



Introduction to Discoverology

Piotr Homola

Institute of Nuclear Physics PAN

CREDO Week, Discoverology Workshop, 1.10.2018

CREDO: the first $N_{\text{ATM}} \geq 1$ observatory

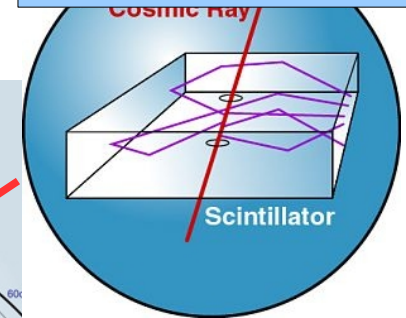
This talk

Cosmic-Ray Extremely Distributed Observatory

March 2016:
„CREDO idea”

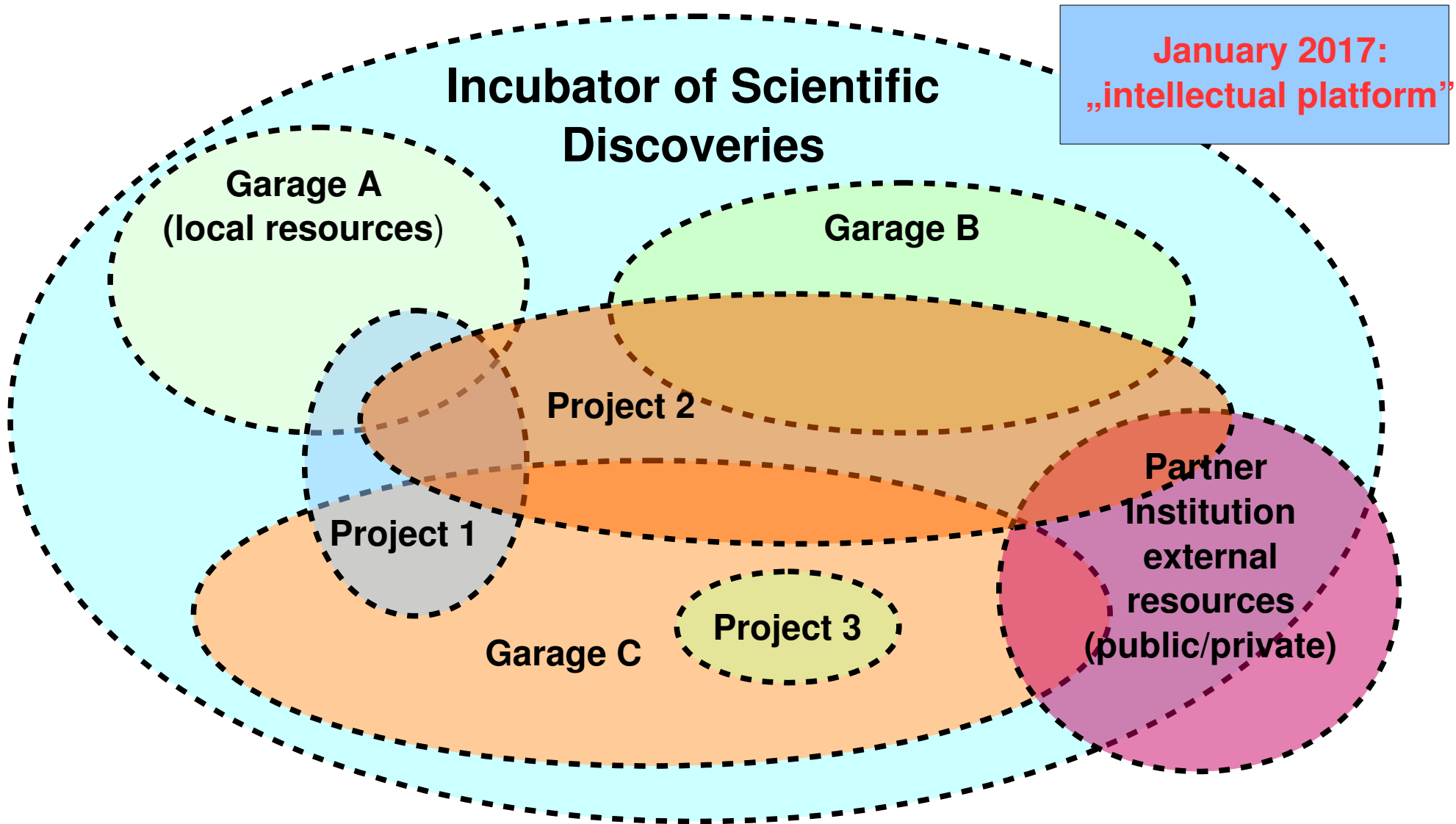


OPEN



Central database/interface: access to everything for everybody

Incubator of Scientific Discoveries: vision



Resources: money, space, tools, skills, competencies, advise, ...

Projects!: team, goal, road map, budget, action, reports, **continuity** → **discoveries!**

Distributed = access to more resources = **synergy** = better chance for discoveries.

Incubator of Scientific Discoveries: Motivation

Incubator role:
discoveries! (scientific **think tank**)

January 2017:
„intellectual training”

↓
Training required
... but no „**discovery education**”

↓
Consecutive approximation method...

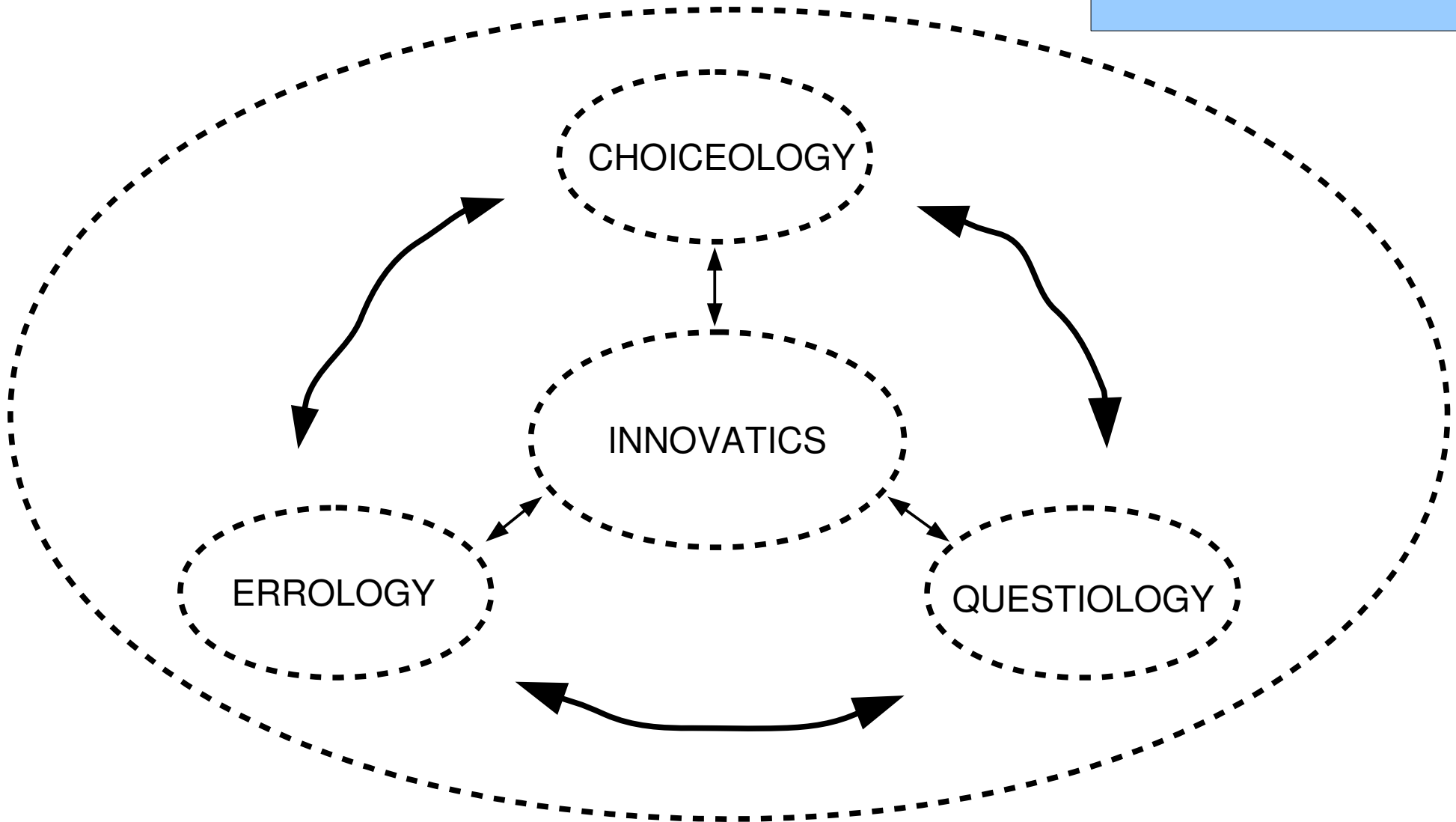


- ↓
- doing science (real discovery-oriented projects)
 - **remove thinking obstacles** (today first obstacle: **public perception of science**):
 - practice the **art of asking questions** (also unspoken so far)

Training to discoveries or... discipline?

DISCOVEROLOGY

January 2017:
„scientific formation”



1st article

April 2018:
„1st public article”



Cornell University
Library

We gratefully acknowledge support from
the Simons Foundation
and member institutions

arXiv.org > physics > arXiv:1804.06235

Search or Article ID

All fields



(Help | Advanced search)

Physics > Popular Physics

Introduction to discoverology

Piotr Homola

(Submitted on 16 Apr 2018)

Can we increase chances for a scientific breakthrough by get trained in discovery-oriented thinking?

Comments: postprint, 21 pages, 7 pages, chapter in "Earth Observation & Navigation. Law and Technology", e-mail: Piotr.Homola@ifj.edu.pl
Subjects: **Popular Physics (physics.pop-ph)**; History and Philosophy of Physics (physics.hist-ph)
Journal reference: "Earth Observation & Navigation. Law and Technology", Geo&IP Series, Warsaw, December 2017, ISBN: 978-83-946766-9-8
Cite as: [arXiv:1804.06235](#) [physics.pop-ph]
(or [arXiv:1804.06235v1](#) [physics.pop-ph] for this version)

Submission history

From: Piotr Homola Dr. [[view email](#)]
[v1] Mon, 16 Apr 2018 11:36:32 GMT (520kb)

[Which authors of this paper are endorsers?](#) | [Disable MathJax](#) ([What is MathJax?](#))

[Link back to: arXiv](#), [form interface](#), [contact](#).

Download:

- [PDF only](#)
(license)

Current browse context:

physics.pop-ph
< [prev](#) | [next](#) >
[new](#) | [recent](#) | [1804](#)

Change to browse by:

[physics](#)
[physics.hist-ph](#)

References & Citations

- [NASA ADS](#)

[Google Scholar](#)

Bookmark ([what is this?](#))



Can we increase chances for a scientific breakthrough by getting trained in discovery-oriented thinking?

2nd article

Piotr Homola – O konieczności uzupełnienia listy praw człowieka o prawo do informacji ...

Piotr HOMOLA

O KONIECZNOŚCI UZUPEŁNIENIA LISTY PRAW CZŁOWIEKA O PRAWO DO INFORMACJI O JAKOŚCI INFORMACJI

Wstęp

W poniższych rozważaniach zostaną przedstawione argumenty za koniecznością namysłu nad wpływem jakości powszechnie dostępnych informacji na ogólnie pojęte bezpieczeństwo strukturalne i personalne oraz, w konsekwencji, na rozwój cywilizacyjny. Nasze rozważania rozpoczniemy posługując się przykładami z obszaru nauk ścisłych i badań podstawowych, tj. w obrębie kompetencji zawodowych autora. Metodologia naukowa dysponuje prawdopodobnie najbardziej precyzyjnym, a przez to uniwersalnym językiem komunikacji interpersonalnej, w związku z tym oczekiwaliśmy, że informacje dostarczane społeczeństwu przez naukowców są i będą godne zaufania, inaczej mówiąc, że jakość tychże informacji będzie „dobra”.

Mimo iż, jak pokażemy, nie zawsze warto ufać naukowcom bezkrytycznie, precyzja języka nauki wciąż pozostaje punktem wyjścia w konstruktywnych rozważaniach nad zapewnieniem odpowiedniej jakości informacji również i w pozostałych dziedzinach aktywności społecznej. Zestandaryzowanie i monitorowanie jakości informacji przyswajanych na co dzień mniej lub bardziej świadomie, a następnie zapewnienie tym informacjom odpowiedniej jakości, wydaje się być misją niezmiernie ważną nie tylko dla naukowców, ale i dla całego społeczeństwa. Tezą niniejszego artykułu jest określenie wagi tejże misji: twierdzimy, że jest to wyzwaniem kategorii „być albo nie być”.

Jeśli faktycznie jakość informacji jest niezbędnie potrzebna do życia poszczególnego człowieka i rozwoju społecznego, dziwić może brak globalnej strategii w kierunku zapewnienia jej jakości. Być może ten artykuł nie zmieni od razu tej niekorzystnej sytuacji, może jednak dostarczyć inspiracji do rozmyślań i do wynikających z nich działań, które zaowocują w przyszłości.

1. Nauka? Podziwiam i ufam...

August 2018:
„2nd public article”

Information quality – why, what, and how?

- <https://www.dropbox.com/s/pmmsrzt6wdb4q6/homola-AWL-tlum-marta-marek.docx?dl=0> (EN translation - v.1)
- <https://www.dropbox.com/s/u79hbz74eok71e8/AWL-final.pdf?dl=0> (published version in Polish, see for Figures)

CREDO Week 2018

NOW!

**Cosmic-Ray Extremely Distributed Observatory:
join a global effort to detect and study
cosmic-ray ensembles.**

Including:

- Discoverology Workshop
- The CREDO School
- Anniversary Symposium
- Collaboration Meeting



**1-5 October, 2018,
Kraków, Poland**



Discoverology Workshop: Purpose, Outline and Rules



Purpose:

- Help science

Outline:

Introduction to Discoverology → Discoverology by Examples

- Executive Conclusions: Can discoverology help science?
If yes, what should be the next steps?





Rules:

- Honest, fearless, biasless thinking (probably impossible, but trying) towards helping science
- Keeping in mind: there are no experts on discoverology, everyone welcome to speak up
- Creative atmosphere: disagreement is good! Provoking is good!



Does science need help?

← → ↻ <https://www.amazon.com/Science-Does-Care-Believe-T-Shirt/dp/B06ZYFSPBV>

Amazon Fashion WOMEN MEN GIRLS BOYS BABY LUGGAGE SALES & DEALS

  Shop **prime** wardrobe  

Clothing, Shoes & Jewelry › Novelty & More › Clothing › Novelty › Men › Shirts › T-Shirts




Gbond Apparel
Science Does Not Care What You Believe T-Shirt
[Be the first to review this item](#)

Price: ~~\$14.99~~ - ~~\$17.99~~

Size:
 [Size Chart](#)

Color: Black







- 100% Premium Soft Cotton
- Pre-shrunk for comfortable fit and feel
- Printed in USA


Does science know it needs help?

← → ↻ <https://www.amazon.com/Science-Does-Care-Believe-T-Shirt/dp/B06ZYFSPBV>

Amazon Fashion WOMEN MEN GIRLS BOYS BABY LUGGAGE SALES & DEALS

  Shop **prime** wardrobe  

Clothing, Shoes & Jewelry › Novelty & More › Clothing › Novelty › Men › Shirts › T-Shirts



**DOES [REDACTED] CARE
WHAT YOU
BELIEVE**


**CONSIDER
EXTERNAL
IMPACTS!**

Gbond Apparel
Science Does Not Care What You Believe T-Shirt
[Be the first to review this item](#)

Price: ~~\$14.99~~ - ~~\$17.99~~

Size:
 [Size Chart](#)

Color: Black



- 100% Premium Soft Cotton
- Pre-shrunk for comfortable fit and feel
- Printed in USA

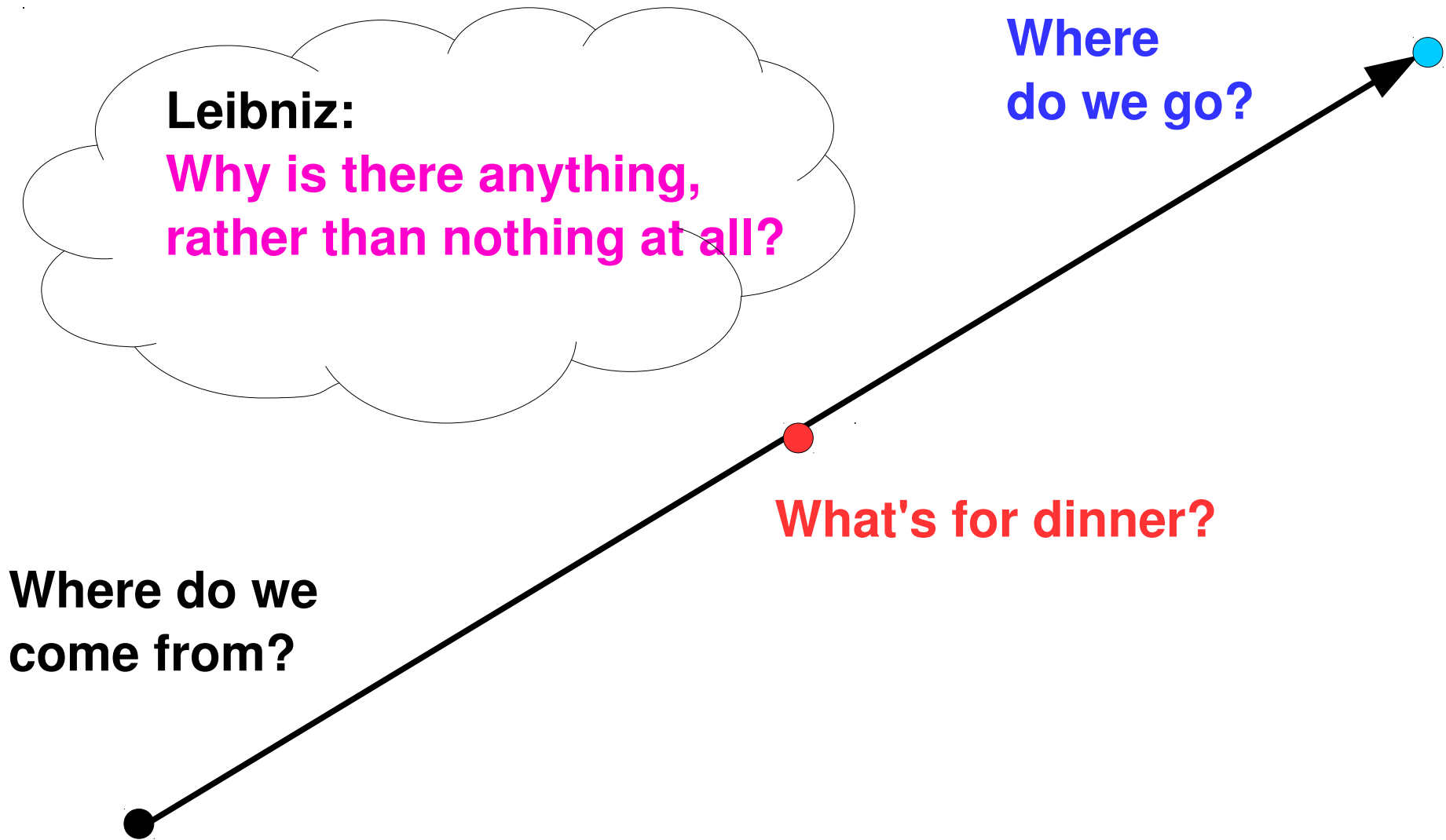
Tools for science

Intelligence:
processing information

Reason:
choosing what to process

Reason > Intelligence

First Aid in Thinking: questions is life



Philosophical Tree: what is the “beginning”?

Why is there anything, rather than nothing at all?



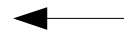
?

Ψ

[Where do I come from?]

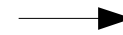
[Where do I come from?]

CREATION

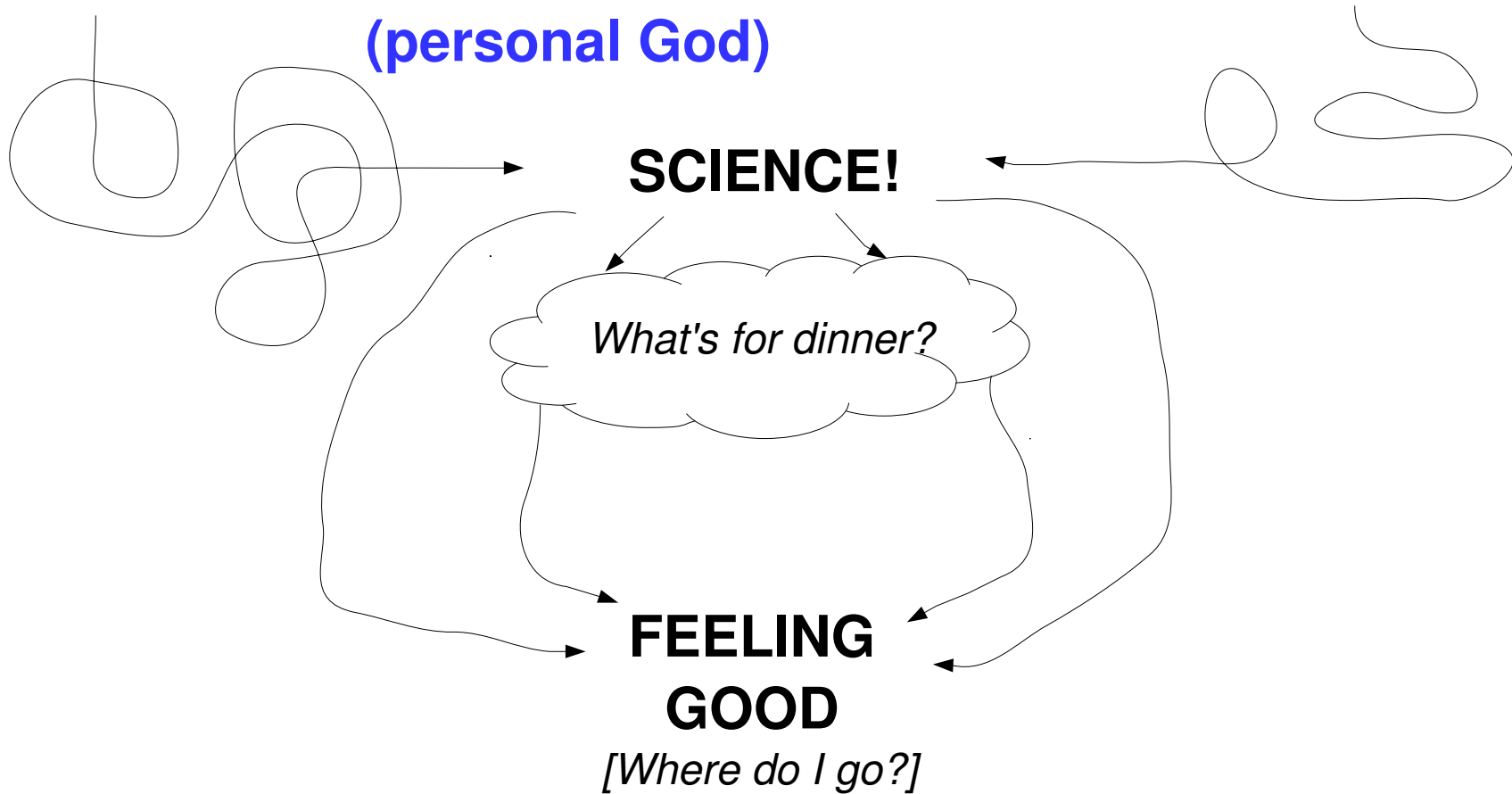


Absolute
(personal God)

absolute



EMERGENCE



[Where do I go?]

Philosophical Tree: reason & faith interplay?

Why is there anything, rather than nothing at all?



?

faith

Ψ

[Where do I come from?]

CREATION

reason

Absolute
(personal God)

absolute

reason

[Where do I come from?]

EMERGENCE

SCIENCE!

What's for dinner?

FEELING
GOOD

[Where do I go?]

faith

reason

faith

reason

faith

reason

faith

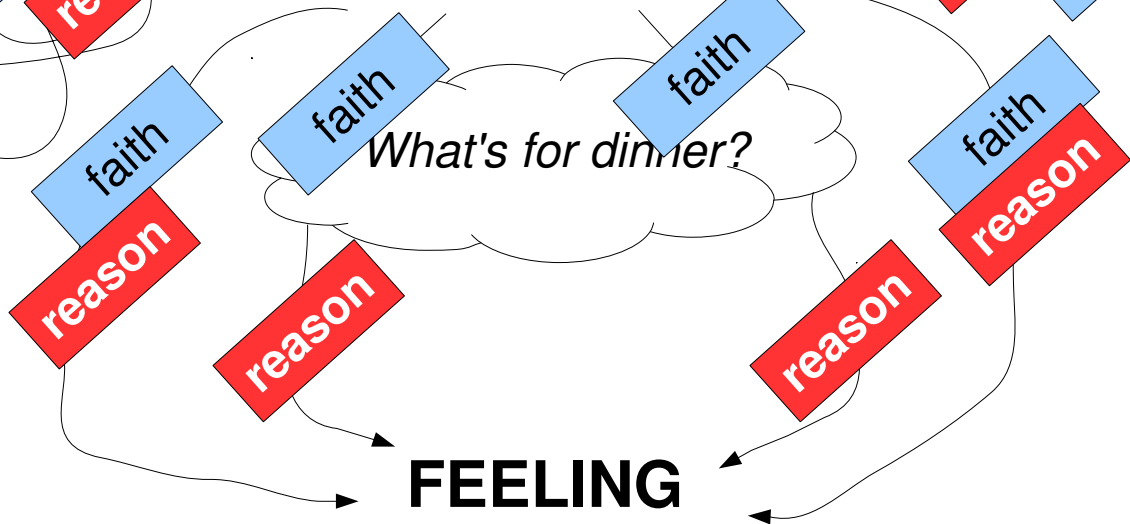
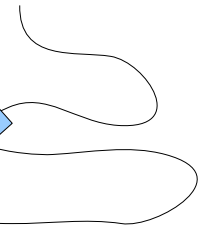
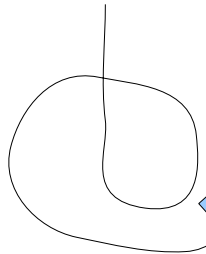
reason

reason

faith

faith

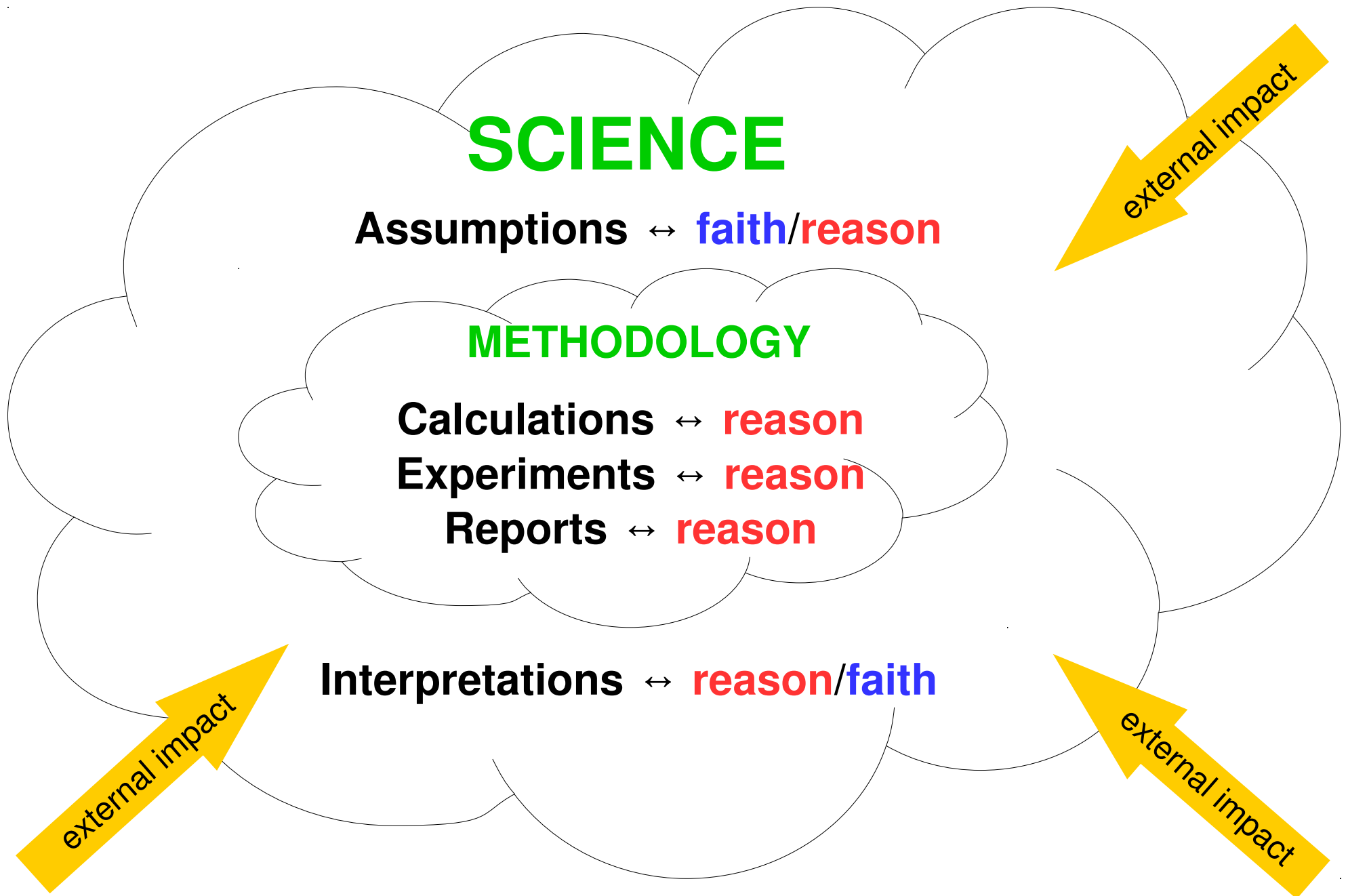
reason



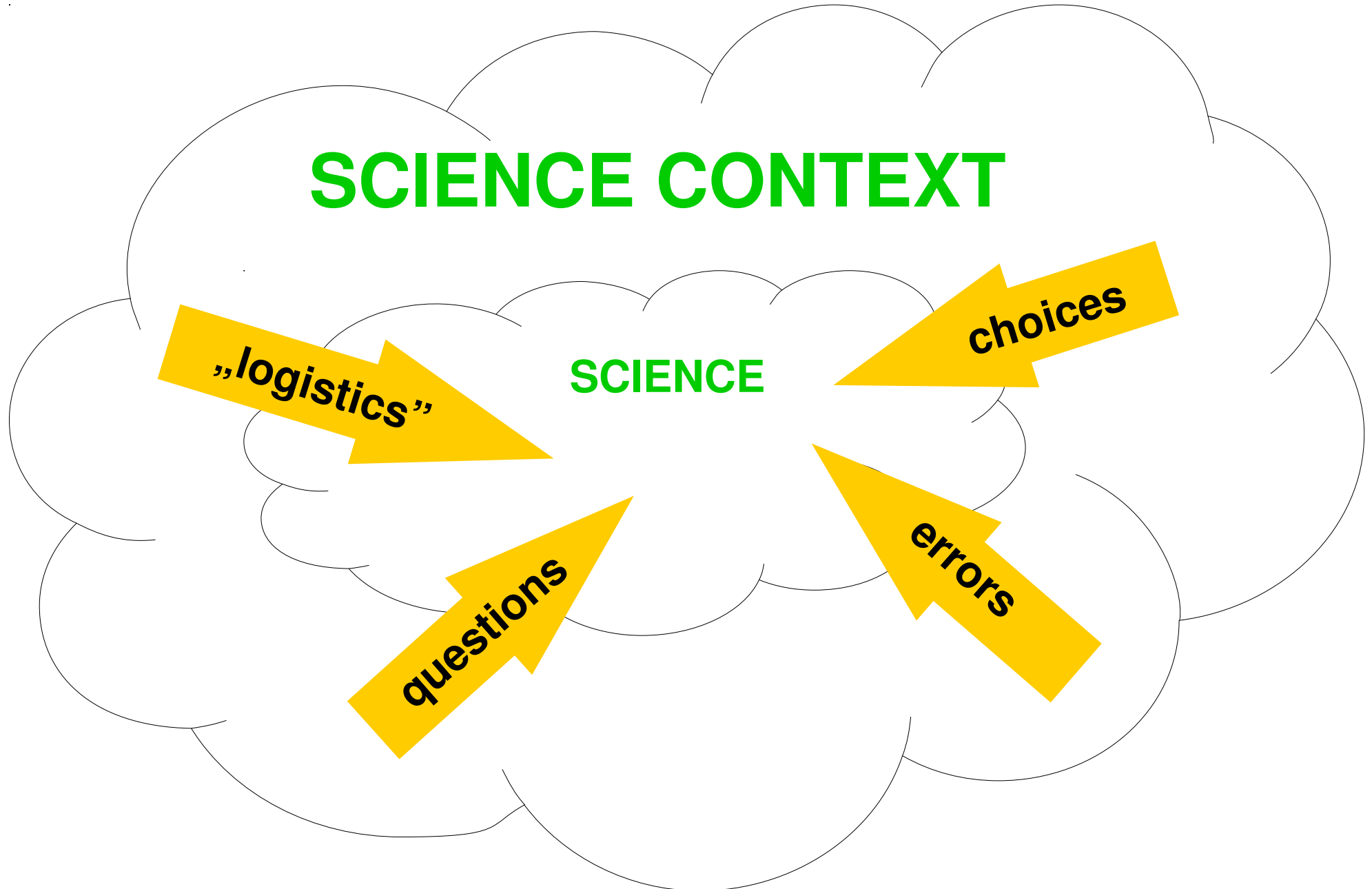


Copernicus vs. Flat Earth Society

Science: reason & faith interplay?

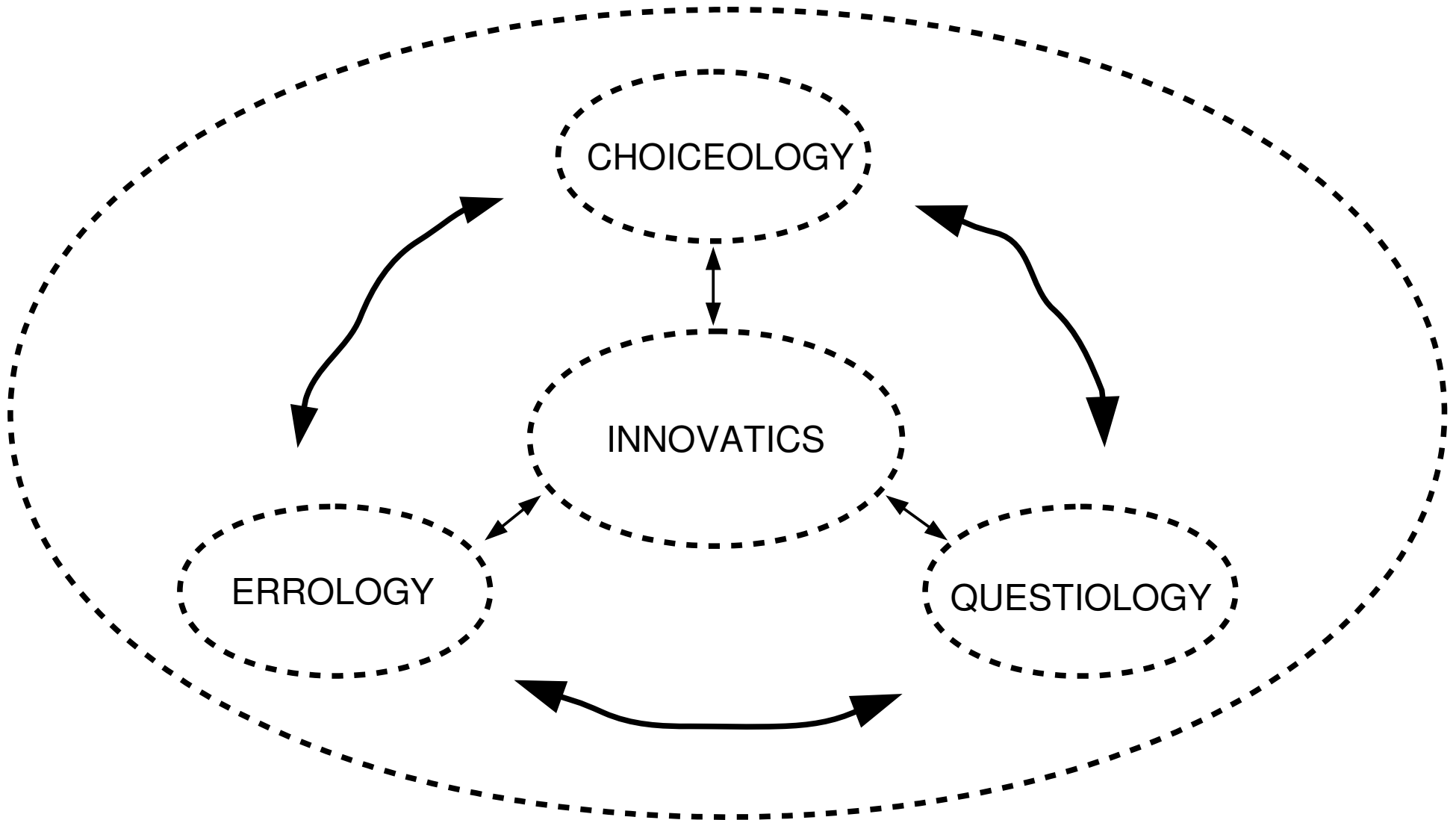


Science & “external” impact



Derived ab initio...

DISCOVEROLOGY

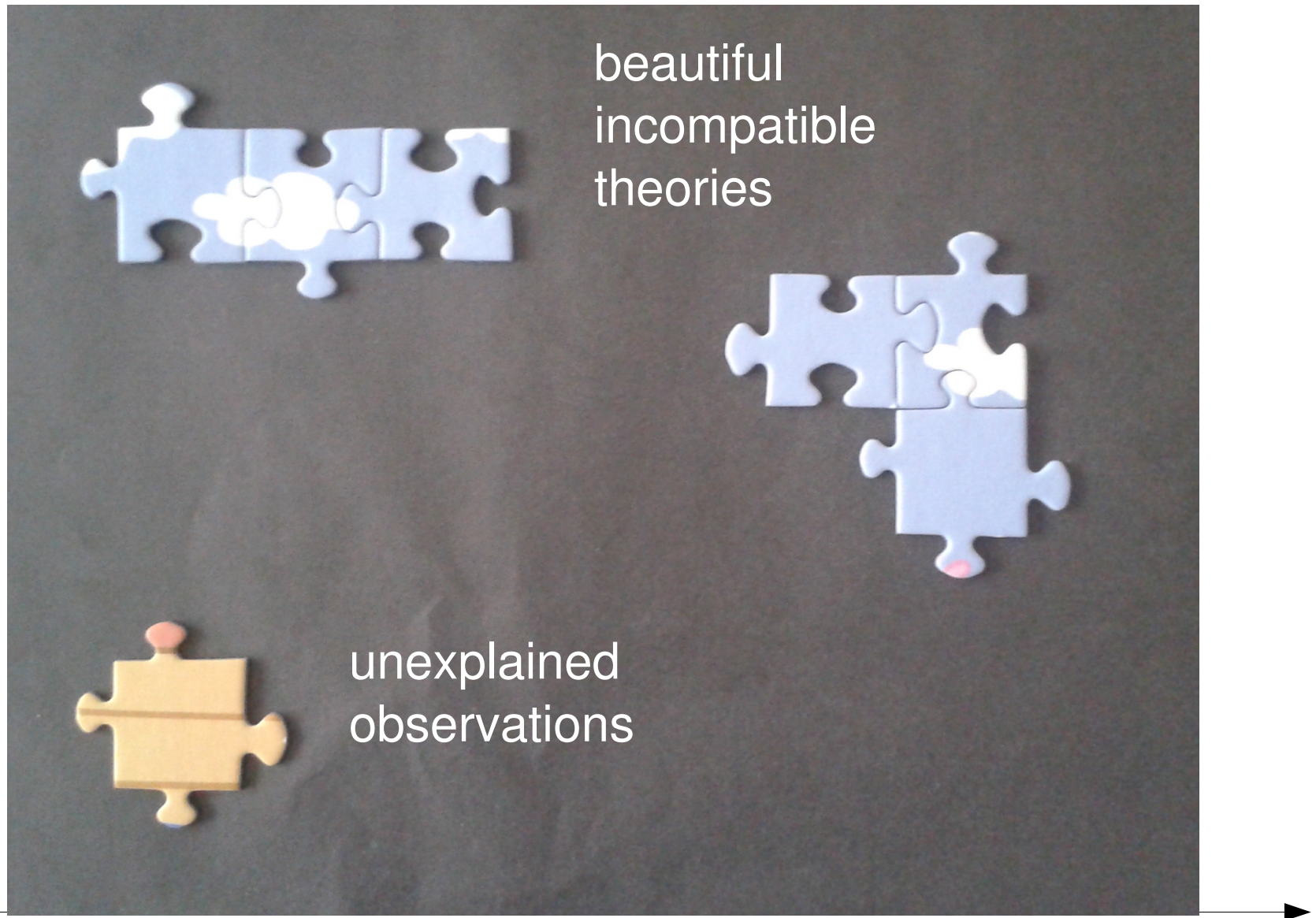




Discoverology by Examples

1. Choiceology

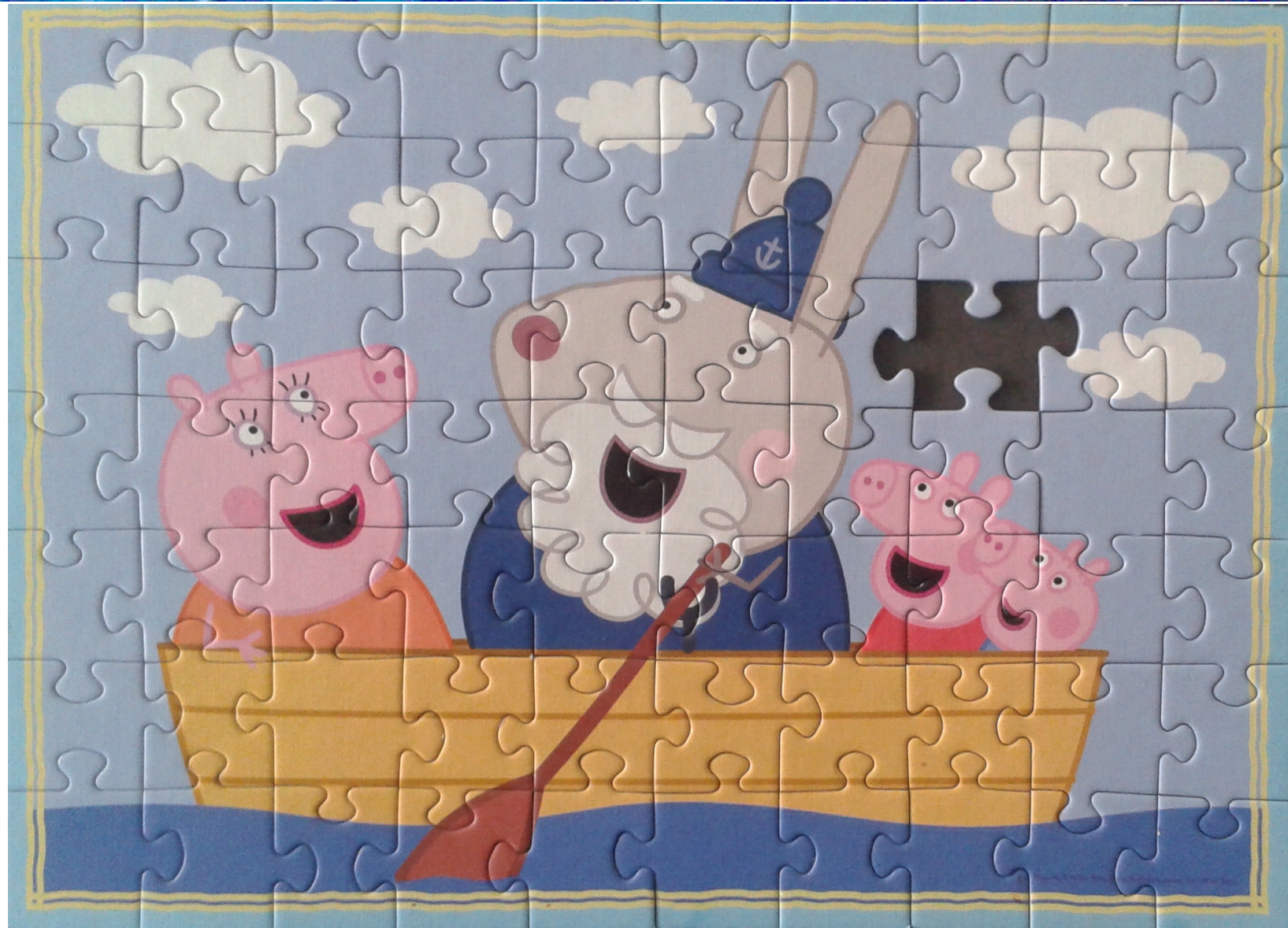
Understanding the Universe



PHYSICAL PARAMETER SPACE

Many discoveries remain to be made?

Understanding the Universe

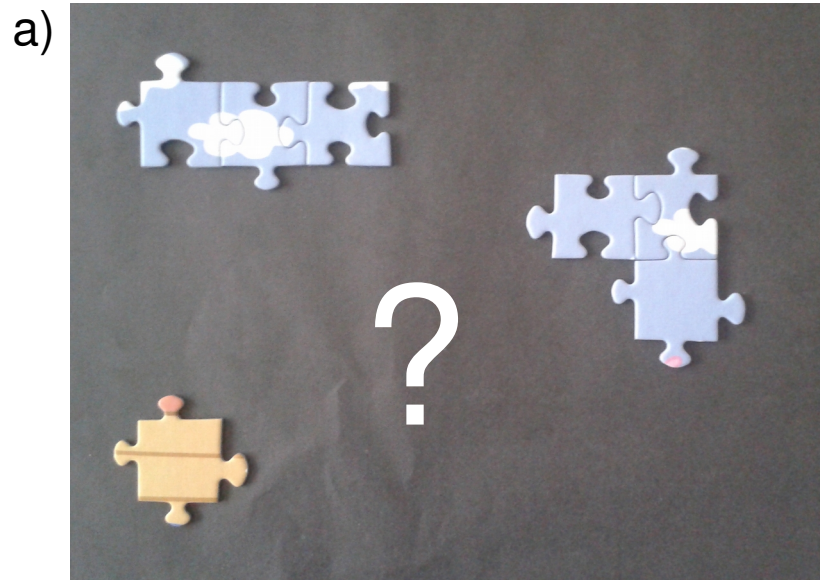


PHYSICAL PARAMETER SPACE

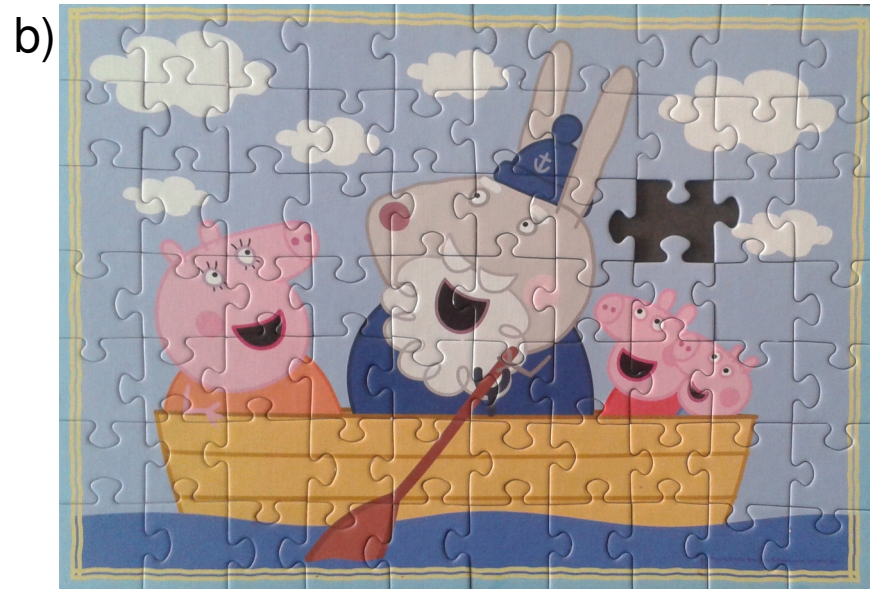
... or very few?

Life changing choice: to science or not to science?

We do not know
more than we know?



We know
more than we do not know?



Popularization of science:

- being aware of the available knowledge
- **being aware of challenges**

popularization of WHAT WE DO NOT KNOW?
especially if we live in the Universe type a) ...?

Example (real) conversation with authority

A: About preshowering: where can it happen outside the geomagnetic field ?
The angular expansion of astrophysical sites with a large field is negligible.
The only object we can consider is the Sun: in that case the signature is obviously
the direction of incidence. **I have examined this scenario many years ago,**
and the conclusion as that the cross section is **not large enough**
to produce a significant signal references

**Strong
discourage!**

PH: I somehow missed your work on preshowering near the Sun, was it a
GAP note or a journal paper? I've always used Bednarek 1999 as
a reference for this, I should add your publication as well, **could you
please let me know the details?** Then I'd read/ask how you did your analysis.

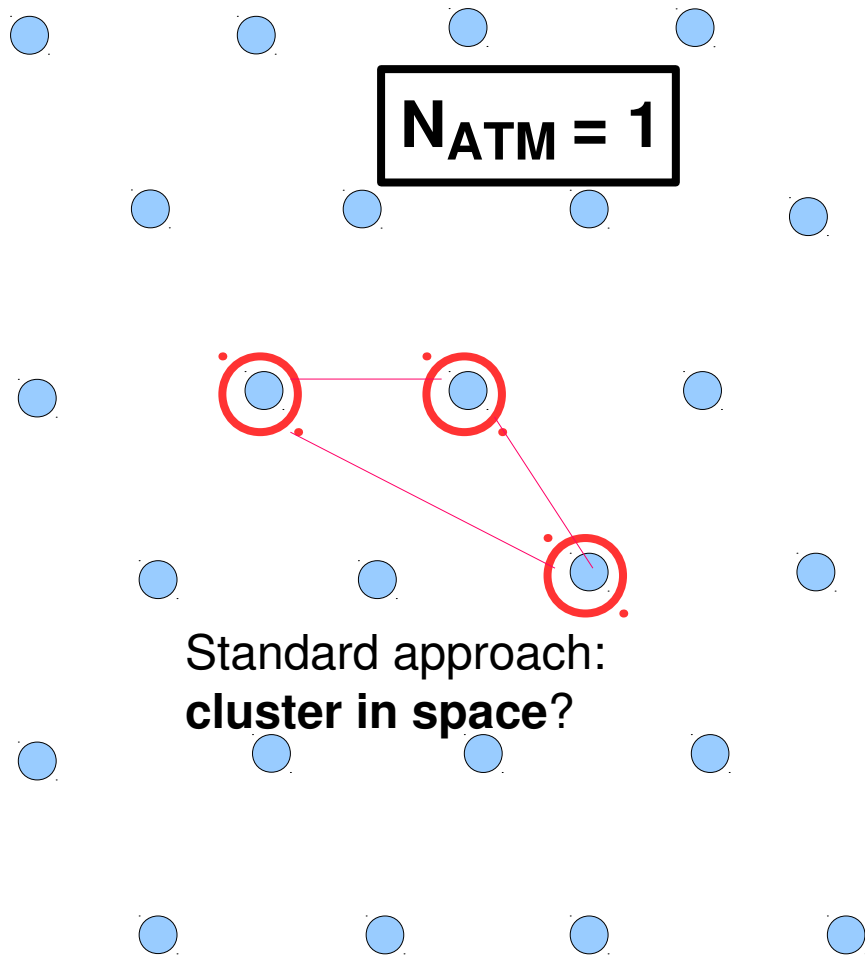
**Limited
trust...**

A: ...Whatever the theoretical foundation of super-preshowers, they will arrive on Earth with
a large spread, so a small local density. Have you seriously computed this spread
and evaluated the probability to activate our global trigger without the help of random signals?
For me, this is a necessary step before searching for a signature.

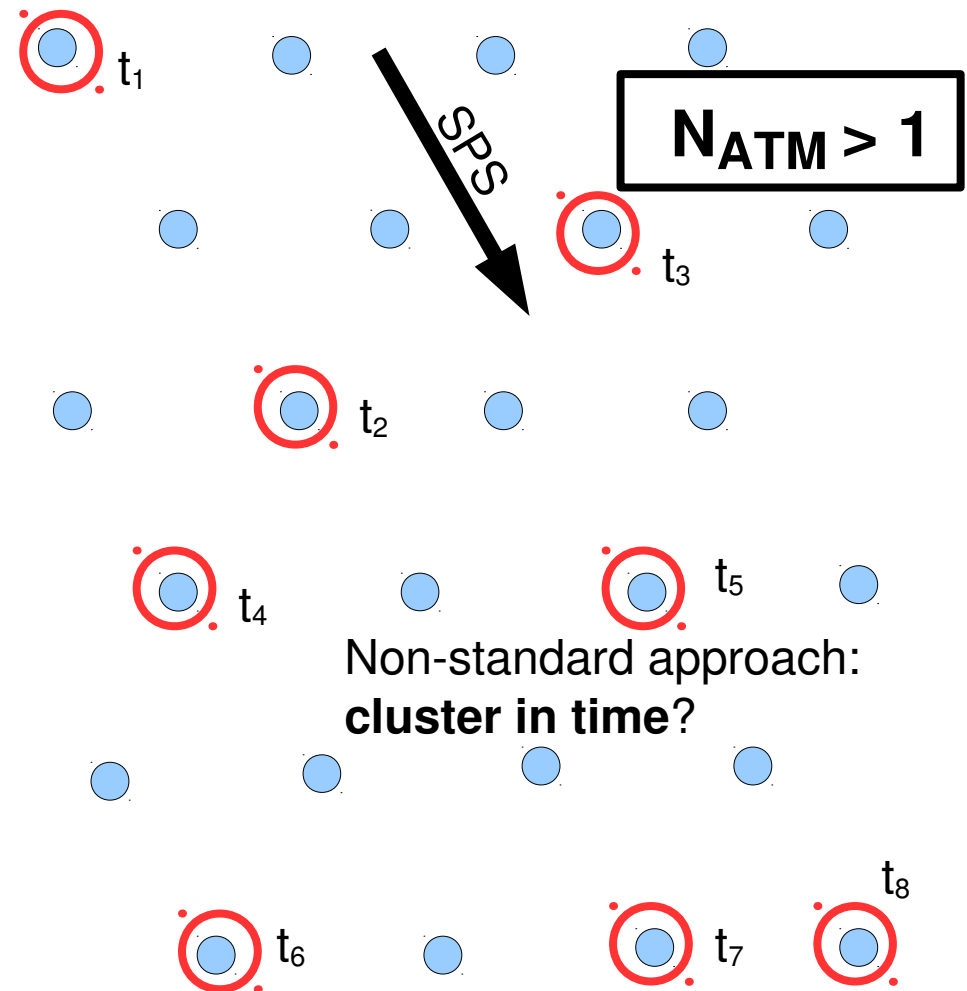
I did not make an estimation, but I suspect that the preshowering should occur close
to the Earth to give a detectable shower (and maybe the Sun is too far away)

**Intuitional (non-scientific!) discourage.
Defence of self-comfort?...**

A chance for a **unique CRE signature**



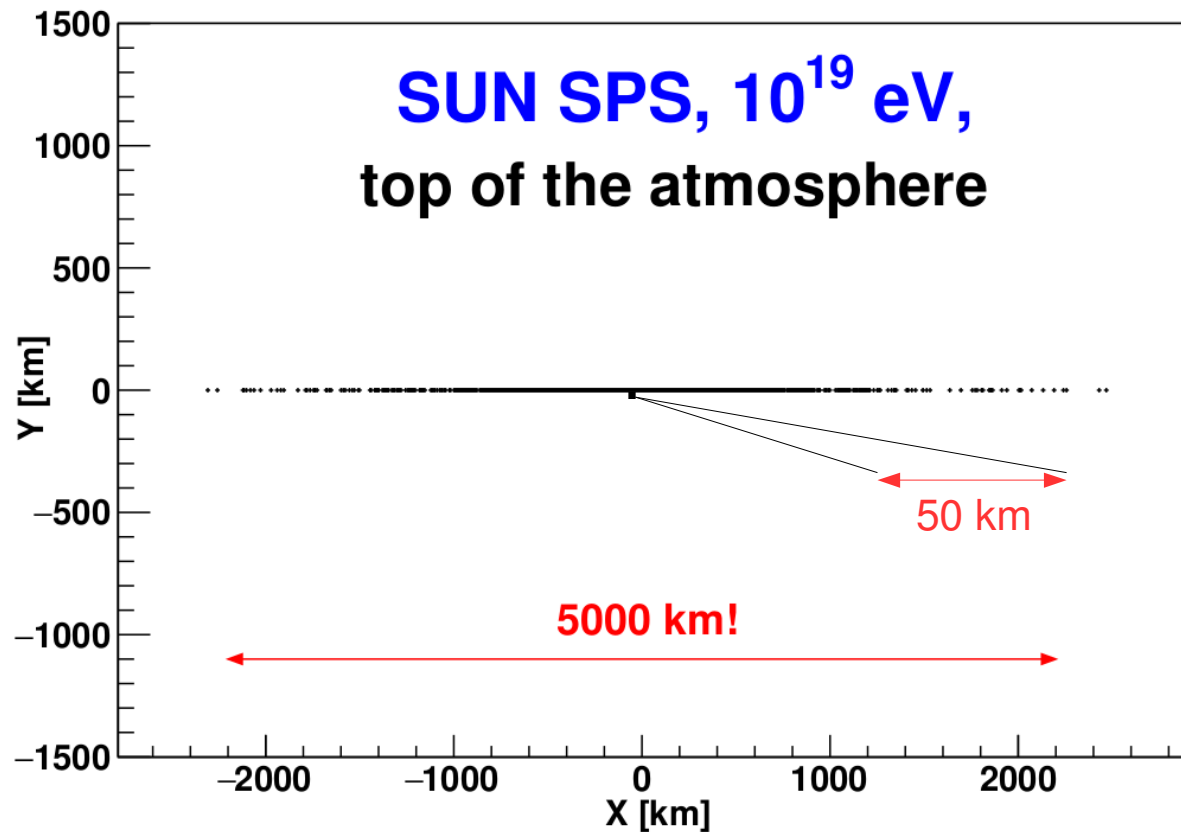
● : a cosmic-ray detector



- 1) $t_n - t_1 < \sim 1 \mu\text{s}$
- 2) $t_1 < \dots < t_n,$

Sun super-preshowers - simulations

Distribution of photons at the top of the Atm

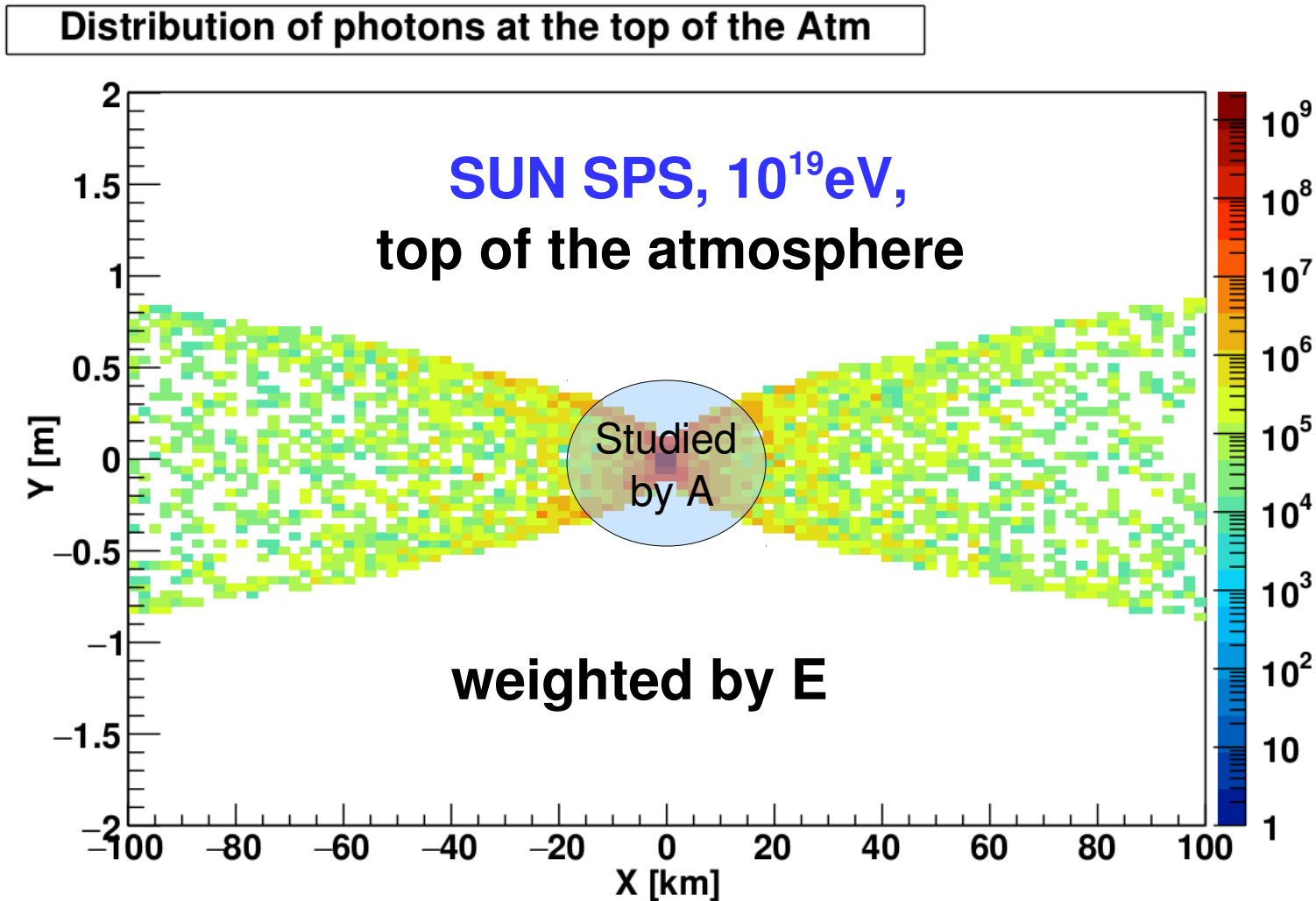


Studied
by A

Distribution of photons ($E > 10^{13}$ eV) at the top of the atmosphere.
 $E_\gamma = 10$ EeV, Impact parameter = $2.5R_S$.

Sun super-preshowers: colorful air shower physics?

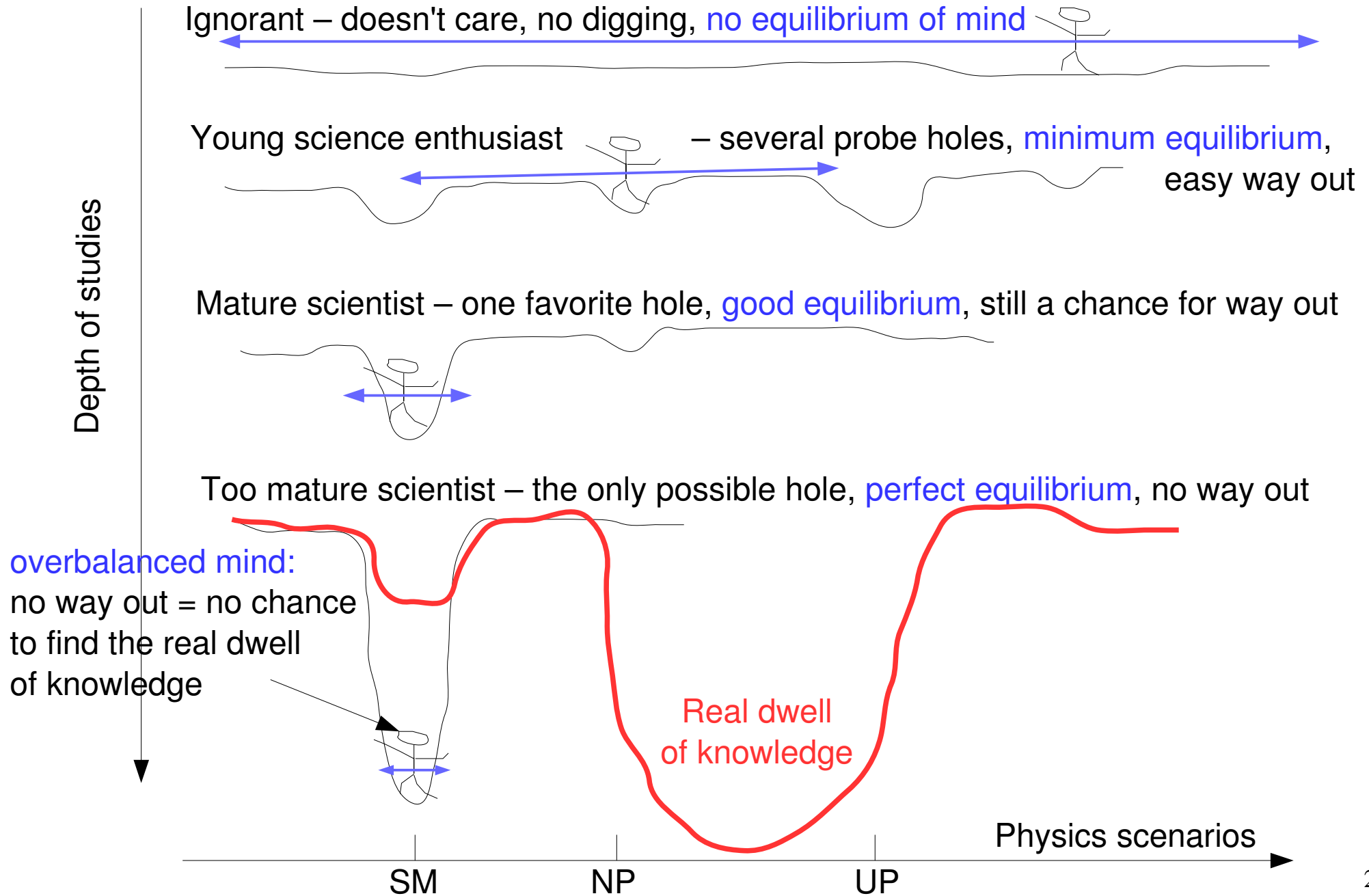
Distribution of photons weighted by their energies.



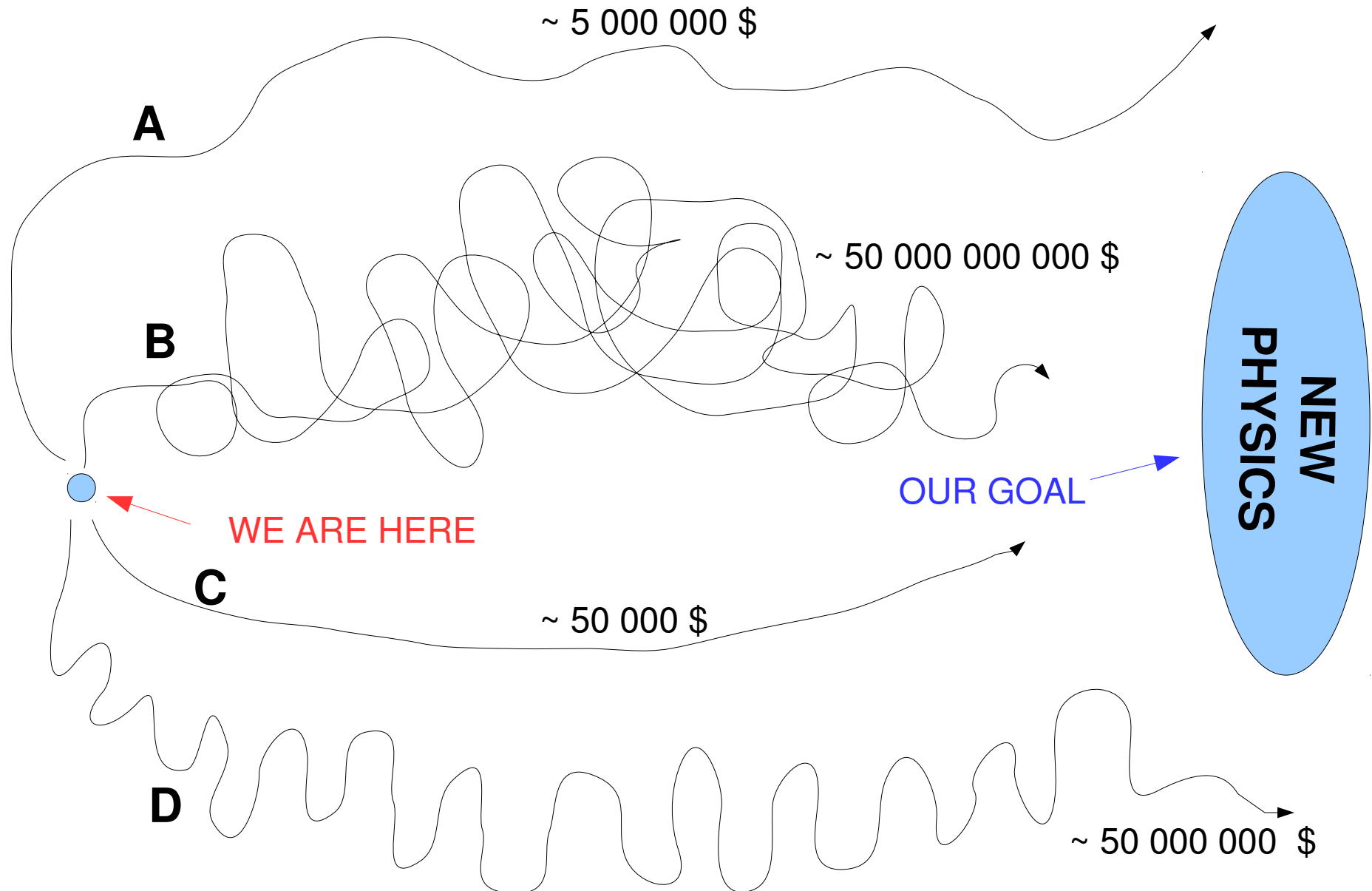
Distribution of photons ($E > 10^{15}$ eV) at the top of the atmosphere.

$E_\gamma = 10$ EeV, Impact parameter = $2.5R_S$.

Digging a well of knowledge or **why young is good**



CHOICEOLOGY: example of practical philosophy



Which project to be funded?

Science: all; Philosophy: the most promising; Economy: cheap; Ethics: good for civilization

To publish or not to publish?

VOLUME 50, NUMBER 26

PHYSICAL REVIEW LETTERS

27 JUNE 1983

Possible Observation of a Burst of Cosmic-Ray Events in the Form of Extensive Air Showers

Gary R. Smith, M. Ogmen, E. Buller, and S. Standil

Physics Department, University of Manitoba, Winnipeg, Manitoba R3T 2N2, Canada

(Received 7 April 1983)

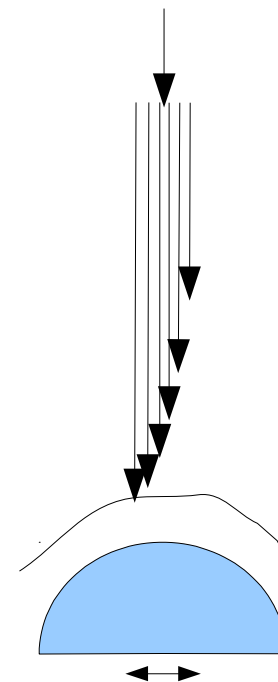
A series or burst of 32 extensive air showers of estimated mean energy 3×10^{15} eV was observed within a 5-min time interval beginning at 9:55 A.M. (CST) on 20 January 1981 in Winnipeg, Canada. This observation was the only one of its kind during an experiment which recorded 150 000 such showers in a period of 18 months between October 1980 and April 1982.

PACS numbers: 94.40.Pa, 94.40.Re, 95.30.-k

Forgotten (!) treasure (?) no. 1

PH: Correlated cosmic rays?

$$N_{\text{ATM}} > 1?$$



Year = 1981

$N_{\text{obs}} = 32$

$N_{\text{exp}} = 1$

$E = 3 \times 10^{15} \text{ eV}$

$\Delta t \sim 5 \text{ min.}$

$\Delta x \geq \text{small}$

To publish or not to publish?

VOLUME 51, NUMBER 25

PHYSICAL REVIEW LETTERS

19 DECEMBER 1983

Observation of a Burst of Cosmic Rays at Energies above 7×10^{13} eV

D. J. Fegan and B. McBreen

Physics Department, University College Dublin, Dublin 4, Ireland

and

C. O'Sullivan

Physics Department, University College Cork, Cork, Ireland

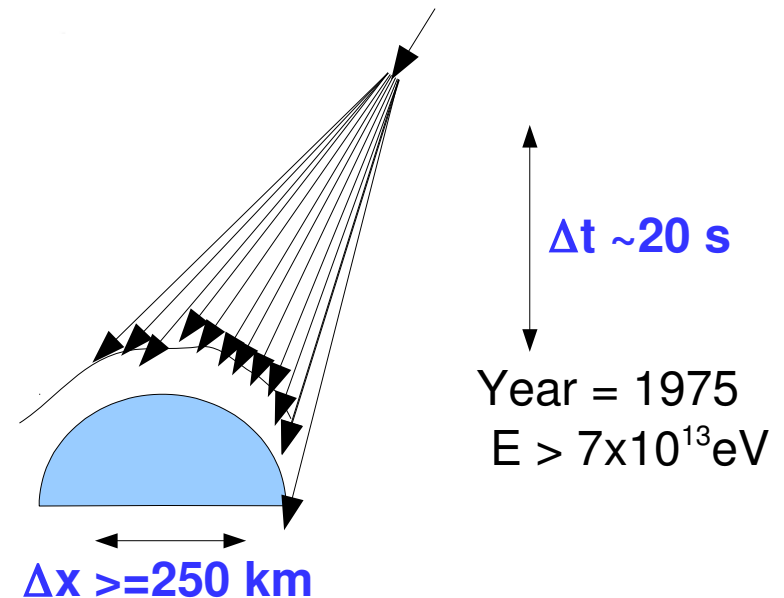
(Received 14 September 1983)

The authors report on an unusual simultaneous increase in the cosmic-ray shower rate at two recording stations separated by 250 km. The event lasted for 20 s. This event was the only one of its kind detected in three years of observation. The duration and structure of this event is consistent with a recently reported single-station cosmic-ray burst. The simultaneity of the coincident event suggests that it was caused by a burst of cosmic gamma rays. There is a possibility that this event may be related to the largest observed glitch of the pulsar in the Crab Nebula.

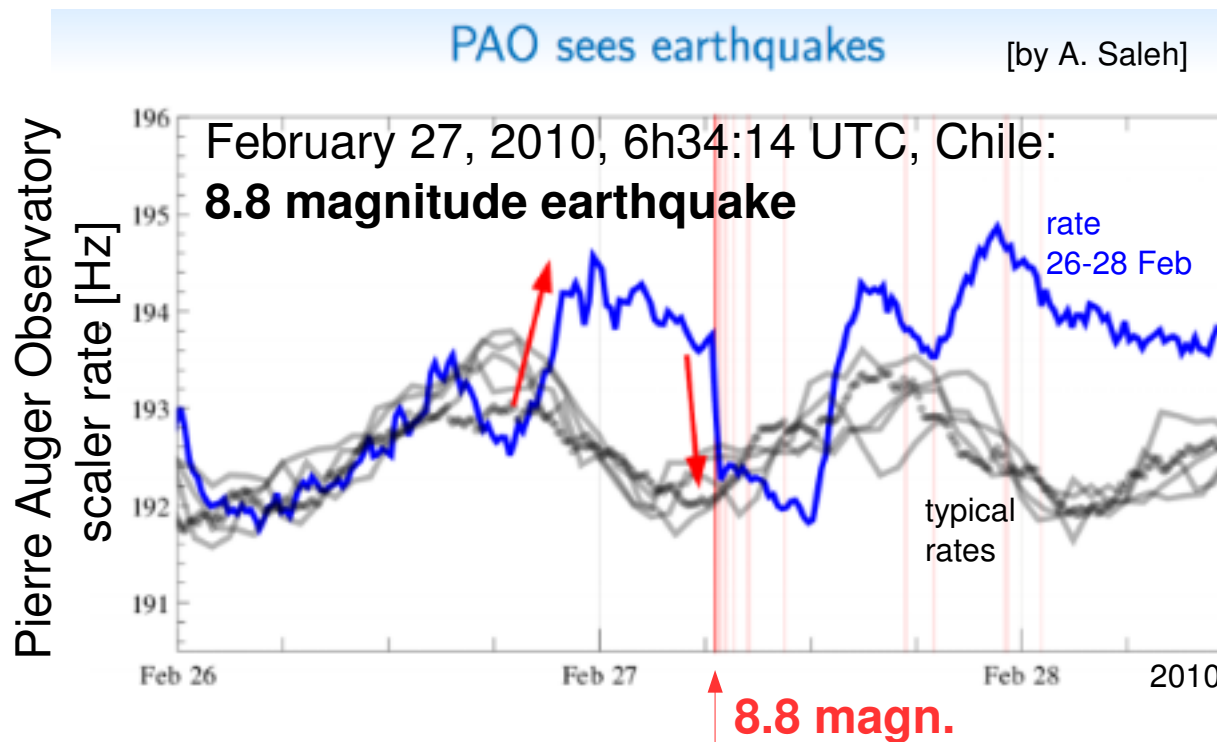
PACS numbers: 94.40.Pa, 95.85.Qx, 97.80.Jp

PH: Correlated cosmic rays?

$N_{\text{ATM}} > 1?$



Scientific diversity: GEO



- Increase of CR before the earthquake
- Strong drop during the earthquake

→ **CREDO-earthquakes task** [already existing]

Inhabitants of territories
threatened by earthquakes
[= potential CREDO
public engagement target]:
2,7 billion people

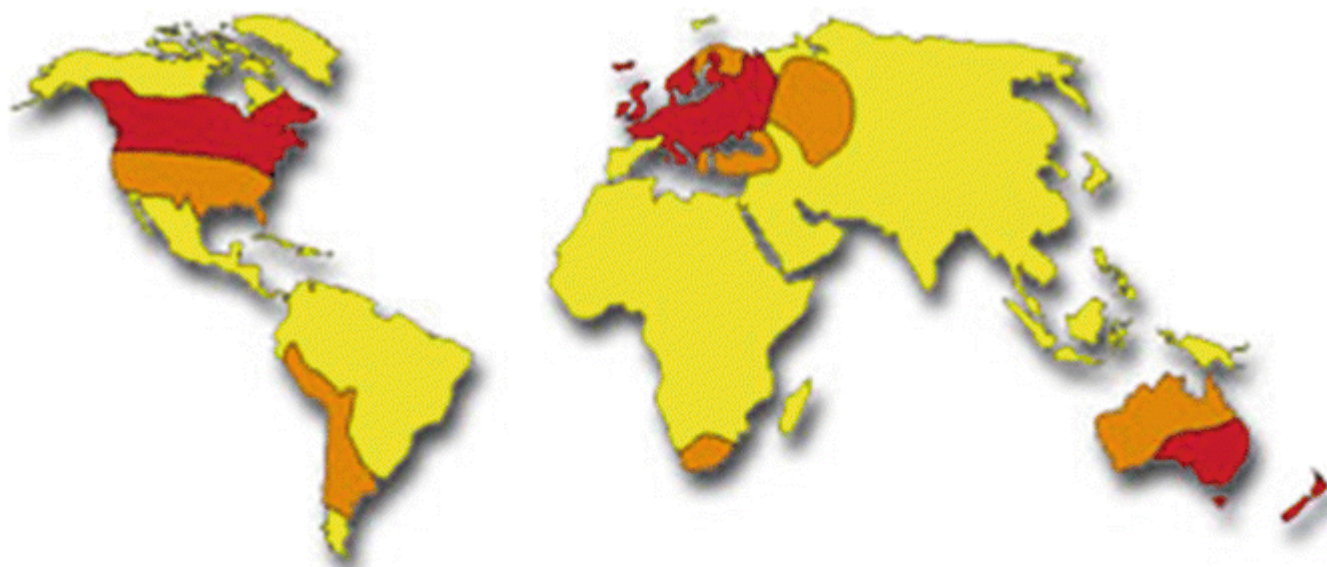
**Science as a service to
the human community?**

Even the smallest chance to
save lives
= a must check!



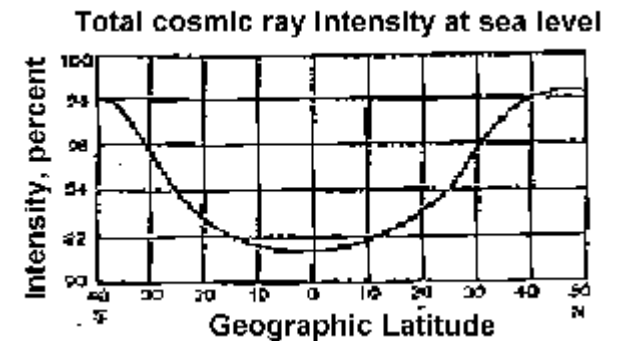
THE QUEST FOR THE UNEXPECTED

Scientific diversity: **BIO**



Worldwide distribution of MS

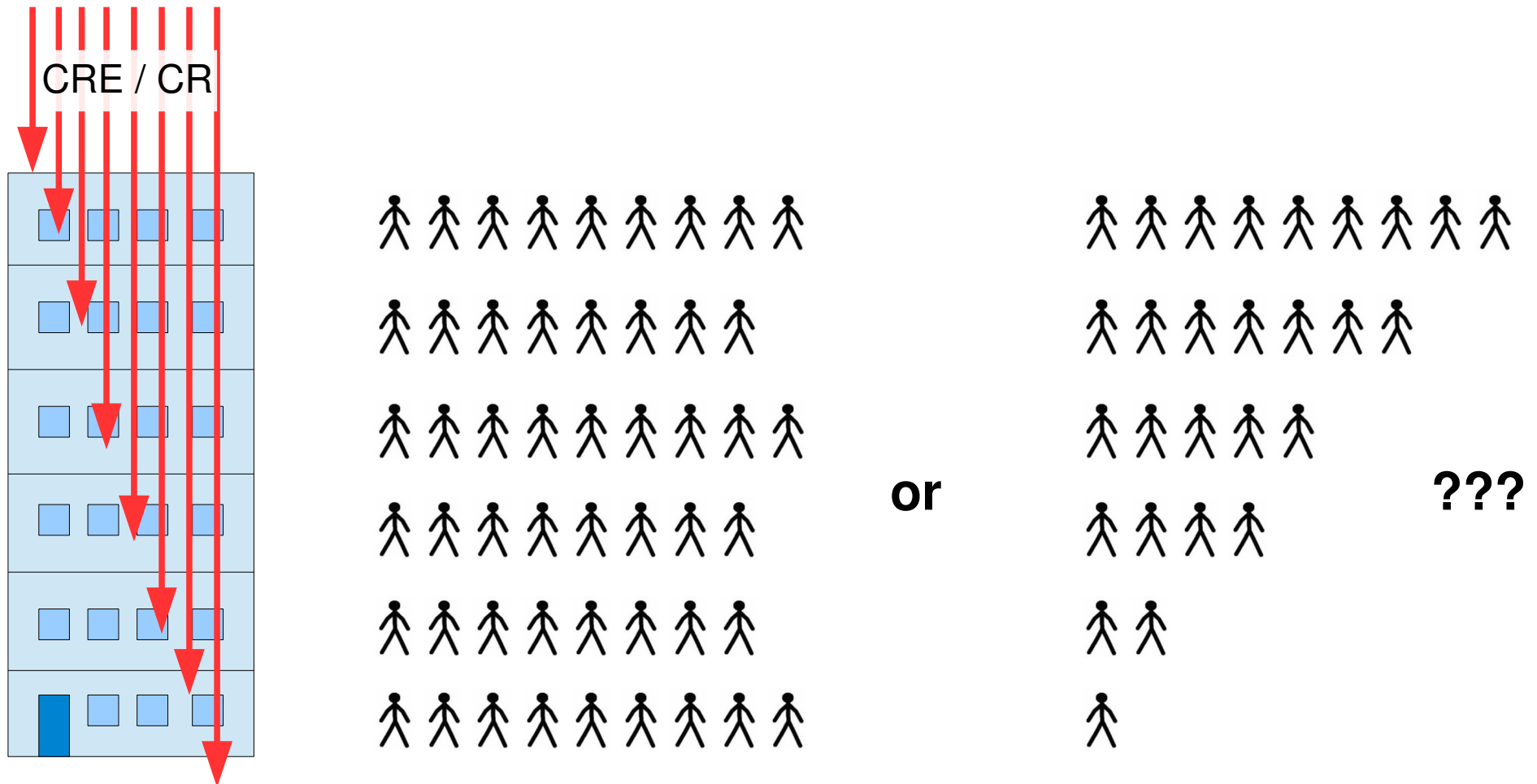
- Higher than 30/100,000
- Between 5/100,000 and 30/100,000
- Below 5/100,000



http://www.geoexplo.com/airborne_survey_workshop_rad.html

Costelloe L., Fletcher J., Fitzgerald D.
(2016) Neuroinflammatory Disorders.
In: Hardiman O., Doherty C., Elamin M., Bede P. (eds)
Neurodegenerative Disorders. Springer, Cham,
https://doi.org/10.1007/978-3-319-23309-3_15

multiple sclerosis and cosmic rays: the floor test???





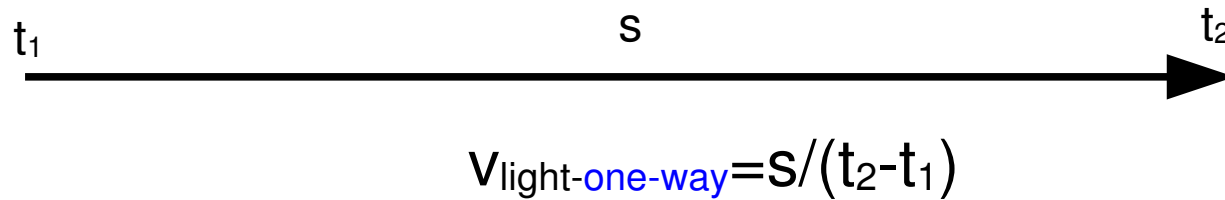
Discoverology by Examples

2. Questiology

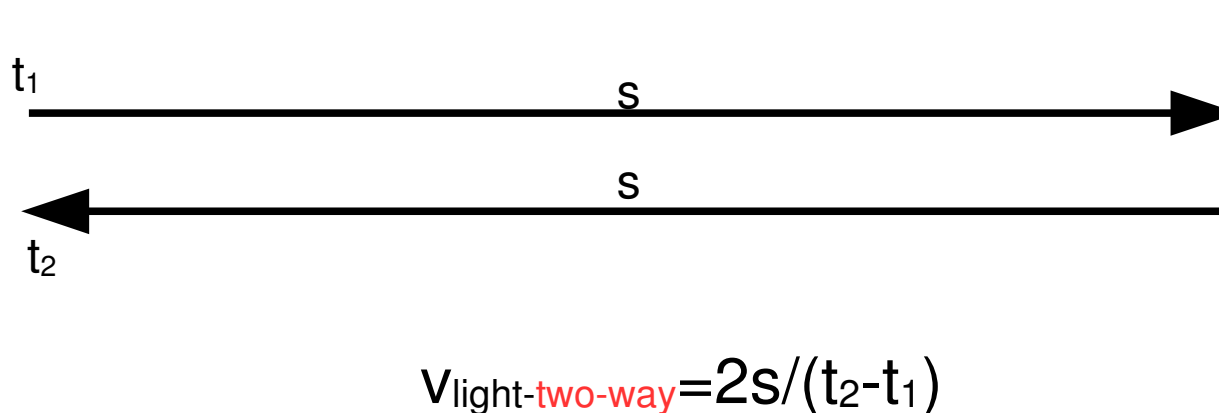


Speed of light = c? Which speed of light:...

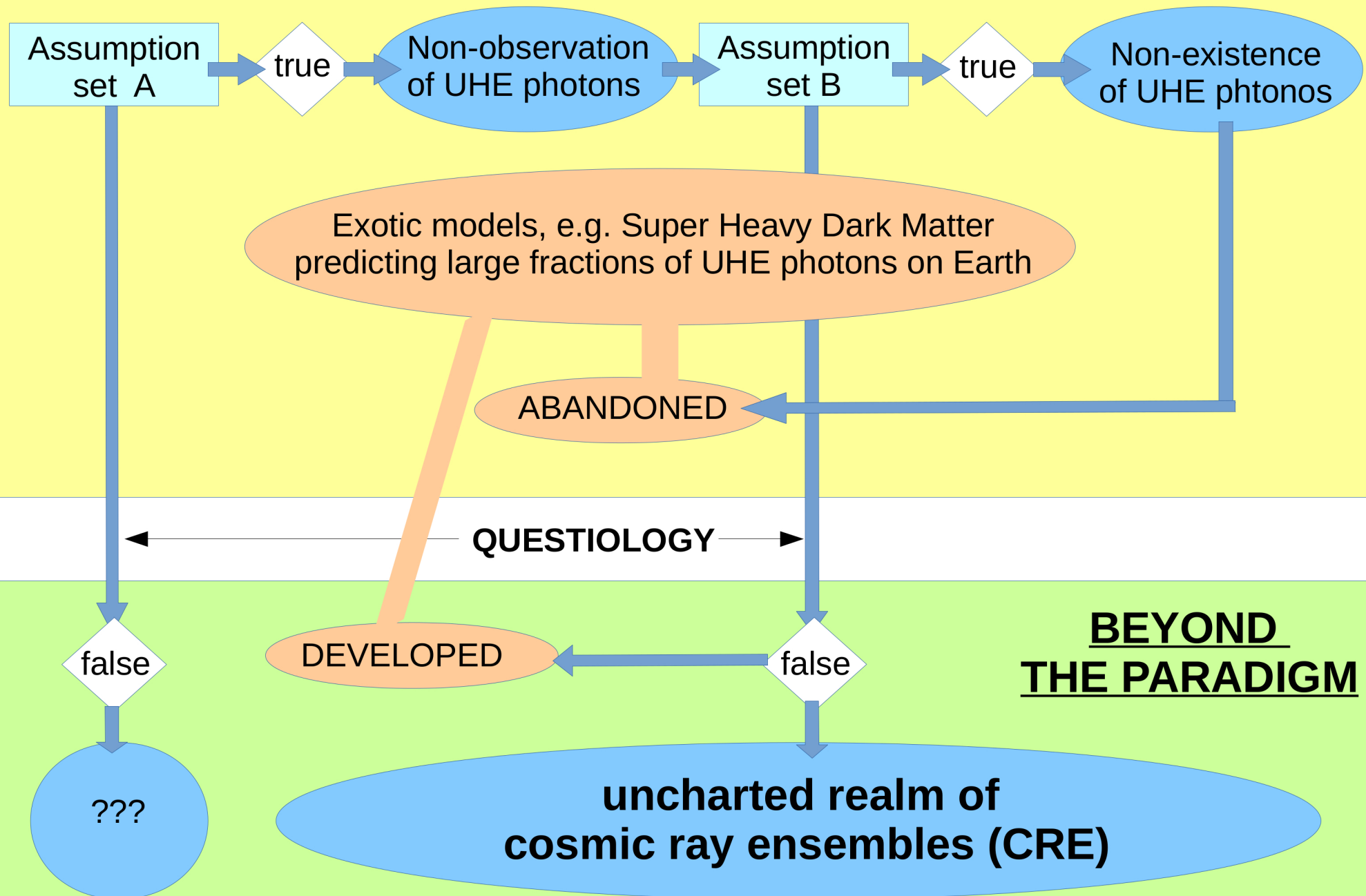
... „one-way” or ...



... „two-way”?



Ultra-high energy cosmic ray (UHECR) PARADIGM

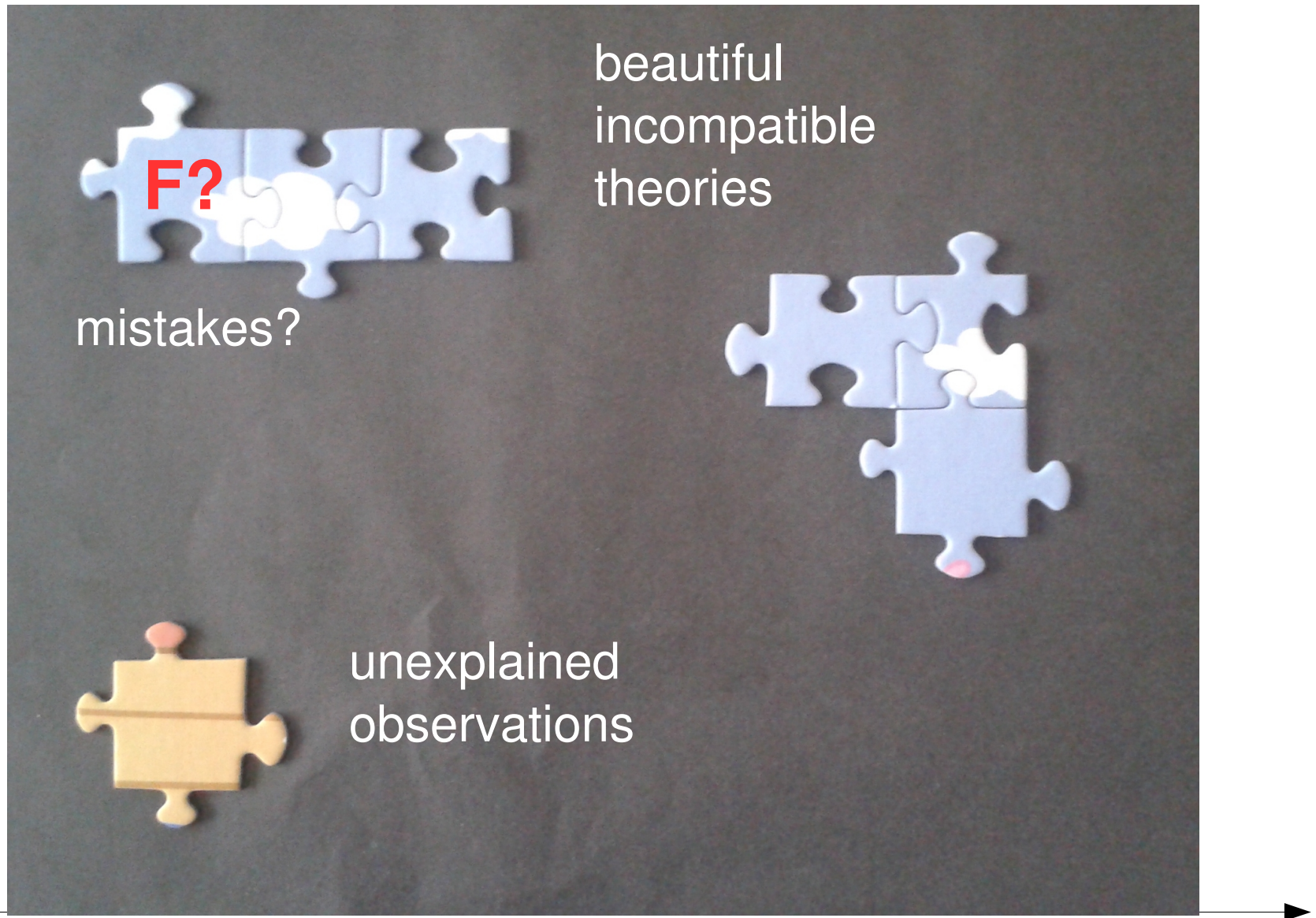




Discoverology by Examples

3. Errology

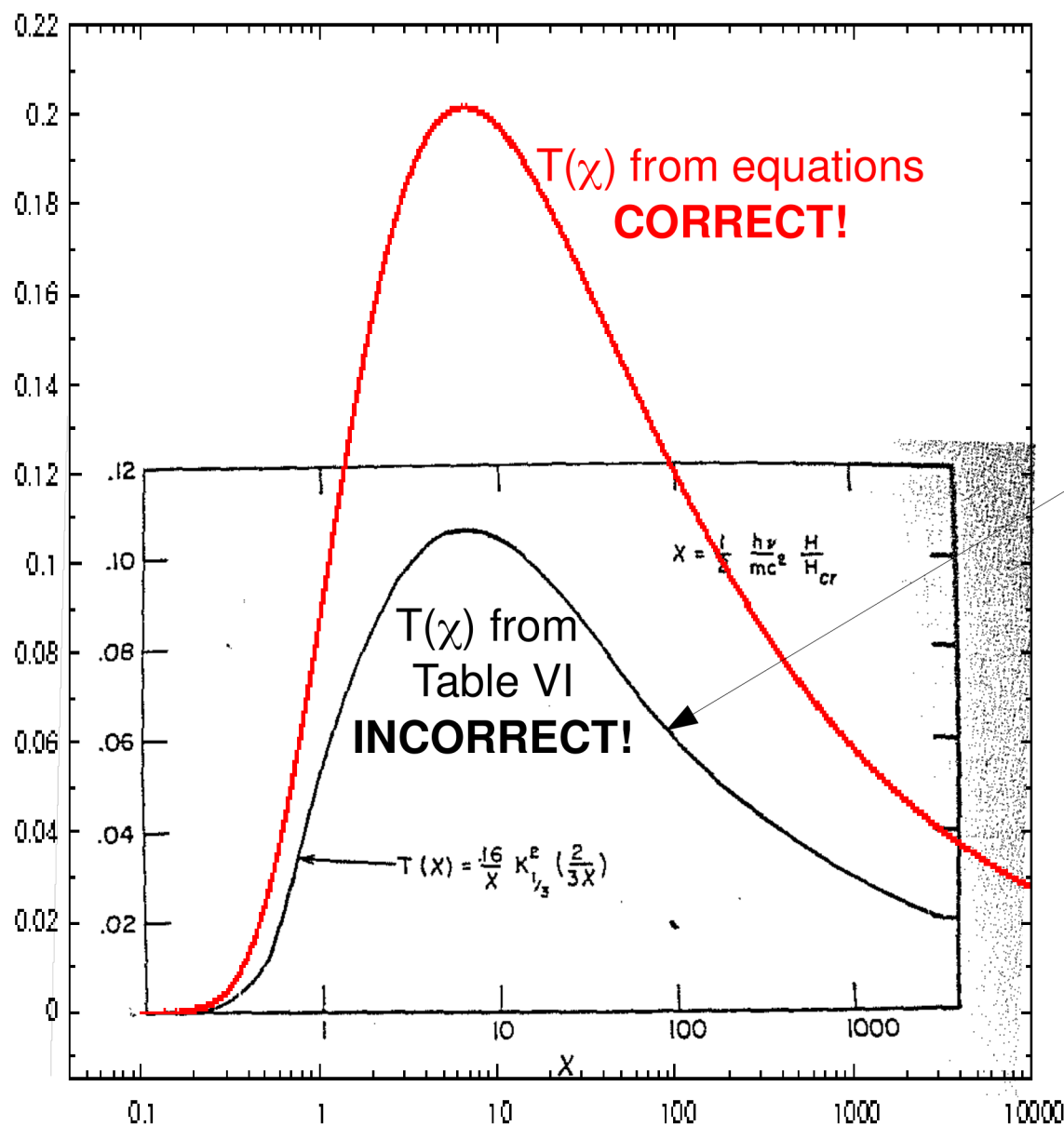
Understanding the Universe: possible mistakes?



What If Question (WIQ): **Mistake(s)?**

PHYSICAL PARAMETER SPACE

Magnetic pair production function: Erber's error



Erber '66:

TABLE VI. The magnetic pair production function $T(\chi)$.

χ	$T(\chi)$
0.2	2×10^{-4}
0.3	2.2×10^{-3}
0.4	6.6×10^{-3}
0.7	0.026
1.2	0.055
3.0	0.094
5.0	0.10
6.0	0.10
7.0	0.10
9.0	0.10
15	0.099
30	0.085

INCORRECT!

$T(\chi)$ from **equations** significantly larger than in Table VI of the standard reference Erber '66.

Taking $T(\chi)$ values from **Table VI** leads to an **underestimation** of pair production probability [!].

Mistake mentioned in:

- Homola et al. 2005
- Klein 2006

Erber '66:

FIG. 9. The magnetic pair production function $T(\chi)$; compare (3.4a-d).

Erber's Error: example of consequences

Basic reference: T. Erber, 1966

Follow-up references

Conclusions on UHE photons (paradigm)

Benchmark reference example (2000): extracts

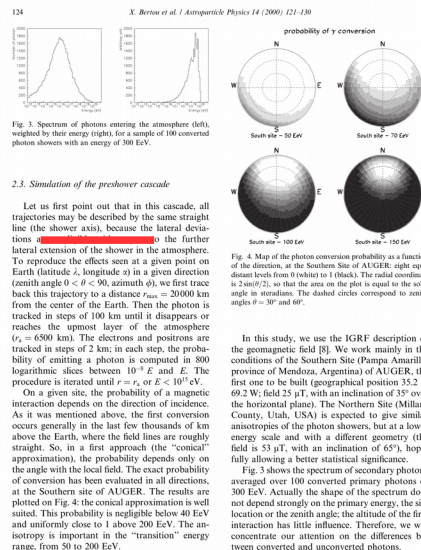
2. Highly energetic photon and electron interactions in a magnetic field

2.1. Magnetic pair production

Following the notations of Ref. [2], the rate of pair production is governed by the dimensionless parameter $\chi = (E_\gamma/2m_e c^2)(B_\perp/B_{\text{cr}})$, where E_γ is the energy of the photon, B_\perp is the magnetic field perpendicular to its movement, $B_{\text{cr}} = m_e^2 c^2 / e \hbar \simeq 4 \times 10^9 \text{ T}$ is a “critical” field.² A good approximation of the photon attenuation length L is given by :

$$L = \frac{2\lambda_C}{\alpha} \frac{B_{\text{cr}}}{B_\perp T(\chi)}$$

$$\text{with } T(\chi) \simeq \frac{0.16}{\chi} \left[K_{1/3} \left(\frac{2}{3\chi} \right) \right]^2,$$

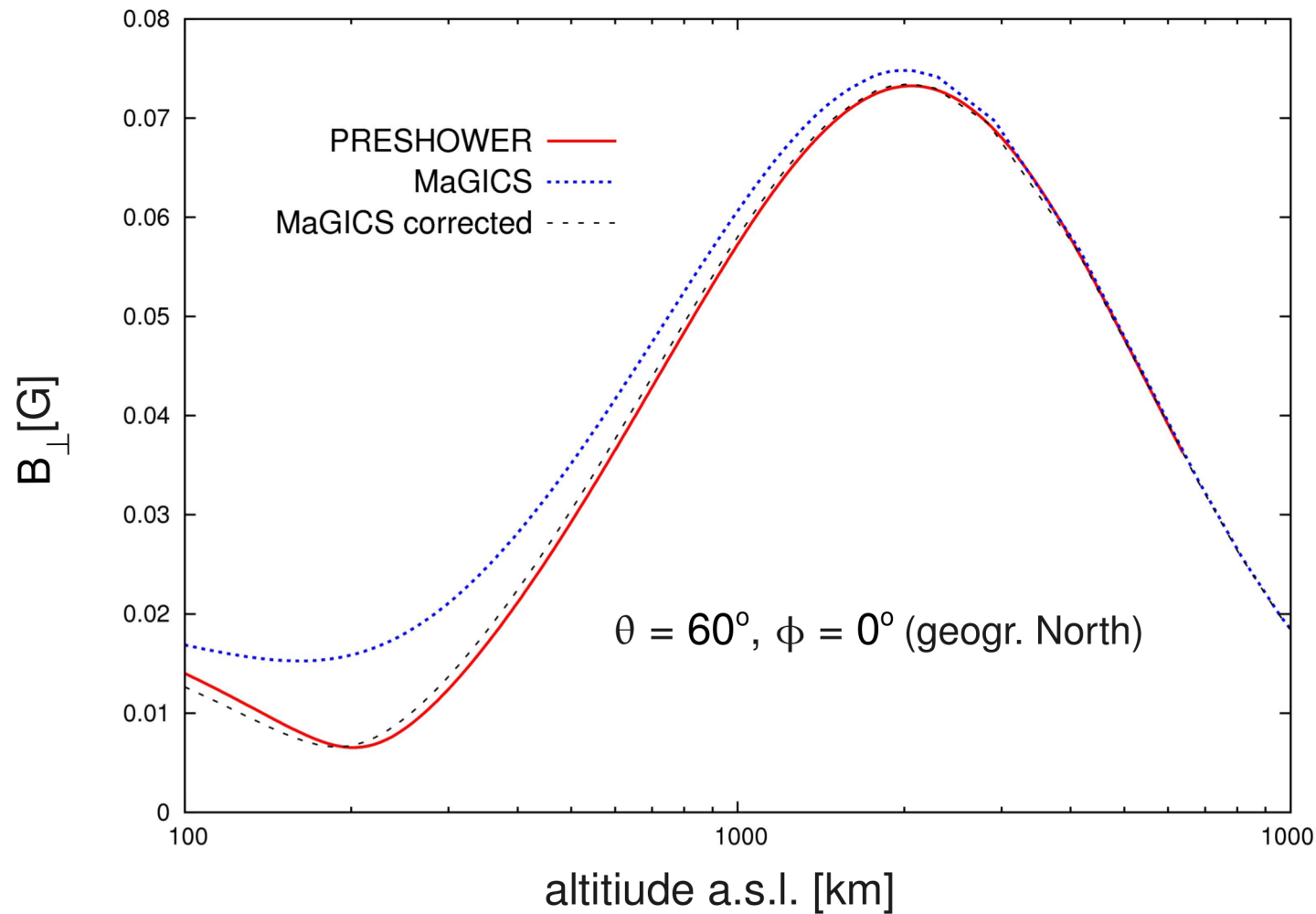


Erber's equations or Table in the **private** code?

No clarification = **no scientific conclusions!**

→ **paradigm questioned!**

PRESHOWER vs. MaGICS, B_{\perp}



A bug (?) in MaGICS: \rightarrow wrong sign in transformation between the AIRES and MaGICS frames of reference

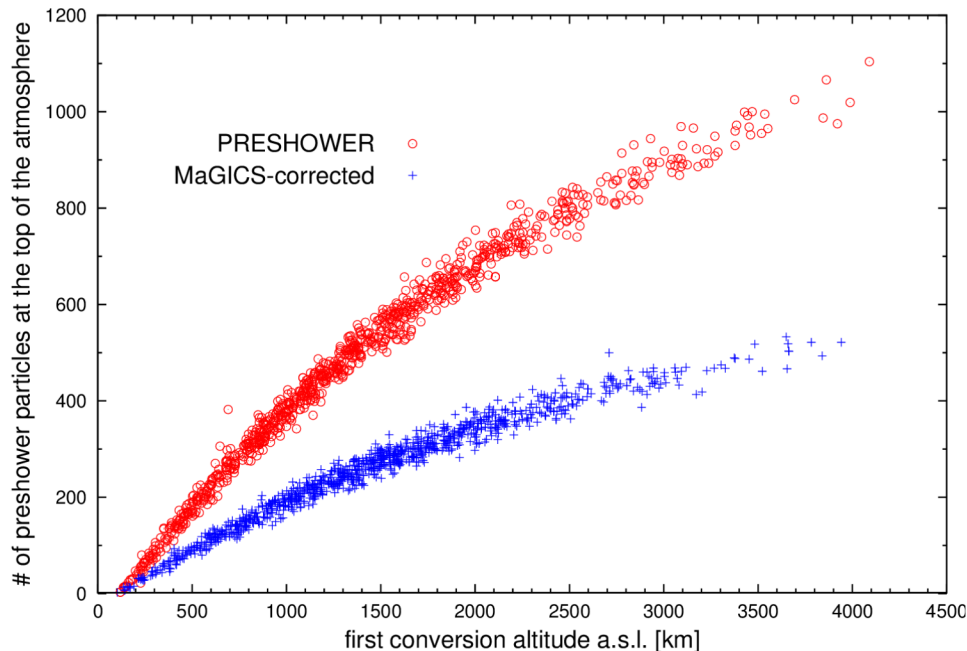
hereafter „MaGICS” \rightarrow „MaGICS corrected”

PRESHOWER vs. MaGICS: discrepancies!

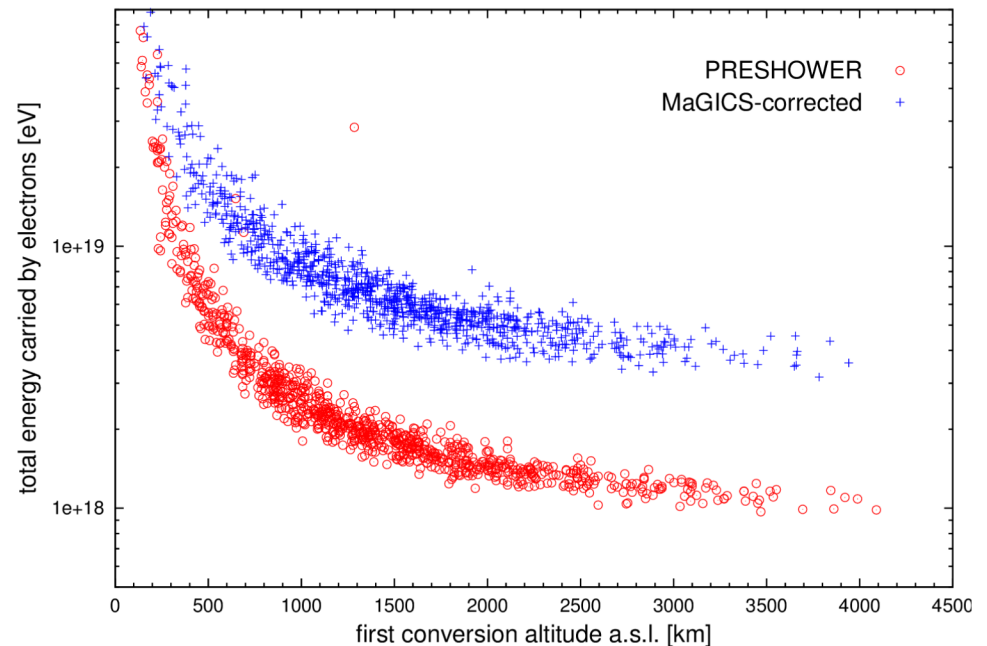
Distributions of preshower particles at the top of the atmosphere

1000 events, Malargüe, $E=10^{20}$ eV, $\theta = 60^\circ$, $\phi=180^\circ$ (arrival from geographical South)

Number of particles



Energy carried by $e^{+/-}$



→ in **MaGICS corrected**,
compared to **PRESHOWER**:

- differences in p_{conv}
- higher energies of $e^{+/-}$
- fewer photons emitted

→ **where are the bug(s)?**

Practical discoverological conclusions for science

Choiceology:

- work with younger colleagues
- be careful of authorities
- open your data

...

Questiology:

- never stop asking yourself
- find money/time to consider „alternatives”

...

Errology

- better code twice
- cross-check everything you can
- no problem with own mistakes / forget self comfort

...

Information (also scientific!) like water!

