Slovakia at CERN
30 years

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History of High Energy Physics in Slovakia

HEP activities started in Slovakia around year 1960 in several institutes:

- Department of Theoretical physics at Comenius University Bratislava
- Department of Nuclear physics at Comenius University Bratislava
- Division of Theoretical physics at the Institute of Physics SAS Bratislava
- Division of High energy physics on the Institute of experimental physics SAS Košice
- Department of Nuclear physics on P.J. Šafárik University Košice

HEP at Joint Institute of Nuclear Research at Dubna

- **Bubble chamber experiments**
- Strong group from the Institute of experimental physics SAS and P.J. Šafárik University Košice worked from 1967 on the several bubble chamber experiments , 1m and 2 m LUDMILA.

- **Experiment ARES**

  group from Department of nuclear physics at Comenius University Bratislava

- **Photo-emulsion experiments**

  group from P.J. Šafárik University Košice

- **Soviet – US experiment on proton channeling and bending in mono-crystals**

  group from Department of nuclear physics at Comenius University Bratislava took part

Search for Dirac magnetic monopole, group from MFF UK Bratislava in IHEP Serpukhov

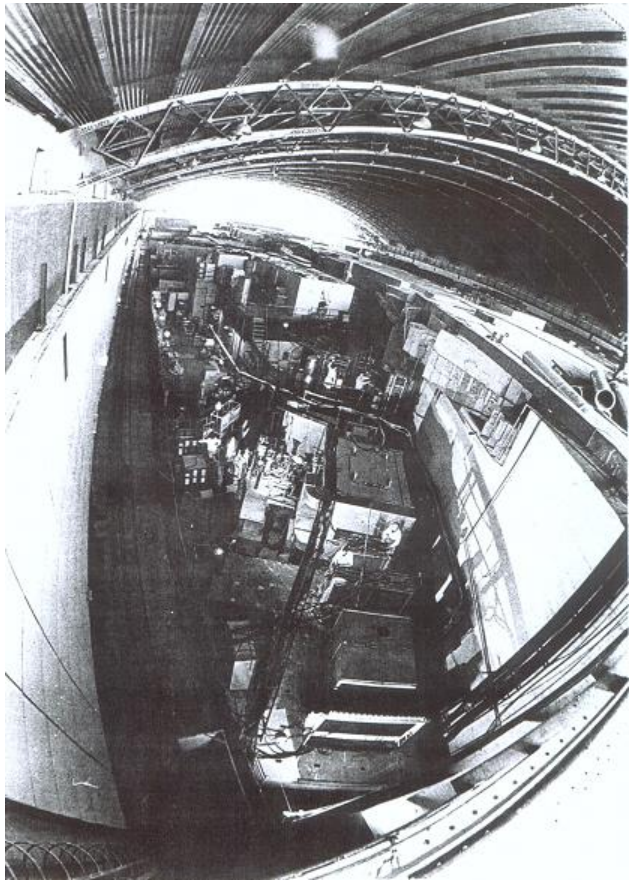
Experiments in IHEP Serpukhov

- **Experiment HYPERON at IHEP Serpukhov**

  strong group from the Department of nuclear physics at Comenius University Bratislava and Institute of experimental physics SAS Košice

- **Experiment RISK at IHEP Serpukhov**

  group from the Institute of experimental physics SAS Košice



HEP activities at DESY and FNAL

- **Participation in the H1 experiment at HERA**
- Physicists from the Institute of experimental physics SAS participated in the H1 experiment from 1987
- They considerably contributed to the hadron calorimeter and the trigger system

- **Experiments at FNAL**
- Stanislav Tokár joined E771 experiment in 1991

Topics:

- Heavy quark physics
- Later extensive work on the Top quark physics at CDF experiment

Steps towards CERN membership

- In 1983 Vladislav Šimák and his colleagues organized the CERN-JINR Summer School at Tábor.

- During this school the CERN DG Herwig Schopper stimulated the closer participation of Czechoslovak institutes in the CERN experiments.

- Košice group started in 1984 contacts with C.W.Fabjan, which led in 1989 to the participation in the NA34 (Helios) experiment with successive stays of Košice experimenters at CERN.
- Associate fellowships with HELIOS:
  Michal Seman (1984), Ladislav Šándor (1987) and Jaroslav Antoš (1989)

Accession of Slovakia to CERN

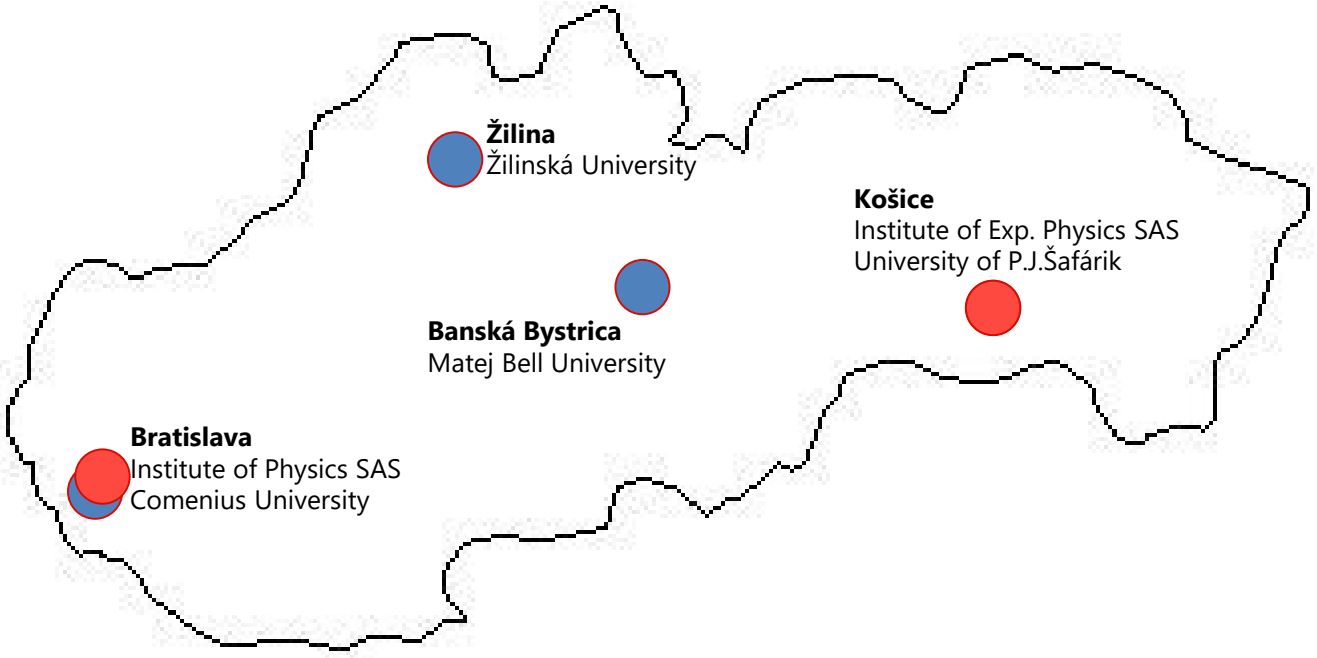
- **Accession of Czechoslovakia to CERN**
- Official contacts of Czechoslovak community of physicists with CERN started in beginning of 1990. The first CS committee for cooperation with CERN was established with Vladislav Šimák as a chairperson and Ladislav Šándor as deputy chairperson
- negotiations started in 1990 during the visit of president Vaclav Havel at CERN, Czechoslovakia became a CERN member state in January 1992

- **CERN membership of Slovak republic**

- After splitting Czechoslovakia into to two independent states in January 1993, Slovak physicists, mainly L. Šándor, J. Pišút, B. Sitár and others prepared Slovak membership at CERN

- CERN Council decided on 25 June 1993 to accept both Slovakia and Czech republic as CERN member states as from 1st July 1993.

Slovak institutions currently active in particle physics



Slovaks at CERN in 2023

114 CERN users, 16 permanent staff, 13 fellows, 21 other positions.

Total 50 long-term positions of Slovaks at CERN

Grand total 164 Slovaks at CERN

Organization of Slovak membership at CERN

- Responsible bodies:
- Science and Funding agency:
- Ministry of education, science, research and sports
- Political: Ministry of foreign affairs

- Advisory and initiative body:
- Committee for Slovak co-operation with CERN

- 50 Slovak long term positions at CERN
- Karel Šafařík – 2003-2011 physics coordinator on the ALICE experiment
- Peter Chochula – ALICE control system
- Marian Ivanov- tracking on ALICE TPC
- Pavol Stríženec – ATLAS calorimetry and data processing

Slovak activities at CERN

Experiments:

Past:

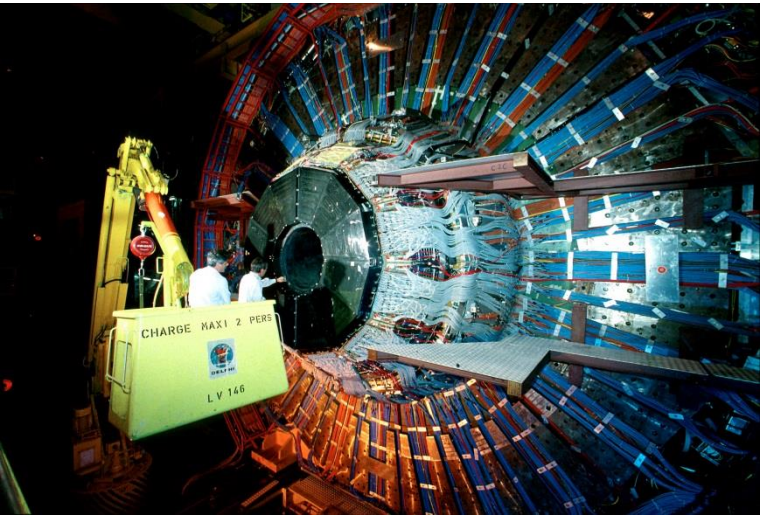
- **NA34/3 HELIOS**
- **DELPHI**
- **WA94**
- **WA97**
- **NA57**
- **NA49**

Present:

ATLAS
ALICE
ISOLDE
NA62
Theory

- Activities are regulated according long-term strategy of Slovak involvement at CERN

Participation in DELPHI collaboration at CERN



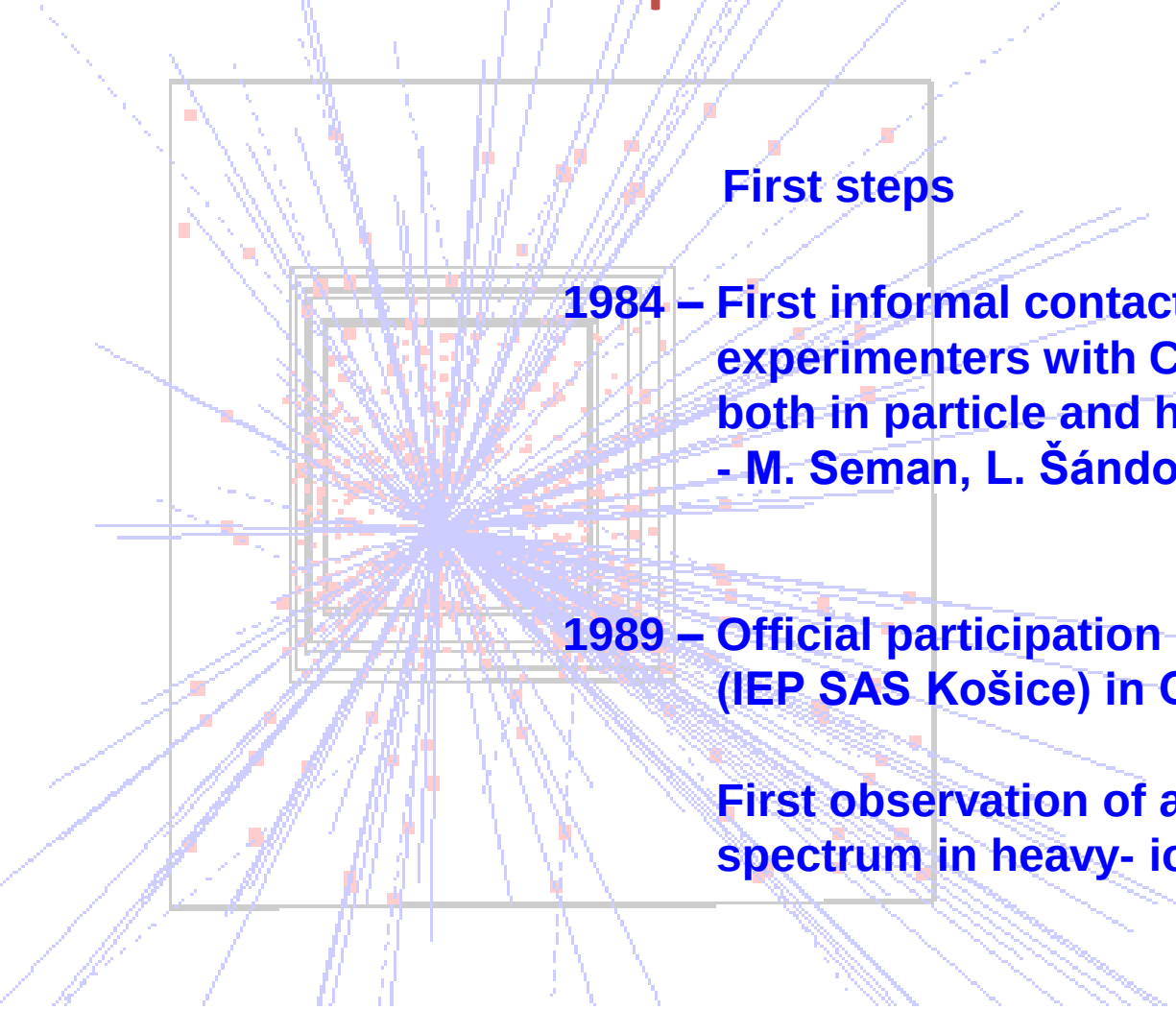
- First contacts with DELPHI established in 1990 by a group (P.Kubinec, P.Chochula, I.Mikulec)
- Thank to generous help of the High Energy Physics Institute (HEPHY) in Vienna, we got involved in several projects closely linked to DELPHI
- The research has been funded within the frames of the East-West coordination project
- Special thanks goes to M. Regler, W.Mitaroff, M.Krammer, R.Fruhwirth and many HEPHY colleagues

Main research activities:

- Study of rare decays and search for Λ_b^0 baryons
- Delevelopment, construction and operation of forward silicon tracker (VFT) in DELPHI
- Participation in running of the experiment (run coordination, slow controls coordination...)
- Development of software tools and components for data reconstruction (track finding algorithms, secondary vertex reconstruction...)

- Bratislava officially joined DELPHI in 1995

Contribution of Slovak physicists to the experiments at the CERN SPS



First steps

1984 – First informal contacts of Slovak experimenters with CERN, NA34 involvement both in particle and heavy-ion program - M. Seman, L. Šándor, J. Antoš

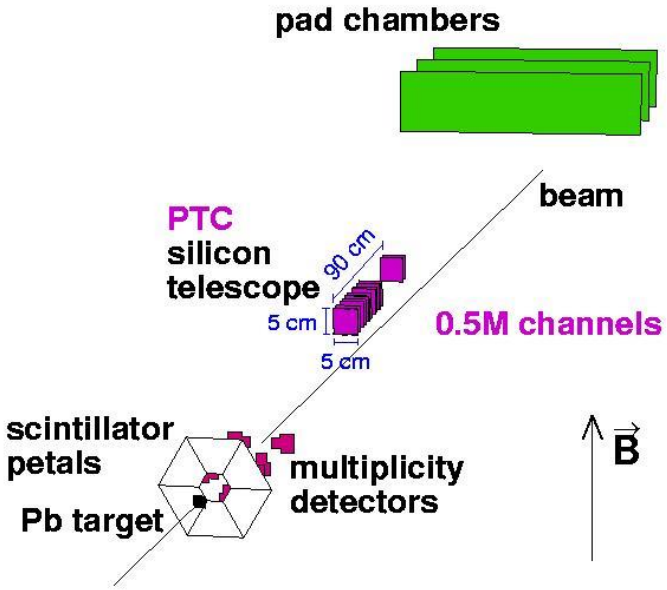
1989 – Official participation of the first CSR institute (IEP SAS Košice) in CERN experiment – NA34/3

First observation of anomaly in the dimuon spectrum in heavy- ion collisions

1991 – WA97 experiment at the Omega facility starts participation of Košice (IEP SAS) group

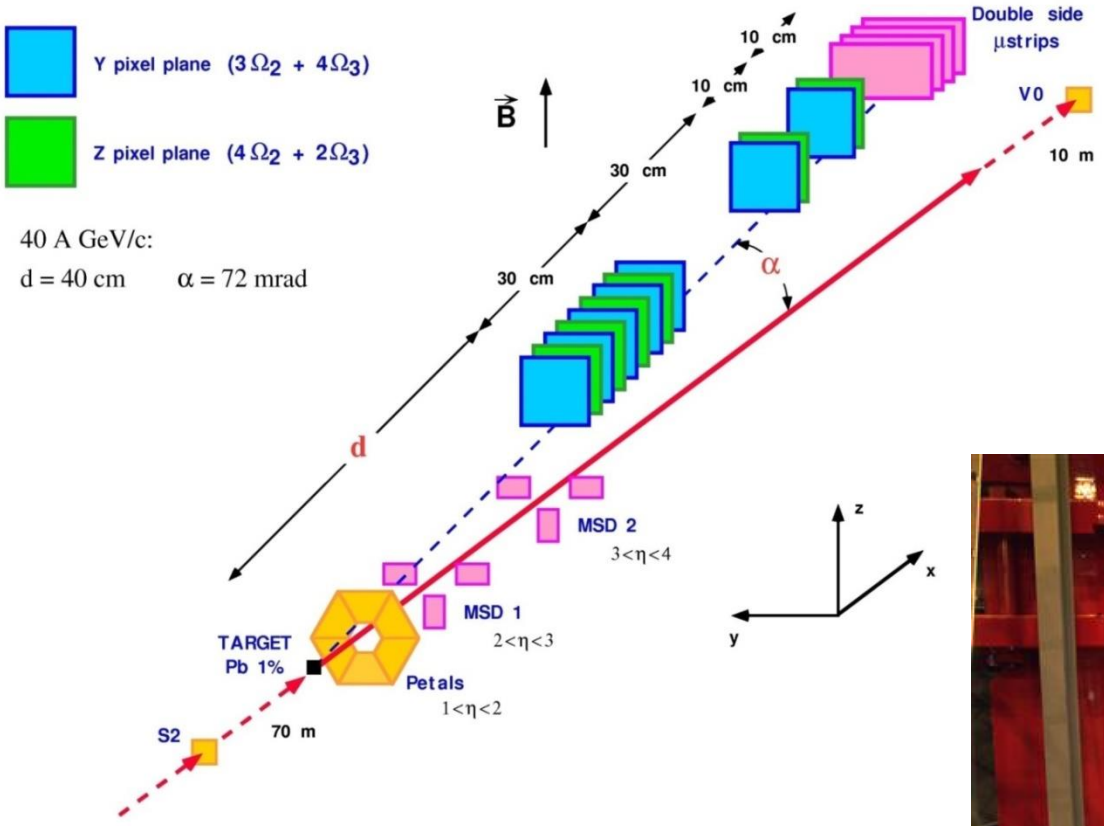
- control electronics for cathode pad chambers
- hyperon and anti-hyperon production in p-Be, p-Pb and Pb-Pb collisions at 158 *A* GeV
- observation of strangeness enhancements at mid-rapidity

WA97 experiment



OMEGA facility in the West experimental hall

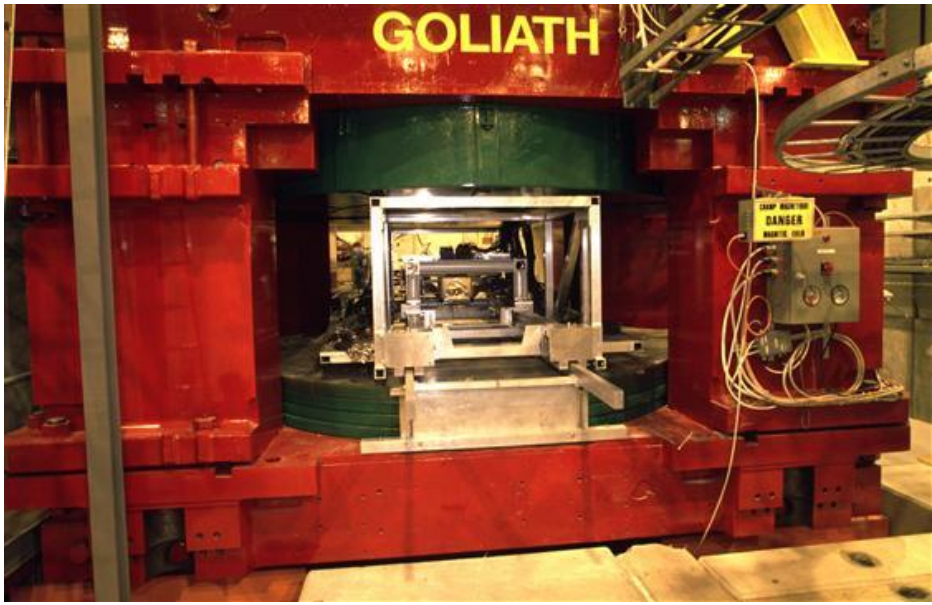
NA57 experiment



Main goal of experinent – study of the dependence of hyperon enhancements on the interaction volume

two different energies – 40 and 158 *A* GeV)

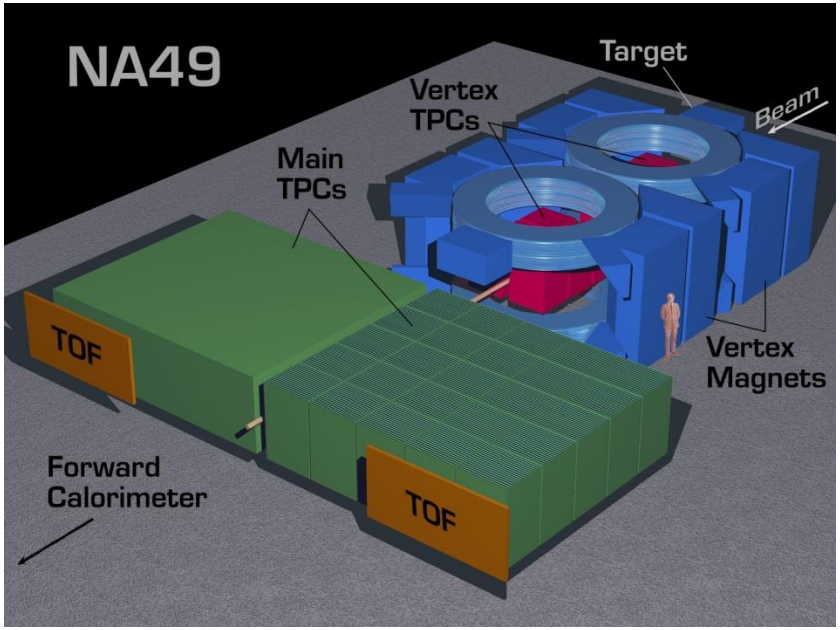
Hyperons at mid-rapidity, Pb-Pb and p-Be collisions



Main tracking detector – the silicon pixel telescope, measurement of charged multiplicity, triggering on centrality

NA49

Large Acceptance Hadron Detector for an Investigation of Pb-induced Reactions at the CERN SPS



- Bratislava joined NA49 collaboration in 1997
- At present the experiment is terminated

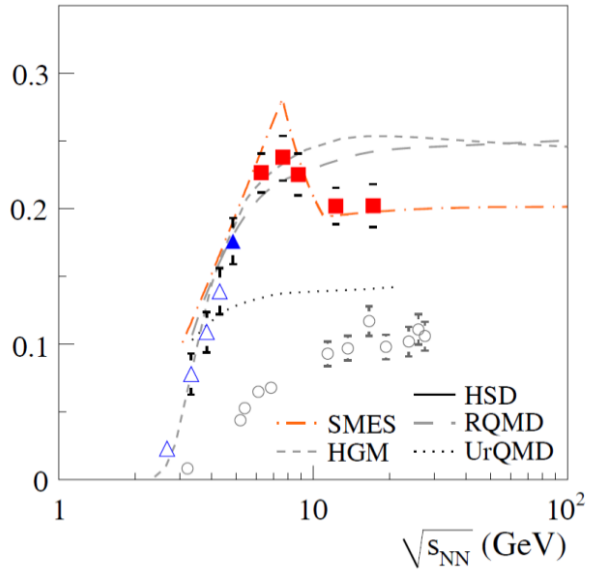
Quark-Gluon Plasma

In the year 2000 CERN announced observation of a new form of matter with the features of a quark- gluon plasma in a Pb-Pb collisions at the energy 158 GeV/nucleon

NA49 and NA57 experiments

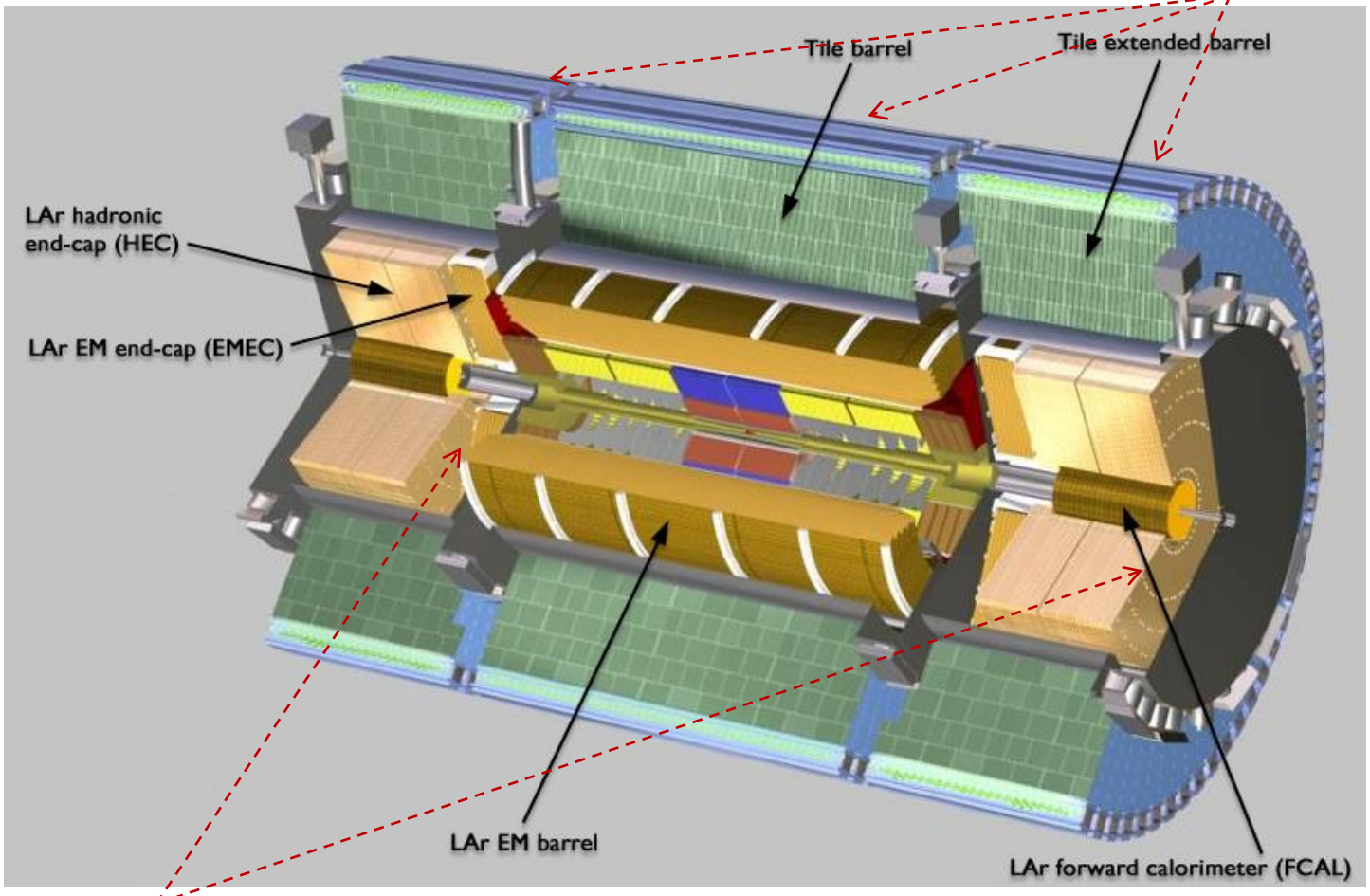
seriously contributed to this fundamental result

The NA49 experiment obtained evidence for the onset of deconfinement from a study of hadron production in central Pb+Pb collisions at the CERN SPS



Atlas: Slovak hardware contribution

Comenius Univ. Bratislava



IEP SAS Košice

Top charge *via* top decay products' charges

- SM (Q_{top} = 2/3): $t^{2/3} \to b^{-1/3} + W^{+1} \to l^{+} + \upsilon_l$
- exotics (Q = -4/3): $\hat{t}^{-4/3} \to b^{-1/3} + W^{-1} \to l^{-} + \bar{\upsilon}_l$

- for top quark determination
  - Charge of W via its lepton decay
  - Determination of b-jet charge
  - Correct lepton – b-jet pairing

$$Q_{b-jet} = \frac{\sum_i^N q_i \left|\vec{j}\cdot\vec{p}_i\right|^{\kappa}}{\sum_i^N \left|\vec{j}\cdot\vec{p}_i\right|^{\kappa}}$$

q_i ($\vec{p}_i$) ≡ ith particle charge (momemtum)

$\vec{j}$ ≡ b-jet direction

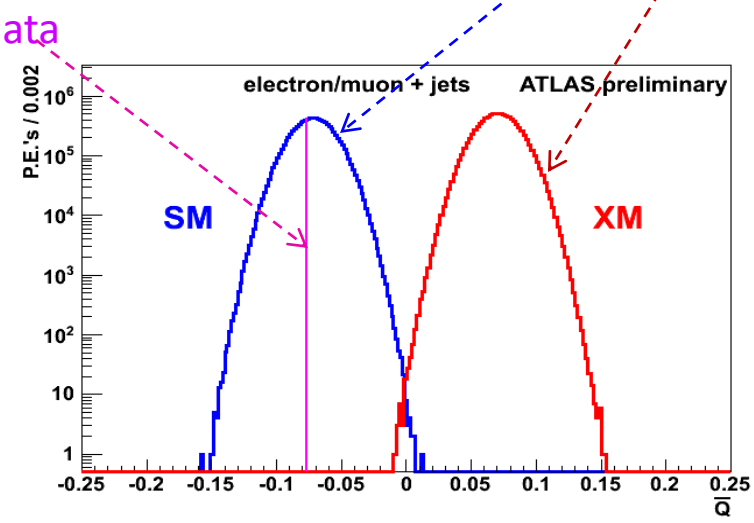
κ ≡ an exponent (=0.5)

$t\bar{t}$ lepton+jets case:

$$m(l,b_{jet}^{(1,2)}) < m_{cr} \;\&\; m(l,b_{jet}^{(2,1)}) > m_{cr}$$

Combined charge: $\langle Q_l \times Q_{bjet} \rangle$ { <0: SM, >0: Exo

Outcomes of experiment for SM and XM

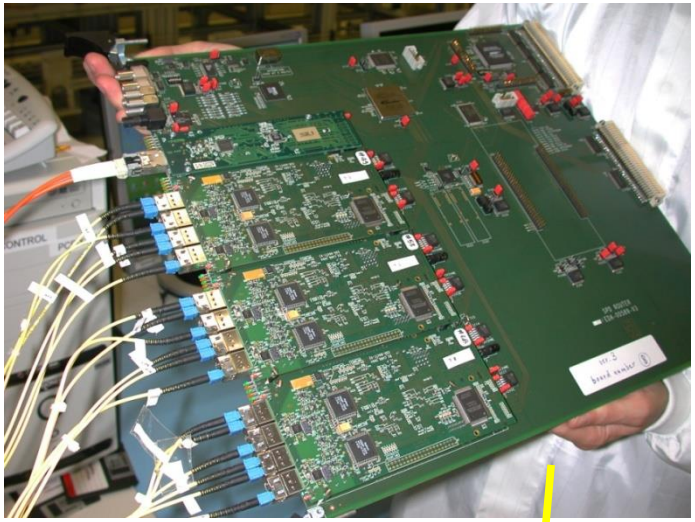


0.7 fb^{-1}: ATLAS-CONF-2011-141 ⇒5σ exclusion XM

2fb^{-1}: Draft 2: ATLAS-TOPQ-2011-13 at pubCom (>8σ)

ALICE Inner Tracking System: Silicon Pixel Detector

Contribution of IEP SAS Kosice



Router for SPD

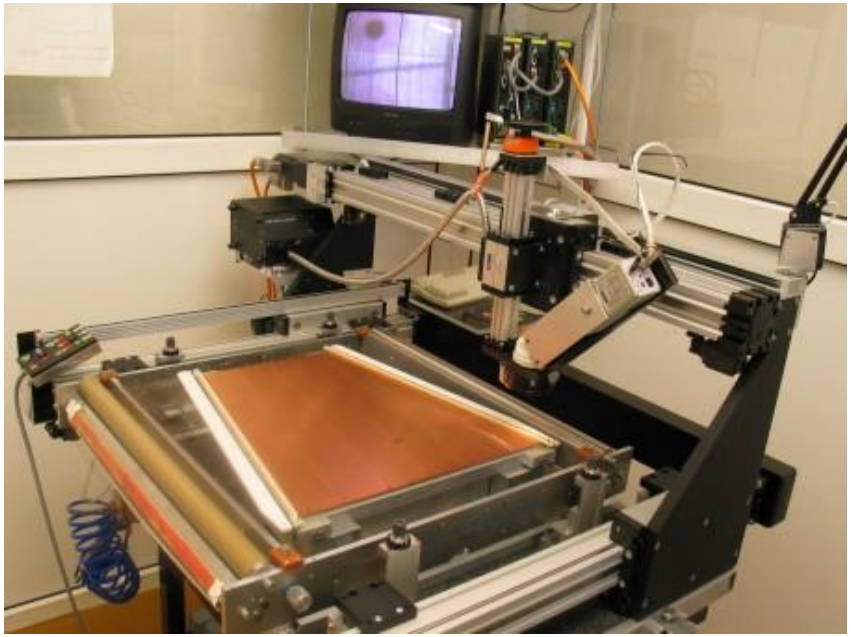
A system consisting of 20 9U VME boards provides communication between the SPD (~10 million channels) and the CTP, DAQ and DCS.
Logic was implemented in the FPGA's

JTAG controller for SPD

An electronic module used for configuration and monitoring of each pixel chip in the SPD.
Logic implemented in FPGA.
24 modules built. Used in pixel detector testing systems

ALICE experiment – contribution of FMFI UK group

Winding machine



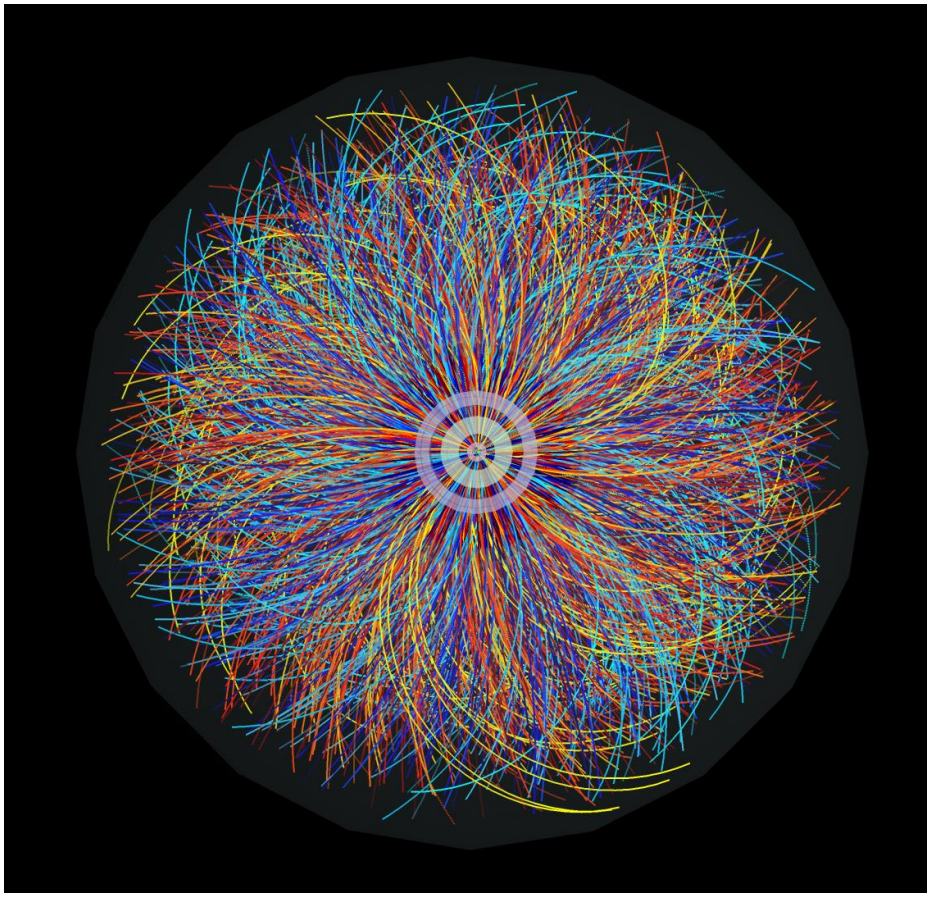
Production of IROC
in a high precision Assembly system

Production of 26 ALICE TPC IROC detectors in Detector Lab. at FMFI UK Bratislava

Installation of the Alice TPC

Slovak physicists and engineers took part in the Alice TPC installation at CERN

Reconstruction of a Pb-Pb interaction with the energy 2.67 TeV/nucleon in the Alice detector



- Part of the tracks are reconstructed by means of IROC detectors produced in the Detector Lab. At FMFI UK Bratislava

World LHC Computing Grid cluster at FMFI Bratislava

2022 year: 115 nods, 1955 cores, 3,29 PB data storage
1.63 million jobs processed

World LHC Computing Grid cluster at IEP SAS Košice

2022 year: 74 nods, 1076 cores, 2,5 PB data storage
1.529 million jobs processed

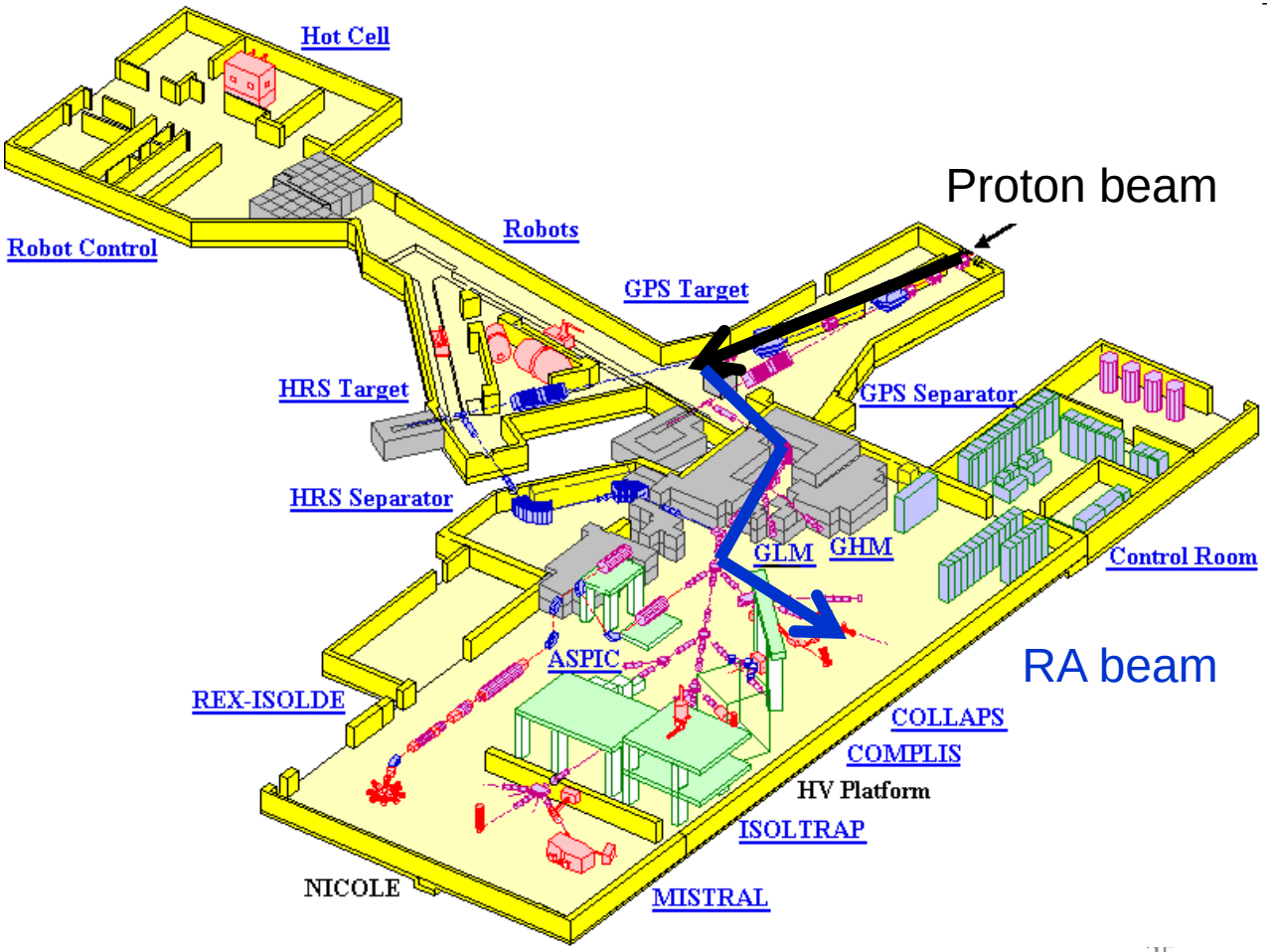
ISOLDE@CERN

Most intense radioactive beams in the world of very high purity.

Possible acceleration up to the 3 MeV/u

(after the HIE-ISOLDE upgrade up to the ~10 MeV/u)

Great possibility to study very rare exotic nuclei and processes.



NA62 Experiment:

Ultra-rare Kaon Decays as $K^+ \to \pi^+ \nu\nu$

Participating Institute: **Comenius Univ. Bratislava**

First Data to be taken at CERN in Fall 2014

Contributing with:

Complete Software Development and Its Maintenance for Local Trigger Unit (LTU) + TTCex TTC interface

Contributions towards Software Production for the Level-0 Trigger and Run Control of the Experiment

Contribution towards Physics Analysis

Decay Amplitude Analysis in Standard Model and Theories that extend it

Current theoretical developments

- **5 institutions,**
  about 20 active physicists (10-12 students)

Topics worked on:

- Constraints on SUSY with non-universal SUSY breaking terms and non-minimal flavour violation from observed rare decays
- Study of SUSY constraints from muon g-2, SUSY predictions for lepton flavour violation in charged leptons
- Leptogenesis, CP violation and unitarity constraints
- Cosmology in non-standard media, cosmic strings
- Fuzzy physics, non-commutative field theory and quantum structure of spacetime
- Matrix models

Contributions of Slovak Industry to the LHC project

969 cryostats for LHC magnets were produced at SES Tlmače

Robots carry LHC magnets and align them with magnet support made by VVÚ ZTS Košice

Return coefficient for supply contracts to CERN was 2.6 within 3 years

Golden Hadron award to VVÚ ZŤS Košice

Education and trainings at CERN

- **Doctoral Student Program**
- It considerably increased the level of PhD thesis in HEP defended in Slovakia
-
- **Technical Student Program**

- **Summer Student Program**
- Is an excellent opportunity for university students to start a career connected with the research at CERN

- About 20 excursions for talented Slovak students came to CERN each year.

- 534 Slovak teachers completed courses of physics at CERN lasting usually one week.
- Courses are organized by Slovak physicists at CERN, namely Karel Šafařík, Peter Chochula, Jan Pišút and others in Slovak language.

Benefits of Slovak membership at CERN

- **Slovak membership at CERN brings to our physicists possibility to work on the highest level scientific research**
- **It is pushing up not only scientific, but also technological level in the country**
- **It is a great opportunity for Slovak industry to participate on the supply contracts to CERN. SR reached a high return coefficient**
- **The technology transfer form CERN to Slovakia can be attractive, but is not fully used yet**
- **Possibility of using WLCG gives to our institutes practically non-limited CERN oriented computational power**
- **Within thirty years Slovak physicists reached at CERN large experience and also outstanding scientific results**