

## Questions

1. Can we use software metrics references to effectively assess the maintainability of a large scale physics software system?
2. Can statistical methods drive us to select proper software metrics for Geant4?

## Background

- We adopted software quality standard, ISO/IEC 25010:2011 (former ISO/IEC 9126) [1], to identify software characteristics related to the maintainability factor.
- We identified and assessed software metrics tools to collect a large number of measurements of software characteristics [2].
- We exploited a set of product metrics to assess the code status [2].

## Methodology

**STEP1** get access to the Geant4 web site  
<https://geant4.web.cern.ch/geant4/support/download.shtml>

Checkout Geant4 releases  
 10.0.4, 10.1.3, 10.2.1

**STEP2** loading of the Geant4 source code into **Imagix 4D**



Metrics measurement  
 Imagix 4D processing 8.0.4

**STEP3** saving of all the collected data at different levels of granularity

Data collection  
 @file, @directory, @class, @function,  
 @namespace, @variable

**STEP4** addition and removal of fields in the cvs files

Data manipulation

**STEP5** application of different statistical methods using R packages, such as **ineq** and **randtests**

Statistical analysis  
 trend, inequality, diversity, concentration,  
 change point

**STEP6** selection of references among relevant peer-reviewed papers, conference proceedings and technical reports [3]

References collection for C++  
 size, coupling, inheritance, control-flow  
 structuredness, cohesion, staticness

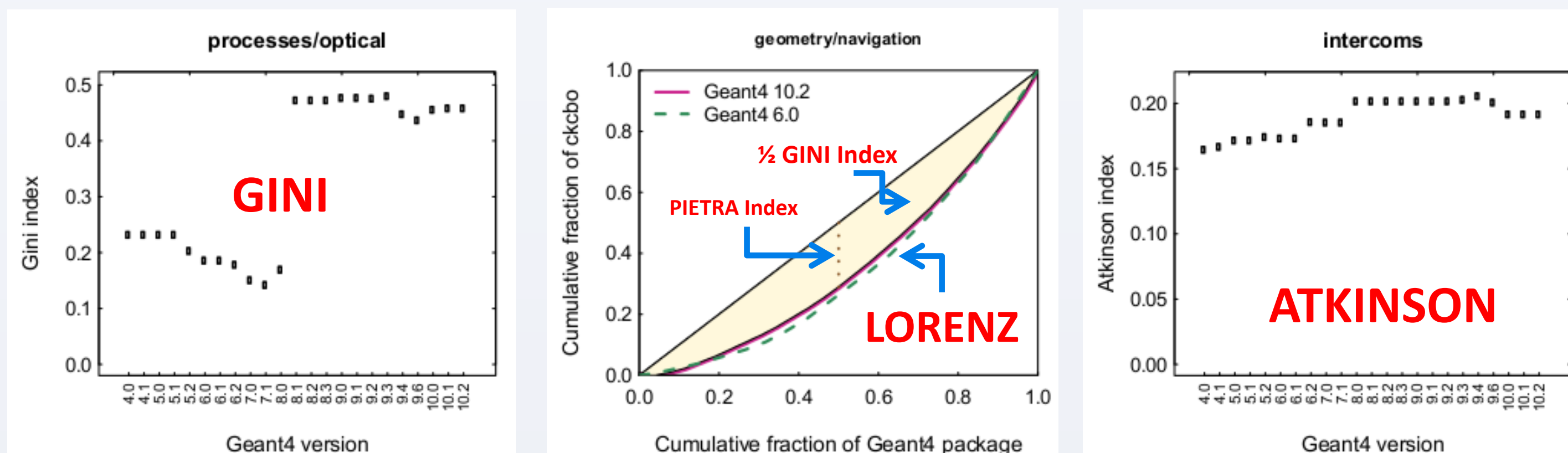
**STEP7** comparison of the Geant4 measures with the references

Maintainability assessment

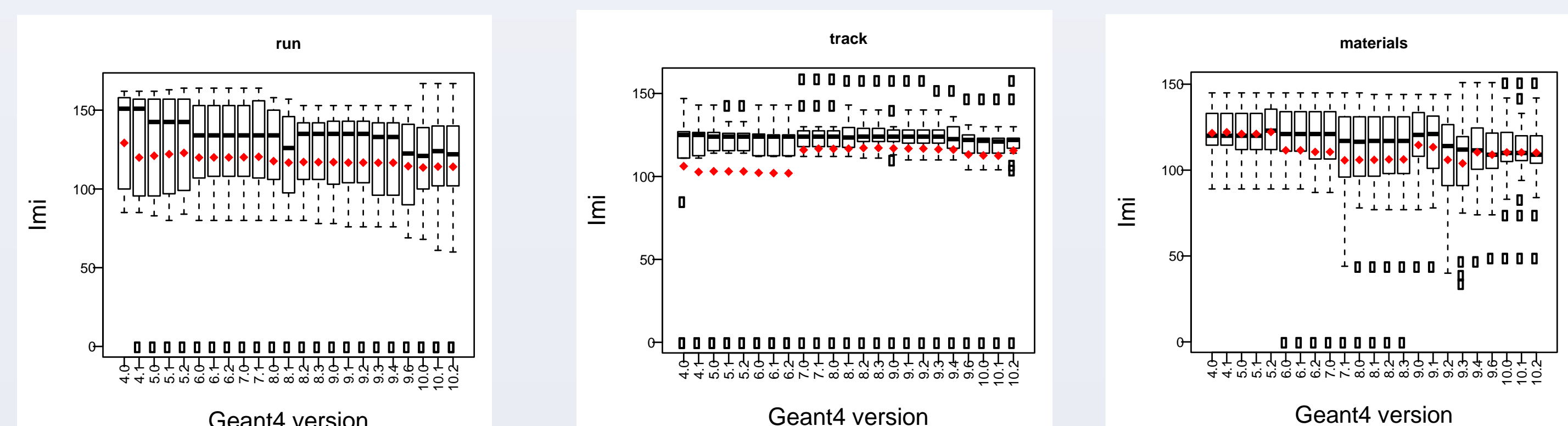
## A sample of results

Acronym	Ref.	Source
DIT (Depth of Inheritance Tree)	6	M. Lorenz and J. Kidd, <i>Object Oriented Metrics</i> , Englewood, NJ: Prentice Hall, 1994
	7	McCabe
RFC (Response For a Class)	2.88	R. Malhotra and A. Jain Bansal, <i>Fault prediction considering threshold effects of object-oriented metrics</i>
	<100	L. H. Rosenberg, <i>Applying and Interpreting Object-Oriented Metrics</i> , Proc. Software Technology Conf.
WMC (Weighted Methods per Class)	[1,20] good [21, 100] moderate high values >100 very high values	NASA SATC
	<100	L. H. Rosenberg and T. Hammer and J. Shaw, <i>Software Metrics and reliability</i>
CBO (Coupling Between Object class)	<5	L. H. Rosenberg, <i>Applying and Interpreting Object-Oriented Metrics</i> , Proc. Software Technology Conf.
	<7	R. Malhotra and A. J. Bansal, <i>Fault prediction considering threshold effects of object-oriented metrics</i>
NC (Number of Children)	3	McCabe
NMM (Number of Member Methods)	<=20	<a href="#">CppDepend</a>
MI (Maintainability Index)	<65 poor maintainability [65, 84] fair maintainability >=85 excellent maintainability	Coleman and Lowther and Oman, <i>The application of software maintainability models on industrial software systems</i>
MCMCC (McCabe's Maximum Cyclomatic Complexity)	[1, 10] low cc [11, 15] medium cc [16-30] high cc >31 very high cc	<a href="#">CppDepend</a>
	[1, 10] low cc [11, 20] medium cc [21, 50] high cc >51	McCabe

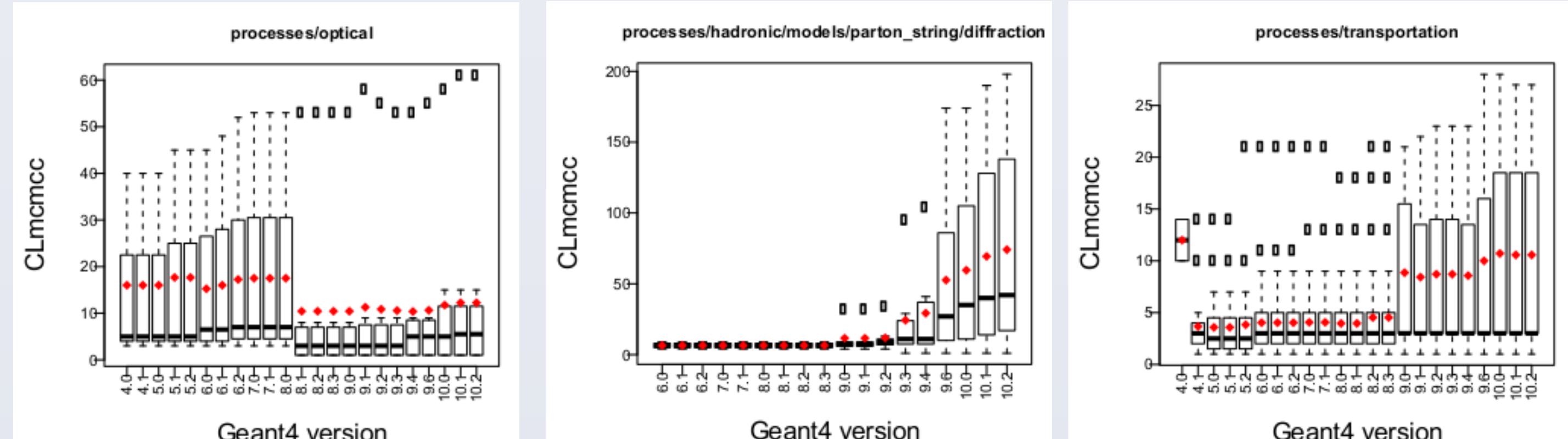
## Inequality measures:



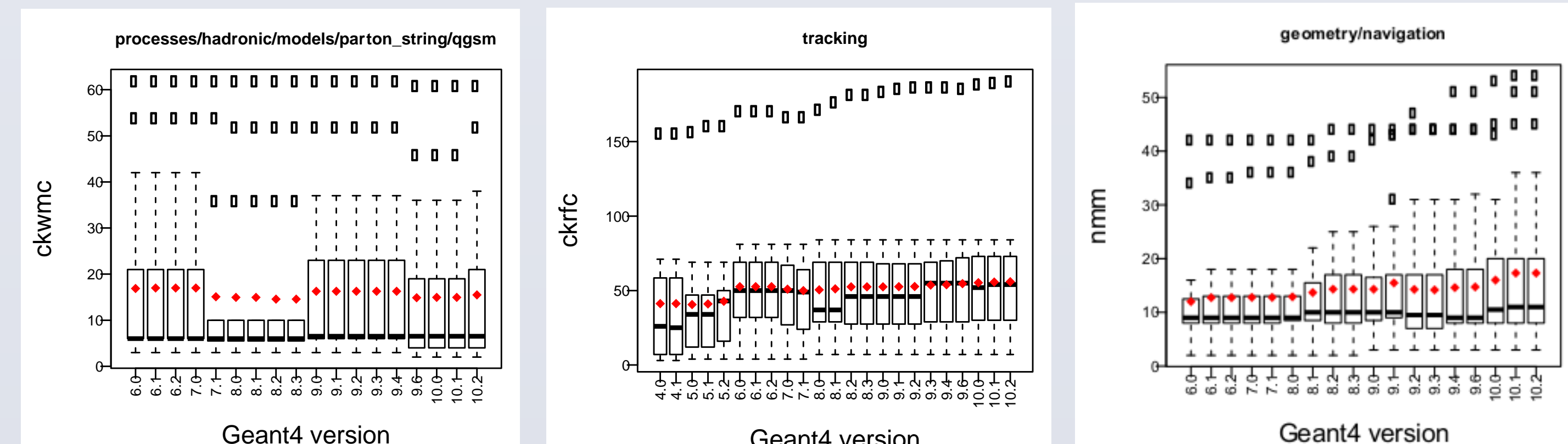
## A Maintainability Index:



## Maximum McCabe Cyclomatic Complexity at class level:



## A subset of Chidamber and Kemerer object-oriented metrics:



## Conclusion

- The use of metrics references contributes to interpret the internal quality of Geant4 software.
- Further investigation is in progress to identify appropriate ranges of metric values for scientific software.
- Statistical methods are valuable to identify the set of metrics that are most significant for a given Geant4 package.
- In future work we are going to explore other econometric/ecology concepts and techniques for the analysis of metrics data.

## References

- [1] [ISO/IEC 25010:2011](#)
- [2] E. Ronchieri, M. G. Pia, F. Giacomini. *Software Quality Metrics for Geant4: An initial assessment*. Presented at ANS RPSD 2014, Knoxville, TN. Included on CD-ROM of American Nuclear Society. Place of publication: <https://arxiv.org/abs/1608.02008v1>
- [3] E. Ronchieri, M. G. Pia, F. Giacomini. *First statistical analysis of Geant4 quality software metrics*. J. Phys. Conf. Series, vol. 664, p. 062053, 2015
- [4] E. Ronchieri, M. Canaparo. *A Preliminary Mapping Study of Software Metrics Thresholds*. Proc. of [ICSOFT-EA 2016](#): 232-240

## Acknowledgements

The authors thanks **Francesco Giacomini** for technical discussions and **INFN CCR** for partly funding this work. We also thank the **Imagix Corporation** that provided an extended free full license of Imagix 4D for performing this work and **CERN library** for providing papers and books.

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