cta
cherenkov telescope array

CTAで迫る物理

CTA Physics Drivers

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CTA Physics Drivers by K. Ioka

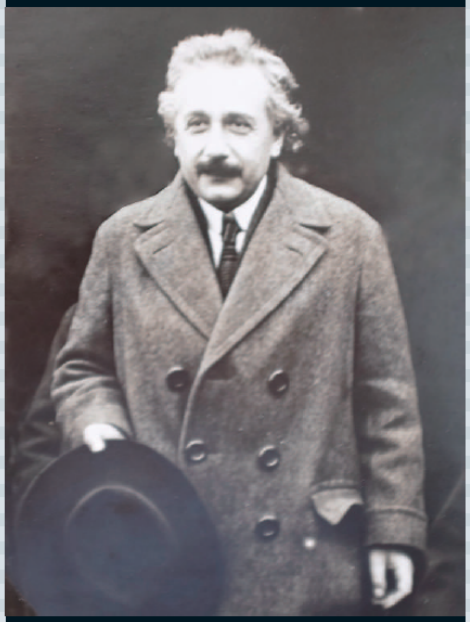
第70巻第2号(通巻786号)ISSN 0029-0181
昭和30年6月13日　第3種郵便物認可
平成27年2月5日発行　毎月5日発行

特集「発展し続ける一般相対論」

代議員選挙(信任投票)

NO. 2
2015 | VOL. 70

BUTSURI
日本物理学会誌

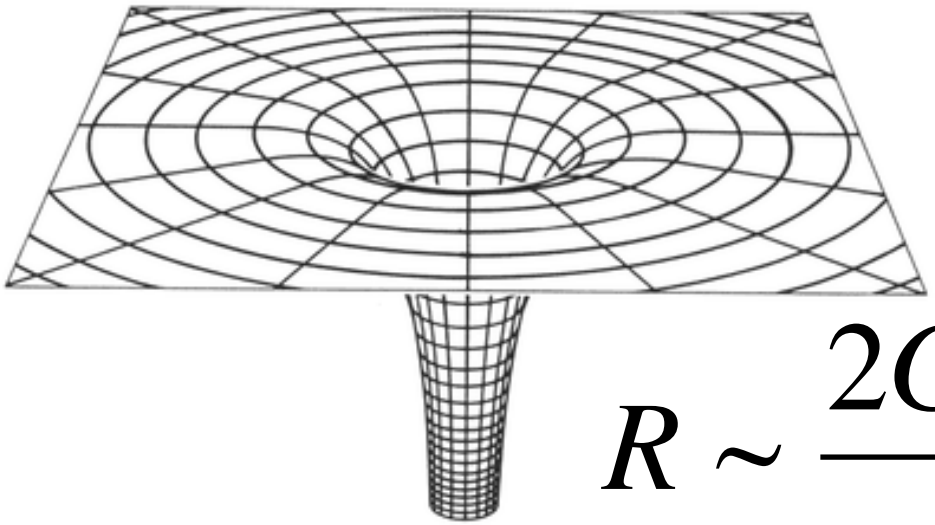


JPS
The Physical Society of Japan
日本物理学会 | www.jps.or.jp

General Relativity

Amazing Predictions

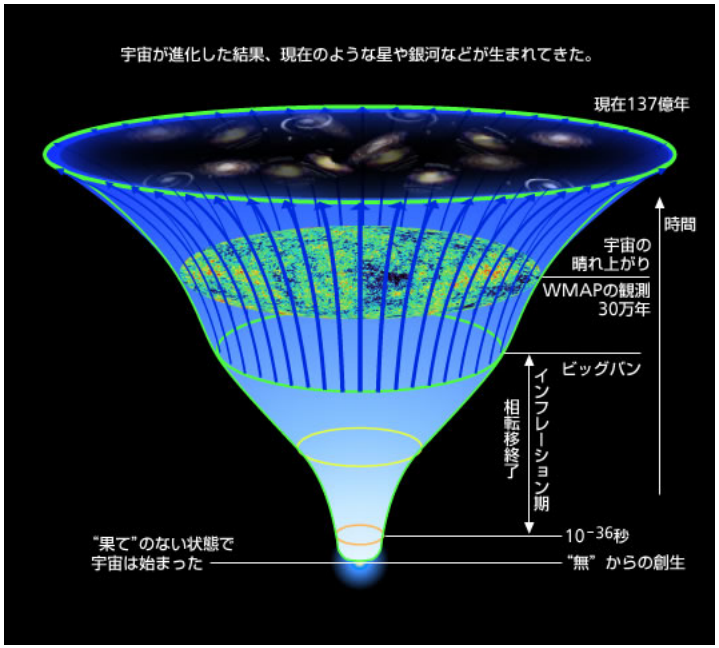
Black Hole



$$R \sim \frac{2GM}{c^2}$$

Final fate of stellar evolution

Expanding Universe

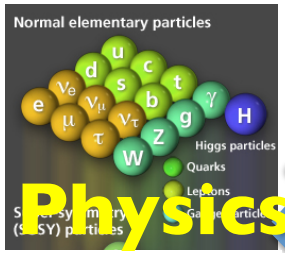


Big Bang

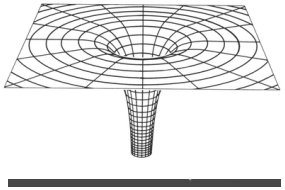
Astrophysics **Cosmology**

Evolution to Black Hole

Gravity
Quantum



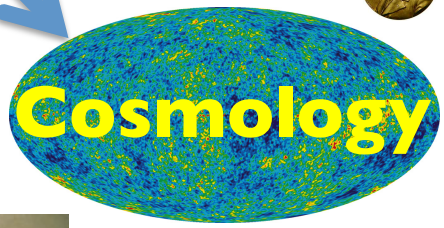
Physics



Computer

Star

Chandrasekhar
Bethe

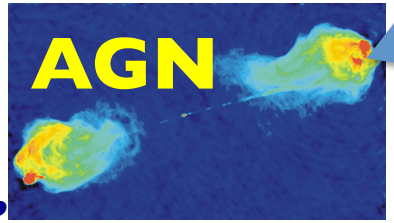


Cosmology

Penzias, Wilson
Perlmutter, Riess,
Schmidt

Supernova GRB

Davis
Koshiba

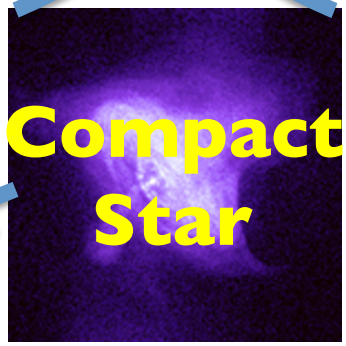


AGN

Active galactic nuclei
Massive black hole
at the center of galaxy

Supernova Remnant

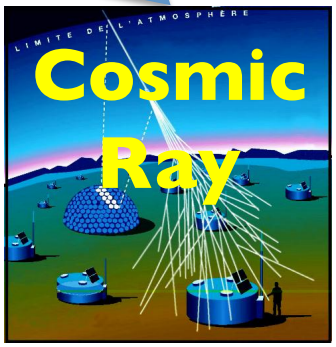
W. A. Fowler



Compact Star

Black Hole
Neutron Star
White Dwarf

Giacconi
Hewish
Hulse, Taylor

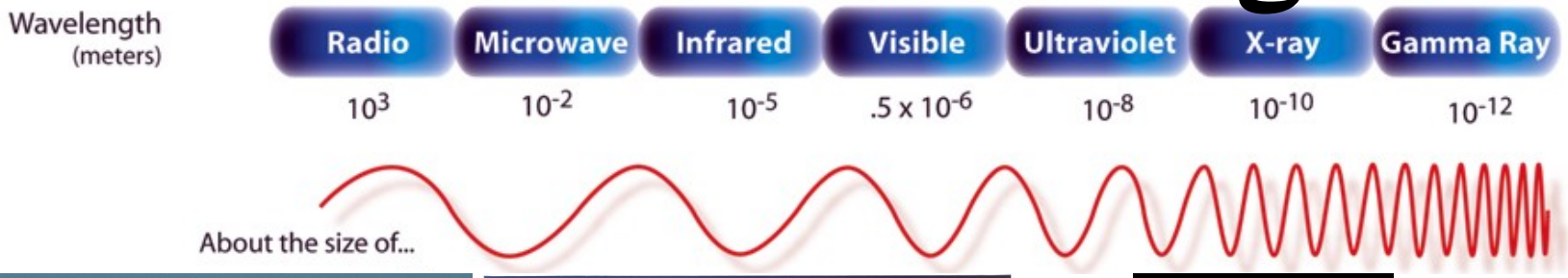


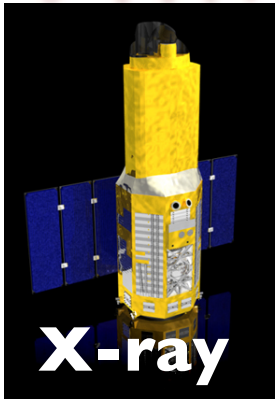
Cosmic Ray

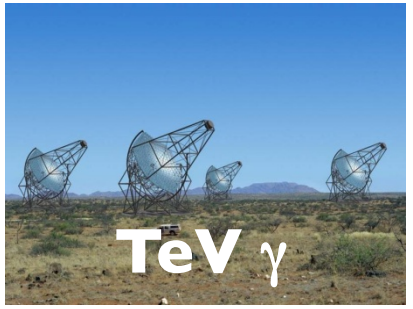
Hess
Anderson
Yukawa
Powell

High Energy Universe

Multi-Wavelength

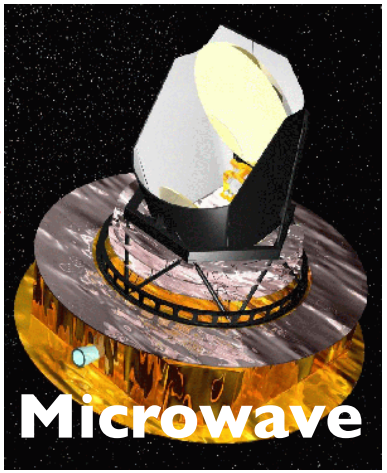






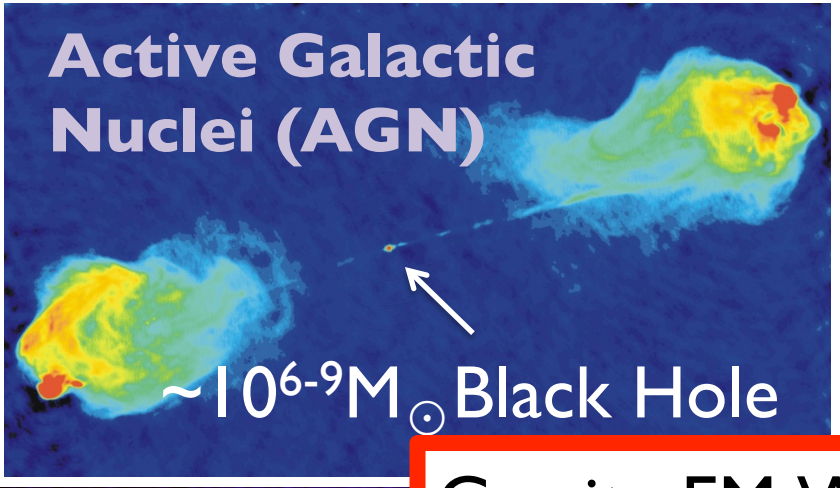
TeV=
10^{12}eV
GeV=
10^{9}eV

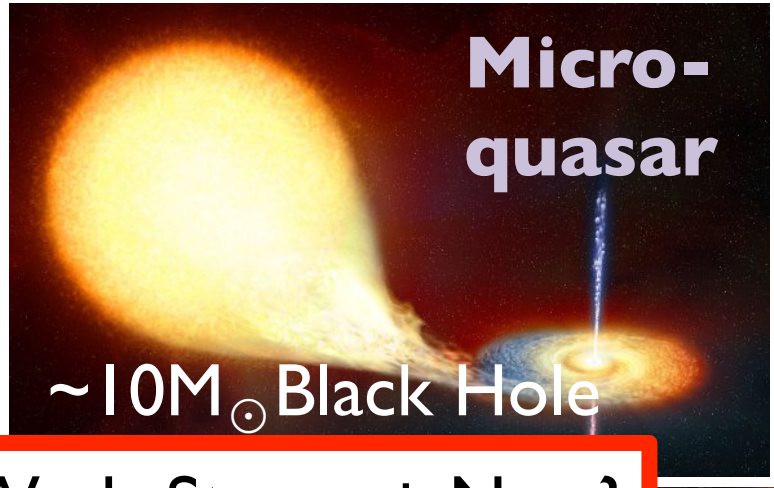
20th century observations:
In particular,
X-γ-VHE γ

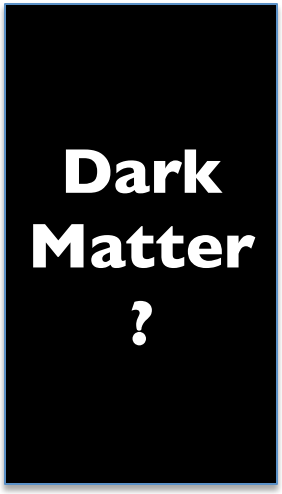


Cosmic Accelerators

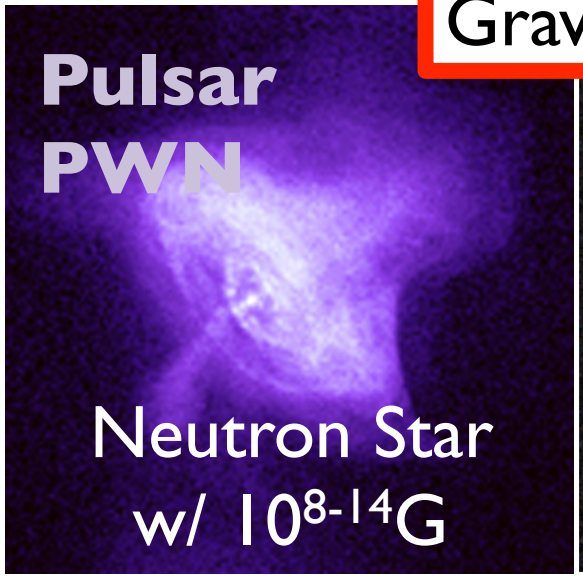
High Energy Phenomena pervade the Universe



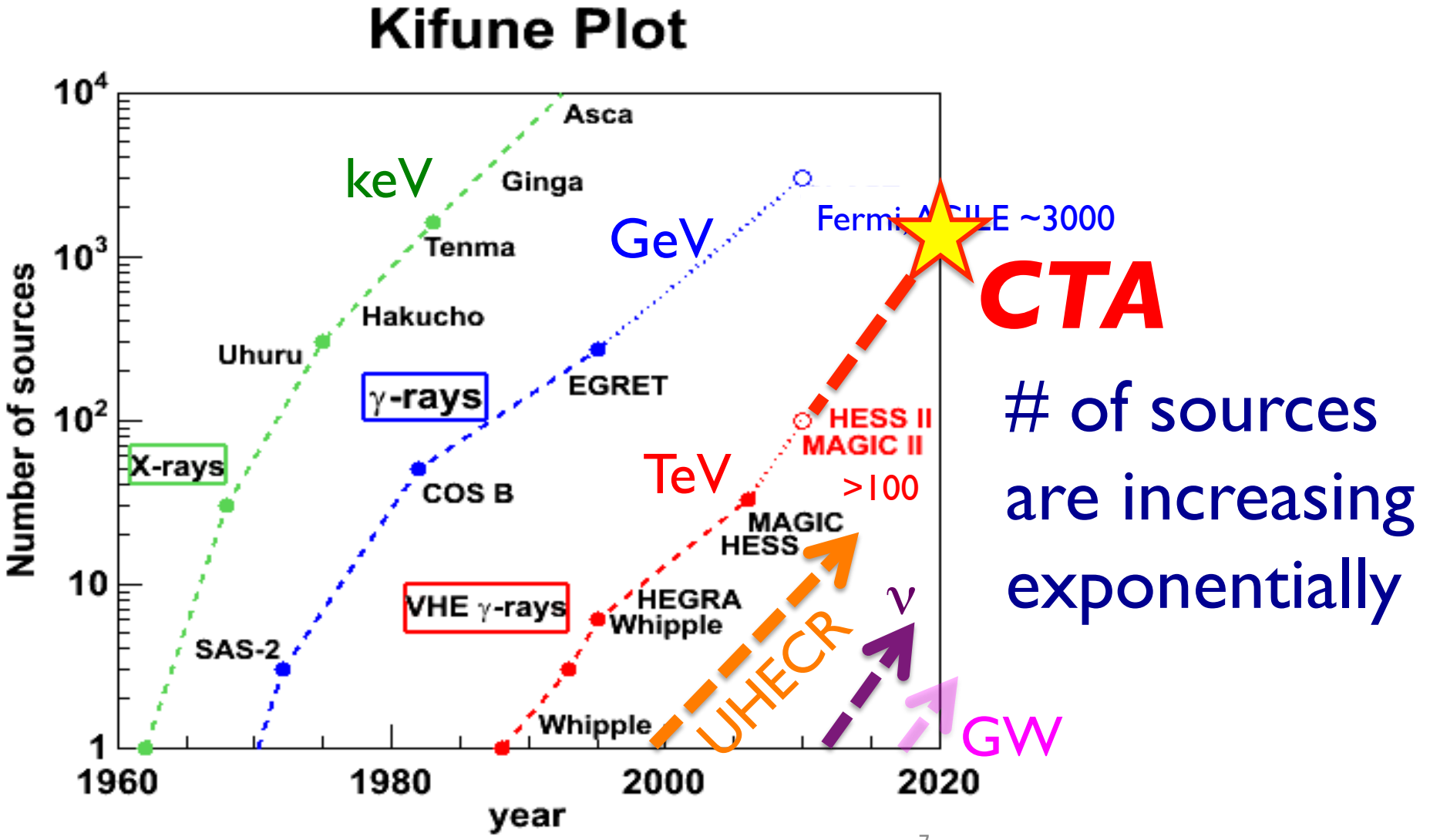




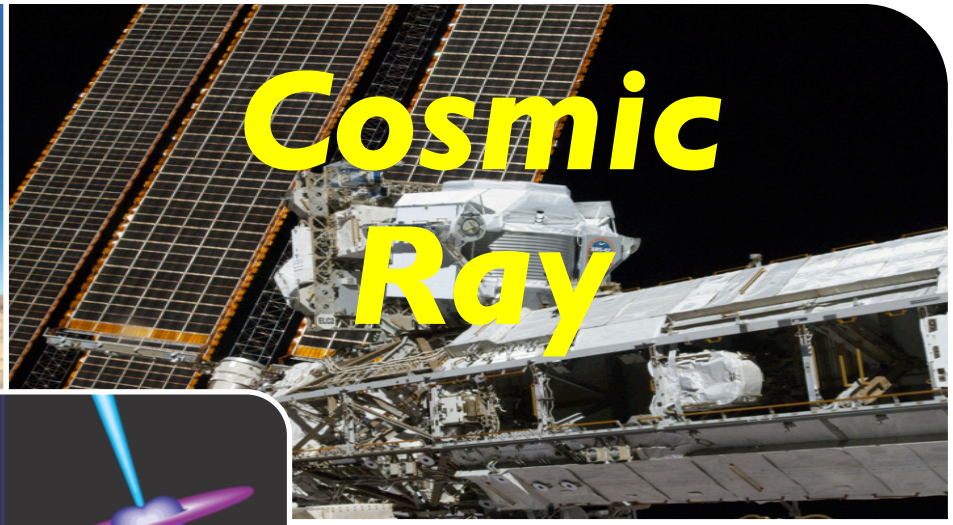
Gravity, EM, Weak, Strong + New?

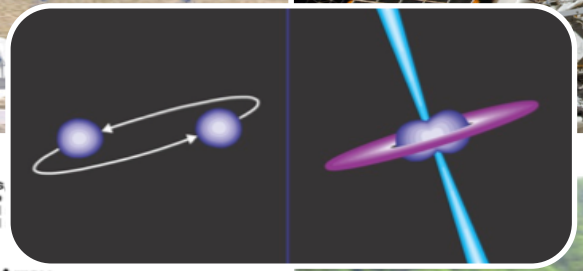


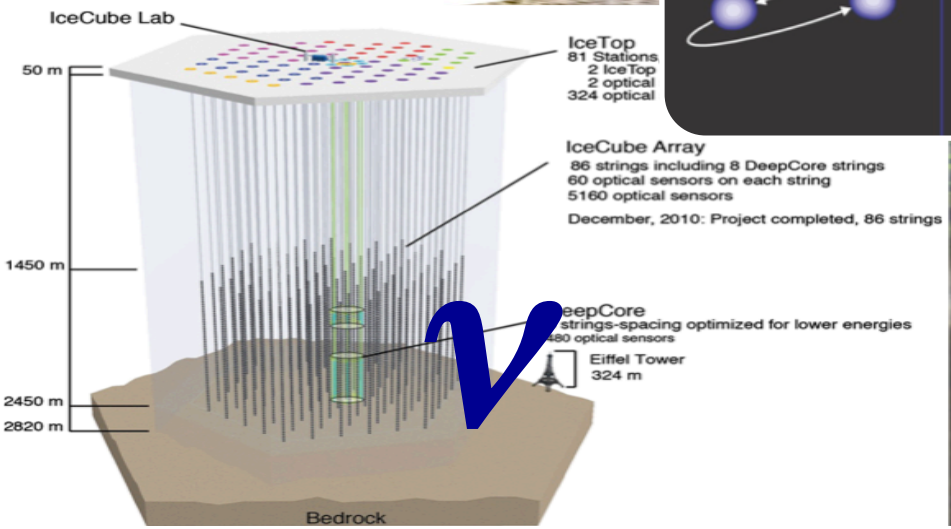
Explosive Development



Multi-Messenger Era







21th Century: Multi-Messenger Era

Mysteries in 21th Century

?

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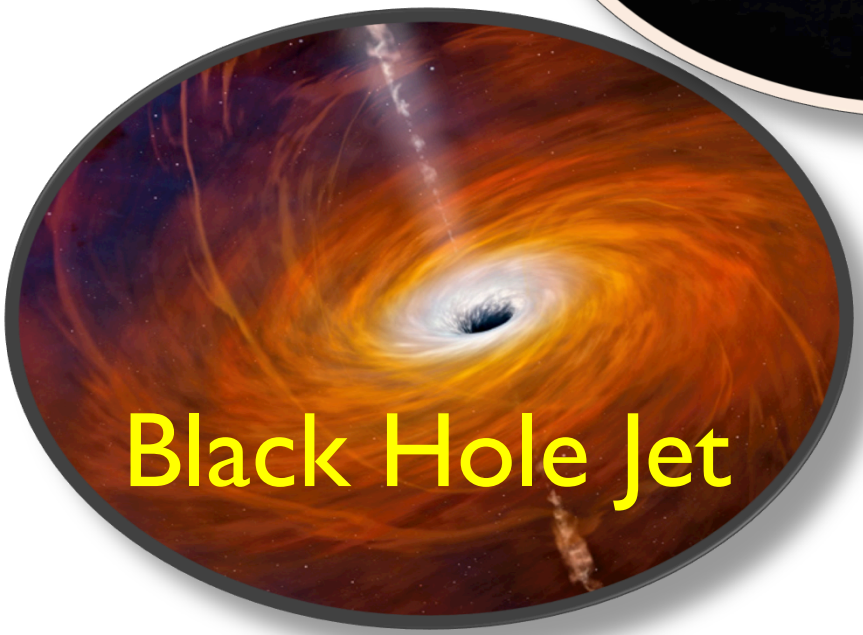

Mysteries in 21th Century

?

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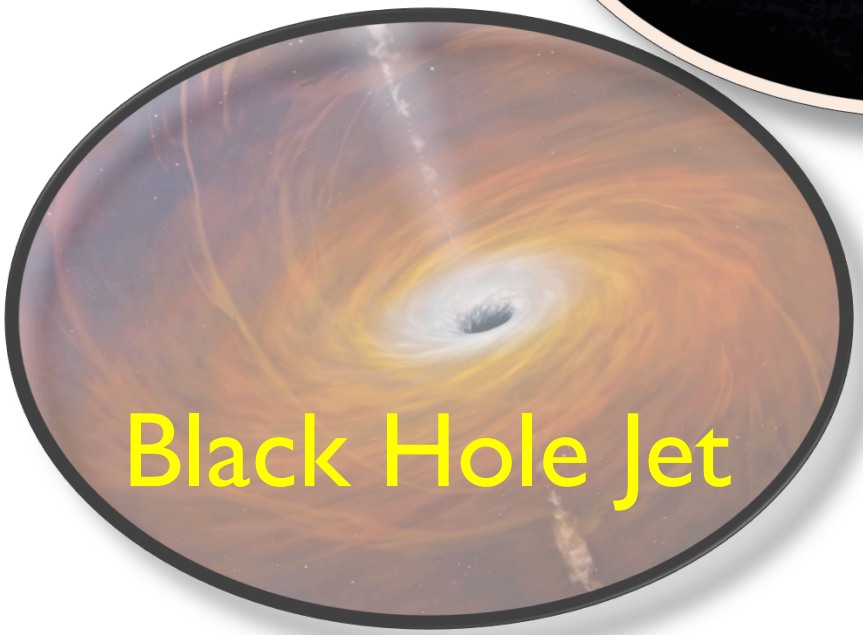
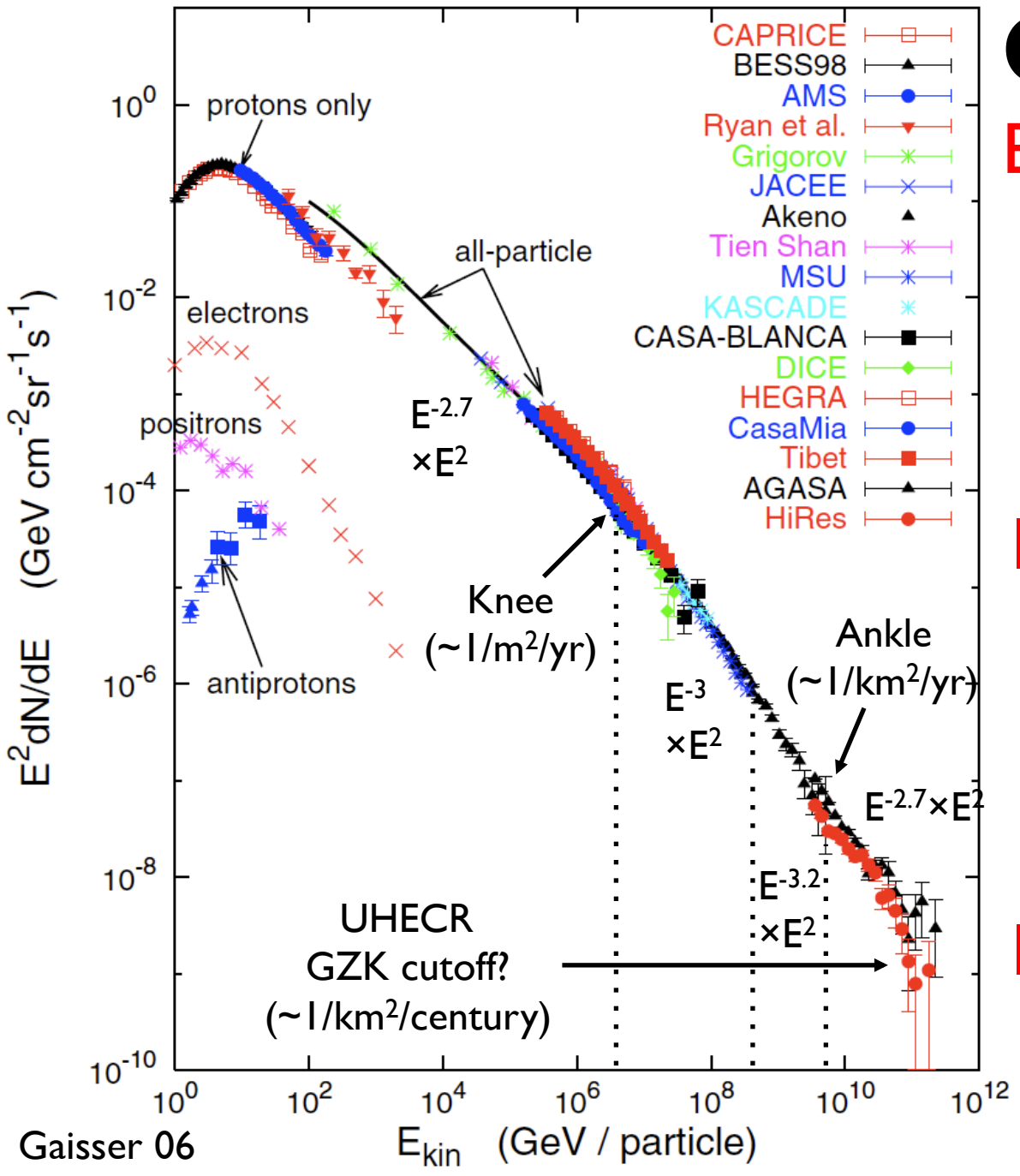




Cosmic Ray

$E<10^{15\text{-}16}$eV (Knee)

$F \propto E^{-2.7}$

Supernova remnant(?)

$L_{CR} \sim 10^{41}$erg/s

$\sim 0.1 E_{SN}/t_{SN}$

$10^{15\text{-}16}<E<10^{18}$eV (Ankle)

$F \propto E^{-3\text{-}3.2}$

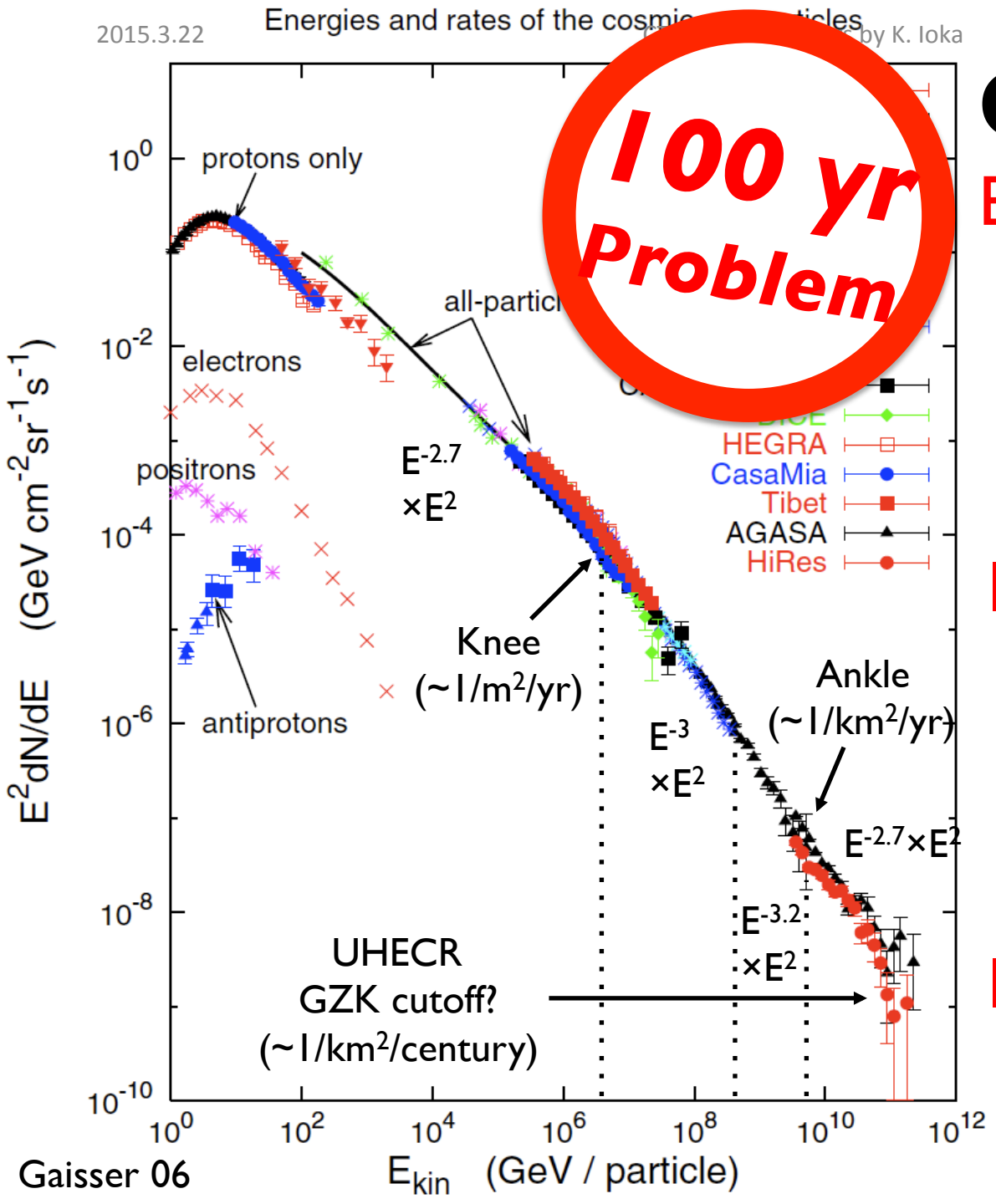
Galactic origin?

$<10^{14\text{-}15}$eV by SNR

10^{18}eV$<E$

$F \propto E^{-2.7}$

Extra-Gal. AGN? GRB?



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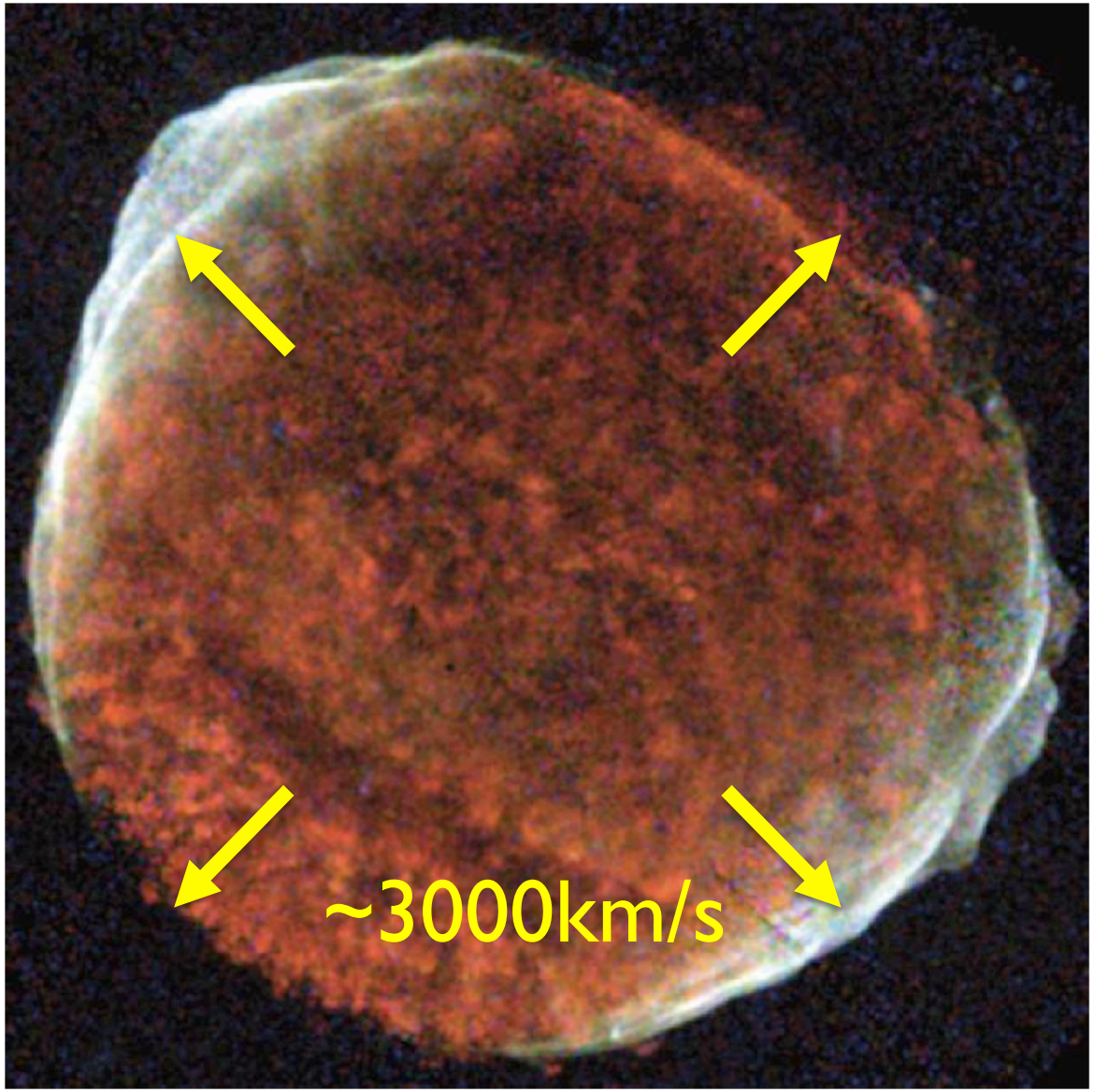
Supernova Remnant



Supernova explosion

(gravity, nuclear)

⇒ Shock

⇒ Heating

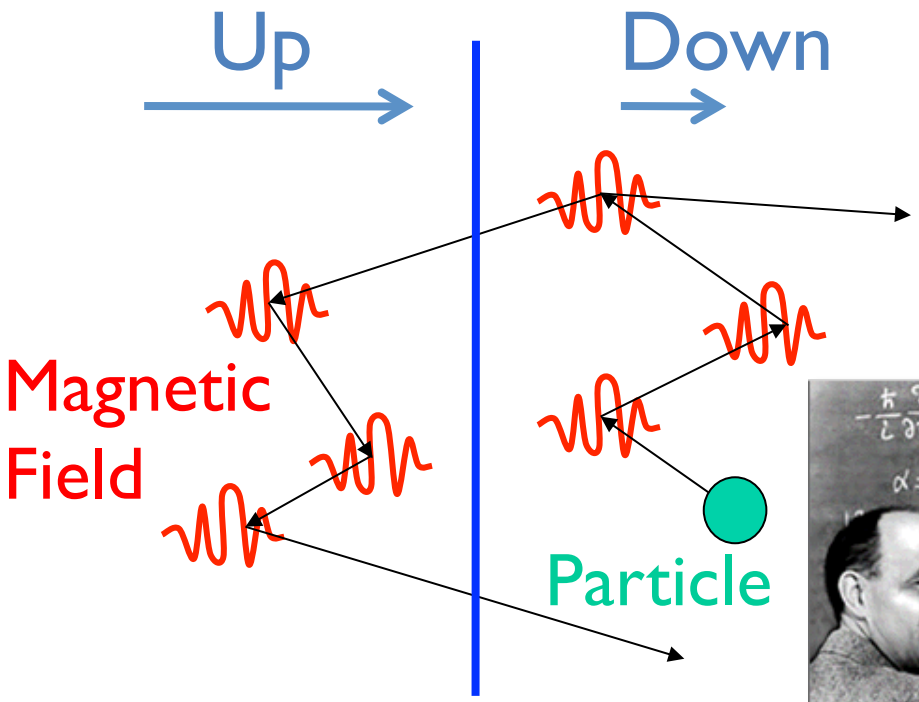
~ keV ~ X-ray

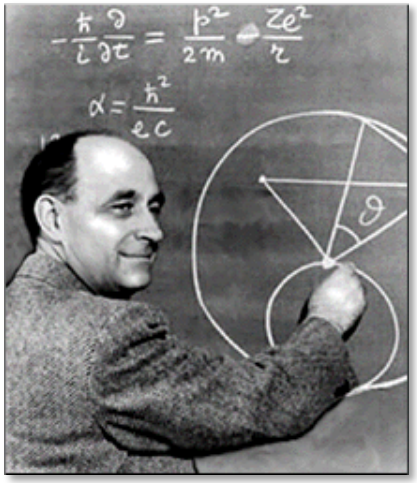
Interstellar Medium

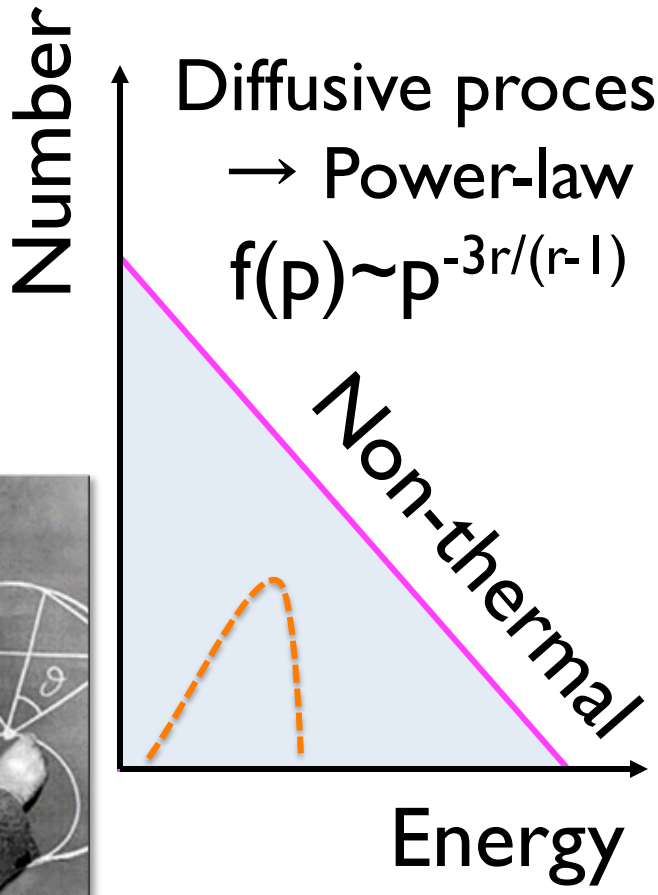
c_s~10km/s

Particle Acceleration

Collisionless Shock

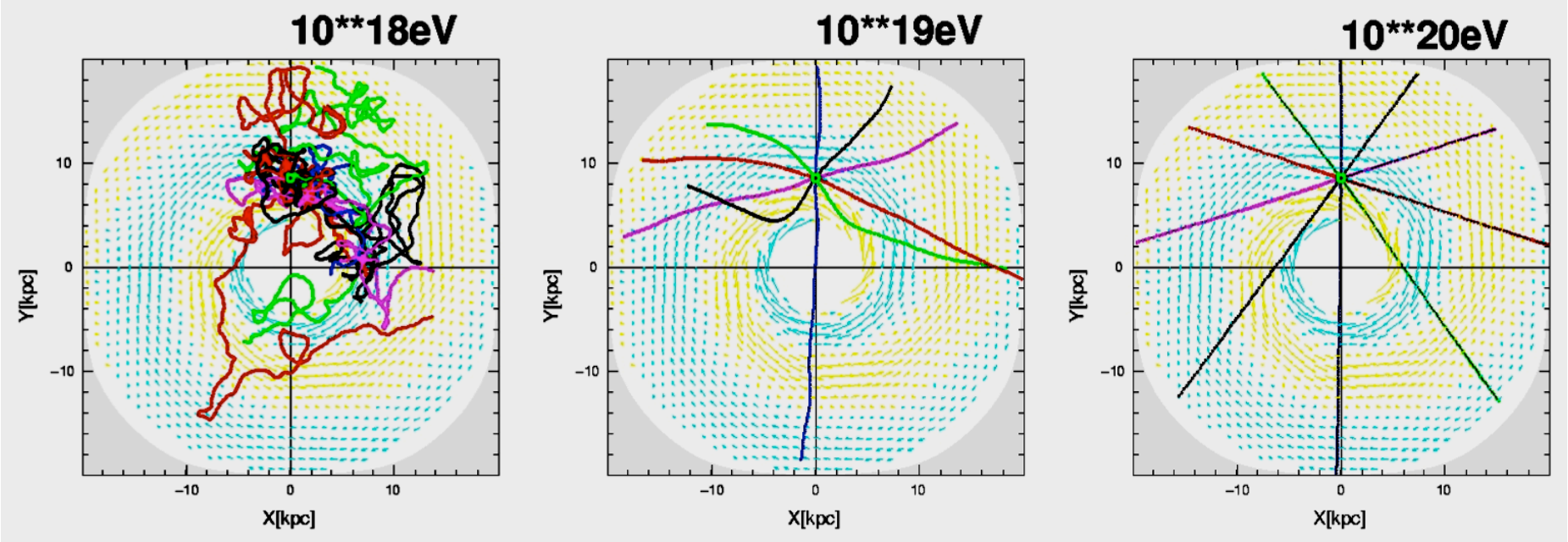






Diffusive Shock (Fermi) Acceleration

Galactic Magnetic Fields

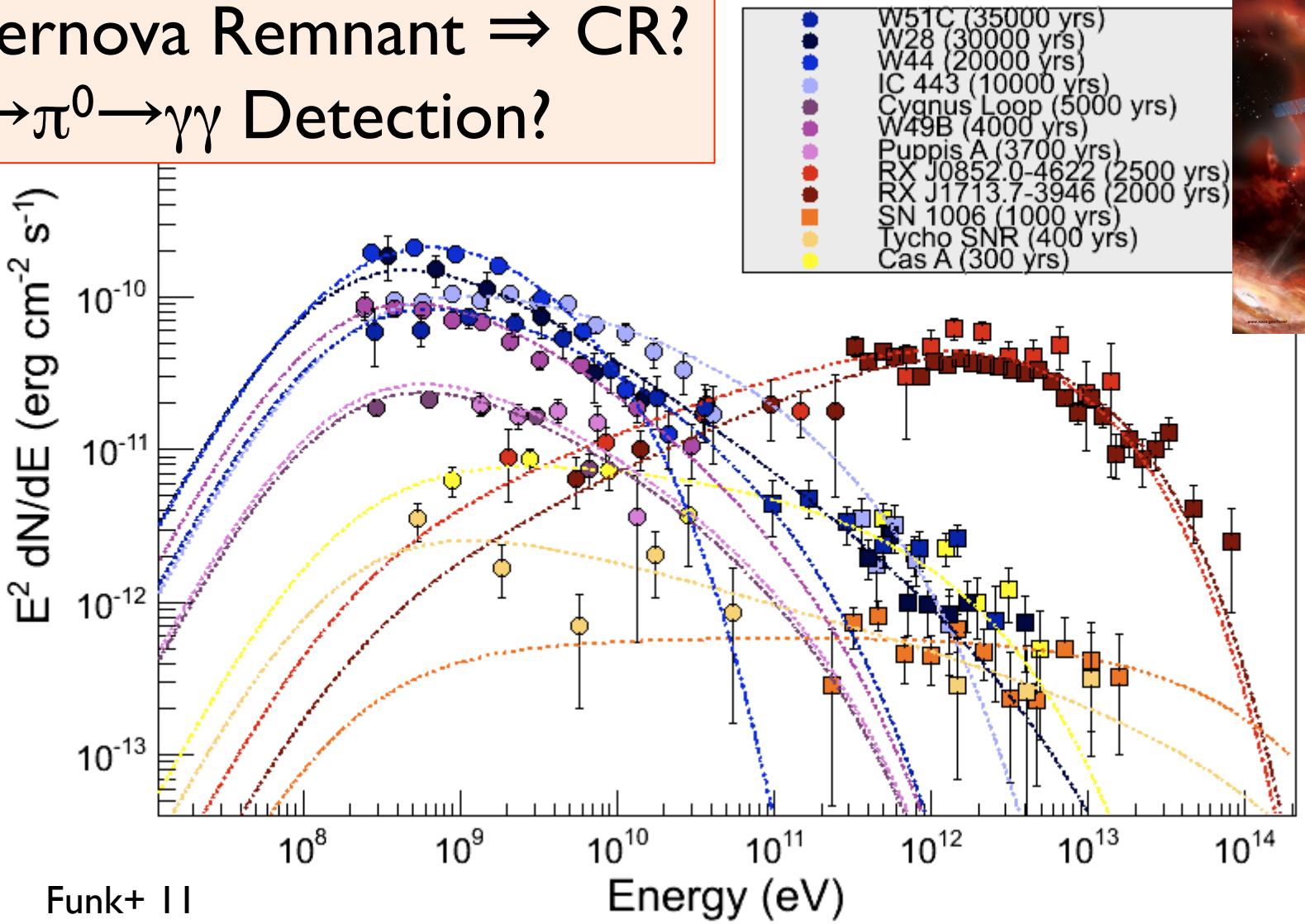


Cosmic Rays below ~10^{18}eV are deflected by Galactic Magnetic Fields ~μG

Cosmic-Ray Origin?

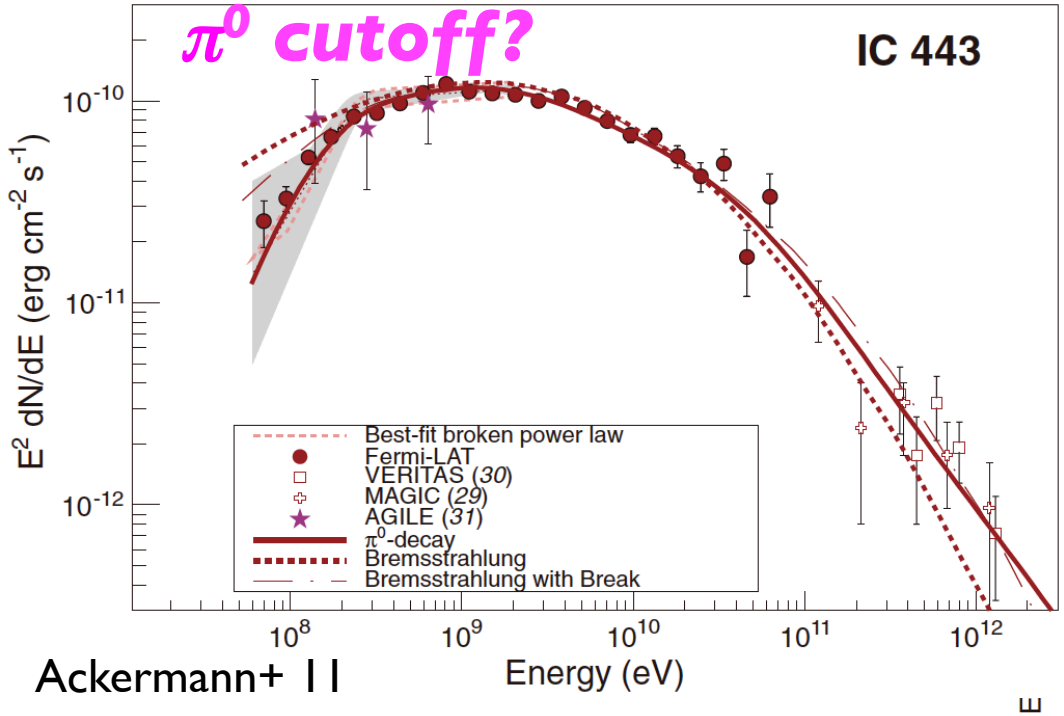
Supernova Remnant ⇒ CR?

$pp \rightarrow \pi^0 \rightarrow \gamma\gamma$ Detection?



Funk+ 11

Hadronic or Leptonic?

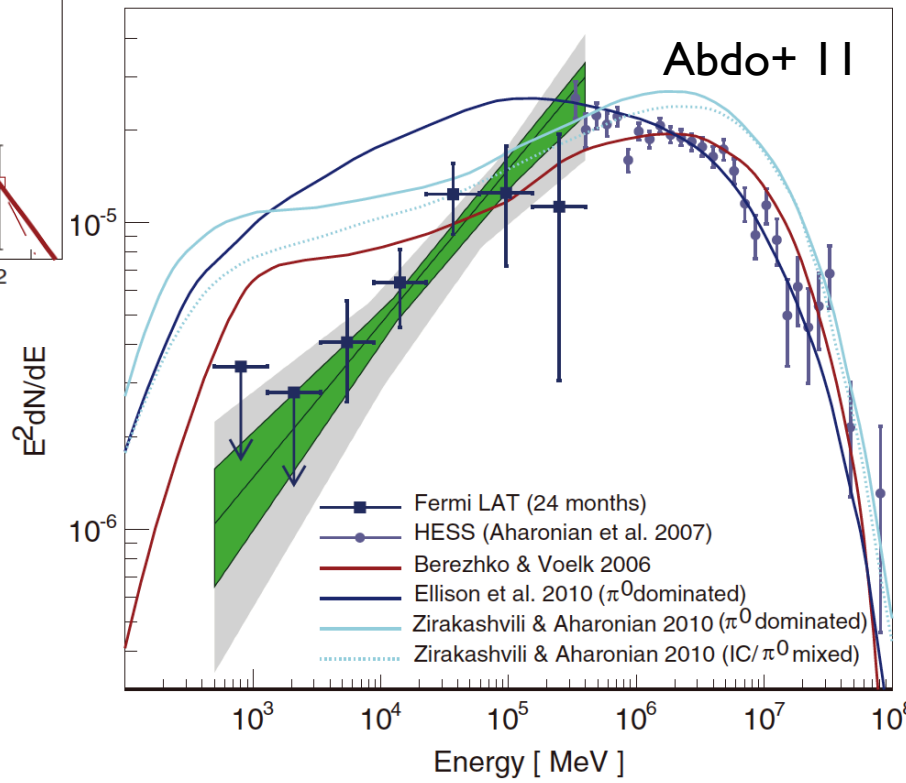


Ackermann+ 11

$pp \rightarrow \pi^0 \rightarrow \gamma\gamma$

$e\gamma \rightarrow e\gamma$

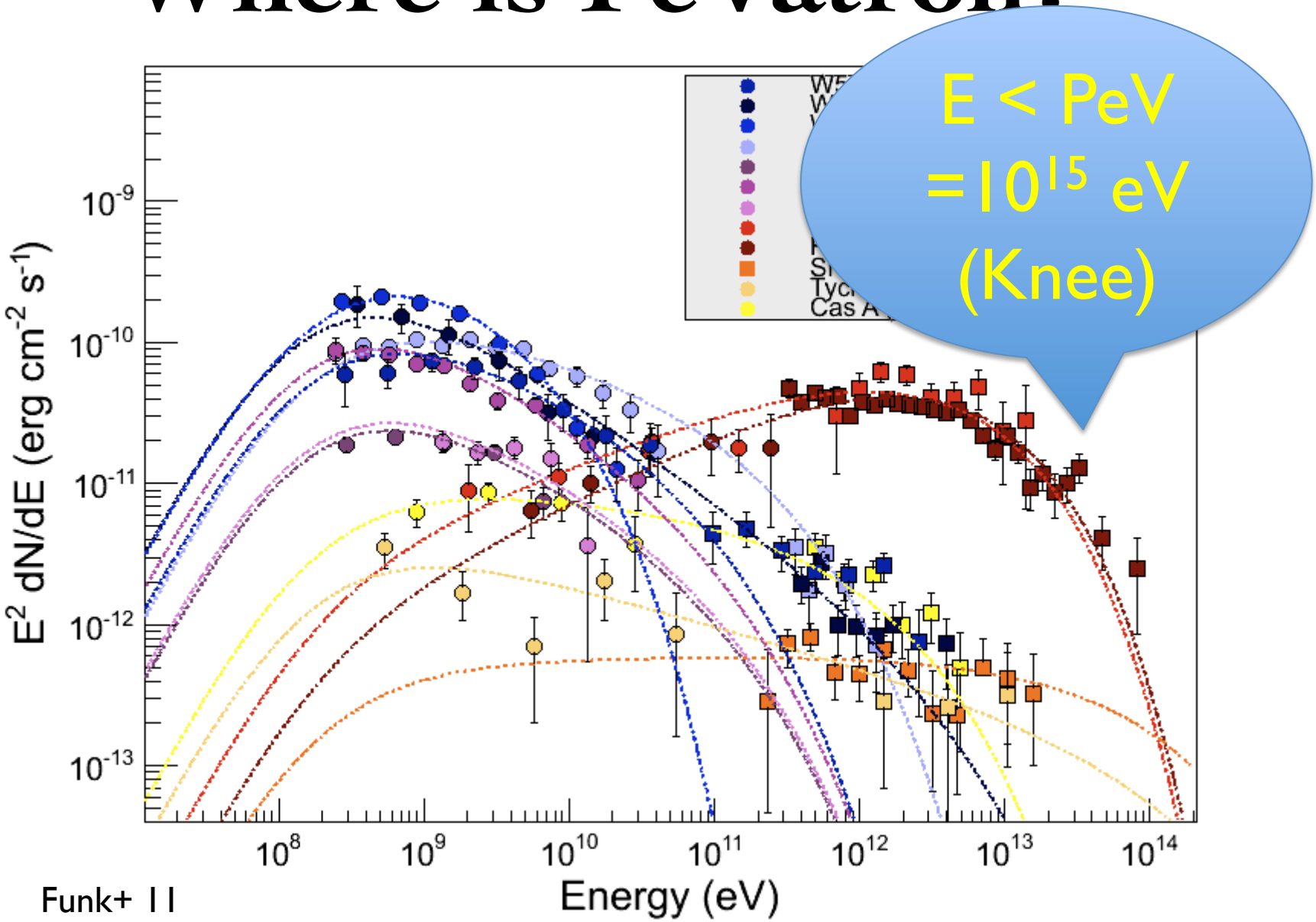
inverse Compton



Evidence of CR Origin

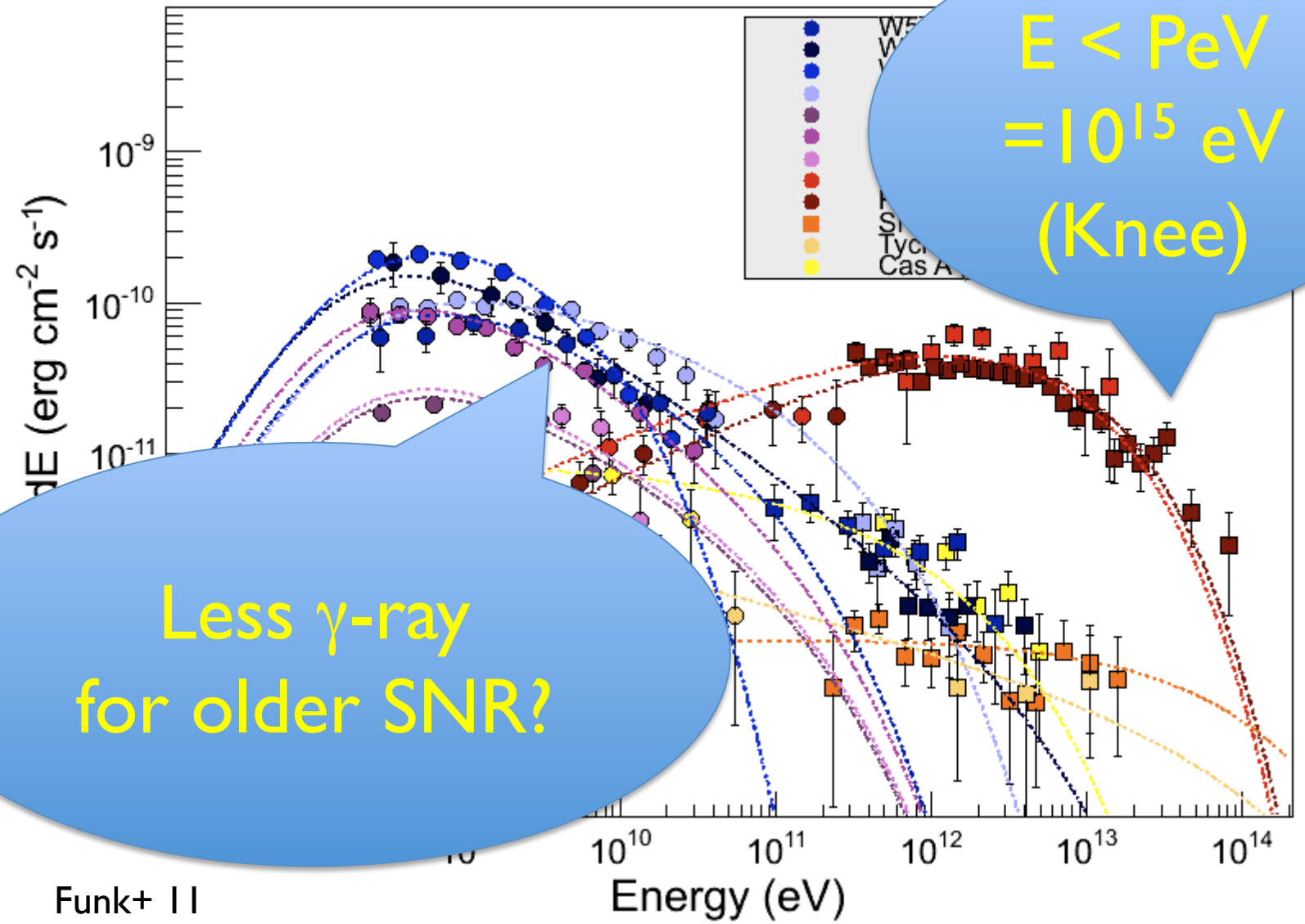
Still under discussions

Where is PeVatron?



Funk+ 11

Where is PeVatron?



Funk+ 11

66th Fujihara Seminar

X-raying the Gamma-Ray Universe
-- CTA-X-ray LINK Meeting --

4 (Mon) - 6 (Wed) Nov. 2013
Yumoto Fujiya Hotel, Hakone-Yumoto, Kanagawa-ken, Japan

Top | Overview | Registration | Program | Participants | Venue

Supported by

The Fujihara Foundation of Science
European Union, within the Framework Programme 7: Preparatory Phase of the Cerenkov Telescope Array, INFRA-2010-2.2.10 / 262053
JSPS Grant-in-Aid for Specially Promoted Research 24000004
KEK
Chair of the organizer: Kunihito Ioka (KEK)

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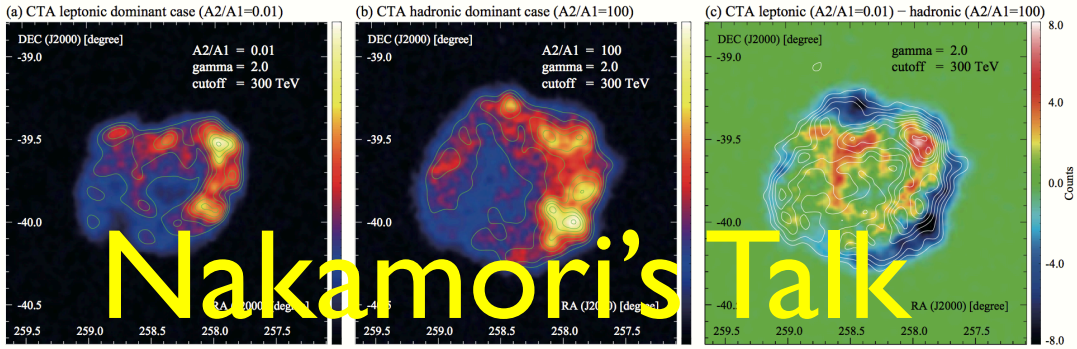


Nakamori's Talk

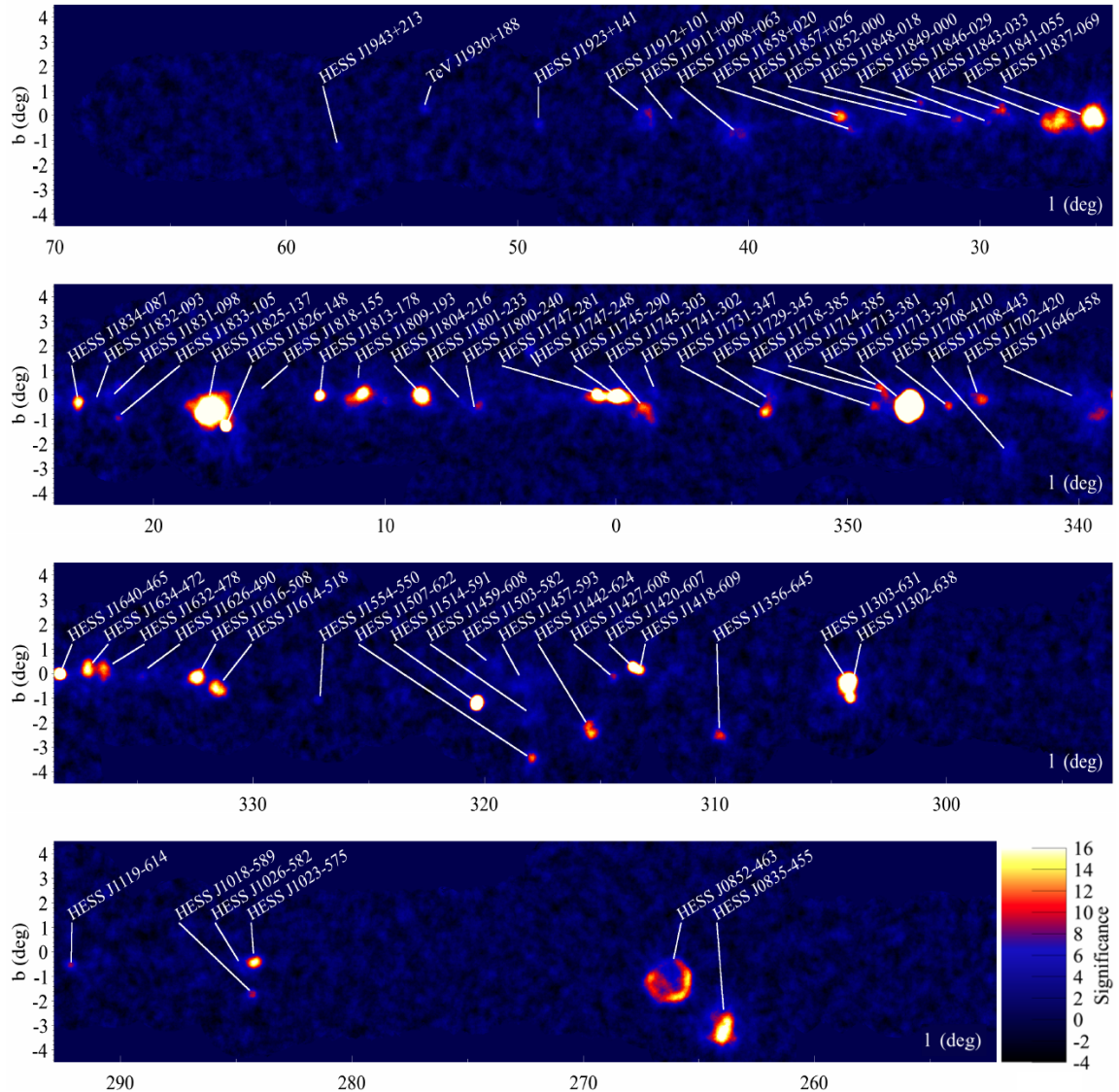
The Fujihara Foundation of Science
藤原科学財団

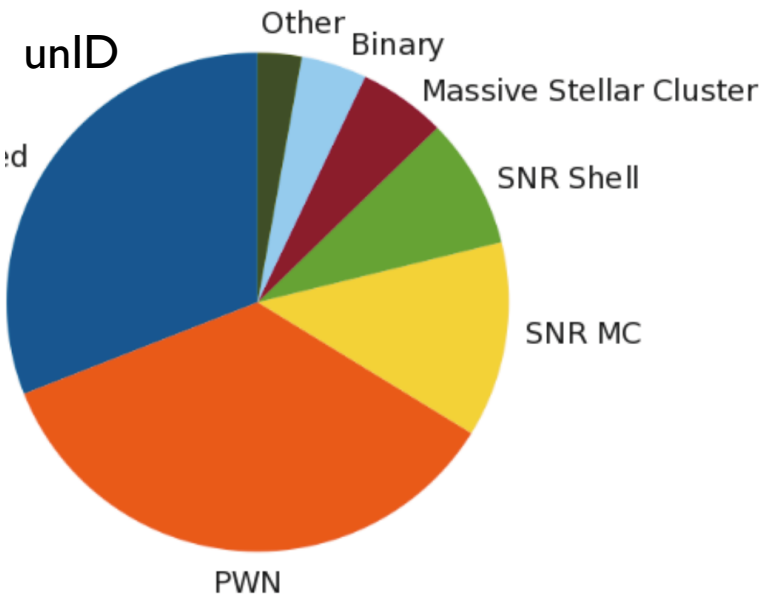
cta cherenkov telescope array

HIGH ENERGY ACCELERATOR RESEARCH ORGANIZATION

TeV Gamma-Ray Sky

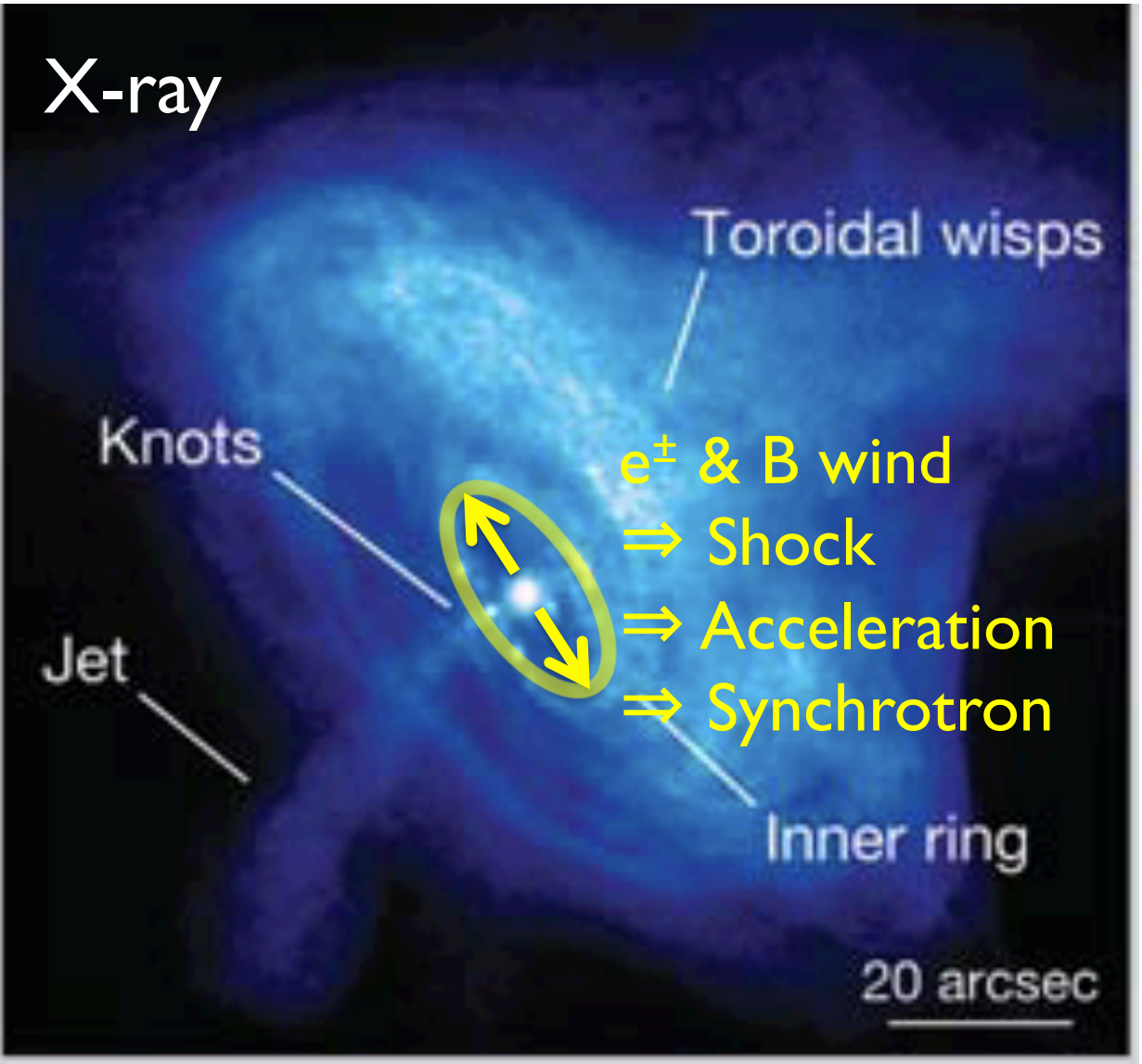
1307.4690





Pulsar Wind Nebula dominates TeV γ-ray sky

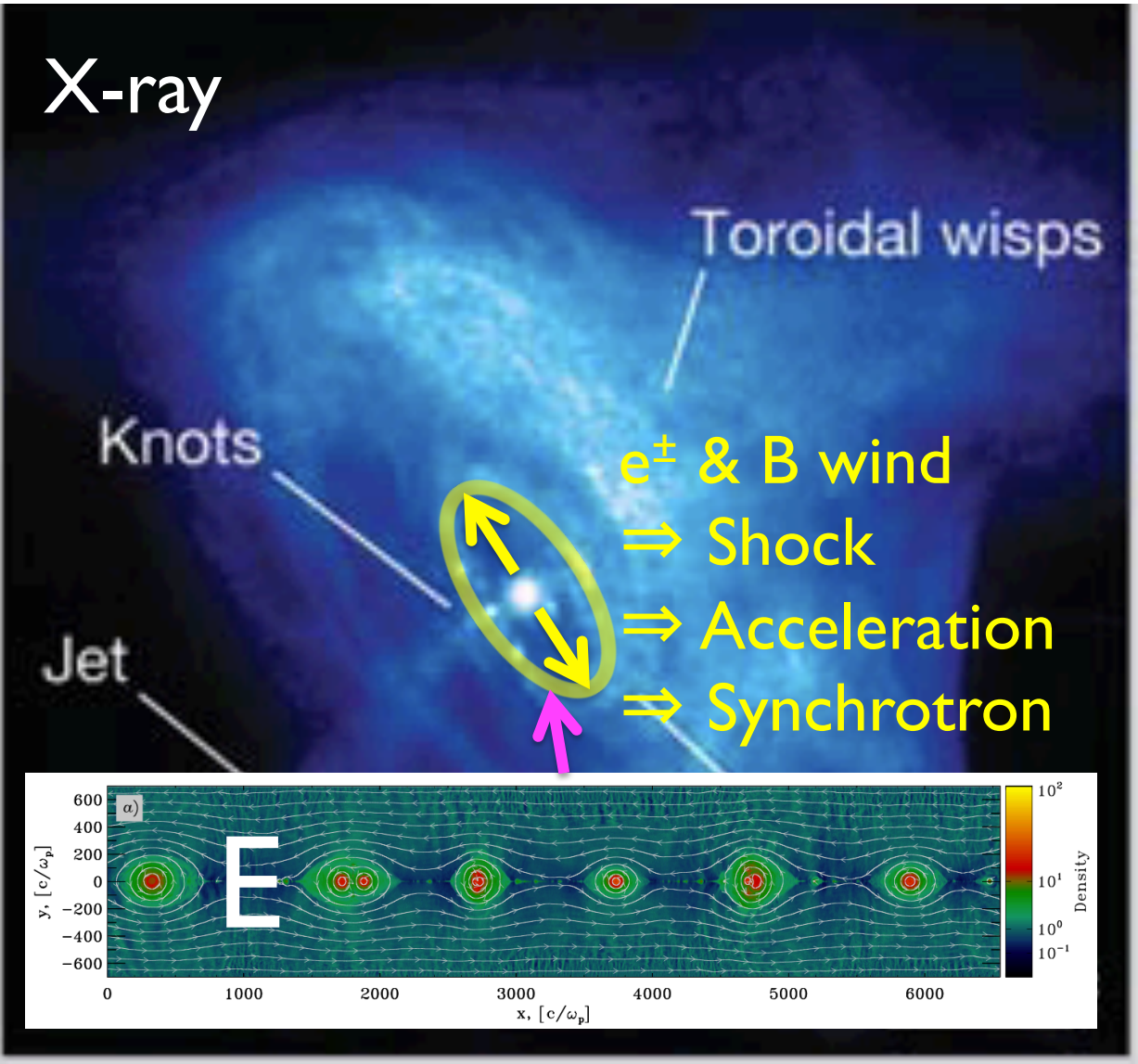
Pulsar Wind Nebula



- Neutron star
  Rotation + B
- Crab nebula
- r_{shock}~0.1pc
- r_{knot}~0.01pc
- ~4days flares

⇒ PeV electron

Pulsar Wind Nebula



- Neutron star Rotation + B
- Crab nebula
- r_{shock}~0.1pc
- r_{knot}~0.01pc
- ~4days flares

⇒ PeV electron

Linear accelerator?

Mysteries in 21th Century

?

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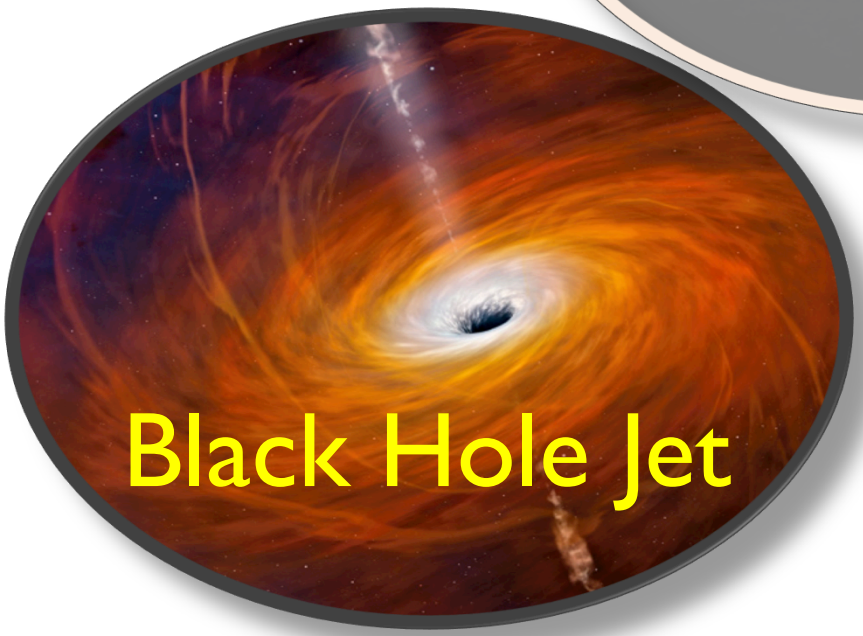
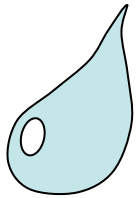
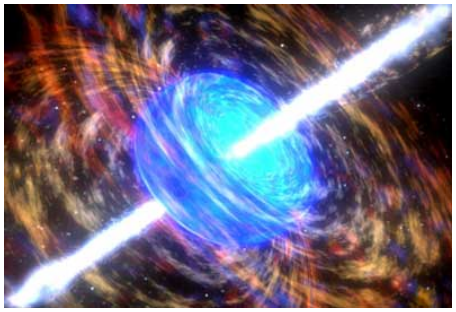


Gamma-Ray Burst

$E=mc^2$ (by Einstein)

=





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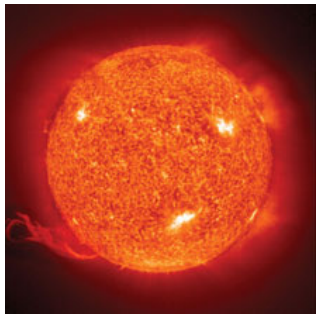


Atomic bomb ~1kg

GRB
~10^{52}erg

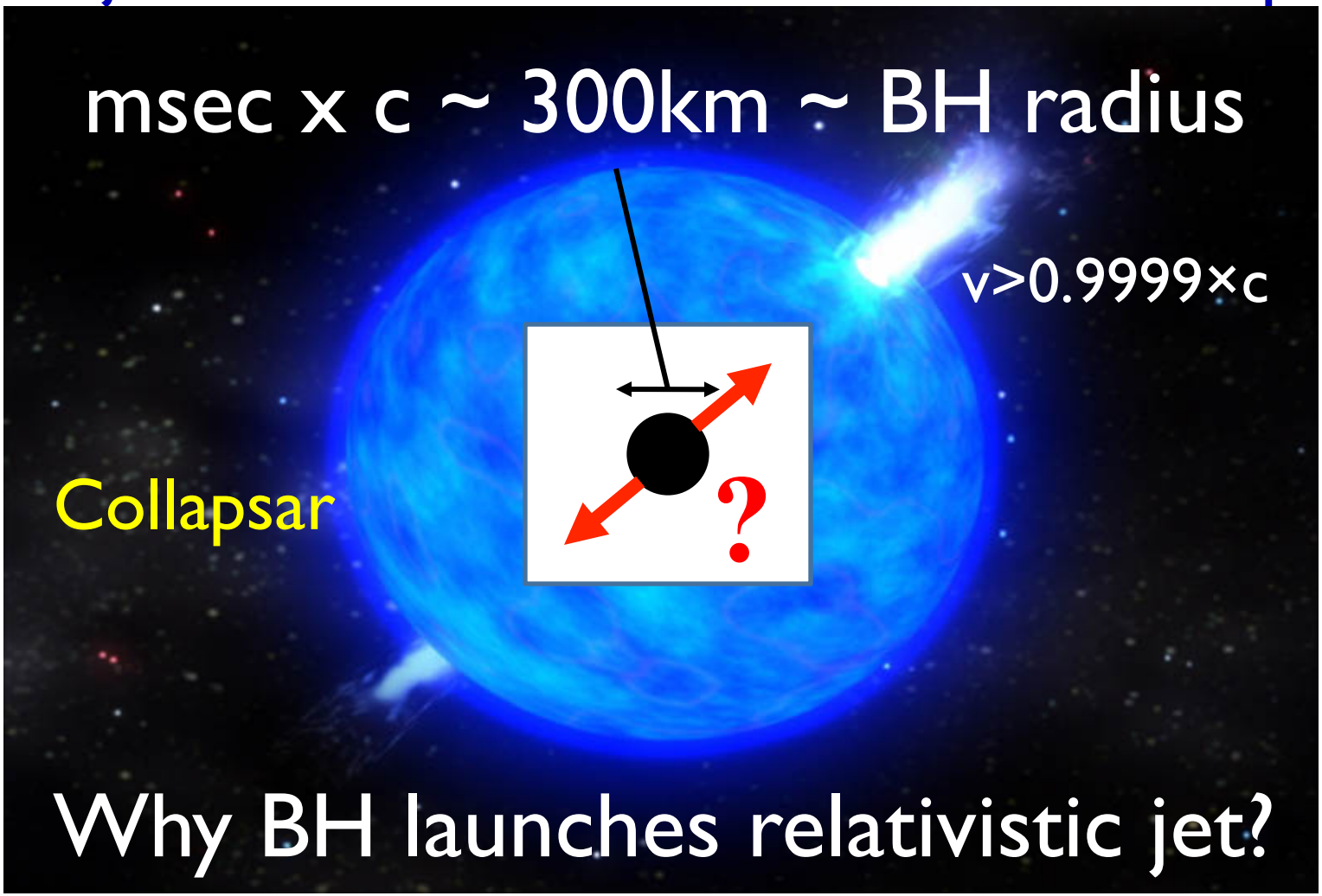
Sun
~10^{33}g

In ~sec, GRB release energy Sun emit over lifetime

GRB is the most luminous object

GRB ≈ Black Hole Formation?

GRB jet breaks out of massive stellar envelope



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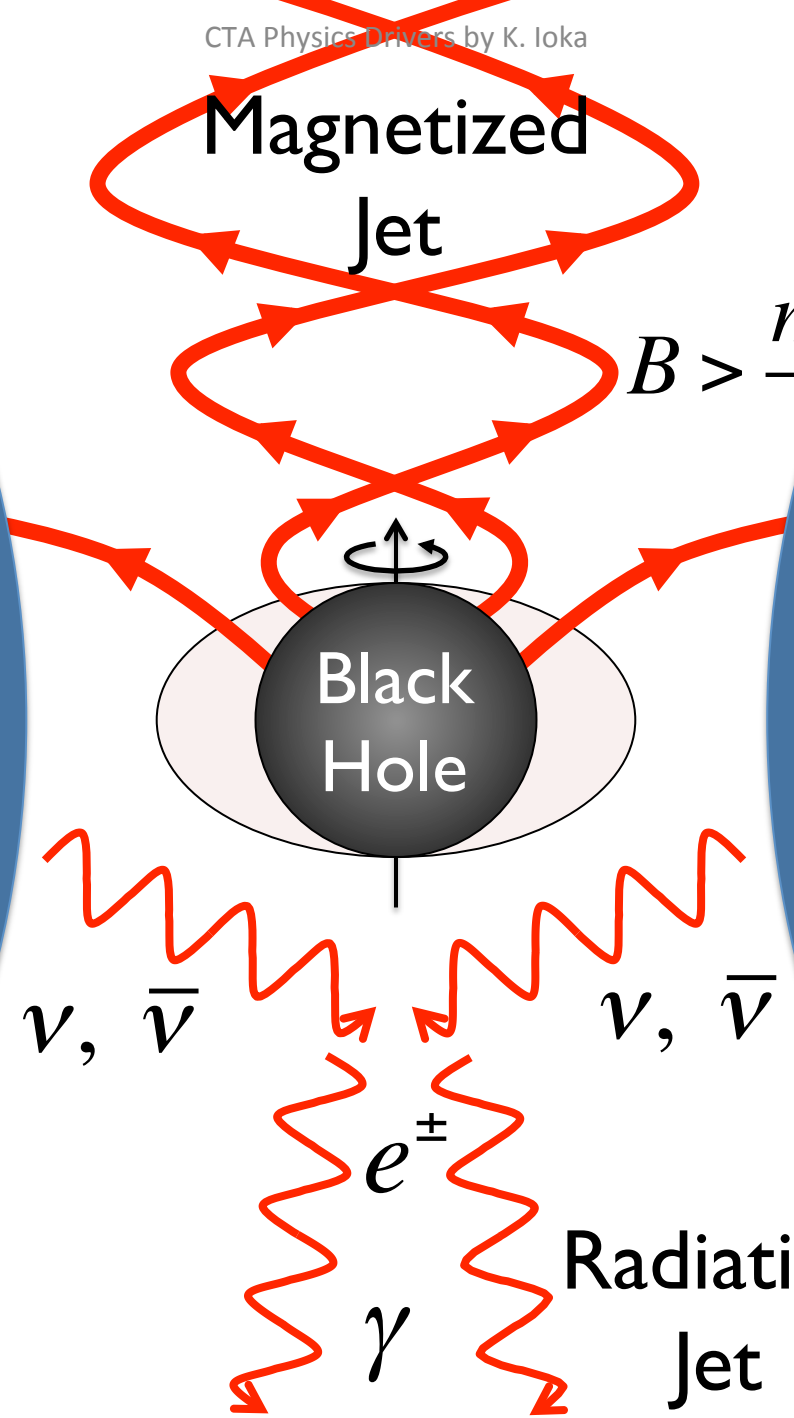
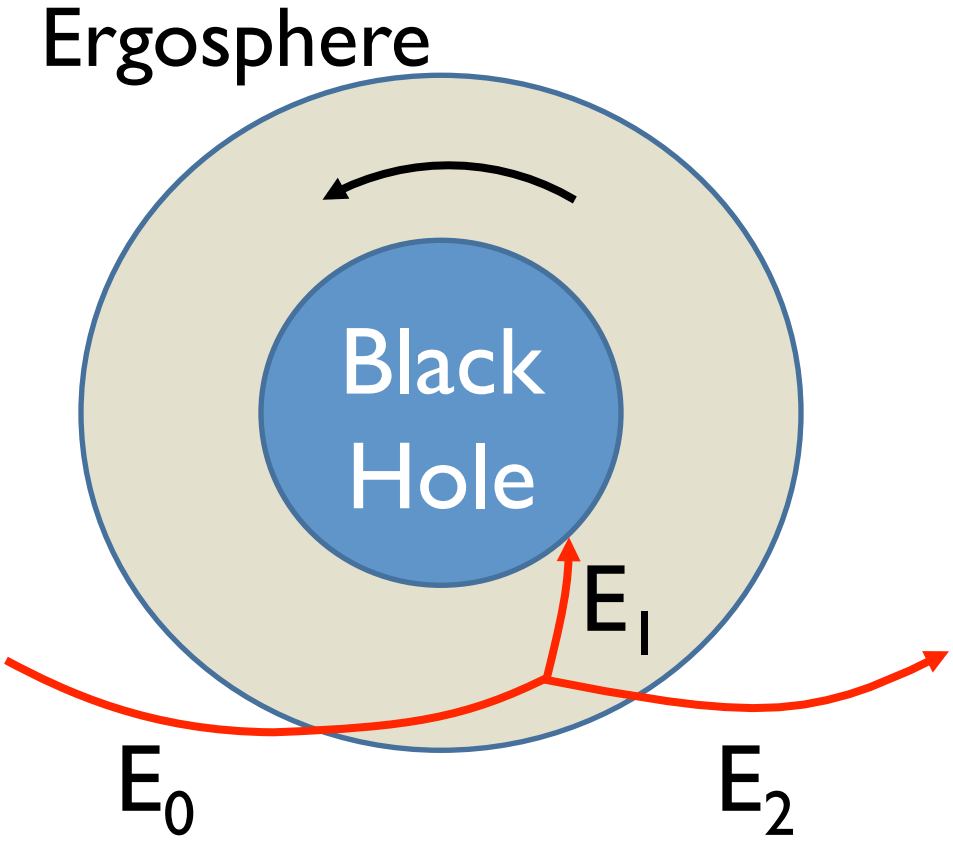


$$B > \frac{m_e^2 e^3}{e\hbar} \approx 4\times 10^{13}\,\mathrm{G}$$

Accretion Disk
(Baryon)

Penrose Process



$E_1<0$ is possible since $g_{tt}<0$ in Ergosphere

$E_0=E_1+E_2$

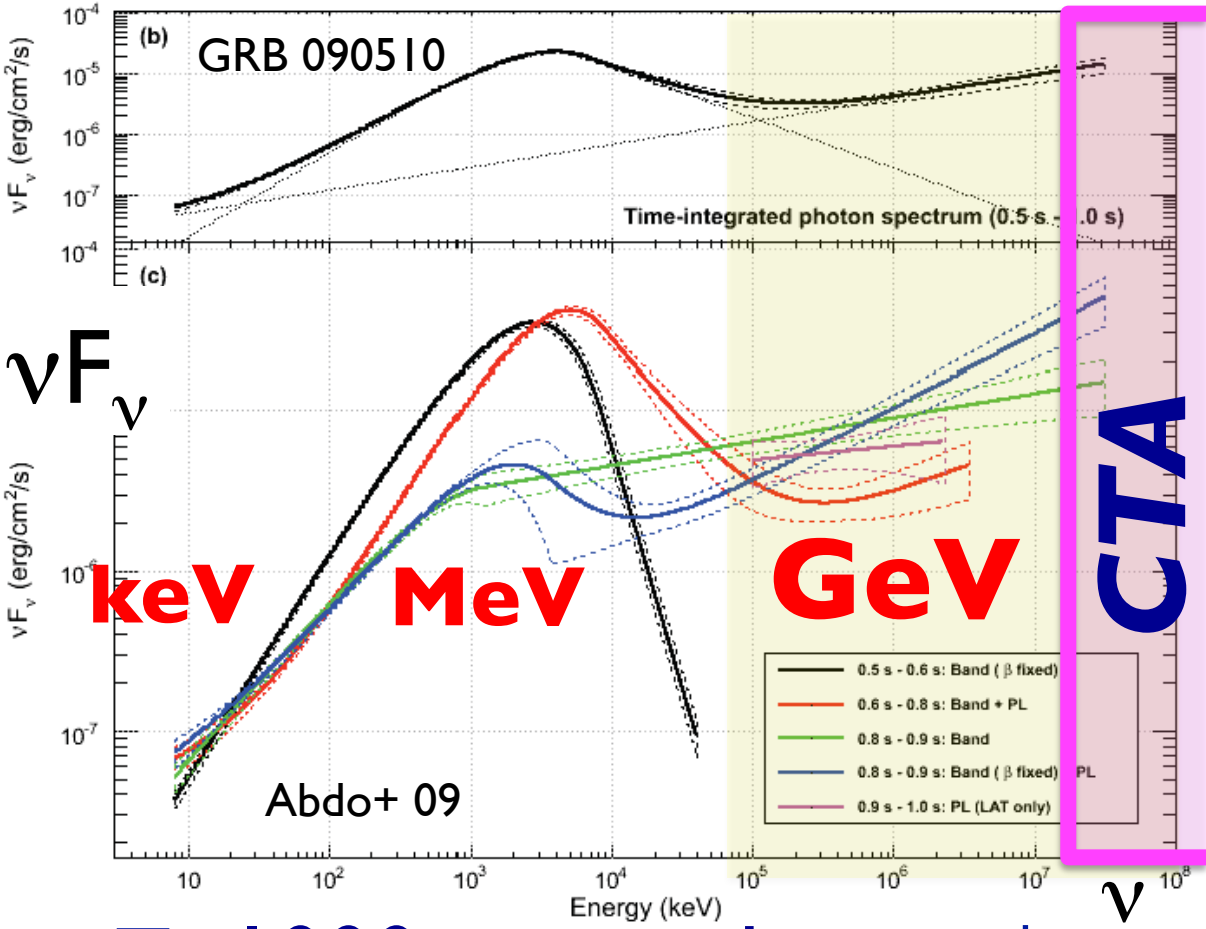
$\Rightarrow E_2>E_0$

Penrose 69; Blandford & Znajek 77

We can extract energy from BH!!

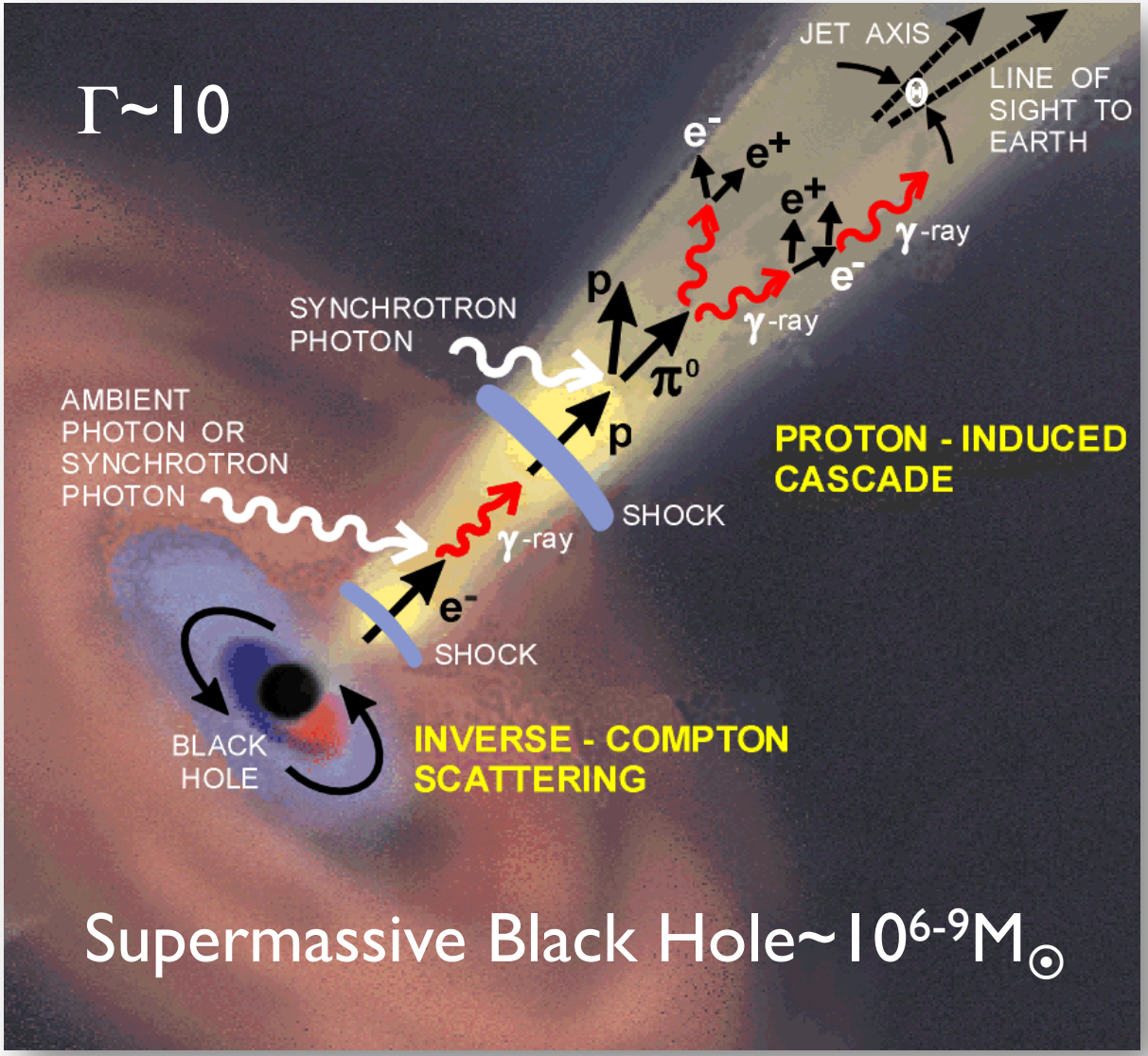
Max~29%Mc^2 (if a=M)

>GeV γ-ray from GRBs



- Γ>1000 to avoid $\gamma\gamma \rightarrow e^+e^-$
- $>10^{17}$eV $p+\gamma \rightarrow \pi \rightarrow \gamma, e?$

Active Galactic Nuclei

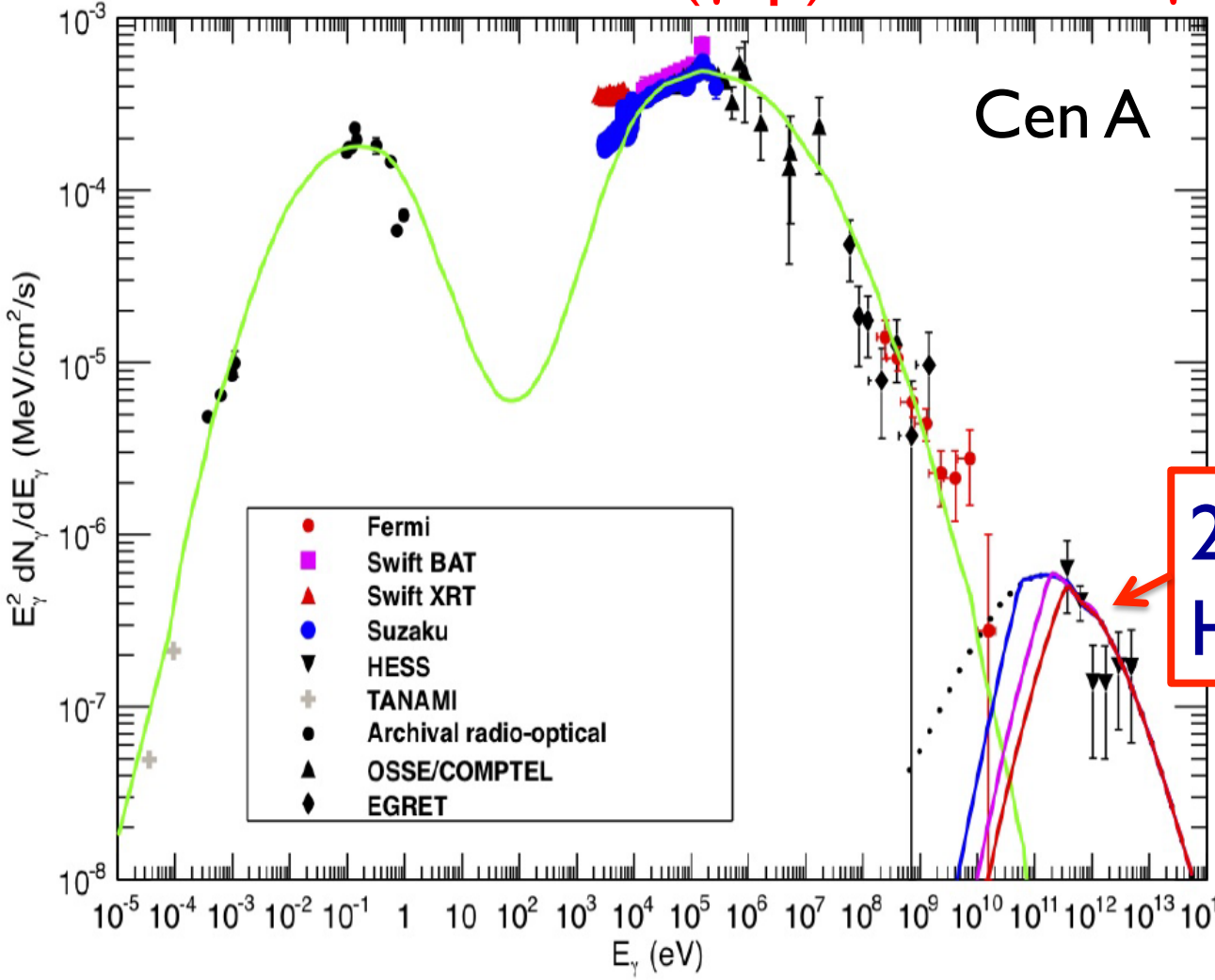


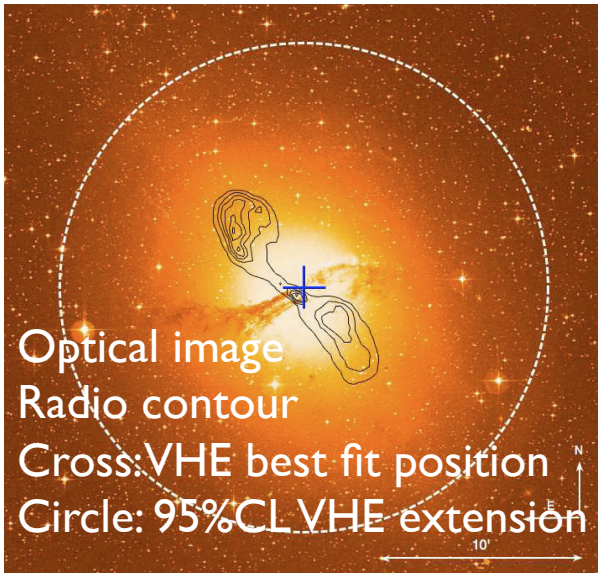
Blazar

Radio galaxy
(BLR,NLR)
(FR I, II)

Off-Axis AGN

UHECR+(γ, p)→π→HE γ

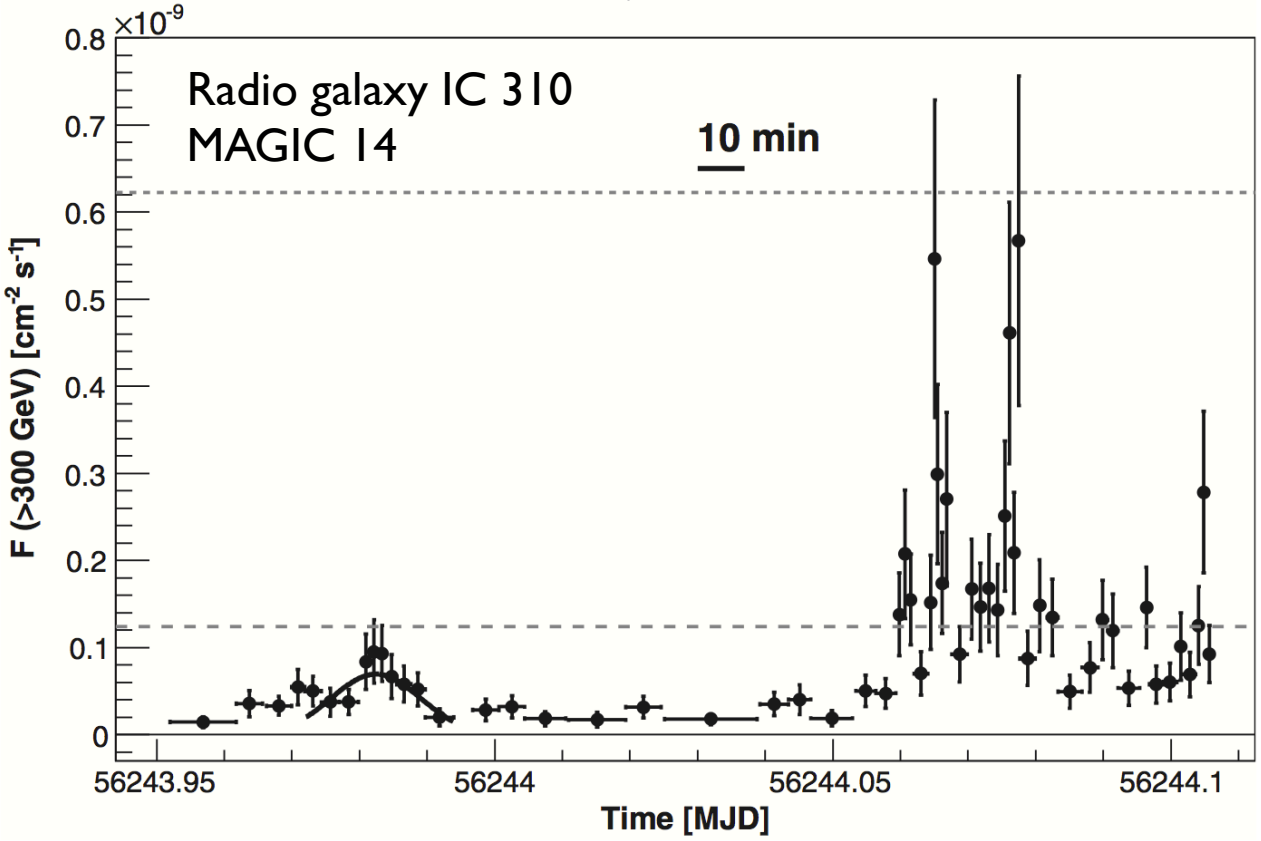


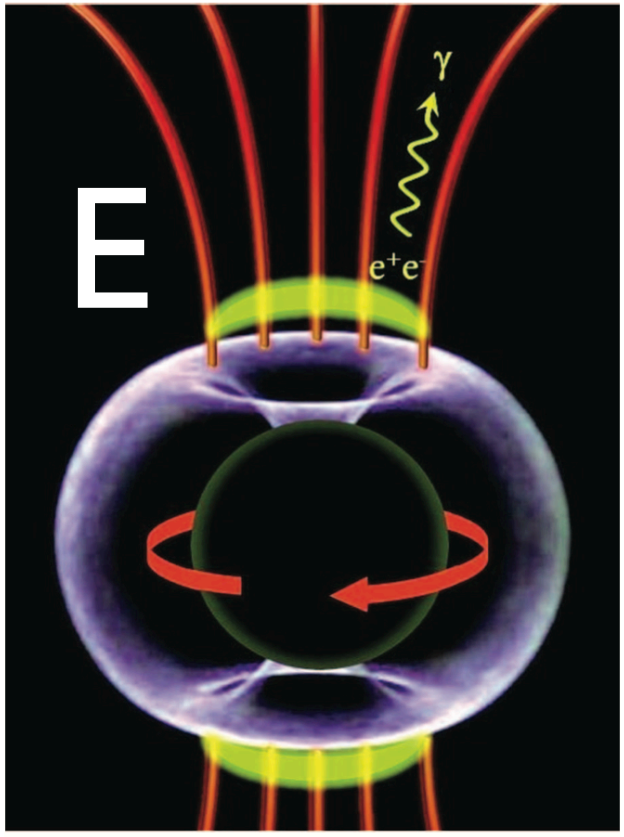


2nd Component
Hadronic origin?

Aharonian+ 09
Abdo+ 10
Kachelrieβ+ 09
Sahu+ 12

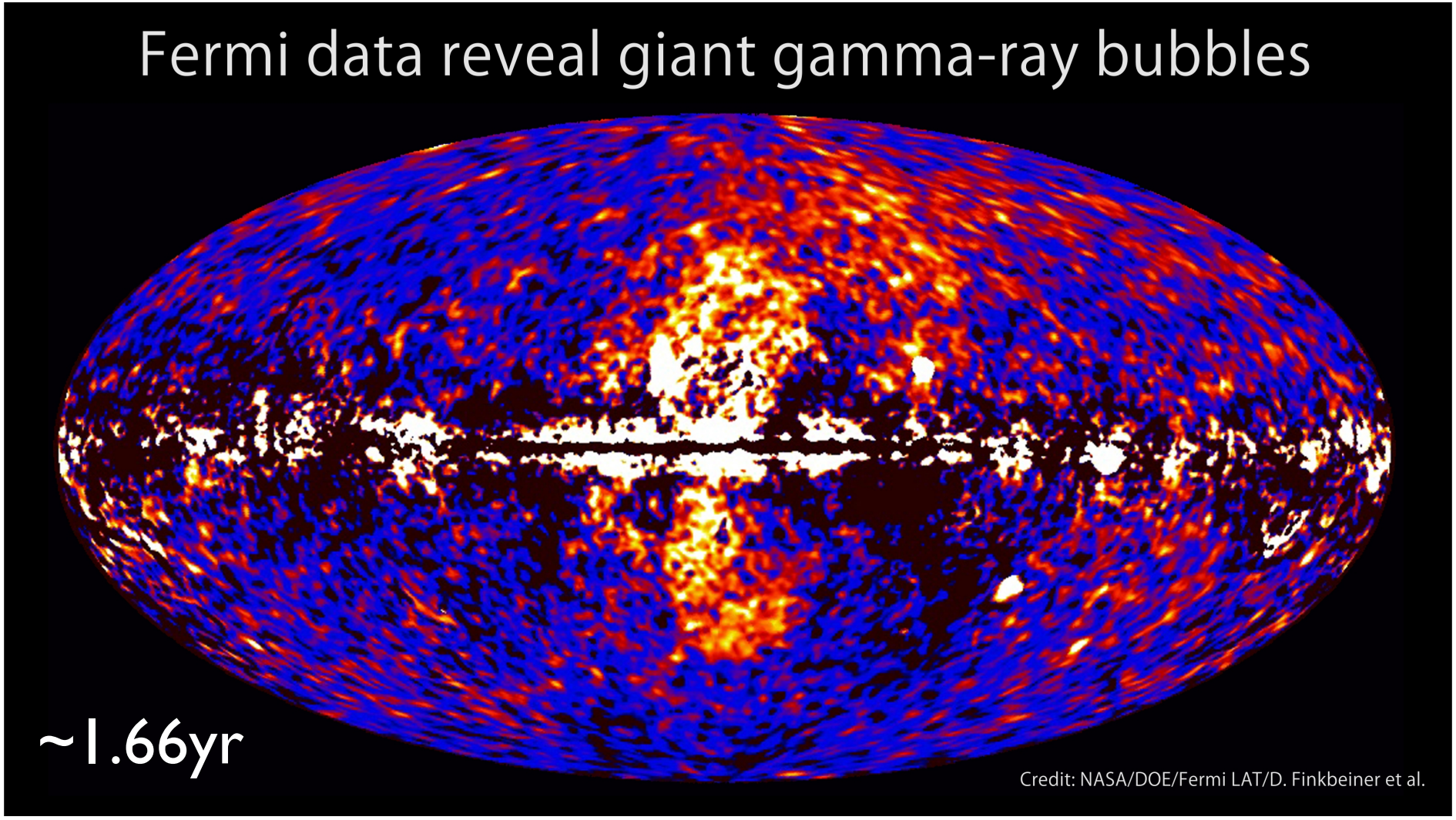
Fast Variability





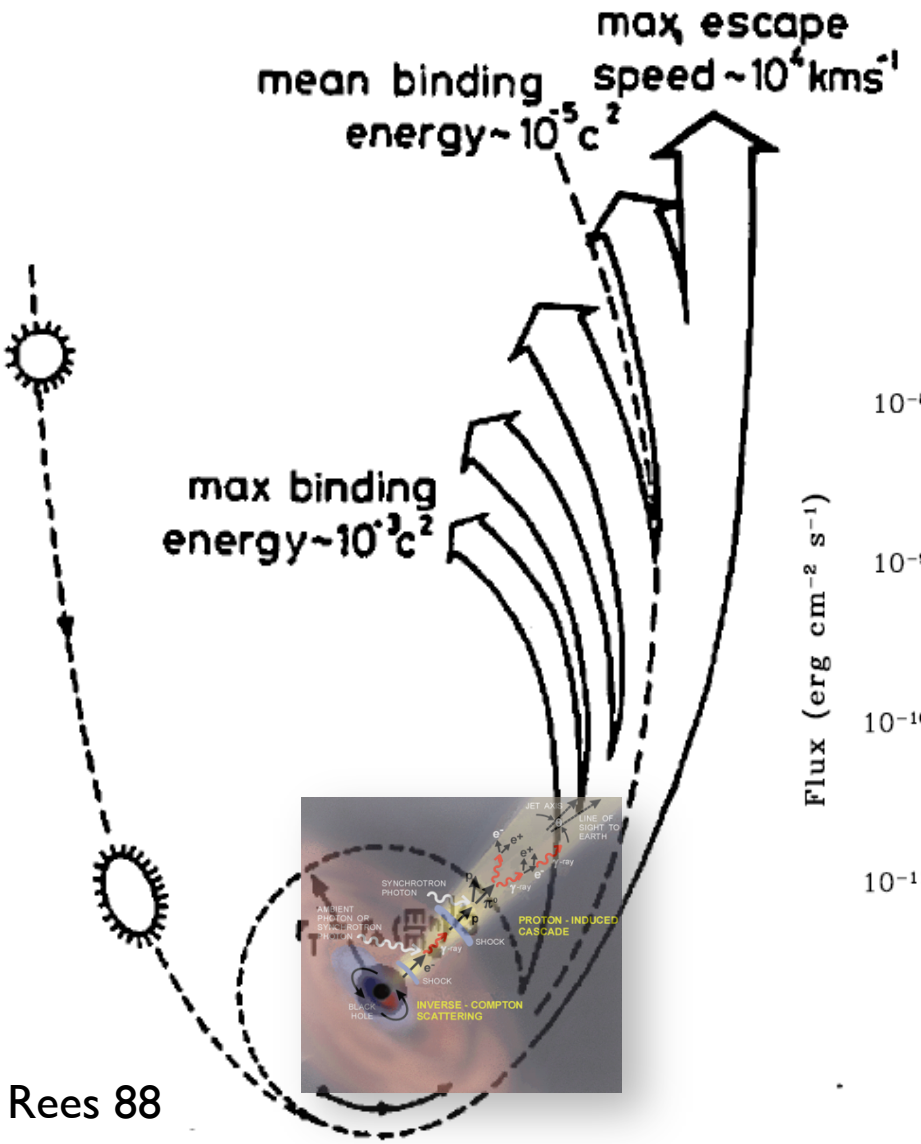
$\Delta t \sim 4.8$ min $\sim 20\%\ r_g$ (Sub-horizon)/c?

γ-ray Bubble Sky Image



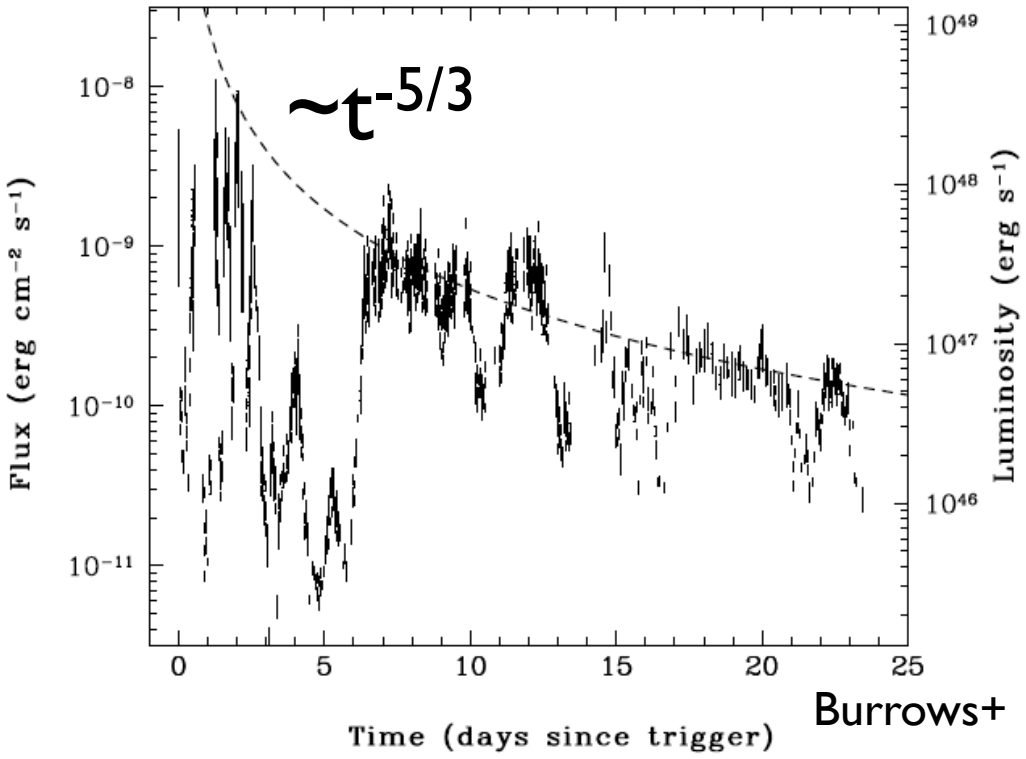
Data subtraction reveals the gamma-ray bubbles

Tidal Disruption Jet



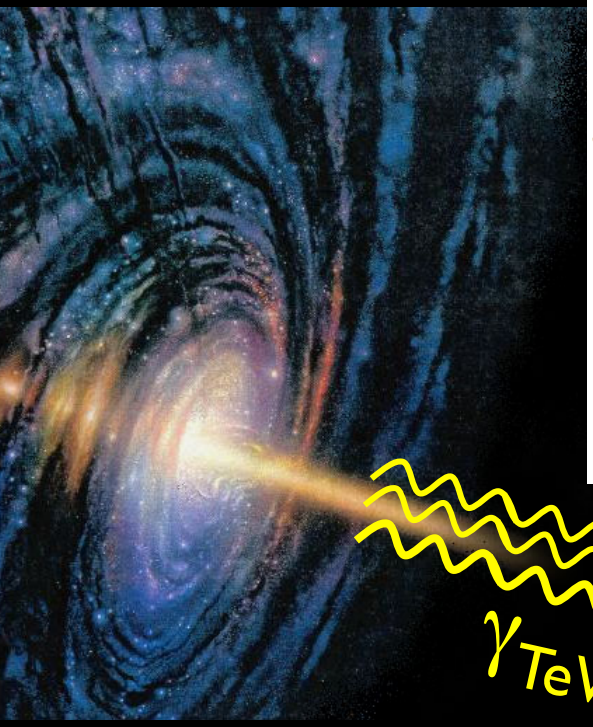
Rees 88

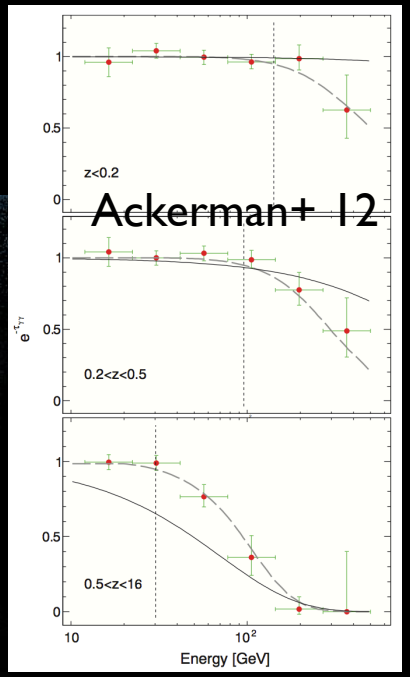
Supermassive BH
disrupts a star ⇒ Jet

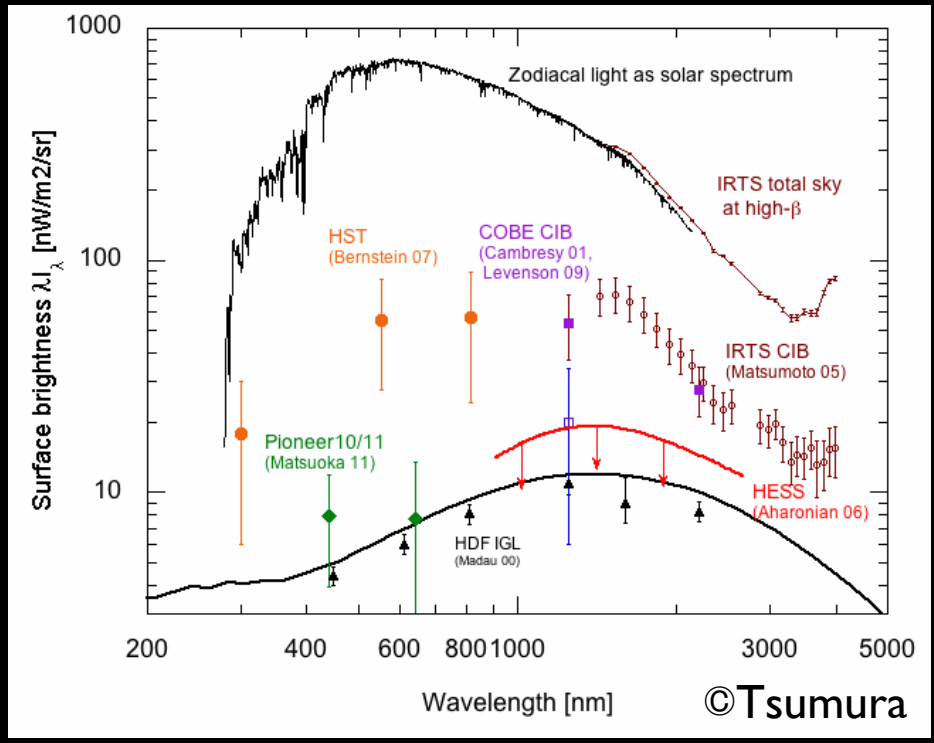


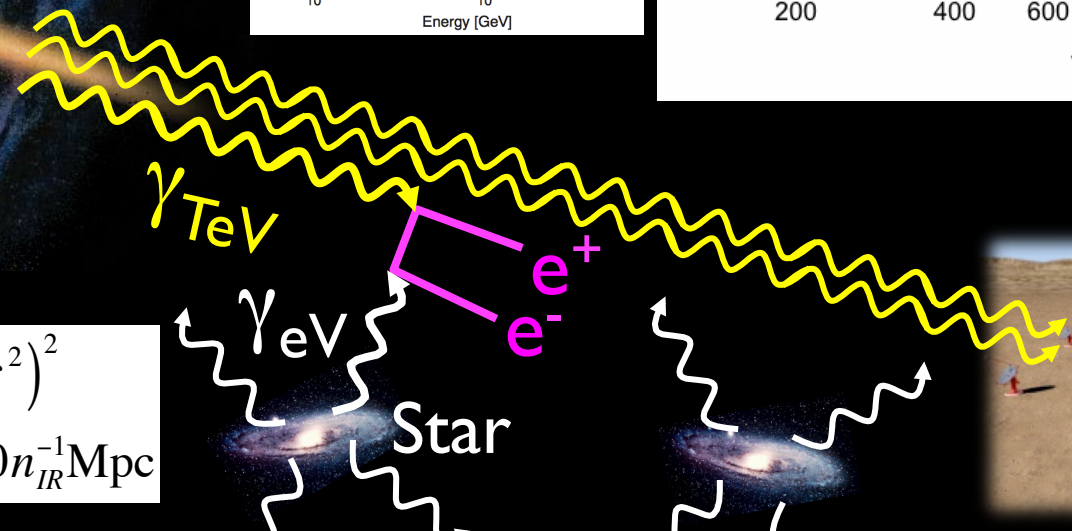
Burrows+ 11

Cosmic Infrared Background



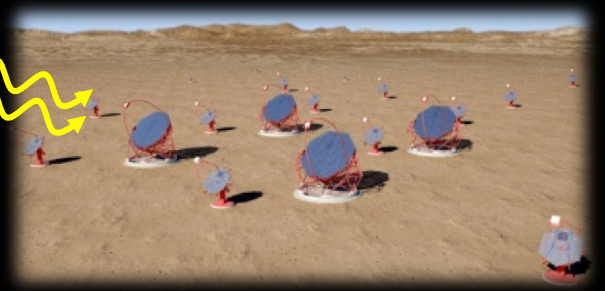




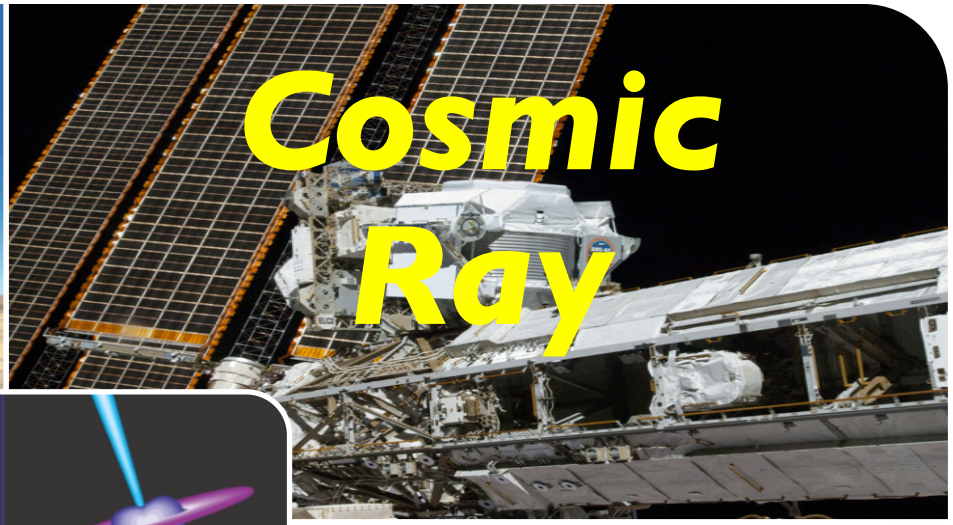


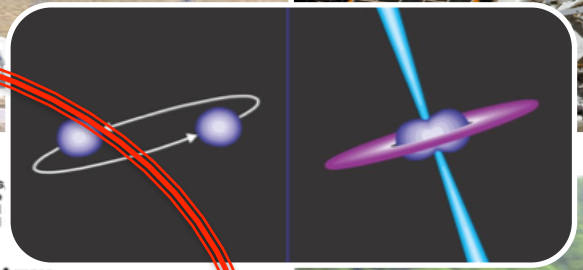
$$\mathrm{eV}\times\mathrm{TeV}\sim\left(m_e c^2\right)^2$$

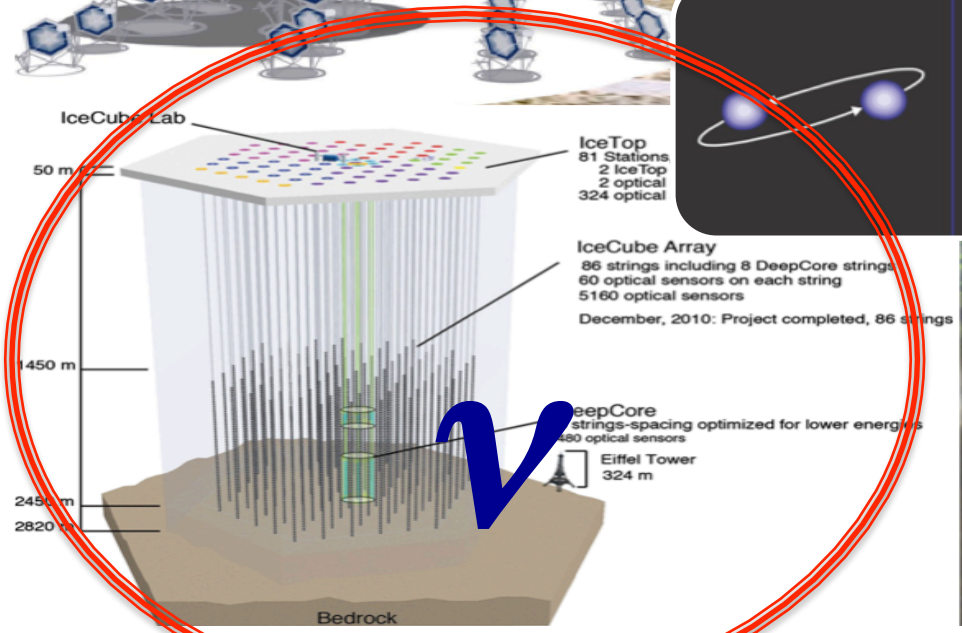
$$l_{\gamma\gamma}\sim 1/\sigma_T n_{IR}\sim 10 n_{IR}^{-1}\mathrm{Mpc}$$



Multi-Messenger

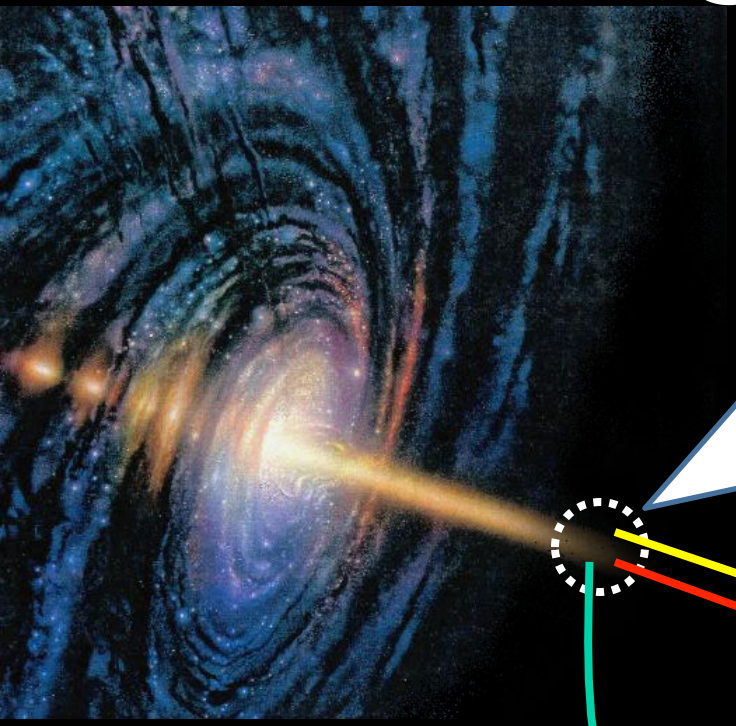


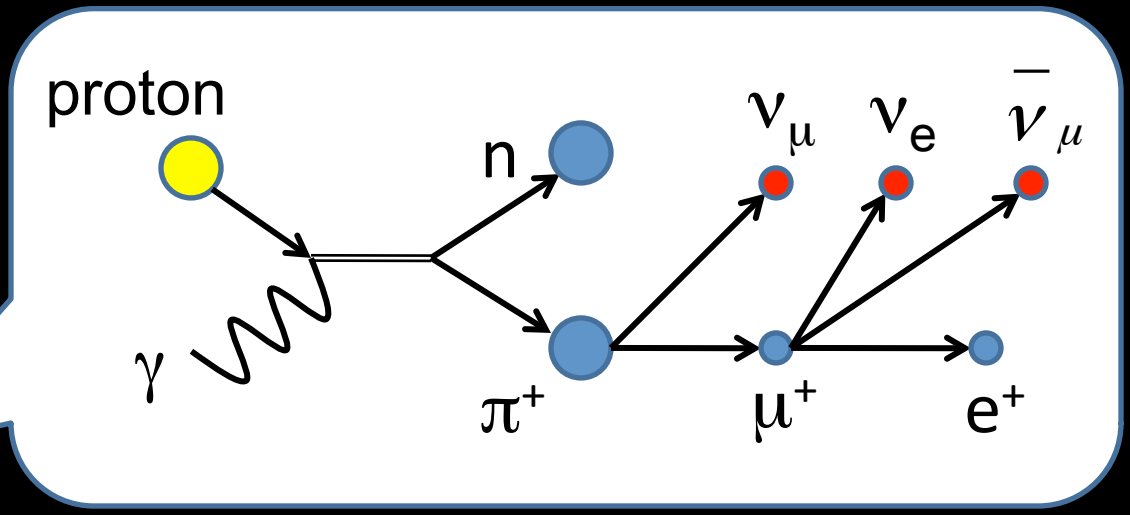




21th Century: Multi-Messenger Era

Cosmic ν



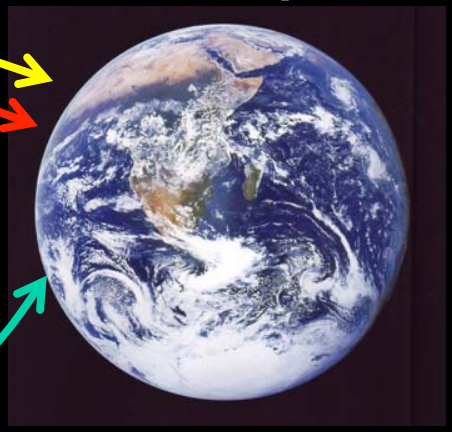


ν

γ

p

Strong penetration
Not delayed



CR origin
ν interaction@>TeV
τ appearance
Limiting ν speed
Equivalence principle

First 2 PeV νs

PeV=10^{15}eV

"Bert" 8 Aug 2011 3 Jan 2012 "Ernie"

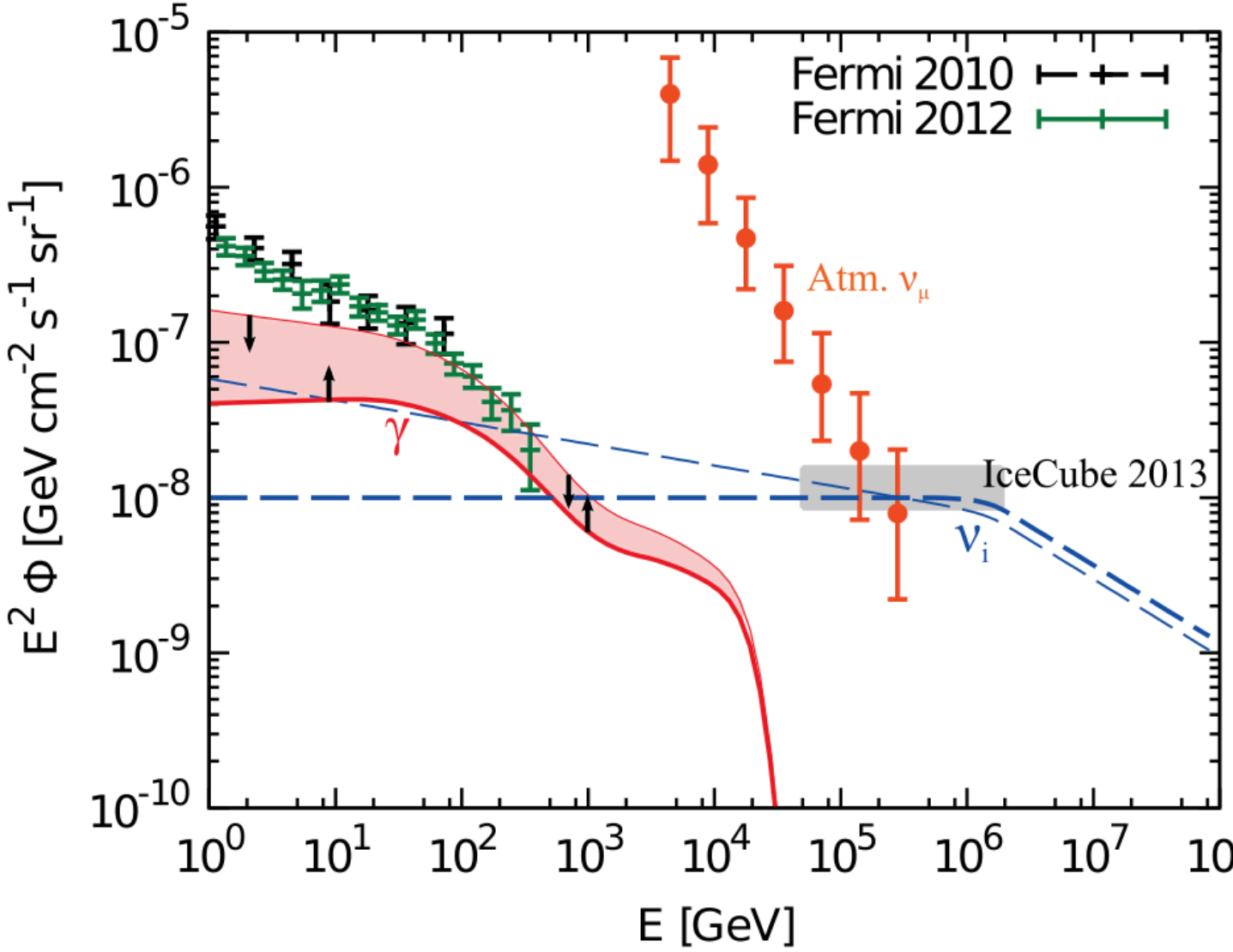
1.04±0.16 PeV 1.14±0.17 PeV

Reported in Kyoto ν 2012

Aartsen+(IceCube), arXiv:1304.5356

Dawn of High-Energy ν Astronomy!!!

Strong γ-Ray Limits

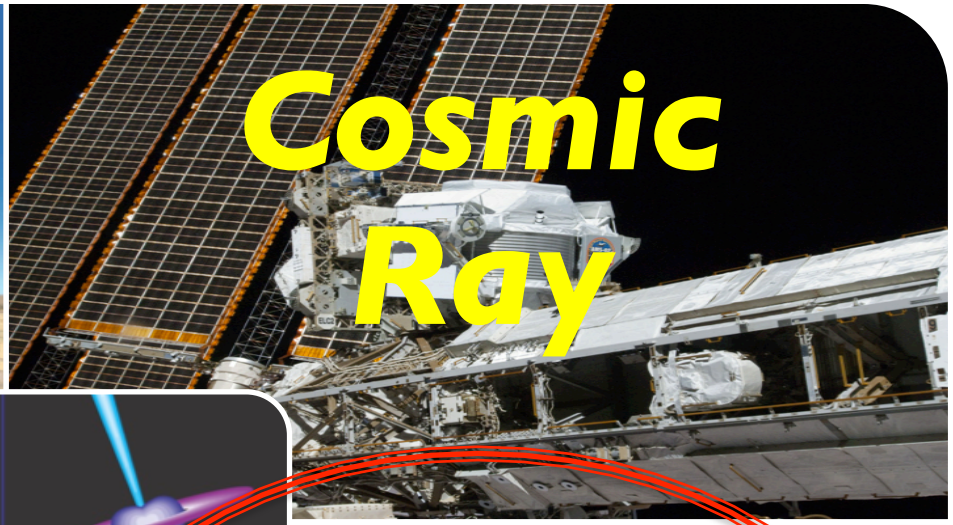


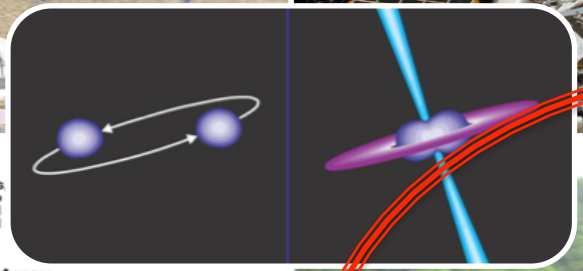
γ-ray extra-galactic BG

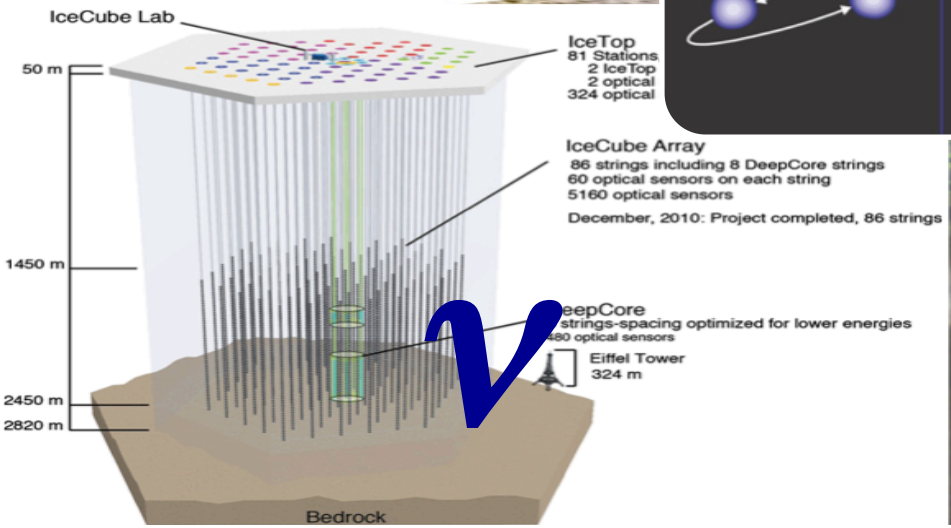
pp
no z-evolution
Γ=2.0 (thick)
Γ=2.14 (thin)

Murase+ 13

Multi-Messenger



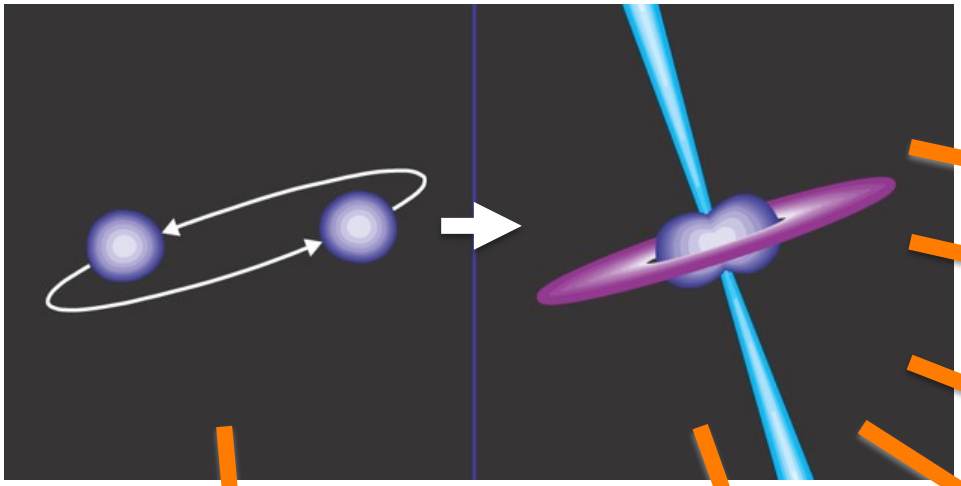




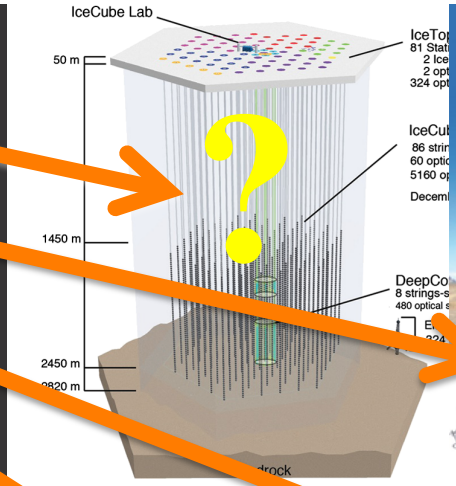
21th Century: Multi-Messenger Era

Counterparts to GW

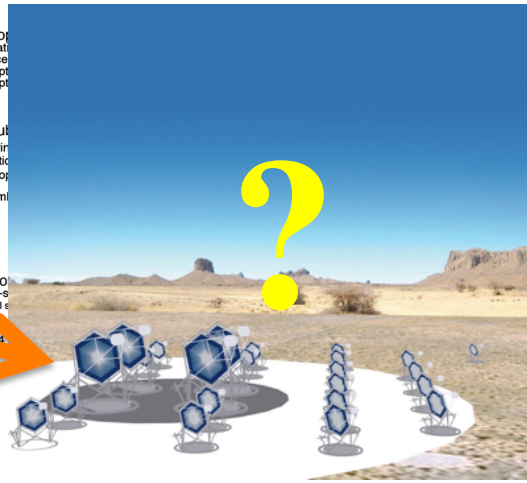
Gravitational Wave Sources

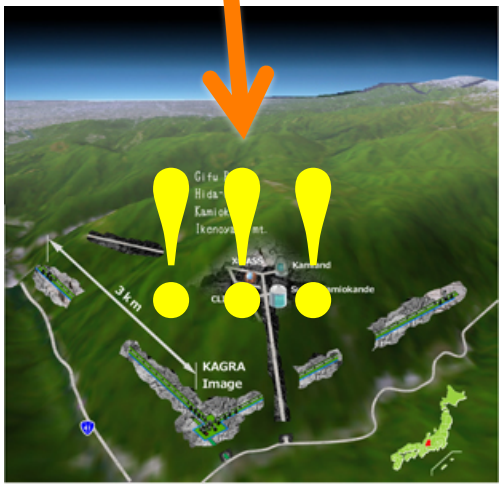


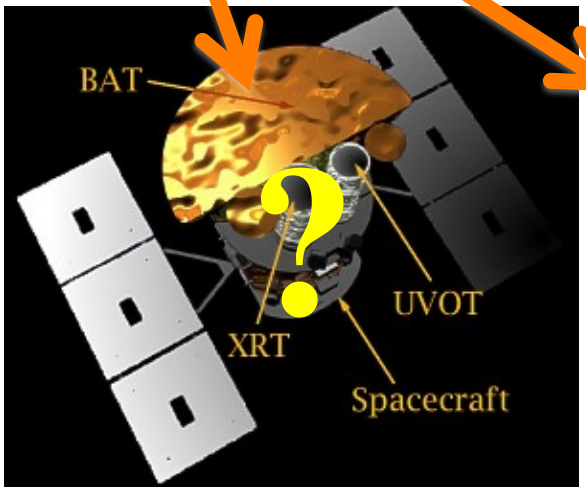
Neutrino



Gamma-ray

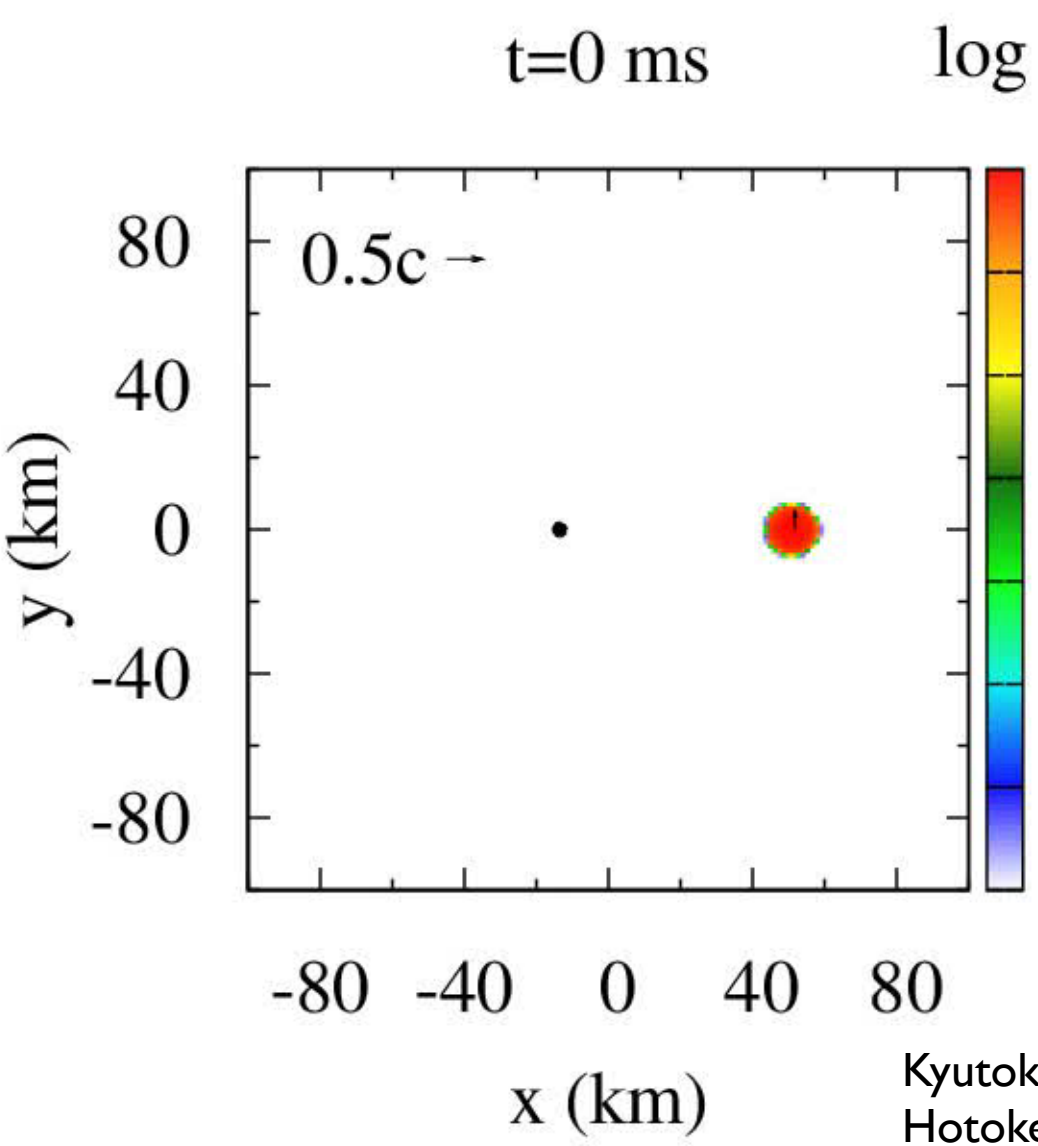






Gravitational wave X-ray IR-Opt Radio

Full General Relativity



Ejecta energy
~ Supernova

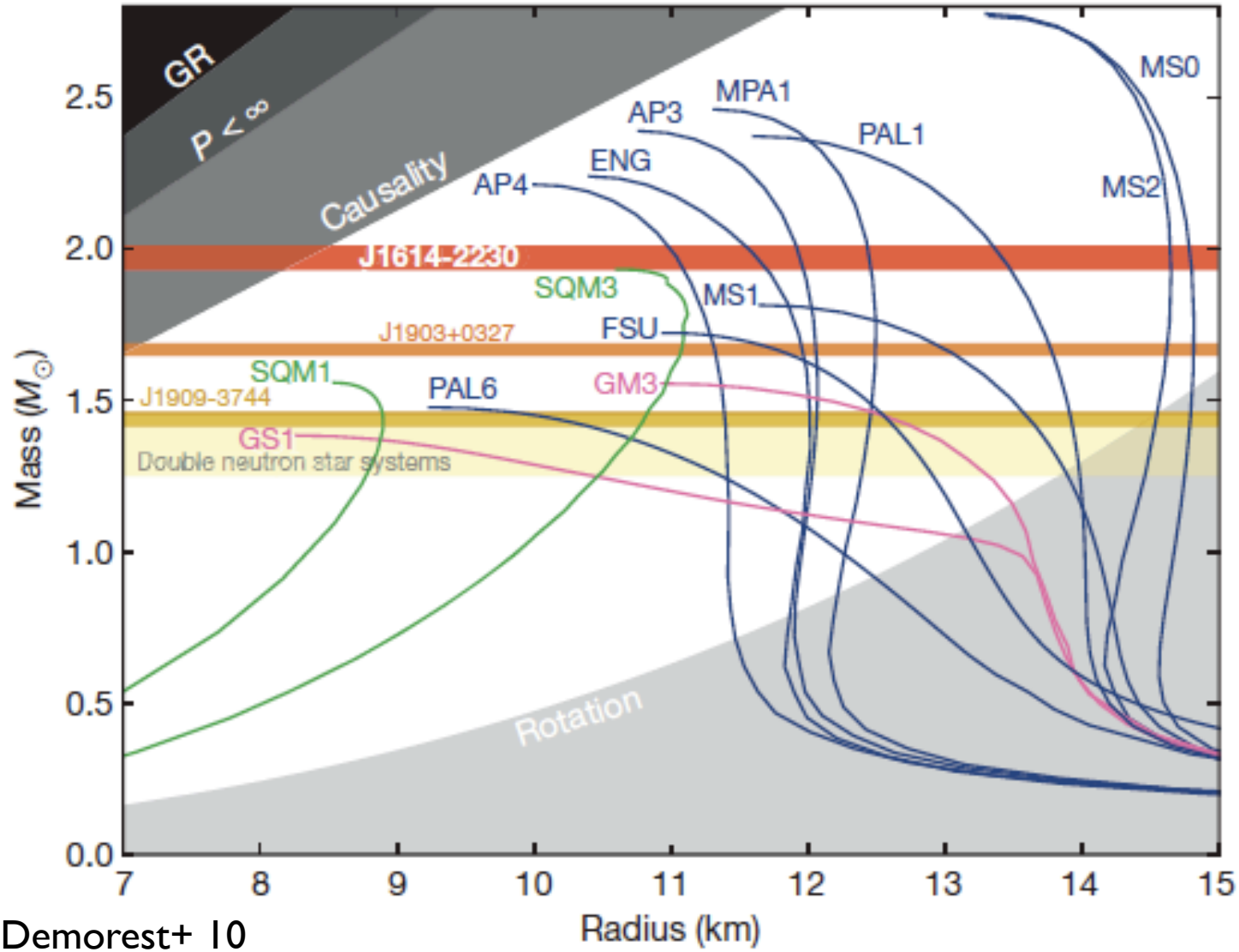
Ejecta velocity
~0.1-0.3 c
>> Supernova

⇒ TeV γ-ray?

Takami, Kyutoku & KI 14

Kyutoku, KI, Okawa, Shibata & Taniguchi 15
Hotokezaka+ 13

Max Mass of Neutron Star



Demorest+ 10

$2M_\odot$

msec NS + $0.5M_\odot$WD

Shapiro delay

$\sim(1.97\pm0.04)M_\odot$

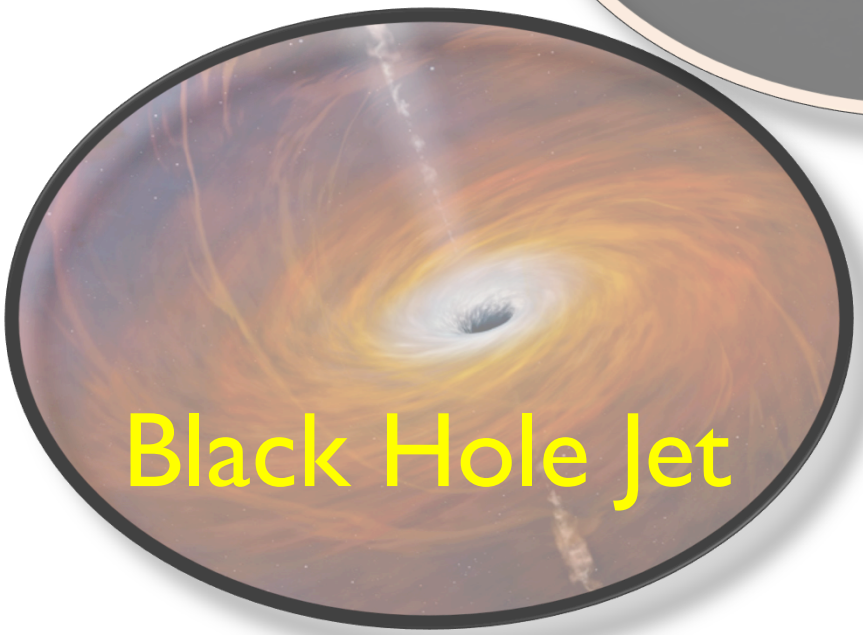
Stiff EOS

(No hyperon?
3-body?
vector force?)

Mysteries in 21th Century

?

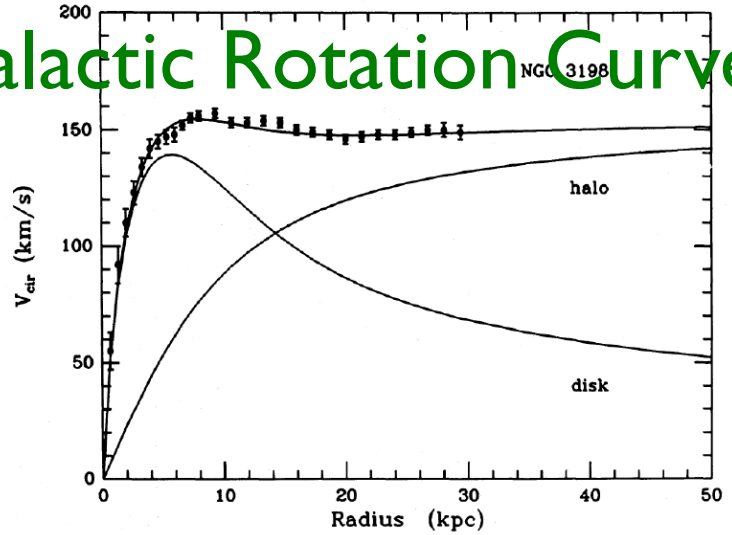
• • •



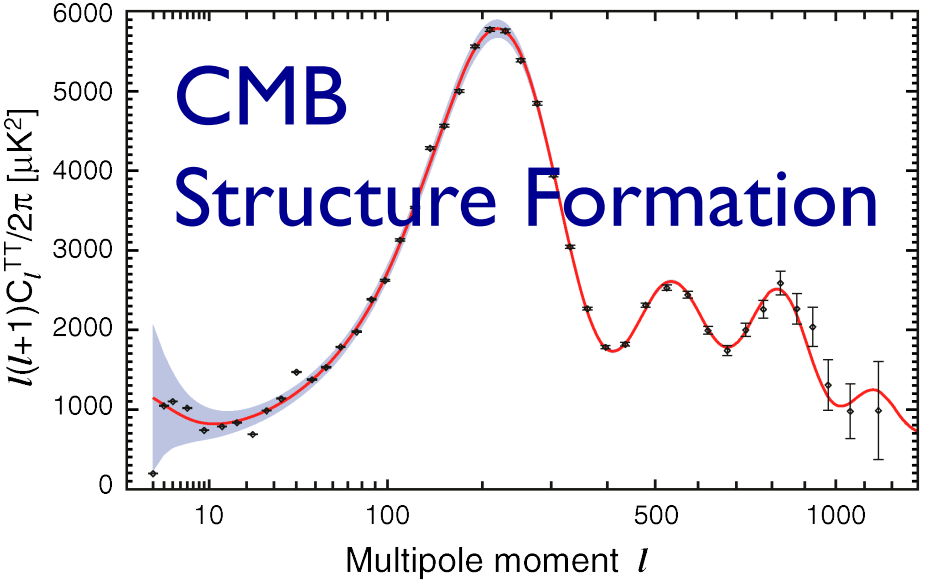
Evidence of Dark Matter

Gravitational Lensing

Galactic Rotation Curve

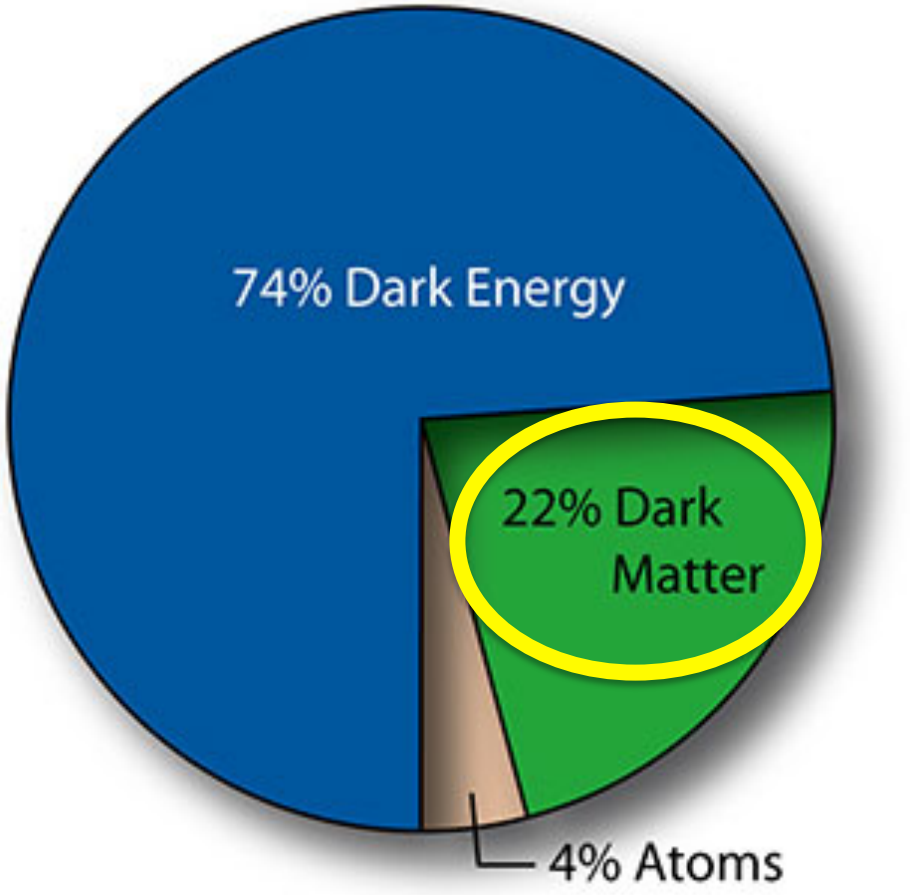


CMB
Structure Formation



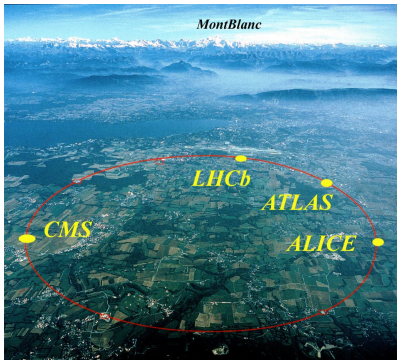
Bullet Cluster

Content of the Universe



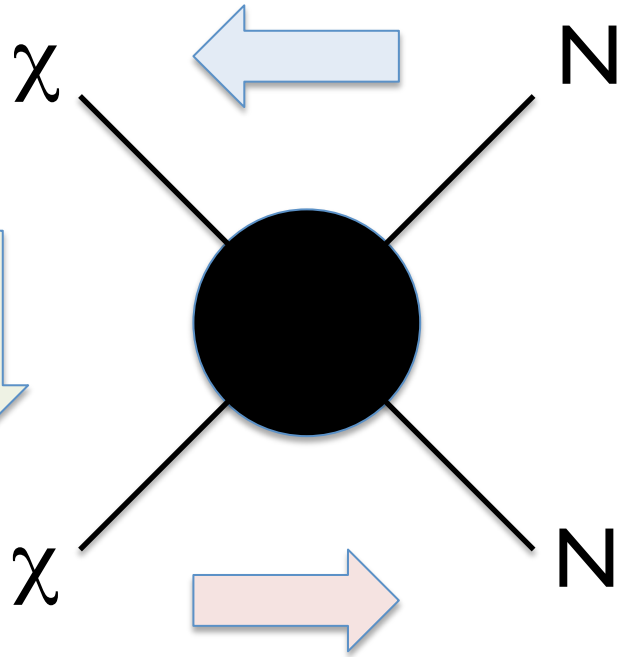
Know particles can NOT be Cold Dark Matter

Searches for Dark Matter



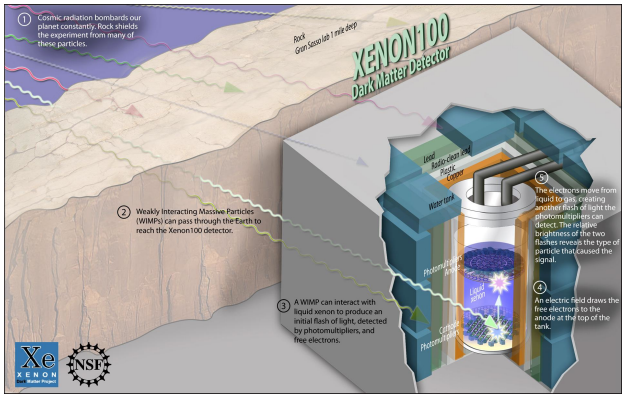
Accelerator

Missing p_T



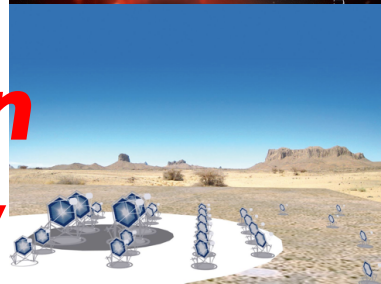
Direct Detection

DM scatters Nuclei

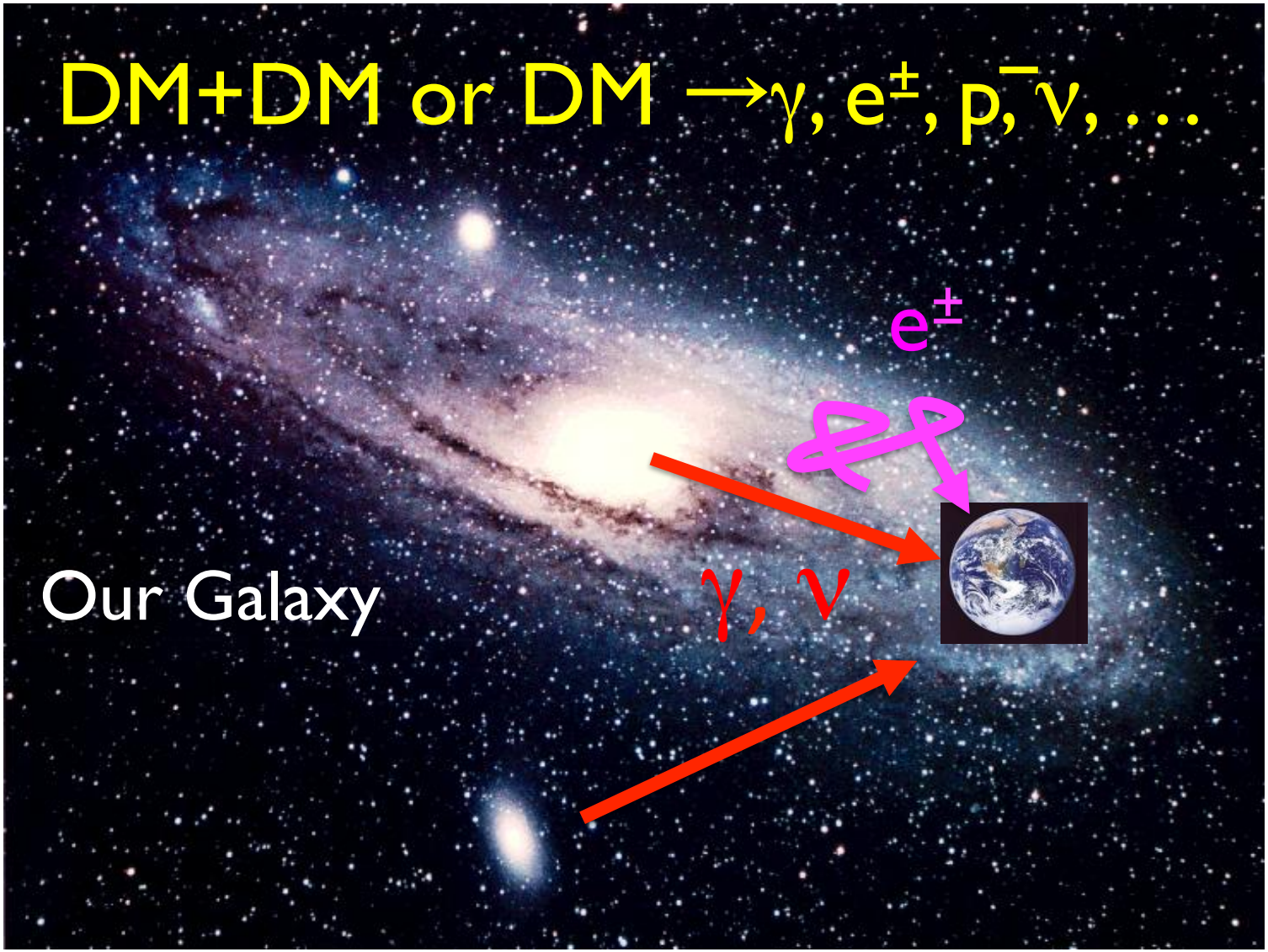


Indirect Detection

High-energy cosmic ray



Indirect Detection



ATLAS SUSY Searches* - 95% CL Lower Limits

Status: SUSY 2013

ATLAS Preliminary

$\int \mathcal{L}\, dt$ = (4.6 - 22.9) fb^{-1} $\sqrt{s}$ = 7, 8 TeV

	Model	e, μ, τ, γ	Jets	E_T^{miss}	$\int \mathcal{L}\, dt$[fb^{-1}]	Mass limit		Reference
Inclusive Searches	MSUGRA/CMSSM	0	2-6 jets	Yes	20.3	$\tilde{q}, \tilde{g}$ 1.7 TeV	$m(\tilde{q})=m(\tilde{g})$	ATLAS-CONF-2013-047
	MSUGRA/CMSSM	1 e,μ	3-6 jets	Yes	20.3	$\tilde{g}$ 1.2 TeV	any $m(\tilde{q})$	ATLAS-CONF-2013-062
	MSUGRA/CMSSM	0	7-10 jets	Yes	20.3	$\tilde{g}$ 1.1 TeV	any $m(\tilde{q})$	1308.1841
	$\tilde{q}\tilde{q}, \tilde{q}\to q\tilde{\chi}_1^0$	0	2-6 jets	Yes	20.3	$\tilde{q}$ 740 GeV	$m(\tilde{\chi}_1^0)=0$ GeV	ATLAS-CONF-2013-047
	$\tilde{g}\tilde{g}, \tilde{g}\to q\bar{q}\tilde{\chi}_1^0$	0	2-6 jets	Yes	20.3	$\tilde{g}$ 1.3 TeV	$m(\tilde{\chi}_1^0)=0$ GeV	ATLAS-CONF-2013-047
	$\tilde{g}\tilde{g}, \tilde{g}\to qq\tilde{\chi}_1^\pm\to qqW^\pm\tilde{\chi}_1^0$	1 e,μ	3-6 jets	Yes	20.3	$\tilde{g}$ 1.18 TeV	$m(\tilde{\chi}_1^0)<200$ GeV, $m(\tilde{\chi}^\pm)=0.5(m(\tilde{\chi}_1^0)+m(\tilde{g}))$	ATLAS-CONF-2013-062
	$\tilde{g}\tilde{g}, \tilde{g}\to qq(\ell\ell/\ell\nu/\nu\nu)\tilde{\chi}_1^0$	2 e,μ	0-3 jets	-	20.3	$\tilde{g}$ 1.12 TeV	$m(\tilde{\chi}_1^0)=0$ GeV	ATLAS-CONF-2013-089
	GMSB ($\tilde{\ell}$ NLSP)	2 e,μ	2-4 jets	Yes	4.7	$\tilde{g}$ 1.24 TeV	$\tan\beta<15$	1208.4688
	GMSB ($\tilde{\ell}$ NLSP)	1-2 τ	0-2 jets	Yes	20.7	$\tilde{g}$ 1.4 TeV	$\tan\beta>18$	ATLAS-CONF-2013-026
	GGM (bino NLSP)	2 γ	-	Yes	4.8	$\tilde{g}$ 1.07 TeV	$m(\tilde{\chi}_1^0)>50$ GeV	1209.0753
	GGM (wino NLSP)	1 $e,\mu+\gamma$	-	Yes	4.8	$\tilde{g}$ 619 GeV	$m(\tilde{\chi}_1^0)>50$ GeV	ATLAS-CONF-2012-144
	GGM (higgsino-bino NLSP)	γ	1 b	Yes	4.8	$\tilde{g}$ 900 GeV	$m(\tilde{\chi}_1^0)>220$ GeV	1211.1167
	GGM (higgsino NLSP)	2 e,μ (Z)	0-3 jets	Yes	5.8	$\tilde{g}$ 690 GeV	$m(\tilde{H})>200$ GeV	ATLAS-CONF-2012-152
	Gravitino LSP	0	mono-jet	Yes	10.5	$F^{1/2}$ scale 645 GeV	$m(\tilde{g})>10^{-4}$ eV	ATLAS-CONF-2012-147
3rd gen. $\tilde{g}$ med.	$\tilde{g}\to b\bar{b}\tilde{\chi}_1^0$	0	3 b	Yes	20.1	$\tilde{g}$ 1.2 TeV	$m(\tilde{\chi}_1^0)<600$ GeV	ATLAS-CONF-2013-061
	$\tilde{g}\to t\bar{t}\tilde{\chi}_1^0$	0	7-10 jets	Yes	20.3	$\tilde{g}$ 1.1 TeV	$m(\tilde{\chi}_1^0)<350$ GeV	1308.1841
	$\tilde{g}\to t\bar{t}\tilde{\chi}_1^0$	0-1 e,μ	3 b	Yes	20.1	$\tilde{g}$ 1.34 TeV	$m(\tilde{\chi}_1^0)<400$ GeV	ATLAS-CONF-2013-061
	$\tilde{g}\to b\bar{t}\tilde{\chi}_1^+$	0-1 e,μ	3 b	Yes	20.1	$\tilde{g}$ 1.3 TeV	$m(\tilde{\chi}_1^0)<300$ GeV	ATLAS-CONF-2013-061
3rd gen. squarks direct production	$\tilde{b}_1\tilde{b}_1, \tilde{b}_1\to b\tilde{\chi}_1^0$	0	2 b	Yes	20.1	$\tilde{b}_1$ 100-620 GeV	$m(\tilde{\chi}_1^0)<90$ GeV	1308.2631
	$\tilde{b}_1\tilde{b}_1, \tilde{b}_1\to t\tilde{\chi}_1^\pm$	2 e,μ (SS)	0-3 b	Yes	20.7	$\tilde{b}_1$ 275-430 GeV	$m(\tilde{\chi}_1^\pm)=2\, m(\tilde{\chi}_1^0)$	ATLAS-CONF-2013-007
	$\tilde{t}_1\tilde{t}_1$(light), $\tilde{t}_1\to b\tilde{\chi}_1^\pm$	1-2 e,μ	1-2 b	Yes	4.7	$\tilde{t}_1$ 110-167 GeV	$m(\tilde{\chi}_1^0)=55$ GeV	1208.4305, 1209.2102
	$\tilde{t}_1\tilde{t}_1$(light), $\tilde{t}_1\to Wb\tilde{\chi}_1^0$	2 e,μ	0-2 jets	Yes	20.3	$\tilde{t}_1$ 130-220 GeV	$m(\tilde{\chi}_1^0)=m(\tilde{t}_1)-m(W)-50$ GeV, $m(\tilde{t}_1)<<m(\tilde{\chi}_1^\pm)$	ATLAS-CONF-2013-048
	$\tilde{t}_1\tilde{t}_1$(medium), $\tilde{t}_1\to t\tilde{\chi}_1^0$	2 e,μ	2 jets	Yes	20.3	$\tilde{t}_1$ 225-525 GeV	$m(\tilde{\chi}_1^0)=0$ GeV	ATLAS-CONF-2013-065
	$\tilde{t}_1\tilde{t}_1$(medium), $\tilde{t}_1\to b\tilde{\chi}_1^\pm$	0	2 b	Yes	20.1	$\tilde{t}_1$ 150-580 GeV	$m(\tilde{\chi}_1^0)<200$ GeV, $m(\tilde{\chi}_1^\pm)-m(\tilde{\chi}_1^0)=5$ GeV	1308.2631
	$\tilde{t}_1\tilde{t}_1$(heavy), $\tilde{t}_1\to t\tilde{\chi}_1^0$	1 e,μ	1 b	Yes	20.7	$\tilde{t}_1$ 200-610 GeV	$m(\tilde{\chi}_1^0)=0$ GeV	ATLAS-CONF-2013-037
	$\tilde{t}_1\tilde{t}_1$(heavy), $\tilde{t}_1\to t\tilde{\chi}_1^0$	0	2 b	Yes	20.5	$\tilde{t}_1$ 320-660 GeV	$m(\tilde{\chi}_1^0)=0$ GeV	ATLAS-CONF-2013-024
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1\to c\tilde{\chi}_1^0$	0	mono-jet/c-tag	Yes	20.3	$\tilde{t}_1$ 90-200 GeV	$m(\tilde{t}_1)-m(\tilde{\chi}_1^0)<85$ GeV	ATLAS-CONF-2013-068
	$\tilde{t}_1\tilde{t}_1$(natural GMSB)	2 e,μ (Z)	1 b	Yes	20.7	$\tilde{t}_1$ 500 GeV	$m(\tilde{\chi}_1^0)>150$ GeV	ATLAS-CONF-2013-025
	$\tilde{t}_2\tilde{t}_2, \tilde{t}_2\to\tilde{t}_1+Z$	3 e,μ (Z)	1 b	Yes	20.7	$\tilde{t}_2$ 271-520 GeV	$m(\tilde{t}_1)=m(\tilde{\chi}_1^0)+180$ GeV	ATLAS-CONF-2013-025
EW direct	$\tilde{\ell}_{L,R}\tilde{\ell}_{L,R}, \tilde{\ell}\to\ell\tilde{\chi}_1^0$	2 e,μ	0	Yes	20.3	$\tilde{\ell}$ 85-315 GeV	$m(\tilde{\chi}_1^0)=0$ GeV	ATLAS-CONF-2013-049
	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+\to\tilde{\ell}\nu(\ell\tilde{\nu})$	2 e,μ	0	Yes	20.3	$\tilde{\chi}_1^\pm$ 125-450 GeV	$m(\tilde{\chi}_1^0)=0$ GeV, $m(\tilde{\ell},\tilde{\nu})=0.5(m(\tilde{\chi}_1^\pm)+m(\tilde{\chi}_1^0))$	ATLAS-CONF-2013-049
	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+\to\tilde{\tau}\nu(\tau\tilde{\nu})$	2 τ	-	Yes	20.7	$\tilde{\chi}_1^\pm$ 180-330 GeV	$m(\tilde{\chi}_1^0)=0$ GeV, $m(\tilde{\tau},\tilde{\nu})=0.5(m(\tilde{\chi}_1^\pm)+m(\tilde{\chi}_1^0))$	ATLAS-CONF-2013-028
	$\tilde{\chi}_1^\pm\tilde{\chi}_2^0\to\tilde{\ell}_L\nu\tilde{\ell}_L\ell(\tilde{\nu}\nu), \ell\tilde{\nu}\tilde{\ell}_L\ell(\tilde{\nu}\nu)$	3 e,μ	0	Yes	20.7	$\tilde{\chi}_1^\pm,\tilde{\chi}_2^0$ 600 GeV	$m(\tilde{\chi}_1^\pm)=m(\tilde{\chi}_2^0)$, $m(\tilde{\chi}_1^0)=0$, $m(\tilde{\ell},\tilde{\nu})=0.5(m(\tilde{\chi}_1^\pm)+m(\tilde{\chi}_1^0))$	ATLAS-CONF-2013-035
	$\tilde{\chi}_1^\pm\tilde{\chi}_2^0\to W\tilde{\chi}_1^0 Z\tilde{\chi}_1^0$	3 e,μ	0	Yes	20.7	$\tilde{\chi}_1^\pm,\tilde{\chi}_2^0$ 315 GeV	$m(\tilde{\chi}_1^\pm)=m(\tilde{\chi}_2^0)$, $m(\tilde{\chi}_1^0)=0$, sleptons decoupled	ATLAS-CONF-2013-035
	$\tilde{\chi}_1^\pm\tilde{\chi}_2^0\to W\tilde{\chi}_1^0 h\tilde{\chi}_1^0$	1 e,μ	2 b	Yes	20.3	$\tilde{\chi}_1^\pm,\tilde{\chi}_2^0$ 285 GeV	$m(\tilde{\chi}_1^\pm)=m(\tilde{\chi}_2^0)$, $m(\tilde{\chi}_1^0)=0$, sleptons decoupled	ATLAS-CONF-2013-093
Long-lived particles	Direct $\tilde{\chi}_1^+\tilde{\chi}_1^-$ prod., long-lived $\tilde{\chi}_1^\pm$	Disapp. trk	1 jet	Yes	20.3	$\tilde{\chi}_1^\pm$ 270 GeV	$m(\tilde{\chi}_1^\pm)-m(\tilde{\chi}_1^0)=160$ MeV, $\tau(\tilde{\chi}_1^\pm)=0.2$ ns	ATLAS-CONF-2013-069
	Stable, stopped $\tilde{g}$ R-hadron	0	1-5 jets	Yes	22.9	$\tilde{g}$ 832 GeV	$m(\tilde{\chi}_1^0)=100$ GeV, 10 μs<$\tau(\tilde{g})$<1000 s	ATLAS-CONF-2013-057
	GMSB, stable $\tilde{\tau}$, $\tilde{\chi}_1^0\to\tilde{\tau}(\tilde{e},\tilde{\mu})+\tau(e,\mu)$	1-2 μ	-	-	15.9	$\tilde{\chi}_1^0$ 475 GeV	$10<\tan\beta<50$	ATLAS-CONF-2013-058
	GMSB, $\tilde{\chi}_1^0\to\gamma\tilde{G}$, long-lived $\tilde{\chi}_1^0$	2 γ	-	Yes	4.7	$\tilde{\chi}_1^0$ 230 GeV	$0.4<\tau(\tilde{\chi}_1^0)<2$ ns	1304.6310
	$\tilde{q}\tilde{q}, \tilde{\chi}_1^0\to qq\mu$ (RPV)	1 μ, displ. vtx	-	-	20.3	$\tilde{q}$ 1.0 TeV	1.5 <$c\tau$<156 mm, BR(μ)=1, $m(\tilde{\chi}_1^0)$=108 GeV	ATLAS-CONF-2013-092
RPV	LFV $pp\to\tilde{\nu}_\tau+X, \tilde{\nu}_\tau\to e+\mu$	2 e,μ	-	-	4.6	$\tilde{\nu}_\tau$ 1.61 TeV	$\lambda'_{311}=0.10$, $\lambda_{132}=0.05$	1212.1272
	LFV $pp\to\tilde{\nu}_\tau+X, \tilde{\nu}_\tau\to e(\mu)+\tau$	1 $e,\mu+\tau$	-	-	4.6	$\tilde{\nu}_\tau$ 1.1 TeV	$\lambda'_{311}=0.10$, $\lambda_{1(2)33}=0.05$	1212.1272
	Bilinear RPV CMSSM	1 e,μ	7 jets	Yes	4.7	$\tilde{q},\tilde{g}$ 1.2 TeV	$m(\tilde{q})=m(\tilde{g})$, $c\tau_{LSP}<1$ mm	ATLAS-CONF-2012-140
	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+\to W\tilde{\chi}_1^0, \tilde{\chi}_1^0\to ee\tilde{\nu}_\mu, e\mu\tilde{\nu}_e$	4 e,μ	-	Yes	20.7	$\tilde{\chi}_1^\pm$ 760 GeV	$m(\tilde{\chi}_1^0)>300$ GeV, $\lambda_{121}>0$	ATLAS-CONF-2013-036
	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+\to W\tilde{\chi}_1^0, \tilde{\chi}_1^0\to\tau\tau\tilde{\nu}_e, e\tau\tilde{\nu}_\tau$	3 $e,\mu+\tau$	-	Yes	20.7	$\tilde{\chi}_1^\pm$ 350 GeV	$m(\tilde{\chi}_1^0)>80$ GeV, $\lambda_{133}>0$	ATLAS-CONF-2013-036
	$\tilde{g}\to qqq$	0	6-7 jets	-	20.3	$\tilde{g}$ 916 GeV	BR(t)=BR(b)=BR(c)=0%	ATLAS-CONF-2013-091
	$\tilde{g}\to\tilde{t}_1 t, \tilde{t}_1\to bs$	2 e,μ (SS)	0-3 b	Yes	20.7	$\tilde{g}$ 880 GeV		ATLAS-CONF-2013-007
Other	Scalar gluon pair, sgluon→$q\bar{q}$	0	4 jets	-	4.6	sgluon 100-287 GeV	incl. limit from 1110.2693	1210.4826
	Scalar gluon pair, sgluon→$t\bar{t}$	2 e,μ (SS)	1 b	Yes	14.3	sgluon 800 GeV		ATLAS-CONF-2013-051
	WIMP interaction (D5, Dirac χ)	0	mono-jet	Yes	10.5	M* scale 704 GeV	$m(\chi)<80$ GeV, limit of<687 GeV for D8	ATLAS-CONF-2012-147

$\sqrt{s}$ = 7 TeV full data | $\sqrt{s}$ = 8 TeV partial data | $\sqrt{s}$ = 8 TeV full data

10^{-1} 1 **Mass scale [TeV]**

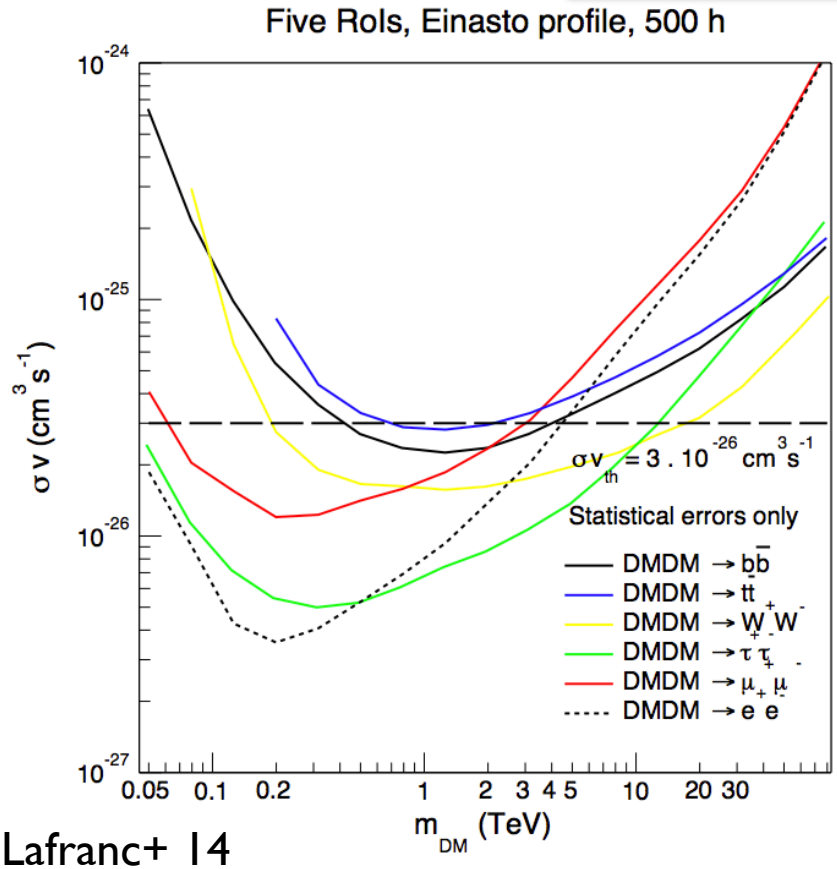
*Only a selection of the available mass limits on new states or phenomena is shown. All limits quoted are observed minus 1σ theoretical signal cross section uncertainty.

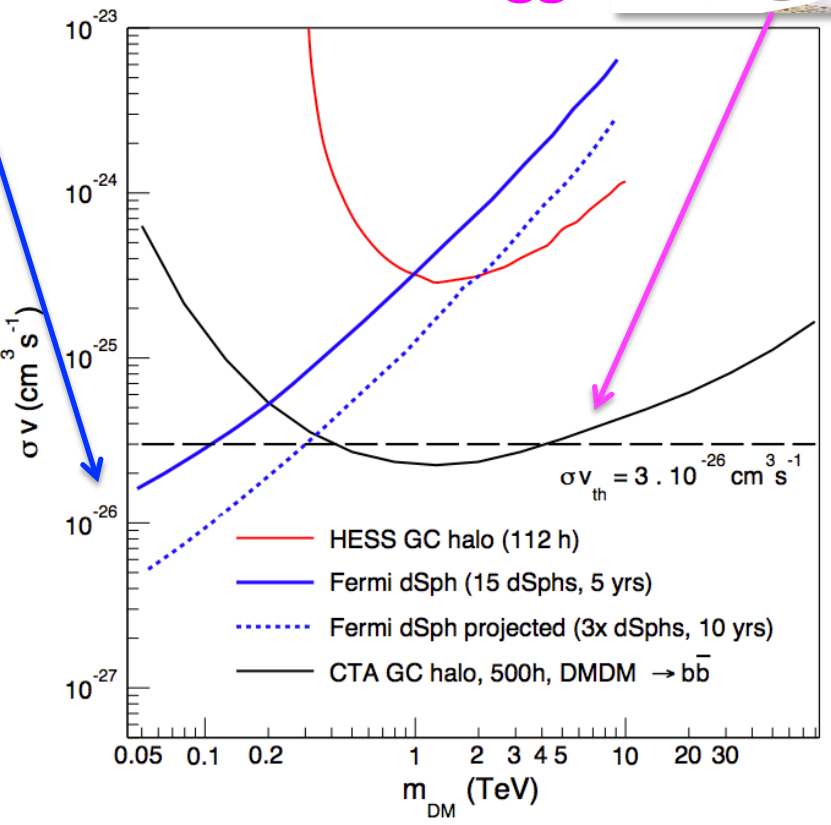
γ-ray Limits on DM

GeV

TeV

Weak scale, Higgs

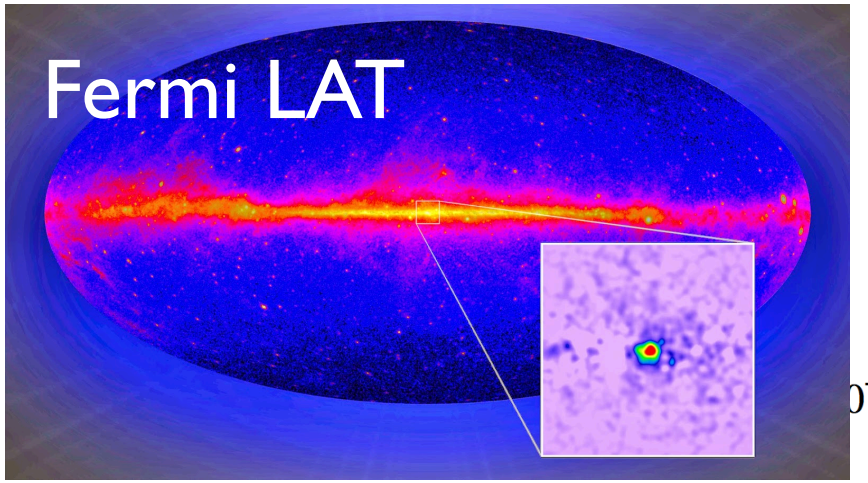




Lafranc+ 14

Complimentary to LHC & Direct detections

Galactic Center GeV Excess



Circular, Extended $\propto \theta^{-2.4}$

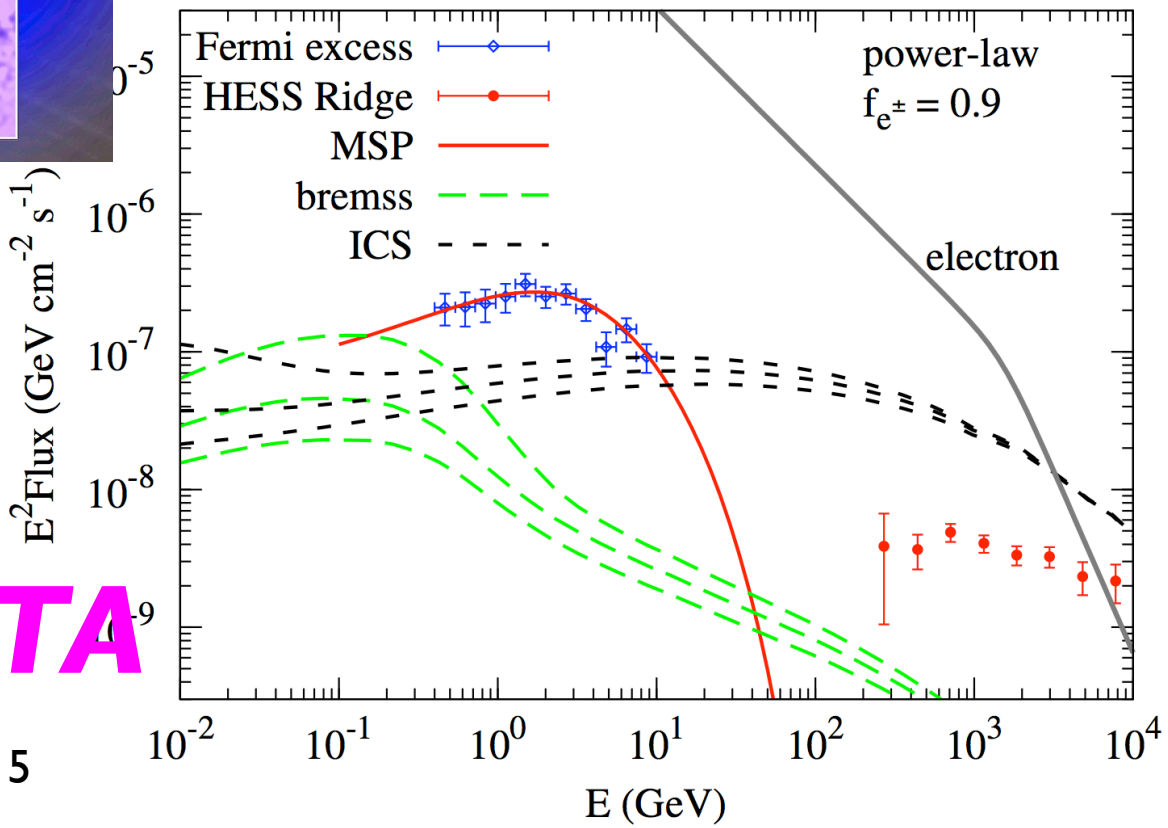
Bump-like spectrum

GeV dark matter?

(so-called Hooperon)

msec Pulsars?

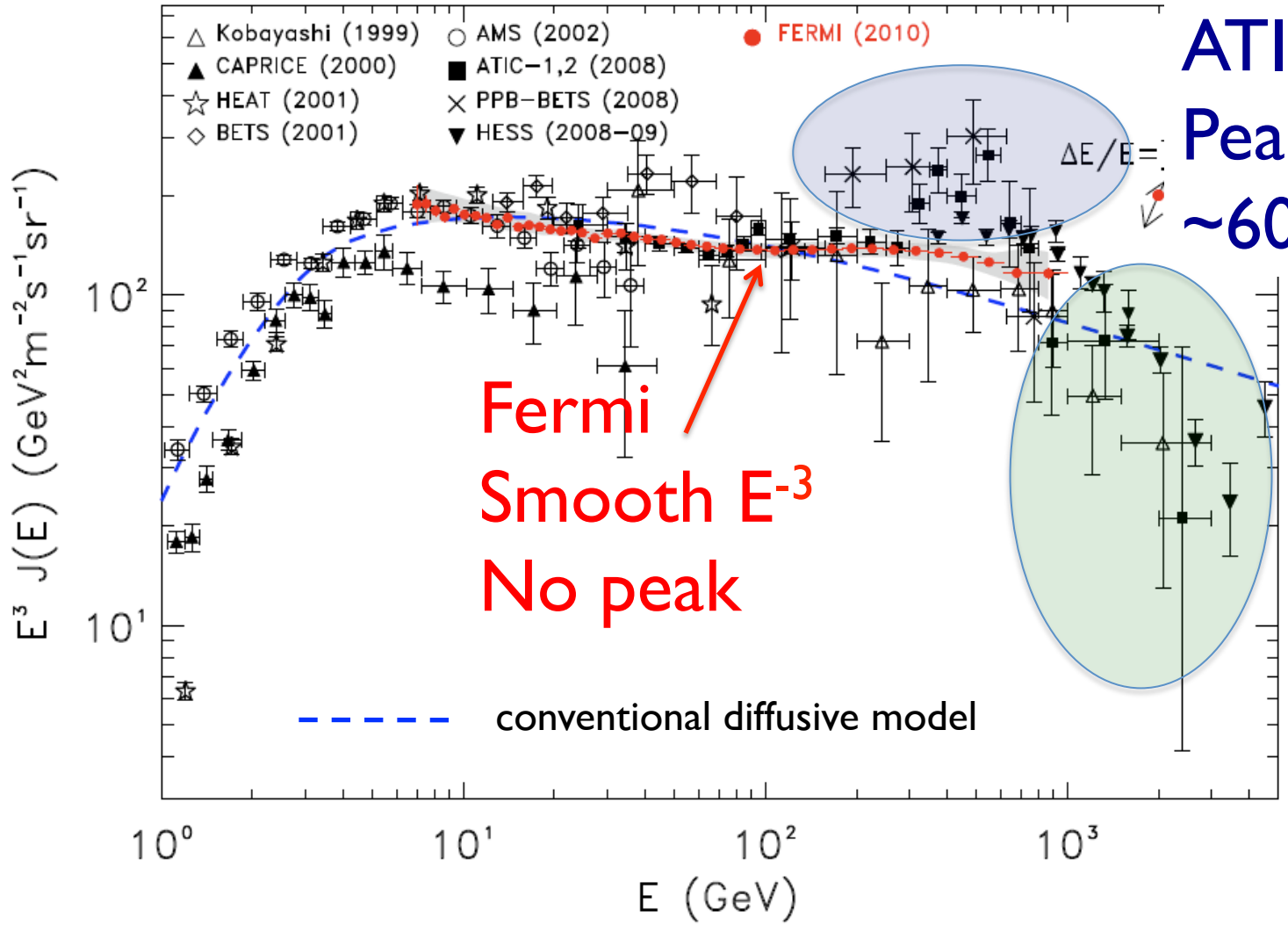
⇒ ***TeV by CTA***



Yuan & KI 15

Cosmic-Ray Electron

An Excess also in (e^++e^-) Spectrum

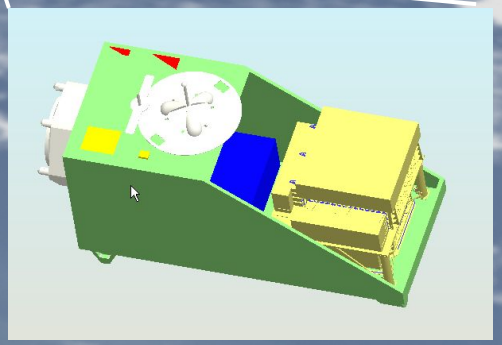


ATIC/PPB-BETS
Peak + Cutoff
~600GeV DM?

HESS
~TeV cutoff

Abdo+ 09
Ackermann+ 10
Chang+ 08, Torii+ 08
Aharonian+ 08, 09
Adriani+ 11

CALET
(CALorimetric Electron Telescope)



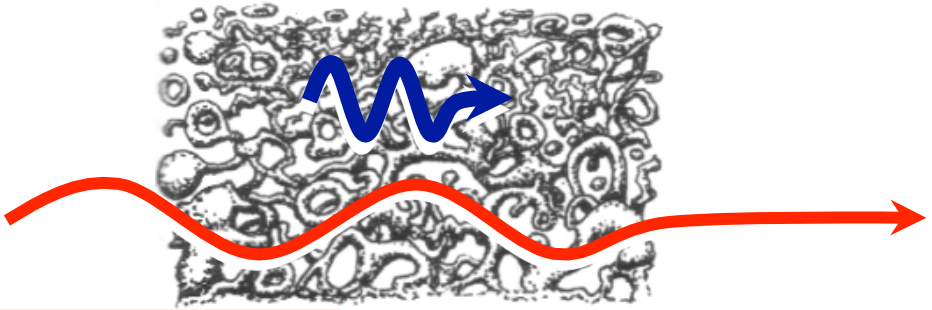
Cosmic Ray Electrons
up to ~10TeV
w/ ΔE~a few % (>100GeV)

© Torii

Lorentz Invariance Violation

- Some Quantum Gravity Theories violate LI

⇒ Energy dependent dispersion & speed of light



$s_n = \pm 1$

$\xi \sim O(1)$

$$\frac{p_\gamma^2 c^2}{E_\gamma^2} - 1 = s_n \left(\frac{E_\gamma}{\xi M_{\rm Planck} c^2} \right)^n$$

$$M_{\rm Planck} = \left(\frac{\hbar c}{G} \right)^{1/2} \approx 1.22 \times 10^{19}\,{\rm GeV}/c^2$$

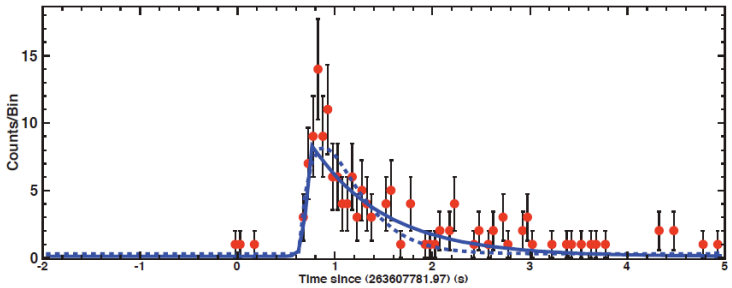
$$v_\gamma = \frac{\partial E_\gamma}{\partial p_\gamma} \approx c \left[1 - s_n \frac{n+1}{2} \left(\frac{E_\gamma}{\xi M_{\rm Planck} c^2} \right)^n \right]$$

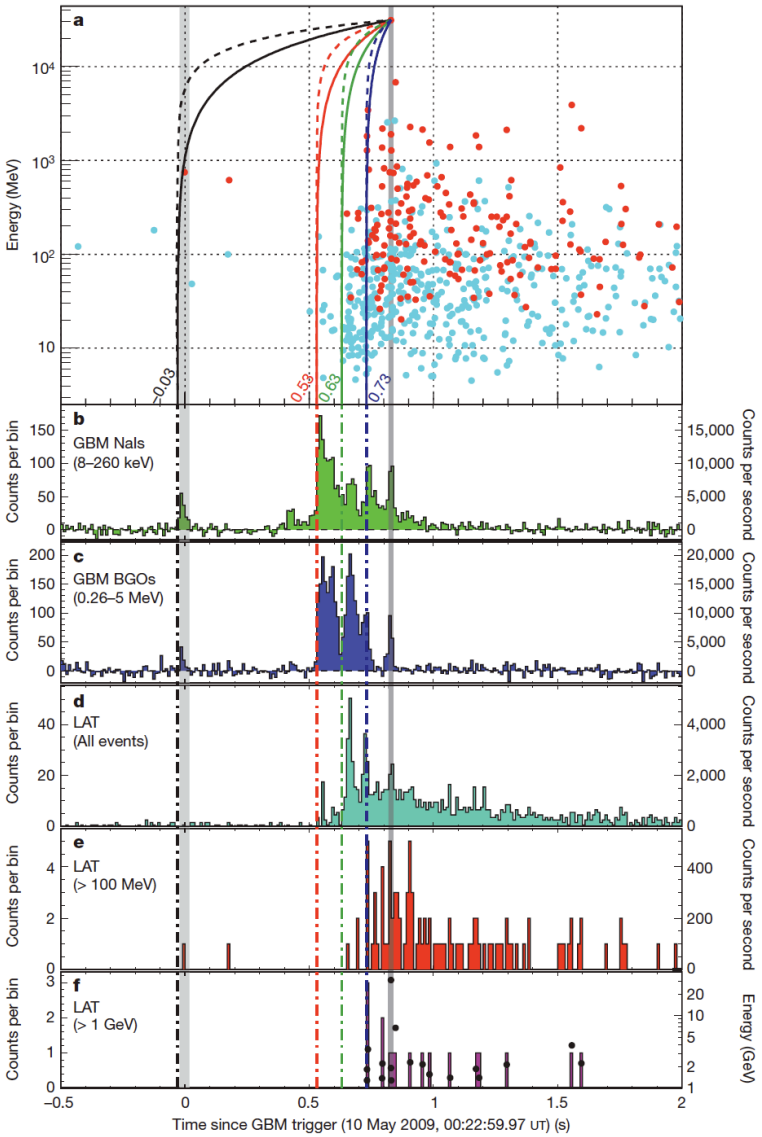
LIV with γ-ray

GRB090510 ($z=0.9$, $E_h=28$GeV)

$\xi = M_{QG,1}/M_{Planck} > 1.2$

lower limit on $M_{QG,1}/M_{Planck}$	limit on $M_{QG,2}$ in 10^{10} GeV/c^2
> 1.19	> 2.99
> 3.42	> 5.06
> 5.12	> 6.20
> 10.0	> 8.79
> 102	> 27.7
> 1.33	> 0.54
> 1.22	—

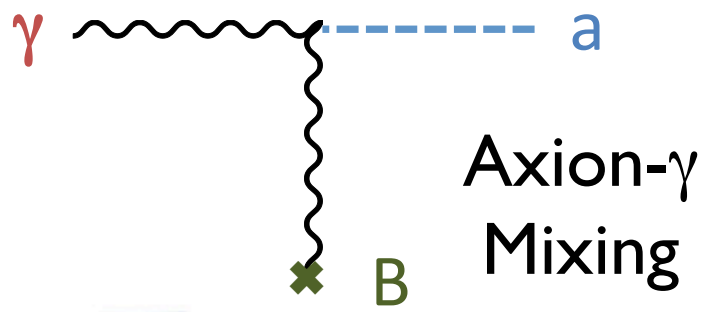


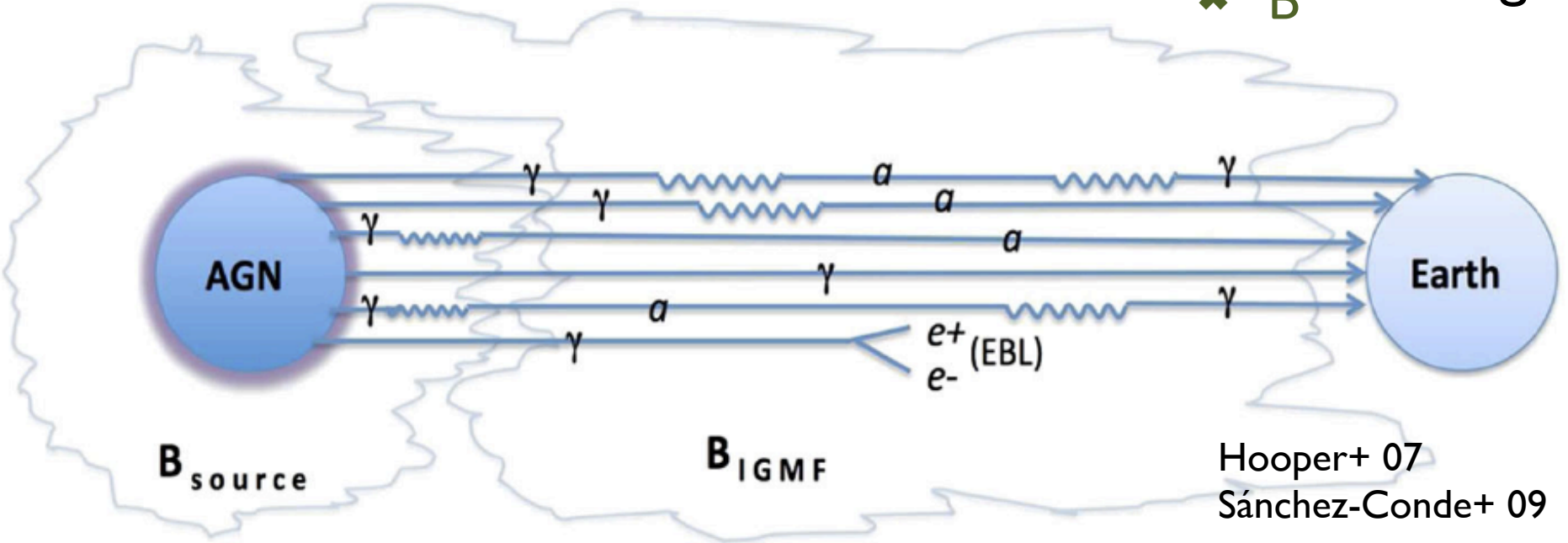


Axion-Like Particle

- aγγ $\mathcal{L}_{a\gamma} = -\frac{1}{4} g_{a\gamma} F_{\mu\nu} \tilde{F}^{\mu\nu} a = g_{a\gamma} \mathbf{E} \cdot \mathbf{B} a,$

γ(TeV γ)+γ(Background)
→ e^+e^- is avoided





Hooper+ 07
Sánchez-Conde+ 09

Mysteries in 21th Century

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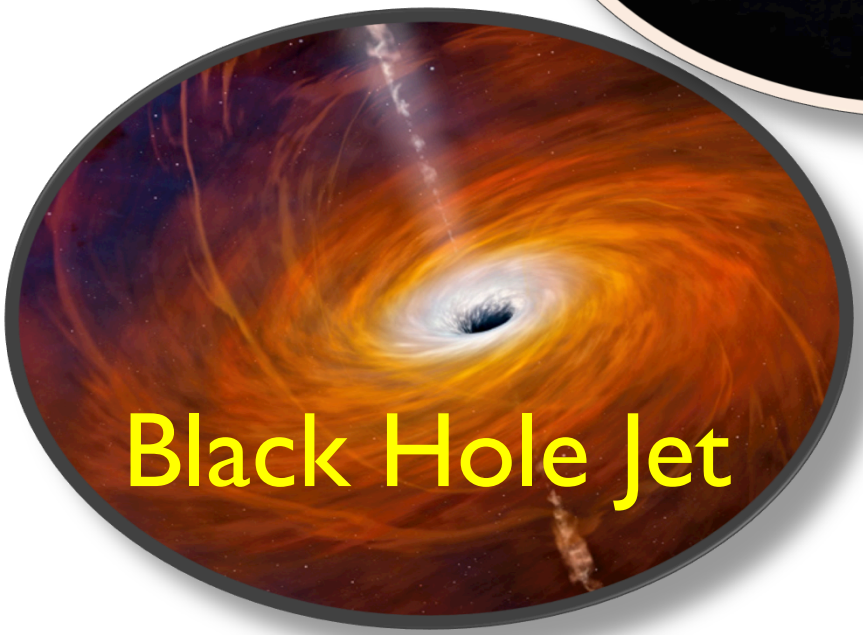

Mysteries in 21th Century

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Serendipity
??????????????

Thank You