ALICE experiment on the threshold of wonderland

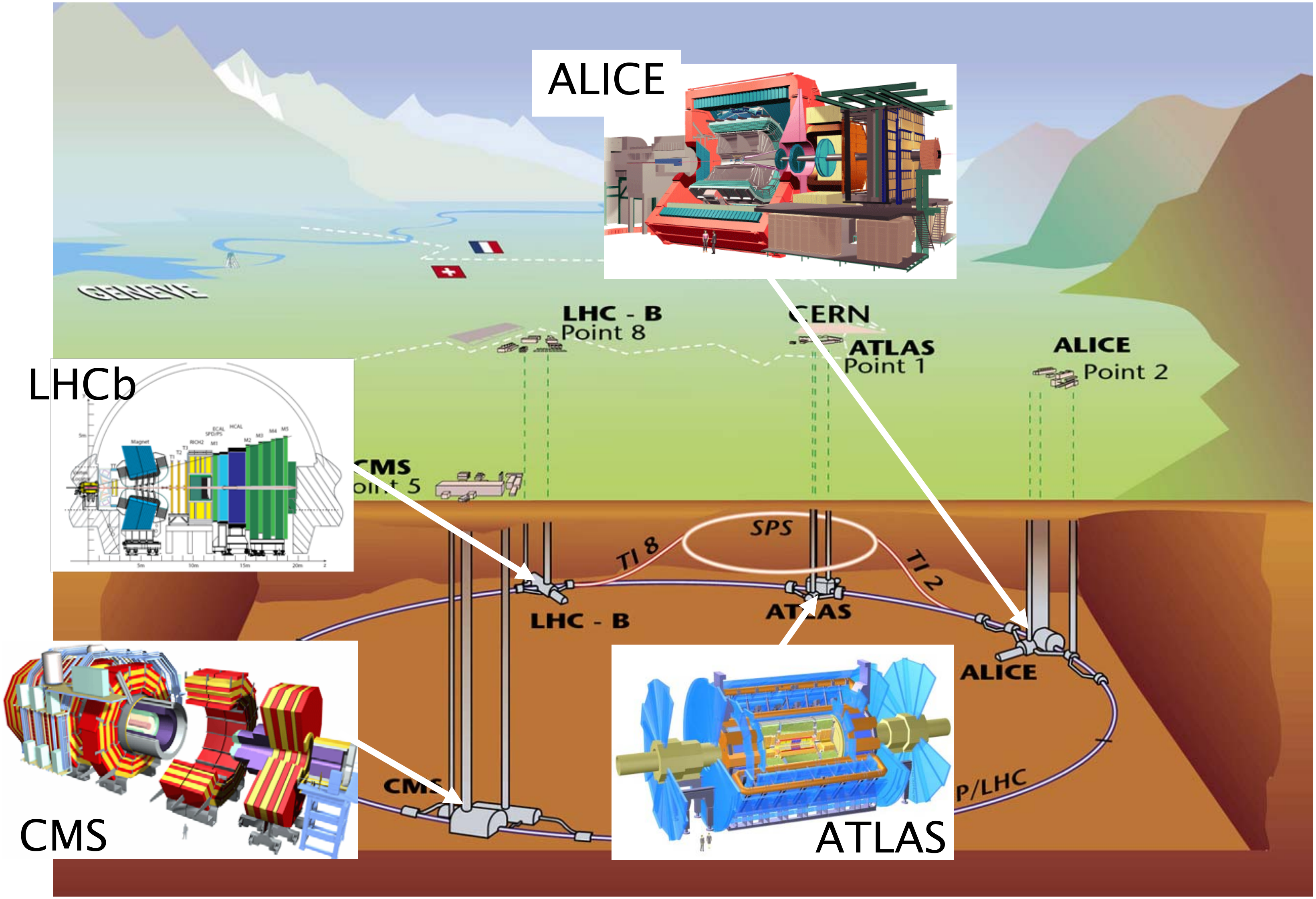
Dariusz Miśkowiec
GSI Darmstadt

Quarks and Hadrons in Strong QCD
415th Wilhelm & Else Heraeus Seminar
St. Goar, March 2008

- LHC and ALICE
- first physics in pp
- first physics in PbPb
- schedule and news

LHC experiments

main colliding systems: p+p sqrt(s)=14 TeV   and   Pb+Pb sqrt(s)=5.5 TeV



physics questions at LHC

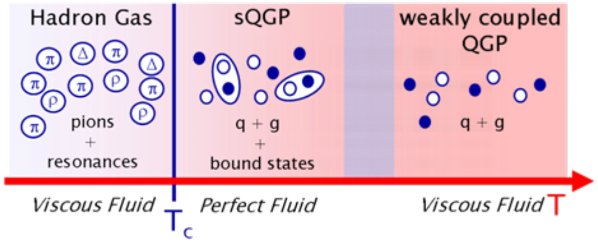
ATLAS, CMS, LHCb:
electroweak symmetry breaking
origin of mass of quarks and gauge bosons
supersymmetric particles
CP violation

ALICE:
chiral symmetry breaking
origin of mass of hadrons
deconfinement
hadronization

ALL:
understanding high energy nuclear interactions
(input needed for cosmic ray studies)

ALICE programme

mission:
create quark-gluon matter
study its properties quantitatively
be prepared for unexpected = be versatile



methods:
spectra and correlations of various particles

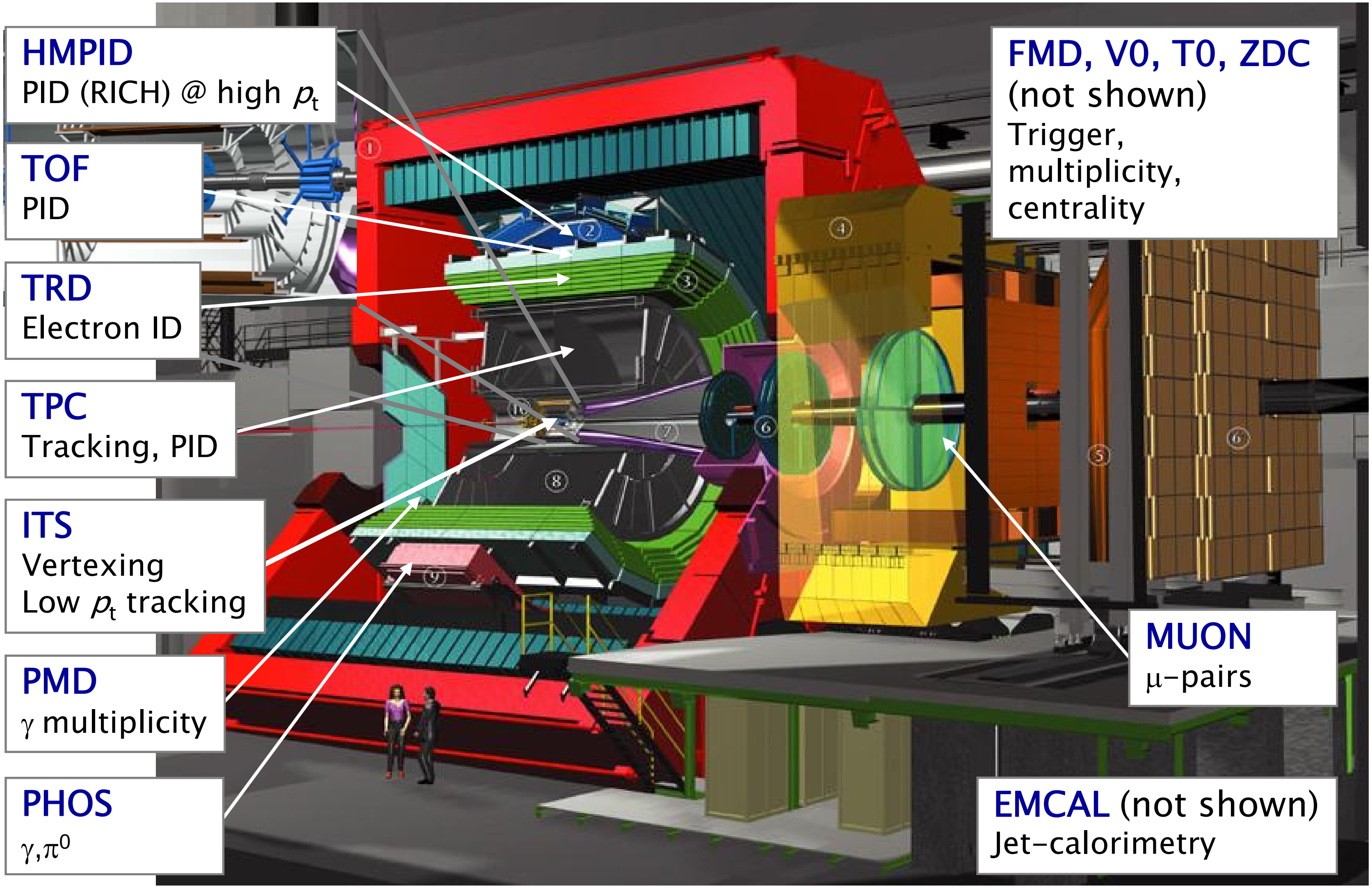
e.g. heavy quarks (open beauty, upsilon-states)
jets in heavy ion environment
weakly interacting probes (Z^0, $W^\pm$)

special at LHC:
higher energy density
larger system
more heavy quarks and jets
weak probes W/Z available
access to lower x

	SPS	RHIC	LHC
$\sqrt{s_{NN}}$ (GeV)	17	200	5500
dN_{ch}/dy	~450	~850	1500-4000
ε(GeV/fm^3)	3	5	15-60
τ_{QGP} (fm/c)	≤ 2	2-4	≥ 10

Alice Detector

height: 16 m ***length 26 m*** ***weight: 10,000 tons*** ***price: 10 € / kg***



HMPID
PID (RICH) @ high p_t

TOF
PID

TRD
Electron ID

TPC
Tracking, PID

ITS
Vertexing
Low p_t tracking

PMD
γ multiplicity

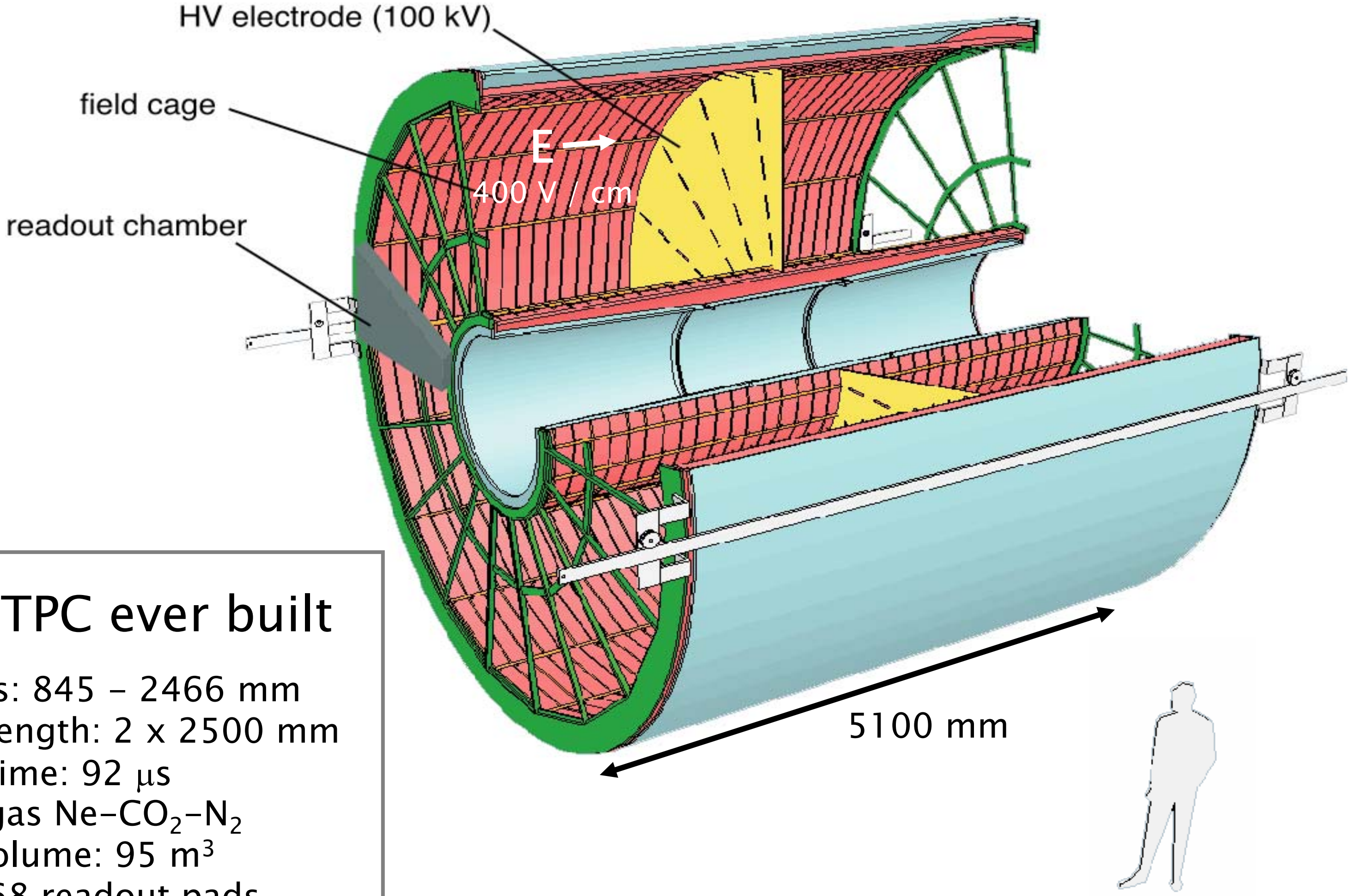
PHOS
γ,π^0

FMD, V0, T0, ZDC
(not shown)
Trigger,
multiplicity,
centrality

MUON
μ–pairs

EMCAL (not shown)
Jet–calorimetry

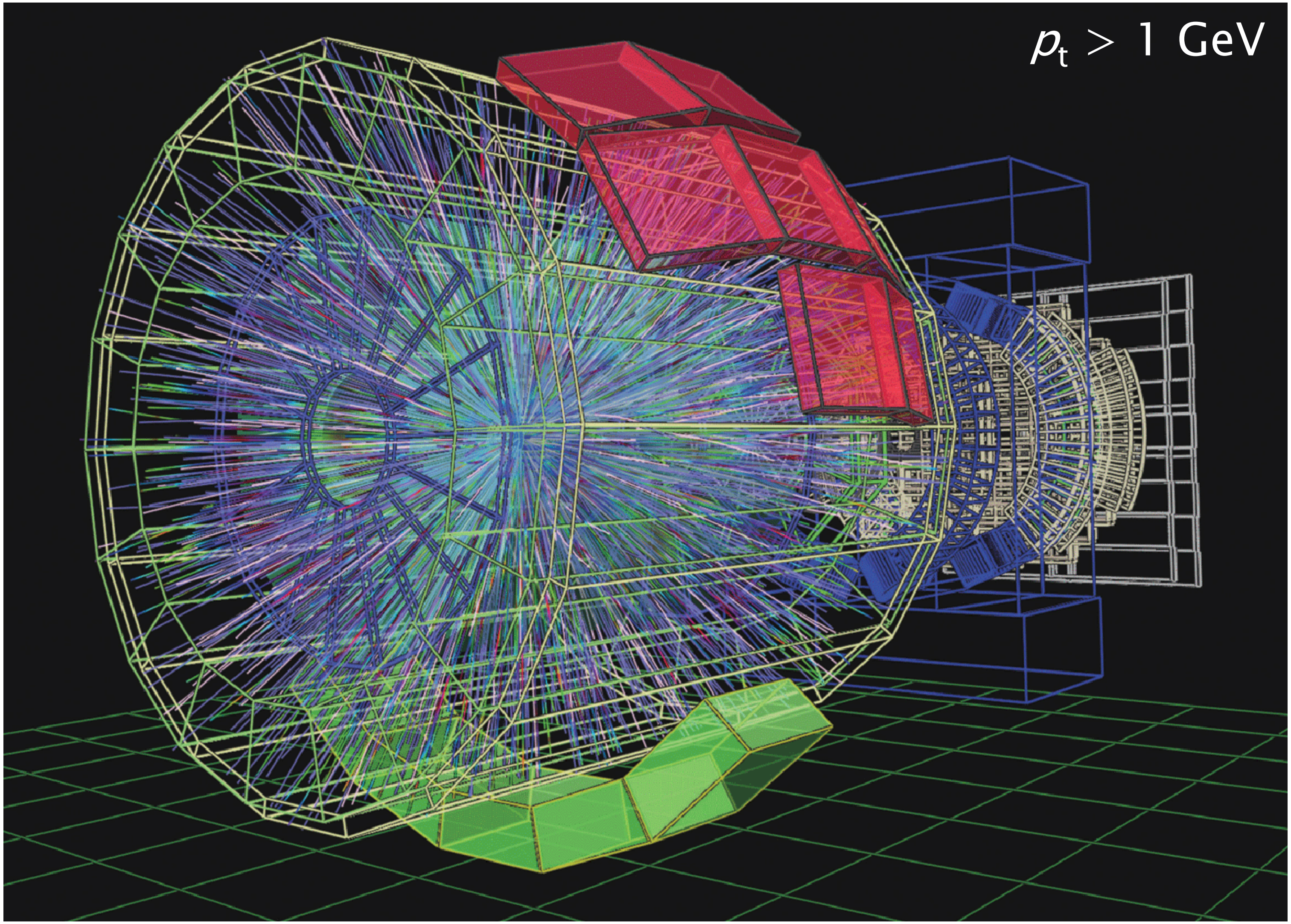
Time Projection Chamber (TPC)



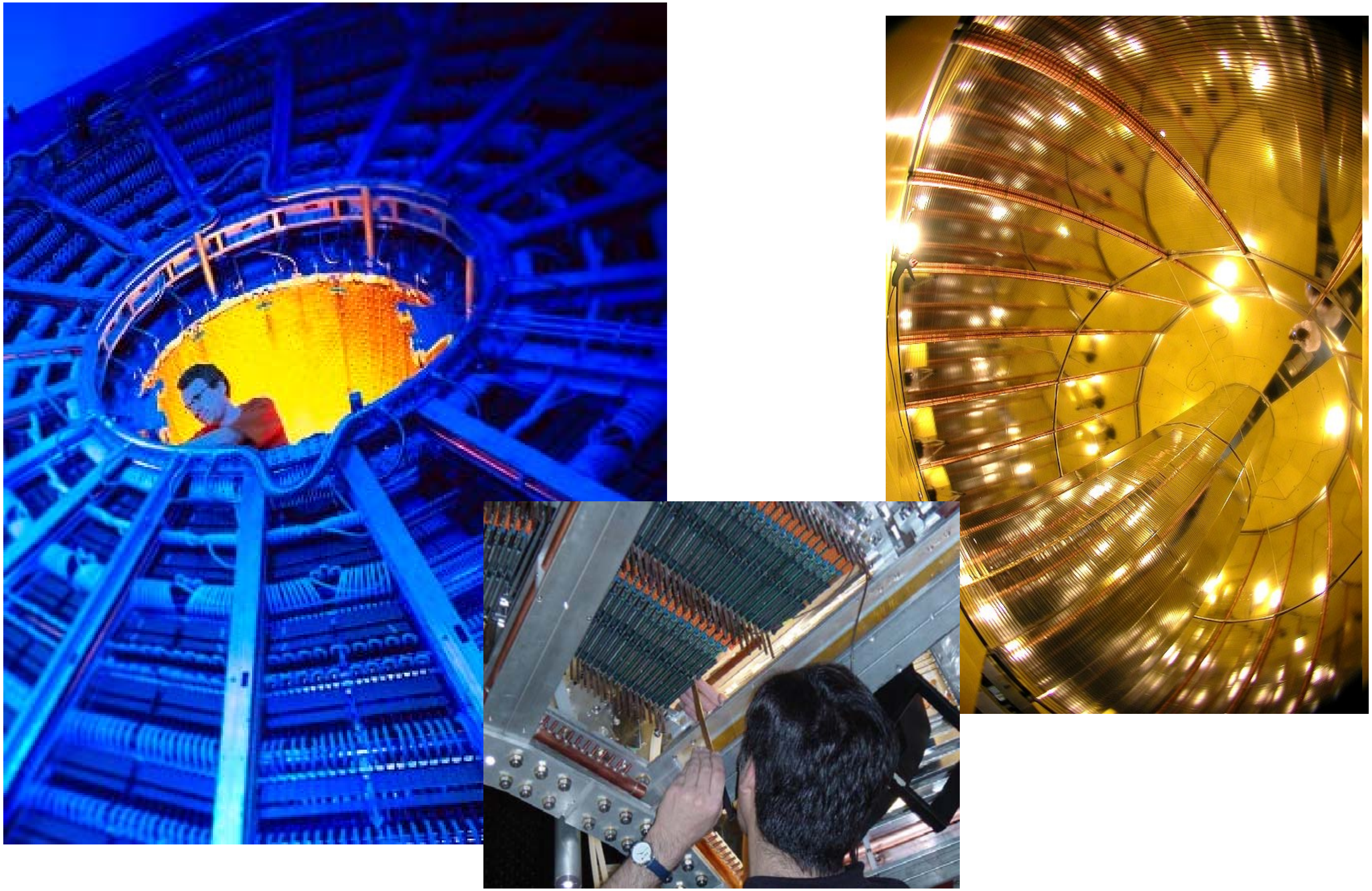
Largest TPC ever built

Radius: 845 – 2466 mm
Drift length: 2 x 2500 mm
Drift time: 92 μs
Drift gas $Ne-CO_2-N_2$
Gas volume: 95 m^3
557568 readout pads
Material: ($\eta=0$) 3% X_0

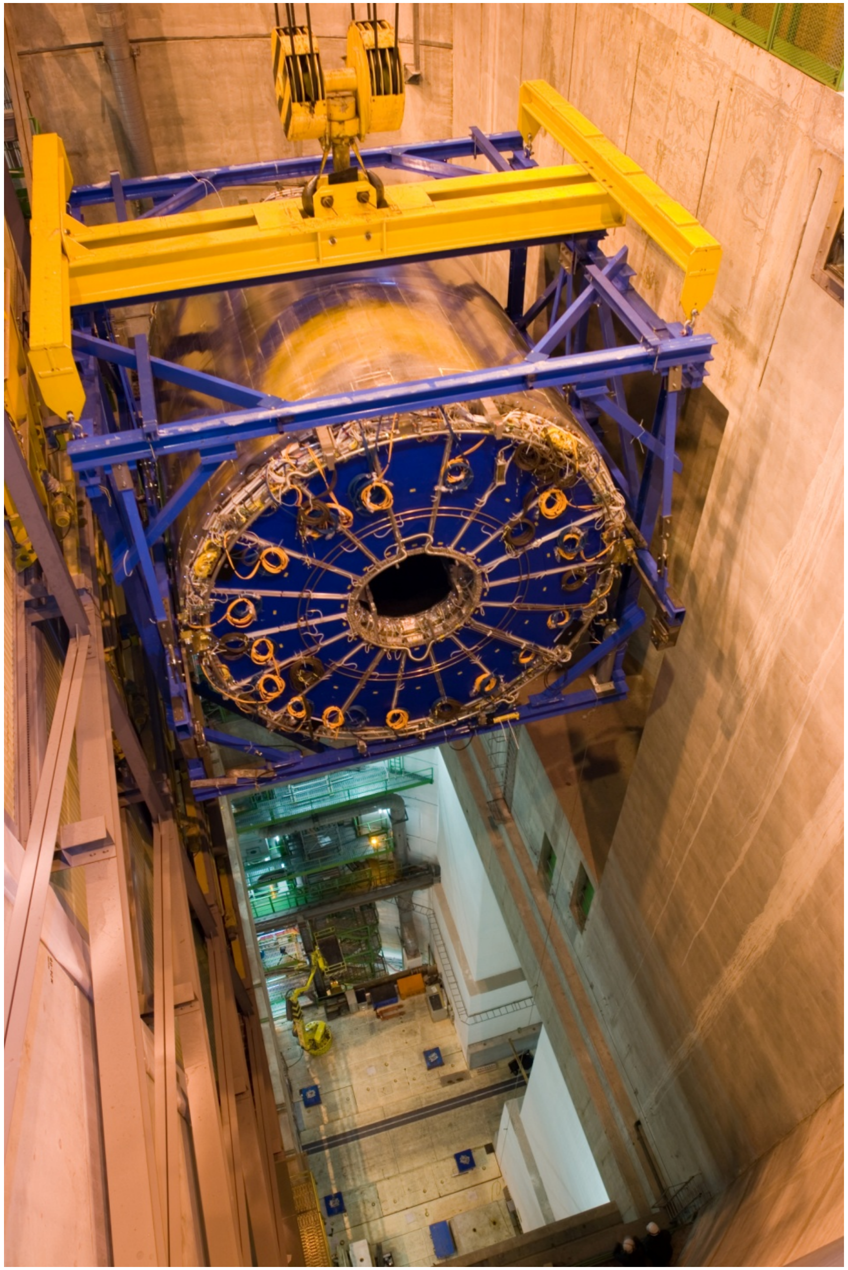
ALICE Event Display



TPC assembly



Lowering and insertion of ALICE TPC (15/01/07)



Transition Radiation Detector (TRD)

Purpose:

Electron-ID

Quarkonia → e^+e^-
Heavy flavour

Some numbers:

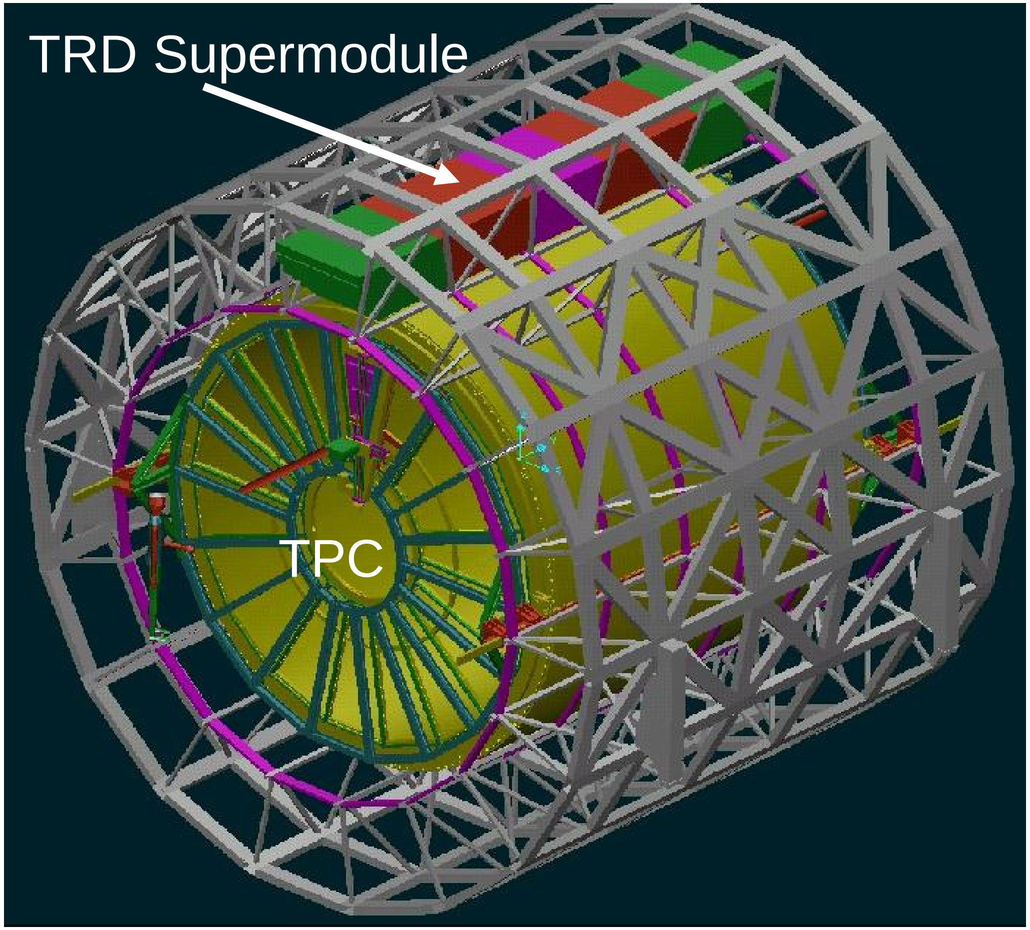
540 chambers

Total area: 736 m^2
(3 tennis courts)

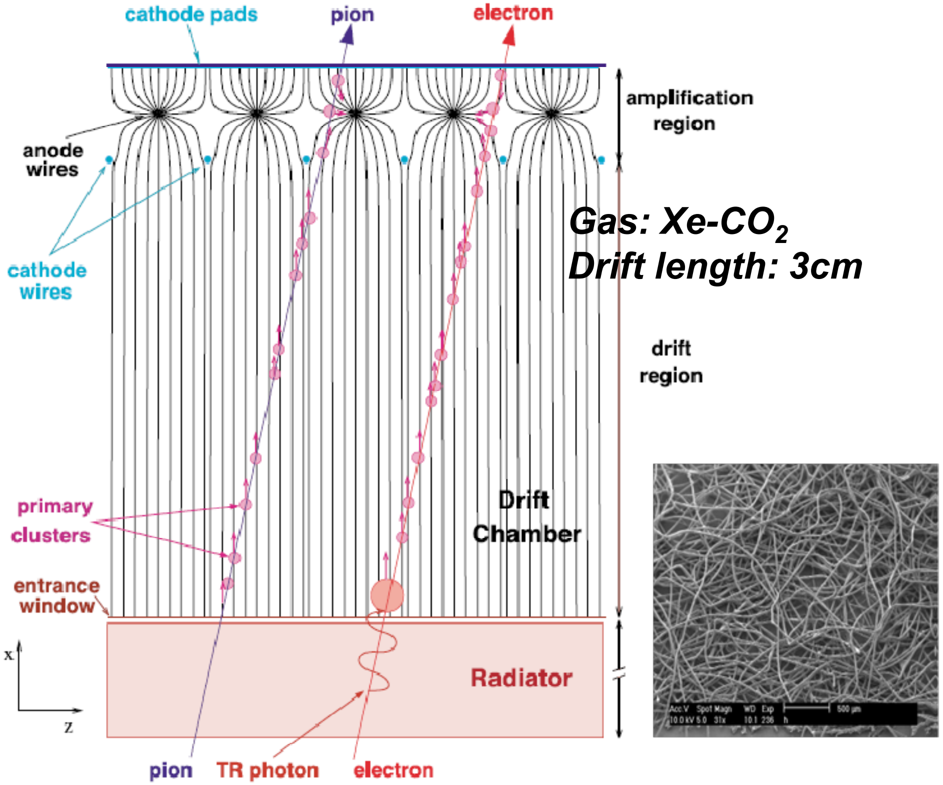
Gas volume: 27.2 m^3

Resolution
($r\varphi$) 400 μm

Number of read out channels: 1.2×10^6



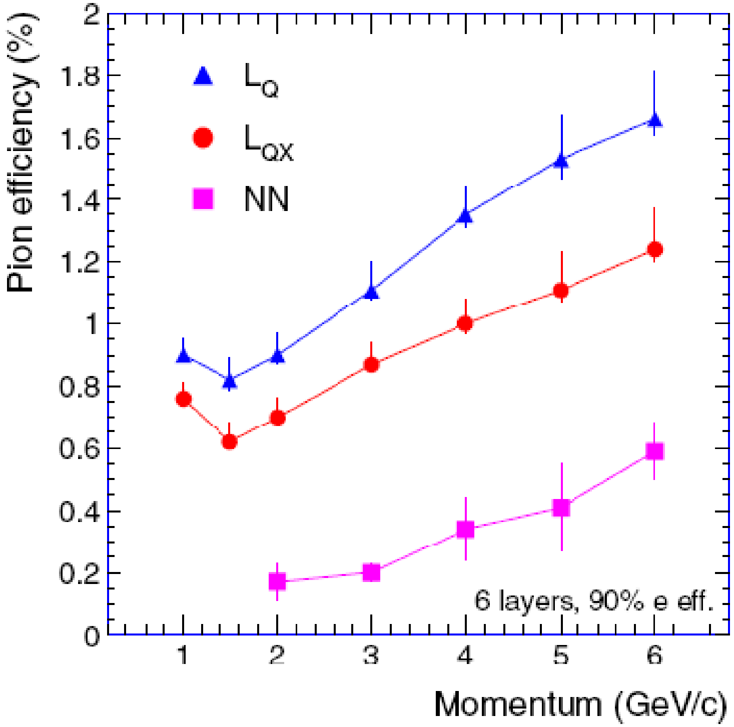
Transition Radiation Detector (TRD)



Gas: Xe-CO$_2$
Drift length: 3cm

Radiator

Fiber/foam sandwich
PP, 17μm



TOF supermodule

TRD Supermodule

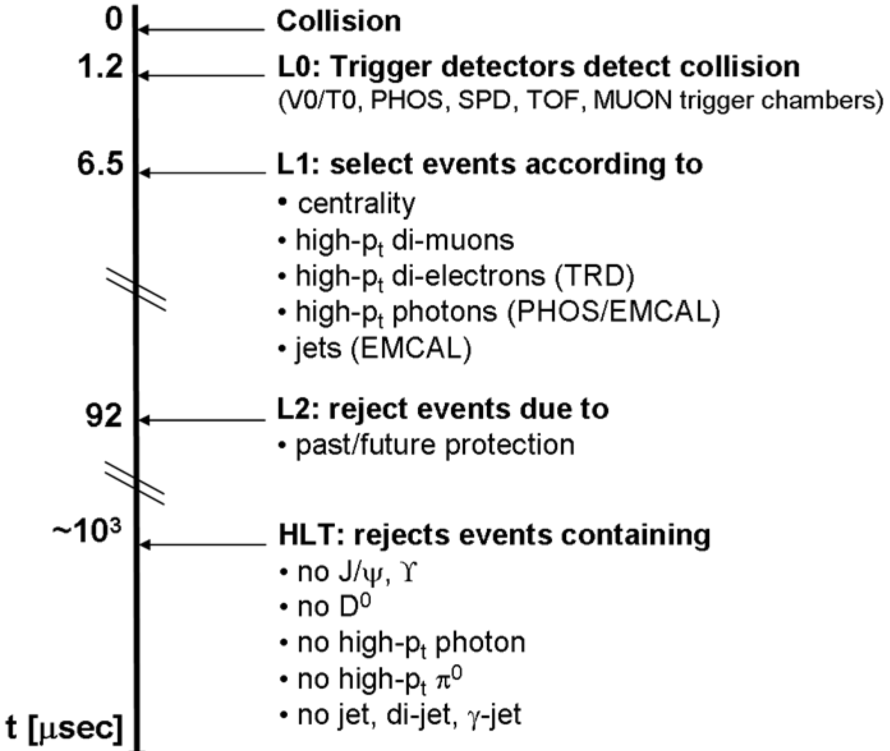
Trigger

Hierarchical architecture

- L0, L1, L2, and HLT

High Level Trigger (HLT)

- Online reconstruction using ~500-600 PCs + FPGAs
- Input rate 200Hz (central Pb-Pb) → up to 20 GByte/s
- Generate physics trigger (e.g. jets, Upsilons, D^0, ...)
- Online data compression
- Calibration tasks



0 — **Collision**

1.2 — **L0: Trigger detectors detect collision**
(V0/T0, PHOS, SPD, TOF, MUON trigger chambers)

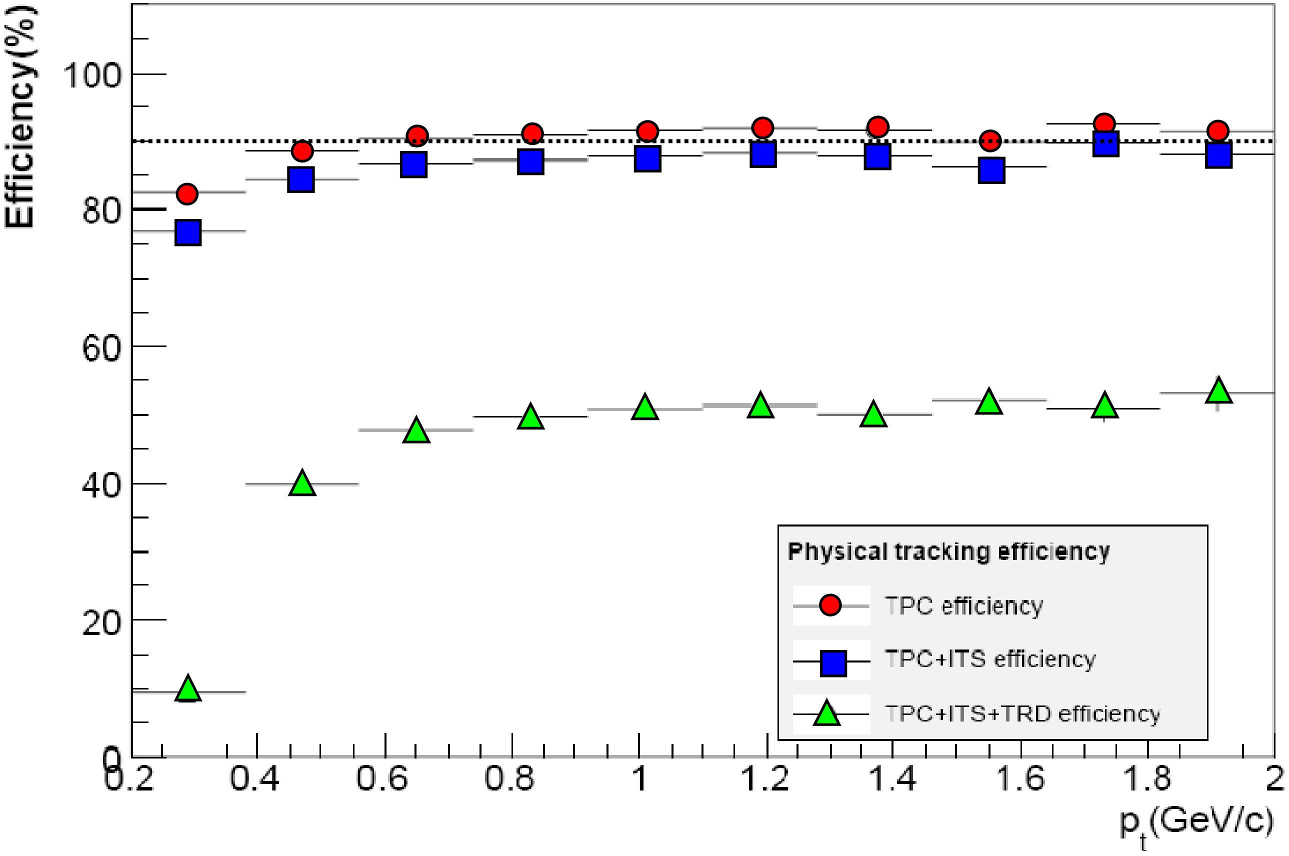
6.5 — **L1: select events according to**
- centrality
- high-p_t di-muons
- high-p_t di-electrons (TRD)
- high-p_t photons (PHOS/EMCAL)
- jets (EMCAL)

92 — **L2: reject events due to**
- past/future protection

~10^3 — **HLT: rejects events containing**
- no J/ψ, Υ
- no D^0
- no high-p_t photon
- no high-p_t π^0
- no jet, di-jet, γ-jet

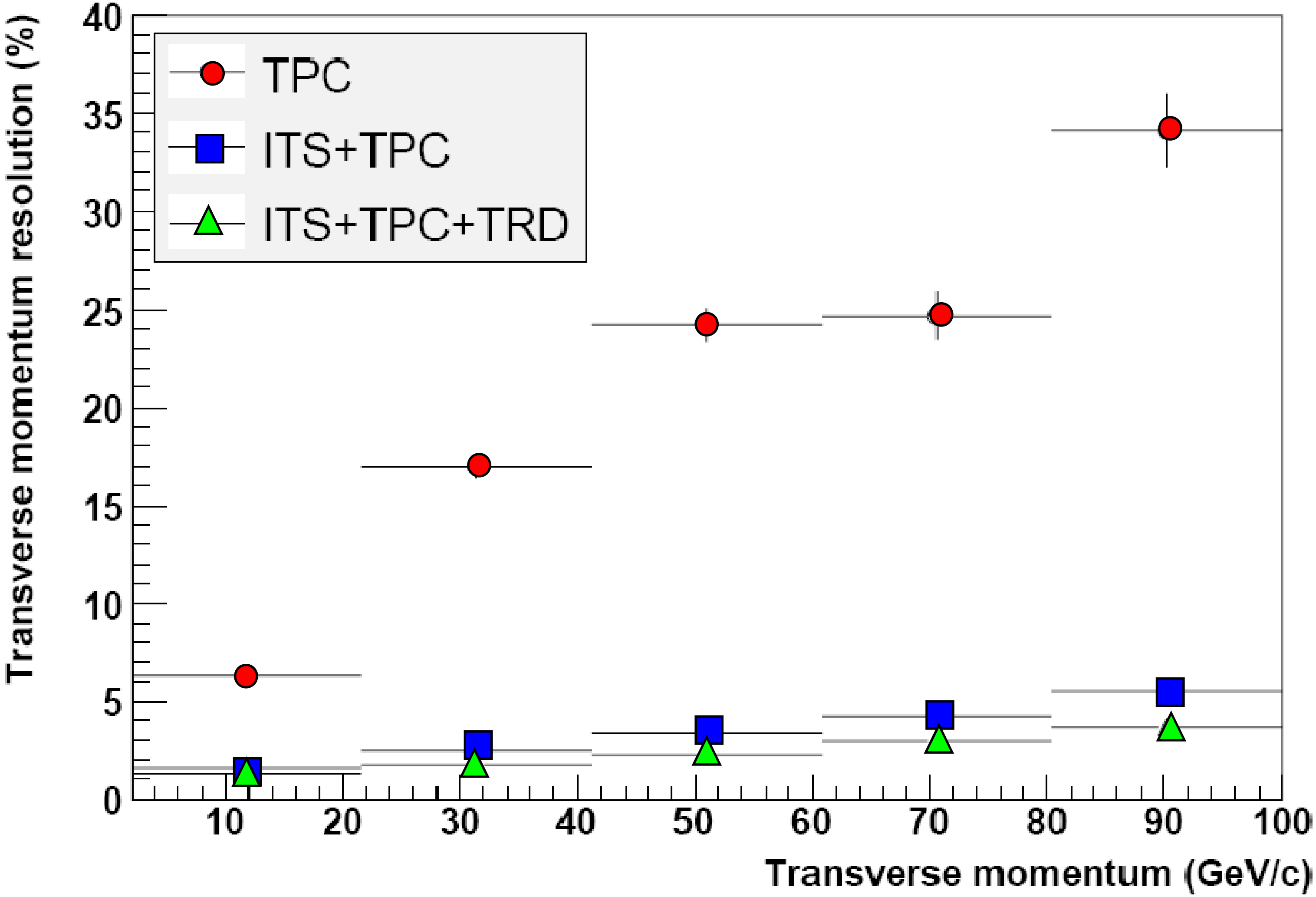
central barrel ($-0.9<\eta<0.9$) efficiency

$dN_{ch}/dy = 6000$

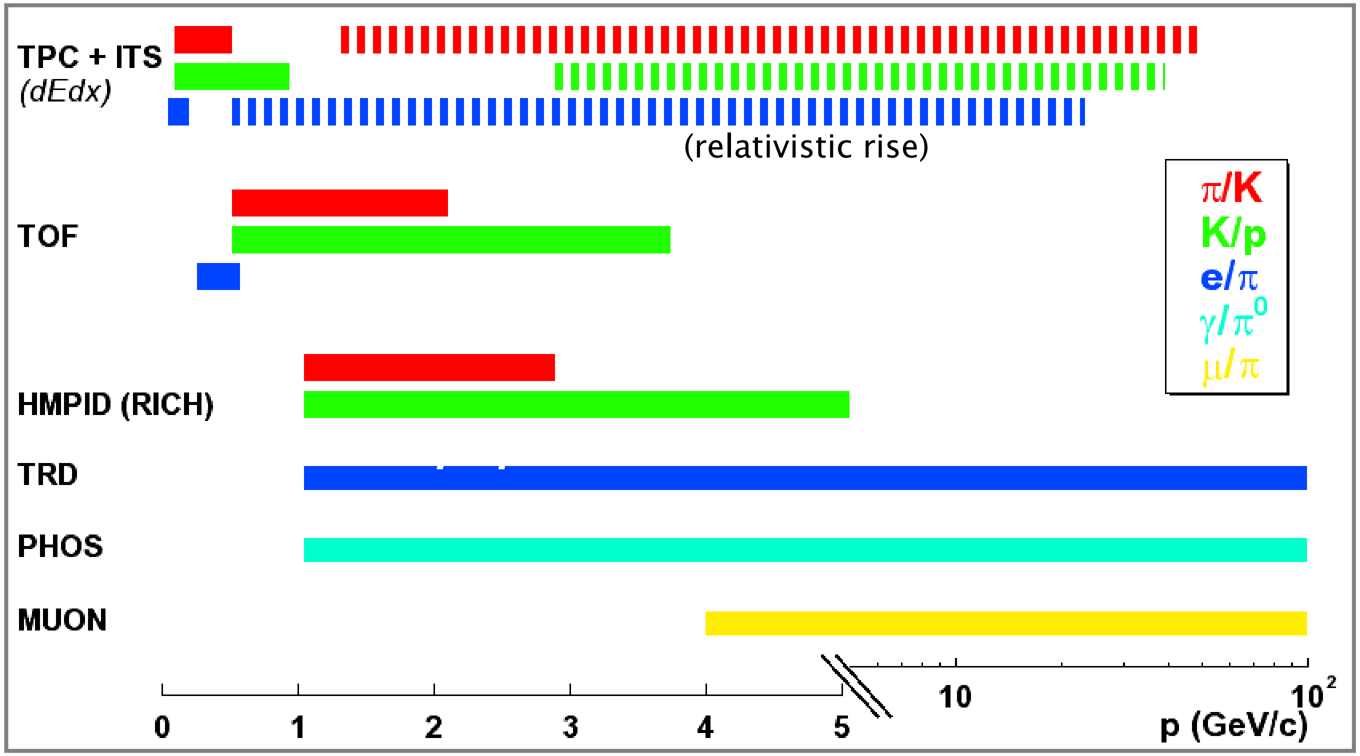


central barrel (-0.9<η<0.9) pt resolution

dN_{ch}/dy = 6000



PID Capabilities



TPC: $\sigma(dE/dx) = 5.5(pp) - 6.5(Pb\text{-}Pb)$ %

TOF: $\sigma < 100$ ps

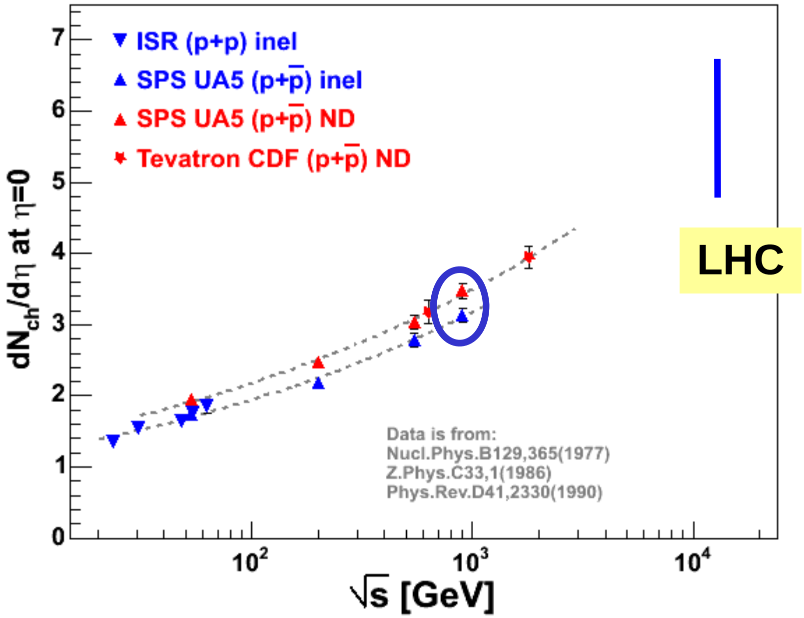
TRD: π suppression $\approx 10^{-2}$ @ 90% e-efficiency

first physics in p+p

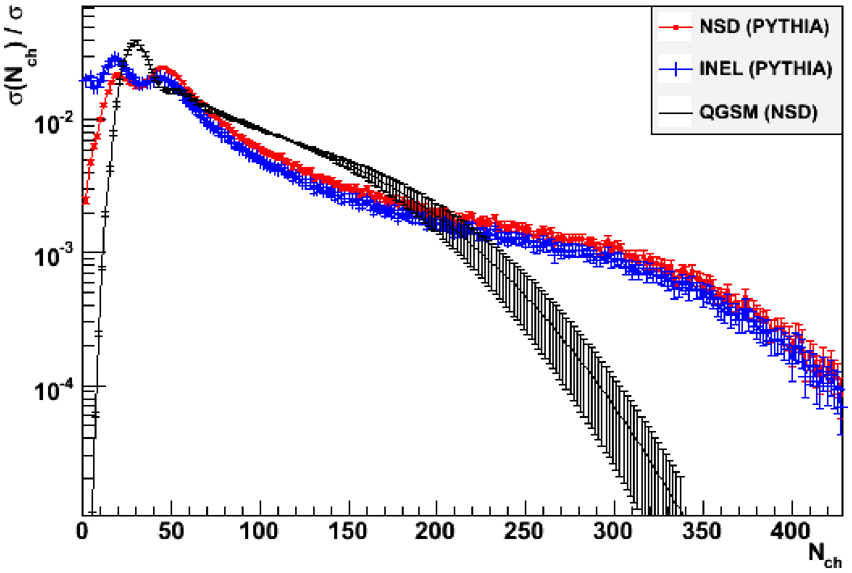
- charged particle multiplicity
- baryon transport
- charm cross section

- reference data for heavy ions

charged particle multiplicity in pp



Data is from:
Nucl.Phys.B129,365(1977)
Z.Phys.C33,1(1986)
Phys.Rev.D41,2330(1990)



- extend existing energy dependence
- unique SPD trigger (L0) for min. bias precision measurement
- completely new look at fluctuations in pp (neg. binomials, KNO…)

trigger efficiency

ND-INEL: 98.2%

SD : 55.4%

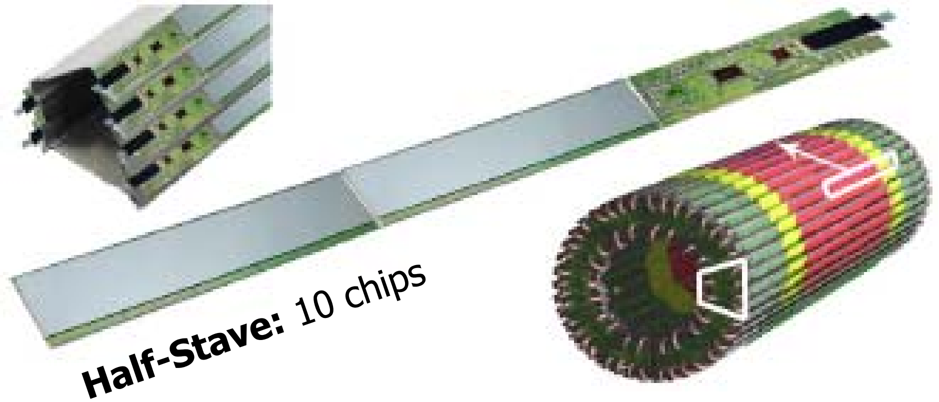
DD : 58.4%

high-multiplicity trigger

Silicon pixel detector

- fast-OR trigger at Level-0
  OR signal from each pixel chip
- two layers of pixel detectors
  400 chips layer 1; 800 layer 2
- trigger on chip-multiplicity per layer

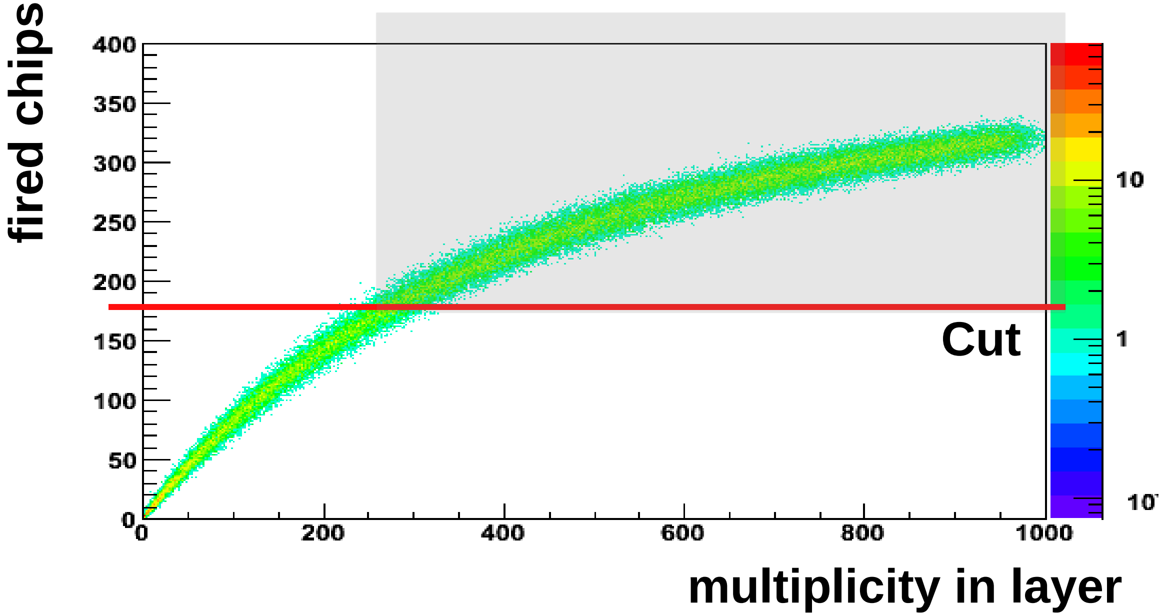
Sector: 4 (outer) + 2 (inner) staves



Half-Stave: 10 chips

SPD: 10 sectors (1200 chips)

Fired chips vs. true multiplicity (in η of layer)



Few trigger thresholds

- tuned with different downscaling factors
- maximum threshold determined by
  event rate
  background
  double interactions

high-multiplicity trigger – example

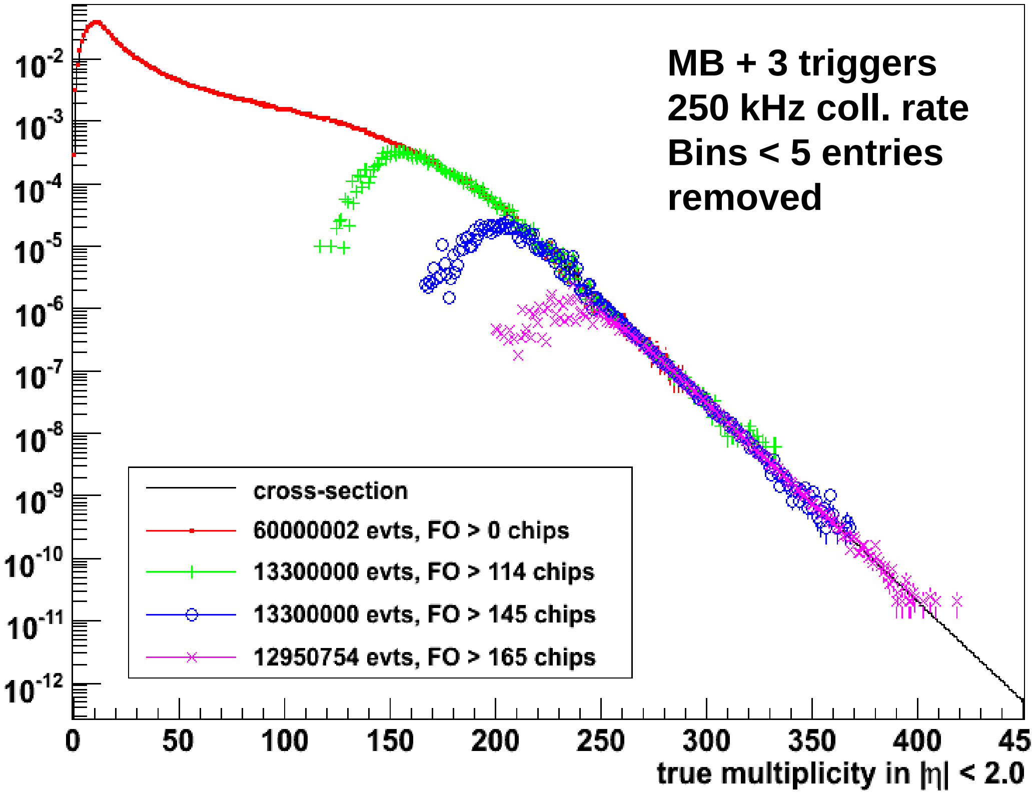
Example of threshold tuning:

MB and 3 high-mult. triggers

250 kHz collision rate
recording rate 100 Hz

MB 60%

3 HM triggers: 40%



trigger rate Hz	*scaling*	*raw rate*	*threshold layer 1*
60.0	*4167*	*250000*	*min. bias*
13.3	*259*	*3453.3*	*114*
13.3	*16*	*213.3*	*145*
13.3	*1*	*13.3*	*165*

baryon number transport

... goes via quark exchange or string junction

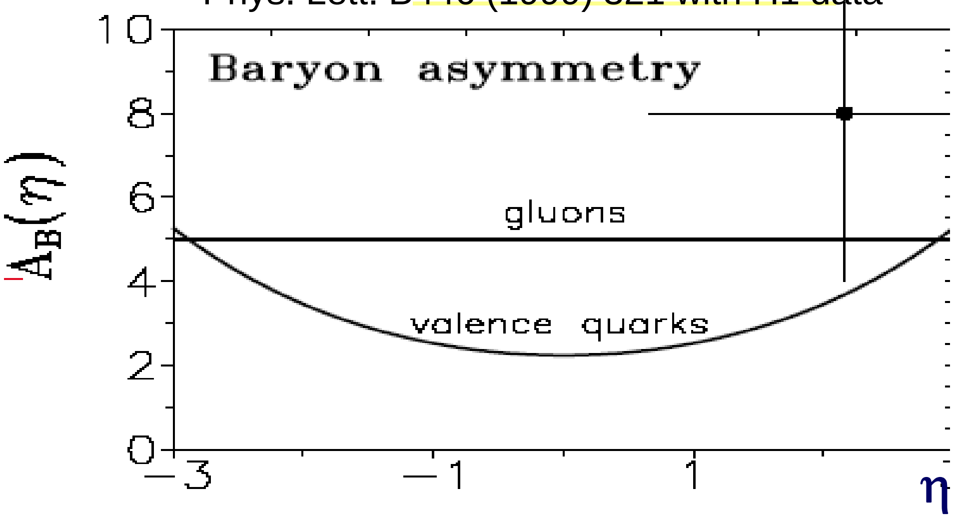
G.C. Rossi and G. Veneziano, Nucl. Phys B123 (1977) 507

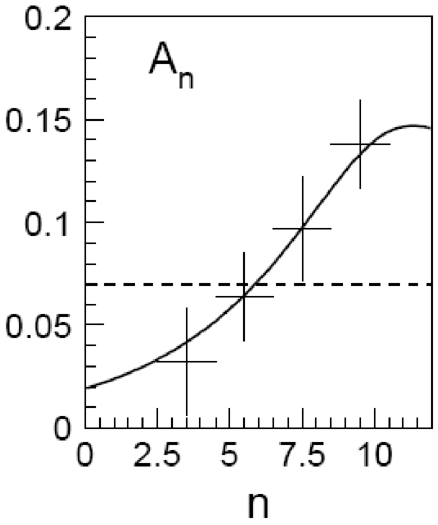
B.Z. Kopeliovich and B. Zakharov, Z. Phys. C43 (1989) 241

proton-antiproton asymmetry allows to distinguish

$$\boxed{A = 2 \cdot \frac{N_B - N_{\bar{B}}}{N_B + N_{\bar{B}}}}$$

Phys. Lett. B446 (1999) 321 with H1 data



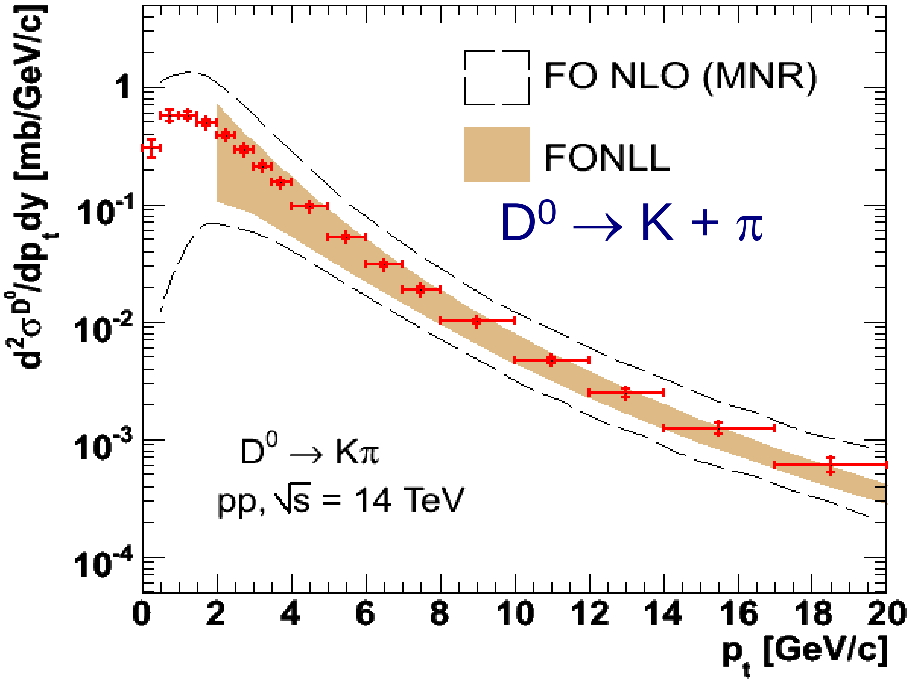


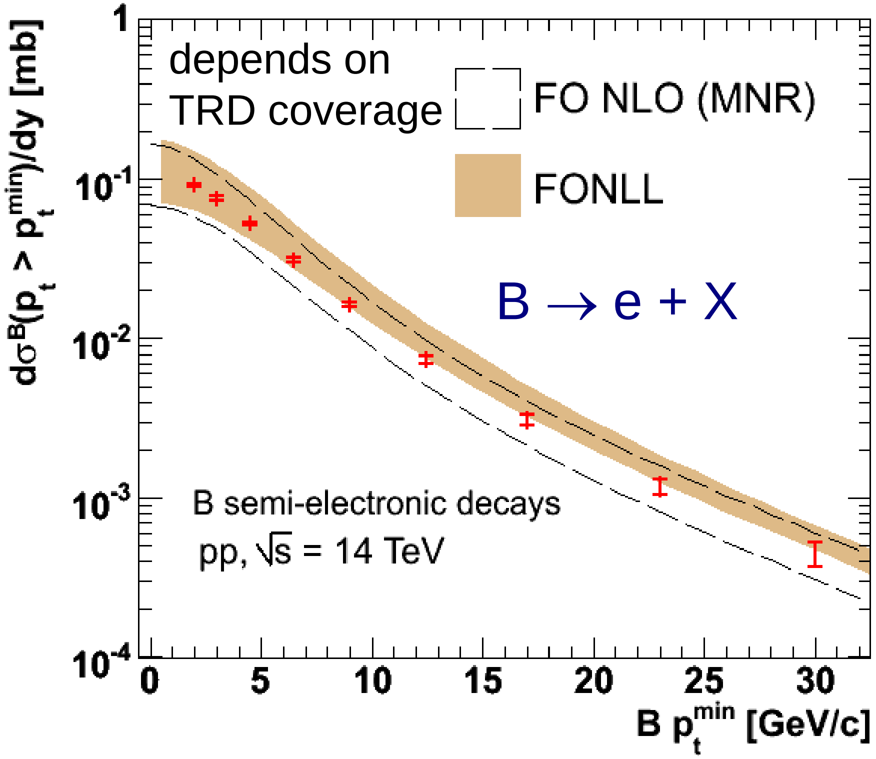
- ***systematic error < 1% for p > 0.5 GeV/c:***
- ***statistical error < 1% for 10^6 pp events (< 1 day)***

charm

Andrea Dainese

for 10^9 pp events





first physics from Pb+Pb

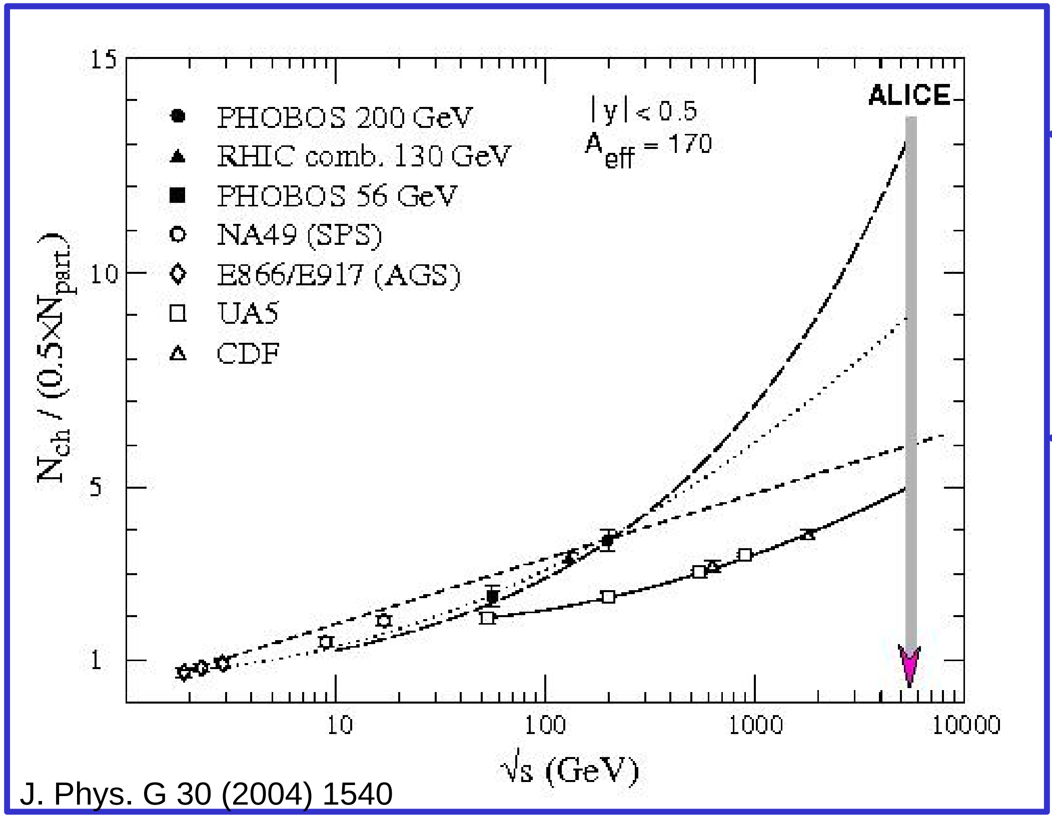
- first 10^5 events: global event properties
  multiplicity, elliptic flow

- first 10^6 events: source characteristics
  pt-spectra, resonances,
  differential flow analysis
  interferometry

- first 10^7 events: hard probes
  jet quenching,
  heavy flavour energy loss,
  charmonium

charged particle multiplicity in Pb+Pb

integrated multiplicity distributions from Au+Au/Pb+Pb collisions and scaled p+p collisions



J. Phys. G 30 (2004) 1540

$dN_{ch}/dy = 2600$

saturation model

Eskola hep-ph/050649

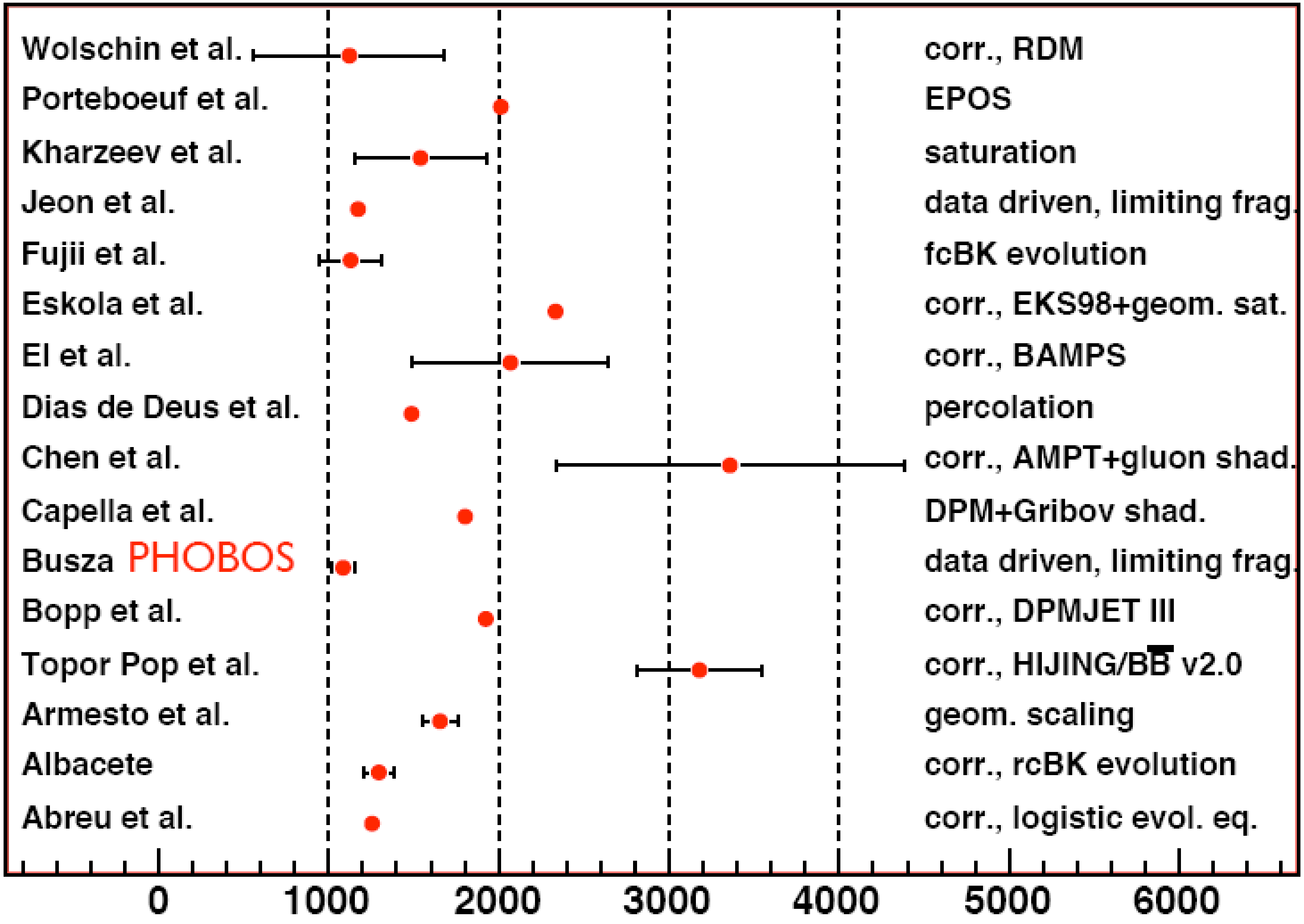
$dN_{ch}/dy = 1200$

ln(√s) extrapolation

multiplicity predictions for LHC

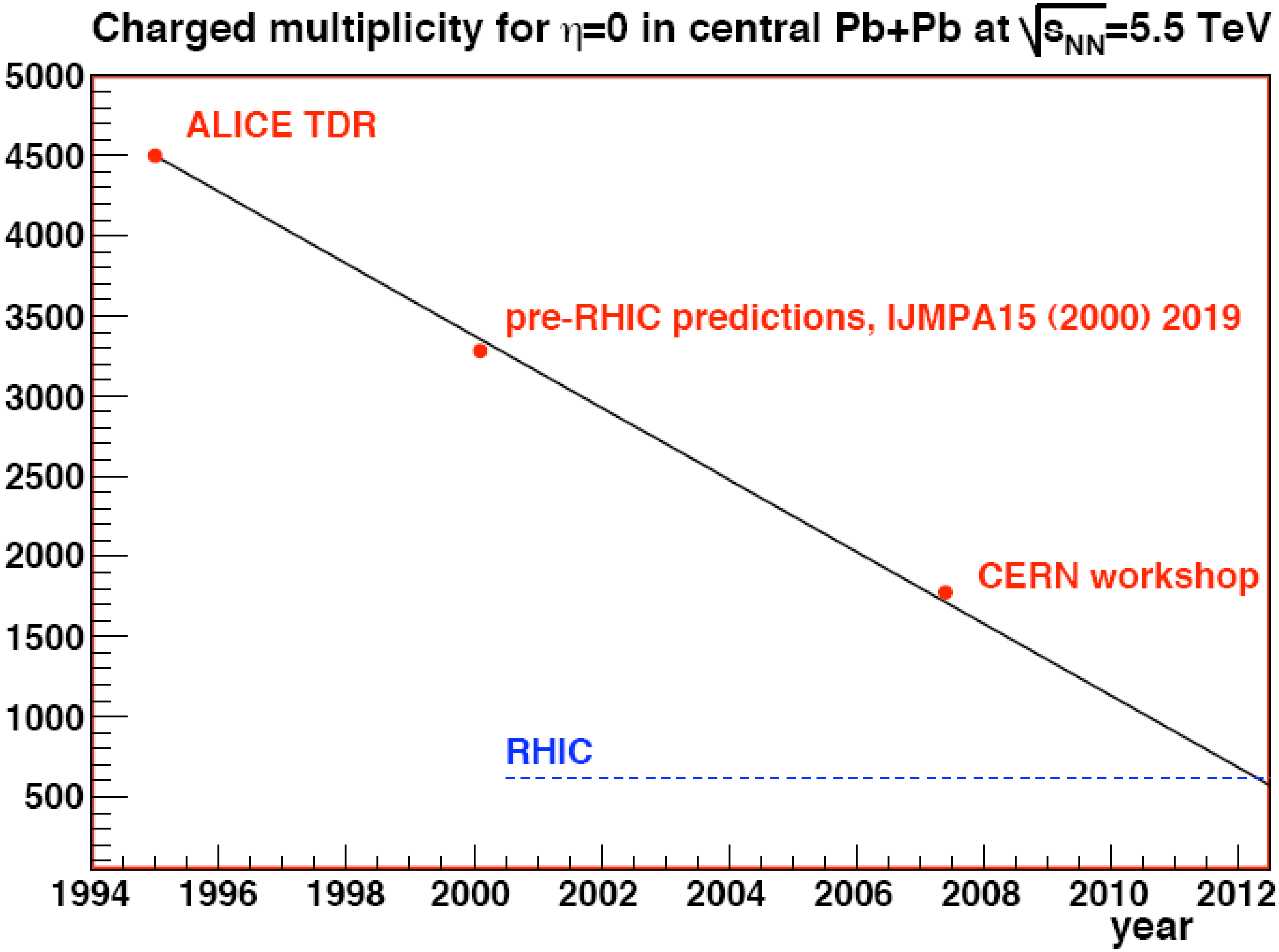
N. Armesto, QM2008

$dN_{ch}/d\eta|_{\eta=0}$ in Pb+Pb at $\sqrt{s_{NN}}$=5.5 TeV for N_{part}=350

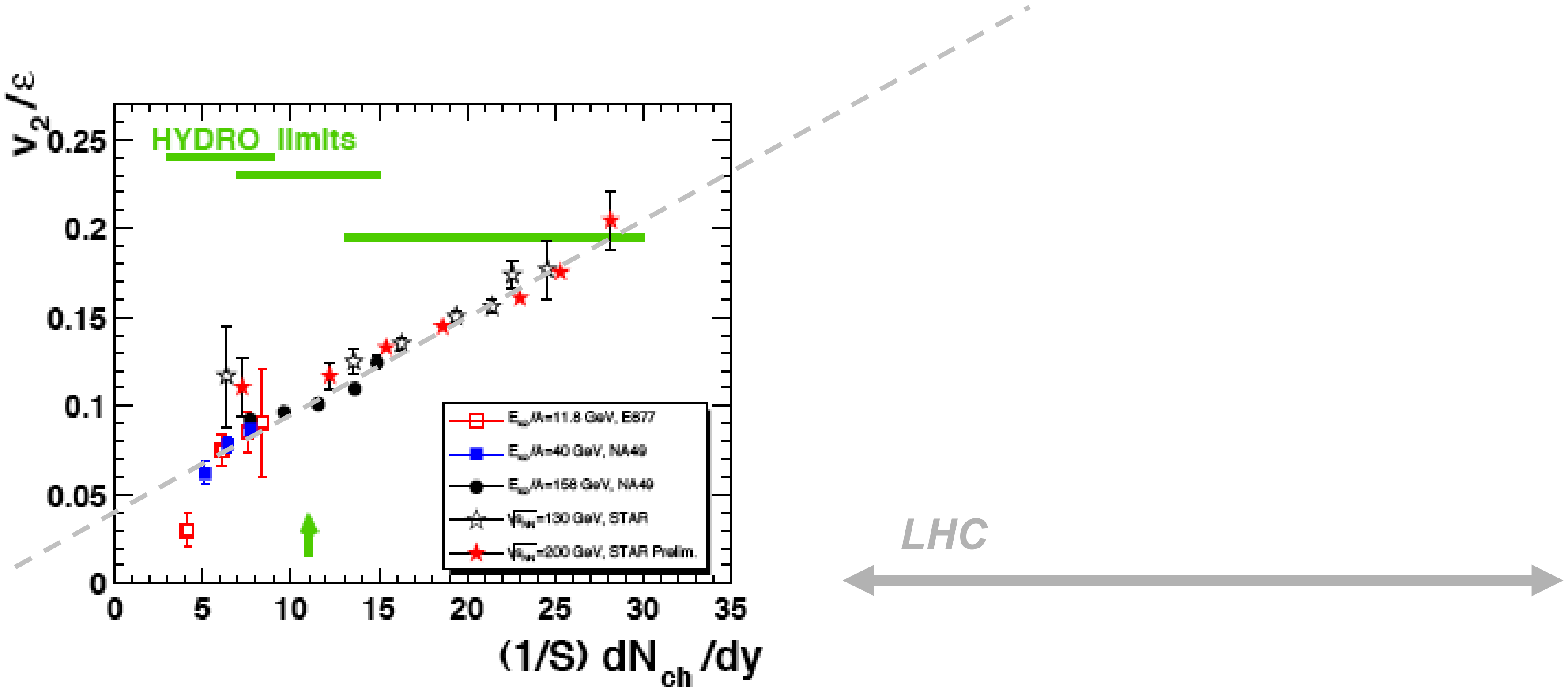


multiplicity predictions for LHC

N. Armesto, QM2008



elliptic flow v_2



- ***standard RHIC statement:*** *v_2 at RHIC is at hydro limit so QGP is perfect liquid*
- ***Ollitrault, Voloshin:*** *no! careful analysis shows that v_2 is still 30-50% below hydro limit so there is room for viscosity (and for ALICE)*
- ***Shuryak:*** *QGP is perfect liquid but is followed by viscous hadronic phase*

open charm and beauty

***goal**:*
measure parton energy loss in QGP

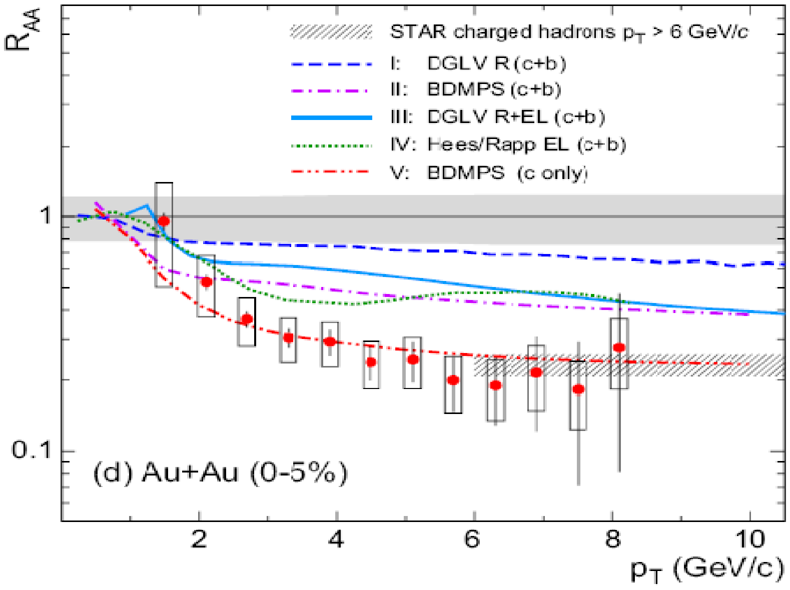
***expectation**:*
energy loss color dependent
(different for quarks and gluons)

energy loss flavour dependent
(smaller for heavy quarks)

***advantage at LHC**:*
high abundance of c and b
(direct reconstruction possible)

c/b

System	*p+p*	*Pb+Pb (5% cent)*
$\sqrt{s_{NN}}$ *(TeV)*	*14*	*5.5*
NN cross section (mb)	*11.2 / 0.5*	*6.6 / 0.2*
Shadowing	*---*	*0.65 / 0.85*
Total multiplicity	*0.16 / 0.007*	*115 / 4.6*



RHIC: Non-photonic electrons used to estimate charm

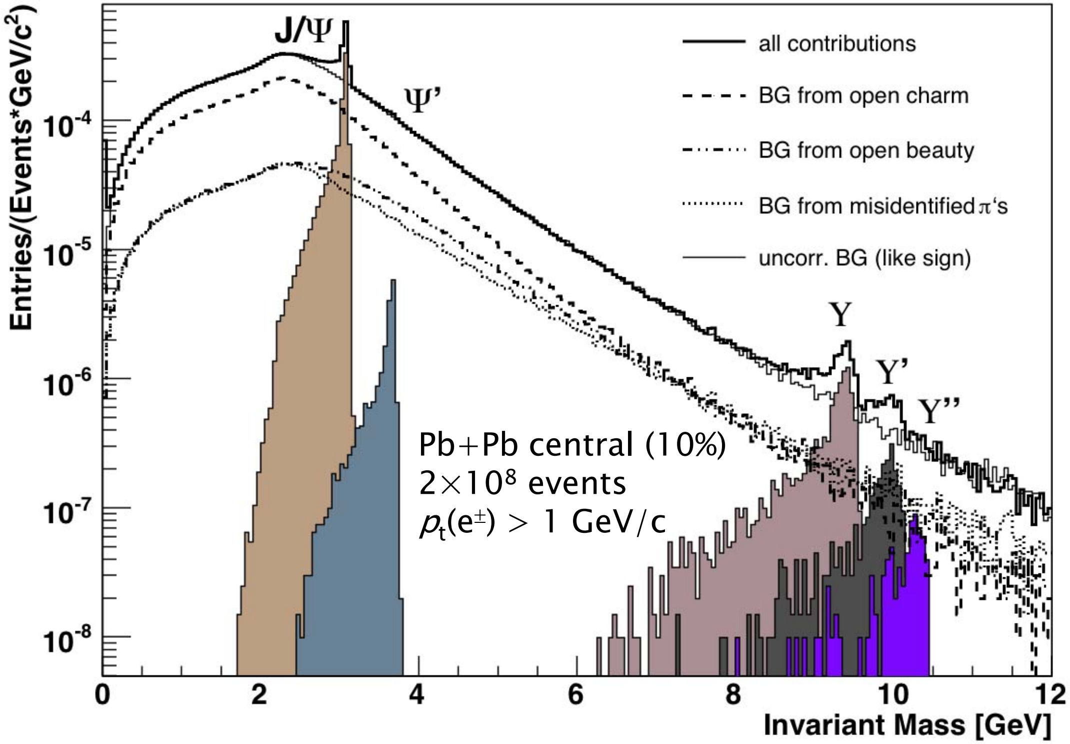
Quarkonia in dielectron channel

Central barrel

ITS+TPC+TRD
$-0.9 < \eta < 0.9$

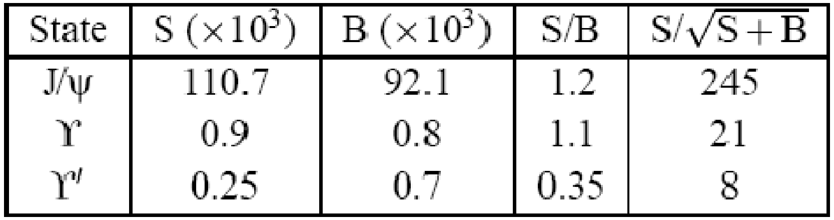
e-ID with TRD

Resolution:
$\sigma_m(J/\psi) \approx$ 30MeV
$\sigma_m(\Upsilon) \approx$ 90MeV



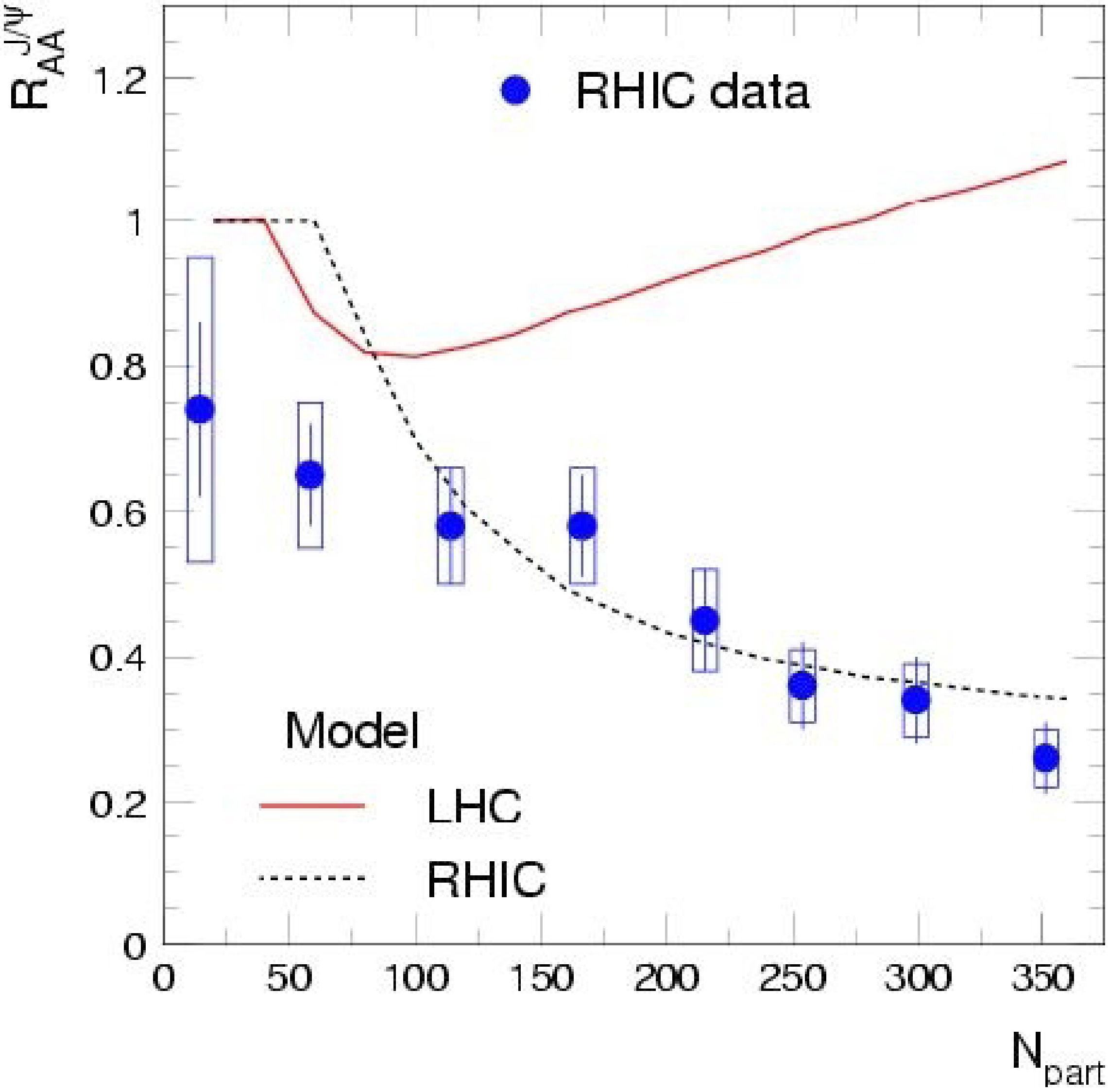
Pb+Pb central (10%)
2×10^8 events
$p_t(e^\pm) > 1$ GeV/c

Di-electron in central barrel



State	S ($\times10^3$)	B ($\times10^3$)	S/B	$S/\sqrt{S+B}$
J/ψ	110.7	92.1	1.2	245
Υ	0.9	0.8	1.1	21
Υ'	0.25	0.7	0.35	8

J/Psi as QGP probe

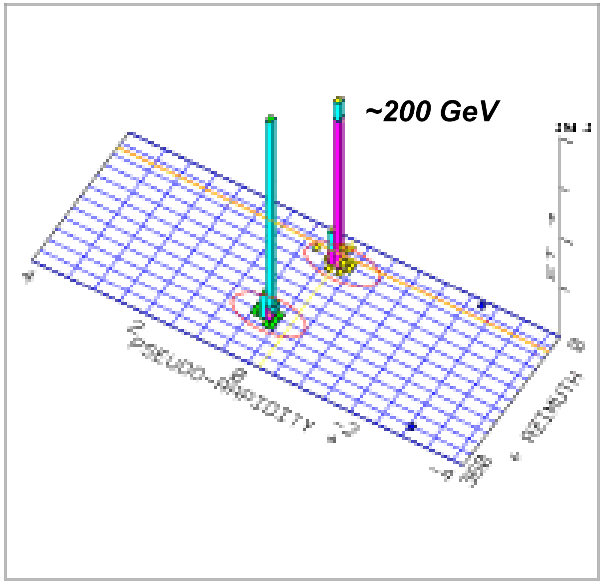


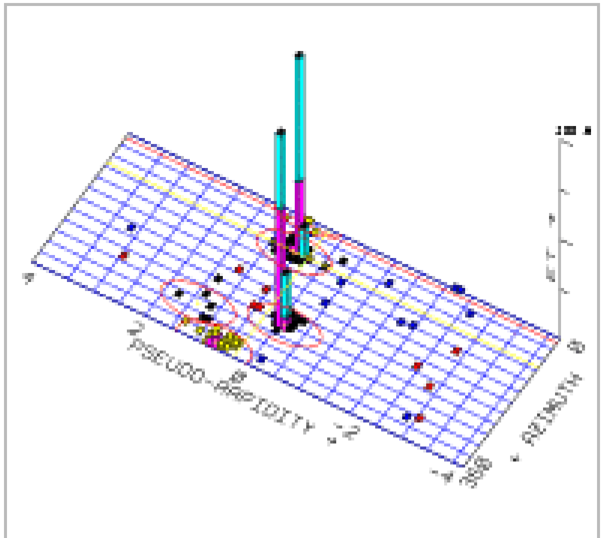
Andronic, Braun-Munzinger:

ccbar production is hard
ccbar→J/Psi is statistical

jets in p+pbar at 1.8 TeV

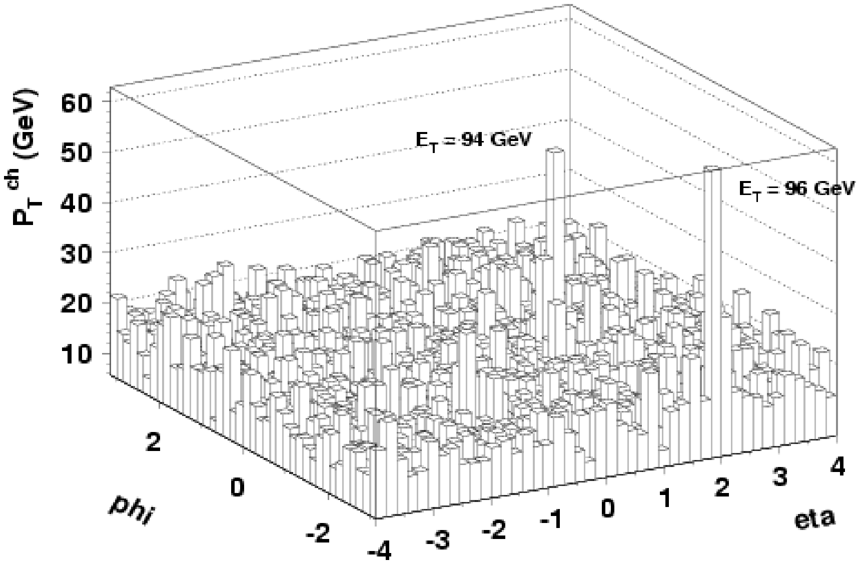
CDF, PRD 64 (2001) 032001

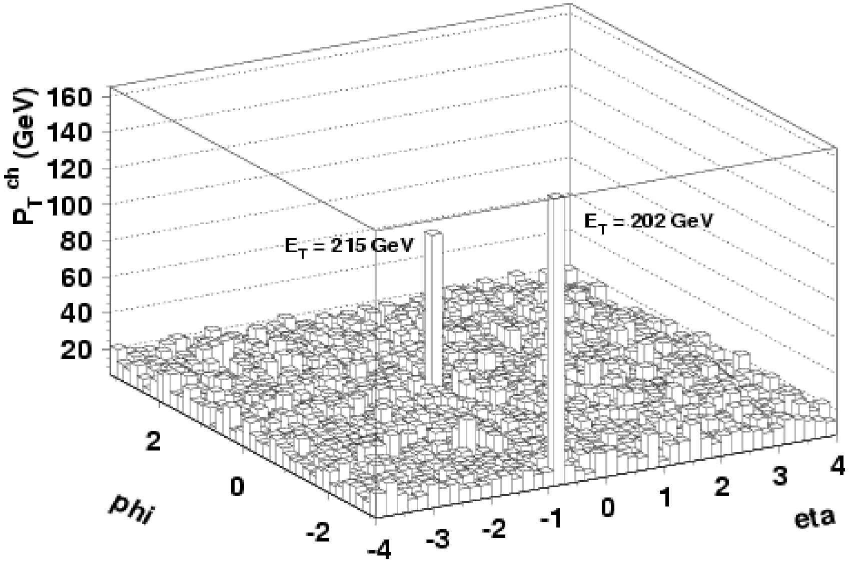




$$R = \sqrt{(\Delta\eta)^2 + (\Delta\phi)^2}$$

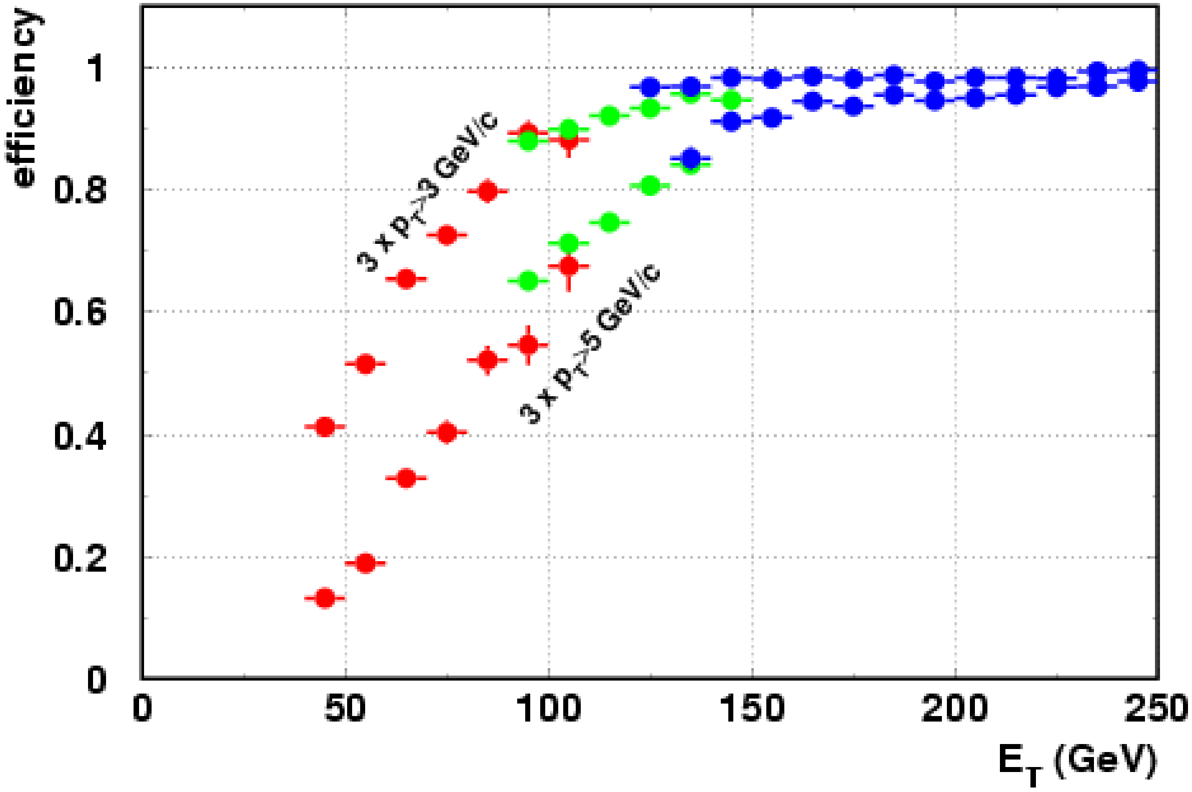
jets in Pb+Pb at 5.5 TeV (ALICE sim)





Jets with ITS, TPC, TRD – TRD trigger

1 month of running	
E_T >	N_{jets}
50 GeV	*2.0×10^7*
100 GeV	*1.1×10^6*
150 GeV	*1.6×10^5*
200 GeV	*4.0×10^4*

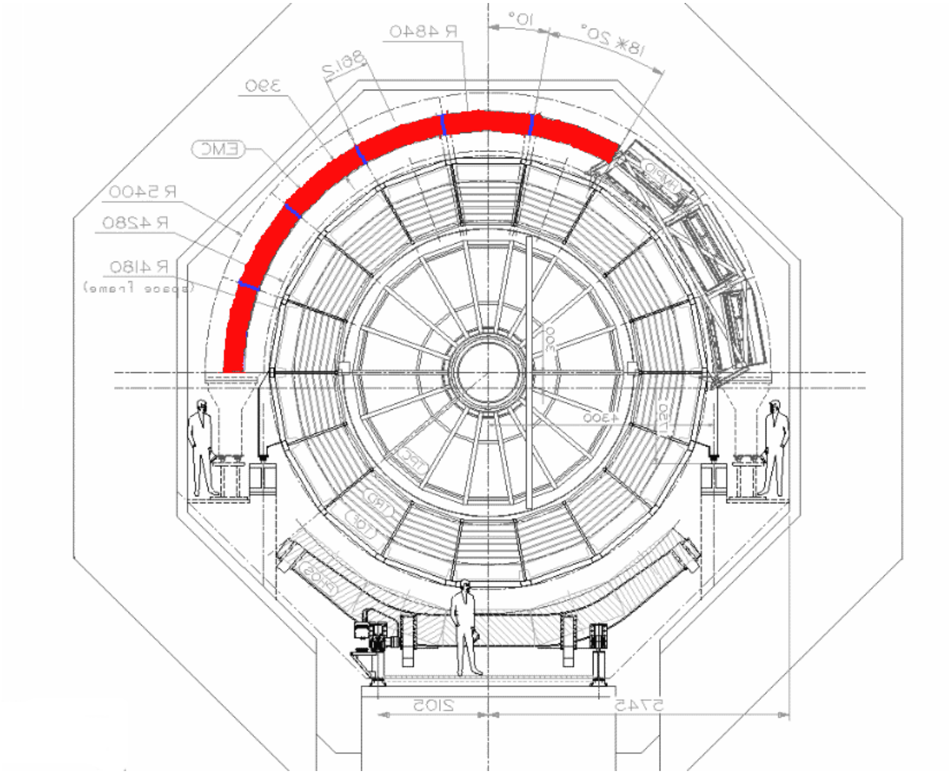


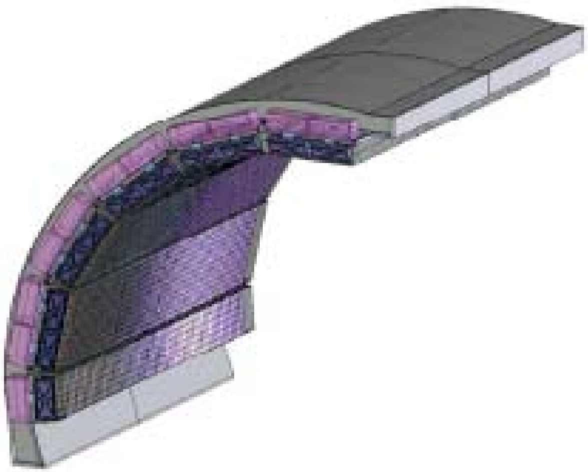
trigger condition:

3 charged particles with p_T>$p_T$min in one TRD module

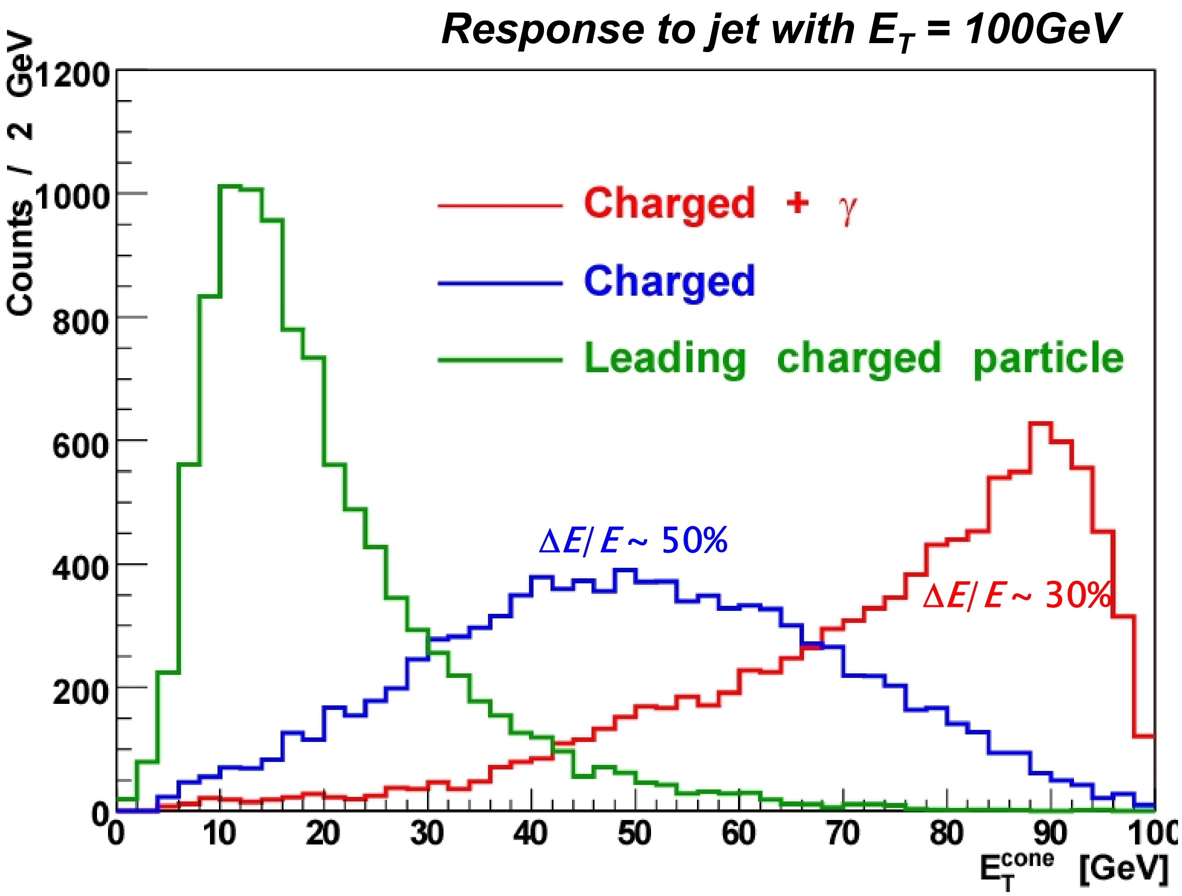
Jets with EMCAL

- ***EM Sampling Calorimeter - latest addition to ALICE by US, France, Italy***
- ***Pb-scintillator linear response***
  $-0.7 < \eta < 0.7$
  $60^o < \phi < 180^o$
- ***Energy resolution $\sim 15\%/\sqrt{E}$***





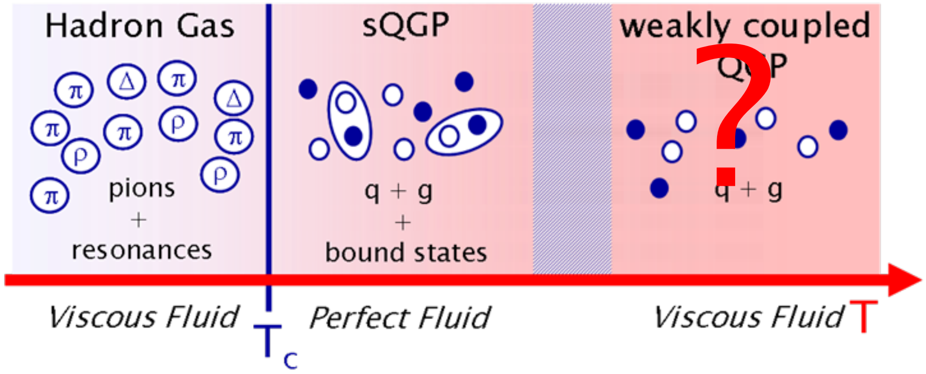
Jets with both



"two extreme scenarios", B. Müller QM2008

1. ***QGP physics at the LHC will be just like RHIC, only at higher (initial) energy density/temperature and with probes that have a (much) larger kinematic range.***

2. ***QGP physics at the LHC will be quite different from that seen at RHIC, involving an (initially) weakly coupled deconfined phase and an initial state dominated by gluon saturation.***



weak or strong coupling?

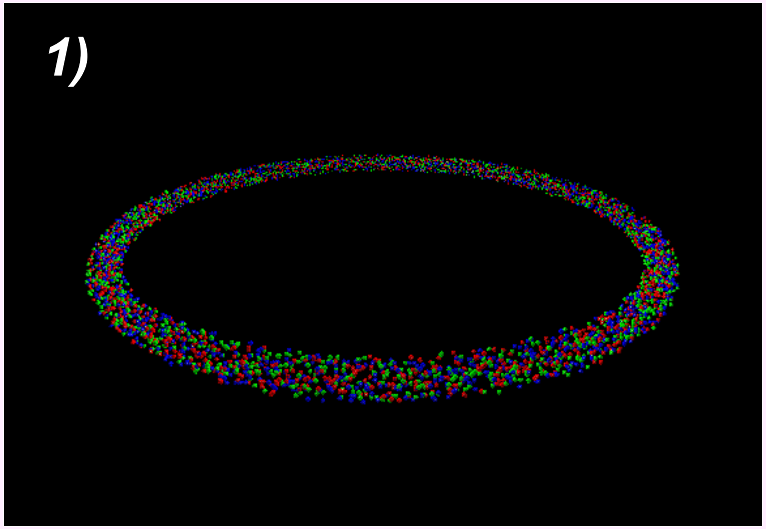
weakly coupled QGP has a principal problem:

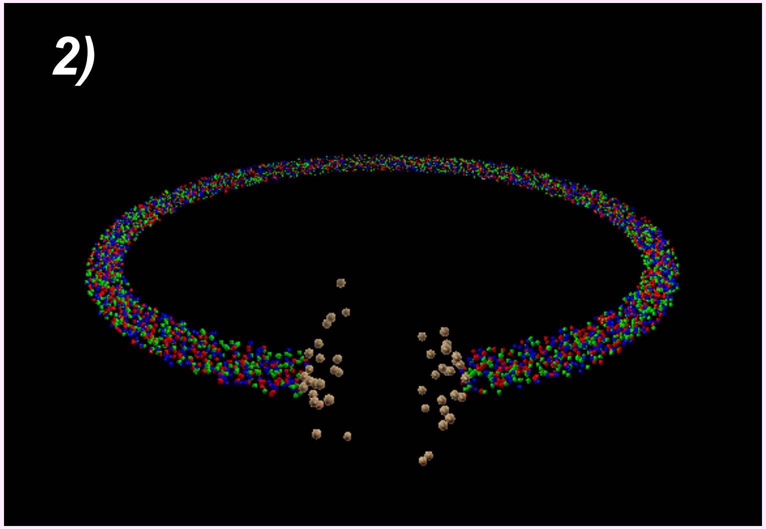
when hadronizing back single quarks can be left because synchronizing hadronization in regions separated by space-like intervals is impossible

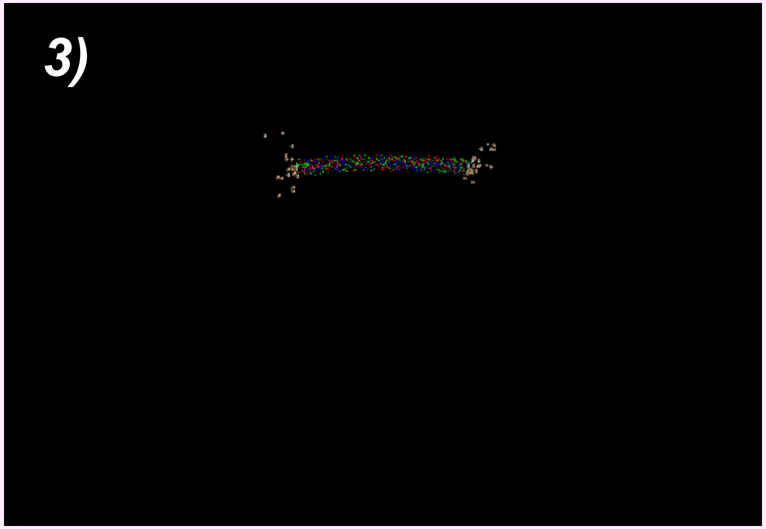
QGP paradox demonstrated

- ***I will start from an allowed state (1 mm^3 of QGP)***
- ***I will never violate any physics law***
- ***I will end up in a not allowed state (with single quarks)***

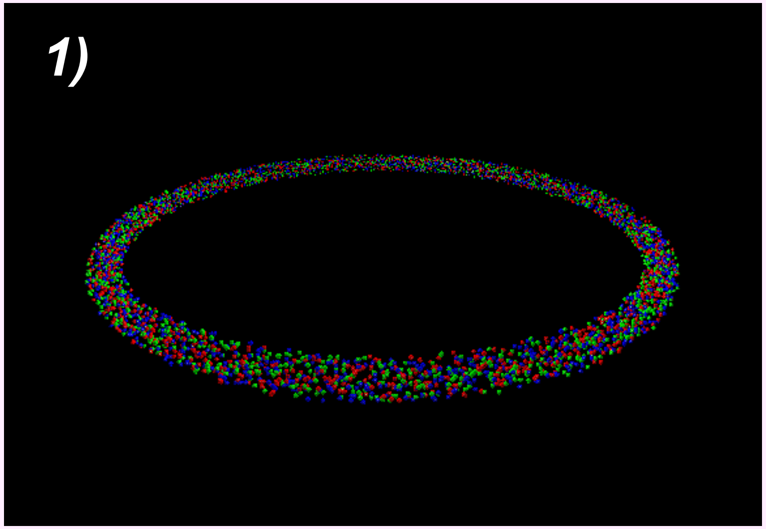
QGP paradox: experiment 1

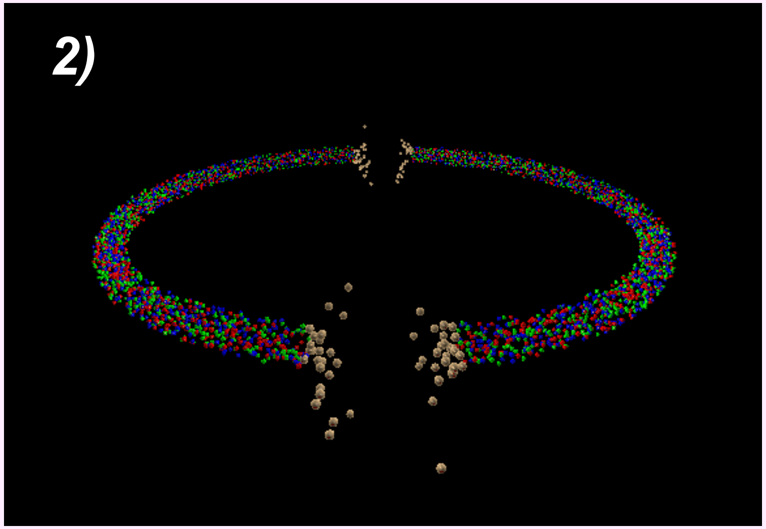


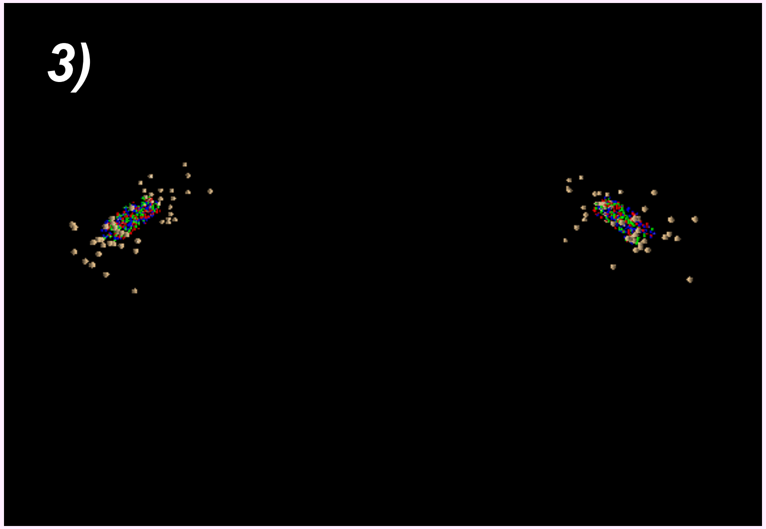


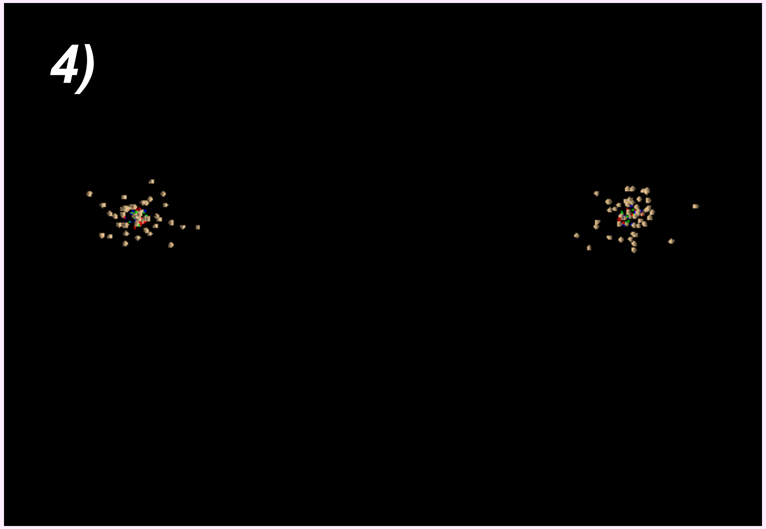


QGP paradox: experiment 2









QGP paradox: 3 ways out

1) fast (volume) hadronization

- single quarks can exist, or
- baryon number not conserved, or
- superluminal information transfer is possible

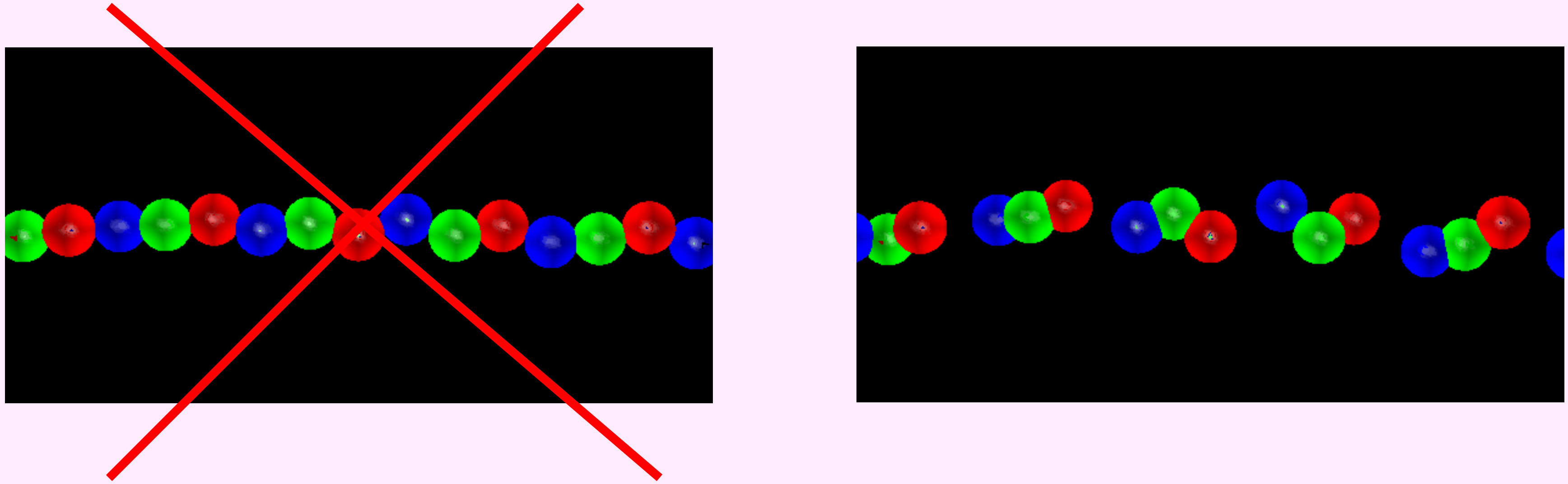
2) slow (surface) hadronization

- holes in QGP not allowed (infinite surface tension)
- too slow: Early Universe at least couple of minutes
- heavy ion collision: the ends hadronize first

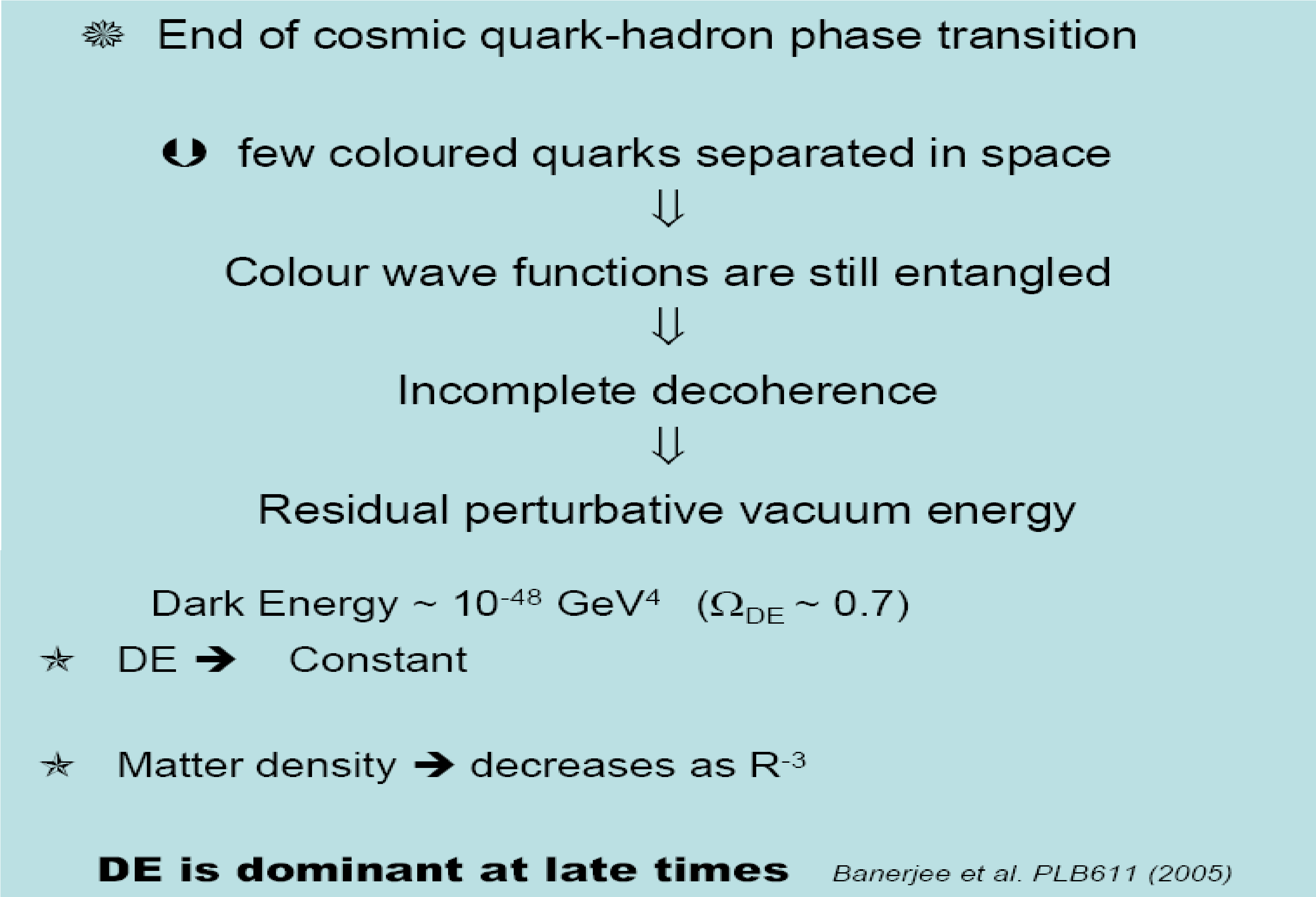
QGP paradox: 3 ways out

3) true QGP with liberated quarks does not exist

- ***quarks are in clusters***
- ***the ring can be cut only between two such clusters***
- ***no problem with hadronization***



S. K. Ghosh, Astrophysics of Strange Matter, QM2008



❋ End of cosmic quark-hadron phase transition

❍ few coloured quarks separated in space

⇓

Colour wave functions are still entangled

⇓

Incomplete decoherence

⇓

Residual perturbative vacuum energy

Dark Energy ~ 10^{-48} GeV^4 (Ω_{DE} ~ 0.7)

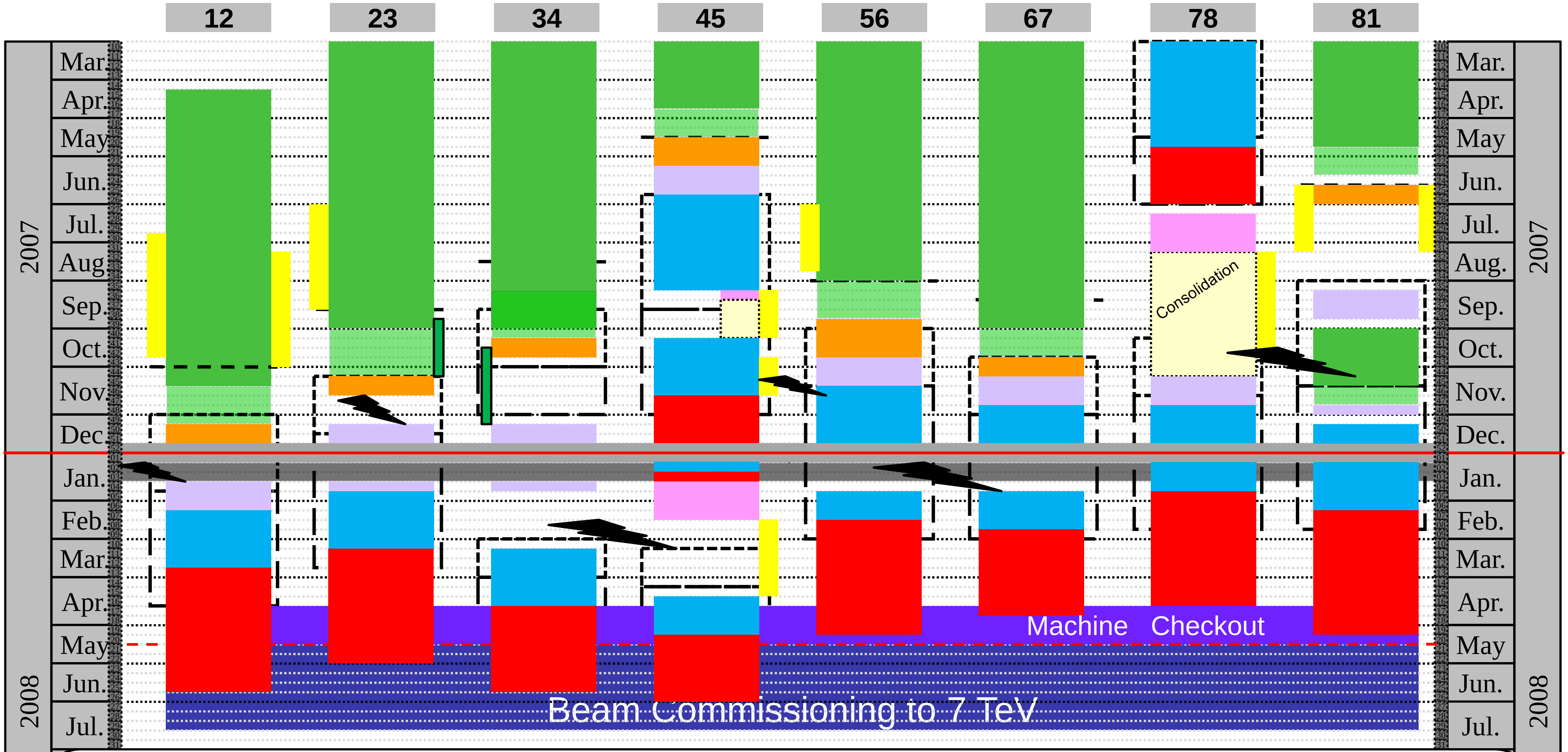
✯ DE ➔ Constant

✯ Matter density ➔ decreases as R^{-3}

DE is dominant at late times *Banerjee et al. PLB611 (2005)*

"orphan quarks" -
possible solution of my QGP paradox

LHC schedule as of 8 Oct 2007



General schedule Baseline rev. 4.0

···· Global pressure test &Consolidation

⬚ Cool-down

⌐ ┘ Powering Tests

🟩 Interconnection of the continuous cryostat

🟩 Leak tests of the last sub-sectors

🟨 Inner Triplets repairs & interconnections

🟧 Global pressure test &Consolidation

🟪 Flushing

🟦 Cool-down

🟪 Warm up

🟥 Powering Tests

ALICE running schedule

- complete & commissioned
  ITS, TPC, TOF, HMPID, MUONS, PMD, V0,
  T0, FMD, ZDC, ACORDE, DAQ
- partially completed
  - TRD (25%) to be completed by 2009
  - PHOS (60%) to be completed by 2010
  - HLT (30%) to be completed by 2009
  - EMCAL (0%) to be completed by 2010/11

- at start-up full hadron and muon capabilities
- partial electron and photon capabilities

- Dec-2007 cosmic run
- Mar-2008 cosmic run
- Apr-2008 cosmic run...
- Jul-2008 p+p
- fall 2009 Pb+Pb

summary: ALICE status and nearest plans

- ***commissioning phase***
  - ***fully commission trigger, DAQ, ECS***
  - ***align and calibrate the entire system***
  - ***further use of beam gas interactions***
- ***first pp run***
  - ***charged particle multiplicity***
  - ***baryon number transport***
  - ***charm cross section***
  - ***reference data for heavy ions***
- ***first few heavy ion collisions***
  - ***global event properties***
- ***first long heavy ion run***
  - ***source characteristics***
  - ***hard probes***

The End

ALICE general running plans

initial phase

- pilot Pb+Pb
- 1-2 years Pb+Pb
- 1 year p+Pb (or like)
- 1-2 years Ar+Ar

subsequent options

- pp at sqrt(s) = 5.5 TeV
- N+N or O+O or Kr+Kr...
- another pA
- lower energy Pb+Pb
- high stat full energy Pb+Pb

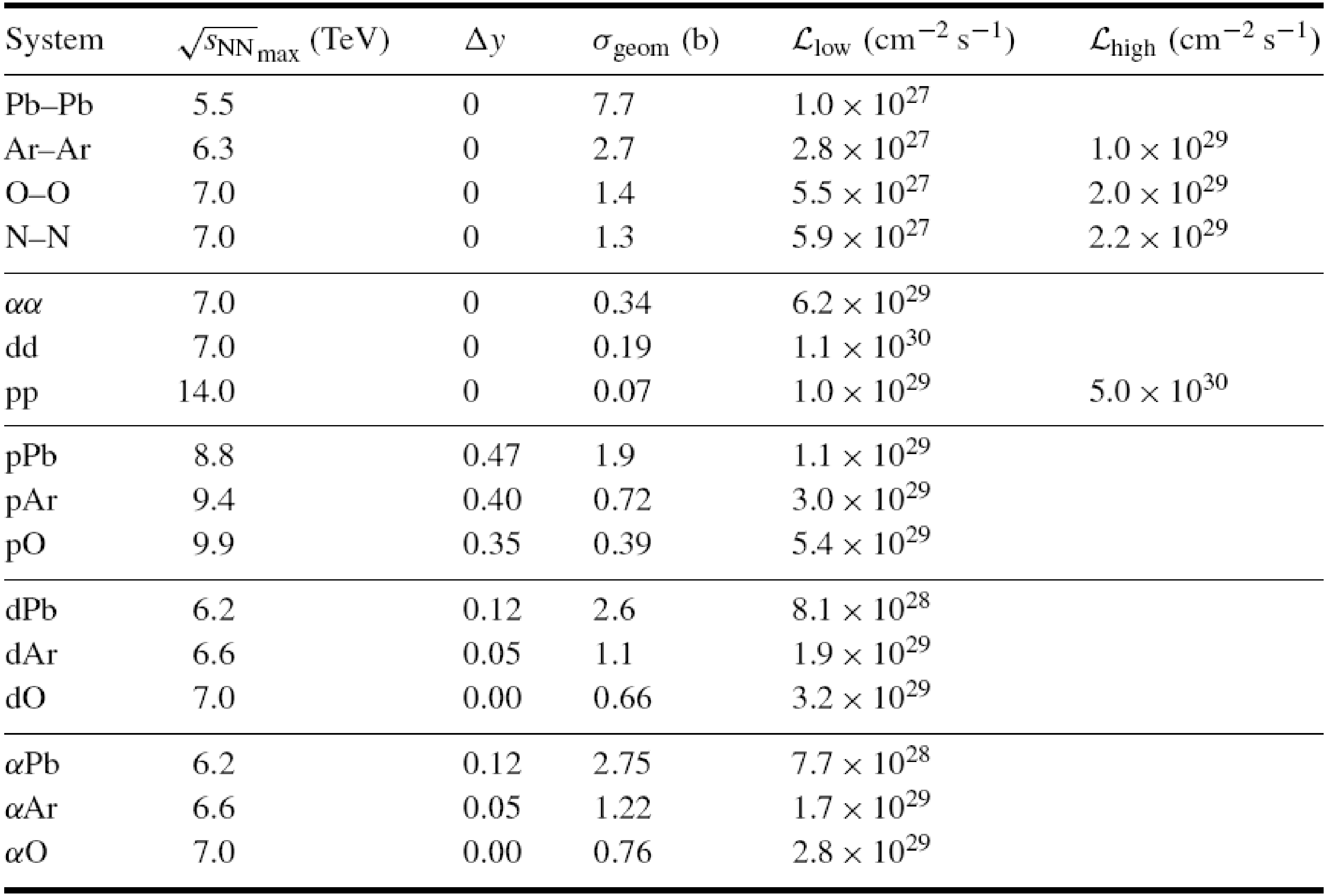
LHC machine parameters

	pp	Pb–Pb
Energy per nucleon (TeV)	7	2.76
β at the IP: β^* (m)	10	0.5
R.m.s. beam radius at IP: σ_{t} (μm)	71[a]	15.9
R.m.s. bunch length: σ_{l} (cm)	7.7	7.7
Vertical crossing half-angle (μrad) for pos. (neg.) μ-spectr. dipole polarization	150 (150)	150 (100)
No. of bunches	2808	592
Bunch spacing (ns)	24.95	99.8
Initial number of particles per bunch	1.1×10^{11}	7.0×10^{7}
Initial luminosity ($\mathrm{cm}^{-2}\,\mathrm{s}^{-1}$)	$< 5 \times 10^{30}$	10^{27} [b]

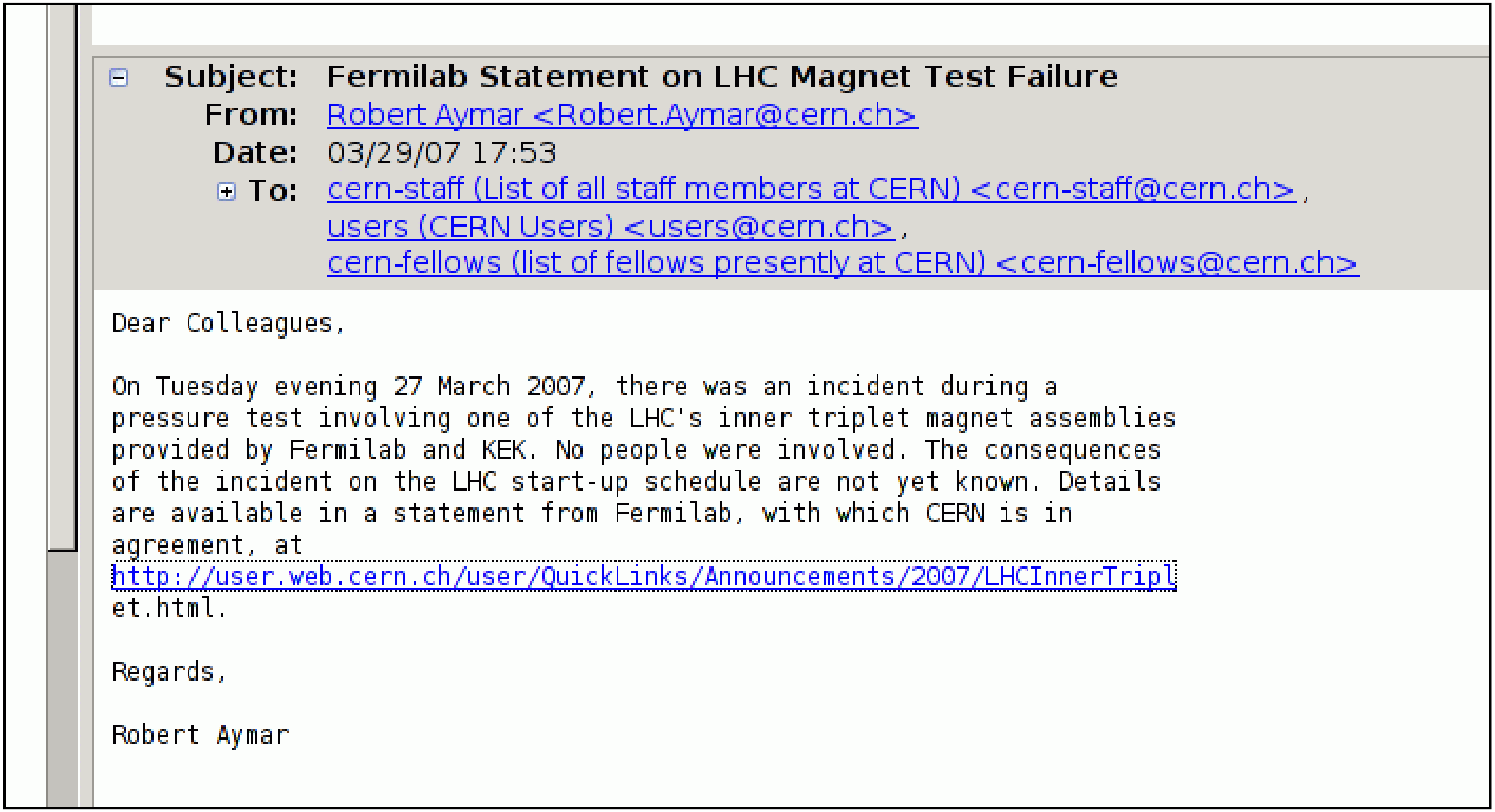
[a] For low-intensity runs β^* could be 0.5 m and $\sigma_{\mathrm{t}} = 15.9\ \mu$m as in Pb–Pb.

[b] Early operation will be with 62 bunches and $\beta^* = 1$ m, which yields an initial luminosity of $5.4 \times 10^{25}\ \mathrm{cm}^{-2}\,\mathrm{s}^{-1}$.

ALICE running conditions



System	$\sqrt{s_{\rm NN}}_{\rm max}$ (TeV)	Δy	$\sigma_{\rm geom}$ (b)	$\mathcal{L}_{\rm low}$ (cm^{-2} s^{-1})	$\mathcal{L}_{\rm high}$ (cm^{-2} s^{-1})
Pb–Pb	5.5	0	7.7	1.0×10^{27}	
Ar–Ar	6.3	0	2.7	2.8×10^{27}	1.0×10^{29}
O–O	7.0	0	1.4	5.5×10^{27}	2.0×10^{29}
N–N	7.0	0	1.3	5.9×10^{27}	2.2×10^{29}
$\alpha\alpha$	7.0	0	0.34	6.2×10^{29}	
dd	7.0	0	0.19	1.1×10^{30}	
pp	14.0	0	0.07	1.0×10^{29}	5.0×10^{30}
pPb	8.8	0.47	1.9	1.1×10^{29}	
pAr	9.4	0.40	0.72	3.0×10^{29}	
pO	9.9	0.35	0.39	5.4×10^{29}	
dPb	6.2	0.12	2.6	8.1×10^{28}	
dAr	6.6	0.05	1.1	1.9×10^{29}	
dO	7.0	0.00	0.66	3.2×10^{29}	
αPb	6.2	0.12	2.75	7.7×10^{28}	
αAr	6.6	0.05	1.22	1.7×10^{29}	
αO	7.0	0.00	0.76	2.8×10^{29}	



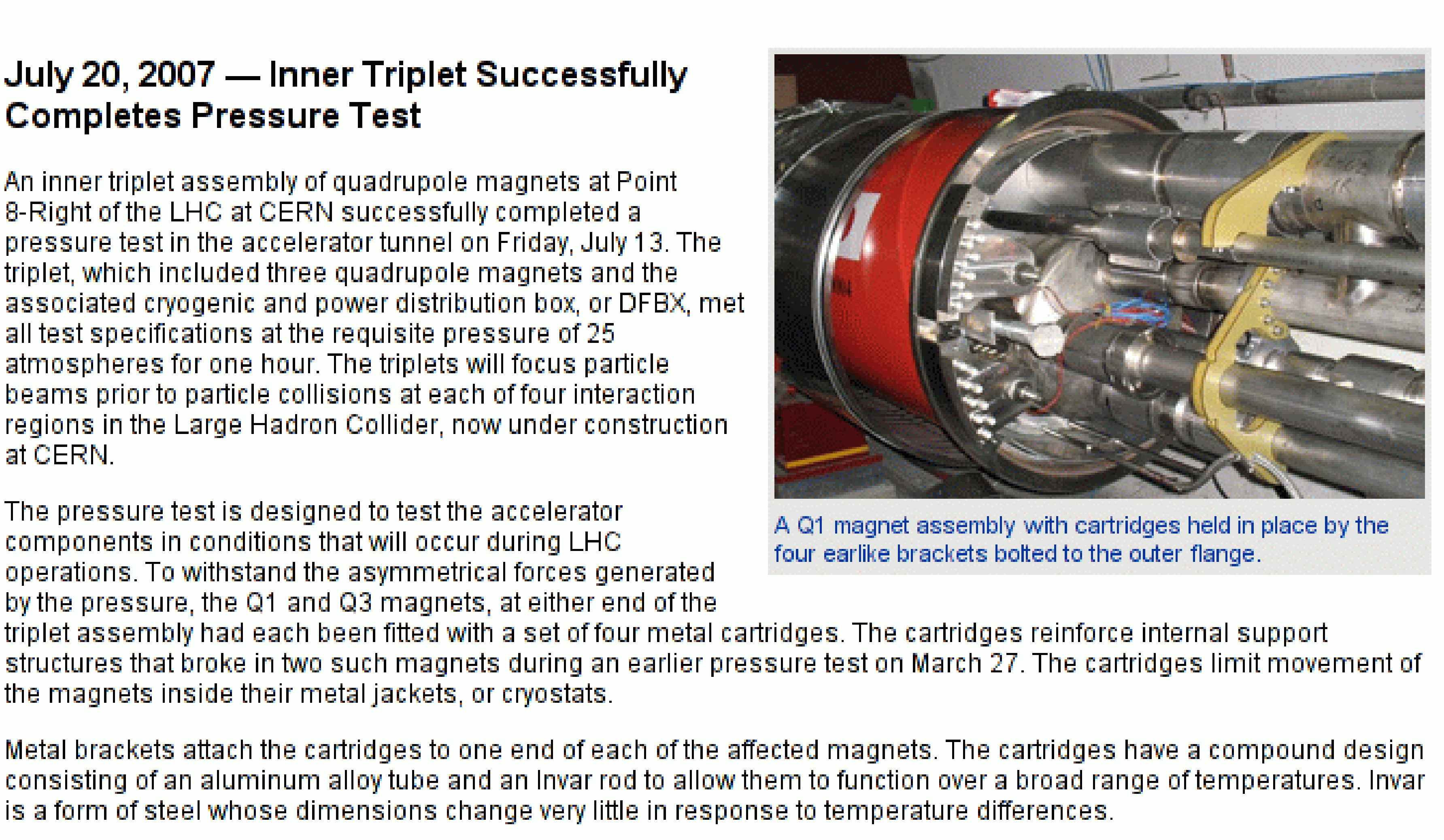
Subject: Fermilab Statement on LHC Magnet Test Failure
From: Robert Aymar <Robert.Aymar@cern.ch>
Date: 03/29/07 17:53
To: cern-staff (List of all staff members at CERN) <cern-staff@cern.ch> ,
users (CERN Users) <users@cern.ch> ,
cern-fellows (list of fellows presently at CERN) <cern-fellows@cern.ch>

```
Dear Colleagues,

On Tuesday evening 27 March 2007, there was an incident during a
pressure test involving one of the LHC's inner triplet magnet assemblies
provided by Fermilab and KEK. No people were involved. The consequences
of the incident on the LHC start-up schedule are not yet known. Details
are available in a statement from Fermilab, with which CERN is in
agreement, at
http://user.web.cern.ch/user/QuickLinks/Announcements/2007/LHCInnerTripl
et.html.

Regards,

Robert Aymar
```



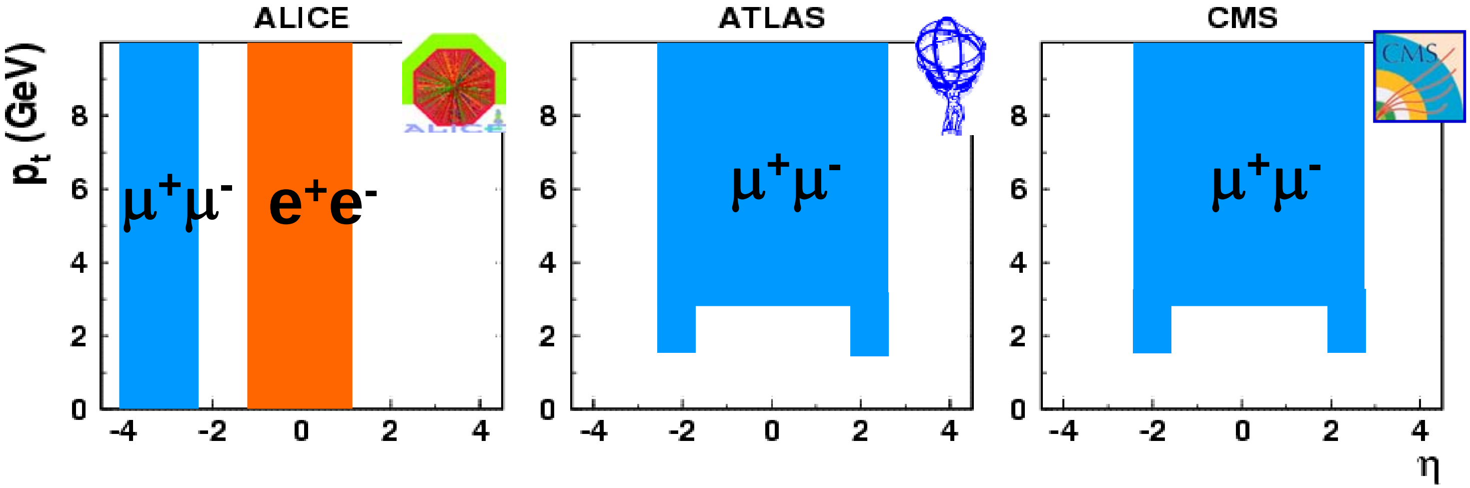
July 20, 2007 — Inner Triplet Successfully Completes Pressure Test

An inner triplet assembly of quadrupole magnets at Point 8-Right of the LHC at CERN successfully completed a pressure test in the accelerator tunnel on Friday, July 13. The triplet, which included three quadrupole magnets and the associated cryogenic and power distribution box, or DFBX, met all test specifications at the requisite pressure of 25 atmospheres for one hour. The triplets will focus particle beams prior to particle collisions at each of four interaction regions in the Large Hadron Collider, now under construction at CERN.

A Q1 magnet assembly with cartridges held in place by the four earlike brackets bolted to the outer flange.

The pressure test is designed to test the accelerator components in conditions that will occur during LHC operations. To withstand the asymmetrical forces generated by the pressure, the Q1 and Q3 magnets, at either end of the triplet assembly had each been fitted with a set of four metal cartridges. The cartridges reinforce internal support structures that broke in two such magnets during an earlier pressure test on March 27. The cartridges limit movement of the magnets inside their metal jackets, or cryostats.

Metal brackets attach the cartridges to one end of each of the affected magnets. The cartridges have a compound design consisting of an aluminum alloy tube and an Invar rod to allow them to function over a broad range of temperatures. Invar is a form of steel whose dimensions change very little in response to temperature differences.


ALICE
ATLAS
CMS
p_t (GeV)
$\mu^+\mu^-$
e^+e^-
$\mu^+\mu^-$
$\mu^+\mu^-$
0
2
4
6
8
-4
-2
0
2
4
η

Sources of information

- ***1995 ALICE Technical Proposal***

  CERN-LHCC 95-71

- ***Physics Performance Report, Volume I***

  J.Phys.G 30(2004)1517-1763

  physics topics, LHC conditions, detector summary, computing

- ***Physics Performance Report, Volume II***

  J.Phys.G 32(2006)1295-2040

  combined detector performance, event reconstruction

Acceptance for Charged Hadrons

- ***central barrel** $-0.9 < \eta < 0.9$*

  ITS,TPC,TRD,TOF 2π tracking, PID

  HMPID single arm RICH

  PHOS single arm EM cal

  EMCAL jet calorimeter (proposed)

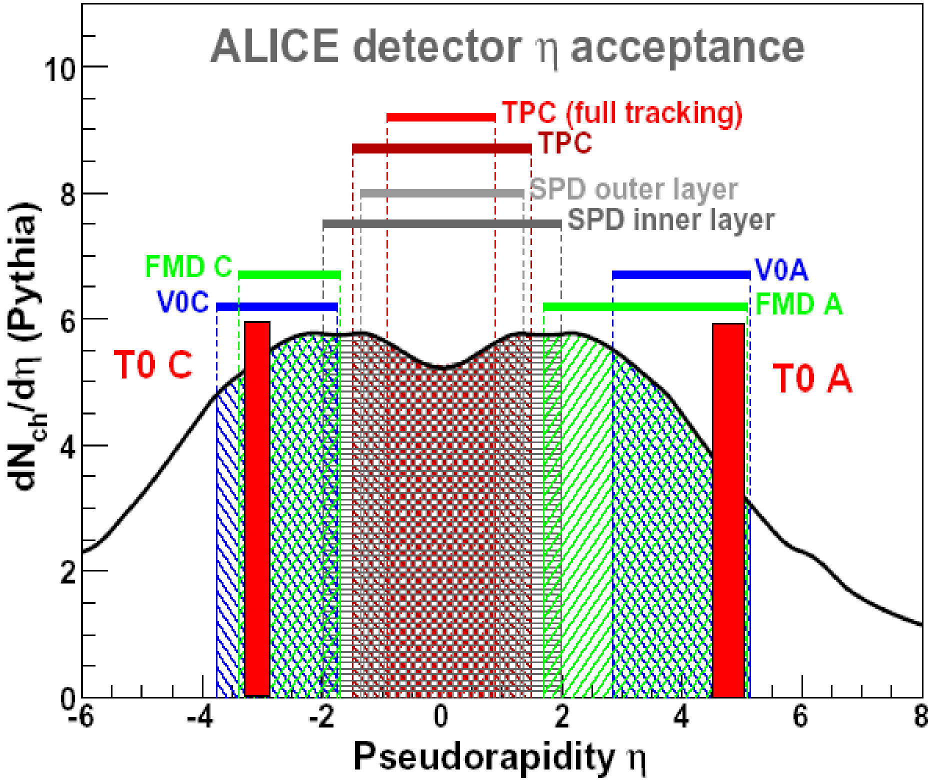
- ***forward muon arm** $2.4 < \eta < 4$*

  absorber, 3 Tm dipole magnet
  10 tracking + 4 trigger chambers

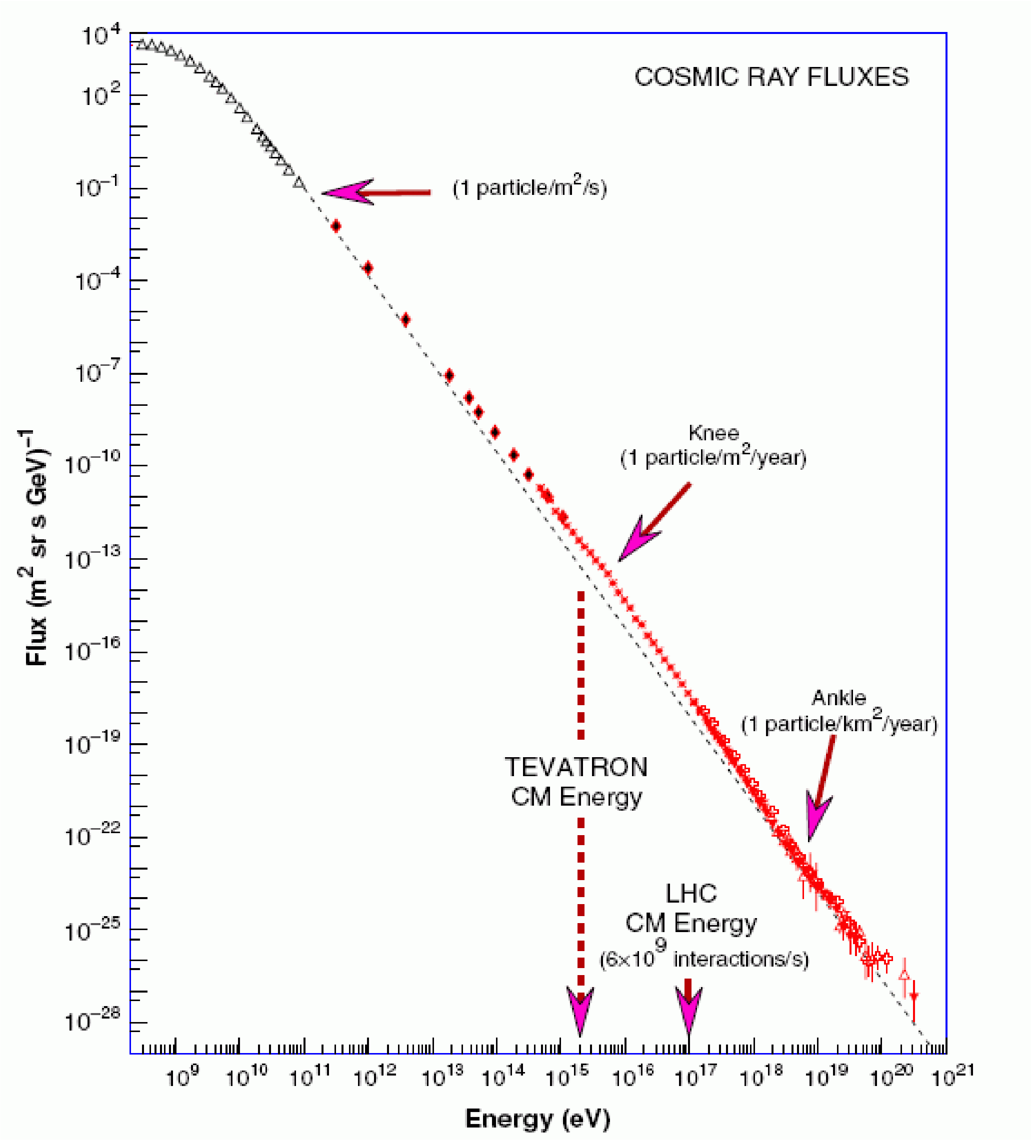
- ***multiplicity** $-5.4 < \eta < 3$*

  PMD including photon counting

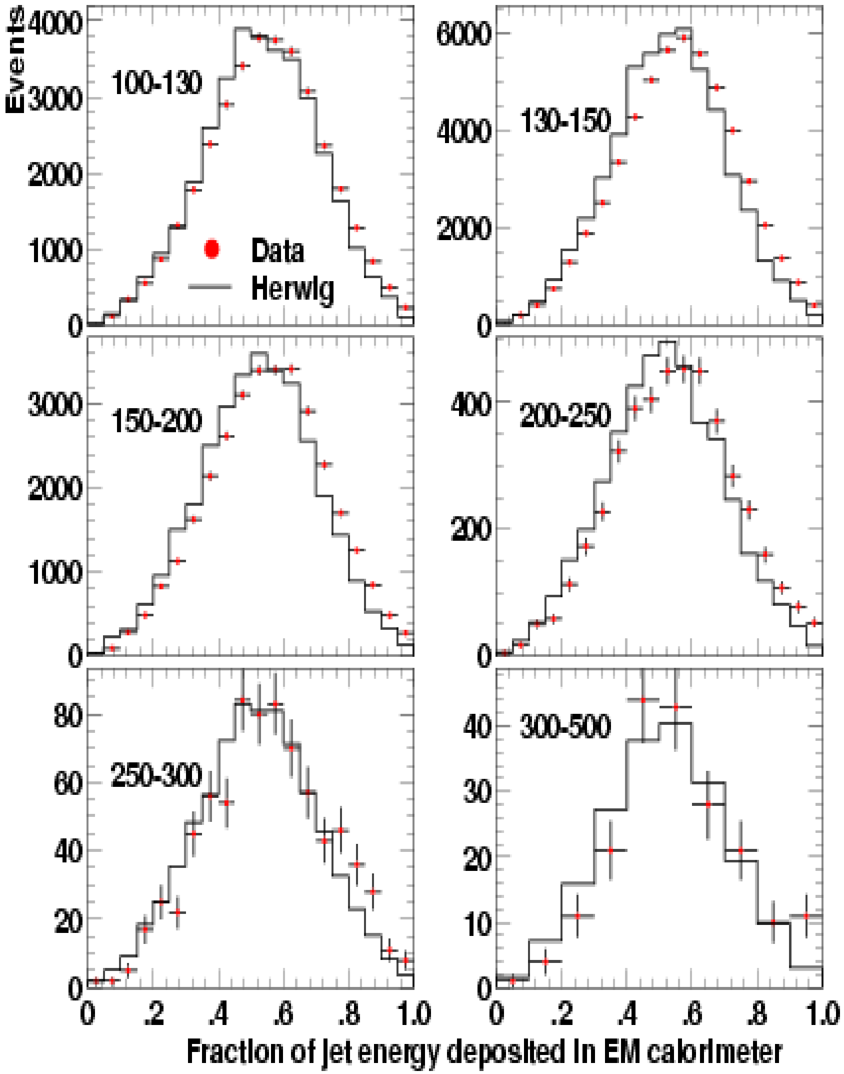
- ***trigger & timing***
  - ***FMD: silicon strip multiplicity det***
  - ***T0: ring of quartz window PMT's***
  - ***V0: ring of scintillator paddles***
  - ***6 Zero Degree Calorimeters***



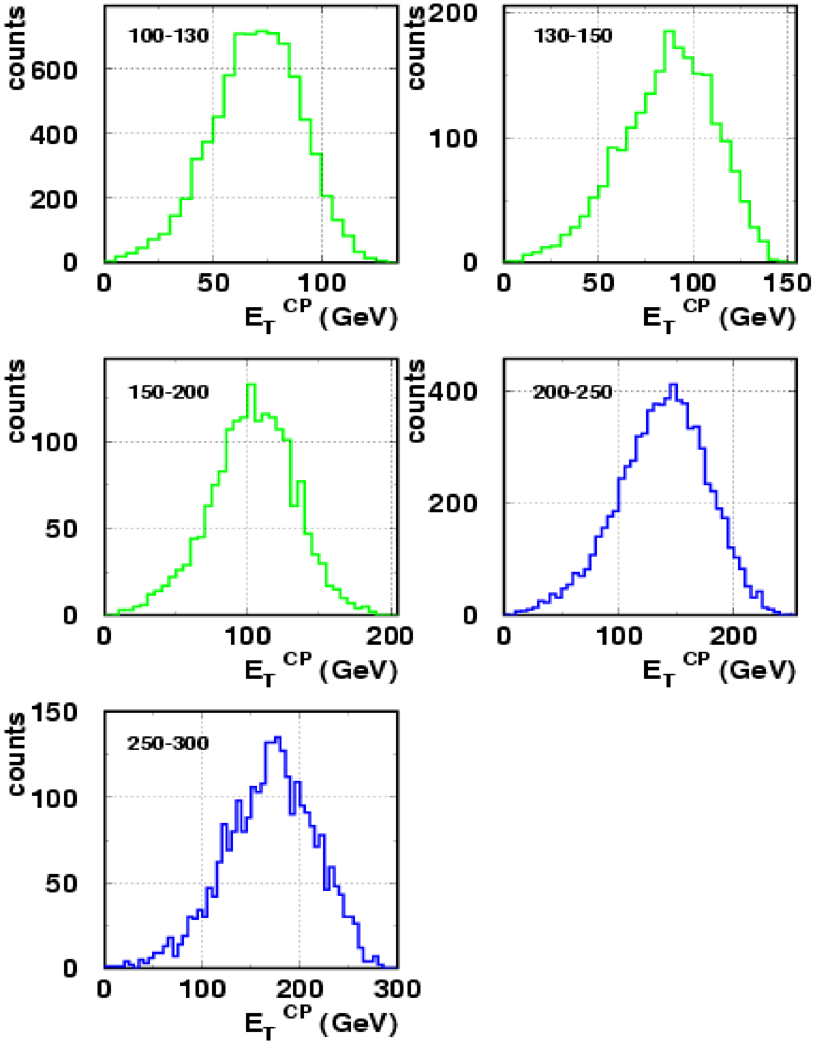
Interactions at energies typical to cosmic rays



jets with an EM calorimeter (CDF)

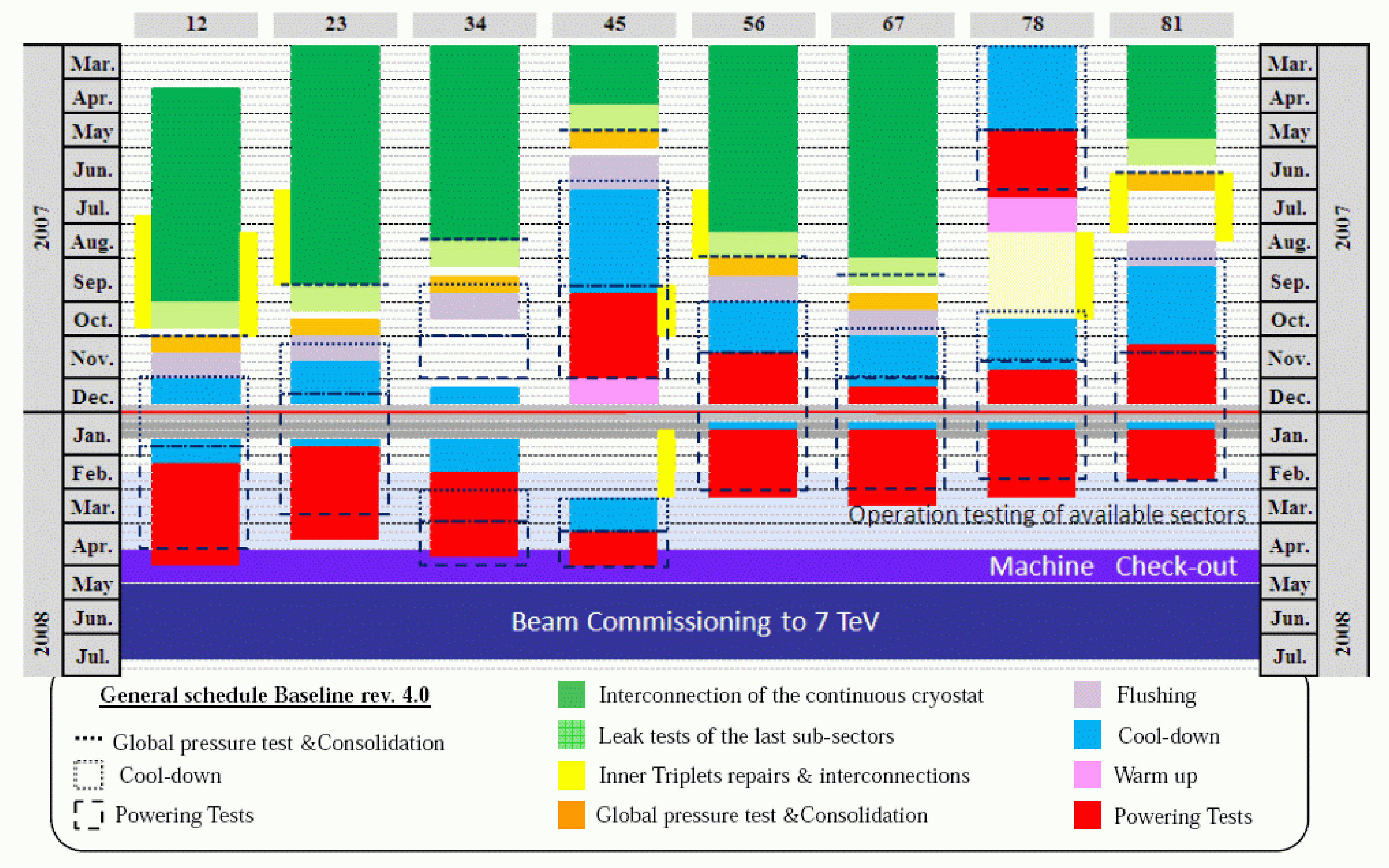


jets with charged particles (ALICE ITS+TPC+TRD)

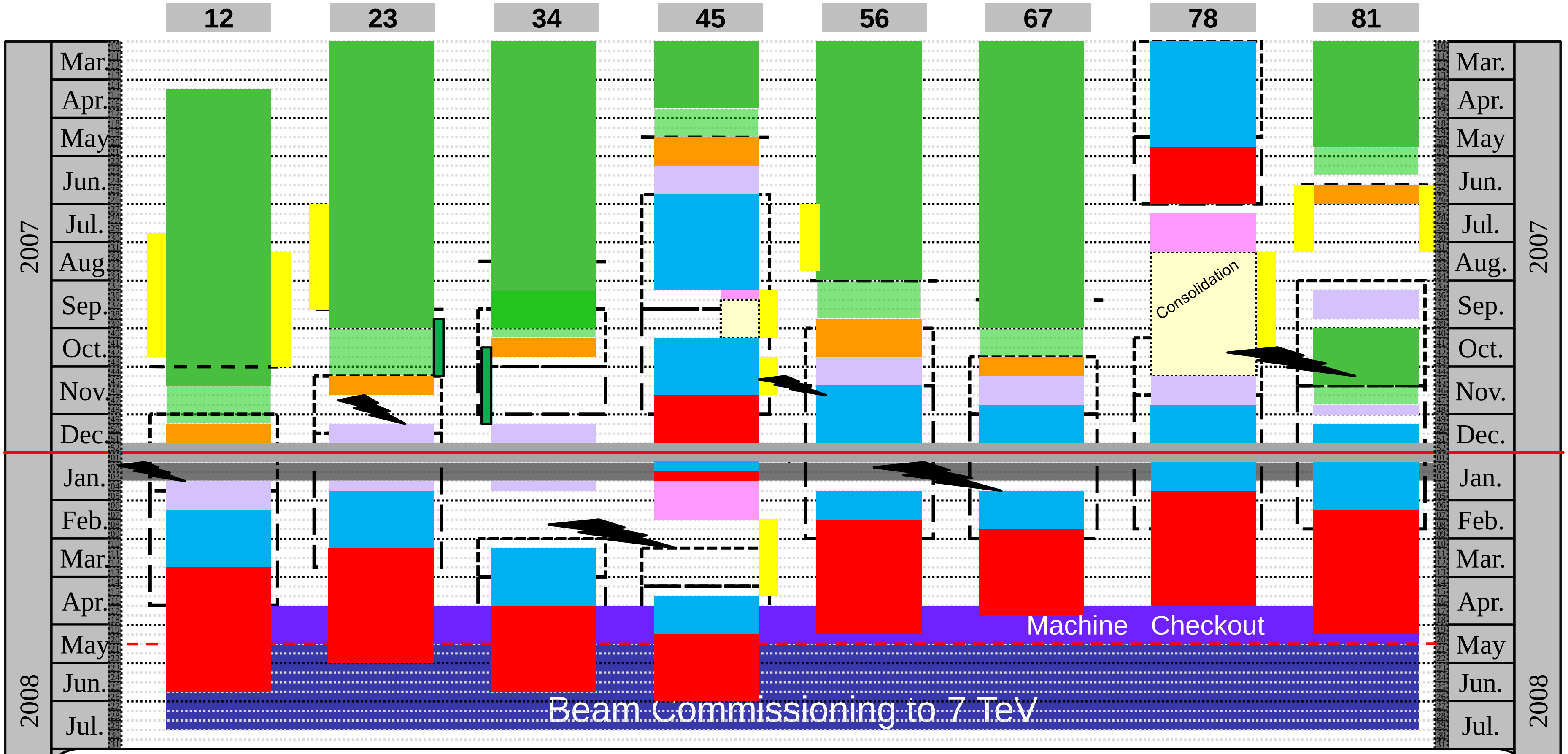


fraction of jet energy in form of charged particles

LHS schedule as of Aug-2007



LHC schedule as of 8 Oct 2007



General schedule Baseline rev. 4.0

- ···· Global pressure test &Consolidation
- ⬚ Cool-down
- ⌜ ⌟ Powering Tests

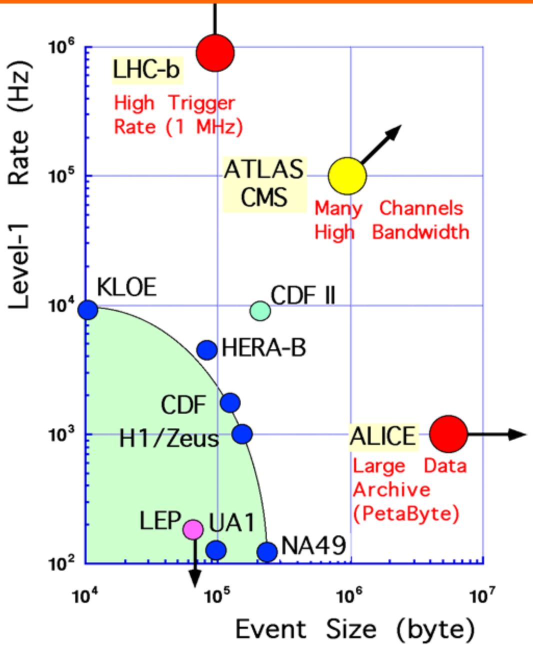
- 🟩 Interconnection of the continuous cryostat
- 🟩 Leak tests of the last sub-sectors
- 🟨 Inner Triplets repairs & interconnections
- 🟧 Global pressure test &Consolidation

- 🟪 Flushing
- 🟦 Cool-down
- 🟪 Warm up
- 🟥 Powering Tests

J.M. Jowett, Quark Matter 2008, Jaipur, 7 February 2008

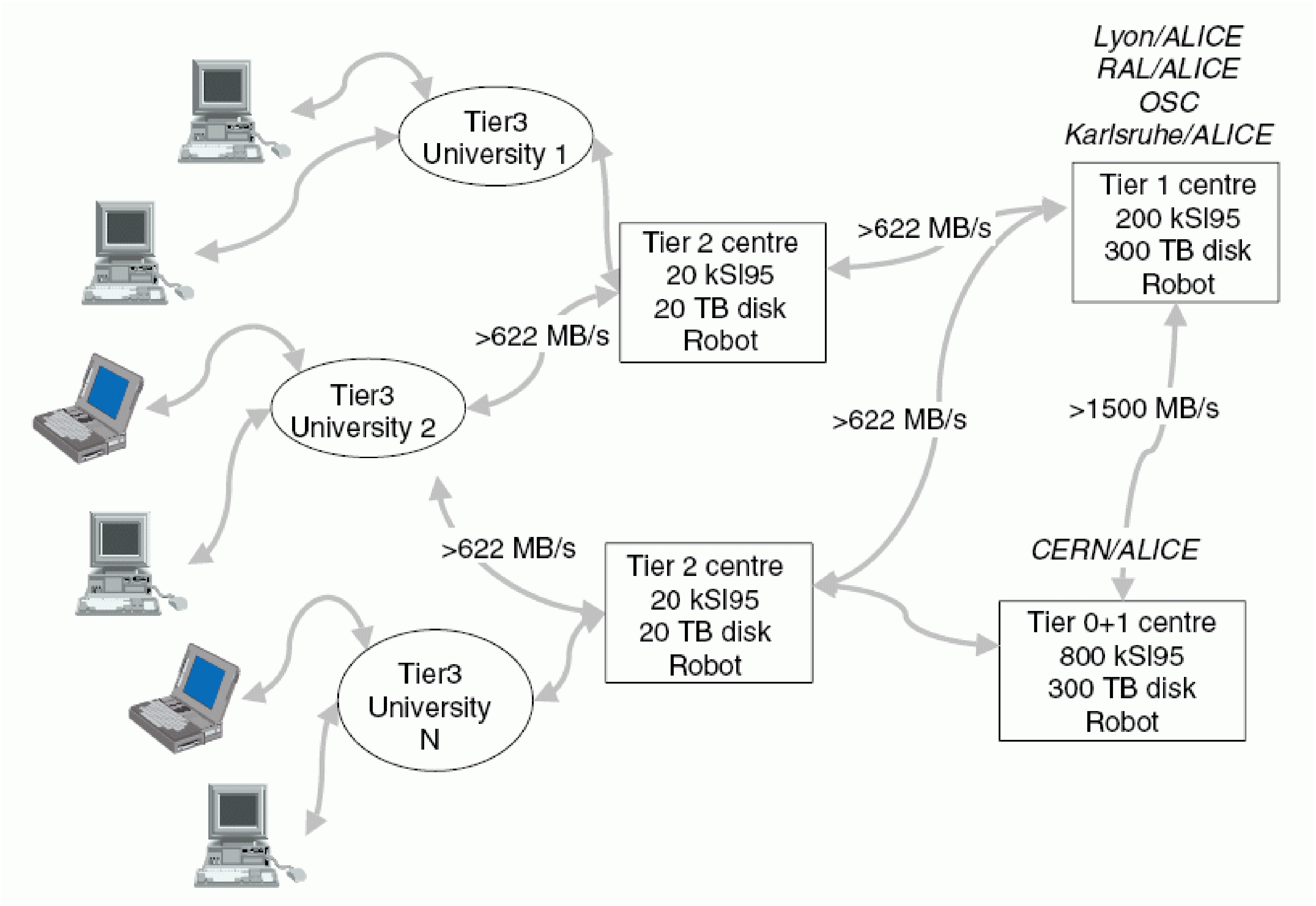
DAQ

Detector	pp (kB)	Pb–Pb (MB)
ITS Pixel		0.140
ITS Drift	1.8	1.500
ITS Strips		0.160
TPC	2450.0	75.900
TRD	11.1	8.000
TOF		0.180
PHOS		0.020
HMPID		0.120
MUON		0.150
PMD		0.120
Trigger		0.120
Total	2500	86.500



	Scenario 1 Rates (Hz)		Scenario 2 Rates (Hz)		Scenario 3 Rates (Hz)		Scenario 4 Rates (Hz)	
	Maximum	DAQ	Level 2	DAQ	Level 2	DAQ	Level 2	DAQ
Central	10^3	20	10	10	20	20	20	20
Minimum-bias	10^4	20	10	10	20	20	20	20
Dielectron			100	100	200	20	200	20
Dimuon	1000	650	1600	1600	1600	1600	1600	1600
Total throughput (MB s^{-1})		1250	1400	1400	700			

Grid


Lyon/ALICE
RAL/ALICE
OSC
Karlsruhe/ALICE
Tier3 University 1
Tier 2 centre 20 kSI95 20 TB disk Robot
>622 MB/s
Tier 1 centre 200 kSI95 300 TB disk Robot
>622 MB/s
Tier3 University 2
>622 MB/s
>1500 MB/s
>622 MB/s
Tier 2 centre 20 kSI95 20 TB disk Robot
CERN/ALICE
Tier 0+1 centre 800 kSI95 300 TB disk Robot
Tier3 University N

Urs Wiedemann, QM2006

Day 1 @ LHC: event multiplicity at y=0

- generic trends in $dN^{ch}/d\eta$
  - extended longitudinal scaling
  - self-similar trapezoidal shape

$$\Rightarrow \quad dN^{ch}/d\eta\Big|_{\eta=0} \propto \ln\sqrt{s_{NN}}$$

- Saturation models predict

Armesto, Salgado, Wiedemann, PRL94 (2005) 022002

$$\frac{1}{N_{\mathrm{part}}}\frac{dN^{AA}}{d\eta}\bigg|_{\eta\sim0} = N_0\sqrt{s}^{\lambda}N_{\mathrm{part}}^{\frac{1-\delta}{3\delta}}$$

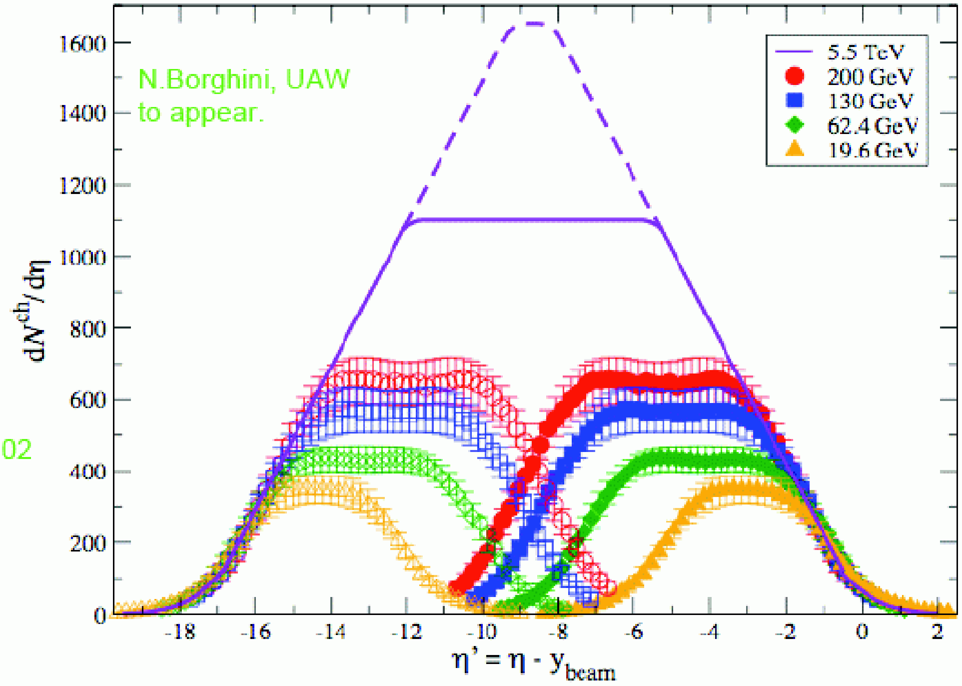
$$\Rightarrow \quad dN^{ch}_{LHC}/d\eta\Big|_{\eta=0} \approx 1650$$

or Kharzeev, Levin, Nardi, NPA747 (2005) 609.

$$\Rightarrow \quad dN^{ch}_{LHC}/d\eta\Big|_{\eta=0} \approx 1800-2100$$

Both consistent with main trends at RHIC, but …

PHOBOS, PRC74 (2006) 021901; W. Busza .



N.Borghini, UAW to appear.

Extrapolations to LHC deviate from so-far generic trends in data

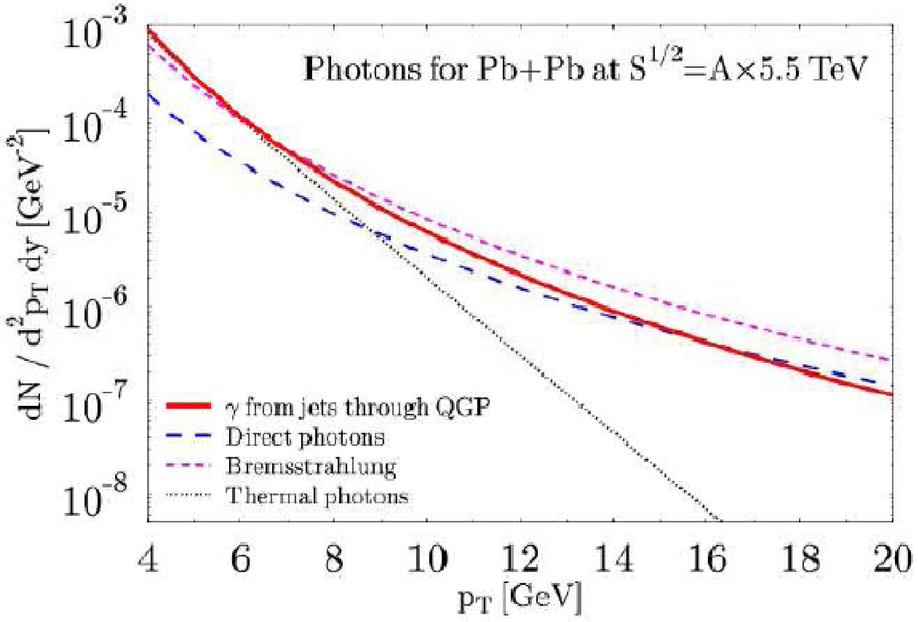
⇒ Impact for understanding the dynamical origin of soft physics at RHIC and LHC.

Photons

***PHOS* - thermal photons (p_t < 5GeV/c)**

***EMCAL* - high energy photons**

***Central Barrel* - $\gamma \to e^+e^-$**



	p_t^{max} (1year) (GeV/c)		High-p_t trigger
	γ	π^0	
PHOS	~100 (shower shape)	~150 (inv. mass)	✓
EMCAL	~150 (shower shape)	~200 (inv. mass)	✓
Central Barrel	~20 ($\gamma \to e^+e^-$)	-	✓

Quarkonia in dimuon channel

MUON-arm

Forward region
$2.4 < \eta < 4.0$

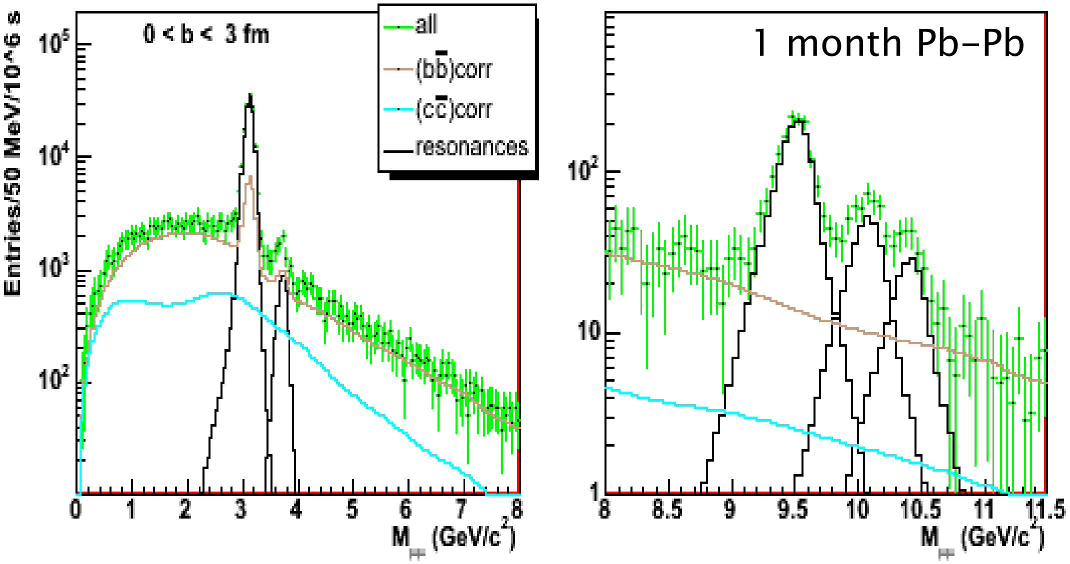
Resolution:
$\sigma_m(J/\psi) \approx 70$MeV
$\sigma_m(\Upsilon) \approx 100$MeV

Sensitivity
($e^+e^-/\mu^+\mu^-$)

J/ψ, ϒ, ϒ’ : High with normal stat.

ϒ”: Needs 2-3 years high lum.

ψ’ : Difficult



State	S[10^3]	B[10^3]	S/B	S/(S+B)$^{1/2}$
J/Ψ	130	680	0.20	150
Ψ’	3.7	300	0.01	6.7
ϒ(1S)	1.3	0.8	1.7	29
ϒ(2S)	0.35	0.54	0.65	12
ϒ(3S)	0.20	0.42	0.48	8.1

Urs Wiedemann, QM2006

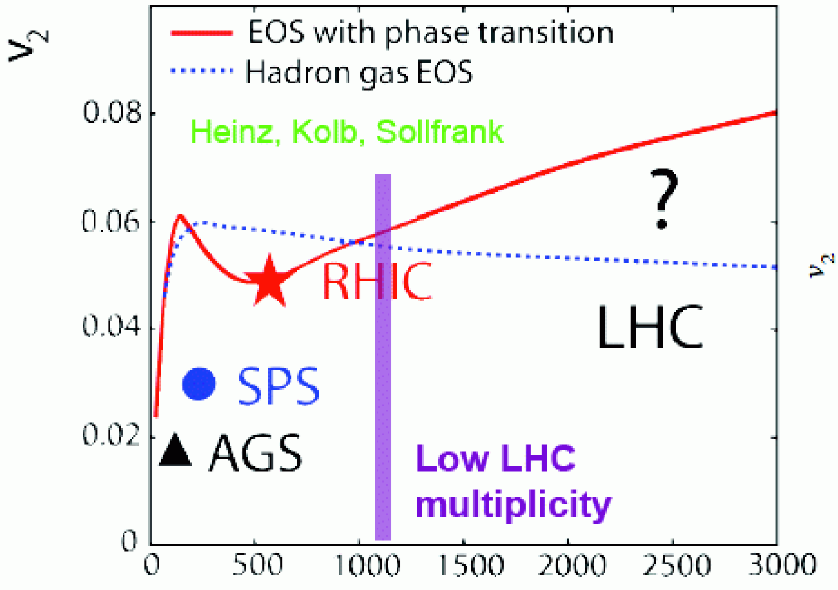
LHC tests the hydro-paradigm

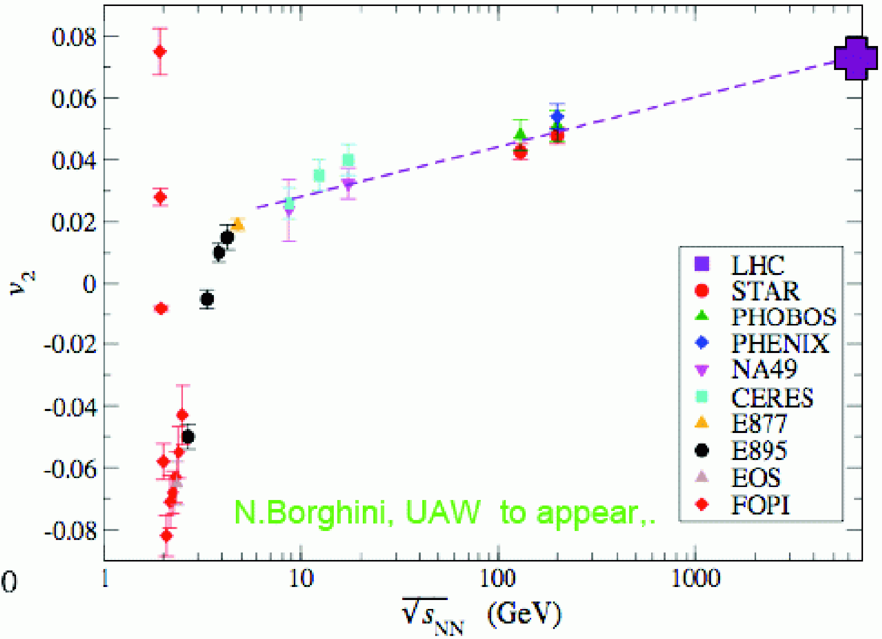
- Hydro prediction for low LHC multiplicity

$$v_2 \approx 0.055$$

- Extrapolation of generic RHIC trend

$$v_2 \approx 0.075$$





Also consistent with
Teaney et al., nucl-th/0110037

(In)consistency with generic trend ↔ Characterization of microscopic dynamics underlying collectivity