

The JUNO Experiment, Addendum

1 Interested community

JUNO is an already well-established Collaboration with 77 participating institutes and more than 600 scientists. Table 1 presents the participant numbers per country.

Table 1: JUNO participation per country.

Region	Institutions	Students	Postdocs	Seniors
Armenia	1	2	0	2
Belgium	1	0	0	1
Brazil	2	1	0	2
Chile	2	2	1	5
China	34	106	16	201
Czech Republic	1	2	1	3
Germany	7	31	3	20
Finland	1	1	1	4
France	5	4	1	16
Italy	8	12	4	52
Latvia	1	0	0	2
Pakistan	1	0	0	10
Russia	3	10	1	26
Slovakia	1	1	2	2
Thailand	3	6	0	13
Taiwan, China	3	9	1	5
USA	3	1	1	3
Sum	77	188	32	367

The list of all participating institutes is the following:

- YerPhI -- Yerevan Physics Institute, *Yerevan, Armenia*.
- ULB -- Université Libre de Bruxelles, *Brussels, Belgium*.
- PUC-Rio -- Pontificia Universidade Catolica do Rio de Janeiro, *Rio, Brazil*.
- UEL -- Universidade Estadual de Londrina, *Londrina, Brazil*.
- PUCCh -- Pontificia Universidad Catolica de Chile, *Santiago, Chile*.
- USM -- Universidad Tecnica Federico Santa Maria, *Valparaiso, Chile*.
- JLU -- Jilin University, *Jilin, Changchun, China*.
- SYSU -- Sun Yat-Sen University, *Guangdong, Guangzhou, China*.
- ZZU -- School of Physics and Engineering, Zhengzhou University, *Henan, Zhengzhou, China*.
- RNCG -- The Radiochemistry and Nuclear Chemistry Group in University of South China, *Hunan, Hengyang, China*.
- WuYi -- Wuyi University, *Guangdong, Jiangmen, China*.

- XJTU -- Xi'an Jiaotong University, *Shanxi, Xi'an, China*.
- PKU -- School of Physics, Peking University, *Beijing, China*.
- BNU -- Beijing Normal University, *Beijing, China*.
- GXU -- Guangxi University, *Guangxi, Nanning, China*.
- IMP -- Institute of Modern Physics, Chinese Academy of Sciences, *Lanzhou, China, China*.
- HIT -- Harbin Institute of Technology, *Heilongjiang, Harbin, China*.
- CUGB -- China University of Geosciences, *Beijing, Beijing, China, China*.
- IGGCAS -- Institute of Geology and Geophysics, Chinese Academy of Sciences, *Beijing, China, China*.
- ECUT -- East China University of Technology, *Nanchang, China, China*.
- USST -- University of Shanghai for Science and Technology, *Shanghai, China, China*.
- BISEE -- Beijing Institute of Spacecraft Environment Engineering, *105, You Yi Road, Haidian District, Beijing, China*.
- NUDT -- College of Electronic Science and Engineering, National University of Defence Technology, *Chang Sha, Hu Nan, China*.
- JNU -- Jinan University, *Guangdong, Guangzhou, China*.
- XMU -- Xiamen University, *Xiamen, China*.
- CQU -- Chongqing University, *Chongqing, China*.
- CIAE -- China Institute of Atomic Energy, *Beijing, China*.
- Nankai -- Nankai University, *Tianjin, China*.
- SJTU -- Shanghai Jiao Tong University, *Shanghai, China*.
- NJU -- Nanjing University, *Nanjing, China*.
- IHEG-CAGS -- Institute of Hydrogeology and Environmental Geology, Chinese Academy of Geological Sciences, *Hebei, Shijiazhuang, China*.
- UCAS -- University of Chinese Academy of Sciences, *Beijing, China*.
- USTC -- University of Science and Technology of China, *Hefei, China*.
- Tsinghua -- Tsinghua University, *Beijing, China*.
- NCEPU -- North China Electric Power University, *Beijing, China*.
- DGUT -- Dongguan University of Technology, *Dongguan, China*.
- IHEP -- Institute of High Energy Physics, *Beijing, China*.
- WHU -- Wuhan University, *Wuhan, China*.
- SDU -- Shandong University, *Jinan, China*.
- ECUST -- East China University of Science and Technology, *Shanghai, China*.
- CU Prague -- Charles University, Faculty of Mathematics and Physics, *Prague, Prague, Czech Republic*.
- RWTH-AC -- III. Physikalisches Institut B, RWTH Aachen University, *Aachen, Germany*.
- JGU Mainz -- Institute of Physics and EC PRISMA, Johannes-Gutenberg University Mainz, *Mainz, Mainz, Germany*.
- EKUT -- Eberhard Karls Universität Tübingen, Physikalisches Institute, *Tübingen, Germany*.
- FZJ-IKP -- Forschungszentrum Jülich GmbH, Nuclear Physics Institute IKP-2, *Jülich, Germany, Germany*.
- TUM -- Technical University of Munich, *Garching, Germany*.
- Hamburg -- Institute of Experimental Physics, University of Hamburg, *Hamburg, Germany*.

- FZJ-ZEA -- Forschungszentrum Jülich GmbH, Central Institute of Engineering, Electronics and Analytics - Electronic Systems (ZEA-2), *Jülich, Germany*.
- JyU -- University of Jyväskylä, Department of Physics, *Jyväskylä, Finland, Finland*.
- APC -- Astro-Particle Physics Laboratory, *Paris, France*.
- SUBATECH -- SUBATECH, CNRS/IN2P3, Université de Nantes, Ecole des Mines de Nantes, *Nantes, France*.
- CENBG -- Centre d'Etudes Nucléaires de Bordeaux Gradignan, *GRADIGNAN, France*.
- CPPM -- Centre de Physique des Particules de Marseille, *Marseille, France*.
- IPHC -- Institut Pluridisciplinaire Hubert Curien, Université de Strasbourg, CNRS/IN2P3, *Strasbourg, France*.
- INFN-LNF -- Laboratori Nazionali di Frascati dell'INFN, *Roma, Italy*.
- INFN-CA -- INFN Sezione di Catania, *Catania, Italy*.
- INFN-MIB -- INFN Milano Bicocca and University of Milano Bicocca, *Milano, Italy*.
- INFN-FE -- Department of Physics and Earth Science, University of Ferrara and INFN Sezione di Ferrara, *Ferrara, Italy*.
- INFN-MI -- INFN Sezione di Milano and Dipartimento di Fisica dell'Università di Milano, *Milano, Italy*.
- INFN-PG -- INFN and University of Perugia - Department of Chemistry, Biology and Biotechnology, *Perugia, Italy*.
- INFN-Roma3 -- University of Roma Tre and INFN Sezione Roma Tre, *Roma, Italy*.
- INFN-PD -- INFN Sezione di Padova, *Padova, Italy*.
- IECS -- Institute of Electronics and Computer Science, *Riga, Latvia, Latvia*.
- PINSTECH -- Pakistan Institute of Nuclear Science and Technology, *Islamabad, Pakistan, Pakistan*.
- JINR -- Joint Institute for Nuclear Research, *Dubna, Russia*.
- INR-RAS -- Institute for Nuclear Research of the Russian Academy of Sciences, *Moscow, Russia*.
- MSU -- Moscow State University, *Moscow, Russia, Russia*.
- DNP-FMPH-UNIBA -- Department of Nuclear Physics and Biophysics, Faculty of Mathematics, Physics and Informatics, Comenius University in Bratislava, *Mlynska dolina F1, 842 48 Bratislava, Slovakia (Slovak Republic), Slovakia*.
- FMFI-UK -- Comenius University Bratislava, Faculty of Mathematics, Physics and Informatics, *Bratislava, Slovakia, Slovakia*.
- CU -- Department of Physics, Faculty of Science, Chulalongkorn University, *Bangkok, THAILAND, Thailand*.
- SUT -- Suranaree University of Technology, *Nakhon Ratchasima 30000, Thailand, Thailand*.
- NARIT -- National Astronomical Research Institute of Thailand, *Chiang Mai, Thailand, Thailand*.
- NCTU -- Institute of Physics National Chiao-Tung University, *Hsinchu, Taiwan, China*.
- NUU -- National United University, *Miao-Li, Taiwan, China*.
- NTU -- Department of Physics, National Taiwan University, *Taipei, Taiwan, China*.
- UMD-G -- Department of Geology, University of Maryland, *College Park, MD 20742, USA*.
- UMD-P -- Department of Physics, University of Maryland, *College Park, MD, USA*.

Three observers complete this list:

- University of Zagreb (Croatia),
- Yale University (USA),
- Department of Physics, University of Malaya (Kuala Lumpur).

2 Timeline

The Figure below presents the JUNO schedule starting from the establishment of the Collaboration in 2014 up to the beginning of data taking. The Collaboration has been established in 2014. According to the present JUNO schedule the data taking period will start end of 2021. The aim of the Collaboration is to provide a neutrino mass hierarchy determination and precise measurement of three oscillation parameters 6 years after.



3 Construction and operating costs

The JUNO underground laboratory is under construction since end of 2014. The civil engineering will be finished by the end of 2019 followed by the detector installation. A final design of the majority of the detector parts already exist. Moreover, many orders have already been placed for many parts of the detector (see main document).

The total cost of the JUNO detector is estimated to about 300 M€. All parts are already funded. The operating cost is expected to be around 3.1 M€ per year. The main contributing Funding Agencies are given by the following table:

Country	Funding Agency
Armenia	Yerevan Phys. Inst.
Belgium	FNRS
Brazil	UEL PUC
Chile	PCUC USM
China	CAS

Czech R.	Charles University
Finland	University of Jyvaskyla
France	IN2P3
Germany	DFG HAP HGF
Italy	INFN
Latvia	IECS
Pakistan	PINSTECH (PAEC)
Russia	JINR INR MSU
Slovakia	FMFI-UK
Taiwan, China	MOST
Thailand	SUT NARIT PPRL
USA	UMD UMD-GEO UCI

The only part which is not yet funded is the reference detector JUNO-TAO, recently proposed. This sub-detector, estimated to cost about 6 M€, could be financed after the installation of the JUNO main detector.

4 Computing requirements.

The expected data volume per year for JUNO is 2 PB for raw data storage, 200 TB for reconstructed data, 20 TB for simulation and 1 TB for analysis. For computing, 12000 CPU cores will be needed. All this computing power and data storage will be provided by IHEP/CAS all interested European Funding agencies.