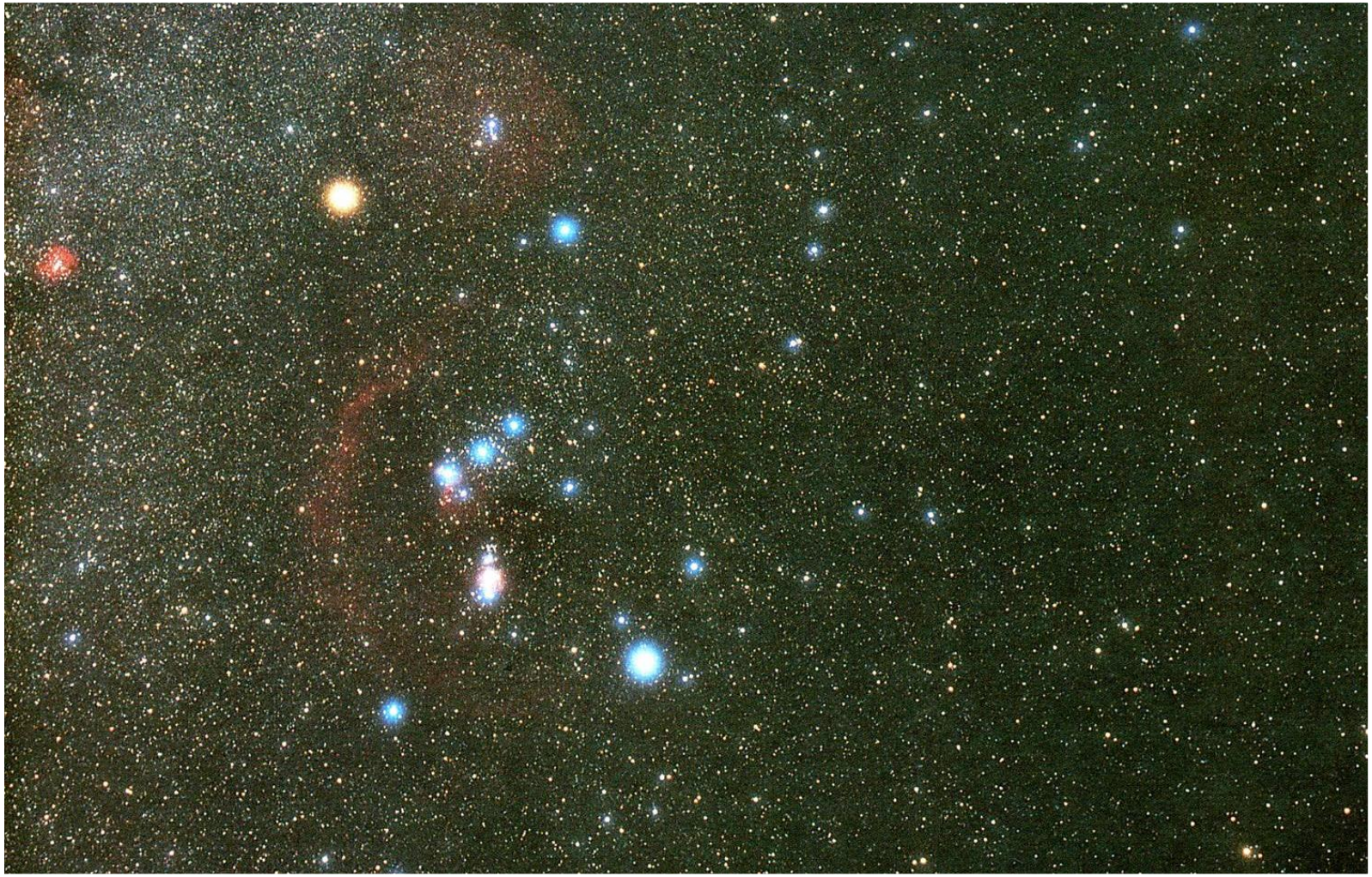
Astronomie mit Gammastrahlung

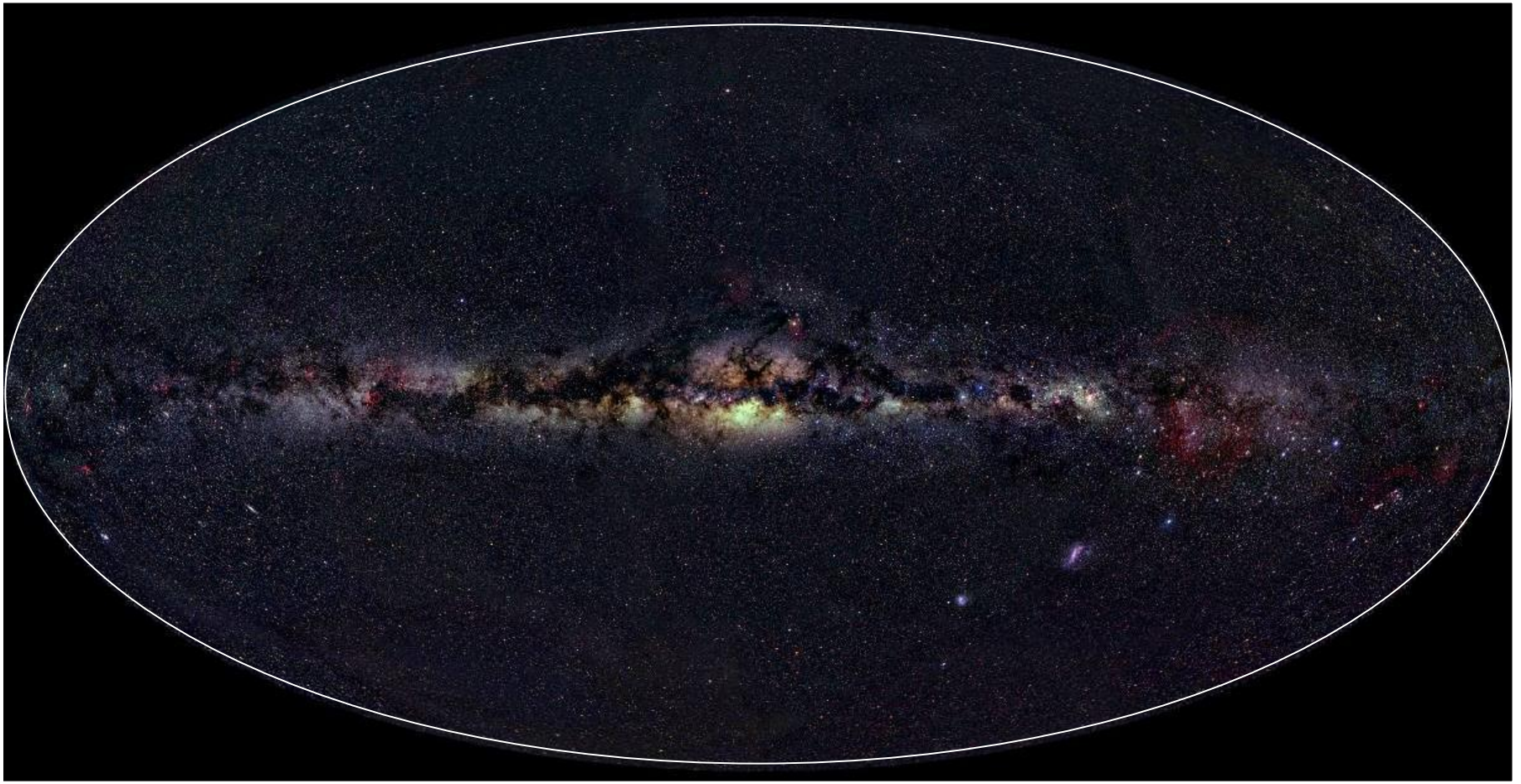
Christian Stegmann
Erlangen Centre for Astroparticle Physics
Universität Erlangen-Nürnberg
Berlin, October 2010

Das Sternbild Orion

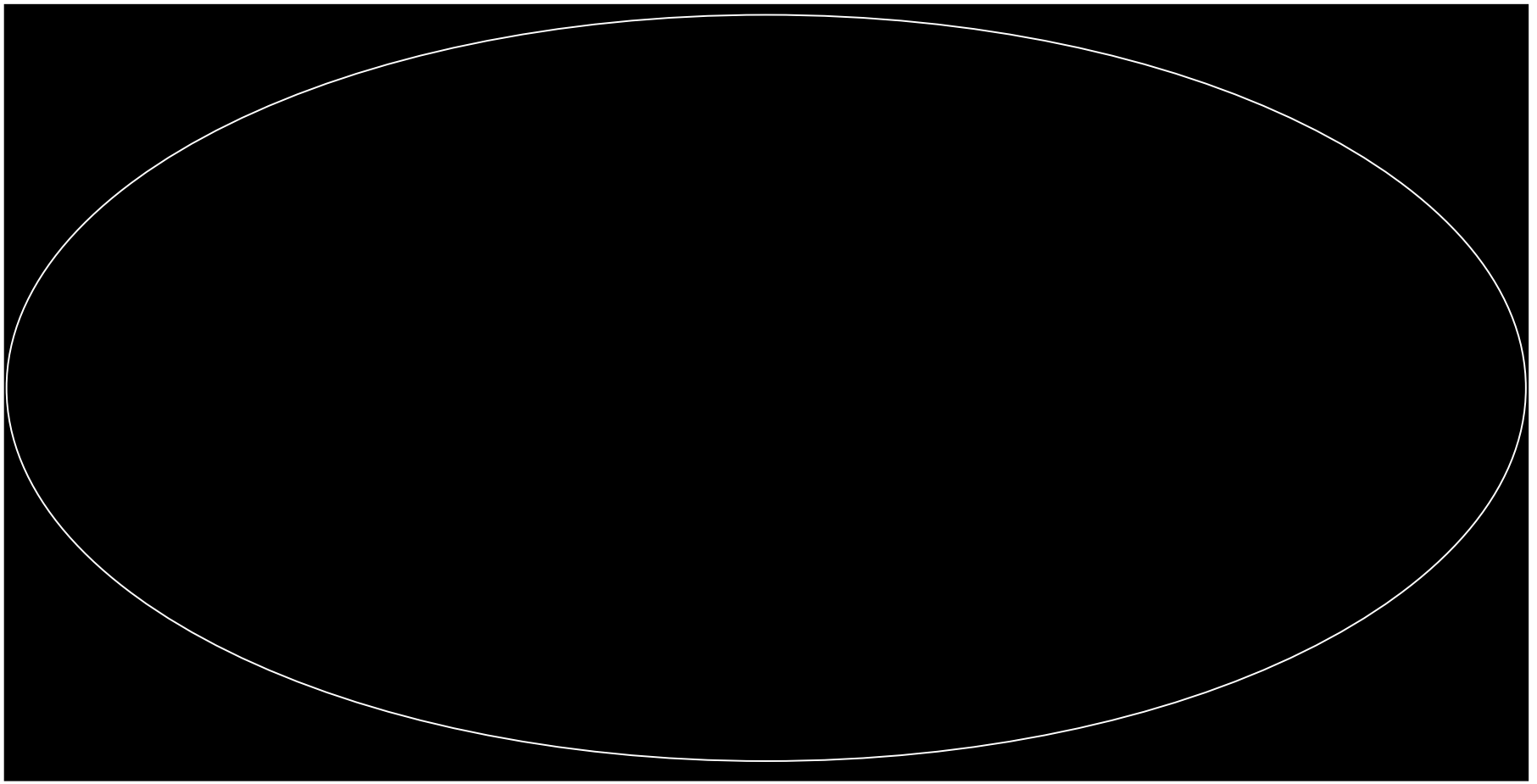


Unsere Milchstrasse

Unser Nachthimmel bei 1 eV

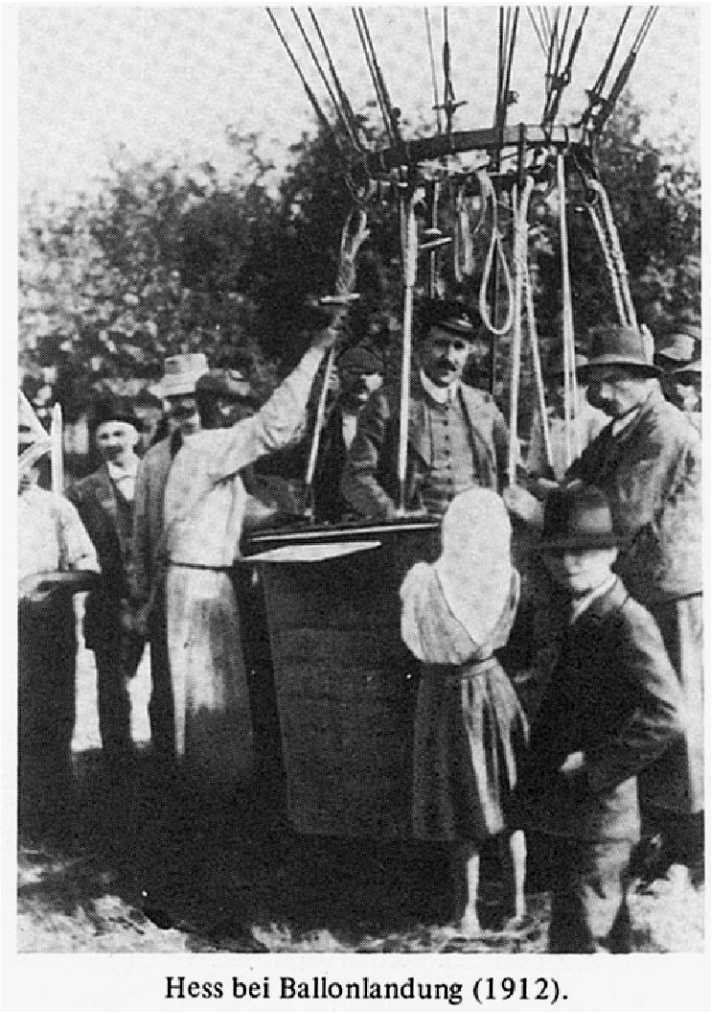


Unser Nachthimmel bei 10^{12} eV (vor 20 Jahren)

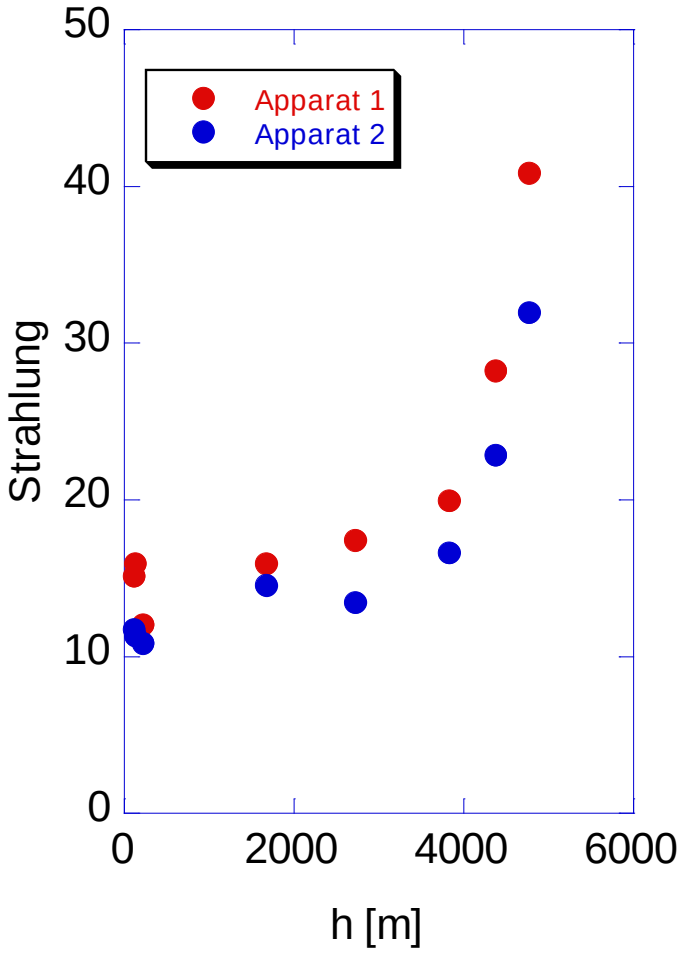


Die Kosmische Strahlung – ein Teilchenregen aus dem Weltall

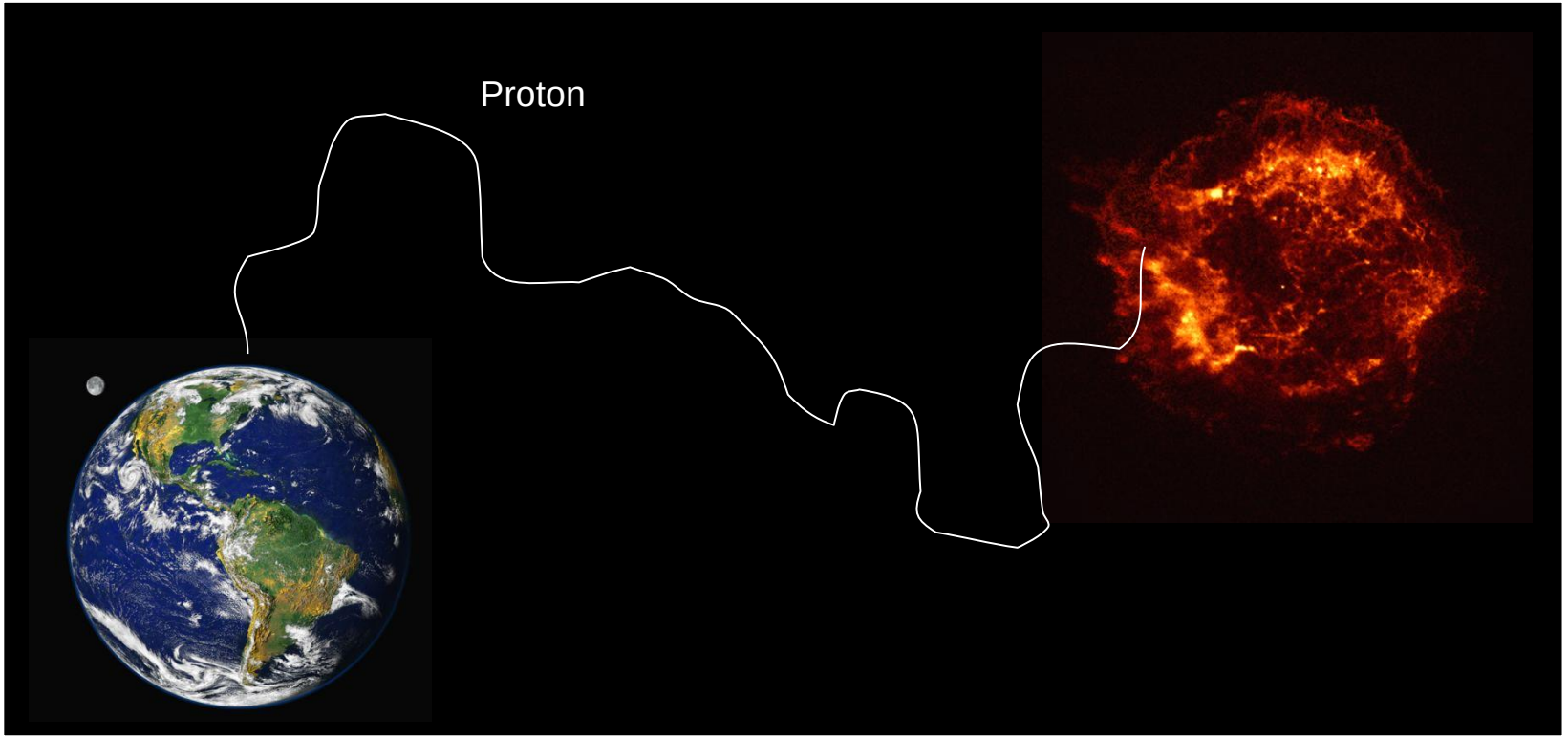
- 1912: Die Entdeckung durch Viktor Hess



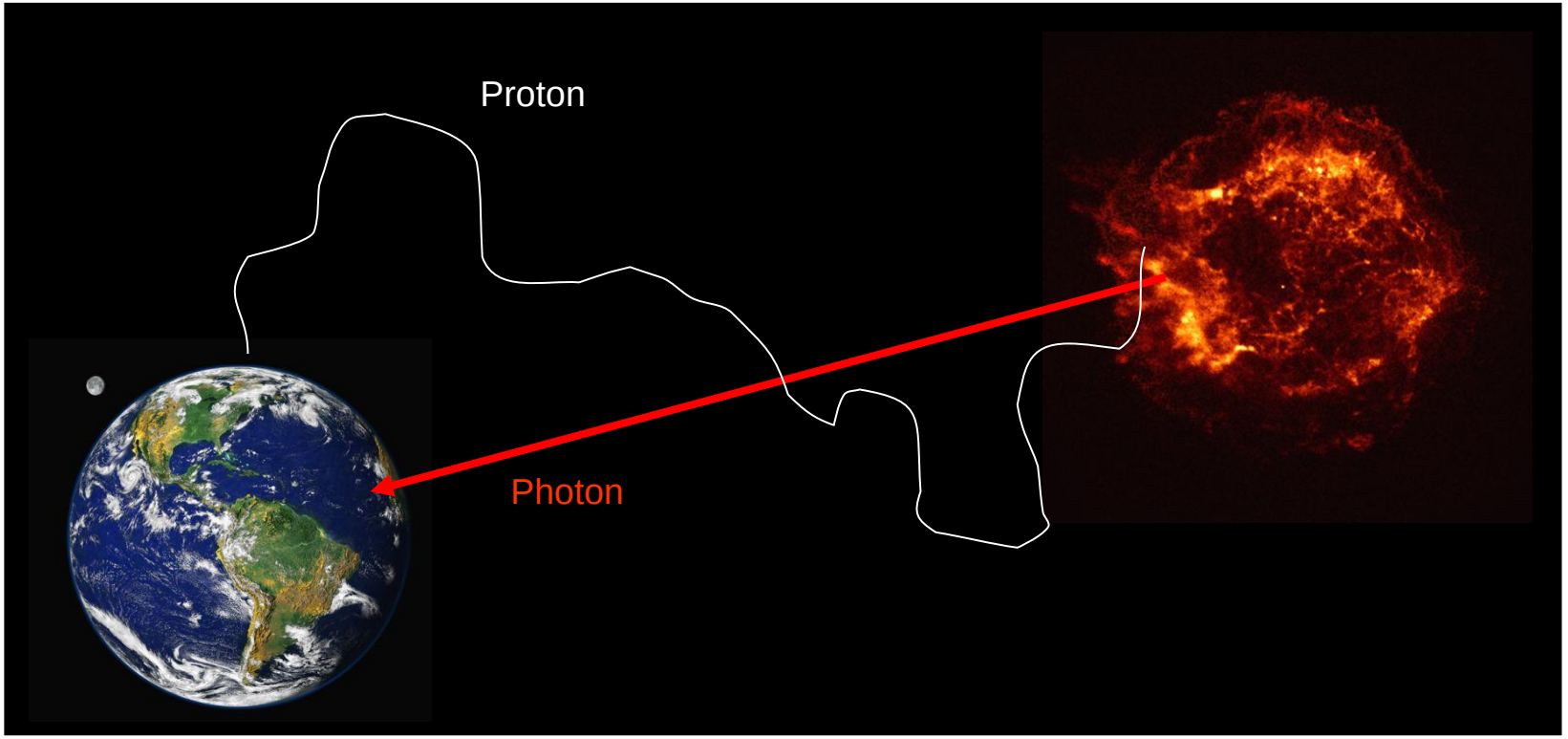
Hess bei Ballonlandung (1912).



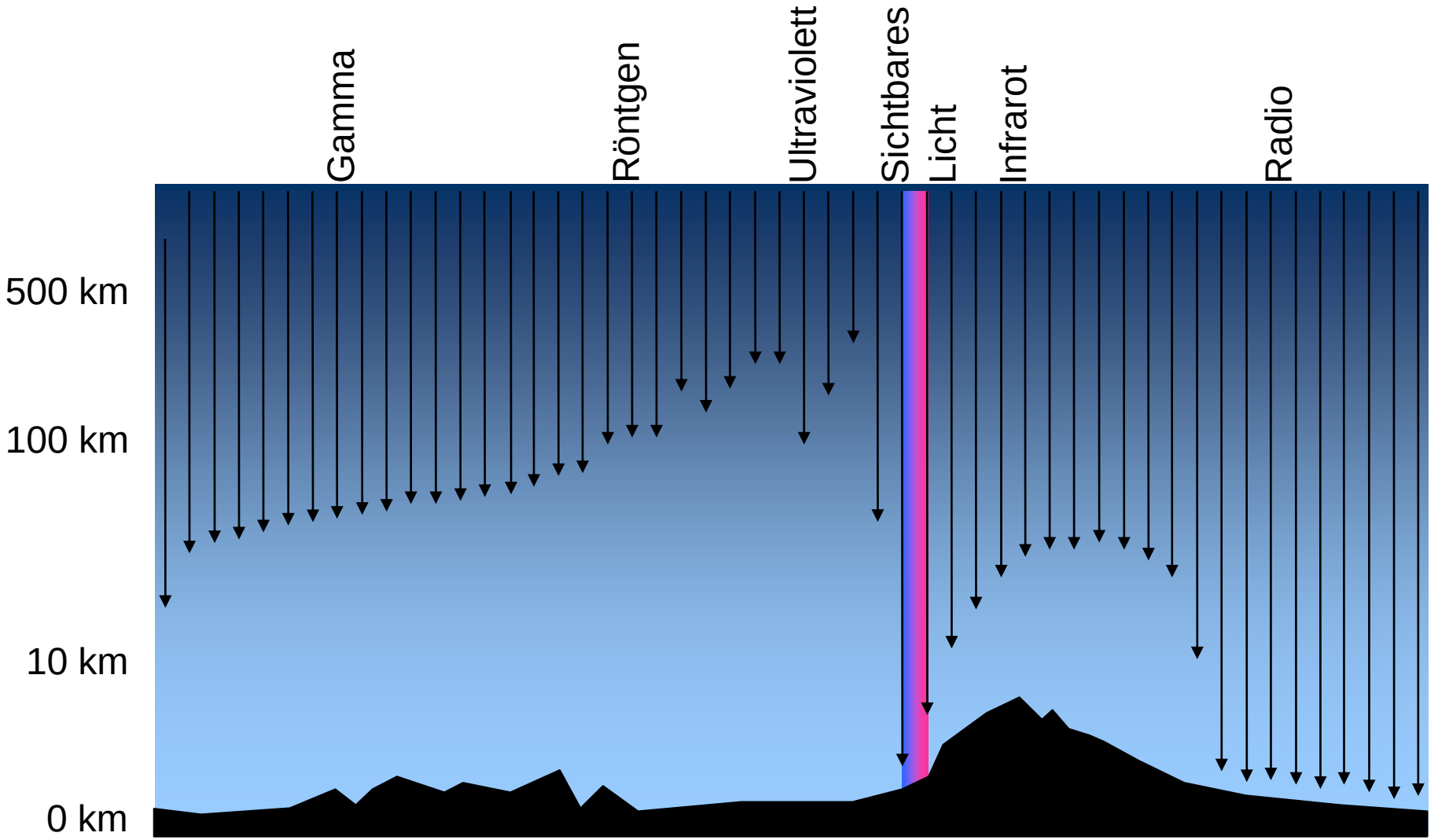
Wo sind die Quellen?



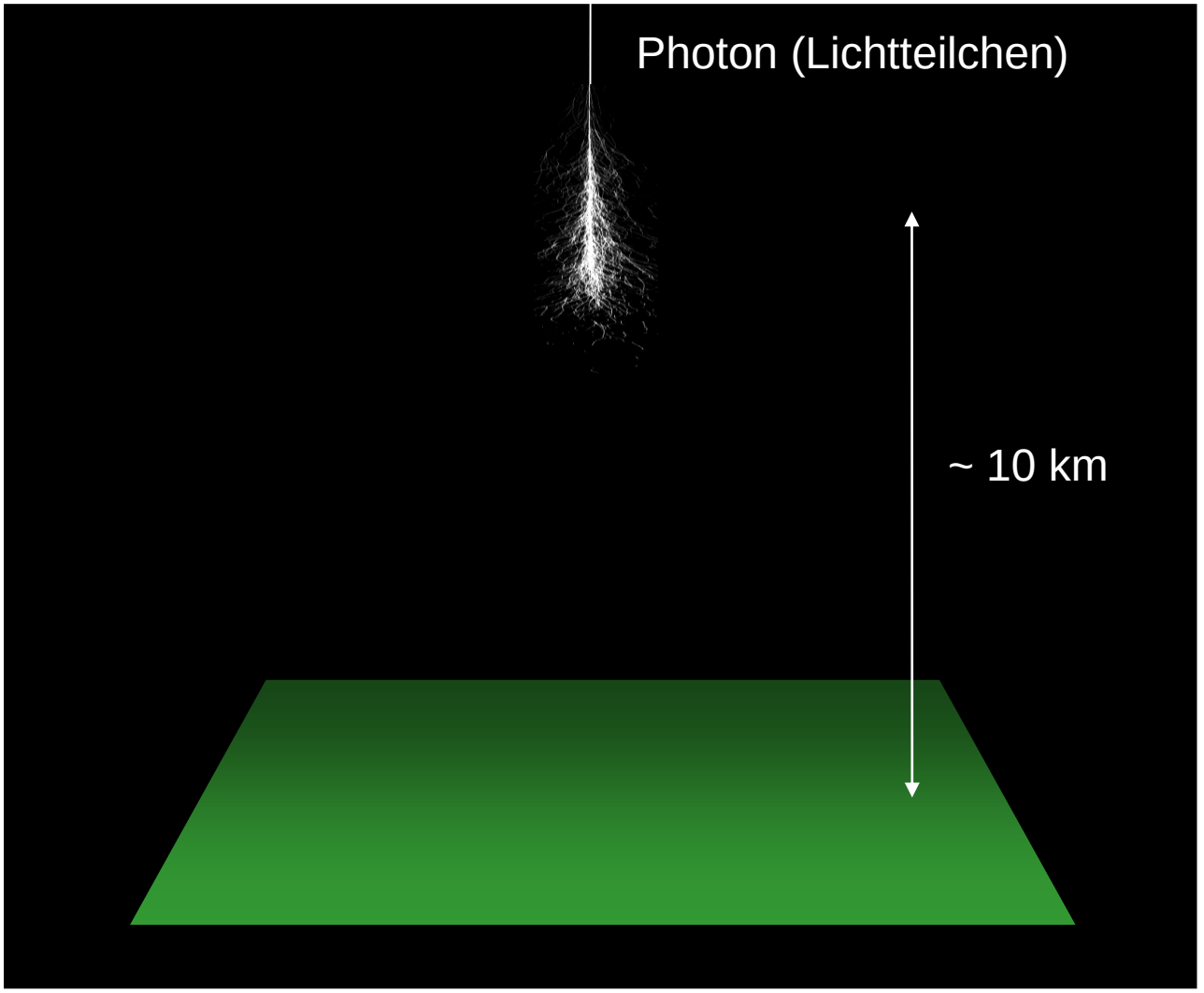
Gammastrahlung zeigt zurück auf die Quelle!



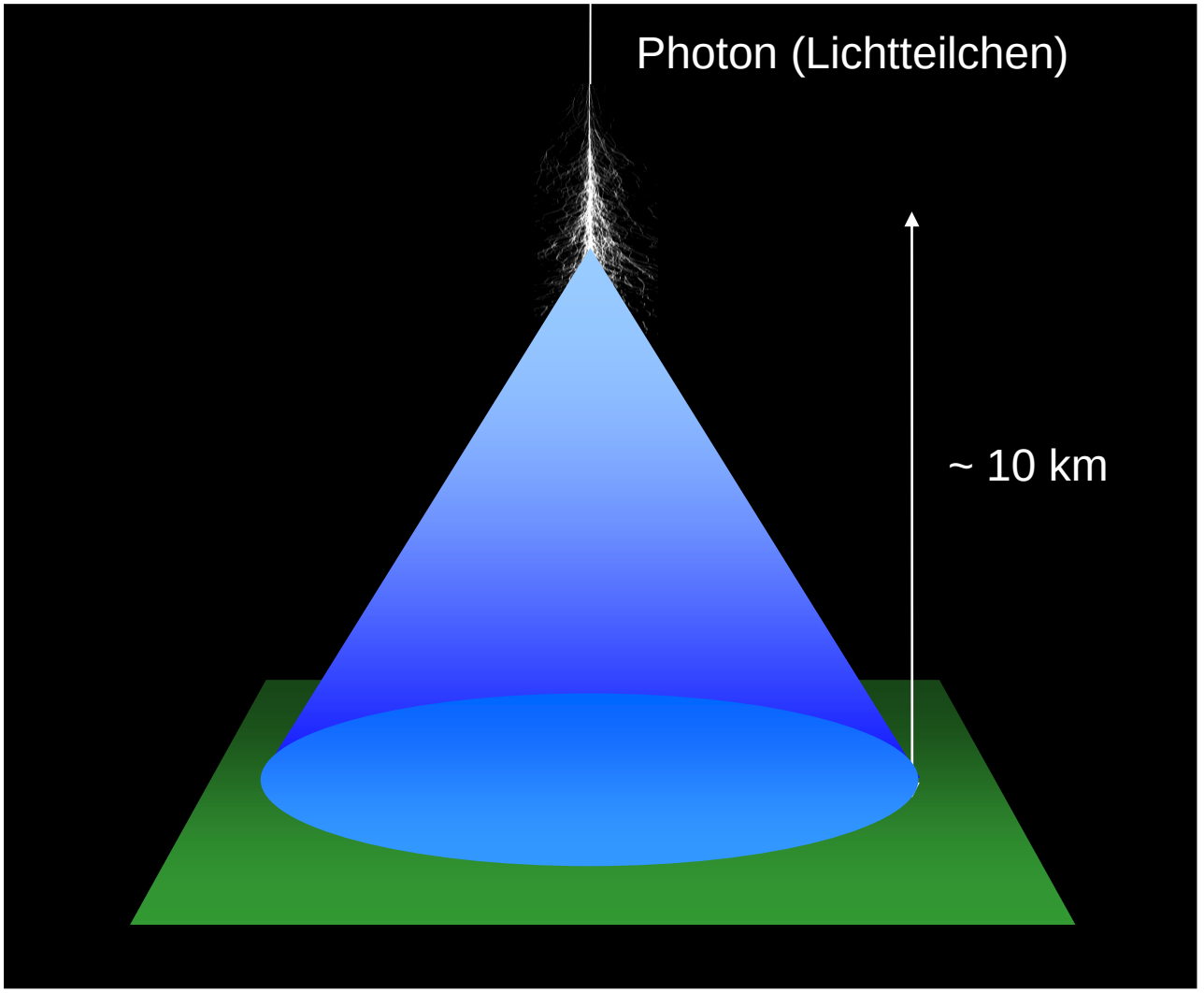
Unsere Atmosphäre ist undurchsichtig für Gammastrahlung!



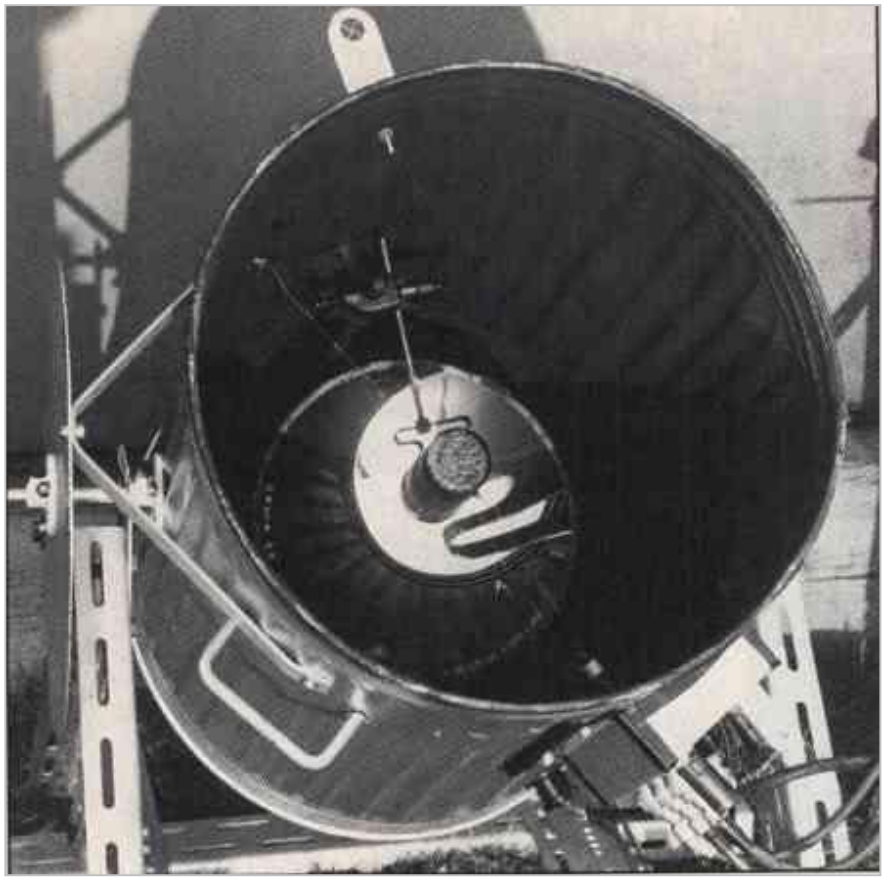
Nachweis der Gammastrahlung



Nachweis der Gammastrahlung



Der Anfang

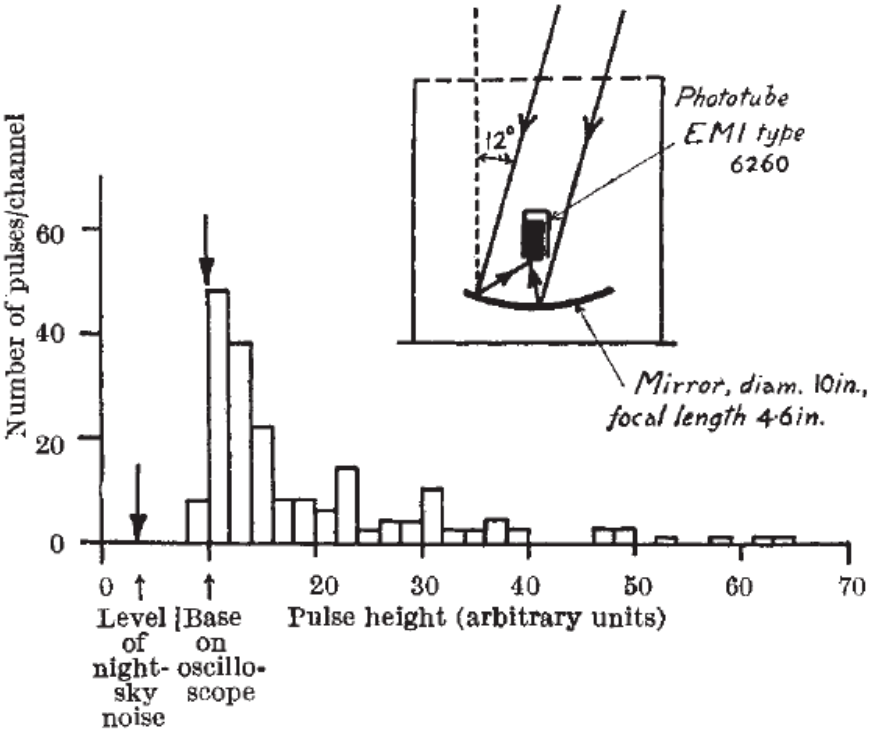


Galbraith and Jelley, 1953

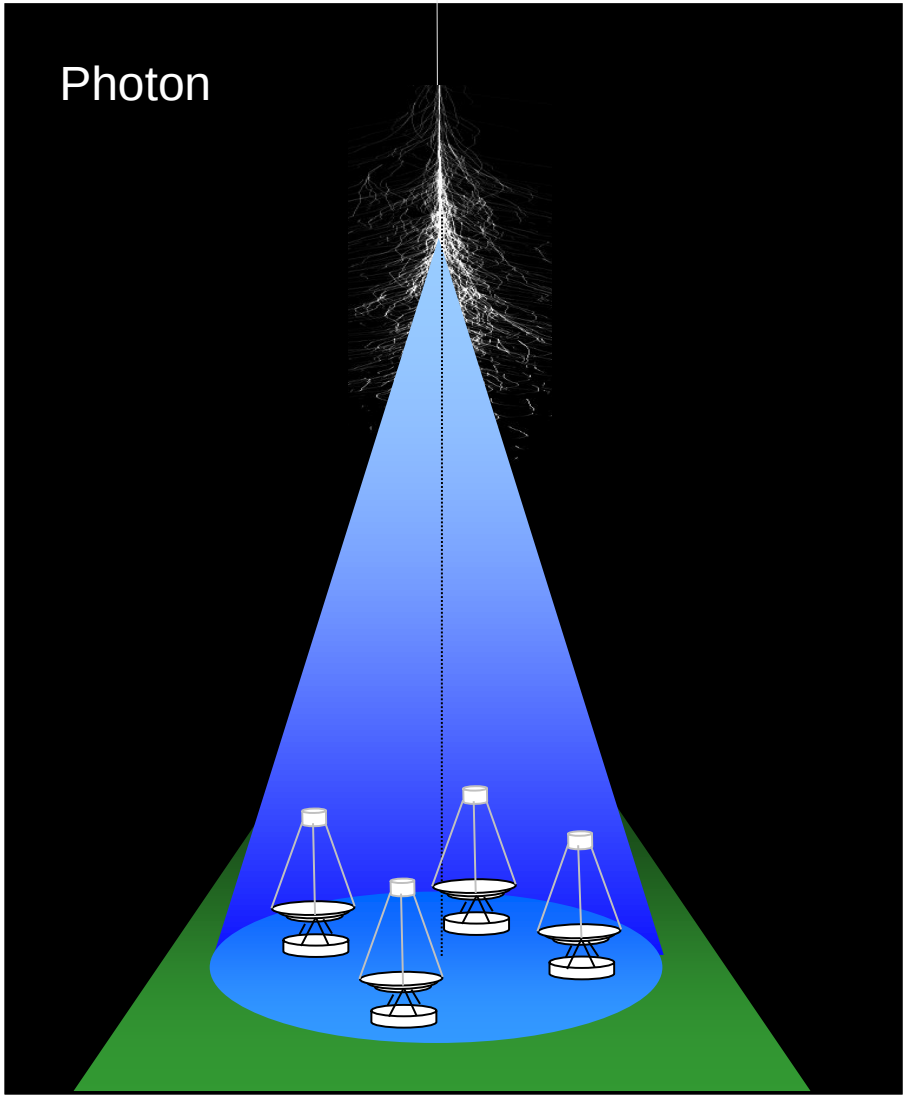
February 21, 1953 NATURE

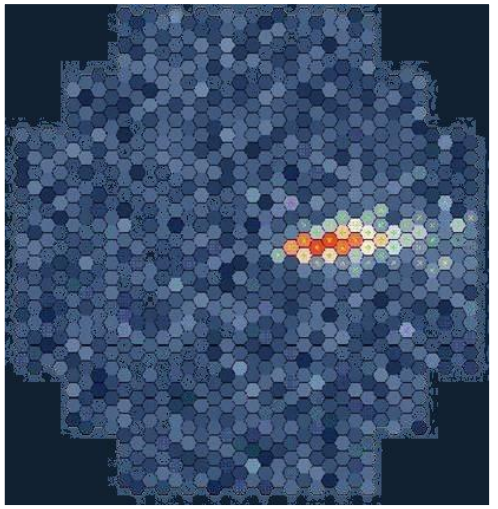
Light Pulses from the Night Sky associated with Cosmic Rays

In 1948, Blackett[1] suggested that a contribution approximately 10^{-4} of the mean light of the night-sky might be expected from Čerenkov radiation[2] produced in the atmosphere by the cosmic radiation. The purpose of this communication is to report the results of some preliminary experiments we have made using a photomultiplier, which revealed the

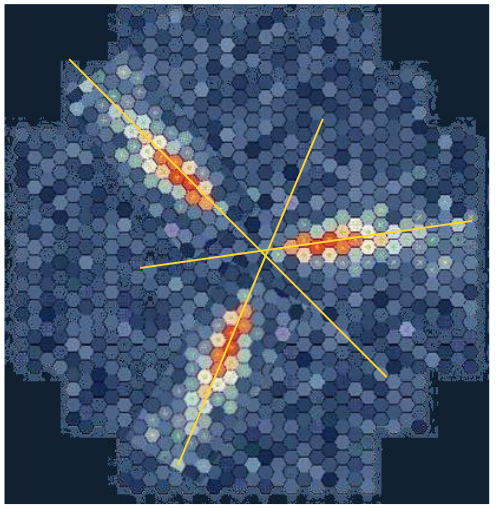


Wie kann man Gammastrahlung messen?





Einzelteleskop-Ereignis



3-Teleskop-Ereignis
In gemeinsamer
Kameraebene

- Intensität → Energie
- Orientierung → Richtung
- Form → Primärteilchen

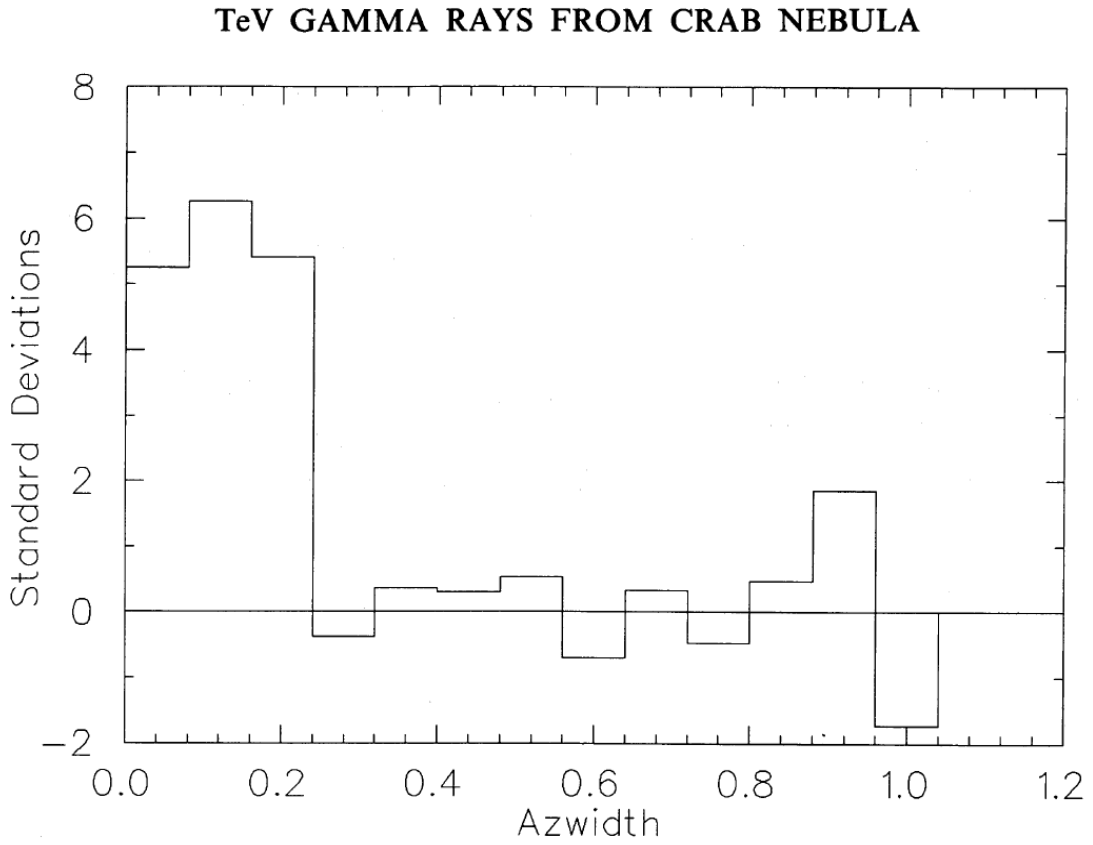
Viele Meteore

Die Entdeckung des Krebs-Nebels (Supernova 1054)

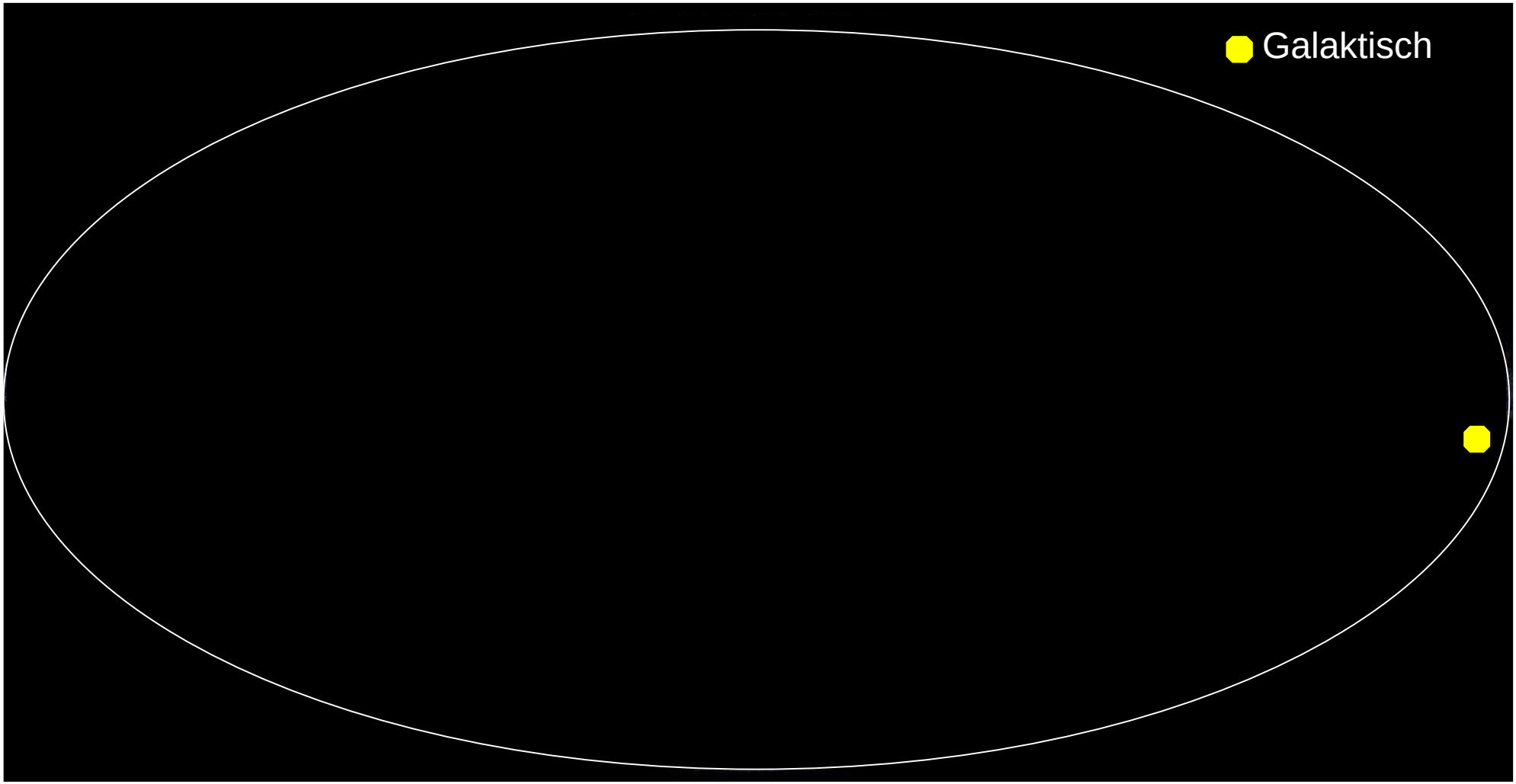
Der Krebs-Nebel im Optischen

1989: Die Entdeckung des Krebs-Nebels (Whipple)

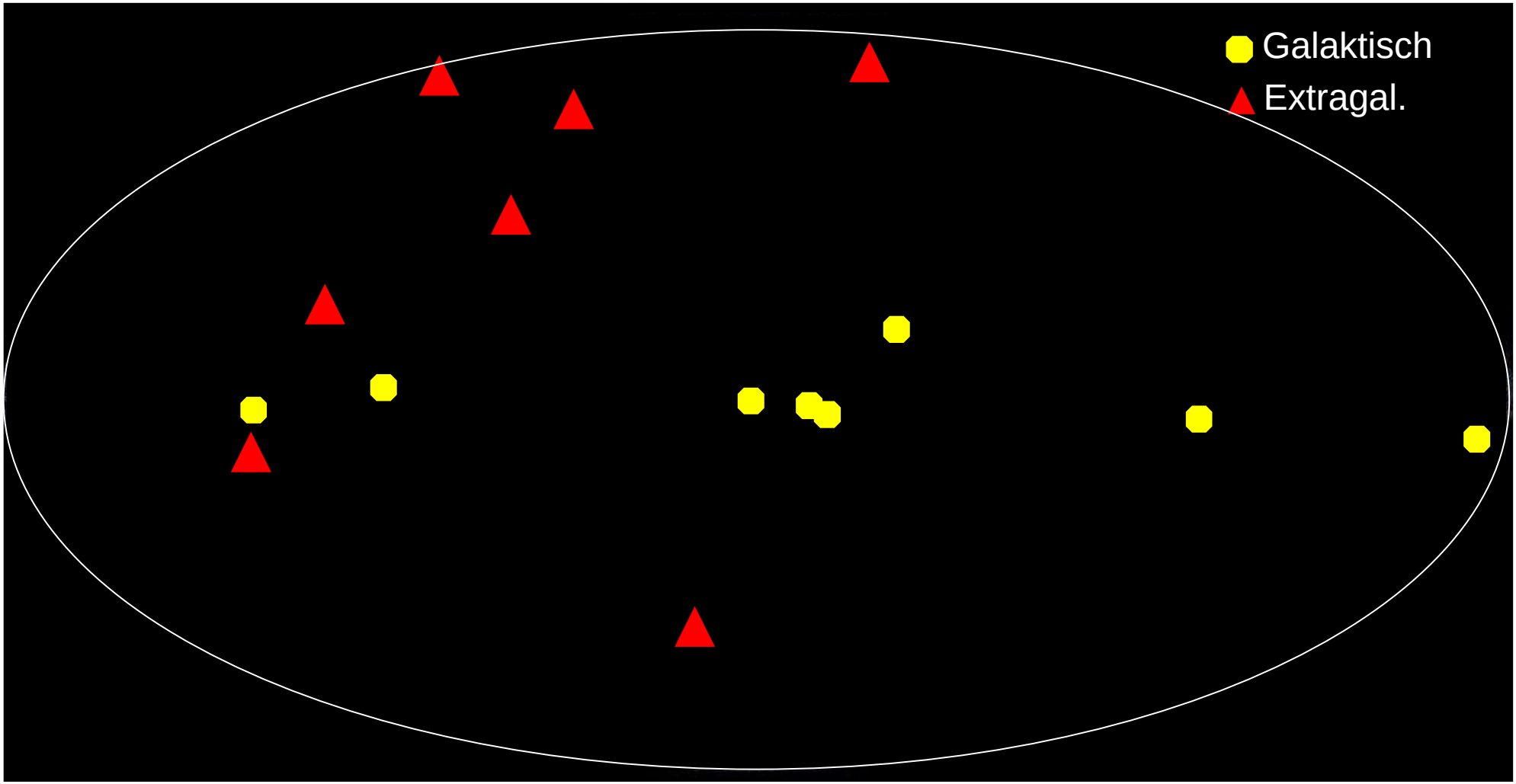
Entdeckung nach 50 Stunden Beobachtung



Unser Nachthimmel bei 10^{12} eV (vor 20 Jahren)



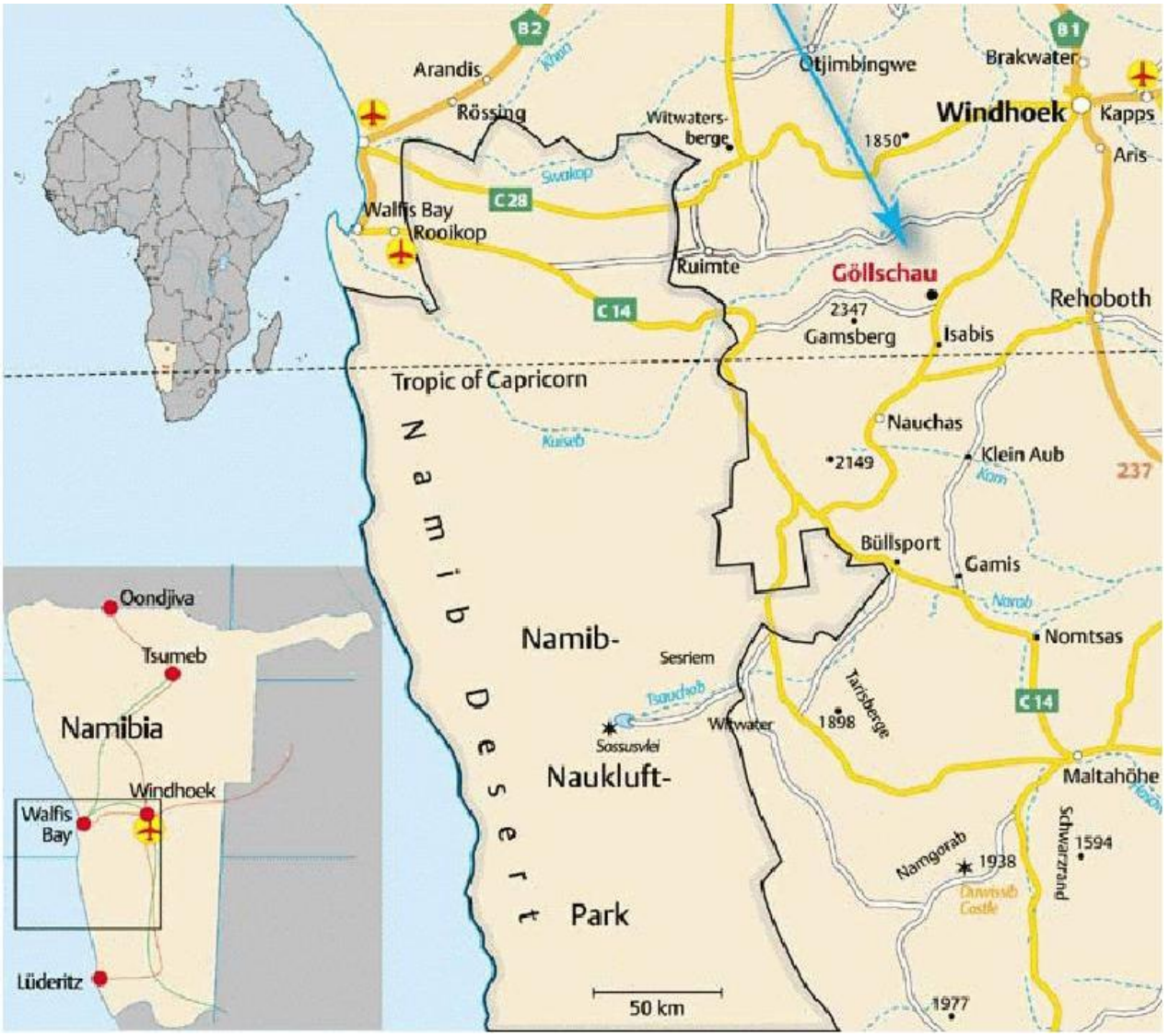
Unser Nachthimmel bei 10^{12} eV (vor 6 Jahren)



2010: Cherenkov-Teleskope weltweit

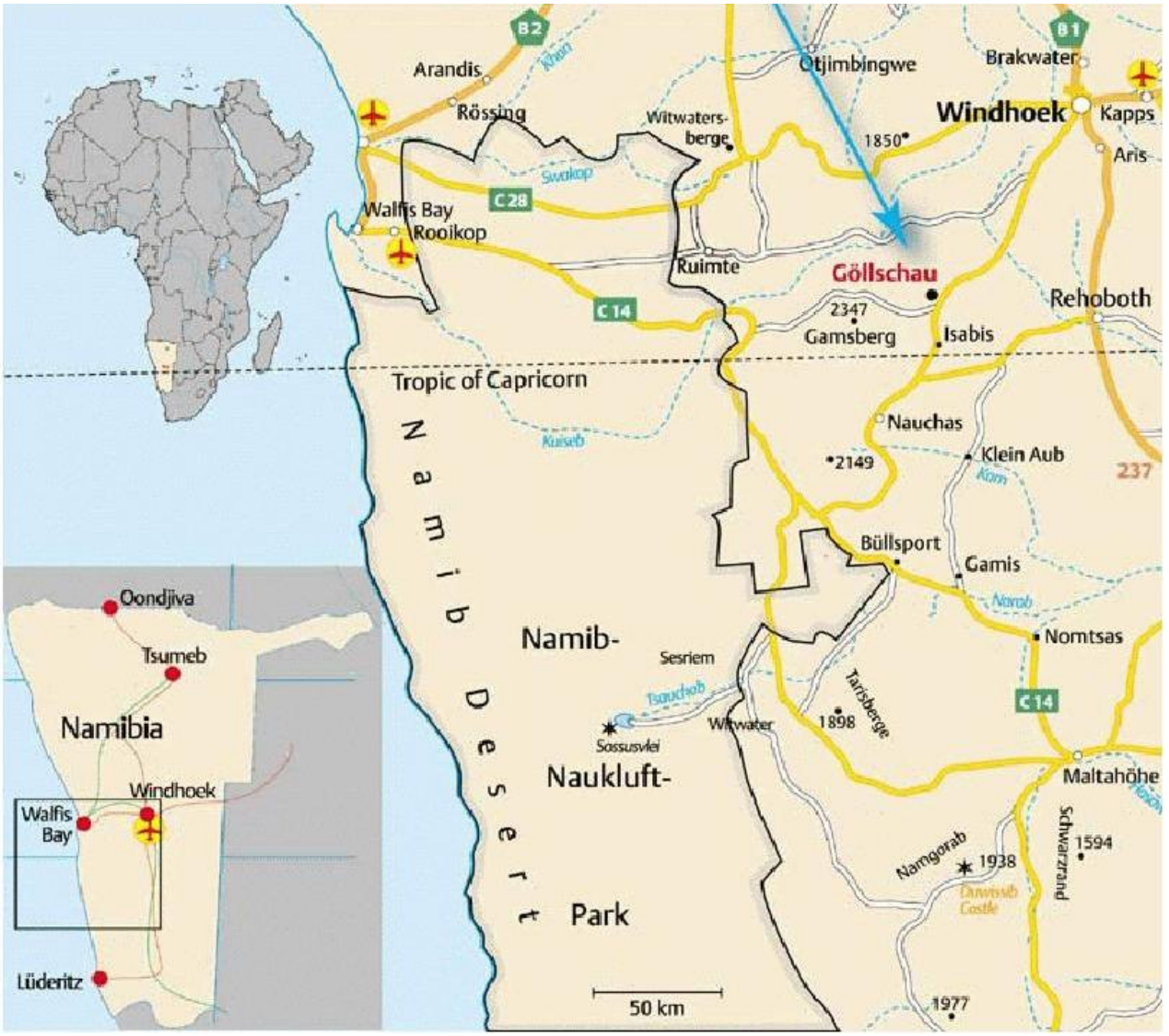
High Energy Stereoscopic System

Namibia


B2
B1
Arandis
Rössing
Witwaters-
berge
Otjimbingwe
Brakwater
Windhoek
Kapps
Aris
1850
C28
Walfis Bay
Rooikop
Ruimte
Göllschau
Rehoboth
2347
Gamsberg
Isabis
C14
Tropic of Capricorn
Nauchas
Klein Aub
2149
237
Büllsport
Gamis
Nomtsas
Namib-
Sesriem
Sossusvlei
Witwater
1898
Tarisberge
C14
Naukluft-
Maltahöhe
Namgorab
1938
1594
Park
1977
50 km
Namib Desert
Oondjiva
Tsumeb
Namibia
Windhoek
Walfis
Bay
Lüderitz

Links abbiegen!

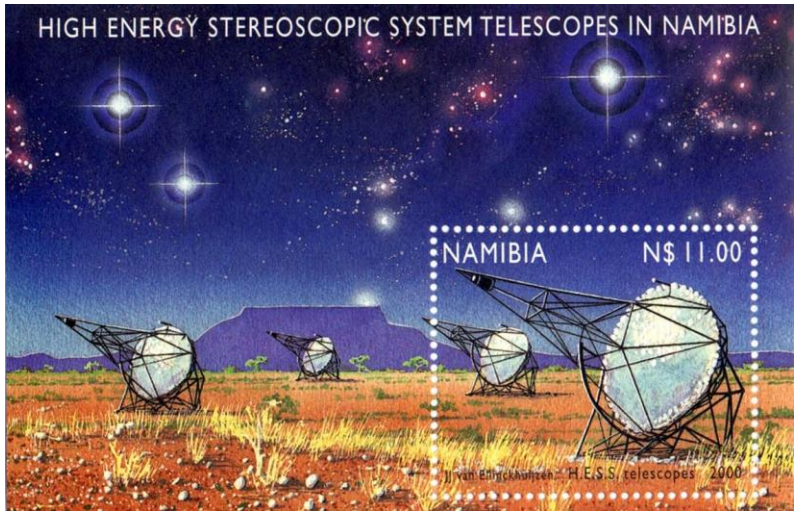
Namibia


B2
B1
Arandis
Rössing
Witwaters-
berge
Otjimbingwe
Brakwater
Windhoek
Kapps
Aris
1850
C28
Walfis Bay
Rooikop
Ruimte
Göllschau
Rehoboth
2347
Gamsberg
Isabis
C14
Tropic of Capricorn
Nauchas
Klein Aub
2149
237
Büllsport
Gamis
Nomtsas
Namib-
Sesriem
Sossusvlei
Witwater
1898
Tarisberge
C14
Naukluft-
Maltahöhe
Namgorab
1938
1594
Park
1977
50 km
Namib Desert
Oondjiva
Tsumeb
Namibia
Windhoek
Walfis
Bay
Lüderitz

Das H.E.S.S-Teleskopsystem

Warum Namibia?

- Klarer Himmel
- Zentrum der Milchstraße im Zenit
- Mildes Klima
- Leichter Zugang
- Gute lokale Unterstützung

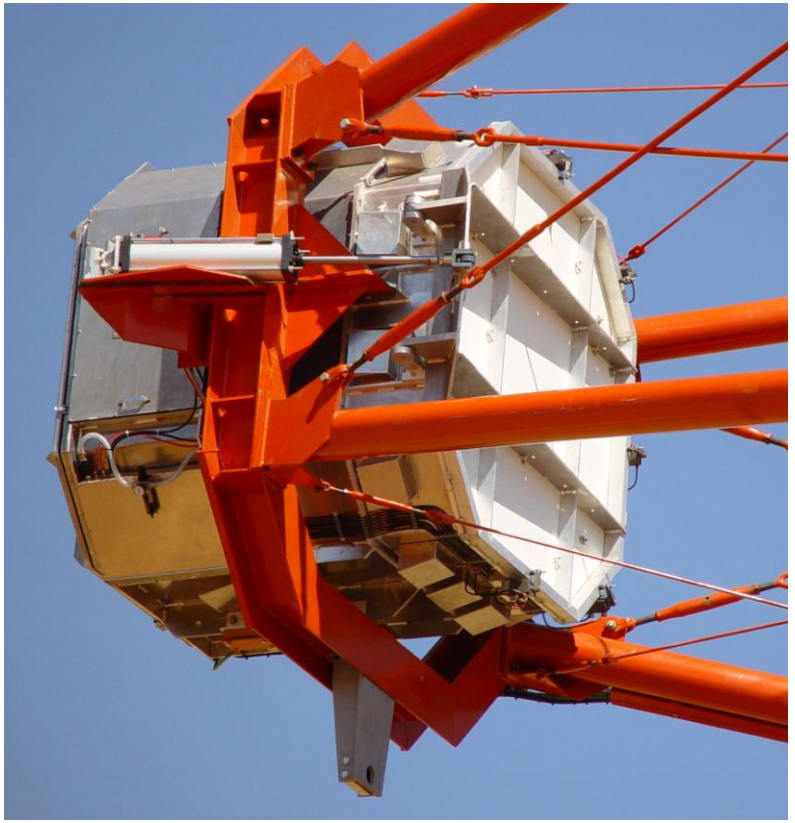


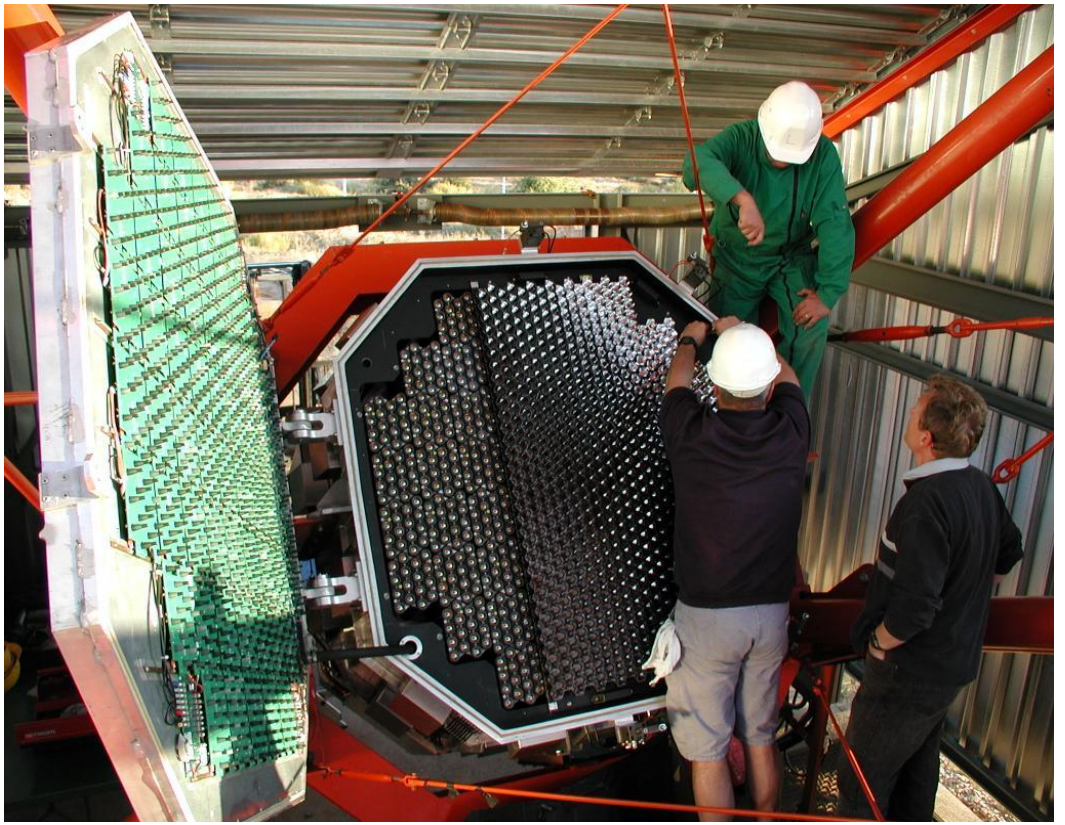
Nicht alles ist schön in Namibia!

Noch eine Schlange ...

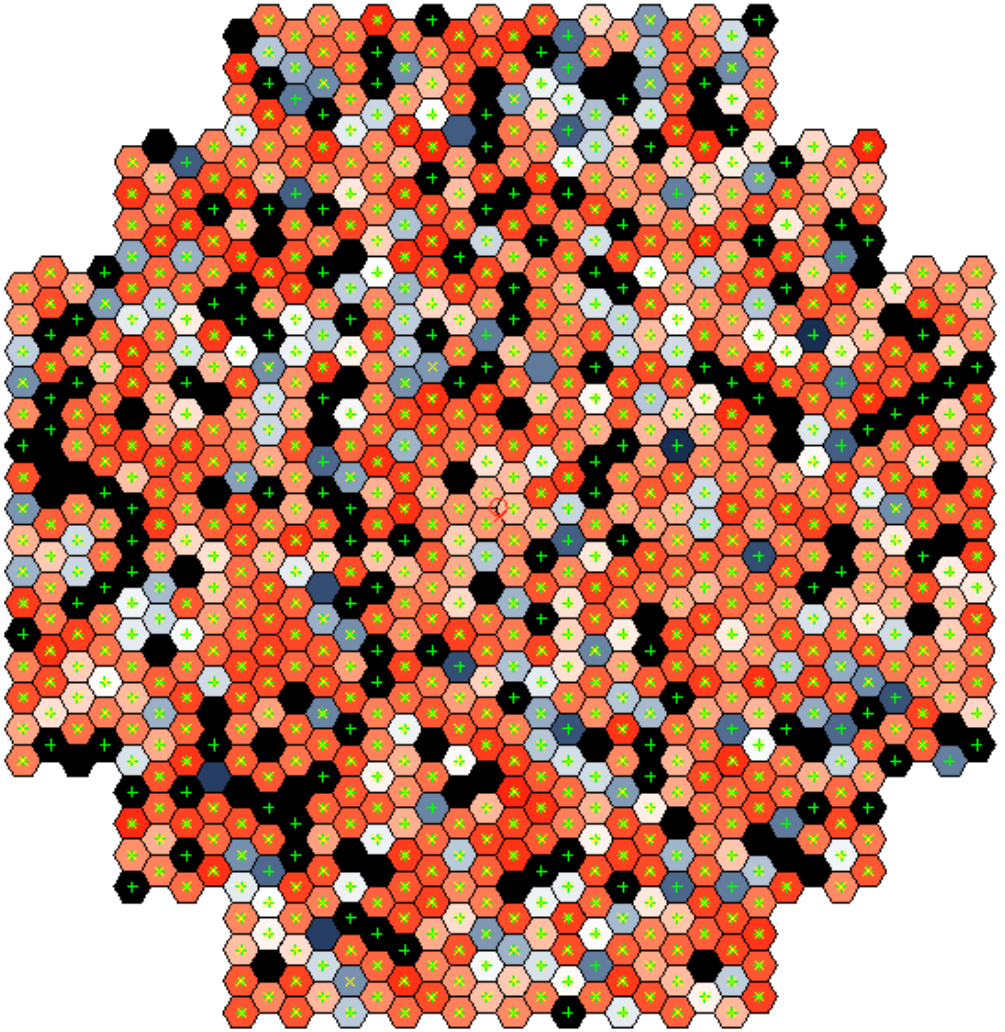
Ein H.E.S.S.-Teleskop

Eine 1 kPix Digitalkamera





Wichtigste Eigenschaft der Kamera: kurze “Verschlusszeiten”



1/10000 s
(100 µs)

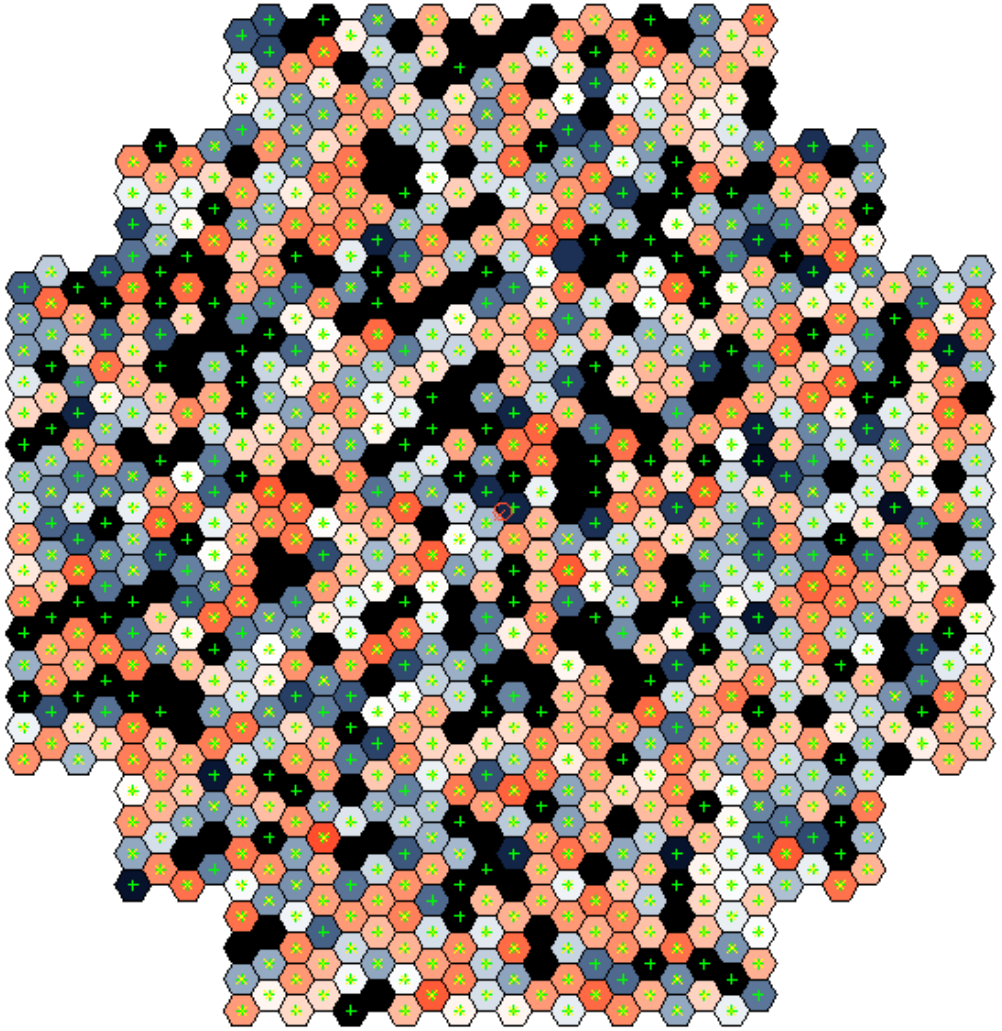
1/100000 s
(10 µs)

1/1000000 s
(1 µs)

1/10000000 s
(100 ns)

1/100000000 s
(10 ns)

Wichtigste Eigenschaft der Kamera: kurze “Verschlusszeiten”



1/10000 s
(100 µs)

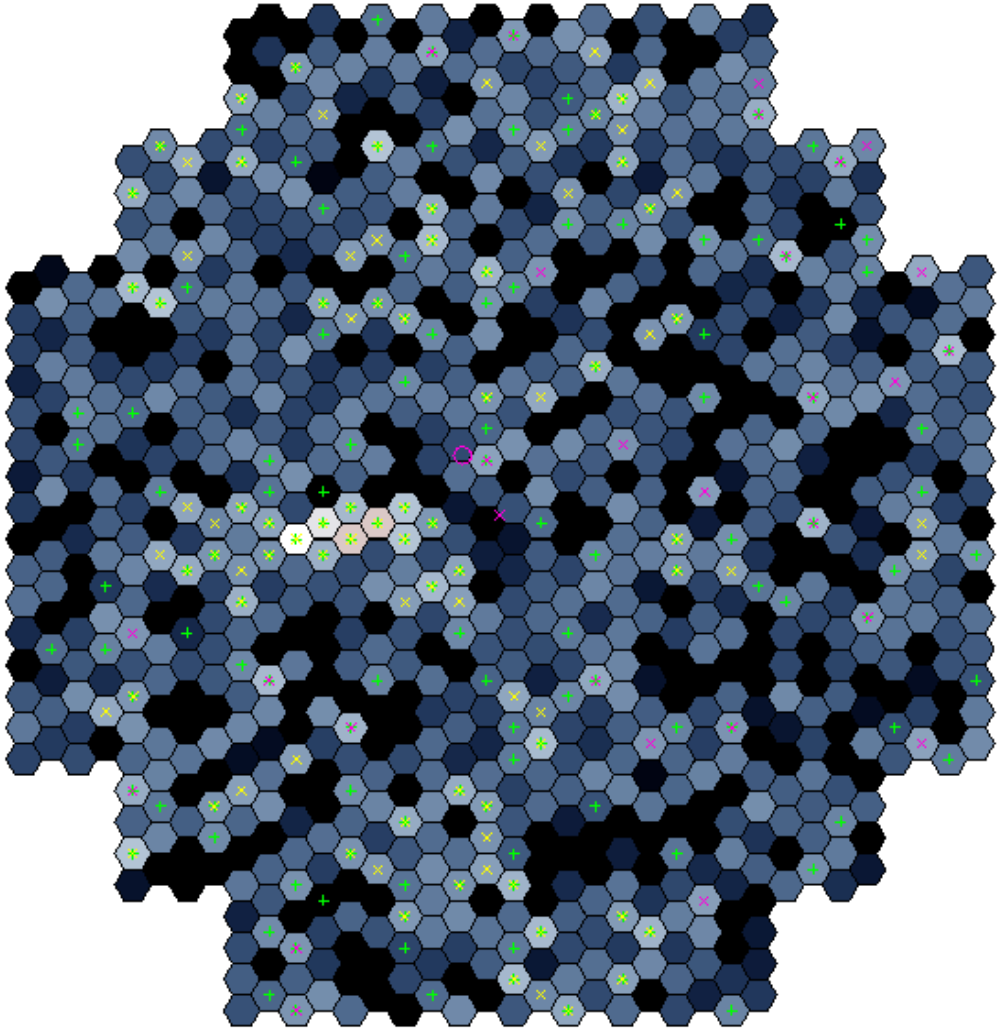
1/100000 s
(10 µs)

1/1000000 s
(1 µs)

1/10000000 s
(100 ns)

1/100000000 s
(10 ns)

Wichtigste Eigenschaft der Kamera: kurze “Verschlusszeiten”



1/10000 s
(100 µs)

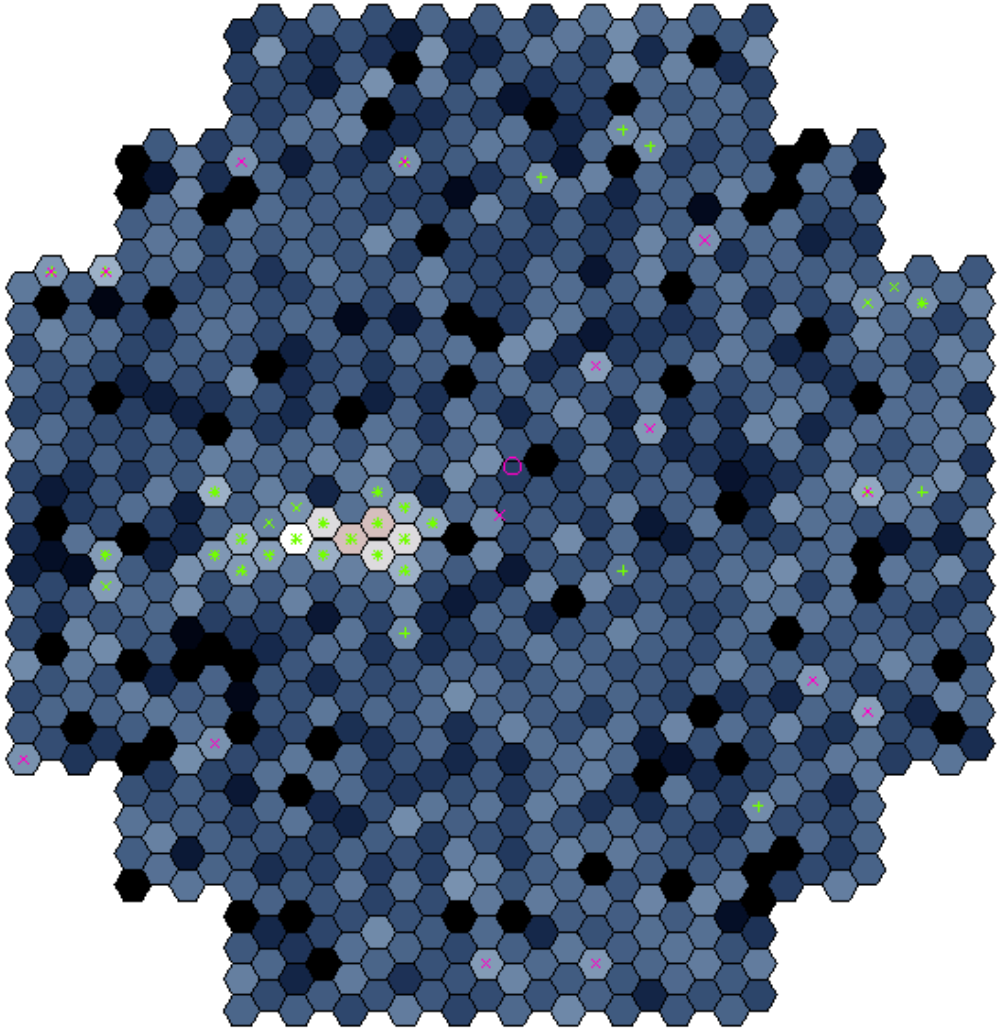
1/100000 s
(10 µs)

1/1000000 s
(1 µs)

1/10000000 s
(100 ns)

1/100000000 s
(10 ns)

Wichtigste Eigenschaft der Kamera: kurze “Verschlusszeiten”



1/10000 s
(100 µs)

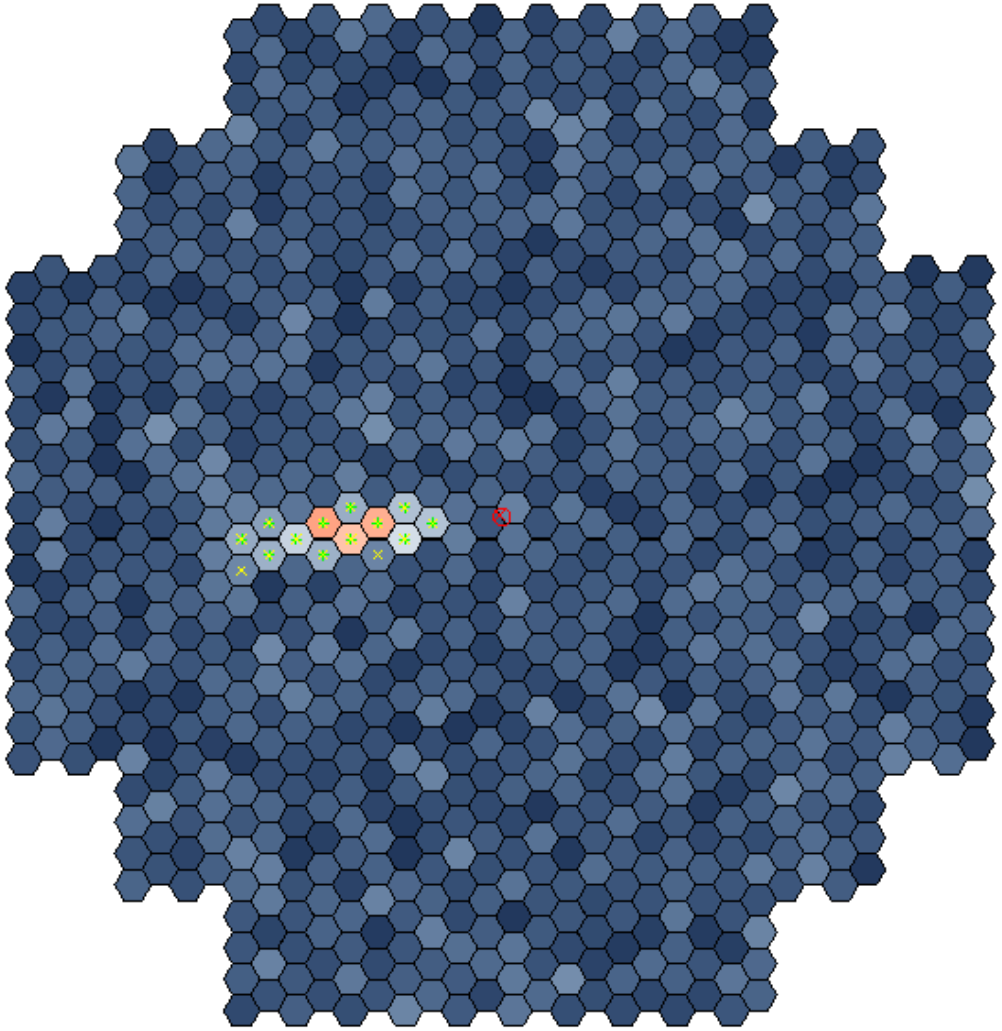
1/100000 s
(10 µs)

1/1000000 s
(1 µs)

1/10000000 s
(100 ns)

1/100000000 s
(10 ns)

Wichtigste Eigenschaft der Kamera: kurze “Verschlusszeiten”



1/10000 s
(100 µs)

1/100000 s
(10 µs)

1/1000000 s
(1 µs)

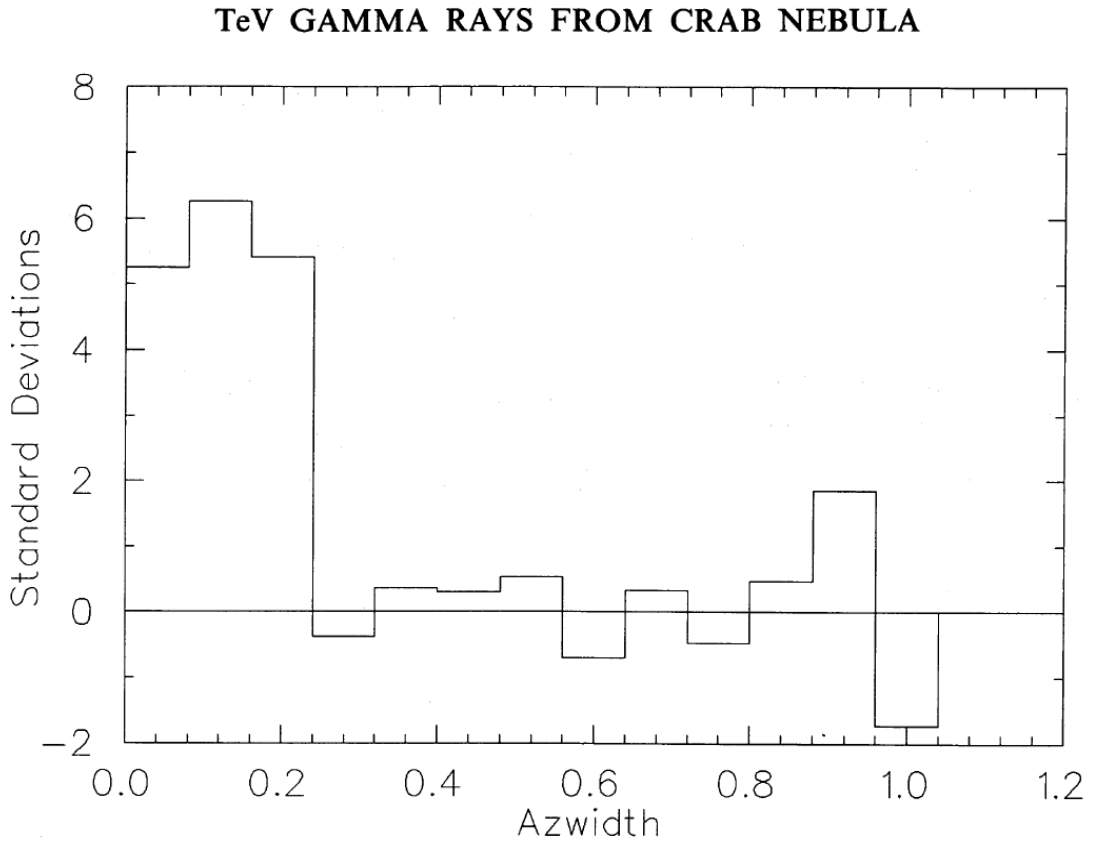
1/10000000 s
(100 ns)

1/100000000 s
(10 ns)

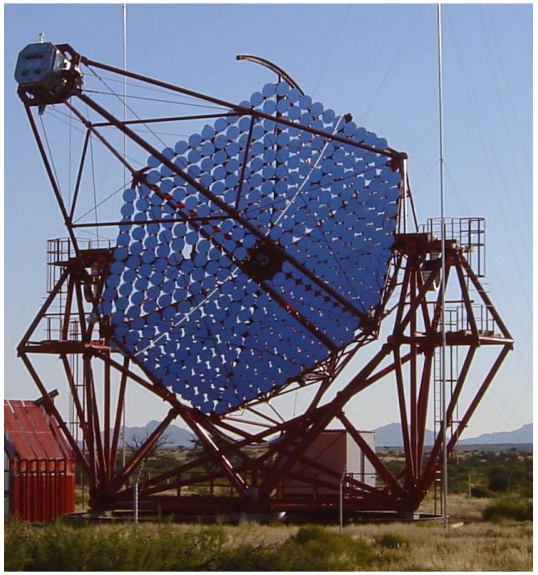
Das Gesichtsfeld

1989: Die Entdeckung des Krebs-Nebels (Whipple)

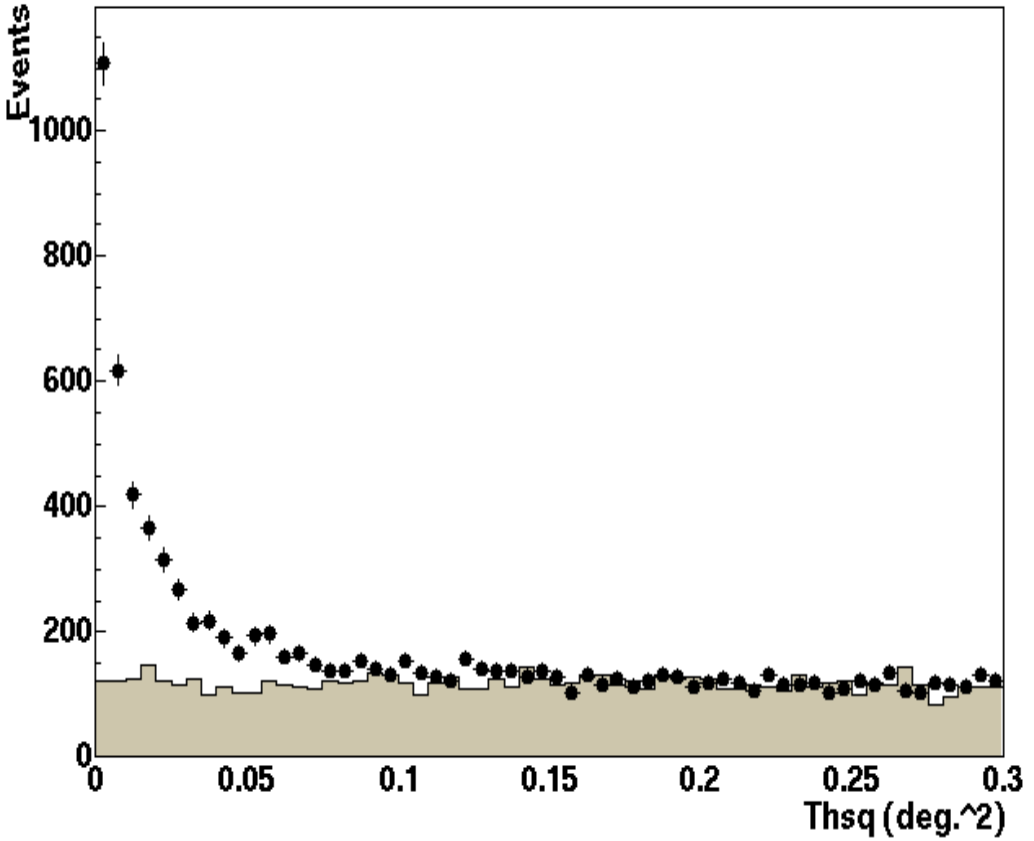
Entdeckung nach 50 Stunden Beobachtung



Fortschritt



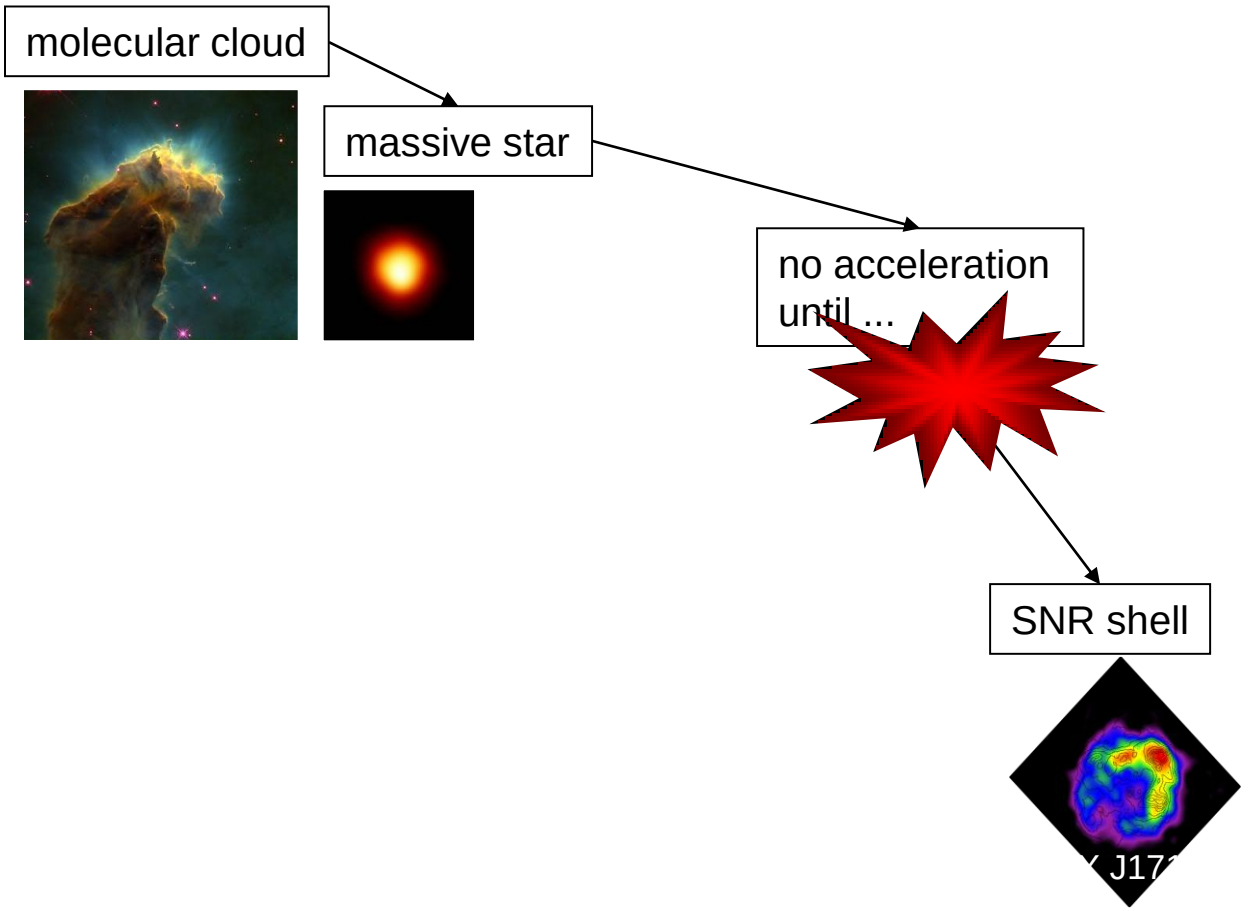
Nachweis nach 30 Sekunden



From Source Hunting ...

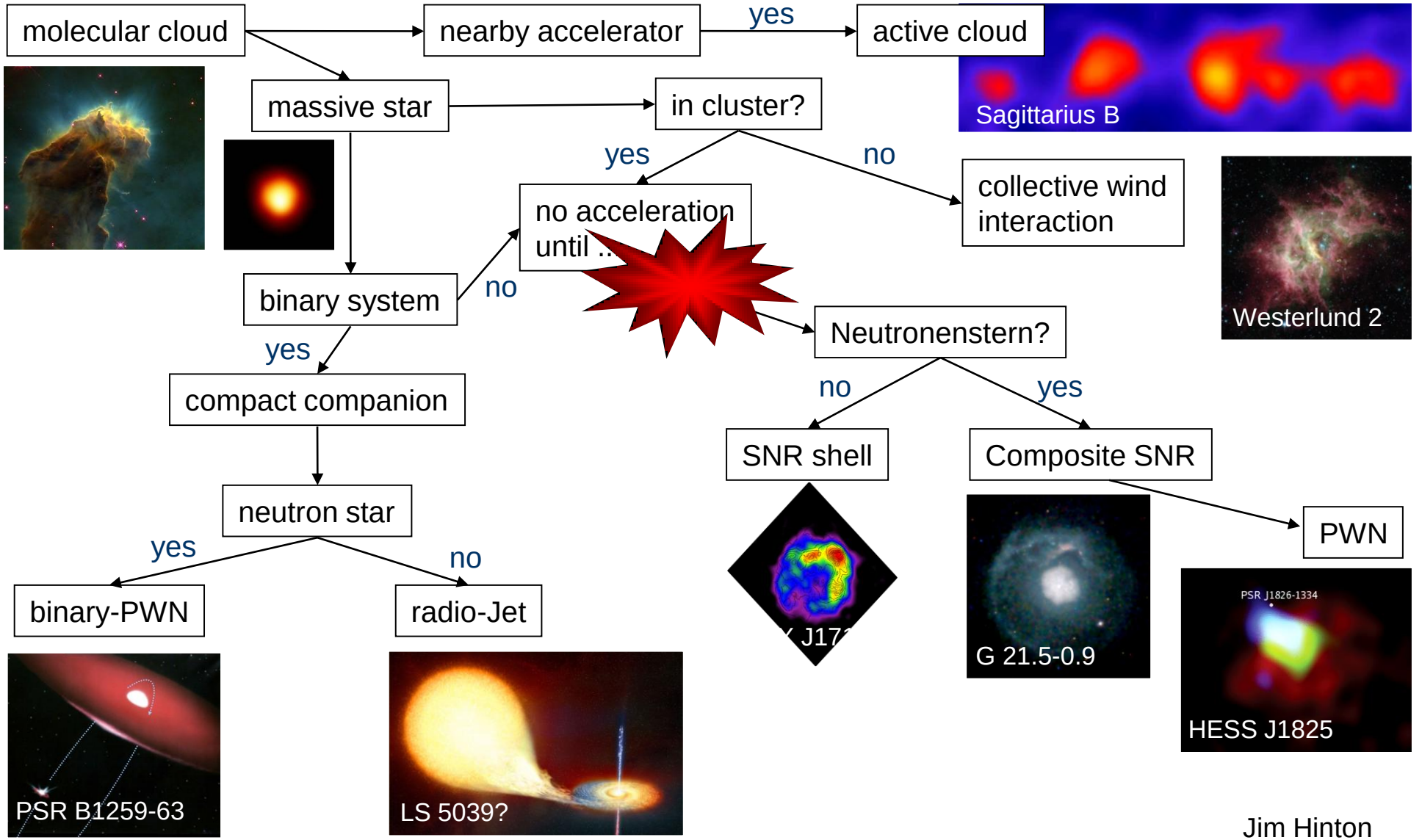
to real Astronomy and Astrophysics

The sources of cosmic rays



Jim Hinton

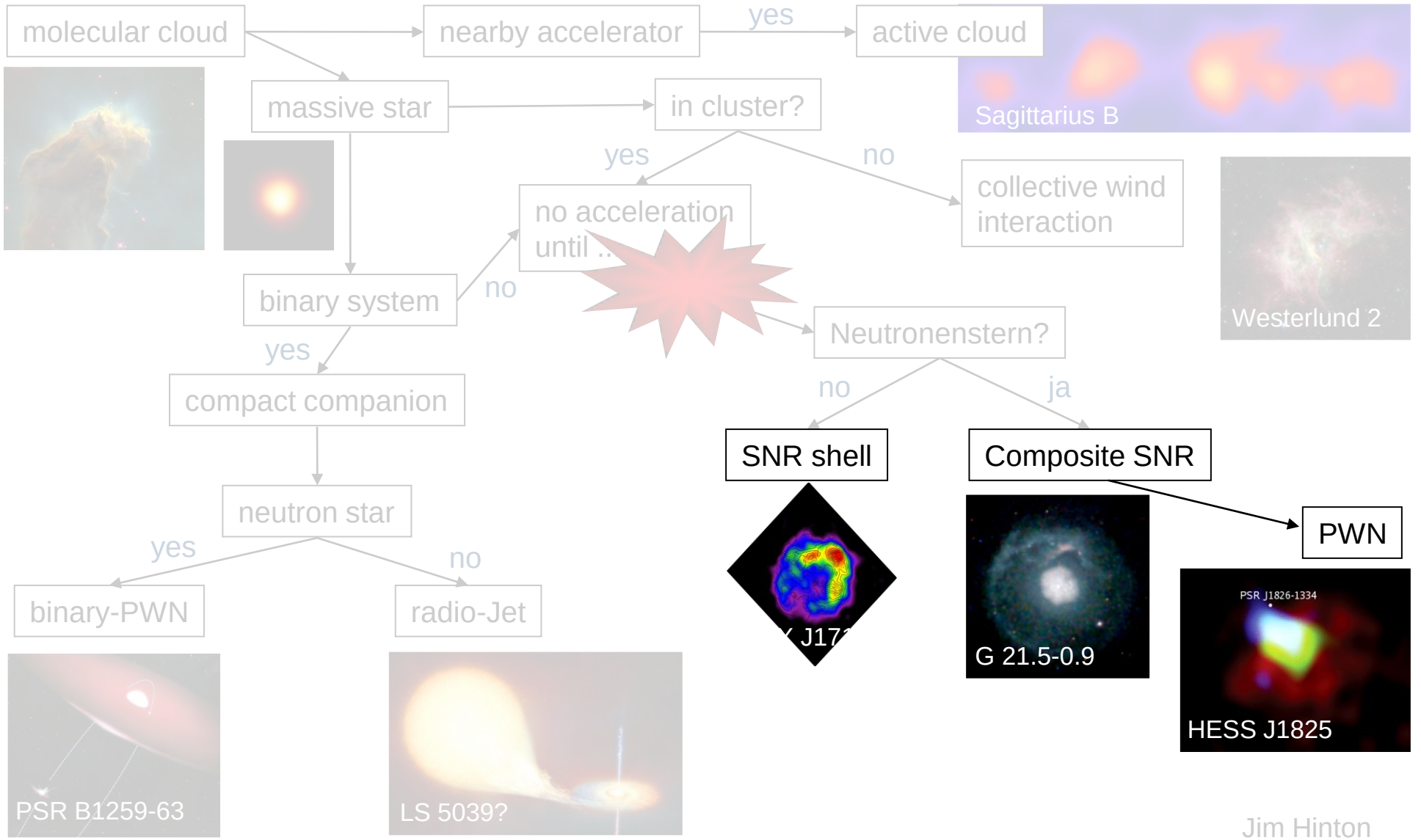
The sources of cosmic rays



Jim Hinton

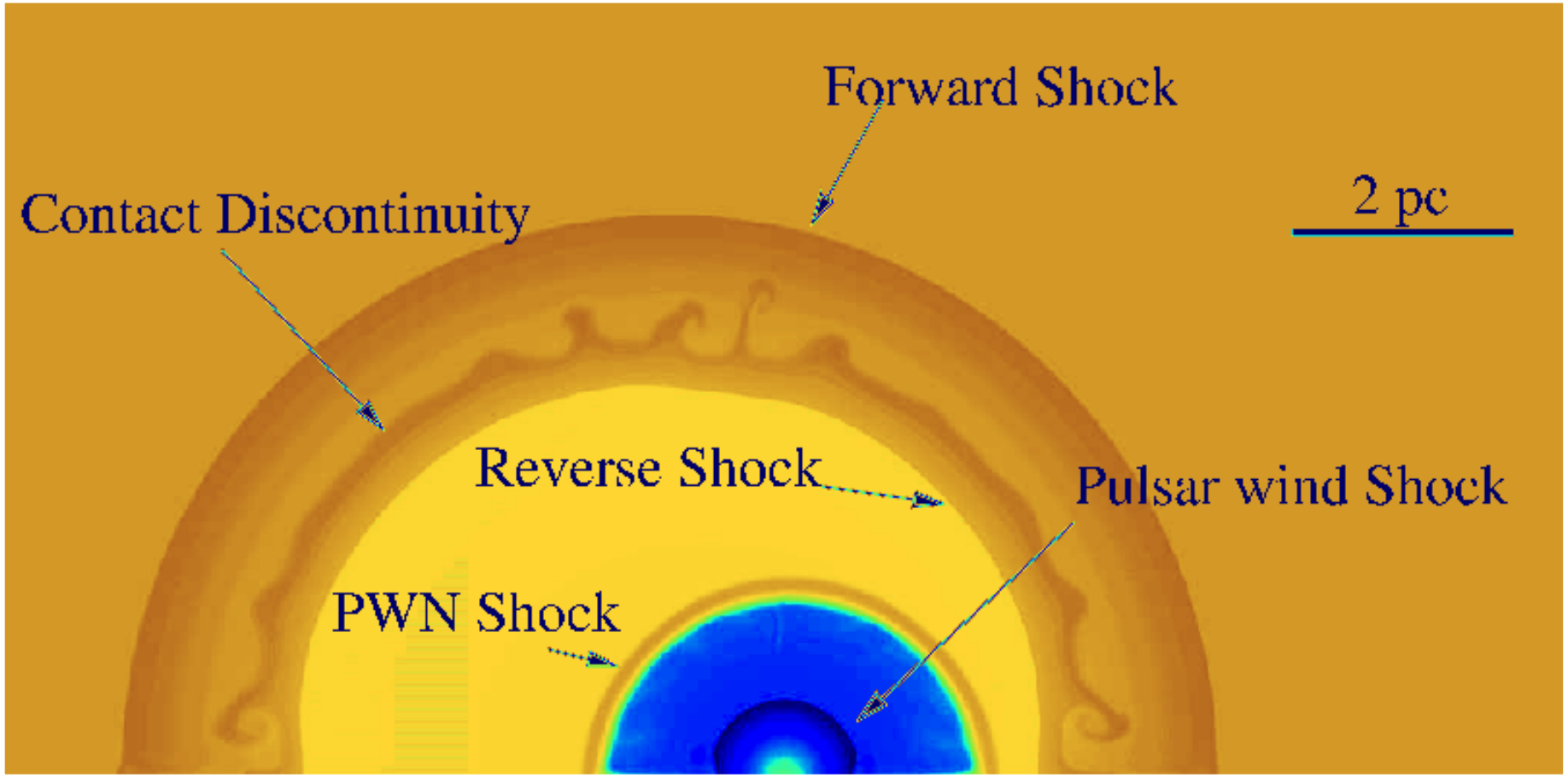
Christian Stegmann, graduate school, Berlin, October 2010

The sources of cosmic rays



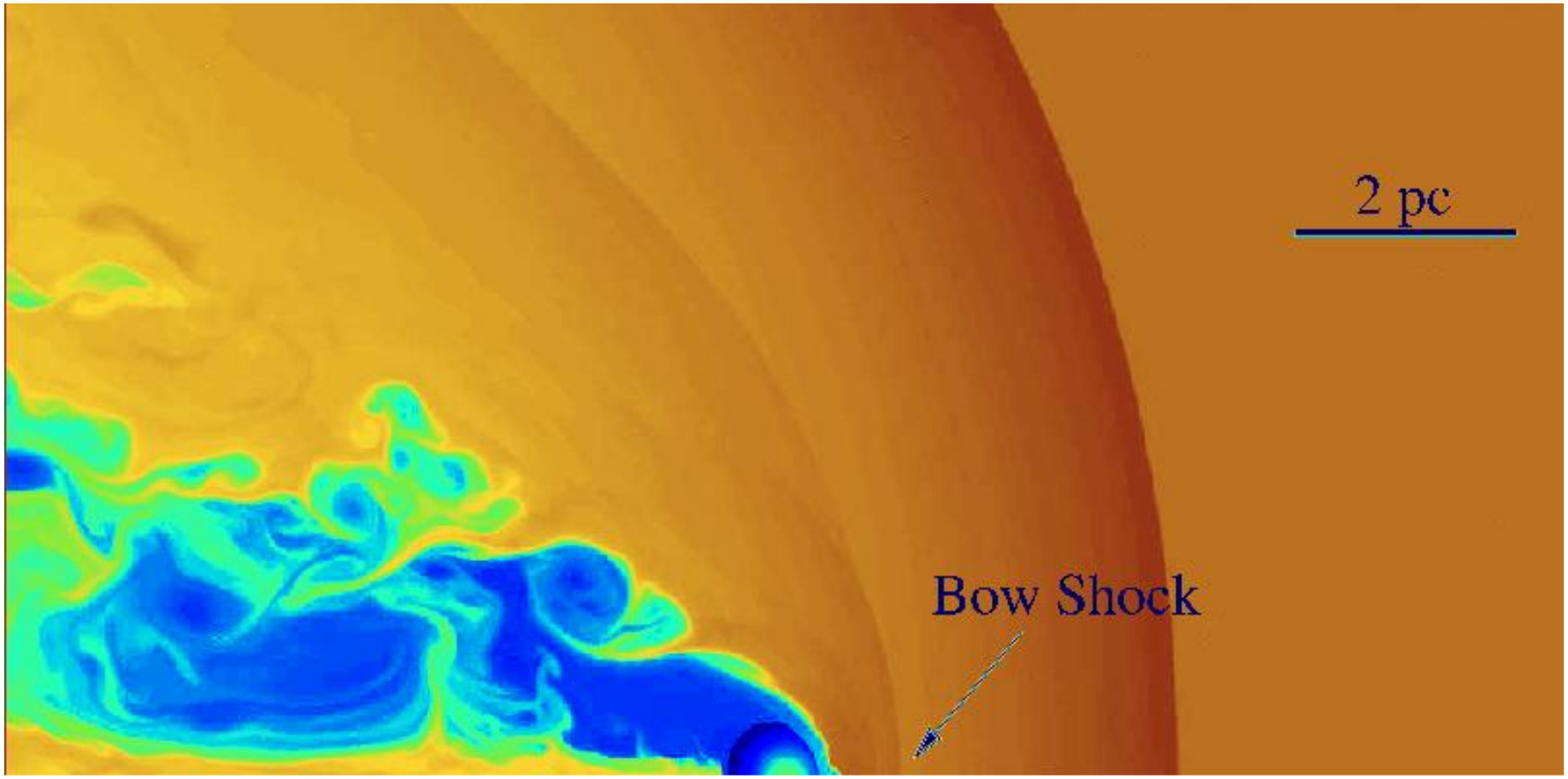
Jim Hinton

Supernova Remnants



van der Swaluw, Downes, & Keegan 2003

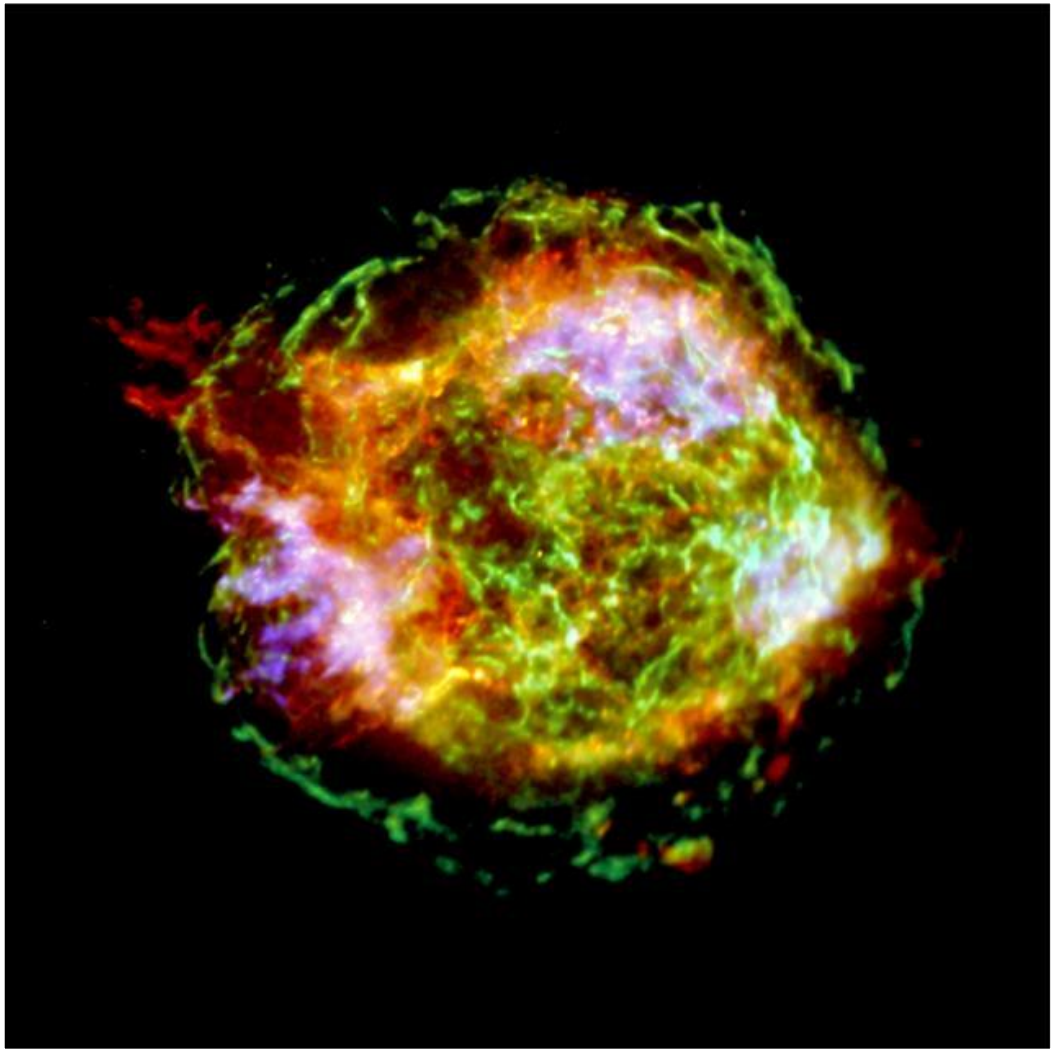
Supernova Remnants



van der Swaluw, Downes, & Keegan 2003

... similar effects due to inhomogeneity of ambient medium

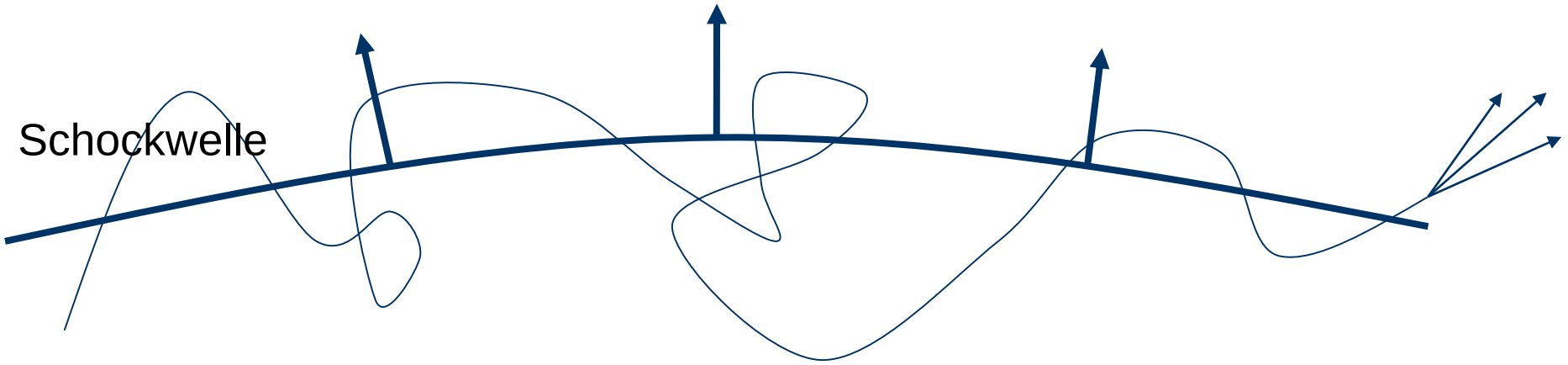
Supernova-Überreste – die Quellen der Kosmischen Strahlung?



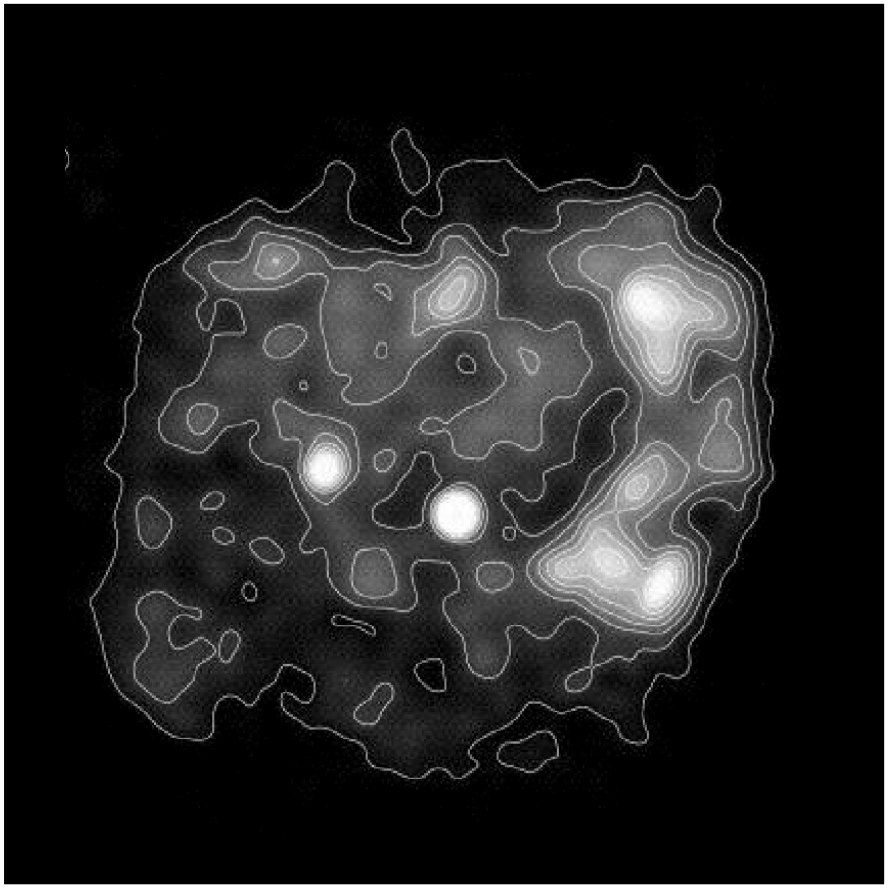
Cas A, Chandra, Röntgen

Die Beschleuniger der Kosmischen Strahlung?

- Warum Supernova-Überreste?
  - Große Energiefreisetzung
    $E_{SNR} \approx 10 \cdot E_{CR}$
  - Beschleunigung in der Schockwelle

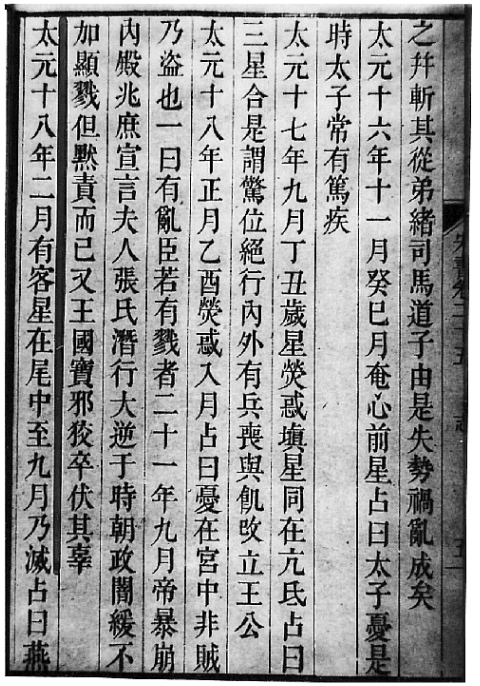


Der Supernova-Überrest RX J1713-3946



ROSAT (Röntgen, keV)

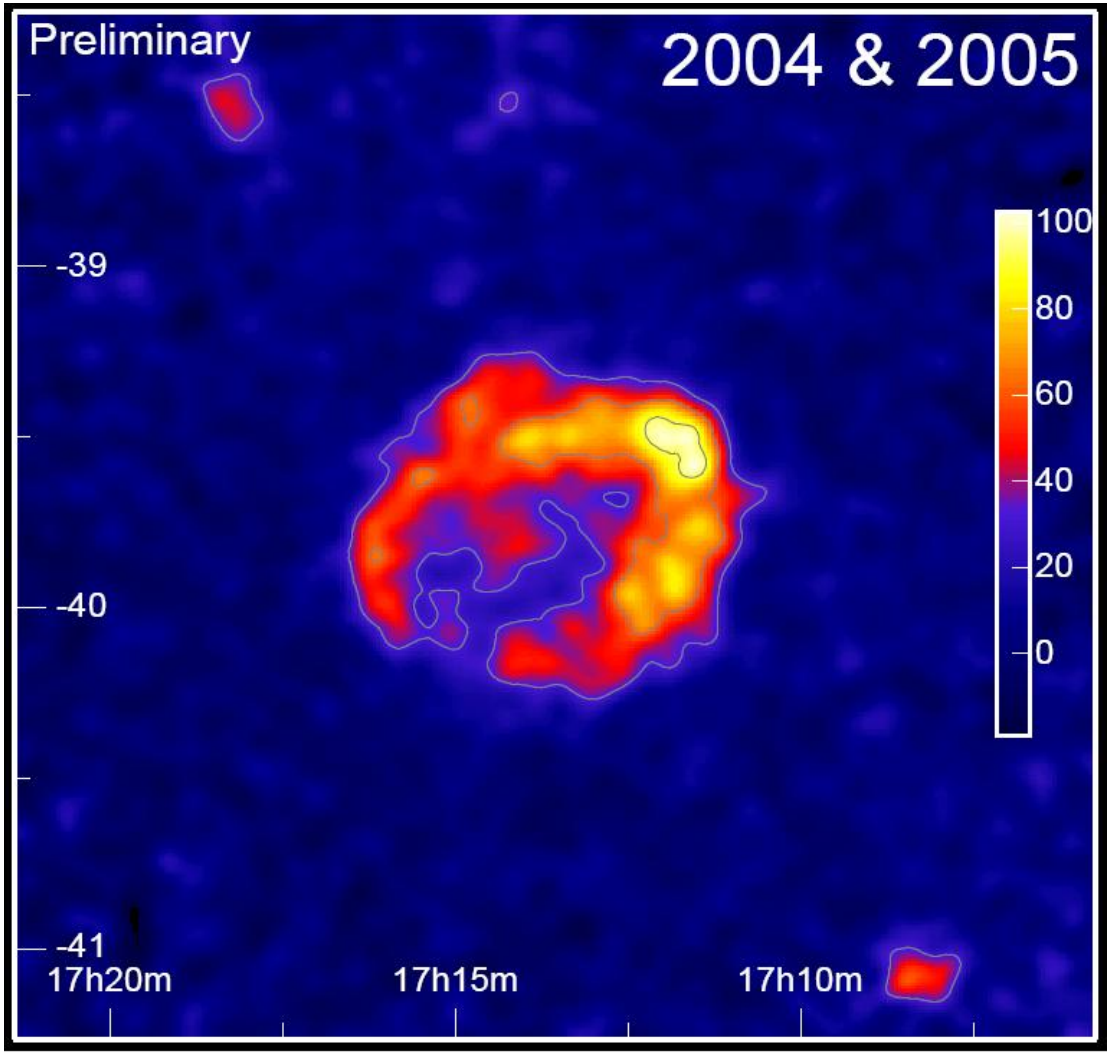
Der Supernova-Überrest RX J1713-3946



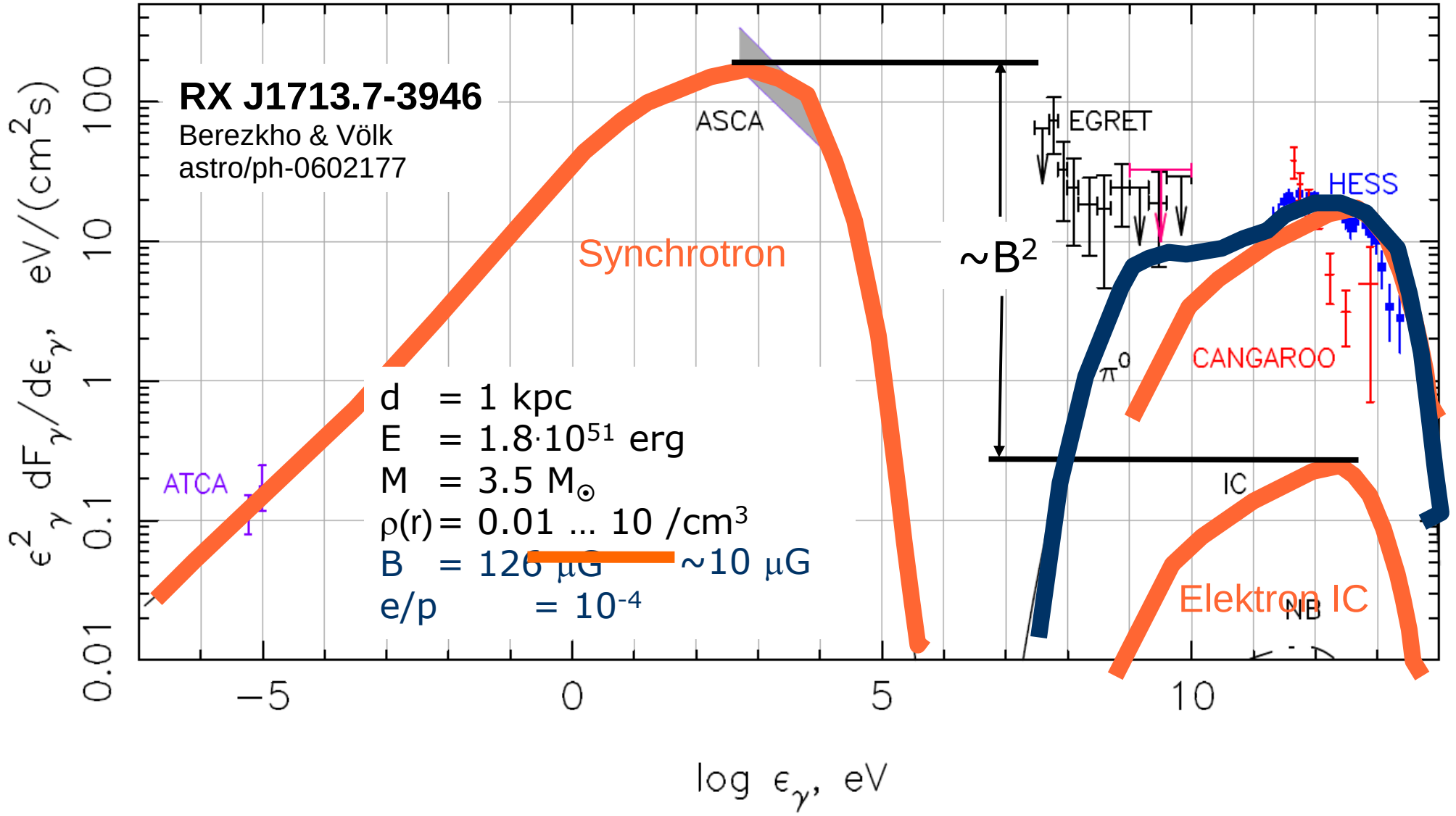
之幷斬其從弟緒司馬道子由是失勢禍亂成矣
太元十六年十一月癸巳月奄心前星占曰太子憂是
時太子常有篤疾
太元十七年九月丁丑歲星熒惑塡星同在亢氐占曰
三星合是謂驚位絕行內外有兵喪與飢改立王公
太元十八年正月乙酉熒惑入月占曰憂在宮中非賊
乃盜也一曰有亂臣若有戮者二十一年九月帝暴崩
內殿兆庶宣言夫人張氏潛行大逆于時朝政闇緩不
加顯戮但黙責而已又王國寶邪狡卒伏其辜
太元十八年二月有客星在尾中至九月乃滅占曰燕

"Ein Gaststern erschien in der Konstellation Wei während des zweiten Mondes des achtzehnten Jahres der Tai-Yuan Regierungsperiode (Feb. – März 393) und verschwand während des neunten Mondes (Okt. – Nov. 393)"

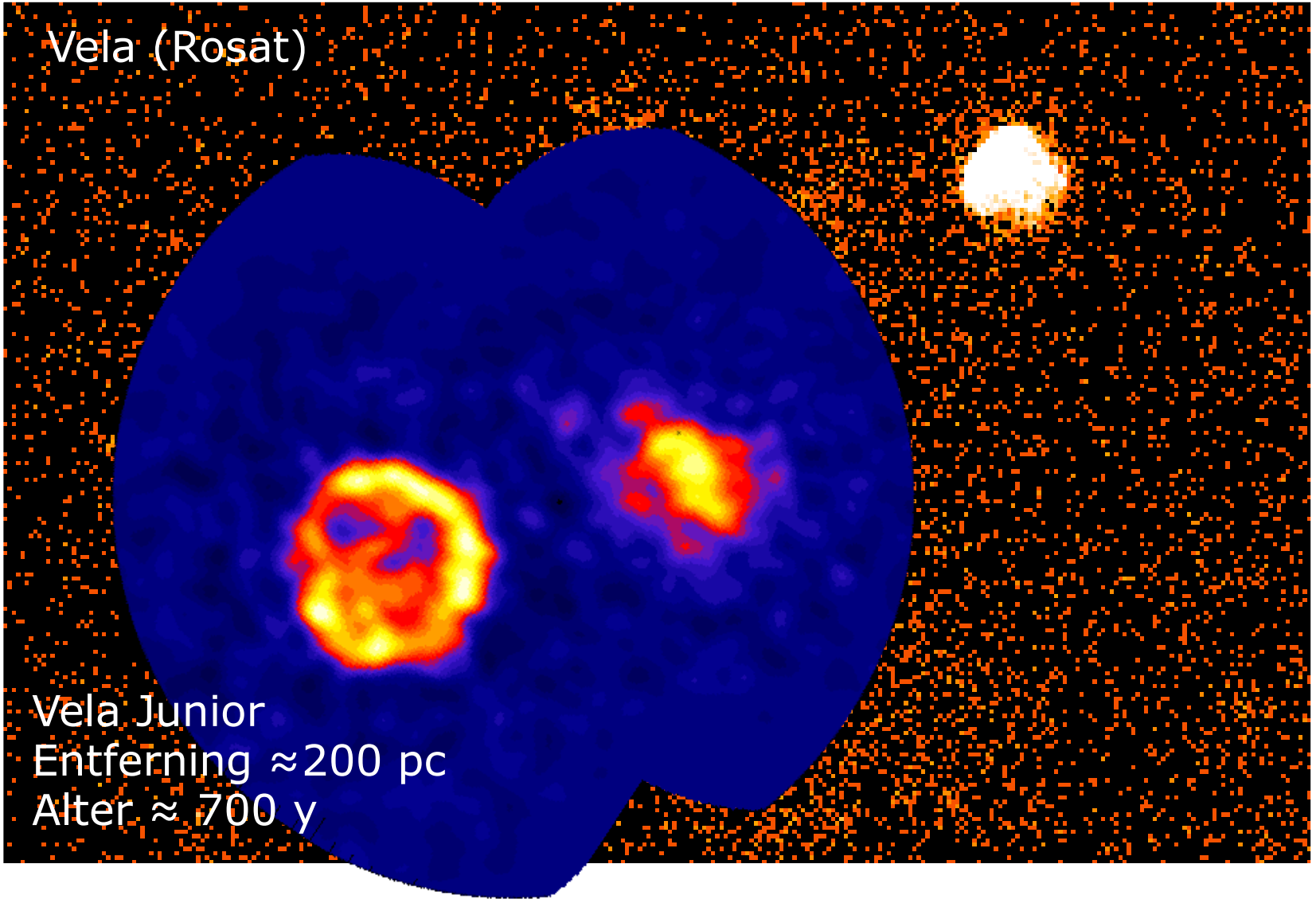
Das erste astronomische TeV Gammastrahlungsbild



RX J1713.7-3946

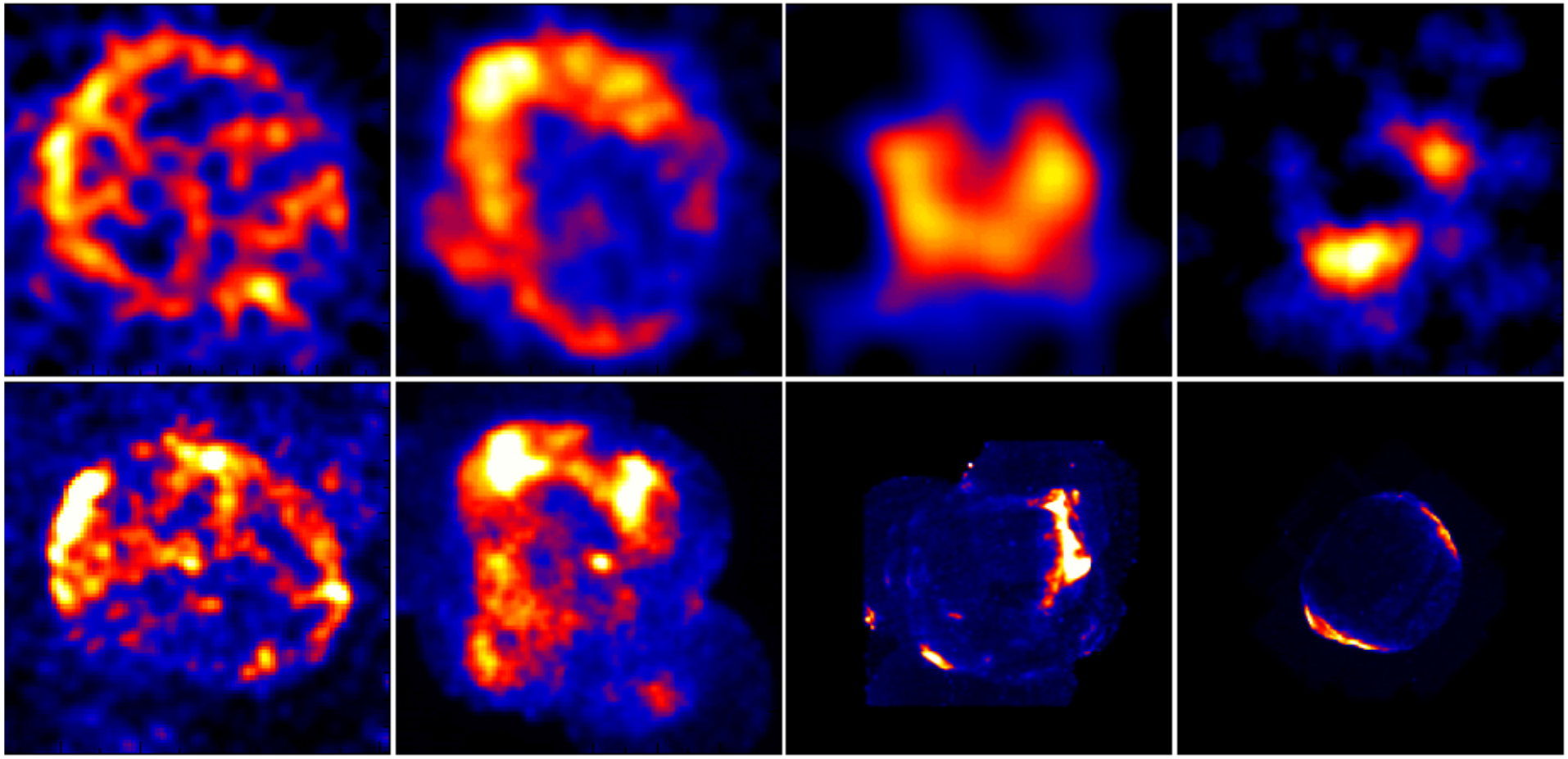


Supernova-Überreste



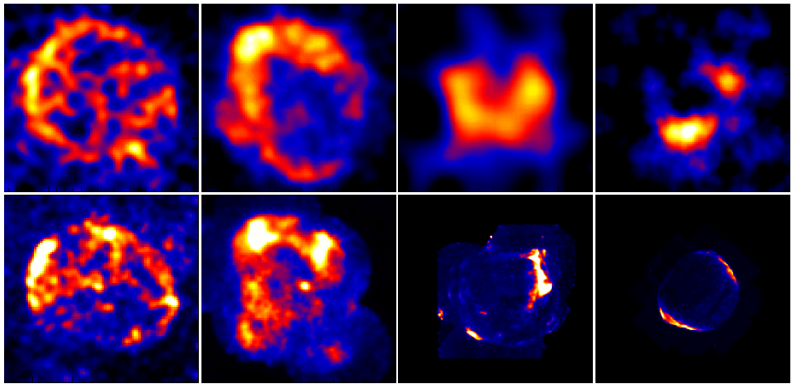
Supernovae in Gamma- und Röntgenstrahlung

Gammastrahlung



Röntgenstrahlung

Wo stehen wir heute?



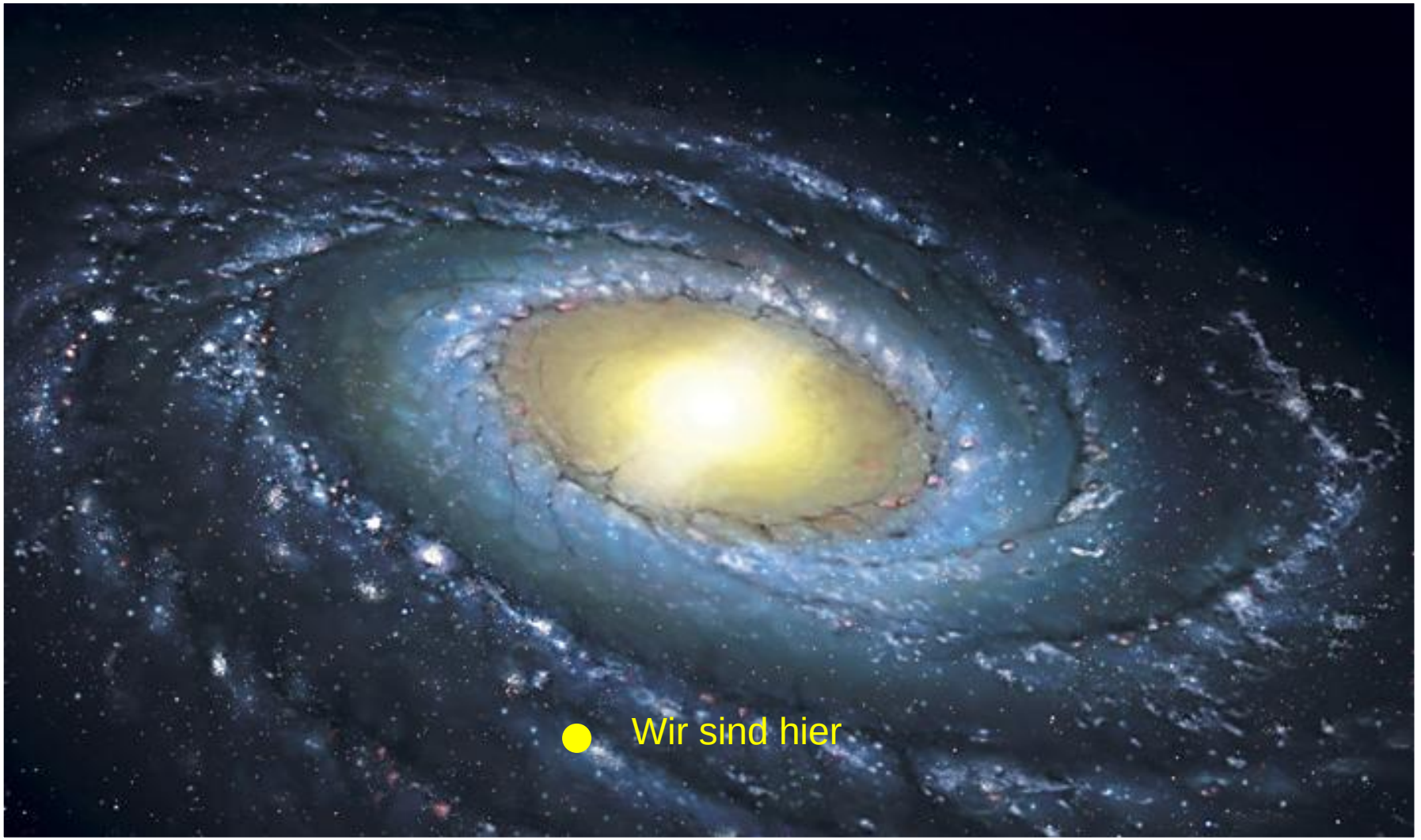
In Supernova-Überreste findet Schockwellenbeschleunigung statt

aber ...

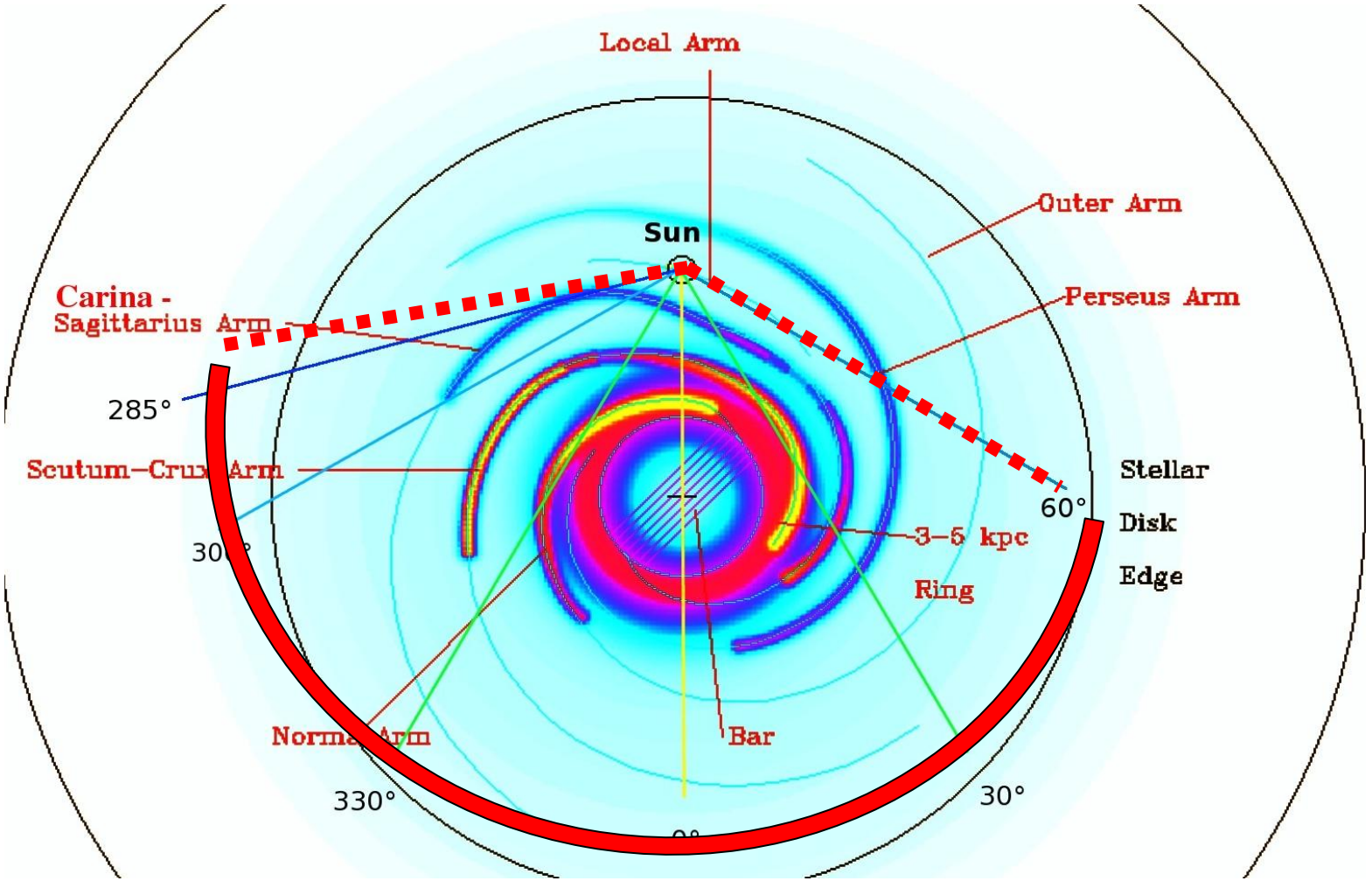
... sind es Protonen oder Elektronen (oder beides)?

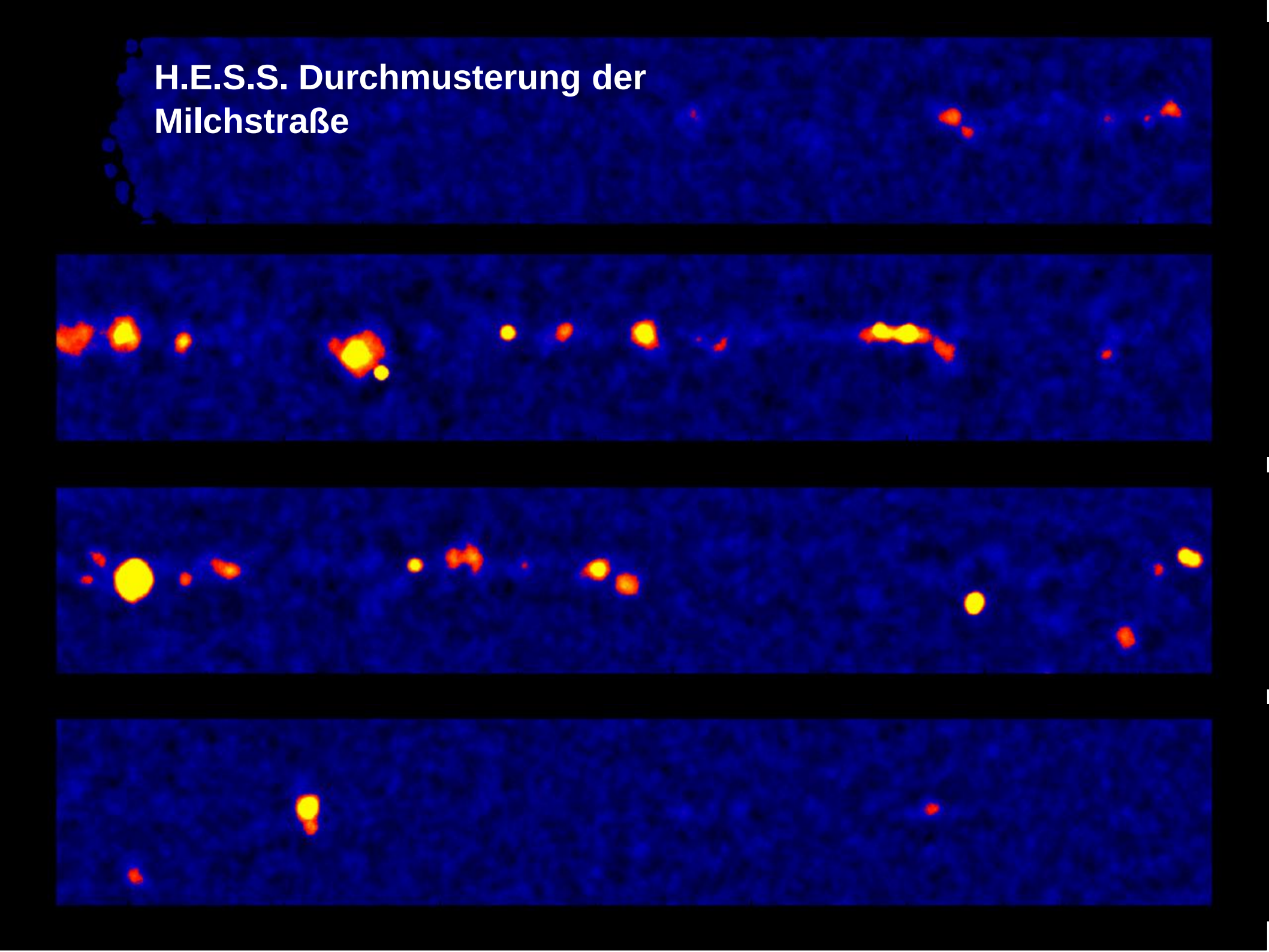
... reicht die Leistung?

Die H.E.S.S. Himmelsdurchmusterung

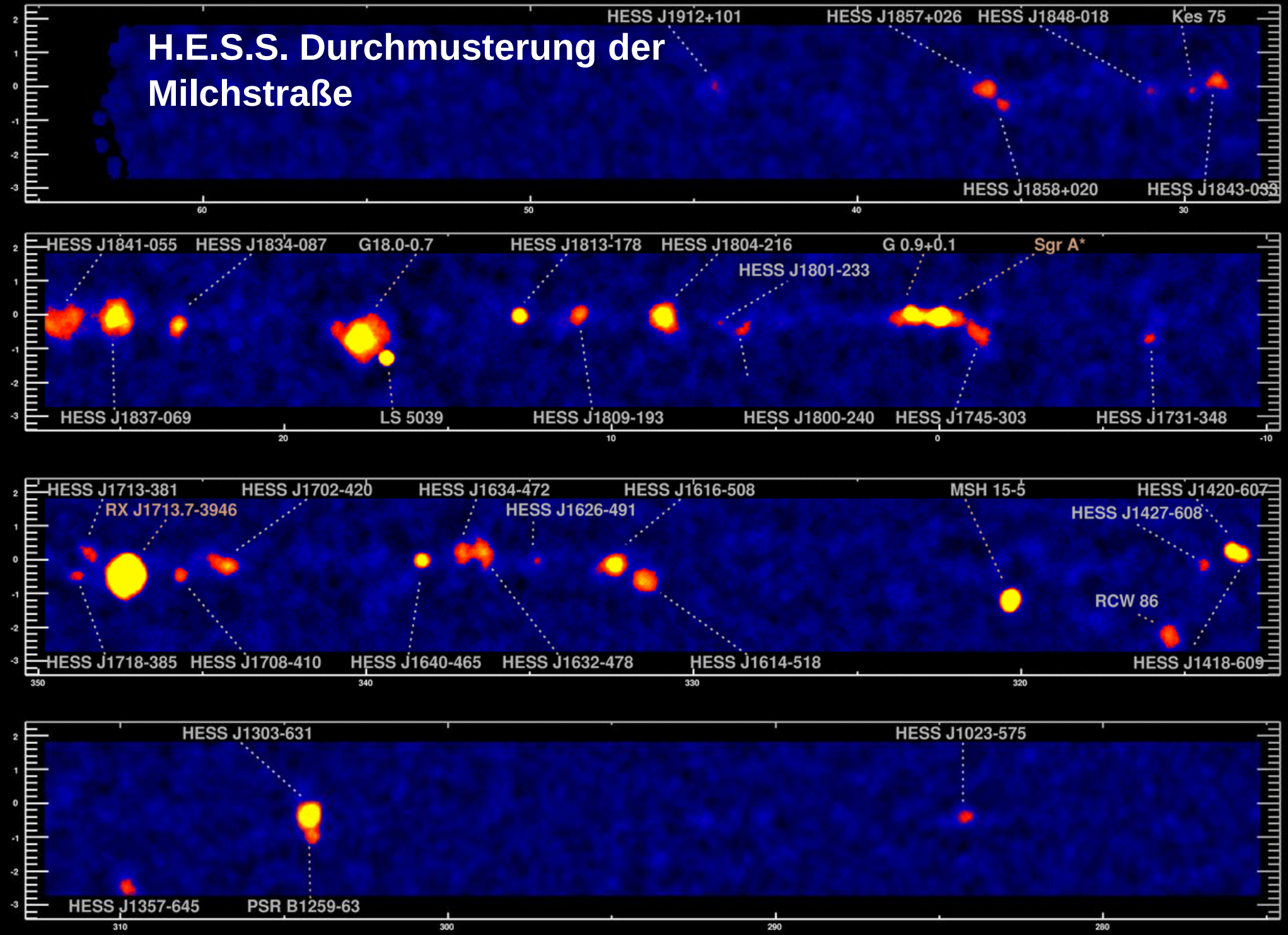


H.E.S.S. Durchmusterung

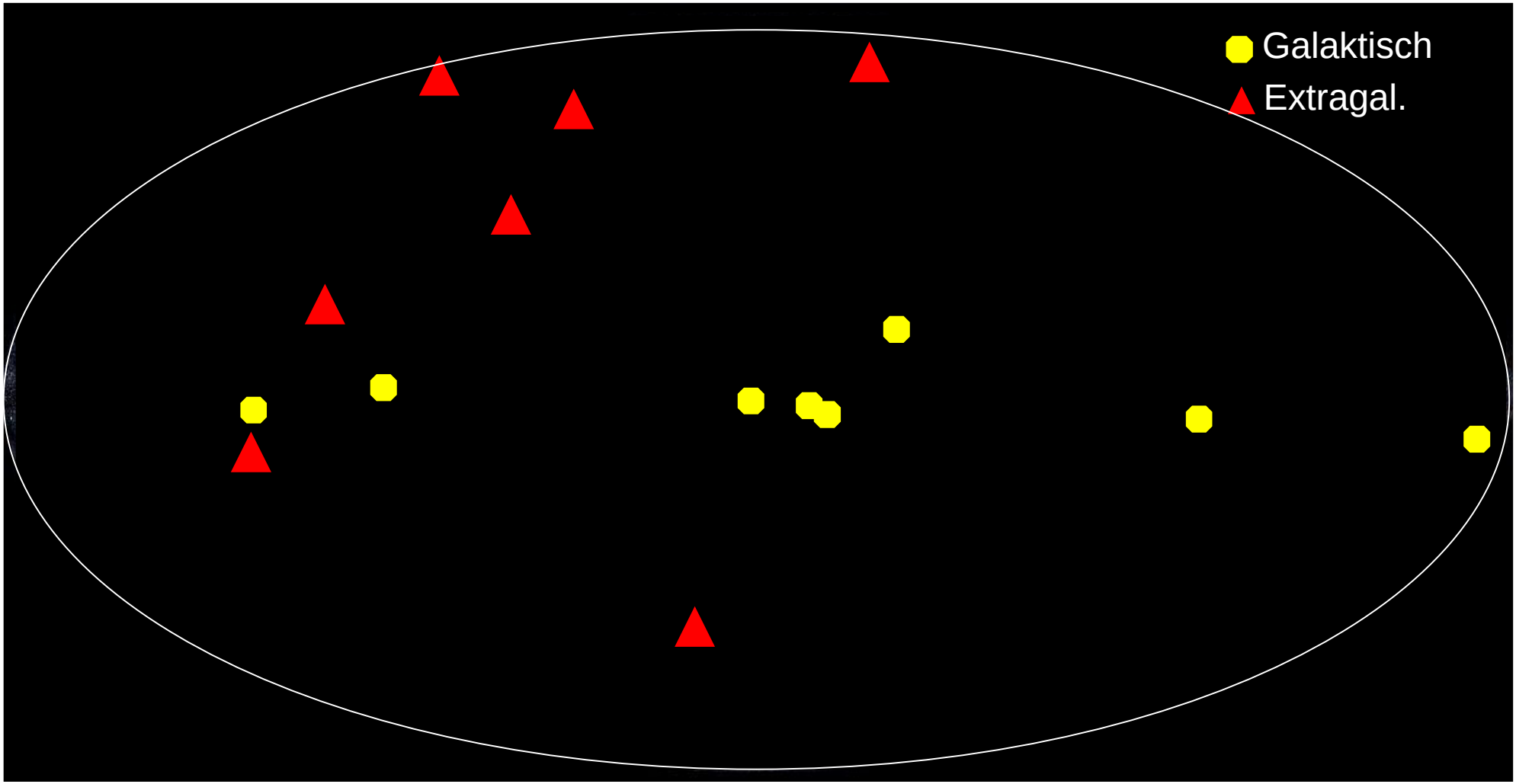



H.E.S.S. Durchmusterung der
Milchstraße

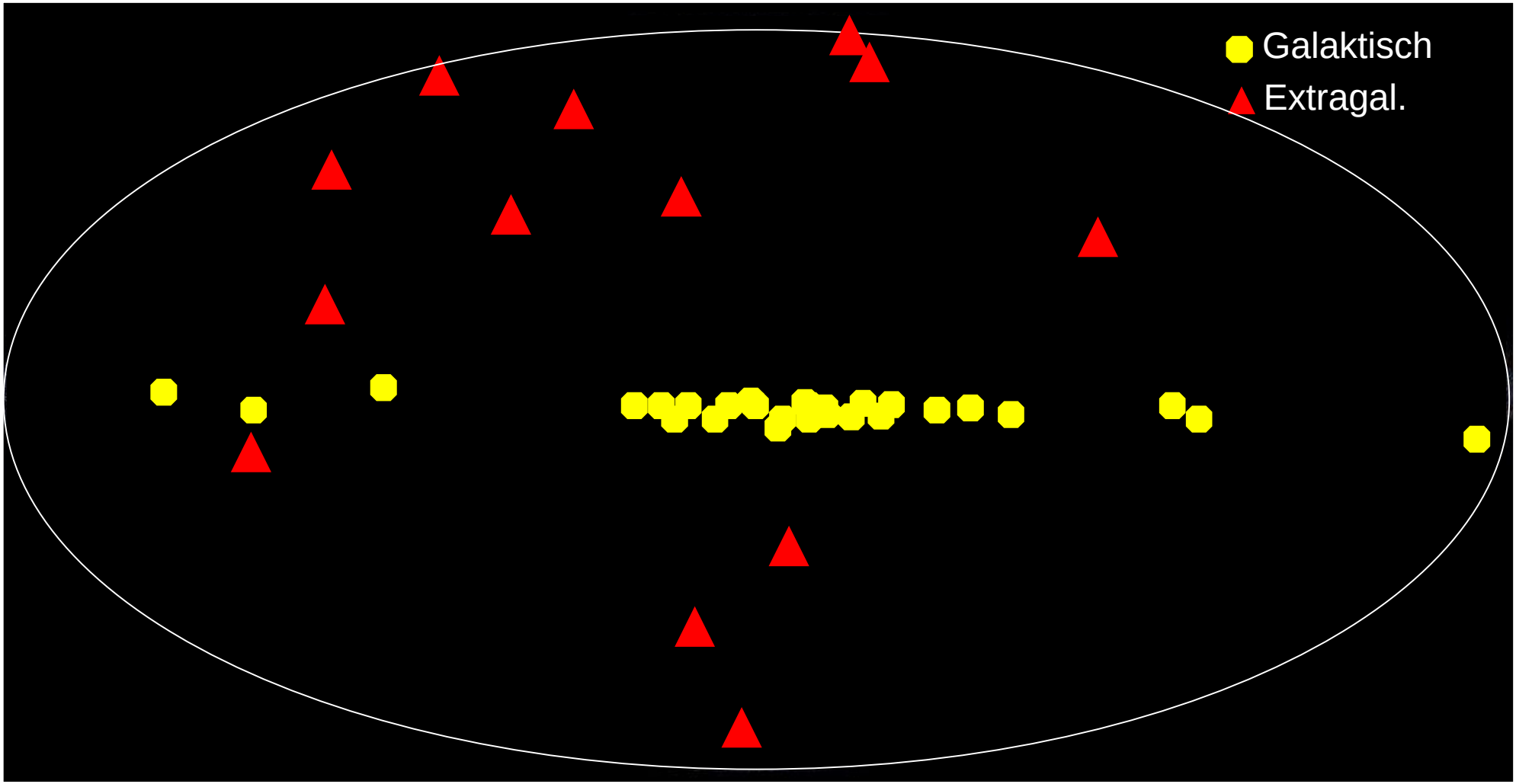
H.E.S.S. Durchmusterung der Milchstraße



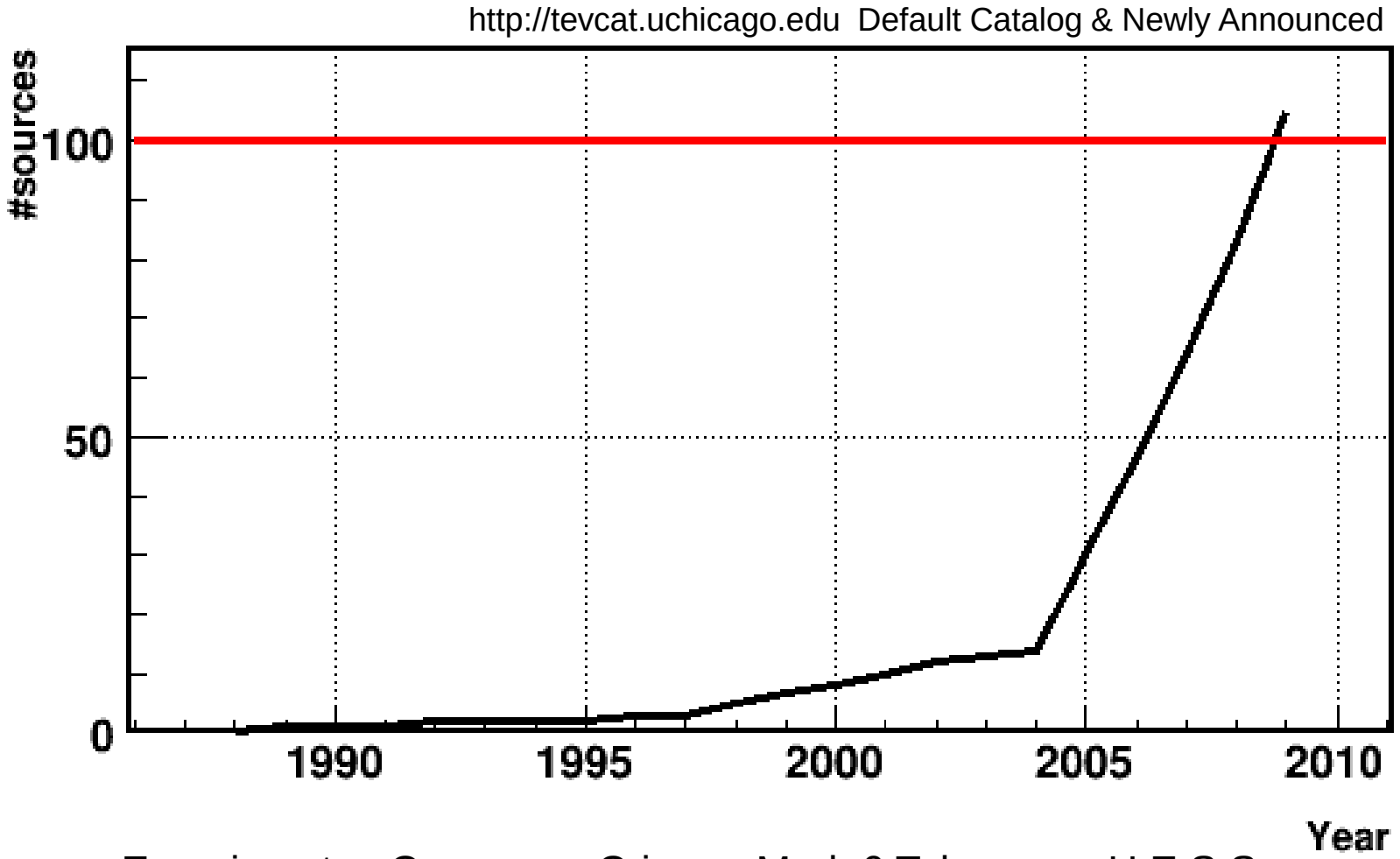
Unser Nachthimmel bei 10^{12} eV (vor 6 Jahren)



Unser Nachthimmel bei 10^{12} eV (Heute)

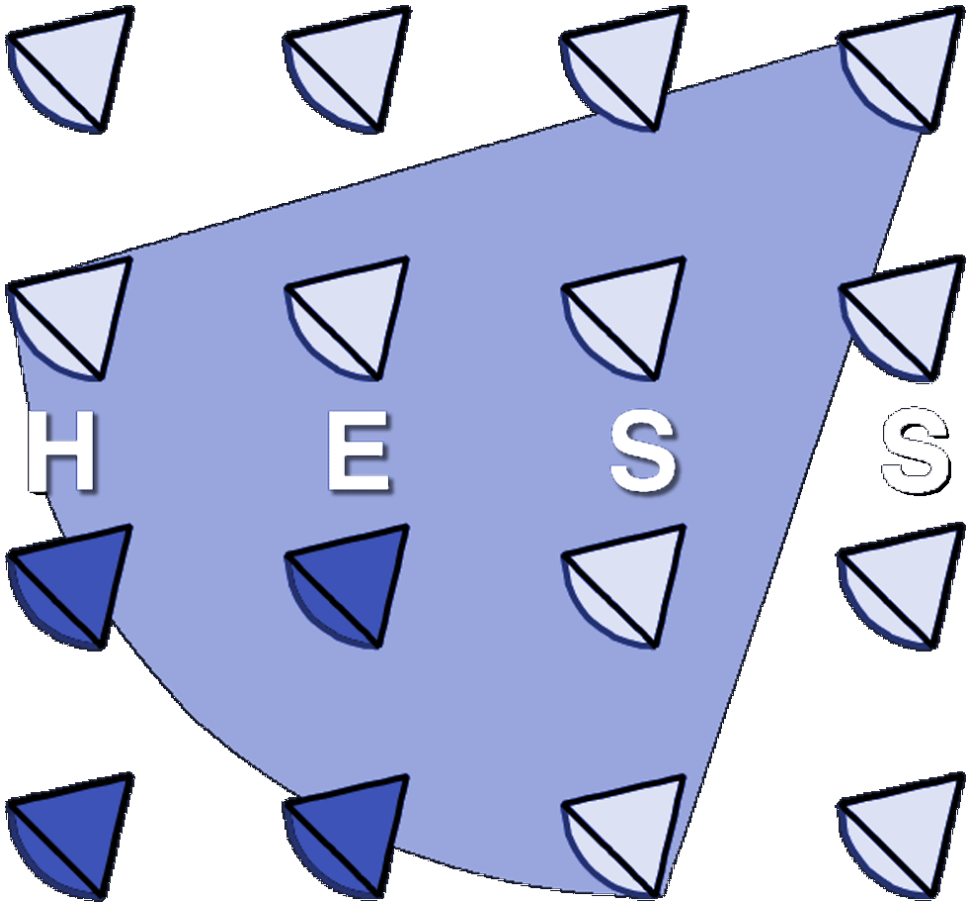


Eine Zeit voller Entdeckungen!

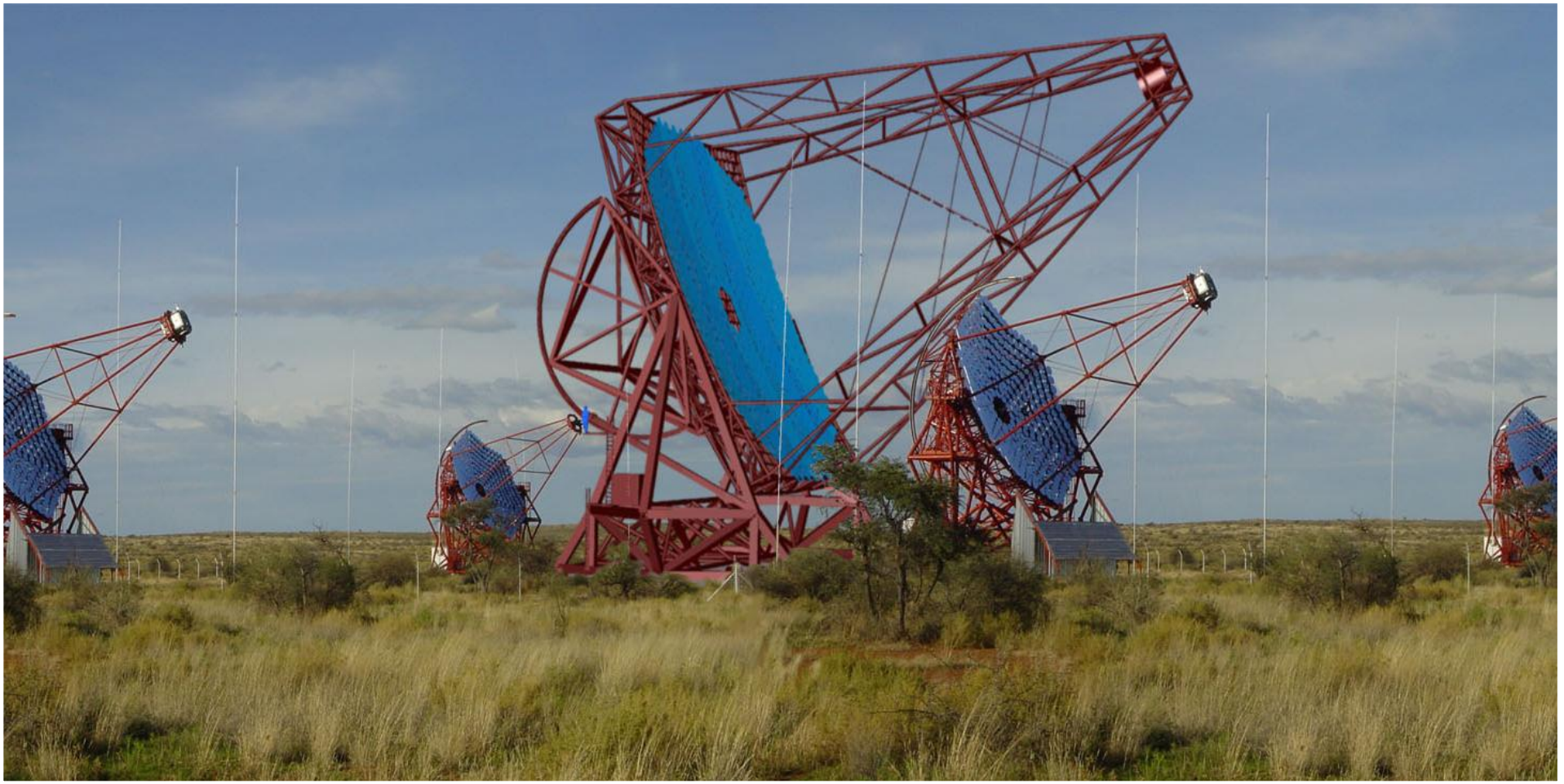


Experiments: Cangaroo, Crimea, Mark 6 Telescope, H.E.S.S., MAGIC, Milagro, Telescope Array, VERITAS, Whipple

Der nächste Schritt



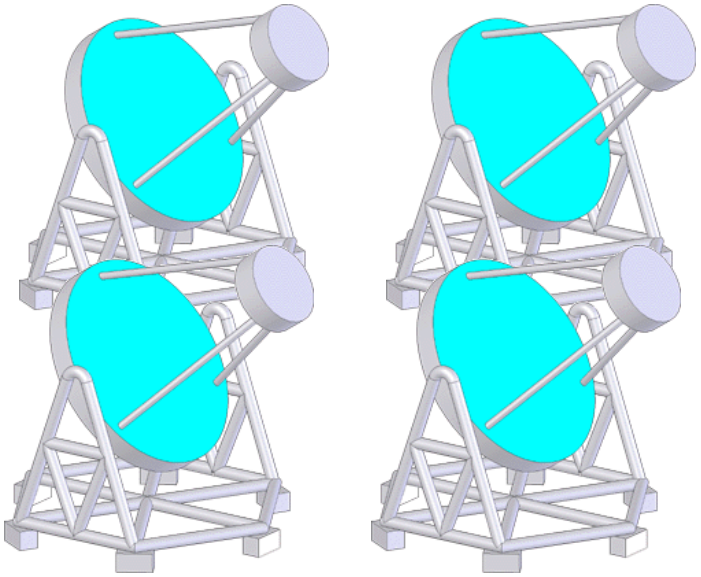
H.E.S.S. II

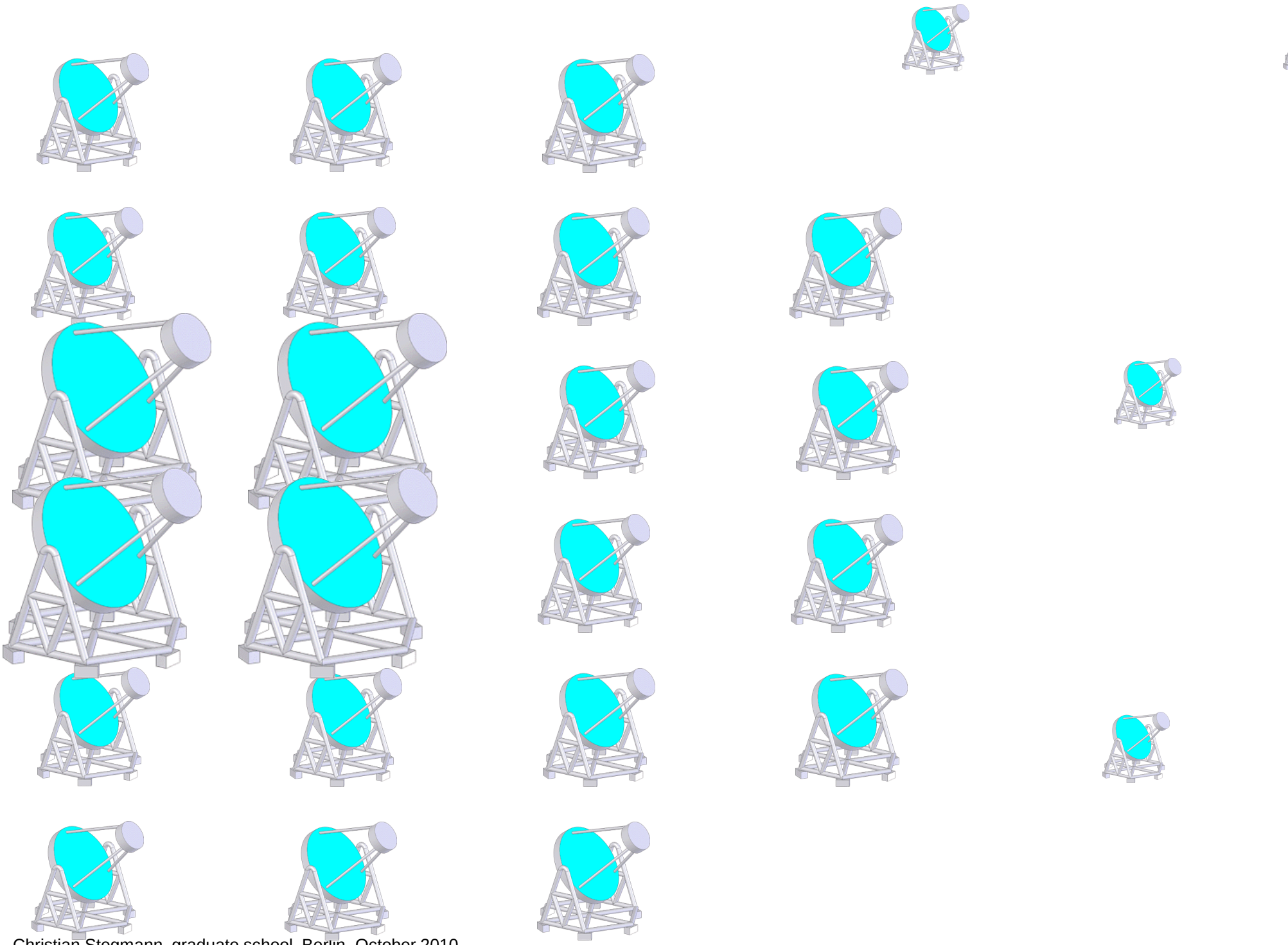


Die Zukunft

Das Cherenkov Telescope Array CTA

Ein Observatorium für Gammastrahlungsastronomie im nächsten Jahrzehnt

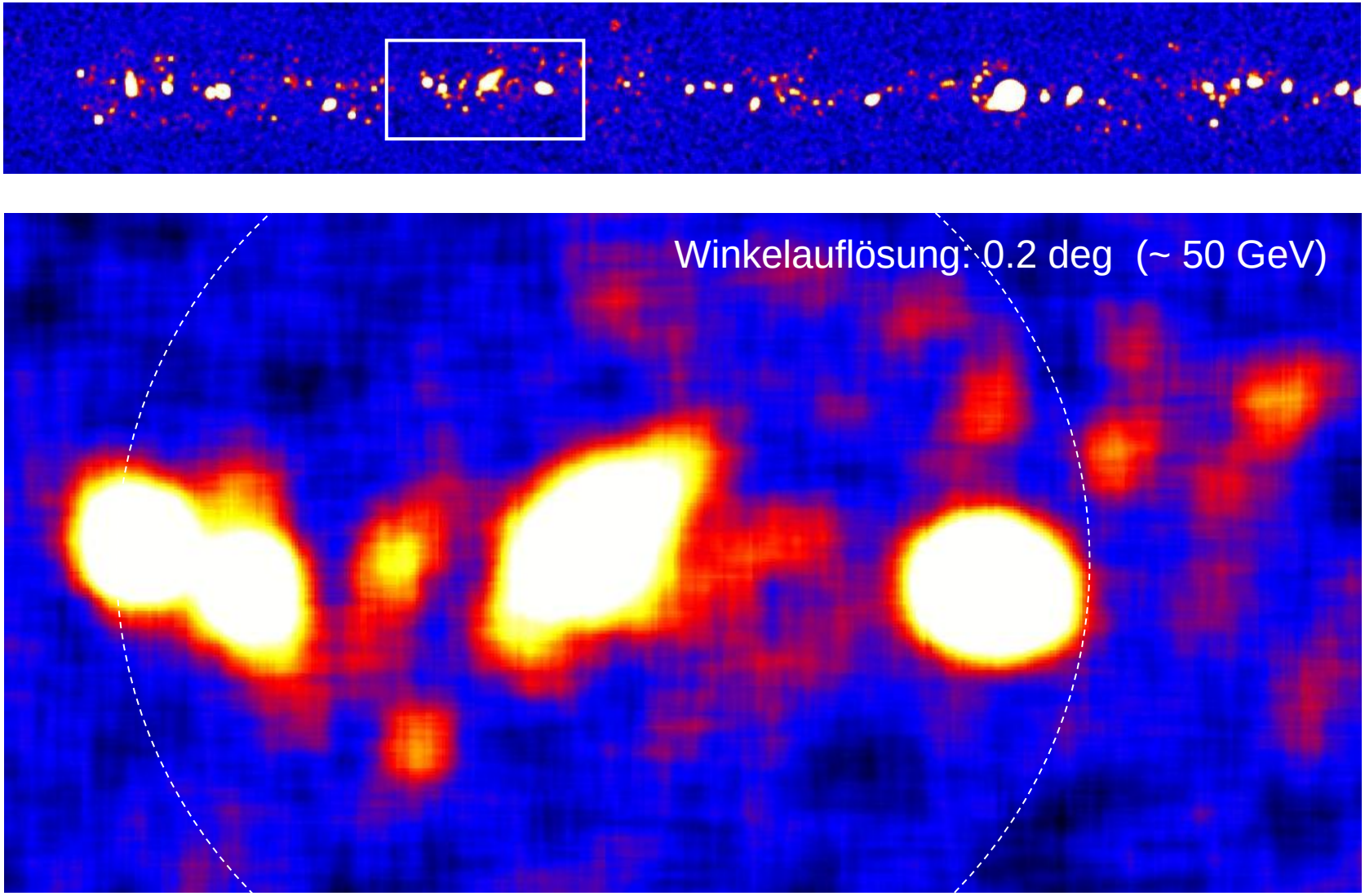




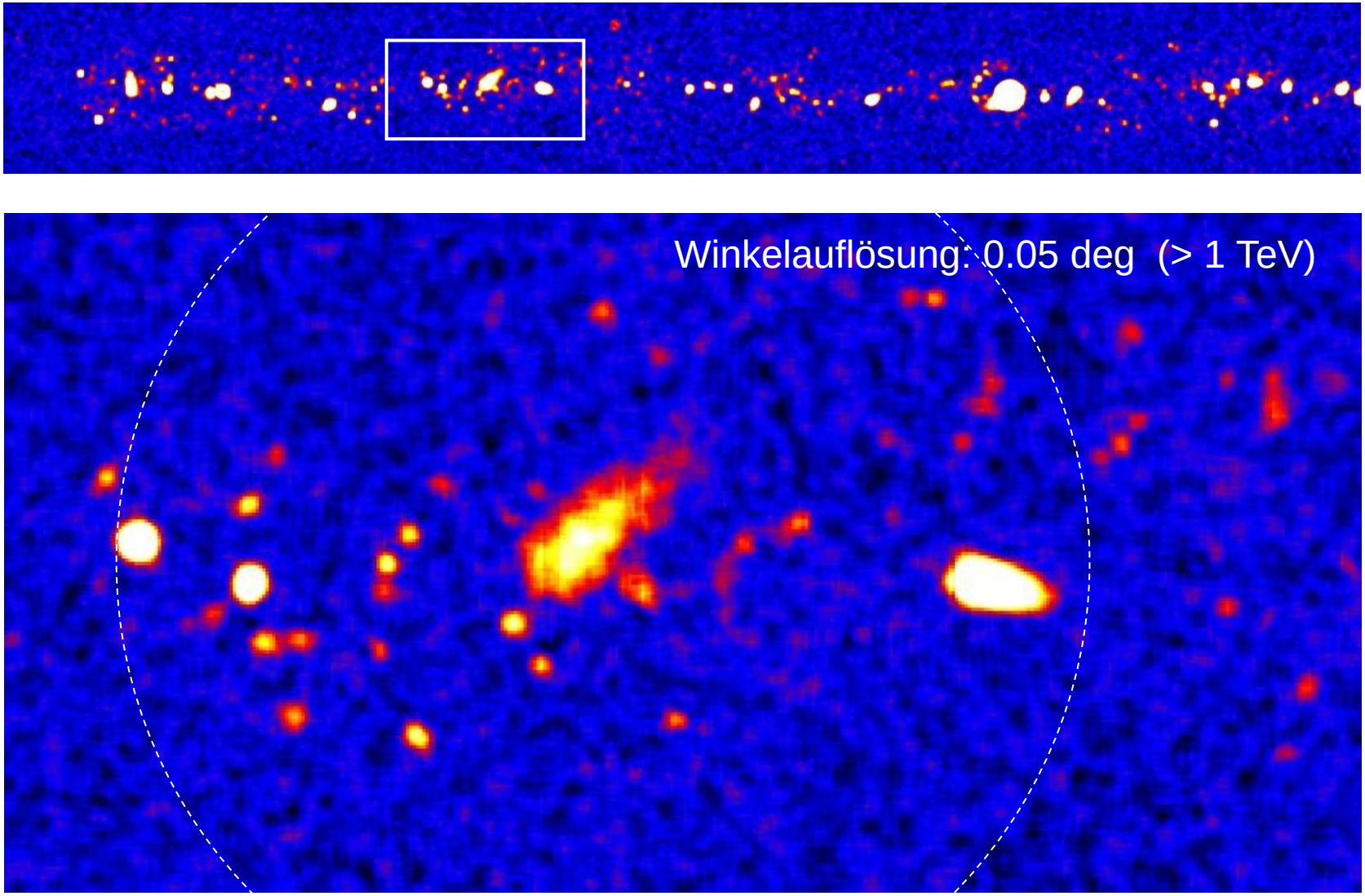
Christian Stegmann, graduate school, Berlin, October 2010

Alle Supernova-Überreste in der Milchstraße!

Die Galaktische Ebene mit CTA



Die Galaktische Ebene mit CTA



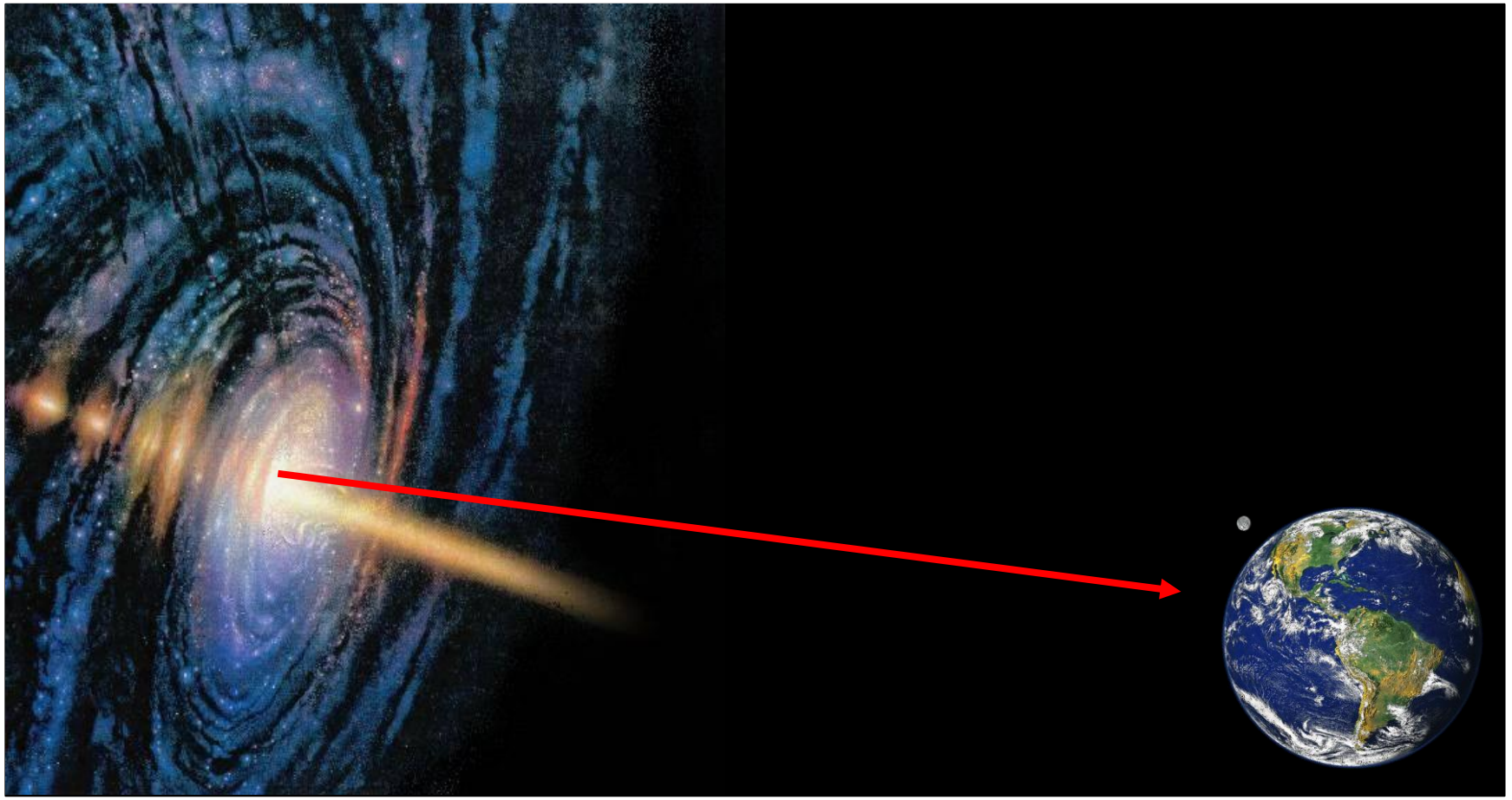
TeV-Gammastrahlungsastronomie ist Wirklichkeit

und hat eine strahlende Zukunft!

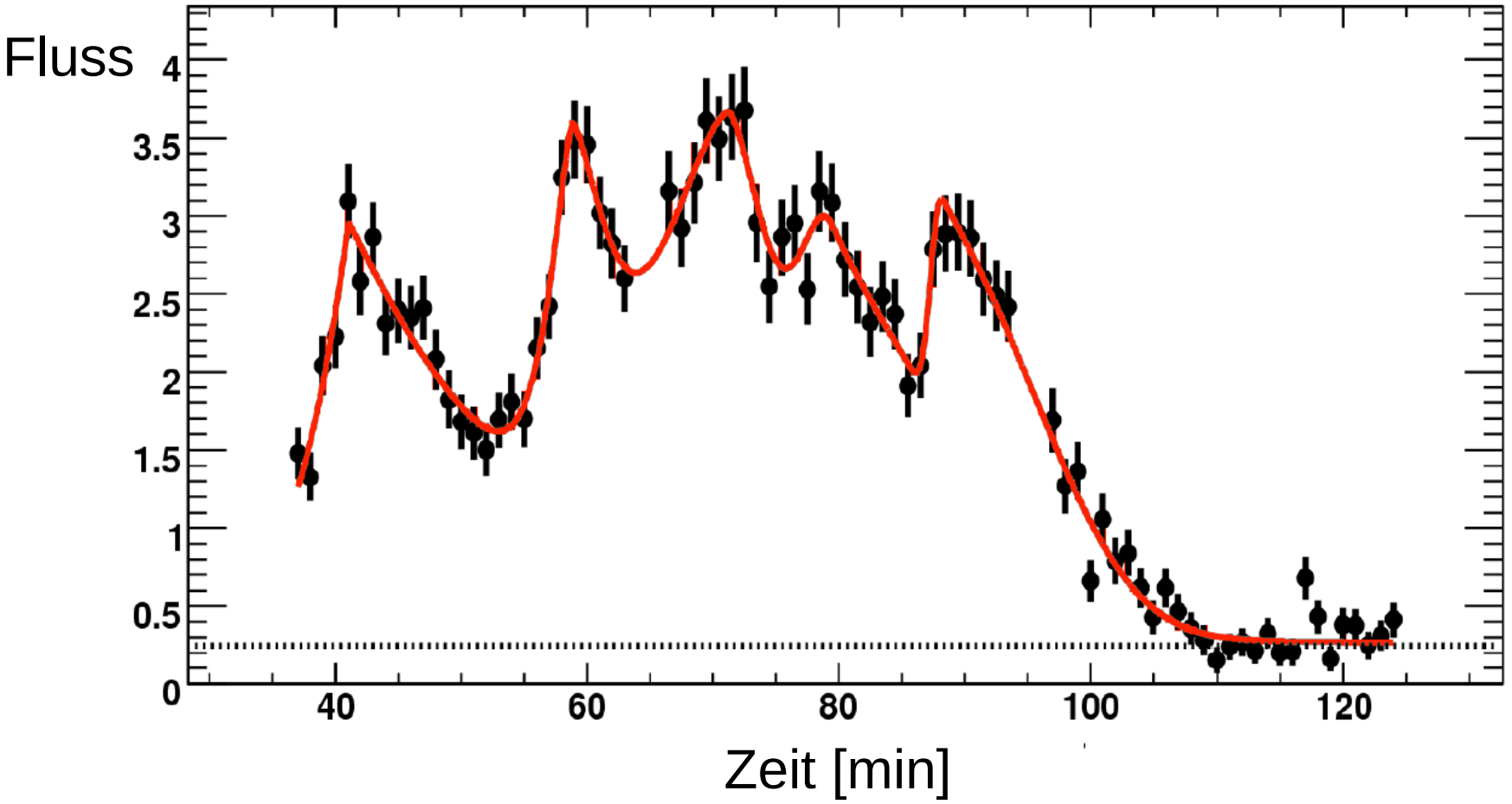
Summary

- Cosmic rays
  - are messengers from the high energy Universe
  - play an important role in the development of our Galaxy
  - are described in our Galaxy as a fluid
- Sources are active
  - accelerate particles in shock waves
- But even 100 years after the discovery the main questions raised by cosmic rays are still unanswered

Außerhalb unserer Milchstraße



Der 28.07.2006 – Der PKS2155-Strahlungsausbruch




PLANT & TOOL HIRE