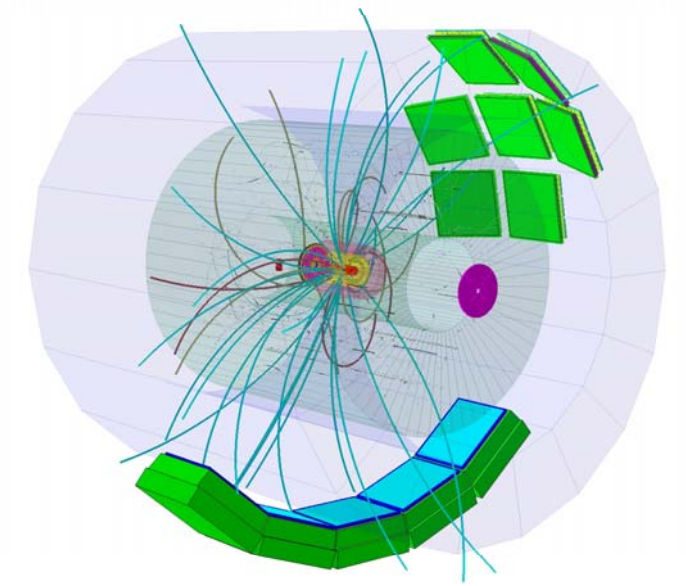
Physics at LHC-2008

29 September - 4 October 2008, Split - CROATIA

First Physics with ALICE: from pp to PbPb



Domenico Elia, INFN Bari
for the **ALICE Collaboration**

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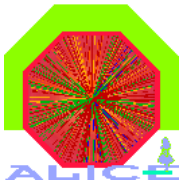
Introduction



- First proton-proton run (starting spring 2009):
  - commissioning ALICE with beams
  - unique pp physics programme with ALICE
  - important pp reference data for heavy ions
- Early heavy-ion run (2009/2010):
  - running 10^6 sec @ 1/20 nominal luminosity
  - first basic issues:
    - global event characteristics
    - bulk properties (thermodynamics, hydrodynamics …)
    - (start of) hard probe measurements

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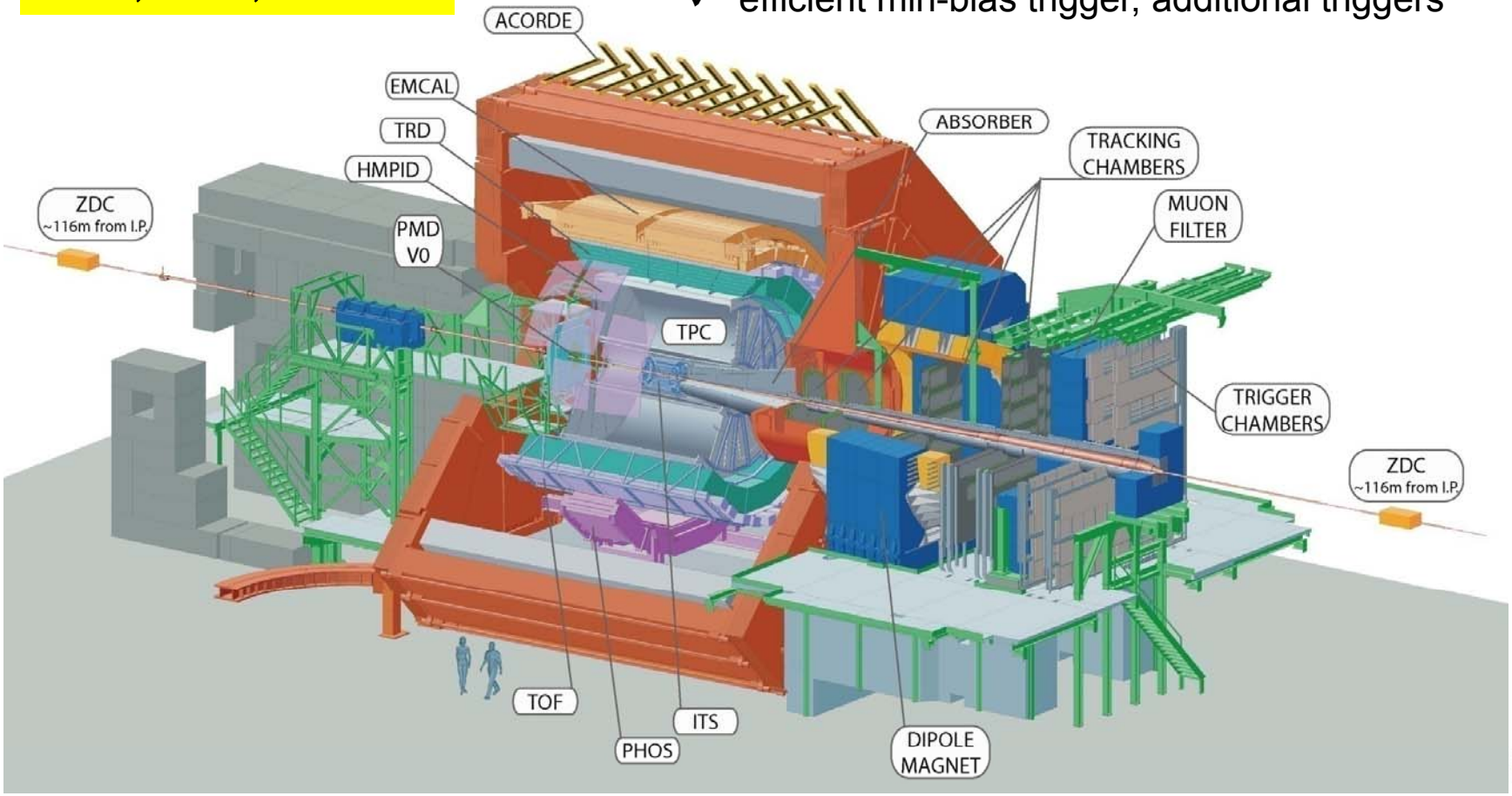
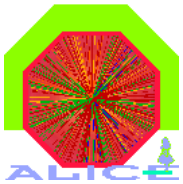
ALICE layout

- ✓ low-momentum cutoff (<100 MeV/c)
  x_T-regime (down to 4×10^{-6})
- ✓ p_t-reach up to 100 GeV/c
- ✓ excellent tracking and PID
- ✓ dedicated di-electrons and di-muons
- ✓ high resolution calorimeter for direct photons
- ✓ efficient min-bias trigger, additional triggers

First pp physics:
SPD, TPC, VZERO



Proton-proton physics with ALICE



- The ALICE first physics:

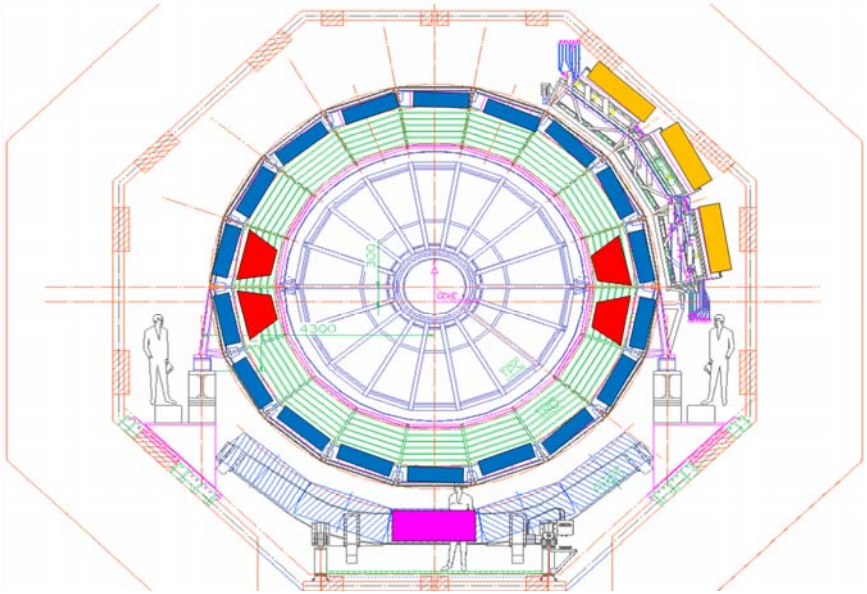
Talk by JF Grosse-Oetringhaus

  - allowing unique pp physics in ALICE eg:
    - charged multiplicity, pseudorapidity density distributions
    - transverse momentum spectra
    - first strange particle studies
    - charm cross section → major input to pp QCD physics
  - providing reference data for heavy ion collisions

- Early pp running scenario:
  - some collisions @ 900 GeV → minimize existing systematics
  - pp nominal run @ 10 TeV (14 TeV):
    - luminosity of **$2*10^{30}$ cm^{-2} s^{-1}** x **10^7 s**, $2*10^{12}$ collisions
    - MB triggers: 20 events pileup (TPC), **10^9 collisions**

Detector startup configuration

- Complete (fully installed and commissioned):
  - ITS, TPC, TOF, HMPID, MUON, PMD, V0, T0, FMD, ZDC, ACORDE



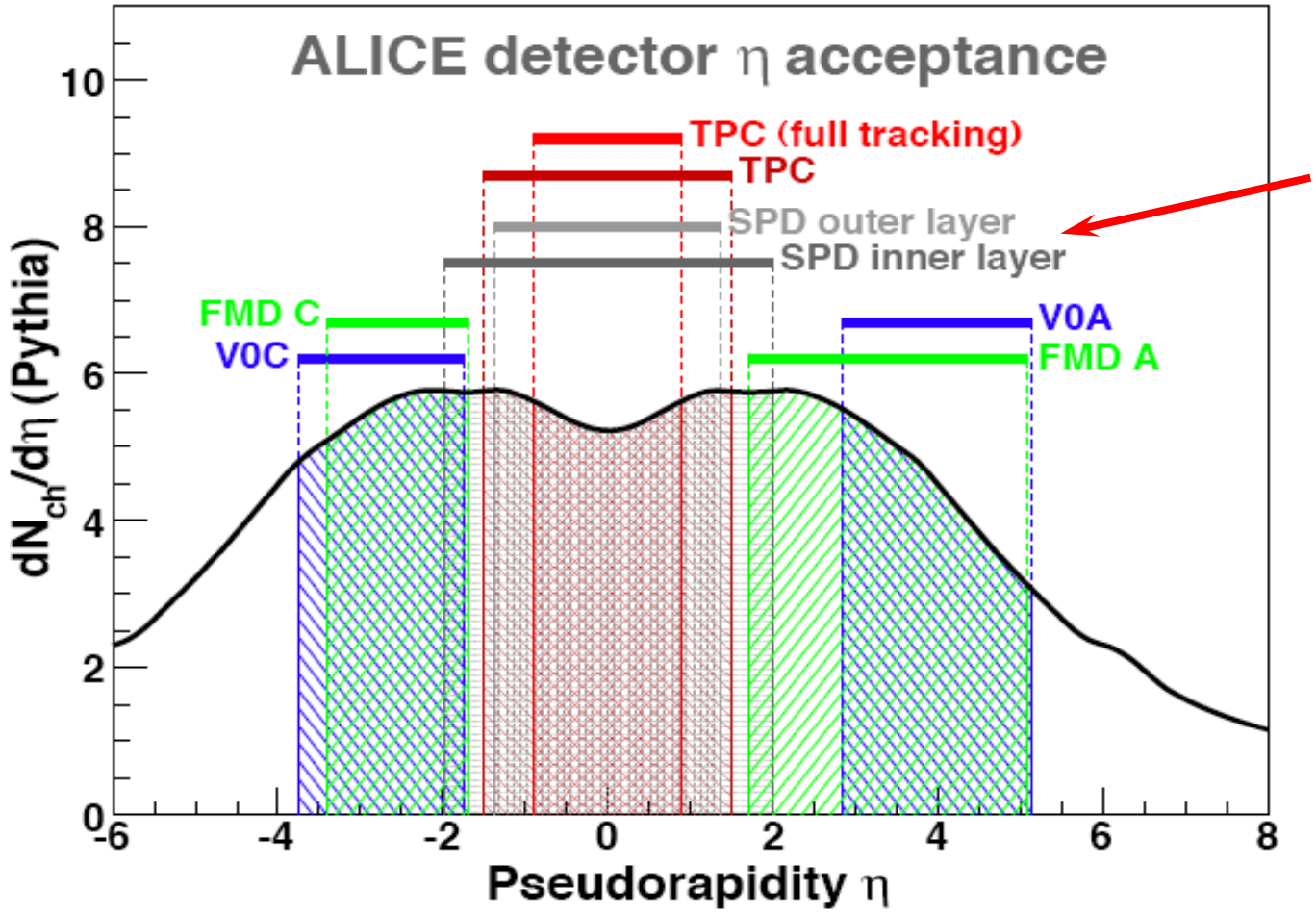
- Partially completed:
  - **TRD (25%)** → 2009
  - **PHOS (60%)** → 2010
  - HLT (40%) → 2009
  - EMCAL (0%) → 2010/11

→ full hadron and muon capabilities @ startup

→ partial electron and photon capabilities

Talks by: J Shukraft
S Chapeland

Charged particle acceptance

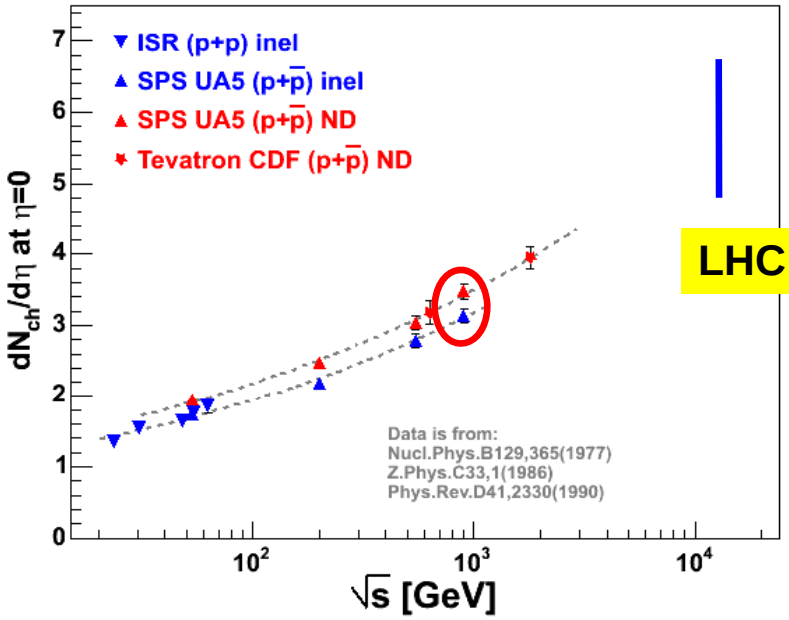


operating with "Fast-OR" L0 trigger from Silicon Pixels (SPD)

Charged particle multiplicity

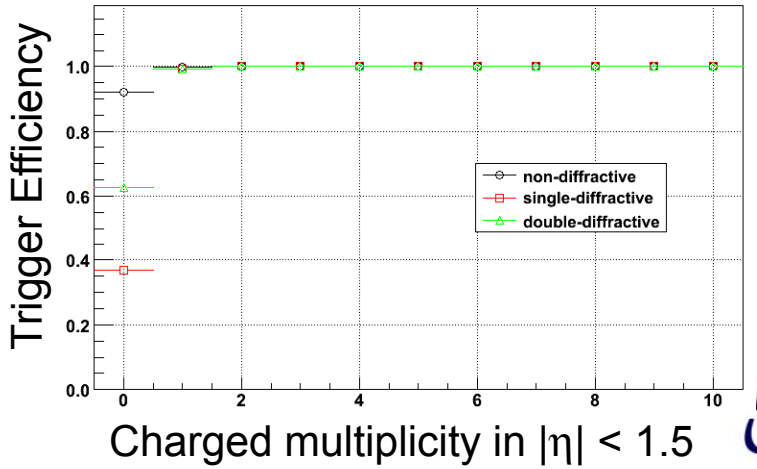
- Will be the first measurement:
  - unique SPD (L0) trigger (min-bias precision measurements)
  - compare with existing measurements (900 GeV)
  - extend existing energy dependence

Initially based on the SPD



LHC

MB trigger efficiency:
ND-INEL 98%, SD 55%, DD 58%

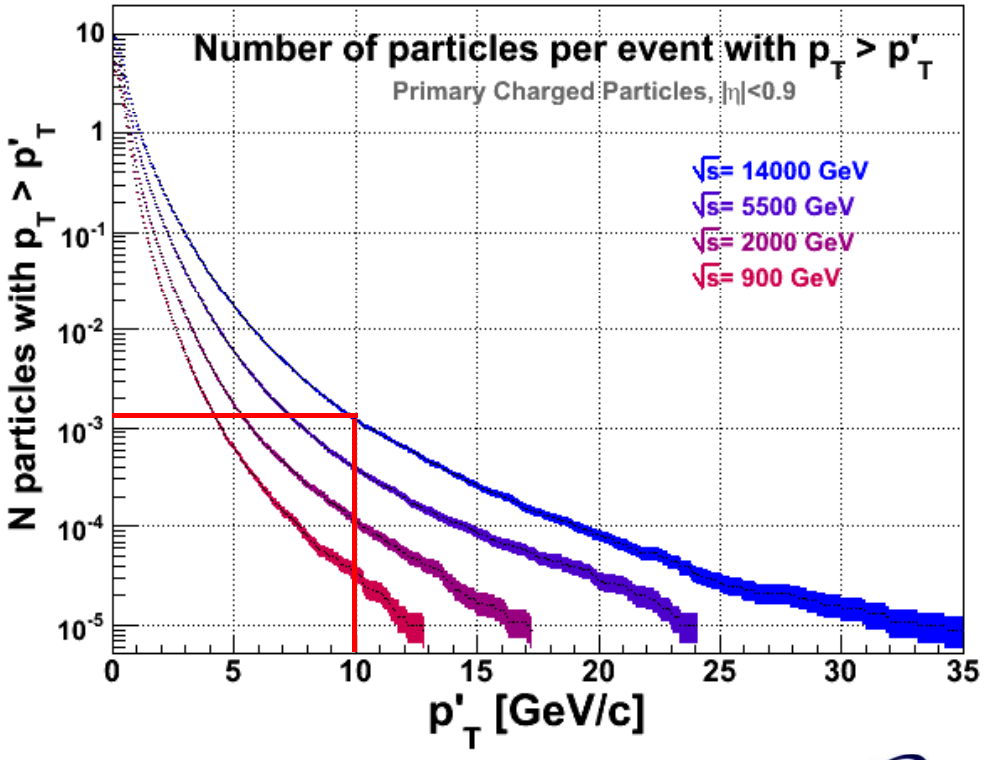


Initial transverse momentum reach

- With 20k MB pp events (first few days):
  - 5 GeV (at 0.9 TeV)
  - 10 GeV (at 14 TeV)

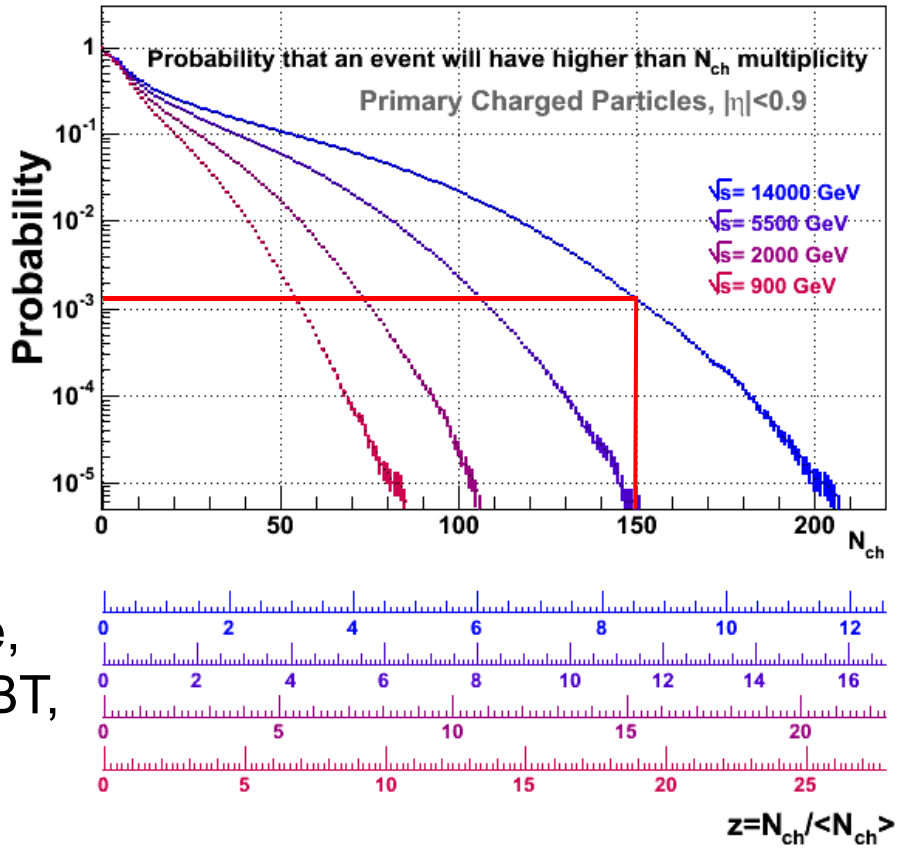
p_T reach up to ~20 GeV already with 200k events

- With O(10^8) events (first month):
  - 15 GeV (at 0.9 TeV)
  - 50 GeV (at 14 TeV)



Initial multiplicity reach

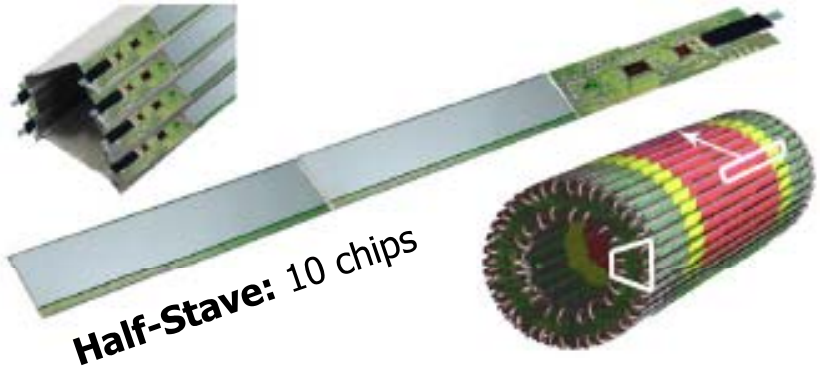
- With 20k MB pp events:
  - up to multiplicities
    ~ 8 times the average
    (30 events beyond)
- High multiplicity trigg:
  - to enrich high multiplicity
  - interesting for multiparton interaction, event structure, multiplicity correlations, HBT, rapidity gaps, …
  - @ 10 times the average multiplicity → energy density as with heavy ions



High multiplicity trigger

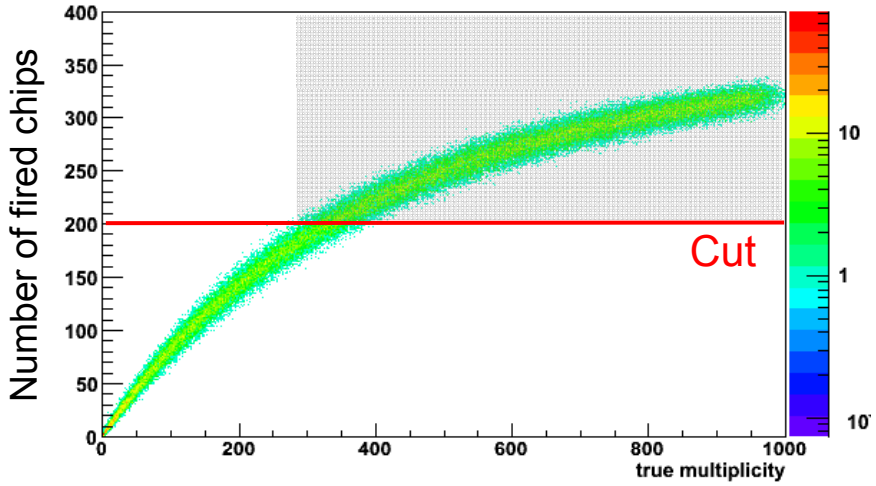
- Based on the SPD Fast-OR:
  - OR signal from each chip:
    - 400 chips inner layer
    - 800 chips outer layer
  - trigger (L0) on fired chip multiplicity per layer

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



SPD: 10 sectors (1200 chips)

Fired chips vs. true multiplicity (η acceptance of the layer)



Few trigger thresholds configured simultaneously:

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

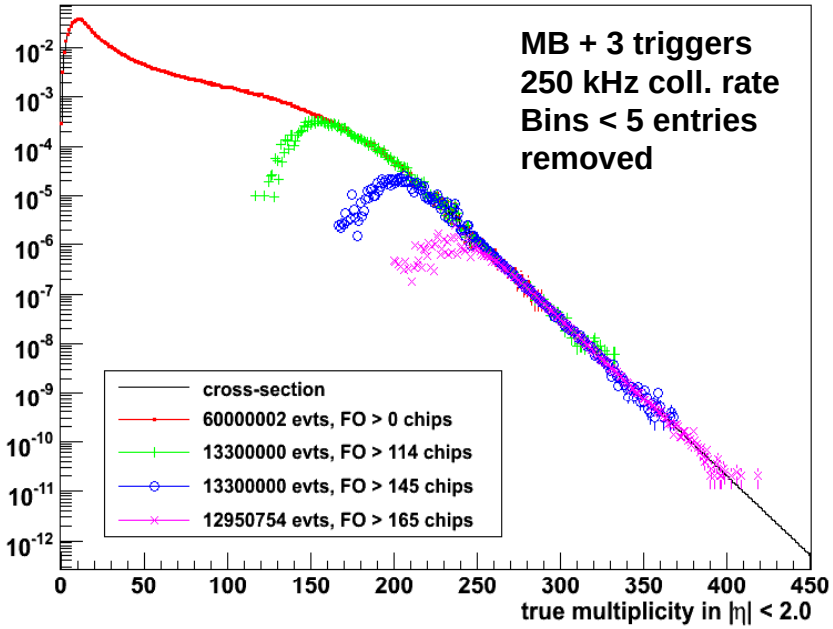
High multiplicity trigger

- Example of threshold tuning:
  - MB and 3 high multiplicity triggers

250kHz collision rate
100 Hz recording rate

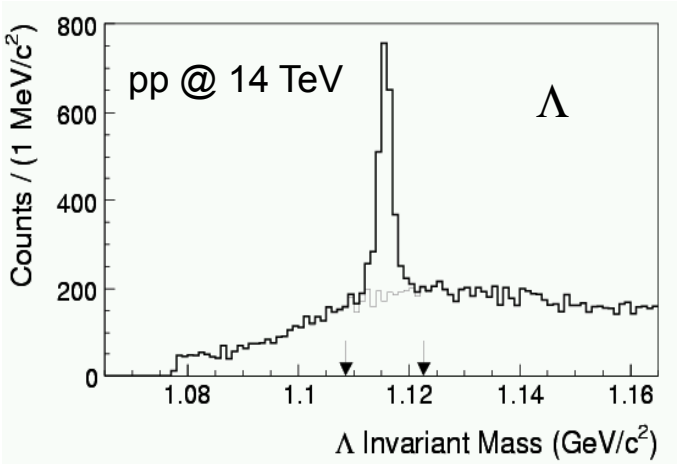
MB trigg → 60%
3 HM triggs → 40%

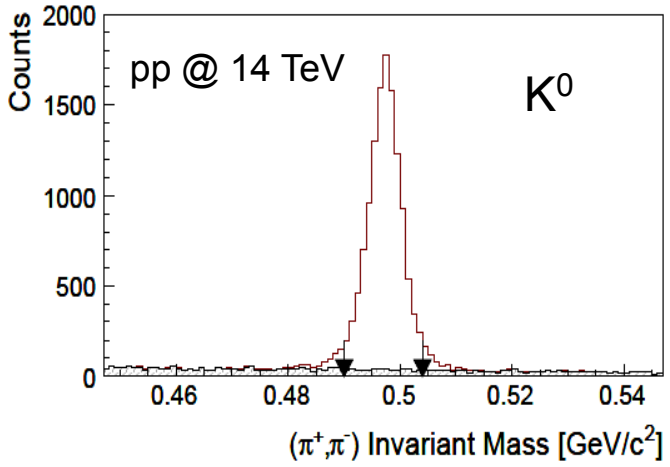
Trigg. Rate (Hz)	Scaling	Raw rate (Hz)	Threshold (layer 1)
60.0	4167	250000	MB
13.3	259	3453.3	114
13.3	16	213.3	145
13.3	1	13.3	165



First strange particle studies

- Significant samples of strange particles:
  - ~70 M min-bias pp events (based on Pythia for LHC):
    - K0 → $7*10^6$
    - Λ → 10^6
    - Ξ → $2*10^4$
    - Ω → 270
  - detailed study of flavour composition



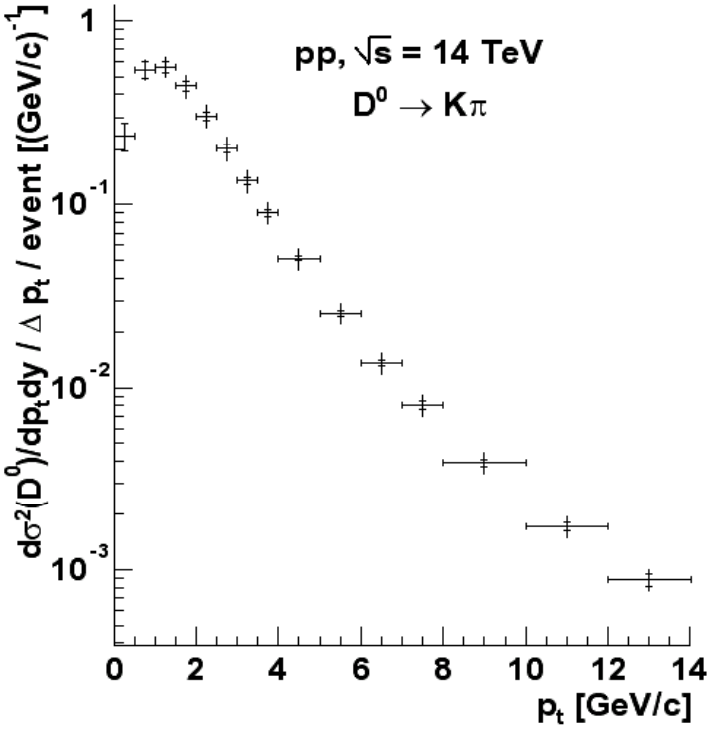


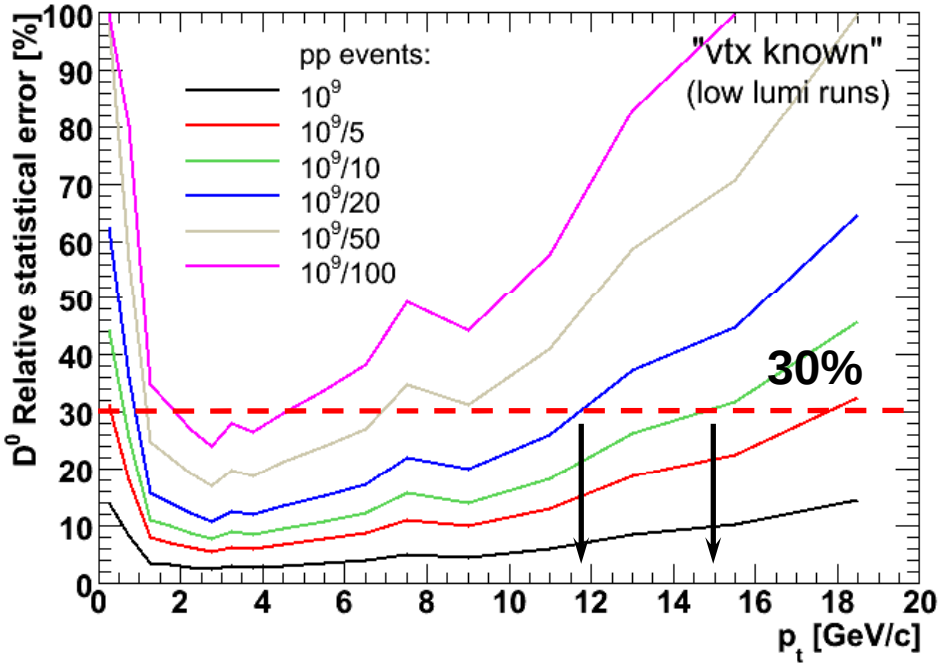
	K^0	Λ	Ξ	Ω	p	$\bar{p}$
Yield	0.1	0.01	$2x10^{-4}$	10^{-5}	0.4	0.4
Stat	10^4	10^4	10^4	10^4	10^4	10^4
pp Evts	10^5	10^6	10^8	10^9	10^4	10^4

Heavy flavour (charm) physics

- Golden channel for open charm:
  - $D^0 \rightarrow K\,\pi$

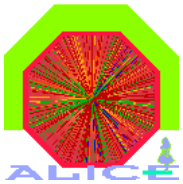
10^9 min-bias pp events





→ reach up to 12 – 15 GeV/c
with 5 – 10*10^7 events

Heavy-ion physics with ALICE

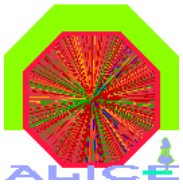


- Physics goals, what and when:
  - fully commissioned detector and trigger:
    - alignment and calibrations available from pp run
  - first **10^5 events** → global event properties:
    - multiplicity, rapidity density, elliptic flow
  - first **10^6 events** → source characteristics:
    - particle spectra, resonances
    - differential flow analysis
    - interferometry
  - first **10^7 events** → high p_T, heavy flavour:
    - jet quenching, heavy-flavour energy loss
    - charmonium production

  → yield bulk properties of created medium

  (energy density, temperature, pressure, viscosity, opacity …)

Heavy-ion physics with ALICE



- Early ion running scenario:
  - running @1/20 of the nominal luminosity
  - luminosity of **$5*10^{25}$ cm^{-2} s^{-1}** x **10^6 s**:
    - 0.05 nb^{-1} for PbPb @ 5.5 A TeV
    - $2*10^8$ collisions
    - minimum bias rate → 400 Hz
    - central collision (5%) rate → 20 Hz
  - muon triggers:
    - ~100% efficiency, < 1 kHz
  - centrality triggers:
    - bandwidth limited
    - N_{PbPb} (minimum bias) → 10^7 events (10 Hz)
    - N_{PbPb} (central collisions) → **10^7 events** (10 Hz)

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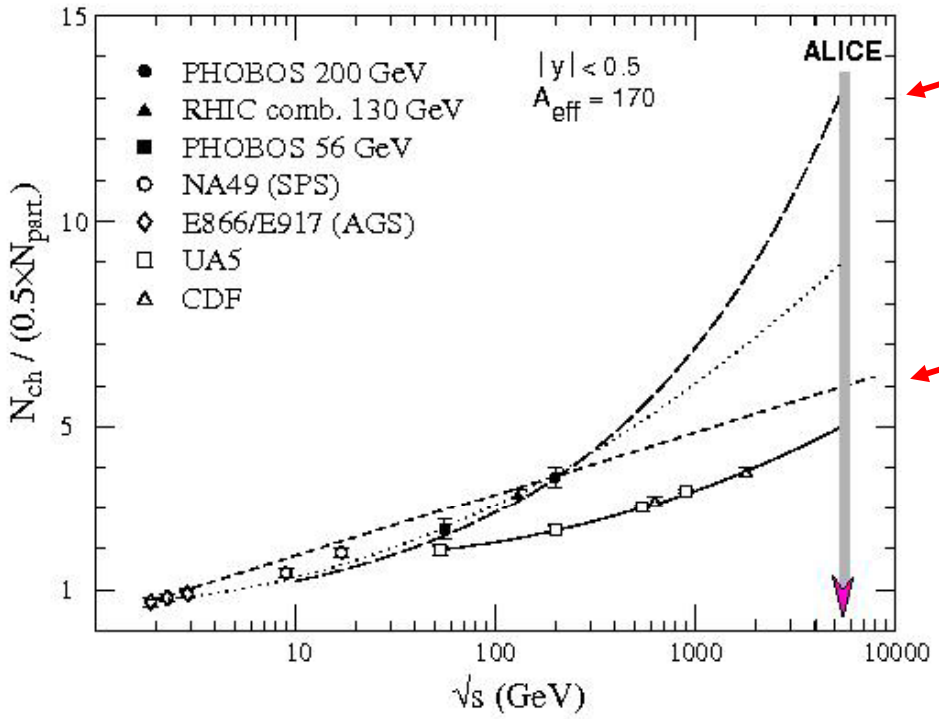
Charged particle multiplicity density

- Getting a first estimate of the energy density:

Integrated multiplicity distributions from AuAu/PbPb collisions and scaled pp collisions



saturation model
Eskola hep-ph/050649

$dN_{ch}/dy = 2600$

ln(√s) extrapolation

$dN_{ch}/dy = 1200$

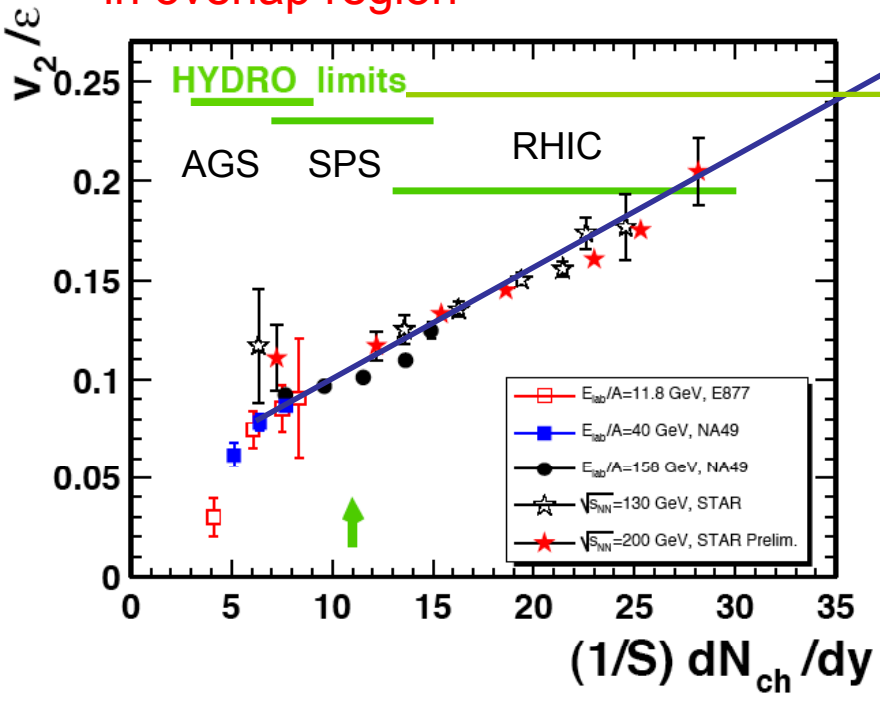
Predictions before RHIC considerably higher (up to $dN_{ch}/dy=8000$)

ALICE designed for $dN_{ch}/dy=3500$, design checked up to $dN_{ch}/dy=8000$

Elliptical flow

- Getting one of the first answers from LHC:
  - is the QGP an ideal fluid ?

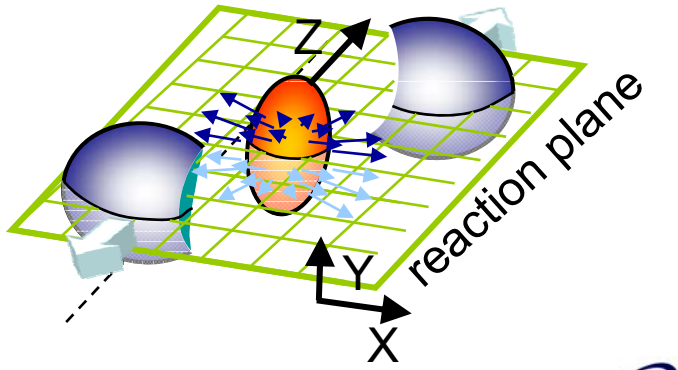
Eccentricity vs. particle multiplicity in overlap region



experimental trend: large increase of flow

LHC ?

hydro limit reached at RHIC → ideal fluid



event plane resolution < 10°
robust signal → no PID needed

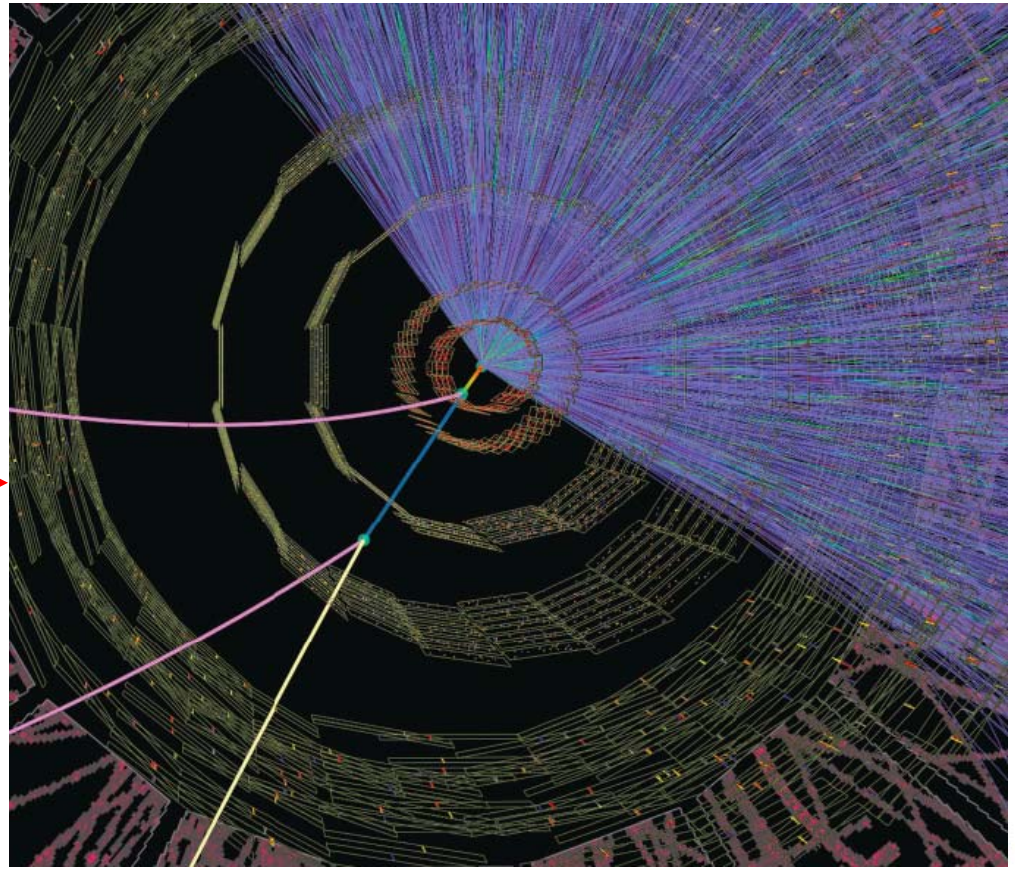
Tracking challenge

- Excellent tracking/vertexing/PID capabilities:
  - key factors
  - ALICE combines all of them!

$\Xi^- \rightarrow \Lambda\ \pi^-$

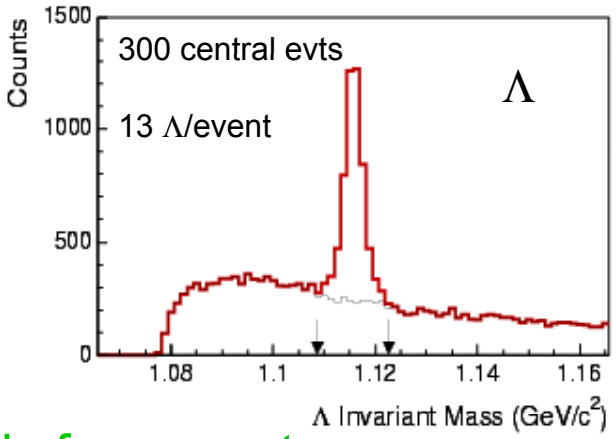
with part of the event removed

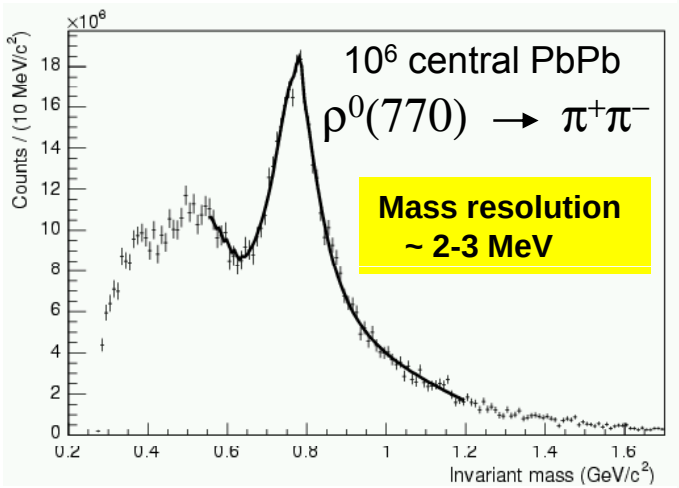
→ displaced vertices can be seen

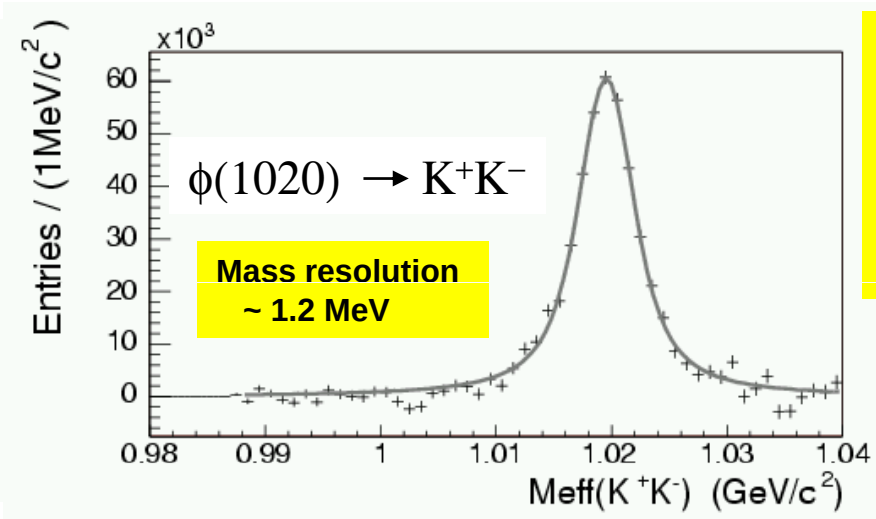


Strange particles, resonances

- Measure (ρ, ϕ, K*, K^0, Λ, Ξ, Ω ...):
  - strangeness production
  - medium modifications of mass,widhts
  - p_T reach (with 10^7 events):
    - ~13-15 GeV (ϕ,K,Λ)
    - ~9-12 GeV (ρ,Ξ,Ω)
  - hadrochemical analysis, chemical/kinetic freeze-out







Reconstruction rates:

Λ: 13/event
Ξ: 0.1/event
Ω: 0.01/event

Jet statistics in pilot Pb run

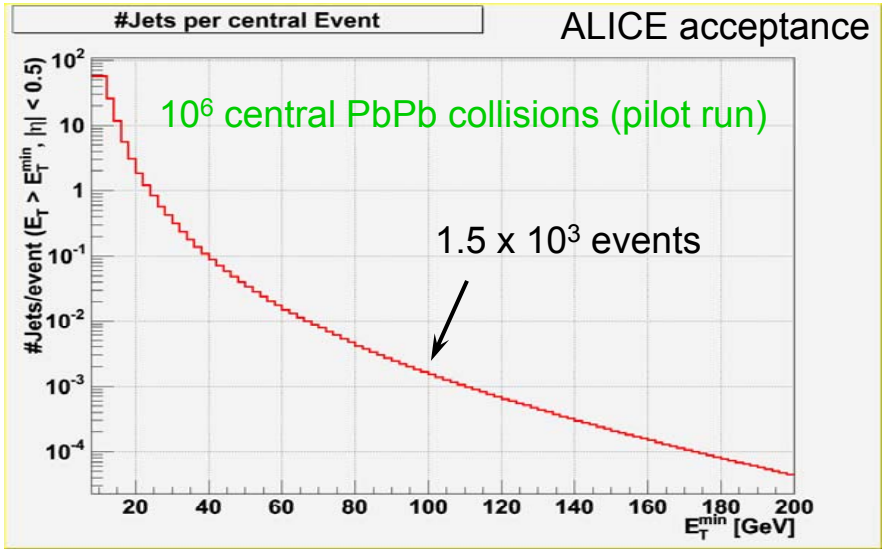
- Jets copiously produced:

p_T (GeV)

2 | 20 | 100 | 200

100/event | 1/event | 10^3 in first 10^6 PbPb events

  - ev-by-ev distinguished objects
  - huge background (underlying event)



10^6 central PbPb collisions

E_T threshold	N_{jets}
50 GeV	5×10^4
100 GeV	1.5×10^3
150 GeV	300
200 GeV	50

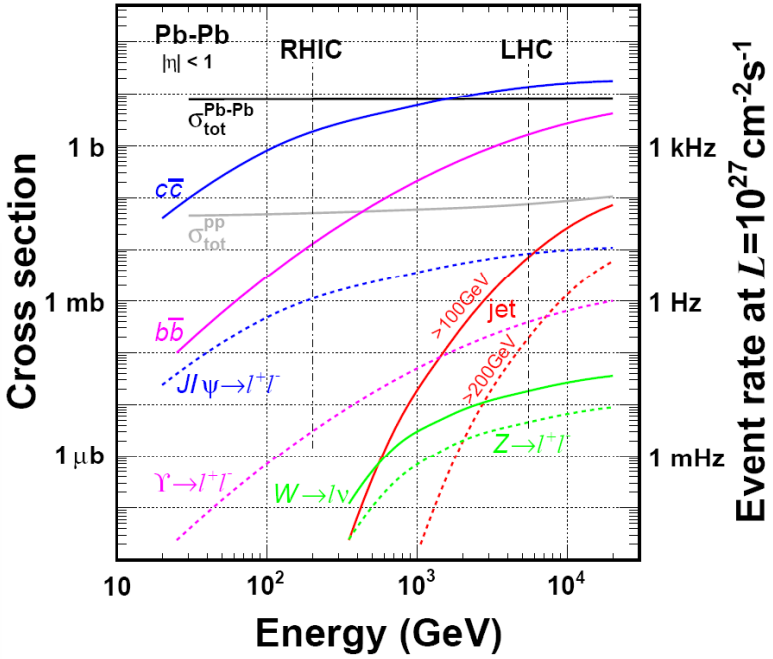
Heavy quarks and quarkonia

- LHC is a heavy flavour machine:

	SPS	RHIC	LHC
N_{cc}/event	0.2	10	200
N_{bb}/event	-	0.05	6

ALICE's Heavy Quark Shopping List

probe	channel	acceptance
$J/\psi, \psi', \Upsilon, \Upsilon', \Upsilon''$	e^+e^-	$\|\eta\| < 0.9$
$J/\psi, \psi', \Upsilon, \Upsilon', \Upsilon''$	$\mu^+\mu^-$	$2.5 < \eta < 4$
$c\bar{c}$ & $b\bar{b}$	e^+e^-	$\|\eta\| < 0.9$
$c\bar{c}$ & $b\bar{b}$	$\mu^+\mu^-$	$2.5 < \eta < 4$
D mesons	π,K	$\|\eta\| < 0.9$
B mesons	$B \rightarrow J/\psi \rightarrow e^+e^-$	$\|\eta\| < 0.9$
D & B mesons	single $e^{\pm}$	$\|\eta\| < 0.9$
$c\bar{c}$ & $b\bar{b}$	$e^{\pm}\mu^{\mp}$	$1 < y < 3$

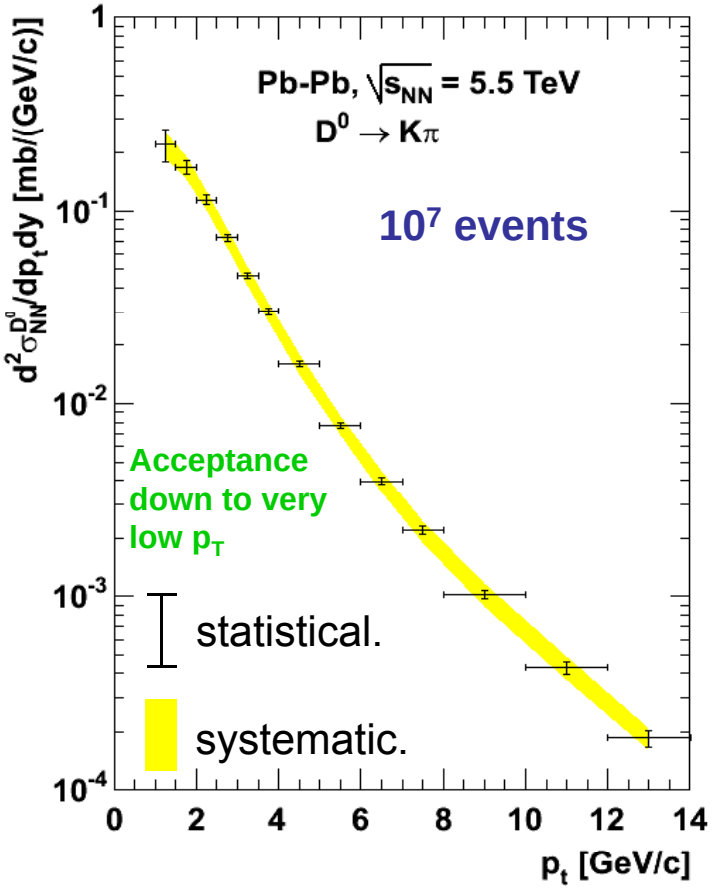


Talk by P Pillot

Open charm and beauty

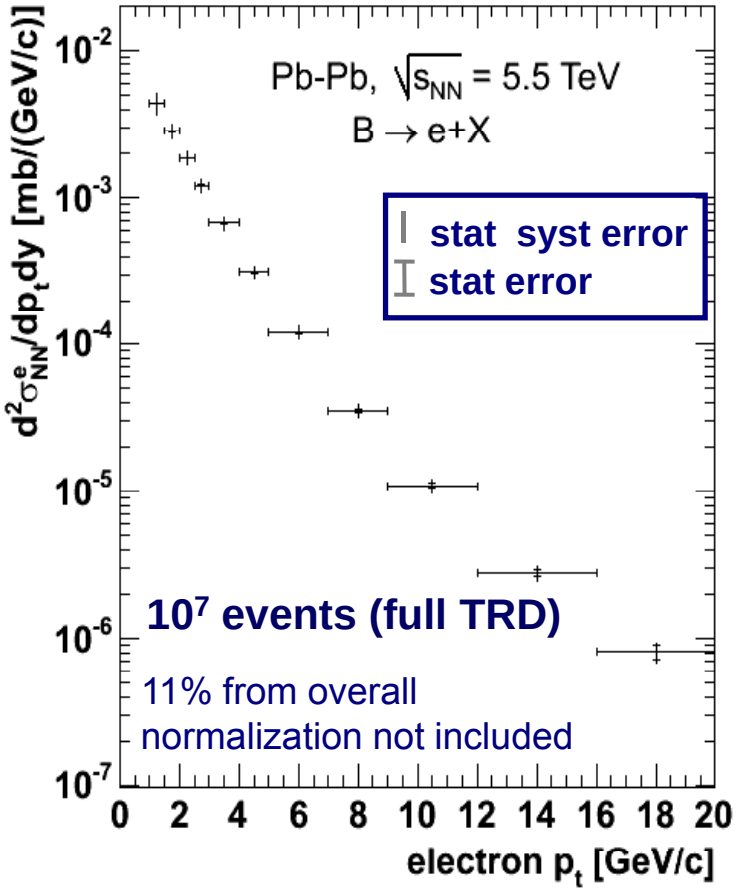
Open charm in $D^0 \rightarrow K\,\pi$ channel

(high precision vertexing ITS+TPC)

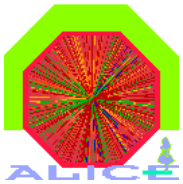


Open beauty in the semielec. channel

(electron ID in TPC+TRD)



Summary



- First proton-proton run:
  - collect important pp reference data for heavy ions
  - study unique pp physics with ALICE:
    - minimum bias running
    - fragmentation studies
    - heavy-flavour cross sections
- Early heavy-ion run:
  - establish global event characteristics
  - measure important bulk properties

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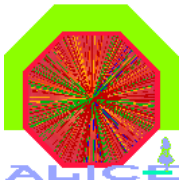
Outlook



- First long heavy-ion run:
  - quarkonia measurements
  - jet-suppression studies
  - flavour dependence studies
- High luminosity heavy-ion run (1 nb^{-1}):
  - dedicated high p_T electron triggers
  - jets > 100 GeV (EMCAL)
  - Υ – states, γ-jets correlations, …
- pA & light ion running

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