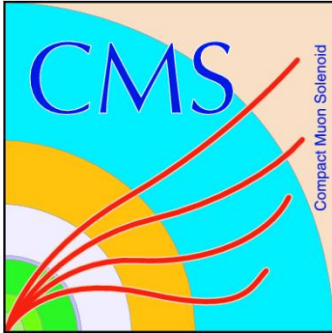


RECFA visit to Poland 2012

Cracow, May 11-12, 2012



Marcin Konecki

University of Warsaw, Faculty of Physics

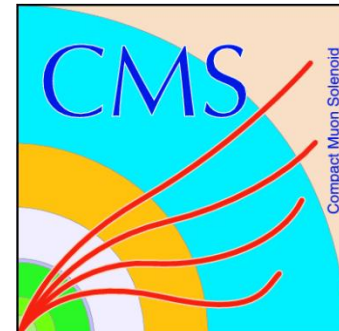
(marcin.konecki@fuw.edu.pl)



pp experiments at LHC – CMS *(Warsaw Group involvement in CMS)*

- *Overview*
- *L1RPC trigger activity*
- *Physics analysis*
- *Funding*

Project: CMS



- Institutions in Poland:
 - Warsaw: UW, NCBJ, WUT(assoc.)
- Participants (active):
 - 21 staff, 4 PhD students, 8 students
- Main contribution:
 - Design and construction of the RPC readout and trigger system (6 MCHF)
- Main responsibilities:
 - Maintenance and support of L1RPC trigger,
 - Physics analyses
- Financing: 2010-2012 (NCN)
NCN – Narodowe Centrum Nauki (National Science Center)



CMS = Compact Muon Solenoid

41 Countries, 189 Institutes, over 3000 Scientists

TRIGGER, DATA ACQUISITION & OFFLINE COMPUTING

Austria, Brazil, CERN, Finland, France, Greece,
Hungary, Ireland, Italy, Korea, Lithuania, New Zealand,
Poland, Portugal, Switzerland, UK, USA

TRACKER

Austria, Belgium, CERN, Finland, France, Germany,
Italy, Mexico, New Zealand, Switzerland, UK, USA

CRYSTAL ECAL

Belarus, CERN, China, Croatia, Cyprus, France, Italy,
Portugal, Russia, Serbia, Switzerland, UK, USA

PRESHOWER

Armenia, CERN, Greece,
India, Russia, Taiwan

SUPERCONDUCTING MAGNET & YOKE

All countries in CMS contribute
to Magnet financing

FEET
Pakistan
China

HCAL

Barrel: Bulgaria, India, USA
Endcap: Belarus, Bulgaria, Georgia, Russia,
Ukraine, Uzbekistan
HO: India

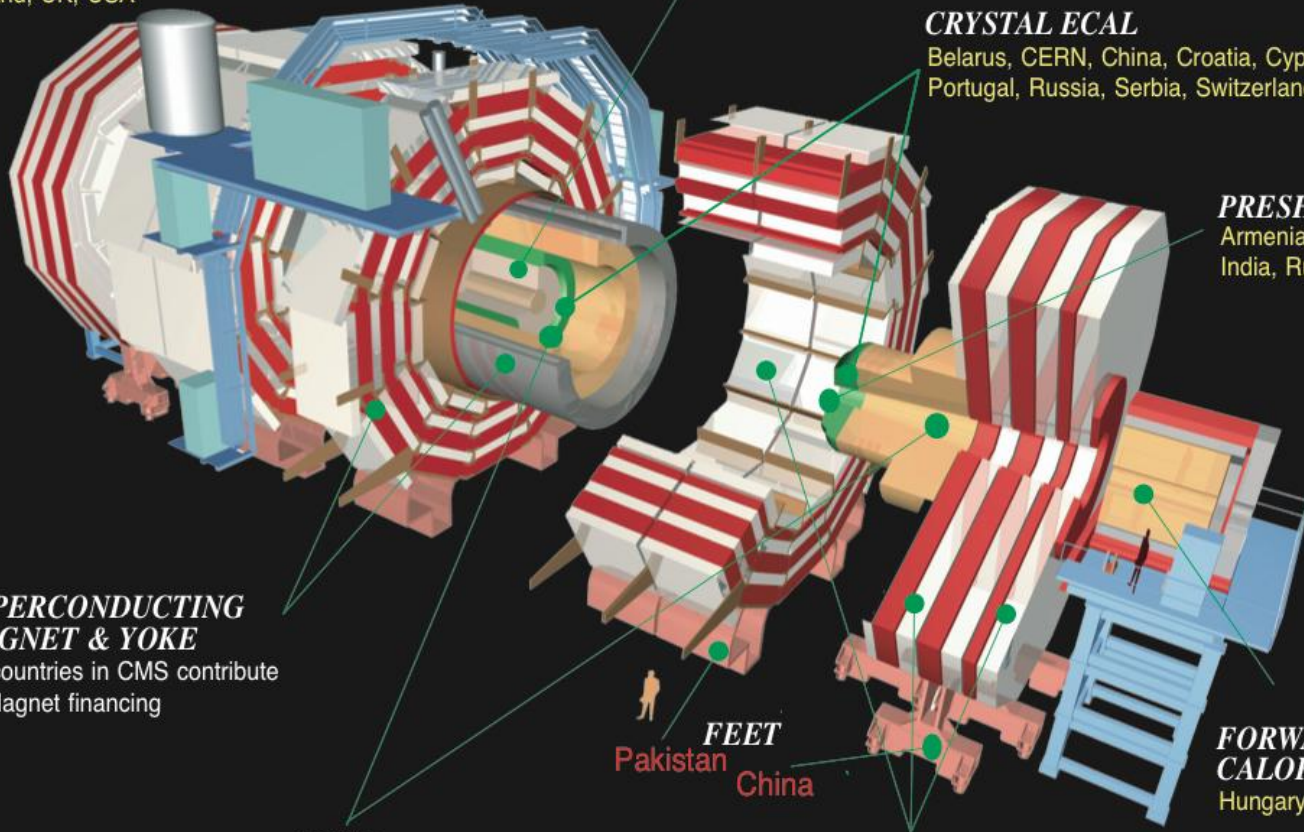
MUON CHAMBERS

Barrel: Austria, Bulgaria, CERN, China,
Germany, Hungary, Italy, Spain
Endcap: Belarus, Bulgaria, China, Colombia,
Egypt, Korea, Pakistan, Russia, USA

FORWARD CALORIMETER

Hungary, Iran, Russia, Turkey, USA

Total weight : 14000 tonnes
Overall diameter : 15.0 m
Overall length : 28.7 m
Magnetic field : 3.8 T



Polish/Warsaw Group in the CMS experiment

- **University of Warsaw, Faculty of Physics**

D.Bartkiewicz, R.Boniecki, G.Brona, K.Buńkowski,
M.Ćwiok, W.Dominik, K.Doroba,
A.Kalinowski, K.Kierzkowski, M.Konecki, J.Królikowski, M.Maćkowski,
M.Misiura, K.Nesteruk, Ł.Obara, W.Okliński, K.Pozniak (also WUT), A.Smykiewicz,
W.Wolszczak, W.Zabolotny (also WUT), M.Zielenkiewicz

physicists (16)
engineers (5)
PhD students (4)
students (8)

- **National Center for Nuclear Research,
High Energy Physics Division**

H.Bialkowska, M.Bluj (on leave), B.Boimska, T.Frubes, R. Gokieli, M.Górski, M.Kazana, I.Kudla (on leave),
K.Nawrocki, K.Romanowska-Rybinska, M.Szleper, P. Traczyk (on leave), G.Wrochna, P.Zalewski,

- **Warsaw University of Technology,
Institute of Electronic Systems (associated institute)**

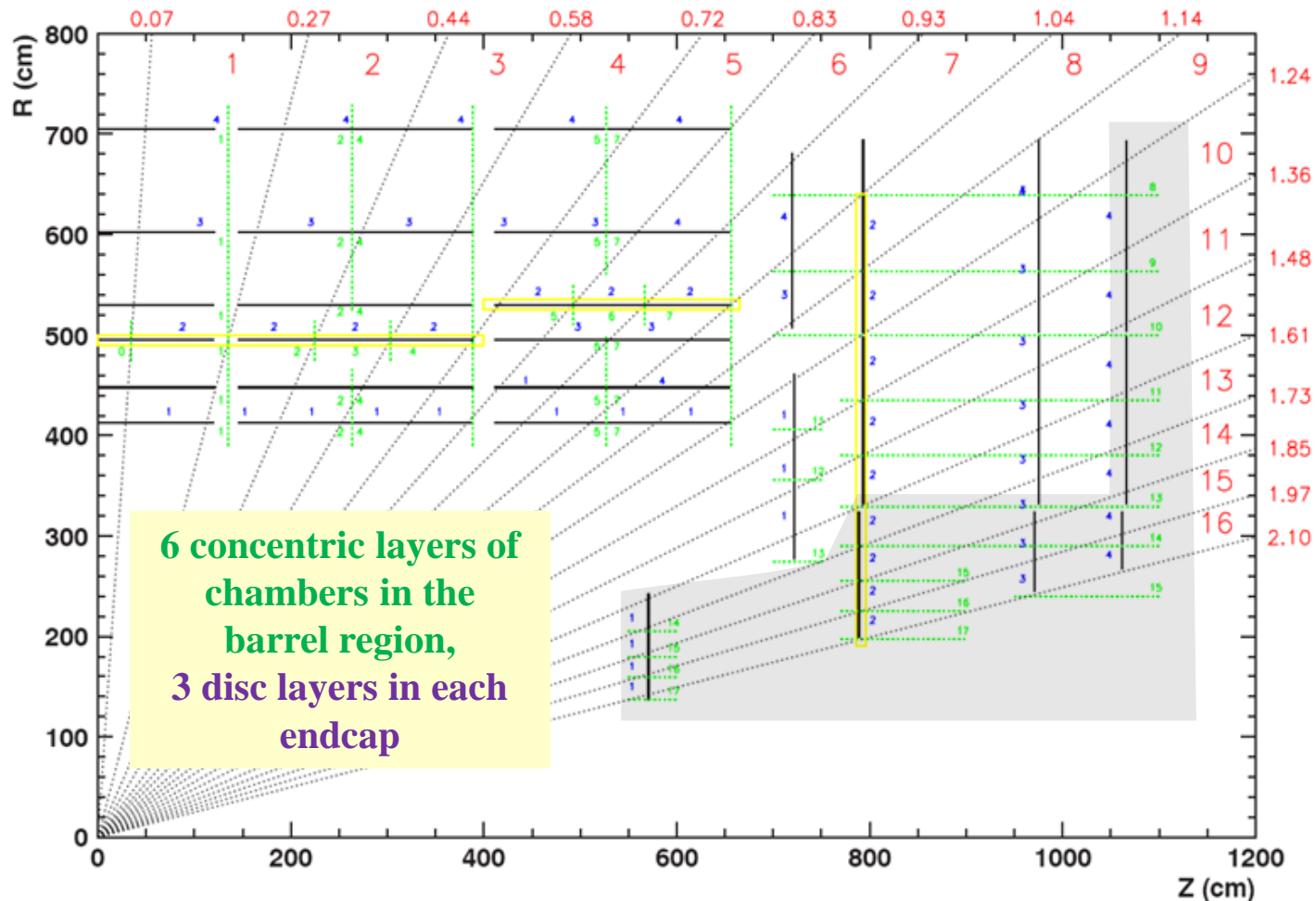
K .Poźniak (also UW), R.Romaniuk, W. Zabolotny (also UW), A.Zagoździńska

Ex-members:: T. Andrzejewski, H. Czyrkowski, R. Dąbrowski, A. Fengler, Ł. Gościło, K. Niemkiewicz,
W. Olejniczak, M. Pietrusiński, Z. Salapa, G. Siemczuk, J. Zalipska, P.Zych

Warsaw Group is one of the founding members of CMS.

L1RPC trigger system

Based on RPC chambers. Design system coverage $|\eta| < 2.1$. At present due to financial and technological limitations endcap part temporary staged ($|\eta| < 1.6$, 4th layer missing)



L1RPC trigger system*

Warsaw Group has designed, build and is operating and maintaining the Level-1 muon sub-trigger system based on RPC chambers (L1RPC). It compares muon hit pattern with the predefined set of patterns.

Warsaw gave also leading contribution to design, funding, installation, maintenance and operation of readout system of the RPC detector.

Resistive Plate Chambers

Up to 6 layers of detectors.

480 chambers in barrel,

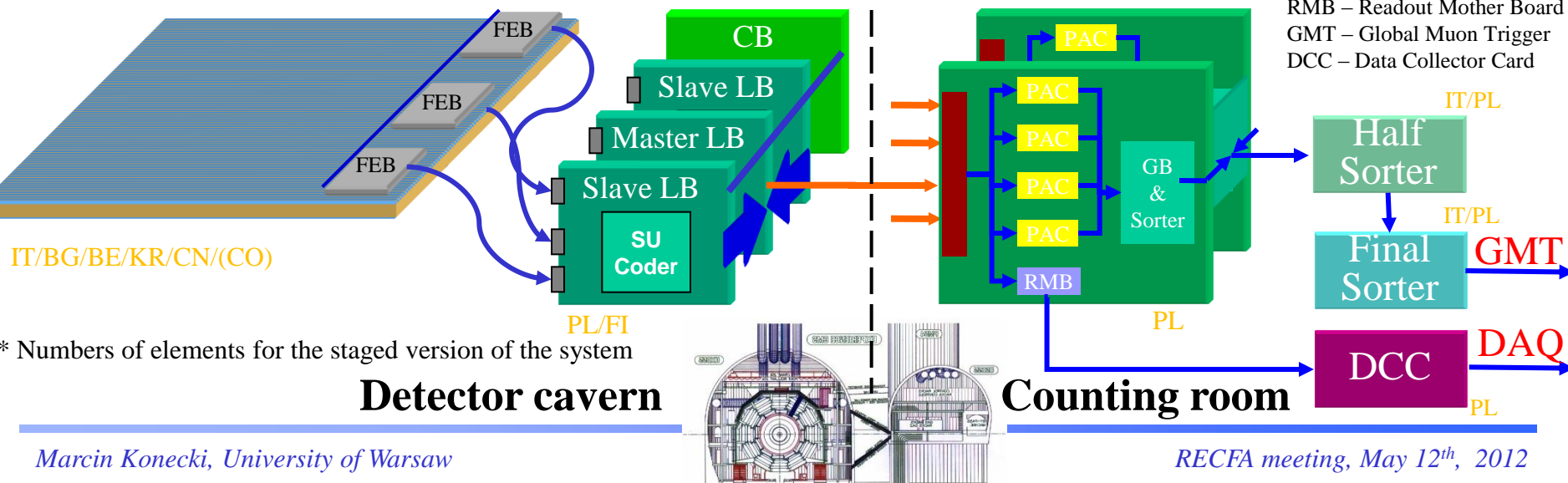
504 in endcaps

1232 Link Boards
in 96 Boxes,
Steered by
Control Boards

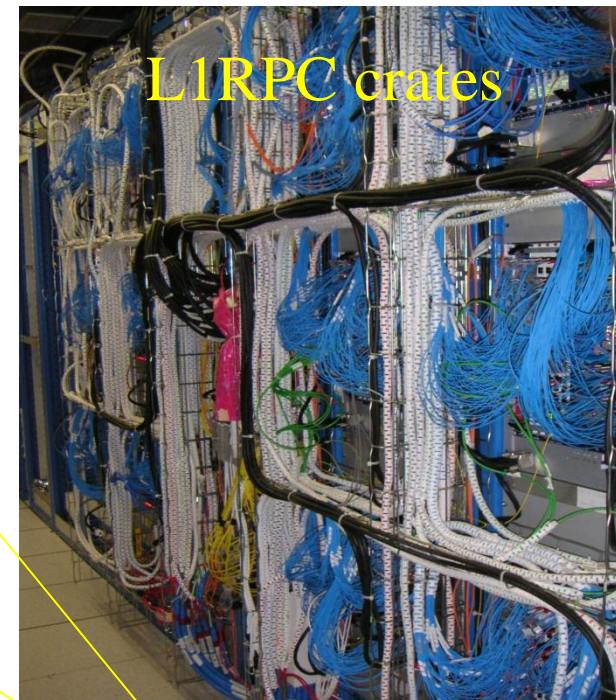
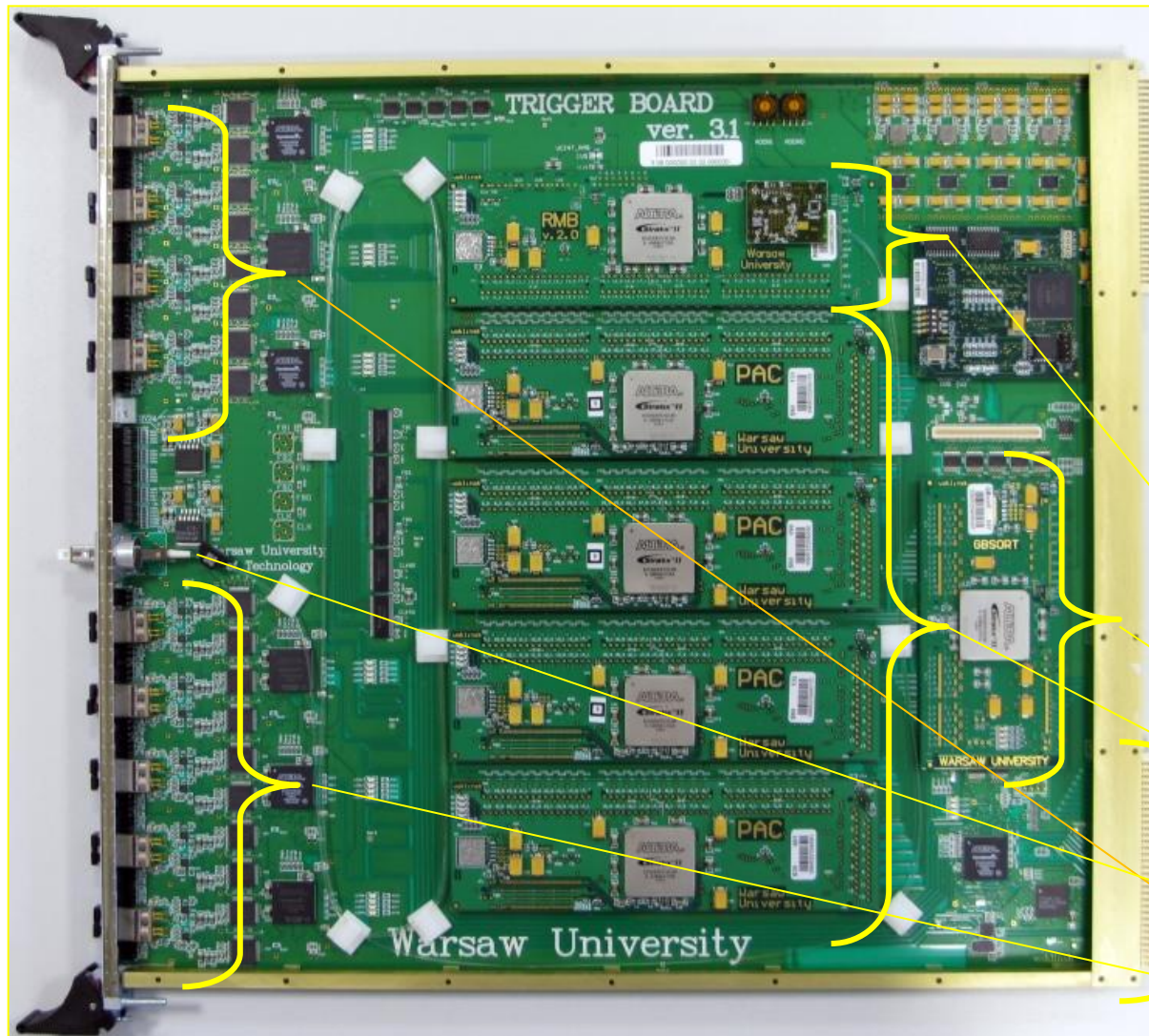
84 Trigger Boards
in 12 Trigger Crates

Optic Links
90 m @ 1.6 GHz
1104 fibers

FEB – Front End Board
LB – Link Board
CB – Control Board
TB – Trigger Board
TC – Trigger Crate
PAC – Pattern Comparator
RMB – Readout Mother Board
GMT – Global Muon Trigger
DCC – Data Collector Card



The heart of the system: Trigger Board



RMB
GB
PAC (trigger)
muon output
data output
data input

As the PAC algorithm is implemented in the reprogrammable FPGAs – Altera Stratix 2, it can be easily changed, to adapt to different requirements and running conditions.

L1RPC operational experience 2011

- **Stable running.**

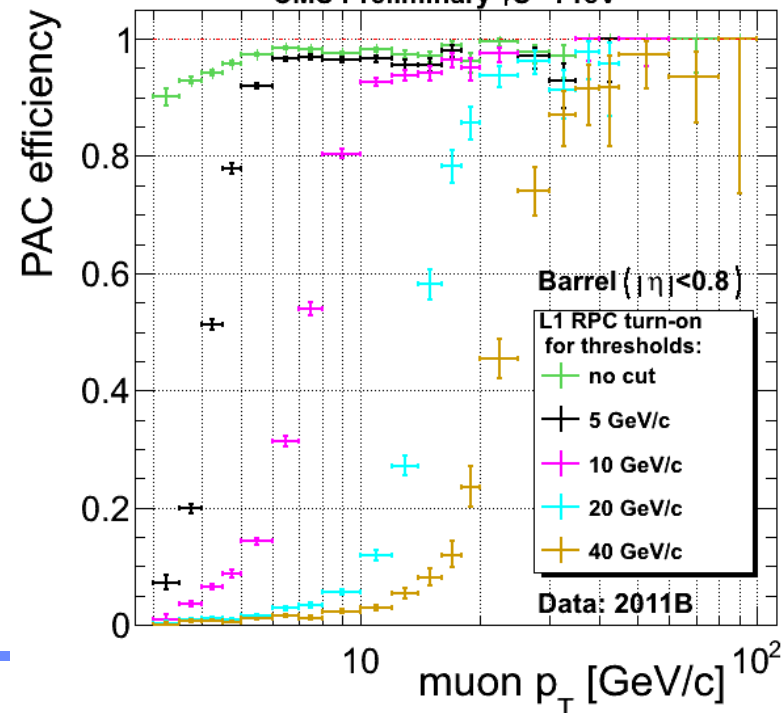
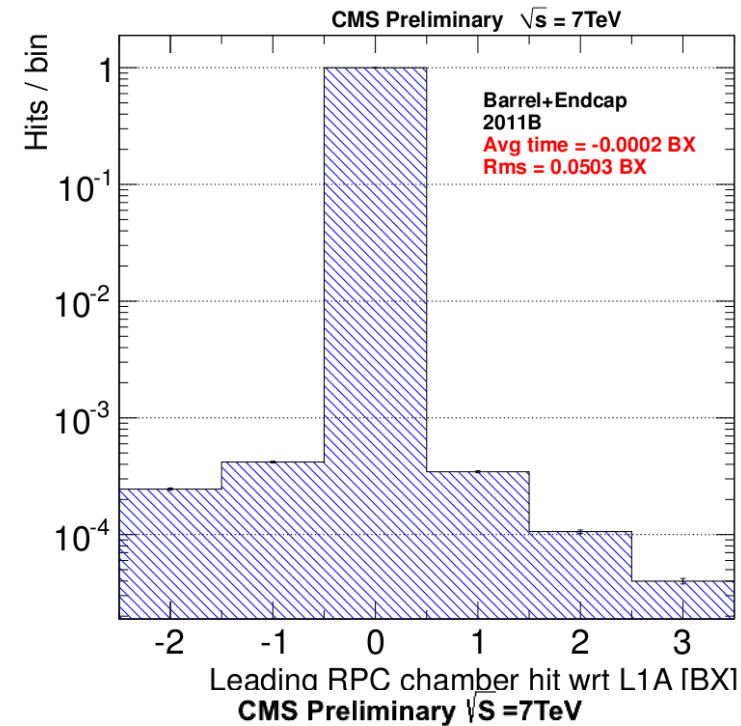
Controlled by Software expert K.Buńkowski (100% at CERN) and 1 on-call shifter (MC, AK, MKo, MG, MKa, K.R-R, MSz) + GT shifts. Technicians during technical stops. M. Konecki - L1RPC coordination .

- **A very good timing assignment**

- **RPC trigger is complementary to DT/CSC.**

It allows us to increase efficiency and decrease the overall muon rate (set lower momentum thresholds). Well suited to veto false triggers.

- In 2011 trigger functionality was extended to handle cases of slow particles (late in muon system) – the only L1 subsystem providing this functionality.



Scenarios of future Warsaw activity (LHC upgrades)

LS1 (2013-14)

- installation of 4th RPC station (not Warsaw activity).
RPC trigger ready for additional inputs
- preparation and implementation of logic dedicated to HSCP
(25ns, time dedicated patterns)
- further pattern improvements
- preparation for hardware changes of RPC to GMT connection (copper to fiber) (2015/16)
- upgrades of Warsaw CMS computing resources.

long term: LHC LS2, LHC-HI/HE

- Warsaw continues operating L1RPC trigger till needed,
- possible extension to high eta with GEMs.
- CMS future muon triggering scenario is being discussed.
(RPC is a limited granularity detector, L1RPC trigger resolution is hard to improve).
- Long term group plans and future hardware activities are being discussed .

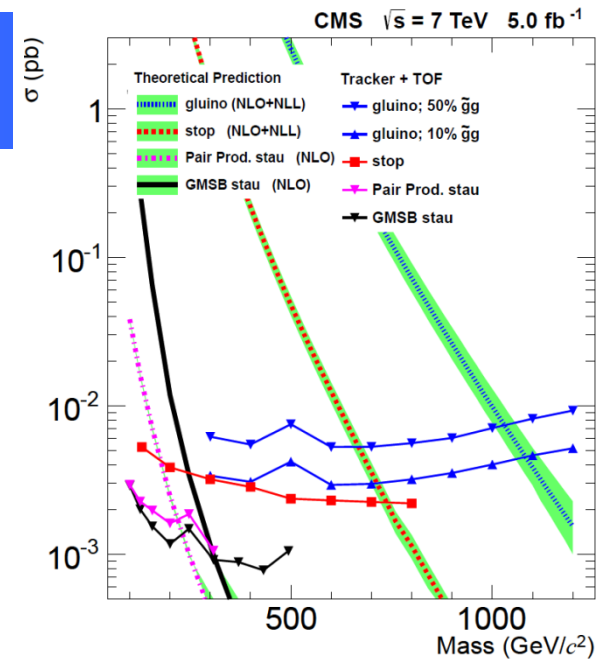
HSCP analyses

Search for heavy long-lived charged particles

P. Zalewski, K. Romanowska-Rybińska,

M. Kazana, K. Nawrocki, P. Traczyk (on leave).

Important contribution to Time-Of-Flight methods for HSCP searches with muon chambers.



H (H/A) $\rightarrow \tau\tau$ analysis

A.Kalinowski, T.Frubes, R.Boniecki in collaboration of 20 persons (LLR/CEA/KA/WAW).

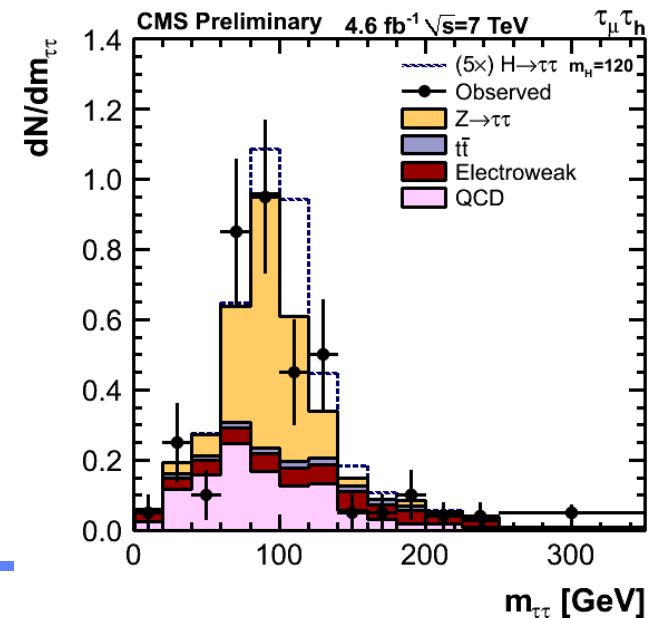
1) Embedding of simulated tau decays in $Z \rightarrow \mu\mu$ events.

TF is one of 2 person involved in this subtask, main code developer. A shape of the main irreducible background is obtained from embedding method.

2) x-check estimation of main reducible backgrounds

(QCD, $W + \text{jet}$) with one of data driven methods (AK, RB)

3) data driven $\text{jet} \rightarrow \tau_h$ fake rate estimation (RB, AK)



Forward Physics

Data analysis from the forward detectors of CMS,

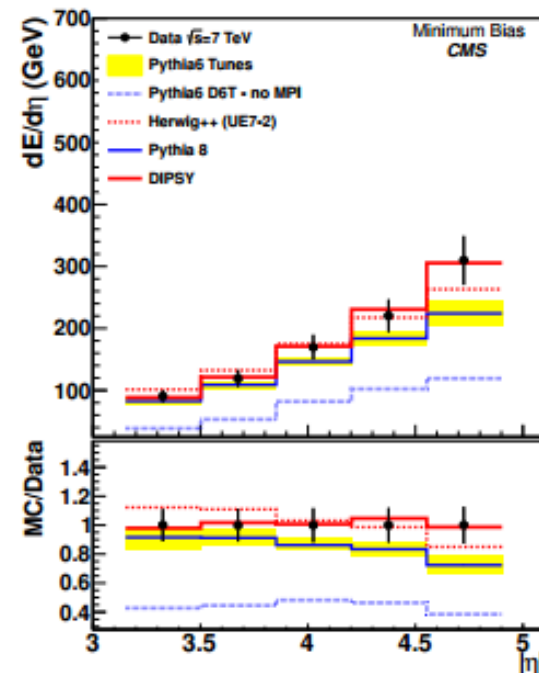
G.Brona, M.Misiura, K.Nesteruk

G.Brona – **convener** of forward jets (2010-11),

small-x QCD (2012-13) – about 30 pers.

Measurement of energy flow at high energy and high pseudorapidity

Leading contribution of GB both to plot and publication.



Heavy Ions

B. Boimska – detector operation during HI runs, DQM

$W_L W_L$ scattering

M. Szleper. Simulation studies of non-Higgs scenarios for HI/HE LHC.

Studies outside CMS, done in cooperation with UW theoreticians. CMS analysis will follow.

CMS online/offline software

- **RPC** (K.Bunkowski, M. Ćwiok, M. Górski, T. Fruboes, A. Kalinowski, M. Kazana, M. Konecki, K. Romanowska-Rybińska, M.Szleper, M. Zielenkiewicz):
 - RPC online software
 - RPC R2D online/offline software+DQM
 - L1RPC emulator+online,offline DQM
 - RPC trigger analysis
- Muon Reconstruction: contribution to high p_T reconstruction & TOF (P. Traczyk)
- Track Reconstruction: contribution to CMS track/muon seeding, simplified 3-hits tracks supporting simplified algorithms, vertexing, rough reconstruction. (M. Konecki)

Computing at Warsaw: T2_PL_WARSAW

Federated tier-2 with Poznań and Cracow. Warsaw resources are dedicated to CMS+LHCB. 150(→230)TB, 1000CPUs. K. Nawrocki (+A.Kalinowski,T.Fruboes) – dedicated manpower for CMS. In addition local farm (T3) of ~120CPUs+24TB for local software development/analyses/teaching.

Funding

J. Królikowski: present funding: NCN Grant (2010-2012), 4 942 kPLN:

Completion of the detection hardware and participation in the physics program of CMS at LHC,

Financing of the participation in the physics program and possible upgrades of the CMS hardware in 2013-2018 is currently under discussion in the HE community in Poland within the framework of preparing the PL HE Roadmap.

P. Zalewski: NCN Grant (2011-14), 490 kPLN

A search for supersymmetry using the CMS detector at the LHC with an emphasis on heavy quasi-stable charged particle signature

A. Kalinowski: FNP Grant (2011-13), co-financed by EU, 209 kPLN

Study of Standard Model processes with a jet identified as hadronically decaying tau and a muon in the final state, using the LHC data collected in 2010/2011 running period by the CMS experiment

G. Brona: FNP Grant (2012-14), 278 kPLN

Forward Physics – a New Window on Quantum Chromodynamics

FNP – Fundacja Na Rzecz Nauki Polskiej (Foundation for Polish Science)

NCN – Narodowe Centrum Nauki (National Science Center)