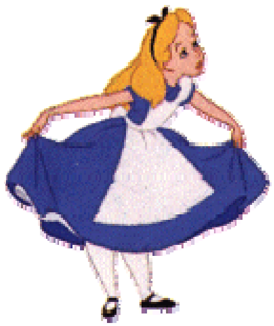
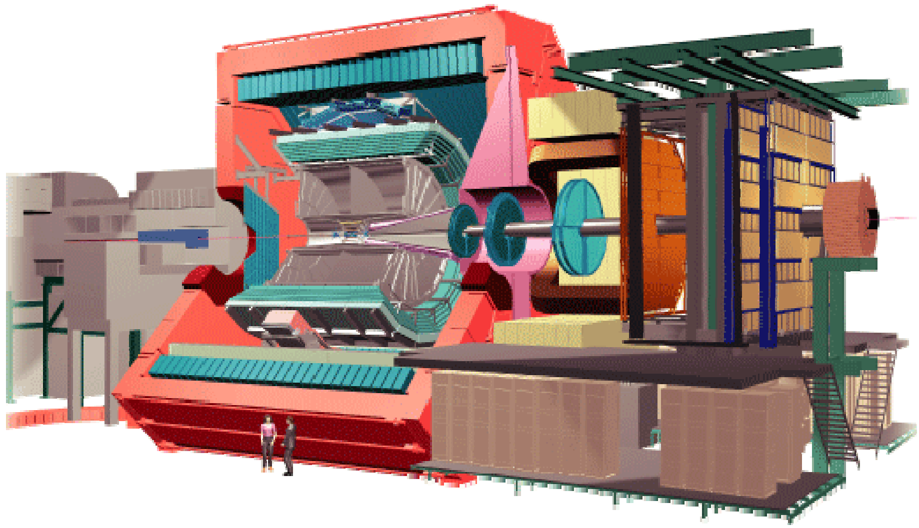




The first physics with ALICE

R. Lietava

The University of Birmingham

Outlook

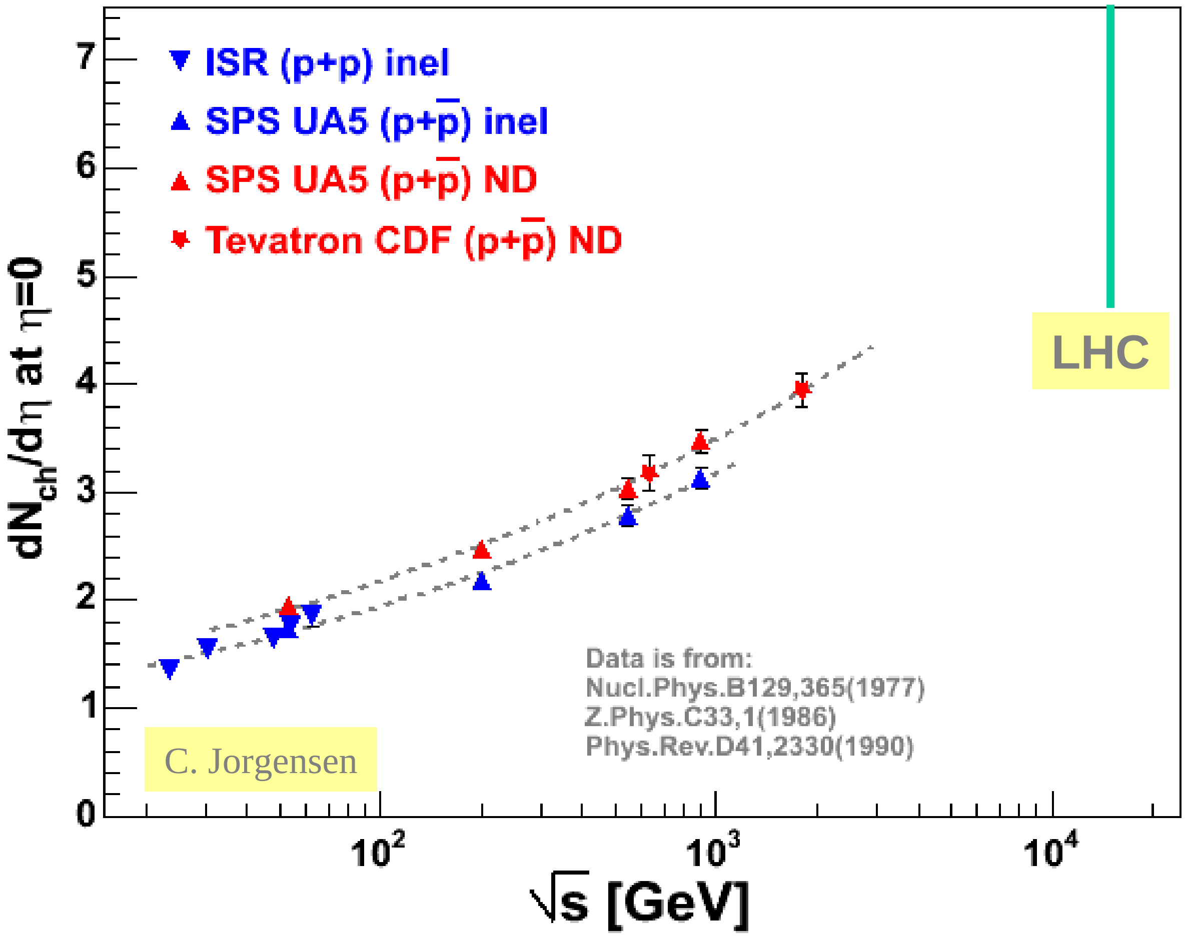
- Motivation
- ALICE detector
- First measurements:

  - charge particle multiplicity
  - transverse momentum
  - strange particles, charm, beauty
- Summary

ALICE p+p physics

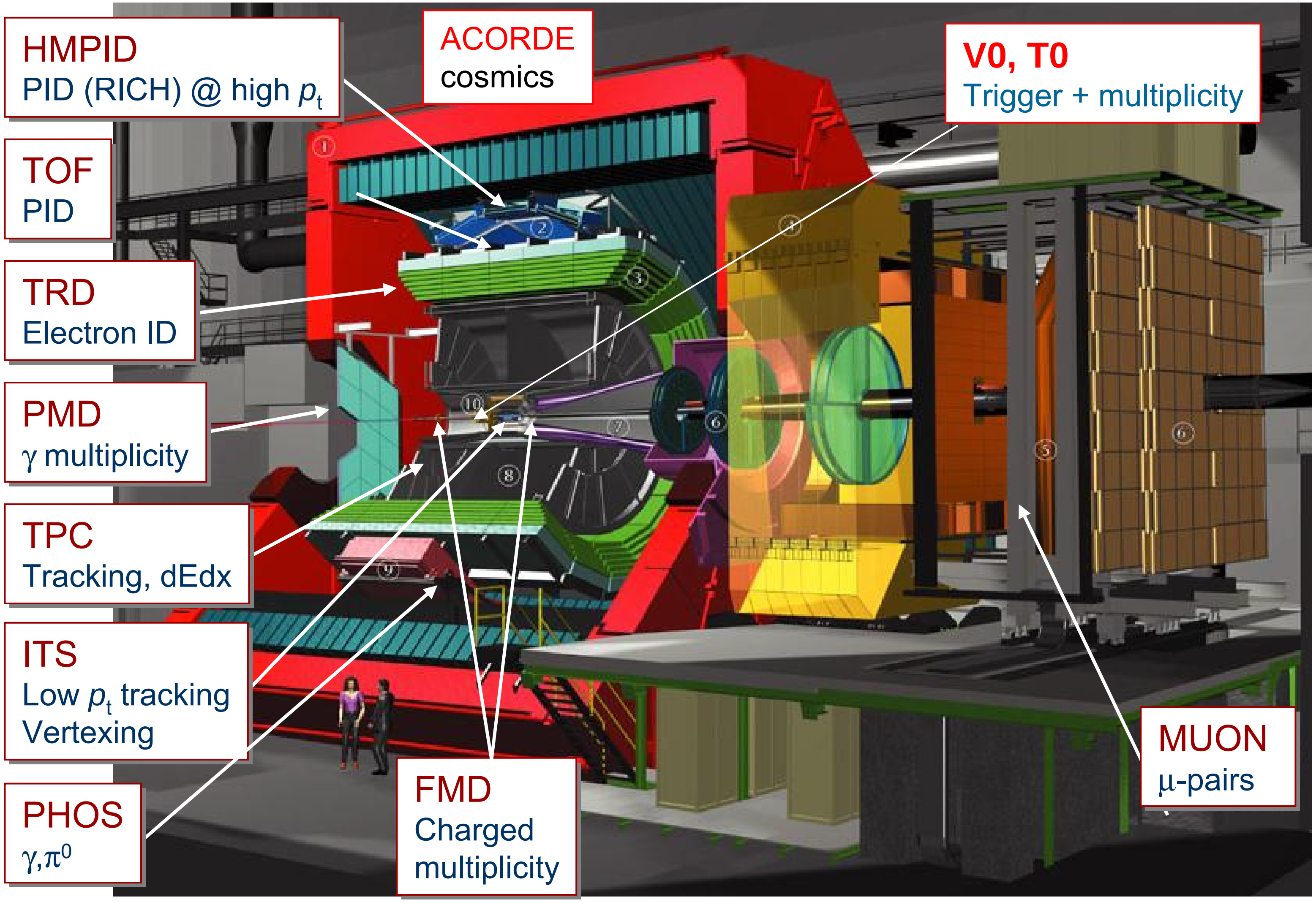
Motivation for p+p program

- soft/MB physics in new energy regime
- QCD testing
- baseline for heavy ions



Fir)06

A Large Ion Collider Experiment



ALICE detector

ALICE unique features:

☺ **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**

LHC commissioning scenario

Beam conditions will be ideal for ALICE pp physics –

TPC drift time ~80μs – no or small pile-up –

$\mathcal{L} = 1x10^{29} cm^{-2} s^{-1}$ corresponds to 1 inelastic event in 160μs

Beam Energy (TeV)	0.45	1.2	6 to 7	6 to 7	6 to 7
Number of bunches	43	43	43	43	156
β^* [m]	10	10	10	10	10
Crossing Angle [μrad]	0	0	0	0	0
Transverse emittance [μm]	3.75	3.75	3.75	3.75	3.75
Bunch spacing [ns]	2025	2025	2025	2025	525
Bunch Intensity	$1x10^{10}$	$1x10^{10}$	$1x10^{10}$	$4x10^{10}$	$4x10^{10}$
Luminosity [cm^{-2} s^{-1}]	$4x10^{27}$	$1x10^{28}$	$6x10^{28}$	$1x10^{30}$	$3.5x10^{30}$
Inelastic Rate [Hz]	160	450	3600	57600	201600

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:

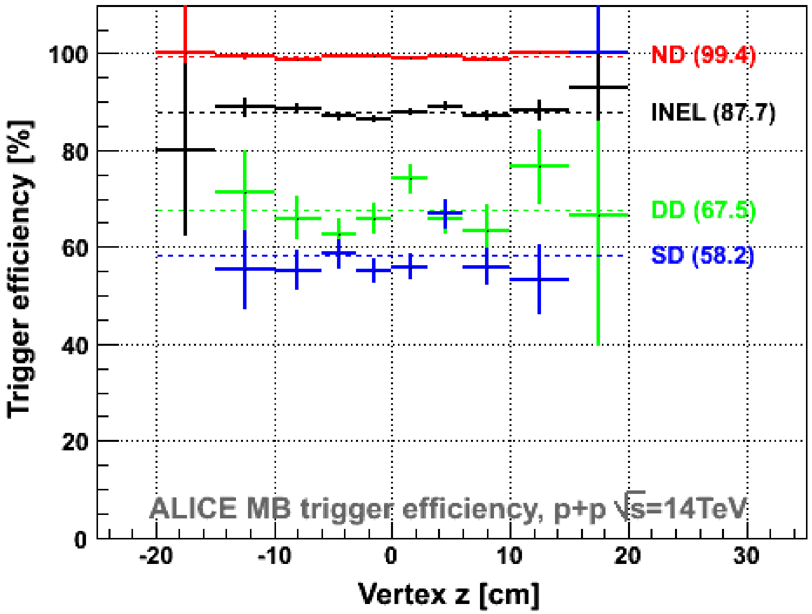
    ⇒ **20k events** in 3 minutes

    ⇒**70M events** in 194 hours (8 days)
- **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

Minimum bias trigger

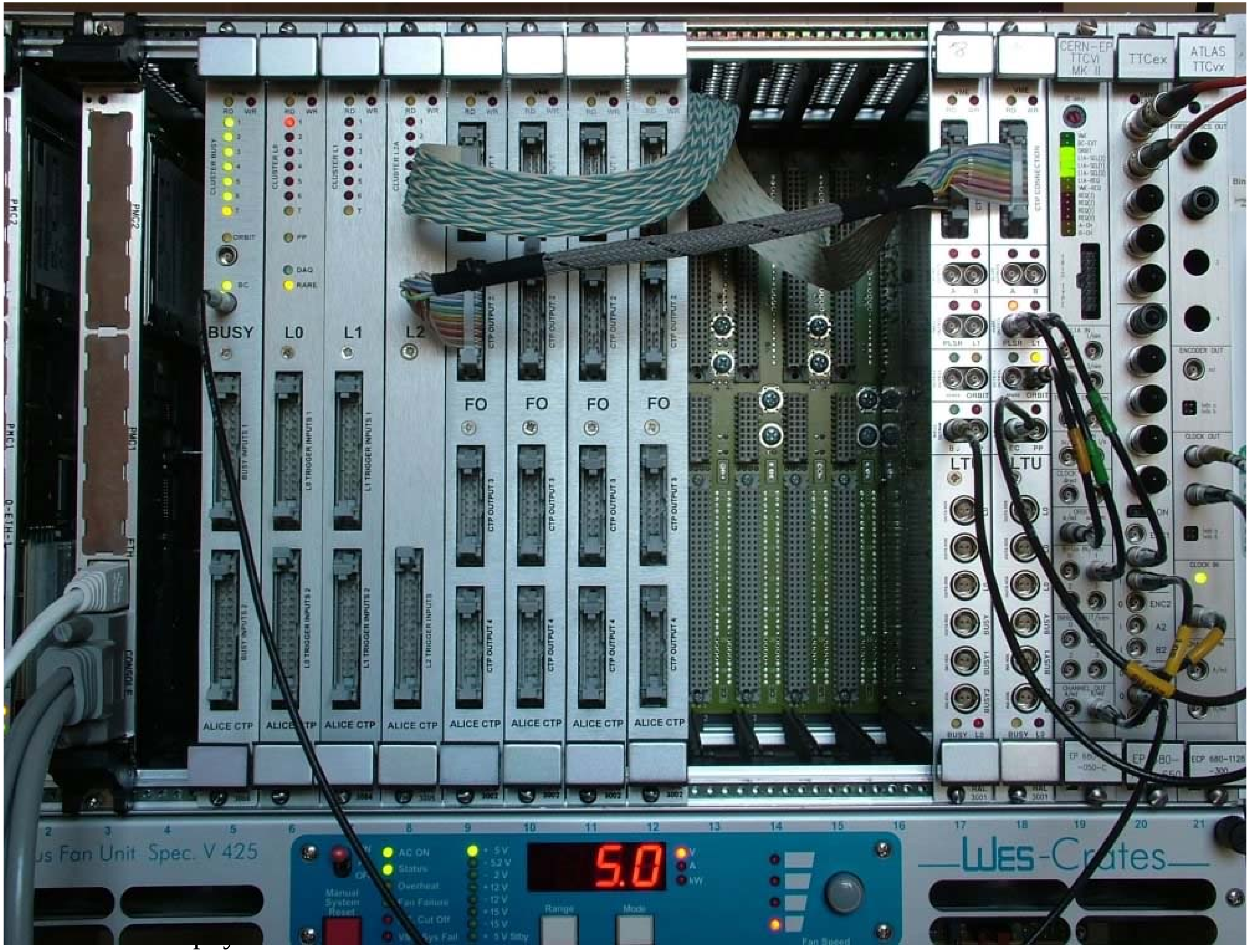
MB: Pixels & VZERO.OR & ¬VZERO.BEAMGAS

How efficient is the MB trigger ?



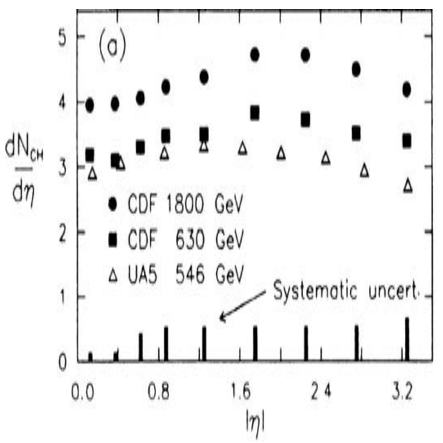
eff. \ √s	0.9 TeV	2.2 TeV	14 TeV
ND	98.9	98.9	99.4
DD	62.0	64.5	67.5
SD	53.9	55.1	58.2
INEL	84.6	85.7	87.7

ALICE Trigger



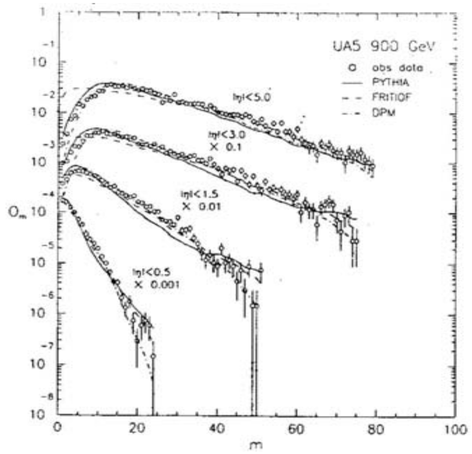
Birmingham trigger group

First Measurements



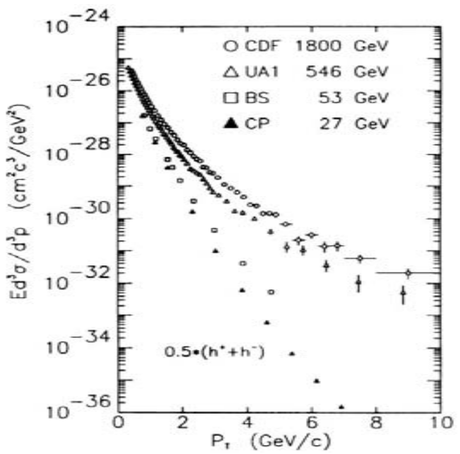
Pseudorapidity density dN/dη

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



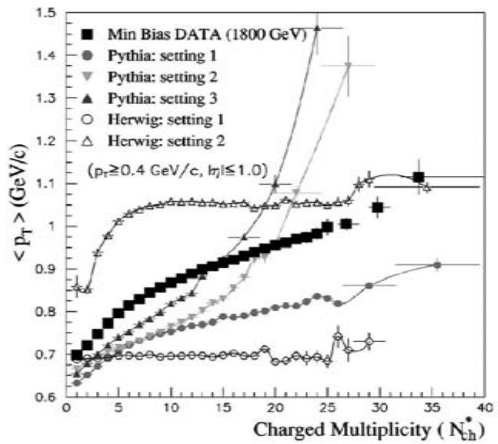
Multiplicity distribution

UA5:
Z. Phys
43, 357 (1989)



p_T spectrum unidentified hadrons

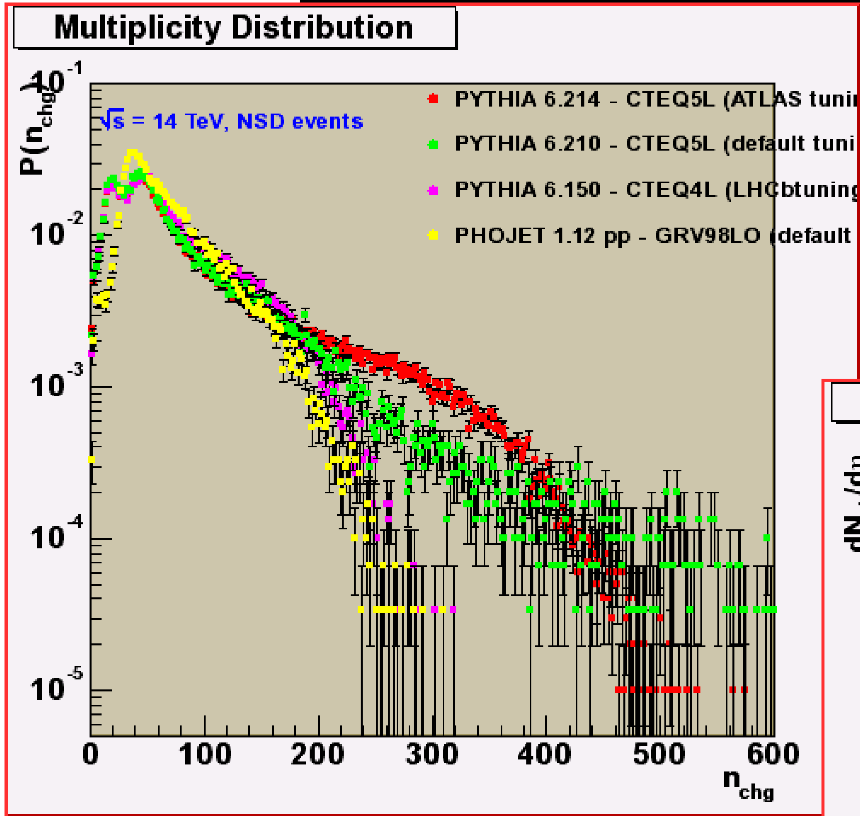
CDF:
Phys. Rev. Lett.
51, 1819 (1988)



Mean p_T vs multiplicity

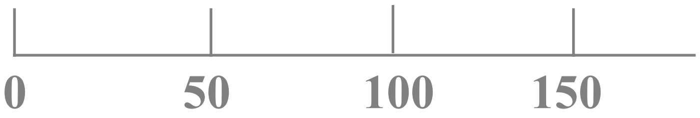
CDF:
Phys. Rev.
D65,72005(2002)

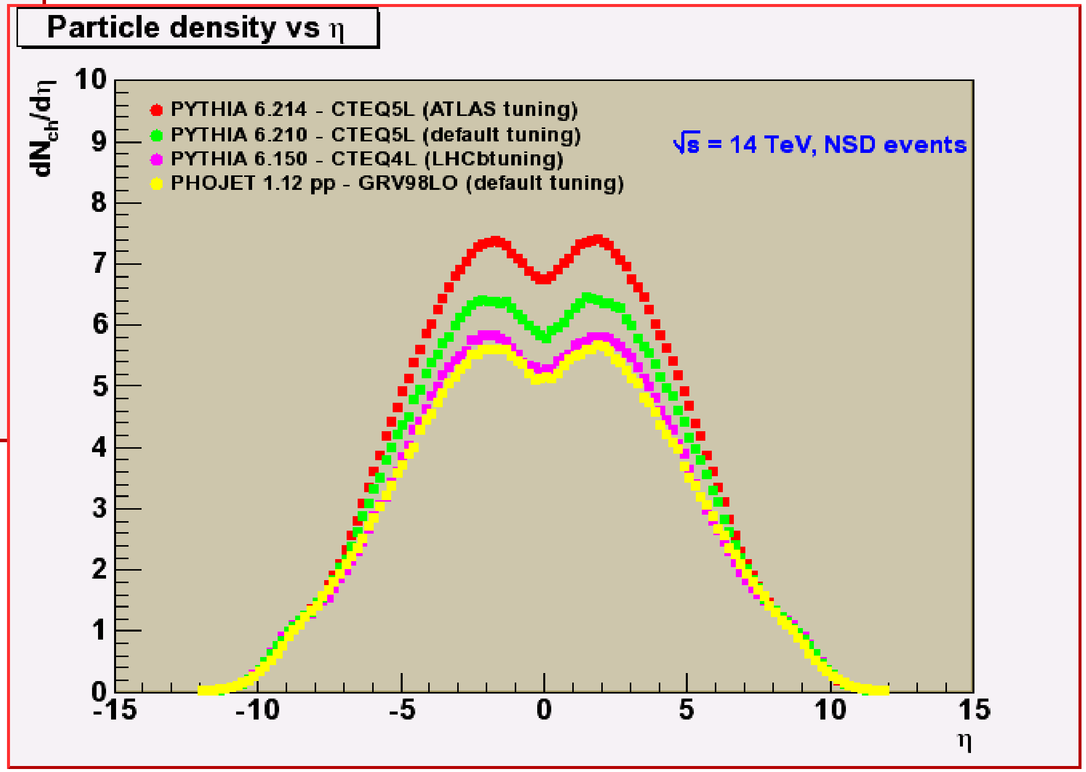
Multiplicity predictions



Different models give very different predictions

especially in the tail of the multiplicity distribution



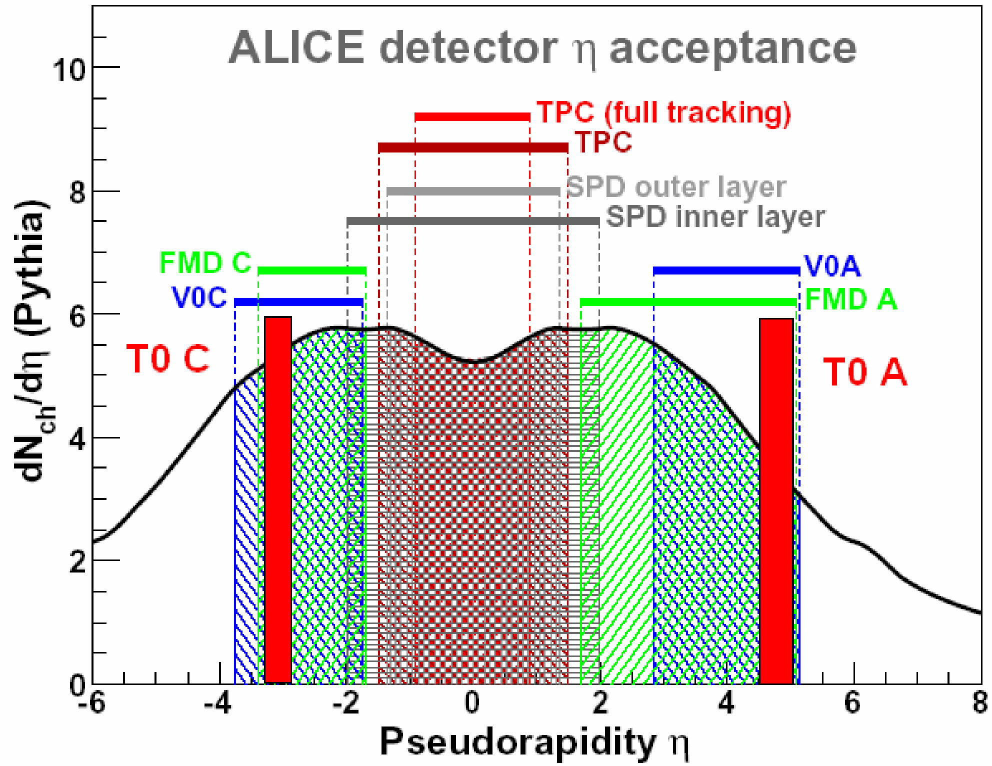


Multiplicity measurement

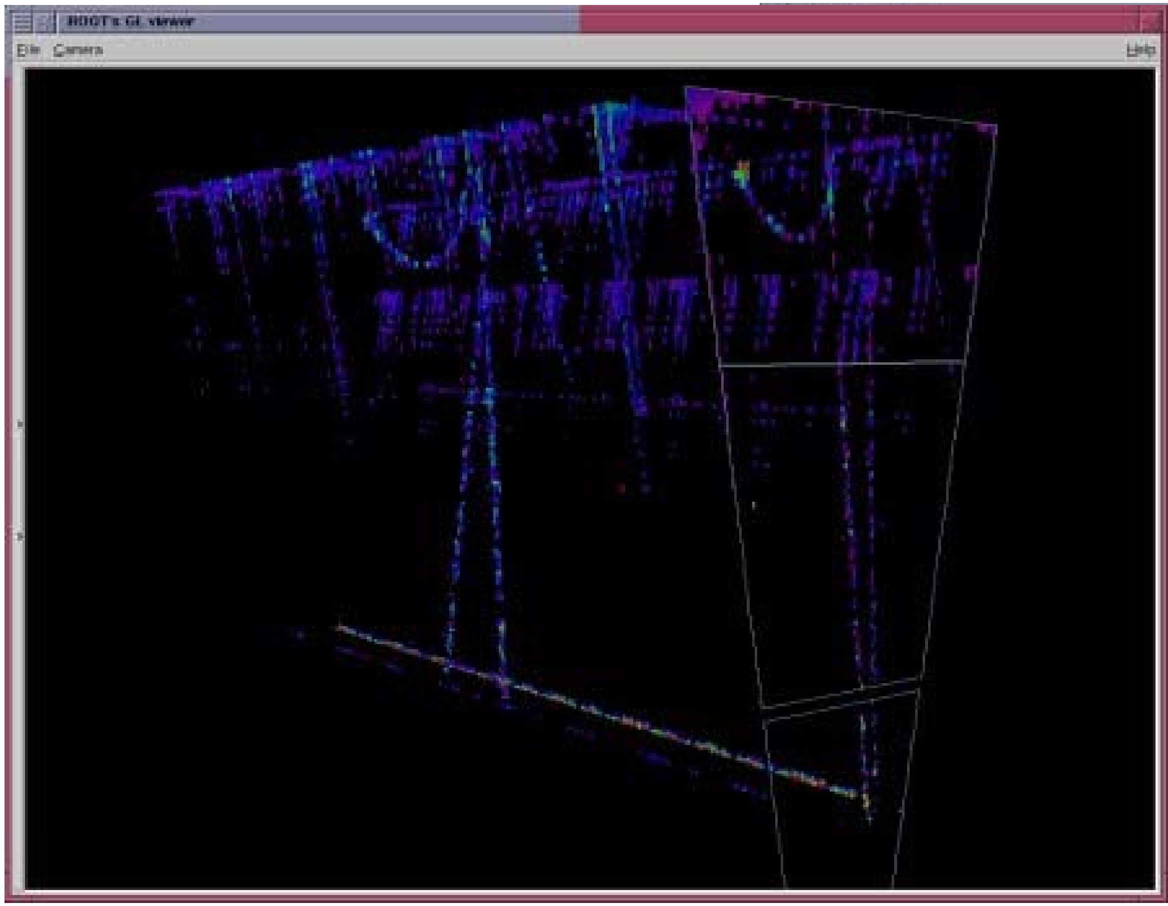
TPC:
⇒ n tracks

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

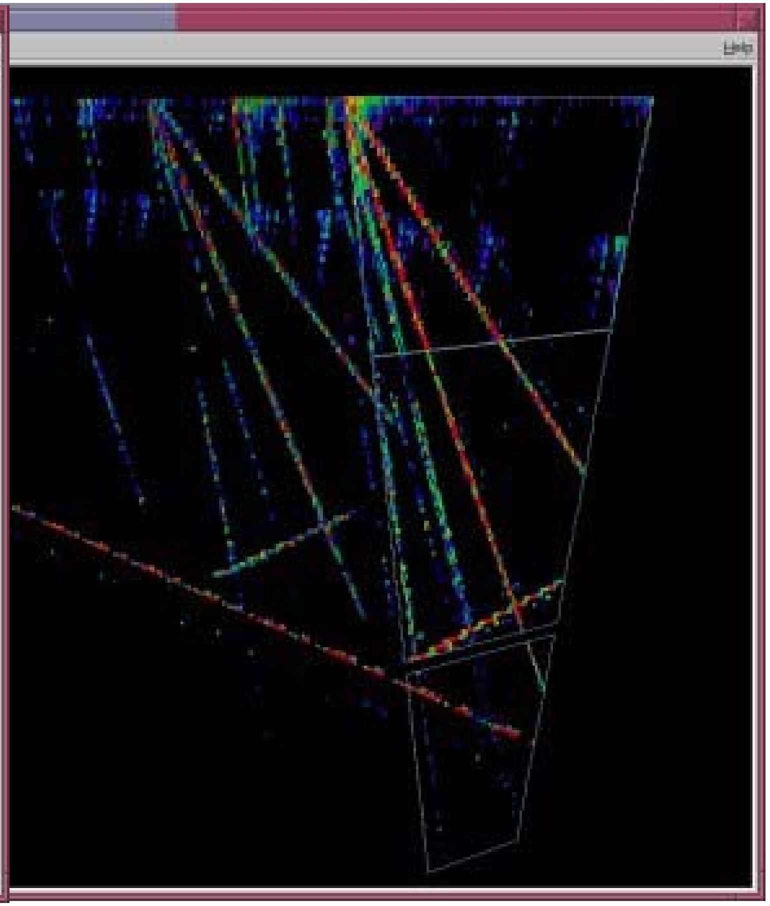
FMD
⇒ naïve method (n hits)
⇒ Poisson method



TPC tracks

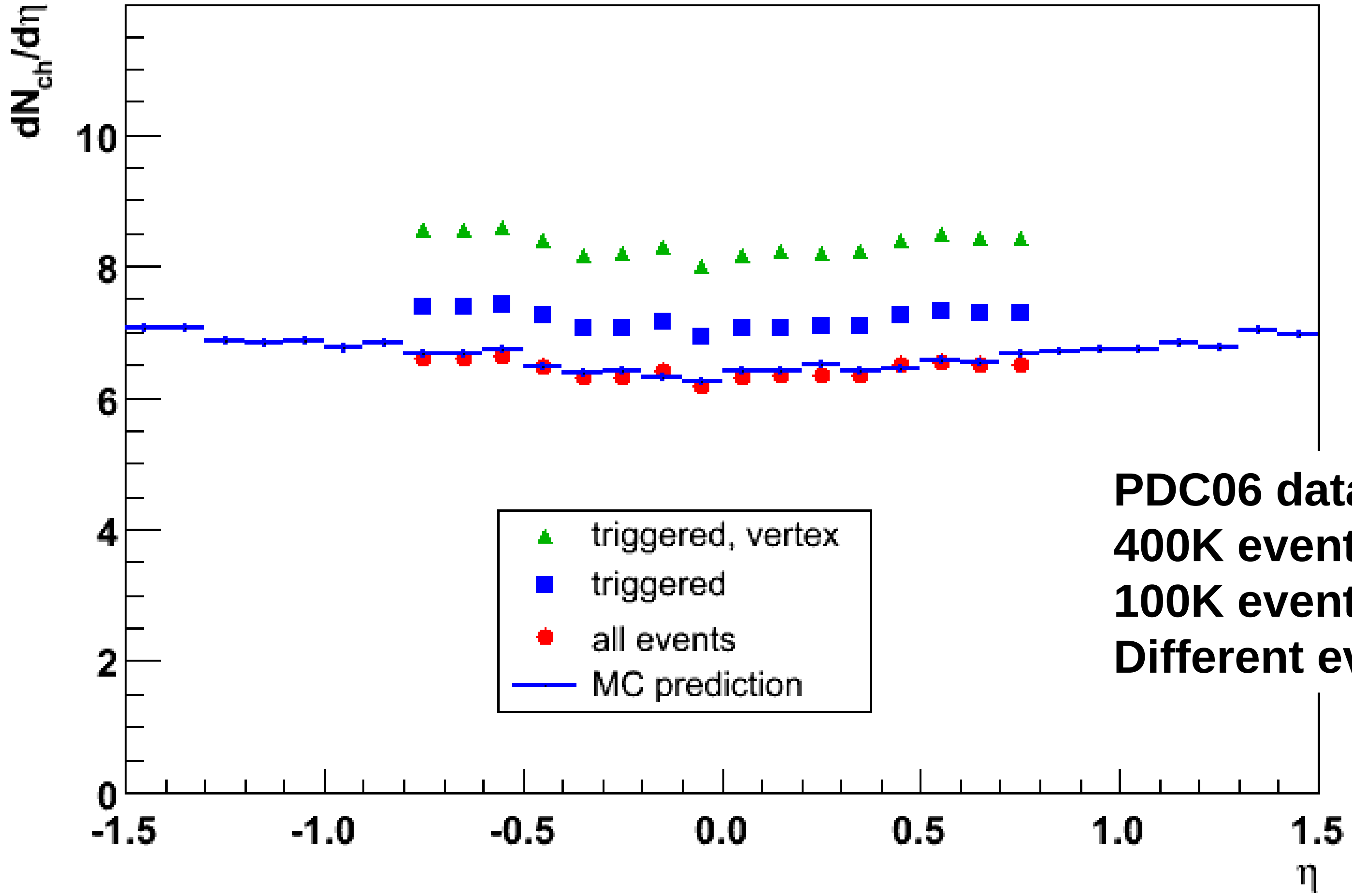


Cosmic tracks



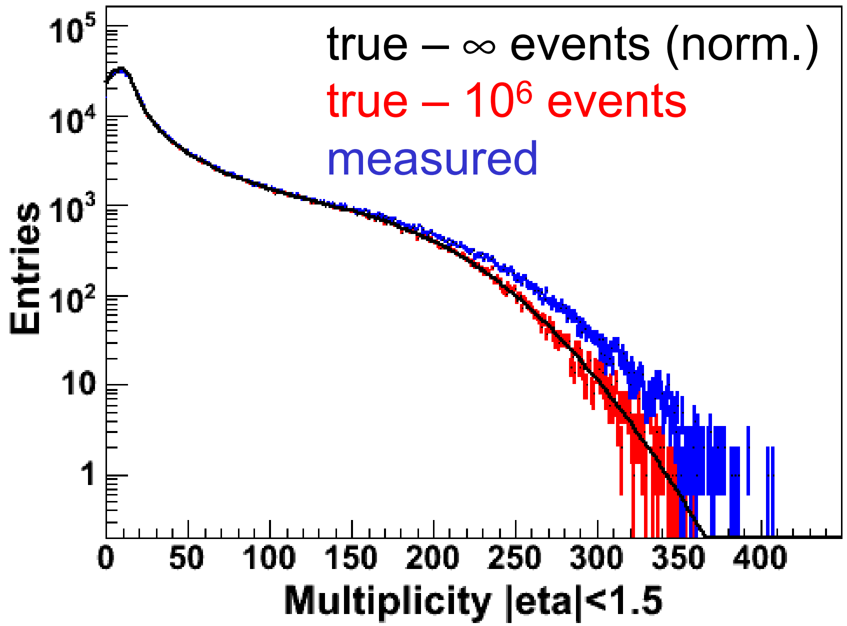
Laser tracks

dN/dη results



PDC06 data:
400K events (corrections)
100K events (analysis)
Different event sample!

Multiplicity distributions



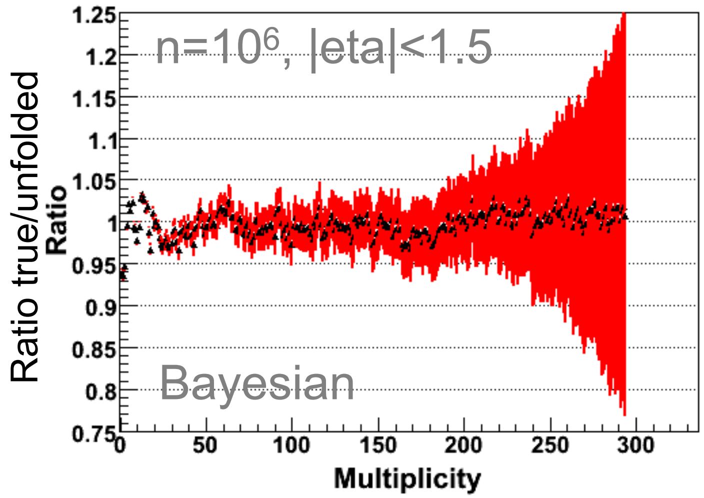
Unfolding (measured ⇒ true) is not a simple problem.

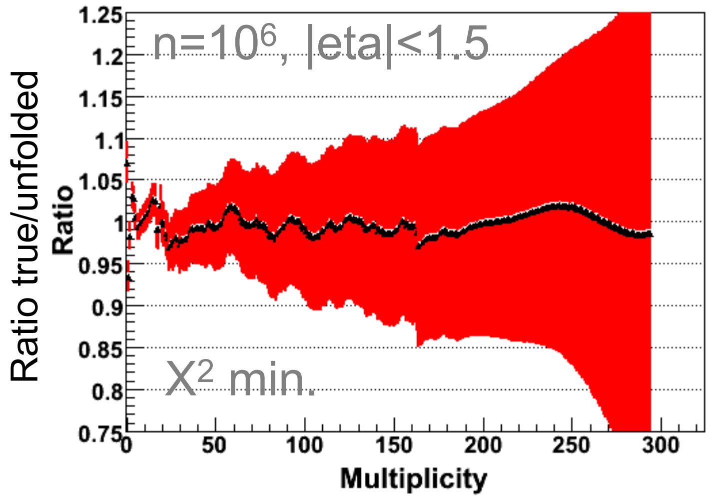
see: Anykeev et al, Nucl. Instr. Meth.A303, 350 (1991)
d'Agostini, DESY 94-099, June 1994.
C. Jorgensen, talk at ALICE p+p meeting, Oct 7, 2005

Multiplicity unfolding

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

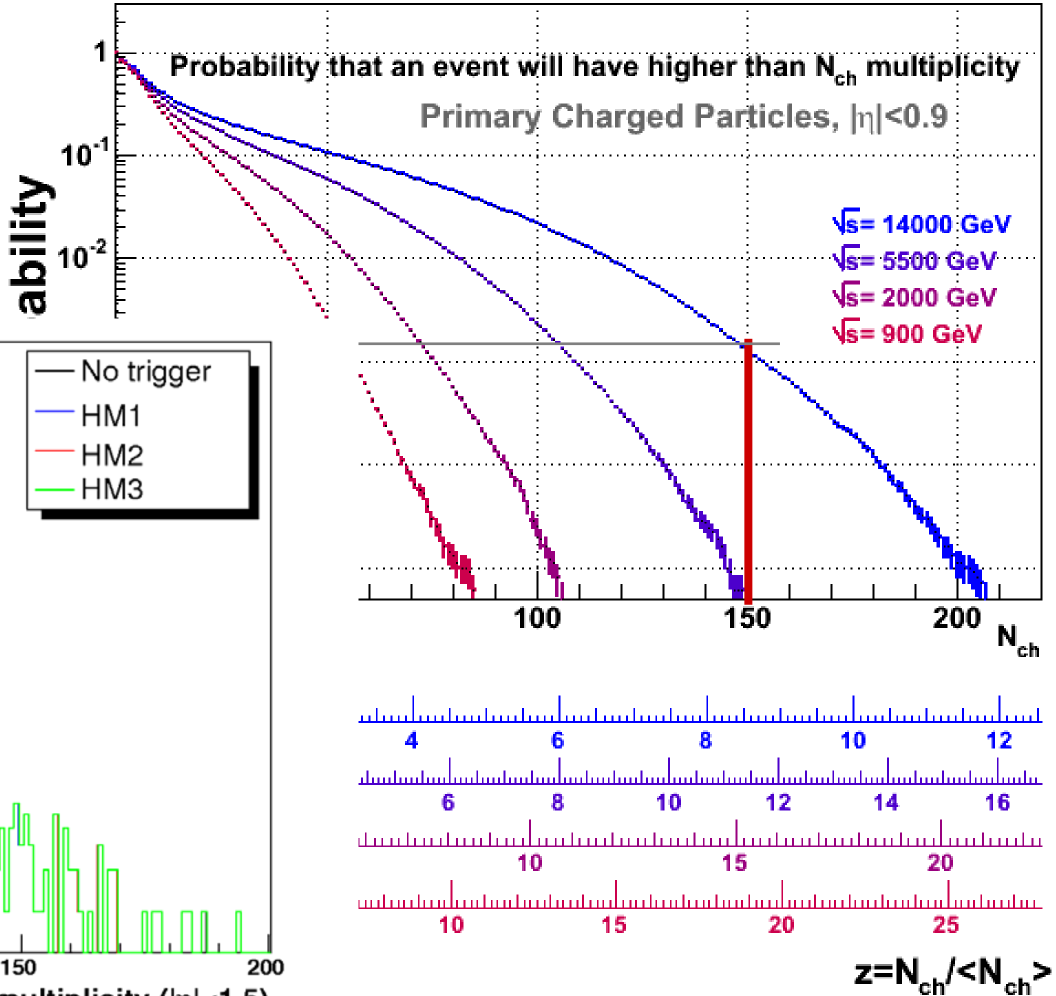
⇒ Get high stat. response
⇒ Add correction for trigger and vertex reco. efficiency
⇒ Error calculation

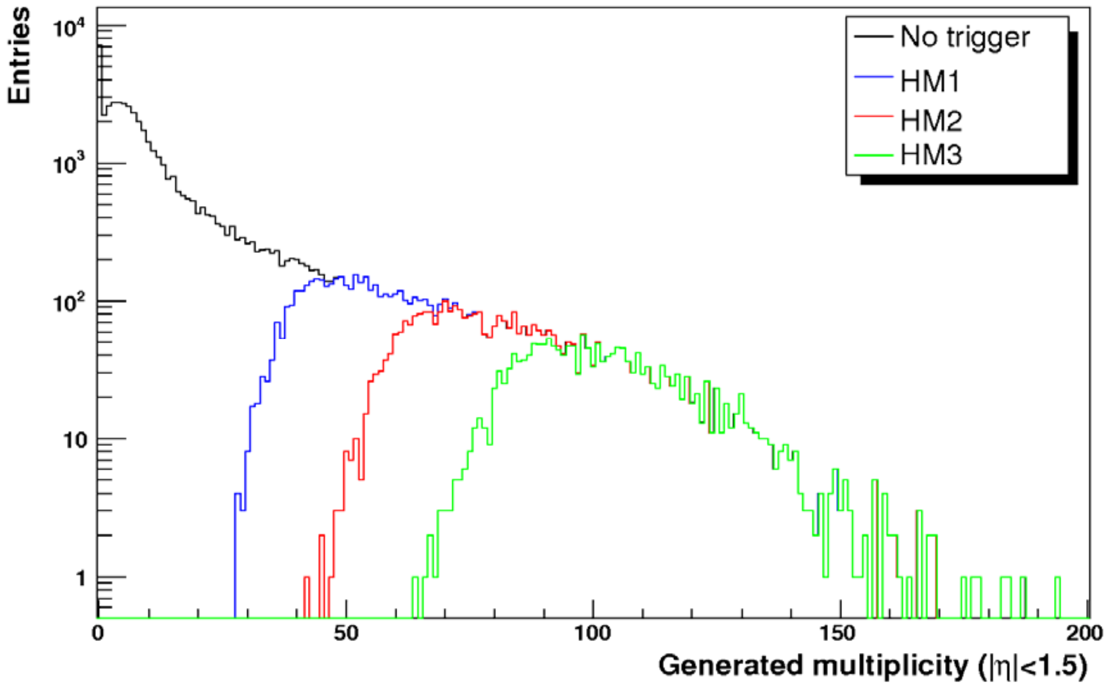




Initial multiplicity reach

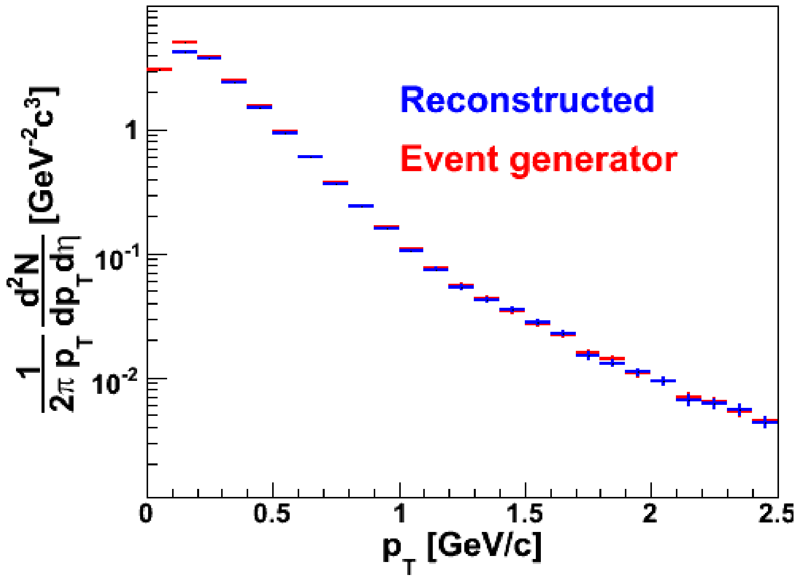
- With $2x10^4$ minimum bias pp events we will have statistics up to multiplicity ~150 – 10 times the average (30 events beyond)
- We plan to use also multiplicity trigger (with silicon pixel detector) – to enrich the high-multiplicity
- Energy density

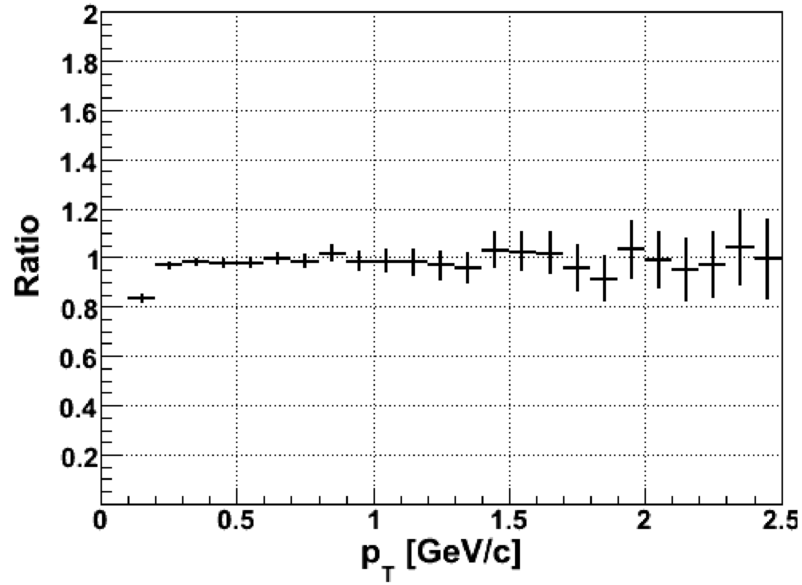




p_T spectra results

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

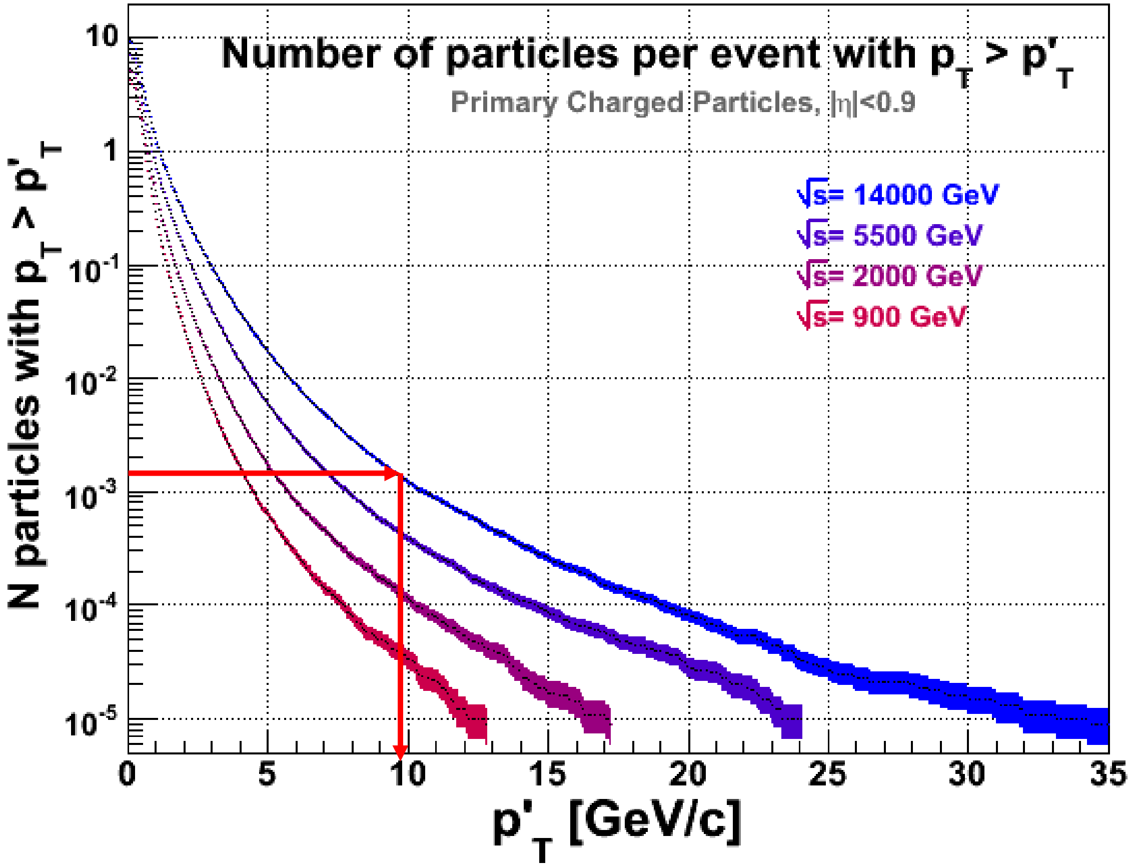




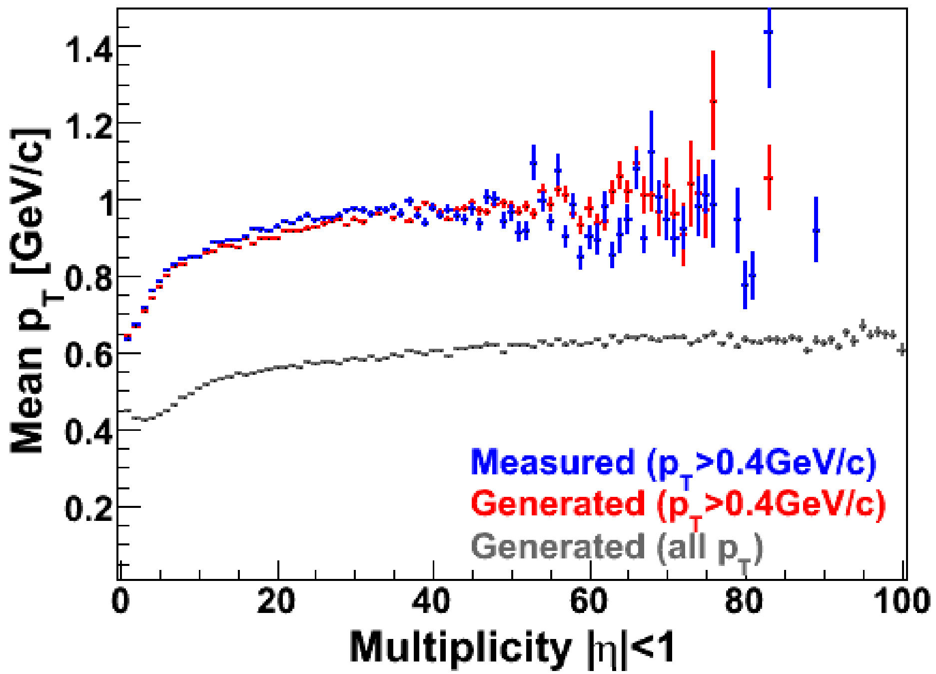
- Systematic errors
  (some studies shown in last p+p meeting, Oct 2005)
- Normalization to cross section (σ_{inel} vs σ_{ND})

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



$\langle p_T \rangle$ vs multiplicity



Extrapolate to p_T=0 GeV/c
- event generator
- simple parameterization

Calculating the mean p_T:
Use the weighted average of $\langle p_T \rangle$ from different true multiplicities:

$$\langle p_T \rangle(n) = \sum_i P(i \mid n) \times \langle p_T \rangle(i)$$

(P(i|n) is found Bayesian way like in multiplicity unfolding)

Study of systematics in charged track multiplicity measurement

Track-to-particle correction	Influence of number of secondaries (±20%)	1 %
	Nσ to vertex cut (±0.5)	2-3 %
	Low p_T cut off (± 0 to 30%)	4 %
	Particle Composition (K/h, p/H ± 50%)	<1 %
	Cosmics	Negl.
Vertex reconstruction	Cross sections of process types (SD, DD) (±50%)	2-3 %
Trigger bias	Cross sections of process types (SD, DD) (±50%)	< 3 %
Vertex Reco. + **Trigger Bias**	Cross sections of process types (SD, DD) (Combining the two above)	5 %
	Beam-gas/Pile-up/Misalignment	Not done

We have an upper limit, real data may help reduce some of the systematics. The total systematic error on

$dN/d\eta$ @ $\eta = 0 \leq 7\%$ (CDF 3.3%)

First strange particle studies

- Based on Pythia prediction at LHC, we can predict significant samples of strange particles in 70M minimum bias events:

K^0 : $7x10^6$

Λ: 10^6

Ξ: $2x10^4$

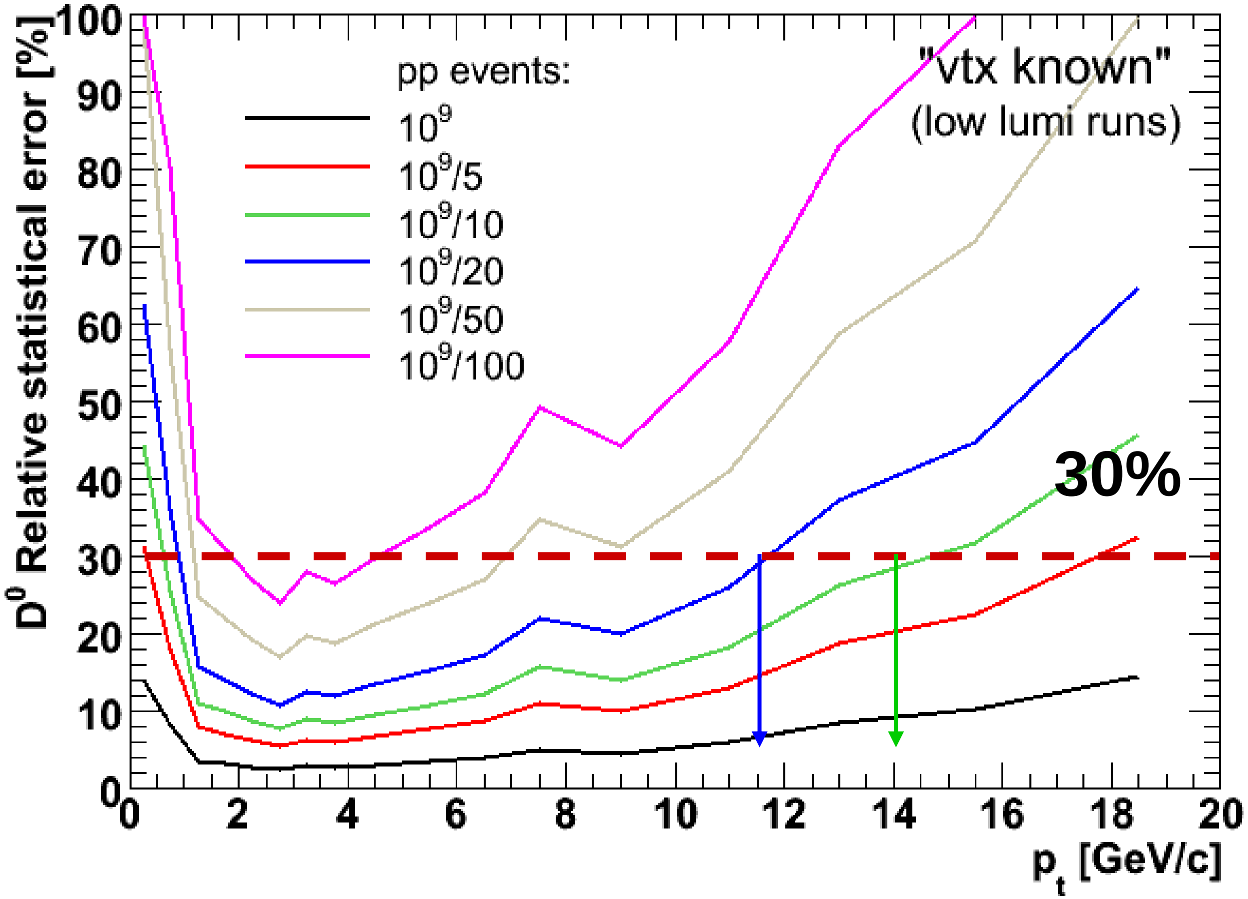
Ω: 270!

	K_S^0	Λ	Ξ	Ω	P	$\overline{\text{P}}$
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

Will exceed the statistics of UA1 and CDF !

First heavy flavour physics: charm

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



Andrea Dainese

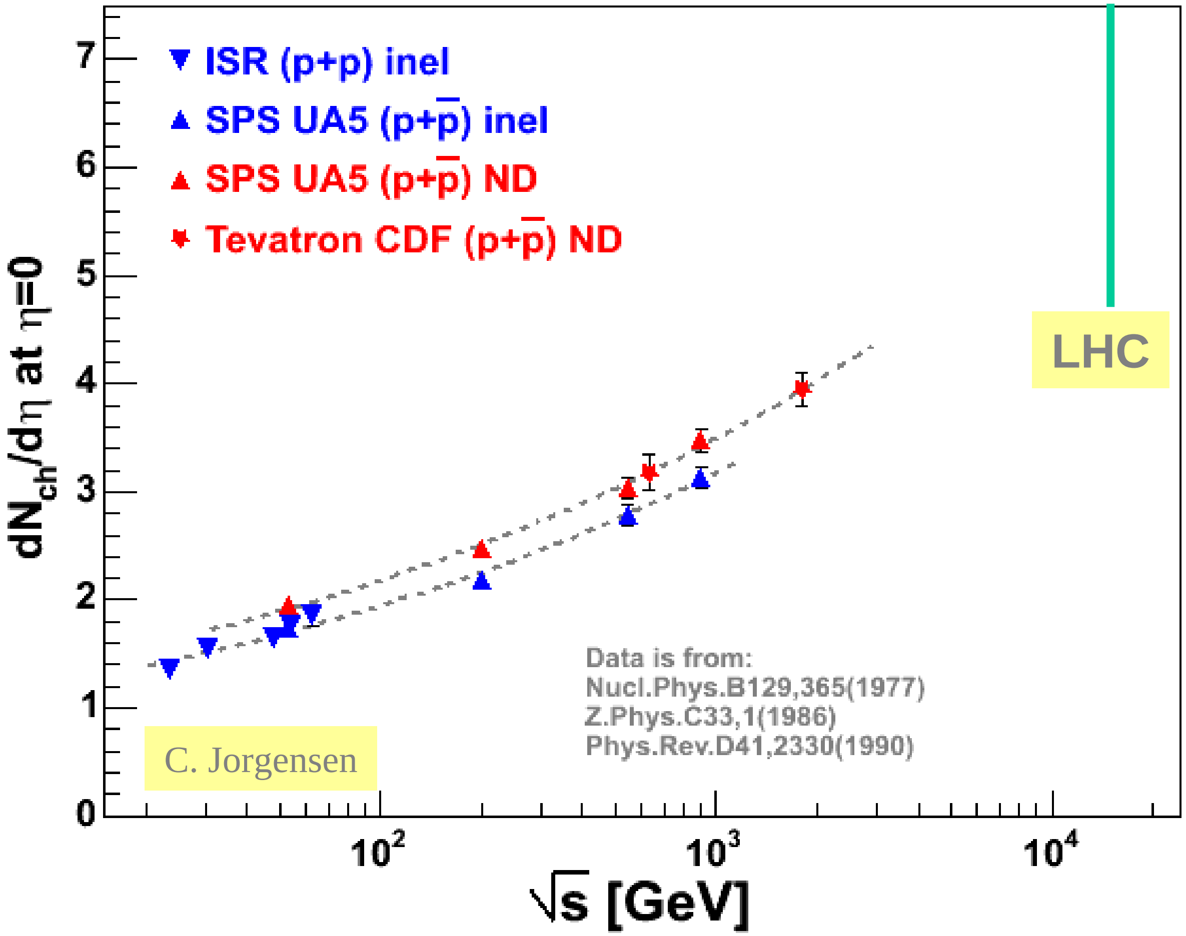
reach up to 11.5 – 14 GeV/c with 7×10^7 evts

… and in one year

- Baryon number transfer
- Semielectronic beauty production
- Jets
- J/psi, Y production

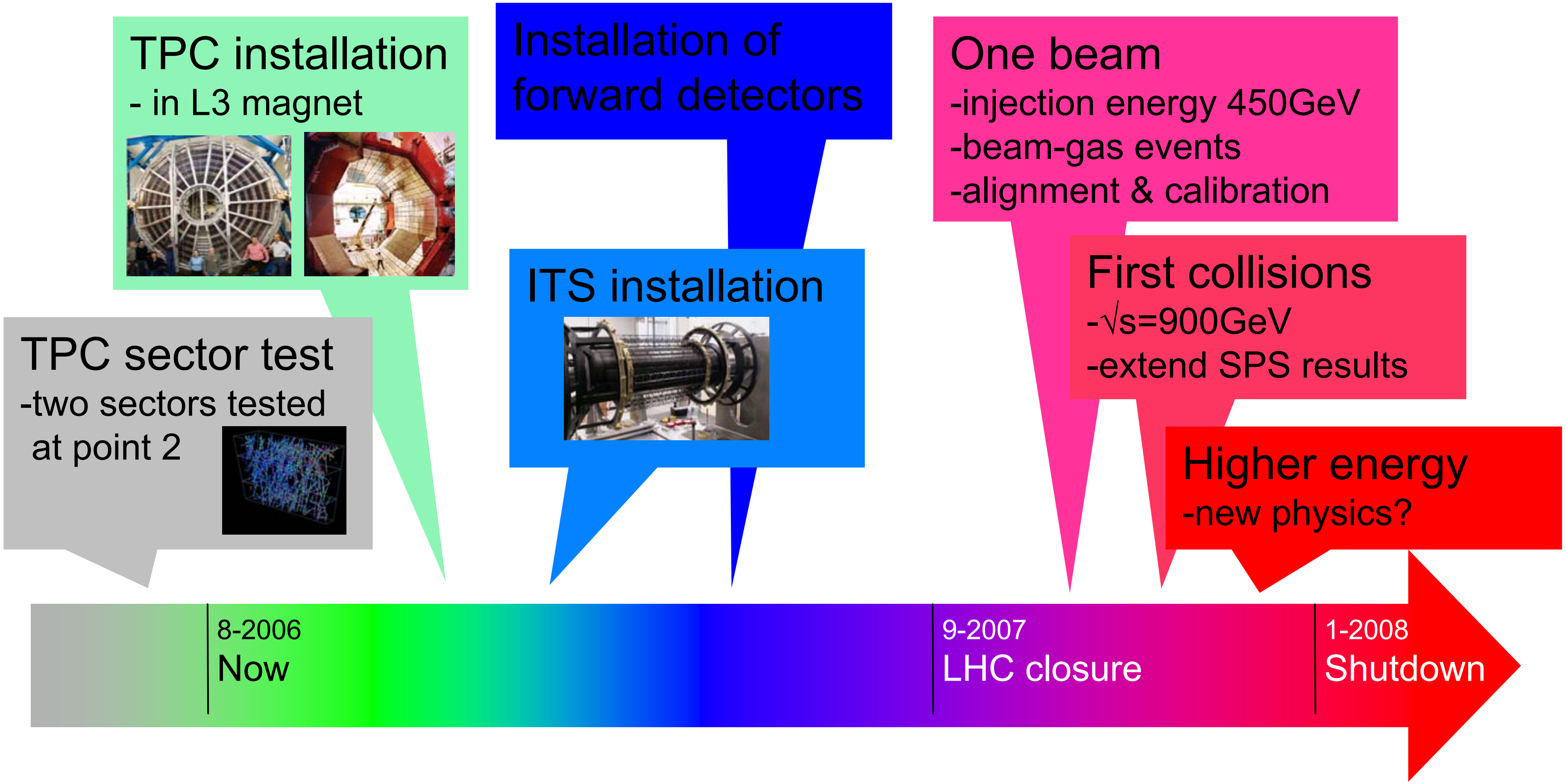
Summary

ALICE would like to add as soon as possible several points on this plot up to 14 TeV



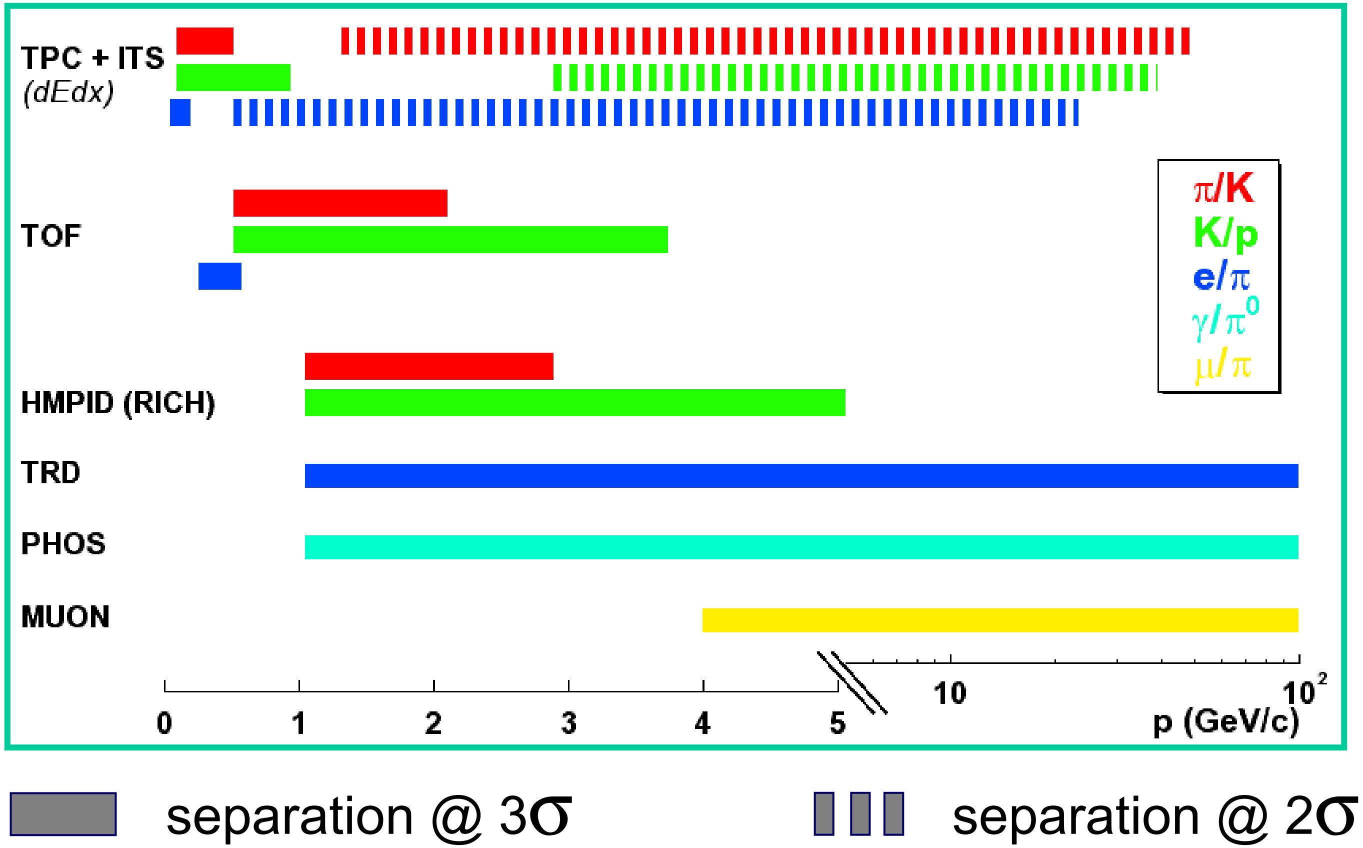
END

ALICE time schedule

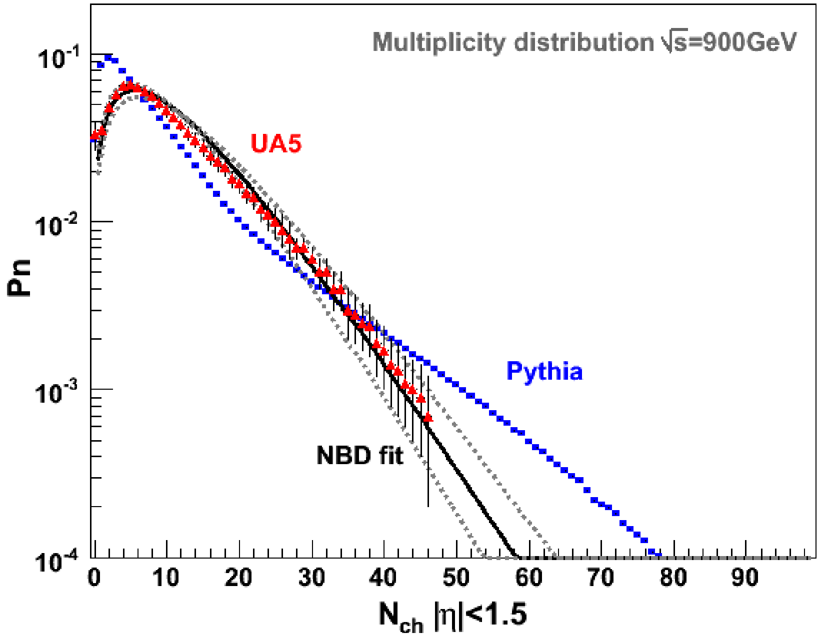


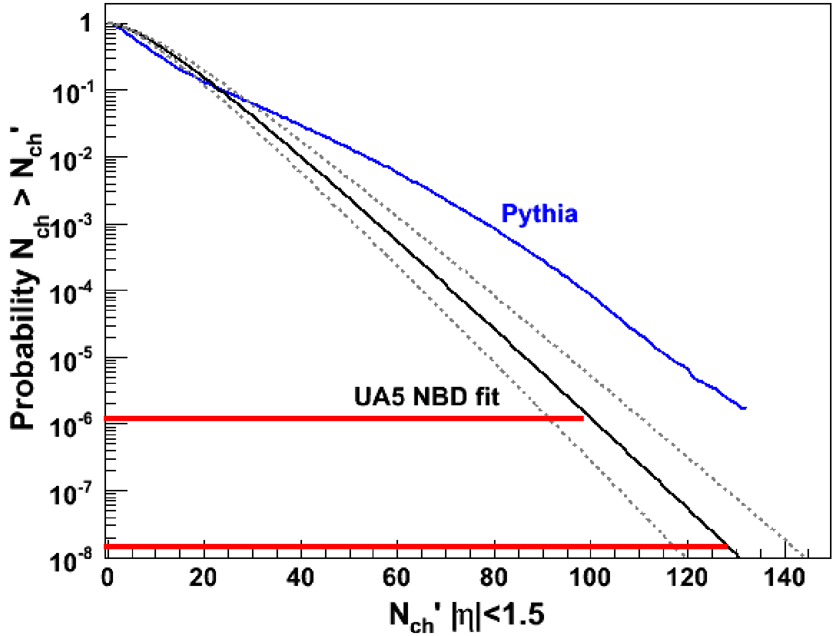
Particle Identification

- Very good PID over broad momentum range



Multiplicity reach at 900 GeV





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

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

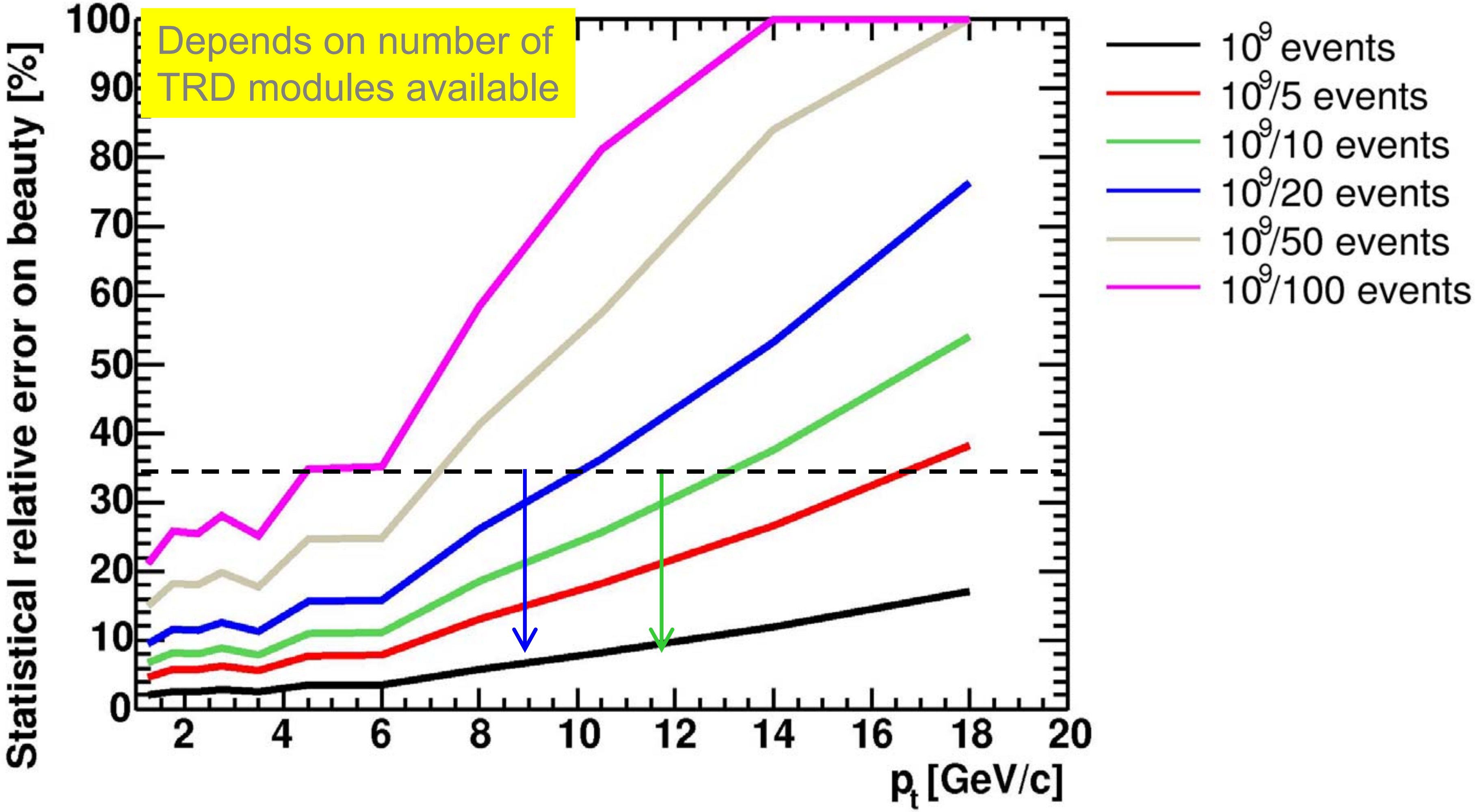
Using NBD fits to UA5 data to estimate multiplicity reach:

$\Rightarrow 10^6$ ev. ~ Max $N_{ch}^{|\eta|<1.5} \approx 90$

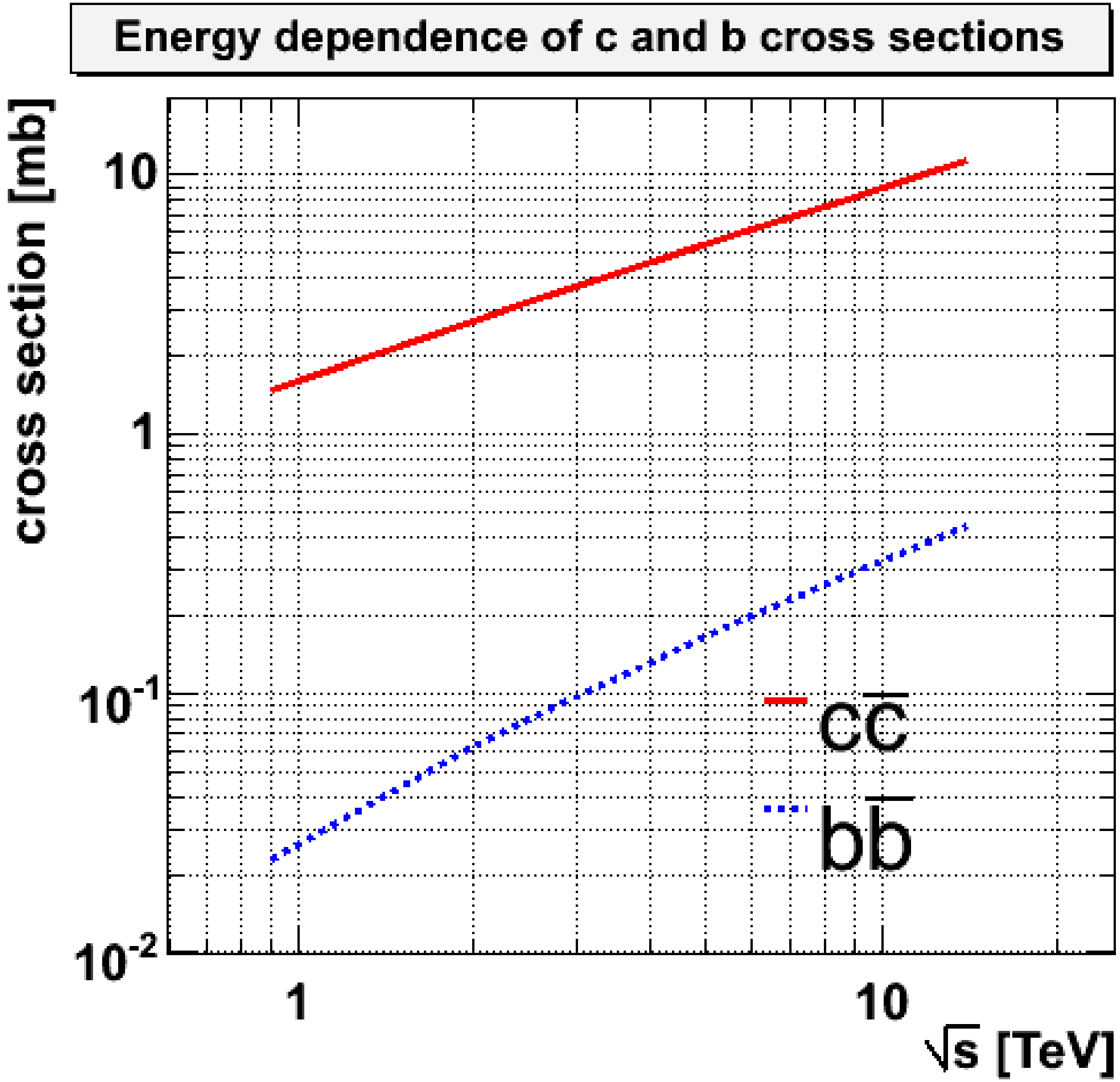
$\Rightarrow 10^8$ ev. ~ Max $N_{ch}^{|\eta|<1.5} \approx 120$

First heavy flavour physics: beauty

- Semielectronic beauty in pp



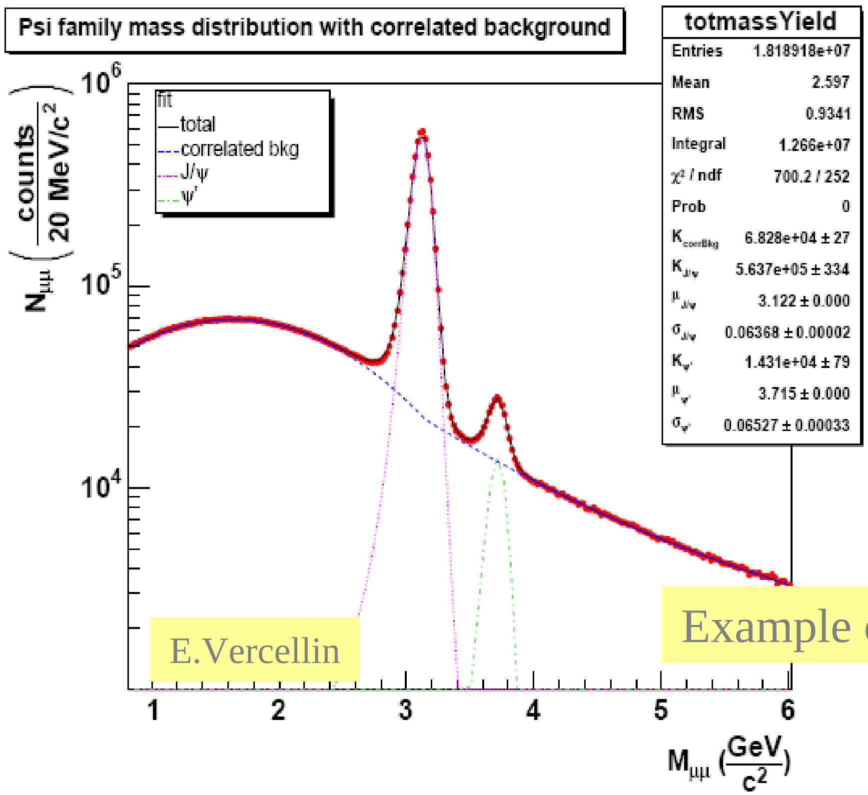
Total cross sections



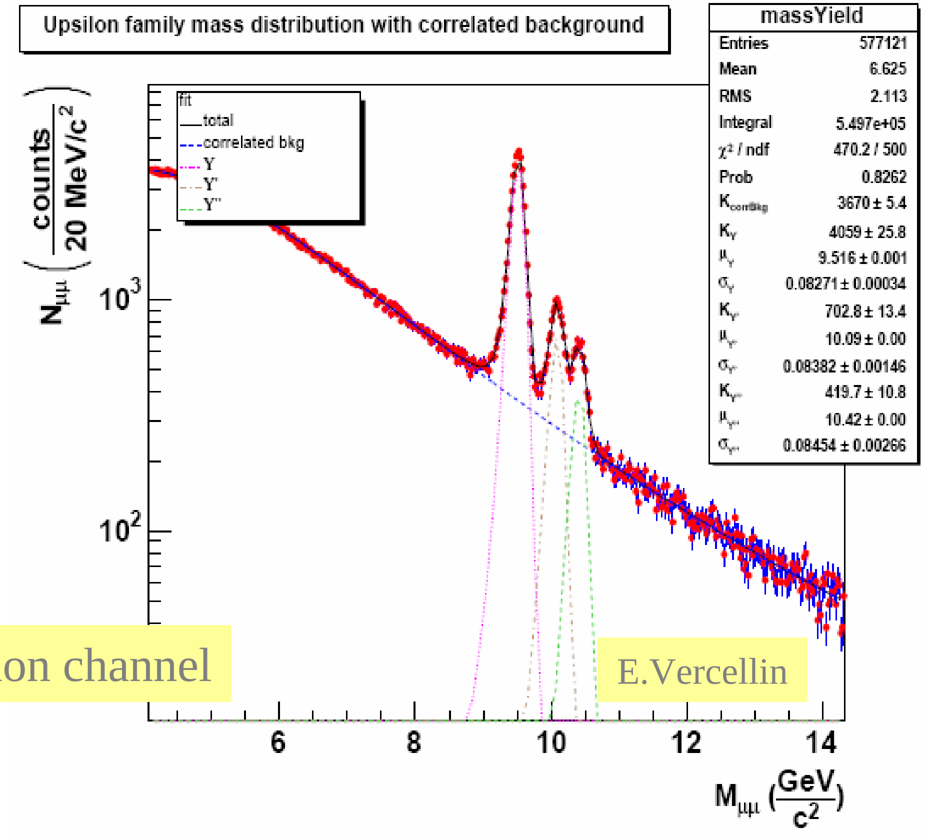
- Values at 14 TeV:
  - charm 11.3 mb
  - beauty 0.44 mb
- PPR (older PDFs):
  - charm 11.2 mb
  - beauty 0.51 mb
- Ratio 14TeV / 2.4TeV:
  - charm 3.6
  - beauty 5.9

Quarkonia physics

- **Muon channel:** (2.5 <y< 4): 60’000 J/Psi and 2000 Y (Ginés Martínez et al.)
- The initial sample should be sufficient to measure at least production rates for J/Psi and Y, in the muon channel
- **Electron channel**: it will depend on how much of the TRD is installed

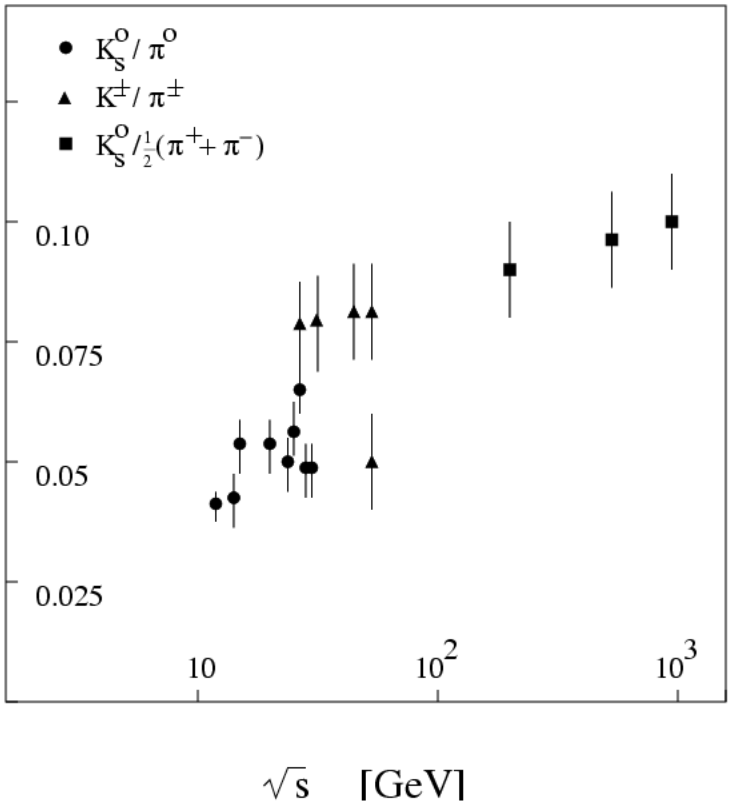


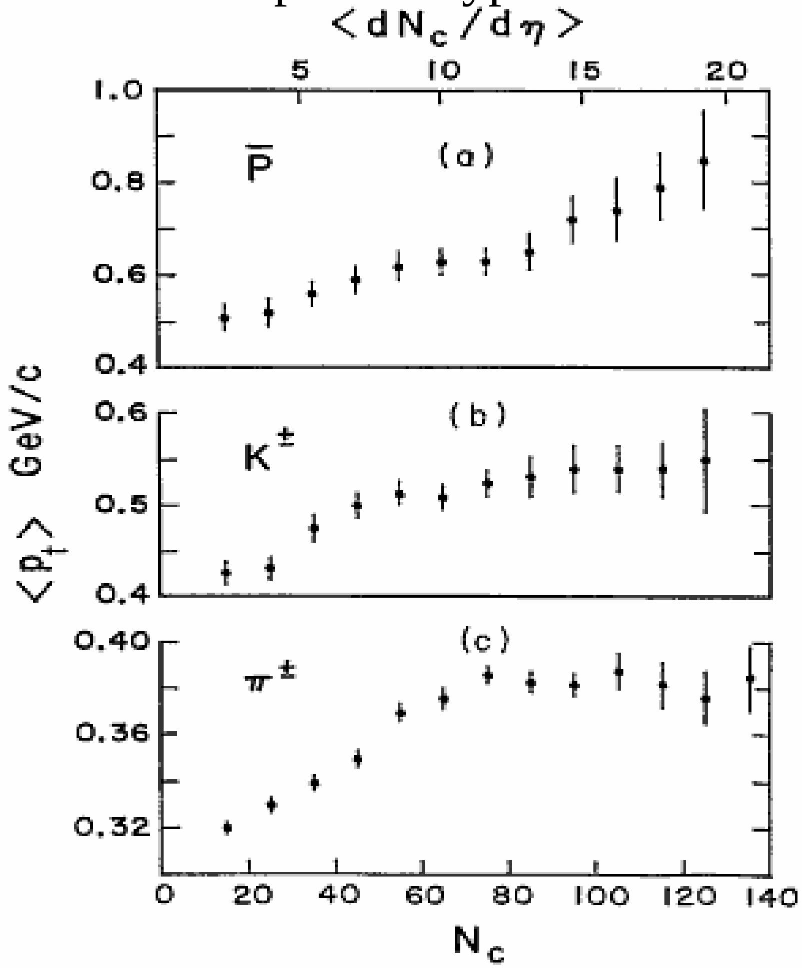
Example of muon channel



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





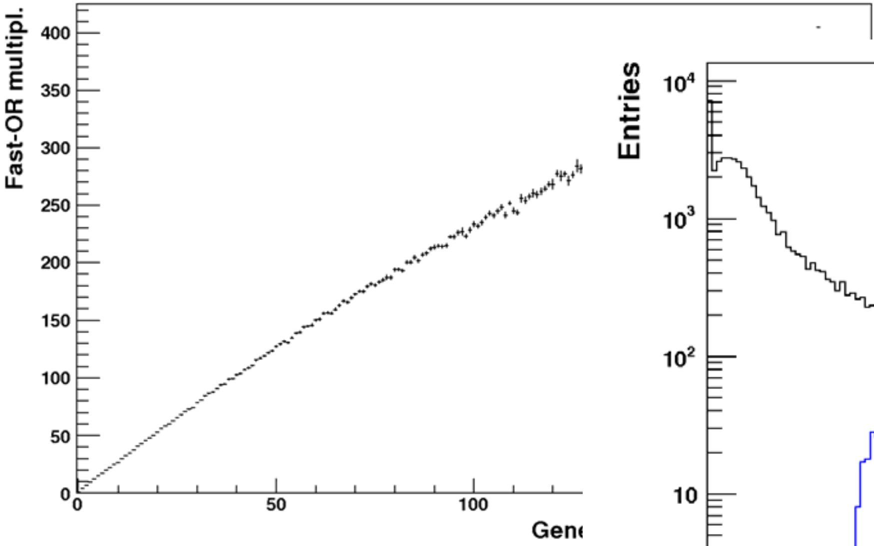
E735 Fermilab

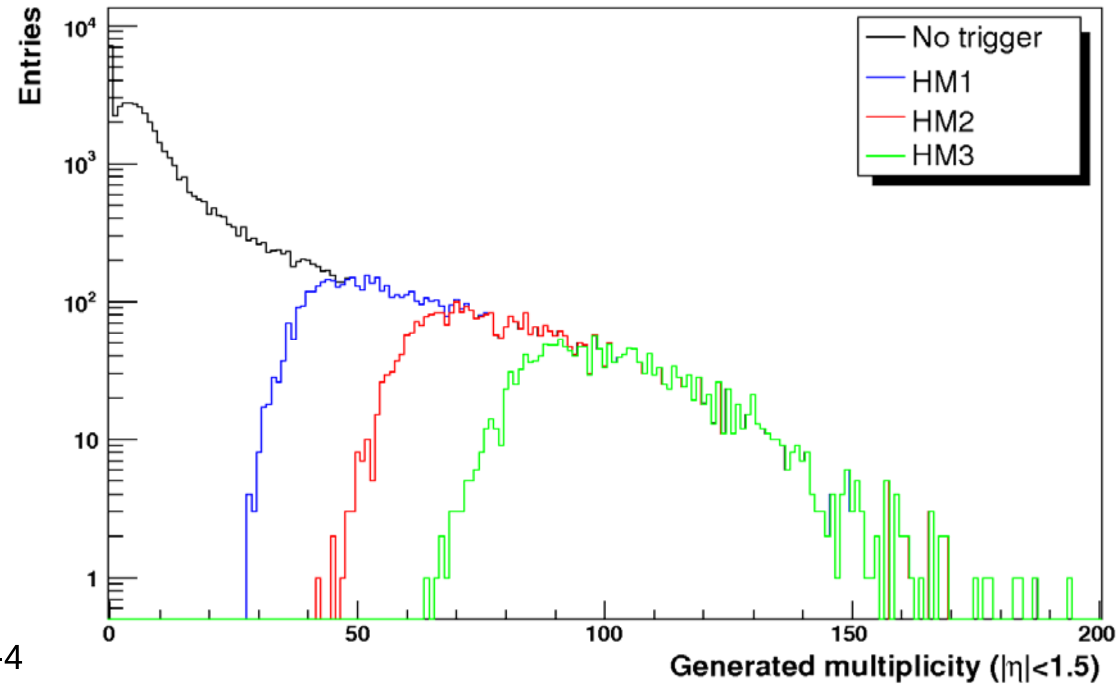
High multiplicity trigger with pixels

Update on Pixel trigger Domenico Elia & *Maria Nicassio*

- Fast-OR vs multiplicity:

```
HM1 = NFO>100 .and.V0AND.and.notBG
HM2 = NFO>150 .and.V0AND.and.notBG
HM3 = NFO>200 .and.V0AND.and.notBG
```





for all HMs:
selected bkg < 10^{-4}

Only the beginning of the study. Other trigger combinations to be studied as well as background contributions.

Tracks in the sectors A04 and A13