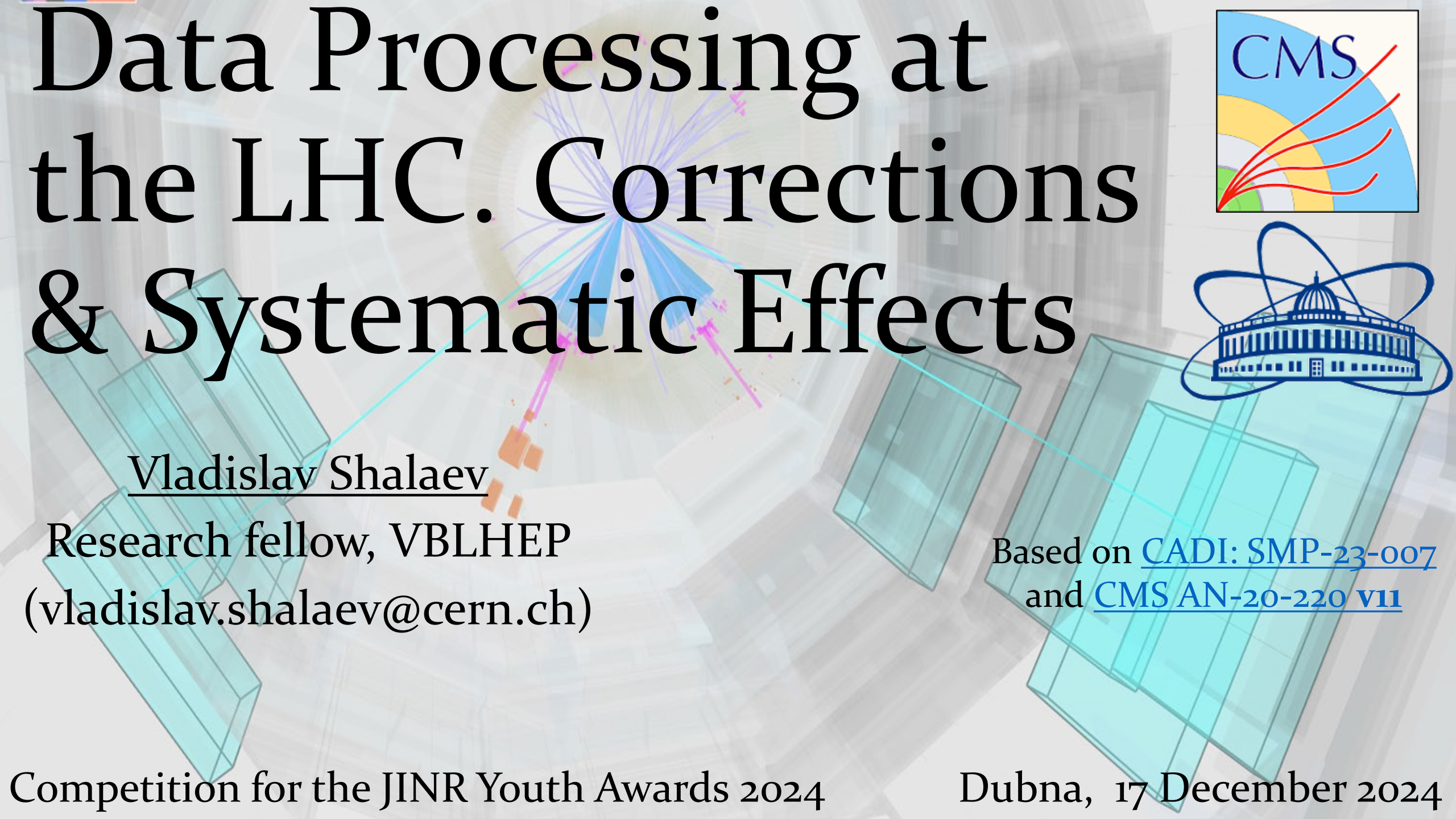
Data Processing at the LHC. Corrections & Systematic Effects



Vladislav Shalaev
Research fellow, VBLHEP
(vladislav.shalaev@cern.ch)

Based on CADI: SMP-23-007
and CMS AN-20-220 v11

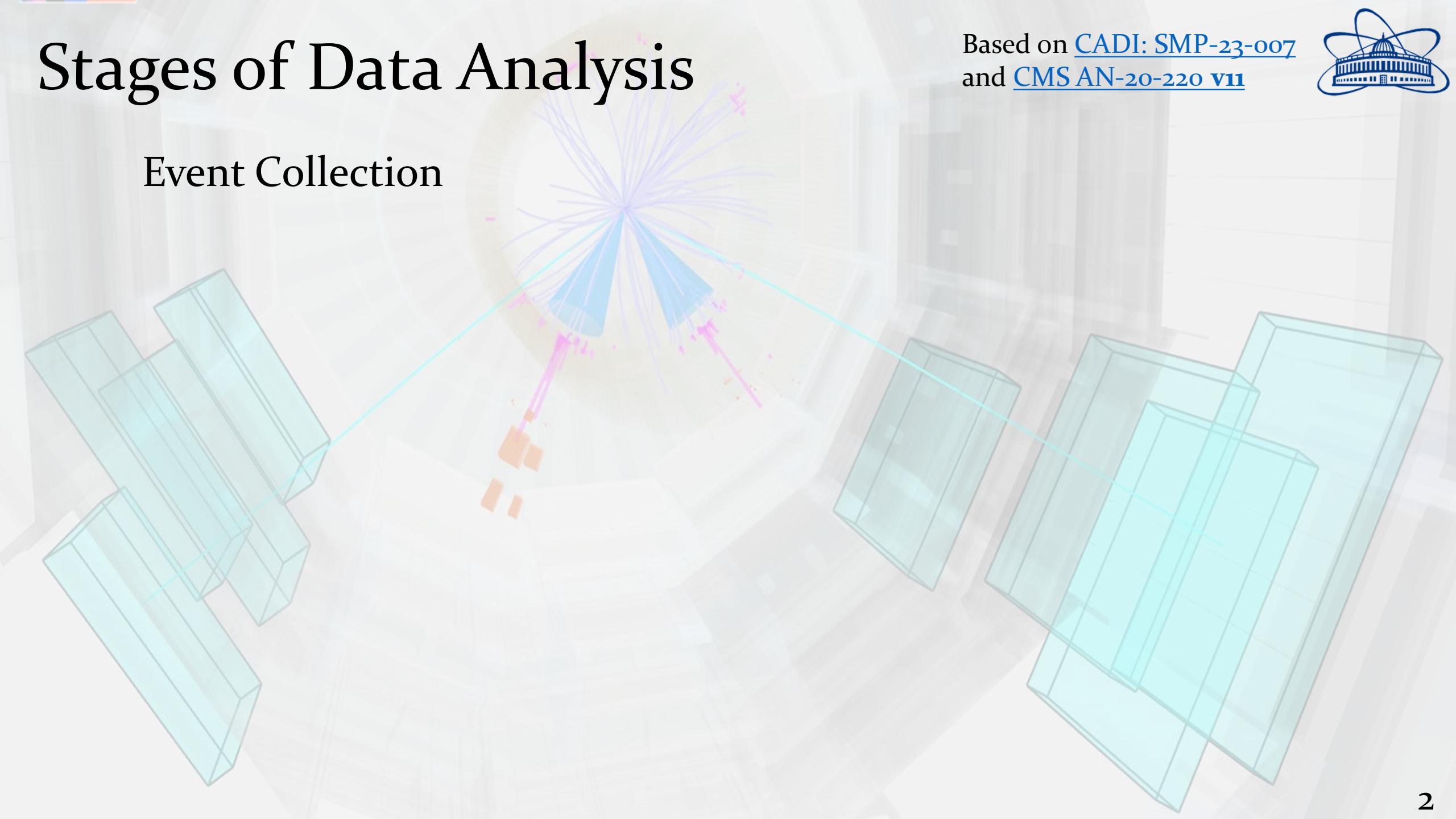
Competition for the JINR Youth Awards 2024

Dubna, 17 December 2024

Stages of Data Analysis

Based on CADI: SMP-23-007
and CMS AN-20-220 **v11**

Event Collection



Stages of Data Analysis

Based on CADI: SMP-23-007
and CMS AN-20-220 **v11**

Event Collection

⬇

Data Certification

Simulation

Stages of Data Analysis

Based on CADI: SMP-23-007
and CMS AN-20-220 **v11**

Event Collection

⬇

Data Certification Simulation

⬇

Event selection

Stages of Data Analysis

Based on CADI: SMP-23-007
and CMS AN-20-220 **v11**

Event Collection

⬇

Data Certification Simulation

⬇

Event selection

⬇

Data and modeling corrections

Stages of Data Analysis

Based on CADI: SMP-23-007 and CMS AN-20-220 **v11**

Event Collection

⬇

Data Certification

Simulation

⬇

Event selection

⬇

Data and modeling corrections

⬇

Measurement

Stages of Data Analysis

Based on CADI: SMP-23-007 and CMS AN-20-220 **v11**

Event Collection

⬇

Data Certification Simulation

⬇

Event selection

⬇

Data and modeling corrections

⬇

Measurement

⬇

Uncertainty estimation

Stages of Data Analysis

Based on CADI: SMP-23-007 and CMS AN-20-220 **v11**

Event Collection

⬇

Data Certification Simulation

⬇

Event selection

⬇

Data and modeling corrections

⬇

Measurement

⬇

Uncertainty estimation

Stages of Data Analysis

Based on CADI: SMP-23-007 and CMS AN-20-220 **v11**

Event Collection

⬇

Data Certification

Simulation

⬇

Event selection

⬇

Data and modeling corrections

⬇

Measurement

⬇

Uncertainty estimation

- Pileup
- Misalignment
- Efficiency
- Prefiring

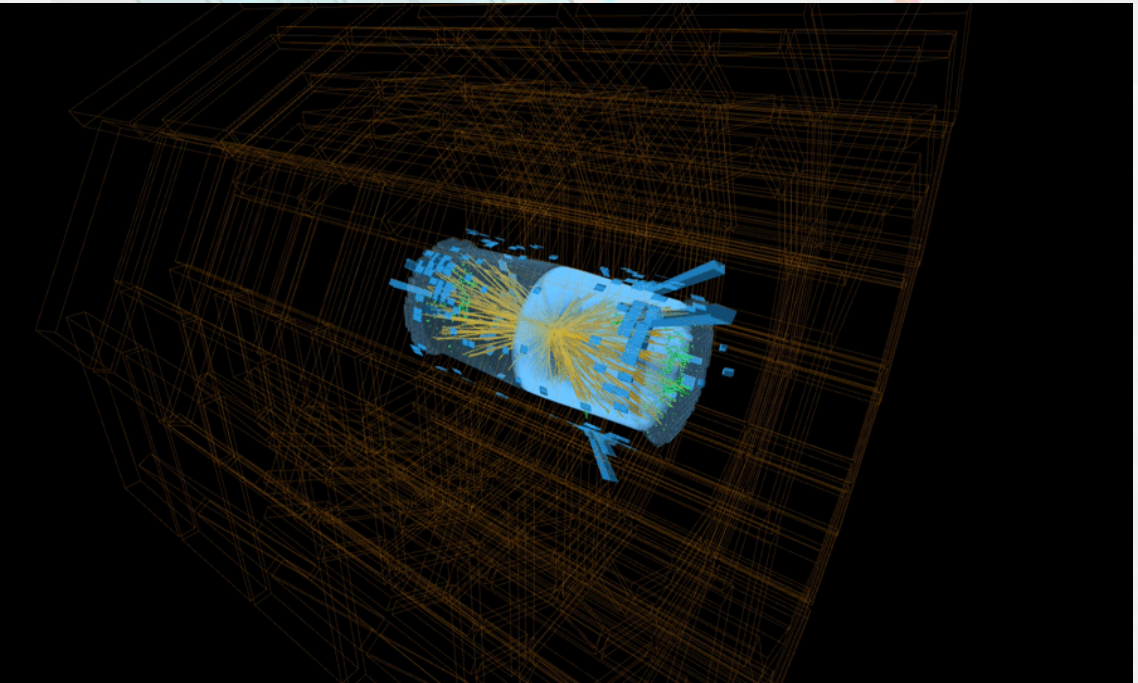
- Integral Luminosity
- PDF and α_S
- Simulation Cross section
- QCD Scale Factors

Pileup

Origin: $L_{inst} \sim 10^{34}\ cm^{-2}s^{-1}$

- Bunch crossing (BX) every **25 ns**
- ~**60-70** pp-collisions per BX
- ~ **60** charged particles per pp-collision

~**1500-2000** charged particles per BX or $\mathbf{10^{11}}$ per second



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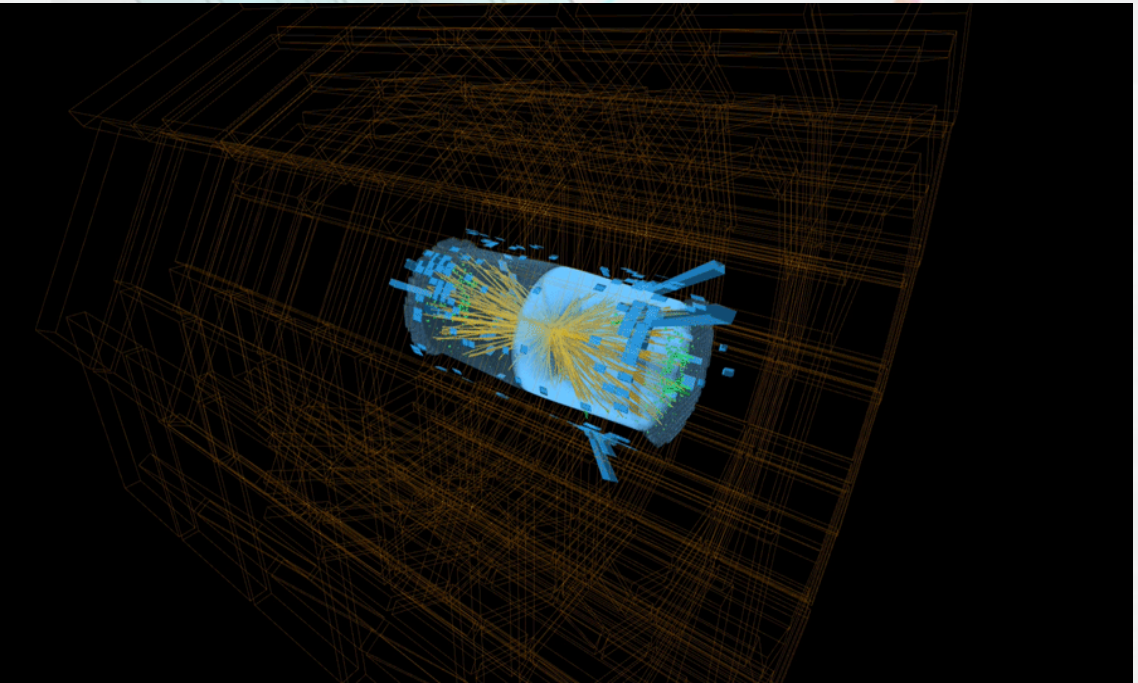
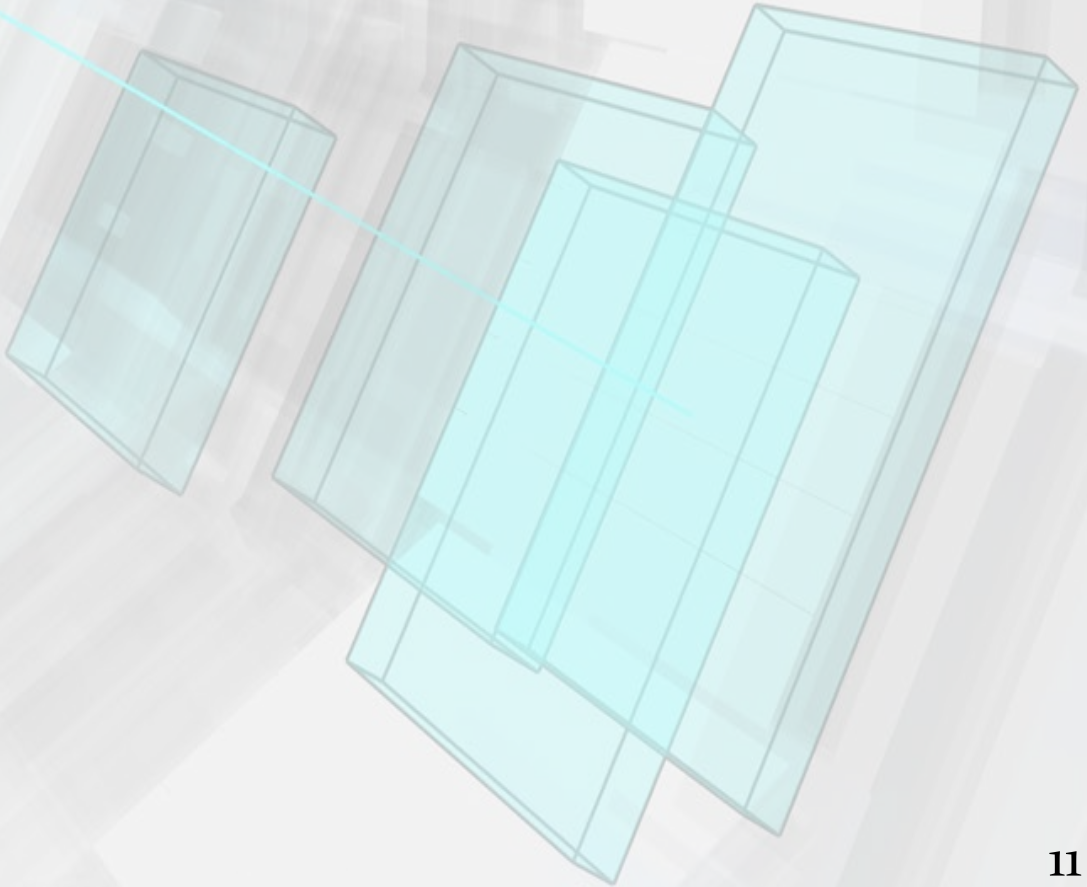


Correction: Average pileup is reweighted in MC in according with Data



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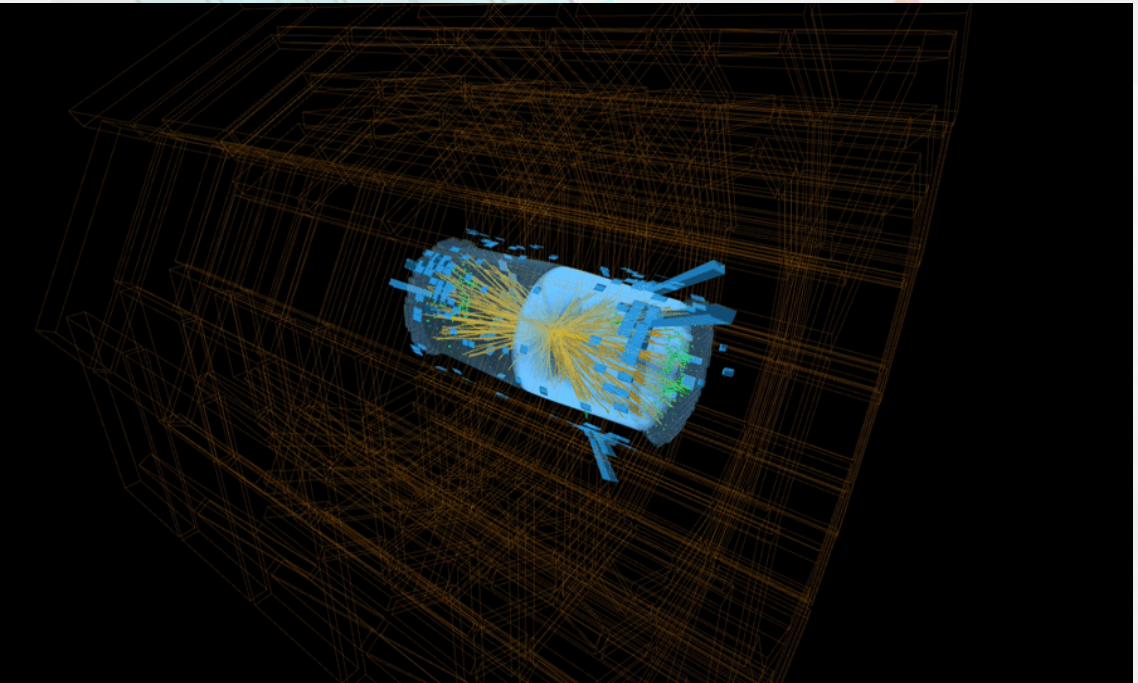

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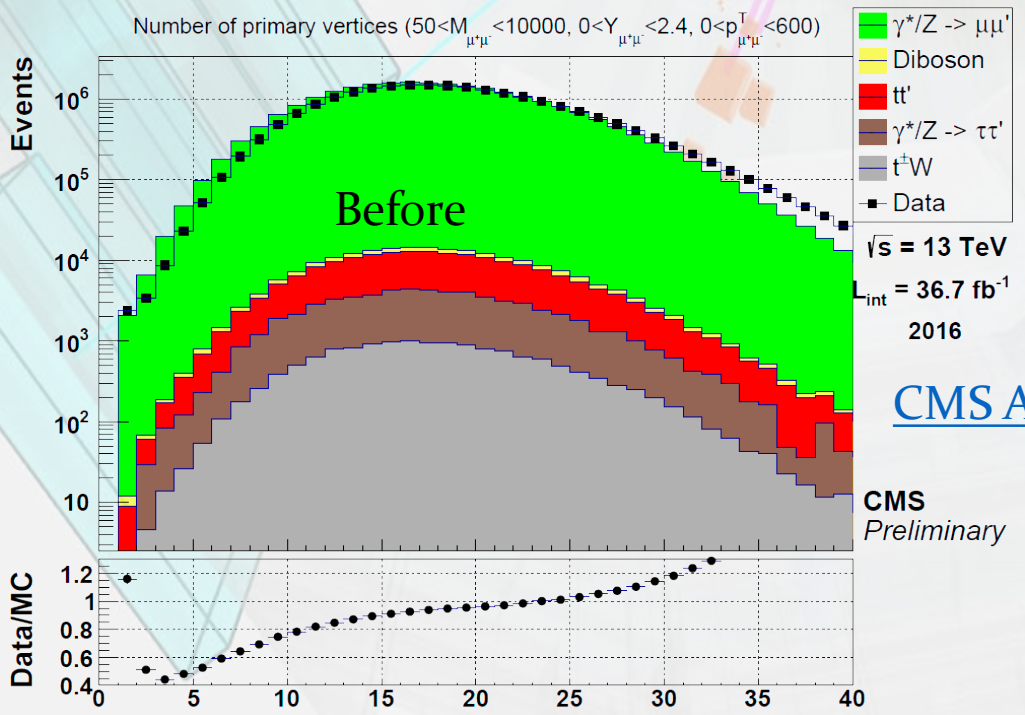

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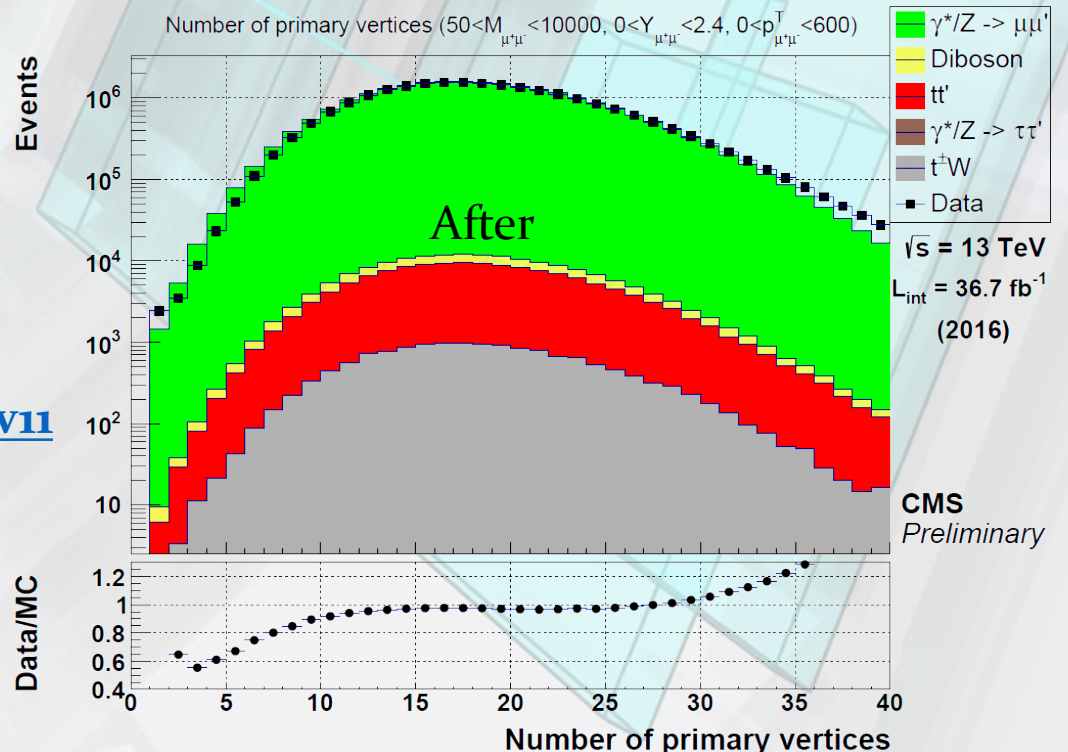
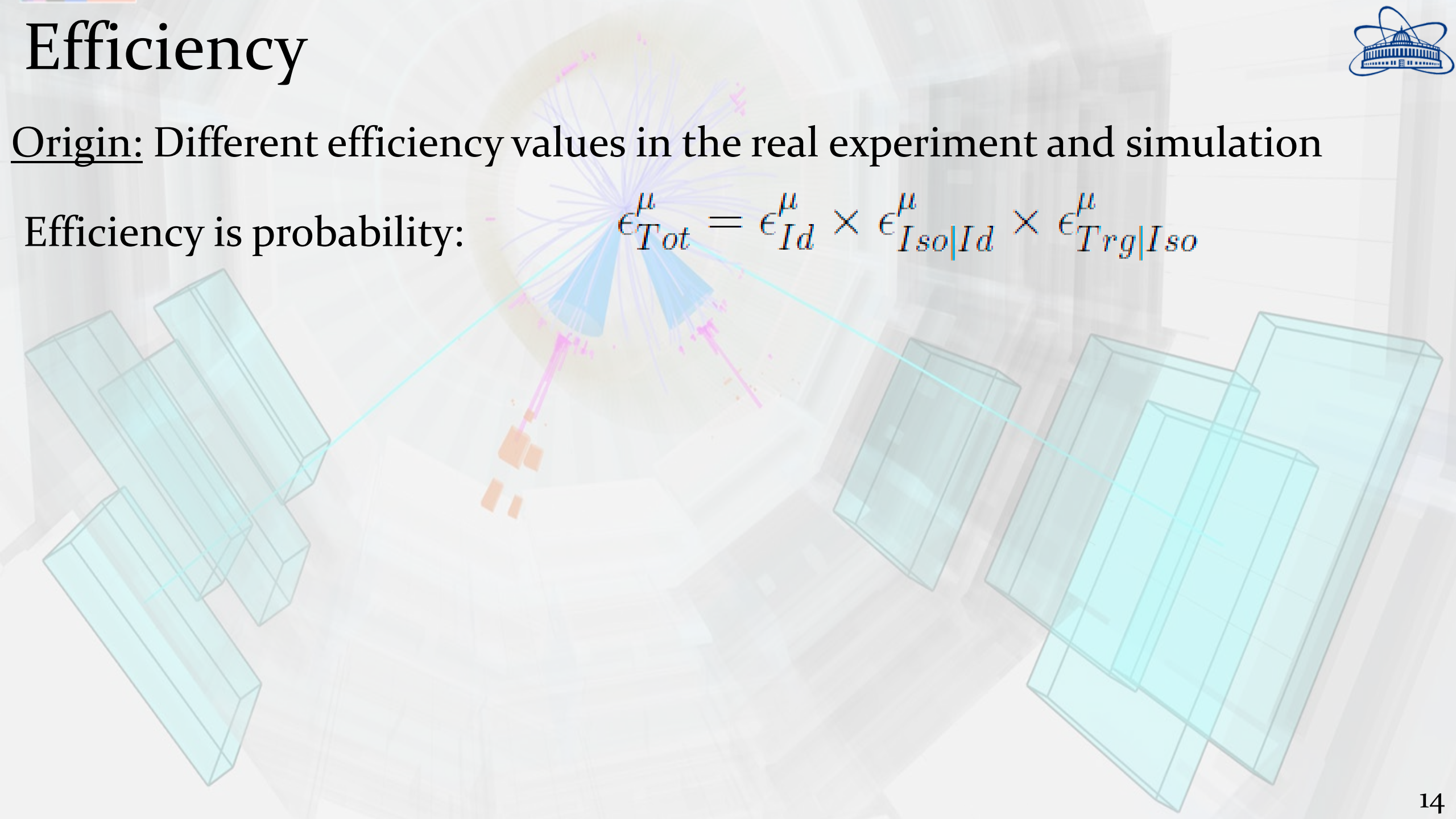


Efficiency

Origin: Different efficiency values in the real experiment and simulation

Efficiency is probability: $\epsilon^{\mu}_{Tot} = \epsilon^{\mu}_{Id} \times \epsilon^{\mu}_{Iso|Id} \times \epsilon^{\mu}_{Trg|Iso}$



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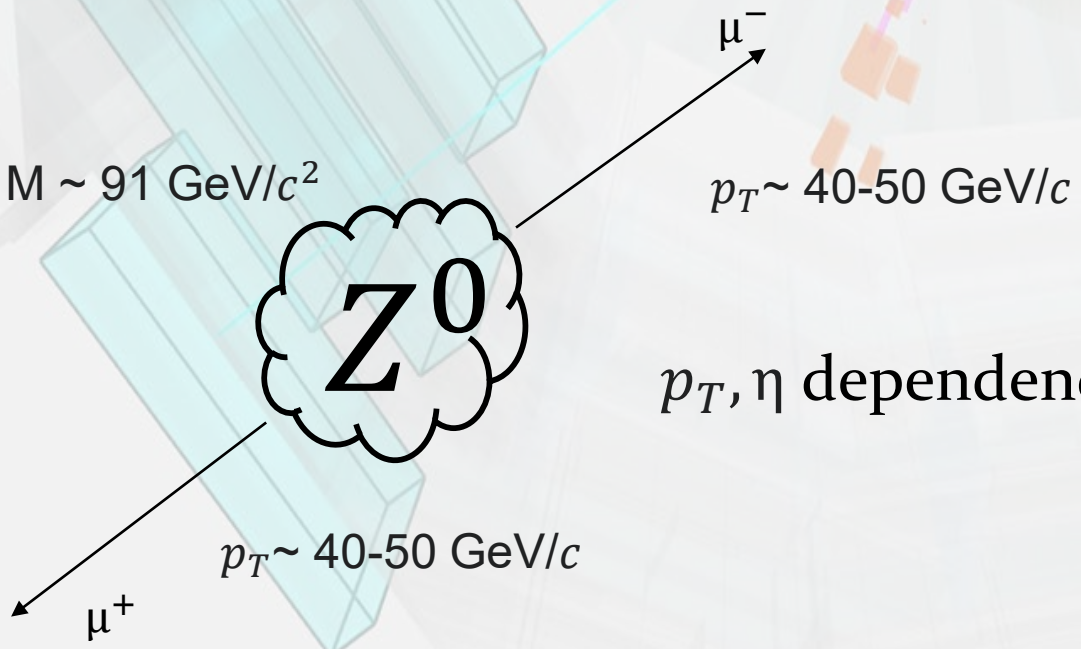

p_T, η dependence!

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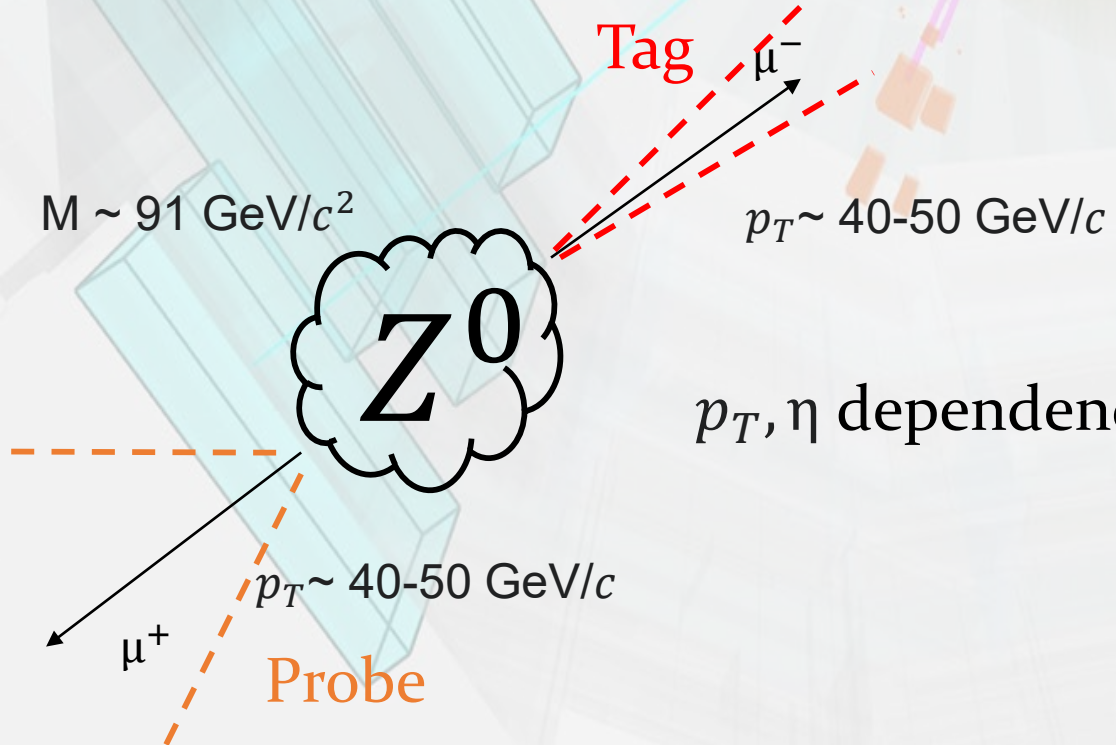

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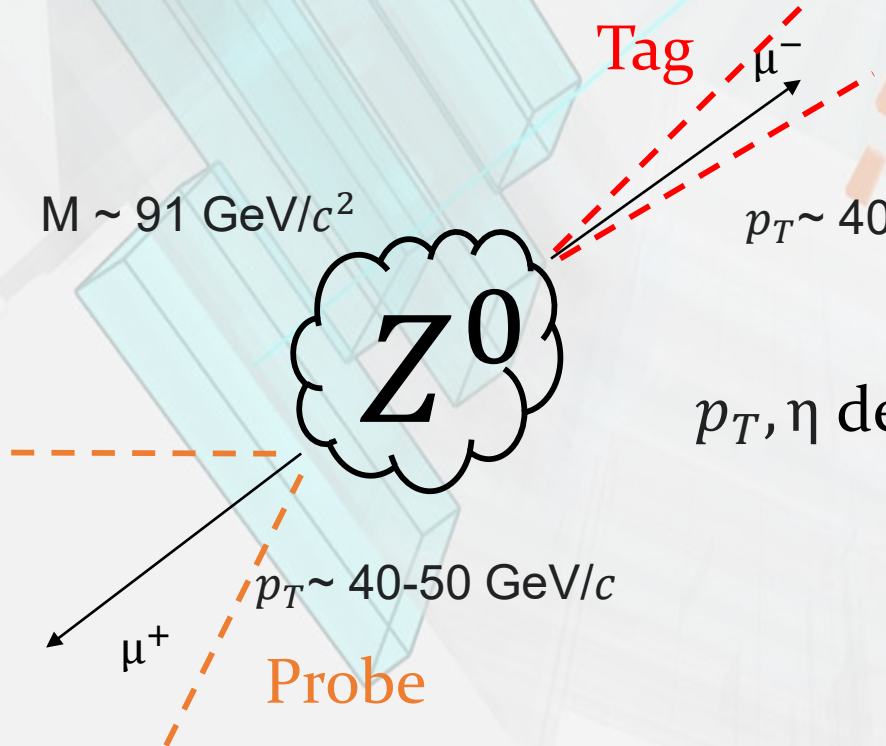


p_T, η dependence!

Uncertainty: Variation each of weights. Sum in quadrature

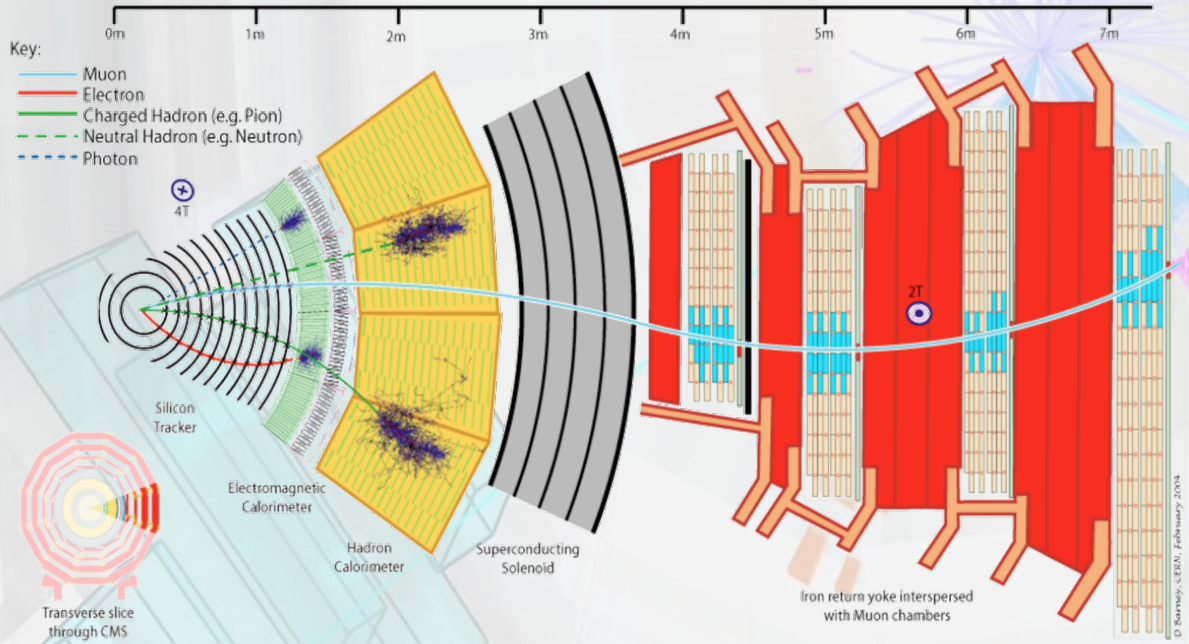
$$\Delta = \sqrt{\sum_{k}^{N} \delta_k^2}$$

- A_i^k - Variated value of A_i coefficients results from variation of uncertainty source
- A_i^0 - central value of A_i coefficient

Most significant type of uncertainty!

Misalignment

Origin: Non-accuracy of detector model



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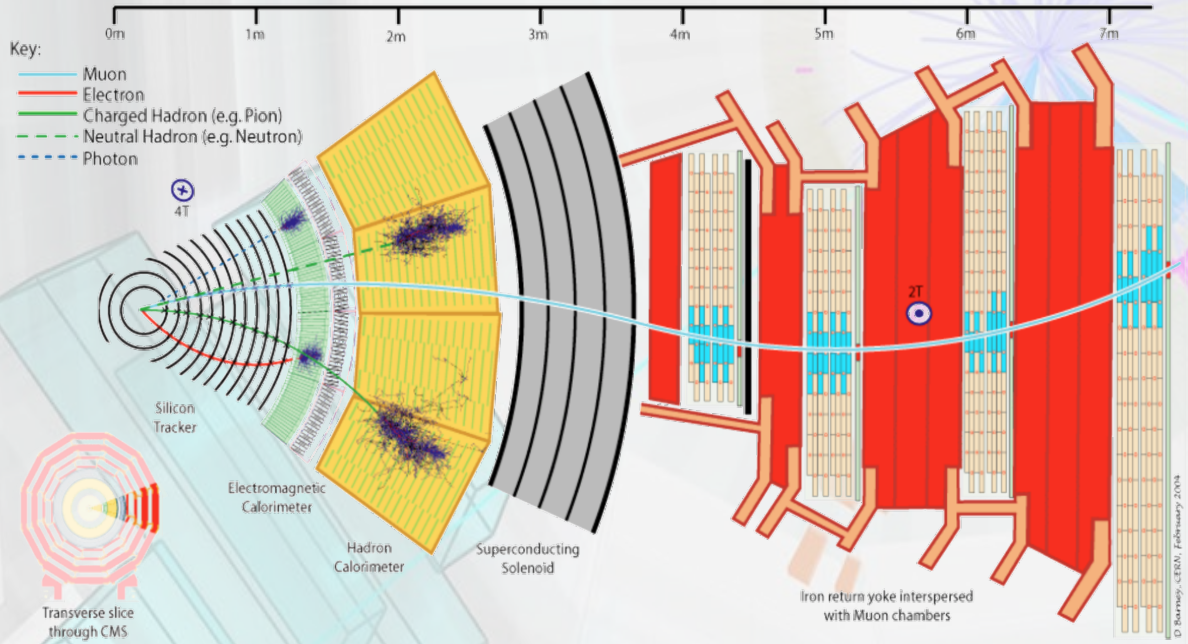

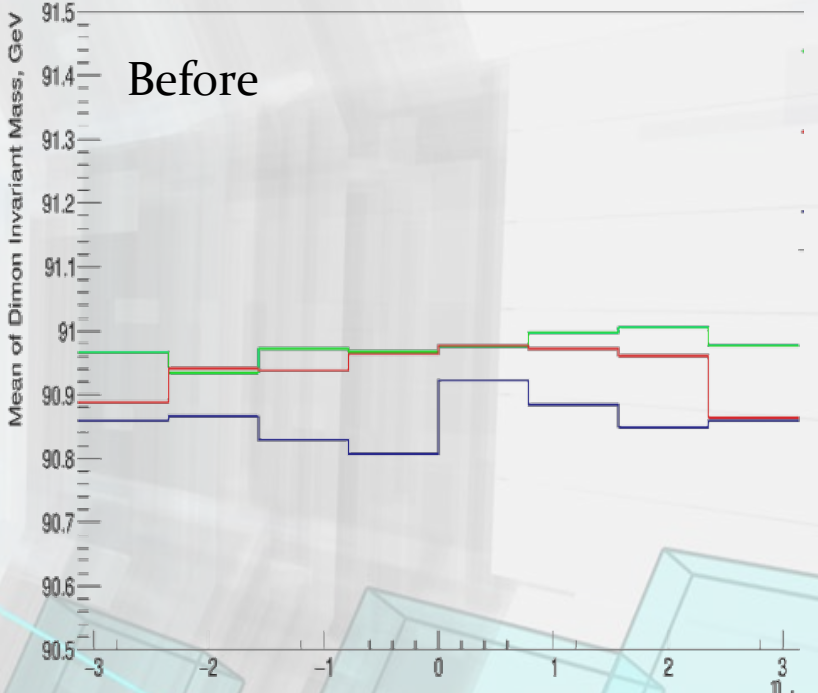

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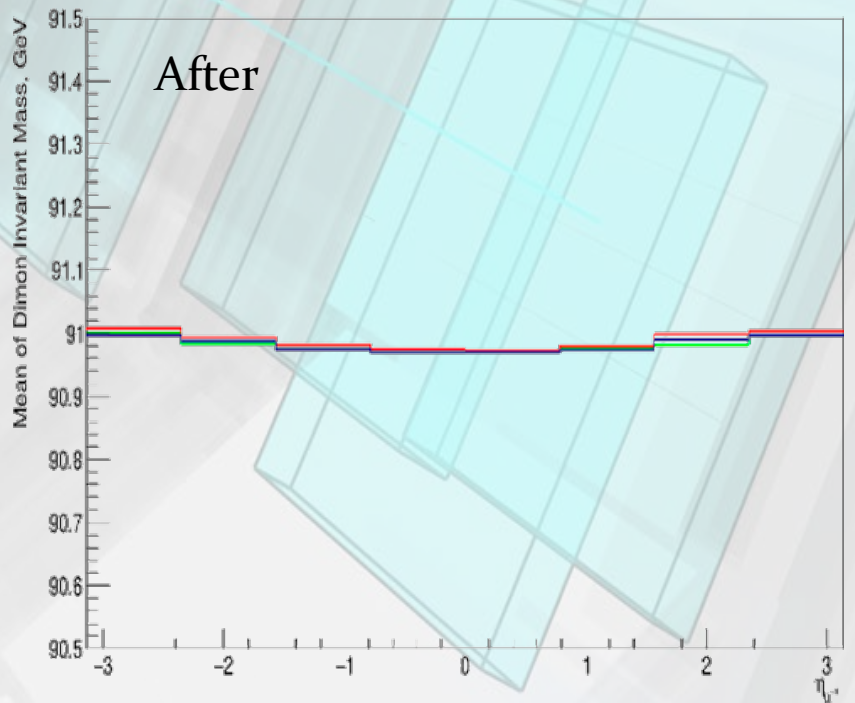

Correction: Tag & Probe with Rochester correction (Eur. Phys. J. C 2012. V. 72, P.)

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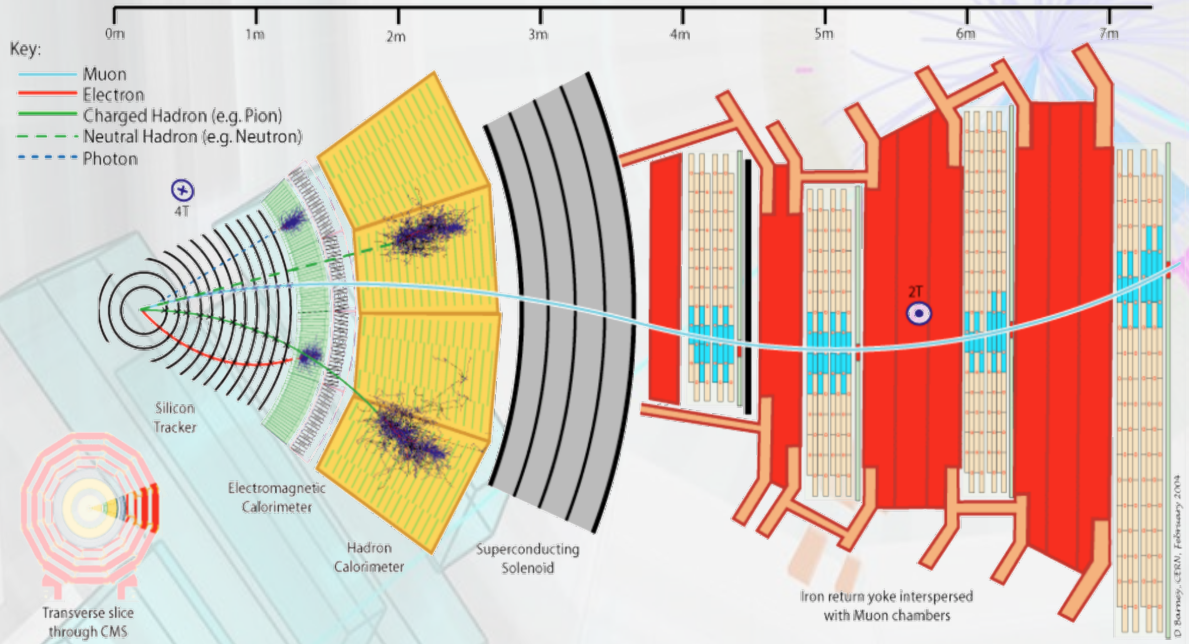
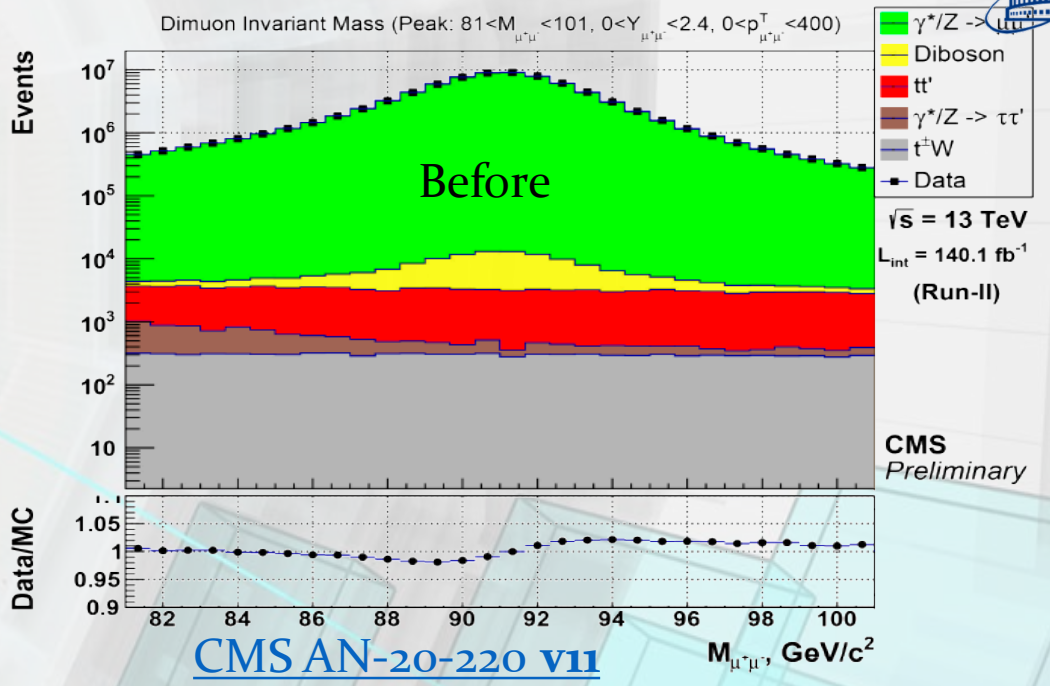
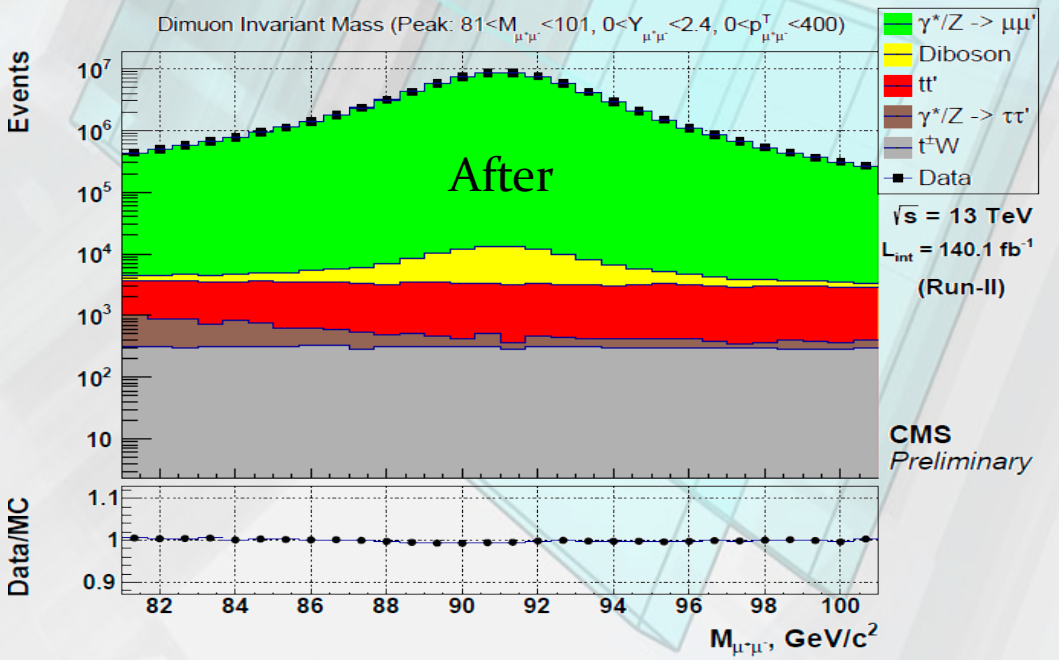




CMS AN-20-220 v11



Correction: Tag & Probe with Rochester correction (Eur. Phys. J. C 2012. V. 72, 2194.)

Misalignment

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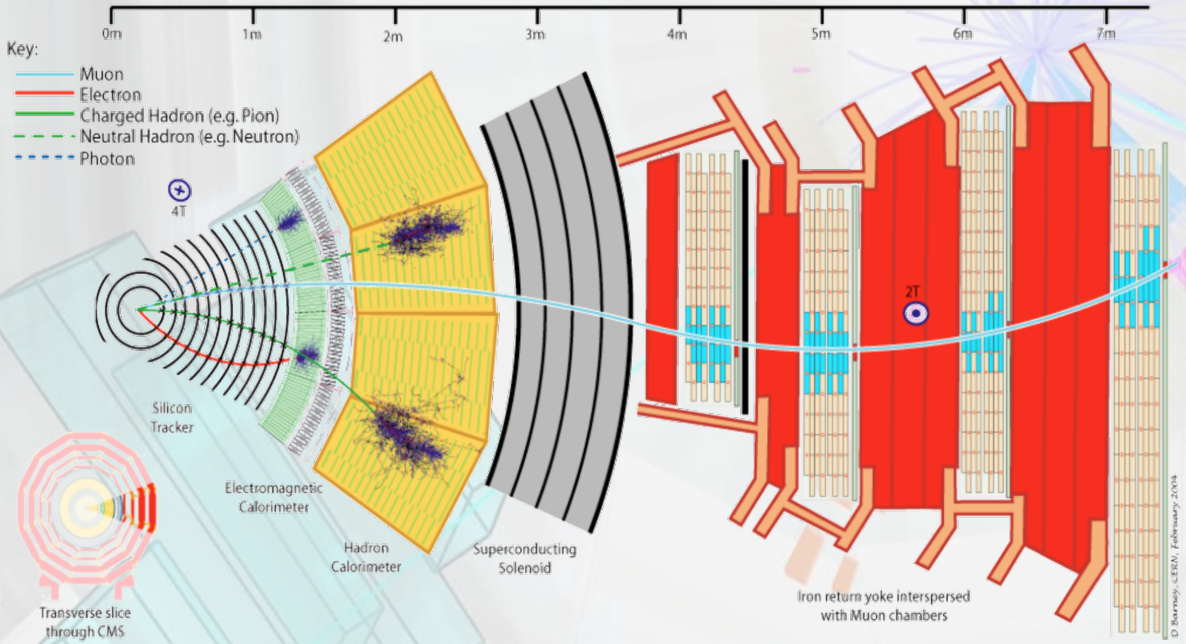
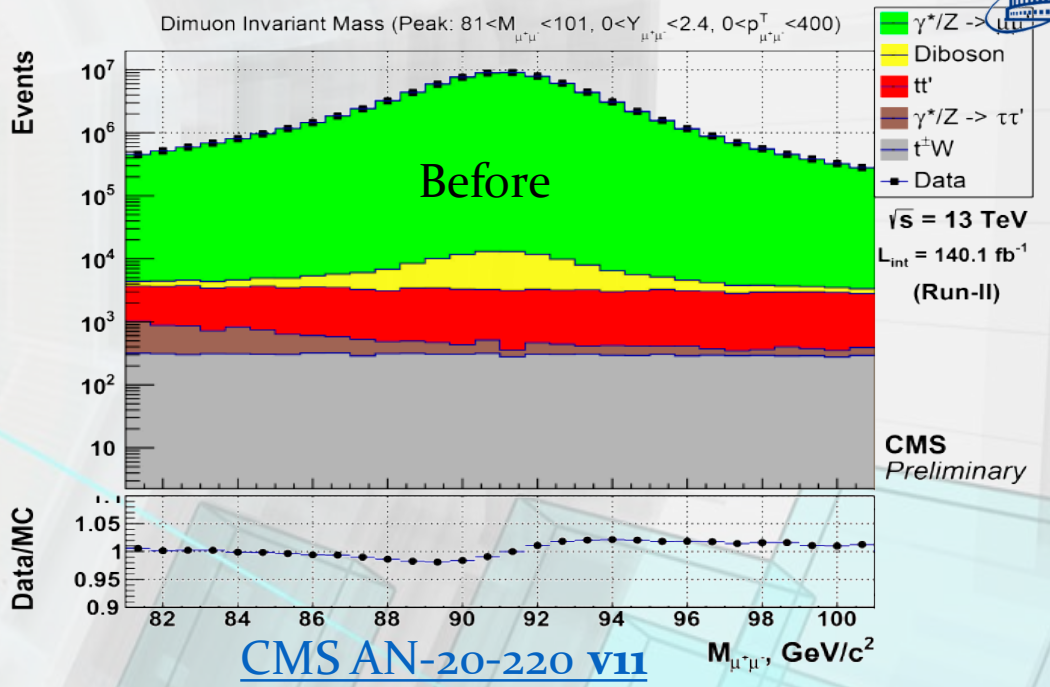
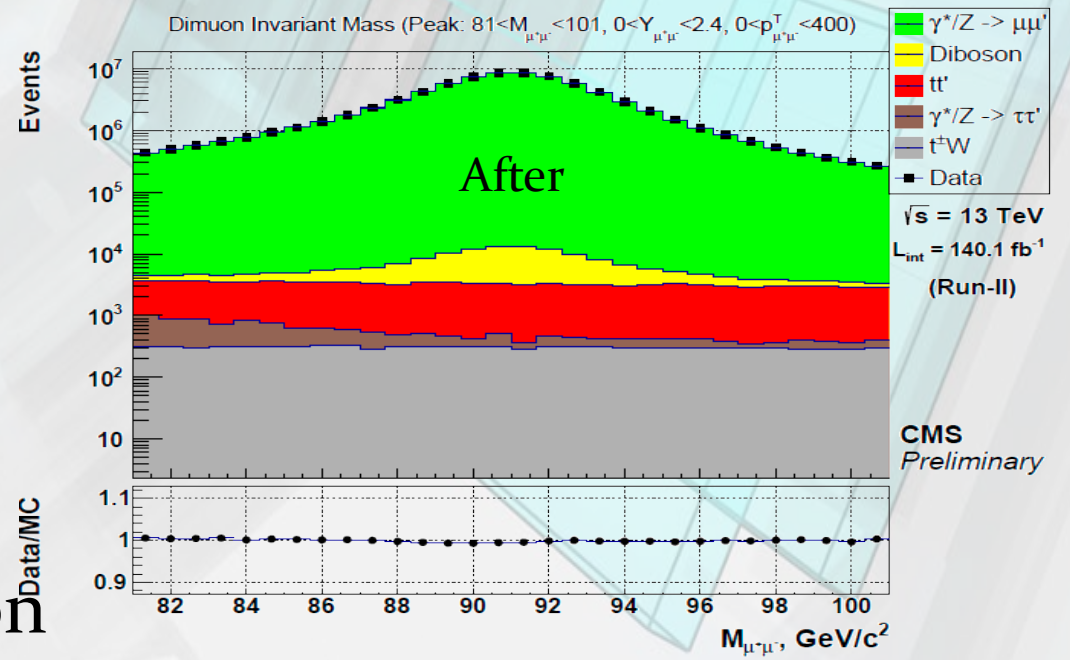




CMS AN-20-220 v11



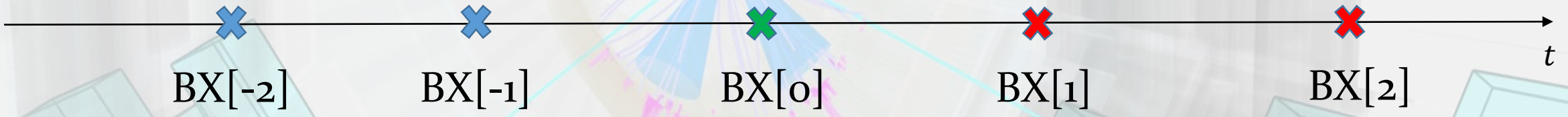
Correction: Tag & Probe with Rochester correction (Eur. Phys. J. C 2012. V. 72, 2194.)

Uncertainty: 100 "toys" and RMS calculation

Prefiring

Origin: L_{inst} ~10^{34} $cm^{-2}s^{-1}$ and L1 Trigger time desynchronization

Normal Case:



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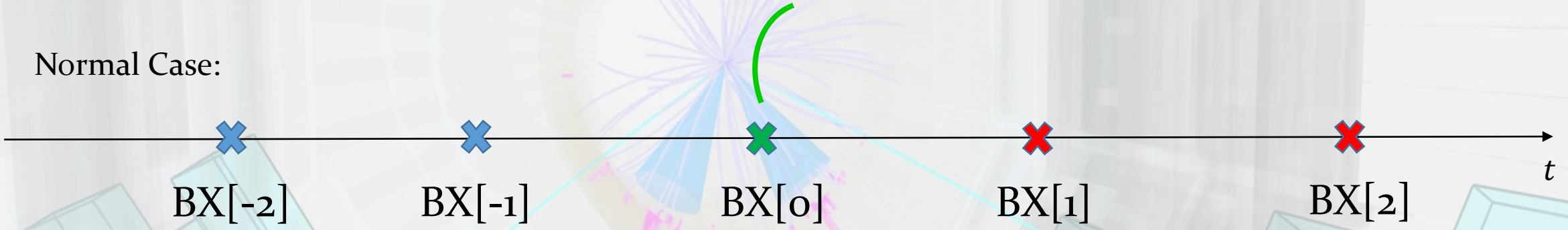
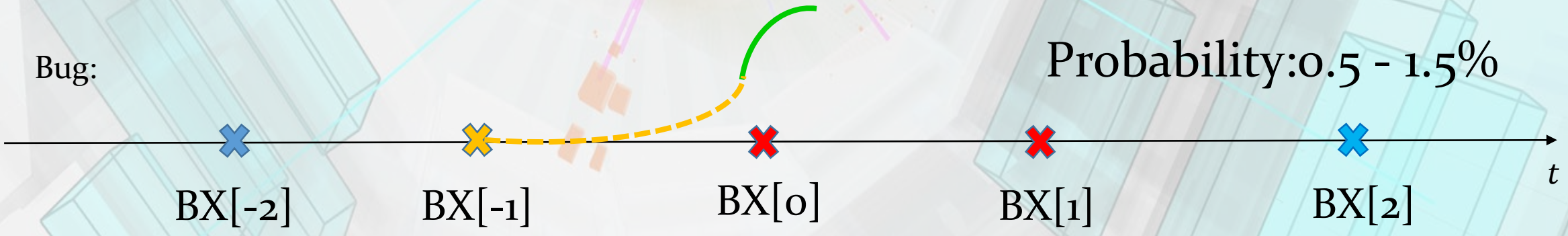


Bug:

Probability:0.5 - 1.5%



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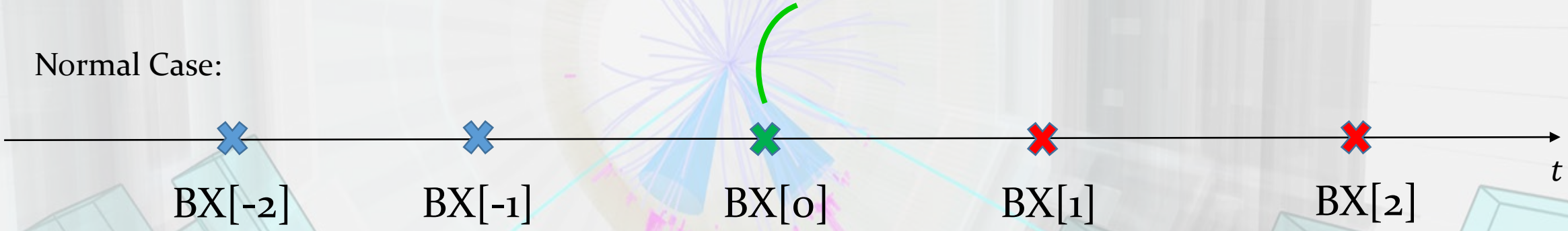

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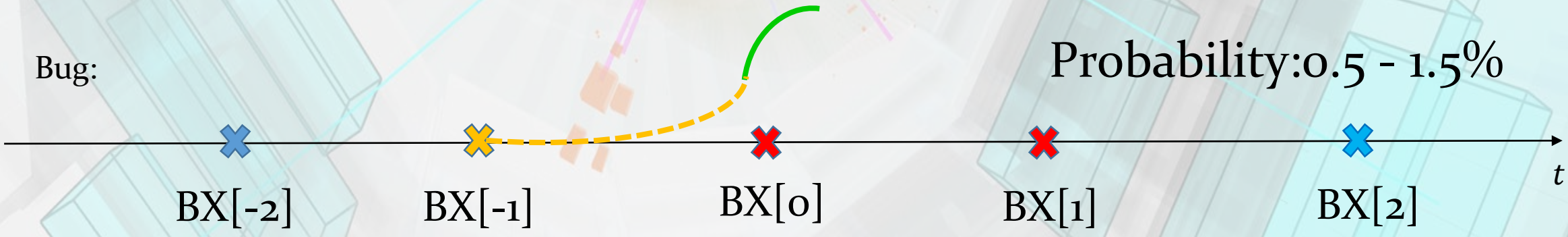
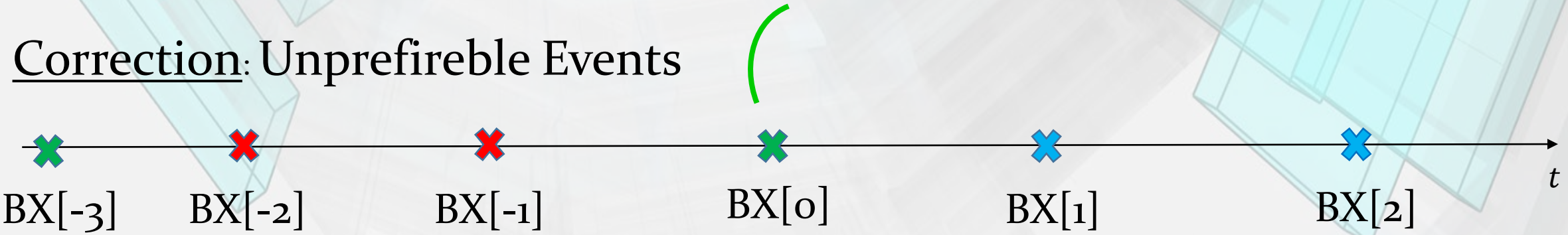


Correction: Unprefireble Events



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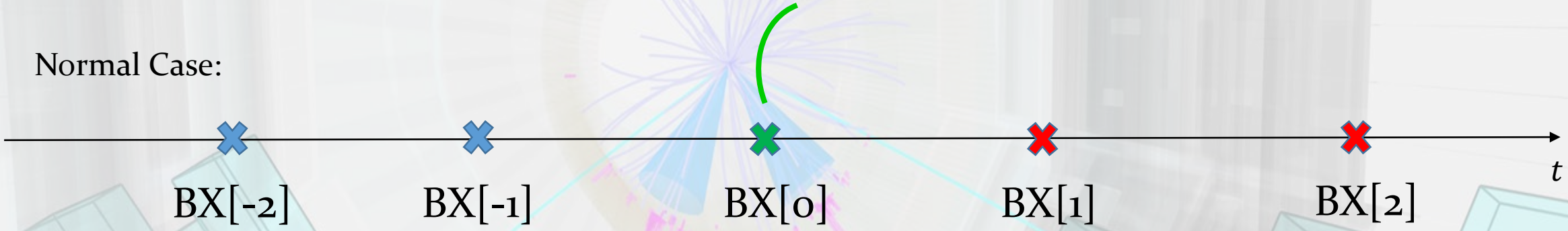
Normal Case:



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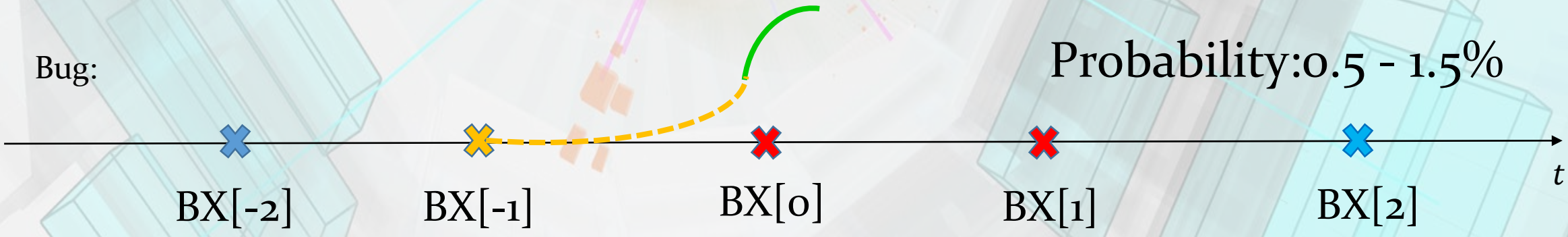
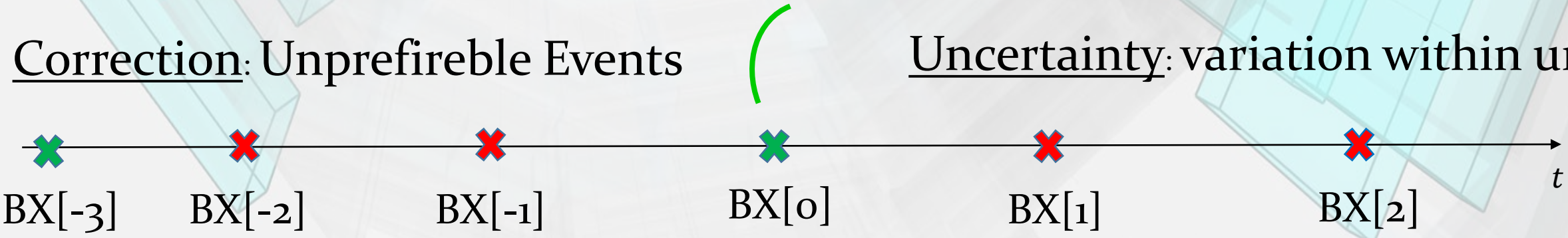


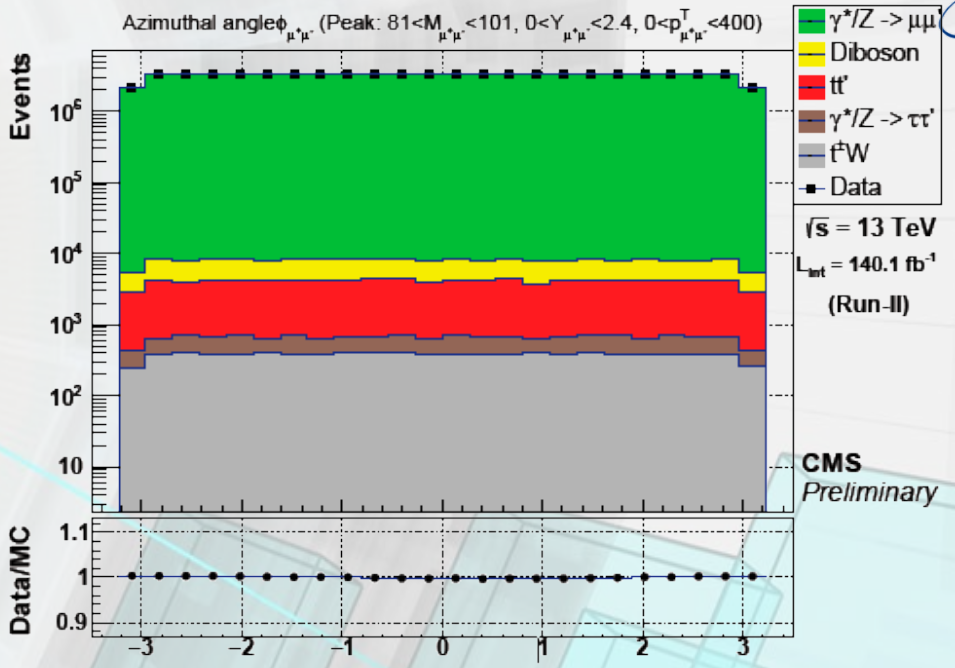
Correction: Unprefireble Events

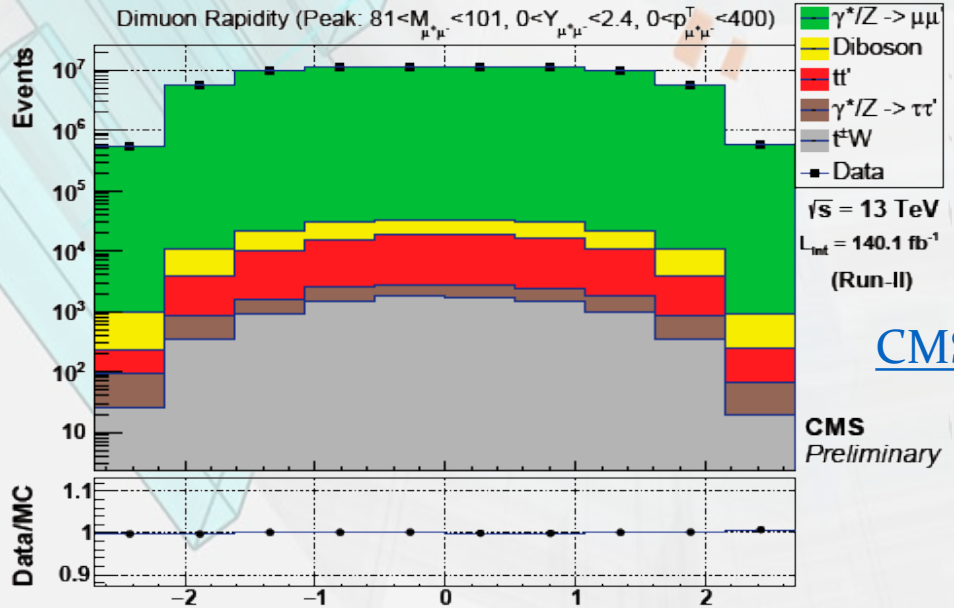
Uncertainty: variation within unc.



Conclusions

- Effects of difference between data and simulation are constantly being studied and could be successfully corrected.
- In analysis SMP-23-007 this steps are successfully done. Good agreement between data and MC is observed
- The results is the basis for PhD thesis





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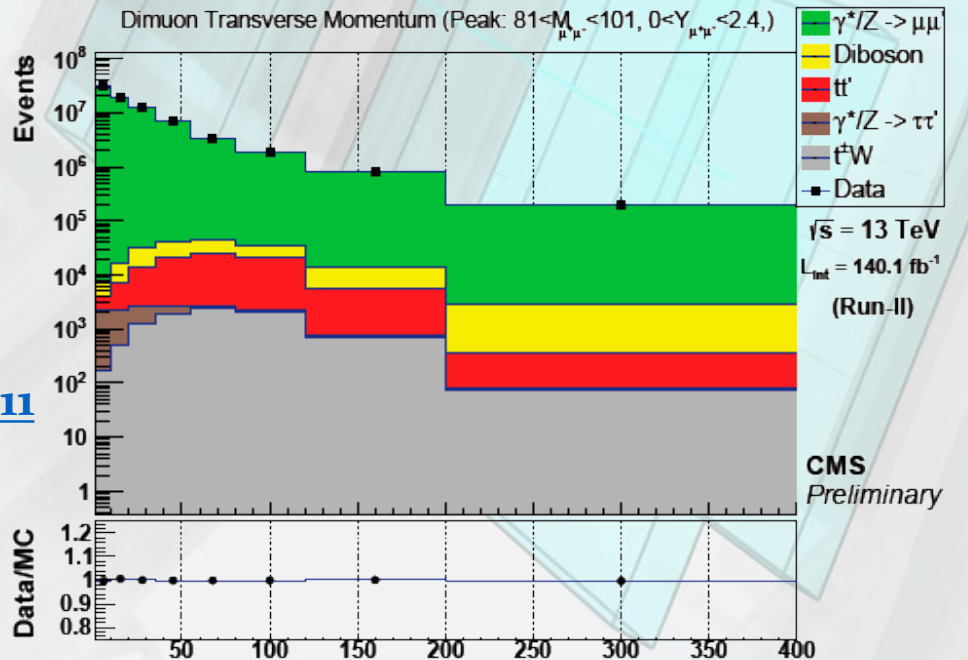

Curriculum Vitae

Name: Vladislav Shalaev

Education: Ms. of Science, Dubna State University (2018)

Position: Research fellow

Department: НЭОФCMS, VBLHEP

Length of work: 8 y. (VBLHEP JINR)

Supervisor: Dr. Sergei Shmatov

PhD Thesis (in progress): The Drell-Yan Angular Coefficients in pp collisions at $\sqrt{s}$ = 13 TeV as a function of transverse momentum and rapidity

Work Field: Standard Model Physics, LHC, CMS, Data processing.

Publications: 10 as the main author. 279 as CMS collaboration co-author

Publications (on the report materials):

My Role: The main author. The main performer of the work

1. **В.В. Шалаев**, И.Н. Горбунов, С.В. Шматов. Оценка влияния эффектов высших порядков КХД на значения угловых поляризационных коэффициентов в процессе Дрелла-Яна в условиях LHC. *Физика ядра и элементарных частиц* – Т. 55. – 2024. – С. 252–262. https://doi.org/10.1134/S1063779624010143

2. **V. Shalaev**, I. Gorbunov "The Drell-Yan Angular Coefficients in pp collisions at $\sqrt{s}$ = 13 TeV as a function of transverse momentum and rapidity" CMS Draft Analysis Note, 15.10.2024, (CMS AN-20-220 **v11**)

3. **V. Shalaev**, I. Gorbunov "The Drell-Yan Angular Coefficients in pp collisions at $\sqrt{s}$ = 13 TeV as a function of transverse momentum and rapidity", CMS Paper Draft **v8**, 15.10.2024 (CADI: SMP-23-007)