Scientist looking to the future

Ученый устремленный в будущее

"…He was a giant in CMS, on whose shoulders many of us stood, to accomplish whatever we could…"

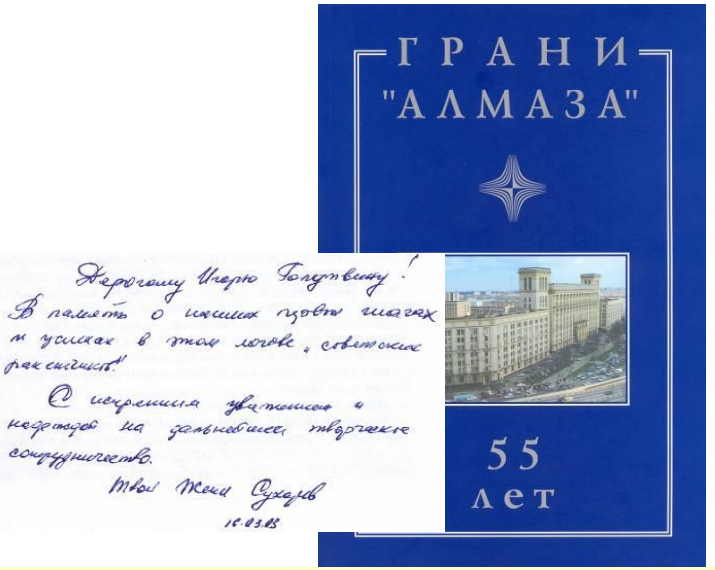
"…Он был гигант в CMS на чьих плечах стояли многие из нас, доводя до совершенства все что только могли…"

Jim Virdee 2023

The first steps in science

Igor Golutvin during education at MPhTI and later on till 1957 was working in DB-1, known as A.A.Raspletin Research and production association "Diamond", were he learned the basis of engineering science and understood a beauty and greatest of large-scale engineering projects, a role and importance of technical progress in a development of science and society

Desing Bureau -1
A.A.Raspletin Research and production association "Diamond"
КБ-1,
НПО «Алмаз» им. А.А.Расплетина



Подобно ребенку, который за первые годы жизни учится ходить, говорить и думать, за несколько лет, проведенных в КБ-1, многие молодые специалисты впитали в себя азы и принципы инженерной науки, красоту и величие крупных инженерных проектов, роль и значение технического прогресса в развитии науки и общества." –

И.А.Голутвин 24 ноября 2005 заседание РАИН

The first steps in science

But Igor Golutvin was interesting for nuclear science and that is why he jointed a team to develop a prototype of the iron-less synchrotron for Budker in Sukhumi PhTI.

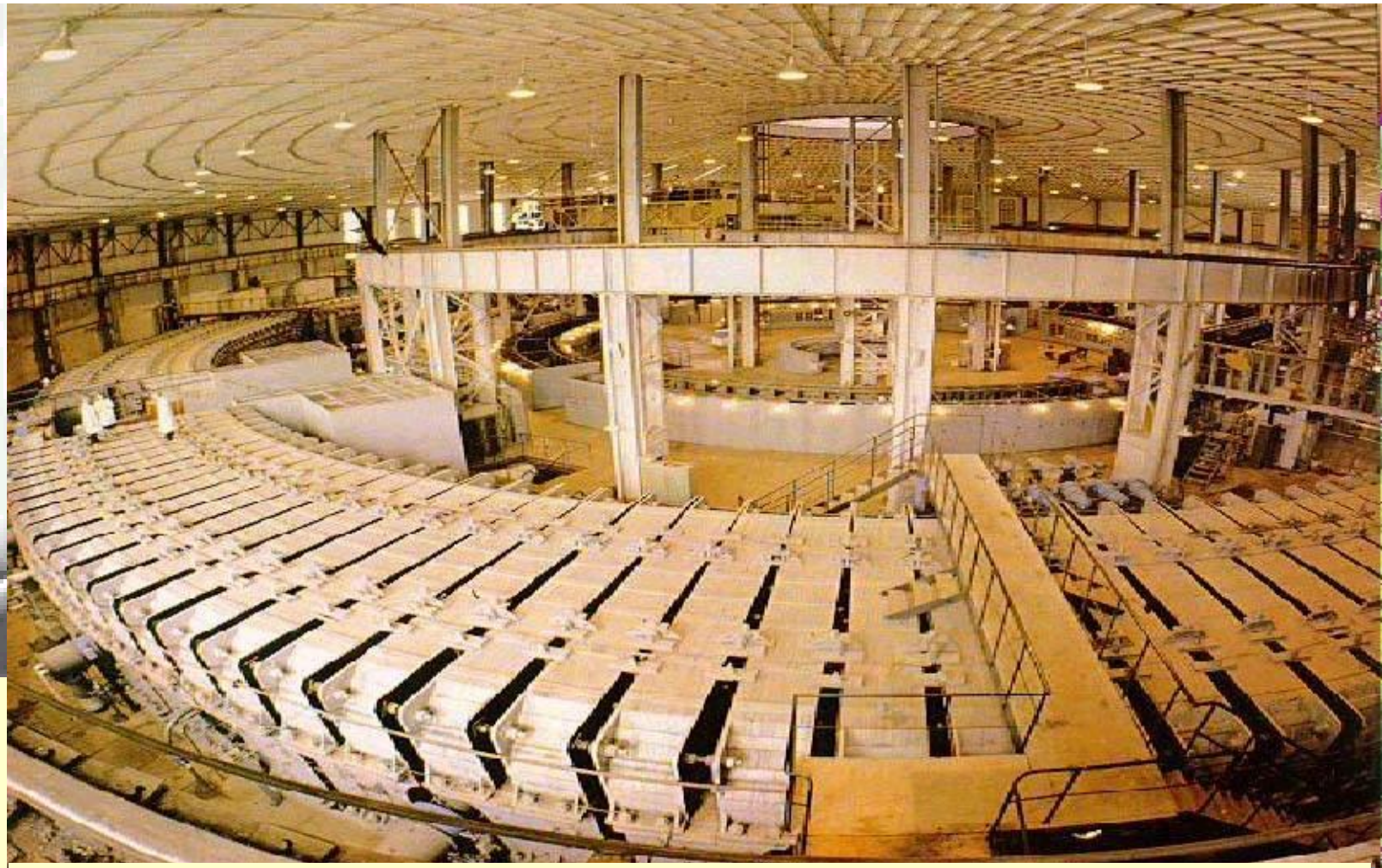
His dream was a big science and in 1958 he, with his friend Yuri Karjavin, and others was invited to JINR in Dubna, were he worked up to the end of life.

A big Science at Synchrophasotron

V.Veksler

Director of LHE

Designer of Synchrophasotron



SPT parameters: energy 10 GeV

intensity $4\ 10^{12}$ ppp

First steps at JINR, Dubna since 1958

A main detectors were photo-emulsions and bubble chambers with film readout

The first task of Golutin was a development of automatization of chamber's film

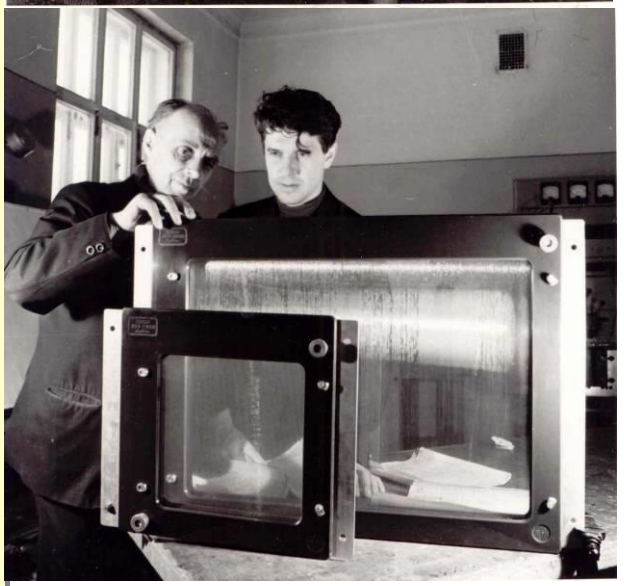
Application of scintillator and Cherenkov counters required an electronics readout

So, the second task was a development of the first nuclear electronics based on transistors

And finally pioneer works on developments of spark chambers technology with film-less readout, invention of magnet-strictive readout for spark chambers

It was a beginning high energy physics on the largest accelerator in the world

In 1964 Veksler send him to CERN, were Golutvin has found a confirmation that he is in the right way



Enthusiasts of filmless Tracking Detectors

Well known wire chamber inventors:

G.Charpak - MWPC and A.Walenta - DC

But the way for gaseous tracking detection was opened due to development of the **filmless readout**

at CERN **- F.Krienen**

at JINR **- I.Golutvin –**

pioneer and enthusiast of the tracking detectors development and its on-line applications at JINR and abroad

The first in USSR HEP on-line experiment

1967 $\pi^- p$ scattering at small transfer momenta at Dubna Synchrophasotron

Goal:

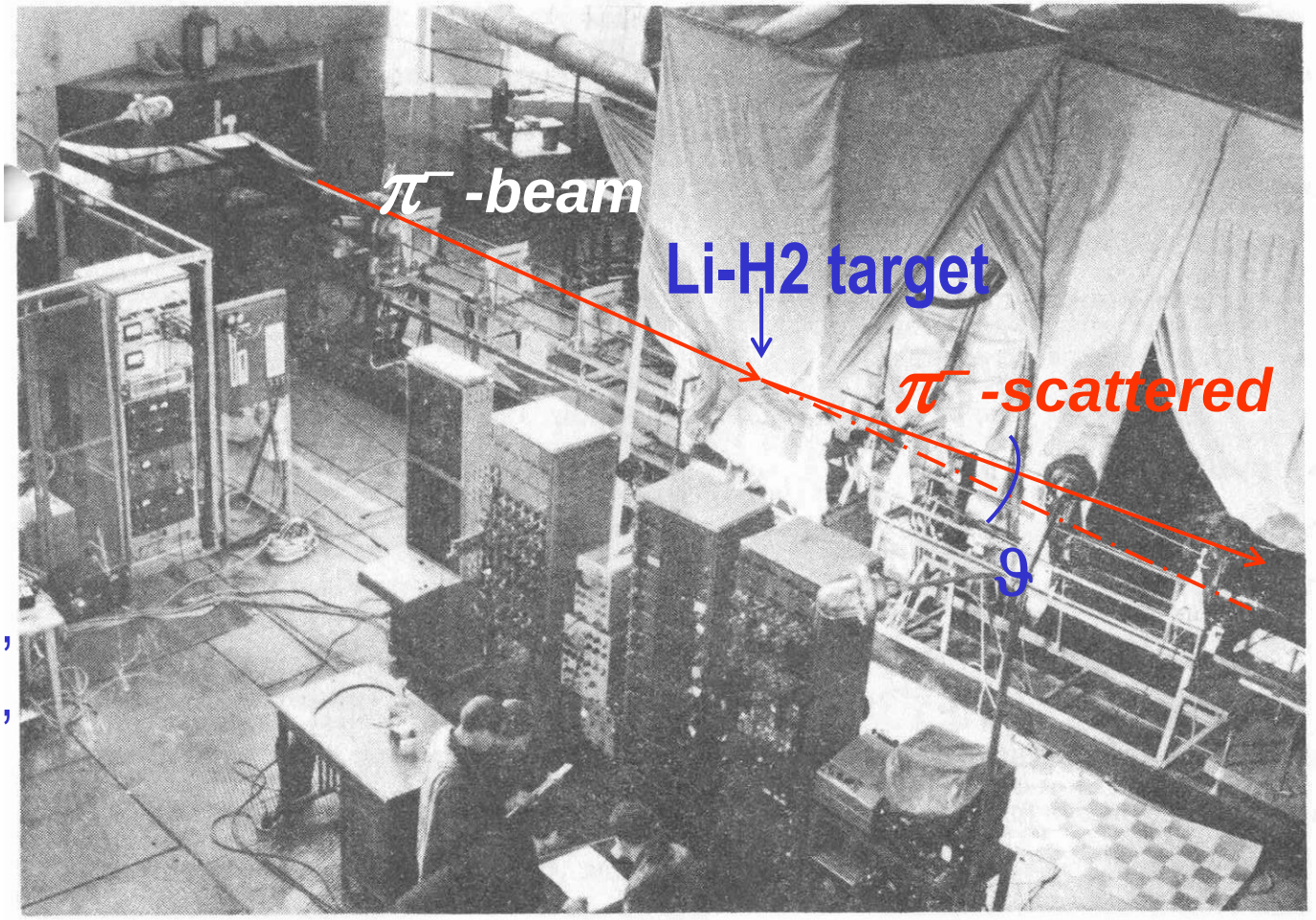
verification of forward dispersion relations

$10^{-4} \leq -t \leq 10^{-2}$ (GeV/c)^2

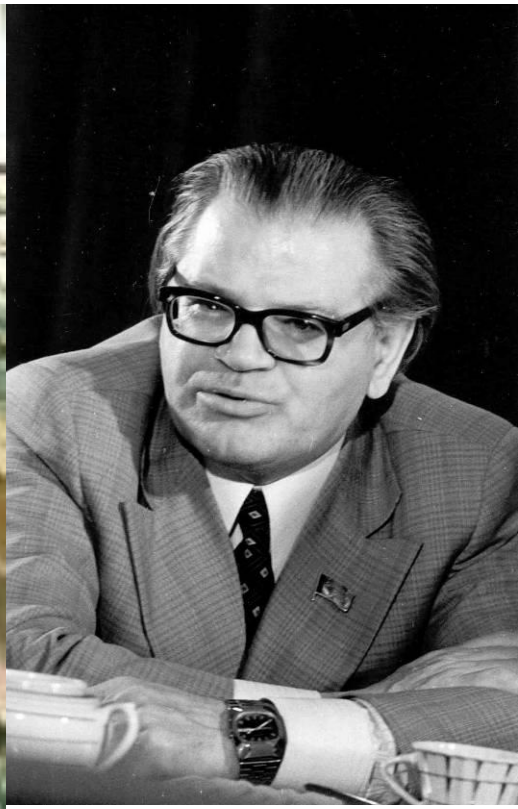
P_π = 1 - 7 GeV/c

2 mrad$\leq \vartheta \leq \pm$22 mrad

- angular resolution < 1 mrad,
- momentum resolution ~ 1%,
- high statistics ($\Delta\sigma$~1%),
- small systematics



Experiments at U-70 in Protvino

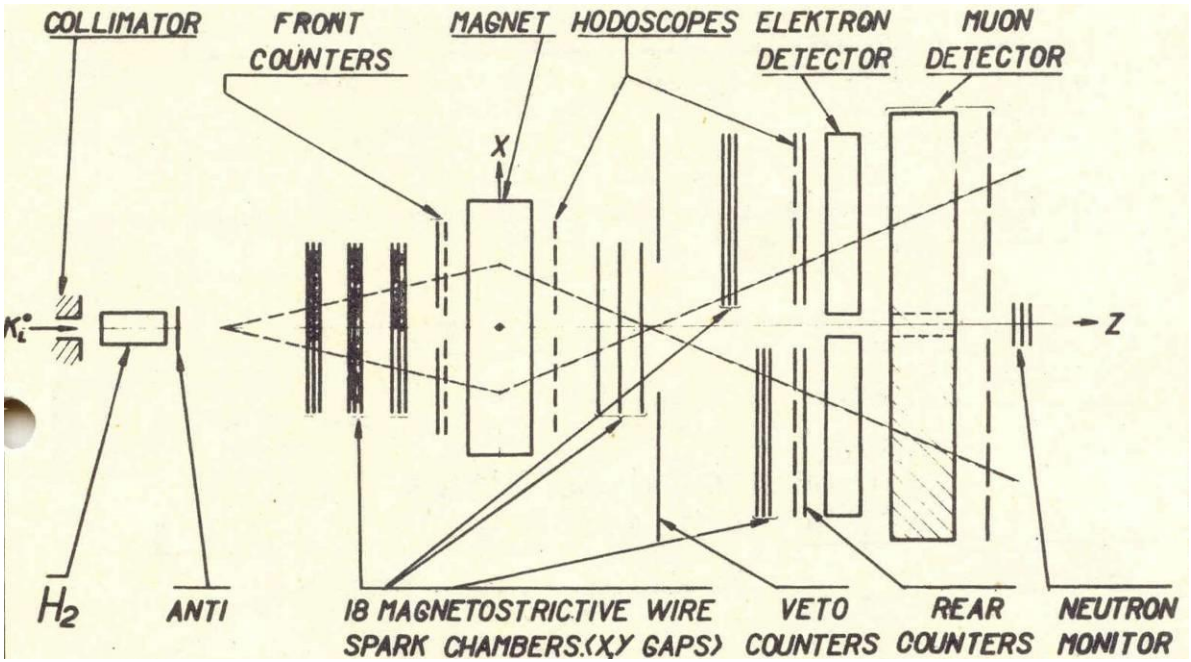


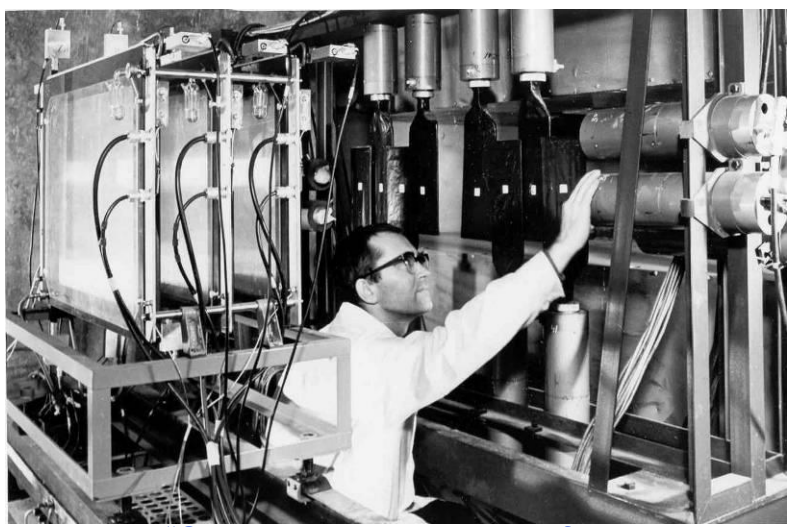
A.Logunov

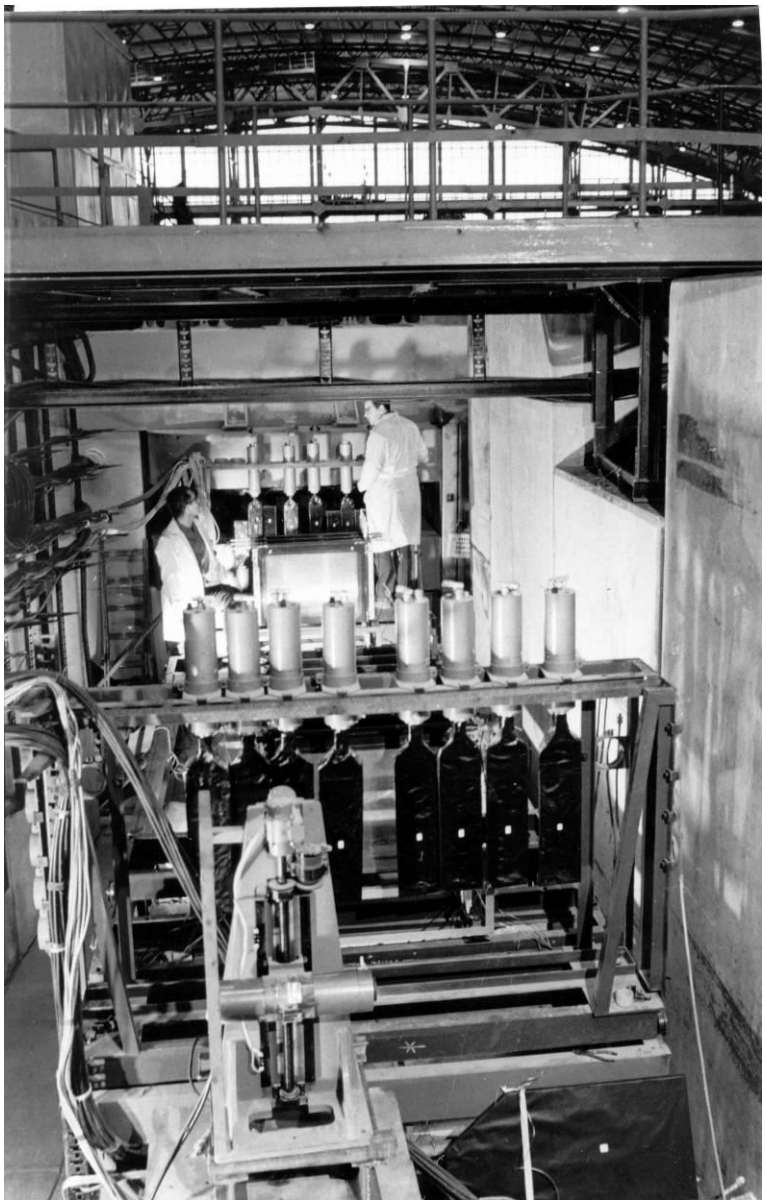
Director of IHEP

U-70 parameters:	energy	76 GeV
	intensity	1.7 10^{13} ppp

Experiment on K^0_L – K^0_S regeneration

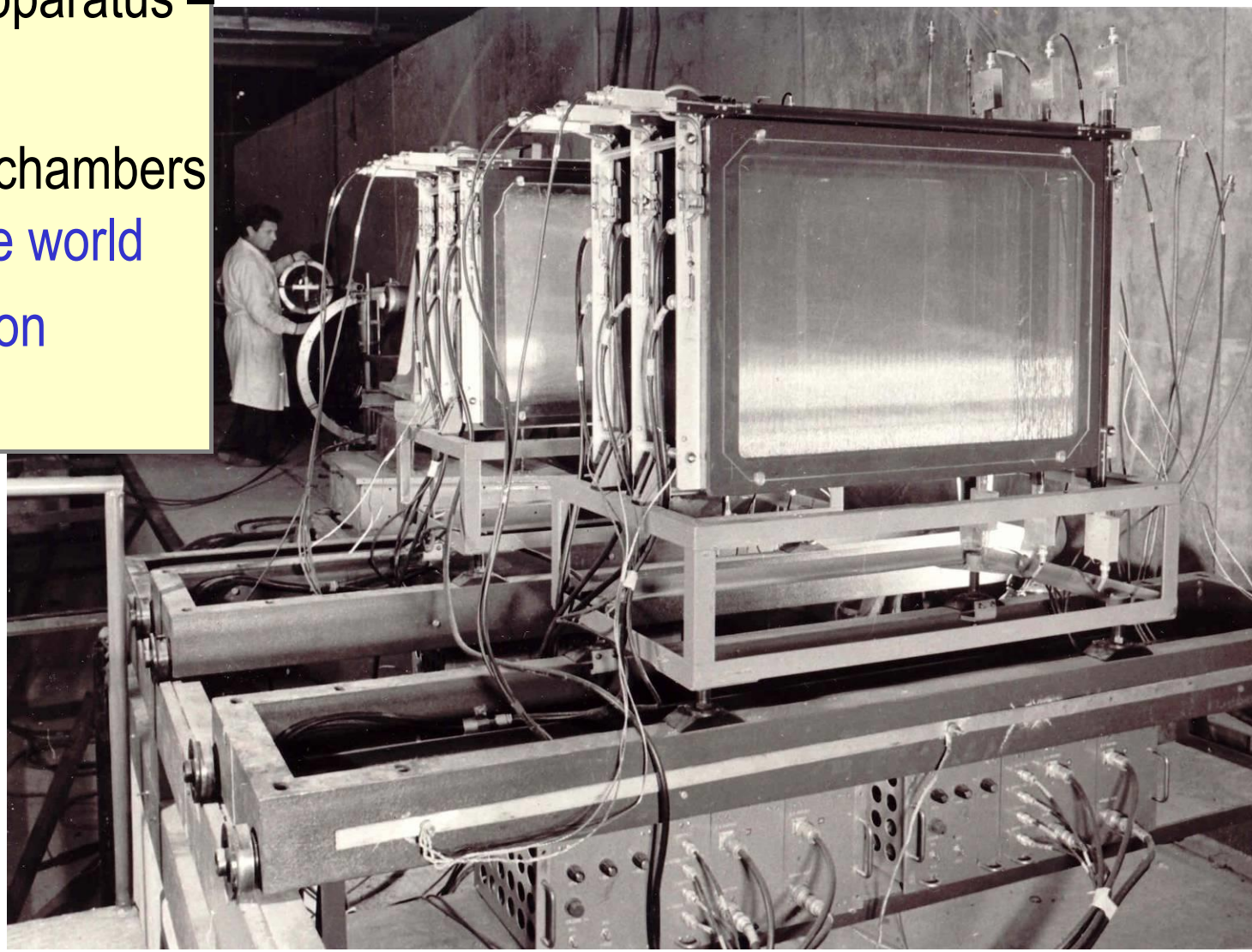






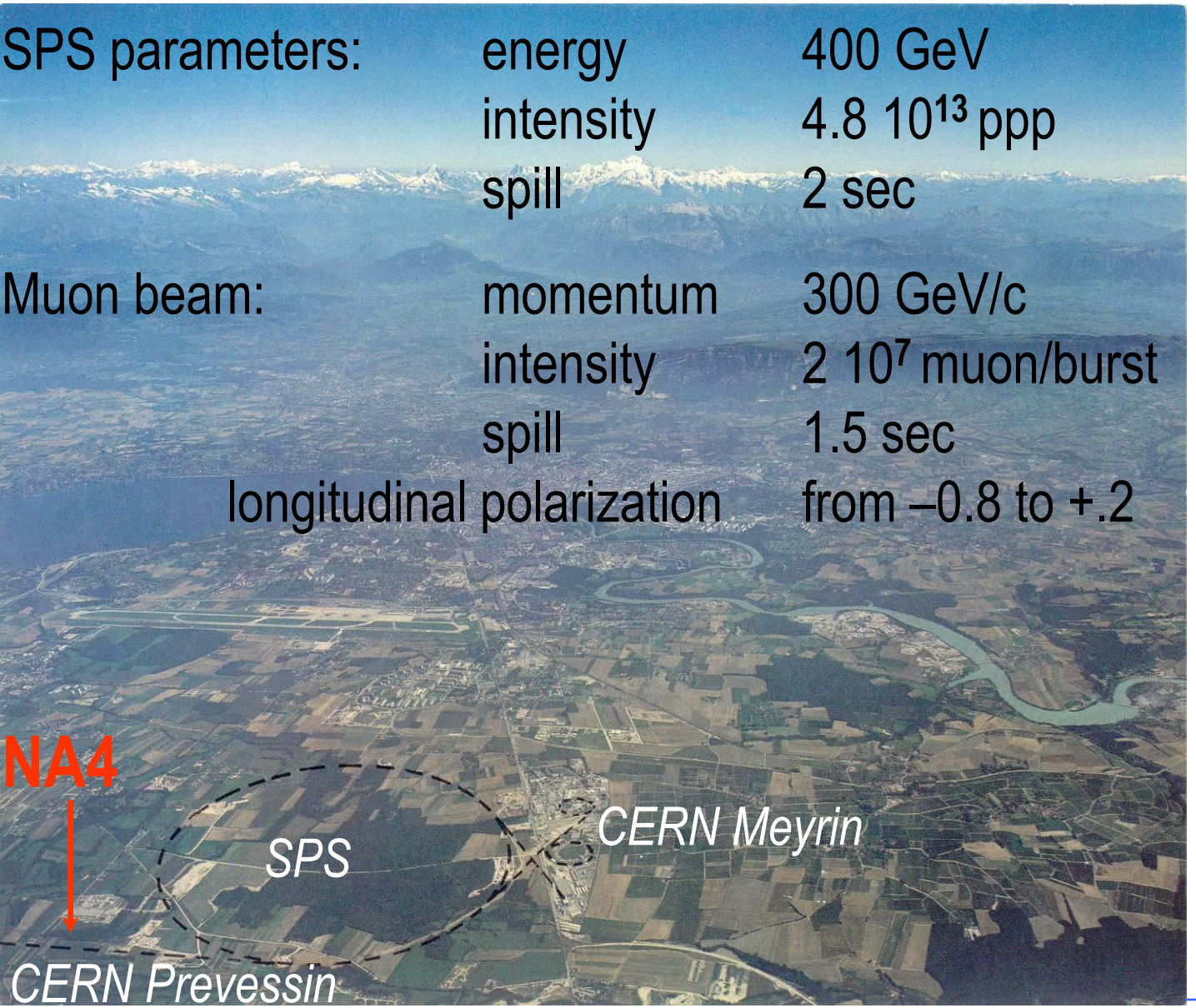
Experiment on $K^0_L - K^0_S$ regeneration

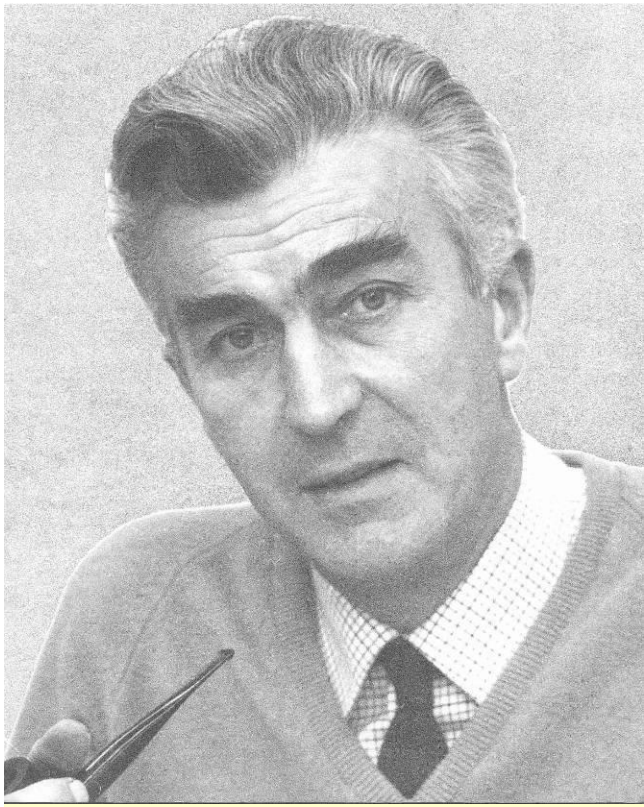
The main part of the apparatus – 18 double coordinate magnitostrictive spark chambers provided the best in the world invariant mass resolution



Co-operation with CERN at SPS

SPS parameters:	energy	400 GeV
	intensity	4.8 10^{13} ppp
	spill	2 sec
Muon beam:	momentum	300 GeV/c
	intensity	2 10^{7} muon/burst
	spill	1.5 sec
	longitudinal polarization	from –0.8 to +.2





John Adams

Director – General of CERN

Director of the SPS project – Super Proton Synchrotron

Co-operation with CERN at SPS

High Luminosity spectrometer for deep inelastic muon scattering

07 May 1975 – 16 August 1985

BCDMS
NA4 Collaboration

Bologna

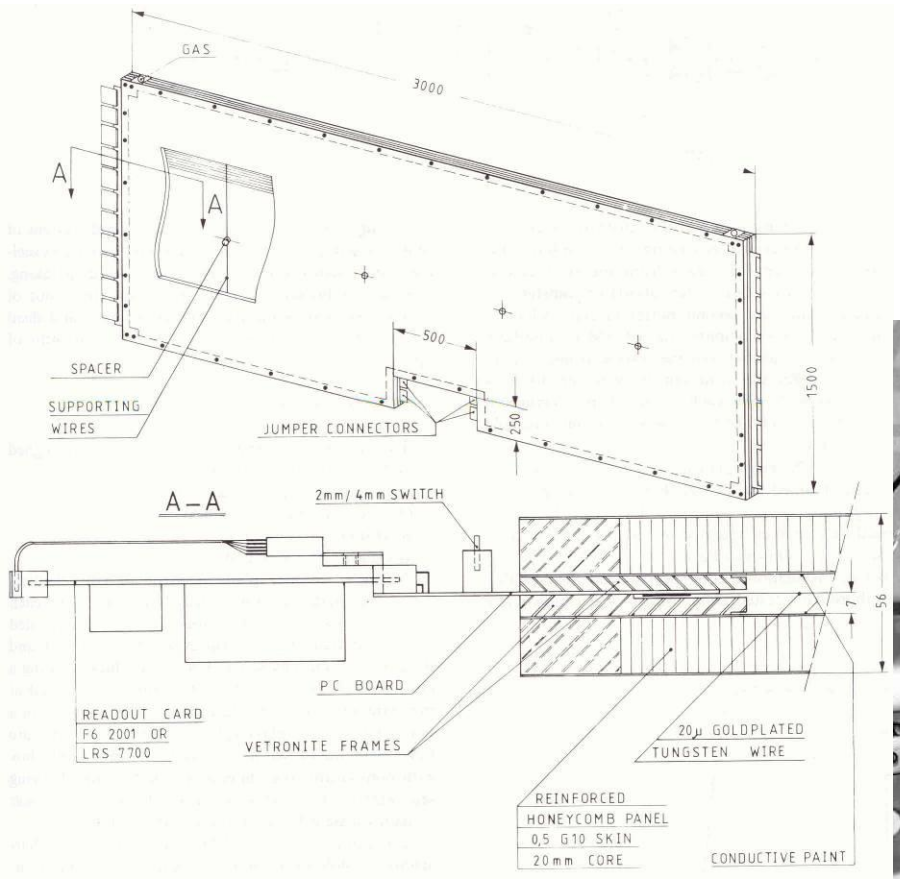
CERN

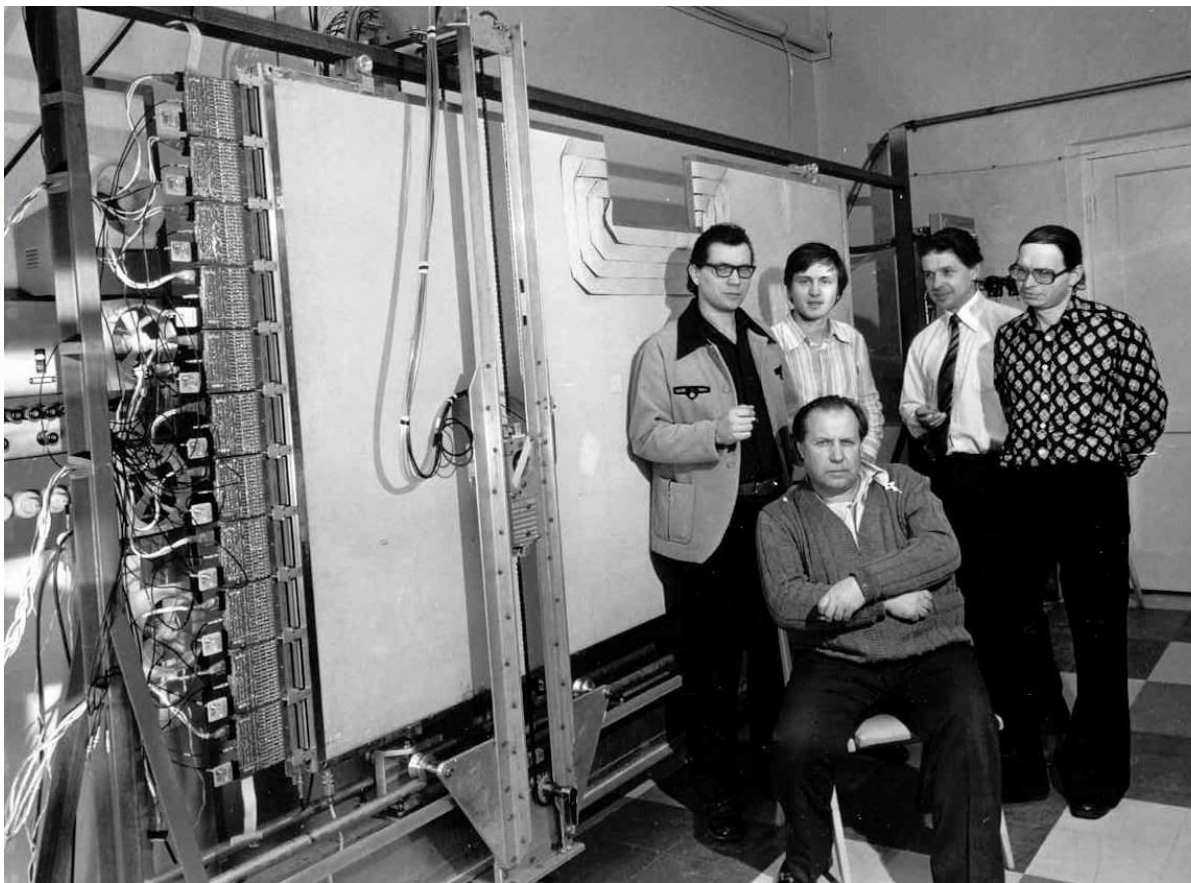
Dubna

Munich

Saclay

Co-operation with CERN at SPS

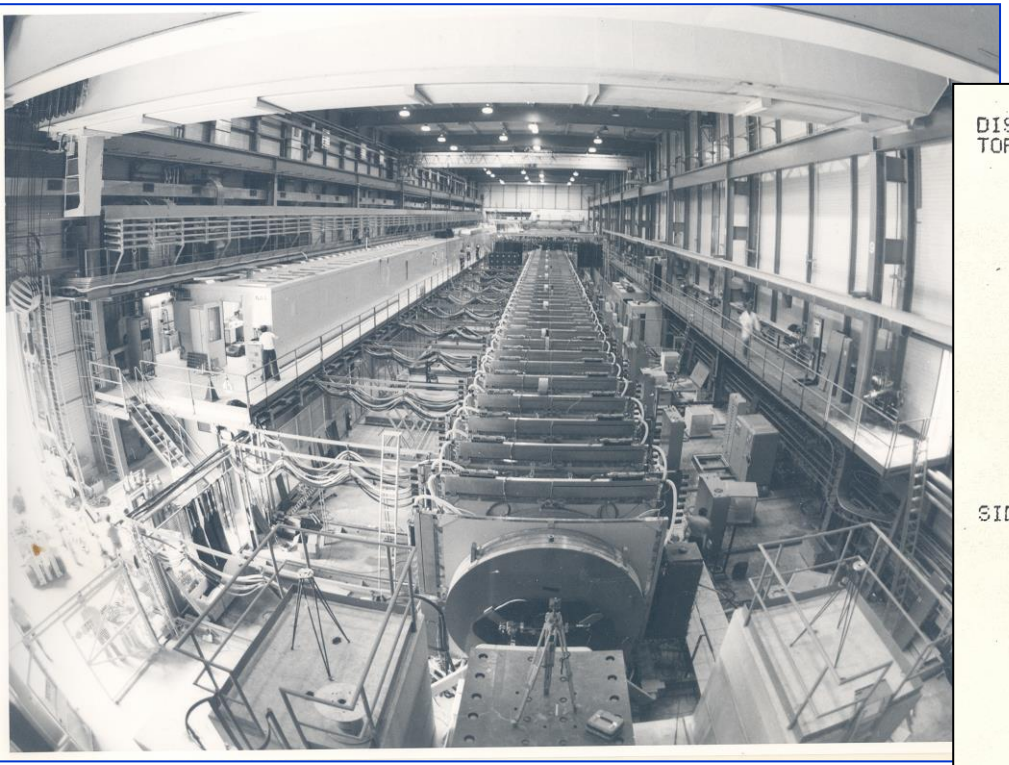




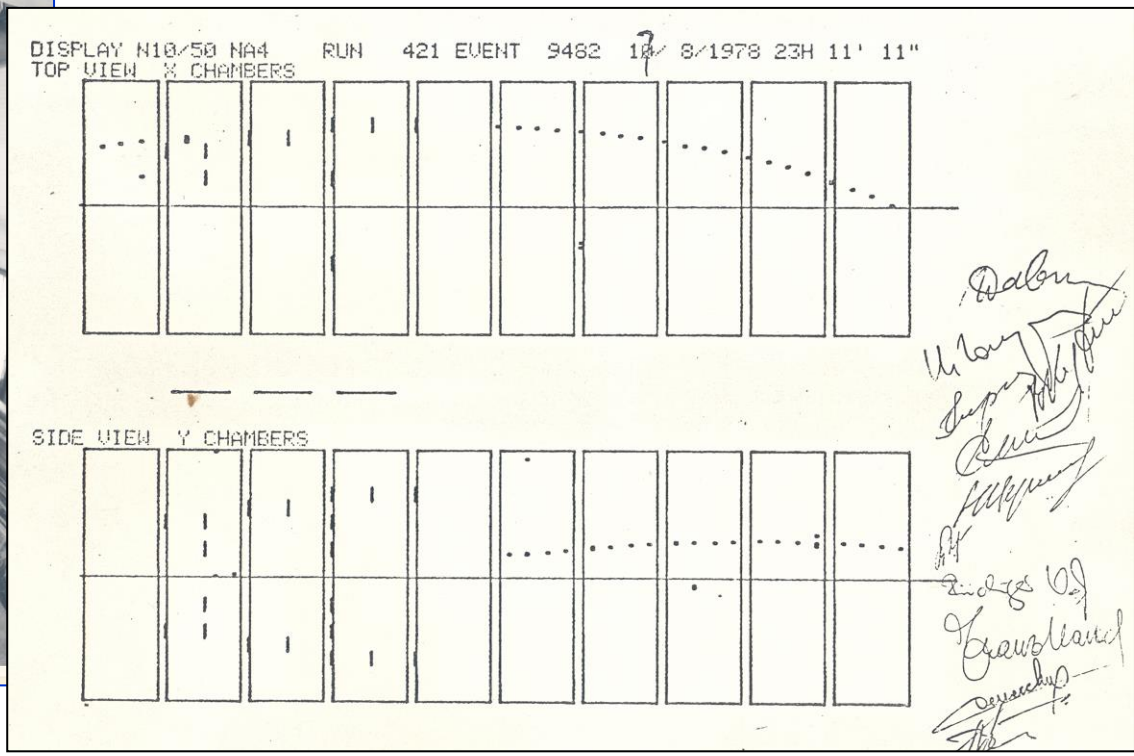
Co-operation with CERN at SPS

Installations

Chambers were tested before and after transportation, installed in the magnet and putted in operation in 1978



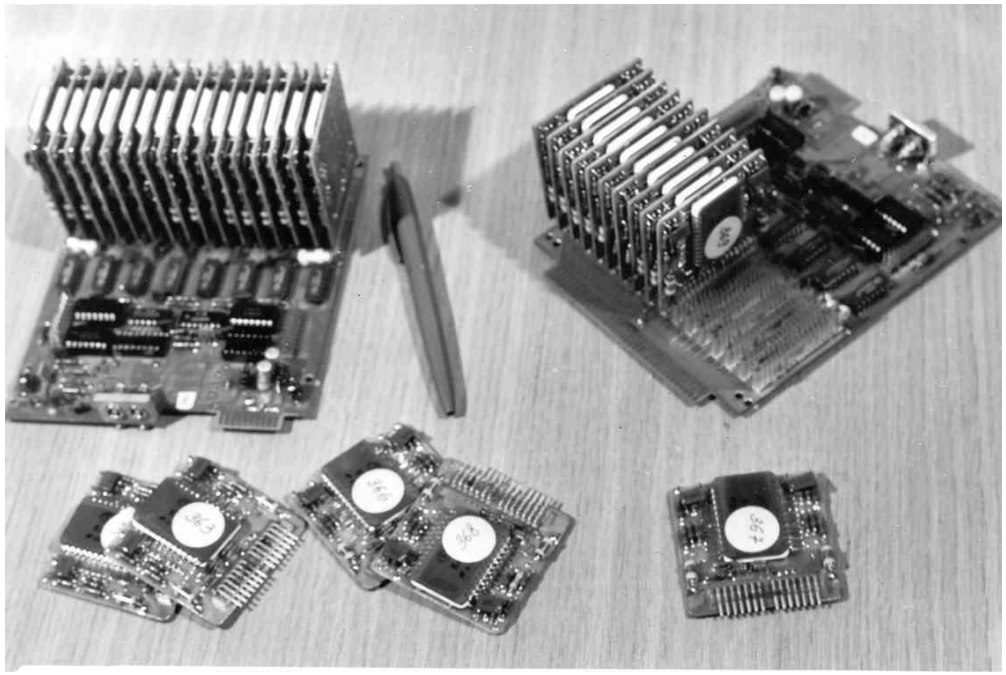
The very first muon track recorded by the spectrometer in the Dubna chambers with signatures of participants



Wide R&D on tracking detectors

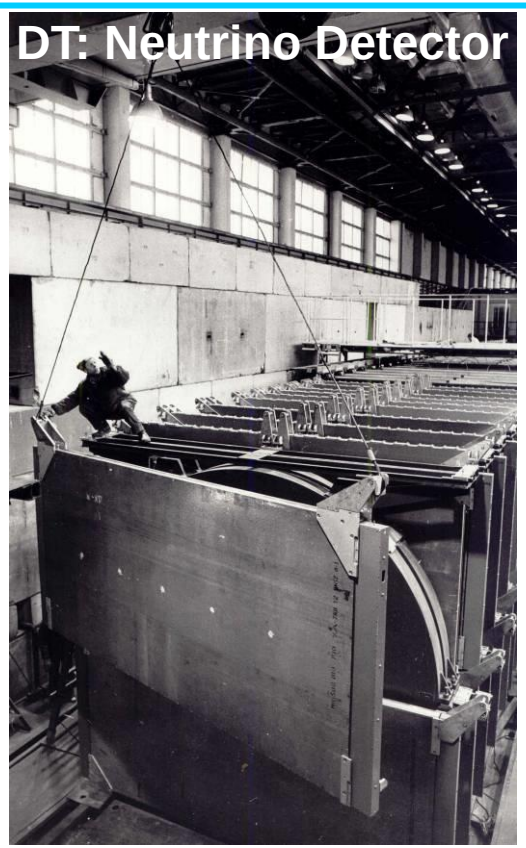
Based on NA4 experience Golutvin organized a powerful base at JINR for development and construction of tracking detectors - different types of proportional and drift chambers, drift tubes, straw tubes, planar silicon setectors – for needs of HEP experiments.

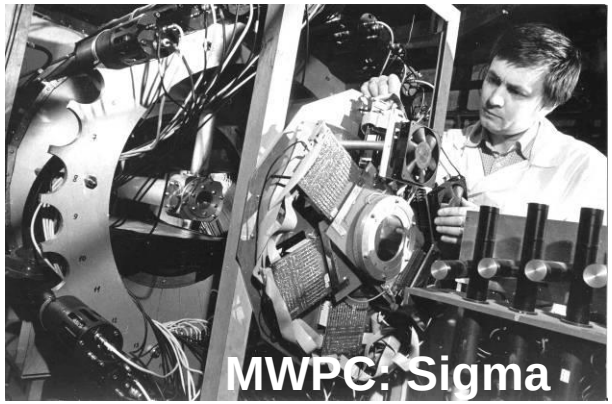
And also development and production of nuclear electronics for this detectors.

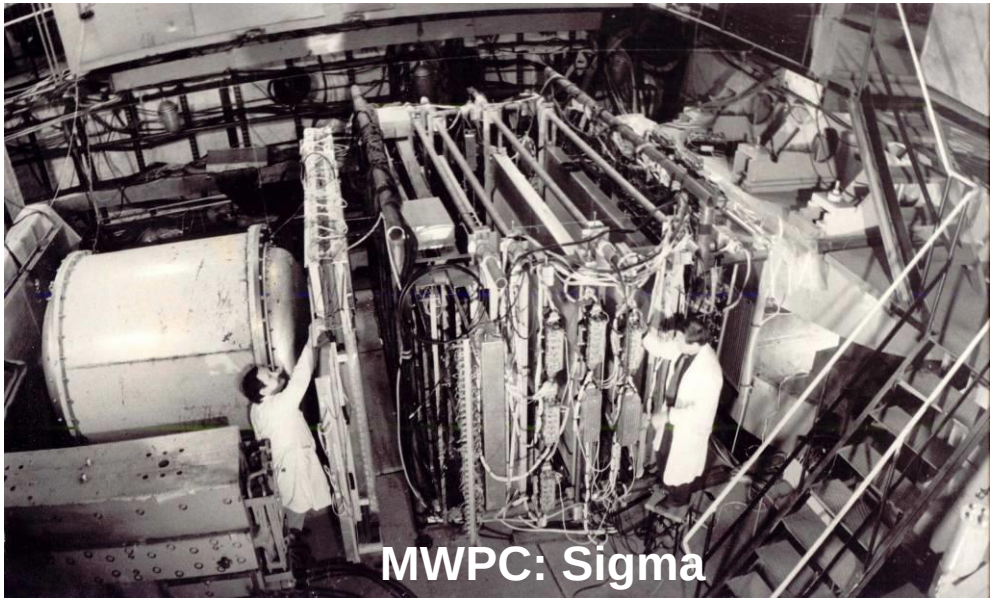


RPK-32 MWPC readout electronics were produced in industry and widely used in many HEP experiments

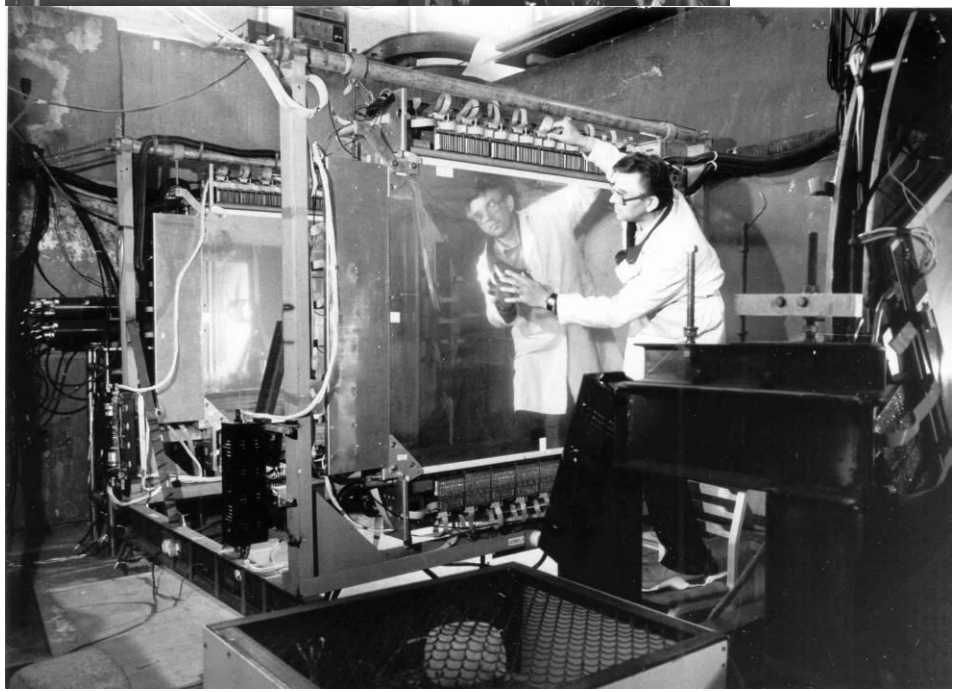
Installations in 80-90th at IHEP

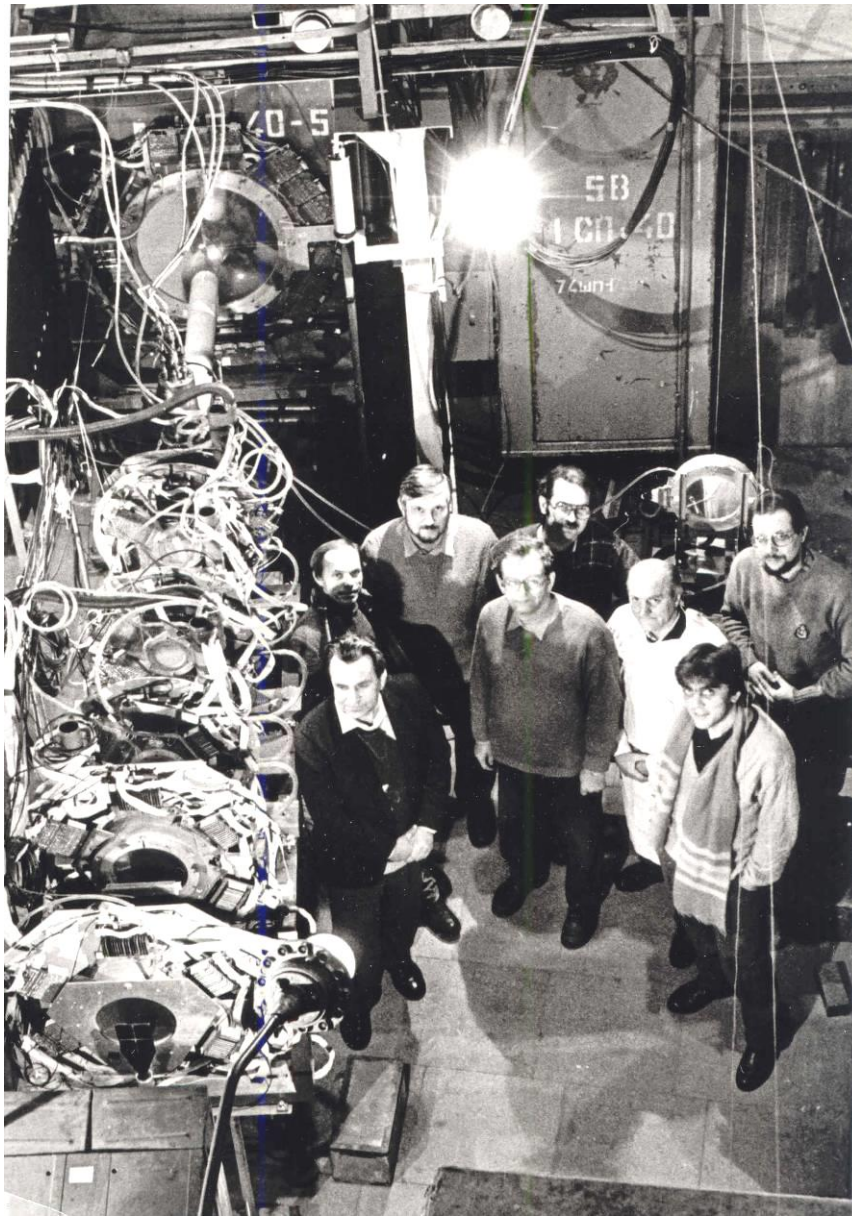




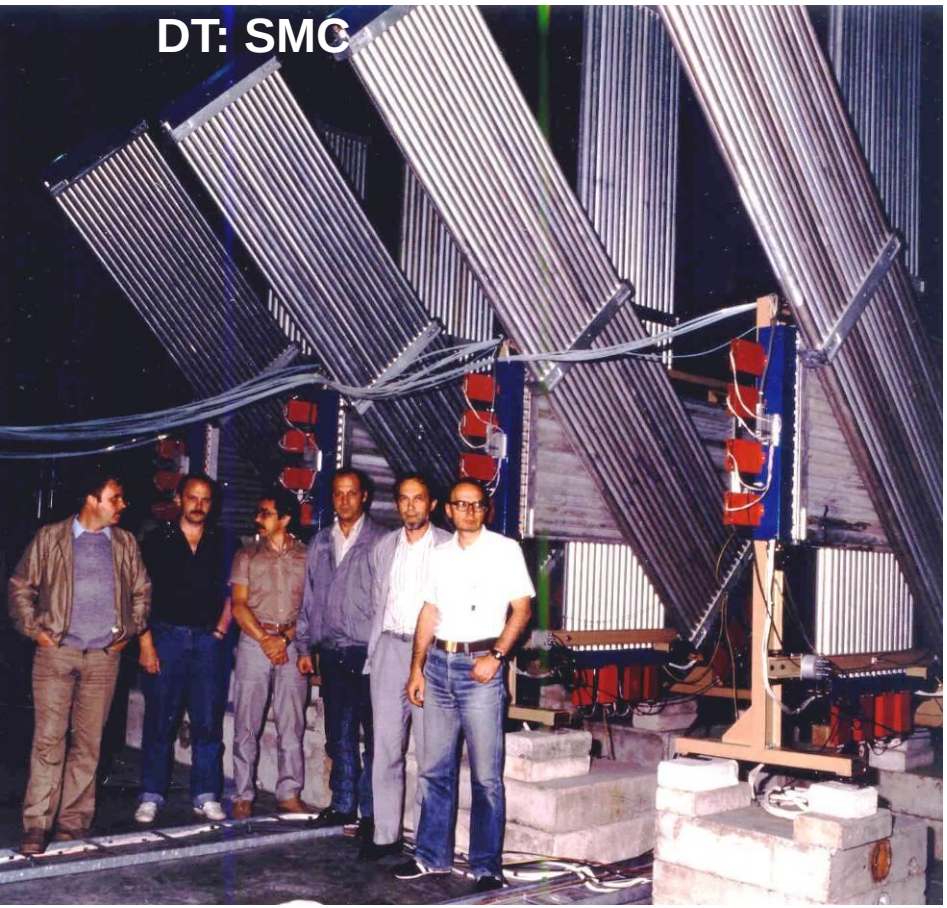


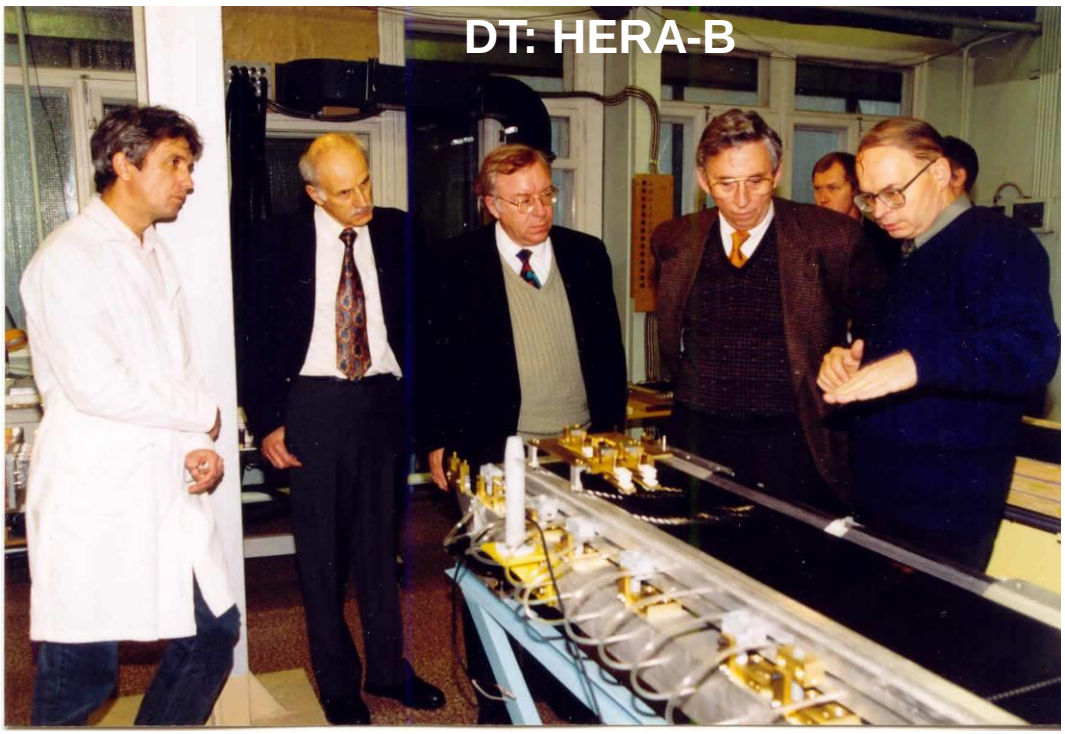
Installations in 80-90th at JINR



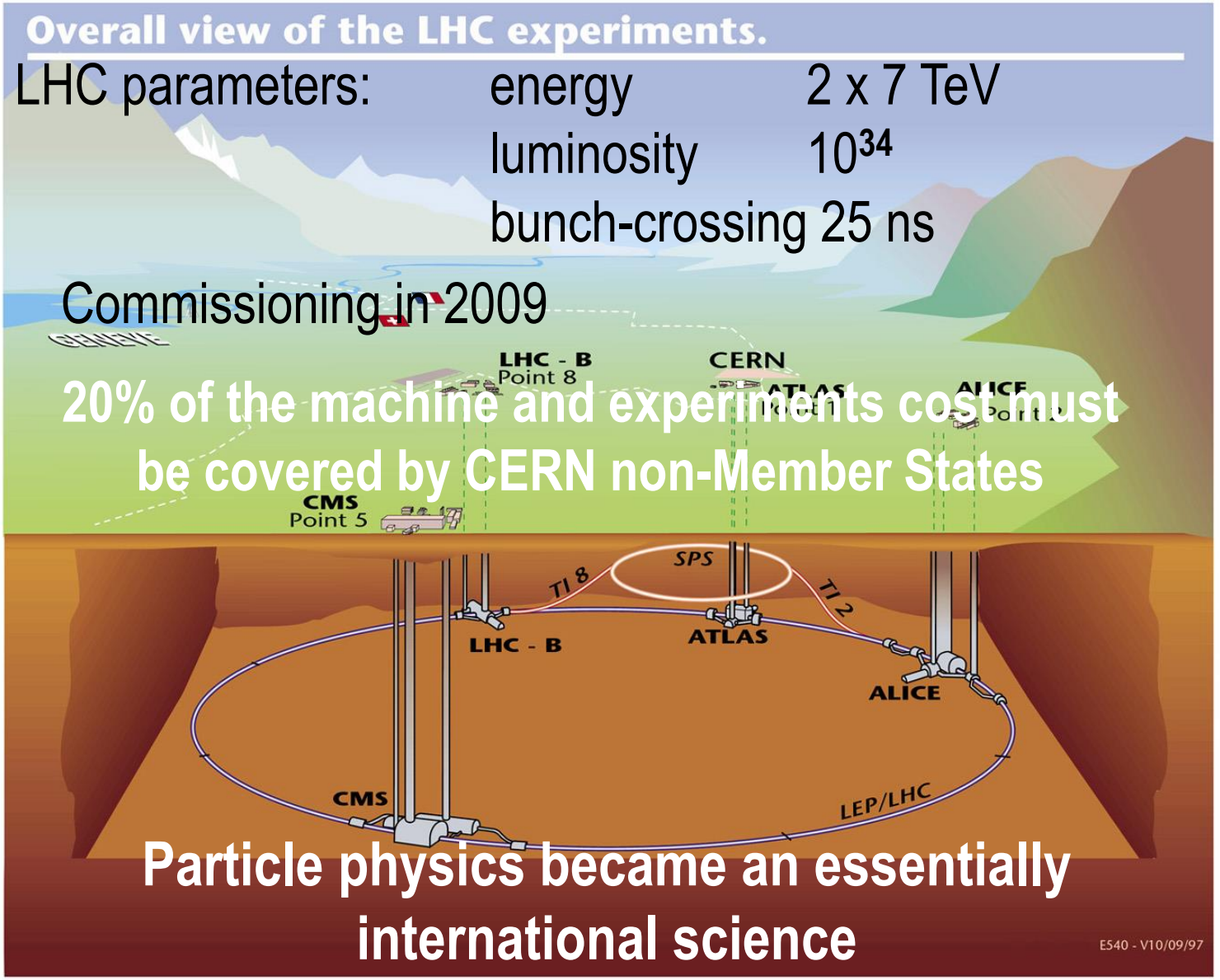


Installations in 90th at CERN and DESY





Co-operation with CERN at LHC



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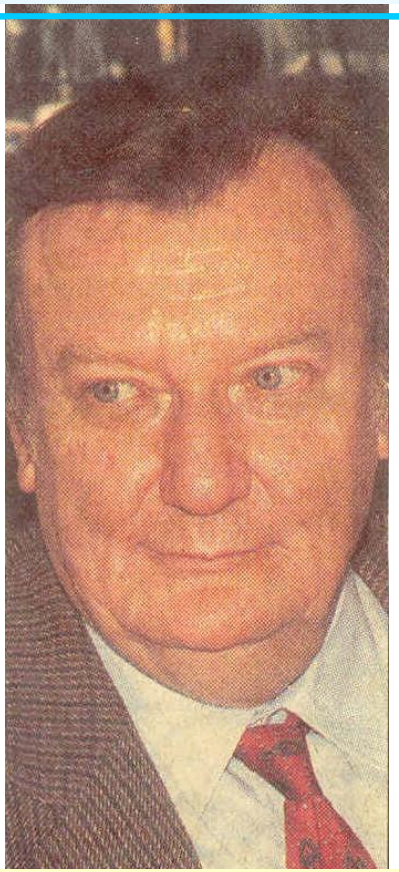


Carlo Rubbia

Director – General of CERN

Initiator of the LHC project – Large Hadron Collider

CMS Foundation, March 1992, Evian

- **5 - 8 March 1992: 650 physicists meet in Evian to discuss experiments on CERN's new accelerator project, the Large Hadron Collider (LHC)**
- **Michel Della Negra presented a concept of LHC Experiment based on super conducting solenoid with a strong magnetic field "Compact Muon Solenoid - CMS"**
- **I.Golutvin was one of the founder of the CMS experiment. CMS Expression of Interest was signed by 49 Institutions from 21 countries**

In a short time - 6 month later:

- **Letter of Intent on 1 October 1992 was signed by 62 Institutions from 25 countries**
  - powerful tracker based on Silicon and MSGC
  - precise crystal electromagnetic calorimeter
  - two options of hermetic hadron calorimeter
    - **cooper + scintillator**
    - **cooper + silicon**
  - precise muon system
  - magnetic field 3.8 T in a large volume

Letter of Intent, 1 October 1992. Physics Goal

- **Abstract of the CMS Letter of Intent, submitted to the LHC Experiments Committee (LHCC) on 1 October 1992**
- *"We propose to build a general purpose detector designed to run at the highest luminosity at the LHC. The CMS (Compact Muon Solenoid) detector has been optimized for the search of the* ***SM Higgs boson*** *over a mass range from 90 GeV to 1 TeV, but it also allows detection of a wide range of possible* ***signatures from alternative electro-weak symmetry breaking mechanisms.*** *"*

CMS was designed as an experiment for discovery!

And required an excellent Collaboration

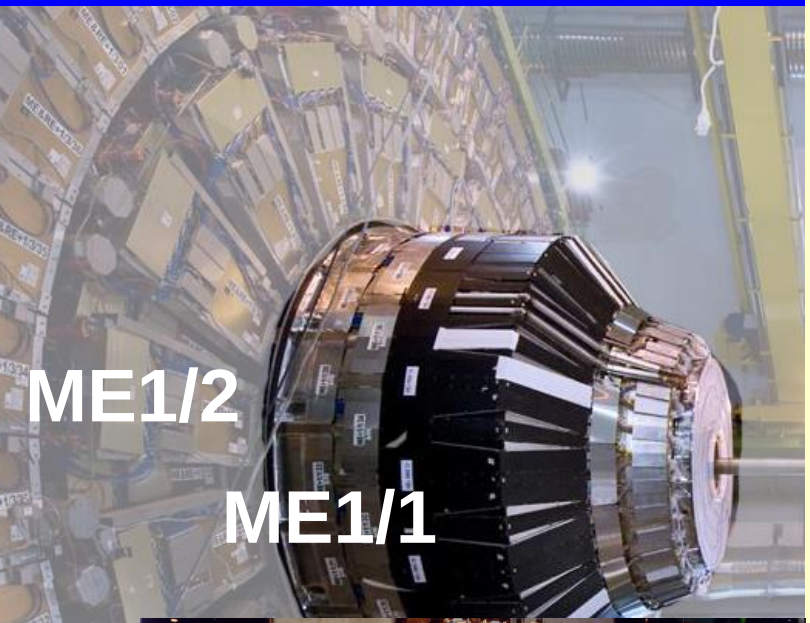
RDMS CMS Foundation, 1994, by I.Golutvin

- **JINR member-states participate in CMS Project in frame of Russia and Dubna Member States – RDMS CMS Collaboration**
- **Formally RDMS was established in Dubna on 27 September 1994**
- **In fact RDMS physicists have participated in CMS since 1992 before formal decision were made**
- **In RDMS there are about 300 scientists and 32 Students, from 7 States and 23 Institutions**

- **Main principles of the RDMS Collaboration:**
  - participation of Institutions in the CMS experiment as independent scientific groups;
  - unification of technical and financial contributions and obligations of different Institutions as the joint Collaboration deliverables to experiment
- **Main aims of the Collaboration strategy:**
  - unification of the efforts of many groups from different institutions and countries;
  - concentration of efforts at several well defined CMS sub-systems (for example Endcap)
  - and broad involvement of Industry of participating States

Wide application of CSC in HEP

I.Golutvin invented, proposed and developed a wide application of new detectors in order to construct a frontier CMS



Cathode Strip Chambers, CSC

Cathode Strip Chambers were proposed for CMS Endcap Muon System. The first prototype in 1993 demonstrate precision of 53 mkm

I. Golutvin et al
Dubna 0.5x0.5 m2 RD5 CSC prototype, 1993:
Milestones Report, CMS Collaboration,
CERN/LHCC 93-48, p.70, 1993

The innermost ME1/1 stations of Endcap muon system located in 4Tesla solenoid developed by JINR in cooperation with Minsk, with I.Golutvin as Project Leader. Other endcap station were build by US institutes in cooperation with Gatchina

310 CSCs, 340,000 channels in CMS

1979 First Cathode Strip Chamber

1979:

- The very first Cathode Strip Chamber was designed at JINR for NA4 R&D in 1979 to improve a vertex:

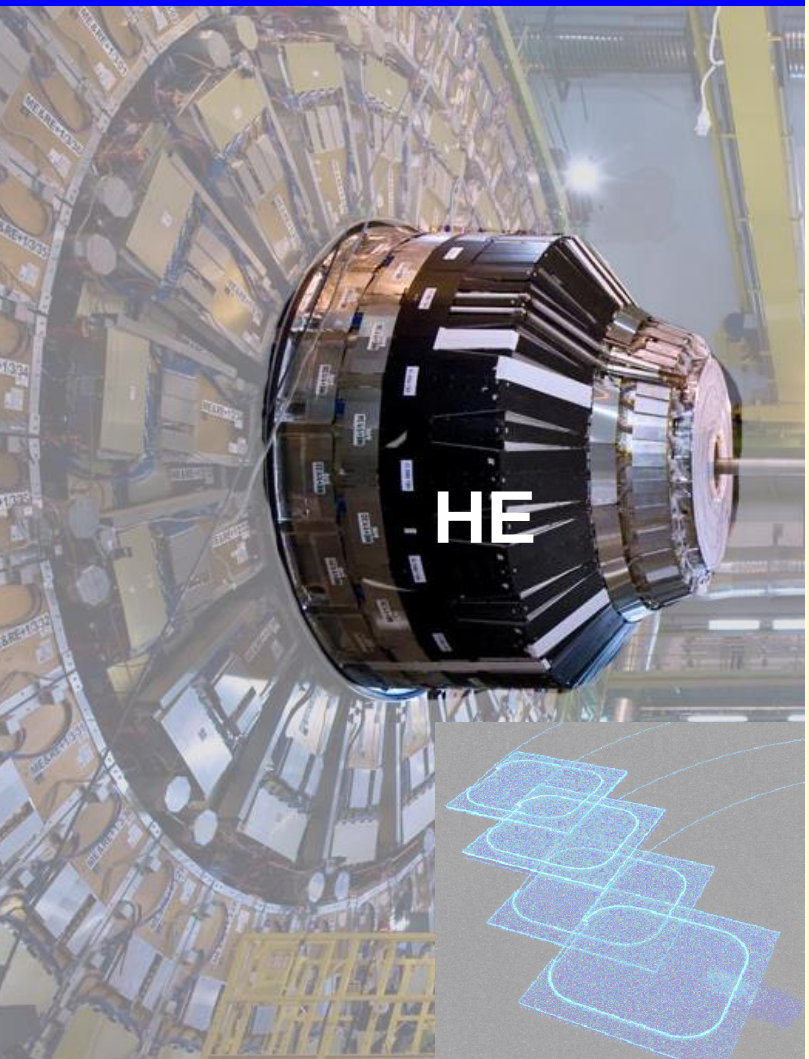
Chamber size	- 3x1.5 m
Strip length	- 1.5 m
Strip width	- 20 mm
Gap	- 7 mm
Wires	- 20 mkm

Cathode resolution ~ 2 mm

- Next studies of set of small prototypes with optimal cells demonstrate a cathode resolution of 50 mkm

Wide application of Sigma Tiles in HEP

RDMS Scientists invented and developed a wide application of new detectors in order to construct a frontier CMS



Hadron Calorimetry

Based on plastic scintillators with embedded WLS fibers, so called sigma tiles, proposed for Hadron calorimetry in 1986 in IHEP, Protvino

V. I. Kryshkin and A. I. Ronzhin,
Nucl. Instr. Meth. A 247 (1986) 583

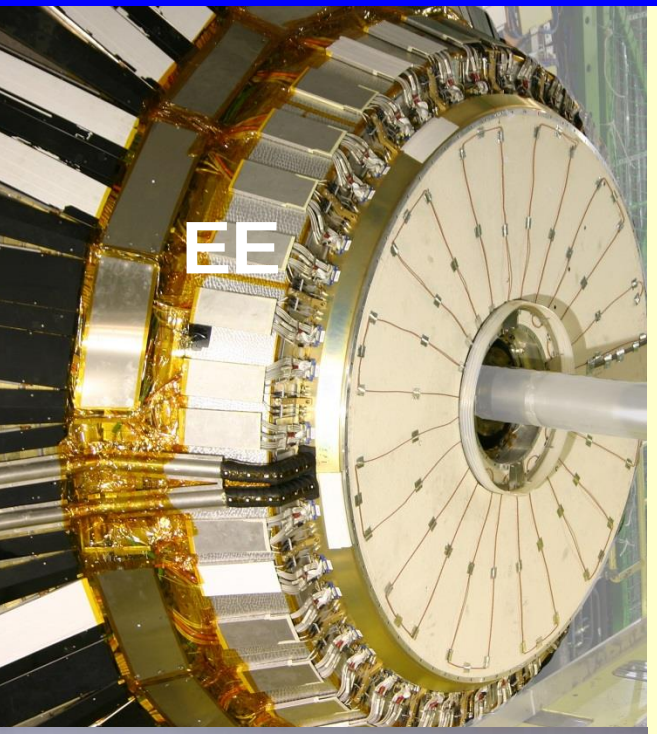
Endcap calorimeters developed by RDMS under leadership of I.Golutvin as Project Manager in cooperation with Rosatom enterprises and MZOR, Minsk

600 tons of brass absorber were made of military shells

8,000 channels in CMS

Wide Application of PWO crystal in HEP

RDMS Scientists invented and developed a wide application of new detectors in order to construct a frontier CMS.



PWO crystal was born in "SingleCrystal", Kharkov

PWO_4 crystals were proposed for EM-calorimetry in 1992 by IHEP, Protvino

V. A. Kachanov.
"Study of characteristics of real-size $PbWO_4$ crystal cells for precise EM-calorimeters to be used at LHC energies" Workshop, Chamonix, 1992

This R&D led to wide application of PWO in HEP

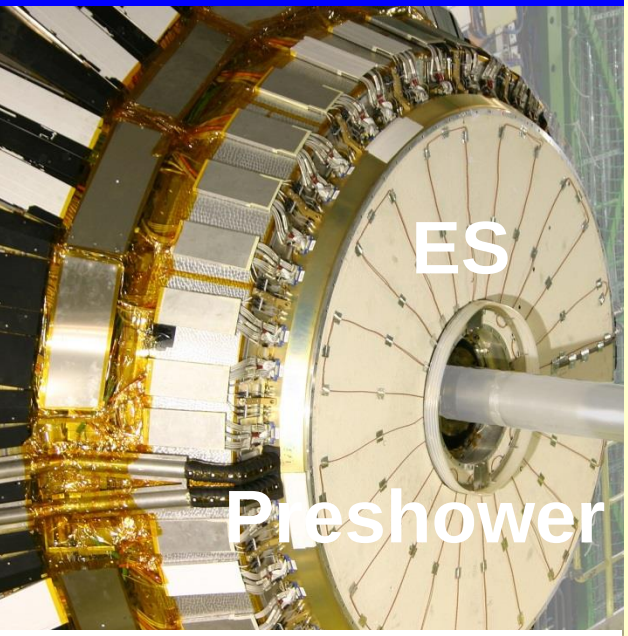
Precise Electromagnetic Calorimeters, EB for barrel and EE for endcaps were developed by RDMS and other CMS institutes in cooperation with Bogoroditsk plant

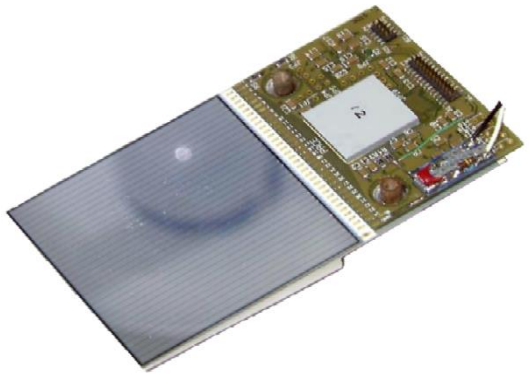
76,000 crystal channels in CMS

Also PWO crystals widely used in ALICE at LHC and many other HEP experiments

Wide application of Si detectors in HEP

I.Golutvin proposed, invented and developed a wide application of new detectors in order to construct a frontier CMS





Based on Dubna Silicon Program in cooperation with Italian scientists a new technology for pad (pixel), thin and coarse strip Si-detectors was developed in 90-th.

Also Silicon Option for the Endcap HCAL invented for CMS LoI in 1992.

I.A.Golutvin et al.
RD35: "Silicon Hadron Calorimeter module for LHC",
CERN/DRDC/91-54, DRDC/P34, January 13th 1992

This R&D led to wide application of Si tracking in HEP

CMS Preshower developed by JINR in cooperation with Zelenograd, ELMA and other CMS groups
18 m^2, 144,000 channels in CMS

All Si Tracker developed by CMS

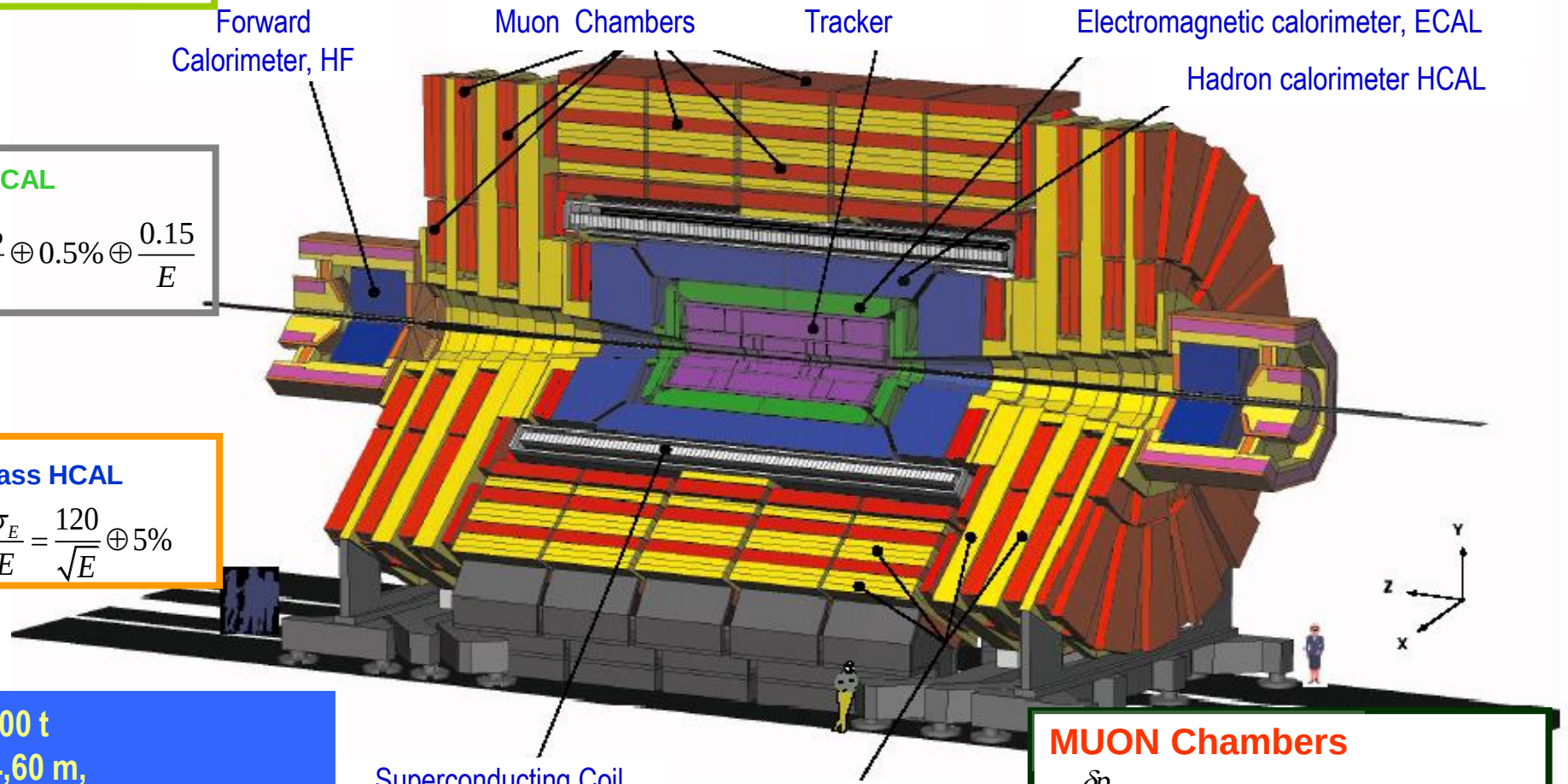
Today, 30 years later, the idea of Si tracking HCAL accepted by CMS at the modern level as High Granularity Calorimeter for HL-LHC

RDMS is 30 years in CMS

Silicon Tracker

$$\delta p_T / p_T \sim 15 \times p_T(TeV)\%$$

Detector subsystems are designed as discovery experiment to measure: the energy and momentum of photons, electrons, muons, jets, missing E_T up to a few TeV



$PbWO_4$ ECAL

$$\frac{\sigma_E}{E} = \frac{2.7\%}{\sqrt{E}} \oplus 0.5\% \oplus \frac{0.15}{E}$$

sampling brass HCAL

$$\frac{\sigma_E}{E} = \frac{120}{\sqrt{E}} \oplus 5\%$$

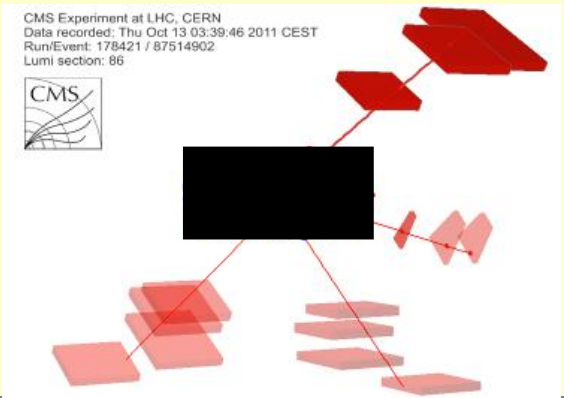
weight - 14500 t
diameter - 14,60 m,
length - 21,60 m,
B-field - 4 T

MUON Chambers

$$\frac{\delta p_T}{p_T} \sim 1.0 - 1.5\% @ 100 GeV$$

Briefly on Dimuons – 25 years ago

- **Today it looks evident and I would say trivial to study dimuon states**
  - But 25 years ago it was a talent of Igor Golutvin - one of the founding fathers of the experiment - from hundreds final state channels - to select Dimuons as perspective direction of the Physics program as well as for Higgs searchs
  - Let me remind that in ~1990 Carlo Rubbia in one of his talk on future physics predicted that at very high lumi – detector will be as a black box and only muons will be available for measurements
    - could be something like that →

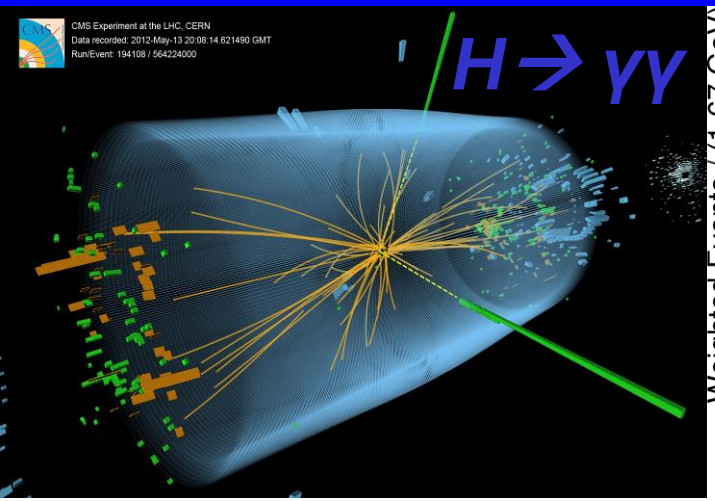


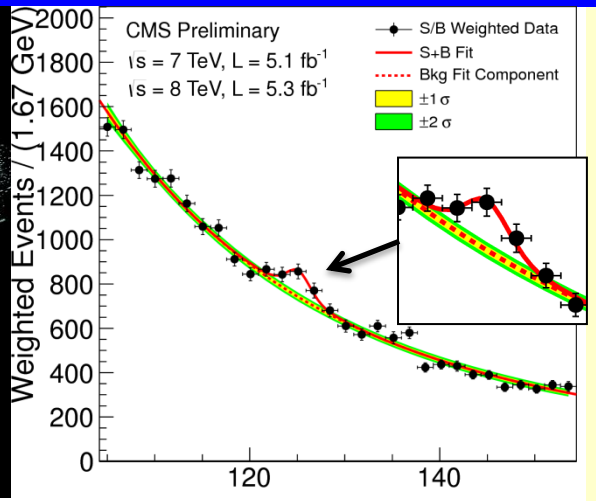
RDMS Achievement in CMS@LHC. Physics

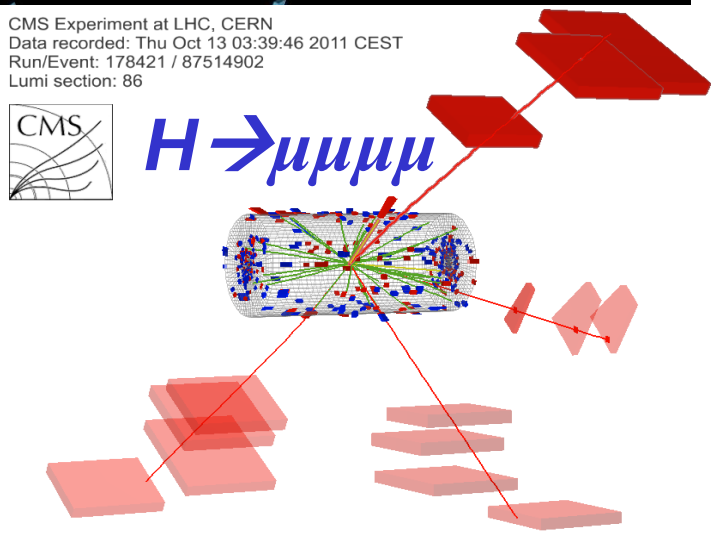
- RDMS scientists developed an adequate computing based on GRID technology, including CMS Tier-1 in JINR with regional Tier-2's at RDMS institutions associated with physics tasks
- CMS Remote Operational Centres for data monitoring and certification developed in Dubna and all RDMS institutes help for data taking and certification
- Data processing and physic analysis performed by RDMS scientists demonstrate manifestation of the Standard Model at 7 and 13 TeV
- No evidence for New Physics beyond SM
- Regular Joint sessions of RDMS Collaboration Board and Executive Committee, All RDMS remote seminar "Physics at LHC", Annual RDMS Conferences are helpful to joint efforts

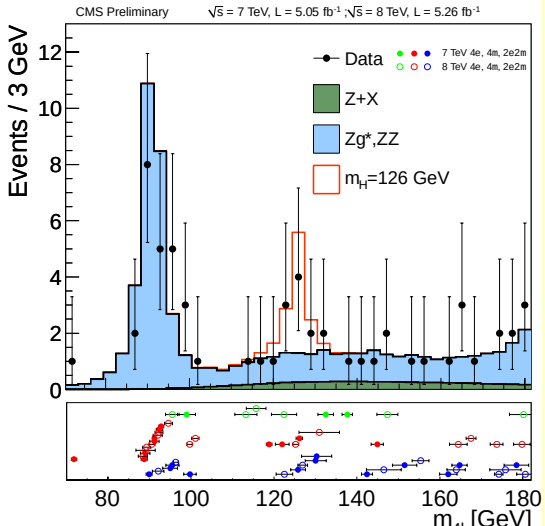
Breakthrough in Experiments @ LHC

The most important event in Particle Physics in XXI century – is the discovery of the Higgs Boson at CMS and ATLAS at LHC, announced by two Collaborations on 4 July 2012 at scientific seminar at CERN









The key and decisively contribution in the discovery of Higgs Boson of RDMS scientists from JINR Member States is honoured with commendation by CMS Spokesperson Joe Incandela in his letter addressed to RDMS authors of discovery on 31 July 2012

Breakthrough in Experiments @ LHC

European Physical Society
PRIZE

The 2013 High Energy and Particle Physics Prize
for an outstanding contribution to High Energy Physics
is awarded to the
ATLAS and CMS collaborations
"for the discovery of a Higgs boson, as predicted by the Brout-Englert-Higgs mechanism"
and to
Michel Della Negra, Peter Jenni, and Tejinder Virdee
"for their pioneering and outstanding leadership rôles in the making of the ATLAS and CMS experiments"

John Dudley
President
European Physical Society

Paris Sphicas
Chairman
High Energy and Particle Physics Division

Stockholm, Sweden, July 2013

Contribution of the RDMS scientists in the discovery of a Higgs Boson, as predicted by the Brout-Englert-Higgs mechanism, is awarded by European Physical Society Prize on the strength of the CMS and ATLAS Collaborations on July 2013.

For outstanding contribution in CMS and ATLAS experiments resulting in discovery of Higgs Boson the leader of Russian team in ATLAS A.M.Zaitsev (IHEP) and the RDMS CMS Spokesperson I.A.Golutvin (JINR) are awarded by P.A.Cherenkov Prize of RAS in 2014

Last years

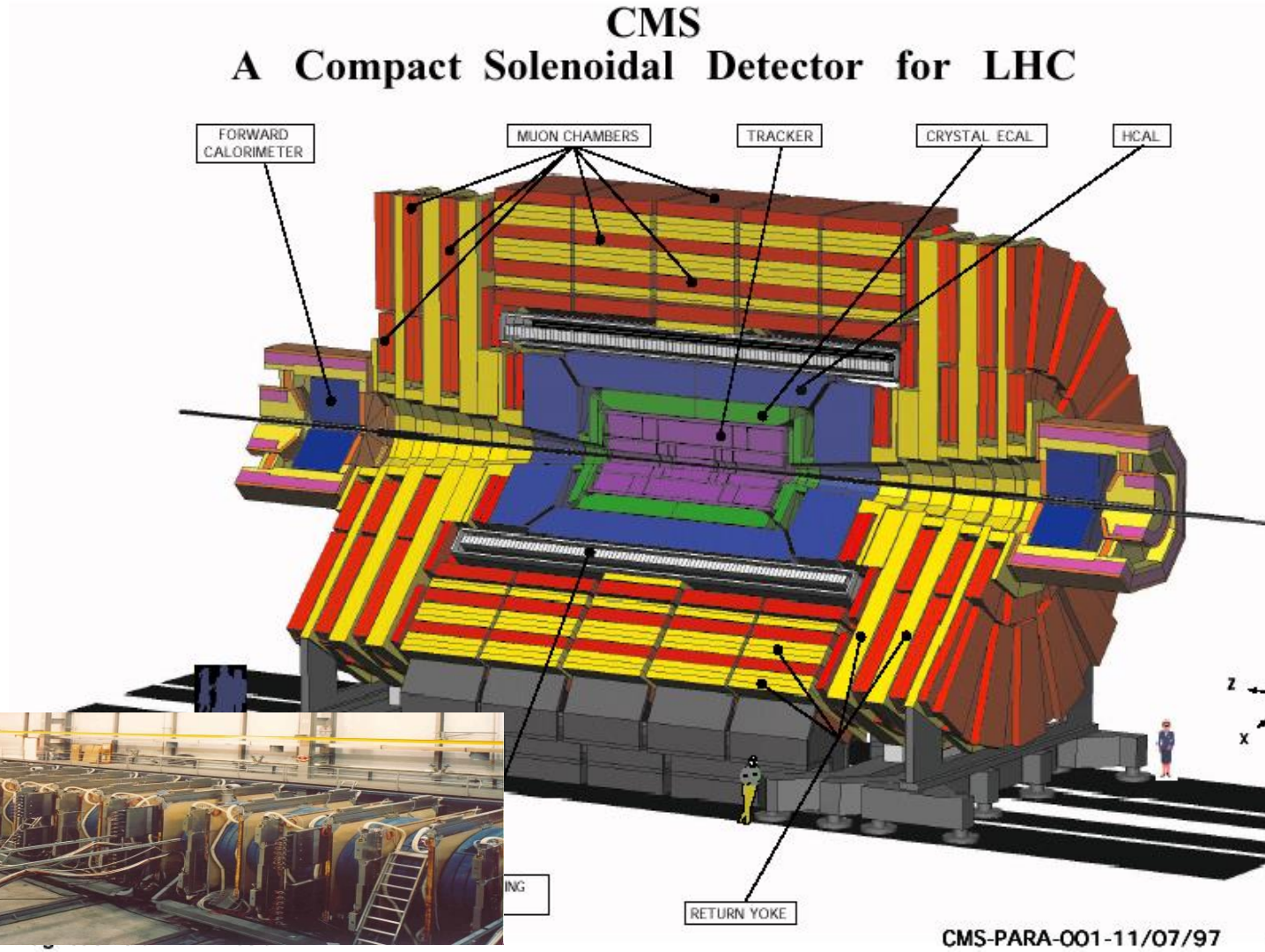
Igor Golutvin was always looking to the future: while we just started a realization or even preparation of the Project, he was developing a new one looking forward for 3, 10 or even 30 years

Last decade he spent for CMS modernization at strong conditions of very high luminosity

And the very last interest of Igor Golutvin was to invent a new type of tracking detector based on scintillation of Xe to search a dark matter – the central problem of modern physics –

at future accelerators and non-accelerator experiments

Conclusion: Scale of the progress



BCDMS

BIS

πp

Conclusion

Igor Golutvin will live on in our hearts, our memory, and our future scientific results

Ten years ago on 8 August 2014
the Star in the Constellation Leo was named
“Professor Igor Golutvin”
by RosCosmos

Memory of Igor Golutin will live on forever under the light of his Star

We hope that the memory of Igor Golutvin will be immortalized in names of alley at JINR, and also street in Dubna, alley at CERN…

“…We will miss his lucid vision of physics, his deep knowledge of the finer details of experimental physics, his personal charisma, and his culture…”

Guido Tonelli 2023