コメント：
EISCATの最新状況とSuperDARNとの連携について

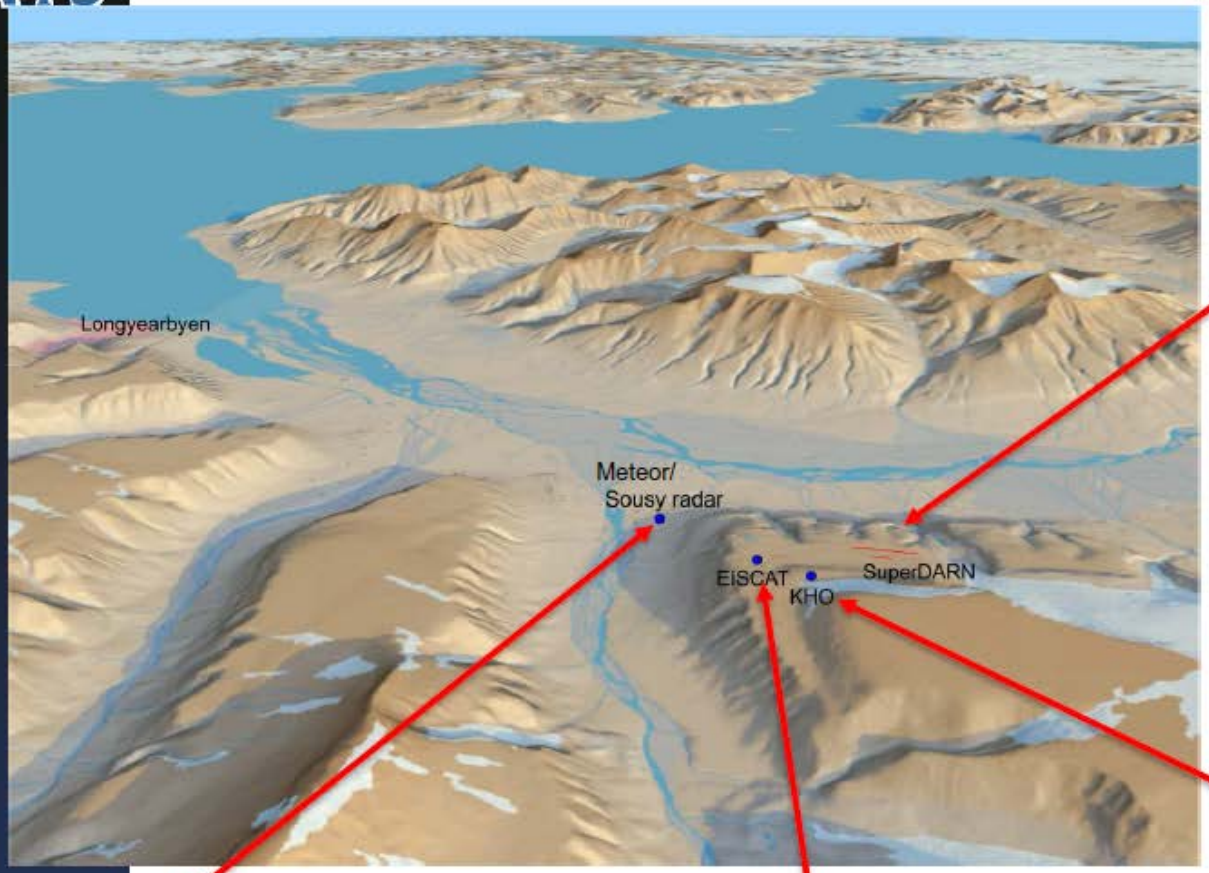
国立極地研究所 国際北極環境研究センター
宮岡　宏

Photo: EISCAT Svalbard Radar

Major infrastructure for research on the upper atmosphere - Longyearbyen

UNIS

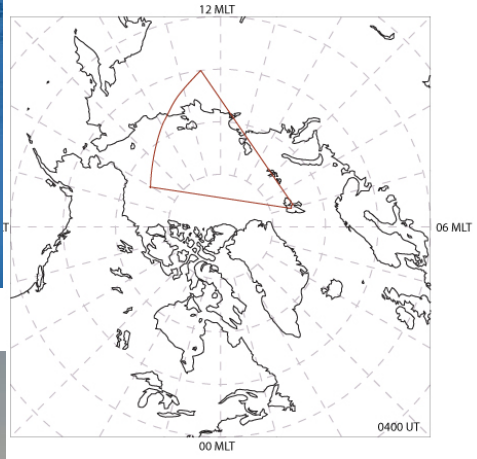
BIRKELAND CENTRE FOR SPACE SCIENCE

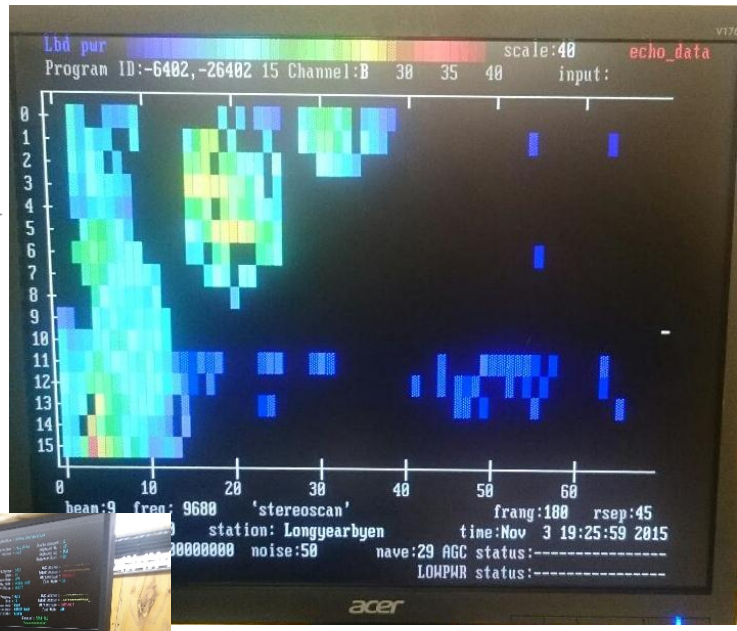


Courtesy of Dag Lorentzen, 2016

Svalbard SuperDARN radar (SvalDARN)

- Industrial cooperation (ConocoPhillips and Lundin)
- Radar construction fall 2015.
- First light – 3rd November 2015.
- Backscatter received!
- Now in commissioning phase

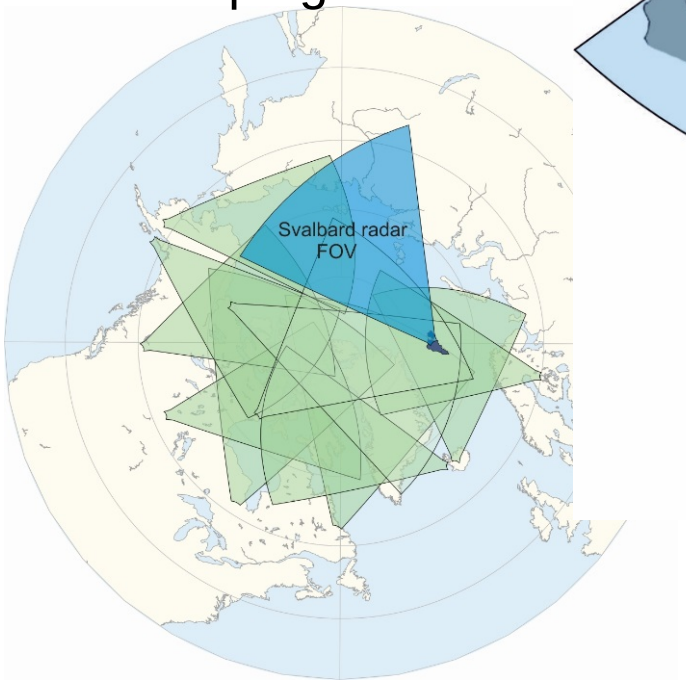


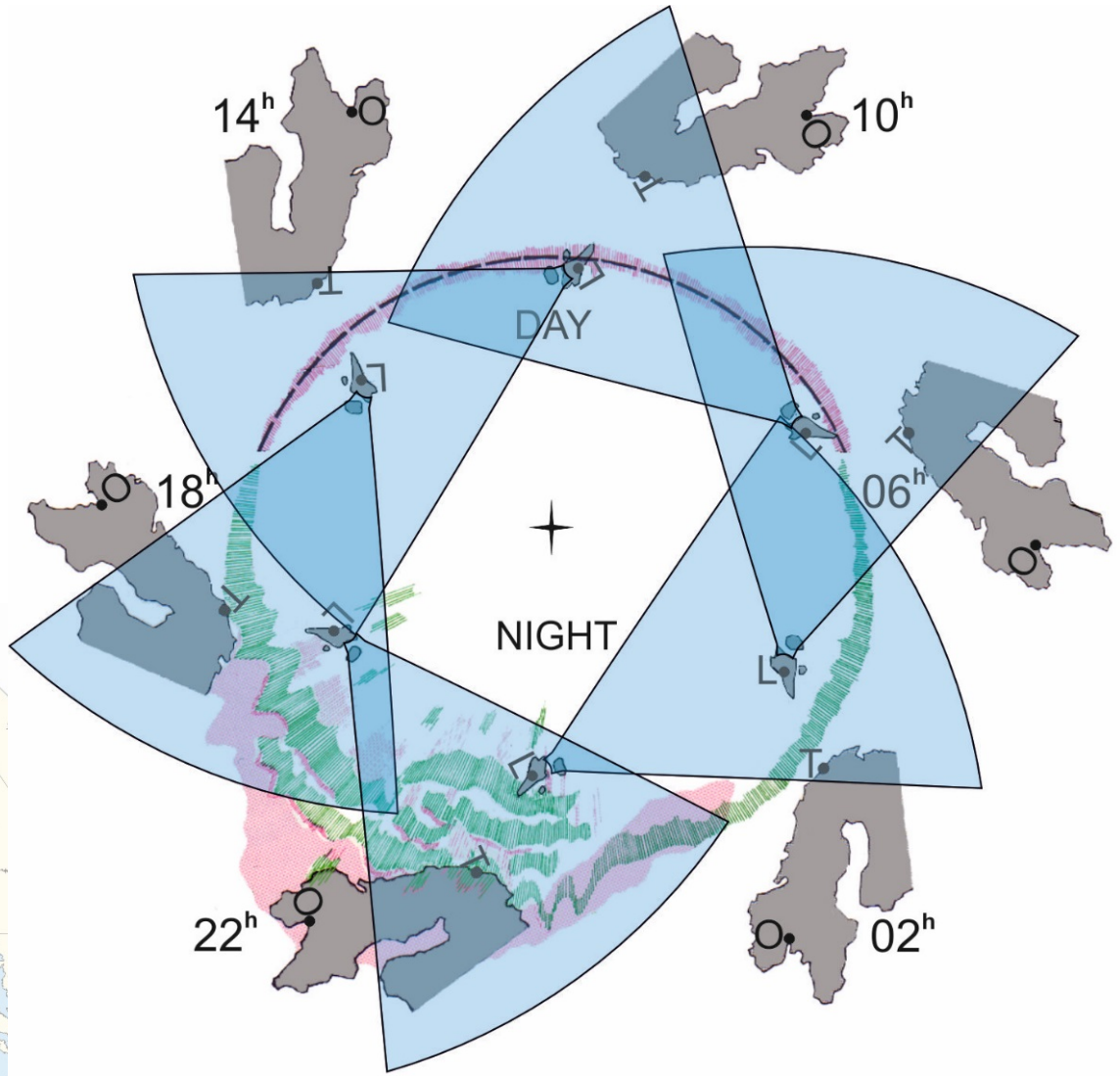


Courtesy of Dag Lorentzen, 2016

Svalbard SuperDARN FOV in relation to the auroral oval

- The radar will give an advanced real time warning of the ionospheric conditions ahead as Svalbard rotates beneath the auroral oval.
- Important for e.g. sounding rocket and other campaigns.





Courtesy of Dag Lorentzen, 2016

Space Plasma Exploration by Active Radar (SPEAR)

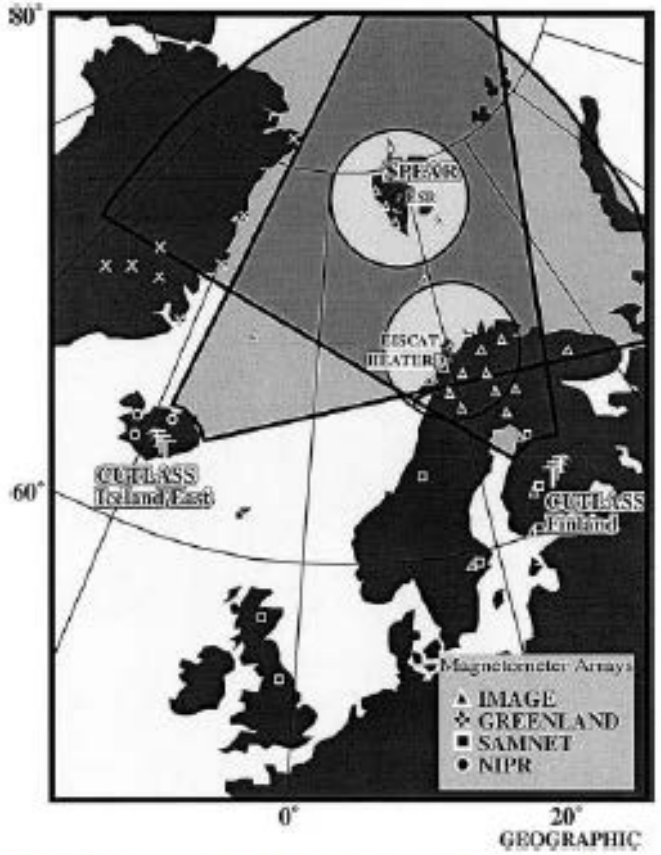
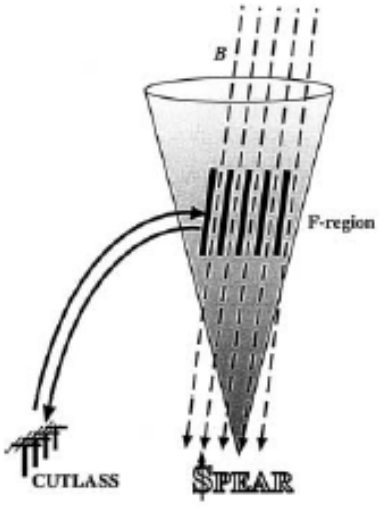
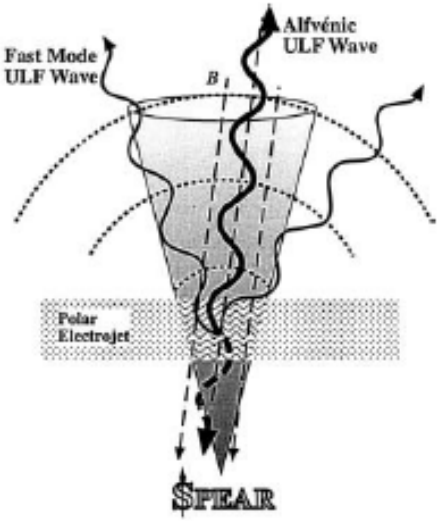


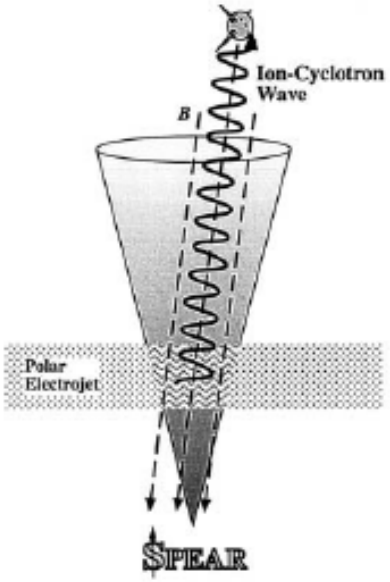
Fig. 1. An illustration of the location of Svalbard and SPEAR with respect to the CUTLASS fields of view and nearby magnetometer networks

Wright et al., 2000

UNIS took over the facility since 2008.







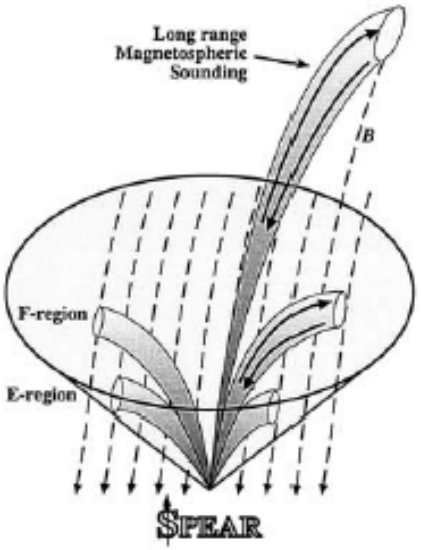
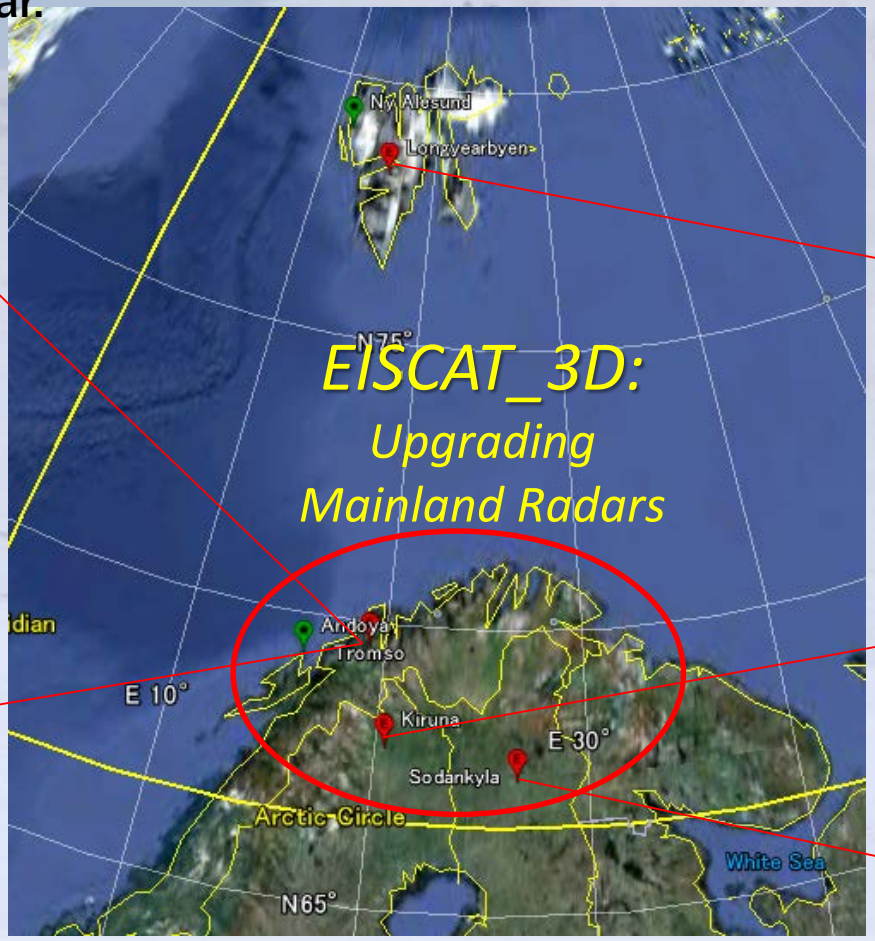


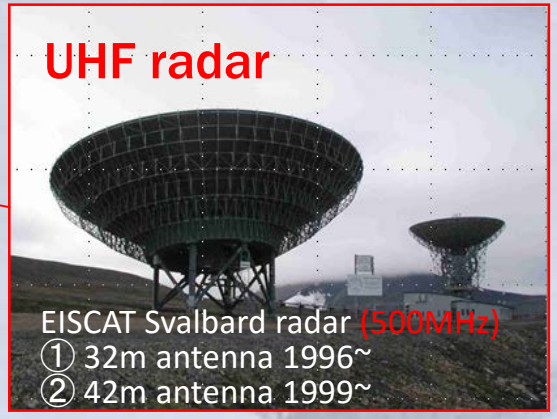
Fig. 2. Schematics representing a the generation of artificial field aligned irregularities by SPEAR utilising its high power transmitters and b the excitation of Alfvénic (resonant) ULF waves, which form a standing mode along magnetic field lines, and fast-mode ULF (non-resonant) waves

Fig. 4. a Artificial modification of the polar electrojet at low frequencies will enable the injection of field guided ion-cyclotron waves in conjunction with satellite overpasses; b SPEAR operating in "all-sky" HF radar mode; when the operation frequency becomes higher than the local ionospheric critical frequency (f_0F2) long range magnetospheric sounding is possible

European Incoherent Scatter (EISCAT) radar

- **EISCAT: International research organization founded in 1975 to undertake fundamental research on atmospheric and geospace science with powerful Incoherent Scatter radars in northern Fenno-Scandinavia and Svalbard.**
- **Japan: affiliated in 1996 as the first associate member outside Europe with funding contribution to the 2nd Svalbard radar.**





EISCAT Mainland Radars

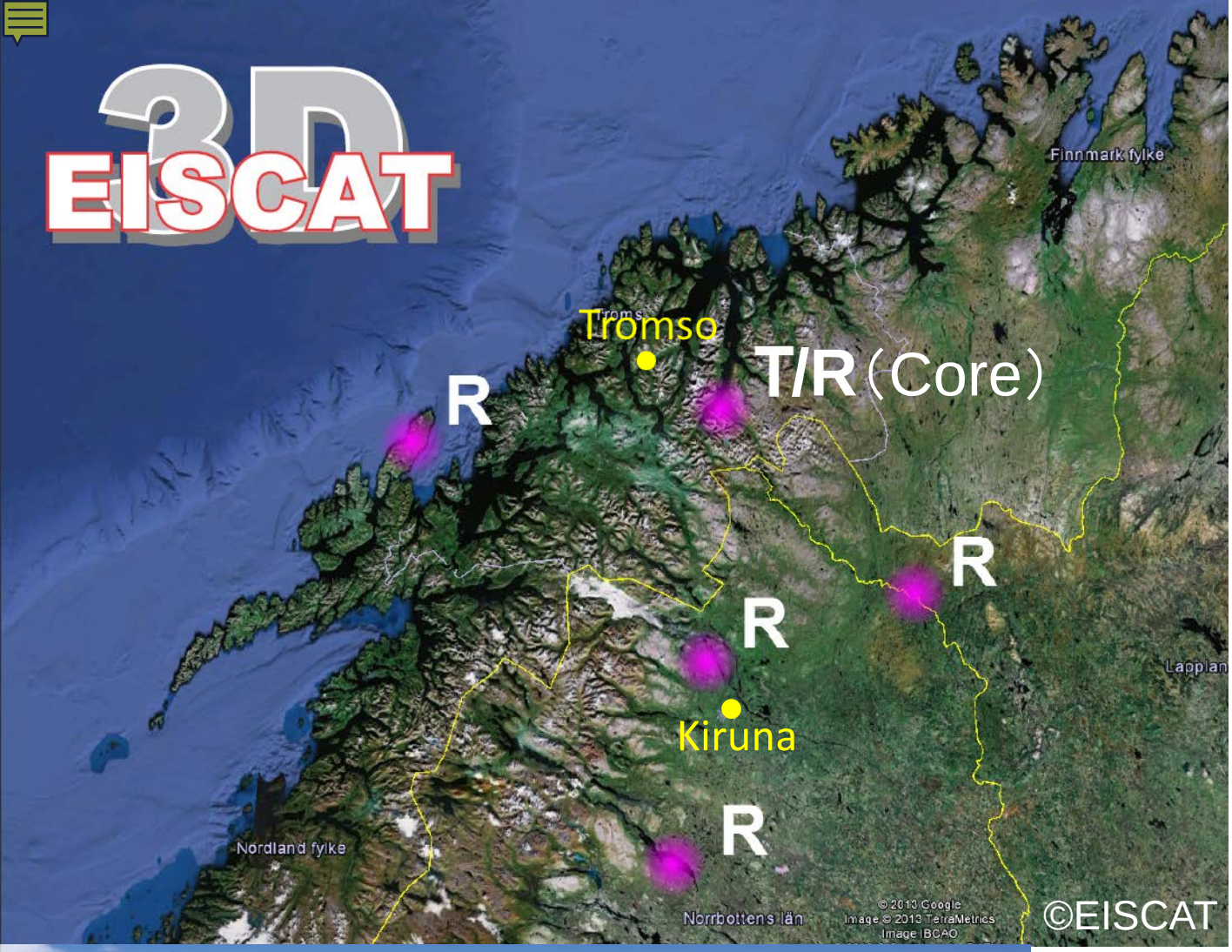
Tromsø, Norway : Core Site

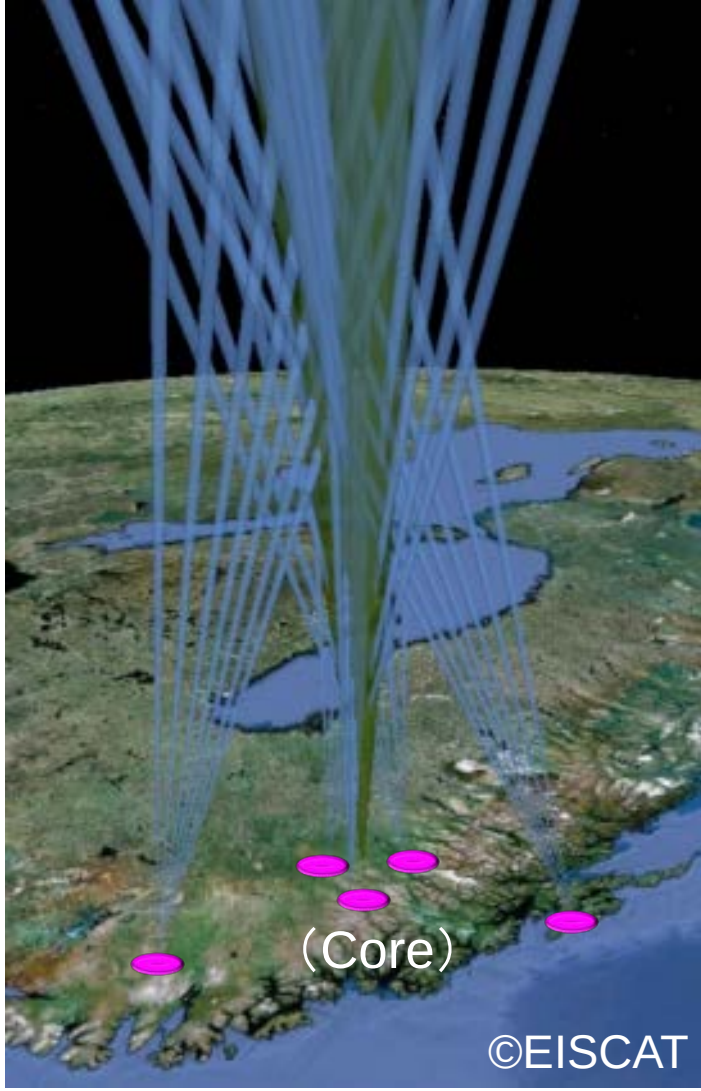
Tx/Rx: 930MHz, 1.7MW

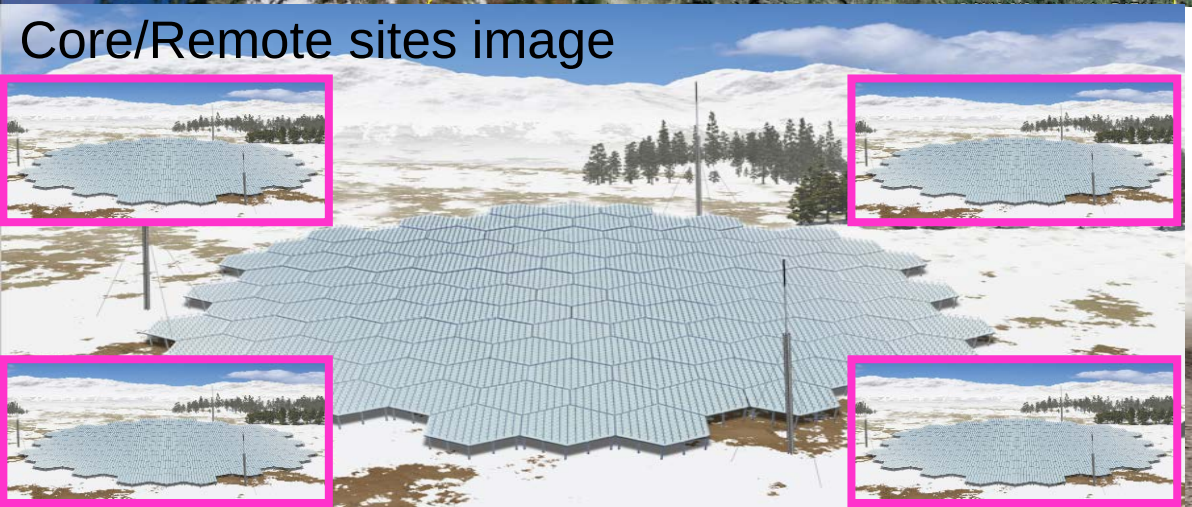
Tx/Rx: 224MHz, 1.7MW

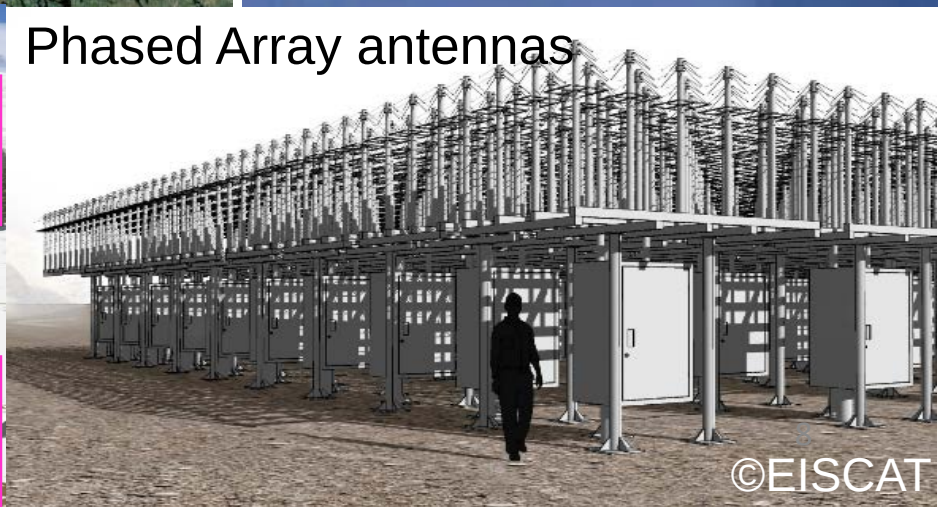
Rx: 930MHz’ 224MHz

Rx: 930MHz’ 224MHz


3D
EISCAT
Finnmark fylke
Tromso
T/R（Core）
R
R
R
R
Lapplan
Kiruna
Nordland fylke
Norrbotten s län
© 2013 Google
Image © 2013 TerraMetrics
Image IBCAO
©EISCAT

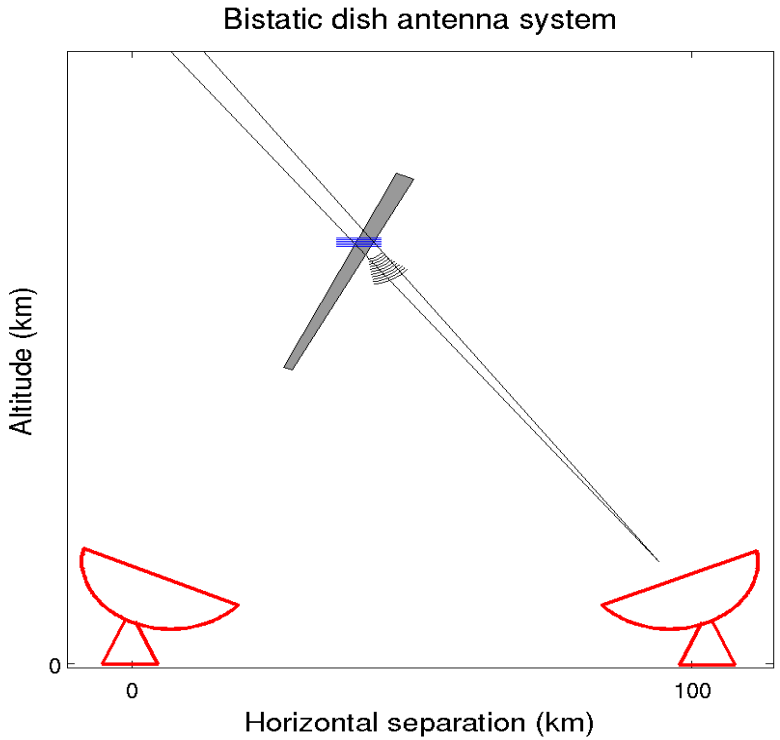

（Core）
©EISCAT

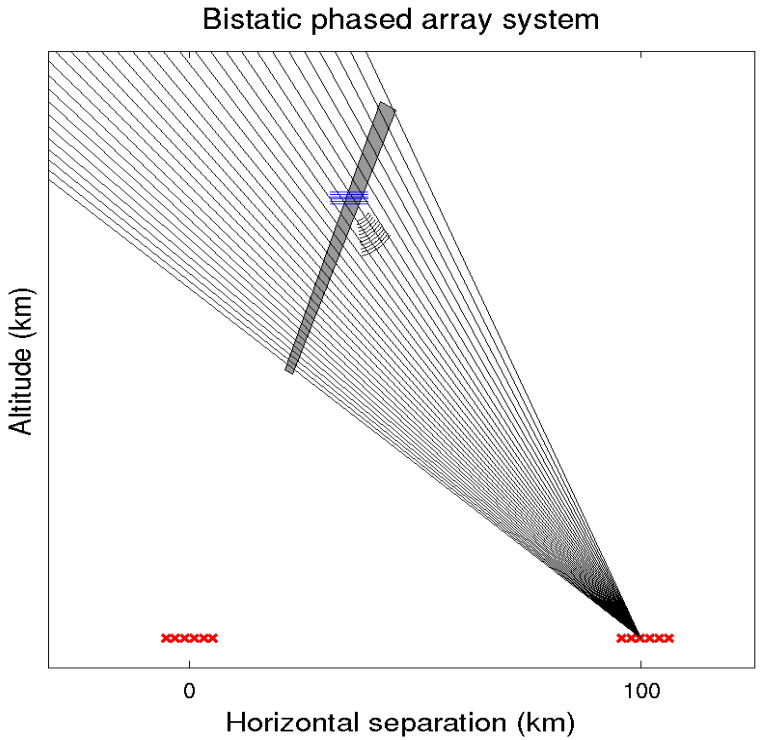

Core/Remote sites image


Phased Array antennas
©EISCAT

EISCAT Scientific Association

EISCAT_3D :
– The World First Multi-static Phased Array





The vector measurement by the existing system with dish antennas is possible only in these points, but the coverage will expand to these volume instantaneously with phased array receiving antenna.

EISCAT_3D整備計画

	2015 (H27)	2016 (H28)	2017 (H29)	2018 (H30)	2019 (H31)	2020 (H32)	2021 (H33)	2022 (H34)	2023 (H35)	2024 (H36)
整備計画フェーズ	第1段階							第2段階	第3段階	第4段階
	＜技術実証＞期間			＜本格整備＞期間						
技術実証システム（ﾄﾛﾑｿ）										
主局（ｼｰﾎﾞﾄﾝ）整備										
受信局（ﾍﾞﾙｸﾞﾌｫｰｽ）整備										
受信局（ｶﾚｽﾊﾞﾝﾄ）整備										
オペレーションセンター整備										
送信出力倍増（→10MW）										
受信局（ｱﾝﾄﾞｰﾔ）整備										
受信局（ﾖｯｸﾓｯｸ）整備										

＜日本の貢献内容＞

・送信機開発
・技術実証用送信機製造200台
・電源ユニット1式
・装置コンテナ開発・製造1基
・現地設置調整（H29）

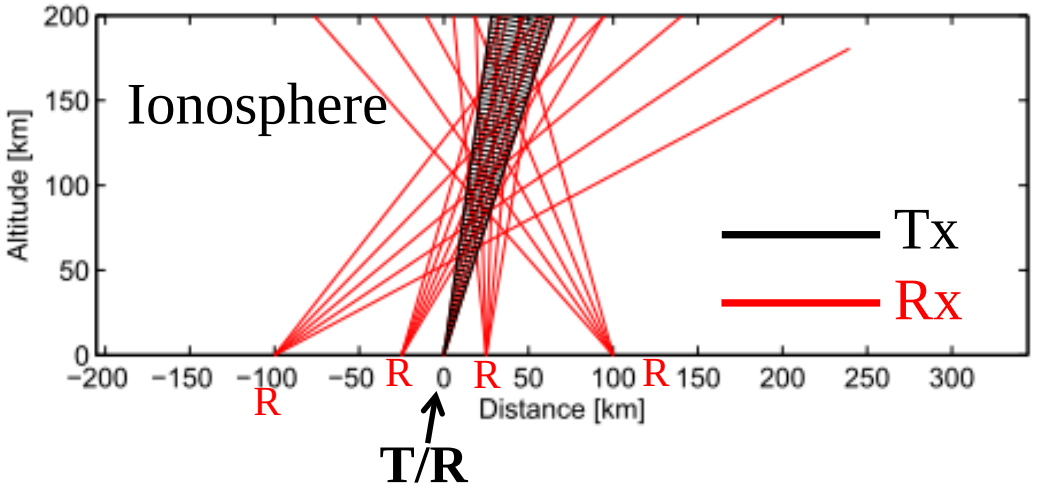
・送信機および装置コンテナ製造年次計画
（計10000台、110基）
H30　1000台、 11基
H31　3000台、 33基
H32　6000台、 66基
・試験システム（1式、H30）
・現地設置調整（H30-32）

＜計画全体の建設経費＞

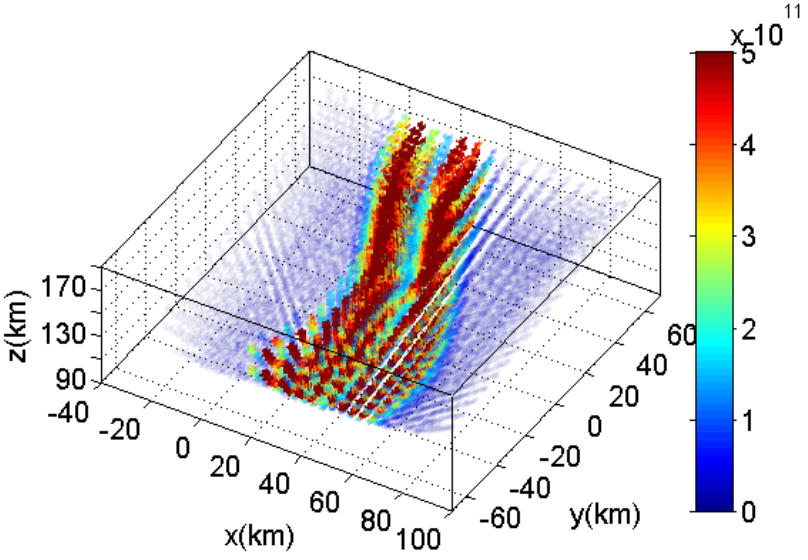
第１段階	10，940百万円
第２段階	2，717百万円
第３段階	2，242百万円
第４段階	2，245百万円
合計	18，144百万円

Time Resolution Upgrade

Plasma parameter @Height	EISCAT	EISCAT_3D	Upgrade Ratio
Ne,Ti,&Te@110km	5 s	0.05 s	100
Ne,Ti,&Te@300km	20 s	0.3 s	67
Vector Vi@110km	500 s	10 s	50
Vector Vi@300km	100 s	1 s	100



EISCAT_3D observation



3D density distribution by EISCAT_3D radar

Current Status on EISCAT_3D Project

1. Site Survey ongoing

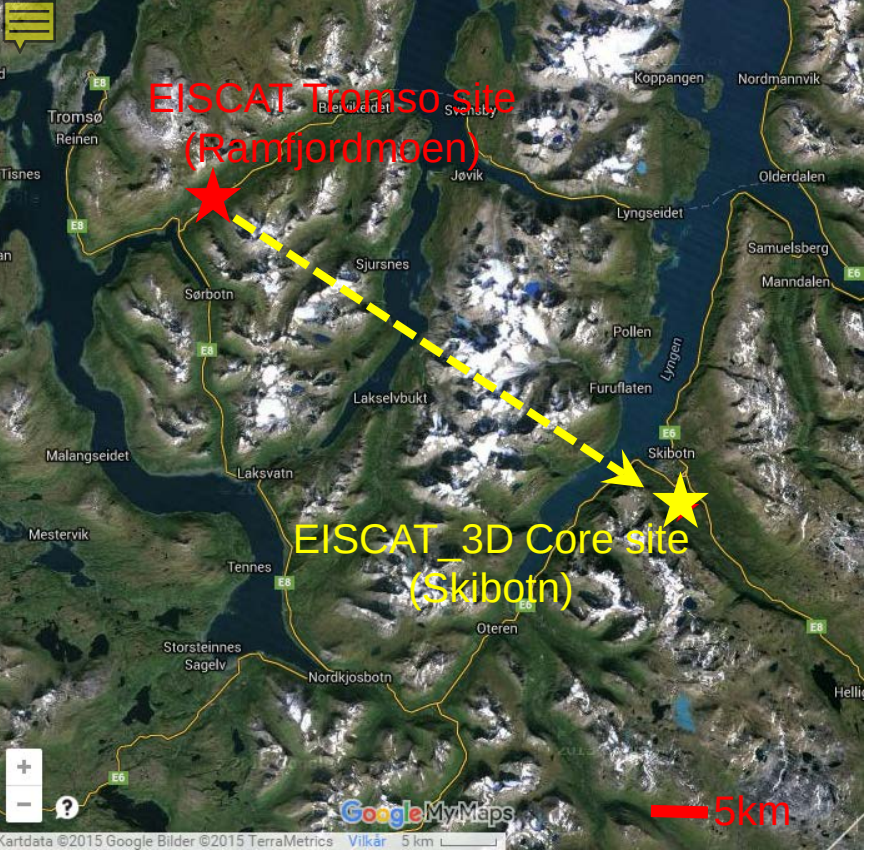
- Core: Skibotn (Norway) supported by UiT
- Remote: (1)Bergfors > Kaiseniemi (Sweden), (2)Karesuvanto (Finland)

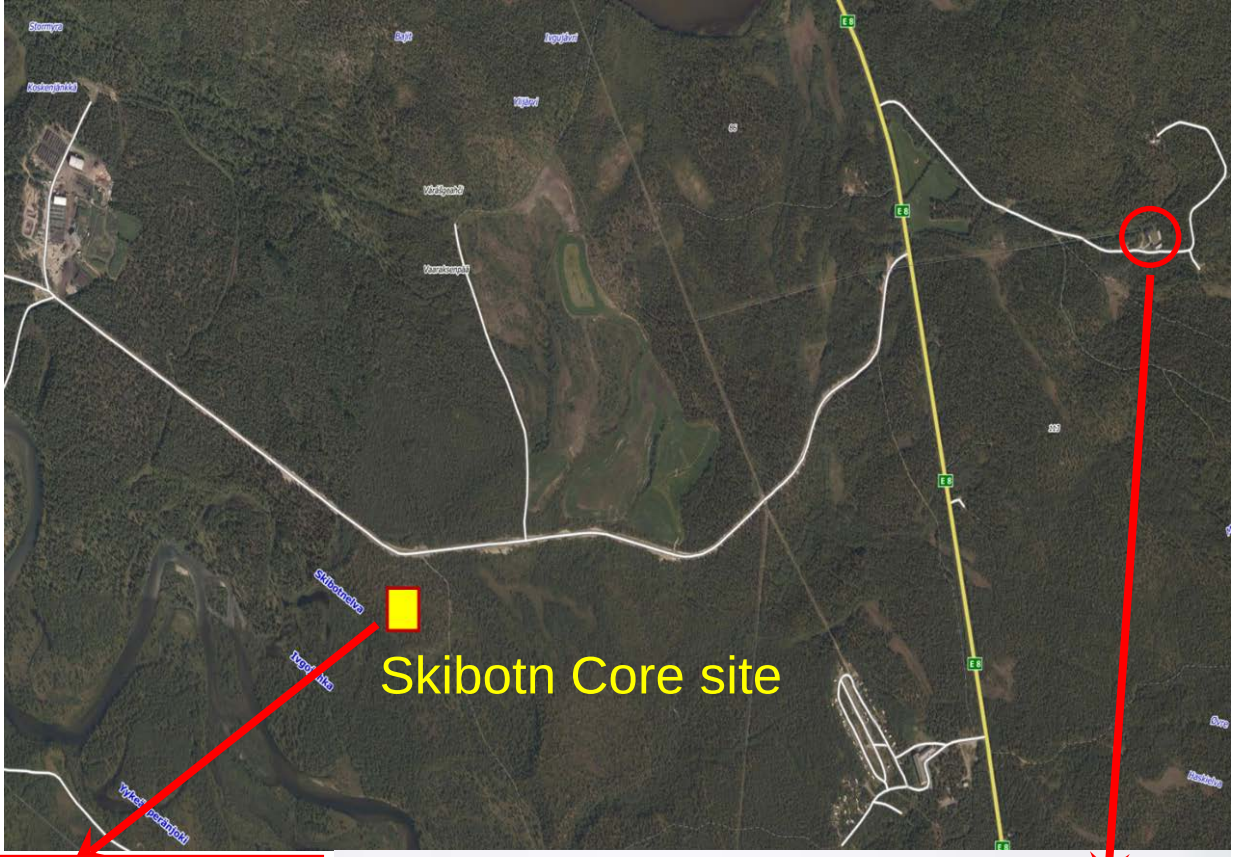
2. EISCAT3D_PfP (2015-2017: EU-funded) started

- Kick-off meeting 22-23 Oct 2015
- Project staff: Dr. Sathyaveer Prasad, Chief Engineer
  Project administrator, Electrical engineer, Software engineer
- Manufacturing consultant: Consoden AB, Uppsala, Sweden
- Engineering assessment of sub-array beamformer finalizes > Identify vendors
- Test sub-array system at Tromso site: Integration will start in Sept. 2016

3. Funding Status

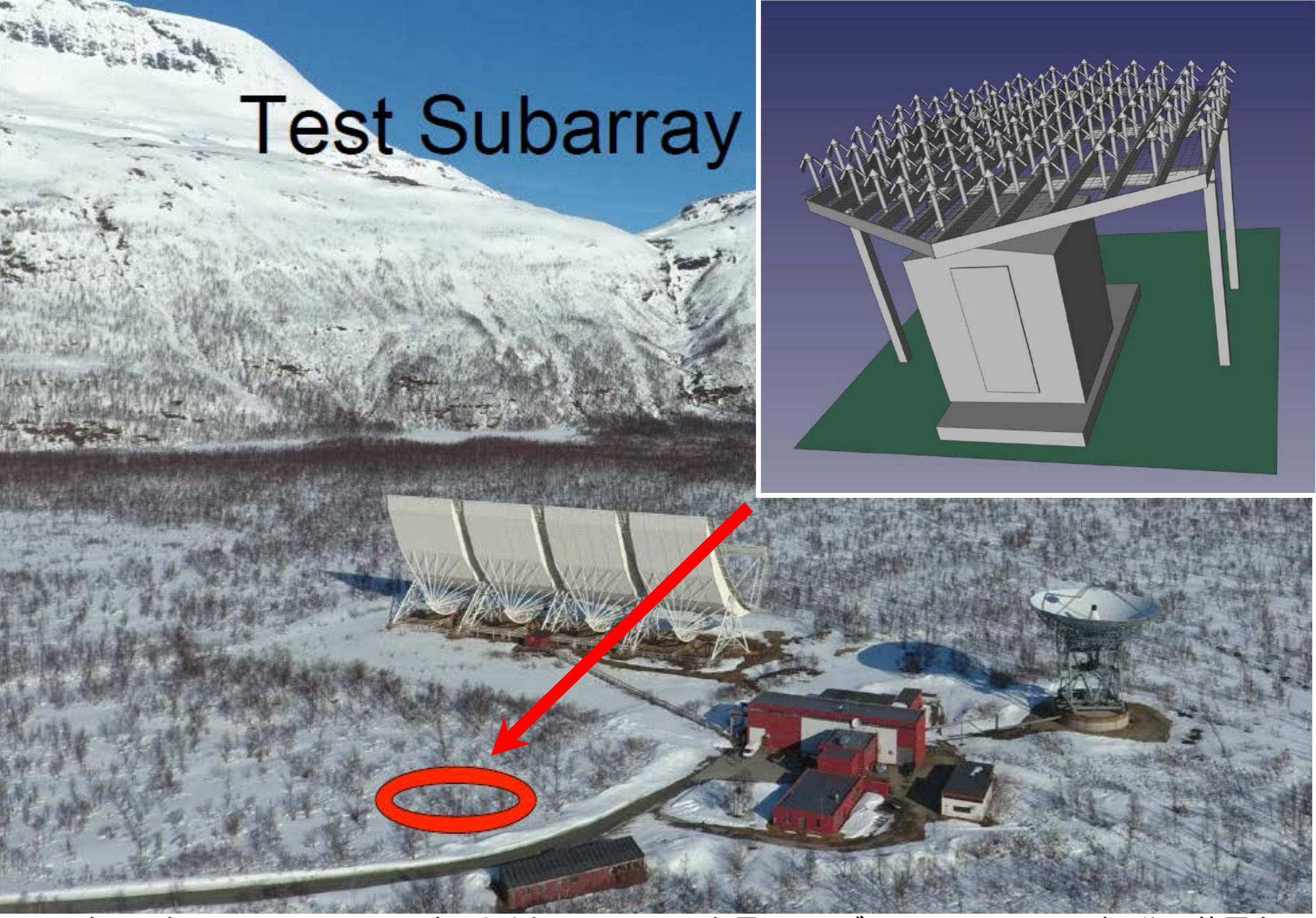
- **EC:** 3.1 MEuro for EISCAT3D_PfP
- **Finland:** 12.8MEuro allocated by Finnish Academy
- **Norway:** 228MNOK allocated by RCN conditionally by the end of 2016
- **Sweden:** 120MSEK allocated by VR conditionally
- **UK:** Identified on the Research Council capital roadmap
- **China:** Proposing for the next 5 year plan
- **Japan:** Proposing for 2017 budget, Development study is partly funded for 2016
  "Letter of Request" from Director-Generals of Nordic Research Councils


EISCAT Tromso site
(Ramfjordmoen)
EISCAT_3D Core site
(Skibotn)
Tromsø
Reinen
Koppangen
Nordmannvik
Jøvik
Olderdalen
Lyngseidet
Samuelsberg
Manndalen
Sjursnes
Sørbotn
Pollen
Lyngen
Furuflaten
Lakselvbukt
Skibotn
Malangseidet
Laksvatn
Mestervik
Tennes
Oteren
Storsteinnes
Sagelv
Nordkjosbotn
5km
Google MyMaps
Kartdata ©2015 Google Bilder ©2015 TerraMetrics Vilkår 5 km


Skibotn Core site


Skibotn Core site


UiT Fieldstation



2017年8月までに、EISCATトロムソ観測所内にEISCAT_3D主局の１サブアレイ（アンテナ91本）分の装置を建設し、本設備製造に向けた技術実証試験を行う。

Investments in Critical Capabilities for

Geospace Science

2016 to 2025

A Portfolio Review of the Geospace Section

of the Division of Atmospheric and Geospace Science

Requested by the
Advisory Committee for Geosciences
National Science Foundation

Report submitted to

George M. Hornberger | Chair, Advisory Committee for Geosciences
Roger Wakimoto | Assistant Director for the Directorate for Geosciences

by the Portfolio Review Committee

Daniel N. Baker, Jorge Chau, Christina Cohen, Sarah Gibson, Joseph Huba, Mona Kessel, Delores Knipp, Louis Lanzerotti, William Lotko (*Chair*), Patricia Reiff, Alan Rodger, Joshua Semeter (*GEO/Advisory Committee Liaison*), Howard Singer

on February 5, 2016 (corrected April 8, 2016)

Recommendation 7.2. The ISR facility at Sondrestrom should be terminated, and science performed at Sondrestrom should be covered by participation, after peer review, in EISCAT and EISCAT-Svalbard for cusp studies.

Sondrestromレーダーの運用を終了し、EISCATレーダー利用に切り替える

Recommendation 7.4. The GS should investigate costs and contractual arrangements for U.S. investigators' access to the existing EISCAT facilities and, more importantly, to the planned EISCAT 3-D facility (See section 7.4.2 for further details).

現行EISCATレーダー利用とともに、EISCAT_3Dレーダー利用条件について検討する

Recommendation 7.23. The GS should solicit proposals from the US GS community to form a US EISCAT consortium that would be funded by a block grant from NSF, initially to join EISCAT as Affiliate and eventually as an Associate.[24] The initial Affiliate status would allow the consortium to gain experience with EISCAT before making a five-year commitment as an Associate and to develop a deeper understanding of EISCAT system capabilities when EISCAT-3D becomes operational. Upon attaining Associate status, the consortium should be tasked with (1) transfer of the EISCAT annual membership fee to EISCAT-3D and (2) development and administration of a proposal and panel review process for the selection of US EISCAT users. The consortium should develop procedures for cost-effective grant administration that minimizes the encumbered overhead expenses of multiple member institutions.

NSF研究資金によりEISCAT科学協会に加盟する。準加盟機関として加入し、EISCAT_3D運用開始後は加盟機関への移行を検討する。

EISCAT-3D is the new world-leading ISR under development. It will give many significant advantages over the current radars, including:

- Phased-array technologies for rapid beam steering (volumetric imaging)
- Multiple sites for 3D vector measurements of the ionosphere plasma
- Sufficient sensitivity for sub-second measurements of auroral phenomena
- Interferometric capabilities for 100m spatial-scale measurements

Thus EISCAT-3D would provide an unparalleled range of new science opportunities for the US geospace science community, particularly for measurements requiring small spatial and fast temporal scales. Observations of cross-scale coupling processes from the micro- to the macro-scales and *vice versa* are essential for obtaining deeper understanding of how the geospace system operates.

EISCAT_3Dは、他に類のない高性能レーダーとして米国の研究コミュニティにも全く新しい科学の機会を提供する。

Table 9.1 Recommended Portfolio in 2015 Dollars (x $1M)

Core Grants Program (Priority 1)		2015	2020	2025	%
AER (1)	Core†	6.14	14.4	14.4	Core
MAG (1)		3.88			
STR (1)		4.36			
Core Grant Total		**14.38**	**14.4**	**14.4**	**33%**

Strategic Grants Program (Priorities 1, 2, 3)			Change from 2015 to 2020		
CEDAR (1)	Targeted†	3.09	8.7	6.7	Strategic
GEM (1)		2.63			
SHINE (1)		2.98			
Space Weather (1)	IGS	1.50	1.5	5.0	
Grand Challenge (2)			1.5		
CubeSat (3)		1.50	1.0	1.0	
FDSS (3)		0.60	0.6	0.6	
Strategic Grants Total		**12.30**	**13.3**	**13.3**	**30%**

Class 1/2 Facilities (All priority 1)		2015[a]	2020	2025[b,c]	Facilities
Arecibo[d]	Class 1‡	4.10	1.1	8.4	
PFISR[e]		1.50	1.5		
RISR-N[e]		1.50	1.5		
Sondrestrom		2.50	0.0		
Millstone Hill[f]		2.10	1.9		
Jicamarca		1.35	1.4		
SuperDARN	Class 2‡	0.96	1.0	4.8	
AMPERE		1.02	1.0		
SuperMag		0.15	0.2		
CCMC		0.50	0.5		
CRRL[g]	not a facility	1.20	0.0		
Class 1/2 Facilities Subtotal		***16.88***	***10.1***	***13.2***	

New Facilities Programs (Priorities 1, 2)					
EISCAT (1)	Class 1‡		1.0	b	
Data Systems (1)	Class 2‡		0.5	c	
DASI (1)			1.6		
Innovation & Vitality (2)	Upgrades: Instruments, Facilities		2.4	2.7	
	Upgrades: Community Models		0.3		
New Facilities Programs Subtotal			5.8	2.7	
Facilities Total		***16.88***	***15.9***	***15.9***	**36%**

Midscale Projects Line[h] out of budget $1-6M/year

GS Reserve	**0.43**	**0.4**	**0.4**	**1%**
Grand Total *	**43.99**	**44.0**	**44.0**	**100%**

NOTES

Priorities: (1) Science Grants Programs; Space Weather; Facilities; EISCAT; Data Systems; DASI. (2) I&V; GC Projects. (3) CubeSats; FDSS

† 2020/25 budget split between core & targeted and between individual programs in core & targeted TBD by proposal pressure

‡ New Class 1/2 facilities may be developed via MRI, Midscale (if created) or MREFC awards; addition may require discontinuation of other facilities

[a] Budget value is 3- or 5-year average based on most recent award, except AO which is in the last year of a 5-year cooperative agreement

[b] EISCAT/EISCAT-3D membership becomes Class 1 facility by 2025

[c] New DASI/Data Systems projects become Class 2 facilities by 2025

[d] If AO use for GS research cannot be secured for $1.1M, redirect its $1.1M budget to the I&V Program

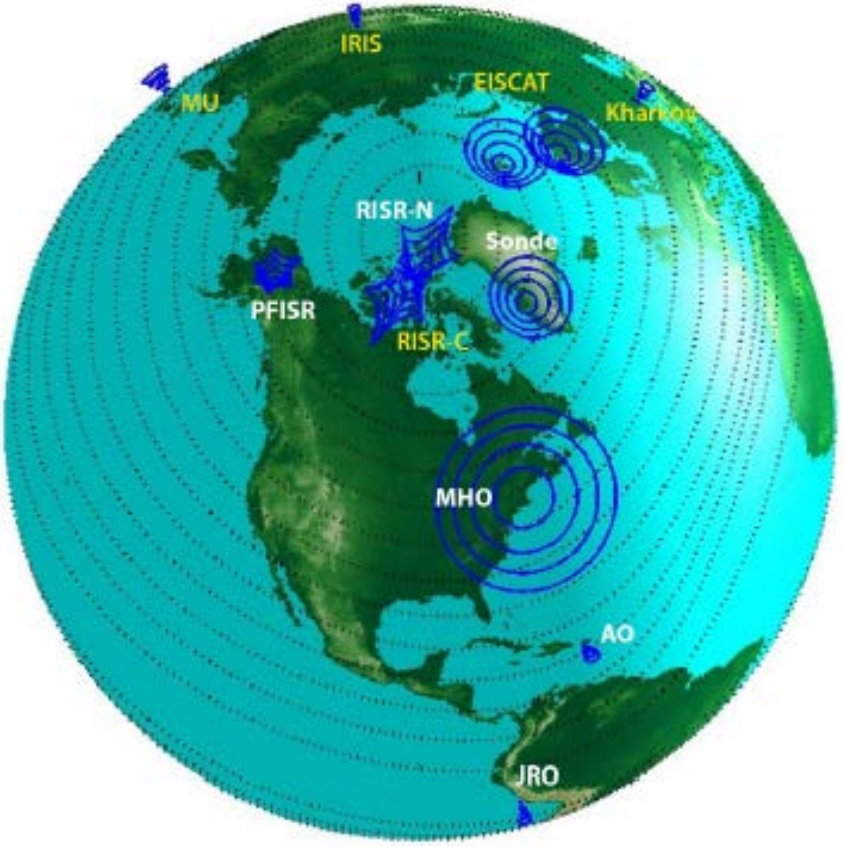
[e] PFISR+RISR-N budget is $3M; delineated 50/50 here

[f] New data systems line to absorb MH Madrigal budget by 2020

[g] CRRL is not currently operating as a facility (Sec. 7.2); it should seek future funding from core or targeted grants programs.

[h] To be funded only with additional future GS funding; if NSF divests from AO, its $1.1M budget should be added to the I&V Line, a portion of which could go to Midscale Projects

* Grand Total exceeds the actual FY 2015 budget of $43.56M because Class 1/2 facilities budgets are 3- and 5-year averages (see note a)



米国が運営するISレーダー施設