

Issue 2  
February 2014

# The Fourth State

Newsletter of the Institute For Plasma Research, Gandhinagar, Gujarat (India)

*From the editorial desk*

The editorial committee of the IPR newsletter wishes to thank all the IPR staff members for their encouragement and support that they have given to the revived newsletter. We hope that this will continue for all the forthcoming issues of "The Fourth State". Please feel free to send any comment / suggestion to the committee at <newsletter@ipr.res.in> for improvement of the look and contents of the newsletter. Thank you..

## The Republic Day Fervor

The 65th Republic Day was celebrated with patriotic fervor and had special programs based on the theme "Freedom from Disease and ill thought" and was attended by large number of IPR personnel. Prof. Dhiraj Bora, Director, IPR, hoisted the tricolor. Dr. V. P. Anitha and Ms. Sapana Mishra livened the occasion with beautifully sung patriotic songs. The *Preksha Dhyana* academy of Gandhinagar conducted a workshop on meditation to improve efficiency and mental health of IPR'ites. Dr. A. K. Srivastava a former scientist and founder of Inner Science Group, Chandkheda Ahmedabad delivered an informative talk on modern day life style disease "Diabetes" emphasizing the need of awareness in the society about the disease.



All set for the flag hoisting ceremony

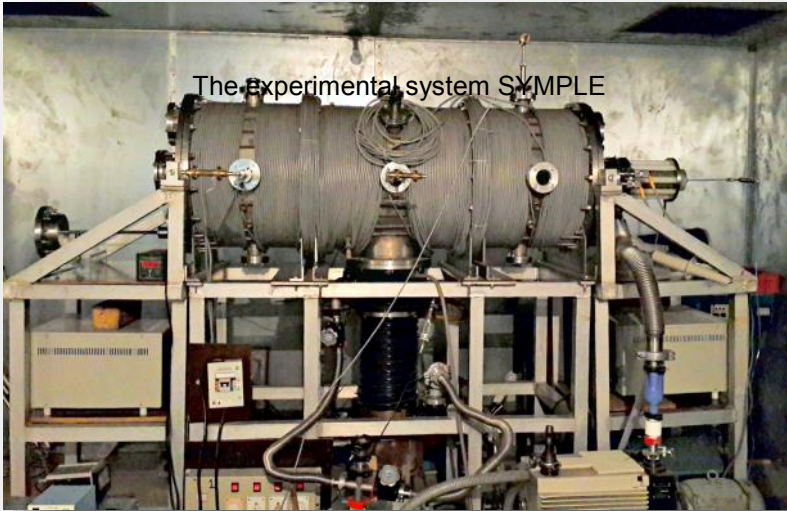


Prof. D. Bora addressing the gathering after the flag hoisting ceremony.

View of the audience during the workshop and motivation lectures.

सारे जहां से अच्छा.. हिन्दुस्तान हमारा !!





The experimental system SYMPLE

- ◆ It is well established that an un-magnetized plasma does not support propagation of low frequency ( $\ll \omega_p$ ) e.m waves. However, depending on the intensity of the incoming wave, several interesting linear and nonlinear interactions occur between the wave and an inhomogeneous plasma at the critical layer ( $\omega = \omega_p$ ), leading to the absorption of the wave in the plasma.
- ◆ In the range where the wave intensity is moderate, observations exist on mechanisms where a resonant wave electric field and a density cavity grow simultaneously through mutual enhancements.
- ◆ When the wave intensity is very high ( $eE_{e.m}/mw \sim c$ ), yet another mechanism is theoretically predicted where the energy transfer from wave to plasma occurs through generation of fast electrons at the location of wave plasma interaction.
- ◆ A detailed understanding of the wave-plasma interaction assumes great importance, in the context of its implications in inertial fusion and laser plasma accelerators.
- ◆ A major challenge in carrying out experiments with lasers is related to the diagnostic access.
- ◆ The plasma that should remain over-dense to the laser frequencies is nearly solid-dense ( $n_e \sim 10^{27}-10^{28}/m^3$ ), leading to fast time scales (a few femtoseconds) and small scale lengths ( $\sim$  few mm) of instabilities, difficult to diagnose.
- ◆ The advent of HPM sources, with power ranging from a few MW to a few GW levels, a new arena of experimental investigations are now possible, on HPM – plasma interaction. Here, the resolution of appropriate length and time scales are not as stringent as in case of lasers.
- ◆ SYMPLE (**S**Ystem for **M**icrowave **P**Lasma **E**xperiments) is an experimental device being developed to investigate the interaction of HPM and plasma.

## Development of LTS Superconductor Based CICC at IPR

- ◆ Magnet Technology Development Division (MTDD) at Institute For Plasma Research (IPR) has been associated with the indigenous development of Fusion Relevant Superconducting Magnet systems (FRSM) including appropriate material development for superconductors, support structures, radiation resistant insulation system, vacuum impregnation facilities for large fusion grade winding pack consolidations and appropriate test facilities to validation.
- ◆ The FRSM has been designed for magnetic field of 5.5Tesla using Niobium Titanium (NbTi) and 10Tesla using Niobium Tin (Nb<sub>3</sub>Sn) based CICC with transport current carrying capacity of 30kA at 4.5 Kelvin.
- ◆ The CICC based approach is adopted due its capability to increase current carrying capacity with high stability; low AC losses and its ability to withstand higher electromagnetic stresses during the operation.
- ◆ Under a joint initiative by IPR and Bhabha Atomic Research Center (BARC), a number of trials has been performed for cabling and fabrication of long length CICC with copper strands to establish cabling and process parameters of CICC fabrication.



On-line CICC Fabrication Facility developed at AFD, BARC

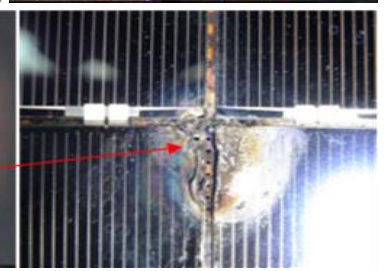
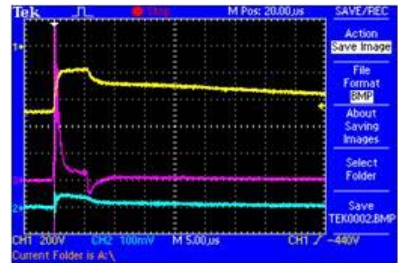


D-shaped NbTi Superconductor CICC for TF Magnet. The dimensions of D-shape magnet are: height  $\sim$  4 m; width  $\sim$  2.5 m

- ♦ The Compact Electron Cyclotron Resonance (ECR) Ion Source is under development at Fusion Neutronics Laboratory, IPR.
- ♦ Magnetic system is a most important part of the Ion Source in which plasma will be produced.
- ♦ It is essential to characterize the magnetic field for the confinement of the plasma and extraction of the ions produces in plasma.
- ♦ A magnetic system is made of three permanent NdFeB ring magnets.
- ♦ The magnetic field is measured for different gap between magnets from 4 mm to 8 mm with increase of 1 mm.
- ♦ Measurements are performed using Gauss meter containing a Hall Probe, which was moved at the central axis inside the chamber.

### Space Surface Interaction Experiments (SPIX)

- ♦ Electro Static Discharge (ESD) is a common phenomenon in satellites due to surface charging by low density plasma present in Lower Earth Orbit (LEO).
- ♦ Such ESD events may generate minor or sustained arc in the solar panel that may leads to permanent failure of the satellites.
- ♦ Therefore, in FCIPT we have simulated ground experiments in lab, in collaboration with ISAC/ISRO Bangalore to reproduce the similar arcing events as occurred in space.
- ♦ For this purpose SPIX facility was developed indigenously equipped with plasma source, plasma diagnostics, power supplies, Arc counting circuit and CCD cameras as shown in the attached figure.
- ♦ Primary focus was to investigate the prominent arcing locations in solar panel, arc threshold voltages, arcs statistics and under lying physics.
- ♦ All the experiments were very time consuming typically running for 5-8 hrs. Hundreds of such arc movies and oscilloscope traces were recorded at various plasma parameters.



Developed facility, DSO traces during arc, Evolution of the major Arc (SAS = 80 V, Bias = -407 V) at a plasma density of  $\sim 1 \times 10^6 \text{ cm}^{-3}$ .

### Adventurous Duo



IPRites- *Vrushank Mehta and Prabhat Kumar*- participated in the Arvind Sabarmati Cyclothon 2014 organized by the Amdavad Municipal Corporation on 2nd February, 2014.

While Prabhat successfully completed the 16 km Dream Ride, Vrushank ran into bad luck when his bike broke down before the race ! Riding with a ligament injury, Prabhat was a shadow of his former self - he had completed the 54 km half century race in the 2013 Cyclothon clocking 119 minutes.

Good luck next time guys. You did well.. !





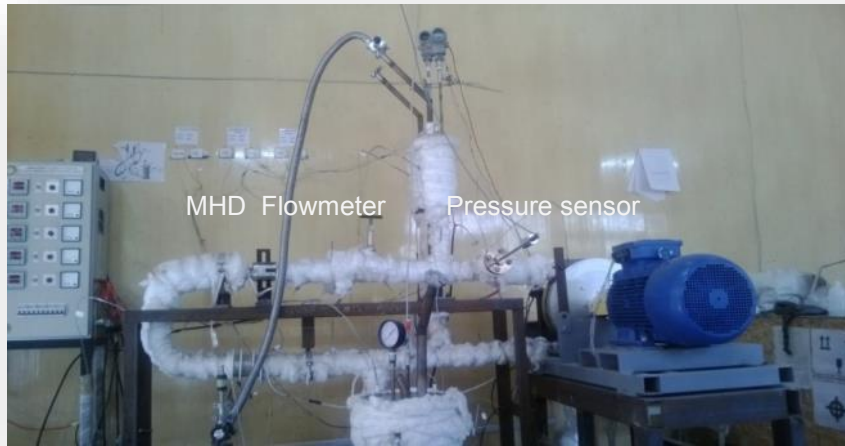


Image of the Pb-Li liquid metal loop at IPR. The loop is equipped with diagnostics for liquid metal temperature, pressure and volumetric flow rate measurement



Pressure sensor



MHD Flowmeter

- ♦ **Liquid Metal Process & MHD division** in TBM group is involved in the development of liquid metal (Lead-Lithium) diagnostics for application in ITER-TBM program. A new state-of-art laboratory has also been commissioned for this purpose at IPR.
- ♦ Hot liquid Lead-Lithium metal ( $T_{in} = 300\text{ }^{\circ}\text{C}$  and  $T_{out} = 460\text{ }^{\circ}\text{C}$ ) will be circulated in a closed loop inside the Test Blanket Module (TBM) to extract heat from the module and also to breed Tritium inside the module.
- ♦ Liquid metal diagnostics are very important for measurement of various process parameters of the loop such as liquid metal pressure, volumetric flow rate and temperature etc. Since the operational temperature is relative high and Pb-Li is corrosive, special diagnostic equipments are required to be used. Such type of diagnostic instruments requires R&D and testing.
- ♦ Recently, diaphragm based liquid metal pressure sensor and MHD flow meter has been developed, successfully tested and calibrated in a Pb-Li liquid metal loop at IPR. These diagnostics are now routinely used to check the reliability of measurement as well as their lifetime in corrosive Pb-Li environment.

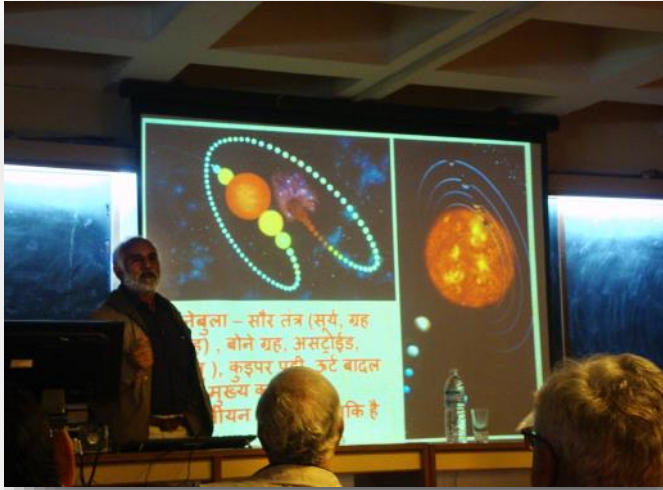
## Visit of Delegates to Aditya

Dr. Anil Kakodkar (Homi Bhabha Chair and former Chairman, DAE), Dr. P. D. Gupta (Director, RRCAT, Indore) and Dr. Dinesh Kumar Srivastava (Director VECC Kolkata) who were here to attend a meeting at IPR on 4th February 2014, took time off to visit the Aditya Tokamak and interacted with the Aditya Group members.



Prof. Dhiraj Bora explaining various aspects of Aditya operation and the machine to the visiting dignitaries.





व्याख्यान देते हुए प्रोफेसर हरि ओम वत्स



प्रश्नोत्तरी को ध्यान से सुनते प्रतिभागी

प्लाज़्मा अनुसंधान संस्थान में 9 जनवरी, 2014 को विश्व हिंदी दिवस समारोह का आयोजन किया गया। इस समारोह में एक वैज्ञानिक व्याख्यान और वैज्ञानिक एवं तकनीकी प्रश्नोत्तरी को शामिल किया गया। इस समारोह में संस्थान के अधिकारियों, कर्मचारियों, प्रशिक्षुओं व शोधकर्ताओं ने बड़े उत्साह से शामिल होकर हिंदी भाषा में रुचि को प्रदर्शित किया। विश्व हिंदी दिवस समारोह कार्यक्रम में राजभाषा कार्यान्वयन समिति के अध्यक्ष श्री राज सिंह जी ने विश्व हिंदी दिवस के इतिहास एवं महत्व के बारे में जानकारी दी। राजभाषा कार्यान्वयन समिति की सदस्य सुश्री प्रतिभा गुप्ता ने कार्यक्रम का संचालन किया। सर्वप्रथम सुश्री प्रतिभा गुप्ता ने अतिथि वक्ता भौतिक अनुसंधान संस्थान, अंतरिक्ष विज्ञान CSSTEAP के पाठ्यक्रम निदेशक प्रोफेसर हरि ओम वत्स का परिचय दिया एवं बुके से उनका स्वागत कर व्याख्यान के लिए आमंत्रित किया। प्रोफेसर हरि ओम वत्स ने 'सूर्य की परिक्रमा करते धूमकेतु' विषय पर व्याख्यान प्रस्तुत किया। इस व्याख्यान में पॉवर पॉइंट एवं वीडियो की मदद से धूमकेतु की असल संरचना एवं उसकी पूंछ में विद्यमान तत्वों के बारे में जानकारी दी। सौर नेबुला - सौर तंत्र को अति सरल तरीके से उन्होंने समझाया साथ ही सौर वायु (प्लाज़्मा) का अति रोचक वीडियो बताया। अब तक देखे गए एवं वैद्यशाला में अध्ययन किए गए प्रचलित धूमकेतुओं जैसे कोहोटेक, लुइलिन, आईसॉ, हेल बोप्प, हयाकुताके, हेल्ली, शूमेकर लेवी आदि के बारे में बताया। ग्रहण के समय सूर्य के नज़दीक दिखाई देने वाले धूमकेतु के अतिविस्मयजनक चित्र दिखाए। धूमकेतु की कक्षा एवं उसका पृथ्वी की कक्षा से संबंध भी समझाया। भारत में स्थित विभिन्न रेडियो दूरबीन का उपयोग कर धूमकेतु के बारे में किस प्रकार जानकारी प्राप्त की जा सकती है इसे भी समझाया। व्याख्यान के पश्चात कार्यकारी मुख्य प्रशासनिक अधिकारी एवं राजभाषा कार्यान्वयन सदस्य माननीय श्री प्रवीण आत्रेय जी ने प्रोफेसर हरि ओम वत्स का अभिवादन किया एवं सुश्री प्रतिभा गुप्ता ने अतिरोचक एवं ज्ञान वर्धक व्याख्यान के लिए प्रोफेसर वत्स को धन्यवाद दिया। समारोह के दूसरे पड़ाव में संस्थान से संबंधित एक तकनीकी प्रश्नोत्तरी का आयोजन किया गया। इसमें बहुविकल्प प्रश्न प्रतिभागियों से पूछे गए। सही जवाब देने पर प्रतिभागी को पुरस्कार दिया गया। राजभाषा कार्यान्वयन समिति के सदस्य श्री नरेश चन्द्र गुप्ता ने मनोरंजनपूर्ण ढंग से प्रश्नोत्तरी का संचालन किया। समारोह के अंत में माननीय श्री प्रवीण आत्रेय जी ने हिंदी में संस्थान की उपलब्धियाँ बताई एवं संचालकों को धन्यवाद दिया। अंततः विश्व हिंदी दिवस कार्यक्रम को सफल बनाने हेतु सुश्री प्रतिभा गुप्ता ने सभी को धन्यवाद दिया।

### Micron Sized IPR Logo

The logo of IPR was etched on the surface of a silicon wafer using a 10 keV Argon ion beam of diameter 15  $\mu\text{m}$ . The size of the etched logo was 600 x 600  $\mu\text{m}$ .

This IPR logo was etched for the IPR Newsletter by Dr. P. Y. Nabhiraj and his colleague Ms. Ranjini Menon of the ECR Ion Sources Facilities Section of Variable Energy Cyclotron Centre (VECC) Kolkata, using their compact ion beam source facility. This facility is capable of achieving a feature resolution of 5-8  $\mu\text{m}$  over an 25x25mm area with a scan resolution of  $\sim 50$  nm.

The IPR newsletter team is thankful to them for gifting us this micro-logo of IPR.





The Indian Test Facility (IN-TF) at IPR with  $\sim 600 \text{ m}^2$  is dedicated to the “Full characterization of the Diagnostic Neutral Beam” for ITER. The prime objective of the facility is to install a full-scale test bed for the qualification of all diagnostic neutral beam parameters and the behaviour of the beam line components prior to installation and operation in ITER. The Indian Test Facility will replicate all aspects of ITER’s diagnostic neutral beam except remote handling and vessel configuration. The civil structure facility is completed and the foundations are now in place for the beam line vessel and its components. This Test Facility is conceived as a collaborative effort between ITER India and ITER Organization. It is integrated into a wider landscape of domestic research on neutral beams in India. ITER India shall provide the dedicated space, beam line components (neutralizer, residual ion dump, and calorimeter), Beam Source (which then be delivered to ITER to become a part of DNB system), the vacuum vessel and auxiliary systems.

‘Indian Test Facility Vacuum Vessel’ (referred to as ‘IN-TF Vessel’ ) is a cylindrical metallic enclosure performing the following functions: 1) Provide part of primary vacuum confinement of the system, 2) Provide support and sustain weight of the beam source, High Voltage Bushing, Beam Line Components (BLCs), Cryopump, 2nd calorimeter, 3) Provide all the feed-throughs that are necessary for passage of the vacuum, coolant, cryogenes, gas and instrumentation lines, diagnostics and calorimeter movement, 4) To allow the access for the beam source installation / maintenance and removal of top lid, and - 5) Fulfils alignment needs for BLC and Beam Source.

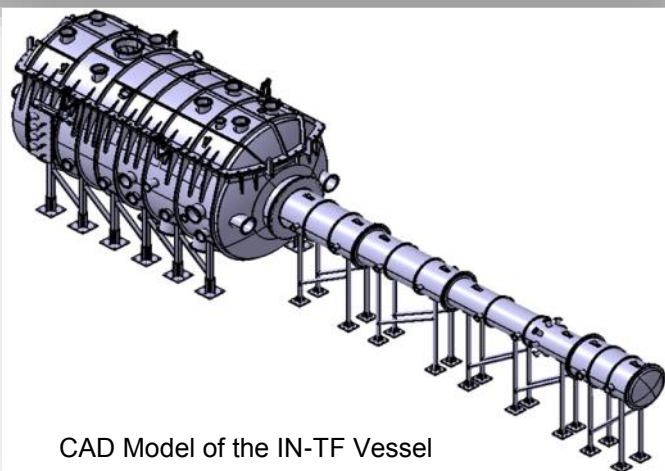


Welding of Main Shell in progress at Bangalore

## IN-TF Vessel Basic Information

Design code	ASME Section VIII Division 1
Material of construction	SS 304 L
Shape	Cylindrical with detachable top lid
Dished Head	Elliptical / Flat of Dia 4400 mm
Length	9800 mm (From Front and back flange), total 21000 mm including duct
Leak rate	$10^{-9}$ mbar l / sec (Local) and $10^{-6}$ mbar l / sec (Global).
Ultimate Vacuum level	$10^{-5}$ mbar Base Pressure

Water spray quenching of dish-end: 1040 °C to  $\sim 200$  °C in 3 mins.



CAD Model of the IN-TF Vessel

Dish-end Inspection before loading into the furnace for solution annealing at Vadodara.



The Configuration design and analysis has been done by ITER-India DNB team. Fabrication is in progress at M/s Vacuum Techniques, Bangalore. **Critical areas of design & manufacturing** (1) Sealing of Top Lid to achieve and sustain vacuum requirements, (2) Maintain flatness and straightness of top flange, (3) Manufacturing of Top Lid and flange assembly of this size with vacuum level of  $10^{-5}$  mbar base pressure, (4) Deflection limits under vacuum  $< 5 \text{ mm}$  whole over the vessel structure and  $< 1 \text{ mm}$  in beam source placement position.





Mr. Chet Narayan Gupta joined IPR in 1985 and he was involved in the design and commissioning of 132 KV and 11 KV power supply systems and high current rectifiers for the Aditya Tokamak.

He currently heads the Aditya power supply division .



Mr. M. Vijayakumaran joined IPR in 1986 and has been associated with the combined Stores and Purchase offices in the past. He presently looks after purchase indent data in the SAP system.



Mr. A. Varadharajalu joined IPR in 1986 and was involved in the design and commissioning of power systems for Aditya and various other experimental systems at the Institute.

He currently heads the SST-1 power system division.

### Staff Club Picnic to Udaipur

The IPR Staff club organized its annual picnic to Udaipur and Kumbalgarh on 1-2 February, 2014. More than 200 people (staff members and family) joined the picnic in a caravan of 4 buses !





- ◆ **Dr. Ashwin Joy**, Institute for Plasma Research, Gandhinagar, gave a talk on "*Percolating Plastic Failure as a Mechanism for Shear Softening in Amorphous Solids*" on 20th January 2014
- ◆ **Dr. R. B. Grover**, Director, Homi Bhabha National Institute, Mumbai, gave a talk on "*Nuclear Energy: Policies, Practices and Future Growth*" on 23 January 2014
- ◆ **Dr. B. B. Nayak**, CSIR-Institute of Minerals and Materials Technology, Bhubaneswar, Odissa, gave a talk on "*Developing Nanotubes based high current carrying Conductors*" on 24 January 2014
- ◆ **Dr. Ashish Ravalia**, Department of Physics, Saurashtra University, Rajkot, gave a talk on "*Swift Heavy Ion Induced Modifications in the Properties of Multifunctional Oxides*" on 27th January 2014
- ◆ **Dr. Lalit Gupta**, Visiting Scientist, Korea Atomic Energy Research Institute KAERI, Daejeon, South Korea, gave a talk on "*Free Electron laser and its applications*" on 5th February 2014
- ◆ **Dr. R. G. Sharma**, Inter-University Accelerator Centre, New Delhi, gave a talk on "*Metallic Superconductors Still Reign Supreme*" on 7th February 2014
- ◆ **Professor Frank Verheest** from University of Ghent, Belgium delivered a general talk entitled "*Fundamentals of Electrostatic Solitary Structures in Multispecies Plasmas*" on 11th February 2014
- ◆ **Prof. Helmut Schober** of Institut Laue- Langevin, Grenoble, France delivered a talk entitled "*Innovation in instrumentation and recent scientific highlights at the ILL*" on 12th February, 2014

### Upcoming Events

- ◆ **6th International Symposium on Advanced Plasma Science and its Applications for Nitrides and Nanomaterials / 7th International Conference on Plasma-Nano Technology & Science**, Meijo University, Nagoya, Japan, 2-6 March 2014.  
<http://www.isplasma.jp/>
- ◆ **7th International Conference on the Physics of Dusty Plasmas (ICPDP 2014)**, 3-7 March 2014, New Delhi.  
<http://www.icpdp2014.com/home>
- ◆ **International Sherwood Fusion Theory Conference**, 24 - 26 March 2014, San Diego, California USA.  
<http://sherwood2014.eng.ucsd.edu/>
- ◆ **Eddy - Mean-Flow Interactions in Fluids**, Santa Barbara, United States, 24 - 27 March 2014.  
<http://www.kitp.ucsb.edu/activities/dbdetails?acro=waveflows-c14>
- ◆ **National Science Day Celebrations** at IPR on 28th February, 2014

### From the IPR Archives



IPR Ver.1.0 -1986 (only ground floor)



IPR Ver.2.0 - 1994 (Ground + 1st floor)

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