Sharing scientific discovery globally: toward a CERN virtual visit service

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Abstract. The installation of virtual visit services by the LHC collaborations began shortly after the first high-energy collisions were provided by the CERN accelerator in 2010. The experiments: ATLAS [1], CMS [2], LHCb [3], and ALICE [4] have all joined in this popular and effective method to bring the excitement of scientific exploration and discovery into classrooms and other public venues around the world. Their programmes, which use a combination of video conference, webcast, and video recording to communicate with remote audiences have already reached tens of thousands of viewers, and the demand only continues to grow. Other venues, such as the CERN Control Centre, are also considering similar permanent installations.

We present a summary of the development of the various systems in use around CERN today, including the technology deployed and a variety of use cases. We then lay down the arguments for the creation of a CERN-wide service that would support these programmes in a more coherent and effective manner. Potential services include a central booking system and operational management similar to what is currently provided for the common CERN video conference facilities. Certain choices in technology could be made to support programmes based on popular tools including (but not limited to) SkypeTM [5], Google Hangouts [6], Facebook Live [7], and Periscope [8]. Successful implementation of the project, which relies on close partnership between the experiments, CERN IT CDA [9], and CERN IR ECO [10], has the potential to reach an even larger, global audience, more effectively than ever before.

1. Introduction

Recognition of public outreach and education as essential components of fundamental research has been steadily advancing in the field of experimental particle physics. This is made evident, for example, by the inclusion of outreach plenary and parallel sessions in major HEP conferences, the support of active science communication and outreach teams on the experiments, the global expansion of international outreach collaborations, and the development of new dedicated communication methods and platforms.

1 Recent conferences with dedicated outreach presentations and sessions: CHEP 2013, 2015, 2016 [11]; ICHEP 2012, 2014, 2016 [12]; LHCP 2014, 2015, 2016 [13], and EPS-HEP 2013, 2015 [14], to name a few.
The virtual visit service, now offered by the major LHC experiments, is an excellent example of an innovative and cost-effective platform designed to engage diverse audiences around the globe. The communication teams of CERN and the LHC collaborations recognized early on the need to be able to reach out to these audiences using remote online systems for the announcement of major events. The interactive nature of virtual visits, however, was quickly found to support interactive engagement with remote audiences, such as classrooms, thus creating a rich educational experience, and providing access to audiences who would not normally have the opportunity to visit CERN.

Although the major LHC experiments are currently all operating active virtual visit programmes, reaching thousands of visitors worldwide, the authors feel that the development of a common service would improve both the efficiency and overall reach. This document provides an overview of our programmes, a description of the hosts and visitors, primary goals for public engagement, details of the current technical equipment and procedures, our motivation for developing a common system, suggested requirements for the new system, and some thoughts on how to share the effort.

2. Virtual Visits

2.1. What is a Virtual Visit?
We define a virtual visit as a live interactive audio and video connection between one or more remote audience locations and one or more scientist hosts, located at an experiment or laboratory facility. Technically, the visit can include a simultaneous webcast and/or video recording of the event, and media content, such as images, slides, or video can be included in a separate stream. But, arguably the most important aspect of any visit is the interactivity between the audience and the scientists. It is a rare opportunity for the public, typically students, to ask questions and voice their own concerns and excitement about the science, the research methods, and the role of the LHC in society.

Virtual visits to the LHC experiments are usually held either adjacent to or inside the detector control rooms, or underground (in service areas when the LHC is running or near the detector during long technical stops, as in Figure 1). The backdrop plays an important role, in that it allows the audience to feel they are being brought into the “action.” The effect is to increase interest and trigger questions, as well as to provide visual information on the running of a complex experiment.

At CERN, the standard video conferencing equipment, Vidyo™ [15], is employed for most visits, as the site-wide license allows for free usage with external participants, installation is simple, bandwidth requirements are minimal, and firewall issues are rare and easy to overcome. These qualities are important, as one of the primary goals of the programmes is to reach audiences that would not normally have the opportunity to travel to CERN. The current Vidyo™ installation also provides recording capabilities, and local encoders provide streaming for the CERN webcast servers.

2.2. Motivation and Goals
Virtual visits to the experiments - like in-person visits - benefit from personal engagement between the scientists and the public. Their interactive nature improves the effectiveness of communication, augments perception through visual stimulus, allows participants to seek answers to specific questions, provides a channel for feedback, and also helps to convey the human side of science.

The primary goals are: 1) to promote the kind of human interaction described above; 2) to reach audiences that would not normally have the opportunity to visit CERN (due to geographical,
economic, political, or cultural reasons); and 3) to act as an entrance point for further, more in-depth engagement. A fourth goal that has arisen from our experience is to train fellow scientists in communication. Since hosts with a variety of nationalities and language skills are needed for the visits, we are obliged to call on our own collaboration members to act as guides. This can act as a “trial by fire” for those colleagues who have never worked in communication before and, when successful, can help to recruit them for other outreach activities.

3. Who are the Participants?

3.1. The Hosts

CERN has been connecting with remote classrooms, as part of its education programme, since the late 1990’s, when IP-based video conferencing and webcasting were relatively new. The early focus was on major scientific events or educational outreach initiatives, but it was not part of a regular scheduled programme. The start-up in 2008 of the Large Hadron Collider, as an example, was anticipated as a major event by the international media, so interactive video sessions were held at the Control Centre and at the four major experiments. Measurements indicated that millions of the public were reached by these sessions, indicating significant interest on the part of the public.

Motivated by the global reach of the start-up event, the ATLAS collaboration installed the first dedicated virtual visit system in 2010 in its control room, using existing equipment, but adding a videoconferencing unit to facilitate interaction with remote locations. That programme has continued to this day, with some upgrades to the equipment, but using the same basic approach, integrating videoconferencing, webcast, and recording. An example visit is shown in Figure 2.

The CMS collaboration exploited the possibility of using the system to provide more of a “virtual tour” of their facility. In 2011, they started a programme that includes a remote unit, allowing hosts to venture underground to provide a view of the detector (during shutdowns) or of the detector services and electronics (during LHC running).

The LHCb collaboration installed a dedicated videoconferencing system in its control room in 2011 that can be used for official meetings or visits, alternatively. They also have the ability to go underground to view the detector when the LHC is not running, an option used on occasion in conjunction with International Masterclasses. The ALICE collaboration has been using a light-weight system, comprising a laptop, camera, and headset, for virtual visits from the control room and underground, since 2013. They are currently installing a dedicated system. The four programmes serve thousands of virtual visitors connecting from hundreds of locations, each year.

Other sites at CERN looking into temporary or permanent virtual visit installations include the CERN Control Centre (CCC) and the Computing Centre (CC). These sites are typically included during major communication events involving large-scale public webcasts, such as LHC re-starts. Permanent installations would facilitate the possibility of inclusion in the experiment programmes or for more frequent periodic communication projects highlighting activities and discovery at CERN.

Outside of CERN, virtual visits have been hosted or co-hosted with LIGO (Hanford facility) [16], IceCube [17] (typically audio only, due to bandwidth restrictions), and Fermilab [18]. It should be noted that there is no technical limit to the number of hosts or visitors connected, although limiting to only a few connections is recommended for quality of interaction. Most visits are typically around 30-60 minutes in duration.
3.2. The Visitors
The most common audience for a virtual visit is a classroom or classrooms from secondary schools (age 12-18). Visits from younger audiences can also work well, depending on the communication skills of the hosts, typically members of the collaborations. Other target audiences include participants of Masterclasses, undergraduate students, teacher groups, public events, off-site open day participants, and policy makers, to name a few.

Currently, although public web forms are available for booking visits, most visitors come from contacts made by collaboration members in association with their own outreach efforts. These can include teachers, education directors, festival coordinators, particle physics masterclass organisers, colleagues hosting public events, etc. Several initiatives have been made to organise coordinated groups of visits focusing on a specific country or language, in order to make the best use of time and resources. To date, the experiments have handled roughly 600-700 visits, reaching around 30,000 participants in all seven continents. A visit from Kigali, Rwanda is presented in Figure 3.

In order to maintain sustainable growth, marketing of the virtual visit programmes has been limited to internal communication within the collaborations and via outreach networks, such as IPPOG [19]. At the moment, the ATLAS and CMS teams each report hosting an average of 8-9 visits per month, and there is general agreement that current methods and resources will not allow significant expansion. Additional limiting factors include logistics arising from sharing the facilities with other outreach or detector operation activities, so a centralised programme will not solve all issues. The authors believe, however, that certain development, such as the implementation of common administration and operation services, could increase efficiency, increasing the potential for a higher quality experience and a much larger audience.

3.3. Participant Feedback
Audience feedback is nearly all positive, with a few exceptions typically due to rare failures in the technology. Most of those issues are due to networking or acoustic problems at the remote locations, but equipment failures can happen, and occasionally visits might be halted or postponed due to clashes with experiment activities.

Here are some quotes collected from participants of recent virtual visits: “This way of gaining knowledge is way more attractive and interesting, because it let us gather information directly from CERN workers on how one of the most important laboratories in Europe works,” (13-year-old student from Poland). “What surprised me today is the fact that I didn’t know the people were trying to find the answer about how the universe was made. I have always thought about that,” (11-year-old student from Los Angeles CA, USA). “This has created quite a lot of excitement and I hope that we can keep this momentum with the master classes offered at the University of Cape Town as well as entry into the Beamline 4 Schools competition,” (science teacher, Carnarvon, South Africa). “One senior citizen, who has some scientific background and has met with many scientists in his life, said it was the first time somebody was able to explain particle physics in such an understandable way,” (Science café attendee in Vilnius, Lithuania).

From these examples (and others), one can gauge the success of the programme in reaching the stated goals of improved communication through interaction and engagement, acting as an entrance point to encourage participation in more in-depth activities, and reaching a diverse, global audience.
4. Toward a CERN-Wide Virtual Visit System

4.1. Current Procedures
Listing 1 presents a list of the technical procedures to produce a virtual visit. Not all steps are followed by all experiments, as some do not supply webcast and/or recording for all visits.

| 1. Receive visit request or booking | 11. Visit: Operate cameras |
| 2. Explain technical requirements | 12. Visit: Push media content |
| 3. Select dates | 13. Visit: Engage in dialogue |
| 4. Identify guide(s) | 14. Visit: Close systems |
| 5. Identify operator | 15. Edit and publish recording |
| 6. Schedule test | 16. Communicate recording |
| 7. Build web page for webcast / recording | 17. Request feedback |
| 8. Include visit on agenda | 18. Evaluate feedback |
| 9. Communicate upcoming visit | 19. Collect educational highlights from video for compilations |
| 10. Visit: Start videoconference, webcast, recording |

In many cases, depending on the complexity of the visit, the visit guide can also serve as the operator. The individual experiments are currently responsible for administration and operation of the visit, as well as for the post-production and communication of the event. CERN’s role is limited to installation and maintenance of the equipment, hosting of the video, webcast, and web services, and occasional remote or local help, in case of technical problems.

4.2. Motivation for a CERN-Wide System
Although the virtual visit programmes of the experiments have developed and evolved independently, there has been significant cooperation and knowledge sharing between the groups. As a result, the procedures and systems have many commonalities. It is the authors’ opinion that certain aspects of preparation, operation, and post-production could be more effectively handled centrally. Furthermore, implementation of a common set of core functions will not only simplify maintenance and operations, but make it possible to link the systems seamlessly for shared activities, such as major events or periodic communication programmes.

Concerning operations, the personnel currently operating the local equipment are typically scientists from the experiments, rather than technical experts. Moreover, several (but not all) of the actions required to run a visit do not require a local presence and could be handled remotely, by a dedicated operator. By moving these operations to a dedicated team of experts, the guides could better focus on the quality of the scientific content of the visit, while the operators focus on maintaining and improving the technical quality of the delivery platform. Such an arrangement would most likely reduce mistakes and time lost due to guides re-familiarising themselves with the equipment. It would also provide a more consistent accounting of errors and fixes, as the technical team would comprise a smaller group with a clear overview of all the installations.

In addition, there are several administrative components of the visits that could benefit from the presence of a more central organisation. Reservations, for example, could utilise a single database workflow that directs visitors toward the experiment of their choice or which cycles through experiments in case there is no preference. Having a front-end interface on the CERN web pages would increase visibility and might help to alleviate the large and growing number of requests for in-person visits. If the experiments wish to maintain their own virtual visit brand, apart from that of CERN, their own front-end interfaces can be adapted to the central database, directing local requests to their own area.
Finally, by maintaining a common virtual visit database, CERN could help to provide a central accounting of the number and types of visits, compile common issues, and make it easier to compare and evaluate metrics. This can help not only to improve the efficiency and quality of the visits, but also to develop a more strategic approach to the programme, serving the interests of the collaborations, as well as CERN stakeholders.

4.3. Suggested Requirements for a CERN-Wide System

Listing 2 proposes a list of requirements for a common CERN-wide system. It is based on our experience with the existing virtual visit systems, hosted by the LHC experiments, and the potential for improvement discussed in the previous section.

**Listing 2. Proposed requirements for a CERN-wide virtual visit system.**

| 1. Technical Infrastructure: |
|-------------------------------|
| a. Robust, High Quality Videoconferencing Systems with Recording Capability (a la existing conference rooms) |
| b. Wireless Microphones, Remote Cameras, Mixers (as requested) |
| c. Simultaneous Public Webcast including Remote & Local Views, High Quality Sound, Shared Media |
| d. Compatibility with PC or Phone-Based Systems, such as Skype, Google Hangout, Facebook Live, etc. (key for communication events or programmes) |

| 2. Technical Support: |
|----------------------|
| a. Installation / Periodic Testing / Maintenance of Installations |
| b. Tests with Remote Sites |
| c. Start / Stop of Equipment (Normally Remotely) |
| d. Audio / Video Recording, Editing, Publication of to CDS |

| 3. Guide Organisation: |
|-----------------------|
| a. Communication Training Similar to On-Site Visit Guides |
| b. Site-Specific Training |
| c. Recognition / Compensation for Contributions |

| 4. Common Reservation Form: |
|----------------------------|
| a. On CERN Public Web Pages, near On-Site Visit Reservations |
| b. Should Specify: Experiment (or no preference), Visit Date, Testing Date, Technical Requirements, Contact Information |
| c. Suggested Information flow: **Form → Virtual Visit Service → Experiment & Technical Service → Guides & Technicians** |

| 5. Virtual Visit Web Interface |
|-------------------------------|
| a. For Each Visit: Host Webcast, then Audio/Video Recording, Related Material (Potential as Educational Platform if Ownership transferred to Teacher) |
| b. Maintain Calendar, Visitor Statistics, and Feedback |

5. Sharing the Effort

5.1. Guidance from Existing Models

There are two existing cooperative agreements between CERN and the experiments that could both be used as models for virtual visit service. First of all, the CERN Visits Service [20] currently operates a number of high quality and highly demanded exhibition sites around the CERN campus, including the experiments. Reservations for visitors are handled centrally, but with input coming from both the Visits Service and from the experiment secretariats, in a cooperative manner, using a common
calendar. Infrastructure for each experiment’s exhibition is designed, purchased, and maintained in a mutually beneficial manner, typically following specifications of memoranda of understanding signed by CERN and the collaboration. Guides for the exhibitions come from a pool that has been trained by CERN, but typically involve scientists associated with the experiment being represented. These guides are compensated for their time, to ensure broad, fair participation.

A second model, which pertains more closely to the equipment used for virtual visits, would be the CERN IT Collaboration, Devices, and Applications (CDA) videoconference agreements. These agreements are also bilateral memoranda of understandings made between each experiment and CERN. They cover the videoconferencing facilities (typically placed in meeting rooms or auditoria) that have been assigned to the collaborations. In general, these agreements define the cost-sharing, with experiments typically paying for hardware (following specified guidelines), but with CERN providing the service (videoconference and/or webcast), maintenance, and assistance for users. In this case, operation is handled by the users, but it is possible for technical experts to intervene remotely, in case of problems or to start and stop important meetings, at request. Upgrade and purchasing strategy is investigated and proposed by CERN, but must be approved by each collaboration.

5.2. Proposal
It is authors’ opinions that the two models presented above could be applied in a similar manner for the virtual visit service, resulting in the fair sharing of resources between the partners. Listing 3 presents our proposal for cost and task sharing in a CERN-wide system.

Listing 3. Proposed resource-sharing model for a CERN-wide virtual visit system.

| 1. The Experiments (or other Location Hosts): |
| a. Provide Monetary Resources for Equipment & Maintenance (Bi-Lateral MoU) |
| b. Potentially Providing Guides |
| c. Coordinate with CERN for Usage of Sites (a la current Visits Service agreements) |
| 2. CERN IT CDA: |
| a. Install, Maintain, Operate Equipment |
| b. Host Required Services and Provides Support (a la current video service agreements) |
| 3. IR ECO: |
| a. Develop and Maintain Web Interface and Booking System |
| b. Train, Coordinate, and Compensate Guides |
| c. Edit and Publish Visit Recordings |
| d. Follow-Up and Statistics |

6. Summary and Conclusions
Independent virtual visit programmes run by the LHC experiments have successfully hosted hundreds of locations and tens of thousands of visitors from around the world for the past several years. Demand for such visits is growing, even without a concerted effort to publicize their availability. The potential to expand is enormous and exciting. It could help to alleviate the large number of potential visitors being turned away by the CERN Visit Service [20] each year, and open up the organisation’s scientific programme to a global audience that, due to geographical, political, cultural, or social reasons, would not normally have the possibility to visit CERN, in person. It is our opinion that a reorganisation of the existing programmes could help to improve the usage of resources and increase the overall capacity, in an effort to meet this demand.

Toward this end, we propose the development of CERN-wide virtual visit service that would:
- facilitate booking through the CERN public web site;
- move much of operations from the scientist hosts to technical experts;
• provide guide training and compensation, similar to the existing Visits Service;
• develop a permanent infrastructure for public communication.
We believe the resources required to make these changes are modest and easily shared in a fair manner among the stakeholders. We also believe that the potential for gain in terms of audience reach and quality of engagement is too important to ignore.

Editor's note: Since the date of this presentation, the CERN Education, Communication, and Outreach (ECO) group has organised a working group that includes representatives from the collaborations, experts from CERN IT CDA, and experts from CERN ECO, to address the development of a CERN-wide virtual visit system. We applaud this effort and look forward to working with the group to reach this goal.

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