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CHROMIE: a new High-rate telescope. Detector simulation and commissioning

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on behalf of the CMS collaboration

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Abstract: The upgrade of the LHC to the High-Luminosity LHC (HL-LHC) is expected to increase the current instantaneous luminosity by a factor of 5 to 7, providing the opportunity to study rare processes and precision measurement of the standard model parameters. To cope with the increase in pile-up (up to 200), particle density and radiation, CMS will build new silicon tracking devices with higher granularity (to reduce occupancy) and improved radiation hardness. During the R&D period, tests performed under beam are a powerful way to develop and examine the behavior of silicon sensors in realistic conditions. The telescopes used up to now have a slow readout ($< 10\ kHz$) for the needs of the CMS experiment, since the new outer-tracker modules have an effective return-to-zero time of 25 ns (corresponding to a 40 MHz frequency) and a trigger rate of 750 kHz. In order to test the CMS Tracker modules under the LHC nominal rate, a new pixel telescope named CHROMIE (CMS High Rate telescOpe MachInE) was designed, built and commissioned at CERN for beam tests with prototype modules for the CMS Phase-II Tracker upgrade. It is based on 16 CMS Phase-I Barrel Pixel modules of the same type as the ones used in the current CMS pixel detector. In this talk, the design of CHROMIE, the calibration of its modules, and its timing and synchronization aspects are presented, along with the first beam test results. In addition, the tracking algorithm developed for CHROMIE and a preliminary simulation study for the estimation of energy loss of primary particles, cluster multiplicity and spatial resolution are discussed.

Keywords: Detector modelling and simulations (interaction of radiation with matter), Interaction of radiation with matter, Radiation-hard detectors, Solid state detectors, Particle tracking detectors (Solid-state detectors), Detector alignment and calibration methods (particle-beams), Detector design and construction technologies and materials

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Contents

1 Some examples and best-practices

For internal references use label-refs: see section 1. Bibliographic citations can be done with cite: refs. [1–3]. When possible, align equations on the equal sign. The package `amsmath` is already loaded. See (1.1).

$$\begin{aligned} x &= 1\,, \qquad y = 2\,, \\ z &= 3\,. \end{aligned} \tag{1.1}$$

Also, watch out for the punctuation at the end of the equations.

If you want some equations without the tag (number), please use the available starred-environments. For example:

$$x = 1$$

The amsmath package has many features. For example, you can use use `subequations` environment:

$$a = 1 \tag{1.2a}$$
$$b = 2 \tag{1.2b}$$

and it will continue to operate across the text also.

$$c = 3 \tag{1.2c}$$

The references will work as you'd expect: (1.2a), (1.2b) and (1.2c) are all part of (1.2).

A similar solution is available for figures via the `subfigure` package (not loaded by default and not shown here). All figures and tables should be referenced in the text and should be placed on the page where they are first cited or in subsequent pages. Positioning them in the source file after the paragraph where you first reference them usually yield good results. See figure 1 and table 1.

We discourage the use of inline figures (wrapfigure), as they may be difficult to position if the page layout changes.

We suggest not to abbreviate: "section", "appendix", "figure" and "table", but "eq." and "ref." are welcome. Also, please do not use `\emph` or `\it` for latin abbreviaitons: i.e., et al., e.g., vs., etc.

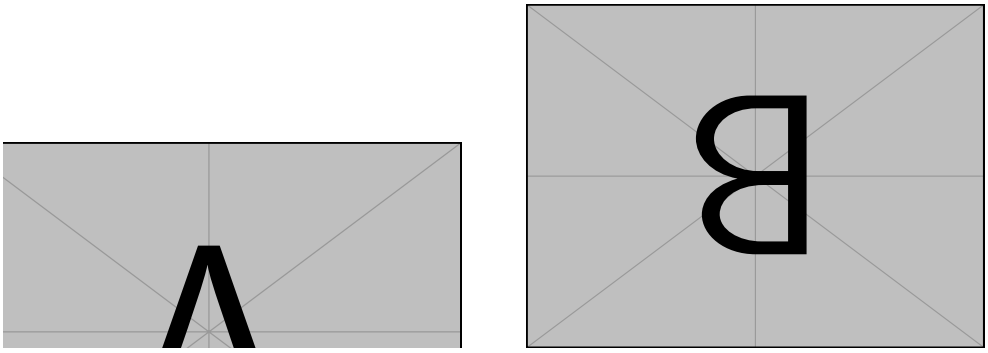

Figure 1. Always give a caption.

Table 1. We prefer to have borders around the tables.

x	y	x and y
a	b	a and b
1	2	1 and 2
α	β	α and β

2 Sections

2.1 And subsequent

2.1.1 Sub-sections

Up to paragraphs. We find that having more levels usually reduces the clarity of the article. Also, we strongly discourage the use of non-numbered sections (e.g. `\subsubsection*`). Please also see the use of "`\texorpdfstring{}{}`" to avoid warnings from the hyperref package when you have math in the section titles

A Some title

Please always give a title also for appendices.

Acknowledgments

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References

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[3] Author, *Title*, Publisher (year).