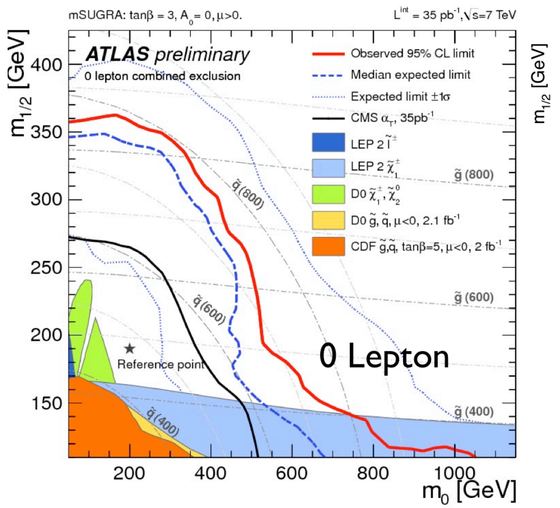
pMSSM phase space

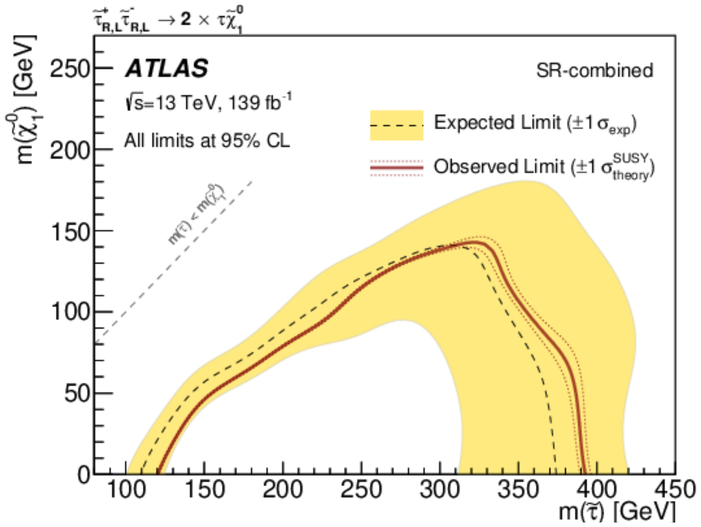
In a world with regular RECAST, what analyses should we do?

Lukas Heinrich, TUM

Simplified Models

When we made the switch from UV-inspired to simplified models reinterpretation a was **always implied**





Simplified Models for LHC New Physics Searches

Daniele Alves,[1] Nima Arkani-Hamed,[2] Sanjay Arora,[3] Yang Bai,[1] Matthew Baumgart,[4] Joshua Berger,[5] Matthew Buckley,[6] Bart Butler,[1] Spencer Chang,[7,8] Hsin-Chia Cheng,[8] Clifford Cheung,[9] R. Sekhar Chivukula,[10] Won Sang Cho,[11] Randy Cotta,[1] Mariarosaria

A. The Purpose of Simplified Models

A model of new physics is defined by a TeV-scale effective Lagrangian describing its particle content and interactions. A simplified model is specifically designed to involve only

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[14]EPFL, CH-1015 Lausanne, Switzerland
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[16]High Energy Physics Division, Argonne National Laboratory, Argonne, IL 60439, USA
[17]Dept. of Physics and Astronomy, Northwestern University, Evanston, IL 60208, USA
[18]Dept of Physics, Carleton University, Ottawa, Ontario, K1S 5B6, Canada
[19]CERN PH-TH, Case C01600, 1211 Geneva 23, Switzerland, USA
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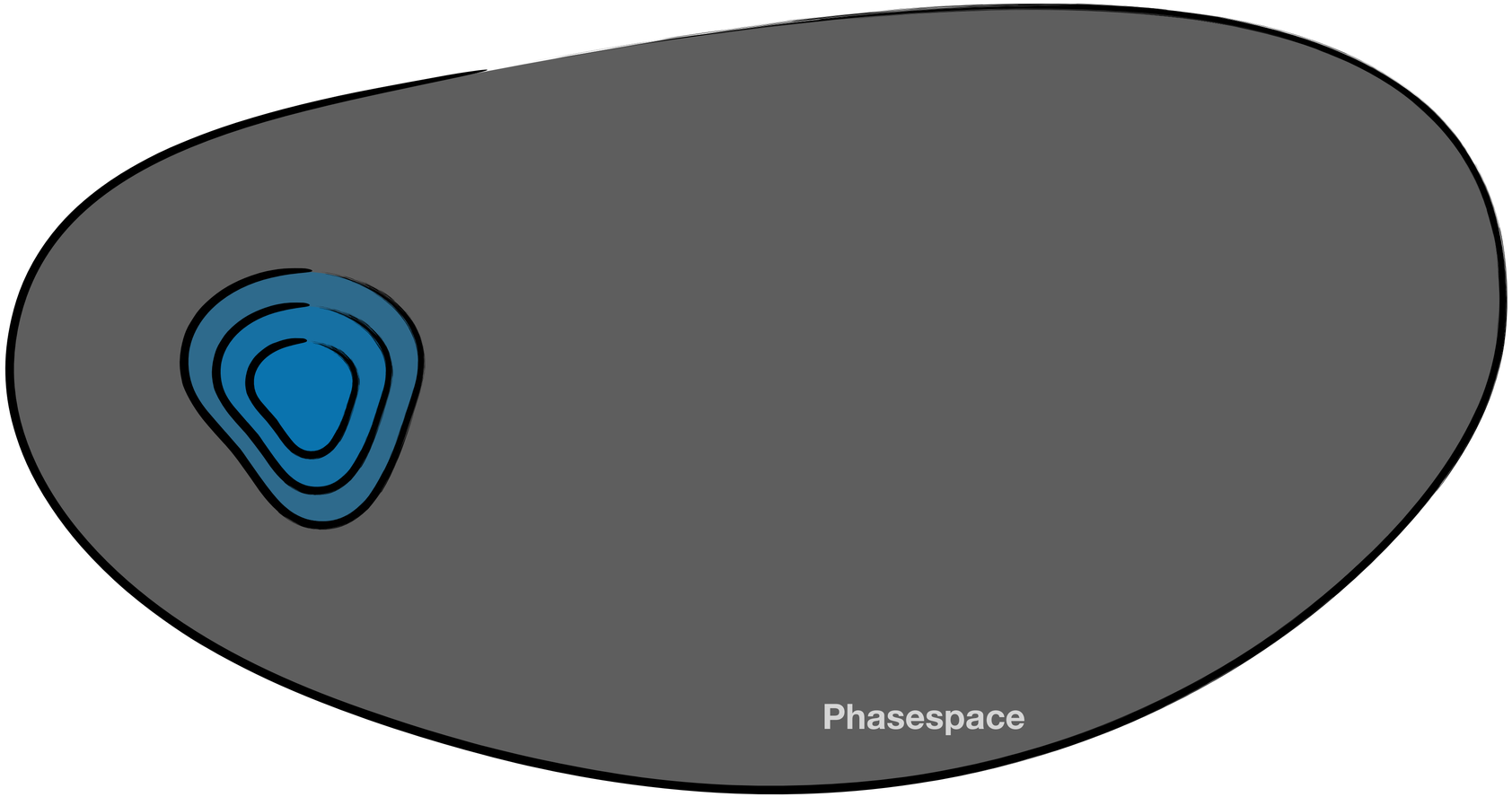
[22]Dept. of Physics and Astronomy, Seoul National University, Republic of Korea

- **Deriving limits on more general models:** Constraints on a wide variety of models can be deduced from limits on simplified models. Within each final state, simplified model limits can be formulated as an upper limit on the number of events in a signal region, and a parametrized efficiency for each simplified-model topology to populate the signal region. Limits on other models giving rise to the same topologies can

~~It should be emphasized that this procedure yields weaker limits than the direct~~ study of experimental efficiencies for a given specific model, as the procedure uses only topologies populated by *both* the specific *and* simplified models. This procedure should therefore be regarded as an initial check only, which can be followed by a dedicated study or RECAST-style analysis [18] if higher precision is needed.

Simplified Models

By analyzing topologies we uncover patches of phase space for reinterpretation



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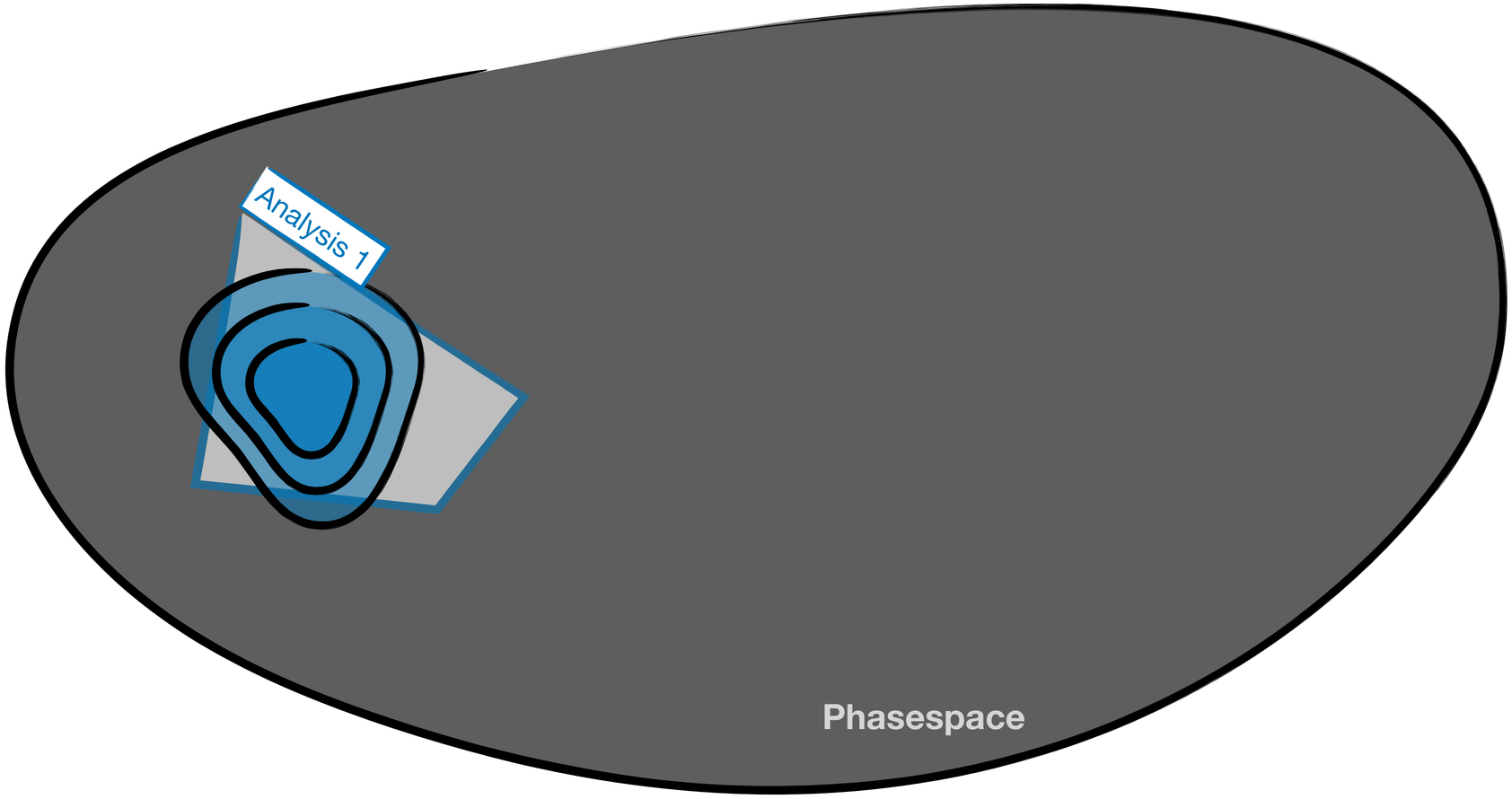

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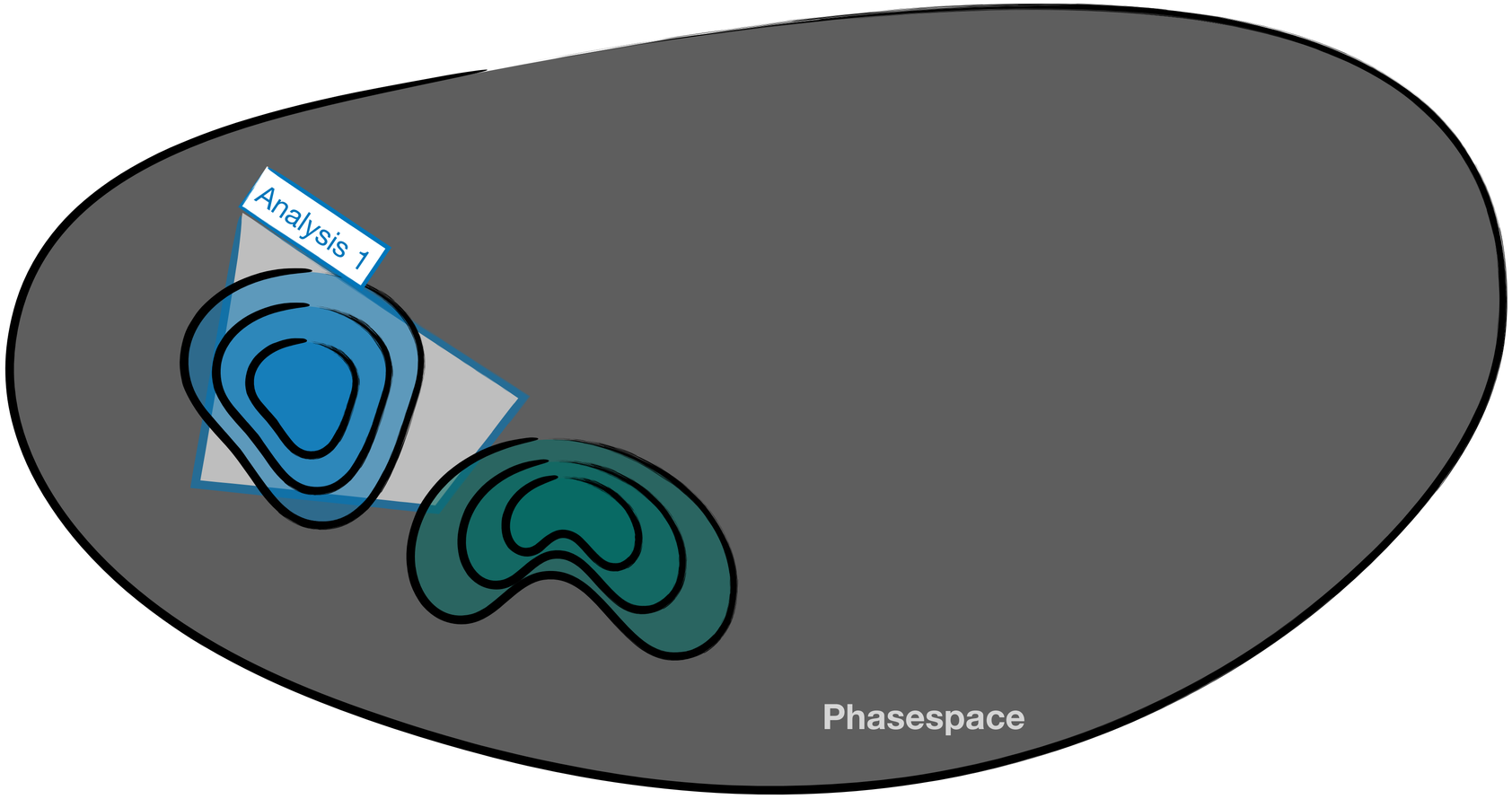

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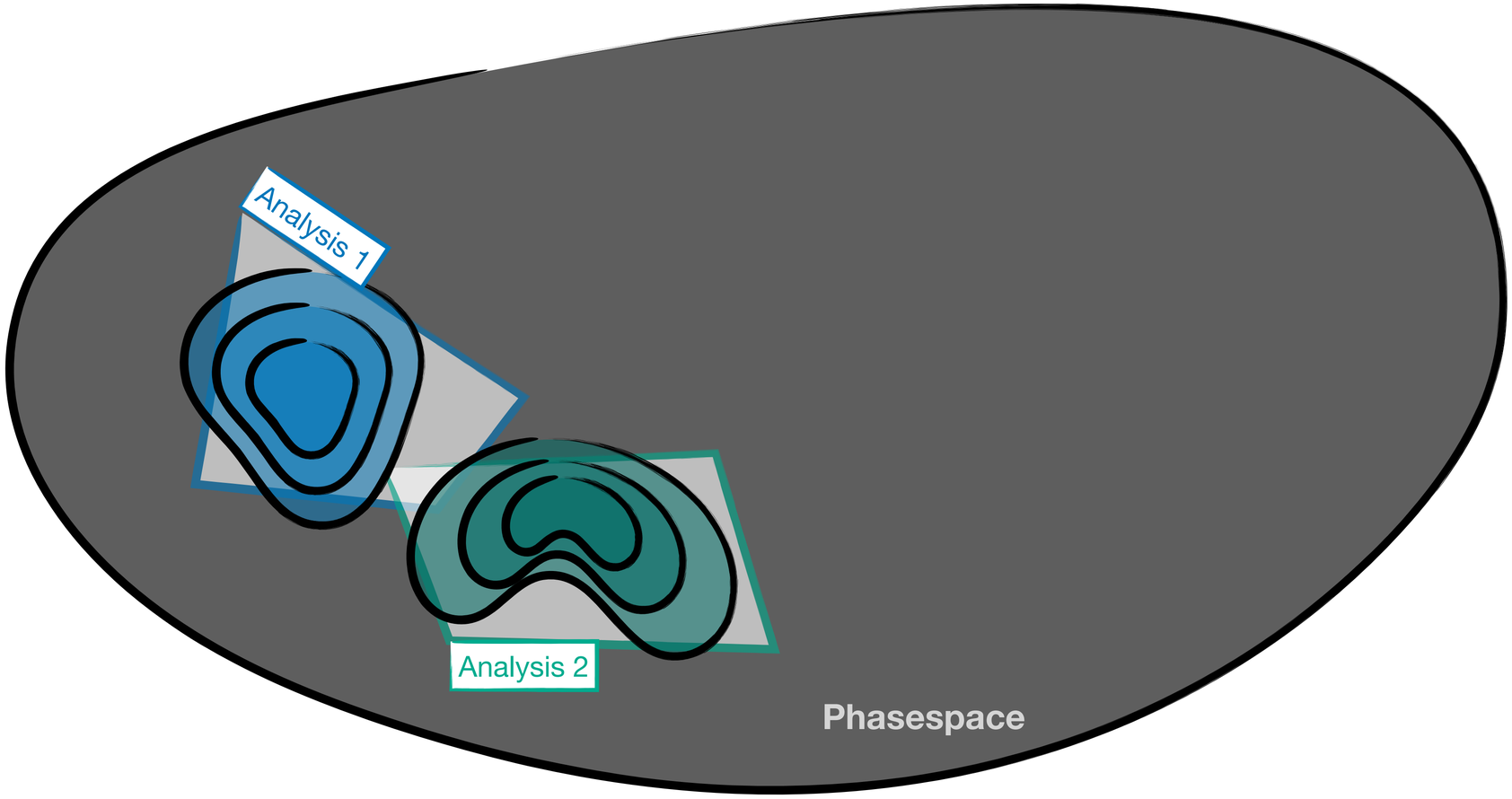

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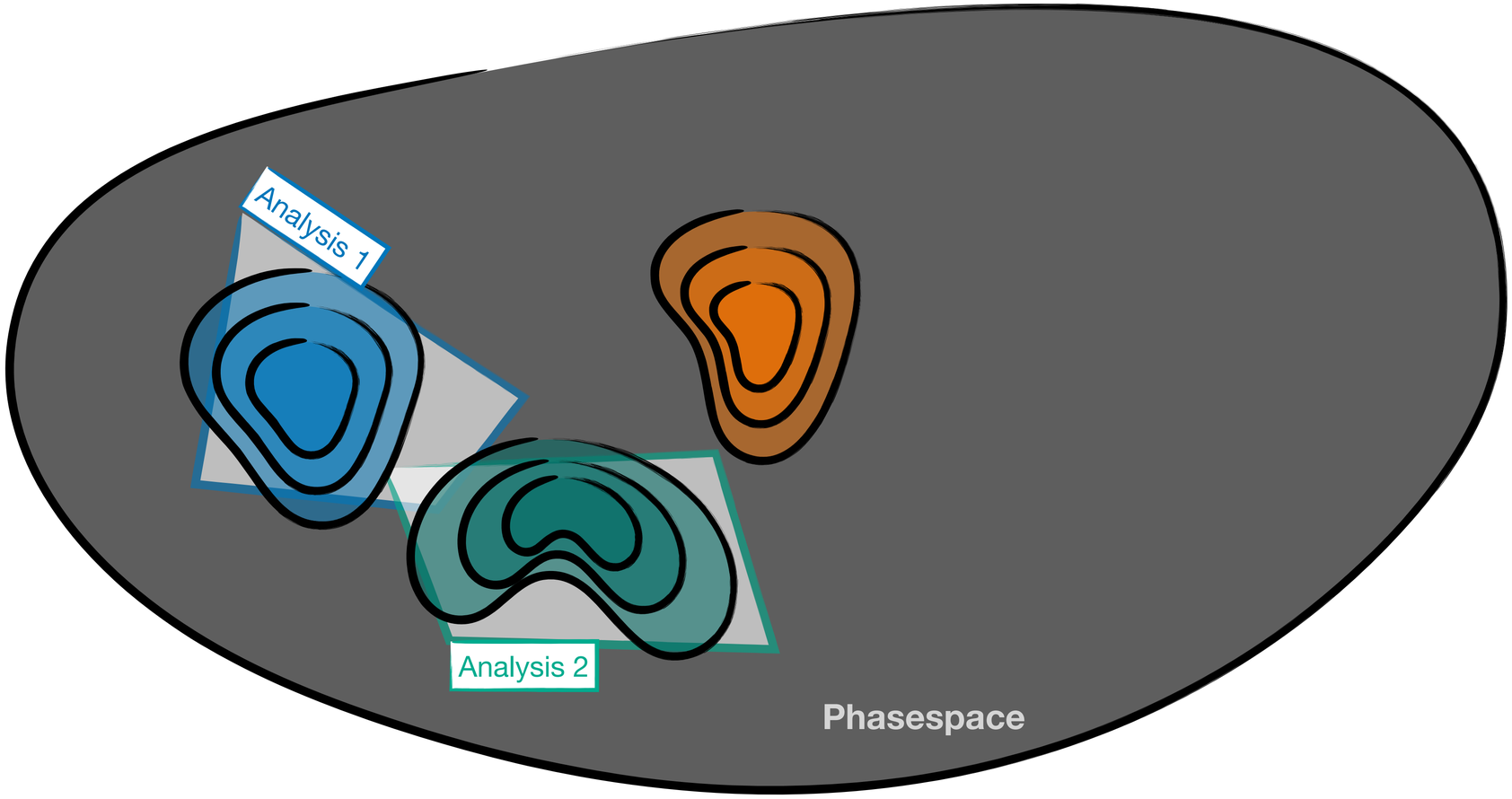

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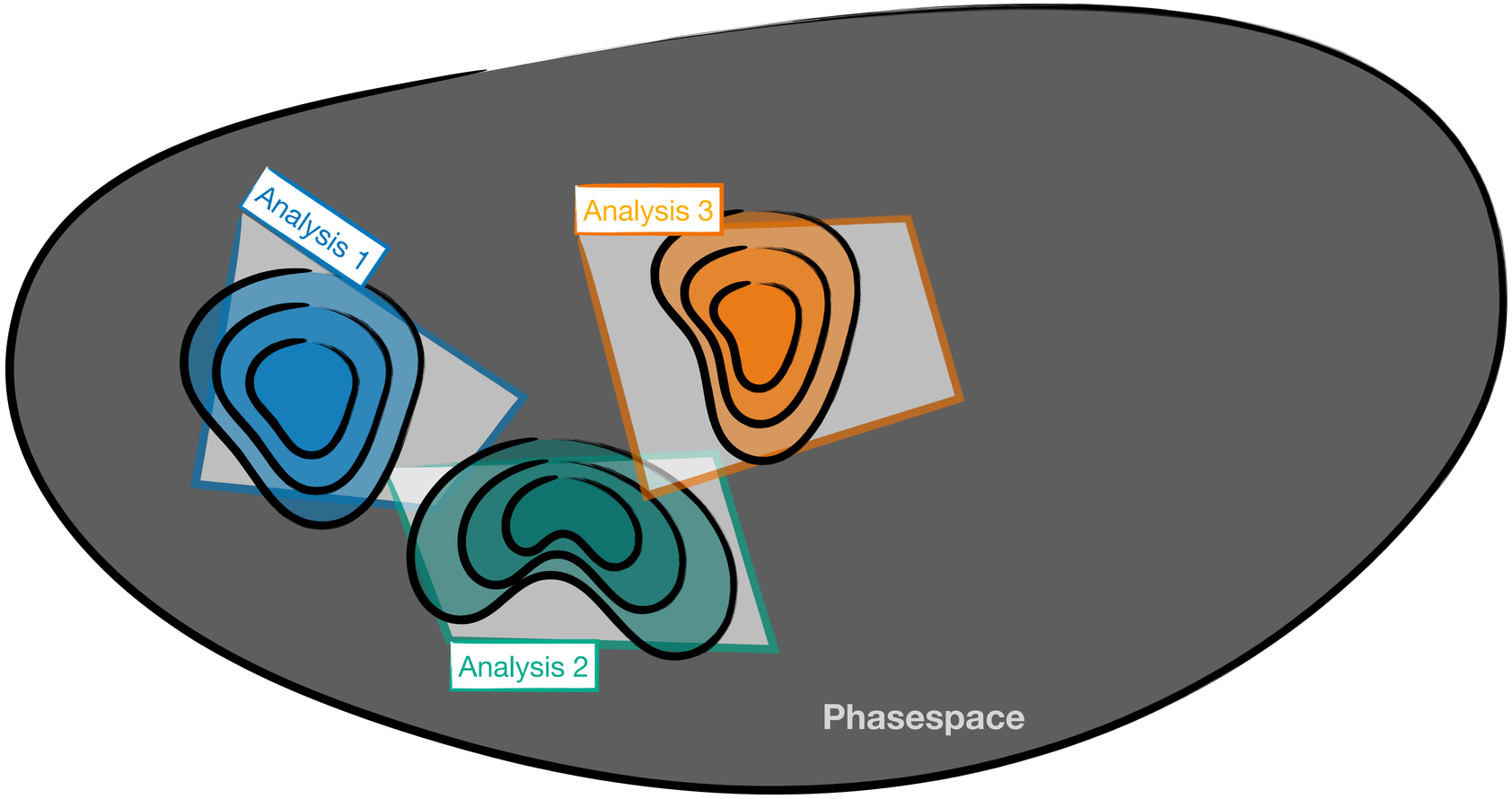

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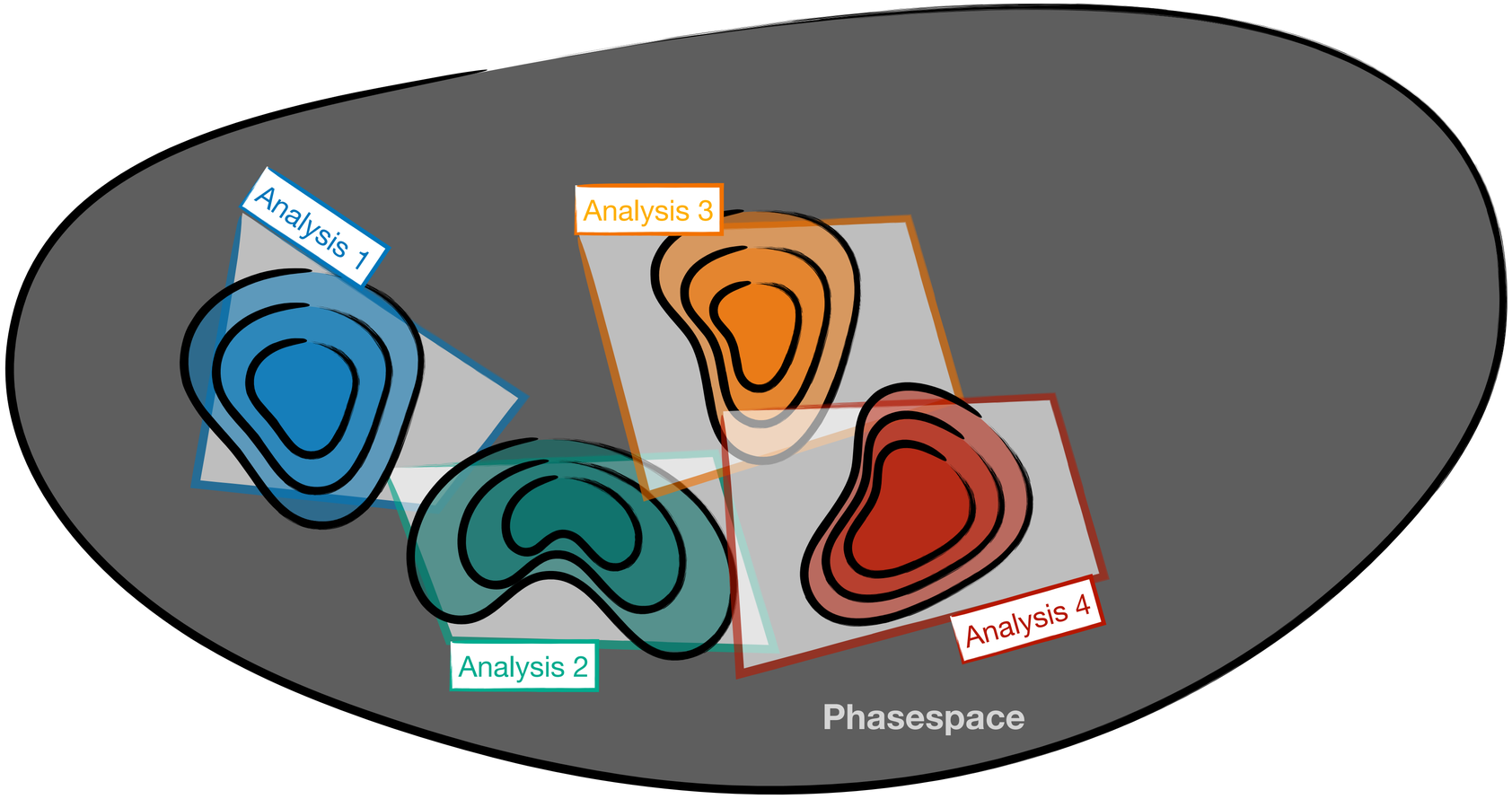
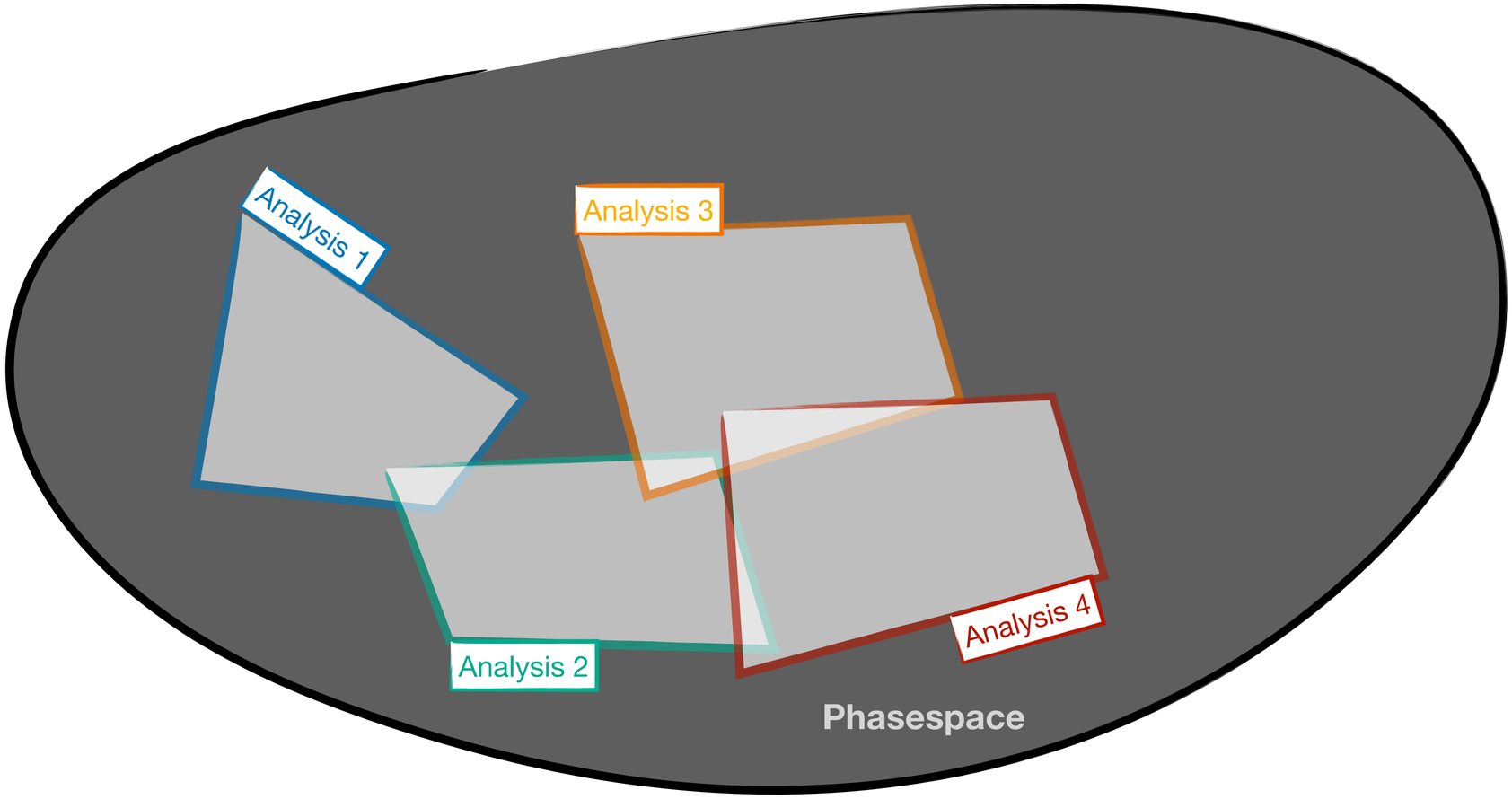


Simplified Models

In the end we have measured phasespace available for reinterpretation



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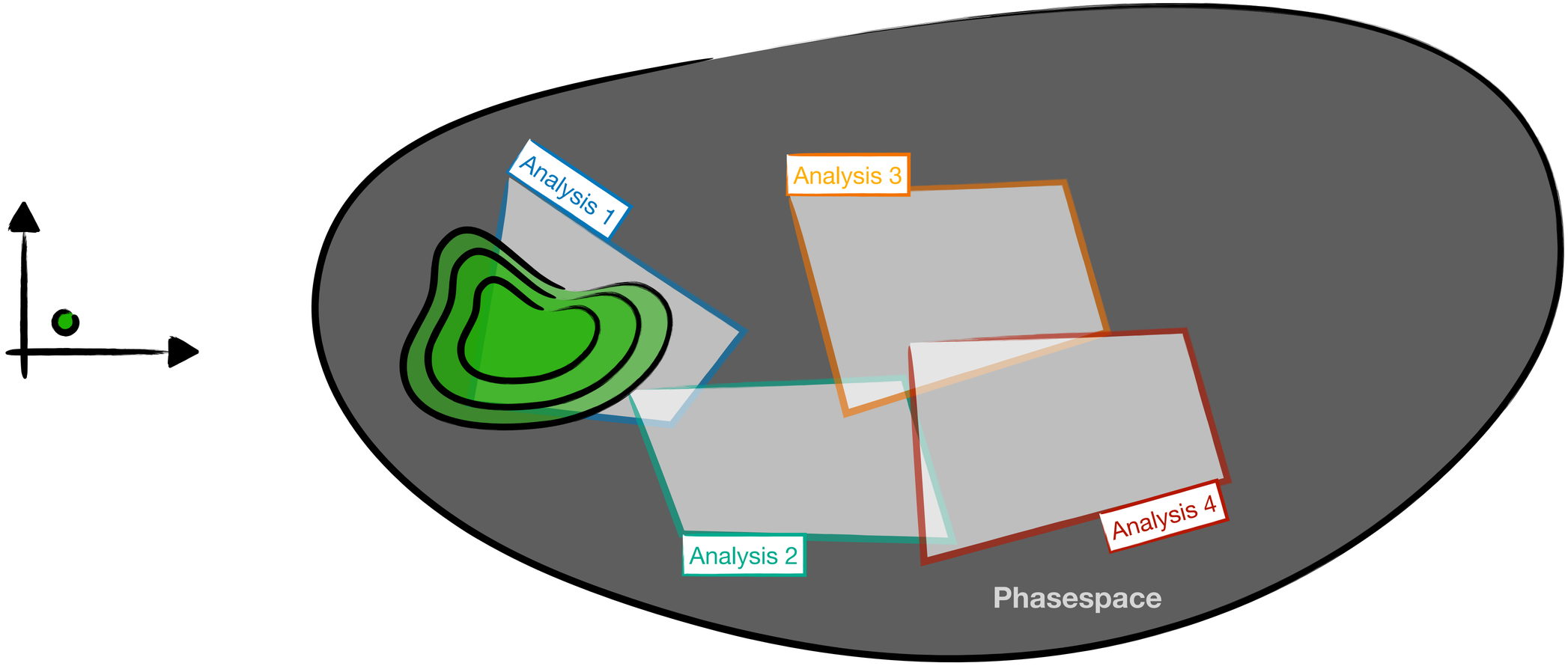

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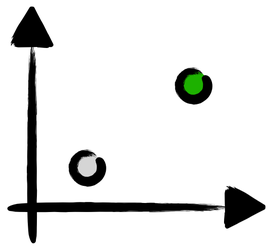
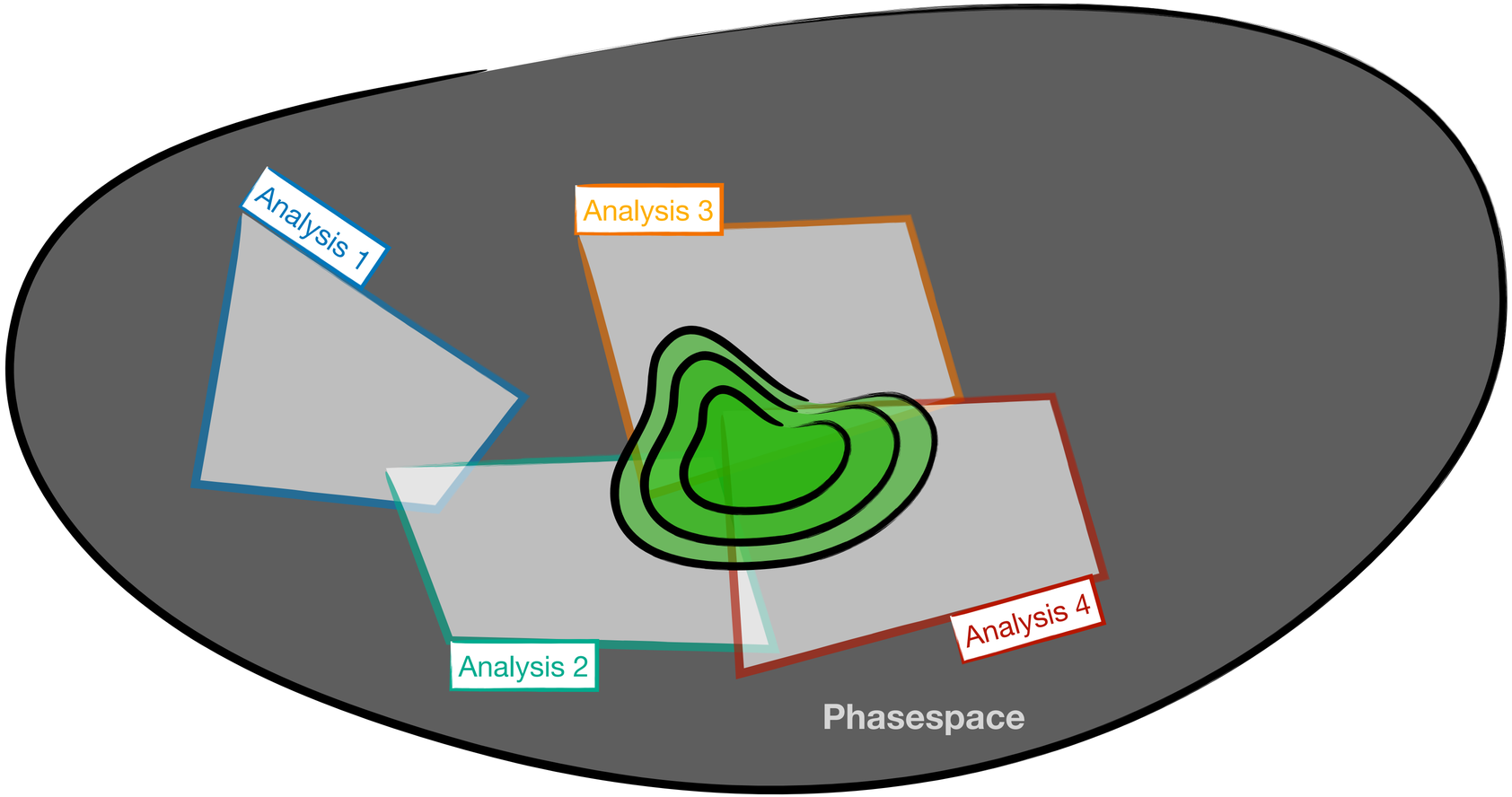


RECAST w/ **Analysis 1**

RECAST w/ **Analysis 3?**

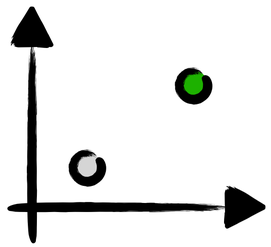
RECAST w/ **Analysis 4?**

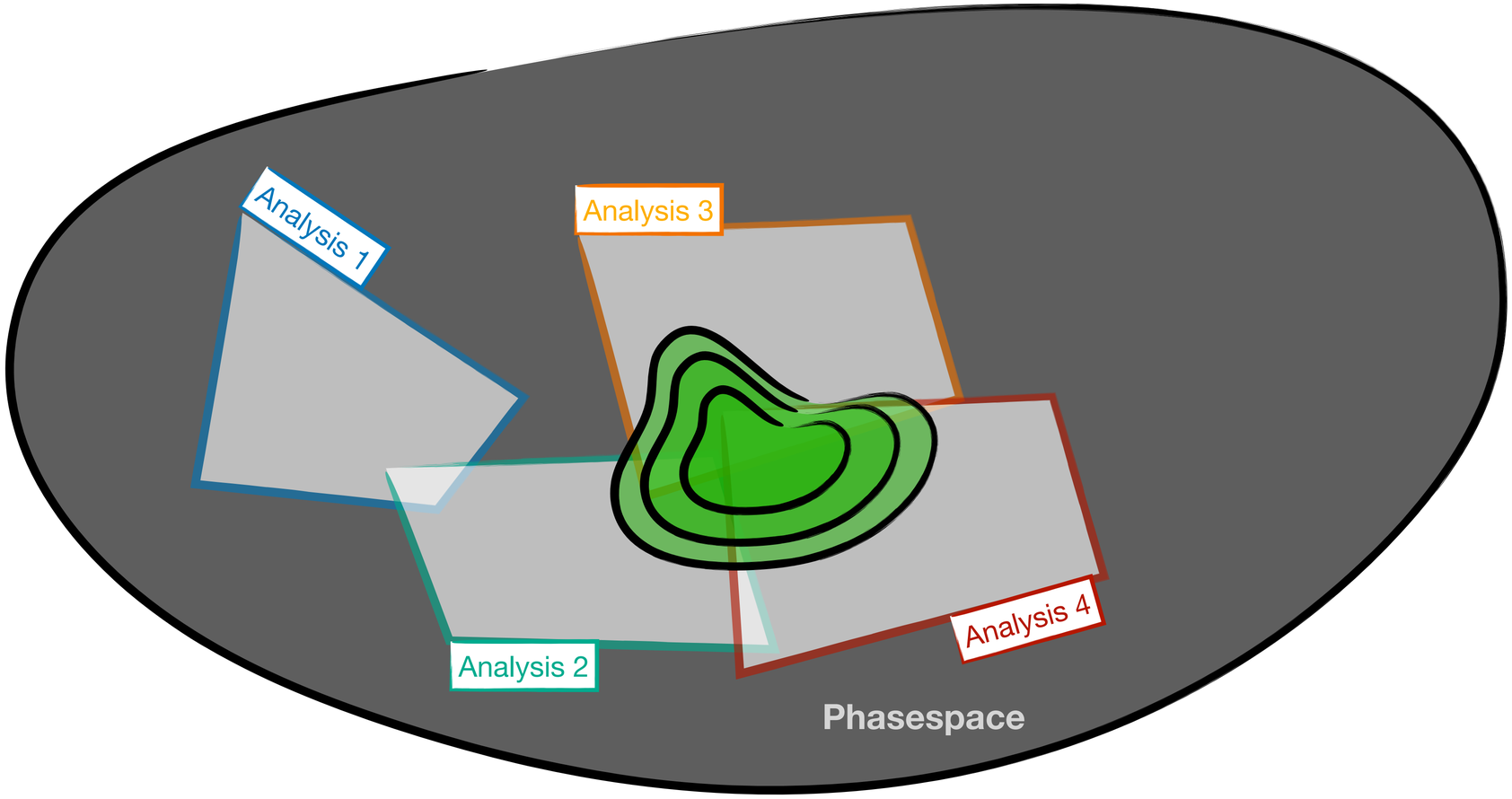
RECAST w/ **Analysis 2?**



Simplified Models

Ideally want to use all the measured phasespace, but **overlap does not allow** for statistical combination





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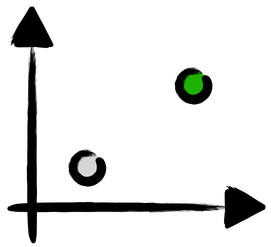
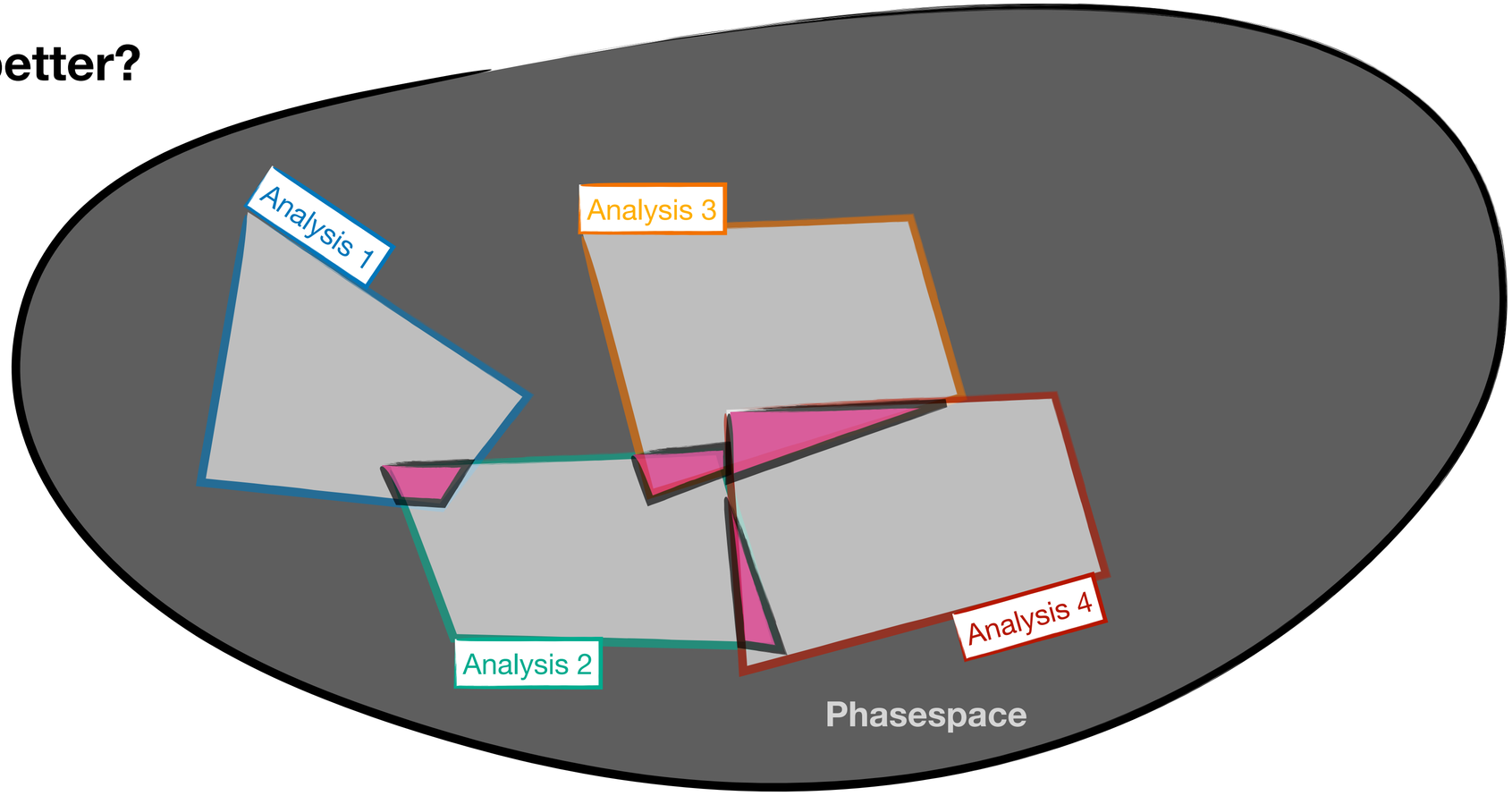
Could we do better?





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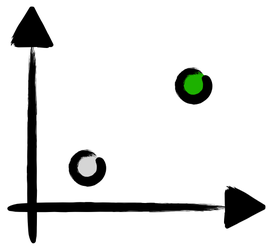
Option A: Deal with it

One option is to assume it's an unavoidable fact of life.. but figure out the best way to select signal regions



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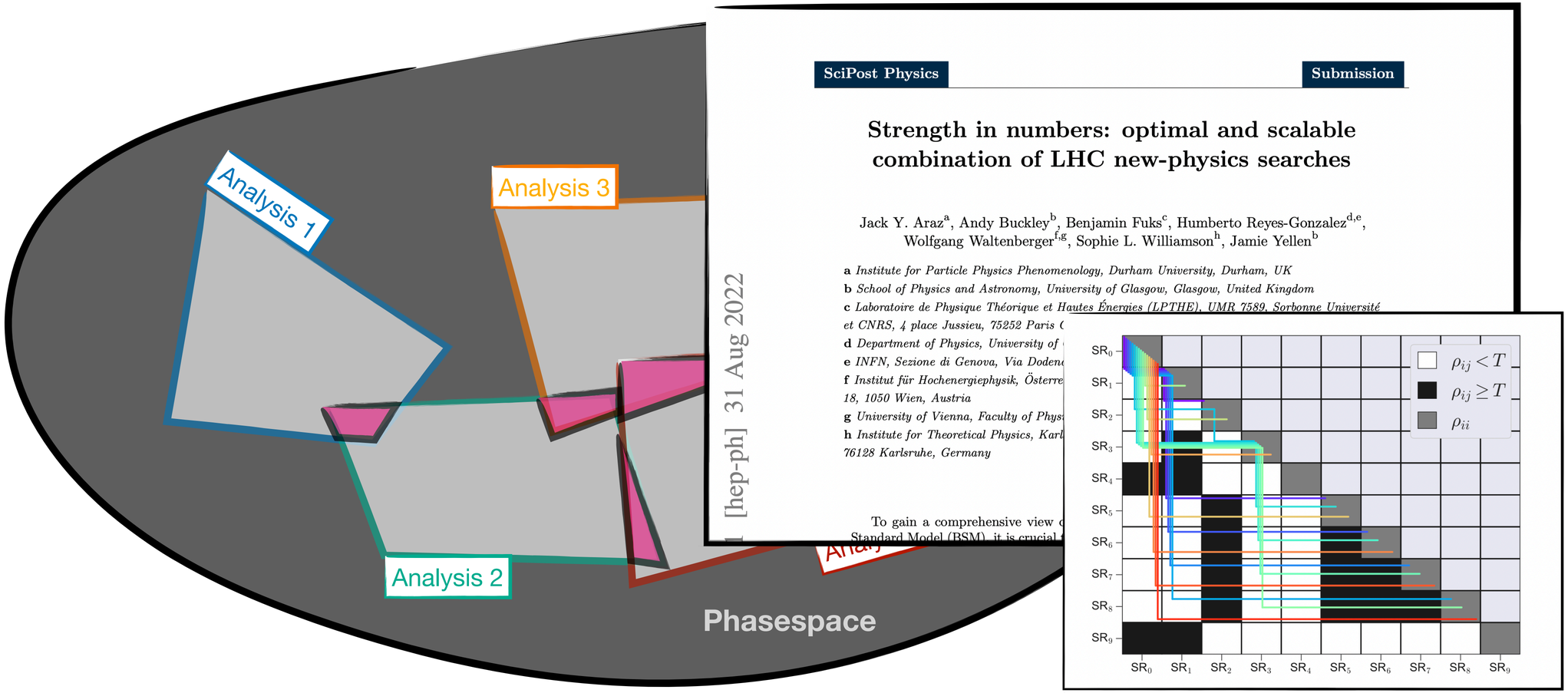

SciPost Physics Submission

Strength in numbers: optimal and scalable combination of LHC new-physics searches

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c Laboratoire de Physique Théorique et Hautes Énergies (LPTHE), UMR 7589, Sorbonne Université et CNRS, 4 place Jussieu, 75252 Paris
d Department of Physics, University of
e INFN, Sezione di Genova, Via Dodec
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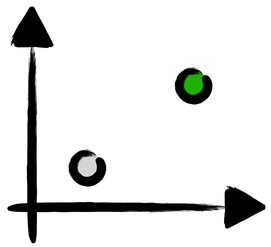
g University of Vienna, Faculty of Phys
h Institute for Theoretical Physics, Karl 76128 Karlsruhe, Germany

[hep-ph] 31 Aug 2022

To gain a comprehensive view
Standard Model (BSM), it is crucial

Option B: Smarter Design?

Another option: we do have agency. Could we not try to avoid overlaps?



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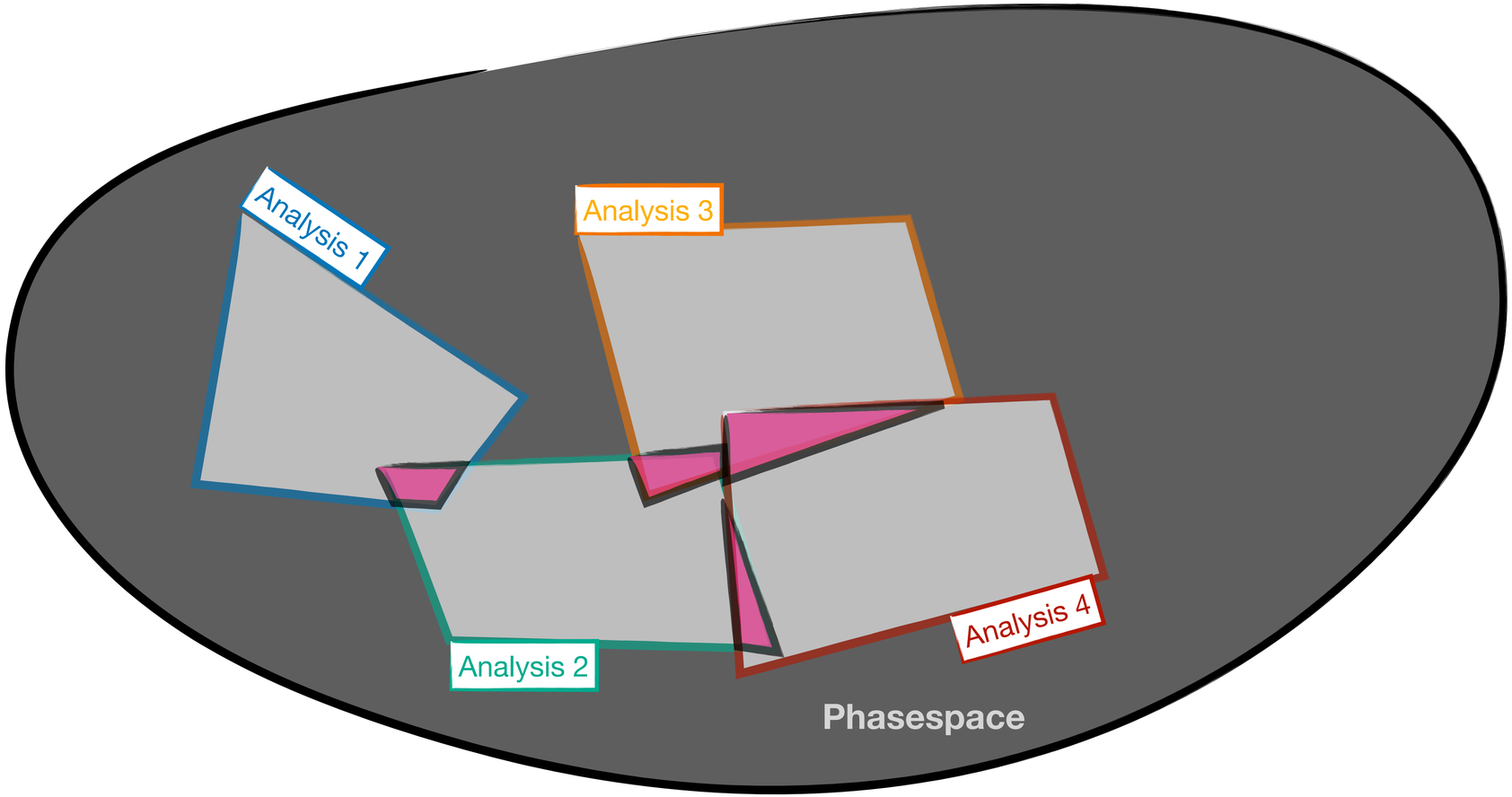
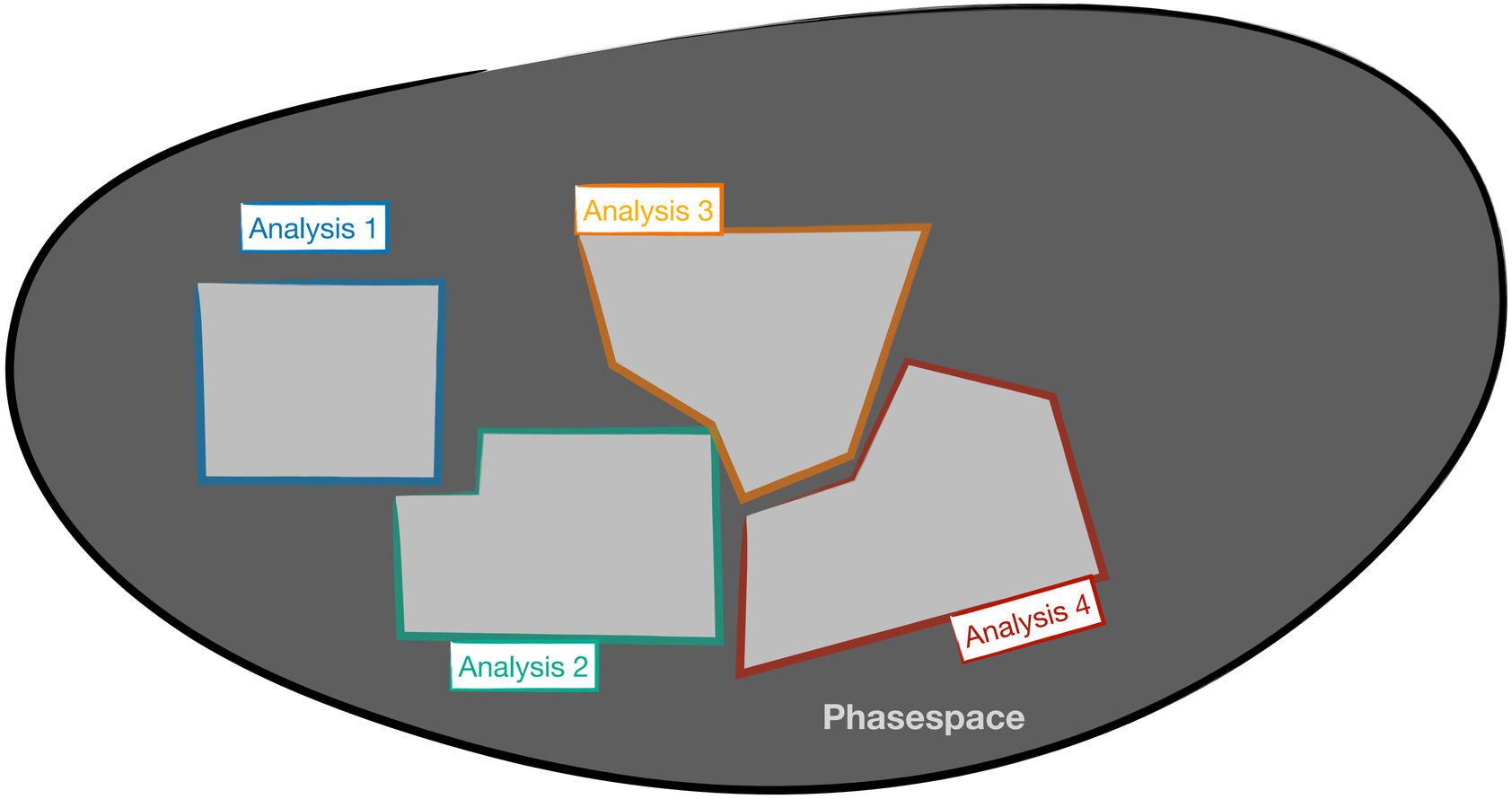


Simplified Models

Maybe it’s possible to tune analyses such that they don’t overlap and are designed from the start for combination



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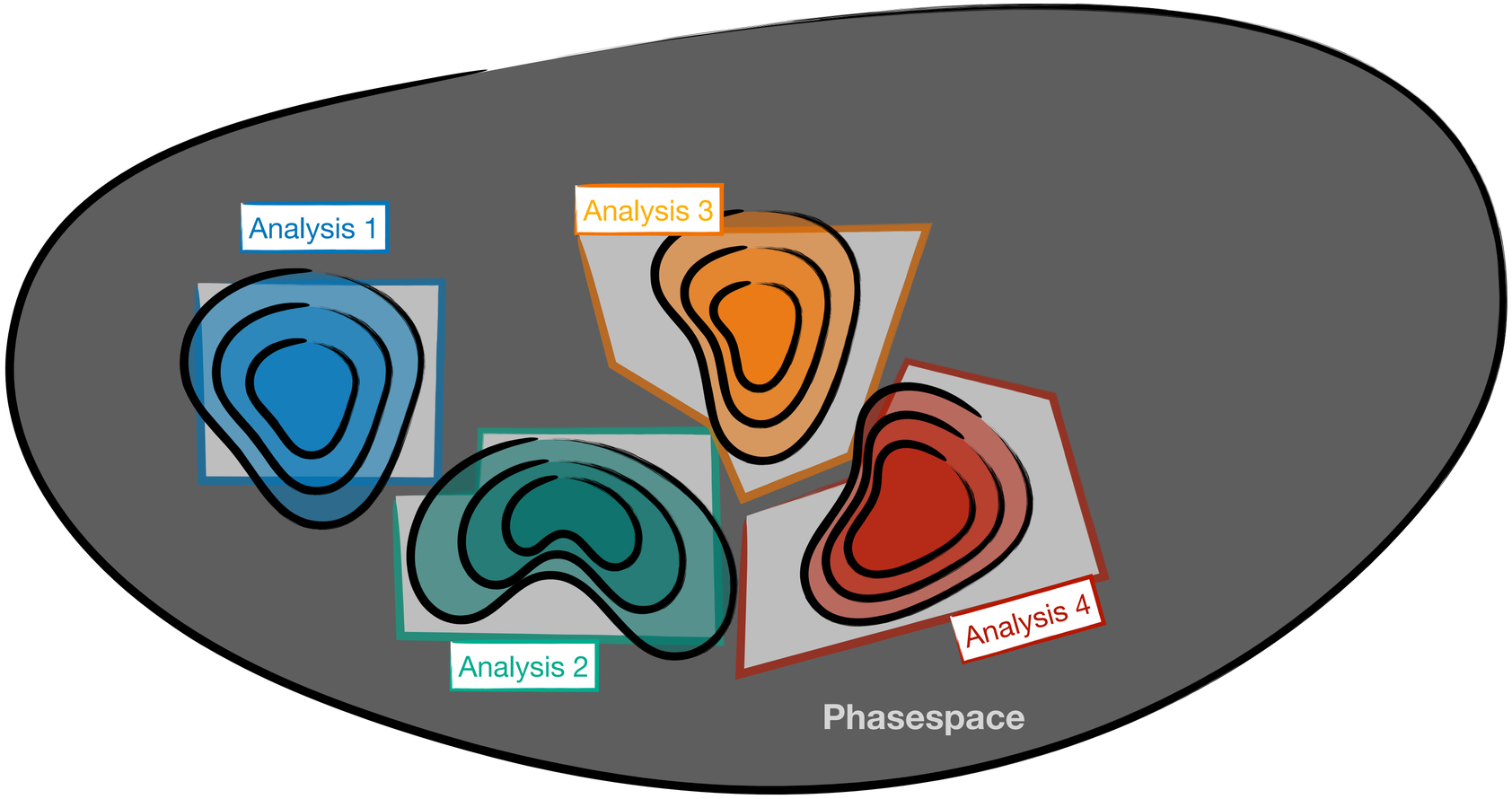

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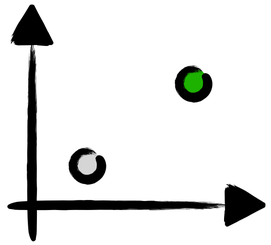
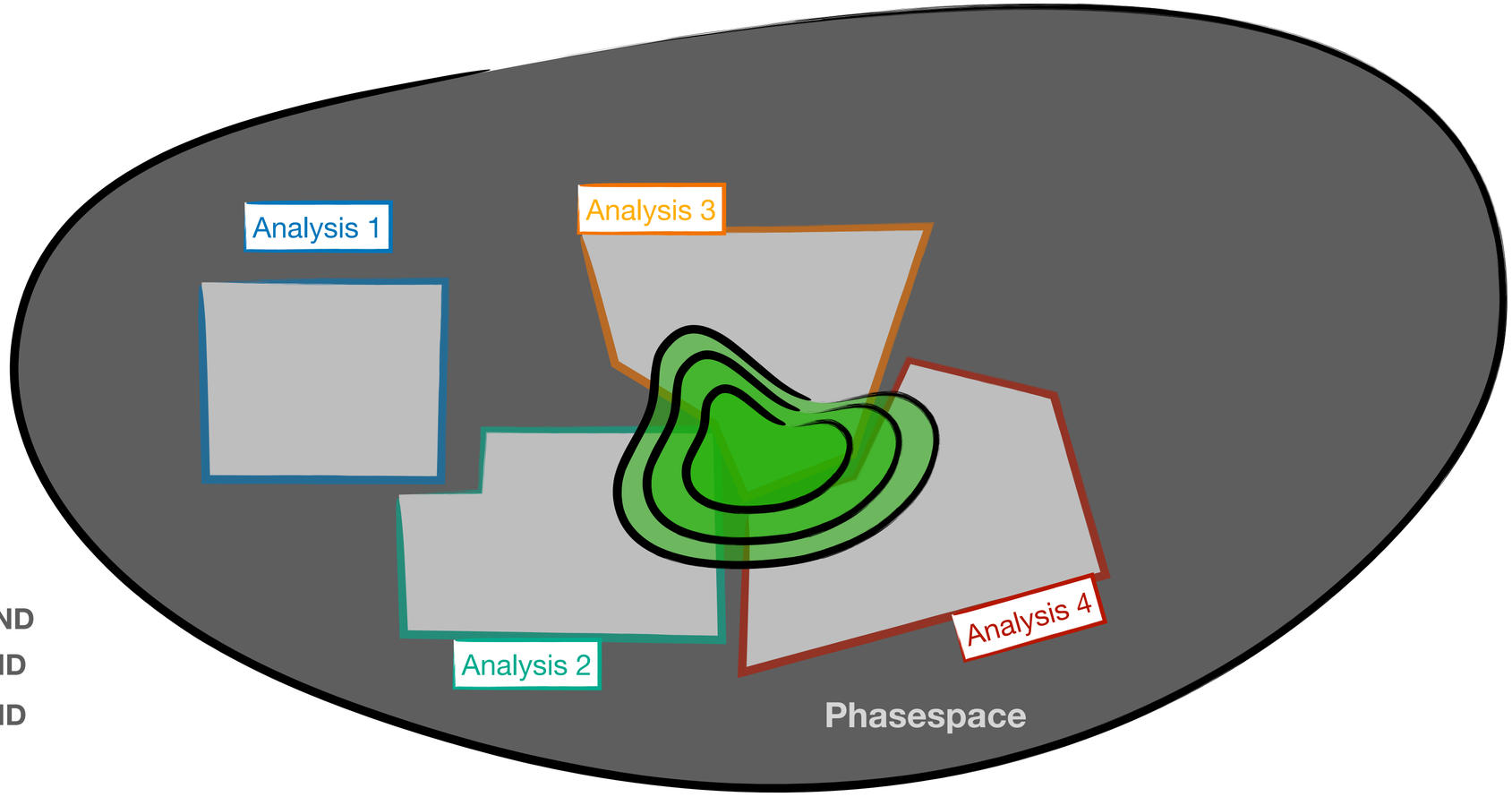




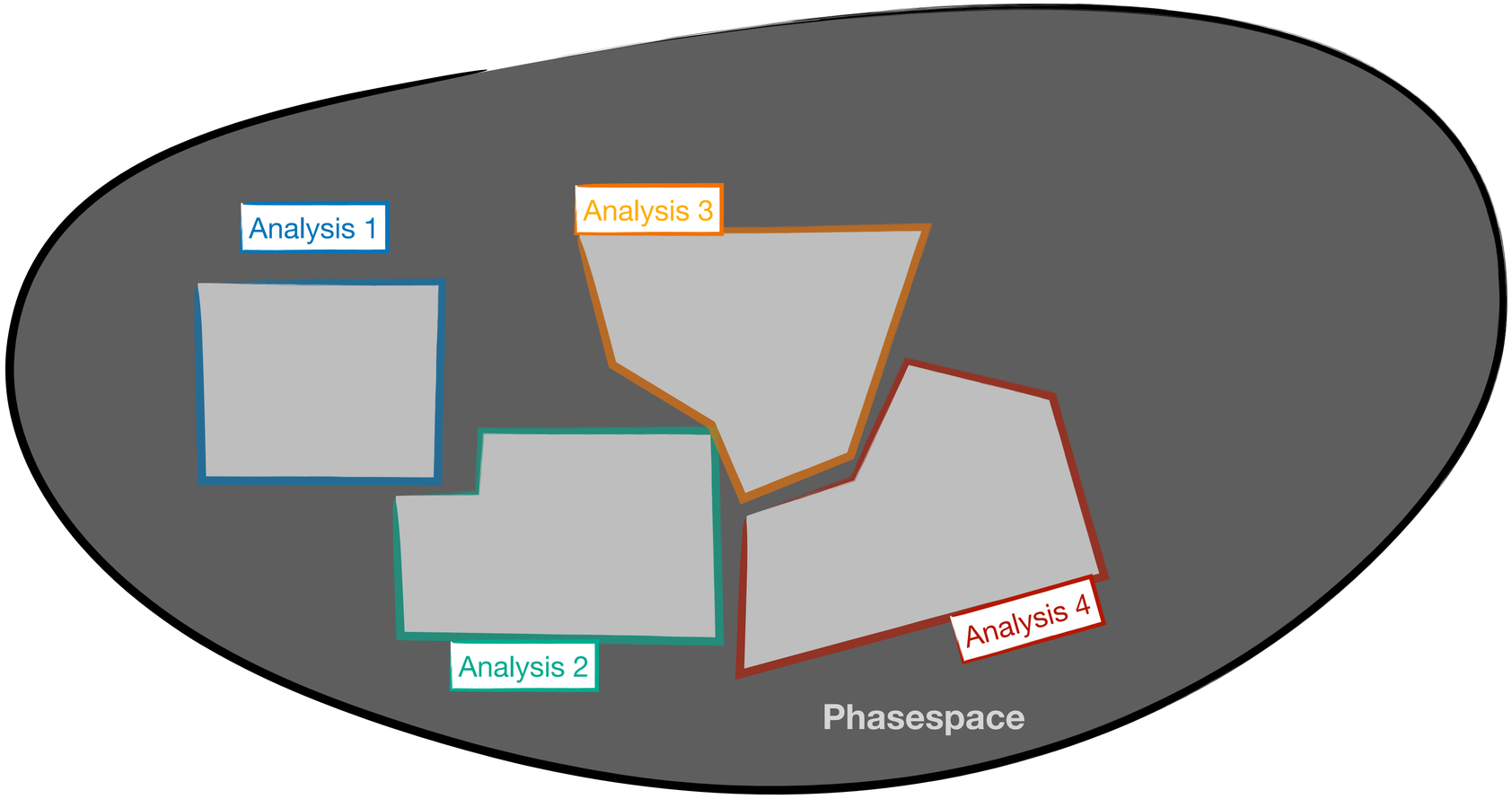
RECAST w/ Analysis 3? AND

RECAST w/ Analysis 4? AND

RECAST w/ Analysis 2? AND

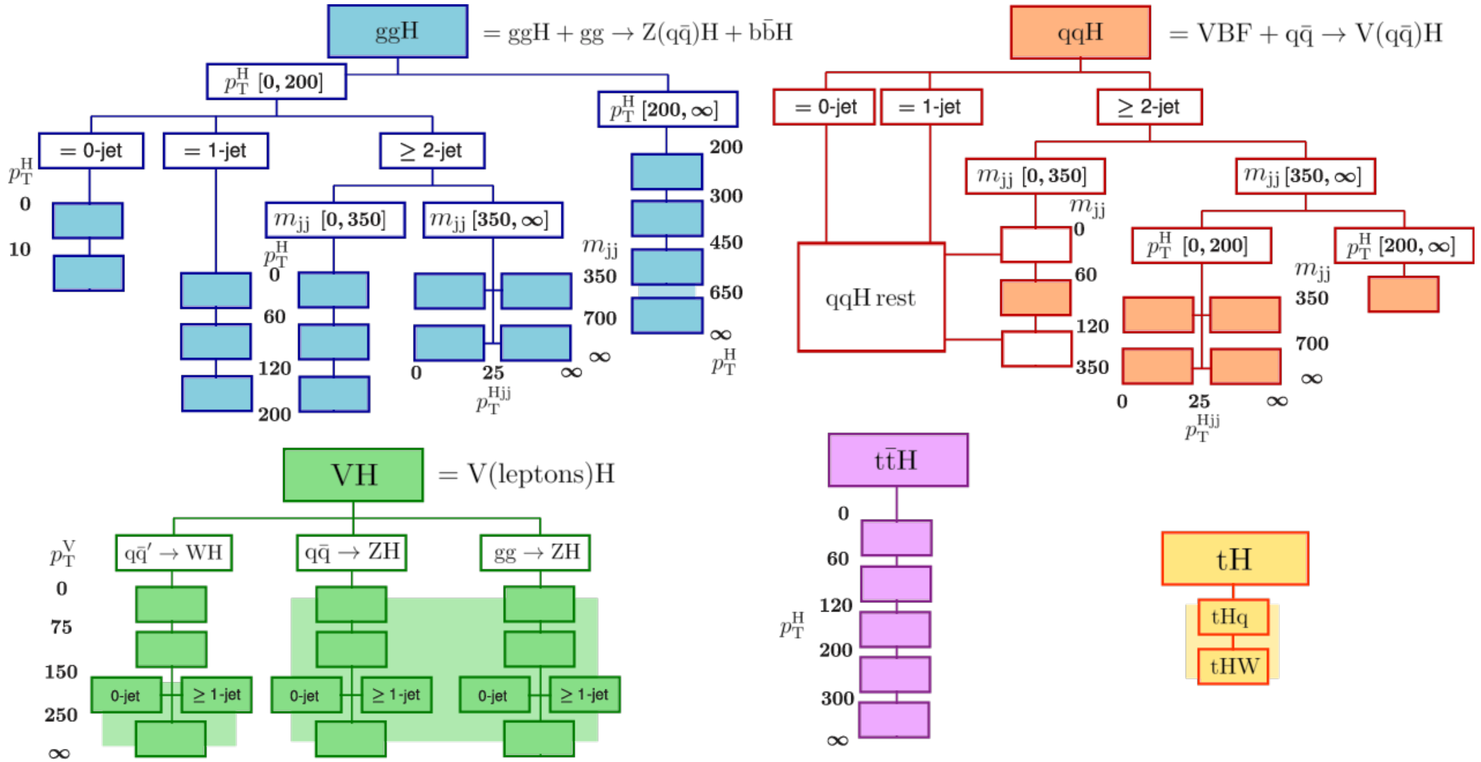
Simplified Models

This requires a higher degree of coordination between analyses. Won’t happen organically. **Could be done as part of the Reinterpretation Forum**

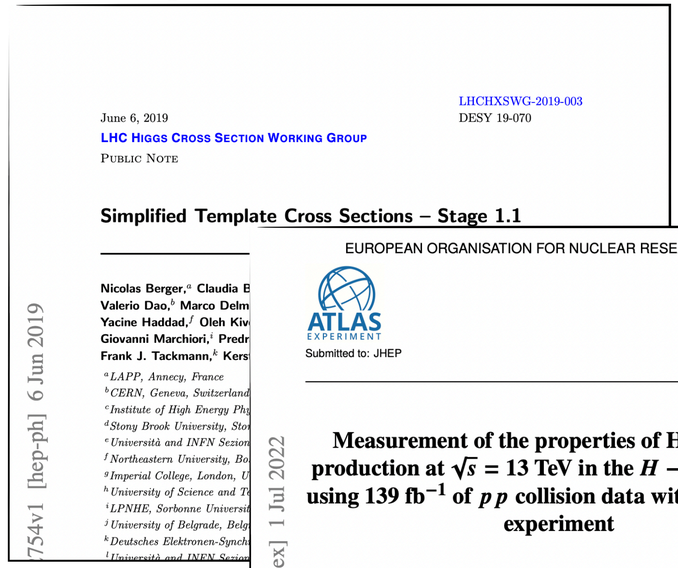


Prior Art from Higgs - STXS

These types of coordinated efforts are not unheard of. STXS is exactly this. Various takes on the exact definitions, but shows **community wide process**



Theory



June 6, 2019

LHCHXSWG-2019-003

DESY 19-070

LHC Higgs Cross Section Working Group

Public Note

Simplified Template Cross Sections – Stage 1.1

Nicolas Berger,[a] Claudia B
Valerio Dao,[b] Marco Delm
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Giovanni Marchiori,[i] Predr
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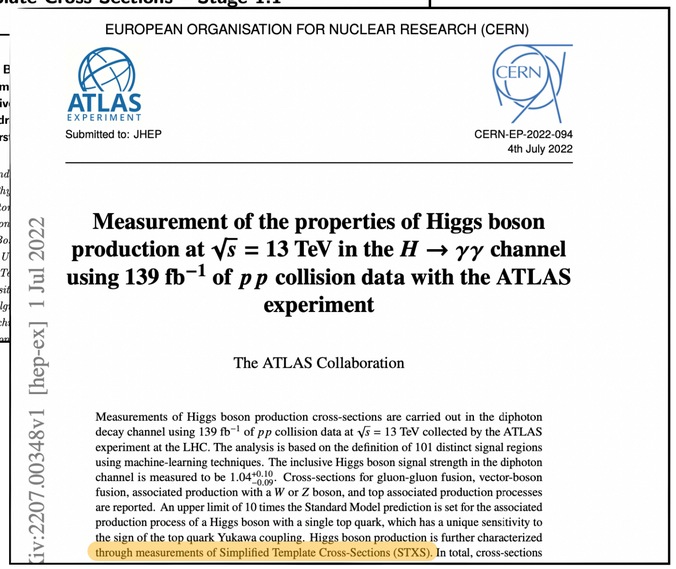
[f] *Northeastern University, Bo*
[g] *Imperial College, London, U*
[h] *University of Science and T*
[i] *LPNHE, Sorbonne Universit*
[j] *University of Belgrade, Belg*
[k] *Deutsches Elektronen-Synch*
[l] *Università and INFN Sezio*

754v1 [hep-ph] 6 Jun 2019

Experiment



EUROPEAN ORGANISATION FOR NUCLEAR RESEARCH (CERN)

ATLAS EXPERIMENT

Submitted to: JHEP

CERN-EP-2022-094

4th July 2022

Measurement of the properties of Higgs boson production at $\sqrt{s} = 13$ TeV in the $H \to \gamma\gamma$ channel using 139 fb^{-1} of pp collision data with the ATLAS experiment

The ATLAS Collaboration

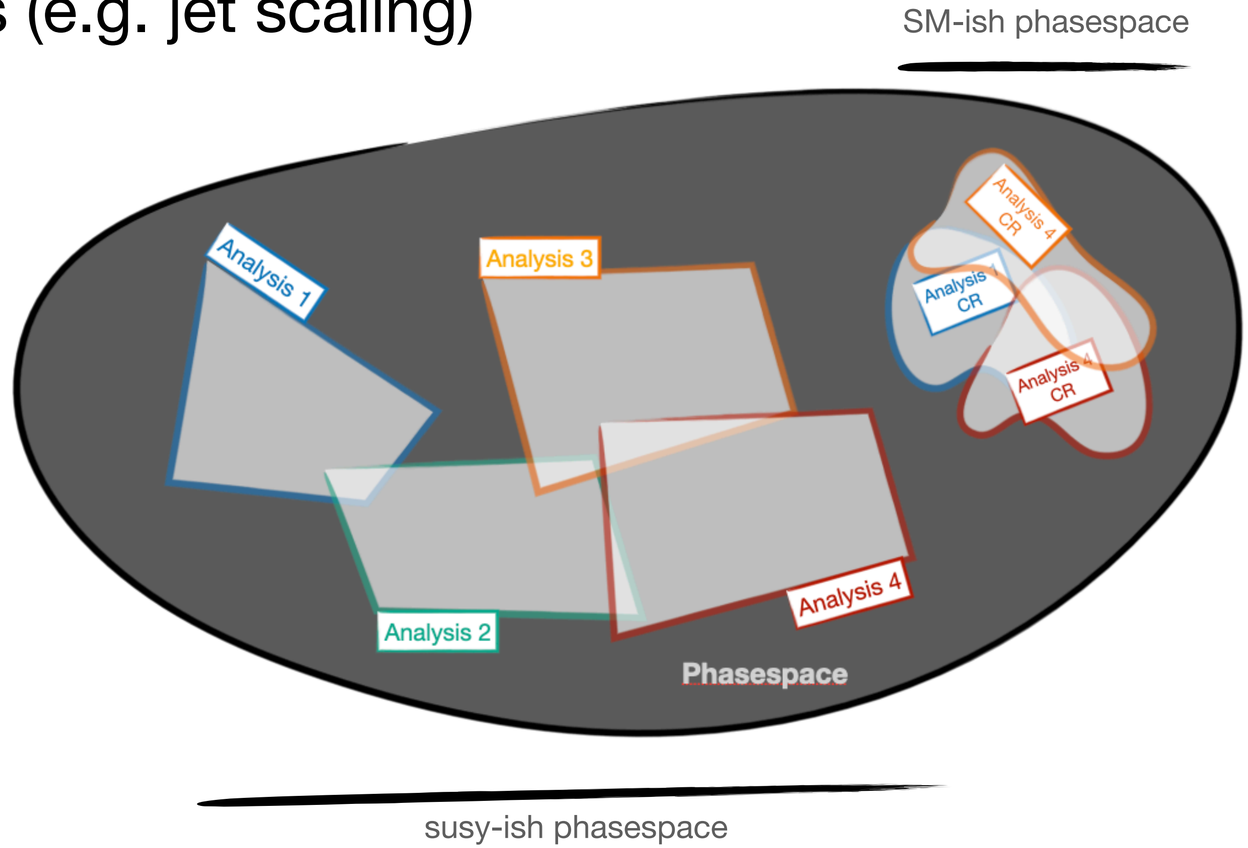
Measurements of Higgs boson production cross-sections are carried out in the diphoton decay channel using 139 fb^{-1} of pp collision data at $\sqrt{s} = 13$ TeV collected by the ATLAS experiment at the LHC. The analysis is based on the definition of 101 distinct signal regions using machine-learning techniques. The inclusive Higgs boson signal strength in the diphoton channel is measured to be $1.04^{+0.10}_{-0.09}$. Cross-sections for gluon-gluon fusion, vector-boson fusion, associated production with a W or Z boson, and top associated production processes are reported. An upper limit of 10 times the Standard Model prediction is set for the associated production process of a Higgs boson with a single top quark, which has a unique sensitivity to the sign of the top quark Yukawa coupling. Higgs boson production is further characterized through measurements of Simplified Template Cross-Sections (STXS). In total, cross-sections

iv:2207.00348v1 [hep-ex] 1 Jul 2022

CR overlap

CRs try to measure SM phasespace, overlap there is probably larger. Those CR might rely on certain “inclusiveness” to provide enough stats to have simpler marginal distributions (e.g. jet scaling)

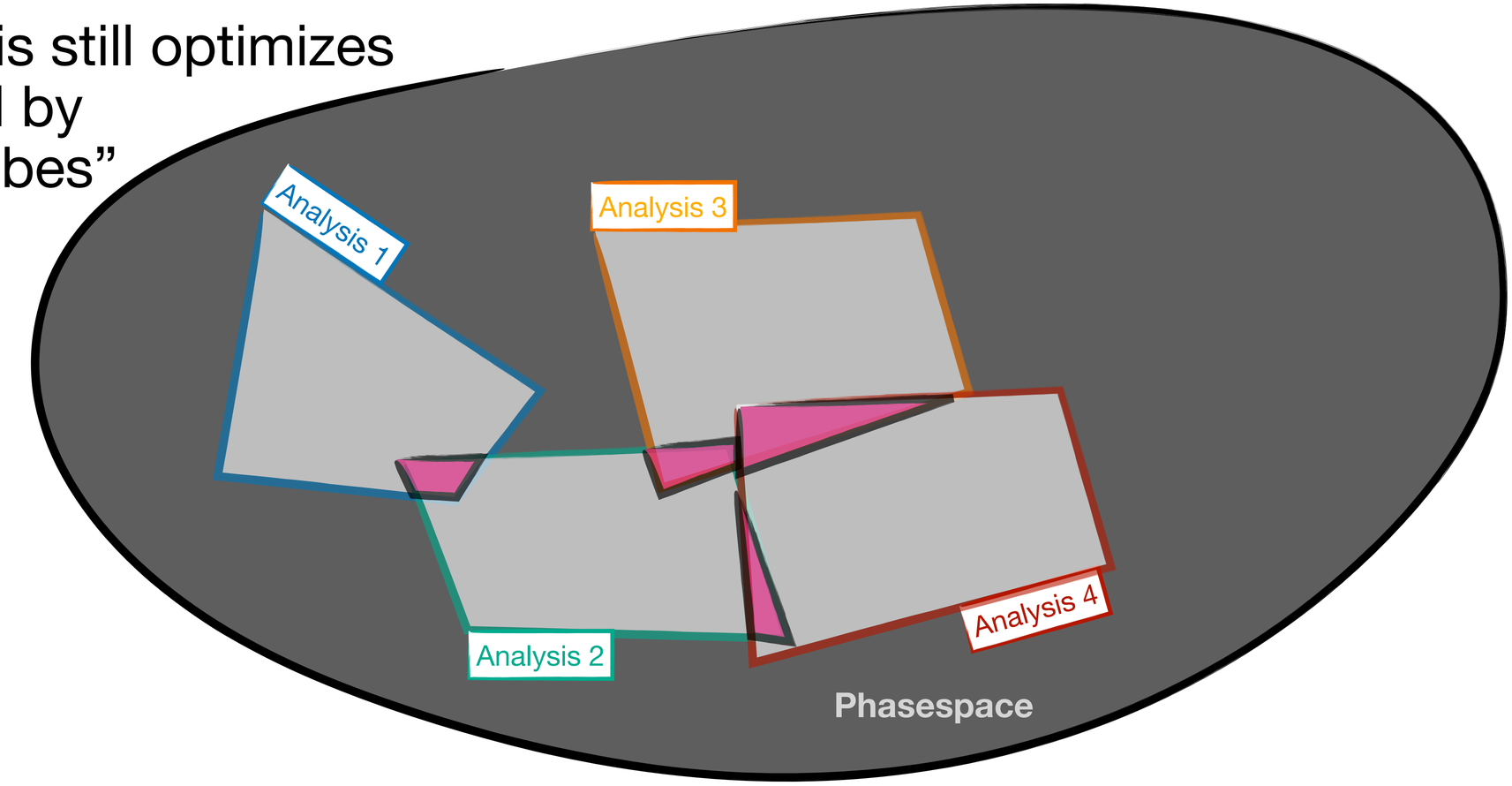
Difficult problem.



Phasespace-“data cubes”

At a coarse level, coordinate which cuts are admissable to slice up PS in cube
internally in a cube could still do neural nets, etc

Each analysis still optimizes
for its model by
“ordering cubes”



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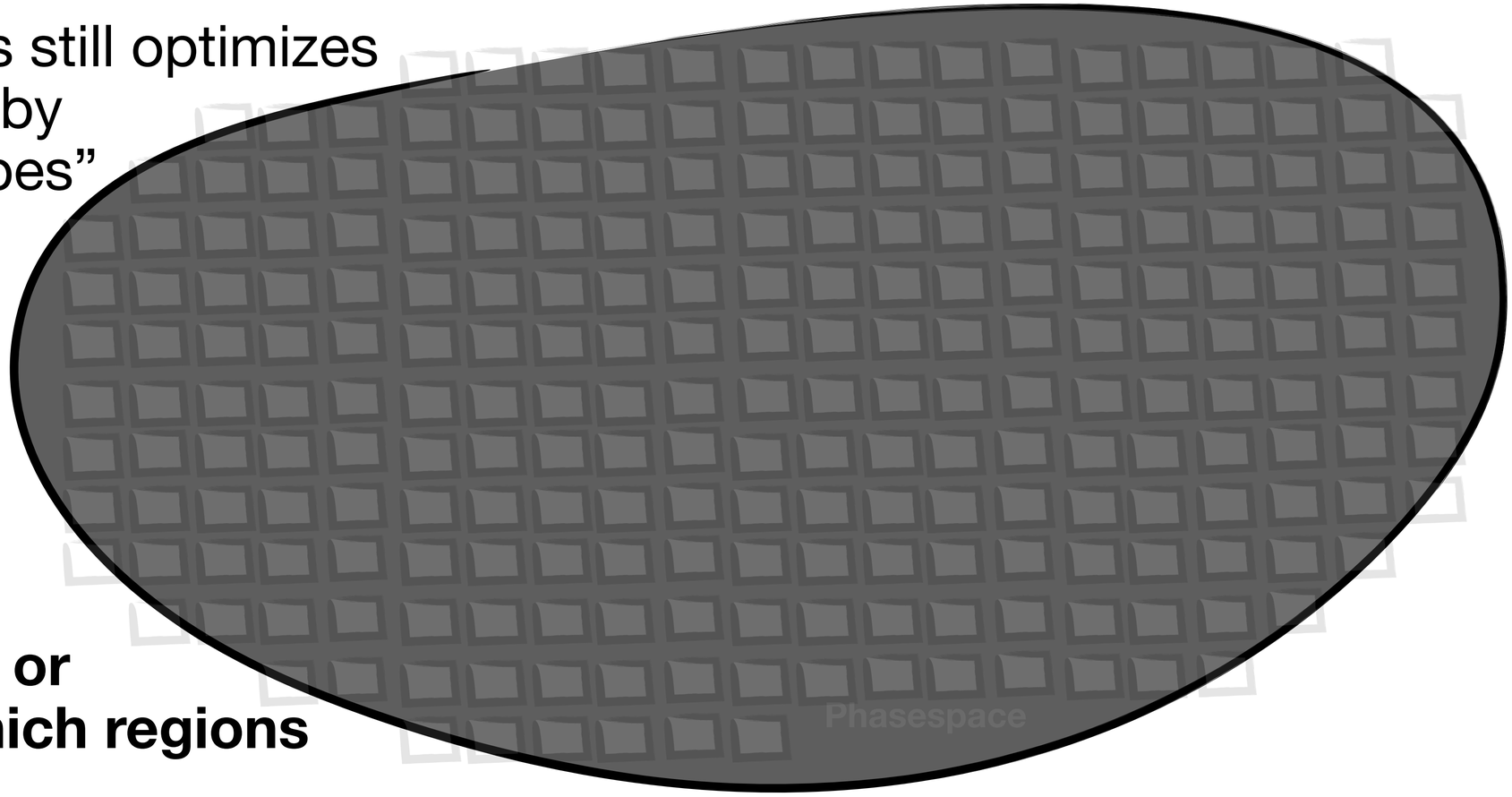

but combo
later on
might be
easier

**no guessing or
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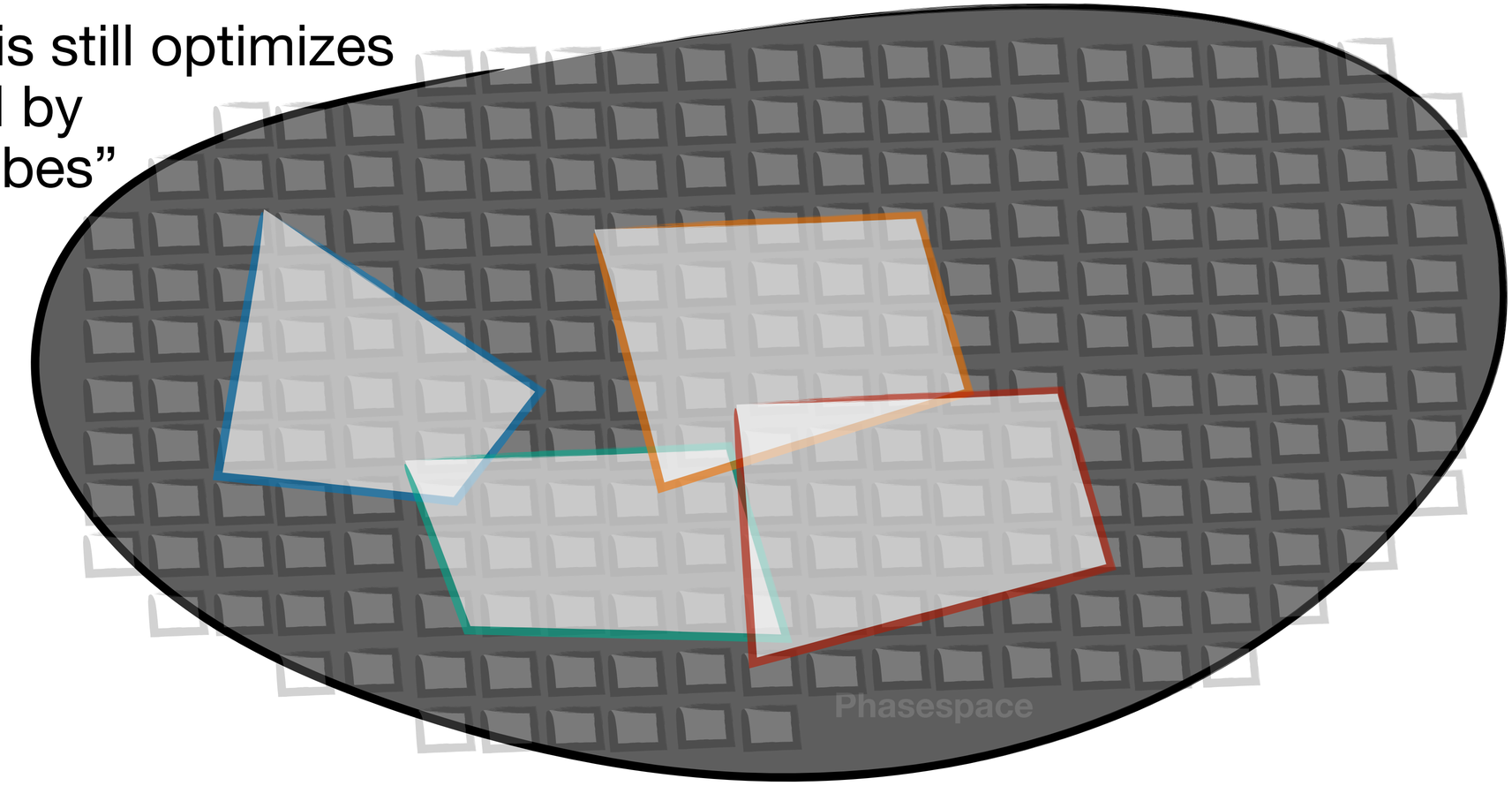

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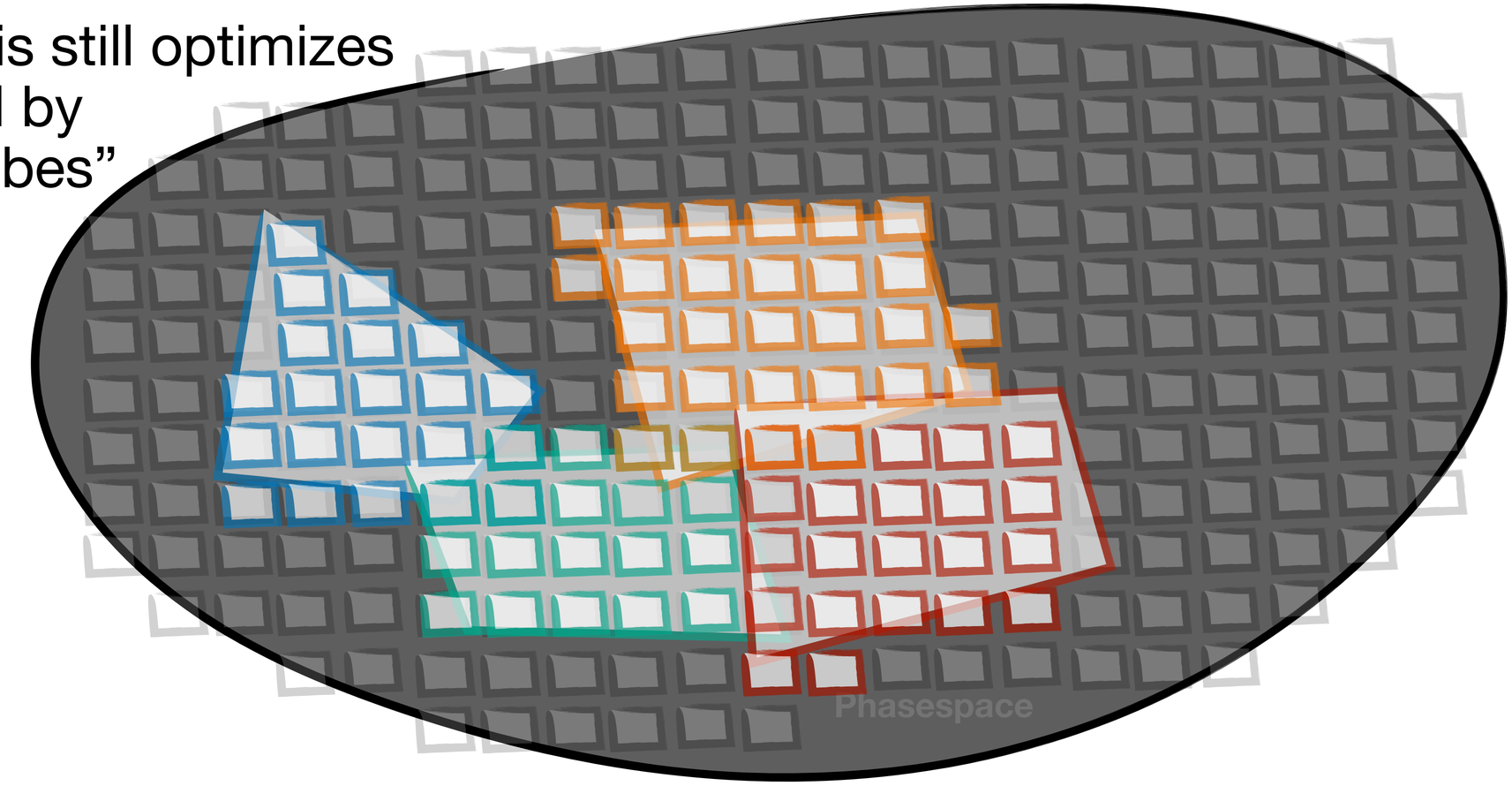

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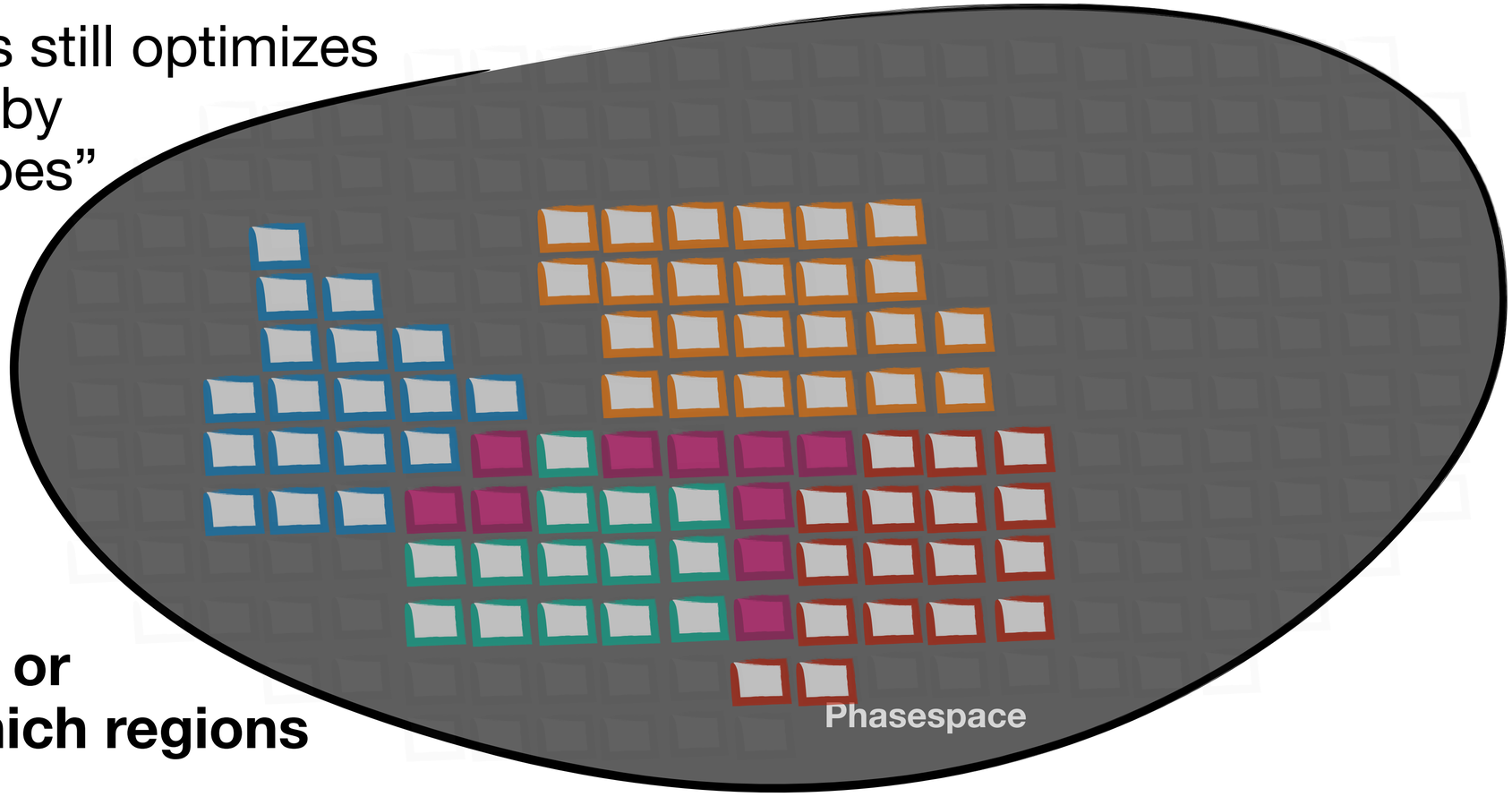

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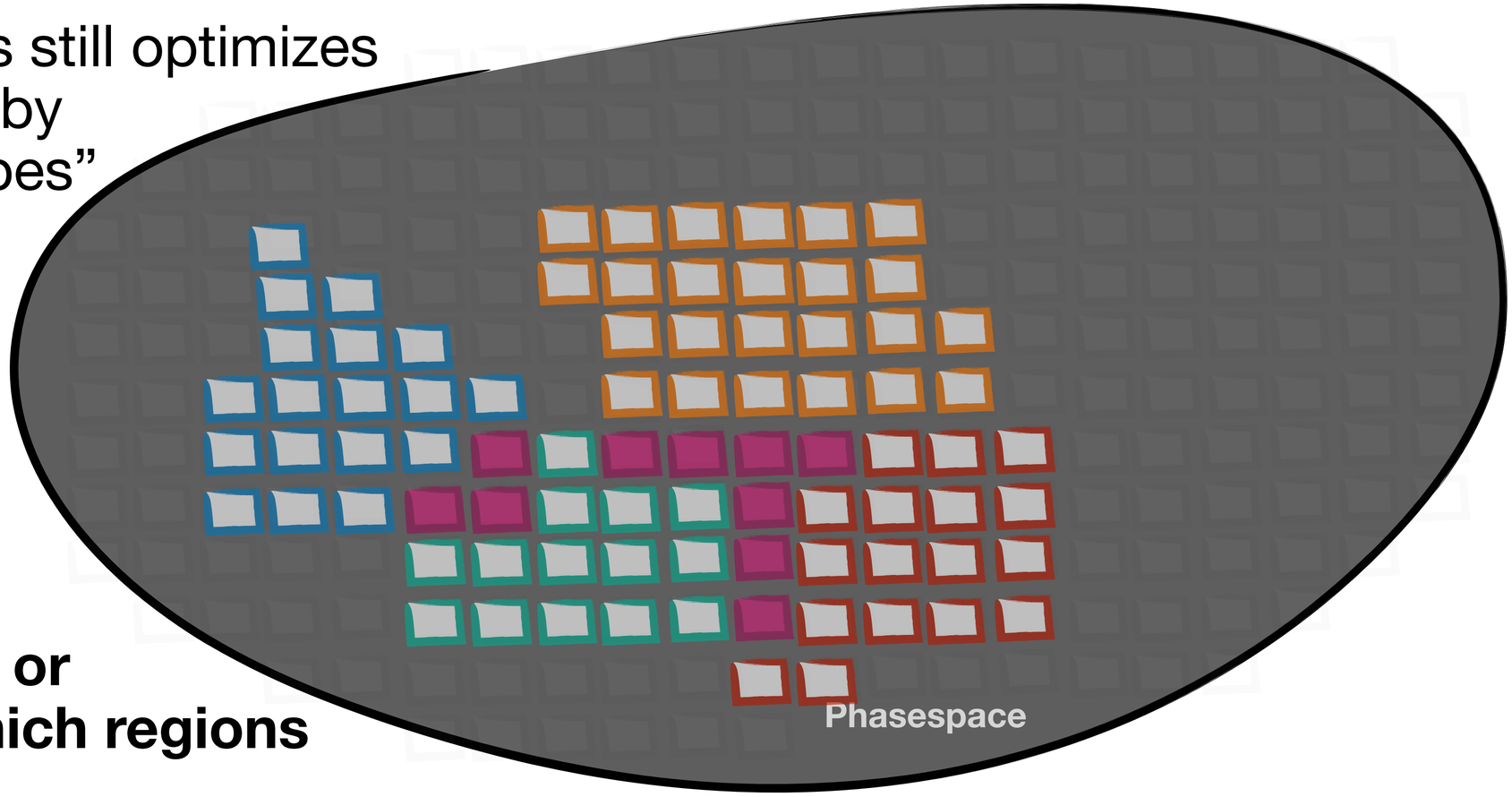

Thoughts?

Could we coordinate SUSY Pheno community to produce something akin to STXS that's mapszout a "wishlist of phasespaces" to be measured?

Reinterpretation Forum seems like the optimal vehicle to drive such a community process

Phrased in a different way:

Assume ATLAS had capacity for N recastable analyses (N = 50) to do in Run-X of the LHC. what would be the optimal subset of phasespace one should measure