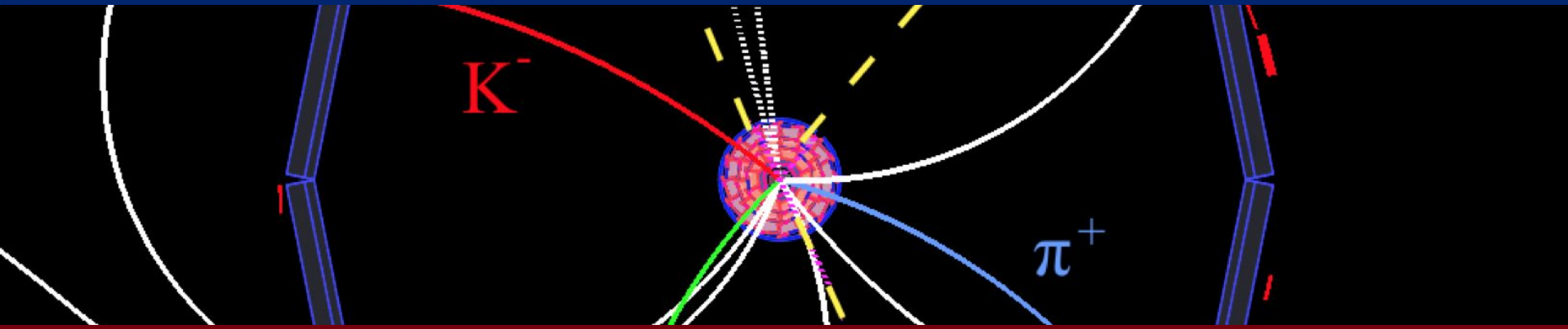
Inclusive $|V_{ub}|$ Measurement at Belle

Details & Discusstion



DESY 13 Nov 2019

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Emmy Noether-Programm
DFG Deutsche Forschungsgemeinschaft

SIMBA - Analysis of B-Meson Inclusive Spectra -

UNIVERSITÄT BONN

Issues

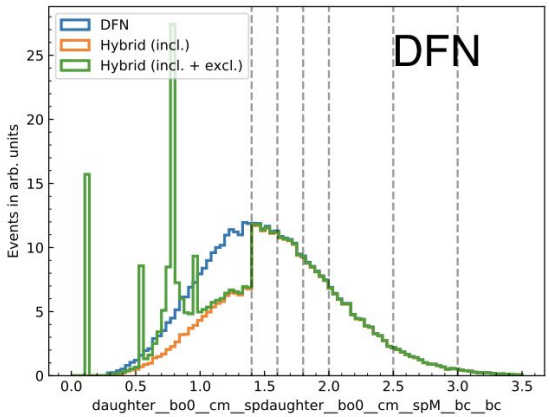
- Hybrid model and systematics
- Unfolding
- $|V_{ub}|$ extraction
- Other items from YOU

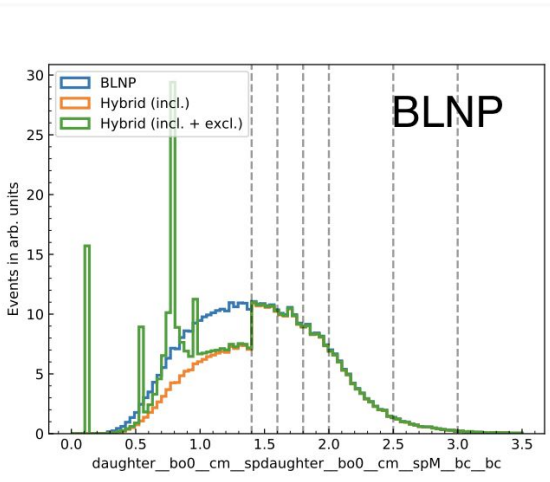
Hybrid Model and Systematics

On-going Preparation for Belle2

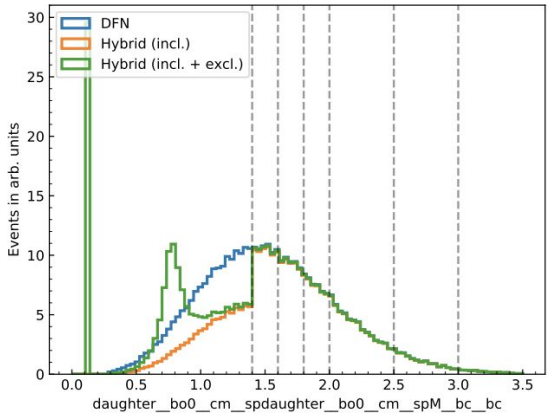
m_X

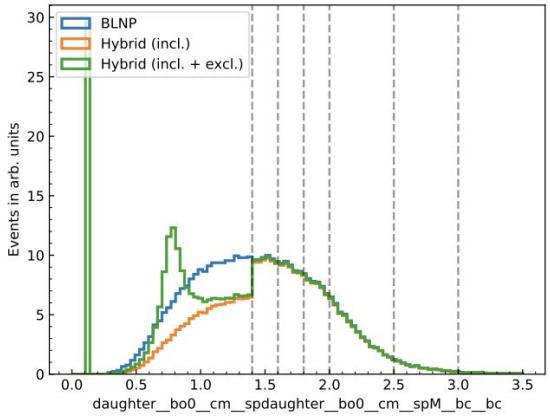
Charged



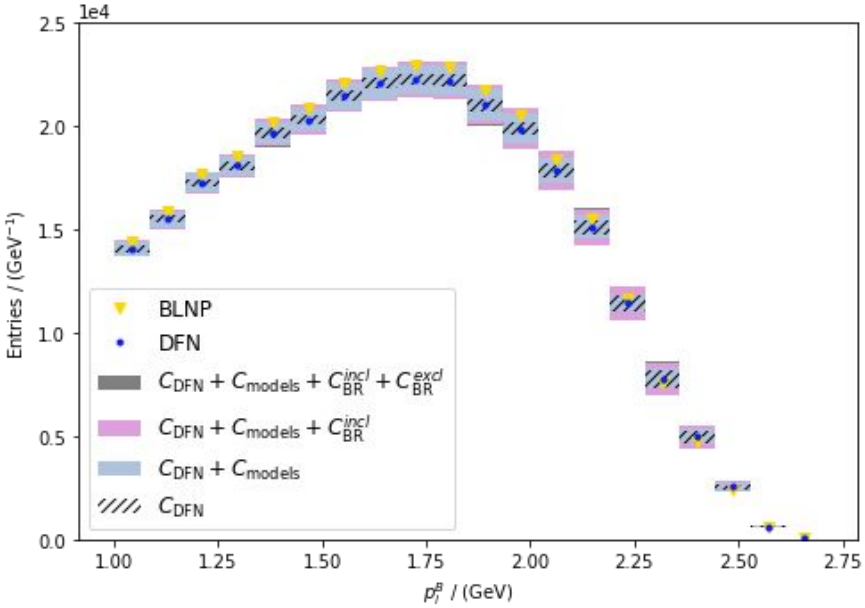


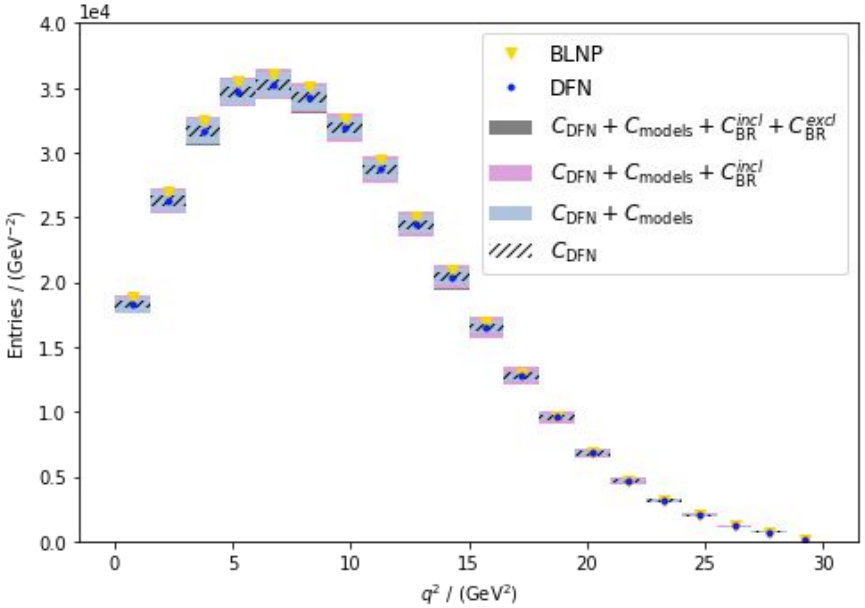
Mixed

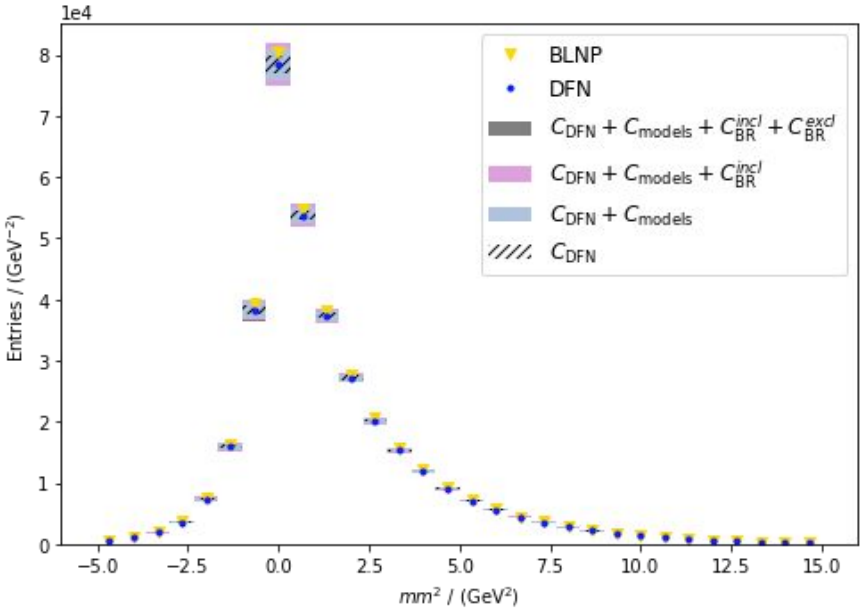


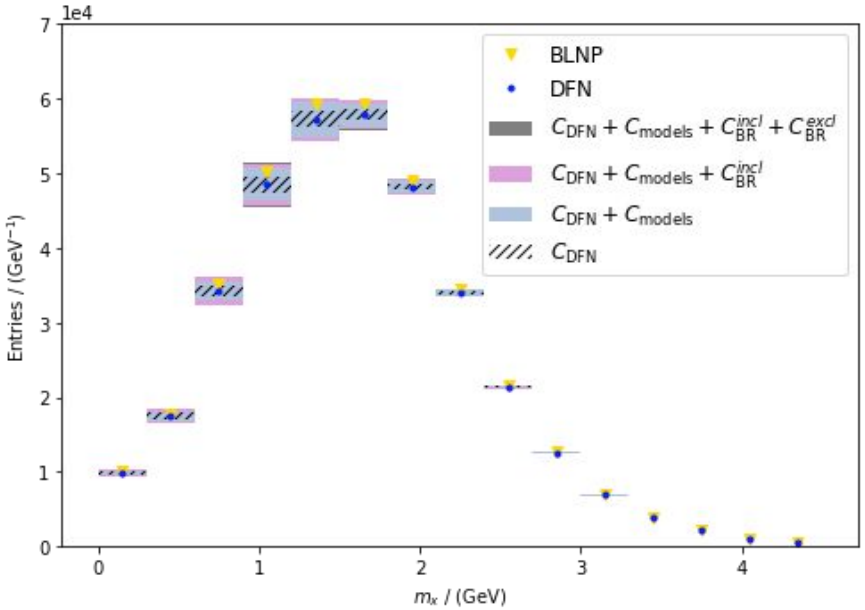


Hybrid Systematics in Belle









From Theory Predictions To MC

- MC simulations base on theory input
- The discrepancies of various theoretical predictions should be considered as one source of the MC systematics
- Decay files readiness for EvtGen:

	Recommen-ded to use	EvtGen Model
ADFR		not regesited
DFN		VUB (?)
DGE		missing
GGOU		missing
BLNP		VUB_BLNP (3 flag para. need to understand)

Open Questions/Tasks

- Figure the unclear parameters for VUBBLNP
- Add missing DGE and GGOU as decay model for EvtGen
- Implement for basf2
- Validation all

One topic for tomorrow Hackathon? -- will be very helpful and effective, since there are BaBar experts and theorists around :)

Issues on Unfolding

Unfolding Methods

Method	Description	Parameters	Comments	Key in PyrooUnfold
Bin-by-bin correction	correct bin content with MC bin-by-bin factors	-	assumes no inter-bin migration	"BinByBin"
Matrix inversion	unregularised invert response matrix	-	singular value removal	"Invert"
TUnfold	matrix inversion with 0-, 1-, or 2-order polynomial, an adjustable regularisation term of neighbouring bins	reg. strength τ	optimal tau can be chosen by scanning L-curve; better when nbin_mea > nbin_true	"TUnfold"
Bayes	use Bayes' theorem to invert response matrix, regularisation by stopping iterations before reaching "true" inverse	iteration n	n needs to be tuned with statistics, bins	"Bayes"
IDS	iterative, dynamically stabilised method, uses stat. significance of the data-MC differences in each bin for regularisation	iteration n	allows to treat the effects of new structures in data and the large fluctuations from background subtraction	"Ids"
SVD	singular value decomposition, regularisation with a smooth cut-off on small singular value contribution	k = 1..nbins	k too small: dominated by MC truth k too large: dominated by stat. fluctuations k needs to be tuned with bins, sample size	"Svd"

NO universally "excellent" method! Performance highly depends on data shape, bins, statistics, etc. One has to evaluate based on specific distribution, and eventually compromises on a balance between biases and fluctuations.

PyrooUnfold

A Python wrapper for **RooUnfold** and more:

- inherits the basic functionality of roounfold with six unfolding methods
- six predefined FoM (see next slide) for biases study
- friendly interface as normal python code for plotting
- fairly easy to extend as much as you want, e.g. add new methods and FoM

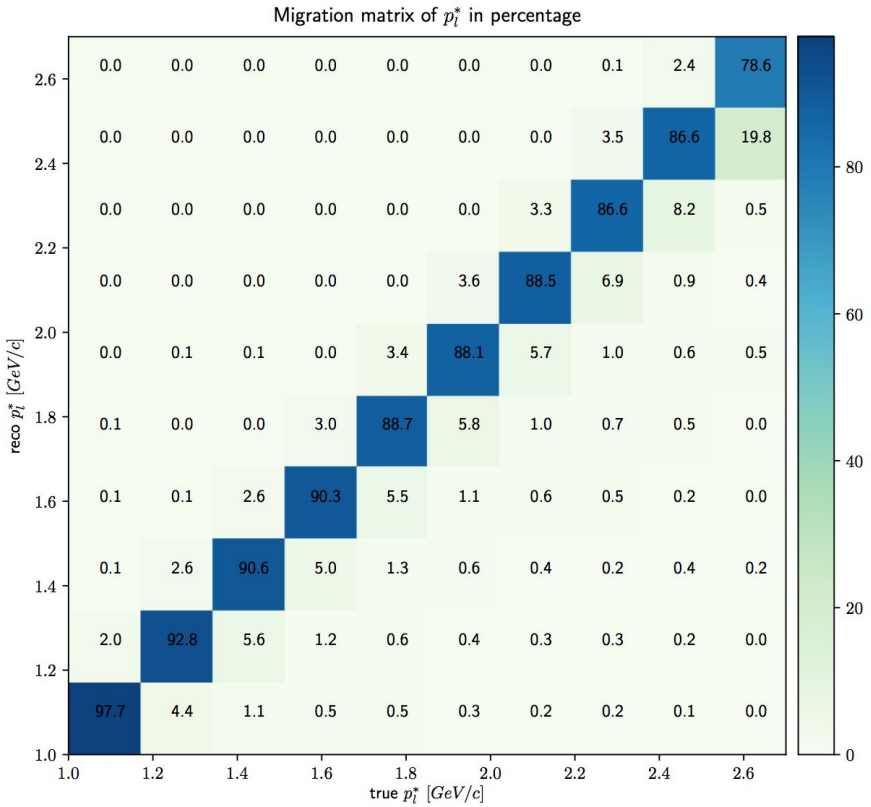
A hands-on tutorial can be provided during Hackathon, if needed.

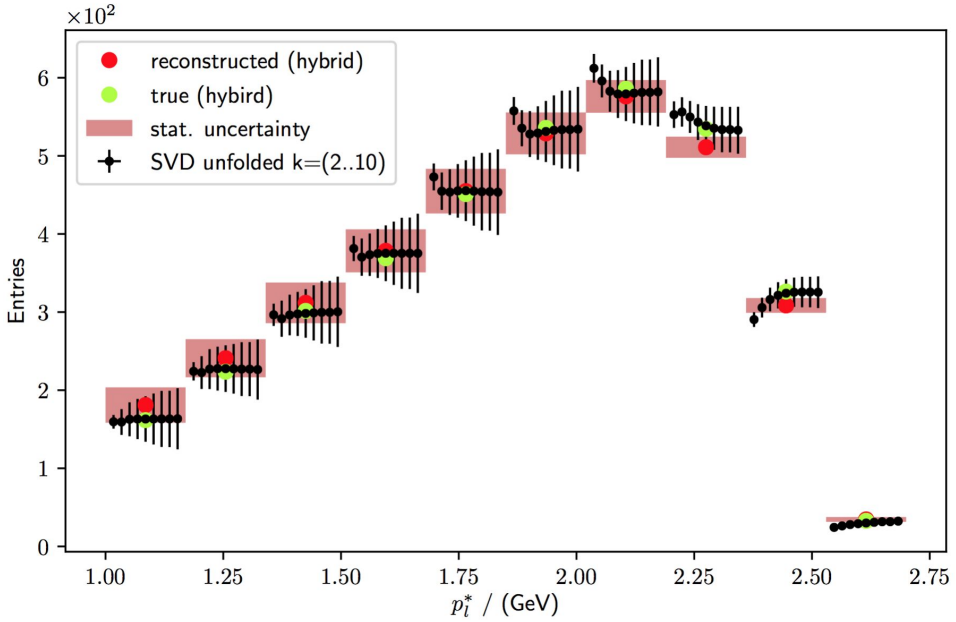
Figures of Merit in PyrooUnfold

Figure of Merit	Description
$\sum_i \lvert b_i \rvert$	The sum of absolute biases, where $b_i = N_i^{\text{unfolded}} - N_i^{\text{true}}$
$\sum_i \lvert b_i \rvert / N_i^{\text{true}}$	The sum of normalised absolute biases when $N_i^{\text{true}} \neq 0$.
$\sum_i b_i$	The sum of biases, which can be zero when significant biases are present in individual bins but cancel in the sum (balanced oscillation).
$\sqrt{\sum_{i,j} Cov_{i,j}}$	The square root of the sum of all elements of the covariance matrix after unfolding, which is the effective total statistical uncertainty. The diagonal elements of the covariance matrix are the square of statistical error and off-diagonal elements present the bin-to-bin correlations.
$\frac{\sum_i \lvert b_i \rvert}{\sqrt{\sum_{i,j} Cov_{i,j}}}$	The ratio of the sum of absolute biases and the effective total statistical error taking into account bin-to-bin correlations. This is used to check that the total bias due to the unfolding is smaller than the stat. uncertainty in terms of the whole distribution.
$\sqrt{(\sum_i \lvert b_i \rvert)^2 + \sum_{i,j} Cov_{i,j}}$	The total biases absorbing the total statistical error with bin-to-bin correlations, which is used to check the general oscillation.

Test on Lepton Spectrum

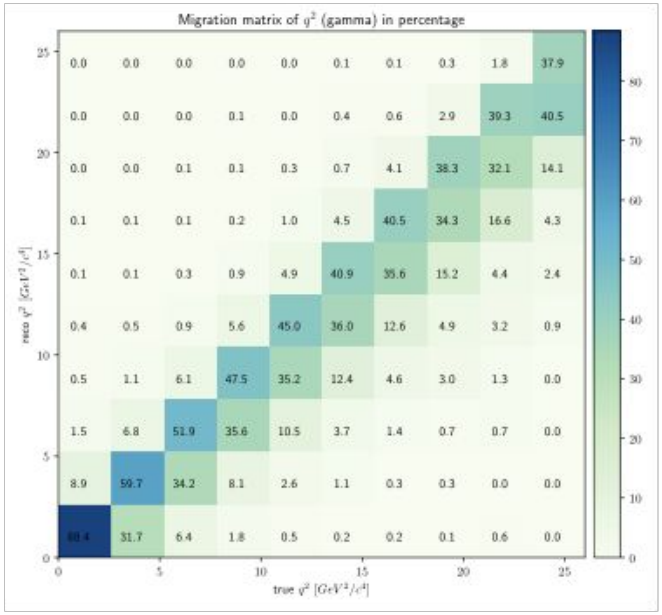
- Framework tested with reconstruted p^*_l (w/o PID corrections included at this point)

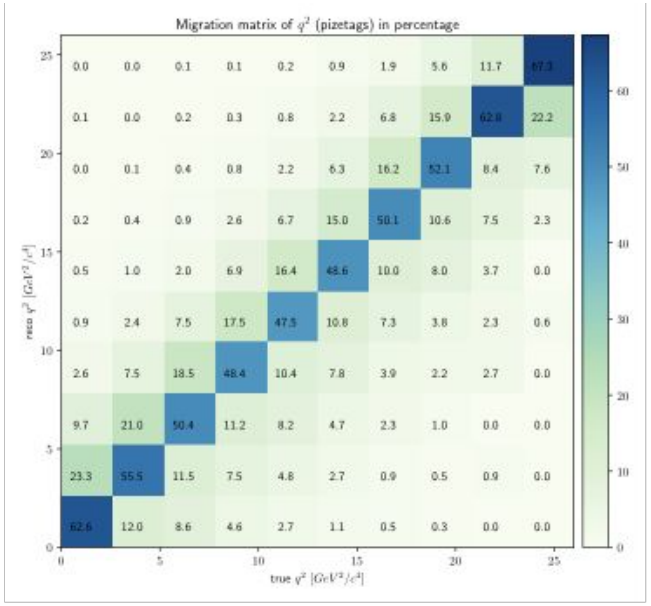




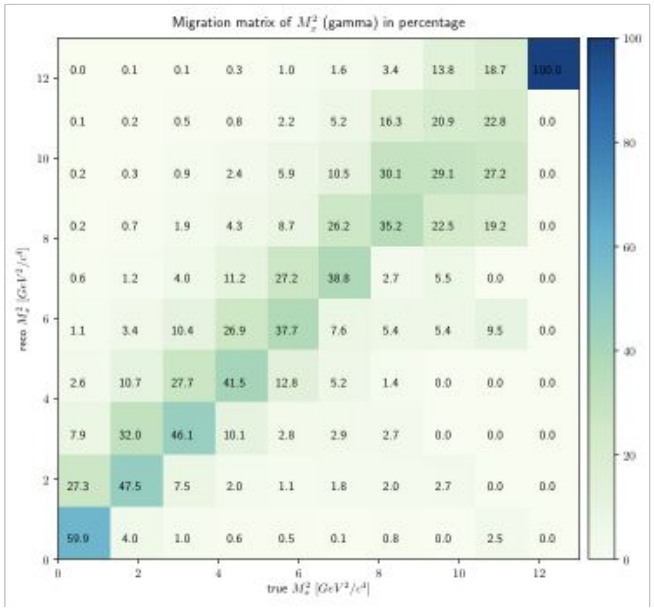
Migration Matrix for Other Variables

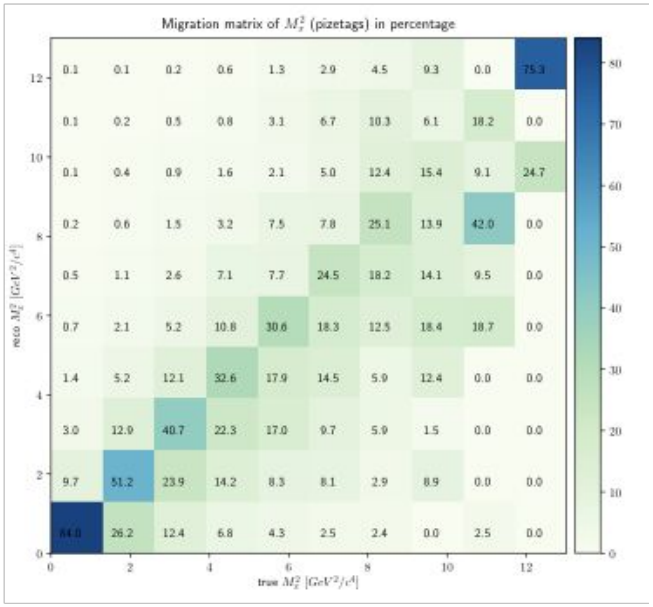
q^2





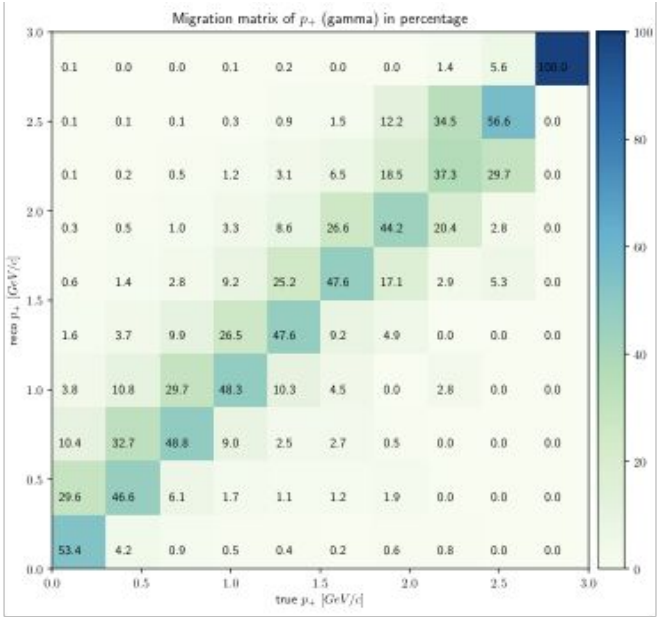
Mx^2

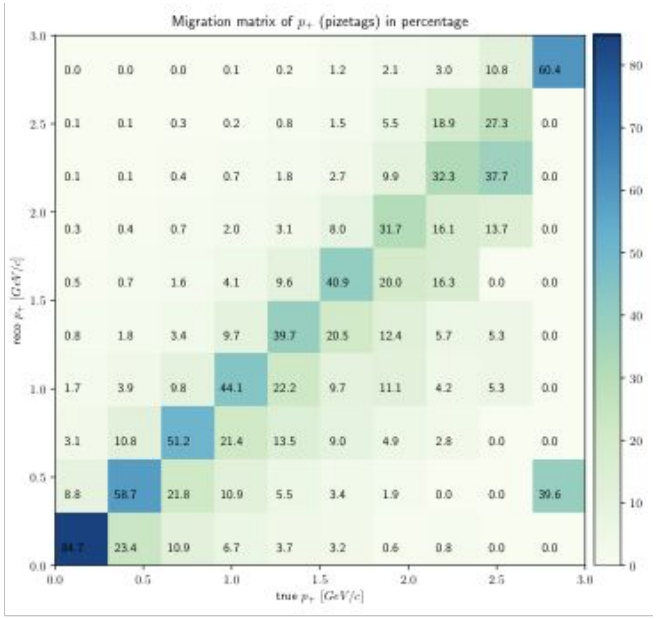




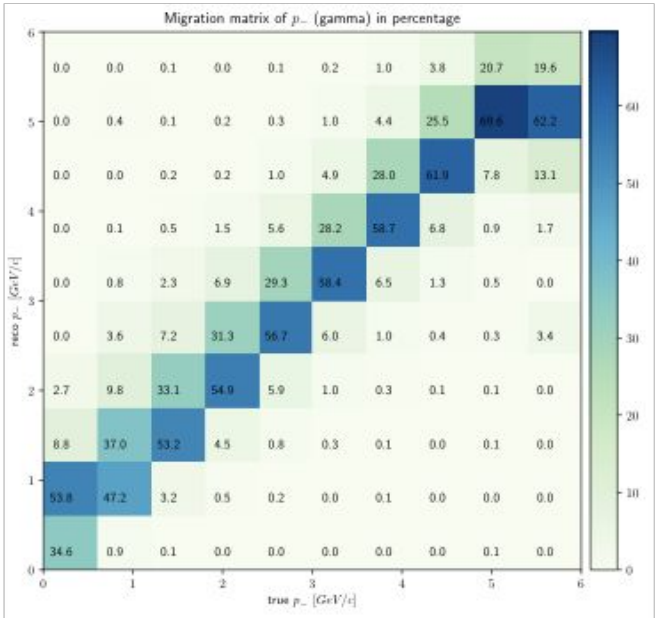
Migration Matrix for Other Variables

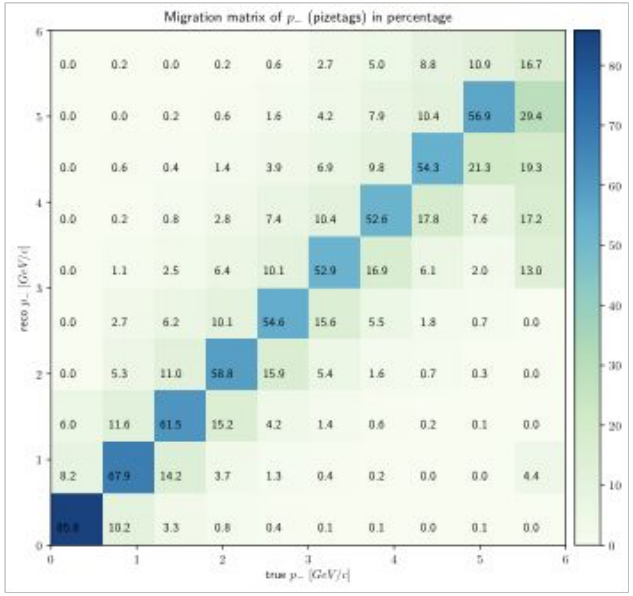
p_+



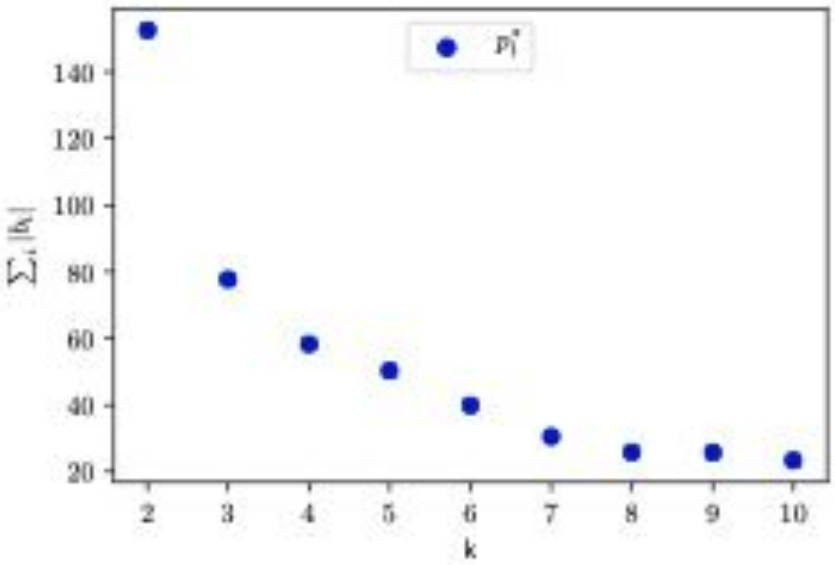


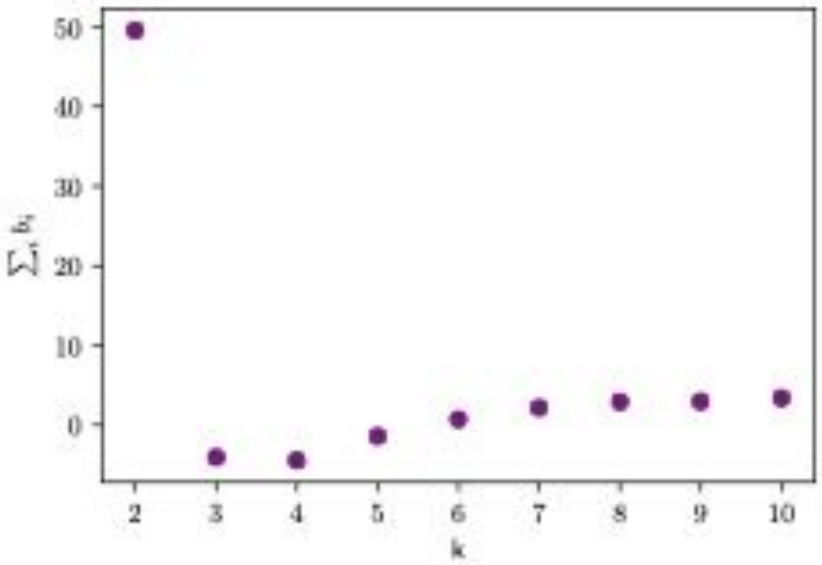
p_-

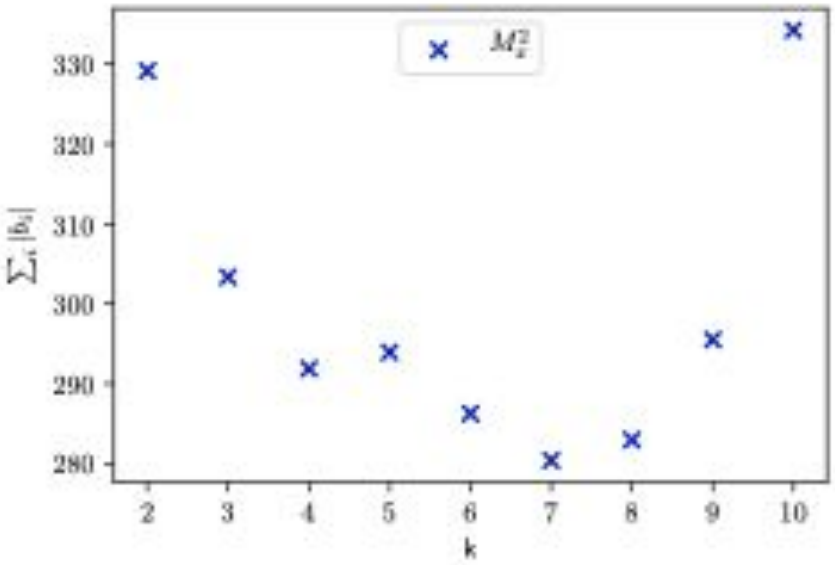


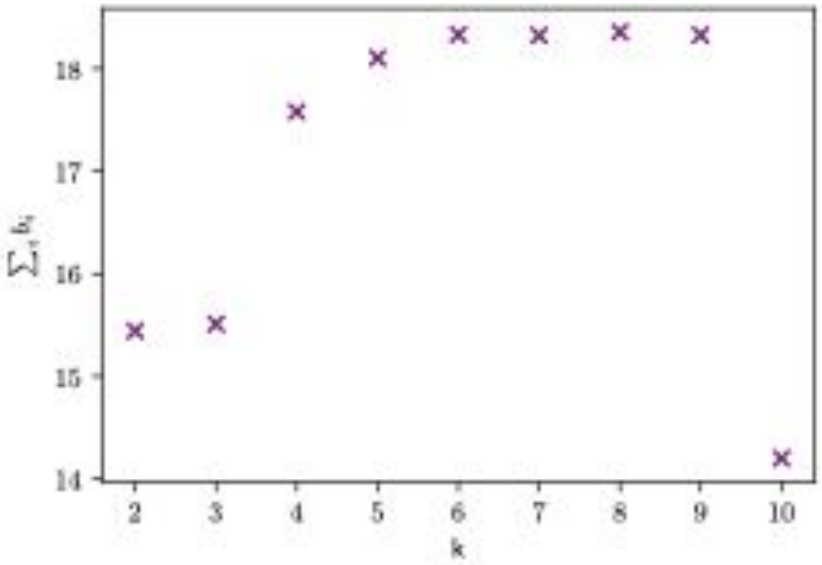


FoM Study on SVD *k*

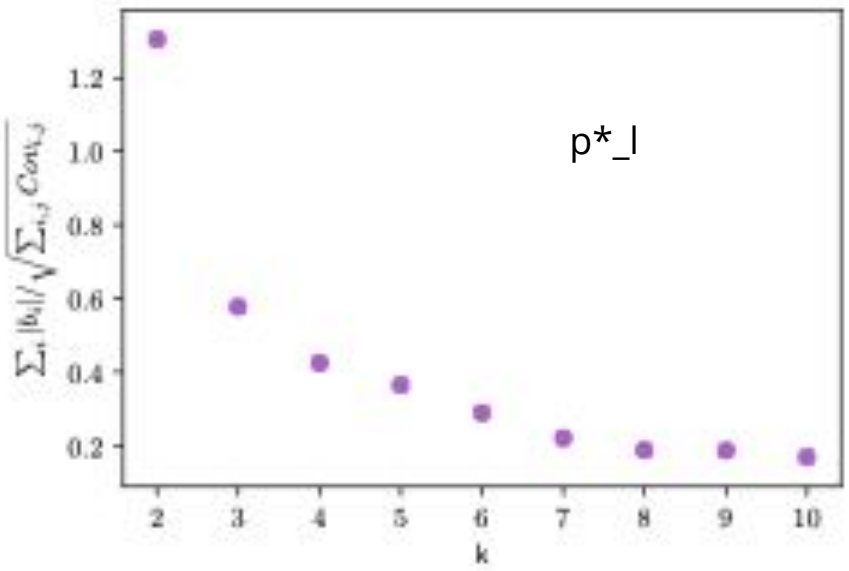


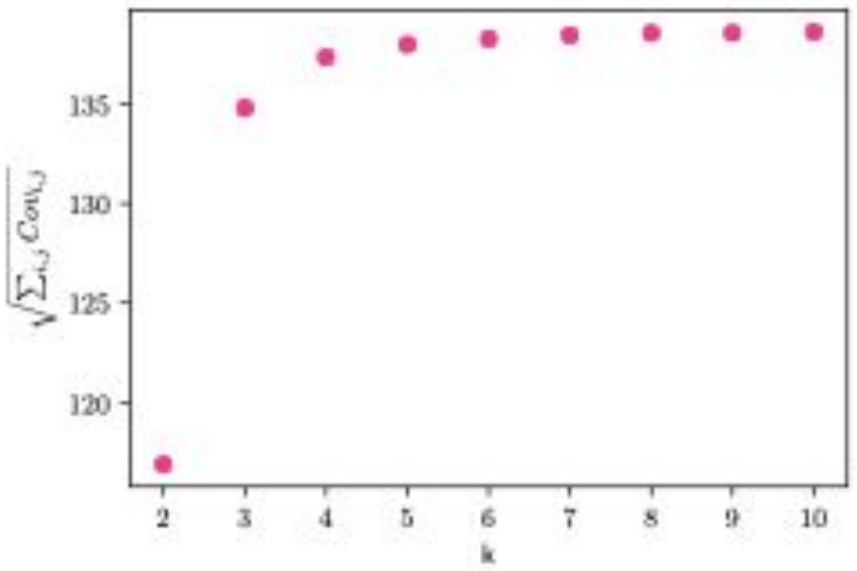


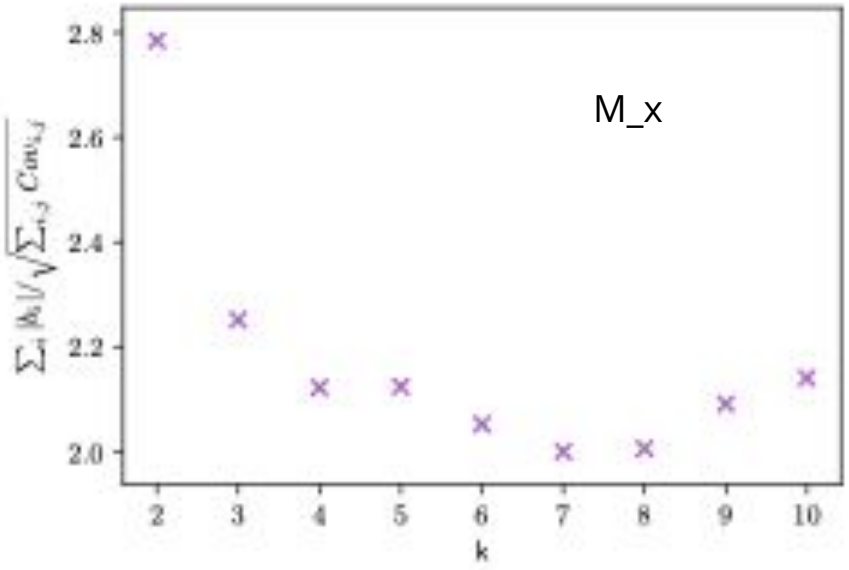


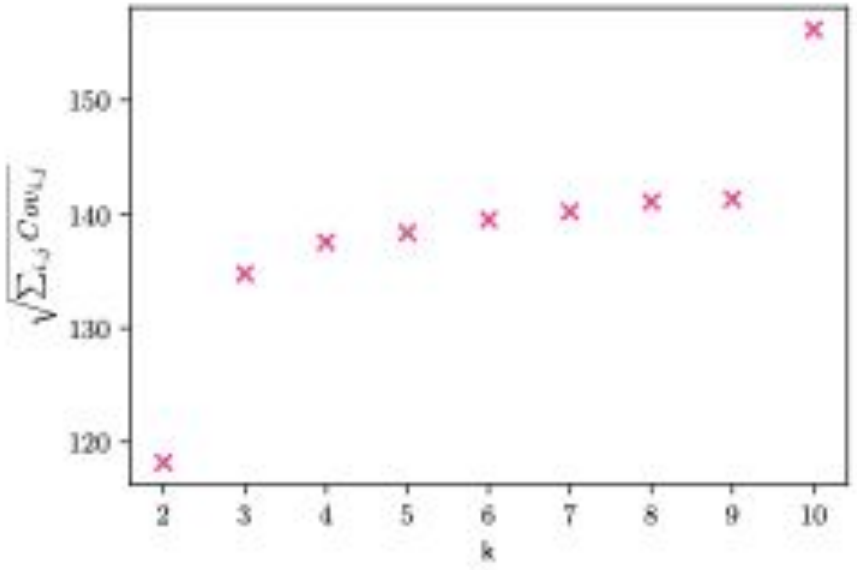


FoM Study on SVD *k*









Open Questions/Tasks

- Choose reasonable binning → better diagonal structure of migaration matrx
- Detailed biases study based on one/multiple FoM

This won't be possible to finish during the Hackathon, but we can start to set up some datasets and scripts.

$|V_{ub}|$ Extraction

So far, we haven’t done/preparaed anything for this yet.

All suggestions and contributions are highly welcome!

Future Vub Meeting

Doodle shows Thursay 1pm is most preferred.

Stay weekly or bi-weekly?