The Social Network of F-theory fibrations: From torsion to discrete symmetries

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Based on arXiv:1408.4808

In collaboration with: D. Klevers, D. Mayorga, H. Piragua and J. Reuter

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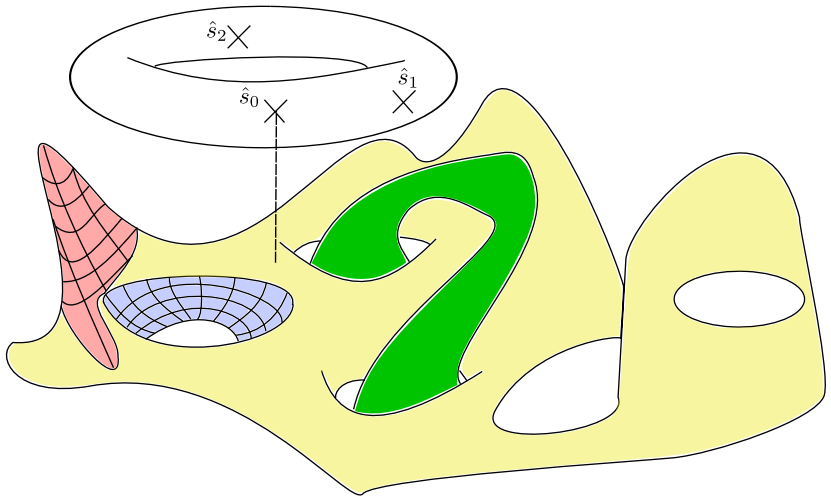
Outline

F-theory in a Nutshell



Geometrize IIB string coupling as complex structure of an elliptic fiber

Elliptic fiber encodes physical information

1. Gauge group:
   - **non-Abelian factors:** Codimension 1 singularities
   - **Abelian factors:** Freely acting Mordell-Weil group: [Morrison,Park'12; Braun,Grimm,Keitel'13]
   - **Quotient group factors:** Mordell-Weil torsion: [Morrison,Palti,Till,Weigand'14]
   - **Discrete symmetries:** n-sections [Braun, Morrison '14]

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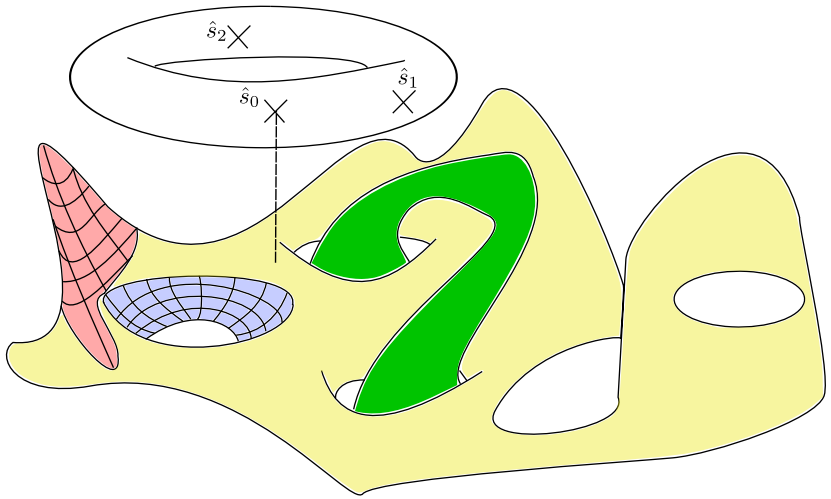

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2. Charged matter: Codimension 2 singularities

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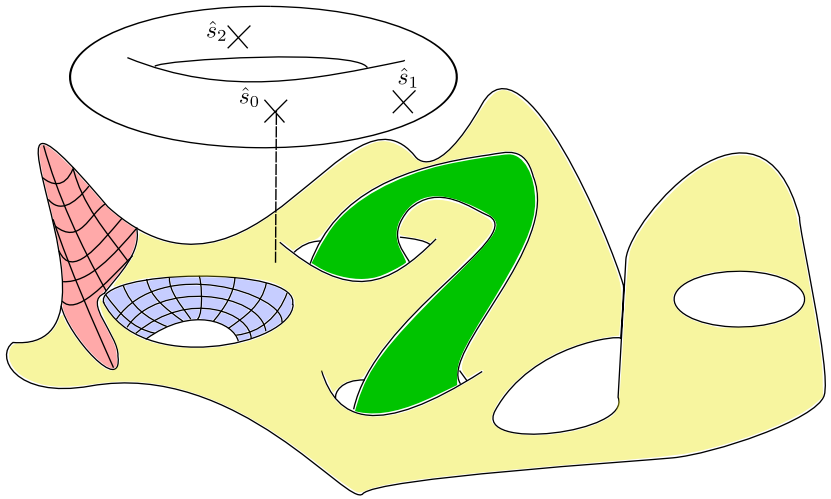

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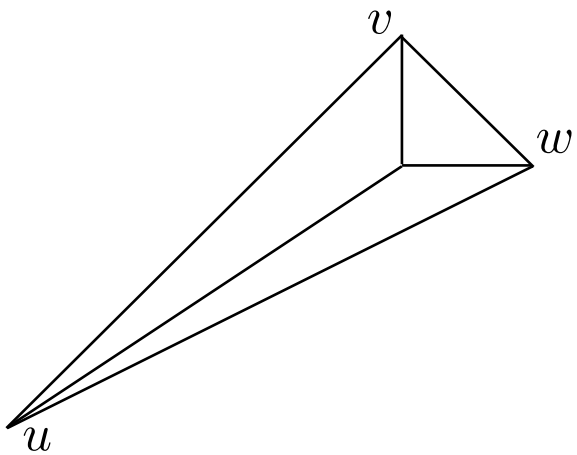
2. Charged matter: Codimension 2 singularities
3. Yukawa couplings: Codimension 3 singularities

Description of the Fiber



How to describe the elliptic fiber

Canonical choice: The Weierstrass form as vanishing degree six polynomial $P_{(1,3,2)}[6]$ in $[u, v, w]$:

$$v^2 - w^3 - fwu^4 - gu^6 = 0, \qquad \Delta = 27g^2 + 4f^3$$

- **zero section:** $[u, v, w] = [0, 1, 1]$
- **Discriminant:** $\Delta = 0 \rightarrow$ singularity directly visible

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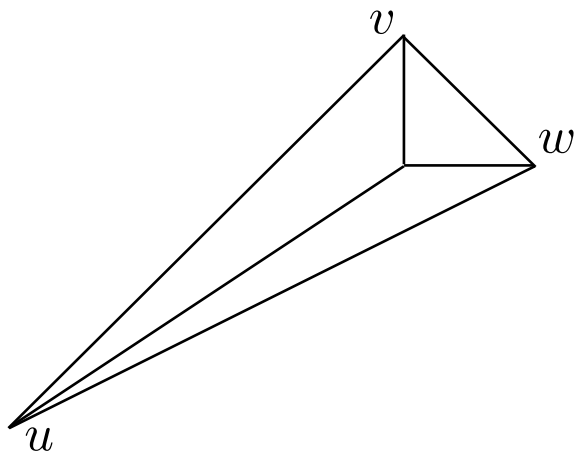

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- Not best starting point to engineer (discrete-) Abelian symmetries

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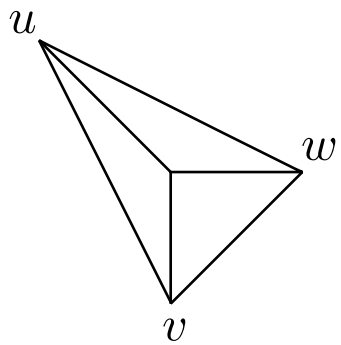

How to describe the elliptic fiber

Start from a **different ambient space** such as $\mathbb{P}^2$:

$$s_1 u^3 + s_2 u^2 v + s_3 u v^2 + s_4 v^3 + s_5 u^2 w + s_6 u v w s_7 v^2 w + s_8 u w^2 + s_9 v w^2 + s_{10} w^3 = 0$$

$\rightarrow$ Genus-one fiber with three-section: $\mathbb{Z}_3$ symmetry [Cvetic,Donagi,Klevers,Piragua,Poretschkin'15]

Benefit:

- Using *tops*, **additional** non-Abelian sectors can be added

  [Bouchard,Skarke'03;Braun,Grimm,Keitel,Borchmann,Mayrhover,Palti,Weigand;Cvetic,Klevers,Piragua'13]

- the above sector of the theory is **invariant** of the *top* completion

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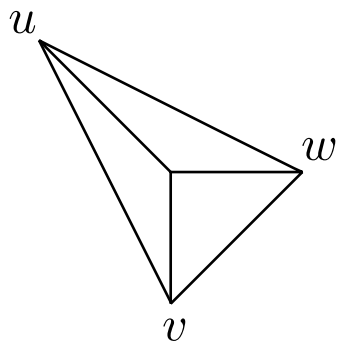

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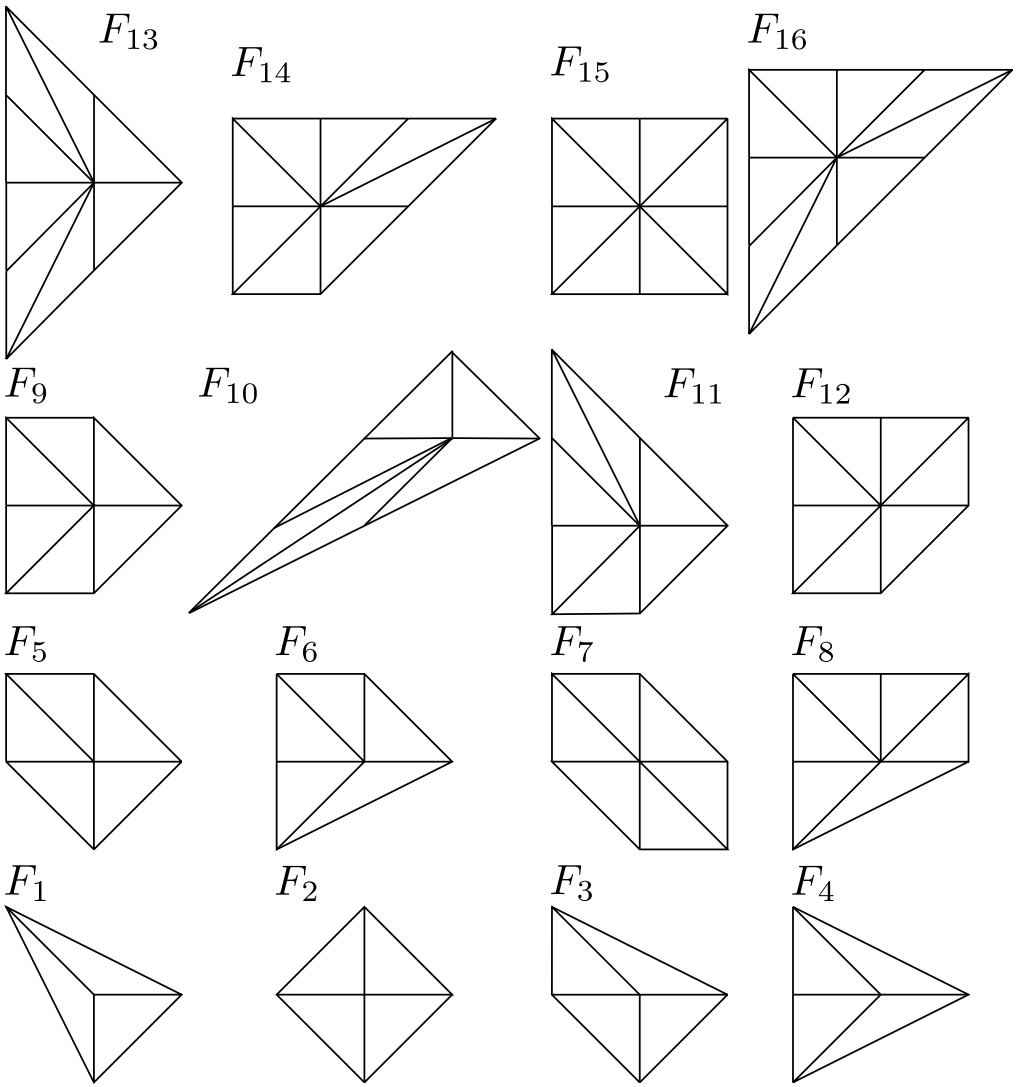
Usefull to fully analyze those **invariant** sectors!

Choose one of sixteen



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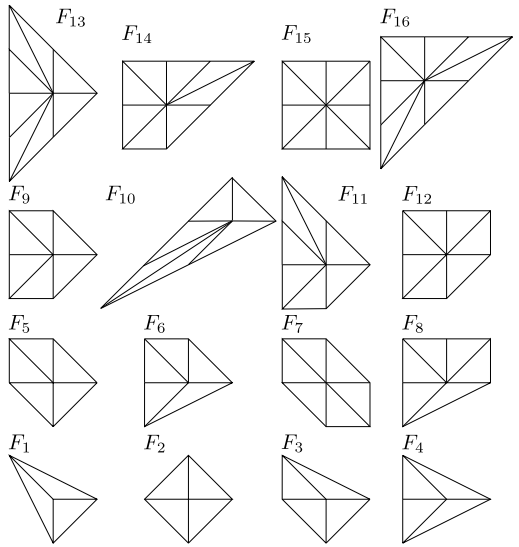


Our program

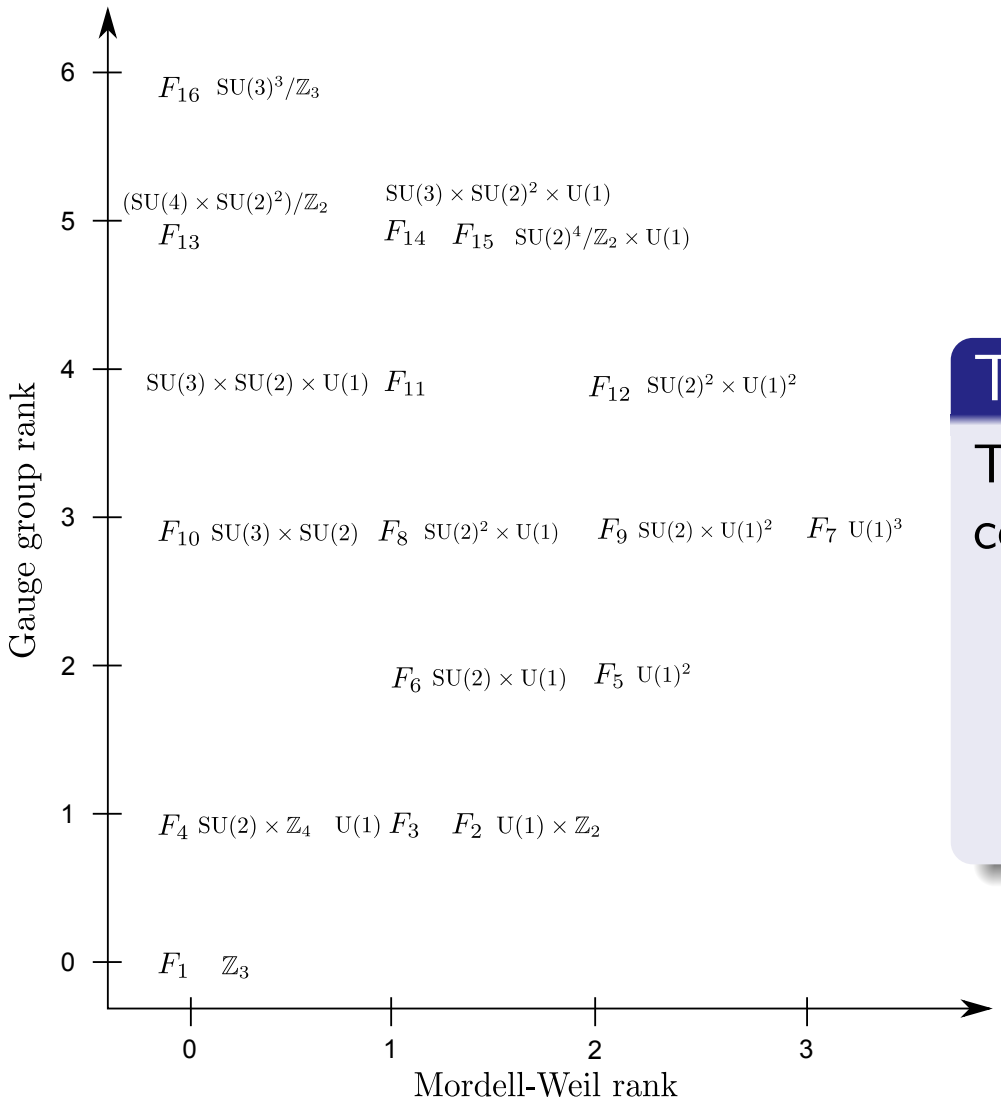
Describe the fiber as a hypersurface in one of **all the** 16, 2D toric varieties!

- What is the **generic** F-theory spectrum?

  [Braun,Keitel,Grimm;Cvetic,Klevers,Piragua;Borchmann,Mayrhofer,Palti,Weigand'13]

- Are there **relations** among those theories?
- Check all consistency conditions for a **general** two dimensional base
  $\rightarrow$ **Globally consistent** family of $6D$ $\mathcal{N} = 1$ SUGRA theories

The Network



The Network

The SUGRA spectrum of F-theory covers all generic features:

- From quotient to discrete symmetries [Saw E. Palti's talk]

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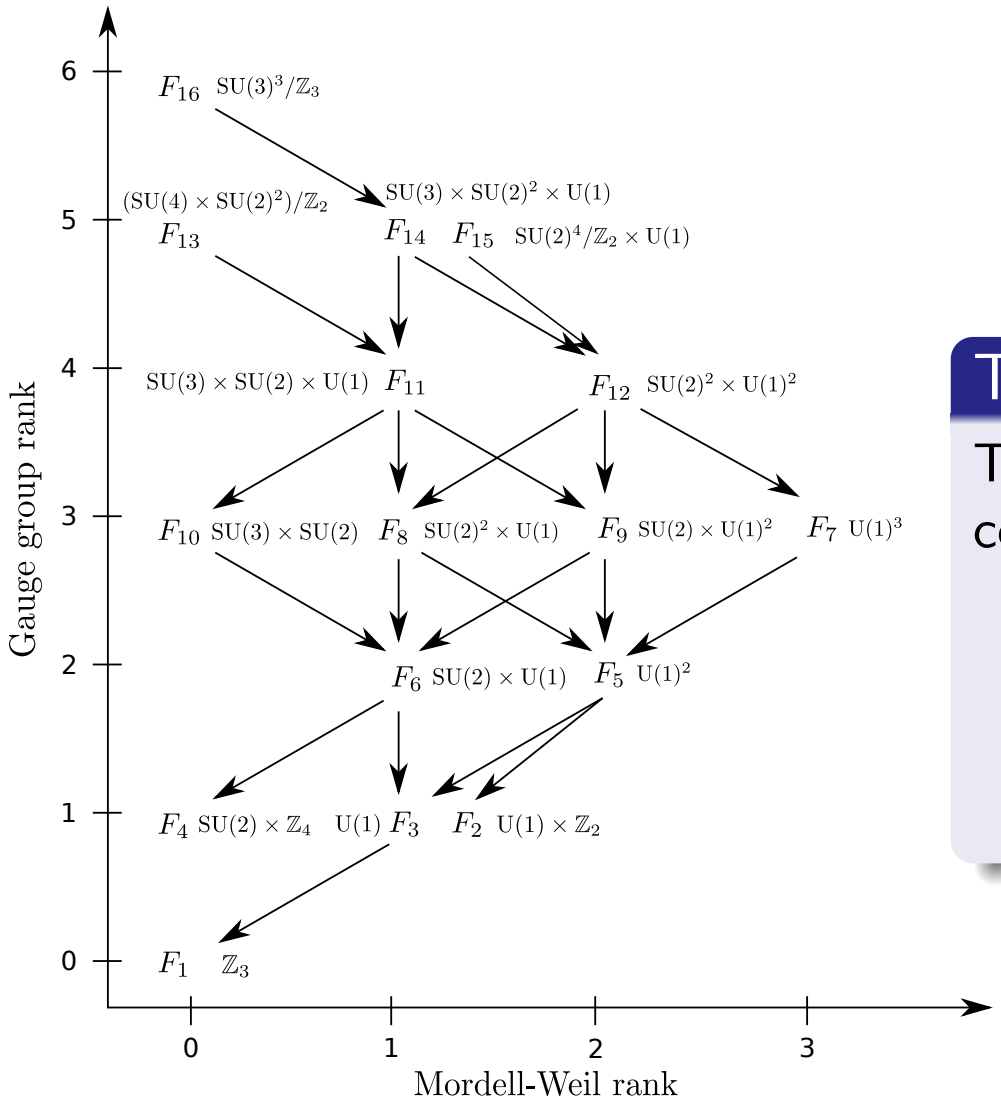

The Network

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- From quotient to discrete symmetries [Saw E. Palti's talk]
- All theories connected to a network

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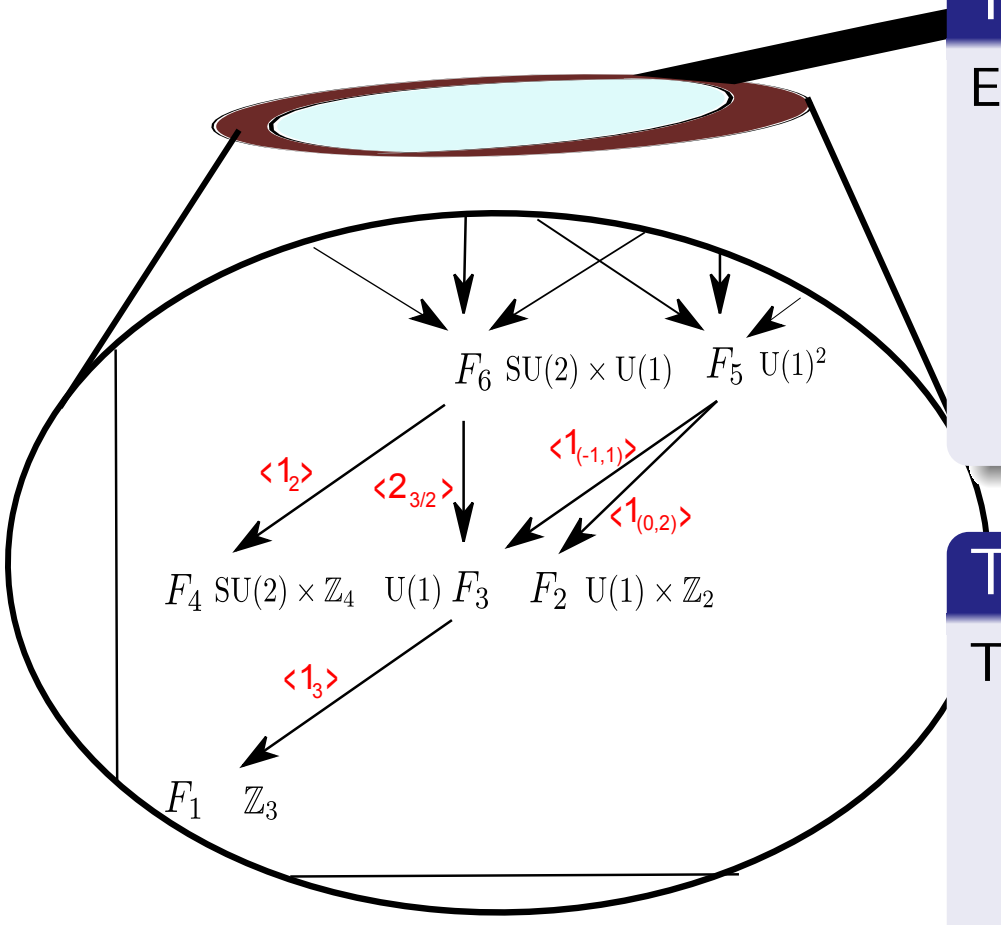


Toric Higgs Effect

The Geometry Side

Extremal transitions:

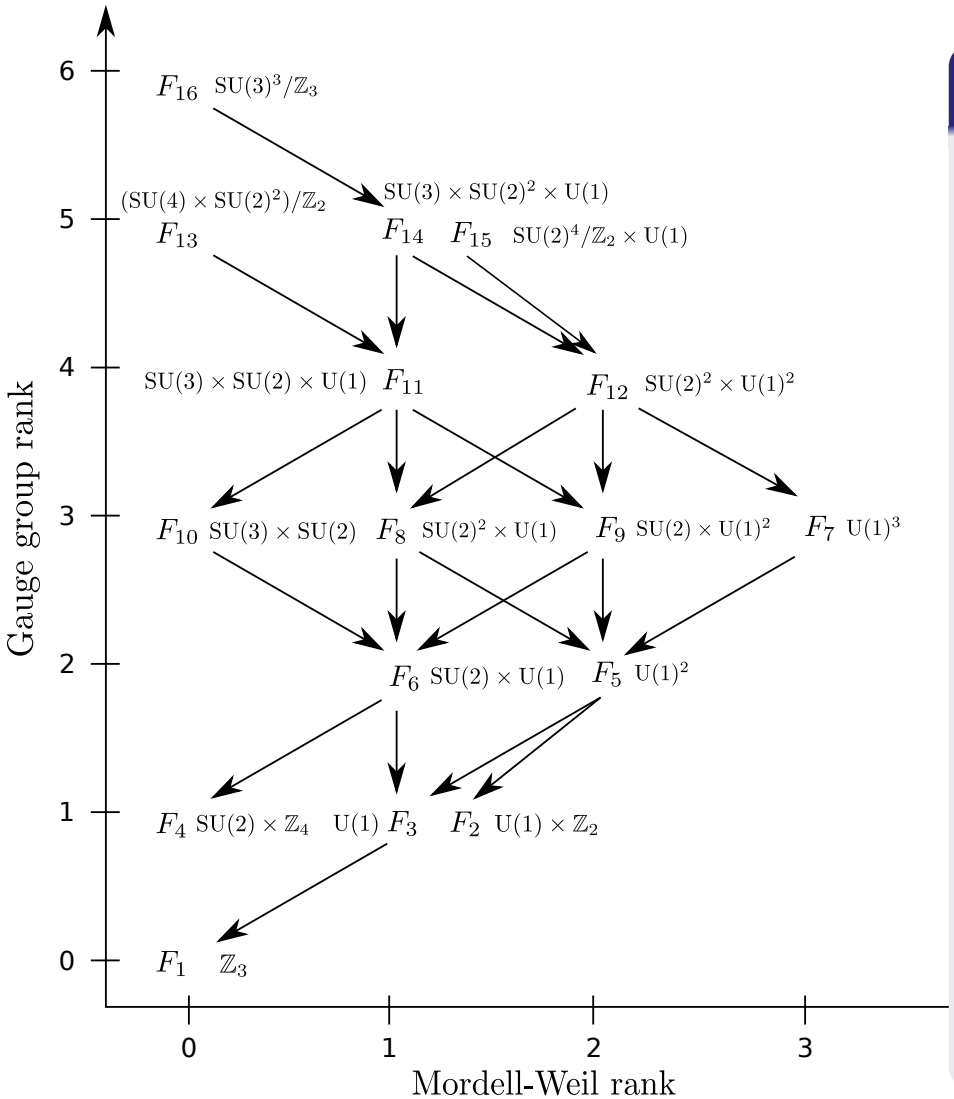
1. blow-up(/down) in the fiber
2. Matching of divisor classes
3. Effectiveness of all divisors
4. ...

The Field Theory Side

The 6D Higgs effect:

1. non-adjoint VEV
2. Matching of field multiplicities
3. D-flatness
4. ...

The Network



Highlights

1. MW-torsion [Mayrhofer,Morrison,Till,Weigand'14]
   - F_{16} : Trinification
   - F_{13} : Pati-Salam
2. F_{11} : The Standard Model
3. F_3 : $q = 3$ $U(1)$ charged matter
4. Multi sections:
   - discrete symmetries

   [Anderson,Garcia-Etxebarria, Grimm, Keitel'14]

   [Mayrhofer,Palti,Till,Weigand '14]
5. Mirror-Symmetry:

MW-torsion
$\Updownarrow$?
n-sections

Conclusion

Our Construction

We have constructed a **network** of

- **globally consistent** families of 6D SUGRA theories within F-theory where
- the fiber is realized as a hypersurfaces **in one of all 16**, 2D toric varieties and
- gave **their full spectrum** and the **Higgs-connections**.

Our Highlights

- Various **examples of discrete symmetries** and matter charges
- The **first** $q > 2$ U(1) charged matter field
- **Interesting** fibrations **for particle physics** (Trinification, Pati-Salam and Standard model) [Saw Denis Talk, See D.Mayorga's talk]
- The network is fully **mirror-symmetric**

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Thank You !

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