STUDY OF QUARKONIA PRODUCTION WITH ALICE MUON SPECTROMETER

FKPPL-LIA Meeting@ Seoul, 8-9 March 2011

Sang-Un Ahn,
On behalf of the ALICE Collaboration
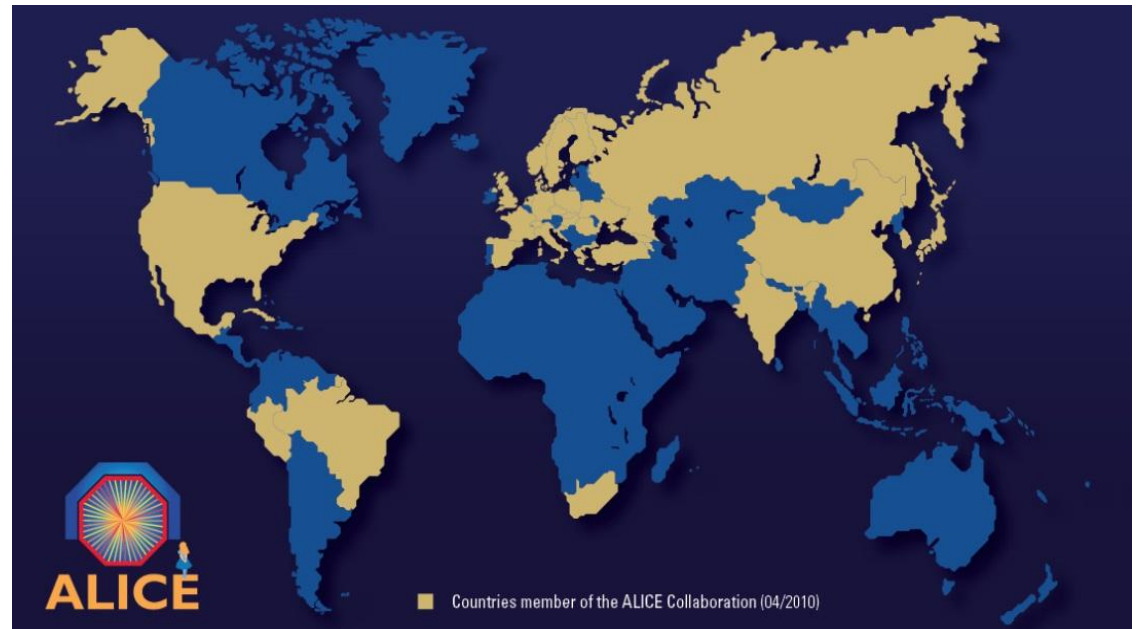
Laboratoire de Physique Corpusculaire, CNRS/IN2P3,
Université Blaise Pascal, Clermont-Ferrand, France,
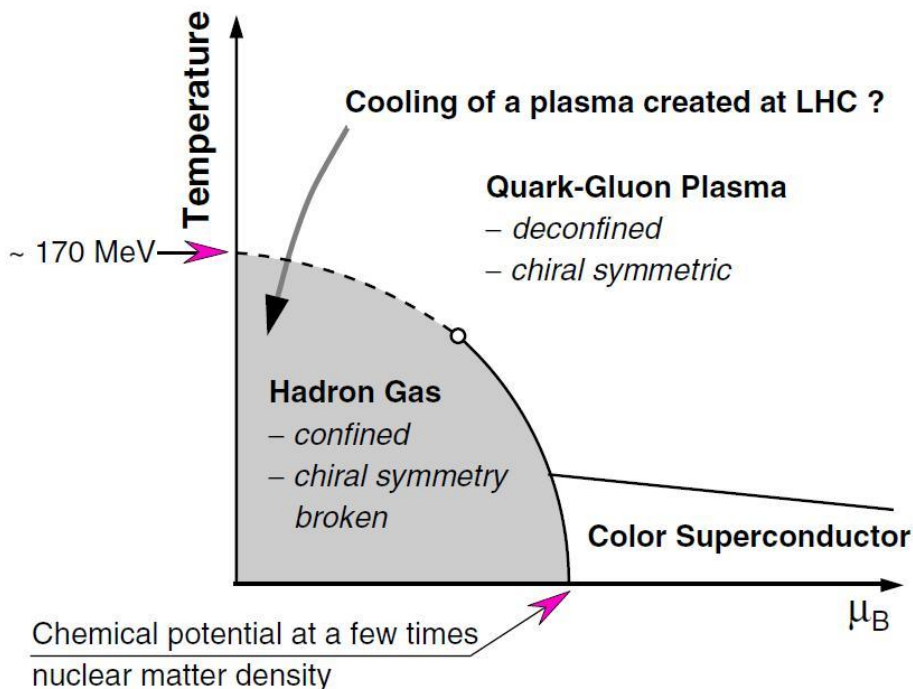*Konkuk University, Seoul, Korea.*

Thesis work with cotutorship between Konkuk and Blaise Pascal University within FKPPL-LIA

The ALICE Experiment

CERN Large Hadron Collider (LHC):

designed to collide two counter rotating beams of protons or heavy ions:

- proton-proton collisions at 14 TeV nominal energy
- lead-lead collisions at 5.5 TeV nominal energy

ALICE, A Large Ion Collider Experiment:

a large detector dedicated to research in the field of physics of strongly interacting matter at extreme energy densities. Such matter is created in relativistic heavy-ion collisions where a new phase, called the **Quark-Gluon Plasma (QGP)**, is formed

International collaboration of 33 countries, 116 institutes, 1000 members

Countries member of the ALICE Collaboration (04/2010)

Cooling of a plasma created at LHC ?

Quark-Gluon Plasma
– *deconfined*
– *chiral symmetric*

~ 170 MeV →

Hadron Gas
– *confined*
– *chiral symmetry broken*

Color Superconductor

μ_B

Chemical potential at a few times nuclear matter density

ALICE Collaboration, 2008 JINST 3 S08002

Study of the QCD phase transition diagram in heavy-ion collisions :

- QCD predicts : quarks and gluons are **deconfined** in QGP at high temperature for $\mu_B = 0$, $T_C \approx 170\ MeV \cong 2 \times 10^{12} K$

Observables in heavy-ion collisions :
- Charged-particle multiplicities
- Soft hadron spectra: freeze-out, flow…
- Particle correlations
- Event by event fluctuations
- Jet quenching
- Heavy-quark/quarkonia production

Same observables in proton-proton collisions as reference

New probe to QGP study :

- Υ is produced at very low yield in heavy-ion collisions at RHIC

- At LHC, measuring the bottomonium yields with significant statistics provides **additional probe to QGP : suppression of quarkonia yields**

  T. Matsui, H. Satz, Phys. Lett. B 178 (1986) 416

STAR Collaboration, arXiv : 1001.2745
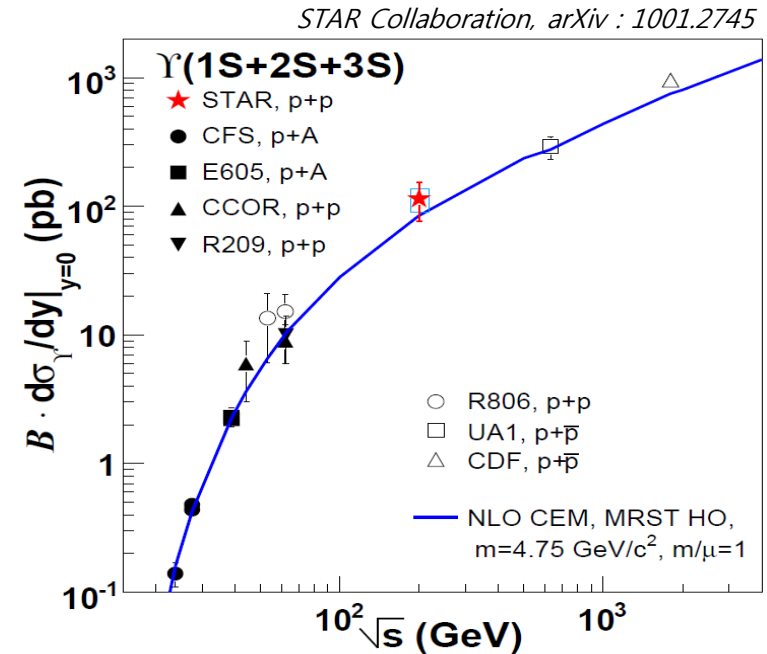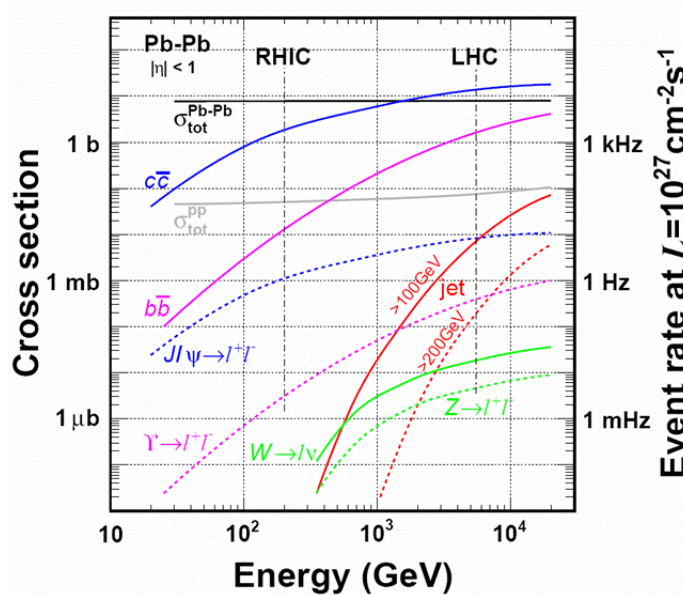
Baseline for Heavy-Ion collisions :

- The measurements in p+p collisions is necessary as references for nuclear collisions

- In Pb-Pb collisions $@\sqrt{s} = 5.5\ TeV$, $N_\Upsilon @LHC \cong \mathbf{100 \times N_\Upsilon @RHIC}$

CERN Large Hadron Collider

Aerial view of the CERN, Photograph: Maximilien Brice, 15 Jul. 2008

CERN Large Hadron Collider

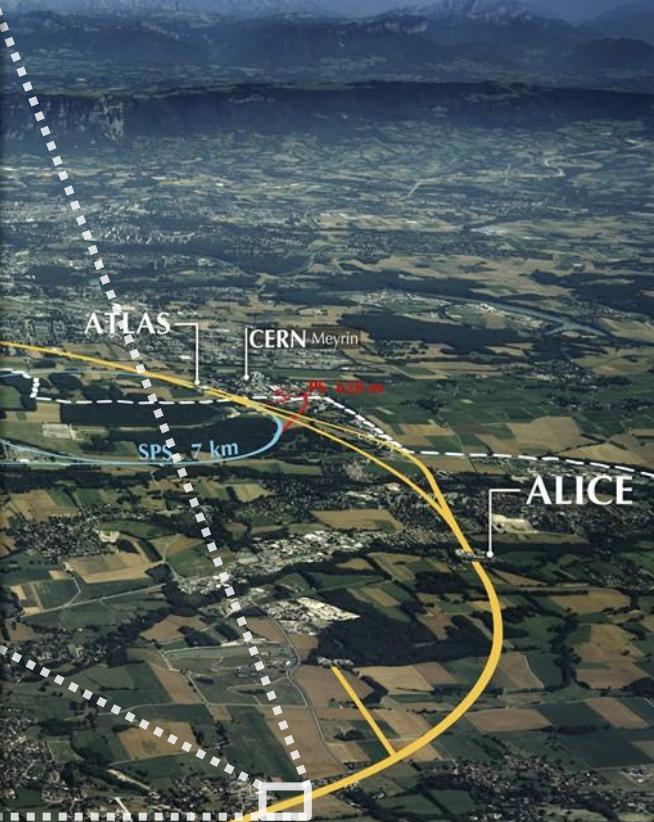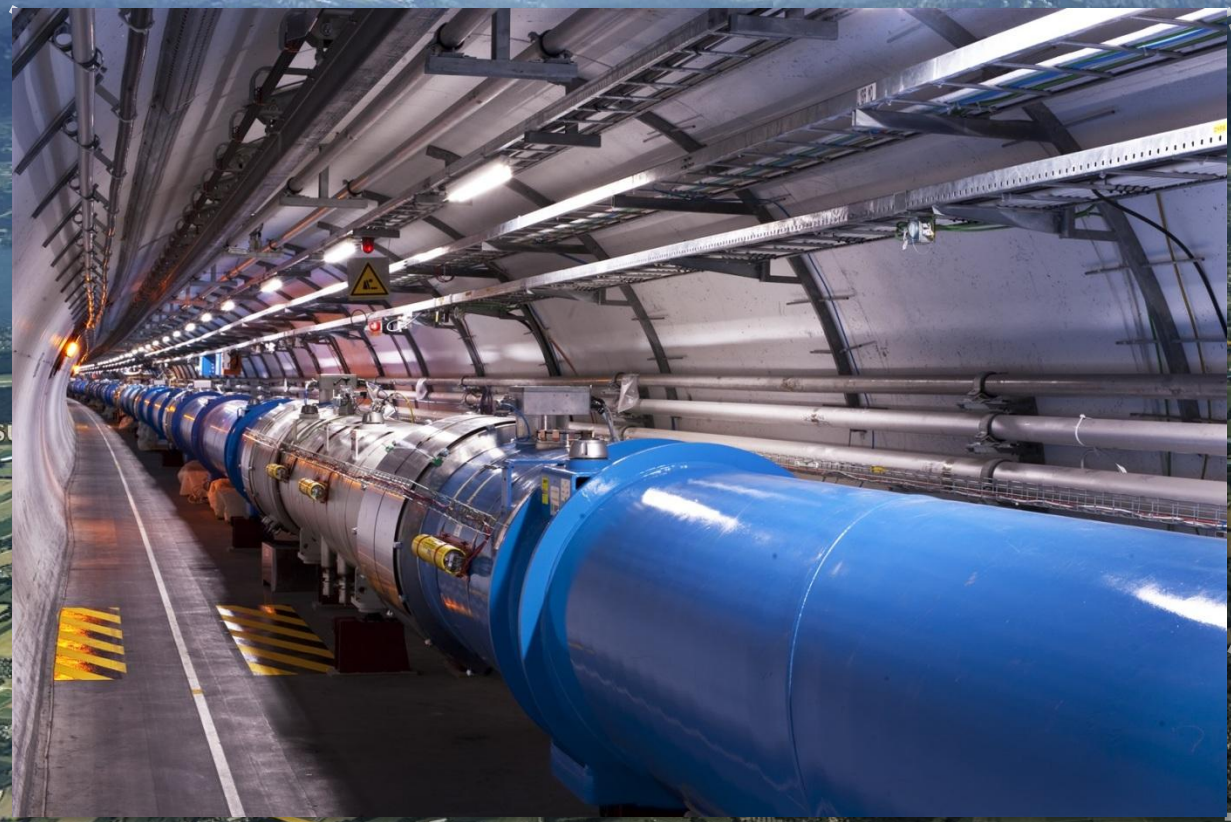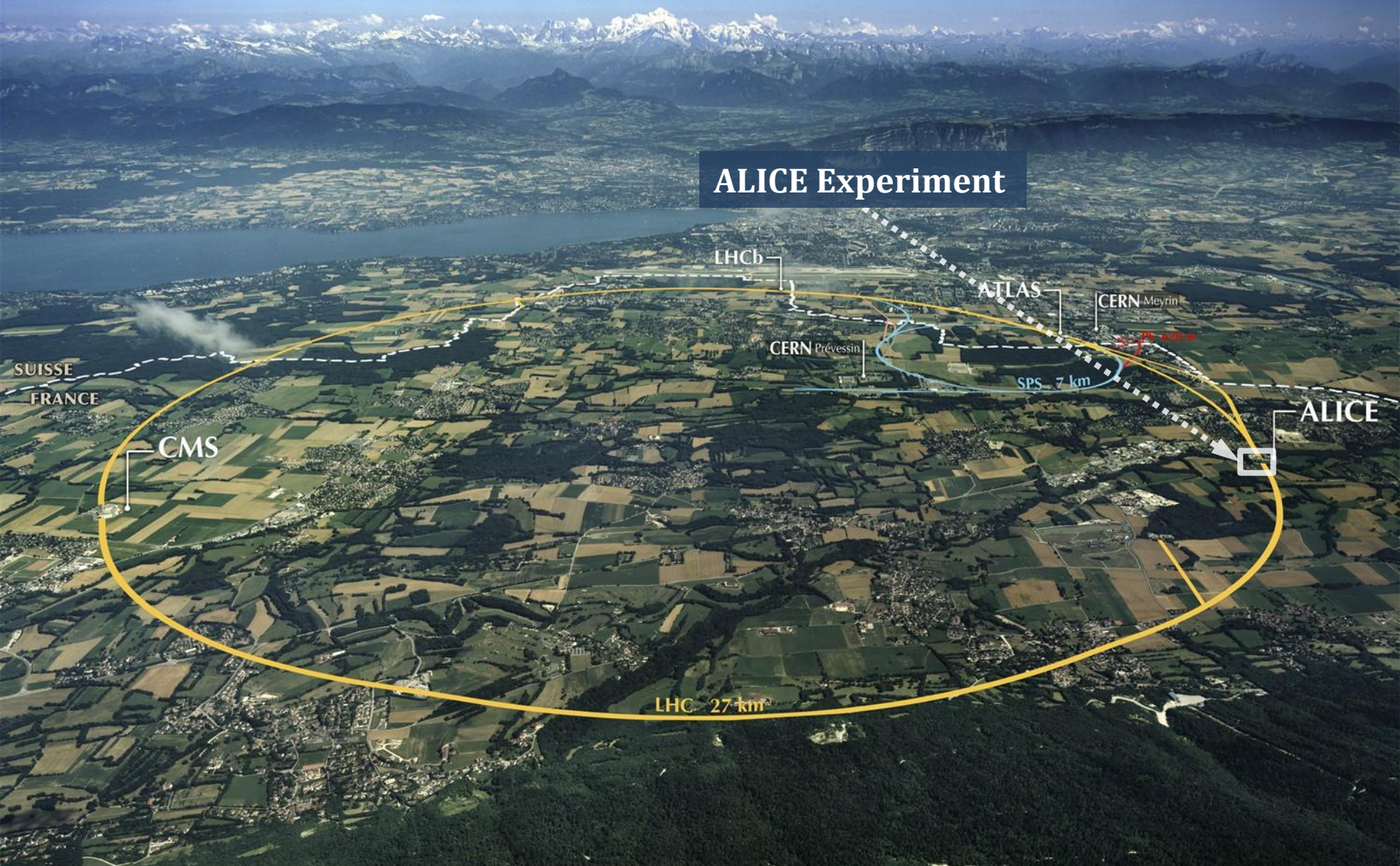*Aerial view of the CERN, Photograph: Maximilien Brice, 15 Jul. 2008*
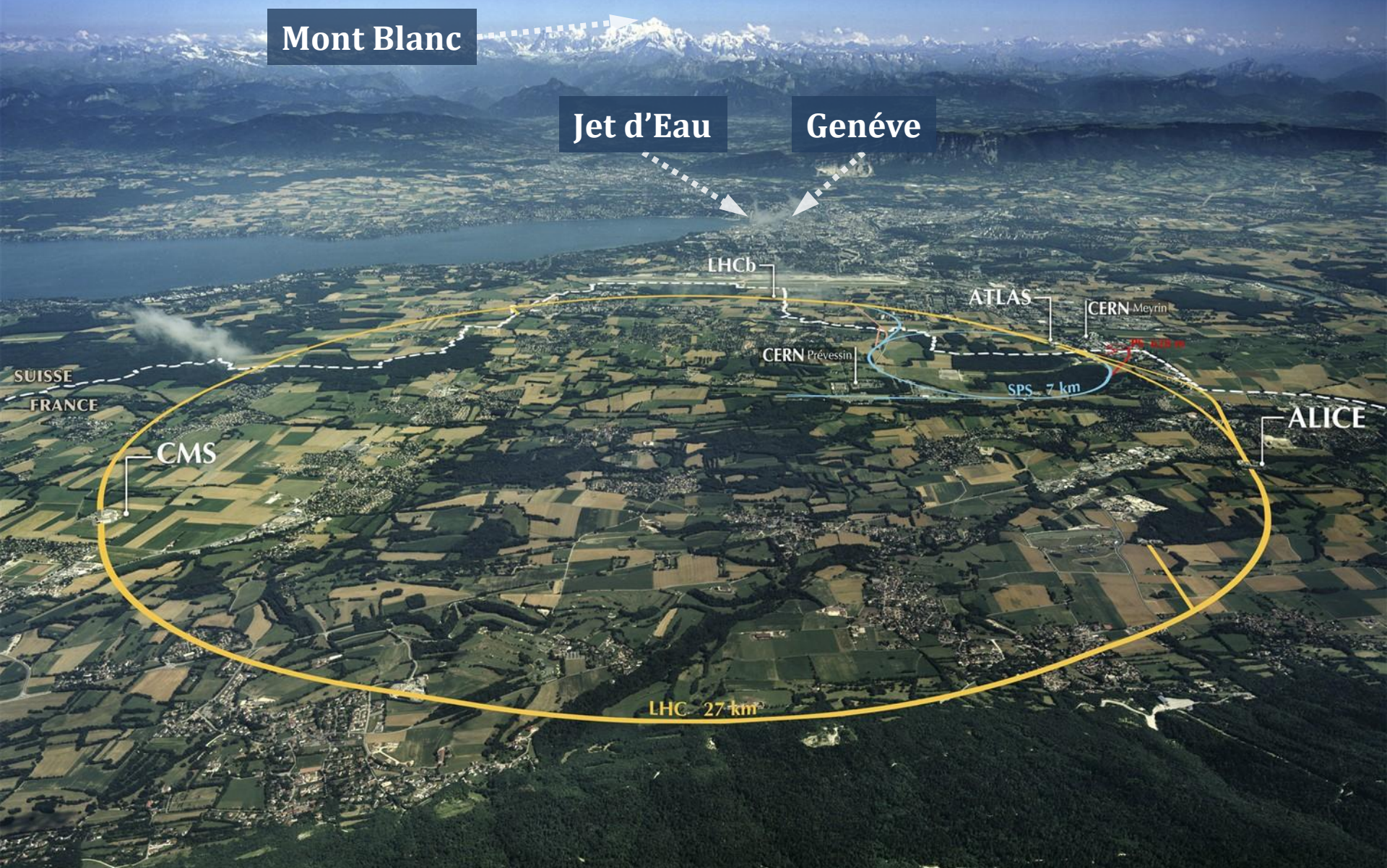
CERN Large Hadron Collider

Aerial view of the CERN, Photograph: Maximilien Brice, 15 Jul. 2008

CERN Large Hadron Collider

Aerial view of the CERN, Photograph: Maximilien Brice, 15 Jul. 2008

ALICE in Wonderland

Aerial view of point 2, location of the ALICE experiment, Photograph: Patrice Loiez; Maximilien Brice, 13 Jul. 2005
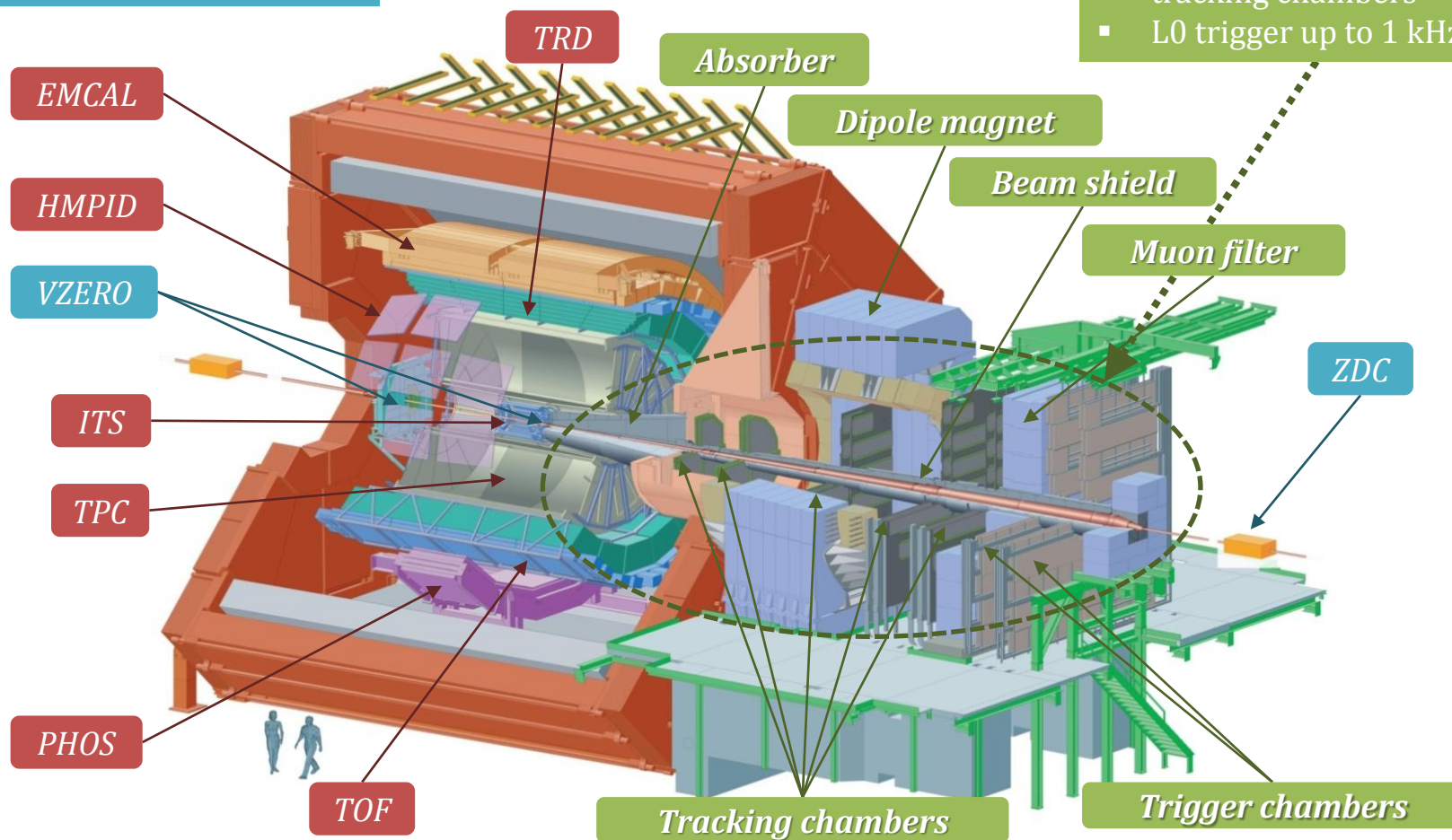
ALICE Detector

General detectors at large η
- Interaction trigger
- Event centrality

Central detectors at $|\eta| < 0.9$
- Hadrons
- Electrons
- Photons

Muon Spectrometer at $-4 < \eta < -2.5$
- 10 high resolution tracking chambers
- L0 trigger up to 1 kHz

EMCAL

HMPID

VZERO

ITS

TPC

PHOS

TOF

TRD

Absorber

Dipole magnet

Beam shield

Muon filter

ZDC

Tracking chambers

Trigger chambers

ALICE Collaboration, 2008 JINST 3 S08002

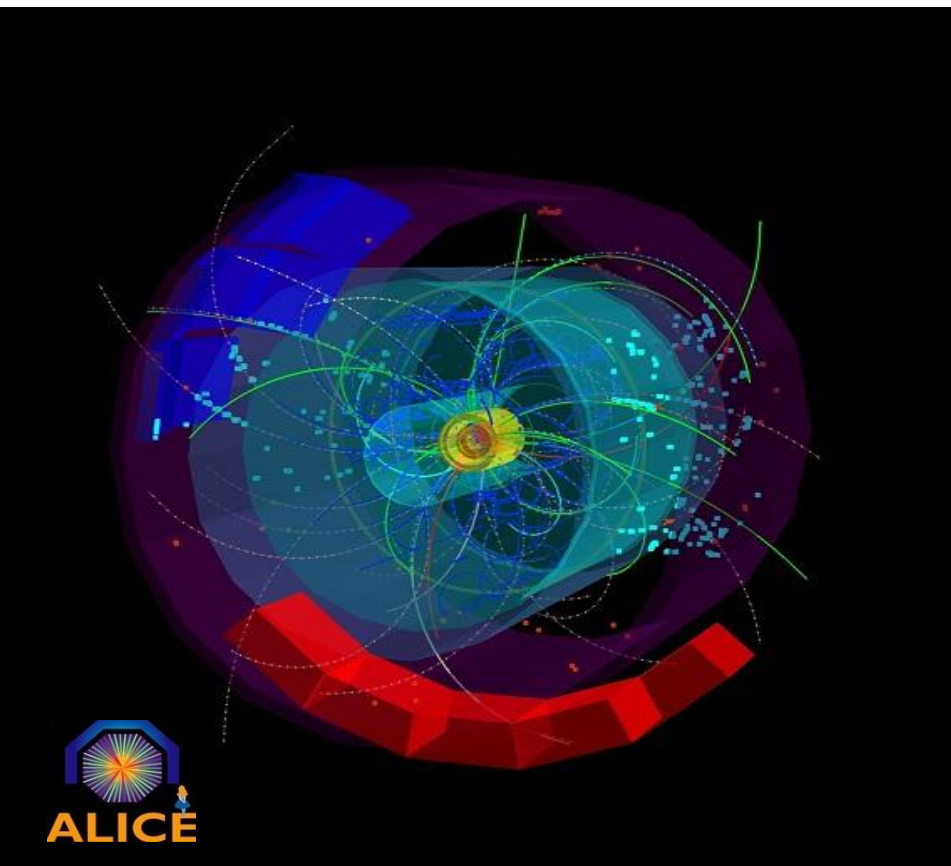# The Muon Spectrometer

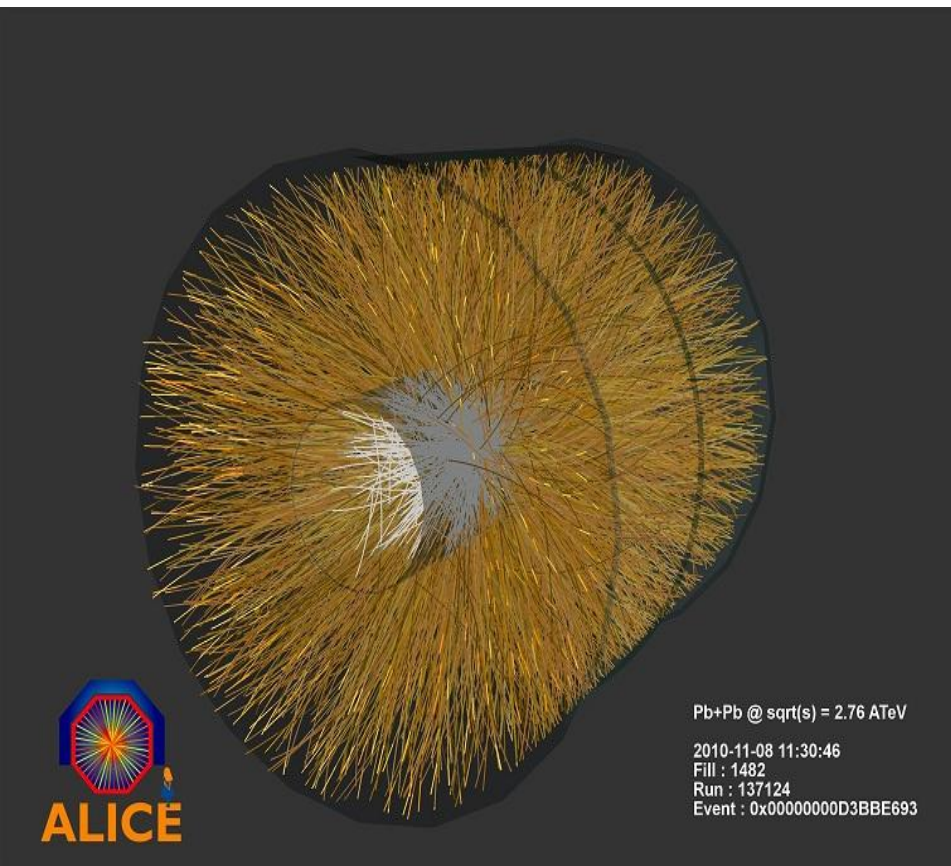**Trigger Chamber**   **Tracking Chamber**   **Dipole Magnet**

ALICE Muon Spectrometer in the experimental cavern, Photograph: Mona Schweizer, 23 Jan. 2008
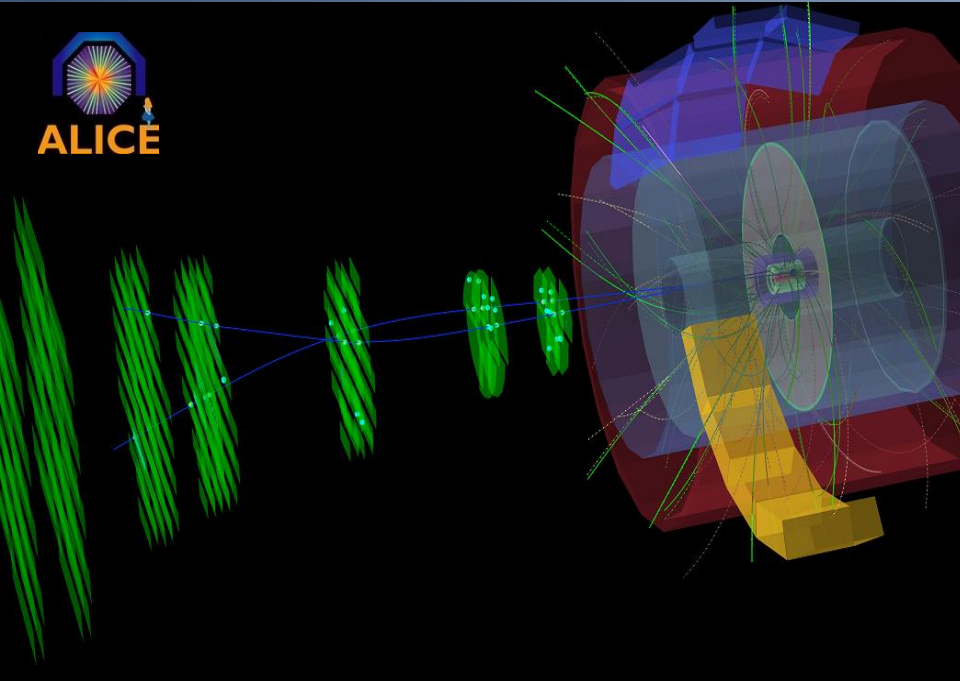
Online reconstructed event from the High Level Trigger

Pb+Pb @ sqrt(s) = 2.76 ATeV

2010-11-08 11:30:46
Fill : 1482
Run : 137124
Event : 0x00000000D3BBE693

First p+p collisions at 7 TeV
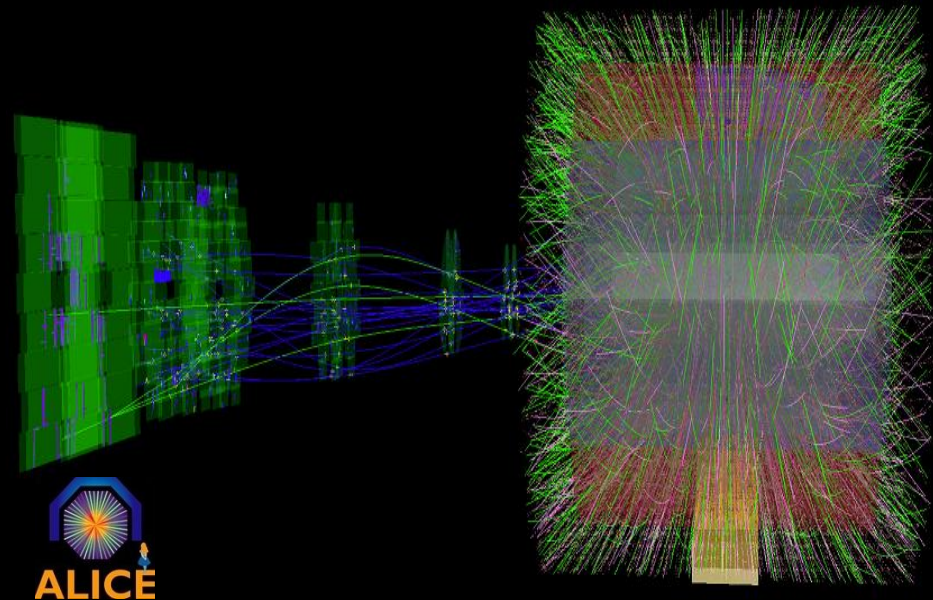
First Pb+Pb collisions at 2.76 TeV

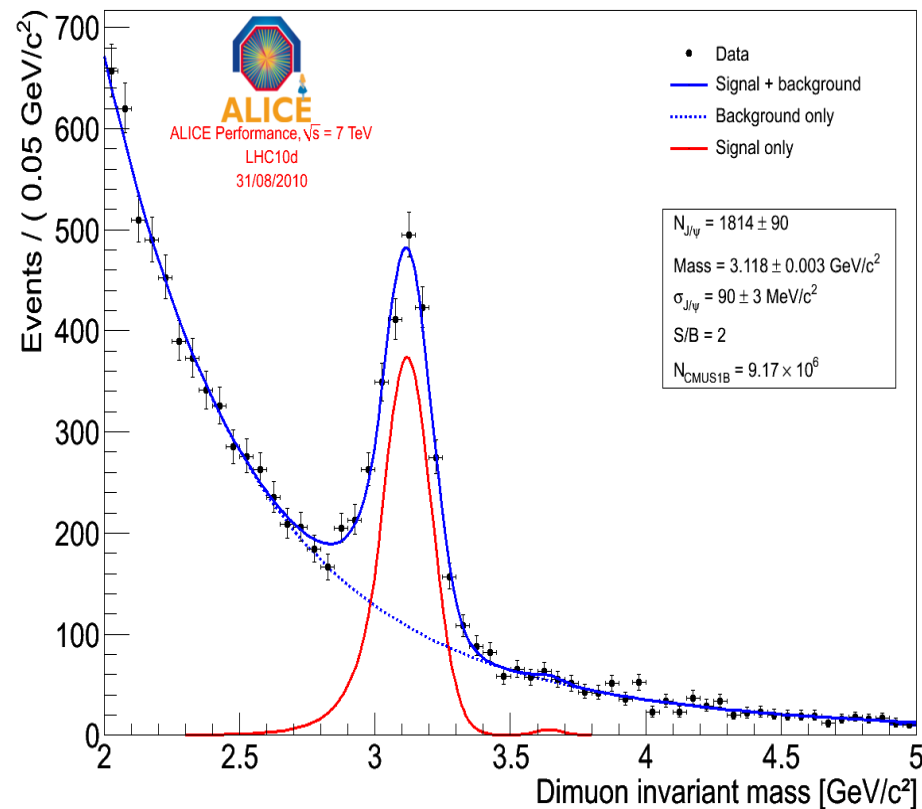First unlike-sign dimuon in p+p collisions at 7 TeV (Run 114783)

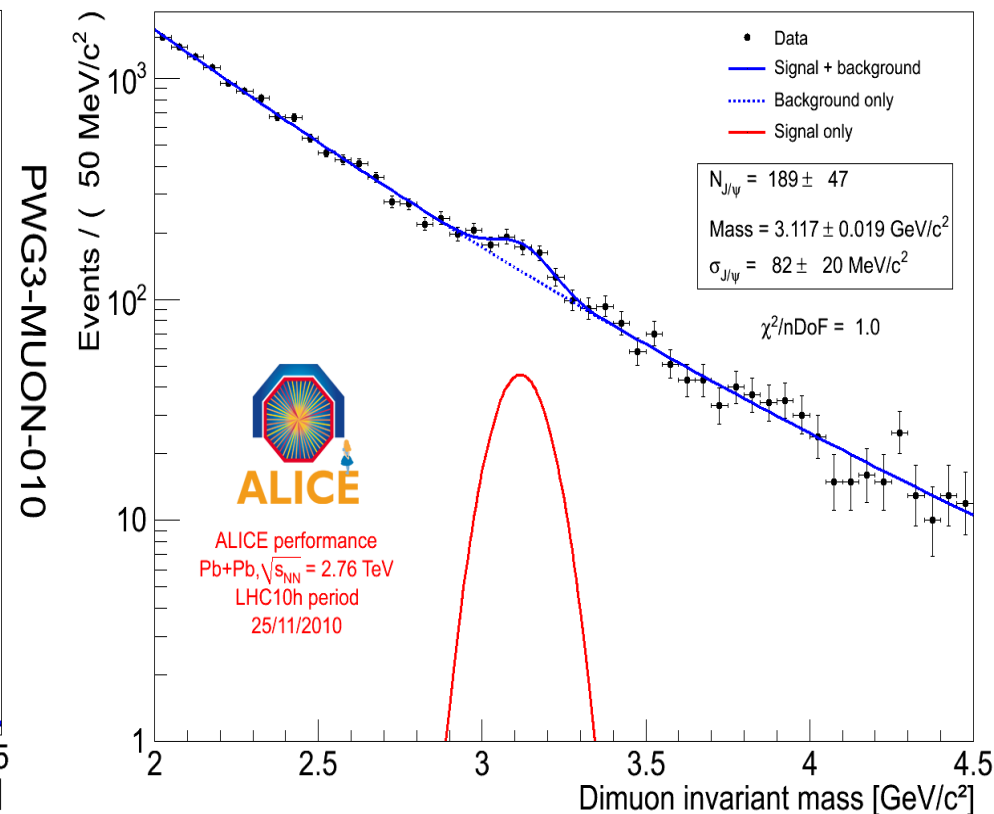High Multiplicity Event, First collisions of lead ions on 08.11.2010

$J/\Psi \rightarrow \mu^+\mu^-$ in p+p collisions @ 7 TeV
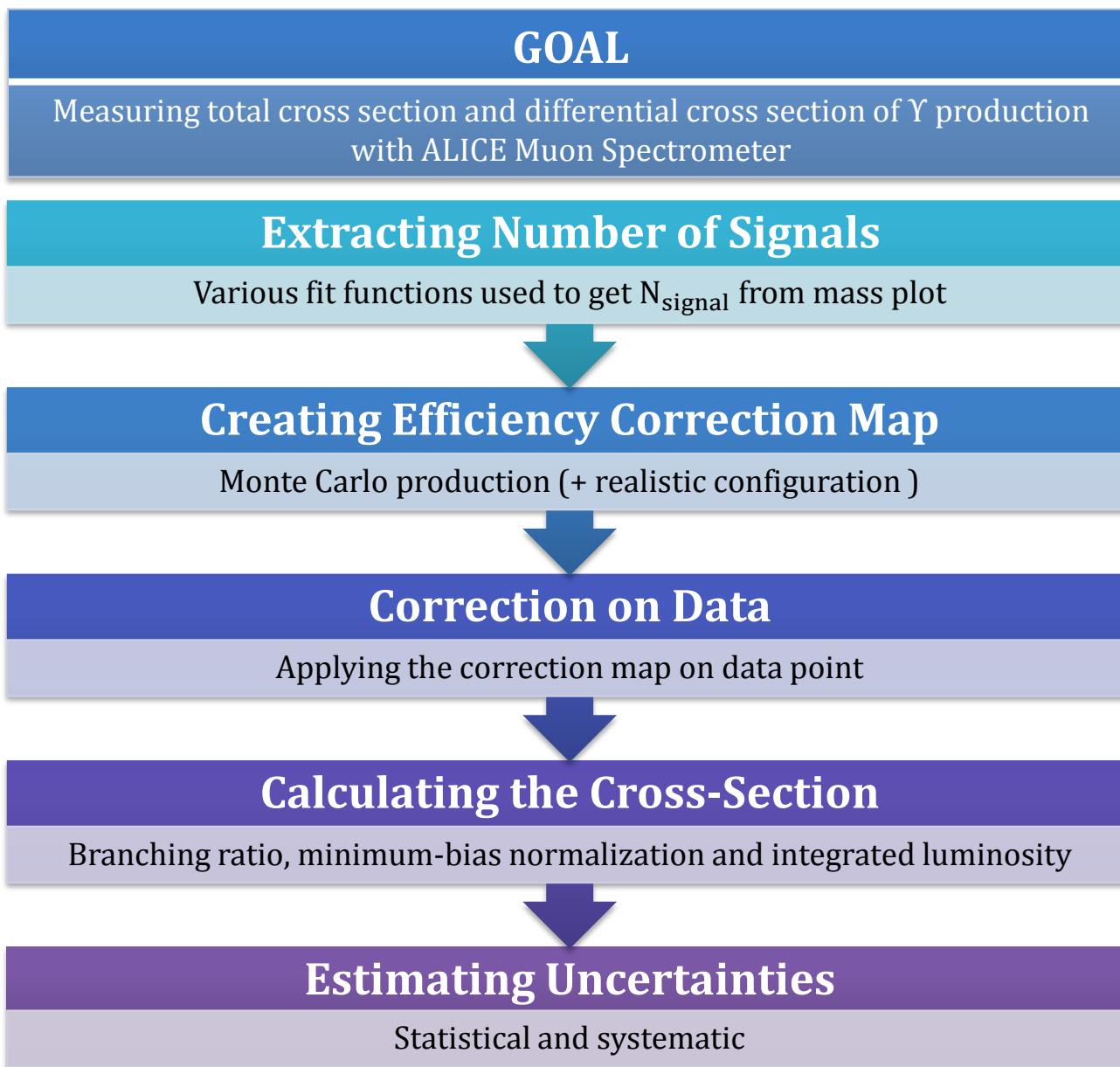
- Muon trig. evts taken in Jun. ~ Jul. 2010

$J/\Psi \rightarrow \mu^+\mu^-$ in Pb+Pb collisions @ 2.76 TeV

- Min-bias trig. Evts in Nov. ~ Dec. 2010

PWG3-MUON-010

ϒ Measurement in p+p collisions with Muon Spectrometer will be possible in 2011 with higher statistics; for Pb-Pb collisions, we will see…

Strategy for ϒ Analysis

GOAL

Measuring total cross section and differential cross section of ϒ production with ALICE Muon Spectrometer

Extracting Number of Signals

Various fit functions used to get N_{signal} from mass plot

Creating Efficiency Correction Map

Monte Carlo production (+ realistic configuration)

Correction on Data

Applying the correction map on data point

Calculating the Cross-Section

Branching ratio, minimum-bias normalization and integrated luminosity

Estimating Uncertainties

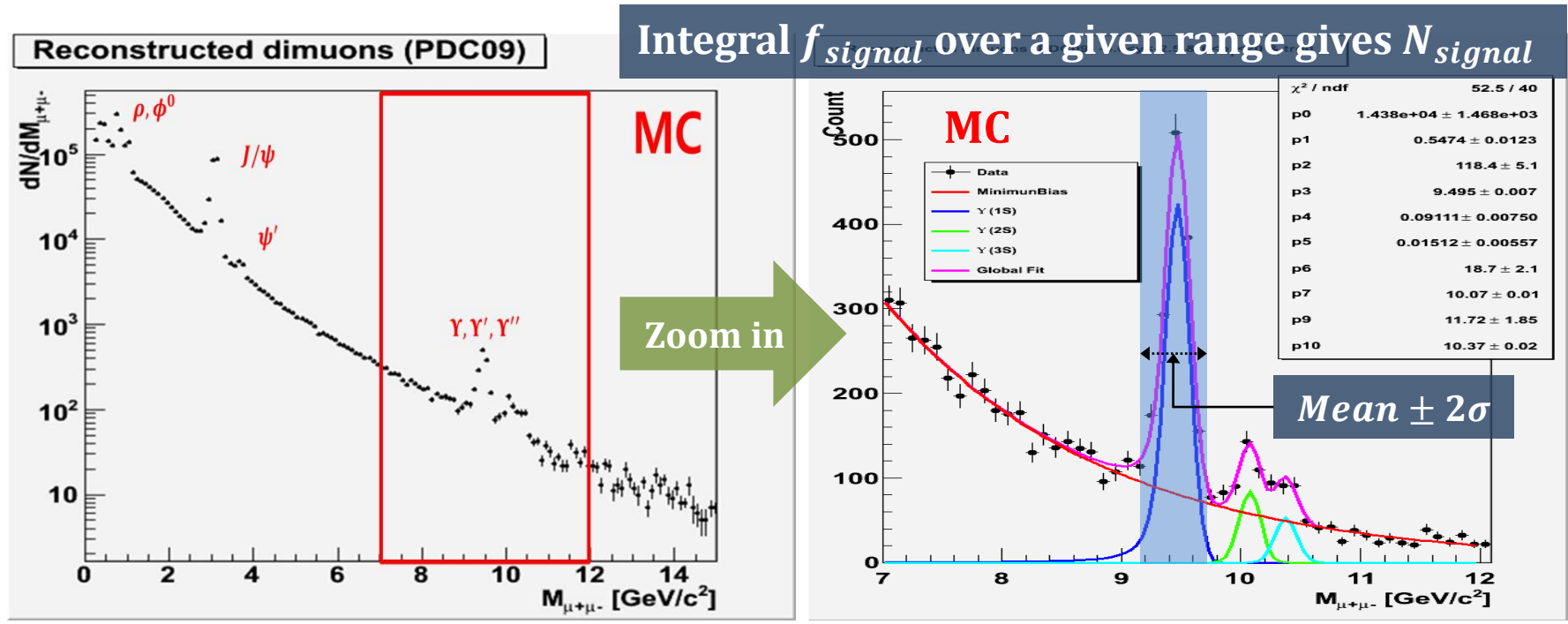Statistical and systematic

N_{signal} obtained by fitting data points in mass plot

- Convolution of Gauss and Landau functions fits well for Υ analysis

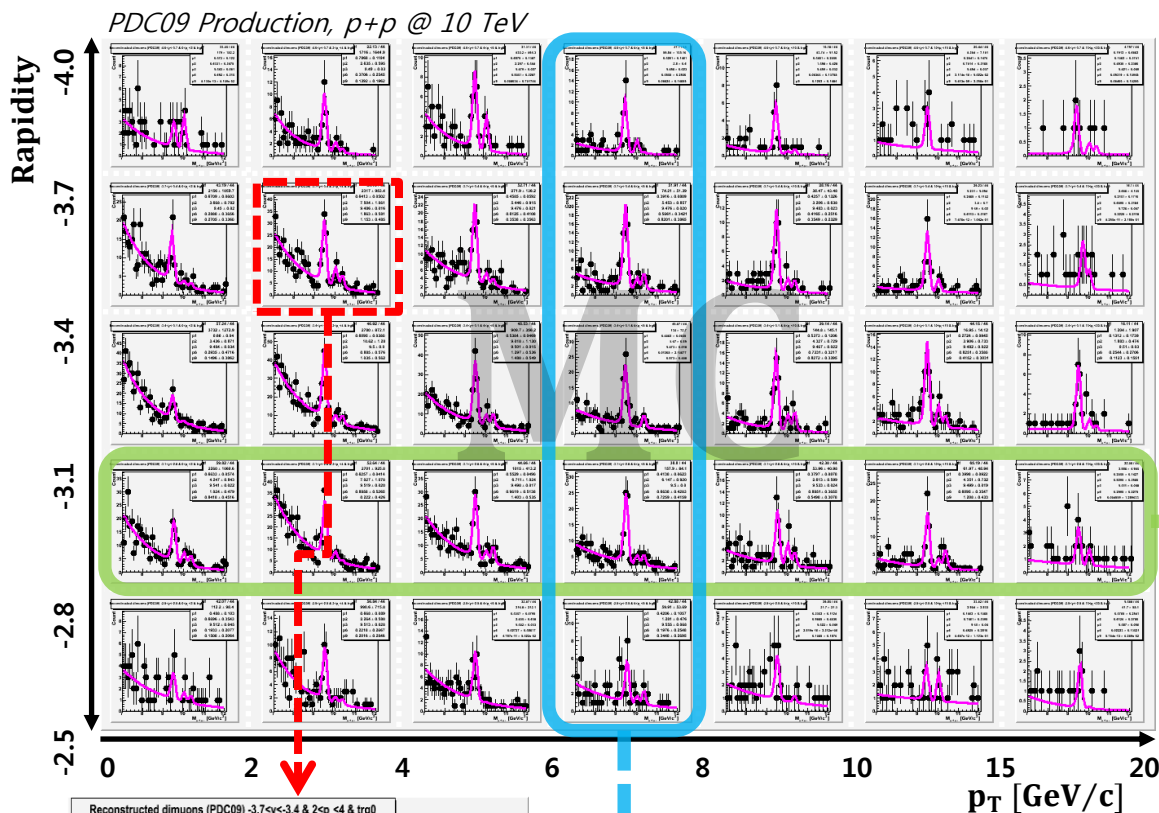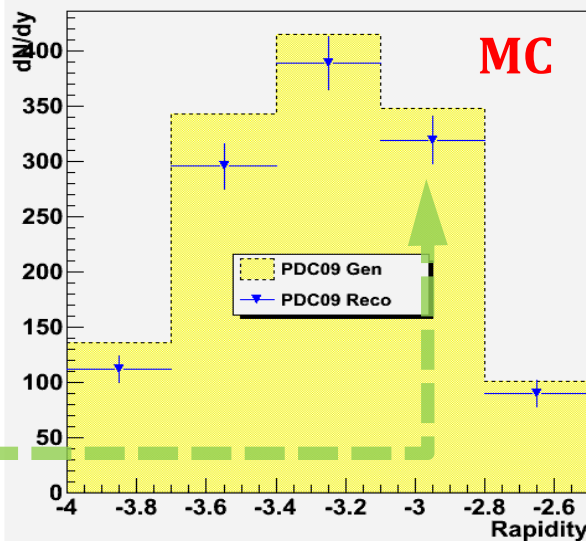*PDC09 Production, p+p @ 10 TeV*

Integral f_{signal} over a given range gives N_{signal}

Mean $\pm 2\sigma$

Transverse momentum and rapidity distribution of Υ can be produced in the similar way

PDC09 Production, p+p @ 10 TeV

$-3.7 < y < -3.4$ & $2 < p_T < 4$

MC
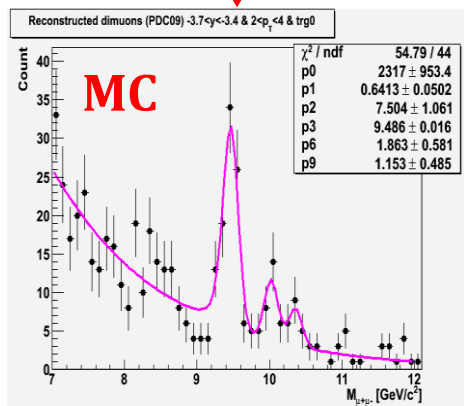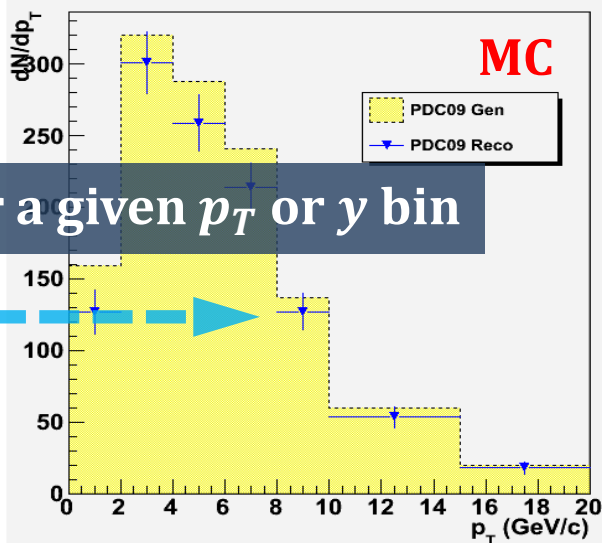
Sum of N_{signal} over a given p_T or y bin
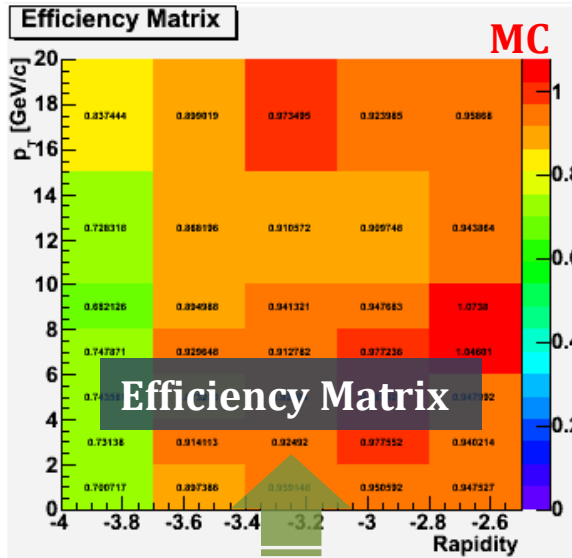
Correcting N$_{signal}$ (MC)

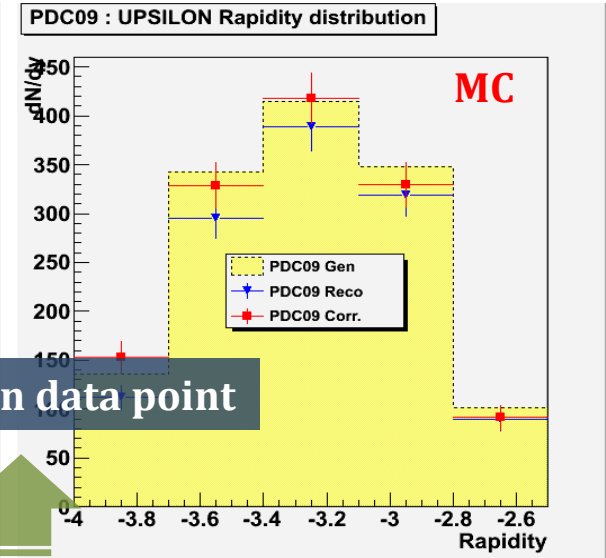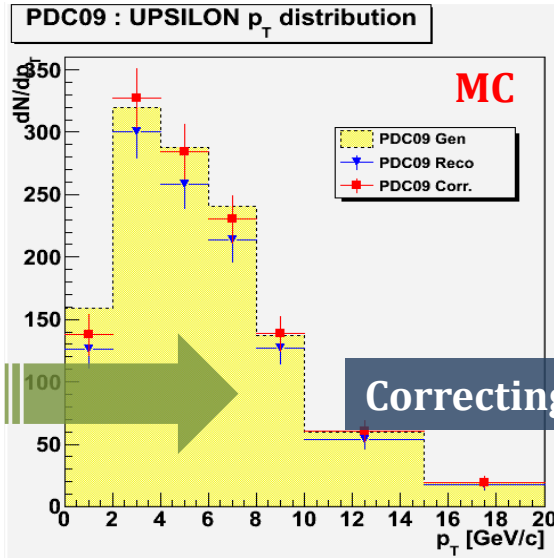## Important in the measurement of the cross-section :

- Imperfection of apparatus
- Calculating efficiency and creating efficiency matrix
- Correcting on data point

Correction Framework

Test of the correction framework for ϒ analysis with Monte-Carlo production

Efficiency Matrix

Correcting on data point

MC Input
+ realistic conf.

p+p or Pb+Pb Data

Analysis framework for ϒ production prepared and tested with MC : ready for data analysis

Summary

- ALICE is the LHC experiment dedicated to the study of QGP in heavy-ion collisions

- Heavy quarkonium measurements provide promising tools for the characterization of QGP

- ALICE has collected data in p+p and Pb+Pb collisions at 7 TeV and 2.76 TeV, respectively

- Muon Spectrometer has been working well

- J/Ψ measurements have been successful in p+p collisions; evidence of J/Ψ signal shown in Pb+Pb collisions

- The first observation of Υ in p+p collisions is feasible in 2011 with more statistics

- Analysis framework for Υ is prepared and tested with MC production:
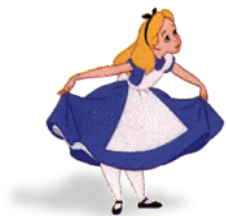
Ready to analyze the real data for Υ

THANK YOU