UNIVERSITÄT BONN

Belle II

BLUB
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University of Bonn

DPG FRÜHJAHRSTAGUNG 2024

DIRECT MEASUREMENT OF $R^{\pm 0}$ AT BELLE II

Florian Bernlochner, Jochen Dingfelder, **Anna-Maria Heyn**, Markus Prim, Munira Khan

s6anheyn@uni-bonn.de

WHY DO WE CARE ABOUT $R^{\pm 0}$?

- Do emerging structures from QCD care about QED?

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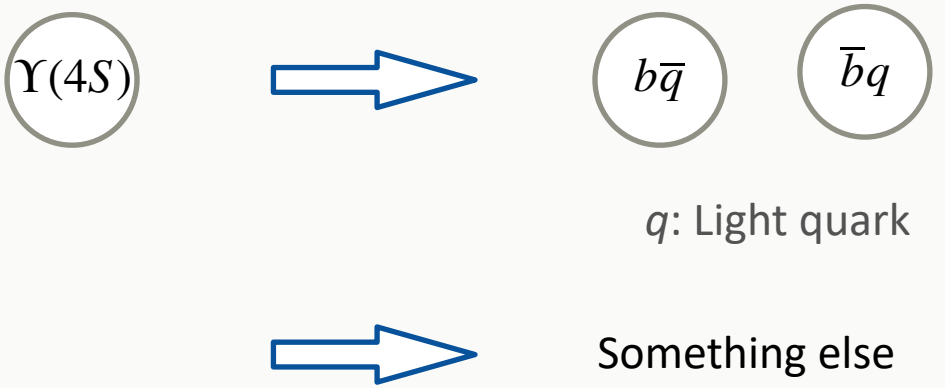
- Do emerging structures from QCD care?
- Look at Belle II:



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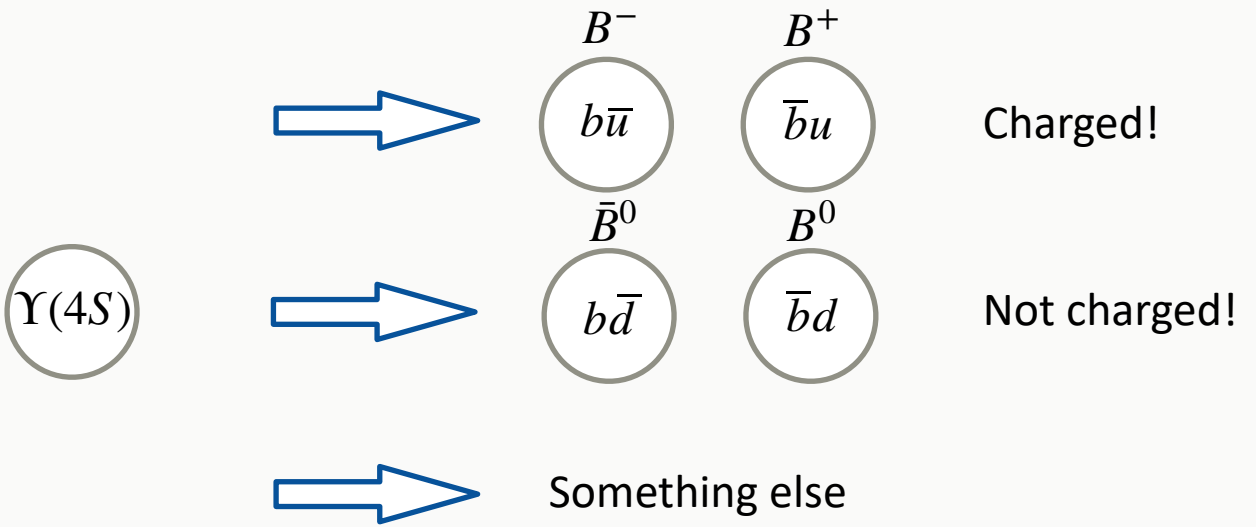
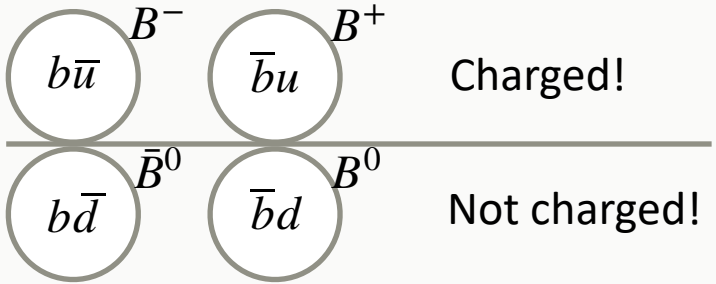


WHY DO WE CARE ABOUT $R^{\pm 0}$?

- Do emerging structures from QCD care?
- Look at Belle II:
- Ratio?



$$R^{\pm 0} = \frac{\Gamma(\Upsilon(4S) \to B^+B^-)}{\Gamma(\Upsilon(4S) \to B^0\overline{B}^0)}$$

WHY IS IT DIFFICULT?

- Currently: $R^{\pm 0} = 1.057^{+0.024}_{-0.025}$ (HFLAV[1])
- So… do QCD emergent structures care?

- But:
  - Theory predictions hard
  - B Mesons decay
  - Treatment of others than $B\overline{B}$

1: https://doi.org/10.1103/PhysRevD.107.052008

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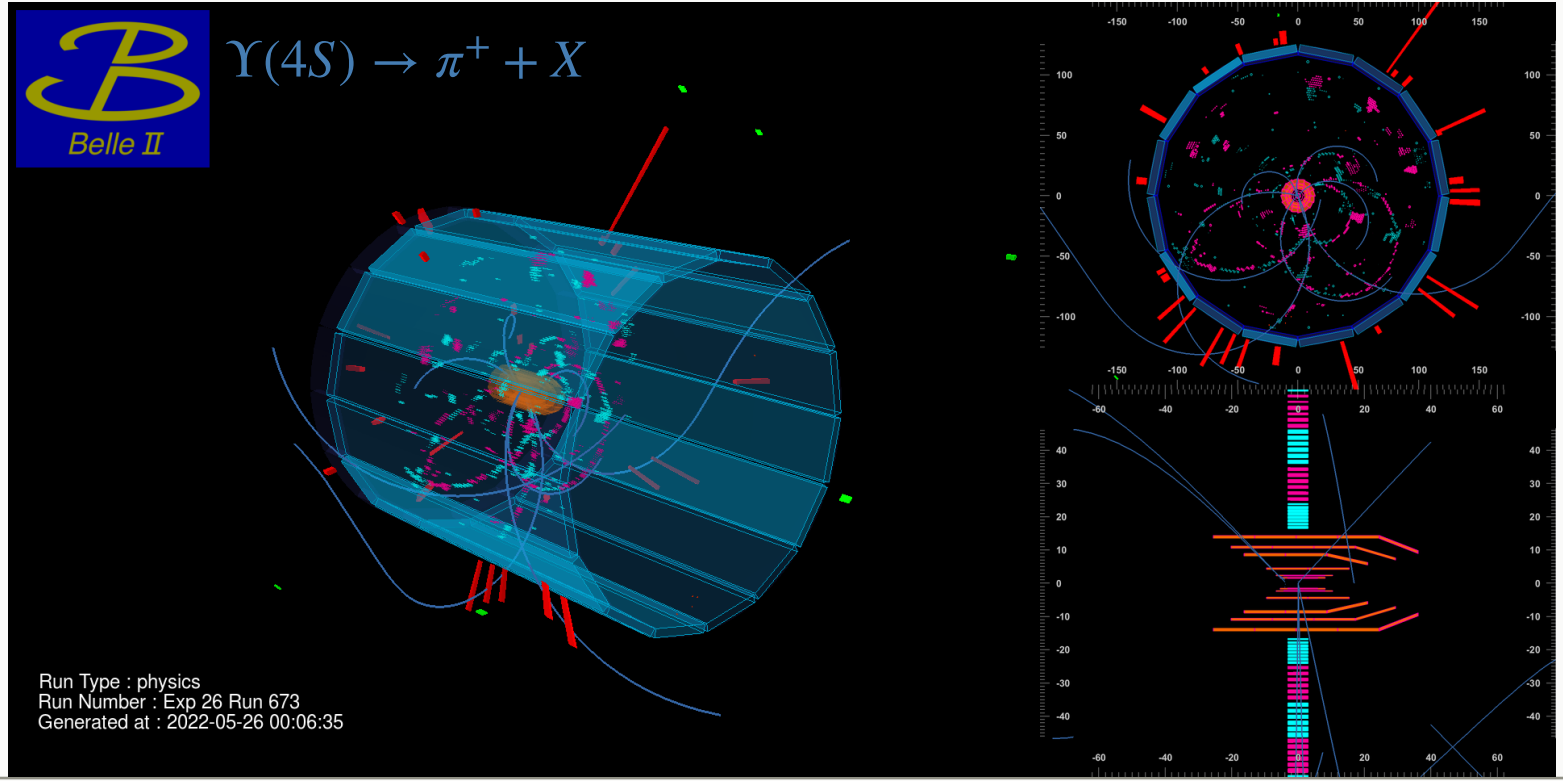
MY MEASUREMENT

NEW APPROACH TO MEASURE $R^{\pm 0}$

MY MEASUREMENT - SELECTION



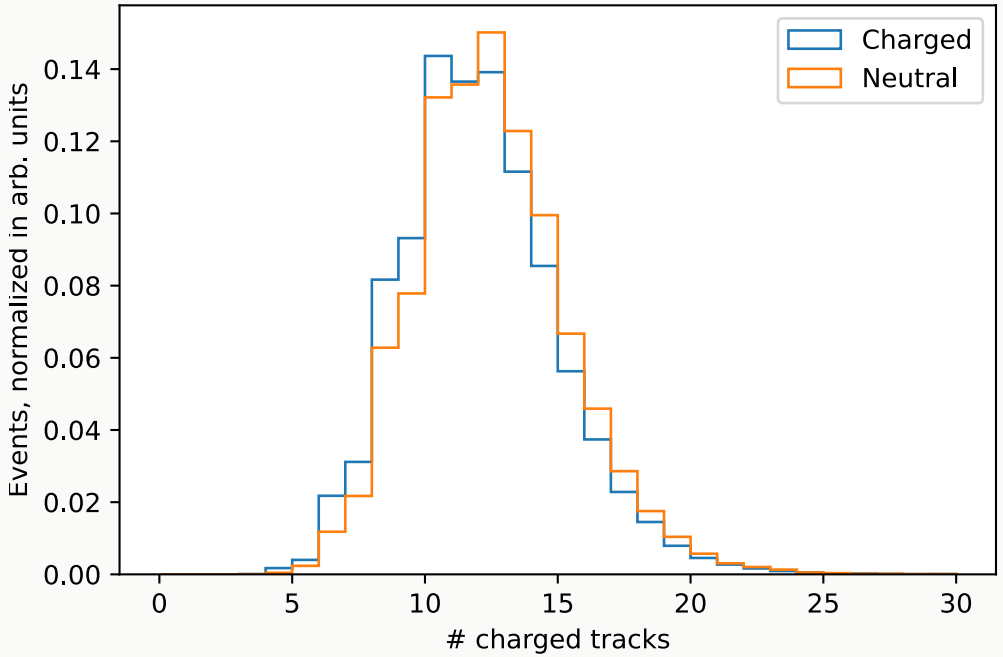
https://evdisp.belle2.org/

MY MEASUREMENT - IDEA

$B^+ \rightarrow$ 1, 3, 5, … charged daughters

$B^0 \rightarrow$ 0, 2, 4, … charged daughters

But: two B Mesons



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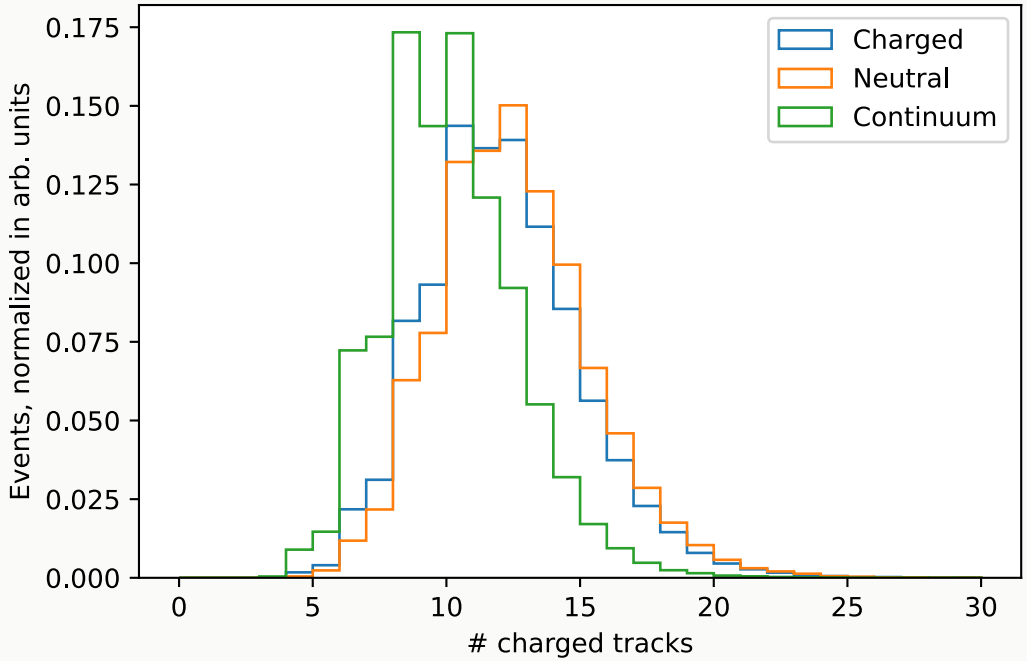
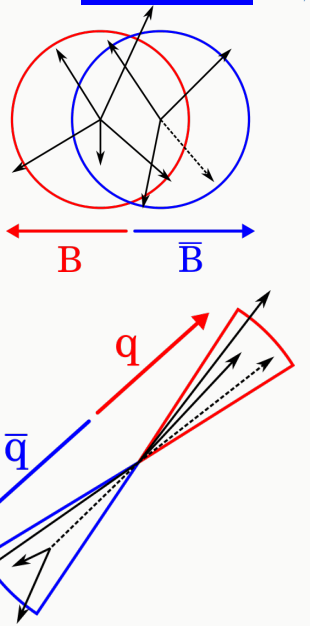


MY MEASUREMENT - CONTINUUM

- Train BDT for Continuum Suppression
- Event shape variables:
  - Event thrust
  - Cosine of polar angle comp. of thrust axis
  - Fox Wolfram moments
  - CLEO cones

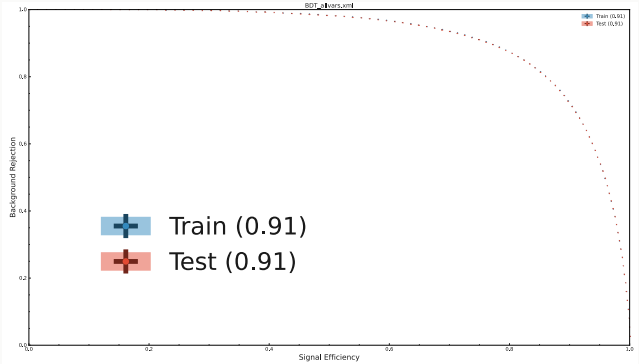


Adapted from Markus Prim

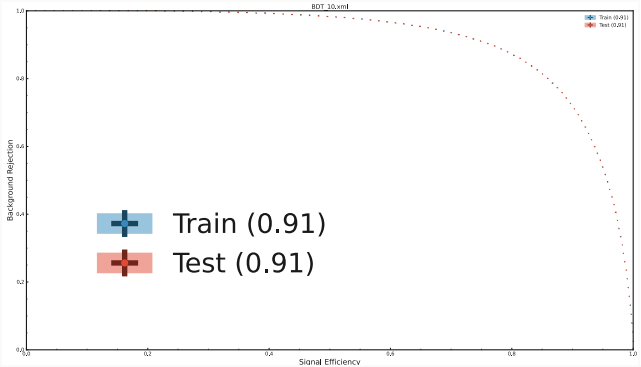
MY MEASUREMENT - BDT

- Trained 3 BDTs:

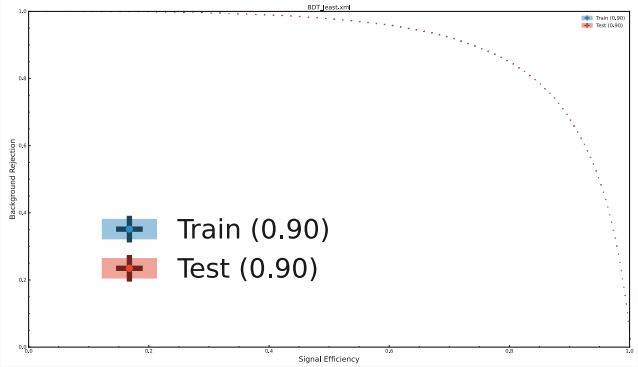
All Variables



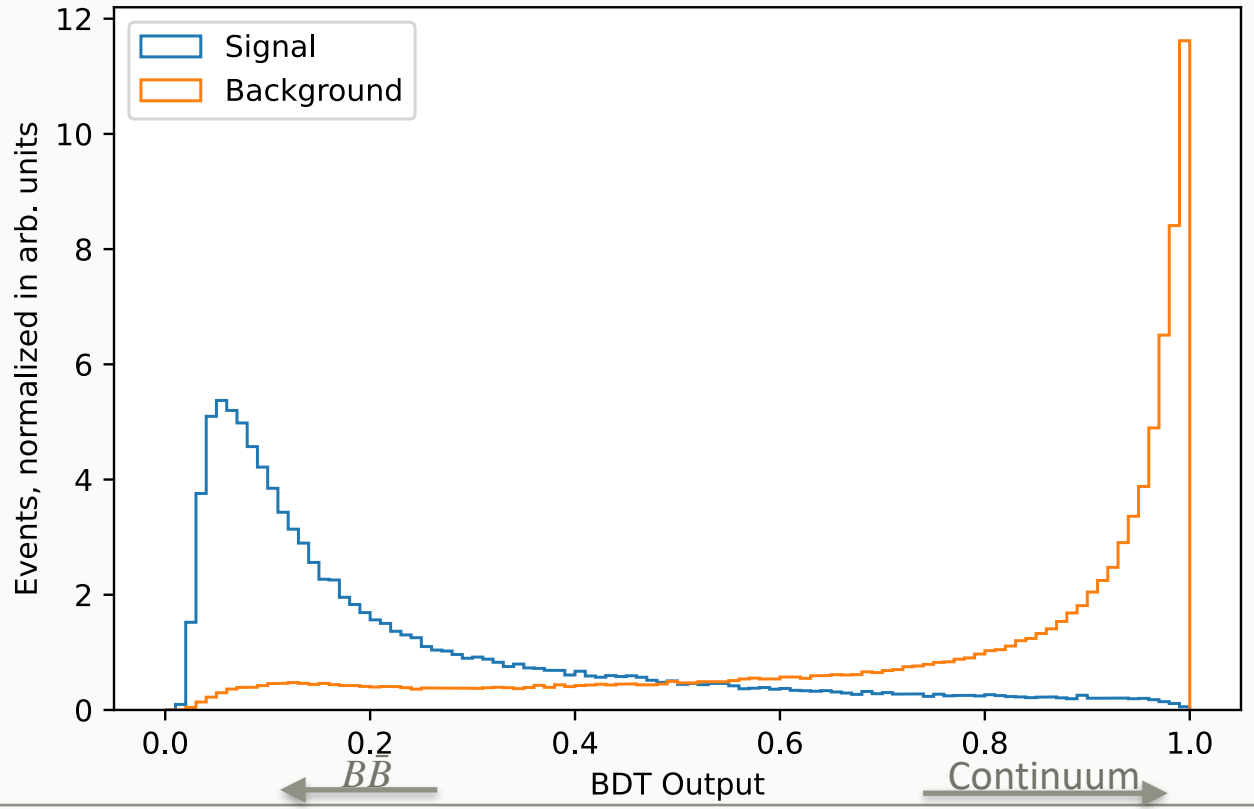
Most important



Least Correlated Variables

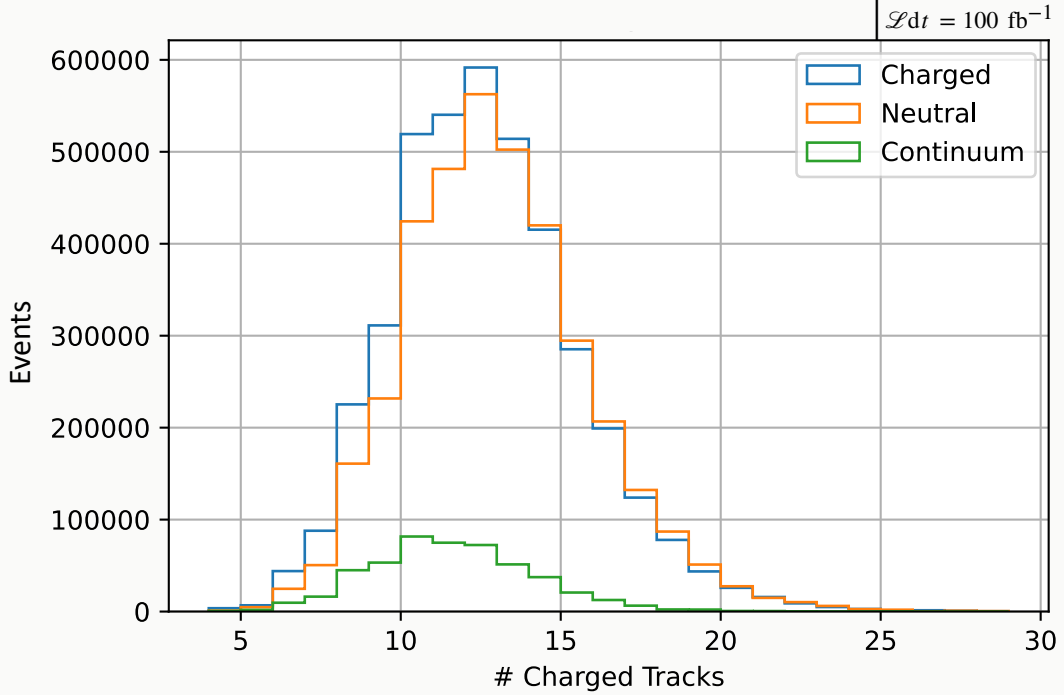


MY MEASUREMENT - BDT



MY MEASUREMENT - FIT

- Choose a BDT cut: 50%



MY MEASUREMENT - FIT

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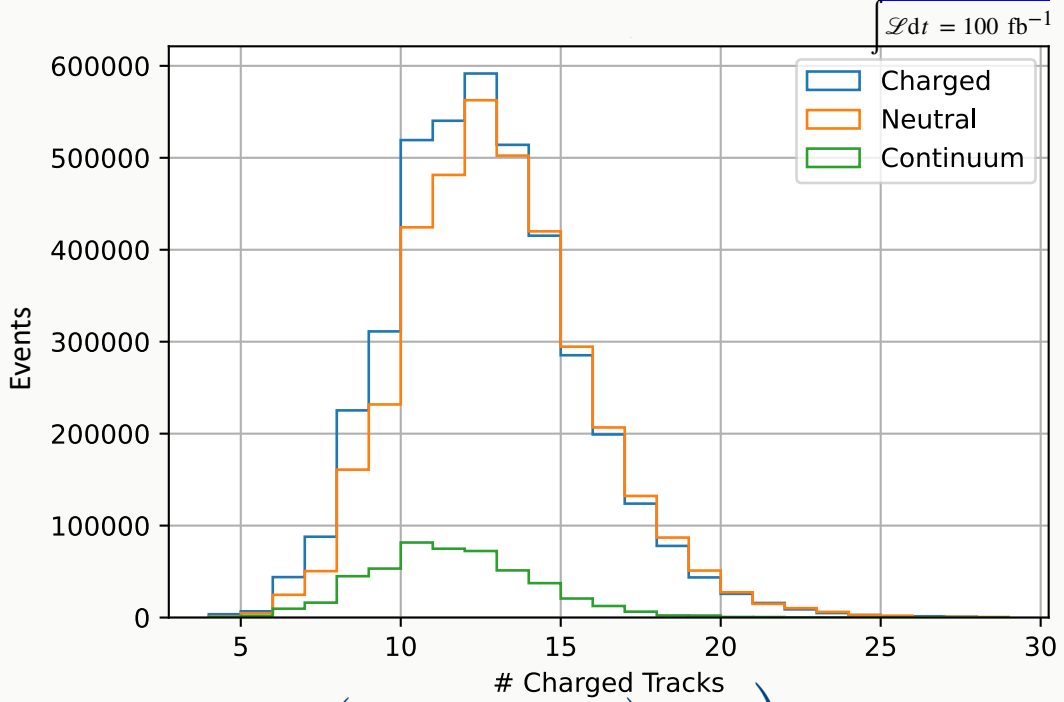


- Template Fit

$$\nu^i = n_{\mathrm{tot}} \left(f_{B^+B^-} p^i_{B^+B^-} + f_{\mathrm{q\bar{q}}} p^i_{\mathrm{q\bar{q}}} + \left(1 - f_{B^+B^-} - f_{\mathrm{q\bar{q}}}\right) p^i_{\mathrm{B^0\bar{B}^0}} \right)$$

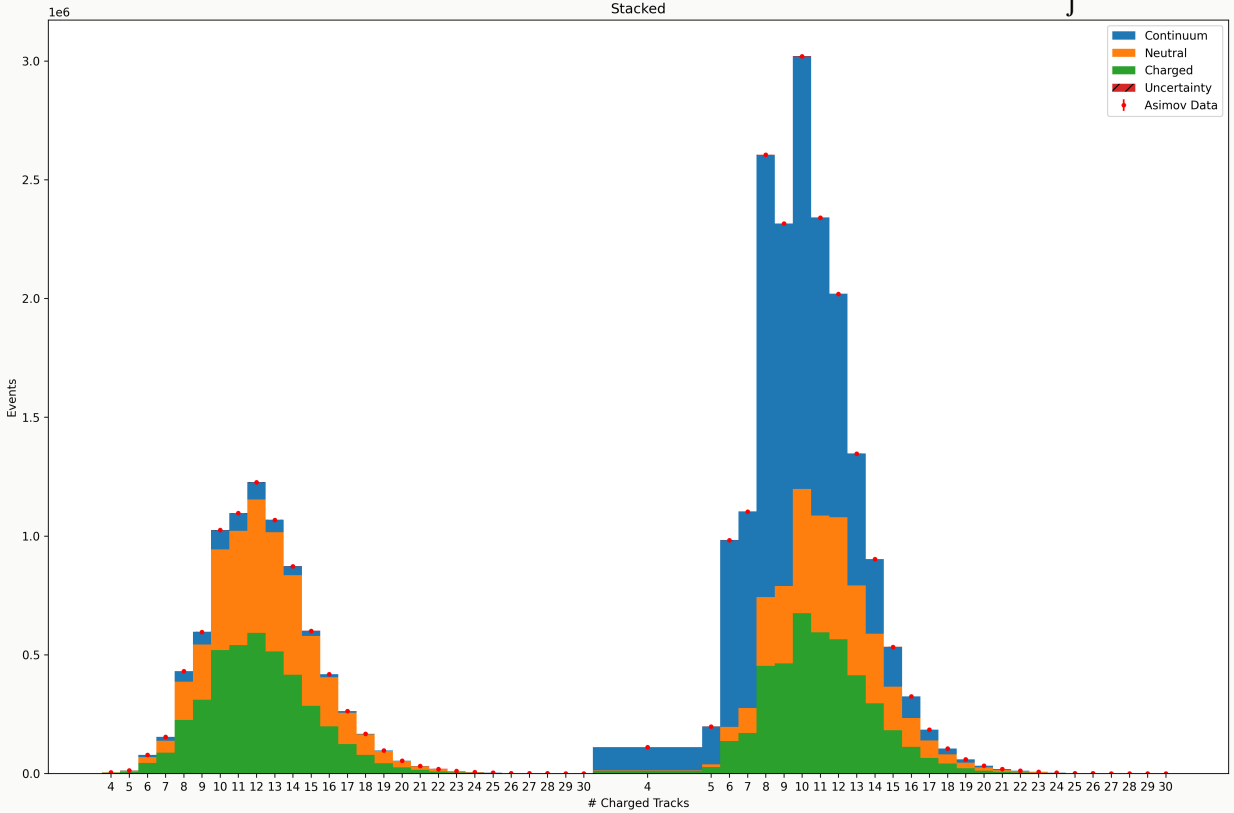
MY MEASUREMENT - FIT

$$\nu^i = n_{\text{tot}} \left(f_{B^+B^-} p^i_{B^+B^-} + f_{q\bar{q}} p^i_{q\bar{q}} + \left(1 - f_{B^+B^-} - f_{q\bar{q}}\right) p^i_{B^0\bar{B}^0} \right)$$

- Correlation($f_{B^+B^-}$, $f_{q\bar{q}}$) = -0.98 ⇒ -0.67

MY MEASUREMENT

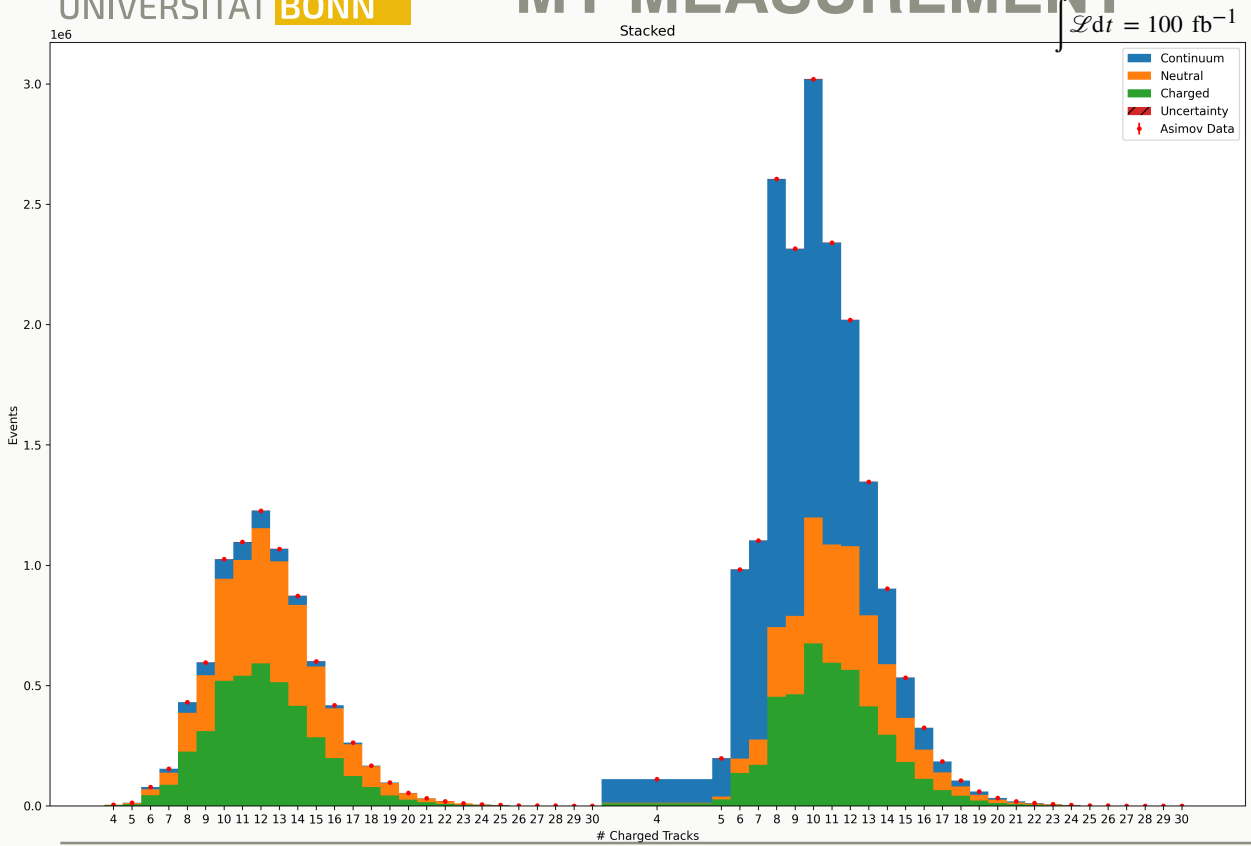
$\int \mathscr{L} dt = 100\ \text{fb}^{-1}$



Cut region

Anti-cut region

MY MEASUREMENT



$$\frac{f_{B^+B^-}}{f_{B^0\bar{B}^0}}$$

Generic MC Input	1.0588
Fit result	1.160501(4)

No efficiencies!

Cut region

Anti-cut region

OUTLOOK

- Corrections and efficiencies
- 4 Calibration modes:
  $\bar{B}^0 \to D^+\pi^-, \bar{B}^0 \to D^{*+}\pi^-, B^- \to D^0\pi^-, B^- \to D^{*0}\pi^-$
- Currently MC only

THANK YOU FOR YOUR ATTENTION

QUESTIONS?

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BACKUP

MY MEASUREMENT - SELECTION

- $\Upsilon(4S) \rightarrow \pi^+ + X$
- Constraints:
  - $|dz| < 1cm, dr < 3cm, p > 0.2MeV$
  - >= 1 hit in the drift chamber, angle in acceptance

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MY MEASUREMENT

Belle II

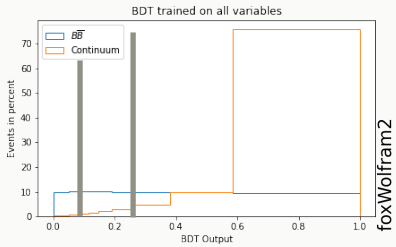
BLUB Belle Lab

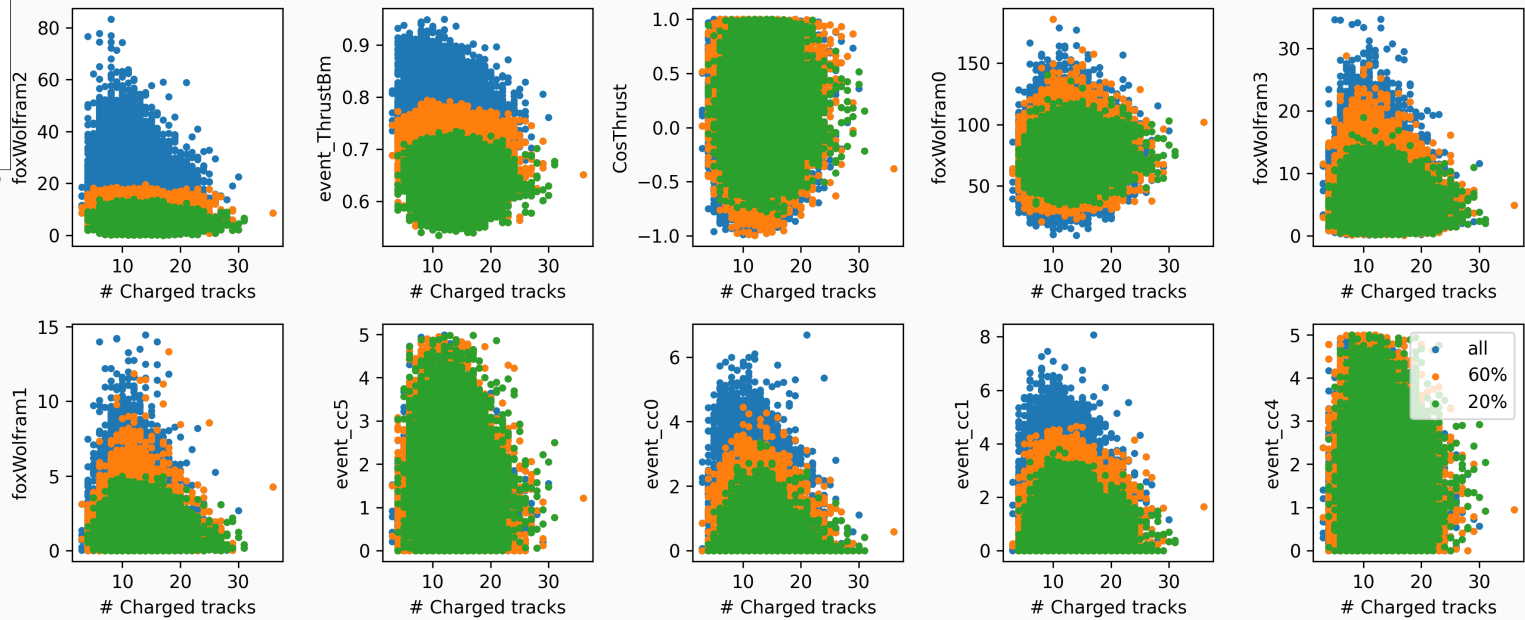
- Some introductions:

$$R^{\pm 0} = \frac{\Gamma(\Upsilon(4S) \to B^+B^-)}{\Gamma(\Upsilon(4S) \to B^0\overline{B}^0)}$$

$$f_{\pm} = \frac{\Gamma(\Upsilon(4S) \to B^+B^-)}{\Gamma(\Upsilon(4S)} \qquad f_{00} = \frac{\Gamma(\Upsilon(4S) \to B^0\overline{B}^0)}{\Gamma(\Upsilon(4S)} \qquad f_{\not B} = 1 - f_{\pm} - f_{00}$$

MY MEASUREMENT - BDT

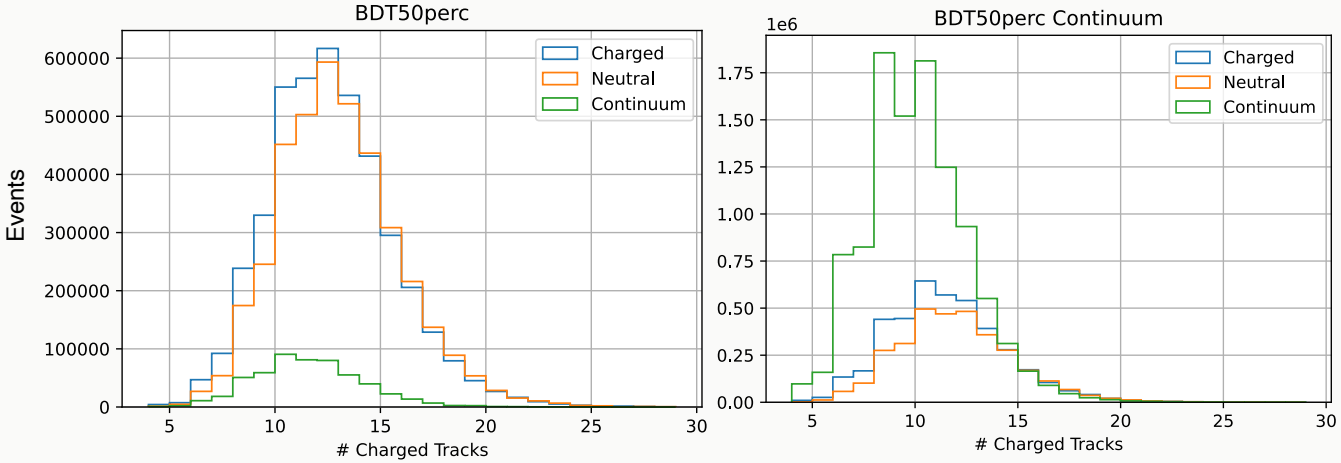




MY MEASUREMENT - FIT

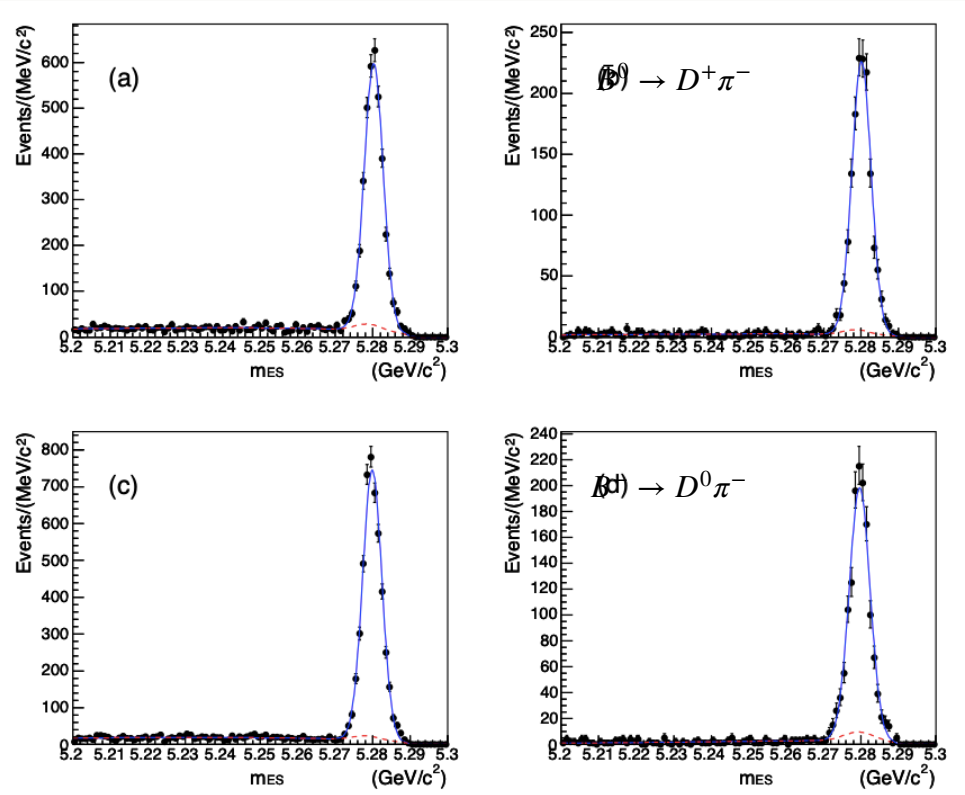
$$n_{\text{tot}}\left(f_{\text{Charged}}p_{\text{Charged}} + f_{\text{Continuum}}p_{\text{Continuum}} + \left(1 - f_{\text{Charged}} - f_{\text{Continuum}}\right)p_{\text{Neutral}}\right)$$

- Fit both above and below BDT cut:



- Now: Correlation(f_{Charged}, $f_{\text{Continuum}}$) = -0.69

CALIBRATION MODES

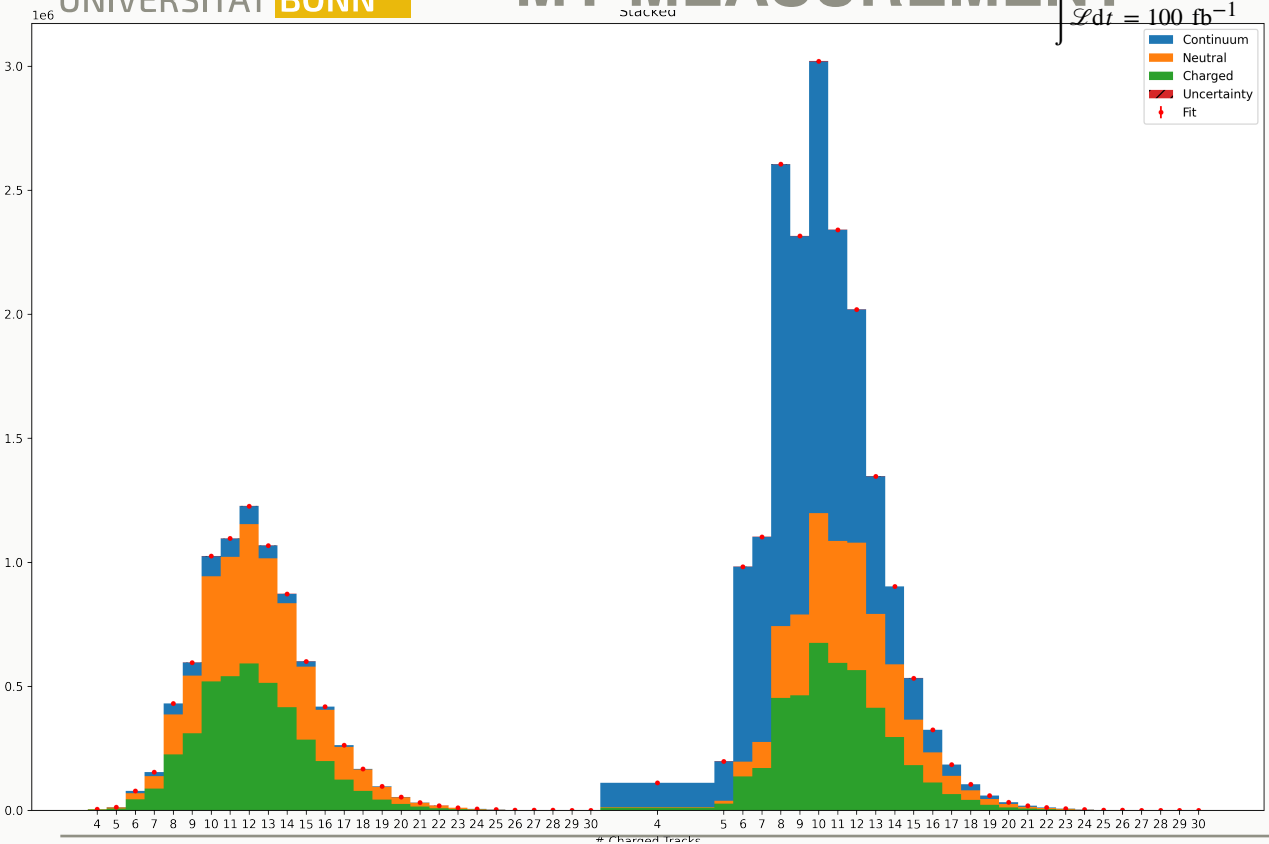


$\bar{B}^0 \to D^{*+}\pi^-$

$B^- \to D^{*0}\pi^-$

https://arxiv.org/pdf/hep-ex/0610027.pdf

MY MEASUREMENT



$$\frac{f_{B^+B^-}}{f_{B^0\bar{B}^0}} = 1.160501(4)$$

Cut region

Anti-cut region