40th European Cyclotron Progress Meeting

Wednesday 20 September 2017 - Saturday 23 September 2017

INFN Laboratori Nazionali di Legnaro

Book of abstracts

FINAL INFORMATION

SCIENTIFIC PROGRAM

The scientific program is available on the meeting website.

Oral presentations are allotted a total of 25 minutes (20' talk + 5' discussion). All speakers are asked to transfer their presentations (MS Power Point or PDF) one day before their talk or early in the morning.

Posters should be presented in A0 portrait format (841 × 1189 mm). Posters can be affixed on Thursday morning prior to the poster session. They have to be removed by 13:00 o'clock of Saturday, Sept. 23. The boards for displaying posters will be marked with a poster code. Please, check in the Book of Abstracts the code given to your poster.

TRANSFERS FROM PADOVA HOTELS TO LNL and BACK

A transfer service has been organized every day from Padova hotels to Legnaro Laboratories and back. Since the bus can stop only for a few seconds, participants are kindly recommended to be **on time** at the pick-up points.

Pick-up Points

Pick-up Point 1: Stefanel shop, Via Emanuele Filiberto di Savoia, 1, Padova next to Piazza Garibaldi.
Pick-up Point 2: Via Falloppio (at the crossraod with Via Ospedale) Via Ospedale, in front of the Newsagent's.

Pick-up times

21 Sept. - Thursday
7:45: pick-up point 1, Via Emanuele Filiberto di Savoia
7:55: pick-up point 2, Via Falloppio
→ to LNL

18:15: from Laboratori Nazionali di Legnaro to:
→ to drop-off point 2: Via Falloppio
→ to drop-off point 1: Via Emanuele Filiberto di Savoia

22 Sept. - Friday
8:15: pick-up point 1, Via Emanuele Filiberto di Savoia
8:25: pick-up point 2, Via Falloppio
→ to LNL

16:30: from Laboratori Nazionali di Legnaro
→ to Piazza Eremitani (Cappella Scrovegni) – this drop-off point only!

19:15: Piazza Eremitani
→ to Restaurant Liviangior (Abano Terme)

22:30 from Restaurant Liviangior (Abano Terme)
→ to drop-off point 2: Via Falloppio
→ to drop-off point 1: Via Emanuele Filiberto di Savoia

23 Sept. - Saturday
8:15: pick-up point 1, Via Emanuele Filiberto di Savoia
8:25: pick-up point 2, Via Falloppio
→ to LNL

14:30: from Laboratori Nazionali di Legnaro
→ to drop-off point 2: Via Falloppio
→ to drop-off point 1: Via Emanuele Filiberto di Savoia
→ to Railway Station

SOCIAL EVENTS

The following events are planned:

- **Wednesday, September 20th, at 18:00**: **Welcome Reception** at Caffe' Pedrocchi (http://www.caffepedrocchi.it/), Via VIII Febbraio, 15 - Padova. A dedicated desk will be available on site for conference registration from 17:30.
- **Thursday, September 21st, at 14:30: visit to the Legnaro Laboratories**, including the cyclotron premises.
- **Friday, September 22nd, at 17:15:** guided visit to the **Giotto's Scrovegni Chapel** (http://www.cappelladegliscrovegni.it/). A bus, leaving form LNL at 16:30, will take participants directly to Piazza Eremitani for the visit. Participants not joining the visit are kindly asked to reach their hotels on their own and to reach again the meeting point at Piazza Eremitani for the transfer to the social dinner.
- **Friday, September 22nd, at 20:00: Conference Dinner** at Restaurant Liviangior (http://www.liviangior.it/), Via Marza, 11, Montegrotto Terme. The bus to the Restaurant will leave from Piazza Eremitani at 19:15. After the dinner, the bus will take participants back to the morning pick-up points.

The Organizing Committee

Mario Maggiore (Chair)
Piergiorgio Antonini
Andrea Calore
Daniela Campo
Augusto Lombardi
Lorenzo Pranovi
Anna D'Este (secretary)

CONTACT

meeting secretariat: ecpm2017@lnl.infn.it
fee payment: ecpm2017@leonardiviaggi.com
website: http://agenda.infn.it/event/ecpm2017

The event is sponsored by

40th European Cyclotron Progress Meeting", Legnaro (Padova), Italy, September 20-23, 2017

Scientific Program

Thursday, September 21

Session Chairman: A. Lombardi

09:00	09:20		**Welcome address** (D. Bettoni , LNL Director)	
09:20	09:45	G. Prete	*The SPES project at the INFN- Laboratori Nazionali di Legnaro*	THU11
09:45	10:10	M. Maggiore	*Status of High Intensity Beam Facility at LNL*	THU12
10:10	10:35	L. Calabretta	*Upgrading of the LNS Superconducting Cyclotron to deliver beam power higher than 2-5 kW*	THU13
10:35	11:00		**Coffee-break**	
11:00	11:25	I. Kalagin	*The New DC-280 Cyclotron. Status and Perspectives*	THU21
11:25	11:50	A. Denker	*Status of the HZB cyclotron*	THU22
11:50	12:15	B. Jones	*The heavy ion irradiation facility at KVI-CART*	THU23
12:15	12:40	O. Kamalou	*Status Report on GANIL and Upgrade of SPIRAL1*	THU24
12:40	13:05	D. May	*Status of the Texas A&M Radioactive-Beam Project*	THU25
13:05	14:30		**Lunch**	
14:30	16:00		LNL visit	
16:00	17:00		Poster Session	
17:00	17:20		**Coffee-break**	
17:20	18:00		Poster Session	

Friday, September 22

Session Chairman: P. Antonini

09:00	09:25	V. Gupta	*Activities from Cyclotrons at German Cancer Research Center (DKFZ), Heidelberg - A Status Report*	FRI31
09:25	09:50	S. Braccini	*Multi-disciplinary research activities and beam diagnostic detector developments at the Bern medical cyclotron*	FRI32
09:50	10:15	O. Felden	*Extension of JULICs irradiation capabilities*	FRI33
10:15	10:40	G. Asova	*Status Update of Cyclotron Laboratory at Institute for Nuclear Research and Nuclear Energy*	FRI34
10:40	11:00		**Coffee-break**	
11:00	11:25	J. Esposito	*LARAMED - LAboratory of RAdionuclides for MEDicine: Status of the research facility at INFN LNL*	FRI41
11:25	11:50	L. Silvestrin	*Status of NEPIR, the NEutron and Proton Irradiation facility at SPES cyclotron*	FRI42
11:50	12:15	J. Van de Walle	*The S2C2 : experiences from in-factory testing and on-site installations*	FRI43
12:15	12:40	L. Sarchiapone	*Radiometric Survey at the LNL Cyclotron*	FRI44
12:40	13:05	A. Caruso	*Low-Level/High-Level - How and Why the RF System is Changing at INFN-LNS*	FRI45
13:05	14:30		**Lunch**	
14:30	14:55	A. Monetti	*Design and study of the 8kW Diagnostic Box for the SPES proton beam line*	FRI51
14:55	15:20	H. Skliarova	*Magnetron sputtering for corrosion protection of liquid cyclotron target for Fluorine-18 production*	FRI52
15:20	15:45	S. Cisternino	*Experimental set-up for thermal resistance at interface measurements*	FRI53
15:45	16:30		**Coffee-Break/poster session**	
16:30	19:00		Scrovegni Chapel Visit	
20:00	22:00		Social Dinner	

Saturday, September 23

Session Chairman: M. Maggiore

09:00	09:25	G. Vecchio	*Management Software and Data Exchange Protocol for the INFN-LNS Accelerators Beamlines*	SAT61
09:25	09:50	Y.-N. Rao	*Correction of nu_r-nu_z=1 Resonance in TRIUMF Cyclotron*	SAT62
09:50	10:15	G. D'Agostino	*Investigation on the spiral inflector and central region of the IsoDAR test bench cyclotron*	SAT63
10:15	10:40	O. Karamyshev	*Final design of the SC202 superconducting cyclotron for hadron therapy*	SAT64
10:40	11:00		**Coffee-break**	
11:00	11:25	D. Mascali	*The AISHA Ion Source: Commissioning and preliminary results*	SAT71
11:25	11:50	S. Bogomolov	*DECRIS-PM ion source for the DC-280 cyclotron*	SAT72
11:50	12:15	G. Castro	*H2+ beams for Cyclotrons*	SAT73
12:15	12:40	T. Kalvas	*Status of a new 18 GHz ECRIS HIISI*	SAT74
12:40	13:05	M. Maggiore	Concluding Remarks	
13:05	14:30		**Buffet Lunch**	

Poster Session

V. Malinin	Extraction simulations for the SC202 cyclotron for proton therapy for JINR Dubna	POS01
D. Du	Best Cyclotron Control Systems: A unique integration of the traditional PLC controls and the digital microprocessor controls	POS02
D. Popov	Evaluating and improving accuracy of the magnet simulation.	POS03
T. Boesian	Compact extraction system for the B70 Cyclotron	POS04
V. Ryjkov	BEST 70p cyclotron beam commissioning at LN Legnaro	POS05
P. Martini	High Quality Technetium-99m by Medical Cyclotrons .	POS06
O. Karamishev	Beam dynamics simulations in the Dubna SC202 superconducting cyclotron for hadron therapy	POS07
A. Calanna	Optimization of the return yoke for the upgraded superconducting cyclotron of INFN-LNS	POS08
A. Russo	Preliminary design of the new FRagment SEparator at INFN-LNS	POS09
A. Denker	First Operational Experiences for Therapy of Ocular Melanomas with a Modern Low Level RF Control	POS10
P. Antonini	Design of an injection buncher for the 70 MeV cyclotron	POS11
A. Caruso	PRACTICAL MEASUREMENT METHODS TO DETERMINE SHUNT RESISTANCE, Q FACTOR, DEE VOLTAGE AND MULTIPACTORING PHENOMENA	POS12
M. Montis	Cyclotron Integration into the SPES Main Control System: Proof of Concept Based on EPICS and OPC	POS13
S. Braccini	Novel PET Radioisotope Developments with the Bern medical Cyclotron	POS14
P. Calvo Portella	Optimization and characterization of the ion source for the compact superconducting AMIT cyclotron considering different chimney configurations	POS15

Table of contents (oral contributions)

Session 1 - THU11

The SPES project at the INFN- Laboratori Nazionali di Legnaro

PRETE, Gianfranco [1]

[1] *LNL*

Corresponding Author: gianfranco.prete@lnl.infn.it

The SPES project is in the construction phase at the Legnaro National Laboratory (LNL) of INFN. It is an interdisciplinary project, ranging over nuclear physics, nuclear medicine and materials science. SPES will provide a Radioactive Ion Beam facility for the study of neutron rich unstable nuclei of interest to nuclear and astro-nuclear physics research. At the same time, it will host a laboratory for research and production of radioisotopes to be applied in nuclear medicine.
SPES is based on a dual exit high current Cyclotron, with proton beam energy 35-70 MeV and 0.2-0.5 mA, used as proton driver to supply an ISOL system with an UCx Direct Target able to sustain a power of 10 kW and produce neutron rich ions at intensities one order of magnitude higher than existing facilities. The second exit will be used for applied physics: radioisotope production for medicine and neutrons for material study.
The main SPES physics program is based on the use of the re-accelerated exotic beams by the ALPI superconductive linac which allows having beams at energies in the range of 10 MeV/n. At these energies nuclear reactions with radioactive beams will be possible, and more exotic nuclei by transfer reaction will be produced and studied.
The layout of SPES was designed in such a way to operate two targets at the same time distributing the beam according to a schedule that minimizes the radiation problems. The proton beam can be sent to two ISOL target caves, three caves for radioisotopes production and developments and an area for neutron production and material study.

Session 1 - THU12

Status of High Intensity Beam Facility at LNL

MAGGIORE, Mario [1]; LOMBARDI, Augusto [1]; ANTONINI, Piergiorgio [1]; CAMPO, Daniela [1]; PRANOVI, Lorenzo [1]; CALORE, Andrea [1]

[1] *LNL*

Corresponding Author: mario.maggiore@lnl.infn.it

The High Intensity Beam Facility cyclotron based is under commissioning at LNL. The facility is developing in the SPES project framework and the proton driver will provide a beam up to 50 kW power and 70 MeV energy for research in nuclear physics, medical and neutron source applications as well.

Session 1 - THU13

Upgrading of the LNS Superconducting Cyclotron to deliver beam power higher than 2-5 kW

CALABRETTA, Luciano [1]; CALANNA, Alessandra [1]; RIFUGGIATO, Danilo [1]; RUSSO, Antonio Domenico [1]; CUTTONE, Giacomo [1]; D'AGOSTINO, Grazia

[1] *LNS*

Corresponding Author: calabretta@lns.infn.it

The LNS Superconducting Cyclotron has been in operation for more than 20 years. To fulfil the demand of users aiming to study rare processes in Nuclear Physics, the beam power has to be increased up to 2⊠10 kW for ions with mass lower than 40 a.m.u.. Extraction by stripping has been envisaged as the best solution for this purpose.
To perform the extraction by stripping, a significant refurbishing operation of the Cyclotron is needed, including a new cryostat with new superconducting coils, a new extraction channel with a 60 mm vertical gap, additional penetrations to host new magnetic channels and new compensation bars.
A general description of the refurbishing project is presented.

Session 2 - THU21

THE NEW DC-280 CYCLOTRON. STATUS AND PERSPECTIVES

Dr. GIKAL, Boris [1]; Dr. KAZARINOV, Nikolay [1]; Mr. OSIPOV, Nikolay [1]; Mr. IVANOV, Gennady [1]; KALAGIN, Igor [1]; Dr. GULBEKIAN, Georgij [2]; Dr. BOGOMOLOV, Sergey [1]; Mr. IVANENKO, Ivan [3]; Prof. DMITRIEV, Sergey [1]; Prof. OGANESSIAN, Yuri [1]

[1] *JINR*

[2] *JINR, Russia, Dubna*

[3] *JINR, Dubna*

Corresponding Author: kalagin@jinr.ru

The status of the project of the DC-280 cyclotron is presented. The DC-280 will be the basic facility of the Super Heavy Element Factory which is being created at the FLNR JINR. The energy of the ions extracted from the cyclotron will be vary from 4 up to 8 MeV/amu. The expected ion beam intensity at DC-280 extraction is 10 pmkA for ions with masses 50-60. The main parts of the DC-280 are already made and are being assembled. In according to FLNR plans the cyclotron has to be assembled in the period from 2016 to 2017. The cyclotron commissioning will be in 2018.

Session 2 - THU22

Status of the HZB cyclotron

DENKER, Andrea [1]

[1] *Helmholtz-Zentrum Berlin*

Corresponding Author: denker@helmholtz-berlin.de

For nearly 20 years, eye tumours are treated in collaboration with the Charité - Universitätsmedizin Berlin. In January 2017 we celebrated the 3000th patient.
Parallel to the ongoing tumour therapy, beam time was allocated to experiments. These ranged from radiation hardness testing and nuclear physics over dosimetry to accelerator development. Single pulses of Protons and Helium with different energies have been delivered with repetition rates up to 2 MHz.
In order to improve the beam diagnosis between the 2 MV injector Tandetron and the cyclotron a harp has been installed. The first measurements yielded some interesting results, which are not yet fully understood.

Session 2 - THU23

The heavy ion irradiation facility at KVI-CART

JONES, Brian [1]; Dr. GOETHEM, Marc-Jan van [2]; Mr. KRAMERS, Rob [3]; Mr. KIEWIET, Harry [3]; Dr. VAN DER GRAAF, Emiel [3]; Prof. BRANDENBURG, Sytze [3]

[1] *KVI-CART University of Groningen, The Netherlands*

[2] *KVI-CART and University Medical Center Groningen*

[3] *KVI-CART University of Groningen*

Corresponding Author: b.n.jones@rug.nl

An in-air heavy ion irradiation facility equipped for providing masses up to xenon at 30 MeV/u is being developed at the Kernfysisch Versneller Instituut Center for Advanced Radiation Technology (KVI-CART). KVI-CART has operated a proton irradiation facility for radiobiological research since 1998. Since 2005, this facility has also been used for radiation hardness testing. The K600 superconducting AGOR (Accelerator Groningen Orsay) cyclotron at KVI-CART has been designed to provide ion beams with a large range of charge-to-mass ratios and energies. We are in the process of extending the radiation hardness test capabilities by providing heavy ion beams at several energies ranging from about 8 MeV/u to 90 MeV/u. KVI-CART will provide these irradiations for scientific and commercial users starting in 2018.

Three irradiation set-ups are being developed. For irradiations demanding lighter ions, including helium to oxygen at 90 MeV/u, the AGOR FIRM set-up, which was originally developed for protons [1], can be used with minor adaptations. For heavy ion beam irradiations with energies in the range of 8-10 MeV/u, the irradiations must be performed in vacuum using the BIBER irradiation set-up [2], which has been donated to us by HZB Berlin. We are additionally installing a new set-up for irradiations in air with heavy ion beams, specifically for carbon to xenon at 30 MeV/u, that allows for easy access of the device under test. The uniformity, dosimetry, beam purity and switching times of the different ion beams have had an influence on the design considerations of the facility and in particular on the choices of the ions in the beam cocktails. These considerations, as well as new strategies adopted to efficiently operate the sources and cyclotron, will be highlighted.

[1] The AGOR Facility for Irradiations of Materials, van der Graaf, E. R., Ostendorf, R. W., van Goethem, M. J., Kiewiet, H. H., Hofstee, M. A. Brandenburg, S. 2010 RADECS 2009 Proceedings. p. 443

[2] BIBER - The Berlin Ion Beam Exposure and Research Facility Optiz-Coutureau, J., Bundesmann, J., Denker, A., & Homeyer, H. Journal: Radiation and its Effects on Components and Systems, RADECS 2003, Proceedings of the 7th European Conference, held 15-19 September 2003 in Noordwijk, The Netherlands. Edited by K. Fletcher. ESA SP-536, ESA/ESTEC, 2004., p.507

Session 2 - THU24

STATUS REPORT ON GANIL AND UPGRADE OF SPIRAL1

KAMALOU, Omae [1]; Dr. SAVALLE, Alain [2]; Dr. CHAUTARD, Frédéric [3]; Mr. DUBOI, Mickael [4]

[1] *GANIL*

[2] *CEA*

[3] *CNRS*

[4] *CNRS/GANIL*

Corresponding Author: kamalou@ganil.fr

The GANIL facility (Grand Accélérateur National d'Ions Lourds) at Caen is dedicated for acceleration of heavy ion beams for nuclear physics, atomic physics, and radiobiology and material irradiation. Nowadays, an intense exotic beam is produced by the Isotope Separation On-Line method at the SPIRAL1 facility since 2001. New demands from the physics community motivated the upgrade of this facility in order to extend the range of post-accelerated radioactive ions. A 2 M€ project allowed the profound modification of the installation and the commissionning has started. The status of the installation and the last results will be presented. The review of the cyclotron operation from 2001 to 2017 will be presented as well.

Session 2 - THU25

Status of the Texas A Radioactive-Beam Project

MAY, Donald [1]; Dr. TABACARU, Gabriel [2]; Dr. ARJE, Juha [2]; Dr. KIM, George [2]; Dr. ROEDER, Brian [2]

[1] *Cyclotron Institute, Texas A&M University*

[2] *Texas A University Cyclotron Institute*

Corresponding Author: may@comp.tamu.edu

The effort at the Texas A Cyclotron Institute to produce reaccelerated, radioactive beams is progressing. The K150 cyclotron in combination with ion guides will be used for the production of radioactive ions to be then charge-bred by an electron-cyclotron ion source (ECRIS) for acceleration to intermediate energies by the K500 cyclotron. The methods for tuning and detecting the radioactive beams as well as a new method for direct injection of the low-charge-state radioactive ions into the charge-breeding ECRIS will be presented.

Session 3 - FRI31

Activities from Cyclotrons at German Cancer Research Center (DKFZ), Heidelberg – A Status Report

GUPTA, Viplav [1]; Mr. STRICKER, Sebastian [1]; Mr. BURKERT, Daniel [1]; Mr. SCHÄFER, Martin [1]; Dr. NEELS, Oliver [1]; Prof. KOPKA, Klaus [1]

[1] *German Cancer Research Center, Heidelberg*

Corresponding Author: v.gupta@dkfz.de

The onset of cyclotron history at DKFZ dates back since 1971, when the first compact cyclotron (protons and α-particles: 22MeV; deuterons: 11MeV; 3He: 28MeV) was purchased from Allgemeine Elektrizitäts-Gesellschaft (AEG)-Telefunken, Germany. After its installation at DKFZ, it was employed to produce short lived radionuclides (15O, 18F, 13N, 11C, 81Rb) for the radiochemistry and nuclear medicine. In parallel, an active research program in the field of radiobiology and dosimetry using fast neutrons and light ions was also established. After ca. 17 years of successful operation (1973 - 1990), it was clear that the existing AEG compact cyclotron would not be able to keep up the increasing future demands. Supplies and parts were obsolete, spare parts were nonexistent and operational reliability faded away. Moreover, the applications necessitate higher energies and currents and an application for a higher energy cyclotron was submitted.

A second compact cyclotron, and subsequently one of the first available negative ion cyclotrons MC32NI (M = Mini; C = Cyclotron; 32 = 32 MeV proton energy, NI = Negative Ion) from Scanditronix, Uppsala, Sweden, with relatively higher energies (proton: 32MeV; deuterons: 16MeV) was purchased and installed in 1991. Since 1991, the MC32NI cyclotron has had been employed for multiple projects e.g. radionuclides production for clinical (15O, 18F, 13N, 11C, 81Rb) and preclinical (64Cu) applications, nuclear physics experiments, dosimetry, wear measurements of industrial machine parts followed by labeling with 57Co (for ZAG Karlsruhe, Germany) and educational studies. In July 2017 the management board of the DKFZ has decided to shut down the existing cyclotron and replace it with the similar energy cyclotron in another building. The next cyclotron will be employed for clinical applications as well as producing more and more radiometals used in both diagnostic and therapeutic techniques, thereby heading more closely towards appropriate matched-pair combinations – theranostic approach.

The existing DKFZ cyclotron facility (≈ 800m2) and its decommissioning, performance and status of the MC32NI cyclotron, different target and beam lines systems, some technical problems occurred in recent times, ongoing radionuclides development, future planned projects, installation of a new cyclotron and bunker systems will be presented in brief.

Session 3 - FRI32

Multi-disciplinary research activities and beam diagnostic detector developments at the Bern medical cyclotron

BRACCINI, Saverio [1]

[1] *University of Bern*

Corresponding Author: saverio.braccini@cern.ch

The cyclotron laboratory at the Bern University Hospital was conceived for both industrial production of radio-pharmaceuticals and multi-disciplinary research activities. It is based on an IBA CYCLONE 18 MeV proton cyclotron equipped with a 6 m long research beam line accessible by a separate bunker. Studies on accelerator and detector physics, radiation protection, radiation hardness of components for physics experiments and space missions, and novel PET radioisotopes are on-going. The production of radioisotopes via the irradiation of highly enriched materials in form of powders (as enriched calcium for scandium 43 and 44) is challenging and a specific method based on a compact 60 cm long mini beam line equipped with an active beam diagnostic system and a solid target station is being developed. Research on non-destructive beam monitoring detectors is pursued. The UniBEaM is based on doped silica fibers passed through the beam to obtain beam profiles in a large intensity range from 1 pA to 20 uA. Four optical beam profilers of this kind were used to build a specific instrument to measure the transverse beam emittance on-line and to study its behavior as a function of several cyclotron parameters. A two-dimensional non-destructive beam profiler based on a 4 um ultra-thin phosphor screen read out by a CCD camera was conceived and a prototype built. The first results are promising in view of several applications of ion beams such as radioisotope production and hadrontherapy.

Session 3 - FRI33

Extension of JULICs irradiation capabilities

FELDEN, Olaf [1]; Dr. GEBEL, Ralf [1]

[1] *Forschungszentrum Jülich*

Corresponding Author: o.felden@fz-juelich.de

At the Forschungszentrum Jülich (FZJ) the variable energy cyclotron JULIC is used as injector of the Cooler Synchrotron (COSY) and performs well for low to medium current irradiations. Main task is to support the FZJ radionuclide research programme of the Institute for Neuroscience and Medicine INM-5 for medical imaging approaches and radioligand development for decoding the complex functions and structure of the human brain (JARA-BRAIN). Target holders of the INM-5 were implemented to the external target station of JULIC to obtain reliable irradiations with 45 MeV protons and 76 MeV deuterons for nuclear reaction cross section measurements and medical radionuclide production. For testing of radiation effects, displacement damage DD and single event effects SEE, with energetic protons for electronics used in space and accelerators the beam can be extracted to a dedicated test stand, e.g. used by Fraunhofer INT. A new external target station is set up inside the BigKarl-Experimental area offering huge space for complex detector setups. This will mainly be used for neutron yield investigations and neutron target development with high power proton or deuteron beam in perspective of a high brilliance accelerator based neutron source (HBS) with the Juelich Center for Neutron Science JCNS-4. In this type of compact neutron sources the neutrons are produced exposing light beryllium targets to proton or deuterium particles of relative low final particle energy in the MeV range and will be optimized for neutron scattering on small samples and to be realized at reasonable costs. But the new target station will be used for other purposes like electronic or detector test and irradiation as well. This report briefly summarizes the history of JULIC and the technical activities for its future perspectives.

Session 3 - FRI34

Status Update of Cyclotron Laboratory at Institute for Nuclear Research and Nuclear Energy

ASOVA, Galina [1]; Dr. TONEV, Dimitar [1]; Dr. GOUTEV, Nikolay [1]

[1] *INRNE*

Corresponding Author: gasova@gmail.com

The Institute for Nuclear Research and Nuclear Energy is preparing to operate a high-power cyclotron for production of radioisotopes for nuclear medicine, research in radiochemistry, radiobiology, nuclear physics, solid state physics. The cyclotron is a TR24 produced by ASCI, Canada, capable to deliver proton beam in the energy range of 15 to 24 MeV with current as high as 400 uA. Multiple extraction lines can be fed. The primary goal of the project is the production of PET and SPECT isotopes as 18F, 67, 68Ga, 99mTc, etc.
This contribution reports the status of the project. Design considerations for the cyclotron vault will be discussed for some of the target radioisotopes.
The research has been supported by the Bulgarian Science Fund under Contract No. DN 08/6, 13.12.2016.

Session 4 - FRI41

LARAMED – LAboratory of RAdionuclides for MEDicine: Status of the research facility at INFN LNL

ESPOSITO, Juan [1]; PUPILLO, Gaia [1]; PALMIERI, Vincenzo [1]; FIORENTINI, Giovanni [2]; Prof. DUATTI, Adriano [2]; MOU, Liliana [1]; PASQUALI, Micòl [3]; MARTINI, Petra [1]; ROSSI ALVAREZ, Carlo [4]; SKLIAROVA, Hanna [1]; CISTERNINO, Sara [4]; GOBBO, Matteo [5]; KEPPEL, Giorgio [1]

[1] *LNL*

[2] *FE*

[5] *INFN-LNL*

Corresponding Author: juan.esposito@lnl.infn.it

LARAMED is a new research infrastructure, now under construction at Legnaro National labs (LNL), which will take advantage of the high performance BEST 70p cyclotron (70 MeV, 750 μA) recently commissioned in the framework of SPES project. LARAMED project is indeed the LNL proposal for an international-class level and well-established research center, which main goals cover different topics, ranging from nuclear physics (excitation function experimental measurements), to engineering aspects (high power production targets) and radiochemistry issues (improvements of separation purification techniques). LARAMED has been conceived, since the beginning, to meet a double research scope: either to develop a more efficient production for well-established radionuclides already playing a key role in nuclear medicine (NM), or to investigate yet unexplored production routes for novel radionuclides, having potential interest for medical applications, but still unavailable in NM. Ultimately, the major objective of this project is to establish a production facility at LNL for a number of relevant medical radionuclides to be distributed to hospitals and clinical departments, both for routine use in patients' treatment and clinical research purposes.

The LARAMED infrastructure comprises three dedicated irradiation bunkers, each one having specific beamlines and target stations. One devoted to research purposes, the so-called RadioIsotope LABoratory (RILAB), while the remaining two being available, through settled collaboration agreement with a commercial partner, for routine radionuclides production such as 82Sr/82Rb, 68Ga/68Ge etc., the so-called RadioIsotope FACtory (RIFAC). Both RILAB and RIFAC bunkers will be connected to dedicated radiochemistry laboratories through pneumatic pipelines, designed to transfer irradiated targets into hot cells for separation, purification and handling of the radionuclides of interest. Moreover, a dedicated low-current beam line will be available as well for high-precision determination of nuclear excitation functions.

LARAMED was designed according to the following research lines: (1) high-precision determination of nuclear reaction's cross-sections potentially useful for obtaining novel medical radionuclides, including re-evaluation of previously investigated reaction routes; (2) development of new target technology suitable for operating with high-current, high-energy proton beams, especially for an improved production of 64/67Cu isotopes; (3) development of alternative, more efficient procedures for obtaining important medical radionuclides, including 99mTc, 64/67Cu, 52Mn, 82Sr, 68Ge and 89Zr, 63Zn, 186Re and 44/47Sc; (4) development of fully-automated dedicated radiochemical procedures for target processing, separation and purification of medical radionuclides; (5) design and development of novel radiopharmaceuticals for targeted guided imaging and therapy in oncology.

Session 4 - FRI42

Status of NEPIR, the NEutron and Proton Irradiation facility at SPES cyclotron

SILVESTRIN, Luca [1]; BISELLO, Dario [1]; MASTINU, Pierfrancesco [2]; PRETE, Gianfranco [2]; Dr. MAGGIORE, Mario [2]; WYSS, Jeffery [1]; ESPOSITO, Juan [2]

[1] *PD*

[2] *LNL*

Corresponding Author: mario.maggiore@lnl.infn.it

At INFN-Legnaro (LNL) there is an ongoing effort to create a suite of neutron sources based on two high current proton accelerators: a 5 MeV (30 mA) linac developed at LNL and the new 35-70 MeV (0.75 mA) cyclotron of SPES. These will produce cold, thermal, epithermal, and fast neutrons for a variety of applied and basic research programs (material characterization, imaging, neutron detectors, nuclear astrophysics, neutron data for MC development, boron neutron capture therapy, radiation damage in electronics…).
In particular, the SPES cyclotron will feed NEPIR, an irradiation facility that will deliver both quasi mono-energetic neutron and direct proton beams in the 20-70 MeV energy range for multi-disciplinary applications. A complementary continuous energy atmospheric-like neutron beam for studying neutron-induced Single Event Effects in electronics will also be available.
In this contribution, we report on the status of the design and construction plans of NEPIR in view of recent funding.

Session 4 - FRI43

The S2C2 : experiences from in-factory testing and on-site installations

VAN DE WALLE, Jarno [1]; Dr. KLEEVEN, Willem [1]; Mr. MANDRILLON, Jerome [2]; Dr. NUTTENS, Vincent [1]; Dr. FORTON, Eric [1]; Mr. VERBRUGGEN, Patrick [1]

[1] *IBA*

[2] *Ion Beam Applications*

Corresponding Author: jarno.vandewalle@iba-group.com

The ProteusONE proton therapy system by IBA, equipped with the superconducting synchro-cyclotron (S2C2) is now operational at 2 proton therapy centers and three more centers are currently being installed.
The on-site installations and further in-factory testing of the S2C2 has provided much insight in the reproducibility of the beam characteristics and has showed us a fast and efficient approach to machine commissioning.
In this contribution the emphasis will be put on the alignment of the beam out of the S2C2 into the rotating gantry (site experiences), the energy stability and range of the S2C2 and the reproducibility of the beam characteristics. Additionally, the different simulation tools will be presented which enable us to track the beam from the center of the S2C2 up to isocenter. In this way, we can investigate possible perturbations in the ProteusONE system and their impact on the beam performance at the patient level.

Session 4 - FRI44

Radiometric Survey at the LNL Cyclotron

SARCHIAPONE, Lucia [1]; ZAFIROPOULOS, Demetre [1]

[1] *LNL*

Corresponding Author: lucia.sarchiapone@lnl.infn.it

The cyclotron recently installed and commissioned at the National Laboratory in Legnaro can deliver proton beams with current up to 700 microA and energy in the range 35-70 MeV. During the machine commissioning, the operational quantities used for radiation protection purposes have been monitored in the installation, both during the beam acceleration/extraction and after the end of irradiation, in order to evaluate prompt and residual radiation. In this work the results of such survey will be shown, compared with numerical simulations used as reference. Measurements of activation of the beam line equipment and of the cooling water will also be shown, together with a discussion on the possible source of contamination.

Session 4 - FRI45

LOW-LEVEL/HIGH-LEVEL – HOW AND WHY THE RF SYSTEM IS CHANGING AT INFN-LNS

CARUSO, Antonino [1]; LONGHITANO, Alberto [1]; SPARTA', Antonino [1]; ZAPPALA', Emilio [1]; GALLO, Giuseppe [1]

[1] *LNS*

Corresponding Author: caruso@lns.infn.it

The INFN-LNS RF system can be considered a sort of continuous work in progress, since the commissioning of the k-800 superconducting cyclotron, more than 20 years ago. We would like to show the most important changes, upgrades and improvements of the entire RF system, related to the low level, high level and mechanics. Some of the improvements are related to the system’s age, to the outmodedness of important spare parts, like in the case of the High Level System, but some are related to modifying the system to achieve better performance, like in a few mechanical components of the cavities. Some improvements regard the low level system, to keep up with electronic innovations and, more importantly, to follow the requests and suggestions of the accelerator operators, in order to have, especially in the phase of tuning the entire cyclotron, a clear RF control panel where all the main parameters are displayed and the RF operation becomes easy, intuitive and, in the event of failures, the feedback is immediate. This progressive changing of the RF system is shown in this work.

Session 5 - FRI51

Design and study of the 8kW Diagnostic Box for the SPES proton beam line

MONETTI, Alberto [1]; Dr. ANDRIGHETTO, Alberto [1]; Dr. MANZOLARO, Mattia [1]; Dr. SCARPA, Daniele [1]; Dr. CORRADETTI, Stefano [1]; Mr. ROSSIGNOLI, Massimo [2]; Mrs. BORGNA, Francesca [3]; BALLAN, Michele [1]

[1] *LNL*

[2] *LNL-INFN*

[3] *LNL - INFN*

Corresponding Author: alberto.monetti@lnl.infn.it

The SPES project (Selective Production of Exotic Species) is a second-generation ISOL facility under construction at the LNL. The aim is the production of radioactive ion beams on the neutron rich side of the nuclide chart for nuclear structure and reaction studies, astrophysics research and interdisciplinary applications. The heart of the facility is the multi-foil UCx target where the fission of the uranium atoms induced by a 40 MeV proton beam occurs. The 8 kW of beam power delivered to the target produces about 1013 fissions per second and maintains the target at high temperatures, on the order of 2200°C, to let the products effuse out of the disks and diffuse to the ion source.
In this talk, the studies carried out on the target and the beam properties requested will be presented and some of the possible failure scenarios on the beam managing discussed. On the other hand, the overall assembly on the proton beam line inside the production bunker will be analysed inasmuch it has to support the beam and characterize it. The main constraints on the design were the dissipation of the beam power, the overall dimensions and the high radioactive environment due to the huge neutron flux produced by the uranium irradiation.

Session 5 - FRI52

Magnetron sputtering for corrosion protection of liquid cyclotron target for Fluorine-18 production

SKLIAROVA, Hanna [1]; CISTERNINO, Sara [1]; Dr. AZZOLINI, Oscar [2]; Dr. JOHNSON, Richard [3]; PALMIERI, Vincenzo [1]

[1] *LNL*

[2] *LNL-INFN*

[3] *Best Theratronics Ltd*

Corresponding Author: hanna.skliarova@lnl.infn.it

Chemically inert coatings on Havar® entrance foils of the liquid cyclotron targets for Fluorine-18 production are needed to decrease the amount of ionic contaminants released from Havar®. For efficient corrosion protection, both chemical inertness and microstructure of the coating are important. The corrosion damage of coated entrance foils is caused mainly by the diffusion of highly reactive products of water radiolysis through the protective film toward Havar® substrate. Since amorphous metal alloys (metallic glasses) are well known to perform a high corrosion resistance, the glass forming ability, microstructure and diffusion barrier efficiency of binary alloys containing Nb, Ta, Zr were investigated. Preliminary study of the co-sputtered Nb−Ta, Nb−Zr and Ta−Zr films of different alloy composition was realized in order to define the glass forming abilities. Though co-sputtered Nb−Ta and Nb−Zr alloy films of different contents were crystalline, Ta−Zr alloy was found to form amorphous microstructures in a range of composition with 30−73% atomic Ta. Diffusion barrier efficiency tests used reactive aluminum underlayer and protons of HCl solution as corrosion inducing particles. The diffusion barrier efficiency of Nb−Zr and Nb−Ta alloy coatings decreased with increase of Nb content. The diffusion barrier efficiency of sputtered Ta−Zr alloy coatings increased with the transition from nanocrystalline columnar microstructure to amorphous for coatings with 30−73 at.% Ta. In the next step, the properties of TaZr (1:1) protective films deposited from mono-target by magnetron sputtering were studied. The deposition parameters were optimized in order to provide dense amorphous coating with minimal level of intrinsic stress. The TaZr (1:1) coating is to be sputtered onto planar Havar® foils for Fluorine-18 target of IBA CYCLONE 18/9.

Session 5 - FRI53

Experimental set-up for thermal resistance at interface measurements

CISTERNINO, Sara [1]; SKLIAROVA, Hanna [1]; GOBBO, Matteo [2]; ROSSI ALVAREZ, Carlo [2]; Dr. ZANON, Alessandro [3]; ESPOSITO, Juan [1]

[1] *LNL*

[3] *LNL-INFN*

Corresponding Author: hanna.skliarova@lnl.infn.it

To increase the production yield of radioisotope of medical interest, elevated particle currents are required. This is associated with elevated thermal power that should be dissipated by appropriate cooling system. The conventional solid cyclotron target for medical radioisotope production is cooled with circulating water from the back and helium gas turbulent flow from the front (optional). The water cooling system can be of two types: open circuit, when the water is in direct contact with the backing plate of the target, and closed circuit, when heat exchange is realized through the contact between the backing plate and water-cooling chamber. The closed circuit approach is providing easy target manipulation and less problem with activated water, but is limited by the thermal resistance at the interface. Several models in order to predict the thermal resistance were developed but they are not in agreement with each other and not proved by experiments.
During current study, an experimental set-up was developed in order to measure the thermal resistance at the interface between different materials in respect to the quality of the contact.
The first measurements of the thermal resistance at interface between two copper samples in respect to the contact pressure were realized. The thermal resistance at interface of copper with standard lathe machining is at the range of 7E-05 K·m2/W for 1.3 MPa and 4E-05 K·m2/W for 4.2 MPa in the contact. In future other parameters influencing the performance of the heat exchange, will be tested, such as the aging (the oxidation level of the samples), the roughness of the surface in contact and different materials. These results will help to define the concept for the high power target station for 70 MeV cyclotron at LNL-INFN.

Session 6 - SAT61

Management Software and Data Exchange Protocol for the INFN-LNS Accelerators Beamlines

VECCHIO, Gianfranco [1]; PULVIRENTI, Salvatore [1]; DIANA, Benedetto Filippo [1]; COSENTINO, Luigi Giovanni [1]; FURIA, Enrico [1]; CAVALLARO, Salvo Rita [1]; AURNIA, Salvatore [1]

[1] *LNS*

Corresponding Author: vecchio@lns.infn.it

My presentation will describe the design and the development of an innovative management software for the accelerators beamlines at INFN-LNS. The Graphical User Interface, the data exchange protocol, the software functionality and the hardware will be illustrated.
Compared to traditional platforms for the accelerators console, at INFN-LNS we have developed a new concept of control system and data acquisition framework, based on a data structures server which so far has never been used for supervisory control.
We have chosen Redis as a highly scalable data store, shared by multiple and different processes. With such system it is possible to communicate cross-platform, cross-server or cross-application in a very simple way, using very lightweight libraries.
A complex and highly ergonomic Graphic User Interface allows to control all the parameters with a user-friendly interactive approach, ensuring high functionality so that the beam operator can visually work in a realistic environment.
All the information related to the beamline elements involved in the beam transport, can be stored in a centralized database, with suitable criteria to have a historical database.

Session 6 - SAT62

Correction of nu_r-nu_z=1 Resonance in TRIUMF Cyclotron

RAO, YI-NONG [1]

[1] *TRIUMF*

Corresponding Author: raoyn@triumf.ca

The second order linear coupling resonance nu_r-nu_z=1 is driven by an asymmetry in the median plane of the cyclotron due to presence of the first harmonic in B_r. In TRIUMF cyclotron, this resonance is encountered at about 166\,MeV and 291\,MeV, where $\nu_r\simeq 1.2$ and $\nu_z \simeq 0.2$. When the beam is off-centered radially to pass through this resonance, the radial oscillation gets converted into vertical oscillation, which can cause beam loss to occur, though these loss modes do not reduce the machine transmission under normal operation. In this paper, we present the results of simulations and measurements that we have performed to correct this resonance by using the existing harmonic coils.

Session 6 - SAT63

Investigation on the spiral inflector and central region of the IsoDAR test bench cyclotron

D'AGOSTINO, Grazia [1]; Dr. KLEEVEN, Willem [2]; Dr. FORTON, Eric [2]; Dr. NUTTENS, Vincent [2]; Dr. ZAREMBA, Simon [2]; CALABRETTA, Luciano [1]; CALANNA, Alessandra [1]

[1] *LNS*

[2] *IBA*

Corresponding Author: grazia.dagostino@lns.infn.it

The IsoDAR project aims to perform searches for the sterile neutrino looking at intense neutrino source placed near the neutrino detector of Kamland. The neutrinos are produced by the collision between 10 mA proton beam and a target, leading to the generation and subsequent decay of 8Li. The proton beam will be produced by a cyclotron able to accelerate a 5 mA H2+ up to the energy of 60 AMeV. The H2+ ions will be extracted using an electrostatic deflector.
Due to the high beam intensity, the design of the injection and of central region is a key issue for the IsoDAR cyclotron since the space charge effects play an important role in the beam dynamics both along the injection line and the central region, included the spiral inflector.
As the beam injection and the central region are challenging items for IsoDAR cyclotron, a 1 AMeV test bench cyclotron is being designed to study and test either the beam injection from the ion source into the cyclotron and the acceleration in the first turns of the machine.
An overview of the IsoDAR test cyclotron is presented. In addition, the preliminary results of the simulations of the spiral inflector and the central region design for the test bench cyclotron, realized at IBA, are shown. Particular attention has been given to the space charge calculations during the present study.

Session 6 - SAT65

Final design of the SC202 superconducting cyclotron for hadron therapy

Prof. SHIRKOV, Grigori [1]; Mr. MALININ, Vladimir [2]; Mr. GURSKIY, Semen [3]; KARAMYSHEV, Oleg [1]; Dr. KARAMYSHEVA, Galina Karamysheva [2]; Mr. POPOV, Dmitriy [4]; Dr. SONG, Yuntao [5]; Dr. DING, Kaizhong [5]; Dr. CHEN, Gen [5]; Dr. BI, Yanfang [5]; Dr. MOROZOV, Nikolay [3]; Dr. SAMSONOV, Evgeny [3]; Dr. SHIRKOV, Stepan [3]

[1] *Joint Institute for Nuclear Research*

[2] *JINR*

[3] *JINR, Dubna, Russia*

[4] *DLNP, JINR*

[5] *ASIPP, Hefei, China*

Corresponding Author: gkaram@jinr.ru

The physical design of the compact superconducting cyclotron SC202 for proton therapy has been finished. Two copies of SC202 will be manufactured, according to the agreement between JINR (Dubna, Russia) and ASIPP (Hefei, China). First copy will be used for proton therapy in Hefei, and the second copy will be used to replace “Phasotron” in the research and treatment program by at JINR. Parameters of main systems and final schemes of extraction systems different for the Hefei cyclotron and the Dubna cyclotron are presented.

Session 7 - SAT71

The AISHA Ion Source: Commissioning and preliminary results

CELONA, Luigi Giuseppe [1]; GAMMINO, Santo [1]; CHINES, Francesco [1]; CASTRO, Giuseppe [1]; LEONARDI, Ornella [1]; Dr. MASCALI, David [1]; NERI, Lorenzo [1]; Dr. TORRISI, Giuseppe [1]

[1] *LNS*

Corresponding Author: davidmascali@lns.infn.it

The AISHa ion source is an Electron Cyclotron Resonance Ion Source designed and developed for the generation of high brightness multiply charged ion beams with high reliability, easy operations and maintenance for feeding linear accelerator or cyclotrons. Its innovative magnetic field is provided by a Halbach-type permanent magnet hexapole (radial confinement) and for four high field He-free superconducting magnets (longitudinal confinement). This hybrid solution allows to get higher performances limiting manufacturing and maintenance costs. The present work shows the preliminary results of the AISHa commissioning, either in terms of total current (up to 18 mA extracted from the source) and in terms of charge state distribution. Next steps for the upgrade of the AISHa source to full power conditions will be also commented.

Session 7 - SAT72

DECRIS-PM ion source for the DC-280 cyclotron

BOGOMOLOV, Sergey [1]; Dr. EFREMOV, Andrey [1]; Mr. IAZVITSKII, Nikolay [1]; Dr. KONEV, Nikolay [2]; Mr. BONDARCHENKO, Andrey [1]; Mr. BEKHTEREV, Vladimir [1]; Mr. KOSTYUKHOV, Yuri [1]; Mr. KUZMENKOV, Konstantin [1]; Mr. LEBEDEV, Alexander [1]; Mr. LOGINOV, Vladimir [1]; Dr. MIRONOV, Vladimir [1]

[1] *JINR*

[2] *ITT Group*

Corresponding Author: sbogomolov@jinr.ru

A new all-permanent magnet ECR Ion source DECRIS-PM had been developed to be used at the high voltage platform of DC-280 cyclotron. The source has been designed at the FLNR JINR (Dubna) in collaboration with the “ITT-group” company (Moscow, Russia).
The operating frequency selected to be 14 GHz for the source. The corresponding values of Binj, Bmin and Br were chosen according to scaling laws for the axial magnetic field configuration. The injection magnetic field maximum was chosen to be around 1.3 T to have a reasonable weight of the system and basing on the earlier experience of conventional ion sources.
Combination of the permanent magnet rings and soft iron plates makes the magnetic structure flexible, and provides the possibility of magnetic field correction during assemblage stage. Other specific feature of the source is an additional coil placed at the center of the structure between the hexapole and central PM ring. The coil will be used to tune the Bmin value during the source operation.
Presently the source is under tests at the test bench. In the first experiments the intense beams of Ar8+ (920 eμA), Ar11+ (200 eμA), Ar12+ (150 eμA), Kr15+ (180 eμA) and Kr17+ (125 eμA) were produced. The source is also tested for production of metal ion beams (Mg, Ca and Fe).

Session 7 - SAT73

H2+ beams for Cyclotrons

CASTRO, Giuseppe [1]; CELONA, Luigi Giuseppe [1]; Dr. MASCALI, David [1]; GAMMINO, Santo [1]

[1] *LNS*

Corresponding Author: mario.maggiore@lnl.infn.it

Several projects will require high beam current for H2+either for neutrino factories and for applications. Different strategies have been envisaged, including overdense plasmas in microwave discharge ion sources (MDIS) and the recent developments in terms of production of high current high stability beams are satisfactory. The paper will describe the state of the art and the future optimization of the PS-ESS source, designed for protons, in order to fulfill the requirements of the above cited projects. In particular, the trial for correlating the relative H2+/p abundance inside the plasma (by optical emission spectroscopy) and in the beam will be discussed.

Session 7 - SAT74

Status of a new 18 GHz ECRIS HIISI

KALVAS, Taneli [1]; Dr. KOIVISTO, Hannu [2]; Dr. TARVAINEN, Olli [3]

[1] *University of Jyvaskyla*

[2] *University of Jyväskylä, Department of Physics*

[3] *University of Jyvaskyla, Department of Physics, Accelerator Laboratory*

Corresponding Author: taneli.kalvas@jyu.fi

The Accelerator Laboratory at the University of Jyvaskyla (JYFL) has performed radiation effects testing of electronics since 1998 using a K130 cyclotron and cocktail beams produced with ECR ion sources (ECRIS). Currently most of the tests are done at 9.3 MeV/u energy which is achievable with the charge states produced by the 14 GHz ECRIS of the laboratory. The radiation effects community has shown a strong desire to reach 15 MeV/u, which is approaching the limits of achievable charge states without superconducting ECR technology using the K130 cyclotron, i.e. requiring ions with m/q < 3. A high-energy cocktail has been proposed to be used at JYFL with Xe 44+ as the heaviest component. Production of such very high charge states have so far been demonstrated only with fully superconducting ECRIS, e.g. 18 GHz SUSI at MSU. The desire for the very high charge states has initiated a project to push the performance of normal conducting ECRIS by developing an 18 GHz ECRIS HIISI (Heavy Ion Ion Source Injector). The new ion source being developed features several novel ideas to reach the high magnetic fields required for the production of the highest charge states: The permanent magnet hexapole is refrigerated down to -20 C allowing the use of high-remanence, low-coercivity permanent magnet grade N45SH otherwise unusable in such application. The cooling also increases the remanence of the magnets by up to 5% compared to room temperature. The source has a non-cylindrical plasma chamber with 5 mm deep grooves on the magnetic poles to increase the radial mirror ratio within the plasma flux. The injection field has been optimized using a structure with magnetic steel plug with a Permendur tip and a magnetic steel bias disc. The source has three coils allowing tuning of Bmin independently of Binj and Bext. At nominal solenoid currents of Iinj/Iext/Imiddle = 1000/820/-300 A the field values are Binj=2.80 T, Bext=1.30 T,Bmin=0.42 T and Brad=1.32 T. The plasma can be heated using microwaves from three separate waveguide ports for 18 GHz klystron, 14 GHz klystron and 11-18 GHz TWTA, with a total microwave power capacity of 5 kW.

The commissioning is under way. The first beam from the new ion source was extracted in May 2017. So far the source has produced 160 uA of oxygen 7+ beam with 600 W of microwave power. The design of the 18 GHz ECRIS is presented together with the most recent results producing high charge-state oxygen and xenon beams.

POSTER SESSION

Table of contents (poster contributions)

Poster Session - POS01

Extraction simulations for the SC202 cyclotron for proton therapy for JINR Dubna

MALININ, Vladimir [1]; Dr. KARAMYSHEV, Oleg [2]; Dr. KARAMYSHEVA, Galina [1]; Prof. SHIRKOV, Grigori [2]; Dr. SHIRKOV, Stepan [1]; Mr. POPOV, Dmitriy [1]

[1] *JINR*

[2] *Joint Institute for Nuclear Research*

Corresponding Author: malinin@jinr.ru

The SC202 superconducting cyclotron for hadron therapy is under development by collaboration of ASIPP (Hefei, China) and JINR (Dubna, Russia). Extraction is one of the most challenging elements of the cyclotron. Dubna version of the cyclotron is not in production yet so time can be spent on optimising the extraction for better beam quality. We will use an extraction schema which differs substantially from the one used for the cyclotron SC202 for Hefei medical center. The schema of extraction system and results of beam dynamics simulations for Dubna cyclotron are presented.

Poster Session - POS02

Best Cyclotron Control Systems: A unique integration of the traditional PLC controls and the digital microprocessor controls

Mr. DU, David [1]; CARLSON, Mark [2]; Mr. RAINIER, Jarrett [3]; Mr. TARNOPOLSKI, Iouri [4]; Mr. SABAIDUC, Vasile [5]; Dr. JOHNSON, Richard [6]

[1] *Best Cyclotron Systems inc.*

[2] *Best Cyclotron Systems*

[3] *Best Cyclotron Systems, Inc*

[4] *Best Theratronics Ltd.*

[5] *Best Cyclotron System, Inc*

[6] *Best Cyclotron Systems, Inc.*

Corresponding Author: daviddu@teambest.com

Best Cyclotron Systems Inc (BCSI) has designed and manufactured a 70 MeV compact cyclotron for radioisotope production and research applications. The control system architecture for the Best 70 MeV compact cyclotron is based on Siemens PLCs and Artila Matrix 504D Device Server. The Siemens PLC is the centre of the control system. The PLC handles all the real-time control, monitoring and interlocking of cyclotron components, including gate valves, power supplies and beam stops. Siemens PLCs are also used for motor control for extraction probes and communication to the Low-level RF controller. Low level RF (LLRF) control of the cyclotron is based on an advanced digital microprocessor-FPGA core that provides precise phase and amplitude control loops, fast spark recovery and multiple other automatic procedures with programmable parameters. The Artila Matrix 504D Device Server communicates between the Siemens PLC and the serial and ethernet devices such as vacuum gauge controllers, turbopump controllers and magnet power supplies. This allows for digital communication and digital control of the setpoints and readbacks of these devices.

The Best Cyclotron control system uses the WinCC Professional for alarming, data logging, trending, and graphical user interface. The Best cyclotron control systems allows for a unique integration of the traditional PLC controls and the digital microprocessor controls.

Poster Session - POS03

Evaluating and improving accuracy of the magnet simulation.

POPOV, Dmitriy [1]; Mrs. KARAMYSHEVA, Taisia [2]; Dr. KARAMYSHEV, Oleg [3]; Mr. MALININ, Vladimir [4]

[1] *DLNP, JINR*

[2] *LIT, JINR*

[3] *Joint Institute for Nuclear Research*

[4] *JINR*

Corresponding Author: podivs@mail.ru

Acute precision and fast calculation of magnetic flux density in median plane area is crucial to provide high quality cyclotron production. Using various up to date codes like Tosca, CST, Comsol and comparing their results (along with other methods) we can evaluate errors in calculation, supported with powerful modern hardware we can achieve accuracy of 0.1-0.25 Gauss for magnetic field modelling, which allowed us to do fully realistic beam dynamics simulation from ion source to the extraction. There is some different methods based on the geometry and field features to reduce this error or/and time of calculation. Special mathematical algorithms were used in order to reach high accuracy and high efficiency of beam dynamics simulations.

Poster Session - POS04

Compact extraction system for the B70 Cyclotron

BOIESAN, Teodor [1]; Mr. CARLSON, Mark [2]

[1] *Best Cyclotron Systems Inc.*

[2] *Best Cyclotron Systems*

Corresponding Author: teodor.boiesan@teambest.com

Best Cyclotron Systems Inc (BCSI) has designed and manufactured a 70 MeV compact cyclotron for radioisotope production and research applications. The cyclotron extractor design allows negative ion stripping to extract protons between 35 and 70 MeV. The extractor is consistent with the requirement for high current operation with a minimum of intervention. Twenty-two extractor foils are available in any selection sequence on each side of the cyclotron. The foil exchange is performed in vacuum so that an exchange takes about 2 minutes while obeying safety protocols. The 22 foils are contained in a cartridge that can be exchanged through a vacuum load lock. An added benefit is that the extractor modular design reduces the operational space requirement outside of the cyclotron thus reducing the vault footprint and shielding requirement.

Poster Session - POS05

BEST 70p cyclotron beam commissioning at LN Legnaro

RYJKOV, Vladimir [1]

[1] *Best Theratronics Ltd*

Corresponding Author: vladimir.ryjkov@teambest.com

Best Cyclotron Systems Inc (BCSI) 70 MeV compact cyclotron is installed at INFN Legnaro. Results from the recent tests are presented. The current during around the clock test operation was in the 200uA range, limited by the beam dump. The cyclotron demonstrated very stable beam delivery, the beam on target drift over multiple hours of operation was <1% without any operator adjustments. Vacuum level in the main tank was stable during operation, in the 5E-8Torr range

Poster Session - POS06

High Quality Technetium-99m by Medical Cyclotrons

MARTINI, Petra [1]; BOSCHI, Alessandra [2]; ROSSI ALVAREZ, Carlos [3]; ESPOSITO, Juan [1]; CICORIA, Gianfranco [4]; ZAGNI, Federico [4]; CORAZZA, Andrea [4]; UCCELLI, Licia [2]; PASQUALI, Micòl [5]; Prof. DUATTI, Adriano [5]; PUPILLO, Gaia [1]; MARENGO, Mario [4]; LORIGGIOLA, Massimo [1]; SKLIAROVA, Hanna [1]; MOU, Liliana [1]; CISTERNINO, Sara [1]; CARTURAN, Sara Maria [1]; MELENDEZ-ALAFORT, Laura [6]; UZUNOV, Nikolay M. [3]; BELLO, Michele [1]

[1] *LNL*

[2] *Department of Morphology, Surgery and Experimental Medicine, University of Ferrara, Ferrara, ITALY*

[3] *Legnaro Laboratories of the Italian National Institute for Nuclear Physics (INFN), Legnaro, Padova, ITALY*

[4] *Nuclear Medicine S. Orsola Hospital, Bologna, ITALY*

[5] *FE*

[6] *Veneto Institute of Oncology IOV-IRSS, Padova, ITALY*

Corresponding Author: petra.martini@lnl.infn.it

One of the best technetium-99m (99mTc) alternative production routes, which has been selected in order to overcome the possibility of a shortage at a global scale, is to get a direct accelerator-99mTc production via the 100Mo(p,2n) reaction route. In the short-term vision, hospital’s Nuclear Medicine Depts radiopharmacies, that house a suitable cyclotron (16-19 MeV), could become 99mTc self-manufacturer, as already happen for the local routine production of fluorine-18. The aim of our work was focused on the development of a technology consistent with medical cyclotrons and able to produce 99mTc using the already existing PET cyclotrons’ network in Italy to provide on-site supply for regional radiopharmacies in support or even in replacement of 99Mo /99mTc generators in case of future shortages. To achieve this aim: (1) a target assembly able to fit an on-site solid target station has been designed; (2) an automated extraction and purification procedure has been developed; (3) enriched molybdenum target material recovery step process has been studied and determined. In order to validate such a technology, several production tests have been performed in a nuclear medicine department equipped with a 16 MeV cyclotron by irradiating 100Mo-enriched molybdenum metallic targets. Preparation and quality evaluation of cyclotron-produced 99mTc-labeled radiopharmaceuticals and preclinical imaging studies on phantom by clinical gamma camera have been conducted as well. The developed technology allowed to obtain GBq amount of cyclotron-produced [99mTc]TcO4- suitable for clinical application with a Quality Assurance (QA) process in compliance with the European Pharmacopoeia recently issued. No substantial differences in images quality and radiopharmaceuticals stability, between generator- and cyclotron- produced 99mTc have been found. In conclusion, local nuclear medicines equipped by medical cyclotrons and our technology will be able to self-produce sufficient amount of 99mTc for their daily diagnostics needs.

Poster Session - POS07

Beam dynamics simulations in the Dubna SC202 superconducting cyclotron for hadron therapy

Dr. KARAMYSHEV, Oleg [1]; Mr. POPOV, Dmitriy [2]; Dr. CHEN, Gen [3]; KARAMYSHEVA, Galina Karamysheva [4]; Prof. SHIRKOV, Grigori [1]; Mr. MALININ, Vladimir [4]

[1] *Joint Institute for Nuclear Research*

[2] *DLNP, JINR*

[3] *institute of plasma physics, chinese academy of sciences*

[4] *JINR*

Corresponding Author: gkaram@numail.jinr.ru

The SC202 superconducting cyclotron for hadron therapy has been developed by collaboration of ASIPP (Hefei, China) and JINR (Dubna, Russia). The cyclotrons will deliver 200 MeV proton beam for proton therapy and research. Accurate and effective beam dynamics simulation is the key to design a compact accelerator with a high magnetic field. New schema of extraction system and results of beam acceleration and extraction simulations starting from the ion source for Dubna cyclotron are presented. The codes and methods used for the beam tracking are described.

Poster Session - POS08

Optimization of the return yoke for the upgraded superconducting cyclotron of INFN-LNS

CALANNA, Alessandra [1]; CALABRETTA, Luciano [1]; RIFUGGIATO, Danilo [1]; RUSSO, Antonio Domenico [1]; GALLO, Giuseppe [1]; Mrs. D'AGOSTINO, Grazia [2]

[1] *LNS*

[2] *INFN-LNS*

Corresponding Author: calabretta@lns.infn.it

The LNS Superconducting Cyclotron (CS) has to be upgraded is planned to deliver beam ion with mass <40 with power of about 2-10 kW.
This improvement will be reached extracting by stripping a specific set of light ions and energies. Nevertheless, the extraction through the two electrostatic deflectors, providing a beam power limited to 100 W, will be also maintained to fulfil the users' requests. The new design could strongly affect the beam dynamics. The iron yoke penetrations do not respect the three folds symmetry of our cyclotron and have a complex shape, due to the double extractionmethods and all services' entrances. This inhomogeneity produces unwanted field harmonics, which have to be reduced as much as possible to avoid beam precession or second order effects. The studies accomplished to minimize the perturbation of the non-three fold field symmetry using the current sheet approximation (CSA) is presented, along with the state-of-art configuration of the updated cyclotron.

Poster Session - POS09

Preliminary design of the new FRagment SEparator at INFN-LNS

RUSSO, Antonio Domenico [1]; CALABRETTA, Luciano [1]; CARDELLA, Giuseppe [2]; RUSSOTTO, Paolo [1]

[1] *LNS*

[2] *CT*

Corresponding Author: calabretta@lns.infn.it

The superconducting cyclotron upgrade plans to increase the beam ion power up to 10 kW. Unfortunately, due to radioactive protection issues the existing setup of FRIBs facility [1] at INFN-LNS of Catania cannot be operated with beam in excess of 100-200 W. In this perspective it is convenient to build a new FRAgment In-flight SEparator (FRAISE) facility in a position where it will be possible to build proper shielding to use beam power of at least 2 kW or more.
The features and the performances of FRAISE will be presented. In particular, the new beam transport line able to select the required radioactive ion, the operating principle of the system optic, the constraint posed by the space available in the new location, the mass resolving power and performances of the system will be discussed.

Poster Session - POS10

First Operational Experiences for Therapy of Ocular Melanomas with a Modern Low Level RF Control

DENKER, Andrea [1]

[1] *Helmholtz-Zentrum Berlin*

Corresponding Author: denker@helmholtz-berlin.de

For nearly 20 years, eye tumours are treated in collaboration with the Charité - Universitätsmedizin Berlin. However, parts of the cyclotron electronics date back to the 70ies, when the machine was installed. The down-time due to failures in the electronics was low. Thus, we were concerned about the possibility to get spare parts, as many of the installed components have become obsolete and we had to find modern replacements. Furthermore, the wire wrap cards got more and more contact problems.
In order to keep the cyclotron on a modern level, we decided to use the Low Level RF control developed by iThemba Labs for their cyclotrons.
A description of the installation process and first operational experiences will be given.

Poster Session - POS11

Design of an injection buncher for the 70 MeV cyclotron

ANTONINI, Piergiorgio [1]; LOMBARDI, Augusto [1]; Dr. MAGGIORE, Mario [1]; PRANOVI, Lorenzo [1]

[1] *LNL*

Corresponding Author: piergiorgio.antonini@lnl.infn.it

To operate the 70 MeV continuously with increased reliability one improvement is the installation of a beam buncher between the ion source and the injection point. The buncher is needed to decrease the ion current provided by the ion source without decreasing the extracted current.
A double-gap buncher is at the moment in design stage, the general layout and the considerations that led to it are here presented.

Poster Session - POS12

PRACTICAL MEASUREMENT METHODS TO DETERMINE SHUNT RESISTANCE, Q FACTOR, DEE VOLTAGE AND MULTIPACTORING PHENOMENA

CARUSO, Antonino [1]; LONGHITANO, Alberto [1]; Dr. YUNTAO, Song [2]; Prof. SURA, Jozef [3]; SPARTA', Antonino [1]; GALLO, Giuseppe [1]; ZAPPALA', Emilio [1]; Dr. CHEN, Gen [4]; Dr. KARAMYSHEVA, Galina Karamysheva [5]; Dr. KARAMYSHEV, Oleg [6]; Prof. SHIRKOV, Grigori [6]

[1] *LNS*

[2] *ASIPP, Hefei, China*

[3] *Warsaw University, Warsaw, Poland*

[4] *institute of plasma physics, chinese academy of sciences*

[5] *JINR*

[6] *Joint Institute for Nuclear Research*

Corresponding Author: caruso@lns.infn.it

A lot of simulation software provides accurate 3D models for the numerical solution of Maxwell's Equations, from statics up to the highest frequencies. This relatively new software is very powerful and the quality of the results is extremely close to the ideal model of our design. The simulated model, unfortunately, cannot take into account all the mechanical imperfections/connections/matching/soldering of a real model, for example a designed and assembled RF cavity. Unexpectedly, lately I have received many requests, on how to verify important parameters of coaxial resonators practically, such as shunt impedance, Q factor, dee voltage and/or multipactoring phenomena. These methods were recently used during the RF measurements of a coaxial resonator prototype for the SC200, a compact superconducting cyclotron for proton therapy. The SC200 is under construction at Hefei, in the mainframe of a joint research project between ASIPP (Hefei, China)-JINR (Dubna, Russia), with the INFN-LNS collaboration. I found the complementary aspect between these practical measurement methods and the new 3D software simulation programs quite interesting. A summary of these traditional methods, simulations, experimental results and considerations is presented.

Poster Session - POS13

Cyclotron Integration into the SPES Main Control System: Proof of Concept Based on EPICS and OPC UA

GIACCHINI, Mauro [1]; MONTIS, Maurizio [1]; ANTONIAZZI, Loris [1]; BELLATO, Marco Angelo [2]

[1] *LNL*

[2] *PD*

Corresponding Author: maurizio.montis@lnl.infn.it

SPES* project an ISOL facility under construction at the Legnaro National Laboratories (LNL) dedicated to the production of radioactive ion beams with high energy and high degree of purity. This new facility requires the integration between the accelerator systems actually used and the new line composed by the primary proton beam provided by a commercial cyclotron with high output current (~0.7 mA) and high energy (up to 70 MeV) plus the new ISOL target. Because of the proton beam characteristics, its control and supervision is crucial during experiments and for the operation performance; as consequence it is required to the cyclotron to integrate information in the SPES main control system based on EPICS**: to provide this task, a proof of concept based on OPC UA*** has been designed and prepared for preliminary tests.
* https://web.infn.it/spes/
** http://www.aps.anl.gov/epics/
*** https://opcfoundation.org/about/opc-technologies/opc-ua/

Poster Session - POS14

Novel PET Radioisotope Developments with the Bern medical Cyclotron

Mr. CARZANIGA, Tommaso Stefano [1]; BRACCINI, Saverio [2]

[1] *AEC-LHEP, University of Bern*

[2] *University of Bern*

Corresponding Author: saverio.braccini@cern.ch

Research in radioisotope production is carried on at the cyclotron laboratory at the Bern University Hospital (Inselspital). The laboratory is equipped with an IBA 18 MeV medical cyclotron, 4 liquid targets for routine F-18 production, a compact solid target station with a pneumatic transport system to the hot cells, and a 6 m long research Beam Transport Line (BTL) bringing the beam to a second bunker with independent access. The production of PET radiometals such as Ga-68, Cu-64 Sc-44, and Sc-43 is investigated, together with V-48 to be used as a positron source for fundamental and applied research. Production cross-sections were measured by means of the BTL with a method based on irradiating the whole target by a constant surface density proton beam. For this purpose, the beam was controlled on-line by a dual-axis UniBEaM profiler. This kind of detector is based on doped silica fibers passing through the beam, was developed by our group and industrialized by D-PACE (Canada). Test productions were performed with the solid target station using a novel coin target allowing the irradiation of powders compressed in pellets and thin foils.

Poster Session - POS15

Optimization and characterization of the ion source for the compact superconducting AMIT cyclotron considering different chimney configurations

CALVO PORTELA, Pedro [1]; Mr. OBRADORS, Diego [1]; Mr. GARCIA-TABARES, Luis [1]; Mr. MUNILLA, Javier [1]; Dr. OLIVER, Concepcion [1]; Dr. TORAL, Fernando [1]; Dr. PODADERA, Ivan [1]; Mr. VARELA, Rodrigo [1]; Mr. DOMINGUEZ, Manuel [1]; Mr. ESTEVEZ, Antonio [1]; Mr. GAVELA, Daniel [1]

[1] *CIEMAT*

Corresponding Author: pedro.calvo@ciemat.es

Given the increasing demand of local radioisotope production for PET imaging techniques, a compact cyclotron has been developed in the framework of AMIT project. AMIT cyclotron relies on a superconducting 4T magnet with an internal cold cathode PIG ion source for H- production. The compactness of the accelerator has motivated the development of an experimental facility for the commissioning of such ion source. The versatility of this test bench, which includes a movable puller with DC extraction, gives us the opportunity to validate and characterize the ion source behavior as well as to optimize the H- production. Different chimney geometries for the ion source, in which the distance between the plasma column and the extraction wall is varied, have been tested to obtain the best relation between ion production and plasma conditions. These studies conclude the optimal conditions for the operation of the ion source, taking into account the efficiency of the source as well as the production of H-.