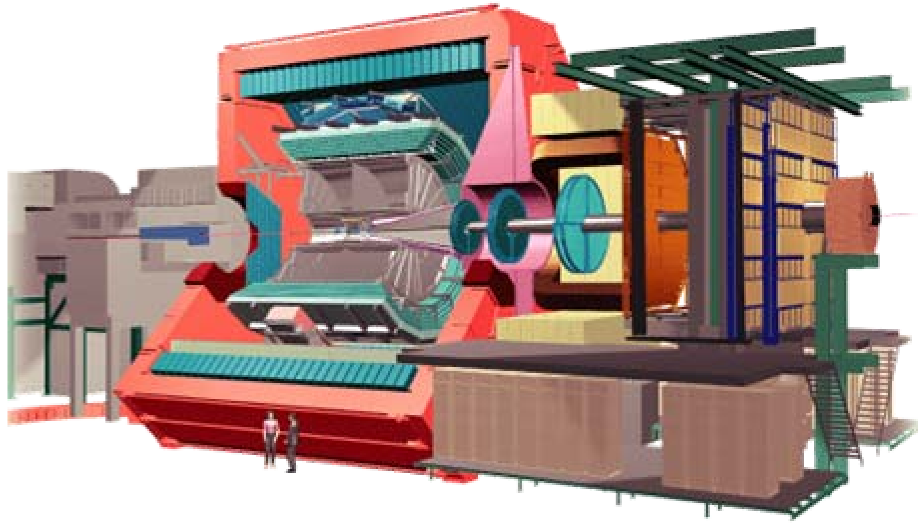


A Large Ion Collider Experiment

R. Lietava

The University of Birmingham

Outlook

- **Motivation**
- **ALICE detector**
- **ALICE installation and commissioning**
- **First physics with ALICE**
- **ALICE trigger (= UK contribution)**
- **Summary**

ALICE physics

- **p-p**
  - reference to AA
  - minimum bias physics => soft QCD (underlying event)
  - unique pp physics with Alice (baryon transport, charm cross section)
- **A-A (macroscopic QCD)**
  - equation of state
  - phase diagram
  - kinetic coefficients (viscosity)

The ALICE collaboration

~ 1000 Members

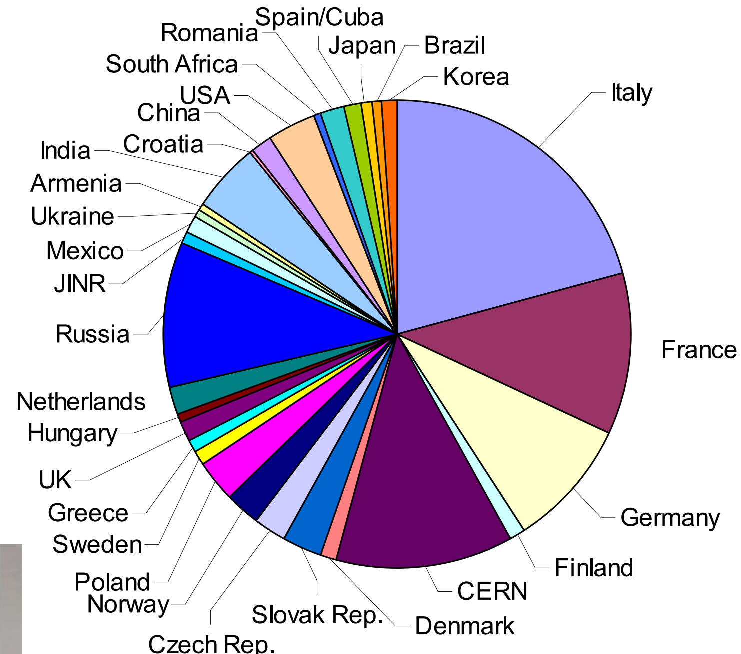
(63% from CERN MS)

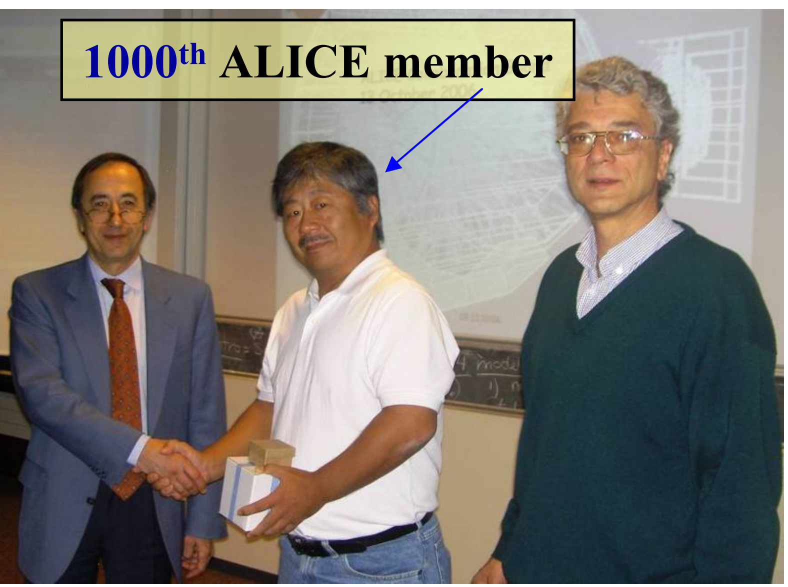
~30 Countries

~90 Institutes

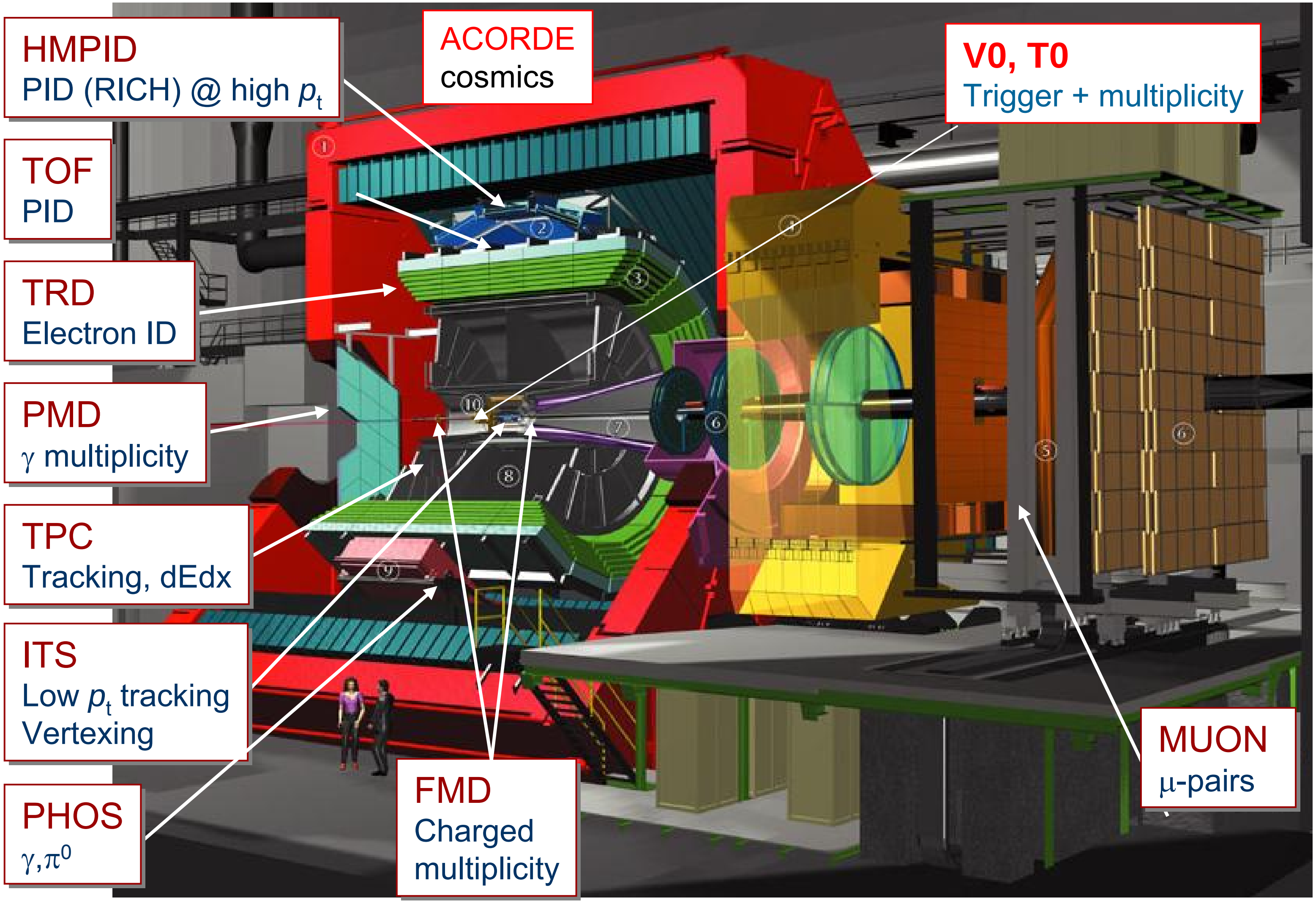
~ 130 MCHF capital cost

(+ 'free' magnet)



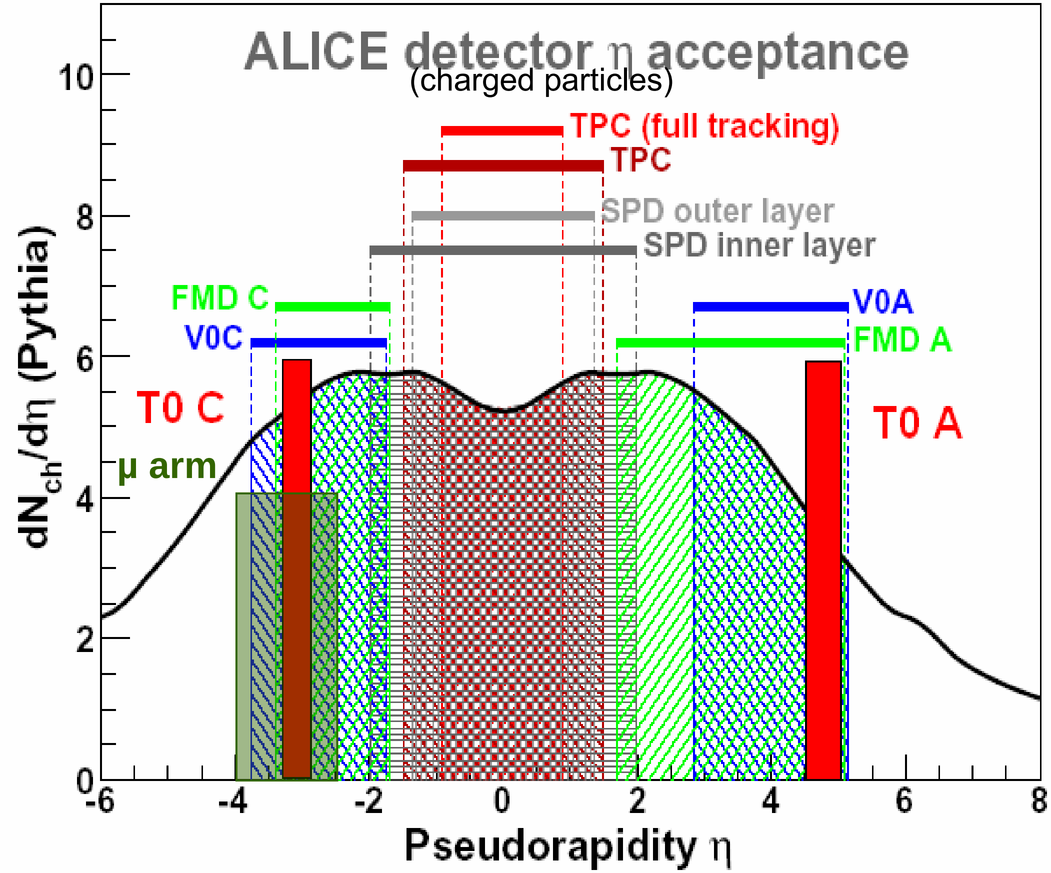


A Large Ion Collider Experiment



ALICE Acceptance

- central barrel -0.9 < η < 0.9
  - 2 π tracking, PID
  - single arm **RICH** (HMPID)
  - single arm **em. calo** (PHOS)
  - jet calorimeter (proposed)
- forward muon arm 2.4 < η < 4
  - absorber, 3 Tm dipole magnet 10 tracking + 4 trigger chambers
- multiplicity -5.4 < η < 3
  - including photon counting in **PMD**
- trigger & timing dets
  - **T0:** ring of quartz window PMT's
  - **V0:** ring of scint. Paddles



ALICE detector

<u>ALICE unique features:</u>

☺ **acceptance at low p_T** (~ 0.2GeV/c)

⇒ relatively low field (0.5T)

⇒ low material budget (total X/X0=7%)

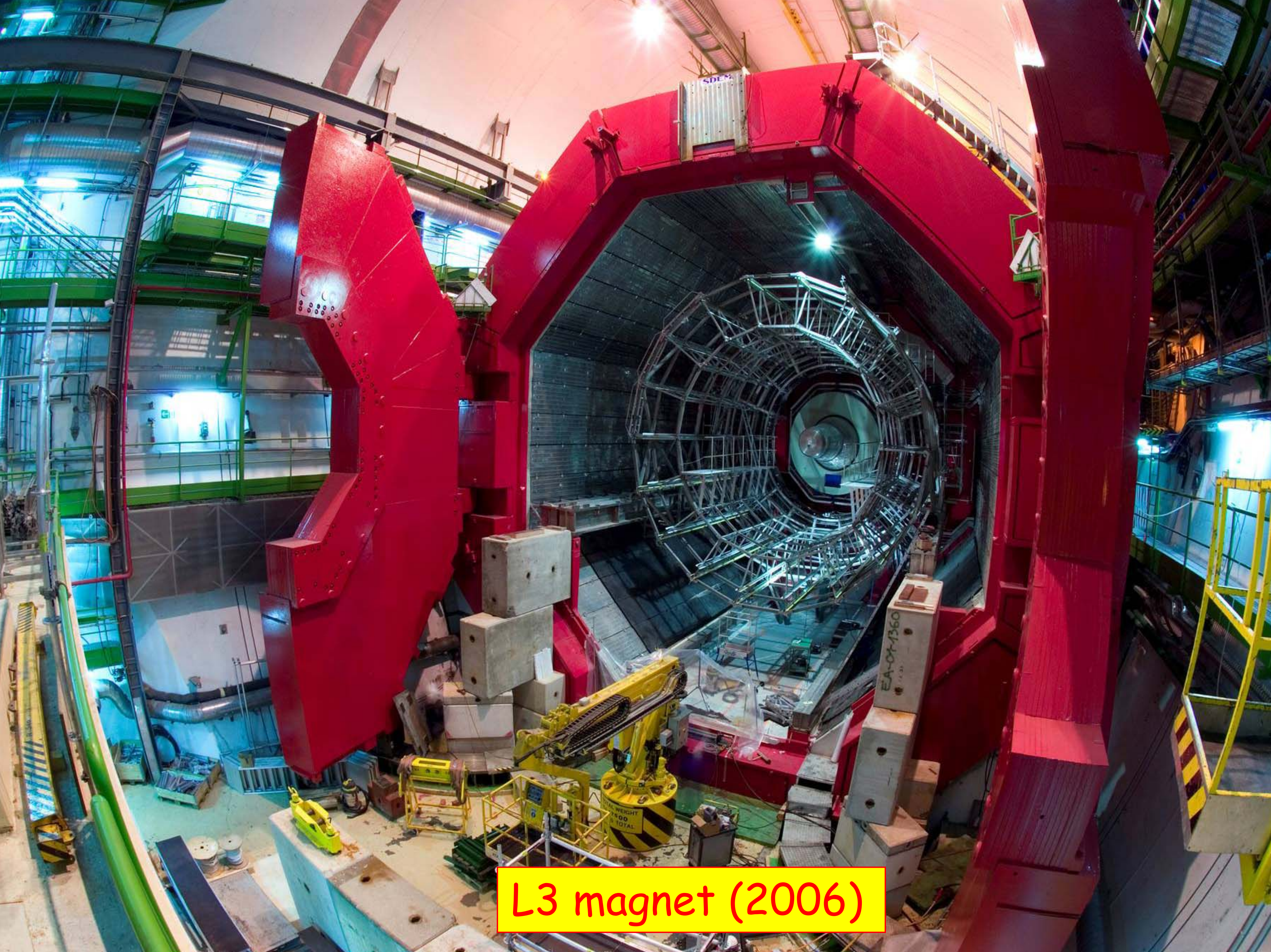
☺ **excellent PID capabilities**

⇒ dE/dx (TPC/ITS), TRD,

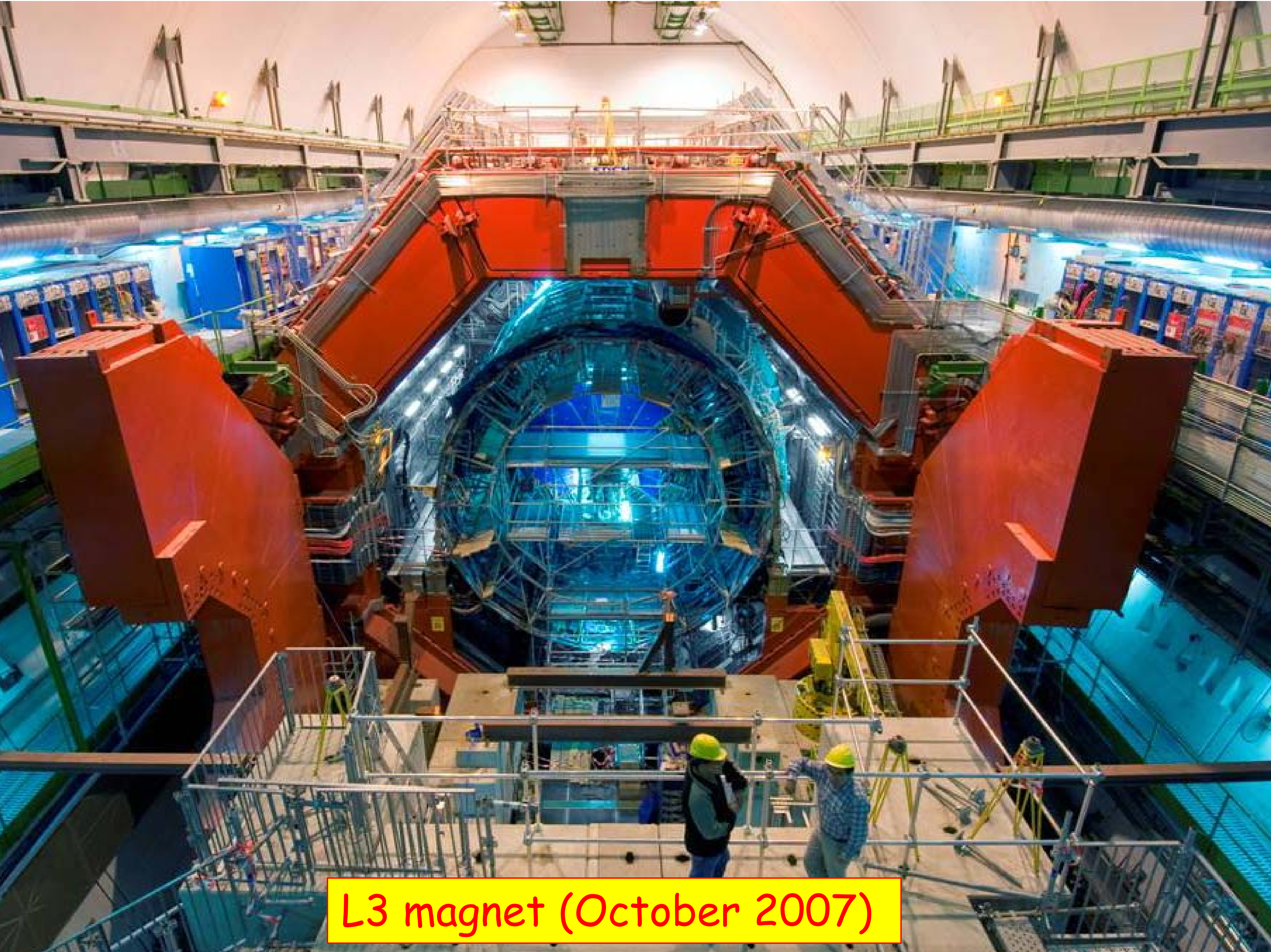
TOF, HMPID, PHOS, (EMCAL)

☹ **limited in luminosity**

L3 magnet (2002)



L3 magnet (2006)



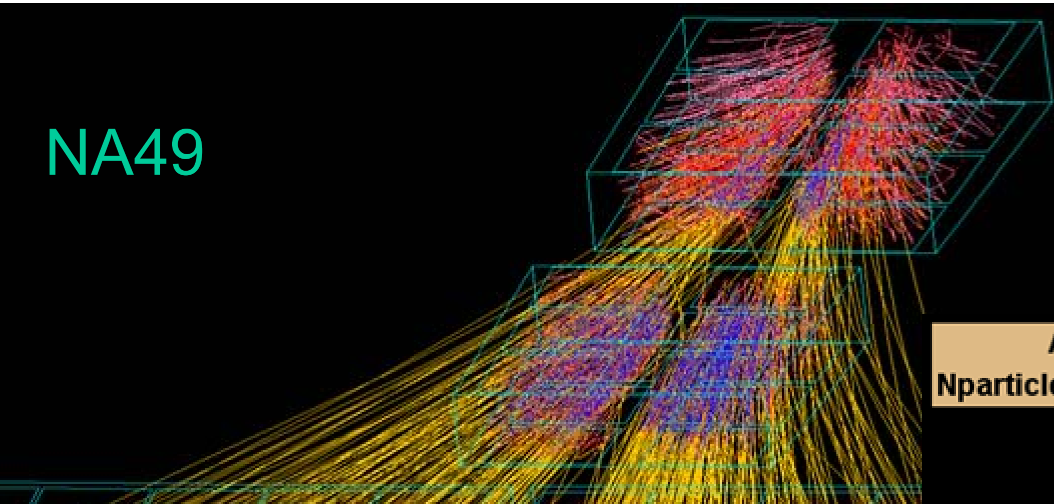
L3 magnet (October 2007)

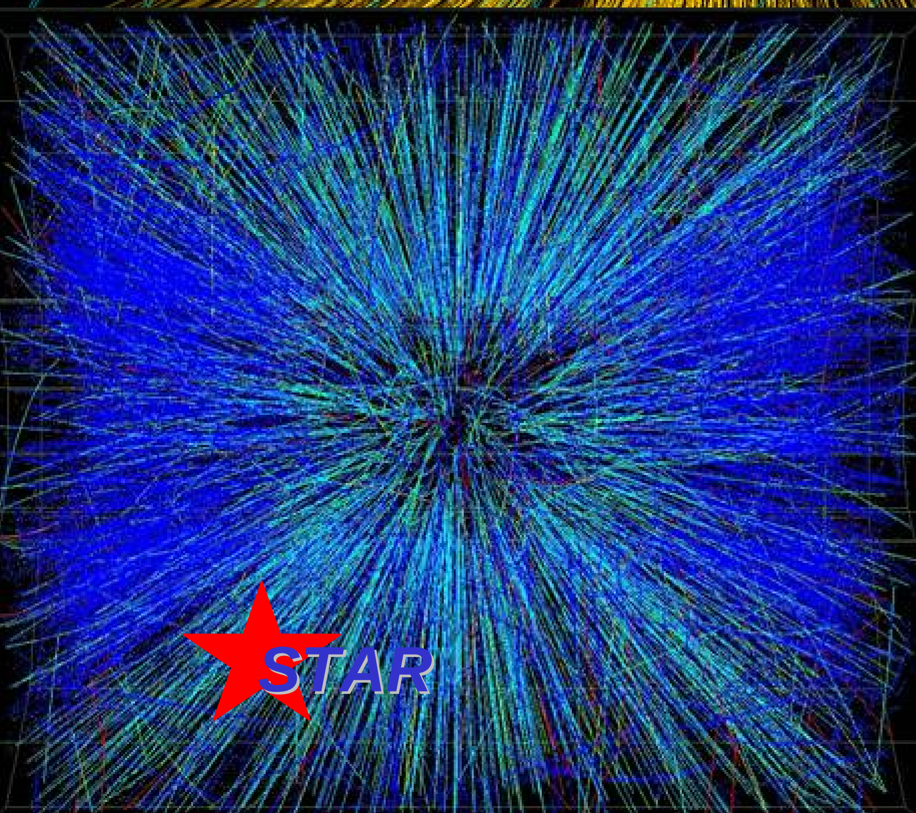
Tracking Challenge

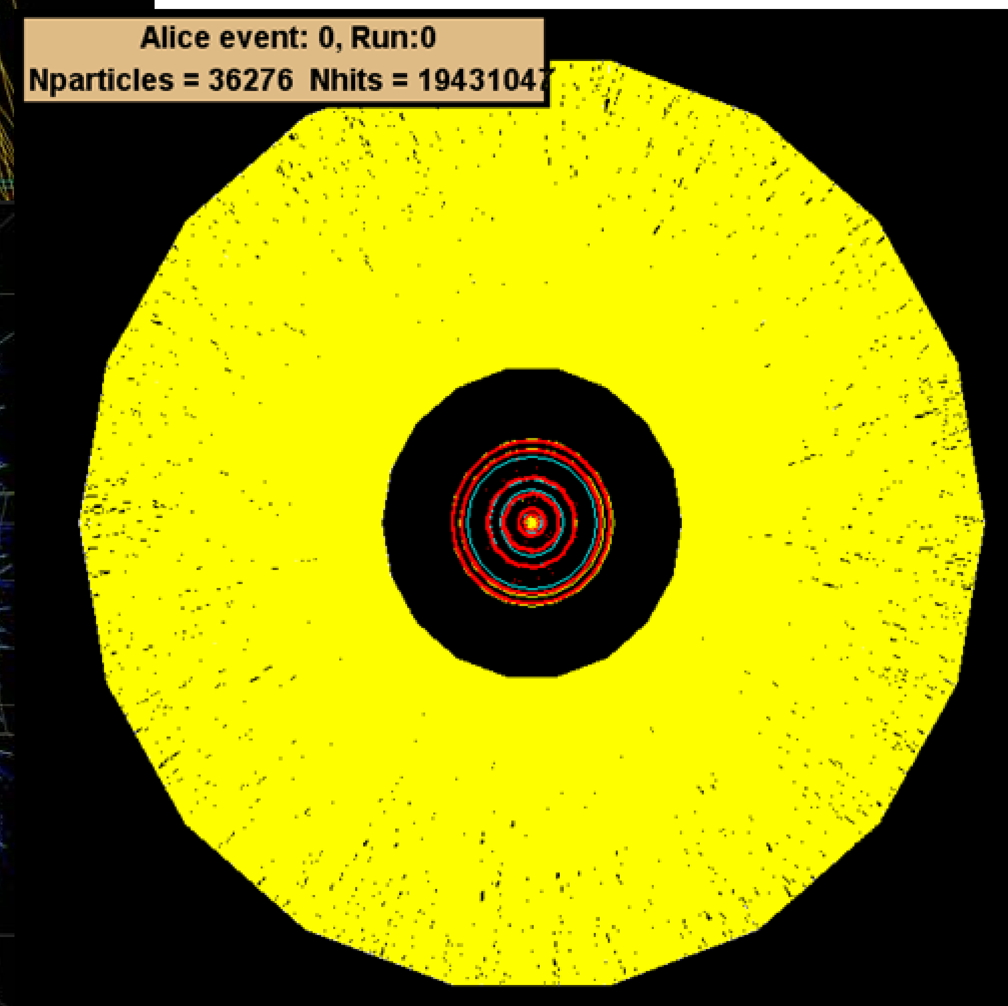
LHC: dN_{ch}/dy = 2000 - 4000

ALICE 'worst case' scenario:

dN_{ch}/dy = 8000







Inner Tracking System ITS

- Three different Silicon detector technologies; two layers each
  - Pixels (SPD), Drift (SDD), Strips (SSD)

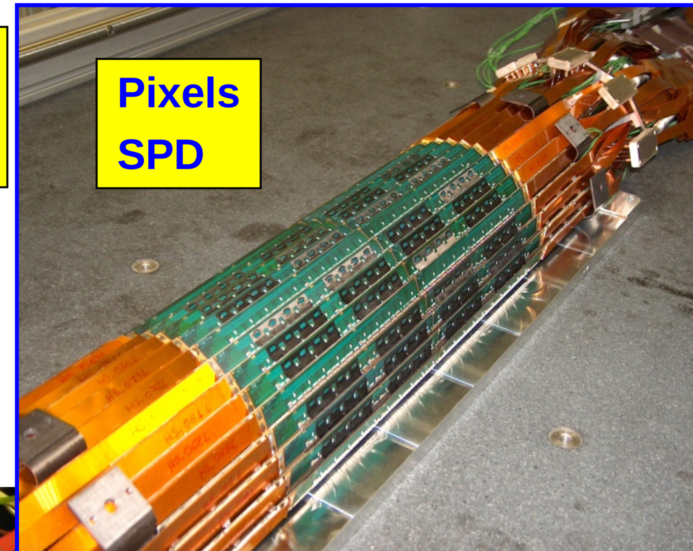
Detector	Acceptance (η,ϕ)	Position (m)	Dimension (m^2)	N. of channels
ITS				
SPD	$\pm2, \pm1.4$	0.039, 0.076	0.21	9.8 M
SDD	±0.9	0.150, 0.239	0.42, 0.89	133 000
SSD	$\pm0.97, \pm0.97$	0.38, 0.43	5.0	2.6 M

Status: installed; being commissioned

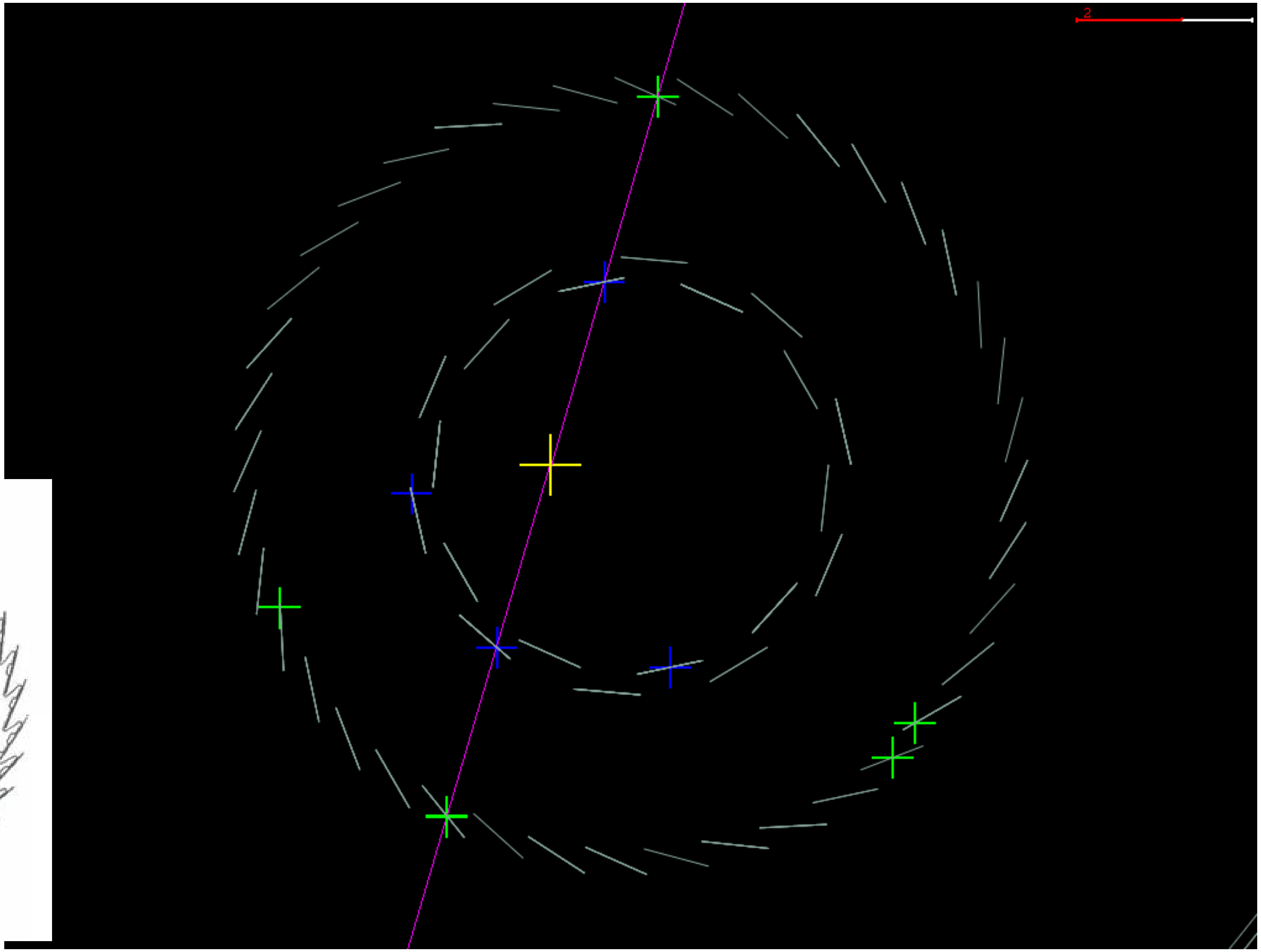
- $\Delta(r\varphi)$ resolution: 12 (SPD), 38 (SDD), 20 (SSD) μm
- Total material traversed at perpendicular incidence: 7 % X_0

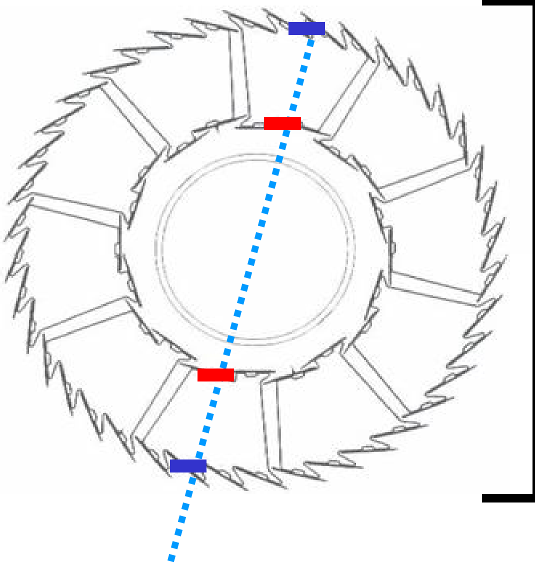
Inner Silicon Tracker

Inner Tracking System
~ 10 m^2 Si detectors, 6 layers
Pixels, Drift, double sided Strips



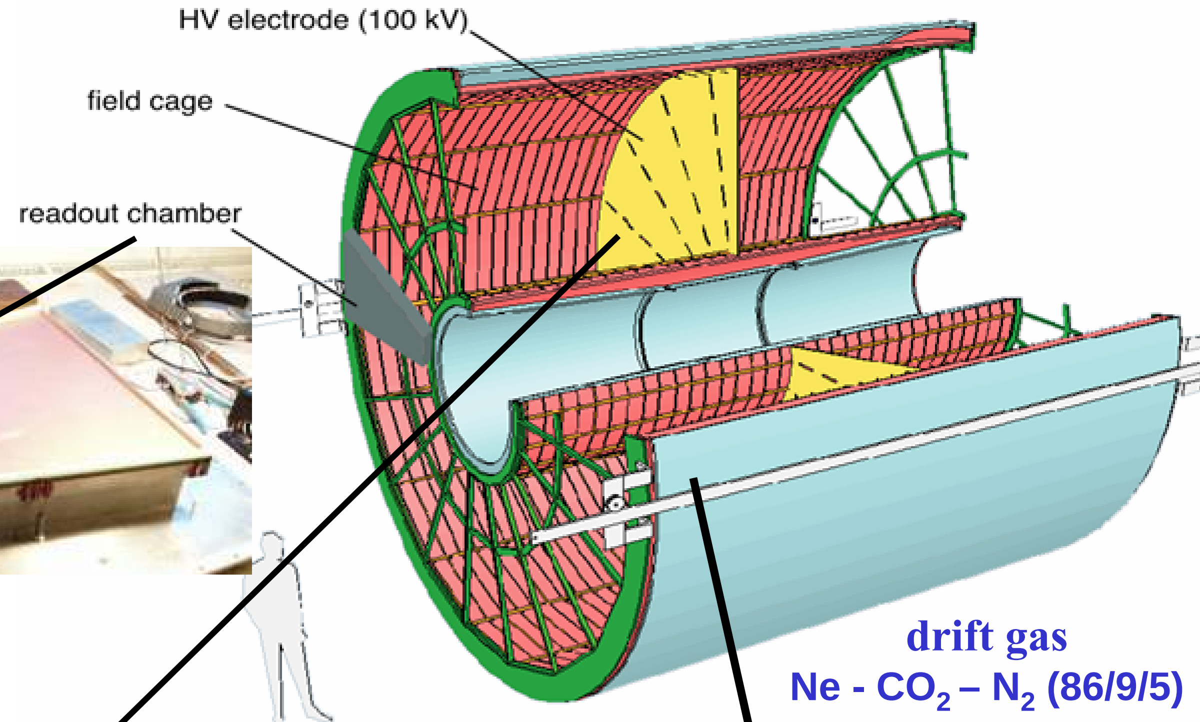
1st muon in SPD: Feb 17, 2008

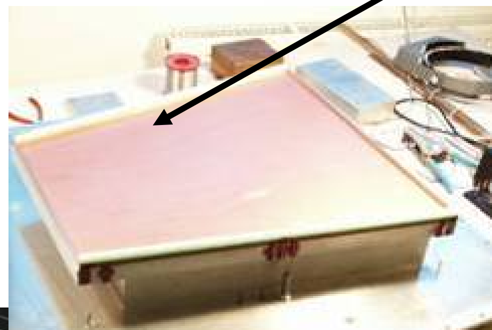




TPC

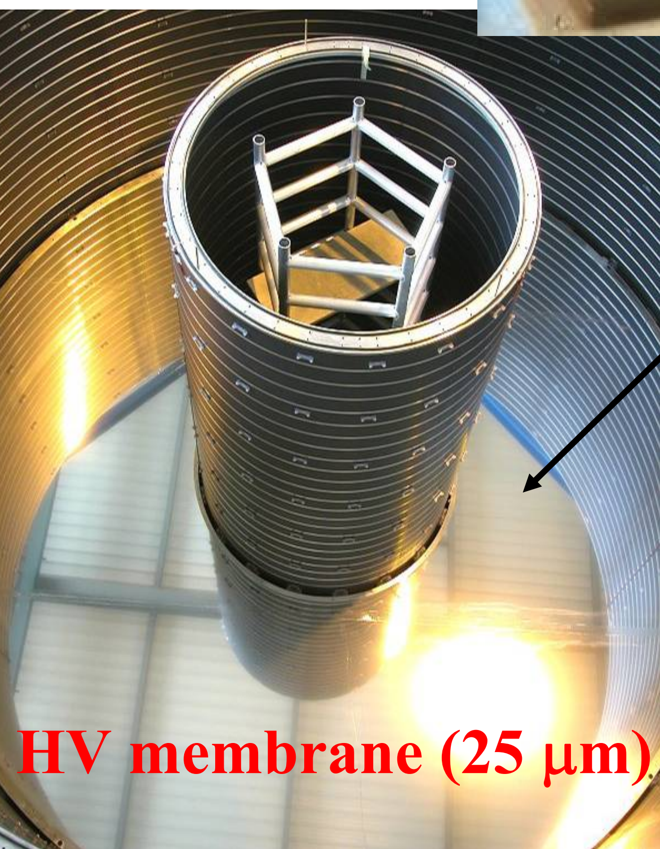
- largest ever:
  $88m^3$, l=5m,
  d=5.6m
  570 k channels



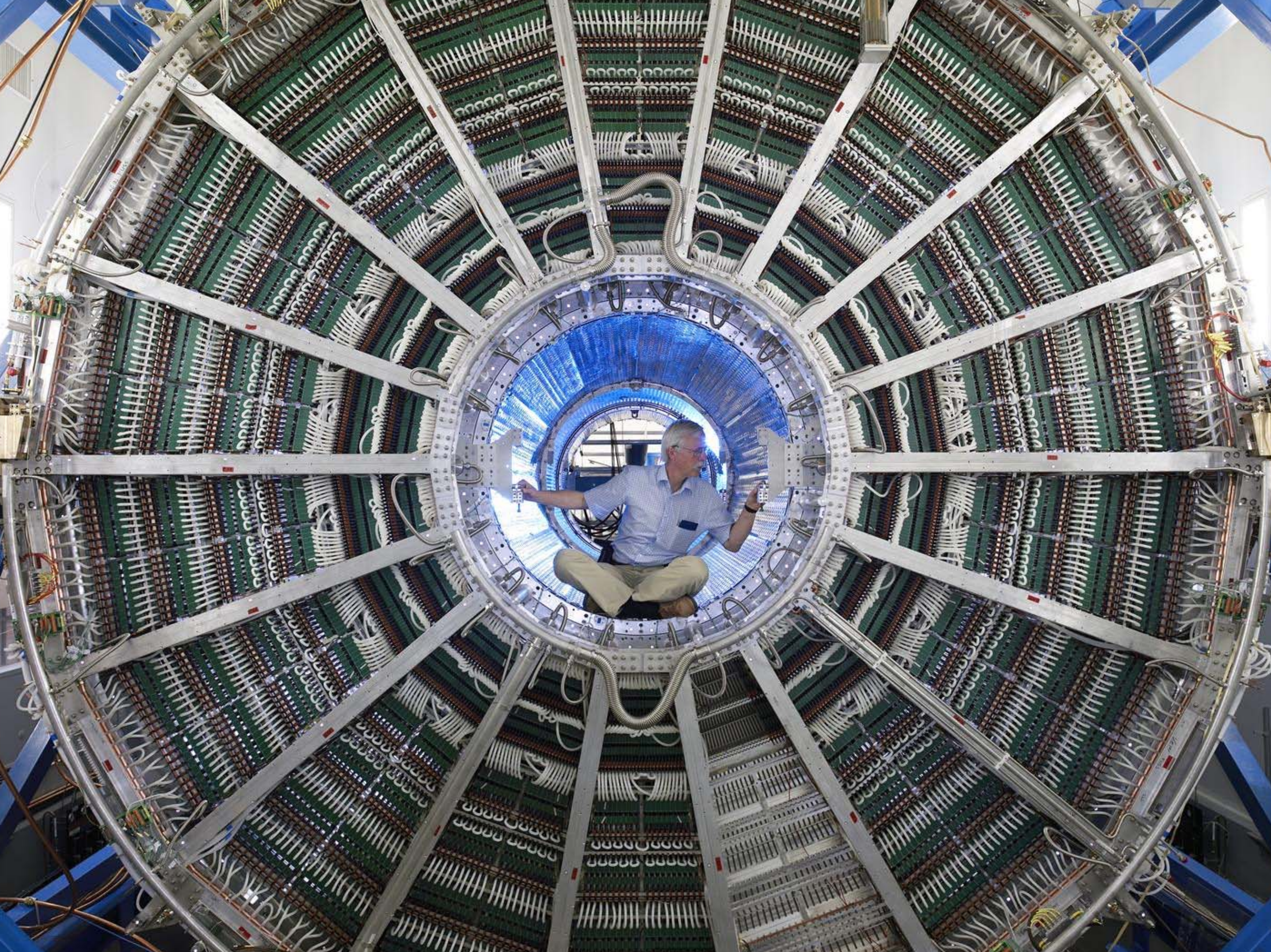


drift gas

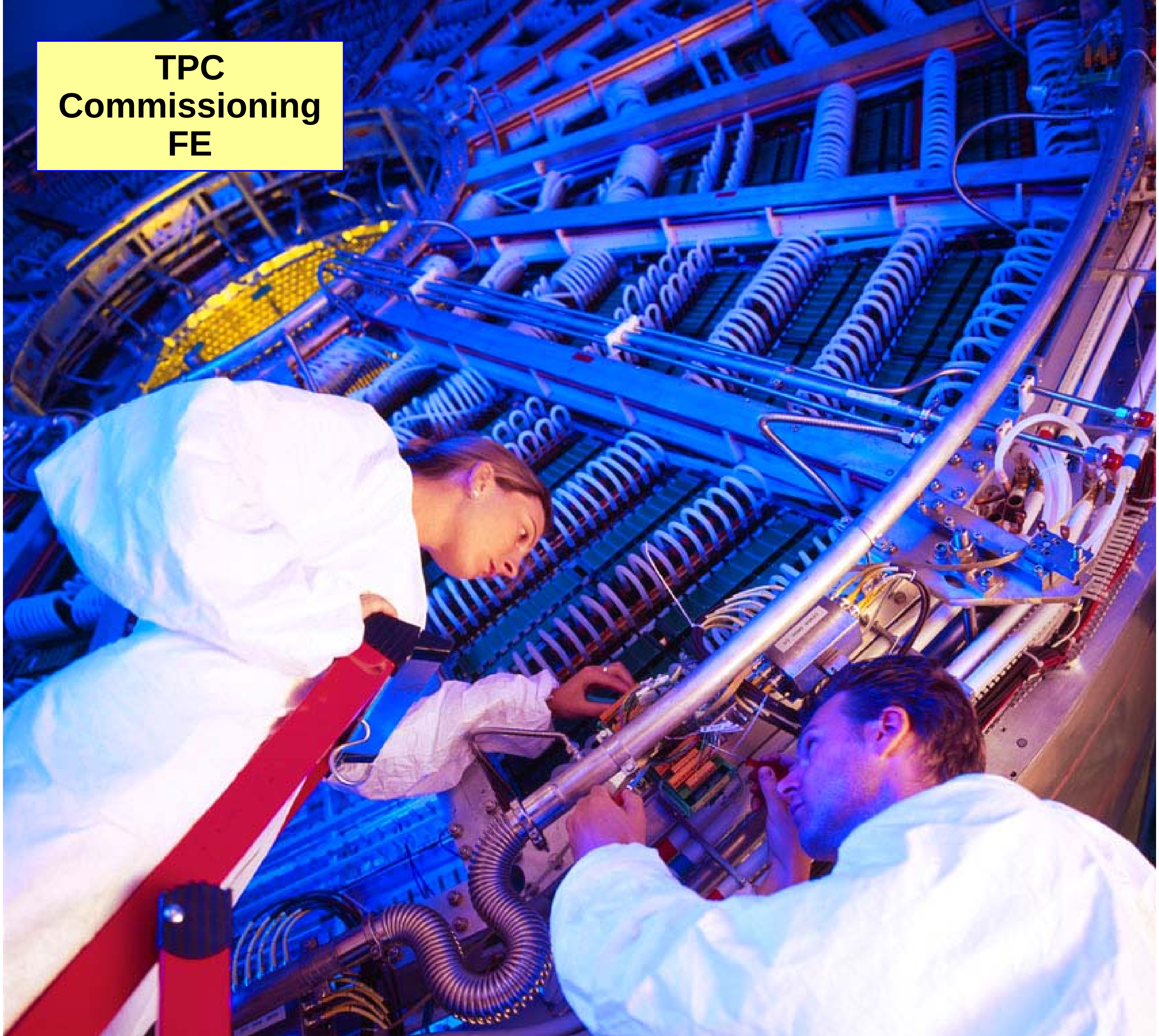
Ne - CO_2 – N_2 (86/9/5)



TPC Field Cage



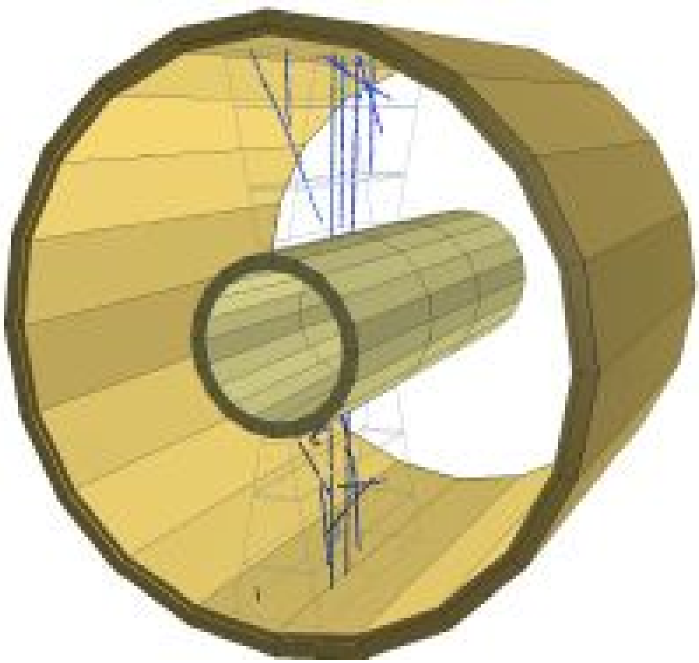
TPC Commissioning FE

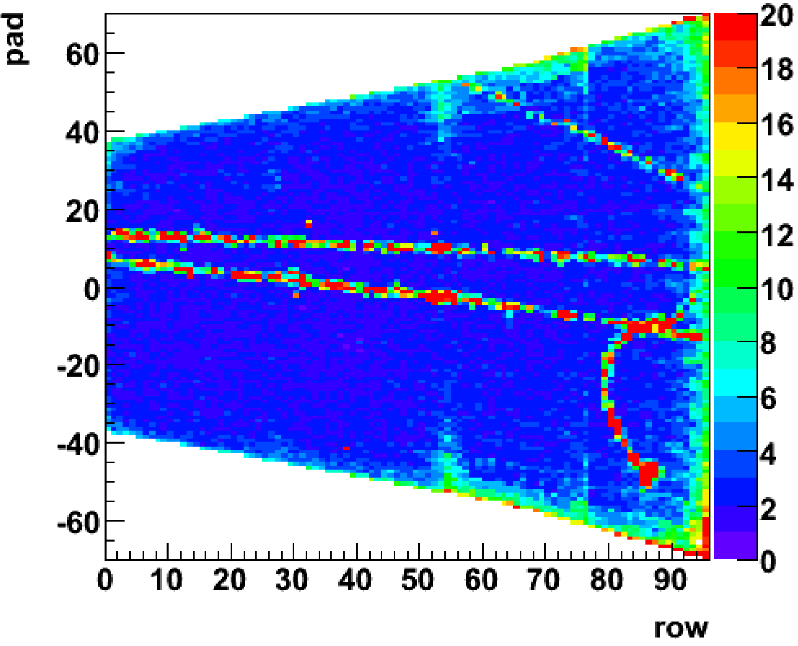


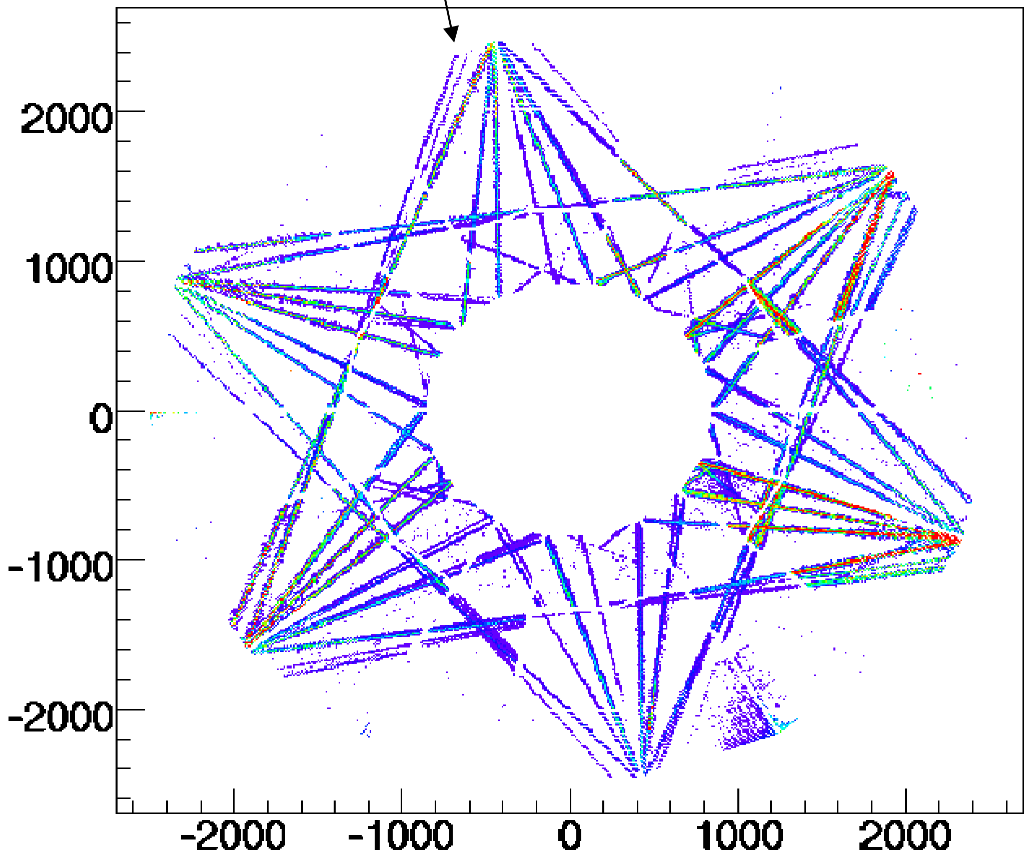
First TPC Tracks

16 May 2006

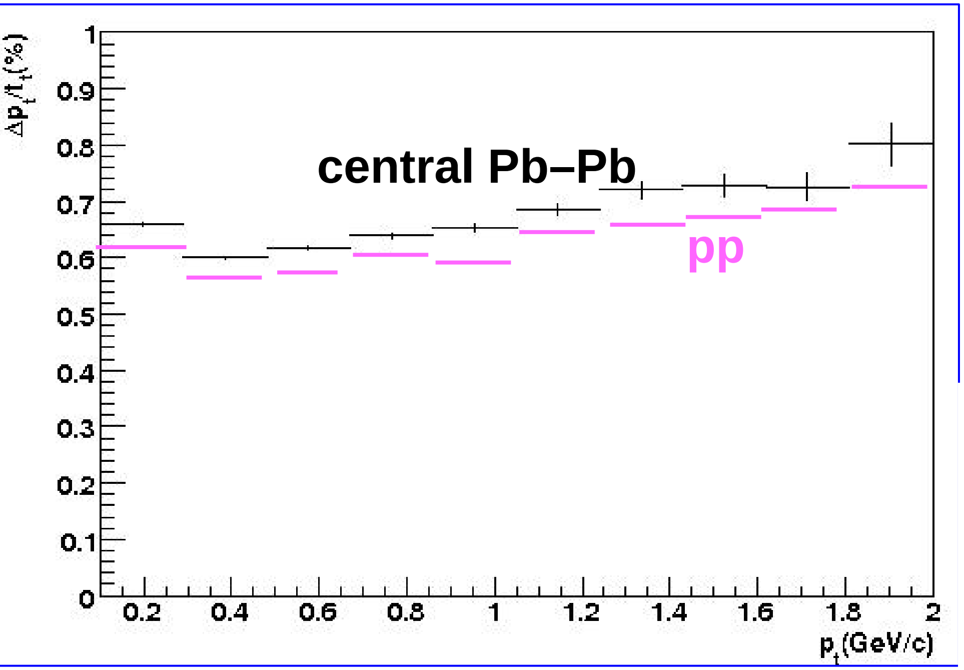
First cosmic and laser tracks !





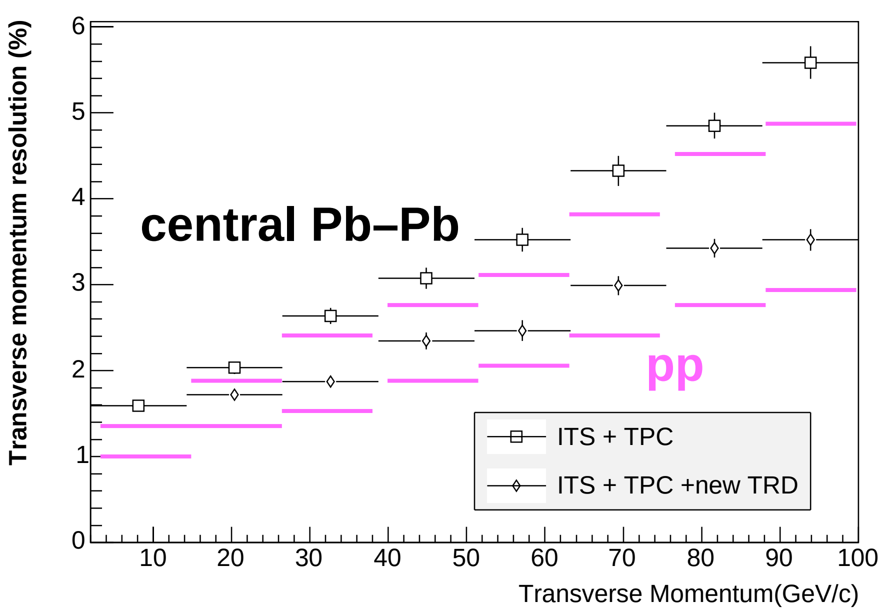


Momentum resolution



at low momentum dominated by

- ionization-loss fluctuations
- multiple scattering

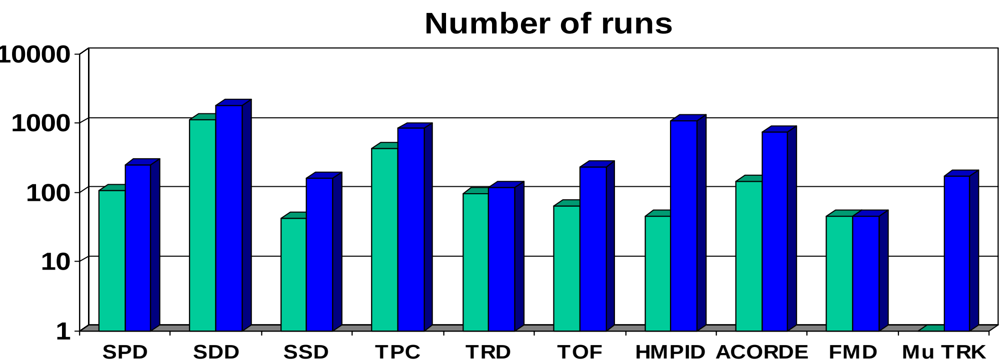


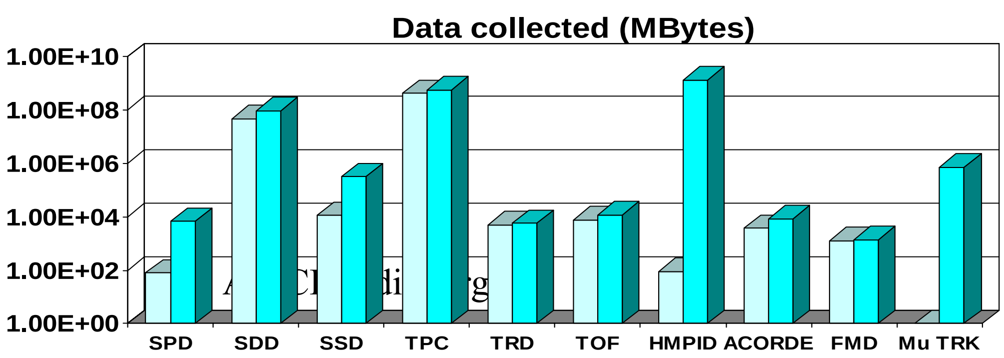
at high momentum determined by

- point measurement precision
- and the alignment & calibration
(*which is here assumed ideal*)

Commissioning

- individual (groups of) detectors 'in situ' from the ACR
  1) individual detector operation (LV, HV, gas, cooling, FEE)
  2) integration with online systems **(DAQ/HLT/Trigger/DCS/ECS)**
  3) operation of several detectors together
- 'global commissioning' with cosmics
  - 10-21 Dec, 4 weeks in February, April, …
- includes detector calibration and alignment





Alice Control Room

Start-up configuration 2008

- complete – fully installed & 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

Statistics for pp physics analysis

- **First ALICE physics is not limited by luminosity nor by acquisition period**
  - event rate is above the normal acquisition rate (100 Hz)
  - sufficient statistics will be collected very fast:

    ⇒ **20k events** in 3 minutes

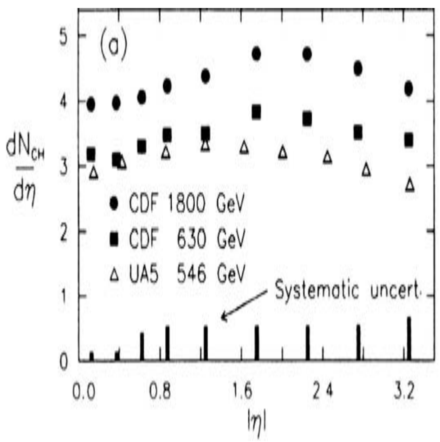
    (20k is the statistics needed for ITS alignment)

    ⇒**70M events** in 3 weeks (8 days)

    (70M is the statistics needed for final TPC gain calibration)

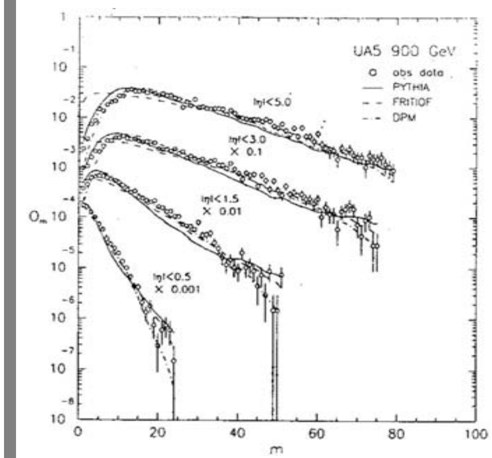
    ⇒ **10^9 collisions** in 10^7 secs ~ 115 days (nominal run)
- **Fast physics output is rather limited by analysis speed**
  - all necessary tools and analysis have to be prepared in advance
- **Different physics studies will necessitate different accuracy in**
  - geometrical alignment
  - detector calibration
  - particle identification calibration

First 3 minutes



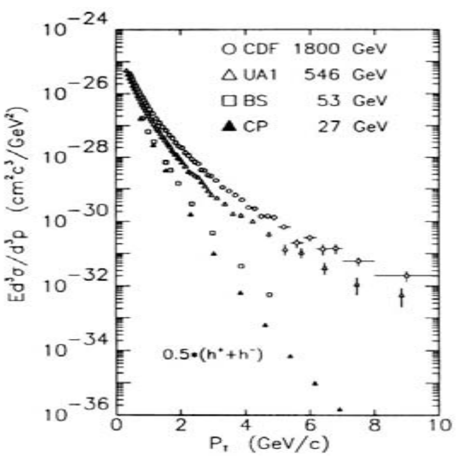
Pseudorapidity density dN/dη

CDF:
Phys. Rev.
D41, 2330 (1990)



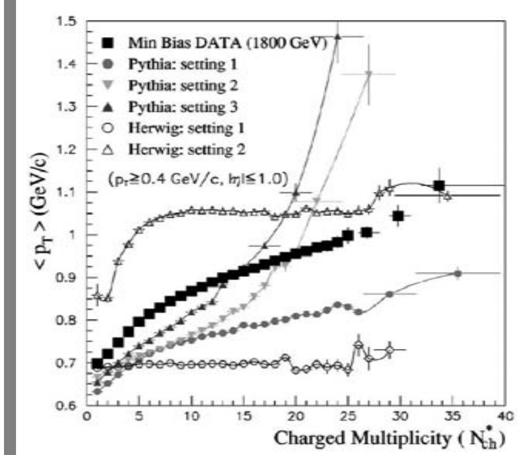
Multiplicity distribution

UA5:
Z. Phys
43, 357 (1989)



p_T spectrum unidentified hadrons

CDF:
Phys. Rev. Lett.
51, 1819 (1988)



Mean p_T vs multiplicity

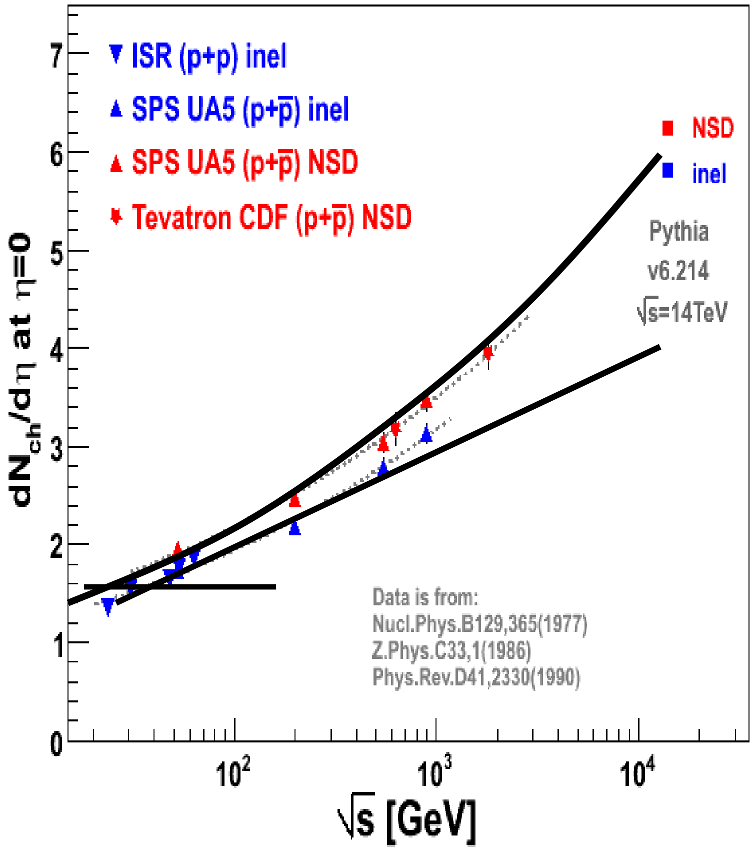
CDF:
Phys. Rev.
D65,72005(2002)

dN/dη at η=0

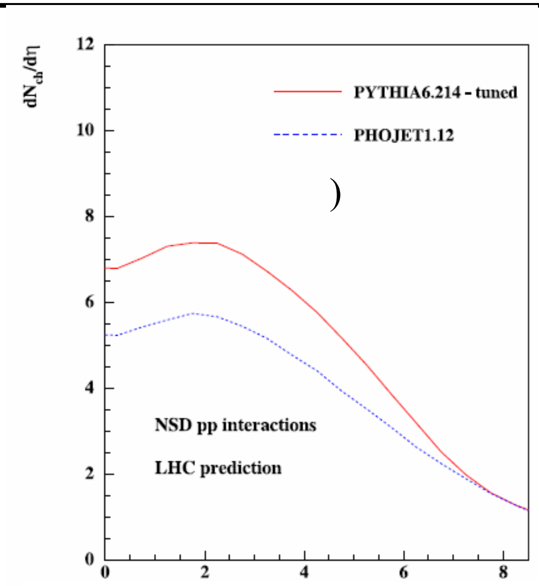
- Feynman (1969):
  $N_{tot} = a + b*\ln(s)$
  $dN/d\eta = const$

- ISR(1977):
  $dN/d\eta = a + b*\ln(s)$

- SppS (1981):
  $dN/d\eta = a + b*\ln(s) + c*\ln(s)^2$

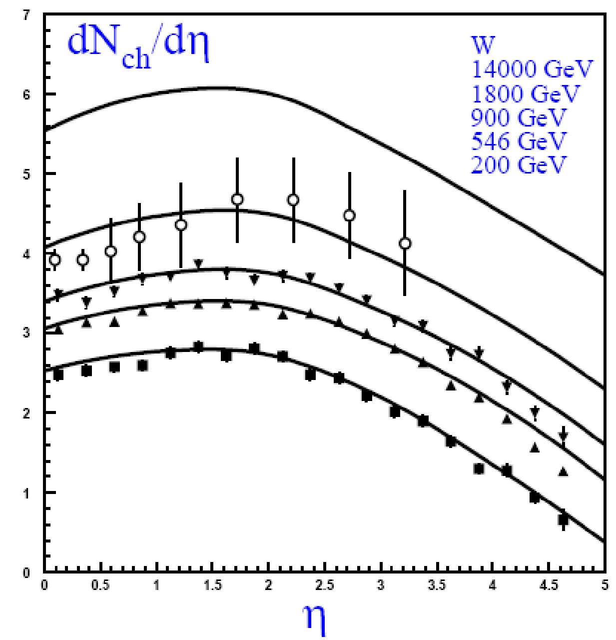


Model discrimination/tuning



- Pythia and Phojet predictions different
  => First measurements will be able to distinguish

Eur. Phys. J. C 50, 435–466 (2007)



- Colour glass condensate

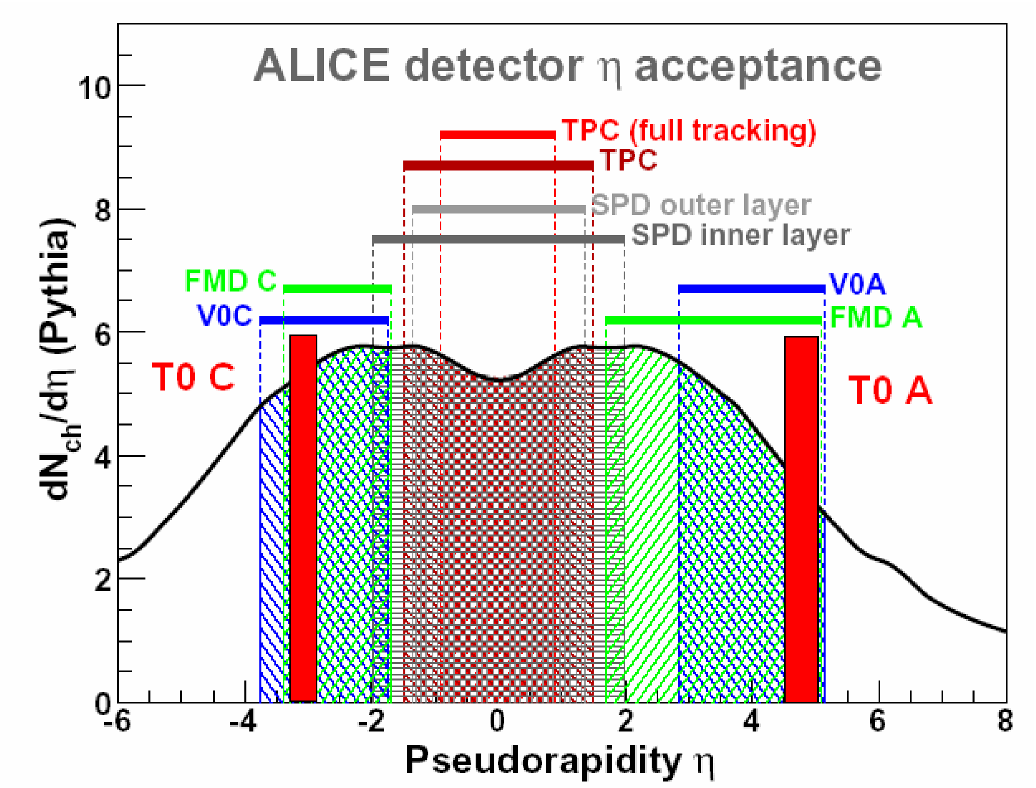
Nucl.Phys.A747:609-629(2005)

Multiplicity measurement

TPC:
⇒ n tracks

ITS Pixel:
⇒ n clusters (in layer 1)
⇒ n tracklets

FMD
⇒ naïve method (n hits)
⇒ Poisson method

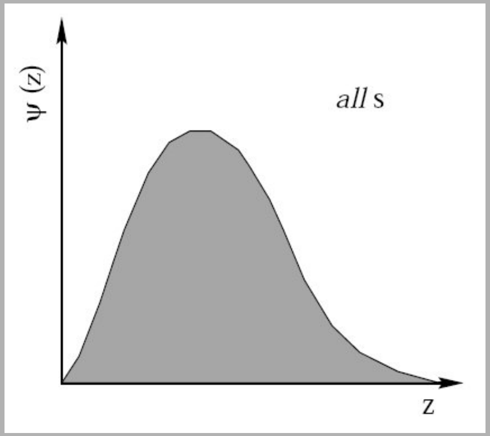


Multiplicity distribution

1972:
KNO (statistical) scaling law

$$P_n(s) = \frac{1}{\langle n \rangle} \Psi\left(\frac{n}{\langle n \rangle}\right)$$

$\Rightarrow$ shape of distribution is independent of s



NPB 40, 317 (1972)

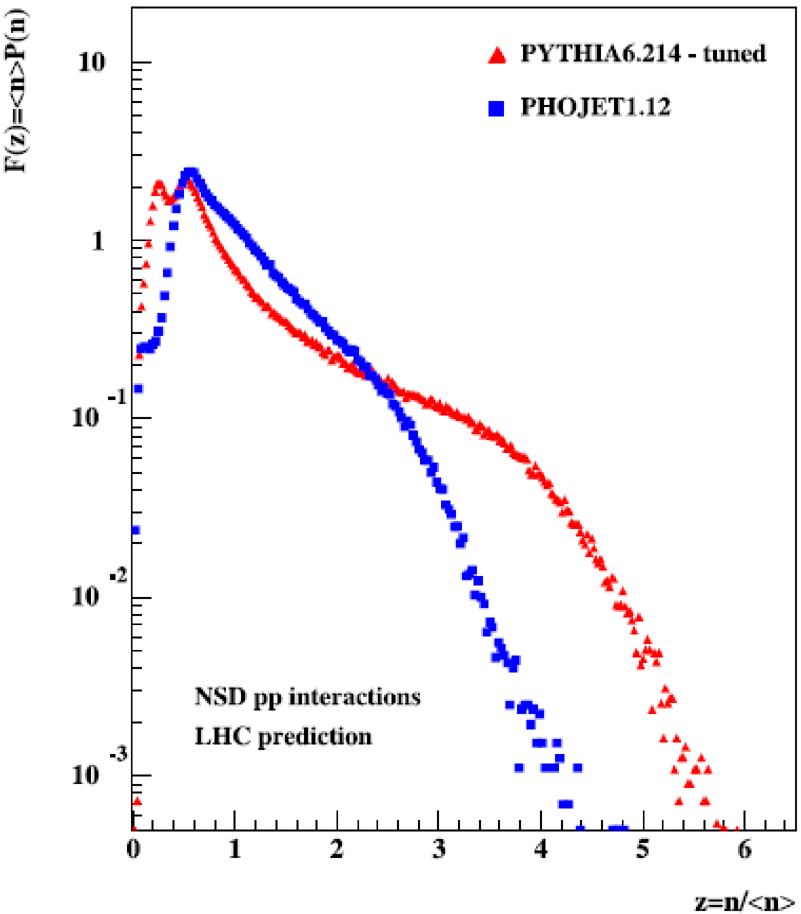
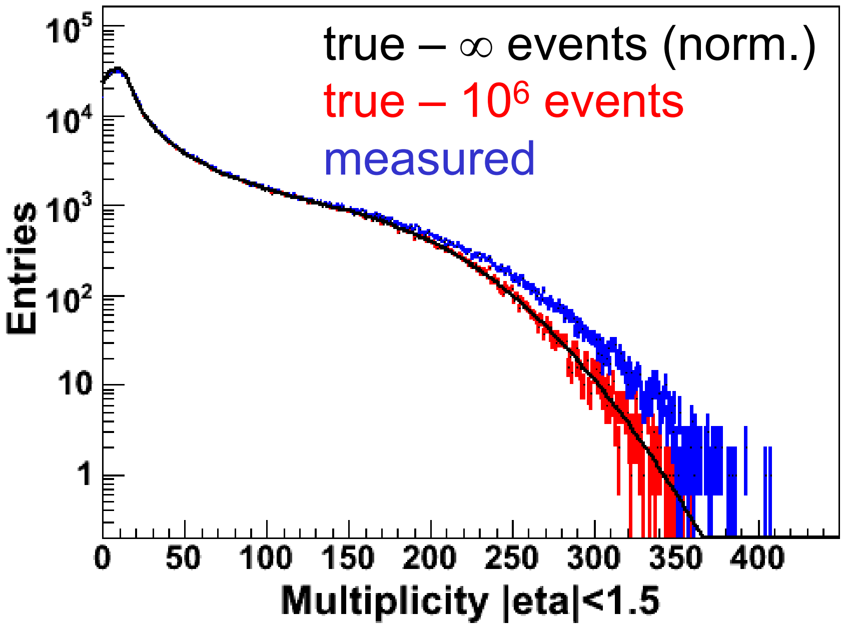


Fig. 28. Charged multiplicity distribution for NSD pp collisions at $\sqrt{s} = 14$ TeV. Predictions generated by PYTHIA6.214-tuned and PHOJET1.12

Multiplicity distributions



Unfolding (measured ⇒ true) is not a simple problem.

see: Anykeev et al, Nucl. Instr. Meth.A303, 350 (1991)
d'Agostini, DESY 94-099, June 1994.
C. Jorgensen, talk at ALICE p+p meeting, Oct 7, 2005

Multiplicity Unfolding

Unfolding by X^2 minimization

- Sum of differences between measured and guess μ smeared with response (Rij = P(i|j))
- Regularization term R(μ) adds "smoothness"
- Minuit used for minimization

X^2 calculation

$$\chi^2(\vec{\mu}) = \sum_{i=1}^{n_{meas}} \frac{(n_i - \sum_{j=1}^{n_{true}} R_{ij}\mu_j)^2}{n_i} + \mathcal{R}(\vec{\mu})$$

Bayesian unfolding

- Iterative method using Bayes theorem
  1) P(j|i) is calculated assuming prior P_0
  2) Guess is calculated from P(j|i) and measured
  3) Prior is updated (set to normalized guess)
  4) Go to 1

(d'Agostini, DESY 94-099, June 1994)

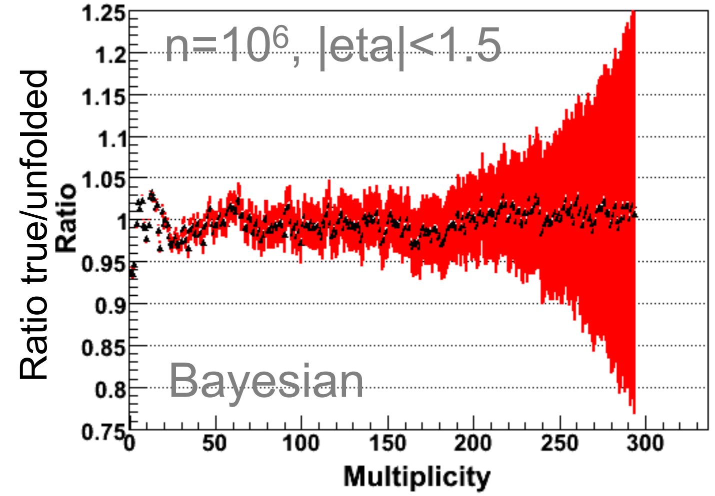
Bayes theorem

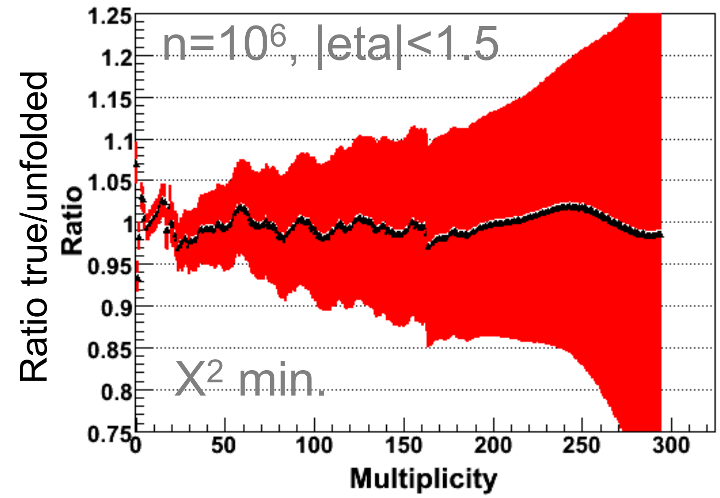
$$P(j_{true}|i_{meas}) = \frac{P(i_{meas}|j_{true}) \cdot P_\circ(j_{true})}{\sum_{l=1}^{n_{true}} P(i_{meas}|l_{true}) \cdot P_\circ(l_{true})}$$

Multiplicity unfolding

- Unfolded spectrum within 5-10% of generated.
- Consistency between the two methods.
- Stable
  - varying statistics
  - varying true distribution

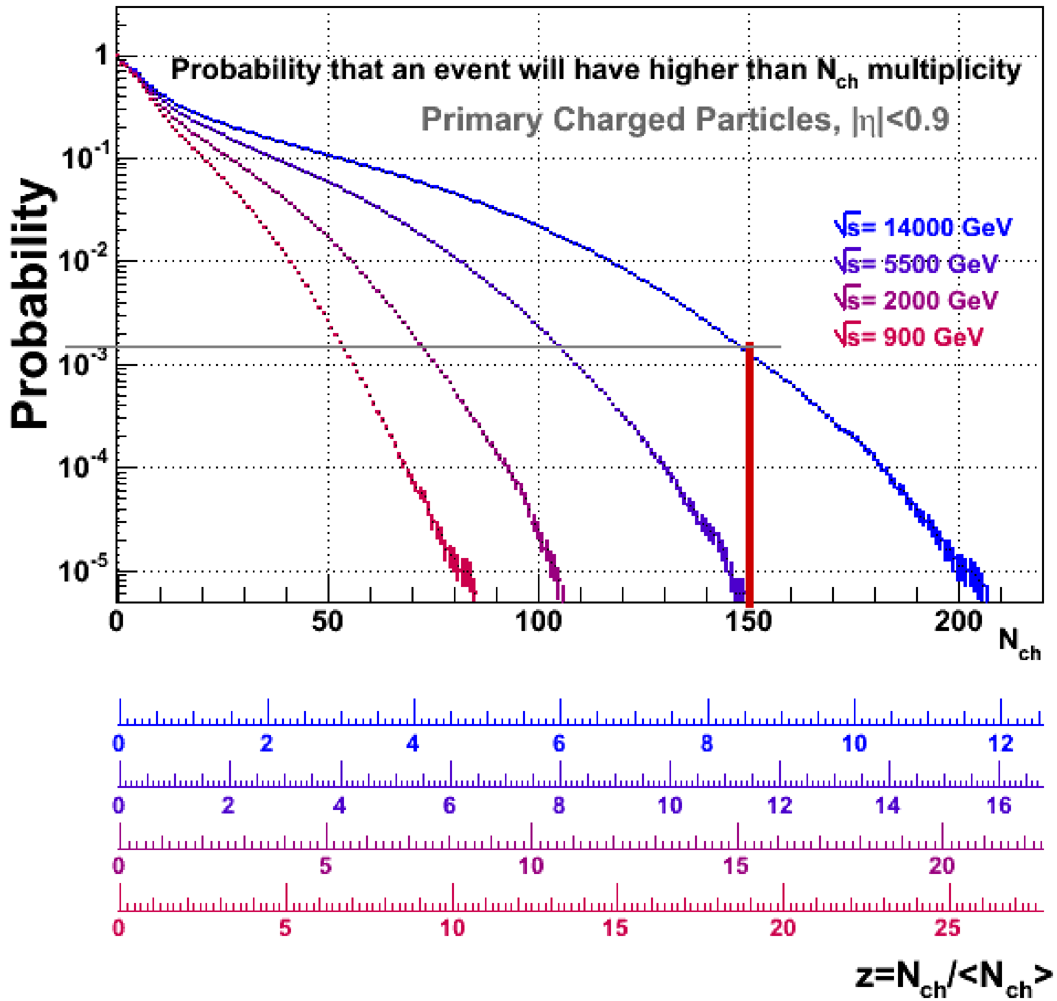
⇒ Get high stat. response
⇒ Add correction for trigger and vertex reco. efficiency
⇒ Error calculation





Initial multiplicity reach

- With $2x10^4$ minimum bias pp events we will have statistics up to multiplicity ~150 – 10 times the average (30 events beyond)
- We plan to use also multiplicity trigger (with silicon pixel detector) – to enrich the high-multiplicity
- Energy density in high-multiplicity pp events can reach the one in heavy-ion collision (according Bjorken formula), however, in much smaller volume



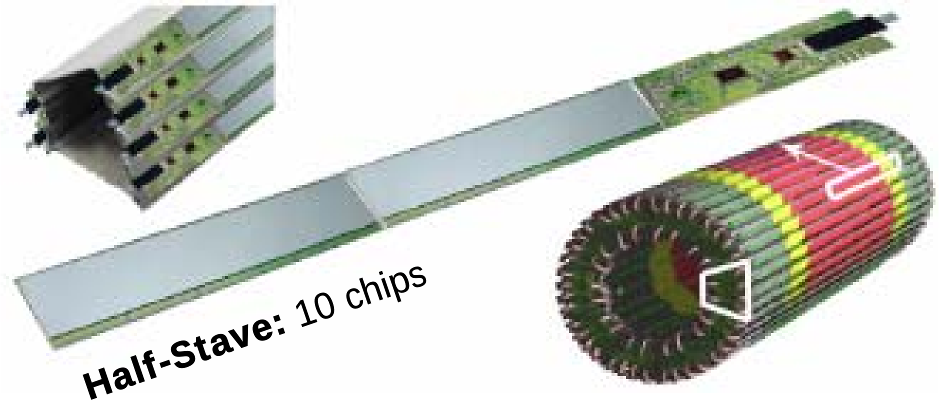
Claus Jorgensen

High-multiplicity trigger

Silicon pixel detector

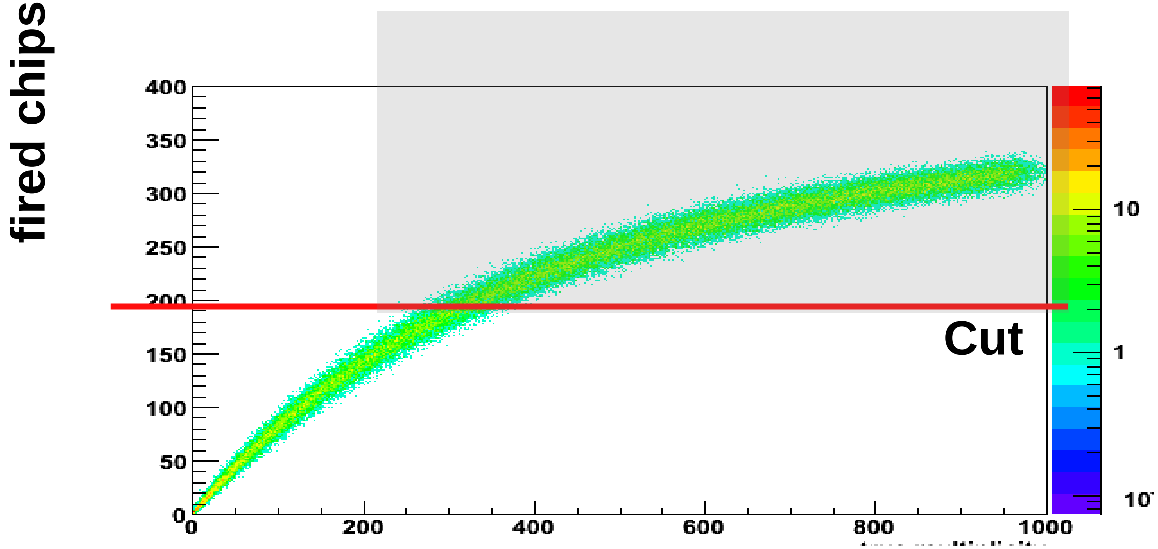
- fast-OR trigger at Level-0
  OR signal from each pixel chip
- two layers of pixel detectors
  400 chips layer 1; 800 layer 2
- trigger on chip-multiplicity per layer

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



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

J F Oetringhaus

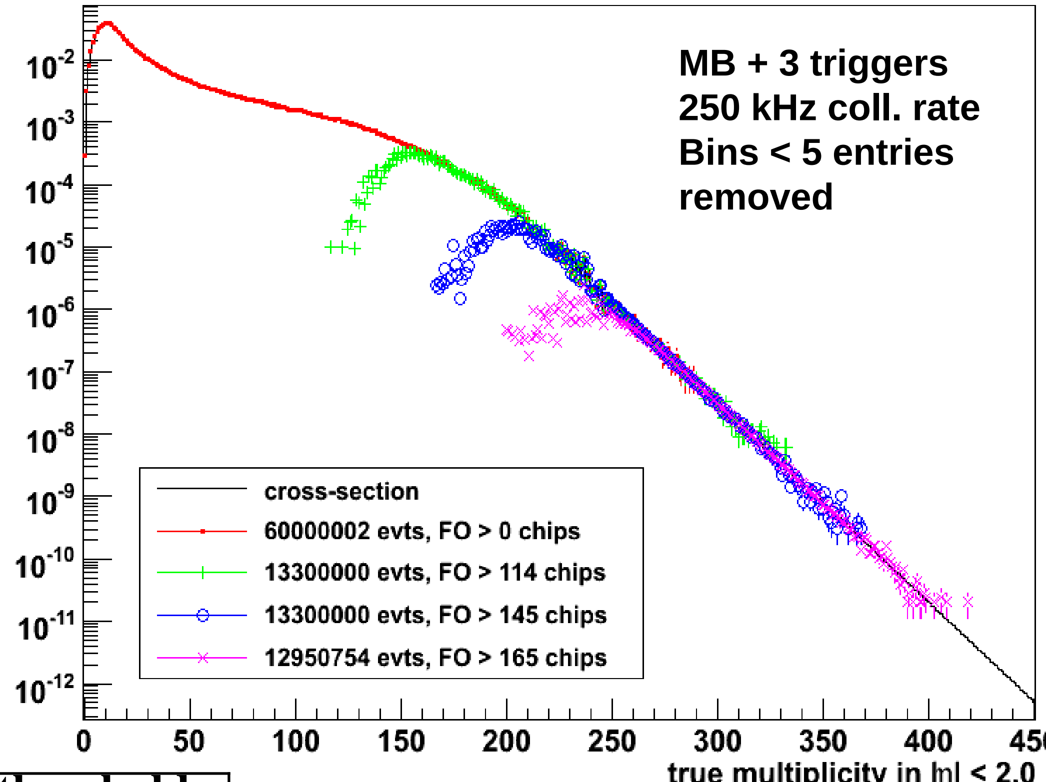
Example of threshold tuning:

MB and 3 high-mult. triggers

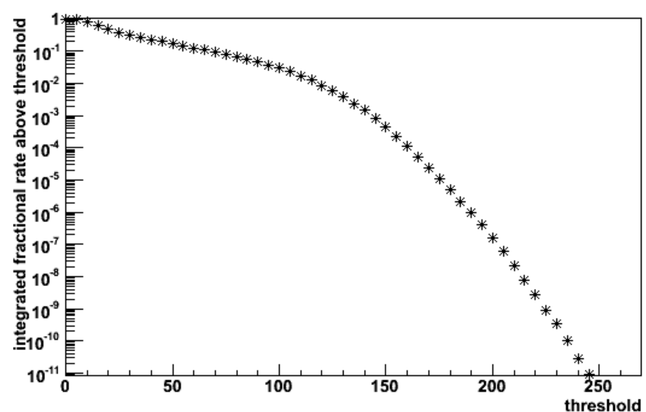
250 kHz collision rate
recording rate 100 Hz

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



p-p high multiplicity

- Can one separate the 'soft' from the 'hard' component (e.g with offline veto on jets) ? CDF (**Phys.Rev.D65:072005,2002** ,STAR (**Phys.Rev.D74:032006,2006**)
- Comparison between pp and AA at same dN/dy
  - pt spectra, strangeness

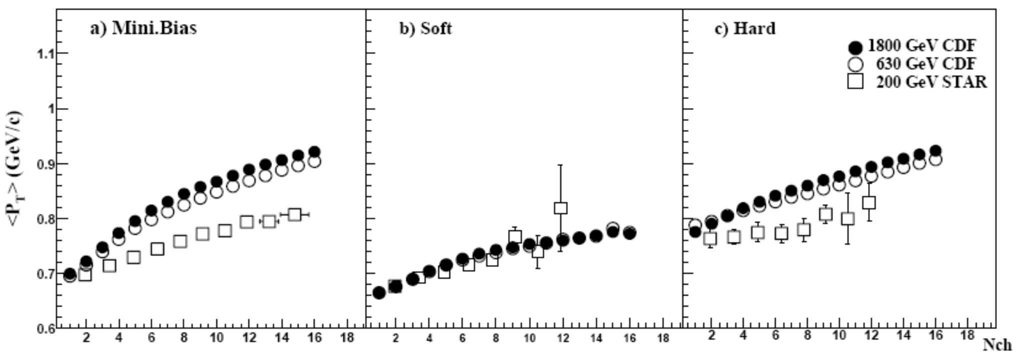


Fig1. The mean transverse momentum <P_T> dependence on the multiplicity Nch in minimum bias, soft and hard events. The errors bars are statistical errors only. The STAR acceptance is extended from $|\eta|<0.5$ to $|\eta|<1.0$ by HIJING to compare the results with CDF.

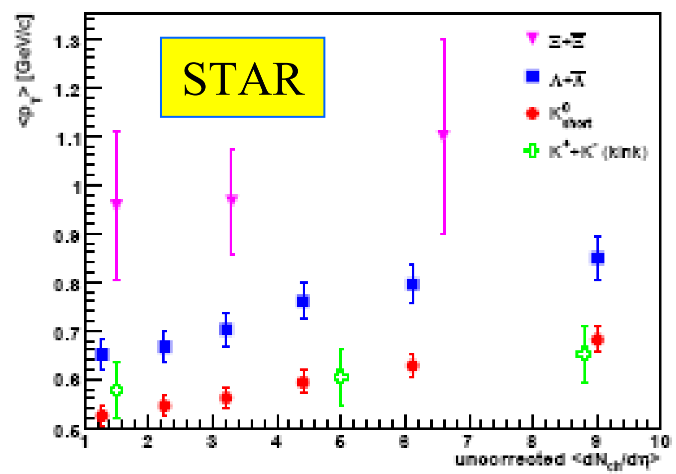
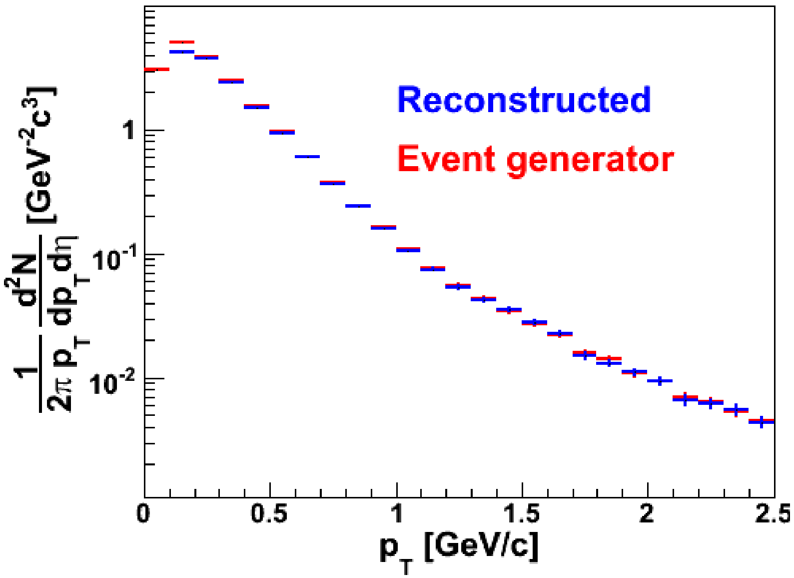
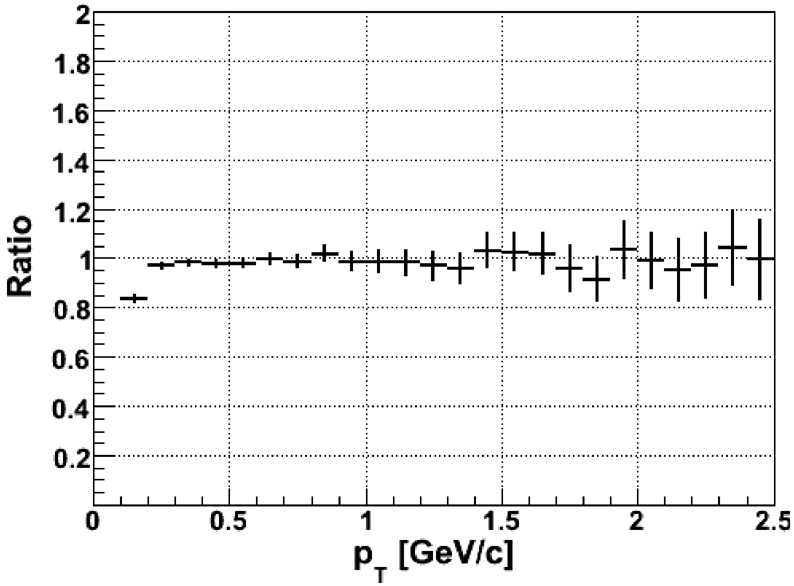


FIG. 12: $\langle p_T \rangle$ vs charged multiplicity for K^+, K^-, K^0_S, $\Lambda+\overline{\Lambda}$, and $\Xi+\overline{\Xi}$. The points for $\Xi+\overline{\Xi}$ have been determined using

p_T spectra results

Check made with map (from Pythia) and independent Pythia sample

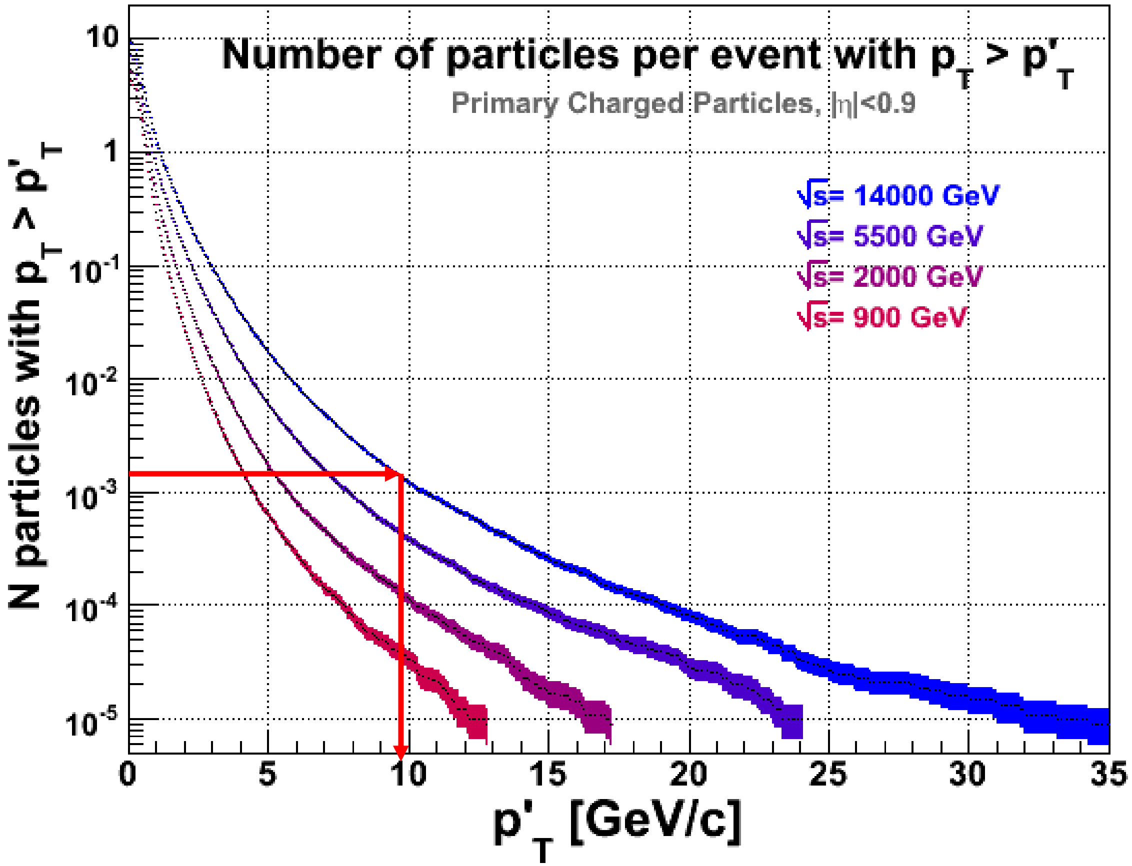




- Systematic errors
  (some studies shown in last p+p meeting, Oct 2005)
- Normalization to cross section (σ_{inel} vs σ_{ND})

Initial transverse momentum reach

- With 20k events, we can reach 10 GeV/c (~30 events beyond)
- With 70M events, we can reach 50 GeV/c



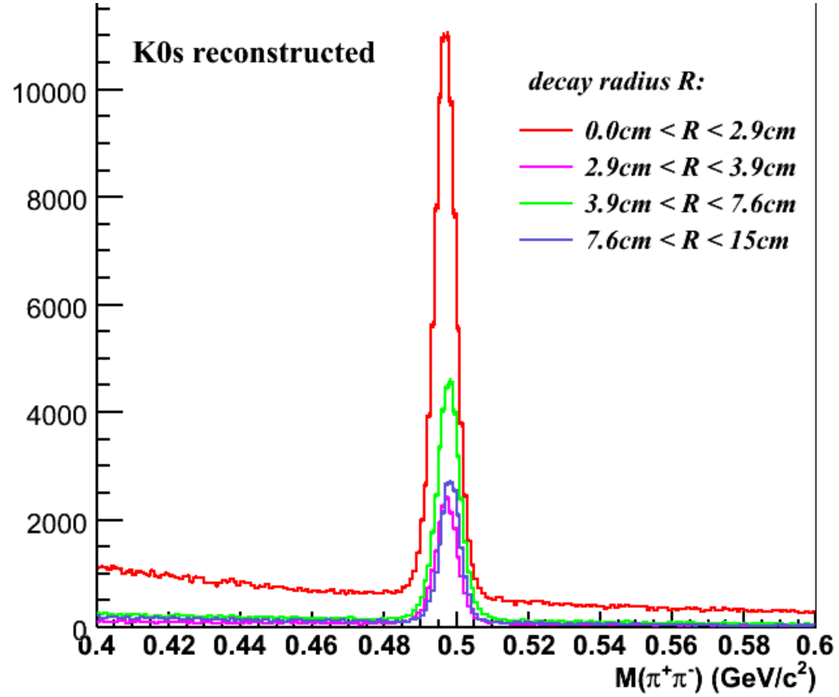
First three weeks

- Strange particles
- Resonances

First strange particle studies

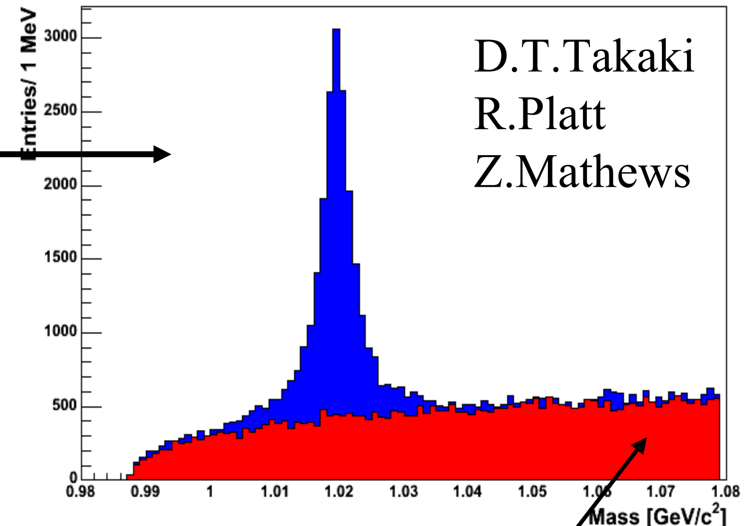
- based on Pythia for LHC
- significant samples of strange particles in 70 million minimum bias events:
- K^0 : $7x10^6$
- Λ: 10^6
- Ξ: $2x10^4$
- Ω: 270
- detailed study of flavour composition

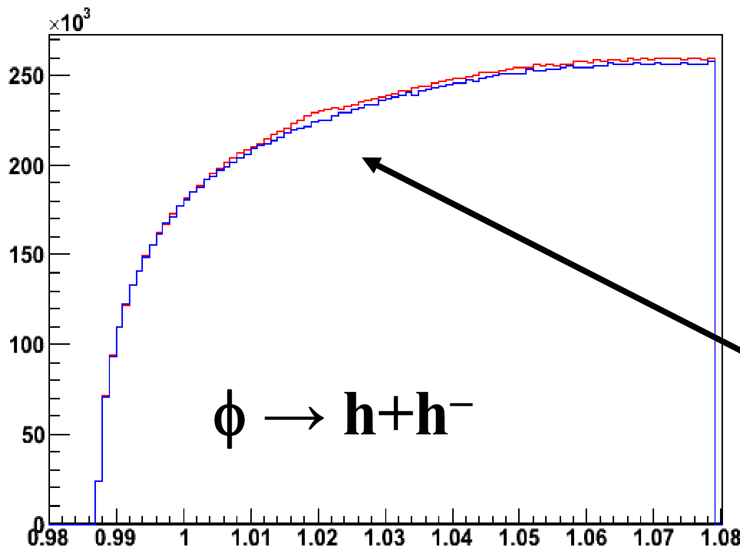
	K_S^0	Λ	Ξ	Ω	p	$\bar{p}$
yield per event	0.1	0.01	2×10^{-4}	10^{-5}	0.4	0.4
statistics needed	10^4	10^4	10^4	10^4	10^4	10^4
pp events needed	10^5	10^6	10^8	10^9	10^4	10^4



Φ physics in pp Interactions (work carried out at B'ham)

PYTHIA MB pp events in ALICE
Perfect PID
$\phi \rightarrow k^+k^-$
2 x 10^6 pp events (5.5 hours)





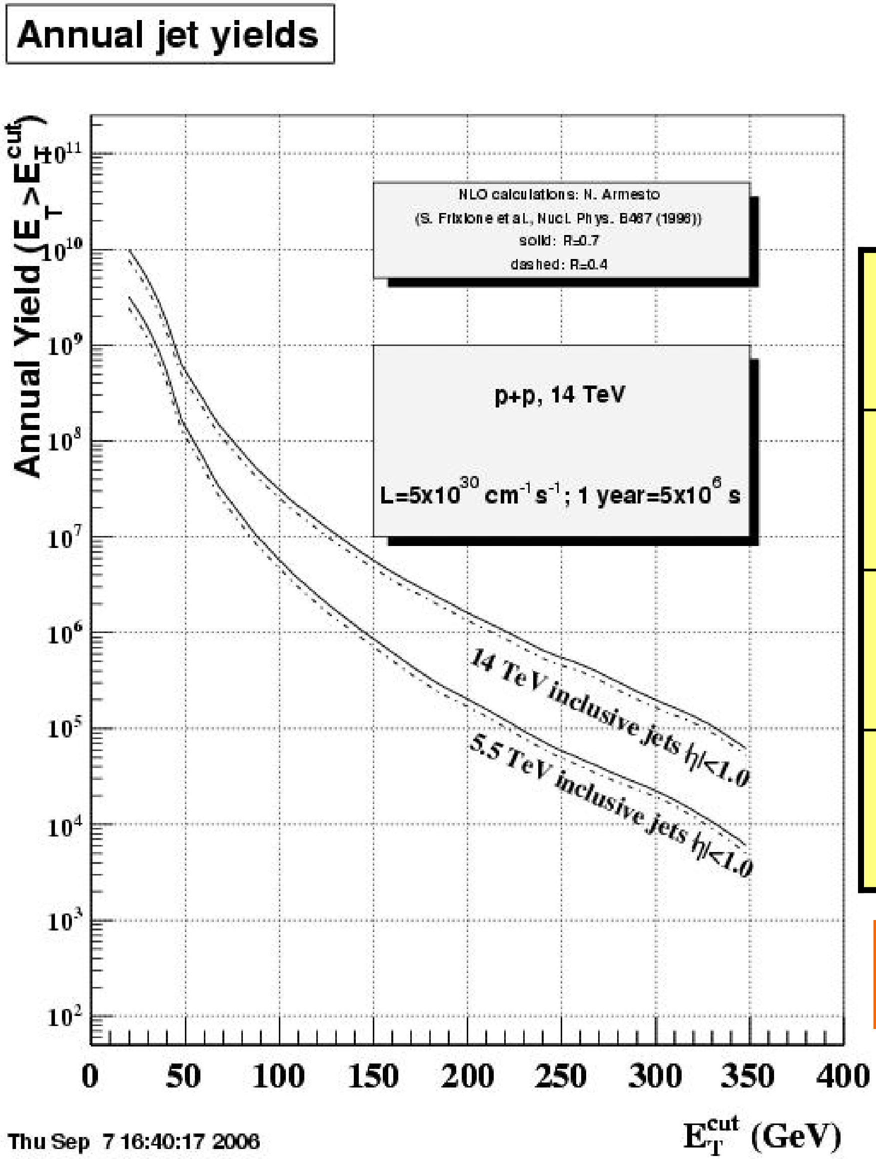
Φ visible even with no PID

Like-sign background

First three months

- Jets
- Heavy flavours

Jets rates at LHC



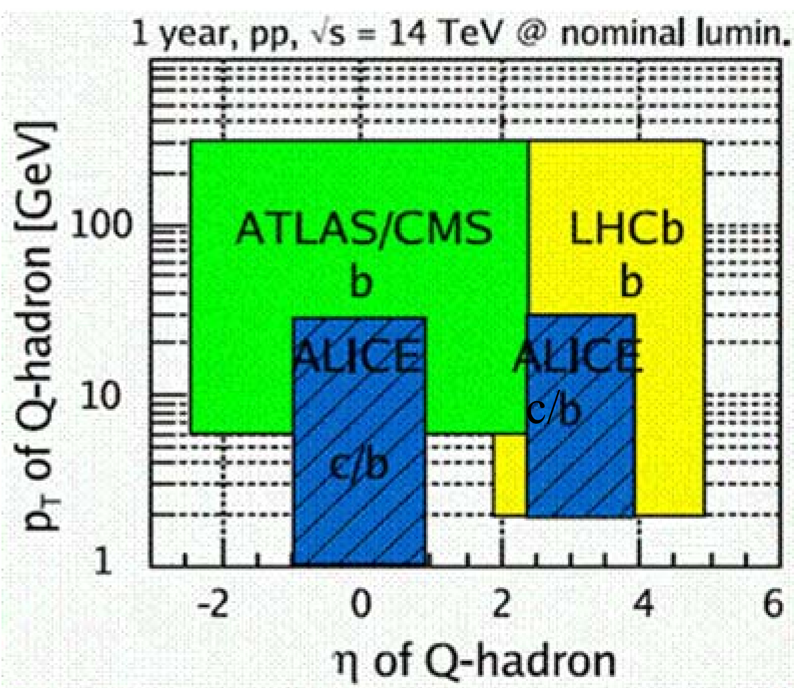
10^7 s, 100 Hz DAQ rate,
10^9 events (MB trigger)
(1 day = 8.6×10^6 events)

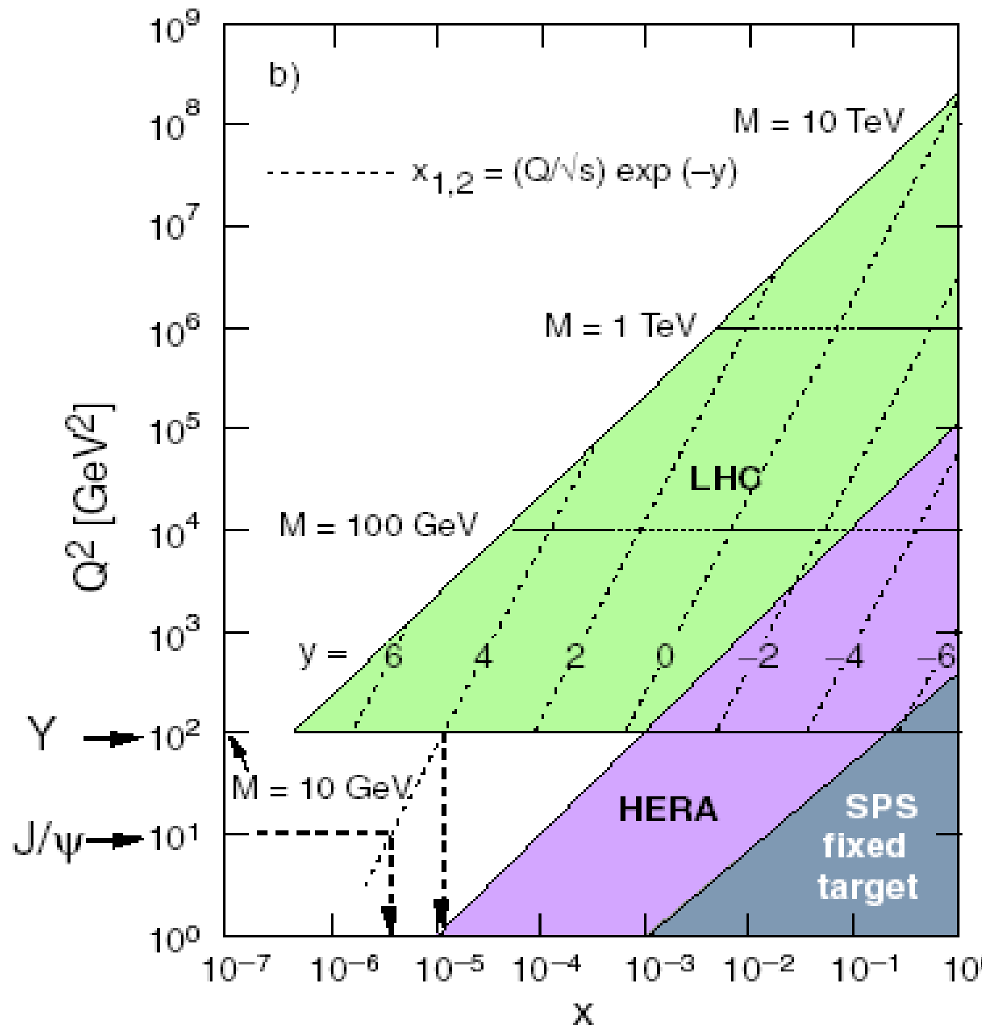
$\sqrt{s}$ [GeV] / E_T [GeV]	**900**	**5500**	**14000**
50	600	30000	150000
100	6	1800	7500
200	6×10^{-3}	60	3750

1 year: $E_T \sim 100$ GeV

Heavy flavours

- Test QCD at large Q^2 and small Bjorken x (down to 10^{-5})
- Baseline for p-A and AA

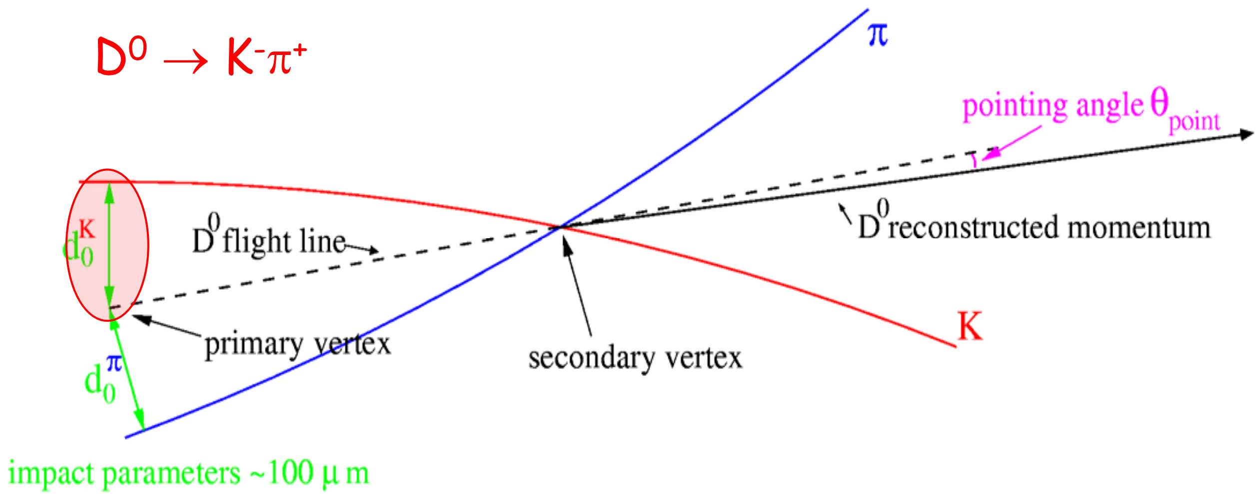




14/03/2008

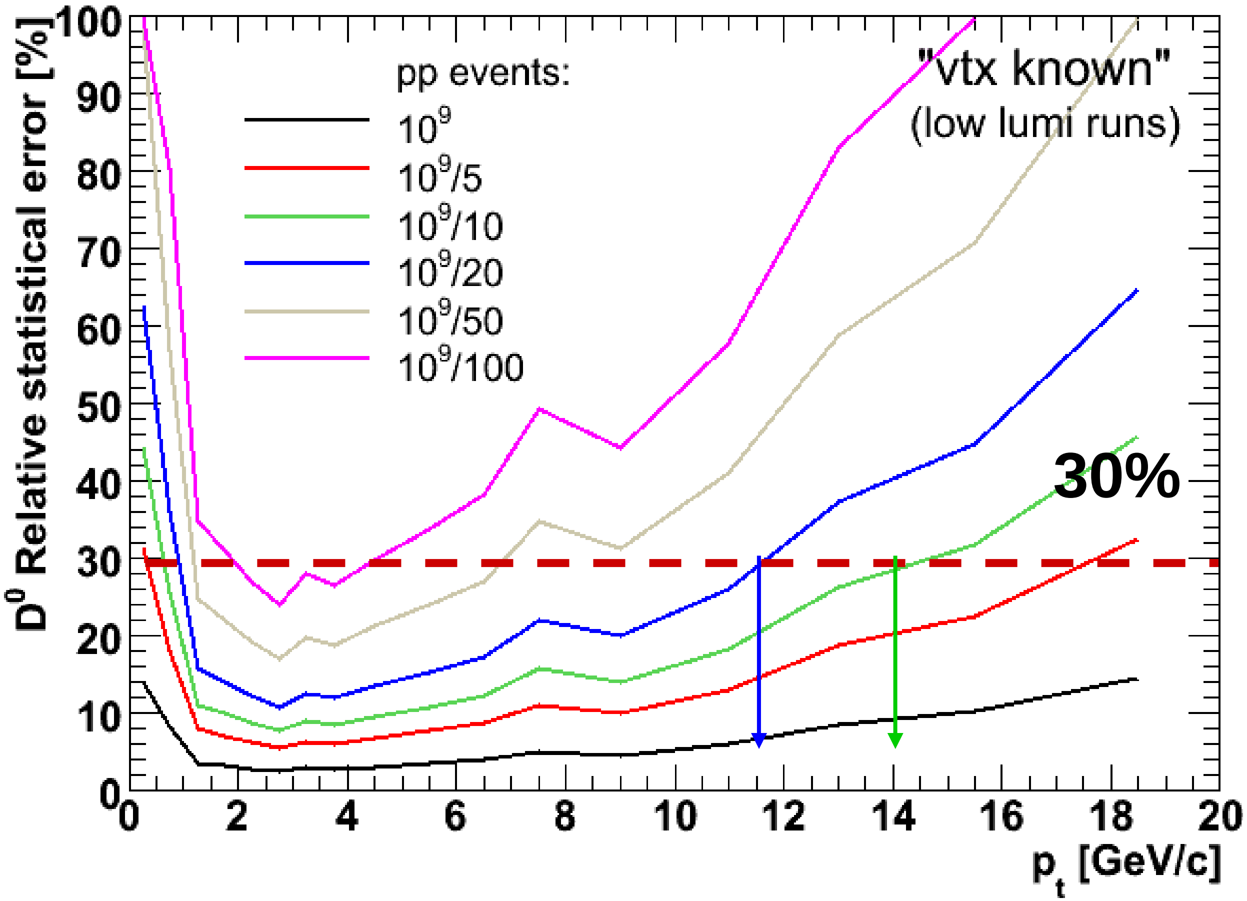
$D^0 \rightarrow K\pi$ channel

- $c\tau$=123 μm
- High precision vertexing, better than 100 μm (ITS)
- High precision tracking (ITS+TPC)
- K and/or π identification (TOF)



First heavy flavour physics: charm

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

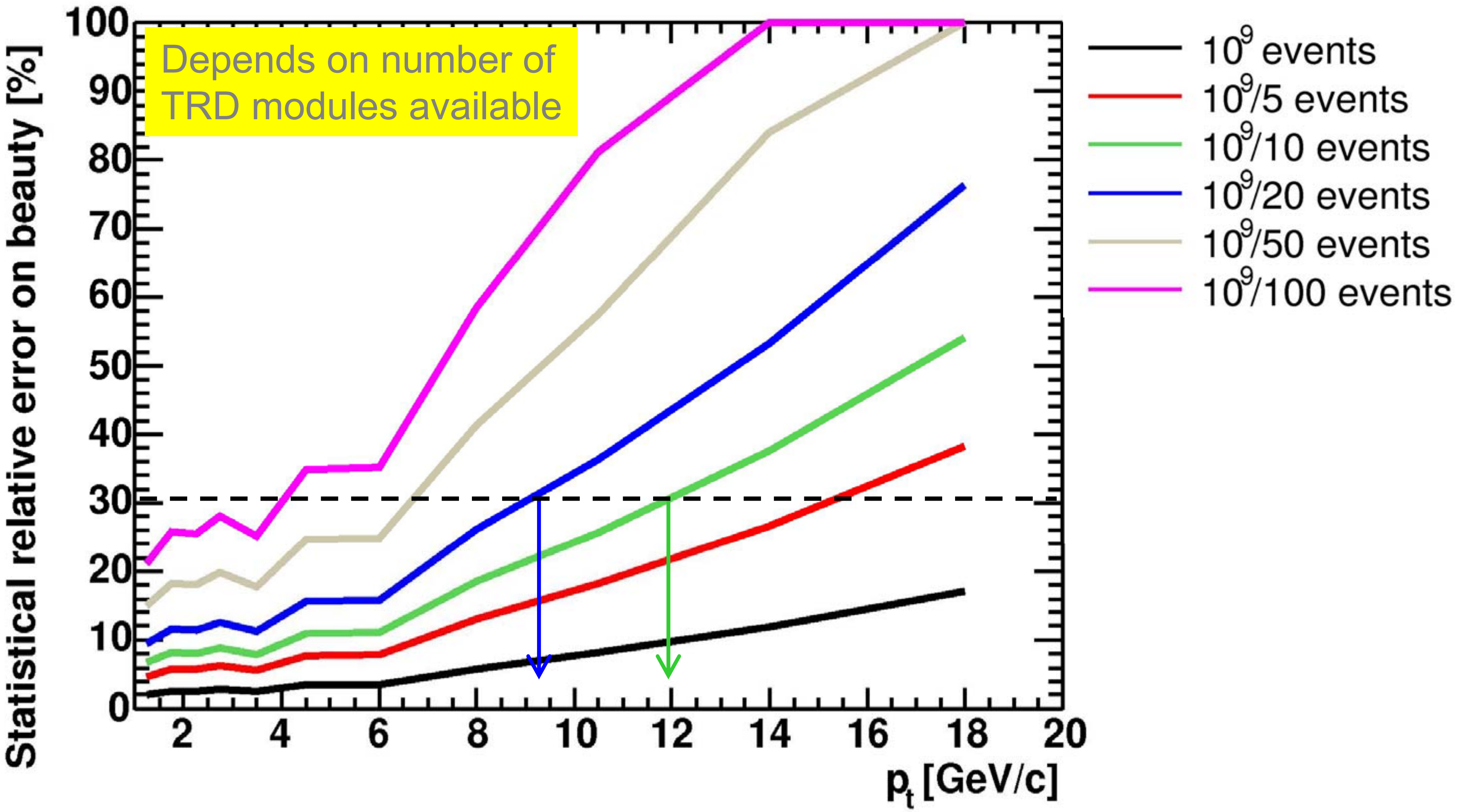


Andrea Dainese

reach up to 11.5 – 14 GeV/c with 7×10^7 evts

First heavy flavour physics: beauty

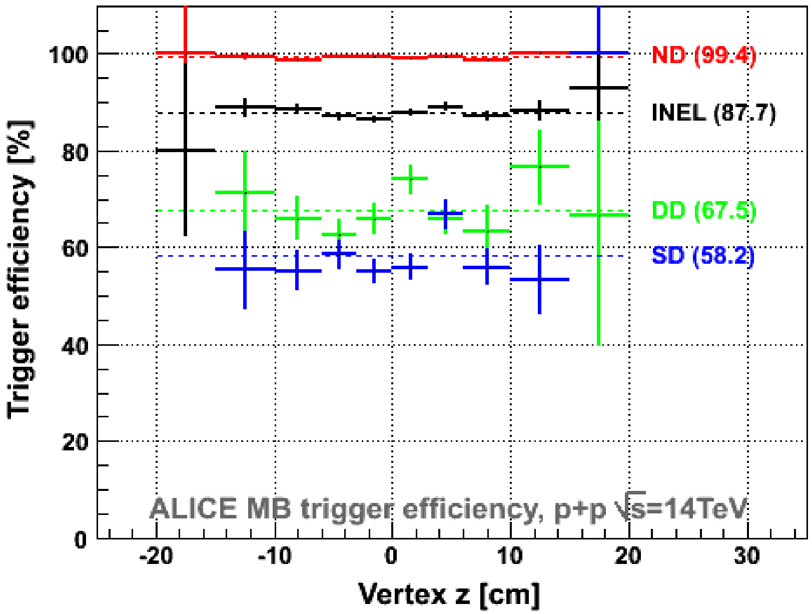
- Semielectronic beauty in pp



Minimum bias trigger

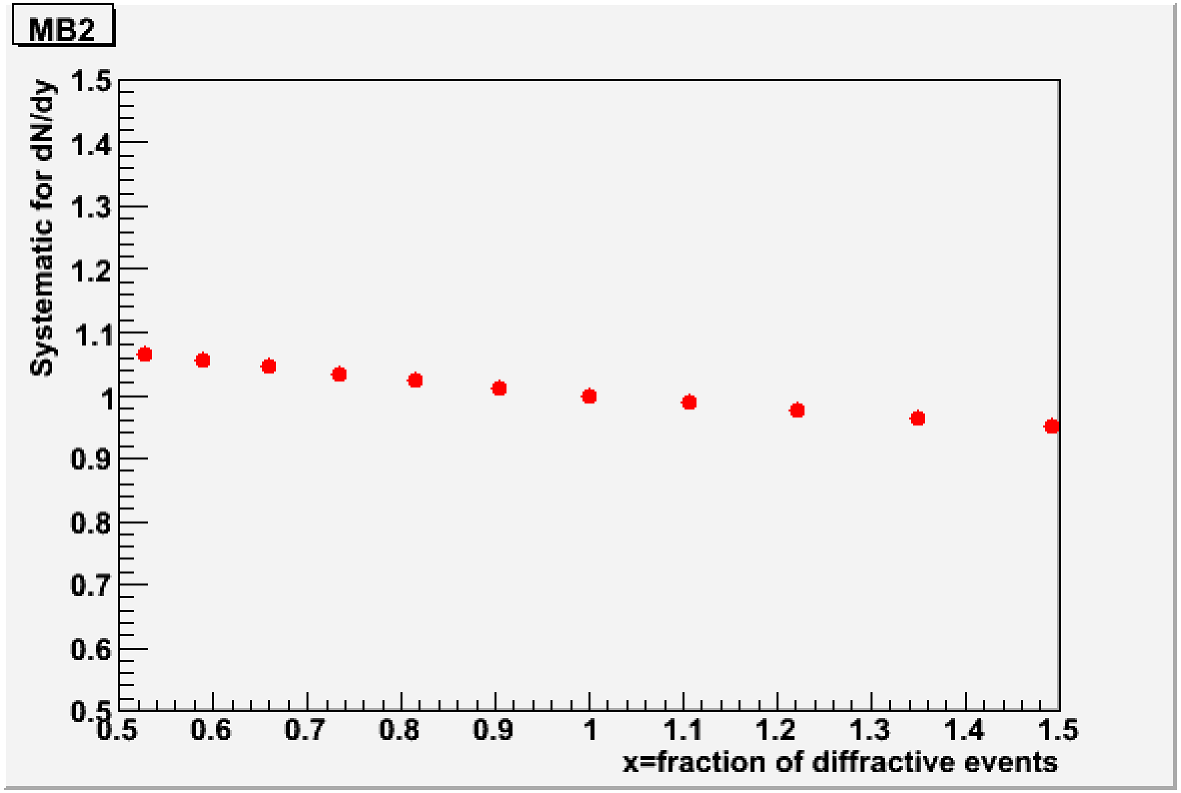
MB: Pixels & VZERO.OR & ¬VZERO.BEAMGAS

How efficient is the MB trigger ?

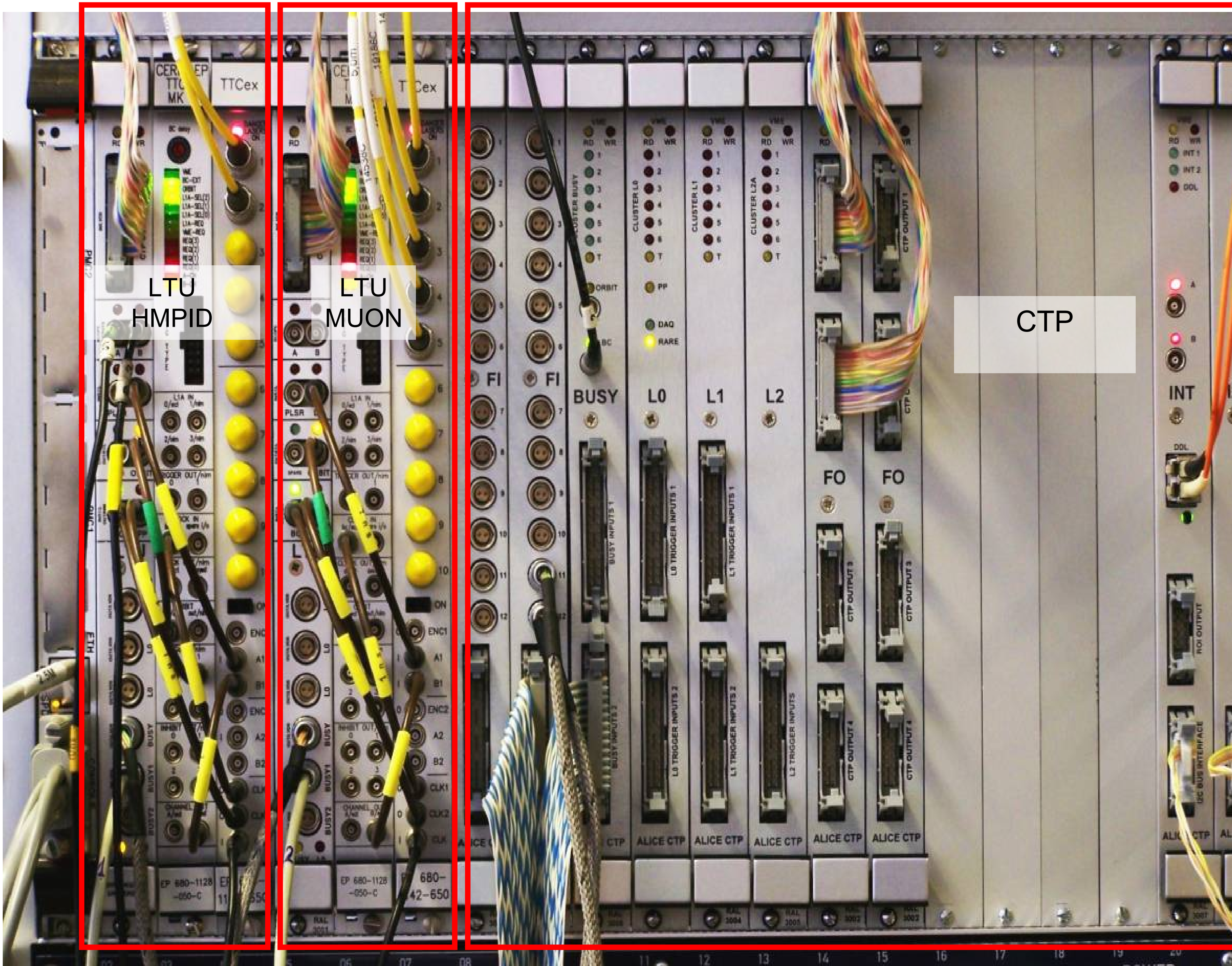


eff. \ √s	0.9 TeV	2.2 TeV	14 TeV
ND	98.9	98.9	99.4
DD	62.0	64.5	67.5
SD	53.9	55.1	58.2
INEL	84.6	85.7	87.7

Trigger Efficiency Systematic



Systematic uncertainty due to different trigger efficiencies for ND,SD and DD interactions.

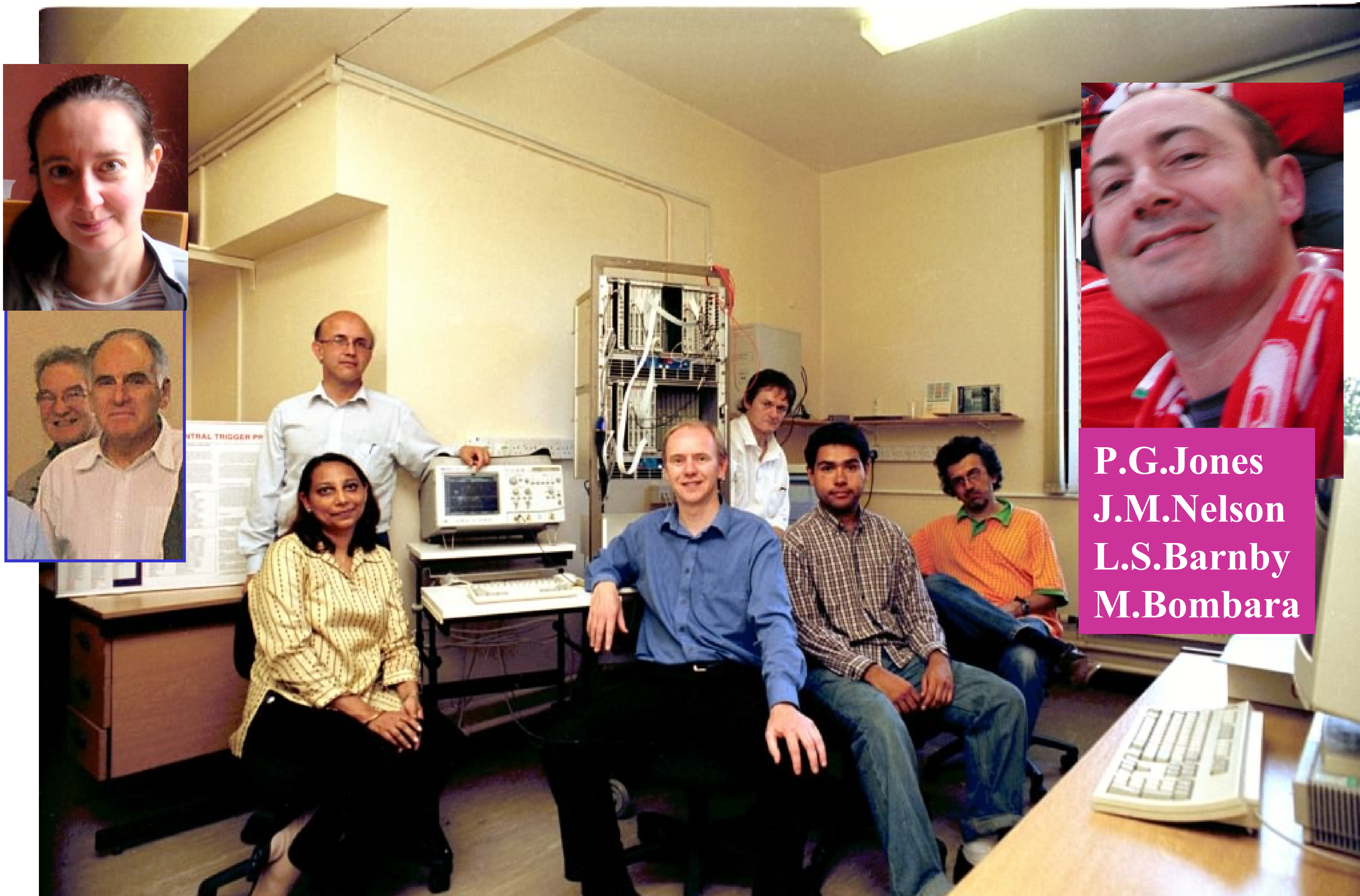

LTU
HMPID
LTU
MUON
CTP
TTCex
FI
FI
BUSY
L0
L1
L2
FO
FO
INT
ALICE CTP

ALICE Central Trigger Processor

ALICE CTP features:

- **3 Levels (L0,L1,L2 ~ 1μs, 6μ, 88μs)**
- **Partitioning of detectors into independent groups** – e.g. muon arm and central barrel
- **Pile up (past-future) protection** – tens of interactions in TPC drift time

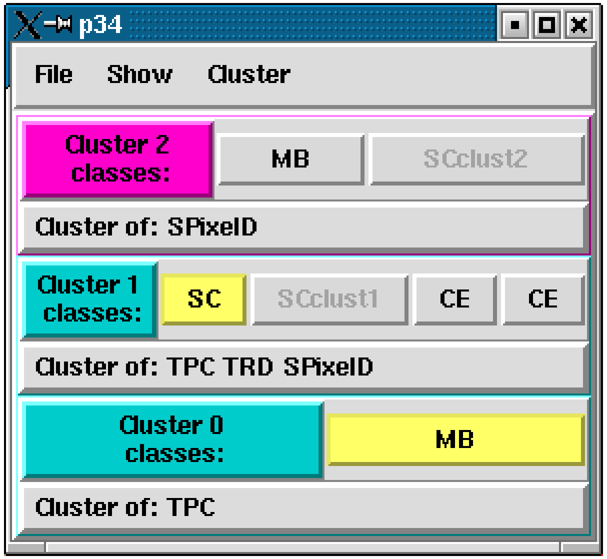
Birmingham ALICE Group

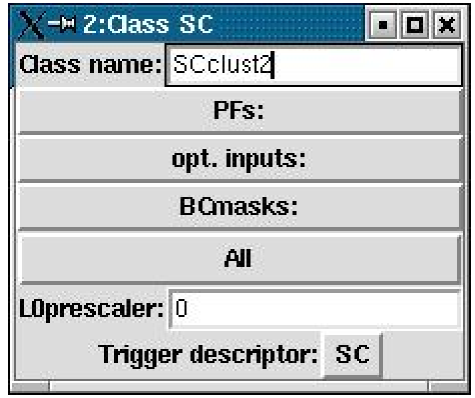


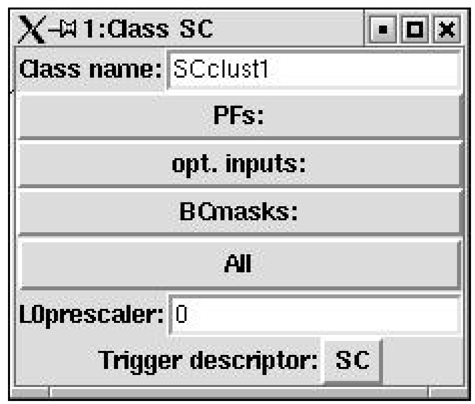
ALICE trigger software

- **Testing**
- **Configuration**
  - trigger logic
  - timing
- **Monitoring**
  - triggering detectors
  - luminosity
  - dead time
- **Offline**
  - cross section calculation
  - trigger corrections

User interface – partition editor

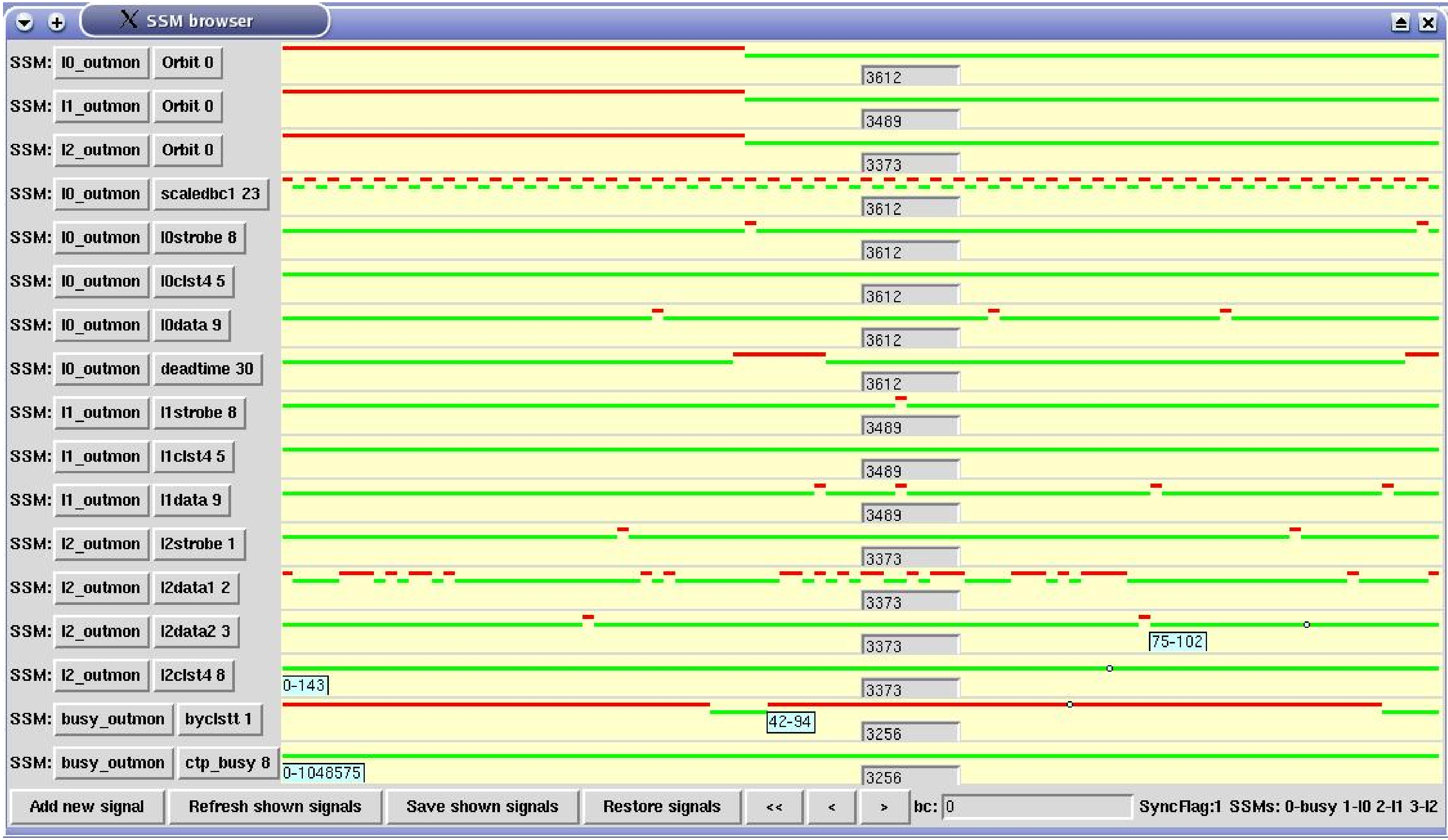






Main window = one partition = list of classes in clusters

Snapshot memory browser



Trigger input alignment in time

Alignment: adjusting the trigger input delays to assure that the trigger signals originating from the same bunch crossing reach the CTP in the same clock cycle

Without the beam: Before doing any timing tests, we have information on *expected* timing from tabulated cable lengths.

With the beam methods:

- Oscilloscope/Snapshot (L0,L1,L2 level), if rate and noise are low
- **Correlation analysis**

Possible data sources for analysis:

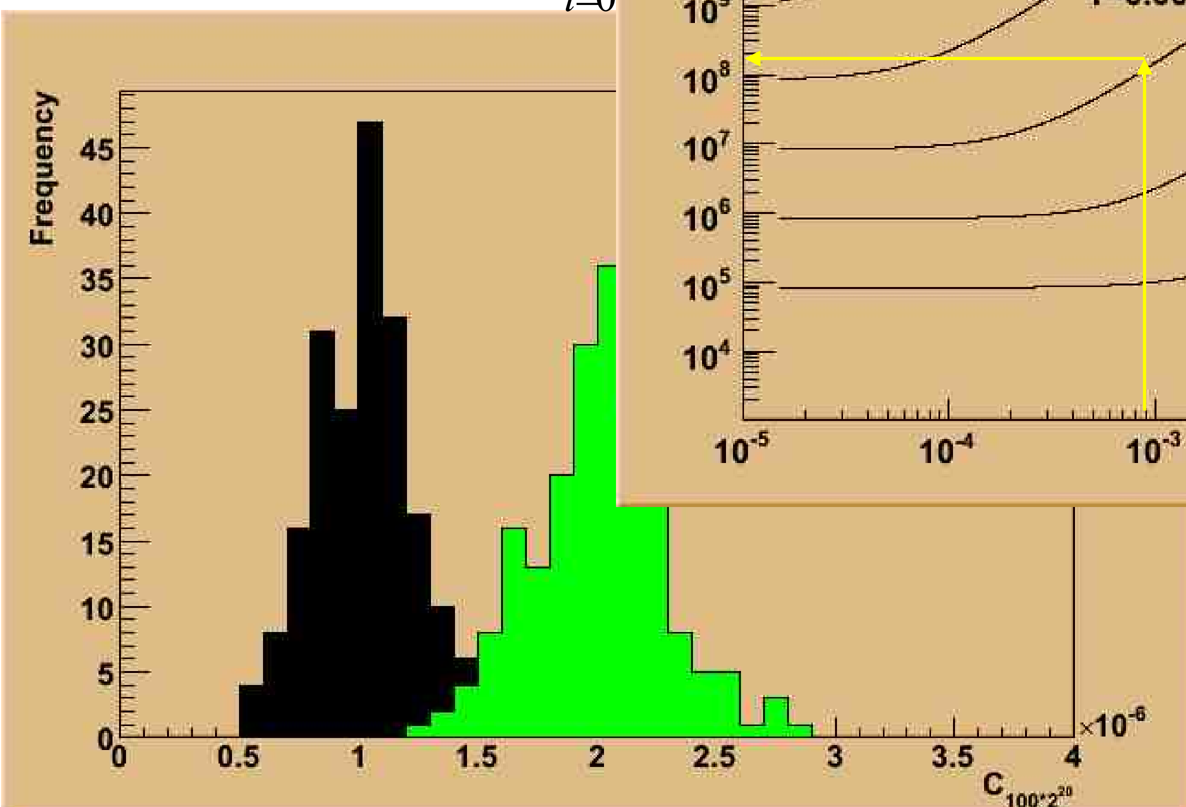
- **SnapShot**
- Interaction record

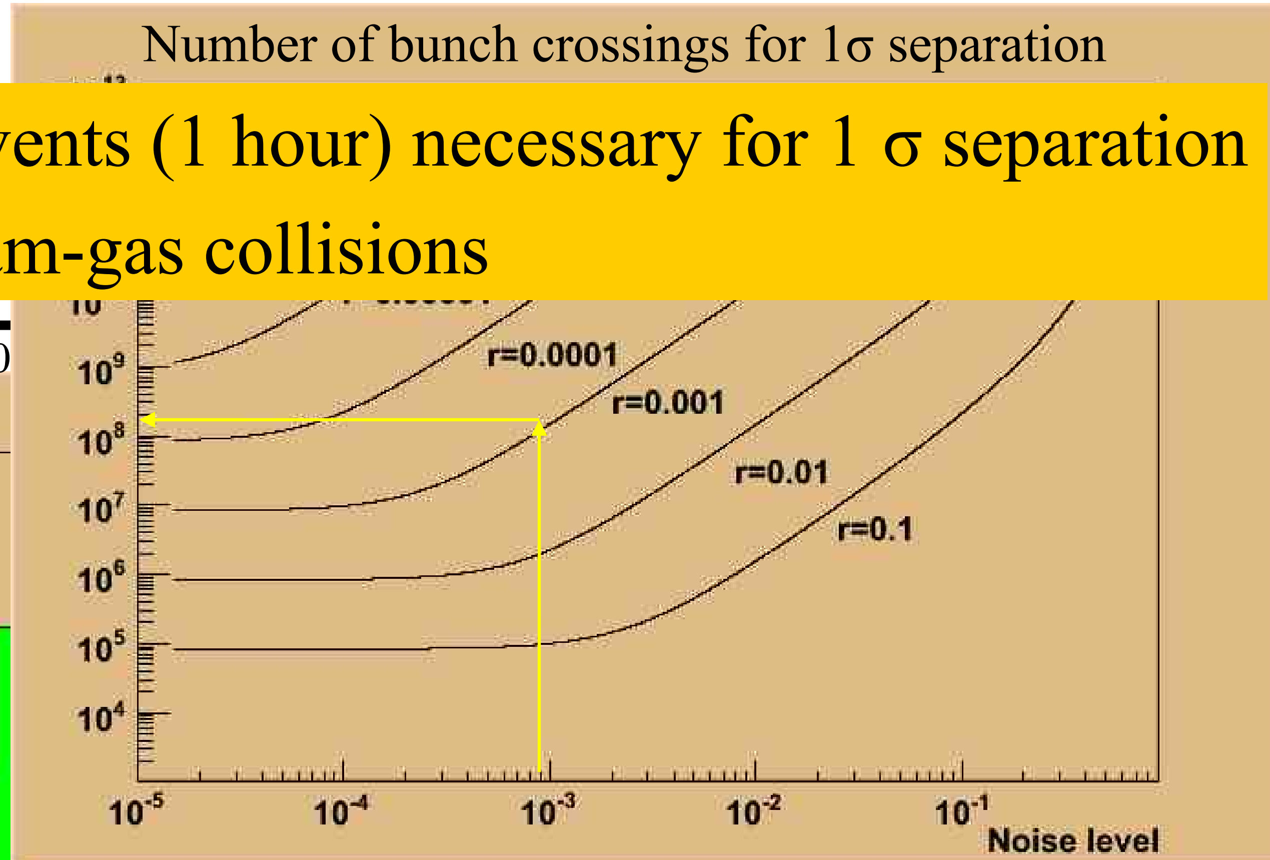
Trigger inputs alignment

a_i* ,*b_i – trigger inputs generated
by detectors A,B at ti

Correlation function:

$$C_N(\delta) \quad \frac{}{N}\sum_{i=0}$$



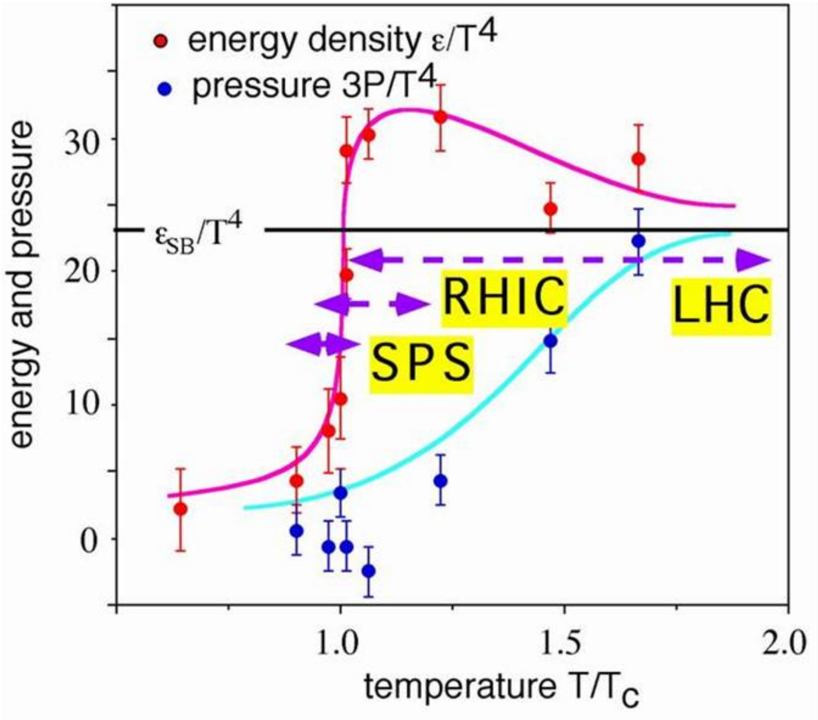


10^8 events (1 hour) necessary for 1 σ separation in beam-gas collisions

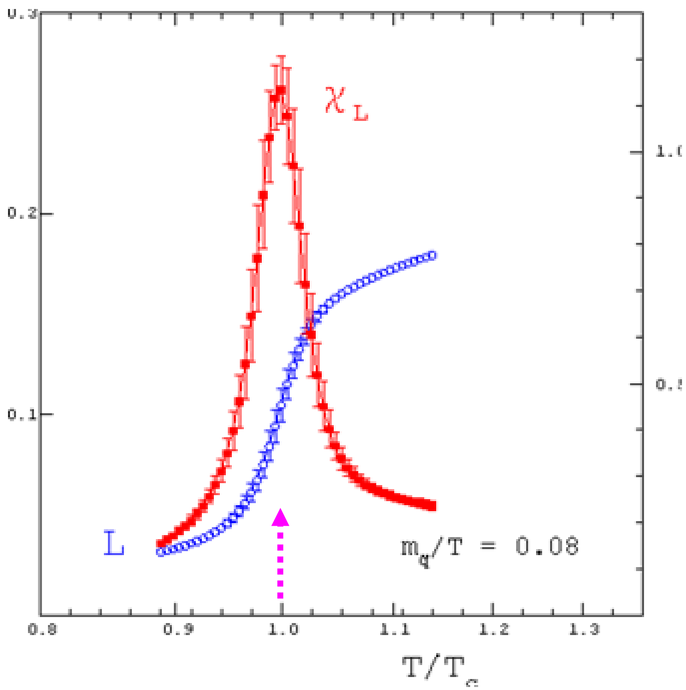
Quark Gluon Plasma

- the phase transition from lattice QCD
  - **T/T_c 0.9 -> 1.1 => factor ~2 in ε => factor ~ 9 in √s**
  - we need big factors in energy to cover the QCD phase diagram

ε ~ T^4 ε (τ=1 fm/c) ~ dN/dy ~ ln(√s)



Order parameter for deconfinement



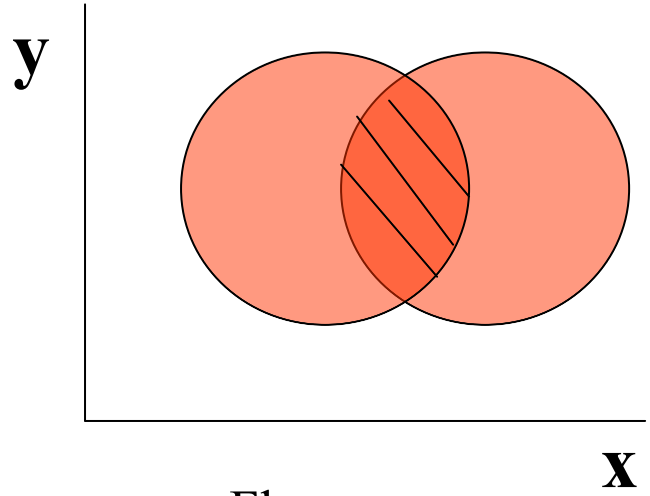
Heavy-ion physics with ALICE

- early ion scheme (2009)
  - **1/20 of nominal luminosity**
  - **$\int L dt = 5 \cdot 10^{25}$ cm^{-2} s^{-1} x 10^6 s**
    0.05 nb^{-1} for PbPb at 5.5 TeV
    $N_{pp\ collisions} = 2 \cdot 10^8$ collisions
    400 Hz minimum-bias rate
    20 Hz central (5%)
  - **muon triggers:**
    ~ 100% efficiency, < 1kHz
  - **centrality triggers:**
    bandwidth limited
    $N_{PbPbminb} = 10^7$ events (10Hz)
    $N_{PbPbcentral} = 10^7$ events (10Hz)

- fully commissioned detector & trigger
  - **alignment, calibration available from pp**
- 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 flavours**
  - **jet quenching, heavy-flavour energy loss**
  - **charmonium production**
- **yield bulk properties of created medium**
  - **energy density, temperature, pressure**
  - **heat capacity/entropy, viscosity, sound velocity, opacity**
  - **susceptibilities, order of phase transition**

Flow

Azimuthal asymmetry in the transverse plane:



Eccentricity:

$$\varepsilon \equiv \frac{\langle y^2 - x^2 \rangle}{\langle y^2 + x^2 \rangle}$$

Flow:

$$E\frac{d^3N}{d^3p} = \frac{1}{2\pi}\frac{d^2N}{p_t dp_t dy}\left[1 + \sum_{n=1}^{\infty} 2v_n \cos(n\phi)\right]$$

v_1 = directed flow v_2 = elliptic flow

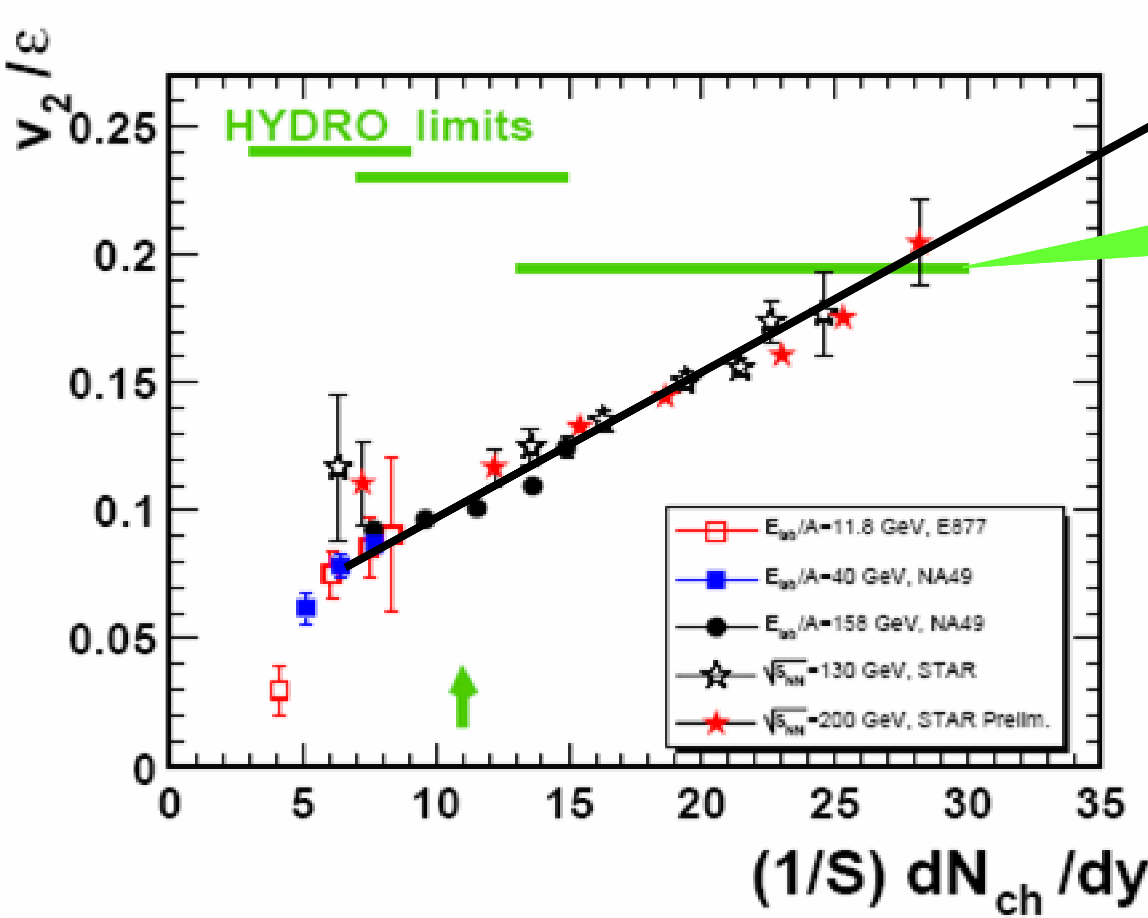
Φ – angle with respect to reaction plane

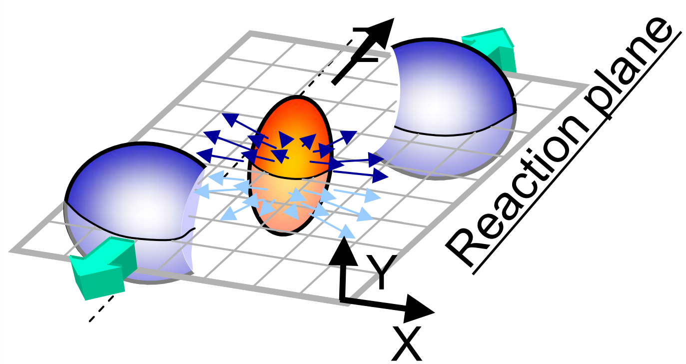
Relativistic hydrodynamics prediction: v_2/ε=constant

Is the QGP an ideal fluid ?

- one of the first ‘expected’ answers from LHC
  - Hydrodynamics: modest rise (Depending on EoS, viscosity, speed of sound)
  - experimental trend & scaling predicts large increase of flow

LHC ?





BNL Press release, April 18, 2005:

RHIC Scientists Serve Up "Perfect" Liquid

New state of matter more remarkable than predicted – raising many new questions

Summary & Outlook

- first pp run
  - **important pp reference data for heavy ions**
  - **unique physics to ALICE**
    - **minimum-bias running**
    - **fragmentation studies**
    - **baryon-number transport**
    - **heavy-flavour cross sections**
- first few heavy-ion collisions
  - **establish global event characteristics**
  - **important bulk properties**
- first long heavy-ion run
  - **quarkonia measurements**
  - **Jet-suppression studies**
  - **flavour dependences**

Outlook

- high luminosity heavy ion running ($1nb^{-1}$)
  - **dedicated high p_t electron triggers**
  - **jets > 100 GeV (EMCAL)**
  - **γ - jet correlations**
  - **Υ – states**
  - …
- pA & light ion running

We are looking forward to very exciting times

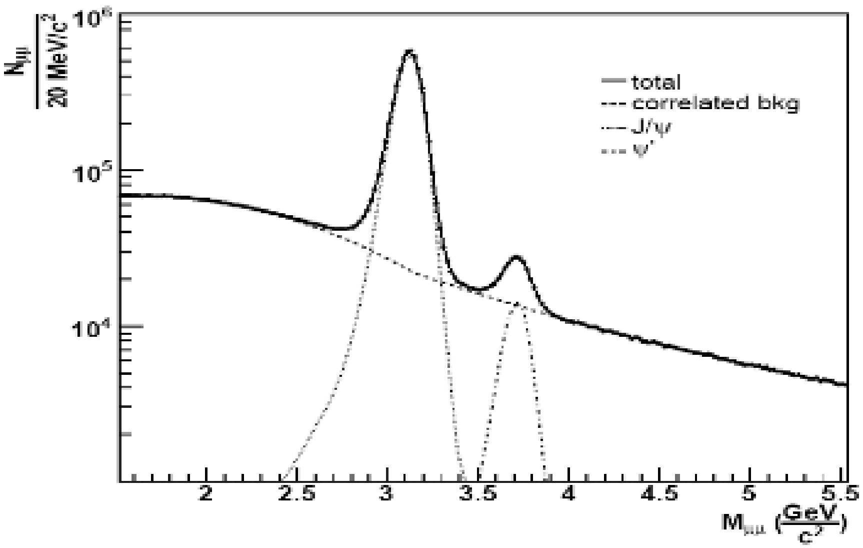
Terra incognita: hic sunt dracones !
Be prepared for anything !

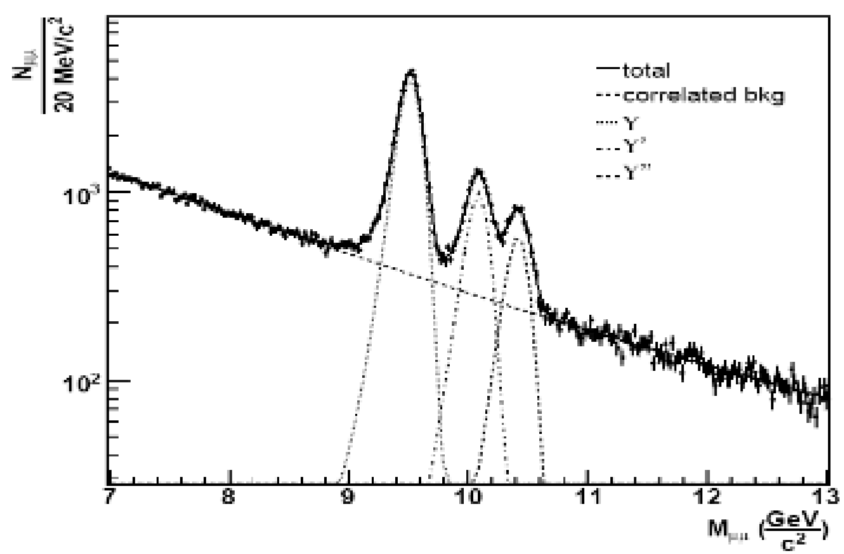
END

Quarkonia physics

p-p @ 14 TeV, L = 3.10^{30} cm^{-2} s^{-1}, t = 10^7 s, 30/pb

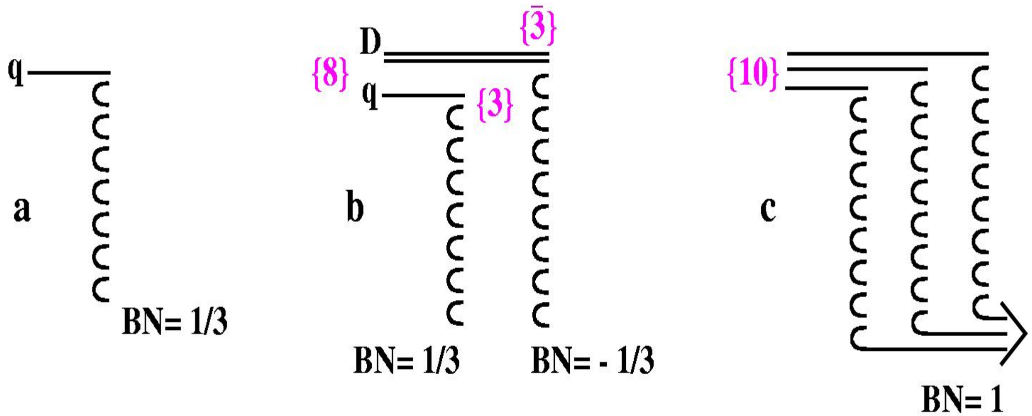
Muon channel: (2.5 <y< 4): 2.9M J/Psi and 27k Y (N.Bastid et al.)

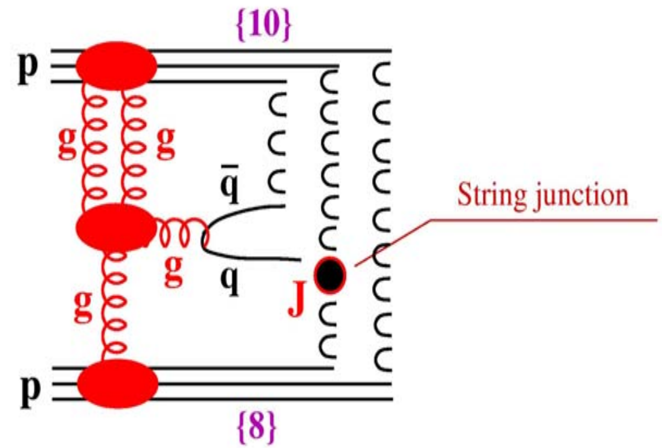




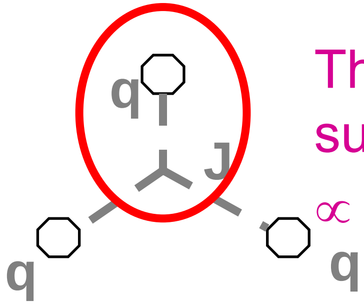
Baryon number transfer in rapidity

- **When original baryon changes its colour configuration (by gluon exchange) it can transfer its baryon number to low-x without valence quarks – by specific configuration of gluon field**





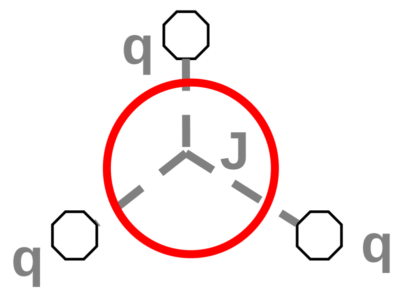
Standard case – quark exchange



This exchanged is suppressed

$\propto$ exp (-1/2 Δy)

Gluon mechanism



Different prediction for junction exchange:

$\propto$ exp (-α_J Δy)

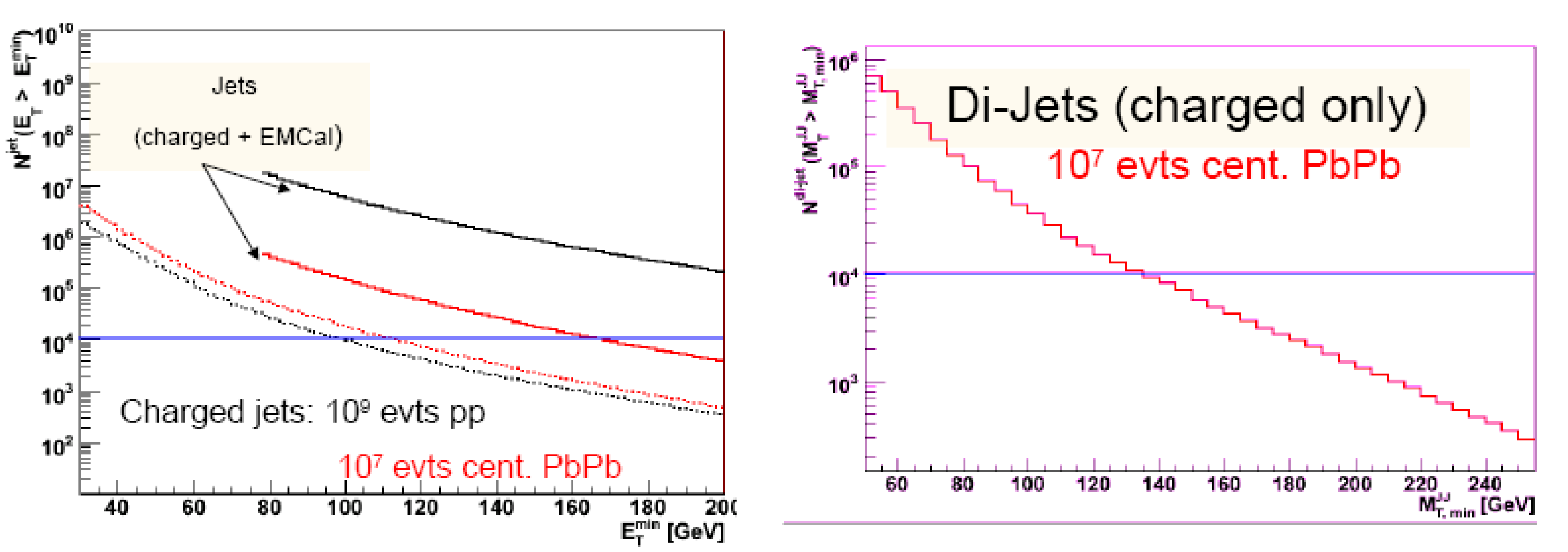
α_J = 0.5 Veneziano, Rossi

α_J = 0   Kopeliovich

- experimentally we measure baryon – antibaryon asymmetry
- largest rapidity gap at LHC (> 9 units)
- predicted absolute value for protons ~ 2-7%

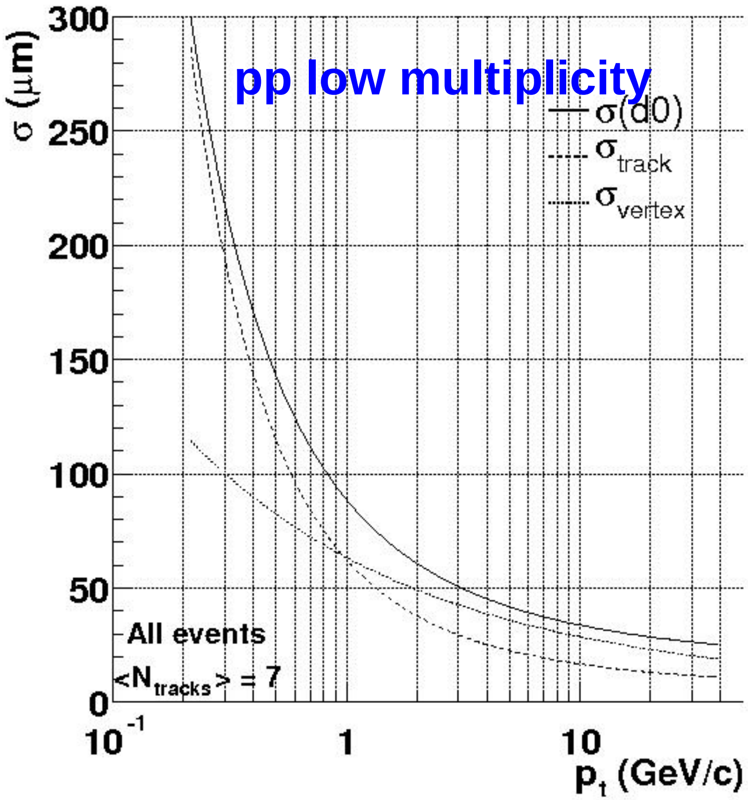
$$A = 2 \cdot \frac{N_B - N_{\bar{B}}}{N_B + N_{\bar{B}}}$$

Rates



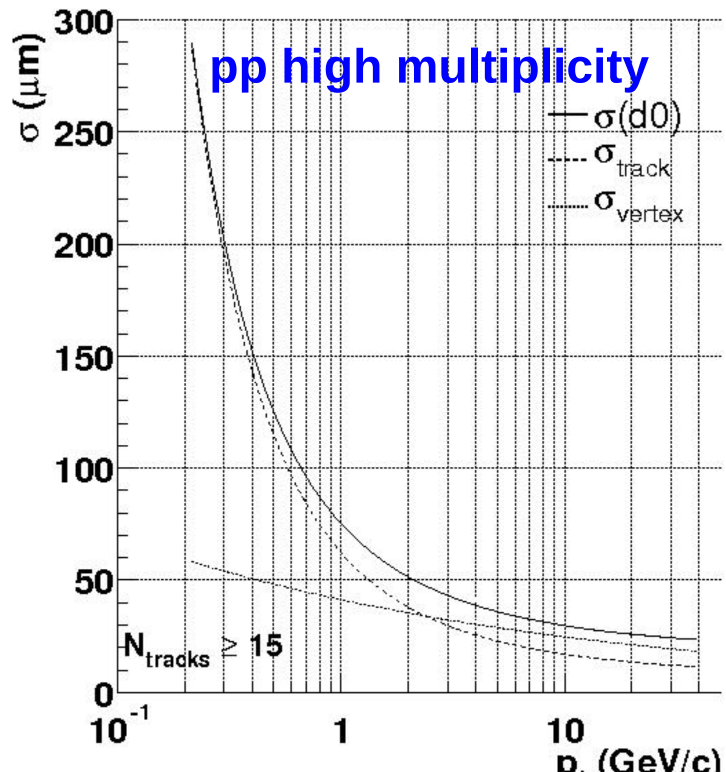
- **First jet physics**
  - with TPC up to $E_T \approx$ 100 GeV in p+p and Pb+Pb
  - Minimum bias data: No high luminosity needed

Impact parameter precision



Impact parameter resolution is crucial for the detection of short-lived particles - charm and beauty mesons and baryons

At least one component has to be better than 100 μm ($c\tau$ for D^0 meson is 123 μm)

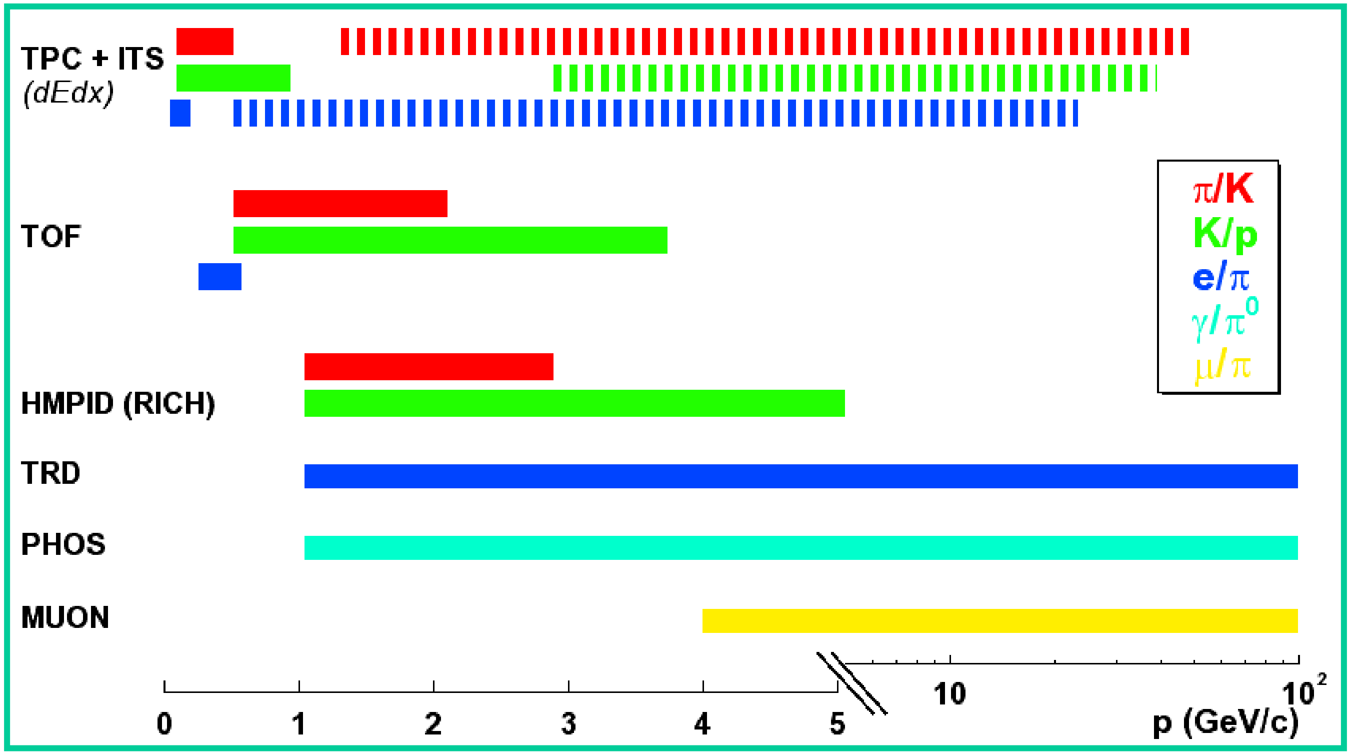


For low-multiplicity events (i.e. pp) the contribution from primary-vertex resolution is not negligible

Full reconstruction with primary tracks has to be used

Particle Identification

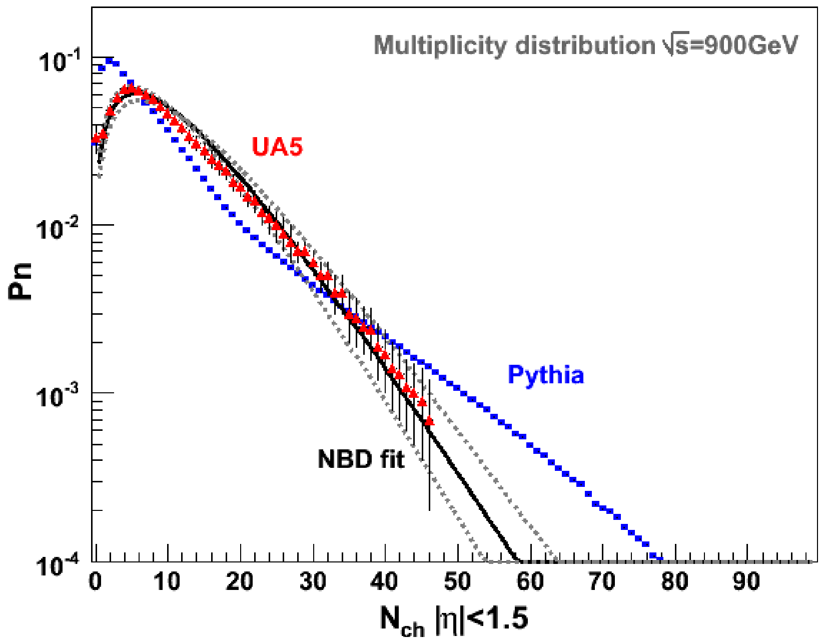
- Very good PID over broad momentum range

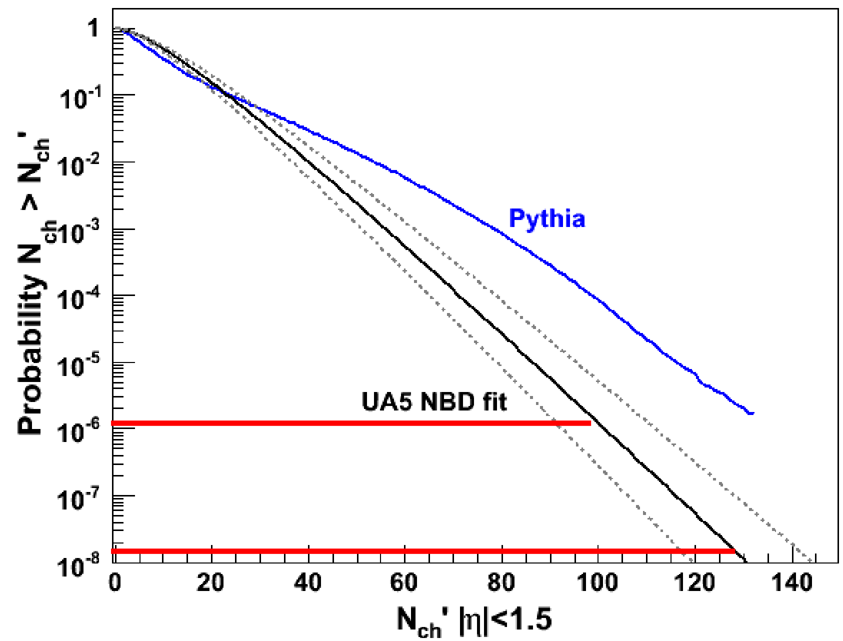


separation @ 3σ

separation @ 2σ

Multiplicity reach at 900 GeV



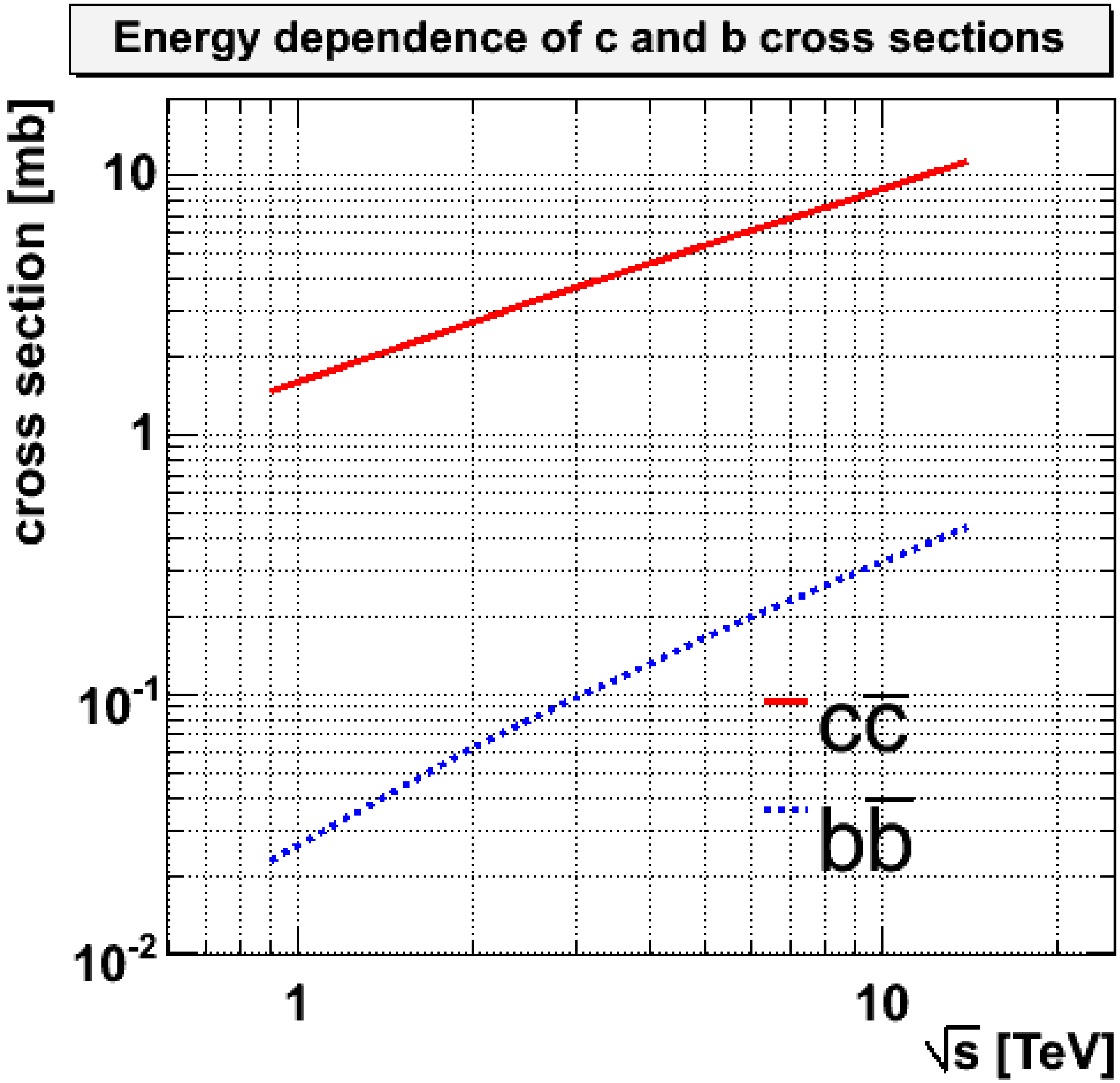


Pythia 6.214 (in Aliroot)
UA5: ZPC43,357(1989)

6839 ev. ~ Max $N_{ch}^{|\eta|<1.5}$=47

Using NBD fits to UA5 data
to estimate multiplicity reach:
$\Rightarrow 10^6$ ev. ~ Max $N_{ch}^{|\eta|<1.5} \approx 90$
$\Rightarrow 10^8$ ev. ~ Max $N_{ch}^{|\eta|<1.5} \approx 120$

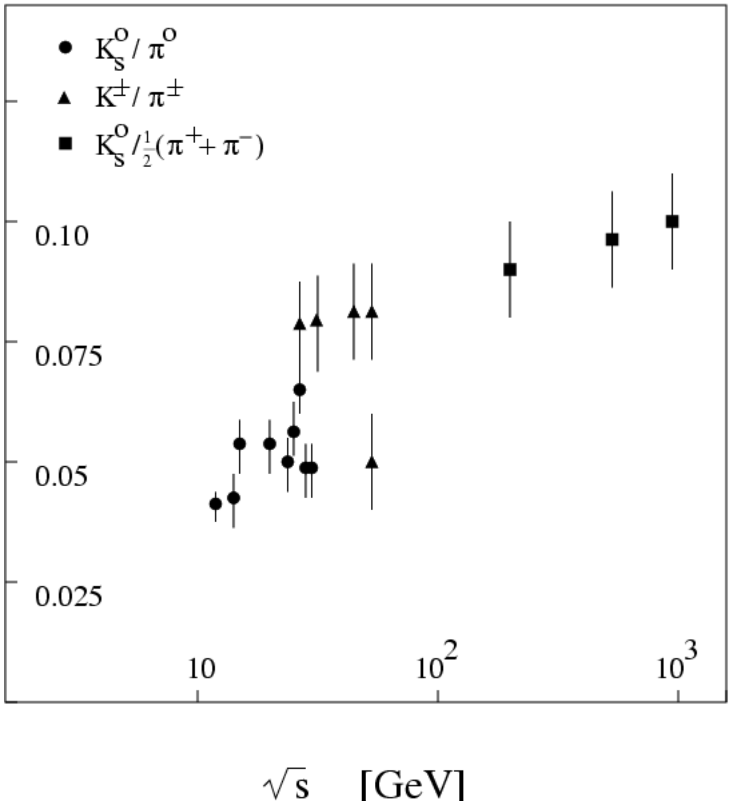
Total cross sections

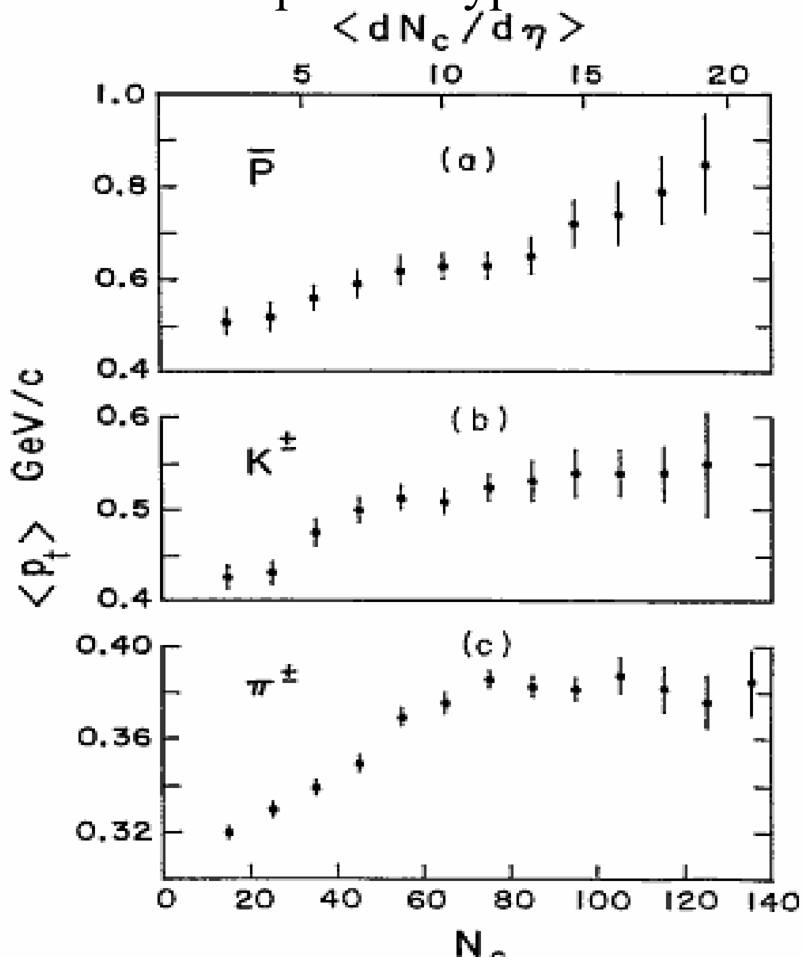


- Values at 14 TeV:
  - charm 11.3 mb
  - beauty 0.44 mb
- PPR (older PDFs):
  - charm 11.2 mb
  - beauty 0.51 mb
- Ratio 14TeV / 2.4TeV:
  - charm 3.6
  - beauty 5.9

Identified particles yields and spectra

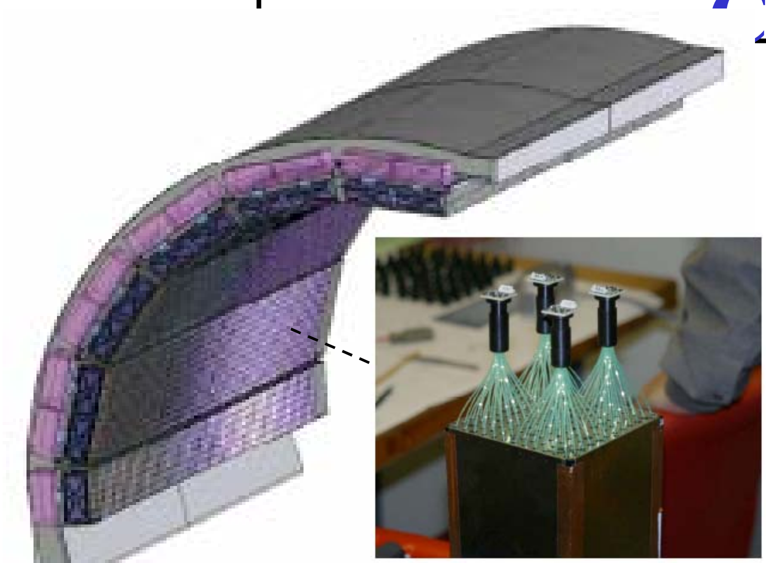
- Data on K/π in anti-p p interactions show steady (slow) increase with energy and with multiplicity
- Mean pt as a function of multiplicity for different particle types – shows different behaviour





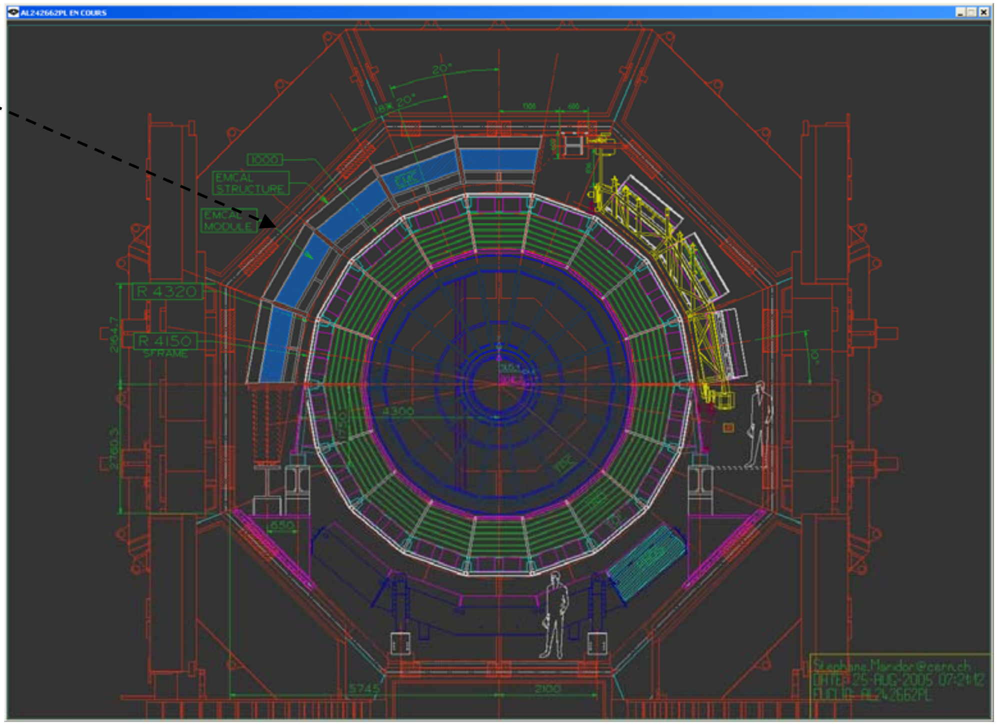
E735 Fermilab

ALICE Electromagnetic Calorimeter


EMCal Module = 4 towers

- upgrade to ALICE
- ~17 US and European institutions

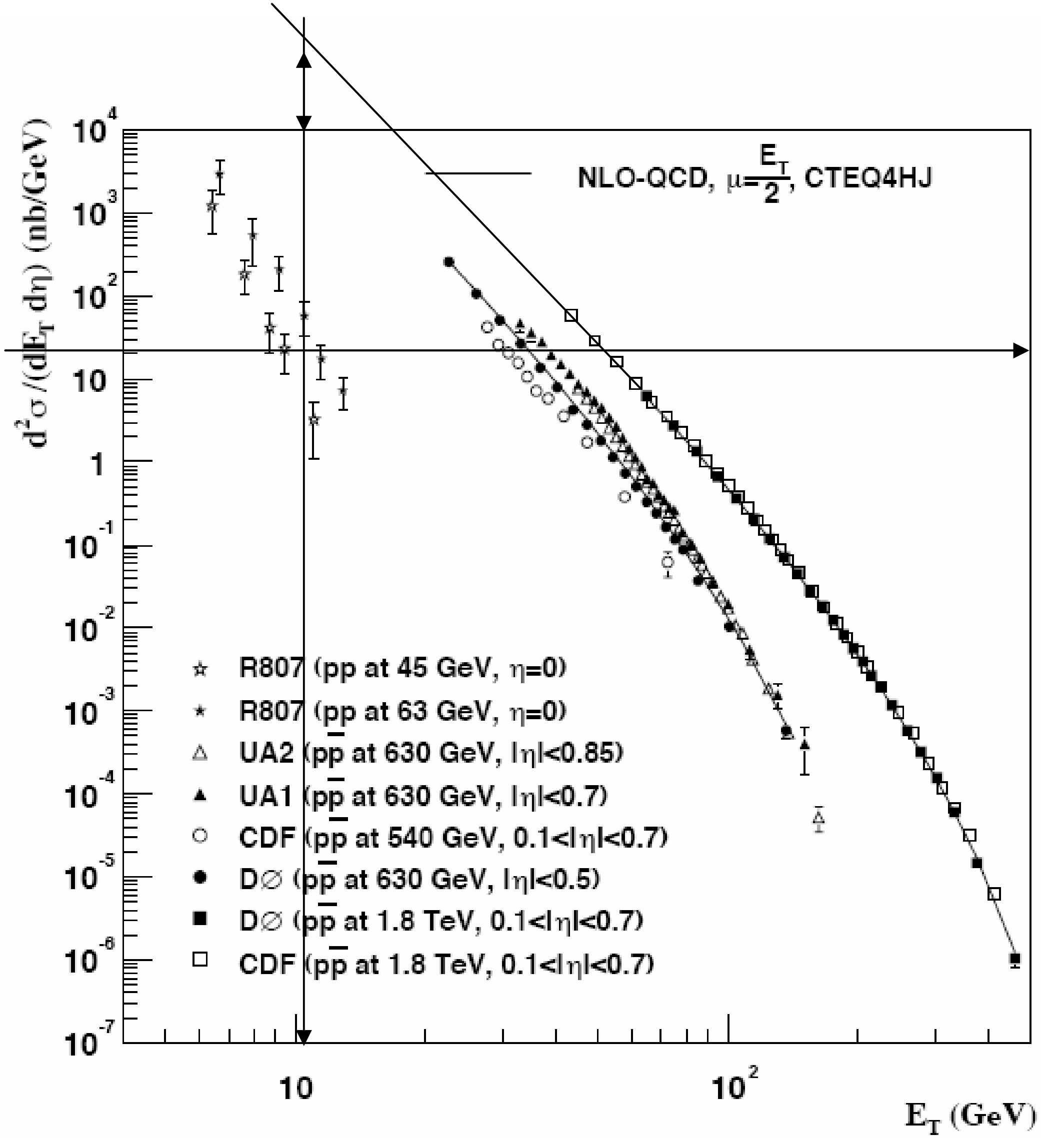
Current expectations:
- 2009 run: partial installation
- 2010 run: fully installed and commissioned



Lead-scintillator sampling calorimeter
Shashlik fiber geometry
Avalanche photodiode readout

Coverage: $|\eta|<0.7$, $\Delta\phi=110^o$
~13K towers ($\Delta\eta x \Delta\phi \sim 0.014x0.014$)
depth~21 X_0
Design resolution: $\sigma_E/E \sim 1\% + 8\%/\sqrt{E}$

Jet rate at LHC



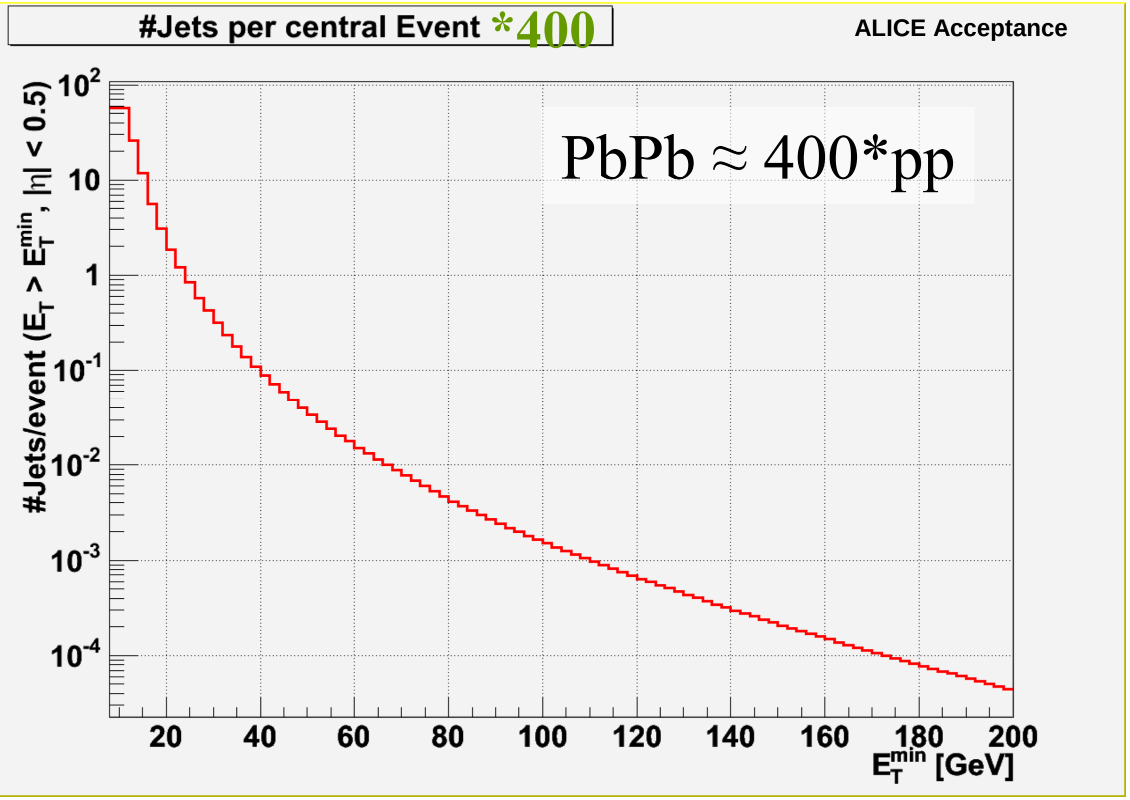
$$E_T^3 d\sigma_1 / dE_{T1} / d\eta = f(2E_T/\sqrt{s})$$

$$\frac{d\sigma_1 / dE_{T1} / d\eta}{d\sigma_2 / dE_{T2} / d\eta} = \frac{\sqrt[4]{s_2}\,E_{T2}^3}{\sqrt[4]{s_1}\,E_{T1}^3}$$

200/14000=0.014

0.014=25.2/1800

Jet rates at LHC

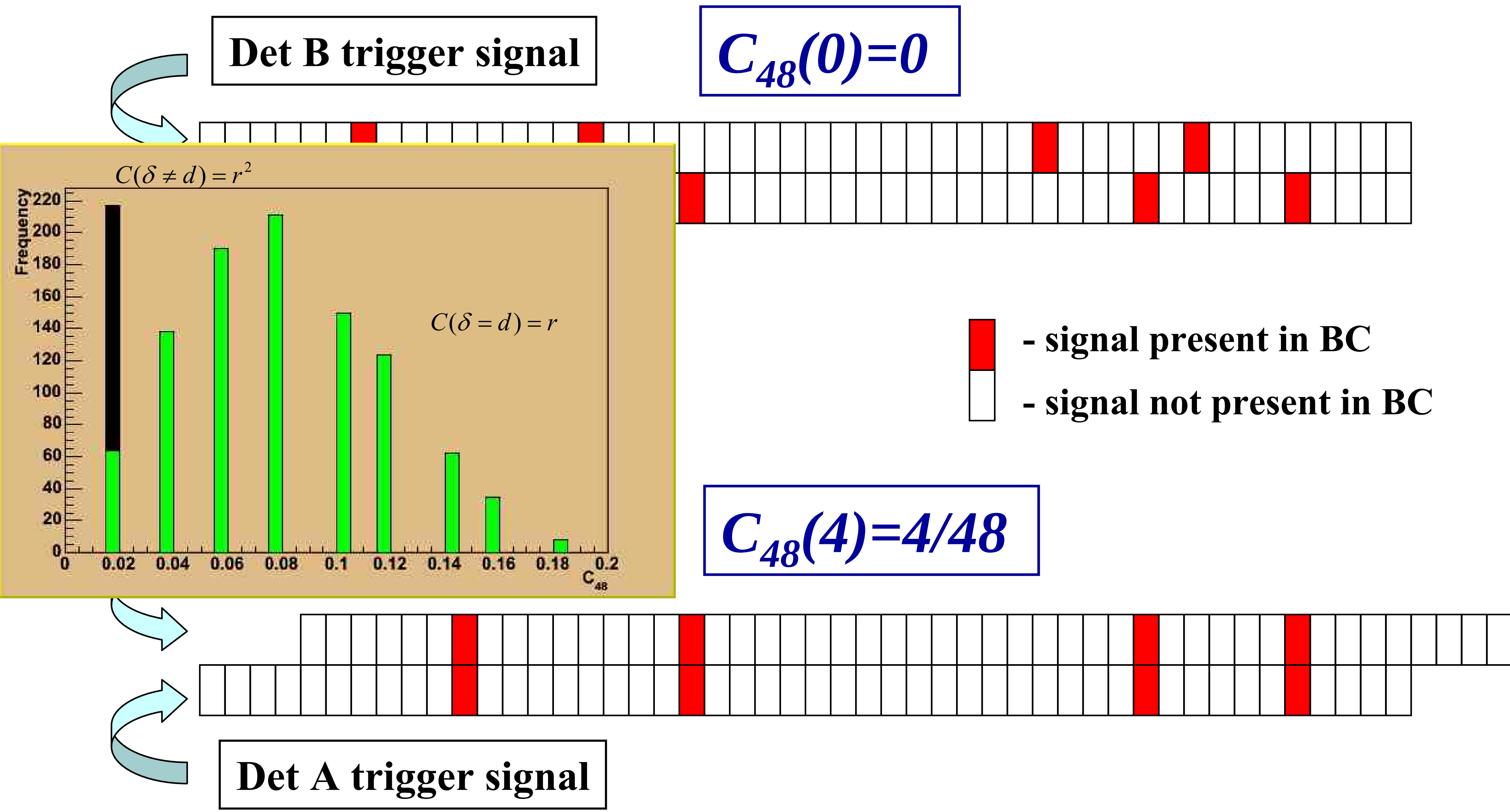


10^7 s, 100 Hz TPC rate,
10^9 events (MB trigger)

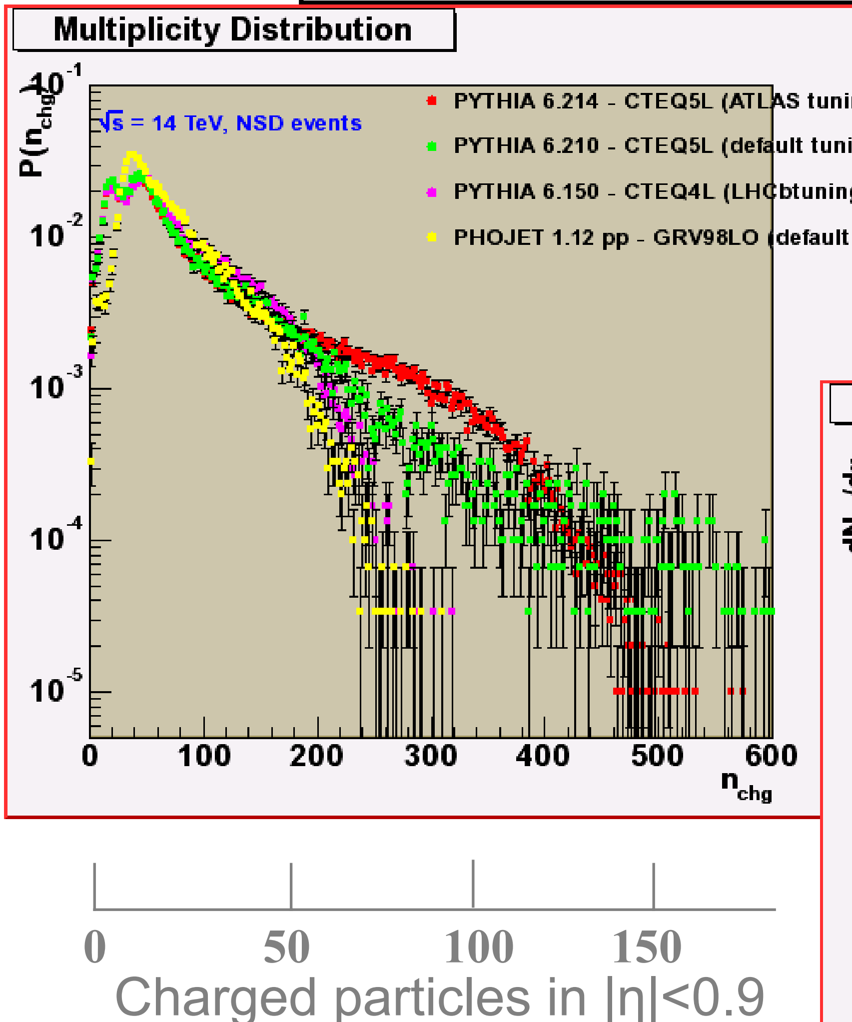
E_T threshold	N_{jets}
50 GeV	1×10^5
100 GeV	2×10^3
150 GeV	6×10^2
200 GeV	1×10^2

$$\frac{\#\,jets}{event} = \frac{\sigma_{jet}^{PbPb}}{\sigma_{inel}^{PbPb}} = \frac{A^2}{100}\frac{\sigma_{jet}^{pp}}{\sigma_{inel}^{pp}} = 400\frac{\sigma_{jet}^{pp}}{\sigma_{inel}^{pp}}$$

Correlation function example

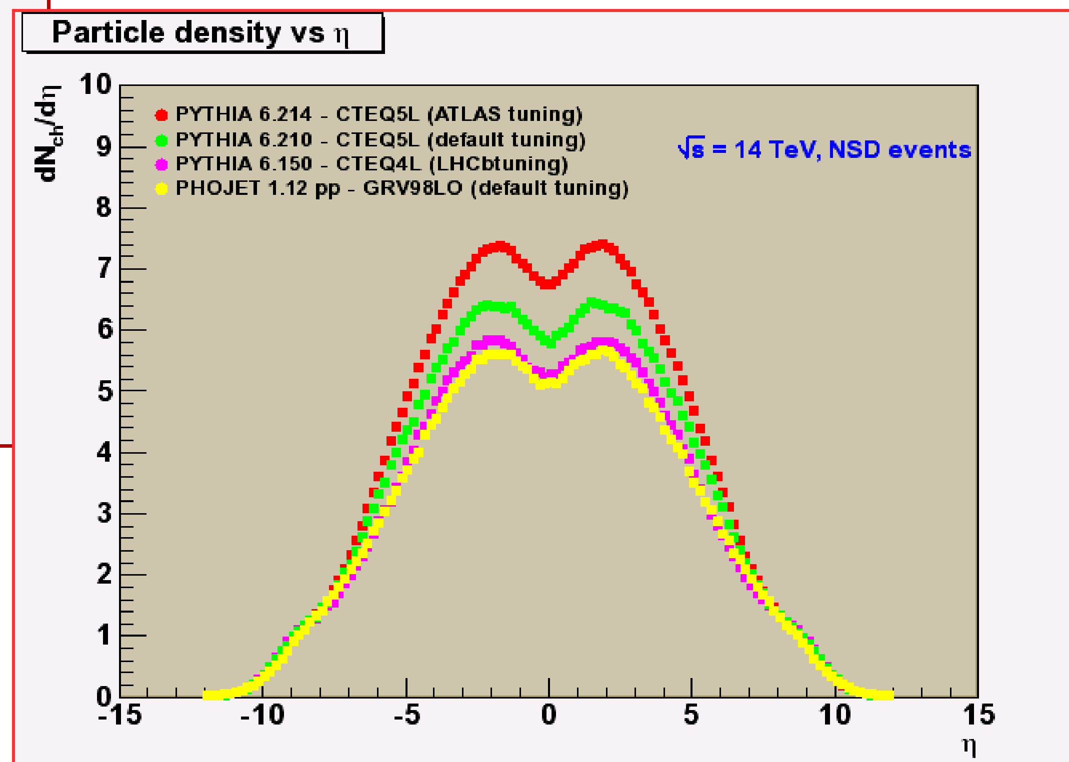


Multiplicity predictions

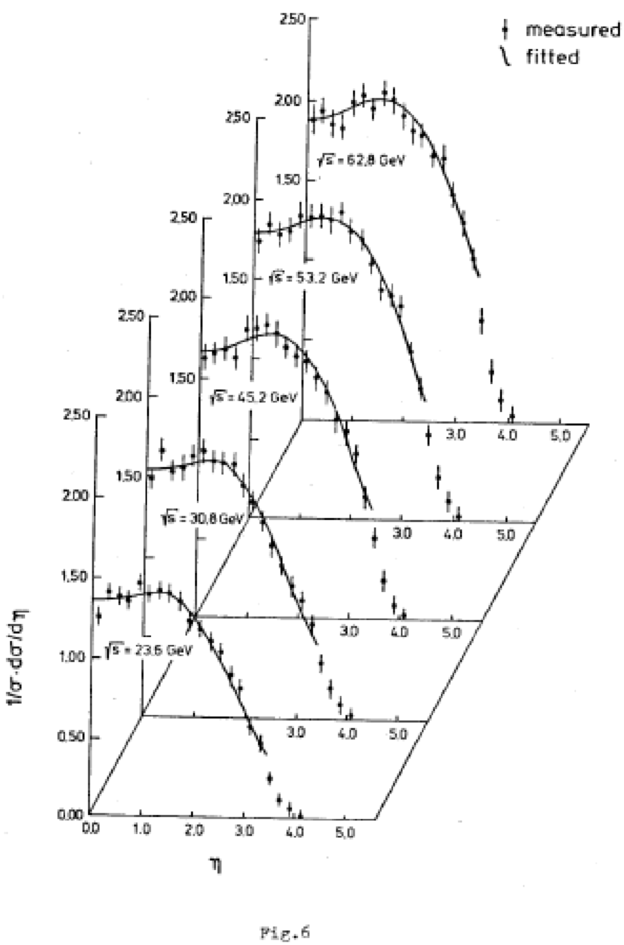


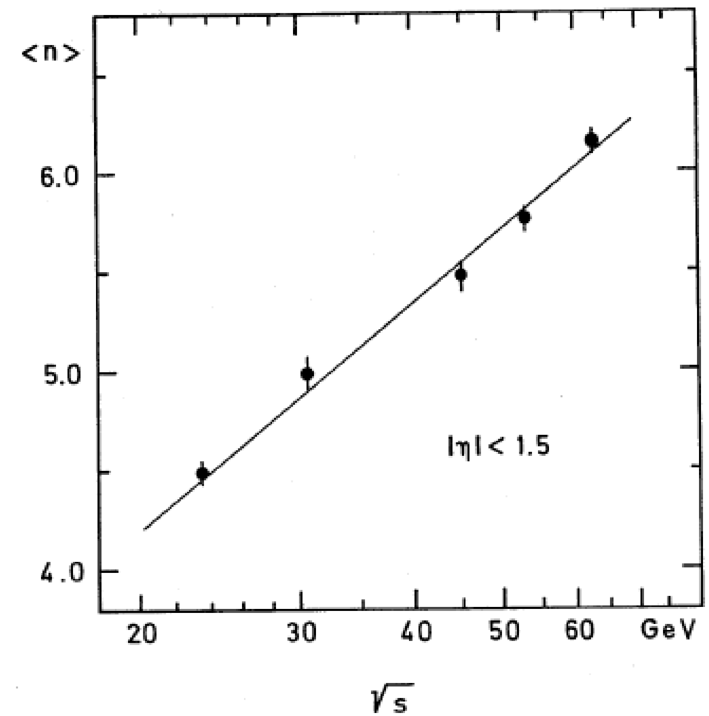
Different models give very different predictions

especially in the tail of the multiplicity distribution



ISR



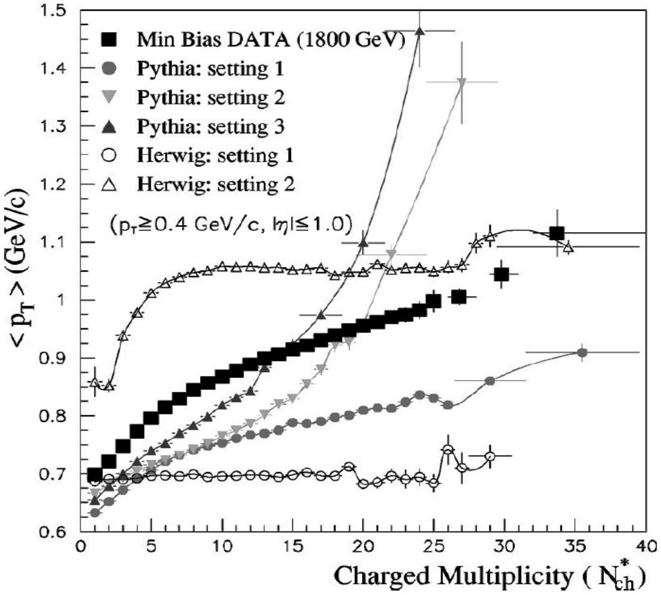


W.Thome et al,: NPB129,365,1077

p-p nominal run

- $\int L dt = 3 \cdot 10^{30}$ cm^{-2} s^{-1} x 10^7 s
  - 30 pb^{-1} for pp run at 14 TeV
  - $N_{pp\ collisions} = 2 \cdot 10^{12}$ collisions
- minimum-bias triggers:
  - 20 events pile-up (TPC)
  - $N_{pp\ minb} = 10^9$ collisions

⟨p_T⟩ vs. multiplicity



Mean p_T grows with multiplicity

⇒ high p_T jets have higher multiplicity
BUT: same behavior in "soft" events
events with no jets/clusters with E_T>1.1GeV
(CDF: PRD65,072005,2002)

Physics triggers

Trigger inputs:

	L0 pp	L1 pp	L2 pp
1	V0 Minimum bias	PHOS jet low p_T	
2	V0 Beam Gas	PHOS jet high p_T	
3	V0 High Multiplicity	TRD unlike e-pair high pt	
4	V0 Beam gas A	TRD like e-pair high pt	
5	V0 Beam gas C	TRD electron	
6	T0 A	TRD hadron low pt	
7	T0 C	TRD hadron high pt	
8	T0 Vertex		
9	PHOS MB		
12	Cosmic		
13	DM like high p_T		
14	DM unlike high p_T		
15	DM like low p_T		
16	DM unlike low p_T		
17	DM telescope		
18	DM single		
19	TRD pre-trigger		
20	ZDC		
21	TOF MB		
22	pixel trigger		
23			
24			

- Minimum Bias
- Muons
- Pixels
- Electrons

high-mutiplicity trigger:
reserved bandwith ~ 10Hz
muon triggers:
~ 100% efficiency, < 1kHz
electron trigger:
~ 25% efficiency of TRD L1