A Search for Neutral Higgs Bosons at High tanß with the DØ Detector

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for the DØ Collaboration

Outline

- Higgs in the Super-Symmetric World – an Introduction
- The $b\bar{b}h$ Signature
- Selecting $b\bar{b}h$ events
- Backgrounds
- Results

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Higgs and MSSM

MSSM introduces a second scalar doublet

Three neutral eigenstates h, H (CP even) and A (CP odd); two charged H^+, H^-

α: neutral Higgs eigenstates' mixing angle

$\tan\beta$: ratio of neutral Higgs vacuum expectation values

Modified SM Yukawa couplings:

$b\bar{b}h$: $\sin(\beta-\alpha) - \tan\beta \cos(\beta-\alpha)$

$b\bar{b}H$: $\cos(\beta-\alpha) + \tan\beta \sin(\beta-\alpha)$

$b\bar{b}A$: $\tan\beta$

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MSSM Higgs At Large tanß

tanβ is free parameter; large values m_t/m_b favored

At large tanβ

- A nearly degenerate with h or H, depending on m_A
- A and one of h, H have enhanced b coupling
- branching ratio to $b\bar{b}$ ~90% in the mass range of our interest

Production cross sections scale with $\tan^2\beta$

Here, h or H assumed to be degenerate with A, increasing the cross section of a visible neutral Higgs boson

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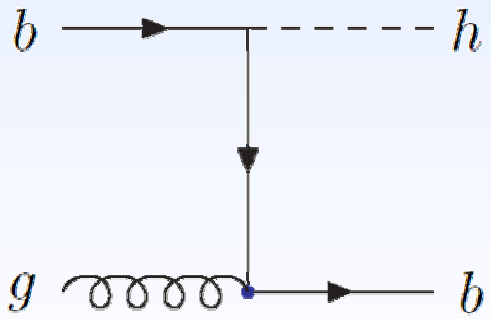
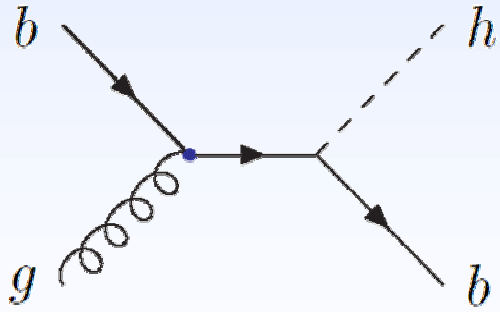
h and $b\bar{b}$

For Tevatron, dominant Higgs signature is
$p\bar{p} (\rightarrow gb) (\rightarrow bh) \rightarrow bb\bar{b}$

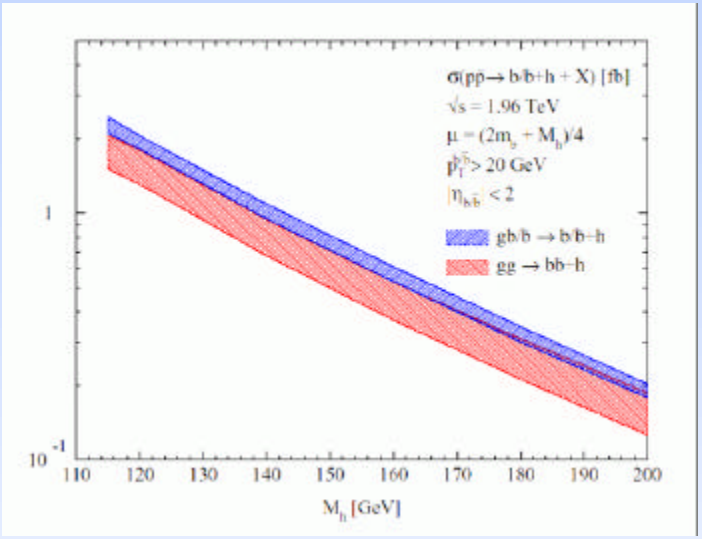
Three bottom quarks in final state increases signal rate over background rate; important signature for discovery



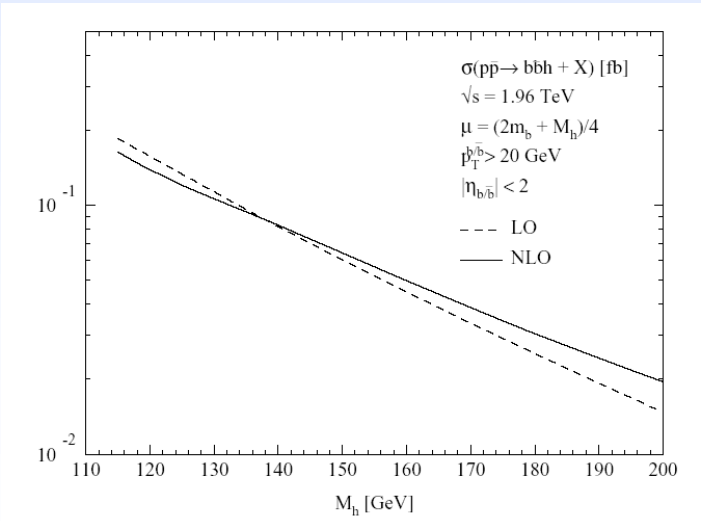


b(b)h Predictions

H and b quark is field of active theoretical research, see e.g. NLO predictions for Tevatron and LHC in hep-ph/0405302 for bh and bbh production



Cross section for at least two jets from b quarks ("b-jets") in final state with E_T>20 GeV



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Selecting b(b)h

Using 131pb^{-1} of DØ's data from Sept 2002 to July 2003

Look for peak in invariant mass spectrum of two highest E_T jets in events with at least three b-tagged jets

Signal selection, simulation:

- Event selection depends on m_h, e.g. for m_h=120GeV: 1 jet with E_T>45GeV, one with E_T>35GeV, 2 with E_T>15GeV
- signal distributions predicted by Pythia, NLO re-weighting

Background prediction, simulation:

- predict background from data, assuming negligible signal content
- distributions of $b\bar{b}j$, $b\bar{b}jj$, $b\bar{b}b\bar{b}$ from ALPGEN
- $t\bar{t}$ from Pythia

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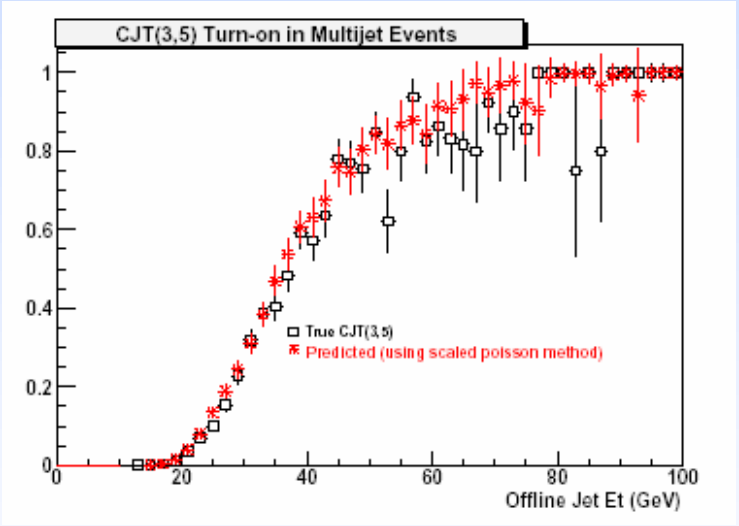
Selecting bbh - Triggering

Three levels of triggering (old and new trigger version)

Level	Old	New
L1: tower E_T	4*5GeV	3*5GeV
L2: jet E_T $\Sigma(E_T>5GeV)$	3*8GeV 50GeV	
L3: jet E_T	3*15GeV	2*25GeV 1*15GeV



Efficiencies relative to offline selection of 68-80%, depending on m_h

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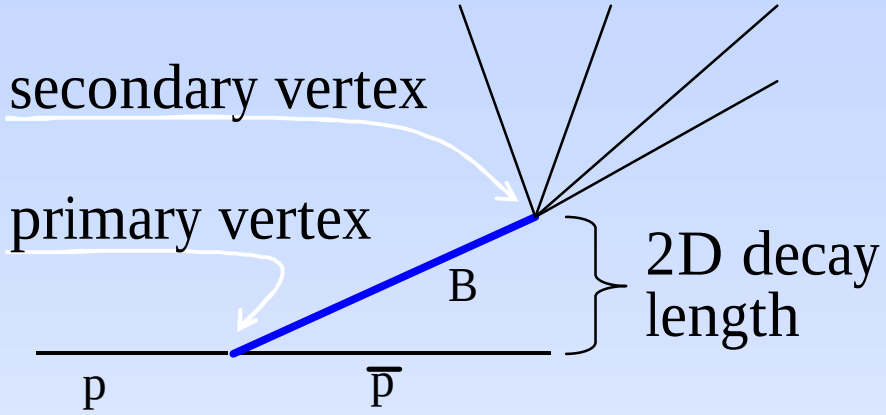
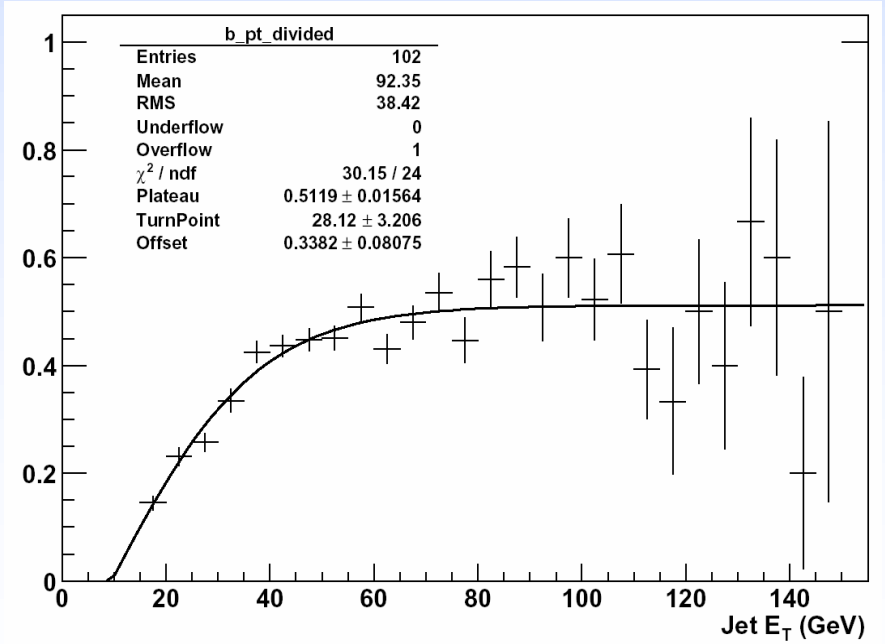
Selecting bbh – Tagging b-Jets

Loose b-tag requirement:
require secondary vertex, cut on 2D decay length significance

Efficiency plateau for b-jets at 50%, light jet ("mis-tag") efficiency ~2%, both derived from data





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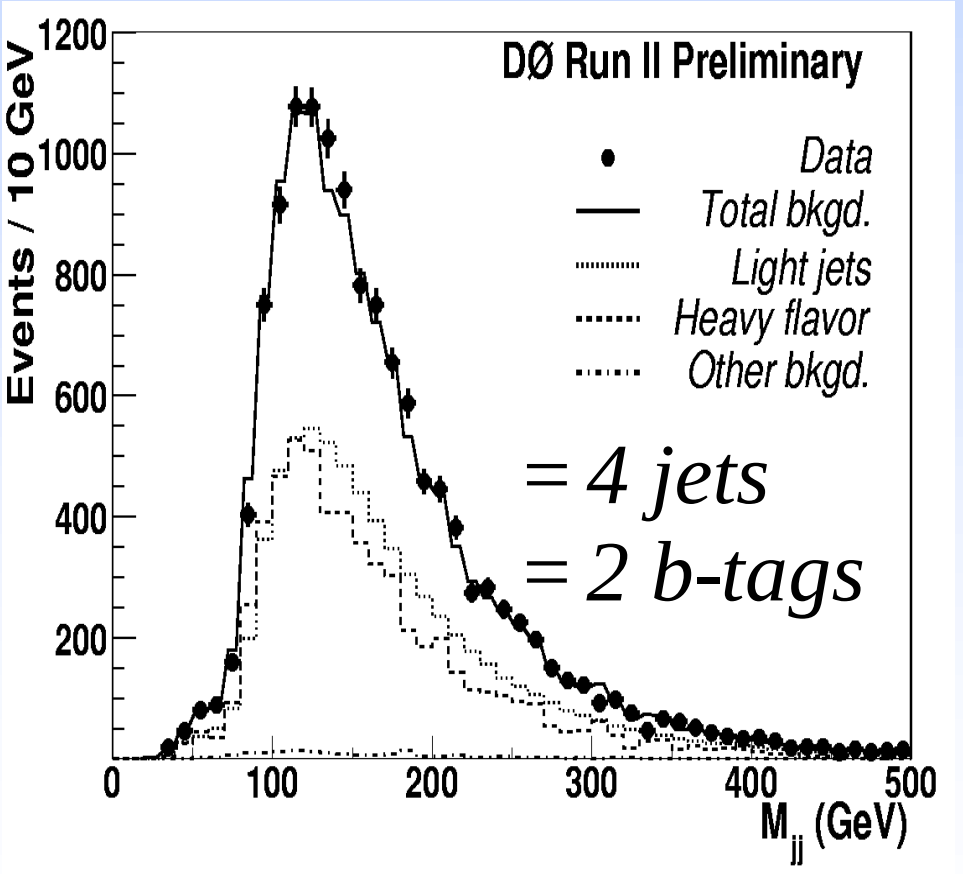
Backgrounds

Main background contributions (j: light jet, b: b-jet)

- jjjj, 3 mis-tagged
- $b\bar{b}jj$, mis-tagged jets
- $b\bar{b}b\bar{b}$ small, $Zb\bar{b}$ and $t\bar{t}$ even smaller

Estimate mis-tags: given a 2 b-tag m_{jj} spectrum, calculate each bin's contribution to 3 b-tag m_{jj} spectrum



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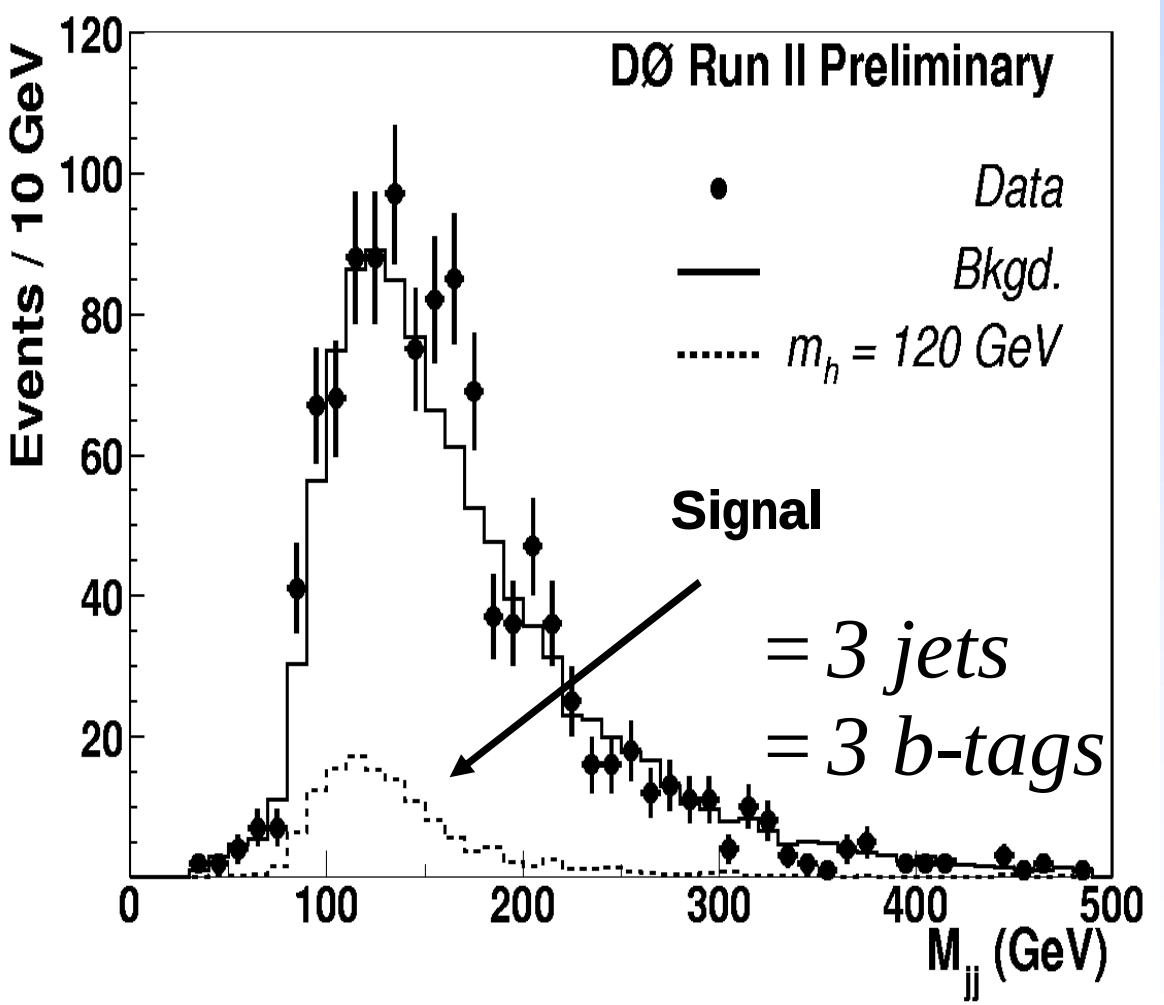
Results – Invariant Mass

Invariant mass distribution of two leading jets in a 3 jet sample with 3 b-tagged jets

Using Monte Carlo for prediction of b(b)h signal only



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Results - Uncertainties

Systematic uncertainties of acceptance in %

Signal (GeV/c^2)	NLO/LO	Trig	Resolution	JES	Jet ID	B–tag	Total
n_j^{min}=4, m_h=100	5	9	8.0	20	3.8	13.5	27.7
n_j^{min}=4, m_h=120	5	9	12.0	16	3.4	13.5	26.5
n_j^{min}=4, m_h=150	5	9	11.9	13	3.5	13.8	24.9
n_j^{min}=3, m_h=100	5	9	7.5	12	3.7	13.5	22.4
n_j^{min}=3, m_h=120	5	9	12.5	7.5	3.5	13.2	22.5
n_j^{min}=3, m_h=150	5	9	12.8	3.4	3.6	13.4	21.8

Systematic uncertainties for backgrounds 8-10% (depending on n_j^{min}, m_h); mostly b-tagging related

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Results – Exclusion Limit

Exclusion limits are calculated using
background / (signal + background)
likelihood ratio using ROOT's TLimit

Based on mclimit (CLs method), see NIM A434, p. 435-443, 1999

Sweep through tanβ, given m_A

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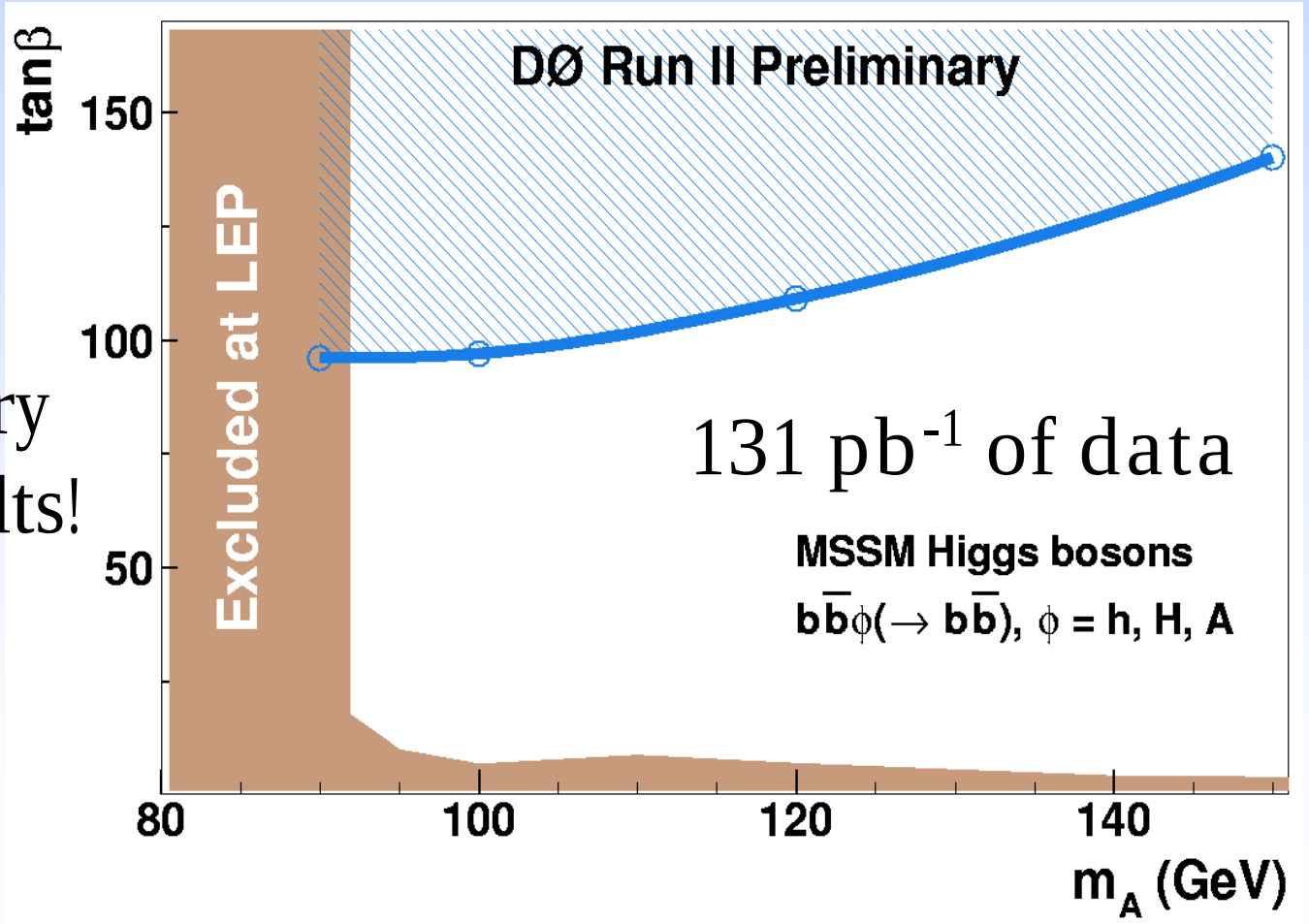
Results - Exclusion

MSSM excluded for (m_A, tanβ) parameter space

Complementary to LEP results!



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Summary & Outlook

Limit compatible with old limits – this will change!

Expect improvements soon due to

- larger dataset
- better b-tagging
- better JES
- better triggers
- better cuts

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- better b-tagging
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- better cuts (4b giving additional leverage)

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