

# **High energy physics in Slovakia**

**Branislav Sitar**

**Comenius University Bratislava**

**RECFA meeting**

**Open session**

**Košice 27.5.2011**

# Topics

- High energy and Nuclear physics in Slovakia
- Financial scheme, students and young physicists
- CERN activities
- Experiments at FNAL
- Neutrino physics
- Nuclear physics: ISOLDE, GSI, FAIR, Dubna
- Accelerators in Slovakia
- GRID computing on WLCG
- XFEL activities
- CERN industrial return



# Slovakia



Area: 49 035 km<sup>2</sup>

Number of inhabitants: 5.43 mil.

8 regions

HEP centers in Slovakia:

- Around 250 HEP and Nuclear Physicists
- 80 CERN users



# High energy and Nuclear physics in Slovakia

- ❖ CERN: ALICE, ATLAS, NA 49, NA 57, NA 62, ISOLDE
- ❖ FNAL: CDF
- ❖ DESY: HERA
- ❖ Neutrino experiments: NEMO 3, Super NEMO
- ❖ GSI: FRS, SHIP,
- ❖ FAIR: NUSTAR, Super FRS
- ❖ JINR Dubna
- ❖ XFEL
- ❖ Slovak Cyclotron center, accelerators in Slovakia
- ❖ Theory

# Organization and financing of HEP and Nuclear physics in Slovakia

- Supervisor and funding agency for Slovak activities at CERN is Ministry of education, science and sport of Slovak Republic
- Coordination of CERN activities: Slovak Committee for Cooperation with CERN
- JINR Dubna and XFEL have special funds from Ministry of education
- Other HEP or Nuclear Physics activities are financed form regular funding agencies as VEGA or APVV
- A road map for collaboration with European laboratories in the framework of ESFRI: CERN, XFEL, FAIR, Spiral 2 is prepared
- Grant scheme for students and Post docs for stages at European laboratories was launched. 14 students worked at CERN half a year in 2009 and 24 in 2010 years.



# Slovakia in CERN

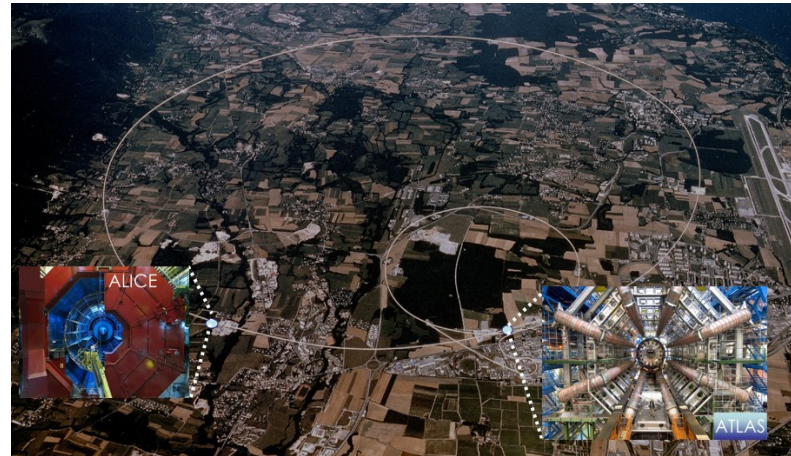


Slovakia is a CERN Member State from 1993

Today research in high-energy physics is carried out mainly at Institutes:

- Comenius University Bratislava FMFI
- Institute of Physics of the Slovak Academy of Science, Bratislava
- Šafárik University Košice
- Institute of Experimental Physics of the Slovak Academy of Sciences, Košice
- Universities: Banská Bystrica, Žilina

According a long-term Conception  
efforts are concentrated on  
participation in the LHC experiments  
**ALICE** and **ATLAS**



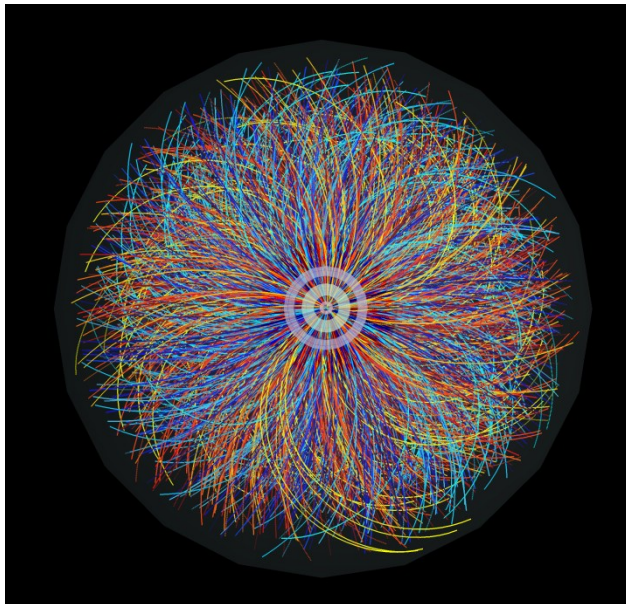


## Slovak institutes participating in ALICE:

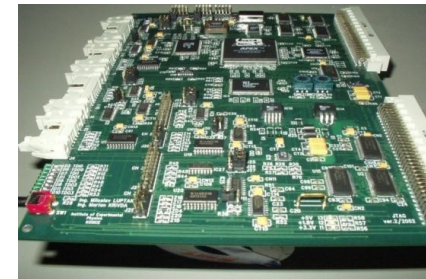
Comenius University Bratislava (B. Sitár)

Institute of Experimental Physics of the Slovak Academy of Sciences, Košice  
(L. Šándor)

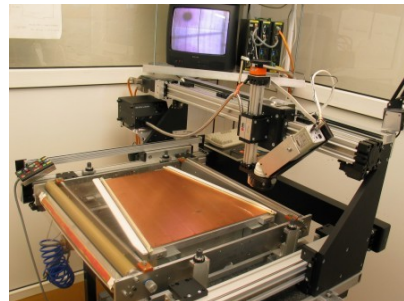
Presently: 16 physicists and engineers, 6 PhD students



**TPC: Bratislava**  
Production and  
test of 26 IROC  
readout chambers  
at Bratislava  
Detector  
Laboratory



**Pixel detector:**  
**Košice**  
Electronics for  
readout



**Pixel detector installation**

**IROC chambers produced at Bratislava work well in  
ALICE TPC**



## Participation of Bratislava group on ALICE physics

Baryon – antibaryon asymmetry  
in central rapidity region at LHC in ALICE experiment

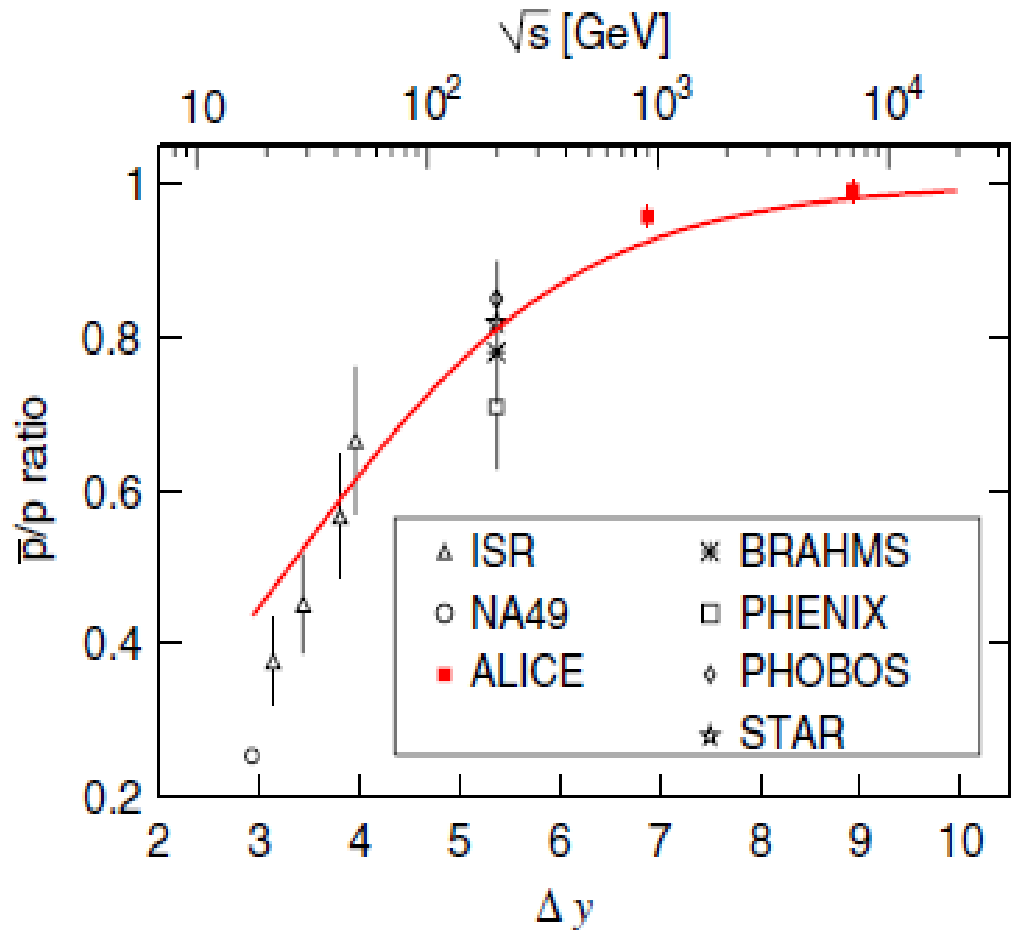
- in proton – proton collisions
- in Pb – Pb collisions

WLCG farm at Bratislava is used for this research



# Recent Bratislava group results on Midrapidity antiproton to proton ratio in p-p collisions

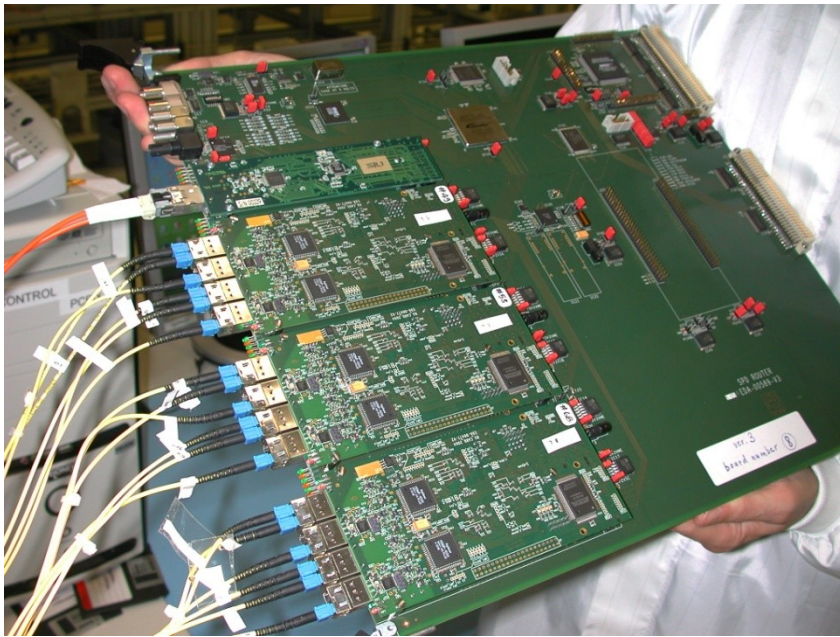
- Results at 900 GeV show small excess of baryons over antibaryons
- At 7 TeV mid rapidity ratio goes to unity
- Results are well described with BN transfer via Regge trajectory using  $\alpha \approx 1/2$
- No significant contribution with constant BN transport with  $\alpha \approx 1$  is needed





# Activities of Košice ALICE team

8 physicists, 3 engineers and 4 PhD students from  
Faculty of Science, P.J.Šafárik University and  
Institute of Experimental Physics, Slovak Academy of Science



Router electronics for the  
ALICE silicon pixel detector

- **Router electronics for the SPD (Silicon Pixel Detector)**
- Contribution to the central trigger (CTP) electronics and software**
- **Simulations of the radiation situation in ALICE environment**

## **Main present activities of ALICE KE group:**

- **active participation in the analysis of strange particle and resonance production in p-p and Pb-Pb collisions**

### **study of diffractive processes**

- **software development and upgrade (analysis code for resonance production study, event mixing, trigger performance monitoring, beam quality monitoring)**

**ALICE analysis facilities development and maintenance (SKAF cluster operation), contribution to the GRID computing**

- **participation in R&D activities towards the ITS (inner tracking system) upgrade**



## Institutes participating in ATLAS:



**Comenius University Bratislava** (S. Tokár)

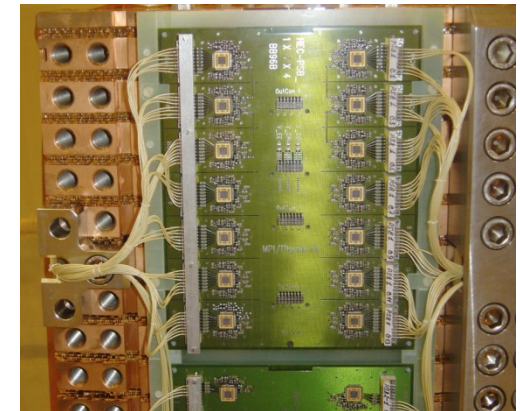
**Institute of Experimental Physics** of the Slovak Academy of Sciences,  
Košice (D. Bruncko)

9 scientists with PhD, 6 doctoral students



Tile calorimeter in test beam

**Tile calorimeter:**  
**Bratislava**  
Iron tiles produced  
in Dubnica



**Electronics cards for LAr  
endcap calorimeter:**  
**Košice**

Lifting devices for calorimeter modules produced in Prešov



## ATLAS Košice group

5 Physicists, 1 engineer, 1 student, 3 technicians

### Hardware:

filter boxes for LAr calorimetry  
Shielding for LAr, calibration  
board for HEC, some electronics  
For HighLumi tests

### Software:

Monitor system for on-line  
calibration, system for on-line  
calibration for HEC, FEB together  
with Columbia Univ.

### Data processing:

on-line calibration for full ATLAS calorimetry  
(P. Stríženec is convener);

Participation on HighLumi analyze, and ATLAS electronic upgrade (ADC)  
The analyze of the top/anti-top quark production in the dilepton channel.

**WLCG:** still not included in WLCG the farm is used locally

# Bratislava team in ATLAS



## Construction and testing of Hadronic Tile Calorimeter

- ✓ Testing of photomultiplier using the single photoelectron approach
- ✓ Test beams: reconstruction of calorimeter response to pions and comparison of the test beam results to MC
- ✓ Test of calorimeter modules by means of cosmic muons

## Top quark properties:

- ✓ top quark charge

## Soft QCD: Bose Einstein correlations

## B-tagging: soft muon tag

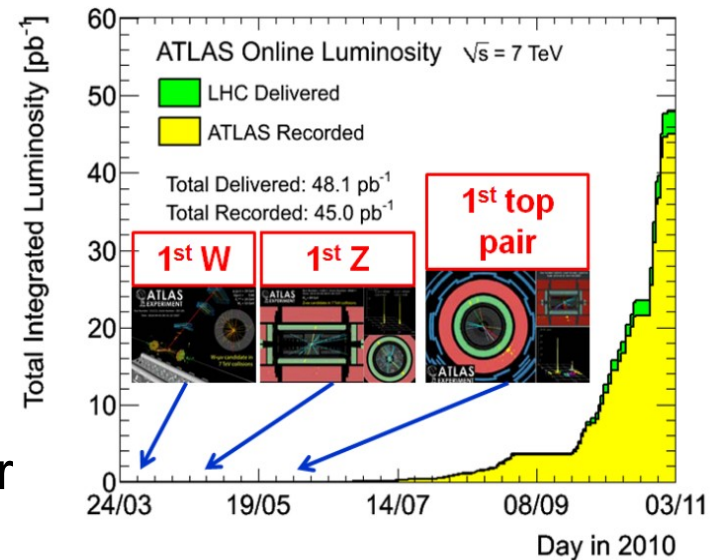
## service work:

- ✓ Participations in ATLAS shifts
- ✓ Data quality coordinator
- ✓ Software development for data quality control
- ✓ Monitoring of GRID computing

Bratislava team - Physicists: [S.Tokar](#), [I. Sykora](#), [T. Zenis](#)

PhD students: [P. Federic](#), [M. Pecsny](#), [L. Batkova](#)

Und. students: [M. Bagljas](#), [L. Plazak](#)



# NA49

Bratislava mainly in pp group

Collaboration started in 1997, 11 physicists took part

At present terminating activity

Main  
TPCs

Vertex  
TPCs

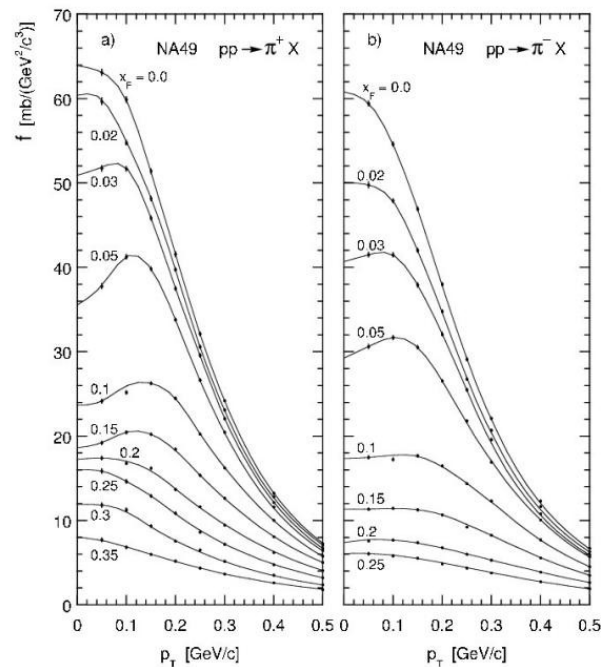
Target

Beam

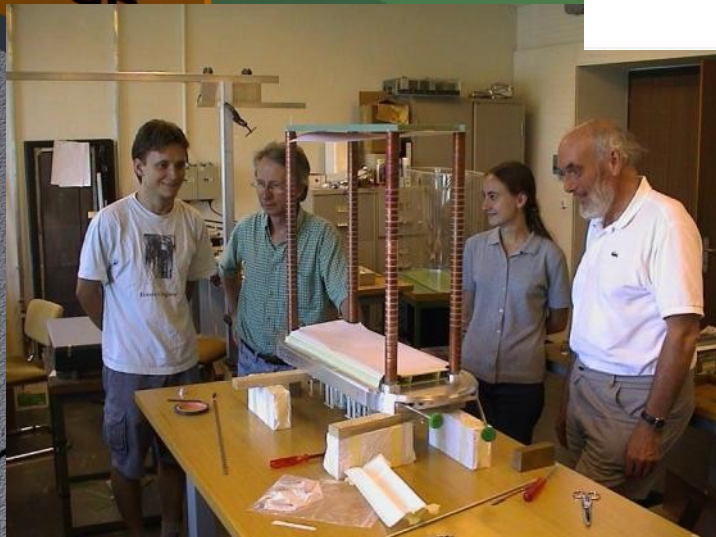
## Inclusive Production of Charged Pions in p+p Collisions at 158 GeV/c Beam Momentum

C. Alt<sup>8</sup>, T. Anticic<sup>17</sup>, B. Baatar<sup>7</sup>, D. Barna<sup>4</sup>, J. B. Boimska<sup>15</sup>, M. Botje<sup>1</sup>, J. Bracinek<sup>3</sup>, P. Bu P. Dinkelaker<sup>8</sup>, J. Dolejsi<sup>12</sup>, V. Eckardt<sup>11</sup>, V. Friese<sup>6</sup>, M. Gaździcki<sup>8,10</sup>, K. Grebies: M. Kliemant<sup>8</sup>, S. Kniege<sup>8</sup>, V.I. Kolesnikov<sup>7</sup>, M. Krepš<sup>8</sup>, M. van Leeuwen<sup>1</sup>, B. Lungwitz G.L. Melkumov<sup>7</sup>, M. Mitrovski<sup>8</sup>, S. Mrówc R. Renfordt<sup>8</sup>, M. Rybczyński<sup>10</sup>, A. Rybici P. Seyboth<sup>11</sup>, F. Siklér<sup>4</sup>, E. Skrzypczak<sup>16</sup>, C J. Sziklai<sup>4</sup>, P. Szymanski<sup>9,15</sup>, V. Trubni G. Vesztergombi<sup>4</sup>, D. Vranic<sup>6</sup>, S. Wenig<sup>6</sup>

(The NA49



Construction of gap TPC



Excellent student supervising

High quality pion inclusive spectra in pp at 158 GeV

# NA57 experiment

Participation of 6 physicists from Košice institutions  
(Šafárik University, Slovak Academy of Science)

Final analysis activities, termination in 2010  
Study of strange and multi-strange hyperons in Pb-Pb and p-Be  
(reference data) collisions

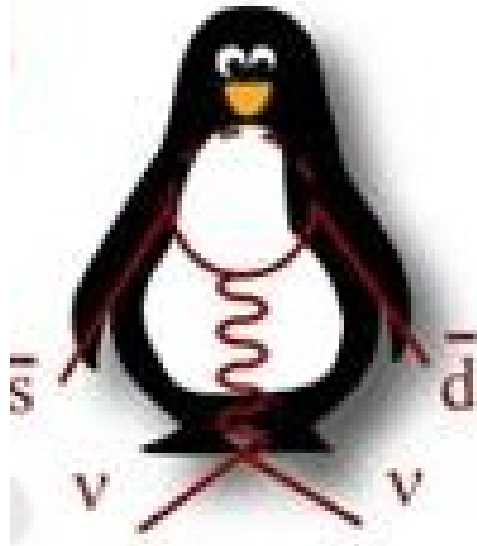
Main results: observation of strangeness enhancements at  
central rapidity at 158 A GeV/c and 40 A GeV/c, analysis  
of thermal freeze-out conditions

(see F. Antinori et al., J. Phys. G: Nucl. Part. Phys. **32** (2006) 427-442;  
F. Antinori et al., J. Phys. G: Nucl. Part. Phys. **37** (2010) 045105)

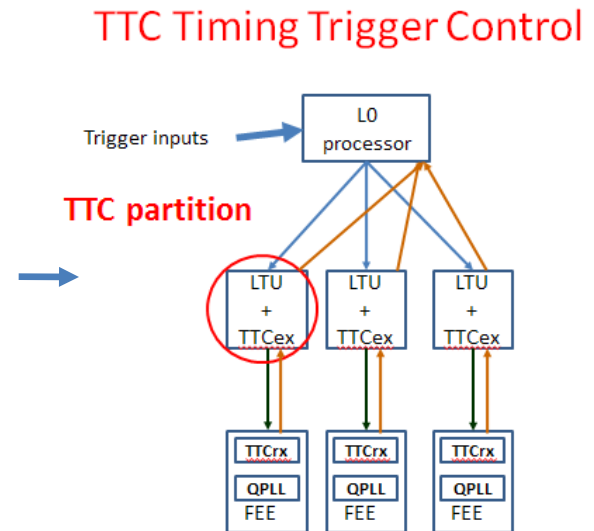


# Bratislava participation in NA62: Ultra-rare kaon decays

3 physicists + 3 students , started in 2010



fourteen  
subdetector  
systems



Software for LTU + TTCex TTC interface:

Two regimes:

- global: communication of properly synchronized trigger information to subdetectors
- standalone: emulation of trigger sequences to debug communication with frontend electronics

Expertise in supersymmetric models and physics beyond standard model (beyond the penguin diagram shown above)

# Experiments at CERN-ISOLDE



Participating researchers : 5

Participating students : 3

Hardware/software contributions : analysis software, Geant-4 simulation routines for detection of low energy gamma rays.

Work in progress : analysis of data from the experiment IS466, preparation of the experiment IS521, design of experimental setup for approved LoI for the HIE-ISOLDE

Participation since : not members of the ISOLDE collaboration, participation in selected experiments approved by INTC committee, starting from 2009

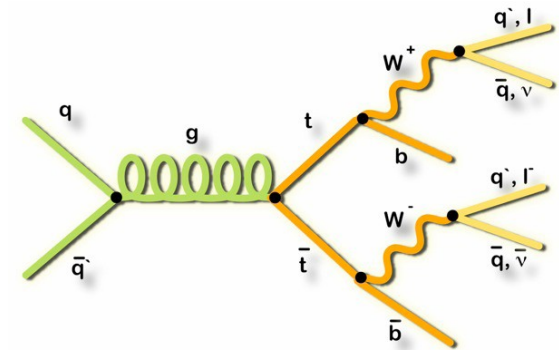
Other activities : Autumn Workshop on GEANT4 simulations in low-energy nuclear physics, in Častá-Papiernička, Slovakia on 9th.-12th. of October 2011. The workshop is organized by Slovak Academy of Sciences (SASc) and ISOLDE collaboration.

# Activities of Slovak teams in CDF



## □ Top quark properties:

- ✓ Forward –backward asymmetry in  $t\bar{t}$  production
- ✓ W boson helicity
- ✓ top quark charge
- ✓  $t\bar{t}$  spin correlations
- ✓ top quark mass in Dilepton channel (3 analysis)



## □ Higgs boson search: $H \rightarrow WW$

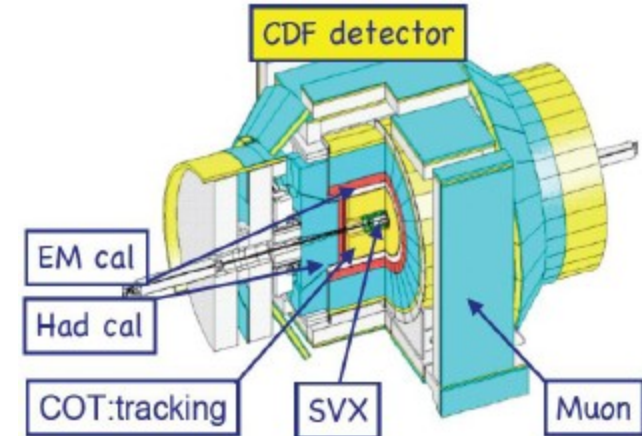
## □ Soft QCD: Bose Einstein correlations

## □ service work:

- ✓ CDF Offline management
- ✓ Muon efficiency calculation
- ✓ FNAL GRID management
- ✓ Jet energy scale calculations
- ✓ CDF Computing on GRID FARM in IEP

**Slovakia group:** Kosice team: J. Antos, R. Lysak

Bratislava team: S.Tokar, P. Bartos, P.Bednar, A. Brisuda, L. Lovas





## *Neutrino Physics in Slovakia*



**Department of Nuclear Physics and Biophysics  
Comenius University, Bratislava**

**Experiments:**  $0\nu\beta\beta$  ( NEMO3, Super NEMO – 2004/2010, TGV-2002, COBRA-2005)

$0\nu\varepsilon\varepsilon$  (on  $^{74}\text{Se}$  in Bratislava, proposal for LSM Modane) - 2009  
charge-changing reaction at RCNP Osaka - 2008  
beta beams at ISOLDE -2009

**Participants:** 8 physicists, 5 PhD students, 2 technicians

**Hardware:** underground facility at Comenius University, facility for radon concentration measurements

**Software:** Codes for energy distributions of emitted electrons in the case of Single State Dominance hypothesis, bosonic neutrinos etc.

**Current tasks:** NEMO3 data analysis, SuperNEMO simulations, Bi-Po background measurements, new proposals ...

# HEP theory in Slovakia

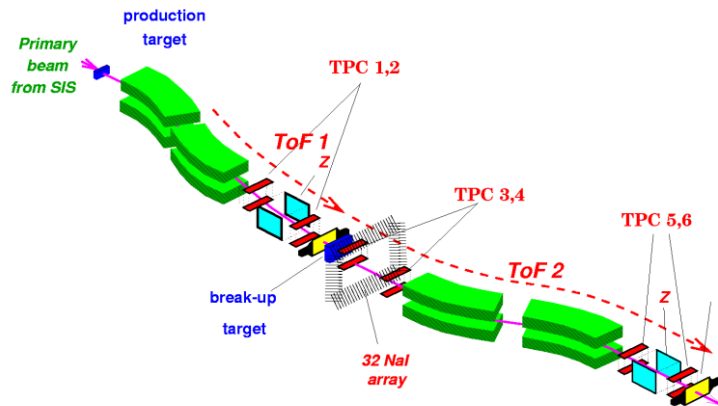
- 5 institutions,  
about 18 active physicists (w/o students)

## Topics worked on:

- hot and dense matter (lattice, equation of state, compact stars, heavy ion phenomenology)
- hadron structure in reactions (EW formfactors, quark structure, hadronic production)
- neutrino physics (neutrinoless double beta decay)
- beyond standard model (strong electroweak symmetry breaking)
- theoretical developments (light front formulation)



## Bratislava group on Fragment Separator FRS and developments for Super FRS on FAIR



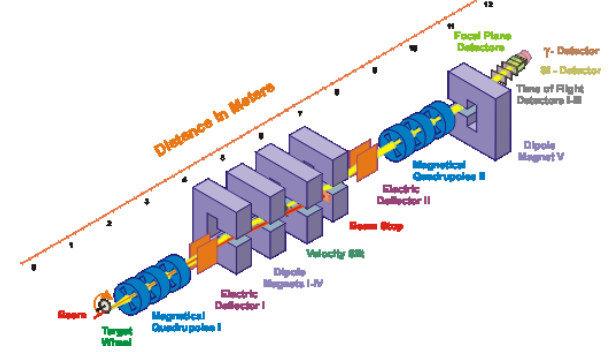
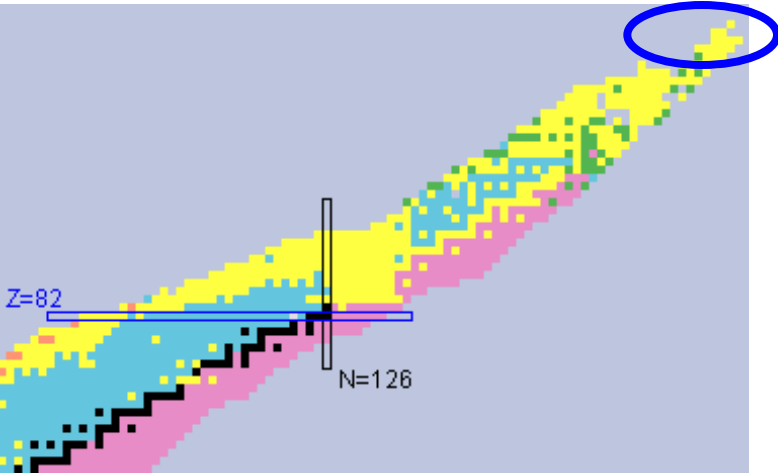
FMFI  
Comenius University Bratislava

Cooperation with GSI Darmstadt from 1994  
5 physicists and engineers + PhD students

- ❖ Hardware contribution: tracking detectors on FRS
- ❖ Participation on many experiments on FRS
- ❖ Bratislava group was asked by NUSTAR collaboration to develop tracking for Super FRS on FAIR

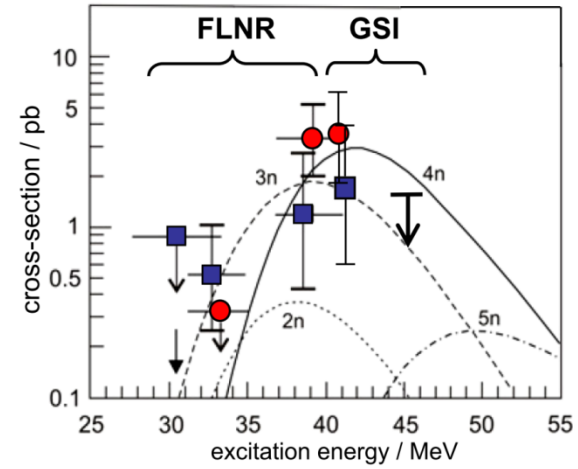
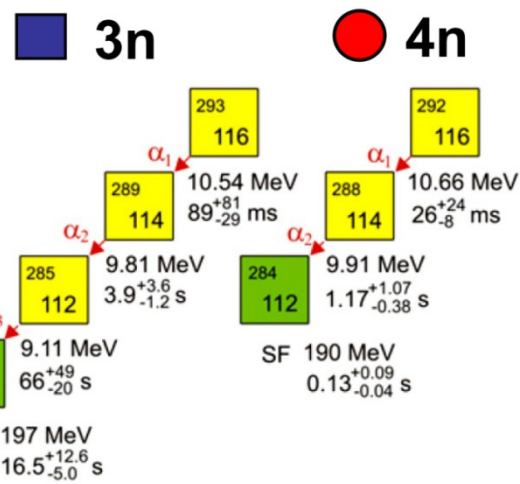
# Nuclear structure research at SHIP in GSI Darmstadt

Studies of superheavy nuclei



2006 – reaction  $^{48}\text{Ca} + ^{238}\text{U} \rightarrow ^{286}112^*$   
 S. Hofmann et al. EPJ A32, 251 (2007)

2010 – production of  $^{293}116$  and  $^{292}116$  in  
 $^{48}\text{Ca} + ^{248}\text{Cm} \rightarrow ^{296}116^*$



Theory: V. Zagrebaev, W Greiner (2008)  
 Experiments: Yu. Ts. Oganessian et al. (2000,2001, 2004)  
 S. Hofmann et al. (2010)

Czechoslovakia participated in JINR from 1956  
Slovakia from 1993

At present in JINR perform research

- 5 research institutes from the Slovak Academy of Sciences
- 11 faculties of several Slovak Universities
- and few independent research Slovak institution in:
  - theoretical physics
  - experimental nuclear and particle physics
  - heavy ions physics
  - applied mathematics
  - neutron physics
  - solid state physics and material research
  - biological materials.





# X-Ray Free Electron Laser XFEL

~20 people involved in research on 2<sup>nd</sup>, 3<sup>rd</sup> and 4<sup>th</sup> (free electron laser) photon sources.

~200 people participated in training (popularization) courses with main topic: X-ray light sources and their applications.

## Representatives in XFEL organs

Prof RNDr. Pavol Sovák CSc. - *Vice Chair of the European XFEL Council,  
member of the Administrative and Finance Committee XFEL*

Ing. Karel Saksl, DrSc. - *member of the European XFEL Council,  
member of The Scientific Advisory Committee XFEL*

Ing. Štefan Molokáč, CSc. - *member of the In-kind Review Committee XFEL*

## Activities towards the European XFEL

- to join leading international research groups, be part of the collaborations, propose and perform experiments at the XFEL.
- transfer of the FEL knowledge and technologies to Slovak scientific groups at universities and research institutions with aim to involve them to different areas of R&D needed for this technology. Be involved in User consortia, shaping the end experimental stations of the XFEL.

# Accelerators in Slovakia

## PET centre at Bratislava

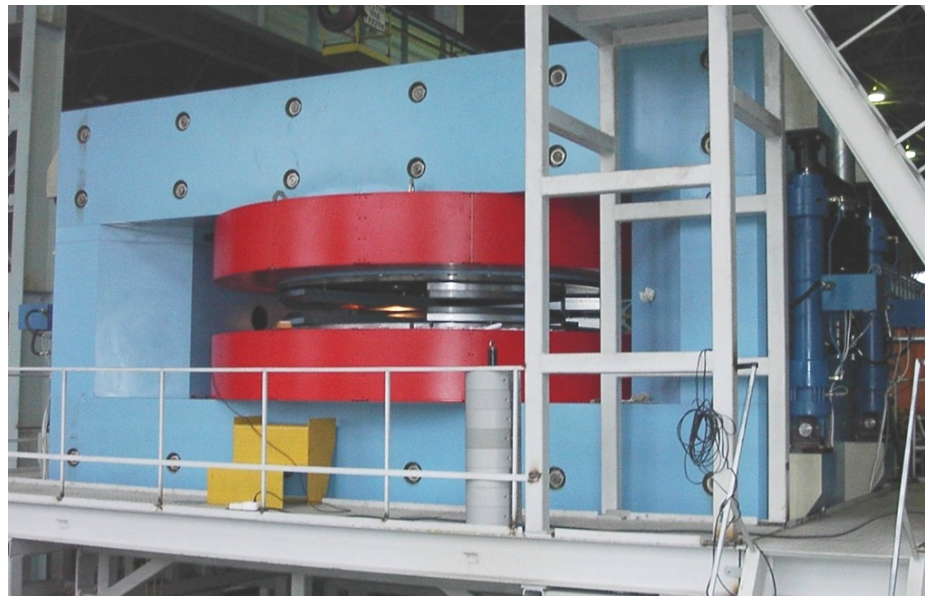


# Proton therapeutic centre at Ružomberok



Proton synchrotron 30 - 340 MeV ( in development – first beams in 2010 )

# 72 MeV proton and heavy-ion cyclotron produced at JINR Dubna for Bratislava Cyclotron Centre

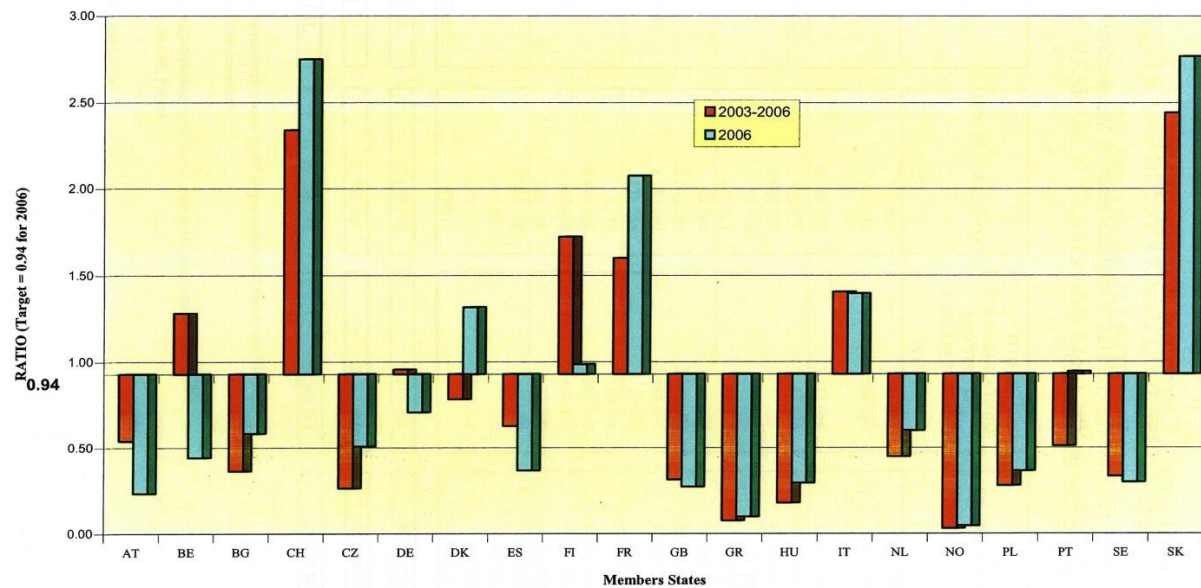


## Students and young physicists at CERN and in European laboratories

- A grant scheme of the Ministry of education allowed 14 students and young physicists stay at CERN 1/2 year in 2009
- In 2010 the program was enlarged to European research laboratories in framework of ESFRI – 35 students spent in Euro Labs ½ of the year, from this 24 at CERN
- The program at CERN was highly effective - students and young physicists worked with top class supervisors, obtain a lot of knowledge and produced interesting results useful also for CERN collaborations
- Slovak Committee for cooperation with CERN appreciate this scheme and supports its prolongation and enlargement to more students and more laboratories

# CERN industrial return to Slovakia in 2003 - 2010

**Table IV**  
**INDUSTRIAL RETURN TO MEMBER STATES FOR SUPPLIES\***  
**FOR THE PERIOD 2003-2006 AND 2006**  
 (Excluding visiting research teams and collaborations, fluids and miscellaneous expenditure)



\* Including commitments carried forward from previous years and excluding commitments for future years.

**2003-06**

**2006**

**2007**

**2008**

**2009**

**2010**

**2.45**

**2.77**

**1.59**

**0.20**

**0.14**

**0.17**

## **Biggest deliveries from Slovakia to CERN**

- **IT-2952/EST/LHC -PRECISION TRANSFER EQUIPMENT SETS**

**Winner : VVÚ ZŤS Košice, Slovakia**

- **IT -3200 /TS / LHC -Motor units**

**Winner : VVU ZŤS Košice, Slovakia**

- **CERN/FC/4865 Supply Burndy connectors**

**Winner : Elektrické systémy Trnava, Slovakia**

- **IT -4645 Supply and assembly of the LHC short straight section cryostat**

**Winner: SES Tlmače, Slovakia**



## Contributions from Slovakia Industry to the LHC

Cryostats for LHC magnets were produced at SES Tlmače



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



LHC award to VVU ZTS



## Conclusion

- ❑ Main task for Slovak HEP community given by previous RECFA session in Slovakia in 2004 was to improve conditions and involvement of students and young physicists.
- ❑ We consider, that we fulfill this goal with long term stages at CERN and other EU Labs. Work of students and young physicists at CERN was highly effective and useful. The scheme should continue in the future.
- ❑ This measure enlarged the number of Slovak CERN users from 55 in 2004 to 80 in 2011, from which majority are young people.
- ❑ Important step forward to higher involvement of Slovak physicists in European Labs. is signing the MoU with XFEL, where Slovakia is a member state. Slovakia also signed MoU with FAIR. We hope, that Slovakia will participate on FAIR as a full member.

An aerial photograph of a rural landscape, likely in a valley, showing a patchwork of green and brown agricultural fields. A large, thin white circle is drawn around the central part of the image. The text "Thank you for attention" is overlaid in white, sans-serif font across the middle of the circle. In the background, a large body of water is visible on the right side, and a road or railway line runs along the bottom right edge. The overall scene is a mix of natural and human-made elements.

Thank you for attention