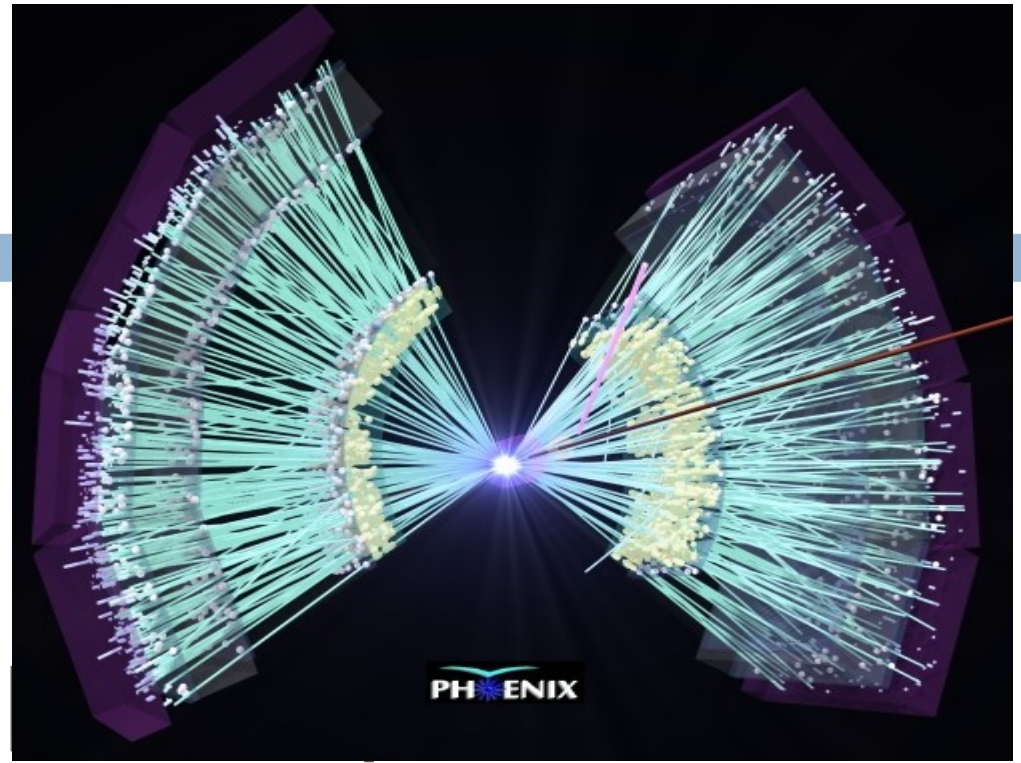




+



The P  
TOTEM/LHC  
Experiments  
Status and Hungarian  
activities

M. Csanád for PHENIX/Hu & TOTEM/Hu

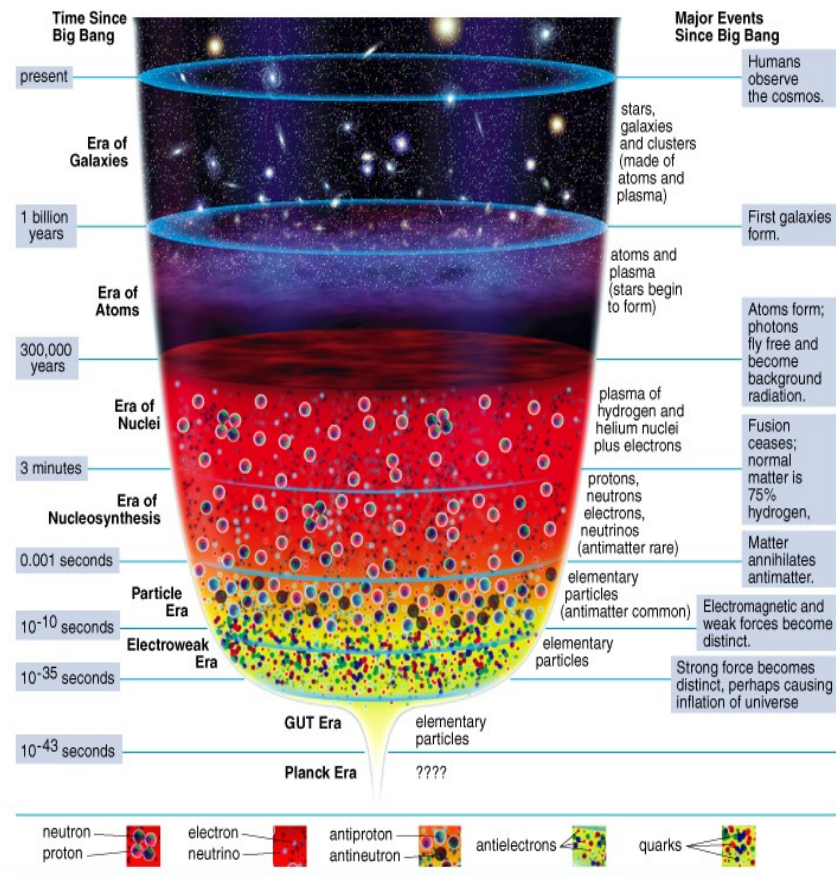
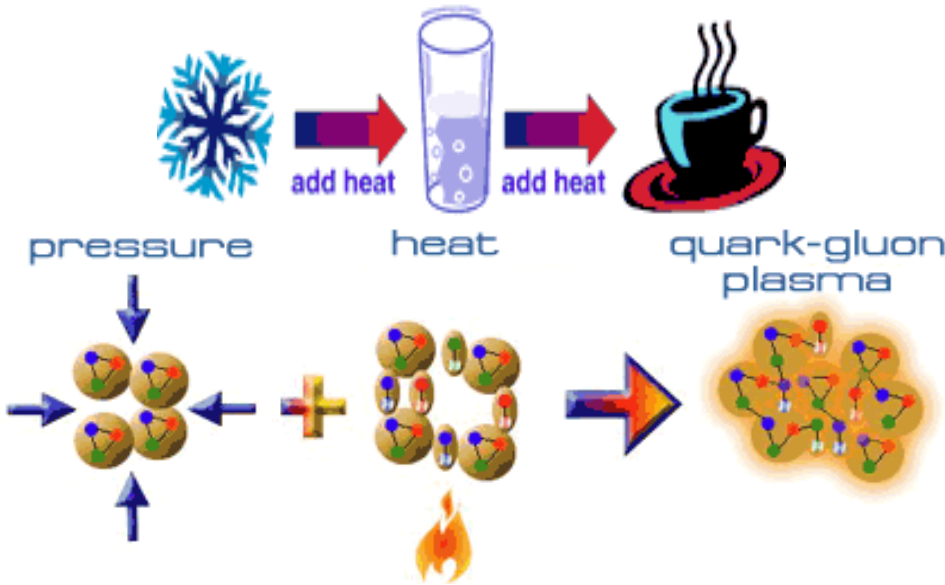


# Heavy Ion Physics

2

## Recreate conditions similar to those at the Big Bang

Ice → water → steam → matter



# The Relativistic Heavy Ion Collider

3

RHIC: Brookhaven Nat'l Lab: Au+Au, Cu+Cu, d+Au, p+p

4 experimental collab's: STAR, PHENIX, BRAHMS, PHOBOS



# Collision modes, recorded data

4

Two independent rings

Separate magnetic fields

Proton polarization

Many different modes

9.2 GeV/n (Au)

22 GeV/n (Au, Cu, p)

56 GeV/n (Au)

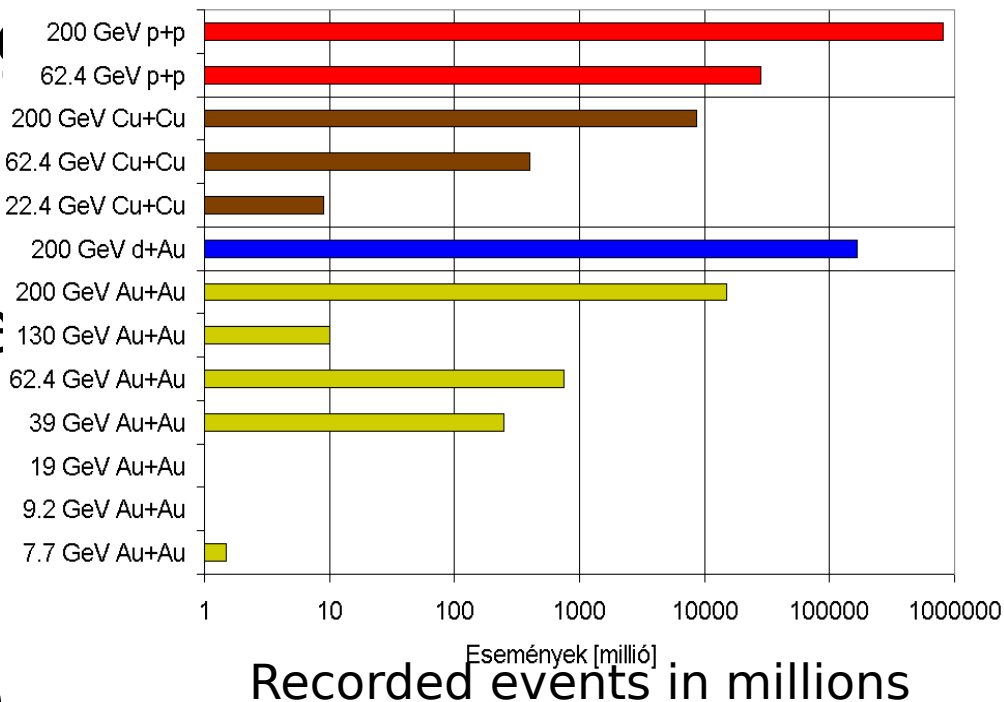
62 GeV/n (Au, Cu, p)

130 GeV/n (Au)

200 GeV/n (Au, Cu, p)

410 GeV/n ( $\pi$ )

500 GeV/n ( $\pi$ )





# PHENIX setup

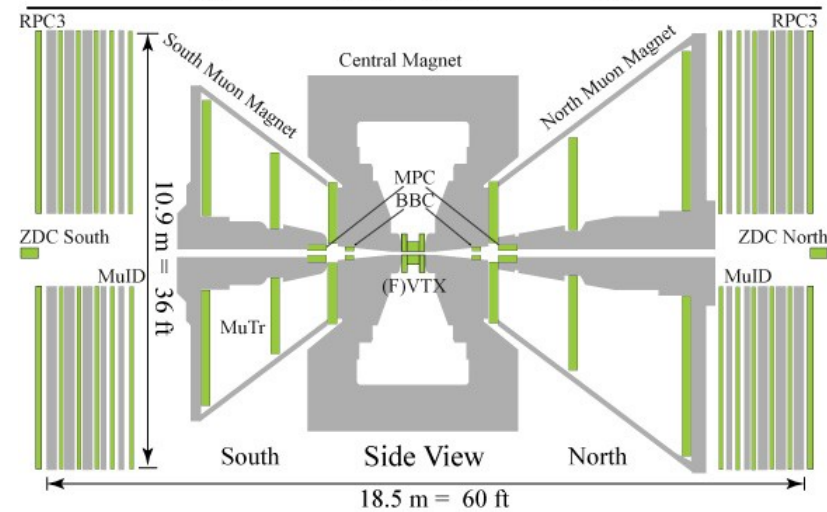
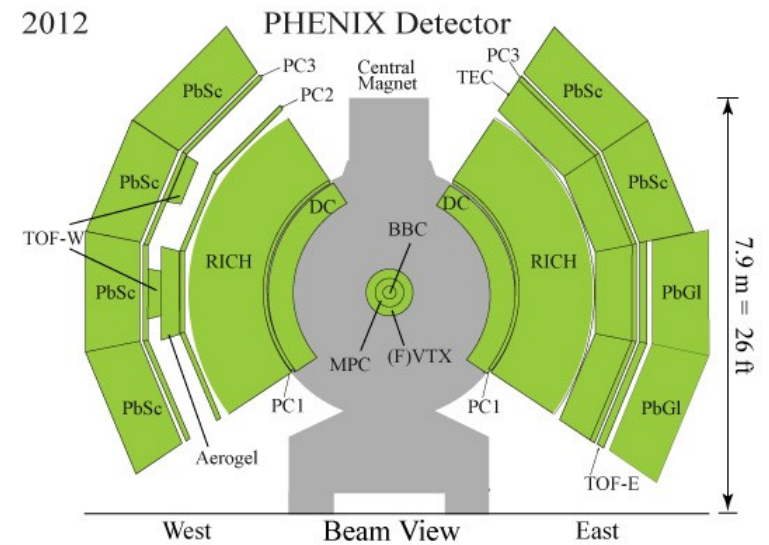
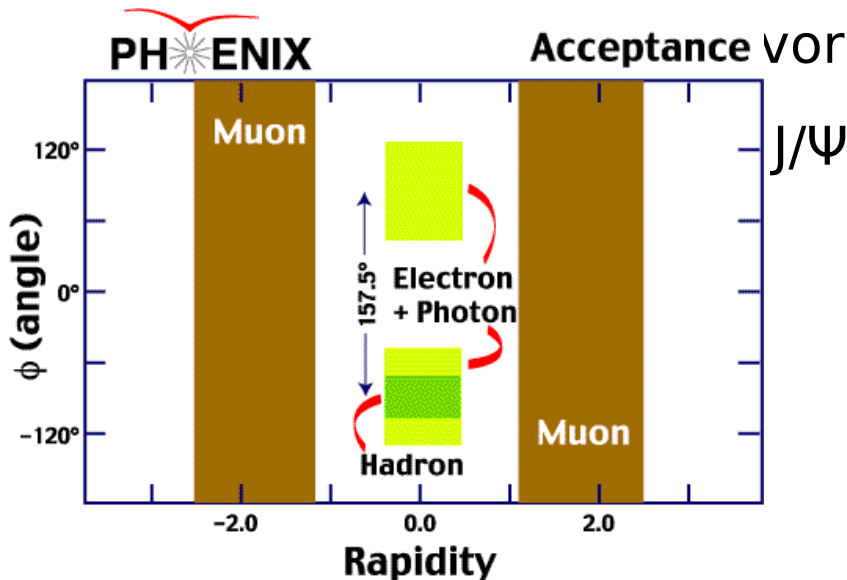
6

Tracking, calorimetry,  
identification

Charged hadrons ( $\pi^\pm$ ,  $K^\pm$ , etc.)

Photons, direct or decay ( $\rightarrow \eta$ ,  $\pi^0$ )

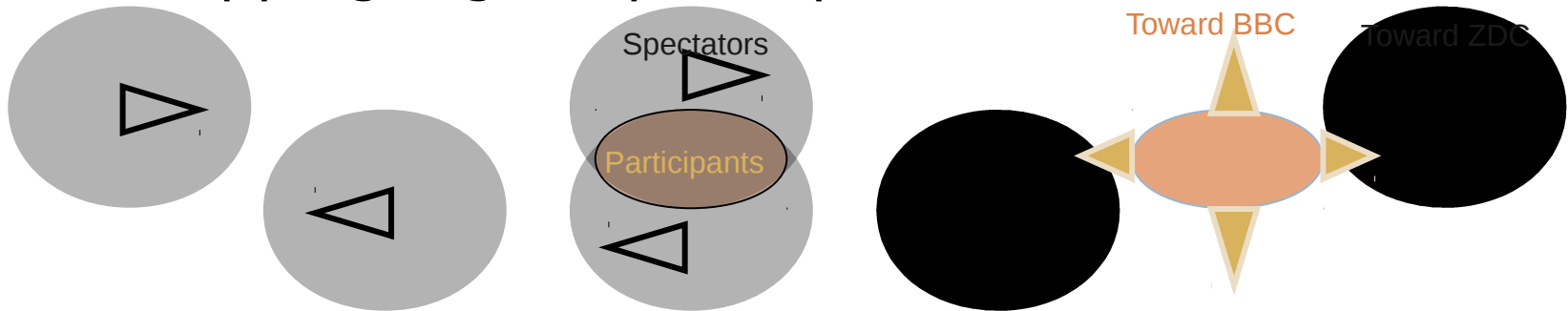
Light mesons  $\phi$ ,  $\omega$  and  $\eta$



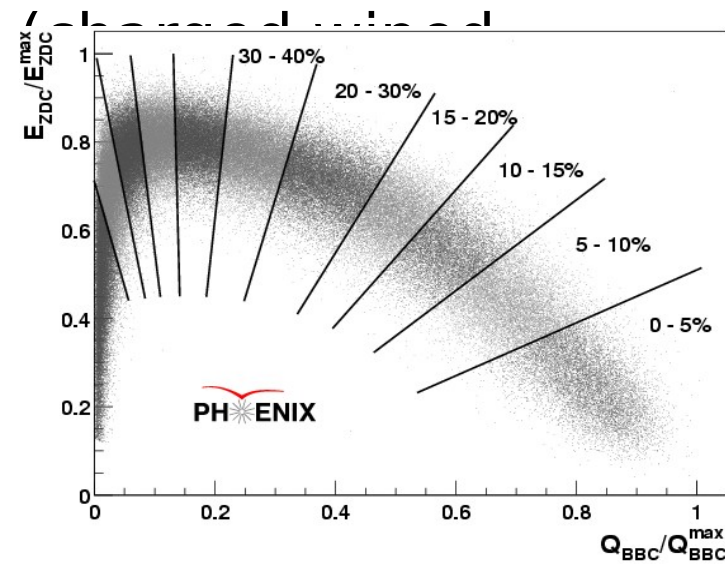
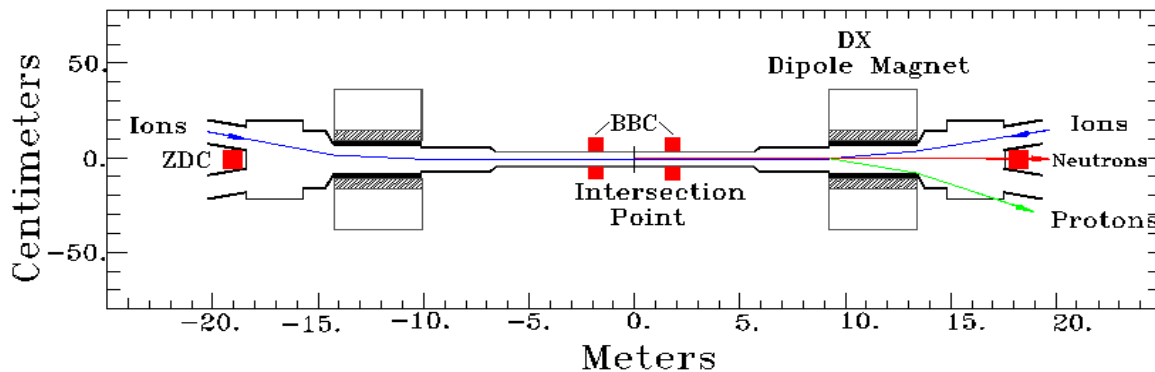
# Centrality determination

7

## Overlapping region: participants

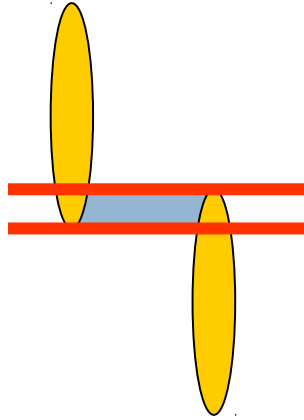


## Evaporated neutrons: toward ZDC

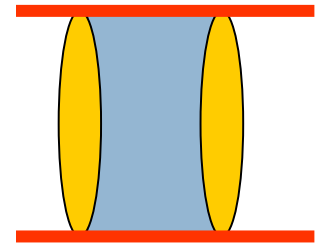
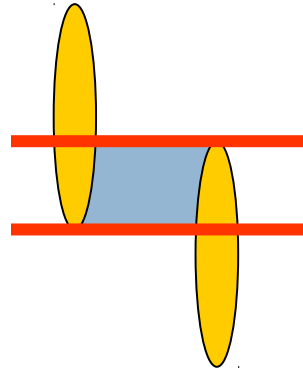


# Collisions of different centrality

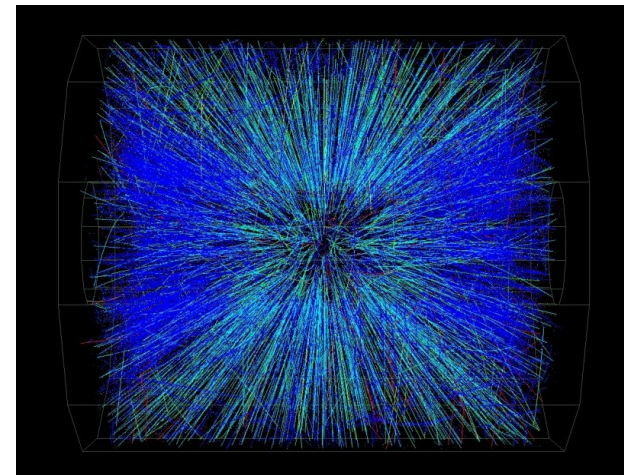
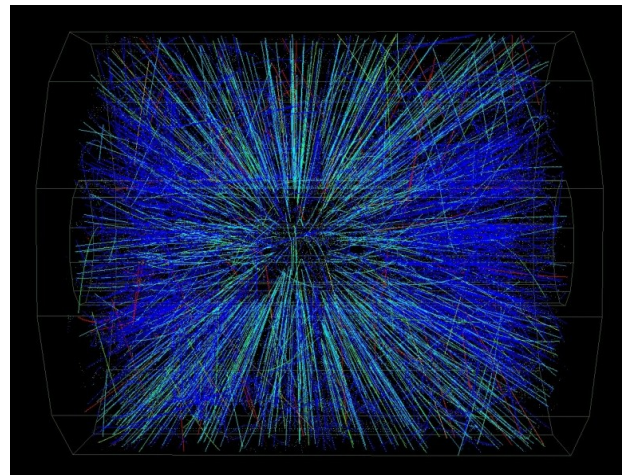
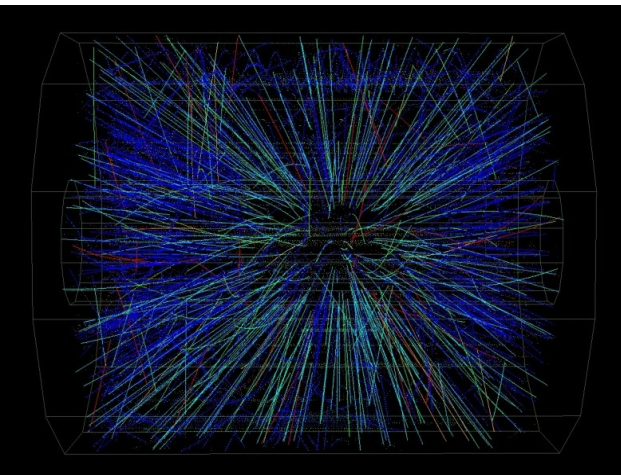
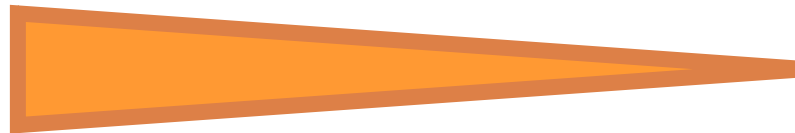
8



**Peripheral**



**Central**





# A PHENIX Event

9

## A Head-On Gold-Gold Collision as seen by PHENIX

*Animation by Jeffery Mitchell*

Particle  
Energy  
Spikes

Muon  
Trajectory

The  
Collision  
Was  
Here

Detector "hits"

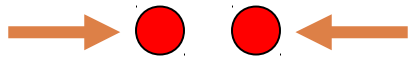
Charged Particle Trajectories



# The first milestone: nuclear modification

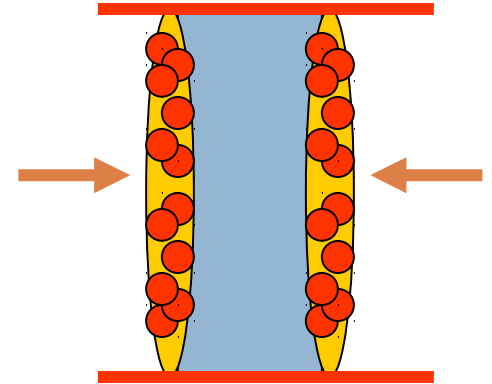
10

Proton+proton



Simply just more?  
 $A+A = \text{many } p+p?$

Nucleus+nucleus



RAA

Particle yield in  $A+A$

Particle yield in  $p+p$

$\times$

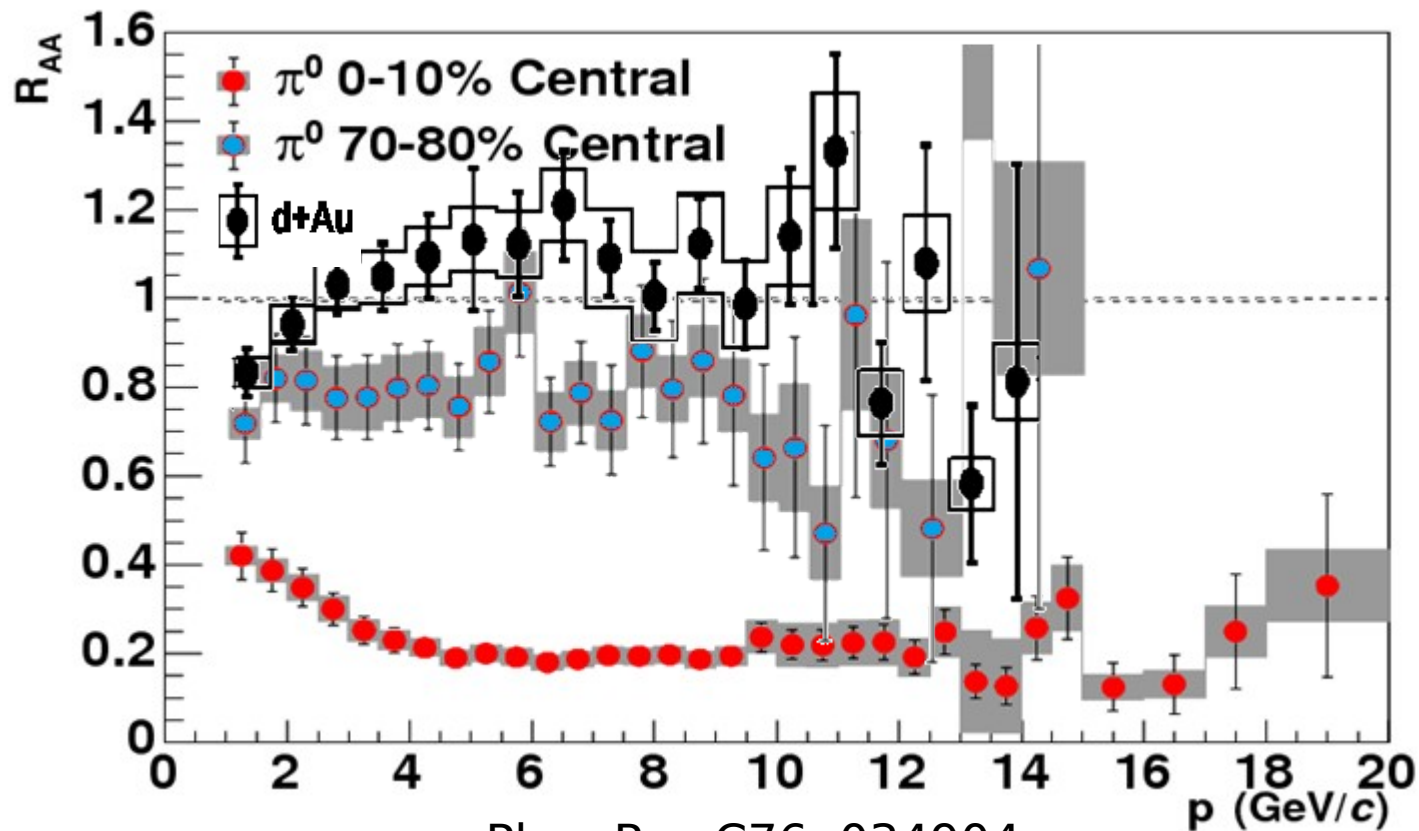
Number of  $p+p$   
collisions

# Suppression of high energy particles

11

Peripheral Au+Au and d+Au: no suppression

Central Au+Au: large suppression



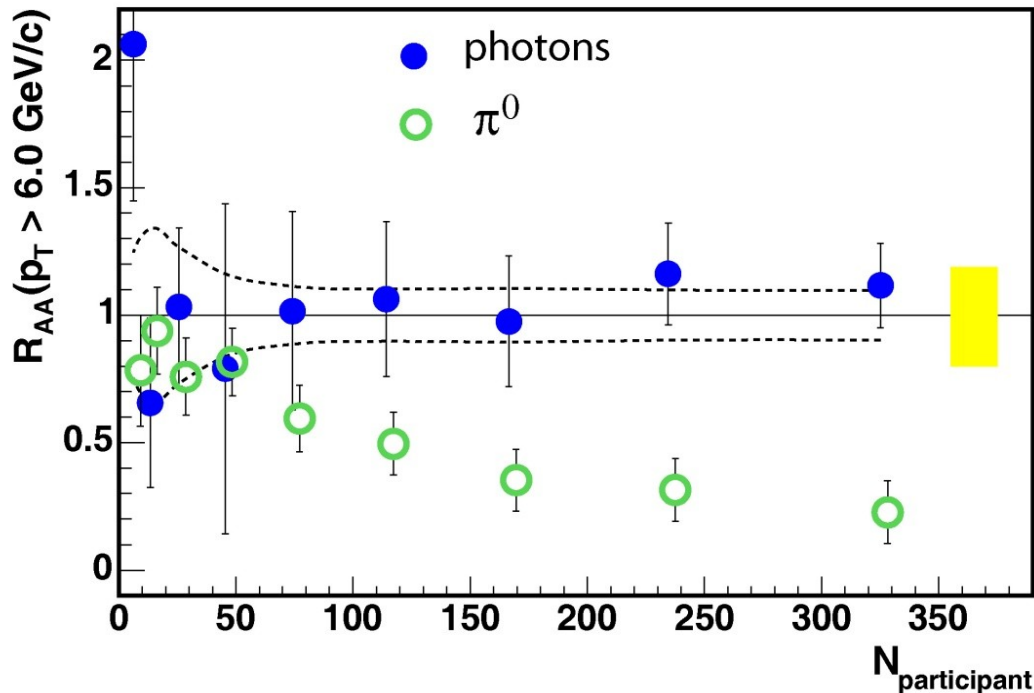
Phys.Rev.C76, 034904  
(2007)

# Strongly interacting medium

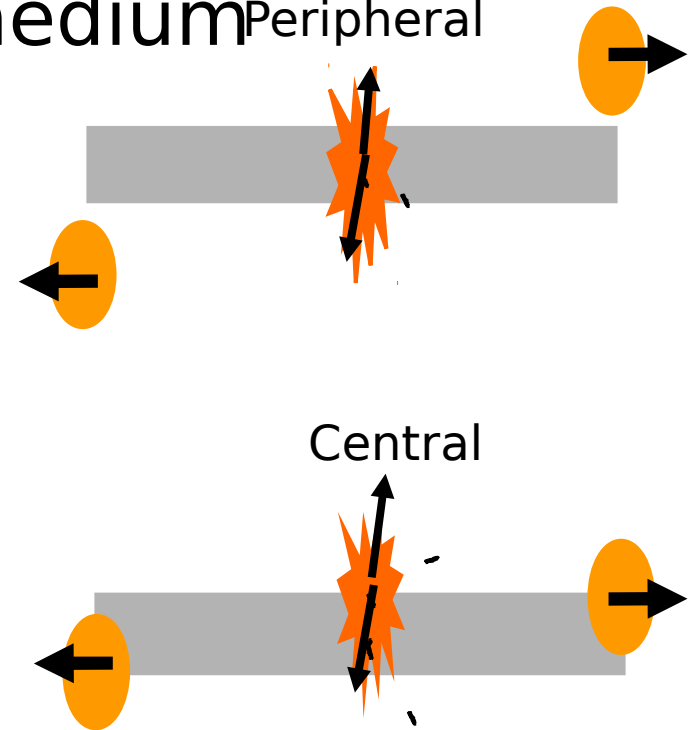
12

Hadrons suppressed, photons not!

Strong interaction in the medium



Phys.Rev.Lett.94, 232301 (2005)



# Perfect fluid of quarks

13

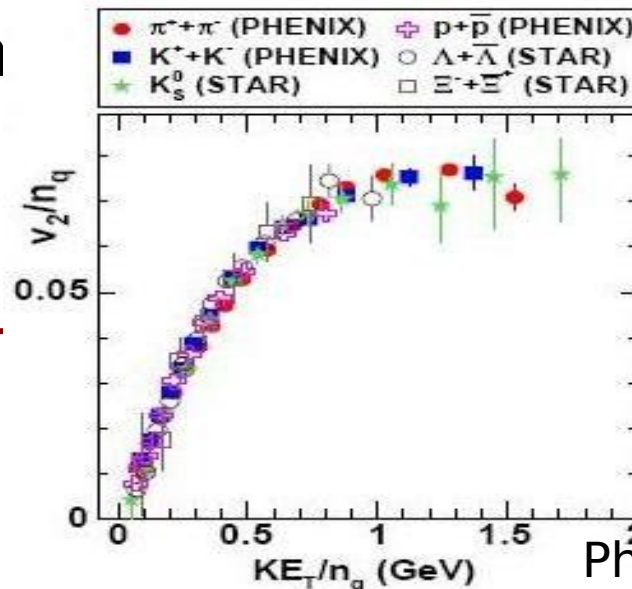
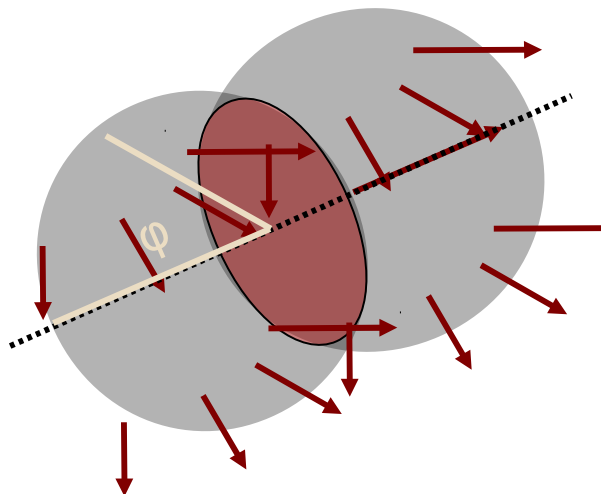
Elliptic flow measures azimuthal asymmetry,  $v_2$

Hydro picture: collective evolution,  $v_2 > 0$

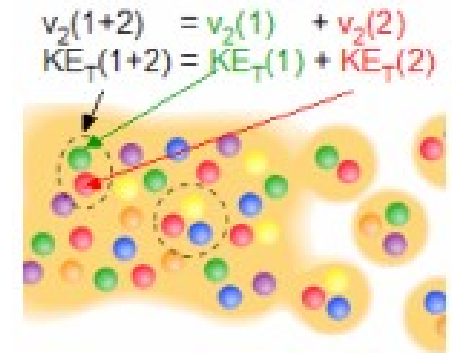
Even heavy flavour flow: perfect hydro confirmed

Scaling of elliptic flow with constituent quark number

Flow versus kin



Several hadrons

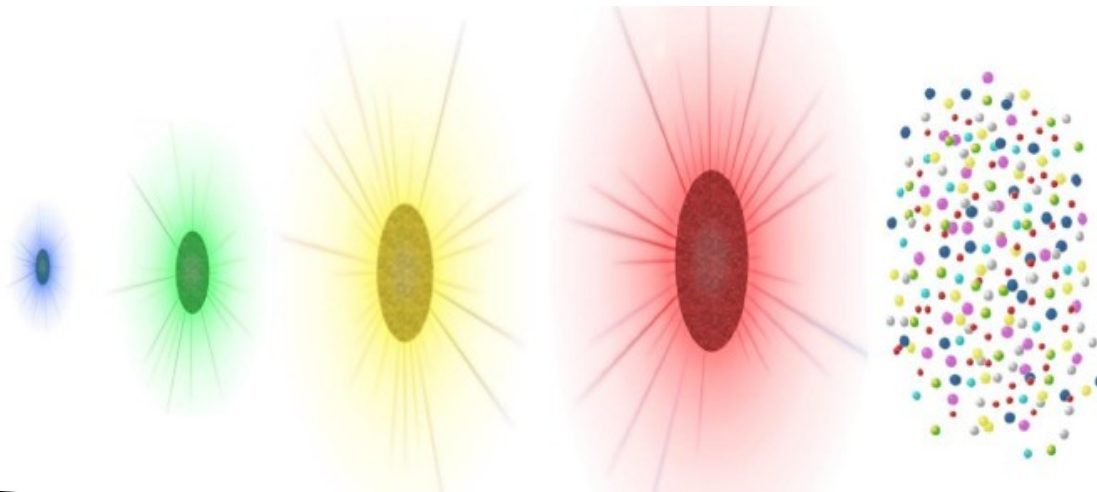


# Temperature from direct photons

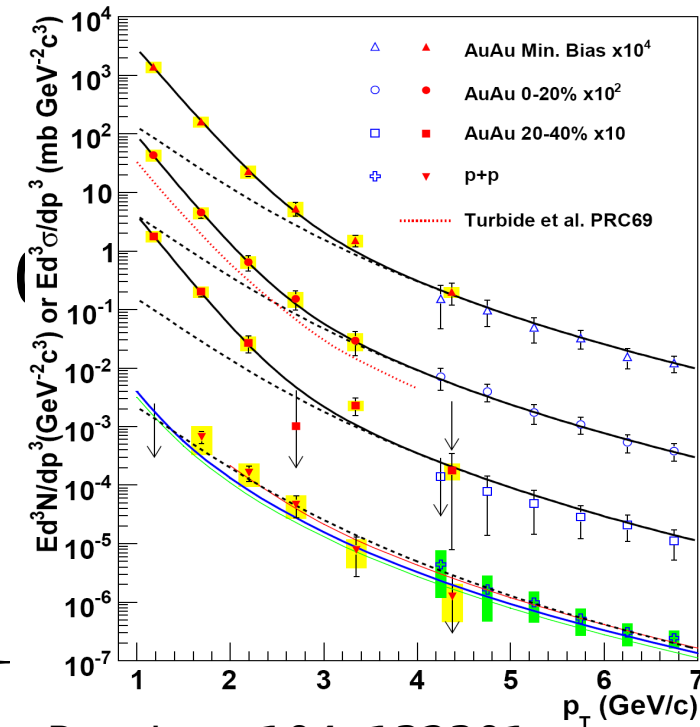
14

Photons fly out of the medium: penetrating probe

Information on the temperature



n, cooling ..... Freeze-out



Phys. Rev. Lett. 104, 132301

# The TOTEM experiment at LHC

15

Measure  $p+p$   $\sigma_{tot} \pm 1 \mu\text{b}$ ,  $\lambda$ υμινοσιτυ-  
ινδεπενδεντλψ

Ελαστικη σχαττερινη ατ  $\tau \approx \frac{16\pi}{1+\rho^2} \frac{dN_{el} / dt|_{t=0}}{N_{el} + N_{inel}}$

Ινελαστικη ρατεσ ασ ωελλ

Μεασυρε δστοτ/δτ  $10^{-3} L \sigma_{tot} \approx N_{el} + N_{inel}$

Μεασυρε ΛΗΧ λυμινοσιτυ πρεχισελψ

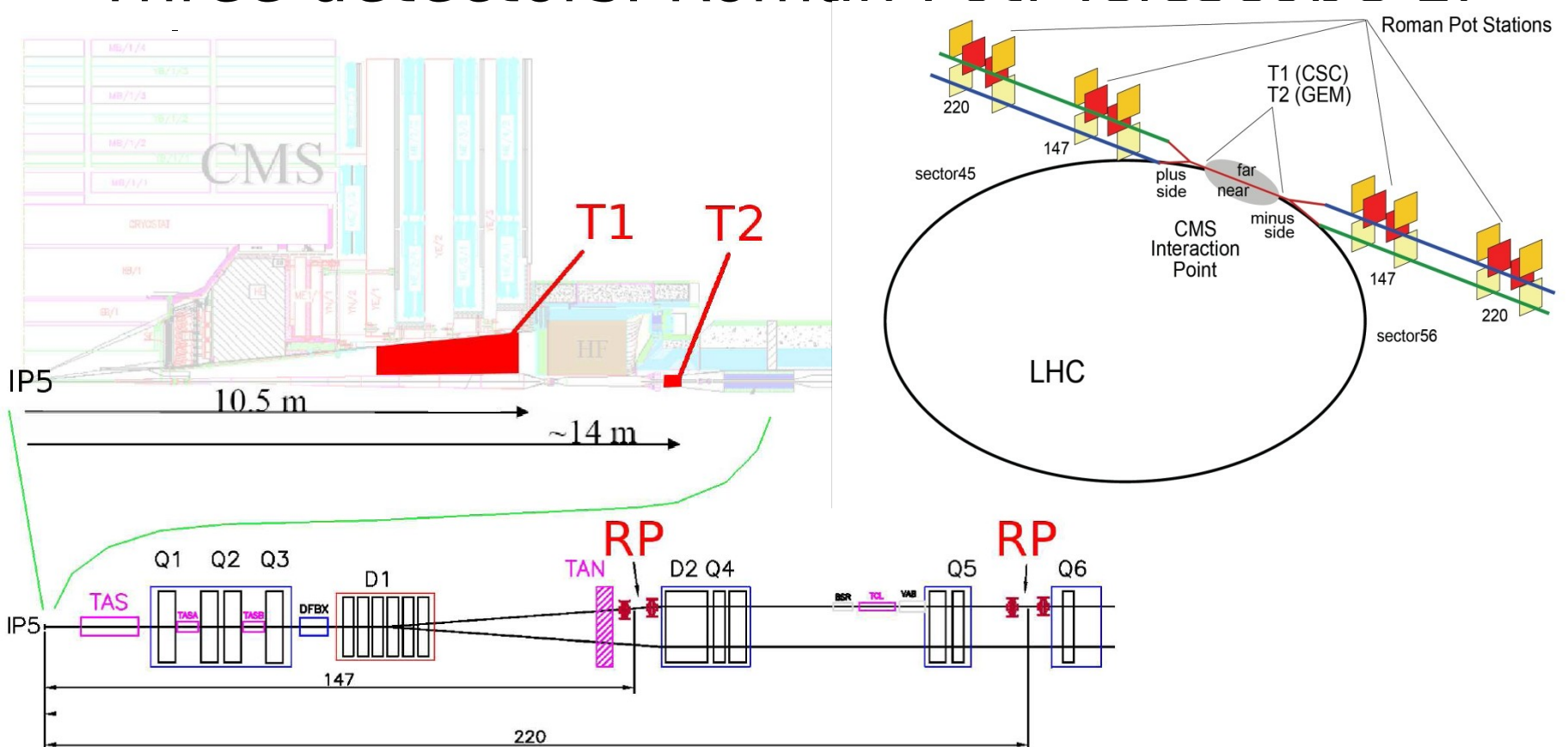
Μεασυρε διφφραχτιωε δισσοχιατιον

# TOTEM Setup

16

At the CMS interaction point

Three detectors: Roman Pot, Telescope 1.

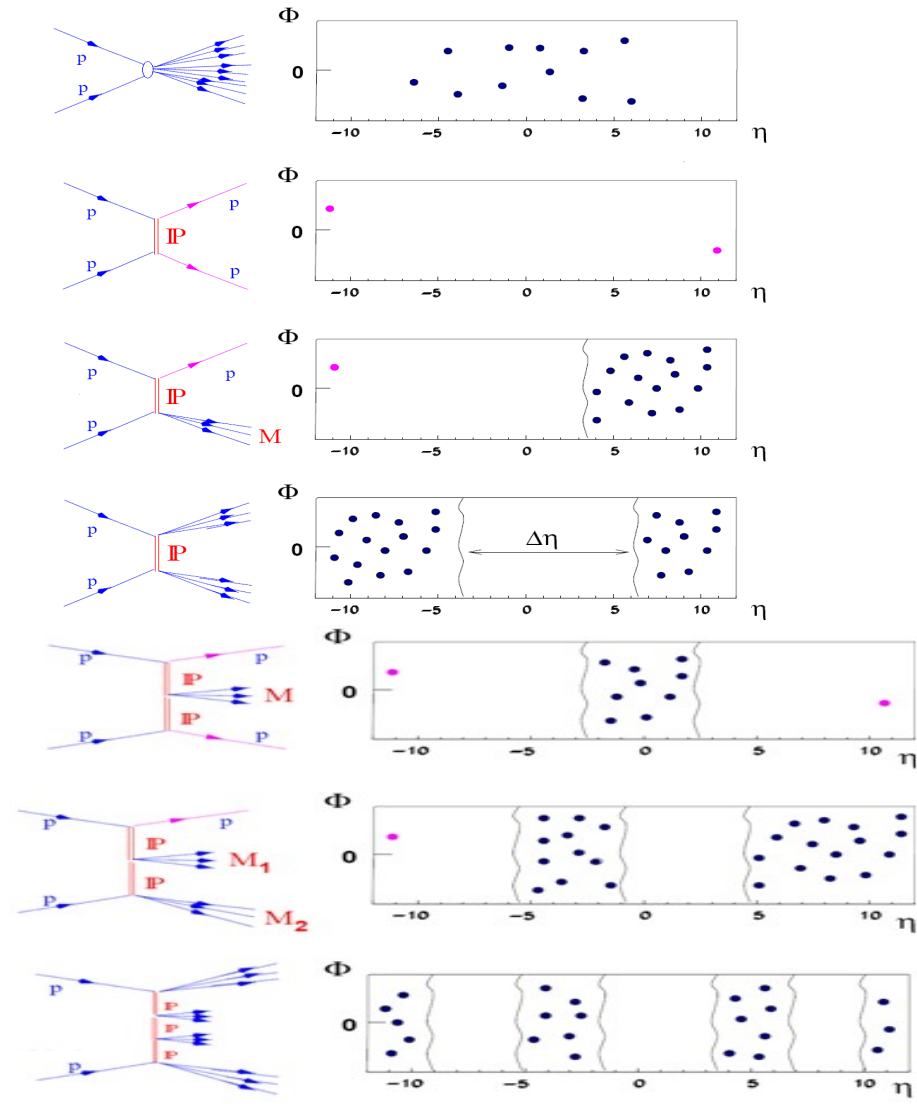
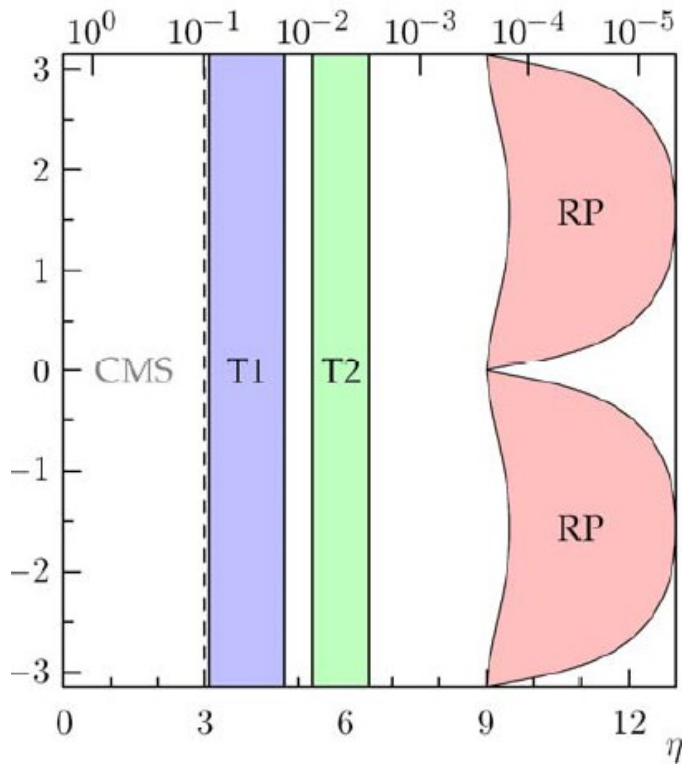




# Proton-proton scattering at the LHC

17

Different proc. in p+p  
 Elastic, diffractive, inelastic  
 Trigger: large rapidity

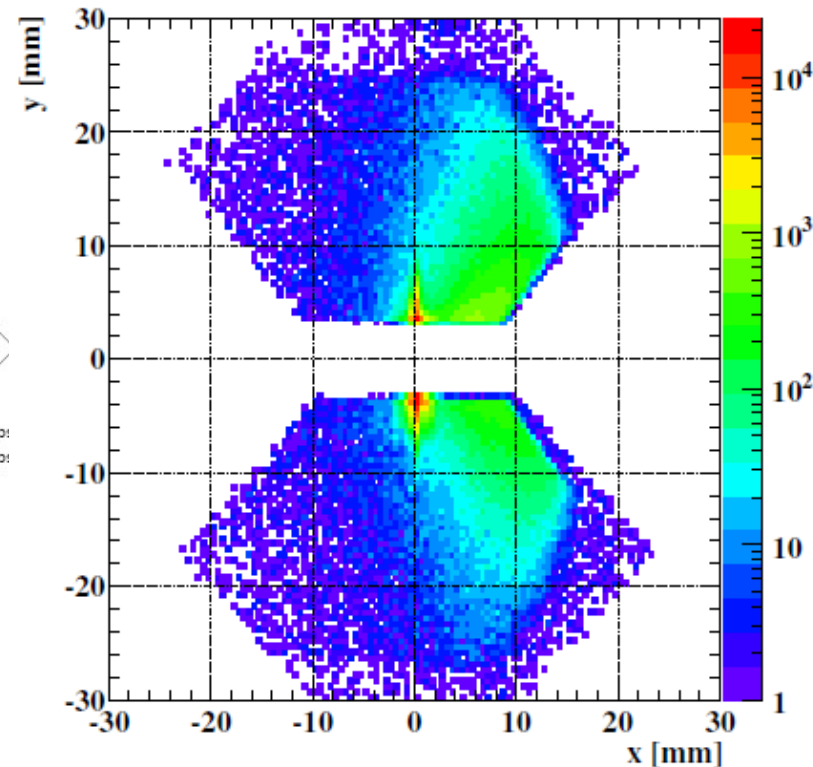
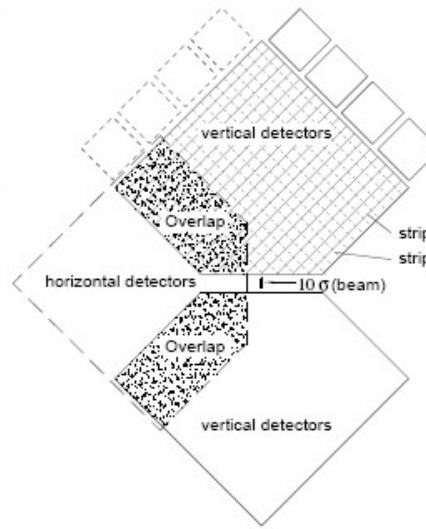
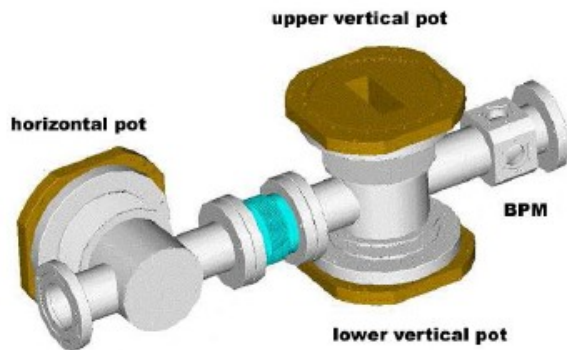


# Roman Pot detectors of TOTEM

18

Special „edgeless” design to move close to beam

Distance  $\sim 10 \sigma$



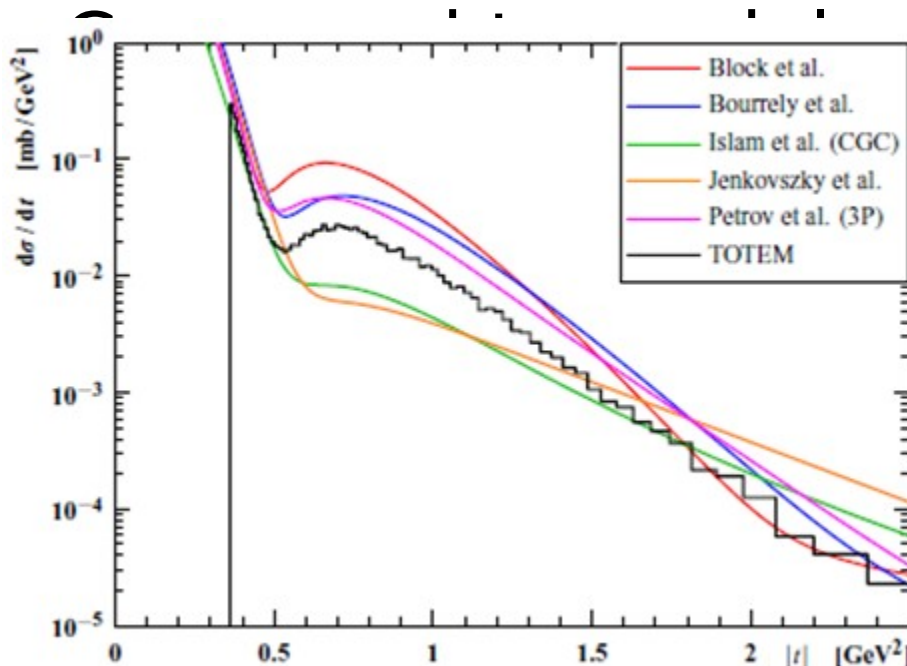
# Differential cross-section at

19

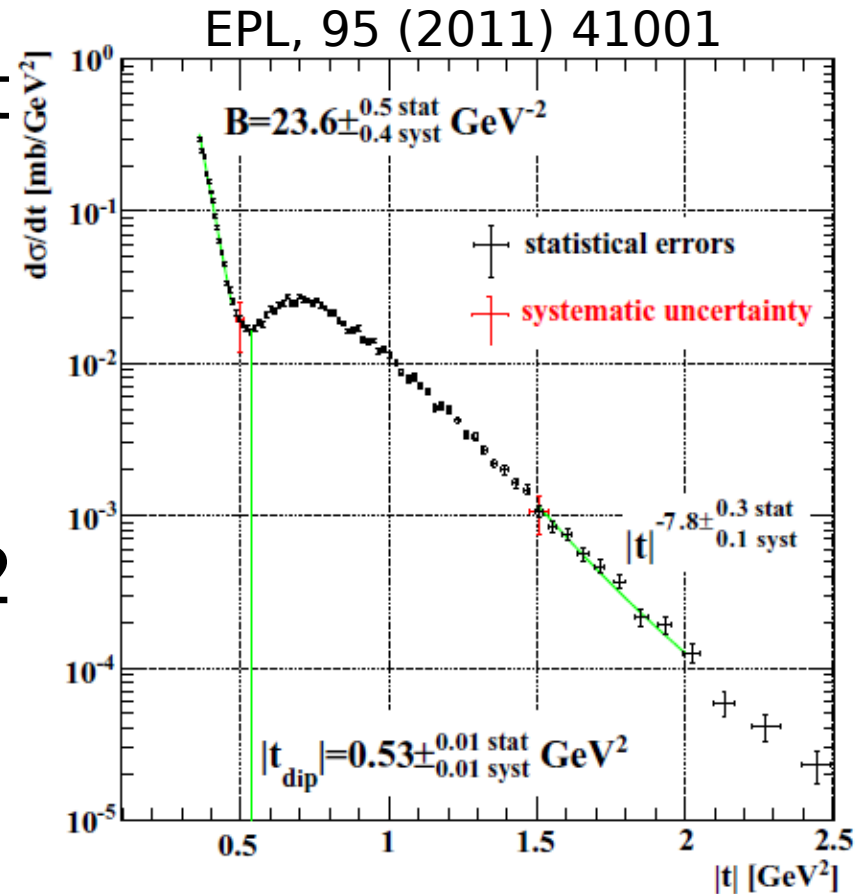
## $\beta^* = 3.5$ m

Measured over a large  $|t|$  range, will be extended

Dip-hump structure first present here



-2



# Total cross-section results at

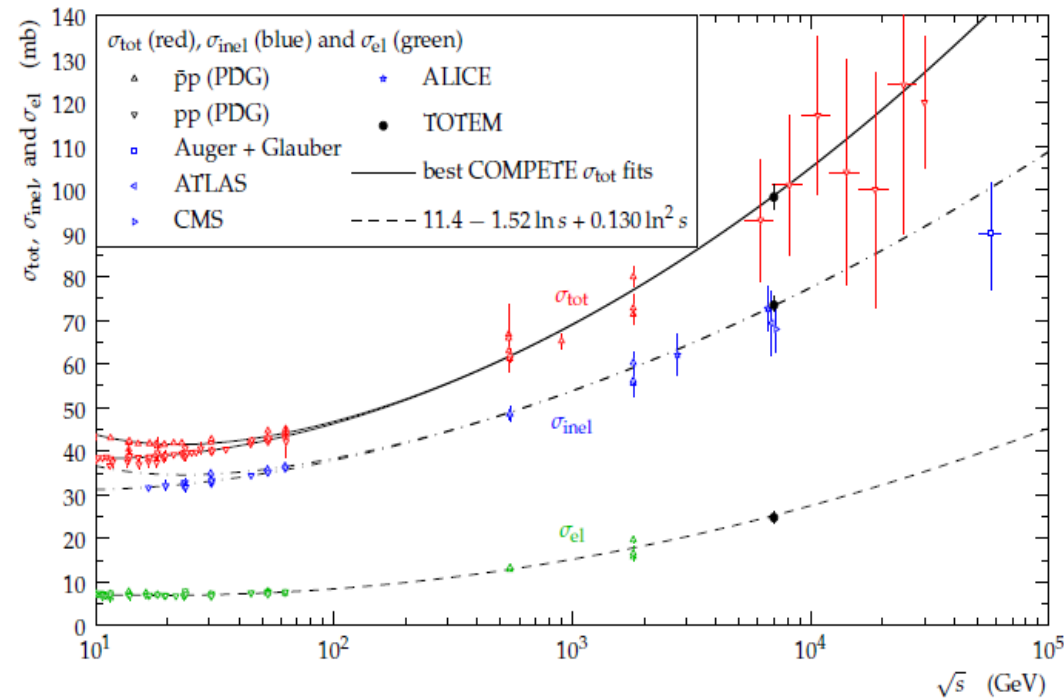
20

## $\beta^* = 90 \text{ m}$

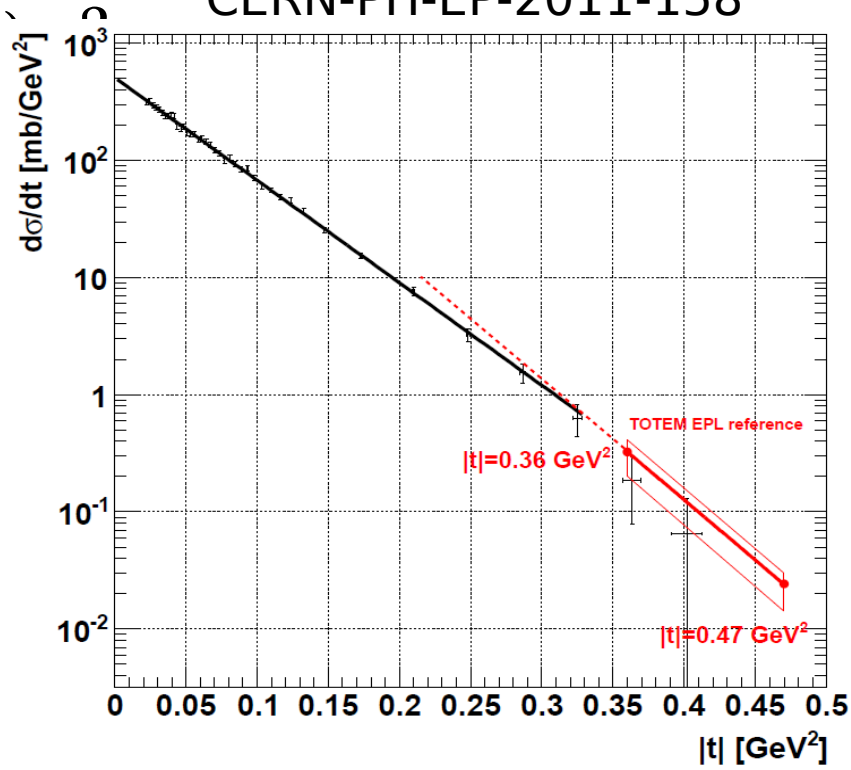
Special LHC optics, agreement w/ previous measurement

Result from  $t=0$  extrapolation:

$$\sigma_{\text{TOT}} = (98.3 + 0.2\sigma_{\text{TOT}} + 2.8 - 2.7)$$

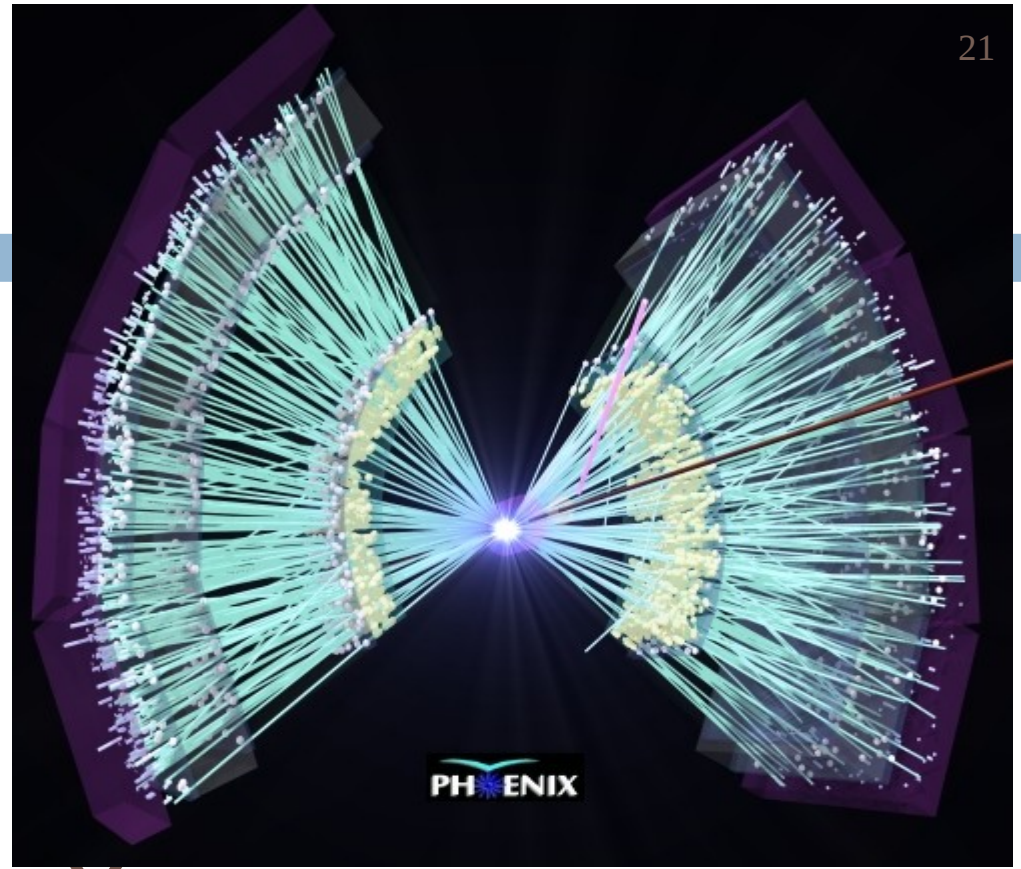


CERN-PH-EP-2011-158





+



Thank You



for your attention

# The PHENIX/Hu group

22

>20 PHENIX talks  
>50 internal working  
group talks

~15 analysis notes

11 papers with direct  
participation (paper  
group)

<http://phenix.elte.hu>

<http://phenix.kfki.hu>

The logo for PHENIX features the word "PHENIX" in a bold, black, sans-serif font. A red, stylized bird-like shape is positioned above the "E". A white sunburst or starburst graphic is centered over the "E". Below the text are three horizontal lines in red, white, and green.



# The TOTEM/Hu group

23

Tasks during setup: DAQ, data monitoring, Roman Pot  
Physics projects on the way, e.g.  $d\sigma_{el}/d\tau$

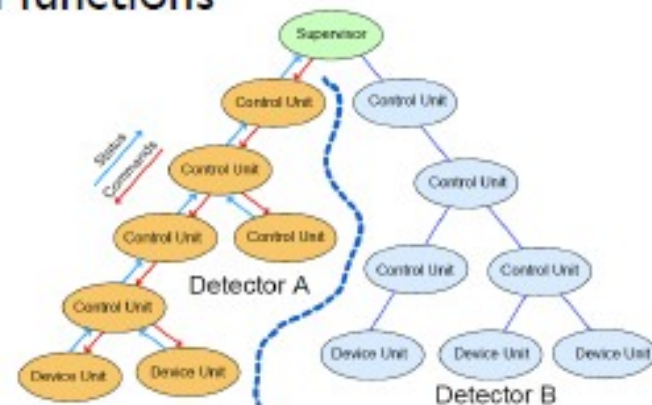
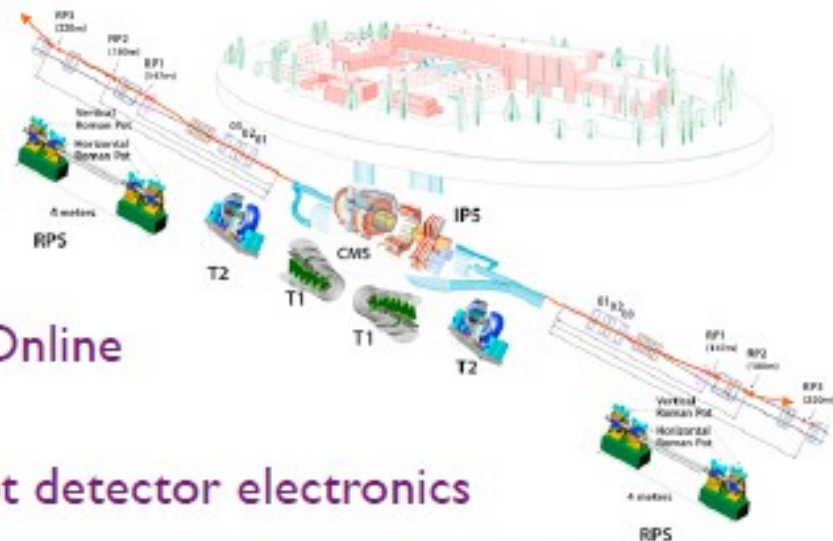
Ωορκινγ χλοσελψ το τηεορψ γρουπς



# TOTEM (RMKI, ELTE)



- ▶ Development of the **D**etector **C**ontrol **S**ystem
- ▶ Development of the **D**ata **A**c**Q**uisition system
- ▶ Development and maintenance of the **O**nline and **O**ffline Monitoring systems
- ▶ Financial contribution to the Roman Pot detector electronics
- ▶ Software development and edge efficiency studies for Roman Pot detectors
- ▶ Survey of the magnet system to verify the optical functions
- ▶ Development of the analysis framework
- ▶ Measurement of diffractive processes
- ▶ Study of scattering models

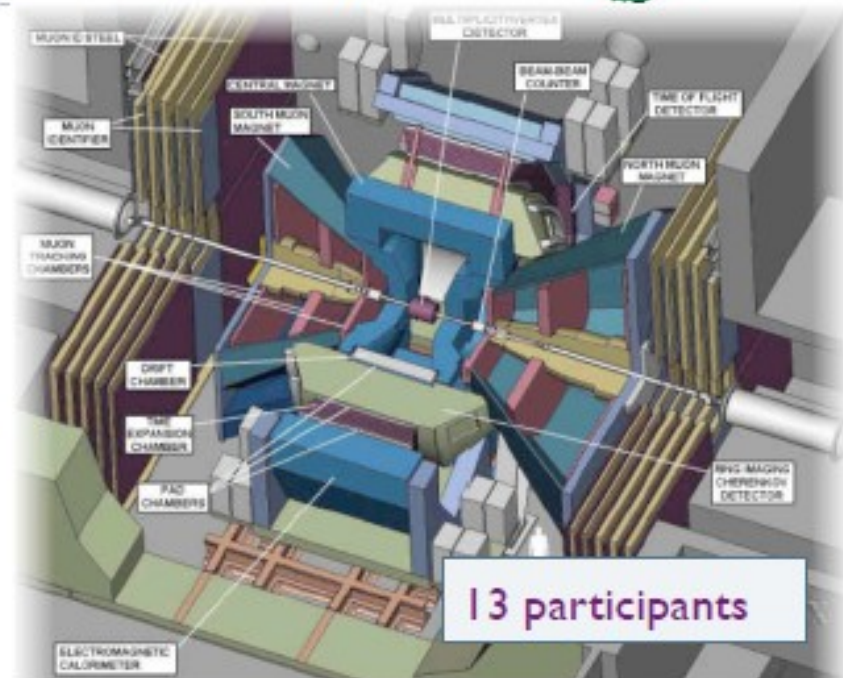




# PHENIX @ BNL RHIC (RMKI, ELTE)



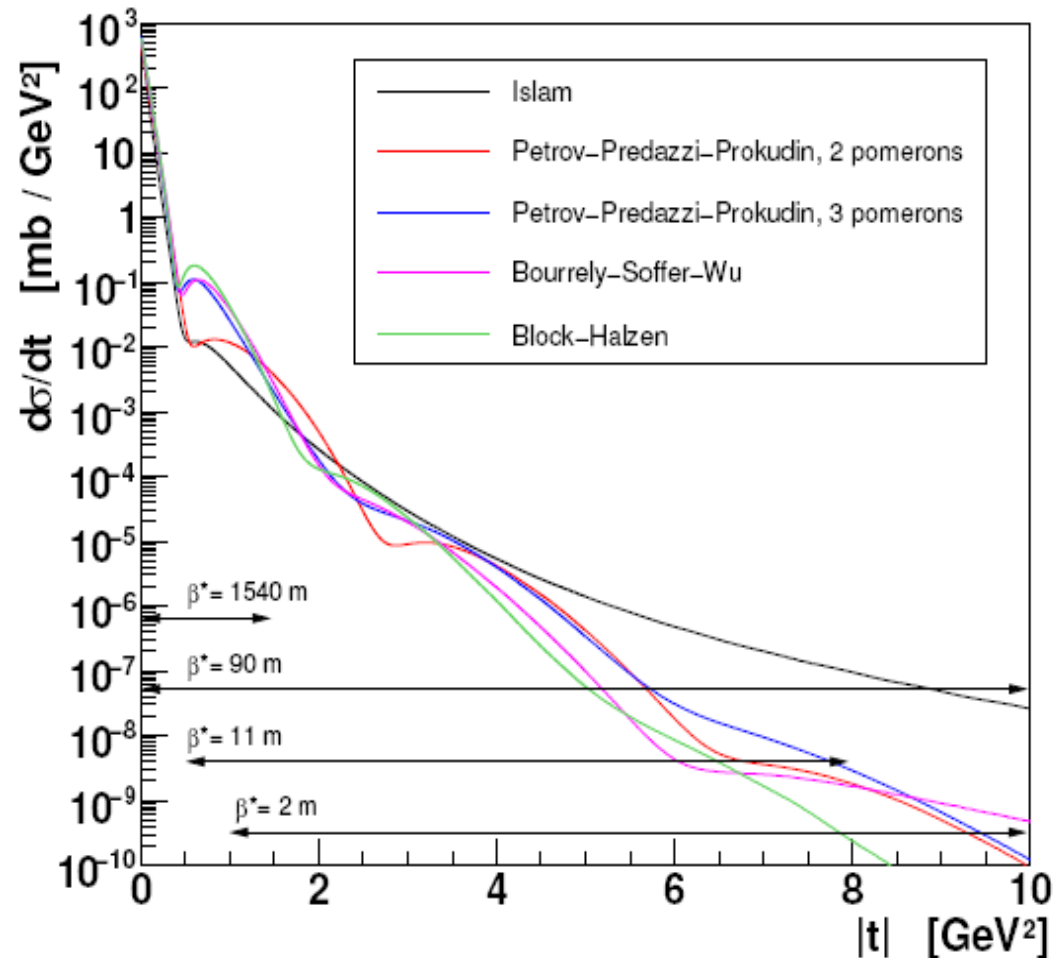
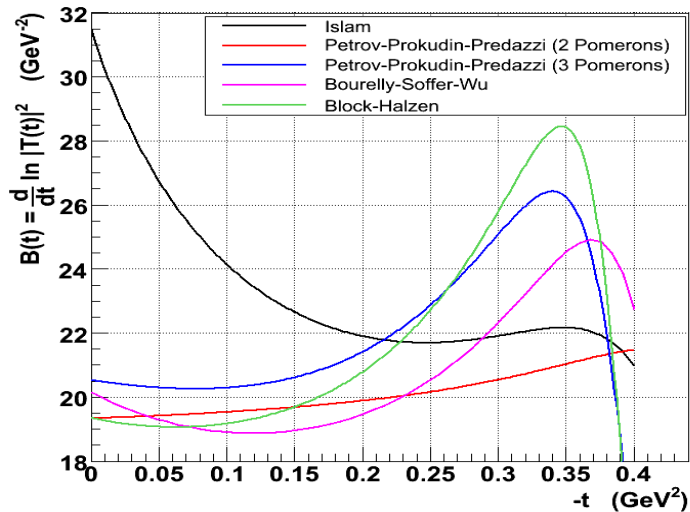
- ▶ Zero Degree Calorimeter: operation, software development, simulation
- ▶ Development of low momentum hadron identification algorithm
- ▶ Simulation and analysis cluster (35 PC + storage) in RMKI
- ▶ Measured Bose-Einstein correlation of pion and kaon pairs revealing a long tail of particle emission due to anomalous diffusion in an expanding fireball
- ▶ Combined PHENIX and STAR analysis of pion correlation found a decreased  $\eta'(958)$  mass at the time of production for a very short time indicating the restoration of the  $U_A(1)$  symmetry in the hot and dense hadronic matter
- ▶ Measured photoproduction of  $J/\psi$  in ultra-peripheral collisions to test distribution functions at low relative parton momentum
- ▶ Study of squeezed correlations, particle spectra and hydrodynamical flow profile



# Elastic scattering slope at low $t$

26

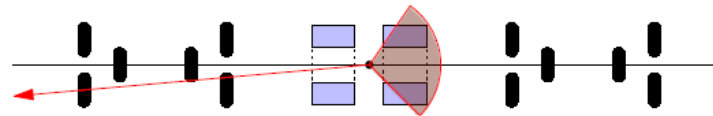
Theoretical predictions differ in many aspects



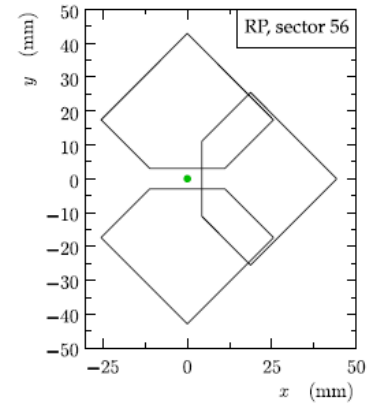
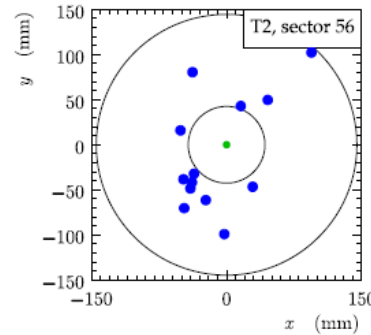
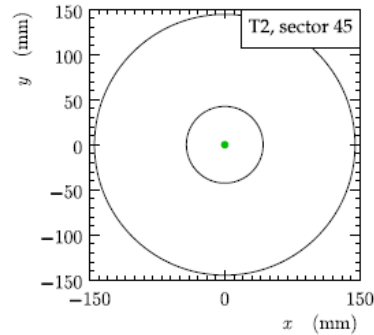
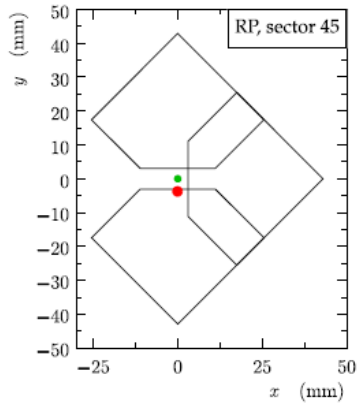
# Single diffraction low $\begin{matrix} \square \\ \square \end{matrix} = \begin{matrix} \square \\ \square \end{matrix} p/p$

sector 45 IP sector 56

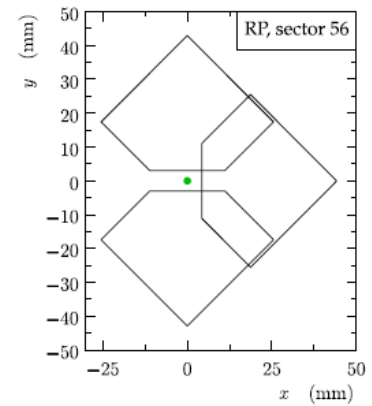
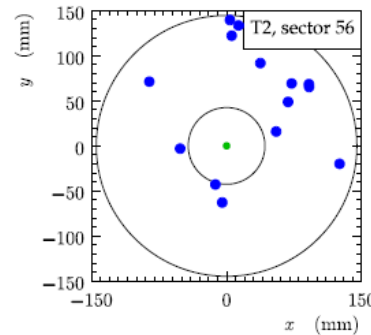
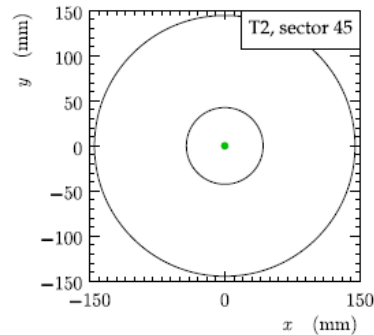
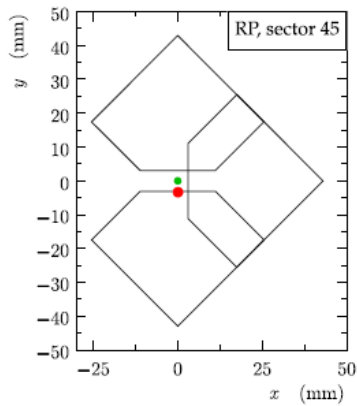
RP T2 T2 RP



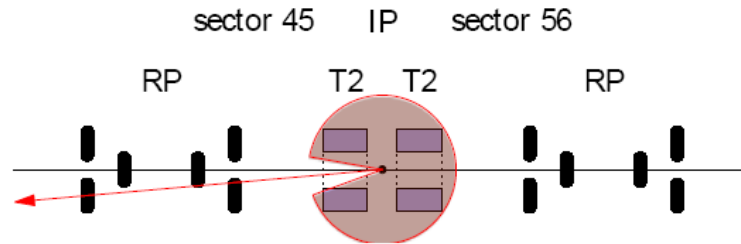
run: 37280003, event: 3000



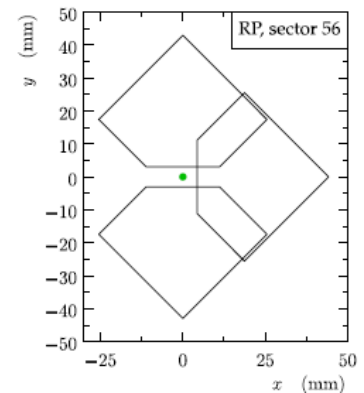
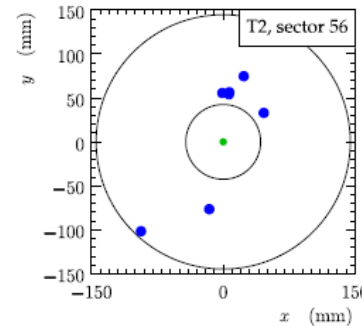
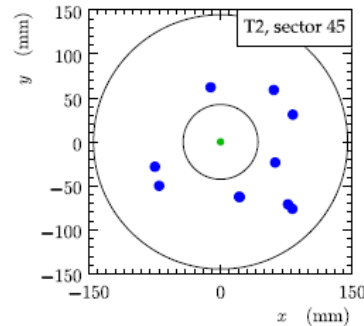
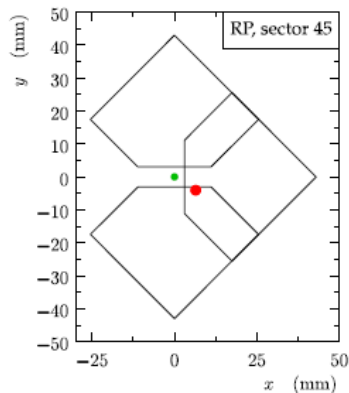
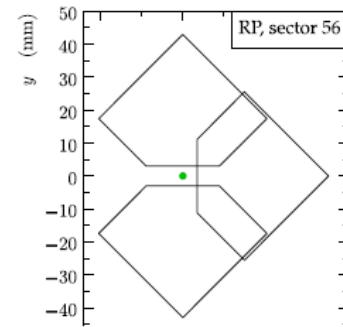
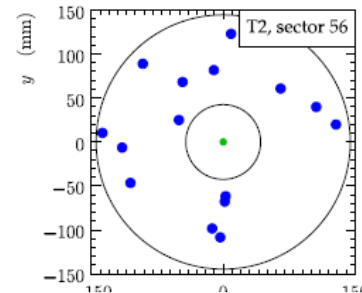
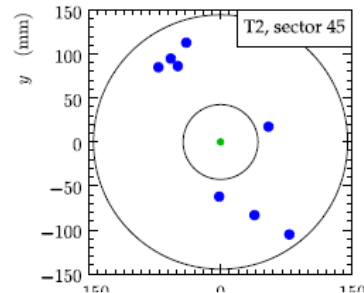
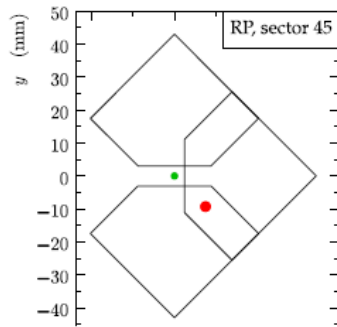
run: 37280004, event: 22784



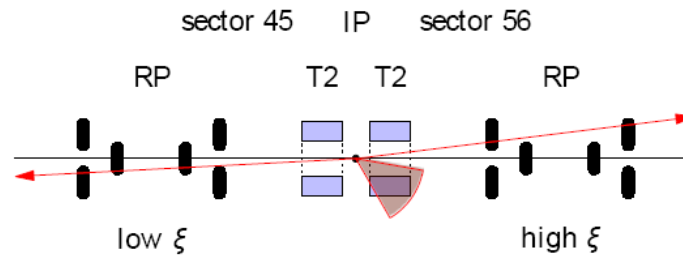
# Single diffraction large



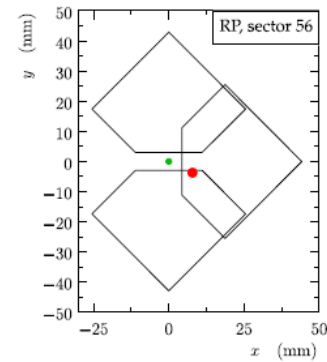
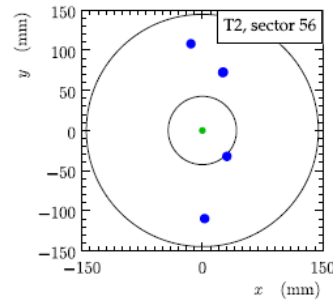
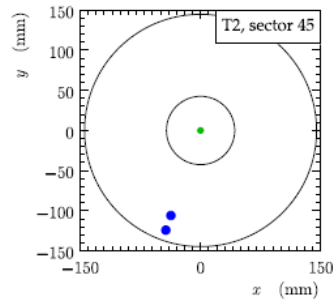
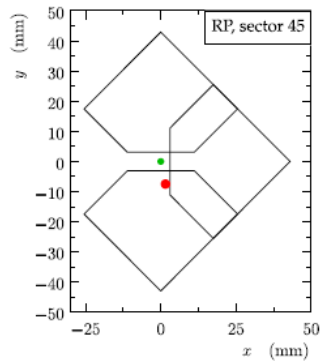
run: 37280006, event: 9522



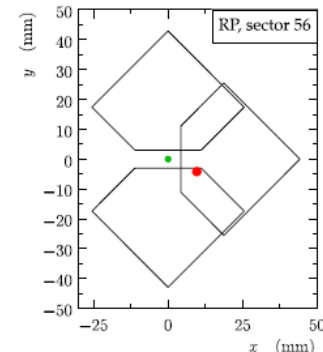
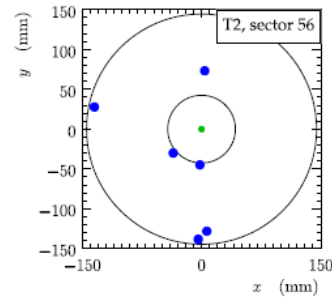
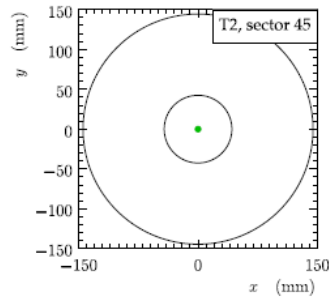
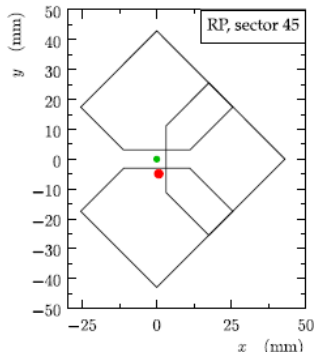
# Double POMERON exchange



run: 37250009, event: 14125



run: 37220007, event: 9904



# Double POMERON exchange

