†, 0. 13. (E U' - N - l -) FI' - O - a " OÖ' 28 ON' PÖ. l - a " ONÖ' - B - PÖ' NNÖ' - O' Ø. † O' a - a i - " O' U' O' a Ö. NO' NÖÖB, O' ÖP l " " O' O' (000' - NO ON' PÖ, a 14) i - " O' U' O' l U' - OO. FI' OÖNON, N - E - a - l, ON, OU - P' ON' N - Nl, ON' - P' OÖa' P' " O' OÖ' , ONNO' - OÖO' OÄU' - OÖNON, NE - a - AEN - N' i " NO' P' " O' OÖ' - " - O' - O' - NÖÖB U' - O' ON' - P' - O' ONaO - NÖÖB - " U' a ÖNU' U - N' ÖÖNU - " - N - OÖ' . † NO' - Oa' N' O' " O' U' O' - U' - OÖN' OÖO' ONaO - NÖÖB N' N' 8%, Ö. a' a' OÖa' - N' O' OU' - " - U' O' B - P' .

OÖa' P' - lOO' - N [64], - ON' - N, aEO ON' O' - ÖB aO - PÖ P' - N' - N' .

¶ U' O' ON' - " O' O' BÖ ON' - O' Ø - " N' - " OU' O' " " N' - N' " NO' U' O' N' - " " N' - NE - N' , O' NÖÖ - OÖ ÖB - " ON' PÖ, a Ö a - O' l - - aE - N' OÖN' - , ØNÖa - " N' O' O' OU' ÖÖB UO' - P' U' l - N' N' BÖNl - " OÖa' PÖ - lOO' - N [52]. † OÖNl OÖNON - P' , N' BÖU' - OÖN' - EÖ - U' OÖa' - OÖa' PÖ O' NÖ x' O - PÖ - lOO' - N' N' E - P' P' - P' OÖNON' NE' - ÖBÖa' - EÖU' - Oa' - AEN' - " NÖNÖP' P' - P' O' O' OÖO' ON' - P' - ON' - N' . CN' - ON' - N' , O' - NÖ OÖa' PÖ - lOO' - N' O' a' - ON' OÖ' OÖN' - EÖU' OÖa' - AEN' - N' , O' Nl - " N' E - NÖÖ - E' ÖBÖa' - PÖN' Na - O' O' U' O' N' O' U' OÖ' OÖ' AEN' - N' . † lU' O' OÖN' - N' OÖa' ONNO' - OÖO' OÄU' l - AEN' - N' , O' O' OÖO' ON' - PÖ - O' OÖON' IceCube, " NÖNÖPl - N' E - E' - OÖNaO - ÖB aÖNÖ - NÖÖNÖ.

† lU' O' O' E' O' U' N' O' - N' P' - " ÖB - ONÖ' P' NÖ - NÖ O' B - N' ÖÖNU' - " N' - NÖ - N' NÖ - NÜ - a " O' - N' - AEN' - N' , N' O' O' - PÖ ONÖN' O' , UÖN' OÖ' - ÖB x' N - N' PÖ ax' " ON' - " O' - PÖ - AEN' - PÖ ON' PÖ, a O' O' U' - , N' - ONÖPÖ, NÖaÖB E' ON' OÖU' - " Nl OÖ' O' OÖ' . † O' O' , N' - N' , - ON' - ÖB, UÖN' - " PÖN' Na - O' O' U' O' Ø OÖ OÖN' PÖ OÖ' N' ON' PÖ, a O' AEN' - P' OÖ' - ON' - P' ON' OÖ' - AÖ O' O' - P' ON' P' - O' a' , O' UÖN' NÖ - NÜ - " O' - N' OÖ' - 21:7 - ON' - ON' OÖ' OÖa' O' NÖ - NÜ - " ON' ON' 1:1:1.

† NÖN' P' O' - ÖB - N' BÖU' - O' ÖB' ON' PÖ - aE - N' N' - OÖO' - (- N' BigBird) P' N' N' - OÖ - E' - NÖOÖ' - OÖU' - 10% - Nl - P' NÖ' - PÖ IceCube-86, - O' - PÖ - ONÖNl - N' O' - NÖP. † OÄU' l U' - OÖN' - N' E' O' E' - " OÖ' - " - N' - OU' - " EÖU' OÖa' - OÖ' AEN' - N' - O' ONÖ' IceCube-59, " N' - OÖ' - 2012 - P' N' - OÖE' - AEN' - O' O' Nl - PÖN' Nl a - O' l: N' N' N' 400 - aE (O' . O' O' . 10). † lU' O' OÖN' - N' OÖa' ONNO' - OÖO' OÄU' l - " - PÖ IceCube-79 , IceCube-86, O' O' BÖ ÖP' " NÖNÖN' N' O' OÖ NÖÖ' - N' - P' , - ONaO - N' , E' - " OÖ 2014 . < ON' - ON' - N' , - OÖ' - OÖ - Pl - " O' - N' ON' - P' IceCube-40 , IceCube-59 - O' OÖ' - AEU' - P' U' - " - P' - N' - ON' - Ø - N' - x' - OÖ - U' l - O' ONÖ' IceCube.

6. Ø' ÖÜ' .

† - N' - N' - OÖONl - O' ONÖ' IceCube UÖ - OÖ' O' B - NÖÖB " N' - B - P' - OÖNU' - " x' O' - P' ONÖN' - N' ONÖ' - 1000 O' ON' OÖ' - AÖ O' O' - N' Nl - O' O' - 1990 - Ø - N' - N' - N' - ON' OU' - N' - " Ø O' - O' BÖÖ' ON' - P' - N' - B - P' - OÖNU' - " - N' NÖO' - OÖU' - O' - N' - OÖNU' - " N' - O' - U' ON' - N' aEO - aÖBÖa - Ø NÖ' O' PÖ' O' ON' NÜBÆ IceCube OÖ' OÖ' N' - " NÖ' - - PÖ' O' U' - U' - O' N' B' Ø O' O' OÖU' - a - ON' - N' Ø - " N' O' O' Pl OÖNÖP' OE' OÖN' - NÜ' OÖ' - O' ON' - " - PÖON' O' O' - O' - ØN' - NÖNÖN' - P' ON' OU' - P' O' - O' BÖÖ' - " - N' - N' - " x' O' - Pl ONÖN' .

" O' OaÖB' OaÖ O' U' - " O' ONÖ' ONa' - a O' O' - PÖ N' U' Ø - l U' O' U' O' PÖ' - OaÖ' O' a ONÖ' OÖ' - OÖ' - a O' O' PÖ OÖ' O' U' O' Ø OÖ' NE' - l ON' OÖON' - O' BÖÖ' O' O' - O' NÖN' - lOO' - N' PÖN' Ø a - O' l - P' , N' - NE' - N' , OÖ' - ÖB " ON' - NÖNÖ - N' O' OÖ - OÖ. EON' - ONaO - N' , O' O' - " O' O' P' - aÖ - N' - O' E' - a N' - ON' - a O' - Nl - lOO' - N' PÖN' Ø a - O' l!

EÖ' aÖN' - O' O' - OÖ' a' , - E - P' - a O' ÖU' l OÖO' O' - OÖ' - N' - l - aÖNl N' - OÖ' . EÖ' O' P' - OÖa' N' - NÖ - Nl - N' - NE' - NÖÖB - ÖB - Pl O' O' OÖON' O' BÖÖ' - P' - O - N' ON' OÖU' - ONÖN' - O' - ONÖ' - OÖO' - N' - 1 - " O' O' - ONÖON' ÖB O' OÄ' - ONÖOÄ' O' N' - N' OÖN' OÄ' OÖO' - N' O' - O' - " - U' - N' - N' - OÖE' ÖB' OE' - P' a' O' - NÖ - N' O' B - P' / O' - O' ON' - ÖB N' - OÖE' - " N' - B - PÖ OÖNU' - " N' ON' - B' a' , - N' - ONaO - NÖÖB Ø NÖ' O' PÖ, a PÜ' , U' - N' - N' N' O' Ø ONÖ' . < N' - U - N' , NÖO' - B - OÄ' N' - x' - OÖ' U' AEN' BÖN' N' O' - O - N' - lOO' - N' N' O' - O' NÖ' O' O' O' O' - O' - ÖP' - ÖB OÖN' a' - O' ÖU' Ø - PÖ IceCube, NÖO' - aEU' Ø , - O' N' B' N' - E - P' OÖ' - " O' N' B' N' - E - P' " O' - P' , " N' - N' N' E - N' PÖB " U' OÖ' - N' NÖÖO' - N' - a a - O' - O' N' - O' - N' - NÖN' - " - U' O' OÖON' O' BÖÖ' O' - Ø - O' ONÖN' - " - O' - O' , O' - AEN' - " O' O' O' O' - O' O' U' O' - a' IceCube) NÖ' O' PÖ' .

¥ a † - O - N' N' ON' OU' O' a' ÖÖB - " OÖN' - O' i KM3NeT - † O' - N' - NÖ' . GVD (Gigaton Volume Detector, - O' ONÖ' - ON' - N' N' Y') - c' l' .

¥ O' ONÖ' KM3NeT, - ONaO - N' , O' O' ONÖONaÖB - O' N' B' Ø NÖ' - B - PÖ - N' - N' OÖ' - O - N' O' - N' N' O' , " ON' - N' - O' O' . 14' - NÖ' x' P' OÖN' O' ON' - a' , x' - - O' OÖ' - N' - f' ONÖ' lO' - ONN' U' OÖ' - N' , ONÖ' OÄ' - U' l ON' - NÖN' O' B - Nl x' P' (- ØN' - NÖNÖNl - P' O' - O' - NÖ - P' N' - U' OU' a' Ø Ø - U' O' l OÖN' O' [65]), ONN' U' - OÖ' - N' KM3NeT - " - N' P' N' OÖ' - N' O' - N' - x' NÖ' - B - OÄ' " N' - NÖ' U' AEN' - O' - ON' - OÖa' OÖO' - " ÖB - O' ONÖ' N' Y' - N' ≈ 5 - " - U' - a O' 2014 - " - U' a OÖ' - " - OÖU' l NÜ' - " OÖa' OÖ' - O - N' - 225 - " - ON' . † OÜ' OÖ' OÄU' l O' - OÖ' OÖ' OÖ' - O' O' - OÖP' - " - O' ONÖ' OÖO' - OÖO' - N' - OÖ' - OÖ - PÖ - N' - N' . EÖ' - N' - NE' O' PÖB OÖO' - N' - N' N' U' OÖ' OÖ' - OÖ - PÖ - N' - N' - OÖ' Ø - OÖ' Ø - ON' - " O' NÖ' O' N' - , † U' - " - NÖ' .

E - OÖNaU' - O' a' P' - N' OE' 40' - ON' - ON' - NÖN' - O' - x' O' OÖO' OÖO' P' - N' - OÖO' U' N' - PÖ - N' - x' - O' - O' U' l - " OÖ' Ø OÖO' - N' - N' ¶ O' - U' " O' (KM3NeT, OÖ' - a 1). † OÄU' - U' - N' - O' O' KM3NeT, OÖ' - a 1,5, - AEU' AEU' a - O' a N' - " N' - N' Y' - N' - ON' - Pl 1 - " O' - N' - NE' - NÖÖBÆ NÖOÜ' - OÖ' aÖB x' - U' O' OÄ' OÖN' O' - O' - ON' O' - " - N' - OÖN' - IceCube. FI' aÖN' ONÖO' O' OÖa' U' 50° 70' - " - ON' O' - OÖ OE' - P' - PÖ 40' - .

GVD
±0~ , ā ll
27 " , 00° ON~ ,
8 ~ , ā~
~ "É~N~
Ép0N0° 600 ~
48 OM
~ " , ā~ 0

†, 0. 14. (°) E~ , 0~ 000 N~ -N~ N~ , U°00, 00° ON~ ~~~~~ p0^, N~N~ KM3NeT. (°) ∫0~ , -N~ , N~0° É~ , ~ ONONl 0000~ , GVD 0 N~ U~ , N~Y~ N~
N~N~ Nl 1,5 ~3.

E †N00~ , C l " ~ B0~ " a "N~ , ~N0° U~ , ā 0~ , ~ 00° 0 ON~
ā0° 0~N~ 0~ ~~~~~ 00p~ ~ , ~ C l " ~ ~ ~ ON~ -N~ N~ 0~
ON0° GVD ~ , N~ ~ 00N~N~N~ ~ 0U0~ ~ [66], 0N00NaU~ N~
~ " , 00° ON~ ~ , ā~ , ~ -N0°N~ B~0 00~ -N~ 00a NÜ~ ~ -p~
UON 0° 0~N~ -Ü~ B~N 0~ , ~ 00~ p l N~Y~ ~ ~ 0,5 ~3 0E~
~ ~N00° ONÜ~ , 0°00~ 00~ ~~~~~ 00a ~ , ā~ , 0~ , 0~ "ON0° 0
~Ü~ 0° ON~ ~ , ā~ BÜ~ , N~Y~ N~ (0, 0. 14°). E 2008° 2013~
00NÜ~ , 00p0~ , ā ~ ~N~p0 ā~ ~ -ON~ , 0° 0~N~ N~ Ü~
0°Nl 0° U~ 0~ , 0° 0° Nl ON~ -N~ 0U0~ ~ -Nl ~ , ā~ Nl
~ 0° a ON~ 0~ , ā~ ~ , < N~Ü~ 000~ B~p l 00N~ "0 āON~N~
~ 0° "ON0° 00~ 00~ ~ ~ 0° N0~ [67].

j UON~ - Ä É~N~ ON~ Ä0°? E 0~ 0~ ~ ~ ~ -N~ ON~ ÜÜ~
-p0~ ~ -p0~ N~ ~ ~ ~ -p0~ -l 00~ -N~ ON~ - NÜ~ ~ -p~
Ü~ ~ , 00~ -N~ ā00a 0~ , Ü~ , N~Y~ ~ IceCube , N00~
~ , ā~ N~ 0° NÜ~ 0° 0° ~ 00N~ 0 ÜÜ~ ON~ ~ p0N~ , 0
ā~ 0° l (00~ ~ , ā~ B~N~ ~ ~ ~ -N~N~N~ 0° "ON0° i
DecaCube). †~ 0° B0° 0p 0° 0° p0 , 00~ ~N~ -l 0~ , 0
0, 00~ ~ ~ ~ -N~ p~ , 00~ 00~ ~ -p~ 0° N0~ [68].

° ~ , ~ N~N~ NE~p0 N~x~ , 00° Ü~ , l , 0N00NaU~ ā~ , 100
Ü~ ON~N~ 0° ~ -0~ -p0~ , ā~ , 000~ -N~ ~ -p0~ N~ "00~
IceCube, 0N~ ~ ~ ~ , ā~ , 0. 15. -0, N~Y~ ~ 7 ~3 , ā~ 0~
~ 0° Ü~ 0°N~ ONON~ ON0a~ ~ 10~ , āE ā0~ ~ 0° "ON0~ ā
0, 00~ ~ ~ 0° 0°N~ ~ 0B Ü0~ 00~ , ā~ B~N00BÄ~ ~ ÄN~p~
00~ ~ ~ ("0~ ~ ~ ~) ~ 3 (7) 0° ~ pÜ~ Ü0~ 00~ , ā~ B~N00~
IceCube. j ~ , ā~ 00° 00N~p0 00° N~ , ~ , N~ Ü~p l ON~ 0,
N~N0N0N~ N~N0~ , N0B~ 0° ~ ~ ~ 5.4, 0N~N~ , ā 0N~ ÜÜ~ 0B~
4° 8 0° ~ N~ BÜ~ , ā~ , B~p0 ON~p0 l , Ü~ ~ IceCube (~
~ , ā~ N00~ , N0~ N00~ , É~ ~ N~N~ 00N~ -ā ON~ ~ ~ , ā xN~ 0
0° ~ Ü~ 0° "ON0~Nl 0, 00~ ~ p). -N0°N~ B~0 000~ -N~ ~ 0~
~ 0ÄÜ~ N~ON~N~ , ā 00° 0° ~ 0° 0° ~ N~N~ NE~N00B N~ -00~
É~ , ā~ N~N~ B~p0 00NÜ~ , N~N~ , É~N~ 0° 0° N00~ , ~ ON~
~ 0B~ ~ 0° "ON0° ~ N0~NÜ~ , ~ 0° ~ 000° Ü~ , ~ ÄN~p0
00° N~ , ~ ~ ~ , ÜÜ~ 0° 0° ~ 0° l -00~ ~ ~ , ā.

E p~ ~ , ~ ON~p0 l N0~ , ÜÜ~ 0~ ~ , "N0° Ü~ 0~
~ -l 00~ -N~ NE~N0~ ÜÜ~ 0B ON00~ 00~N~ 50~ 0° 0° N~N0° 0°
Ü~ 0~ , ā 00Ü~ 00° 0ÄÜ~ l ~ 0° "ON0~Nl 0, 00~ ~ p IceTop,
00N~ B~0a, N~N~Ü~N~ , N~N~ ~ Ü~ 0ÄÜ~ 0° 0° N~N~ Ä~ 0° ~
Ü~ ~ 0° 000Na~ , ~ É~ 0° , ā~ ~ ON 00~ ~ , Ä~ 0° 0°
~N~p~ ~ IceCube. ~ ~ , ā~ 0° "ON0~ ā 0, 00~ ~ 0° NE~0°
~p0N~N~x~ , ā~ , N~ 0° ÄÜ~ 0B~ 0° N0~x~ 0° p~ -l 00~ -N~ 0
ā~ 0° l pÜ~ 100~ , āE.

° ~ , ~ N~ 0° l Ü~ 0° ~ Ü~ 00~ ~ , ā "N~ , ~N0° Ü~
IceCube - 0N~ , 00a 00N~ "0 PINGU (00° Ü~ , N~ -ā ~ N~ 0°
~ , ā Ü~ ā IceCube 0~ , 0ÄÜ~ N~ ON~N~ , ā) (0° , 0, 0B~ N~ N

†, 0. 15. E~ , 0~ 000 N~N~ NE~N~N~ N~0000° , ~ -N~N~ 0° , 0° ~ 0° ON~
0° DecaCube (0° Ü~ , 0~ ~ 0° "ON0° IceCube ~ N~ 00B~ p0N~ , 0
ā~ 0° l) 0N 100~ N0N~ , ā~ , B~p~ , ā~ , ā~ , ON~ -p l N~Y~ N~N~ N
7 ~3 [68].

~ ~ 0° ~ , ā0 "N~ , ~N0° Ü~ , PINGU° IceCube [69]). / ~ ~
~Nl Ü~ , BÄ 00N~ "0° PINGU ā~ , ā 00a N00~ ~ ~ , ā 0°
0~ , ~ 00~ -l 00~ -N~ 0, 00N~ B~N~ ~ , ā x~ , ā 0° N~ -0°
0° 0° ~ 00° Ü~ 0° , 0° NÜ~ , āÜ~ l 0° N0~x~ 0° -p0~ -l 00~ -N~
~ , ÉÜ~ 00a 0° N~B~ ~ , Ä~ , -0, ā~ 0° , ā0~ , É~ 10°
15 /āE ā0~ , NÜ~ , āÜ~ , 0° 00 00~ , ā~ 0B~ " ONa~ ~ , Ä~
N00~ ~ ~ -Nl 0000° 000p~ , 0, N0~N00~ , 0° 0° ~ 00N~ ā~ 0°
~ , ā~ , 0° -p l 0° N~ , ~N0N00Ä~ NE~N~ , ā 0B 0 ON~
~ NÜBÄ PINGU. E ~ ~N~Nl ~ 00~ , ~ 0° "ON0° PINGU ON~
00N~ 0° , 40~ N0N~ , ā~ , B~p0~ , ā~ , ā~ (ON 60 , ° fi ~ ~ É~
~Nl), 0° ~ Ü~ -p0~ N~ ~ -000~ -l Ü~ 00~ ~ 0° "ON0°
DeepCore. ∫~ 0° 0° Ü~ 0° l ONON~ ON00~ , ā~ 0° 0° N~ B~N
/āE. fl 0, 00~ ~ 16 ON~ ~ -p NÜ~ , ~ 00° 0, 00~ Ü~ 0° Nl
~ Ü~ , N00~ , N00~ ~ , ā~ , 0° 00~ , ~ 00~ ~ N0N0p~
00Ü~ 00° 0ÄÜ~ , ~ , 00N~ "0 00~ ~ p~ , 000~ -N~ ~ ~ .

j ~ , N~ Ü~N~ , 00~ ~N~ ~ , 00N~N~ , 00a~ ā 00~ , ~ ~
~N~ N00~N~N~ 00N~ "0° ORCA (Oscillation Research with
Cosmics in Abyss) [71], ~ "N0N0N~ 0° "É~ 0° 00~ 00~ , 00a
N~N~ NE~N00B 0° N0p 0 00Ü~N~ , Ü~ 00p0 v ~ , v ~ , 00~N~
0, 0° , ā~ -0N0~ , ~N~ - ANTARES [72].

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High-energy neutrino astronomy: a glimpse of the Promised Land

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In 2012, physicists and astronomers celebrated the hundredth anniversary of the detection of cosmic rays by Viktor Hess. A year later, in 2013, the first evidence for extraterrestrial high-energy neutrinos emerged, promising fundamental insight into the origin of cosmic rays. The evidence was obtained from the data from the IceCube neutrino telescope at the South Pole. When the idea of this telescope was first discussed at the 1973 International Cosmic Ray Conference, it was beyond anyone's imagination that it would take biblical forty years before the first discoveries would be made and the Promised Land of the high energy neutrino would first be glimpsed. This paper sketches the development towards really sensitive detectors, describes the latest results from the IceCube and ANTARES neutrino telescopes, and takes a look at the future.

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