# Improving Background Estimation for Di-Higgs Searches with ATLAS

PHYS 437B Presentations

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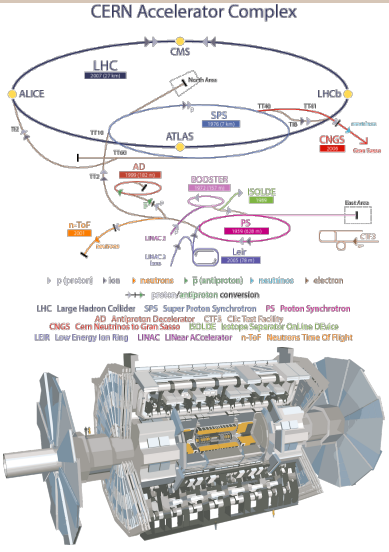
# Overview: Higgs Research





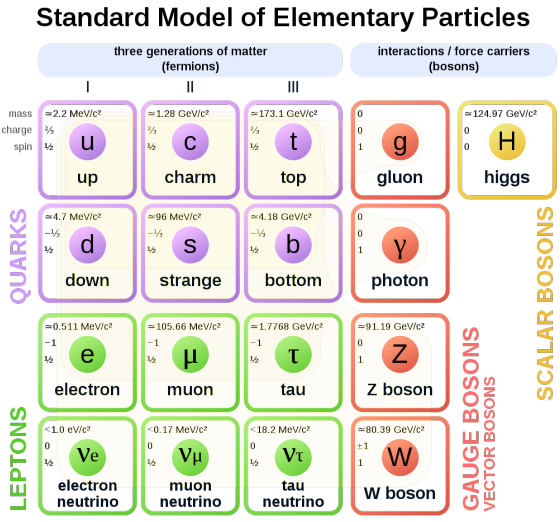



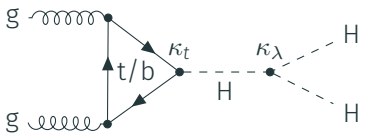

Image sources: Accelerator Complex, ATLAS, Standard Model

# The Big Picture – Measuring the Higgs Self-Coupling

Relevant section of the SM Lagrangian for Higgs potential:

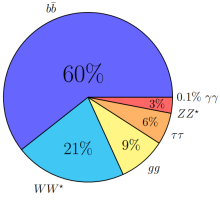
$$V(\phi) = -\mu^2\phi^2 + \lambda\phi^4 + \ldots \text{ Taylor exp. at min } \rightarrow V_T(\phi) = -\frac{\mu^4}{4\lambda} + \frac{\sqrt{2}\mu^3}{\lambda}\phi - 4\mu^2\phi^2 + 2\sqrt{2\lambda}\mu\phi^3 + \ldots$$

Constant and $\phi$ terms: can eliminate with change of coordinates, $\phi^2$: mass term,
$\phi^3$: self-interaction or self-coupling term, not well constrained
(current best: $\kappa_\lambda = (2\sqrt{2\lambda}\mu)/(2\sqrt{2\lambda}\mu)_{\text{SM}}$, $\kappa_\lambda \in [-2.3, 10.3]$ at 95% confidence)




To find $\kappa_\lambda$ we need *HH* events, and we can find them using jets!

# Jets and Pairing




$$H \to 60\% b\bar{b} \to 2 \times b \text{ hadrons} \to 2 \times b\text{-jets}$$

- Jets are collections of particles with appx. the same direction
- ATLAS can't directly detect $H$ or $b$. Instead, use $b$-jets, which can be directly detected (using secondary vertices)
- $b$-jet detection is not a perfect process (hence 437A report), and neither is pairing – choosing which jets came from which $H$

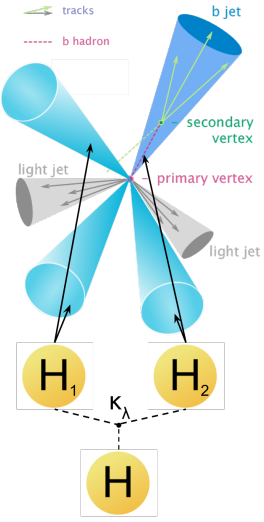



Image adapted from here

# The Background Modelling Problem, and the 2$b$RW solution

**Potential problems**

This is a potato

# All caps

This frame uses the `allcaps` titleformat.

**Potential Problems**

This titleformat is not as problematic as the `allsmallcaps` format, but basically suffers from the same deficiencies. So please have a look at the documentation if you want to use it.

# Elements

# Typography

```
The theme provides sensible defaults to
\emph{emphasize} text, \alert{accent} parts
or show \textbf{bold} results.
```

becomes

The theme provides sensible defaults to *emphasize* text, accent parts or show **bold** results.

# Font feature test

- Regular
- *Italic*
- SmallCaps
- **Bold**
- ***Bold Italic***
- **Bold SmallCaps**
- `Monospace`
- *`Monospace Italic`*
- **`Monospace Bold`**
- ***`Monospace Bold Italic`***

# Lists

Items

- Milk
- Eggs
- Potatos

Enumerations

1. First,
2. Second and
3. Last.

Descriptions

**PowerPoint** Meeh.

**Beamer** Yeeeha.

# Animation

- This is important

# Animation

- This is important
- Now this

# Animation

- This is important
- Now this
- And now this

# Animation

- This is really important
- Now this
- And now this

# Figures

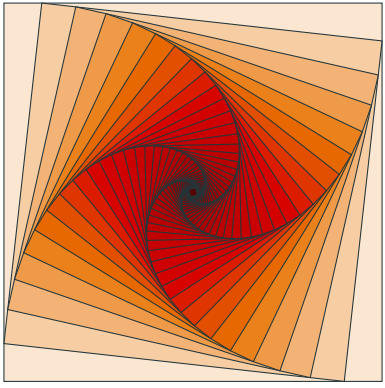


**Figure 1:** Rotated square from texample.net.

# Tables

**Table 1:** Largest cities in the world (source: Wikipedia)

| City | Population |
|---|---|
| Mexico City | 20,116,842 |
| Shanghai | 19,210,000 |
| Peking | 15,796,450 |
| Istanbul | 14,160,467 |

# Blocks

Three different block environments are pre-defined and may be styled with an optional background color.

**Default**

Block content.

**Default**

Block content.

**Alert**

Block content.

**Alert**

Block content.

**Example**

Block content.

**Example**

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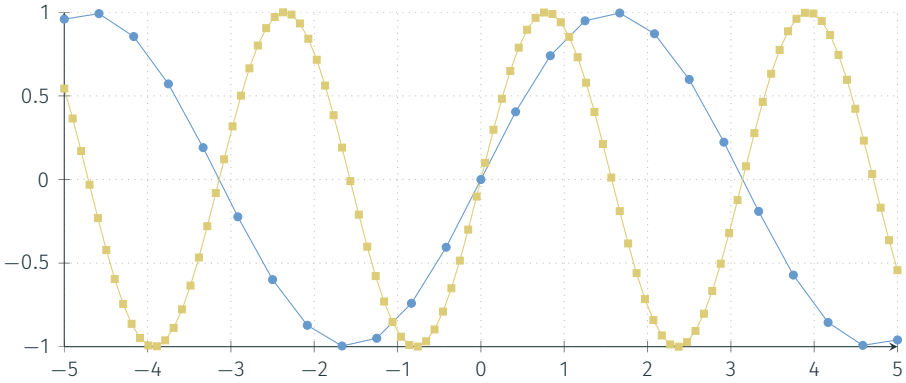
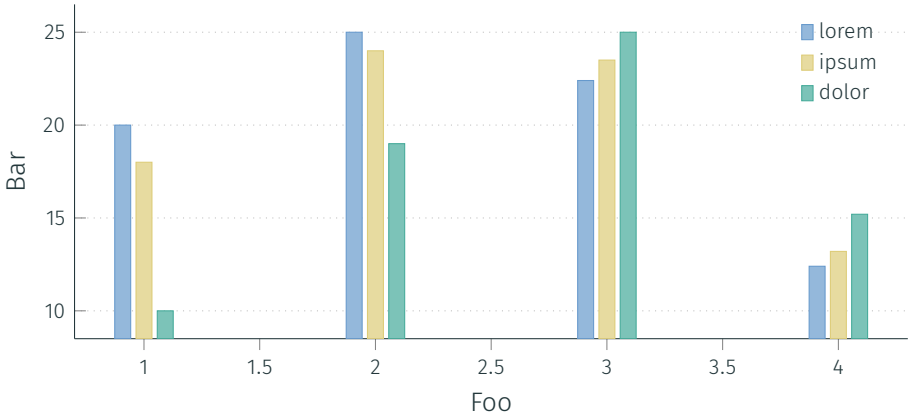
# Math

$$e = \lim_{n \to \infty} \left(1 + \frac{1}{n}\right)^n$$

# Line plots



# Bar charts



# Quotes

*Veni, Vidi, Vici*

# Frame footer

METROPOLIS defines a custom beamer template to add a text to the footer. It can be set via

```
\setbeamertemplate{frame footer}{My custom footer}
```

# References

Some references to showcase [allowframebreaks] [?, ?, ?, ?, ?]

# Conclusion

# Summary

Get the source of this theme and the demo presentation from

`github.com/matze/mtheme`

The theme *itself* is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

Questions?

# Backup slides

Sometimes, it is useful to add slides at the end of your presentation to refer to during audience questions.

The best way to do this is to include the `appendixnumberbeamer` package in your preamble and call `\appendix` before your backup slides.

METROPOLIS will automatically turn off slide numbering and progress bars for slides in the appendix.

# References i