PROCEEDINGS OF SCIENCE

CMS outreach overview

Marina Passaseo[a,*] **on behalf of the CMS collaboration**

a INFN Padova,
Via Marzolo, 8 – 35131 Padova, Italy
E-mail: marina.passaseo@pd.infn.it

Effective scientific communication and public outreach are essential components of modern high-energy physics research, serving to educate the public, engage stakeholders, and ensure continued support for fundamental science.

This article presents a comprehensive analysis of the communication and outreach strategies implemented by the Compact Muon Solenoid (CMS) experiment at CERN, one of the flagship experiments at the Large Hadron Collider (LHC). The CMS communications program demonstrates how large-scale scientific collaborations can effectively reach diverse audiences through multi-platform engagement, educational initiatives, and innovative digital content creation.

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*Speaker

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1. Introduction

The landscape of scientific communication has undergone significant transformation in recent decades, driven by technological advances, changing media consumption patterns, and increasing demands for scientific transparency and public engagement. High-energy physics, as a field that addresses fundamental questions about the Universe while requiring substantial public investment, faces challenges in communicating complex concepts to diverse audiences ranging from policymakers and funding agencies to students and the general public.

The Compact Muon Solenoid (CMS) experiment represents one of the most ambitious scientific endeavours in modern physics, involving thousands of researchers from around the world in the quest to understand the fundamental nature of matter and energy. As such, it serves as an exemplary case study for examining how large-scale scientific collaborations can develop and implement comprehensive communication strategies that serve multiple stakeholder groups while advancing both scientific and educational objectives.

2. Methodology and framework

The CMS communications program operates under a structured framework led by a Head and Deputy of External Communications, supported by specialized teams focusing on different aspects of communication and outreach.

This organizational structure reflects a professionalized approach to scientific communication, recognizing that effective outreach requires dedicated expertise and resources rather than being treated as an ancillary activity.

The CMS communications strategy employs a multi-audience approach, targeting distinct groups including press, science-minded individuals, other particle physicists, education sector (students, teachers, schools), other STEM academics, politicians, funding agencies, and the general public. This segmentation allows for tailored messaging and platform selection appropriate to each audience's information needs and consumption patterns.

3. Communication channels and content strategies

The central hub for CMS information is maintained through the cms.cern repository, which features comprehensive detector information, physics content, and news. This includes specialized content such as "The Cylindrical Onion" blog for enthusiast experiences and "Physics Briefings" that explain the latest CMS collaboration activities and results.

The web-based approach reflects modern information consumption patterns while ensuring that authoritative, scientifically accurate content remains accessible to diverse audiences with varying levels of technical expertise.

The monthly CMS newsletter, “Point Cinq”, serves as a comprehensive summary of activities, results, and news from the previous month. Originally distributed via email to CMS collaboration members, the newsletter has evolved to include a public version available to external subscribers since March 2025. All content included in the newsletter is archived for reuse in other communication methodologies (see later).

Visual communication encompasses posters, brochures, banners, standard images of CMS (photos and 3D representations), event displays (static, animated, and user-adjustable), and animated slices of the detector. The Communication group produces graphics such as SketchUp

images showing the HL-CMS detector configuration and printed 3D models as gifts, for celebrations, and as aids for guides, with visitors able to purchase them in the CMS shop.

The program also incorporates virtual reality experiences and video production for various platforms, including timelapse movies to show long-term activities at the P5 site in Cessy and laboratories around the world, at the same time showcasing research, technology, and the people behind CMS.

The success of visual communication demonstrates that complex scientific concepts are communicated more effectively through multimedia approaches combining textual explanations with visual representations.

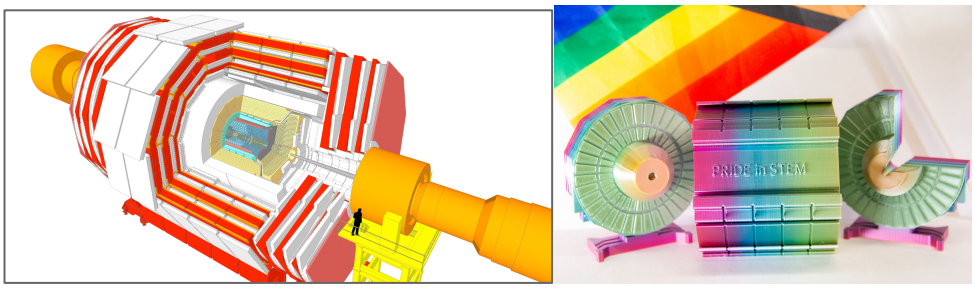

Figure 1: CMS SketchUp image for HL-CMS, and celebrative 3D printed model

CMS maintains presence across multiple social media platforms including YouTube, Facebook, Instagram, TikTok, X, Bluesky, and LinkedIn, targeting people of different ages and backgrounds, highlighting discoveries and results, event coverage, and behind-the-scenes glimpses. The strategy has evolved from traditional broadcast-style communication to more interactive, community-building approaches that encourage participation from both collaboration members and external audiences, with increased engagement through initiatives like “photo of the month” voting and live streaming of visits to the CMS facilities underground.

4. Educational and Public Engagement Activities

The CMS program includes guided tours of facilities both in-person and virtual, with live streaming on YouTube (which also hosts recordings for offline viewing), Instagram, and TikTok. Guides receive training that focuses on memorable stories/anecdotes concerning CMS’ history, collaboration, physics goals, construction, analyses (not only the “big” analyses) and upgrades. Posters and exhibits are being produced with focus on HL-CMS (the upgraded detector to operate at the High-Luminosity LHC), Physics Analyses, and Coordination Areas (e.g. Technical Coordination, Run Coordination, Offline and Computing). Posters are strategically placed at locations around the P5 visit site to aid the guides and are available to everyone for making their own copies.

This approach recognizes that effective science communication requires not just factual accuracy but also narrative engagement that helps audiences connect emotionally with scientific discovery.

Scientific institutions have responsibilities to their local communities. That's why CMS actively works to improve its relationships with locals, especially around P5, by participating in events such as the “Cessy Colour Run”, “forum des associations” and “Fête de la science”.

Figure 2: Coverage of conferences and workshops, tours and visits, local connection events

5. Collaborative Networks and Partnerships

The communication work relies on invaluable support from subsystem communication contact persons (CCPs), who volunteer to help gather and convey interesting content produced by the work of CMS members in their respective areas of the experiment. The content ranges from simple "ideas" of things that should be documented/disseminated, to photographs and movies of upgrade projects, blogs and short news articles. This distributed model ensures that communication efforts are informed by expertise from across the collaboration while avoiding over-reliance on central communication staff.

External key partnerships include the Open Data initiative, with the release of 10 years of data and the tools needed to analyse them, providing an important boost for spreading knowledge of CMS work to researchers, educators, and enthusiasts worldwide. Collaboration with the CERN Communications Team increases visibility of CMS results and announcements, leveraging CERN's wider audience base through written media, social media, and long-form videos whilst providing this central team with high-quality materials for general use.

Additional collaborations include working with content creators who visit the experiment to reach audiences CMS doesn't normally target and in languages not typically used by the CMS communication efforts. CMS participates in IPPOG (International Particle Physics Outreach Group) activities like International Masterclasses (including the production of the necessary online tools and data samples) and engages in monthly LHC Outreach Group (LOG) meetings with representatives from all four LHC experiment communication teams and CERN Communications.

6. Documentation and archival strategies

The communications program maintains comprehensive documentation that captures the complete construction and installation process of HL-CMS for inclusion in a future commemorative photo book, for example. Contributions from all systems include photos, videos, and timelapse movies that are archived in the CDS (CERN Document Server) repository as a resource for the entire collaboration as well as interested parties from outside CMS, using CERN's general CC-BY open-access license.

This documentation serves as both a technical record and visual narrative of the experiment's evolution from conception to completion, ensuring that the institutional knowledge and visual history of the project are preserved for future researchers and historians of science.

7. Results and Impact Assessment

After approximately two years of dedicated work, the CMS communications program has significantly boosted collaboration engagement and transitioned nearly all activities to sustainable operations that don't depend on a handful of individuals working in overdrive, though a few such cases still remain. Despite this shift toward sustainability, overall output has actually increased compared to two years ago. This achievement demonstrates that strategic professional communication programs can achieve both improved effectiveness and operational sustainability when properly structured and resourced.

The transition from broadcast-style to interactive communication approaches has resulted in measurable increases in audience engagement across platforms. The introduction of participatory elements such as photo voting and live streaming has created more dynamic relationships between the CMS collaboration and its various audiences.

The CMS communications program exemplifies the evolution of scientific communication from an ad hoc activity conducted by researchers in their spare time to a professionalized function requiring dedicated expertise and resources. This transformation reflects broader recognition within the scientific community that effective communication is essential for securing public support, attracting talent, and fulfilling the social contract between science and society.

The success of CMS's multi-platform approach demonstrates the importance of meeting audiences where they are rather than expecting them to seek out scientific information through traditional channels. By maintaining presence across diverse platforms from traditional websites to emerging social media channels, the program maximizes reach while tailoring content to platform-specific audiences and consumption patterns.

The distributed communication model employed by CMS, which relies on volunteer communication contacts throughout the collaboration, provides a template for how large scientific projects can scale their communication efforts without proportionally increasing central staff. This approach also ensures that communication content remains scientifically accurate and reflects the full breadth of collaboration activities.

8. Challenges and Future Directions

The high-energy physics field faces significant challenges in the years ahead, and the field's continued success and growth will in part depend on exceptional communication from all HEP participants across diverse audiences, supported by specialized communication experts, as acknowledged by the original European Strategy for Particle Physics and its updates.

The rapidly evolving digital media landscape requires continuous adaptation of communication strategies and platforms. The emergence of new social media platforms, changing algorithms, and shifting audience preferences demand flexibility and responsiveness from scientific communication programs.

While engagement metrics provide some indication of communication effectiveness, developing more sophisticated methods for measuring the actual impact of communication activities on public understanding, policy decisions, and career choices remains a significant challenge for the field.

As scientific collaborations become increasingly international, communication programs must grapple with linguistic and cultural diversity among both collaboration members and target audiences.

9. Conclusions

The CMS communications program provides a comprehensive model for scientific communication in the 21st century, demonstrating how large-scale research collaborations can effectively engage diverse audiences while maintaining scientific integrity and operational sustainability. The program's evolution from dependence on a few overworked individuals to a sustainable, professional operation that actually increased output demonstrates that investment in communication infrastructure coupled with increased collaboration (physicists, engineers etc.) involvement yields measurable returns. As the scientific community faces increasing demands for transparency, accountability, and public engagement, the CMS model provides valuable insights for other research collaborations seeking to develop effective communication strategies.

The success of the CMS communications program also underscores the broader principle that scientific communication is not merely about translating complex research for public consumption, but about building relationships, fostering community engagement, and creating shared understanding between the scientific community and society. In an era where scientific literacy and public support for research are more crucial than ever, such comprehensive communication approaches are not just beneficial but essential for the continued advancement of scientific knowledge and its application to societal challenges.

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