Conformal Bootstrap

* New/old way to constrain & solve strongly coupled FT's.

idea: Fix correlators using only symmetry constraints

⇒ similar to old S-matrix program

* Does not require large N, supersymmetry, etc...
  - → depends on conformal symmetry of fixed point
  - → results are non-perturbative

* Very broad range of application

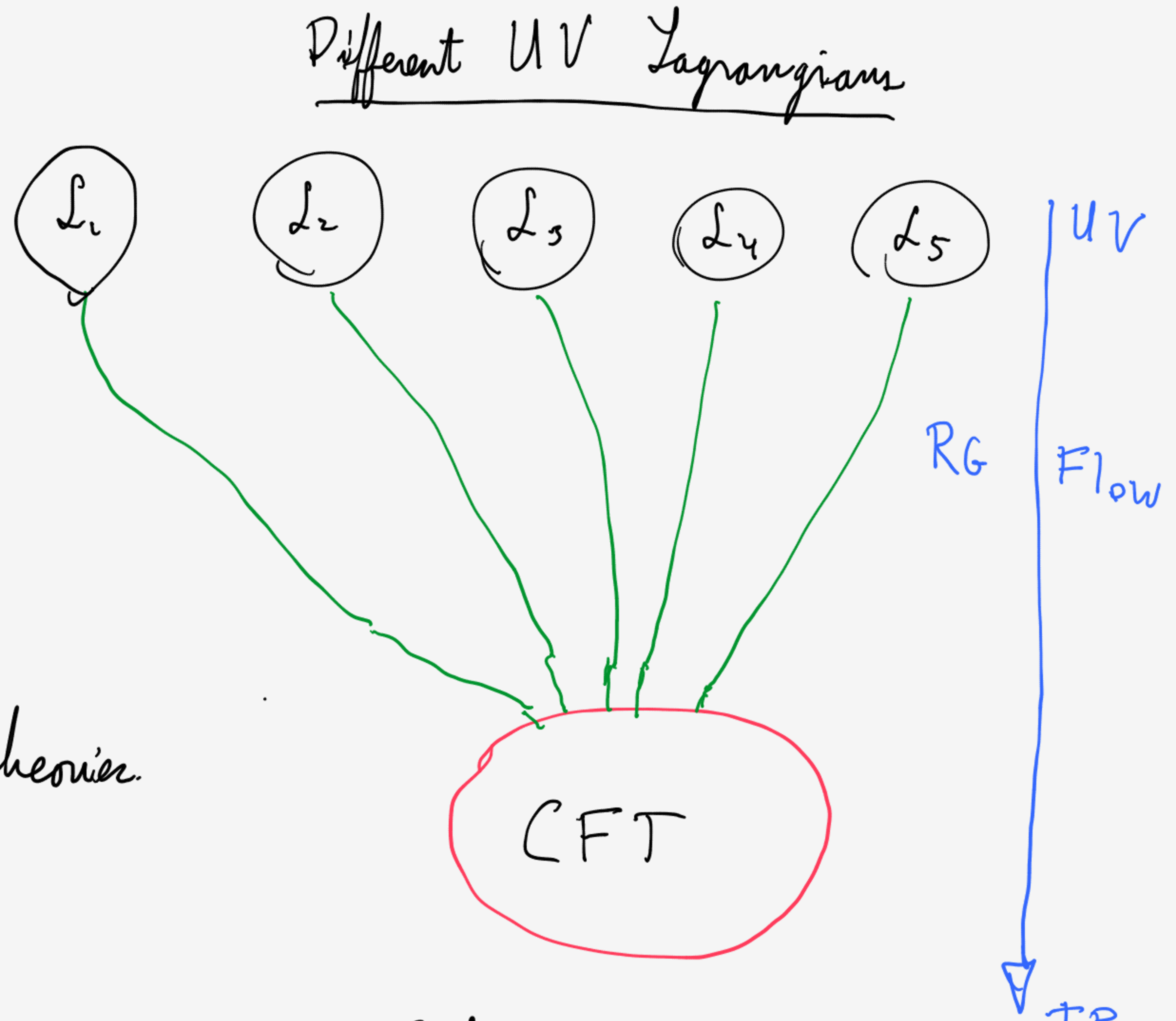
* Fixed points universal

  ⇒ many theories flow to same fixed point (CFT).

* ∞ number of constraints

* In 2d allowed us to "solve" some theories.

* Many applications:
  - 3d Ising
  - Technicolor
  - $N=4$ SYM (non-planar strong coupling)
  - 3d SYM



Enhanced Symmetry:

Scale + Conformal

$SO(D,2)$ vs $SO(D-1,1)$

Approach

Impose crossing symmetry on 4-pt correlator:

$$\langle \sigma(x_1)\,\sigma(x_2)\,\sigma(x_3)\,\sigma(x_4)\rangle = \langle \sigma(x_1)\,\sigma(x_2)\,\sigma(x_3)\,\sigma(x_4)\rangle$$

- σ "lightest" scalar in theory.
- Imposes constraints on anomalous dimensions of all fields.
- With some additional (mild) assumptions solution is Unique.

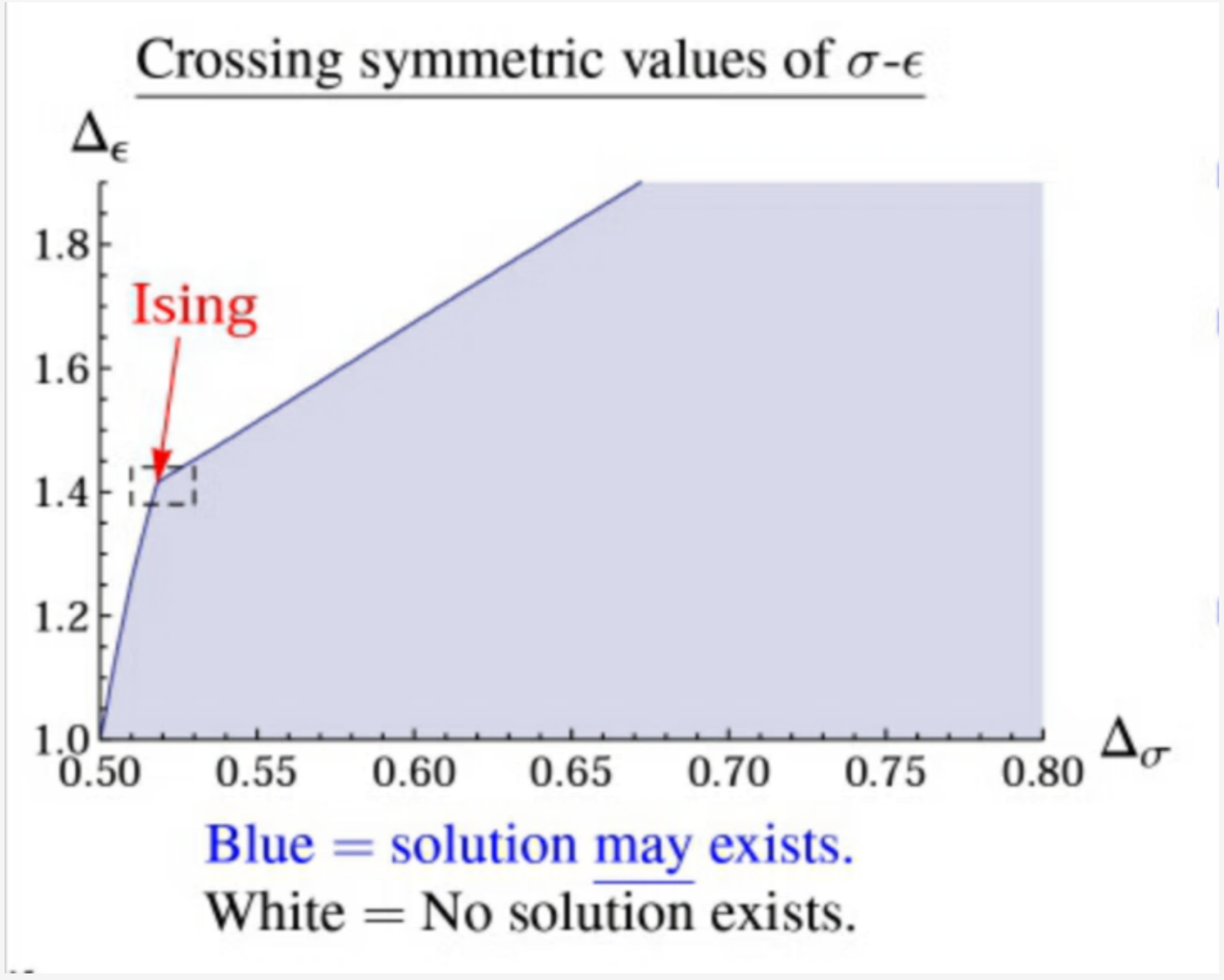
Constraints very powerful

* Study theories without Lagrangian perturbation theory.

e.g. 3d Ising model stands out in space of sol'n to constraints.

* Constraints

- Completely non-perturbative
- Apply to all CFT's
- Numerical



Numerical Solutions

* Numerically solve for:
  - Anomalous dimensions
  - 3 pt coupling

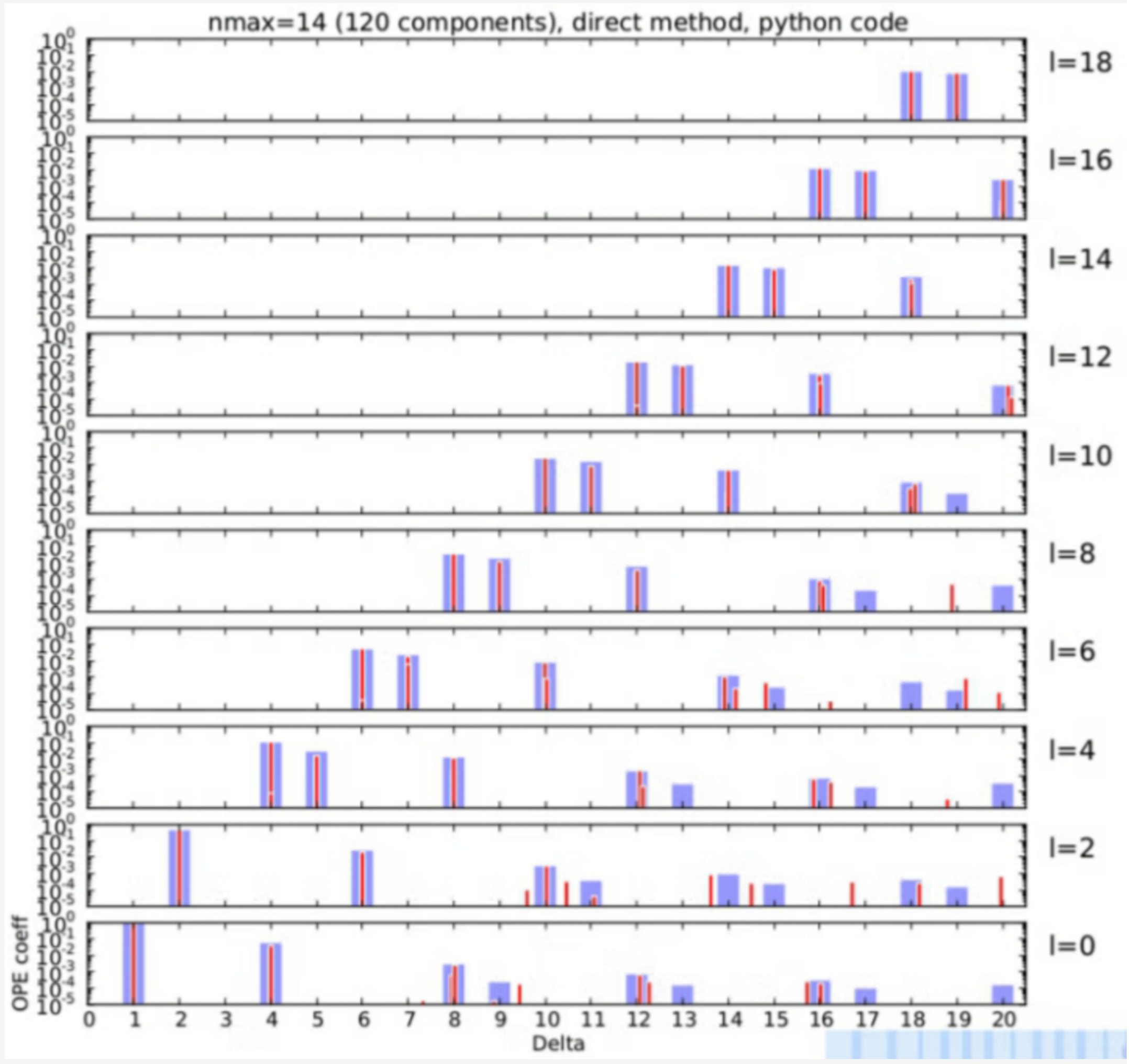
} full CFT data

* Compare to exact results in $d=2$.

2d ising

- 21 anom dims @ 0.01% (100 at 10%)
- 20 couplings to 10%
- some quantities to 10^{-7}

} Runs on a laptop



3d Ising Model

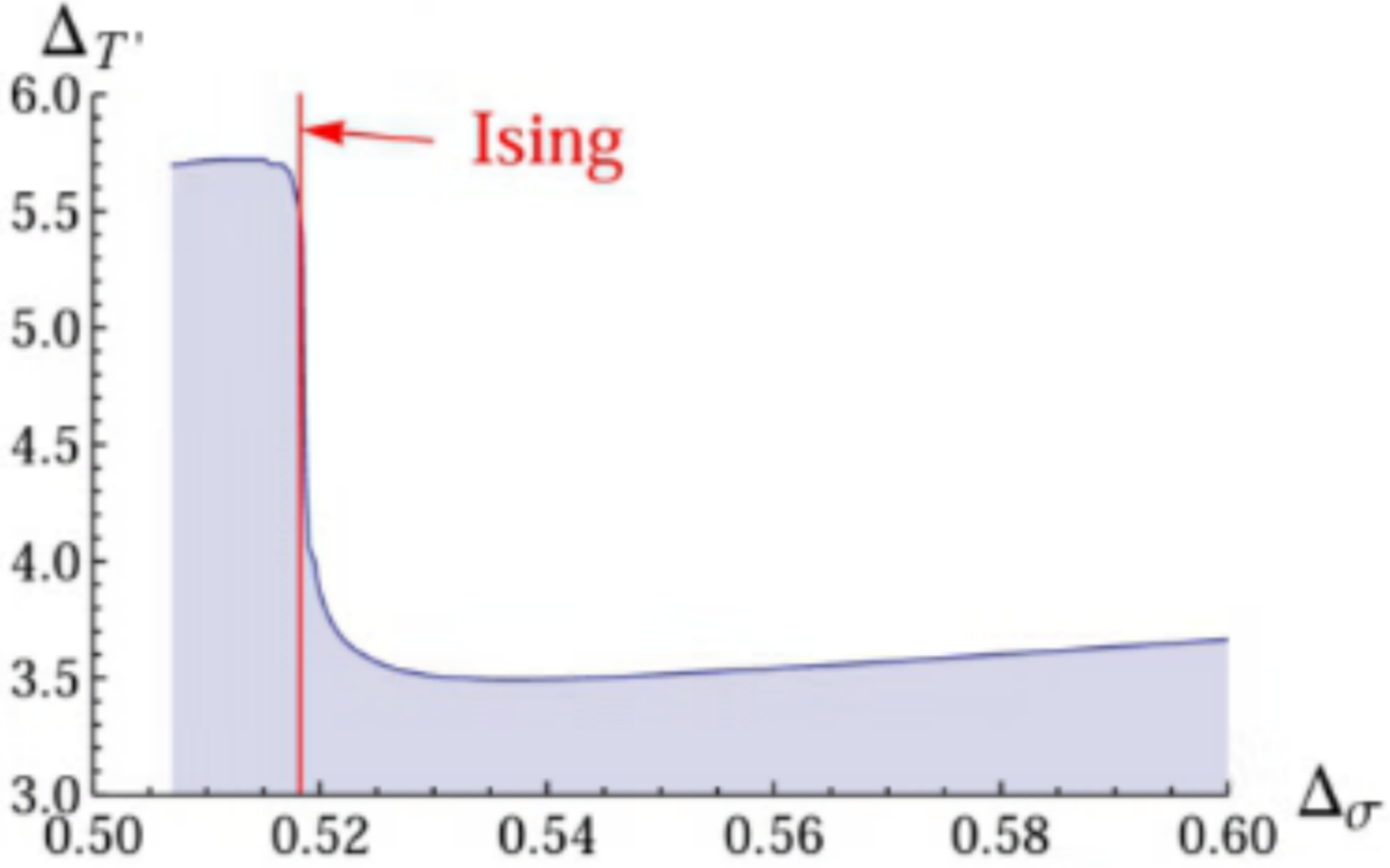
* Old & difficult problem
  - ⇒ Monte Carlo, ε-expansion, etc...
  - ⇒ only 5 critical exponents computed (error ~ 0.5% or more)

* Our method has already reduced errors & suggested approx new exponents

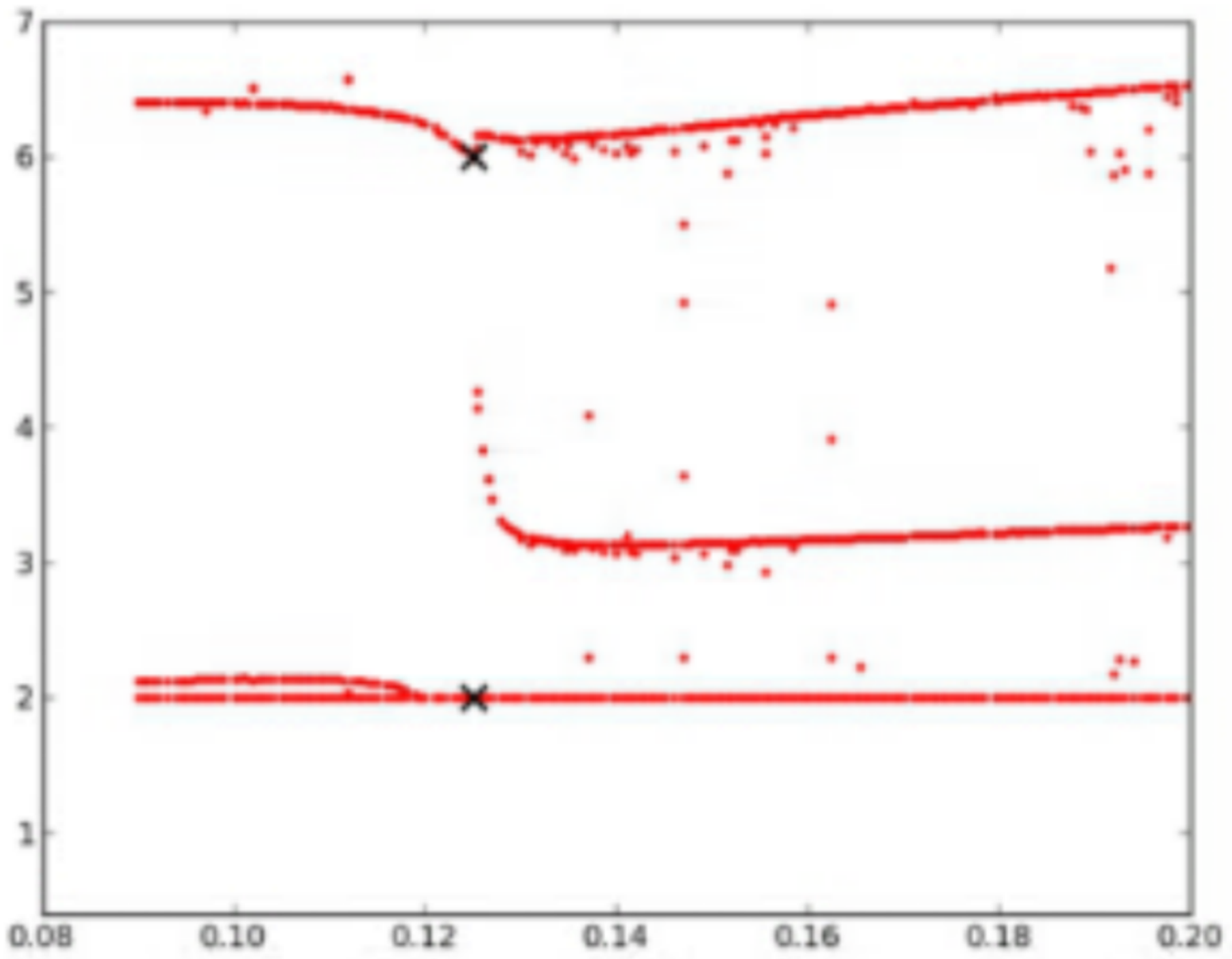
* Revealed surprising birational structure
  - ⇒ Analogous to structures that make 2d Ising solvable!!

* Structure both a boon & a bane.

Spin 2 Bound in D=3



Spin 2 Spectrum in D=2



Same structure (Null states) appear in $d = 2$ & 3.

Computed spectrum very sensitive to parameter (Δ_σ: anom dim of lightest scalar σ)

Applications & interaction

* Our results depend on knowing Δ_σ to high precision

  ⇒ input from lattice or other methods very helpful.

* Can constrain BSM scenarios (original paper Rattazzi, Rychkov et al)

* Physics away from fixed point can (sometimes) be computed starting from CFT (truncated conformal space approach).

* $N=4$ at strong coupling, finite N (Next talk)

* Lots of new non-perturbative techniques & results in QFT / CFT

  ⇒ lots to do! Join in!!