

DM and Baryogenesis as two sides of the same coin: observations and possible future tests

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“Marcel Grossmann - I 6”, PT3-session, July 5, 2021

This talk is mostly based on several recent papers written in collaboration with Astro, Nuclear, AMO people.

Infrasonic, acoustic and seismic waves produced by the Axion Quark Nuggets

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The mysterious bursts observed by telescope array and axion quark nuggets

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Published 29 April 2021 • © 2021 IOP Publishing Ltd

[Journal of Physics G: Nuclear and Particle Physics](#), [Volume 48](#), [Number 6](#)

Citation Ariel Zhitnitsky 2021 *J. Phys. G: Nucl. Part. Phys.* **48** 065201

The ANITA Anomalous Events and Axion Quark Nuggets

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1. THE DM AND BARYOGENESIS AS TWO SIDES OF THE COIN

- THERE ARE TWO (APPARENTLY UNRELATED) PHENOMENA:
- 1. 80-YEARS OLD MYSTERY: THE NATURE OF DARK MATTER (ZWICKY 1937)
- 2. ANOTHER 50-YEARS OLD MYSTERY: **BARYOGENESIS** (SAKHAROV, 1967)
- MANY OTHER **OBSERVED** PUZZLES ... TO BE MENTIONED TODAY

Fritz Zwicky and Vera Rubin



The DM side of the coin



Sakharov

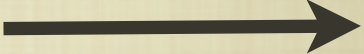
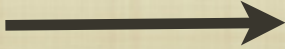
Sakharov formulated precise criteria when such baryogenesis is possible:

1. There must be B-violation;
2. There must be C and CP violation;
3. There must be out-of-equilibrium dynamics

The Baryogenesis side of the coin

- THESE TWO (NAIVELY UNRELATED) PHENOMENA, THE DM AND BARYOGENESIS ARE CONSIDERED TO BE TWO DIFFERENT STORIES... WE WANT TO ARGUE THAT THESE TWO PHENOMENA ARE, IN FACT, INTIMATELY CONNECTED
- FURTHERMORE, OUR CLAIM IS THAT WE HAVE BEEN WITNESSING (INDIRECTLY) THE MANIFESTATION OF THE DM (BEYOND GRAVITY) FOR YEARS WITH MANY PUZZLING OBSERVATIONS (20+ PUBLISHED PAPERS WITH “HINTS”)
- TODAY I SPECIFICALLY FOCUS ON THREE CONSEQUENCES OF THIS CONSTRUCTION:
 1. MYSTERIOUS INFRASONIC AND SEISMIC EVENT OBSERVED BY ELGINFIELD INFRASOUND ARRAY (ELFO)
 2. RECENTLY OBSERVED MYSTERIOUS TELESCOPE ARRAY BURSTS.
 3. RECENTLY OBSERVED ANITA ANOMALOUS EVENTS

2. TWO (NAIVELY UNRELATED) MYSTERIES: DARK MATTER AND BARYOGENESIS.

- 1. “NAIVE” MORAL: DARK MATTER REQUIRES NEW (UNKNOWN) FIELDS SUCH AS WIMPS
- 2. “NAIVE” MORAL: NEW FIELDS MUST BE NONBARYONIC. ARGUMENTS COME FROM STRUCTURE FORMATION REQUIREMENTS, BBN, DECOUPLING DM FROM RADIATION, ETC
- THIS PROPOSAL: INSTEAD OF “NEW FIELDS”  “NEW PHASES” (DENSE COLOUR SUPERCONDUCTOR) OF “OLD FIELDS”
- INSTEAD OF “BARYOGENESIS”  “SEGREGATION OF CHARGES” OF CONVENTIONAL FIELDS (QUARKS) AT $\theta \neq 0$

■ THE IDEA THAT THE DM COULD BE IN FORM OF VERY DENSE QUARK NUGGETS (QN) OF STANDARD MODEL FIELDS IS NOT NEW AND HAS BEEN ADVOCATED BY **WITTEN IN 1984**

■ THE CRUCIAL (FOR COSMOLOGY) PARAMETER σ/M IS SMALL. THEREFORE, THE NUGGETS ARE QUALIFIED AS DM CANDIDATES

$$\frac{\sigma}{M} \ll 1 \left(\frac{\text{cm}^2}{\text{gram}} \right)$$

E. Witten



THERE WERE MANY PROBLEMS WITH THE ORIGINAL 1984-
WITTEN'S IDEA:

1. THERE IS NO FIRST ORDER PHASE TRANSITION IN QCD
2. FAST EVAPORATION
3. HARD TO ACHIEVE STABILITY
4. E.T.C.

NEW ELEMENT TO RESCUE THE NUGGET'S IDEA: **THE AXION**. WE CALL THE OBJECTS THE AXION QUARK NUGGET (**AQN**).

■ 1. THERE IS EXTRA $N=1$ AXION DOMAIN WALL PRESSURE (ACTING ON THE CLOSED AXION DW BUBBLES). IT MAKES THE NUGGETS STABLE (FIRST ORDER PHASE TRANSITION IS NOT REQUIRED, AS IN THE WITTEN'S CASE). THEY ARE ABSOLUTELY STABLE AND CAN SERVE AS DM PARTICLES.

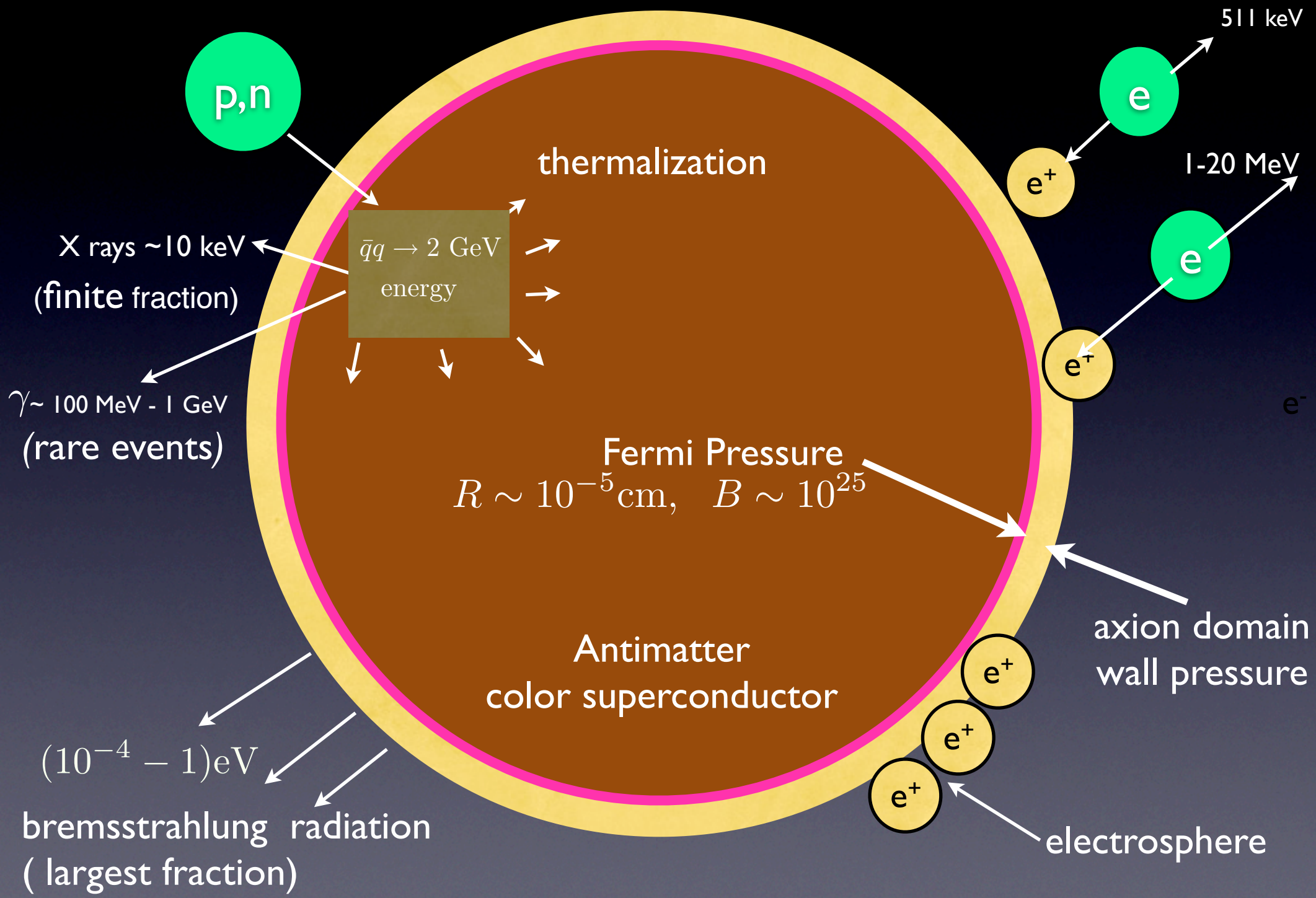
■ 2. THERE ARE TWO SPECIES, THE NUGGETS AND ANTI-NUGGETS. THE SIZE IS DETERMINED BY m_a AS $R \sim m_a^{-1}$

■ A SMALL GEOMETRICAL FACTOR REPLACES A CONVENTIONAL REQUIREMENT FOR A WEAK COUPLING CONSTANT. NUGGETS ARE QUALIFIED AS THE DM CANDIDATES:

$$\epsilon \sim S/V \sim B^{-1/3} \ll 1 \qquad \sigma/M \ll \text{cm}^2/\text{g}$$

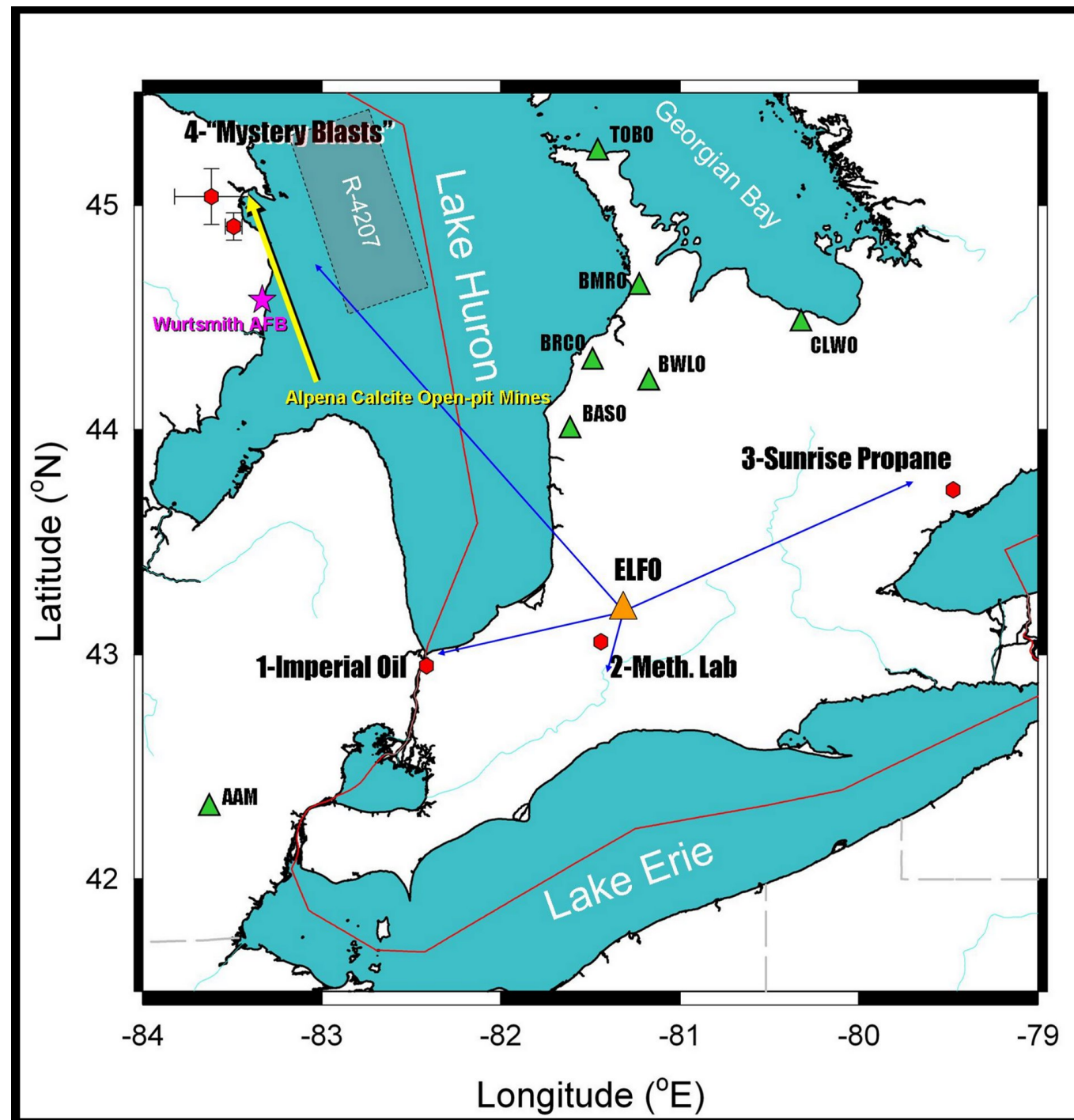
■ COSMOLOGICAL **CP-ODD** AXION FIELD GENERATES THE DISPARITY BETWEEN TWO SPECIES AT $\theta \neq 0$ WHICH IMPLIES THE SIMILARITY BETWEEN DARK AND VISIBLE SECTORS: $\Omega_{\text{dark}} \approx \Omega_{\text{visible}} \sim \Lambda_{\text{QCD}}$

Antiquark nugget structure. Source of emission

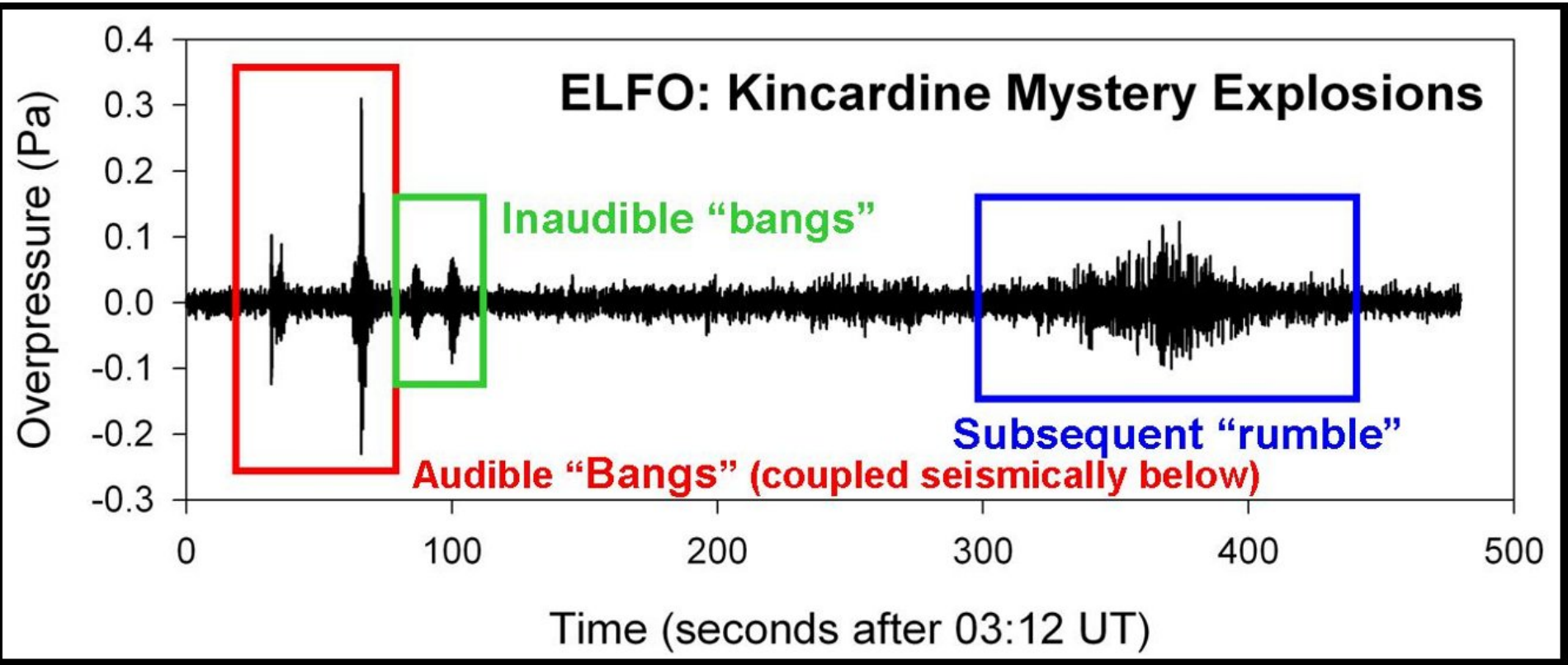


3. SKYQUAKES AND THE AXION QUARK NUGGETS

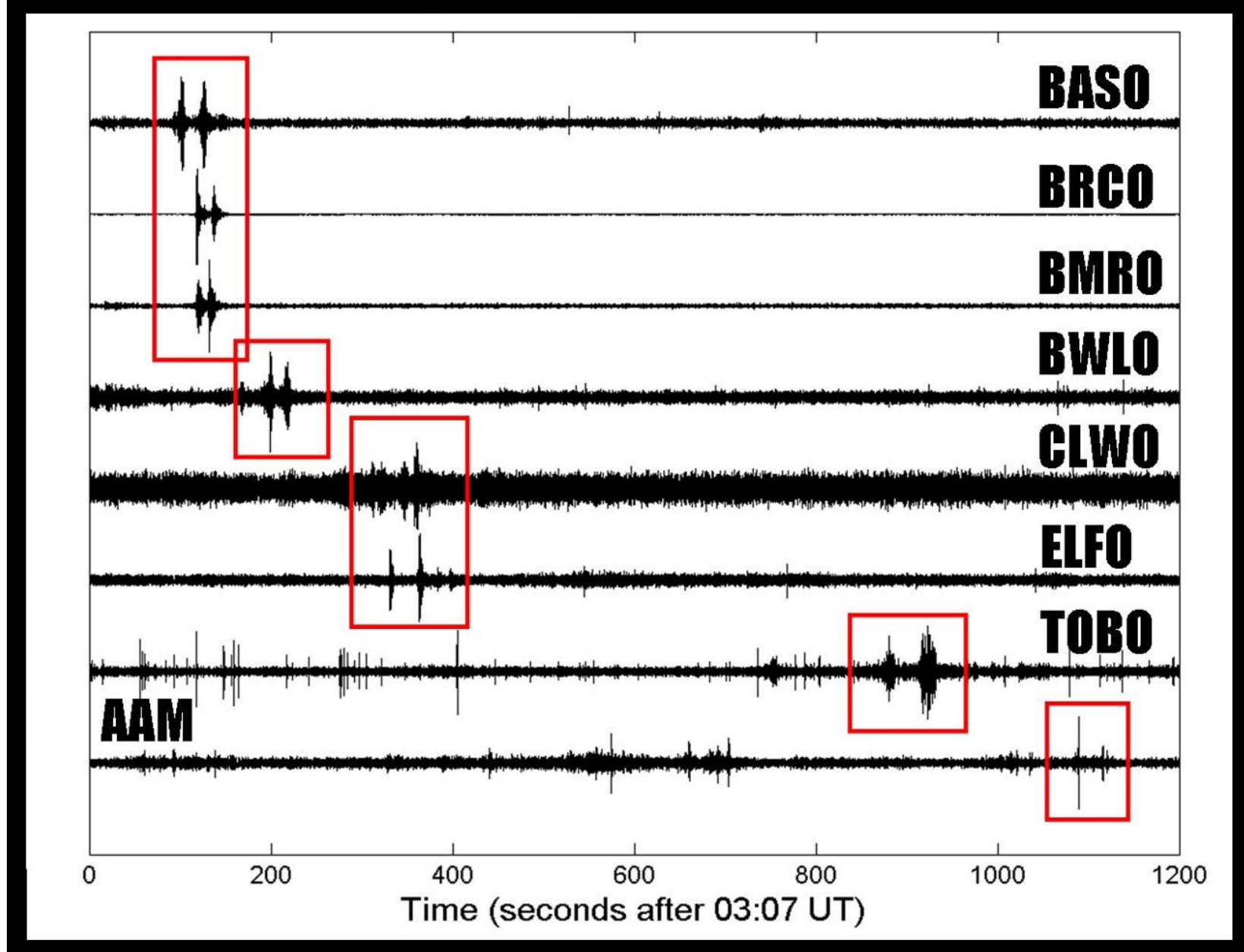
- THERE ARE SOME MYSTERIOUS EXPOSITIONS, THE SO-CALLED SKY-QUAKES WHICH HAVE BEEN KNOWN FOR CENTURIES...
- WE ADVOCATE AN IDEA THAT IT COULD BE A MANIFESTATION OF THE AQNS ENTERING THE EARTH'S ATMOSPHERE
- FORTUNATELY, ONE EVENT WHICH OCCURRED ON JULY 31, 2008 WAS PROPERLY RECORDED BY DEDICATED ELGINFIELD INFRASOUND ARRAY (ELFO) NEAR LONDON, ONTARIO, CANADA.
- THE INFRASOUND DETECTION WAS ACCOMPANIED BY NON-OBSERVATION OF ANY METEORS BY ALL SKY CAMERA NETWORK. FURTHERMORE, CONVENTIONAL METEORS AND ANY HUMAN SOURCES ARE RULED OUT.
- IMPULSES WERE ALSO OBSERVED SEISMICALLY AND CORRELATED WITH INFRASOUND RECORDED BY ELFO.



Map of the area, adopted from ELFO publications



Infrasound impulses as recorded by ELFO station, adopted from ELFO publications



Impulses as observed by seismic stations in the area, adopted from ELFO publications

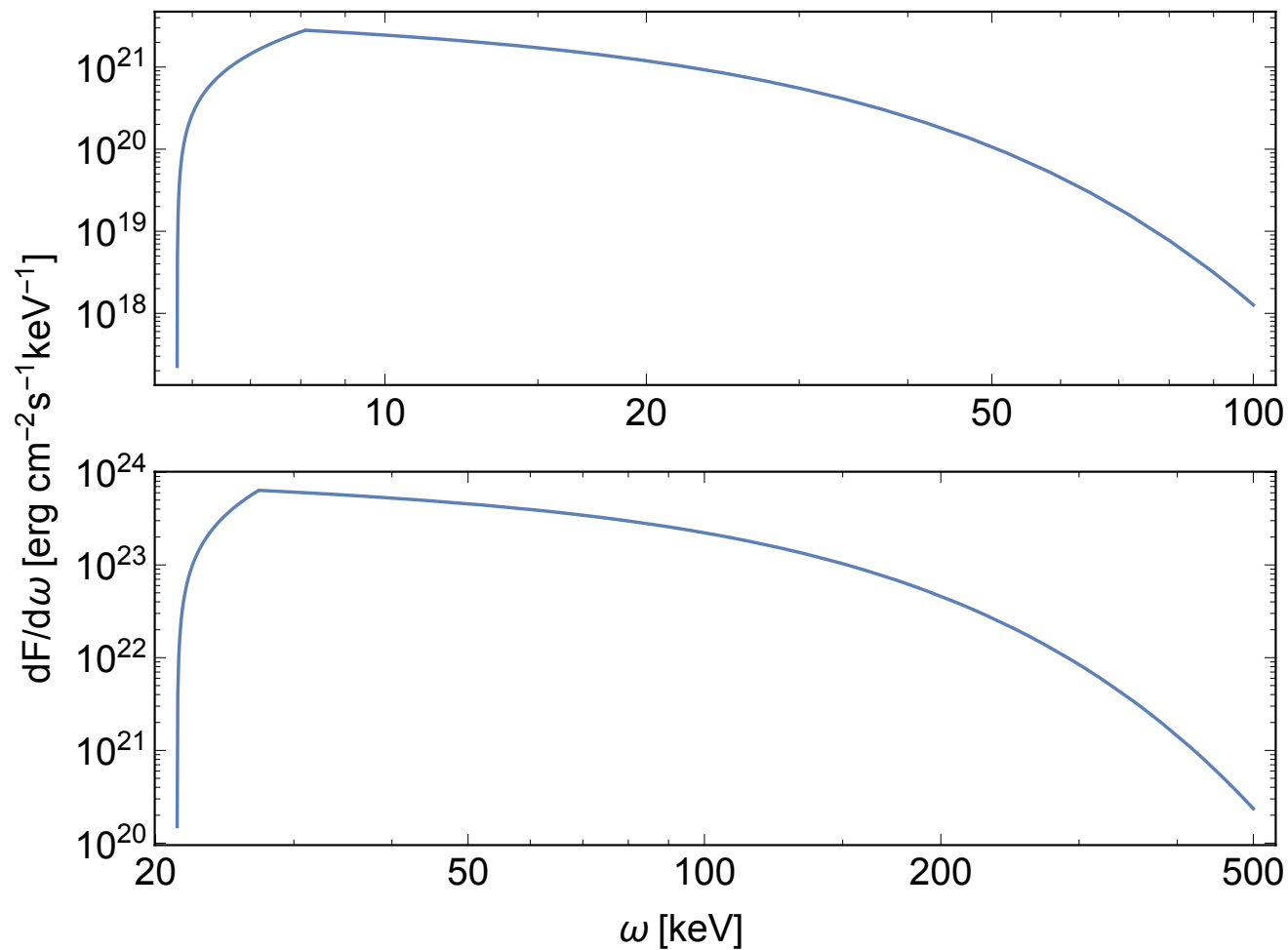
■ THE AQN EVENT RATE IS ABOUT ONE EVENT PER DAY PER AREA $(100 \text{ km})^2$. TO BE MORE PRECISE:

$$\frac{\langle \dot{N} \rangle}{4\pi R_{\oplus}^2} \simeq \frac{4 \cdot 10^{-2}}{\text{km}^2 \text{ yr}} \left(\frac{\rho_{\text{DM}}}{0.3 \frac{\text{GeV}}{\text{cm}^3}} \right) \left(\frac{\langle v_{\text{AQN}} \rangle}{220 \frac{\text{km}}{\text{s}}} \right) \left(\frac{10^{25}}{\langle B \rangle} \right) \left(\frac{\langle B \rangle}{B} \right)^{\alpha}, \quad \alpha \approx (2 - 2.5)$$

■ IT IS RADIATED IN FORMS OF THE AXIONS, NEUTRINOS AND THE X RAYS (THERE IS NO VISIBLE LIGHT, SEE SLIDE BELOW)

■ THE X RAYS WILL BE QUICKLY ABSORBED ON SCALE $\lambda \sim 5 \text{ m}$. HOWEVER, SOME PORTION OF THESE X RAYS WILL GENERATE THE SHOCK WAVE, SIMILAR TO CONVENTIONAL BOMB BLAST WHEN $20 \text{ eV} +$ PHOTONS IS THE SUBJECT OF HUGE ATOMIC PHOTOELECTRIC EFFECT WITH CROSS SECTION $\sigma_{\text{p.e.}} \sim 10^7 \text{ barn}$

■ THE DIFFERENCE WITH CONVENTIONAL OR NUCLEAR EXPLOSION (WHEN THE RADIATION COMES IN 20 eV) IS THAT THE ATTENUATION LENGTH $\lambda \sim 10^{-3} \text{ cm}$, TO BE CONTRASTED WITH X RAYS WITH MUCH LONGER MEAN FREE PATH $\lambda \sim 5 \text{ m}$



Surface emissivity of a nugget for $T = 10$ keV (above) and $T = 50$ keV (below). Key element here is a strong suppression of the low frequency photons $\omega \ll T$ due to the plasma frequency effects. It explains the non-emission (non-observation) in the visible bands from the AQNs.

■ THIS DIFFERENCE LEADS TO SOME DRASTIC OBSERVATIONAL FEATURES IN COMPARISON WITH CONVENTIONAL METEORS:

■ 1. AQNS ARE NOT ACCOMPANIED BY VISIBLE LIGHT, WHICH EXPLAINS WHY ALL SKY CAMERA COULD NOT SEE THEM;

■ 2. THE FREQUENCY OF (INFRA)SOUND IS MUCH LOWER THAN IN CONVENTIONAL EXPLOSIONS

$$\nu(\bar{x}) \approx \frac{\nu_0}{\bar{x}^{1/4}} \approx 5 \text{ Hz} \left(\frac{300 \text{ km}}{r} \right)^{1/4} \quad \tau_0 \sim \frac{L}{c_s}, \quad \nu_0 \equiv \frac{1}{\tau_0} \sim 70 \text{ Hz},$$

■ OVERPRESSURE CAN BE ESTIMATED AS FOLLOWS:

$$\delta p \approx 0.3 \text{ Pa} \left(\frac{B}{10^{27}} \right)^{2/3} \left(\frac{300 \text{ km}}{r} \right)^{3/4},$$

■ IT IS AMAZINGLY CLOSE TO THE OBSERVED ELFO RECORDS

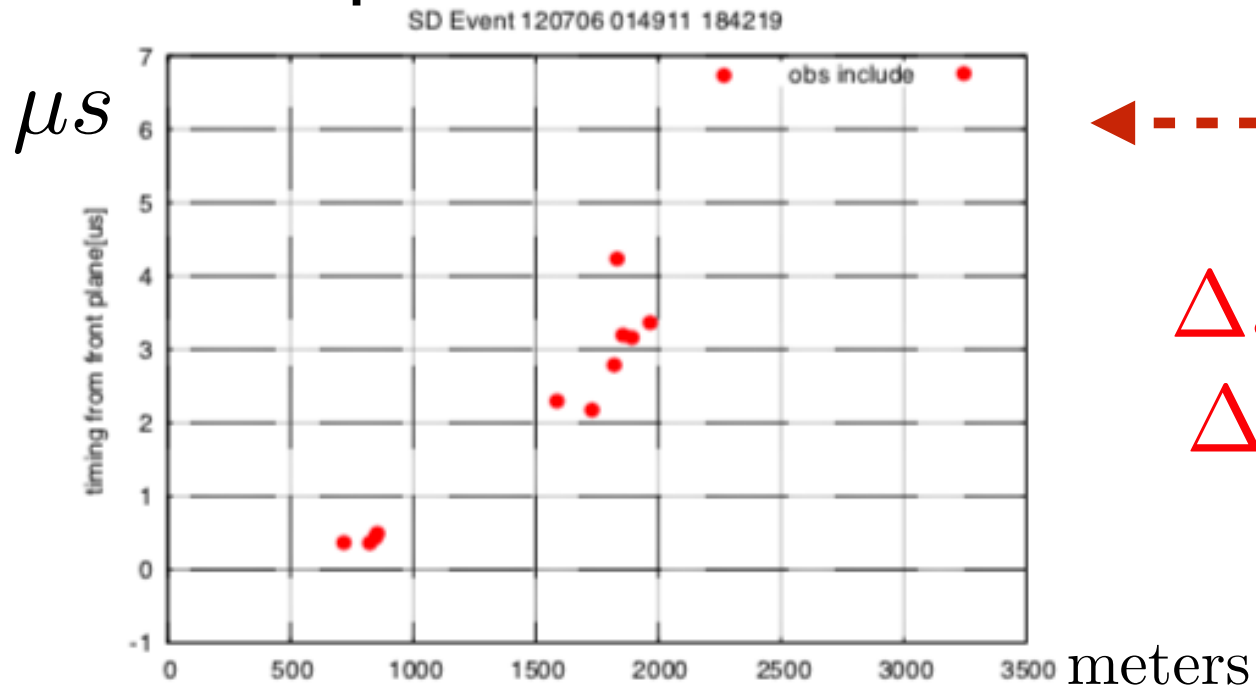
- A RELATIVELY HIGH MEASURED OVERPRESSURE $\delta p \approx 0.3 \text{ Pa}$ IS INTERPRETED AS A RESULT OF VERY LARGE AND VERY RARE AQN EVENTS WITH $[B \approx 10^{27}] \gg [\langle B \rangle \approx 10^{25}]$
- IT MIGHT BE AN EXPLANATION WHY THIS AREA HAS OBSERVED A SINGLE STRONG EVENT IN 10 YEARS, INSTEAD OF OBSERVING THEM MUCH MORE OFTEN
- WE NEED MUCH MORE SENSITIVE INSTRUMENTS TO OBSERVE MUCH WEAKER AND MORE FREQUENT EVENTS WITH $\langle B \rangle \sim 10^{25}$
- PROPOSAL: DISTRIBUTED ACOUSTIC SENSING (DAS) BECOMES A CONVENTIONAL TOOL FOR SEISMIC AND OTHER APPLICATIONS. THE RECENT DEVELOPMENT IS THAT DAS IS CAPABLE OF MEASURING STRAIN CHANGES AT ALL POINTS ALONG THE OPTICAL FIBER AT *acoustic frequencies*.

4. TELESCOPE ARRAY MYSTERIOUS BURSTS

- TELESCOPE ARRAY (TA) EXPERIMENT [ABBASI-2017] HAS RECORDED SEVERAL BURSTS OF AIR SHOWER-LIKE EVENTS. THIS BURSTS ARE VERY DISTINCT FROM CONVENTIONAL SINGLE SHOWERS, AND ARE FOUND TO BE 100% CORRELATED WITH THUNDERSTORM. THE UNUSUAL FEATURES ARE:
- “*clustering puzzle*”: BURST IS DEFINED AS 3+ CONSECUTIVE EVENTS WITHIN 1 MS, WHICH WOULD BE A HIGHLY UNLIKELY OCCURRENCE FOR 3+ CONSECUTIVE HITS IN THE SAME AREA ~ 1 KM IF INTERPRETED AS CR EVENTS
- IF ONE TRIES TO FIT THE OBSERVED BURSTS WITH CONVENTIONAL CODE FOR HECR EVENTS ONE SHOULD EXPECT 10^{13} eV ENERGY RANGE (BASED ON FREQUENCY OF APPEARANCE), WHILE INTENSITY SUGGESTS 10^{19} eV;

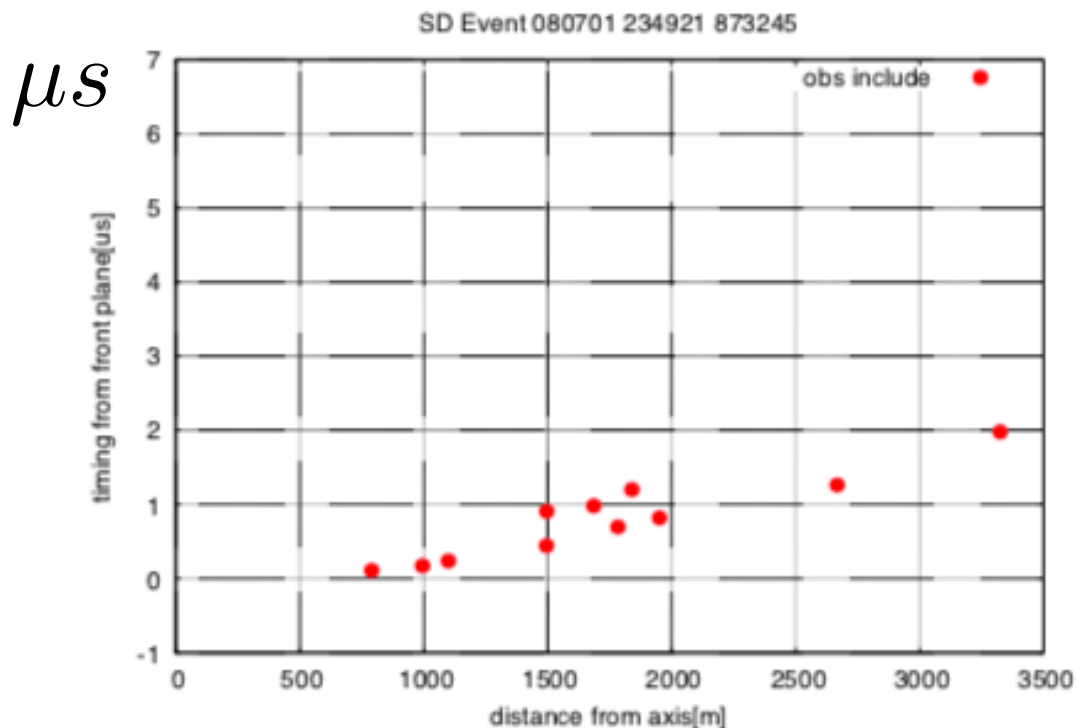
- *“curvature puzzle”*: ALL BURST EVENTS ARE MUCH MORE CURVED THAN USUAL CR AIR SHOWERS. ALSO: THE EDGES IN WAVEFORMS ARE DRAMATICALLY DIFFERENT, *“edge puzzle”* (SEE TWO NEXT SLIDES);
- *“synchronization (with thunderstorm) puzzle”*: MOST OF THE BURSTS ARE SYNCHRONIZED (LESS THAN 1 MS) OR RELATED (LESS THAN 200 MS) WITH THE LIGHTNINGS/FLASHES
- SOME BURSTS ARE NOT RELATED TO LIGHTINGS → THEY CANNOT BE OUTCOME OF FLASHES. ALL OF THEM OBSERVED UNDER THUNDERSTORM. THE TOTAL 10 BURST EVENTS HAVE BEEN OBSERVED DURING 5 YEARS OF OBSERVATIONS;
- RECONSTRUCTED BURSTS START AT MUCH LOWER ALTITUDE THAN CONVENTIONAL HECR SHOWERS (30KM).

adopted from TA collaboration [Abbasi-2017]



←----- typical burst event

$$\Delta s \in (0, 5 - 2)\text{km},$$
$$\Delta t \in (0 - 8)\mu s$$

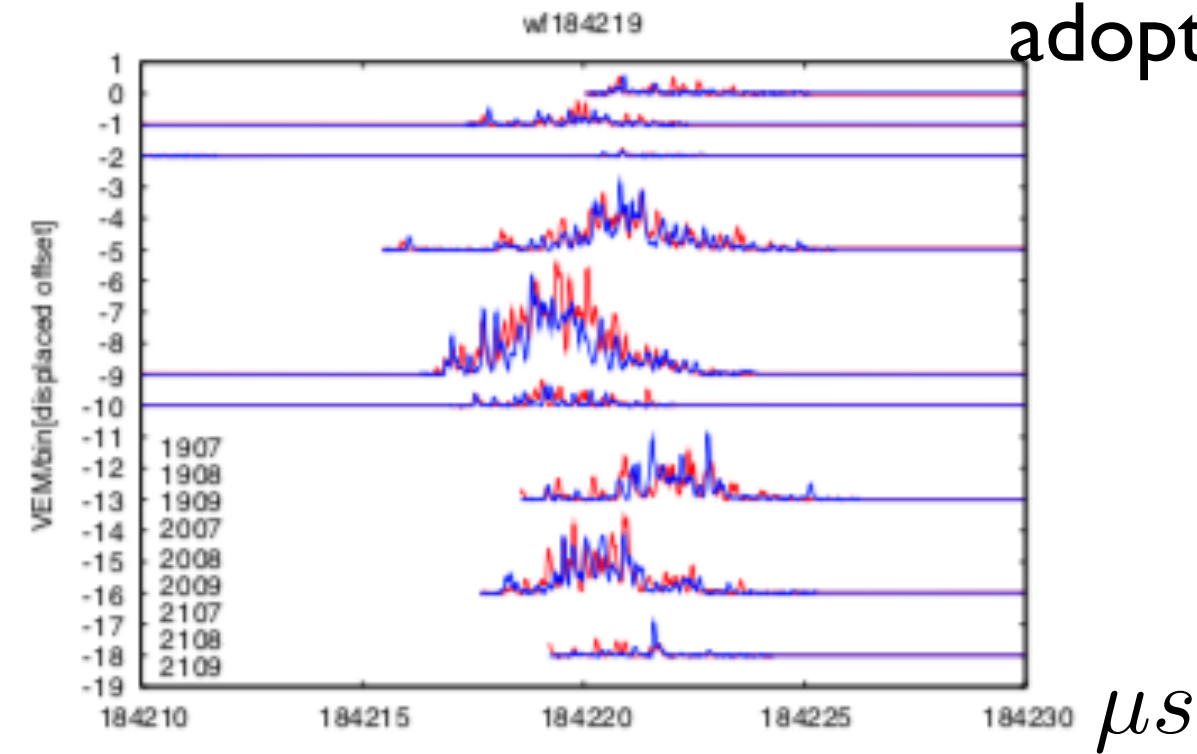


←----- typical CR event

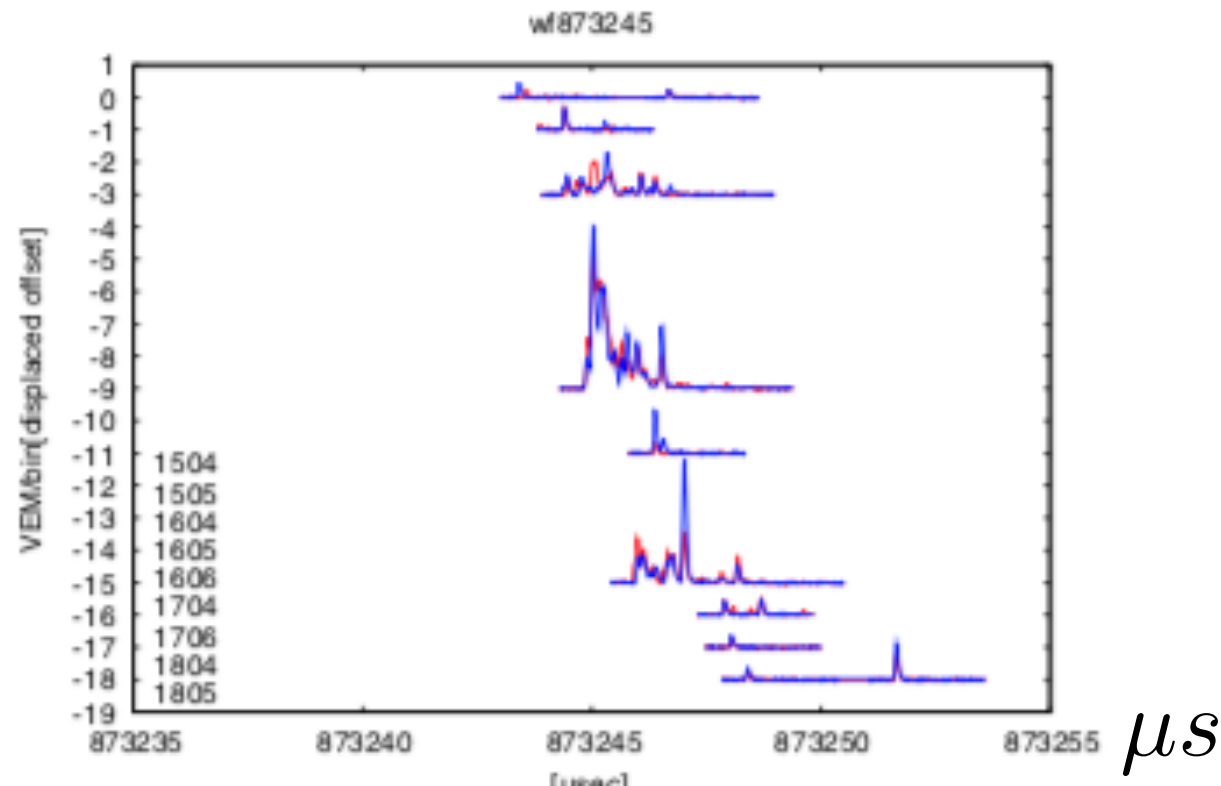
$$\Delta s \in (0, 5 - 3.5)\text{km},$$
$$\Delta t \in (0 - 2)\mu s$$

The “curvature puzzle”

adopted from TA [Abbasi-2017]



← - - typical burst event



← - - typical CR event

The “edge puzzle”

*a journalist published a story about my paper .
I better show few slides by myself*

Cosmic-ray detector might have spotted nuggets of dark matter

21 Jan 2021



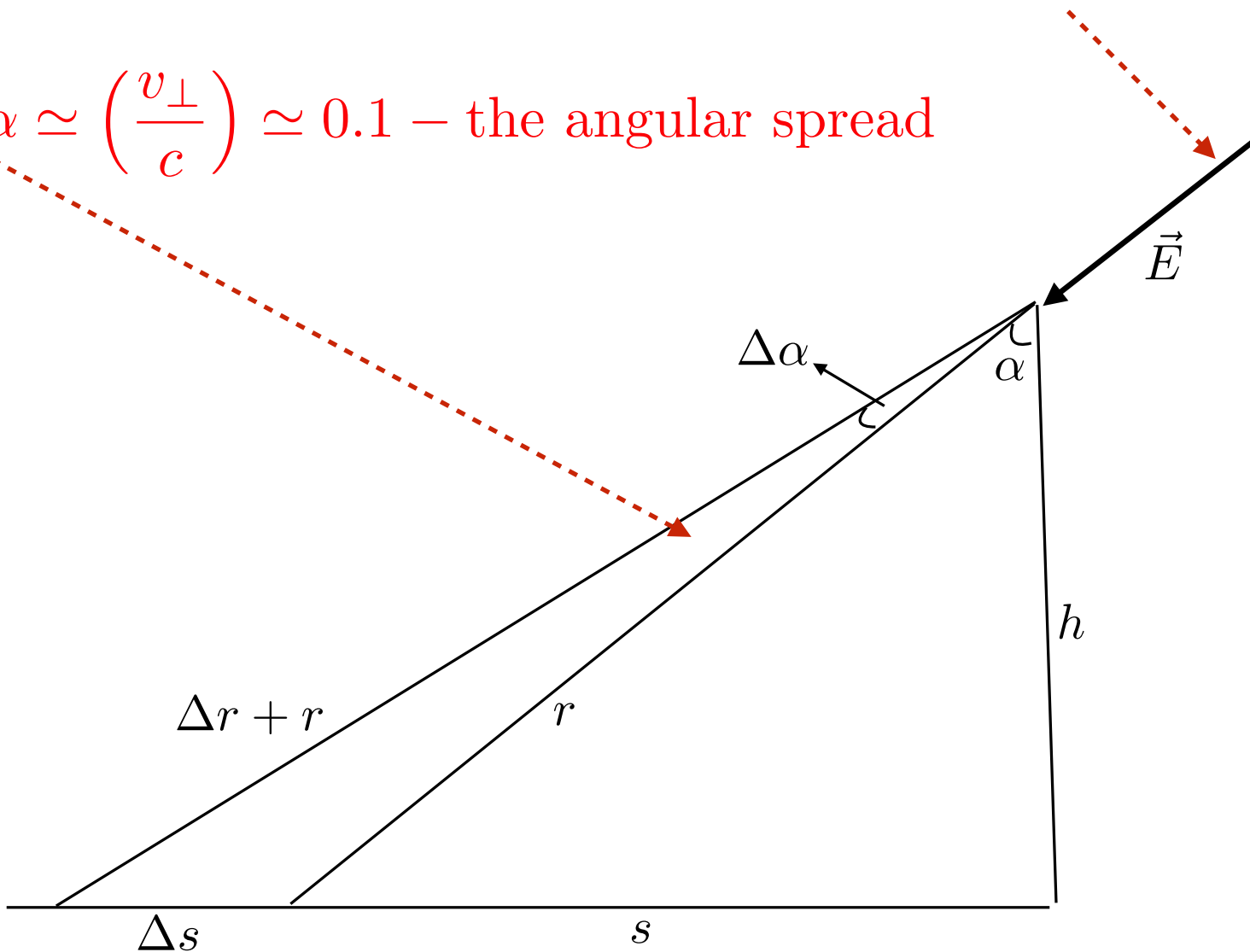
Scanning the sky: the Middle Drum facility of the [Telescope Array](#) observatory in the Utah desert. Could anomalous signals seen by the observatory be evidence for axion quark nuggets? (Courtesy: Ben Stokes/University of Utah)

5. MYSTERIOUS BURSTS AS THE AQN ANNIHILATION EVENTS UNDER THUNDERSTORM

- WHEN THE AQN PROPAGATES IN ATMOSPHERE IT EXPERIENCE A LARGE NUMBER OF ANNIHILATION EVENTS WITH SURROUNDING MATERIAL. INTERNAL TEMPERATURE: $T \sim 10 \text{ keV}$
- IF THE AQN HITS THE REGION UNDER THUNDERCLOUD THE WEAKLY BOUND POSITRONS LOCALIZED AWAY FROM THE NUGGET'S CORE MAY BE LIBERATED BY PRE-EXISTING ELECTRIC FIELD $E \sim \text{KV/CM}$ WHICH IS KNOWN TO EXIST
- AS A RESULT OF STRONG ELECTRIC FIELD THE POSITRONS WILL ACCELERATE TO ENERGIES $\sim 10 \text{ MEV}$ ON SCALES OF ORDER $l_a \sim 100 \text{ m}$ (SO CALLED AVALANCHE SCALE)
- THE MEAN FREE PATH FOR SUCH ENERGETIC POSITRONS IS OF ORDER SEVERAL KM, SO THEY CAN REACH THE TA DETECTOR

Instant direction of the electric field at the moment of exit

$$\Delta\alpha \simeq \left(\frac{v_{\perp}}{c} \right) \simeq 0.1 - \text{the angular spread}$$



Δs - Spatial spread on the surface, observed by TASD

■ THE POSITRONS TRAVELLING THE DISTANCE r THE SPATIAL SPREAD Δs IS ESTIMATED AS

$$\Delta s \simeq r \left(\frac{\Delta \alpha}{\cos \alpha} \right) \simeq \frac{1 \text{ km}}{\cos \alpha} \left(\frac{r}{10 \text{ km}} \right)$$

■ THE TIME SPREAD OF THE ARRIVING PARTICLES IS DETERMINED BY Δr AND ESTIMATED AS FOLLOWS

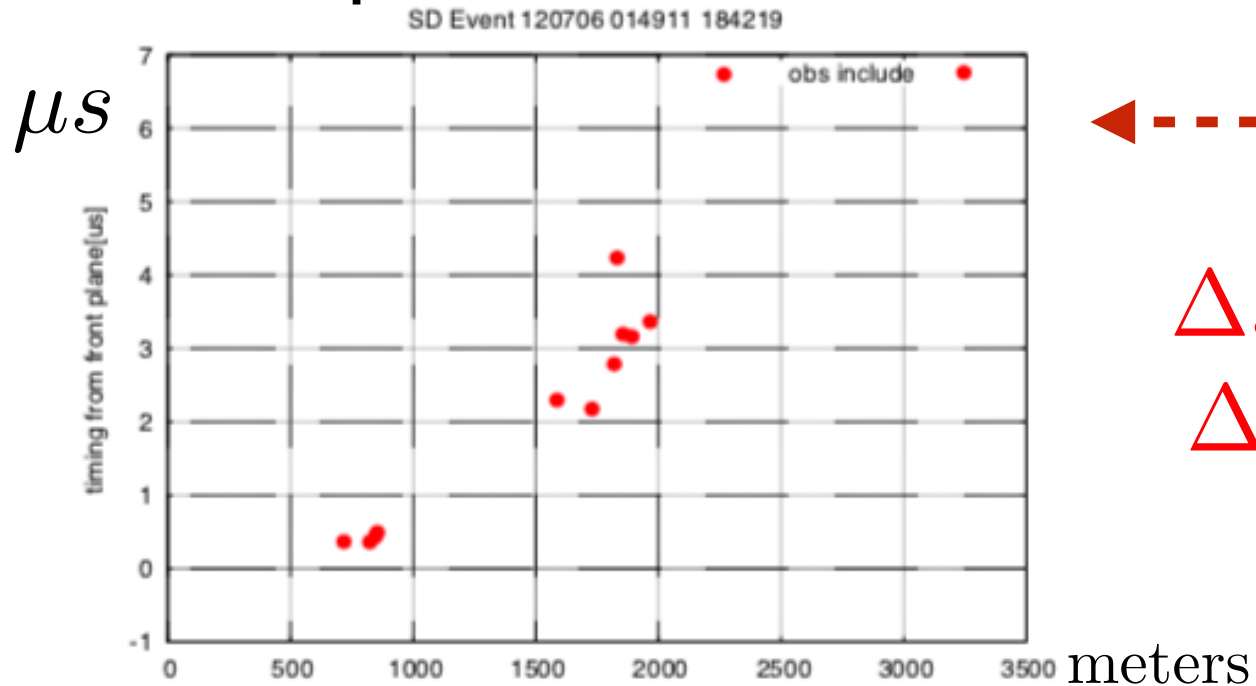
$$\Delta t \simeq \frac{\Delta r}{c} \simeq 3\mu s \cdot (\tan \alpha) \cdot \left(\frac{r}{10 \text{ km}} \right) \text{ where } \Delta r \simeq r \tan \alpha \Delta \alpha$$

■ IMPORTANT: THE BASIC SCALE IS $v_{\perp} \simeq 0.1c$ WHICH IS NOT PRESENT IN CONVENTIONAL CR ANALYSIS

$(2\Delta t)$ varies $(0 - 8)\mu s$ when $(2\Delta s)$ changes between $(0.5 - 2) \text{ km}$

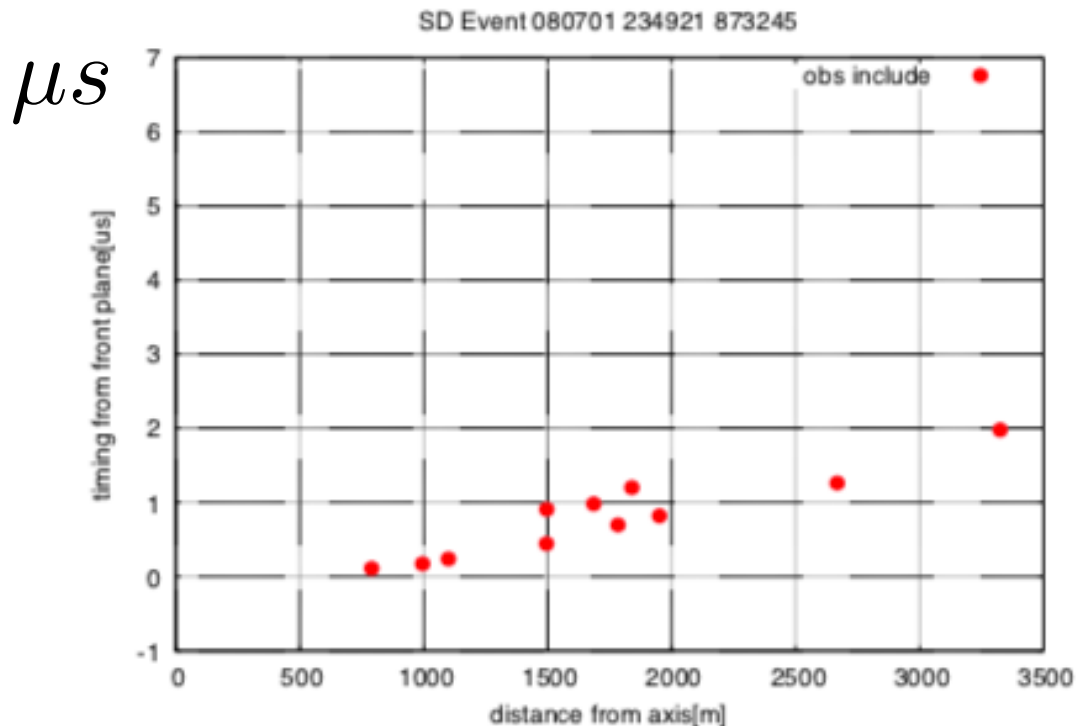
■ IT IS CONSISTENT WITH OBSERVATIONS. IT REPRESENTS RESOLUTION OF “*the curvature puzzle*” WITHIN AQN MODEL

adopted from TA collaboration [Abbasi-2017]



←----- typical burst event

$$\Delta s \in (0, 5 - 2)\text{km},$$
$$\Delta t \in (0 - 8)\mu s$$

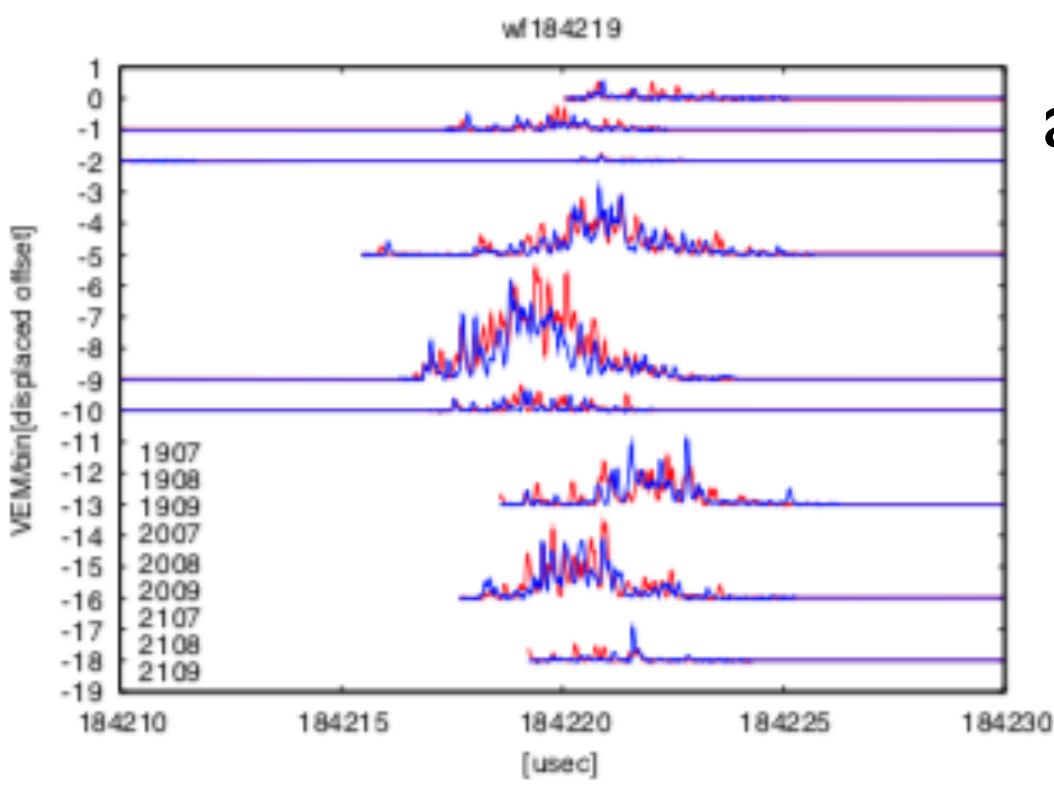


←----- typical CR event

$$\Delta s \in (0, 5 - 3.5)\text{km},$$
$$\Delta t \in (0 - 2)\mu s$$

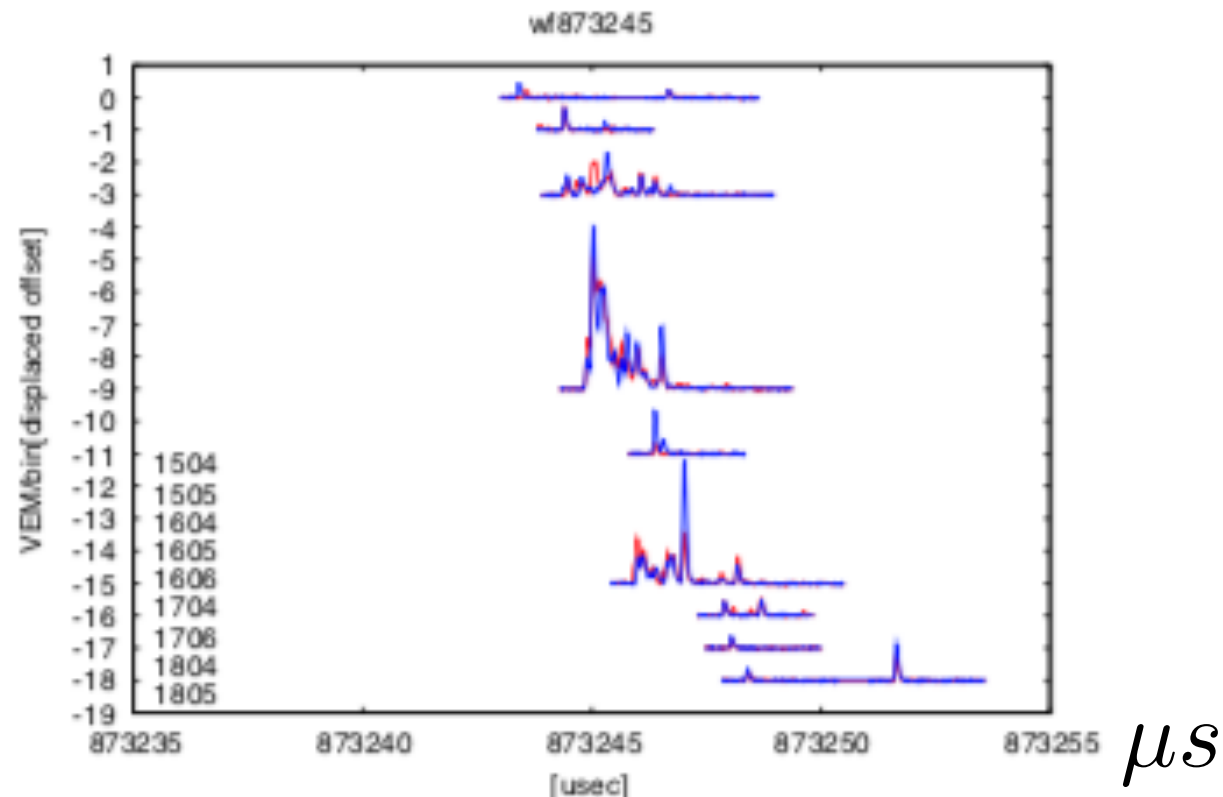
The “curvature puzzle”

- ALL BURSTS ARE OBSERVED UNDER THE THUNDERSTORM. IT IS HARD TO UNDERSTAND HOW CR MAY “KNOW” ABOUT THE THUNDERSTORMS. IN AQN FRAMEWORK THE ELECTRIC FIELD PLAYS THE KEY ROLE BY LIBERATING THE POSITRONS WHICH MIMIC THE CR EVENTS (THIS RESOLVES “*synchronization puzzle*”).
- THE AQN TRAVERSES A SHORT DISTANCE $\sim 0.25\text{km}$ DURING THE BURST 10^{-3}s WHICH IS TREATED AS A CLUSTER OF EVENTS WHEN THE ELECTRIC FIELD FLUCTUATES ON THE SCALE OF ALONG THE AQN’S PATH 10^{-6}s (IT RESOLVES “*clustering puzzle*”)
- OCCURRENCE OF 3+ INTENSE EVENTS DURING 10^{-3}s IN 1KM AREA IS HARD TO EXPLAIN WITH CONVENTIONAL CR ASSUMPTION (IT RESOLVES “*clustering puzzle*”)
- CONVENTIONAL CR SHOWERS HAVE AN ULTRA RELATIVISTIC PARTICLE (SHARP EDGE IN WAVEFORMS). LARGE NUMBER OF POSITRONS PRODUCE NON-SHARP EDGE, RESOLVING “*edge puzzle*”



adopted from TA [Abbasi-2017]

← - - typical burst event

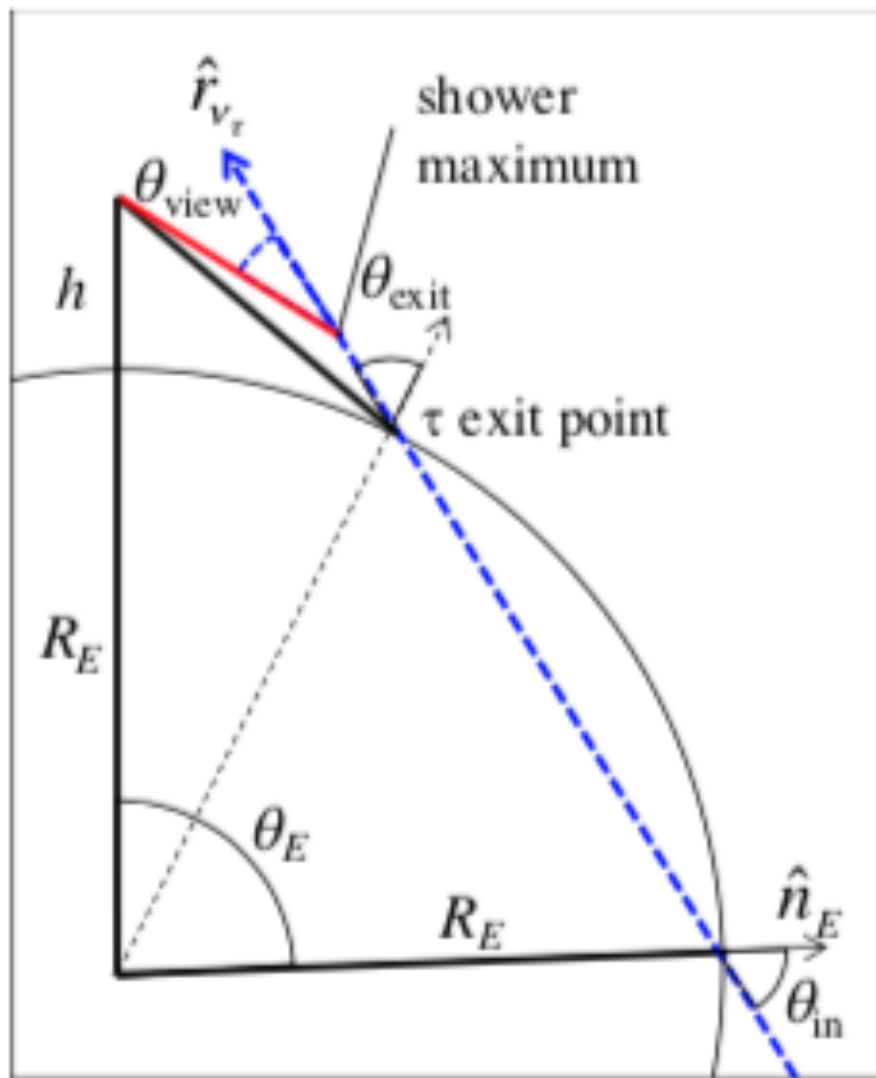


← - - typical CR event

The “edge puzzle”

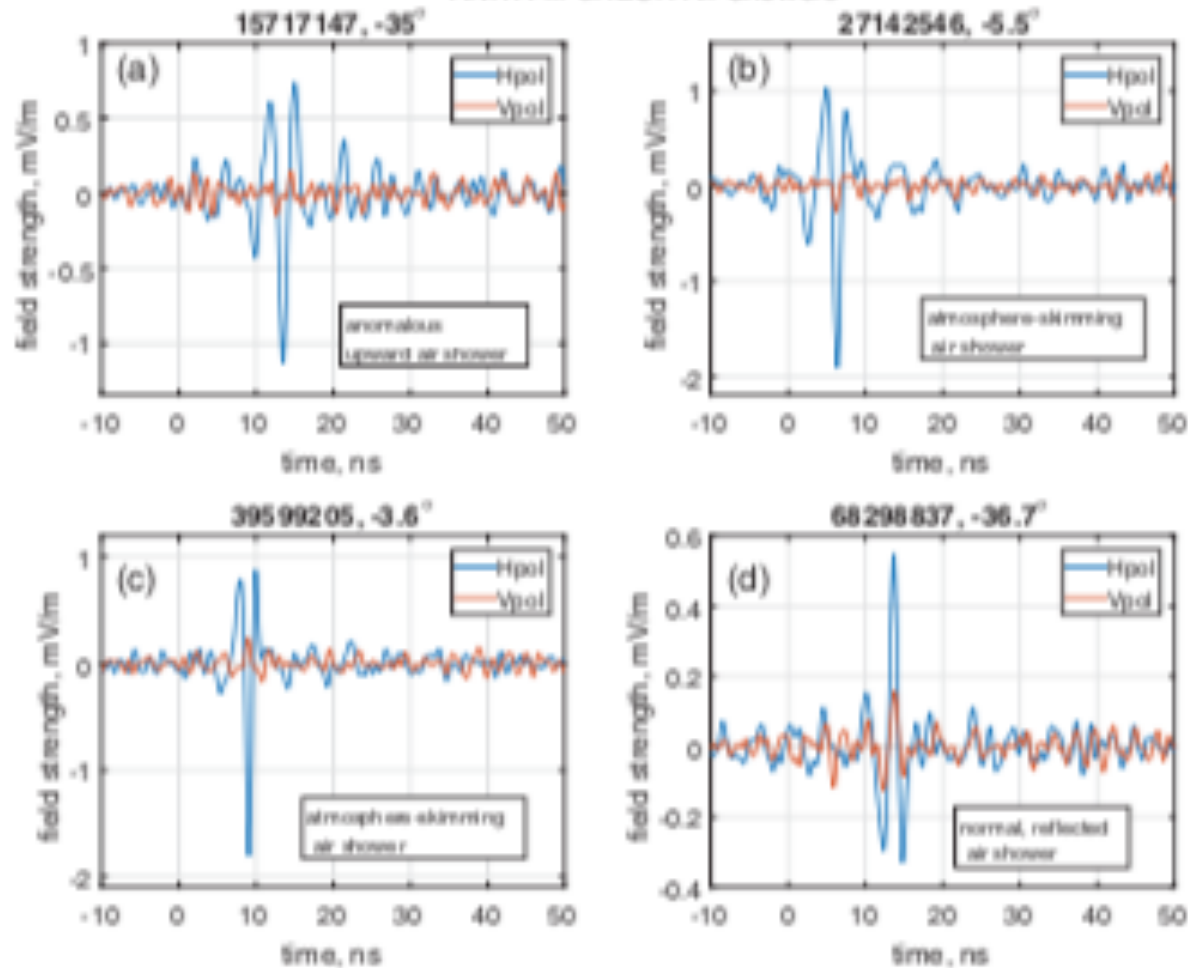
6. ANITA ANOMALOUS EVENTS

- THE ANTARCTIC IMPULSIVE TRANSIENT ANTENNA (ANITA) COLLABORATION OBSERVED TWO ANOMALOUS EVENTS WITH NON-INVERTED POLARITY, SEE SLIDES BELOW.
- THESE TWO EVENTS ARE PROVEN TO BE VERY HARD TO EXPLAIN IN TERMS OF THE CONVENTIONAL CR.
- THE PROBLEM IS THAT THE EXIT ANGLES (RELATIVE TO THE HORIZON) ARE LARGE, $(-27^0, -35^0)$, SEE NEXT SLIDE
- A NEUTRINO MUST TRAVEL $\gtrsim 5 \cdot 10^3 \text{km}$ WITH VERY HIGH ENERGY $E \sim 10^{18} \text{eV}$ TO GENERATE SUCH SIGNAL
- THE SM NEUTRINO IS EXCLUDED AT 5σ CL.



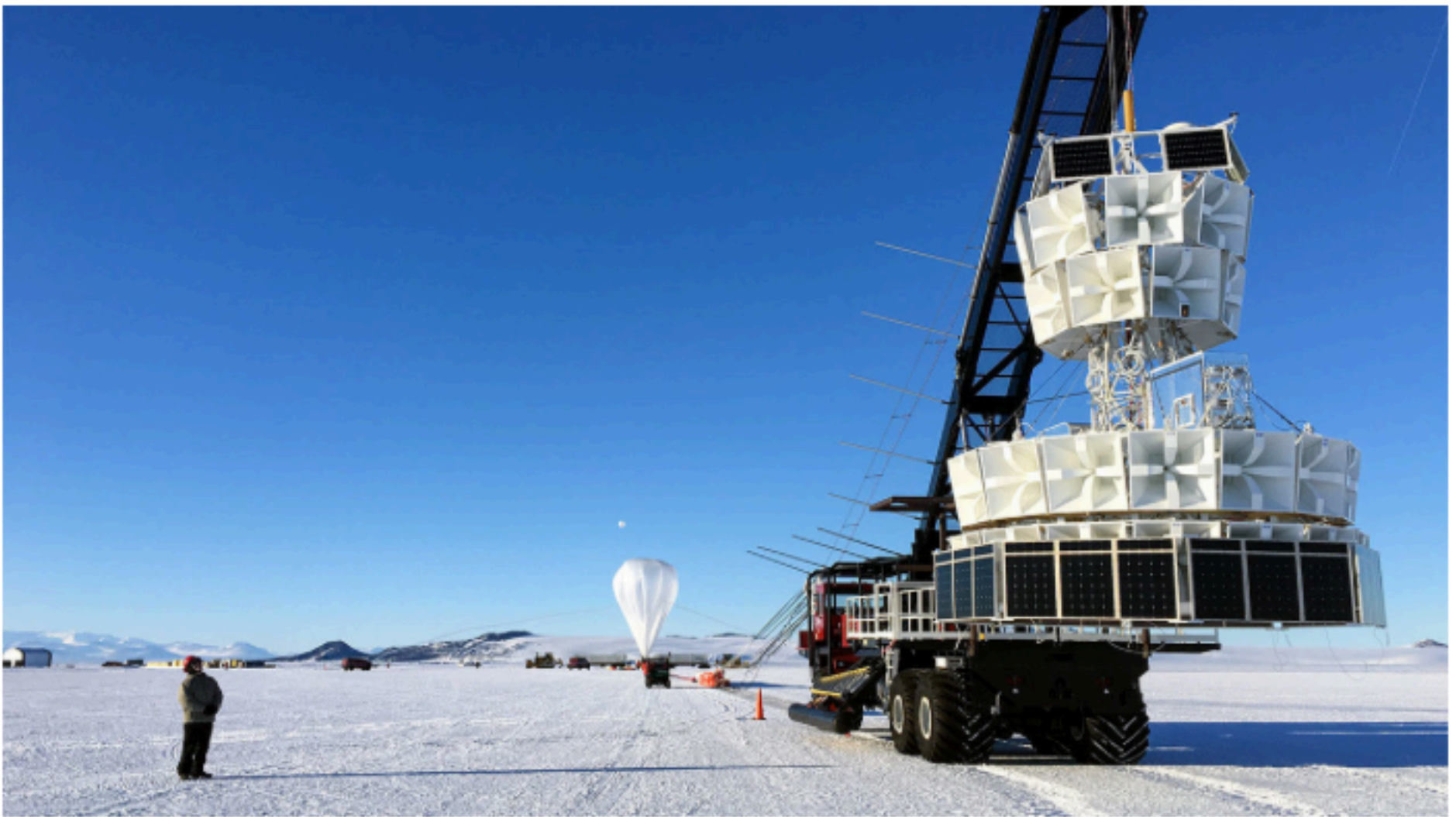
adopted from ANITA
[Gorham-2016]

Large angles ($-27^\circ, -35^\circ$) imply traversing through Earth very large distance (below horizon), considered anomalous. Small angles $\sim (-5^\circ)$ correspond CR propagation above horizon, and considered normal events.



adopted from ANITA
[Gorham-2016]

- a) anomalous event, non-inverted polarity (-35°)
- b), c) normal, above horizon CR events with non-inverted polarity. Angles always are very small: (-5.5° , -3.6°)
- d) normal event with inverted polarity due to the reflection of the conventional CR shower (-36.7°)



The Antarctic Impulsive Transient Antenna balloon experiment has flown four times over Antarctica and has seen two hard-to-explain particle events. NASA

Oddball particles tunneling through Earth could point to new physics

a journalist's description of the problem.

By **Adrian Cho** | Sep. 27, 2018 , 3:00 PM

next slide is my understanding of the problem

7. ANITA ANOMALOUS EVENTS AS AQN EVENTS

- THE AQN EXITS THE EARTH INTERIOR BEING VERY HOT WITH THE TEMPERATURE $T \sim 200 \text{ keV}$
- AT SUCH HIGH TEMPERATURE THE e^+e^- PRODUCTION BECOMES POSSIBLE AS SUPPRESSION $\exp(-2m/T)$ IS NOT VERY DRAMATIC
- AT SUCH HIGH TEMPERATURE A VERY STRONG AQN'S IONIZATION (NEGATIVE CHARGE $-Q$) OCCURS. CONSEQUENCE: A STRONG ELECTRIC FIELD $|E|$ WITHIN THE ELECTROSPHERE EMERGES.
- PRODUCED POSITRONS FROM e^+e^- WILL EXPERIENCE ATTRACTION FORCE AND ASSUME LOCATION CLOSE TO THE AQN'S SURFACE
- PRODUCED ELECTRONS FROM e^+e^- WILL EXPERIENCE REPULSION FORCE AND WILL BE ACCELERATED TO HIGH ENERGY $\langle E \rangle \sim 10 \text{ MeV}$ BY ELECTRIC FIELD $|E|$ BEFORE EXPEL FROM THE SYSTEM

- **PRECISELY THIS BUNCH OF ELECTRONS EMITTED AT THE SAME INSTANT FROM THE SAME LOCATION WITH VERY HIGH ENERGY $\langle E \rangle \sim 10$ MeV PRODUCE A COHERENT RADIO PULSE IN THE BACKGROUND OF GEOMAGNETIC B-FIELD**
- **A TYPICAL NUMBER OF COHERENT ELECTRONS IN A BUNCH IS ESTIMATED ON THE LEVEL $N \sim 10^9$ TO BE COMPARED WITH NUMBER $N \sim (10^8 - 10^9)$ IN EAS WITH $E_{CR} \sim (10^{17} - 10^{18})$ eV**
- **THEREFORE, THE AQN-INDUCED AND CR-INDUCED RADIO SIGNALS MUST BE SIMILAR IN INTENSITY**
- **THE ELECTRIC FIELD OF THE RADIO PULSE AT DISTANCE \mathcal{R} IS COMPUTED IN CONVENTIONAL WAY:**

$$\mathbf{E}(t) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\infty} b(\omega) \mathbf{E}(\omega) e^{-i\omega t} d\omega \approx -\epsilon_{\parallel} \frac{2Ne\rho}{\sqrt{3}\pi c^2 \gamma^2 \mathcal{R}} \operatorname{Re} \left[\int_0^{\infty} b(\omega) \omega K_{2/3}(\xi) e^{-i\omega t} d\omega \right]$$

■ **TYPICAL FEATURES OF THE SYNCHROTRON SPECTRUM: IT IS APPROXIMATELY FLAT WITH CRITICAL (CUTOFF) FREQUENCY**

$$\nu_c \equiv \frac{3\gamma^3 c}{4\pi\rho} \approx 0.7 \text{ GHz} \left(\frac{\gamma}{20} \right)^2 .$$

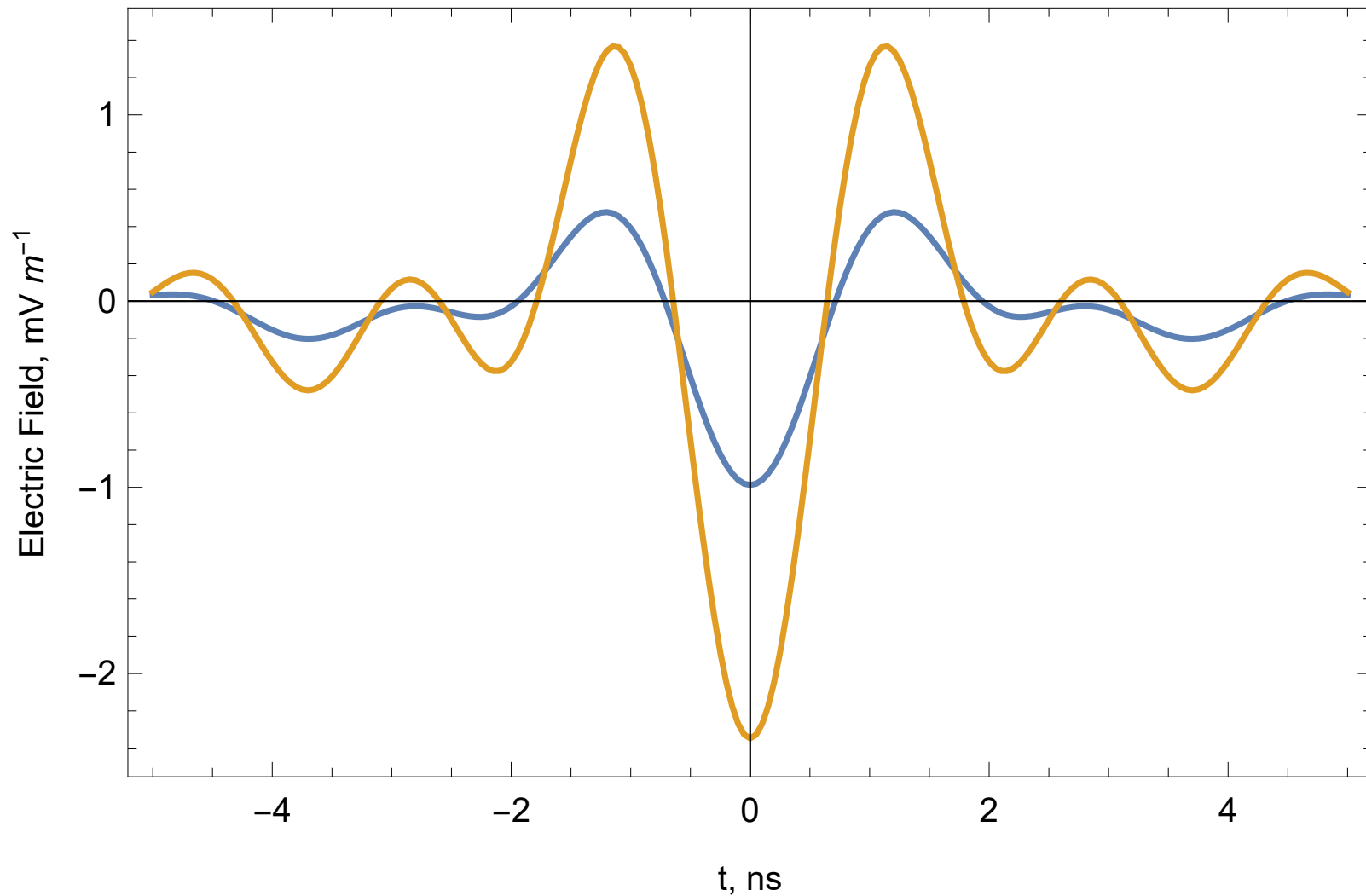
■ **TYPICAL DURATION OF THE SIGNAL IS $(2 - 4)\text{ns}$:**

$$\tau \approx \frac{1}{\Delta\nu} \approx 2 \text{ ns} \left(\frac{600 \text{ MHz}}{\Delta\nu} \right) .$$

■ **TYPICAL INTENSITY OF THE PULSE IS $|\mathbf{E}(\mathbf{t})| \sim \text{mV/m}$**

■ **TYPICAL POWER DENSITY IS $(0.2 - 0.3) \text{ pW m}^{-2} \text{ MHz}^{-1}$**

■ **ALL THESE VALUES ARE VERY CLOSE TO THE OBSERVED MAGNITUDES RECORDED BY ANITA AND CLASSIFIED AS ANOMALOUS EVENTS, SEE SLIDE**



Electric field $|\mathbf{E}(\mathbf{t})|$ in units mV/m

$\theta = 0, N = 5 \cdot 10^8, \gamma = 10$ (blue), and $\gamma = 20$ (orange)

filter $b(\omega) : (40 - 80) \ \& \ (200 - 800) \text{ MHz}$

CONCLUSION

- "NON- BARYONIC DARK MATTER" COULD BE ORDINARY BARYONIC MATTER (WE KNOW AND LOVE) WHICH IS IN THE EXOTIC COLOUR SUPERCONDUCTING PHASE. WE COIN THIS MODEL AS THE AXION QUARK NUGGET MODEL (AQN)
- RATIO: $\Omega_{\text{dark}} \sim \Omega_{\text{visible}}$ IS VERY GENERIC CONSEQUENCE OF THIS FRAMEWORK (NO SENSITIVITY TO AXION MASS m_a , NOR TO THE MISALIGNMENT ANGLE θ_{initial}). IT IS THE DIRECT CONSEQUENCE OF THE FRAMEWORK WHEN THE DARK MATTER AND VISIBLE COMPONENTS ARE PROPORTIONAL TO ONE AND THE SAME FUNDAMENTAL Λ_{QCD} SCALE.
- THIS MODEL OFFERS A SIMULTANEOUS RESOLUTION OF A NUMBER (NAIVELY UNRELATED) OLD MYSTERIES: DM, BARYOGENESIS, SOLAR CORONA MYSTERY, PRIMORDIAL LITHIUM PUZZLE, THE TELESCOPE ARRAY MYSTERIOUS BURSTS, THE ANITA ANOMALOUS EVENTS, SKYQUAKES, ETC

$$\Omega_{\text{dark}} \sim \Omega_{\text{visible}}$$

ANITA anomalous events

“Baryogenesis”
(charge separation)

Dark Matter

Primordial
Lithium Puzzle

Solar corona
Mystery

TA mysterious
bursts

DL annual
modulation

sky-quakes

XMM-Newton
seasonal variations

AQN

We need to discover
the **axion** to unlock
all these mysteries
(simultaneously)

More Elephants!



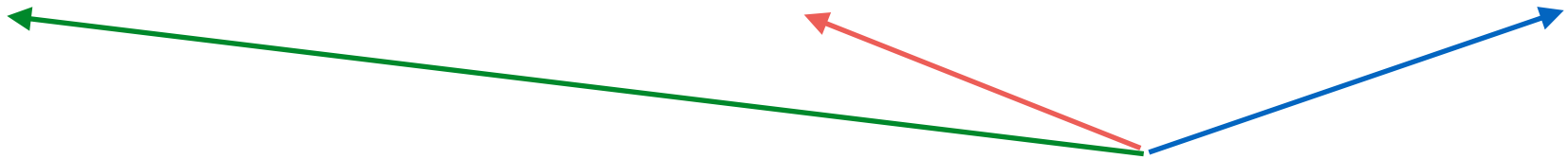
Matter-antimatter Asymmetry



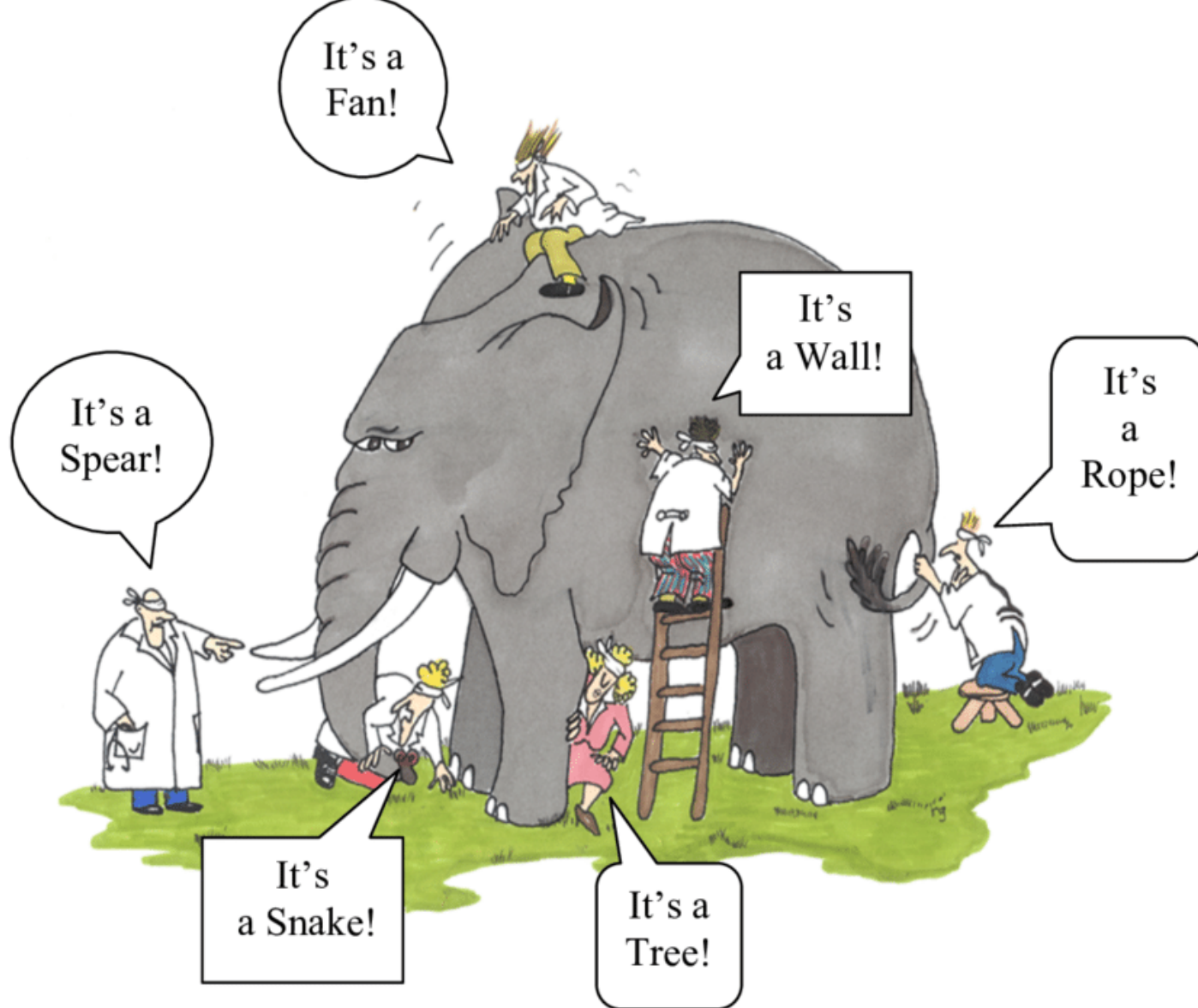
Similar amount of matter and DM



Dark Energy



From Dima Budker's talk "More elephants in the room"



The main essence of my talk: different people (from different fields conducting different experiments around the Globe), in fact, observe and study **different** parts of a body of the **same** elephant