A vision of the future of HE, VHE Gamma Ray Astronomy

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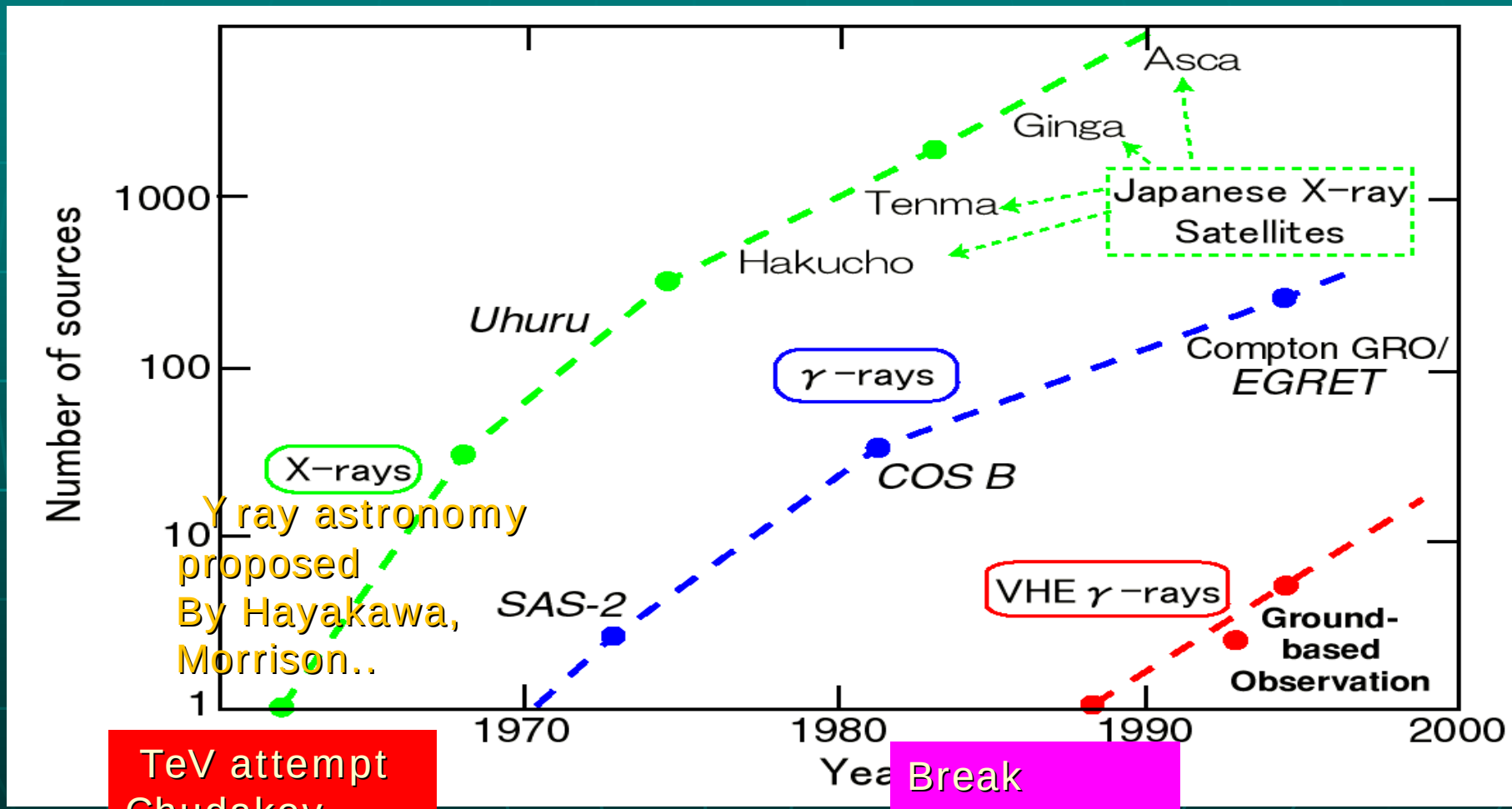
- Congratulations for the inauguration of the MAGIC telescope !
- fun and pleasure to dream about a magical world.

- "Vision" needs to be presented in a logical way based on :
  the present status,
  instrumentation and science in the future

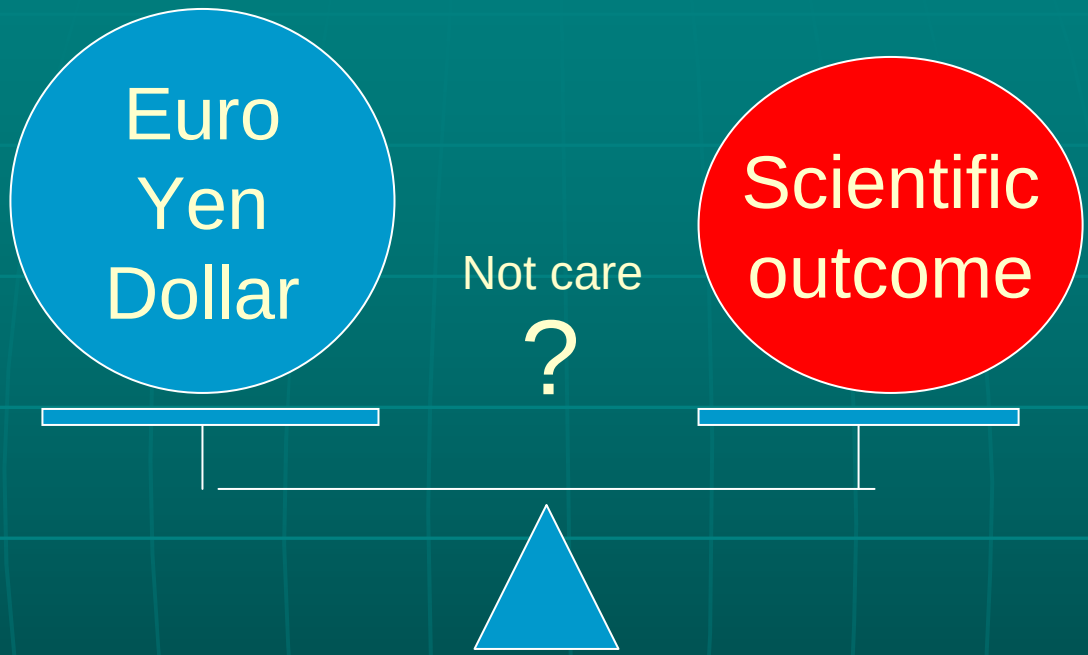
A decade of years, since TeV window was opened.



TeV γ-ray sources

Type			
Pulsar nebulae	2	1	1
SNR		3	more to join.....
X-ray binaries			1?
UnID		1	
Others			2 (GC...)
Blazars	4	1	2
galaxies		1 (NGC253)	1(M87)
GRB			1
Total	6	7	About 10

Good telescope is generally very expensive, and would be too unrealistic, ……, however,



Gedanken experiment is free, and "ultimate case" of "complete calorimeter" is useful to get a broad vision.

e,.g. collection area = detection area

$(20m)^2 X\ 30 = (100m)^2$: not ridiculous

I heard from Trevor, Trümper said

"The total energy of
all the X-ray photons
so far observed by ROSAT
corresponds to
one TeV photon".

To be energetic is something valuable....
"erg/Joule is a jewel !"

Thoughts coming up, about the value of being energetic?

- TeV γ-rays are, as a fact, very energetic events.
- X-ray photons are numerous: Statistics of TeV γ-rays is poor.

- 10^{12} eV = 10^{9} X 10^{3} eV

similarly,

- 10^{20} eV = 10^{8} X 10^{12} eV

- Do we have to collect 10^{8} photons at TeV to keep up with 10^{20}eV cosmic rays?

Radio, x-rays ---------- NS, BH, 2.7K……

Energetic. enigmatic phenomena that γ - ray observation looked for are not successful in retrospect

- No γ -rays from matter-antimatter annihilation
- No microsec burst γ -rays from primordial black holes
- GRB: but not yet in TeV region, and no essencial contribution beyond GeV
- Cyg X-3 (anomalous interaction?) dissapeared……

- Origin of cosmic rays ?
- Dark matter ?
- vacuum modification due to quantum gravity ??
- Top down scenerio of 10^{20}eV cosmic rays ??

Statistics: number of photons so far detected in TeV energy

- $N_X \approx 10^9 = 10^5 \cdot 10^4$: X-rays

  $N_{TeV} \approx 10^4 = 10^3 \cdot 10$: TeV γ s

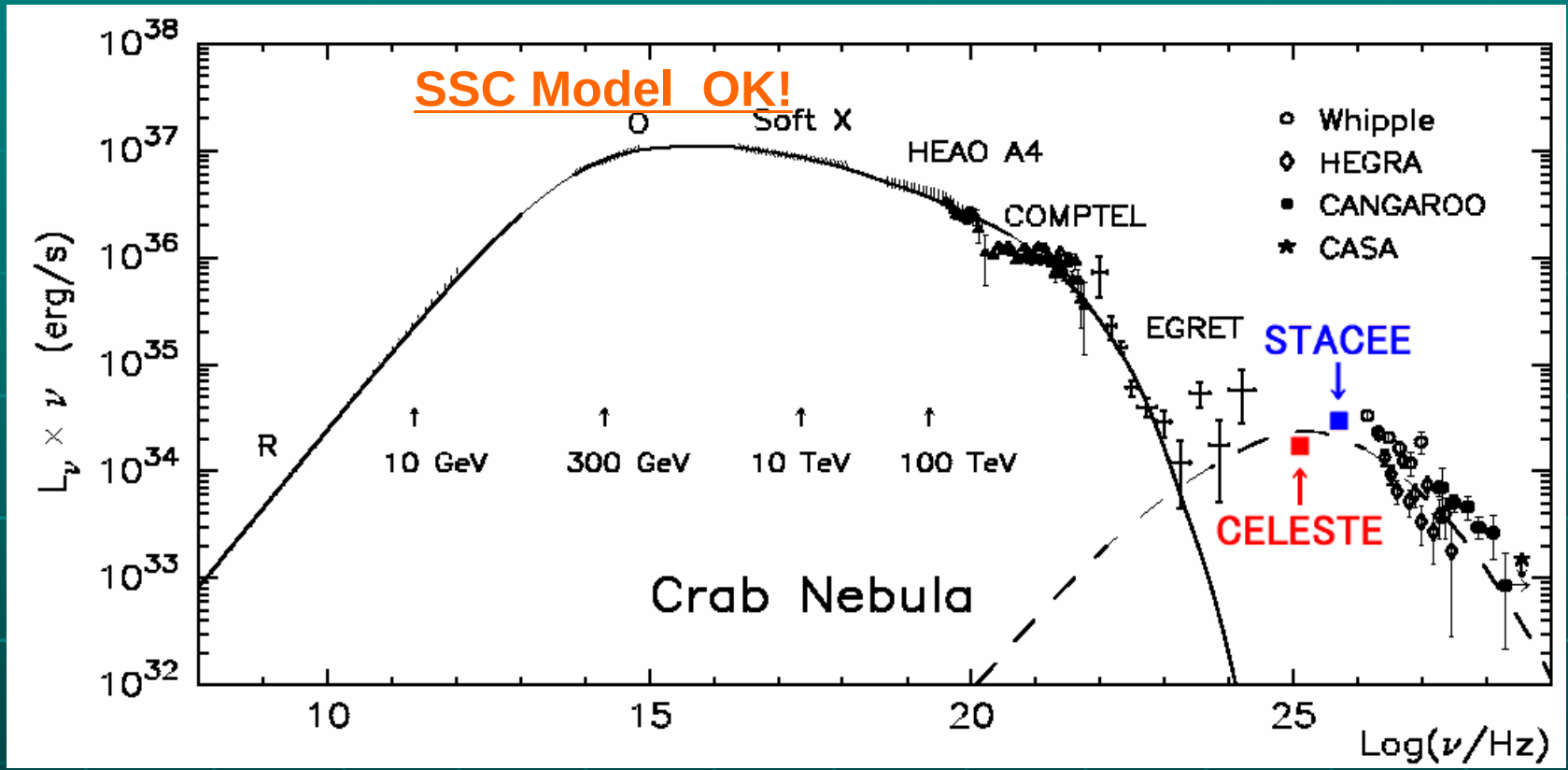
Number of sources

- $N(>E) \sim E^{-1} \cdot S\Omega T$: $E^2 dN/dE = \text{constant}$

$N/Nx = (Ex/E) \cdot (10^4 m^2/1m^2) = 10^{-9}\ 10^4 = 10^{-5}$

Roughly explained

Crab nebula(unpulsed) is the standard source for calibration, but not the standard to represent the other TeV sources

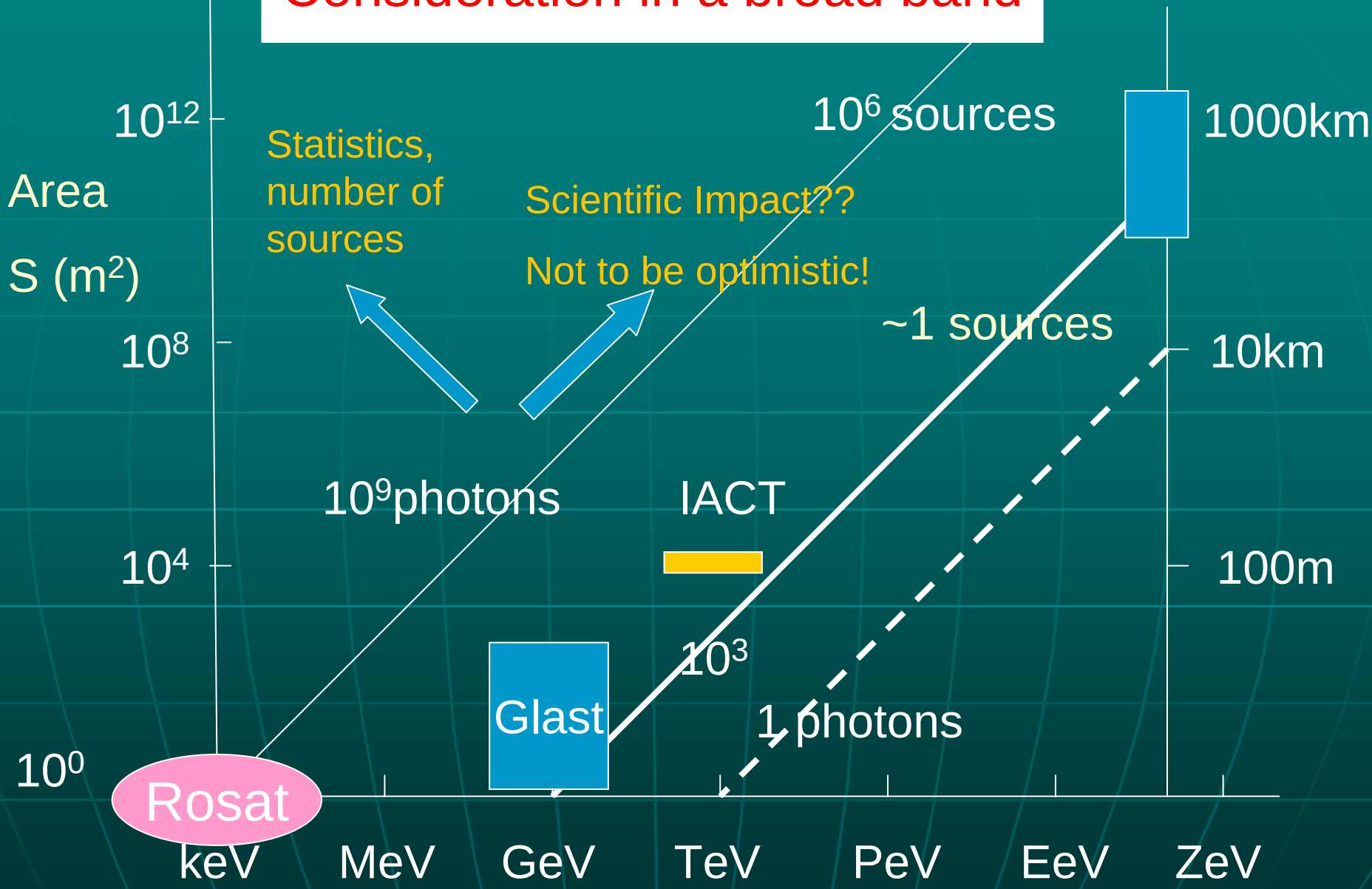


the sole SNR/plerion :
"complete" multi wavelength Spectrum
With definite flux in any band.

Max. acceleration energy ?

~20 TeV or >100 TeV

Consideration in a broad band



Results from Ten thousands TeV photons implies we need more sources!

- six blazars
  - **How peculiar/standard they are?**
    - in comparison with GeV blazars
- three SNRs (+ PSRs) : against 100 ≈ $10^{4\sim5}$yrs/50yrs
  - **How peculiar/standard they are?**
    - E_{acc} up to 10^{15}eV?
- two galaxies
  - **How peculiar/standard the Galactic CRs are?**
    - Disk emission?
    - Normal galaxies by deeper observation
  - **γ-ray observation extends CR physics to extragalactic space**

directions that HE and VHE γ-ray astronomy will take in future

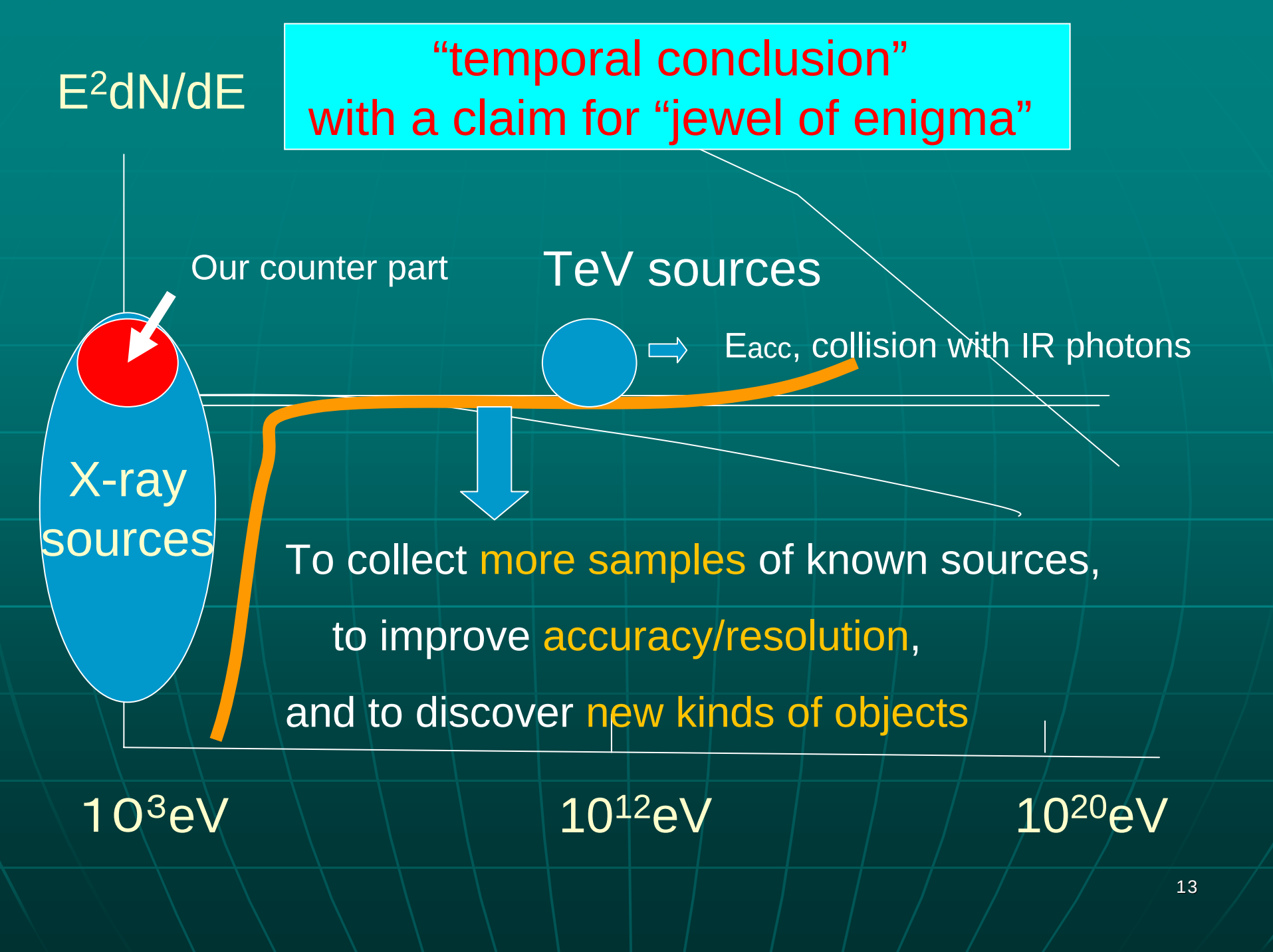
Variety of possibilities, corresponding to various kinds of TeV sources and depending on their phenomena in interest.

It seems natural to go to lower energy region
with larger dishes

Sub 100GeV ~ 1 TeV region
10~100 sources for systematic study of SNRs, blazars ,....
discovery of more, new types of γ ray sources

- However, the current efforts satisfying?---stereo & big dish:

- Let us not give up 10TeV ~ 100TeV region
origin of cosmic rays : maximum acceleration energy?
blazars : absorption by IR background radiation


E²dN/dE
"temporal conclusion"
with a claim for "jewel of enigma"
Our counter part
TeV sources
Eacc, collision with IR photons
X-ray sources
To collect more samples of known sources,
to improve accuracy/resolution,
and to discover new kinds of objects
10³eV
10¹²eV
10²⁰eV

direction (1) towards sub-100 GeV ?

- more (weak) sources:

  Nγ increases with decreasing energy
  with a constant detection area S = $10^4 m^2$,
  providing a good sensitivity.

  For further drastic improvement, Ω ! (like GLAST)

  or multiple telescopes > 10 ?

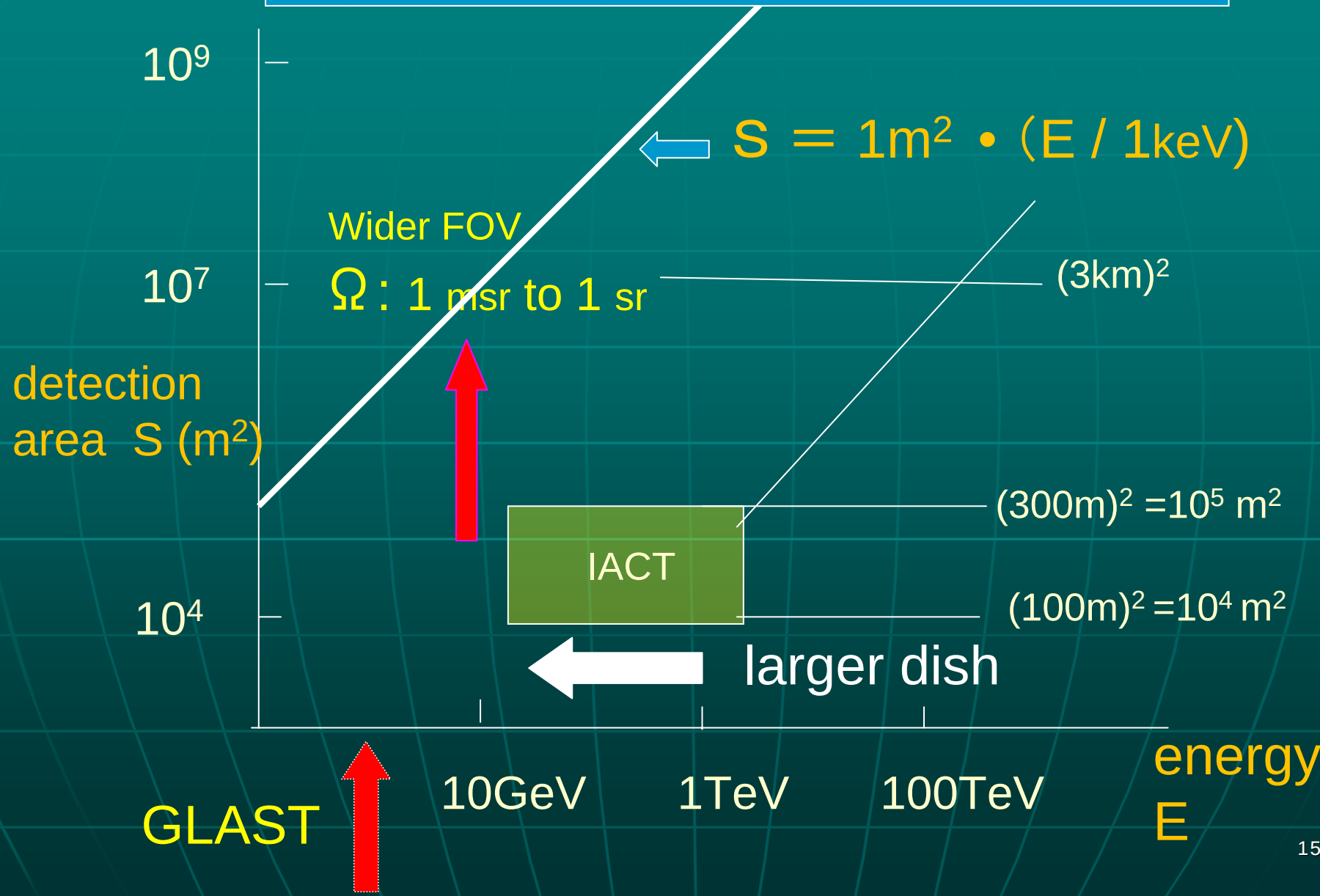
- comparison with GeV phenomena(Glast)?

  --- for sharp difference, electrons?

  (proton spectrum is featureless)

  anti-counter and "MAGIC technique"

Detection area , energy and dish size



direction (2) towards 10-100 TeV ?

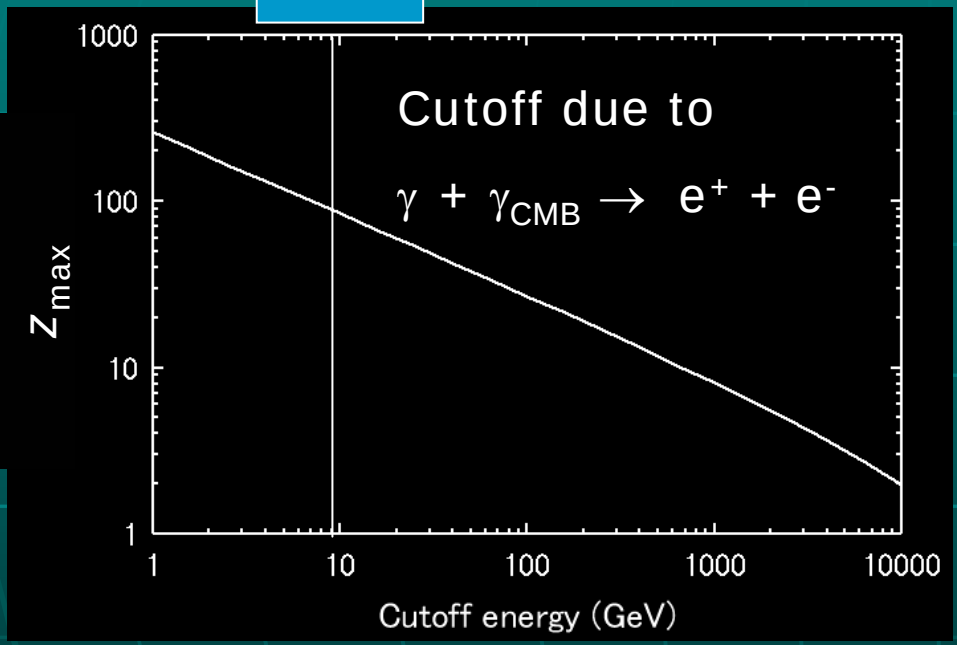
- SNRs, blazars:
  to find SNRs with Eacc ≈knee energy 10^{15}eV
  distant blazars, “pair halos”,
  “extreme blazars” of acceleration energy
  beyond TeV etc.
- Unkown sources?
  not very likely
- Regeneration of absorbed gamma rays

- S = const. = $10^4 m^2$ is small and fatal.

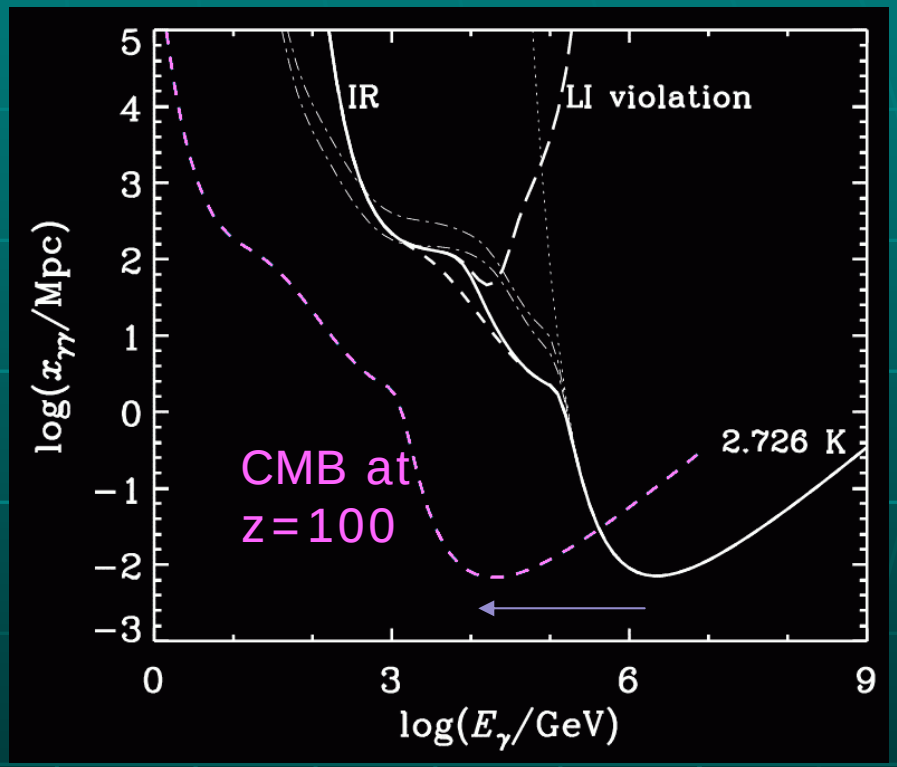
Interesting possibilities but like a bet.

Cosmological gamma-ray horizon

10GeV



Fazio & Stecker 1970 Nature 226, 135



10 GeV gamma-rays can explore the Universe up to z=100!

MAGIC concept : big dish: a role of the key

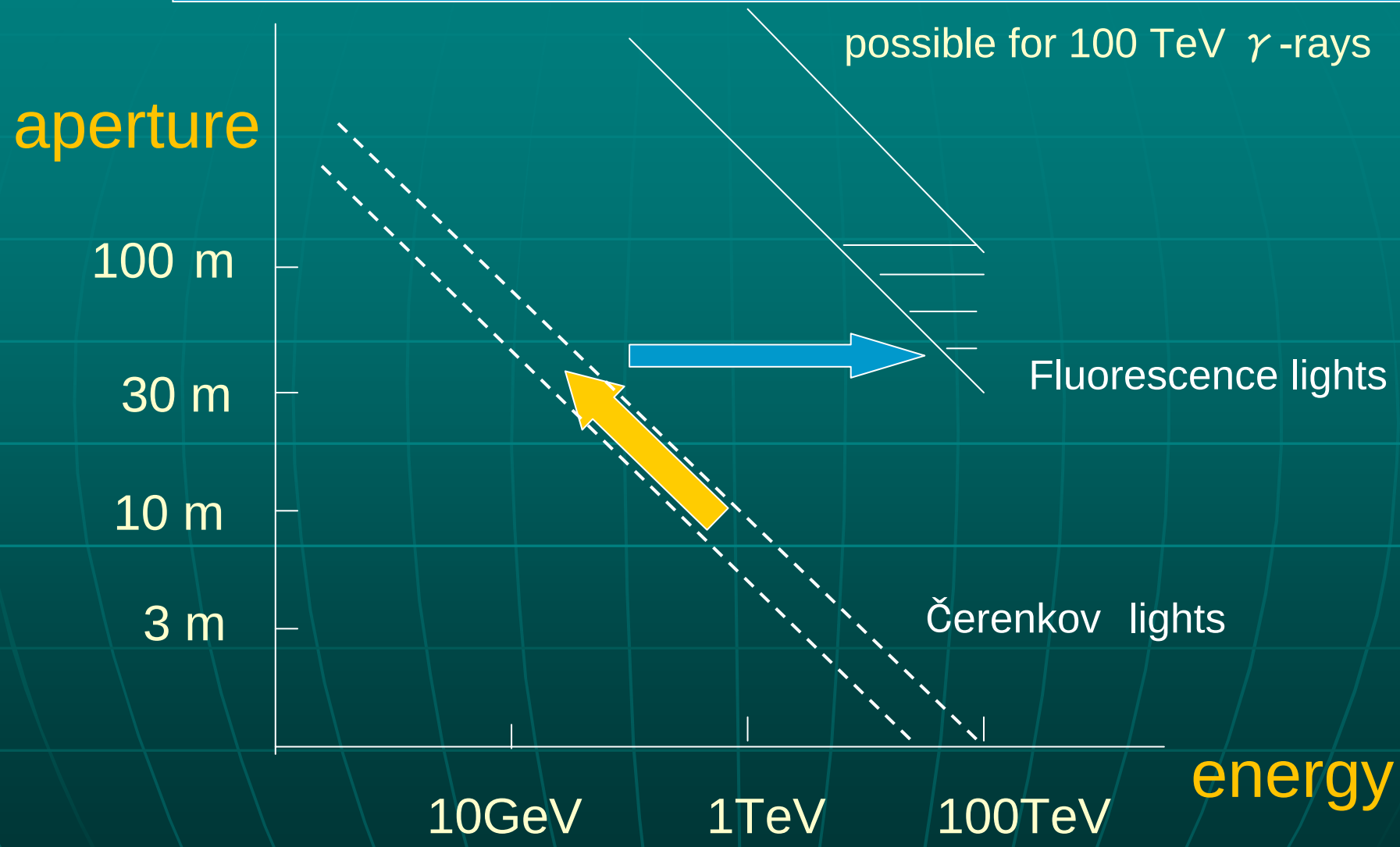
- (1) Lower threshold energy
  (2) good accuracy ⇨

- MAGIC : 17m
  H.E.S.S. & VERITAS 12m
  CANGAROO :10m
- A^2 is about 10^{-2} of detection area S.

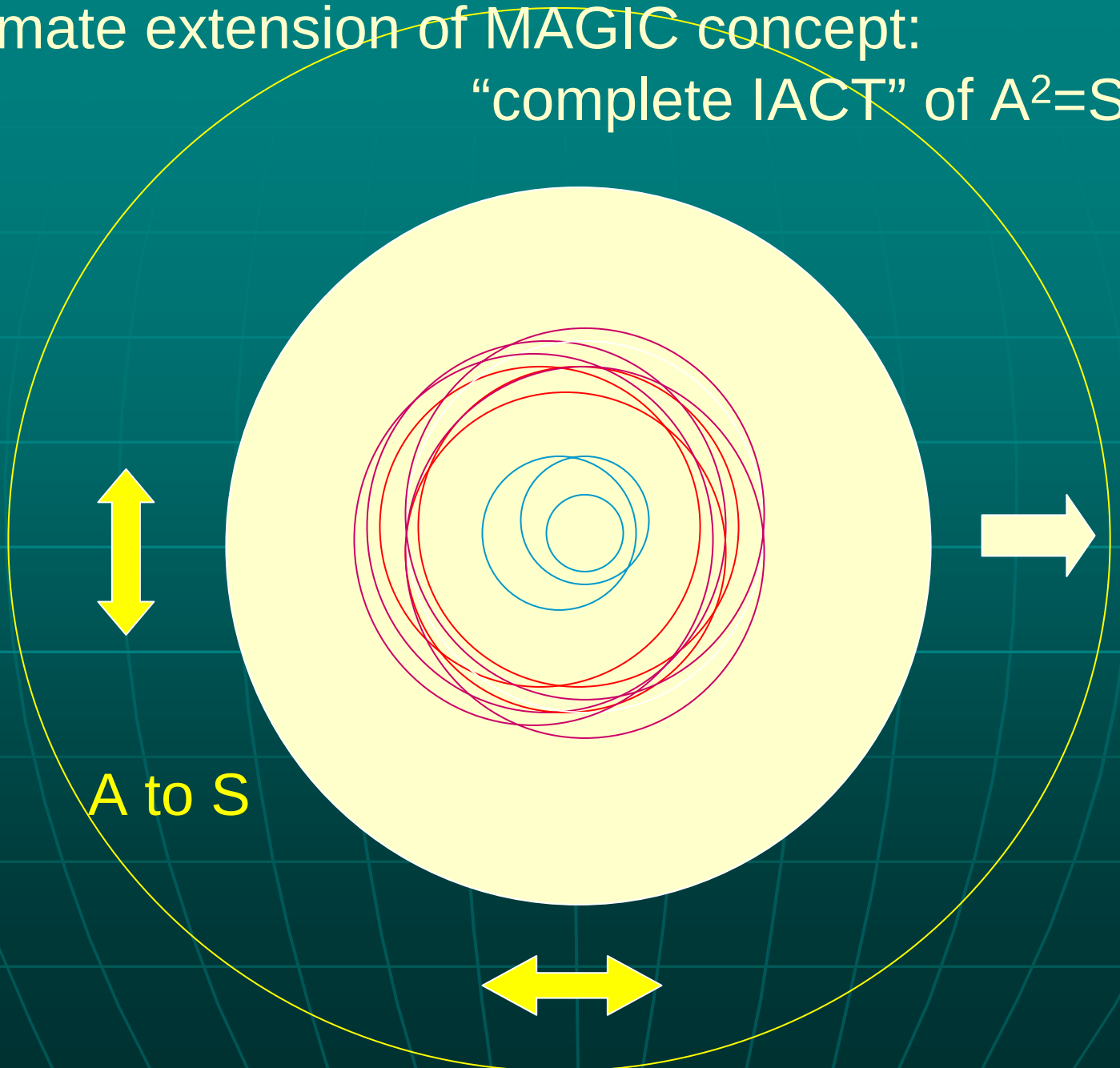
- $(5m)^2$ X 10 = $(16m)^2$ $(7m)^2$ X 10 = $(22m)^2$

How big the dish size, A, will be?

Byproduct of larger A: S = 1km^2 to (10km)^2



Ultimate extension of MAGIC concept:
"complete IACT" of A^2=S



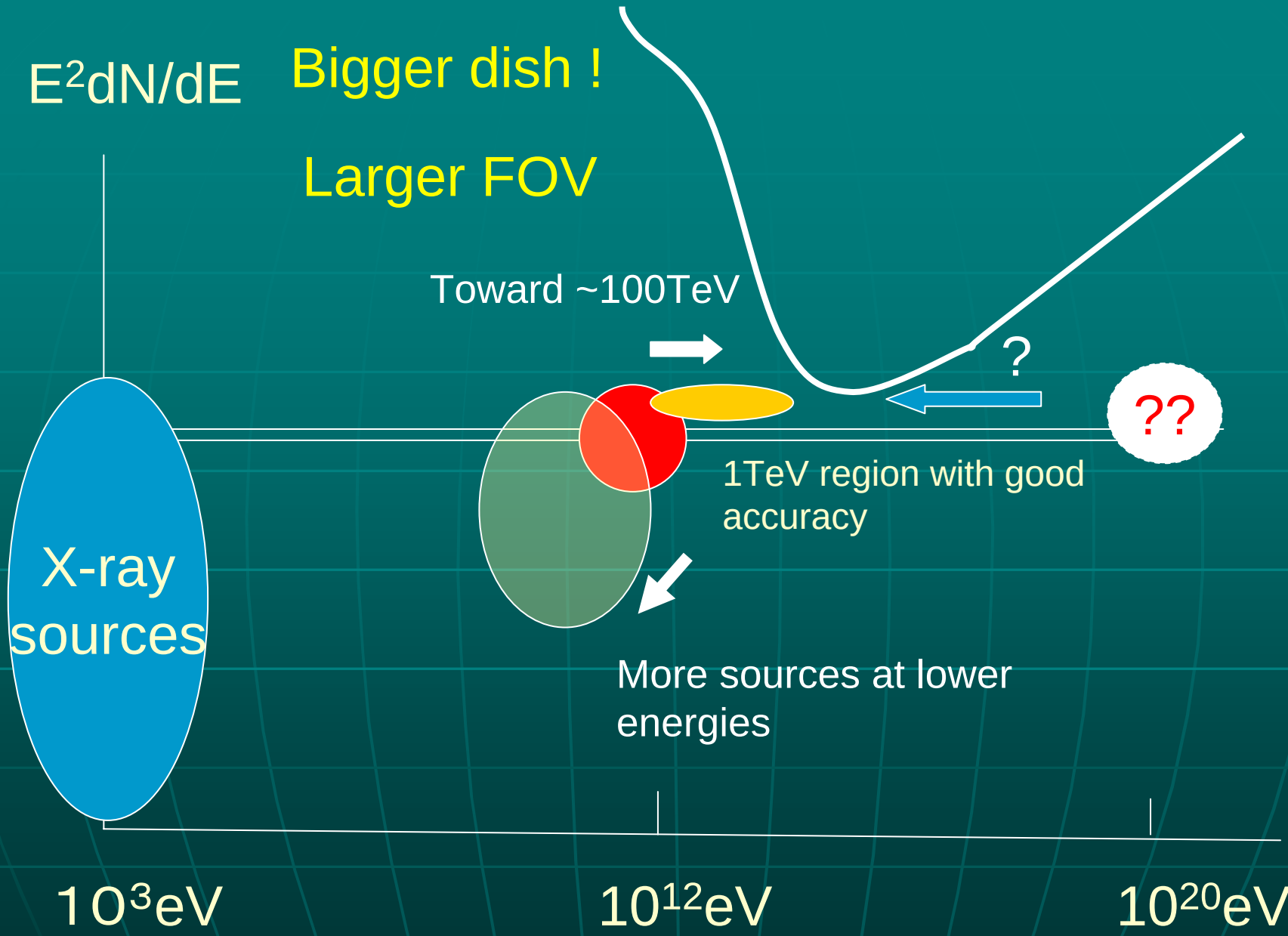
summary

Expected are 3 views for 3 energy regions,
which are not separated but quite interrelated.

- Going down to $E_{th} \leq 100$ GeV is the "first way" to take ;
  with additional efforts for increasing solid angle Ω of FOV

- Dish size A > 20m for 1 TeV
  (though no justification presented)
  (Or packed multiple telescope)

- Even larger dish size, will pave the way towards10~100TeV,
  where a big "jewel" might be hidden.


E²dN/dE
Bigger dish !
Larger FOV
Toward ~100TeV
?
??
1TeV region with good accuracy
X-ray sources
More sources at lower energies
10³eV
10¹²eV
10²⁰eV