Collider reach$^{\beta}$

Quick (and dirty) estimates for hadron machines

Gavin Salam (CERN-TH)
Andi Weiler (CERN-TH & DESY)

BSM physics opportunities at 100 TeV

Aim

- Want to give you a quick (and dirty) estimate of the relation between the mass reaches of different proton-proton collider setups

- Ignore all subtleties, just allow for a base-line check

- If the estimate differs a lot from sophisticated simulations, something interesting has happened:

    - brick-wall (new irreducible backgrounds, granularity of assumed detectors, …)

    - too conservative or non-optimal estimates

Example

Assume we are currently sensitive to gluinos of 1200 GeV (95% CL_s, 8 TeV, 20 1/fb), how well can we *in principle* do at

14 TeV, 300 ifb ?
14 TeV, 3000 ifb ?
33 TeV, 3000 ifb ?
100 TeV, 3000 ifb ?

Assumptions

- We don’t need to worry about scaling of background vs. signal
- Reconstruction efficiencies, background rejection, etc all stay reasonably constant

- Cross-sections are simply proportional to

$$\boxed{N(m,s) = \frac{1}{m^2}\sum_{ij} C_{ij}\,\mathcal{L}_{ij}(m^2,s)\,.}$$

$$\mathcal{L}_{ij}(m^2,s) = \int_\tau^1 \frac{dx}{x} x f_i(x,m^2)\,\frac{\tau}{x} f_j\left(\frac{\tau}{x}, m^2\right) \qquad \tau \equiv \frac{m^2}{s}$$

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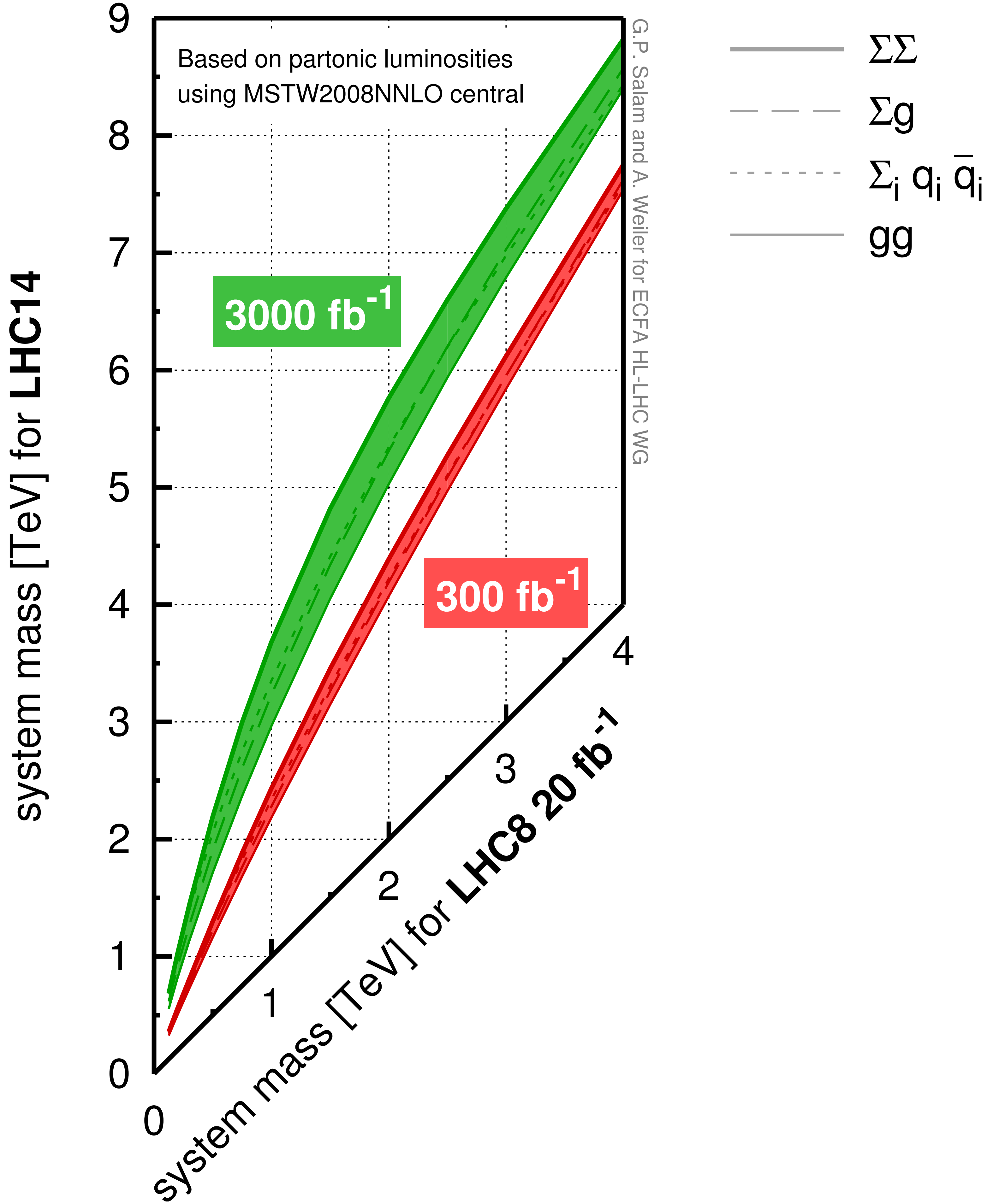
Very basic estimate: solve following equation for ***M*****high**

$$\frac{N_{\text{signal-events}}(M^2_{\text{high}}, 14\,\text{TeV}, \text{Lumi})}{N_{\text{signal-events}}(M^2_{\text{low}},\ 8\,\text{TeV},\ 19\text{fb}^{-1})} = 1$$

Even simpler: instead of ratio of # of events, use ratio of partonic luminosities (e.g. q$\bar{\text{q}}$ lumi, gg lumi)



Based on partonic luminosities
using MSTW2008NNLO central
3000 fb^{-1}
300 fb^{-1}
system mass [TeV] for **LHC14**
system mass [TeV] for **LHC8 20 fb^{-1}**
G.P. Salam and A. Weiler for ECFA HL-LHC WG
ΣΣ
Σg
$\Sigma_i\, q_i\, \bar{q}_i$
gg
0
1
2
3
4
5
6
7
8
9

G. Salam/AW

LHC comparison

1208.1447
ATLAS-CONF-2013-024

gg

stop limits [expected] (lsp = 0gev)

7tev, 4.7 ifb 500 gev

8tev, 20.5 ifb 650 gev ---> 675 GeV

qqbar

ATLAS EXOT-2011-06
ATLAS-CONF-2012-129
ATLAS-CONF-2013-017

sequential z-prime [expected]

7tev, 1.1 ifb 1800 gev

8tev, 6 ifb, 2500 gev ---> 2450 GeV

8 tev, 20 ifb 2800 gee ---> 2790 GeV

EXOT-2011-07
ATLAS-CONF-2012-088
ATLAS-CONF-2012-148

qg

excited quark q* [expected] (NB,sig ≠ bgd scaling)

7 tev, 1 ifb 2900 gev

8 tev, 5.8 ifb 3500 gev ---> 3700 GeV

8tev, 13 ifb 3700 gev ---> 3900 GeV

LHC comparison

1208.1447
ATLAS-CONF-2013-024

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Baseline

qqbar

ATLAS EXOT-2011-06
ATLAS-CONF-2012-129
ATLAS-CONF-2013-017

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LHC comparison

1208.1447
ATLAS-CONF-2013-024

gg

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8tev, 20.5 ifb 650 gev ---> 675 GeV

Baseline

qqbar

ATLAS EXOT-2011-06
ATLAS-CONF-2012-129
ATLAS-CONF-2013-017

Lumi method

sequential z-prime [expected]

7tev, 1.1 ifb 1800 gev

8tev, 6 ifb, 2500 gev ---> 2450 GeV

8 tev, 20 ifb 2800 gee ---> 2790 GeV

EXOT-2011-07
ATLAS-CONF-2012-088
ATLAS-CONF-2012-148

qg

excited quark q* [expected] (NB,sig $\neq$ bgd scaling)

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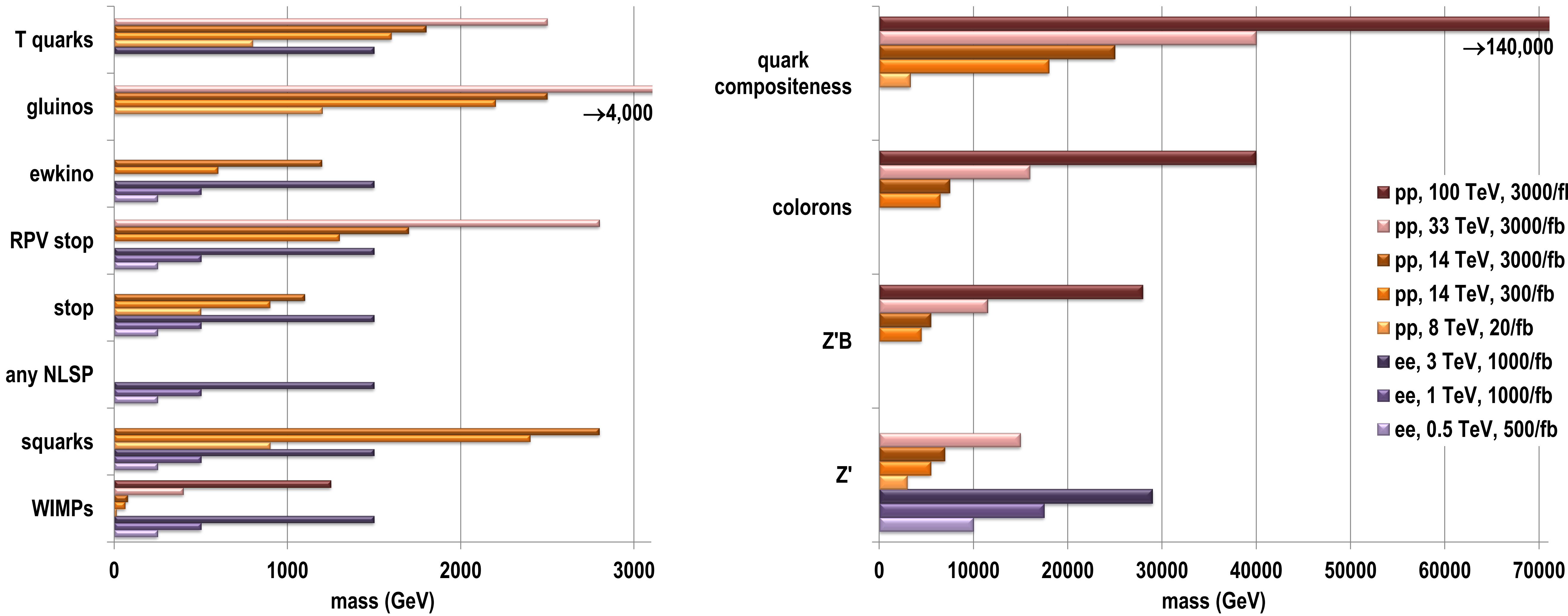
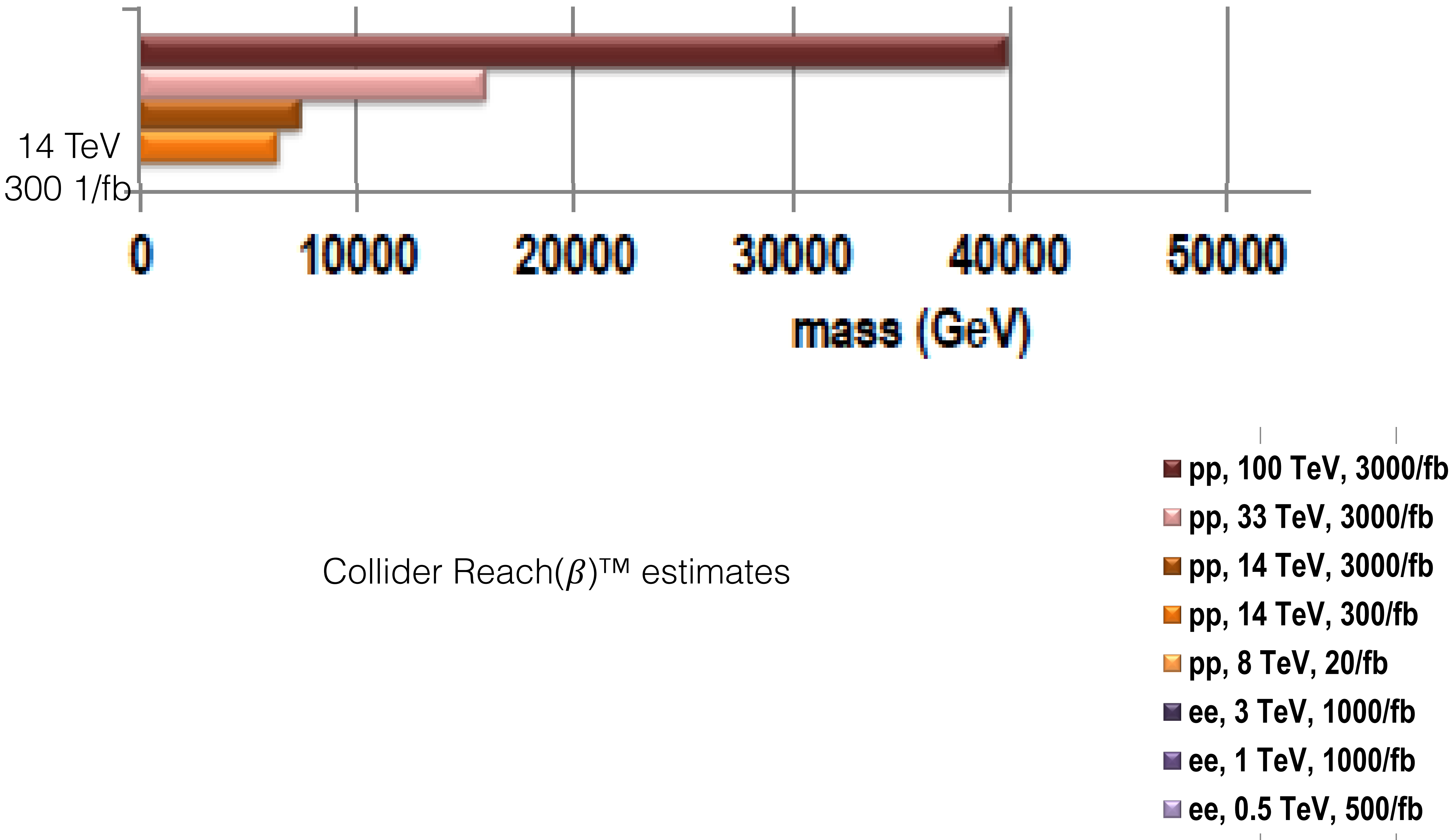
8tev, 13 ifb 3700 gev ---> 3900 GeV

Future colliders comparison



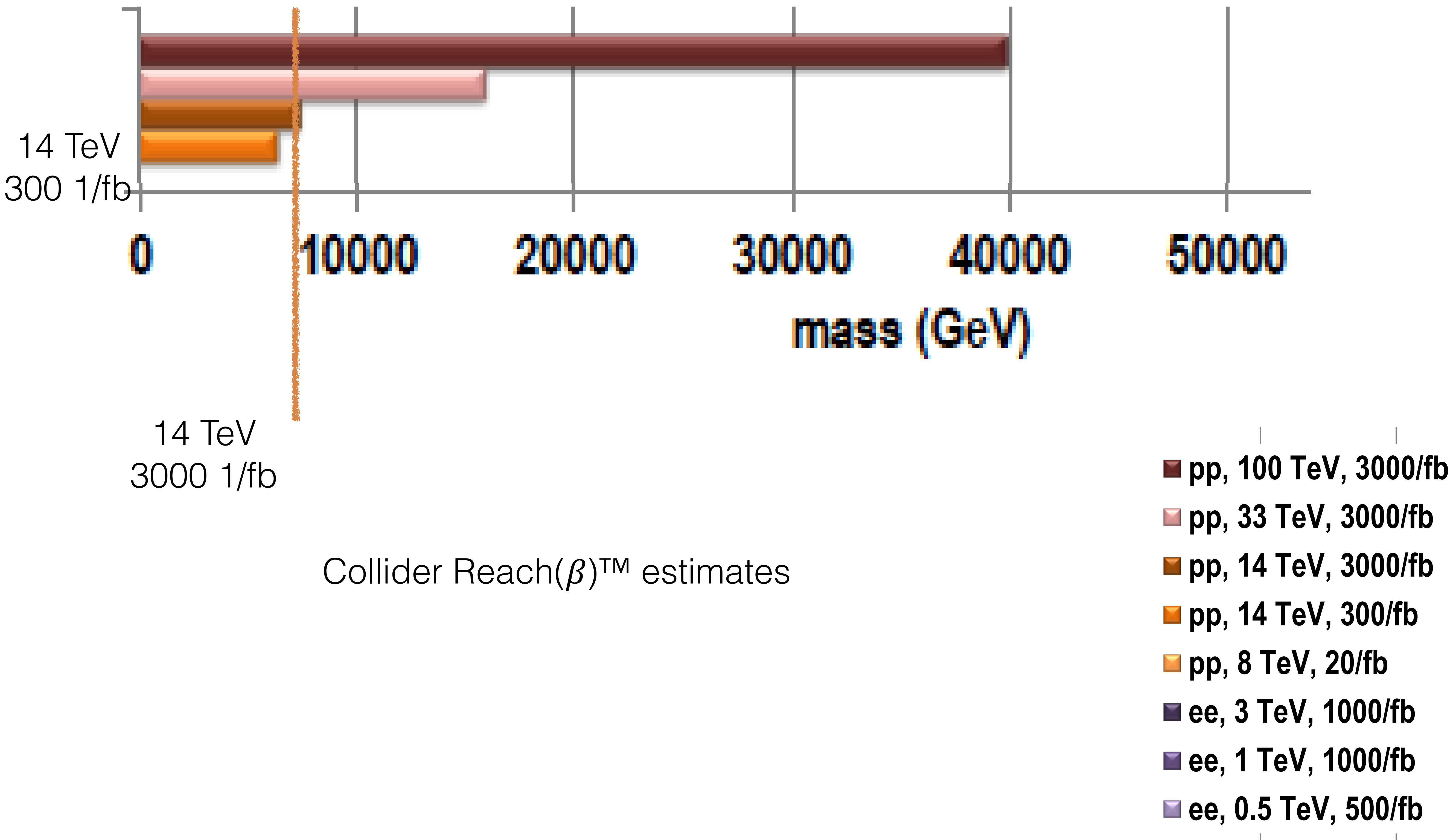
Energy Frontier Snowmass study (1311.0299)

Colorons



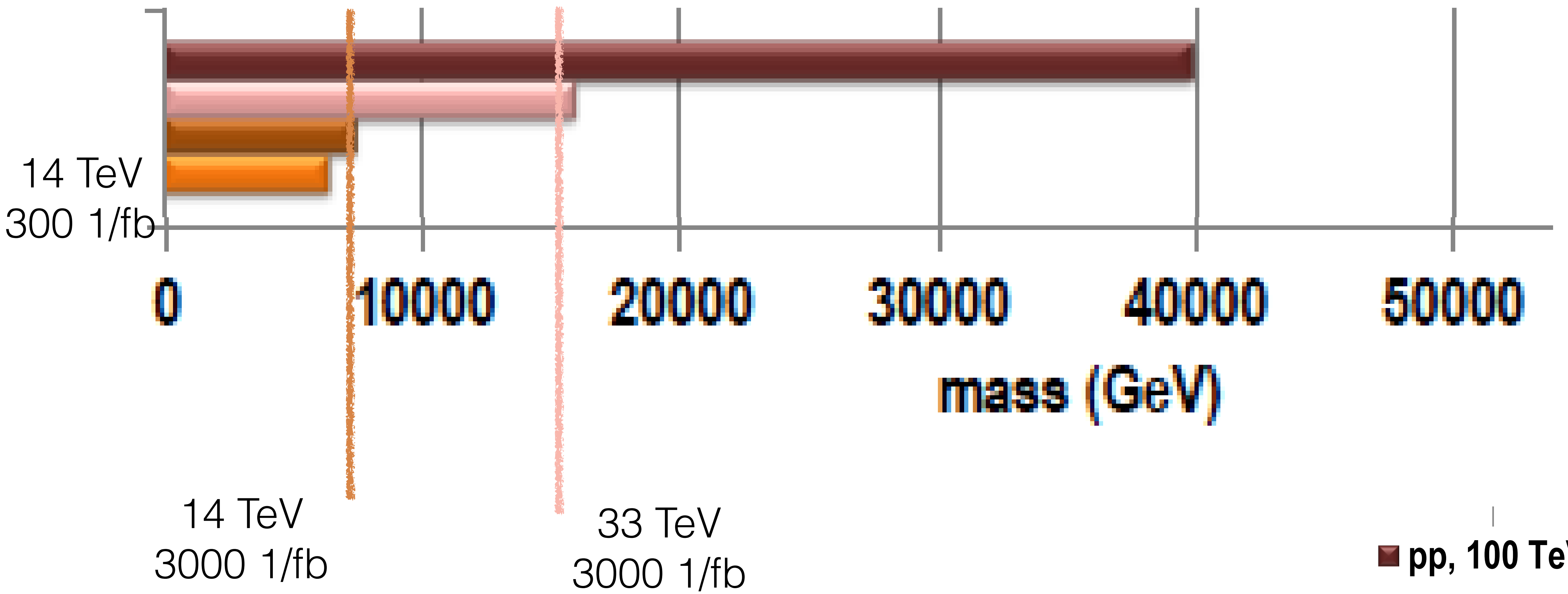
Collider Reach(β)™ estimates

Colorons



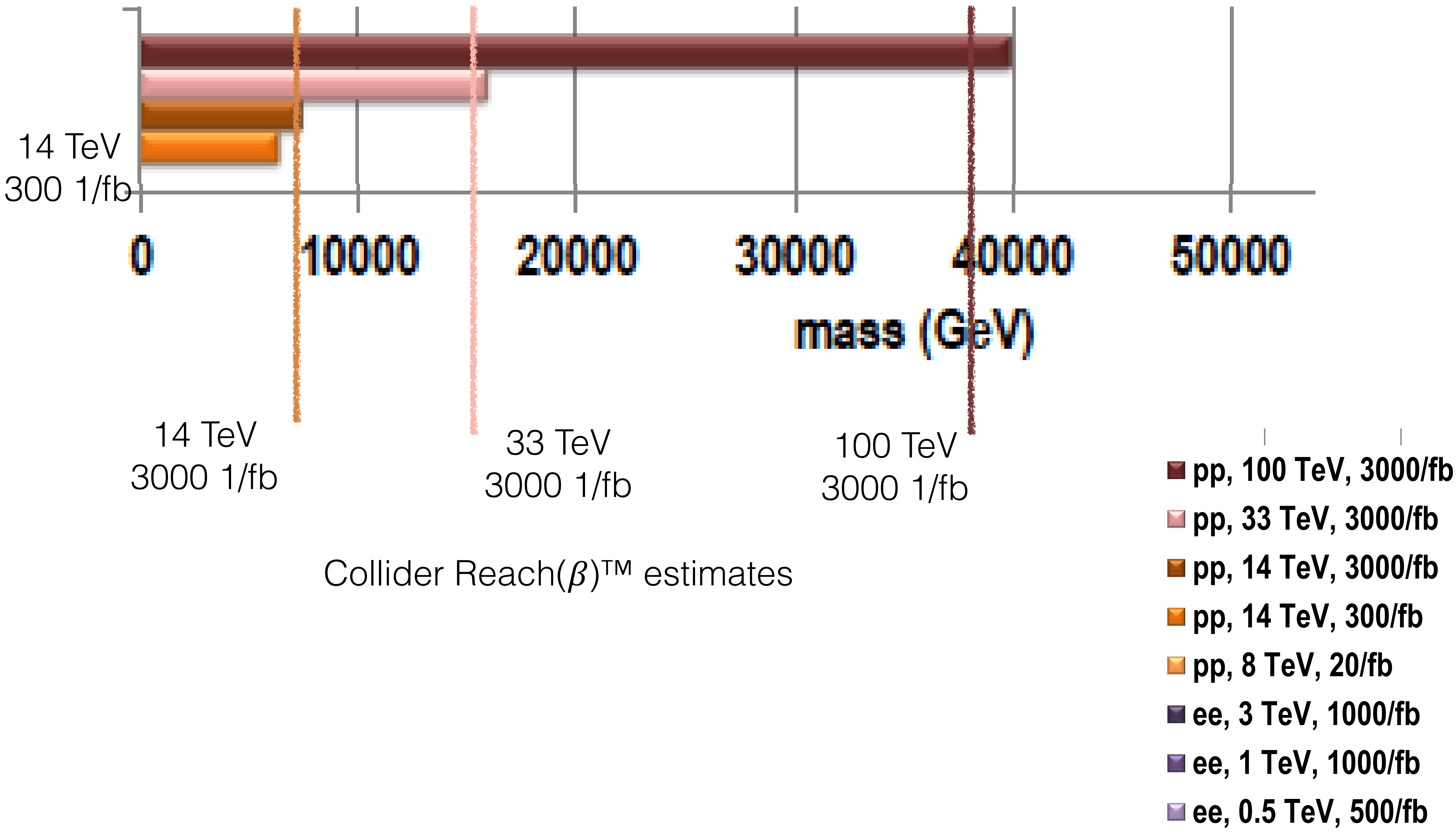
Collider Reach(β)™ estimates

Colorons



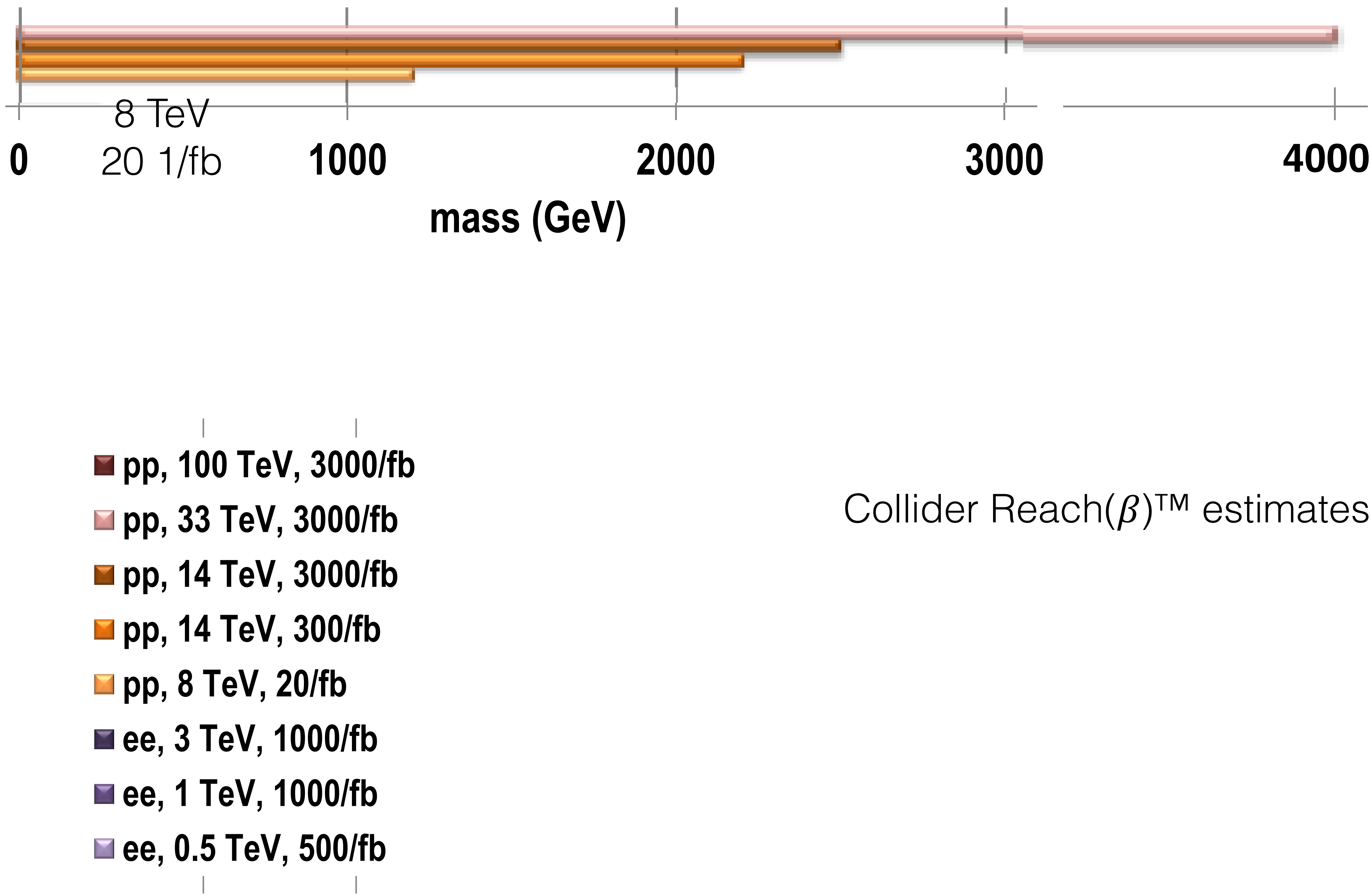
Collider Reach(β)™ estimates

Colorons



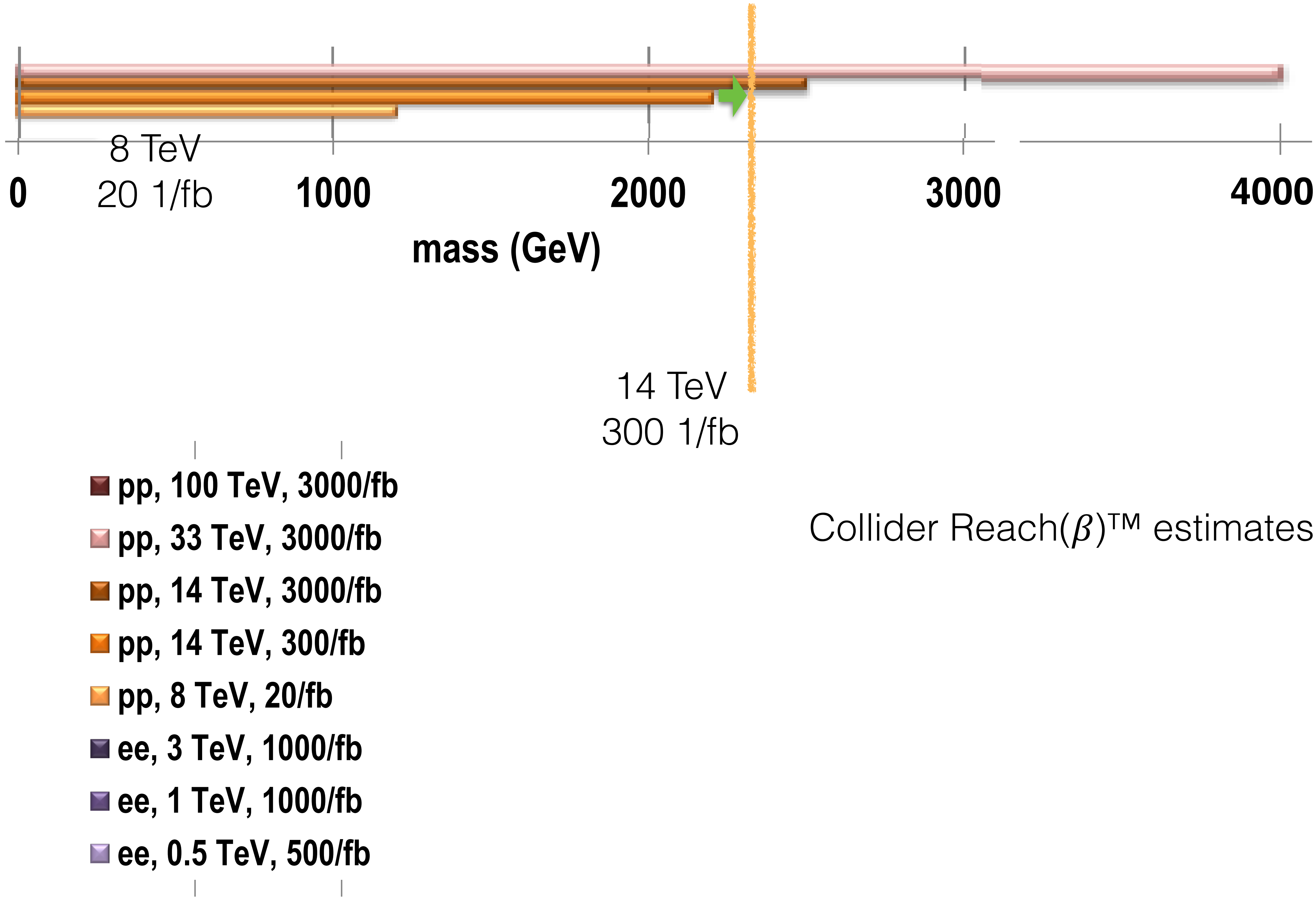
Collider Reach(β)™ estimates

Gluinos



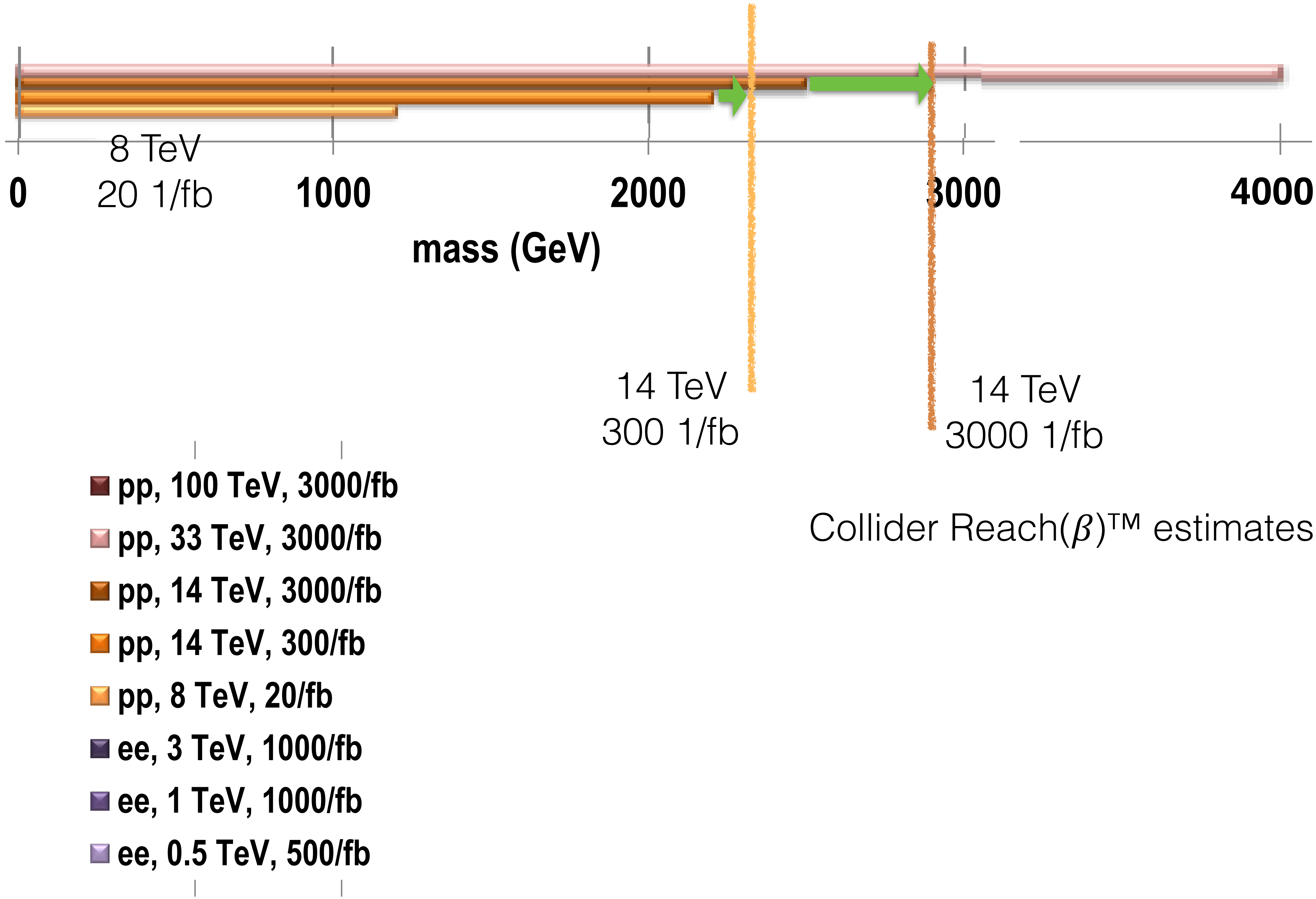
Collider Reach(β)™ estimates

Gluinos



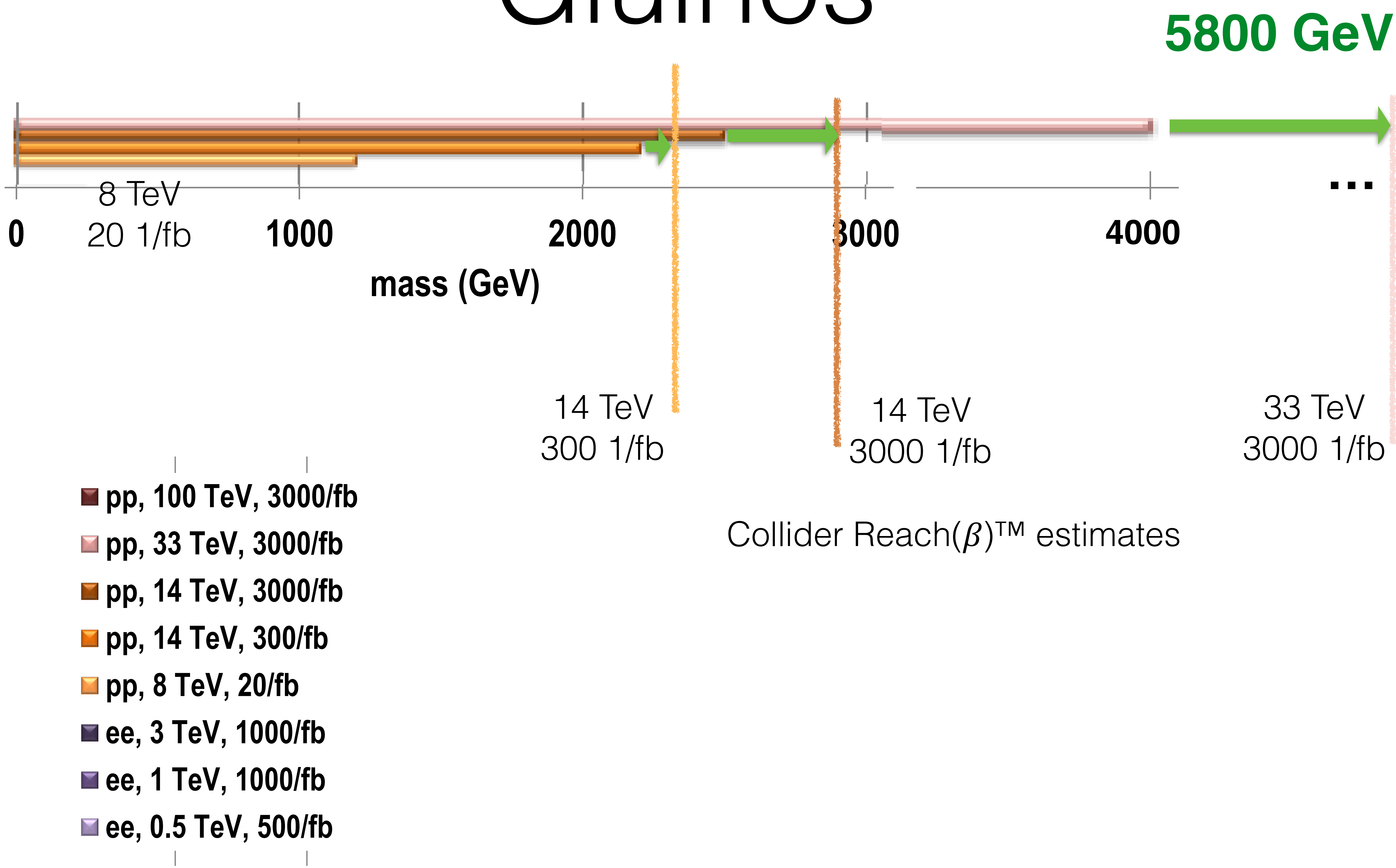
Collider Reach(β)™ estimates

Gluinos



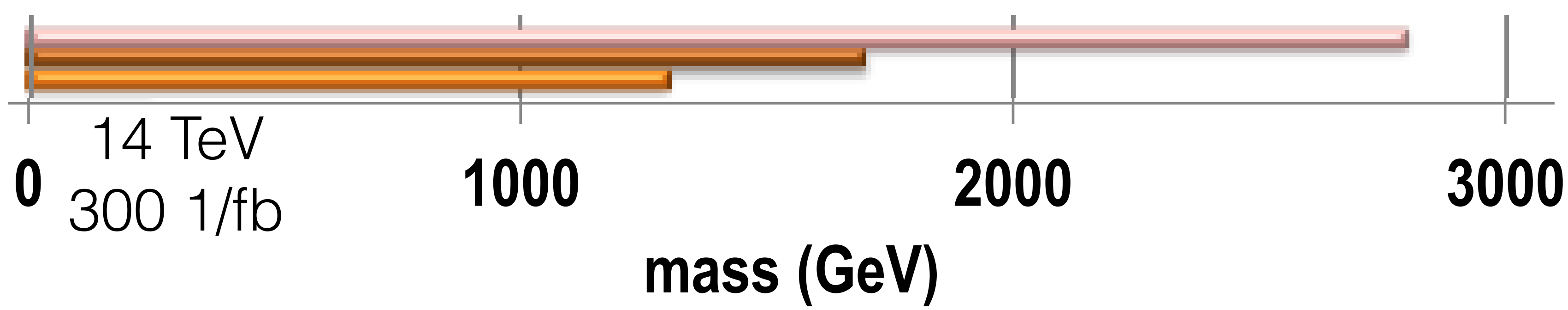
Collider Reach(β)™ estimates

Gluinos



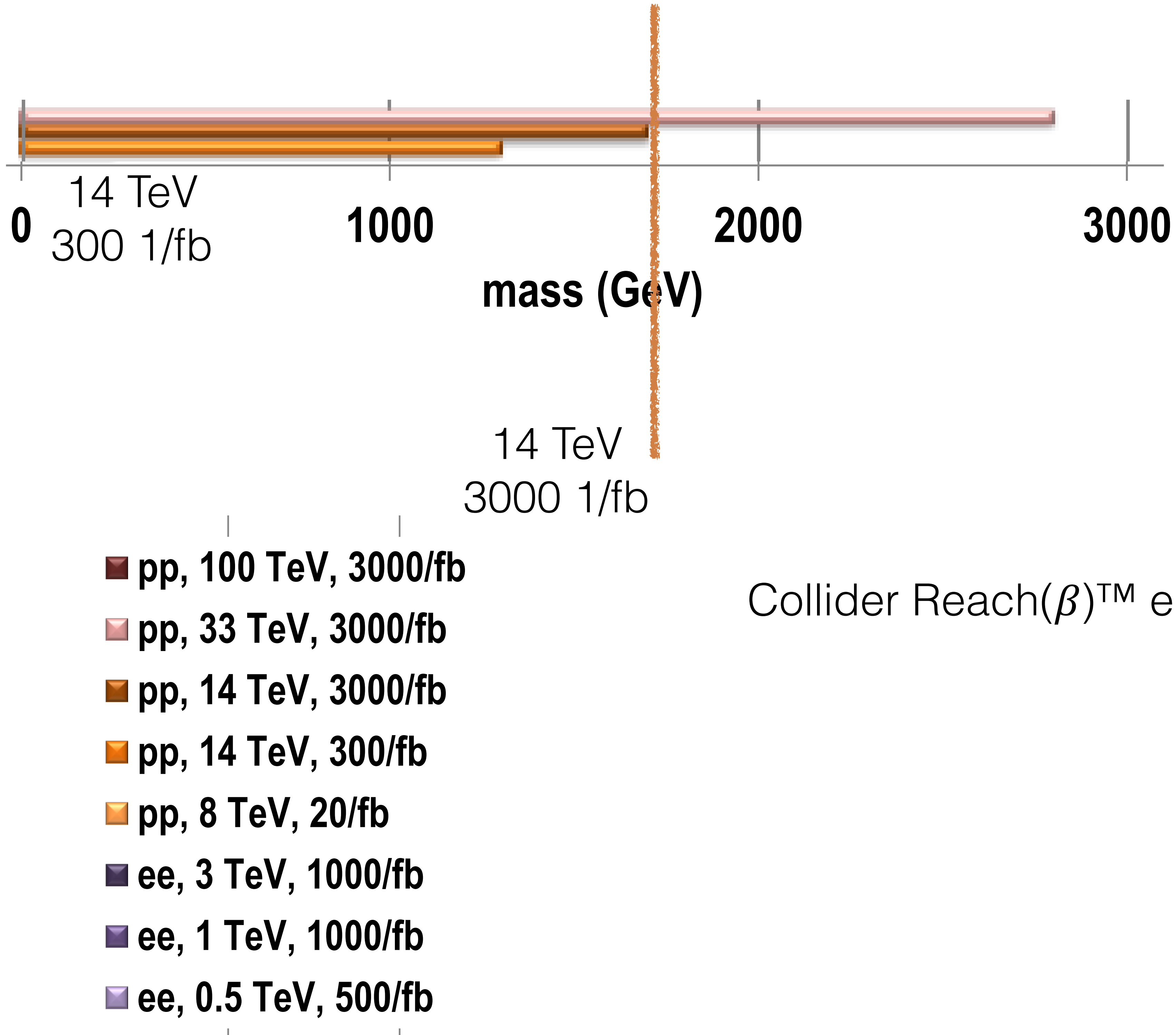
Collider Reach(β)™ estimates

RPV stops



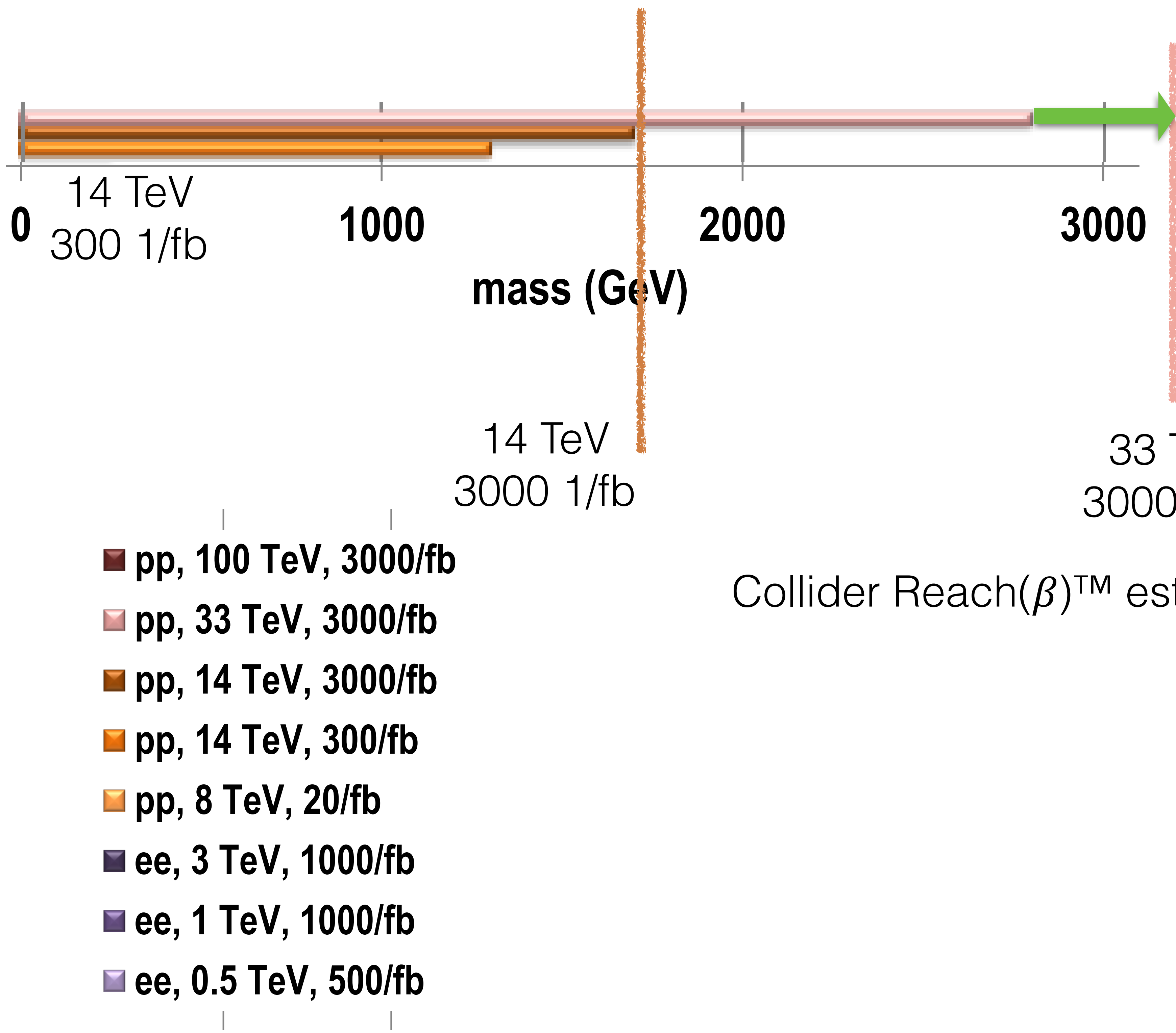
Collider Reach(β)™ estimates

RPV stops



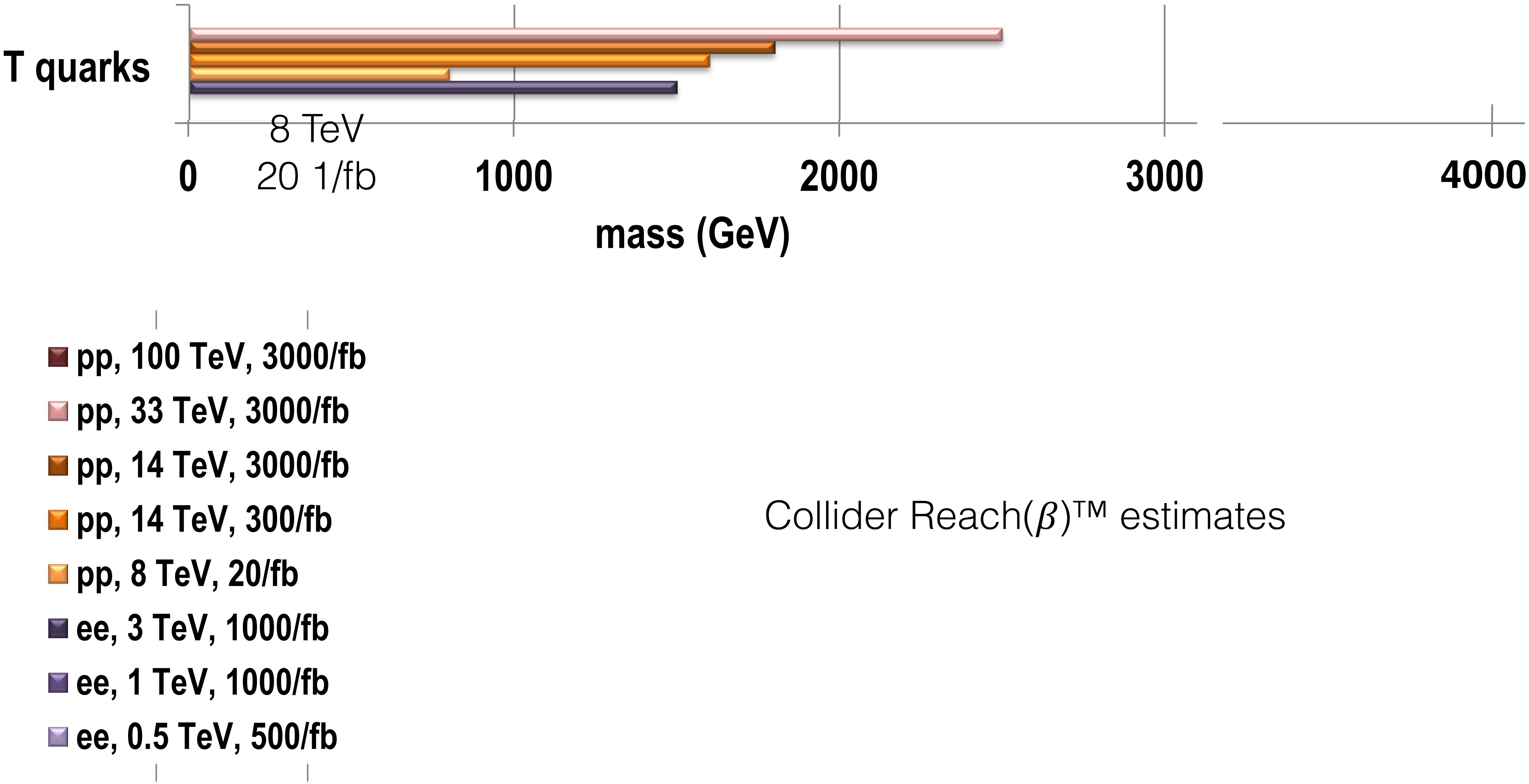
Collider Reach(β)™ estimates

RPV stops



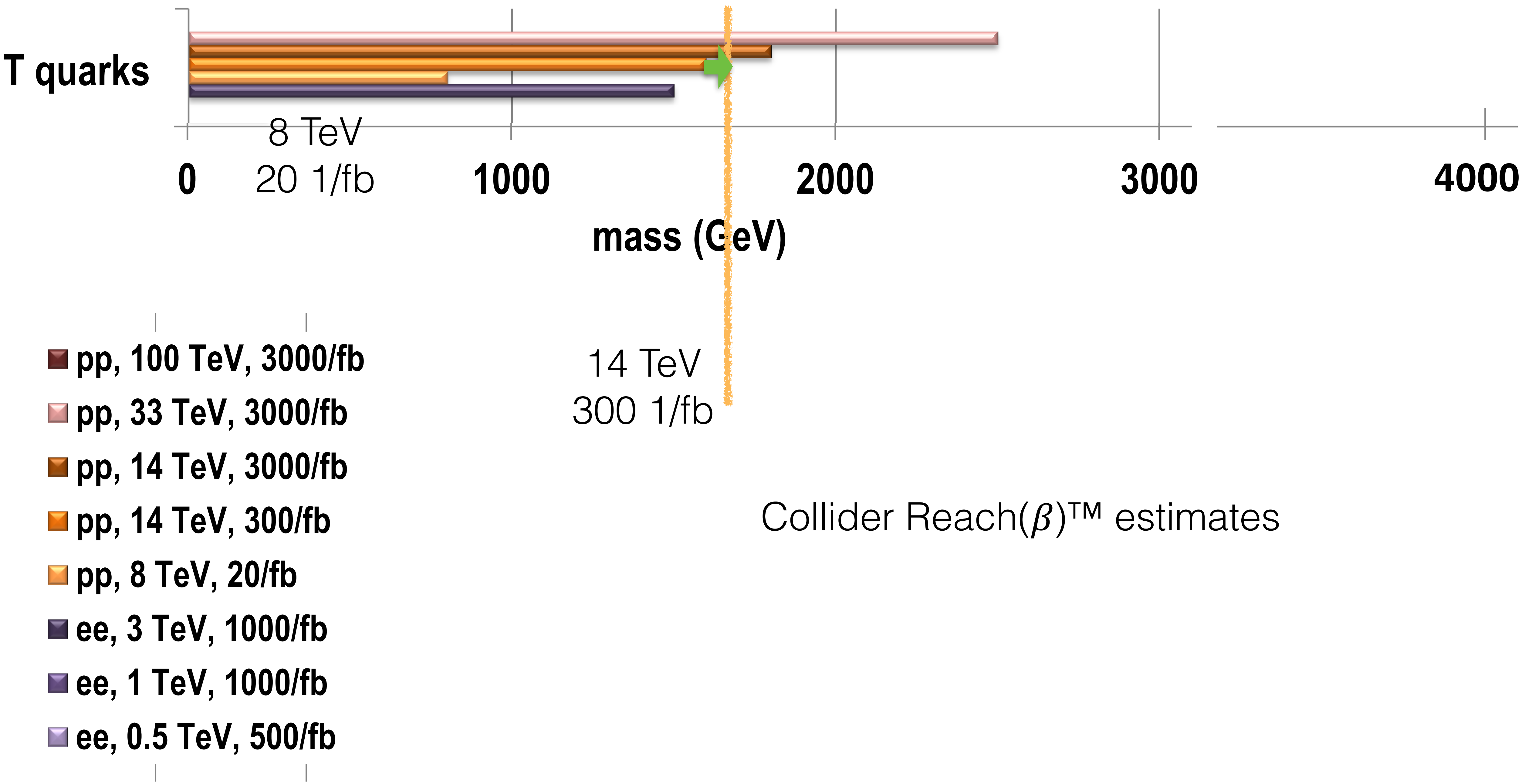
Collider Reach(β)™ estimates

T Quarks



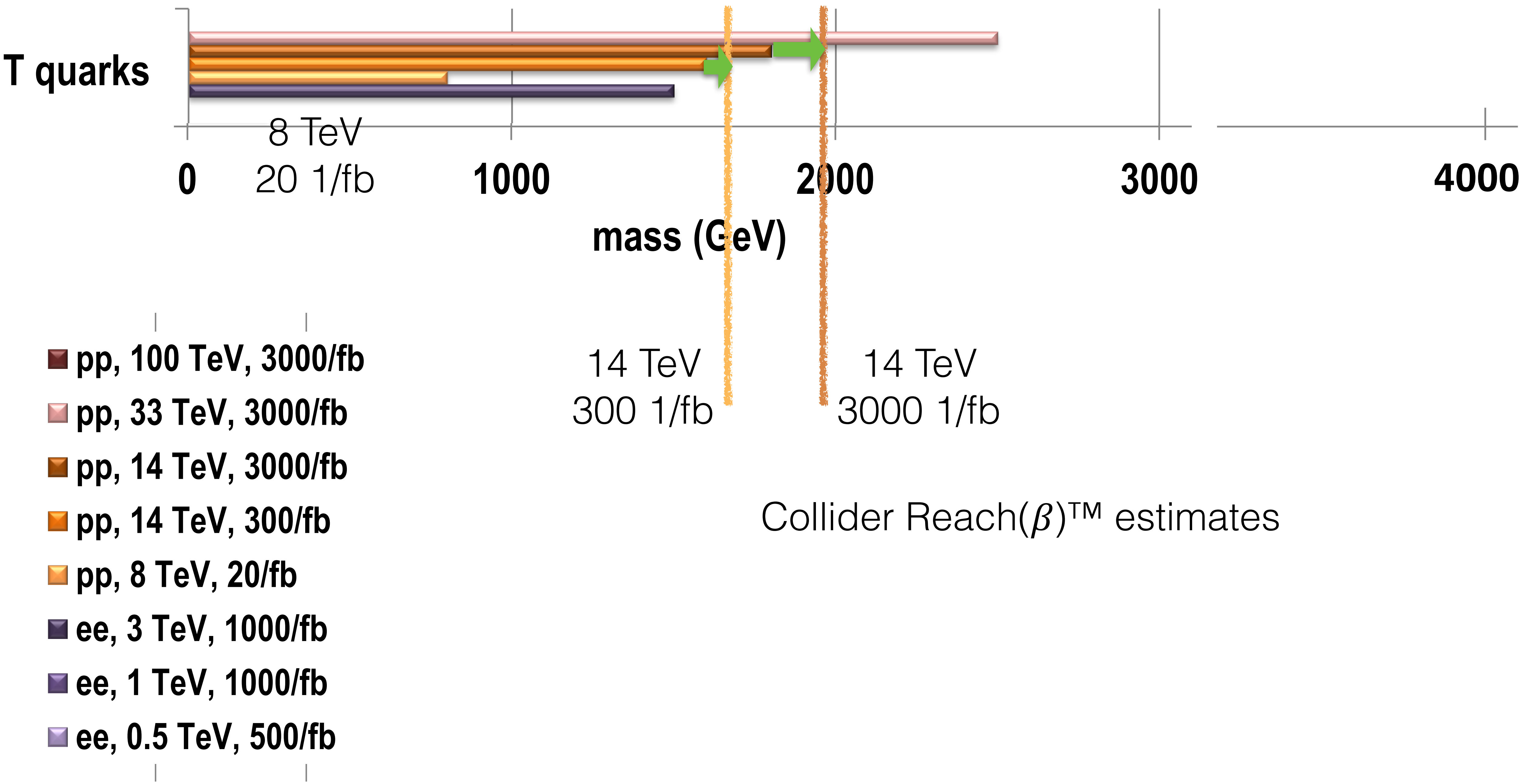
Collider Reach(β)™ estimates

T Quarks



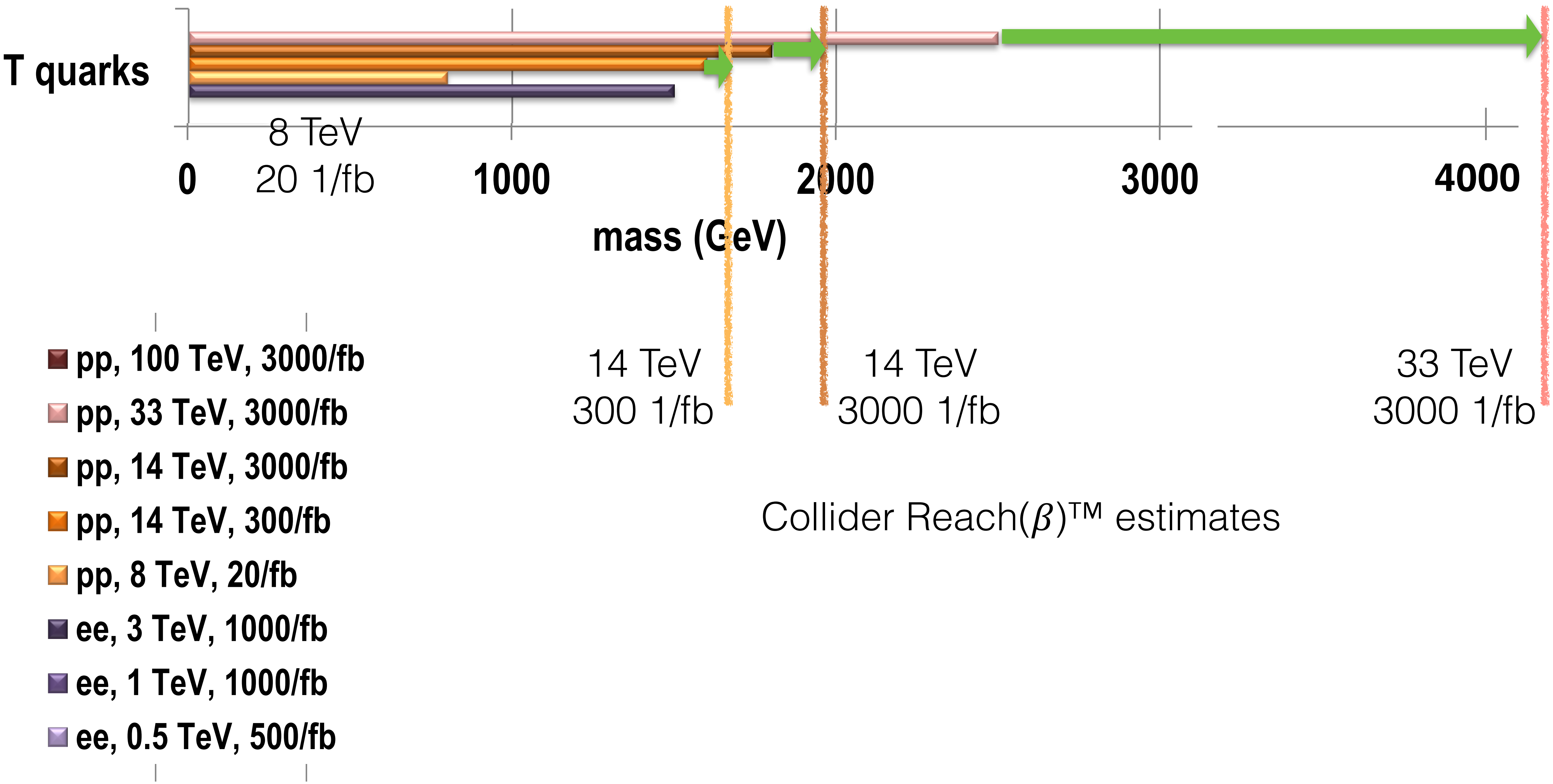
Collider Reach(β)™ estimates

T Quarks



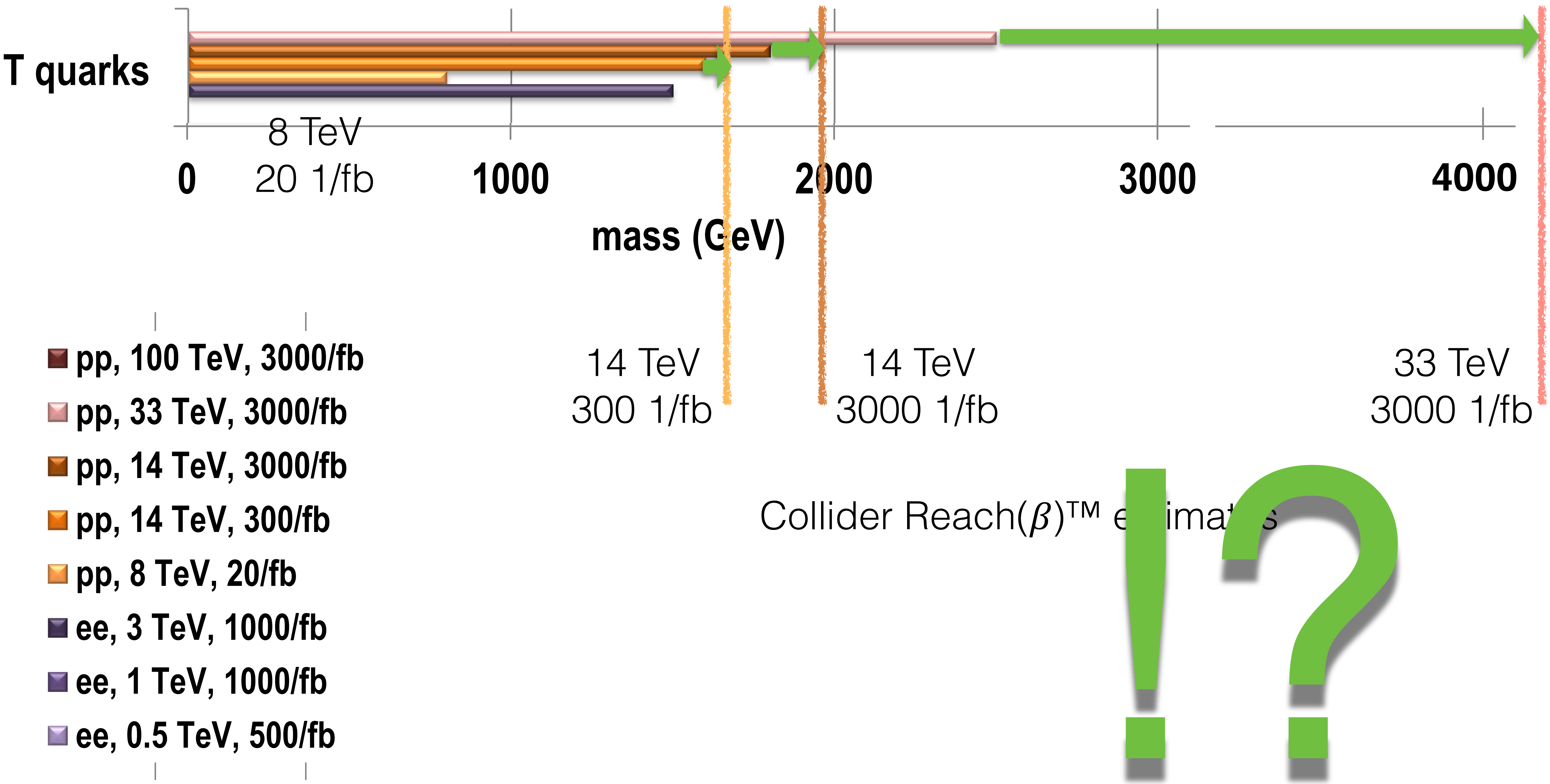
Collider Reach(β)™ estimates

T Quarks



Collider Reach(β)™ estimates

T Quarks



T quarks
8 TeV
20 1/fb
0
1000
2000
3000
4000
mass (GeV)
pp, 100 TeV, 3000/fb
pp, 33 TeV, 3000/fb
pp, 14 TeV, 3000/fb
pp, 14 TeV, 300/fb
pp, 8 TeV, 20/fb
ee, 3 TeV, 1000/fb
ee, 1 TeV, 1000/fb
ee, 0.5 TeV, 500/fb
14 TeV
300 1/fb
14 TeV
3000 1/fb
33 TeV
3000 1/fb
Collider Reach(β)™ estimates
!?

cern.ch/collider-reach

Collider Reach (β) **Home** Plots About

The Collider Reach tool gives you a quick (and dirty) estimate of the relation between the mass reaches of different proton-proton collider setups.

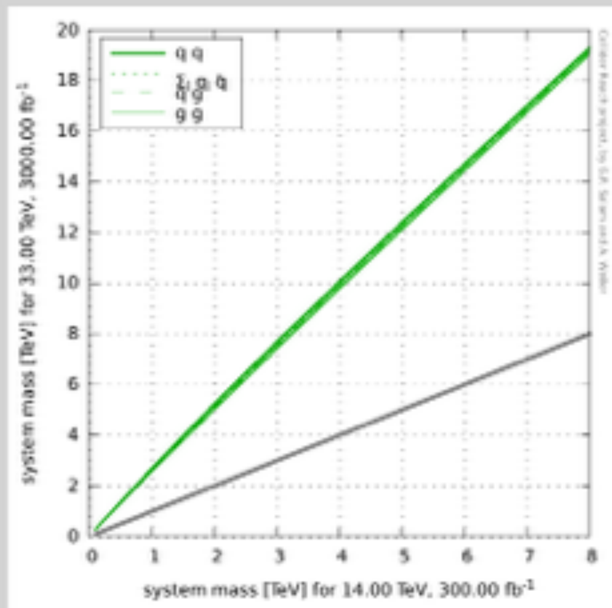
Collider 1: CoM energy 14 TeV, integrated luminosity 300 fb^{-1}

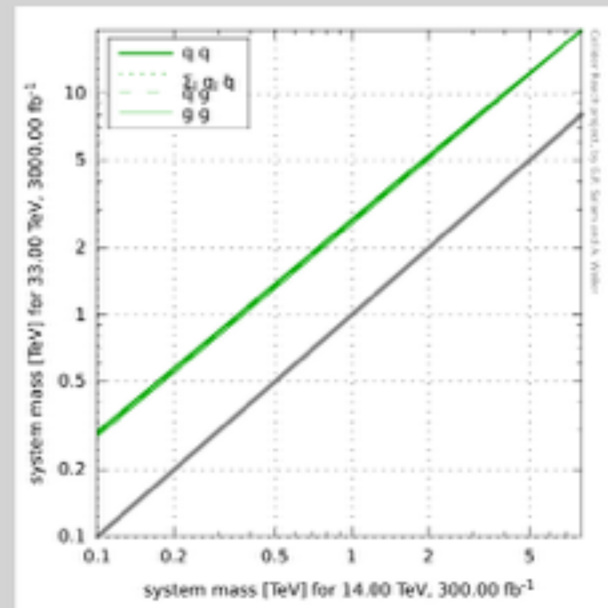
Collider 2: CoM energy 33 TeV, integrated luminosity 3000 fb^{-1}

PDF: CT10nlo

Submit

Plots



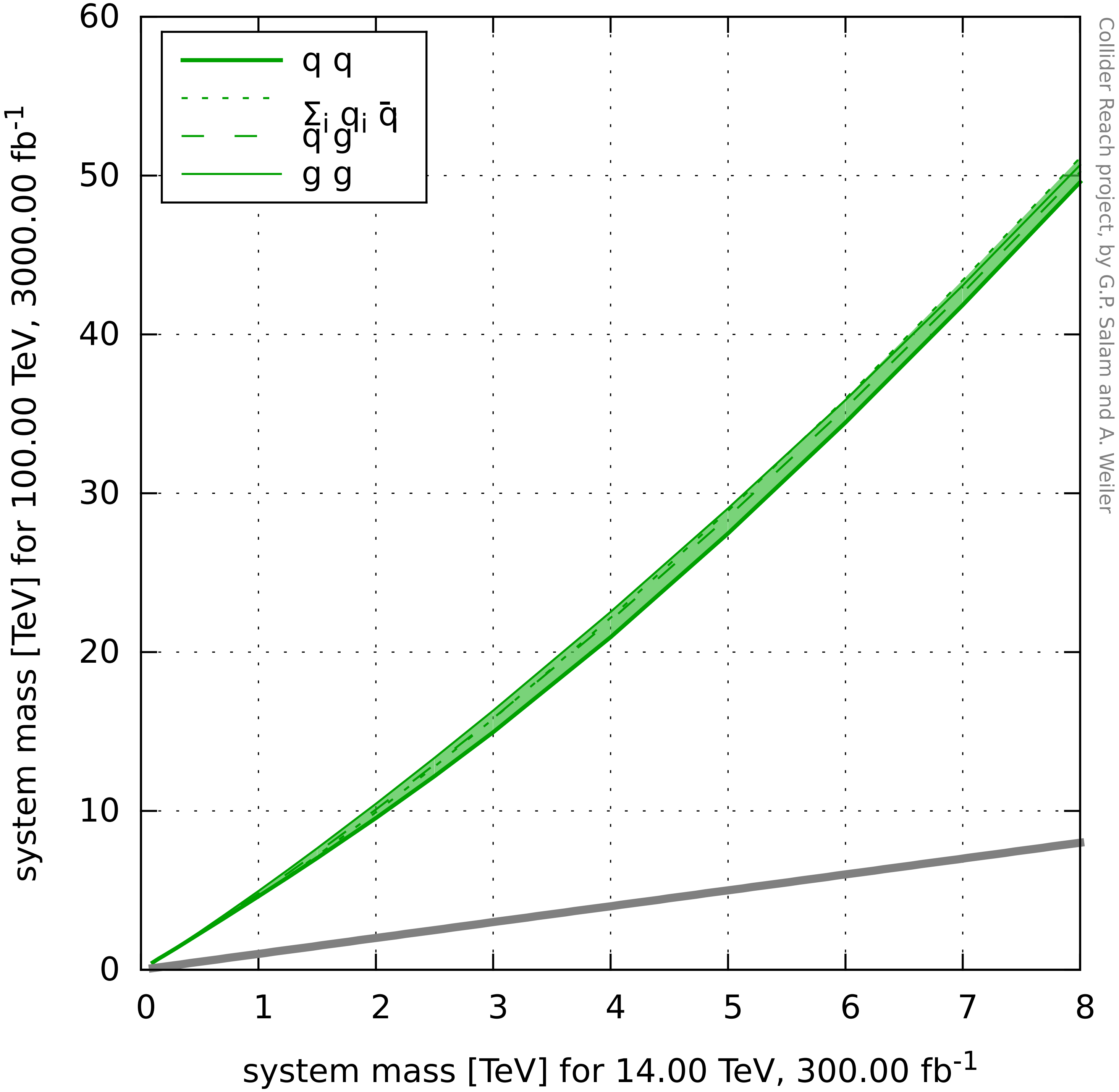


Download: collider.pdf, colliderloglog.pdf, plot generation log file

The PDF choice was CT10nlo.LHgrid

Original mass	gg	qg	allqq	qqbar
100.	283.	291.	298.	297.
125.	350.	359.	368.	367.
150.	416.	427.	438.	437.
200.	547.	562.	576.	575.
300.	806.	827.	848.	847.
500.	1317.	1350.	1386.	1382.
700.	1822.	1866.	1916.	1907.
1000.	2570.	2628.	2702.	2680.
1250.	3188.	3256.	3349.	3314.
1500.	3802.	3879.	3990.	3939.
2000.	5018.	5110.	5251.	5169.
2500.	6223.	6327.	6488.	6380.
3000.	7417.	7530.	7703.	7578.
4000.	9782.	9904.	10082.	9945.
5000.	12120.	12246.	12417.	12284.
6000.	14439.	14565.	14726.	14601.
7000.	16748.	16871.	17021.	16905.
8000.	19053.	19169.	19310.	19206.

14 TeV$_{300\ 1/fb}$ → 100 TeV$_{3\ 1/ab}$



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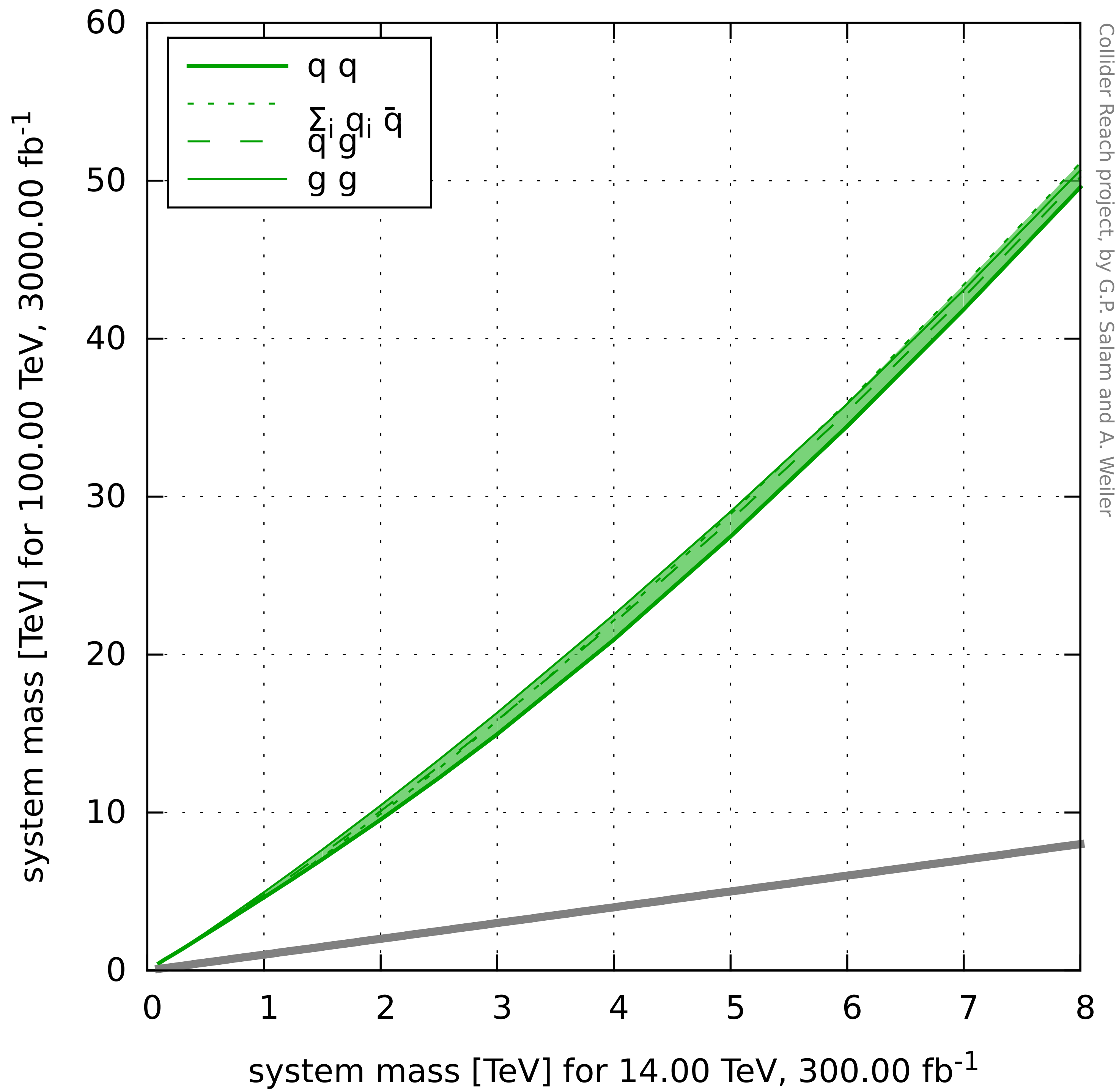

The PDF choice was CT10nlo.LHgrid

Original mass	**gg**	**qg**	**allqq**	**qqbar**
100.	469.	465.	462.	457.
125.	585.	579.	575.	568.
150.	702.	693.	687.	679.
200.	937.	923.	912.	902.
300.	1414.	1386.	1365.	1350.
500.	2394.	2332.	2279.	2261.
700.	3401.	3300.	3206.	3194.
1000.	4956.	4793.	4619.	4640.
1250.	6287.	6072.	5818.	5892.
1500.	7647.	7382.	7038.	7187.
2000.	10444.	10090.	9552.	9905.
2500.	13337.	12908.	12185.	12781.
3000.	16319.	15833.	14954.	15795.
4000.	22531.	21986.	20933.	22162.
5000.	29050.	28508.	27467.	28894.
6000.	35863.	35366.	34451.	35960.
7000.	43079.	42620.	41854.	43411.
8000.	50671.	50230.	49590.	51132.

Conclusions

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* currently only accessible from within CERN, security clearance should arrive anytime soon

Based on LHAPDF and HOPPET