SUSY global fit of with CEPC using GAMBIT

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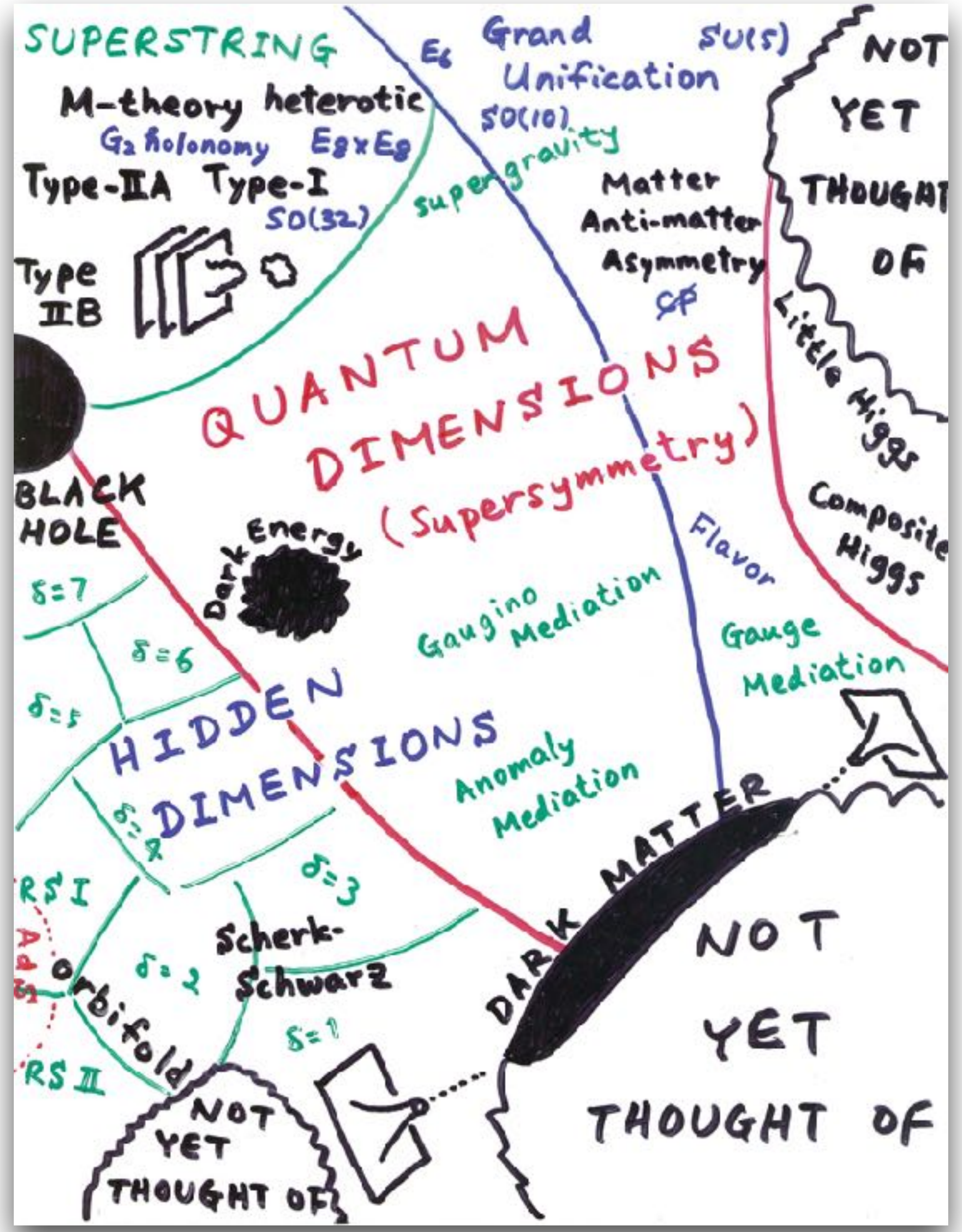
Outline

- Motivation
- Status of global SUSY fits
- Recent progress

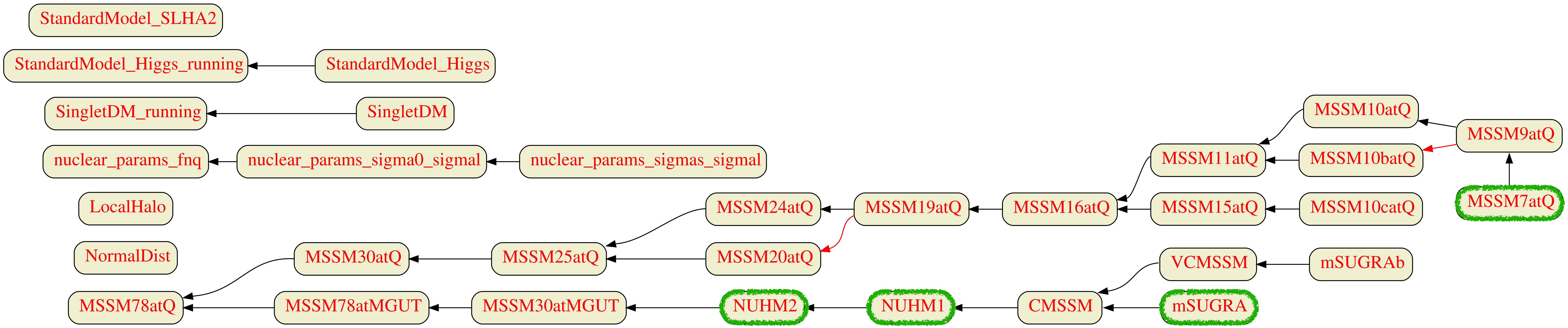
Why do we need global fits?

- Many BSM theories
  - Which one is better?
- BSM models have a large amount of parameters
  - Explore full parameter space
  - Where is my theory valid?
- Many experimental constraints
  - Collider searches, dark matter, precision observables, flavour anomalies, ...
  - Simultaneously include all constraints
  - Does my theory fit the experimental data?



SUSY global fit of with CEPC

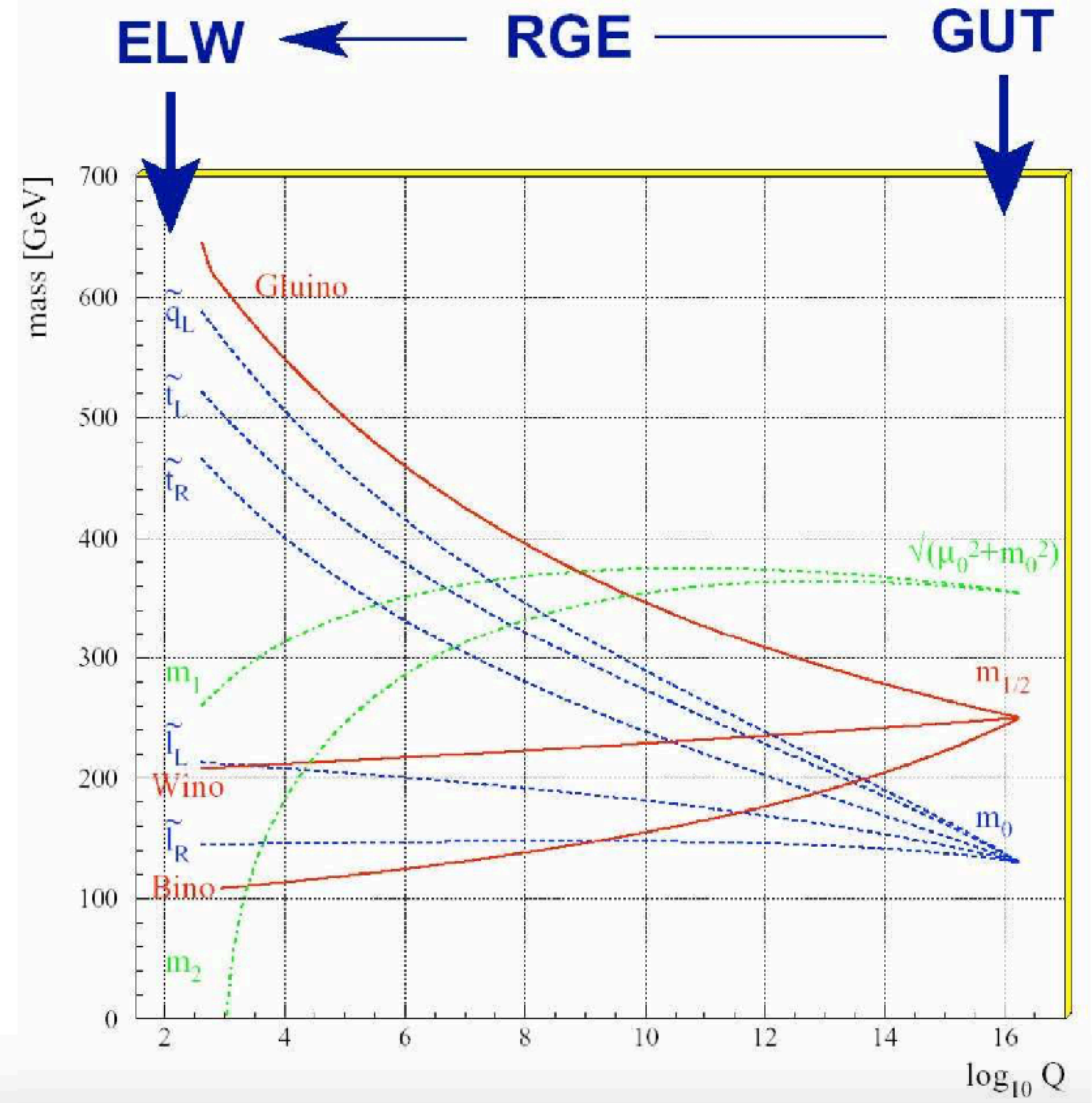
- Study the impact of future electron-positron colliders, such as CEPC, CLiC, ILC and FCC-ee, on global fits of the simplest supersymmetric models, such as the CMSSM, NUHM1,NUHM2 and pMSSM-7.



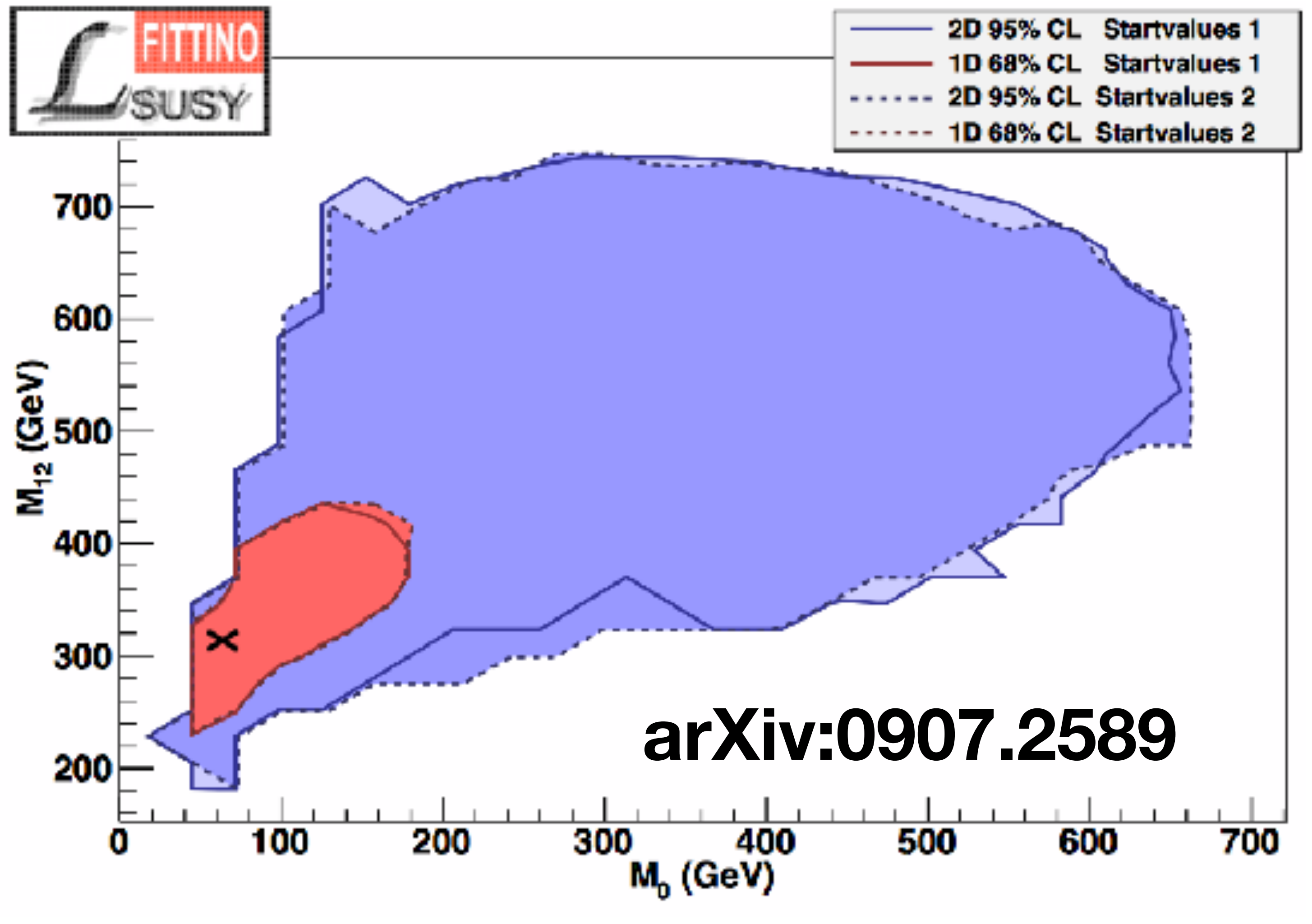
CMSSM/mSUGRA

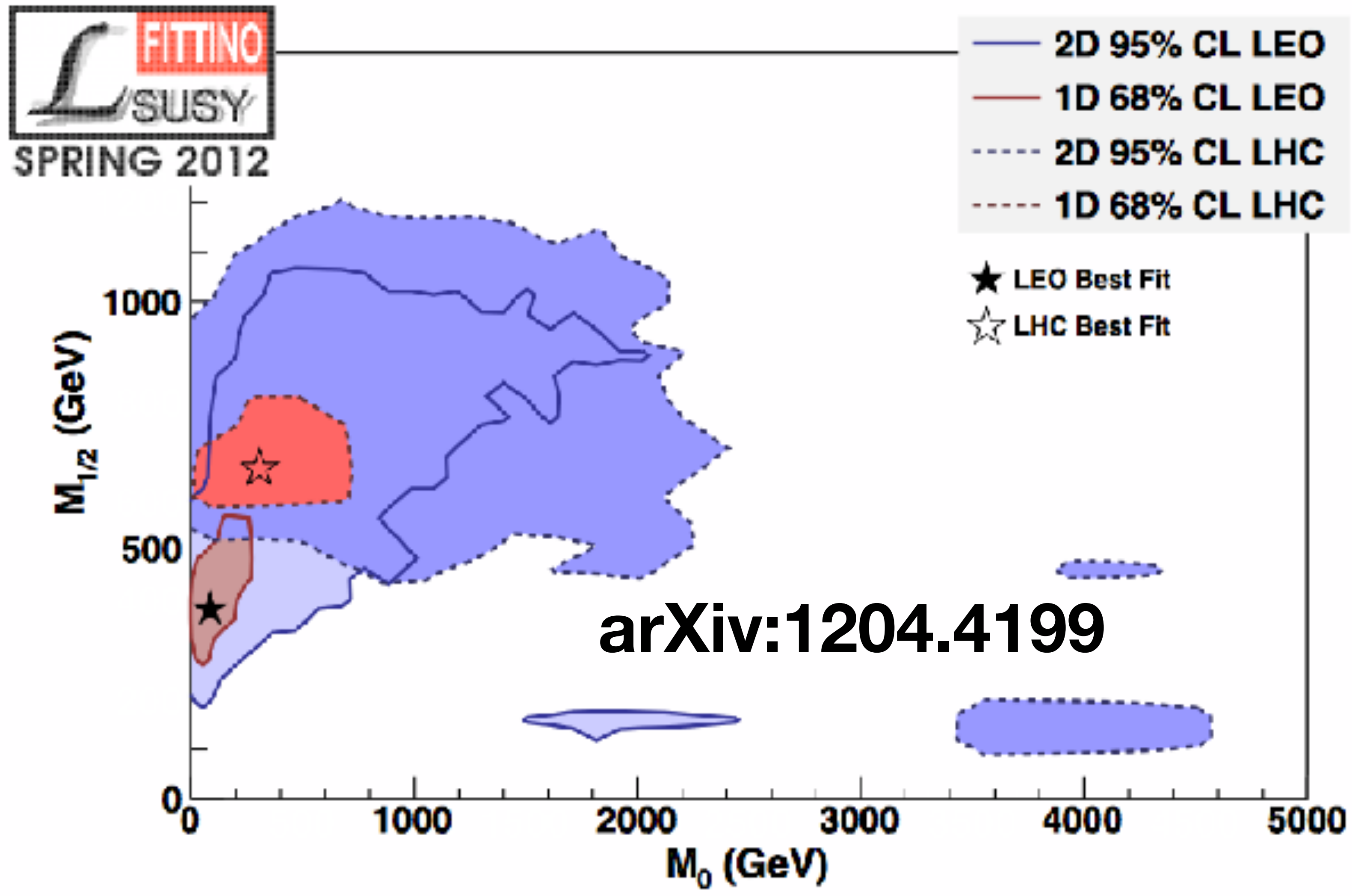
- SUSY is broken by gravity

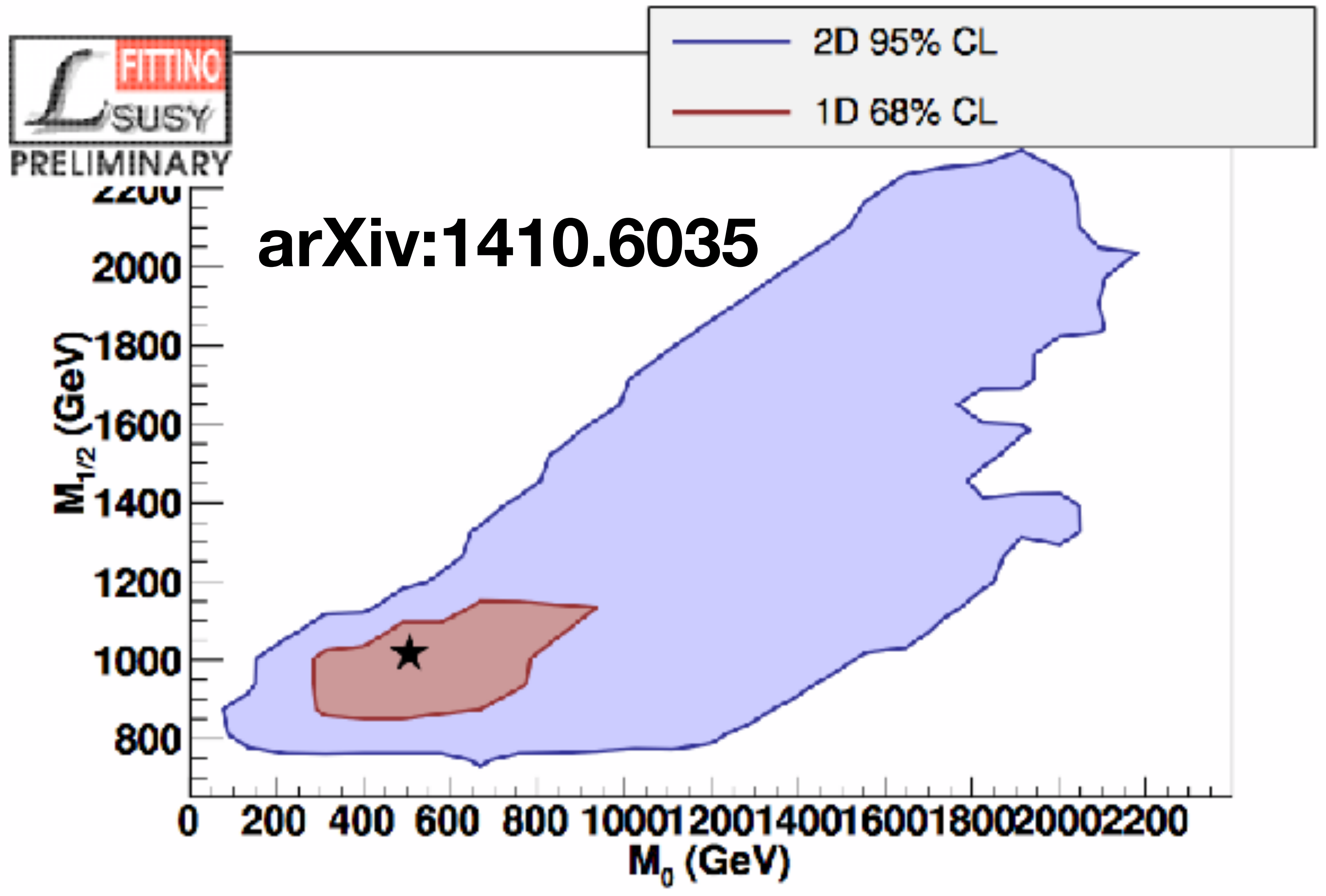
- Assume universal masses at GUT scale:
    - m_0 – common mass of scalars (squarks, sleptons, Higgs bosons)
    - $m_{1/2}$ – common mass of gauginos and higgsinos
    - A_0 – common trilinear coupling
    - $\tan\beta$ – ratio of Higgs vacuum expectation values
    - $\text{sign}(\mu) = \pm 1$ – sign of μ SUSY conserving Higgsino mass parameter

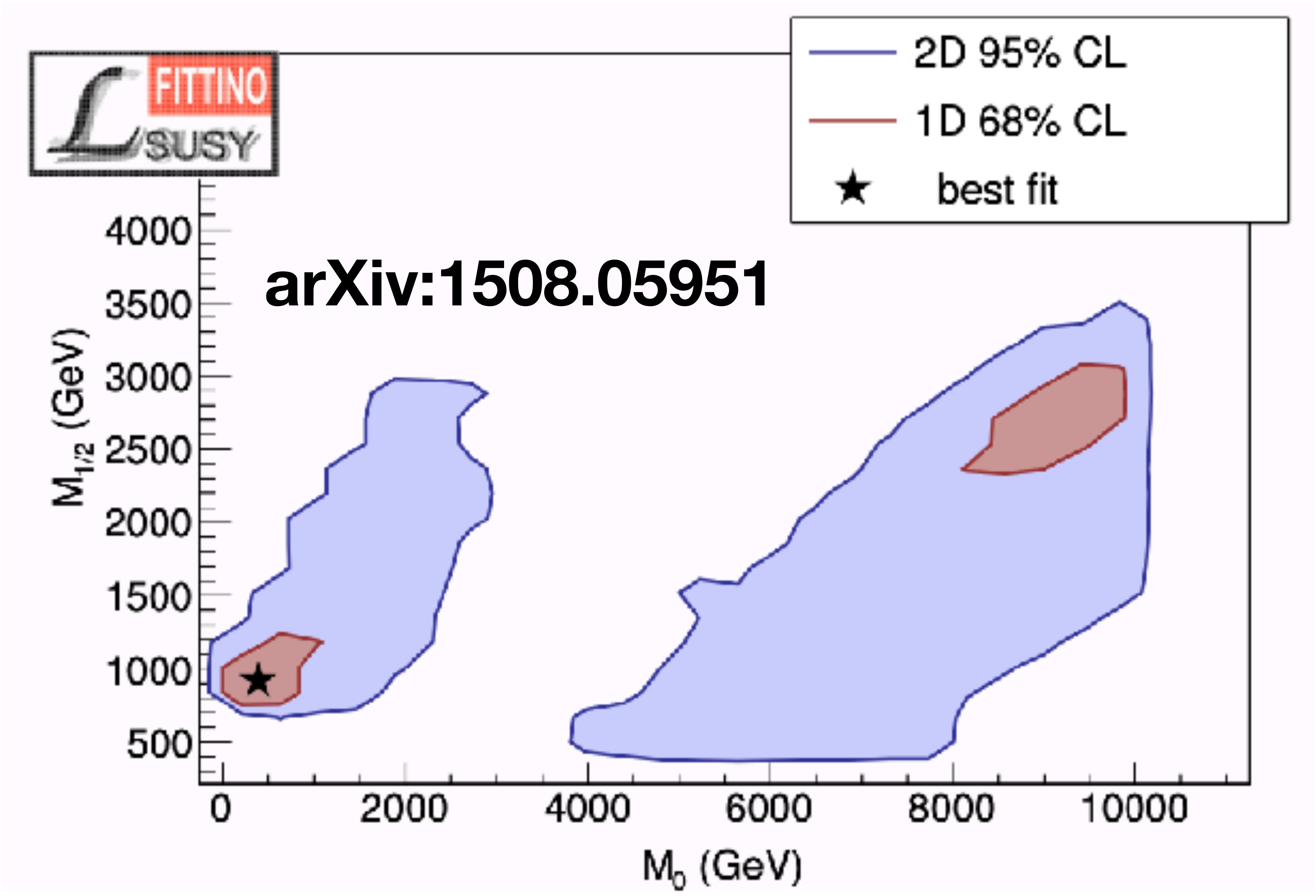


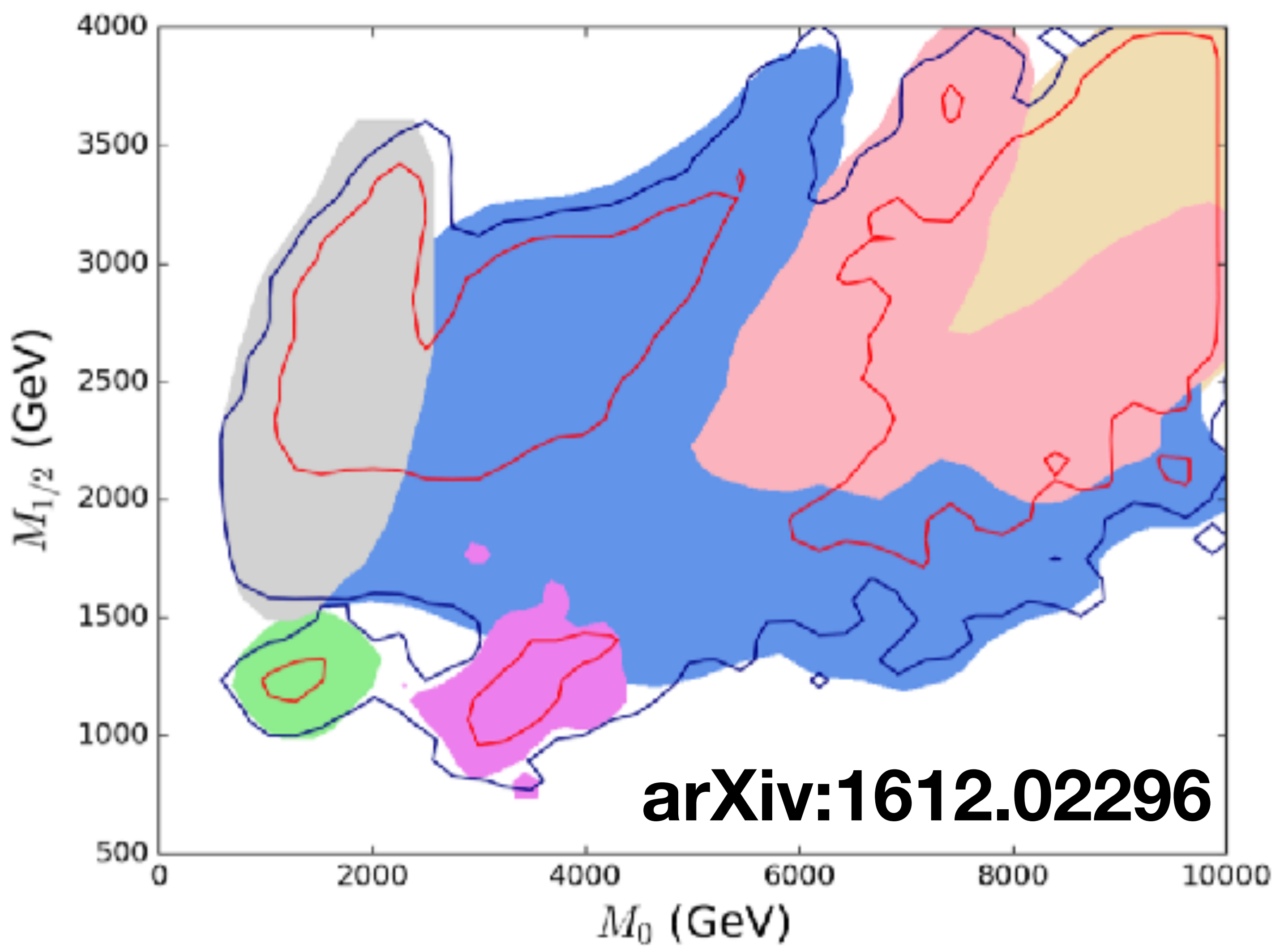
Status of global CMSSM fits

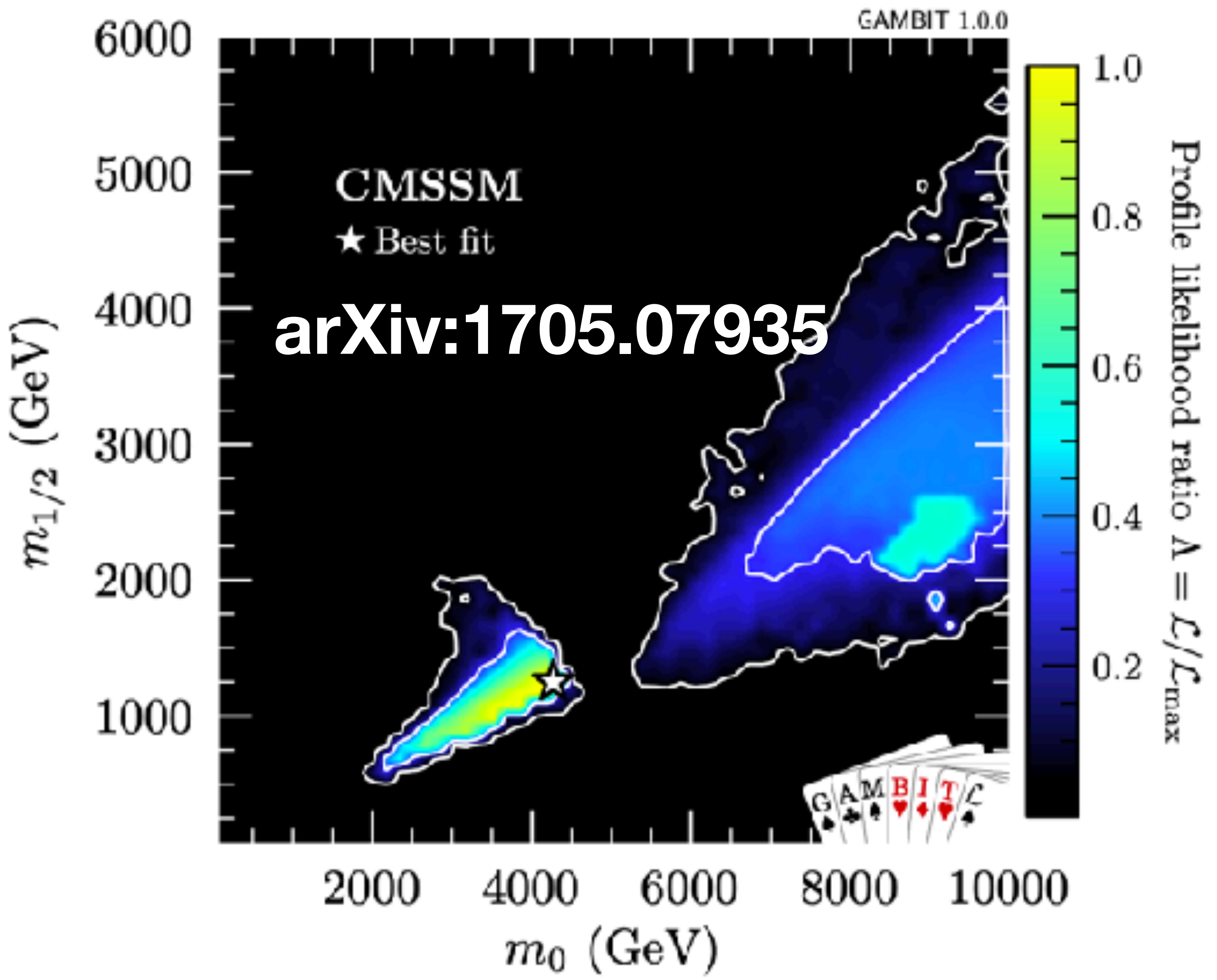












Status of global CMSSM fits

- Collider searches
  - LHC searches for SUSY particles
  - LEP SUSY searches
  - Higgs physics
- Dark matter constraints
  - Relic density of DM
  - Direct detection
  - Indirect detection
- Precision observables
  - Electroweak precision
  - Anomalous magnetic moment μ
- Flavour physics
  - B and D meson decays
  - Lepton flavour universality ratios

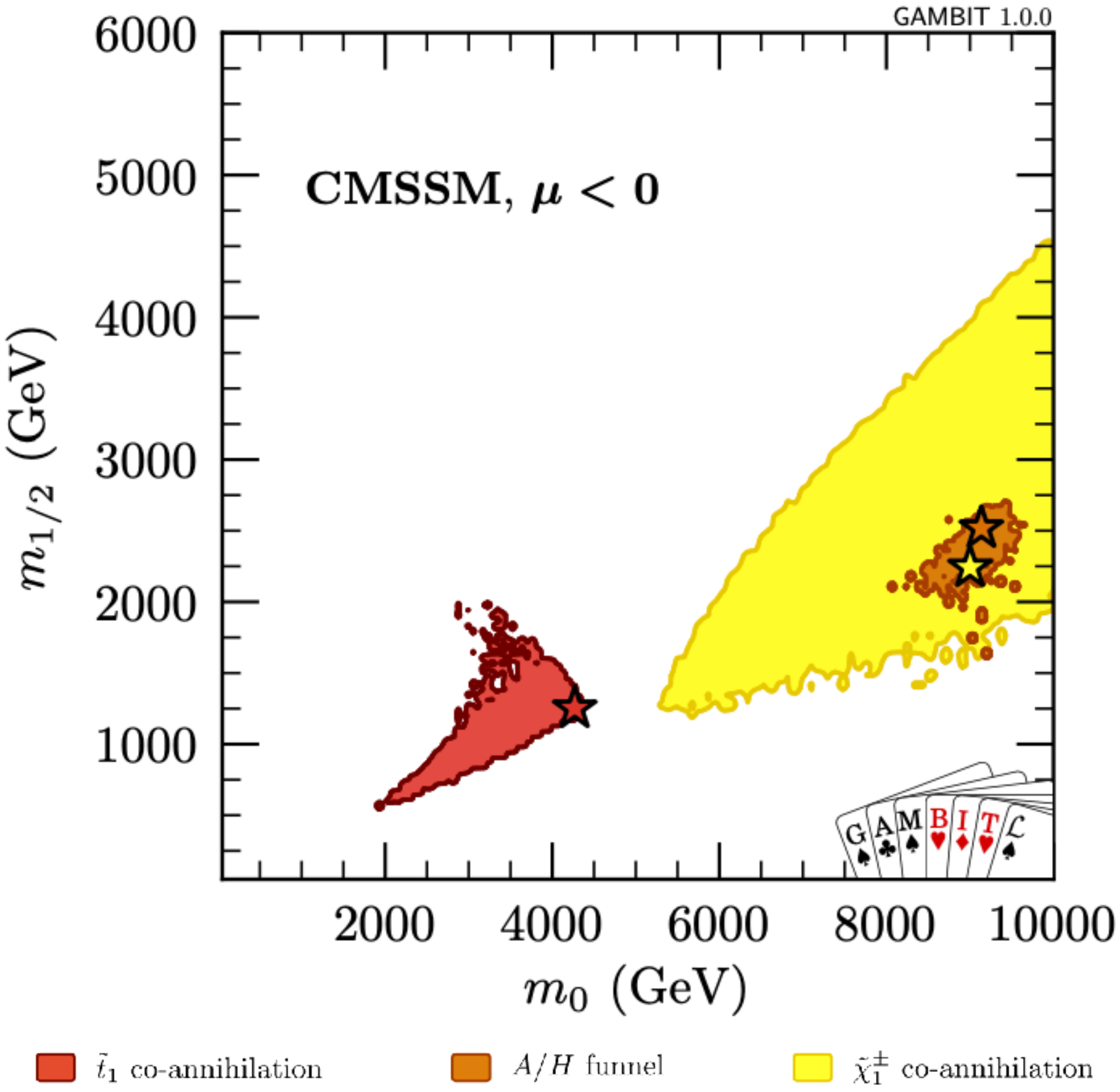
Likelihood term
LHC sparticle searches
LHC Higgs
LEP Higgs
ALEPH selectron
ALEPH smuon
ALEPH stau
L3 selectron
L3 smuon
L3 stau
L3 neutralino leptonic
L3 chargino leptonic
OPAL chargino hadronic
OPAL chargino semi-leptonic
OPAL chargino leptonic
OPAL neutralino hadronic
$B_{(s)} \to \mu^+\mu^-$
Tree-level B and D decays
$B^0 \to K^{*0}\mu^+\mu^-$
$B \to X_s\gamma$
a_μ
W mass
Relic density
PICO-2L
PICO-60 F
SIMPLE 2014
LUX 2015
LUX 2016
PandaX 2016
SuperCDMS 2014
XENON100 2012
IceCube 79-string
γ rays (Fermi-LAT dwarfs)
ρ_0
σ_s and σ_l
$\alpha_s(m_Z)(\overline{MS})$
Top quark mass

ATLAS_13TeV_MultiLEP_strong_139invfb
ATLAS_13TeV_RJ3L_lowmass_36invfb
ATLAS_13TeV_RJ3L_2Lep2Jets_36invfb
ATLAS_13TeV_RJ3L_3Lep_36invfb
ATLAS_13TeV_2OSLEP_chargino_80invfb
ATLAS_13TeV_2OSLEP_chargino_binned_80invfb
ATLAS_13TeV_2OSLEP_chargino_inclusive_80invfb
ATLAS_13TeV_2OSLEP_chargino_139invfb
ATLAS_13TeV_2OSLEP_chargino_inclusive_139invfb
ATLAS_13TeV_2OSLEP_chargino_binned_139invfb
ATLAS_13TeV_2OSLEP_Z_139invfb
ATLAS_13TeV_2LEPsoft_139invfb
ATLAS_13TeV_4LEP_36invf
ATLAS_13TeV_4LEP_139invf
ATLAS_13TeV_1Lep2b_139invfb
ATLAS_13TeV_2b2H_sbottom_139invfb
ATLAS_13TeV_2b2W_stop_139invfb
ATLAS_13TeV_2bMET_36invfb
ATLAS_13TeV_3b_24invfb
ATLAS_13TeV_3b_discoverySR_24invfb
ATLAS_13TeV_3b_36invfb
ATLAS_13TeV_3b_discoverySR_36invfb
ATLAS_13TeV_HtoPhotons_139invfb
ATLAS_13TeV_PhotonGGM_36invfb
ATLAS_13TeV_ZGammaGrav_CONFNOTE_80invfb
ATLAS_13TeV_MONOJET_36invfb

Status of global CMSSM fits

- The stau co-annihilation region is finally ruled out at more than 95% CL.

- Without violating any experimental constraints, the lightest neutralinos and charginos can still have masses as low as ~100 GeV, the lightest stau can be as light as ~200 GeV, and the lightest stop can be as light as ~500 GeV.



Recent progress

- Implemented CEPC likelihood in GAMBIT
  - Assuming the results are centering on the SM values.
- Postprocess part of the CMSSM data.
- Compare the old likelihood with the CEPC likelihood.

From CEPC CDR Vol2 Physics-Detector

Property	Estimated Precision
m_H	5.9 MeV
Γ_H	3.1%
$\sigma(ZH)$	0.5%
$\sigma(\nu\bar{\nu}H)$	3.2%

Decay mode	$\sigma(ZH) \times$ BR	BR
$H \to b\bar{b}$	0.27%	0.56%
$H \to c\bar{c}$	3.3%	3.3%
$H \to gg$	1.3%	1.4%
$H \to WW^*$	1.0%	1.1%
$H \to ZZ^*$	5.1%	5.1%
$H \to \gamma\gamma$	6.8%	6.9%
$H \to Z\gamma$	15%	15%
$H \to \tau^+\tau^-$	0.8%	1.0%
$H \to \mu^+\mu^-$	17%	17%
$H \to$ inv	–	$< 0.30\%$

Table 11.3: Estimated precision of Higgs boson property measurements expected from a CEPC dataset of 5.6 ab^{-1} at $\sqrt{s} = 240$ GeV. All precision are relative except for m_H and $\mathrm{BR}(H \to \mathrm{inv})$ for which Δm_H and the 95% confidence level upper limit on $\mathrm{BR}_{\mathrm{inv}}^{\mathrm{BSM}}$ are quoted respectively. The $e^+e^- \to e^+e^-H$ cross section is too small to be measured with a reasonable precision.

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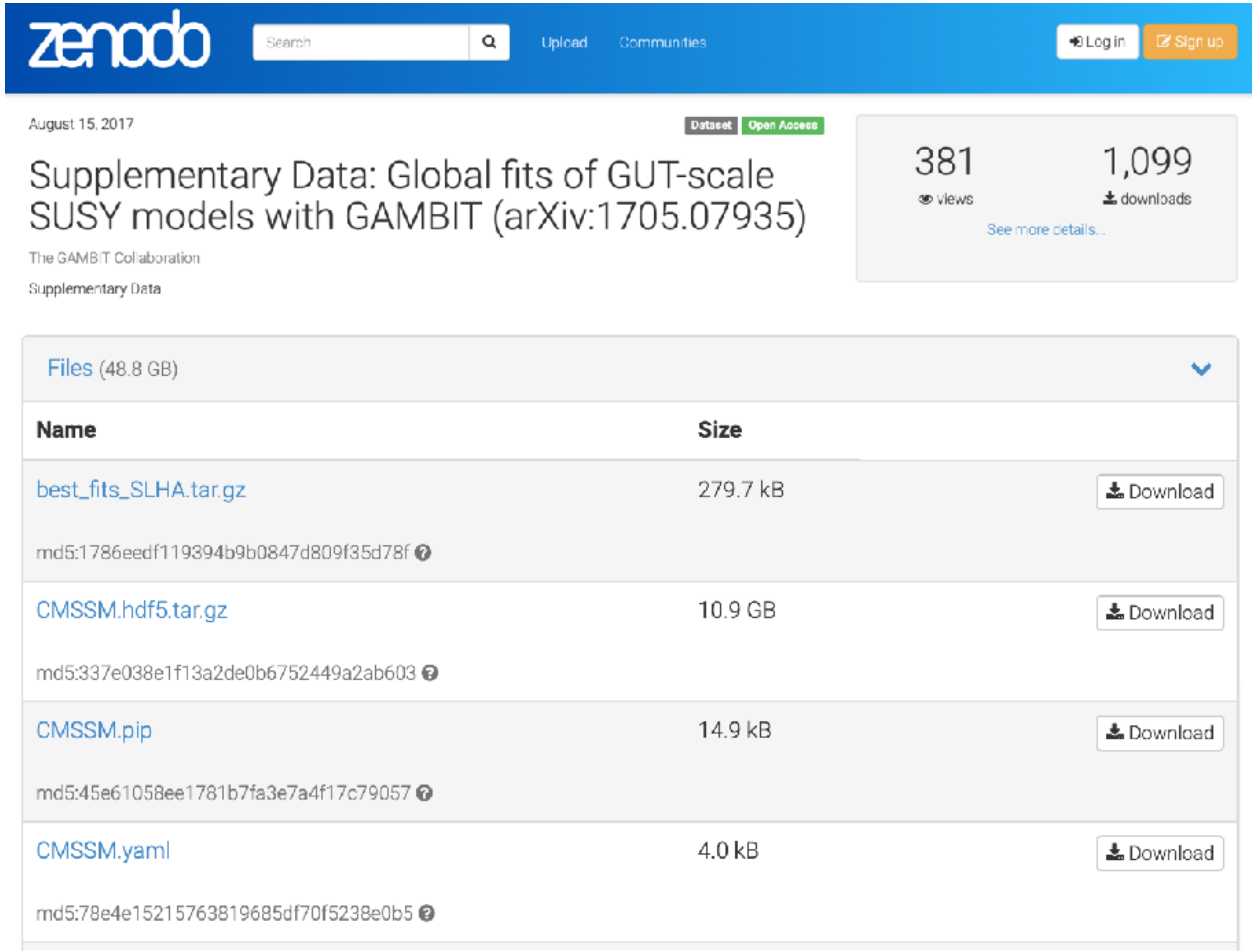

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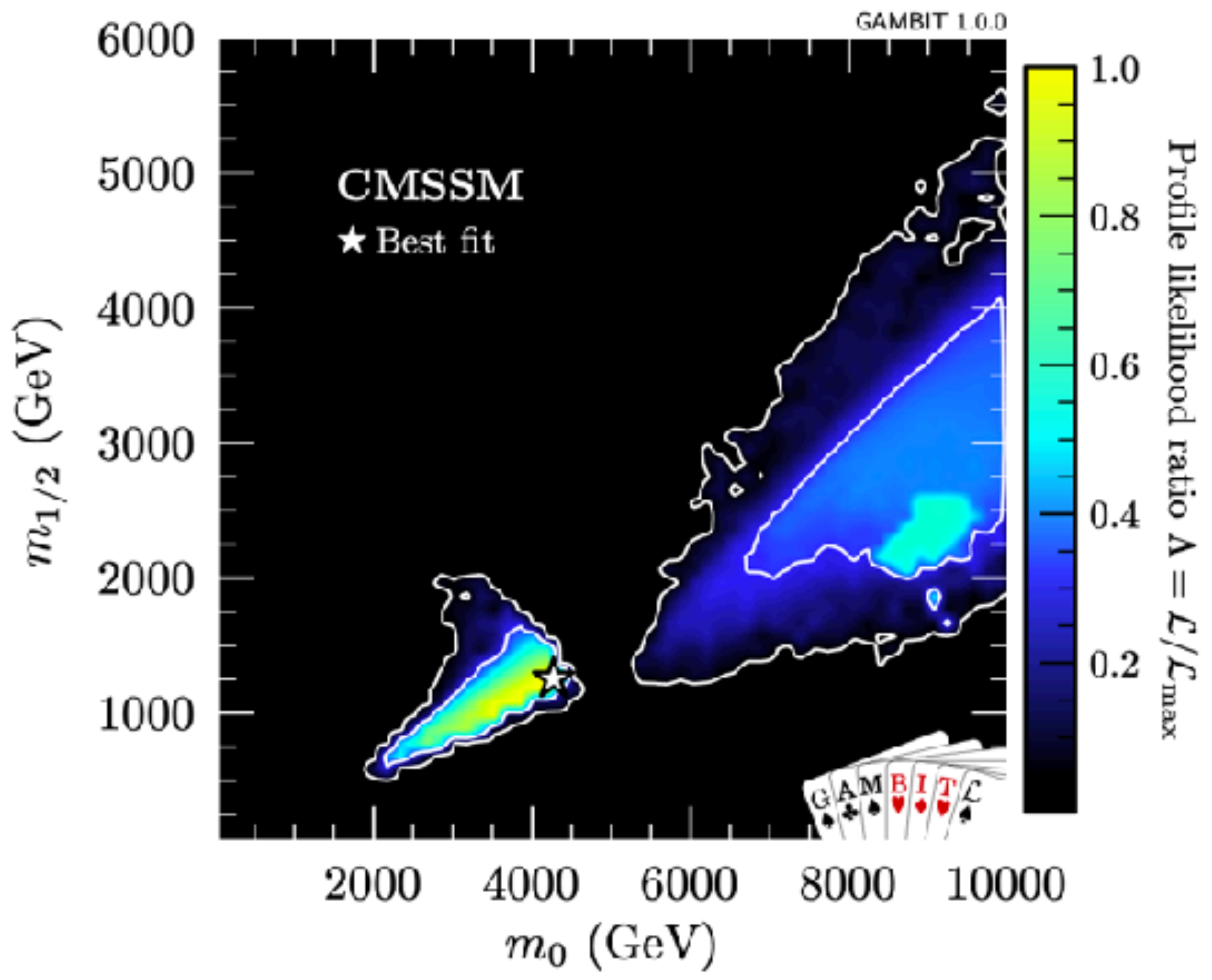
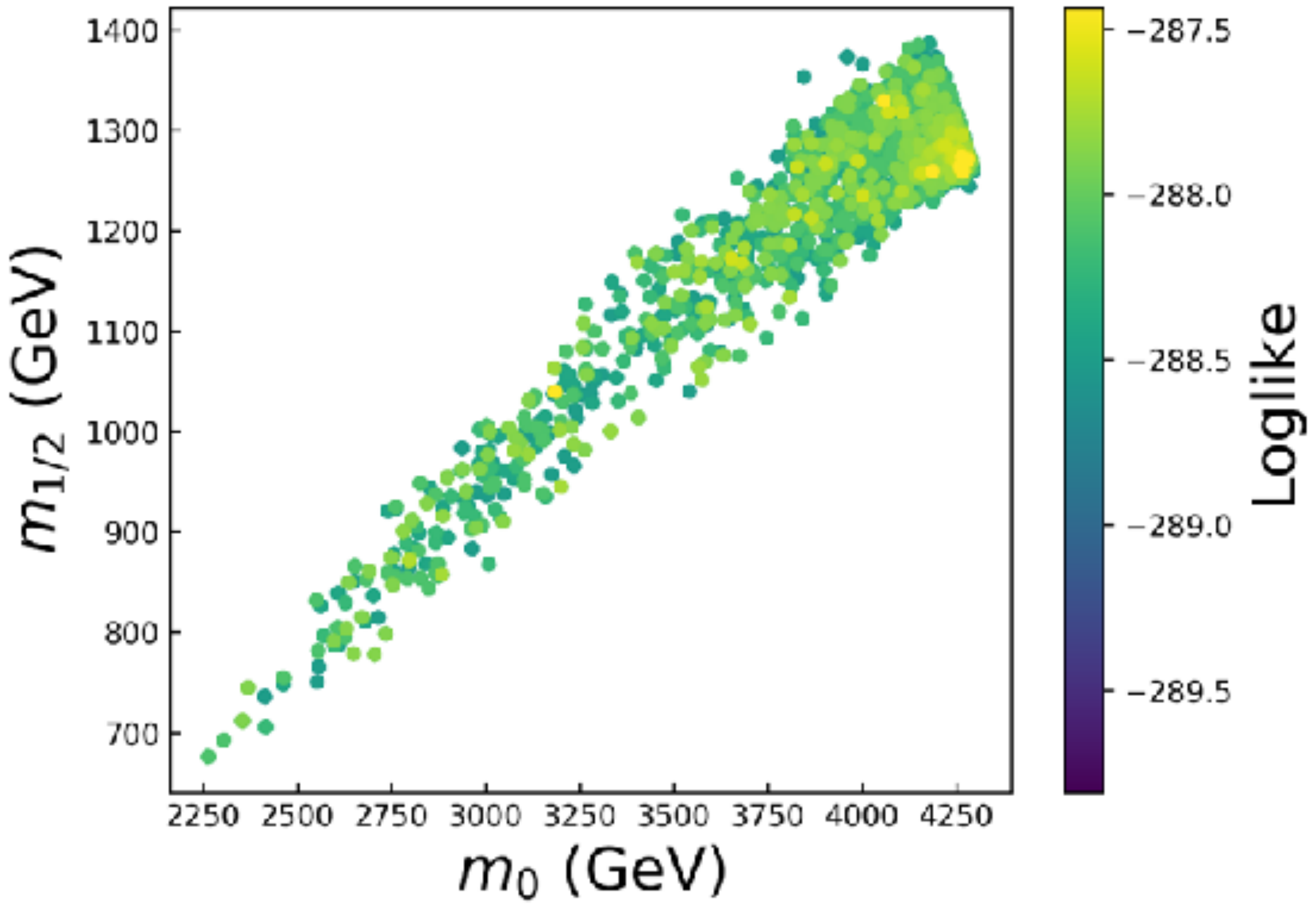


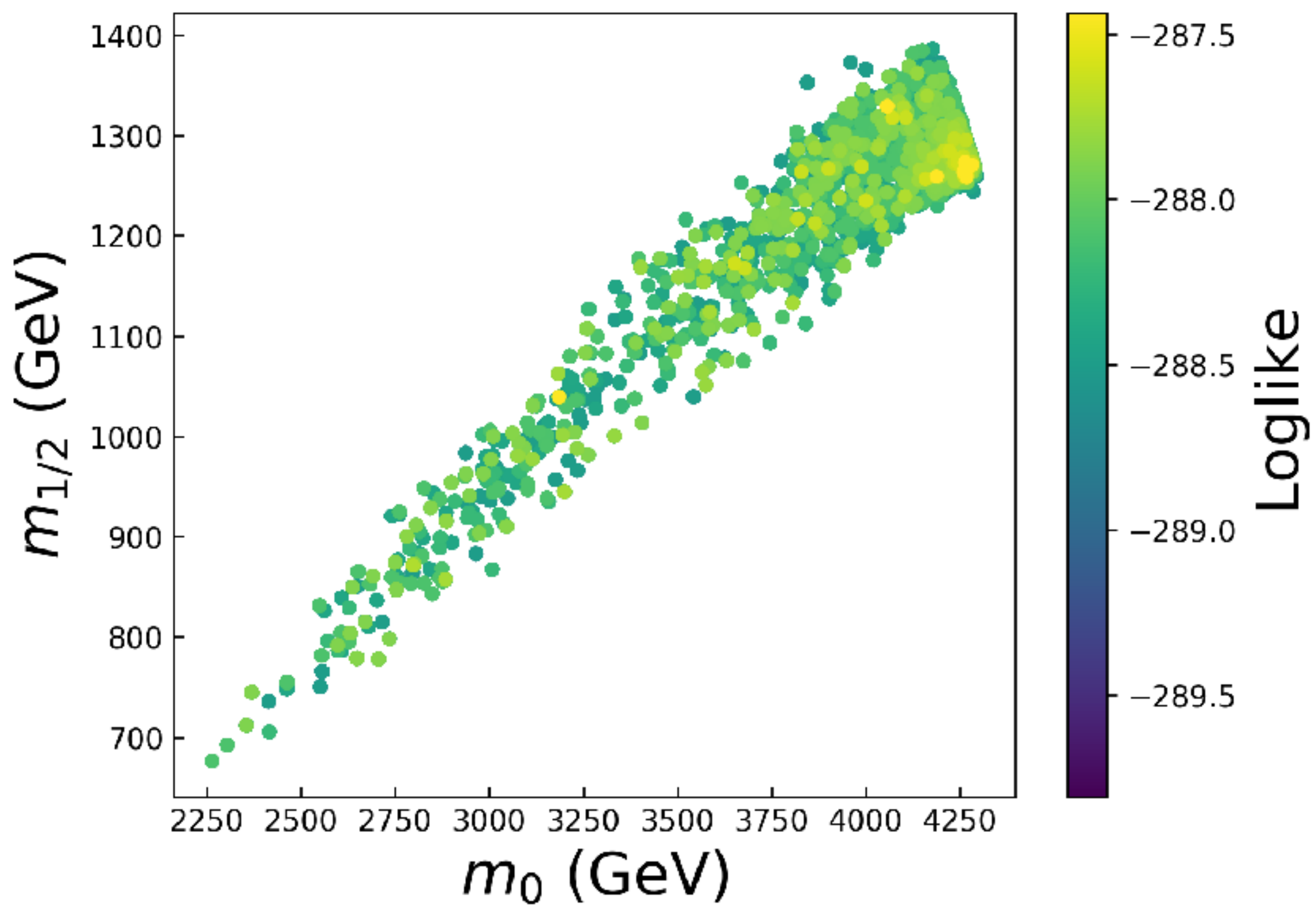
7276105 samples

60000 samples

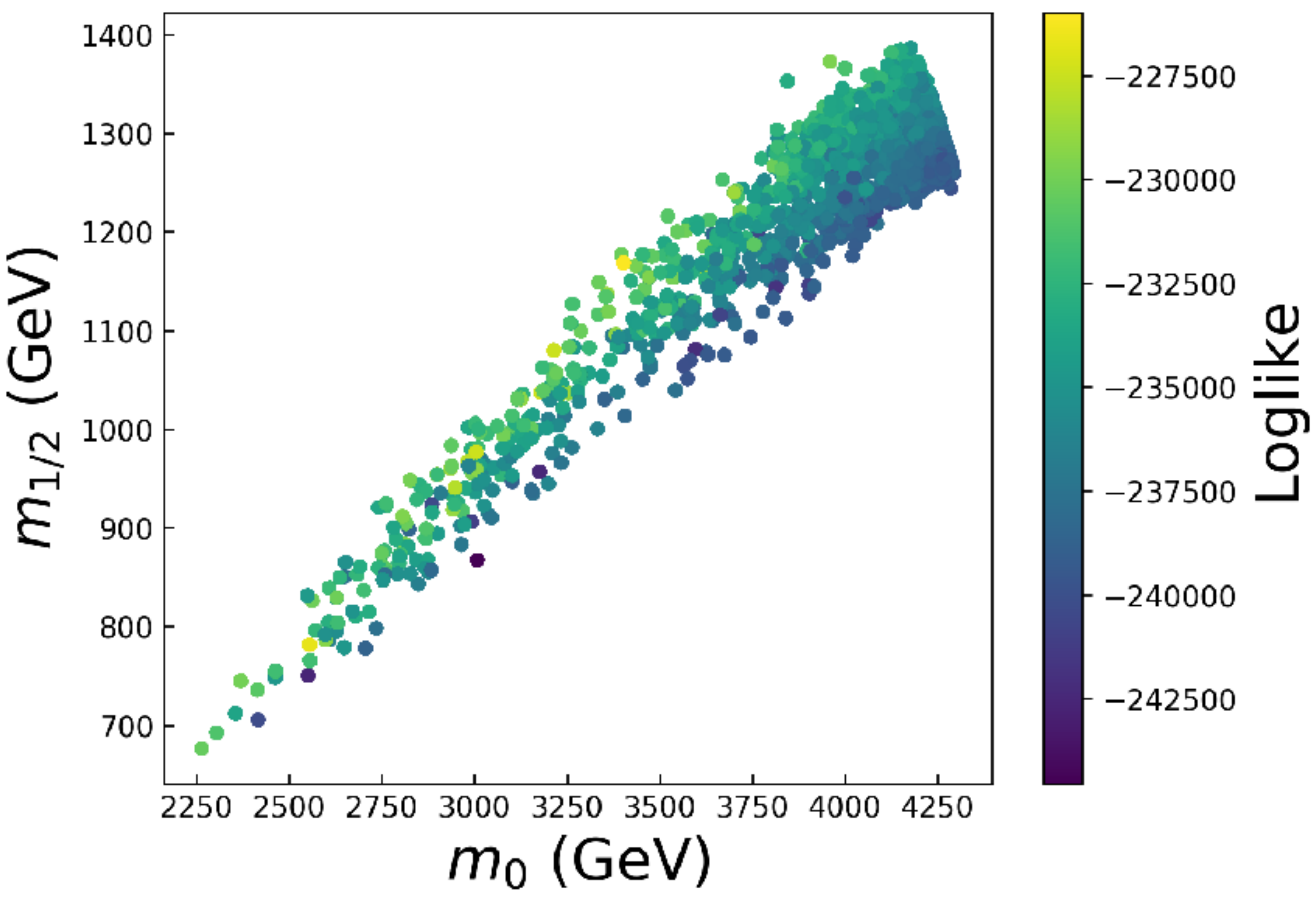


Recent progress

Old likelihood

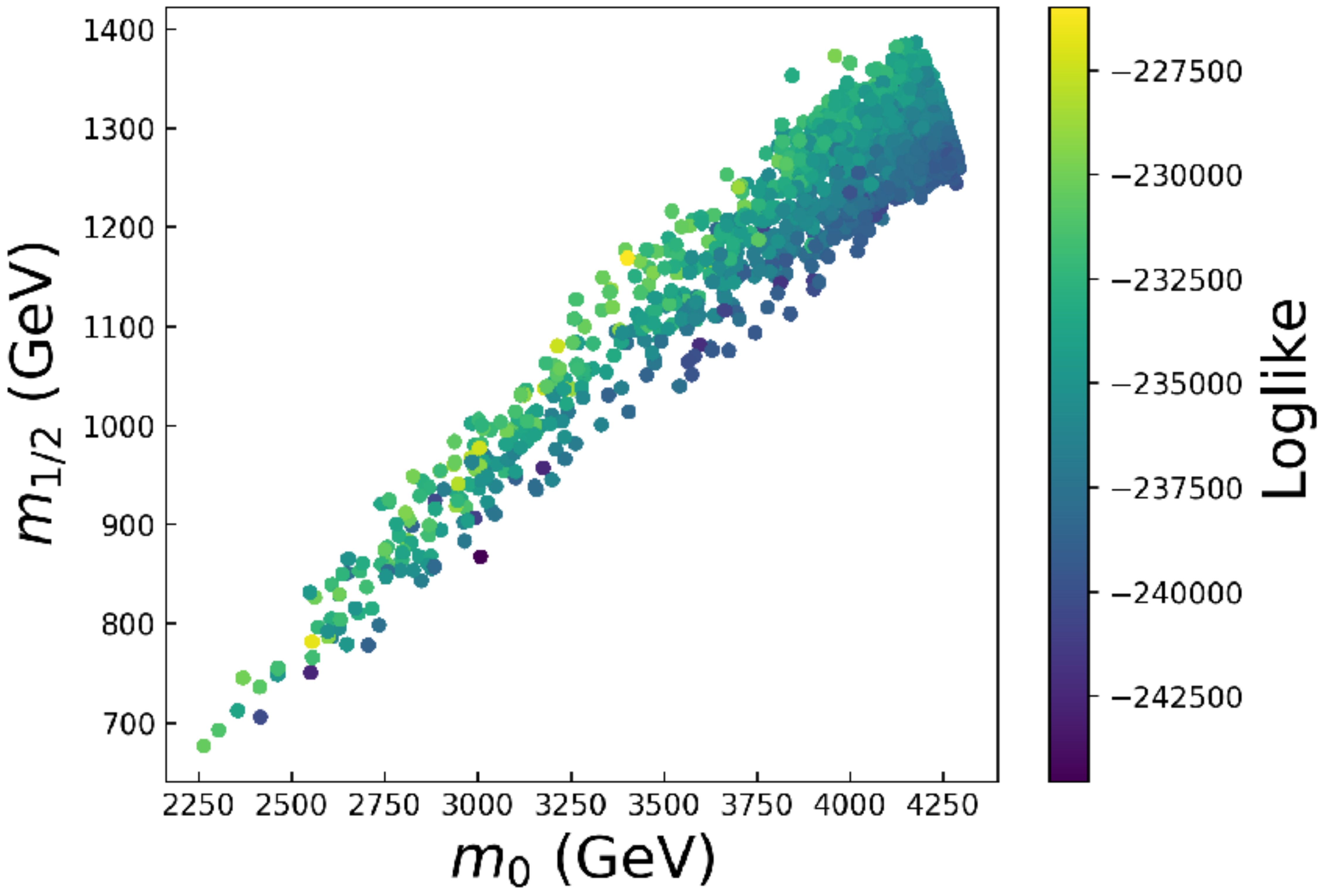


CEPC likelihood of Higgs

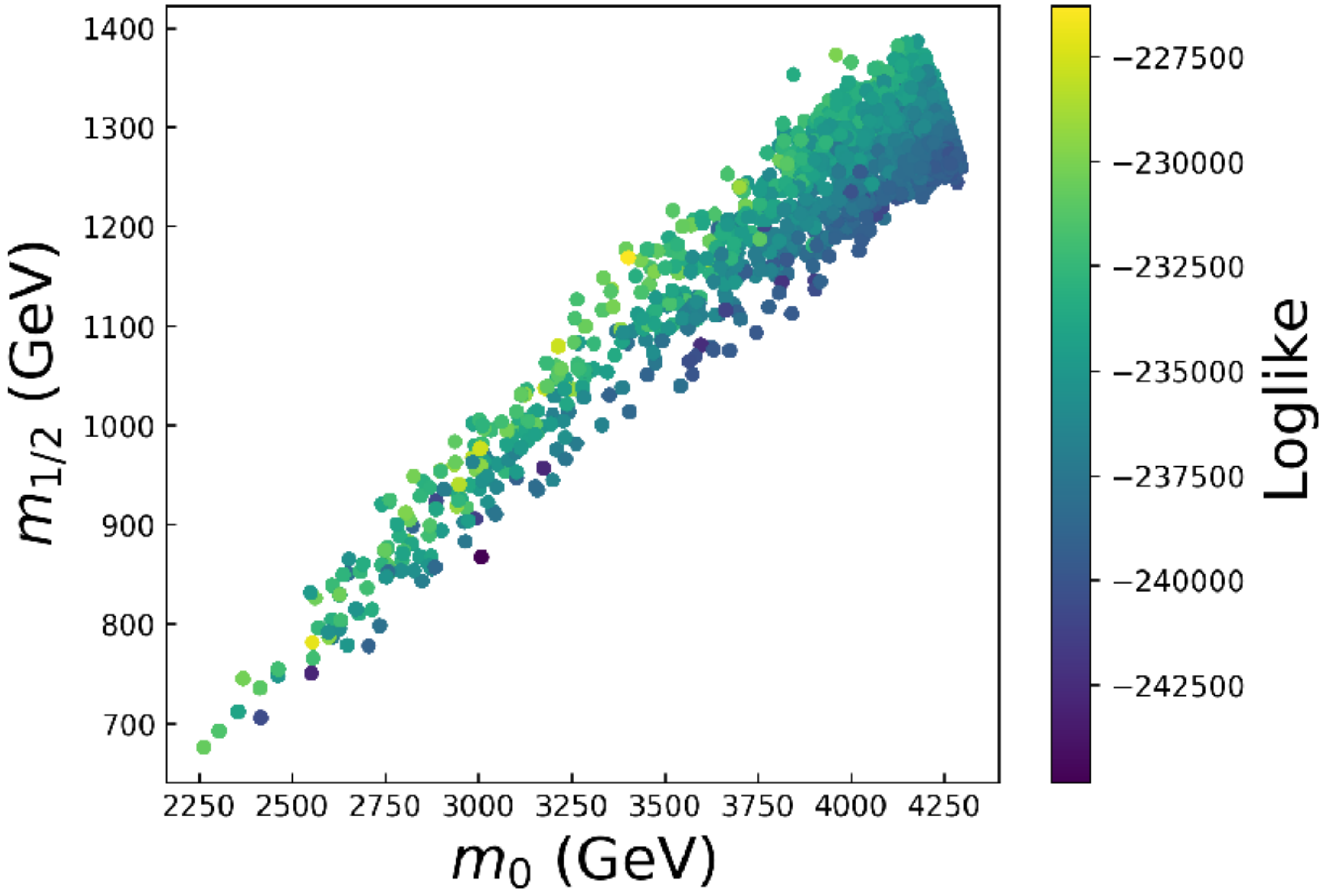


Recent progress

CEPC likelihood of Higgs



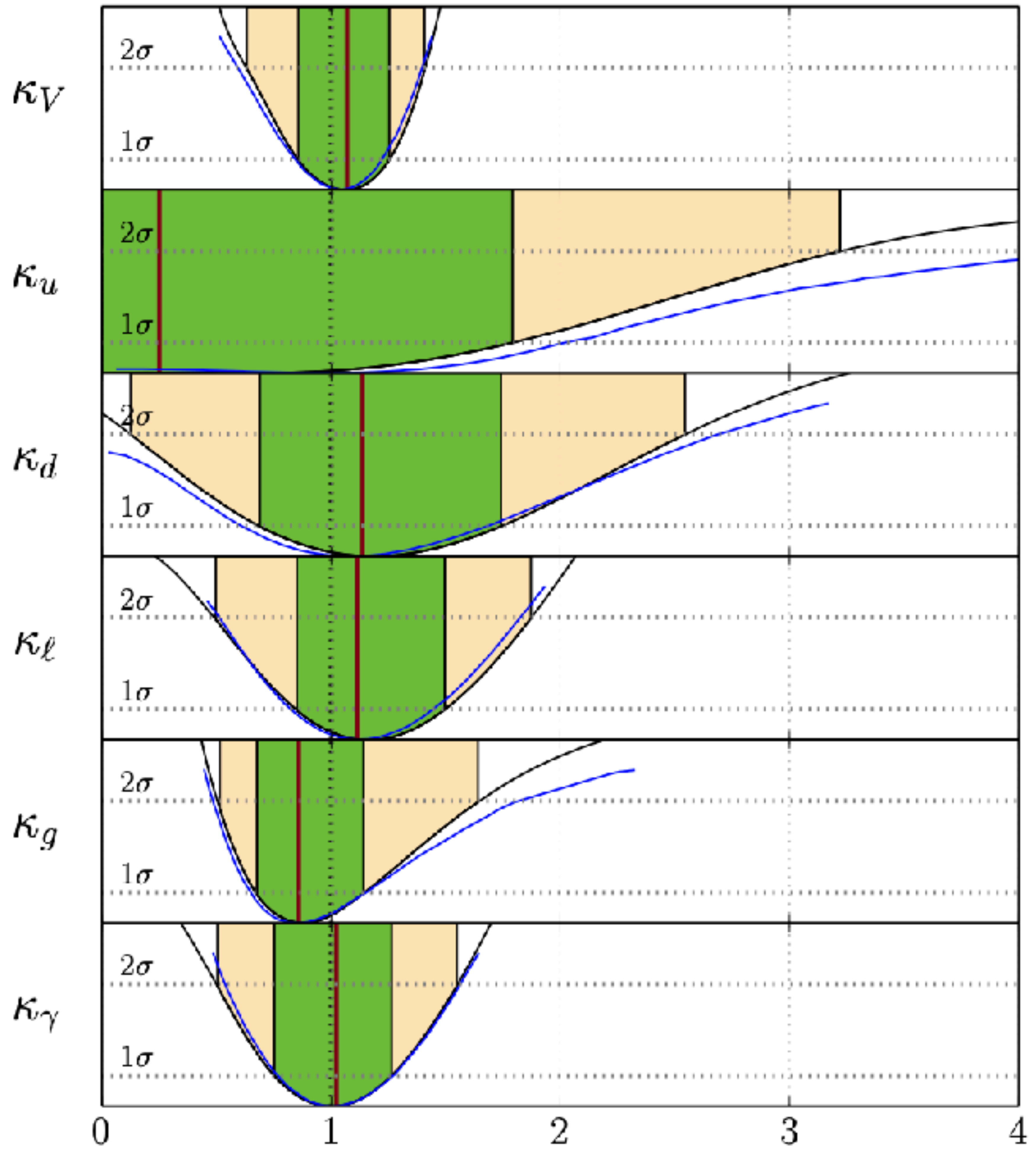
Old + CEPC likelihood of Higgs



Recent progress

- We used the SM Higgs couplings as the centre value of CEPC likelihood.
- The points I selected are favoured by present Higgs measurements.
- The best fit point of present Higgs measurements is not exactly SM Higgs.
- Anyway, the CEPC likelihood will have significant impacts on global SUSY fit.

From HiggsSignals, arXiv:1403.1582



Todo list

- Check the implemented CEPC likelihood, and further investigate the result.
- Assuming the CEPC results are centering on the present supersymmetric best-fit point, or other values.
- Update existing GAMBIT results using likelihoods for the latest searches for supersymmetry and Higgs at the LHC, direct and indirect searches for dark matter, electroweak precision and flavour observables.
- Postprocess all the samples.
- Calculate Kullback-Leibler divergence, etc.