MC Activities in ALICE

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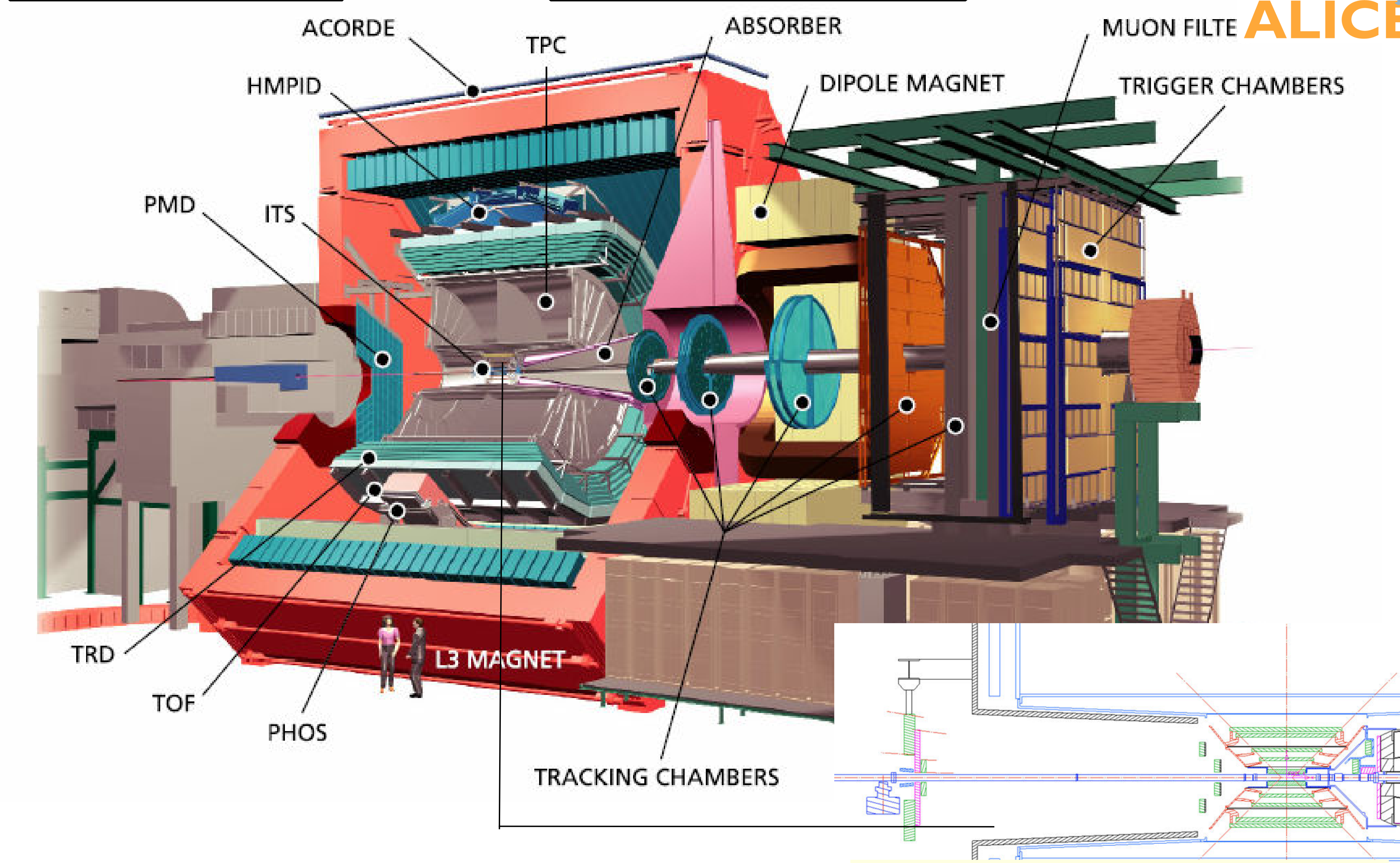
MCNet Meeting

CERN 14/01/2010

A Large Ion Collider Experiment

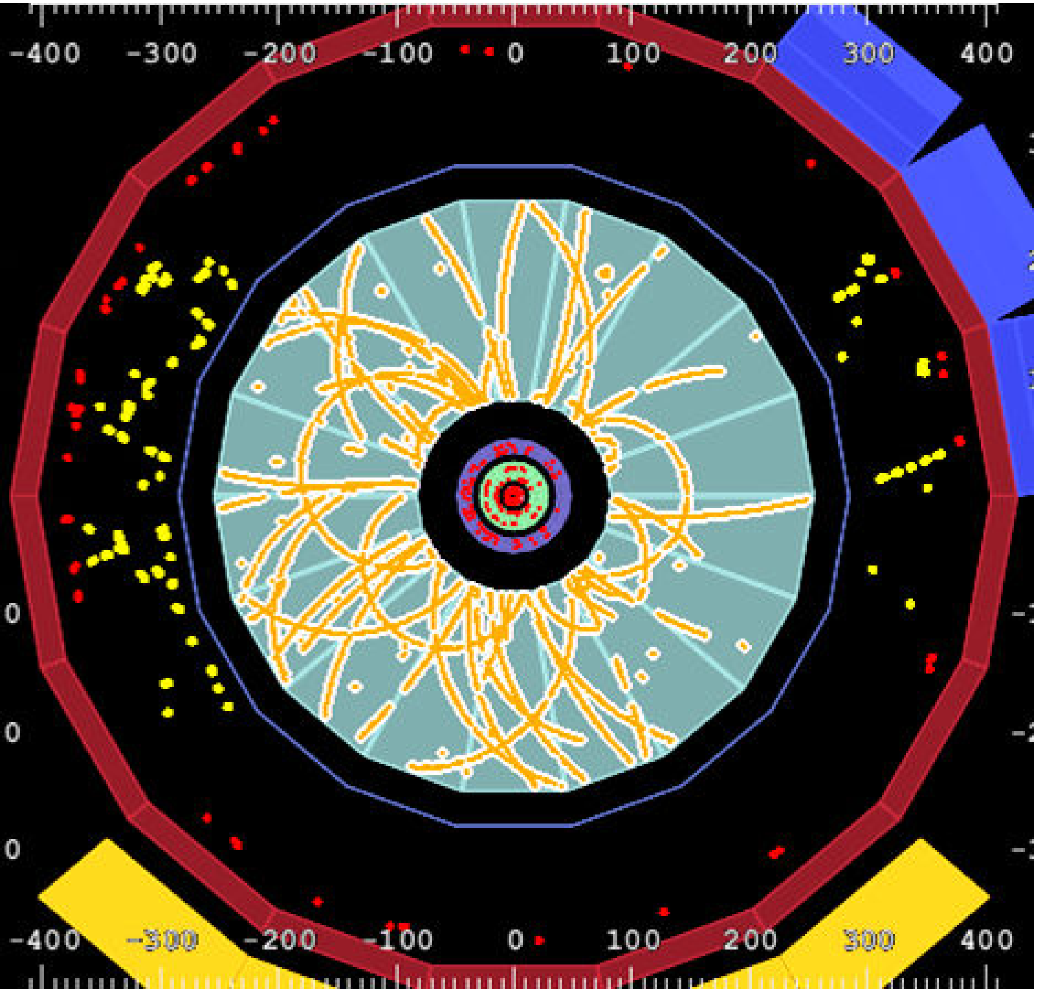
Size: 16 x 26 meters
Weight: 10,000 tons

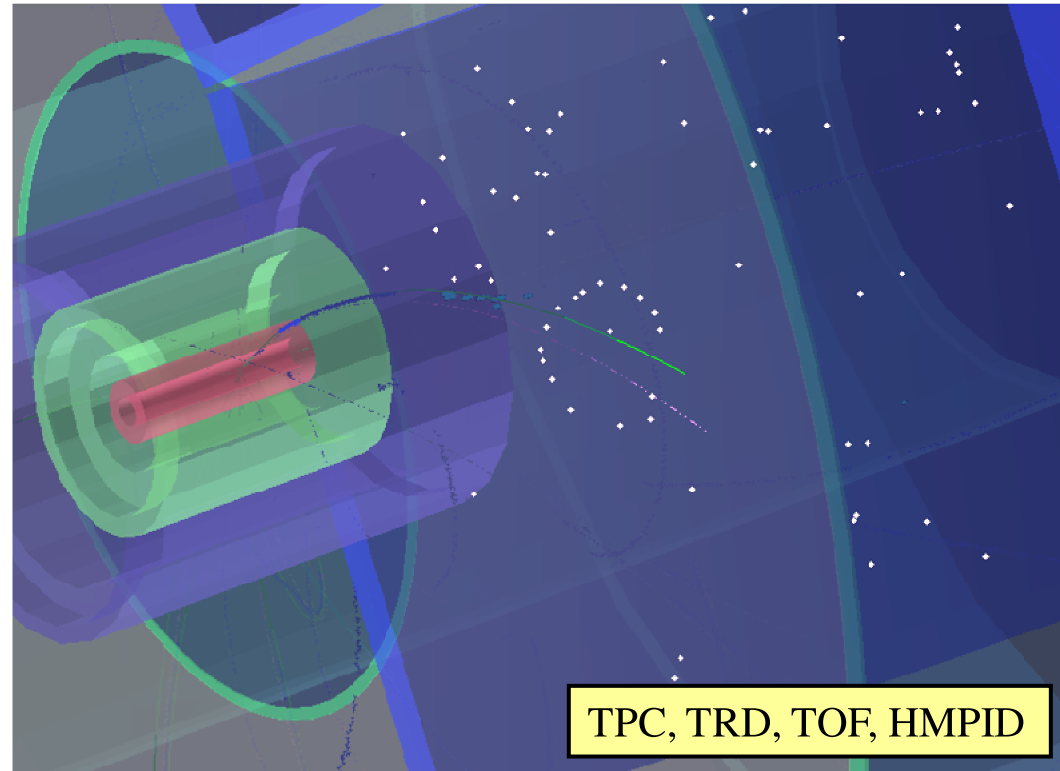
Solenoid Magnet: 0.5 T
Dipole Magnet: 3 Tm



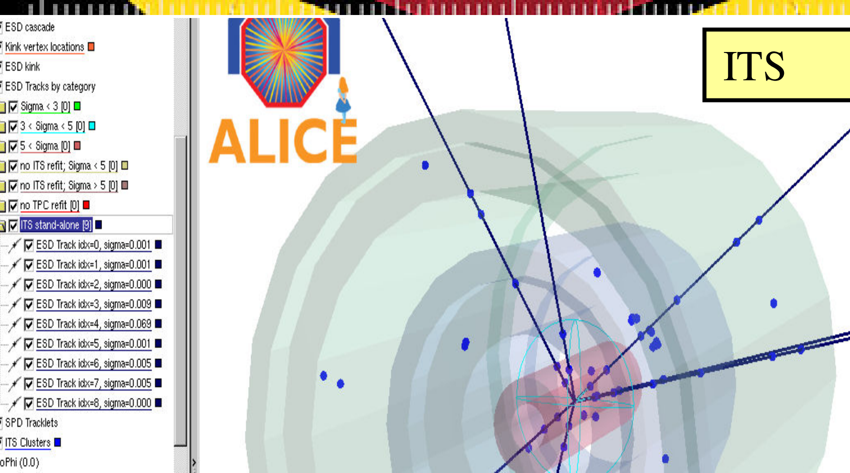
Only ~10% X_0 for R < 280 cm !

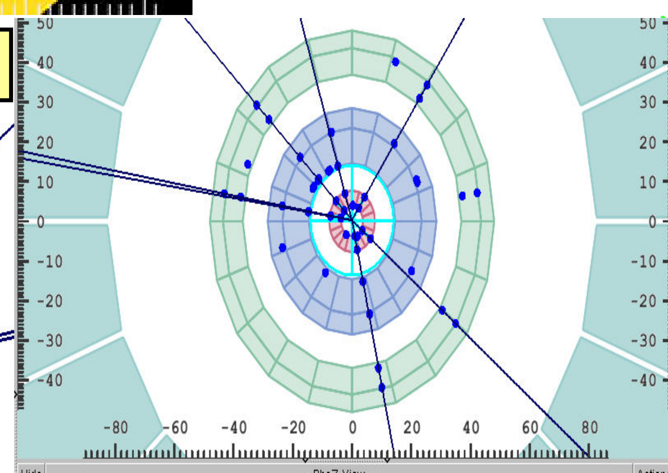
Forward detectors for Triggering and global event characterisation

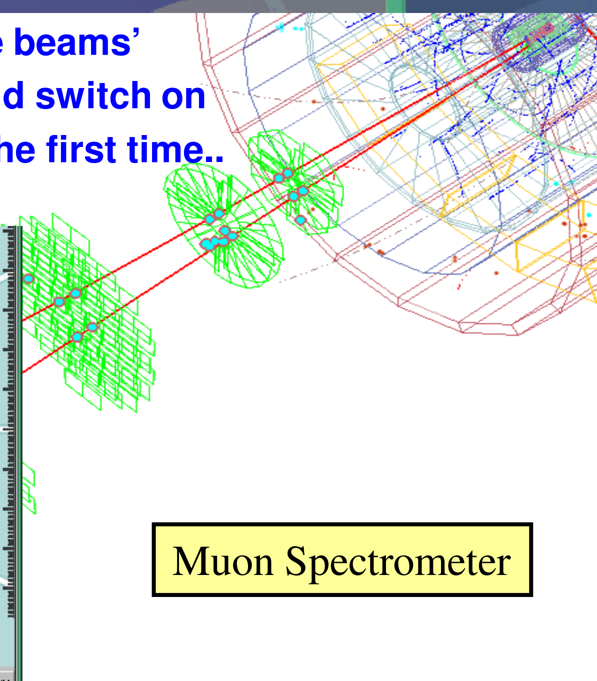


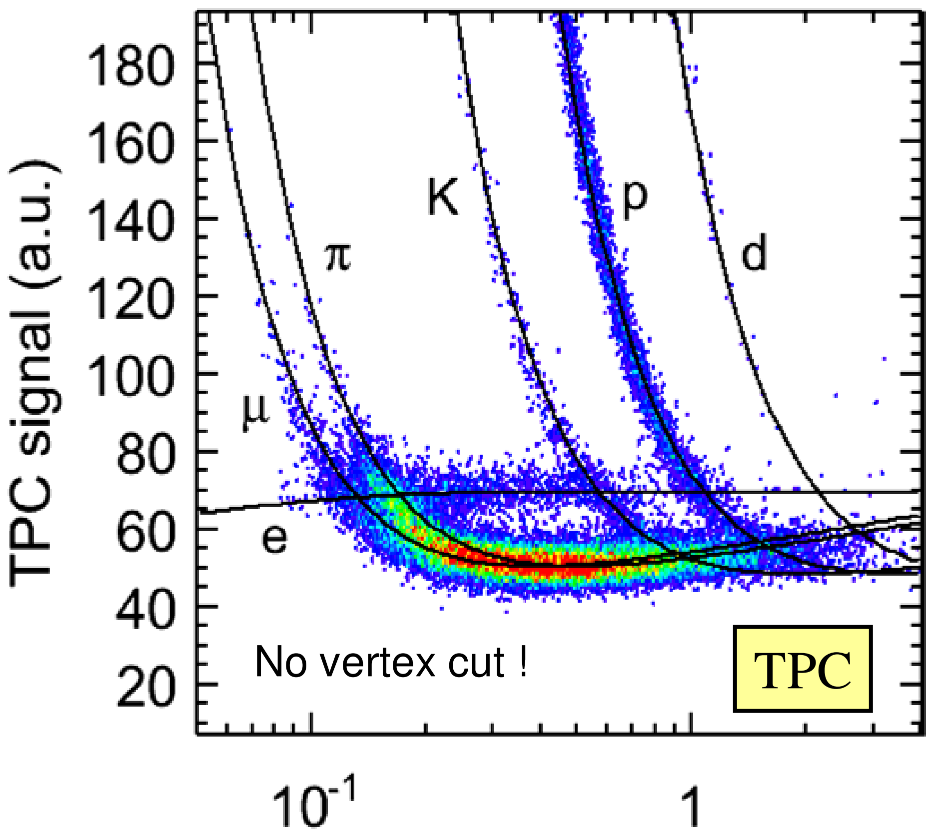


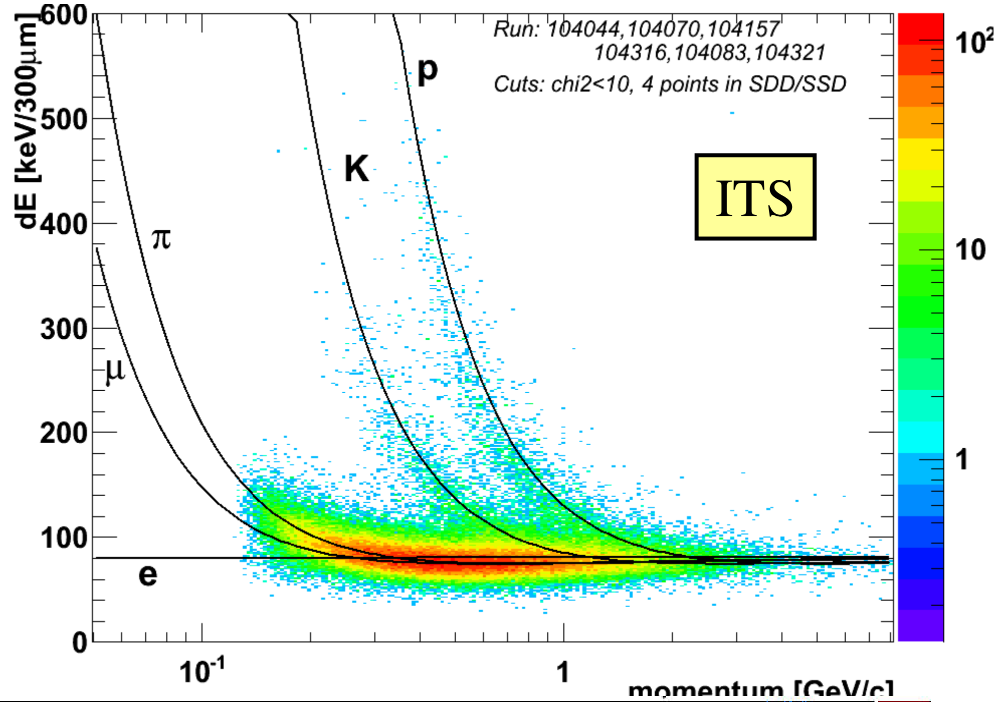
On 6th December, 'stable beams' were declared & we could switch on all ALICE detectors for the first time..

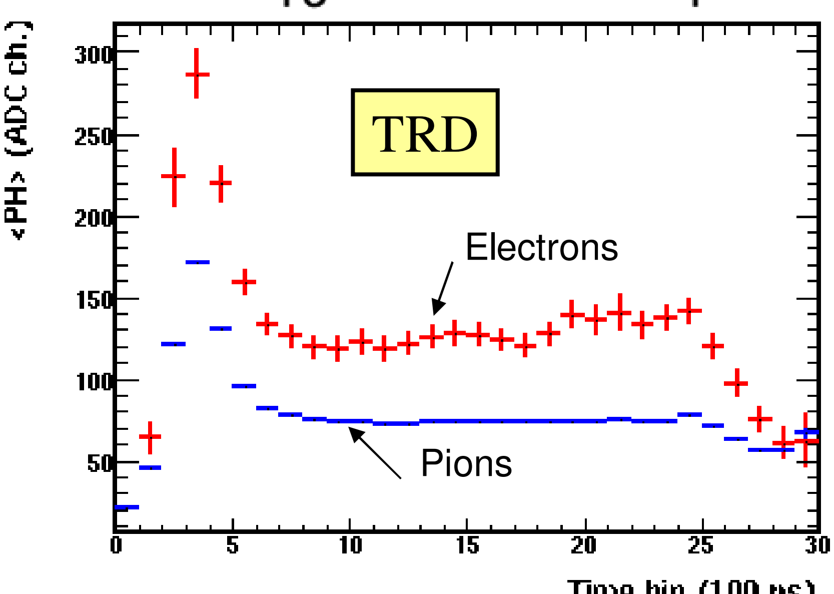


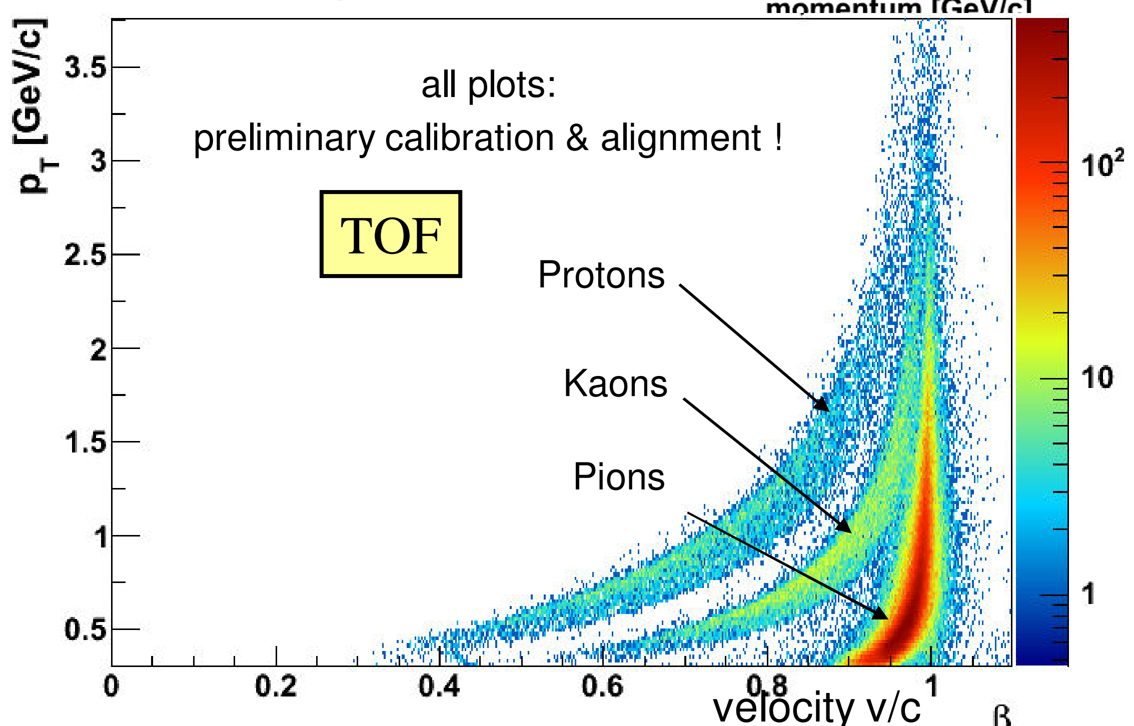


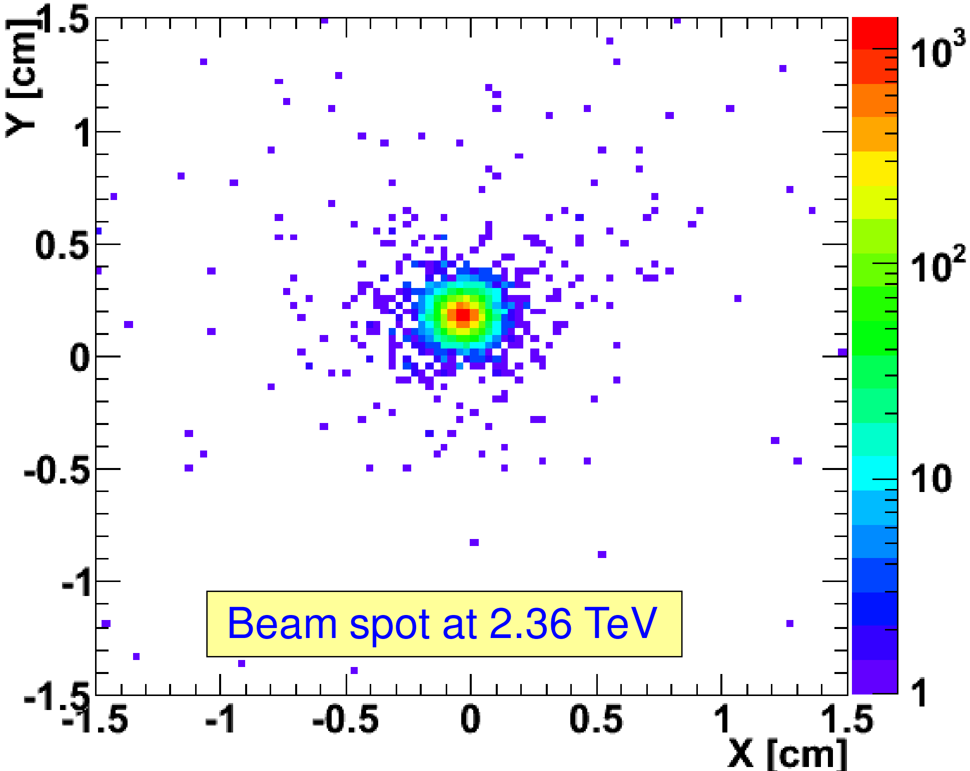


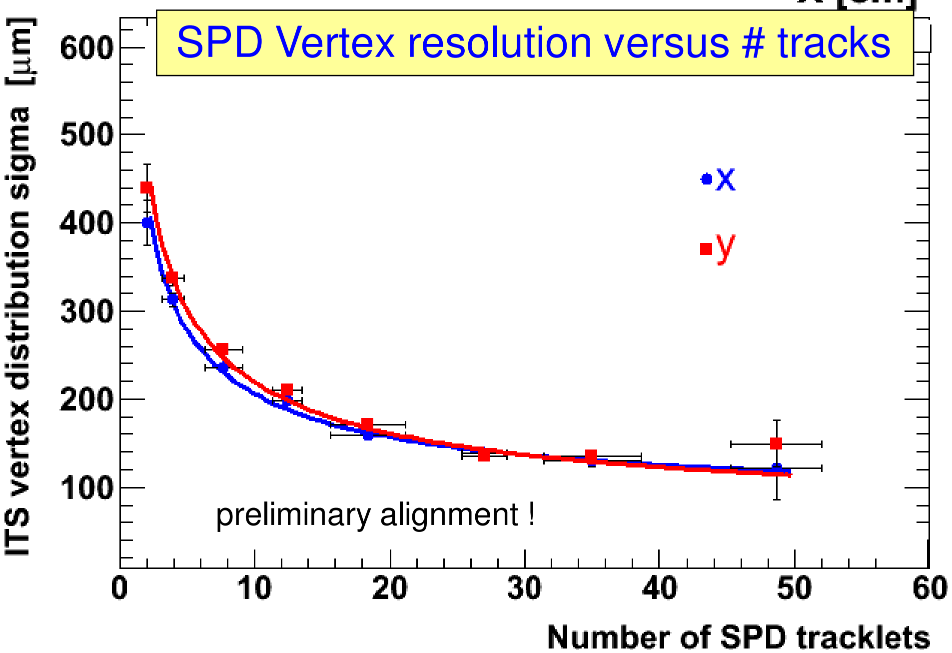

TPC signal (a.u.)
180
160
140
120
100
80
60
40
20
μ
π
K
p
d
e
No vertex cut !
TPC
10^{-1}
1

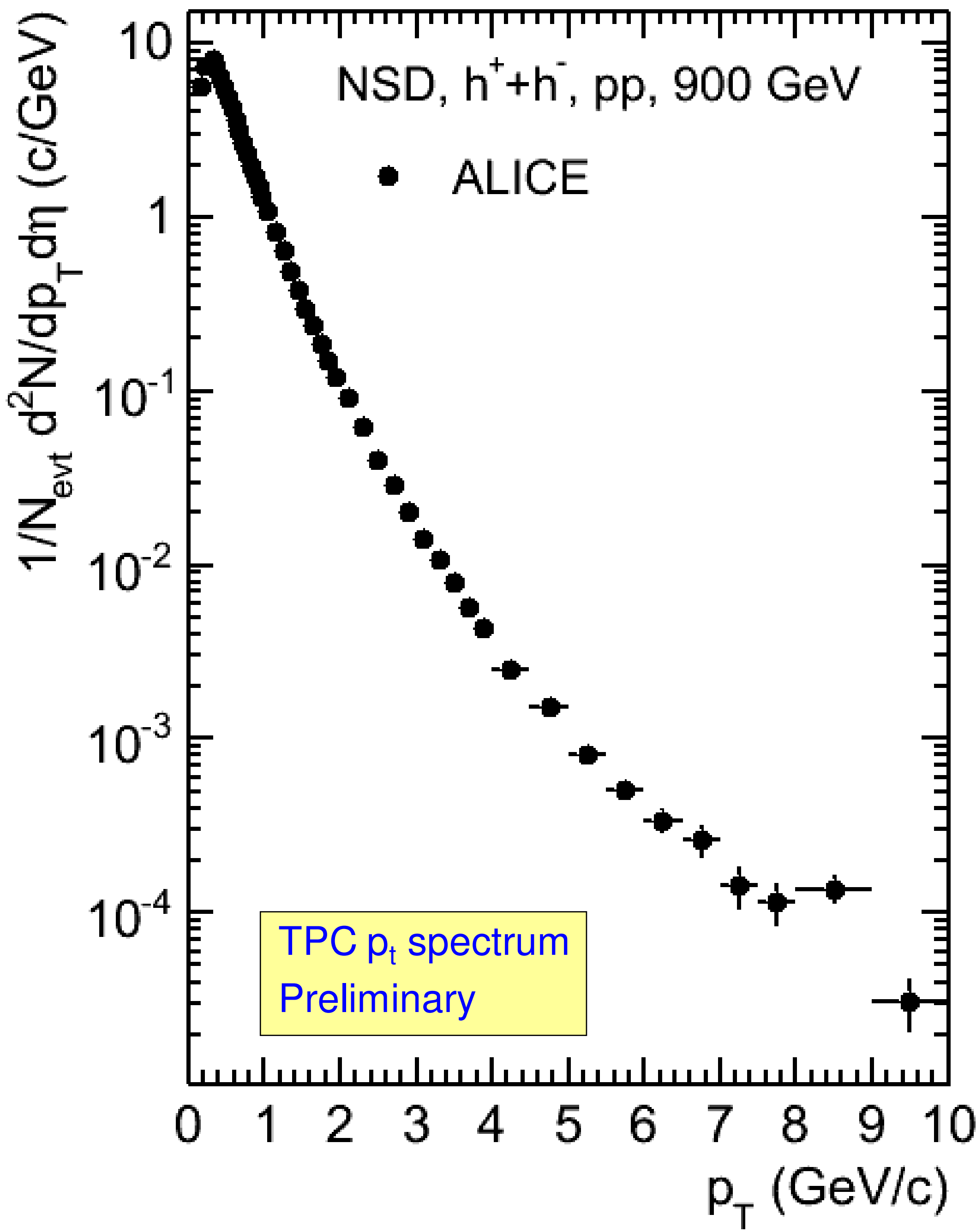

dE [keV/300μm]
600
500
400
300
200
100
0
Run: 104044,104070,104157
104316,104083,104321
Cuts: chi2<10, 4 points in SDD/SSD
p
K
π
μ
e
ITS
10^2
10
1
10^{-1}
1
momentum [GeV/c]

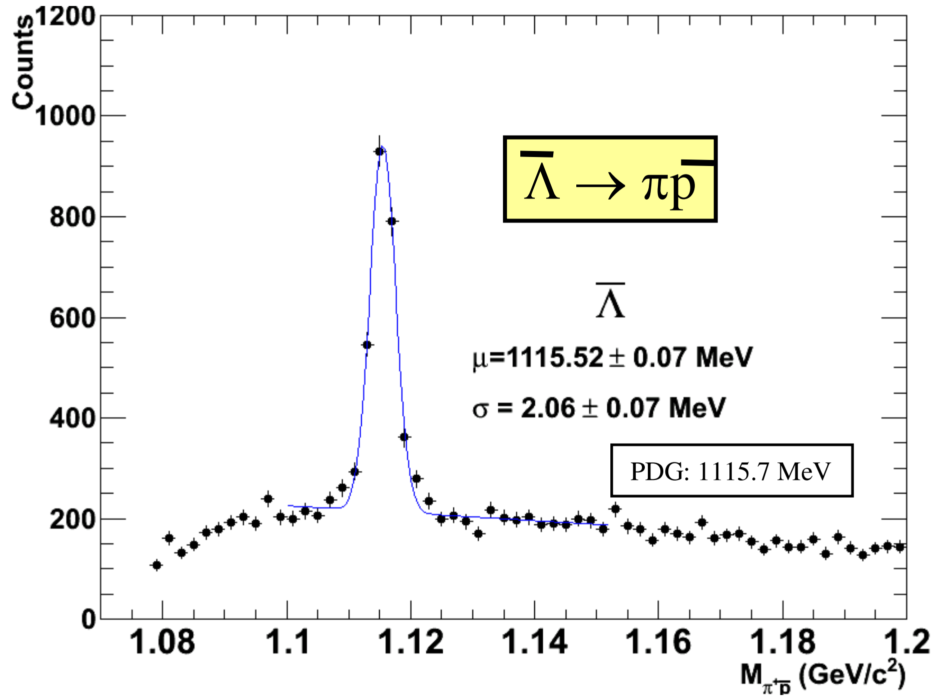

<PH> (ADC ch.)
300
250
200
150
100
50
TRD
Electrons
Pions
0
5
10
15
20
25
30
Time bin (100 ns)

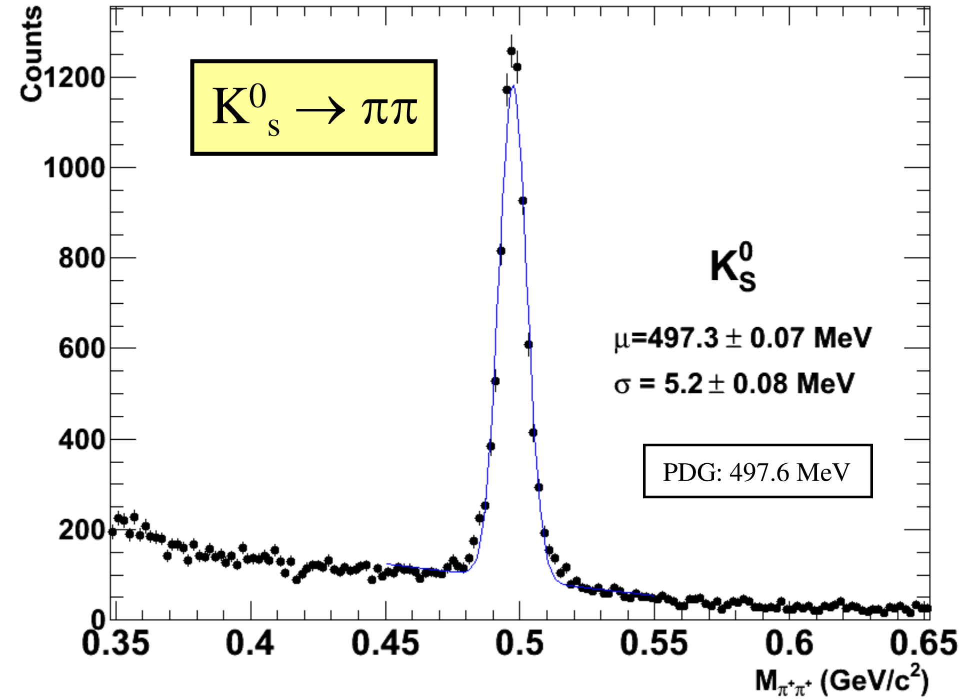

p_T [GeV/c]
3.5
3
2.5
2
1.5
1
0.5
all plots:
preliminary calibration & alignment !
TOF
Protons
Kaons
Pions
10^2
10
1
0
0.2
0.4
0.6
0.8
1
velocity v/c
β

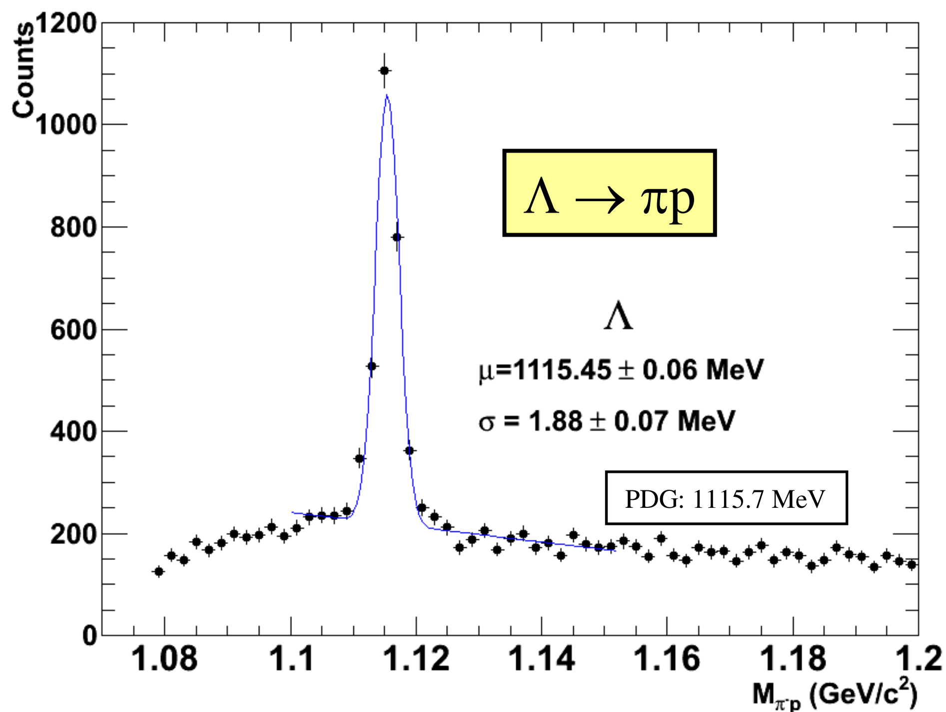

Beam spot at 2.36 TeV
Y [cm]
X [cm]
1.5
1
0.5
0
-0.5
-1
-1.5
10^3
10^2
10
1

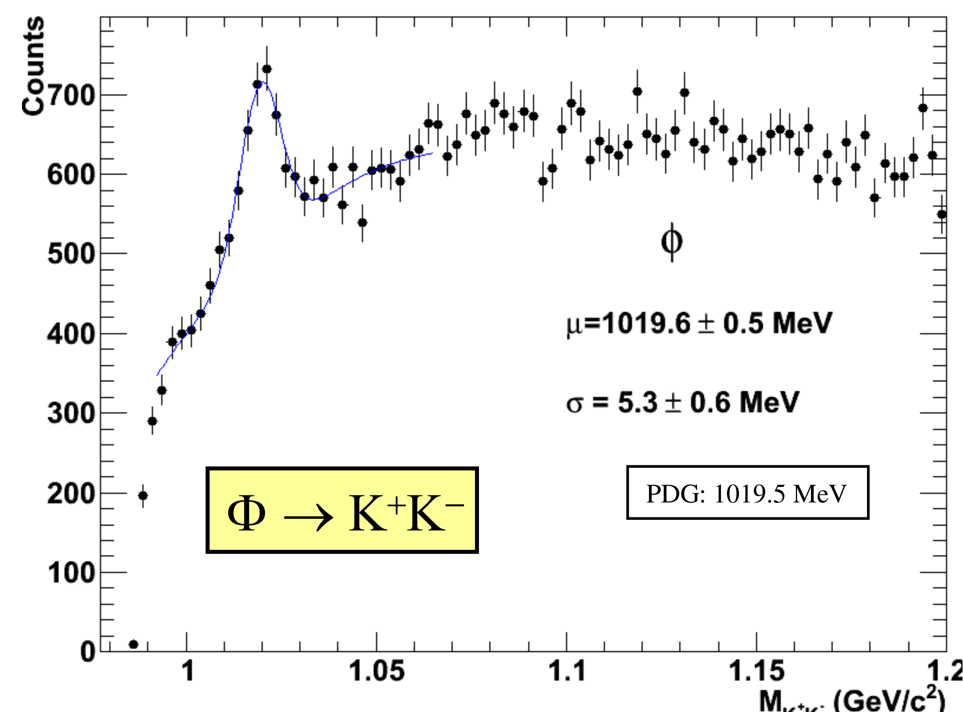

SPD Vertex resolution versus # tracks
ITS vertex distribution sigma [μm]
Number of SPD tracklets
x
y
preliminary alignment !
600
500
400
300
200
100
0
10
20
30
40
50
60


NSD, $h^+ + h^-$, pp, 900 GeV
ALICE
$1/N_{evt}\ d^2N/dp_T d\eta$ (c/GeV)
p_T (GeV/c)
TPC p_t spectrum
Preliminary
10
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
0
1
2
3
4
5
6
7
8
9
10

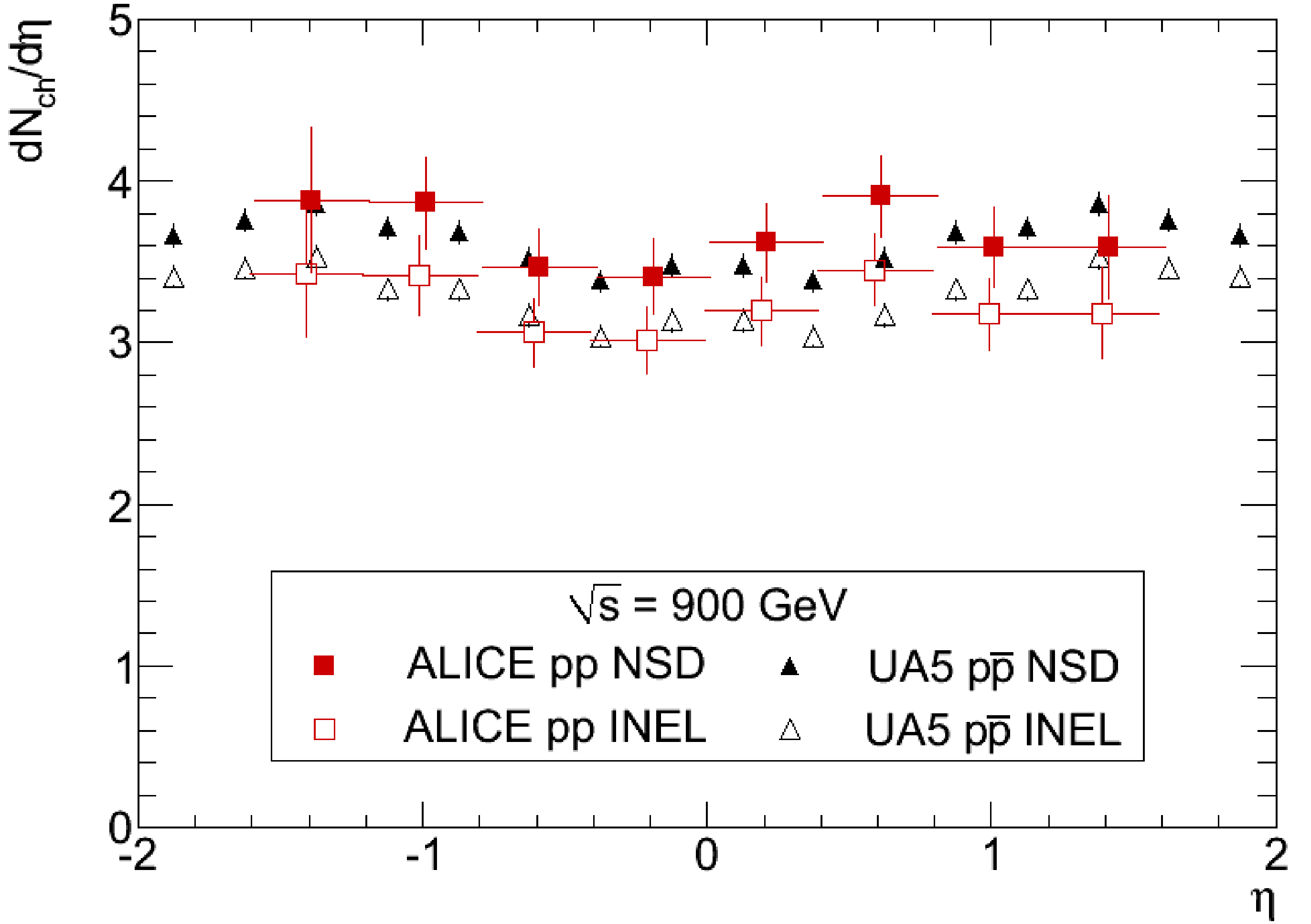

Counts
$\bar{\Lambda} \rightarrow \pi\bar{p}$
$\bar{\Lambda}$
μ=1115.52 ± 0.07 MeV
σ = 2.06 ± 0.07 MeV
PDG: 1115.7 MeV
$M_{\pi^+\bar{p}}$ (GeV/c^2)


Counts
$K^0_s \rightarrow \pi\pi$
K^0_S
μ=497.3 ± 0.07 MeV
σ = 5.2 ± 0.08 MeV
PDG: 497.6 MeV
$M_{\pi^+\pi^+}$ (GeV/c^2)


Counts
$\Lambda \rightarrow \pi p$
Λ
μ=1115.45 ± 0.06 MeV
σ = 1.88 ± 0.07 MeV
PDG: 1115.7 MeV
$M_{\pi^- p}$ (GeV/c^2)

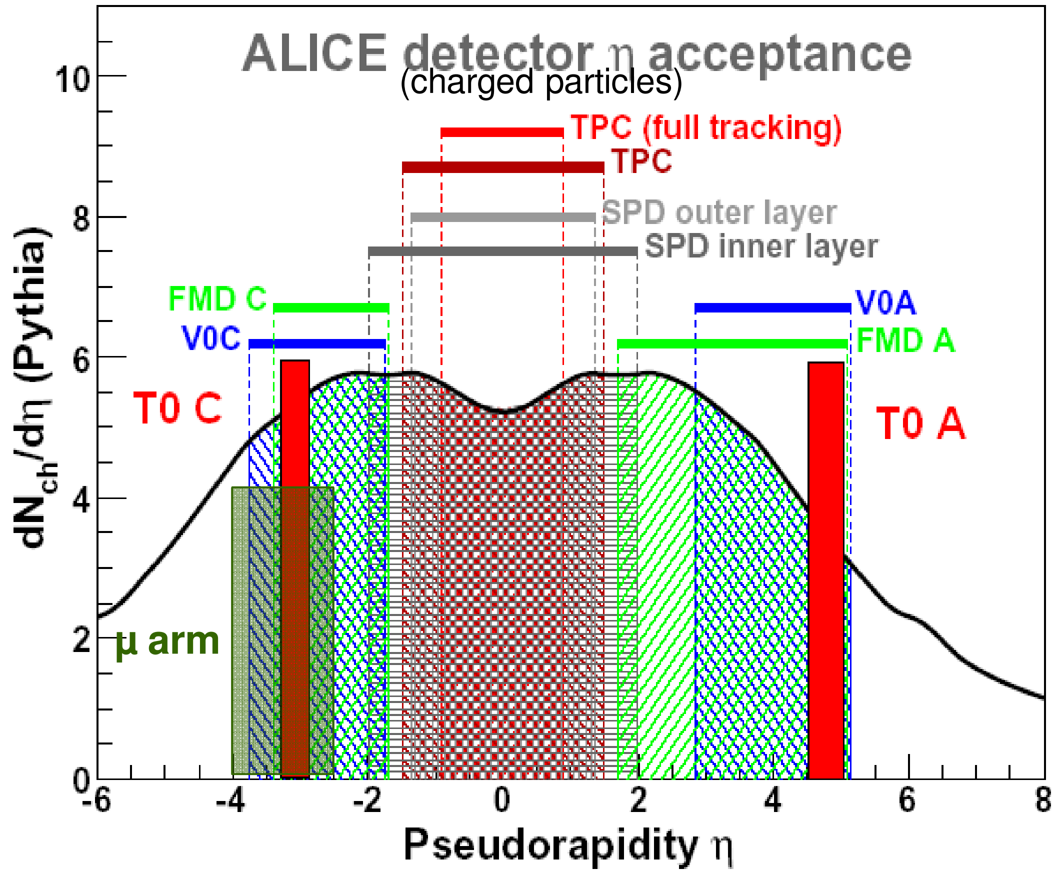

Counts
φ
μ=1019.6 ± 0.5 MeV
σ = 5.3 ± 0.6 MeV
$\Phi \rightarrow K^+K^-$
PDG: 1019.5 MeV
$M_{K^+K^-}$ (GeV/c^2)

First LHC Paper



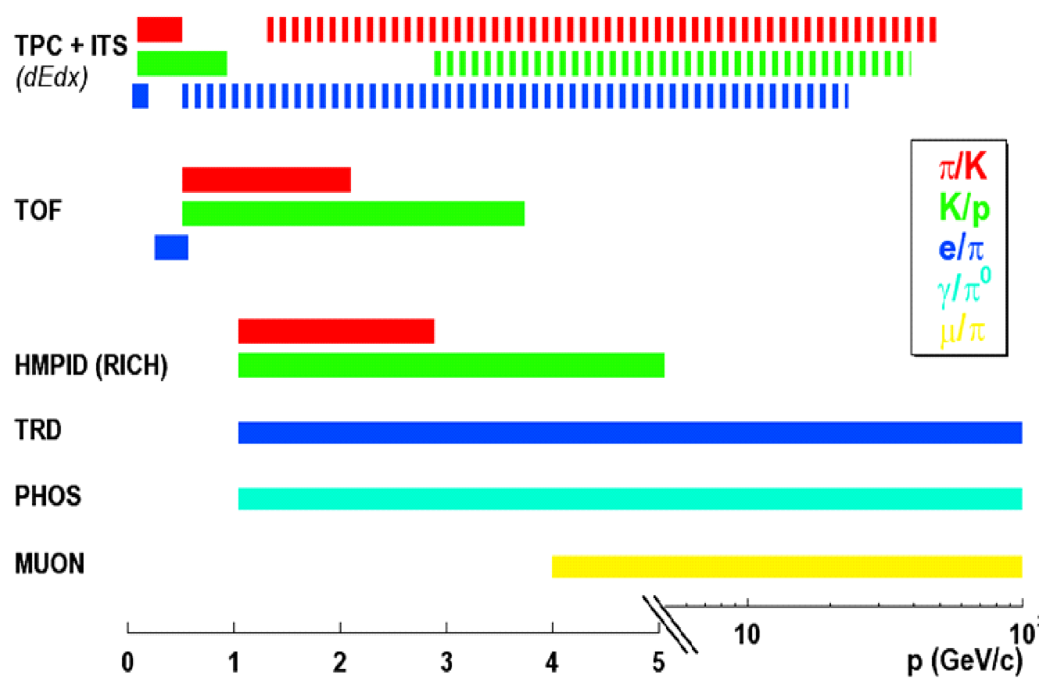
ALICE Acceptance

- Central barrel -0.9 < η < 0.9
  - 2 π tracking, PID
  - single arm RICH (HMPID)
  - single arm em. calo (PHOS)
  - EMCAL
    -0.7 < η < 0.7, ΔΦ = 107°
- Forward muon arm 2.4 < η < 4
- Multiplicity -5.4 < η < 3
  - Including photon counting in PMD



Design Highlights

- Robust tracking optimized for high particle densities (up to 15 000 particles in the acceptance)
  - 3dim hit information
  - < 150 points
  - Moderate magnetic field (0.5 T)
- Large dynamic range for momentum measurements (50 MeV/*c* – 100 GeV/*c*) achieved by
  - Low material budget
  - Large lever arm for tracking
- PID over much of this momentum range
  - Using essentially all known PID techniques
- c-, b- vertex recognition
- Excellent photon detectio (in $\Delta\phi = 45^0$ and $\Delta\eta = 0.1$).

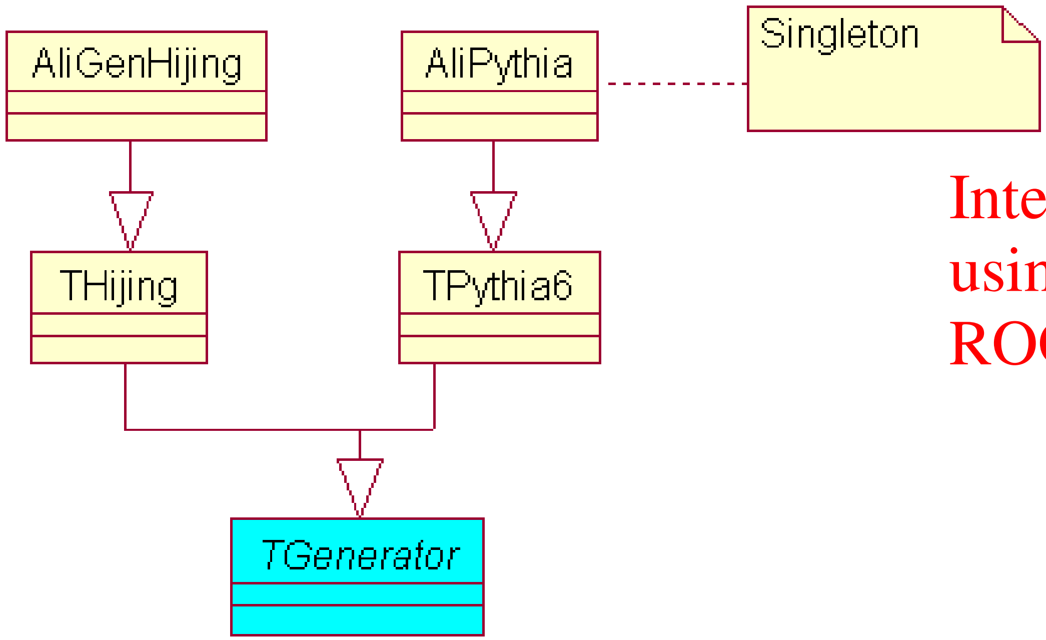


Monte Carlo Generators in the ALICE Offline Framework (AliRoot)

Primary Event Simulation in ALICE

- The simulation framework provides an interface to external generators, like Pythia, Phojet, Herwig, ... HIJING, ...
- A parameterised "signal free" underlying event with multiplicity as a parameter is provided (AA).
- Rare signals can be generated using
  - External generators
  - Libraries of parameterized p_t and rapidity distributions
- The framework provides tools to assemble events from different signal generators
  - On the primary particle level (cocktail)
  - On the digit level (merging)
- After-Burners are used to introduce
  - Soft particle correlations
  - Jet quenching

Event Generator Interfaces: External Generators



Interface to external generators using the *TGenerator* class from ROOT

TGenerator realisations

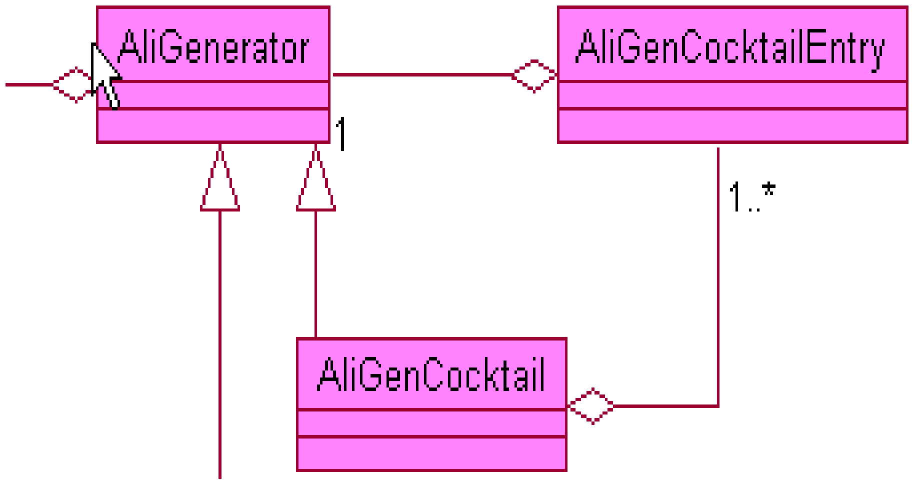
- TPythia6
  - Using pythia6.2.14, pythia6.4.21
  - Optionally using q-show for quenching with pythia6.4.14 (Q-Pythia)
- TPythia8
- THerwig
  - herwig6.5.10+jimmy

TGenerator realisations

- TEpos
  - Epos-167
- TDPMjet
  - phojet1.12-35c3 with pythia6.2.14
  - dpmjet3.0-5
- THijing
- THydjet

Event Generator Interfaces

- Cocktail class to assemble events, for example:
  - Underlying event + hard process
  - Different muon sources
  - pA + slow nucleons



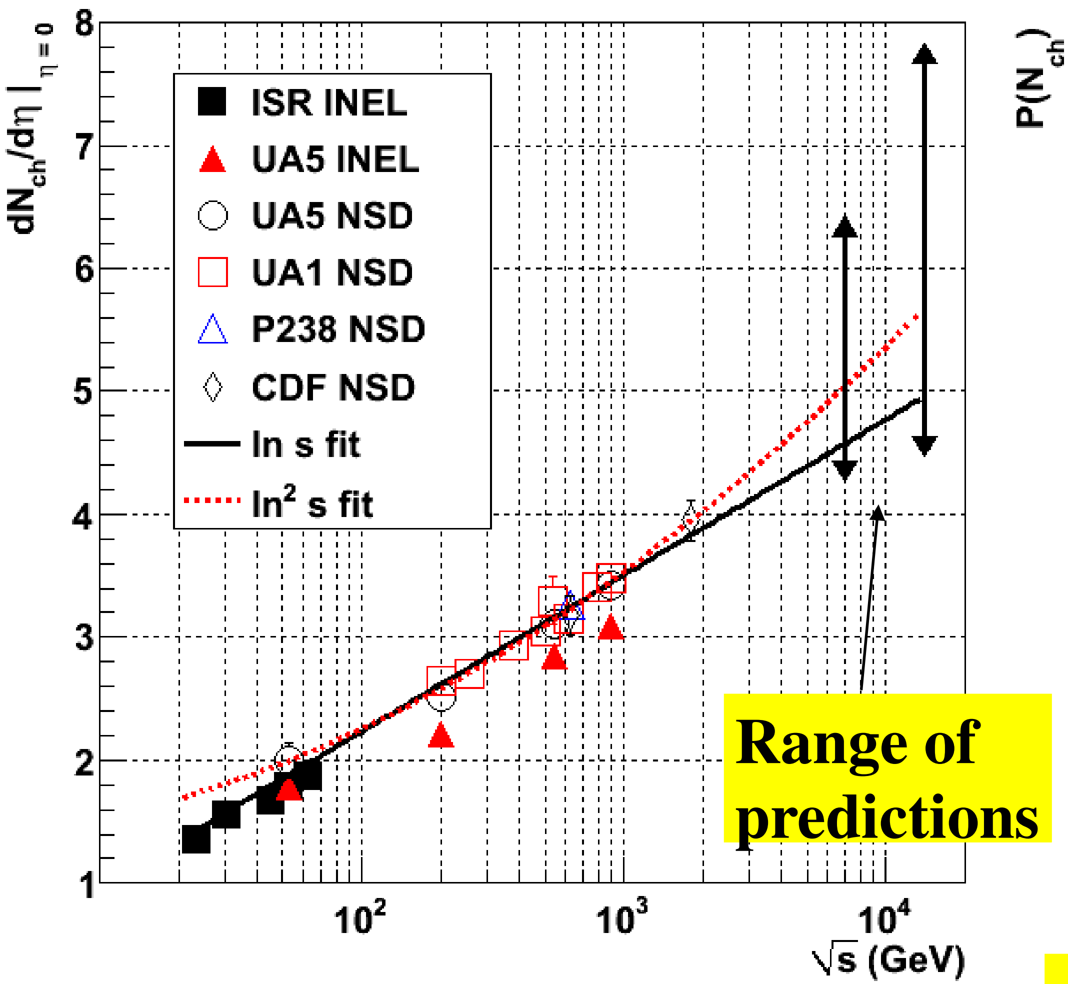
Minimum Bias Studies

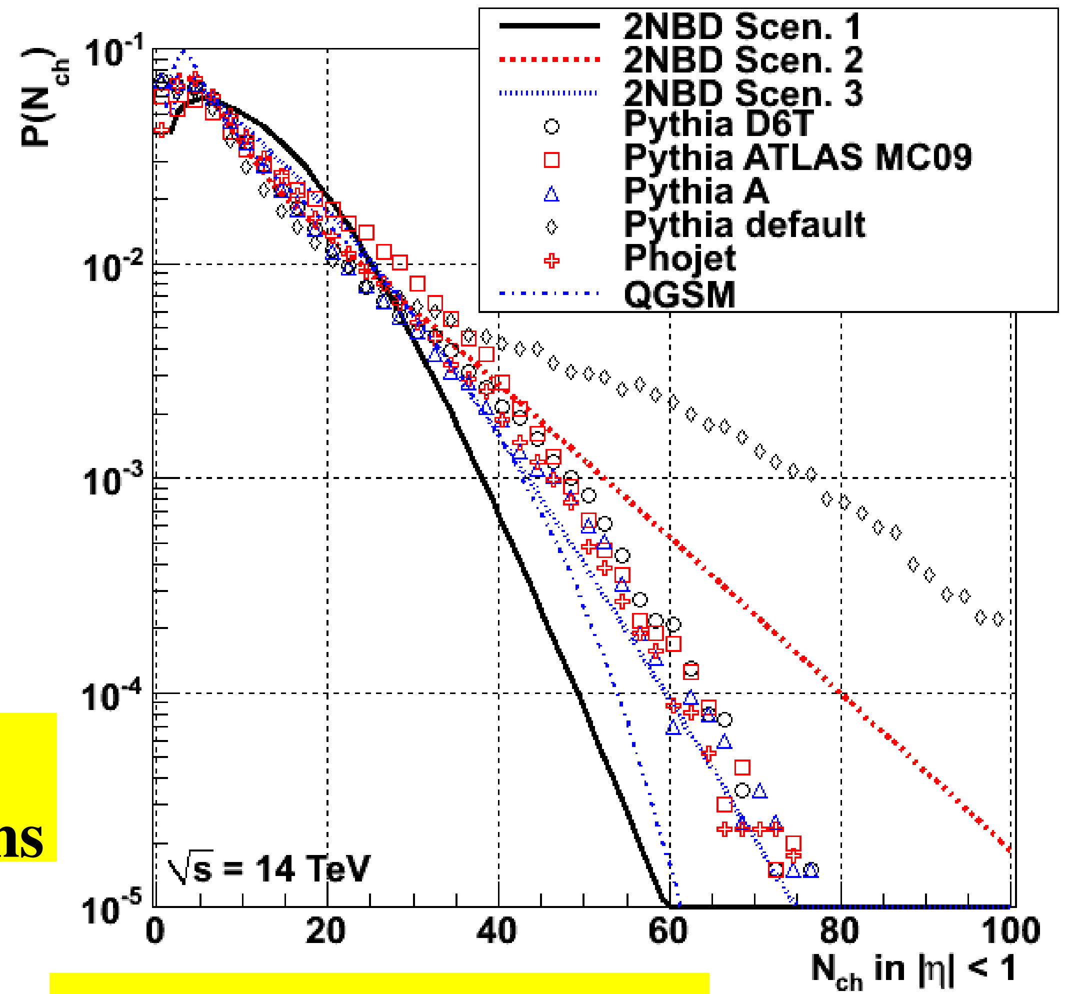
Global-Event Properties

- ALICE features
  - Tracking (multiplicity) starting from 50 MeV/c
  - Tracking with p_T starting from 150 MeV/c
- High-statistics measurements
  - Pseudorapidity density in $|\eta| < 2$
    - Eventually extend to $-3.4 < \eta < 5$ (but larger syst. unc. in that region)
    - First measurement had 7% stat. uncertainty
  - Multiplicity distribution in $|\eta| < 1.4$
  - Transverse-momentum distribution in $|\eta| < 0.9$
    - And with larger syst. unc. in $|\eta| < 1.5$
  - Average-p_T vs. multiplicity
- We plan to produce these distributions for INEL and NSD events

Predictions for LHC Energies

- Significant spread of distributions (also MC generators)





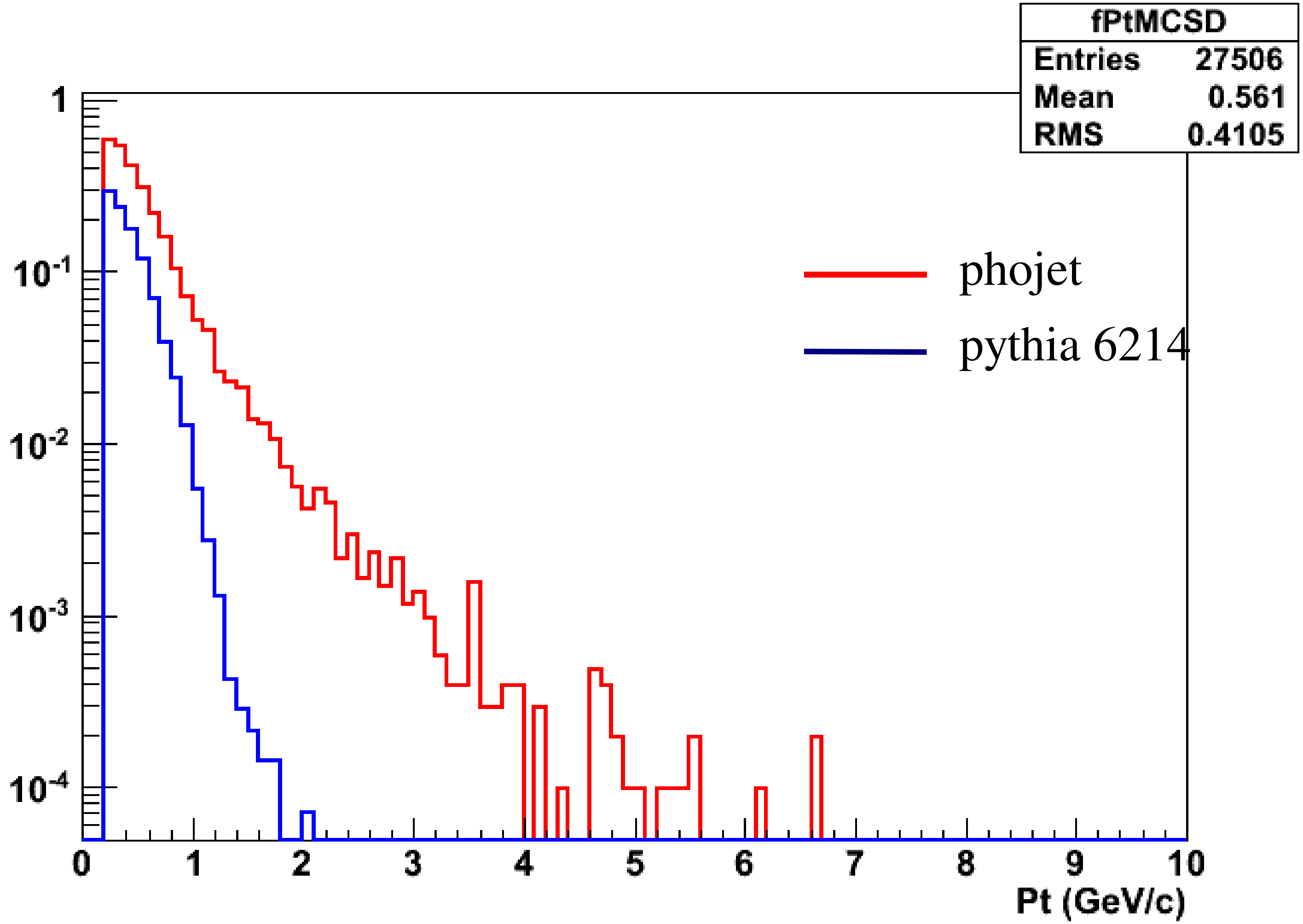
arXiv:0912.0023 [hep-ex]

Jan Fiete Grosse Oetringhaus

Simulation of SD and DD pp Collisions

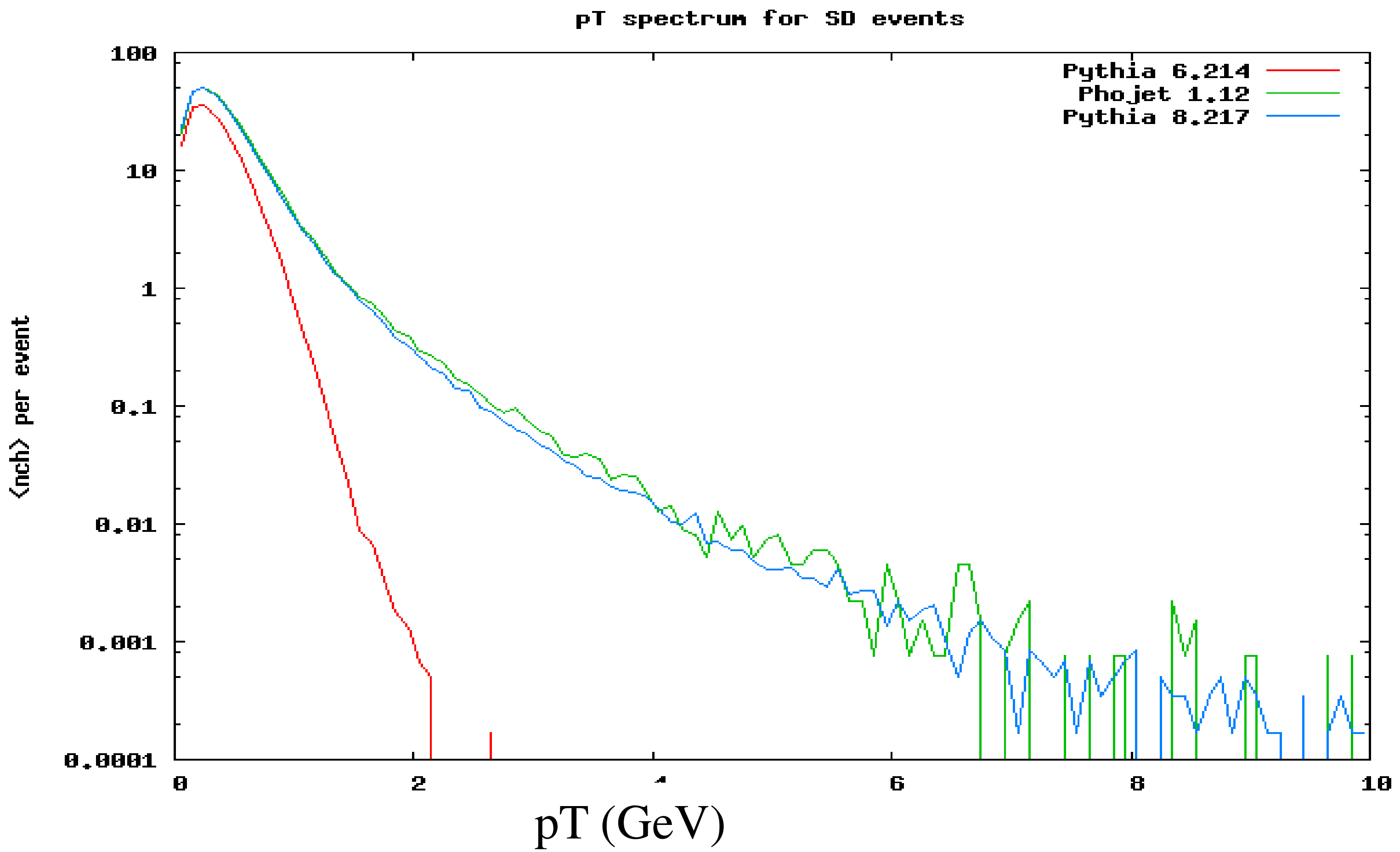
• So far we used Pythia6 and Phojet to estimate systematic error from contribution of diffractive events to inelastic cross-section.

SD -pT



Diffraction in Pythia 8

- From version 8.130 onwards
- Pomeron-p collisions are simulated
- Improvement in pT and multiplicity tails in diffractive events

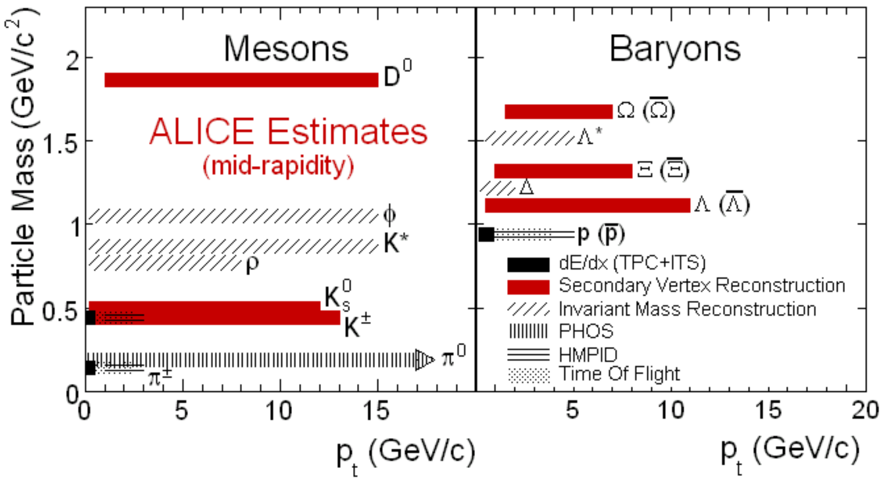


Monte Carlo event generators used in "Spectra"

Mainly driven by the ALICE PID capabilities in the soft sector and in heavy-ion collisions

ALICE Physics Performance Report vol.2

Figure 6.87. Transverse momentum ranges for particle identification at mid-rapidity using the main sub-detectors of the ALICE experiment. Each range is an estimate for 10 M most central events. Mesons and baryons p_t ranges are shown in the left panel and right panel respectively. Arrows are specified when the PID range exceeds that of the figure i.e. 20 GeV/*c*.



For efficiency calculation: basically PYTHIA 6.2

For Model comparisons of identified p_T spectra and (pseudo)-rapidity distributions:

in p+p:

➡mainly with **PYTHIA 6.2** / **6.4** (**8.1** also interfaced but no Physics Data Challenge yet);
➡tunes: D6T (109), A.Moraes et al (306) and Perugia 0 (320) (+ tests with soft 322) consistent with first ALICE paper;
➡also **HIJInG**/**BBar** and **QGSM**;
➡also **EPOS** (collectivity) and **qPYTHIA** (quenching) more related to heavy-ion collisions comparisons;

in A+A:

➡basically **HIJInG**

Specific interests and possible developments in p+p:

- identified particle spectra;
- gluonic baryon junction;
- multiple parton interactions;
- collective effects (e.g. transverse radial flow build-up).

Hard Probes
(Heavy Flavor, Jets, Photons)

ALICE Heavy Flavor Baseline definition

- **Reference rates and spectra from NLO calculation**
  - "reasonable" values for masses and scales
  - average of results with different PDF sets
  - EKS98 for shadowing effect
  - "reasonable" values for intrinsic k_t broadening
  - extrapolation to pA and AA using Glauber model
- Event generation using PYTHIA "tuned" to match NLO pQCD results for quark single-inclusive p_t distributions

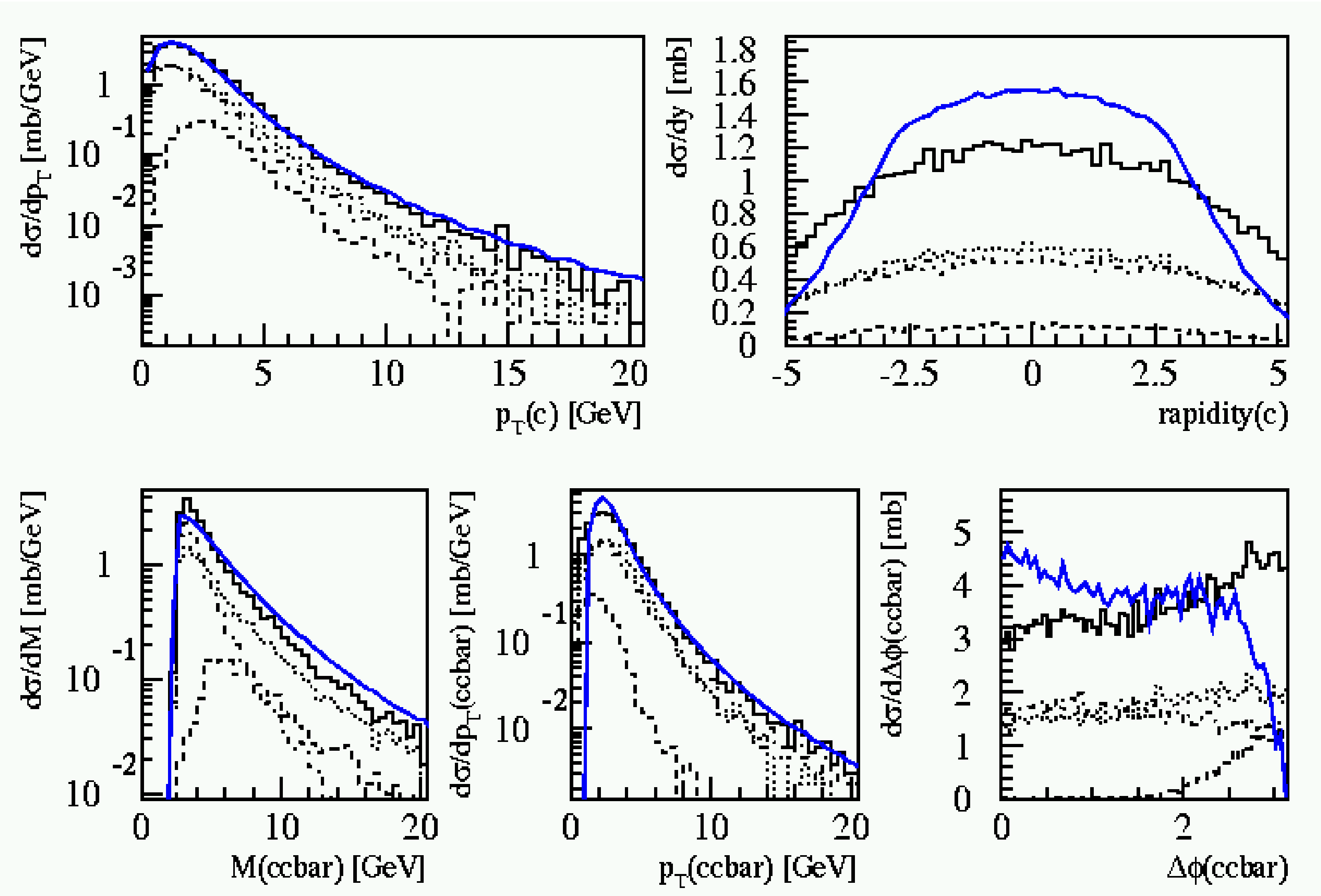
Tuning of PYTHIA parameters

- Comparison at the bare quark level
- Heavy Quarks in PYTHIA:
- MSEL = 1 → initial and final state Parton Shower processes describe contributions above LO
  - agreement with MNR NLO not good
    - parton shower processes ≠ NLO processes
  - massless Matrix Elements! cross section diverges at $p_t^{hard} \to 0$
  - Tuning of parameters less "physics inspired"
  - Main parameter tuned: min. p_t^{hard} (2.1 GeV/c for c, 2.75 GeV/c for b)

Charm NLO: pp 14 TeV

MNR —— Pythia

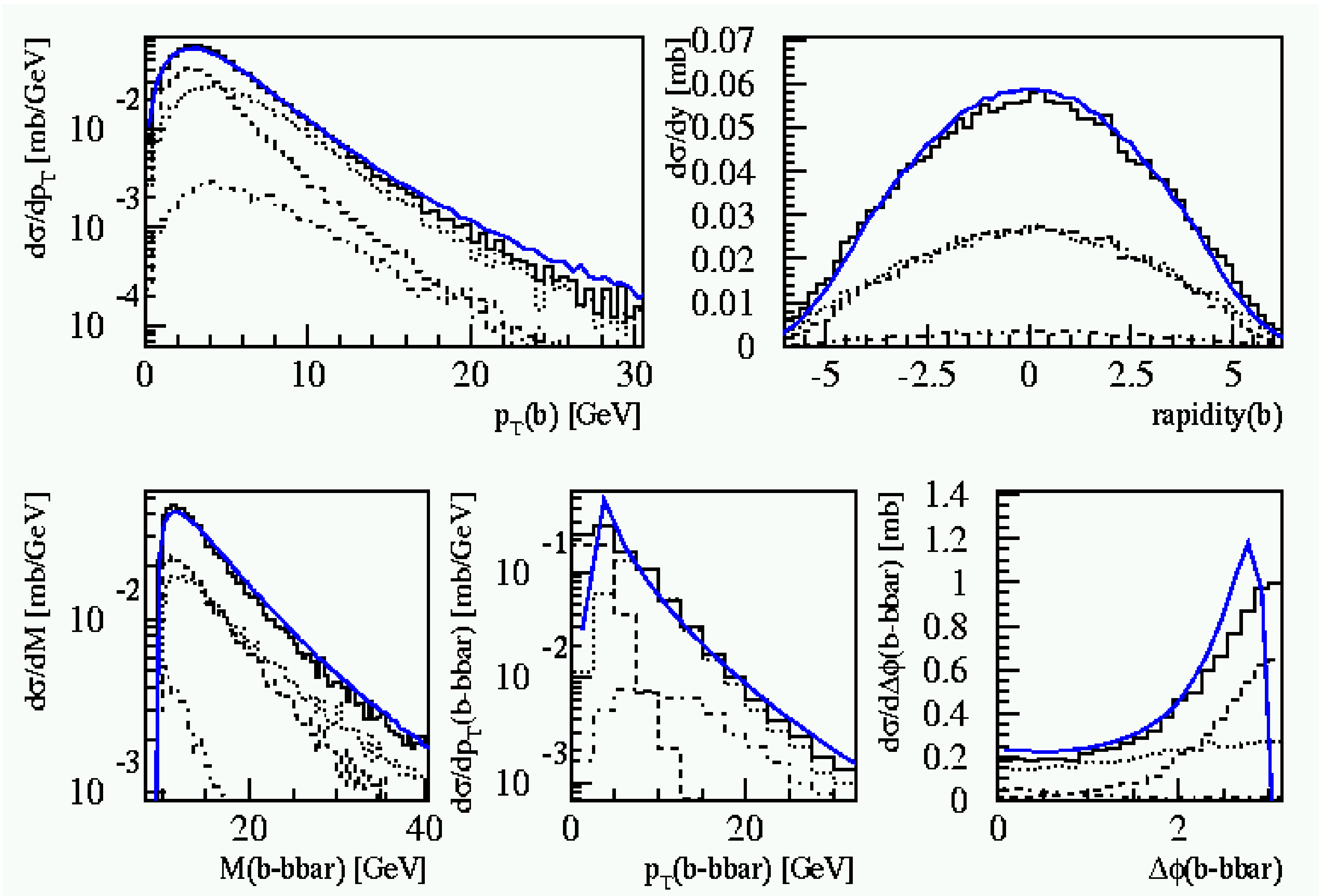
- - - - pair creation
······ flavour excitation
-·-·- gluon splitting
—— TOTAL



Beauty NLO: pp 14 TeV

MNR ——— Pythia

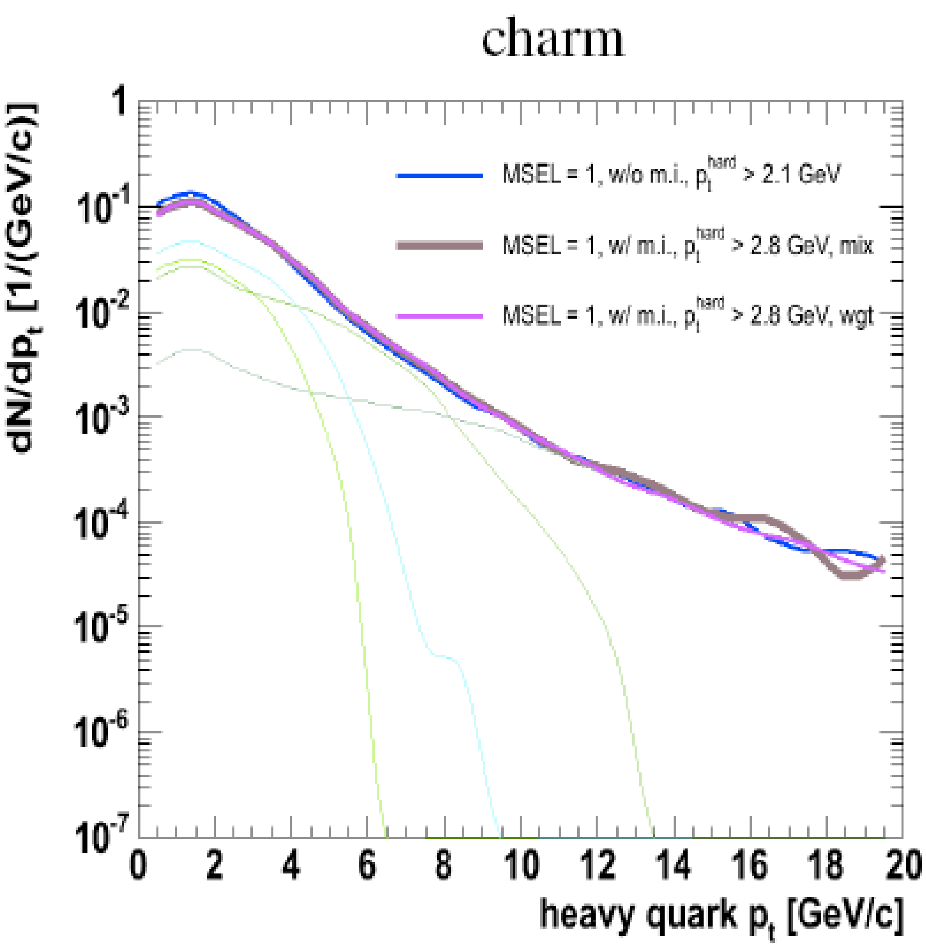
- pair creation
- flavour excitation
- gluon splitting
- TOTAL



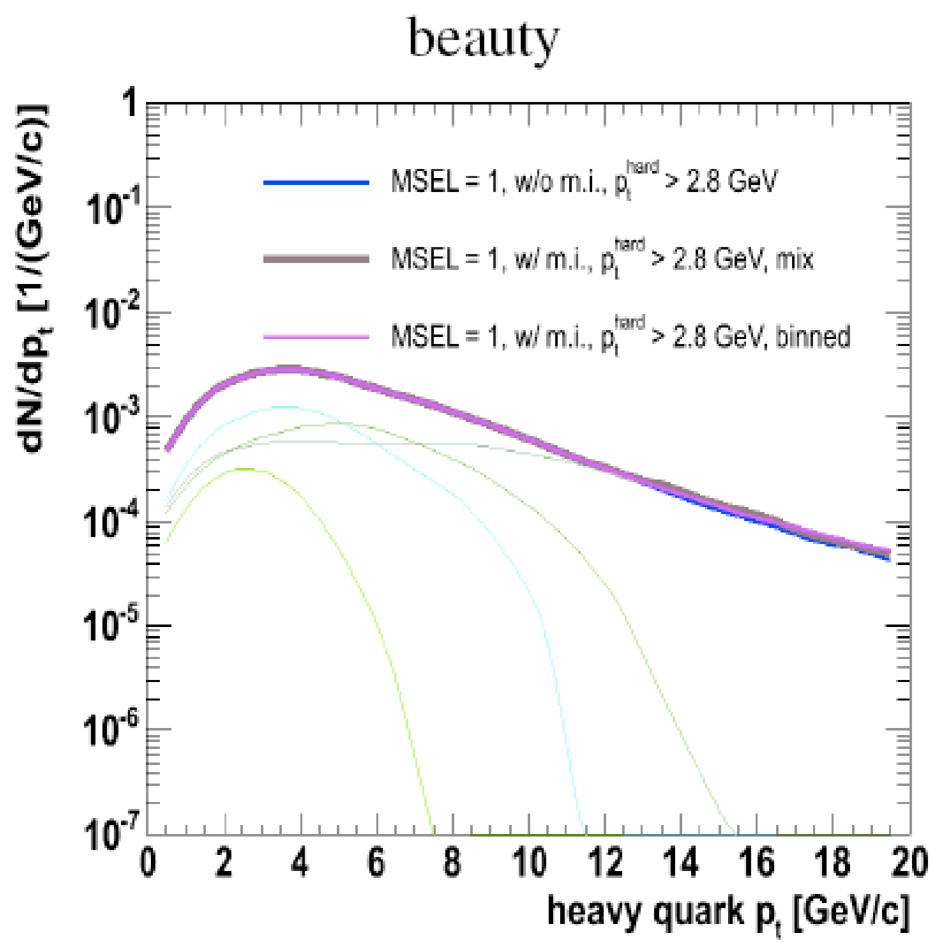
HF in pp min.bias samples "Physics Run" composition

- Assuming $\sigma^{inel} = 70$ mb:
  - 14.14% of MSEL=1 events with ccbar (in 4 subsamples)
    - one such event takes about 2 × CPU time as min.bias events
  - 0.73% of MSEL=1 events with bbbar (in 4 subsamples)
    - one such event takes about 6 × CPU time as min.bias events
  - 85.13% of MSEL=0 events (including diffractive) with QQbar switched off (these events will be partly enriched with Ω and J/ψ)

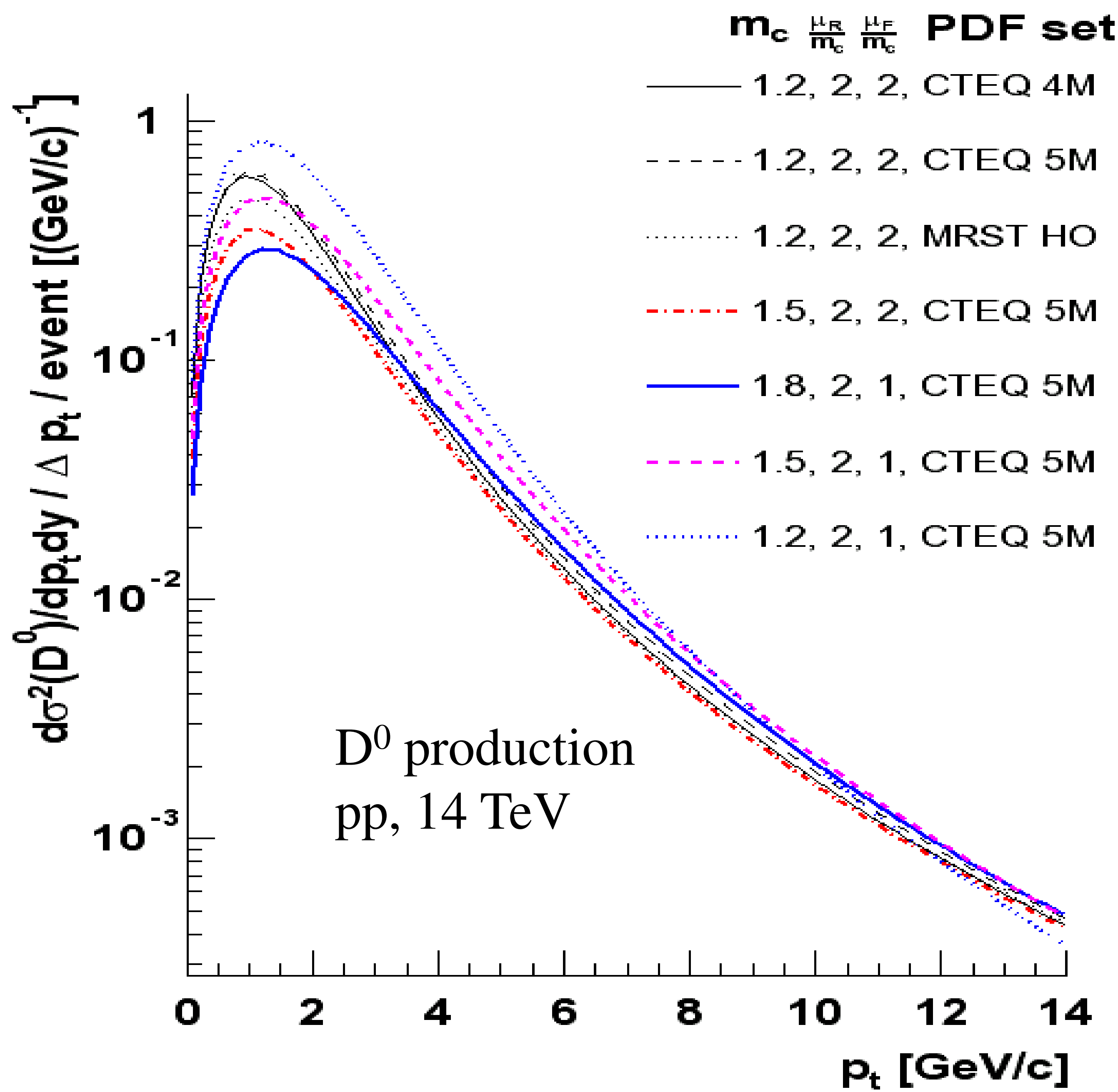
Heavy quark pt distribution



4 bins: 2.76-3, 3-4, 4-8, >16



4 bins: 2.76-4, 4-6, 6-8, >16



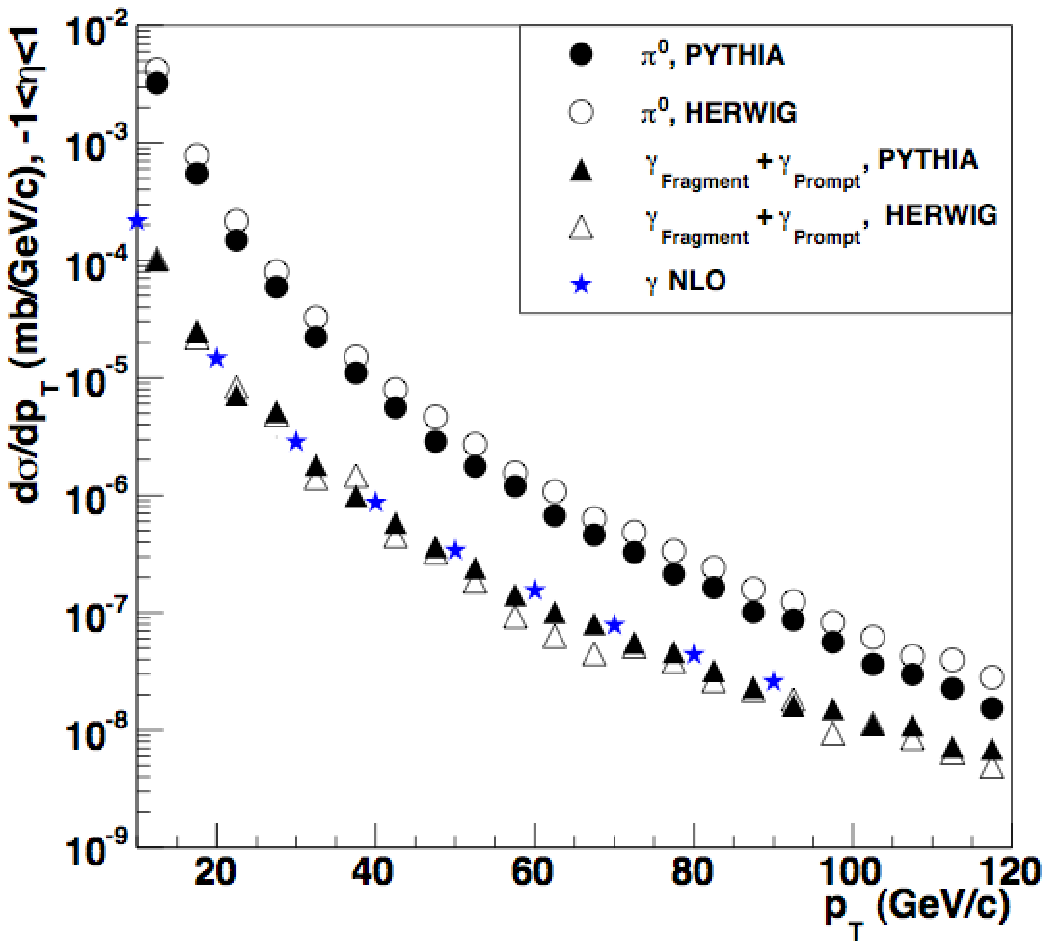
m_c μ_R/m_c μ_F/m_c PDF set
1.2, 2, 2, CTEQ 4M
1.2, 2, 2, CTEQ 5M
1.2, 2, 2, MRST HO
1.5, 2, 2, CTEQ 5M
1.8, 2, 1, CTEQ 5M
1.5, 2, 1, CTEQ 5M
1.2, 2, 1, CTEQ 5M
dσ²(D⁰)/dp_t dy / Δ p_t / event [(GeV/c)⁻¹]
1
10⁻¹
10⁻²
10⁻³
0
2
4
6
8
10
12
14
p_t [GeV/c]
D⁰ production
pp, 14 TeV

Photons and Jets

- PYTHIA (v6.2 Tune A)
- HERWIG (5.)
- So far only FORTRAN versions

Photons: Observables

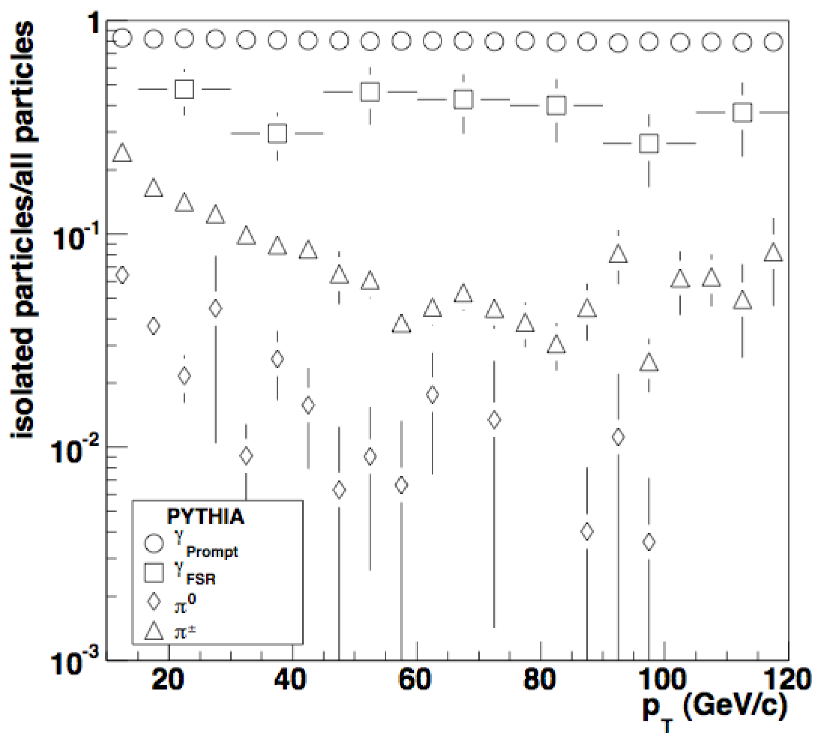
- Direct photon, π^0 … p_T distributions, their ratios etc



Photons: Observables

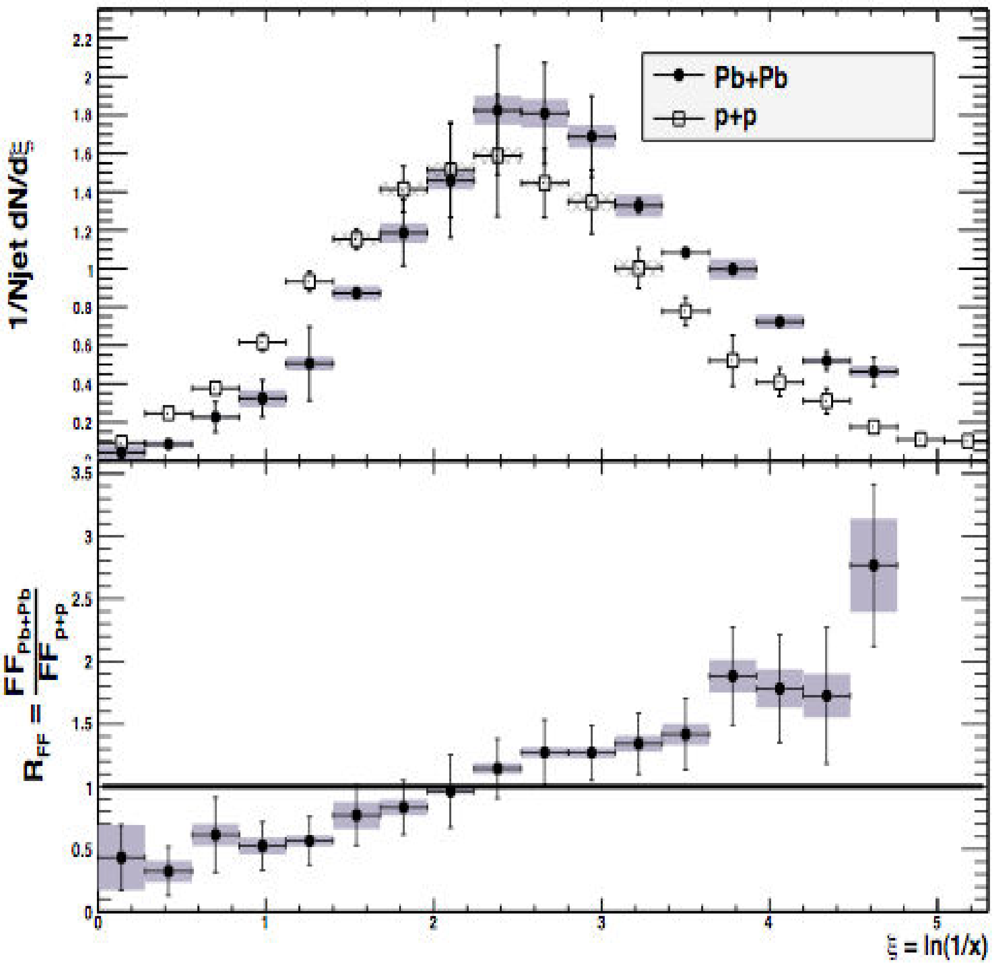
- Particle isolation (not a jet particle)
  - Particle distribution (underlying event) around generated isolated (direct) photon
  - Isolation Parameters: no particle in cone of size R=0.4, and $p_T^{th} > 1$ GeV/c

Isolation rejection



Photon: Observables

- "Fragmentation function" of isolated photons associated jet



x =p_T hadron / p_T gamma

Problems/Requests

- NLO generator for high pT photons/pi0 etc, neither pp nor PbPb.
- Is simulation of fragmentation photons correct ?
  - Fragmentation photons seem to be too isolated in PYTHIA/HERWIG

Summary

- So far used in production
  - Pythia6 (various tunes), Phojet, Hijing
  - Many other generators integrated via the TGenerator interface
- C++
  - We integrated and use Pythia8
- Interest to participate in MC tuning