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University of Oslo

FYS3610 – Introduction

Lasse Clausen

Outline

- Technicalities
- Kristian Birkeland
- Sun-Earth connection, Northern lights
- Space weather effects on technological systems
- STAR development center
- Student opportunities

Technicalities

- Website
- List of participants
- Project work
  - Pick a date from the list
  - Groups of two
  - 10-15 pages
  - Due by 21 November 2013
- Exams

Overview over lectures

Week	Topic	Keywords	Curriculum	Lecturer
34	Introduction, plasma basics	Gyration, 1st order drifts, magnetic mirror, loss cone, Debye length, plasma frequency		LBNC
35	Magnetohydro-dynamics	Particle distribution function, Vlasow equation, MHD equations, magnetic reconnection		LBNC
36	The Sun	Internal structure, atmospheric layers, dynamics		LBNC
37	Solar wind	Properties, Parker model, Parker spiral , sectoring & current sheets, radial dependence		LBNC
38	Structure of the magnetosphere	Internal magnetic field, spherical harmonic expansion, dipole description, Chapman-Ferraro current, tail current		LBNC
39	Structure of the ionosphere	Ionization profile, D-, E-, F-layer,dynamics		LBNC
40	Structure of the atmosphere	Composition, thermal structure, vertical profiles of state parameters		LBNC
41	Midterm exam			
42	Ionospheric conductivity and currents	Pedersen & Hall conductivities & currents, collision frequencies and mobilities		LBNC
43	Open magnetosphere	Dungey cycle, IMF By dependence, corotation, convection		LBNC
44	MHD waves and space weather	Alfven & fast waves, space weather		LBNC, YJ
45	Substorms and aurora	ECPC, region 1/2 currents, generation of aurora, proton aurora, substorm phenomenology		JM
46	Instrumentation	Incoherent & coherent radars, magnetometers, all-sky imagers		JM
47	Reports, repetition			
48	Exam			

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Kristian Birkeland (1867-1917)

- The ”first auroral physicist”
- Professor at 31 years old
- Experiment + Theory = Innovation (60 patents)
- Fixation of Nitrogen – gave birth to Norsk Hydro/Yara - a world leading fertilizer company
- After three expeditions in 1902-1903 he concluded that northern lights are associated with currents floating along magnetic field lines – The Birkeland currents

The Terrella experiment (1901)

Terrella – a magnetized sphere placed in a vaccum camber

The auroral oval

Birkeland currents

Norway’s fortunate location

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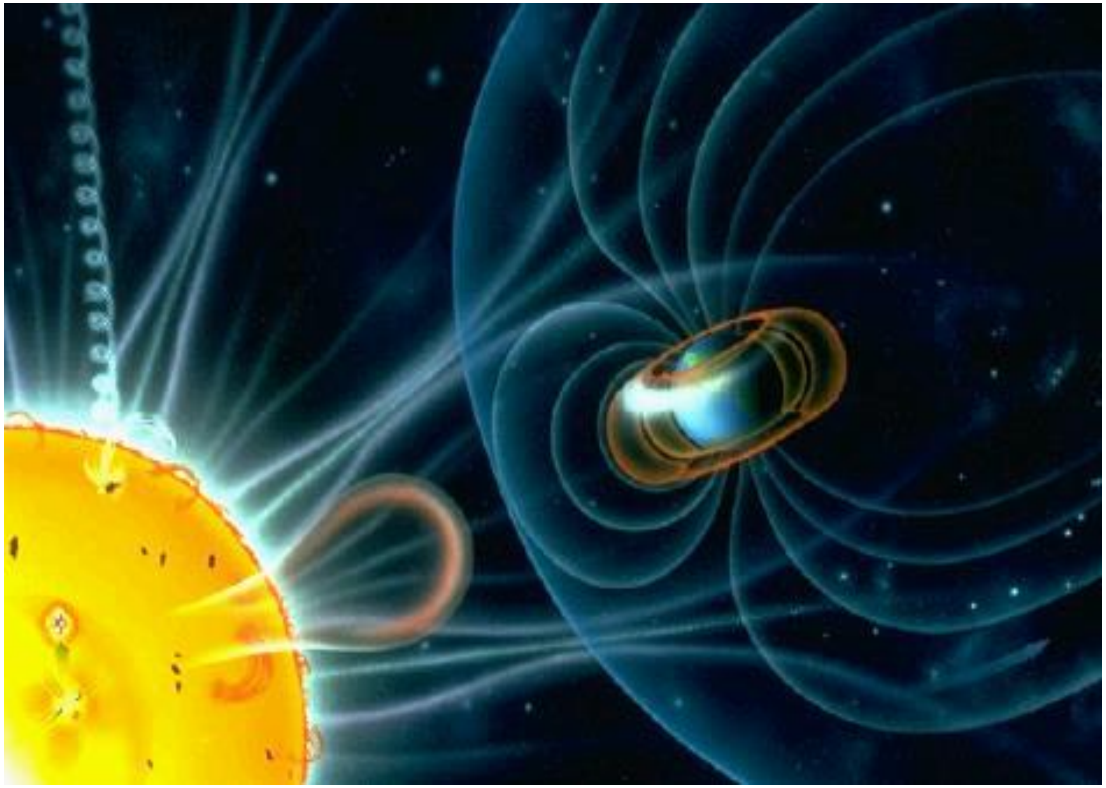
Space weather

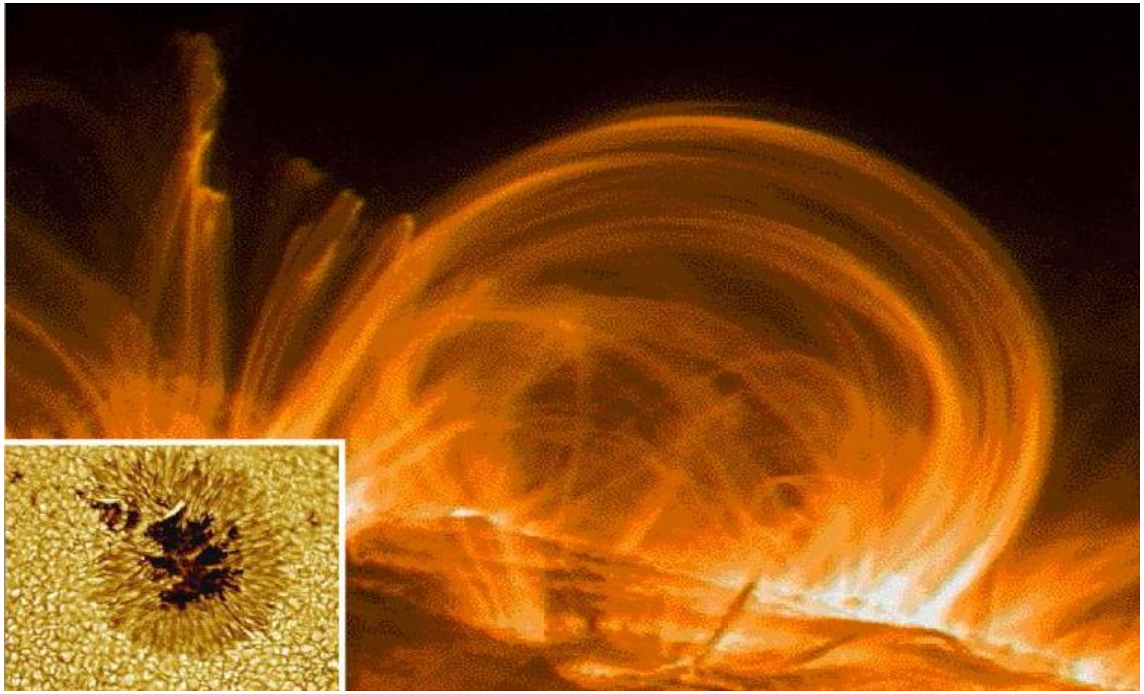
We live in the extended atmosphere of a variable star – the Sun

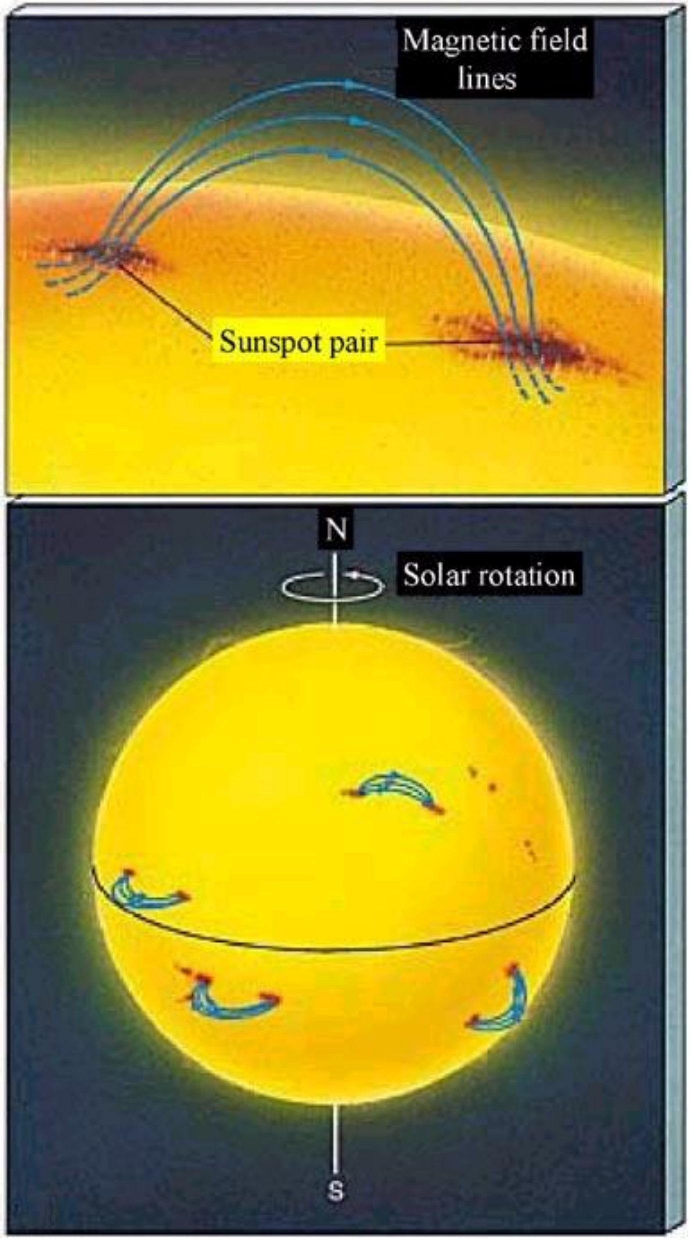
- Radiation
- Solar Wind
- Energetic Particles



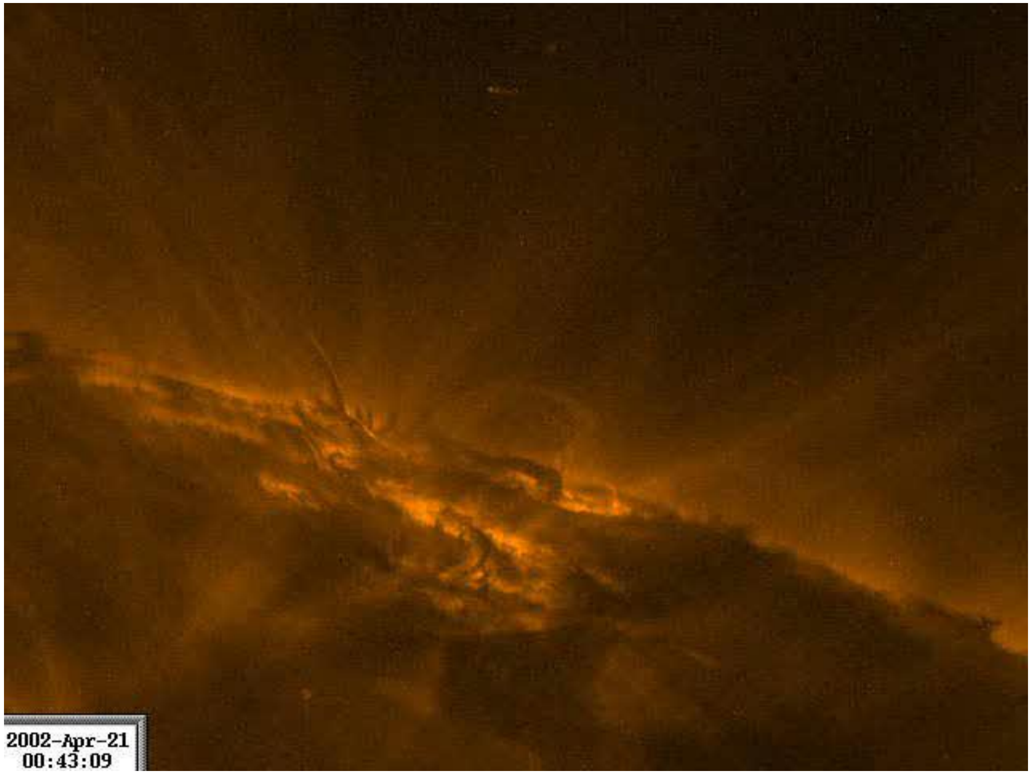
Dynamic Sun

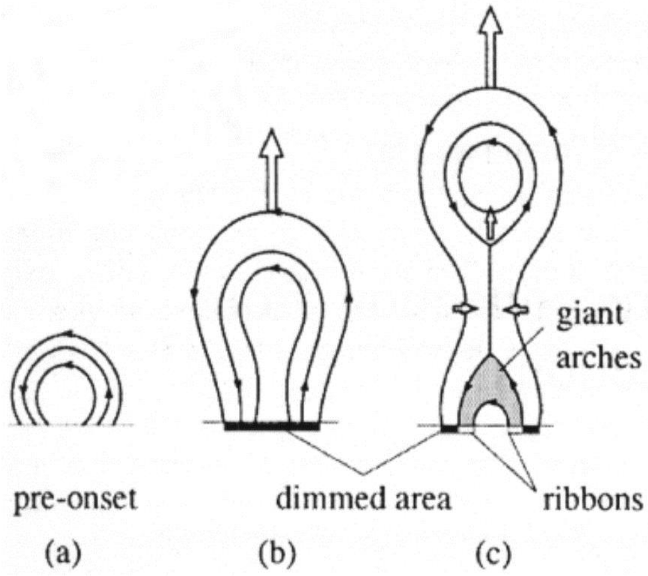
- The Sun does also have a magnetic field
- Sun spots occur in pairs connected by magnetic field lines



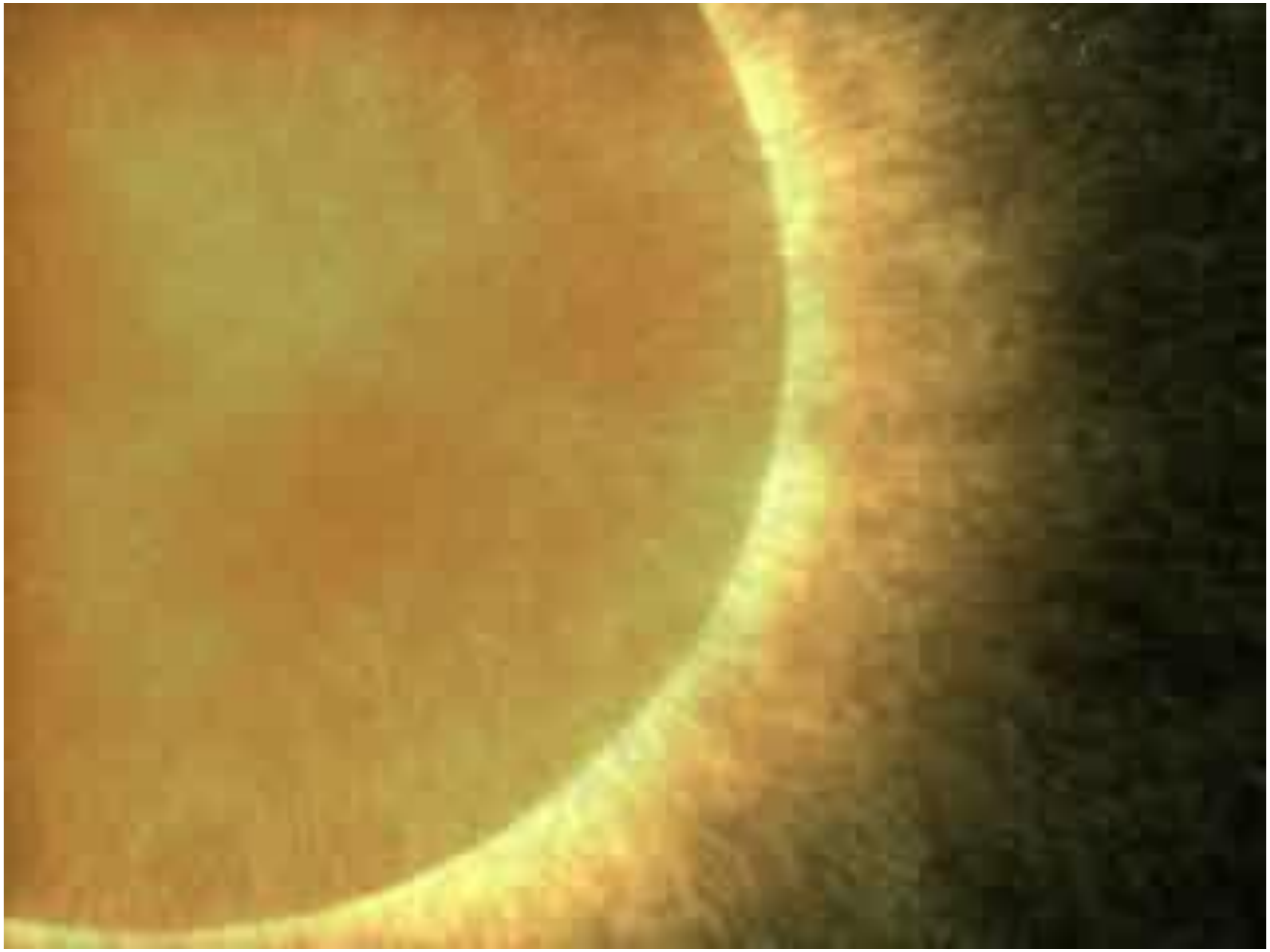


Protuberance

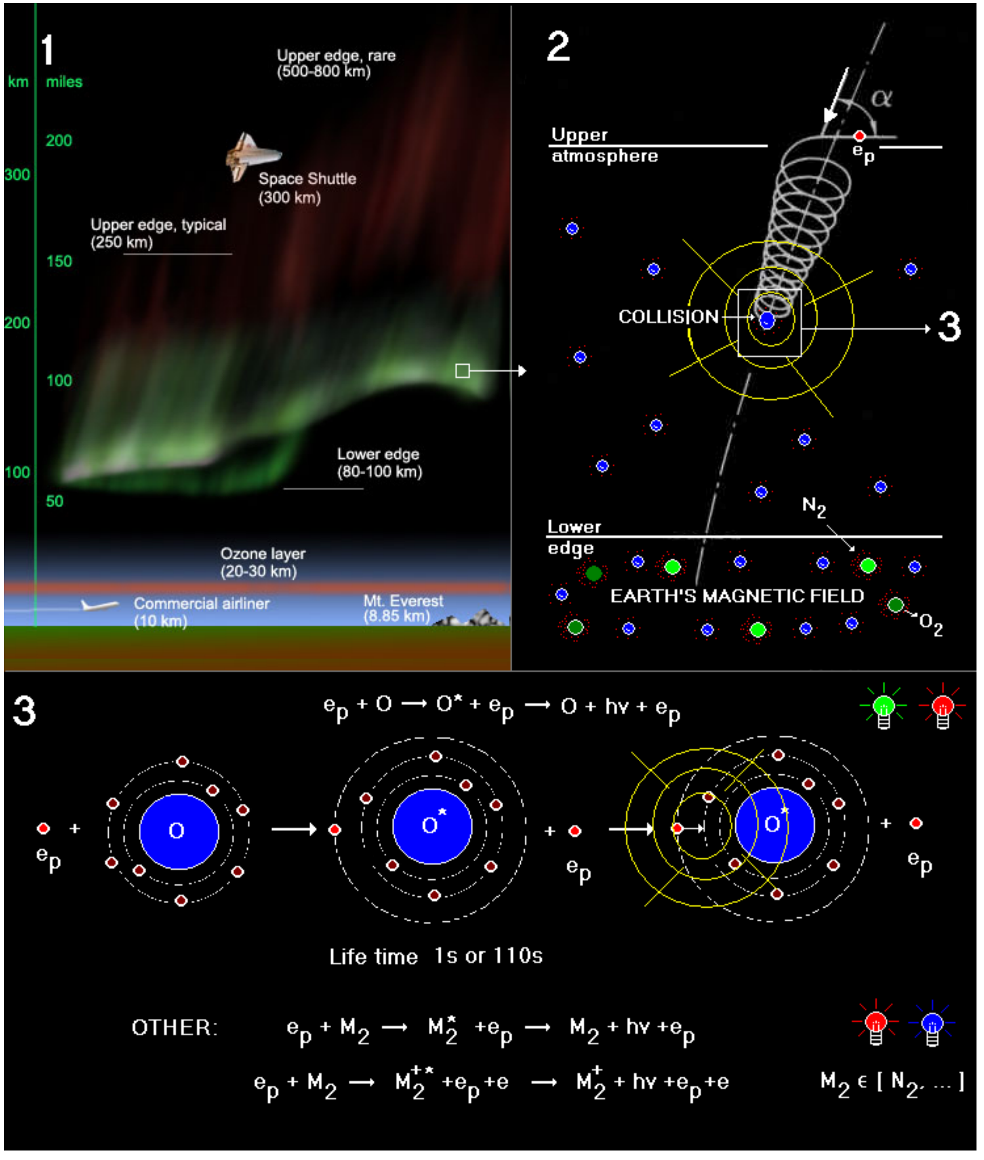




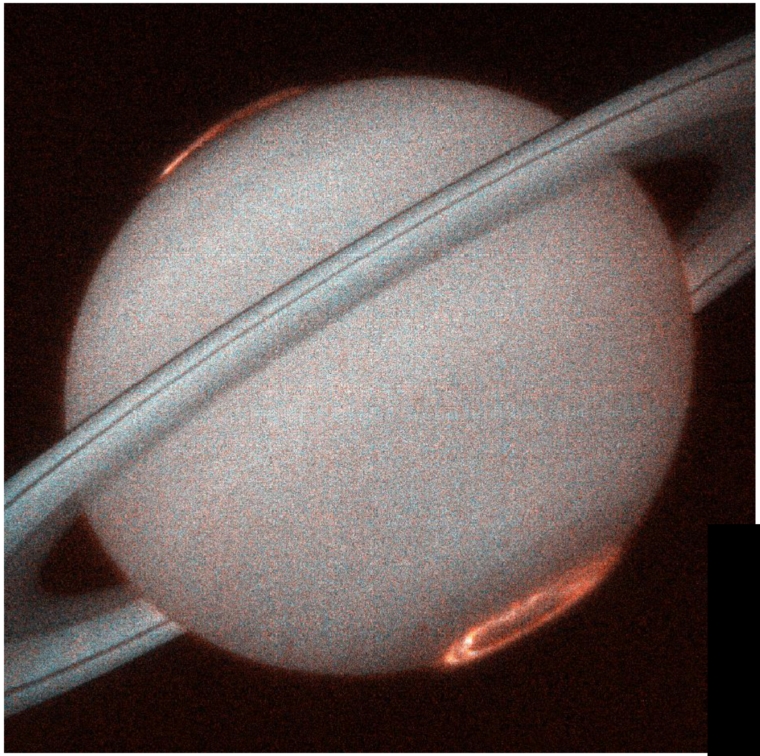
Active Sun

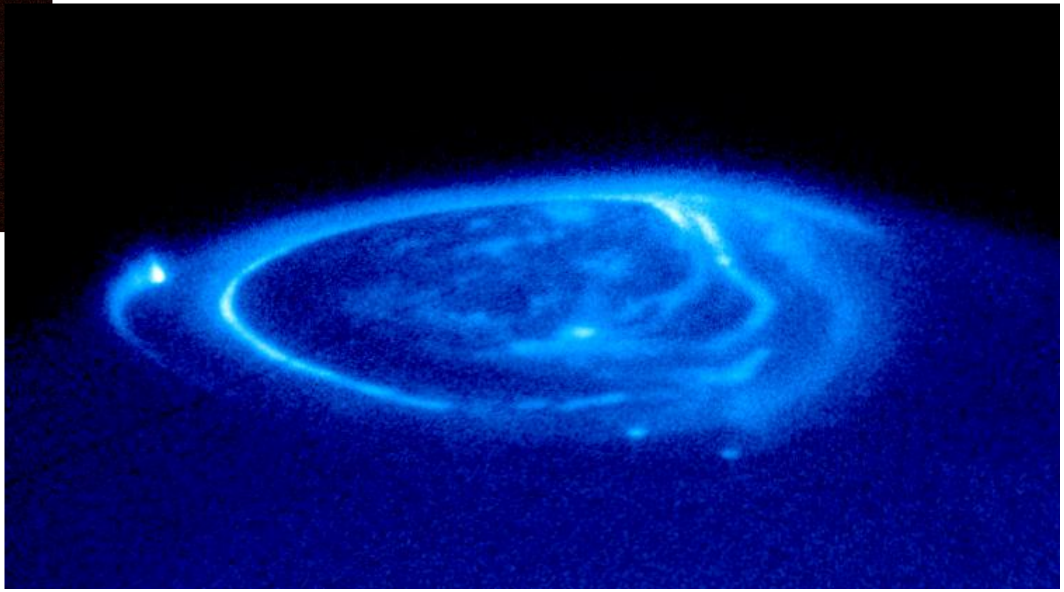


Earth's atmosphere



Aurora on other planets (HST)





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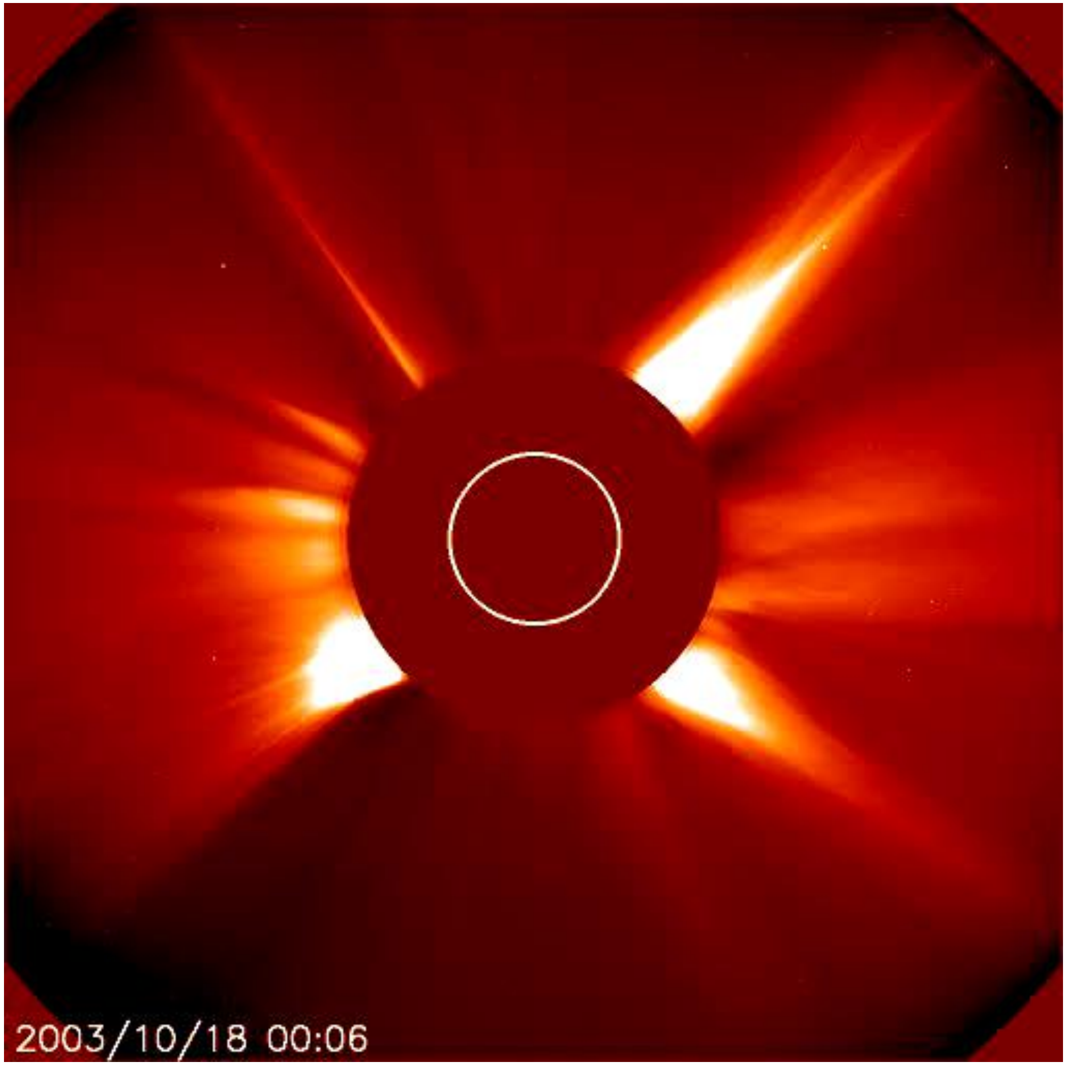
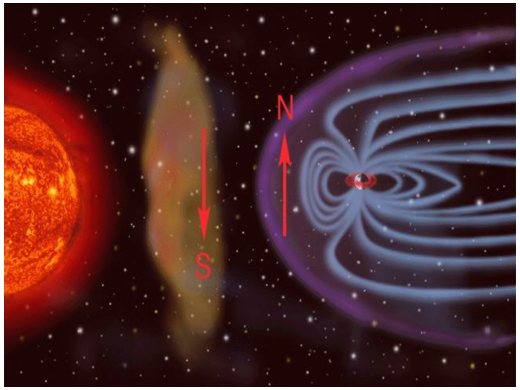
Halloween superstorm Oct. 2003



Kristian Birkeland (1867-1917)



- Aircrafts communication systems at HF/VHF suffered severe degradation and periods of complete blackout (above 57 degrees N) during Polar Cap Absorption (PCA)
- Terrestrial HF communication systems experienced outages during the radiation storms (PCAs) for arctic paths.
- Trans-polar flights were re-routed from Polar 3 to Polar 4 routs to avoid radiation hazards.
- HF radio relay paths in Antarctica experienced over 130 hours of blackout during the Halloween storms.
- More than 20 satellites (many of them Earth Observation satellites) and spacecrafts were affected. Half of NASA satellites affected. 1 Japanese satellite lost

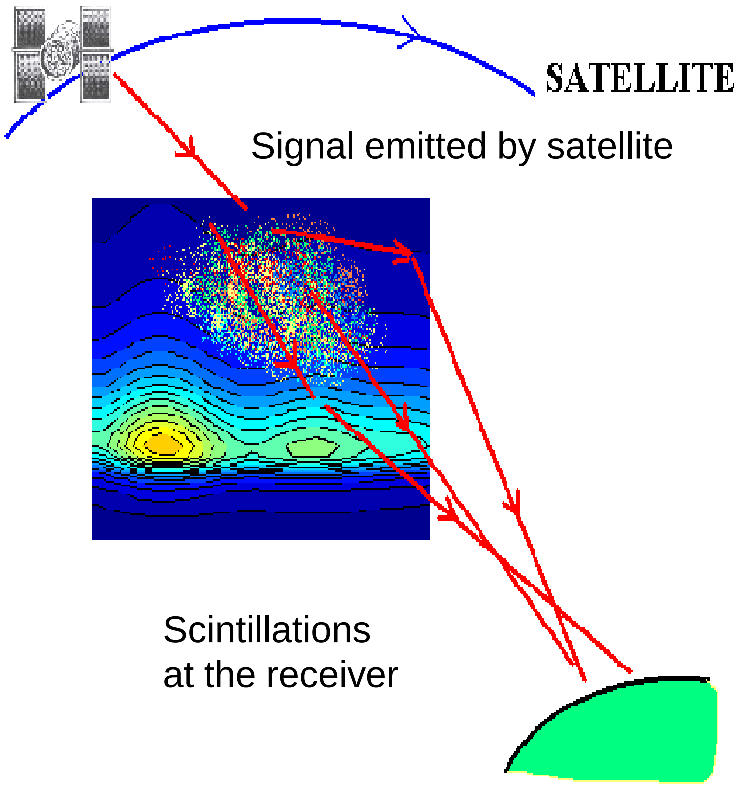
Space weather effects of Halloween storm

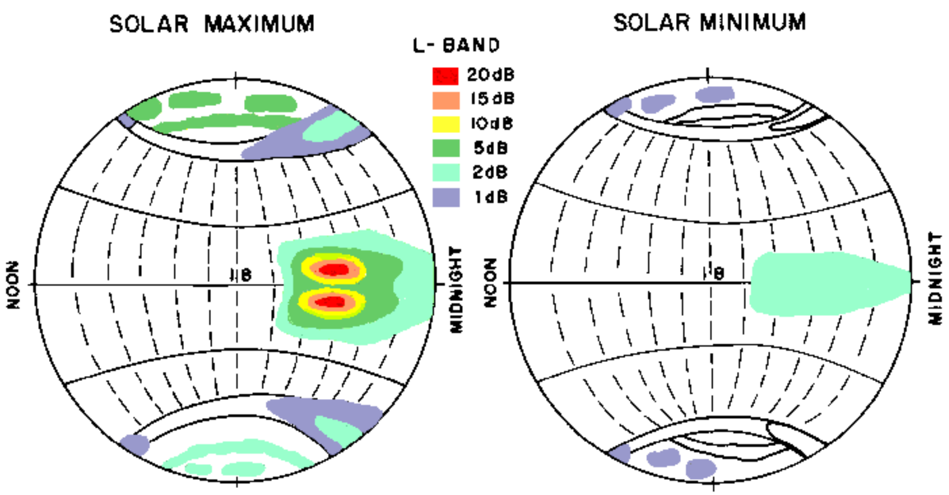
- Astronauts on International Space Station went into service module for radiation protection.
- FAA issued first-ever alert on radiation doses received by airplane passengers above 25,000 feet.
- Power system failure in Malmo, Sweden (30 October).
- Wisconsin and New York: High current levels in transmission lines.
- US Coast Guard to temporarily shut down LORAN C navigation system.
- WAAS service interrupted over US; high-latitude GPS receiver outages

(Webb and Allen, Space Weather, 2004)

Radio waves and the ionosphere

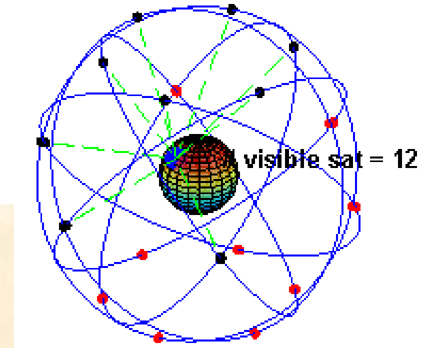
- Ionospheric irregularities produce short term phase and amplitude fluctuations in radio waves
- These effects are called scintillations
- Severe amplitude fading and strong phase scintillation affect the reliability of GPS systems and satellite communications.

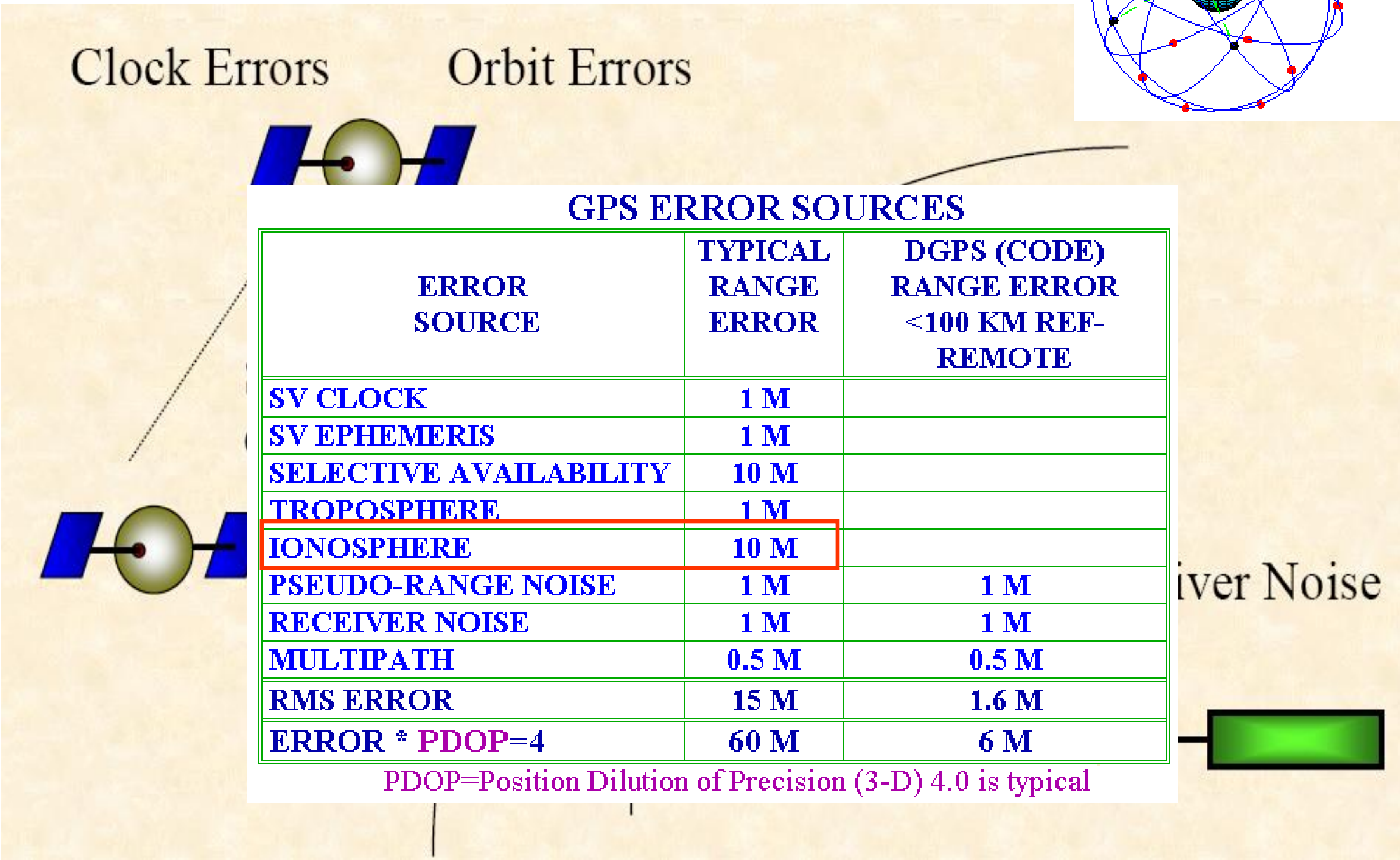




The scintillations occur mainly at polar, auroral and equatorial regions; more frequently around the solar maxima

GPS error sources





GPS ERROR SOURCES

ERROR SOURCE	TYPICAL RANGE ERROR	DGPS (CODE) RANGE ERROR <100 KM REF-REMOTE
SV CLOCK	1 M	
SV EPHEMERIS	1 M	
SELECTIVE AVAILABILITY	10 M	
TROPOSPHERE	1 M	
IONOSPHERE	10 M	
PSEUDO-RANGE NOISE	1 M	1 M
RECEIVER NOISE	1 M	1 M
MULTIPATH	0.5 M	0.5 M
RMS ERROR	15 M	1.6 M
ERROR * PDOP=4	60 M	6 M

PDOP=Position Dilution of Precision (3-D) 4.0 is typical

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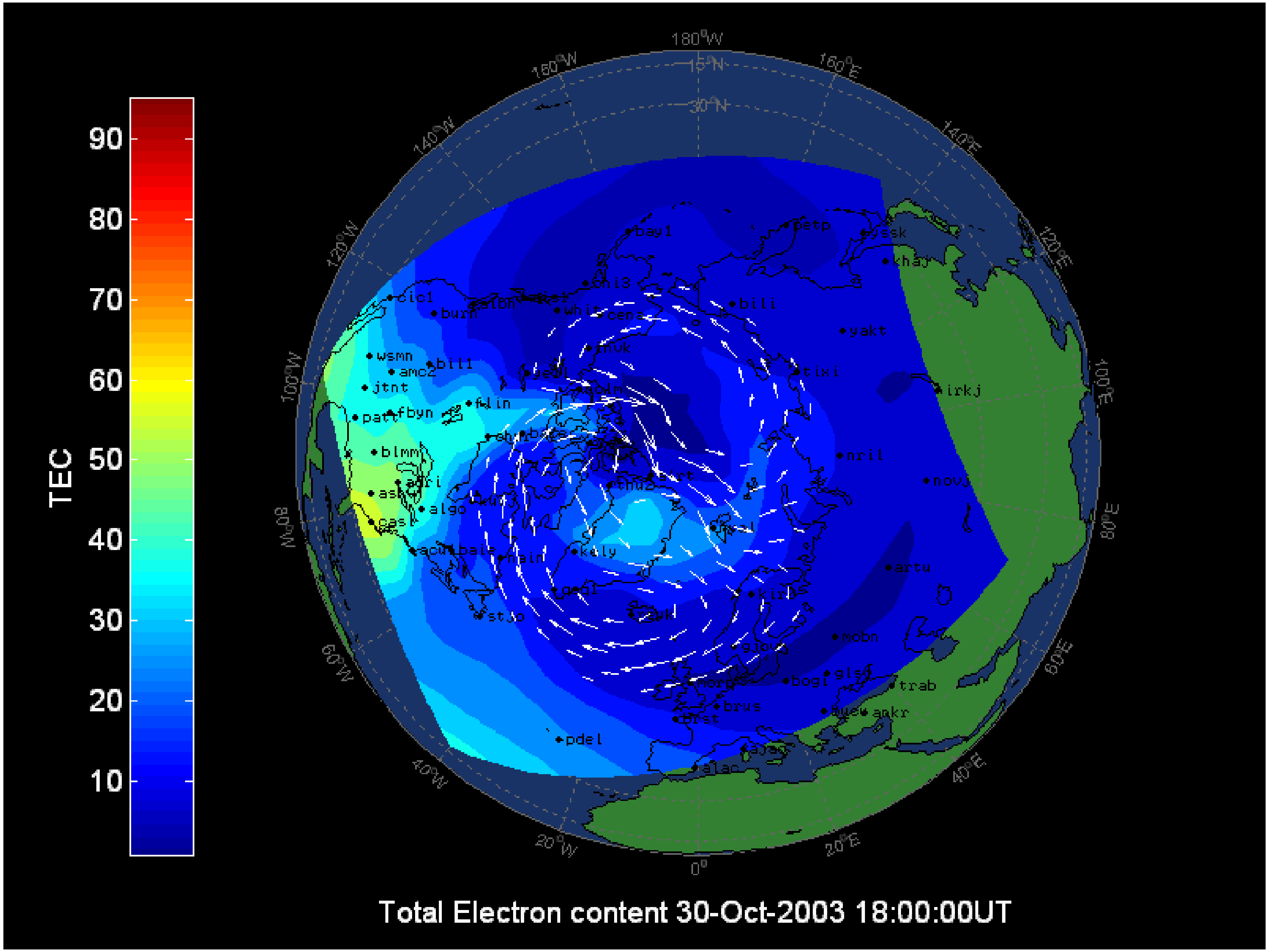
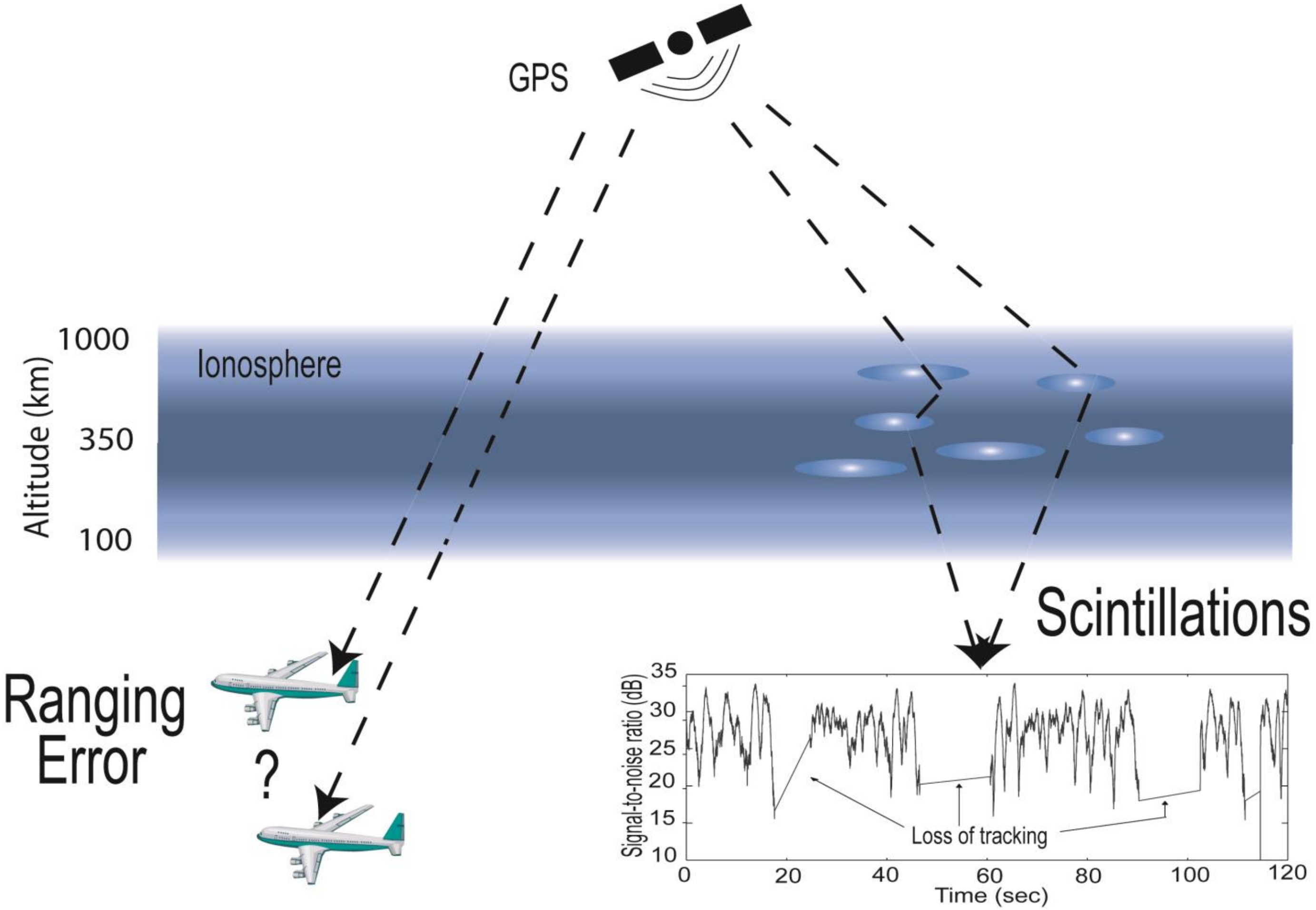
Ionosphere during Halloween storm

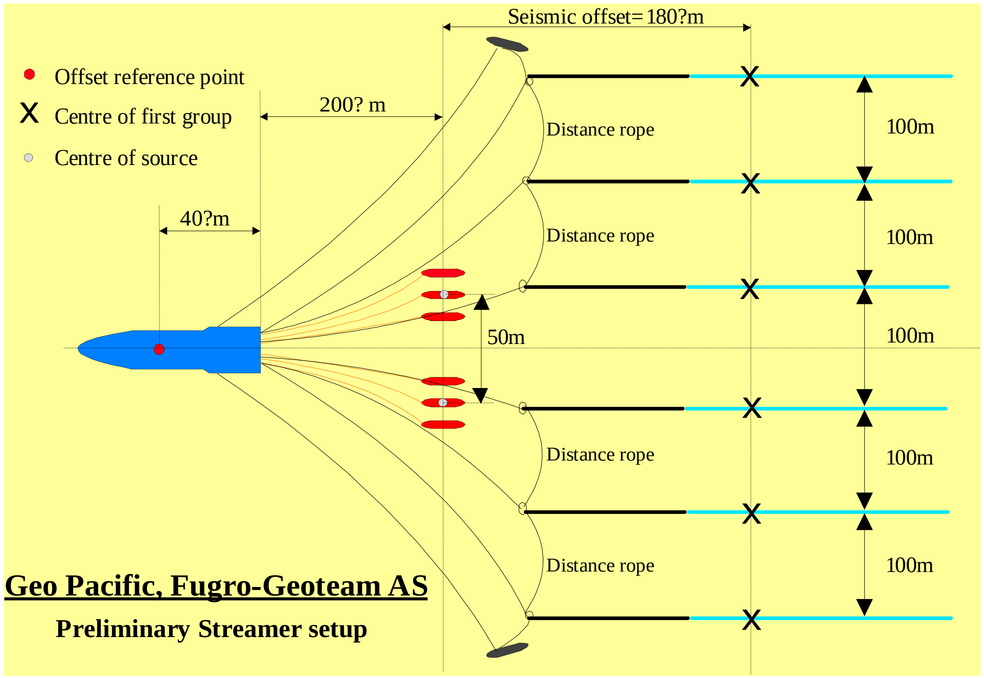


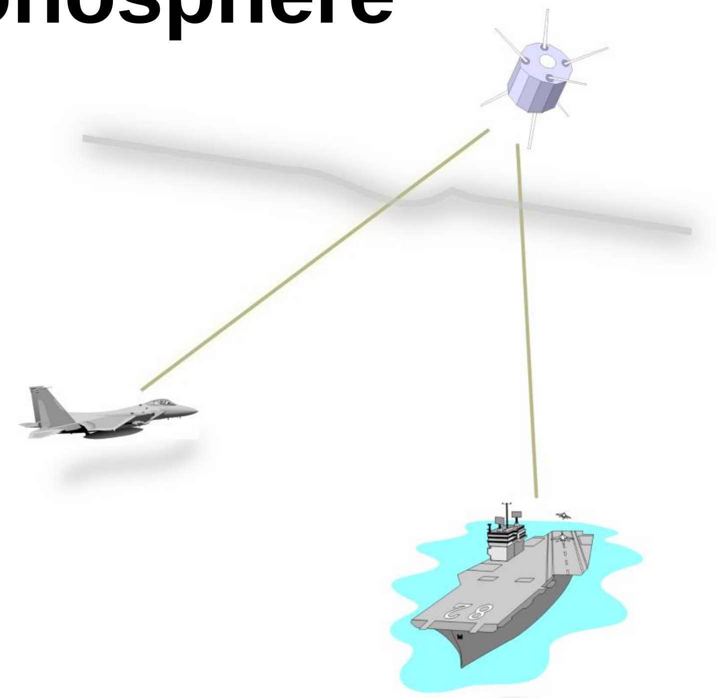
GPS disturbances by the ionosphere



Amplitude
og phase

GPS disturbances by the ionosphere





ICI science objectives

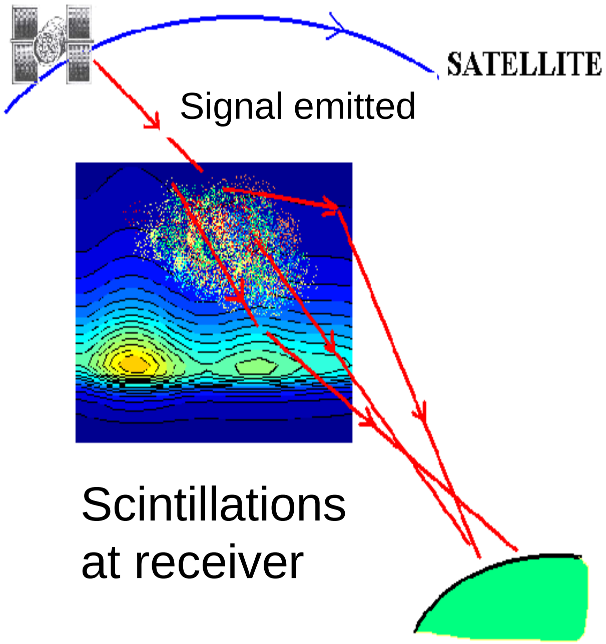
User needs:

- Scintillation forecasts
- Signal integrity
- Position accuracy

To be able to do that you need:

- Determine which plasma instability processes involved
- Quantify their growth rates
- Determine the plasma structures in the irregularity layer

Meter resolution is needed!



Space Technology And Research

Plasma and Space Physics:
Prof. Jøran Moen (Head)
Prof. Hans Pecseli
Assoc. Prof. Wojciech Miloch
Prof. Per Even Sandholt
Prof. Ulf Peter Hoppe (FFI)
Dr. Lasse Clausen
Dr. Swadesh Patra
Dr. Yvonne Rinne
Prof. II Tom Blix
Prof. Dag Lorentzen (UNIS)
Prof. Fred Sigernes (UNIS)
Assoc. Prof. Lisa Baddeley (UNIS)
Dr. Margit Dyrland (UNIS)

Electronics:
Assoc. Prof. Torfinn Lindem
Assoc. Prof. II Jan K. Bekkeng

Micro- and nanoelectronics:
Prof. Oddvar Søråsen
Prof. II Snorre Aunet

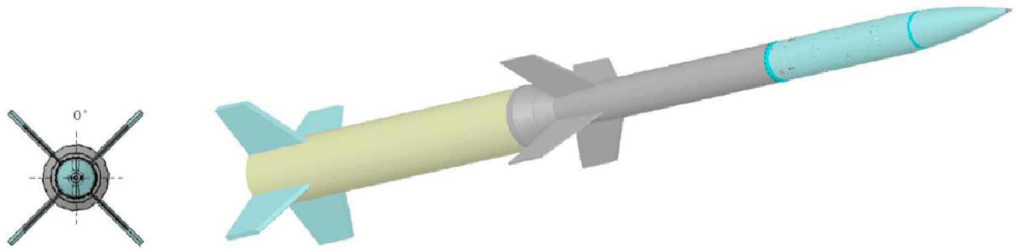
Technicians:
Bjørn Lybekk
Espen Trondsen
Halvor Strøm

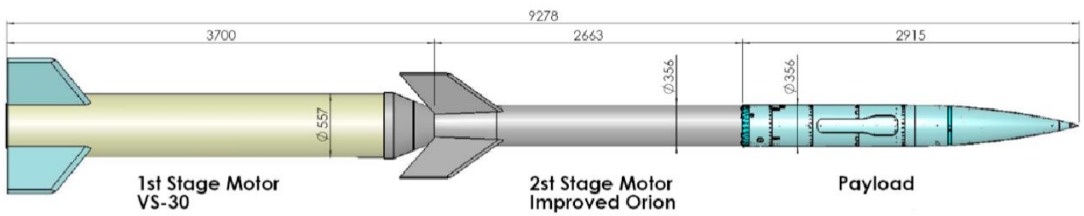
Students:
~8 PhD students
~10 Master students

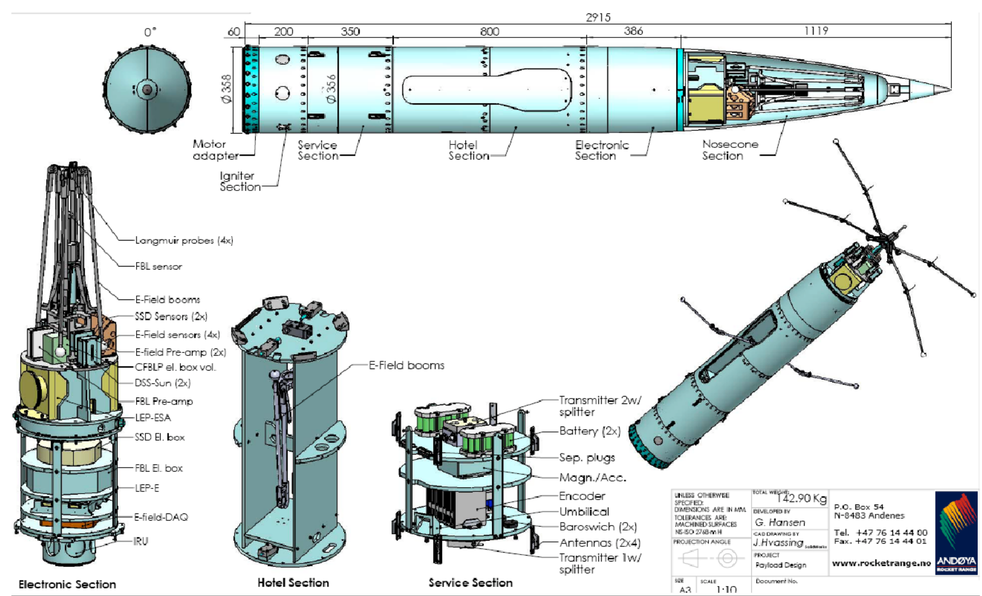
Electronics Lab

Mechanical Workshop

ICI rocket


0°

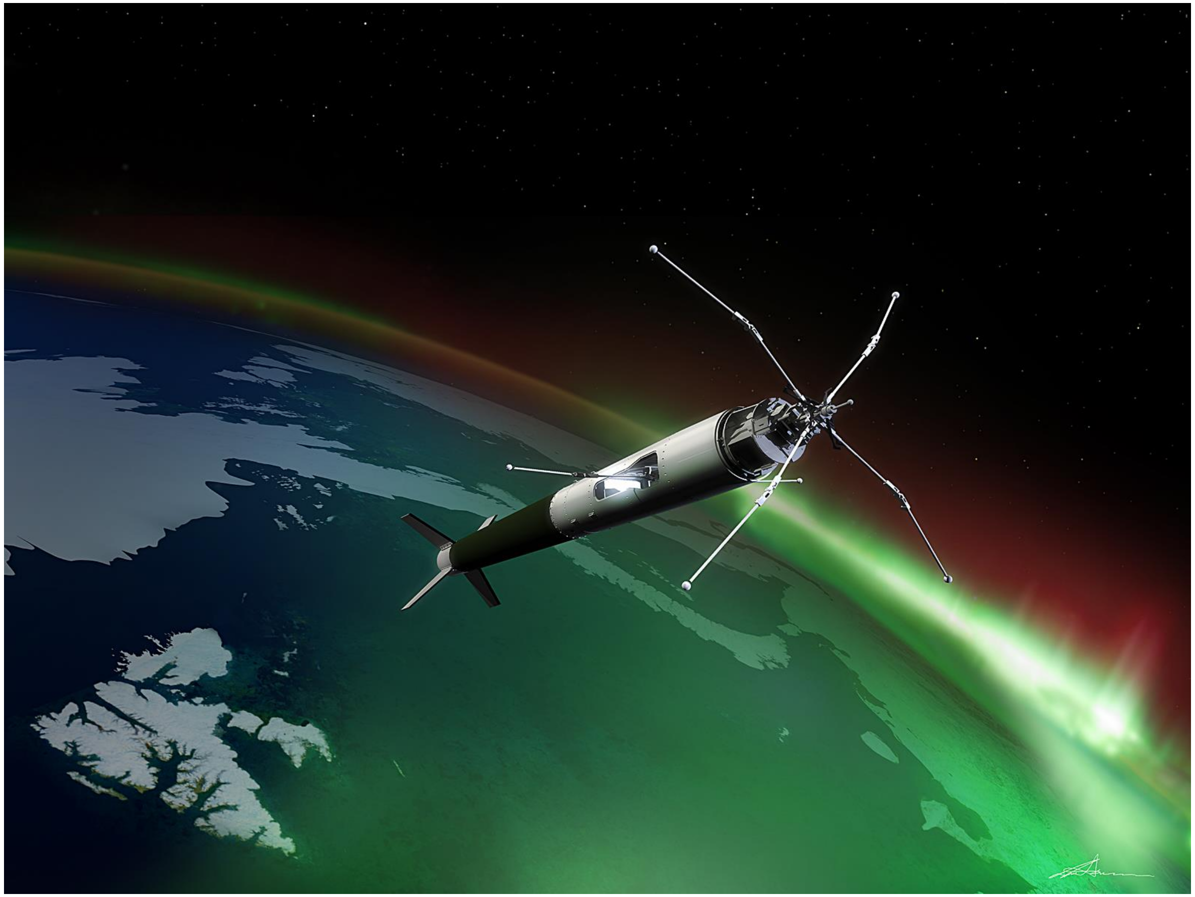

9278
3700
2663
2915
Ø 557
Ø 356
Ø 356
1st Stage Motor
VS-30
2st Stage Motor
Improved Orion
Payload


2915
60
200
350
800
386
1119
0°
Ø 358
Ø 356
Motor adapter
Service Section
Hotel Section
Electronic Section
Nosecone Section
Igniter Section
Langmuir probes (4x)
FBL sensor
E-Field booms
SSD Sensors (2x)
E-Field sensors (4x)
E-field Pre-amp (2x)
CFBLP el. box vol.
DSS-Sun (2x)
FBL Pre-amp
LEP-ESA
SSD El. box
FBL El. box
LEP-E
E-field-DAQ
IRU
E-Field booms
Transmitter 2w/ splitter
Battery (2x)
Sep. plugs
Magn./Acc.
Encoder
Umbilical
Baroswich (2x)
Antennas (2x4)
Transmitter 1w/ splitter
Electronic Section
Hotel Section
Service Section
142.90 Kg
G. Hansen
J.Hvassing
Payload Design
P.O. Box 54
N-8483 Andenes
Tel. +47 76 14 44 00
Fax. +47 76 14 44 01
www.rocketrange.no
ANDØYA
A3
1:10

ICI so far

ICI 1: 2003 : failed
ICI 2: 5Dec2008: Success!
ICI 3: 3Dec2011: Success!
ICI 4: Winter 2013
ICI 5: Winter 2016

All rockets launched from Svalbard



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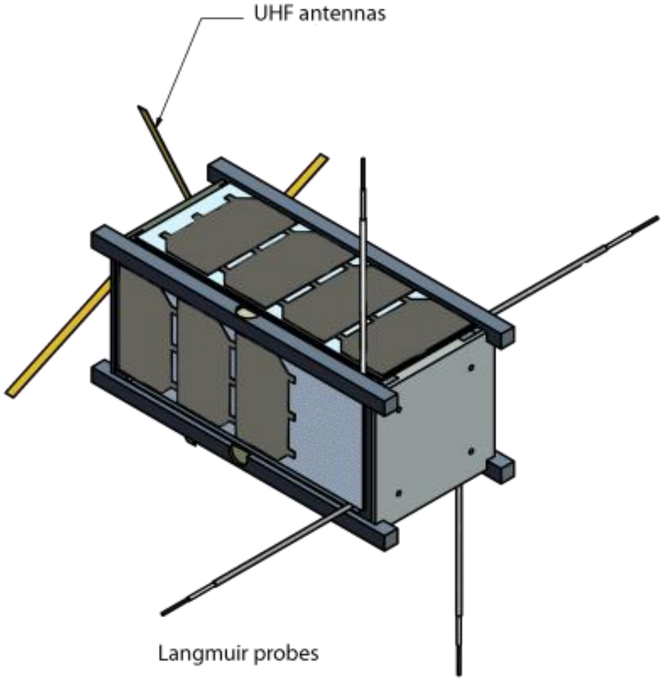
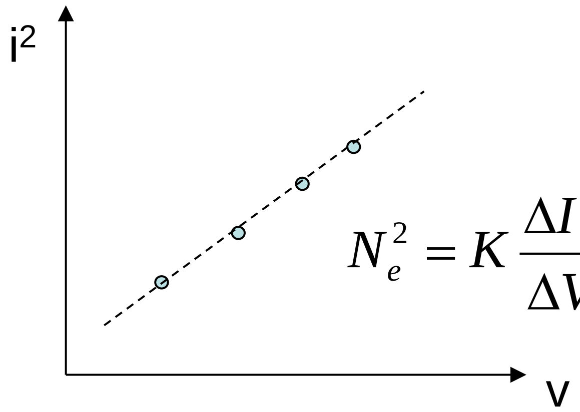
CubeSTAR – a space weather satellite

UiO's Langmuir probe concept: m-NLP
(Multiple Needle Langmuir Probes)



Achieve meter resolution instead km resolution of electron density structures



$$N_e^2 = K \frac{\Delta I^2}{\Delta V}$$

STAR in space projects

- Cluster
- Rosetta
- Bepi-Colombo
- ICI series of sounding rockets
- CubeSTAR
- Student rockets

Take 1 or 2 semesters at UNIS, Svalbard?

CaNoRock

- Canadian Norwegian Student Sounding Rocket Program (2011 – 2021)
- CaNoRock STEP 2012-2016 Exchange opportunities with
  - U. of Alberta, Edmonton
  - U. of Saskatchewan, Saskatoon
  - U. of Calgary, Calgary