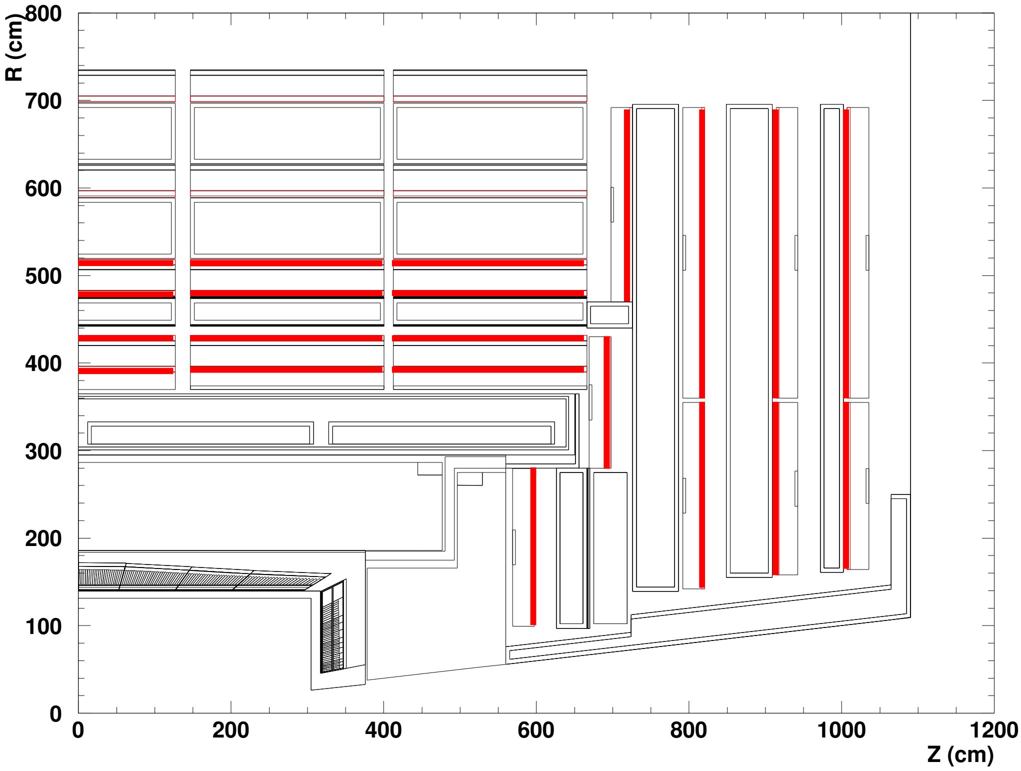
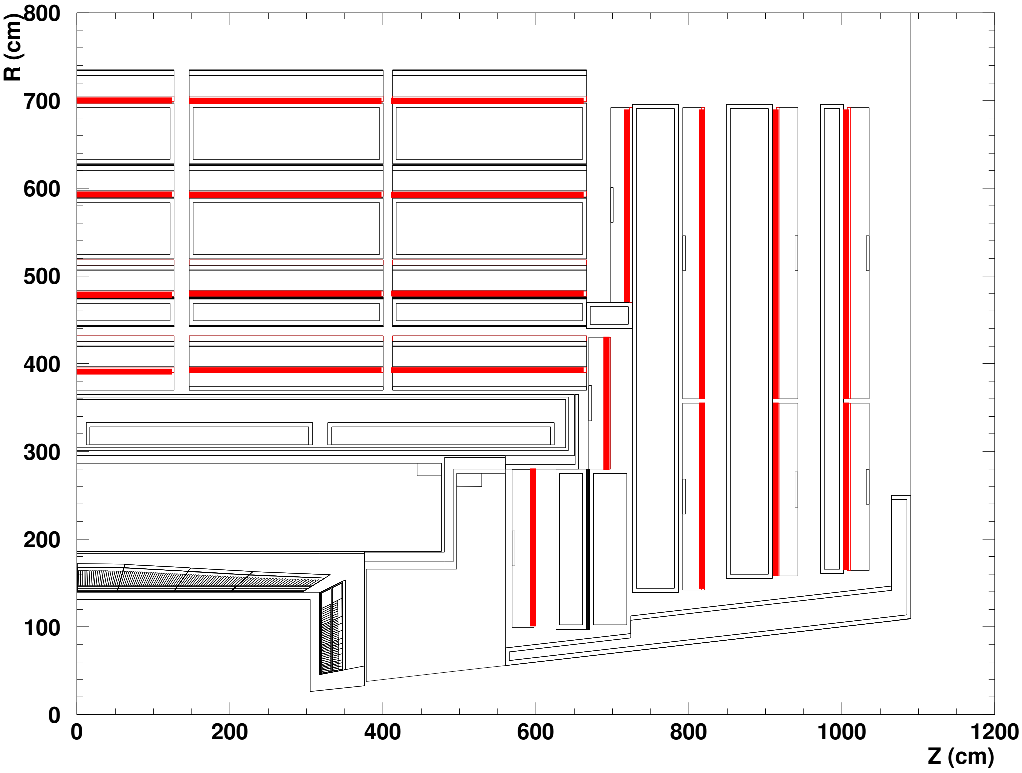
RPC trigger - 4 planes

“low p_t trigger”: $p_t \leq 5$ GeV

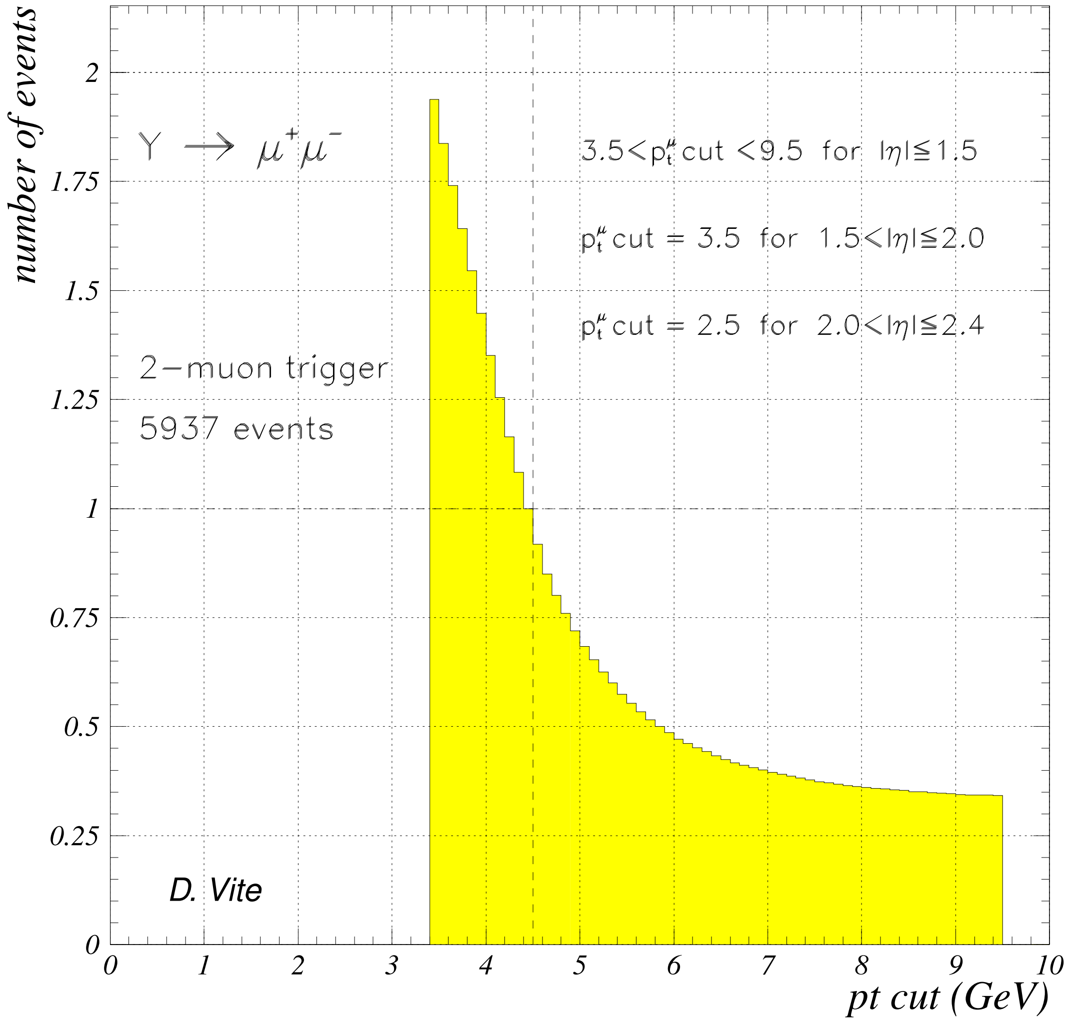


“high p_t trigger”: $p_t > 5$ GeV



Trigger for Υ → μμ

Muons from Υ decays are very soft.



The p_t spectrum rapidly falls down.

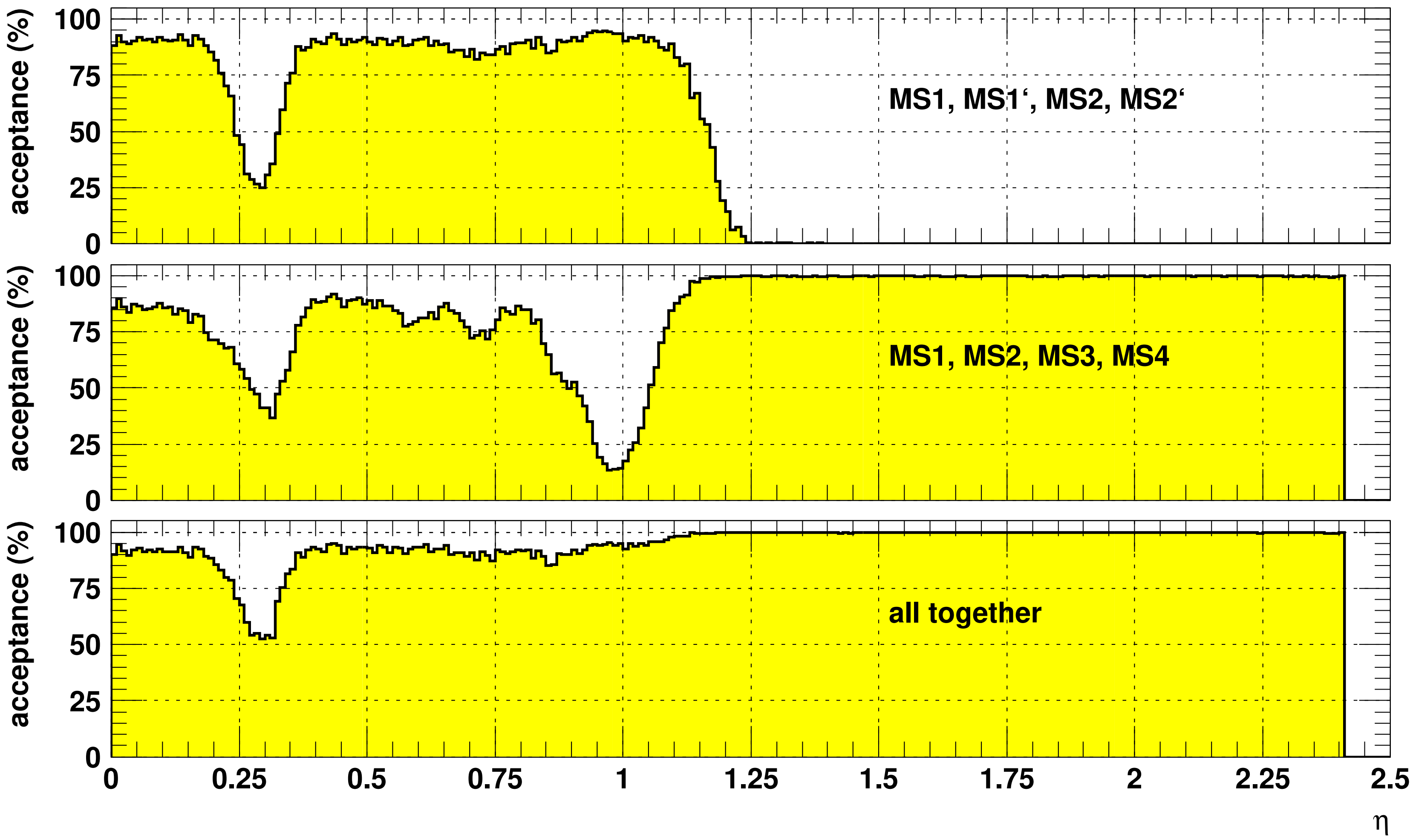
Therefore the lowest possible trigger threshold should be used.

Muon trigger acceptance

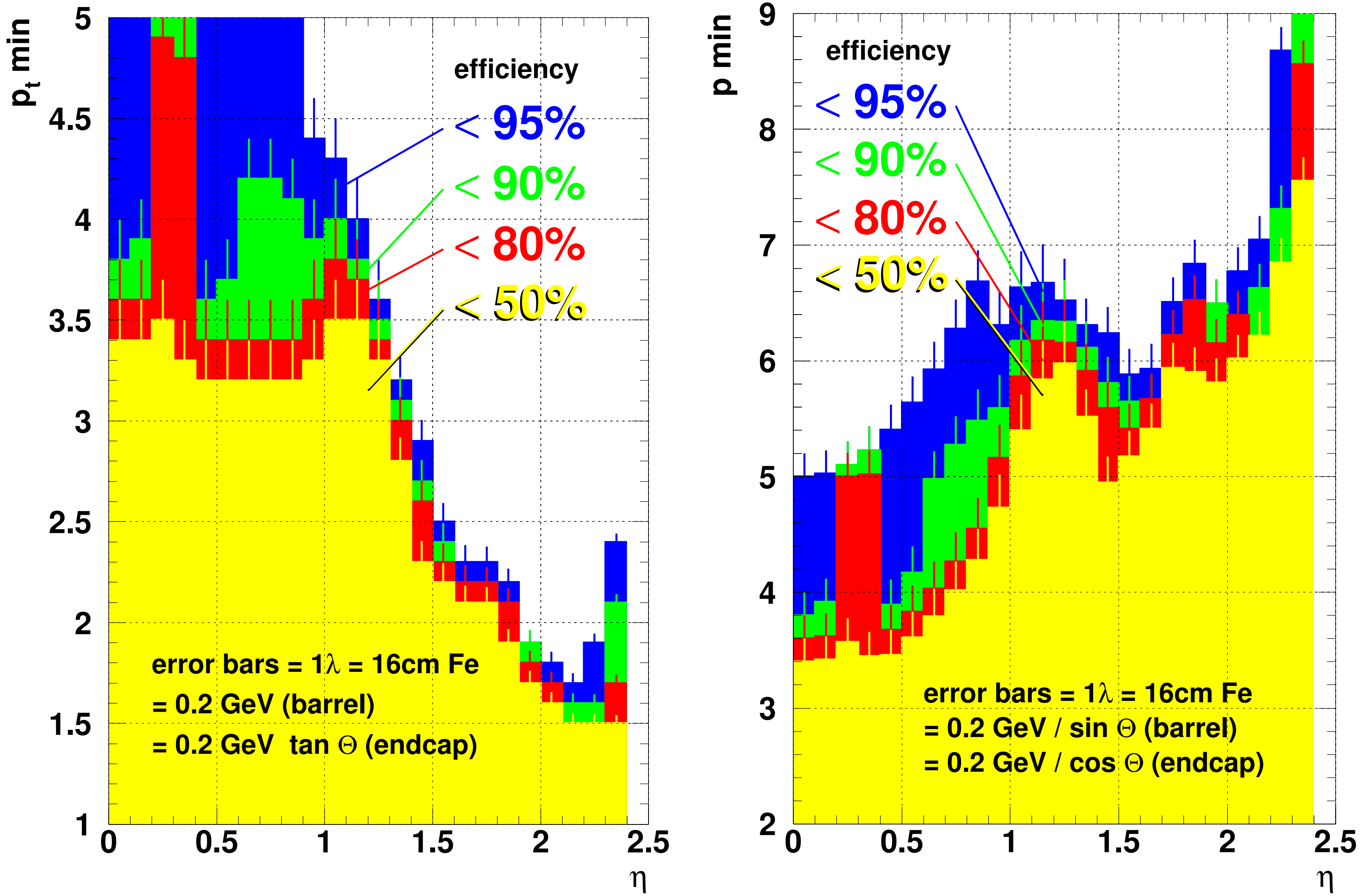
p_t min (vertical axis, 1.5 to 5); η (horizontal axis, 0 to 2.5)

92	92	80	82	94	93	92	91	87	92	94	99	100	99	100	100	99	100	99	100	100	100	99	100	100
91	90	74	81	93	93	92	90	89	93	95	99	99	99	99	100	99	100	100	100	100	100	100	99	100
92	91	69	78	93	92	92	90	90	93	94	99	100	99	99	100	99	100	99	100	99	99	100	99	100
91	90	66	77	92	91	90	89	90	94	95	99	99	99	100	99	99	100	99	99	100	100	100	99	100
91	90	56	73	91	91	91	90	88	93	95	99	99	100	99	99	99	99	99	100	99	99	99	99	100
89	90	55	71	91	92	90	87	89	95	95	99	99	99	99	100	100	99	99	100	99	100	100	99	
90	89	53	69	91	90	88	88	88	93	95	98	99	99	100	100	100	100	100	99	100	99	100	100	100
91	89	54	74	91	92	90	90	90	94	94	98	99	99	99	100	100	99	99	99	99	99	99	99	100
92	88	49	72	90	92	88	88	90	92	93	98	99	99	99	100	99	99	99	99	99	99	99	99	100
91	88	50	72	90	91	88	89	89	91	91	96	99	99	100	99	99	99	100	99	100	100	99	99	100
90	90	50	72	92	90	88	87	88	90	89	93	99	99	99	99	99	99	99	99	99	99	99	99	100
92	87	52	75	91	92	87	86	88	88	84	91	99	99	99	100	100	99	99	99	99	99	99	99	90
89	86	53	75	89	91	89	88	87	85	78	83	97	99	99	99	99	99	99	99	99	99	99	99	100
86	82	54	76	90	89	87	88	86	80	71	73	95	99	99	100	99	99	100	99	100	99	99	99	91
77	74	54	78	89	87	84	86	84	72	58	60	91	99	99	99	99	99	99	99	99	99	99	99	100
66	57	47	71	83	80	80	82	81	64	42	40	83	98	99	100	99	99	99	99	99	99	99	99	100
47	34	33	65	73	73	69	75	72	53	29	25	69	97	99	100	99	99	99	99	99	99	99	98	100
28	14	19	44	53	55	51	62	59	39	19	12	49	96	99	99	99	99	99	99	99	99	99	98	91
15	2	8	23	29	29	30	41	43	28	11	4	33	94	99	99	99	99	99	99	99	99	99	98	95
7		1	6	9	10	14	23	24	17	6	2	17	88	98	99	99	99	99	99	99	99	99	98	87
1				2	2	3	8	10	8	3	1	8	77	97	99	99	99	99	99	99	99	99	97	90
							1	3	2	1		3	64	94	99	99	99	99	99	99	99	99	97	83
									1			1	47	91	99	99	99	99	99	99	99	99	97	90
													28	84	99	99	99	99	99	99	99	99	97	90
													16	76	98	99	99	99	99	99	99	99	95	100
													11	66	94	98	98	99	99	99	99	99	95	87
													8	53	88	96	96	98	99	99	99	99	94	55
													5	36	70	90	91	97	99	99	99	98	93	66
													2	22	44	72	74	94	99	99	99	98	90	81
														10	17	38	42	79	98	99	99	97	89	69
														3	4	10	9	57	95	98	98	96	85	75
														1	1			23	83	97	98	94	84	85
																		3	53	92	96	93	81	50
																			16	74	91	90	76	25
																			1	37	82	83	70	37

Acceptance for $4.5 < p_t^{\mu} < 5.0$ GeV



Minimal muon p_t & p thresholds



Hadron spectra

$$\frac{dR}{dp_t}\left[\frac{\mathrm{Hz}}{\mathrm{GeV}\cdot\eta\text{-unit}}\right] = A\cdot\exp-\frac{\sqrt{m_\pi^2+p_t^2}}{T} \quad \text{for} \quad p_t \le p_t^{lim}$$

$$= \frac{B}{(1+p_t/p_t^0)^n} \quad \text{for} \quad p_t > p_t^{lim}$$

where $A = B\cdot(1+p_t^{lim}/p_t^0)^n \cdot \exp-\frac{\sqrt{m_\pi^2+p_t^{lim2}}}{T}$

Parameter B was choosen to give 2500 particles per η-unit

	CDF pp	**PYTHIA**	**HIJING**
T	0.16 GeV	0.16 GeV	0.16 GeV
p_t^0	1.30 GeV	0.74 GeV	0.16 GeV
n	8.28	7.2	5.1
p_t^{lim}	0.5 GeV	0.5 GeV	1.1 GeV
B	$8.120\cdot10^8$	$8.804\cdot10^8$	$9.355\cdot10^8$

Fits to data simulated with PYTHIA and HIJING
by ALICE (see ALICE note 95-05).

Scaling of hadron spectra

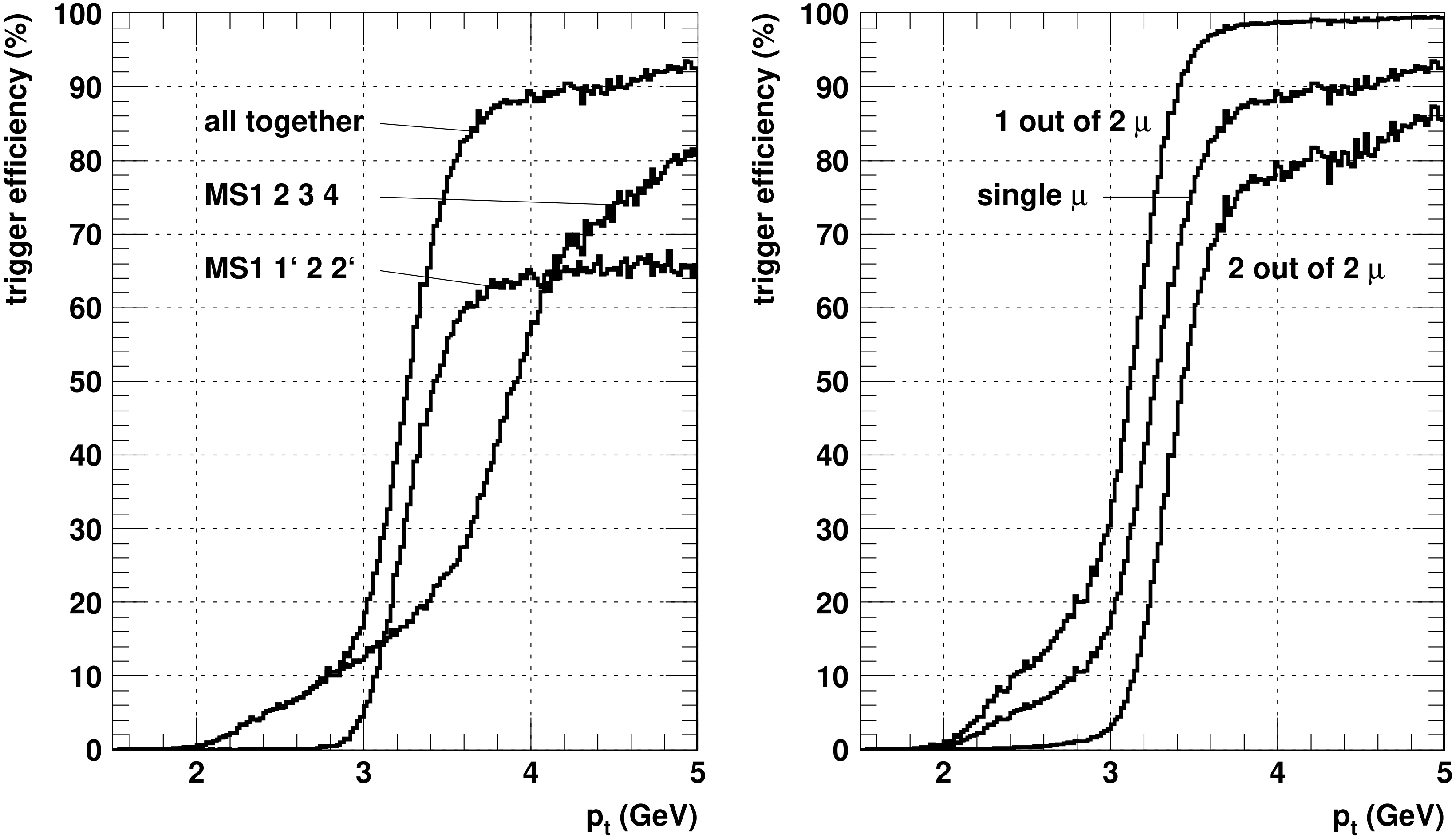
$$\frac{dR}{dp_t}\left[\frac{\text{Hz}}{\text{GeV} \cdot \eta\text{-unit}}\right] = C \cdot 1.1429\times10^{10} \cdot (p_t^{1.306} + 0.8251)^{-3.781}$$

$$\sigma_{AA}^{hard} = A^{2 \cdot 0.95} \cdot \sigma_{pp}^{hard}$$

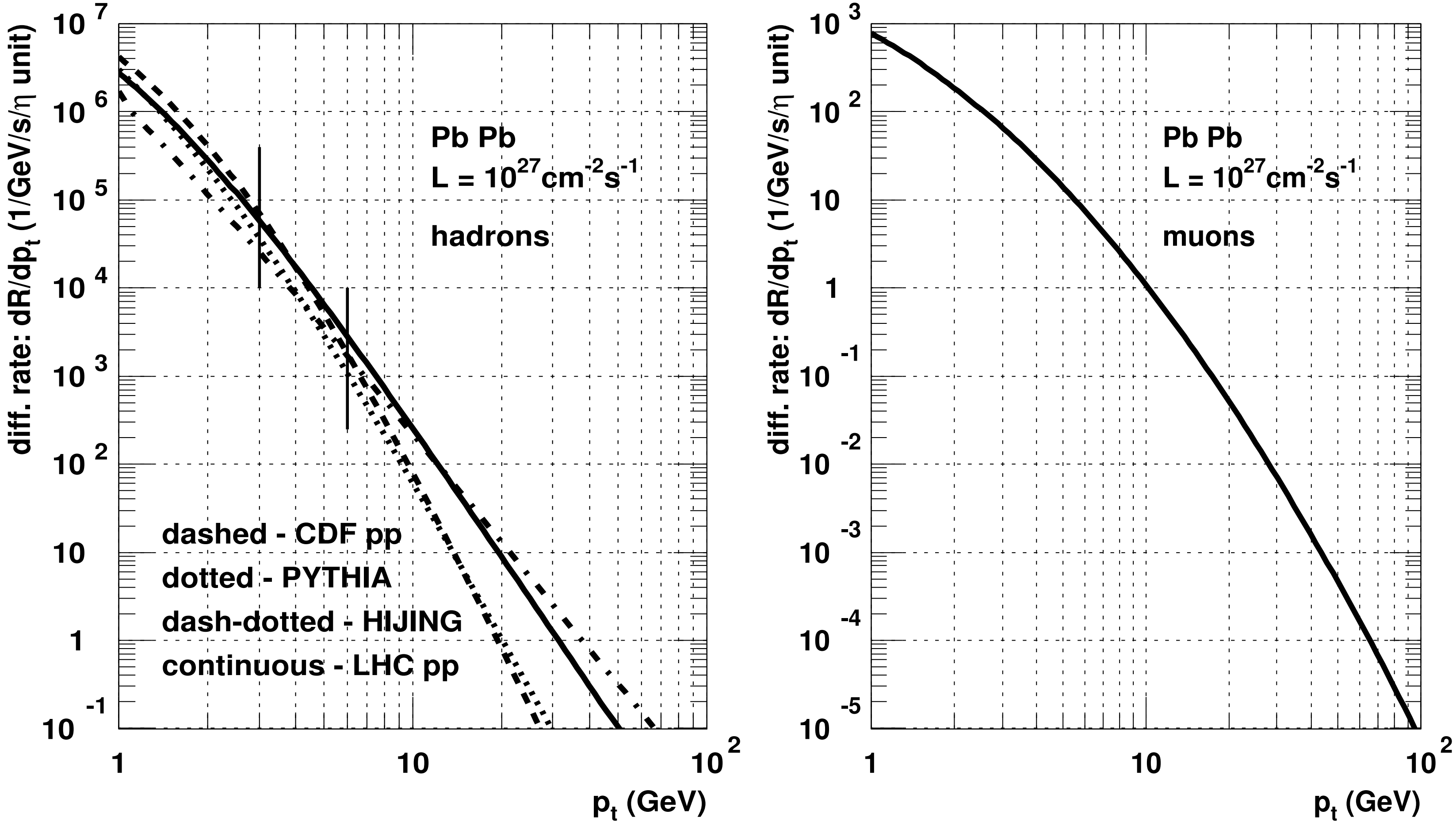
$$C = \frac{R_{AA}(p_t)}{R_{pp}(p_t)} = \frac{\sigma_{AA}^{hard} \cdot L_{AA}}{\sigma_{pp}^{hard} \cdot L_{pp}} = A^{2 \cdot 0.95} \cdot \frac{L_{AA}}{L_{pp}}$$

	pp	**O O**	**Ca Ca**	**Nb Nb**	**Pb Pb**
A	1	16	40	93	207
luminosity [$cm^{-2}s^{-1}$]	10^{34}	$3.2 \cdot 10^{31}$	$2.5 \cdot 10^{30}$	$9 \cdot 10^{28}$	10^{27}
C	1	0.621	0.277	0.0495	0.00251

3 out of 4 RPC planes, $|\eta|<1.5$



Particle rates in Pb-Pb collisions



Hadron simulation

CMSIM101 / **GEANT** / **FLUKA** with the following cuts:

distance to μ-chambers	far	close	inside
electrons/photons	100 MeV	10 MeV	10 keV
neutrons	1 MeV	1 MeV	1 MeV
charged hadrons	1 MeV	1 MeV	100 keV
muons	10 MeV	10 MeV	100 keV

Simulation time at SHIFTCMS

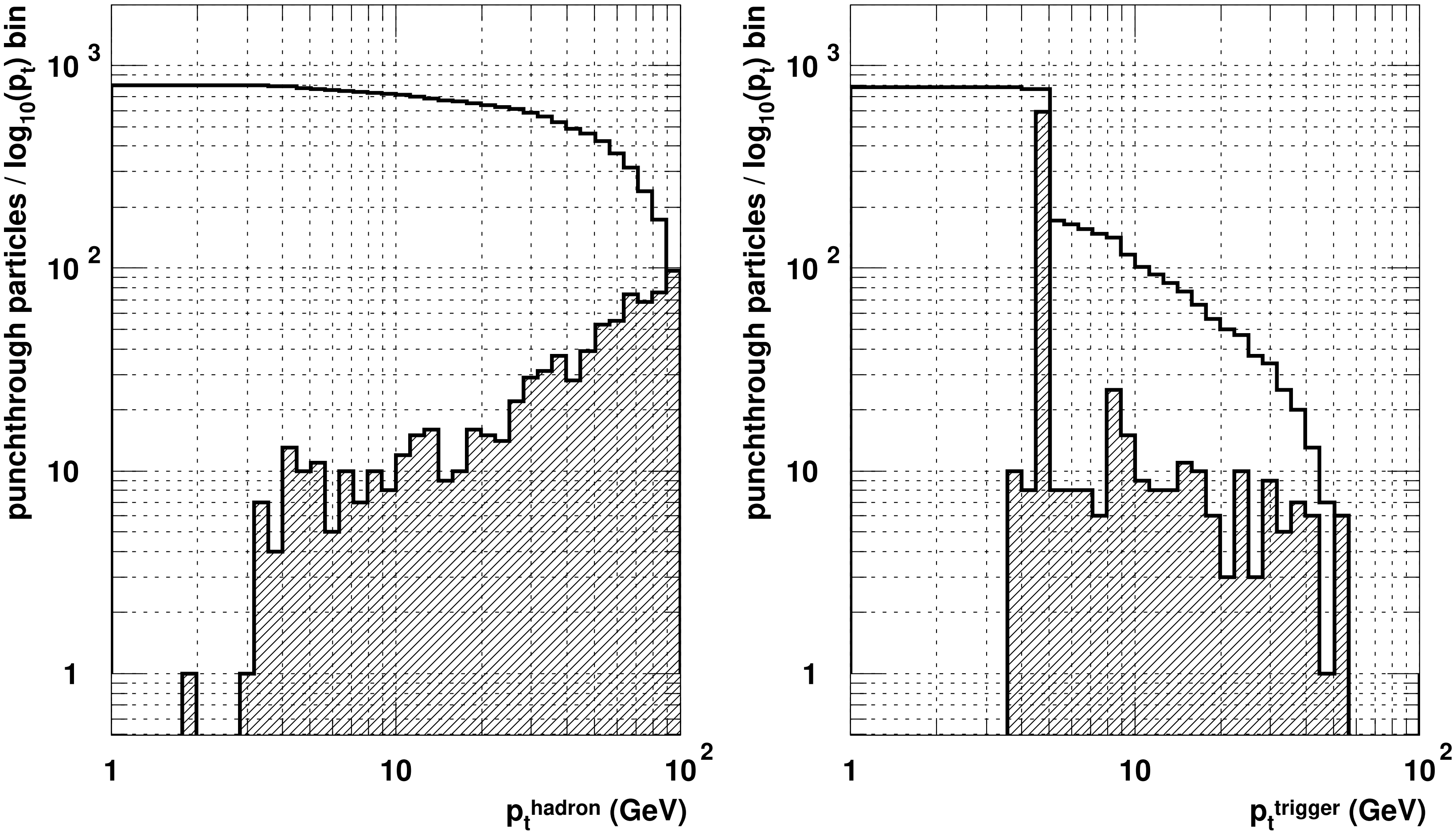
μ	$\langle\pi\rangle \in$ 1-100 GeV	π = 100 GeV	π = 1 TeV	min. bias event
0.04 s	2.2 s	1 min.	5 min.	1 min.

Single hadrons were generated with flat $\log_{10}(p_t)$ distribution at $|\eta|<0.25$:

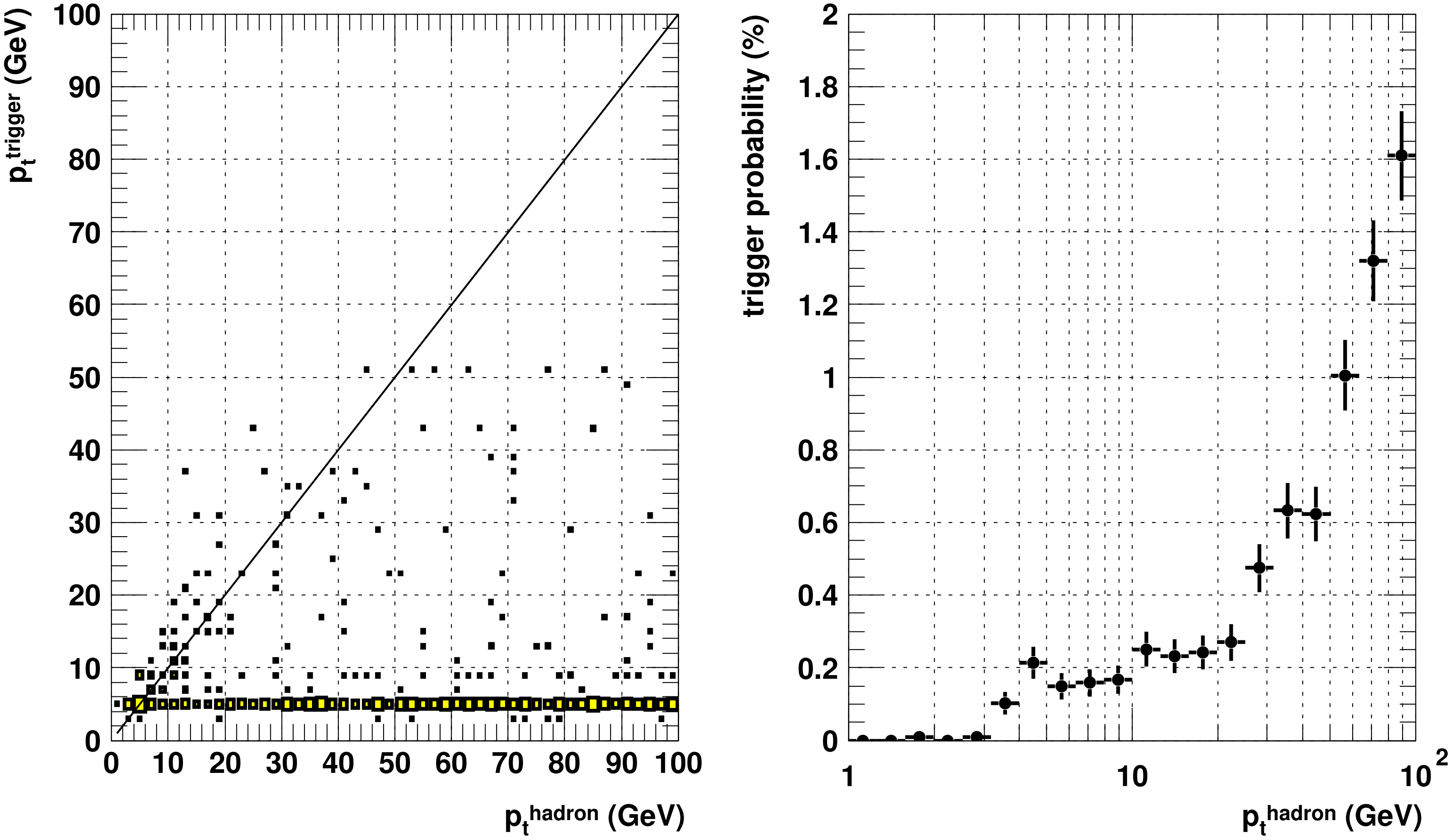
31.62% of π^+, π^-,   5.32% of K^+, K^-, K^0_L, K^0_S,   3.87% of p, $\bar{p}$, n, $\bar{n}$

simulation time	events simulated	triggered	fraction
5.5 CPU days	215 000	803	0.37%

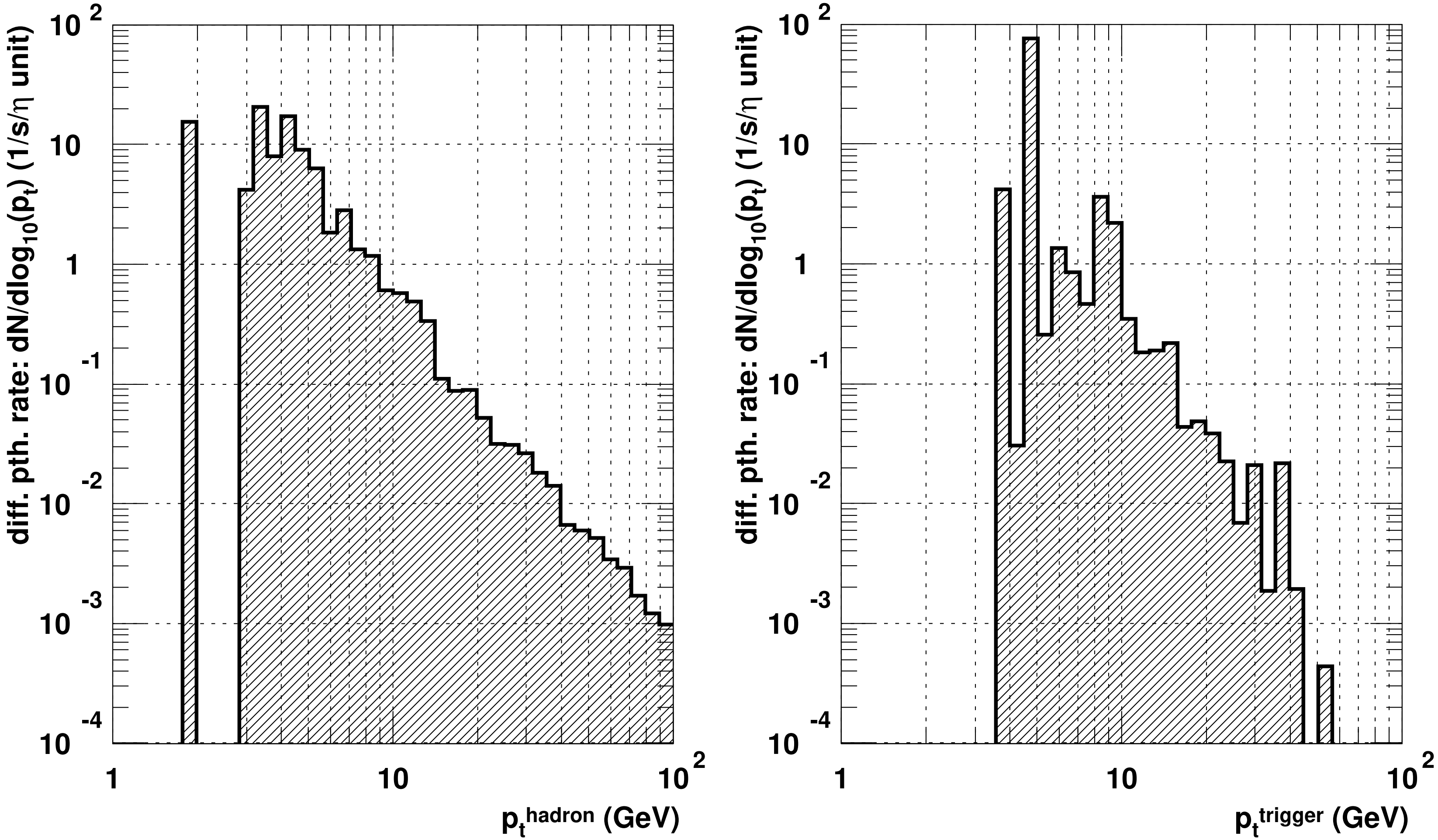
Raw spectra of triggering hadrons



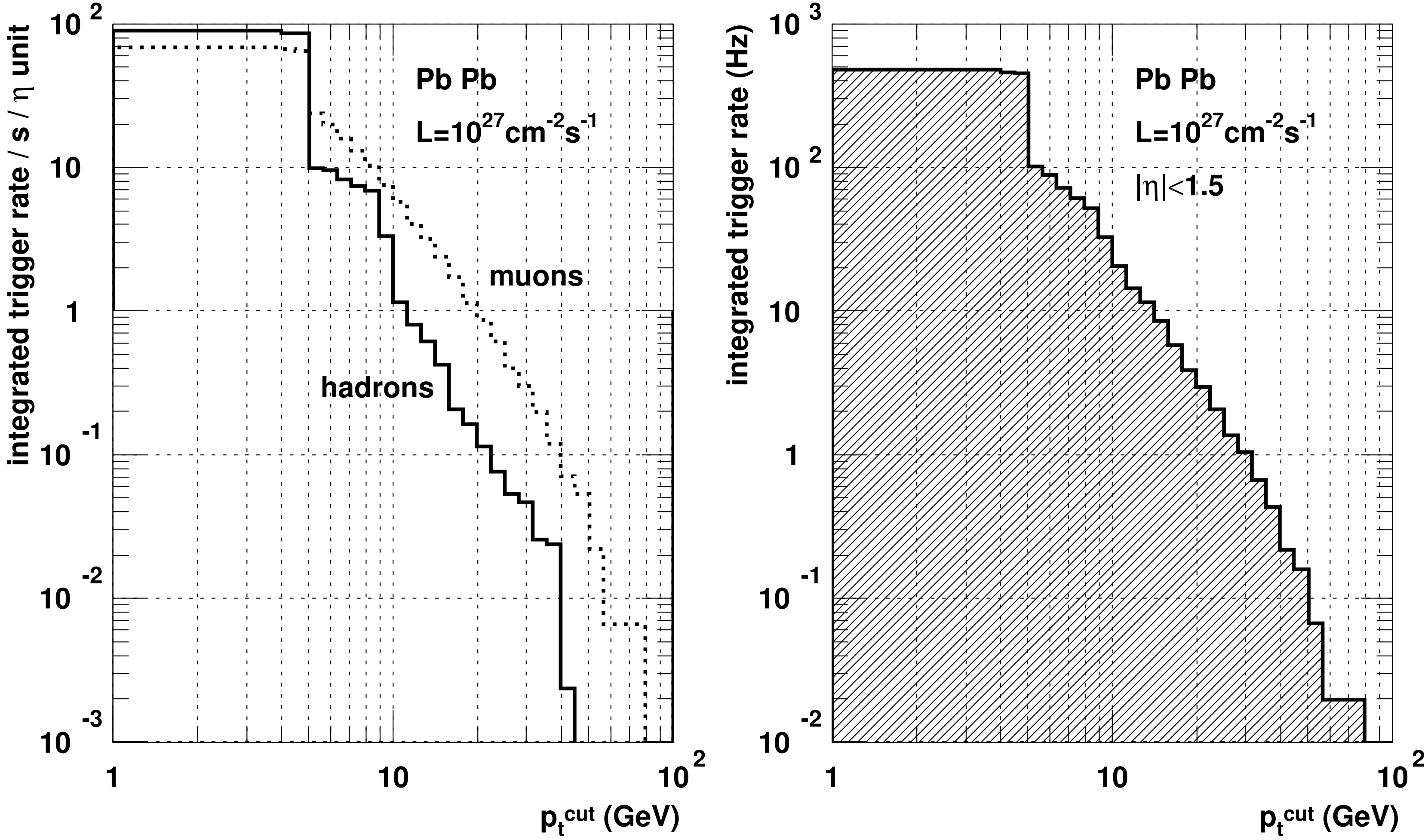
Hadrons causing a trigger



Spectra of hadrons causing a trigger



Single muon trigger rates



Luminosity and trigger rates

Initial luminosities for 1 experiment, 125 ns bunch spacing

	pp	**O O**	**Ca Ca**	**Nb Nb**	**Pb Pb**
luminosity [$cm^{-2}s^{-1}$]	10^{34}	$3.2 \cdot 10^{31}$	$2.5 \cdot 10^{30}$	$9 \cdot 10^{28}$	10^{27}
average collision rate [kHz]	550 000	32 000	5200	400	7.6
1μ trigger rate [kHz]	190	120	53	10	0.5

- **bunch spacing 25 ns ⇒ luminosity × 4-5** (not possible for Pb-Pb)
- **2 experiments ⇒ luminosity / 3-4**
- **3 experiments ⇒ luminosity / 6-9**

Pb Pb: experiments	**1**	**2**	**3**
luminosity [$cm^{-2}s^{-1}$]	10^{27}	$3.3 \cdot 10^{26}$	$1.7 \cdot 10^{26}$
average collision rate [Hz]	7600	2500	1300
1μ trigger rate [Hz]	500	165	85
2μ trigger rate [Hz]	60	20	10

O O collisions

- **Bunch spacing of 125 ns gives bunch crossing rate of**

8 MHz

- **Luminosity quoted** (e.g. by ALICE LOI) **for O-O collisions**
  – 1 experiment, 125 ns bunch spacing

$$L = 3 \cdot 10^{31} cm^{-2} s^{-1}$$

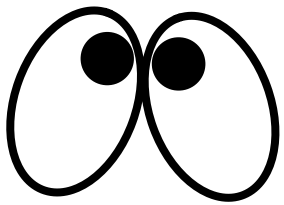
- **With a cross section of σ = 1 barn this gives the average collision rate of**

30 MHz

- **Thus we have on average a pileup of**

4 O-O collisions per bunch crossing !!!

- ***Isn't it too much of happiness?!***



Conclusions

- **The p_t spectra above 1 GeV in AA collisions at $\sqrt{s}$ = 5-7 TeV are not much different from those in pp collisions at $\sqrt{s}$ = 14 TeV**
- **Simple scaling by $A^{2 \cdot 0.95}$ works well**
- **Thus one can use a lot of predictions calculated for the pp case**
  - For example one gets Pb-Pb rates at $L=10^{27} cm^{-2}s^{-1}$ multiplying pp rates at $L=10^{34} cm^{-2}s^{-1}$ by 0.0025
- **For Pb-Pb at $L=10^{27} cm^{-2}s^{-1}$ one can expect single muon trigger rate:**
  - **210 Hz** from prompt muons *(c- and b-quark decays)*
  - **280 Hz** from hadronic punchthrough and decays *(mainly π and K)*

Strategy for dimuon trigger

Assumptions:

– $L=10^{27} cm^{-2}s^{-1}$ (1 experiment running at the time) for Pb-Pb
– mass storage capacity: 60 events/s
– equal rates for muon and calorimeter triggers

- **Require single muon trigger** ($|\eta|<1.5$) **at the first level** $\Longrightarrow$ **500 Hz**
- **Search for a second muon** ($|\eta|<1.5$) **at the second level** $\Longrightarrow$ **60 Hz**

One can write to tape 30 dimuon events/s $\Longrightarrow$ factor 2 missing

Possibilities:

- **have a bigger mass storage**
- **reduce the luminosity**
- **reconstruct** $\Upsilon \rightarrow \mu\mu$ **at the virtual third level**

  assume farm of 500 processors, divided equally for 2^{nd} and 3^{rd} level, and for muon and calorimeter events

  $\Longrightarrow$ available processing time per event = 500 / 2 / 2 / 60 Hz = **2 s**

  Is it feasible?