

Young astronomer in Denmark from 1946...

My life with the stars

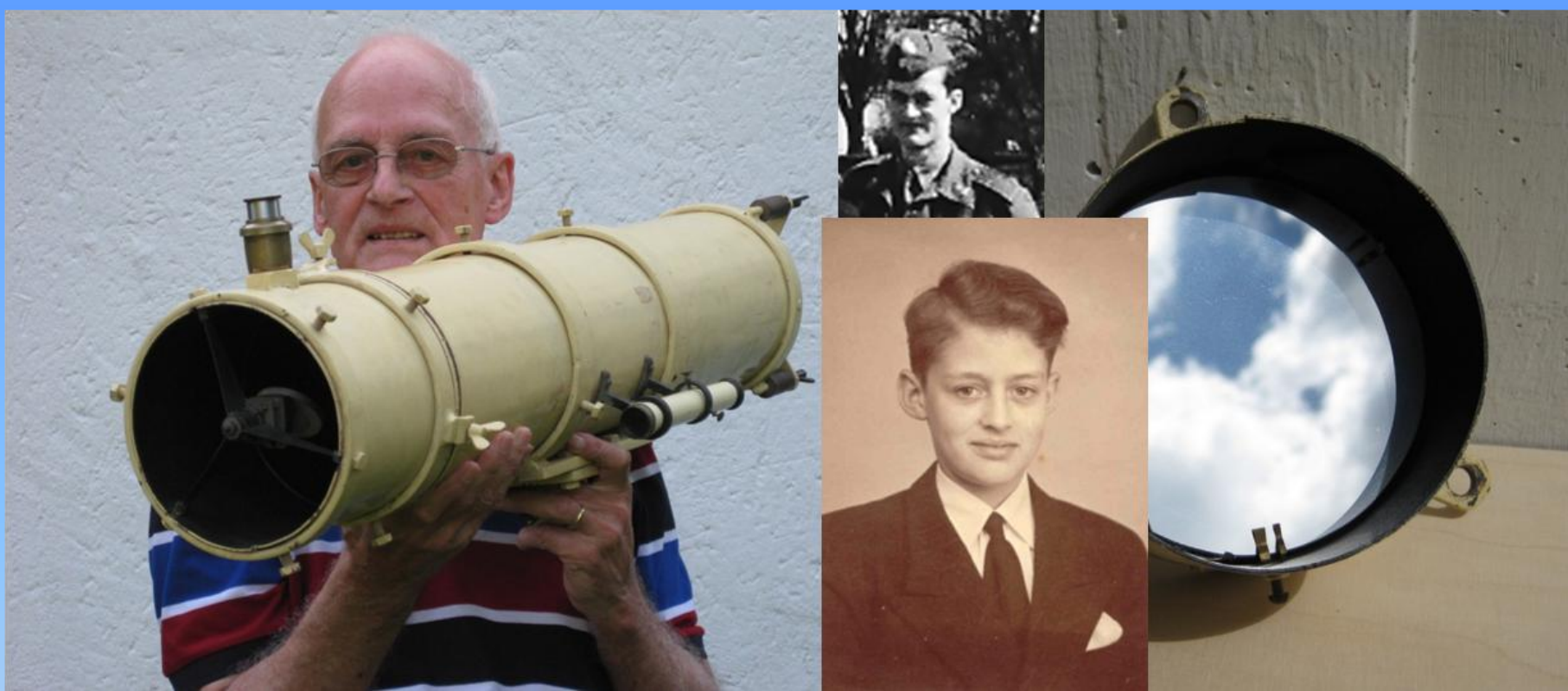
Erik Høg - Niels Bohr Institute, Copenhagen, Denmark

Bogota Planetarium, September 2016

Brorfelde Observatory, June 2016

Astronomische Gesellschaft in Kiel, September 2015

Working Group History of Astronomy



First telescope built of eyeglasses when I was 15
Two mirrors ground, polished, silvered
The 12 cm telescope completed when 17
local blacksmith built the mounting...
Observed variable stars with Argelander method
Telescope sold 1950 - returned after 60 years

Basic design of two astrometry satellites:

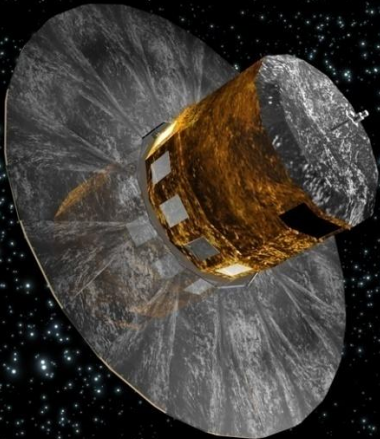
In 1975 Hipparcos

In 1992 Gaia



Gaia torus 2011

with one of the mirrors
mounted



Astronomy

A guided tour through the Universe

Moon and Sun

planets and stars

galaxies and black holes

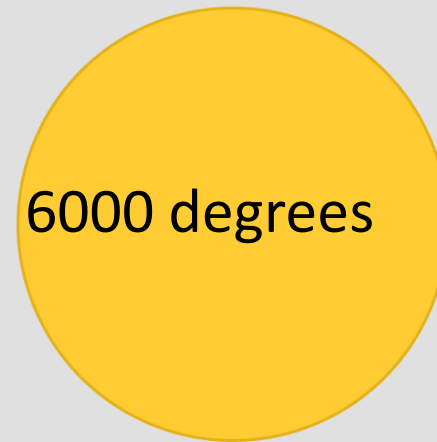
First:

What is a star?

A star is like our Sun

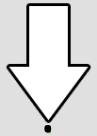
A ball of glowing gas

Most of it is hydrogen and helium



Sun

110
times
smaller
than the Sun



Earth

Why is the Earth round?

Sun, Earth, Moon, planets
are spheres because of **gravitation**
from their own mass

Gravitation = **Mass attraction**

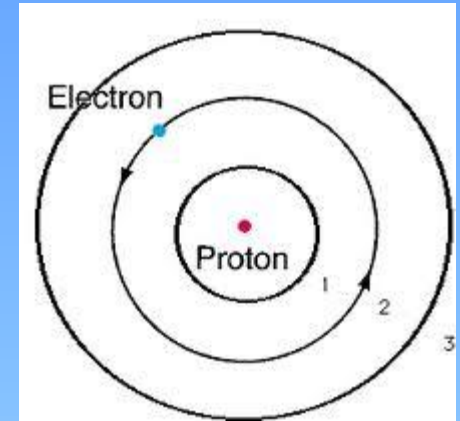
is the strongest force in the Universe
at distances > atoms

Gravitation = mass attraction

Newton 1687

The strongest force in the universe

But gravitation is *much weaker*
than the forces *inside the atoms...*

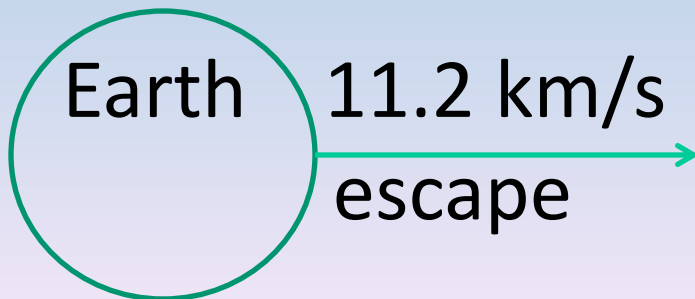


Einstein 1905 og 1915: Theory of Relativity

1905: the special RT: velocity of light in vacuum...

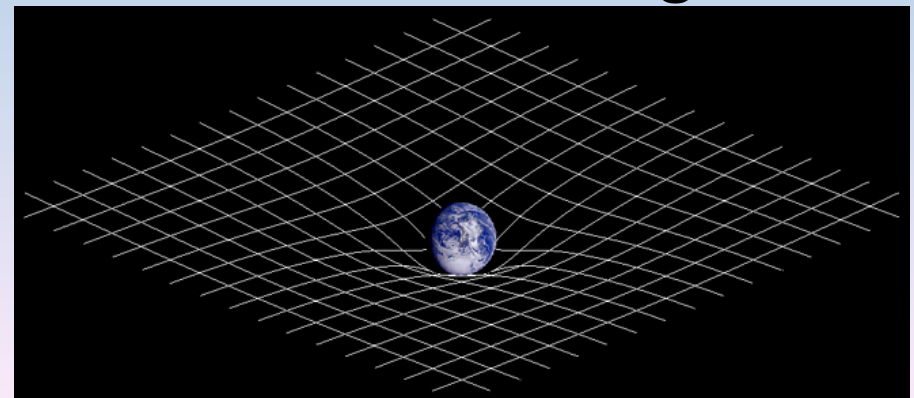
1915: the general RT: gravitation as curvature
of space and time. - **MATHEMATICS**

Watches go slower close to Earth and when moving - **GPS**



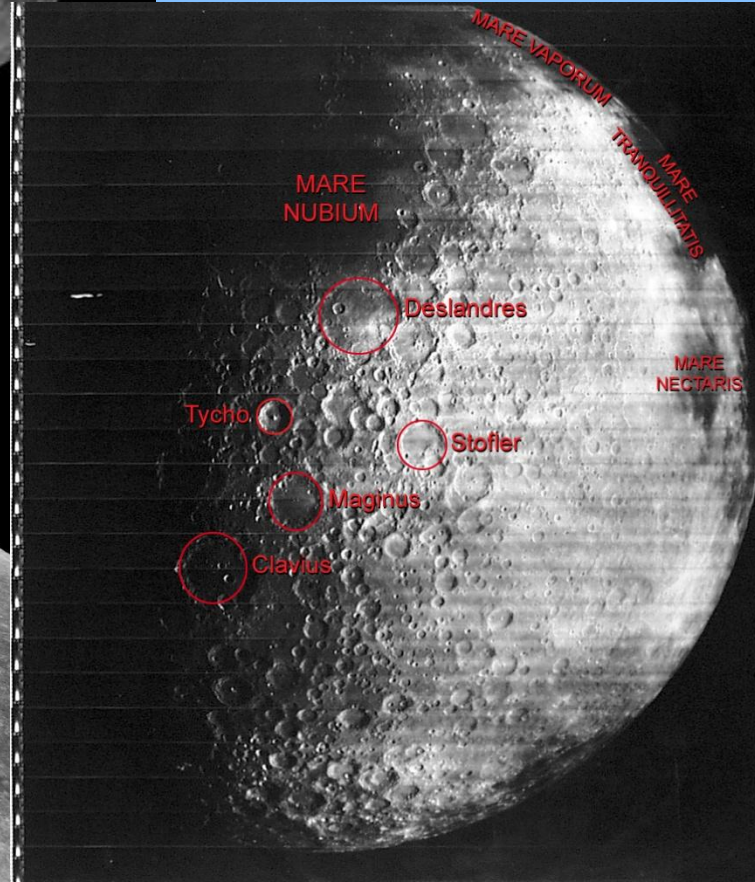
Erik Høg

http://en.wikipedia.org/wiki/Black_hole



12700 km

Earth and Moon
distance 400 000 km
light takes 1.3 second



Tour through the Universe continues: Planets



Mercury



Venus



Earth



Mars

Erikhøg = an asteroid



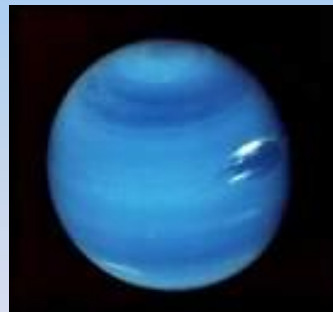
Jupiter



Saturn



Uranus



Neptune



Charon

Pluto has 4 moons

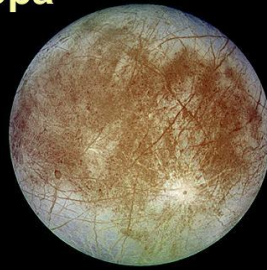
**Light takes
6 hours**

Jupiter's moons, the four biggest

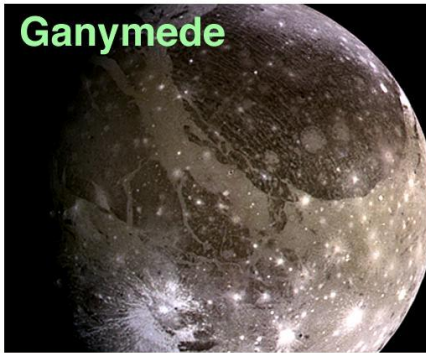
Io



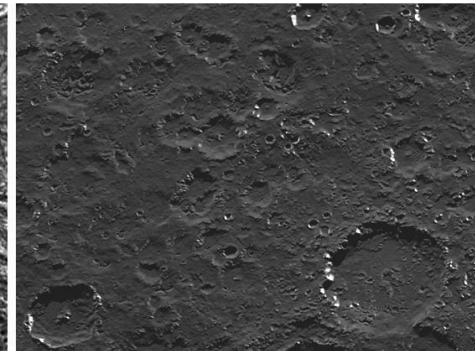
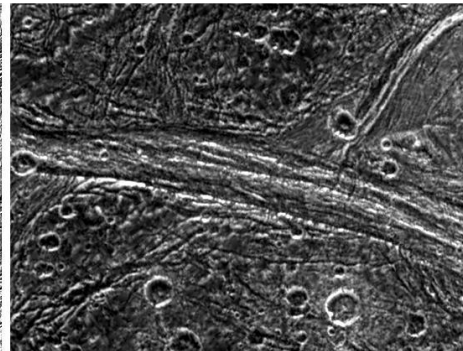
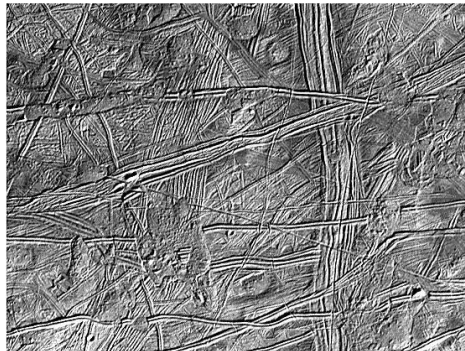
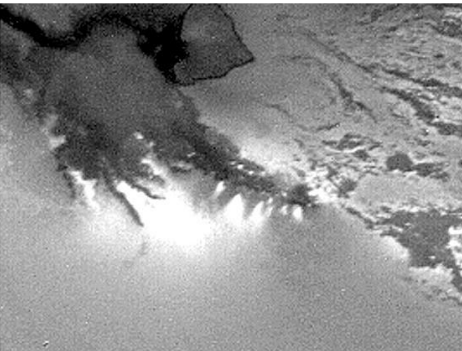
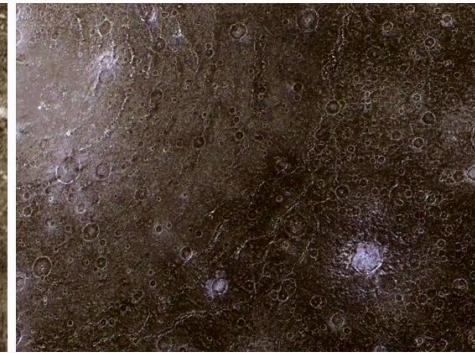
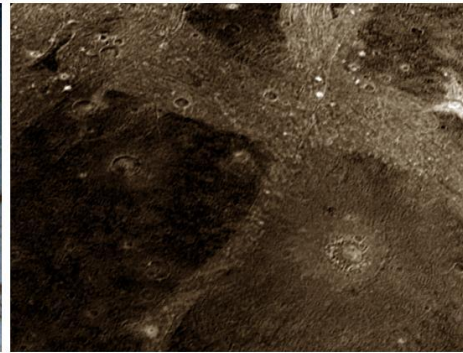
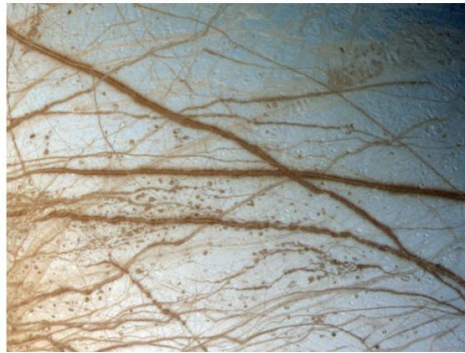
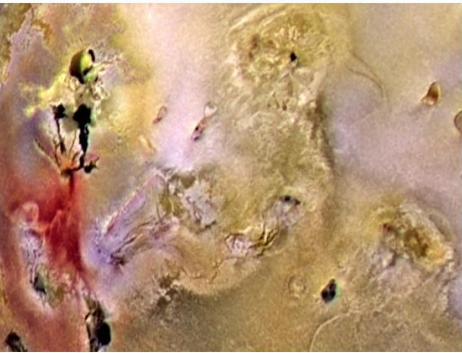
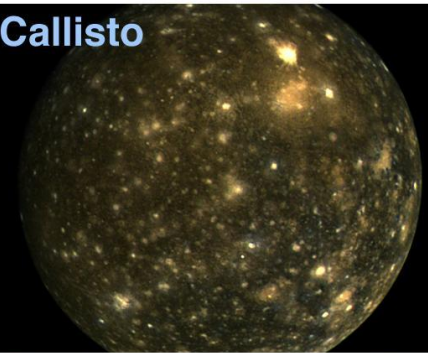
Europa



Ganymede



Callisto



Names were given by Galilei og Simon Marius...

Crab Nebula - Dust and gas at a distance of 3400 light years

Light has traveled 3400 years to us

A supernova exploded here in 1054 AD

It was seen by astronomers in China and Japan

Stars are re-cycling stations in the Universe:

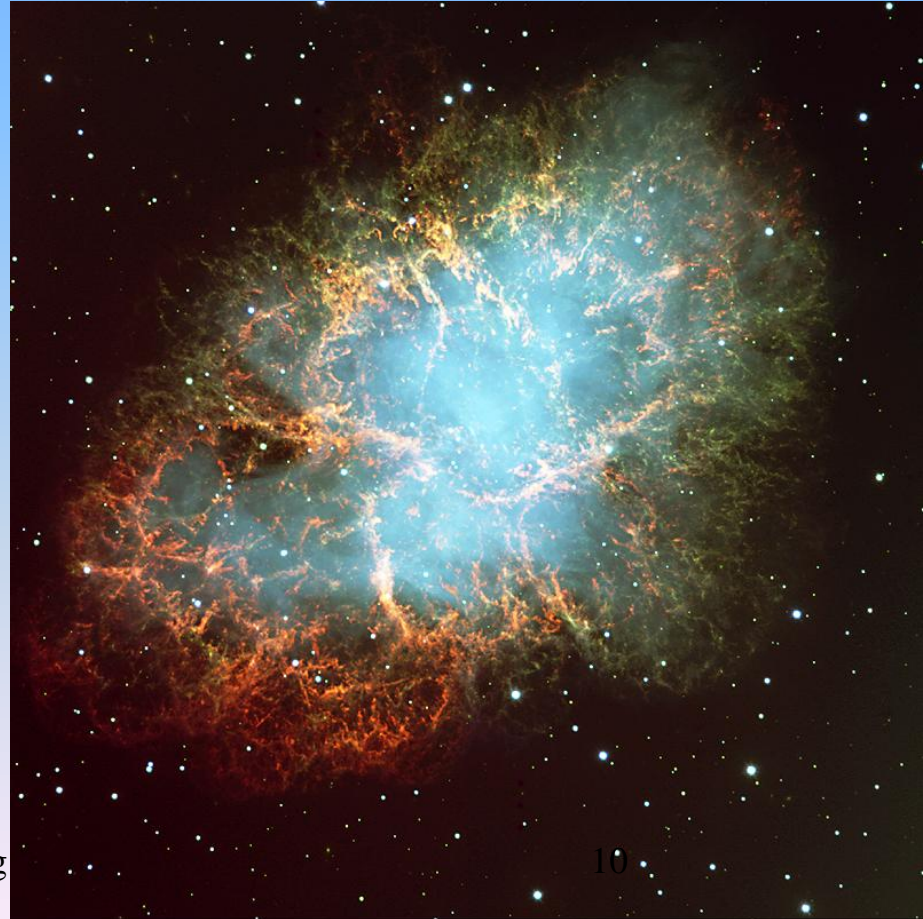
Hydrogen → Energi+Helium + **heavy elements**

9 billion years

after Big Bang

→ **Sun + Earth**

→ **Human beings**



Andromeda galaxy

with two dwarf galaxies



100 billion stars
= 20 stars per human

Distance =
2.2 million light years

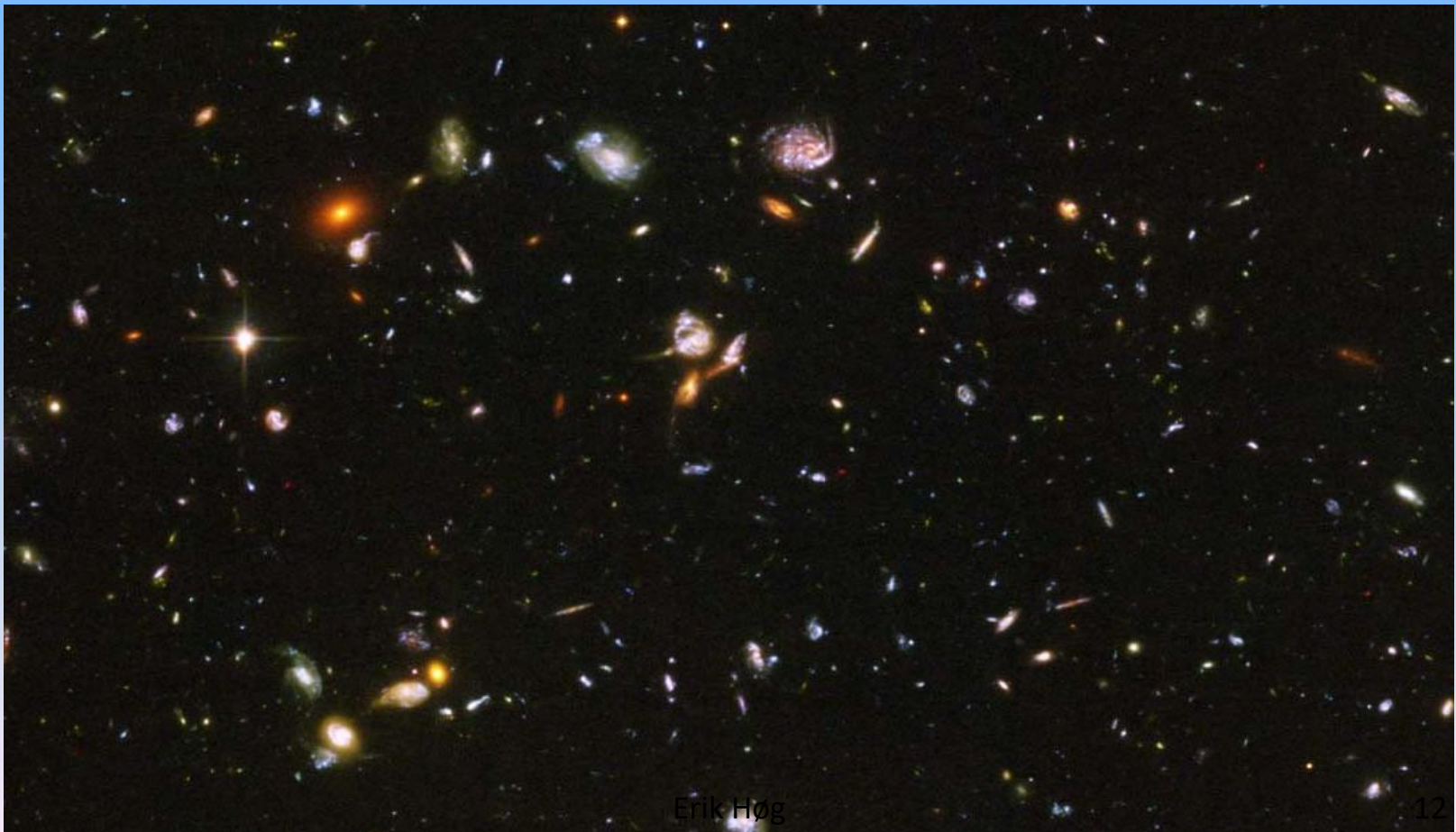
1 light year =
9 500 000 000 000 km

The whole Universe is about 14 billion years old

Universe expands...

Hubble Space Telescope:

The faintest galaxies are seen 13 billion light years away



On Lolland

Workshop and house

My grandfather and
father were painters

but not Erik *1932
Always positive
response ...



**Three families
dressed for
Sunday ~1936**

**The three men
had lived all
their lives there
at the forest**

**Denmark was
occupied 1940-
45 by the Nazis**



**My birthday
in 1945
with my smaller
brother and sister**

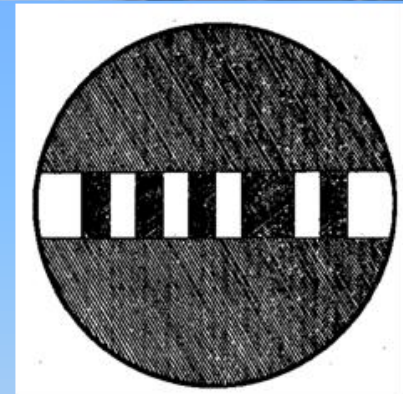


**Youngsters from the
grammer school
late at night in 1949**





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Two mirrors ground, polished, silvered
The 12 cm telescope completed when 17
local blacksmith built the mounting...
Observed variable stars with Argelander method
Telescope sold 1950 - returned after 60 years



Julie Vinter Hansen Bengt Strömgren in 1948
Many letters...

2010: Peter Naur Erik Høg
Strömgren's slit system in 1925...

Logaritmer

$\log x$

	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
50	6990	6998	7007	7016	7024	7033	7042	7050	7059	7067	1	2	3	3	4	5	6	7	8
51	7076	7084	7093	7101	7110	7118	7126	7135	7143	7152	1	2	3	3	4	5	6	7	8
52	7160	7168	7177	7185	7193	7202	7210	7218	7226	7234	1	2	3	3	4	5	6	7	7
53	7243	7251													4	5	6	6	7
54	7324	7332													4	5	6	6	7
55	7404	7412													4	5	5	6	7
56	7482	7490													4	5	5	6	7
57	7559	7566													4	5	5	6	7
58	7634	7642													4	4	5	6	7
59	7709	7716													4	4	5	6	7

Madas 20BZS



Calculation tools in 1950s: Logarithms and mechanical
Peter Naur, my mentor in astronomy, became the first
 Danish professor of computer sciences...



Old Copenhagen observatory

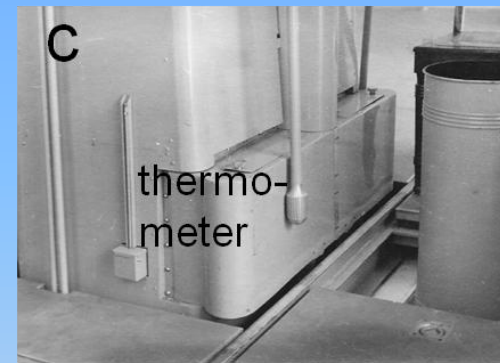
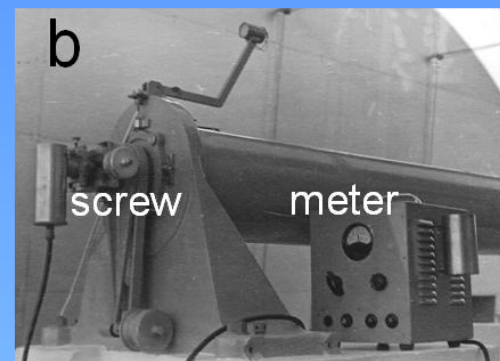
New meridian circle in Brorfelde

50 km from Copenhagen

**I became the first student there in 1953
and became fascinated by astrometry**



**1955 view from top of the pavilion in Brorfelde
towards the houses
1986 personel of 27
1996 abandoned by all astronomers ...**

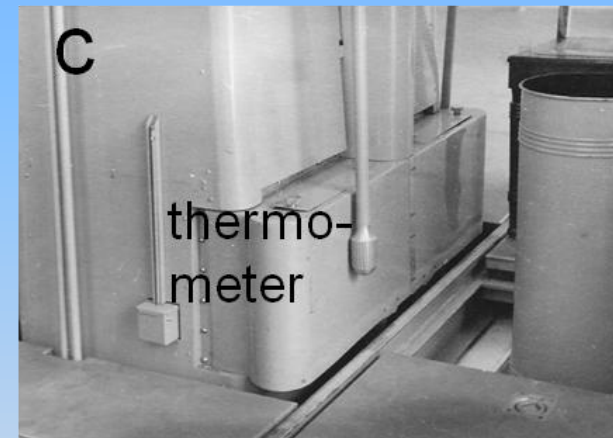
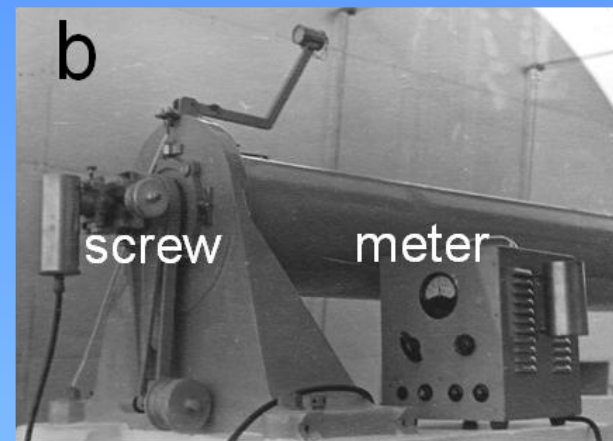


The meridian circle in 1955

Photoelectric device at the collimator
Nadir

In 1957:

Division lines on the circle – a new method designed
Automatic scanning of photographic plates designed



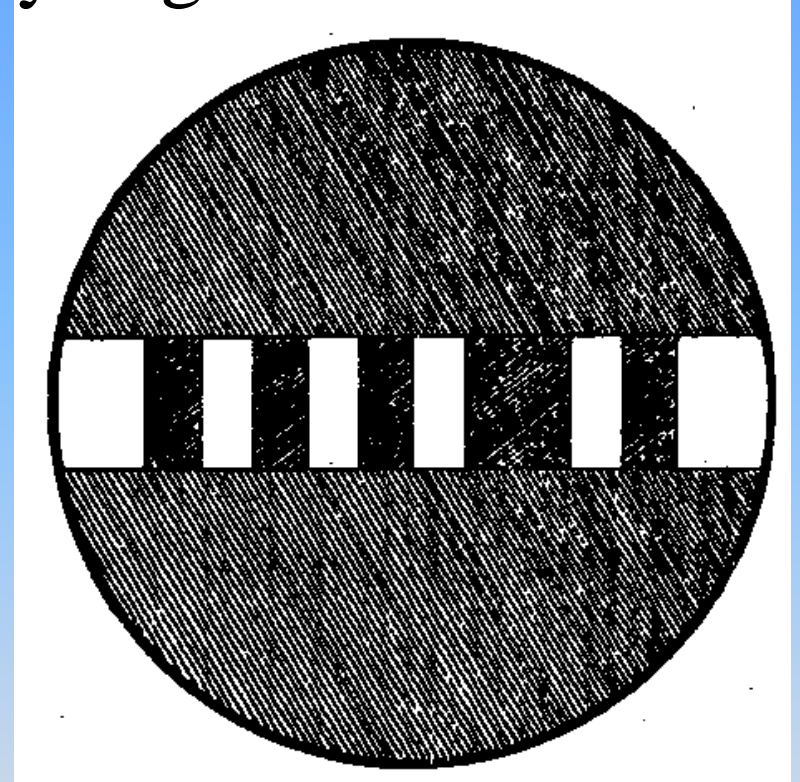
**I was fascinated by the meridian circle and astrometry
– but from 1958 in Hamburg
I wanted to become an astrophysicist – but 1960...**

The old Copenhagen meridian circle from 1861

Photoelectric astrometry begins here in 1925

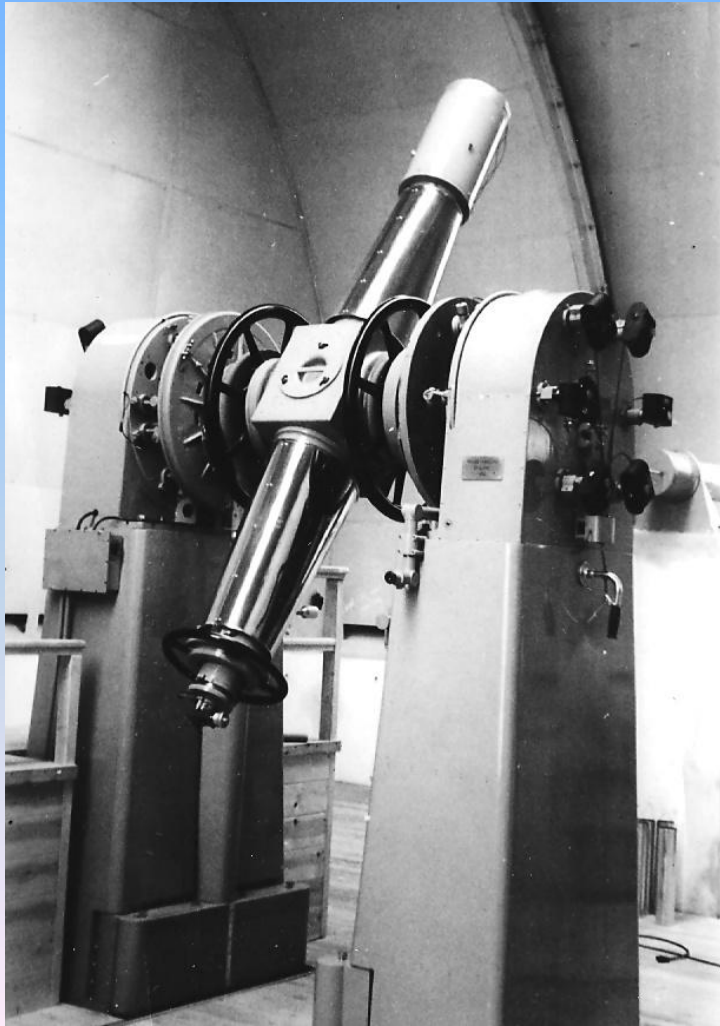


Courtesy: Sleno Museum, Aarhus



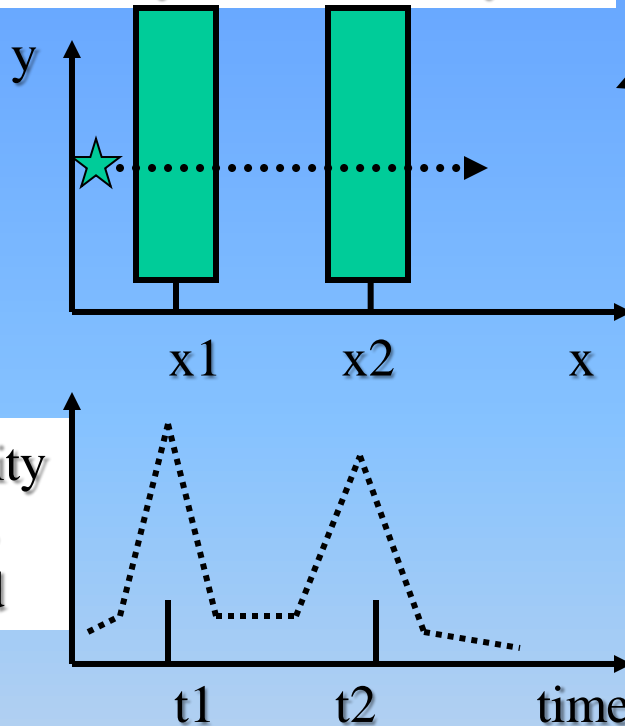
Bengt Strömgren 1925
Experiments with
photoelectric recording of transits

New meridian circle
initiated by Bengt Strömgren 1940
installed in Brorfelde 1953



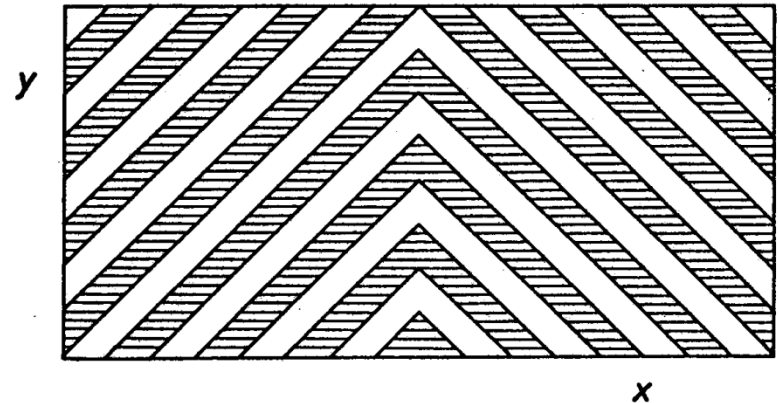
Høg - Soldier 1957
Atomic bombs
Counting techniques

Slits + Photon counting vs. Time
=> Astrometry + Photometry



Light intensity
= Photons
per second

Ideas 1960



In France called: *Une grille de Høg*

B. Strömgren 1925: Slits and photo cell
1930s: Photomultiplier Tube (PMT) and Image
Dissector Tube (IDT) developed
Atomic bombs 1957 : Counting techniques
E. Høg 1960 : Slits + counting >>>

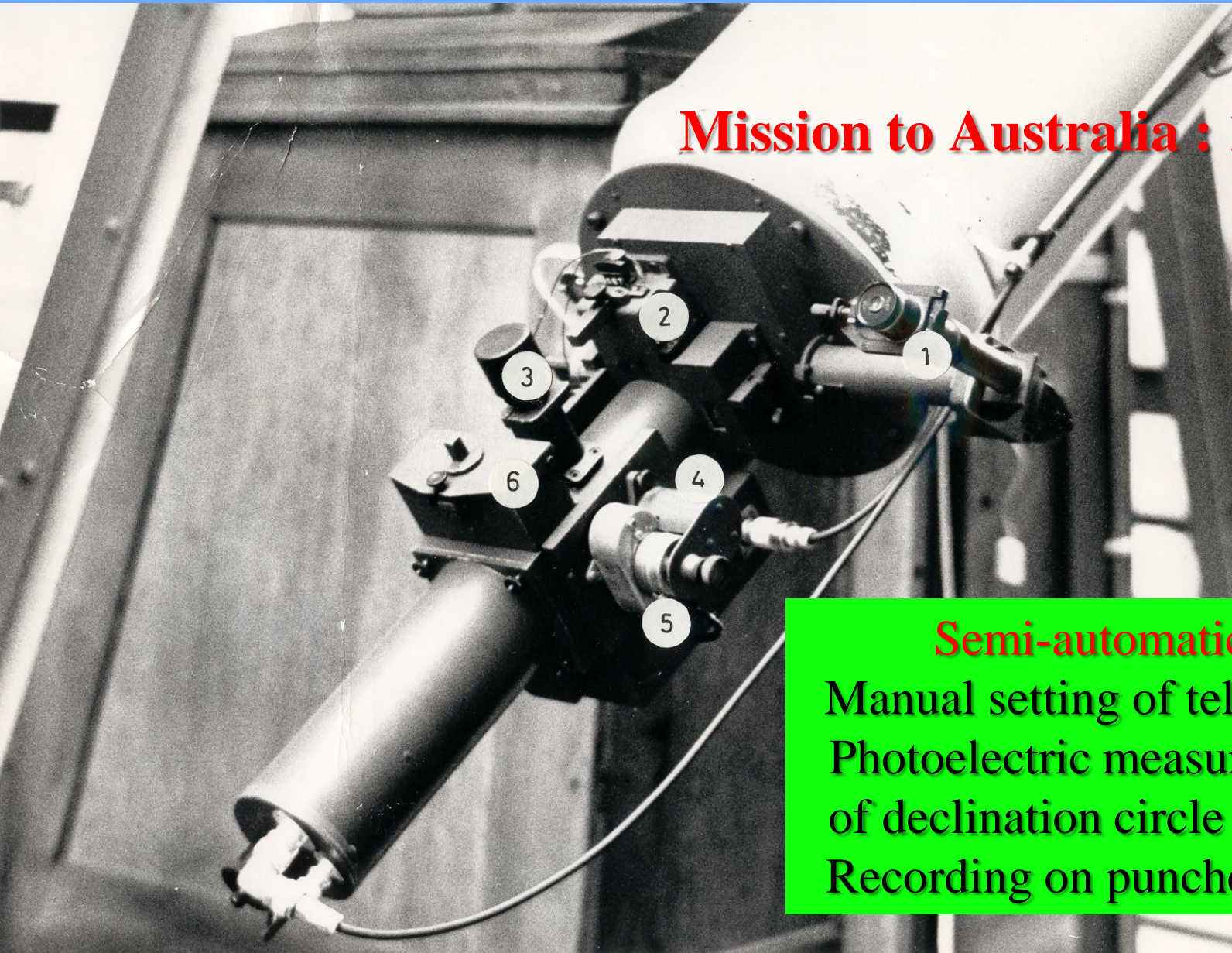
implementation on meridian circles
Used in the Hipparcos satellite 1989-93



Otto Heckmann
Immediate support

Hamburg – **First slit micrometer** on a meridian circle 1966

Mission to Australia : 1967-72



Semi-automatic:

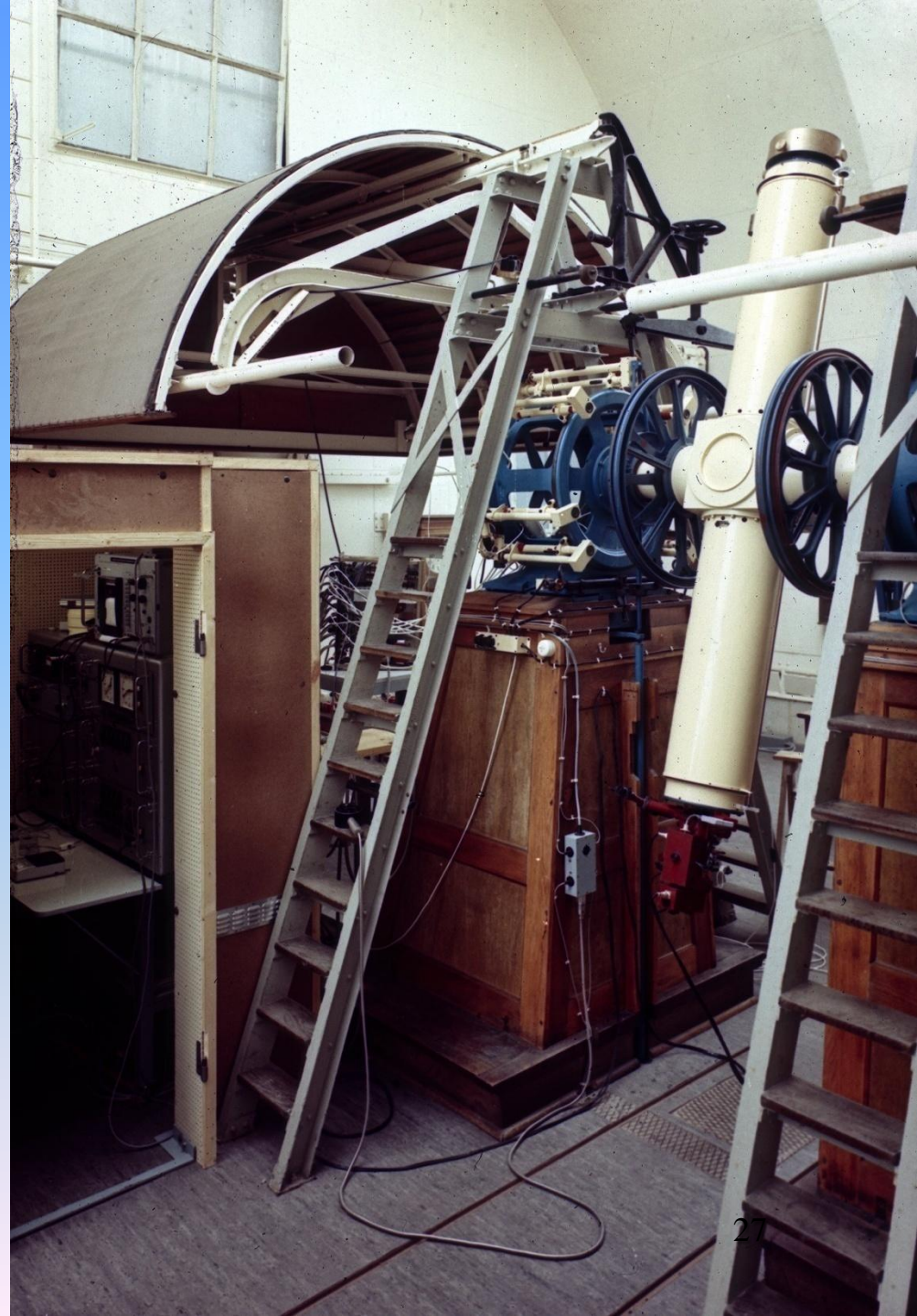
Manual setting of telescope
Photoelectric measurement
of declination circle and star
Recording on punched tape

Hamburg 1966 Repsold meridian circle

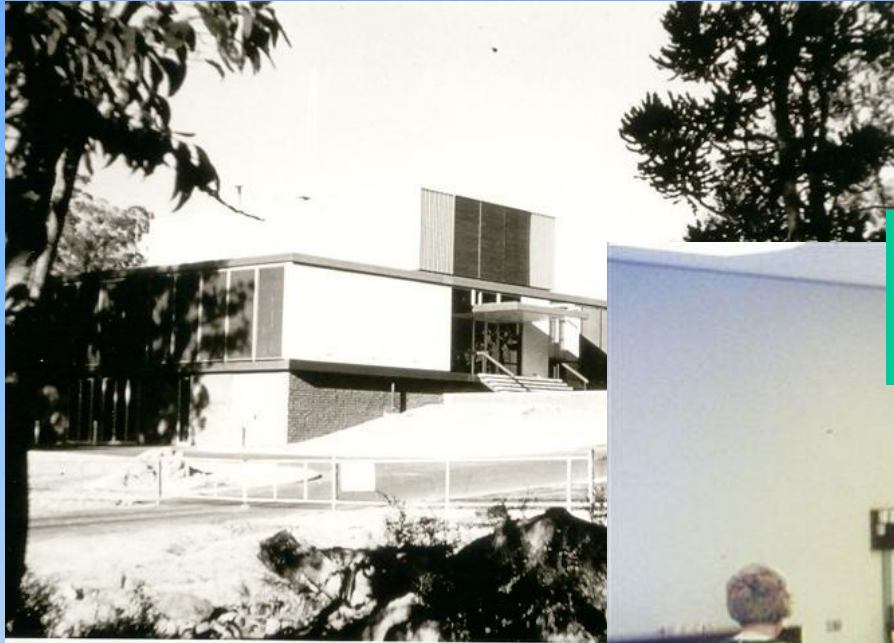
Ready for Perth in Western Australia

Semi-automatic:

Manual setting of telescope
Photoelectric measurement
of declination circle and star
Recording on punched tape



Perth Observatory – 1967-72-80



GIER computer
GIER was *transistorized*

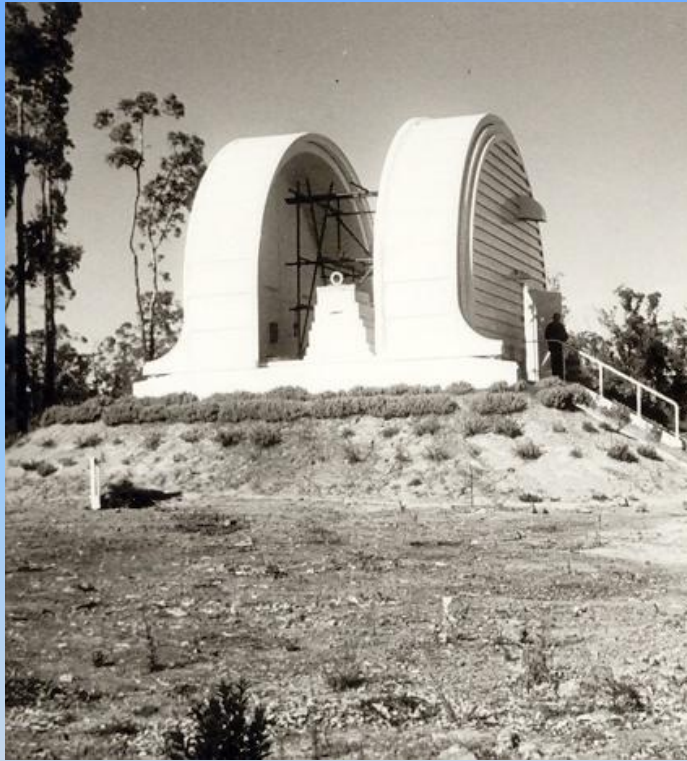
RAM: 0.000 005 Gbytes
Drum: 0.000 07 Gbytes
0.000 0007 Gflops



Mrs. Ilse Holst

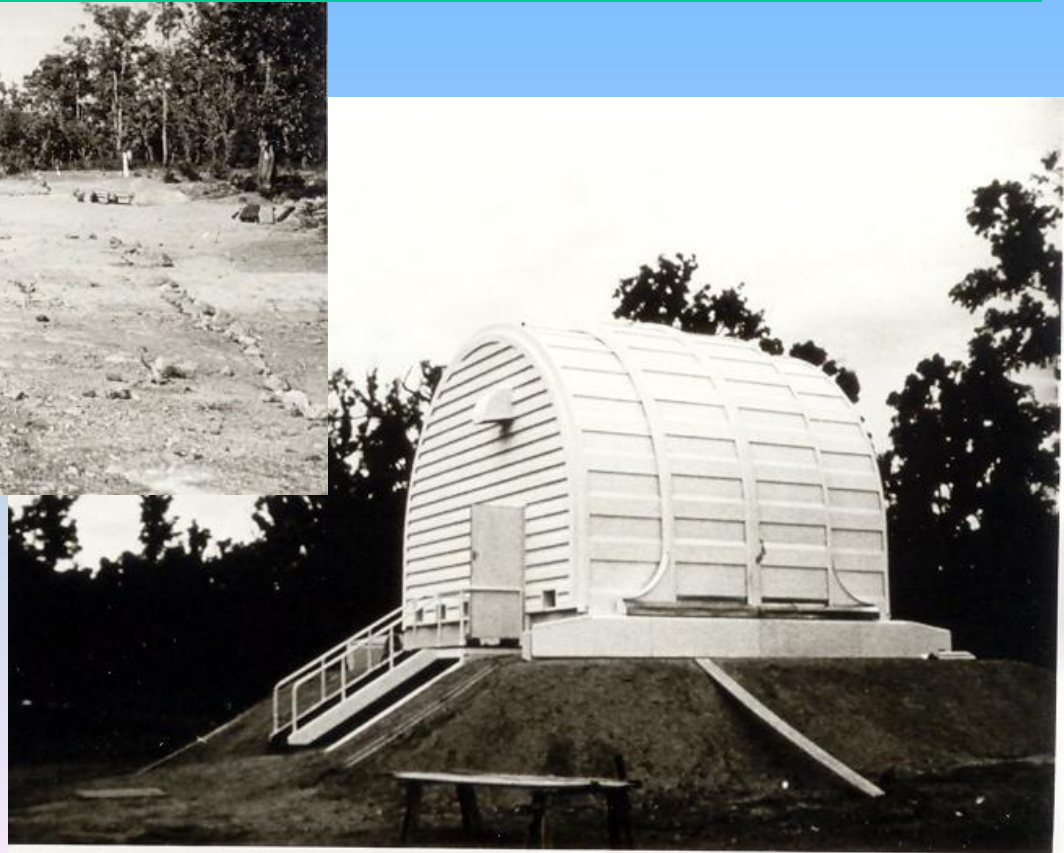
8-channel punched tape:
0.000 1 Gbytes

Perth – meridian pavilion



~260 star obs. per night, incl. 40 FK4s
~22 000 per year !!!

Fantastic for 1970



1975 camping with family



Astrometry

Brorfelde 1953-

Positions & proper motions & parallaxes

Absolute and relative astrometry

Absolute optical astrometry:

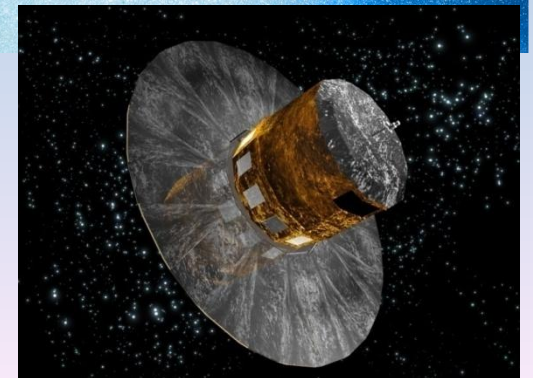
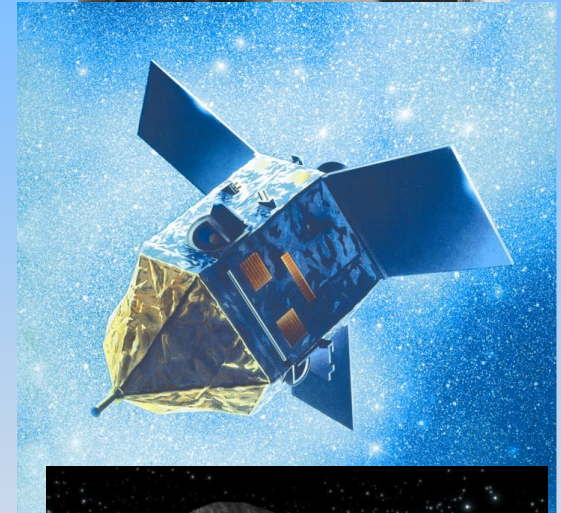
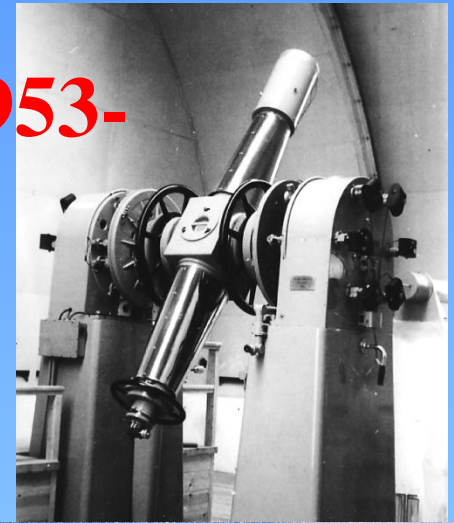
1705- ~1990 by meridian circles
invented and used by Ole Rømer

1989-1993 by Hipparcos satellite
with Tycho experiment 2.5 million stars

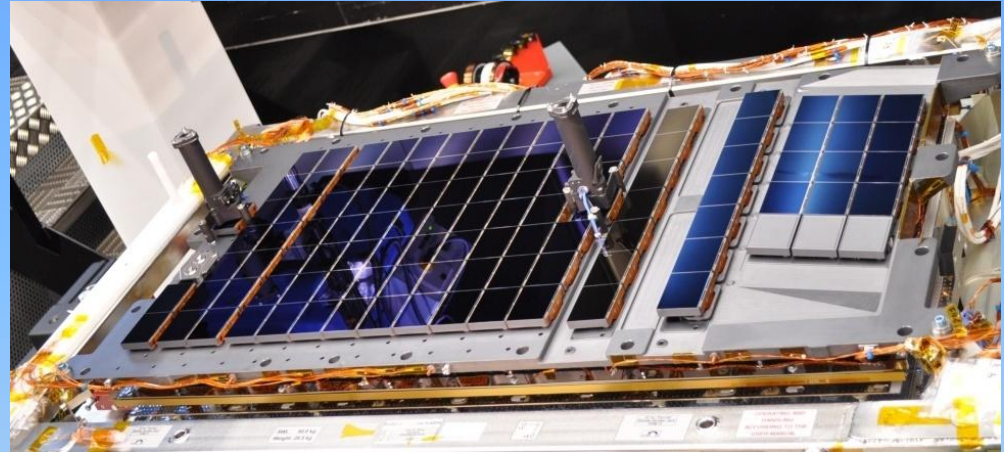
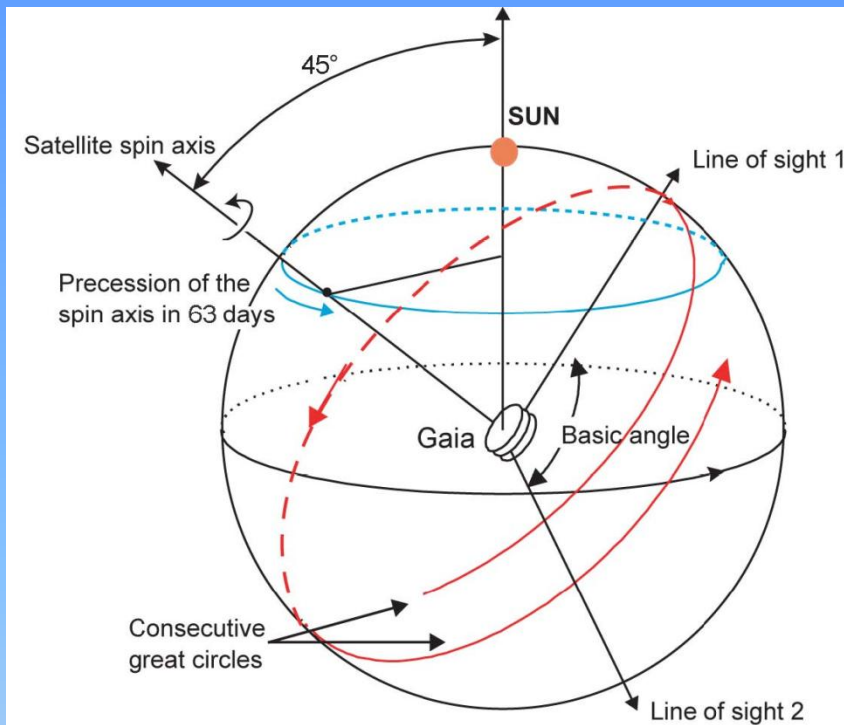
2013... by Gaia satellite
>1000 million stars

Future???

Gaia successor **needed by 2035...**



Gaia Measurement principle



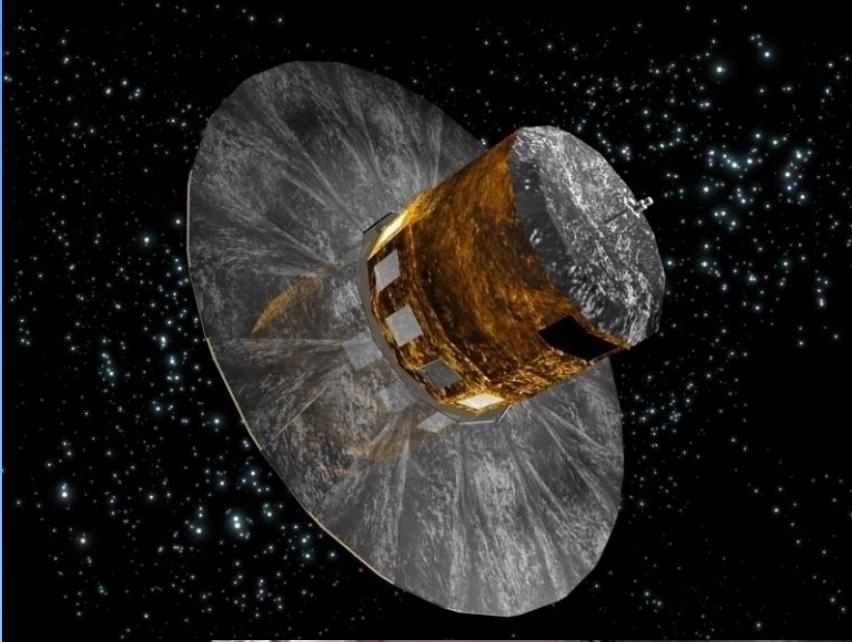
Gaia capabilities

Resolution of the images 0."1, comparable to Hubble Space T.
Gaia will map the entire sky with this detail to 20th magnitude!

With more than 1000 million stars

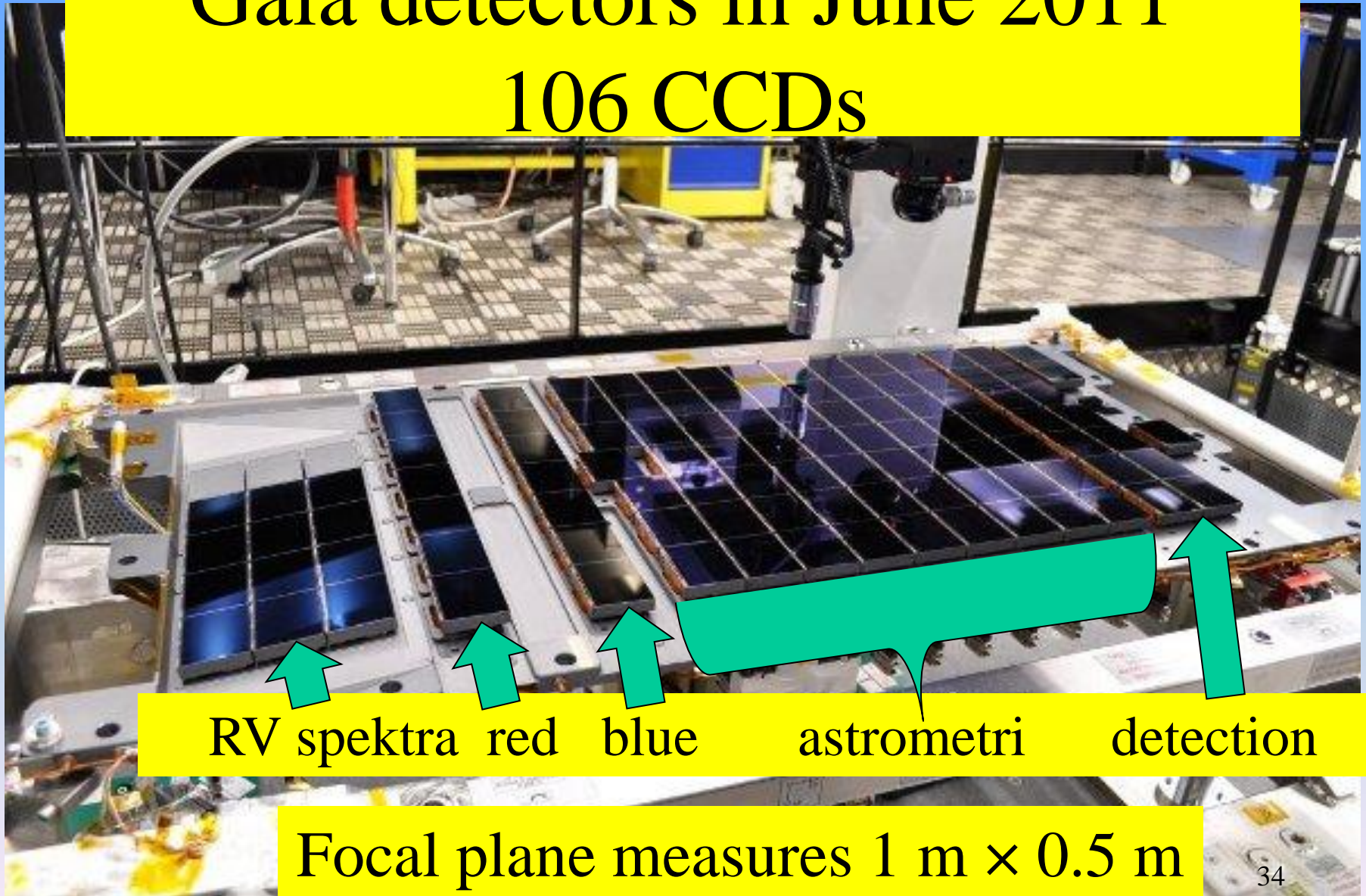
Gaia torus 2011

with one of the mirrors mounted

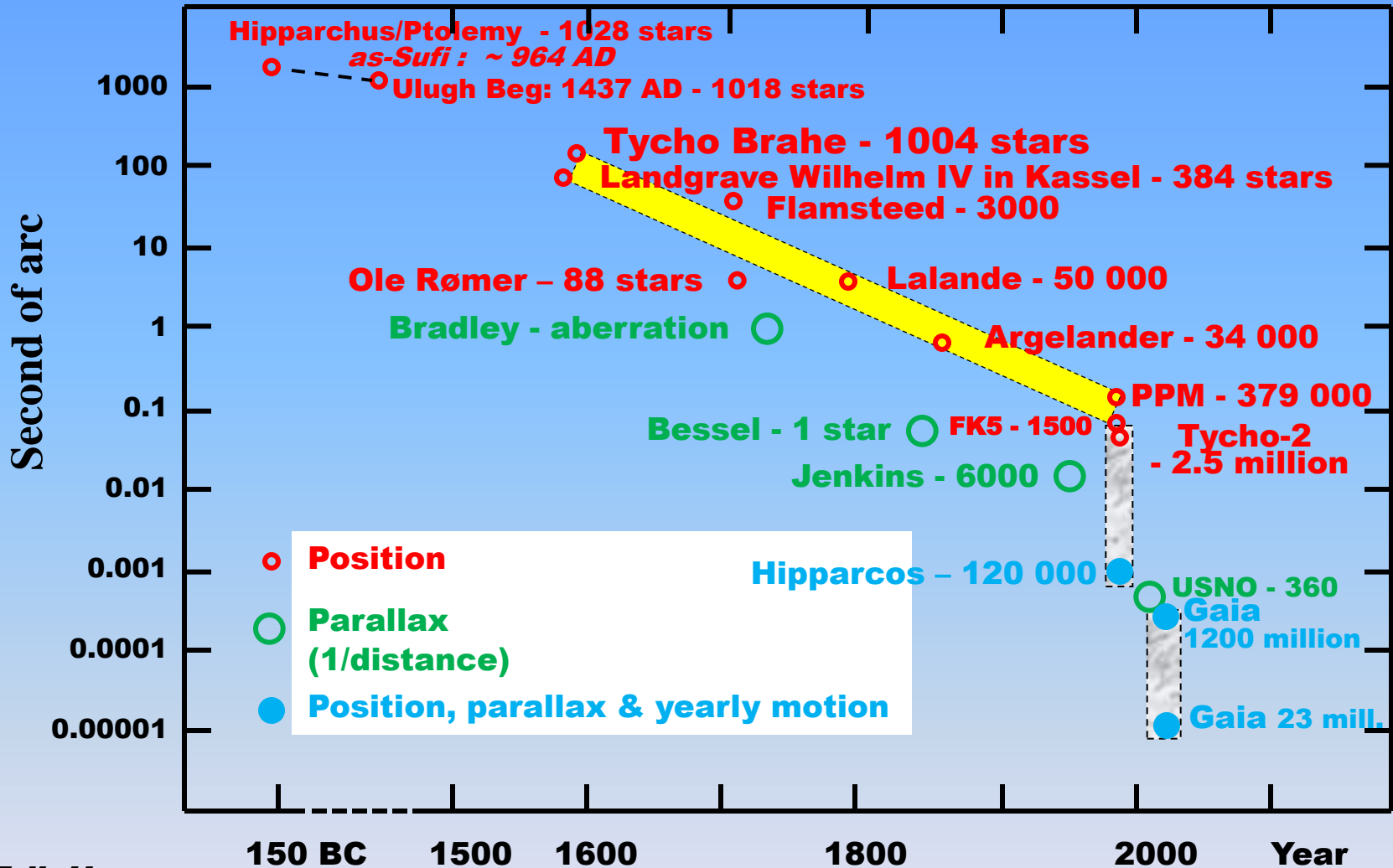


Gaia detectors in June 2011

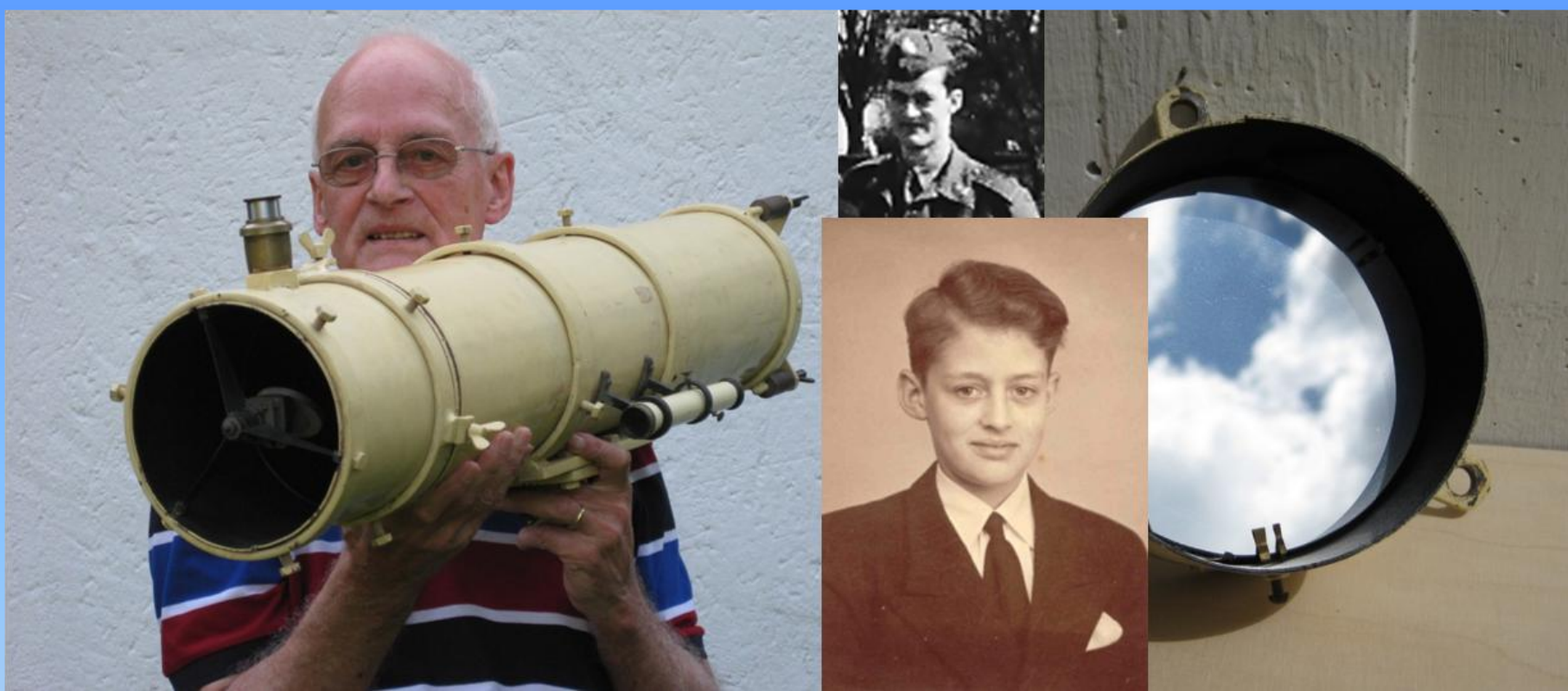
106 CCDs



Astrometric Accuracy during 2000 Years



Erik Høg
1995/2016



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