

Performance Studies for the KM3NeT Neutrino Telescope



Claudio

Kopper

Nikhef

Amsterdam

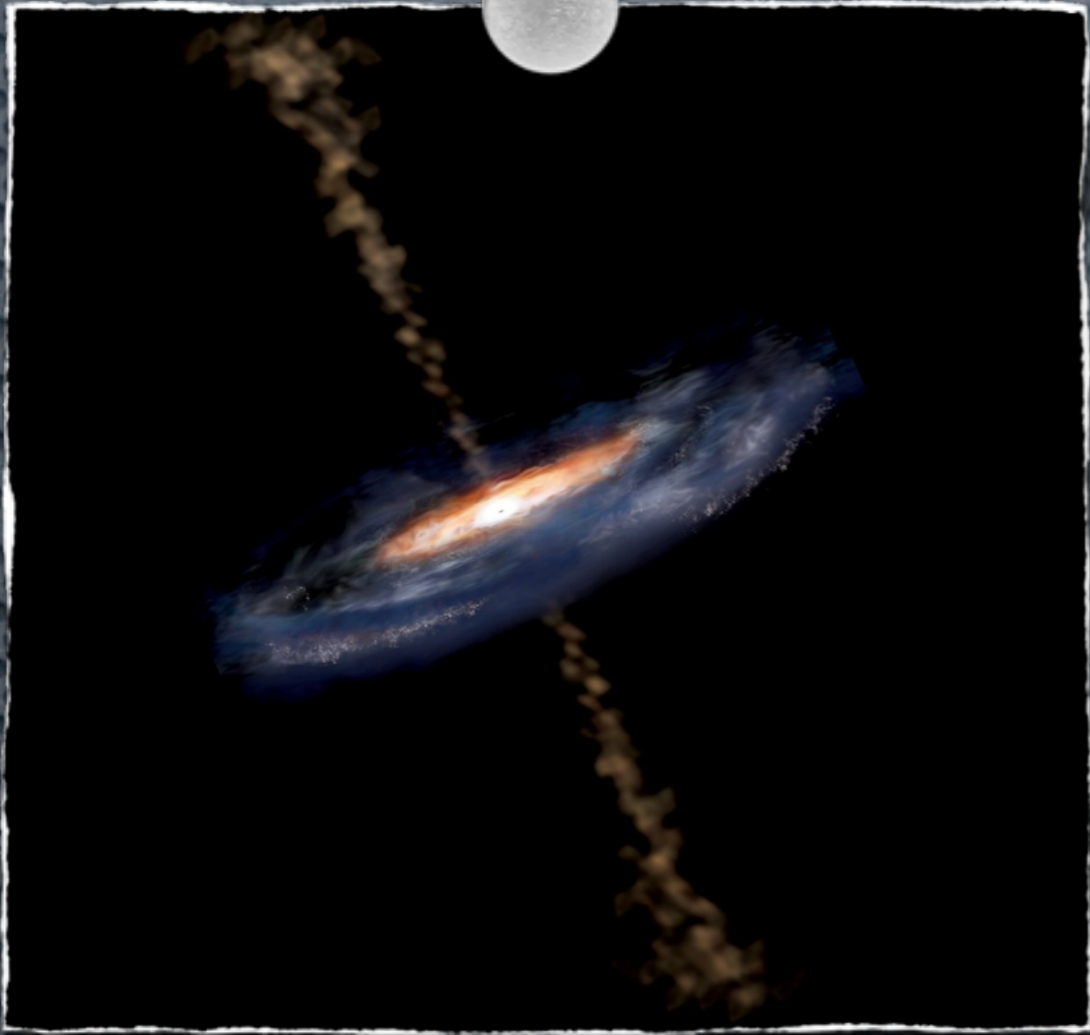
RICAP '11

on behalf of KM3NeT

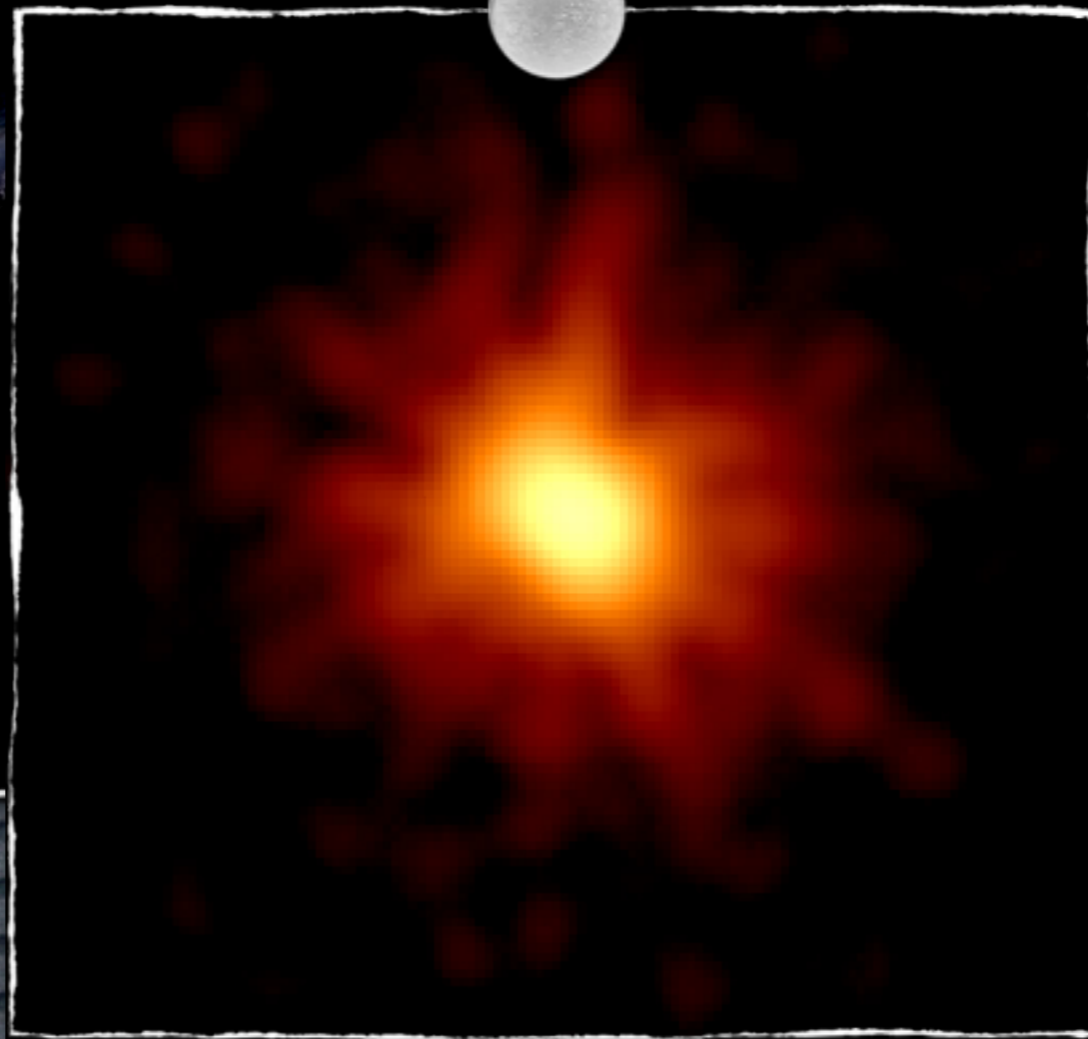
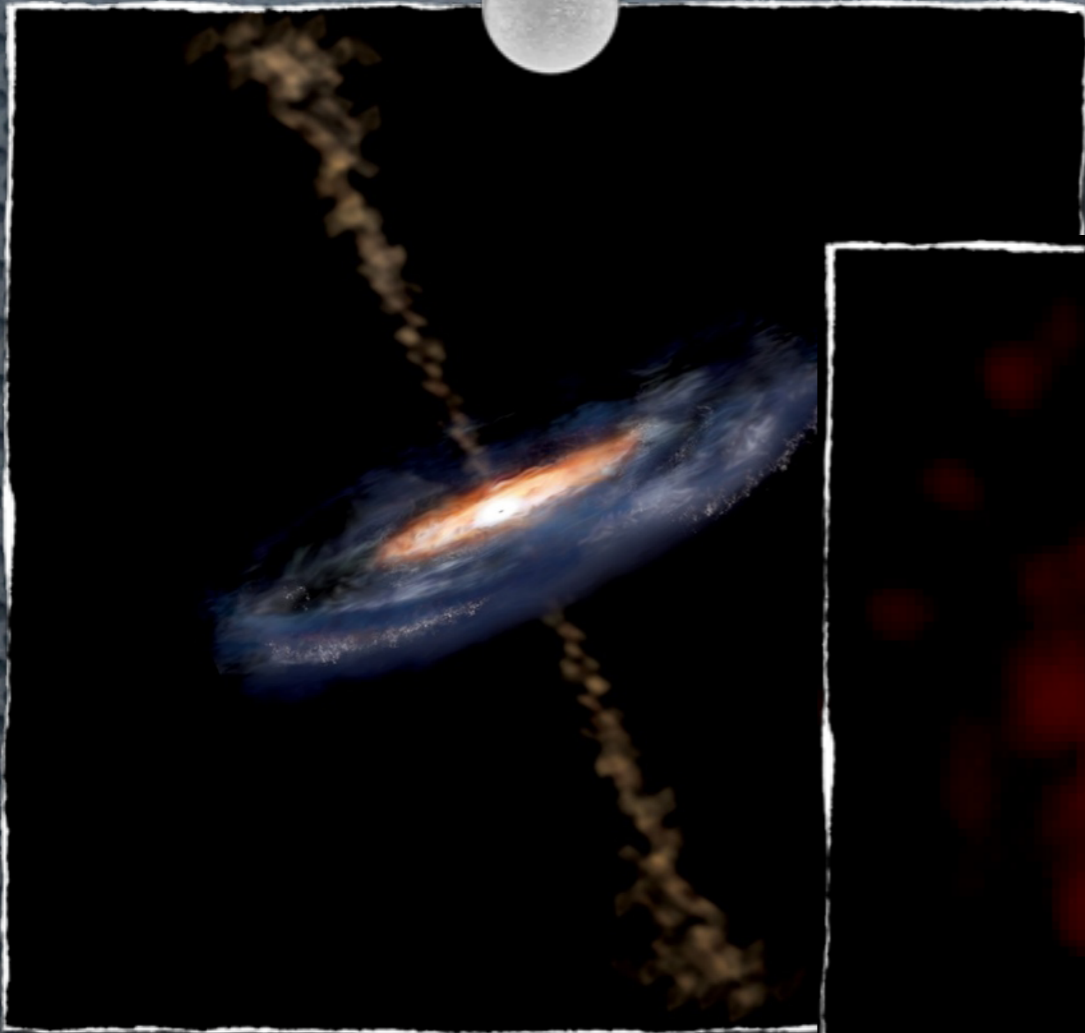


possible sources

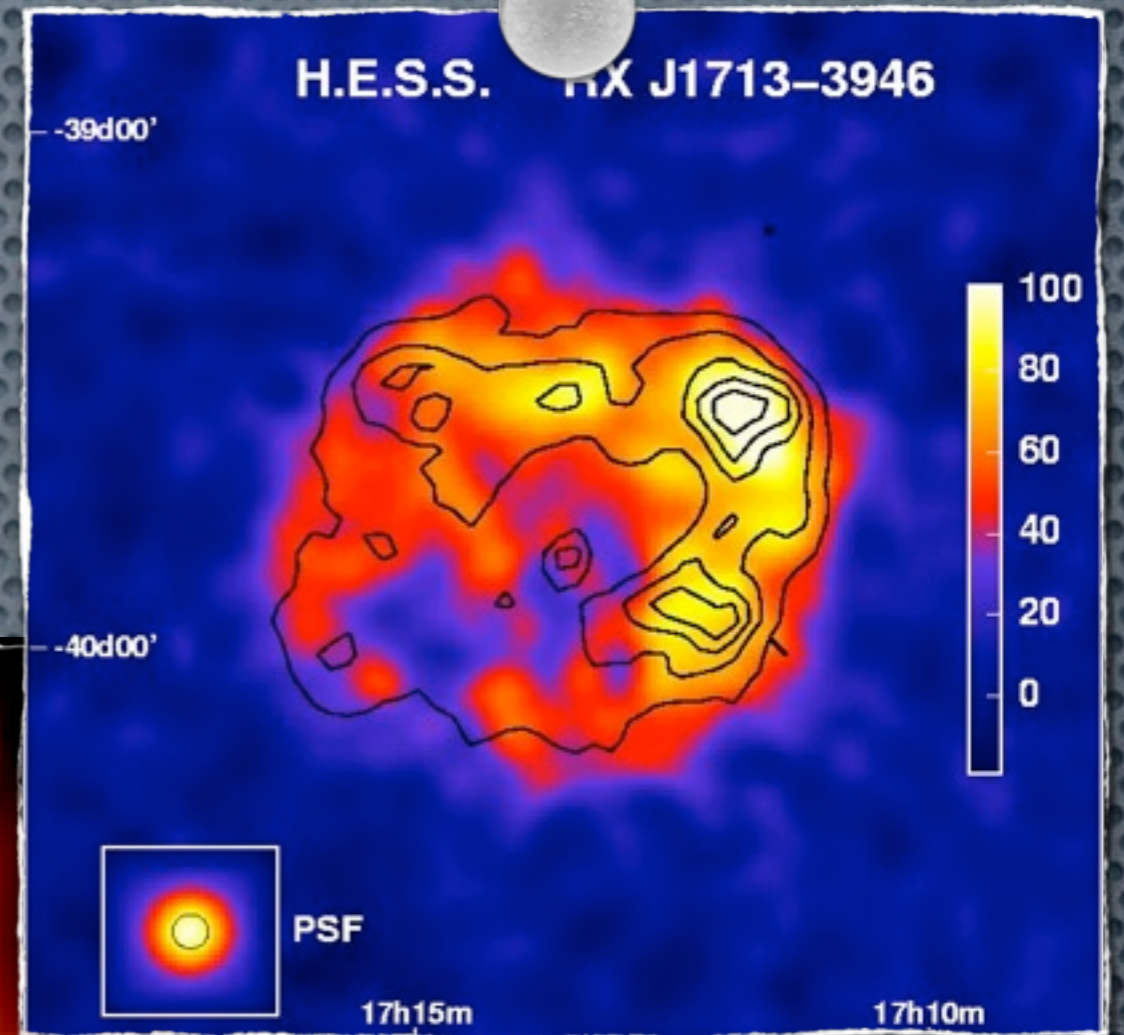
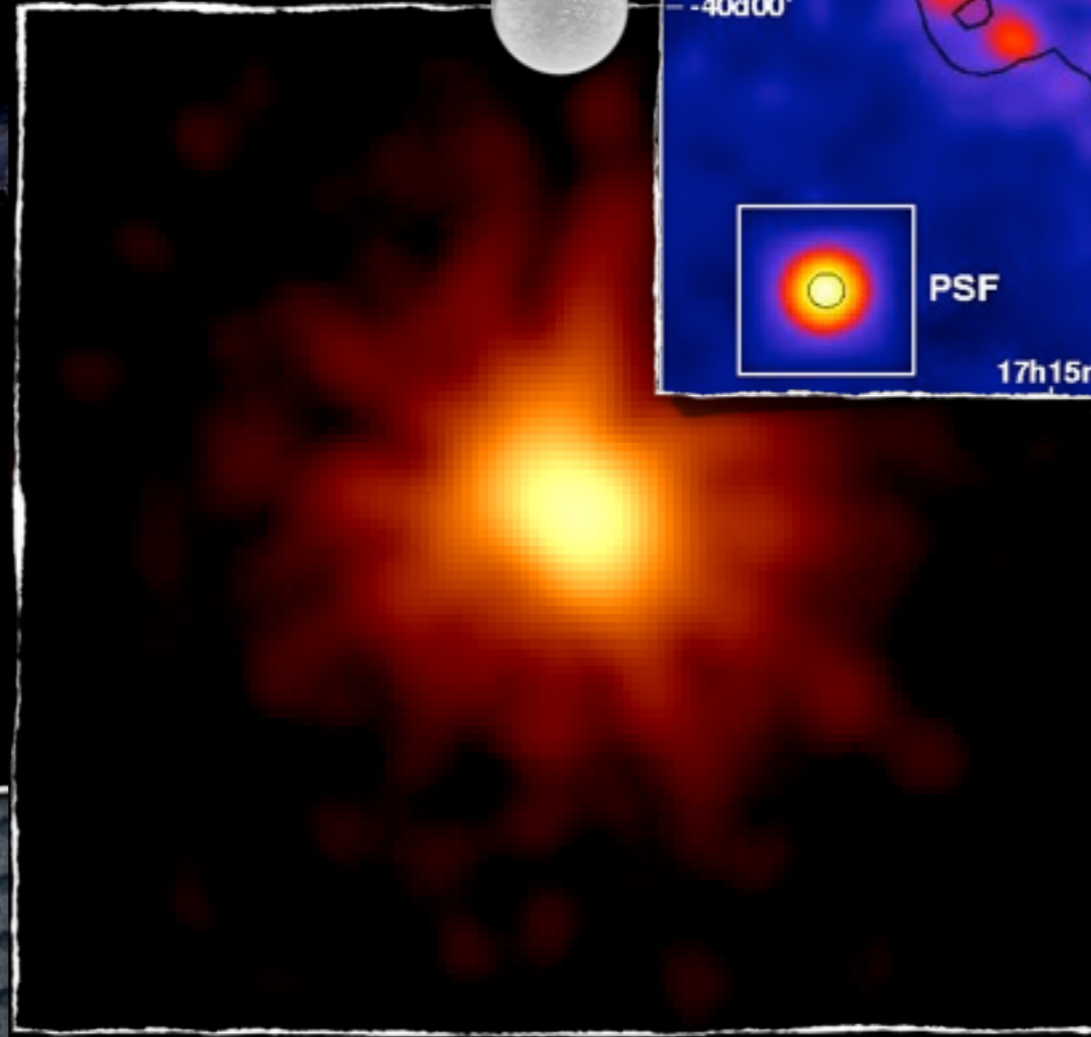
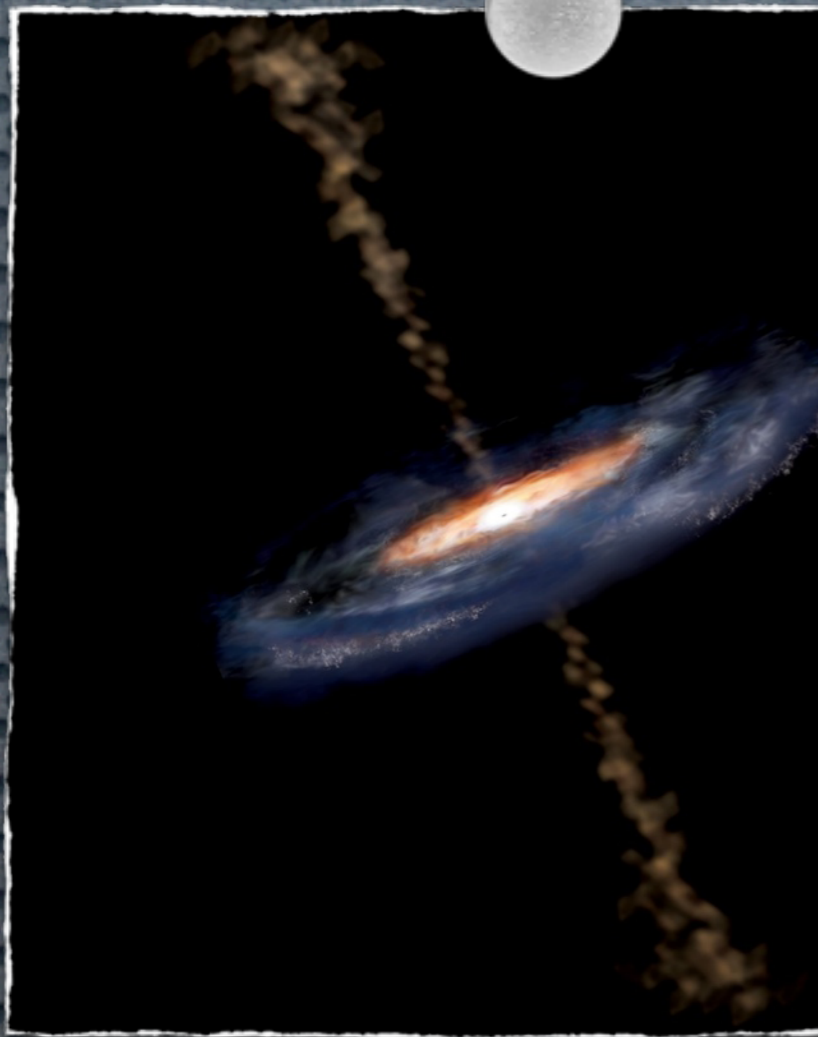
possible sources



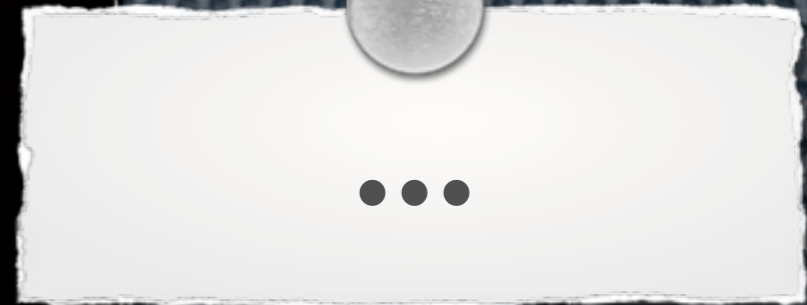
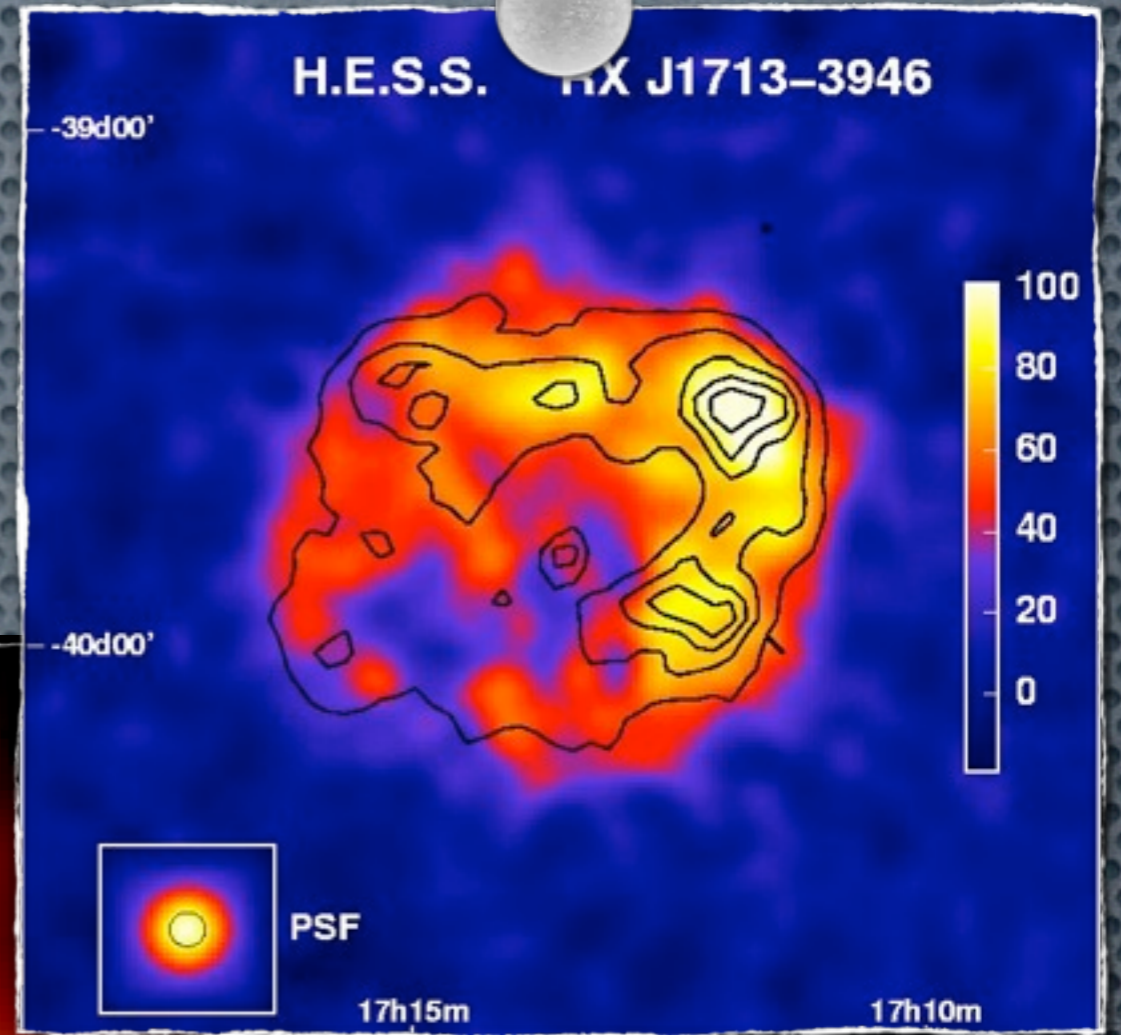
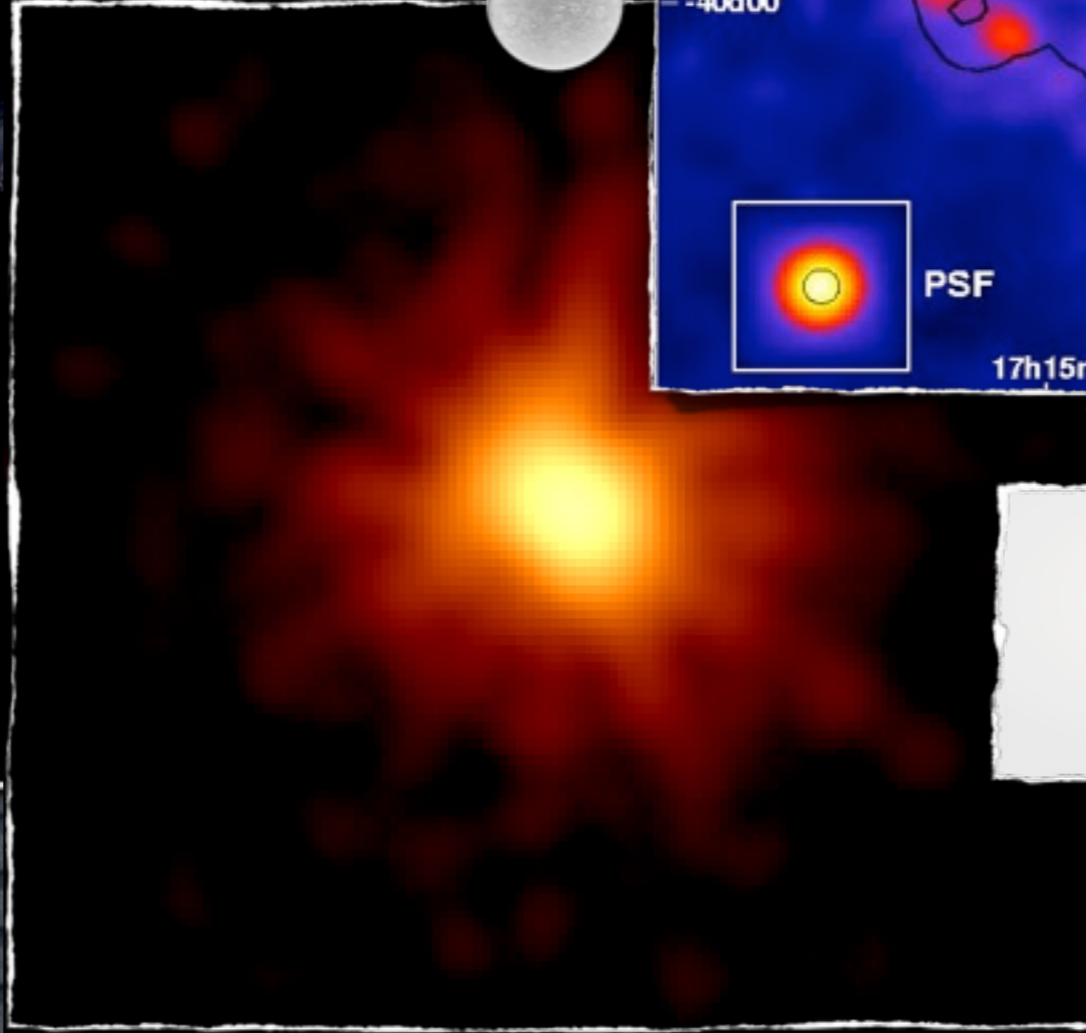
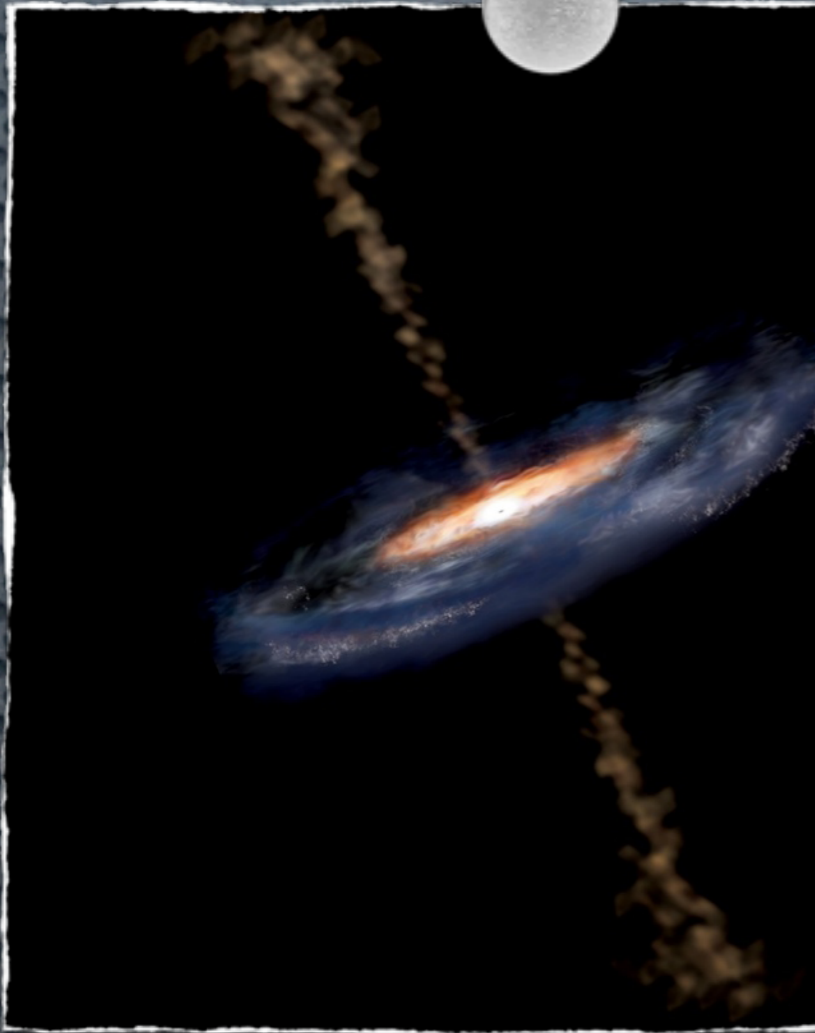
possible sources



possible sources



possible sources



ν production

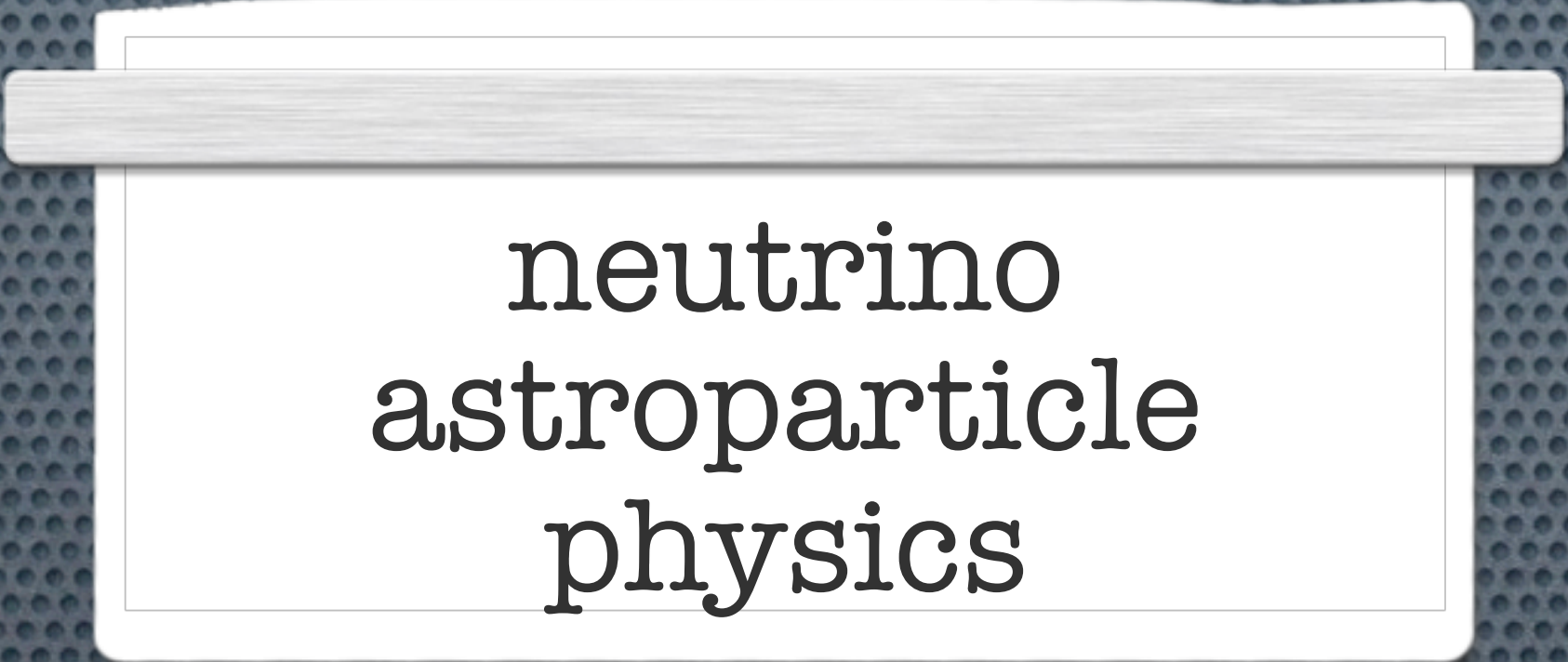
shock fronts
("Fermi-acceleration")

interactions with photons
or matter

$e + \gamma \rightarrow e + \gamma$ (TeV)
(inverse compton scat)

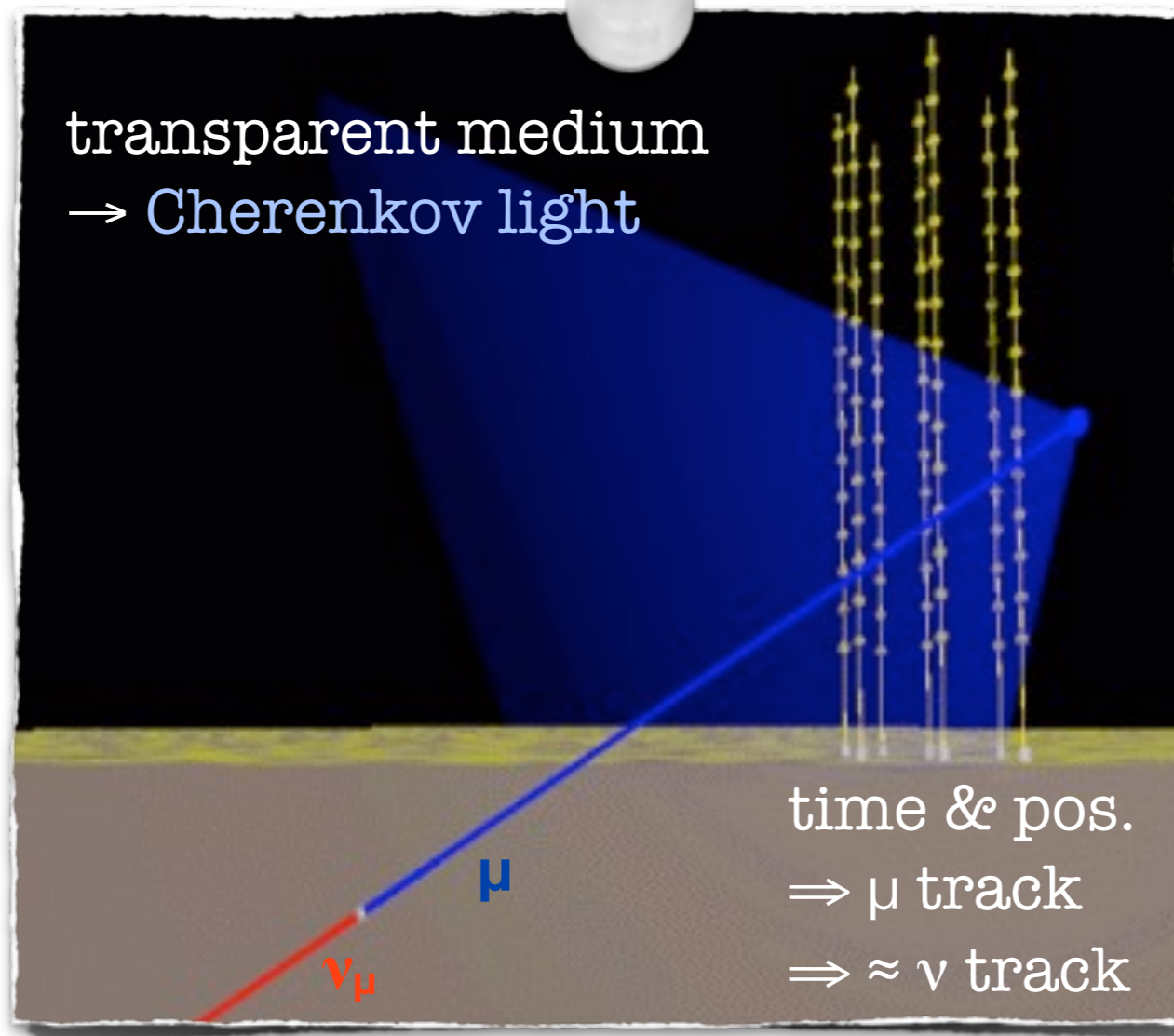
$p + p/\gamma \rightarrow \pi^0 + X$
 $\hookrightarrow \gamma + \gamma$ (TeV)

$p + p/\gamma \rightarrow \pi^\pm + X$
 $\hookrightarrow \mu + \nu_\mu$
 $\hookrightarrow e + \nu_\mu + \nu_e$

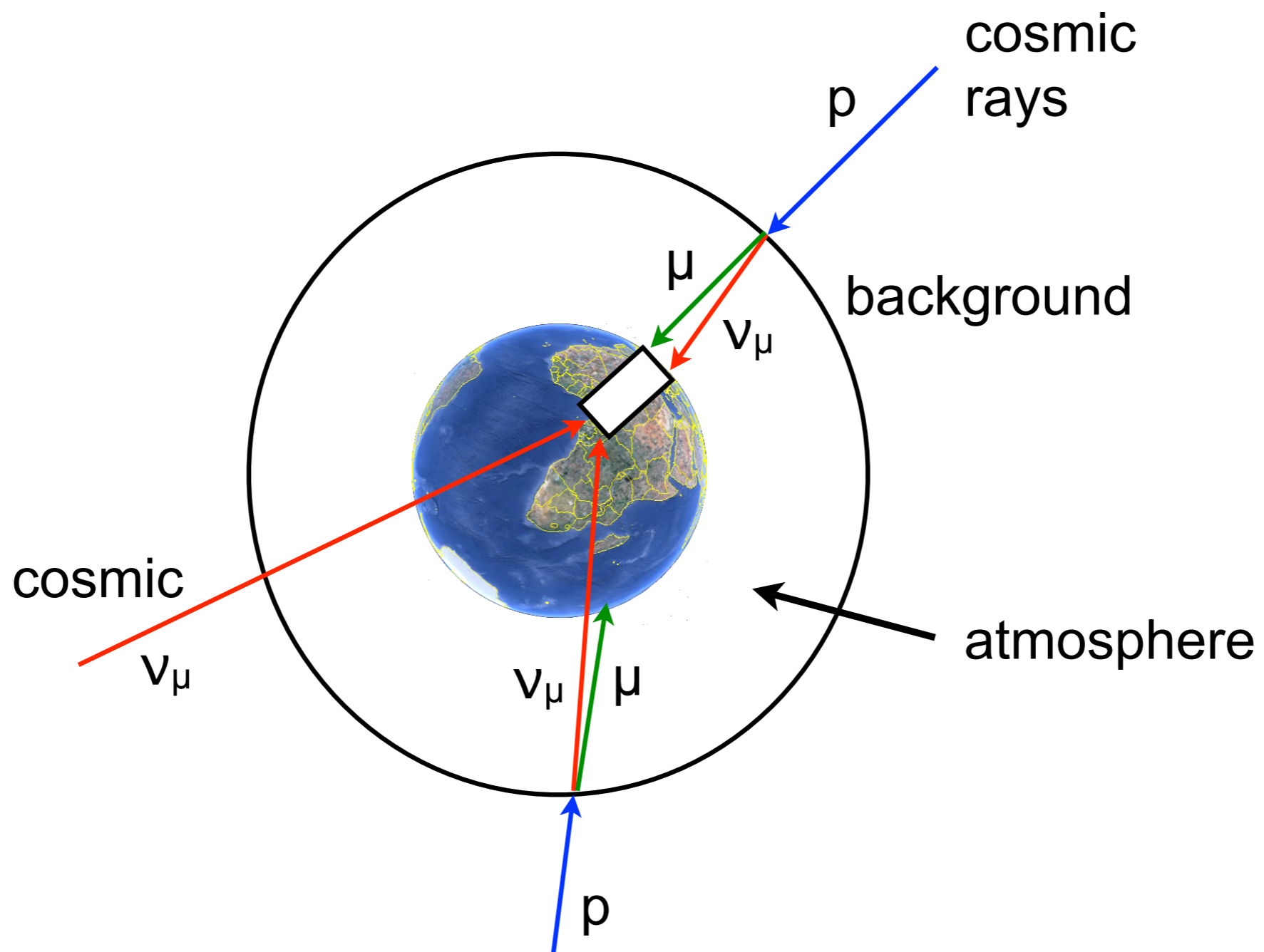


neutrino
astroparticle
physics

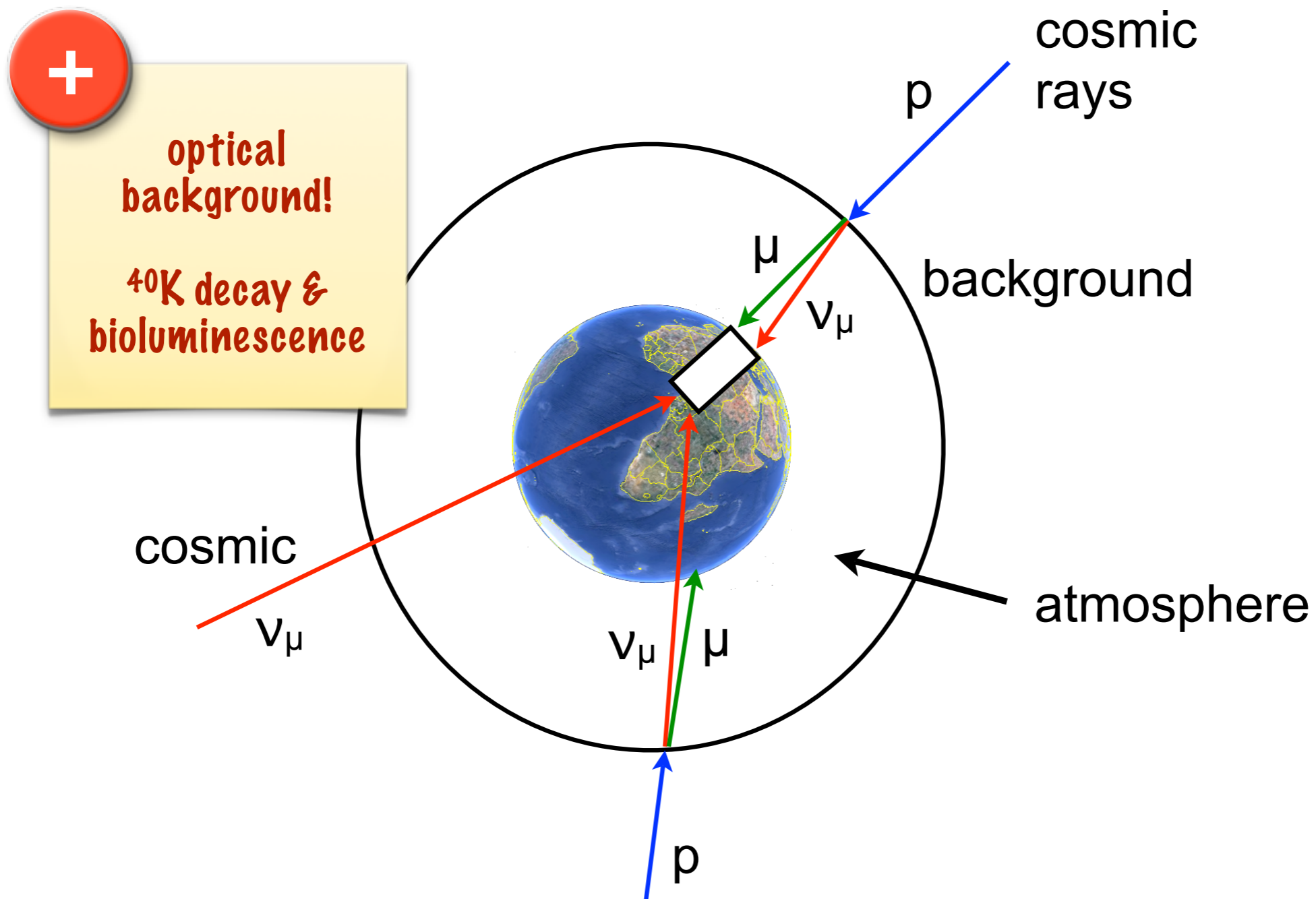
neutrino telescopes



signal and background



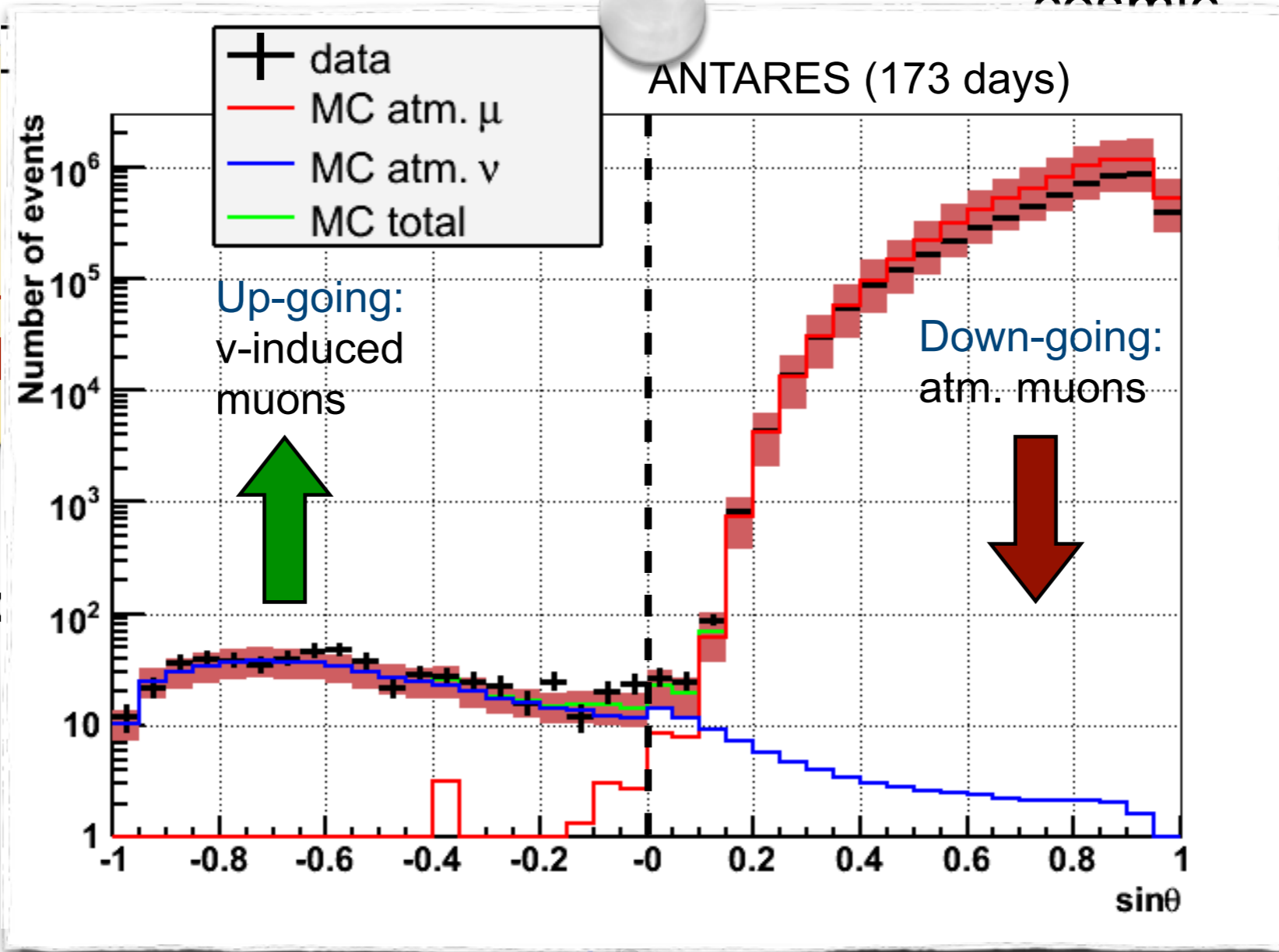
signal and background



signal and background

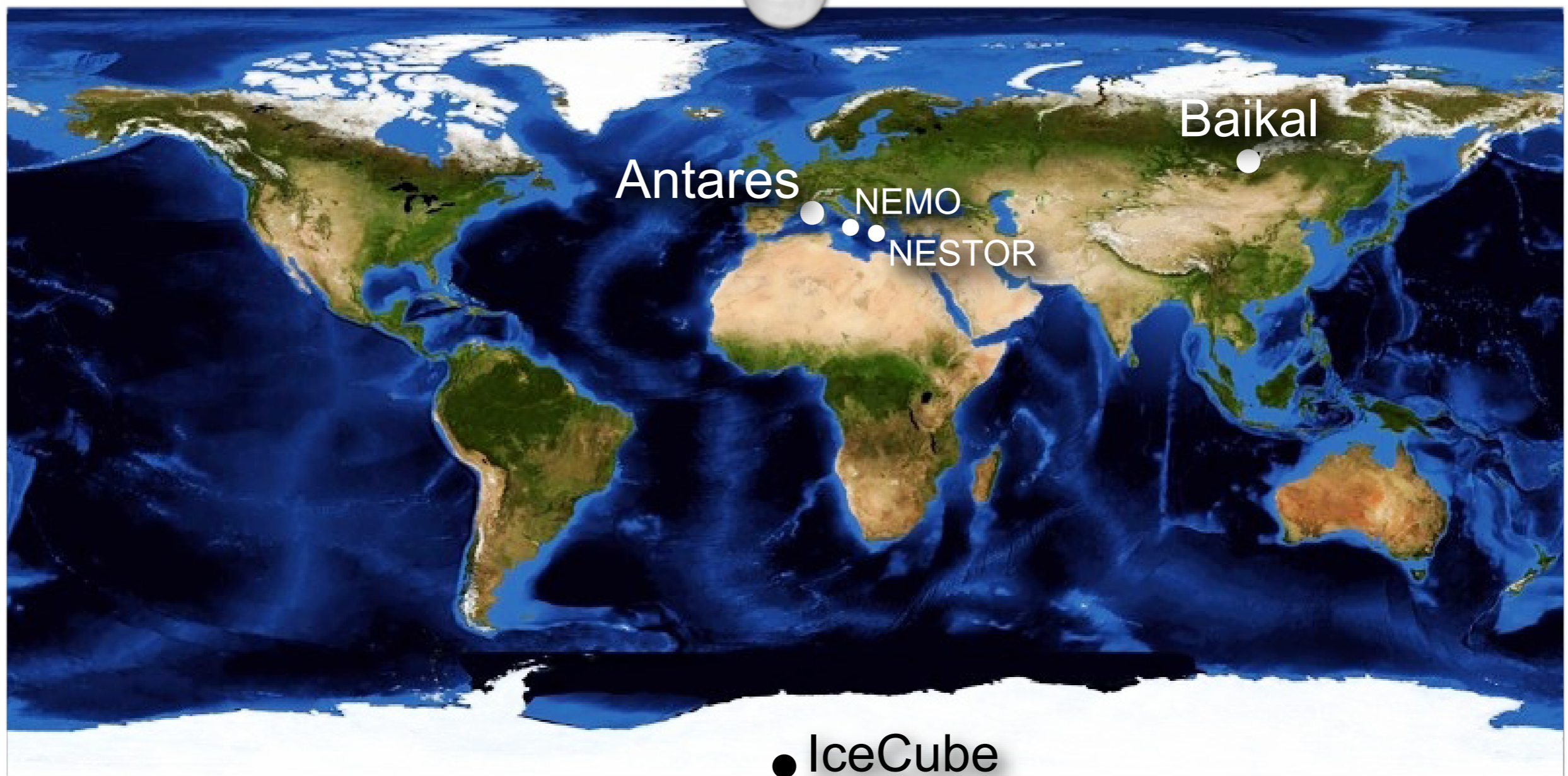


b
4
biol

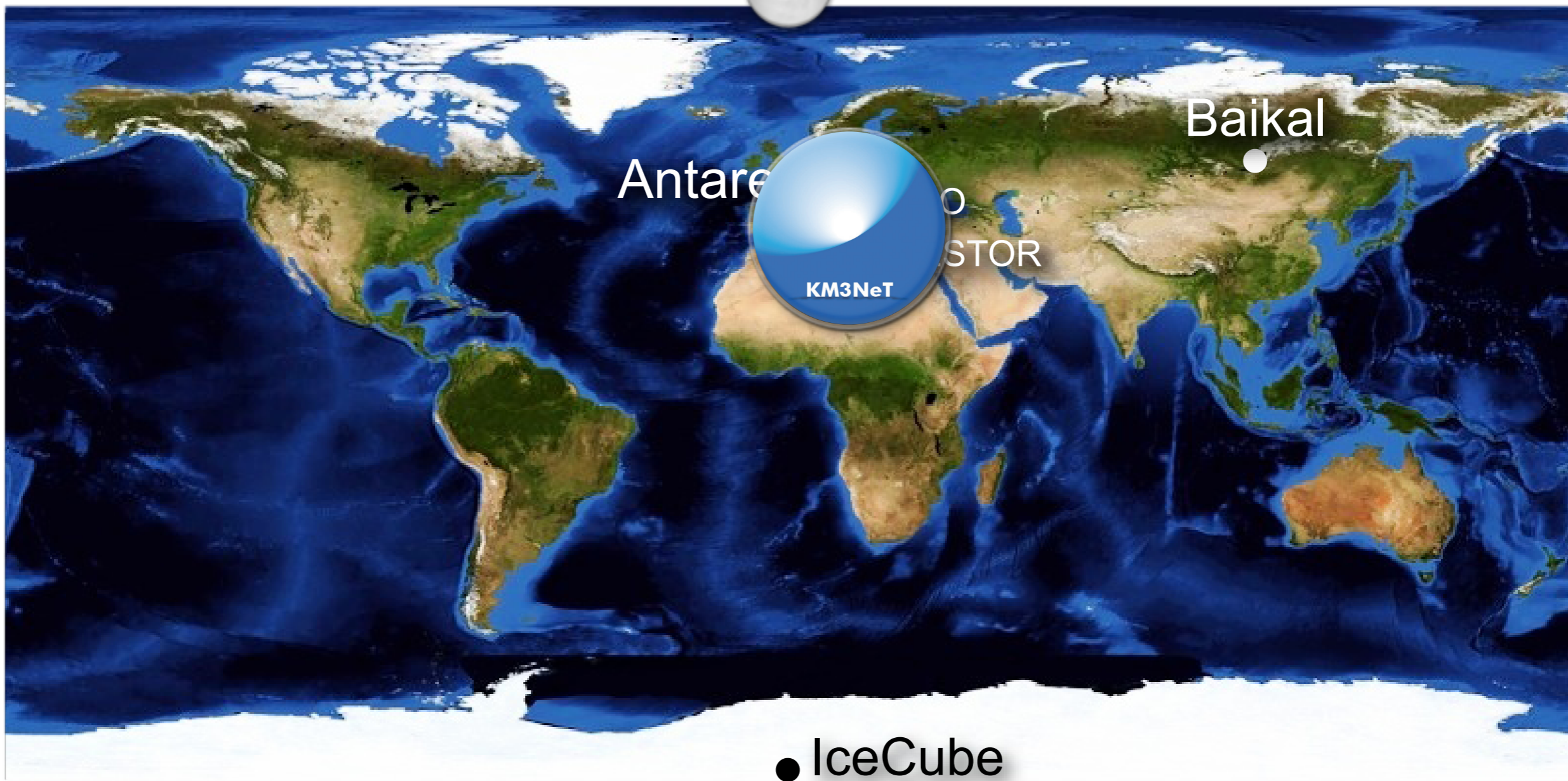


/ p

re



● IceCube



goal:

best possible
design for
KM3NeT

goal:

best possible
design for
KM3NeT



goal:

best possible
design for
KM3NeT



multiPMT

goal:

best possible
design for
KM3NeT

needed a new
track
reconstruction
algorithm



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based on
generic
probability
dist. func.



multiPMT

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based on
generic
probability
dist. func.

directional
scanning



multiPMT

questions

floor design?

optical module
design?

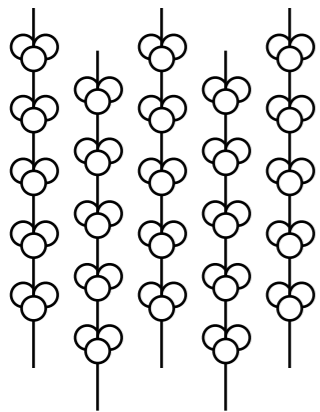
number of strings/
towers?

number of floors
per DU?

placement of
strings?

inter-tower
distance?

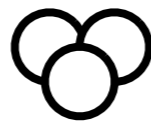
....



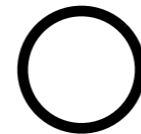
detector



**detection
unit**



floor



OM

questions

what does
"best possible"
actually mean?

floor design?

optical module
design?

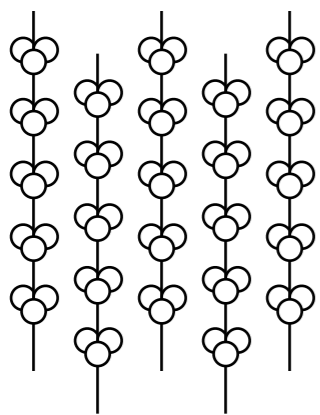
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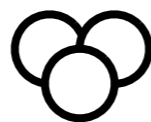
....



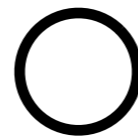
detector



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floor



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simulation

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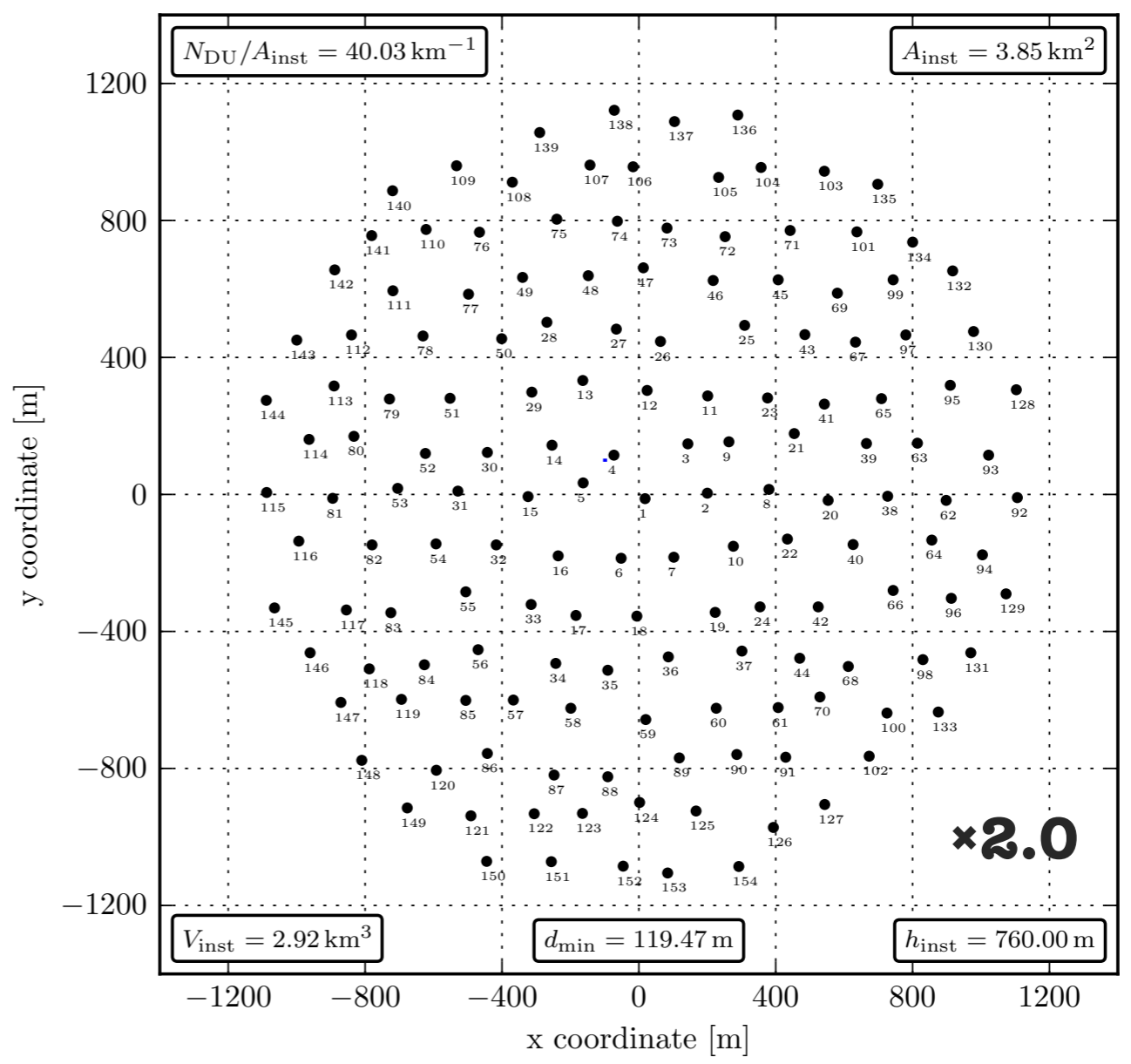
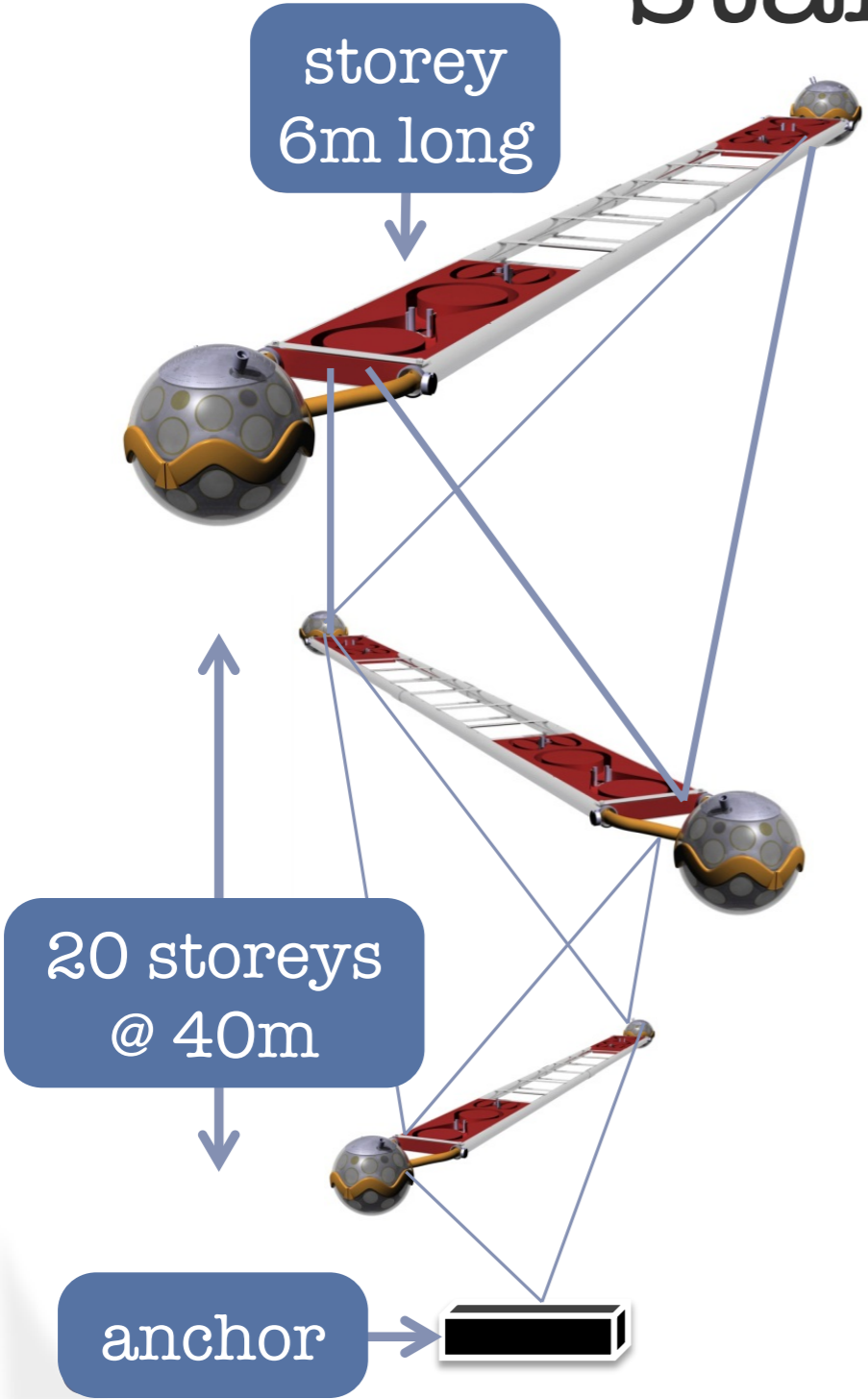
analysis

inter-tower
distance?

....

optimize!

starting point



2x 127 towers, av. distance 180m



(point source)
analysis

E^{-2} flux

$$\frac{d\phi_{\nu_{\mu}}}{dE} = 1.0 \cdot 10^{-8} \left(\frac{E}{\text{GeV}} \right)^{-2} \text{GeV}^{-1} \text{cm}^{-2} \text{s}^{-1}$$

exclude with e.g. 90% C.L.
("sensitivity")

$$\left(\frac{d\phi_{\nu_{\mu}}}{dE} \right)_{\text{sens.}} = MRF \cdot \frac{d\phi_{\nu_{\mu}}}{dE}$$

MRF:

"model rejection factor"

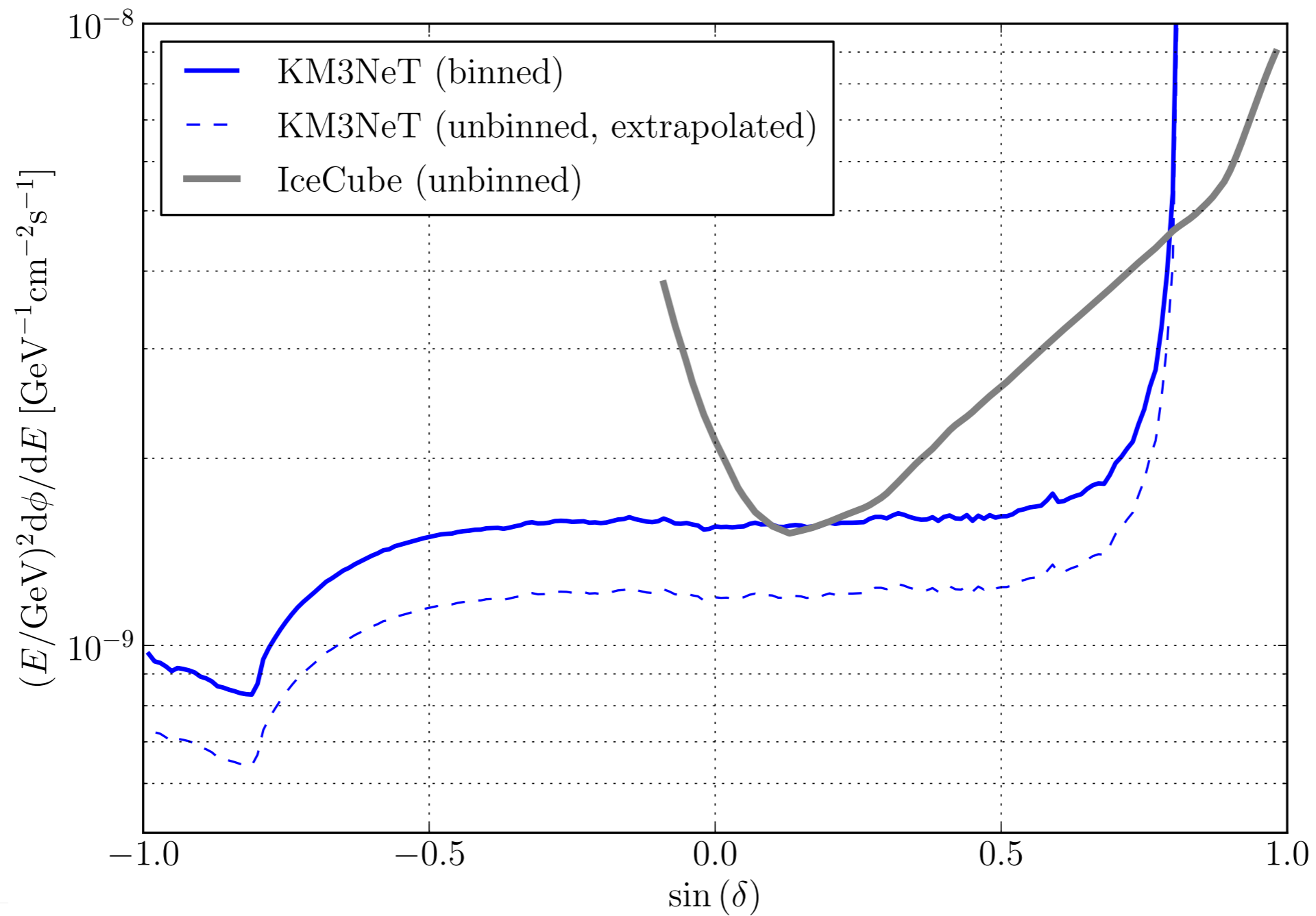
discovery with (e.g.) 5σ in
50% of experiments
("discovery potential")

$$\left(\frac{d\phi_{\nu_{\mu}}}{dE} \right)_{\text{disc.}} = MDF \cdot \frac{d\phi_{\nu_{\mu}}}{dE}$$

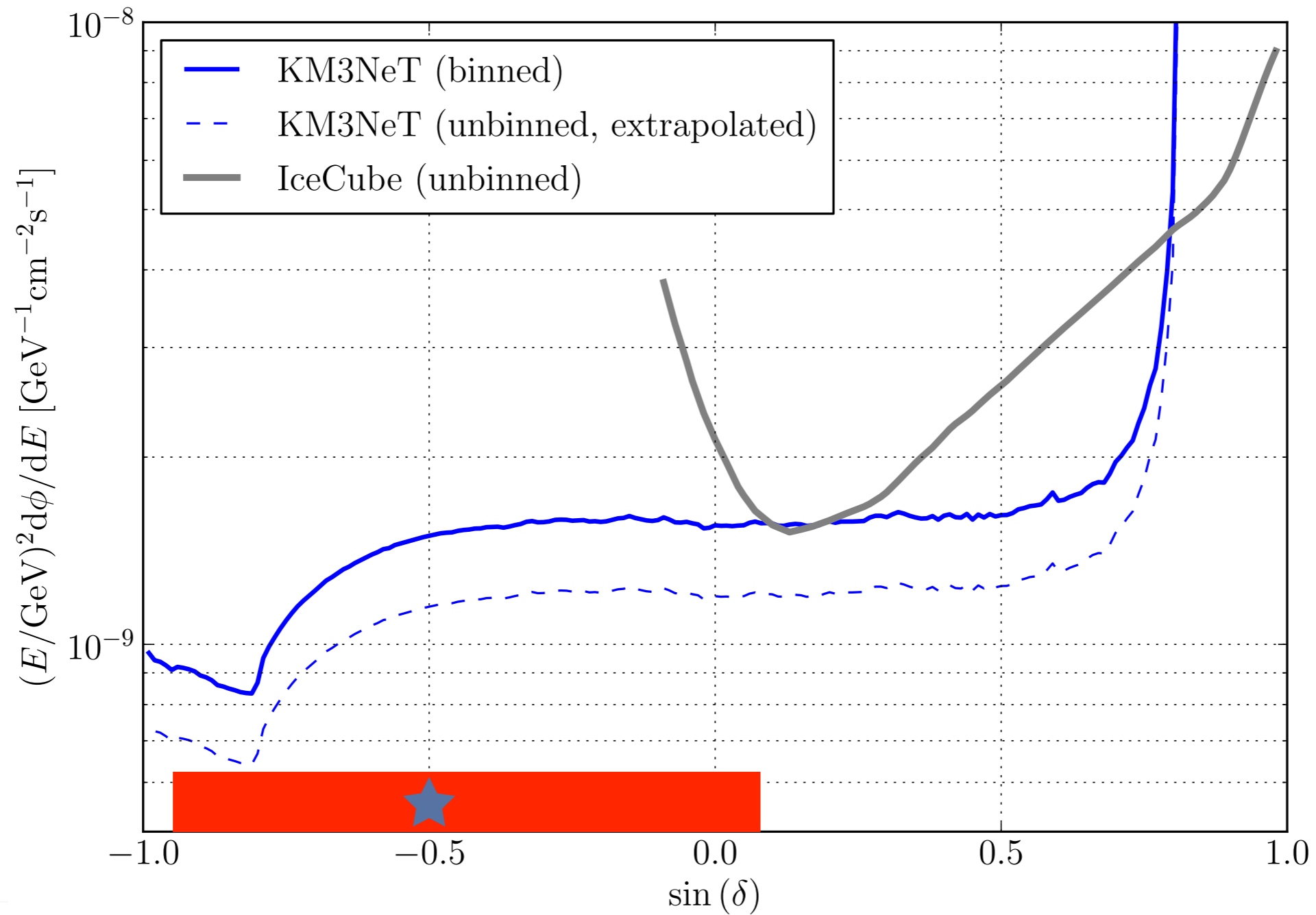
MDF:

"model discovery factor"

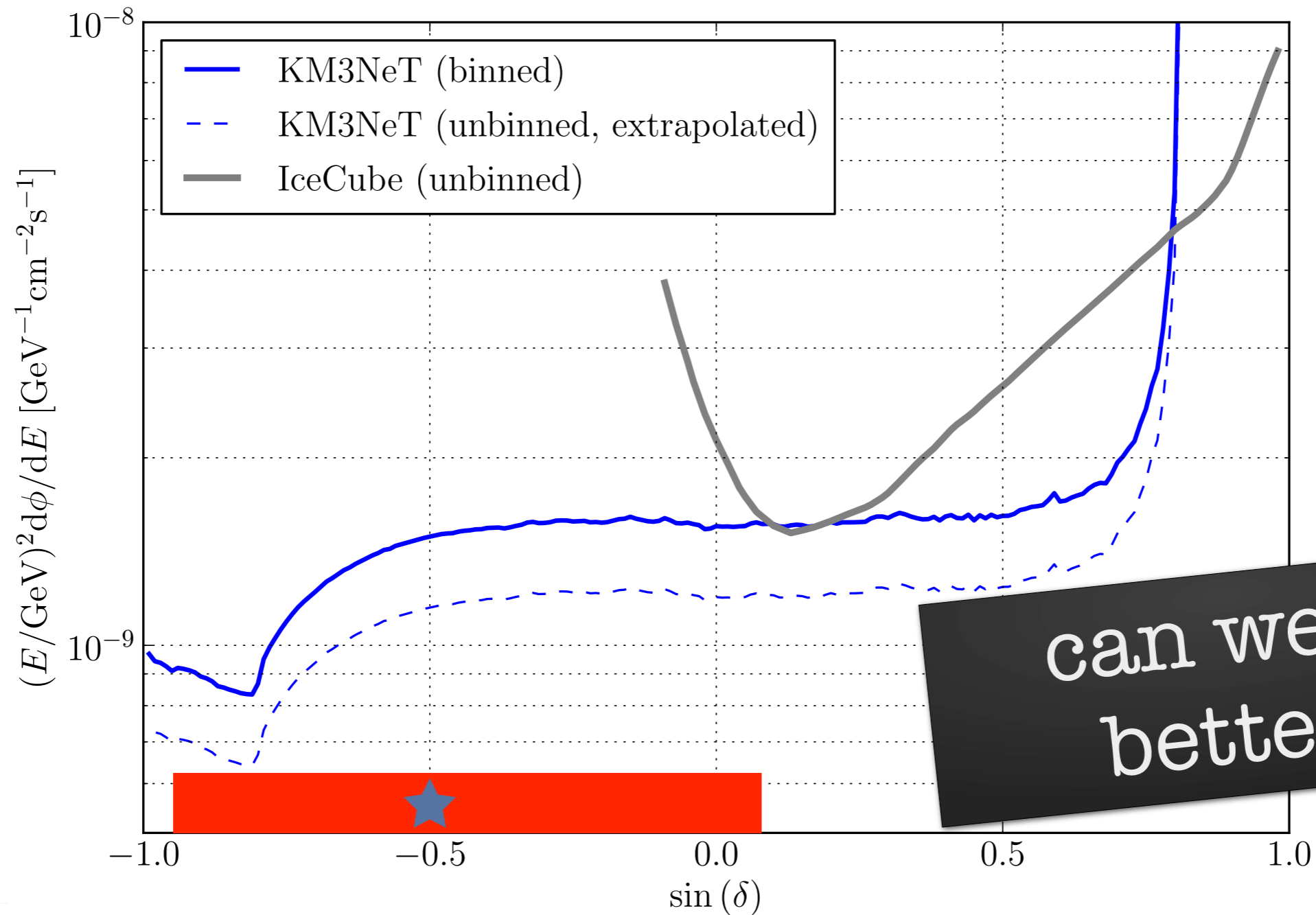
E^{-2} flux sensitivity 90% C.L.



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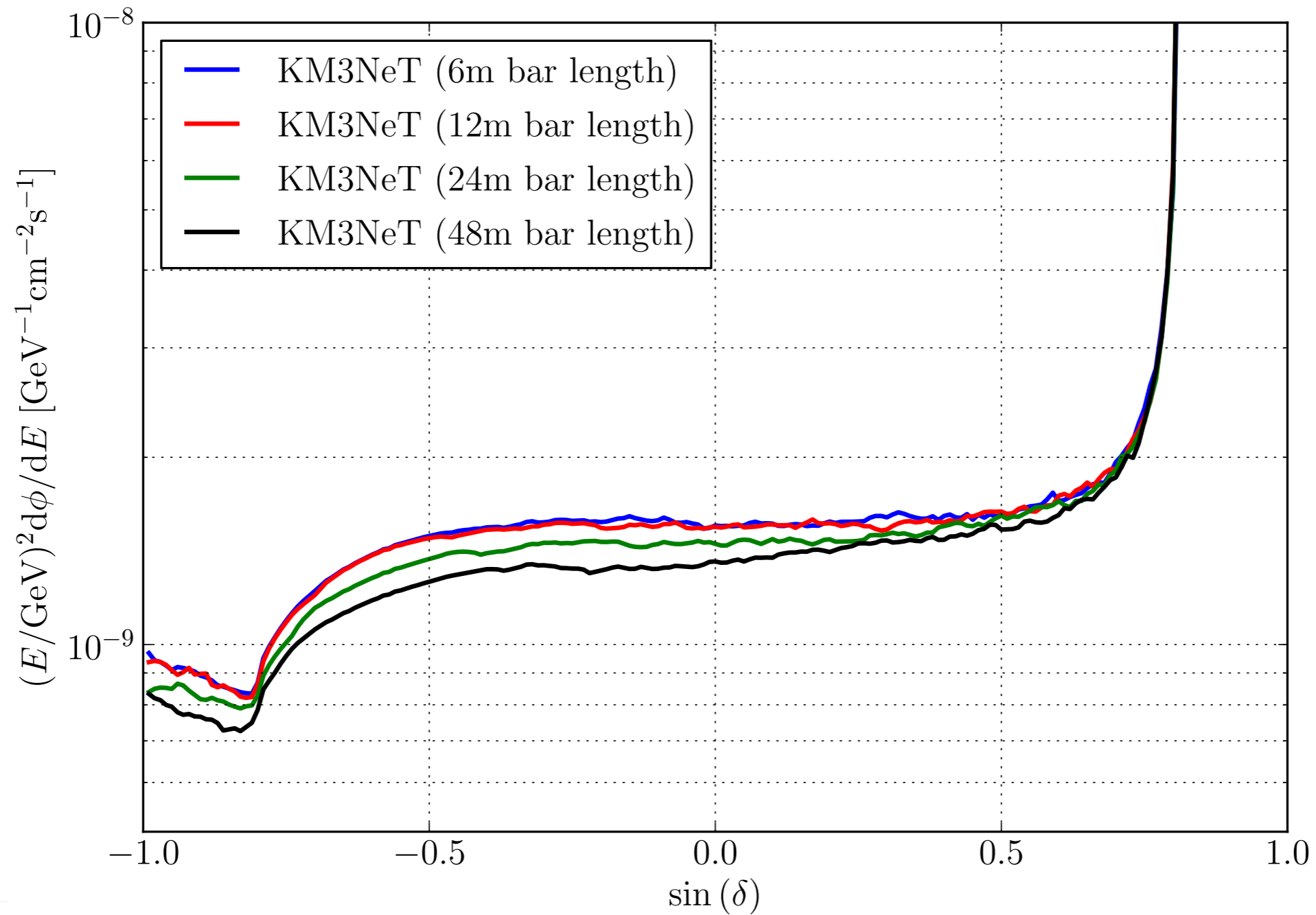


E^{-2} flux sensitivity 90% C.L.

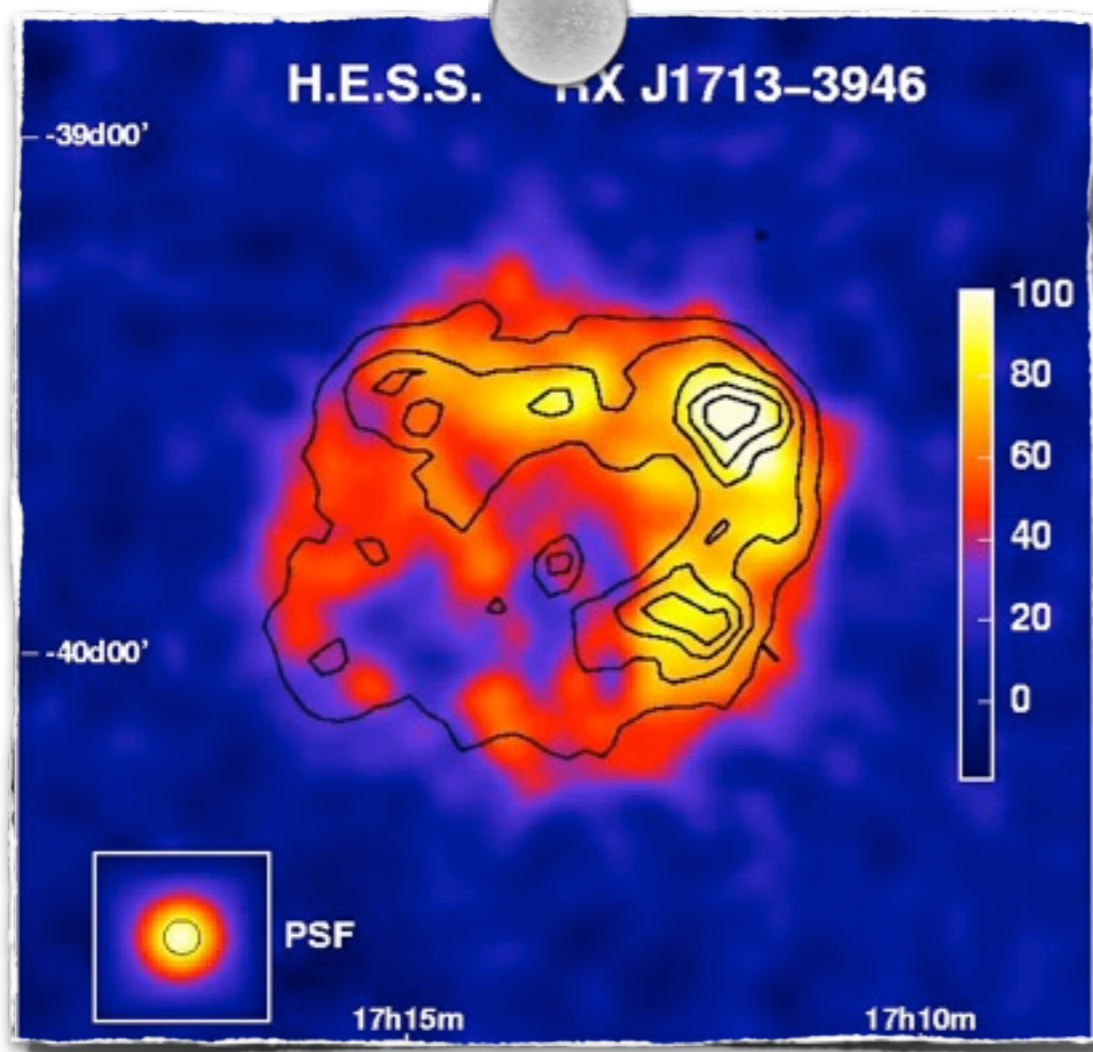


can we do better?

E^{-2} flux sensitivity 90% C.L.



example source



RX J1713.7-3946

$$k (E/\text{TeV})^{-\gamma} \exp\left(-\sqrt{E/e}\right)$$

$$k = 16.80 \cdot 10^{-15} \text{ GeV}^{-1} \text{ s}^{-1} \text{ cm}^{-2}$$

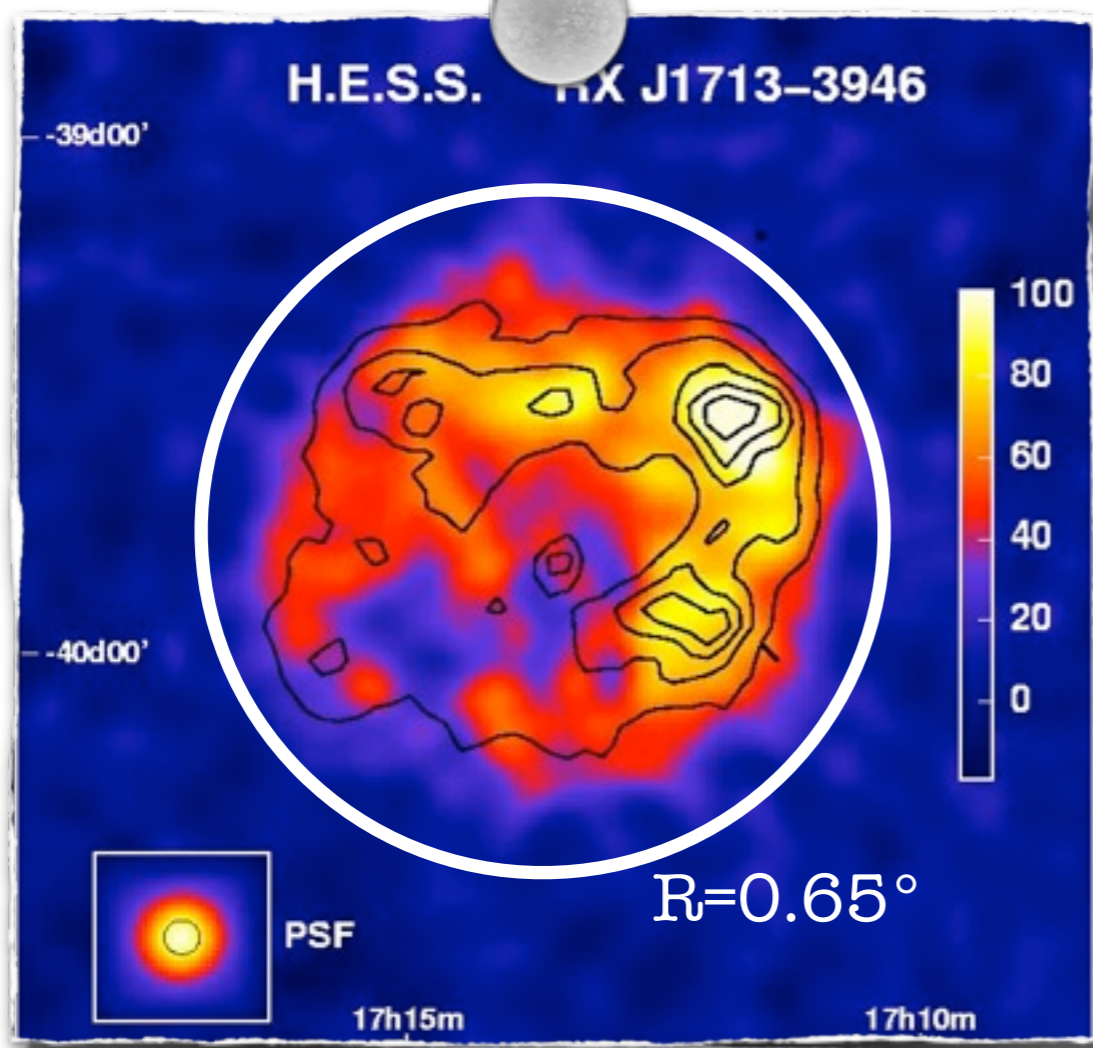
$$\gamma = 1.72$$

$$e = 2.10 \text{ TeV}$$

assumed: disc with radius 0.65°

provided by A. Kappes

example source



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provided by A. Kappes

example source

Fermi-LAT
results
suggest
leptonic
acceleration

RX J1713.7-3946

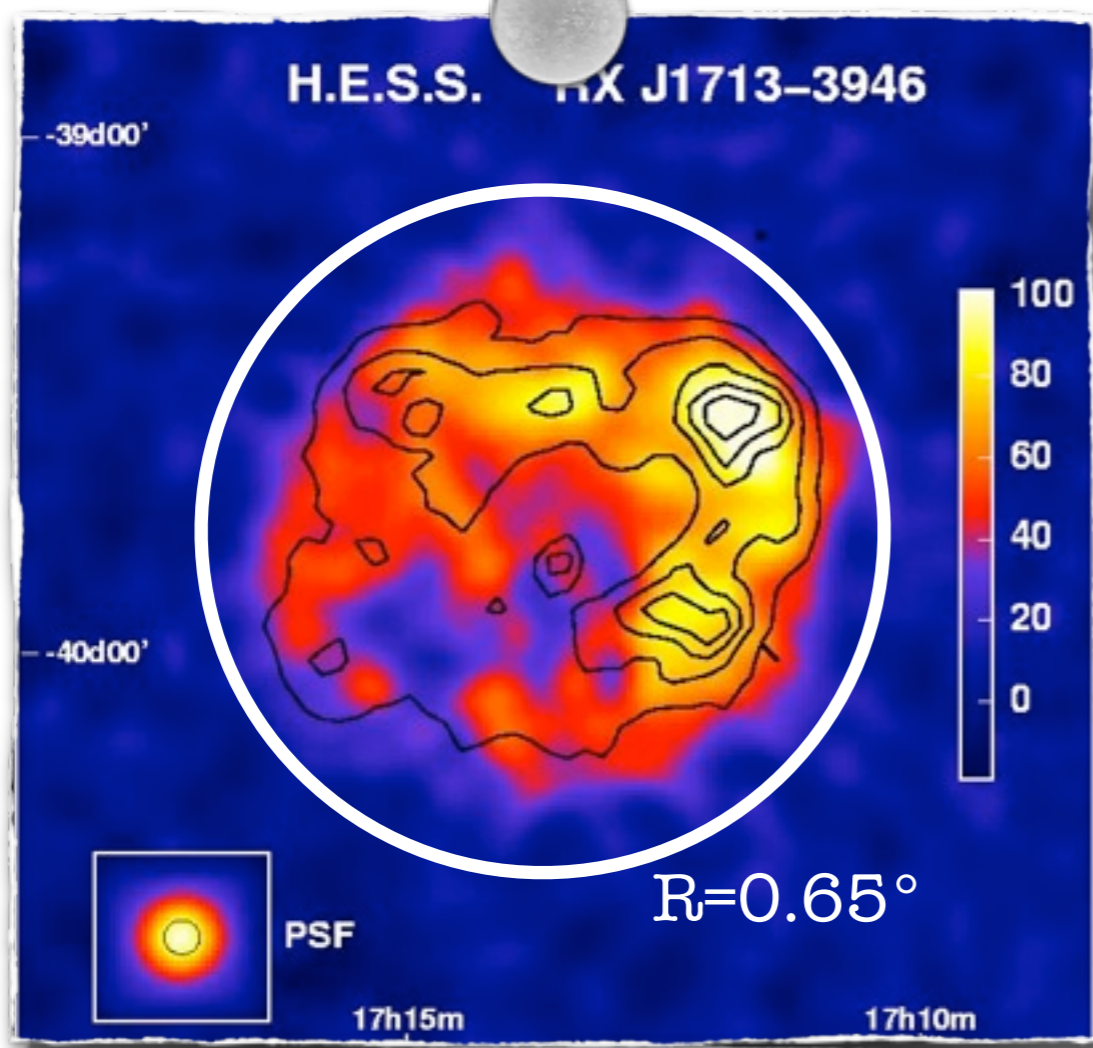
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provided by A. Kappes

example source

however:
may still be
hadronic

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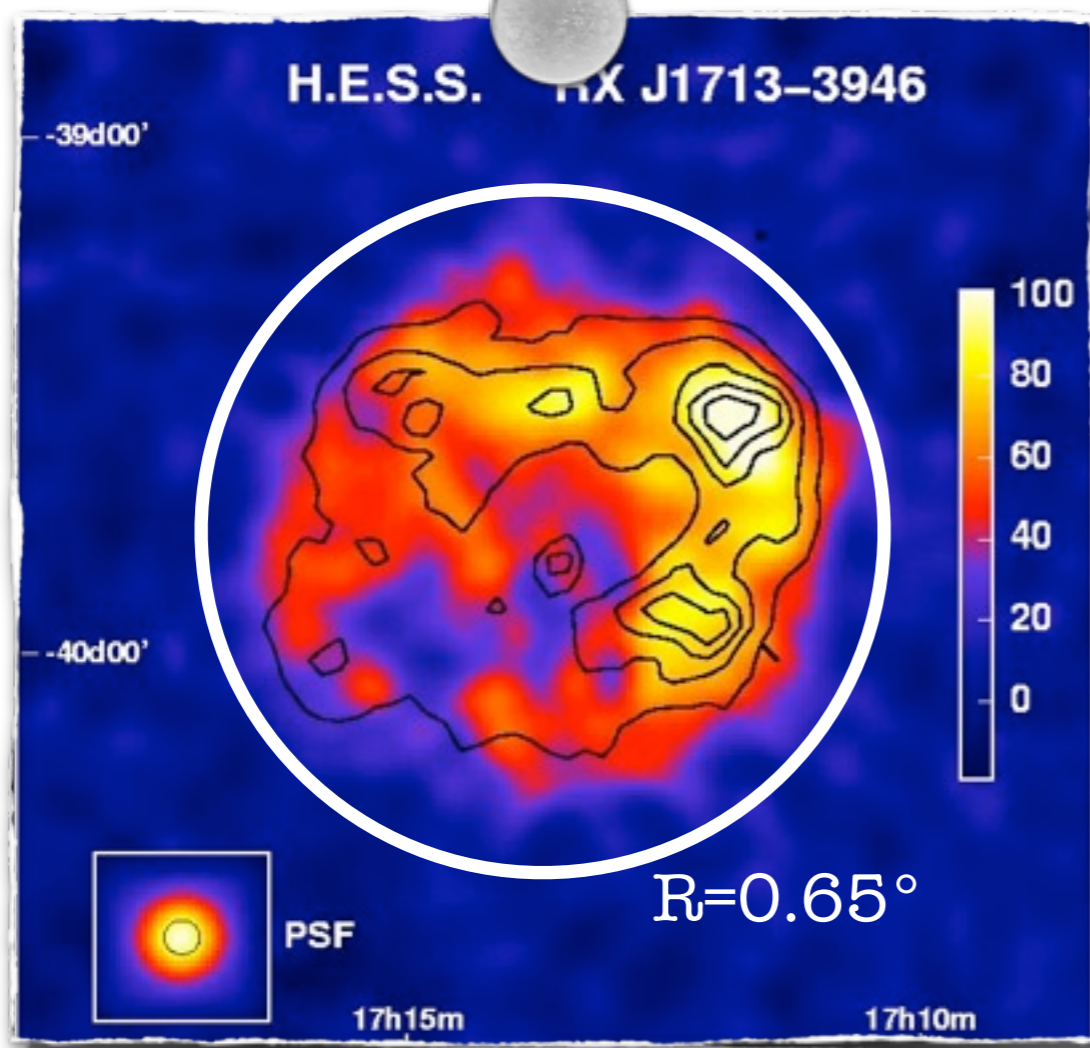
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provided by A. Kappes



example source

use it as a benchmark

RX J1713.7-3946

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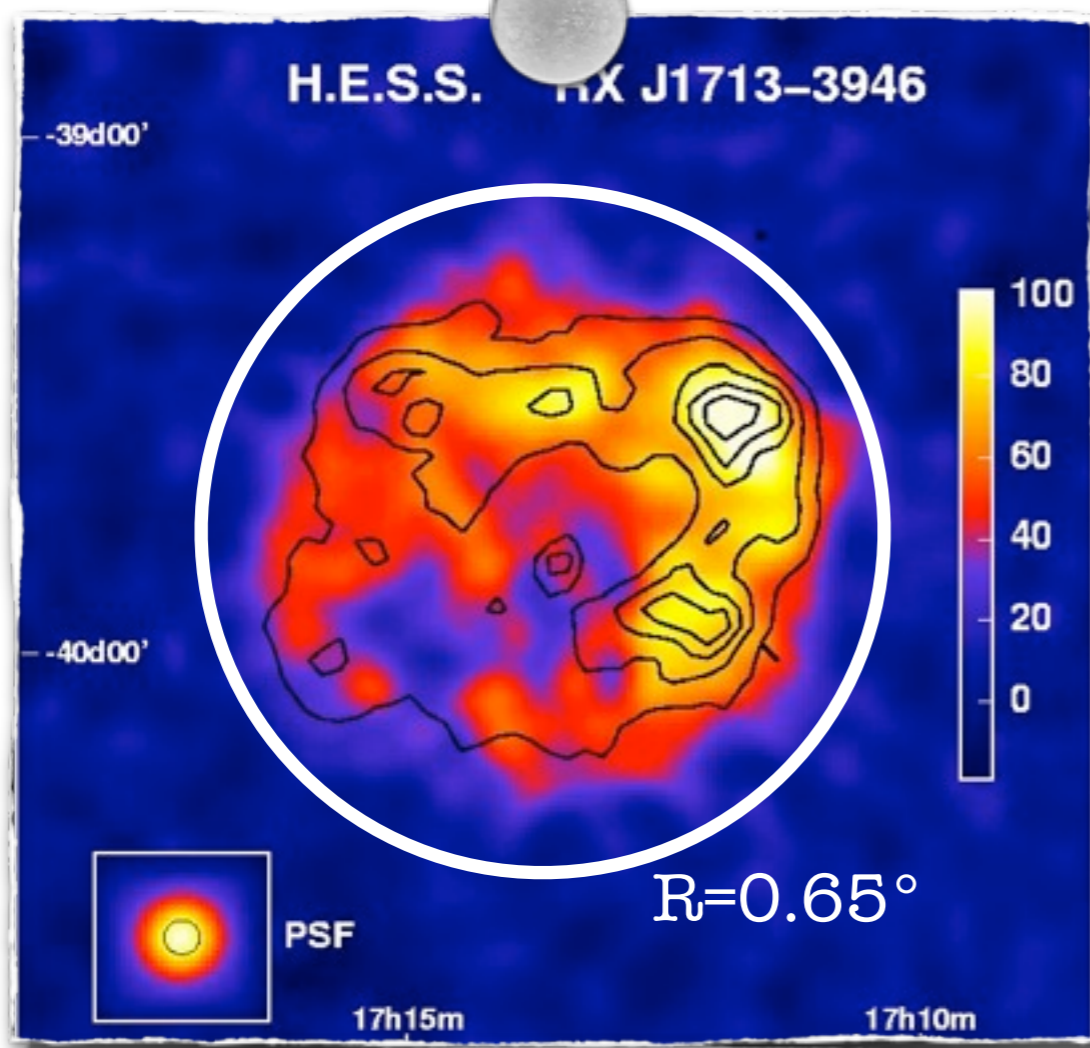
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provided by A. Kappes



5σ detection of RX J1713

(5σ , one-sided in 50% of exp.)	disc with $R=0.65^\circ$	point-like
6m bar length (starting point)	12 years	5.4 years
12m bar length	11 years	4.9 years
48m bar length	8.5 years	3.8 years

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use source
topology

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**use source
topology**

**result will
be somewhere
in between**

5 σ detection of RX J1713

optimize
detector
footprint

one-sided
(in 50% of exp.)

disc with $R=0.0$

use source
topology

point-like

6m bar length
(starting point)

12 years

5.4 years

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result will
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5 σ detection of RX J1713

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optimize
analysis
method
(unbinned)

disc with $R=0.0$

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in 50%

5 σ detection of RX J1713

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...

use source
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3.8 years

in 50%

h R=0.0

conclusions

technology and
software are in place

galactic sources are
in reach for KM3NeT

we'll know (for sure)
if sources are
hadronic or not

conclusions

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software are in place

galactic sources are
in reach for KM3NeT

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if sources are
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build it and
get started
with physics!

Thank

you!

