CHALLENGE BASED INNOVATION (CBI)

The Research Board approved in December 2015 the experimental GRADE MoU framework for detector pre-R&D and educational student activities. This new framework was inspired by the DRDC and based on the model of the Neutrino Platform, offering here institutes the possibility to establish small collaborations or experiments for exploring new, next-generation detector R&D concepts while engaging students to explore potential use for these technologies outside high energy physics. These are hosted or supported by IdeaSquare at CERN, which offers administrative and technical support to projects (e.g. lab space, semi-clean room facilities, EU-funding application support etc.).

Since 2016, the main educational arm in GRADE has become Challenge Based Innovation (CBI) student course. CBI has, until present, engaged more than 600 MSc-level students from different disciplines, mostly from engineering, business management and design. While the students have focused on UN's SDG-driven assignments by their home universities, they are exploring or benefiting from knowledge being developed at CERN, either in the specific detector related GRADE projects or elsewhere at CERN. For practical reasons, CBI-related student activities have been administratively handled through SIMPLE, one of the four current GRADE projects, but CBI students have actively engaged with other GRADE projects, as well. CBI has several brands, depending on the size, duration and main location of the projects, ranging from a few weeks to six months. An on-line version of CBI has also been launched, offering students the possibility to contribute to certain projects remotely.

Examples of the ways CBI students interact with detection and imaging related R&D projects at IdeaSquare and elsewhere include investigations of possible use MDTs in early-warning earthquake systems, use of GEM-technologies in detecting microplastics in oceans, use of photo (and audio) sensors in industrial plant automation and detection of underground water cavities in dried areas, use of optical sensors in farm land irrigation, use of neural networks and machine learning in and use of Augmented Reality tools in large detector maintenance tasks for educating young children. Other, more general CERN-inspired examples can be found in Appendix 1.

While at CERN, the CBI students stay at IdeaSquare and make active use of the laboratory facilities there and interacting with the researchers at IdeaSquare and elsewhere on the CERN site. At the end of theirs stay, they build conceptual prototypes as part of their student assignments and final presentations to the invited CERN

audiences. For each team, a mentor or "champion" is assigned from the CERN community, typically detector experts from the projects the students are interacting with. The Knowledge Transfer Group from IPT is also actively involved, helping the students to connect with the potentially relevant technologies and people. It should be noted that primary focus in CBI is educational, with the aim of fostering next generation of scientists, engineers and innovators.

As SIMPLE is coming to its foreseen end this year (2019), and given that CBI activities have strongly grown during the past years, CBI merits now to have it its own, dedicated project structure under GRADE. This is also timely as IdeaSquare is supporting several EU-funded ATTRACT-projects (for example, CERN is involved in 19 of them), and CBI-like student activities will become an integral element of interactions between the funded ATTRACT projects, and is being prototyped at IdeaSquare for these purposes having in mind the next Framework program (Horizon Europe). While each detection & imaging project may have their own technical or PhD students as part of their collaborations, a dedicated structure is required to handle the interface for the cross-disciplinary (CBI) student teams. Moreover, the universities sending their students and teaching staffs to CERN are not necessarily familiar with high energy physics research (e.g. business and design schools) and will require administrative support.

During the next four years, the CBI program intends to integrate more deeply into the on-going detection and imaging R&D projects at IdeaSquare and CERN (e.g. ATTRACT). This means embedding cross-disciplinary students into the R&D teams for longer time periods or to "shadow" the researchers on site, while doing market research and potential user interviews related to the technological areas of interest. This requires a more stable project structure with coordination across the different institutes involved, to avoid the unwanted administrative overhead falling on the shoulders of the detector R&D projects themselves. The CBI students will also be more exposed to experimental prototyping at IdeaSquare, where they are already regularly introduced to rapid prototyping skills like 3D-printing and programming of Raspberry Pi's and Arduino's, and use of basic machining tools.

Following feedback received from the Advisory Board overseeing the GRADE and Ideasquare activities, the use of (CBI) students also *after* their assignments to engage with the on-going R&D projects at CERN, will be experimented. The KT Group would also play a crucial role in this. This means exploring the possibility of more systematic creation of start-ups or other entrepreneurial initiatives involving the R&D teams,

possibly engaging also their own students. Promising results have already been obtained from mixing (CBI) MSc-students with early-phase technical PhD students.

The planned enlarged CBI experimentation aims at creating a new and novel way for pre-R&D detection and imaging projects at CERN to benefit from cross-fertilization with students from other fields, with the aim of finding new potential future use of emerging new detector concepts in areas not familiar to the researchers themselves, supported by conceptual prototypes constructed at IdeaSquare. The progress will be documented and reported in journals like the CIJ and alike. The results of all projects are published on the web, as has been the case from the beginning.

Currently, CBI (including its brands) has 14 participating universities from Australia, Finland, Germany, Italy, Norway, Portugal, Spain and the UK. They have all expressed their keen desire to continue in the proposed new experimental setting. The funding comes from the participating universities. IdeaSquare provides the space and administrative support.

APPENDIX 1

Examples of CBI courses inspired by the LHC Experiments and CERN technologies.

Project name	Challenge	UN SDG Objective addressed	Output prototype	CERN/Detectors technology inspiration	Link
CORTEX	Global quality education to decrease inequality.	No Poverty. Quality Education.	Decentralized and distributed network for academic records.	CERN Grid Zenodo	https://www.cbi-course.com/team-wu-cortex-decentralised-and-distributed-network-for-academic-records/
SENTRA	Training of professionals acting in emergency sanitary situations.	Good Health and Well-Being.	Haptic suit equipped with AI and VR.	WRM chip of ATLAS (EU EDUSAFE project, AUGMENT) CERN Media Lab	https://www.cbi-course.com/team-sutherland-sentra-the-sensory-training-system-of-the-future/
GEIGER	Reducing the risk of Radon exposure.	Industry, Innovation and Infrastructure. Sustainable Cities and Communities.	Internet platform of Radon Detectors.	Radon Dose Monitor (RaDoM) project, HEALTH	https://www.cbi-course.com/team-geiger-saker-radon-awareness/
SYMETRA	Maintenance of critical infrastructures.	Industry, Innovation and Infrastructure. Sustainable Cities and Communities.	Augmented reality wearables for enabling maintenance service professionals.	WRM chip of ATLAS (EU EDUSAFE project), AUGMENT CERN Media Lab	https://www.cbi-course.com/team-watt-symmetra-ar-in-maintenance-work/

DALI	Future high quality education.	No Poverty. Quality Education. Reduced inequality.	Virtual platform for knowledge exploration/acquisition.	WRM chip of ATLAS (EU EDUSAFE project), AUGMENT CERN Media Lab	https://www.cbi-course.com/team-nash-dali-learning-environment-of-the-future/
Well2Go	Water scarcity.	Clean water and sanitation.	Monitoring and maintaining water points in northern Ghana through affordable sensors	ATLAS and CMS fiber optic sensors.	https://www.cbi-course.com/team-planck-well2go/
The Mat	Avoiding food waste.	Responsible consumption and production.	Perishable food monitoring system.	Impedance sensors of ATLAS and CMS.	https://www.cbi-course.com/the-mat-food-security/
PENROSE	Reducing child and youth illiteracy.	No Poverty. Quality Education. Reduced inequality.	Learning through a gamification platform.	CERN Media Lab.	https://www.cbi-course.com/team-penrose-creating-a-literate-world/