Part II: What we have learnt thus far

- QCD is a rich (yet very challenging) theory
- Interactions qualitatively depend on the scale
  - Long wavelength – hadrons, npQCD
  - Short wavelength – partons, pQCD
- Colour force is confining – no free partons
  - Pulling out a parton causes it to hadronize
  - Not understood theoretically, just modelled
- How else can we try and understand QCD?
  - How do we understand other forces in nature?

The kinematical range accessible

Small x

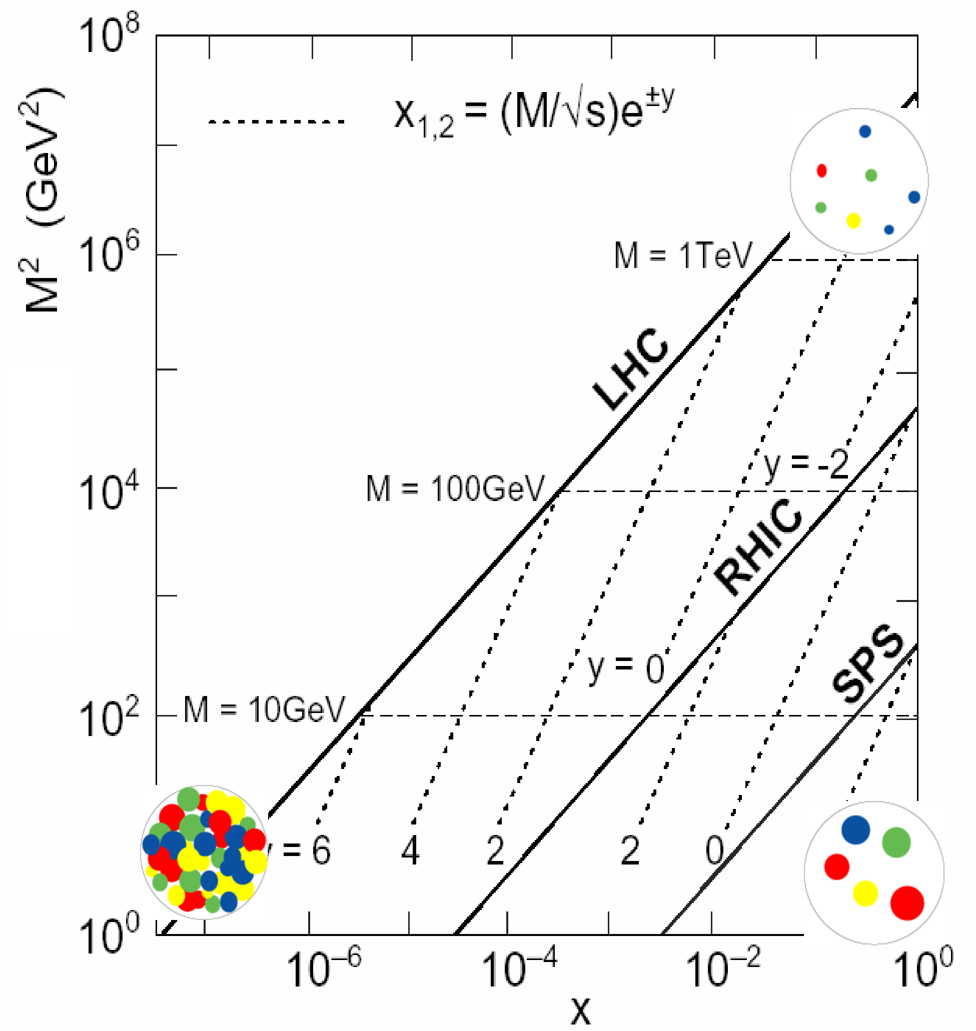
- higher initial parton density
- qualitatively different matter produced at LHC mid-rapidity?

tests of saturation phenomena?
- bulk observables
- pt-spectra in scaling regime
- rapidity vs. $\sqrt{s_{NN}}$ dependence
- …

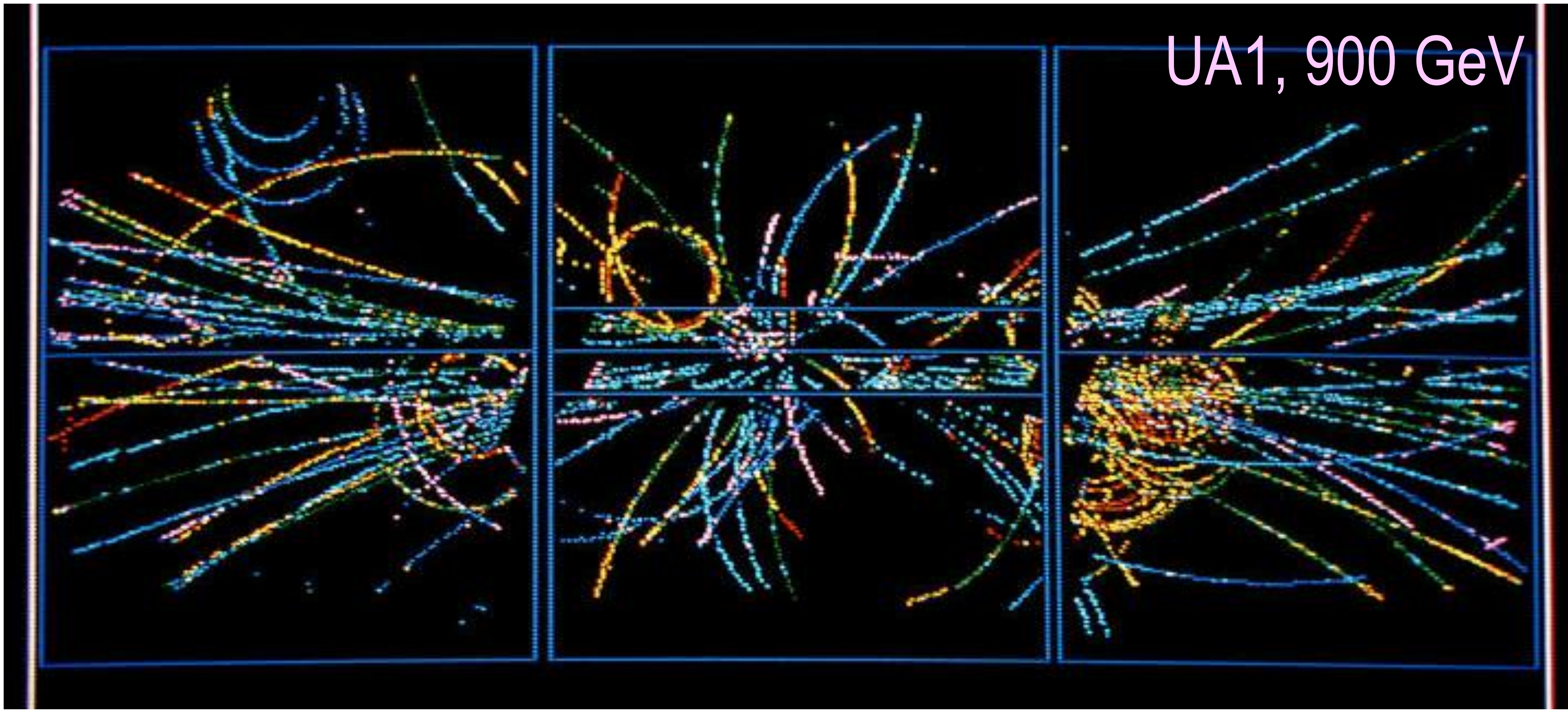
Large Q^2

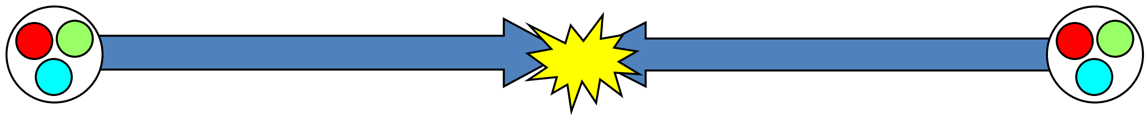
- abundant yield of hard probes
- precise tests of properties of produced matter

- color field strength
- collective flow
- viscosity
- …



$Sp\bar{p}S$ Collisions (1980's)

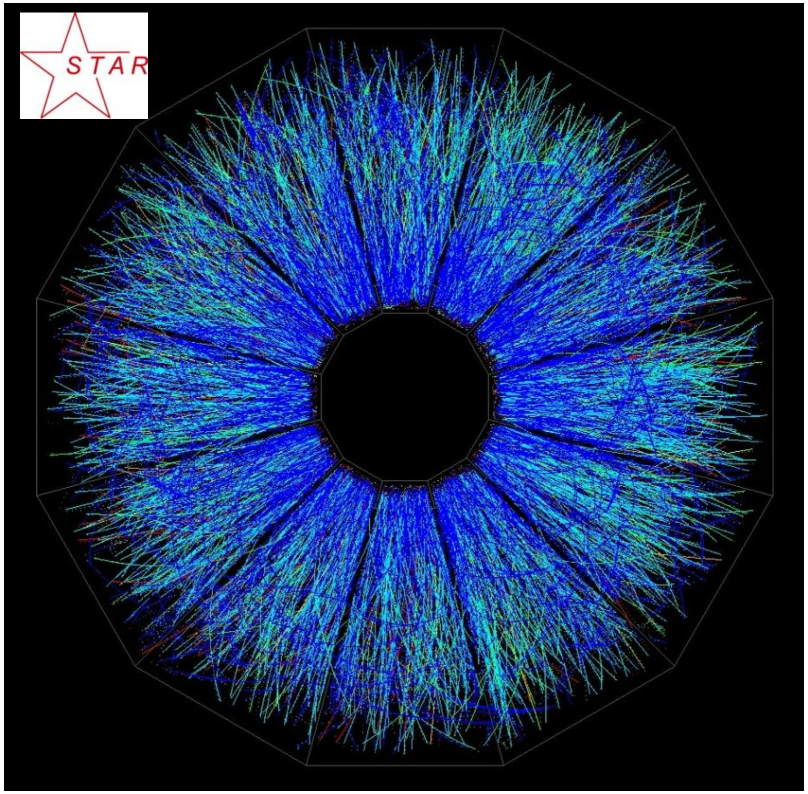


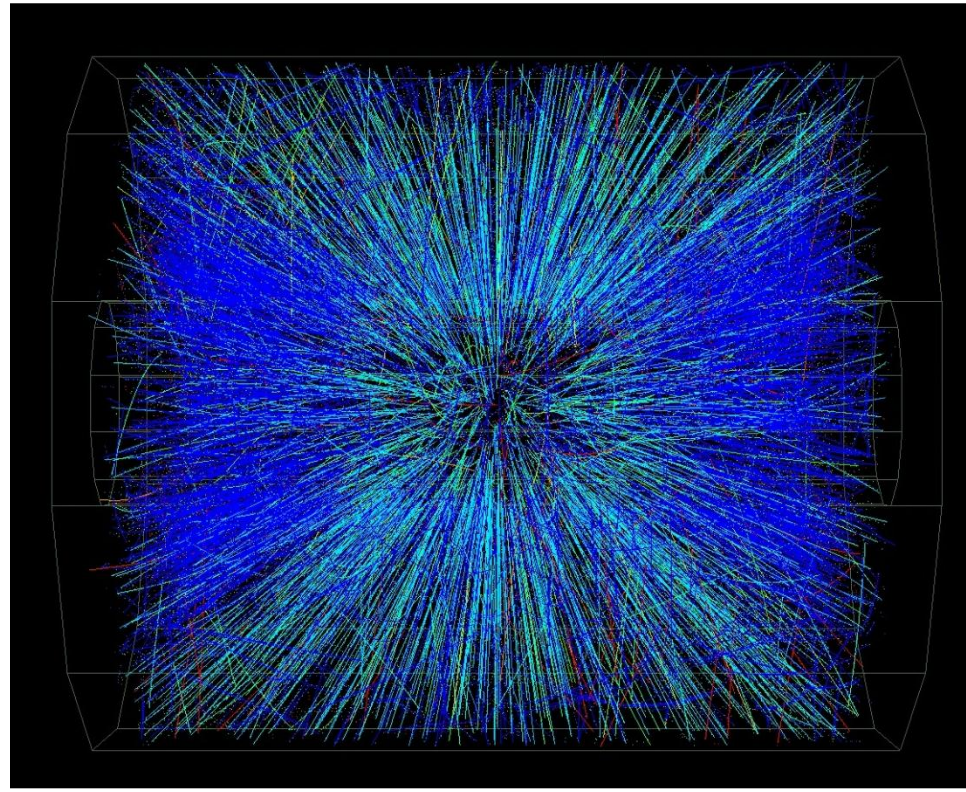


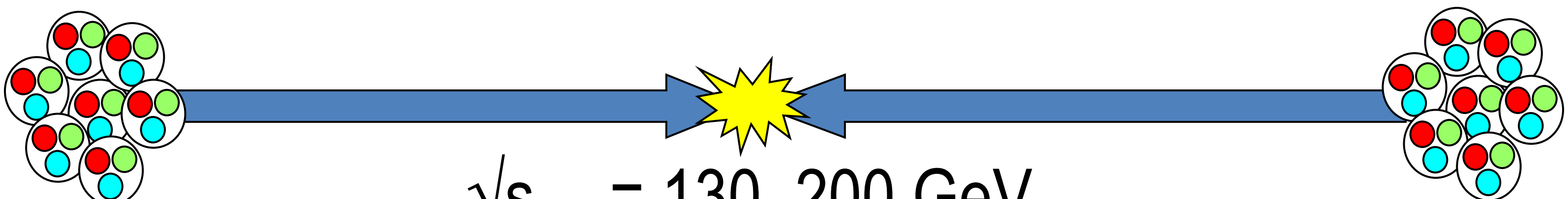
proton $\sqrt{s}$ = 200, 546, 900 GeV anti-proton

10's of particles

RHIC Collisions (2000 -)







Gold

$\sqrt{s_{NN}}$ = 130, 200 GeV

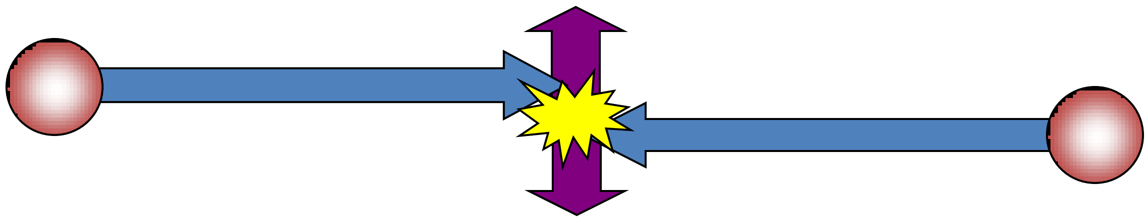
(center-of-mass energy per nucleon-nucleon collision)

Gold

1000's of particles

Rapidity

- Hadronic collisions are characterized by limited transfer of transverse momentum



- Most particles we observe carry only small fraction of (anti)proton longitudinal momentum ($x = p_z/p_{z,max}$)

- “Rapidity” variable increases dynamic range ($x<.1$)
  - Lorentz boost changes y by a constant

$$y = \frac{1}{2}\ln\left(\frac{E+p_z}{E-p_z}\right) \sim \ln(x)$$

$$y \overset{\beta}{\Rightarrow} y + \frac{1}{2}\ln\left(\frac{1+\beta}{1-\beta}\right)$$

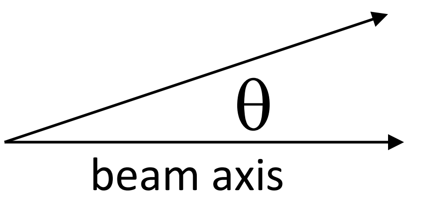
Pseudorapidity

- Rapidity requires complete characterization of 4-vector

Conceptually easy, but requires a spectrometer

- Experiments with high multiplicities and limited resources use "pseudorapidity"

$$\eta = -\ln \tan \theta/2$$

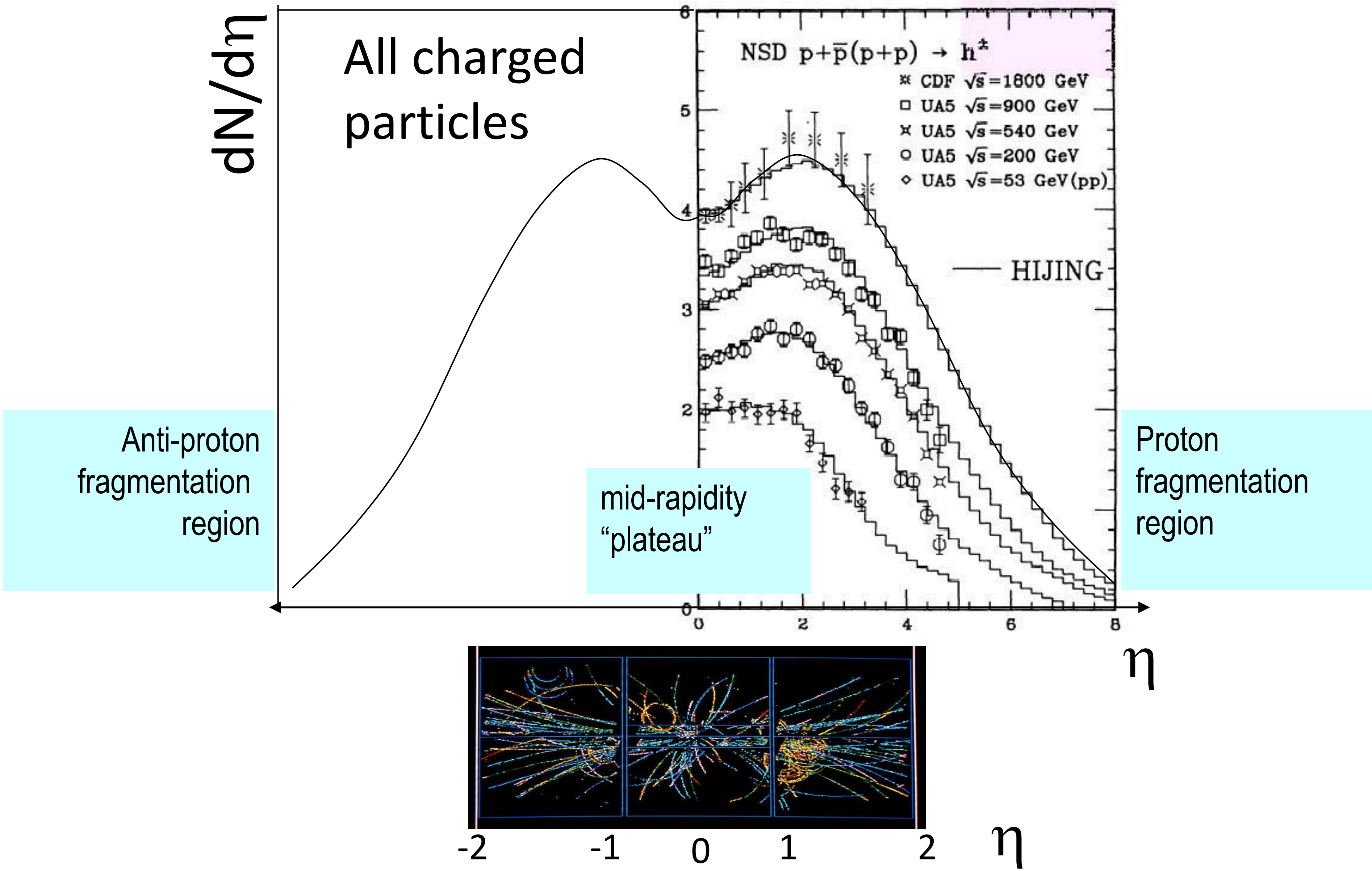


- dN/dη related to dN/dy, but not the same, especially for slower particles

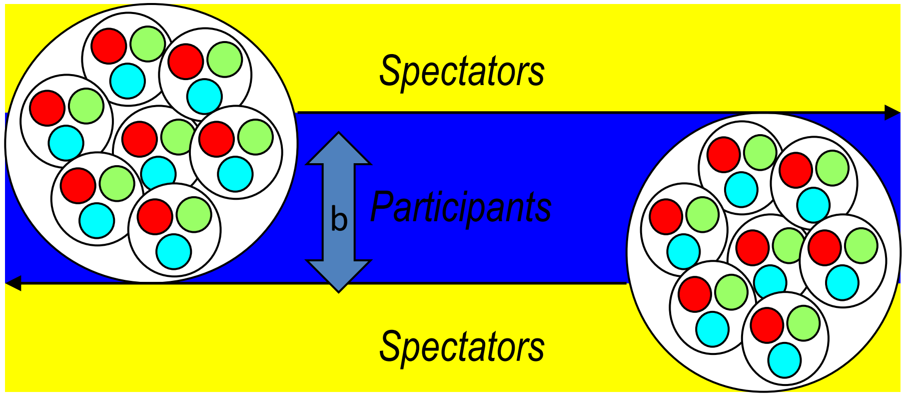
$$\frac{dN}{d\eta d\mathbf{p}_T} = \beta \frac{dN}{dy d\mathbf{p}_T}$$

Pseudorapidity Distributions in $p\bar{p}$

UA5, ZPC 33 (1986) / CDF, PRD 41 (1990)



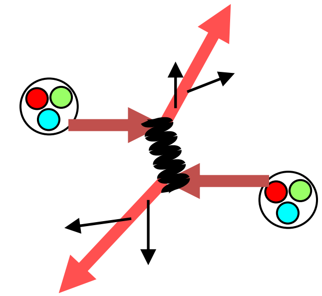
Geometry of AA Collisions



“Glauber” model of AA

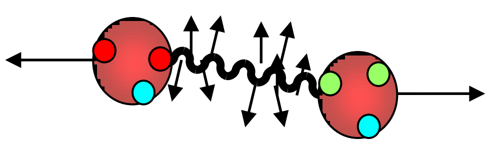
Binary Collisions:

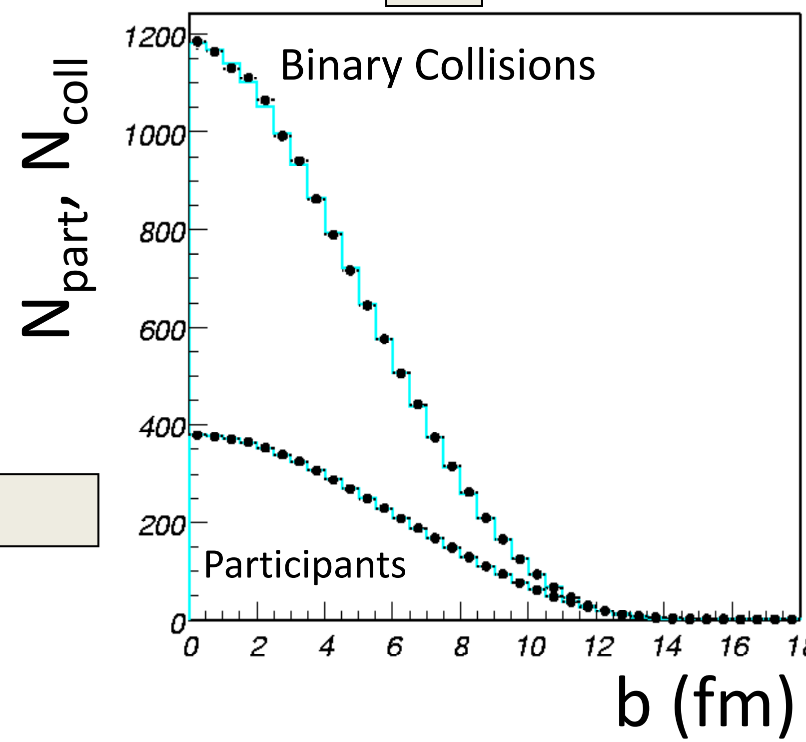
1. Jet Production
2. Heavy Flavor



Colour Exchange:

1. Soft Hadron Production
2. Transverse Energy





Some Measurables

- In nucleon-nucleon (NN) collisions, we study the height of the “plateau”

$$dN/d\eta\Big|_{|\eta|<1}$$

- In AA collisions, normalize by number of participant **pairs** to compare to NN

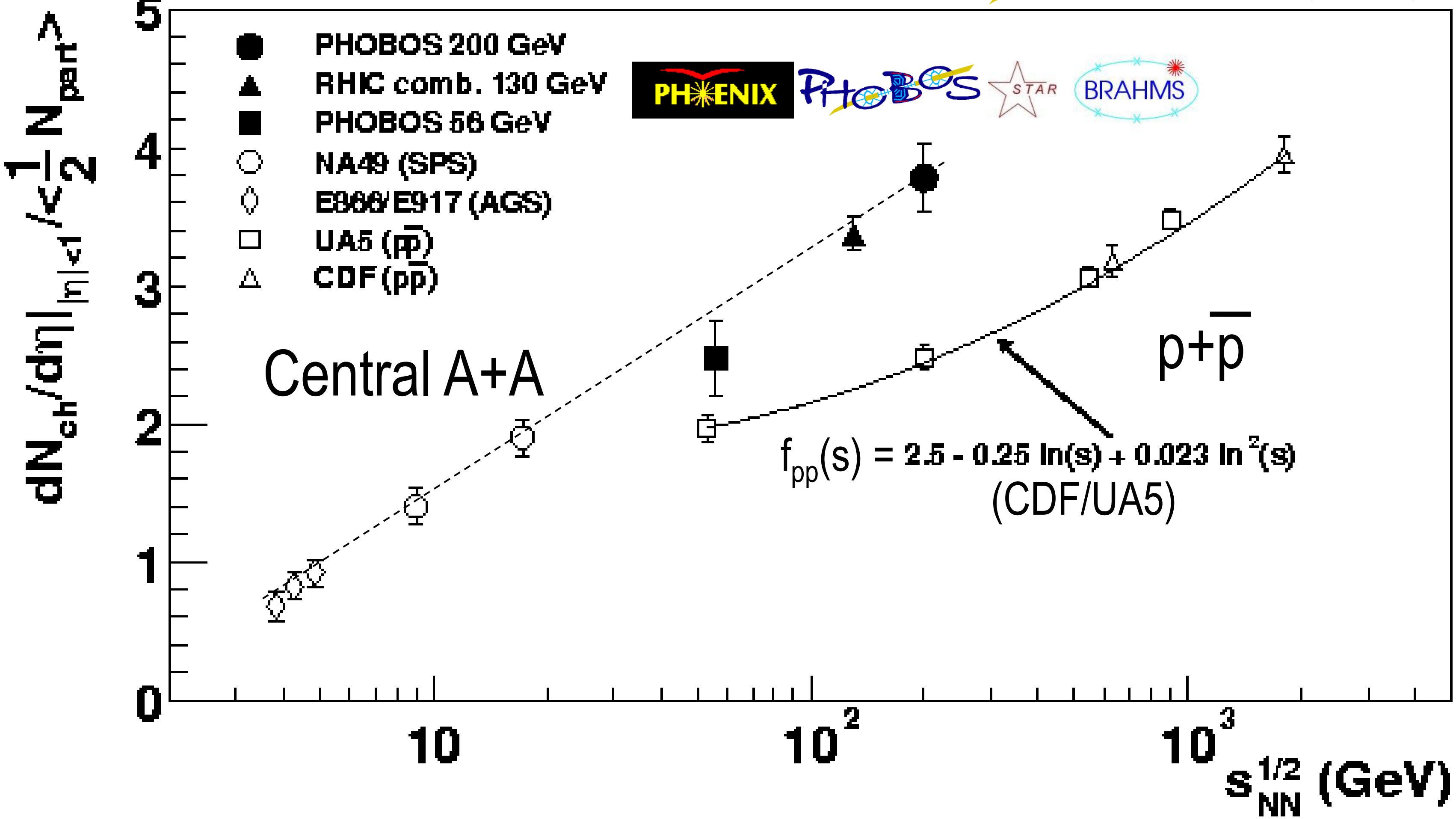
$$\frac{dN/d\eta\Big|_{|\eta|<1}}{N_{part}/2}$$

Glauber model

- Nucleons are distributed according to a density function (e.g. Woods-Saxon)
- Nucleons travel in straight lines and are not deflected as they pass through the other nucleus
- Nucleons interact according to the **inelastic cross section** σ_{NN} measured in pp collisions, even after interacting
  - Participants – counts nucleons which interact
  - Binary collisions – counts collisions

AA normalized to equivalent NN

PRL 87 (2001)



- Each effective nucleon-nucleon collision in central collisions of nuclei produces 50% more particles than pp!

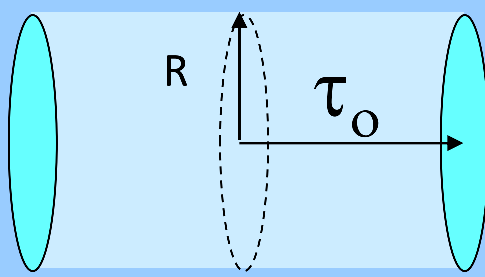
Energy Density

Q: Is there a connection between height of plateau and the energy density

$$\left\langle \frac{dE_T}{d\eta} \right\rangle_{\eta=0} = \begin{array}{l} 503 \pm 2 \text{ GeV} \\ (130 \text{ GeV}) \end{array}$$

PHENIX PRL 87 (2001)

Bjorken Estimate



$$\varepsilon_{BJ} = \frac{dE_T / dy|_{y=0}}{\pi R^2 \tau_o} = 4.6\, GeV / fm^3$$

(iff $R \sim 1.18 A^{1/3}$ & $\tau_o \sim$ 1fm/c)

PHENIX a *constant* amount of transverse energy(E_T) per particle, implying :

ε(200 GeV) = 4.6 x 1.14 = 5.2 GeV/fm^3

PHENIX PHOBOS

QGP revisited

A **quark–gluon plasma** (**QGP**) or **quark soup** is a phase of quantum chromodynamics (QCD) which exists at extremely high temperature and/or density. This phase consists of asymptotically free quarks and gluons, which are several of the basic building blocks of matter

Energy loss by gluon radiation and elastic collisions - strong coupling of gluons w.r.t quarks - in dense media!

✓ Dead cone effect: gluon radiation from heavy q is suppressed @ angles < $M_q/E_q \Rightarrow$ small energy loss from heavier quark

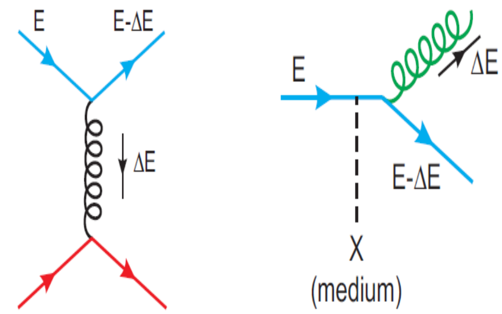
✓Casimir effect: $<\Delta E> \sim \alpha_s C_R q L$, where α_s QCD coupling, C_R Casimir factor, 4/3 (3) for q(g), q transport coeffecient, L path length in the medium. $\rightarrow$HF mainly from *q* fragmentation , light hadrons from *g*.

Heavy quarks in QGP medium

Diagnostic tool for the formation of the QGP

- Heavy quarks are produced at the beginning of the collisions (high Q^2)
- Pass through the medium and interact with it, losing energy by gluon radiation and elastic collisions

- energy loss mechanisms
  - parton mass (Dead cone effect)
  - colour charge (Casimir factor)



$$\Delta E_g > \Delta E_{u,d,s} > \Delta E_c > \Delta E_b$$

- Compare heavy / light flavour observables

$$R_{AA}(p_t,\eta) = \frac{1}{\langle N_{coll} \rangle} \frac{d^2N_{AA}/dp_t d\eta}{d^2N_{pp}/dp_t d\eta}$$

Medium density & size

$R_{AA}^{(\pi)} < R_{AA}^{D} < R_{AA}^{B}$

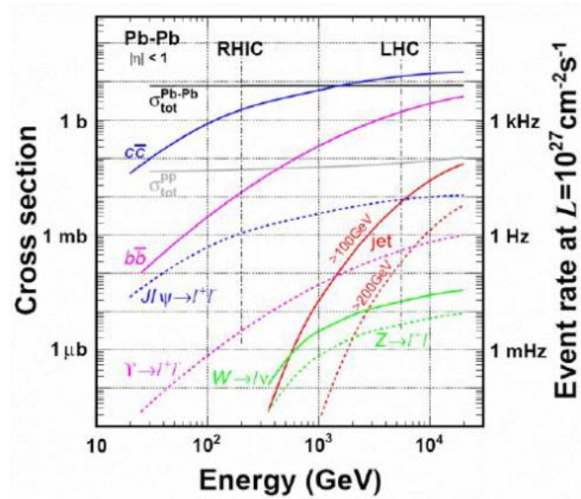
- Probe medium properties

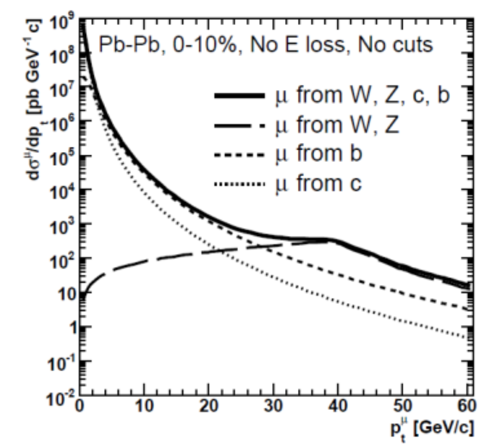
Yu. Dokshitzer and D.E. Kharzeev, Phys.Lett. B 519, 199-206 (2001).
Armesto, Salgado, Wiedemann, PRD 69 (2004) 114003.
Djordjevic, Gyulassy, Horowitz, Wicks, NPA 783 (2007) 493.

HF muon production @ the LHC?

machine	SPS	RHIC	LHC
$\sqrt{s_{NN}}$ (GeV)	17	200	2760

- $\sqrt{s_{LHC}}$ → best conditions to study QGP (S. Abreu, et al. arXiv:0711.0974) Access hard probe production cross sections
- Muon sources @ LHC
  - Light mesons decays: π, *K*,
  - Charm decays: *D*, $c\bar{c}$ *mesons* ($J/\psi \rightarrow \mu+\mu-$) (~ 20 x RHIC)
  - Beauty decays: *B*, $b\bar{b}$ *mesons* ($\Upsilon \rightarrow \mu+\mu-$) (~100 x RHIC)
  - W / Z decays
- Muon p_t distribution in HI *is sensitive* to b-quark energy loss effects → R_{AA} reduction due to nuclear shadowing of PDF
- W / Z yields expected to scale with $\langle N_{coll} \rangle$ in parton-parton scattering ⇒ calibration for HF R_{AA} & test of the binary scaling assumptions

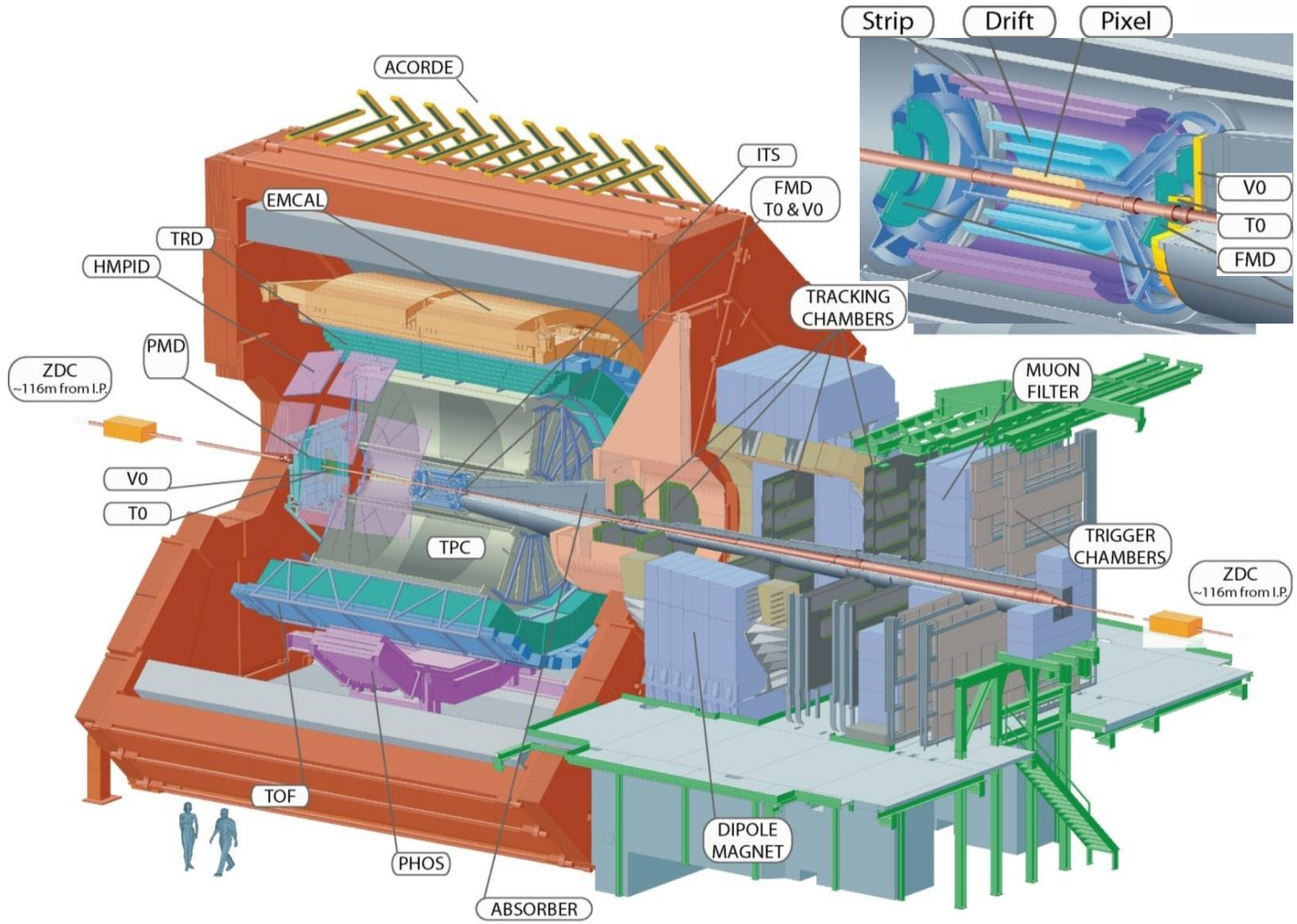




Z.Conesa del Valle et al., arXiv:0712.0051v1

The ALICE Experiment

Size: 16 x 26 meters
Weight: 10,000 tons
Detectors: 18



- HI collisions: measure all known observables to characterise the medium formed in the collisions
- pp collisions: baseline for A-A and intrinsic interest, test pQCD models J. Instrum. 3, S08002 (2008)

ALICE Collaboration

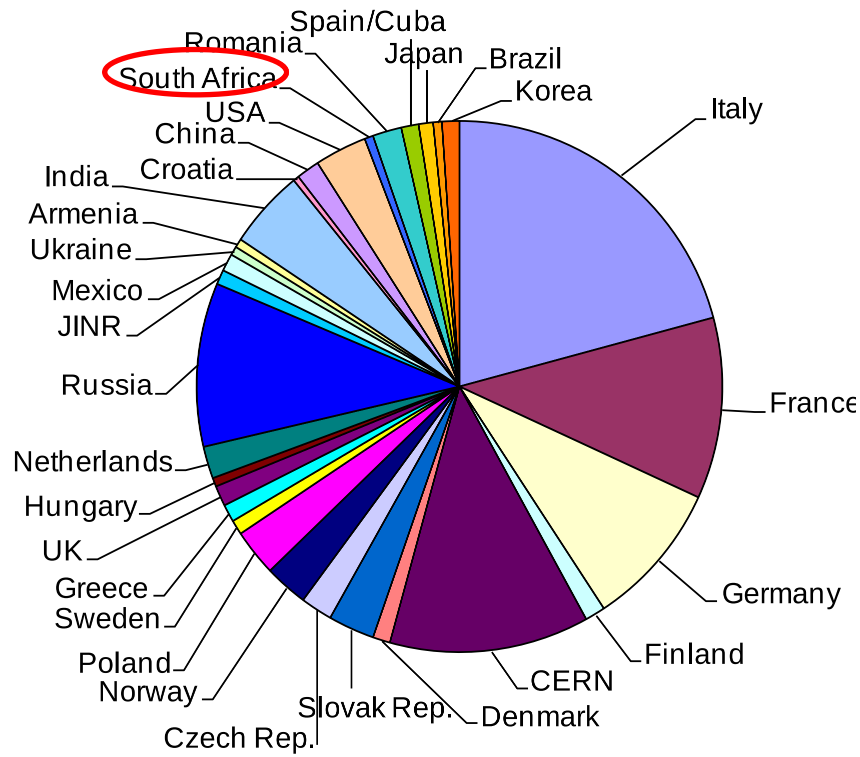
> 1000 Members from both NP and HEP communities

33 Countries

116 Institutes

~ 150 MCHF capital cost

(+ 'free' magnet)



History

1990-1996: Design

1992-2002: R&D

2000-2010: Construction

2002-2007: Installation

2008 -> : Commissioning

3 TP addenda along the way:

1996 : muon spectrometer

1999 : TRD

2006 : EMCAL

ALICE Acceptance

- <u>Central barrel:</u> -0.9 < η < 0.9

2 π tracking, PID (ITS, TPC, TRD, TOF)

– single arm **RICH** (HMPID)
– single arm **em. calo** (EMCAL)
– PHOS

} Reduced acceptance

Quarkonia: *e+e- channel*

Heavy flavour: *hadronic channel, semi-leptonic decays (e+/-)*

- **<u>Forward muon arm:</u> 2.5<y<4 ⇒ Probe small Bjorken-x (10^{-5} – 10^{-3})**

Resolution (ΔP/P) goal: 1% @ 20 GeV/c, 4% @ 100 GeV/c

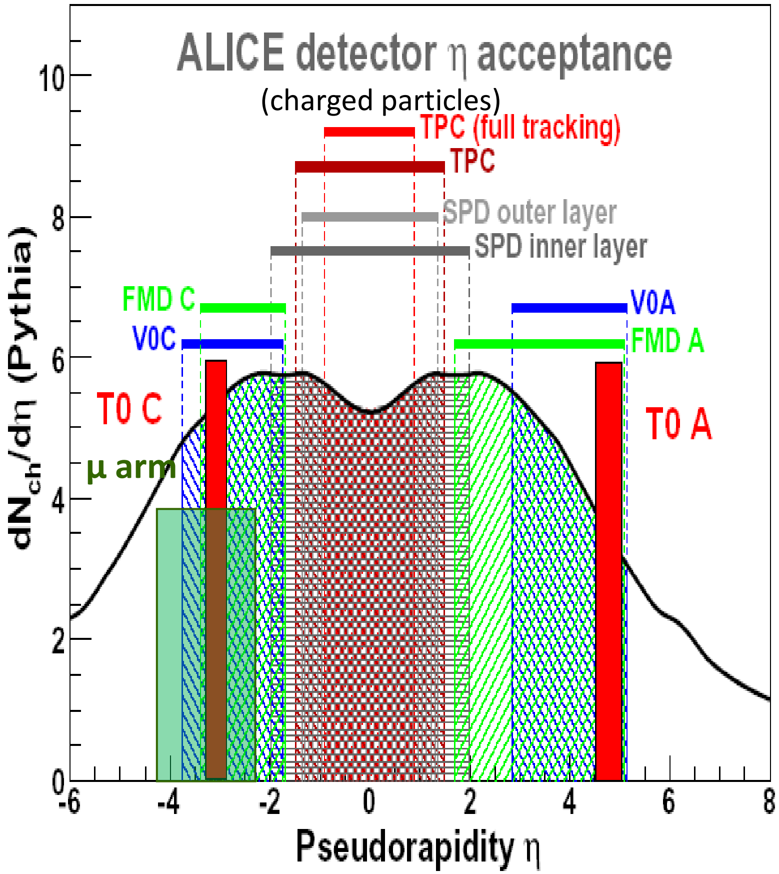
absorber, 3 Tm dipole magnet

10 tracking + 4 trigger chambers

Quarkonia: μ+μ- channel

Heavy flavour: semi-leptonic decays (μ+/-)

- <u>Backward + Forward small acceptance detectors</u>: **multiplicity, centrality, luminosity & triggering**



J. Instrum. 3, S08002 (2008)

Particle Identification

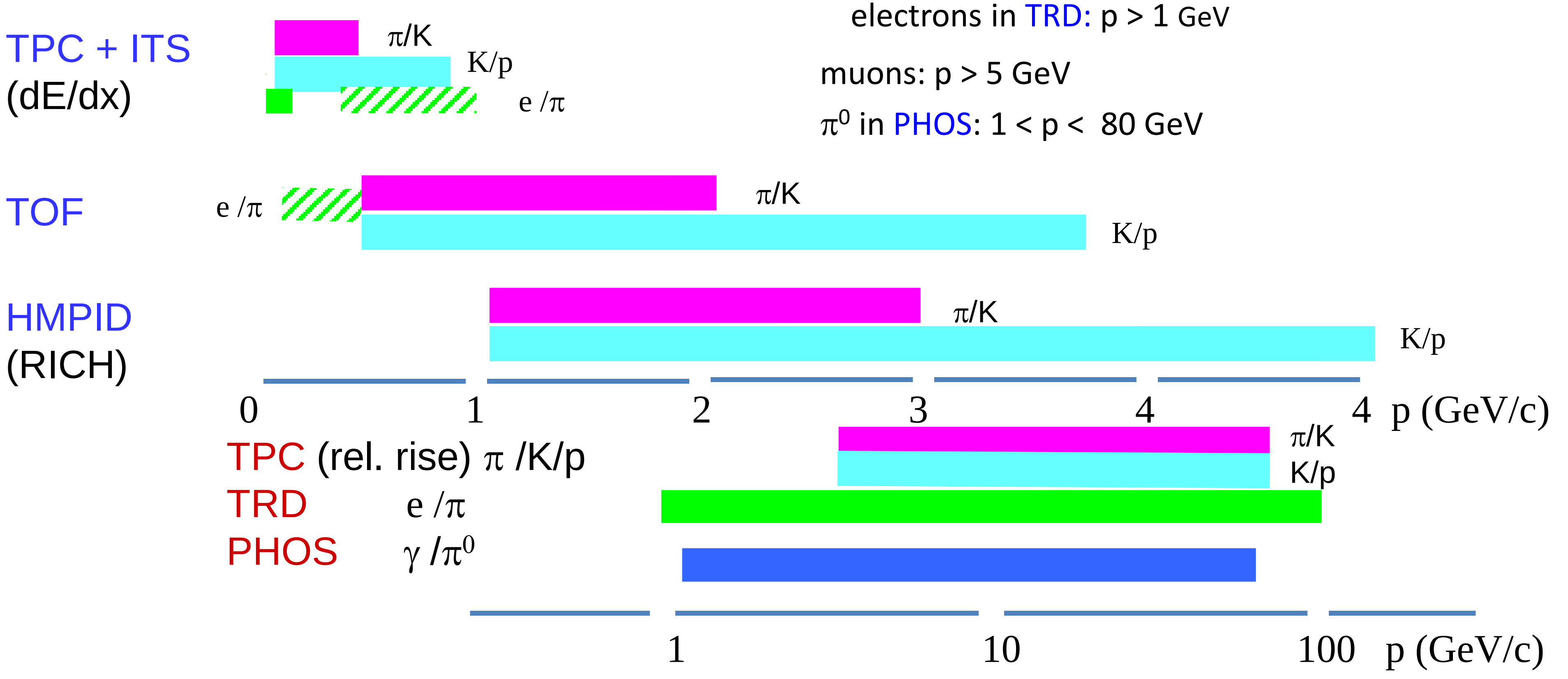
- stable hadrons (π, K, p): 100 MeV < p < 50 GeV
  - dE/dx in silicon (ITS) and gas (TPC) + Time-of-Flight (TOF) + Cerenkov (RICH)
  - dE/dx relativistic rise => extend PID to several 10 GeV
- decay topology (K^0, K^+, K^-, Λ, D^+,…)
  - K and Λ decays up to > 10 GeV
- leptons (e, μ), photons, η,π^0

Alice uses ~ all known techniques!

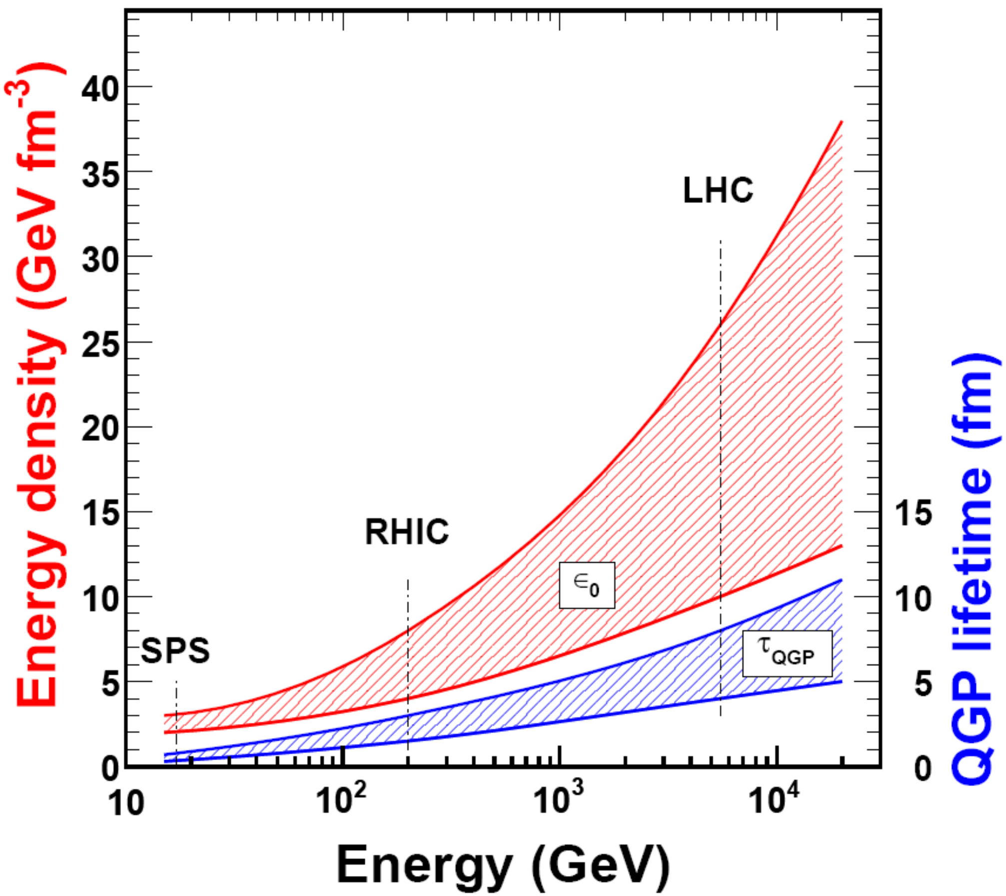
electrons in TRD: p > 1 GeV

muons: p > 5 GeV

π^0 in PHOS: 1 < p < 80 GeV



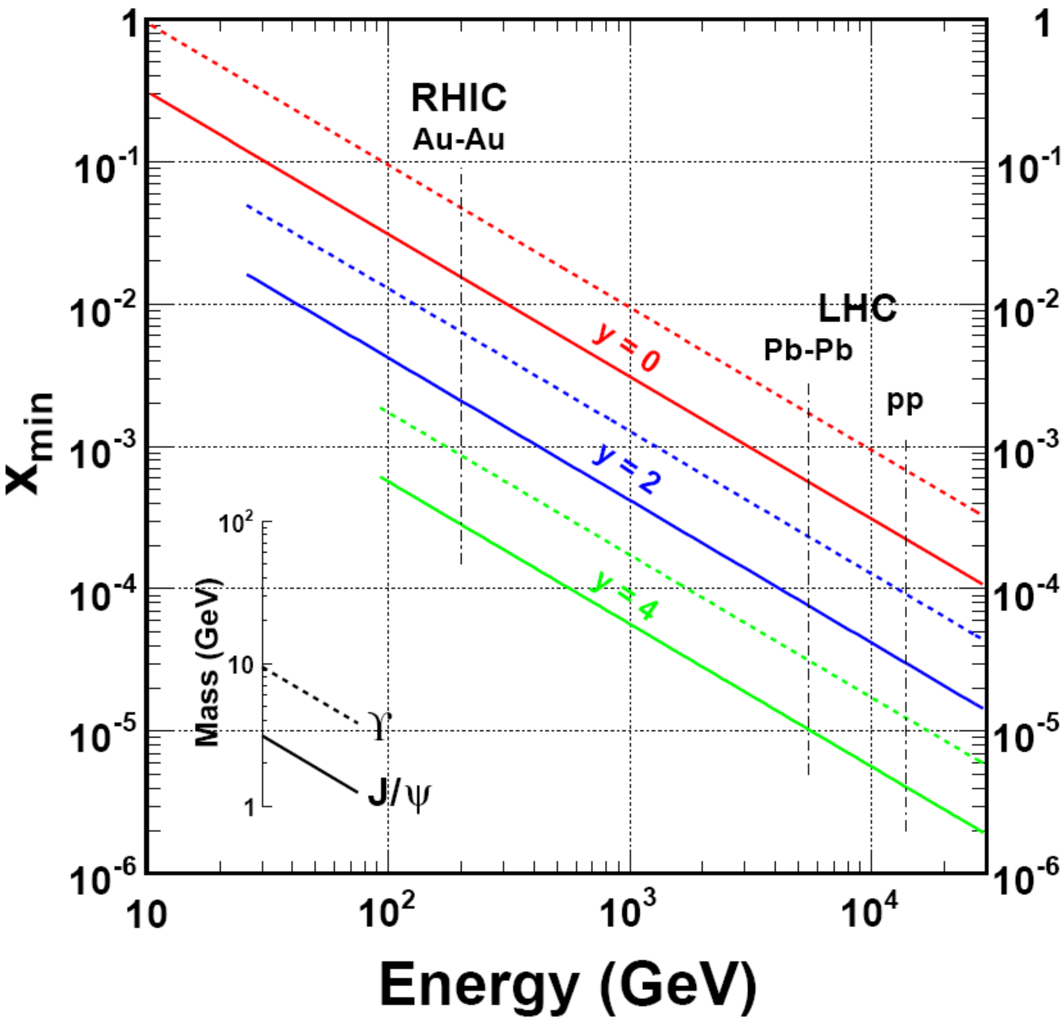
LHC: Plasma Energy Density; Lifetime



Energy density expected to increase by factor ~ 2 – 3

Lifetime of QGP by Factor ~ 2 – 3

LHC: extending the low-x Reach



RHIC as opened the low-x frontier finding indications for new physics (CGC ?)

LHC will lower the x- frontier by another factor 30

Can reach x = 3 * 10^{-6} in pp,
10^{-5} in PbPb

Managing the Data: Trigger, HLT, DCS, DAQ, ECS

- Central Trigger Processor (CTP)
  - Hierarchy of three Levels (L0, L1, L2)
- High-Level Trigger (HLT) : 1000 processors; scaleable to 20 000
  - sharpened trigger decisions; data pre-processing and compression;
- Detector Control System (DCS)
- Data Acquisition (DAQ): Bandwidth 500MBytes/ s; planned: 1.2 GBytes/s (following Luminosity increase)
- Experimental Control System (ECS)
  - top layer; interface to experiment operation
-

Status: all systems installed; operational, commissioning continuing

C Fabian (QM08)

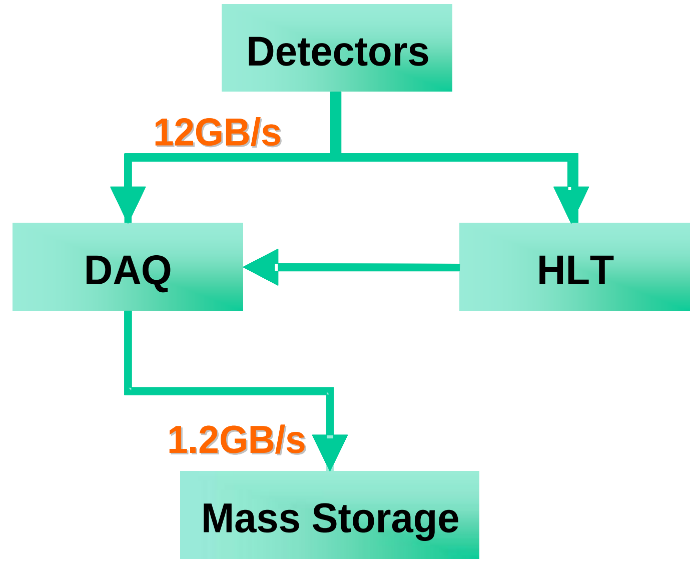
High-Level Trigger(1)

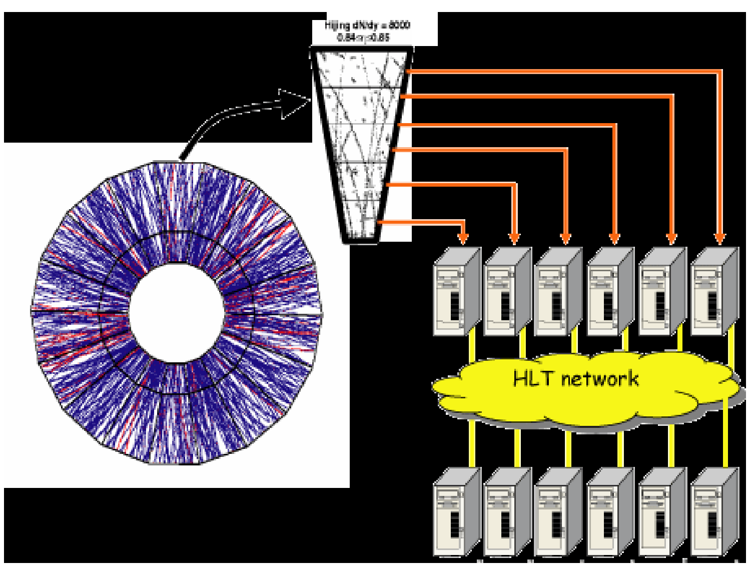
- Data rate from central PbPb collisions (dN/dy~2000-4000):

  200Hz*(30Mb-60Mb)= 6-12Gb/s

- Max mass storage bandwidth ~1.2Gb/s

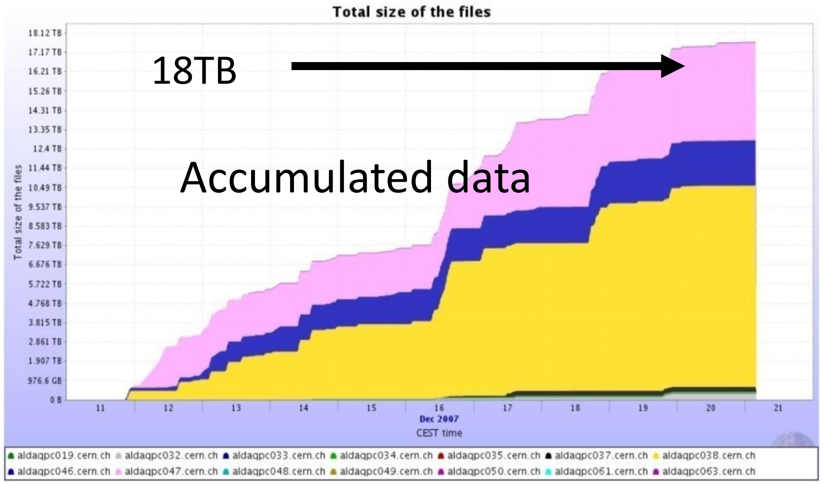
- Goal of HLT is to reduce the data rate without biasing important physics information:
  - Event triggering
  - “Regions of Interest”
  - Data compression





- Requirements:
  - Fast and robust online reconstruction
  - Sufficient tracking efficiency and resolution
  - Fast analysis of important physics observables

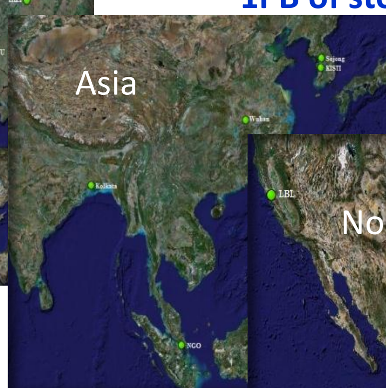
Off-line Data processing



Data Processing during
1st global Commissioning Run (Dec 2007:)

systematic reconstruction of all RAW data
Reconstructed events made available to collaboration

- **In 2007:**
  - **65 Sites on 4 continents**
  - **7500 CPUs**
  - **1PB of storage**



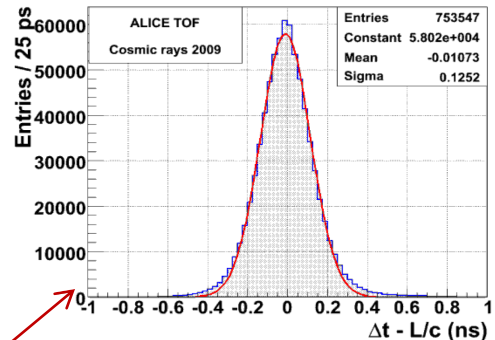
GRID operation during December Run

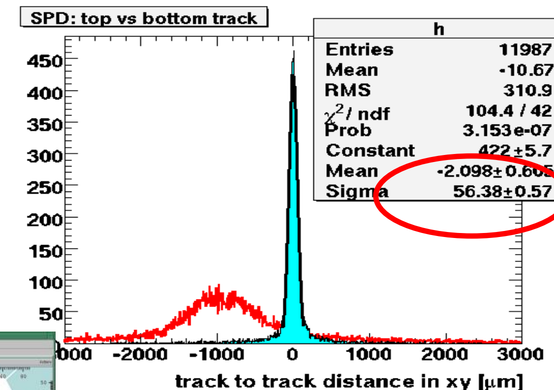
Talk by F. Carminati (QM08)

ALICE recent history

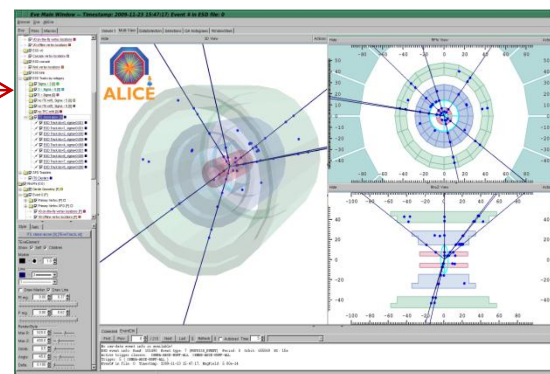
Detector installation until **July 2009**:

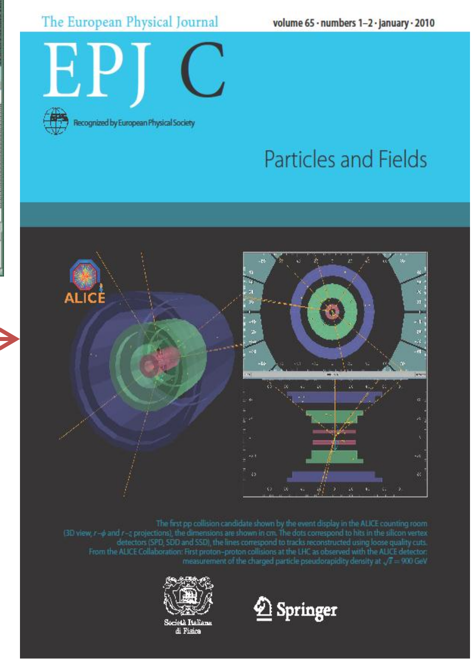
Cosmic runs (calibration, alignment) from **August** to mid **November 2009.**
Example: ITS pixel alignment, TOF resolution





23/11/09 **First LHC pp coll. at 900 GeV … and first LHC paper**



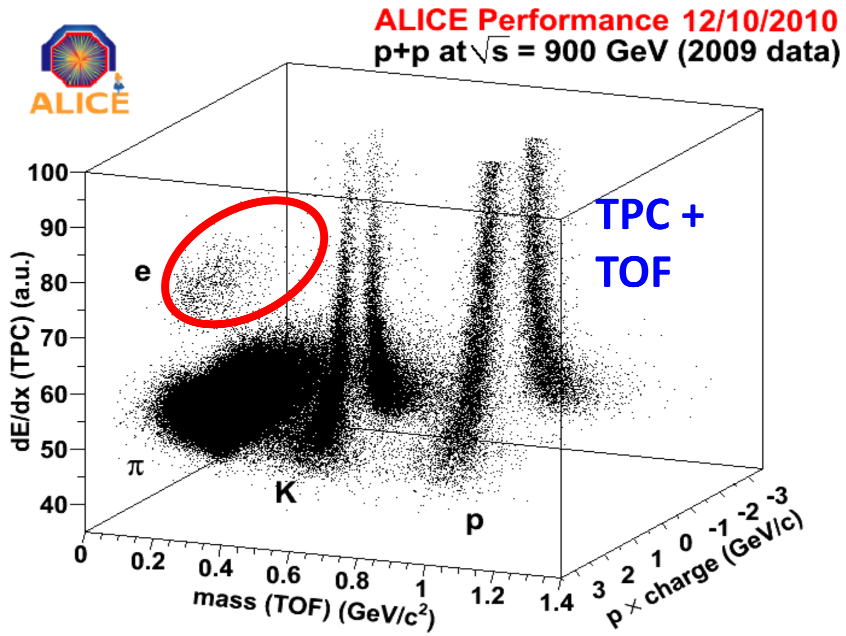


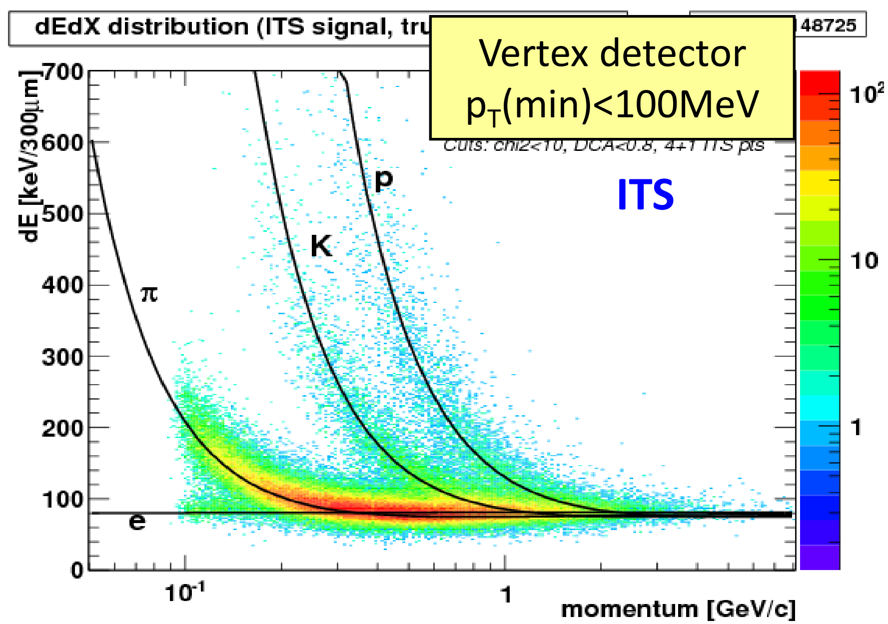
14/12/09 **pp coll. at 2.36 TeV**

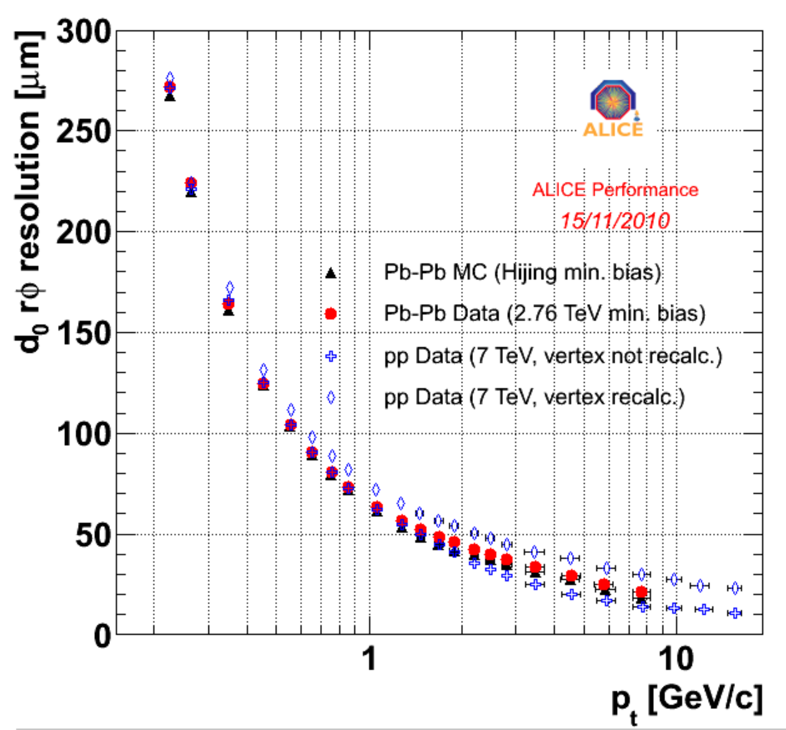
March 2010 **pp coll. at 7 TeV**

Nov. 2010 **Pb-Pb coll. at 2.76 ATeV**

PID and vertexing

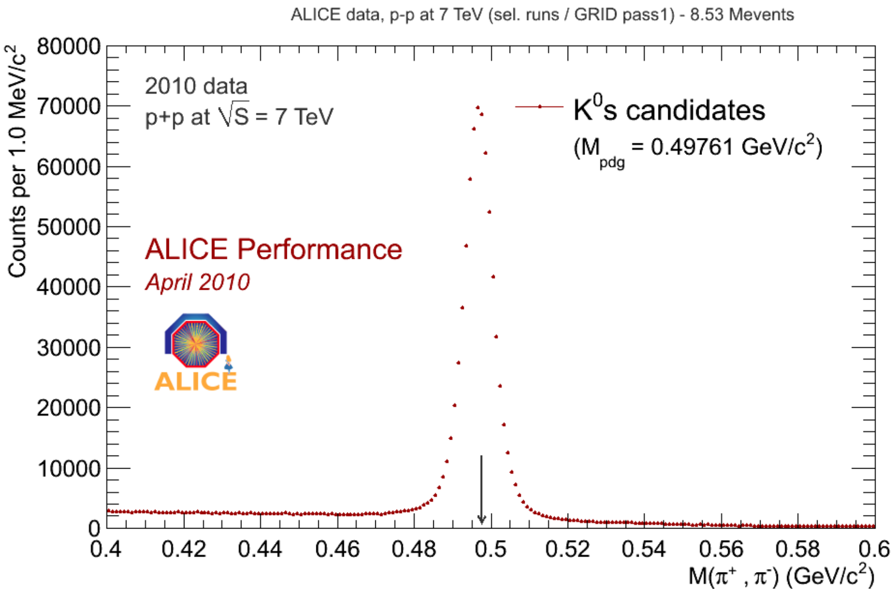


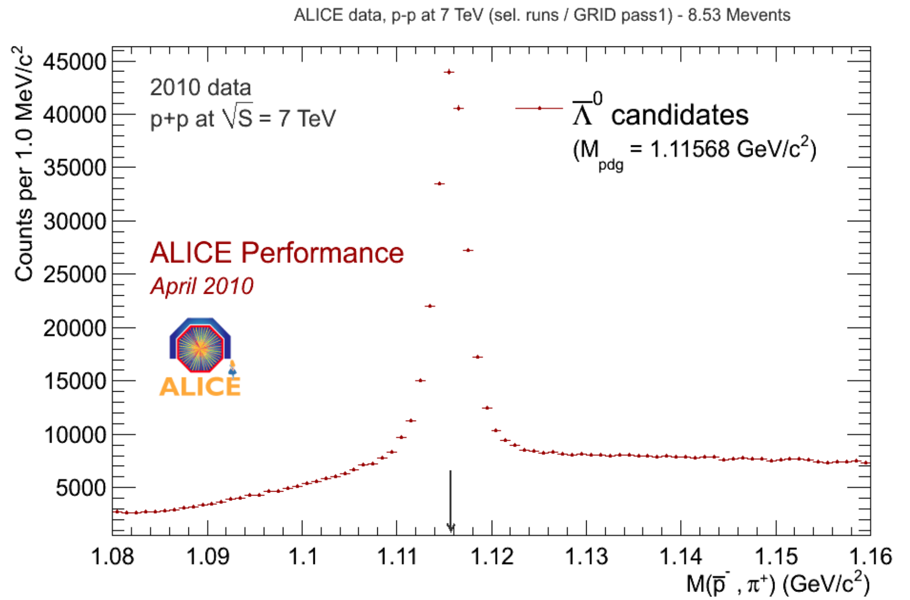


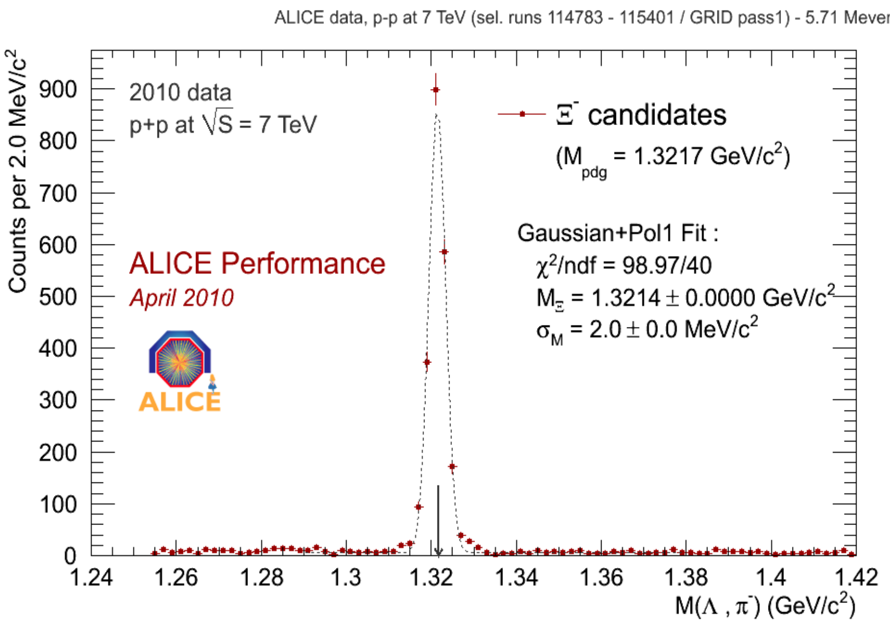


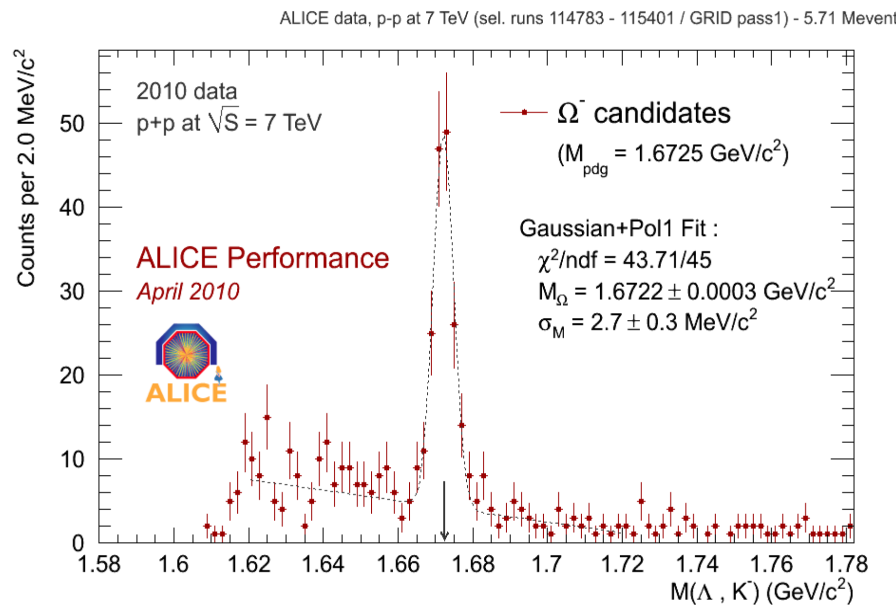
Resolution better than 75 μm above 1 GeV/c, and very close to target performance, essentially the ***same in PbPb and pp***

Identification of strange particles

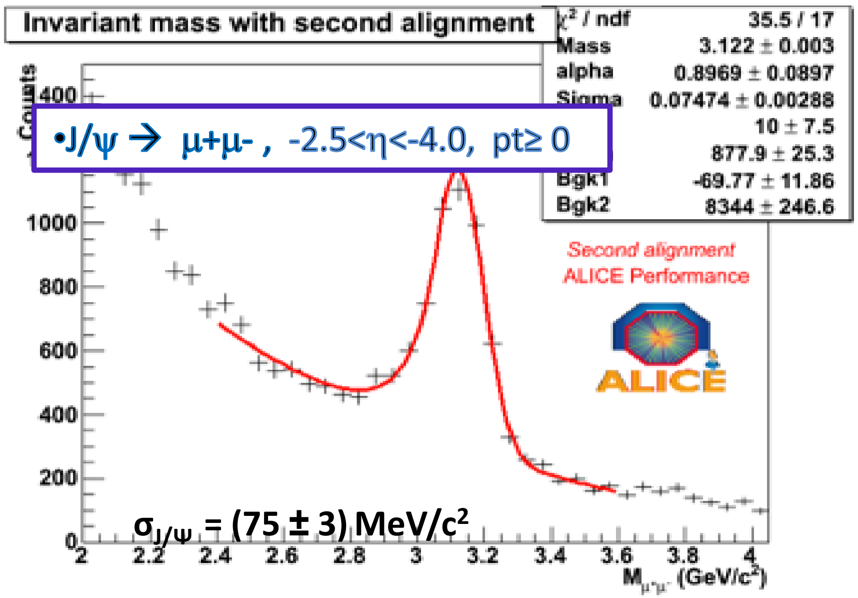


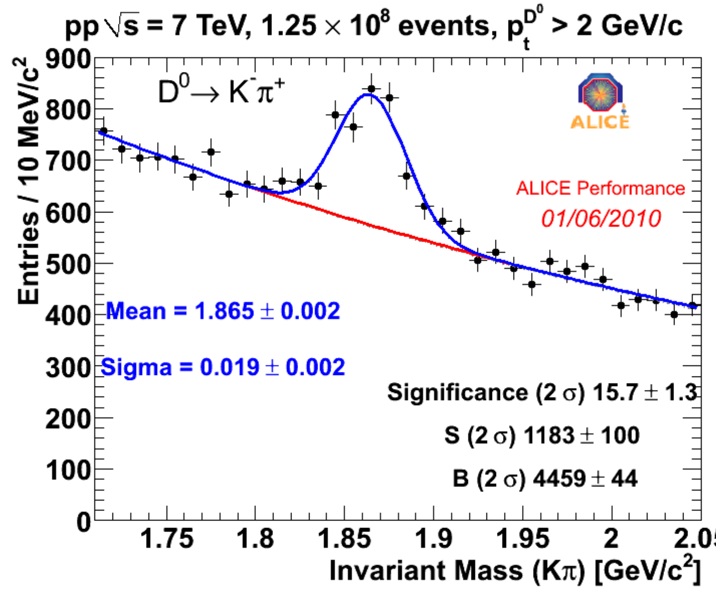


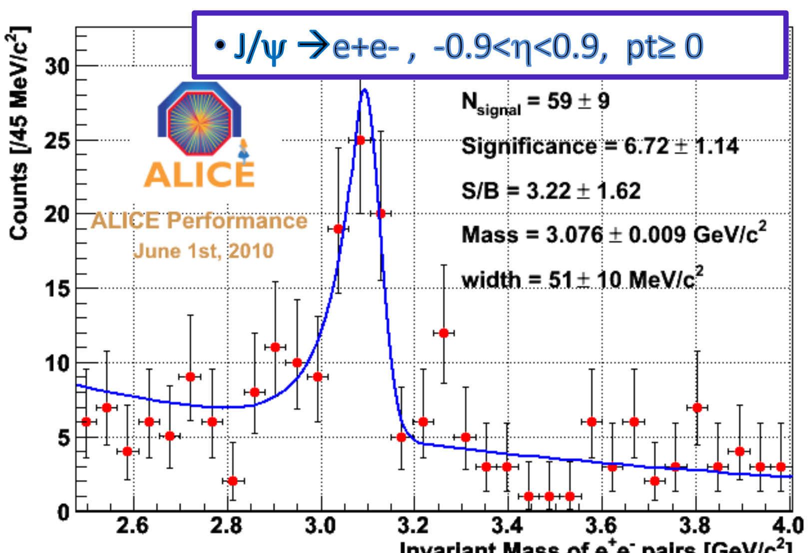


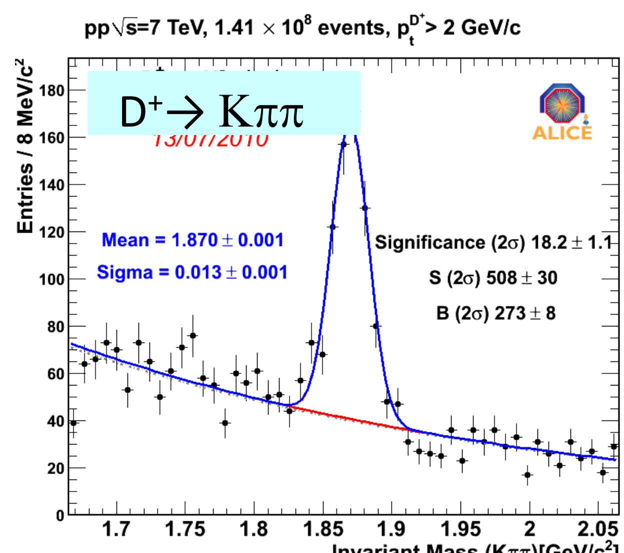


Charmonium and D mesons

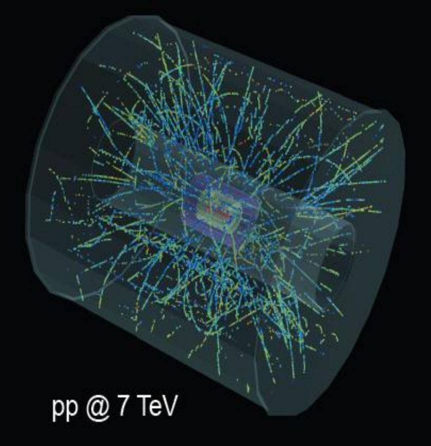


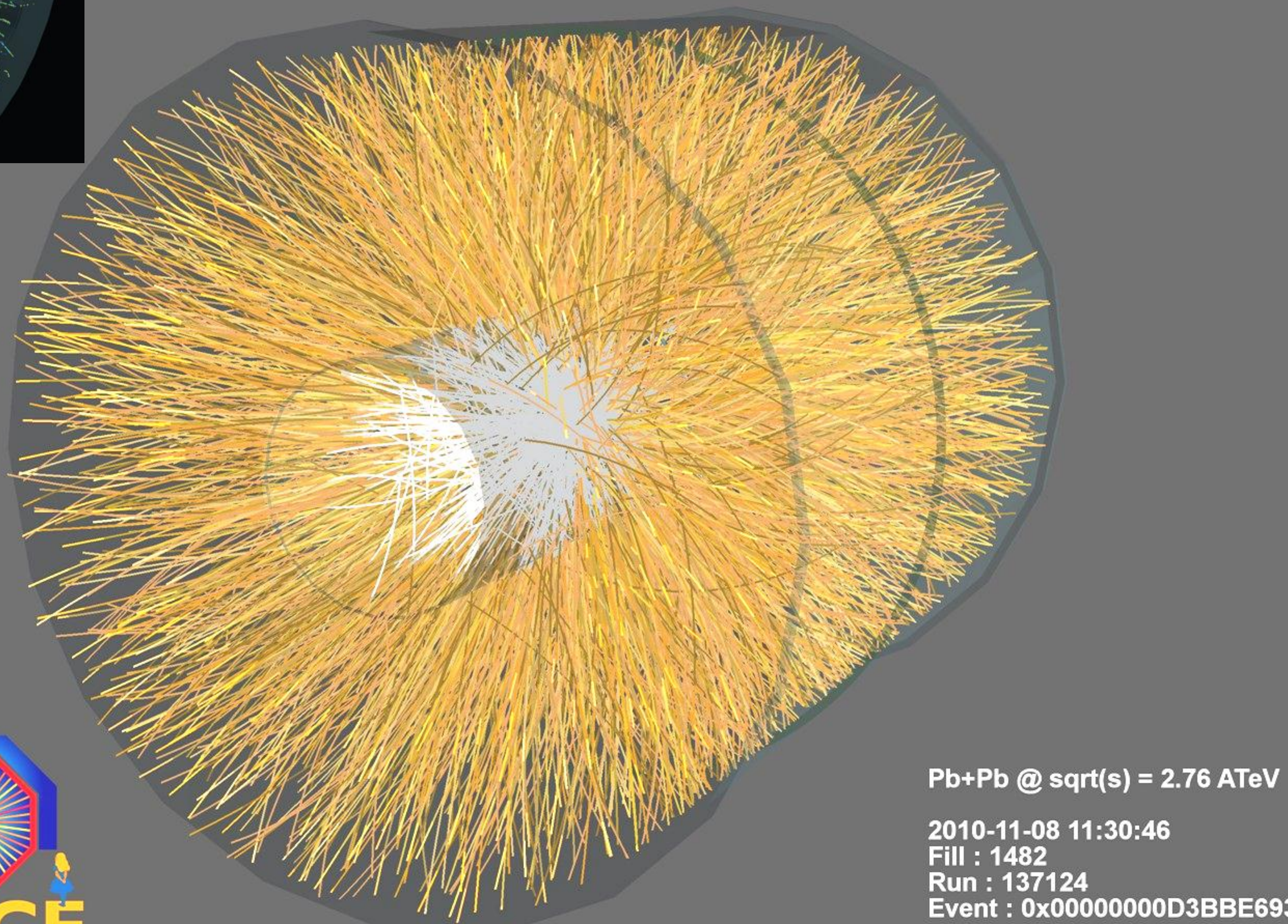




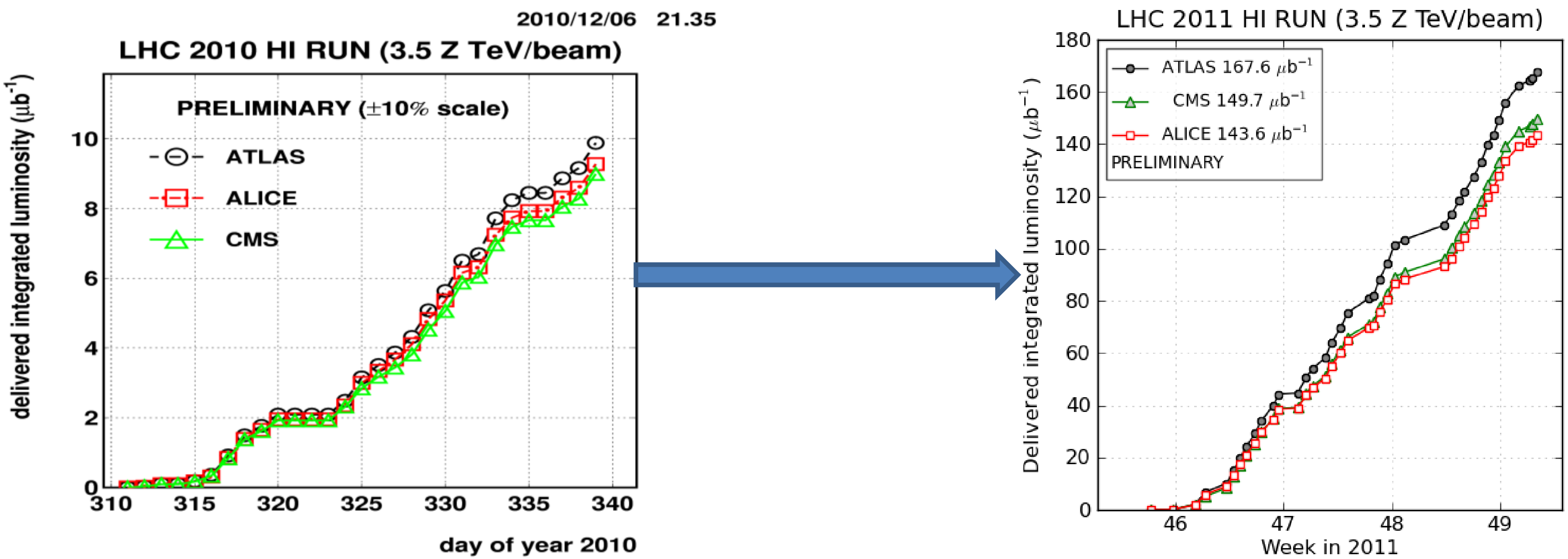


Pb-Pb collisions





Recent PbPb runs @ the LHC



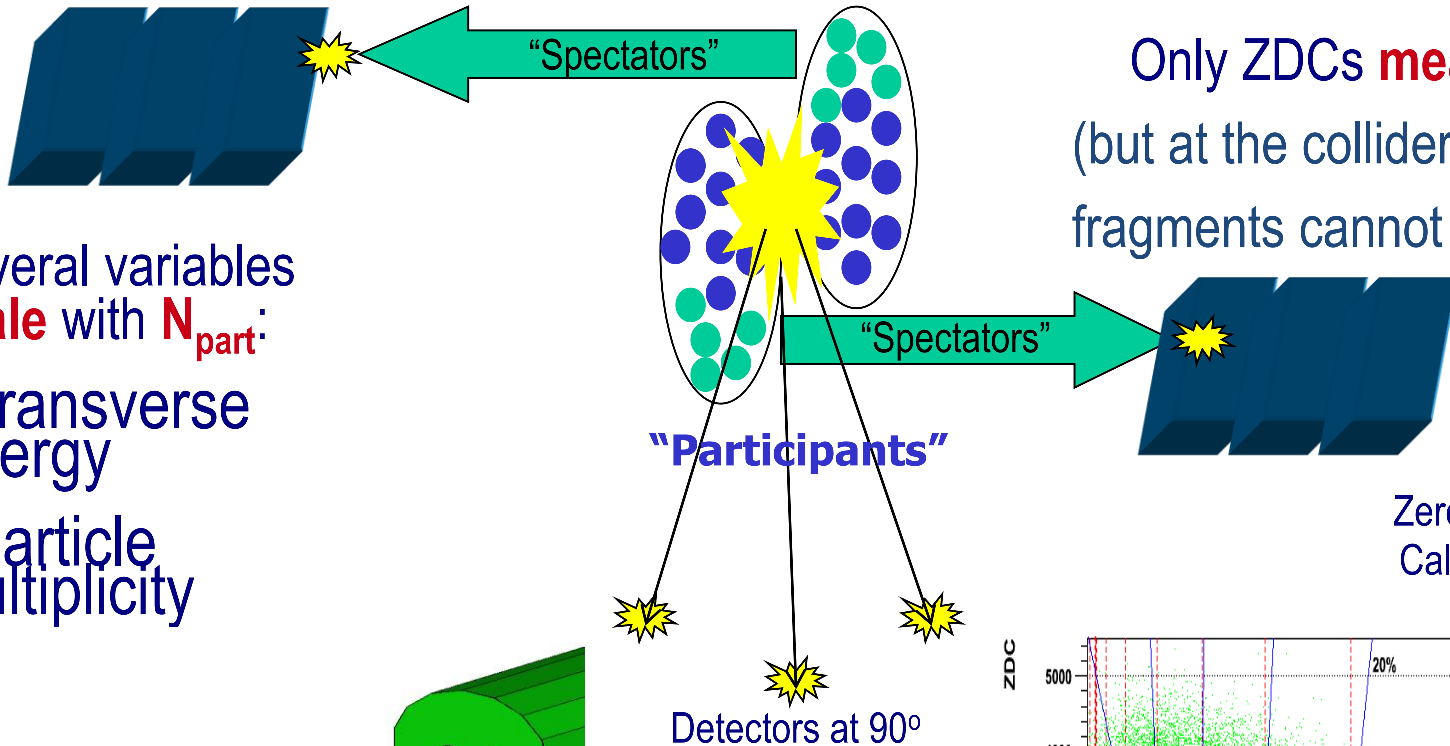
http://lpcc.web.cern.ch/LPCC/index.php?page=luminosity_charts

Increase in luminosity $\Rightarrow$ statistics increase by ~ 18 times more than in 2010.
High p_t reach for HF muon production, e.g. W and Z decay muons ?

Centrality determination

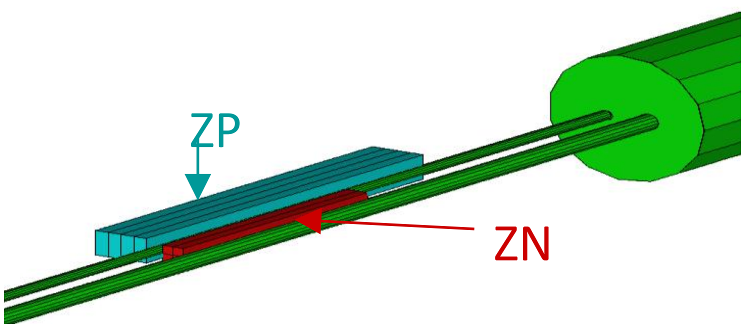
The collision geometry (i.e. the impact parameter) determines the number of nucleons that **participate** in the collision

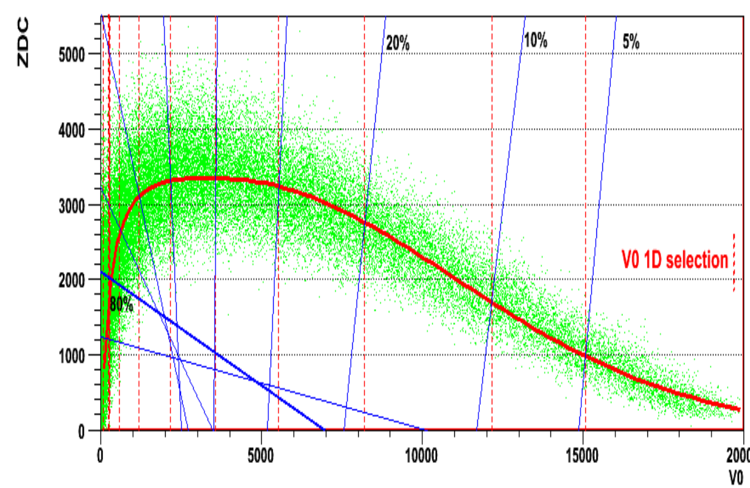
Only ZDCs **measure N_{part}** (but at the colliders nuclear fragments cannot be detected)



Several variables **scale** with **N_{part}**:

- Transverse Energy
- Particle Multiplicity



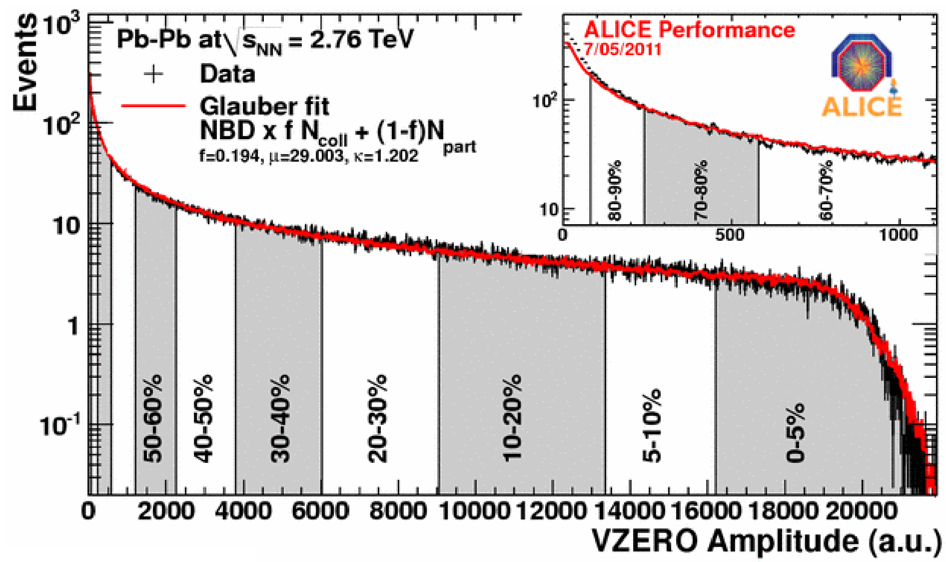


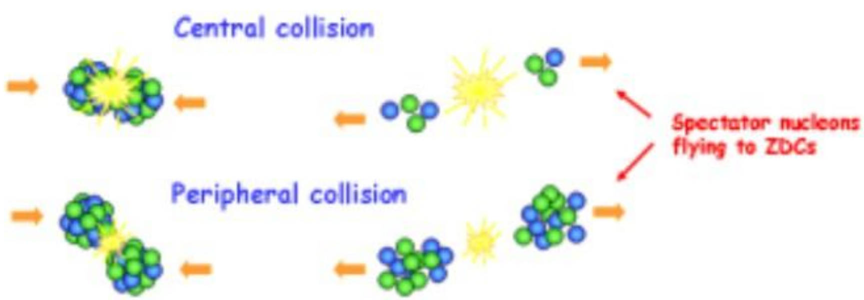
Zero Degree Calorimeters
~ 100m away from the interaction point

Centrality measurements in PbPb collisions @ 2.76 TeV

<u>Events: </u>- MB trigger events
Centrality class: 0-80% determined by V0
Glauber model analysis of large-η V0 scintillator amplitudes :V0A : 2.8 < η < 5.1, V0C : -3.7 < η < -1.7

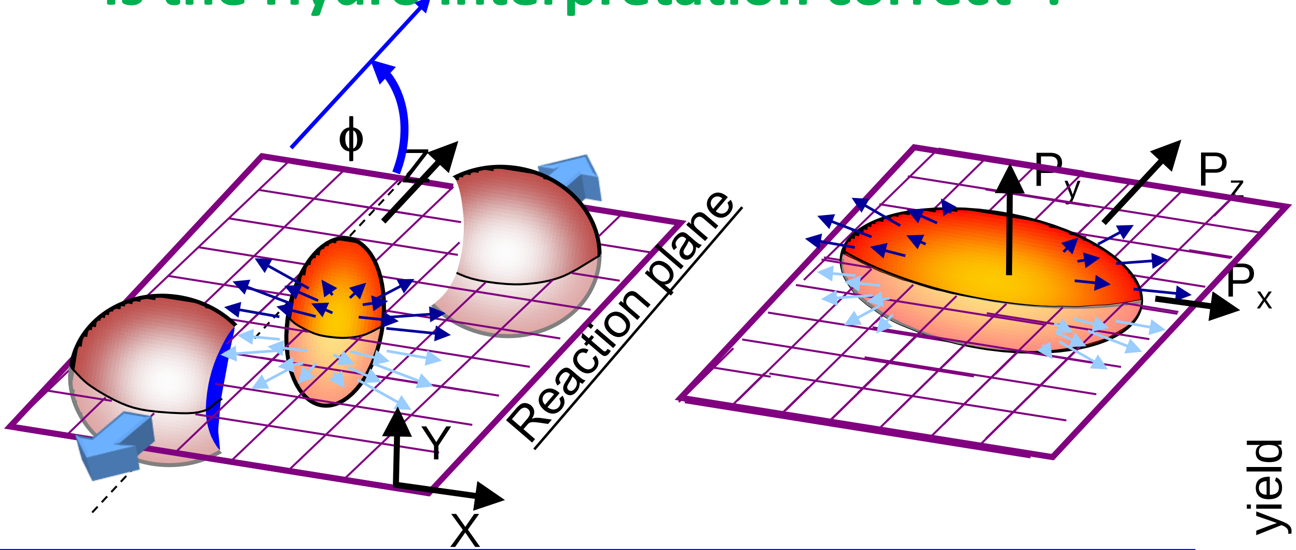
Phys. Rev. Lett. 106, 032301 (2011)

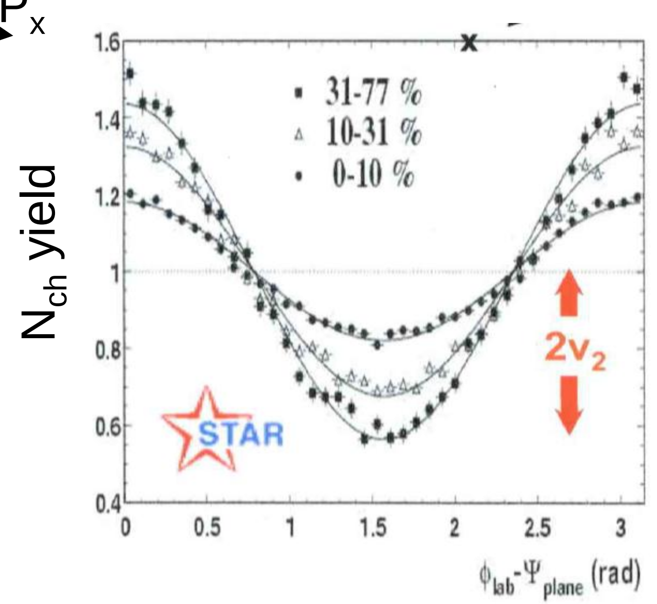




Elliptic Flow

- Elliptic **Flow**: one of the most anticipated answers from LHC
  - **experimental observation:** particles are distributed with azimuthally anisotropic around the scattering plane
  - **Is the Hydro interpretation correct ?**

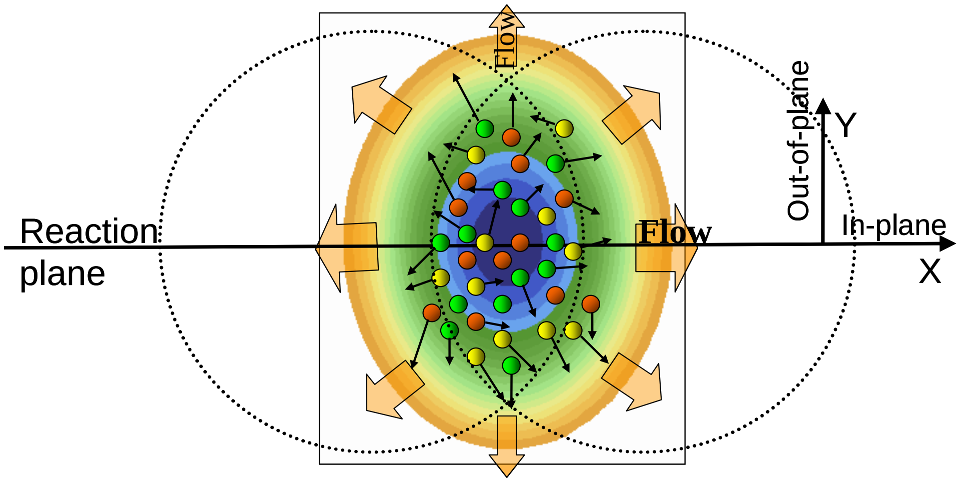




Elliptic Flow v_2 as interpreted by **Hydrodynamics**

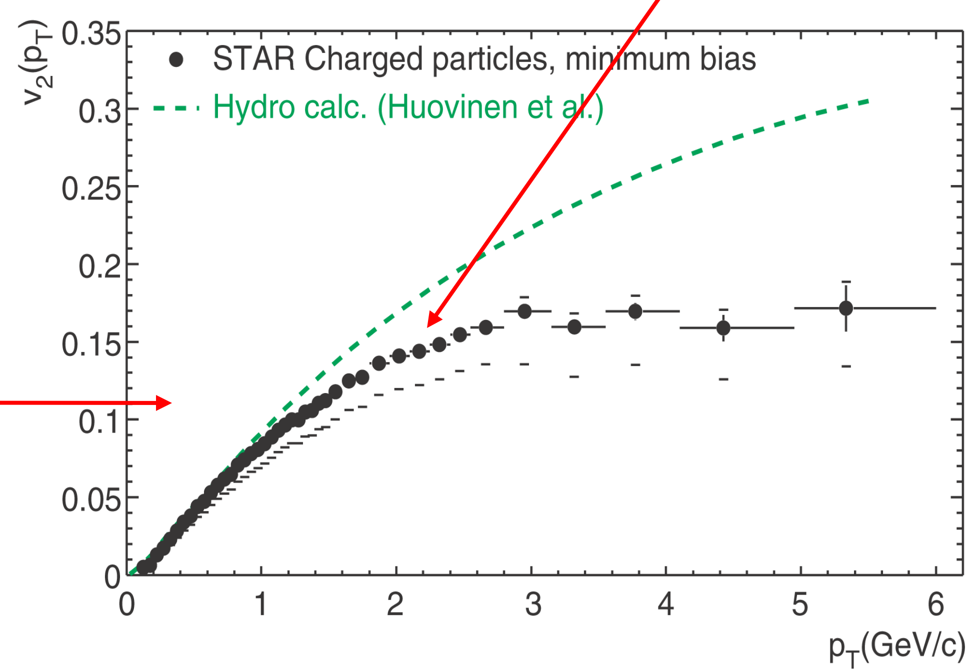
Pressure gradient converts spatial anisotropy → momentum anisotropy → particle yield anisotropy

RHIC: “Perfect Liquid”?



- Transfer of spatial asymmetry to momentum space provides a measure of the strength of collective phenomena

$$\frac{dN}{p_T dp_T dy d\varphi} = \frac{1}{2\pi} \frac{dN}{p_T dp_T dy}\left(1 + 2v_1 \cos(\varphi) + 2v_2 \cos(2\varphi) + \dots\right)$$

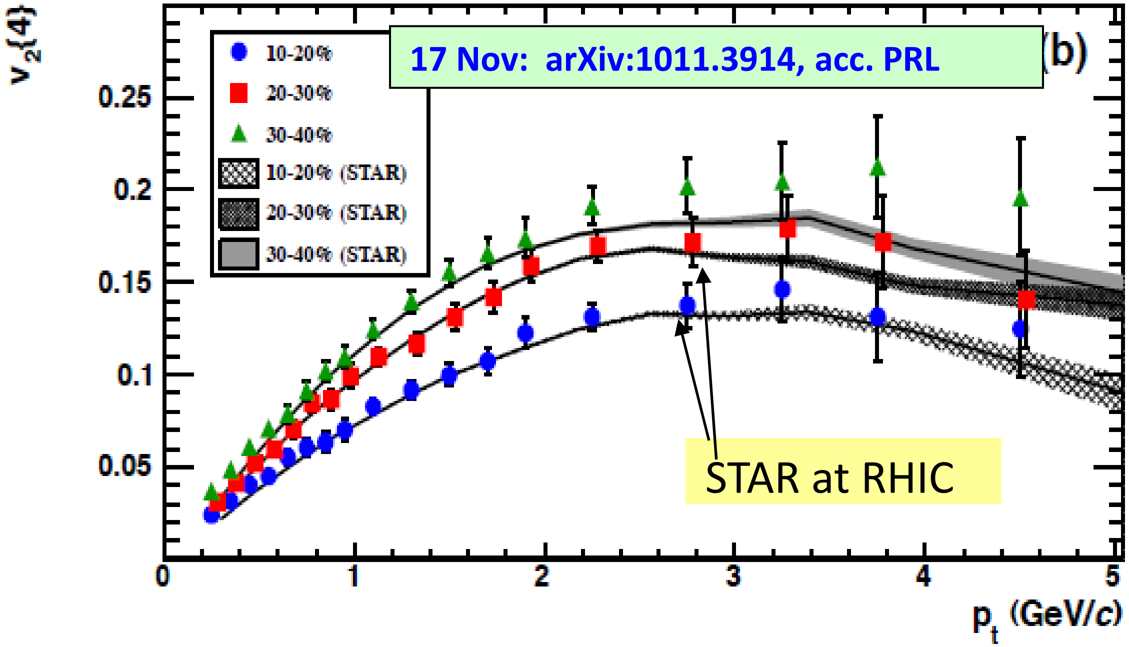


- at low p_T: azimuthal asymmetry as large as expected at hydro limit

First Elliptic Flow Measurement at LHC

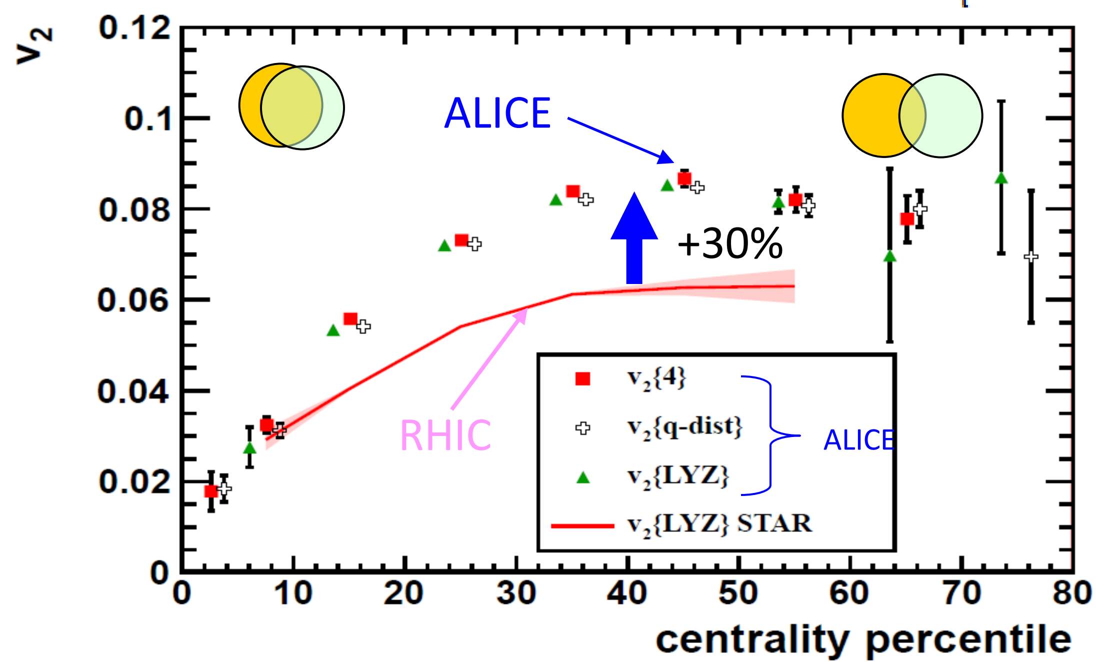
v_2 as function of p_t

- **practically no change with energy !**
  - extends towards larger centrality/higher p_t



v_2 integrated over pt

- **30% increase from RHIC**
- $<p_t>$ increases with √s
- Hydro predicts increased 'radial flow'
  - very characteristic p_t and mass dependence; **to be confirmed !**



Jet Quenching

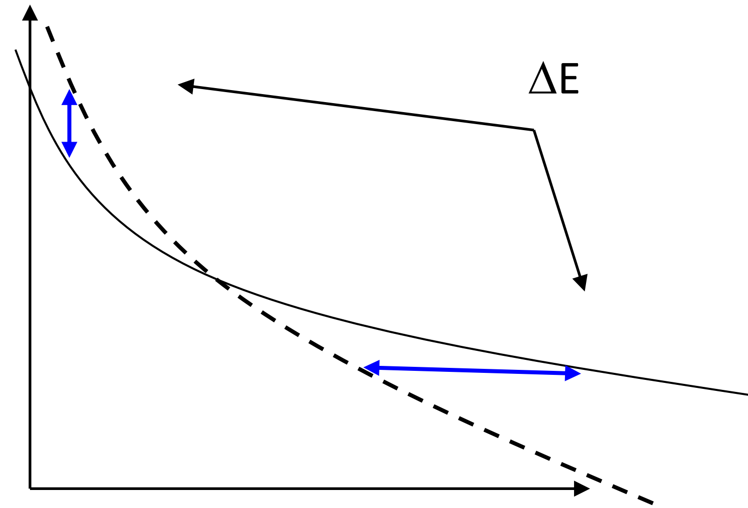
- Jet quenching:
- **jet E -> jet E' (=E-ΔE) + soft gluons (ΔE)** **modified jet fragmentation function** via matter induced gluon radiation/scattering

  → probe of QGP properties

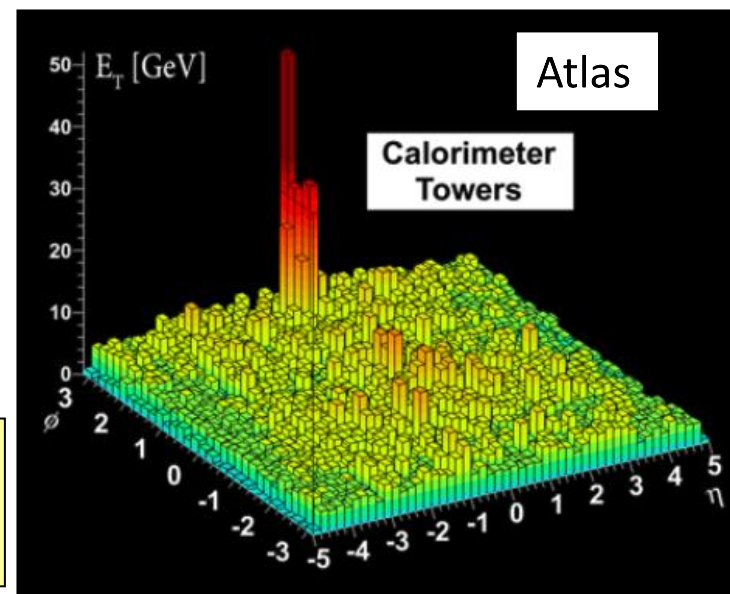
  – **how much energy is lost ?**
    - may depend on jet cone R, p_t-cutoff, ..

  – **how is it lost ?**
    - (e.g. multiple soft or few hard gluons ?)

  – **'response of QGP'**
    - shock waves, Mach cones



Fragmentation function f(z)

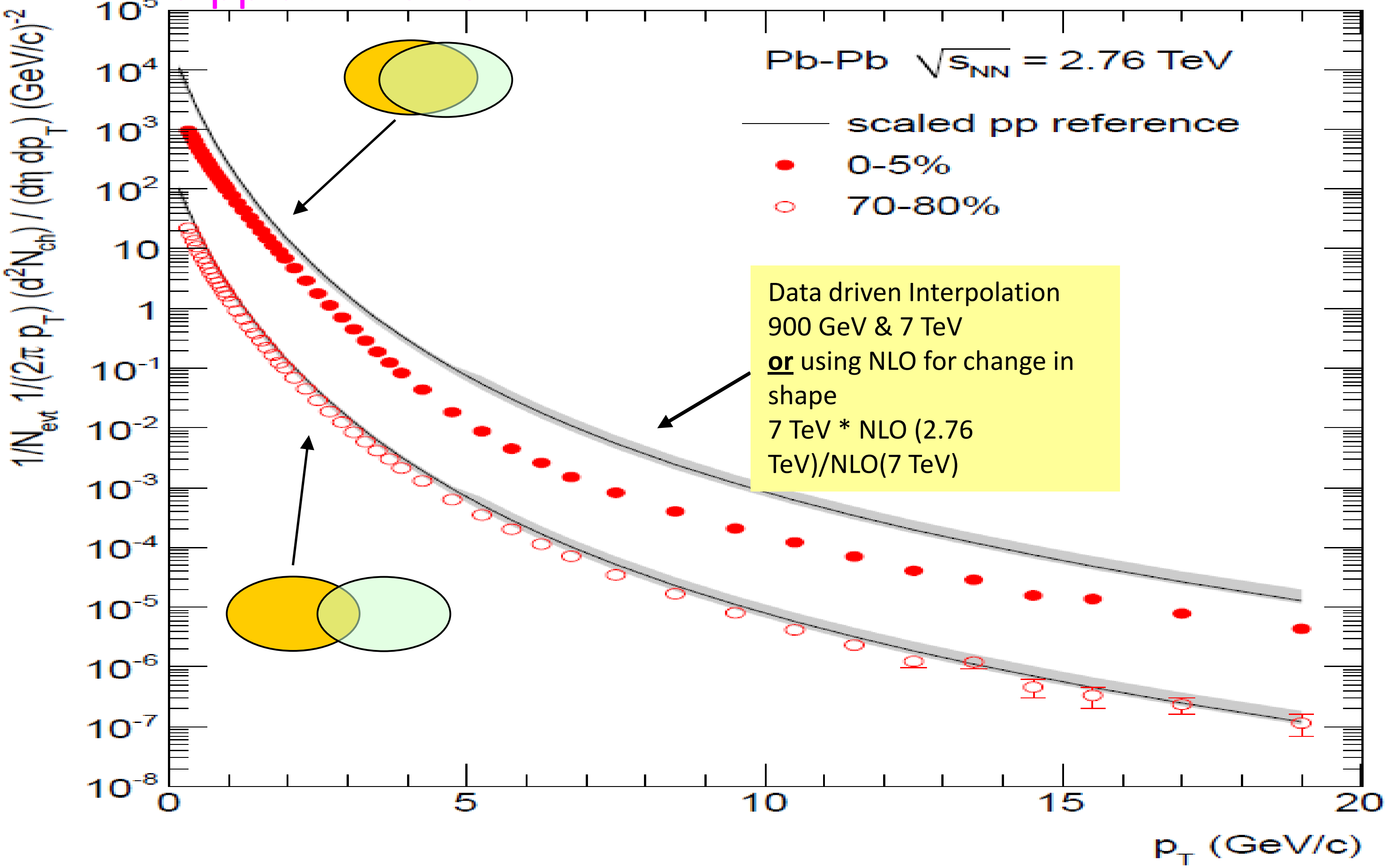


Both Atlas and CMS see very striking effects in the dijet-imbalance for central events !

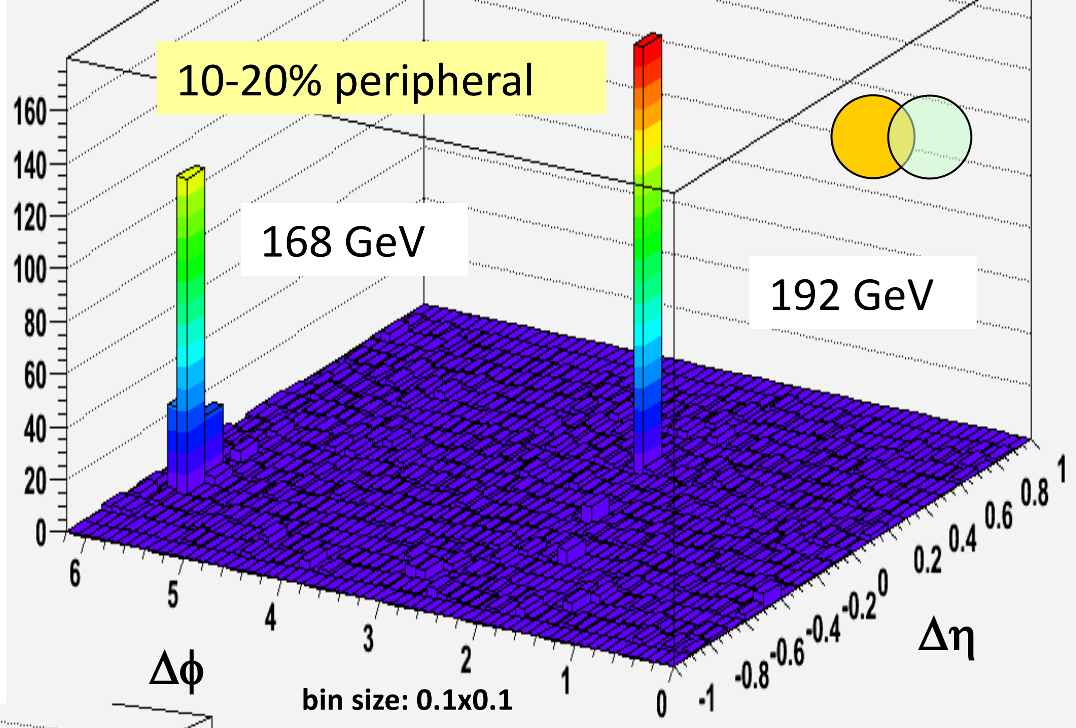
Jet Quenching as seen by p_t spectra

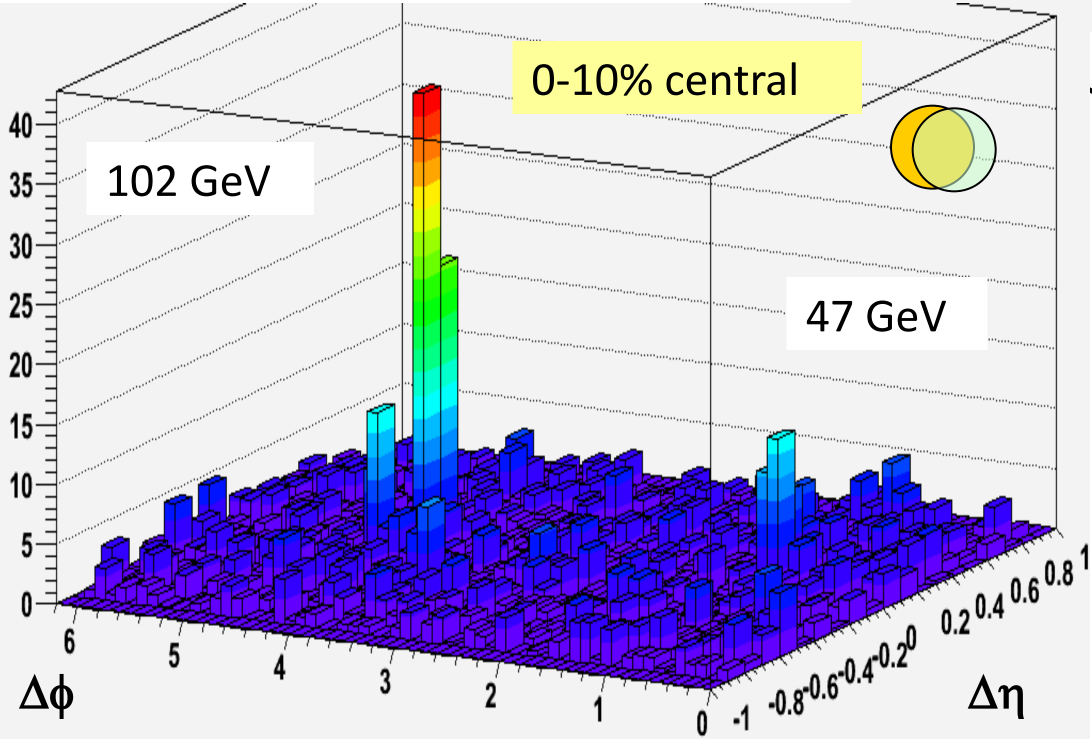
Suppression of high p_t particles (~ leading jet fragments)

- Min. R_{AA} ~ 1.5 – 2 x smaller than at RHIC
- Rising with p_t ! (ambiguous at RHIC !)
- accuracy limited by pp reference
  => need pp at 2.76 TeV



Charged Jets



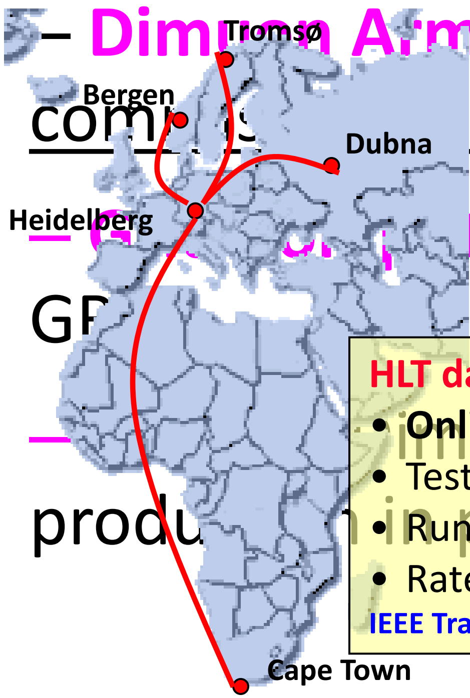


Jets in ALICE (TPC)

- qualitatively similar effect seen
- quantitative analysis is ongoing
  - small acceptance (statistics), => need full 2010 data
  - try to include low p_t (study p_t-cut off dependence of imbalance)

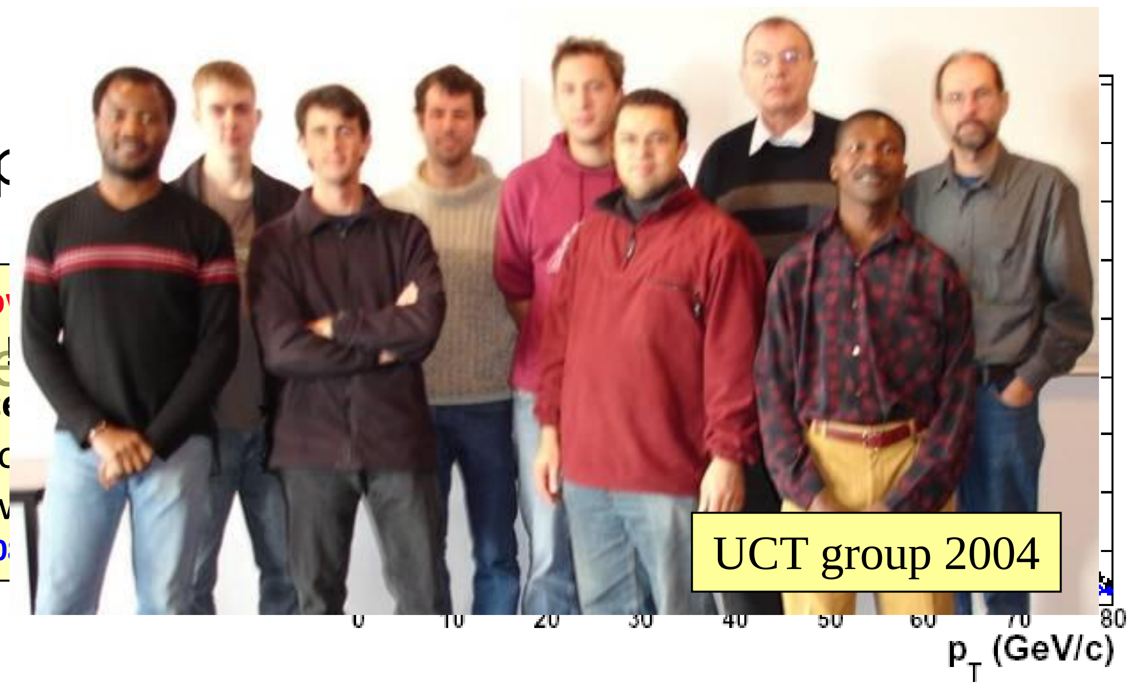
Participation of SA in ALICE

- Cape Town in ALICE: currently 6 senior staff + several students
  – **UCT** joined **2001**, became **UCT-CERN** research center in **2003**
  – **iThemba LABS** joined in **2008**
- Projects
  – **Dim**... **A**...**m:** algorithms for online High Level Trigger (dHLT, com... in 2008)
  – ...**ting:** Comp...
  GR...
  – ...imuon studie...
  produ... in pp,...



HLT data challenge: Nov...
- **Online test** on 'Grid' ...
- Test **latency toleranc**...
- Run stable for > 15 h...
- Rate limited by band...

IEEE Trans.Nucl.Sci.55:703,200...



Outlook on new study:
$W^{\pm}$ production via single muon channel in the forward rapidity region of ALICE: $2.5 < y < 4.0$

- Carried out by teams in SA

Motivation

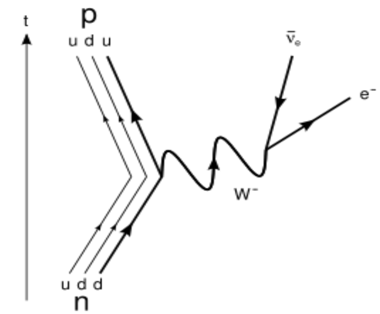
Initial study "W production in pp, PbPb & pPb collisions @ LHC energies: $W^{\pm}$ detection in the ALICE Muon Spectrometer"

Z.Conesa del Valle et al., Eur. Phys. J. C61 (2009) 729-733

Scientific motivation:

- W muons have a high $p_t \sim M_W/2 \Rightarrow W^{\pm}$ as reference for observing QGP induced effects on QCD probes, e.g. suppression of high p_t heavy quarks
- Probe PDF in the Bjorken-x:

  $x \in (10^{-4}–10^{-3}) \Rightarrow 2.5 < y < 4.0$ @ $Q^2 \sim M^2_{W\pm}$
- study nuclear modification of quark distribution, validate binary scaling



$M_W = 80.398 \pm 0.25$ GeV/c^2, electric charge: ± 1 e, spin = 1

weak interactions → change generation of a particle (quark flavour change)

Measurements in the forward rapidity region of ALICE: $2.5 < y < 4.0$, p_t>1 GeV/c, P > 4 GeV/c will be complimentary to those done by ATLAS & CMS @ central rapidity $|\eta| \leq 2.5$, with large p_t > 3-4 GeV/c

Predictions with PYTHIA

Process: 2 → 1, initial and final state radiation $f\bar{f} \to W^{\pm}$

Decay channels : $W \to \mu + \nu_{\mu}$ (10.57 ± 0.15%),

$W \to cX \to ... \to \mu Y$ (33.6 ± 2.6 %)

PbPb collisions @ $\sqrt{s}$ = 5.5 TeV: pp, nn & np combinations.

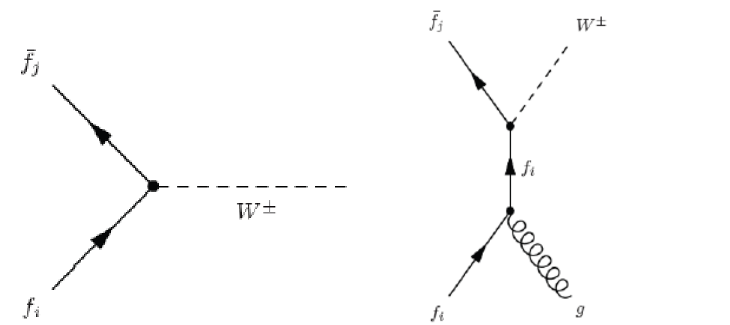
PDF → EKS98 shadowing parameterization K.J Eskola et al Euro. Phys. J. C, 9:61, 1999

Differential cross section - *Frixione* and *Mangano,* Hep-ph/0405130

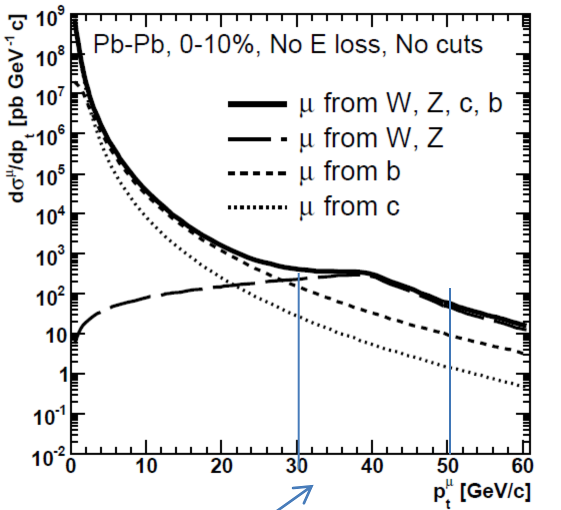
$$\sigma^{th}(W) = \sigma^{\exp}(W) = \frac{1}{BR(W \to \mu)} \frac{1}{\int Ldt} \frac{N^{Obs}}{A_W}$$

$\langle L \rangle_{PbPb} \sim 5 \cdot 10^{32}$ cm^{-2}s^{-1} for t = 10^7 s (~ 0.5 nb^{-1}) G. Martinez, hep-ex/0505021v1 (2005), F. Carminati et al. J. Phys G30, 1517, 2004

$(\sigma_W)_{PYTHIA}$ x $BR_{W\to\mu}$ = 17.3 nb , spectra *normalised to NLO* calculations: $\sigma^{th}(W)_{NLO}$ x $BR_{W\to\mu}$ = 20.9 nb *Lai et al, arXiv:hep-ph/9060399v2,10 Aug 996*

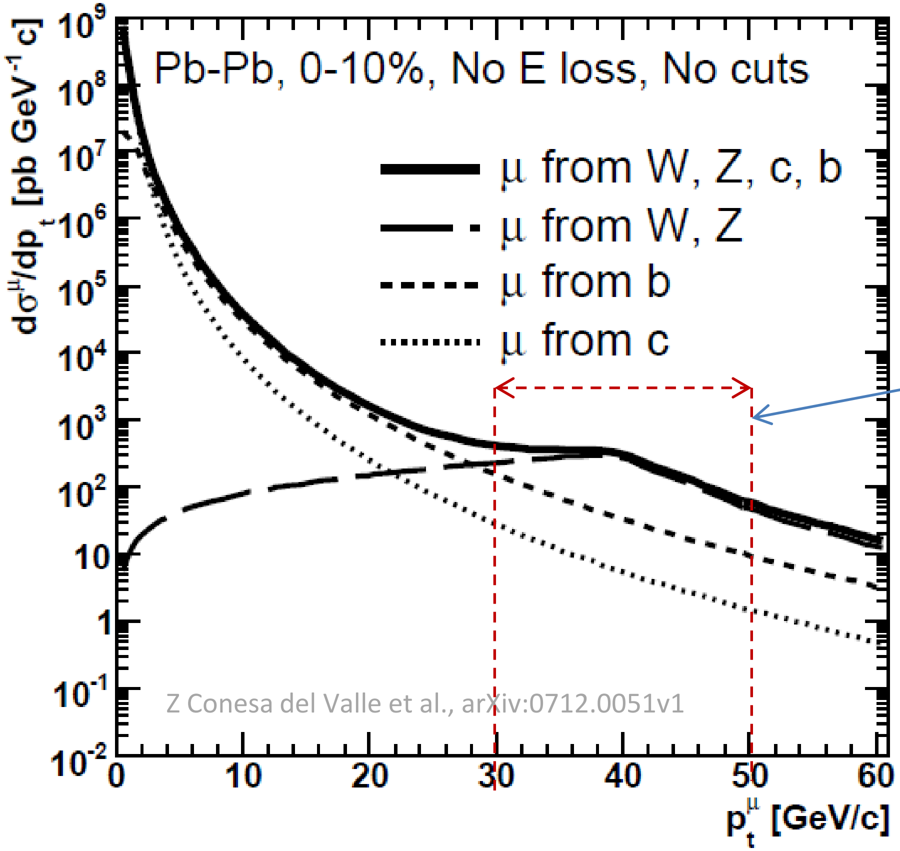


Lowest & 2[nd] order diagrams for W production in hadron-hadron collisions



W muons have a high $p_t \simeq M_W/2 \approx 30 - 50$ *GeV/c. It is estimated that @ p_t =(30, 50) GeV/c the reconstructed yield,* $N_{\mu\leftarrow W}$ = 6.9x10^3 the forward rapidity range: 2.5 < *y* < 4.0 . Z Conesa del Valle et al., arXiv:0712.0051v1

Strategy for $W^{\pm} \to \mu^{\pm}$ production in PbPb collisions with ALICE



- Measure differential cross sections as function of p_t and y in forward region:

$2° < \theta < 9° \Rightarrow 2.5 < y < 4$, pt >1 GeV/c, P > 4 GeV/c

- Subtract background in the p_t region below $p_t \approx M_W / 2 \approx 30–50$ GeV/c.
- Use high level trigger to reject background. J. Phys: Conf. Series 219 (2010) 02244
- Compare single muons ratios: μ^+ / μ^-

$\Rightarrow$ charge asymmetry.

- Extract R_{AA}, R_{CP}.
- Compare with theoretical predictions.

Contributions by the iTL/UCT group to the CERN-SPS experiments
Physics goals of the NA61 experiment (I):

Physics of strongly interacting matter

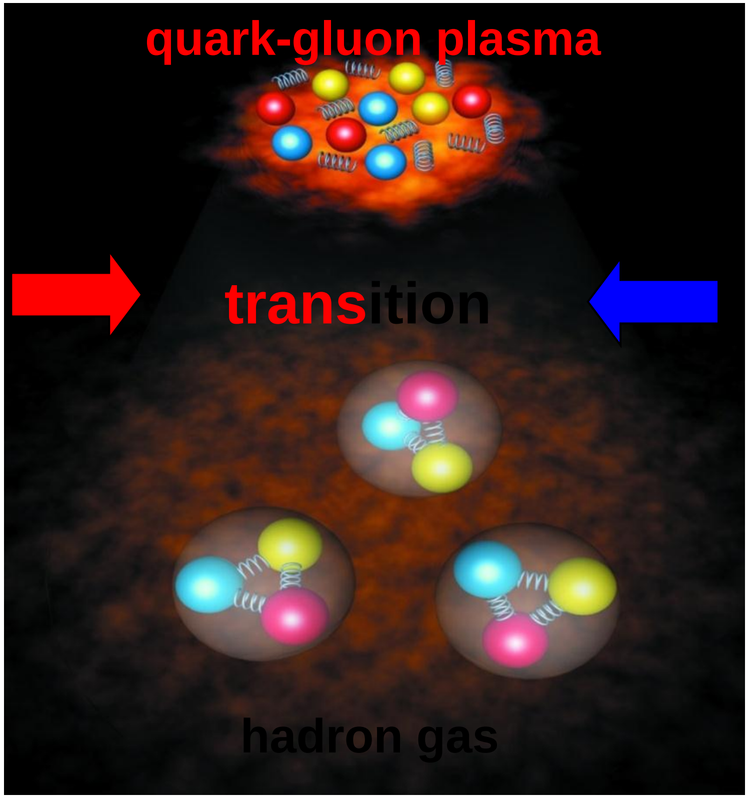
Discovery potential:

Search for the critical point of strongly interacting matter

Precision measurements:

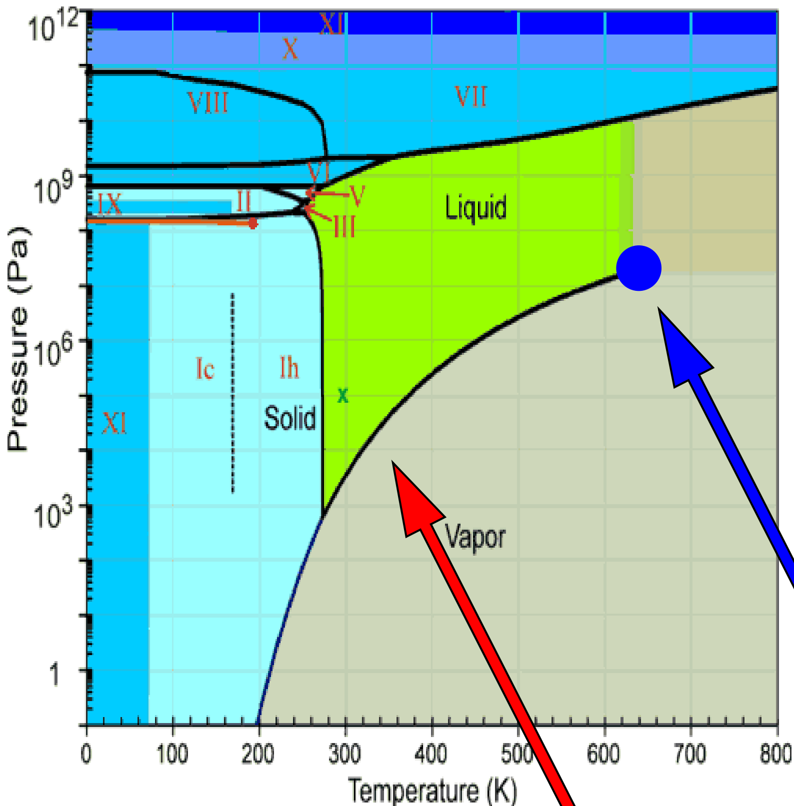
Study the properties of the onset of deconfinement in nucleus-nucleus collisions

Measure hadron production at high transverse momenta in p+p and p+Pb collisions as reference for Pb+Pb results

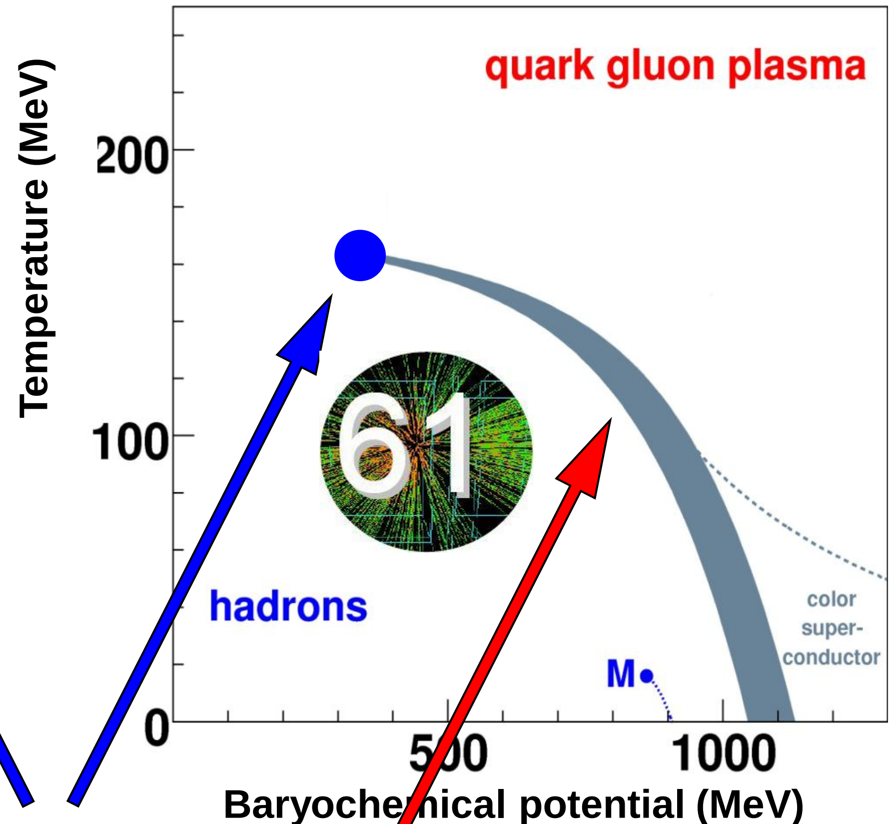


Searching for the critical point

water



strongly interacting matter



critical point

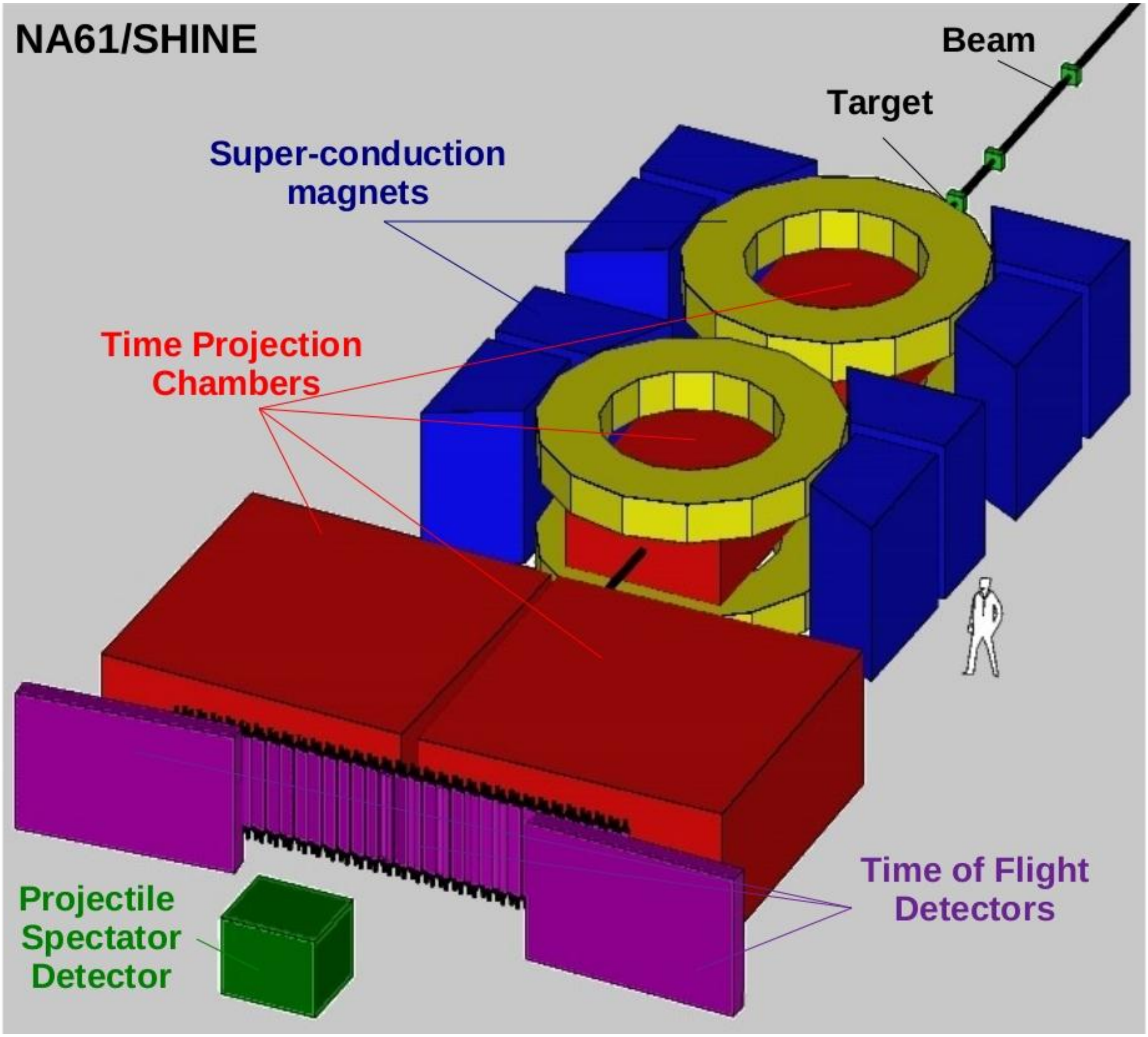
1st order phase transition

The NA61/SHINE Collaboration:

122 physicists from 24 institutes and 13 countries:

University of Athens, Athens, Greece
University of Bergen, Bergen, Norway
University of Bern, Bern, Switzerland
KFKI IPNP, Budapest, Hungary
Cape Town University, Cape Town, South Africa
Jagiellonian University, Cracow, Poland
Joint Institute for Nuclear Research, Dubna, Russia
Fachhochschule Frankfurt, Frankfurt, Germany
University of Frankfurt, Frankfurt, Germany
University of Geneva, Geneva, Switzerland
Forschungszentrum Karlsruhe, Karlsruhe, Germany
Institute of Physics, University of Silesia, Katowice, Poland
Jan Kochanowski Univeristy, Kielce, Poland
Institute for Nuclear Research, Moscow, Russia
LPNHE, Universites de Paris VI et VII, Paris, France
Faculty of Physics, University of Sofia, Sofia, Bulgaria
St. Petersburg State University, St. Petersburg, Russia
State University of New York, Stony Brook, USA
KEK, Tsukuba, Japan
Soltan Institute for Nuclear Studies, Warsaw, Poland
Warsaw University of Technology, Warsaw, Poland
University of Warsaw, Warsaw, Poland
Rudjer Boskovic Institute, Zagreb, Croatia
ETH Zurich, Zurich, Switzerland

Detector

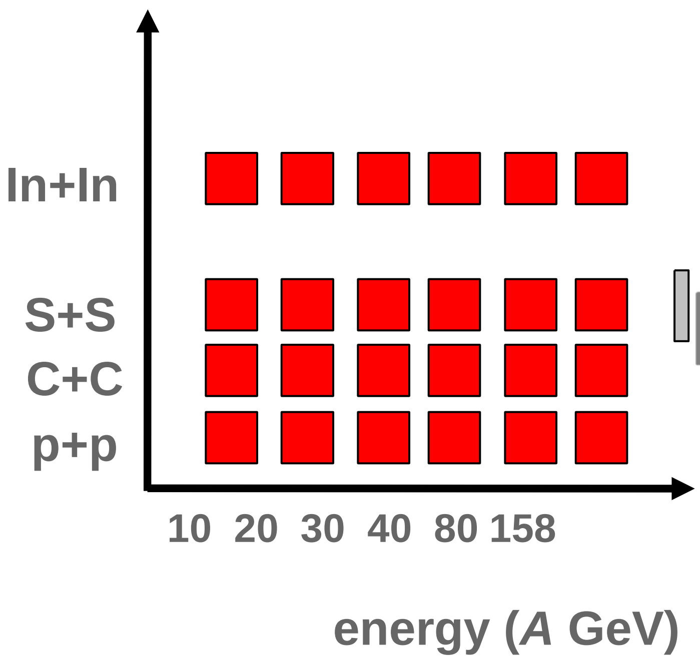


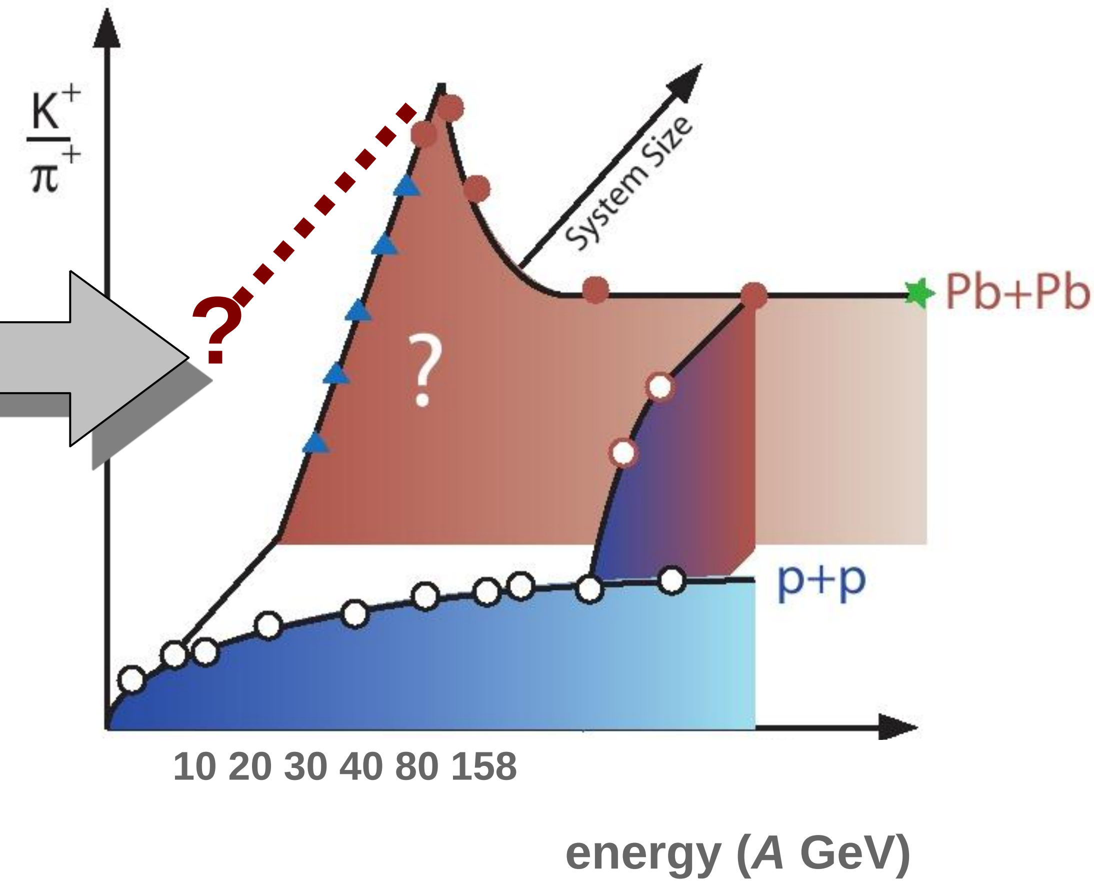
NA49 facility +

TPC read-out (x10)
ToF (x2)
PSD (x10)
Beam pipe (x10)

NA49: Nucl. Instrum. Meth. A430, 210 (1999)
NA61 upgrades: CERN-SPSC-2006-034, SPSC-P-330

Study the onset of deconfinement

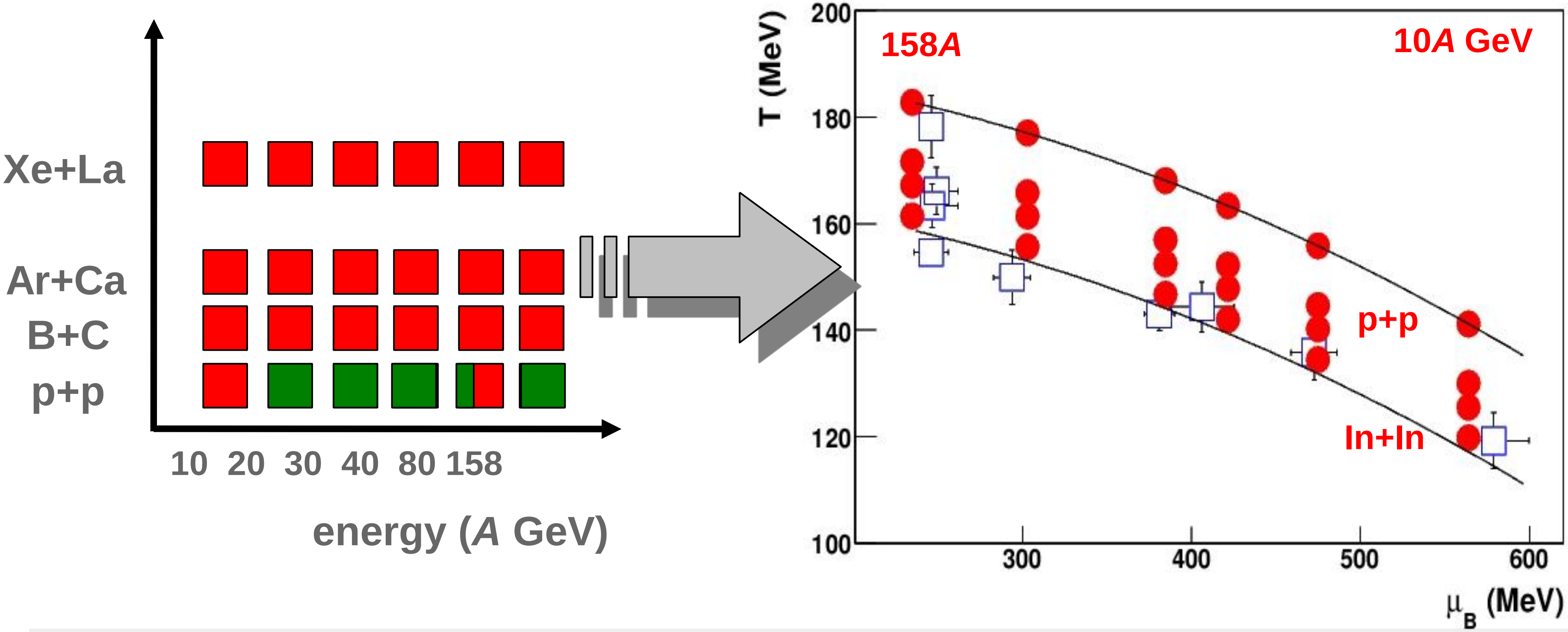


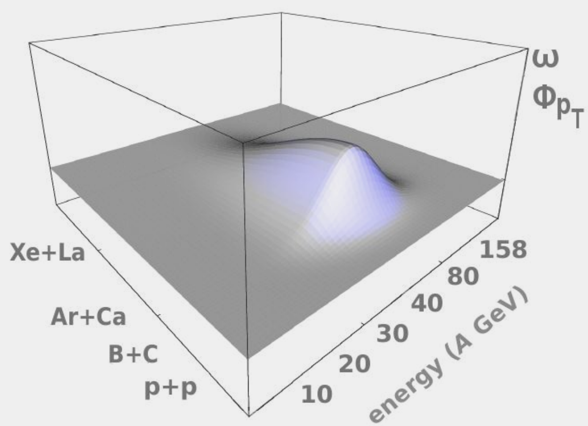


Search for the onset of the horn in collisions of light nuclei

Precision measurements following the NA49 discovery

Searching for the critical point

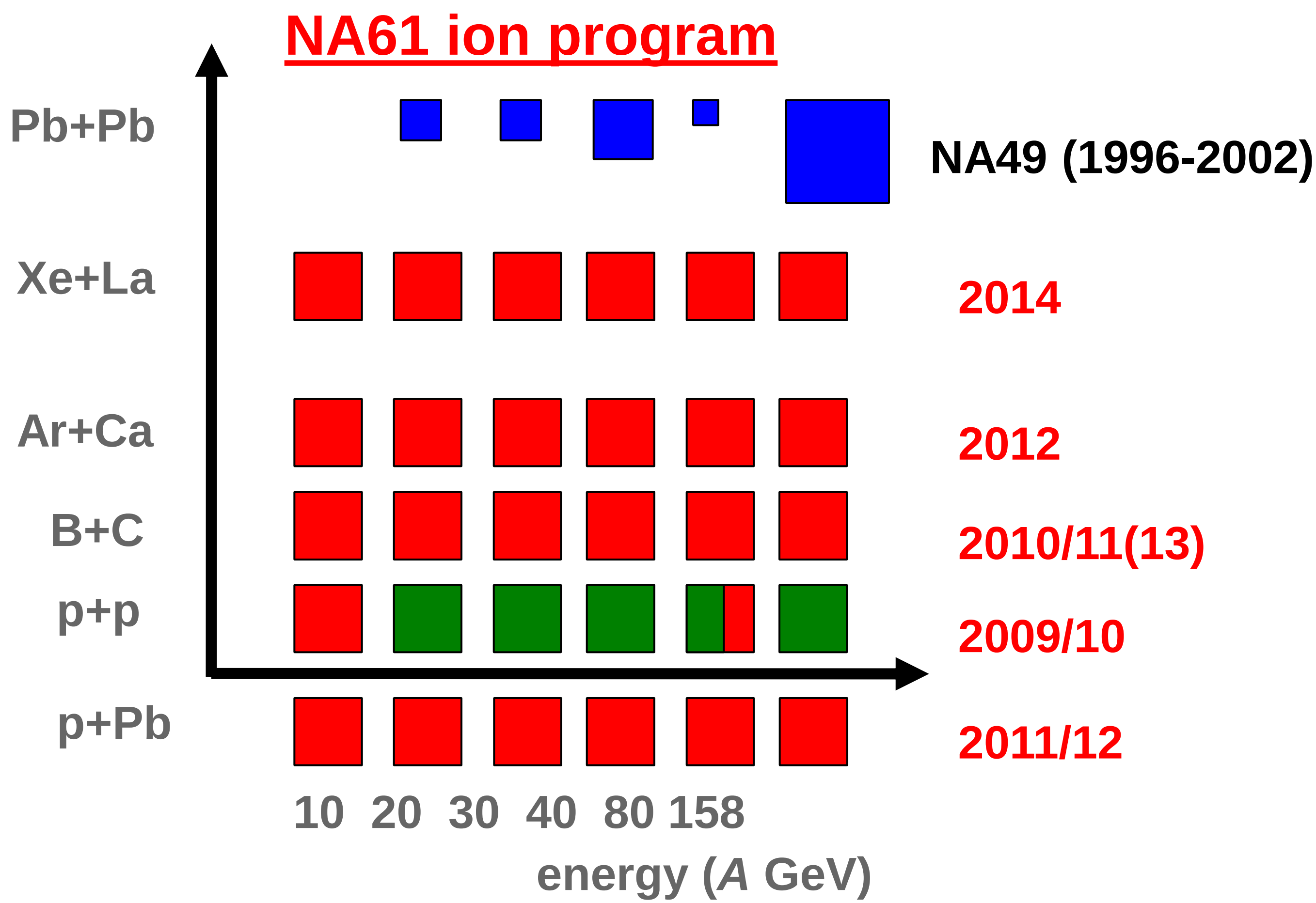




Search for the hill of fluctuations

Discovery potential

Revised data taking schedule with ion beams



The first 2D scan in history of A+A collisions

The NA61 revised data taking plan

	Beam Primary	Beam Secondary	Target	Energy (A GeV)	Year	Duration days/MDs	Physics	Status
	p	p	p	400 158	2010	77 d	High p_T	*recommended*
FR test-1	Pb	^{11}B	none	20,80 20,80	2010	10 MDs	FS test-1	*to be discussed*
	p	p	Pb	400 158	2011	77 d	High p_T	*recommended*
secondary (FR test-2)	Pb	^{11}B	C	10,20,30,40,80,158 10,20,30,40,80,158	2011	20 d	FS test-2	*to be discussed*
	p	p	Pb	400 10,20,30,40,80,158	2012	6x8 d	CP,OD	*recommended*
primary	Ar		Ca	10,20,30,40,80,158	2012	6x8 d	CP,OD	*recommended*
(secondary)	Pb	^{11}B	C	10,20,30,40,80,158 10,20,30,40,80,158	2013	6x10 d	CP,OD	*to be discussed*
primary	Xe		La	10,20,30,40,80,158	2014	6x8 d	CP,OD	*to be discussed*

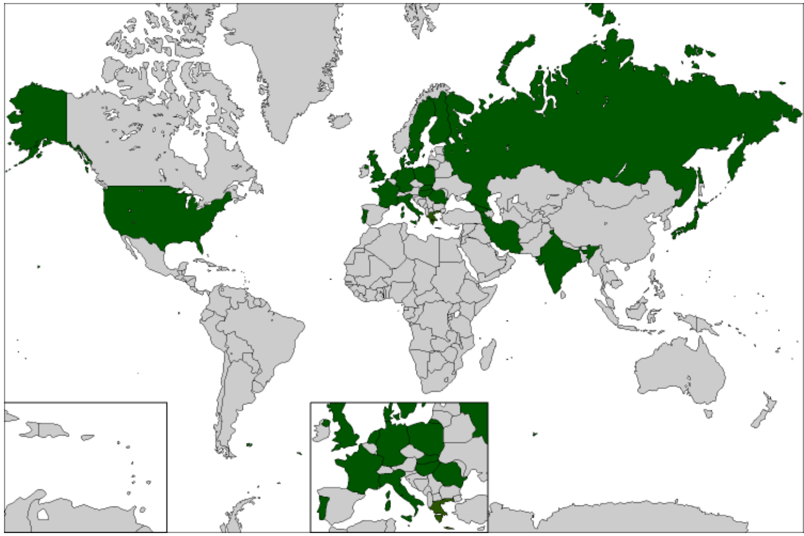
iThemba LABS comes into the party

Grenoble Test Source 2 (GTS2)at iThemba LABS

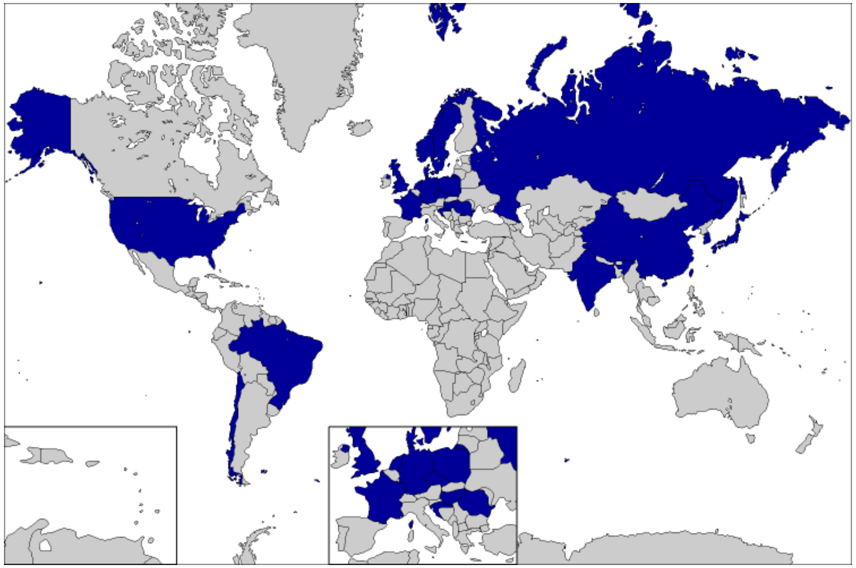
iThemba LABS is in the process of assembling an electron cyclotron resonance ion source (ECRIS GTS2) that was designed by CEA in Grenoble, France, but not manufactured by them, because that division closed down. iThemba LABS bought the design drawings of the source from them and is now in the final stage of assembling the source. This source is the only other source that is based on the same design as the heavy-ion ECRIS used at the Large Hadron Collider (LHC) facility at The European Organization for Nuclear Research (CERN) facility in Europe, and subsequently a collaboration agreement was proposed by CERN. A Letter of Intent was signed between iThemba LABS and CERN to outline the terms and conditions of the collaboration agreement, which involves the initial commissioning of the GTS2 ECRIS at iThemba LABS, followed by the study of specific heavy-ion beams as requested by the fixed target experiment (NA61) group at CERN. The aim will be to find the optimal source settings and to characterize the source behavior for these specific ion species..

From the Bevelac to the LHC:

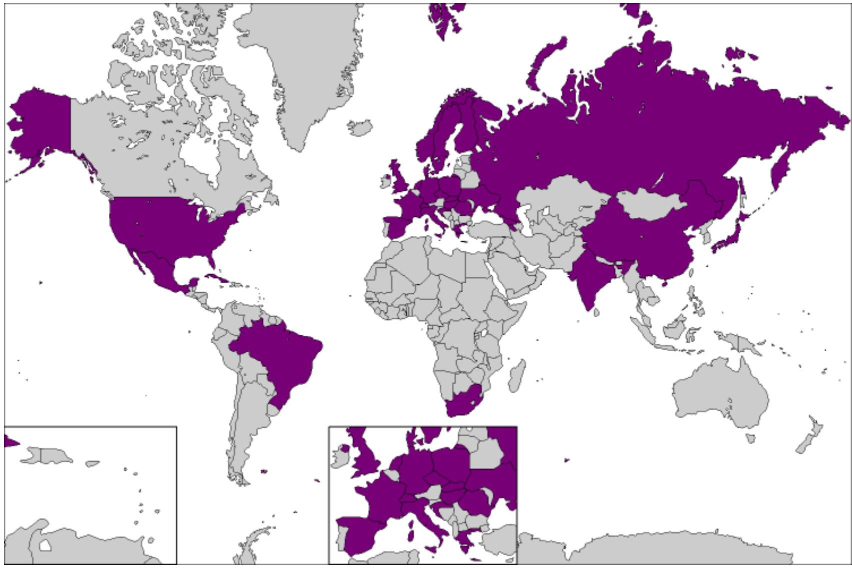
AGS



SPS



RHIC



Heavy Ions at LHC

Hoping to see some of you joining (and /or) working with some of you across the African continent

The End