of Physics), H. Gutbrod (GSI Darmstadt), K. Hansen (NBI Copenhagen), R. Kamermans (Utrecht), P. Kienle (GSI Darmstadt), J. Kinson (Birmingham), L. Kluberg (Palaiseau), A. Komar (Lebedev Phys. Inst. Moscow), P. Lehmann (IN2P3), G. Lovhoiden (Bergen), M. Martin (Geneva), I. Otterlund (Lund), G. Paic (Zagreb), A. Panagioutou (Athens), K. Pretzl (Bern), E. Quercigh (CERN), L. Riccati (Torino), R. Ricci (Padua), N. Russakovitch (JINR Dubna), K. Safarik (College de France, Paris), R. Santo (Muenster), H. Satz (CERN), N. Schmitz (MPI Munich), J. Schukraft (CERN), B. Sinha (Calcutta), P. Sonderegger (CERN), R. Sosnowski (Warsaw), H. Specht (Heidelberg), R. Stock (Frankfurt), Y. Sumi (Hiroshima), I. Tserruya (Weizmann Inst.), C. Voltolini (CRN Strasbourg)

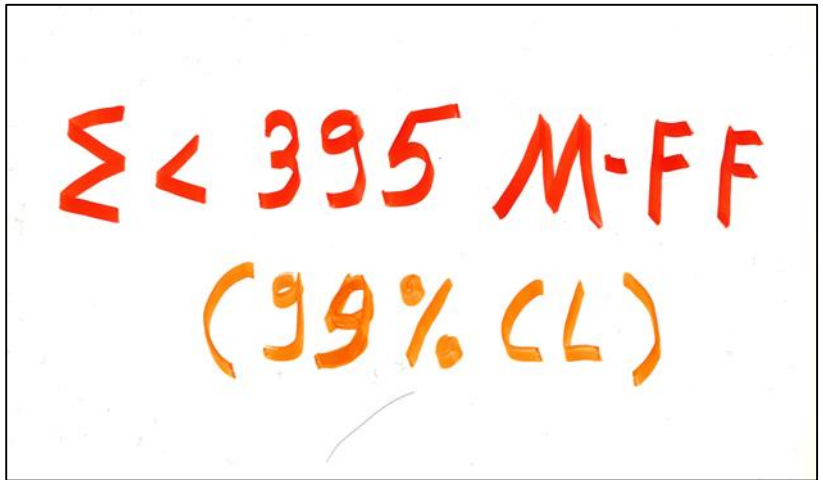
Challenges

- Challenges for the Heavy Ion community in early ’90’s
  - ⇨ huge extrapolation from SPS to LHC (^{32}S at 20 GeV -> ^{208}Pb at 5500 GeV)
    - ✪ **x 7** in mass, **x 300** in energy (3 GeV Adone -> 1 TeV ILC)
    - ✪ => large uncertainties in what to expect
  - ⇨ limited experience in building large detectors
    - ✪ ‘pilot’ detectors (1986- 1990) assembled largely from existing detectors (Bevalac, ISR, CERN fixed target expts, ...)
  - ⇨ no previous example of a truly ‘general pur
    - ✪ AGS/SPS/RHIC: handful of complementa
    - ✪ significant conceptual (& sociological) cha all observables & people in a si
  - ⇨ resources (money and people) incredibly s
    - ✪ ongoing data analysis of SPS light ion pr
    - ✪ building 2nd generation experiments for S
    - ✪ RHIC approved in 1990, dedicated to HI,
    - ✪ **little left for LHC preparations…**



The Making of ALICE

- Pre-History
  - ⇨ **early 80's**: LHC first discussed
  - ⇨ **1986:** start of Heavy Ion Physics at SPS & AGS
  - ⇨ **1990:** RHIC approved
- Conceptual Studies
  - ⇨ **1990: First ideas** developed for HI@LHC (Aache
  - ⇨ **1992: Expression of Interest** (Evian)
    - ✪ 1) **modified LEP experiment** (Delphi): **impossible**
    - ✪ 2) **pp experiment** (CMS): **seemed possible** for selected hard signals ($\mu\mu$)
    - ✪ 3) **dedicated** general purpose **HI detector** => **ALICE**

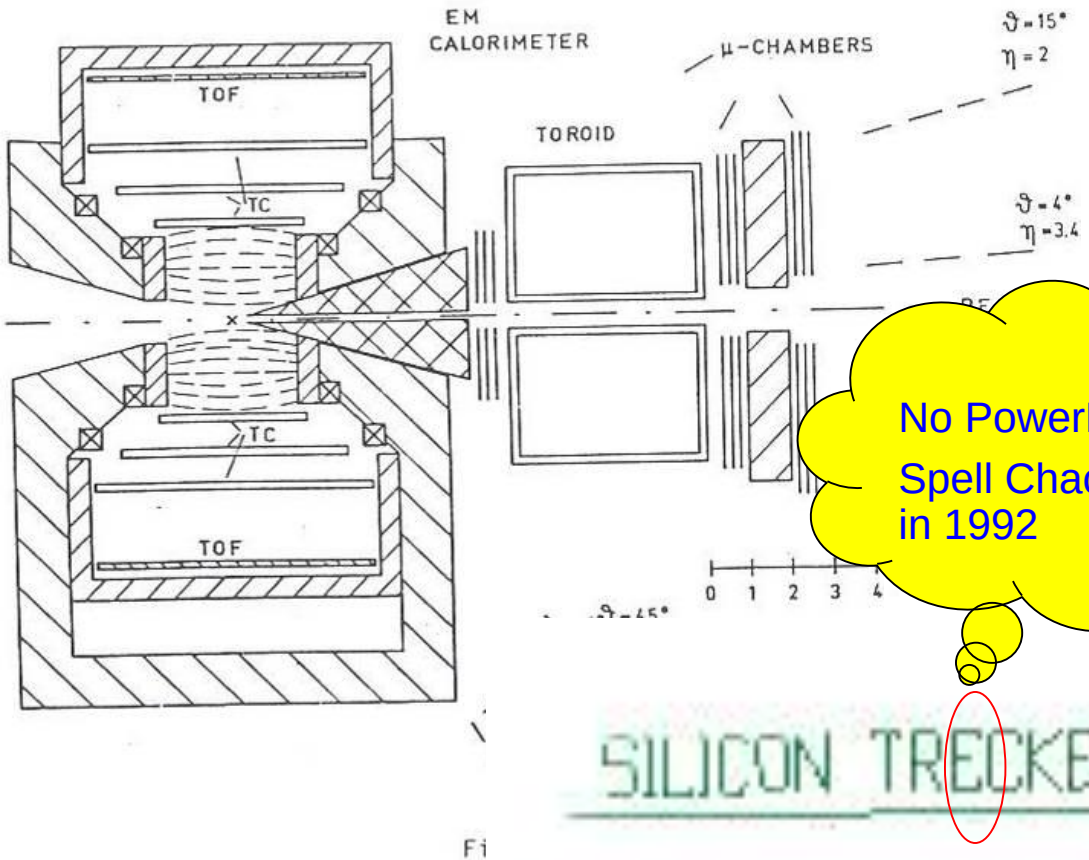


Expression of Interest for a dedicated heavy ion experiment at the LHC

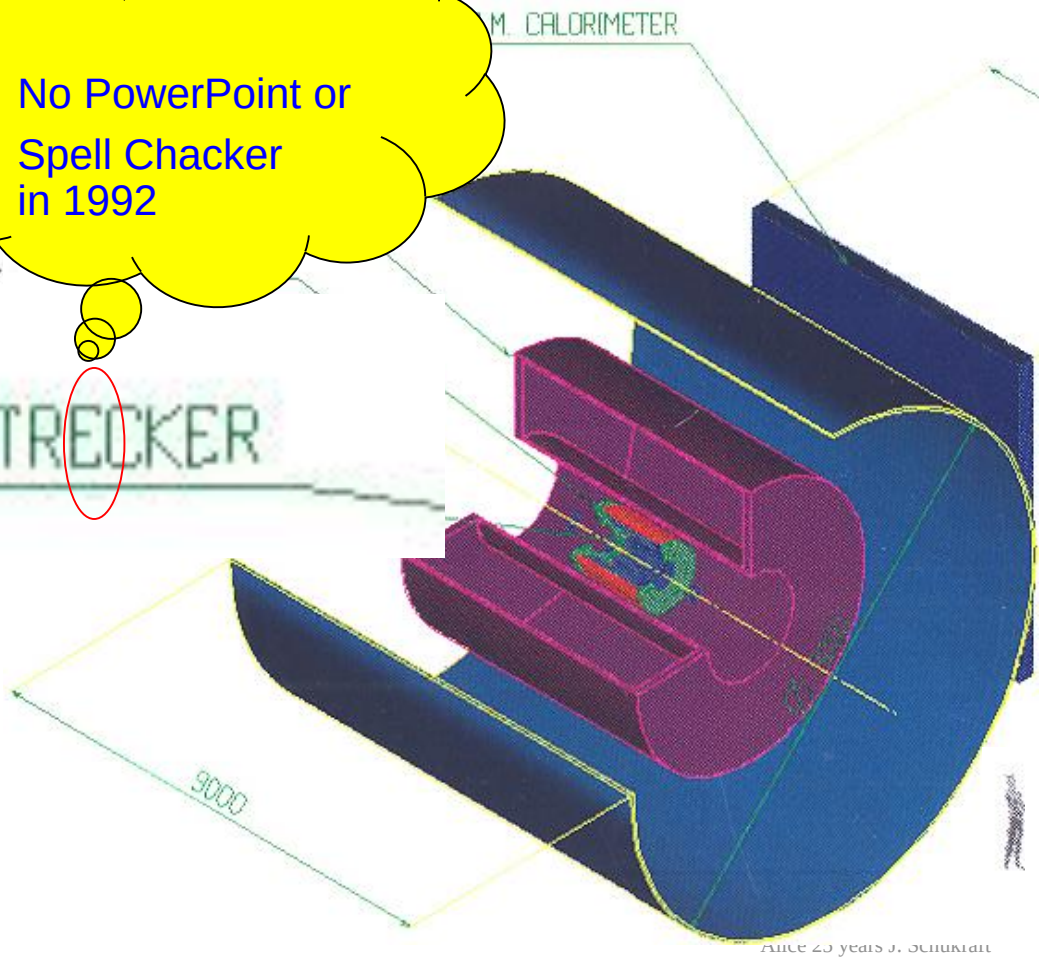
R. Boskovic Institute, *Zagreb*, **Croatia**
Inst. of Exp. Physics, Slov. Acad. of Science, *Kosice*, **CSFR**
Physics Inst., Czech. Acad. of Science, *Prague*, **CSFR**
IPN, *Lyon*, **France**
Lab. de Phys. Corpusculaire, College de France, *Paris*, **France**
CRN, CNRS-IN2P3 & Univ. of *Strasbourg*, **France**
G.S.I., *Darmstadt*, **Germany**
Inst. für Kernphysik, Univ. of *Frankfurt*, **Germany**
Phys. Dept., Univ. of *Giessen*, **Germany**
Phys. Dept., Univ. of *Heidelberg*, **Germany**
Phys. Dept., Univ. of *Marburg*, **Germany**
MPI-Physik, *München*, **Germany**
Phys. Dept., Univ. of *Münster*, **Germany**
Phys. Dept., University of *Athens*, **Greece**
Variable Energy Cyclotron Centre, *Calcutta*, **India**
Weizmann Inst., Dept. of Physics, *Rehovot*, **Israel**
Phys. Dept., University and INFN, *Bari*, **Italy**
Phys. Dept., University and INFN, *Catania*, **Italy**
Phys. Dept., University and INFN, *Padova*, **Italy**
Phys. Dept., University la Sapienza and INFN, *Roma*, **Italy**
Phys. Dept., University and INFN, *Torino*, **Italy**
NIKHEF, *Amsterdam*, the **Netherlands**
Univ. of *Utrecht* (RUU), the **Netherlands**
Univ. of *Bergen*, **Norway**
Inst. of Nucl. Physics, HEP Lab., *Cracow*, **Poland**
JINR, *Dubna*, **Russia**
INR, *Moscow*, **Russia**
ITEP, *Moscow*, **Russia**
Kurchatov Inst., *Moscow*, **Russia**
C.I.E.M.A.T *Madrid*, **Spain**
Div. of Cosmic and Subatomic Phys., Univ of *Lund*, **Sweden**
CERN, *Geneva*, **Switzerland**
Phys. Dept., Univ. of *Geneva*, **Switzerland**
Phys. Dept., University of *Birmingham*, **U.K**

Early ALICE Designs

1992 Design (Evian)
no muons
thin (<17%X_0) and small **solenoid**



No PowerPoint or
Spell Chacker
in 1992



1990 Design (Aachen)
open axial field **magnet**
(AFS/ISR, + NA38 muons)

The Making of ALICE

- **Pre-History**
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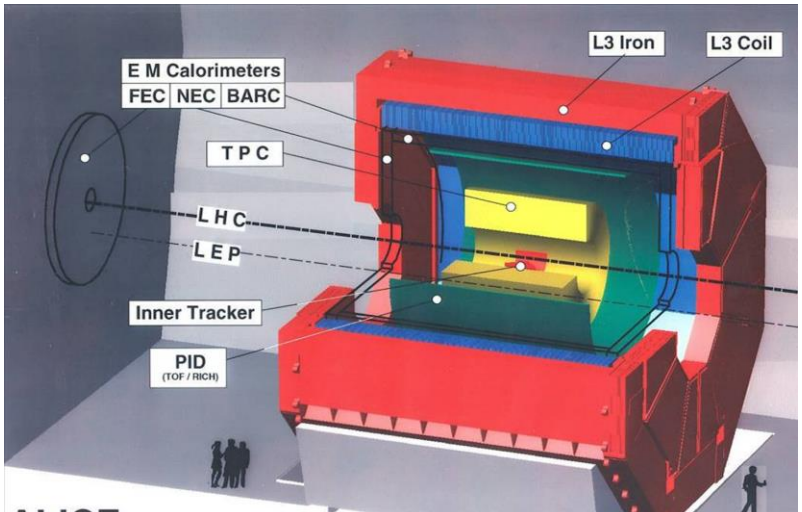
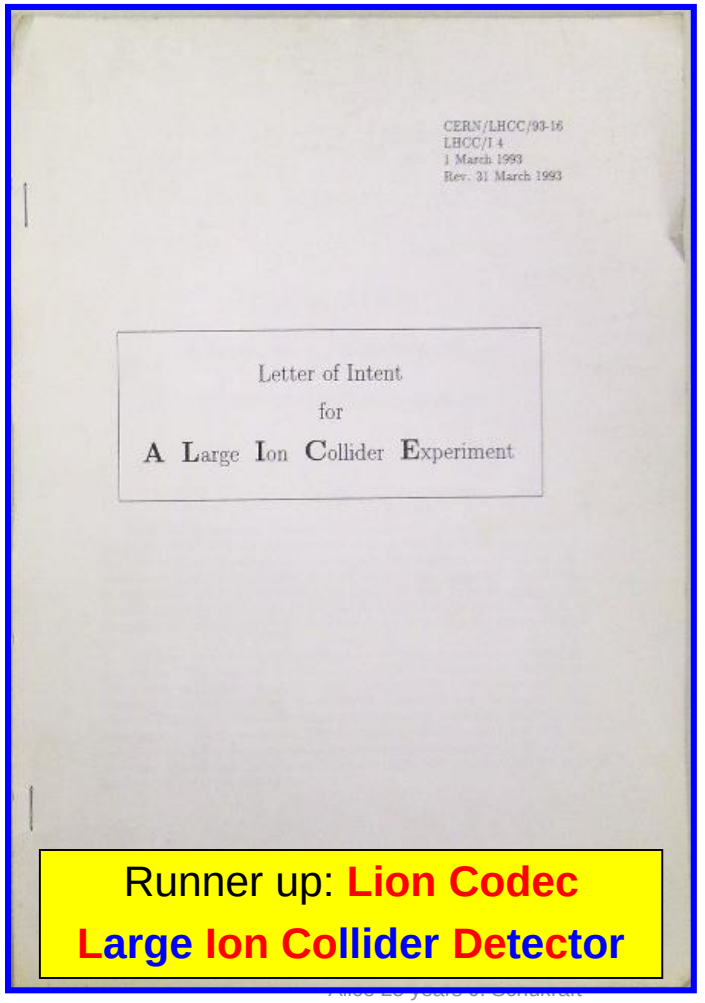
- **Conceptual Studies**
  - ⇨ **1990: First ideas** developed (Aachen)
  - ⇨ **1992: Expression of Interest** (Evian)
- **Design** and R&D
  - ⇨ **1993: Letter of Intent** (central detector)

230 people, 42 Inst.

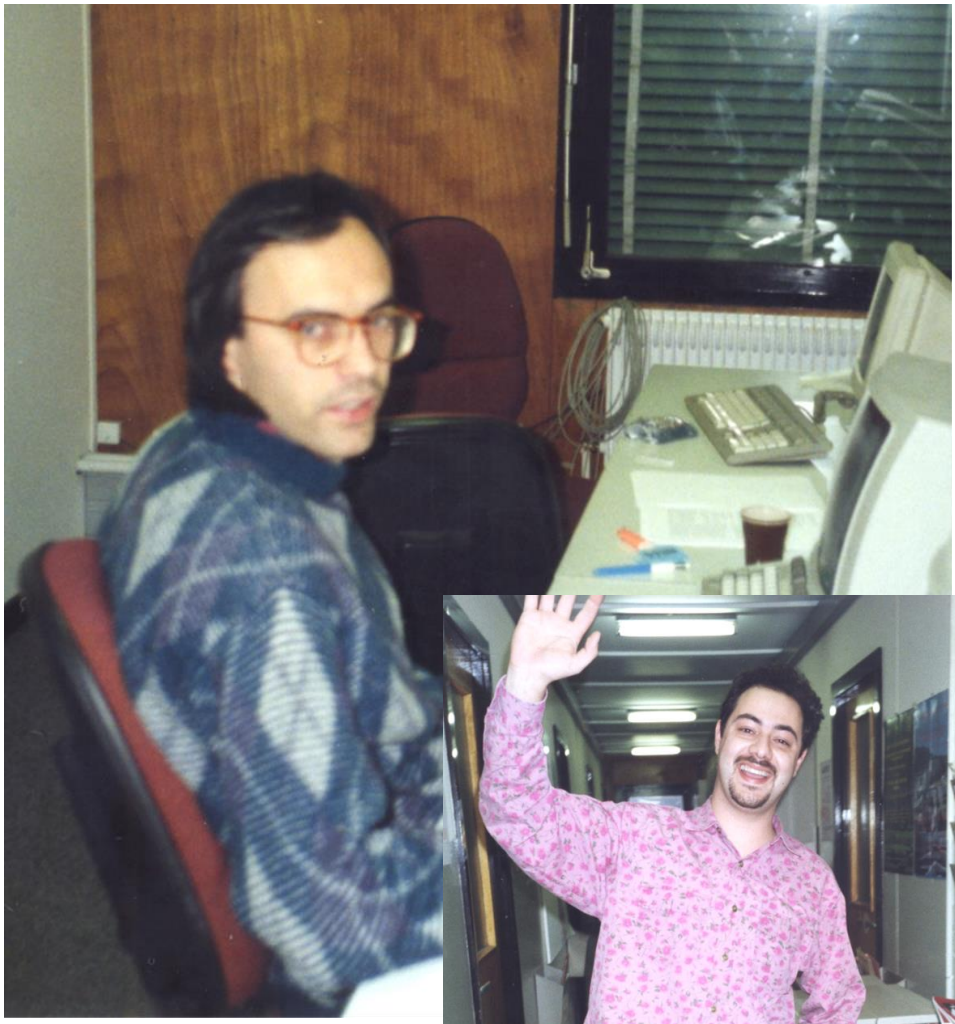


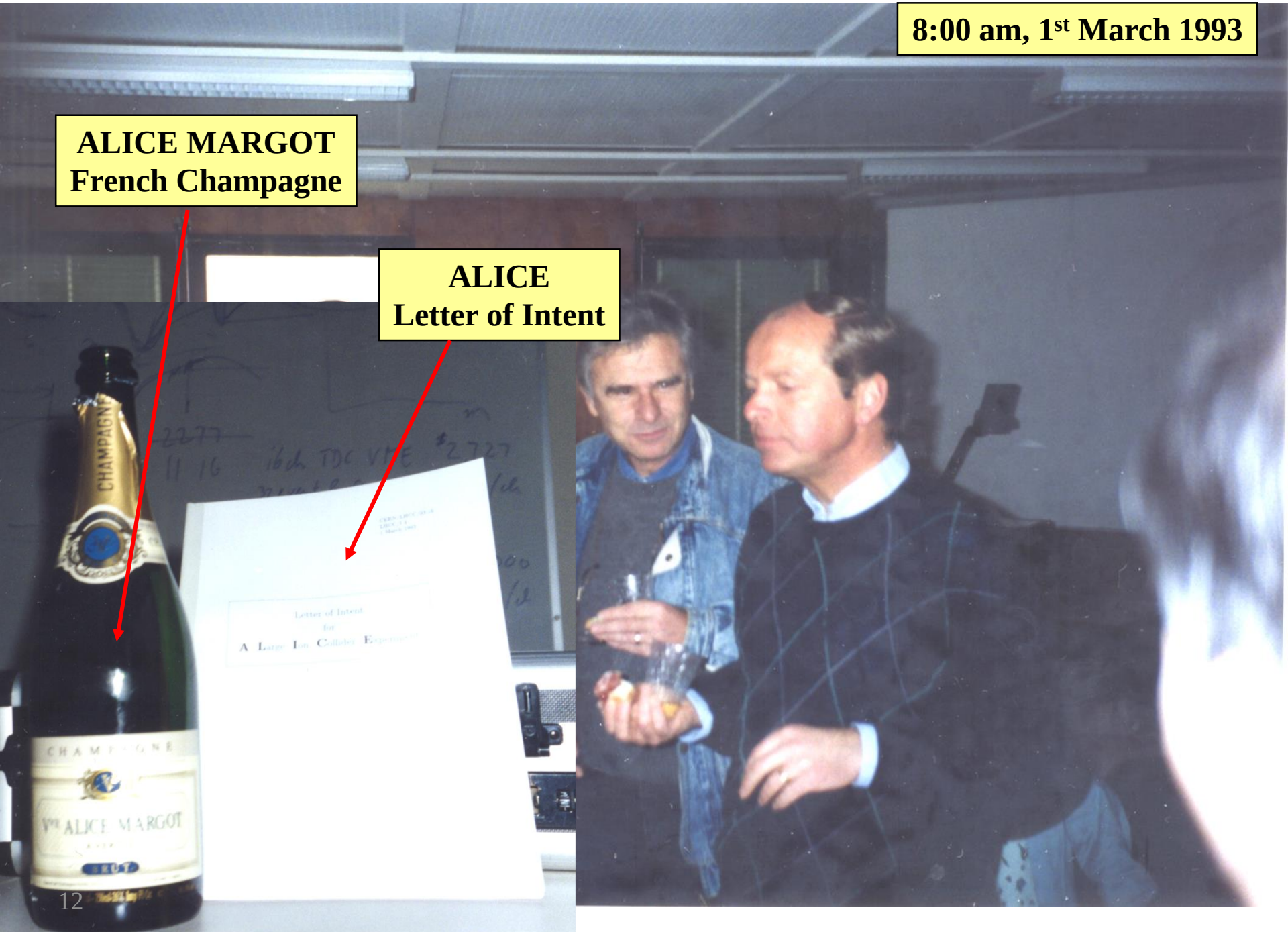
Christening of ALICE :
"A Large Ion Collider Experiment"



Runner up: **Lion Codec**
Large Ion Collider Detector

Final touches on the LoI




8:00 am, 1st March 1993
ALICE MARGOT
French Champagne
ALICE
Letter of Intent
CHAMPAGNE
Vve ALICE MARGOT
Letter of Intent
for

The Making of ALICE

- Pre-History
  - ⇨ **early 80's**: LHC first discussed
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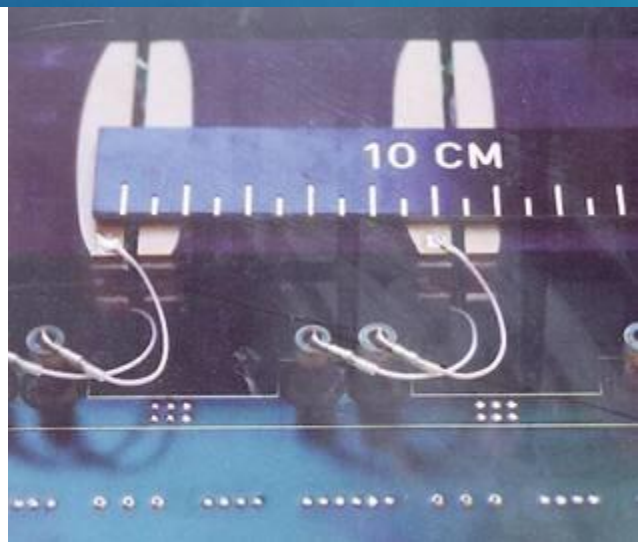
  - ⇨ **1992: Expression of Interest** (Evian)
- Design and **R&D**
  - ⇨ **1993: Letter of Intent**
  - ⇨ **1990 – 2002+: Detector R&D**



The Making of ALICE

- **Pre-History**
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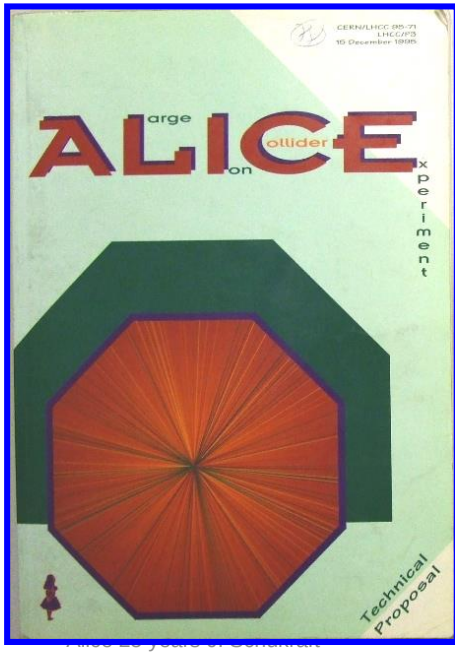
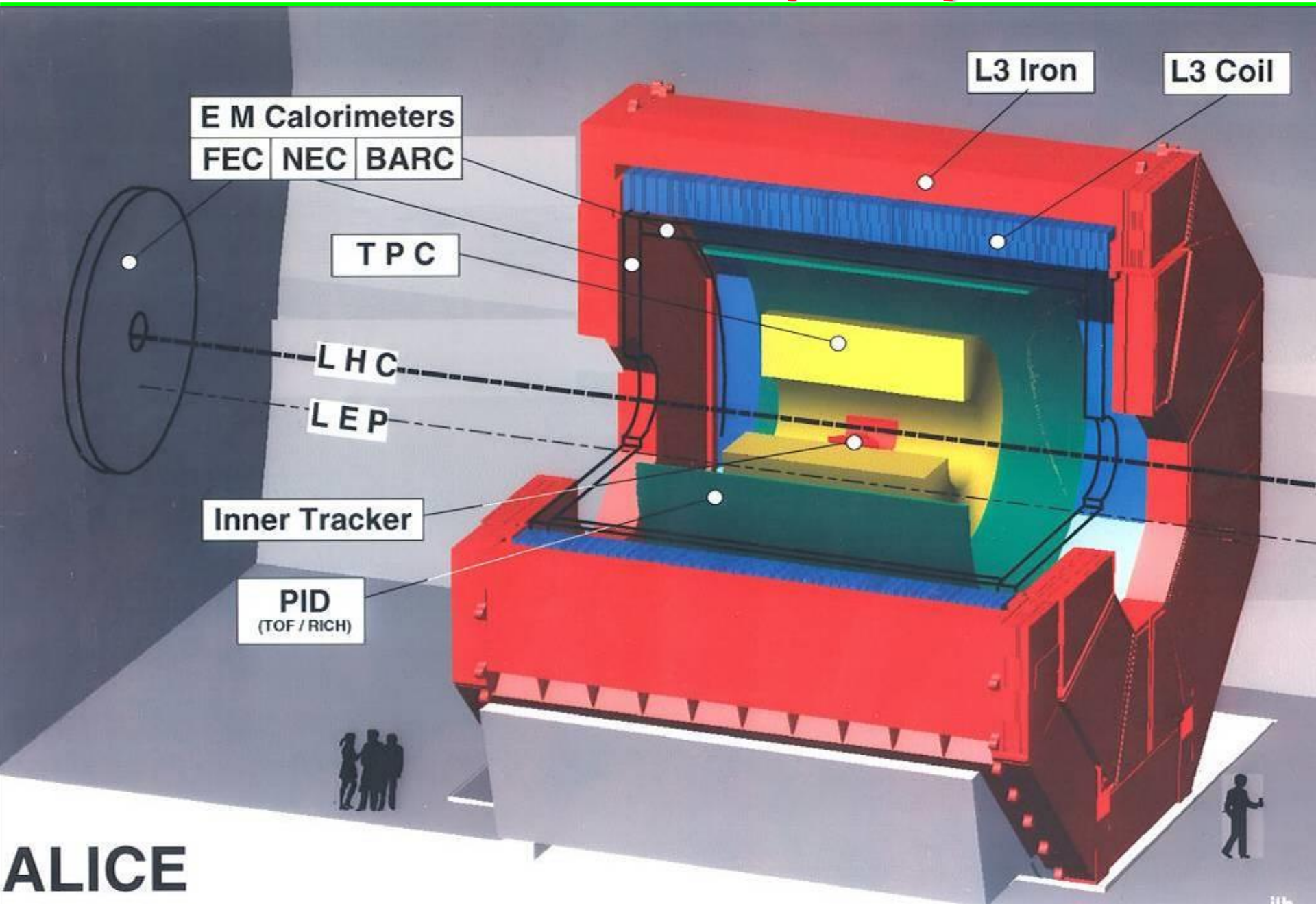
  - ⇨ **1992: Expression of Interest** (Evian)
- **Design and R&D**
  - ⇨ **1993: Letter of Intent**
  - ⇨ **1990 – 2002+: Detector R&D**
  - ⇨ **1995**: **Technical Proposal** **ALICE approved in 1997**
    - ✪ 1996 TP Addendum 1: add muon spectrometer
    - ✪ 1999 TP Addendum 2: add electron-spectrometer (TRD)
    - ✪ 2006 TP Addendum 3: add jet calorimeter (EMCAL)
    - ✪ **!! ALICE upgrades underway continuously since 1996 !!**
  - ⇨ **1998 – 2008:** Technical Design Reports

Mexico City, Mexico, Centro de Investigación y de Estúdios Avanzados[‡]: G. Herrera Corral, E. Linares and H. Mendez.

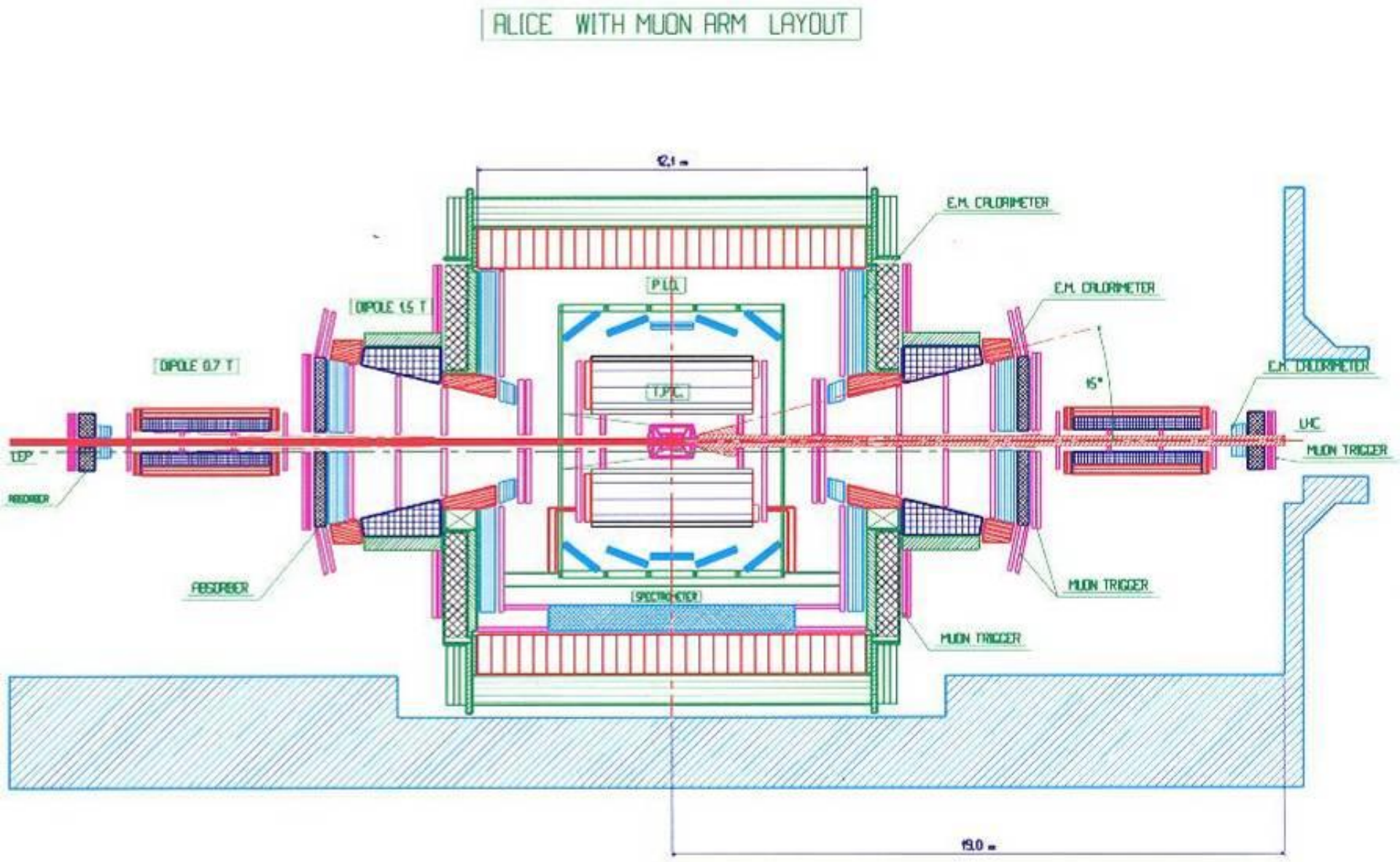


LoI Detector (1993)

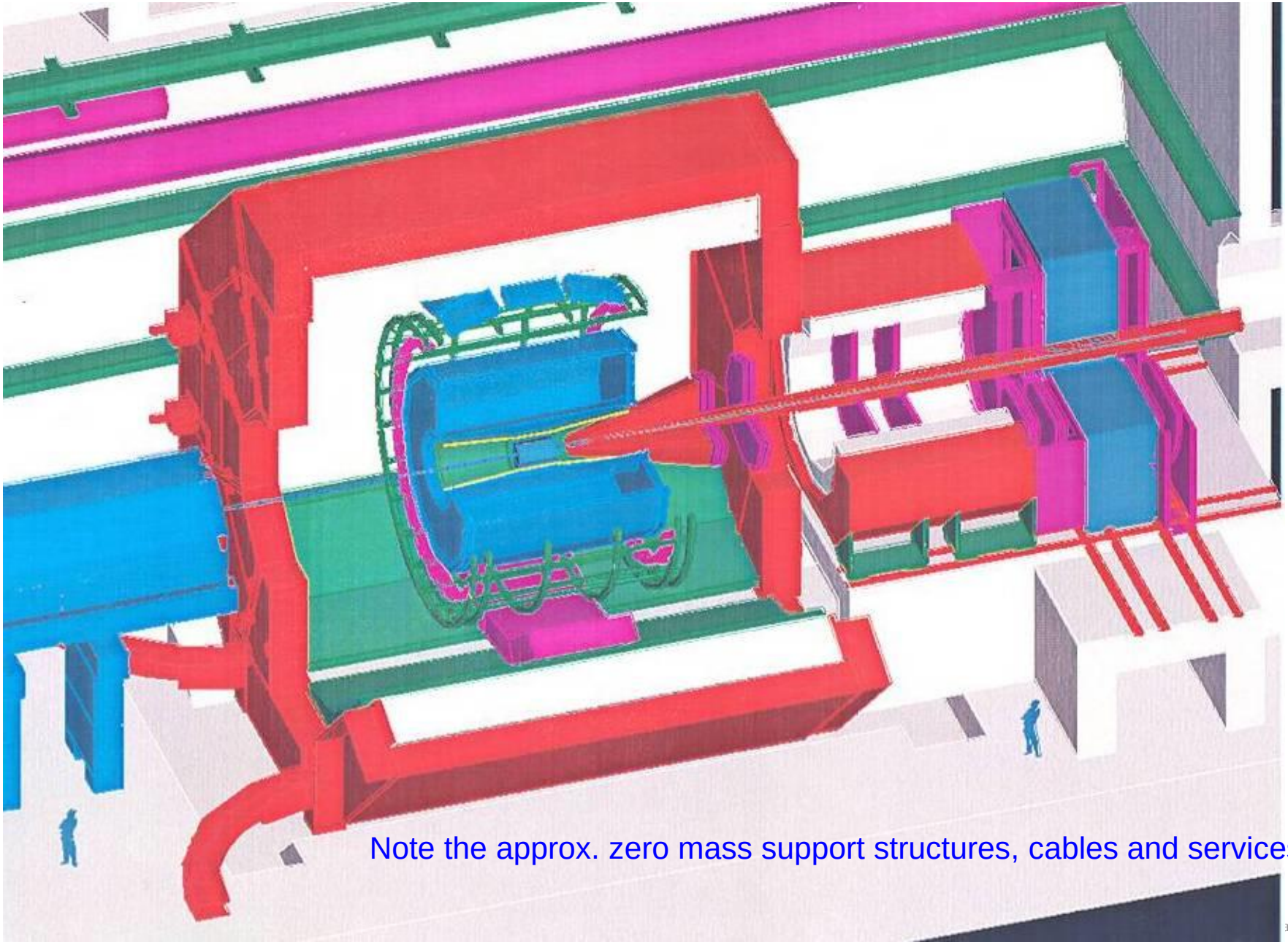


Mega-ALICE (1994)

2 muon arms + assorted forward detectors (later outsourced to ‘Felix’ proposal)

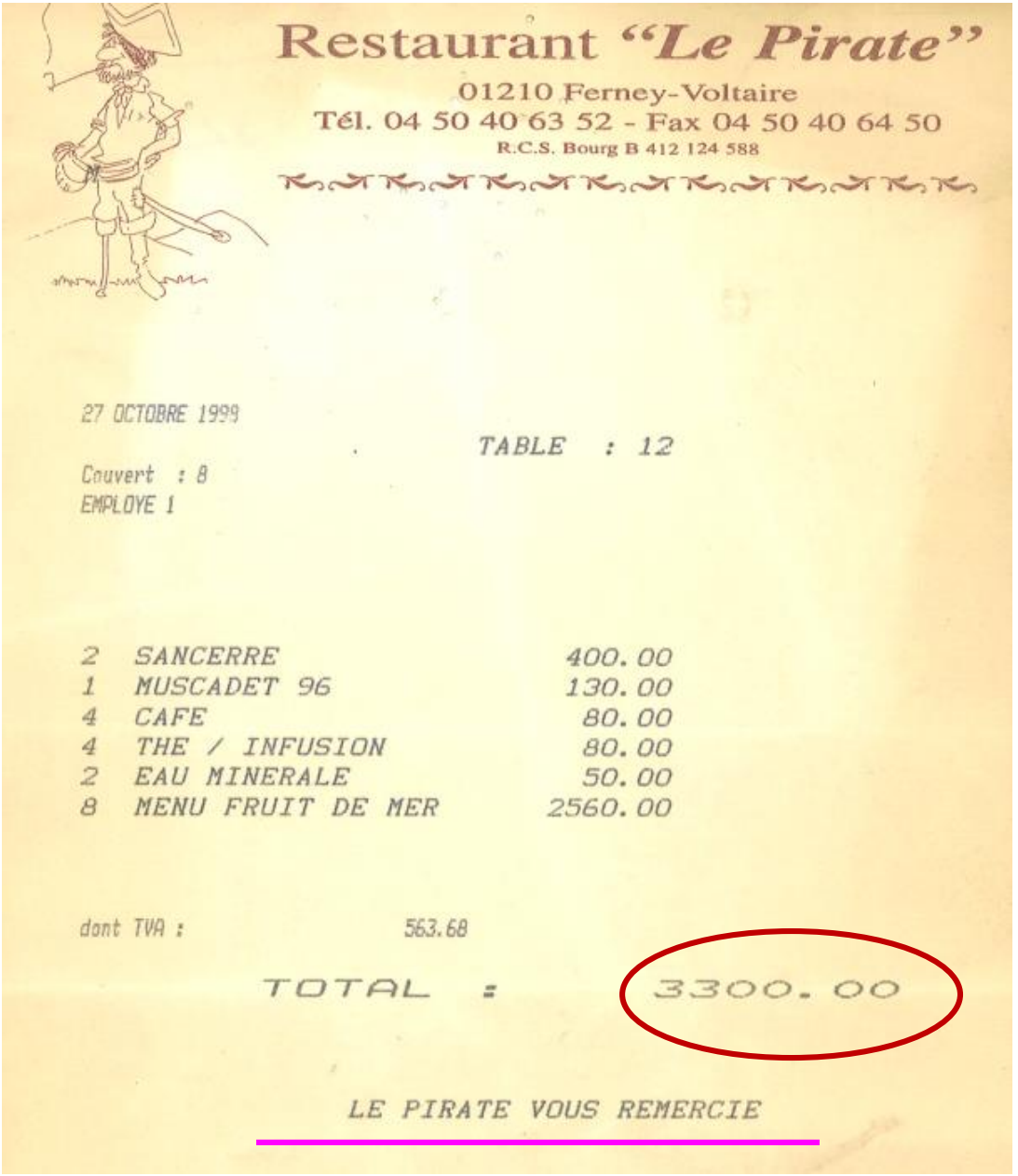


TP Design (1995)



Note the approx. zero mass support structures, cables and services !

27 October 1999
The ‘L3’ magnet formally changes hands



Restaurant “Le Pirate”

01210 Ferney-Voltaire
Tél. 04 50 40 63 52 - Fax 04 50 40 64 50
R.C.S. Bourg B 412 124 588

27 OCTOBRE 1999

TABLE : 12

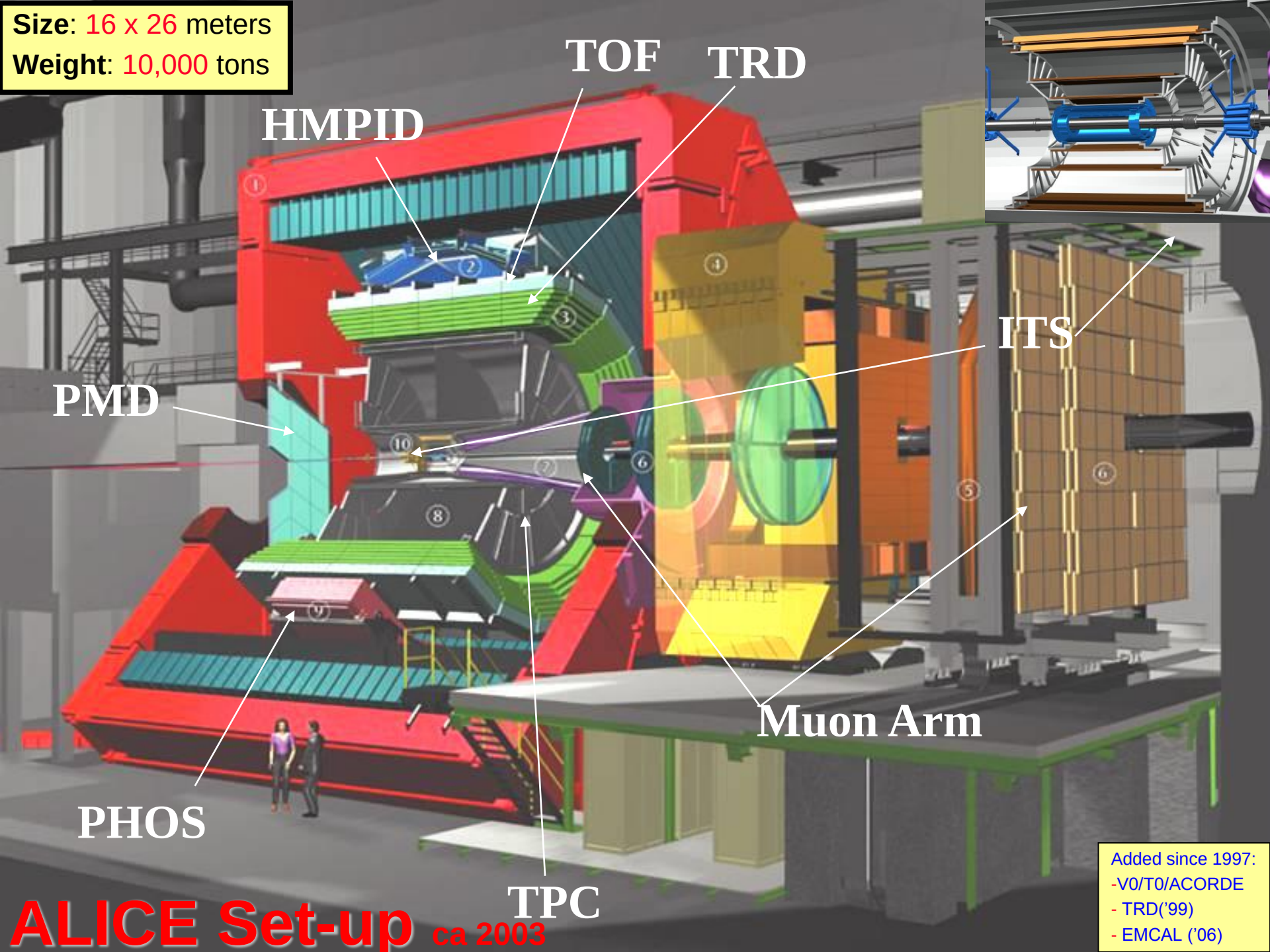
Couvert : 8
EMPLOYE 1

2	SANCERRE	400.00
1	MUSCADET 96	130.00
4	CAFE	80.00
4	THE / INFUSION	80.00
2	EAU MINERALE	50.00
8	MENU FRUIT DE MER	2560.00

dont TVA : 563.68

TOTAL : 3300.00

LE PIRATE VOUS REMERCIE


Size: 16 x 26 meters
Weight: 10,000 tons
TOF
TRD
HMPID
ITS
PMD
Muon Arm
PHOS
TPC
ALICE Set-up ca 2003
Added since 1997:
-V0/T0/ACORDE
- TRD('99)
- EMCAL ('06)

ALICE Collabora

42 countries, 176 institutes, 1800 members

- **~ 1000 Members**

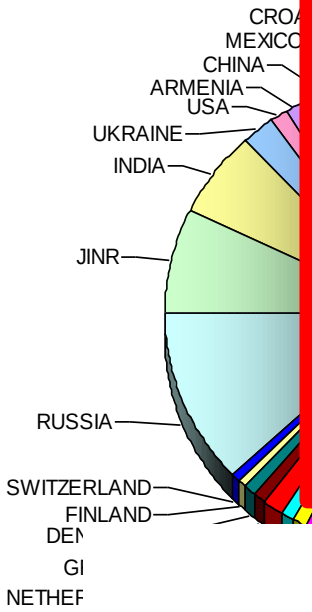
  (63% from CERN MS)

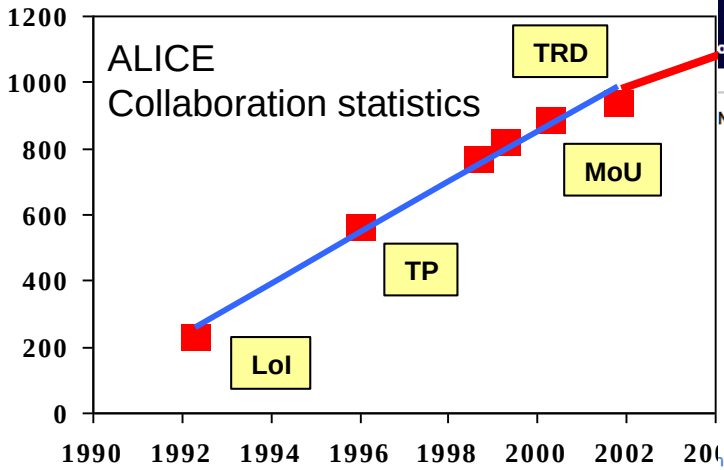
- **~30 Countries**

- **~100 Institutes**

- **~ 150 MCHF capital cost**

  (+ 'free' magnet)





ALICE

ALICE - A Large Ion Collider Experiment

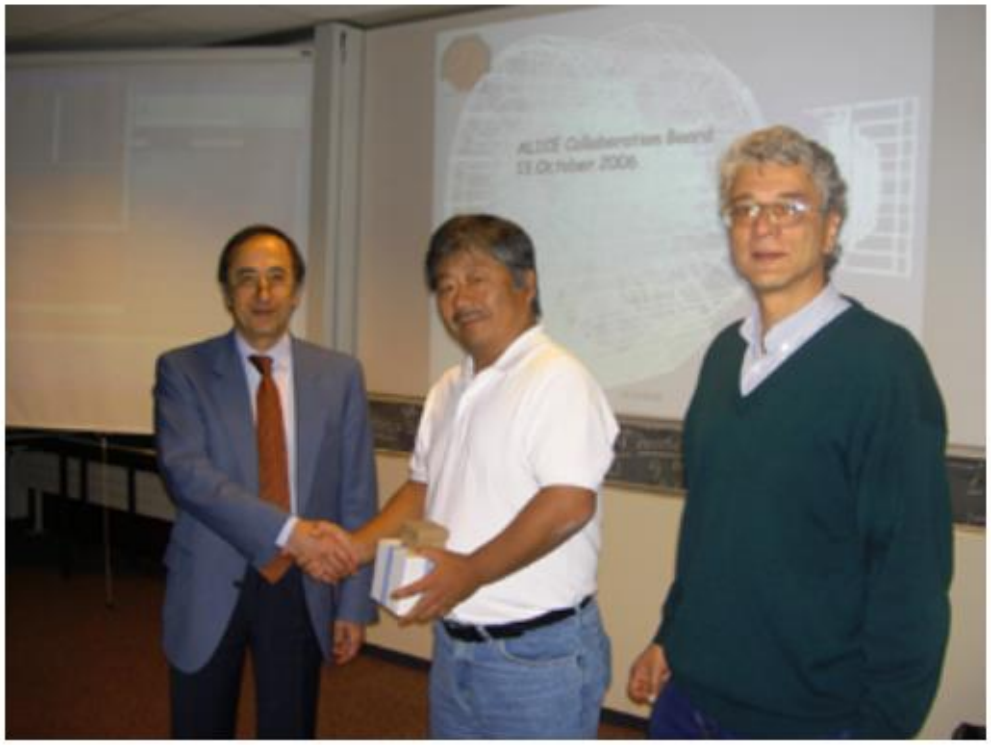
SYNONYM:
RESEARCH PROGRAMME: LHC
APPROVED: 06-02-1997
BEAM:
STATUS: Data Taking

Overview | Institutes | Participants

SPOKESPERSON: Federico ANTINORI
DEPUTY SPOKEPERSON(S): Boris HIPPOLYTE, Tapan Kumar NAYAK
CONTACT PERSON:
TECHNICAL COORDINATOR: Werner RIEGLER

NUMBER OF INSTITUTES: 167
NUMBER OF AUTHORS: 919
NUMBER OF PARTICIPANTS: 2802
NUMBER OF COUNTRIES: 41

THE THOUSANDTH ALICE MEMBER



From left to right: Lodovico Riccati, Toru Sugitate and Jurgen Schukraft.

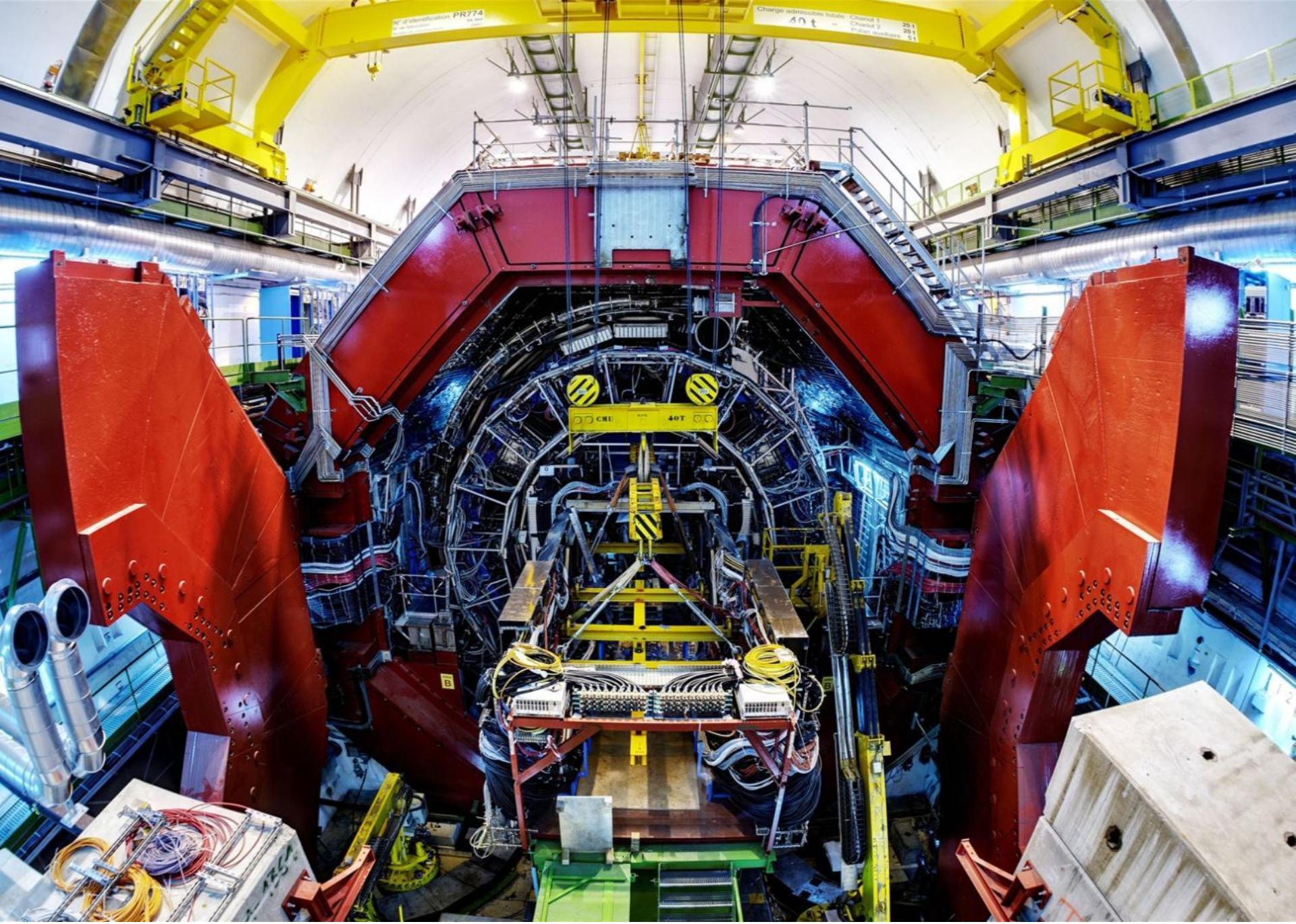
On Friday 13 October, the ALICE Collaboration Board accepted, as full members, nine new institutes, bringing the number of scientists from 982 to 1015. To celebrate this event, Lodovico Riccati, Chair of the Collaboration Board, and Jurgen Schukraft, Spokesperson of the ALICE Experiment, presented a small award to the thousandth collaborator, Toru Sugitate, from Hiroshima University.

The Making of ALICE

- **Pre-History**
  - ⇨ **early 80's**: LHC first discussed
  - ⇨ **1986:** start of Heavy Ion Physics at SPS & AGS
  - ⇨ **1990:** RHIC approved
- **Conceptual Studies**
  - ⇨ **1990: First ideas** developed (Aachen)
  - ⇨ **1992: Expression of Interest** (Evian)
- **Design and R&D**
  - ⇨ **1993: Letter of Intent**
  - ⇨ **1990 – 2002+: Detector R&D**
  - ⇨ **1995-2008**: **Technical Proposals & Technical Design Reports**
- **Construction & Installation & Comissioning**
  - ⇨ **2000 – 2007:** Bulk of construction
  - ⇨ **2002 – early 2008:** Installation
  - ⇨ **2007 – first beam:** detector commissioning in situ

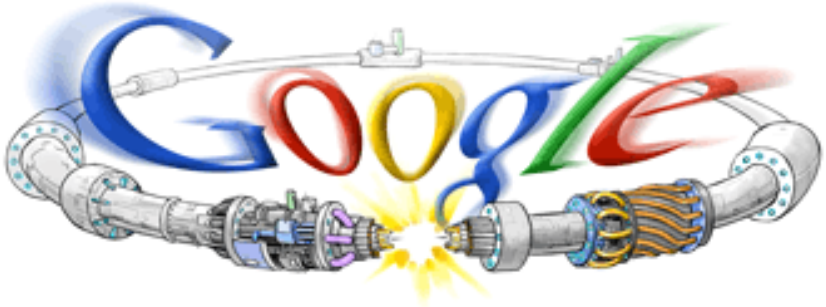
finished only in 2010/11 (TRD/EMCAL)

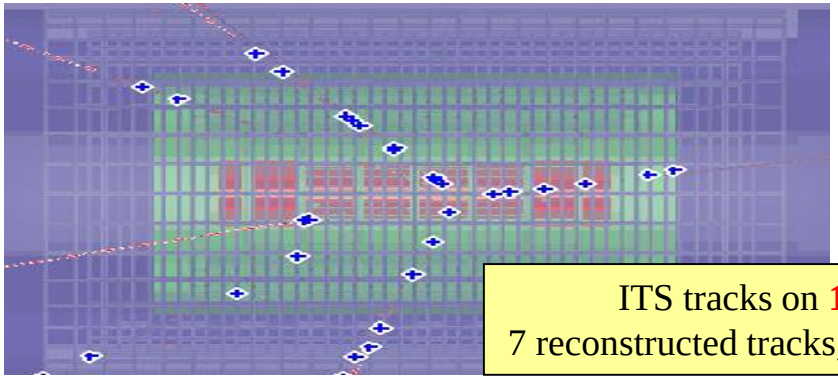
Spring Cleaning in 2001


CMU
40T

Fast Forward to

- September 2008:
  - ⇨ LHC starts





ITS tracks on **12.9.2008**
7 reconstructed tracks, common vertex

- November 2009:
  - ⇨ Start of Physics @ LHC

Magnet accident **19.9.2008**

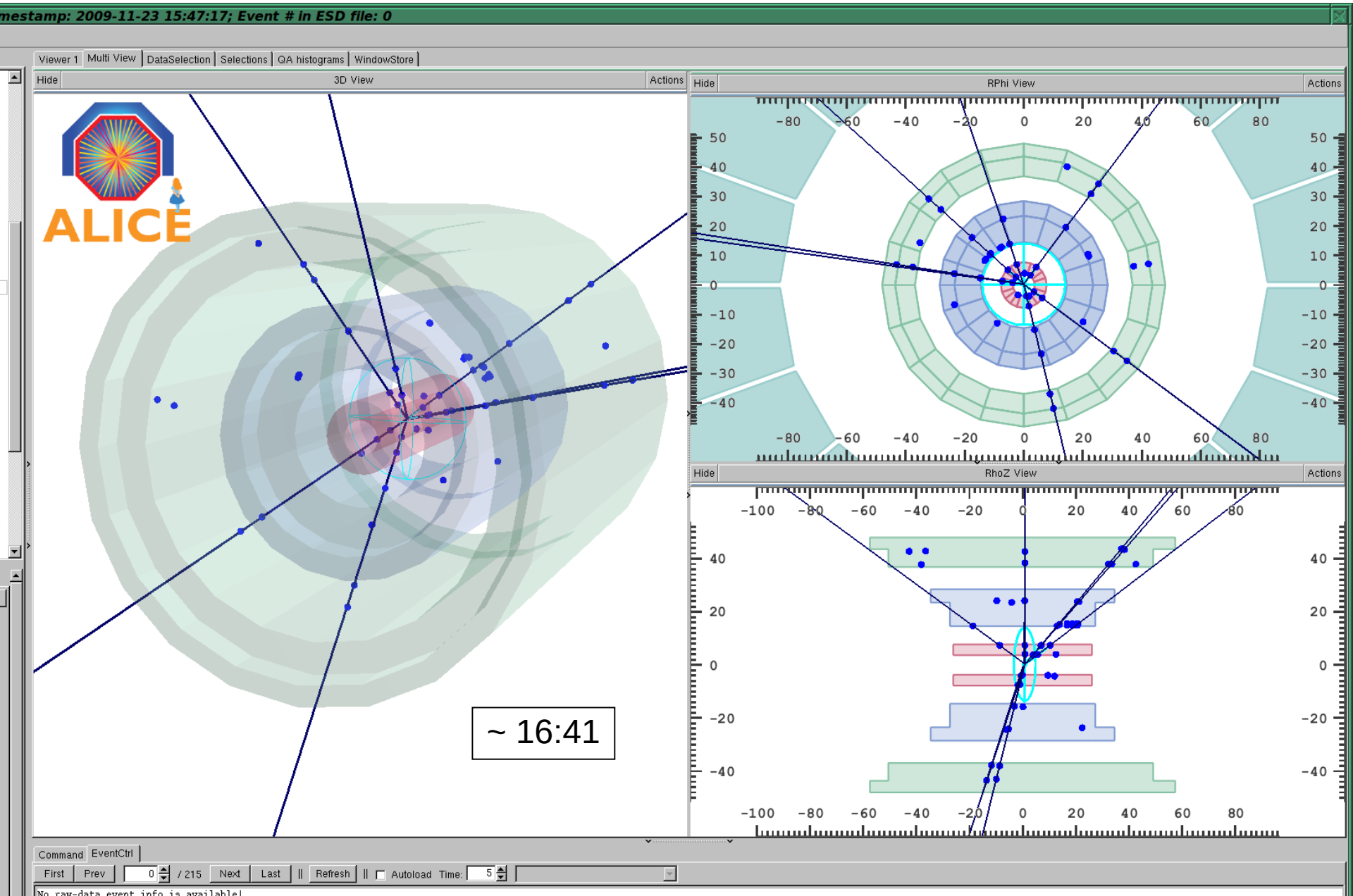
First collisions at LHC: 23 November 2009

..after concentrated preparations..

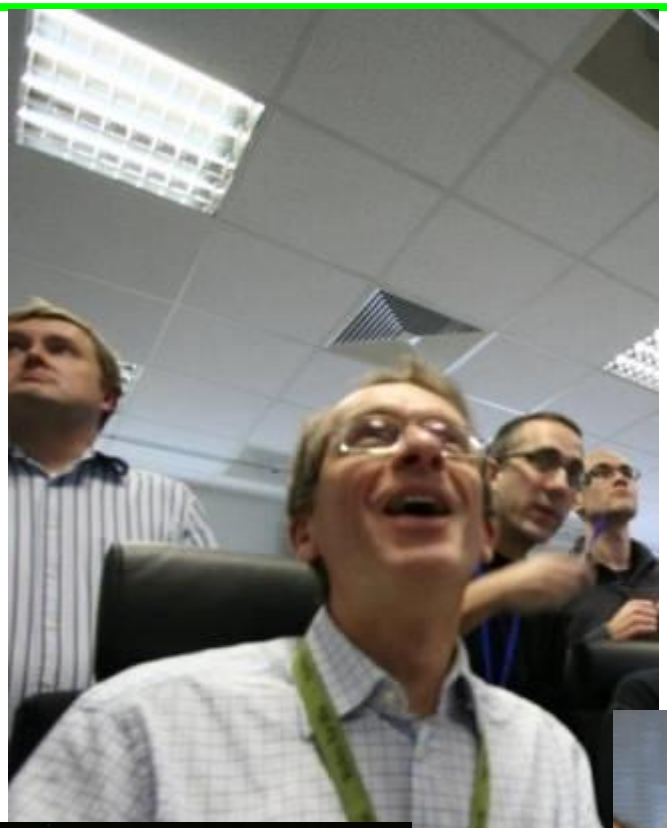
.. and tense anticipation..

Monday, 23rd November, ~15:30
in the ALICE Control Room

The first ‘event’ pops up in the ACR



Relief and jubilation..

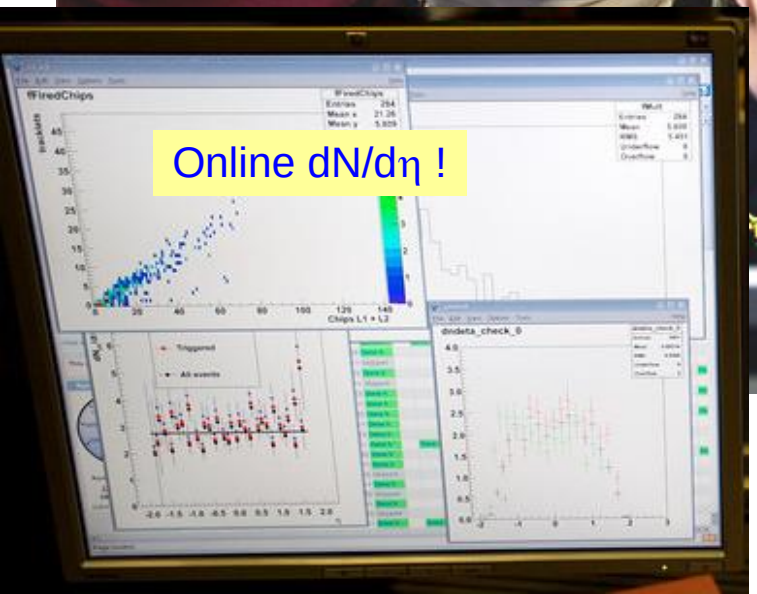


Collisions in ALICE !!

~ 16:42

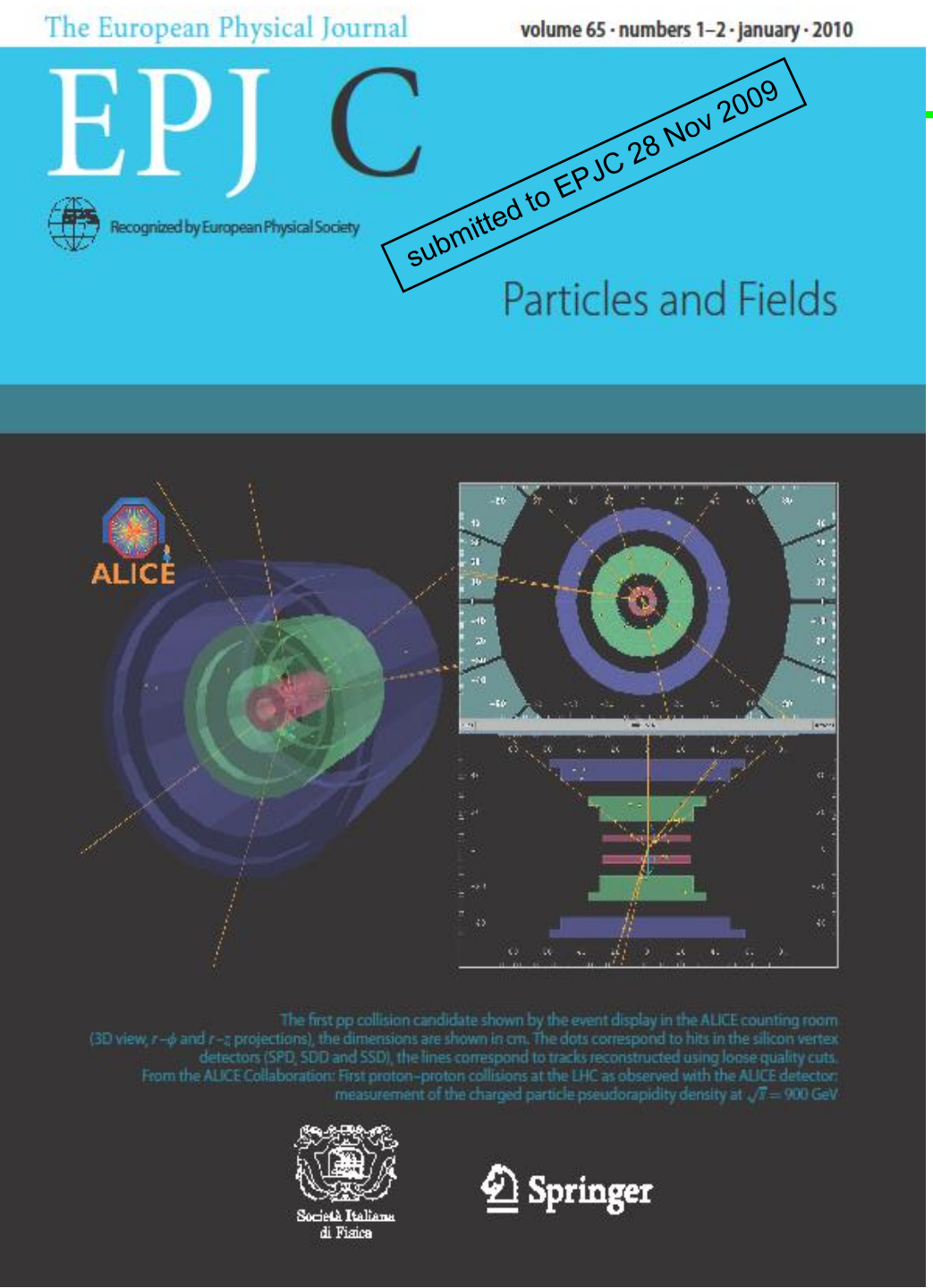
.. and some celebration..

‘First Physics’ in the making



~ 18:00

After years of looking at simulated data, there was no holding back:
First physics results examined,
ca 1 hour after data taking finished (284 events !)..



- It took:
  - ⇨ 20 years to built ALICE
  - ⇨ 40 minutes to take the data
  - ⇨ 1 hour to get the prel. result (±10%)
  - ⇨ 2 days for the final result
  - ⇨ ……
  - ⇨ and **3 days** to agree on the Authorlist

What did we measure ?

The average number of charged particles created perpendicular to the beam in pp collisions at 900 GeV is:

$dN/d\eta = 3.10 \pm 0.13\ (stat) \pm 0.22\ (syst)$

$\approx \pi$

National Geographic News (4 Dec.)

'….a machine called ALICE.... found that **a** (!) proton-proton collision recorded on November 23

dominated by data

dominated by Author list

- Did we make a discovery ?
  - ⇨ **discovered strong violation of 'Stocks law':**
    - ✪ 'For heavy ion experiments using a TPC, the number of tracks/event is equal to the number of authors/publication: **T/A ~ 1**'
    - ✪ discovered accidentally by NA35, confirmed by NA49 (SPS) and Star (RHIC)
    - ✪ badly broken at LHC: $T/A = 3\times10^{-3} \pm 0.13\times10^{-3}\ (stat) \pm 0.5\times10^{-3}\ (syst)$
  - ⇨ **discovered that time travel is possible:**
    - ✪ **first publication was submitted 7 days BEFORE first scheduled collisions !**

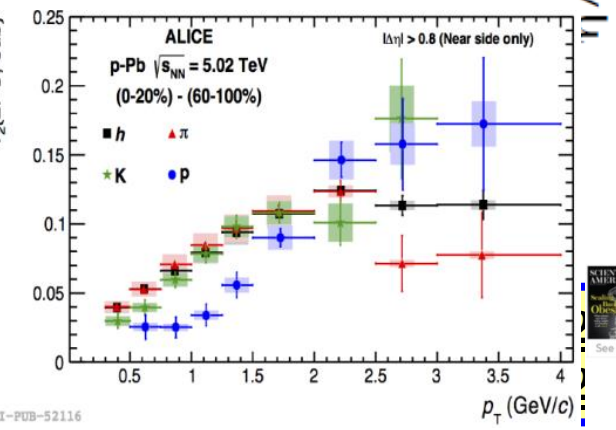
Heavy Ion Physics@LHC: a 'Smashing' Success

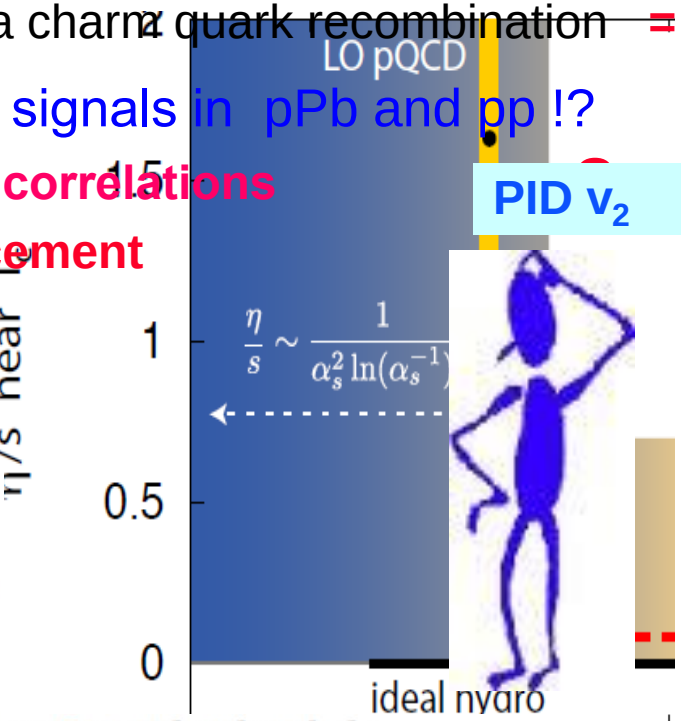
- QGP precision measurements
  - ⇨ almost frictionless ideal liquid: $1/4\pi < \eta/S < 2/4\pi$
  - ⇨ very strongly interacting: $\hat{q} = 1.9 \pm 0.7\ GeV^2/fm$

η/S = shear viscosity /Entropy

q = opacity ('stopping power')

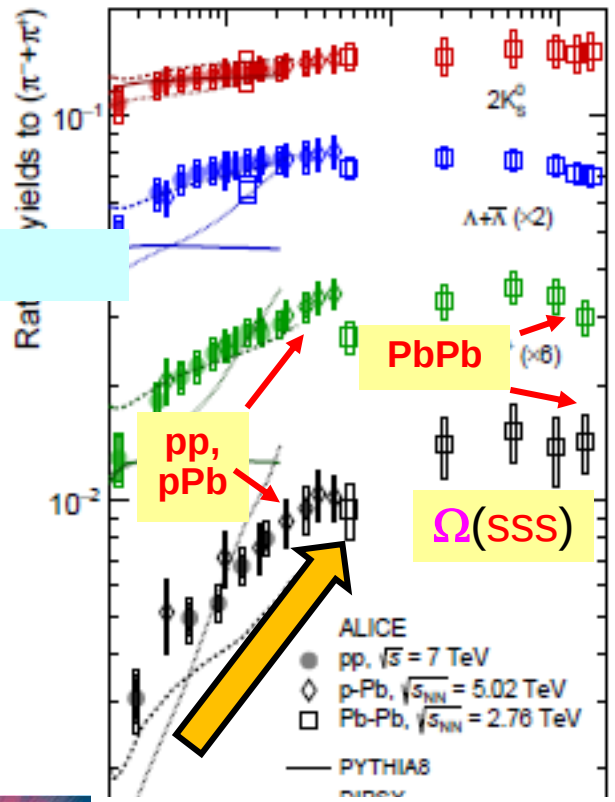
- Deconfinement
  - ⇨ sequential **Y suppression** =
  - ⇨ **J/Ψ enhancement** via charm quark recombination =
- **Surprise:** 'QGP-like' signals in pPb and pp !?
  - ⇨ **collective 'flow-like' correlations**
  - ⇨ **strangeness enhancement**

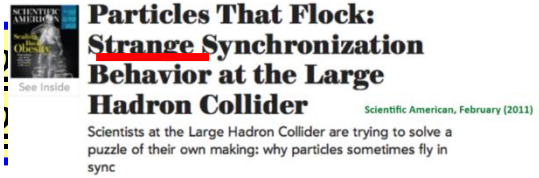




PID v_2

Strangeness Enhancement





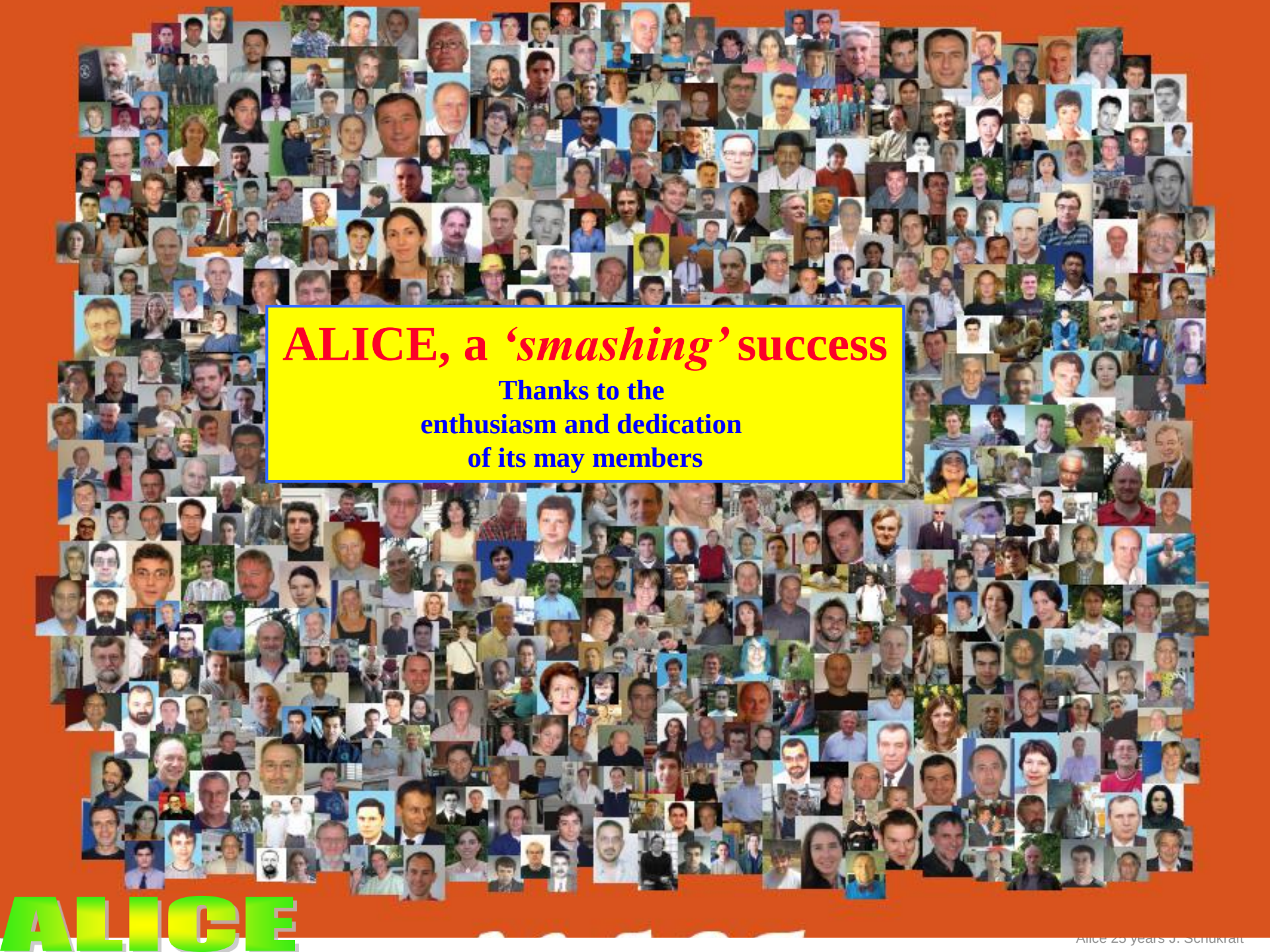
Particles That Flock: Strange Synchronization Behavior at the Large Hadron Collider

Scientific American, February (2011)

Scientists at the Large Hadron Collider are trying to solve a puzzle of their own making: why particles sometimes fly in sync

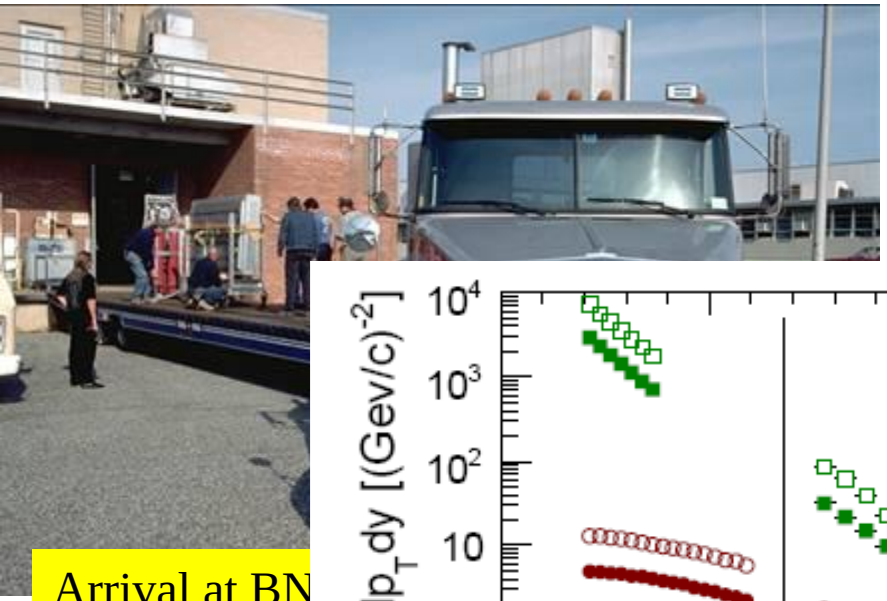
News and Views

Particle physics: Alice in strangeland

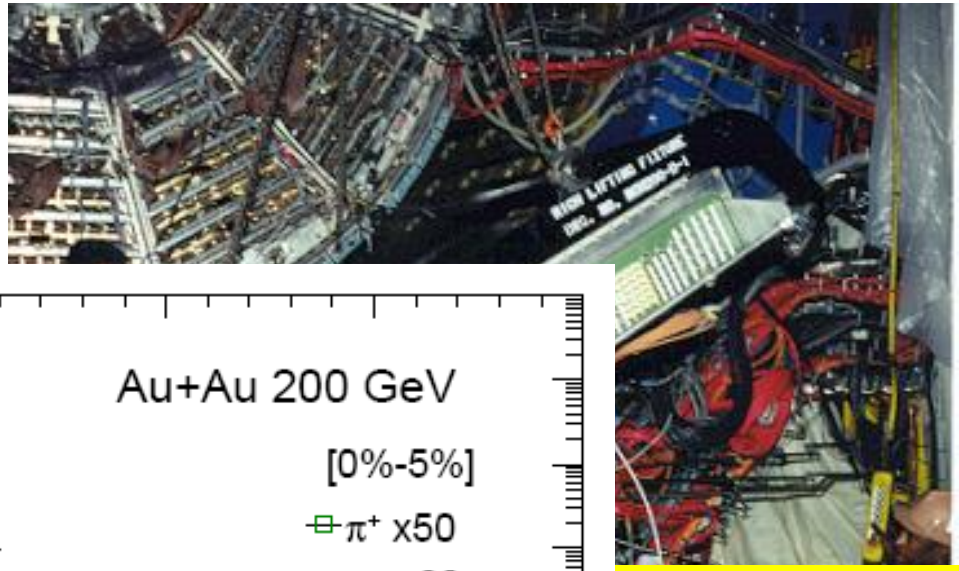

ALICE, a 'smashing' success
Thanks to the
enthusiasm and dedication
of its may members
ALICE

Spares

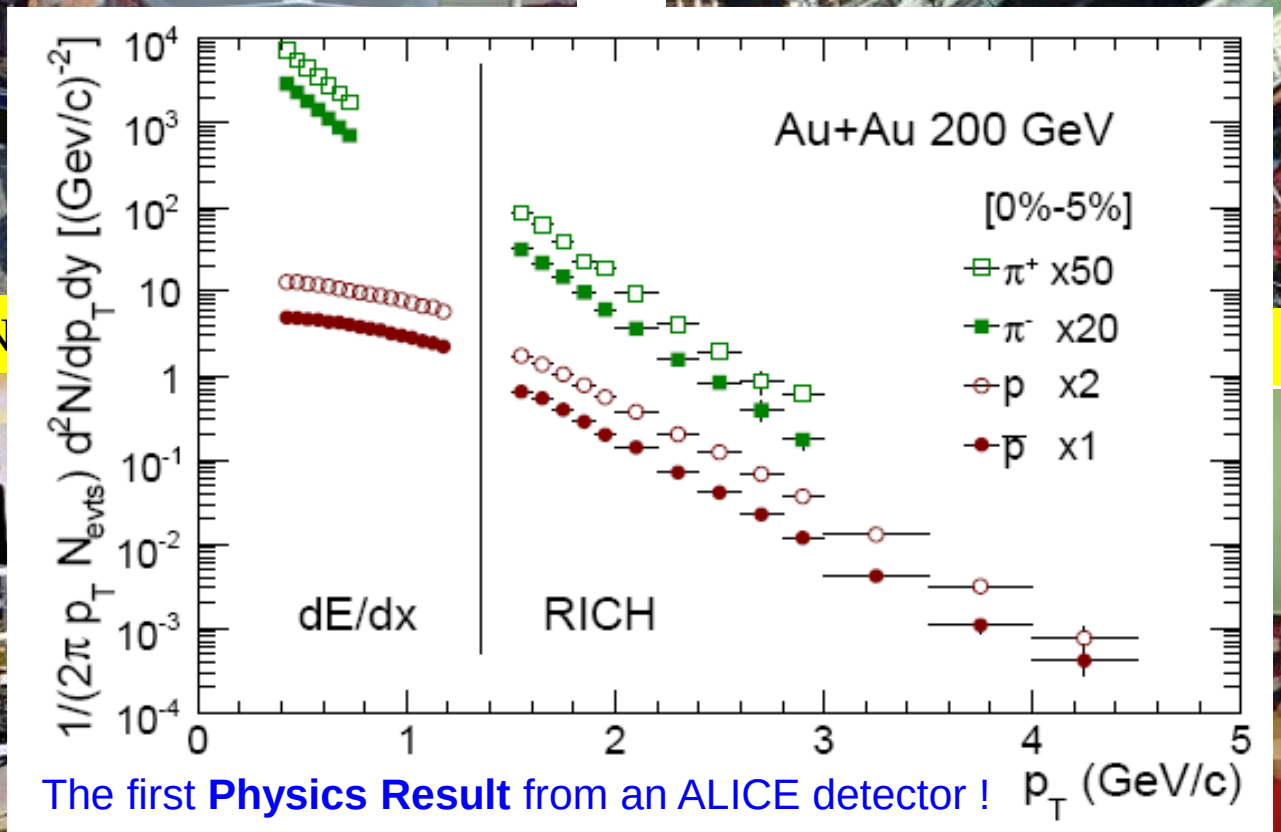
RICH proto-2: Sabbatical at RHIC



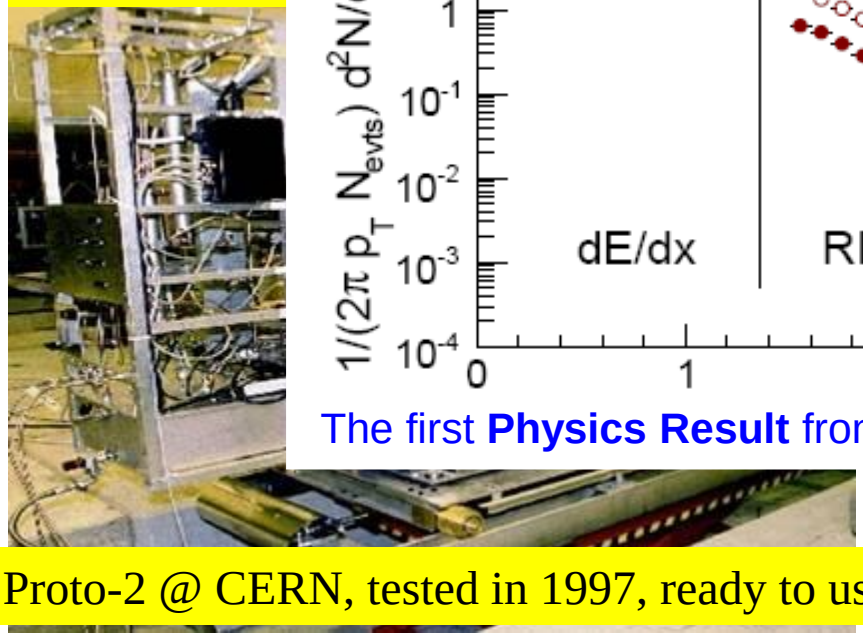
Arrival at BN



November 1999



The first **Physics Result** from an ALICE detector !



Proto-2 @ CERN, tested in 1997, ready to use

July 2002: Back home again

ALICE R&D

1990-2002:Strong, well organized, well funded R&D activity

Inner Tracking System (ITS)

- Silicon Pixels (RD19)
- Silicon Drift (INFN/SDI)
- Silicon Strips (double sided)
- low mass, high density interconnects
- low mass support/cooling

RHIC RHIC

PID

- Pestov Spark counters
- Parallel Plate Chambers
- Multigap RPC's (LAA)
- low cost PM's
- CsI RICH (RD26)

RHIC RHIC

TPC

- gas mixtures (RD32)
- new r/o plane structures
- advanced digital electronics
- low mass field cage

RHIC

DAQ & Computing

- scalable architectures with COTS
- high perf. storage media
- GRID computing

em calorimeter

- new scint. crystals (RD18)

misc

- micro-channel plates
- rad hard quartz fiber calo.
- VLSI electronics

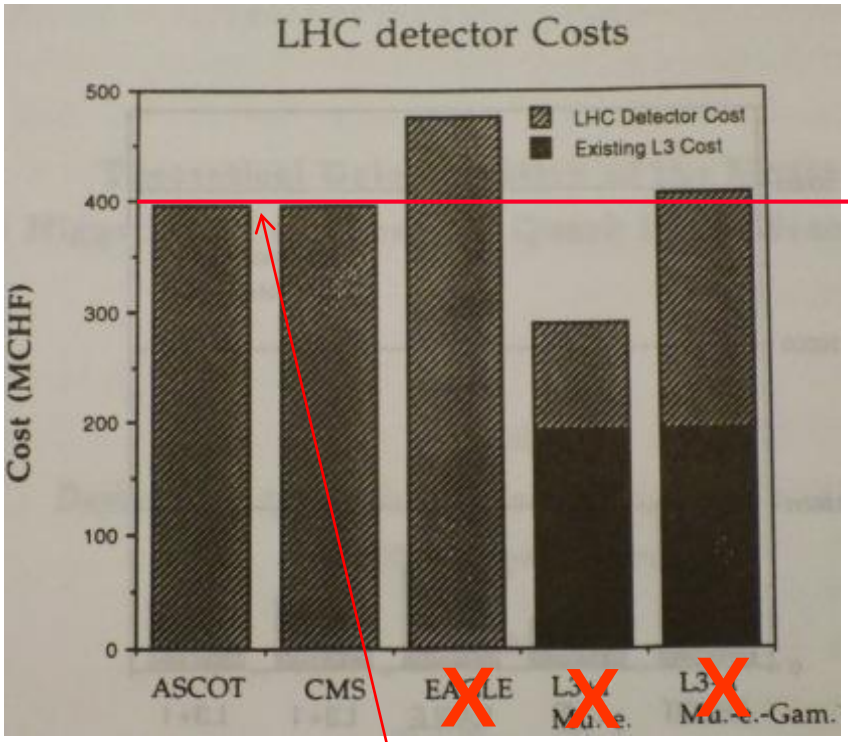
- **R&D made effective use of long (frustrating) wait for LHC**
- **was vital for all experiments to meet LHC challenge !**


Members of the ALICE Technical Board 2002


The ALICE
magnet end 2001:
ready for the experiment to move in!

Evian Workshop 1992

Summary by C. Rubbia:



Start of construction; ’94
Start of physics: ’98

Ascot = 395 M
CMS = 395 M
ALICE = 395M