Project proposal: HEP_05

Interplay between collider and flavour physics

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on behalf of HEP_05 project members

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Project target

Search for physics beyond standard model

- SM is *not* the theory of everything
- BSM phenomena
  - neutrino oscillations → right-handed neutrino
  - cosmology: inflation, dark matter, baryon asym., …

BSM is the target

- TeV-scale is explored by collider and flavour physics
- Hints of BSM have been observed
- Interplay of collider and flavour

Complementarity

COLLIDER		FLAVOUR
— high energy —		— precision —
direct production of new particles	signal	indirect detection via rad. corrections
beam energy TeV scale (LHC)	sensitivity	accuracy/intensity (>)TeV scale
particle mass, charge, spin, …	measure	scale, interactions (flavour, CP structure)

Interplay

Any *single* signal cannot reveal global picture of BSM

Case A: new signal at ‘collider’

- *That* particle is determined, but global structure is not
- New sources of flavour are introduced

  → global picture by ‘flavour’ studies

Case B: new signal at ‘flavour’

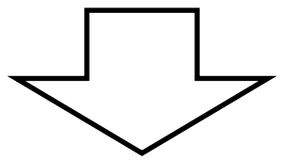
- Information of global structure, but entangled
- Target energy scale is deduced

  → directly produce new particles at ‘collider’

→ *Interplay* is important to understand BSM

Purpose

- We study BSM signals both in collider and flavour
- There are no clear signals, but only tantalizing hints
- Need deep insights into collider and flavour physics
  - Signals: higher accuracy, QCD, hadrons, …
  - Models: naturality, simplicity, consistency, …
- Need tight communications among theory experts



New collaboration

Interplay between collider and flavour physics

Members

Opportunity to start and expand collaboration

France

LPSC Grenoble group

- Kentarou Mawatari (collider)
- Sabine Kraml (collider)
- Christopher Smith (flavour)

*Some of members have joined after the application was submitted

Japan

KEK group

- Motoi Endo (flavour)
- Satoshi Mishima (flavour)
- Toru Goto (flavour)

collaboration w/.

- Mihoko Nojiri (collider)
- Ryuichiro Kitano (model)
- lattice group

Research plan in 2016-2017

- Focus on signal candidates of BSM
- New discussions have already started among us

Collider hints

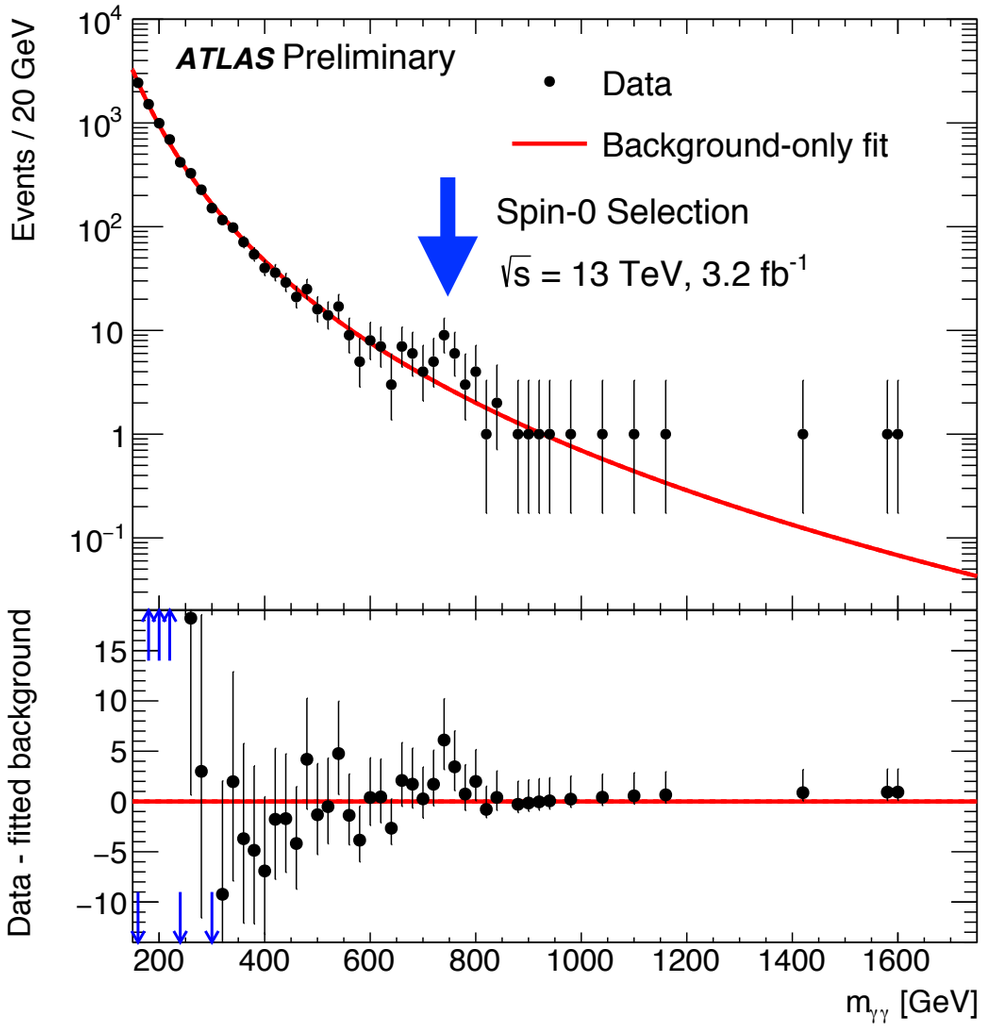
- 750GeV diphoton excess [ATLAS,CMS 13TeV]
- …

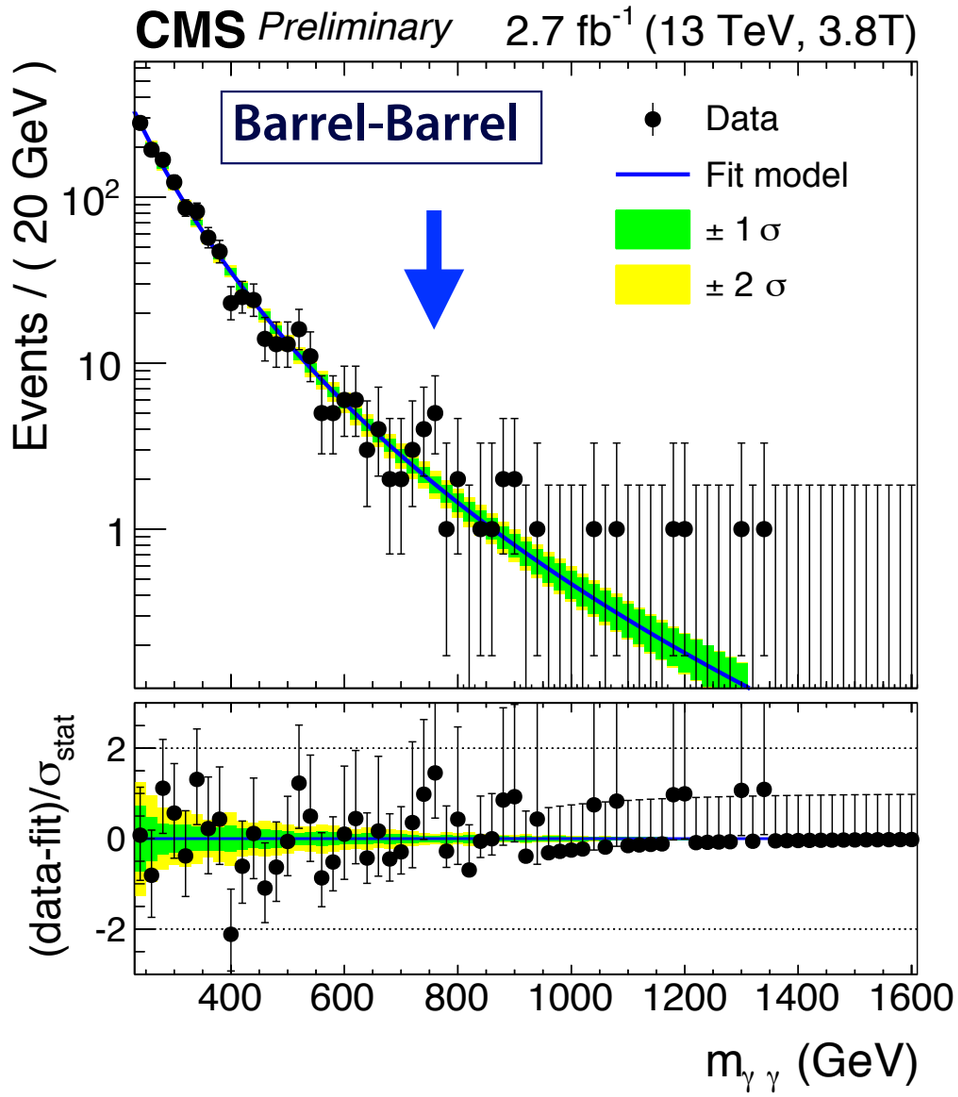
Flavour hints

- Muon anomalous magnetic moment [Brookhaven E821]
- B anomalies [BaBar, Belle, LHCb]
- …

750GeV diphoton excess

Peak of diphoton invariant mass = new particle





750GeV diphoton excess

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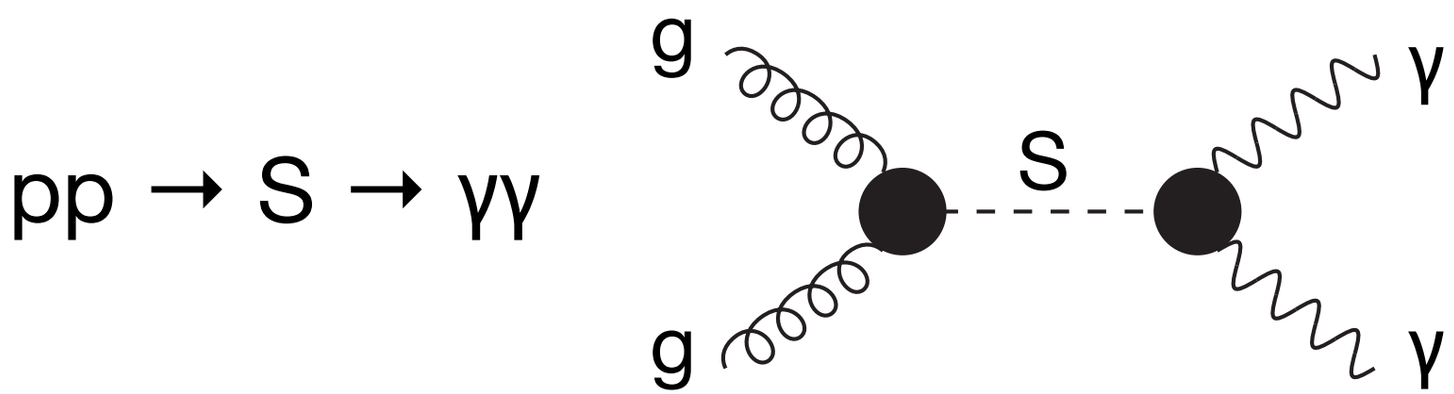


→ hint of new particle at ‘collider’

Naive scenario: SM + singlet *cannot* explain the signal

Need extra particles/structures → ‘flavour’

2016-2017

- Confirmation at LHC (probably) in this summer
- >300 publications
- Model discrimination by flavour structure

  Spin of 750GeV particle

  - spin-0: extra particles have new flavour structures
  - spin-2: KK graviton, bulk fermion structures

- 750GeV signal will be studied by collider & flavour especially for targeting BSM discrimination

Muon g-2

magnetic moment: $\vec{\mu} = -g\frac{e}{2m}\vec{S}$

tree-level: g=2 → radiative corrections: g≠2

Muon g-2 $a_\mu = \frac{g_\mu - 2}{2}$

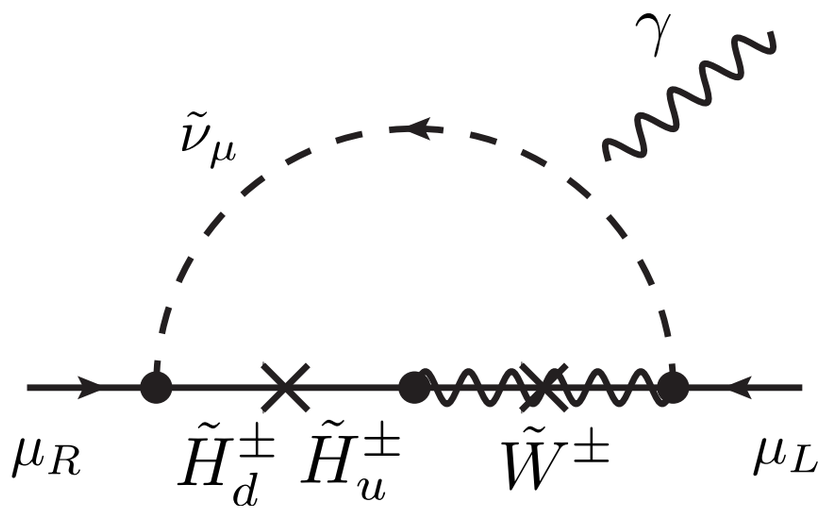
$$a_\mu^{(\mathrm{exp})} - a_\mu^{(\mathrm{SM})} = \begin{cases} (26.1 \pm 8.0) \times 10^{-10} & \text{[HLMNT]} \\ (28.7 \pm 8.0) \times 10^{-10} & \text{[DHMZ]} \end{cases}$$

> 3σ deviation

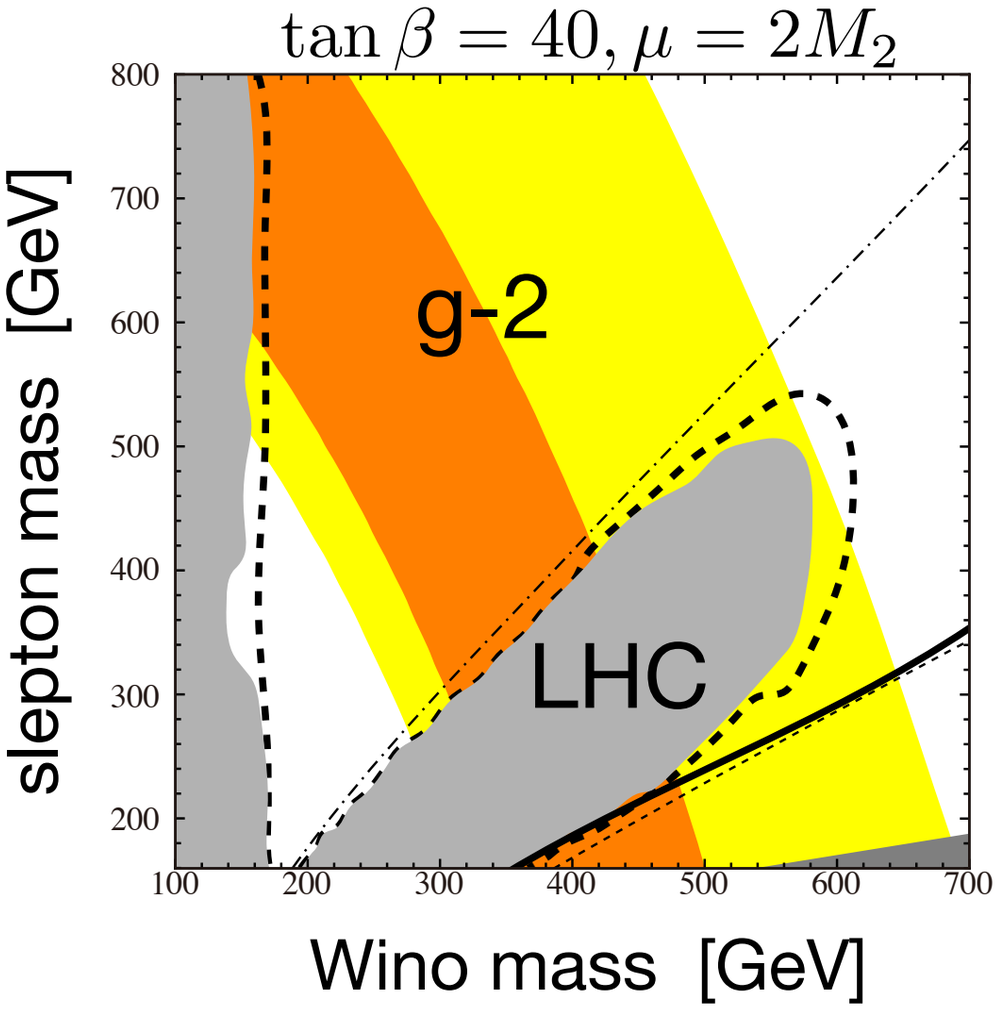
(possibly) a signal of new physics of ‘flavour’

SUSY solution

- chargino-muon sneutrino



- light SUSY particles (~100GeV)
- "SUSY solution" can be tested by discovering SUSY particles



[ME,Hamaguchi,Iwamoto,Yoshinaga]

2016-2017

- Experiments of muon g-2 in preparation
- Focus on ‘collider’ test of BSM solution
- In some regions, SUSY particles have degenerate mass
  → challenging signatures at LHC
    high precision and deep insight on ‘collider’
- BSM solution to muon g-2 anomaly will be studied by collaborating with collider experts as well as flavours

Budget request

Budget request for improving communications between French and Japanese groups

- LPSC Grenoble: 2950 Euros
  visit KEK, Japan for 2 weeks (1 travel)
- KEK: 400 kYen
  visit Grenoble, France for 2 weeks (1 travel)

Summary

- Target is to search for BSM by exploring interplay between collider and flavour physics
- They are complementary, and their interplay is important to reveal global picture of BSM
- In 2016, we focus on experimental hints:
  - ‘collider’: 750GeV diphoton excess
  - ‘flavour’: muon g-2
  - more hints: on-Z exces, $B \to D^* \tau \nu$, …
  - upcoming results e.g., from LHC 13TeV run

Backup slides

Experimental side

- Collider: LHC
  - Tantalizing hints of BSM at 8TeV and 13TeV
  - Luminosity increases, further upgrade discussed
- Flavour: many experiments
  - Hints of BSM
  - Future: LHCb, Belle-II, KOTO, NA62, μ, ν, …

New results will show up from Europe and Japan

→ communicate with experiments