PHELEX:

The Experiment on the Search for Dark Photons

Anatoly Kopylov, Igor Orekhov, Valery Petukhov, Alexei Solomatin

Institute for Nuclear Research of Russian Academy of Sciences

The aim of experiment:
the search for Dark Matter as Hidden Photons

Virial theorem:
kinetic energy of gravitationally bound system of objects should be equal to – 0.5 of their potential energy

Zwicky (1937) – analyses of red shifts of the Coma Cluster of galaxies: surprisingly high mass-to-light ratio

To-day, according to a combination of all data: the dark matter accounts for about **84 %** of the matter content of the Universe

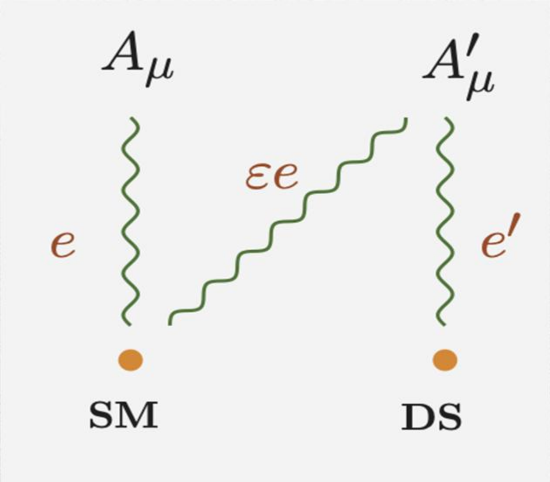
WIMPS, Axions …. ?

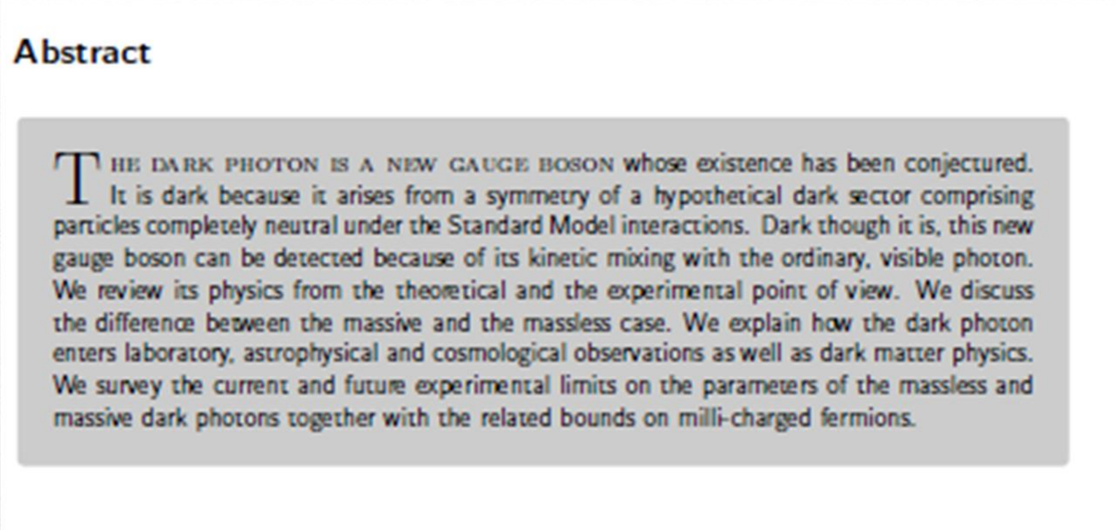
What if: dark photons?

First articles on the topic:

- P. Fayet, On the search for a New Spin 1 Boson, Nucl. Phys B 187 (1981) 184-204.
- L. B. Okun, Limits of Electrodynamics: Paraphotons, Sov. Phys. JETP 56 (1982) 502 [Zh. Eksp. Thedor. Fiz. 83 (1982) 892.
- H. Georgi, P. H. Ginsparg, and S. L. Glashow, Photon Oscillations and the Cosmic Background Radiation, Nature 306 (1983) 765 – 766.

The dark Photon





Abstract

THE DARK PHOTON IS A NEW GAUGE BOSON whose existence has been conjectured. It is dark because it arises from a symmetry of a hypothetical dark sector comprising particles completely neutral under the Standard Model interactions. Dark though it is, this new gauge boson can be detected because of its kinetic mixing with the ordinary, visible photon. We review its physics from the theoretical and the experimental point of view. We discuss the difference between the massive and the massless case. We explain how the dark photon enters laboratory, astrophysical and cosmological observations as well as dark matter physics. We survey the current and future experimental limits on the parameters of the massless and massive dark photons together with the related bounds on milli-charged fermions.

M. Fabbrichesi, E. Gabrielli, G. Lanfranchi

The Physics of the Dark Photon, Springer Briefs in Physics (Springer, 2021)

V. Dzunushaliev, V. Folomeev, A.Tlemisov

Linear Energy Density and the Flux of an Electric Field in Proca Tubes

Symmetry 2021, *13*, 640. https://doi.org/10.3390/sym13040640

V. Dzunushaliev, V. Folomeev

Axially symmetric particlelike solutions with the flux of a magnetic field in the non-Abelian Proca-Higgs theory

Phys. Rev. D 2021, 104, 116027

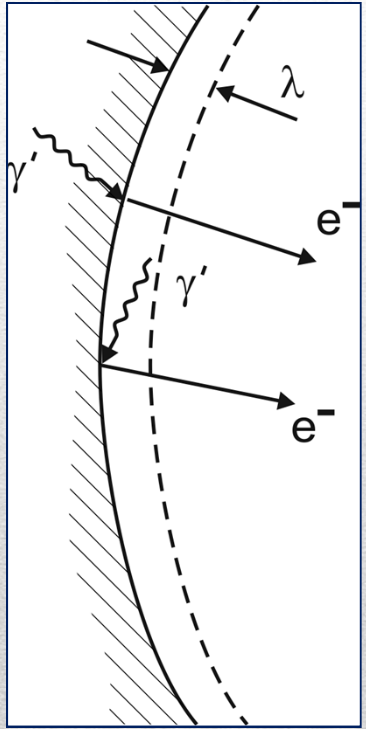
V. Dzunushaliev, V. Folomeev

Proca balls with angular momentum or flux of electric field

Phys. Rev. D 2022, 105, 016022

arXiv:2112.06227v.2 [hep-th] 16 Feb 2022

PHELEX – PHoton-ELectron EXperiment



multicathode counter technique as an extension of a method of a dish antenna to higher masses (energies)

$$P = 2\alpha^2 \chi^2 \rho_{CDM} A_{dish}$$

$$\alpha^2 = <\cos^2\theta>$$

θ – angle between electric field of a photon and the surface
χ- dimensionless parameter quantifying a kinetic mixing

(D.Horns, J.Jackel, A.Lindner, A.Lobanov, J.Redondo, A.Ringwald , "Searching for wispy cold dark matter with a dish antenna" *Journal of Cosmology and Astroparticle Physics*, vol.4. article 16, 2013)

$\rho_{CDM} \approx 0.4$ GeV/cm^3

$\rho_{\odot}$ = (0.43 ± 0.06) GeV/cm3 (Salucci et al 2010)

Galactic dark matter halo.
But locally, near the Sun?
Primordial Solar dark matter halo?
arXiv:2007.11016
(N.B.Anderson, A.Partenheimer, and T.D.Wiser)

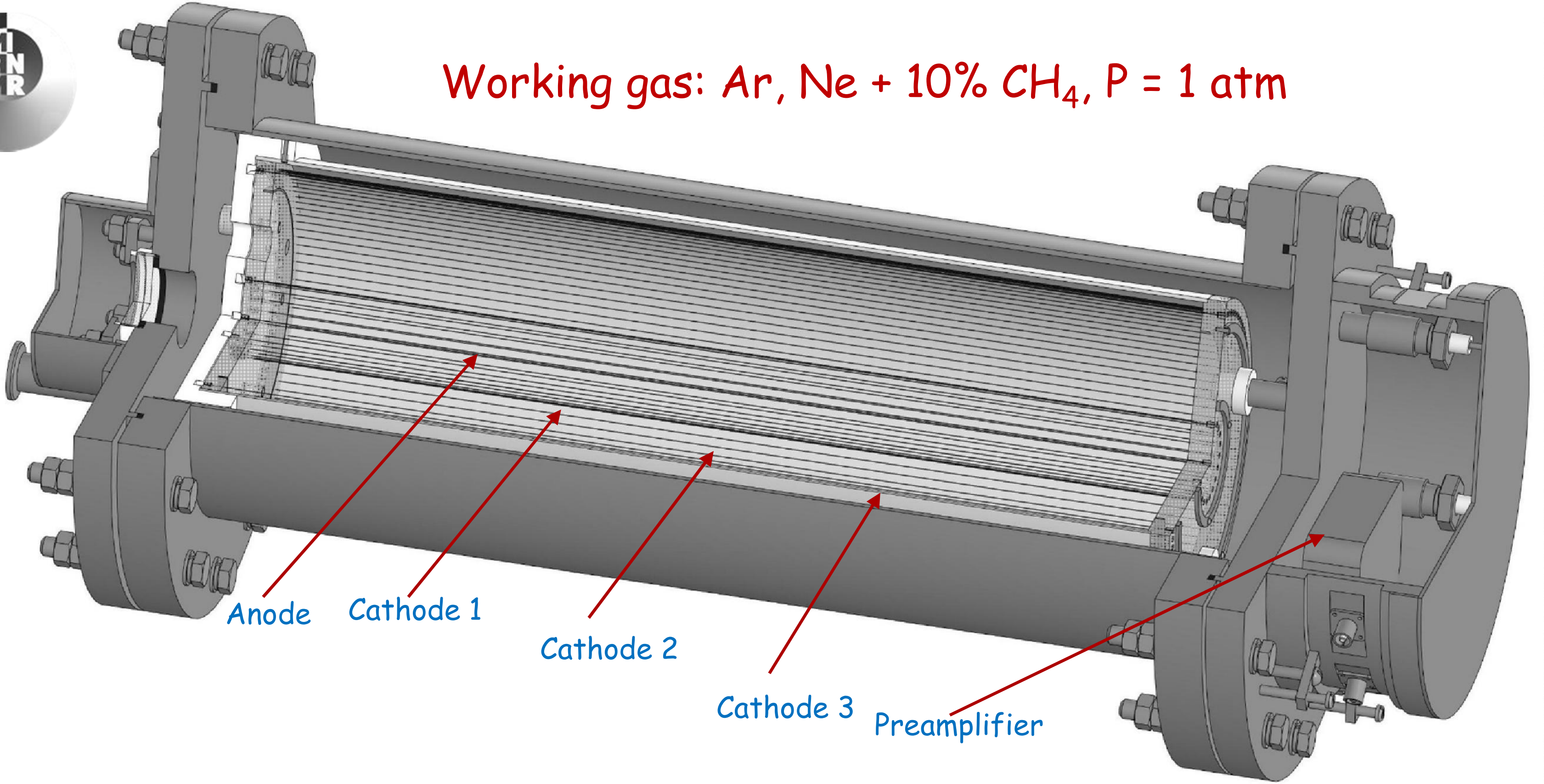
In our case: due to low reflectivity of the surface the photon gets absorbed and emits an electron

$$P = R_{MCC} m_{\gamma'} / \eta$$

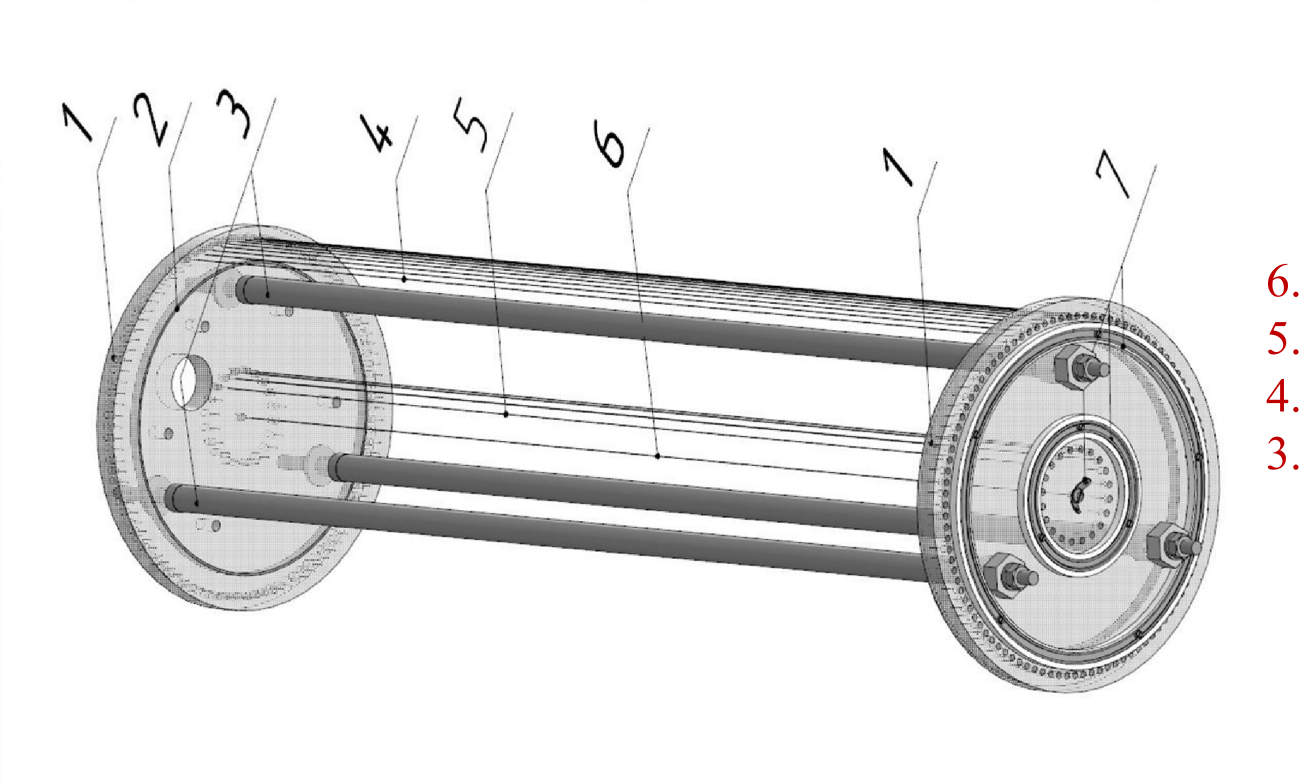
Sensitivity:

$$\chi = 2.9 \cdot 10^{-12} \left(\frac{R_{MCC}}{\eta \cdot 1Hz}\right)^{\frac{1}{2}} \left(\frac{m_{\gamma'}}{1eV}\right)^{\frac{1}{2}} \left(\frac{0.3GeV/cm^3}{\rho_{CDM}}\right)^{\frac{1}{2}} \left(\frac{1m^2}{A_{cath}}\right)^{\frac{1}{2}} \left(\frac{\sqrt{2/3}}{\alpha}\right)$$

Working gas: Ar, Ne + 10% CH_4, P = 1 atm

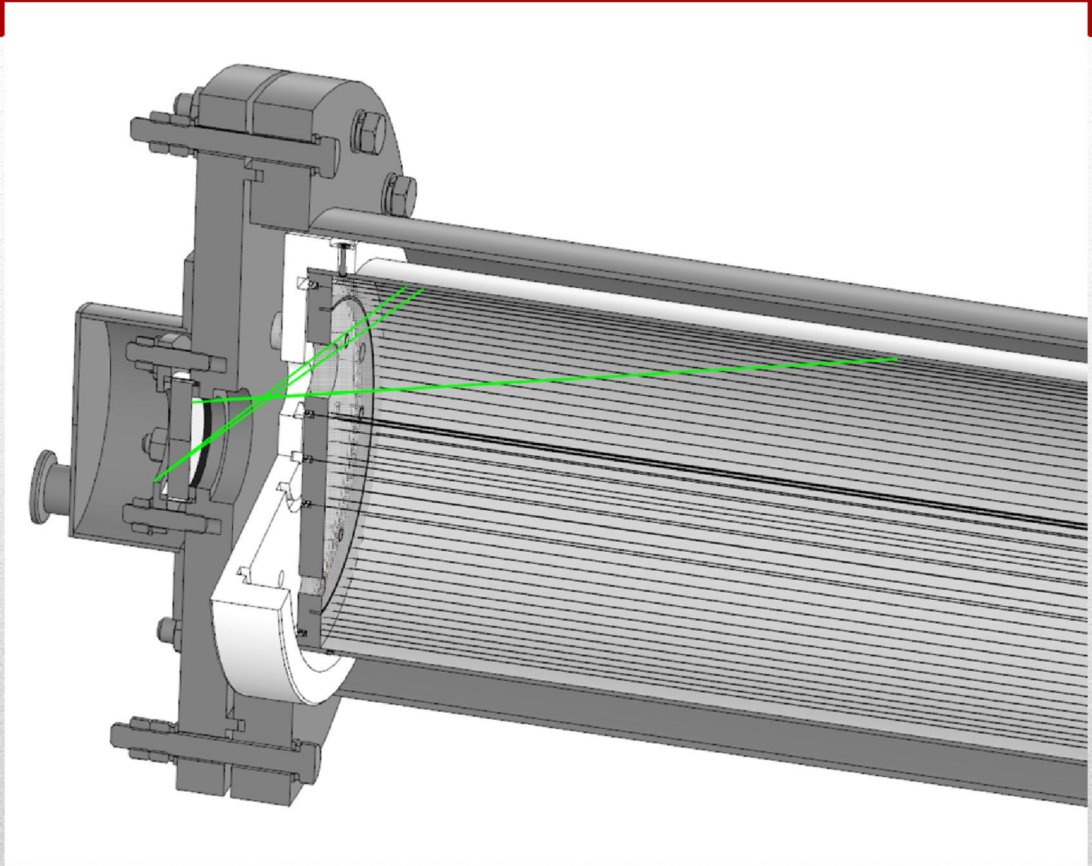


Multicathode counter, calibration from the end of the counter



6. Anode
5. 1st cathode
4. 2nd cathode
3. Assembling rods

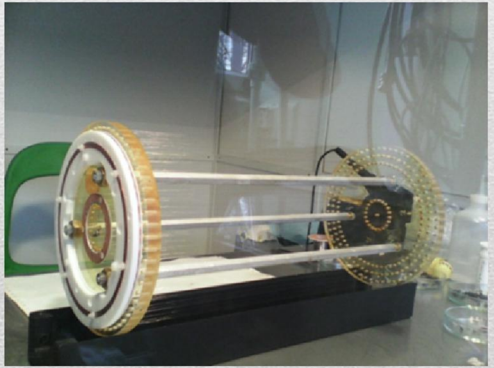
With auxiliary rods for tensioning cathode wires

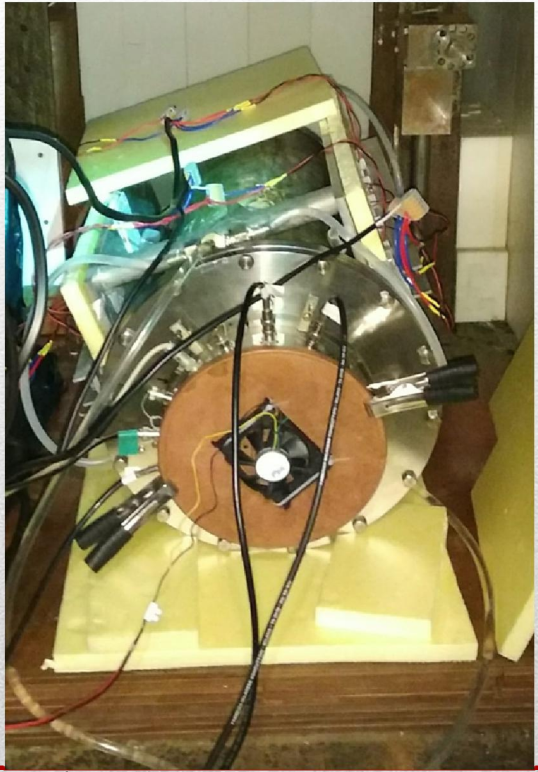


Calibration by UV lamp

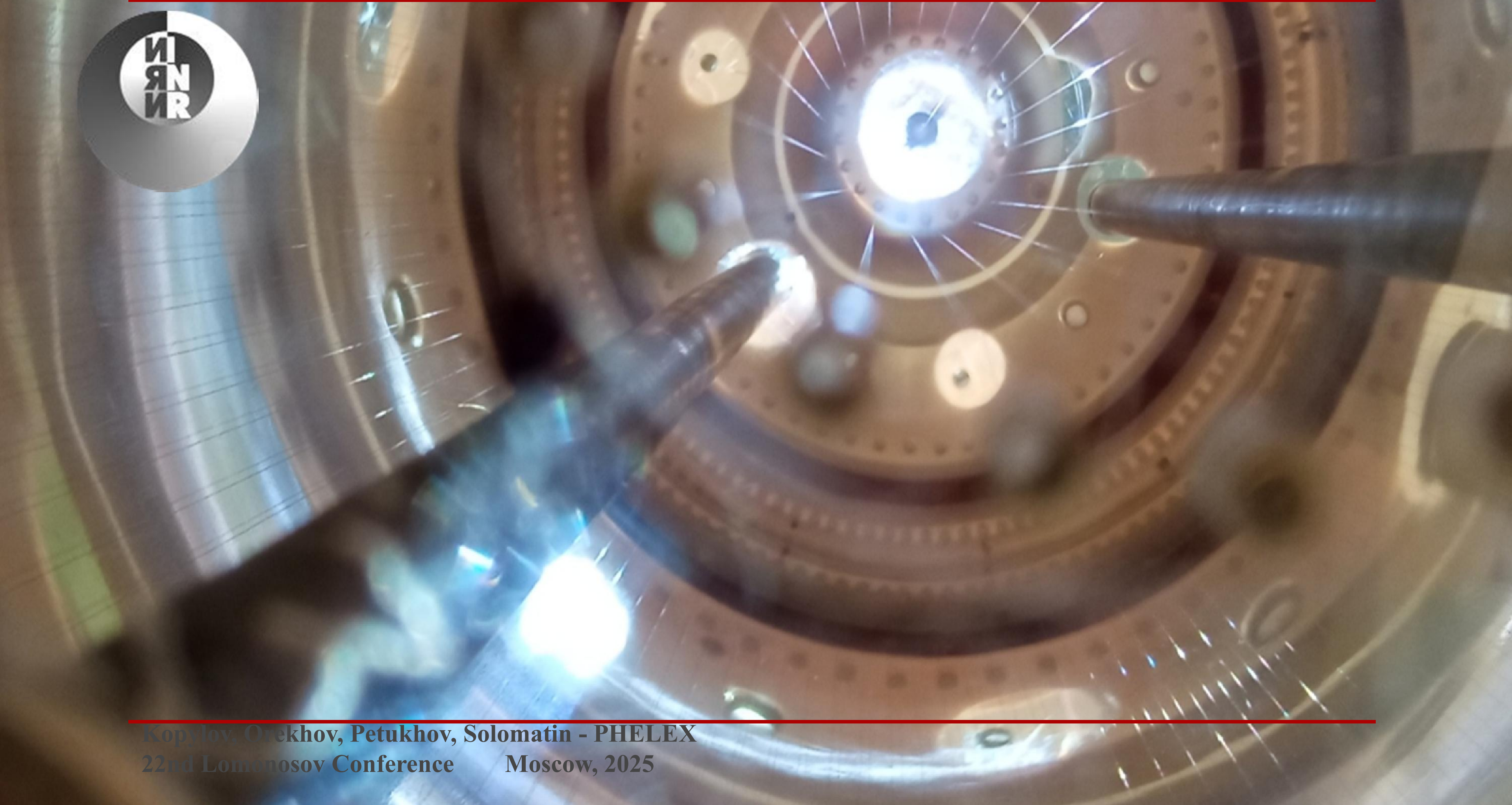
Multicathode counter, calibration from the end of the counter

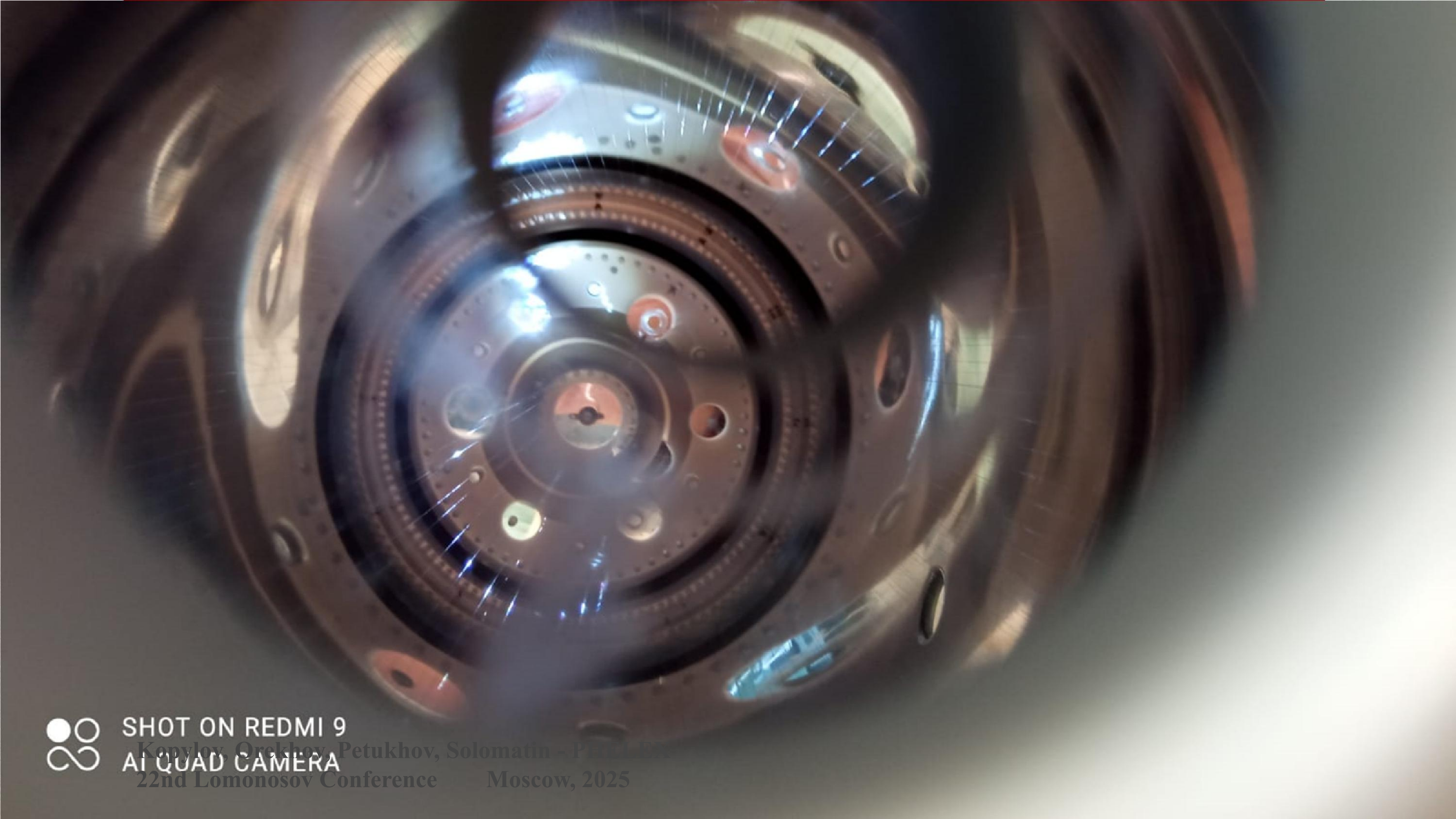
Multicathode counter: assembling and testing





Assembling the counter




SHOT ON REDMI 9
AI QUAD CAMERA


NANPino
INTERNATIONAL WORKSHOP
ON NON-ACCELERATOR NEW PHYSICS
in neutrino observations
Dubna
July 19-22, 2000
Organizers:
TOPICS:
present status and future prospects;
Solar and atmospheric neutrino anomalies as
of non-zero neutrino masses and mixing;


SHOT ON REDMI 9
AI QUAD CAMERA

R.B.Cairns and J.A.R.Samson Journal of optical society of America
Vol. 56, Number 11, November 1966, 1568-1573

$\approx 8(p/h)^3$

$T_\nu = 1.95\ {}^0K$

In 1 cm^3:
≈ 150 relic neutrinos
≈ 500 relic photons

Dark photons in the vicinity of The Sun:
From 10 to 40 millions/cm^3 !

$\rho_{CDM} \approx 0.4\ GeV/cm^3$

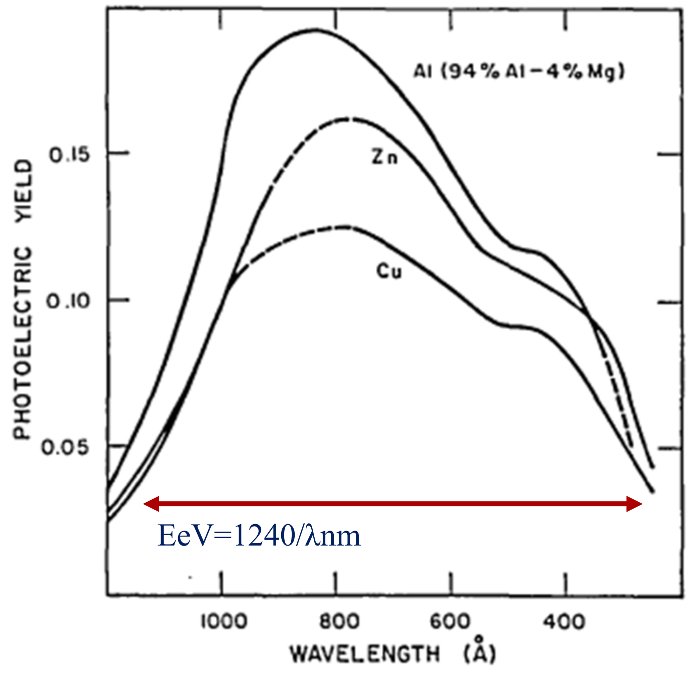


FIG. 4. Photoelectric yields of Al–Mg, Zn, and Cu.

Mass of Dark Photon
from 10 to 40 eV

16:02

New Scientist

Galaxy SDSS J0946+1006 acts as a gravitational lens, helping astronomers see the signs of dark matter

NASA/ESA/R. Gavazzi, T. Treu/University of California/SLACS

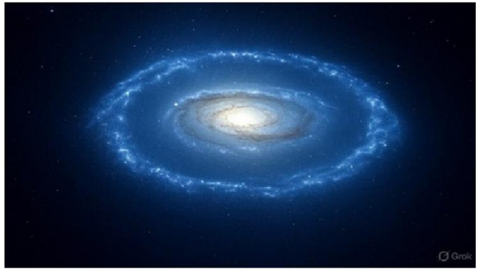
An unusually dense galaxy could be the first clear evidence for the existence of an unconventional form of “sticky” dark matter, altering our understanding of this mysterious cosmic substance.

In the standard picture of cosmology, so-called cold dark matter only interacts with the rest of the universe through gravity, which causes it to bunch together in invisible, puffy clouds around galaxies. We can map these

10:29

iXBT.com Статьи Новости HONOR реклама

Астрономы из Портсмутского университета обнаружили в галактике SDSS J0946+1006 необычно плотное темное гало, которое может стать ключом к разгадке природы темной материи. Открытие указывает на возможное существование «липкой» темной материи, которая способна взаимодействовать сама с собой, что противоречит традиционным представлениям о ее поведении. Уникальная структура галактики, состоящей из трех объектов на расстоянии 3, 6 и 11 миллиардов световых лет, позволила ученым использовать гравитационное линзирование для точного анализа распределения массы.



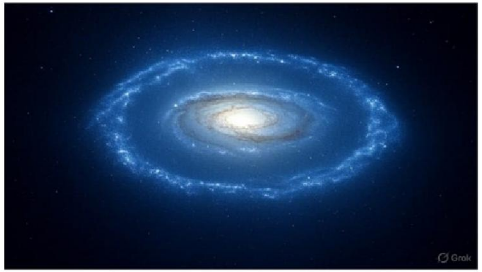
Изображение сгенерировано Grok

В стандартной космологической модели темная материя считается «холодной» и взаимодействует с окружающим миром только через гравитацию, формируя рыхлые облака вокруг галактик. Однако плотность гало в SDSS

10:20

iXBT.com Статьи Новости HONOR реклама

анализа распределения массы.



Изображение сгенерировано Grok

В стандартной космологической модели темная материя считается «холодной» и взаимодействует с окружающим миром только через гравитацию, формируя рыхлые облака вокруг галактик. Однако плотность гало в SDSS J0946+1006 оказалась выше ожидаемой, что соответствует гипотезе о самовзаимодействующей темной материи. Используя данные телескопа «Хаббл» и статистическое моделирование, исследователи подтвердили, что гало расположено в центре галактики, а его характеристики совпадают с теоретическими предсказаниями. «Гравитационное линзирование — наш главный инструмент для изучения невидимой массы, которая не излучает свет», — отметил профессор Томас Коллетт.

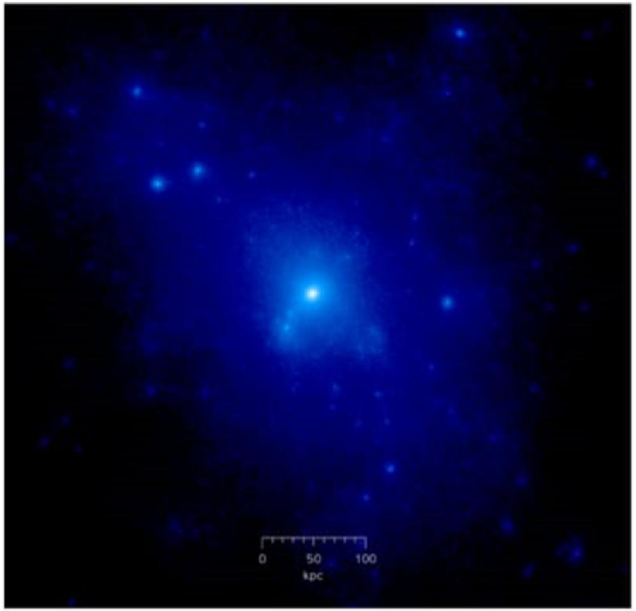
MNRAS **540,** 247–263 (2025) https://doi.org/10.1093/mnras/staf697 Advance Access publication 2025 April 30

The overconcentrated dark halo in the strong lens SDSS J0946 + 1006 is a subhalo: evidence for self-interacting dark matter?

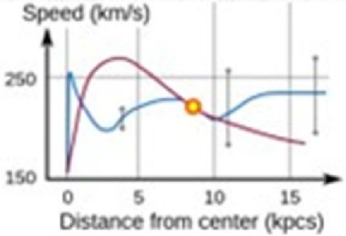
Wolfgang J. R. Enzi , [1] ‹
Coleman M. Krawczyk , [1]
Daniel J. Ballard [1] , [2] and
Thomas E. Collett [1] [1] *Institute of Cosmology and Gravitation (ICG), University of Portsmouth, Burnaby Rd, Portsmouth PO1 3FX, UK* [2] *Sydney Institute for Astronomy, School of Physics, University of Sydney, NSW 2006, Australia* Accepted 2025 April 18. Received 2025 March 22; in original form 2024 November 13

A B S T R A C T The nature of dark matter is poorly constrained on subgalactic scales. Alternative models to cold dark matter, such as warm dark matter or self-interacting dark matter, could produce very different dark haloes on these scales. One of the few known dark haloes smaller than a galaxy was disco v ered in the triple source plane strong lens system J0946 + 1006. Previous studies have found that this structure is much more concentrated than expected in Lambda cold dark matter (CDM), but have assumed the dark halo is at the same redshift as the main deflector (z_{main} = 0 . 222). In this paper, we fit for the redshift of this dark halo. We reconstruct the first two sources in the system using a forward modelling approach, allowing for additional complexity from multipole perturbations. We find that the perturber redshift is $z_{halo} = 0.207^{+0.019}_{-0.019}$, and lower bounds on the evidence strongly prefer a subhalo o v er a line-of-sight structure. Whilst modelling both background sources does not impro v e constraints on the redshift of the subhalo, it breaks important degeneracies affecting the reconstruction of multipole perturbations. We find that the subhalo is a more than 5 σoutlier from the CDM v_{max}–r_{max} relation and has a steep profile with an average slope of $\gamma_{2D} = -1.81^{+0.15}_{-0.11}$ for radii between 0 . 75 and 1 . 25 kpc. This steep slope might indicate dark matter self-interactions causing the subhalo to undergo gra v othermal collapse; such collapsed haloes are expected to have $\gamma_{2D} \approx -2$.

Key words: gravitational lensing: strong –dark matt

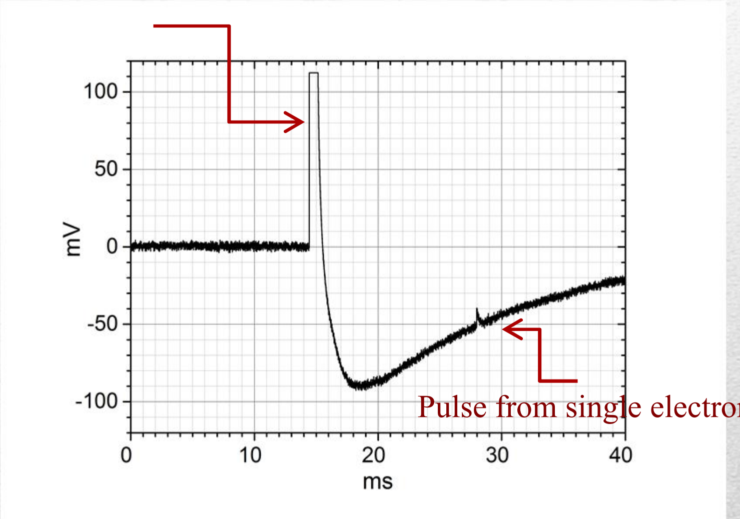


Simulated dark matter halo from a cosmological N-body simulation

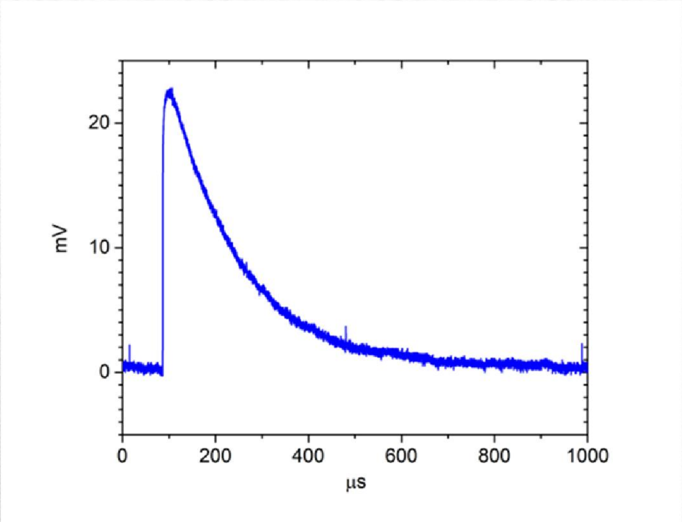


Galaxy rotation curve for the Milky Way. Vertical axis is speed of rotation about the galactic center. Horizontal axis is distance from the galactic center. The sun is marked with a yellow ball. The observed curve of speed of rotation is blue. The predicted curve based upon stellar mass and gas in the Milky Way is red. Scatter in observations roughly indicated by gray bars. The difference is due to dark matter or perhaps a modification of the law of gravity.[8][9][10]

Pulse from muon crossing the counter



The restored shape of the pulse

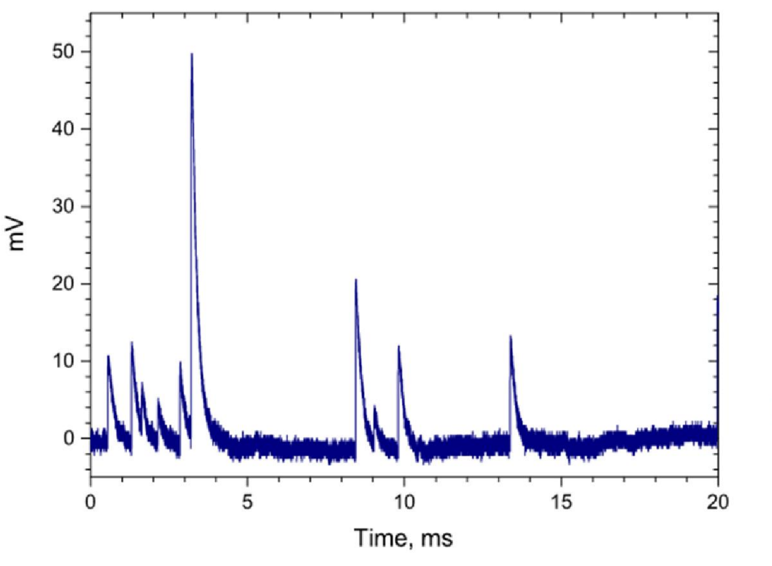


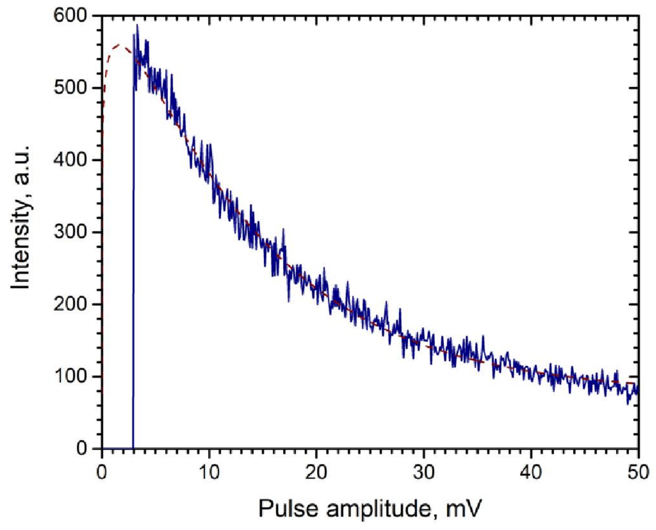
From muons at sea level: ≈ 15 pulses per second → ≈ 15% dead time (10 ms per each pulse)

Pulses from single electrons during calibration by UV light

Polya distribution

$$P(A) = C\left(\frac{A}{\bar{A}}\right)^{\theta} e^{-\left((1+\theta)\frac{A}{\bar{A}}\right)}$$





From muons at sea level: ≈ 15 pulses per second → ≈ 15% dead time (10 ms per each pulse)

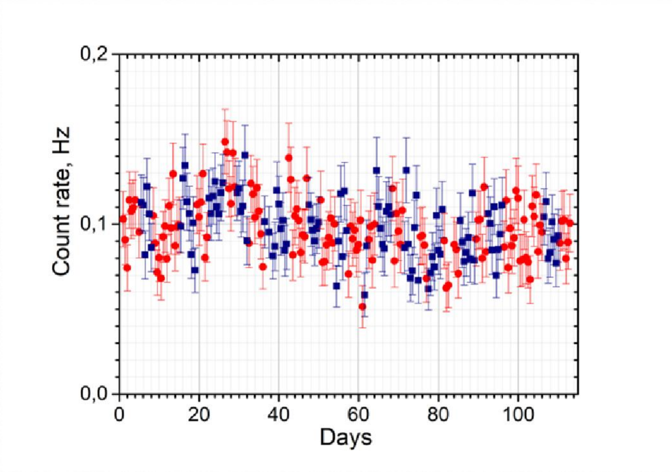
Results of measurement

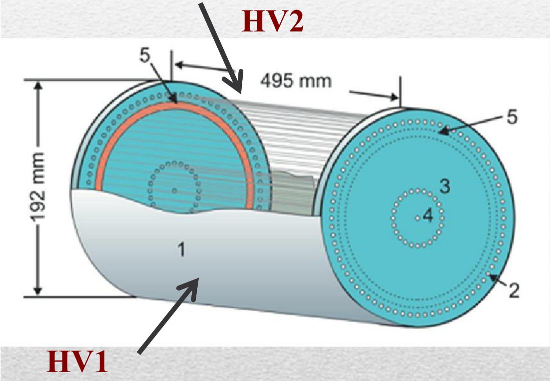
with gas mixture Ar +CH_4(10%) и Ne + CH_4(10%)

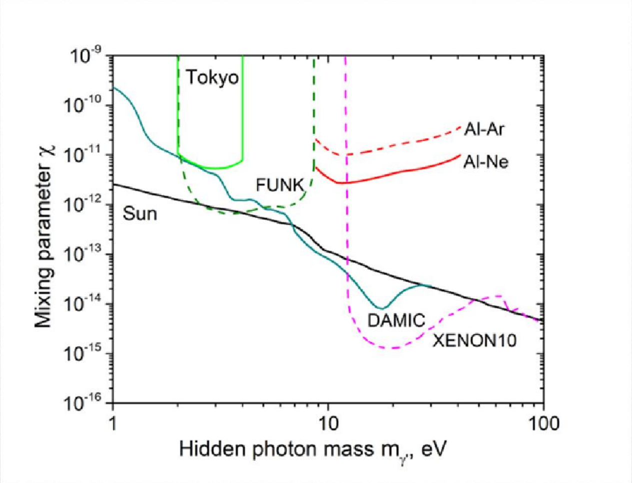
Target – free electrons of a degenerate electron gas of a metal

Result is included in compilation of the data

Review of Particle Physics in Prog. Theor. Exp. Phys. 2020, 083C01 (2020).



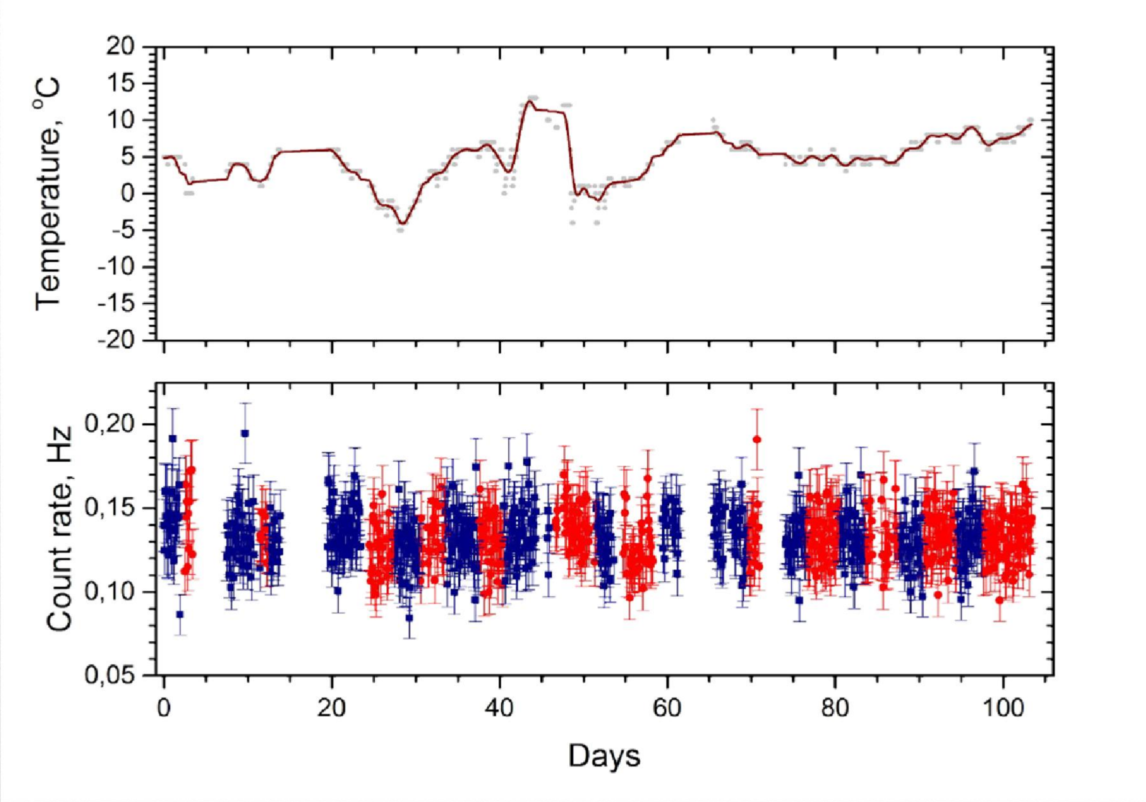




R_1 – red, R_2 - blue

- ***Target – valence electrons***

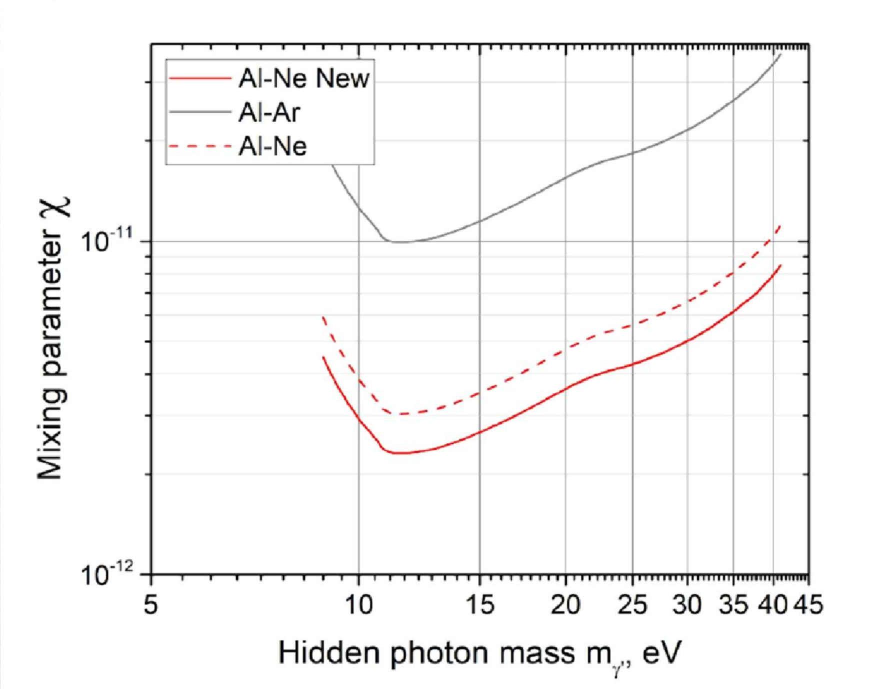
$$r_{MCC} = (-0.33 \pm 0.7)\cdot 10^{-6}\ Hz/cm^2$$



Red – configuration 1
Blue – configuration 2

871 points;
In previous measurements – 200 points

New measurements Al – (Ne + CH_4(10%) 1 Bar)



New result:

C1-C2 = - 0.00018 ± 0.00101 Hz

Then @ 95 C.L.

R_{MCC} = 1.646σ/ε = 0.00164/0.608 =
= 0.0027

ε – efficiency of counting

New upper limit

Result is included in compilation of the data by PDG

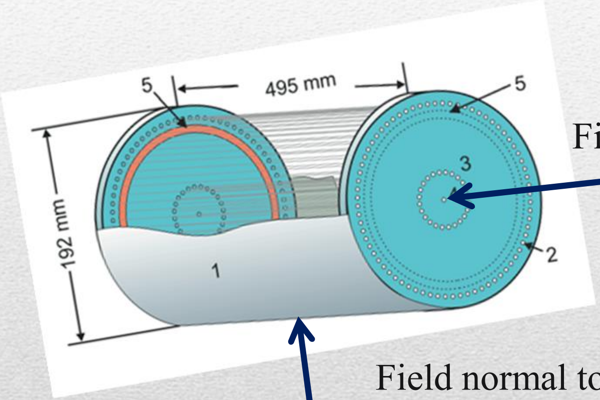
Review of Particle Physics in Prog. Theor. Exp. Phys. 2022, 083C01 (2022).

Directionality of the counting

$$P = 2\alpha^2 \chi^2 \rho_{CDM} A_{dish}$$

$$\alpha^2 = \cos^2 \theta$$

θ – angle between a field of a hidden photon and the surface
χ- dimensionless parameter quantifying a kinetic mixing



Field along the axes of the counter

$$< \cos^2 \theta >= 0$$

Field normal to the axes of the counter

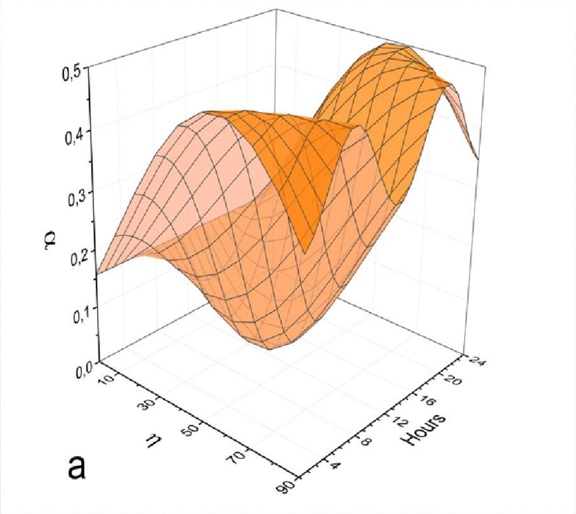
$$< \cos^2 \theta >= \frac{1}{2}$$

(D.Horns, J.Jackel, A.Lindner, A.Lobanov, J.Redondo, A.Ringwald , "Searching for wispy cold dark matter with a dish antenna" *Journal of Cosmology and Astroparticle Physics*, vol.4. article 16, 2013)

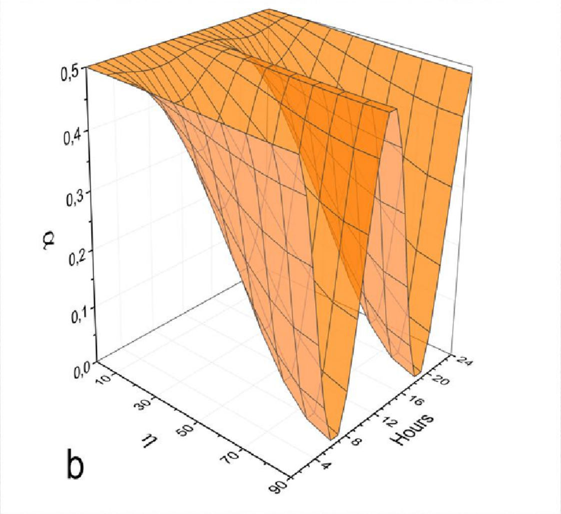
- **By rotation of the counter – variation of the count rate**

If the surface is mirror-like!
The counter with a matt surface – for the control measurements

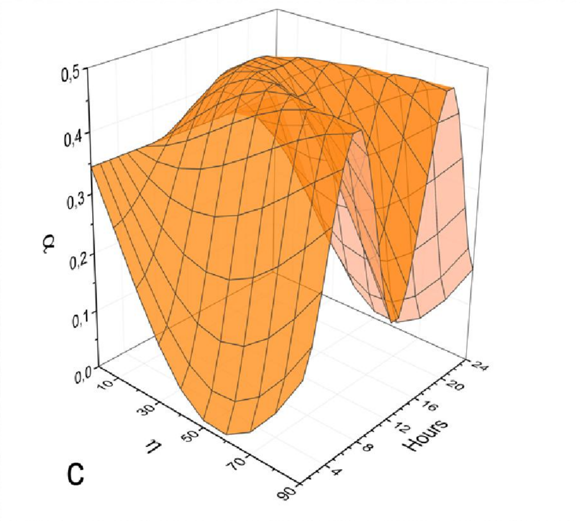
Diurnal variations, Moscow, Russia 55º 45’ N



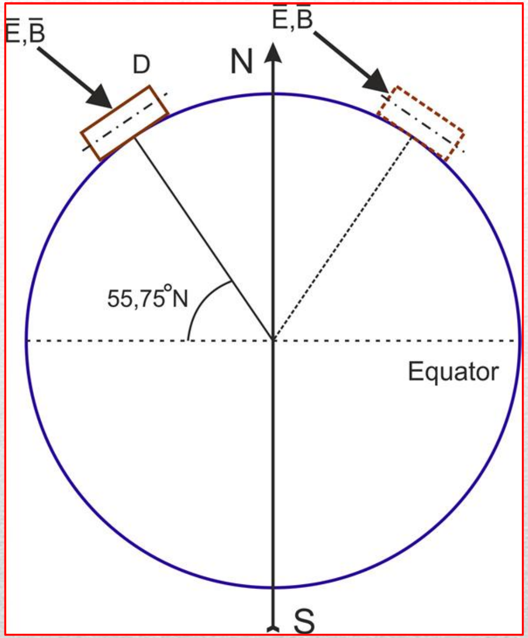
Vertical orientation



East-West orientation

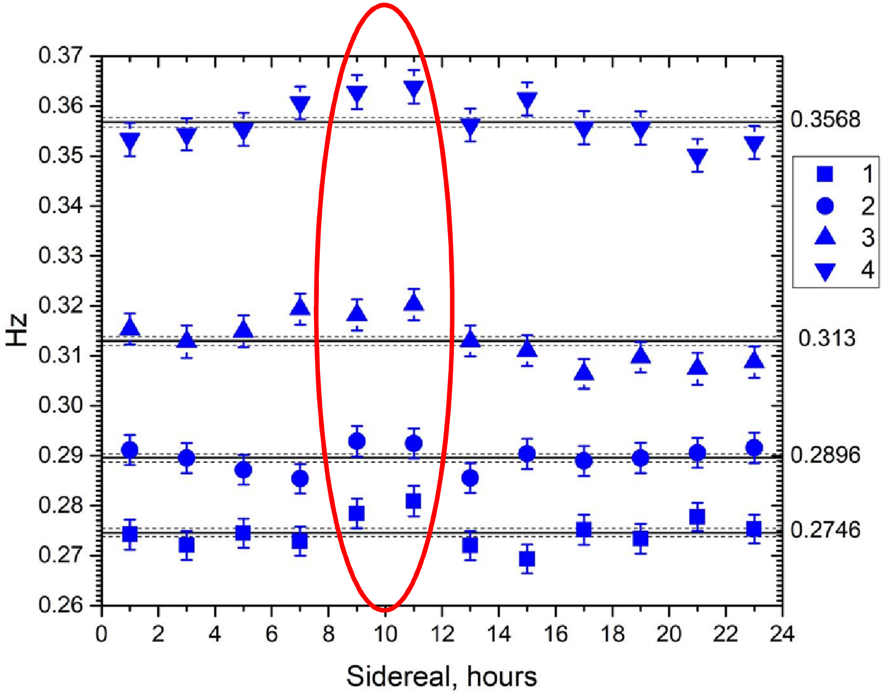


North-South orientation



The direction of the vector of E-field in case of the observation of one peak for the counter oriented along the meridian

Left: for maximum and
Right: for minimum of the count rate



1^{st} series of measurements in 2023 y (January –July)

Time of start-stop in each 4 Runs of measurements
1: 27.12.22 12:00 - 25.02.23 20:00
2: 25.02.23 22:00 - 15.04.23 16:00
3: 15.04.23 18:00 - 4.06.23 10:00
4: 4.06.23 12:00 - 24.07.23 10:00

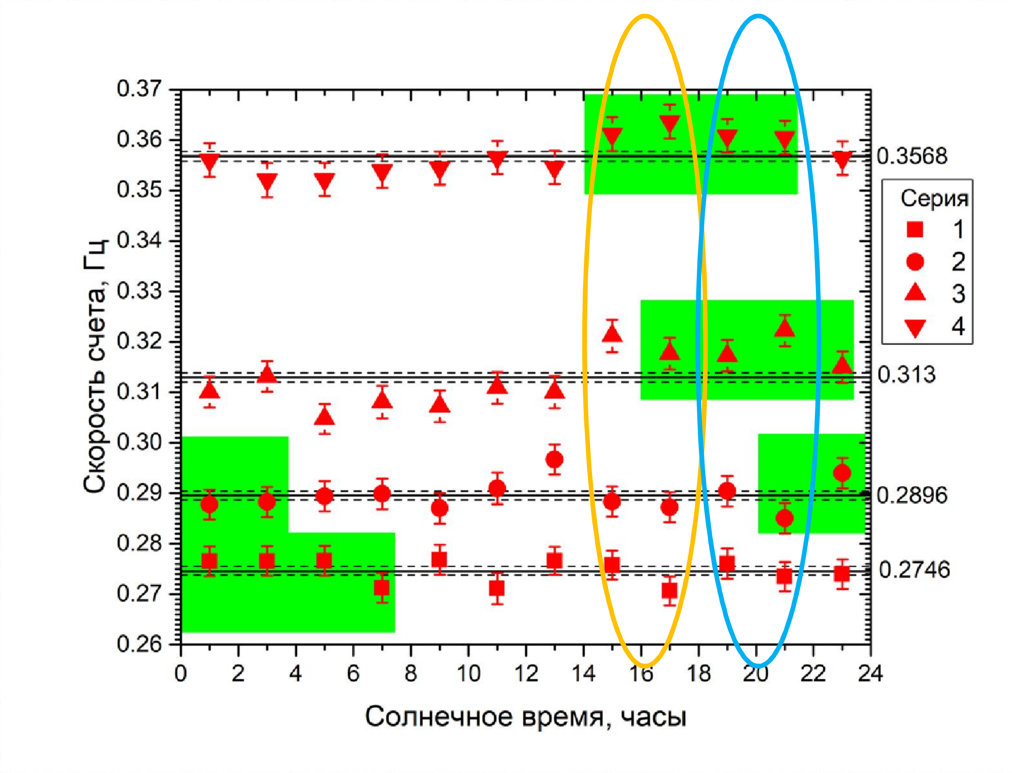
DIURNAL VARIATIONS IN SIDEREAL TIME (configuration 1)

$$p = 12\prod_{i=1}^{2n}\left(0,5\,erfc\left(\frac{x_i}{\sqrt{2}}\right)\right)$$

here: n – number of Runs,
x_i – the deviation from an average value in σ for each 2h interval between 8-00 and 12-00 of sidereal time in each 4 Runs of measurements

For sidereal time $p = 7.6\times10^{-10}$,
Confidence level > 6 σ (1×10^{-9}).

The possible interpretation:
in first half year of 2023 y the solar system has been moving through space where the vector of E-field of dark photons in the time interval between 8-00 and 12-00 of sidereal time was in the plane of Moscow meridian with an angle to the axes of the Earth between 20^0 and 50^0.



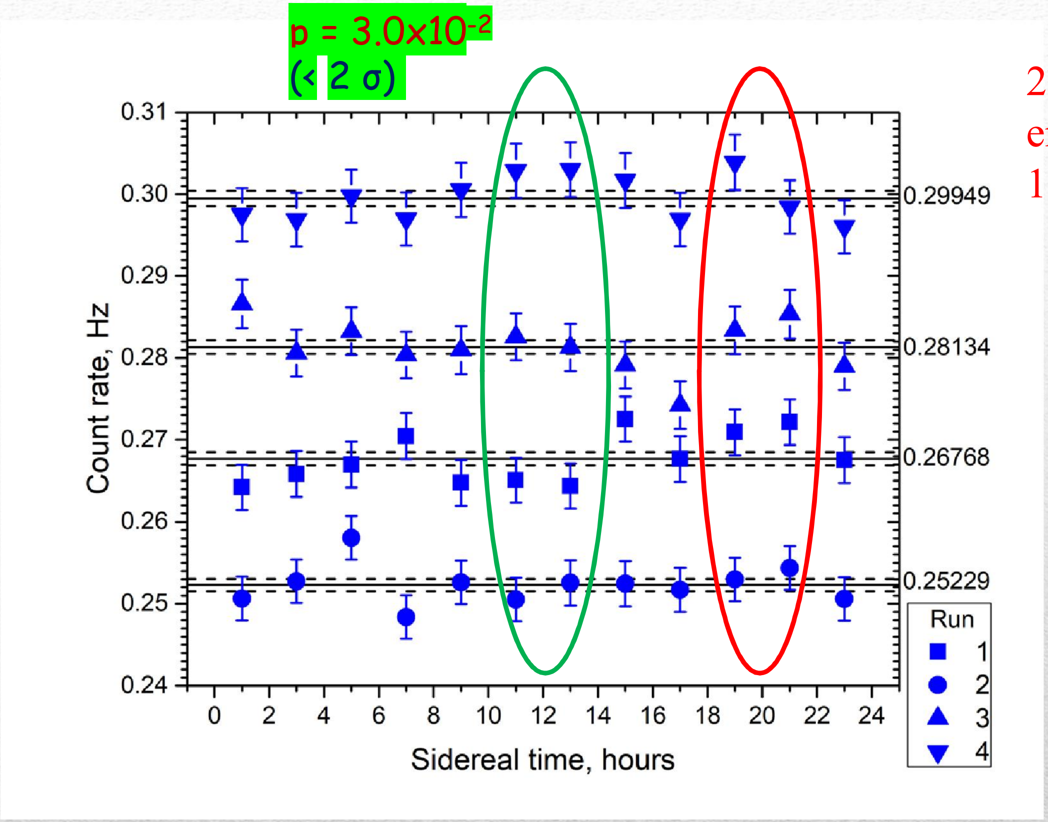
$p = 1.6 \times 10^{-5}$

$> 4\ \sigma\ (3.17 \times 10^{-5})$

$p = 5.05 \times 10^{-6}$

$> 4\ \sigma\ (3.17 \times 10^{-5})$

DIURNAL VARIATIONS IN SOLAR TIME



2^{nd} series of measurements end of 2023 y – 1^{st} quarter of 2024 y

Time of start-stop in each 4 Runs of measurements
1: 21.09.23 12:00 - 9.11.23 22:00
2: 10.11.23 00:00 - 29.12.23 22:00
3: 30.12.23 00:00 - 21.02.24 10:00
4: 21.02.24 12:00 - 3.04.24 8:00

DIURNAL VARIATIONS IN SIDEREAL TIME (configuration 1)

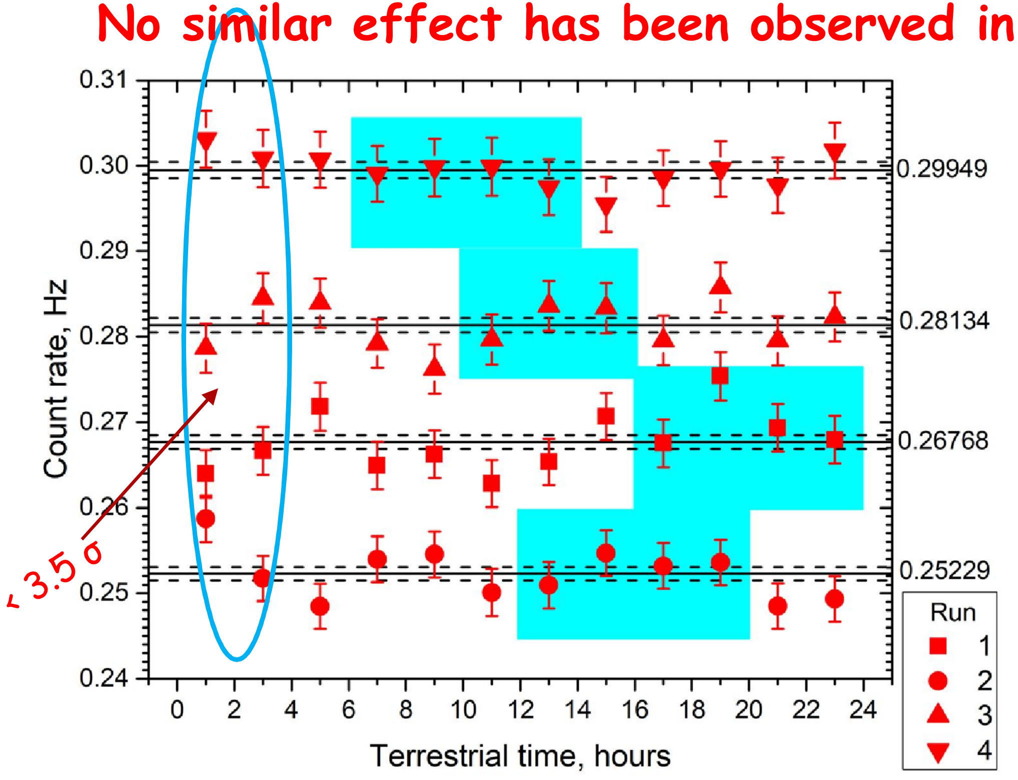
$$p = 12\prod_{i=1}^{2n}\left(0,5erfc\left(\frac{x_i}{\sqrt{2}}\right)\right)$$

here n – number of Runs,
x_i – deviation from an average value in σ в in each 2h intervals between 18-00 and 22-00 of sidereal time in each 4 Runs of measurements.

For sidereal time $p = 9.1\times10^{-6}$,
Confidence level > 4 σ (3.17×10^{-5}).

The possible interpretation:
Since September 2023 till March 2024 the solar system has been moving through space region, where the vector of E-field of dark photons between 18-00 and 22-00 of sidereal time was in the plane of Moscow meridian with an angle to the axes of the Earth between 20^0 and 50^0.

No similar effect has been observed in solar time



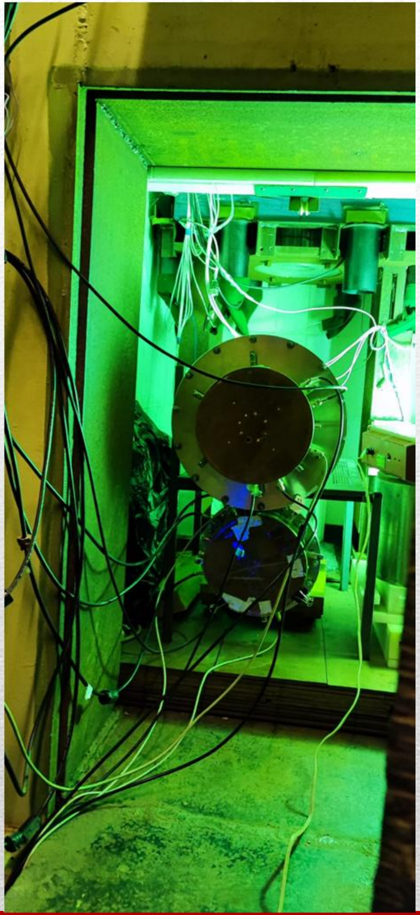
DIURNAL VARIATION IN SOLAR TIME

In solar time we have not observed any synchronous fluctuations In all 4 Runs which could be connected with any technogenic or other processes at the Sun or at the Earth

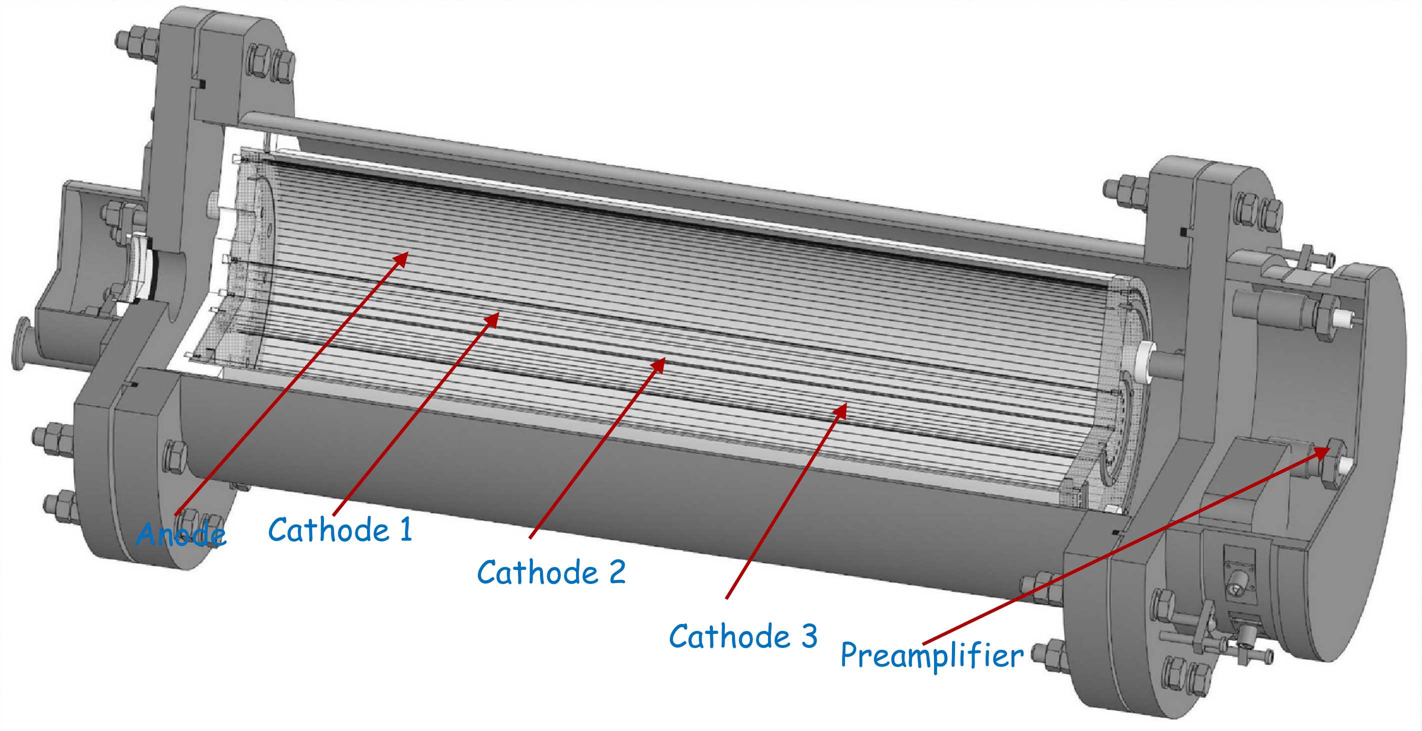
To get into the time interval between 18-00 and 22-00 of sidereal time the events should belong to the time intervals of solar time, colored in blue, which are regularly shifted in time

If C.L. < 3.5 σ – noise, if C.L. > 4 σ – Candidate for the effect

Present Status:
Detector test
in Troitsk,
INR RAS
Moscow



Working gas: Ar, Ne + 10% CH_4, P = 1 atm

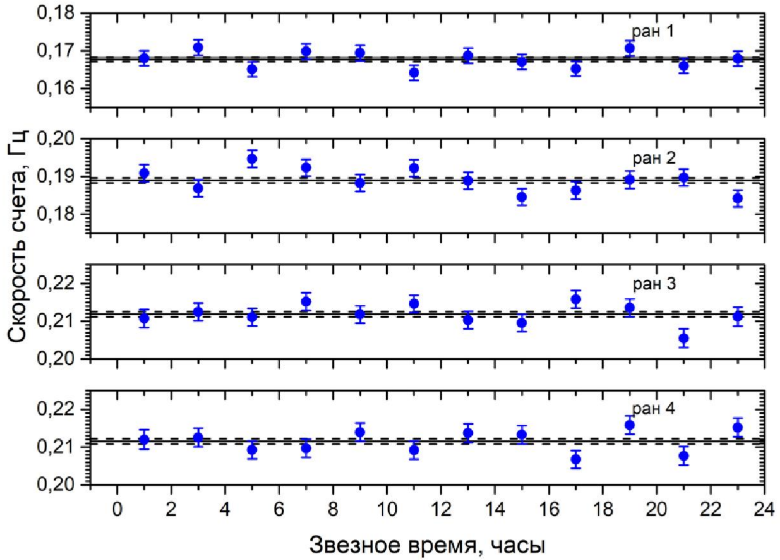


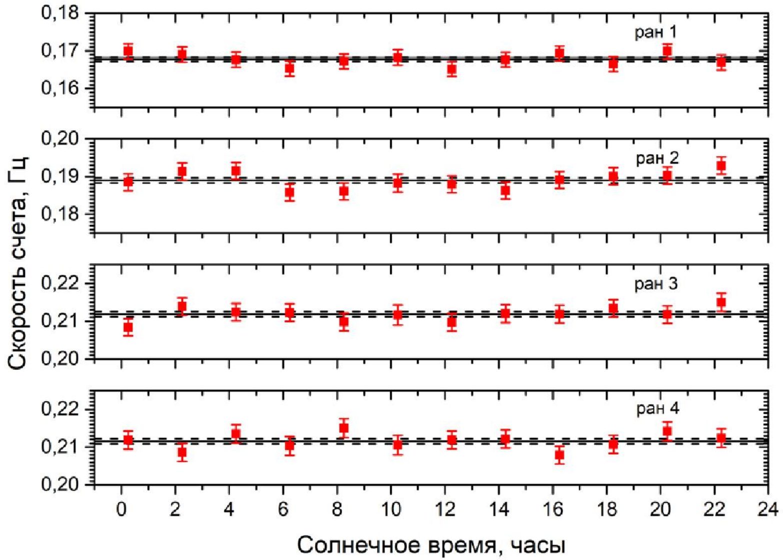
Multicathode counter, calibration from the end of the counter

Sidereal time

Fe-counter

Solar time



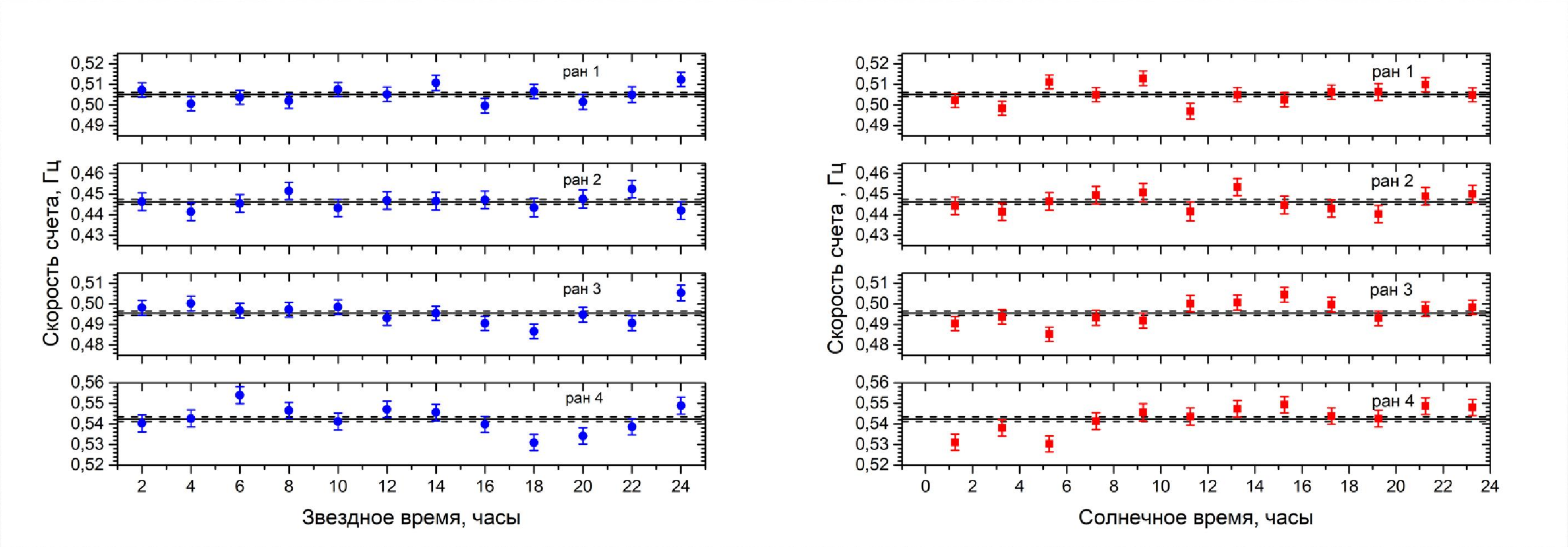


Diurnal variations of the count rate in 4 Runs
each Run ≈ 60 days

Sidereal time

Al-counter

Solar time



Diurnal variations of the count rate in 4 Runs
each Run ≈ 60 days

Summary

Method has shown its efficiency. The results are included in PDG

Three experimental series were conducted, each consisting of 4 runs lasting approximately 60 days per run. One can expect an excess in the single electron count rate above the average level if the polarization vector of dark photons in the region traversed by the Sun forms an angle between 20° and 50° with the Earth's rotational axis. Such an effect was observed in the first series (significance 6σ) and the second series (significance 4σ). However, in the third series, which employed two identical detectors simultaneously, the effect was not observed on either detector. **This result practically excludes the possibility that the effect observed earlier was purely instrumental. The results of the three series may be interpreted as a possible effect arising from the Sun's passage through regions of dark matter characterized by different orientations of the dark photon polarization vector.**

Our publications:

1. A.V. Kopylov, I. V. Orekhov, V. V. Petukhov and A. E. Solomatin, Construction of a Multicathode Counter for Dark Photon Search, *Instruments and Experimental Techniques*, 2025, Vol. 68, No 1, pp. 7-13, DOI:10.1134/S0020441225700149

2. Anatoly Kopylov, Igor Orekhov, Valery Petukhov, and Alexei Solomatin, PHELEX with a Multi-Cathode Counter in the Search for Dark Photons, *Physics of Atomic Nuclei,* 2024, Vol.87, No. 6, pp 810-814, DOI: 10.1134/S1063778824700777

3. A. Kopylov, I. Orekhov, V. Petukhov, Latest Results on the Search of Dark Photons with a Multicathode Counter, *Physics of Atomic Nuclei*, 2023, Vol.86, No. 6, pp 1009-1013 DOI: 10.1134/S106377882306011X

4. A. Kopylov, I. Orekhov, V. Petukhov, PHELEX: Present Status, *Moscow University Physics Bulletin,* 2022, Vol. 77, pp, 315-318. DOI: 10.3103/S0027134922020539

5 . A. Kopylov, I. Orekhov, V. Petukhov, Diurnal Variations of the Count Rates from Dark Photons, *Particles* 2022, 5, 180-187. https://doi.org/10.3390/particles5020016

6. A. Kopylov, I. Orekhov, V. Petukhov, Мульти катодный счетчик как детектор скрытых фотонов, *Physics of Atomic Nuclei,* 2022, Vol.85, No. 6, pp 1-9, (2022). DOI: 10.31857/S0044002722060083

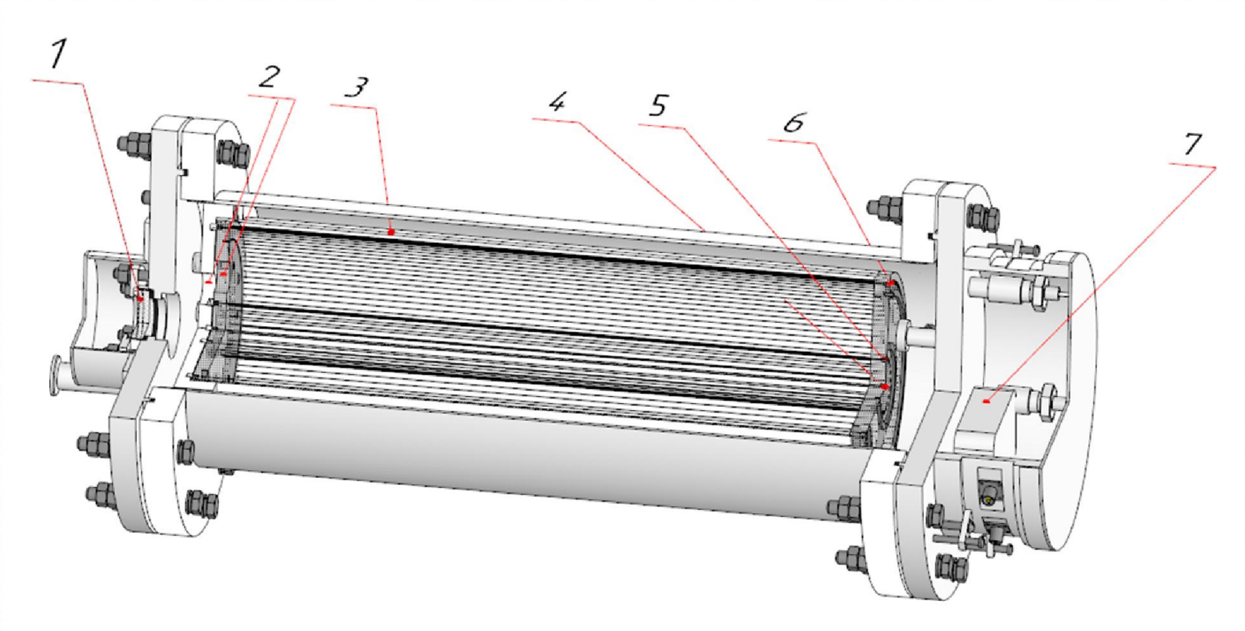
7. A. Kopylov, I. Orekhov, V. Petukhov, Present Status of the Experiment on the Search for Dark Photons by a Multi-Cathode Counter, *Physics of Atomic Nuclei*, 2021, Vol.84, No. 6, pp 860-865

Our publications:

8. A. Kopylov, I. Orekhov, V. Petukhov, On the possibility of observing diurnal variations in the count rate of dark photons using a multicathode counters, *Physics of Particles and Nuclei,* 2021, Vol.52, No.1, pp. 31 - 38
9. A. Kopylov, I. Orekhov, V. Petukhov, First results and future prospects with PHELEX, *Journal of Physics, Conference Series*, 1690 (2020) 012002, doi:10.1088/1742-6596/1690/1/012002
10. A. Kopylov, I. Orekhov, V. Petukhov, Results from a hidden photon dark matter search using a multi-cathode counter, *JCAP*, 07, 008 (2019)
11. A. Kopylov, I. Orekhov, V. Petukhov, Method of search for hidden photons of Cold Dark Matter using a multi-cathode counter, *Physics of Atomic Nuclei*, Vol.82, No. 9, pp 1-8, (2019)
12. A. Kopylov, I. Orekhov, V. Petukhov, Search for Hidden Photon Dark Matter using a Multi-Cathode Counter. Proceedings of the 4th International Conference on Particle Physics and Astrophysics (ICPPA-2018), *Journal of Physics: Conference Series*, 1390 (2019) 012066
13. A. Kopylov, I. Orekhov, V. Petukhov, A multi-cathode counter in a single-electron counting mode, *NIM* A, 910, 164 (2018)
14. A. Kopylov, I. Orekhov, V. Petukhov, *Tech. Phys. Lett* 42, 102 (2016)
15. A. Kopylov, I. Orekhov, V. Petukhov, *Adv. High Energy Phys.*, 2058372 (2016)

Thank you for attention !

Рабочий газ: аргон, неон + 10% метан, P = 1 атм



1. Кварцевое окно
2. Окна со смещением от центра
3. Сплошной катод 3
4. Анод
5. Нитяной катод 1
6. Нитяной катод 2
7. Предусилитель

Мультикатодный счетчик, калибровка с торца

Масса фотона ≠ 0
Уравнения Прока
Калибровка Лоренца X

B ≠ rot A

div B ≠ 0
div E ≠ 0

Продольная мода электрического E и магнитного B поля

Уравнения Прока:

$$\Box\Phi - \frac{\partial}{\partial t}\left(divA + \frac{\partial\Phi}{\partial t}\right) = -m^2\Phi \qquad (1)$$

$$\Box A + grad\left(divA + \frac{\partial\Phi}{\partial t}\right) = -m^2 A \qquad (2)$$

Применяем к (1) $\frac{\partial}{\partial t}$, а к (2) – div и складываем, получаем:

$$2\Box\left(divA + \frac{\partial\Phi}{\partial t}\right) = -m^2\left(divA + \frac{\partial\Phi}{\partial t}\right)$$

Или:

$$\Box\left(divA + \frac{\partial\Phi}{\partial t}\right) = -\frac{1}{2}m^2\left(divA + \frac{\partial\Phi}{\partial t}\right)$$

Обозначим:

$$\chi = \left(divA + \frac{\partial\Phi}{\partial t}\right) \qquad (3)$$

И тогда:

$$\Box\chi = -\frac{1}{2}m^2\chi \qquad (4)$$

Проверяем подстановкой, что решением уравнения (4) является,

$$\chi = \Upsilon_0(r)e^{imt} \qquad (5)$$

То есть стационарное локализованное решение, колеблющееся как e^{imt}

Действительно, после подстановки имеем:

$$\Delta\Upsilon_0 + m^2\Upsilon_0 = -\frac{1}{2}m^2\Upsilon_0$$

Или:

$$\Delta\Upsilon_0 = -\frac{3}{2}m^2\Upsilon_0 \qquad (6)$$

Ref: R.B.Cairns and J.A.R.Samson Journal of optical society of America
Vol. 56, Number 11, November 1966, 1568-1573

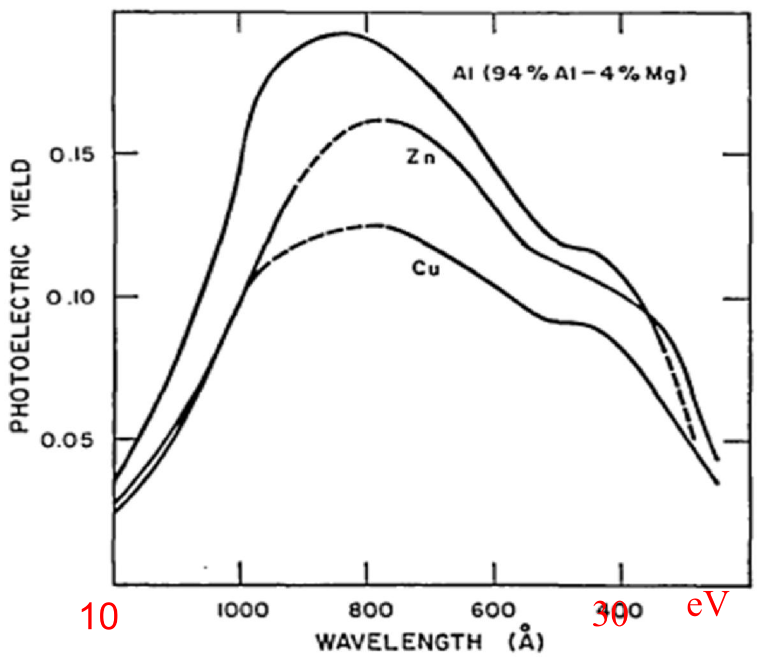


FIG. 4. Photoelectric yields of Al–Mg, Zn, and Cu.

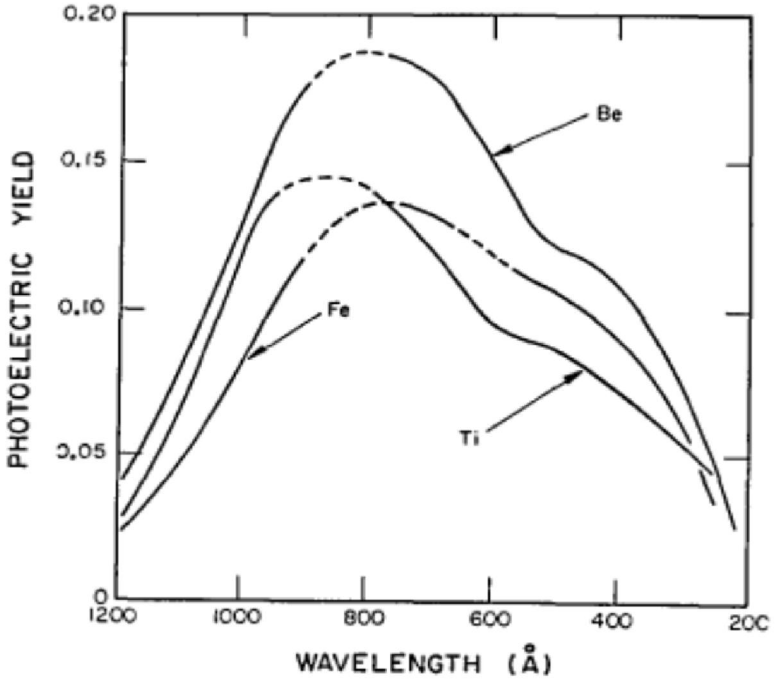
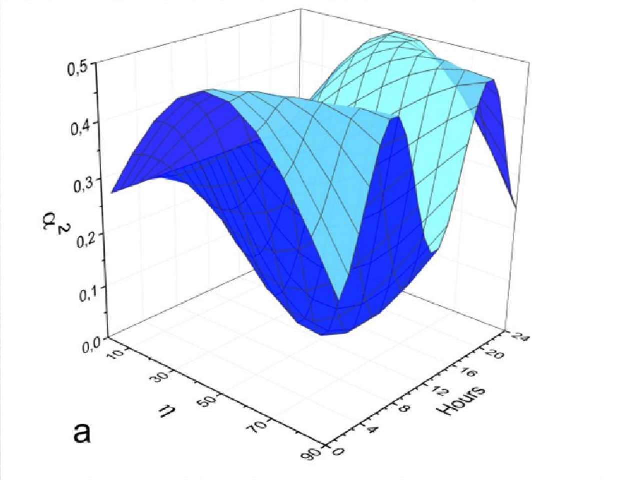


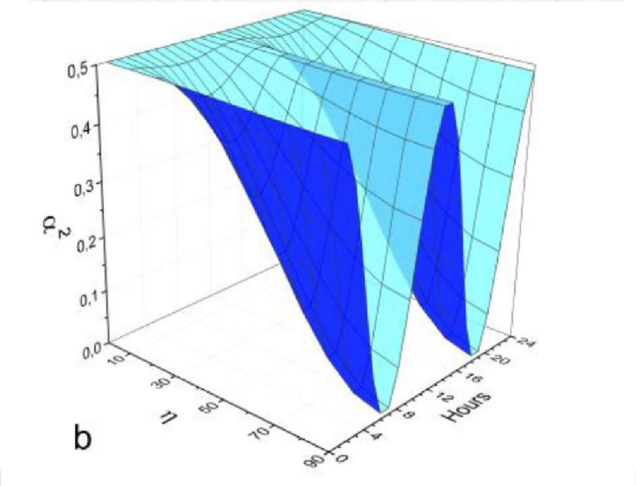
FIG. 5. Photoelectric yields of Be, Fe, and Ti.

Diurnal variations, BNO, Russia 43°

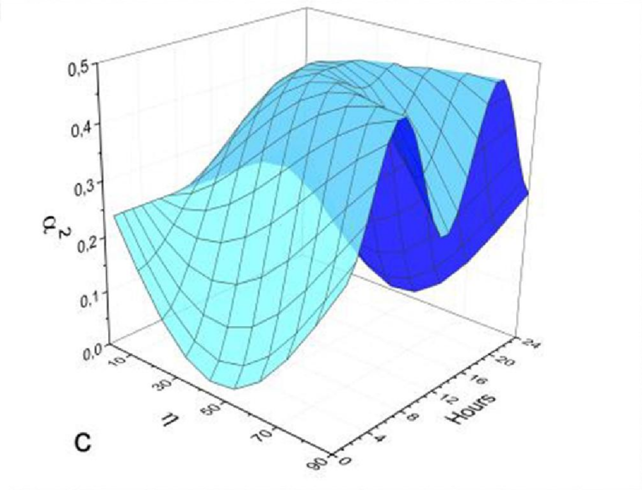
<α²> averaged for 1 hour



Vertical orientation

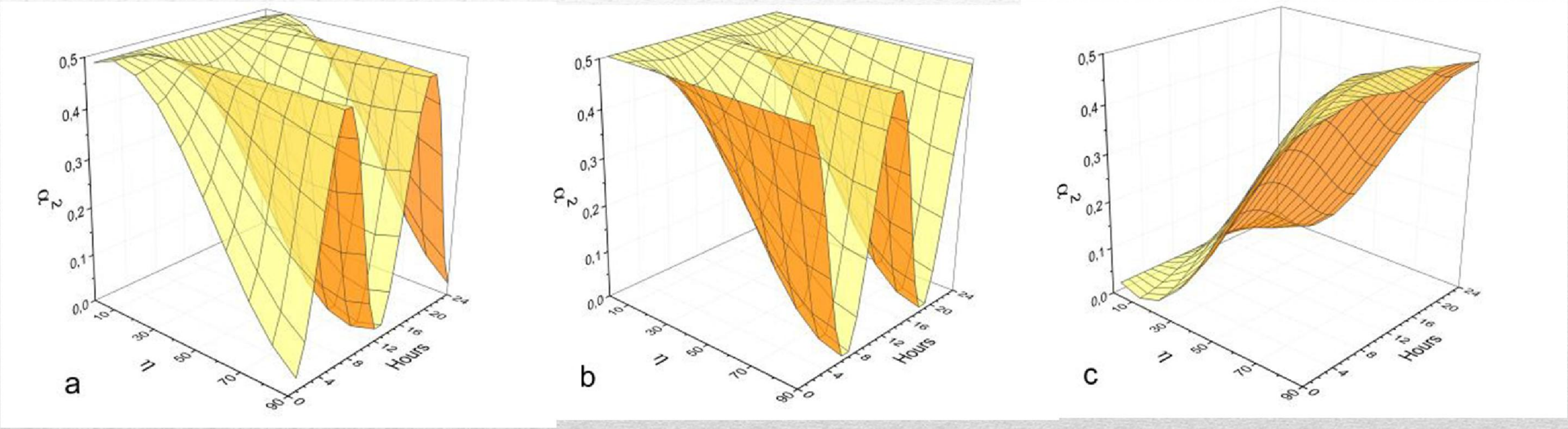


East-West orientation



North-South orientation

Diurnal variations, INO, India 10º

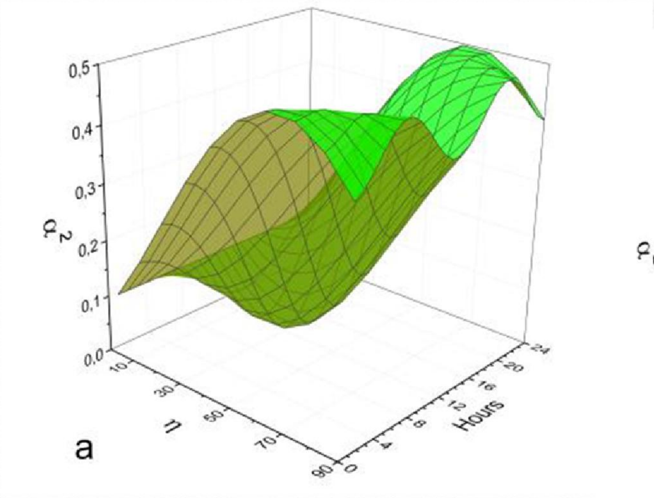


Vertical orientation

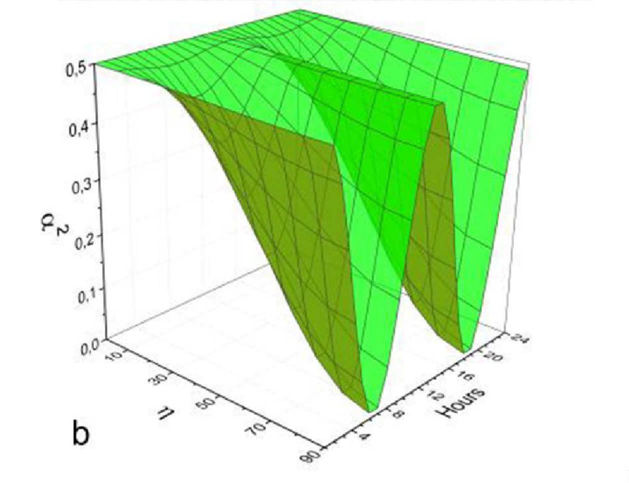
East-West orientation

North-South orientation

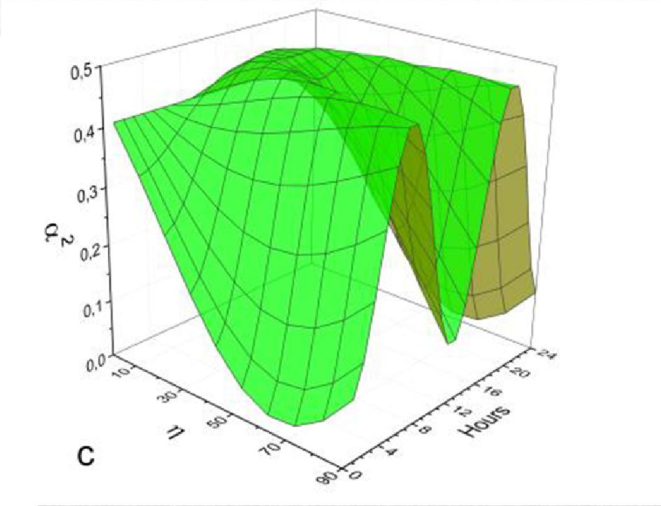
Diurnal variations, Pyhäsalmi, Finnland 64º



Vertical orientation



East-West orientation



North-South orientation

$$p = 12\prod_{i=1}^{2n}\left(0,5\,erfc\left(\frac{x_i}{\sqrt{2}}\right)\right)$$

Эффект > 6 σ плюс эффект > 4 σ это хороший знак!

Однако! Для получения доказательной базы еще нужно:

- Провести измерения с двумя детекторами

(1) оба ориентированы вдоль меридиана

(2) один - вдоль меридиана, другой – вдоль параллели

- Эффект не должен наблюдаться во второй конфигурации
- Провести измерения с детектором, расположенным на той же широте, но на другой долготе – должен наблюдаться эффект со сдвигом по времени, соответствующим разности долгот

Например: г. Томск с широтой 56.495^0 и 4 часами разницы с Москвой. Эффект наблюдаемый в Москве должен запаздывать на 4 часа относительно Томска.

Провести измерения с детекторами с другим материалом катода

Authors: A. Kopylov, I. Orekhov, V. Petukhov

Title: Results from a Hidden Photon Dark Matter Search Using a Multi-Cathode Counter

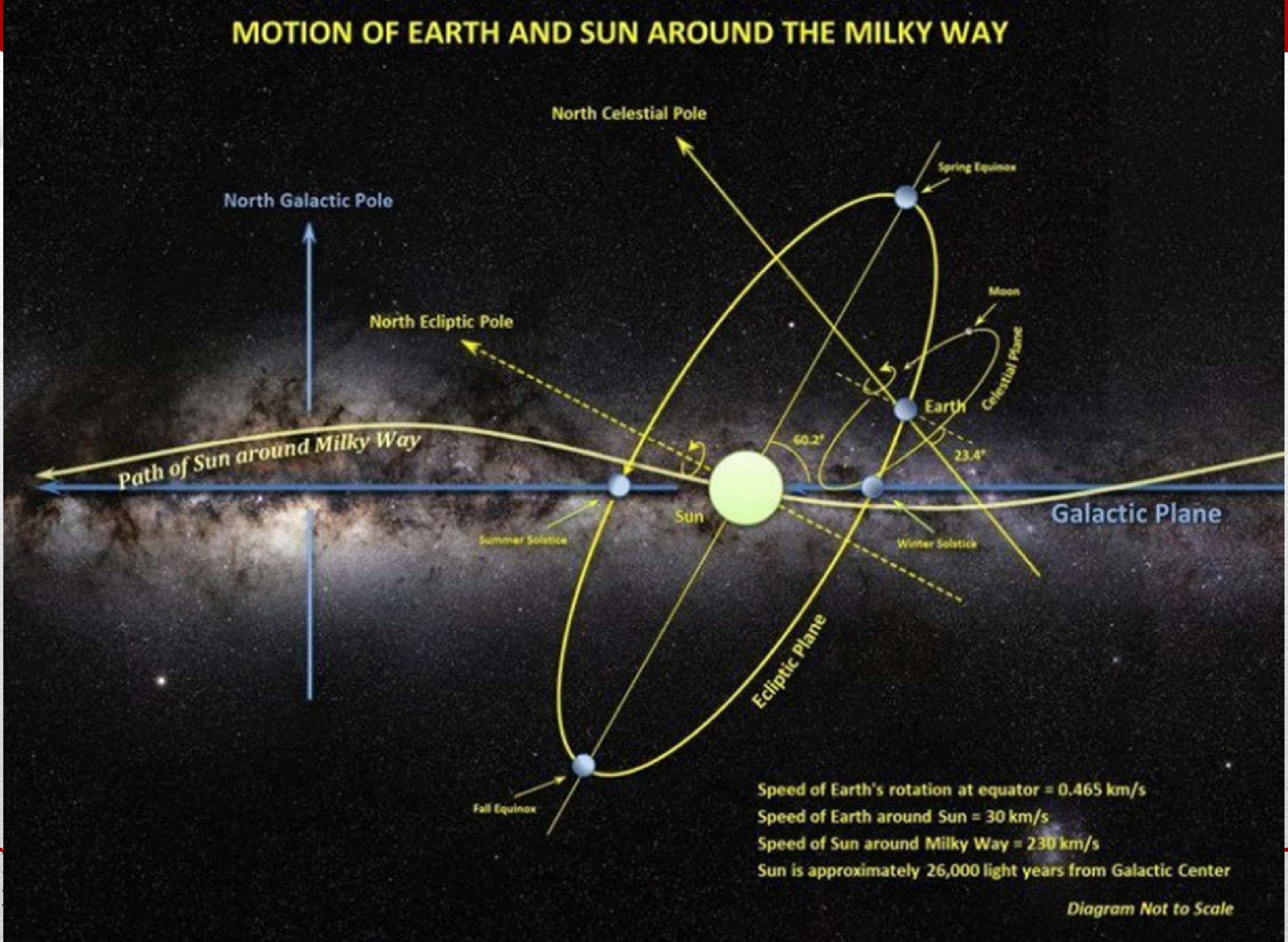
Received: 2019-01—29 08:16:45.0

Referee report:

Their experiment is very interesting and their idea has both novelty and originality. I consider that this preprint is acceptable for publication in JCAP.

'The new guiding principle should be "no stone left unturned": we should look for dark matter not only where theoretical prejudice dictates that we "must", but wherever we can.

G.Bertone and T.M.P.Tait A New Era in the Quest for Dark Matter arXiv:1810.01668


MOTION OF EARTH AND SUN AROUND THE MILKY WAY
North Celestial Pole
Spring Equinox
North Galactic Pole
Moon
North Ecliptic Pole
Celestial Plane
Earth
60.2°
23.4°
Path of Sun around Milky Way
Sun
Galactic Plane
Summer Solstice
Winter Solstice
Ecliptic Plane
Fall Equinox
Speed of Earth's rotation at equator = 0.465 km/s
Speed of Earth around Sun = 30 km/s
Speed of Sun around Milky Way = 230 km/s
Sun is approximately 26,000 light years from Galactic Center
Diagram Not to Scale

Dark photons as a Dark Matter

Search for Dark Photon Dark Matter: Dark E-Field Radio Pilot Experiment

Benjamin Godfrey, J. Anthony Tyson,* Seth Hillbrand, Jon Balajthy,† Daniel Polin, S. Mani Tripathi, Shelby Klomp,‡ Joseph Levine, and Nate MacFadden§
Physics Department, UC Davis, Davis, CA 95616

Brian H. Kolner and Molly R. Smith¶
Electrical and Computer Engineering Department, UC Davis, Davis, CA 95616

Paul Stucky
Chemistry Department, UC Davis, Davis, CA 95616

Arran Phipps
Physics Department, CSU East Bay

Peter Graham and Kent Irwin
Physics Department, Stanford University
(Dated: January 11, 2021)

We are building an experiment to search for dark matter in the form of dark photons in the nano- to milli-eV mass range. This experiment is the electromagnetic dual of magnetic detector dark radio experiments. It is also a frequency-time dual experiment in two ways: We search for a high-Q signal in wide-band data rather than tuning a high-Q resonator, and we measure electric rather than magnetic fields. In this paper we describe a pilot experiment using room temperature electronics which demonstrates feasibility and sets useful limits to the kinetic coupling $\epsilon \sim 10^{-12}$ over 50–300 MHz. With a factor of 2000 increase in real-time spectral coverage, and lower system noise temperature, it will soon be possible to search a wide range of masses at 100 times this sensitivity. We describe the planned experiment in two phases: Phase-I will implement a wide band, 5-million channel, real-time FFT processor over the 30–300 MHz range with a back-end time-domain optimal filter to search for the predicted $Q \sim 10^6$ line using low-noise amplifiers. We have completed spot frequency calibrations using a biconical dipole antenna in a shielded room that extrapolate to a 5σ limit of $\epsilon \sim 10^{-13}$ for the coupling from the dark field, per month of integration. Phase-II will extend the search to 20 GHz using cryogenic preamplifiers and new antennas.

I. INTRODUCTION

The physical nature of dark matter is unknown. Sensitive searches for weakly interacting massive particles (WIMPS) have found nothing [1]. In recent years the WIMP hypothesis has dominated searches for dark matter since a generic weak-scale thermal relic could account for all of the observed dark matter in the universe [2]. Experimenters continue to probe new WIMP parameter space by developing larger and more sensitive detectors, however these tend to lose sensitivity when the mass of the dark matter particle is small, leaving a large range of parameter space open for exploration [3].

The 2014 P5 report [4] emphasizes the importance of searching for dark matter along every feasible avenue. To date, relatively little effort has been spent on detection of ultra-low mass dark matter candidates where it is best described as a wave rather than a particle [5]. This requires development of new detectors.

The *dark photon* is a hypothetical, low-mass vector boson which has been posed as a candidate for dark matter. Dark photons could account for much of the dark matter, and are theoretically motivated via fluctuations of a vector field during the early inflation epoch of our universe. A relic abundance of such a particle could be produced non-relativistically in the early universe in a similar way to axions, through either the misalignment mechanism or through quantum fluctuations of the field during inflation [6, 7].

In contrast to axions, a massive, inflation-produced vector boson like a dark photon would have a power spectrum that is peaked at a length scale of roughly 10^{10} km, and rapidly decreases in intensity at large length scales, consistent with CMB observations. Furthermore, a dark photon would adopt the adiabatic fluctuations of the inflaton making it a good dark matter candidate [7]. The high phase space density required for dark photons to constitute a significant portion of the local dark matter density implies that they would behave as an oscillating field and would oscillate with a frequency equal to the mass of the dark photon. In general, for a theory with

* tyson@physics.ucdavis.edu
† Now at Sandia National Laboratories.
‡ Now at Physics Department, Northwestern University.
§ Now at Physics Department, University of Waterloo.
¶ Now at ... Seattle, WA

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Измерение индуцированного электрического поля

arXiv:2101.02805v1 [physics.ins-det] 8 Jan 2021

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As in WIMP searches, there are two unknowns: the frequency of the wave (a proxy for the mass) and its weakly coupled amplitude. We measure the induced electric field with a wideband antenna. The experiment is conducted inside a large (≈ 27.4 m^3) electromagnetically shielded room, searching for a weak narrowband signal between 30 MHz and 20 GHz from dark photons converting from within the shield. The antenna is polarization sensitive, enabling detection of the expected E-field in any direction whence aligned. The challenge is detecting a 1 ppm spectrally pure signal, varying only on 12-hour timescales (Earth rotation), at femtovolt levels, in wideband noise. Since the frequency of the line

Наш препринт: A.Kopylov, I.Orekhov, V.Petukhov, About the possibility to observe diurnal variations of the count rate of dark photons by the multicathode counters. arXiv:2006.05452

NORDITA-2021-036

Dark photon limits: a cookbook

Andrea Caputo,[1,2,a] Ciaran A. J. O'Hare,[3,4,b] Alexander J. Millar,[5,6,c] and Edoardo Vitagliano[7,d]

[1]*School of Physics and Astronomy, Tel-Aviv University, Tel-Aviv 69978, Israel*
[2]*Department of Particle Physics and Astrophysics,Weizmann Institute of Science, Rehovot 7610001, Israel*
[3]*ARC Centre of Excellence for Dark Matter Particle Physics, Sydney, NSW, Australia*
[4]*School of Physics, Physics Road, The University of Sydney, NSW 2006 Camperdown, Australia*
[5]*The Oskar Klein Centre, Department of Physics, Stockholm University, AlbaNova, SE-10691 Stockholm, Sweden*
[6]*Nordita, KTH Royal Institute of Technology and Stockholm University, Roslagstullsbacken 23, 10691 Stockholm, Sweden*
[7]*Department of Physics and Astronomy, University of California, Los Angeles, California, 90095-1547, USA*

The dark photon is a massive hypothetical particle that interacts with the Standard Model by kinetically mixing with the visible photon. For small values of the mixing parameter, dark photons can evade cosmological bounds to be a viable dark matter candidate. Due to the similarities with the electromagnetic signals generated by axions, several bounds on dark photon signals are simply reinterpretations of historical bounds set by axion haloscopes. However, the dark photon has a property that the axion does not: an intrinsic polarisation. Due to the rotation of the Earth, accurately accounting for this polarisation is nontrivial, and highly experiment-dependent. We show that if one does account for this polarisation, and the rotation of the Earth, experimental sensitivity to the dark photon's kinetic mixing parameter can be improved by over an order of magnitude. We detail the strategies that would need to be taken to properly optimise a dark photon search. These include judiciously choosing the location and orientation of the experiment, as well as strategically timing any repeated measurements. We also point out that several well-known searches for axions employ techniques for testing signals that preclude their ability to set exclusion limits on dark photons, and hence should not be reinterpreted as such.

arXiv:2105.04565

Наш препринт: A.Kopylov, I.Orekhov, V.Petukhov, About the possibility to observe diurnal variations of the count rate of dark photons by the multicathode counters. arXiv:2006.05452