The CTA Project

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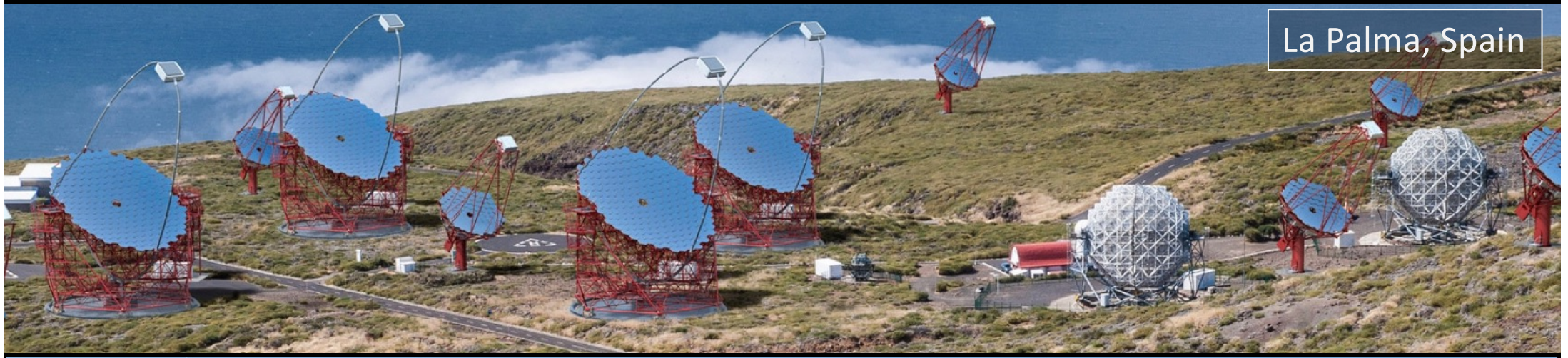
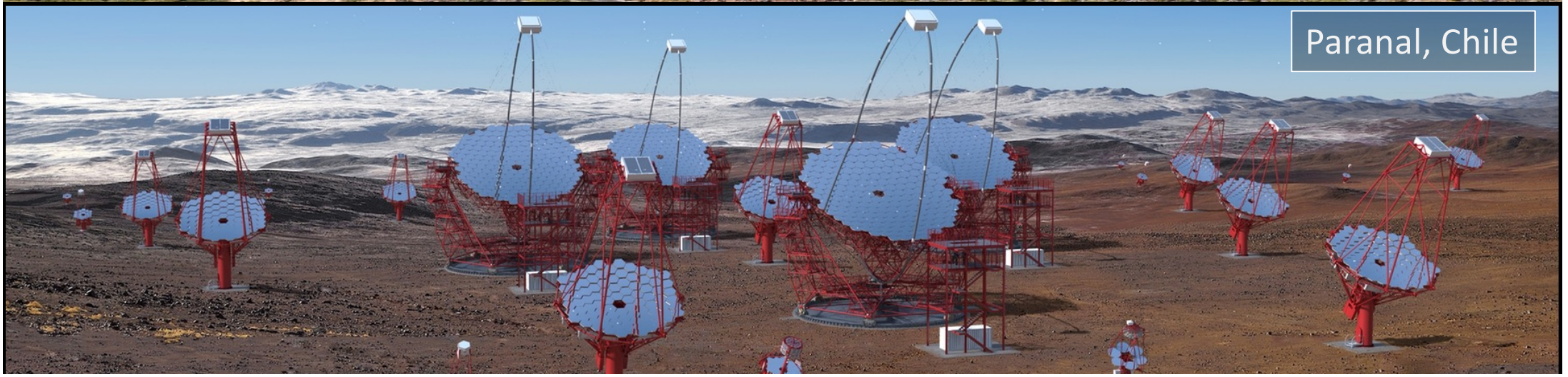
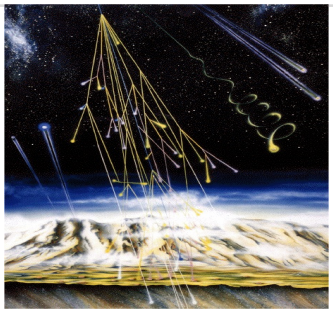
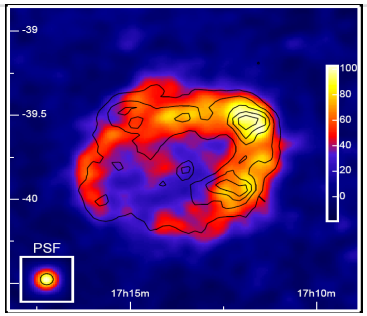




Science of CTA is very wide

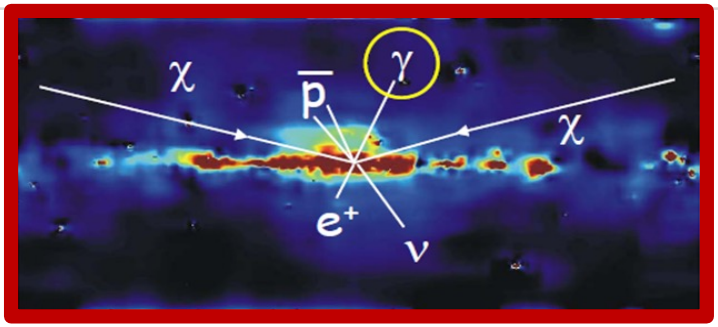
CTA-LST will cover S.M.B.H., Dark Matter, AGNs, GRBs





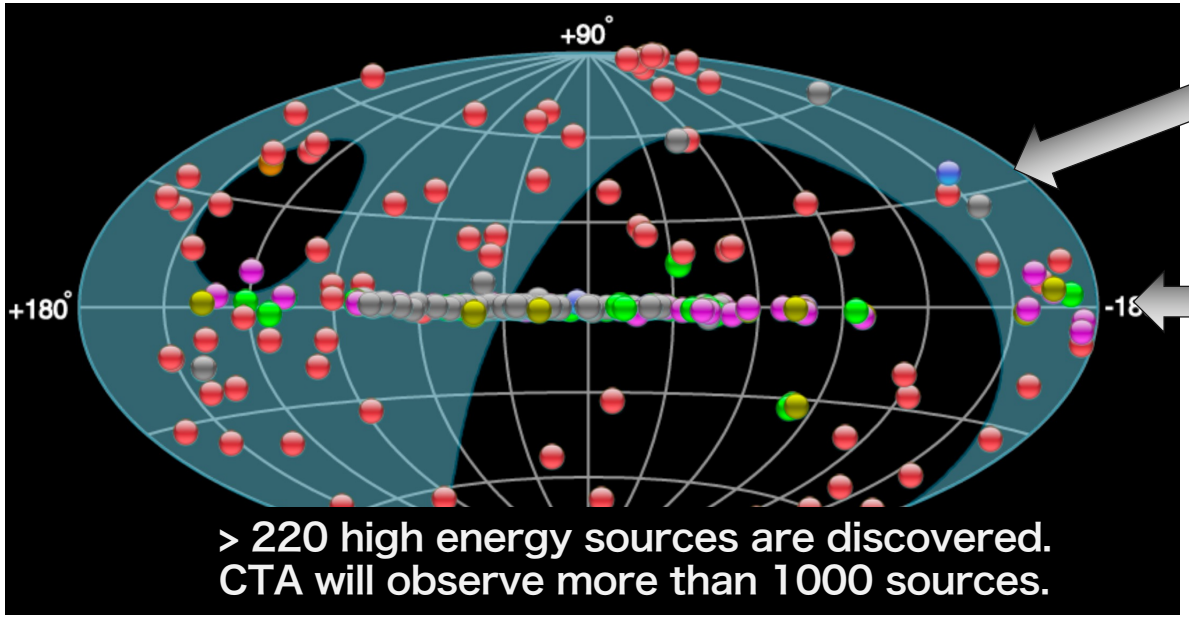
Cosmic Ray Origin

Super Massive Black Holes



Dark Matter Search (Discovery)

- Origin of Cosmic Rays (Big accelerators)
- Black Hole and S.M.B.H.
- Dark Matter Search

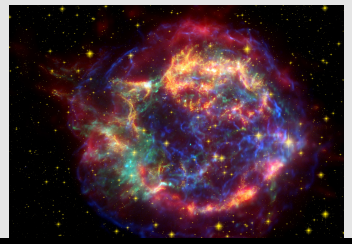


Extragalactic Sources

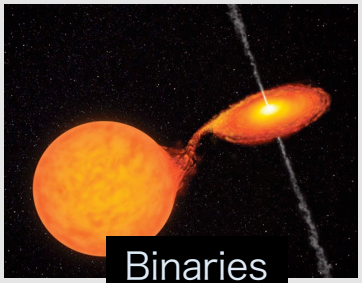
Active Galactic Nuclei

Gamma Ray Bursts

Galactic Sources



Super Nova Remnants



Binaries

共同利用体制

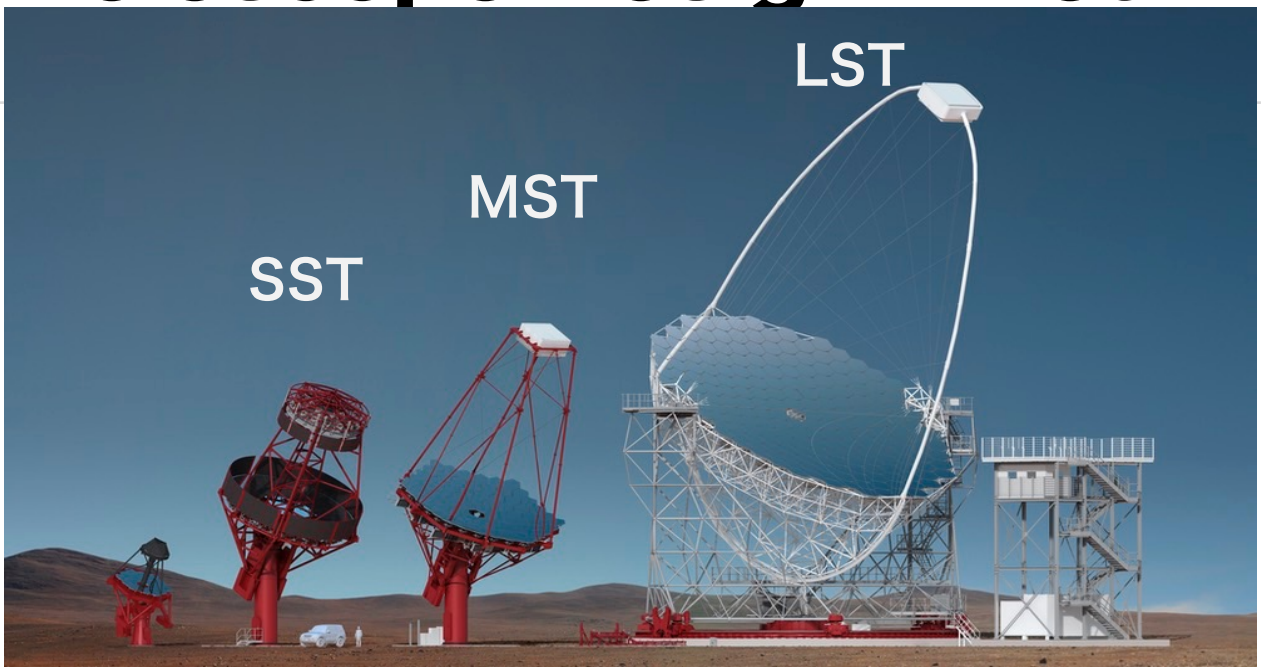
- 宇宙線研究所共同利用の現在
  - １４件の共同利用研究、１６０名の研究者
- CTAOとしての国際共同利用（公開天文台）
  - 40% Key Science Program（CTAC members)
    - 130-160 members can sign the papers among 1400 (10%)
    - 銀河中心、銀河面サーベイ、AGN、トランジェント、etc.
  - 40% Open Call for Proposals (Country/community)
    - 日本枠は 40% x 10% ➔ 4% (50hrs)
  - 20% Host premium
    - ESO (ESO メンバー国へ還元）、IAC(Spain)
- CTA South への貢献が日本の共同利用をさらに推進する。

Key Science Programs
40% obs. Time in the first 10years

Theme		Question	Dark Matter Programme	Galactic Centre Survey	Galactic Plane Survey	LMC Survey	Extra-galactic Survey	Transients	Cosmic Ray PeVatrons	Star-forming Systems	Active Galactic Nuclei	Galaxy Clusters
Understanding the Origin and Role of Relativistic Cosmic Particles	1.1	What are the sites of high-energy particle acceleration in the universe?		✔	✔✔	✔✔	✔✔	✔✔	✔	✔	✔	✔✔
	1.2	What are the mechanisms for cosmic particle acceleration?		✔	✔	✔		✔✔	✔✔	✔	✔✔	✔
	1.3	What role do accelerated particles play in feedback on star formation and galaxy evolution?		✔		✔				✔✔	✔	✔
Probing Extreme Environments	2.1	What physical processes are at work close to neutron stars and black holes?		✔	✔	✔			✔✔		✔✔	
	2.2	What are the characteristics of relativistic jets, winds and explosions?		✔	✔	✔	✔	✔✔	✔✔		✔✔	
	2.3	How intense are radiation fields and magnetic fields in cosmic voids, and how do these evolve over cosmic time?					✔	✔			✔✔	
Exploring Frontiers in Physics	3.1	What is the nature of Dark Matter? How is it distributed?	✔✔	✔✔		✔						✔
	3.2	Are there quantum gravitational effects on photon propagation?						✔✔	✔		✔✔	
	3.3	Do Axion-like particles exist?					✔	✔			✔✔	

Figure 3.1 – Matrix of CTA science questions and proposed Key Science Projects (KSPs). The KSPs are sets of observations addressing multiple science questions within the CTA themes. KSPs which contribute to the programme aimed at dark matter detection are indicated in green, with the exclusively dark-matter-oriented targets described entirely within the Dark Matter Programme in Chapter 4. For KSPs simultaneously addressing dark matter and other physics/astrophysics, the motivation and context for the dark matter element is again described in Chapter 4. The order of the KSPs in this table starts with dark matter due to its importance and transversal nature and follows with surveys and more focused KSPs by increasing distance scale. The check marks are intended to give a qualitative assessment of the impact of each KSP on a particular science question.

プロジェクトの熟成度
Telescope Design Fixed



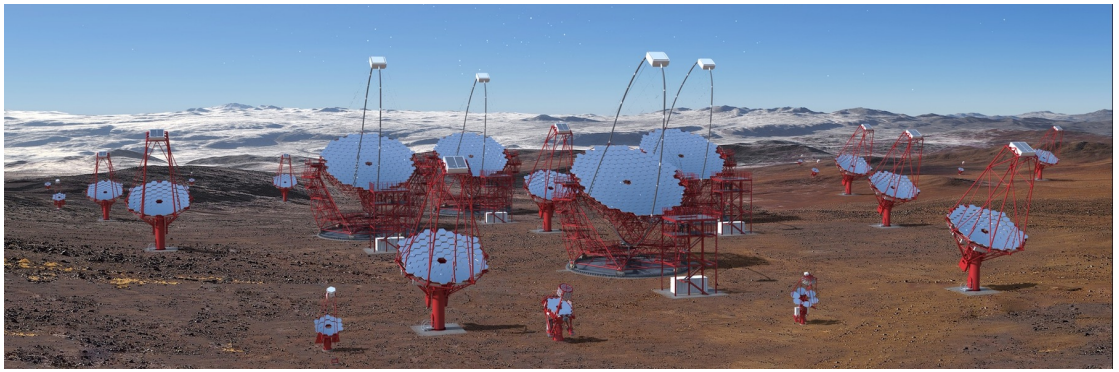
Telescope Types	SST	MST	LST
Optics	Schwarzschild-Couder	Davies-Cotton	Parabolic (Isochronous)
FoV and Camera	10.5 deg SiPM	7.5 deg PMT	4.3 deg PMT
Mirror Diameter	4.3m	11.5m	23m
Energy Range	3 TeV - 200 TeV	100GeV - 10TeV	20GeV – 2000GeV
Science Target	Galactic Sources PeVatron (UHE CR)	Galactic Sources Nearby AGNs (z<0.5) Dark Matter	Transient Sources AGNs(z<2), GRBs(z <4) Dark Matter

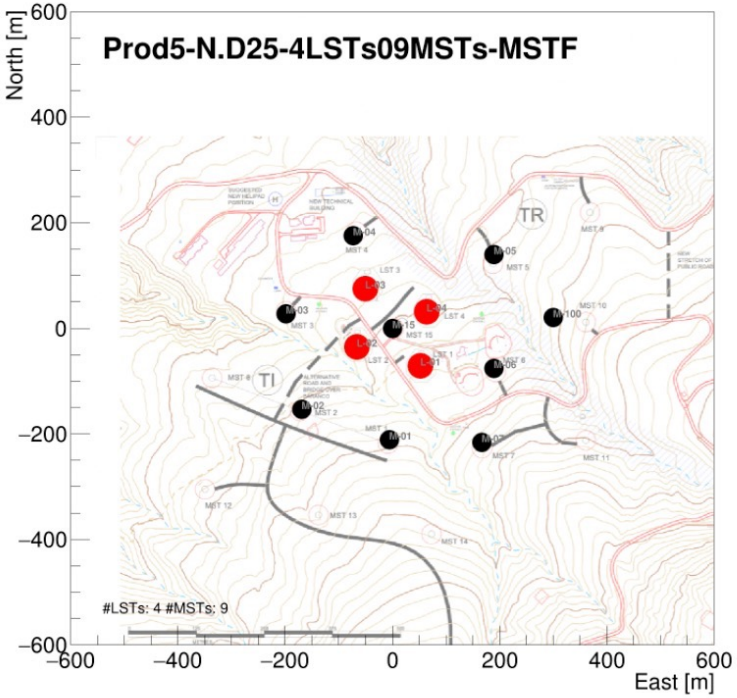
プロジェクトの熟成度

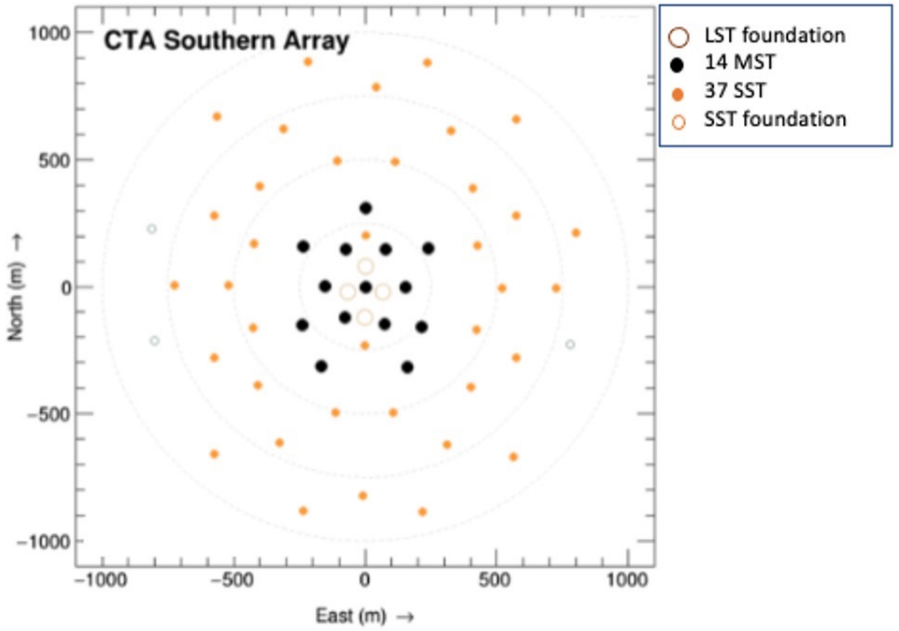
Alpha Configuration (CTAO Council, CTAO BGR) is decided with the financial constrants

Roque de los Muchachos Observatory
La Palma, Spain

Paranal, Chile







プロジェクトの成熟度

2006 HESS-MAGIC CTA Meeting, Project 議論を開始
2008 ESFRI Projectとして認定を受ける
2008-2012 Baseline Design, Telescope R&D 開始
2012 CTAC設立、CTA Resource board 設置
CTAO設置、STAC設置、LST/MST/SST Projects設置
2014 CTA South, CTA North sites 決定　(in CTA Resource Board)
2014 CTAO Council 設置
2014 LST/MST/SST Critical Design Review
2015 Business Plan 策定(柏ミーティング）, CTAO Council
2017 CTAO ERIC を目指して、CTAO BGR が作られる
2018 LST-1 が最初のCTA望遠鏡として建設される
2018 ESFRI Landmark Project として認定される
2019 CTAO
2020 LST CDR を通過
2021 Alpha Config, CTAO Statutes 定款をまとめる、EC に10月提出
2022 CTAO ERIC 発足予定、CTAO建設開始

CTAC主導

CTAO主導

CTA Timeline

- 2016-2018　大口径望遠鏡 LST1 が最初のCTAサイトに建設される
- 2021-2022　Array配置、各国からの予算が決定され、CTAO ERIC が設立される。
- 2021-2024　CTA North にLST４基のアレイが建設・完成され、運用が開始される。
- 2024-2028　14MSTs、37MSTs が 建設される。

<table>
<tr><th></th><th>2020</th><th>2021</th><th>2022</th><th>2023</th><th>2024</th><th>2025</th><th>2026</th><th>2027</th><th>2028</th><th>2029</th><th>2030</th></tr>
<tr><td rowspan="2">Organization</td><td colspan="4">CTAO gGmbH (Heidelberg)</td><td colspan="7"></td></tr>
<tr><td colspan="3"></td><td colspan="8">CTAO ERIC (European Research Infrastructure Consortium)</td></tr>
<tr><td>Alpha Config</td><td>2020</td><td>2021</td><td>2022</td><td>2023</td><td>2024</td><td>2025</td><td>2026</td><td>2027</td><td>2028</td><td>2029</td><td>2030</td></tr>
<tr><td rowspan="2">LST North</td><td colspan="5">Comissioning and Operation of LST1</td><td colspan="4" rowspan="2">Operation as 4 LST Array</td><td rowspan="5" colspan="2">Observatory Operation</td></tr>
<tr><td colspan="2">CDR</td><td colspan="3">Deployment of LST2-4</td></tr>
<tr><td>MST North</td><td colspan="3">Design and Finance</td><td colspan="6">Construction of 9MSTs</td></tr>
<tr><td rowspan="2">CTA South</td><td colspan="2" rowspan="2">Array config, Finance and CDR</td><td colspan="2" rowspan="2">INFRA</td><td colspan="4">Construction and Deplyment of 14 MSTs</td></tr>
<tr><td colspan="4">Construction and Deployment of 37 SSTs</td></tr>
<tr><td>Extension</td><td>2020</td><td>2021</td><td>2022</td><td>2023</td><td>2024</td><td>2025</td><td>2026</td><td>2027</td><td>2028</td><td>2029</td><td>2030</td></tr>
<tr><td>LST South</td><td></td><td colspan="5">Advanced Design and Proto / Finance / CDR</td><td colspan="4">Construction of 4LSTs</td><td>Operation</td></tr>
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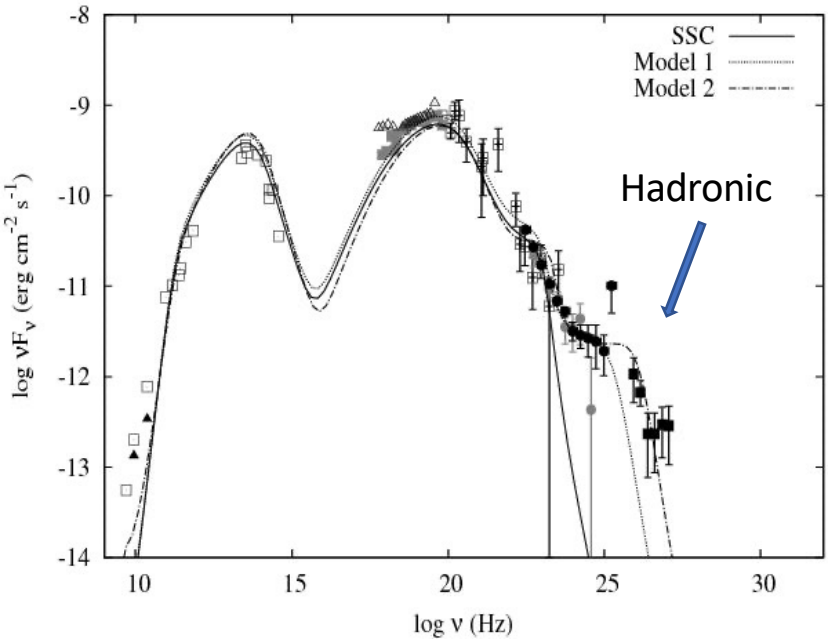
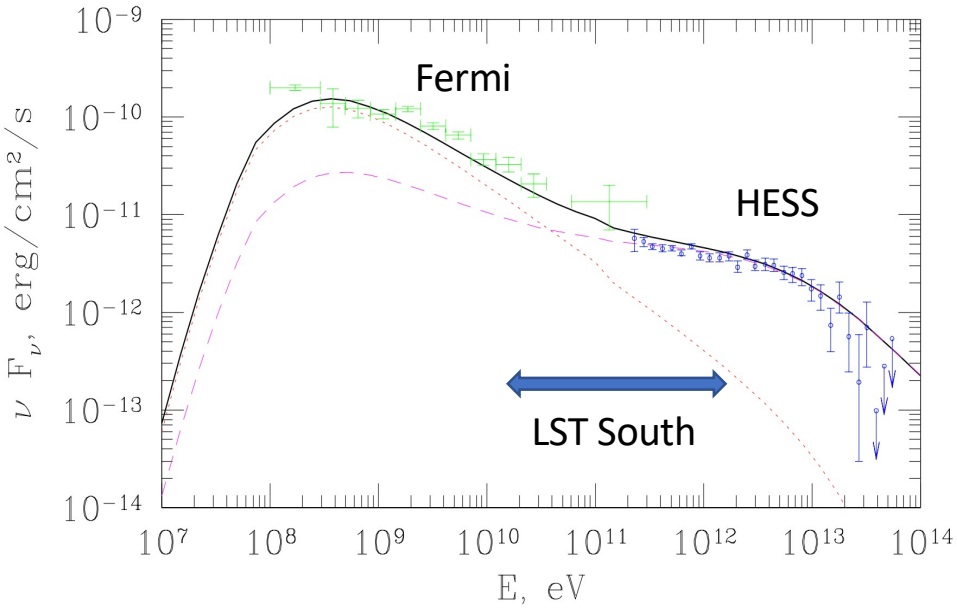
LST South 緊急性

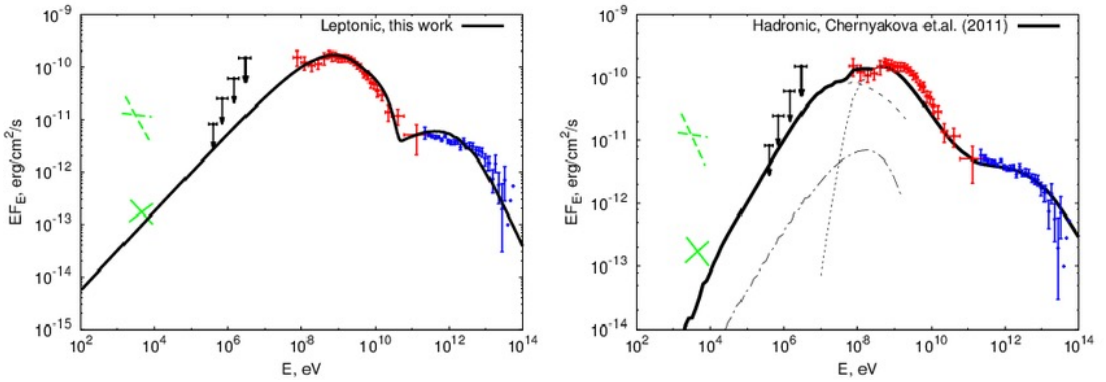
- 南半球でのサイエンスが不十分
  - AGNフレアー、GRB 観測の重要観測が半数
  - 100GeV-1TeV 領域でDM探索感度が不十分
  - G.C. (Soft ➔ Hard at 100GeV)の観測ができない
  - Cen A (Fermi-HESS tension at 100GeV) ➔ Two components
- 予想外の速さで CTAO ERIC の設立が進みつつある。
- First Phaseの後、Second Phase があるのか?
  - Second Phase がない可能性が高い。
  - ５–６年以内に、LST South の建設を行わないといけない。
  - First Phase 後では、マンパワーも拡散してしまう。
  - LSTを建設する技術が喪失される。
- 日本の貢献は10%レベルで、ドイツ、フランス、イタリア、スペインと比べ劣り、バランスが悪い。
  - LST South への貢献で20%レベルとなる。
  - MST、SSTへの貢献は他国が主要な貢献をしている。

Cen A and Galactic Center



Cen A, Leptohadronic Model
N(P)/N(e) ~ 50
By M. Petropoulou et al. 2014 A&A

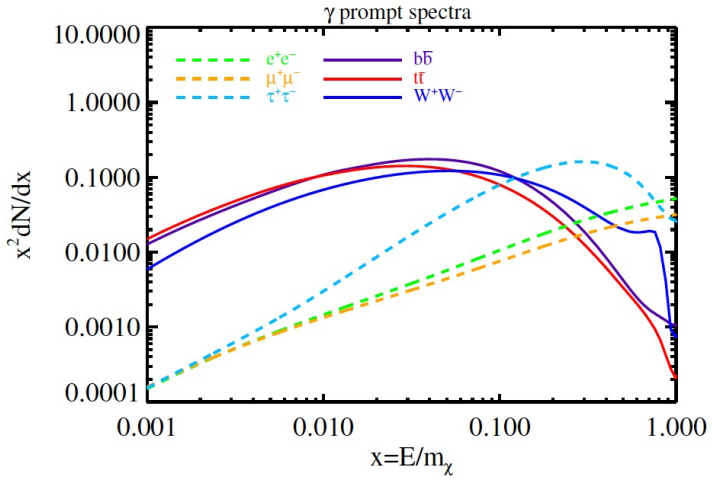




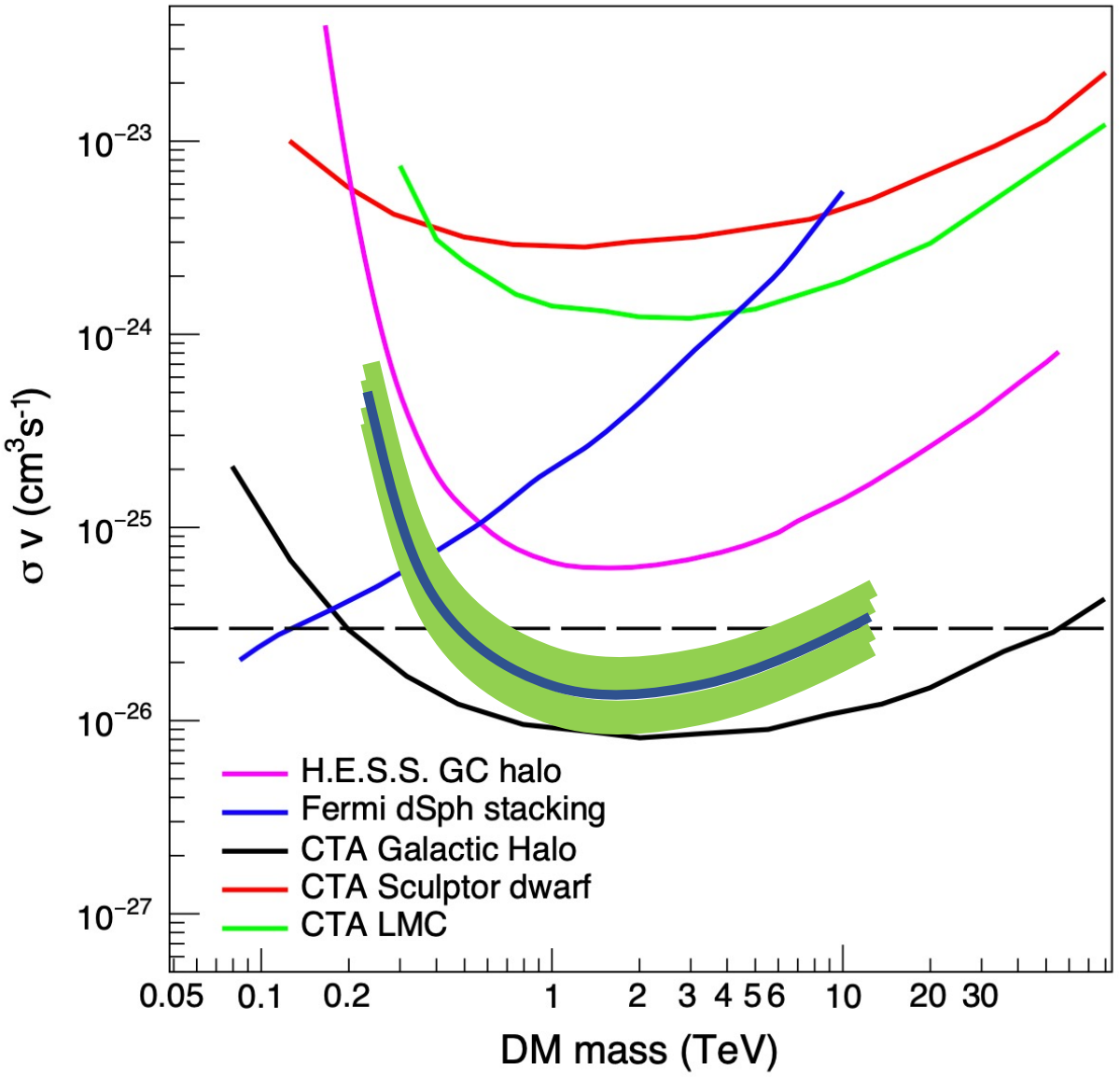
Spectrum of Galactic Center
By Chernyakova 2015

Dark Matter Sensitivity w/o LSTs and SSTs,

Teshima's Guess 2021, Surelly we need MC results.



Gamma rays from Annihilation produce the bump around 1/10 - 1/20 Mχ ➔ 20GeV-1TeV gamma



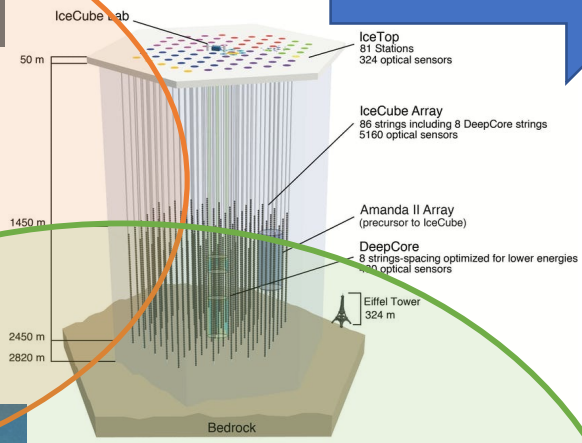
Multi-messenger and Multi-wavelength Astrophysics

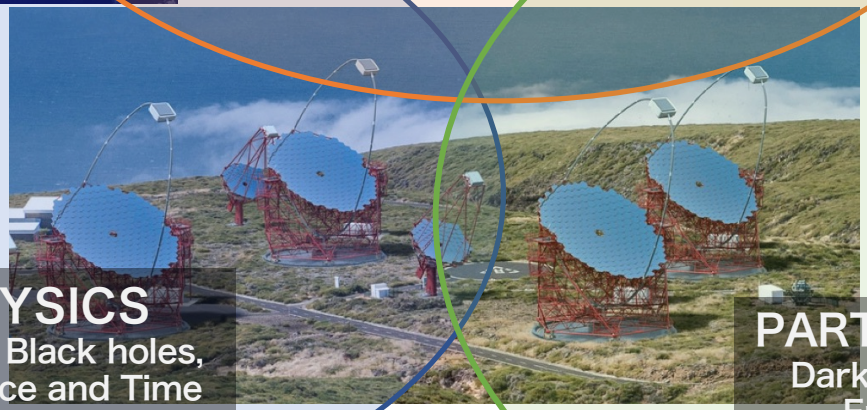
cherenkov telescope array

Wave AstroPhysics

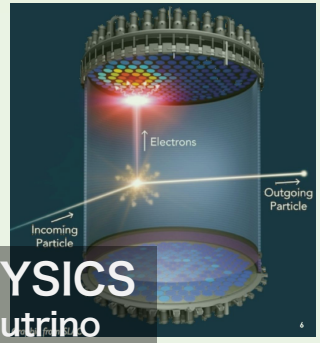
Particle Physics

ASTRO-PARTICLE PHYSICS
Cosmic Ray Physics
High Energy Astrophysics





ASTRO-PHYSICS
Gamma Ray Bursts, Black holes,
Neutron Stars, Space and Time



PARTICLE PHYSICS
Dark Matter, Neutrino
Energy Frontier