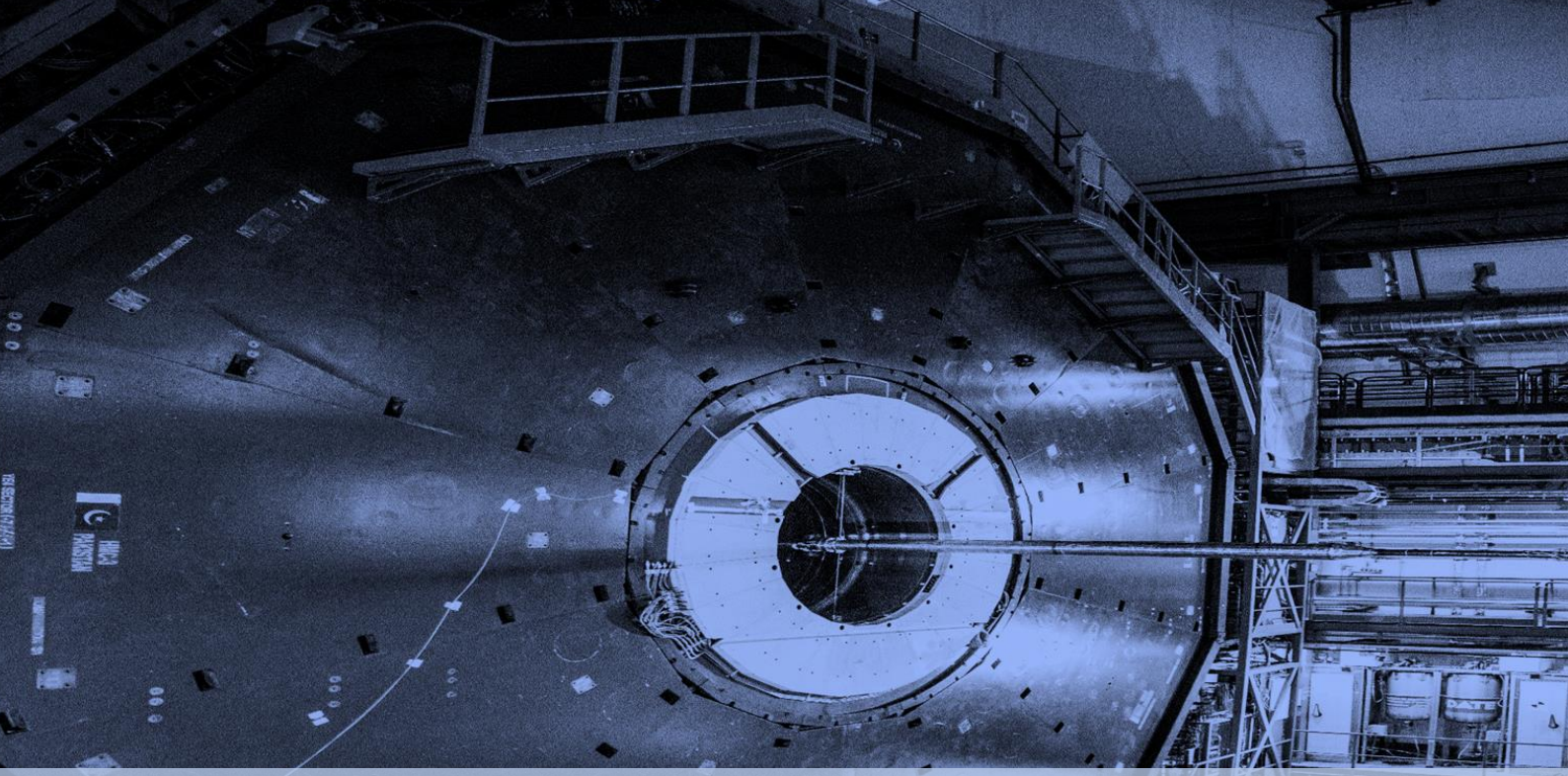


REVIEW OF WEB BASED ACCELERATOR SCIENCE CONTENT

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Introduction

Accelerator Science is a rich and diverse field of science at the intersection of physics, engineering, material science, computing and more. Having a strong online presence is important for the Science, given that most people primarily obtain their information from the internet. This project is an attempt to catalogue the accelerator science content on the internet and organize them according to parameters such as date created, geographical origin, content format and application. We aim to identify any emerging trends in web-based accelerator science content This project is intended to collect web-based information so as to provide input to the IAEA Accelerator Knowledge Portal (AKP) development, IUPAP 14 WG and its partners outreach activities.

Methodology

A computer program was written to handle the data collection. Search results were collected using an application program interface or API, a tool often created by organizations and companies like Google or NASA to allow programmers access their data. In this case Google Custom JSON API was used to collect the top 100 search results. Issues in the API meant that 100 results were not always collected for each search term. The program also handled the the loading of the search results into comma separated value files. A snippet of the program, written in Python, is shown in Figure 1 below.

```
#parameters to pass into Google Custom Search JSON API
parameters = {
    "cx" : "c6e3001bf986f4943",
    "exactTerms" : "gamma irradiator",
    "start" : "1",
    "num" : "10"

}

#Loop to repeatedly call API obtaining top 100 search results
for i in range(1,100,10):
    for key, value in parameters.items():
        if key == 'start':
            parameters[key] =str(i)
    #print(parameters)
    #API request
    search_results = requests.get("https://customsearch.googleapis.com/customsearch/v1?key=AIzaSyCyiQ9vR0zdfOOfvKh7NPenIq47CrO45FI", params=parameters)

    #Visually appealing/formatted json results
    formatted = json.dumps(search_results.json(), indent=4, sort_keys=True)
    #print(formatted)
    print ("Status code", search_results.status_code)

    search_dict = search_results.json()

    #Subdictionary with relevant terms
    lay1 = search_dict["items"]
    key2 = search_dict["searchInformation"]["totalResults"]
    #print(key2)
    #if key2 == '0':
    #   continue

    #accessing the required info in the search Response object
```

Figure 1: Python computer program written to automate data collection

Categorisation

Categorisation was done manually according to the primary author's best judgement.

The categories were:

1. Content format: This describes the manner of presentation of the webpage.
    a. Scientific journal article
    b. Informational article
    c. Video
    d. Document
    e. Infographic
    f. Product Description
2. Application or Domain: This describes the accelerator application (if any) or generally, the theme of the webpage.
3. Geographical location: The location of the organization or individual who published the webpage
    a. North America
    b. South America
    c. Europe
    d. Africa
    e. Oceania
4. Target audience: Content was categorised according to whether it would be understandable by physics researcher, researchers from other science, an undergraduate, or the general public. The categories are hierarchical but not mutually exclusive. For example, it was assumed understood by a physics undergraduate can be understood by researchers from other sciences but not vice versa. This category is certainly the most subjective metric, thus is associated with the highest level of uncertainty

Wikipedia: a clue to what is popular online.

Often, the number of views any given web page information is not privy to the public and only accessible to site owners themselves, thus making it hard to gauge the interest in individual pages. However, thanks to Wikipedia's open data, it is possible to measure interest in broad accelerator topics by looking at page views of various accelerator related terms. Figures 2 and 3 compare the Wikipedia page views for 9 accelerator terms.

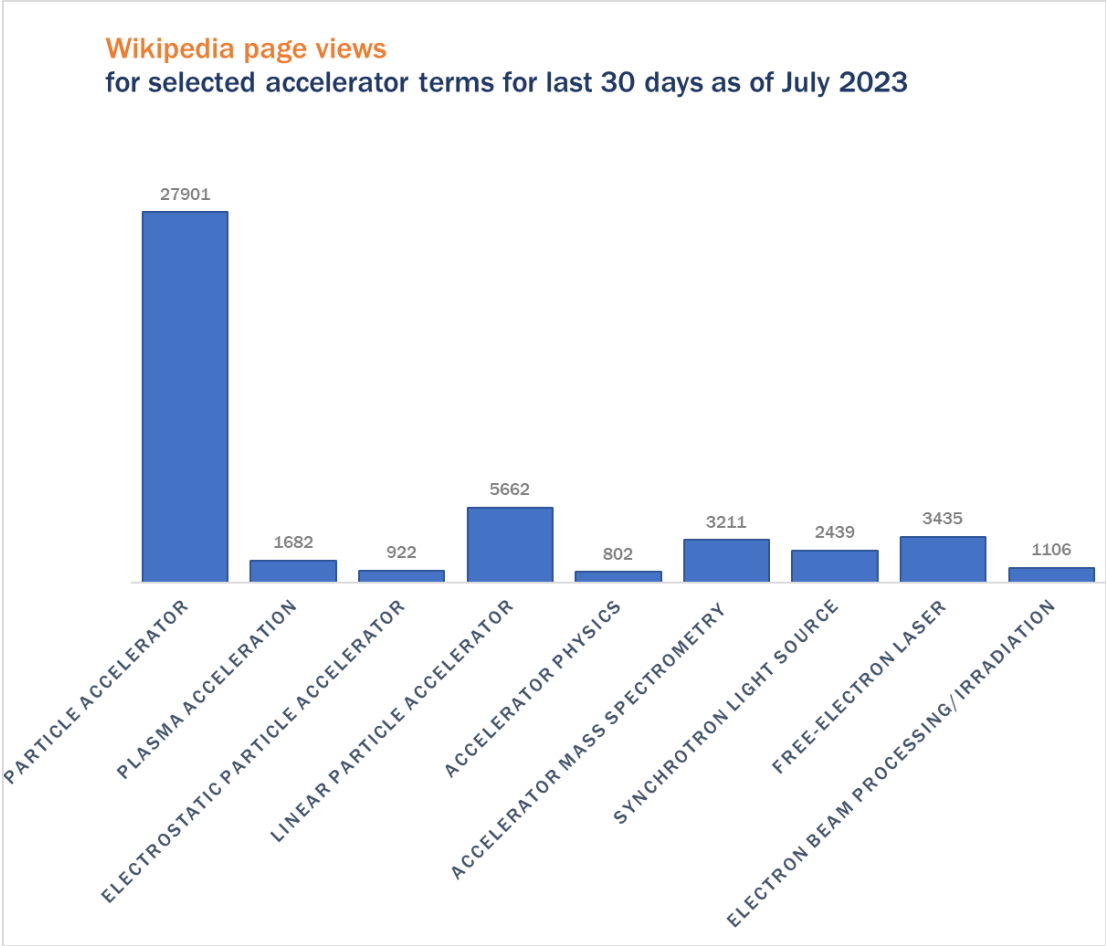


Figure 2: Top viewed accelerator related pages on Wikipedia in July 2023

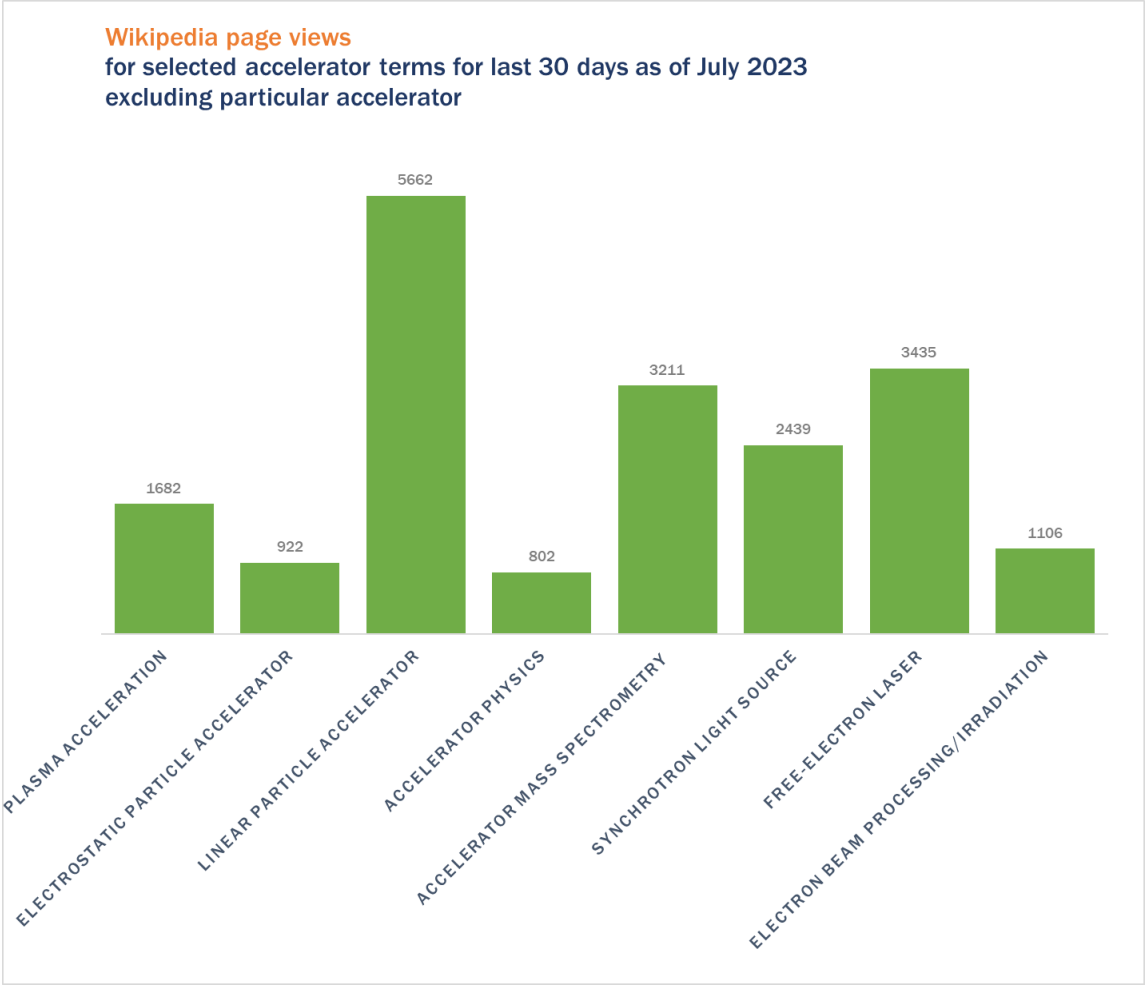


Figure 3: Top viewed accelerator related pages on Wikipedia in July 2023 (excluding particle accelerator)

Top Accelerator Pages on Wikipedia

1. Particle Accelerator
2. Linear particle accelerator
3. Free Electron Laser
4. Accelerator Mass Spectrometry
5. Synchrotron Light Source

The Big Picture

With over 300 webpages analysed, a significant sample of accelerator science web-based content has been gathered. Most content is overwhelmingly text based, either in the form of informational articles, papers from a science journal or articles written in a periodical publication. Visual content accounted for 6% of content. The distribution of content format can be seen in Figure 4.

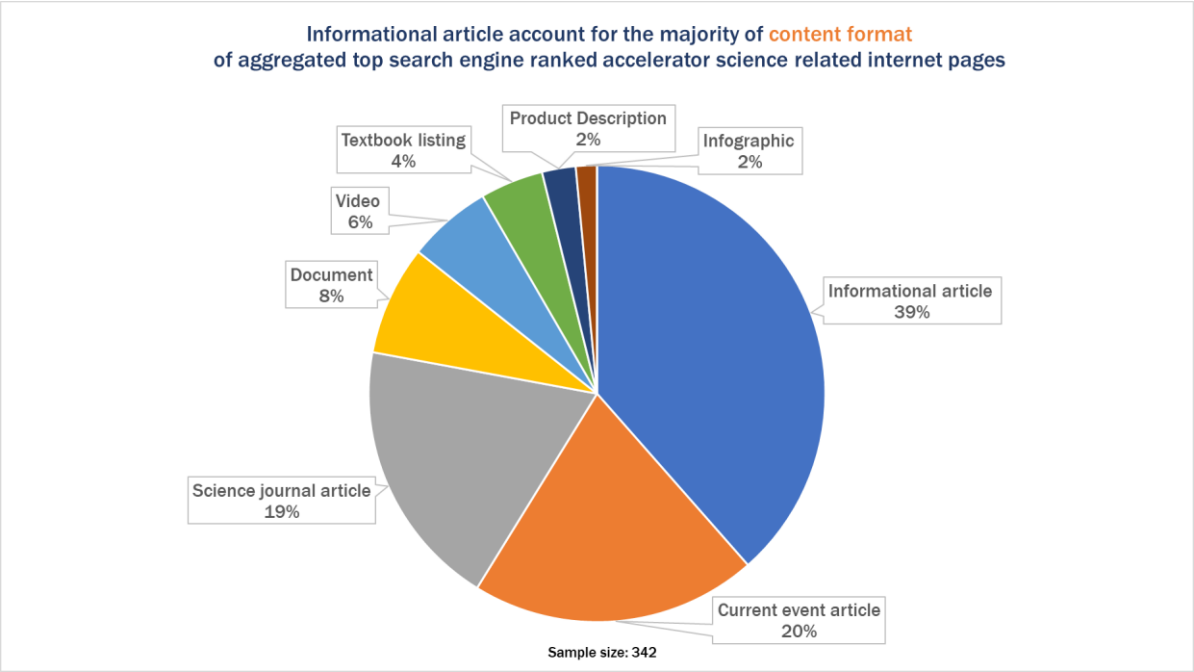


Figure 4: The distribution of content format for total top ranked accelerator science related webpages.

There are many stakeholders who publish accelerator science related content form private companies like publishers and manufacturers to individuals who write personal blogs. Nonprofit or international organizations are the slight majority and mainly consisted of scientific professional societies and the International Atomic Energy Agency.

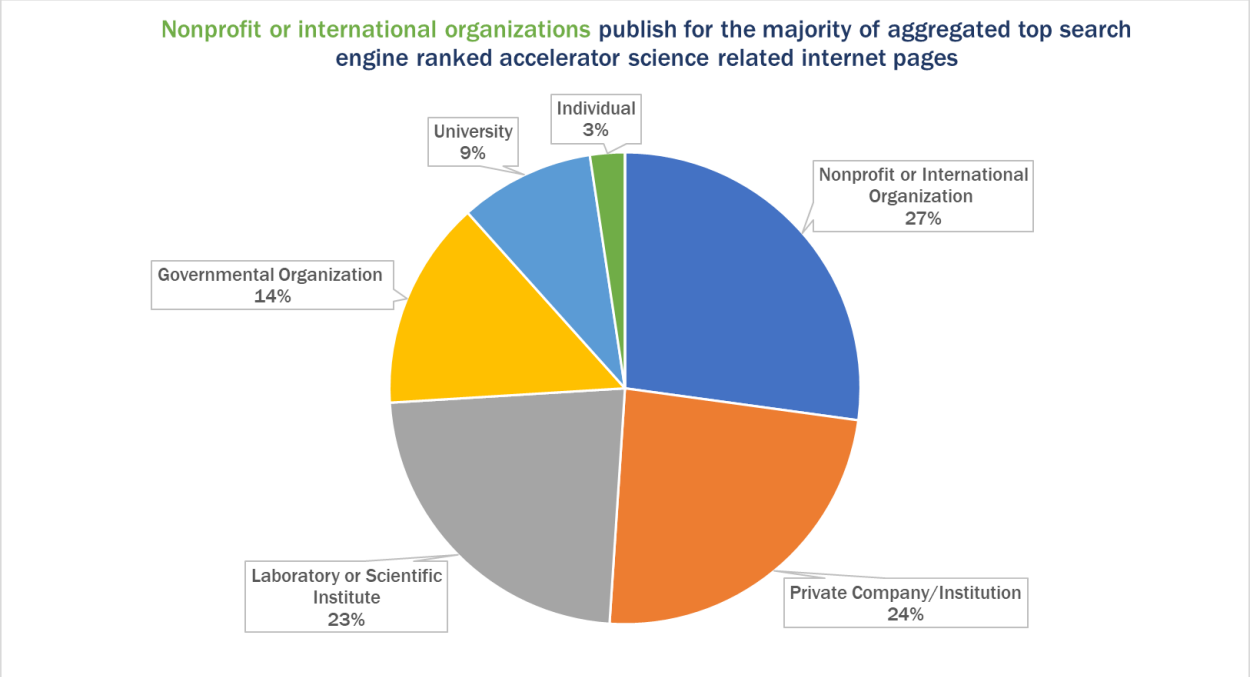


Figure 5:The distribution of institution type for total top ranked accelerator science related webpages.

There was not as much variety when it came it to the geographical location of the publishers of accelerator science relate content. This metric was determined according to the physical location of the institution's headquarters or where the majority of offices were. This does not take into account that many institutions have their operations spread out on different sites.

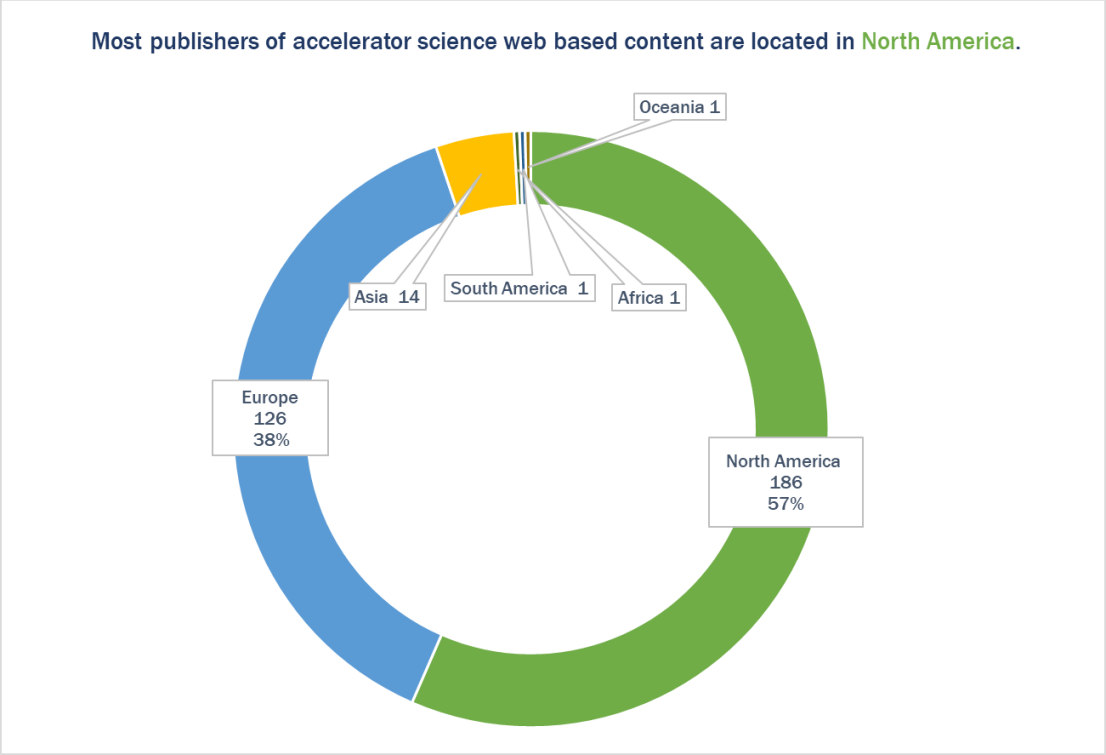


Figure 6: The distribution of geographical location of publishers for total top ranked accelerator science related webpages

The top webpages were generally written in a way that could be understandable to the general public, however this does not mean the content that it would not have been beneficial to other scientifically advanced audiences. It is also noted that the general public is a broad category that included not only individuals who might be curious about accelerator science but also institutions like commercial enterprises.

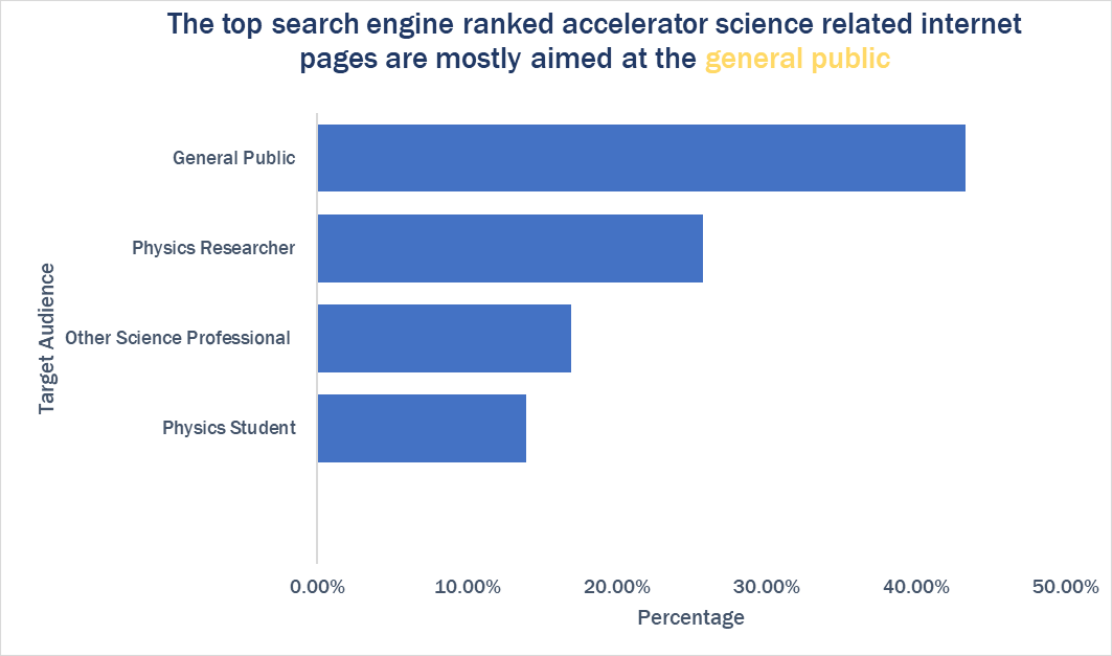


Figure 7: The distribution of target audience for total top ranked accelerator science related webpages

Search result summaries for selected accelerator terms

Using the Wikipedia page views as a clue to what internet audiences are most interested in, the summaries of the top 5 viewed Wikipedia pages are presented in this section.

Particle Accelerator

This search term is likely the entryway for almost everyone who becomes interested in accelerator science. Text based content dominate the results, although for this particular term, informational articles featured many pictures themselves and were overall modern in nature. From the content for which the date created could be determined (about half), it was found that the average date created was 2018.

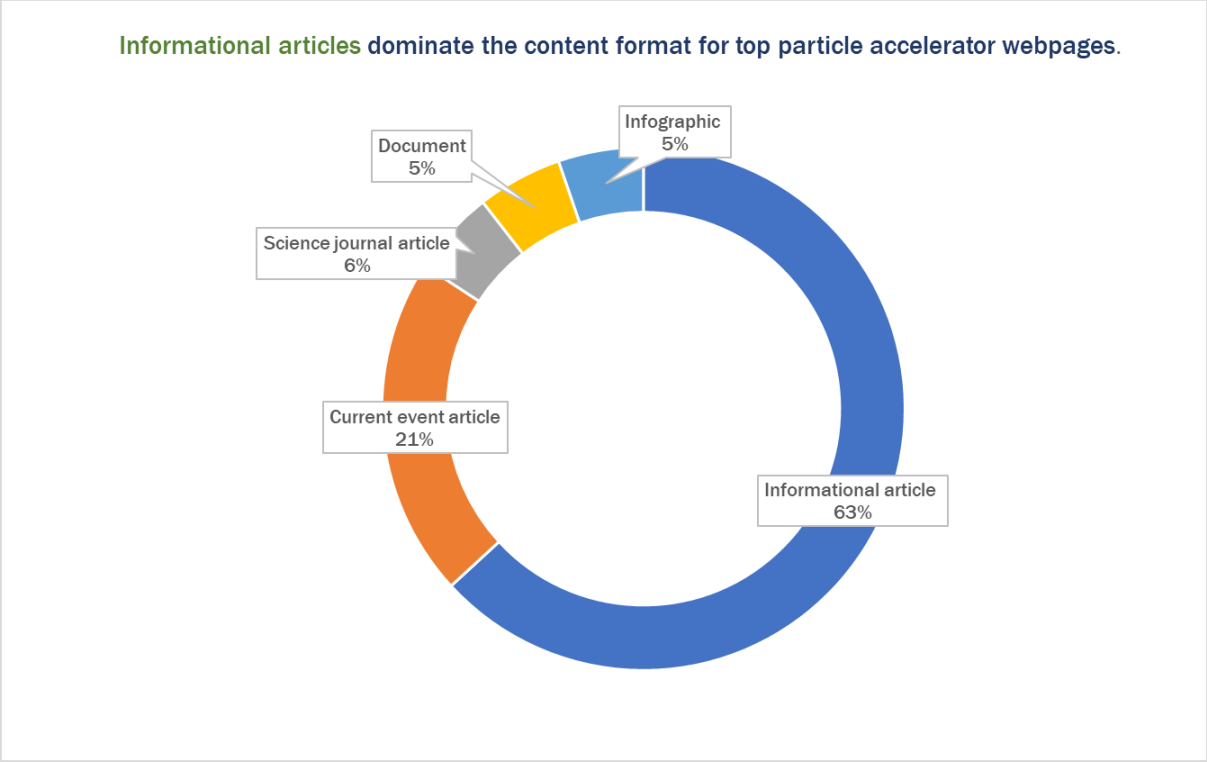


Figure 8: The distribution of content format for top ranked 'particle accelerator' webpages

The distribution of institution types responsible for 'particle accelerator' content is quite evenly distributed. Laboratory or scientific institutes particularly those from the United States National Lab system took the lead.

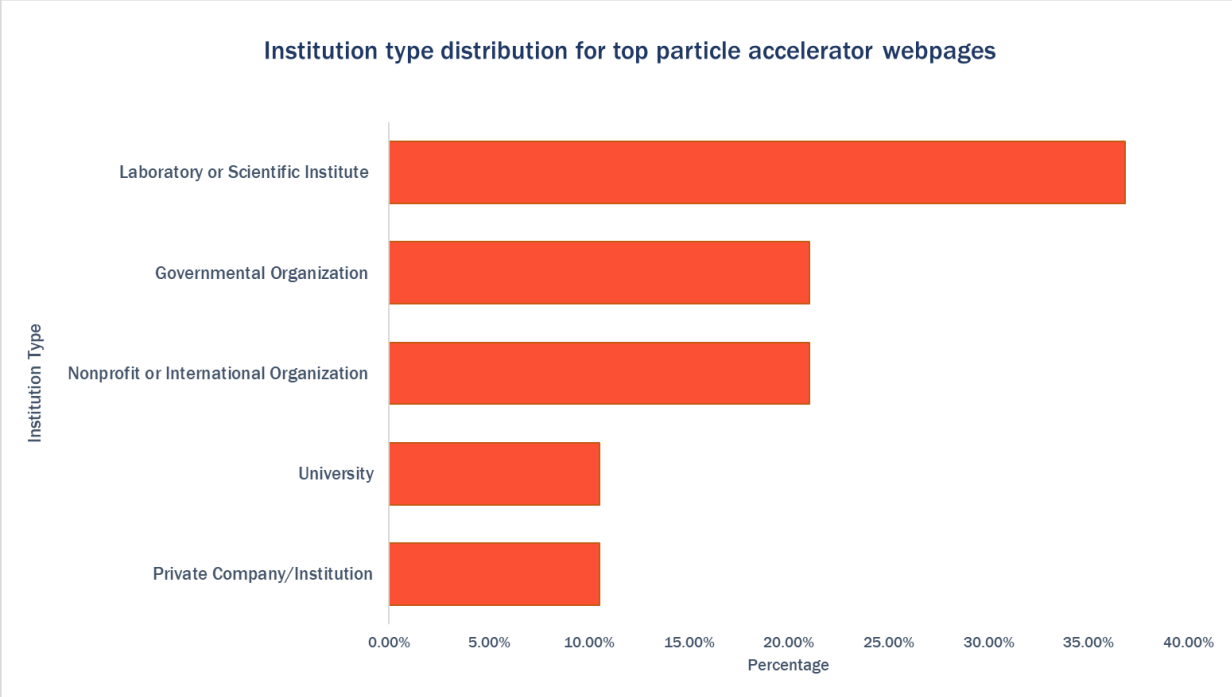


Figure 9: The distribution of institution type for top ranked 'particle accelerator' webpages

Linear Particle Accelerator

The dominant theme of the top results for the term 'linear accelerators' is the application of linear accelerators to radiotherapy treatment. There are two main prongs: patient education content and medical related research content. Science journal articles dominated the content format category, however besides this it was well distributed. Governmental organizations and private companies led the Institution type categories. Governmental organizations primarily consisted of the US National Library of Medicine and the private companies were manufacturers of medical linear accelerators or their support systems.

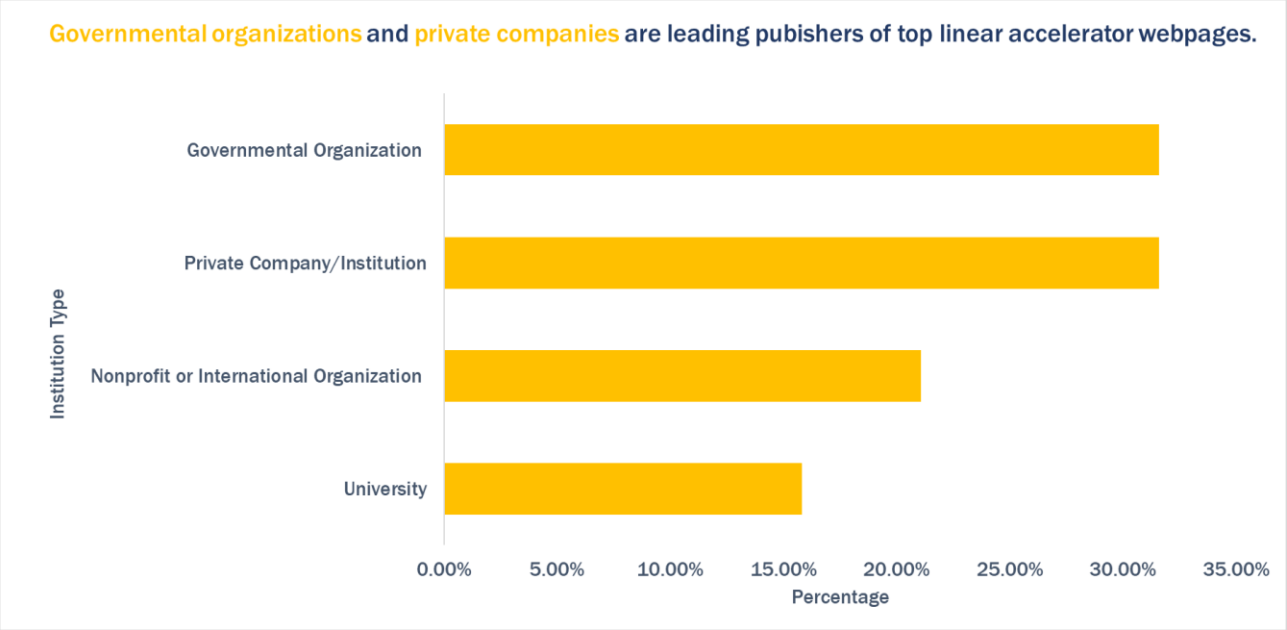


Figure 10: The distribution of institution type for top ranked 'linear accelerator' webpages

Among the most interesting linear accelerator content found was a visually appealing infographic produced by the US Department of Energy explaining basics of particle accelerator s and why they matter was among the very few infographics found in this review.

Free Electron Laser

European laboratories were chiefly responsible for the top search results. The private companies mostly consisted of science journal publishers.

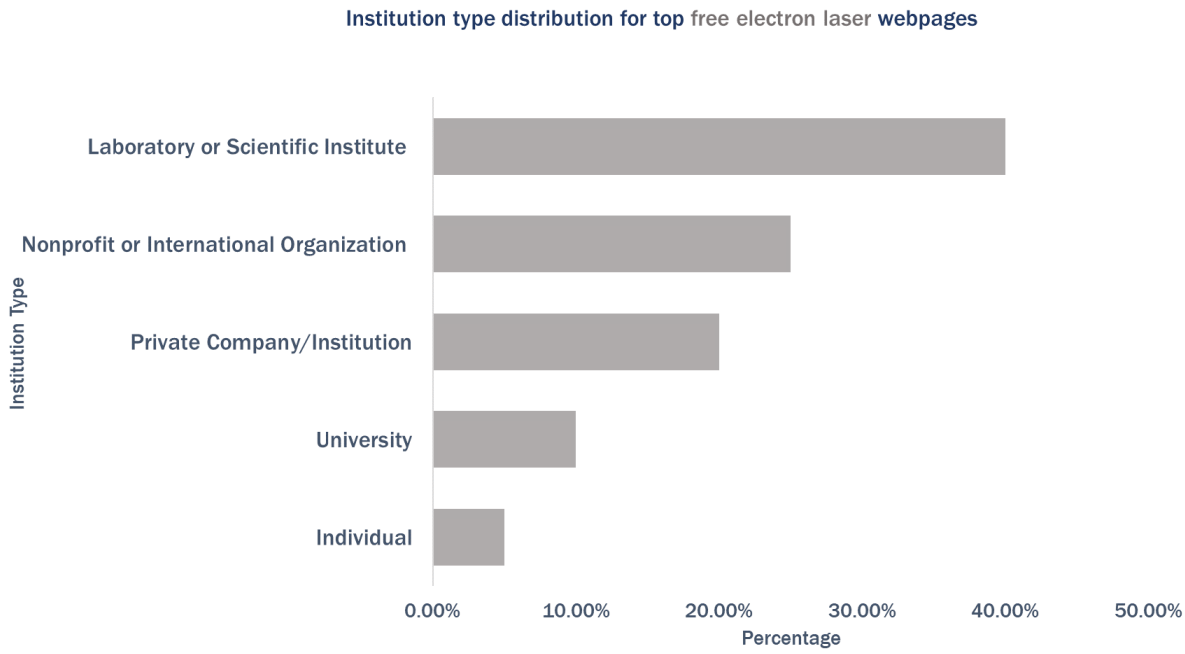
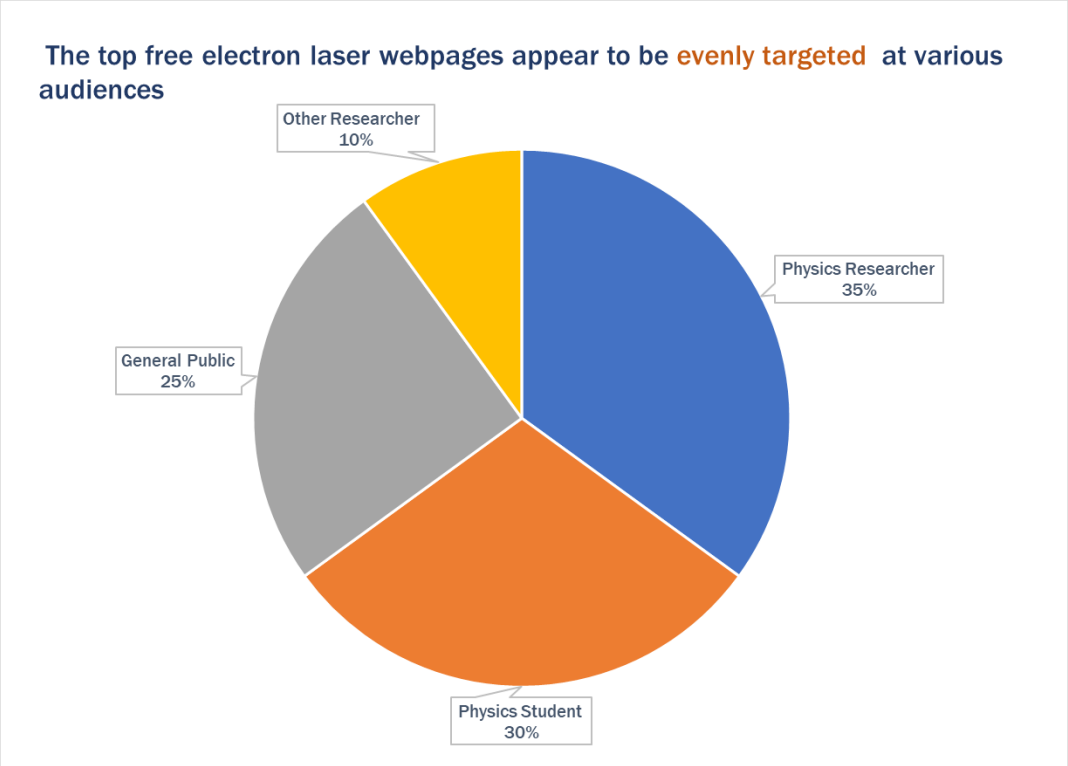


Figure 11: The distribution of institution type for top ranked 'free electron laser' webpages

The most common content format for free electron laser is informational article making up 55% of the top results. The target audience for the informational articles were quite evenly distributed between the general public, physics students and researchers.



Content tended to focus on research into the improvement of free electron lasers themselves rather than applications.

Accelerator Mass Spectrometry

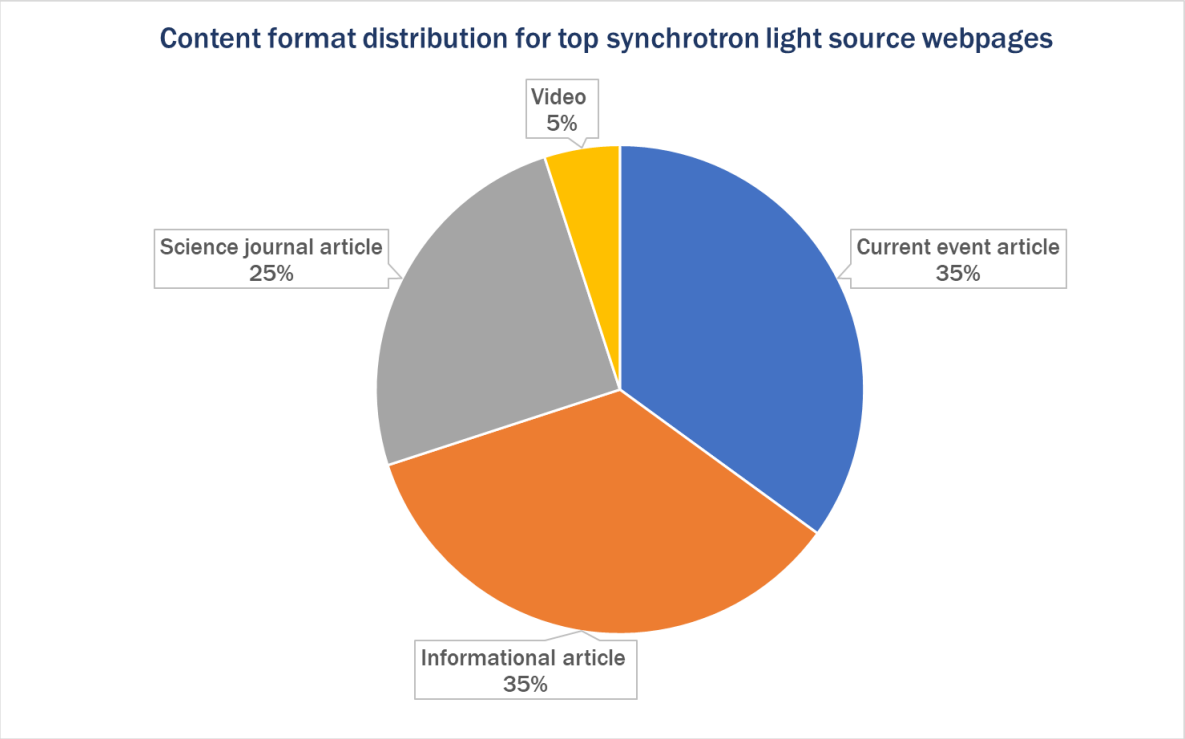
From biomedical research to oceanography, there was a broad range of domains in which the top AMS content exists. Below is a list of the featured domains:

- Biomedicine
- Human health and molecular toxicology
- Oceanography
- Pharmaceuticals and clinical research
- Earth and marine science
- Geology

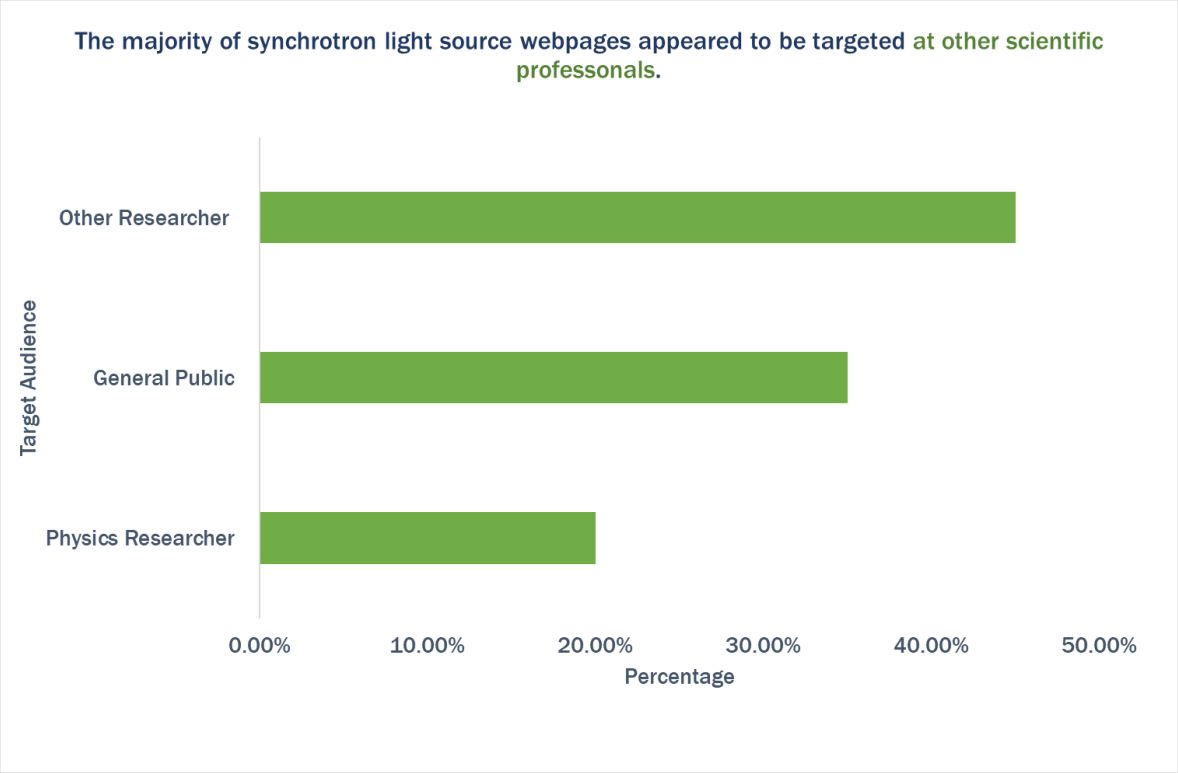
There is an opportunity to bring interest to the field of accelerator technology through these fields. The top results seem catered to researchers who are intending to use the accelerator mass spectrometry technique in their respective domain.

Synchrotron Light Sources

The top results for synchrotron light sources consisted of many well updated current event centred webpages with a quarter of pages being updated within the last year.



Whether it was journal articles on the latest research or sites to check and apply for beamtime, most content was targeted at researchers who synchrotron radiation in their research.



Although North America dominates the top results, as per usual, there was greater than average presence of other regions. Despite none of the content publishers being from Africa or Middle East Region, there was content describing the SESAME facilities and the ongoing preparatory plans for the first African Synchrotron Light Source.

Discussion and Insights

For the burgeoning scientist or science enthusiast interested in the science, operations and details of particle accelerators themselves, there is much to explore from detailed informational articles to science journal articles. This is positive for the recruitment to the field of accelerator science. Students or professionals from other domains who wish or work in accelerator science will be able to make a good orientation of the field using the internet.

However, a quote from an article on Popsci.com, a popular news website focused on communicating science and technology development, highlight the need to promote how particle accelerator are making an impact on society

"Particle accelerators, which are not renowned for their real-world applications, could in fact be used to produce energy,"

We know that particle accelerators have a plethora of applications, but it is pertinent for the accelerator community to more explicitly showcase these applications. In the analysis of the data, determining the application or domain of the content, beyond physics research and higher education, was among the most challenging aspects

The search term with the youngest date created was particle accelerator for energy. The majority of content on this topic was in the form of current event articles. This shows a real emerging interest in how particle accelerators play a role in the domain of climate change an environment, an ever present topic in todays headlines. It is possible to capitalize on other popular topics to showcase the many ways particle accelerators contribute to society.

Conclusion

With over 300 pages reviewed (and approximately 900 pages collected), it is clear that there is a wealth of accelerator science on the internet, mostly in the form of informational articles accessible to or aimed at the general public. On the other hand, there is room for the creation of content that highlights the many benefits of accelerators to society. The conclusions made in this report are not exhaustive and further analysis of the data is encouraged. Certainly, this project has provided an abundance of data that can shape the direction of outreach activities for the accelerator science community.

Appendix

Accelerator Science Online Courses

During an input and feedback period in the initial stages of the project, a review of accelerator science online courses was suggested. A total of 8 courses were identified and categorized. All courses are highly organized and entirely delivered virtually. They all offer a form of certificate upon completion, some are provided at a cost and others, like those offered by the International Atomic Energy Agency are given completely free of charge.

Course Name	Description	Course Length	Estimated Course Level	Prerequisites	Course Owner
Course on Accelerator Mass Spectrometry Radiocarbon Dating for Heritage and Forensic Science	The first MOOC to provide an extensive introduction to synchrotron and XFEL facilities and associated techniques. **What you'll learn** What are x-rays and how are they produced Interactions of x-rays with matter Machine physics Synchrotron and XFEL facilities Beamlines and instrumentation	30 hours	Undergraduate	1st-year undergraduate mathematical concepts.	École polytechnique fédérale de Lausanne
École polytechnique fédérale de Lausanne: Synchrotrons and X-Ray Free Electron Lasers (part 1)	The first course in our NPAP series is the Introduction to Particle Accelerators. It explains how a particle accelerator can generate light of wavelengths down to one Angstrom. It also explains how the ESS facility can create a massive flux of neutrons by accelerating protons and let them smash into a disk of tungsten. The initial modules provide the basic knowledge about linear and circular accelerators that is required to understand other types of accelerators, like the Large Hadron Collider (LHC), at CERN in Geneva. We describe LHC and give an introduction to the elementary particle physics it is used for. We continue by describing some new concepts for future particle accelerators,	11 hours		Very basic physics courses.	Lund University

Course Name	Description	Course Length	Estimated Course Level	Prerequisites	Course Owner
	like plasma driven accelerators.				
Fundamentals of particle accelerator technology (NPAP MOOC)	This course takes you on a journey through the technologies used in particle accelerators: The microwave system which produce the electromagnetic waves that accelerate particles; The magnet technology for the magnets that guide and focus the beam of particles; The monitoring systems that determine the quality of the beam of particles; Finally the vacuum systems that create ultra high vacuum so that the accelerated particles do not collide with molecules and atoms.	26 hours		Basic physics at undergraduate level	Lund University
Introduction to electrostatic accelerators: from basic principles to operation and maintenance	The NPAP - Medical Applications of Accelerators is one out of three courses in the Nordic Particle Accelerator Program (NPAP). Here you will be taken on a tour focusing on the medical applications of particle accelerators. You will see that there are two very important, but different, applications of accelerators in	7 hours		No previous experience necessary	Lund University

Course Name	Description	Course Length	Estimated Course Level	Prerequisites	Course Owner
	hospitals. The first application concerns radiotherapy of tumours and the other concerns the production of medical nuclides for diagnosis and treatment. Both will be included in this course and described through four modules.				
Introduction to Particle Accelerators (NPAP MOOC)	Accelerator mass spectrometry (AMS) enables the separation of isotopic masses and detection of natural abundance of isotopes. AMS radiocarbon dating is based on the existence of various carbon isotopes, the 14C content is directly measured relative to the 12C and 13C ratios. This technique is especially useful for the age determination of cultural and natural heritage objects and materials, and for forensic applications like soft tissue, food, or medicines. This e-learning course provides extensive knowledge on Accelerator Mass Spectrometry dating, and both covering Heritage and Forensics applications. It consists of 6 Modules.	6 hours	Graduate		International Atomic Energy Agency

Course Name	Description	Course Length	Estimated Course Level	Prerequisites	Course Owner
Medical Applications of Particle Accelerators (NPAP MOOC)	Nuclear analytical techniques have provided unique information in many fields due to their multi-elemental sensitivity, low limits of detection, ability to provide spatially resolved and/or quantitative profiling of trace elements, and, very often, traceability of results. Although these analytical techniques are readily available and routinely applied in research, there is still a considerable gap when it comes to routine forensics applications. The purpose of this e-learning tool is to help to bridge the gap between the practitioners of nuclear analytical techniques and forensic science stakeholder communities. It is directed at forensics specialists who wish to learn more about nuclear analytical techniques, and at nuclear techniques practitioners who wish to learn more about the requirements of forensic sciences.	9 hours	Graduate		International Atomic Energy Agency
Nuclear Analytical Techniques for Forensic Science	This e-learning course presents an aid for personnel wanting to increase their knowledge on operation and maintenance of low energy electrostatic ion accelerators and associated infrastructure. The learning objective is to provide introductory and background theoretical and practical information for the effective and safe operation and maintenance of accelerators,	5 hours		Basic familiarity with particle accelerator	International Atomic Energy Agency

Course Name	Description	Course Length	Estimated Course Level	Prerequisites	Course Owner
	ion sources, plant and equipment as well as operational procedures. The course consists of five parts: The electrostatic accelerator Ion sources Beam transport Vacuum Safety considerations				

List of Accelerator Search Terms

The following are the complete list of search terms reviewed in this project. There are search terms summaries available for the terms in bold.:

- **Accelerator Mass Spectrometry**
- **Accelerator physics**
- **Electron Beam Irradiator**
- **Electrostatic accelerator**
- **Free Electron Laser**
- **High energy physics particle accelerator**
- **Industrial particle accelerator**
- **Ion beam accelerator**
- Irradiation facilities
- Laser Plasma accelerator
- **Linear accelerator**
- Medical particle accelerator
- Nuclear Physics accelerator
- Particle accelerator
- **Particle accelerator technology**
- Particle accelerators for energy
- **Spallation Neutron sources**
- **Synchrotron Light Source**