

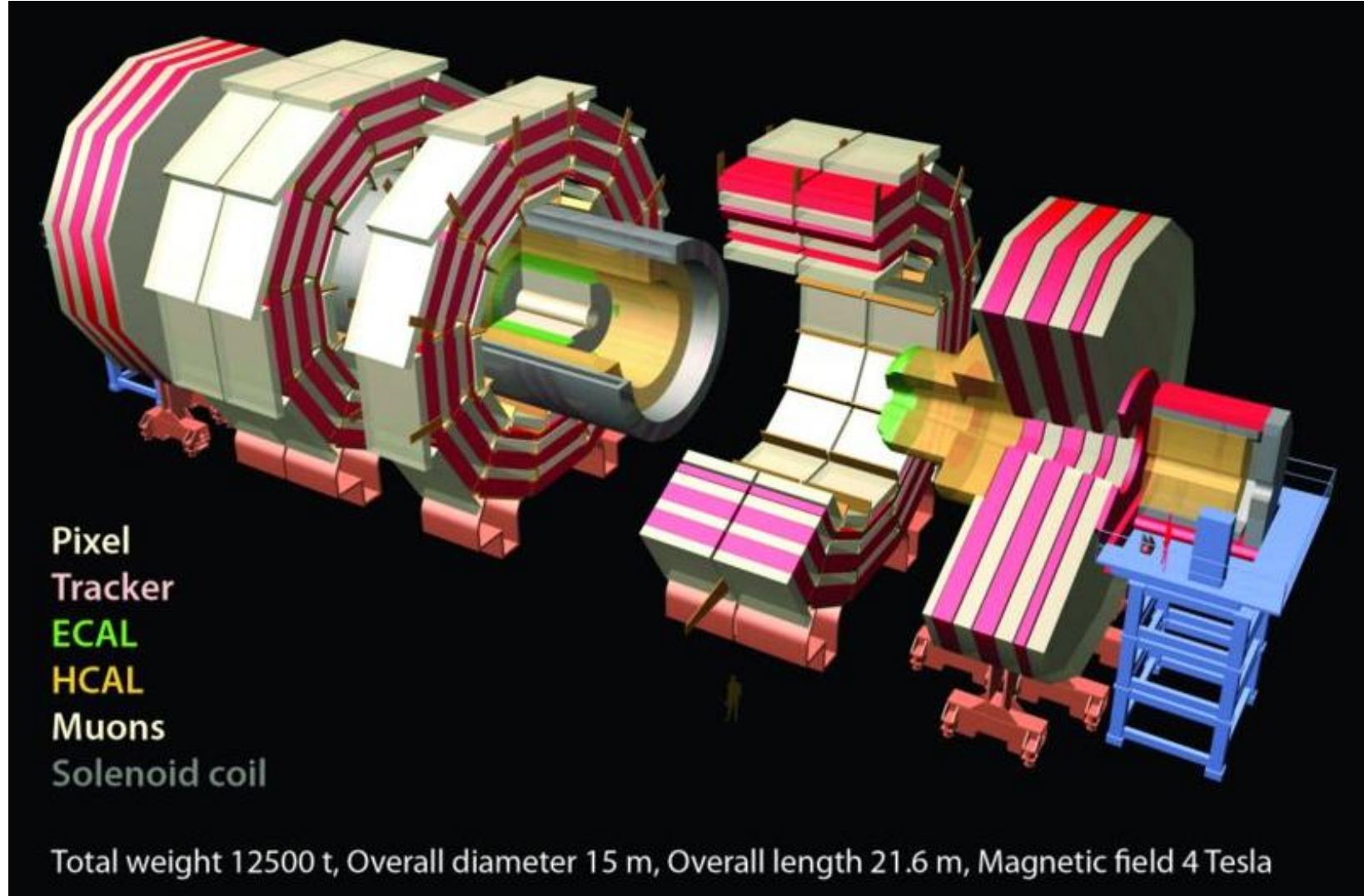
# Hungary in CMS

**Ferenc Siklér, Viktor Veszprémi**  
*Wigner RCP, Budapest*



RECFA visit to Hungary, Budapest  
October 4-5, 2013

# Compact Muon Solenoid

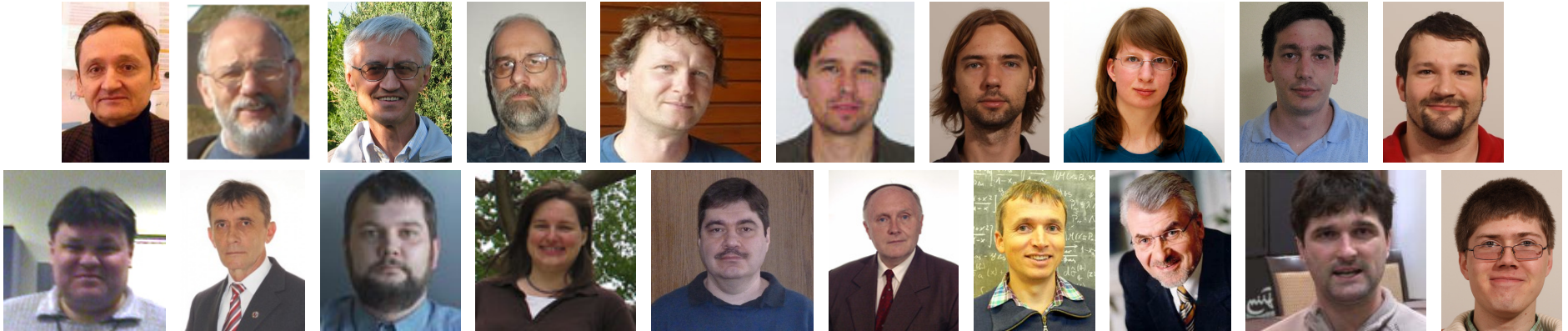


p-p program: discovery of the Higgs boson, search for new physics

Heavy-ion program: nuclear matter under extreme conditions

Participation in several activities: from detector building up to final physics

# Hungarian CMS groups



	Members	Physicists	Engineers	Grads	Undergrs
Wigner RCP, Budapest	26	12	6	2	3
University of Debrecen	6	1	2	3	0
ATOMKI, Debrecen	9	7	4	1	2



# Hungarian CMS groups

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- Wigner RCP, Budapest 
  - Representatives: Gy Vesztergombi, Gy Bencze
  - Signing publications: Gy Bencze, Cs Hajdu, P Hidas, D Horváth, K Krajczár (at CERN), F Siklér, V Veszprémi, Gy Vesztergombi, Anna J Zsigmond
  - Also associated with Eötvös University, Budapest: G Veres (at CERN), Gy Vesztergombi
- University of Debrecen 
  - Representatives: Z Trócsányi, Z Szillási
  - Signing publications: P Raics, J Karancsi, Z Trócsányi, B Ujvári
- ATOMKI, Debrecen 
  - Representatives: J Molnár, Z Szillási
  - Signing publications: N Béni, S Czellár, J Pálinkás, Z Szillási
  - Also associated with ATOMKI: D Horváth

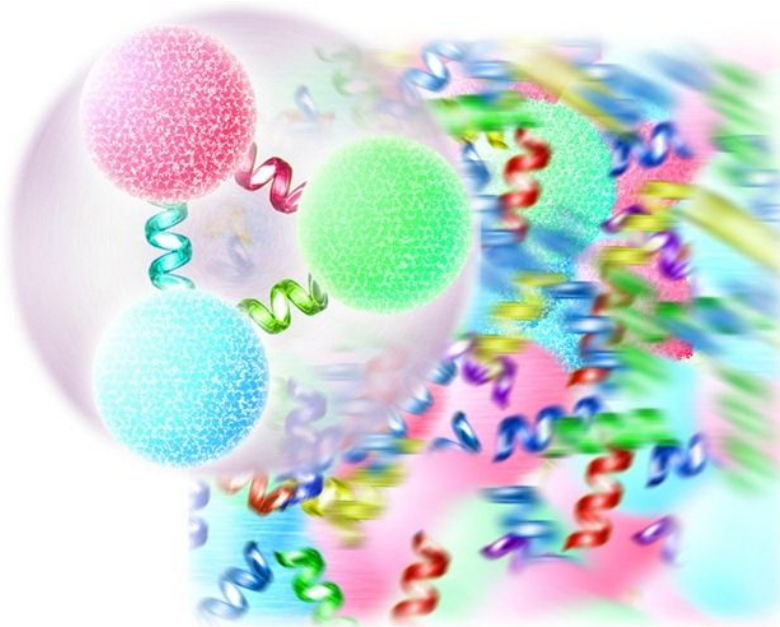
Our work is well visible and recognized by CMS

Convenerships: G Veres (Heavy ions; QCD), F Siklér (QCD), V Veszprémi (Tracker)

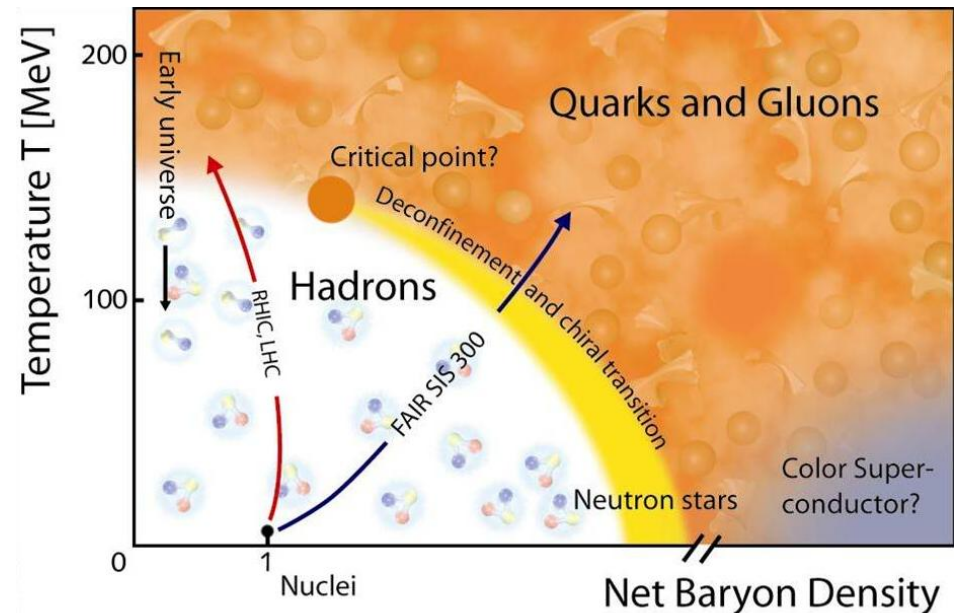
# Hadron physics – the scene

First measurements at LHC ? Quarks and gluons

Strong interaction



Phase diagram of matter

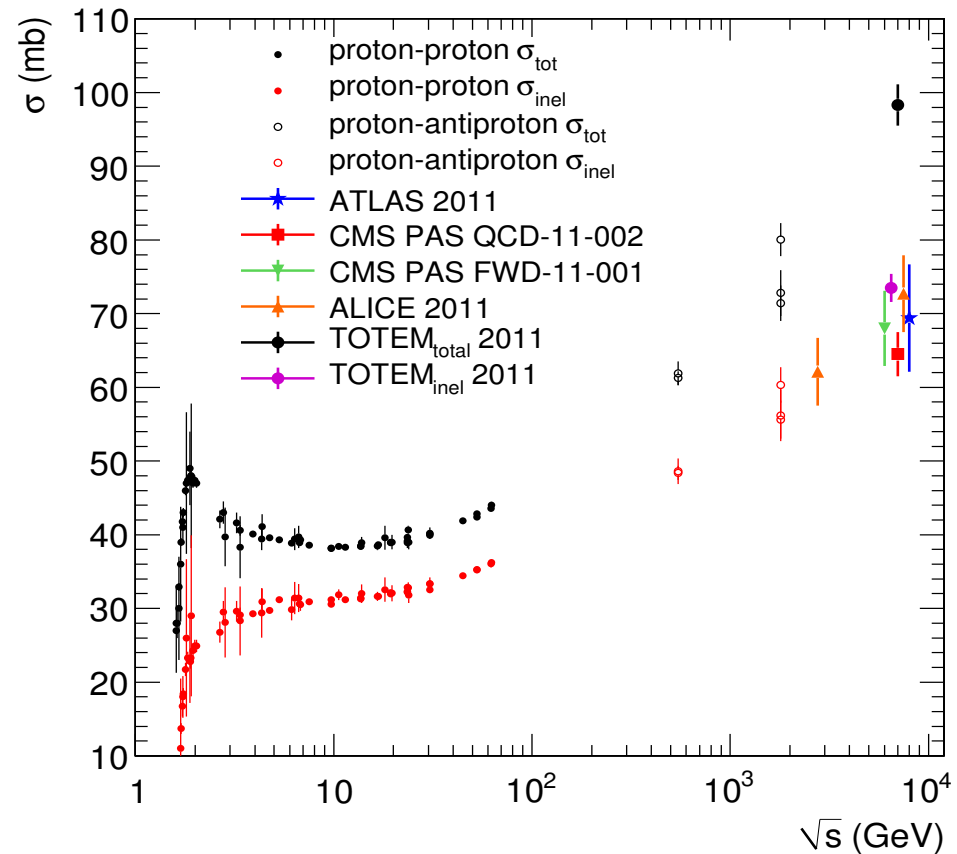
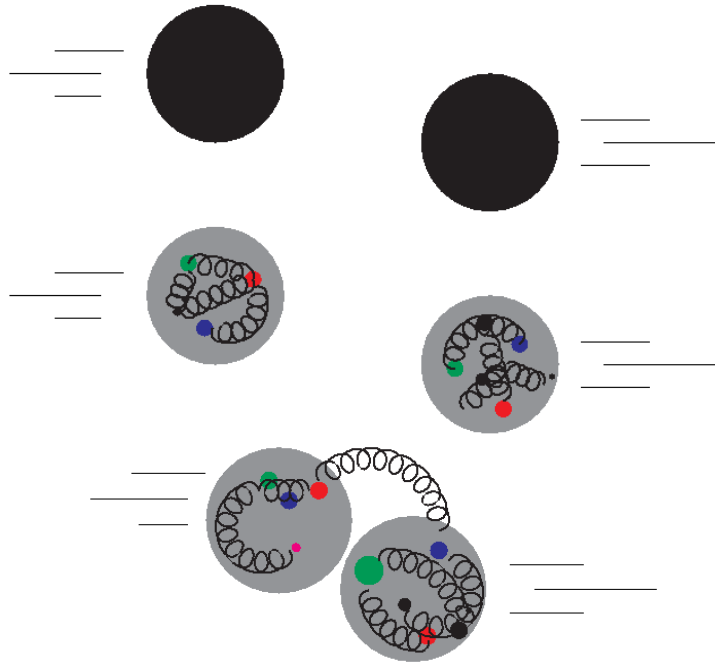


- Goals

- Measure cross-sections precisely
- Benchmark measurements, soft QCD
- Study and compare different collision systems (p-p, p-A, A-A)

I will concentrate here on results where our contribution was decisive/significant

# p-p inelastic cross-section



CMS Coll, Phys Lett B **722** (2013) 5 [CMS AN-2011/061]

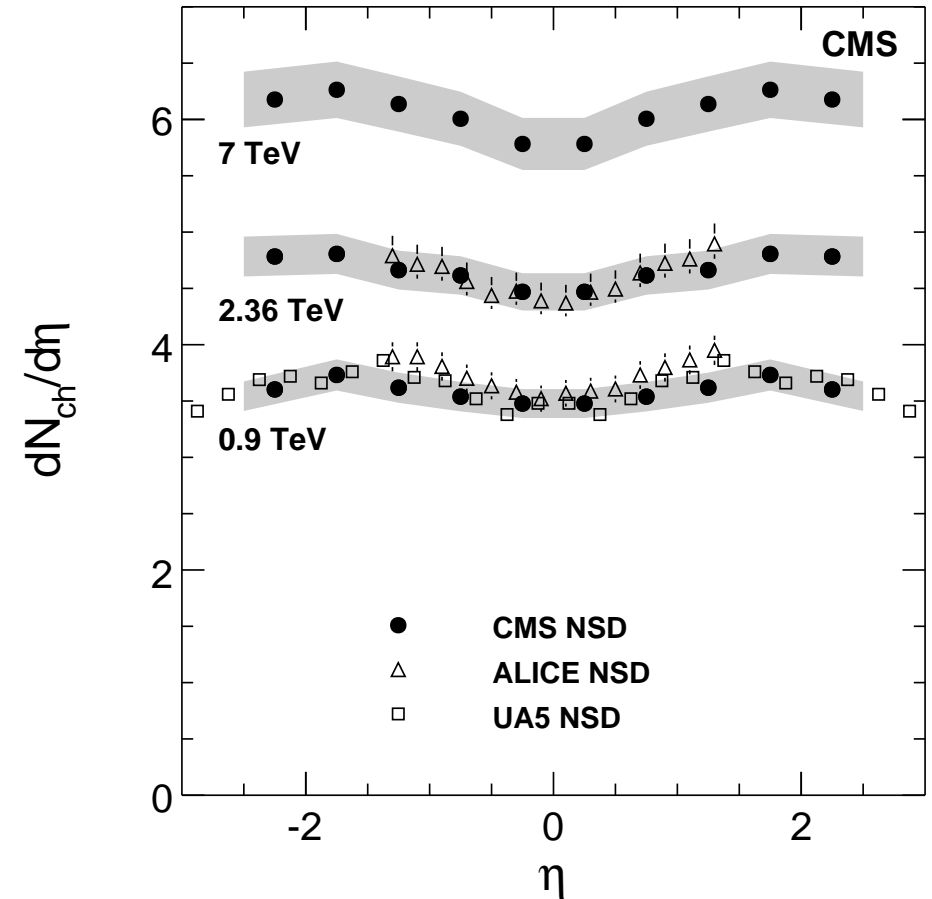
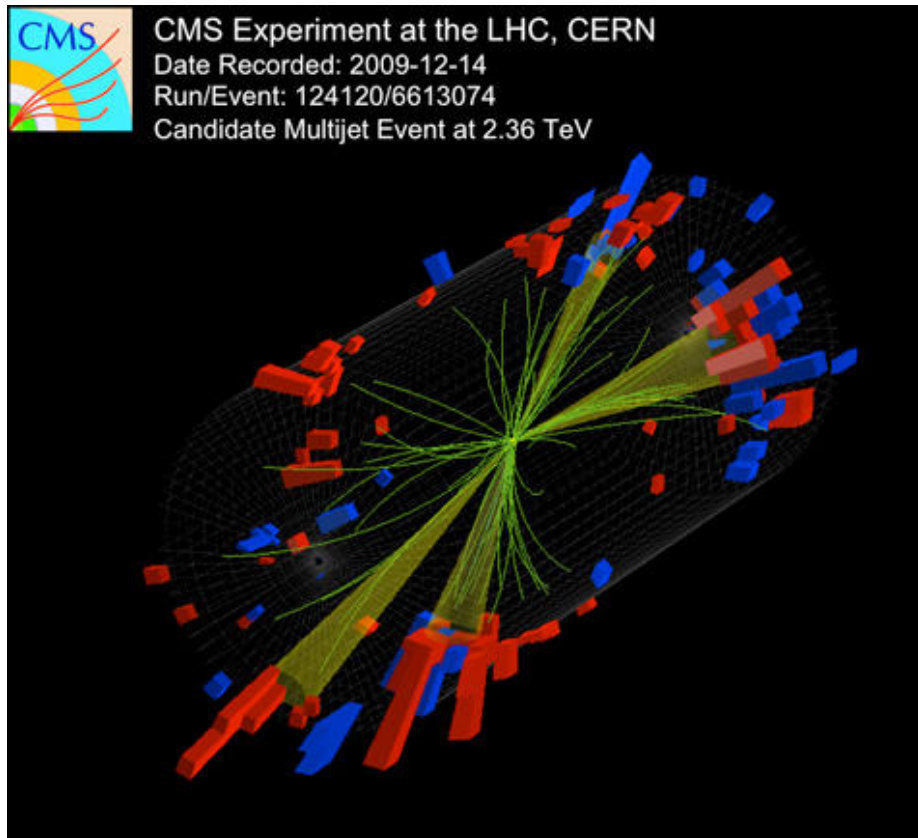
## • Different methods

- We know the intensity of the proton bunches and their shapes
- Count the number of collisions: detect particles using forward detectors

Result =  $7 \text{ fm}^2 \gg r^2\pi$ , and increases

The proton has a more and more extended gluon cloud

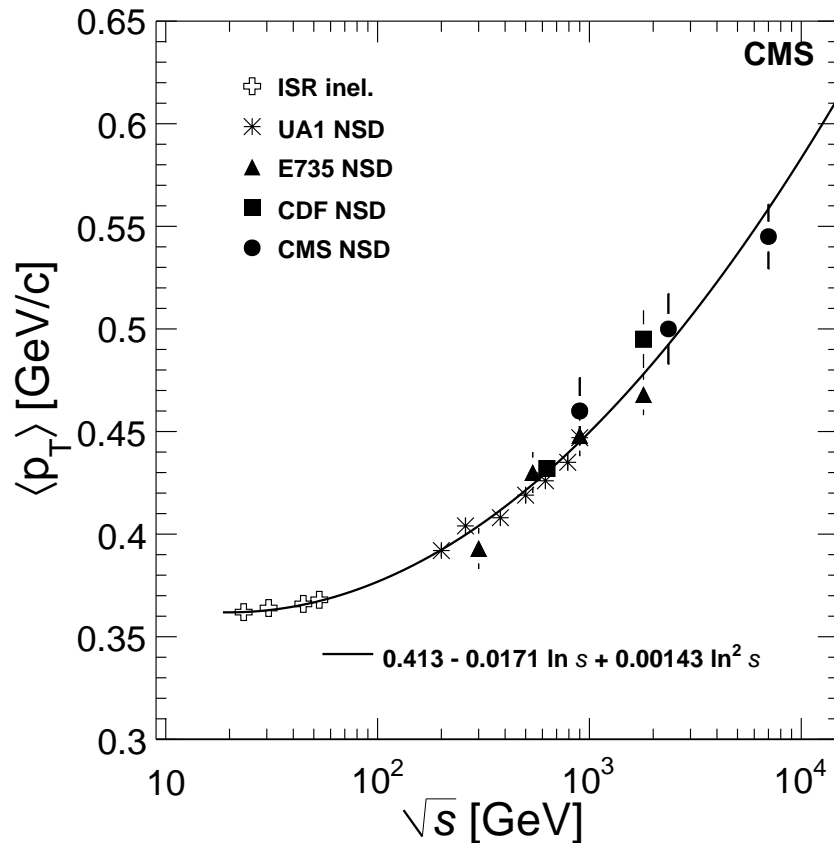
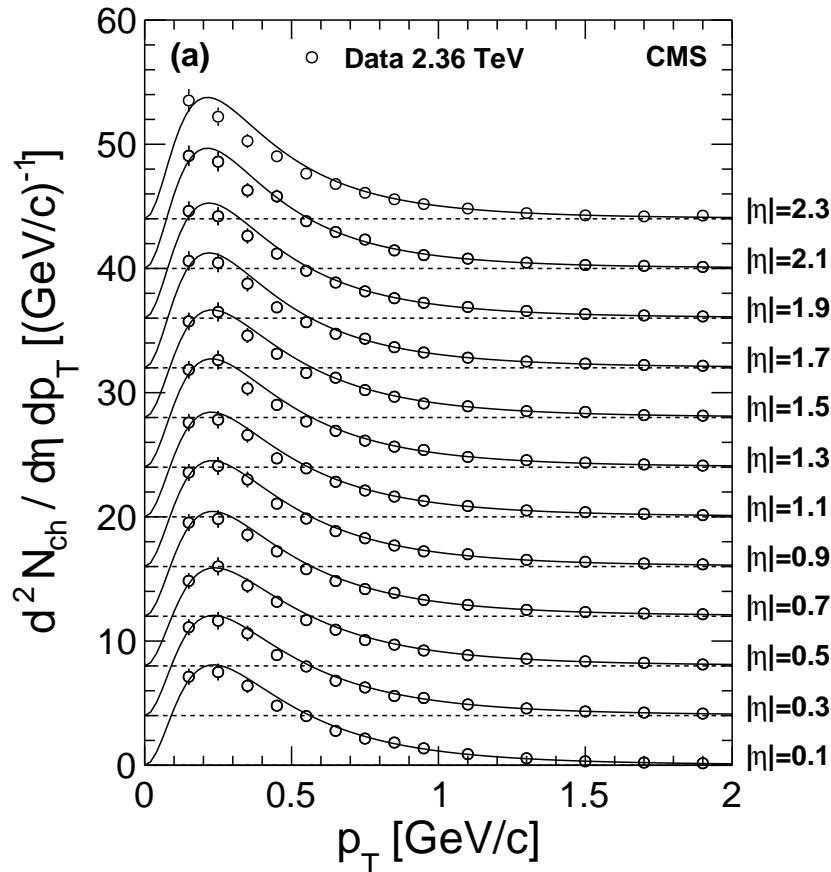
# p-p particle spectra



Study of the strong interaction: important background but also physics

Leading role in the first publications of CMS  
in collaboration with MIT and CERN groups

# p-p particle spectra



CMS Coll, J High Energy Phys **02** (2010) 041 [CMS AN-2009/182]

CMS Coll, Phys Rev Lett **105** (2010) 022002 [CMS AN-2010/069]

- First CMS publications

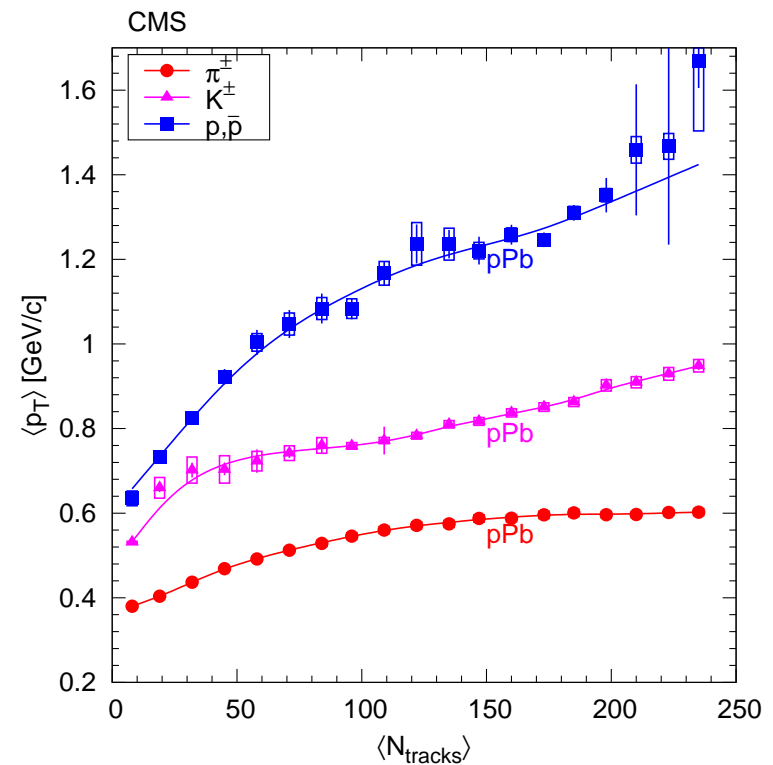
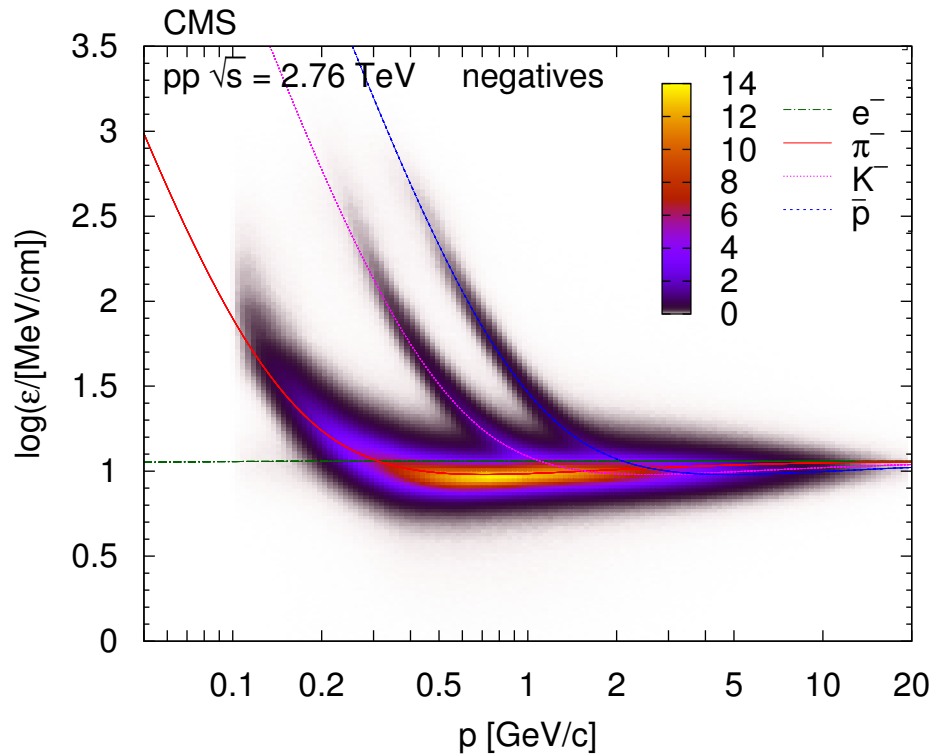
- Development of analysis methods: low  $p_T$  tracking, low bias vertexing

Energy dependence is steeper than expected

Input for MC event generators; success of models based gluon saturation



# Particle identification, comparisons – LHC



CMS Coll, Eur Phys J C **72** (2012) 2164 [CMS AN-2010/143]

CMS Coll, arXiv:1307.3442, submitted to Eur Phys J C [CMS AN/2010-404]

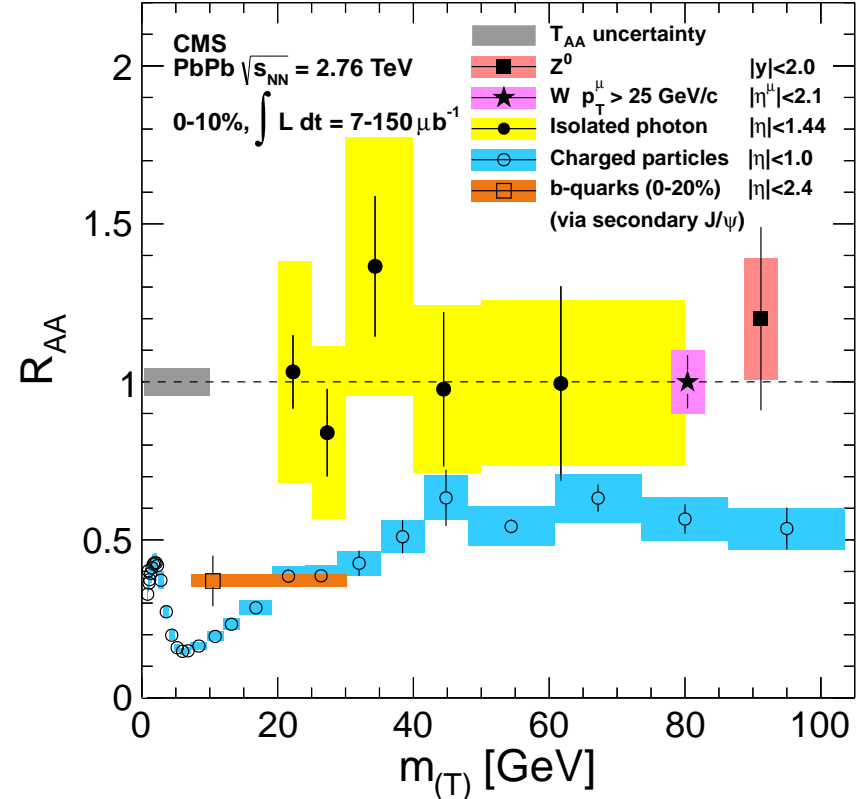
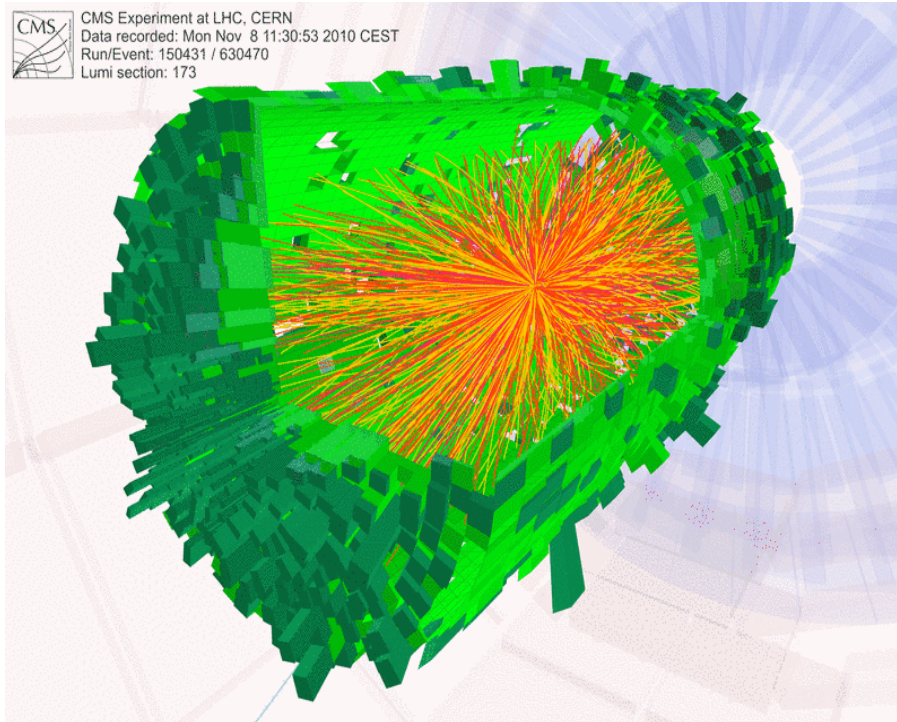
- Pions, kaons, protons

- Simple parametrization of energy loss in silicon tracker
- Extracted hadron yields; also as a function of poor man's centrality
- Event characteristics are strongly correlated with event multiplicity

Results point to gluon saturation in the nucleons

Also supporting hydrodynamic effects already in high multi p-p and p-Pb collisions

# Pb-Pb – suppression of high $p_T$ particles

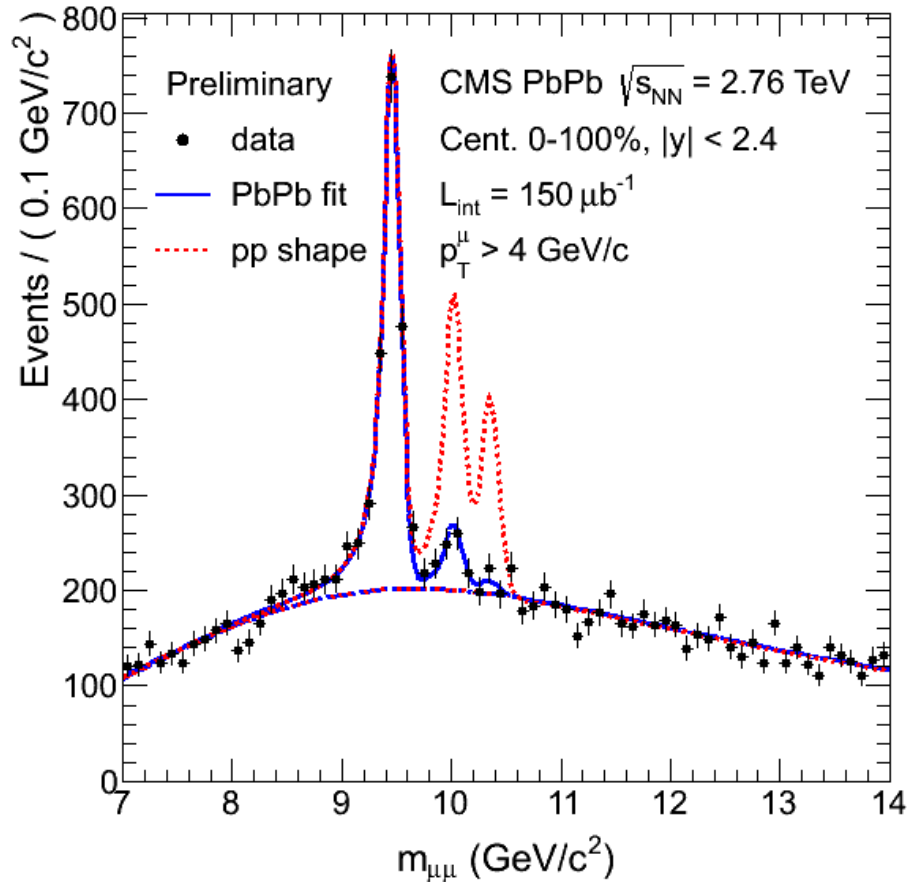


CMS Coll, PAS HIN-12-008 [CMS AN-2012/085]

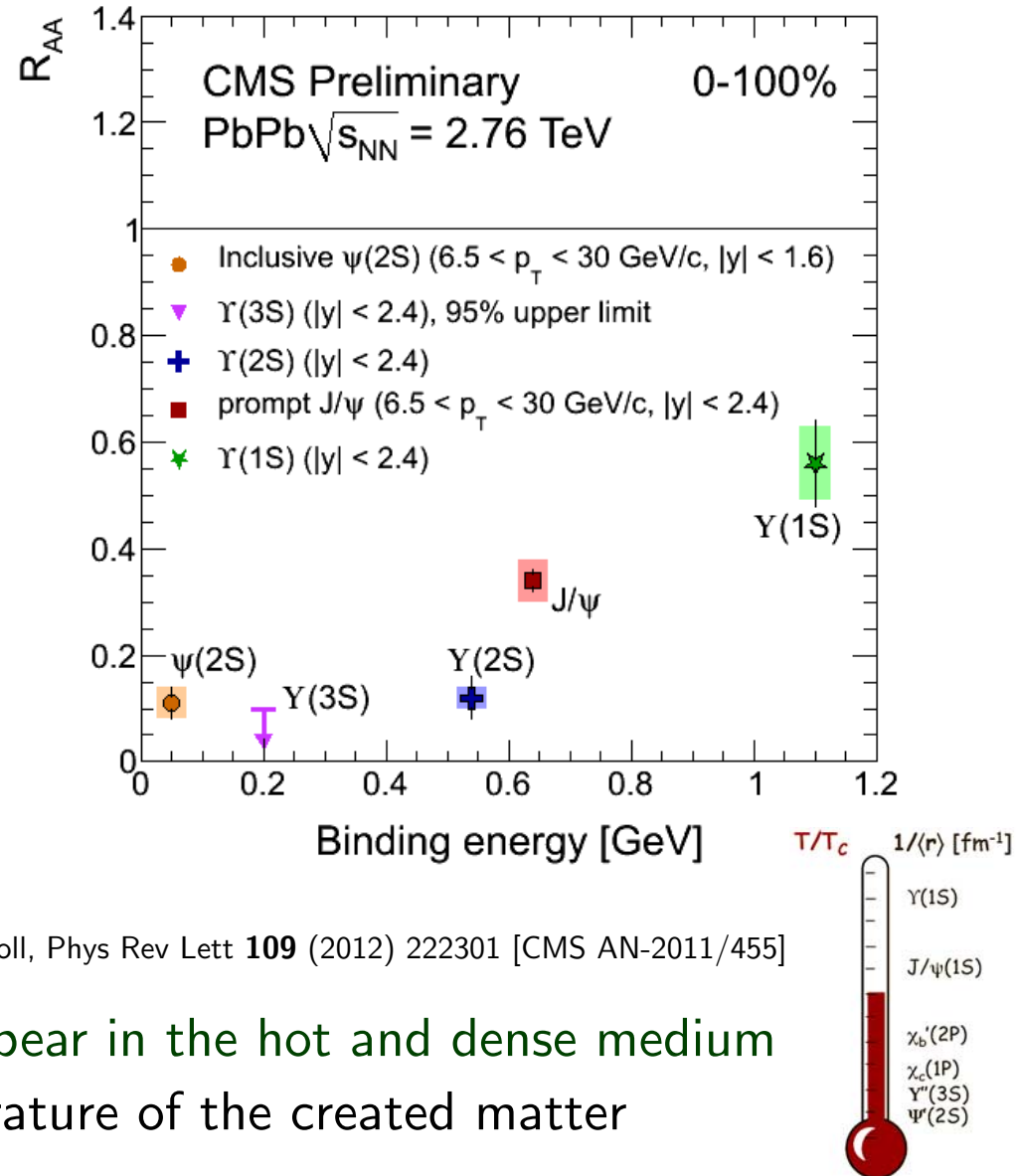
Strongly interacting particles slow down in the hot and dense nuclear matter  
 Electroweak bosons ( $W^\pm$ ,  $Z^0$ , photon) are unchanged

# Pb-Pb – disappearance of loosely bound states

## $\Upsilon$ family



## Suppression of resonances

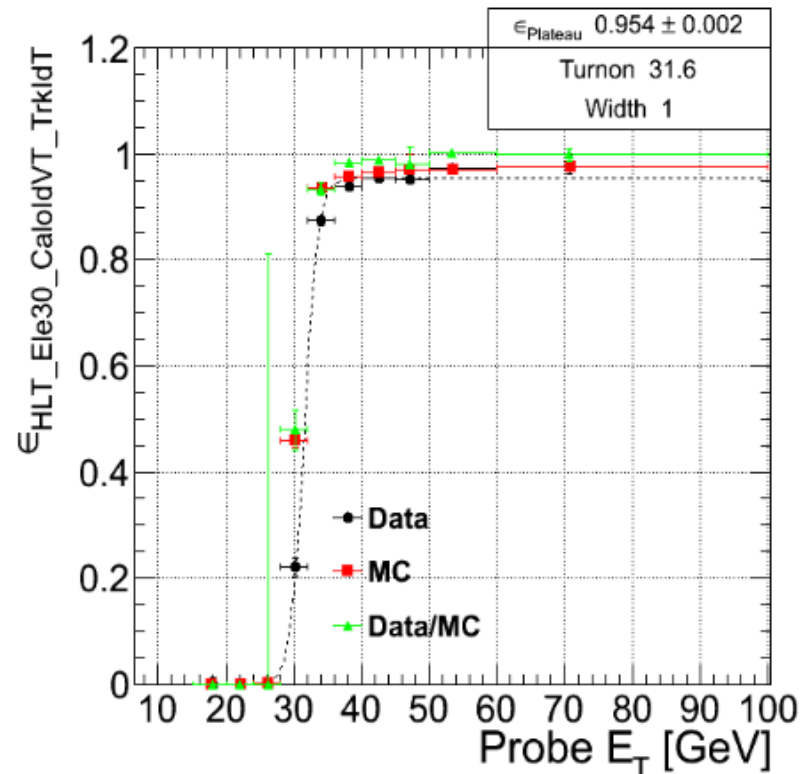
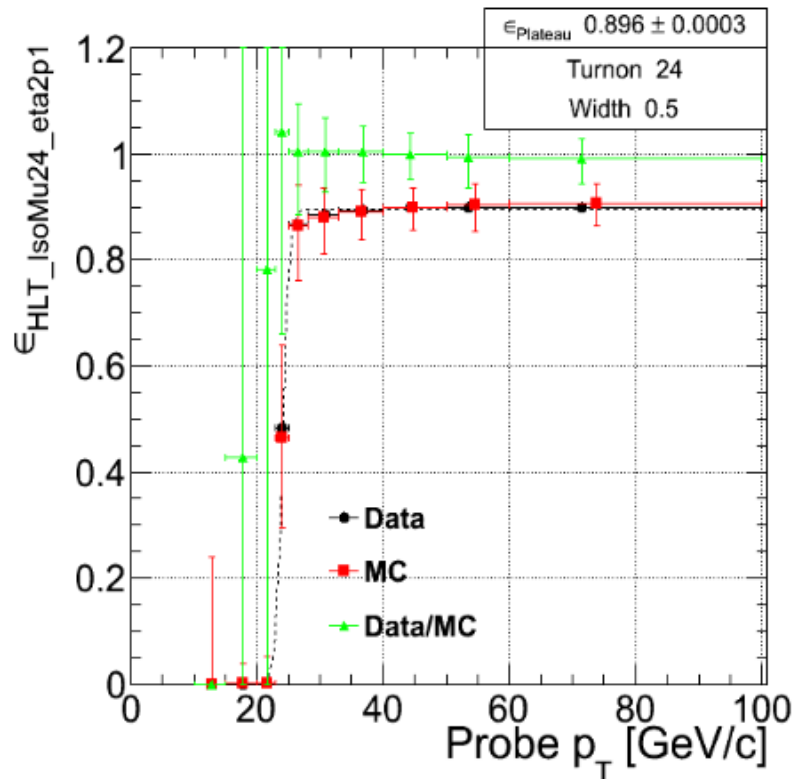


CMS Coll, Phys Rev Lett **109** (2012) 222301 [CMS AN-2011/455]

Resonances (decaying to leptons) disappear in the hot and dense medium

We can measure the temperature of the created matter

# Lepton reconstruction and SUSY searches

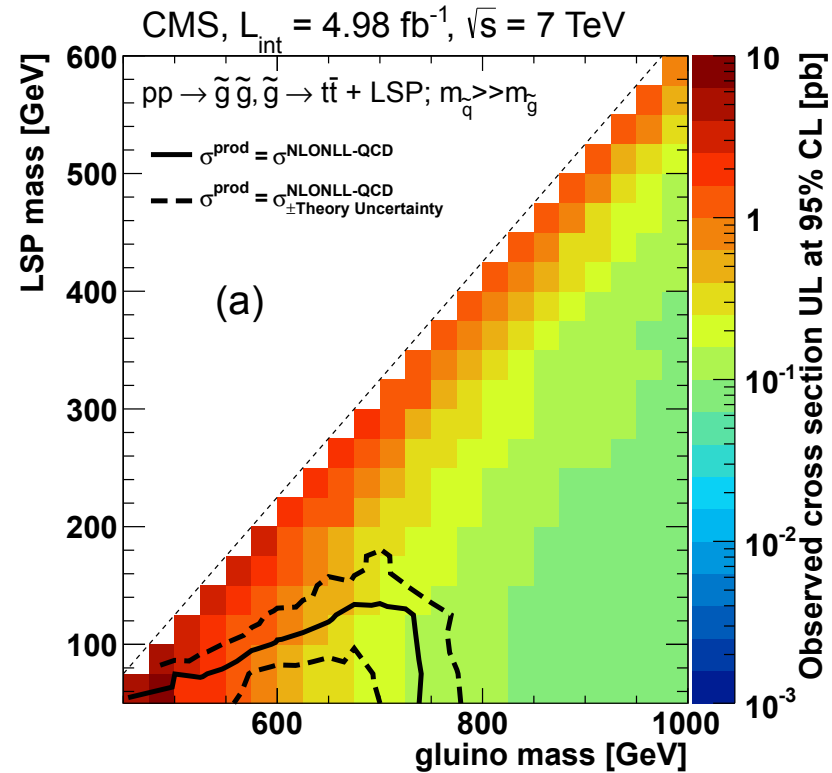
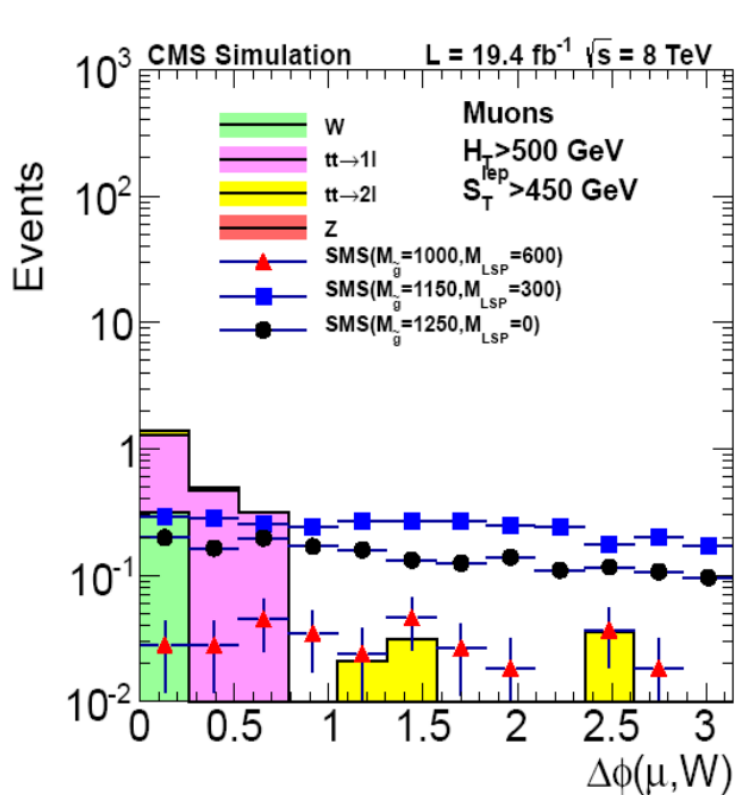


## • Activities

- Study of invariant lepton-lepton mass spectra in a Z-centered window
- Efficiency for online event selection, reco, and identification in SUSY analyses
- Study of simplified MSSM topology: top + LSP via gluino pair-production

Extended SUSY particle exclusion region in 2012 data

# Lepton reconstruction and SUSY searches



## • Activities

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Extended SUSY particle exclusion region in 2012 data

# CMS Hungary – support

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- For groups

- salaries; travel grants for young researchers; research group awards
- Hungarian Scientific Research Fund (OTKA)

PI	Period	Title	[MHUF]
Cs Hajdu	2003-2007	Test of the Standard Model in electron-positron and pp collisions	15.6
Gy Bencze	2003-2007	High energy physics research and development at the	17.6
F Siklér	2005-2009	Hadronic physics at the CMS experiment	12.6
D Horváth	2010-2013	Hungary in the CMS experiment of the Large Hadron Collider	58.0
F Siklér	2010-2014	New analysis methods and tests of QCD at the LHC	12.7
F Siklér	2013-2016	Hungary in the CMS experiment of the Large Hadron Collider	50.6
J Molnár	2013-2016	Hungary in the CMS experiment of the Large Hadron Collider	26.6

⇒ 87 kEUR/year for the next three years

Other sources for M&O

- Hungarian Academy of Sciences: young researchers program
- Swiss National Science Foundation: SCOPES (with ETH Zürich, G Dissertori)

- For individuals

- in Hungary: Bolyai scholarship of the Academy
- at CERN: research fellowship (1), associateship, LD staff (1)