"Overcoming" Combinatorics

Possibility of studying multiparticle resonant states with early STAR data

A. Chikanian
J. Sandweiss

STAR coll. Mtg.
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...sandweiss
STAR Feb. 99

"Overcoming" Combinatorics

Despite what seems like overwhelming combinatoric background, resonant states like $\rho^0 \to \pi^+ \pi^-$ are measurable at STAR

with the very earliest data!

There are two basic reasons:

1) Excellent acceptance of STAR
   - corresponding high statistics

2) The effectiveness of "mixed" event background subtraction in high energy heavy ion reactions.

   - In a typical central heavy ion collision at RHIC ~1000's of particles are made

   Removing one (or two) does not have any sensible effect on the kinematic constraints on the remaining particles.

Mixed Event Background ...

Calculate "Same" spectrum by calculating all $\pi^+ \pi^-$ invariant mass values where $\pi^+ \pi^-$ chosen from a given (same) event

e.g. $\left(\pi^+_i \; \pi^-_j\right)_{ev(k)}$

a) Calclate associated "mixed" spectrum

$$\left(\pi^+_i\right)_{ev(k)} \cdot \left(\pi^-_j\right)_{ev(k+1)}$$

where j chosen randomly from the π^- of event $k+1$.

b) likewise $\left(\pi^-_j\right)_{ev(k)} \cdot \left(\pi^+_i\right)_{ev(k+1)}$

where i chosen randomly from $k+1$.

Mixed spect = average of (a) + (b).

$$\boxed{\text{"True" Spect.} = \text{Same} - \text{Mixed}}$$

There are refinements but this is good 1st app.

Back of Envelope Calculation

Take $\rho^0 \to \pi^+ \pi^-$ example

assume: $1000\ \pi^+$
$1000\ \pi^-$ $\Rightarrow 10^6\ \pi^+\pi^-/ev$

$$\frac{\rho_0}{\pi^0} \cong \frac{\rho^0}{\pi^+} \cong .1 \Rightarrow 100\ \rho^0 \to \pi^+\pi^-/ev$$

Statistical accuracy of mixed event background: TAKE 1000 events

in 1000 events get $1000 \times 10^6 = 10^9\ \pi^+\pi^-$

in 1000 events get $1000 \times 100 = 10^5\ \rho^0 \to \pi^+\pi^-$

$$\frac{\text{Signal}}{\text{Noise}} = \frac{10^5}{\sqrt{10^9}} = \frac{10^5}{3.16 \times 10^4} \cong 3\ \sqrt{N}$$

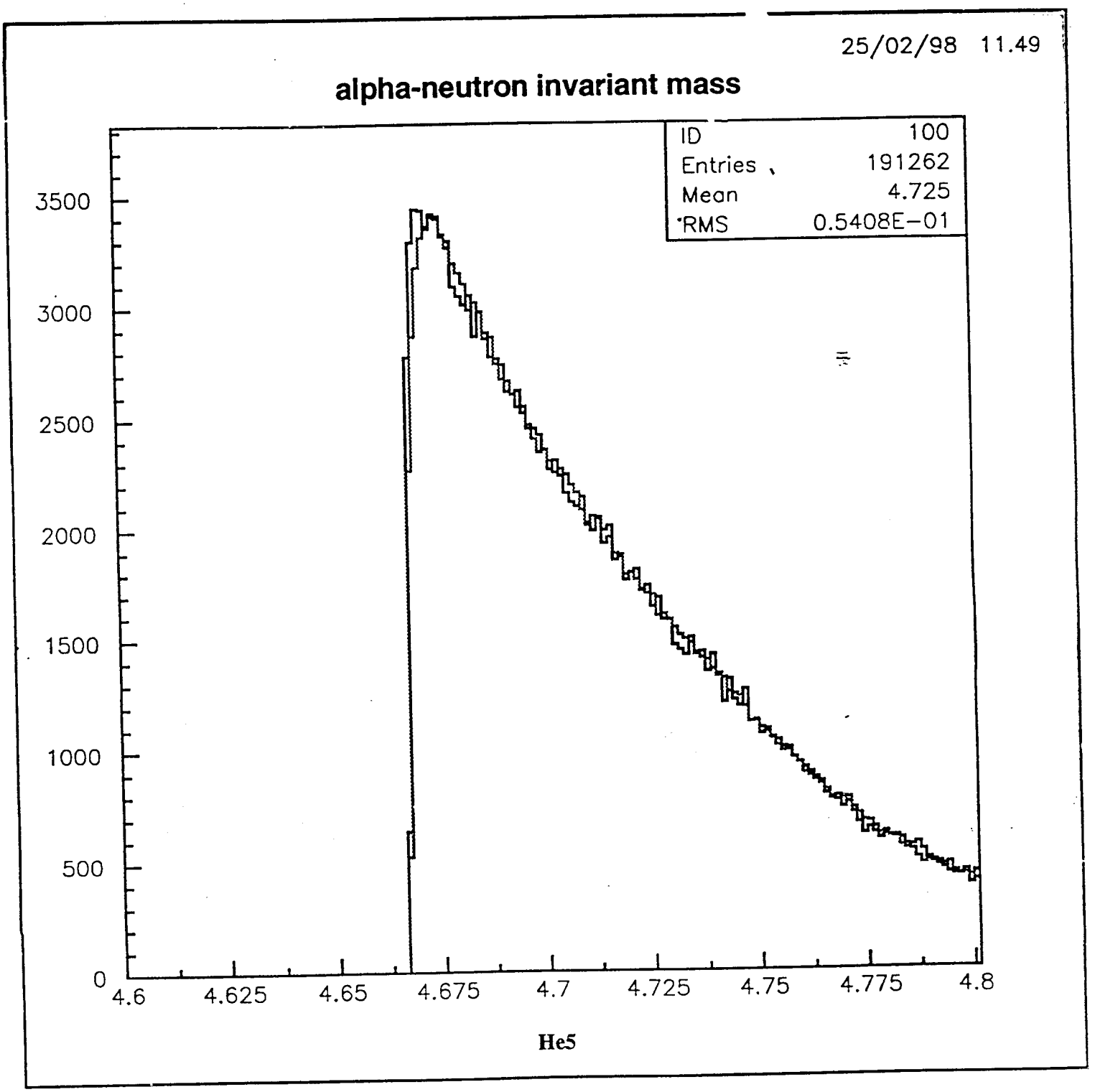
Experimental example: site (nd resonances) from E-896

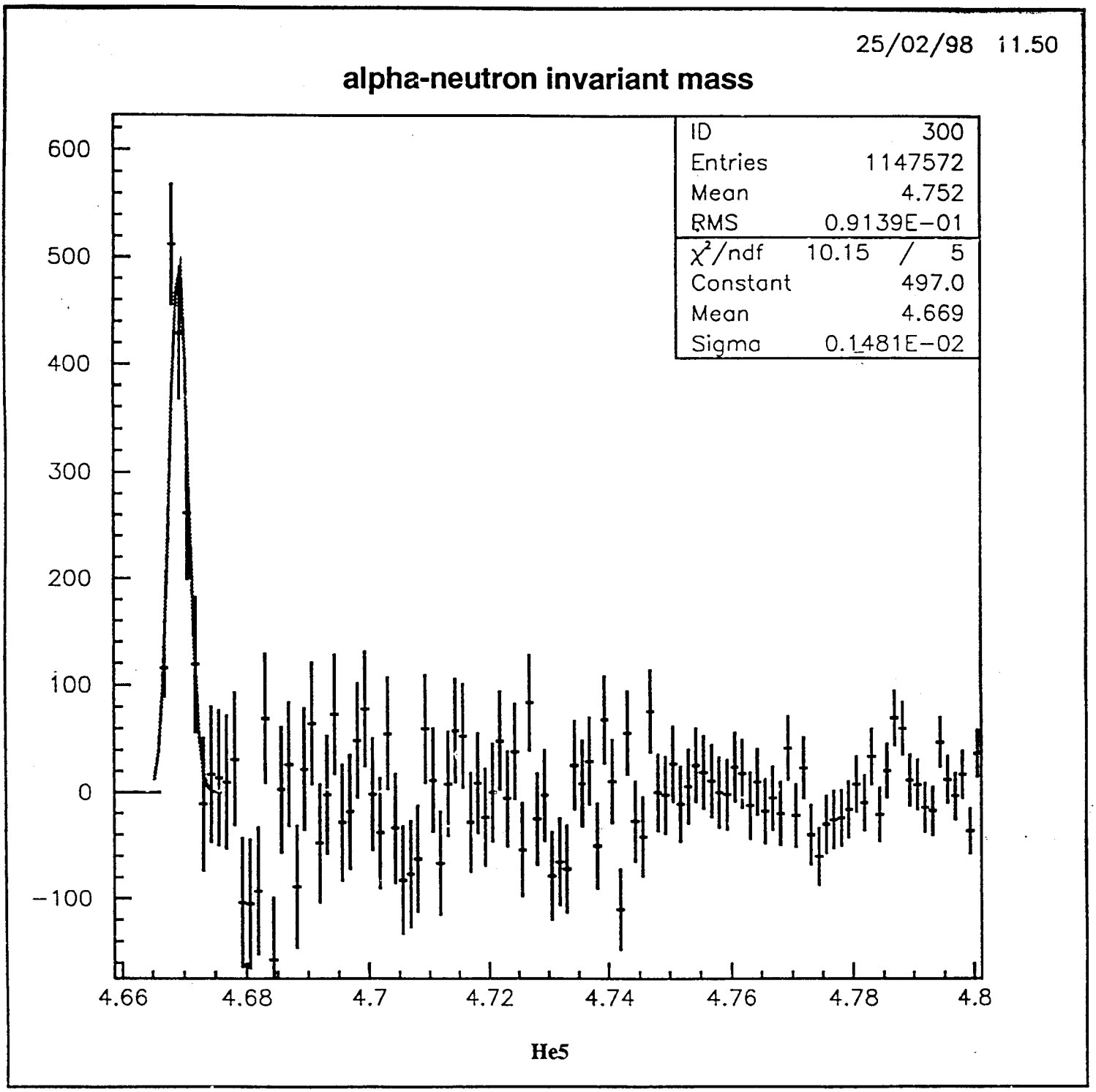
Monte Carlo for STAR at RHIC $100 \times 100\ Au^2$

HIJING: $P_T > 250$ MeV/c
$\theta > 22°$
$\Delta\theta_{+-} > 10$ mr

meas. errors $\frac{\Delta P_x}{P_x} = \frac{\Delta P_y}{P_y} = \frac{\Delta P_z}{P_z} = 3\%$ uncorrel.

April 24-29
ZBX data
"1.5T"
200m events (96-97 Stslt run)




25/02/98 11.50
alpha-neutron invariant mass
ID 300
Entries 1147572
Mean 4.752
RMS 0.9139E-01
χ²/ndf 10.15 / 5
Constant 497.0
Mean 4.669
Sigma 0.1481E-02
600
500
400
300
200
100
0
-100
4.66
4.68
4.7
4.72
4.74
4.76
4.78
4.8
He5

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HIJING

Heavy Ion Jet INteraction Generator

by

X. N. Wang and M. Gyulassy

Lawrence Berkeley Laboratory

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**************************************************
*                                                *
*        HIJING has been initialized at          *
*            Ecm =     200.00 GeV/n              *
*                                                *
*       for A   (197, 79) + A   (197, 79)        *
**************************************************
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V e r s i o n 1.33

Last modification on Apr.10, 1996

List of resonances generated by HIJING event generator
in Au Au collision at 100 GeV/nucl

Total # of generated events is 10688
(~ 3h STAR runnig time, assuming 1 Centr.AuAu ev/sec)

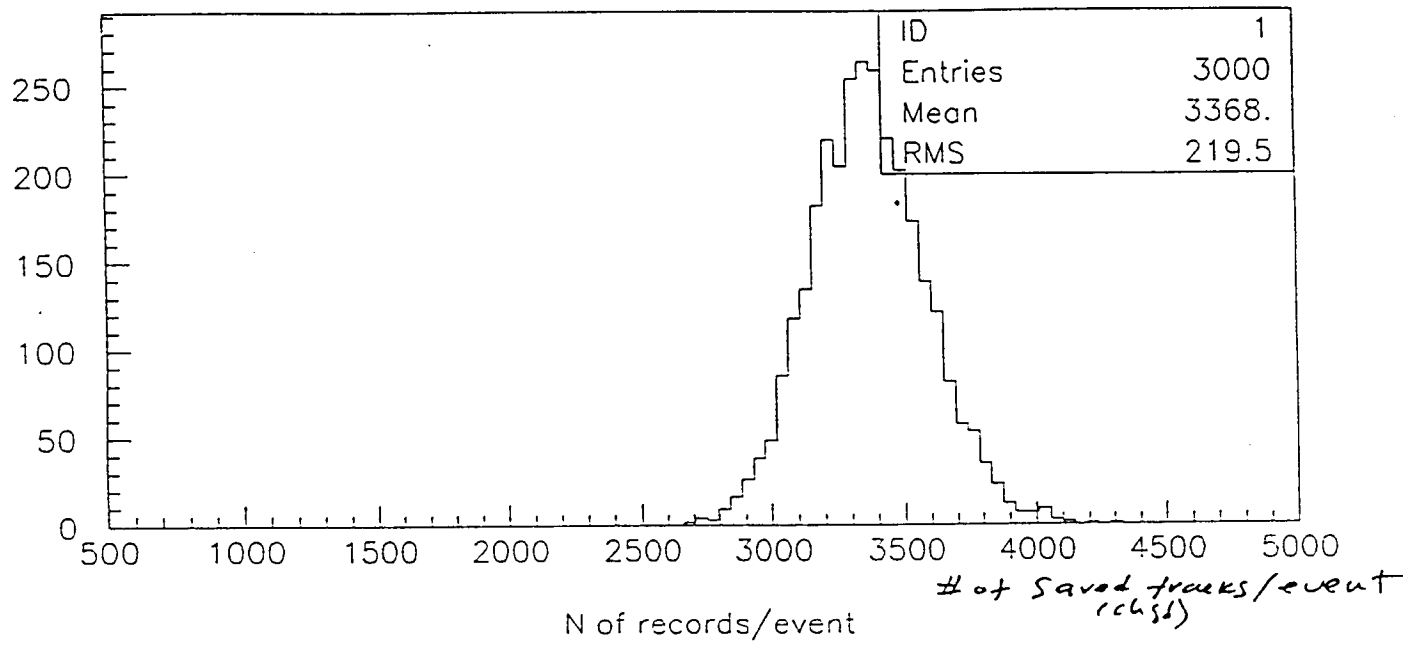
Cuts:	Pt>100 Th>15		Pt>100 Th>22		Pt>250 Th>22		(MeV),(deg)	
	Tot#	#/ev	Tot#	#/ev	Tot#	#/ev	PID	
	2498160	233.7	1913565	179.0	1128591	105.6	113	ρ
	1695898	158.7	1321193	123.6	371768	34.78	223	ω
	372862	34.89	295450	27.64	63756	5.965	221	η
	817468	76.48	636526	59.56	183695	17.19	310	K_s^0
	268872	25.16	212002	19.84	26767	2.504	331	η'
	3927	0.3674	2963	0.2772	1195	0.1118	333	ϕ
	966	0.0904	767	0.0718	366	0.0342	421	D^0
	1019	0.0953	821	0.0768	375	0.0351	-421	
	556	0.0520	440	0.0412	182	0.01703	411	D^+
	564	0.0528	468	0.0438	171	0.01600	-411	
	105	0.0098	90	0.0084	51	0.00477	431	D_s^+
	94	0.0088	76	0.0071	34	0.00318	-431	
	89	8.327E-3	73	0.0068	22	0.00206	4122	Λ_c^+
	88	8.234E-3	70	0.0065	15	0.00140	-4122	
	8	7.485E-4	7	6.549E-4	2	1.871E-4	443	J/ψ
	3	2.807E-4	3	2.807E-4	2	1.871E-4	4232	Ξ_c^+
	1	9.356E-5	1	9.356E-5	0		-4232	
	2	1.871E-4	2	1.871E-4	2	1.871E-4	-531	$\tilde{B}_s^0$
	2	1.871E-4	1	9.356E-5	1	9.356E-5	-521	B^-
	1	9.356E-5	0		0		4132	Ξ_c^0
	3	2.807E-4	3	2.807E-4	0		-4132	
	2	1.871E-4	2	1.871E-4	1	9.356E-5	-5122	$\tilde{\Lambda}_b^0$
	1	9.356E-5	1	9.356E-5	0		511	B^0
	4	3.743E-4	4	3.743E-4	0		-511	

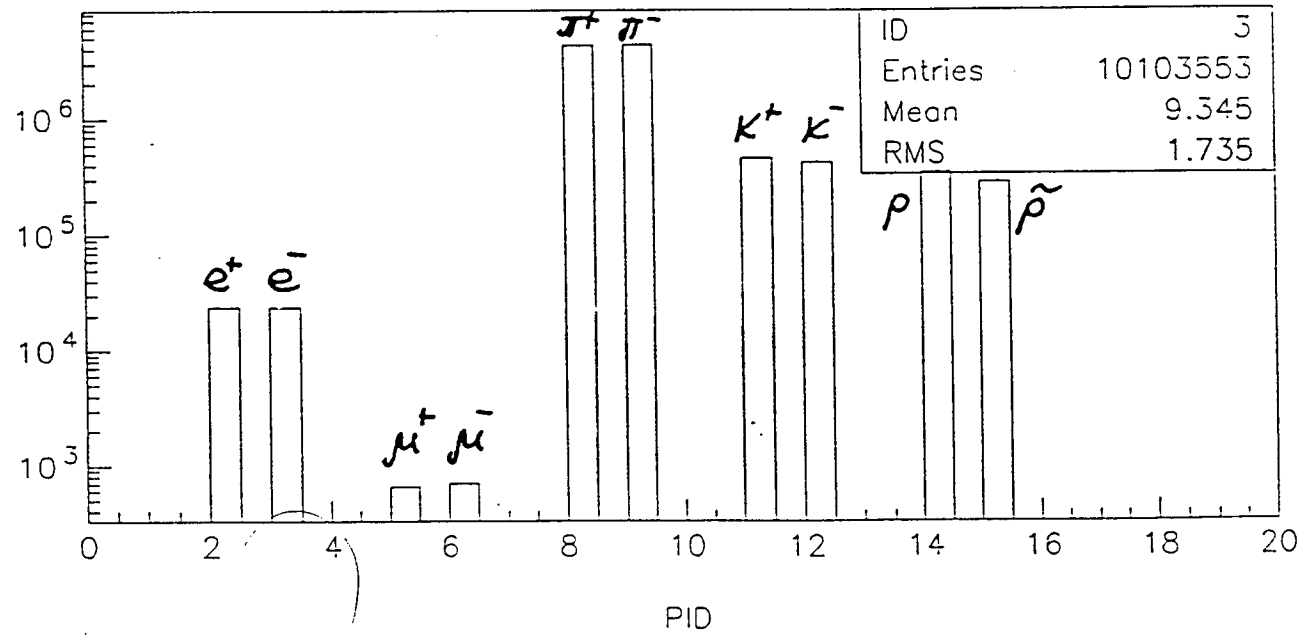
$p_t > 100$ MeV

$|\theta| > 15°$

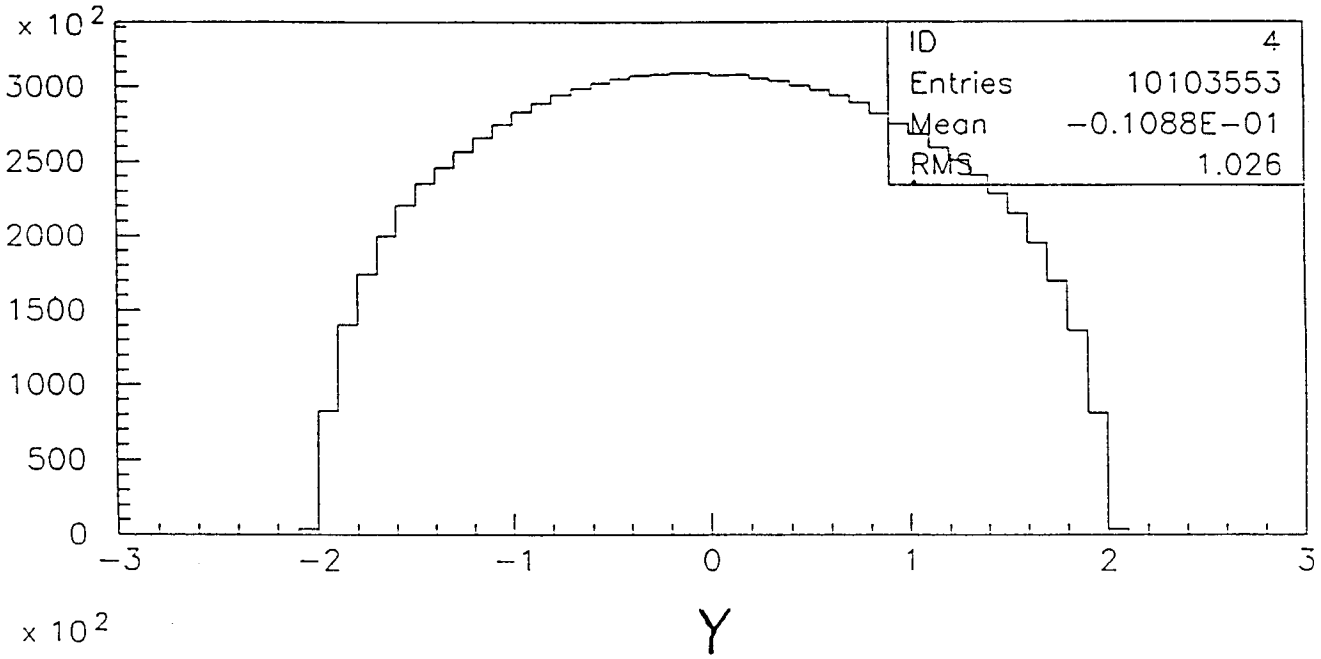
All charge particles

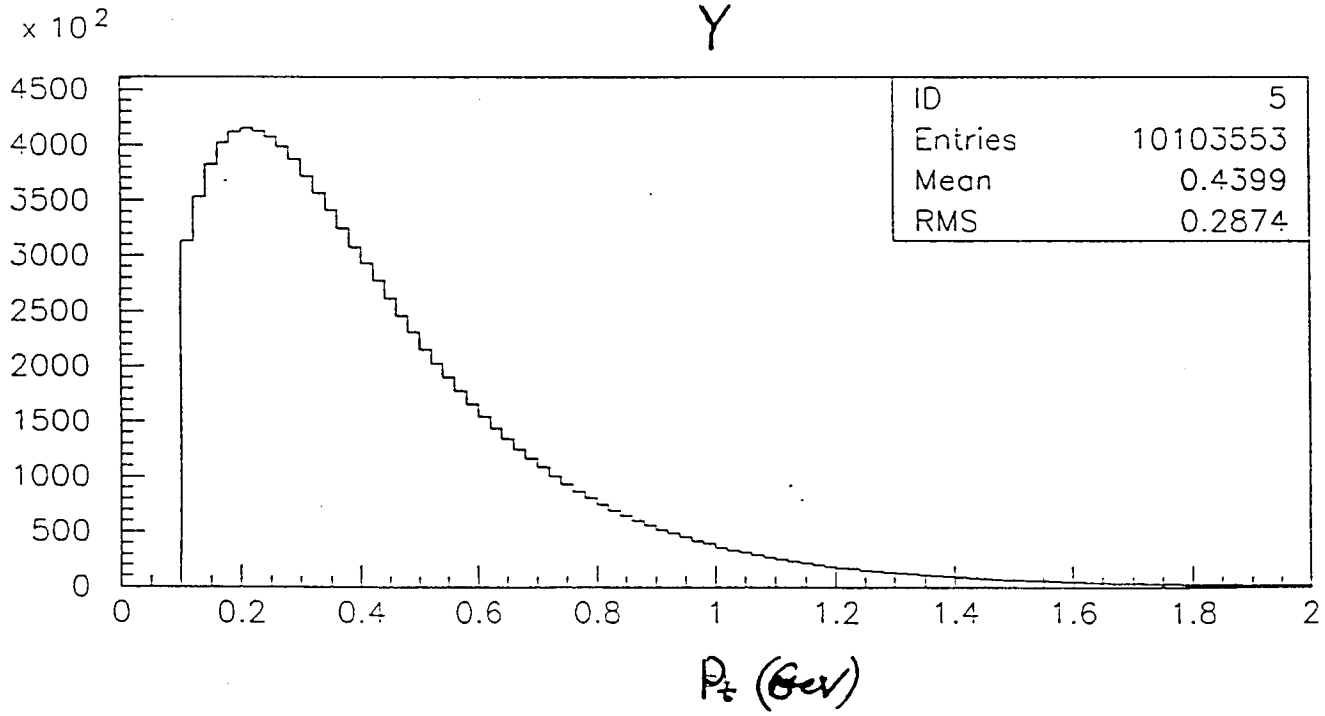
(3000 events (HIJING))

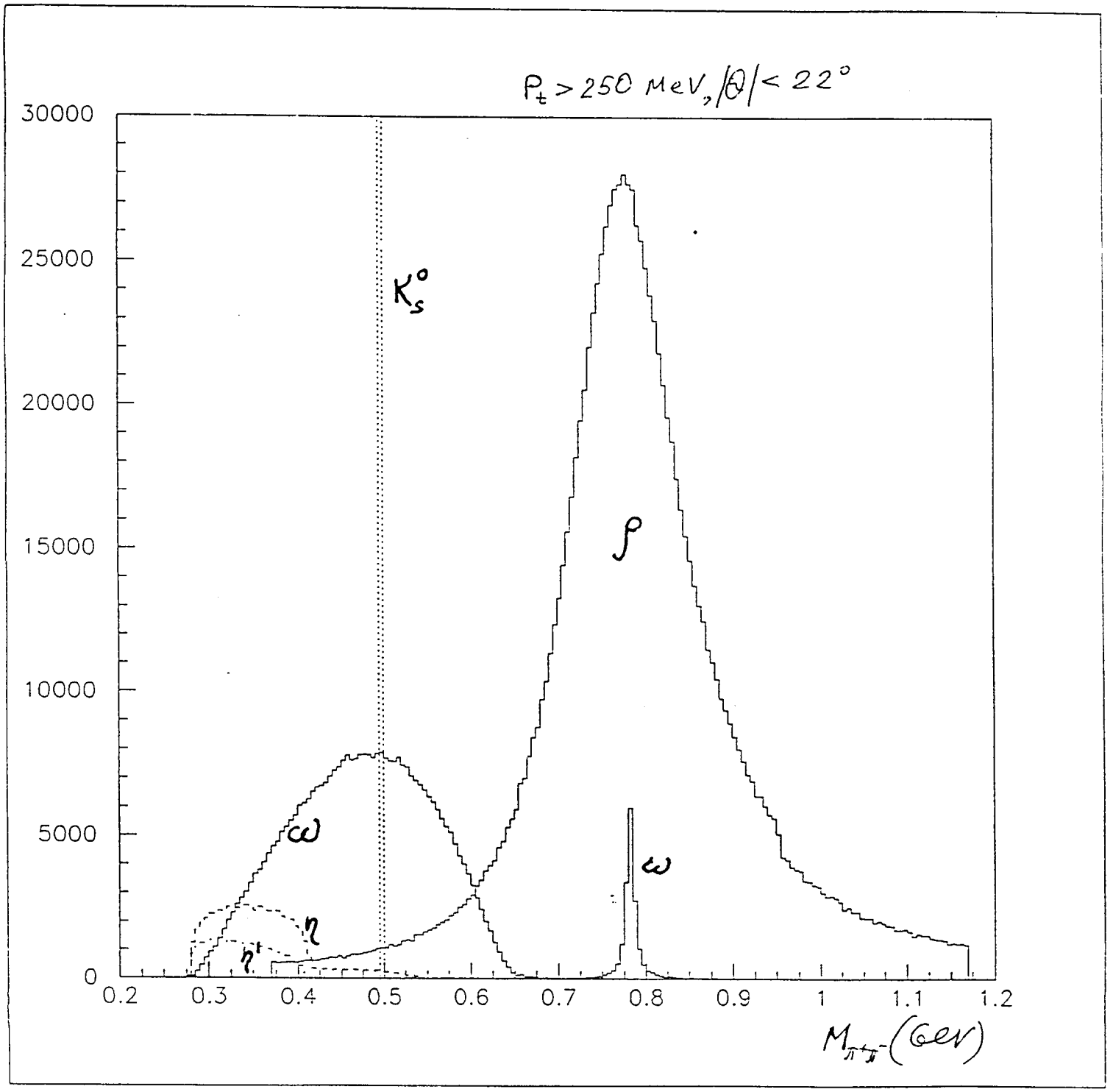




3000 HIJING ev.



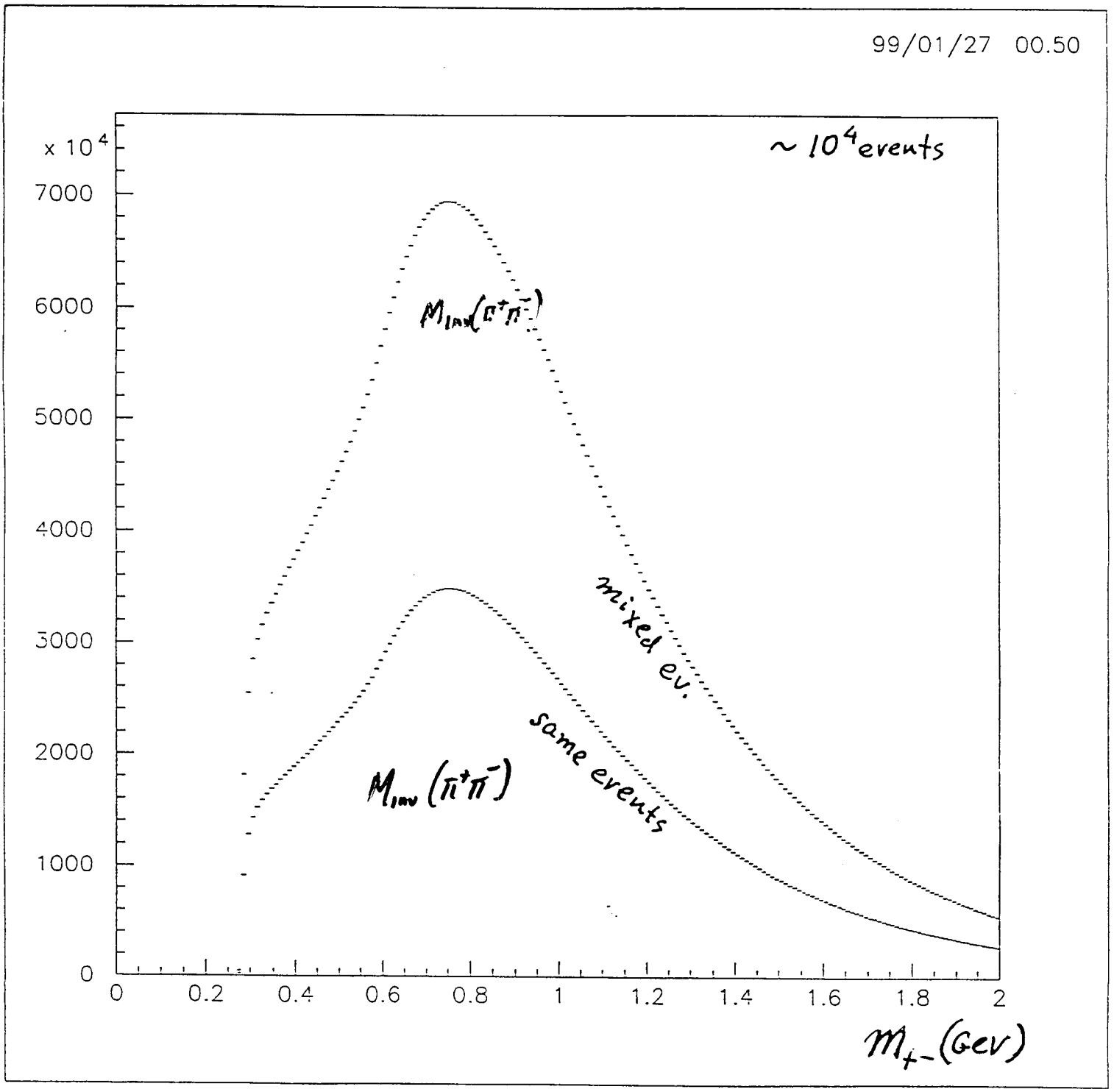



$P_t > 250$ MeV, $|\theta| < 22°$
30000
25000
20000
15000
10000
5000
0
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2
K_s^0
ρ
ω
ω
η
η'
$M_{\pi^+\pi^-}$ (GeV)

$\theta > 220$

$\Delta\theta > 10$ mr

$\frac{\Delta p_i}{p_i} = 3\%$



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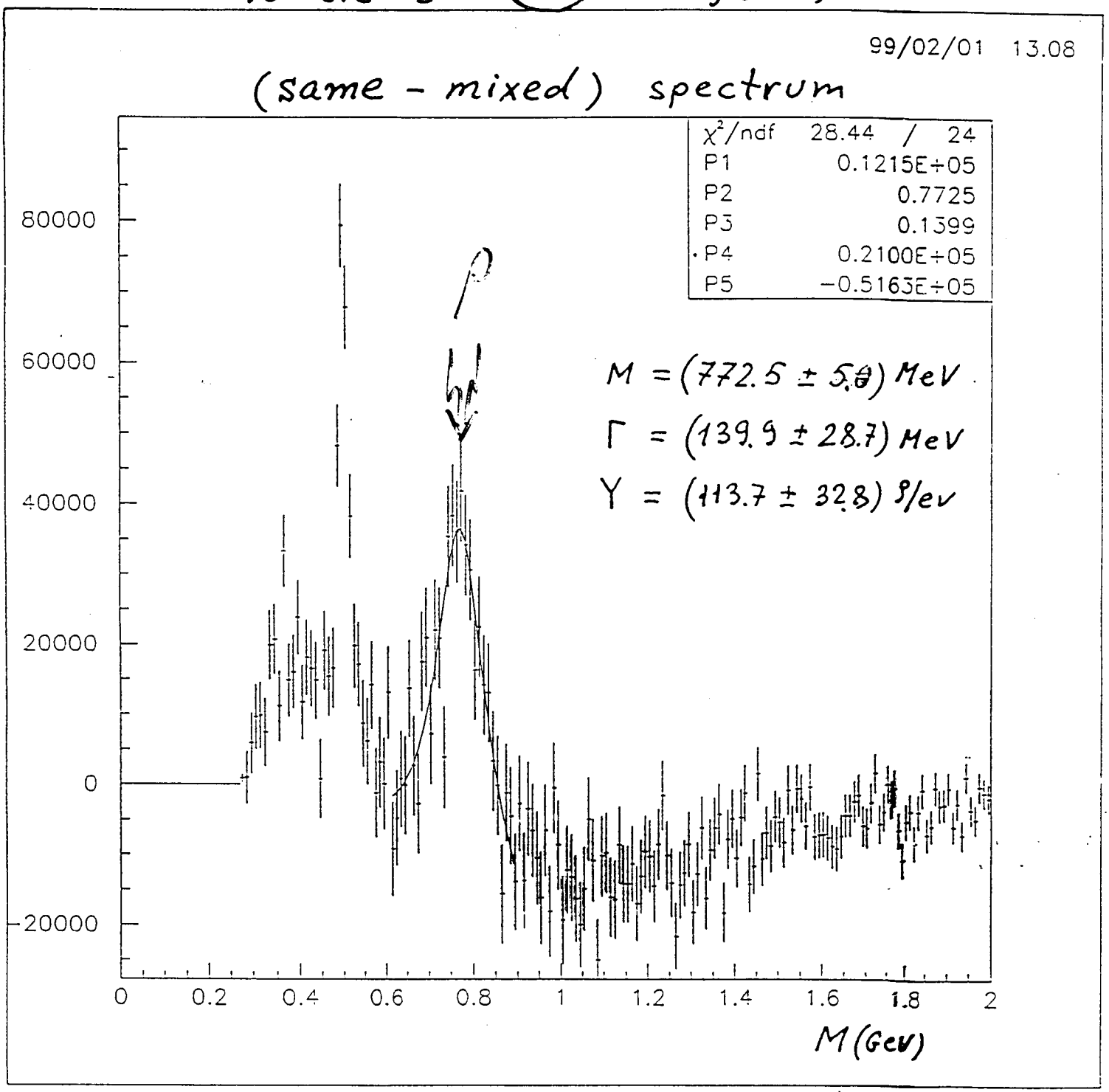
3.722×10^9

7.409×10^9

~10^4 events (3h running time)



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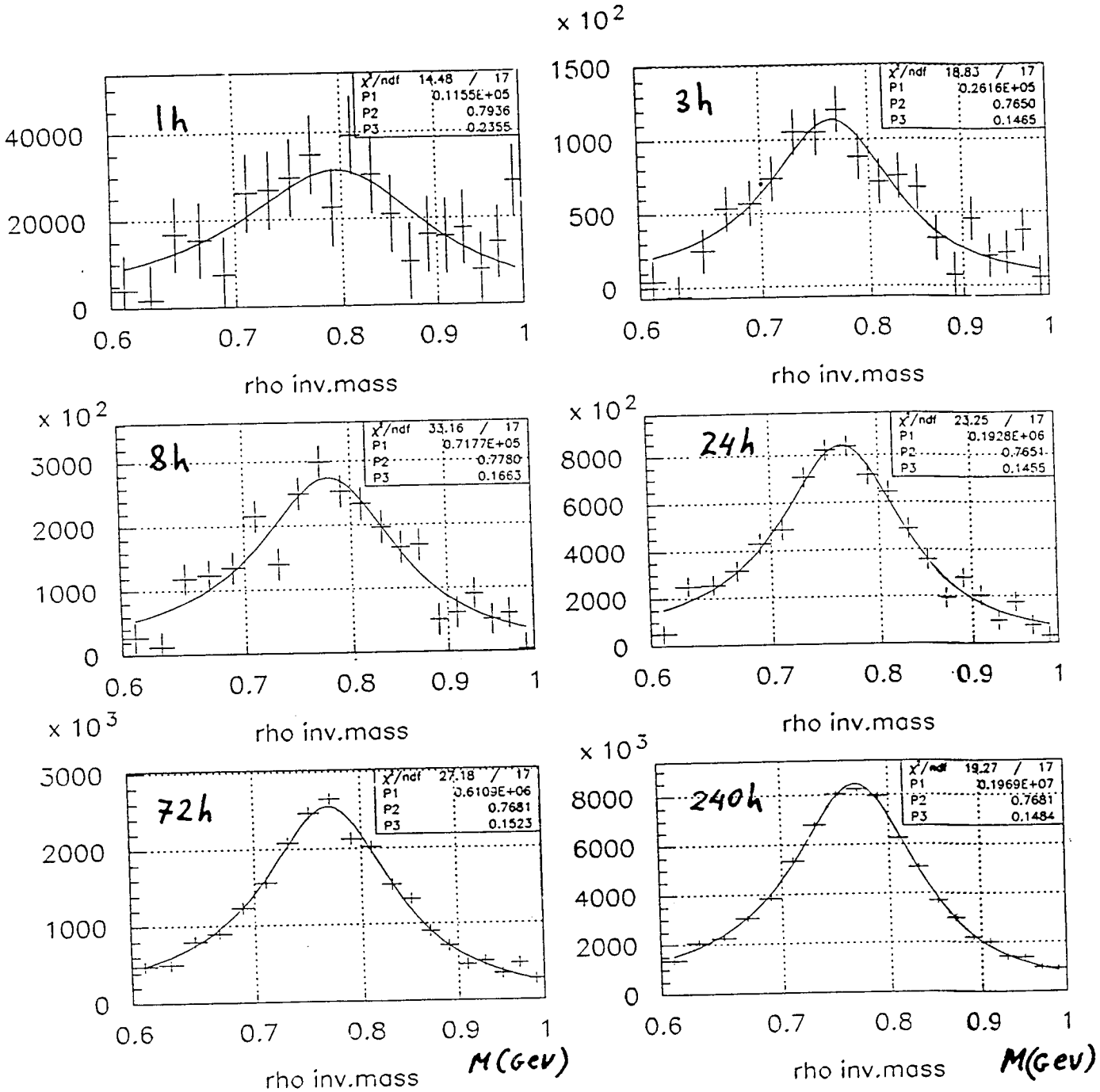
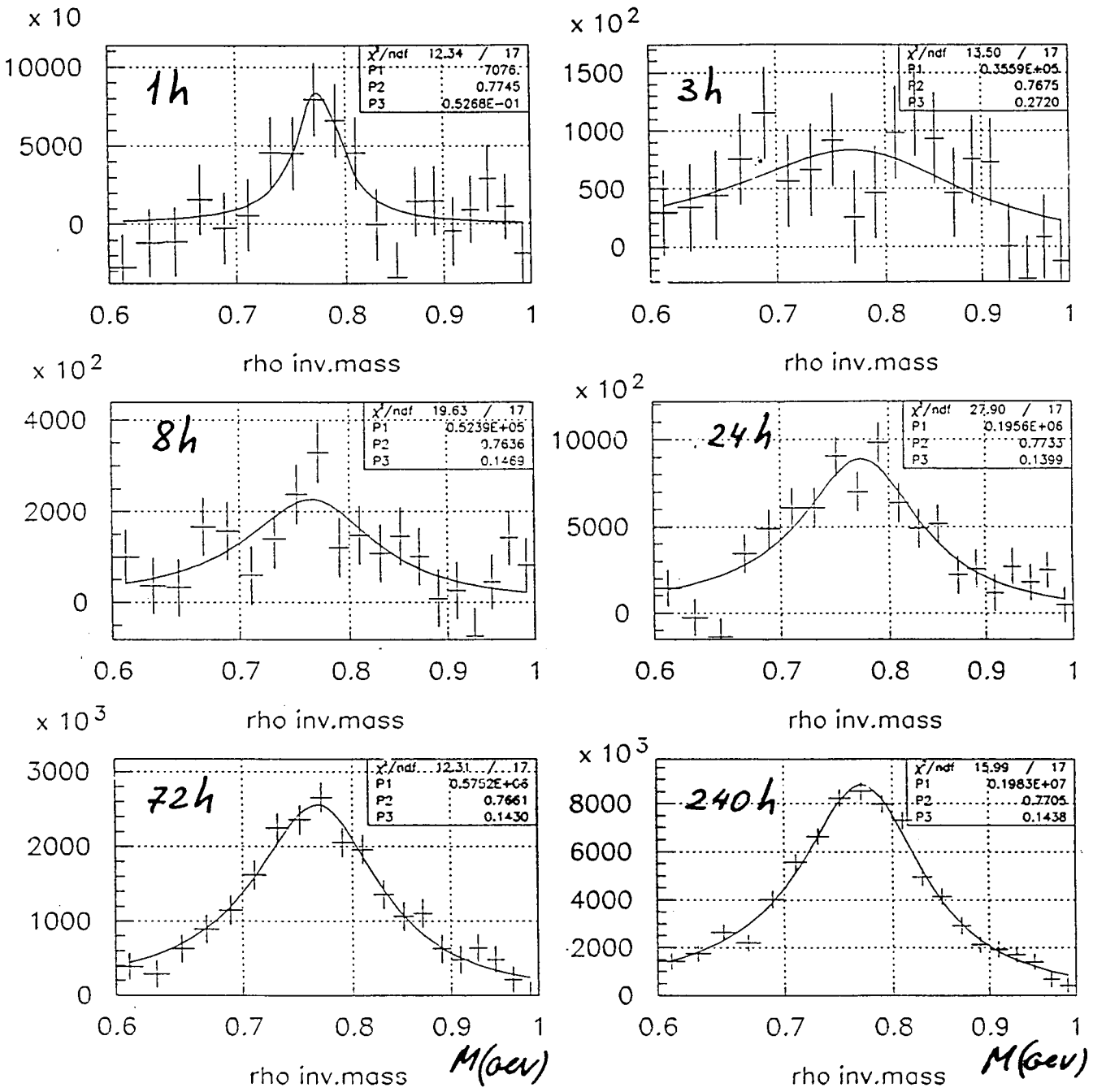
HIJING

99/02/01 10.24



Venus

99/02/01 10.25



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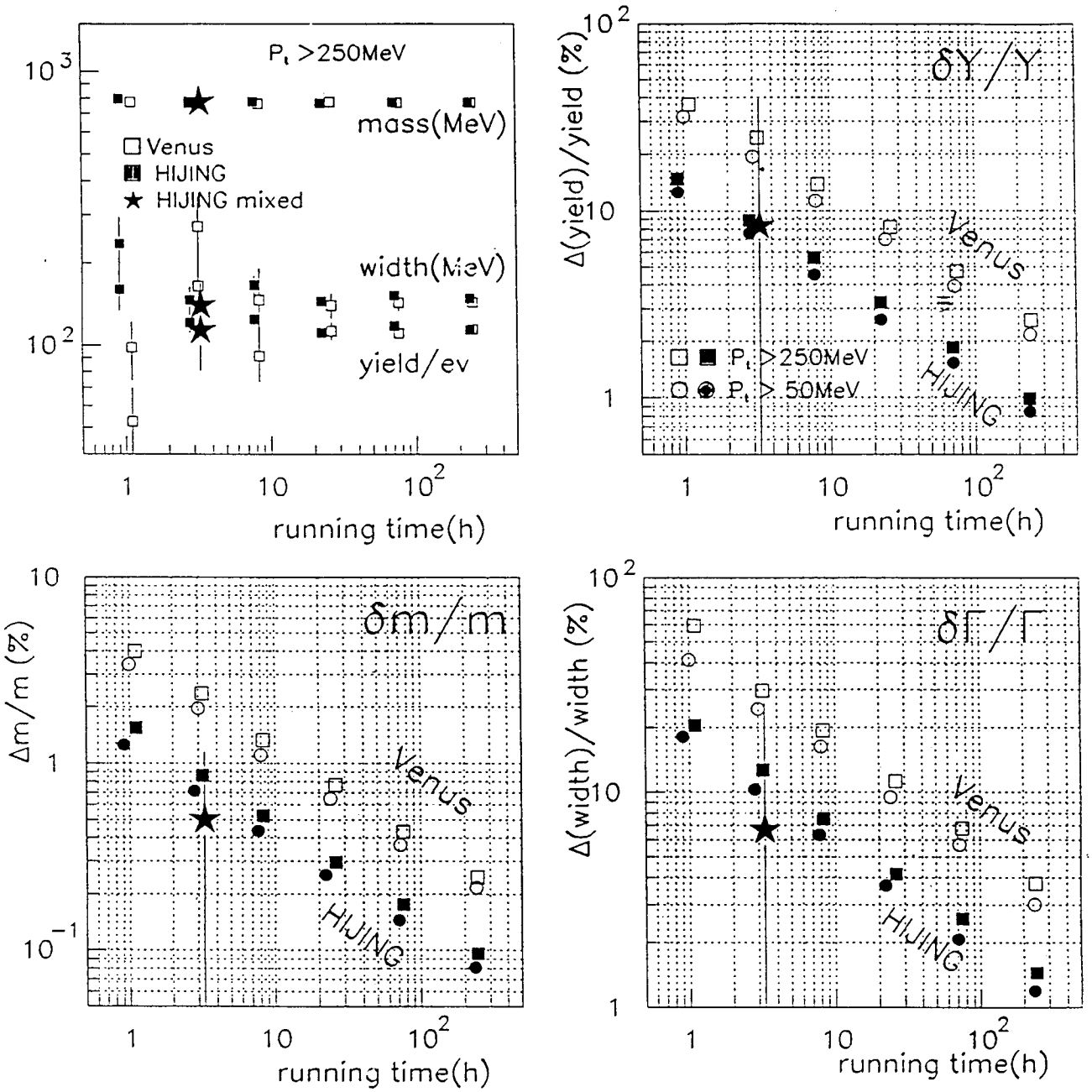
ρ – measurement accuracy in STAR



Conclusions

In the data from the first few days of STAR : NO PID, NO Si VTX det.

we can "easily" measure

$\rho^0 \to \pi^+ \pi^-$ Mass
Width
Yield
Centrality depend.

$K^0_s \to \pi^+ \pi^-$ spectra ...
Yield ...

Future with better statistics
K^*
Δ^{++} (maybe don't need better statistics)

⋮