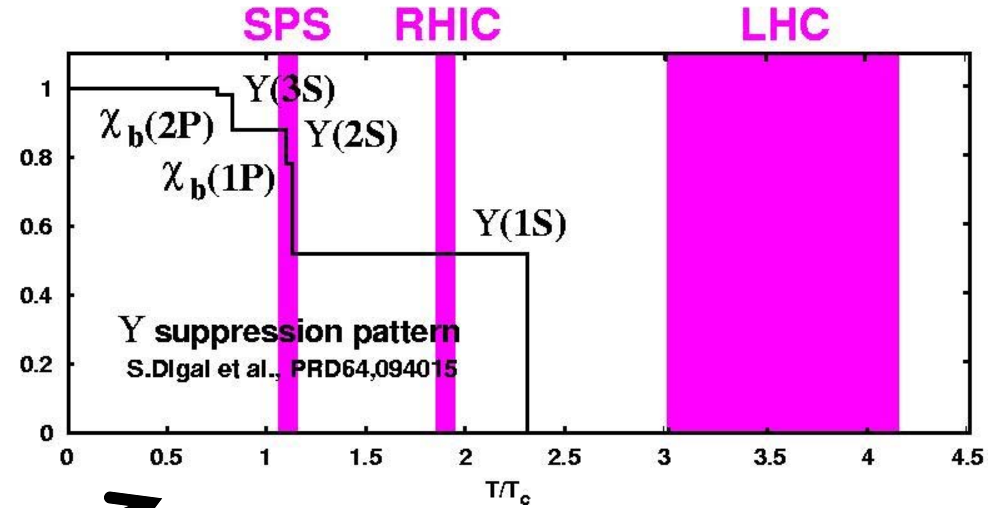
Physics perspectives with the ALICE muon spectrometer

- ✓ **Heavy flavor production in heavy ion collisions at the LHC**
- ✓ **ALICE muon spectrometer performances**
- ✓ **Selected physics channels**

Specificities of heavy flavor production in heavy ion collisions @ LHC

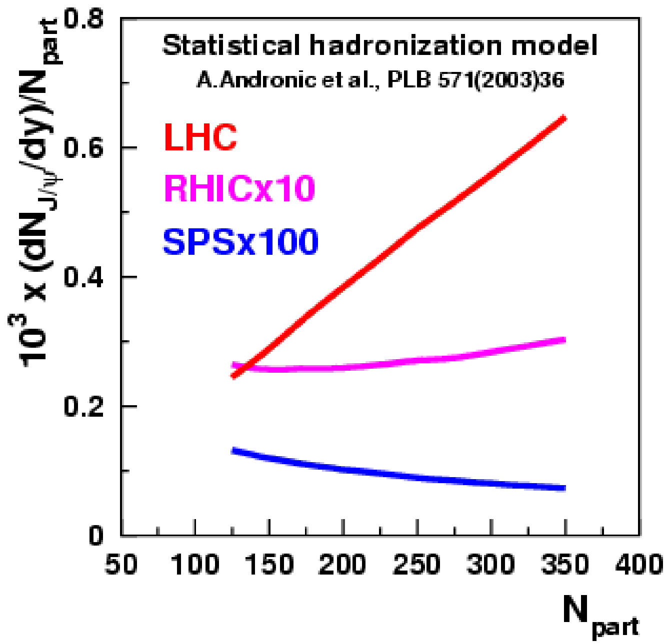
N($q\bar{q}$) per central PbPb (b=0)

	SPS	RHIC	LHC
charm	0.2	10	120
bottom	---	0.05	5



- large primary production
- melting of $\Upsilon(1S)$ by color screening
- large secondary production of charmonia

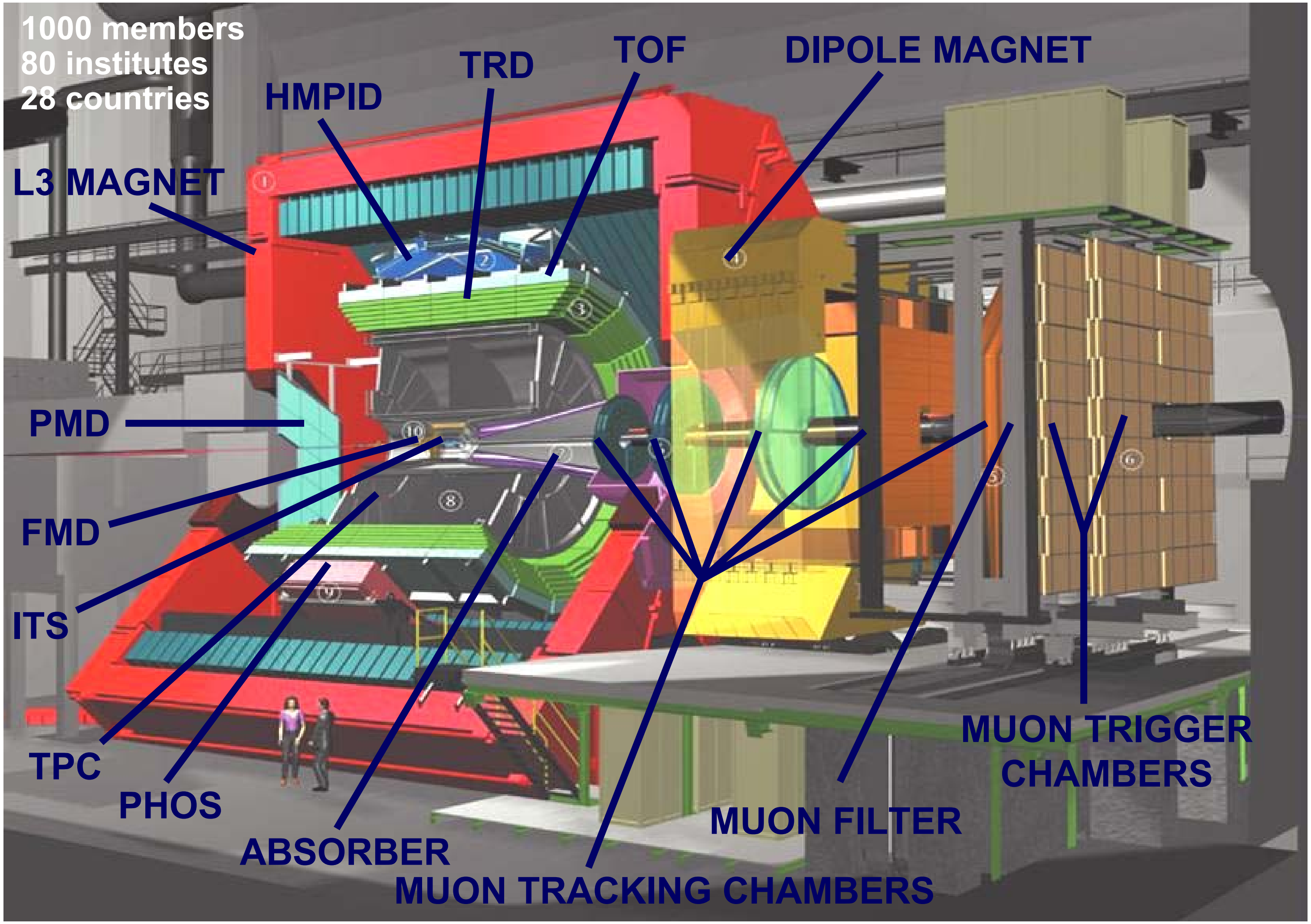
thermal production, kinetic recombination, statistical hadronization, DD annihilation, B hadron decay



rich program & complex background

simultaneous measurements of hidden & open heavy flavors is a must

ALICE: 7(4) SPS(RHIC) experiments in one



Muon spectrometer shopping list

- quarkonia :

  resonances ρ, ω, ϕ, J/ψ, ψ', Υ, Υ', Υ''

  - versus P_t
  - versus centrality
  - versus reaction plane
  - versus system-size

- open heavy flavors

  - single muon p_t distributions
  - unlike-sign dimuon @ high mass
  - unlike-sign dimuon @ low mass
  - like-sign dimuon
  - electron-muon coincidences
  - tri-muons in pp collisions

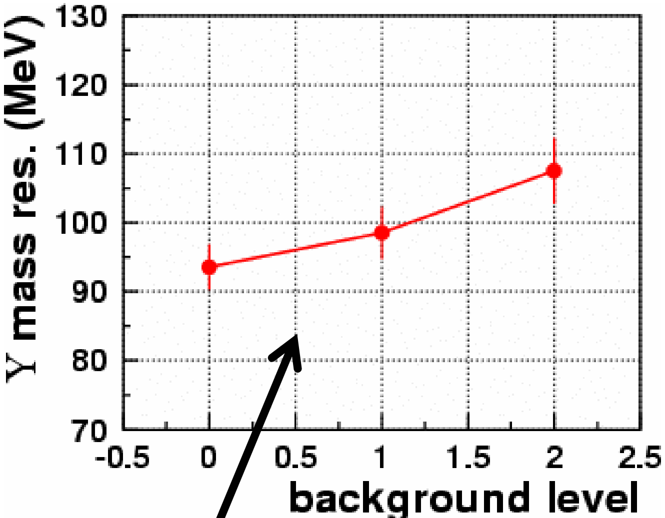
Acceptance : $2° < \theta < 9°$

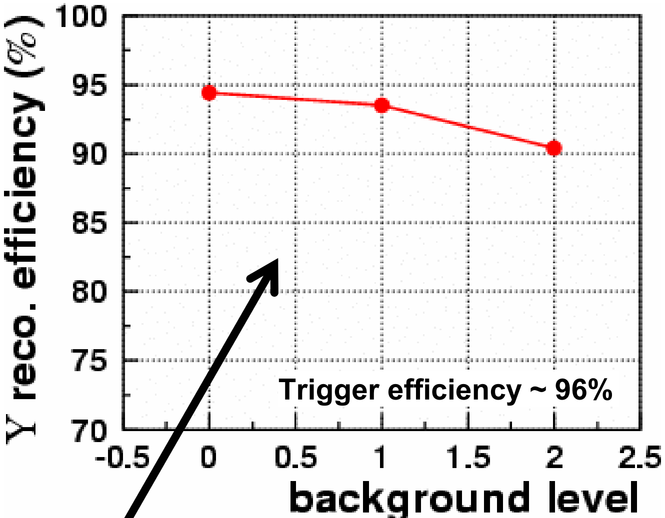
$(2.5 < \eta < 4)$

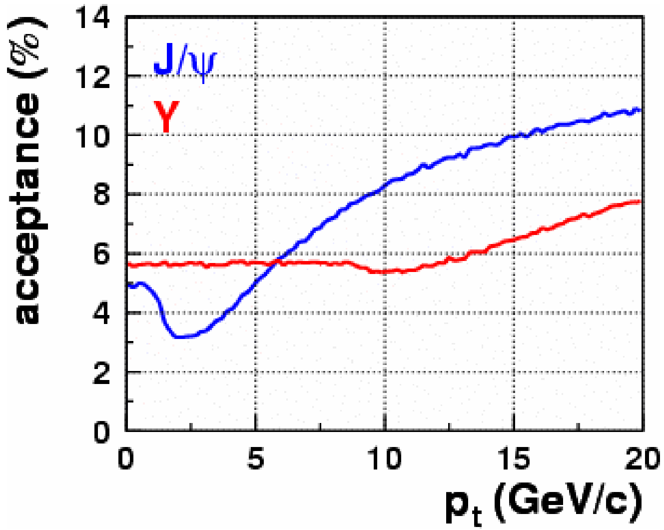
Spectrometer performances for high mass resonance measurements

background level 1 = 2 HIJING evts

with $dN_{ch}/d\eta$ = 6000 @ η = 0 each



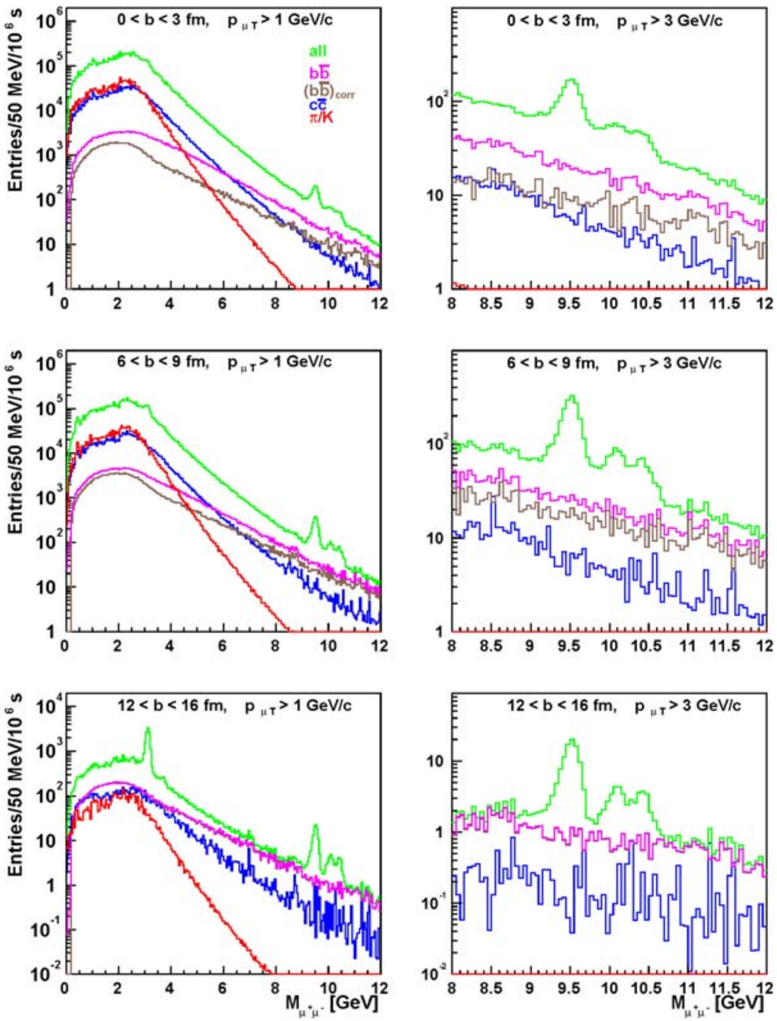




- **ϒ mass resolution ~ 98 MeV**
- **ϒ reconstruction efficiency ~ 93%**
- **J/ψ & ϒ acceptance down to P_t = 0**

Centrality dependence of quarkonium yield

Low p_t^{μ} trigger selection + sharp p_t^{μ} cut $p_t^{\mu} > 1$ GeV/c



Pb – Pb collisions

High p_t^{μ} trigger selection + sharp p_t^{μ} cut $p_t^{\mu} > 3$ GeV/c

***S. Grigoryan*, 2003**

B. Forestier

V. Barret

P. Dupieux

Centrality dependence of quarkonium yield

- x-sections: CERN Yellow Report Hard Probes in Heavy Ion Collisions at the LHC (updated)
- no suppression/enhancement
- full & realistic simulation
  - J/ψ: large stat., S/B & sign. ok
    (allows much narrow centrality bins)
  - ψ': small S/B
  - ϒ: good stat., S/B > 1, sign. ok
  - ϒ': good stat., S/B > 1, sign. ok
  - ϒ'': low statistics
- Large coverage in energy density

PbPb, $\sqrt{s}$ = 5.5TeV, L = 5.10^{26} $cm^{-2}s^{-1}$, T=10^6s,
2σ mass-cut, ε assumes dN_{ch}/dy = 4000 @ y = 0 in central

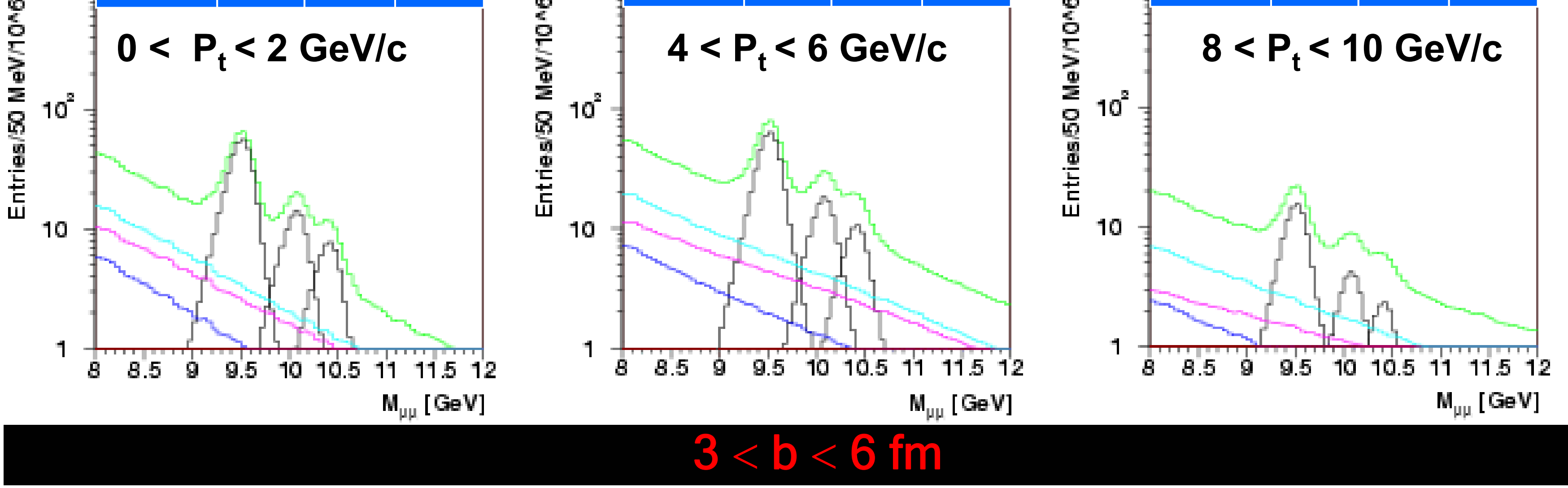
	b (fm)	0-3	3-6	6-9	9-12	12-16	min. bias
	ε (GeV/fm³)	32	30	28	16	5	
J/ψ	S ($x10^3$)	86.48	184.6	153.3	67.68	10.46	502.4
	S/B	0.167	0.214	0.425	1.237	6.243	0.28
	S/√S+B	111.3	180.4	213.8	193.4	94.95	331.5
ψ'	S ($x10^3$)	1.989	4.229	3.547	1.565	0.24	11.57
	S/B	0.009	0.011	0.021	0.063	0.273	0.015
	S/√S+B	4.185	6.902	8.604	9.641	7.171	12.95
ϒ	S ($x10^3$)	1.11	2.376	1.974	0.83	0.118	6.408
	S/B	2.084	2.732	4.31	7.977	12.01	3.246
	S/√S+B	27.39	41.71	40.03	27.16	10.42	69.99
ϒ'	S ($x10^3$)	0.305	0.653	0.547	0.229	0.032	1.766
	S/B	0.807	1.043	1.661	2.871	4.319	1.243
	S/√S+B	11.68	18.26	18.48	13.02	5.077	31.28
ϒ''	S ($x10^3$)	0.175	0.376	0.312	0.13	0.019	1.012
	S/B	0.566	0.722	1.18	1.936	3.024	0.867
	S/√S+B	7.951	12.55	13	9.274	3.73	21.67

P_t dependence of quarkonium yield

	Υ	Υ(2S)	Υ(3S)
S	330	90	50
S/B	4.2	1.7	1.3
S/√S+B	16.2	7.3	5.2

	Υ	Υ(2S)	Υ(3S)
S	370	110	65
S/B	2.1	0.9	0.7
S/√S+B	15.8	7.3	5.2

	Υ	Υ(2S)	Υ(3S)
S	92	25	14
S/B	1.3	0.5	0.4
S/√S+B	7.2	3	2



Semi-central Pb-Pb collisions

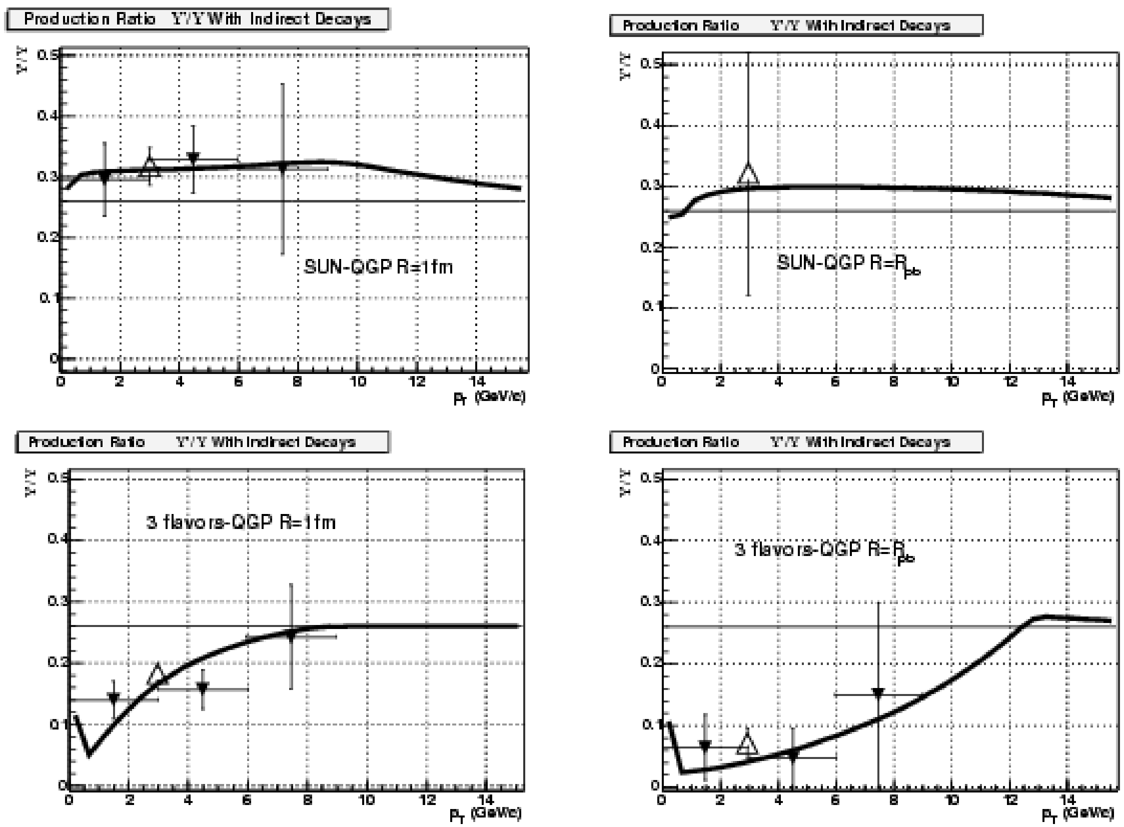
1 month of data taking

***A. De Falco*, 2004**

Υ'/Υ ratio versus P_t

J.P.Blaizot and J.Y.Ollitrault, Phys. Lett. B 199 (1987) 499; F.Karsch and H.Satz, Z. Phys. C 51 (1991) 209; J.F.Gunion and R.Vogt, Nucl. Phys. B 492 (1997) 301

- **Melting depends on**
  - **resonance formation time, dissociation temperature & P_t**
  - **QGP temperature, lifetime & size**
- **Ratio is flat in pp (CDF data)**
- **Any deviation from the pp (pA) value is a clear evidence for the QGP (nuclear effects cancel-out)**
- **The P_t dependence of the ratio exhibits sensitivity to the QGP characteristics**

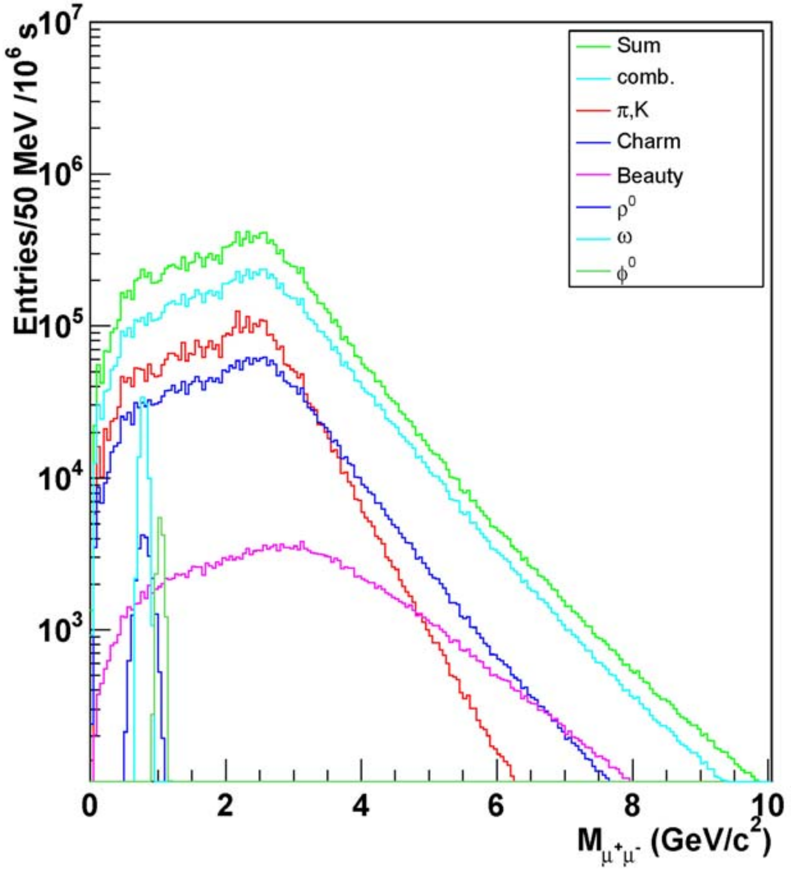


<u>E. Dumonteil</u>, PhD Thesis (2004)

- **full & realistic simulation**
- **error bars = 1 month of central Pb-Pb (10%)**

Low mass resonances

PbPb @ 5.5 TeV, 0 < b < 5 fm
$p_t^\mu > 1$ GeV/c



- probe medium characteristics (CERES @ SPS)
- analysis limited to p_t^μ > 1 GeV/c (trigger threshold for J/ψ) => low acceptance
- for ω : S~5 10^4, S/B~ 0.1, Significance~63 in one month of data taking

__B. Rapp__, PhD Thesis (2004)

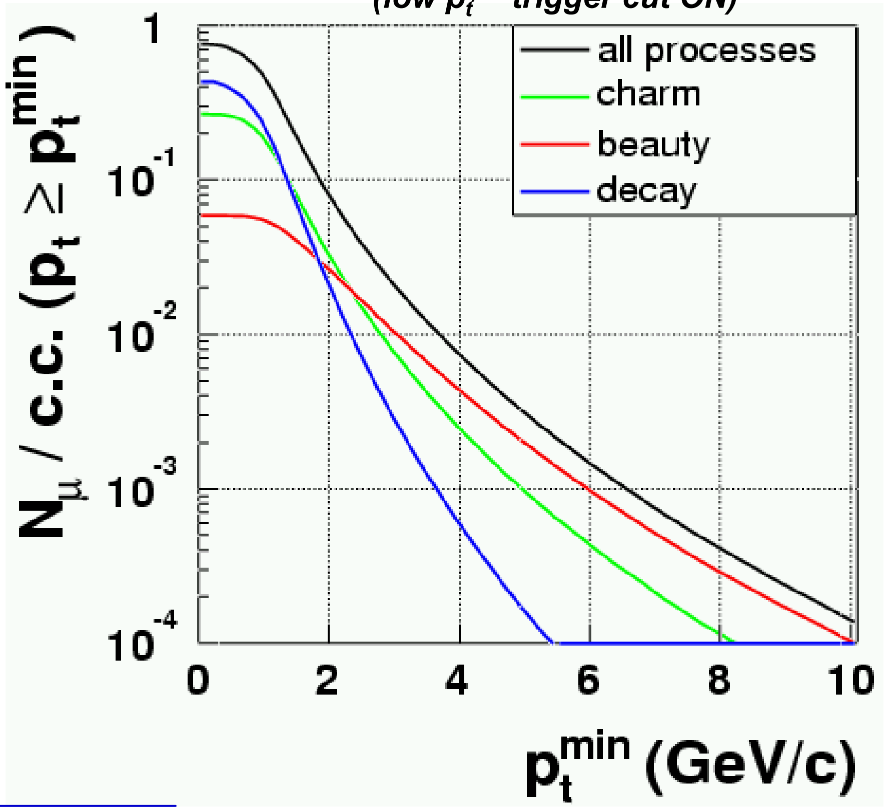
Open heavy flavor measurements

Motivations for measuring open heavy flavors

- in pp : baseline program
- in pA : cold medium effects
- in AA : hot medium effects

⇒ most natural reference to quarkonia suppression/enhancement

number of muons in the spectrometer above a pt threshold, per central PbPb collision (low p_t^{μ} trigger cut ON)



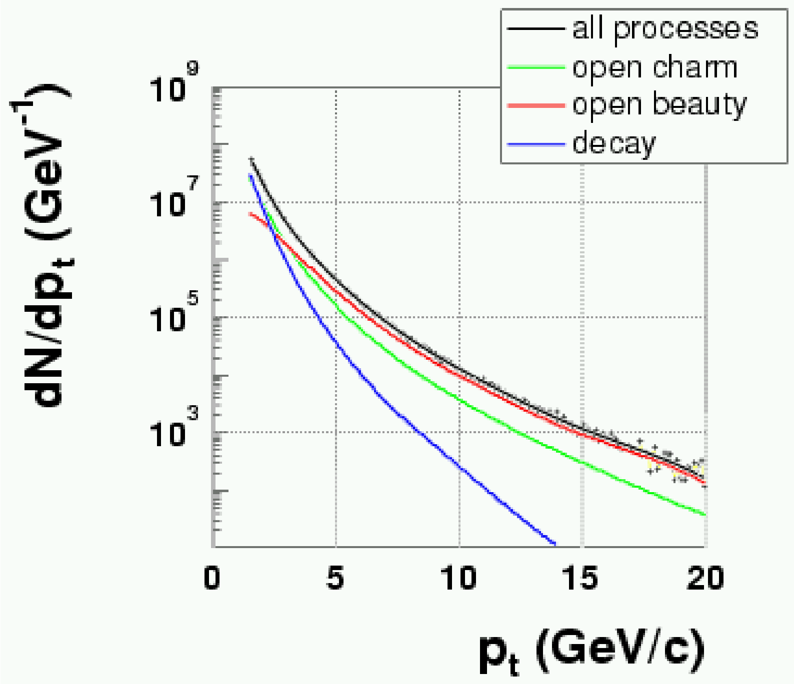
The ALICE muon spectrometer is well suited for open heavy flavor measurements

⇒ large fraction of (single) muons from charm and bottom decay for p_t^{μ} >~ 2GeV/c

Open bottom from single muon

central Pb-Pb (5%)

1 month of data taking

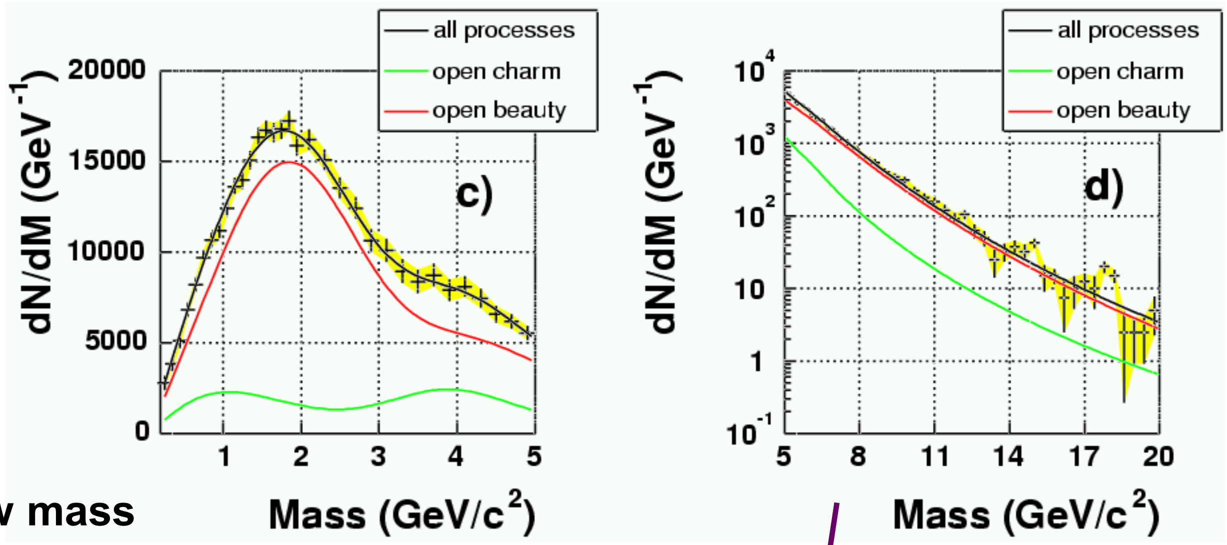


p_t^{μ} (GeV/c)	1.5-3	3-6	6-9	9-30
N_{μ} from b	5.3 10^6	1.7 10^6	0.14 10^6	0.03 10^6

very large statistics is expected

***R. Guernane*, (2004)**

Open bottom from unlike-sign dimuon



dimuon @ low mass

B–chain:

$B^+ \rightarrow \bar{D}^o\, l^+\, \nu_l$

$\quad \hookrightarrow l^- + X$

$B^- \rightarrow X$

dimuon @ high mass

BB–diff:

$\bar{B}^o \rightarrow l^- + X$

$B^o \rightarrow l^+ + X$

Mass (GeV)	0-5	5-20
$N_{\mu\mu}$ from bb	$41\ 10^3$	$7\ 10^3$

central Pb-Pb (5%)
$p_t^{\mu} > 1.5$ GeV/c
1 month of data taking

Large statistics is expected

R. Guernane*, *(2004)

Open bottom from tri-muon events in pp collisions

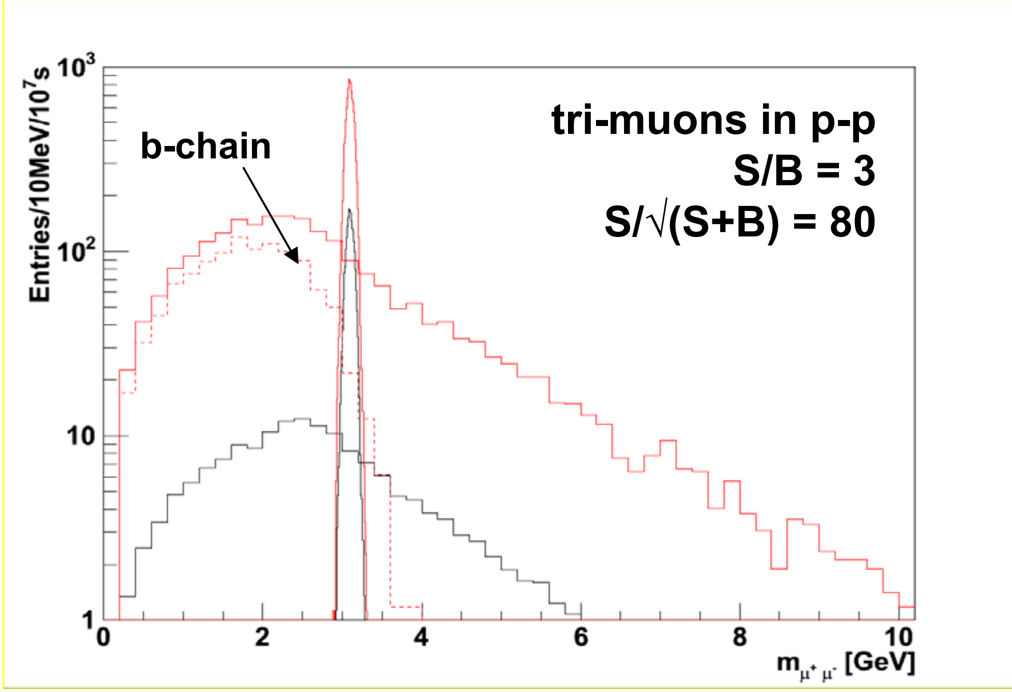
- J/ψ peak (at low Pt) in dimuon p-p evts consists of :
  - ✓ 85% of primary J/ψ
  - ✓ 15% of J/ψ from b decay

- Correlated tri-muons however <u>can only origin from b</u>:
  - ✓ J/ψ peak dominated by
    b-bbar $\rightarrow J/\psi+\mu + X \rightarrow 3\mu + X$

$\Downarrow$

- tri-muons offer a way to measure the fraction of secondary J/ψ w/o direct tagging and select a "clean" beauty sample

  - doable in pp and pA
  - very difficult in central Ar-Ar
  - excluded in Pb-Pb



A. Morsch, (2004)

Summary and outlook

- Very exciting Physics program foreseen with the ALICE muon spectrometer
  - ✓ Quarkonia
  - ✓ Open heavy flavors
- Promising performances of the experimental setup
- Spectrometer capabilities to be investigated in more detail for few channels like
  - ✓ Quarkonia and heavy flavor flow
  - ✓ Like-sign dimuons
  - ✓ Electron-muons coincidences
- Results will be published in the Physics Performance Report of ALICE