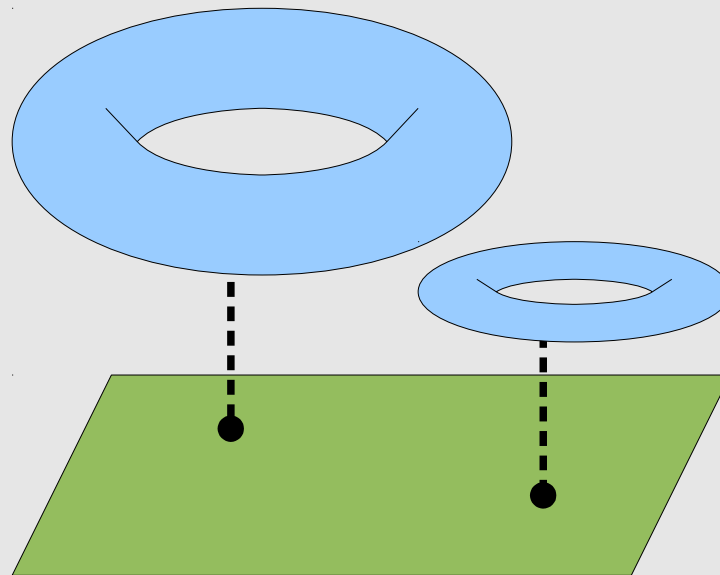


Federico Bonetti – MPI

# F-theory in six dimensions



PPSM Colloquium 18/11/2011

# Outline

- Motivation
- What is F-theory?
- Why six dimensions?
- F-theory set-up
- A 6d example
- Conclusions

# Why F-theory?

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- Promises of string theory...
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  - unification of all interactions
- ... and challenges of string phenomenology
  - many solutions ( $\sim 10^{500}$  !)
  - hard to find realistic vacua
- F-theory is...
  - an important part of the string pheno toolkit
  - a beautiful geometric framework

# What is F-theory?

- Superstring theory
  - extended objects  $\rightarrow$  1+1 worldsheet
  - quantization  $\rightarrow$  10 spacetime dimensions
  - different theories  $\rightarrow$  Type I, IIA, IIB, heterotic



# What is F-theory?

- Superstring theory
  - extended objects  $\rightarrow$  1+1 worldsheet
  - quantization  $\rightarrow$  10 spacetime dimensions
  - different theories  $\rightarrow$  Type I, IIA, IIB, heterotic
- F-theory
  - re-formulation of Type IIB
  - lives in “12” dimensions
  - non-perturbative dynamics & brane backreaction
  - unified geometric framework

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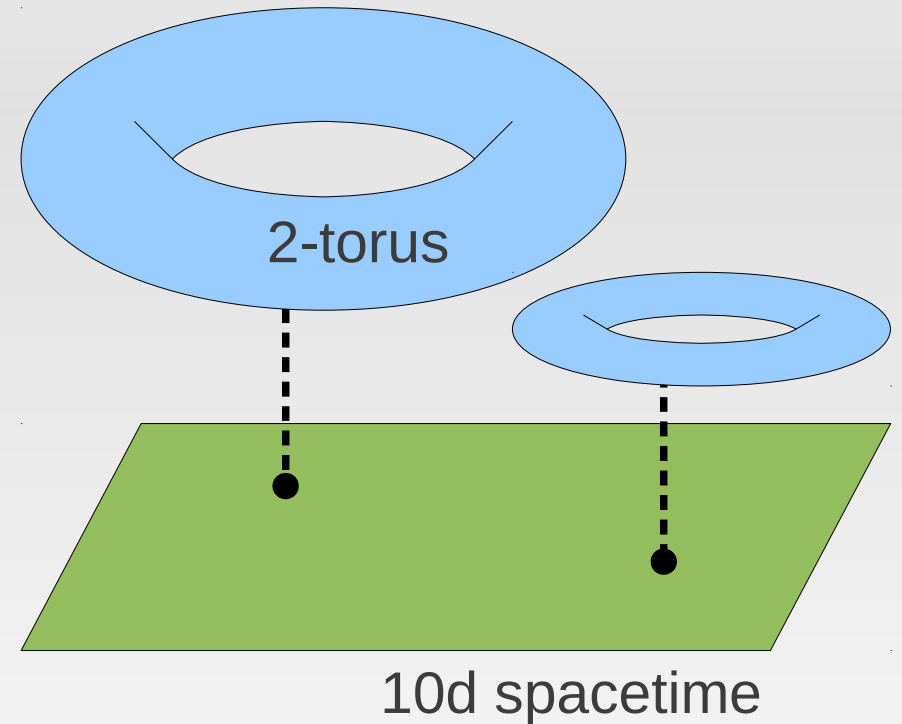
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- Test of string universality conjecture
- Extra motivation: M5 brane

# The F-theory torus

S-duality of Type IIB



symmetry of a 2-torus



# The F-theory torus

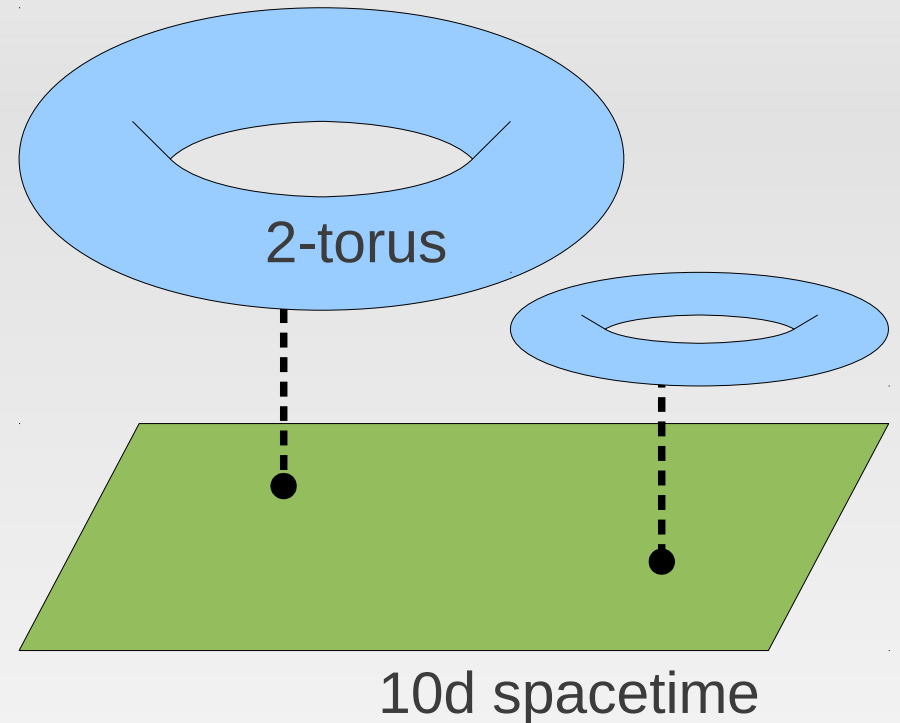
S-duality of Type IIB



symmetry of a 2-torus

geometric information:

$\tau \in \mathbb{C}$  (size and shape)



$$\text{string coupling} \sim \frac{1}{\Im \tau}$$

# A web of dualities

- We do not know the action of F-theory

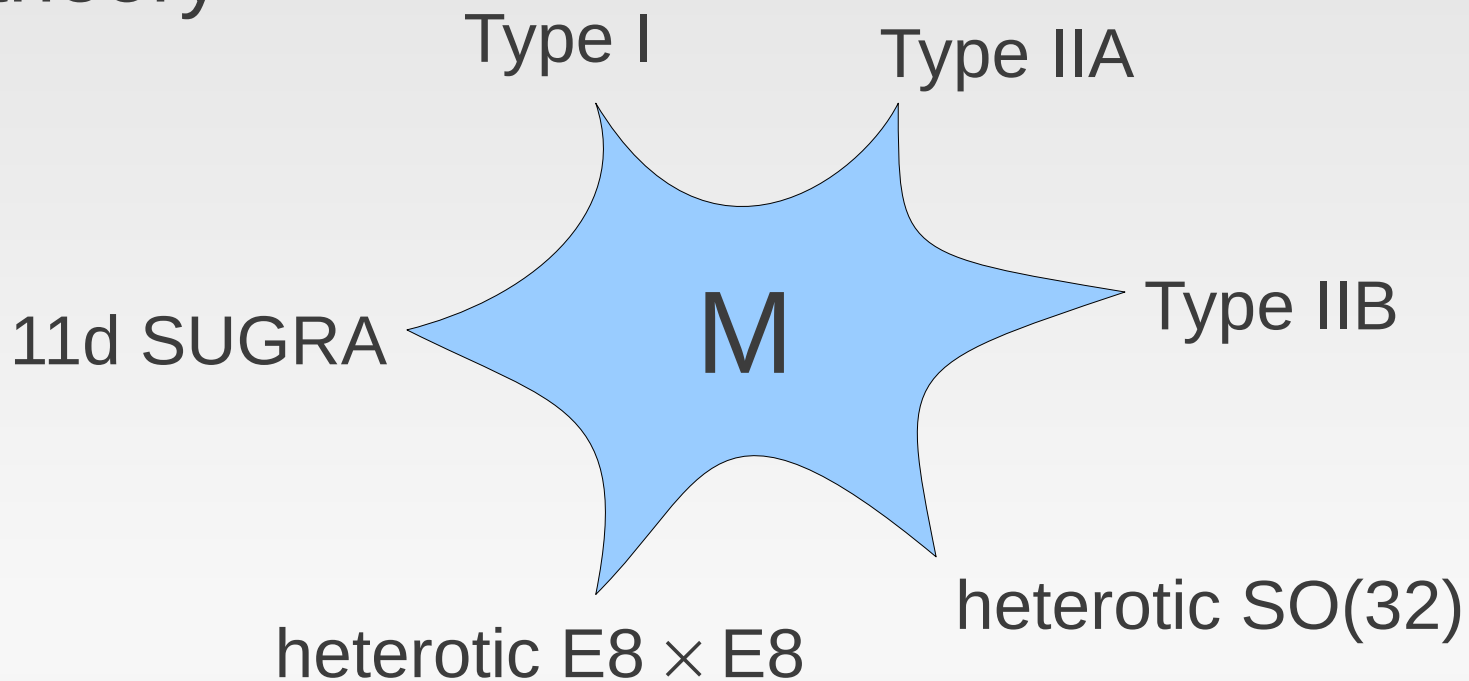


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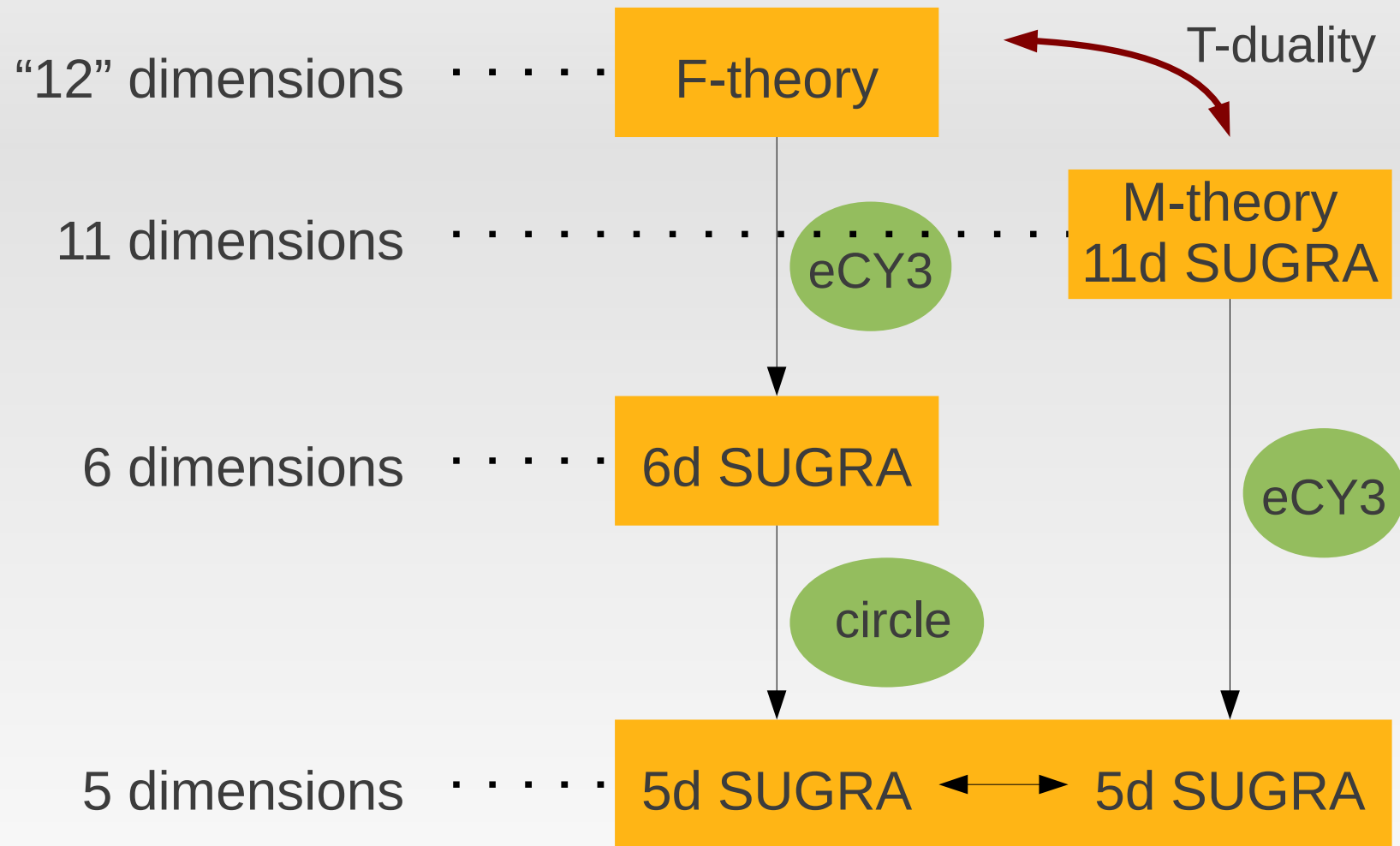
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# A web of dualities

- We do not know the action of F-theory
- Use the web of dualities among string theories
- M-theory

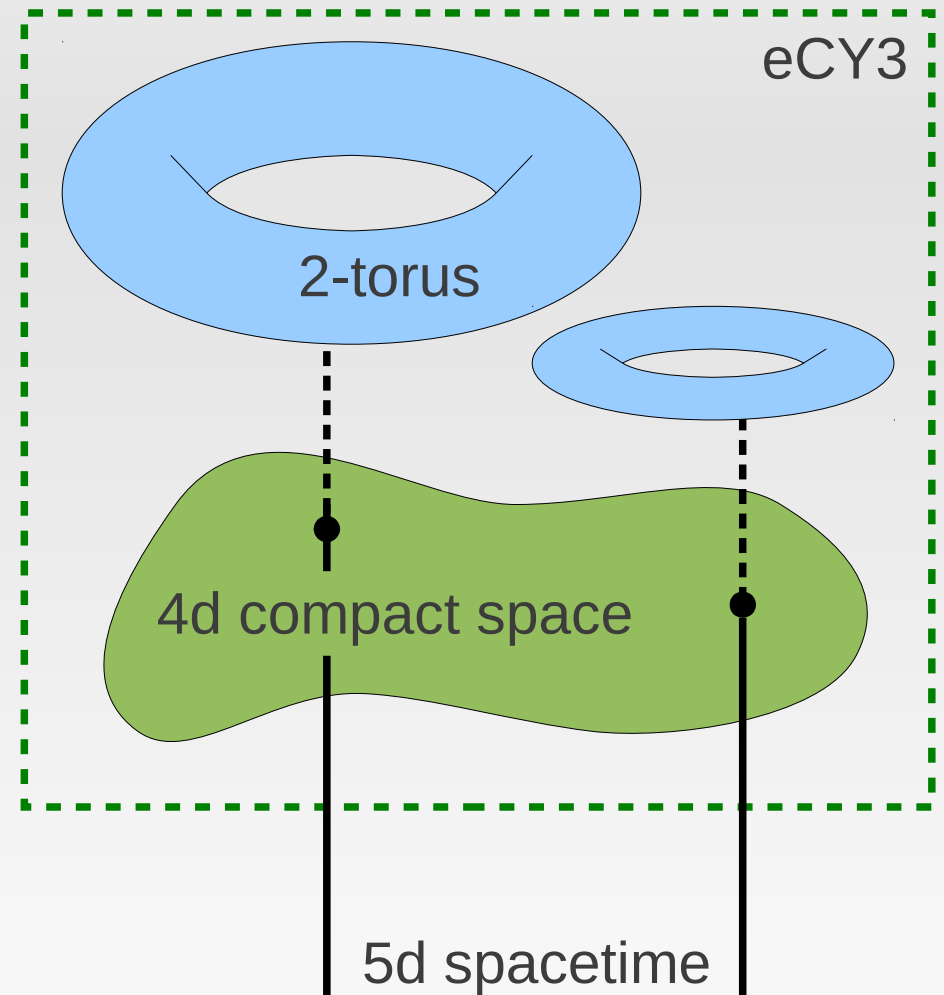


# F-theory via M-theory



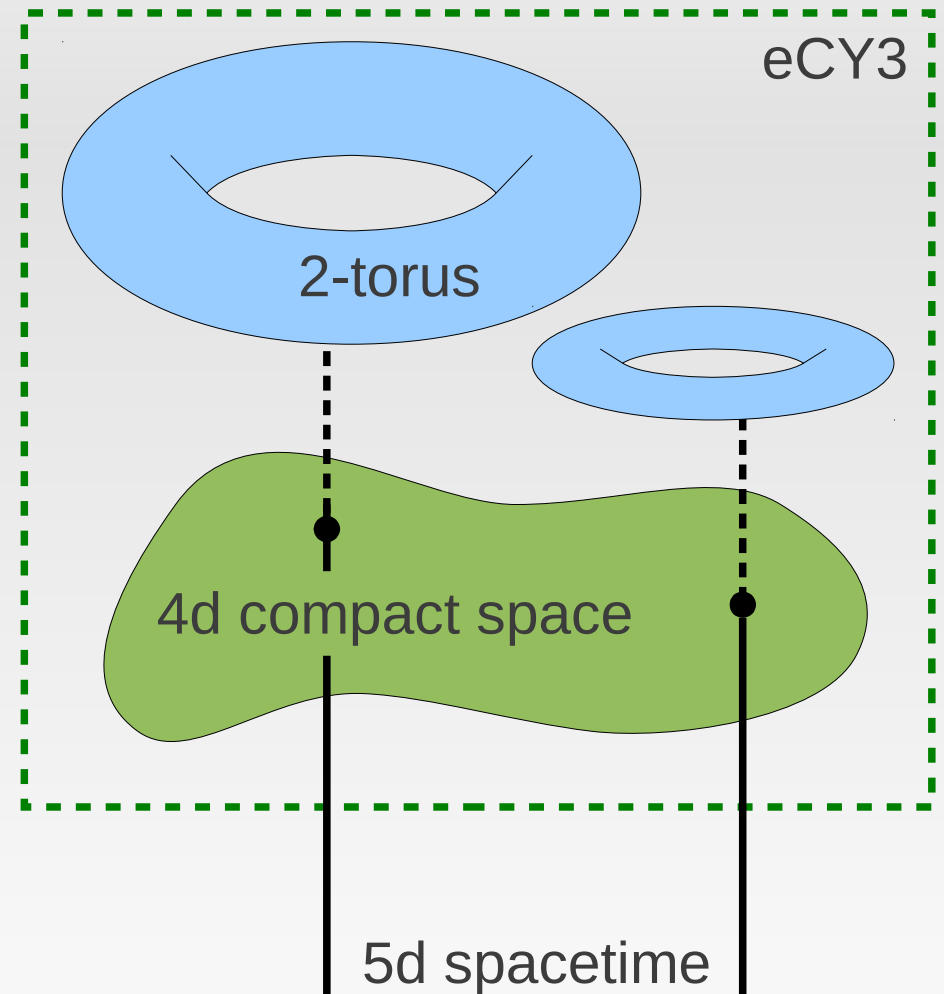
eCY3 = elliptically fibred Calabi-Yau threefold

# F-theory setup



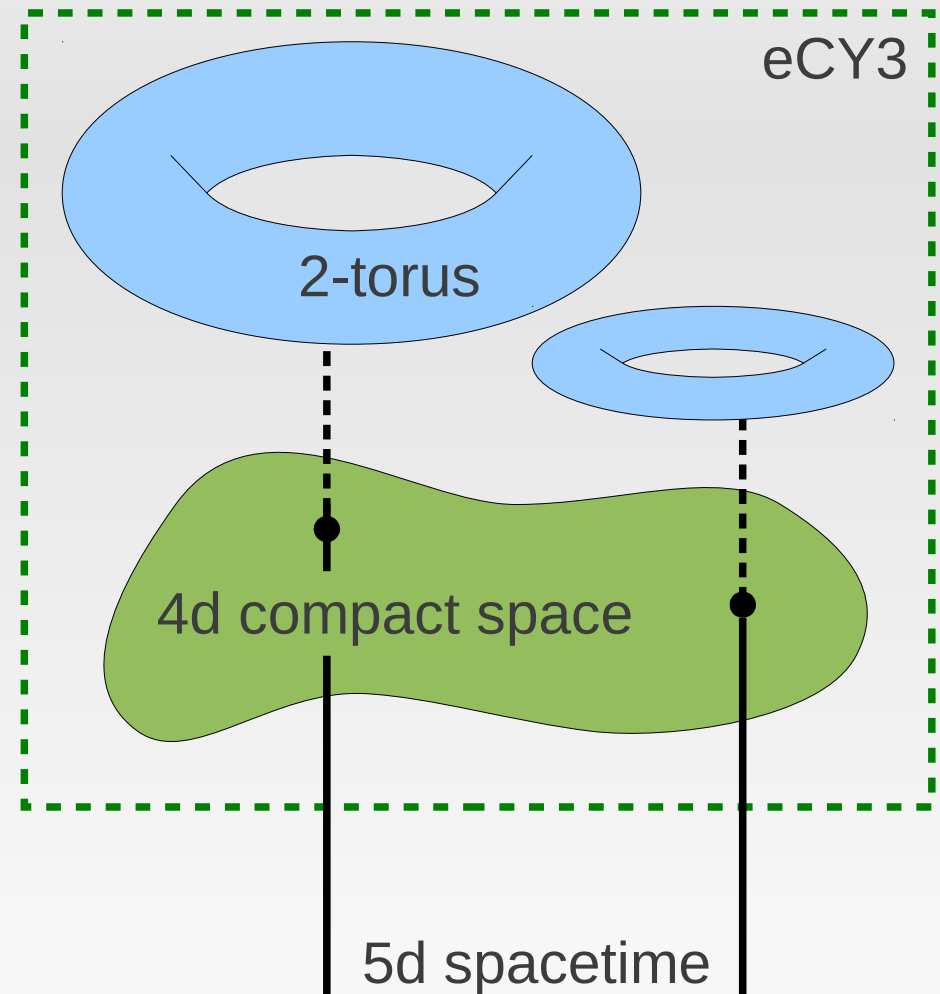
# F-theory setup

- The F-theory torus varies along the compact space

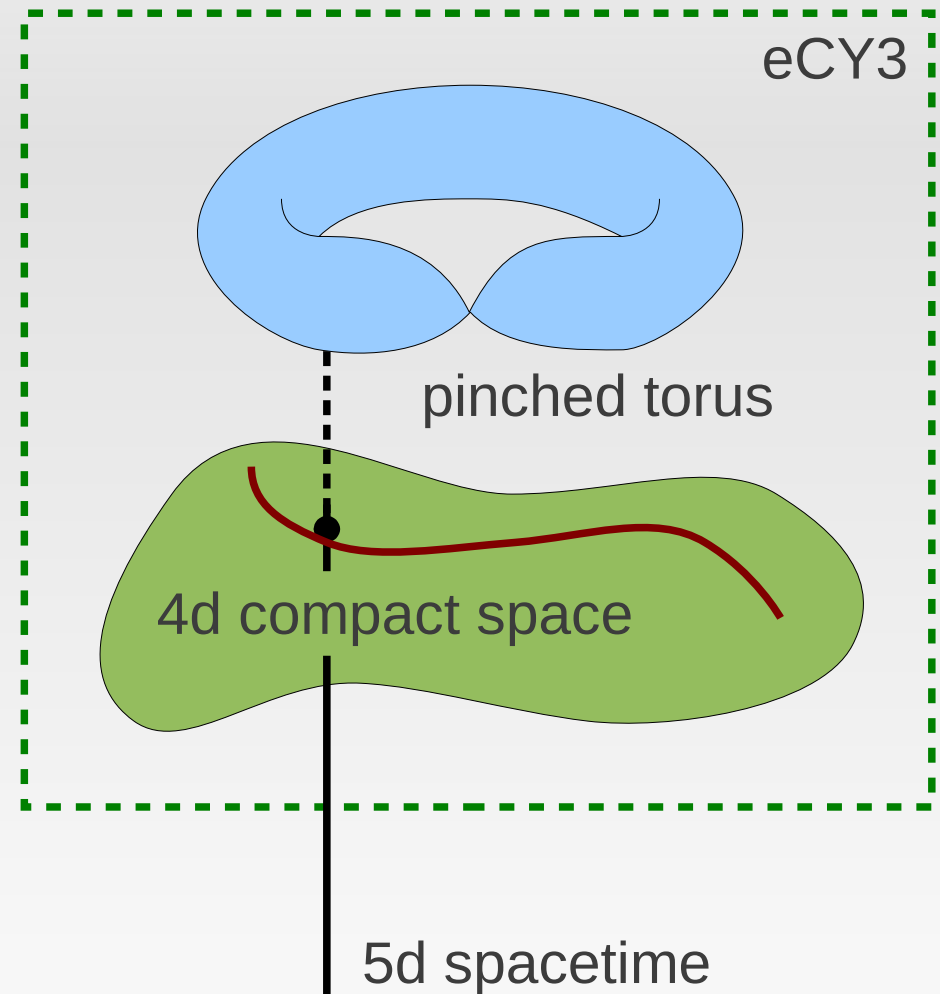


# F-theory setup

- The F-theory torus varies along the compact space
- In the F-/M-theory framework *geometry* encodes:
  - spectrum of the theory
  - interactions

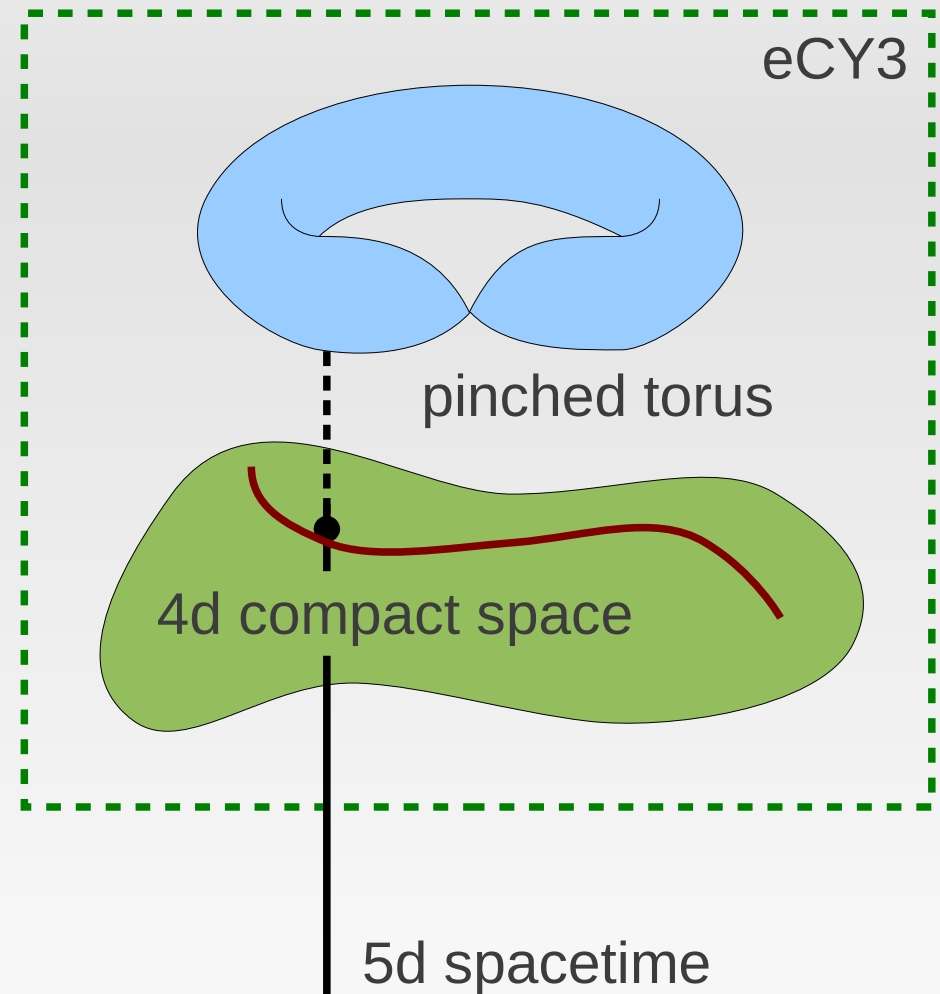


# Singularities and gauge theories



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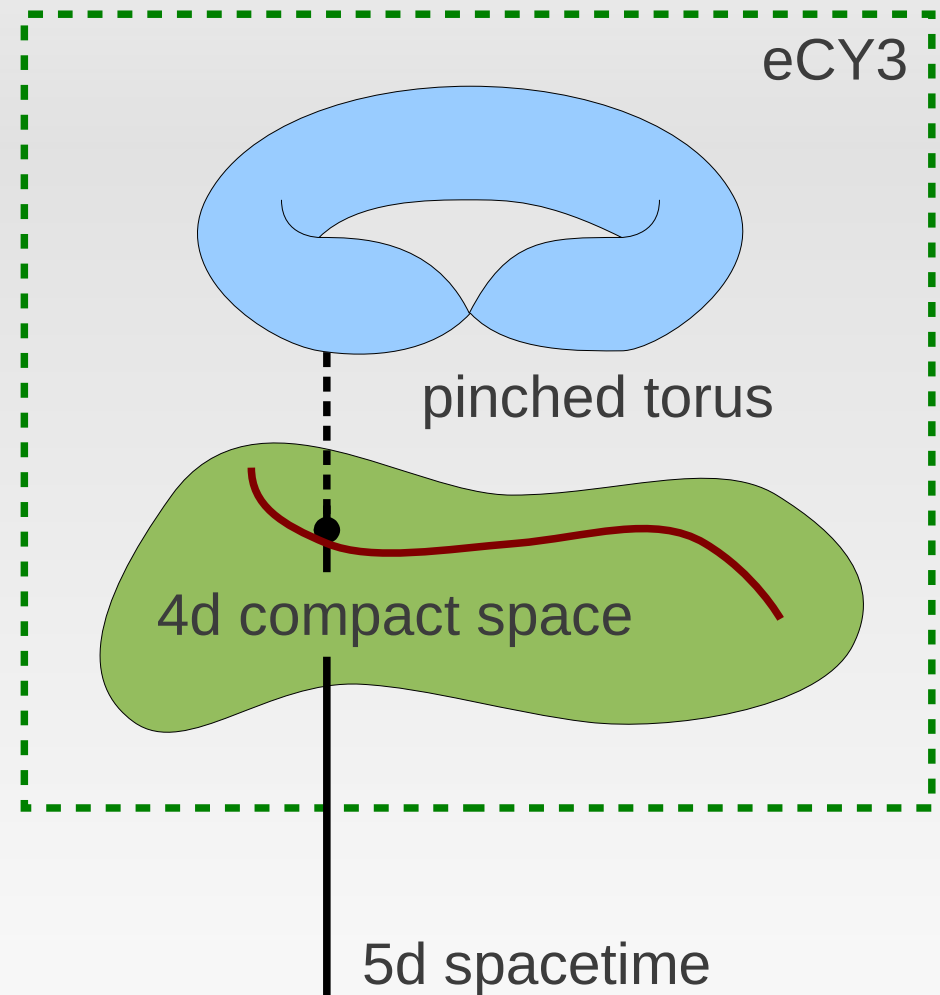
- Singular torus  
→ gauge theory





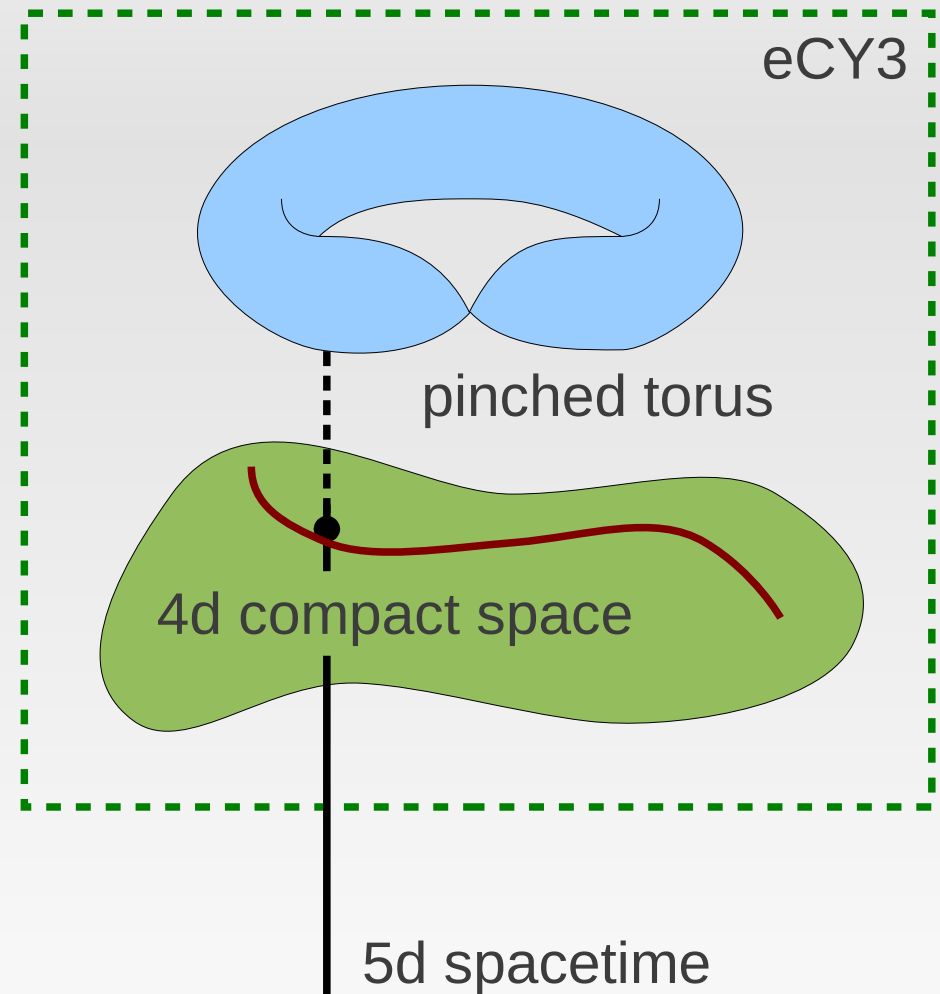
# Singularities and gauge theories

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- Many gauge groups are possible
- Room for GUTs in 4d



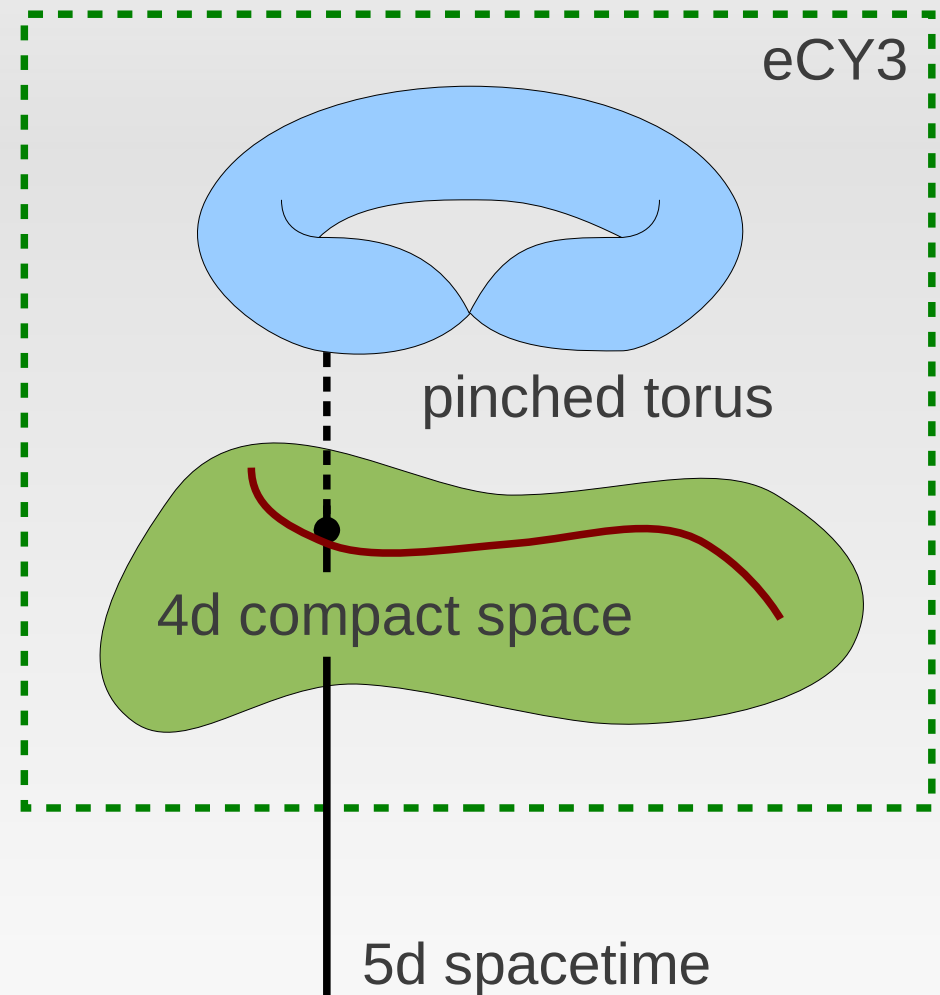
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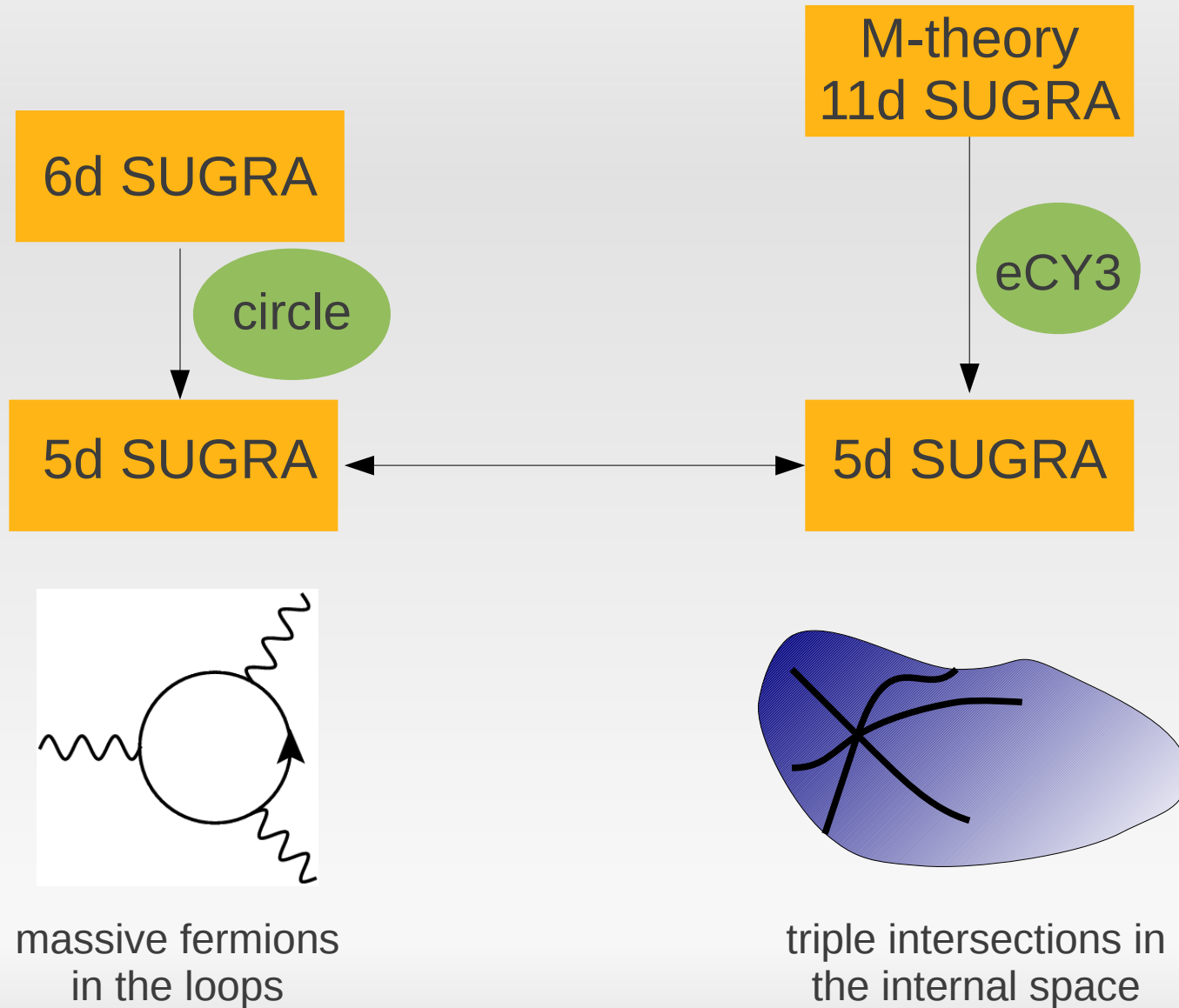


# Singularities and gauge theories

- Singular torus  
→ gauge theory
- Many gauge groups are possible
- Room for GUTs in 4d
- Enhanced singularities  
→ charged matter
- Dual Type IIB picture  
→ D-branes



# Loops VS geometry



# Conclusions

- Toolkit of string pheno → F-theory
- Geometric description
  - beyond weak coupling & brane backreaction
  - gravity + gauge + matter on equal footing
- 6d arena for F-theory
  - warm-up for 4d phenomenology
  - general questions in string theory
  - example: geometry 'computes' loops

# Thank you for your attention

