CONFERENCE SUMMARY

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The 22nd International Conference on Cyclotrons and their Applications held in Cape Town, South Africa, attracted 194 delegates from 45 institutions located in 18 countries. Overall 119 contributions were presented, 52 oral presentations and 67 posters. For the latter, adequate time was allocated for presentation and discussion.

The addressed topics covered a very broad field. They ranged from concepts and new projects, theory and simulations, over cyclotron technology to operation and upgrades as well as applications. The different topics were very well balanced (Table 1).

Table 1: Share of the different presented topics.

Topic	Share
Cyclotron technology	32%
Operation and Upgrades	22%
Cyclotron Applications	19%
Theory, Models and Simulations	14%
Cyclotron and FFAG concepts	11%
Young Scientists	2%

A look at the various applications shows the extremely broad range of fields: accelerator driven systems (ADS), radioisotope production, particle therapy, radiation hardness testing, accelerator mass spectroscopy, and last, but not least – fundamental physics for a better understanding of the universe. All these various applications benefit from cyclotrons and a world without cyclotrons would be a poorer place. Just one example: It is important for our society to find a solution to the problem of long-lived radioisotopes from nuclear waste. The FFA accelerator complex in Kyoto accomplished the first experiments for transmutation of the minor actinides ^{237}Np and ^{241}Am.

Beside the charm and the beauty of cyclotron design in itself, these applications drive the development of the cyclotrons towards:

- Increased beam intensity, among others for ADS and radioisotope production.
- Precise beam delivery, e.g. for particle therapy.
- Increased efficiency: size, cost, energy consumption.
- Improved beam diagnosis and analysis.
- Driving the technical limits in terms of magnetic field, RF, and power.

The topic "Cyclotron technology" included magnets, injection and extraction, sources, and control systems. Mobile phones or tablets will be even more used in the future than today – so an interface to EPICS sounds fascinating.

Several sessions were dedicated to the topic "Operation and Upgrades". Many "small" improvements resulted in higher intensities and better reliability. While GANIL and the IMP have long-term big upgrades based on a Linac, the upgrade plan for CIAE comprises a CW FFAG. Furthermore, complete refits of existing cyclotrons are underway.

The images of a Magnetic Resonance Imaging system (MRI) installed in a proton beam line showed little and predictable shifts due to the fringe field of the beam lines magnets. Furthermore, these are correctable. Improvements on the control of beam intensity for continuous line scanning were presented as well as transparent beam profilers based on secondary electron emission.

A new approach to design FFAs from their orbits was shown, however, most of the talks about simulations were dedicated to OPAL: Development and Surrogate models, a Multi-Objective Optimization which turned out to be good for a quick finding of reasonable solutions, and the inclusion of Monte Carlo methods for residual gas and dissociation by electromagnetic stripping.

There is a range of existing machines of various providers for radioisotope production, which has been extended in the 70 MeV energy range for protons. Furthermore, there are new installations to come in the future with energies up to 100 MeV. Within that topic there was an excellent presentation given by a young scientist about the design of a multi-purpose high-temperature superconducting skeleton cyclotron.

The presentations about accelerators for particle therapy included a proposal for a skeleton cyclotron as well, and a microtron-like design. Furthermore, several new projects for proton therapy sites in China were presented. A design for a 70 MeV/u for both $^{12}C^{6+}$ and H_2^+ is underway.

A very compact cyclotron for accelerator mass spectroscopy with an extraction radius of only 440 mm was presented for archaeometry.

For fundamental research both new designs as new machines were presented: e.g. a high power machine with permanent magnets for better transmission. The DC280 delivered first beam for super heavy elements in January 2019. For the ISIS upgrade a FFA option is considered.

This conference provided exciting and interesting contributions. The invited talks gave a very good overview of the addressed topics and were a perfect introduction into the corresponding sessions. New cyclotrons came into operation, are under construction and being designed. The status reports were honest and realistic, thus permitting a real experience exchange. There was time for intense discussions with colleagues, resulting in new ideas.

The author would like to thank the conference host, iThemba LABS, for running an extremely smooth conference, a very informative excursion to the iThemba LABS accelerators followed by a delicious braai, and giving us the chance to meet old friends and acquire new ones.

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