

# **High Energy Physics activities in Bulgaria**

---

**Prof. Jordan Stamenov**

**INRNE, Sofia, Bulgaria**

**ECFA meeting, November 2007**

## HEP groups in Bulgaria – November 2007

### 1. Institute for Nuclear Research and Nuclear Energy of Bulgarian Academy of Science, Sofia

· Laboratory “Theory of Elementary Particles and Nuclei” - 15

· Laboratory “High Energy Physics ” - 15

Laboratory "Particle physics and Astrophysics" - 9

· Laboratory “Nuclear Physics and Astrophysics” – 20

· Laboratory “Nuclear Methods” – 7

### 2. Faculty of Physics of Sofia University “St. K. Ohridski”, Sofia

· Department “Theoretical Physics” - 2

· Department “Atomic Physics” – 14

### 3. Faculty of Mathematics of Sofia University “St. K. Ohridski”, Sofia - 2

### 4. Chemical and Metallurgical University, Sofia – 2

### 5. Faculty of Physics of Plovdiv University “P. Hilendarski”, Plovdiv

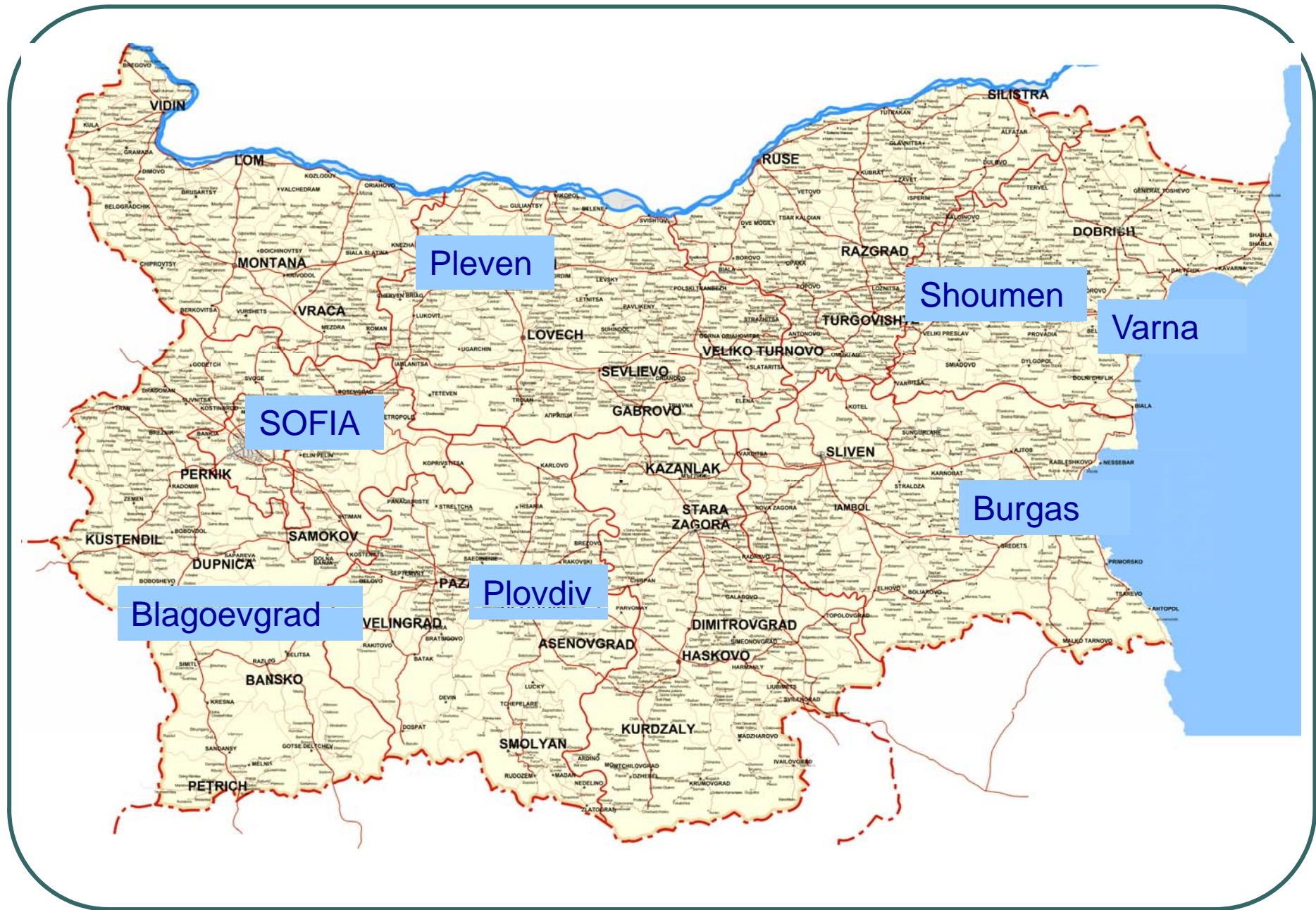
· Department “Atomic Physics” - 2

### 6. Shoumen University “K. Preslavski”, Shoumen

· Department “Physics” – 2

### 7. SW University “N. Rilski” Blagoevgrad – 3

**Total - 93**



**Number of Particle physicists, theory + experiment**

with contracts unlimited in time (incl. Prof.)	78
PostDocs with contracts limited in time	0
active PhD students	15

Sum **93**

**Average length of a PhD work, in years**

3

**Particle Physicists working in (FTE)**

accelerator-based particle physics	41
non-accelerator-based particle physics (excl. astroparticle)	3
astroparticle	8
heavy ion	1
detector R&D	7
accelerator R&D	3
particle physics theory and phenomenology	15

Sum **78**

**CERN users** (pers. stat. table 8, Dec 2004)

62

**CERN staff members** (pers. stat. table 9, cat. 1+2)

7

**Users of other Labs**

DESY	15
FERMILAB	2

## HEP funding

CERN membership fee:	<b>MCHF</b>	2,147
	% of CERN budget	0,21
<hr/>		
<b>Investments of CERN in this country</b>		
Supplies: return coefficient, average last four years		0,59
Services: return coefficient, average last four years		0,2
Investment in experiments at CERN (average per year since last visit)		0,15
total investment in experiments in other Labs (DESY, FERMILAB, non-accelerator, etc)		0,064
M&O for running experiments		0
travel and subsistence money to stay at the accelerator centers		0,005

# Bulgarian participation in HEP Experiments

---

## CERN

- CMS
- HARP
- NA48
- NA49
- MICE
- Totem
- ALICE
- ATLAS
- LHCb

## DESY

- H1

# CMS Collaboration (October 07)

2030 Scientific Authors,  
including about 1000 PhD students  
38 Countries  
174 Institutes



Since **1999** - Bulgaria Member State of CERN

Since **1991** - Member of CMS

**1999** - CMS MoU signed

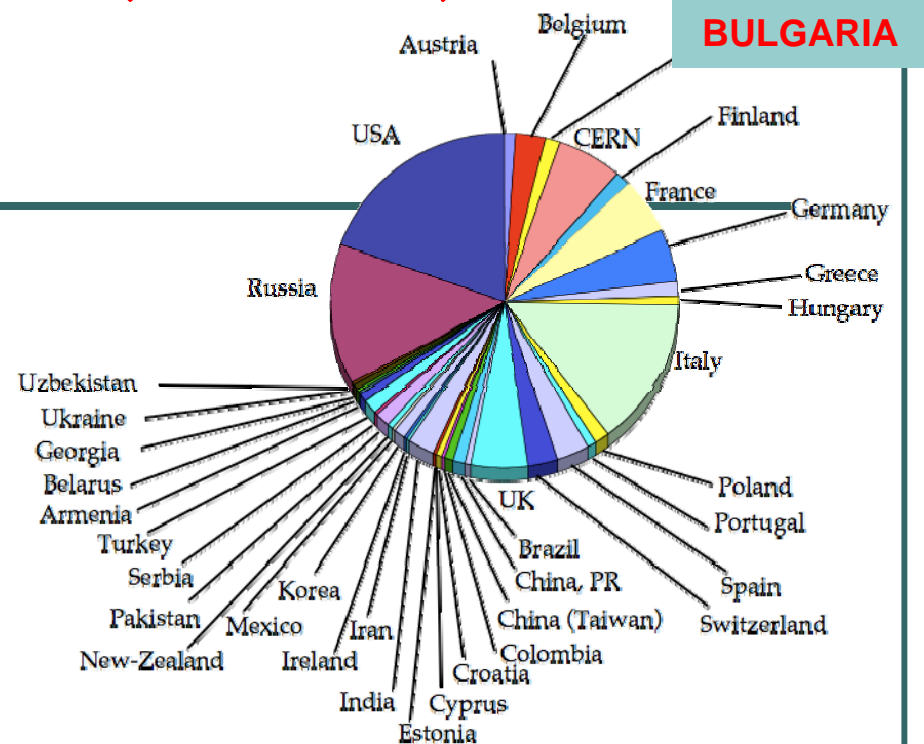
Institute for Nuclear Research and Nuclear Energy: Prof. Vladimir Genchev, Prof. Ivan Vankov  
(**21 members**)

Sofia University: Prof. Leandar Litov, Prof. Matey Mateev (**11 members**)

## Associate Membership:

Central Laboratory for Mechatronics and Instrumentation: Prof. Roman Zahariev

Since 2000 contributions to CMS in framework of cooperation agreement with ETH Zurich



# Installation of Hadron Calorimeter (HCAL)



Installation of the first half-barrel hadrons calorimeter (500 tons) inside the SC coil, completed in April 2006

## Bulgarian contribution to HCAL before 1999



Production of brass absorber plates for 1/2 of barrel in Bulgarian company *Nonferrous Metals*

Design, production and testing of high voltage power supply

Detector performance studies





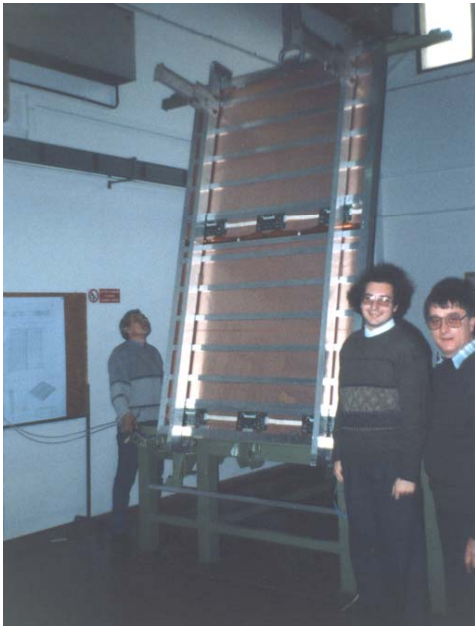
## Bulgarian contribution to RPCs (after 1999)



Production of all aluminium support frames for the barrel RPCs (> 20 tons) at *Stilmet in Sofia*

**Bulgaria** and China share responsibilities for chambers construction, test & commissioning.

At **INRNE**: Assembly and testing of 125 RPCs terminated end of 2005, shipped to CERN

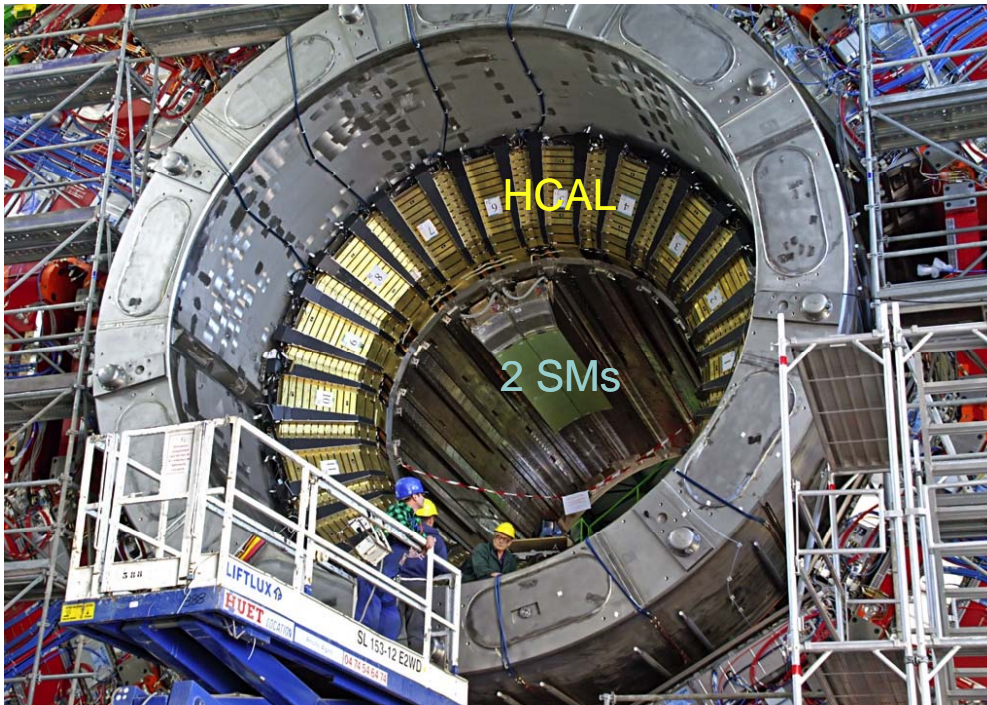


## Installation of barrel muon chambers (DTs, RPCs)

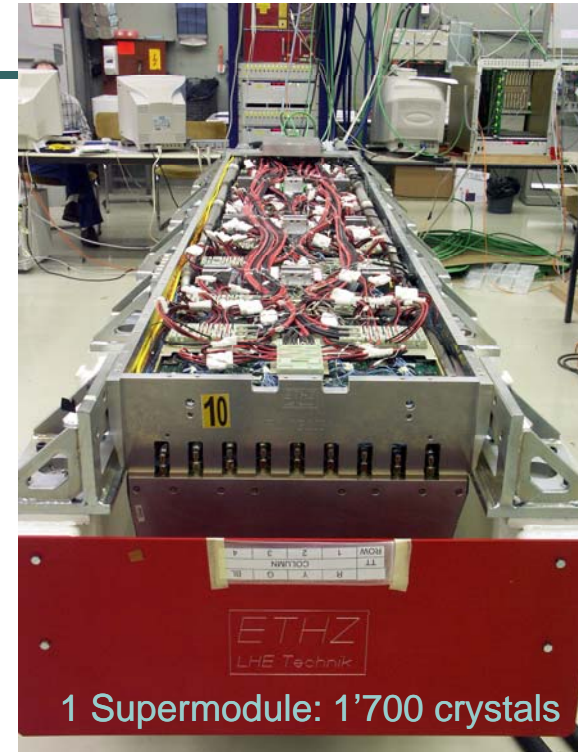


Installation of RPCs with participation of Bulgarian specialists from **University of Sofia** and **INRNE**

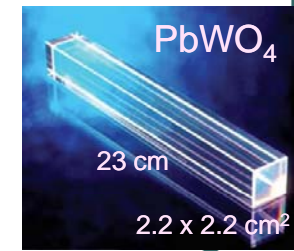
# ...followed by insertion of 2 ECAL Supermodules



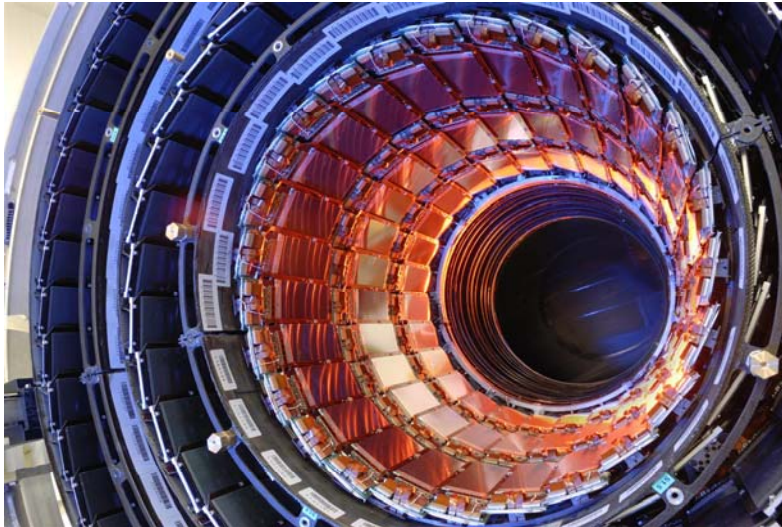
~ 76'000  $\text{PbWO}_4$  crystals  
produced in Russia and China



Important contributions from colleagues of **CLMI (Sofia)**  
to the ECAL electronics integration (ETH responsibility)



Summer 2006 11



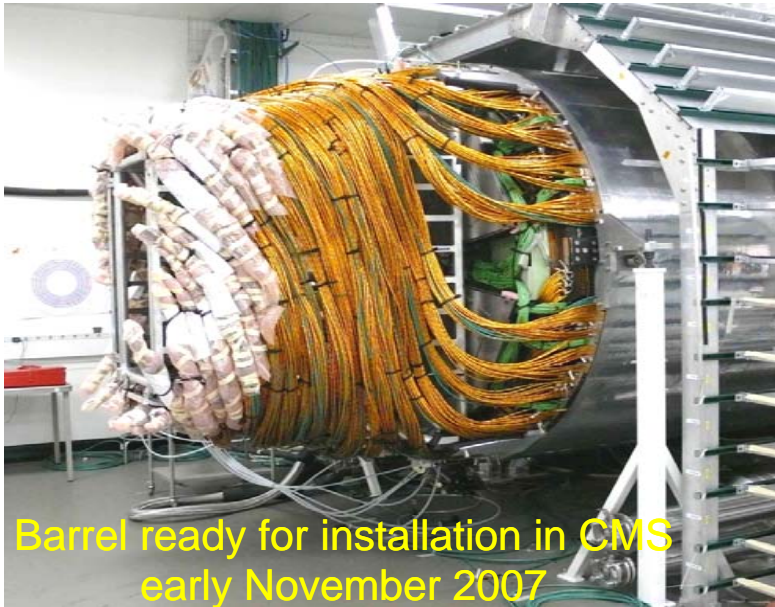
## CMS Tracker:

Total silicon area ~ 210 m<sup>2</sup>

Silicon Strip Detector: 9.6 million channels

Pixel Detector: 66 million channels

Sensors from first half tracker  
inner barrel (October 2006)



Barrel ready for installation in CMS  
early November 2007



CLMI colleagues: module bonding at  
ETH Bonding Lab at CERN

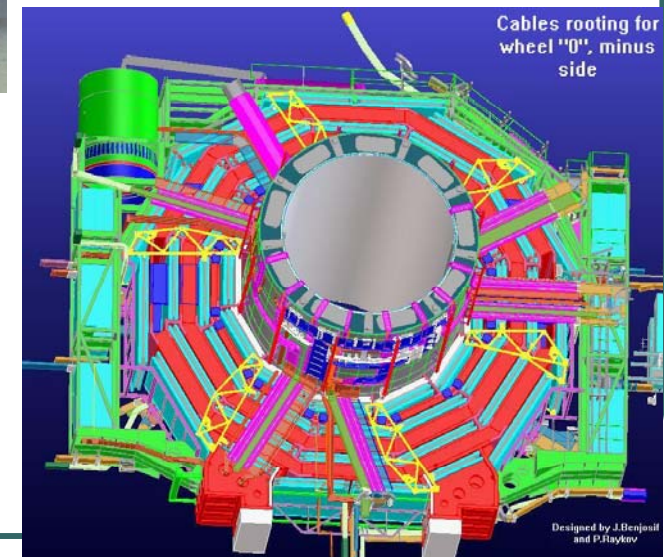
## Bulgarian teams: additional contributions



Bulgarian and ETH colleagues working in EIC and  
ECAL Electronics Integration Center  
October 2007

CMS Engineering and Integration Center  
**CLMI team** (ETH collaboration): design of  
Tracker cable routing

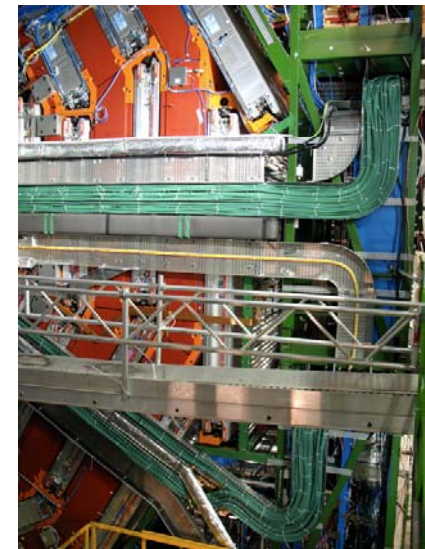
Integration of ECAL  
Endcaps has started at  
ETH ECAL Electronics  
Integration Center with  
participation of **CLMI**  
and **INRNE**



## Bulgarian teams: additional contributions



Cabling team  
from **INRNE**  
working in  
**CMS**



About 43'000 cables with a total length of about 1'200 km have to be installed

# One Crate of HV Power Supply System for CMS Forward Hadron Calorimeter



The system consists of 23 crates with 6 HV modules. 4 HV (10 kV) and 4 bias (100 V) channels in each module.

Produced by INRNE 2004-2006

# One Crate of HV Power Supply System for CMS Forward Hadron Calorimeter



The system consists of 2 crates with 4 HV modules with 3x3 channels in each module.

Produced by INRNE – 2006



# Other experiments

---

# NA49

---

- ❖ **Main goal of the experiment**

- Search for signatures of quark – gluon plasma at SPS energies (20-158 A-GeV)

- ❖ **Data taking - till 2002**

- ❖ **Data analysis – still ongoing**

- **University of Sofia**

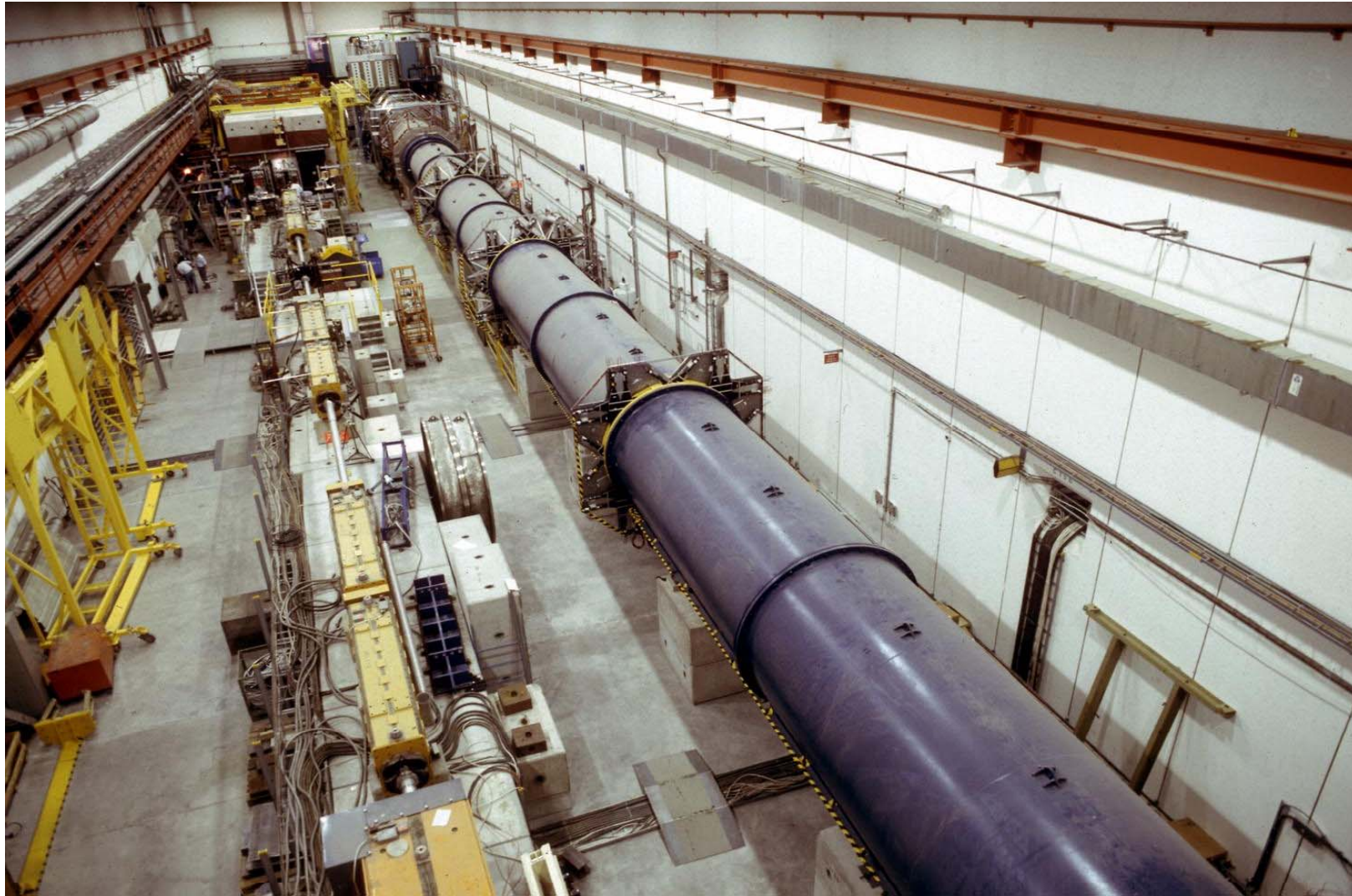
- ✓ 2 physicists 2 PhD student

- ✓ dE/dx calibration of TPC

- ✓ Experiment running

- ✓ Software development and Data analysis

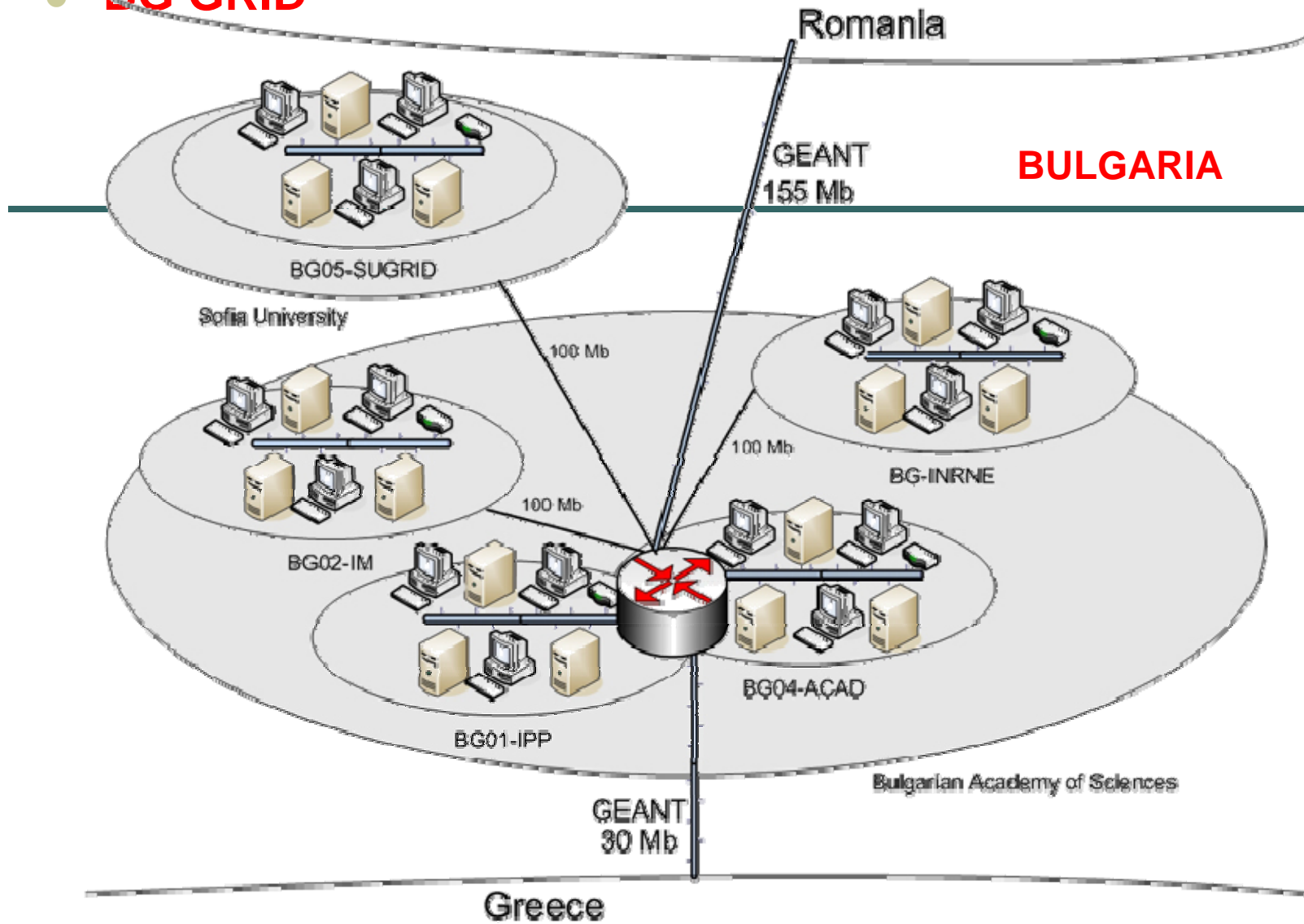
# NA48 experiment



СОФИЙСКИ УНИВЕРСИТЕТ · КЛИМЕНТ ОХРИДСКИ ·  
ФИЗИЧЕСКИ ФАКУЛТЕТ

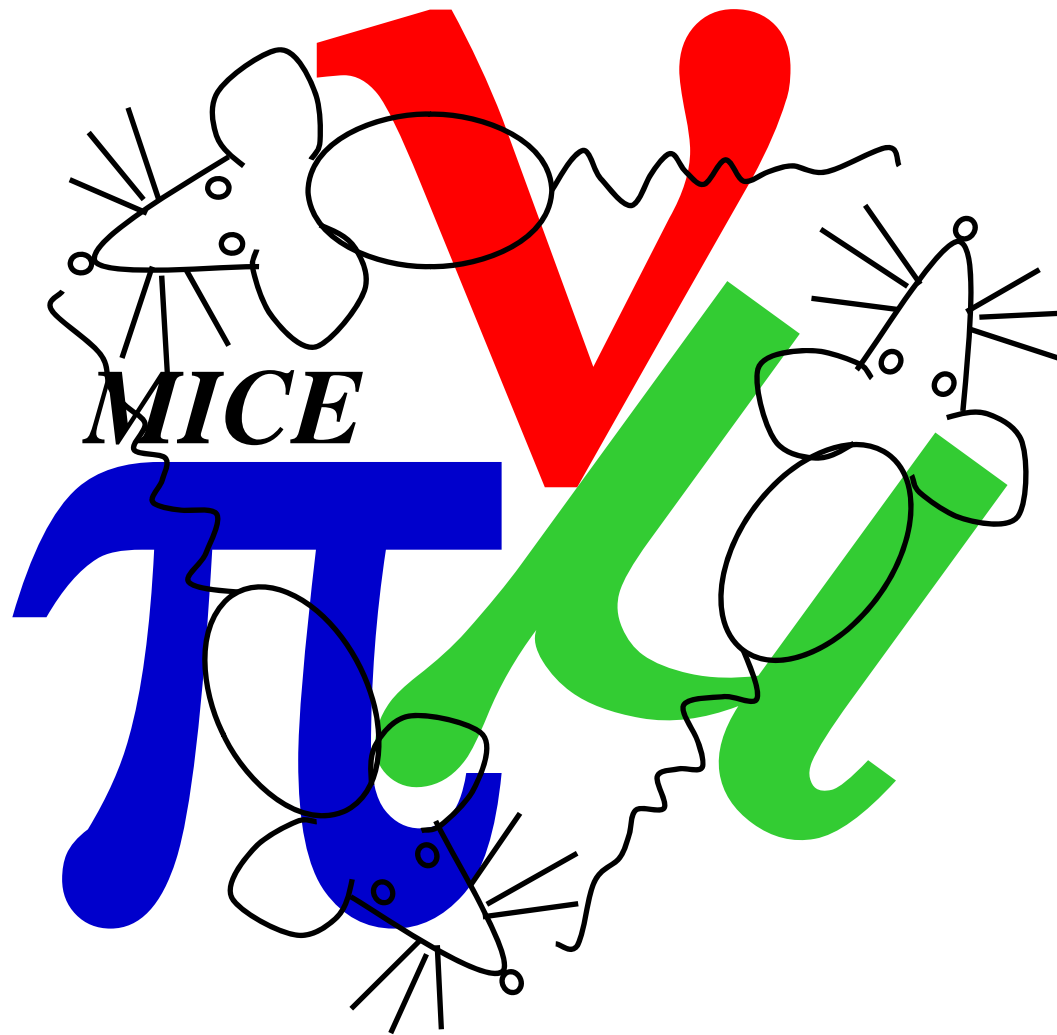


- BG GRID**



# INRNE Computer cluster GRID





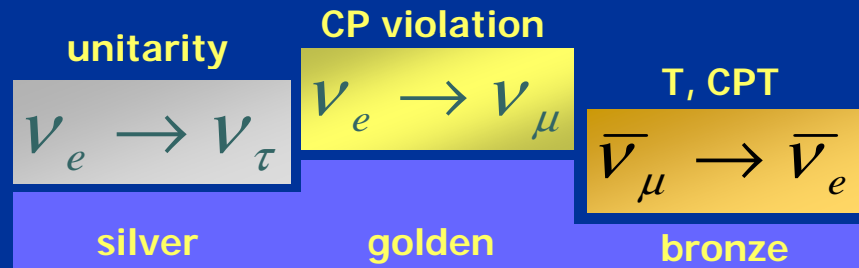
**The International Muon Ionization Cooling Experiment**

# Neutrino factory

- 50%  $\bar{\nu}_\mu$  50%  $\nu_e$  → small beam systematics ... but charge required
- High energy beam → small cross section systematics
- A wide variety of studies are possible:

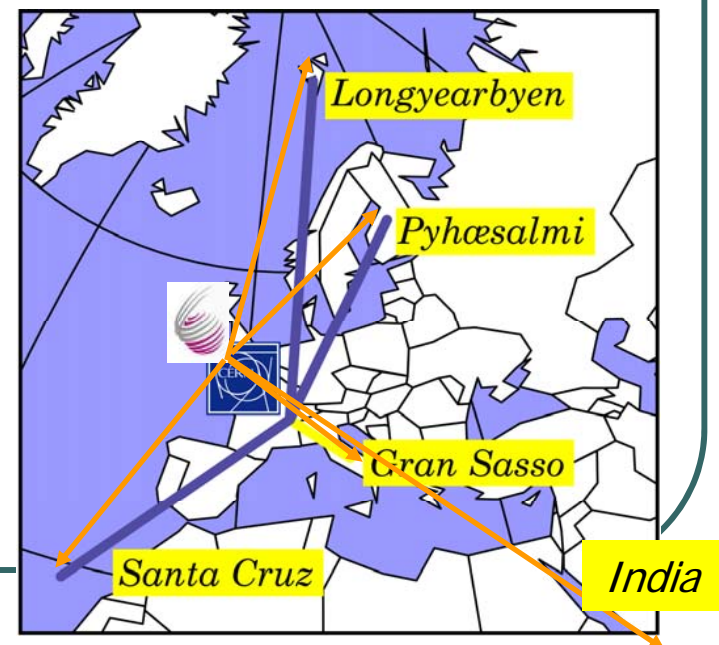
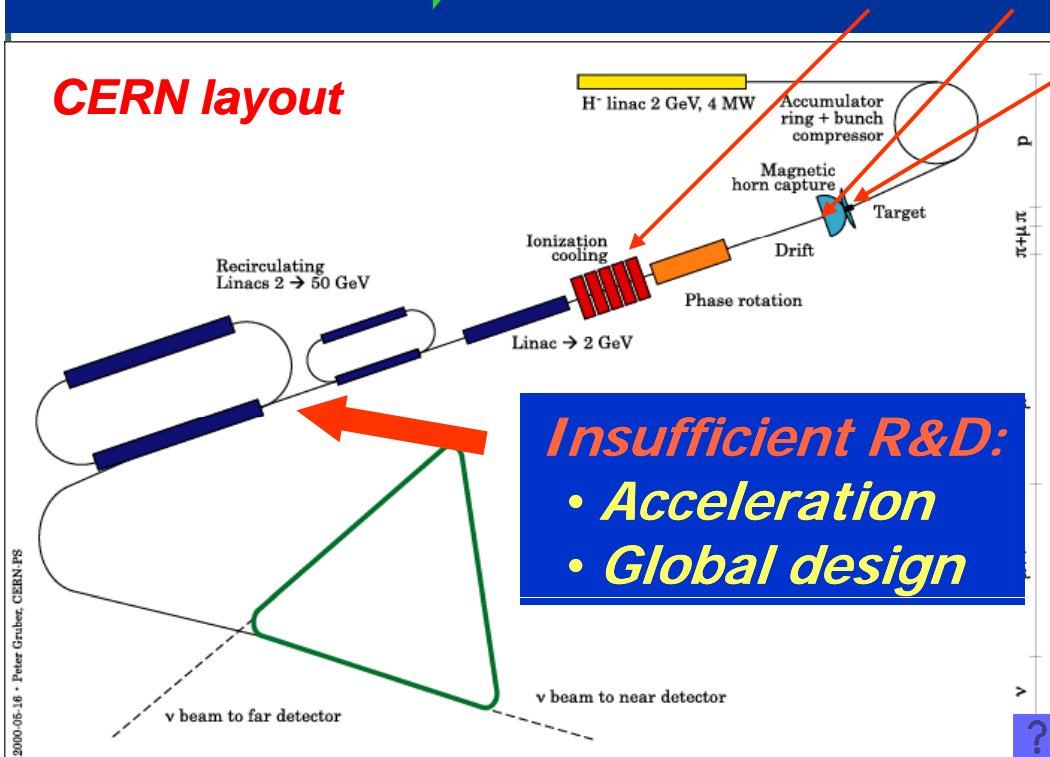
and also:  $\bar{\nu}_\mu \rightarrow \bar{\nu}_\mu$   $\bar{\nu}_\mu \rightarrow \bar{\nu}_\tau$

Atmospheric osc.



- Challenging → Ongoing R&D: *MICE, HARP, MERIT*

## CERN layout







*The HARP experiment*

Thank you for your attention!

---