MODULI SPACES OF 5d SCFTs

A walk in the tropical rainforest

Workshop on Recent Advances in QFT and geometry

December 4th 2020

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Based on: [1810.01495] Cabrera, Hanany, Yagi

[1908.04245] AB, Cabrera, Grimminger, Hanany, Sperling, Zajac, Zhong

[2008.05577] van Beest, AB, Eckhard, Schafer-Namuki

[2011.02033] van Beest, AB, Eckhard, Schafer-Namuki

5d SCFT

RG

RG

5d gauge theory

5d gauge theory

$$\mathcal{L} = \frac{1}{g_{YM}^2} \mathrm{Tr}(F^2) + \dots$$

$\left[\frac{1}{g_{YM}^2}\right] \sim$ energy $\Rightarrow$ Strong coupling at scale $\mu \sim \frac{1}{g_{YM}^2}$

$\Downarrow$

IR-free

- Non trivial CFT in $d > 4$
- Intrinsically strongly coupled
- Rich moduli space

Can be studied using geometric engineering:

M-theory on

$\mathbb{R}^{1,4} \times$ 

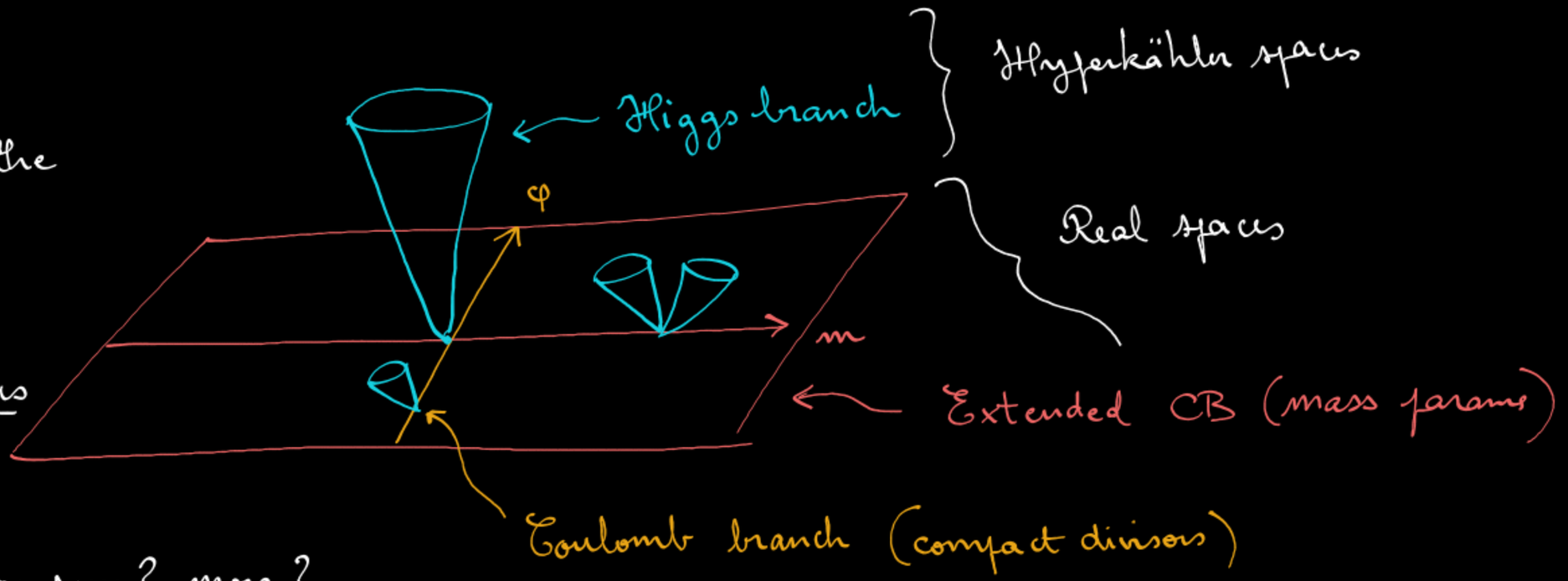
local CY_3 isolated singularity

$\Rightarrow$ SCFT $\mathcal{T}[X]$

GEOMETRY OF X $\Longleftrightarrow$ MODULI SPACE OF 5d SCFT

Extended Kähler cone $\longleftrightarrow$ Extended Coulomb branch

Complex structure deformations $\longleftrightarrow$ Higgs branch



NB: As a function of the ECB parameters, the Higgs branch undergoes discontinuous transitions.

Questions: dimension? flavor sym? more?

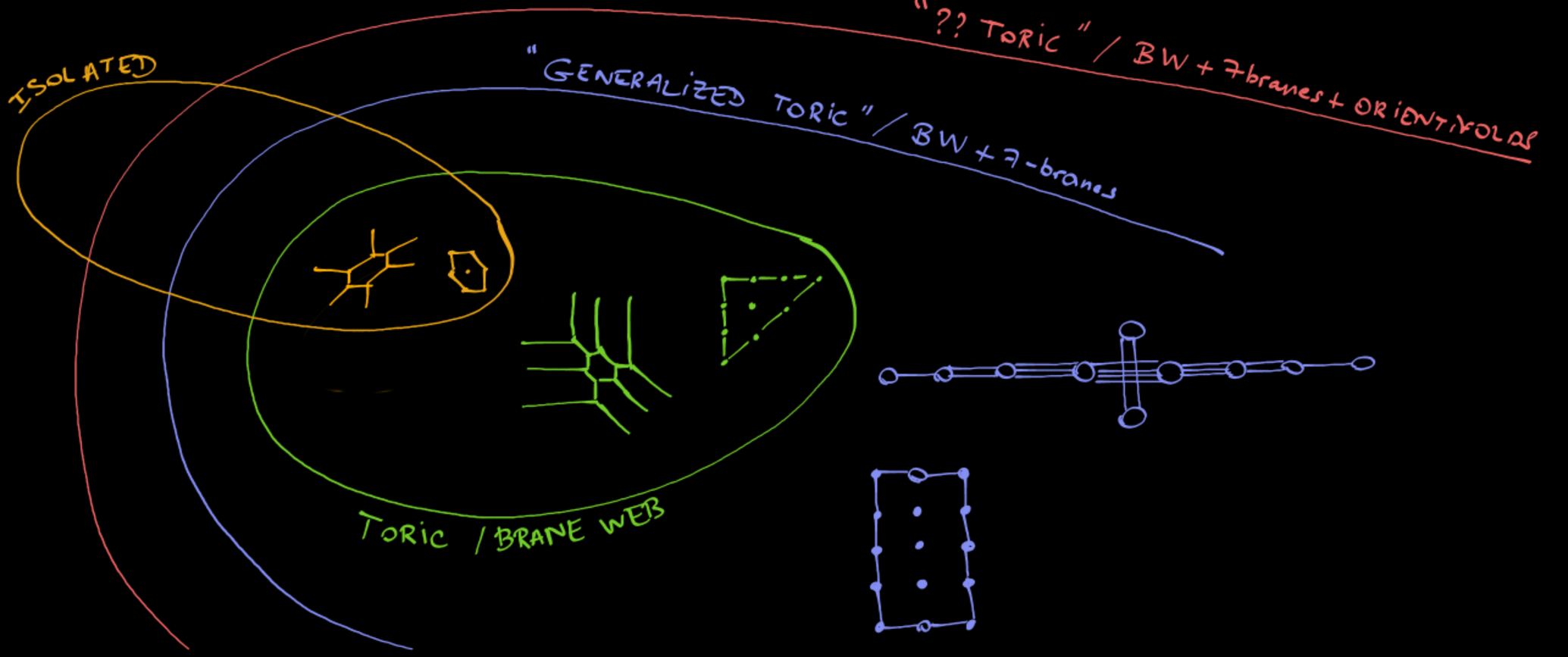
X → Geometry, M/F-theory

[Apruzzi, Lawrie, Lin, Schafer-Nameki, Wang]

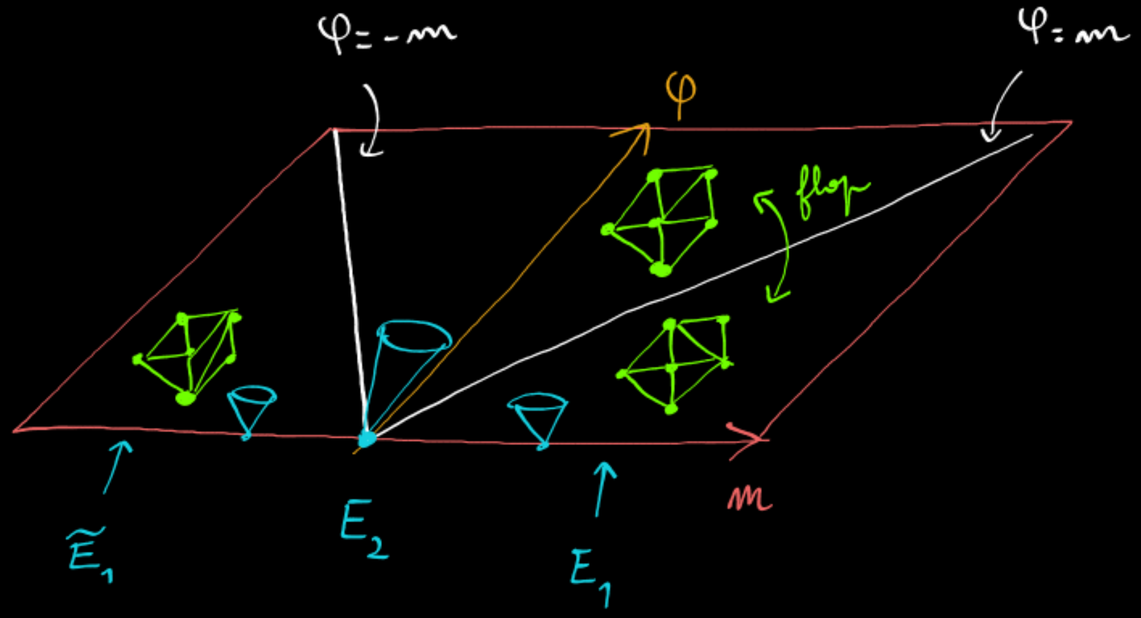
X → IIA picture (D6 branes + geometry)

[Closset, del Zotto, Saxena]

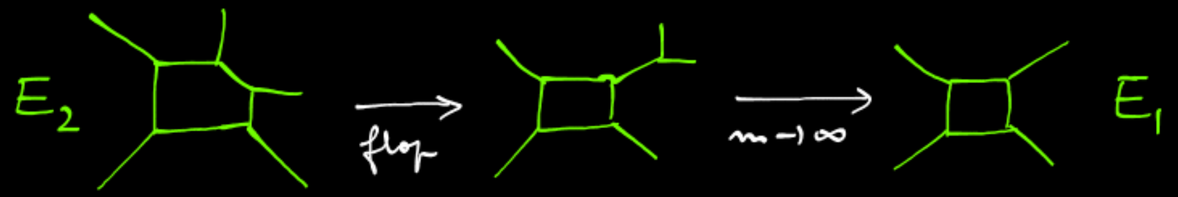
X → IIB picture : BRANE WEBS ⟷ GENERALIZED TORIC DIAGRAMS



Example : SU(2) + 1 F ⟶ E_2 SCFT



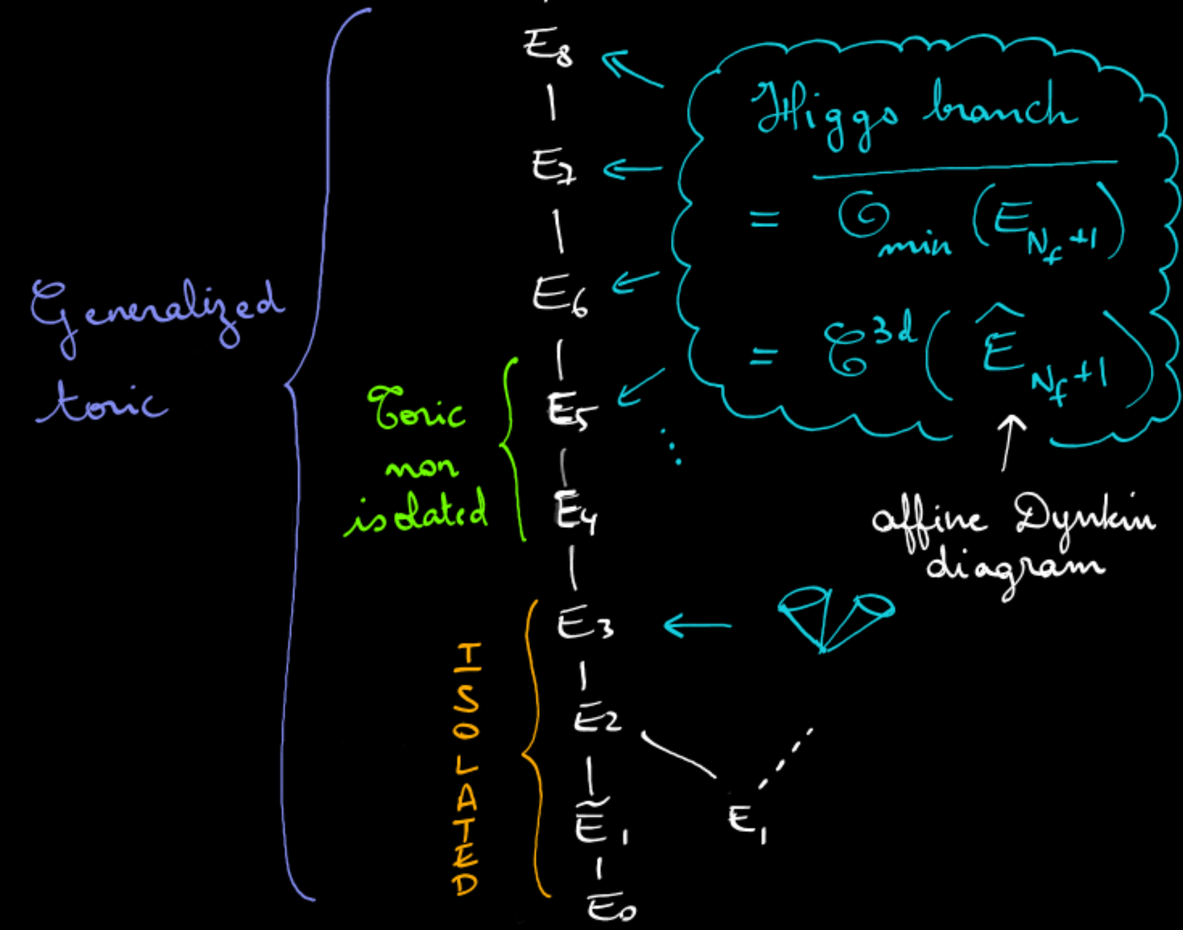
Moving on ECB allows to connect 5d SCFTs via decoupling "trees"



The simplest decoupling tree is:

E-STRING DESCENDANTS

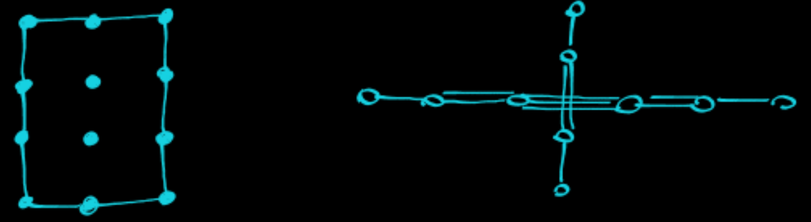
6d marginal ← SU(2) + 8F



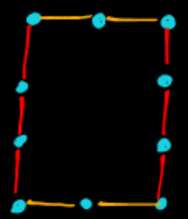
Structure of the HIGGS BRANCH

Symplectic Singularity (or union ...)

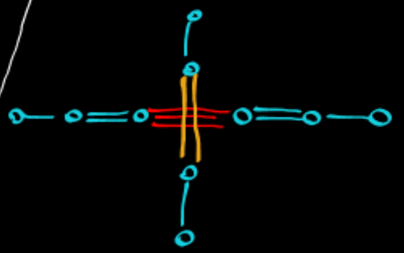
GTP / BRANE WEB



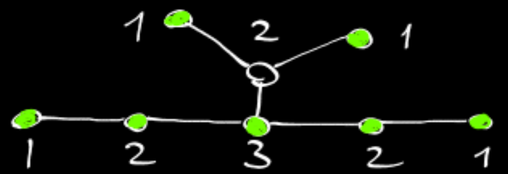
polygon coloring



brane decomposition



MAGNETIC QUIVER



global sym.

$A_5 \times A_1^2$

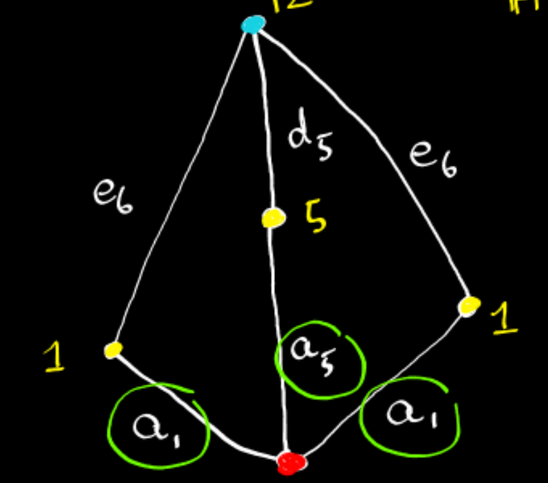
QUIVER SUBTRACTION

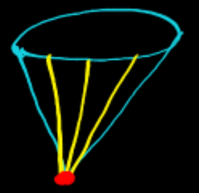
combined into

EXAMPLES

- Du Val $\mathbb{C}^2/\Gamma_{ADE}$
- $\overline{\mathcal{O}_{min}(\mathfrak{g})}$

HASSE DIAGRAM





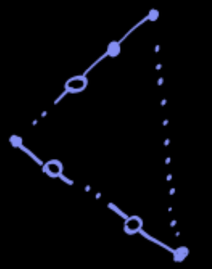
generalization of the classical Higgs mechanism

Decoupling trees for $SU(N)_k + \#F + \#AS$

"Modular" construction of GTPs [Zafrir 1509.02016]

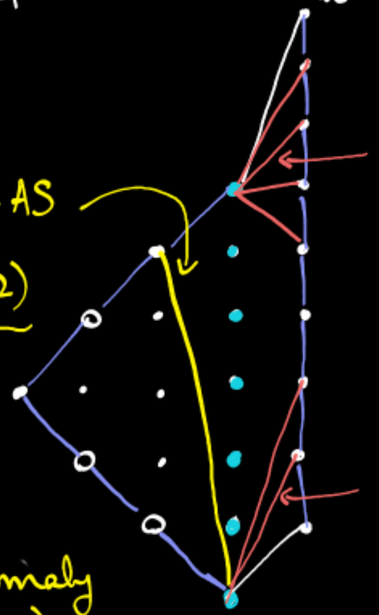
$\longleftrightarrow$ $SU(N)$ gauge group

$\longleftrightarrow$ fundamental hyper



$\longleftrightarrow$ antisymmetric hyper

Example : $SU(2m)_n + 8F + 1AS$:



decouple AS

$k \to k + (n-2)$

$\frac{1}{2}A(AS)$

(triangle anomaly coefficient)

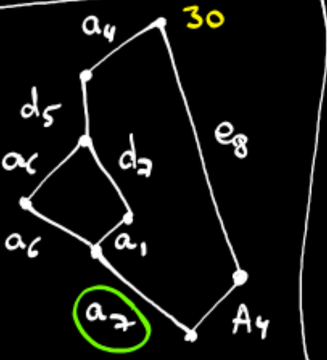
decouple F with $k \to k - 1/2$

decouple F with $k \to k + 1/2$

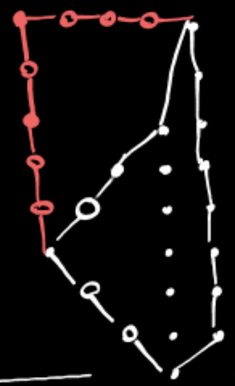
Problem : the polygon is not convex ... $\longrightarrow$ "MONODROMIES"

MAGNETIC QUIVER & HASSE DIAGRAM

$SU(8) \oplus u(1)^2$

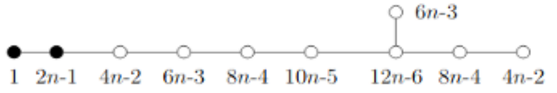
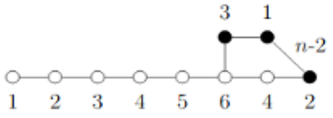
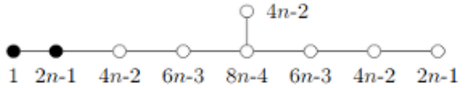
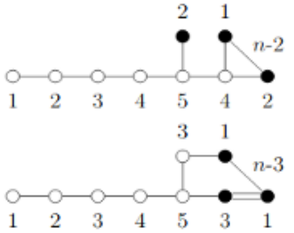
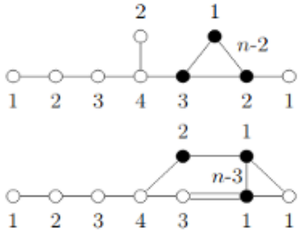
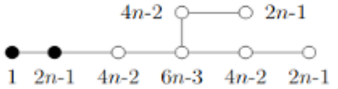
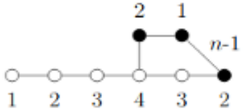
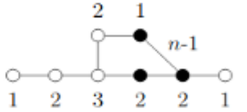
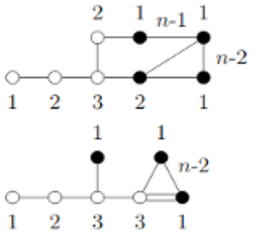
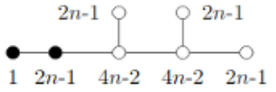
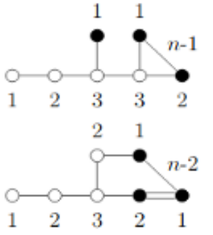
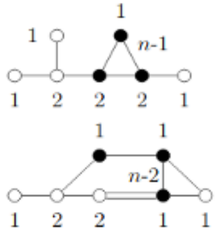
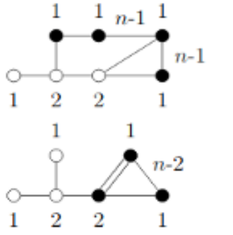
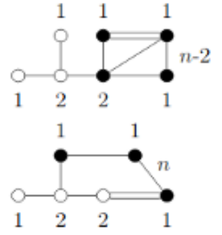


CONVEX GTP



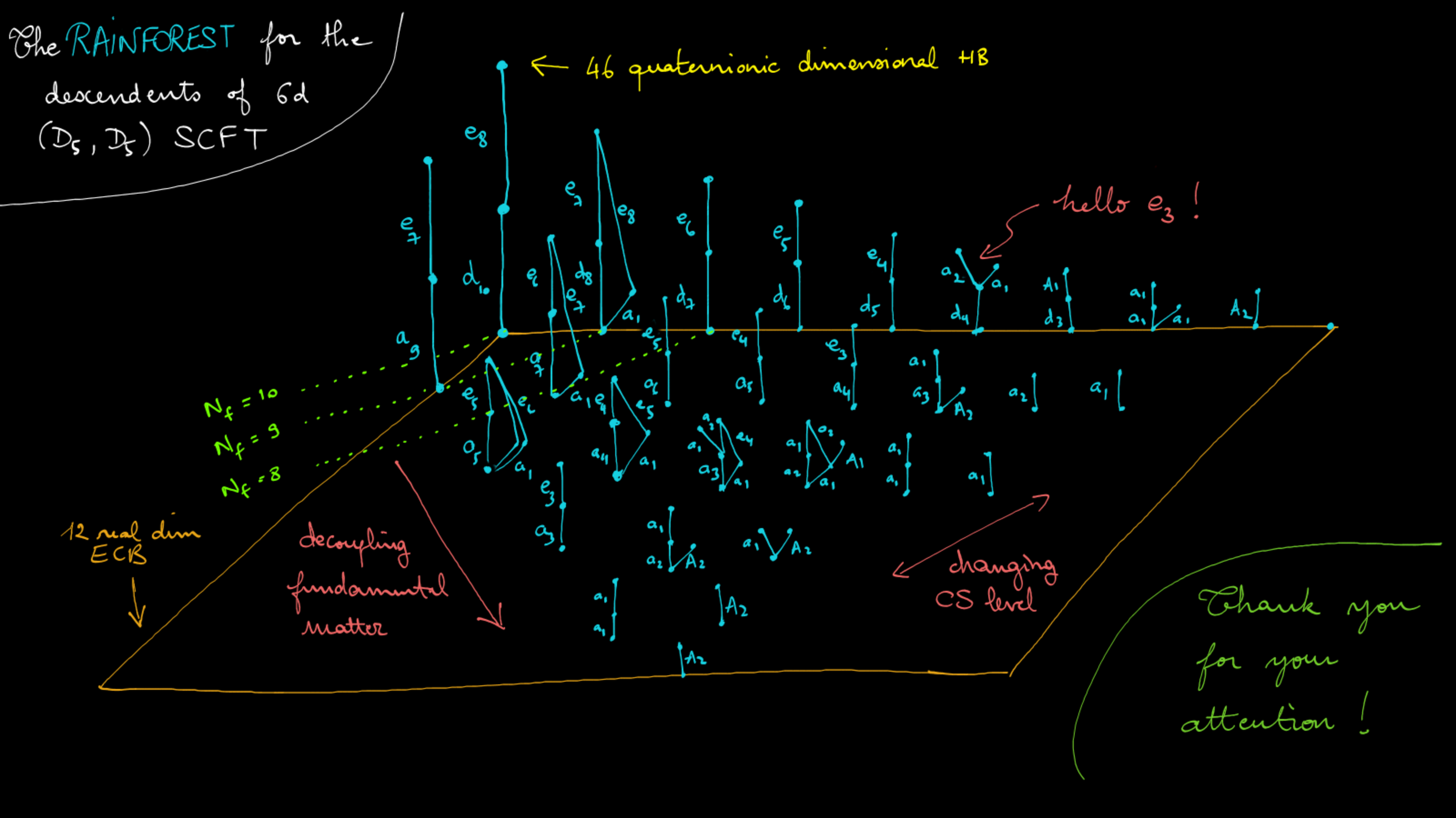
$SU(6)_{5/2} + AS + 7F$

$SU(2n)_n + AS + 8F$ marginal theory decoupling "tree"

$N_F \backslash \frac{N_F}{2} + k$	$n+4$	$n+3$	$n+2$	$n+1$	n
8	Marginal				
7	 $\mathfrak{e}_8 \oplus \mathfrak{su}(2)$	 $\mathfrak{su}(8) \oplus \mathfrak{u}(1)^2$			
6	 $\mathfrak{e}_7 \oplus \mathfrak{su}(2)$	 $\mathfrak{su}(7) \oplus \mathfrak{u}(1)^2$	 $\mathfrak{su}(6) \oplus \mathfrak{su}(2) \oplus \mathfrak{u}(1)^2$		
5	 $\mathfrak{e}_6 \oplus \mathfrak{su}(2)$	 $\mathfrak{su}(6) \oplus \mathfrak{u}(1)^2$	 $\mathfrak{su}(5) \oplus \mathfrak{su}(2) \oplus \mathfrak{u}(1)^2$	 $\mathfrak{su}(5) \oplus \mathfrak{u}(1)^3$	
4	 $\mathfrak{so}(10) \oplus \mathfrak{su}(2)$	 $\mathfrak{su}(5) \oplus \mathfrak{u}(1)^2$	 $\mathfrak{su}(4) \oplus \mathfrak{su}(2) \oplus \mathfrak{u}(1)^2$	 $\mathfrak{su}(4) \oplus \mathfrak{u}(1)^3$	 $\mathfrak{su}(4) \oplus \mathfrak{u}(1)^3$

Results

- Purely algorithmic techniques based on combinatorics
  - with some formidable challenges: { • monodromies • S-rule
- Description of the Higgs branch, including { – dimension – global symmetry – full singularity structure } everywhere on the ECB
  - At least the non-abelian part
  - Including non simply laced algebras
- Reproduction of decoupling trees [Jefferson, Katz, Kim, Vafa, Bhardwaj, Zafir, ...] [Apruzzi, Lawrie, Lin, Shafer-Nameki, Wang ...] [Hayashi, Kim, Lee, Yagi]
- Many new families of moduli spaces / quivers
  - some of them offer challenges for quiver subtraction algorithm [work in progress...]


The RAINFOREST for the descendents of 6d (D_5, D_5) SCFT
← 46 quaternionic dimensional HB
hello e_3 !
$N_f = 10$
$N_f = 9$
$N_f = 8$
12 real dim ECB
decoupling fundamental matter
changing CS level
Thank you for your attention !