2021 PhD Application

Jun Li

Supervisor: Jin Chang

2021/05/08

Self Introduction

- Graduated from Software Engineering, Department of Computer Science , Shandong University.
- Research direction is lhaaso and indirect dark matter detection， co-supervised by Xiaoyuan Huang in PMO.
- Course grade and participation in academic activities during the master's degree：

  The weighted average score of professional courses is 78, and the English level 6 is 425 points.

  Participate in "LHAASO collaboration & Construction Meeting" in April 2021.

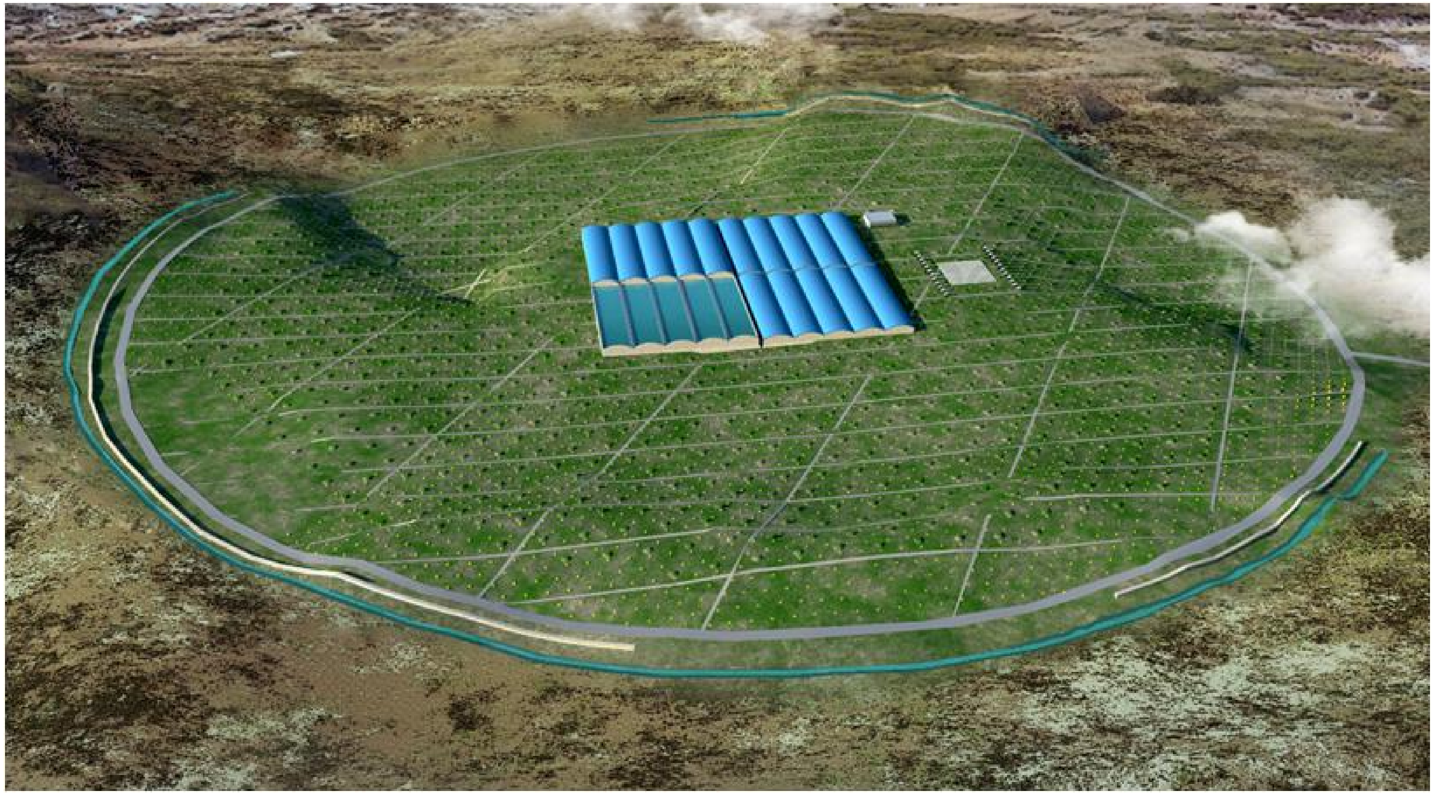
  The shielding effect of cosmic rays about planets on cosmic rays.

Grade

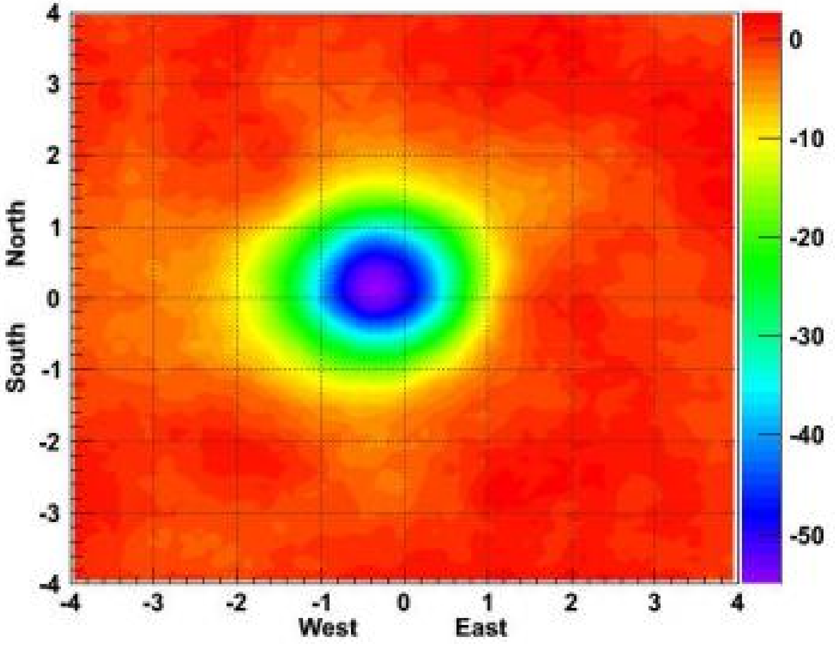
课程编号	课程名称	成绩	学分	学时	教 师
FL05301	研究生综合英语	通过	2	40	-
PS05101a	自然辩证法概论	通过	1	18	李文忠
PS05102a	中国特色社会主义理论与实践研究	通过	2	36	张勤
FL05302	日常交流英语	通过	2	40	-
FL06301	科技论文写作	通过	2	40	夏学文
AY15207	天体物理中的辐射过程	77	4	80	林宣滨
ES15210	可编程逻辑器件原理及应用	70	3	60	宋克柱
ES15702	物理电子学逻辑设计与仿真实验	85	2	-	宋克柱
PH24212	核与粒子物理导论	65	4	80	黄光顺
SH05105	西方科技史	82	4	80	石云里
AY15218	天文数据处理	93	3	60	刘桂琳
AY15221	粒子宇宙学	98	3	60	蔡一夫
AY16206	宇宙大尺度结构	75	4	80	王慧元
004017	粒子探测技术	60	4	80	刘建北
LB05203a	文献管理与信息分析	93	3	60	罗昭锋
GPA：2.82					

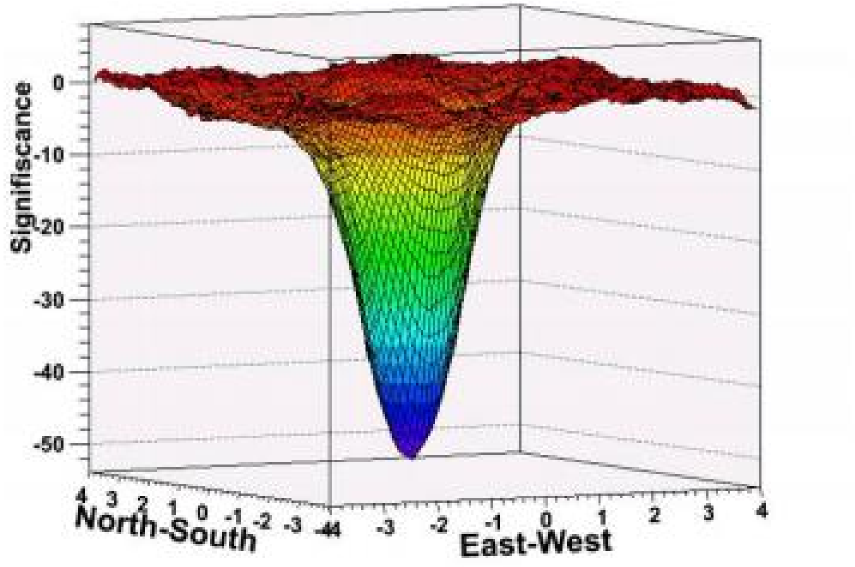
LHAASO

- **LHAASO and sheild effect of the celestial bodies**
- **Analysis of some point sources**
- **LHAASO and indirect dark matter searches(PhD)**



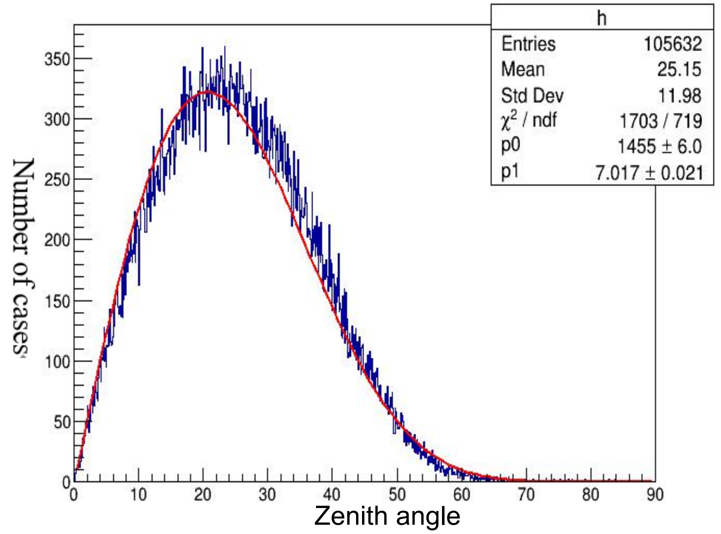
Moon shadow





By conducting a detailed study on the moon shadow, we can check the orientation system error of the detector, estimate the angular resolution of the detector and calibrate the energy of the detector.

Sheild effect of the celestial bodies



$$\varepsilon(\theta) = \cos^7 \theta$$

A measure of cosmic ray occlusion effect

Time interval

$$\eta = \sum \Delta t\, r^2\, \varepsilon(\theta)$$

Detection efficiency

Apparent radius

The purpose of the research is to imitate the analysis and calculation of the planets shadow effect, comparing the moon.

(Cut: zenith < 40°，2020/1/1 00：00——2024/12/30 00：00)

Sheild effect of the celestial bodies

$\sum \Delta t r^2 \varepsilon(\theta)$

Ratio to η of the moon

Celestial bodies	η	Rate	
Critical-list numbered minor planets(650)	6.98885e-07	3.3742988796857558e-09	The minor planets
Distant minor planets(3747)	3.55714e-05	1.7174289785709234e-07	
Unusual minor planets(18169)	0.0857058	0.00041379767046448851	
All minor planets(22166)	0.085742070285	0.00041397278766122186	
Mars	**0.00689729430695**	3.330094715554683e-05	The major planets
Venus	0.0381211310996	0.00018405329912894708	
Mercury	0.00318853988725	1.5394645141018947e-05	
Jupiter	0.0803391225414	0.00038788672125797793	
Saturn	0.000861242620965	4.1581805462412636e-06	
Uranus	0.00145070563109	7.0041772047487175e-06	
Neptune	0.000153157267836	7.394612808612953e-07	
Comets	2.55247e-07	1.2323625004731116e-09	Comets

Significance

For a certain celestial body A:

formula for calculating significance

$$S = \frac{N_{on} - \alpha N_{off}}{\sqrt{N_{on} + \alpha^2 N_{off}}}$$

α is the ratio of the observation time towards the source window and the observation time from the back source window

$$\frac{N_{on,moon}}{N_{on,A}} \approx \frac{N_{off,moon}}{N_{off,A}} \approx \frac{\eta_{moon}}{\eta_A} \Rightarrow \frac{S_A}{S_{moon}} = \sqrt{\frac{\eta_A}{\eta_{moon}}}$$

Without involving coincidence and magnetic field, we can get:

form Rui Zhang's report

$$S_{\text{Venus}} = 0.01357 * S_{moon} = 0.01357 * \boxed{103.25} = 1.401$$

$$S_{Jupiter} = 0.01969 * S_{moon} = 0.01969 * 103.25 = 2.032$$

Analysis of some point sources

Source name (KM2A)	RA (°)	Dec (°)	Extension > 25TeV (°)	$\sqrt{TS}$ > 25TeV	TeVCat	Pulsar	Age (Kyr)	Distance (kpc)
J0534+2201	83.61 ± 0.02	22.00 ± 0.02	PSF	31.1	Crab	J0534+2200	1.3	2.0
J0008+7255	2.09±0.24	72.93 ± 0.06	point[a]	7.2	CTA1	J0007+7303	13.9	1.4
J0342+5257	55.59± 0.22	52.96 ± 0.10	0.33 ± 0.12	7.3	new	B0339+53	2280	1.71
J0621+3745	95.40 ± 0.12	37.76 ± 0.08	0.24 ± 0.09	7.9	new (3HWC)	J0622+3749	207	1.6
J0633+1747	98.33 ± 0.14	17.79 ± 0.13	0.96 ± 0.05	12.8	Geminga	J0633+1746	342	0.25
J0701+1445	105.43 ± 0.26	14.76 ± 0.24	0.96 ± 0.16	7.1	2HWC J0700+143	B0656+14	111	0.29
J1825-1330	276.44± 0.05	-13.50 ± 0.05	0.31 ± 0.048	17.2	HESS J1825-137	B1823-13	21.4	4.0
J1830-1003	277.75 ± 0.14	-10.06 ± 0.21	0.53 ± 0.18	6.8	HESS J1831-098	J1831-0952	128	4.3
J1838-0603	279.68 ± 0.09	-6.06 ± 0.10	0.58 ± 0.08	11.5	2HWC J1837-065	J1838-0549	112	4.1
J1843-0341	280.97 ± 0.07	-3.70 ± 0.07	0.47 ± 0.09	13.5	HESS J1843-033	J1841-0345	56.0	3.8
J1848-0149	282.12 ± 0.16	-1.83 ± 0.14	0.52 ± 0.19	7.3	HESS J1848-018	B1845-01	1990	4.4
J1850-0005	282.55± 0.07	-0.09± 0.07	0.47 ± 0.08	13.4	2HWC J1852+013	J1850-0006	8040	5.63
J1857+0214	284.28 ± 0.12	2.23 ± 0.14	0.63 ± 0.13	8.8	HESS J1857+026	J1856+0245	20.6	6.3
J1908+0617	287.01 ± 0.05	6.29 ± 0.05	0.66 ± 0.06	24.0	MGRO J1908+06	J1907+0602	19.5	2.6
J1912+1008	288.05 ± 0.14	10.14 ± 0.15	0.26 ± 0.21	5.1	J1912+101	J1913+1000	792	7.67
J1928+1804	292.07 ± 0.06	18.07 ± 0.07	0.36 ± 0.07	11.36	J1928+177	J1928+1746	82.6	4.3
J1956+2854	299.09 ± 0.14	28.91 ± 0.09	0.46 ± 0.12	8.9	2HWC J1955+285	J1954+2836	69.0	2.0
J2019+3649	304.86 ± 0.03	36.83 ± 0.03	0.35 ± 0.03	25.5	VER J2019+368	J2021+3651	17.2	1.8
J2031+4120	307.86 ± 0.09	41.33 ± 0.07	0.58 ± 0.10	15.2	J2032+4130	J2032+4127	181	1.7
J2045+4421	311.48 ± 0.15	44.36 ± 0.12	0.21 ± 0.15	5.4	new (3HWC)			
J2109+5155	317.38 ± 0.14	51.92 ± 0.08	0.22 ± 0.08	7.2	new			
J2159+5637	329.93 ± 0.05	56.62 ± 0.09	0.23 ± 0.07	7.1	new			
J2228+6054	337.20 ± 0.11	60.90 ± 0.06	0.41 ± 0.09	16.2	Boomerang	J2229+6114	10.5	3
J2234+5854	338.62 ± 0.28	58.92 ± 0.14	0.59 ± 0.16	7.9	new	J2238+5903	26.6	2.83

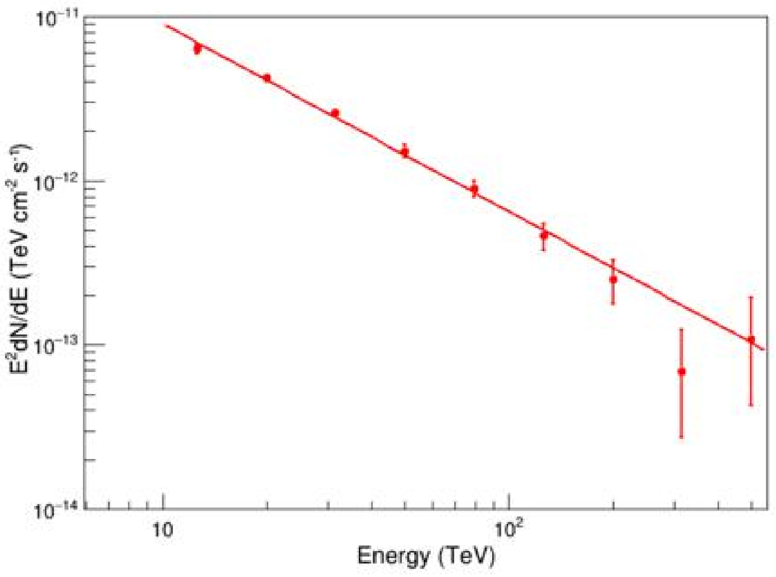
[a] The extension is less than PSF.

- In order to check the correctness of 3D energy spectrum analysis.
- In order to be familiar with the LHAASO energy spectrum analysis process and get the DM limits of LHAASO

Example of point source analysis

J0534+2201

Double_t Non[bin] = {19193, 4555, 517, 167, 93, 31, 11, 2, 2};
Double_t Noff[bin] = {17093.199, 3416.6721, 149.05238, 18.126911, 8.0095165, 1.2181522, 0.2922795, 0.0743711, 0.0329984};



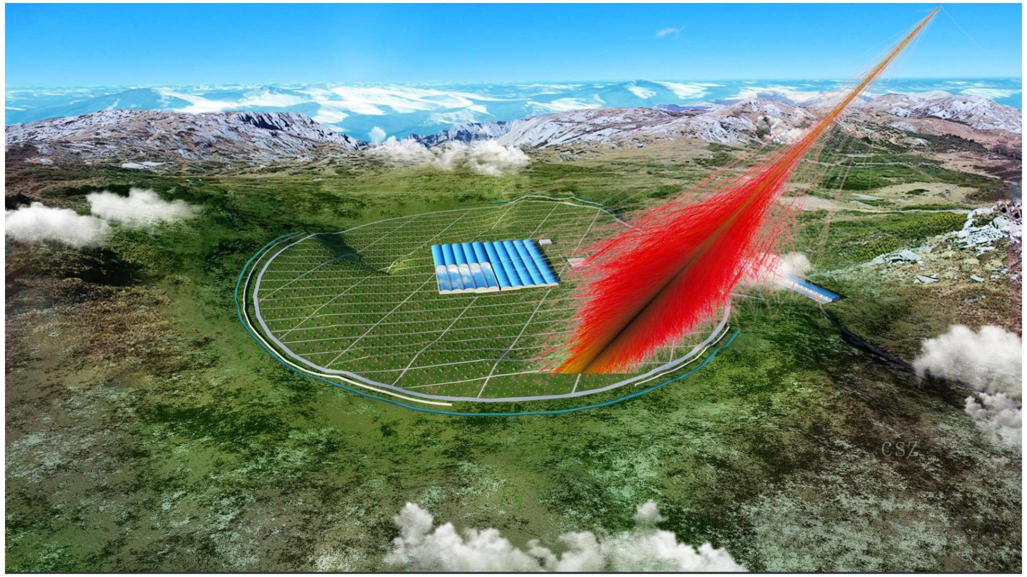
ra:83.61 dec:22.00

E:12.6 flux:4.03e-14 + 2.66e-15 - 2.66e-15
E:20.0 flux:1.07e-14 + 6.32e-16 - 6.32e-16
E:31.6 flux:2.59e-15 + 1.60e-16 - 1.60e-16
E:50.1 flux:6.07e-16 + 5.27e-17 - 5.27e-17
E:79.4 flux:1.42e-16 + 1.62e-17 - 1.62e-17
E:125.9 flux:2.92e-17 + 5.46e-18 - 5.46e-18
E:199.5 flux:6.27e-18 + 2.03e-18 - 1.84e-18
E:316.2 flux:6.87e-19 + 5.56e-19 - 4.15e-19
E:501.2 flux:4.29e-19 + 3.44e-19 - 2.58e-19

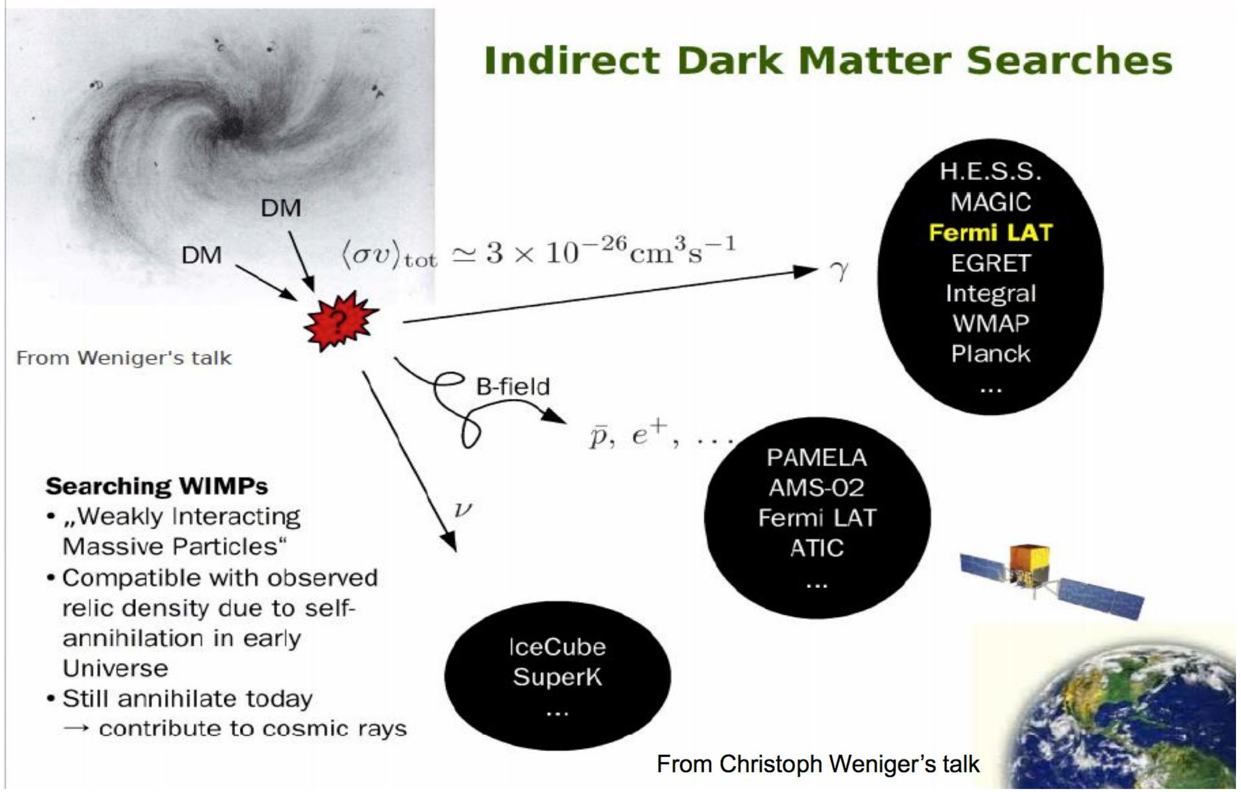
Epoint: 20
alpha:1.02648e-14 (+-)3.38677e-16
beta:-3.1436 (+-)0.0404621

$$f(E) = (1.026 \pm 0.0338) \times 10^{-14} \cdot \left(\frac{E}{20TeV}\right)^{-3.1436 \pm 0.0404}$$

LHAASO and indirect dark matter searches



Research the indirect detection of dark matter through lhaaso



From Christoph Weniger's talk

LHAASO and indirect dark matter searches

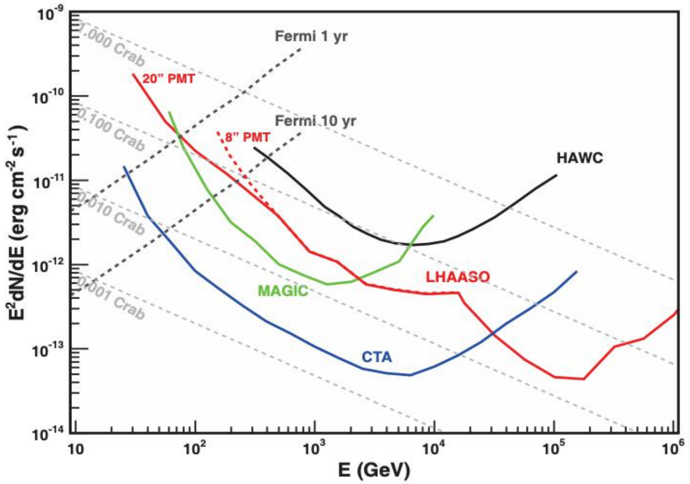
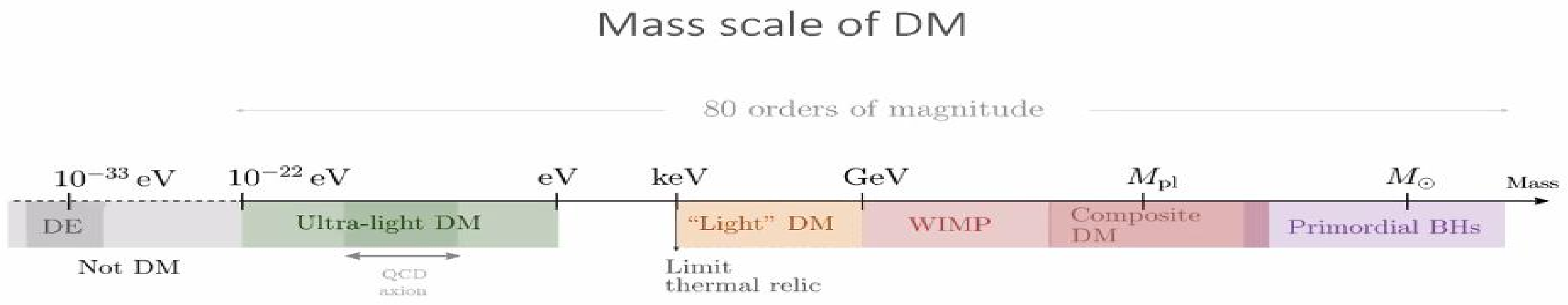
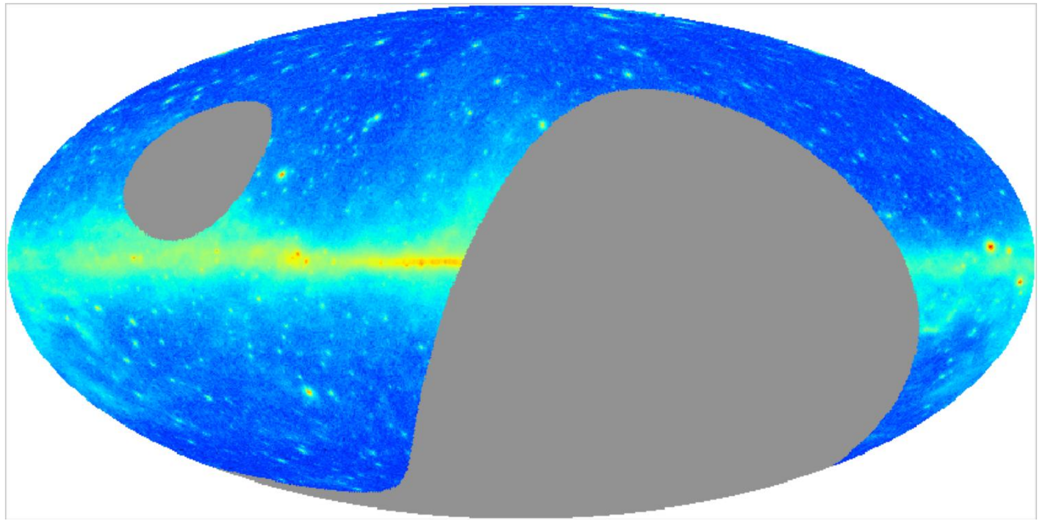
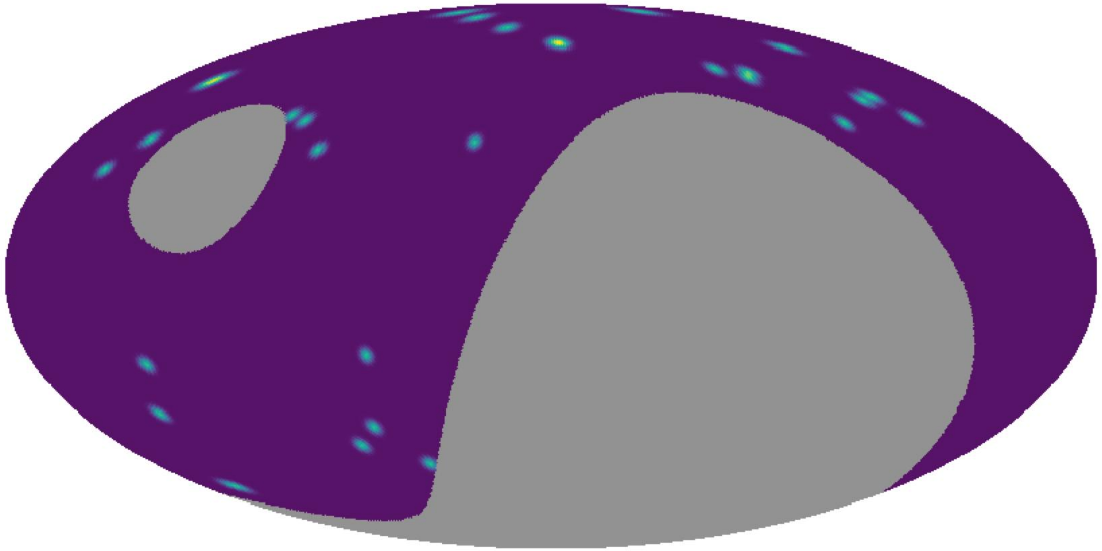


Figure 3: *Differential sensitivity (multiplied by E^2) of LHAASO to a Crab-like point gamma ray sources compared to other experiments. The Crab nebula data obtained by different detectors [1] is taken into account, and the spectral index of -2.6 is extrapolated and extended to 1 PeV.*



LHAASO FOV





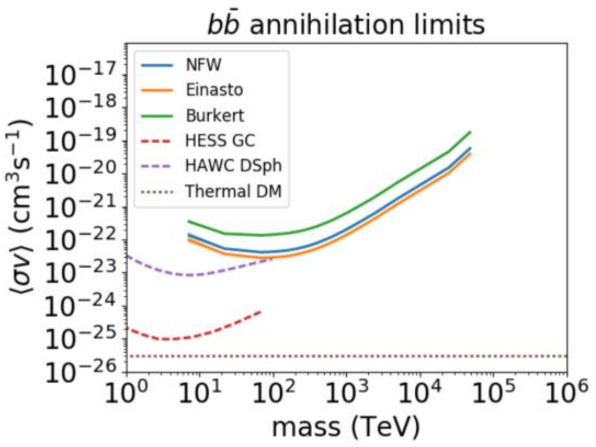
The mass-to-light ratios in dSphs can be of very large order of magnitude, which suggests that they are significantly DM dominated systems.

The LHAASO field of view (FOV) in principle includes all the sky above the horizon, but actually is limited by the decrease of sensitivity at large zenith angles. Considering only the region of the sky visible at zenith angles smaller than 40°, every day LHAASO (located at latitude 29° North) can survey the declination band from -11° to +69° (about 56% of the whole sky) that includes the galactic plane in the longitude interval from +20° to +225°.

Research direction during PhD

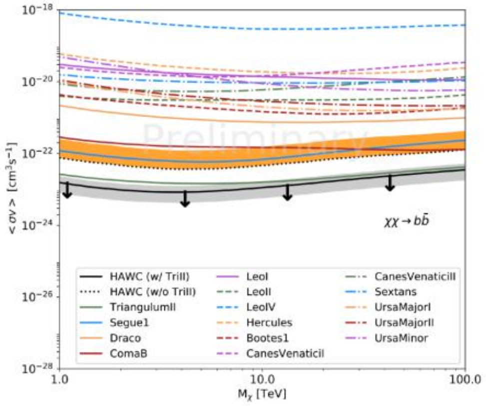
DM Limits from HAWC

Galactic Halo



data energy < 39 TeV

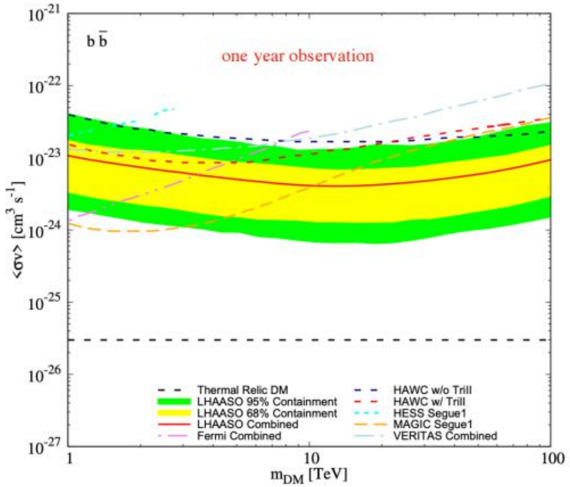
Dwarf Galaxies



LHAASO and dwarf galaxies

Source	RA. (deg)	DEC. (deg)	θ_{max} (deg)	$\log_{10} J_{obs}$ (GeV^{2}cm^{-5})
Boötes I	210.02	14.50	0.47	18.2 ± 0.4
Canes Venatici I	202.02	33.56	0.53	17.4 ± 0.3
Canes Venatici II	194.29	34.32	0.13	17.6 ± 0.4
Coma Berenices	186.74	23.90	0.31	19.0 ± 0.4
Draco	260.05	57.92	1.30	18.8 ± 0.1
Draco II*	238.20	64.56	–	18.1 ± 2.8
Hercules	247.76	12.79	0.28	16.9 ± 0.7
Leo I	152.12	12.30	0.45	17.8 ± 0.2
Leo II	168.37	22.15	0.23	18.0 ± 0.2
Leo IV	173.23	−0.54	0.16	16.3 ± 1.4
Leo V	172.79	2.22	0.07	16.4 ± 0.9
Pisces II*	344.63	5.95	–	16.9 ± 1.6
Segue 1	151.77	16.08	0.35	19.4 ± 0.3
Sextans	153.26	−1.61	1.70	17.5 ± 0.2
Triangulum II*	33.32	36.18	–	20.9 ± 1.3
Ursa Major I	158.71	51.92	0.43	17.9 ± 0.5
Ursa Major II	132.87	63.13	0.53	19.4 ± 0.4
Ursa Minor	227.28	67.23	1.37	18.9 ± 0.2
Willman 1*	162.34	51.05	–	19.5 ± 0.9

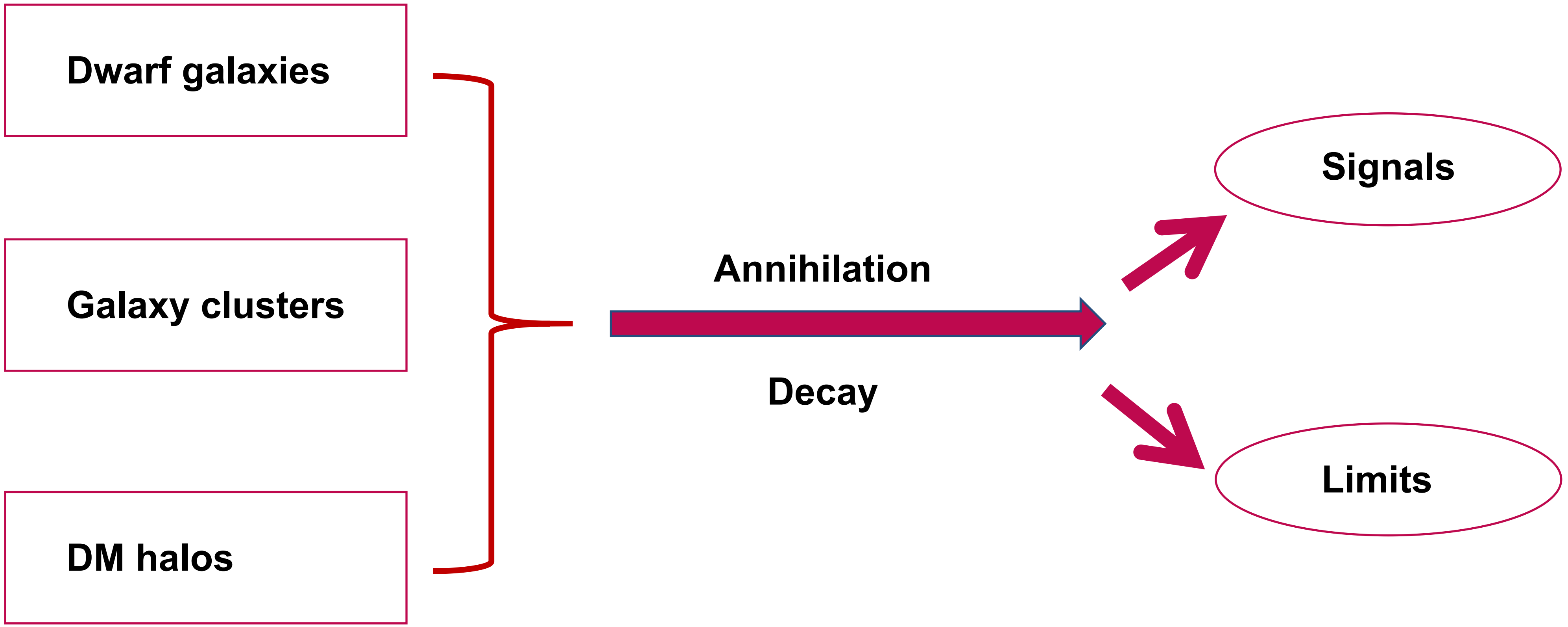
energy range 700 GeV $\sim$ 20 TeV



LHAASO will be able to set stringent constraints on the property of heavy DM particles, especially for those heavier than ~ 10 TeV.

He, Bi, Lin, et al, arXiv: 1903.11910

Research direction during PhD



Thank You