



Study of strong interaction at the LHC

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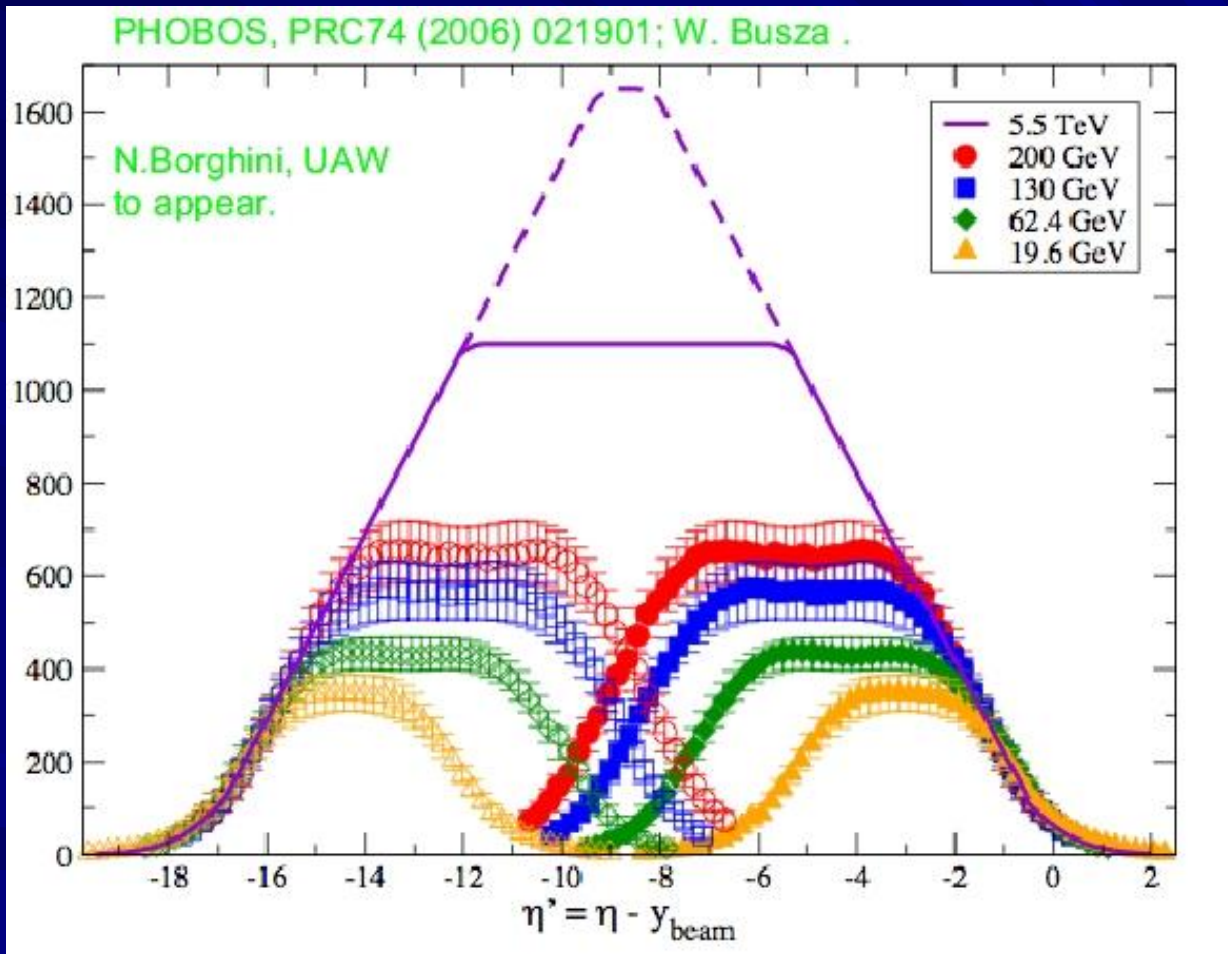
2007 APCTP workshop,

Frontiers in Nuclear and Neutrino Physics,

Disclaimer

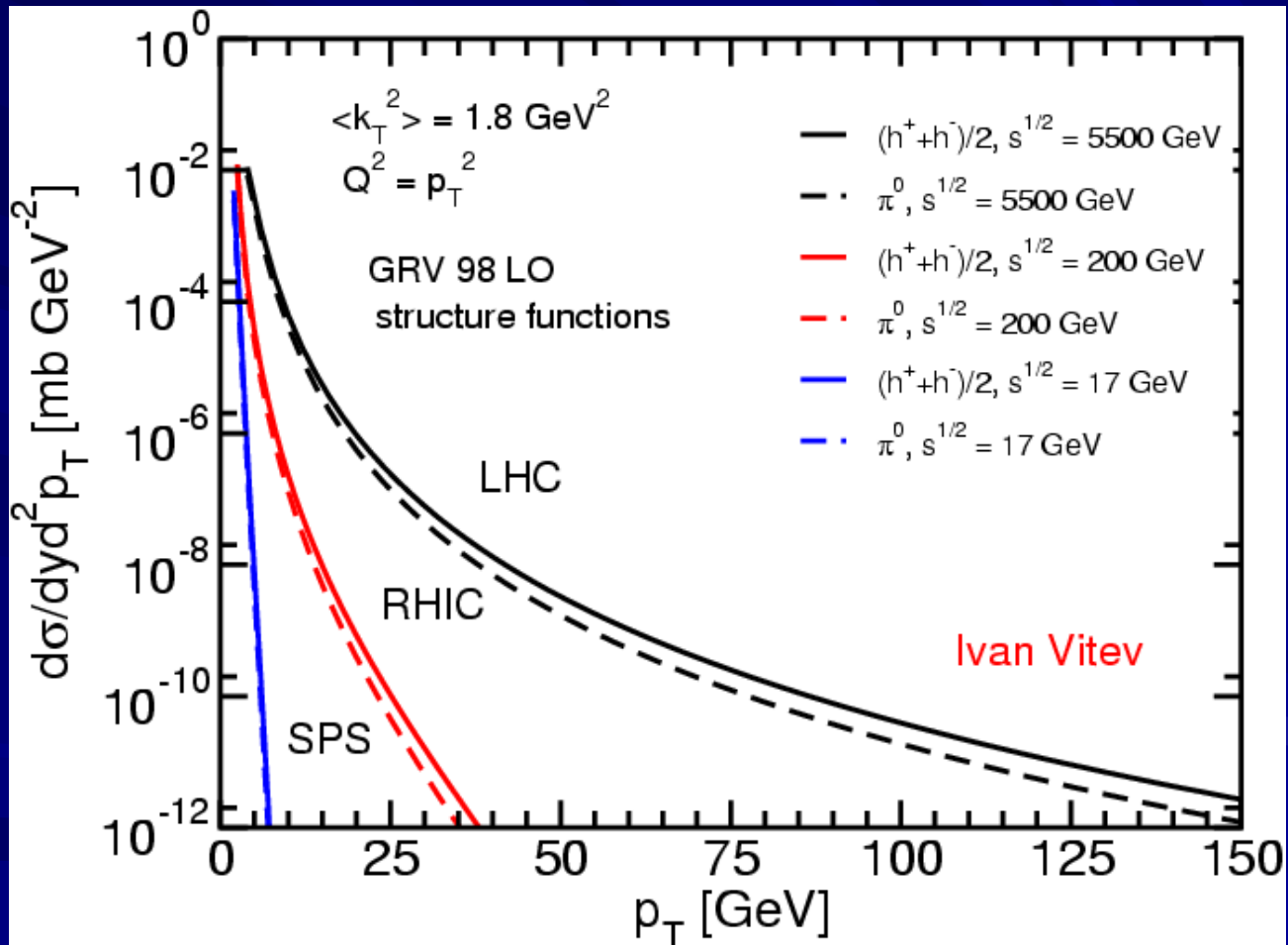
- 실험적인 접근에 집중 ...
- 한국 그룹이 관련된 실험 (ALICE, CMS)
...
- 몇 가지 내용만 간단하게 (day 1)...
 - $dN_c/d\eta$ and $dE_T/d\eta$, v_2 (Elliptical flow)
 - Heavy flavor, Quarkonia
 - Jets (박 인규 선생님 발표참조)
 - Other pQCD probes? 아마도 4월에 ^^;

LHC에서 새롭게 나타나는 일들(I)

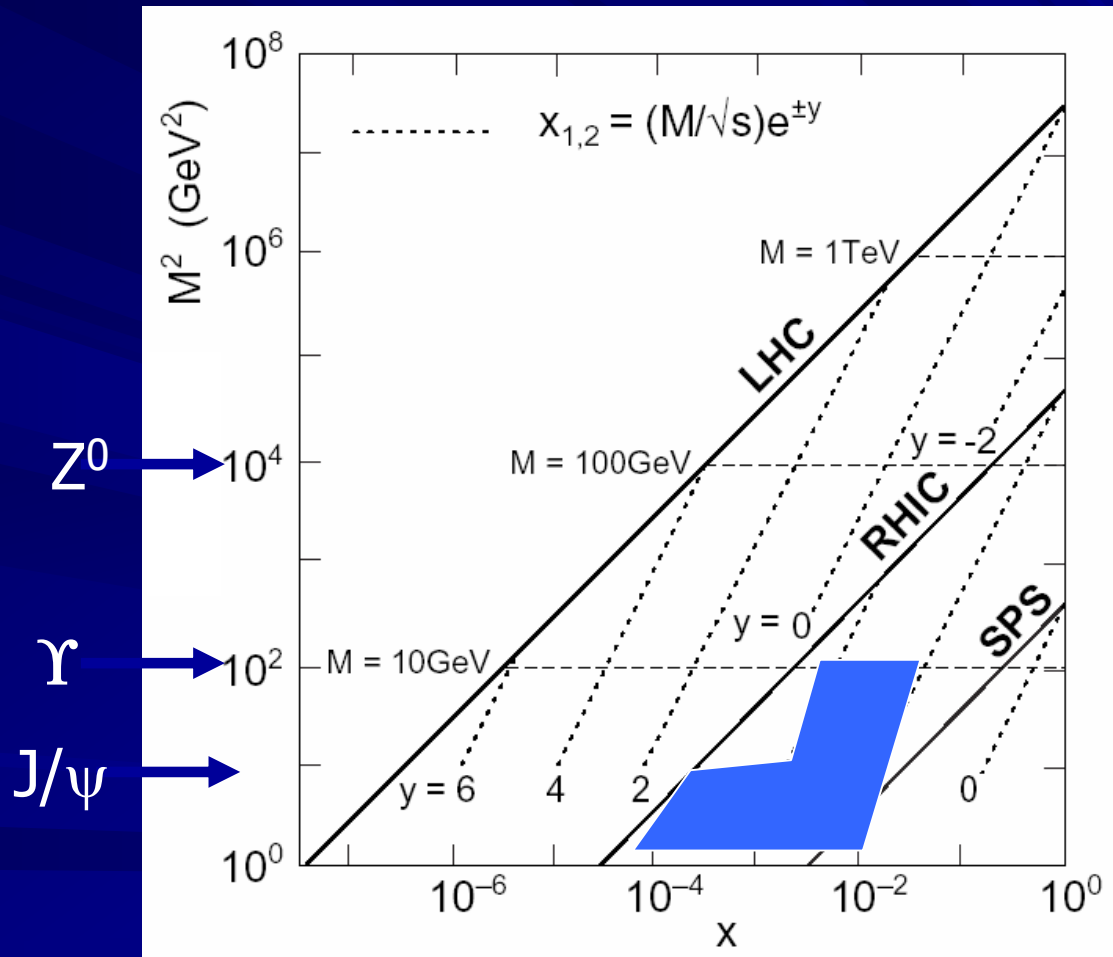


Note : Saturation model, $dN_c/d\eta \geq 1650$

LHC에서 새롭게 나타나는 일들(II)



Expanded Kinematics at the LHC



LHC provides access to the widest range of Q^2 and x

Startup Plans

■ Timeline:

- August 2007: close experiment
- September - November: commissioning
- November - December: pp commissioning run ($\sqrt{s} = 0.9 \text{ TeV}$)
- 2008: first pp run ($\sqrt{s} = 14 \text{ TeV}$)
- followed by first Pb-Pb run (end 2008?)
 - final timing depends on physics landscape by then
 - $\sqrt{s} = 5.5 \text{ TeV}$, $L = 5 \cdot 10^{25} \text{ cm}^{-2}\text{s}^{-1}$

The ALICE experiment

Size: 16 x 26 meters
Weight: 10,000 tons



HMPID

TOF

TRD

PMD

ITS

PHOS

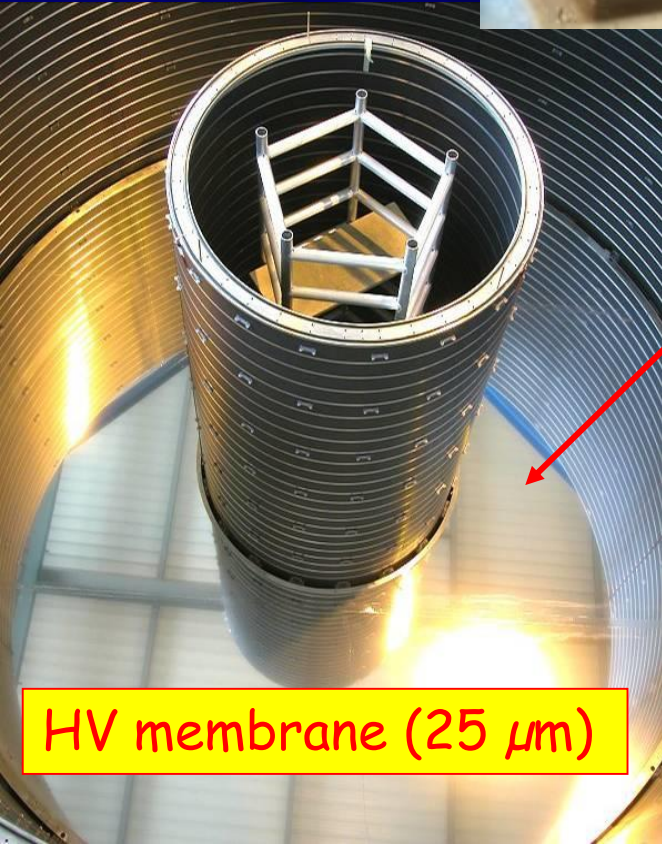
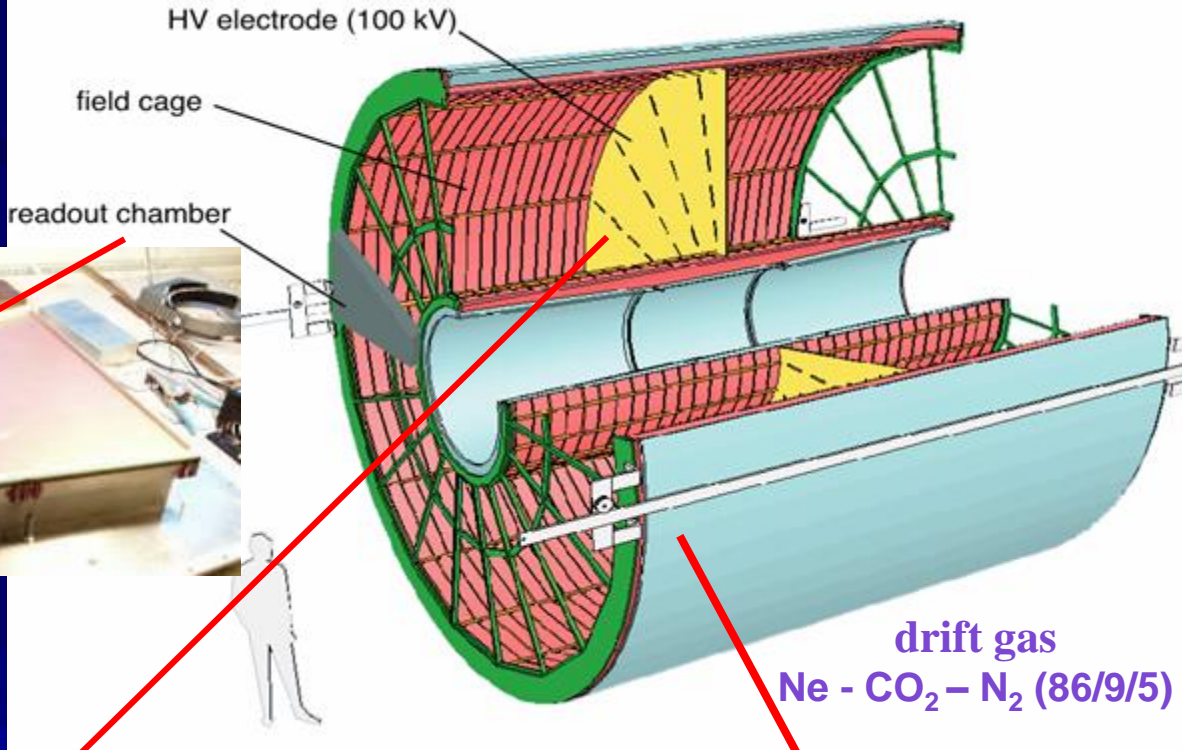
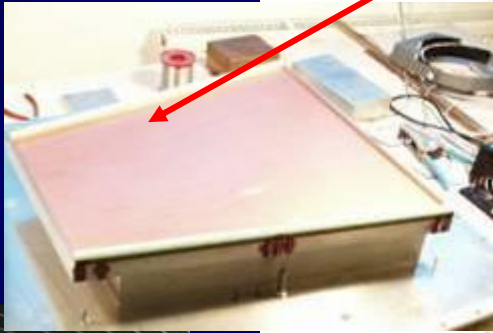
TPC

Muon Arm

**ALICE
Set-up**

Time Projection Chamber (TPC)

largest ever
88 m³, l = 5 m
d = 5.6 m
570 k channels

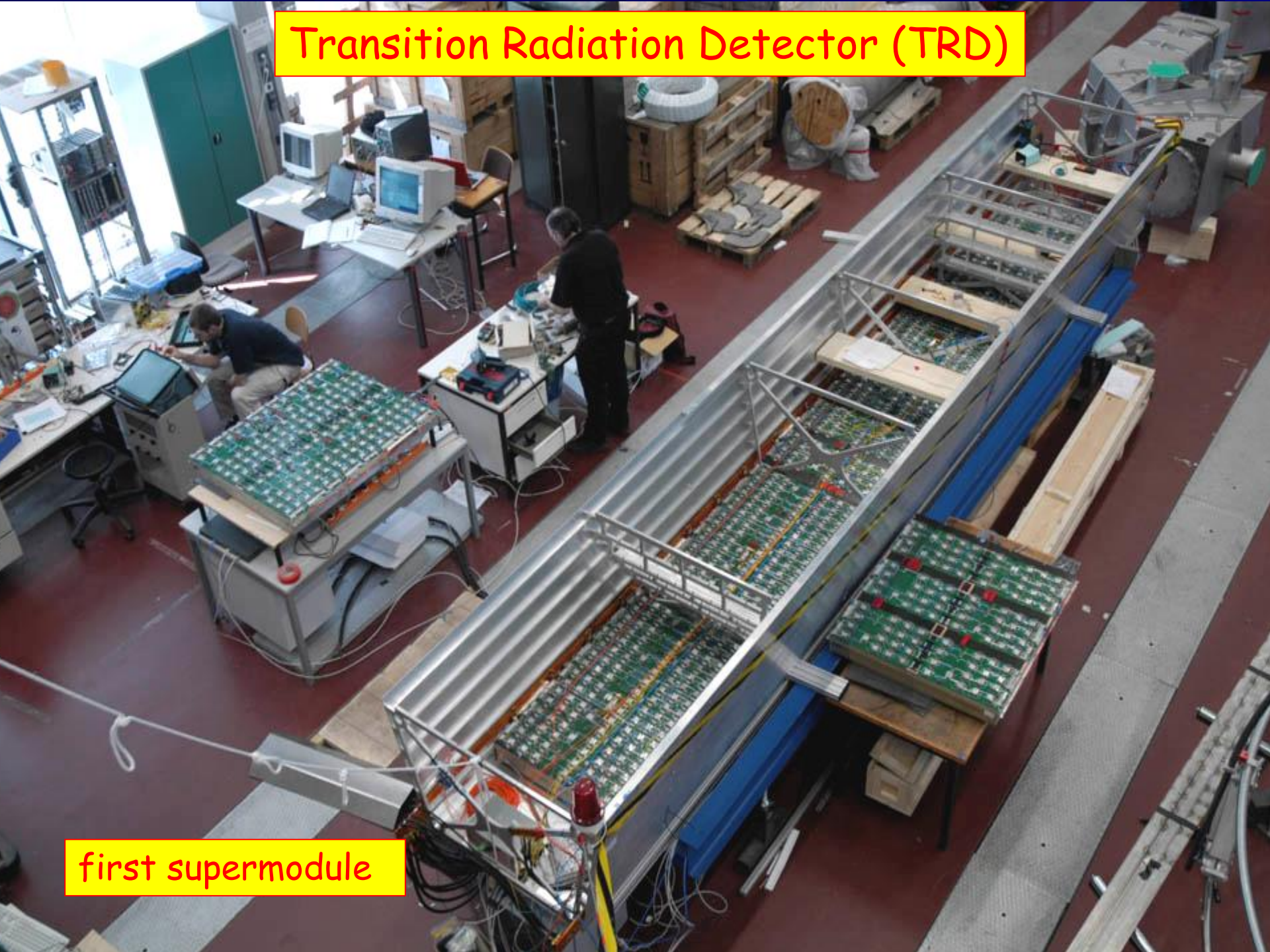


HV membrane (25 μm)



field cage

Transition Radiation Detector (TRD)



first supermodule

Identified particle spectra

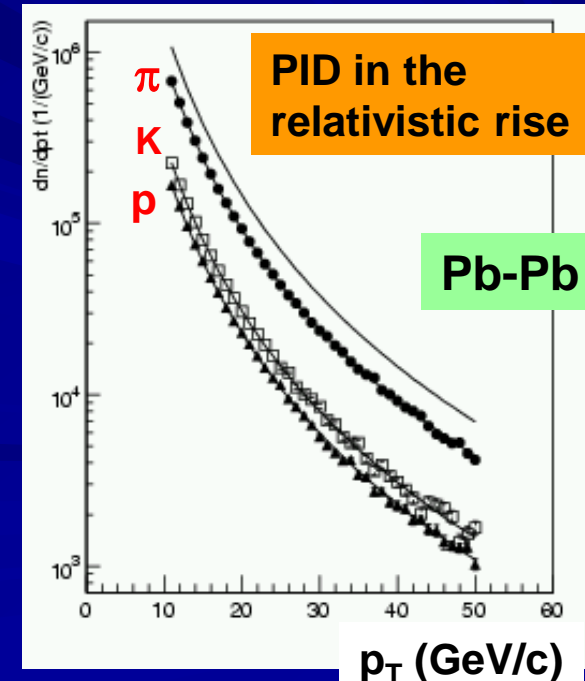
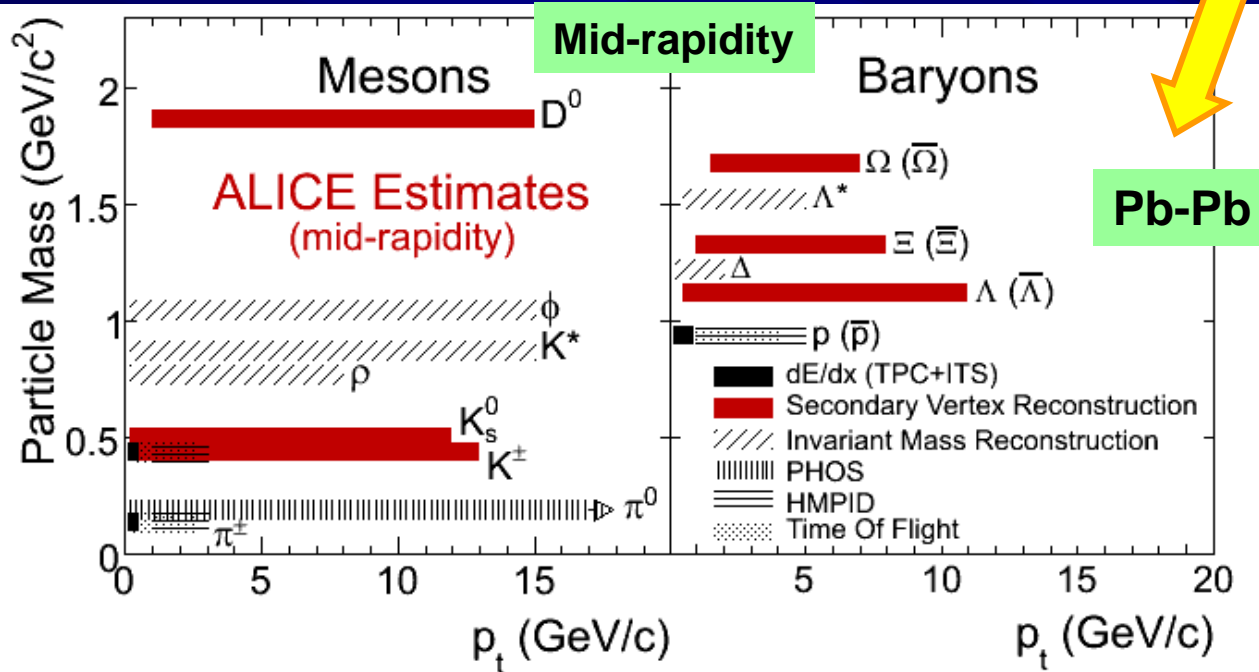
Particle reconstruction and identification capabilities: unique to ALICE
 Global tracking (ITS-TPC-TRD) + dE/dx (low p_T + relativ. rise), TOF, HMPID, PHOS, ...
 Invariant mass, topological reconstruction

Acceptance / efficiency / reconstruction rate (ϵ) / contamination
 p_T range (PID or stat. limits) for 10^7 central Pb-Pb and 10^9 min. bias pp

For ~ 20 particle species for $-1 < y < +1$ and $-4 < y < +2.5$

$\pi, K, p: 0.1 - 0.15 \rightarrow 50 \text{ GeV}$

Weak or strong decaying particles: until 10-15 GeV

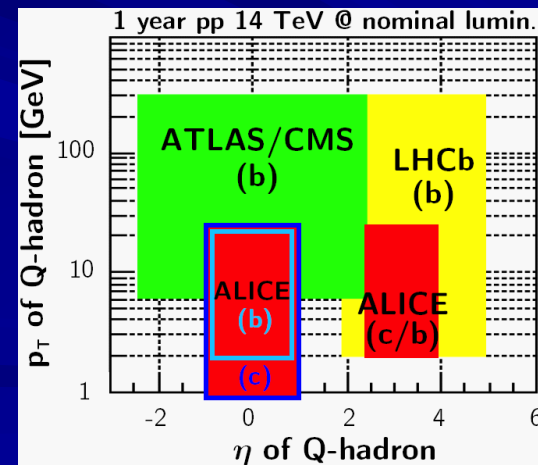
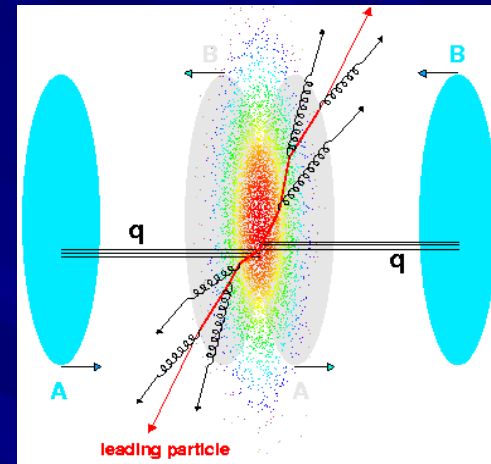


Heavy quarks

High p_T suppression

Parton energy loss?

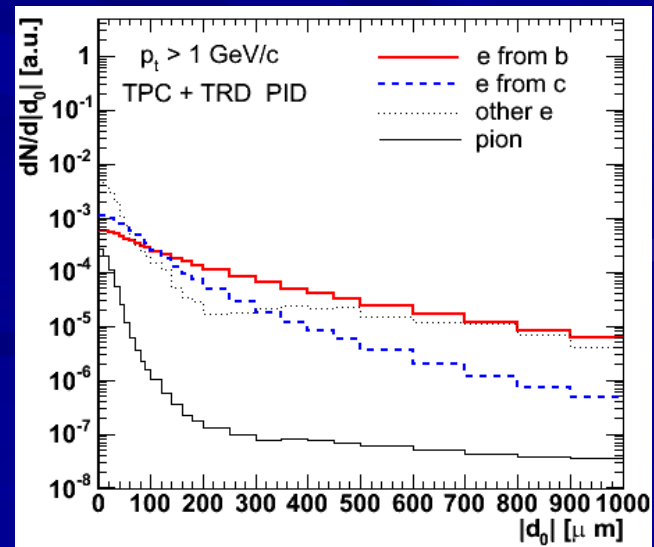
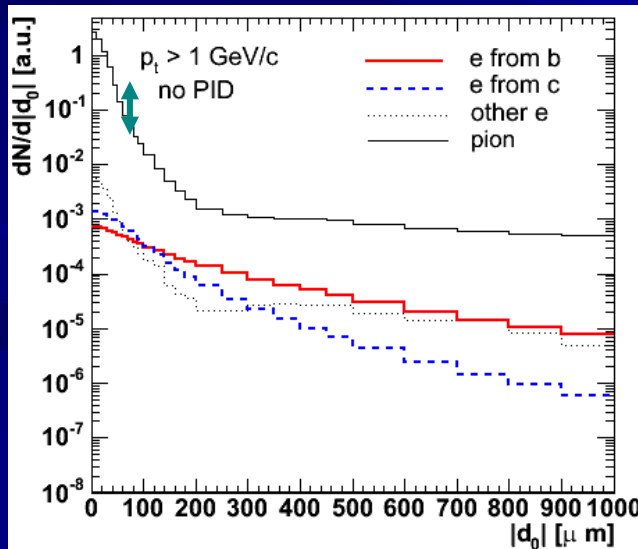
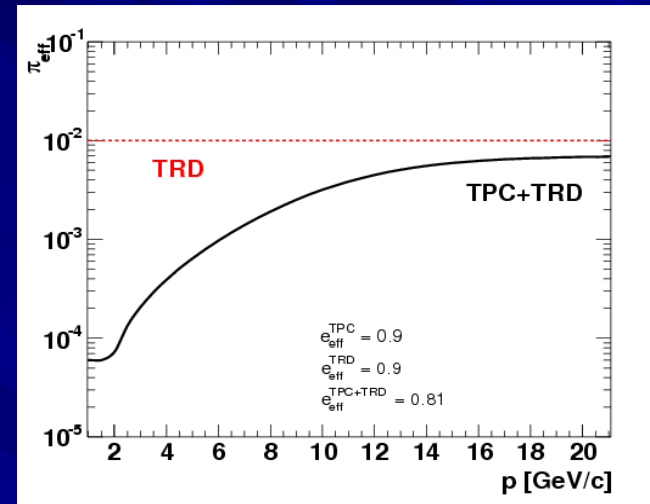
- parton-specific:
gluon vs quark \rightarrow light
hadron vs heavy
flavored hadron
- flavour-specific:
stronger for lighter than
for heavier quarks
(dead-cone effect)



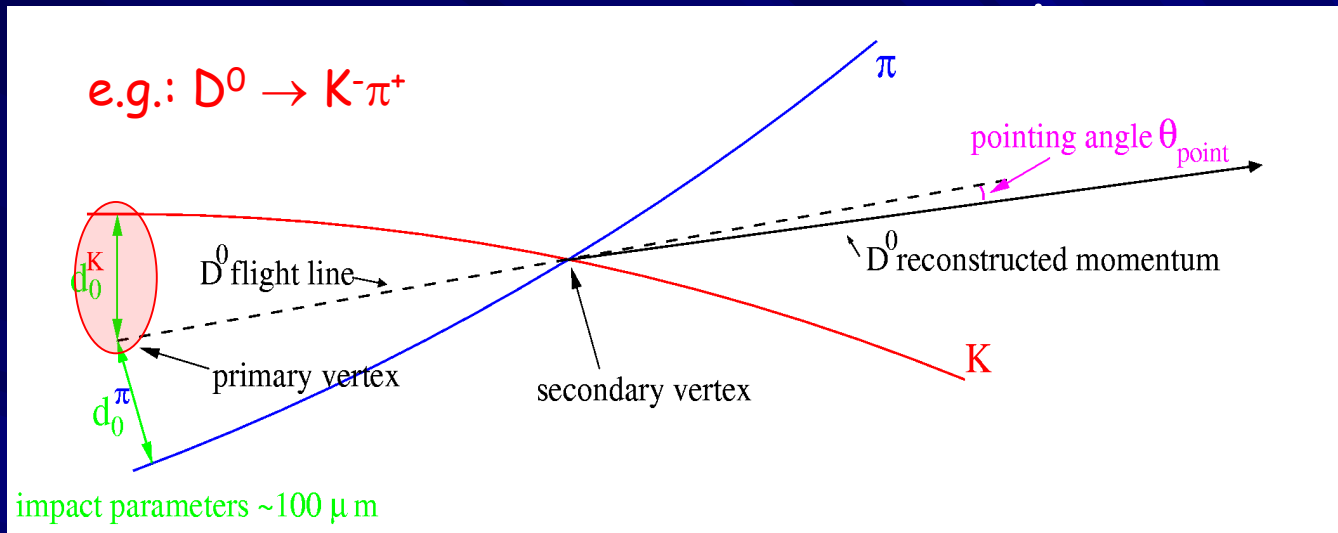
$B \rightarrow e + X$

Electron separation

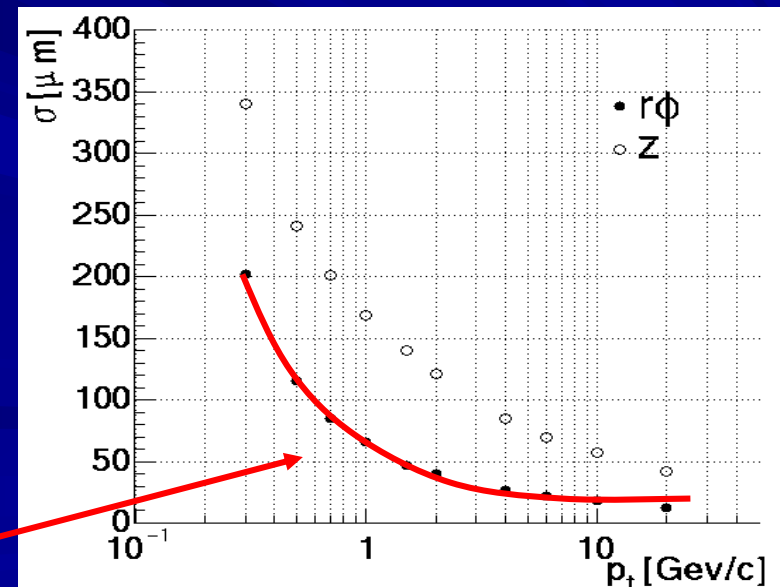
- Combined strategy TRD+TPC
 - TRD rejects 99% of pions and 100% of heavier hadrons (90% electron efficiency)
 - TPC (via dE/dx analysis) rejects again 99% of pions at 90% electrons efficiency (at low p_t 's)



Impact parameter

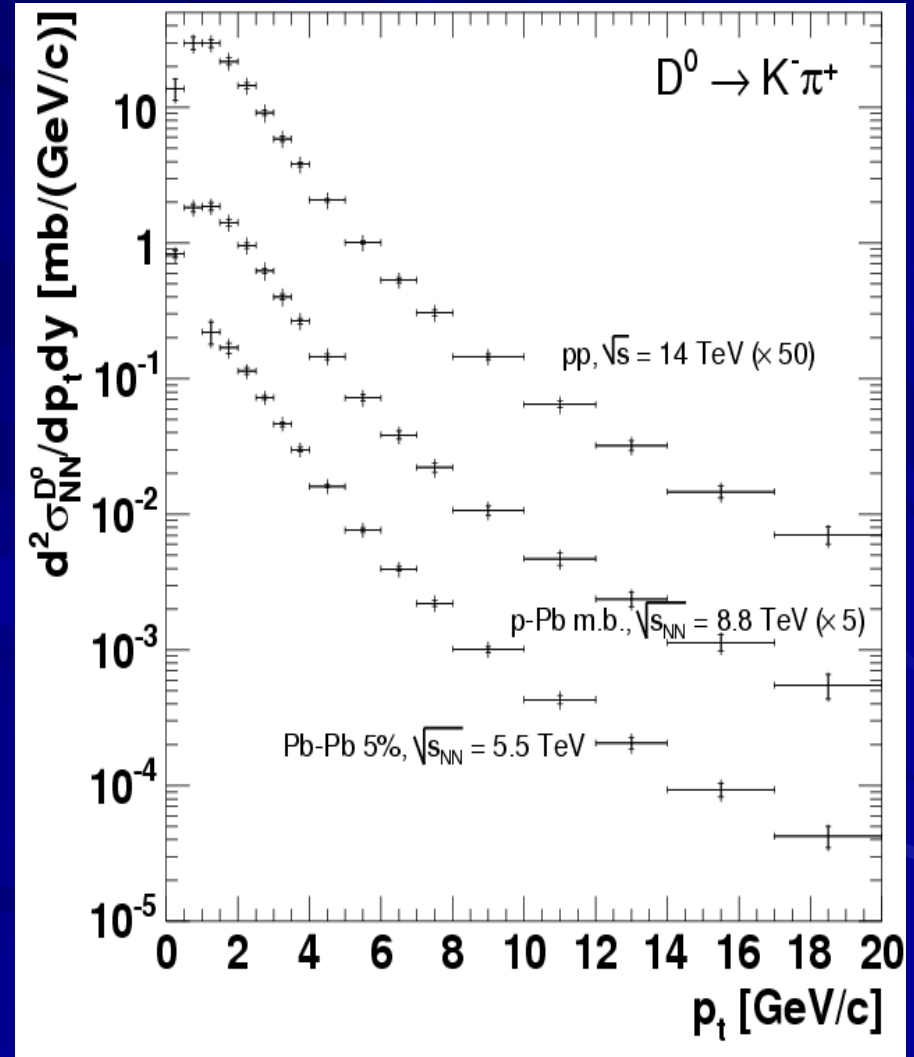
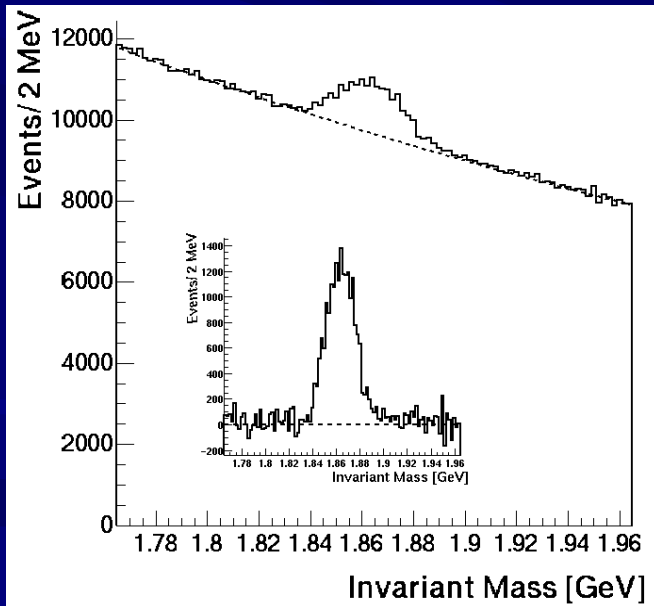


- full reconstruction of D decays
- b/c separation
- control heavy flavour purity of non-photonic sample
- expected resolution (ITS)



$$D^0 \rightarrow K^- \pi^+$$

- expected ALICE performance
 - $S/B \approx 10\%$
 - $S/\sqrt{S+B} \approx 40$
(1 month Pb-Pb running)

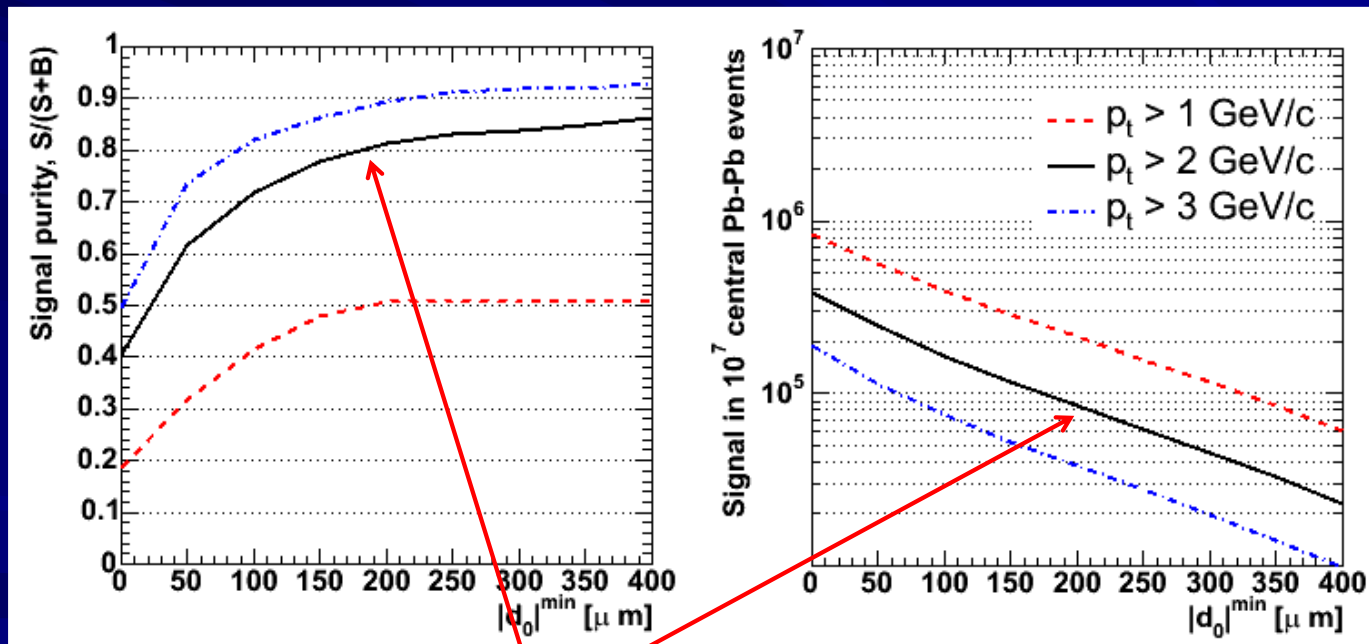


$$B \rightarrow e^{\pm} + X$$

- Expected ALICE performance (1 month Pb–Pb)
 - e^{\pm} identification from TRD and dE/dx in TPC
 - impact parameter from ITS

$S/(S+B)$

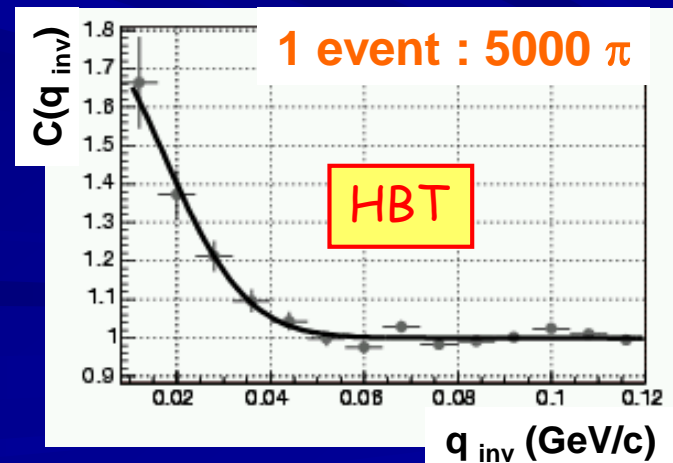
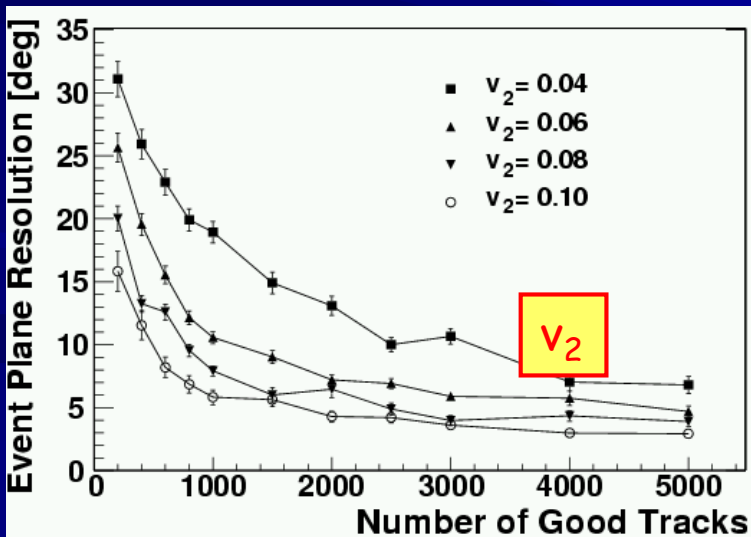
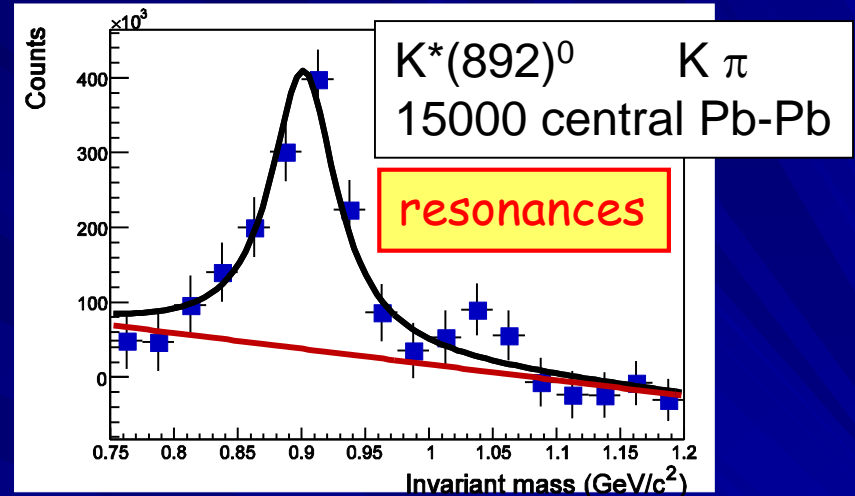
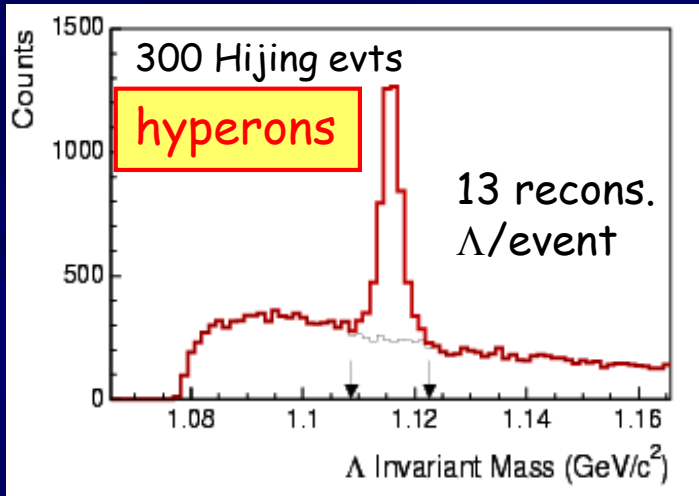
S per 10^7 central Pb–Pb events



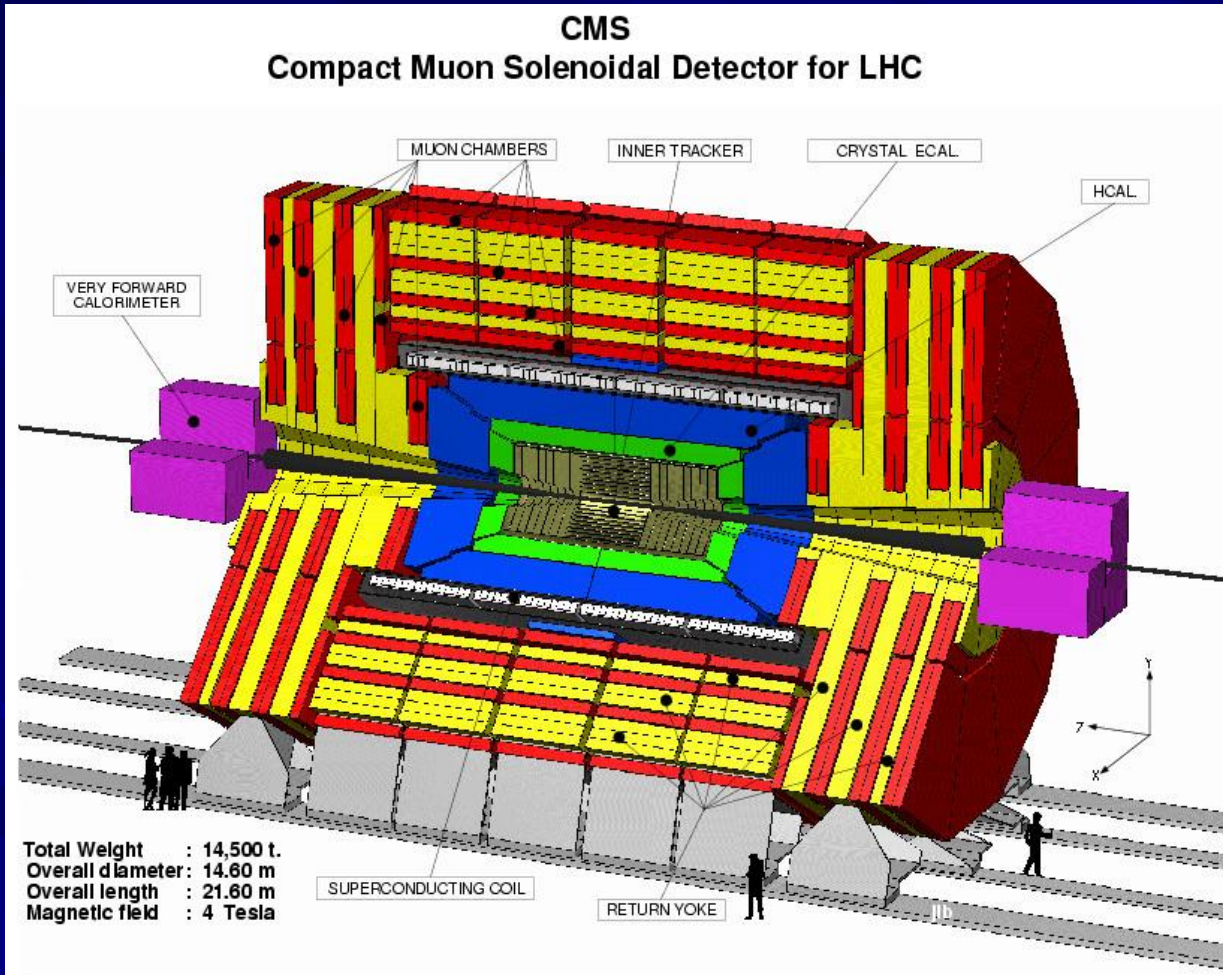
$p_t > 2 \text{ GeV}/c$, $200 < |d_0| < 600 \mu\text{m}$

80% purity
 $8 \times 10^4 e$ from B

“Softer” observables?



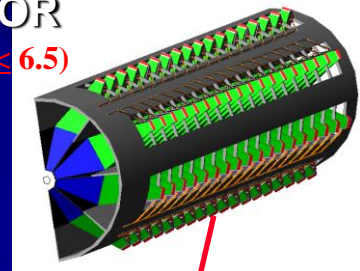
The CMS Experiment



Forward Detectors

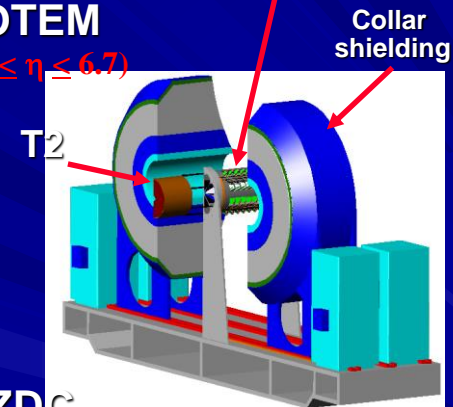
CASTOR

$(5.2 \leq \eta \leq 6.5)$



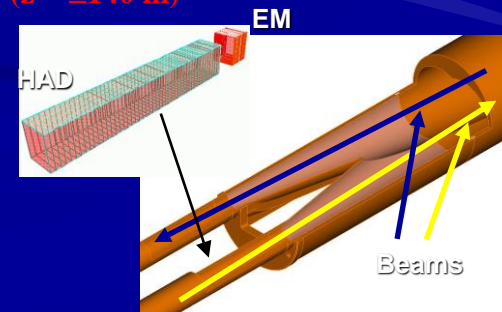
TOTEM

$(5.3 \leq \eta \leq 6.7)$

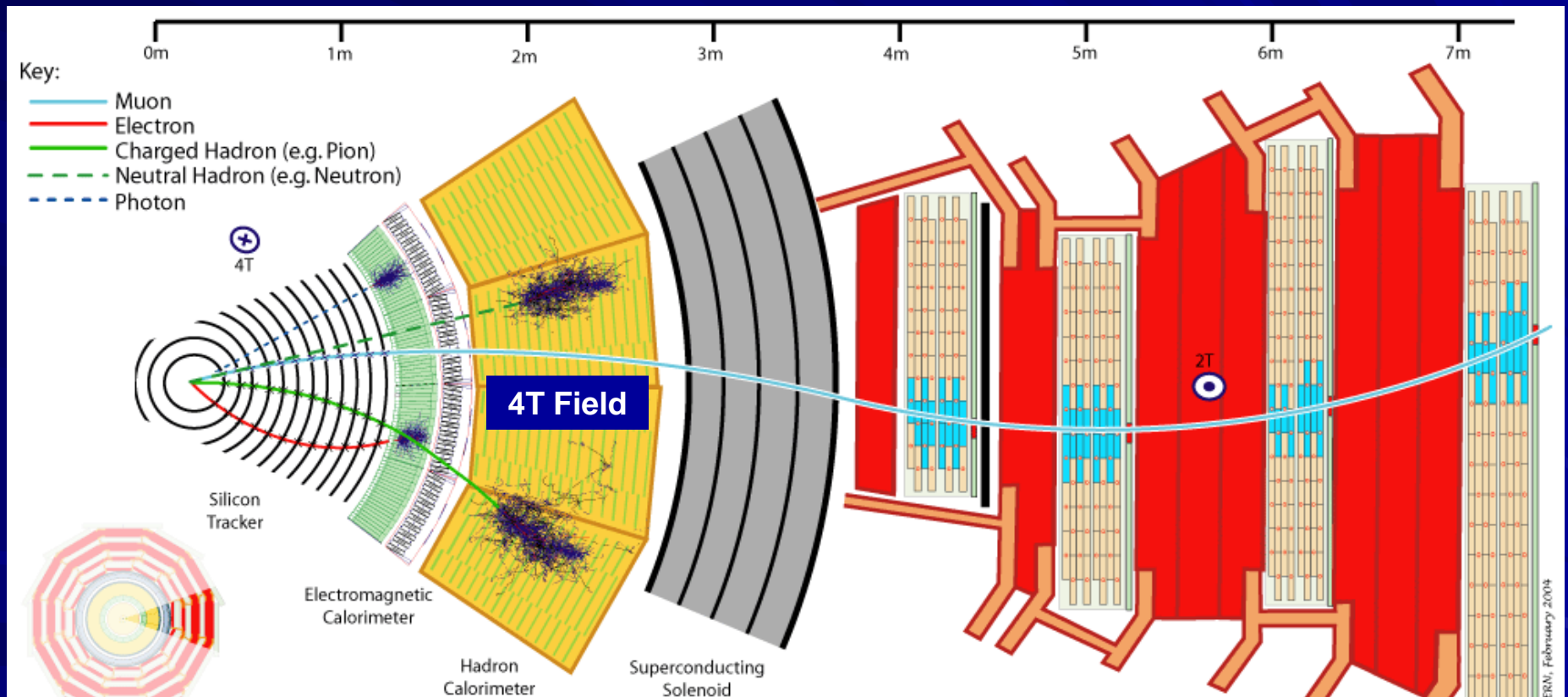


ZDC

$(z = \pm 140 \text{ m})$



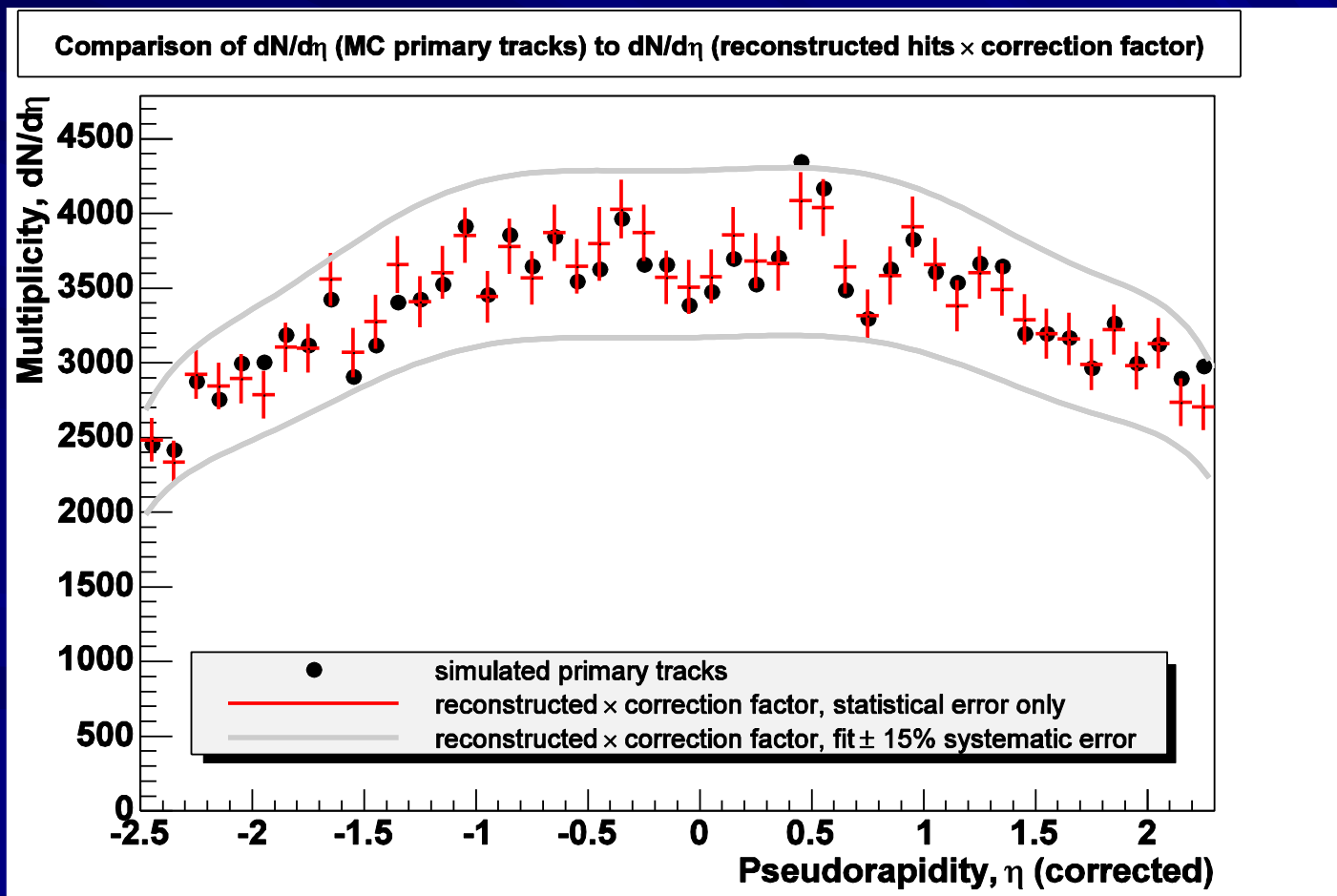
Particle Detection in CMS



Charged Particle Multiplicity: $dN_{ch}/d\eta$

Single Pb+Pb Event

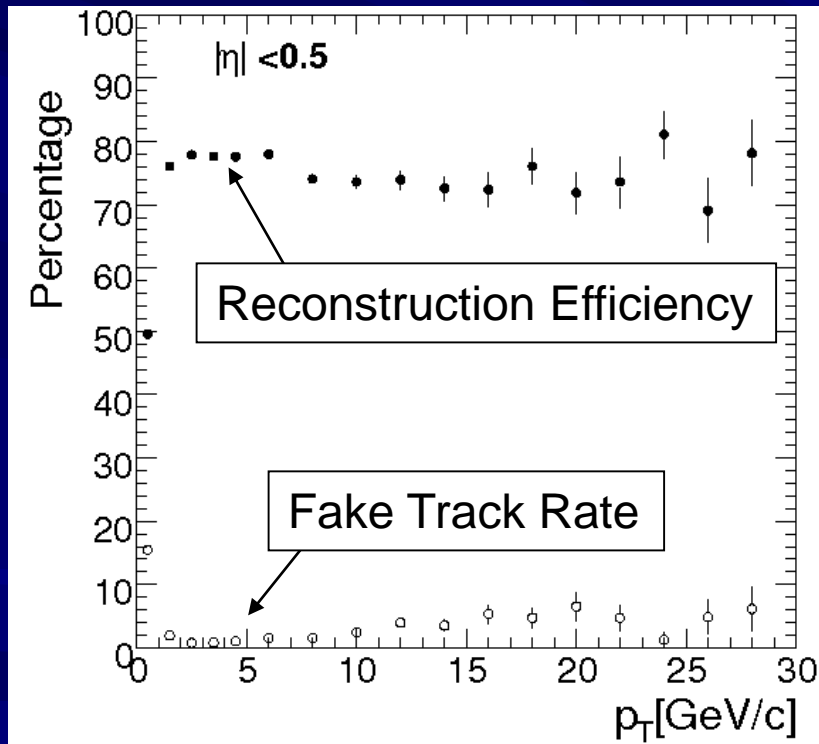
Single layer hit counting in innermost pixel barrel layer



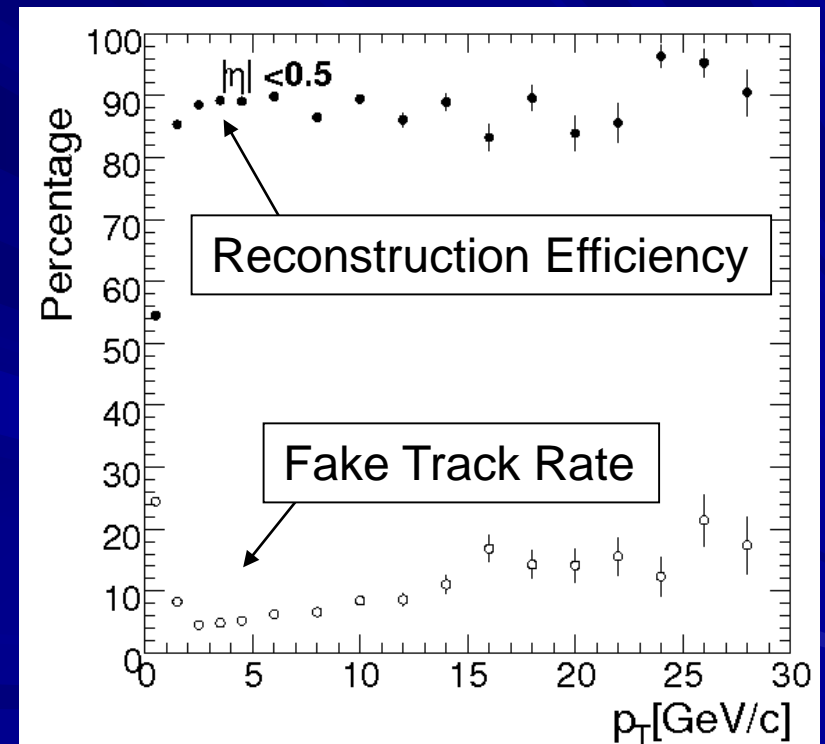
Track Finding Capability

(Pb+Pb collisions; $dN_{ch}/d\eta|_{\eta=0} \sim 3000$)

Optimized for Low Fake Rate



Optimized for High Efficiency



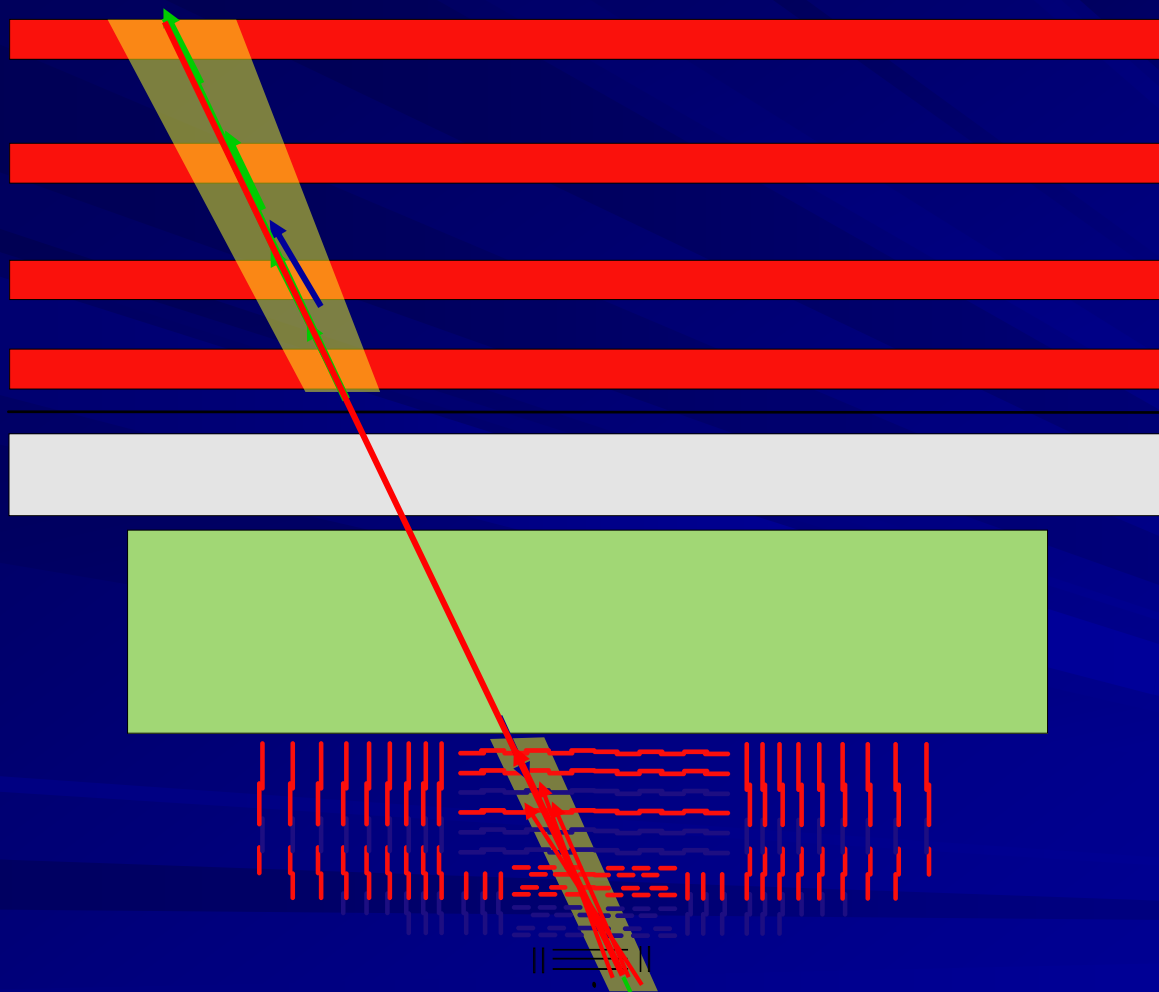
Efficiency ~ 75% with Fakes < 5%



Efficiency ~ 88% with Fakes ~ 10%

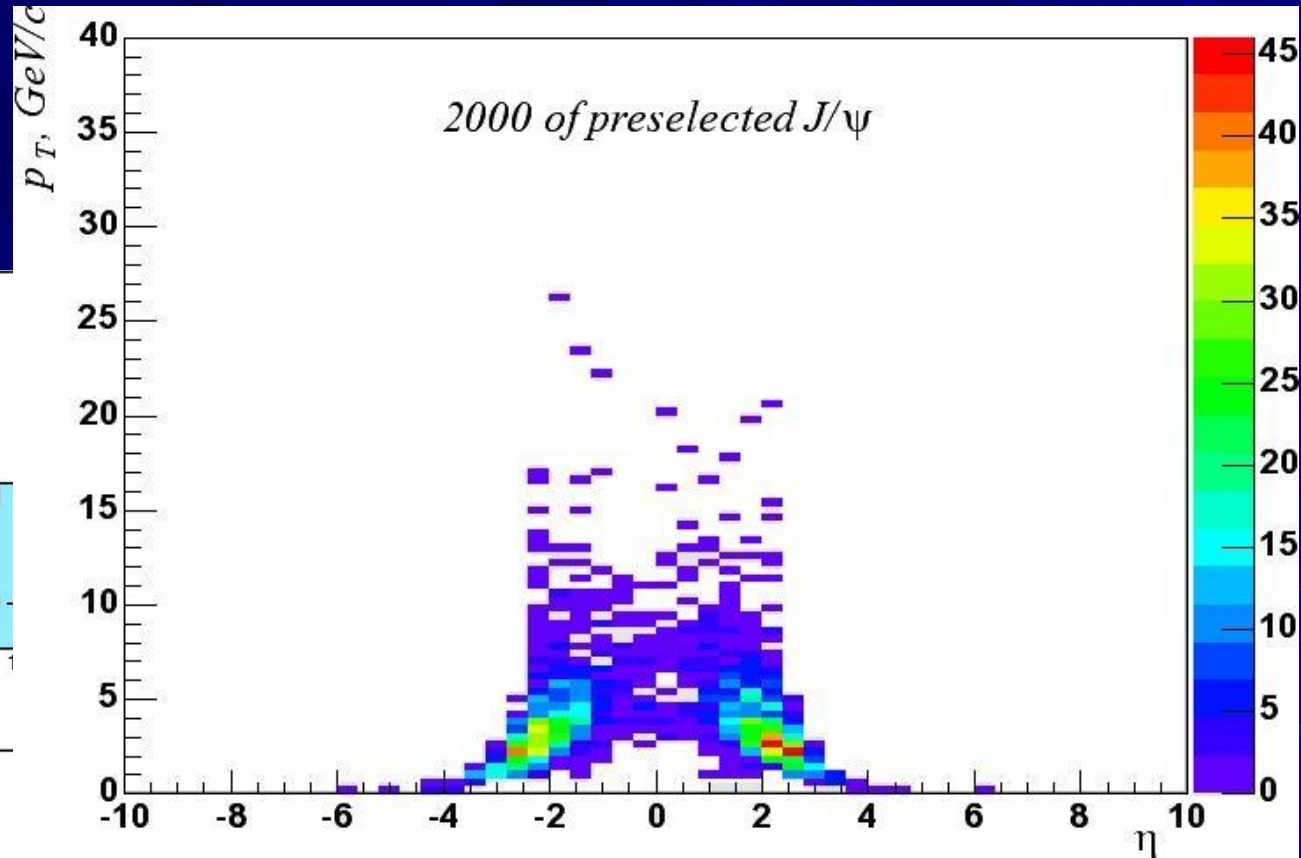
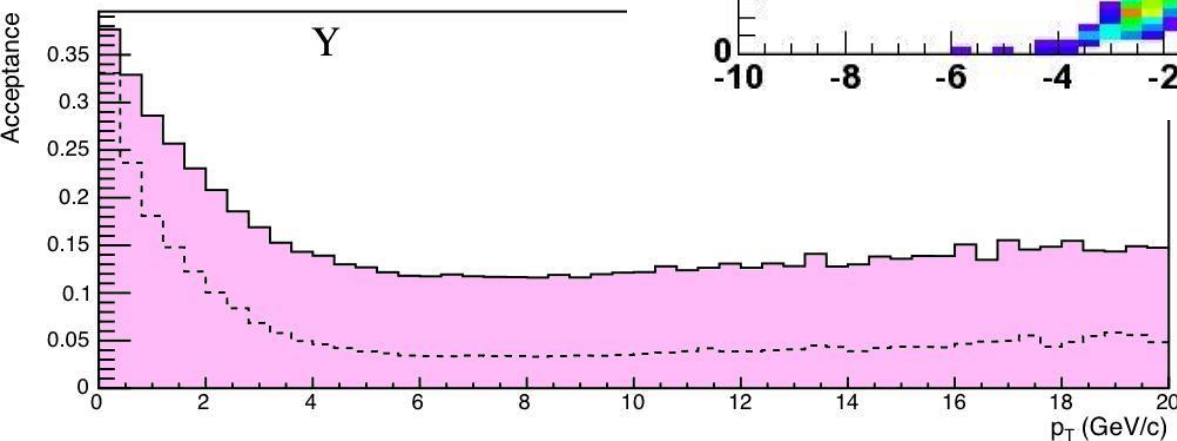
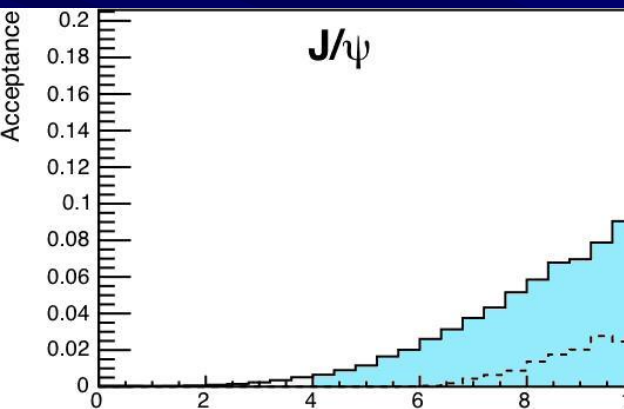


Muon reconstruction



- Best **muon** spectrometer at LHC (**CMS**)
- Excellent coverage:
~5 units of rapidity and 2π
- Strongest magnetic field:
4 T, 2 T (return yoke)
- Tag from mu-chambers,
momentum resolution
from **Silicon tracker**
- Ecal + Hcal + Magnet
Iron absorbs hadrons
 - **Barrel: $p_T^\mu > 3.5 \text{ GeV}/c$**
 - Endcap: $p_L^\mu > 4.0 \text{ GeV}/c$
- **Trigger at Level-1 and High Level Trigger**

J/ψ , Υ acceptances

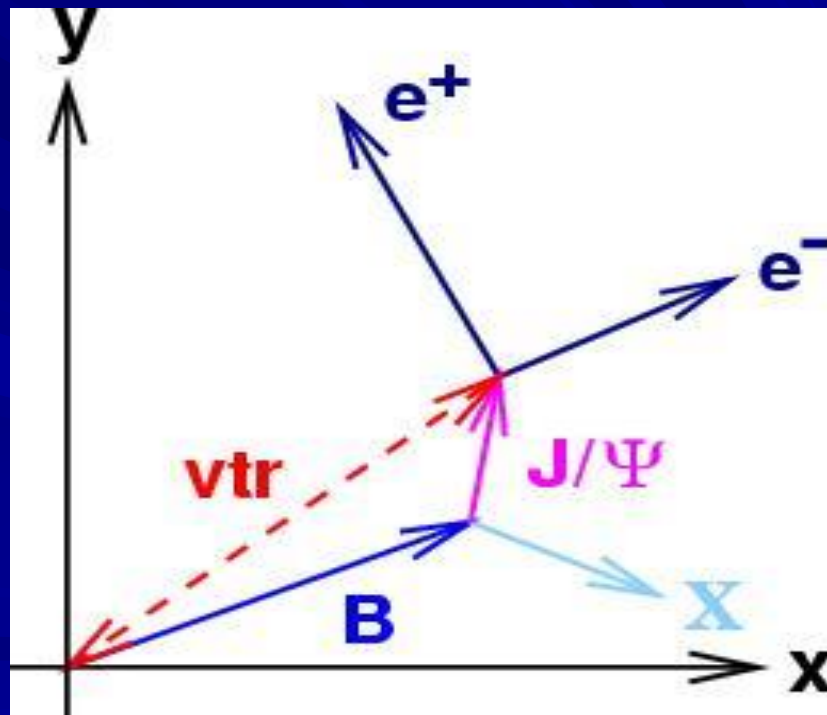
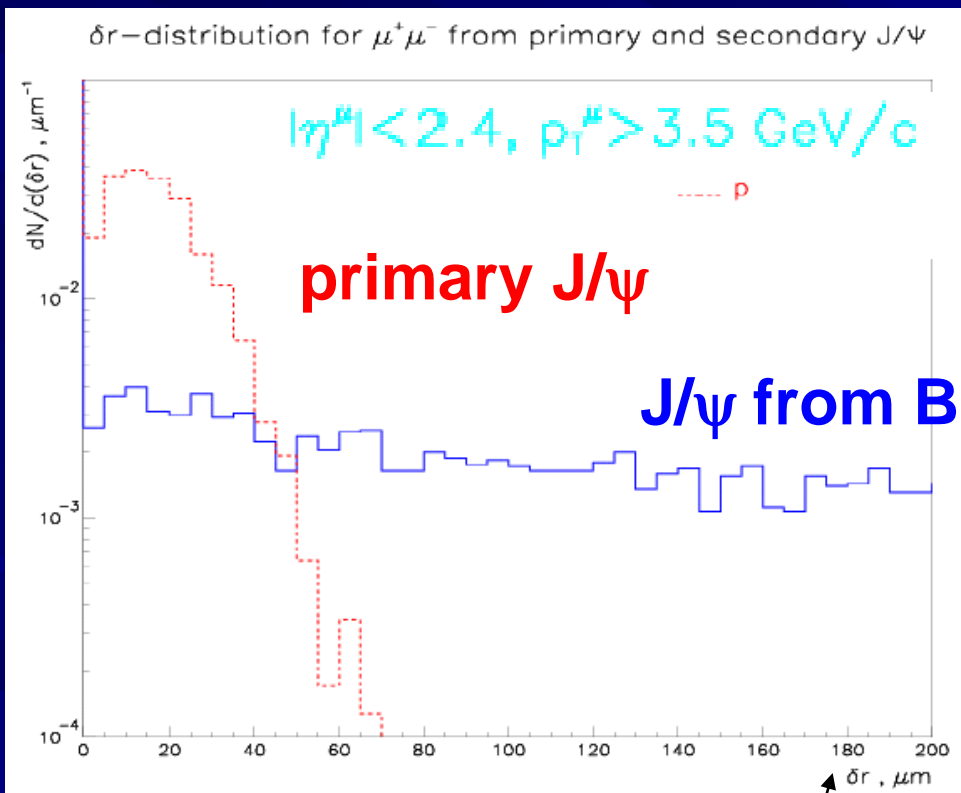




heavy-quarks decays: $b, c \rightarrow \mu / J/\psi + X$

J/ ψ from B decays: $\sim 20\%$ all J/ ψ at LHC

Secondary vertex finding and correlated background rejection:



δr is transverse distance between the points of closest approach to the beam for two different muon tracks

Physics is coming!

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