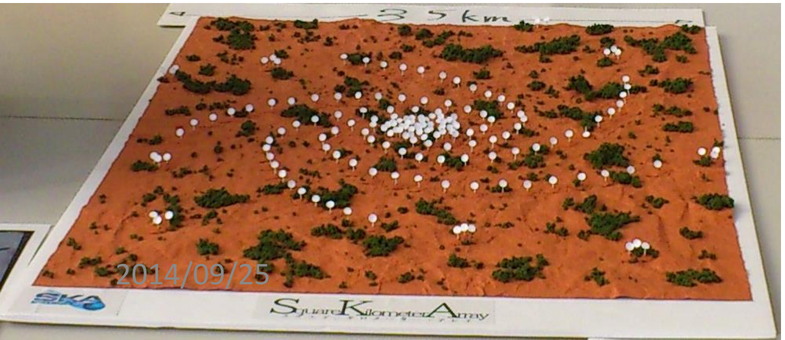
第12回水沢VLBI観測所ユーザーズミーティング

SKAプロジェクト

鹿児島大学　中西裕之



SKA (Square Kilometre Array)

SKA-JP
日本百万平米電波干渉計計画協会

- 集光面積1km級の巨大電波干渉計
  - 10ヶ国が国として推進
  - 興味がある研究者は20ヶ国以上
- 周波数：50MHzから10GHz
- アンテナ総数：15m級3000台
- 最大基線長：3000km
- 建設地：
  - オーストラリア(low-SKA)および南アフリカ(mid-SKA)
- 特徴
  - 高感度
  - 高分解能
  - 広視野
  - 広帯域

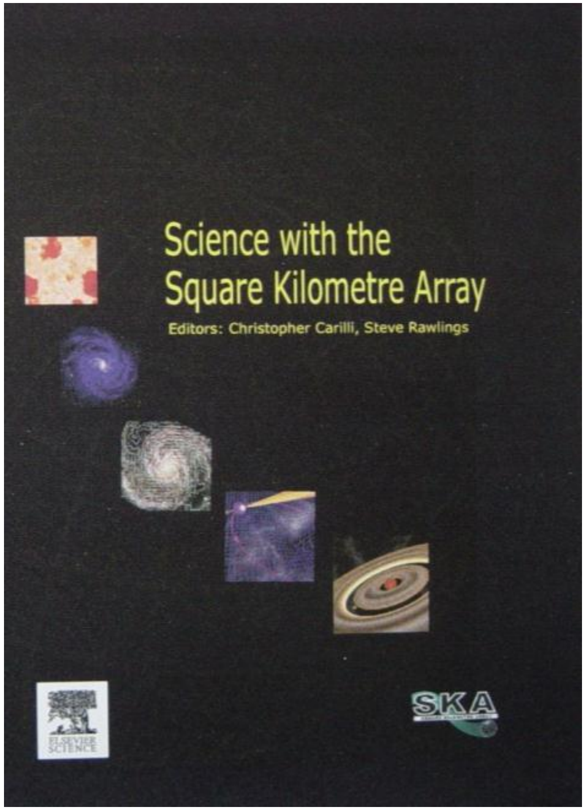
高感度、高分解能、広視野、広帯域の
長波長大陸望遠鏡


SKA完成予想図

SKAによるサイエンス

SKA-JP
日本百万平米電波干渉計計画協会

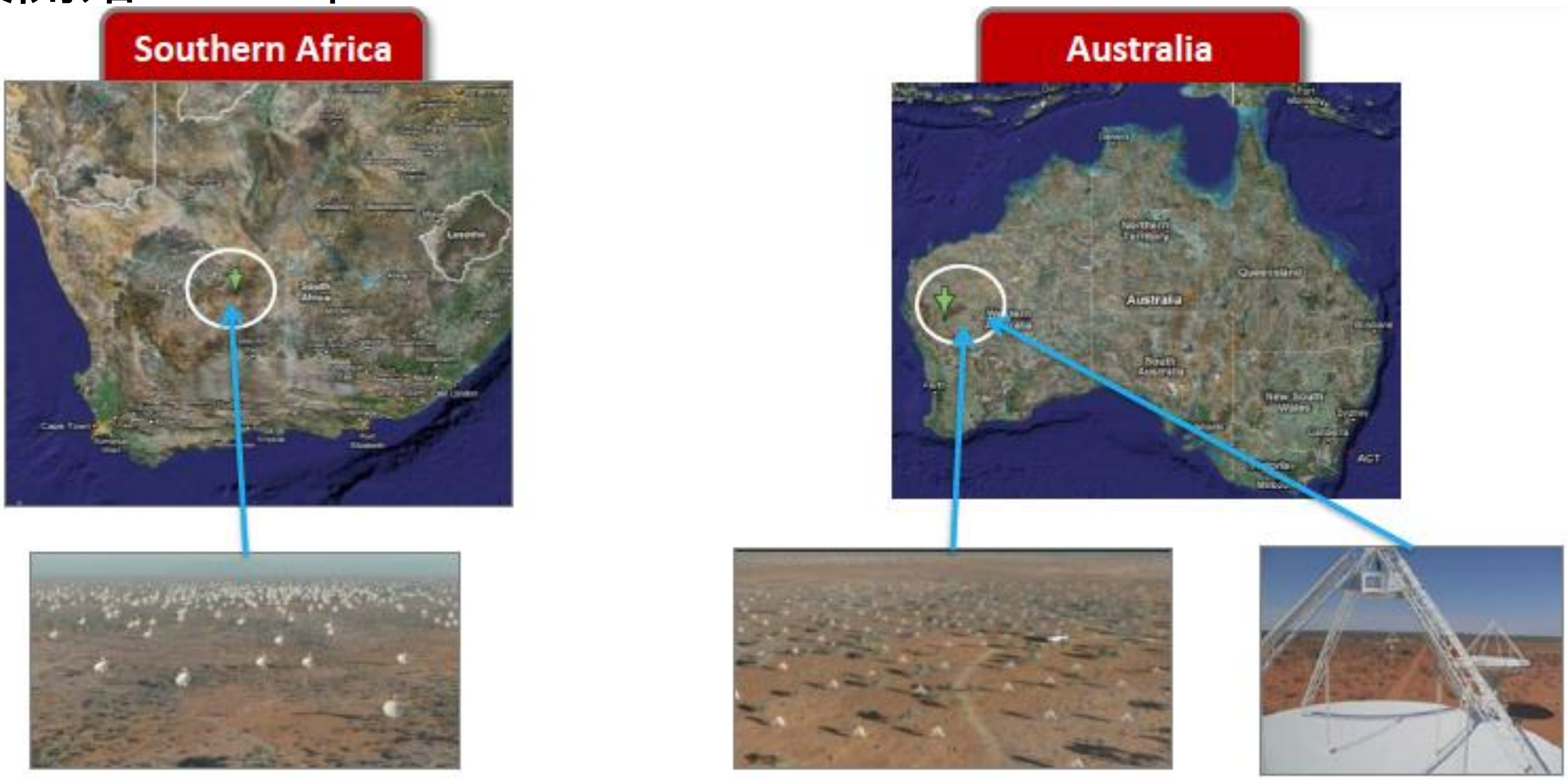
1. 起源
   - HI 21cm線による宇宙再電離(EoR)時代から現在までの宇宙進化
     - 宇宙最初の星・銀河はいつ生まれたか？
     - 銀河はどのように進化するのか？
     - 暗黒エネルギー、暗黒物質の正体は？
   - 宇宙における生命の誕生
2. 基本的な力
   - パルサーによる重力理論検証
   - 宇宙磁場の起源と進化
3. トランジエント天体（新しい現象）



*Science with the Square KilometreArray (2004, eds. C. Carilli& S. Rawlings, New Astron. Rev., **48**)*

SKA phase 1 (SKA1)

- 建設費: €650M （920億円@€1=140円)
- 建設開始 : 2017年



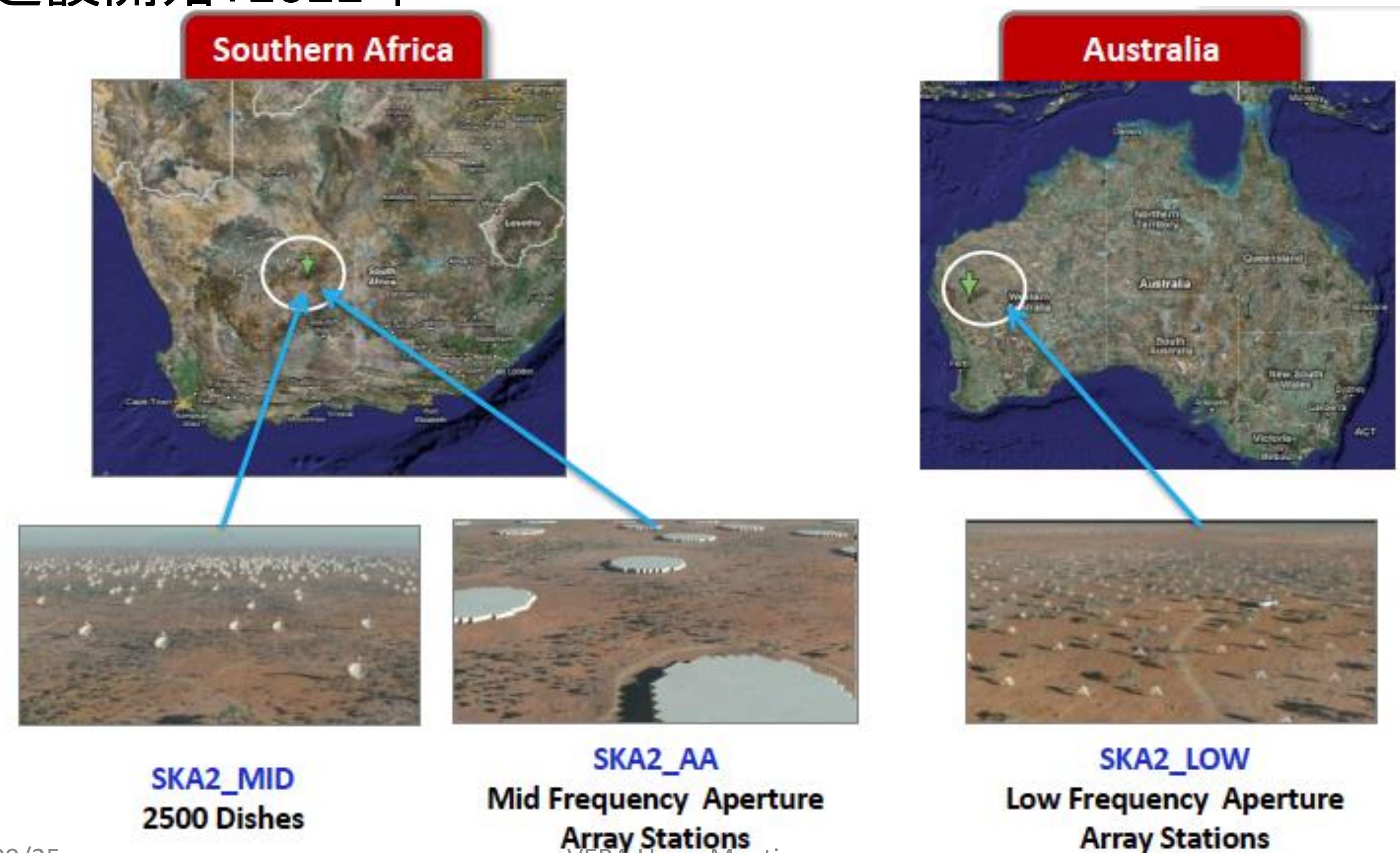
SKA1_MID
254 Dishes including:
64 x MeerKAT dishes
190 x SKA dishes

SKA1_LOW
Low Frequency Aperture
Array Stations

SKA1_SURVEY
96 Dishes including:
36 x ASKAP
60 x SKA dishes

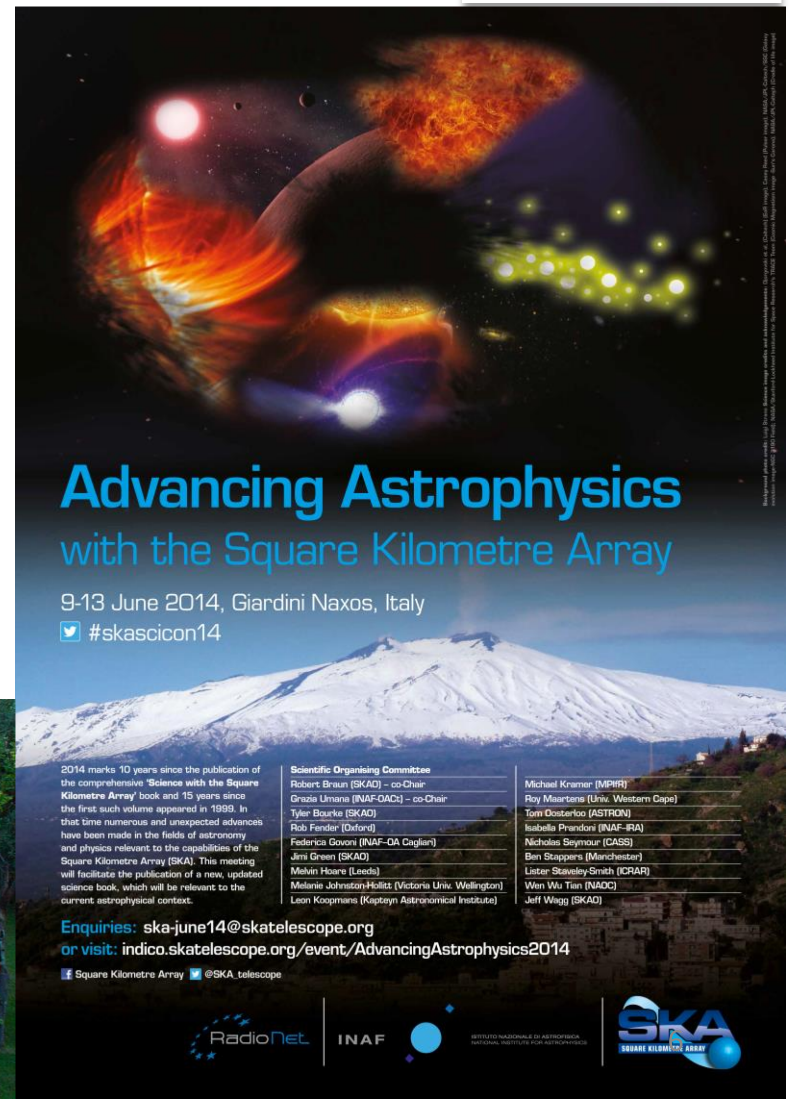
SKA phase 2 (SKA2)

- 建設費: 未定 (>€1.5B=2100億円@€1=140円）
- 建設開始 : 2022年



Advancing Astrophysics
with the Square Kilometre Array

- 初版SKA Science Book作成から10年の節目→ SKAサイエンスを再検討
- Cost cap €6.5億に対し、現在の見積>€10億　→rebaselining
- イギリス予算獲得(£1億)←建設費の15%
- ドイツ脱退(全体の2.5%。大勢に影響 なし)
- 「オープンスカイ」→「貢献度に応じた時間配分』に？



CONCEPT OF OPERATIONS FOR THE SKA OBSERVATORY

Document number SKA.TEL.SE.OPS-SKO-COO-001-0-A
Revision .... B
Author .... D.C.-J.Bock, P.E.Dewdney, S.T.Garrington, J.Horrell,
.... R.Vermeulen, A.Wicenec
Date 2013-10-29
Status...Released

Name	Designation	Affiliation	Date	Signature
Submitted by:				
Douglas Bock	Chair, OWG	CSIRO	2013-10-29	For D. Bock
Accepted by:				
Peter Dewdney				
Approved by:				
Philip Diamond	Director-General	SKA Organisation	2013-10-29	

2.4 Host Country Operations

Operations in the Host Countries will be part of the SKA Observatory and managed by the GHQ. The Directors of Host Country activity will report functionally to the SKA Director-General, within the context of the contractual relations or the overall management structure chosen for the SKA Observatory.

2.5 Other SKA Observatory roles

There are additional roles that the SKA Observatory will have, in common with other observatories:

- Organise and conduct on-going improvements/upgrades
- Retain technical expertise
- Provide scientific leadership

These roles are not considered in detail in this document. Nevertheless, the operating model of the observatory implicitly enables them, since retaining the expertise of relevant individuals and access to the staff of related organisations will be essential to the day-to-day conduct of the observatory.

2.6 Success metrics

Both scientific and operational metrics are needed to guide the management of an observatory. The ultimate goal is maximum scientific discovery and impact. However, operational success metrics are more easily linked to day-to-day operations and can provide earlier diagnostics of the likelihood of scientific success.

Scientific success metrics

The primary success metric for the SKA Observatory will be the significance of its role in making fundamental scientific discoveries and facilitating overall scientific progress, expressed as high impact, peer-reviewed scientific papers using SKA data.[4,8] Additional success metrics such as the total number of users, etc., will also be developed and measured.

Operational success metrics

Operational success metrics will commonly be dependent on the individual telescope design and/or technology, and on the scientific strategies and success metrics. Sustainability, efficiency, telescope and data availability, and user support level are examples of success indicators related most to breadth and size of the user base, while operational success metrics measuring capability and performance may be particularly important to monitor the ability to achieve specific high-impact science results.

3 Science Projects

The SKA Observatory will be designed to accommodate a mix of large co-ordinated observations proposed by large teams and short PI-driven programmes.[4,29]

3.1 Key Science Projects

A limited number of large observing projects designed to address Key Science Programs will be allocated a substantial fraction of observing time. These will be called Key Science Projects.

Large projects in Key Science Program areas are allocated based on proposals, in accordance with the general SKA Access Policy on eligibility and peer review. Regular progress review will be part of the allocation mechanism. In the interest of healthy scientific competition, quarantining of science areas to specific teams will generally be avoided.

Key Science Project teams may propose for specific data processing resources and other support that may be available from the SKA Observatory, but they are also expected to arrange for significant additional resources themselves.

3.2 PI Projects

The SKA will also conduct a program of observations driven by proposals from individual researchers and teams, initially on a fixed cycle of 6-12 months.[4] The time will be allocated based on proposals submitted for evaluation under a process organised by the SKA Observatory. The lifetime of these proposals will normally be for a single proposal cycle (likely to be 6-12 months). In certain cases longer projects will be approved but subject to a process of on-going review.

3.3 Access Policy and Time Allocation

The SKA Board will define the SKA Access Policy governing the right to propose for observations and to have access to archived data.[A17] Currently there are local, national and international astronomy research facilities that operate under one (or sometimes both) of two basic models:

- Open access (often called "open skies"). Under this model, time allocation is based on scientific merit and technical feasibility of the proposed project, irrespective of country or institution of origin of investigators, generally without a significant financial contribution by the investigators. The goal is to maximise total scientific output from the facility. Data may or may not be in the public domain from the outset.
- Access based on affiliation with certain organisations or countries. Under this model, the right to propose observations and receive data is limited (often by quota) to affiliates of organisations or countries that have made a financial contribution. Sometimes a fraction of time is made more broadly available. Generally, results and archival data become public after some period.

The Access Policy for the SKA will be documented here once the Board has agreed it. The Director-General will retain the final authority for time allocation, within the policy framework set by the Board.[A18]

3.4 Director's time and Staff access

A small percentage of observing time will be left unallocated for use at the discretion of the SKA Director-General. Staff will access the telescope through the same mechanisms as other scientists. There will be no specific allocation of telescope time reserved for staff. However, the access policy will make provision for staff scientists who are employed by the observatory to access the telescope irrespective of their association with an SKA partner.

4 Science Operations

Science Operations comprises the broad range of activities needed for the scientific use of the SKA Telescopes. These include all stages of the observing cycle, from preparing and submitting a proposal, preparing for and taking observations, using data archives and working with the data or data products obtained. Science Operations and Engineering Operations will need to be in close

[4] *A model without a fixed cycle is possible but has not yet been evaluated for the SKA.*

SKA.TEL.SE.OPS-SKO-COO-001-0-A
Revision : B

contact in many circumstances and staff should be co-located where possible. A portion of science operations may be conducted from the GHQ.

4.1 Proposal handling and time allocation

Proposals will be accepted for a regular observing cycle (likely to be once or twice a year) and will be ranked according to scientific impact and assessed for feasibility with the requested telescope. In certain cases the resources made available by proposers for large projects will be a discriminant in obtaining observing time. Following time allocation[5] (section 3.3), projects will each be broken into one or more scheduling units capable of being individually observed. A prioritised list of the scheduling units will be formed for each telescope. The prioritised lists will take into account any guaranteed shares of time for countries or organisations contributing to the SKA averaged over a suitably long period. To ensure efficient use of telescope time, the list may consist of more scheduling units than can normally be observed in the observing cycle. The proposers will be informed about the outcome. The entire process will be supervised and/or conducted by GHQ.

4.2 Telescope scheduling and observations

The short-term telescope schedule will be composed by the local telescope staff. At this stage, maintenance and other local scheduling constraints will be taken into account, along with any coordination needed with other observatories. The local staff will have the discretion to vary the order of observations from that in the prioritised list to ensure efficient observing, and to carry a small number of scheduling blocks to the next observing cycle, provided that the overall prioritisation is maintained. Observations will be conducted by Observatory staff. Other than for time-critical and custom projects, project team members will not normally participate in the observing or receive the data in real time. This is motivated by the higher efficiency enabled by flexible scheduling and by the complexity of the system.

4.3 Data processing

Both image processing and time-domain processing will be supported. Image processing will deliver images of the sky in radio wavelengths. Image processing is an iterative process, and access to raw and intermediate data products is required throughout the process. However, data volumes from the SKA are expected to be too large to store permanently, and will have to be buffered. For many imaging observations, only the final image data will be stored: thus the image processing will be a form of lossy compression. Some time-domain processing will also take place in near-real time. Detailed definition of data processing requirements and limitations for both imaging and time-domain processing will occur during the design phase of the SKA.

Data processing will take into account the current state of the telescope system (system model), as well as all of the known events that occurred during the observation (see section 5.2). The events will include RFI, weather events, bad data detected upstream, etc. Real-time processing will be carried out only where warranted (e.g. events that require a decision, action or response). Otherwise the processing system will be designed to keep up with the average load.

4.4 Calibration and data projects

The SKA Observatory will calibrate SKA data and make science-ready data and ancillary products available to the users.[A20] The SKA Observatory will produce tools, procedures, pipelines and databases to collect and track calibration data and instrument performance so as to ensure the

[5] *Actual observing time will normally be allocated, rather than guaranteed outcomes (such as sensitivity).*

SKA-JP (2008年5月設立)

SKA-JP
日本百万平米電波干渉計計画協会

メンバー数 157名

顧問
小林秀行(国立天文台)

会長
杉山 直(名古屋大)

副会長
中西裕之(鹿児島大)
市來浄與(名古屋大)

産業部会
熊澤寿樹(東陽テクニカ)

国立天文台窓口
萩原喜昭(国立天文台)

技術検討班 班長
中西裕之
(鹿児島大)

- デジタル信号処理
  中西裕之(鹿大)
- ソフトウェア
  倉山智春(帝京科学大)
- 広帯域フィード
  氏原秀樹(情報通信研)

科学検討班 班長
高橋慶太郎
(熊本大)

- 宇宙磁場
  赤堀卓也(SIfA)
- パルサー
  亀谷收(国立天文台)
- High-z
  平下博之(ASIAA)
- 星間物質
  半田 利弘(鹿大)
- 位置天文学
  今井 裕(鹿大)
- Transient
  青木 貴弘(早大)

広報
市來浄與
(名古屋大)

予算獲得
今井 裕
(鹿児島大)

国際SKA
科学検討班
赤堀, 市來
今井, 高橋
竹内, 平下
井上進
(MPIf)

日本語版サイエンスブックの作成

- SKA-JPとして何をやるか？
- 2014年度中に完成 → SKA-JP WS2015で議論
- 執筆分野

  宇宙磁場（赤堀）、銀河進化（竹内）、宇宙論（高橋）、再電離（市來）、位置天文（今井）、パルサー（高橋）、星間物理（半田）、Transient（青木）
- 構成
  - イントロダクション：分野の現状（～10ページ）
  - 国際サイエンスのまとめ（～10ページ）
  - 日本が狙うサイエンス（～10ページ）

SKA-JP主催の研究会

SKA-JP
日本百万平米電波
干渉計計画協会

2008.11 SKA Workshop 2008 @三鷹

2010.11 SKA Workshop 2010 @三鷹

2012.06 SKAサイエンス会議「宇宙磁場」@福岡

2013.02 SKAサイエンス会議「high-z」@京都

2013.06 国際研究会 EA SKA WS 2013@名古屋

2013.09 SKAサイエンス会議「宇宙磁場」@水沢

2013.12 宇電懇シンポ2013@三鷹

2014.11.13-14
日本SKAサイエンス会議
「宇宙磁場」2014（第3回）

2015.2-3？ SKA-JP WS 2015

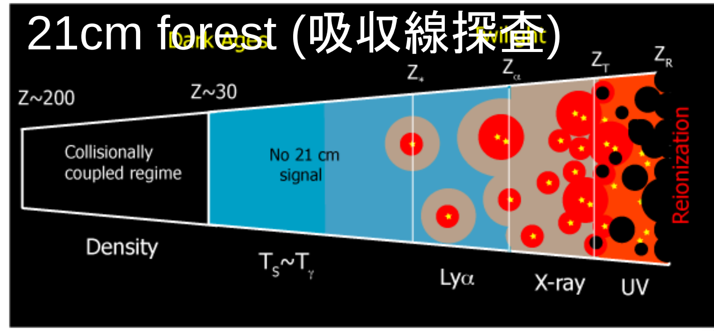
日本SKAサイエンス会議
「宇宙磁場」2013（第2回）

SKA-JPで進めているサイエンス・開発

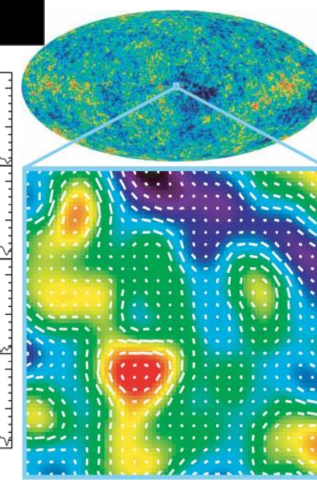
SKA-JP
日本百万平米電波
干渉計計画協会

サイエンス推進

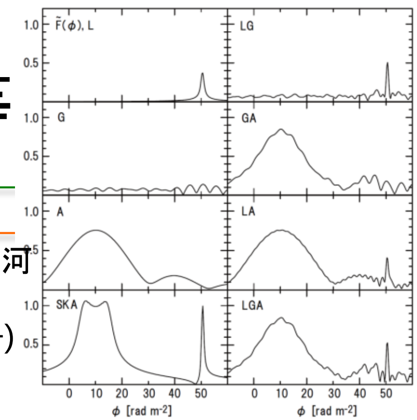
– High-z、宇宙論
– 宇宙磁場
– <u>位置天文</u>
– パルサー、AGN、星間物理 等



原始磁場の生成
Takahashi,Ichiki+



偏波解析ソフトによる銀河間磁場測定(Akahori, Kumazaki, Takahashi+)

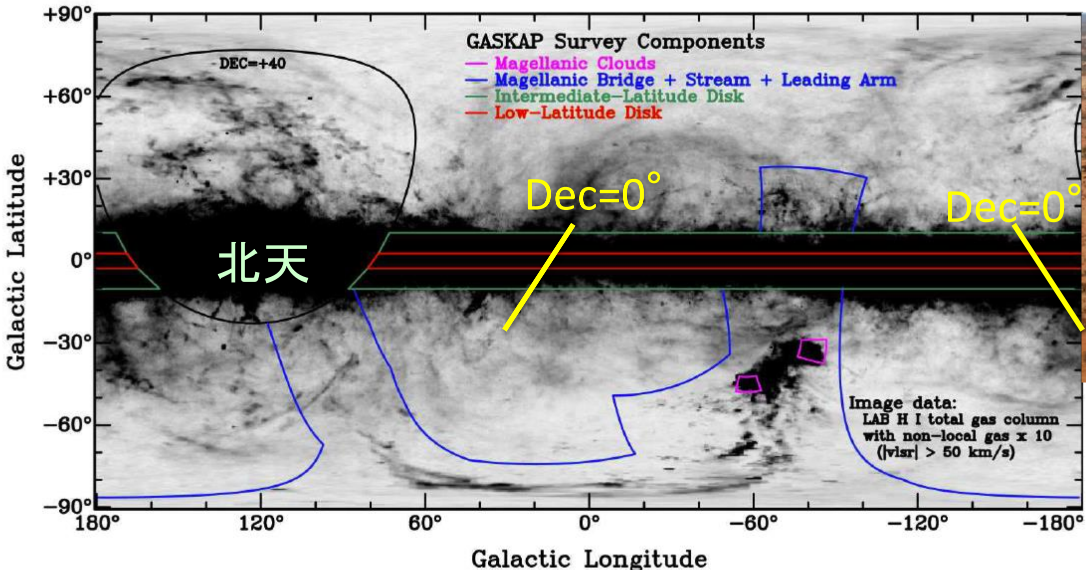


基礎開発推進

– 既存装置による
センチ波天文学
– デジタル信号処理
– ソフトウエア開発

電波天文専用FPGAボード

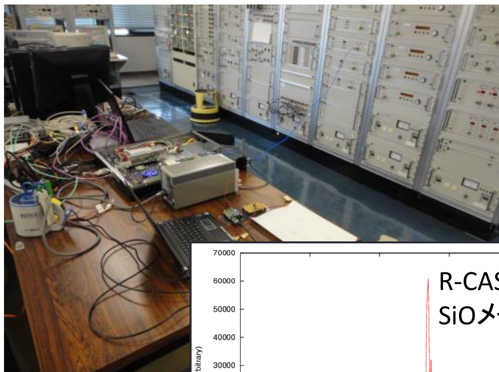
SKAによる位置天文

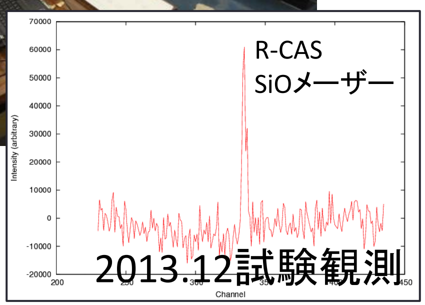


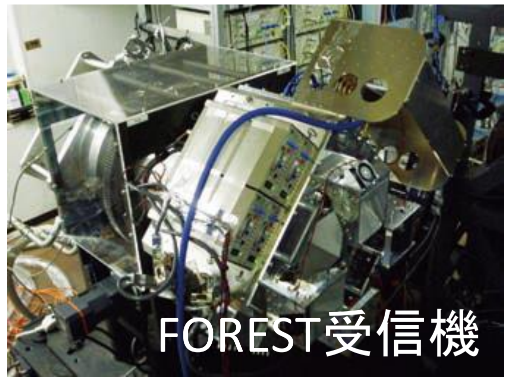
- OHメーザーによるAstrometryの検討→see Imai-san & Gabor's poster
- メタノールメーザー(6.7GHz)も周波数範囲内→現在のVERAの延長
- 南天Astrometry

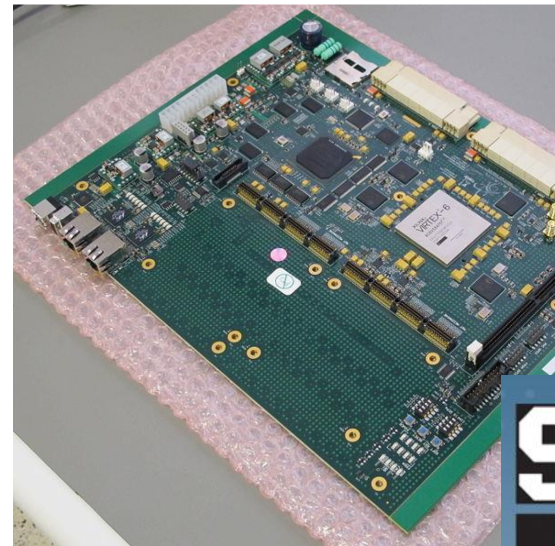
ROACHボード（FPGA）による デジタル信号処理

SKA-JP
日本百万平米電波干渉計計画協会









FOREST用受信機

4ビーム・2偏波・2SB(USB・LSB 8GHz）

→全帯域幅4x2x2×8=128GHz

現在 帯域32GHz→ROACHボードによる帯域拡大

SKA AFRICA
SQUARE KILOMETRE ARRAY

MeerKATで採用

まとめ

- SKAはOrigin, Fundamental force, Transientといった天文学上重要な課題を解明する次世代電波プロジェクトとして、オーストラリア、南アフリカに建設
- 日本では有志によるSKA-JPが中心となり宇宙論/high-z、宇宙磁場、位置天文、デジタル信号処理等を推進
- SKAの最大基線長はVLBIと同等、VERAと共通する周波数帯、VERAではカバー出来ない南天をカバーできることを考え、VERAの将来計画として重要
- 宇電懇からVLBIコミュニティの将来計画としても議論して欲しいとの声