

Results of $B_s \rightarrow$ CP Eigenstates at Belle

XXVI Rencontres de Physique de La Vallée d'Aoste



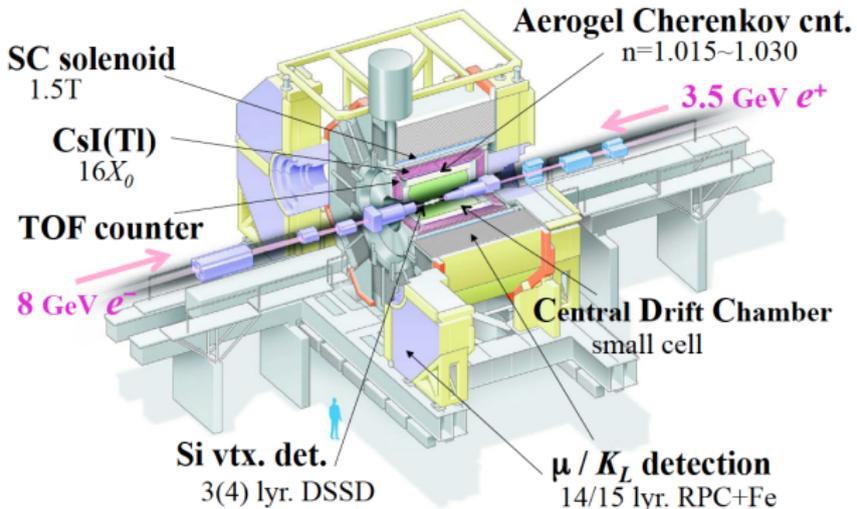
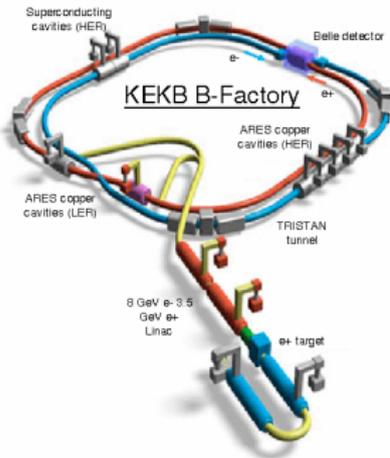
Felicitas Thorne

For the Belle collaboration

February 29th, 2012



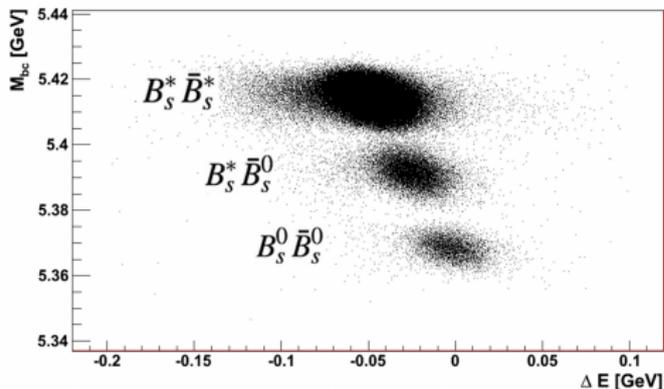
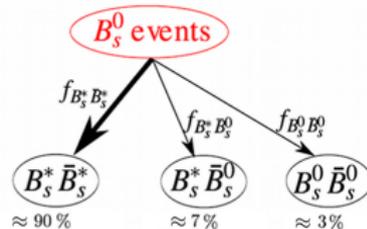
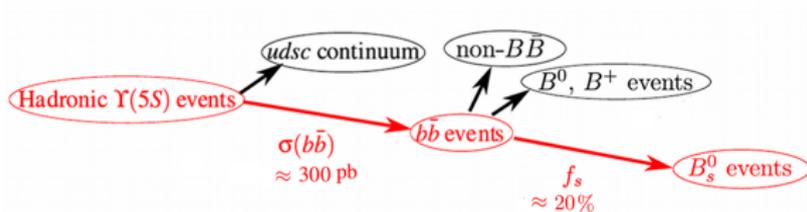
The Belle experiment



$\Upsilon(4S)$ @ 10.58 GeV	711 fb^{-1}
$\Upsilon(5S)$ @ 10.87 GeV	121 fb^{-1}

B decays
B_s spectroscopy **unique!**

The $\Upsilon(5S)$ data sample



- full reconstruction of B_s^0 meson
- no reconstruction of $B_s^* \rightarrow B_s^0 \gamma$
- using two nearly independent kinematic variables for extracting B_s^0 signal:

$$M_{bc} = \sqrt{(E_{\text{beam}})^2 - (p_B^*)^2}$$

$$\Delta E = E_B^* - E_{\text{beam}}$$

PRECISE MEASUREMENT OF

$$B_s \rightarrow J/\psi \phi$$

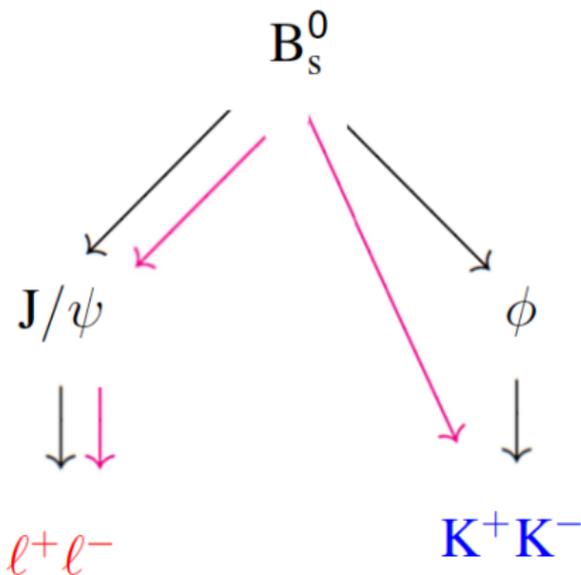
AND

$$B_s \rightarrow J/\psi K^+ K^-$$

Introduction

motivation:

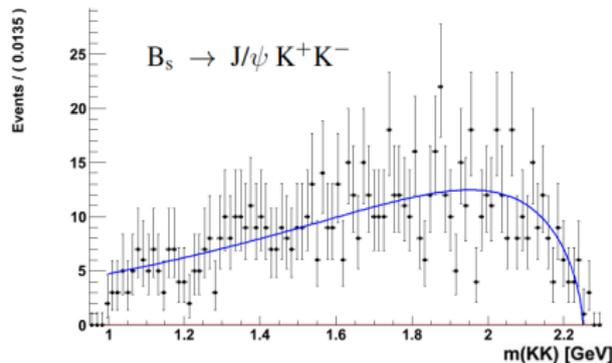
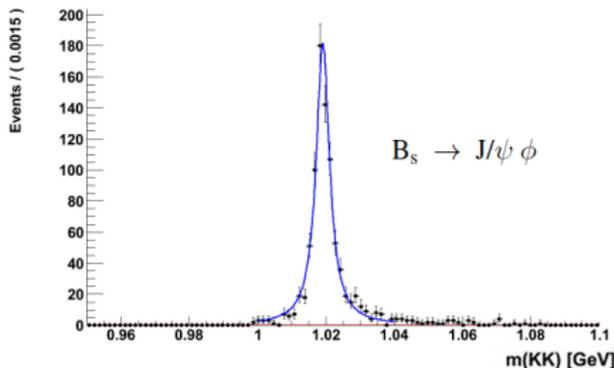
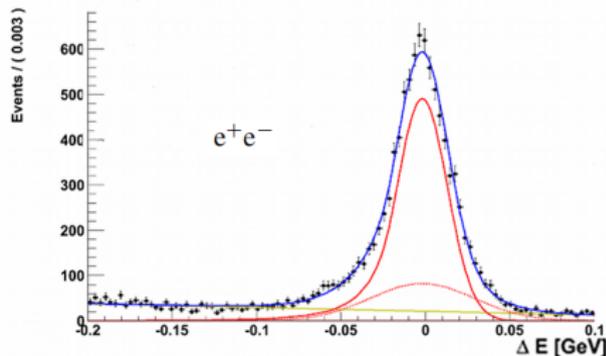
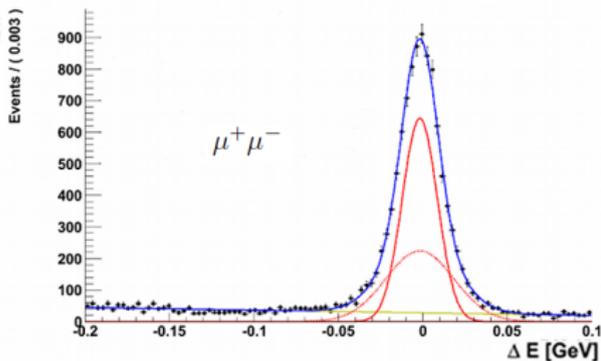
- important mode for CP violation: β_s sensitive to new physics; absolute BR cannot be measured precisely at hadron colliders
- previous measurements: present PDG value: $(1.4 \pm 0.5) 10^{-3}$ (CDF) $\rightarrow \approx 36\%$ relative error
- this analysis: additional measurement of $\mathcal{B}(B_s^0 \rightarrow J/\psi K^+K^-)$ \rightarrow not measured so far



cut on beam constrained mass:
 $M_{bc} > 5.4 \text{ GeV}$
 \Rightarrow only $B_s^* B_s^*$ region used

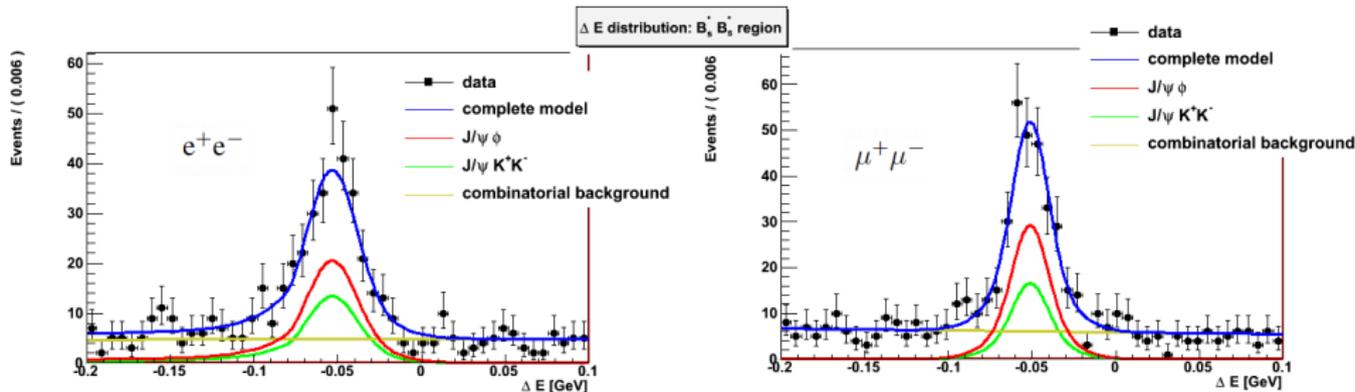
Fitting procedure: 2D unbinned likelihood fit in ΔE and $m(K^+K^-)$

upper plots: real data control sample $B^0 \rightarrow J/\psi K^{*0} (892) \rightarrow \ell^+\ell^- (K\pi)^\pm$



lower plots: generic MC, e^+e^- channel

Results **PRELIMINARY**

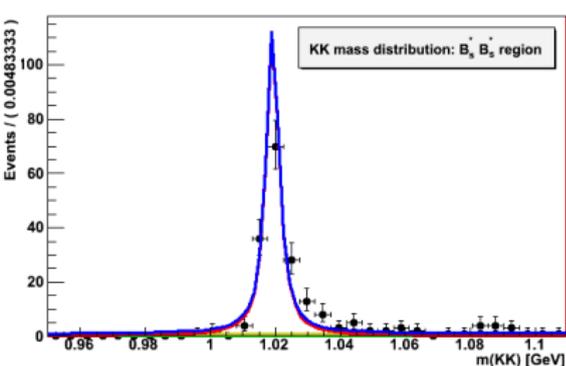


channel	$J/\psi \phi$	$J/\psi K^+K^-$	combinatorial
$\mu^+ \mu^-$	158 ± 13	89 ± 13	304 ± 20
$e^+ e^-$	168 ± 14	110 ± 16	239 ± 20

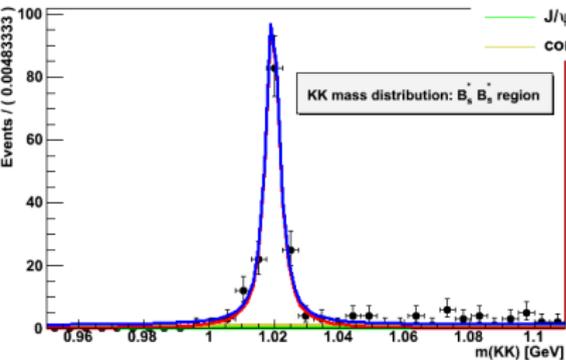
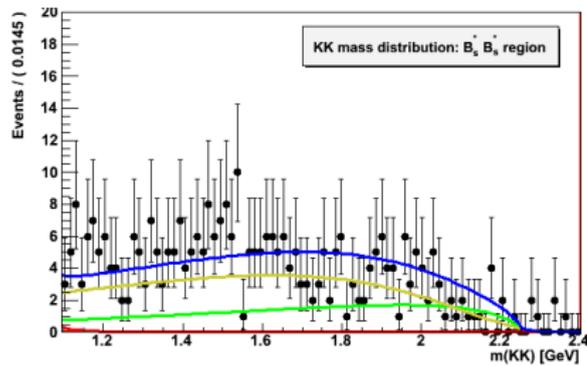
$$\mathcal{B}(B_s^0 \rightarrow J/\psi \phi) = (1.25 \pm 0.07_{\text{stat}} \pm 0.20_{\text{sys}}) 10^{-3} @ 15.9\sigma$$

$$\mathcal{B}(B_s^0 \rightarrow J/\psi K^+K^-) = (0.36 \pm 0.04_{\text{stat}} \pm 0.08_{\text{sys}}) 10^{-3} @ 5.3\sigma$$

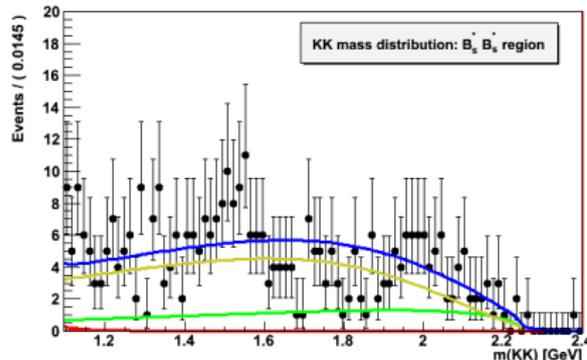
Results PRELIMINARY



e^+e^-



$\mu^+\mu^-$



- data
- complete model
- $J/\psi \phi$
- $J/\psi K^*K^*$
- combinatorial background

Results: s-wave contribution **PRELIMINARY**

assumption:

p-wave contribution from $B_s^0 \rightarrow J/\psi \phi$

s-wave contribution from $B_s^0 \rightarrow J/\psi K^+ K^-$ (phase space)

s- and p-wave distinguished via $m(KK)$ distribution

→ CDF (LHCb, D0) use angular analysis for this purpose

mass range	1.009 GeV -1.028 GeV
CDF	< 6.7% at 95% CL
Belle	$0.61 \pm 0.07_{\text{stat}} \pm 0.06_{\text{sys}}\%$

FOR REFERENCE:

[HTTP://WWW-CDF.FNAL.GOV/PHYSICS/NEW/BOTTOM/100513.BLESSED-BSJPSIPHI_5.2FB/](http://www-cdf.fnal.gov/physics/new/bottom/100513.blessed-bsjpsiPhi_5.2fb/) AND

CDF PUBLIC NOTE: CDF/ANAL/BOTTOM/PUBLIC/9458 (2010)

FIRST OBSERVATION OF

$$B_s \rightarrow J/\psi \eta$$

AND

$$B_s \rightarrow J/\psi \eta'$$

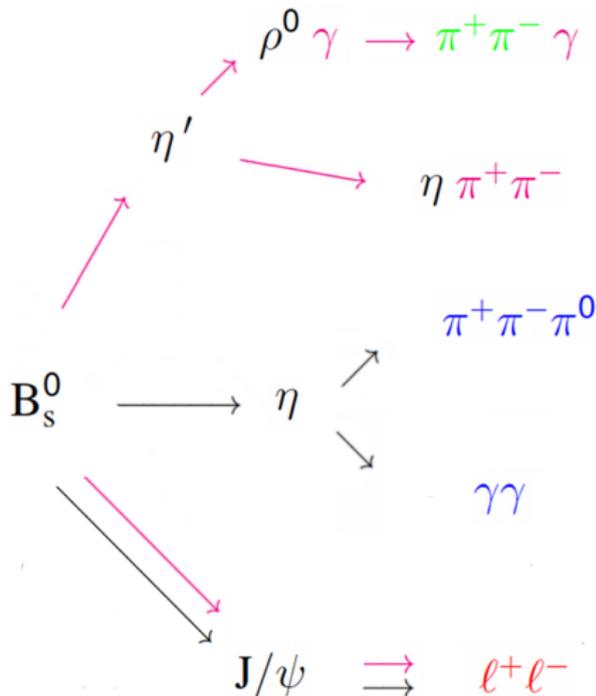
preprint: arXiv:1202.0103 [hep-ex], submitted to PRL

Introduction

- new CP-even eigenstates
- upper limit:
 $\mathcal{B}(B_s \rightarrow J/\psi \eta) < 3.8 \cdot 10^{-3}$ @
 90% C.L.
- SU(3) flavor symmetry predicts:

$$\frac{\mathcal{B}(B_s \rightarrow J/\psi \eta')}{\mathcal{B}(B_s \rightarrow J/\psi \eta)} = 1.04 \pm 0.04$$

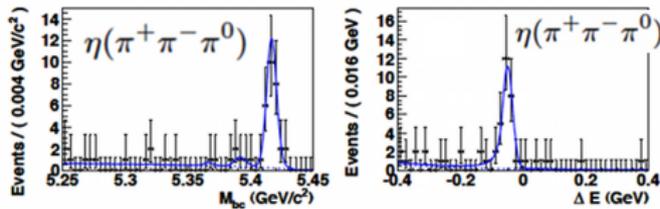
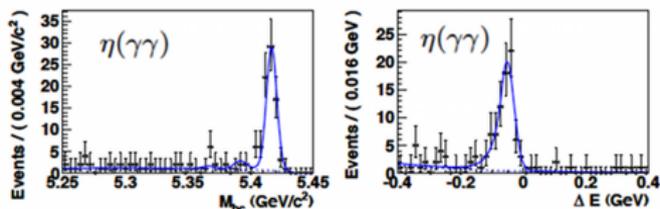
\Rightarrow test SU(3) symmetry and
 $\eta - \eta'$ mixing



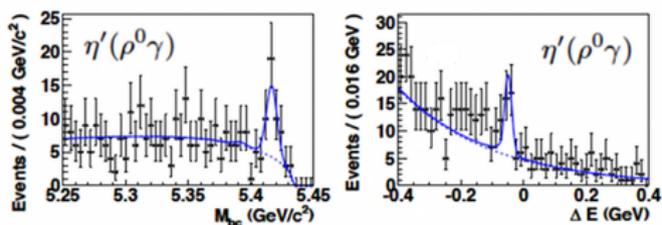
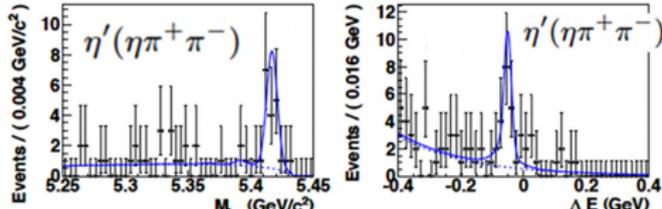
FOR REFERENCE:

M. ACCIARRI ET AL. [L3 COLLABORATION], PHYS. LETT. B
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 P. Z. SKANDS, JHEP 0101, 008 (2001)
 A. DATTA, H. J. LIPKIN AND P. J. O'DONNELL, PHYS. LETT. B
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 C. E. THOMAS, JHEP 0710, 026 (2007);
 R. FLEISCHER, R. KNEGJENS AND G. RICCIARDI,
 ARXIV:1110.5490 [HEP-PH] (2011);

Results



$B_s \rightarrow J/\psi \eta$



$B_s \rightarrow J/\psi \eta'$

$$\mathcal{B}(B_s \rightarrow J/\psi \eta) = \left(5.10 \pm 0.50_{\text{stat}} \pm 0.25_{\text{sys}} \pm 0.79 (N_{B_s^{(*)}\bar{B}_s^{(*)}}) \right) \cdot 10^{-4}$$

$$\mathcal{B}(B_s \rightarrow J/\psi \eta') = \left(3.71 \pm 0.61_{\text{stat}} \pm 0.18_{\text{sys}} \pm 0.57 (N_{B_s^{(*)}\bar{B}_s^{(*)}}) \right) \cdot 10^{-4}$$

Summary

Precise measurement of $B_s \rightarrow J/\psi \phi$ and $B_s \rightarrow J/\psi K^+K^-$

- all results are preliminary
- absolute branching fraction for $B_s \rightarrow J/\psi \phi$ consistent with current PDG value
- first measurement of the absolute branching fraction of the nonresonant decay $B_s \rightarrow J/\psi K^+K^-$
- result for s-wave contribution determined via $m(K^+K^-)$ instead of angular analysis; consistent with CDF limit

First observation of $B_s \rightarrow J/\psi \eta$ and $B_s \rightarrow J/\psi \eta'$

- preprint: arXiv:1202.0103 [hep-ex], submitted to PRL
- B_s fully reconstructed in 5 different final states with η/η' contribution
- calculated branching fractions consistent with SU(3) expectations
- $\frac{\mathcal{B}(B_s \rightarrow J/\psi \eta')}{\mathcal{B}(B_s \rightarrow J/\psi \eta)} = 0.73 \pm 0.14_{\text{stat}} \pm 0.02_{\text{sys}}$
→ deviation at 2.1σ level with respect to prediction

Thank you for your
attention!

Backup

Systematic uncertainties for $B_s \rightarrow J/\psi \phi$ **PRELIMINARY**

Parameter	Value	Error	%	reference
Luminosity	121.061 fb^{-1}	0.847 fb^{-1}	0.7	Belle official
$\sigma_{\text{bb}}^{\Upsilon(5S)}$	0.302 nb	0.014 nb	4.6	Belle, Cleo
f_s	0.193	0.029	15.0	Belle, Cleo
$\mathcal{B}(\phi \rightarrow K^+ K^-)$	0.489	0.005	1.0	PDG
$\mathcal{B}(J/\psi \rightarrow \mu^+ \mu^-)$	0.0593	0.0006	1.0	PDG
$\mathcal{B}(J/\psi \rightarrow e^+ e^-)$	0.0594	0.0006	1.0	PDG
$\epsilon_{\text{MC statistic}}(\mu^+ \mu^-)$	0.325	0.001	0.2	-
$\epsilon_{\text{MC statistic}}(e^+ e^-)$	0.307	0.001	0.3	-
$\epsilon_{\text{Polarisation}}(\mu^+ \mu^-)$	0.325	0.005	1.5	-
$\epsilon_{\text{Polarisation}}(e^+ e^-)$	0.307	0.004	1.3	-
tracking	-	-	1.4	Belle official
lepton and kaon ID	-	-	2.0	-
PDF shape ($\mu^+ \mu^-$)	158 events	3.7 events	2.3	-
PDF shape ($e^+ e^-$)	168 events	4.6 events	2.7	-
sum	-	$0.20 \cdot 10^{-3}$	16.3	-

Systematic uncertainties for $B_s \rightarrow J/\psi \eta$ and $B_s \rightarrow J/\psi \eta'$

Source	$\mathcal{B}(J/\psi\eta)$	$\mathcal{B}(J/\psi\eta')$
Signal shape calibration	+0.4, -0.5	+1.1, -1.3
Track reconstruction	0.8	1.4
Electron identification	1.5	1.5
Muon identification	1.8	1.7
Pion identification	0.5	2.1
$\eta(\pi^0) \rightarrow \gamma\gamma$ selection	4.0	2.8
$\mathcal{B}(J/\psi \rightarrow ll)$	0.7	0.7
$\mathcal{B}(\eta^{(\prime)} \rightarrow \text{final states})$	0.5	1.2
Total (without $N_{B_s^{(*)}\bar{B}_s^{(*)}}$)	4.8	4.8
$N_{B_s^{(*)}\bar{B}_s^{(*)}}$	+22.4, -15.5	