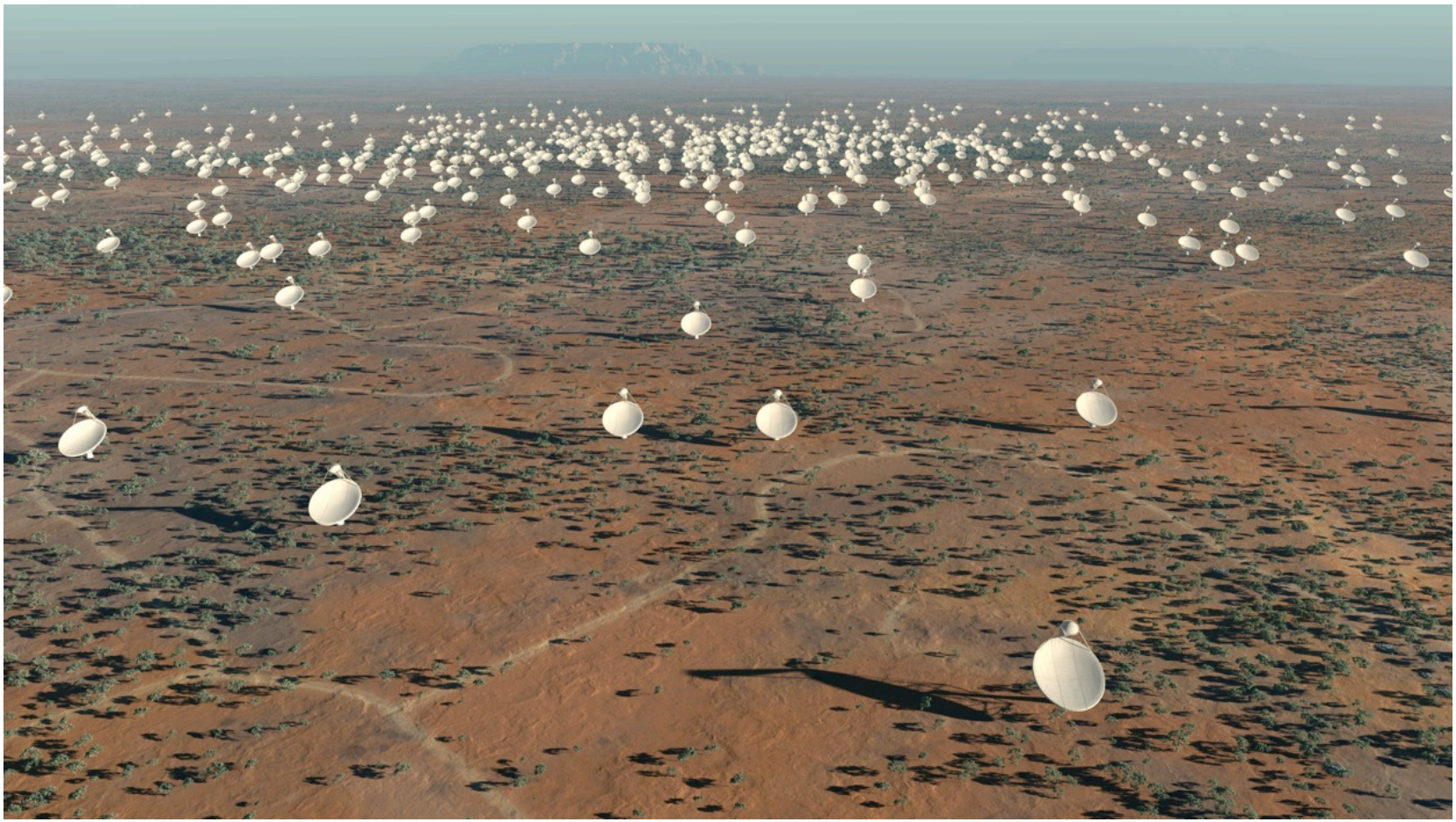
SKA as a green infrastructure

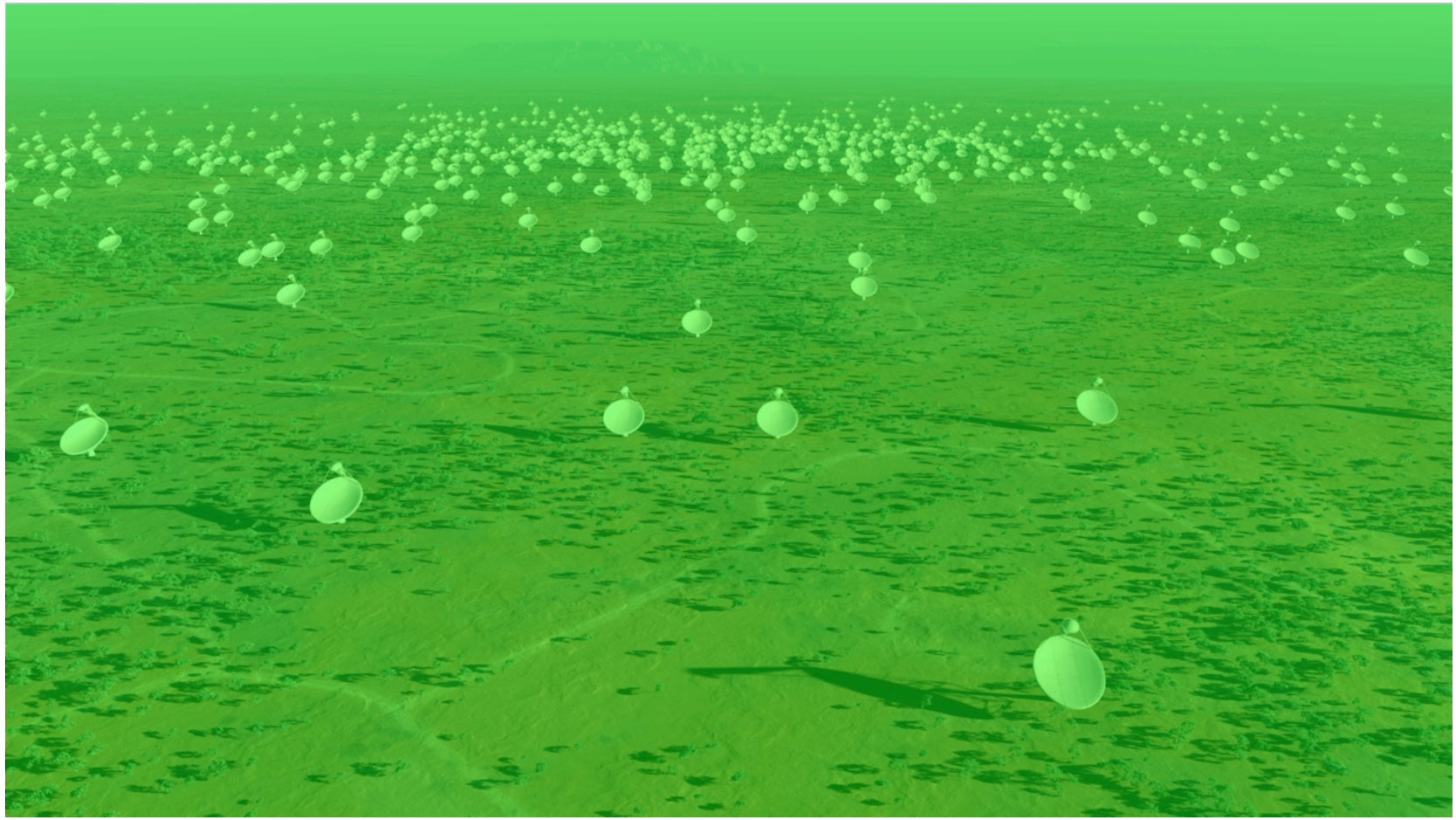


Michael Kramer

20 June2012

MAX-PLANCK-GESELLSCHAFT

SKA as a green infrastructure



Michael Kramer

20 June2012

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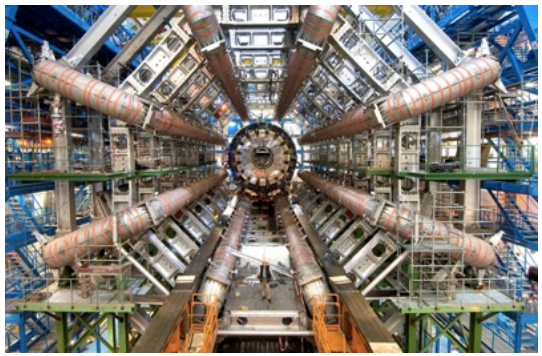
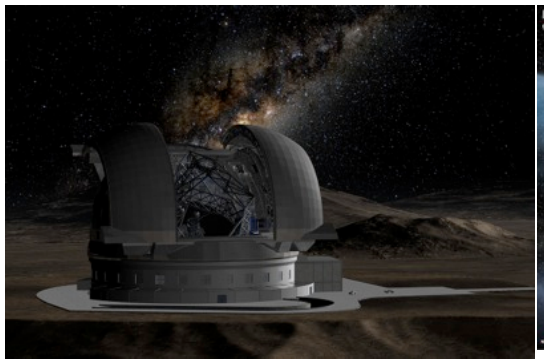
Time for Big Machines

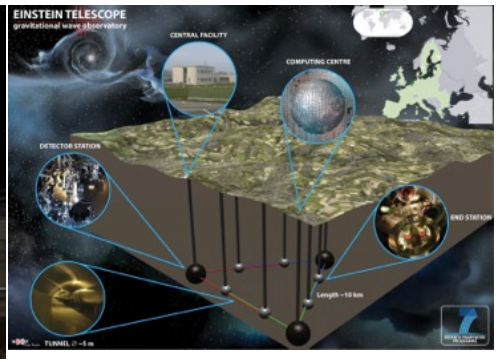
We live in exciting times:

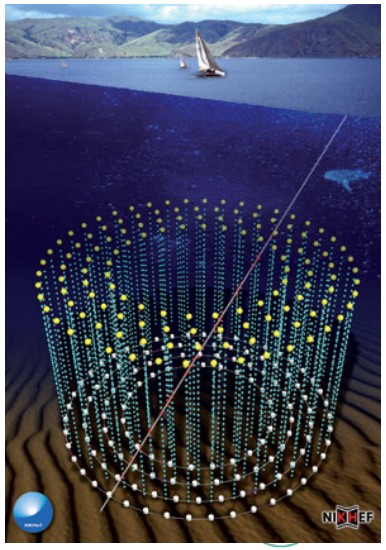
- we are on the verge of confirming some of the most revolutionary theories
- we find clues as to whether these theories are complete or not
- we may find a way to describe large and small scales with one theory
- we are about to trace the complete history of the universe
- we are about to study extra-solar worlds and Earth-like planets
- we are about to open a truly new window to the Universe

But…. It takes increasing efforts to make such fundamental and important discoveries – it needs (typically) BIG machines









Time for Big Machines

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These machines need to be powered – for a long time, hopefully!

➔ Operation costs as well as carbon footprint must be addressed!

This is a realization for a many projects – see talk by Thomas Parker

- here, a radio astronomical example: the SKA!

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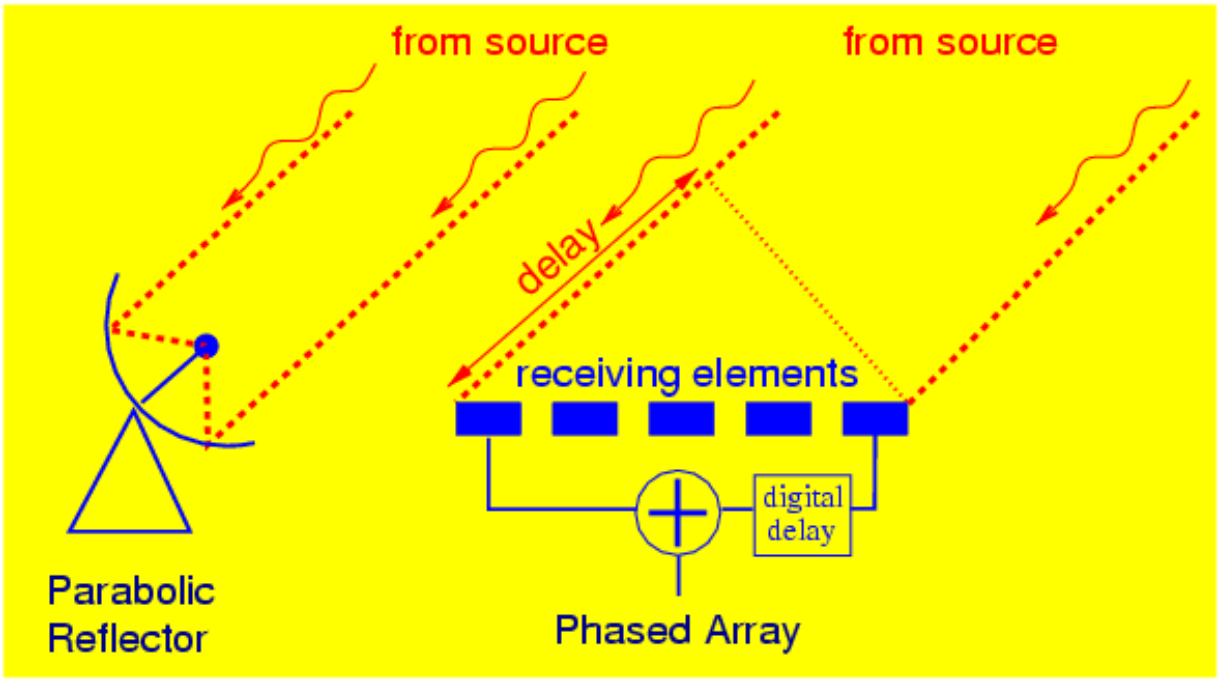
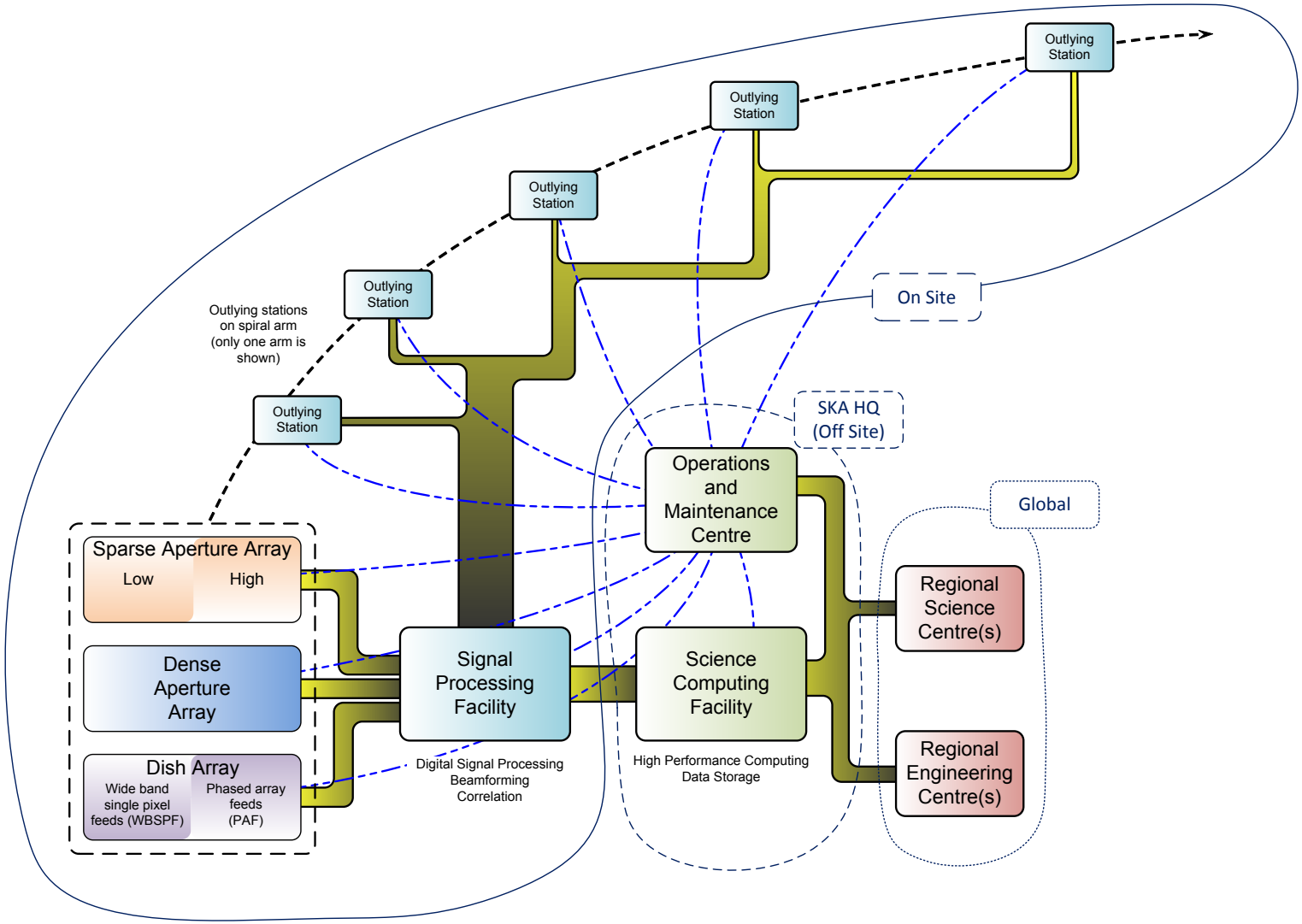
A Revolution in Radio Astronomy

- Go digital! Ability to sample, digitze & process wide bandwidths
- Use of commodity computing power (incl. GPUs) and FPGAs
- Ways of obtaining “cheap” collecting area
- Replacing hardware (i.e. metal) with electronic and software
- Build “radio cameras” to increase “field-of-view” on sky and even allow to look in (sometimes) vastly different directions:



These components are power hungry – we need to feed them!

System Block Diagram



Signal transport networks

European Very Long Baseline Interferometry Network (1 Gbit/s)

EC-FP6 EXPReS

SKA data rates

80 Gbit/s/beam/dish (<200km)

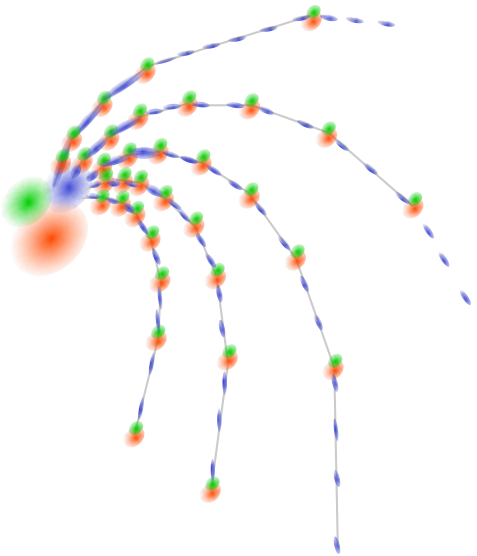
40 Gbit/s/station (20 dishes) (>200km)

~100 Tbits/sec!

About 1 Exabyte per day!! ➔ We need Exa-Scale HPC – that needs power!!

Energy supply

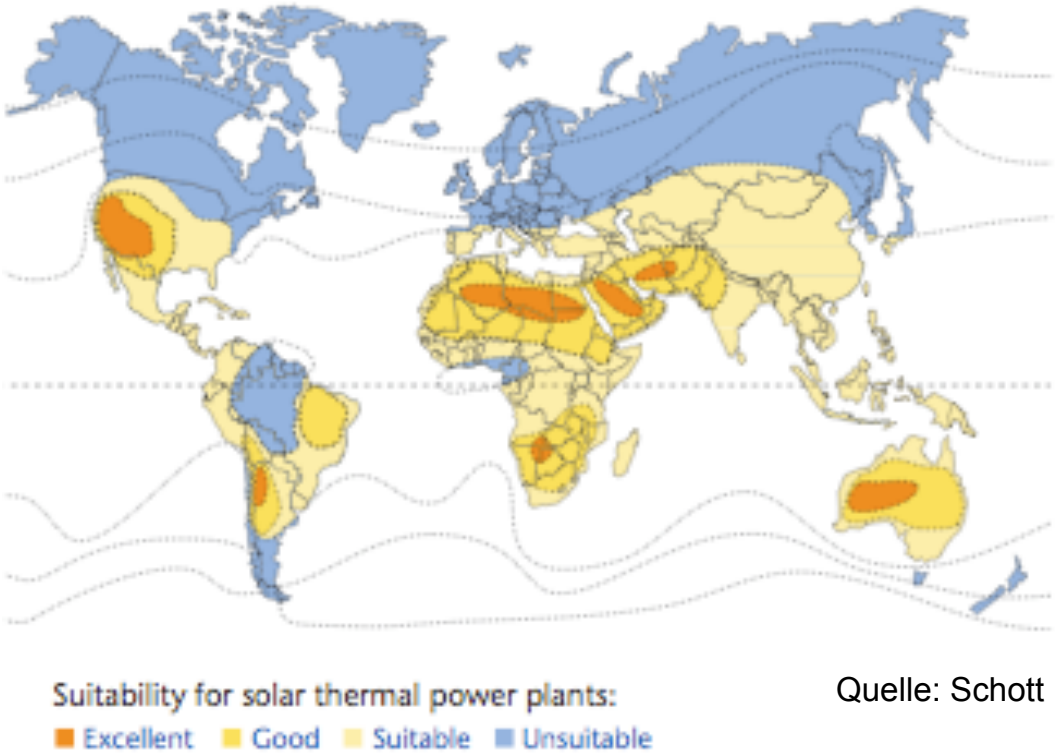
- Digital electronic needs power and needs cooling
- Running costs probably dominated by energy costs
- Sites are far away from civilisation centres and power grid



- Different power requirements – energy mix!
  - Core(s): ~30 to 50 MW
  - HPC centre near core: ca. 50 MW
  - Distant stations: each ~100 kW for ca. 80 stations
  - Differences in peak and average demand (Electronic, cooling, telescope movements)
- Continuous operation 24/7: Storage required?!
- Avoid variations in power supply: power stability
- Environment: Temperature changes, wind, rain

Power supply: Solar Energy?

- Supply with solar energy obvious and best (and only?) solution ?



Quelle: Schott

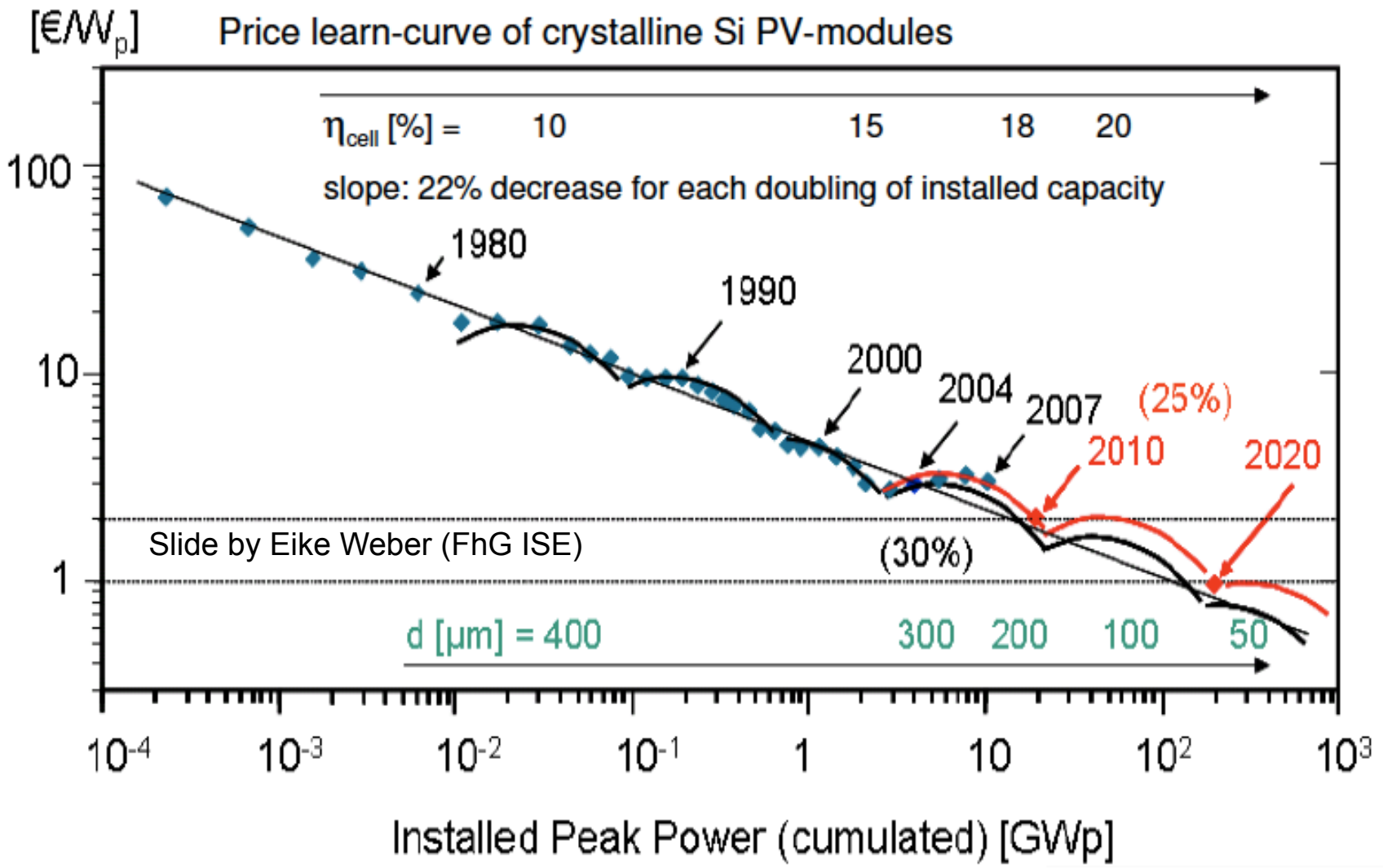
- Excellent light house project for renewable energies (already for "SKA Pathfinders")
- Sustainable energy solution for the whole life time (~50 year)
- Opportunities to open new markets.

The challenges

Power generation is less of a problem, but

- How to store it for 24/7 operation?
- How to avoid causing radio interference?
- How to make it affordable?

Cost evolution



Slide by Eike Weber (FhG ISE)

Note: The SKA will drive innovative solutions in generation, distribution, efficiency and demand reduction in a harsh environment.

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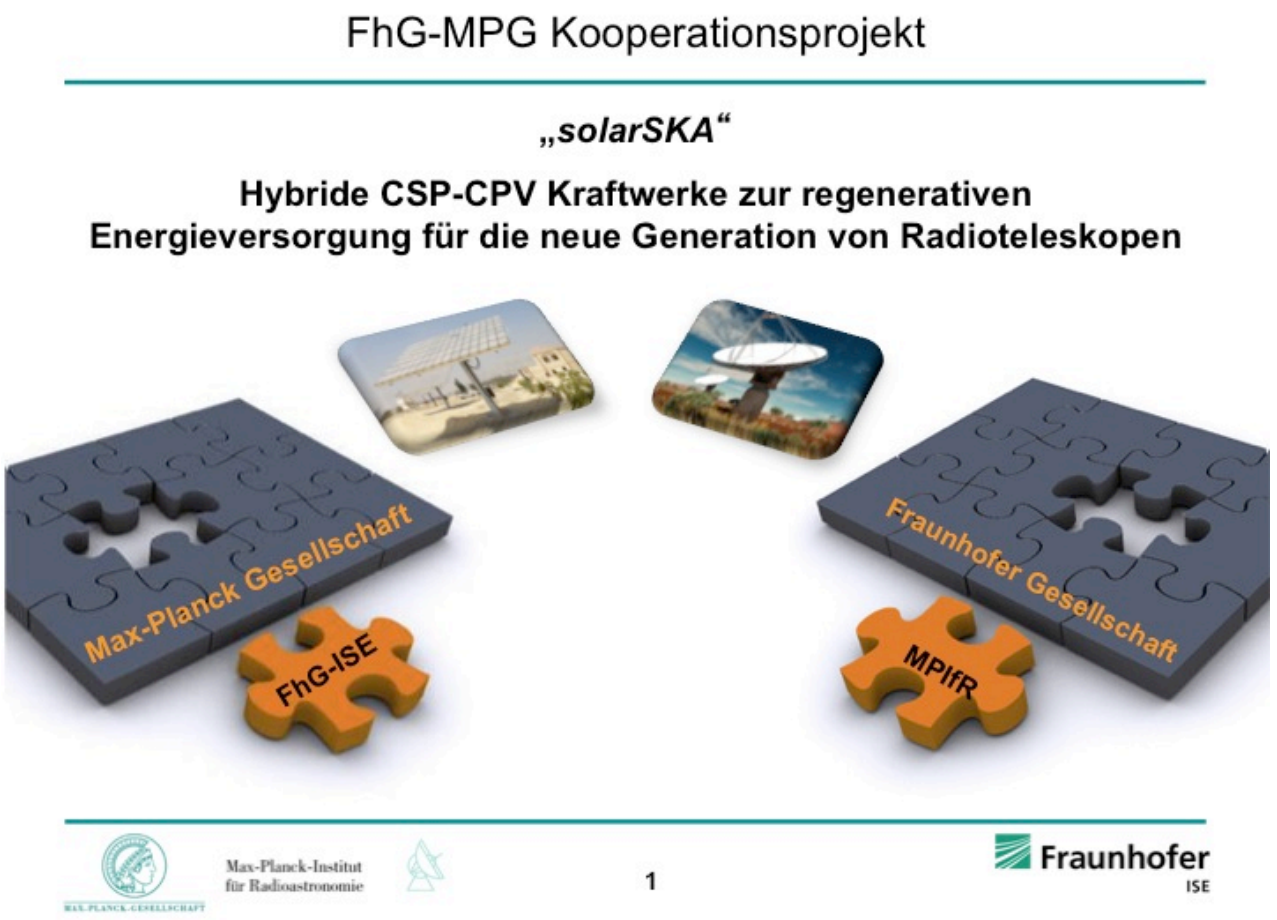
Vision in partnership with Fraunhofer ISE

SKA as lighthouse project for future Mega-Science Projects

World-class sciecne with 100% renewable energy and 0% carbon footprint:



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CPV-Teilsystem: Speicheroptionen

Redox-flow

MW / MWh

NiMh

Source: www.saftbatteries.com

Lithium

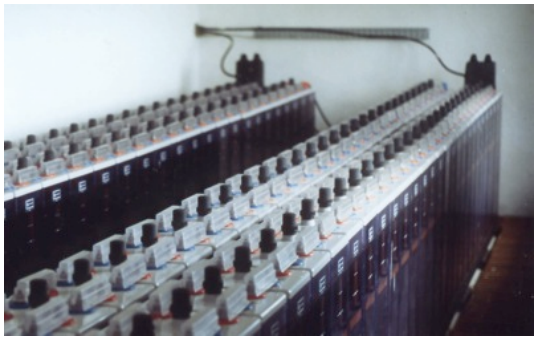
MW

NaS

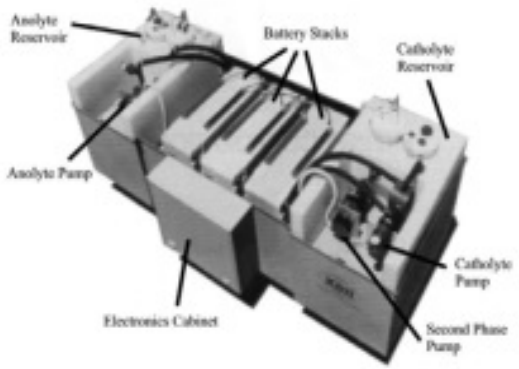
MW / MWh

Source: www.ngk.co.jp

Lead-acid



Zinc-bromine

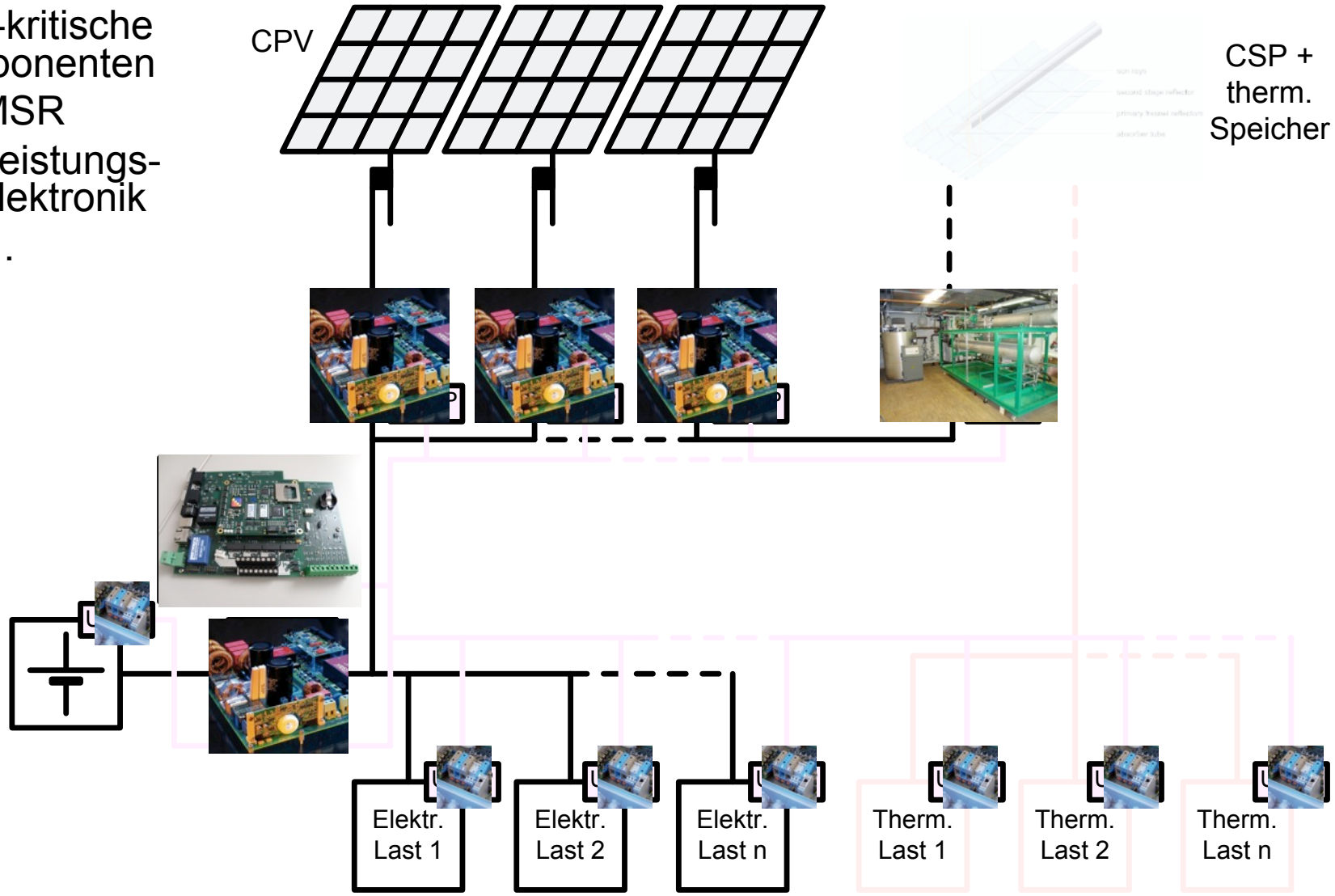


Source: B.L. Norris

SolarSKA: Hybrides CSP-CPV Kraftwerk

EMV-kritische Komponenten

- MSR
- Leistungs-elektronik
- …

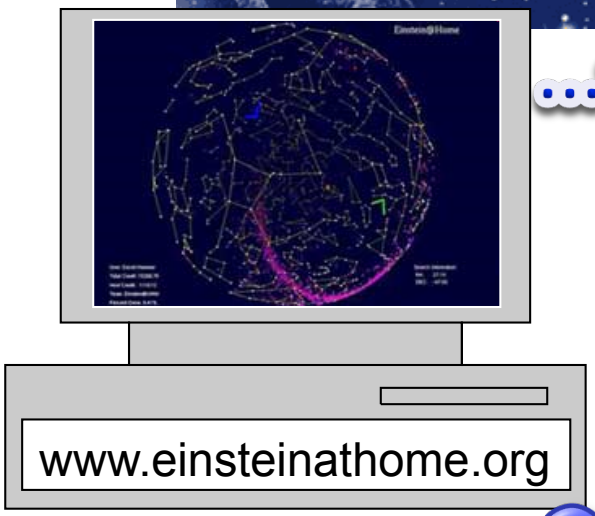


Challenges and ways to make it possible

- Don‘t shoot yourself in the foot:
  - The SKA will be ultra-sensitive – we must avoid producing Radio Frequency Intereference on our own, NB:
    Mobile on the phone = 3rd brightest radio source
  - Balance between power transport, power electronic, losses

- Try to reduce power requirements from the start (green HPC, low-power devices, efficient architecture)
- Use combination of technologies,
  e.g. add geo-thermal cooling
- Develop effective, efficient and inexpensive storage solution
- New Markets: 1.6 Billion people without access to power grid!!
- Use the public attraction of astronomy!

Public is very keen to be involved: An Example...



...finding pulsars with your screen saver!

Over 300,000 volunteers providing 450 TeraFlops

Conclusions

- Green energy solution should be considered for other remote sites (e.g. APEX, ALMA)
- The SKA can serve as a lighthouse project to demonstrate 24/7 operation with 100% renewable energy independent of grid-solutions
- It can be a prime example for sustainable Mega-Science with 0%-Carbon Footprint
- With astronomy (and SKA's Key Science, e.g. Einstein, Black Holes ..) appealing enormously to the public, the SKA can break ground for other projects
- Required energy mix (mini-grid solutions with storage) is likely to produce solutions for many applications
- Key to the success of a 100% RE-SKA will be the development of innovative systems solutions: PV, CPV, CST solar power, wind if available, plus storage
- It is not clear whether we can afford it, but "Green Astronomy" is likely to be spectacularly popular
- In any case, we may not be able to afford to pollute the Earth for the exploration of the Cosmos

It is not easy – but we should certainly try it!

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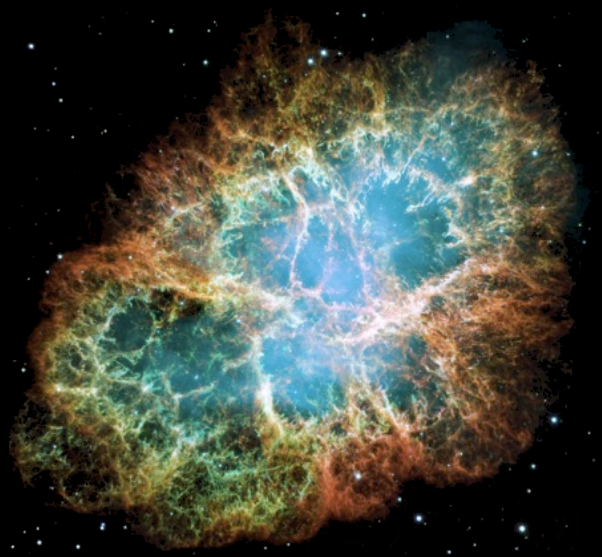
If you let an astronomer dream…



100,000,000,000,000,000,000,000,000,000 MW!

= One second of Crab's energy output sufficient for Universe's lifetime!