Dr. James Allison
CSIRO Astronomy and Space Science

Discovery of a neutral gas outflow in a young radio galaxy using the Australian SKA Pathfinder
Neutral atomic hydrogen (HI) is thought to be the principal reserve for the formation of stars and the triggering of active galactic nuclei (AGN). However, until now, epochs between $0.5 < z < 1$, equating to 4 billion years of galaxy evolution, have remained largely unexplored in HI. The advent of precursor telescopes to the Square Kilometre Array (SKA) will allow us to carry out the first radio-selected 21cm absorption surveys during this period of cosmic history. Using the six-antenna Boolardy Engineering Test Array (BETA) of the Australian SKA Pathfinder, we are carrying out a search for 21cm absorption towards a sample of the brightest and most compact radio sources in the southern sky. We have recently made our first discovery of HI gas towards a gigahertz peaked spectrum (GPS) radio source at $z = 0.44$, with follow-up optical spectroscopic observations (using Gemini South) confirming that this absorption arises from gas in the host galaxy. Analysis of the gas kinematics using radio and optical spectroscopy indicate that the neutral and ionised gases are outflowing at more than 300km/s. We infer that the young radio AGN is expelling gas from the circumnuclear medium at more than 1M_solar/yr. This result is very encouraging for imminent wide-field absorption surveys to be carried with the SKA precursors, which we predict should detect many such intrinsic systems, as well as constraining the evolution of the cosmological HI mass density at moderate redshifts.

Dr. Ramesh Bhat
ICRAR, Curtin UniversityAustralia

Low-frequency pulsar astronomy with the MWA and SKA-low
SKA-low will be a powerful instrument that can be leveraged to accomplish one of the key science goals of SKA1: detection of gravitational waves via pulsar timing-array experiments. Low-frequency observations offer undeniable benefits for tracking interstellar dispersion measure variations and other propagation effects on pulsar signals, which must be accurately measured and corrected for in order to reach the required detection sensitivity to gravitational waves. Observing pulsars with SKA-low however will pose significant challenges given the beam-formation and digital processing requirements that will ensue from its many-element distributed design. The MWA provides an excellent platform to trial and master the related development using its 100+ elements extending out to baselines of a few km. This would be an important preparatory step toward doing science with SKA-low. I will report on ongoing activities to gear up the pulsar science capabilities of MWA, including the newly commissioned capability to form phased-array beams from pre-recorded voltage data. The science programs under way include observations of timing-array pulsars for their low-frequency characterization and targeted searches for pulsars. I will present recent highlights and the plans ahead, and how they are closely aligned with the SKA-low goals.

Dr. Chris Blake
Swinburne University

Cosmology with the SKA
I will summarize the cosmological science case for phase 1 of the SKA, stressing the areas in which the SKA could successfully compete with other facilities, and the challenges that first need to be overcome.

Dr. Robert Braun
SKA Organisation

Science with the Square Kilometre Array
The SKA is now in the final design phase, with construction expected to begin in 2018. Current project status will be presented with an emphasis on the far-reaching scientific capabilities of the Observatory. A major component of the SKA science program will likely take the form of Key Science Projects. The opportunities around the KSP package will be highlighted.

Dr. Kate Chow
CASS

Radio quiet and the SKA in Australia
The Murchison Radio-astronomy Observatory (MRO) is an excellent radio quiet place and unique observatory; the most well protected radio astronomy site in the world. The MRO is the site of the Australian Square Kilometre Array Pathfinder (ASKAP), the Murchison Widefield Array (MWA), and the Australian component of the international Square Kilometre Array (SKA) telescope project is to be sited in the same region. The remote nature of this location makes it an ideal site for radio astronomy. It is protected by government legislation over a frequency range from 70 MHz to 25 GHz, as a part of the Australian Radio Quiet Zone WA (ARQZWA).

RFI can arise from both internal and external activities, including electrical equipment on the telescope site, or transport and agricultural activities external to the telescope. I will describe briefly the government measures currently in place to protect the MRO, and the actions taken to minimize RFI from on-site equipment.

Dr. Luca Cortese
Swinburne University of Technology

HIGHz: a survey of the gas content of the most massive galaxies at z~0.2
I will present the results of the HIGHz Arecibo survey, which measured the HI properties of a unique sample of 39 galaxies with stellar masses ~10^11 Msun at redshift z~0.2. This sample includes the highest-redshift detections of HI emission from individual galaxies to date, which are also among the

most HI-massive systems known. Our analysis indicates that, despite being exceptionally large, the HI reservoirs of HIGHz systems are exactly what is expected from their UV and optical properties. Indeed HIGHz galaxies appear to be rare, scaled-up versions of massive disk galaxies in the local Universe. The HIGHz survey offers a unique laboratory to investigate how star formation proceeds in the HI-dominated regime, and provides a first glance into the properties of the galaxy population that will be gradually detected by the upcoming Square Kilometer Array precursor surveys at higher redshifts.

Dr. Stephen Curran
Victoria University of Wellington

Unveiling a Hidden Population of High Redshift Galaxies with the SKA
"Cold neutral gas in galaxies acts as a reservoir for all star formation in the Universe. Traced by the 21-cm hyperfine transition of atomic hydrogen (HI), it can be detected through absorption by quiescent galaxies, that intervene the line-of-sight to a background active galactic nucleus, or within the host galaxy of the AGN itself. While HI absorption has been detected in over 12000 intervening galaxies, through the Lyman-alpha transition, detections in the host galaxies of AGN are extremely rare: There are only 40 detections of associated 21-cm absorption at redshifts of $z > 0.1$ and only four of these are at $z > 1$ (look-back times in excess of half the age of the Universe).

We attribute this deficit of cold neutral gas to the traditional optical selection of targets, which at high redshift biases towards the most ultra-violet luminous objects, in which all of the neutral gas in the host galaxy is ionised. Thus, in order to find these ""missing"" gas-rich galaxies in the distant Universe, we must dispense with the current reliance upon an optical redshift, to which to tune the receiver, and undertake spectral scans in the radio band. With its wide instantaneous band-width in an RFI-quiet environment, the SKA offers a unique opportunity to unveil a population of distant galaxies which are forever hidden to optical spectroscopy."

Prof. Simon Ellingsen
University of Tasmania Australia

The structure and motion of the Milky Way and Local Group through VLBI with the SKA
The sensitivity and field of view of the SKA will enable a range of new very long baseline interferometry projects to study the scale and structure of the Milky Way and the kinematics of the local group. Through accurate astrometry we will be able to measure distances using trigonometric parallax throughout the Galaxy allowing us to trace the spiral structure and its relation to Galactic dynamics in unprecedented detail. We will be able to form tomographic images of the nearby spiral arms to investigate the physical processes through which spiral arms form and high-mass star formation is triggered. We will be able to detect a large population of masers in local group galaxies and through measurements of their proper motion we can make accurate measurements of their 3D

centre of mass motions which in turn can be related to previous star formation and interaction histories and hierarchical structure formation.

Dr. Christopher Fluke
Swinburne University of Technology

Cubes in a CAVE: Visualisation and Analysis Challenges for the SKA Era
As we move ever closer to the Square Kilometre Array era, support for real-time, interactive visualisation and analysis of tera-scale (and beyond) datasets will be crucial for on-going knowledge discovery. However, the data-on-the-desktop approach to analysis and visualisation will no longer be feasible. Not only do the data volumes exceed the memory and processing capabilities of standard desktop computing environments, but there is a significant mismatch between the available data pixels (or voxels) and the resolution of desktop displays. One option is to leave the desktop and make use of a large-scale immersive 3D environment. The CAVE2 at Monash University is a hybrid 2D/3D visualisation space, comprising 80 screens arranged in an 8-metre diameter ring. Capable of displaying 84 million pixels, the CAVE2 is part advanced visualisation system and part supercomputer, with 80 TFLOP/s of integrated GPU-based processing power. I will provide an overview of the CAVE2, discuss the status of CAVE2 related enhancements to the GPU-accelerated GraphTIVA visualisation and analysis framework, and present results of early experiments in the simultaneous display of O(100) individual three-dimensional data cubes.

Ms. Katinka Gereb
Swinburne University of Technology

On the interplay between gas and radio AGN: the HI absorption "Zoo"
Nuclear activity in radioactive galactic nuclei (AGN) is thought to be connected with the presence and kinematic properties of the gas in the circumnuclear regions. To understand the full picture of the interplay between gas and AGN, large systematic studies of AGN samples are needed. Using the Westerbork Synthesis Radio Telescope (WSRT), we carried out shallow HI absorption observations of a flux-selected (> 50 mJy at 1.4 GHz) sample of 101 radioactive galactic nuclei (AGN). Despite the shallow observations, we obtained a direct detection rate of ~30%, comparable with deeper studies of radio galaxies. The HI absorption spectra show a broad variety of widths, shapes, and kinematic properties, clearly an HI. Detections are found at every continuum flux level, showing that HI absorption detections are not biased toward brighter sources. We study the HI gas properties of the radio sources at low optical depth level using, for the first time, stacking of HI absorption. Furthermore, we characterize the morphological and kinematic properties of the absorption features by fitting the lines and deriving their parameters.

The stacked profiles of detections and non-detections reveal a clear dichotomy in the presence of HI, with the 27 detections showing an average peak optical depth of Ï = 0.02, while the 66 non-detections remain undetected upon stacking with a peak optical depth upper limit Ï < 0.002. We

argue that orientation effects connected to a disk-like distribution of the HI can be partly responsible for the dichotomy that we see in our sample.

A fraction of the AGN sample is confirmed by previous studies as compact, likely young radio sources (compact steep spectrum and gigahertz peaked spectrum sources). Compact sources have a higher detection rate of 55%, higher integrated optical depth, wider stacked profile, and more asymmetric lines compared to extended sources. All these suggest that young radio AGN are embedded in a medium that is rich in unsettled atomic gas. We find three new cases of profiles with blueshifted broad wings (with FW20 > 500 km/s), typically detected in powerful compact AGN. These detections are good candidates for being HI outflows that may arise as a result of jet-cloud interactions. Our results are particularly relevant for future surveys in two ways. The lack of bias toward bright sources is encouraging for the search for HI in sources with even lower radio fluxes planned by such surveys. The results also represent a reference point when searching for HI absorption at higher redshifts.

Dr. George Hobbs
CSIRO

The SKA and Pulsar Timing Arrays

One of the key science drivers for the SKA project is to search for, and study, gravitational waves through observations of pulsars. I will describe the status of current pulsar timing array projects, the contents of the chapter written on timing arrays for recent SKA book and will make some predictions for how SKA-low, survey and mid can also be part of the search for gravitational waves.

Mr. Andrew Jameson
Swinburne University of Technology

Pulsar Timing Instrumentation with SKA1

Since the discovery of pulsars in late 60's, the instrumentation used to discover and analyse pulsar signals has been continuously improved by astronomers and engineers. This activity has been fuelled by advances in digital electronics and computational power, which have enabled greater sensitivity, time and frequency resolution. The SKA1-Mid Pulsar Timing Sub-Element (PST) will push current boundaries by orders of magnitude. I will review the key design aspects of the PST, highlighting the computational challenges and constraints due to budget, power and environment. I will show how the flexibility of our design supports the deployment of new signal processing algorithms, the acquisition of new data products, and a clear upgrade path to SKA2. Finally, after reviewing the scientific motivation, I will demonstrate how the PST design can be readily extended to provide Pulsar Timing capability on SKA1-Low.

Dr. Hansik Kim
The University of Melbourne

The HI mass function as a probe of photoionisation feedback on low mass galaxy formation
We explore the galaxy formation physics governing the low mass end of the HI mass function in the local Universe. Specifically, we predict the effects on the HI mass function of i) varying the strength of photoionisation feedback and redshift of the end of the epoch of reionization, ii) the cosmology, iii) the supernovae feedback prescription, and iv) the efficiency of star formation. We find that the shape of the low mass end of HI mass function is most affected by the critical dark halo mass below which galaxy formation is suppressed by photoionisation. We model the redshift dependence of this critical dark matter halo mass.

Dr. Katherine Mack
University of Melbourne

What the SKA Can Tell Us About Dark Matter
I will discuss how high-redshift observation of the intergalactic medium can illuminate the properties of dark matter, through searches for the effects of annihilation radiation and the impacts of alternative dark matter models on the formation of structure. I will also discuss how the SKA can be used to search for radio counterparts of dark matter annihilation in the local universe.

Dr. Martin Meyer
ICRAR/UWA

Galactic and Magellanic Evolution with the SKA
As we strive to understand how galaxies evolve, we can apply our increased knowledge, and test our theories, in nearby systems that we can observe in much greater detail. Our own Galaxy, the Milky Way, and the nearby Magellanic System provide us with the closest laboratories for studying the evolution of gas in galaxies, including how galaxies acquire fresh gas to fuel their continuing star formation, how they circulate gas and how they turn warm, diffuse gas into molecular gas and ultimately, stars. Atomic hydrogen (H I) is found in a variety of environments, from dense clouds to the diffuse galactic halo and shows structure with size scales from kilo parsecs to a few tens of Astronomical Units. With the SKA, working together with ALMA, we will be able to completely revolutionise our understanding of the evolution of gas in galaxies. In this talk I will review the science case presented for the SKA Science book on Galactic and Magellanic evolution.

Prof. Ray Norris
CSIRO Astronomy & Space Science

ASKAP in the SKA era
I will give an overview of the current status of ASKAP, including the latest results and projected timescale, and discuss its complementarity and support of SKA.

Ms. Emily Petroff
Swinburne University of Technology

Fast Radio Bursts in the lead-up to the SKA era
Fast radio bursts (FRBs) are quickly becoming a subject of intense interest in time-domain astronomy and new surveys are being designed with specific attention paid to FRB science. FRBs have the exciting potential to be used as cosmological probes of both matter and fundamental parameters, but such studies require large populations. Advances in FRB detection using current and next-generation radio telescopes will enable the growth of the population in the next few years. Real-time discovery of FRBs is now possible with 3 sources detected in real-time within the past 1.5 years at the Parkes telescope. I will discuss the developing strategies for maximising real-time science with FRBs including polarisation capture and multi-wavelength follow-up including the most recent efforts undertaken as part of the SUrvey for Pulsars and Extragalactic Radio Bursts (SUPERB). Particularly, I will focus on the real-time detections of FRB 140514, made last year, and of the new burst FRB 150215 discovered earlier this year and how our response to these events can inform next generation surveys and pave the way for the enormous number of FRB discoveries expected in the SKA era.

Dr. Attila Popping
ICRAR / UWA

First results of the COSMOS HI Large Extragalactic Survey (CHILES)

Hydrogen (HI) is the most abundant element in the Universe, and surprisingly, we know very little about the neutral hydrogen beyond z~0.08. The recently upgraded VLA makes it now possible to image the HI in galaxies beyond the local Universe. We are using the broad bandwidth of the VLA to instantaneously probe HI from z=0 to z=0.5 in a single pointing of the COSMOS field for a total integration time of 1000 hours. Once completed, we will have HI images of 300 galaxies across cosmic ti-me in different environments. CHILES is an ongoing survey with many technical challenges, including the processing of a very large data volume. In this talk we will discuss the lessons we have learned and the experiences we have gained so far from the first 170 hours of observations. We will demonstrate two working solutions to combine and image all the data that has currently been observed. We will present the first data-cubes of the survey and show some preliminary results. CHILES is a true pathfinder for other HI surveys in the future and we will discuss how the results of CHILES can be expanded with the SKA.

Dr. Chris Power

ICRAR

HI surveys with the re-baselined SKA

Understanding the evolution of HI across cosmic time is one of the prime research goals of the SKA. I will explore the capacity of the SKA to carry out extragalactic HI survey programs following its recent rebaselining, how this rebaselining has affected previously identified HI science goals, and outline some of the blind and targeted observations that might now offer the best prospects for advancement in the field given the newly defined performance characteristics of the array. As an integral part of survey design, I will also examine the degree to which SKA HI observations can be aligned with existing and future surveys at other wavelengths.

Dr. Christian Reichardt
University of Melbourne

SKA cross mm-wave: What can we do with that?

The next decade will be marked nearly all-sky surveys of unprecedented sensitivity across the electromagnetic continuum, from radio (SKA) to mm-wavelengths (CMB stage 4, LiteBIRD) to optical (LSST) to X-ray (eRosita). These overlapping surveys will present us with a rich dataset for cross-correlation studies. I will discuss the proposed mm-wavelength surveys and current forecasts for intensity mapping x CMB lensing and EoR x CMB measurements.

Mr. Paolo Serra
CSIRO

The low column density HI Universe

I will make the case that a major contribution of the SKA to our understanding of galaxy evolution will be the study of the low-column-density HI Universe. Based on existing data, I will argue that sensitive HI observations reveal fundamental processes that go unnoticed at other wavelengths. I will make the case that observing such processes on large samples out to redshifts relevant for galaxy evolution is crucial to understand, e.g., the emergence of the Hubble sequence and of the morphology-density relation, the cycle of gas in galaxies, and whether or not galaxies accrete cold gas from the cosmic web.

Dr. Nick Seymour
Curtin University

Continuum Surveys with SKA1

I provide an overview of the diverse key science identified by the SKA Continuum Science Working Group. These areas include galaxy evolution, AGN evolution, clusters and diffuse emission, galactic science, cosmology, the local Universe, strong lensing and legacy/serendipity. I will present the `reference' surveys proposed by our WG as being optimal with the rebaselined SKA1 and the science areas above. I will discuss in particular how a tiered `wedding cake' series surveys will address key science goal of measuring the star formation history of the Universe. I will briefly discuss options for commensality between continuum observations with other science areas such as Magnetism, Cosmology, and HI.

Dr. Stas Shabala
University of Tasmania Australia

Quasars and AGN

The SKA and its pathfinders will characterize the radio AGN populations to almost arbitrarily high redshift. While interesting in their own right, radio AGNs are also an important component of galaxy formation models, which routinely invoke feedback from radio AGNs to explain the restricted growth of the most massive galaxies over the last half of the Hubble time. Whether or not the observed AGN population can provide the required feedback, however, is an open question.
I will describe our recent work on modelling the radio AGN populations. Using dynamical models of radio lobes together with a semi-analytic galaxy formation model, we relate AGN physical properties such as kinetic jet power and age to radio observables (luminosity, size, spectral index). By applying our model to a low redshift ($z<0.1$) sample of radio AGN, we can tackle questions such as: "how much energy do the AGN supply to their surroundings? “and what triggers radio AGN activity?" The ASKAP all-sky continuum survey EMU (Evolutionary Map of the Universe) will have the same sensitivity at $z=0.8$ as existing surveys do at $z=0.1$. In principle this will allow us to probe the AGN feedback process at a time when the Universe was much more dynamic and make direct

comparisons with the present-day Universe. I will outline some challenges in applying our models to higher redshifts and steps we are taking to prepare for the analysis of EMU data.

Prof. Lister Staveley-Smith
ICRAR/UWA

Surveys in the era of SKA1
The outcome of the re-baselining process may make it challenging to conduct time-consuming surveys with Phase 1 of the SKA, particularly at GHz frequencies. I will review the current level-0 science requirements against what may be actually achievable with a re-baselined SKA1, concentrating on HI surveys.

Prof. Steven Tingay
Curtin University

The MWA, precursor to key science for the SKA
I'll describe the MWA as a technology and science precursor for the SKA, summarize MWA early science highlights, and describe how Australian astronomers can get involved now with MWA science now, in preparation for the SKA era.

Dr. Andrew Walsh
ICRAR/Curtin

Surveys of the Galactic Plane with the SKA

The SKA is the ideal telescope to conduct wide-field observations of the southern Galactic Plane in order to obtain a complete census of molecular gas. I will discuss planned surveys to this end, including surveys of the hydroxyl radical (OH) and formaldehyde, which will probe the density regime between the atomic and molecular phases of the ISM.

Dr. Randall Wayth
ICRAR/Curtin University

SKA_low and the Aperture Array Verification System
I will give an overview of SKA_low science an update on the status of the SKA_low Aperture Array Design Consortium (AADC), which will deploy the first prototype SKA_low stations at the Murchison Radio-astronomy Observatory at the end of 2015. These stations will form the Aperture Array Verification System 1 (AAVS1), co-located with the Murchison Widefield Array telescope.

Dr. Laura Wolz
The University of Melbourne

Intensity Mapping with the SKA

Intensity mapping of the neutral hydrogen is a new observing technique designed to efficiently map the large scales of the matter distribution in our Universe since hydrogen closely traces the dark matter. The flux of the redshifted 21cm emission is measured on low resolution without identifying individual galaxies such that the 3-dimensional clustering behaviour of the cosmic web is still preserved and cosmological analysis to measure the expansion rate and growth of structure are feasible. Accessing information on the epoch of the cosmic acceleration is one of the primary science goals in future ground and space-based experiments while being very challenging in optical wavelengths. Intensity mapping presents a unique way to probe the large-scale structure at such timescales in the radio regime. Furthermore, in combination with optical surveys, it can tighten constraints on cosmological parameters by mitigating the systematic errors on both probes.

Intensity mapping experiments can be conducted by the Square Kilometre Array with SKA-LOW for redshifts close to the end of the epoch of reionization and with SKA-MID/SUR for redshifts up to 3 either in single dish mode or as interferometric measurements. The main challenges are, on the one hand, the high extra-terrestial foregrounds which require careful subtraction from the signal and, on the other hand, the technical difficulties arising from the instruments itself, for instance, calibration uncertainties for single dish observations or insufficient sensitivity for interferometric arrays. These issues have been considered and partly been addressed in new statistical methods for data analysis in past and on-going intensity mapping projects. For intensity mapping with the SKA, existing methods require to be advanced and carefully adapted to specific instrumental designs such that reliable results can be extracted from these novel datasets