



Ginzburg Conference on Physics
Lebedev Physical Institute

Progress in Gamma-Ray Astronomy in Russia

A. M. Galper

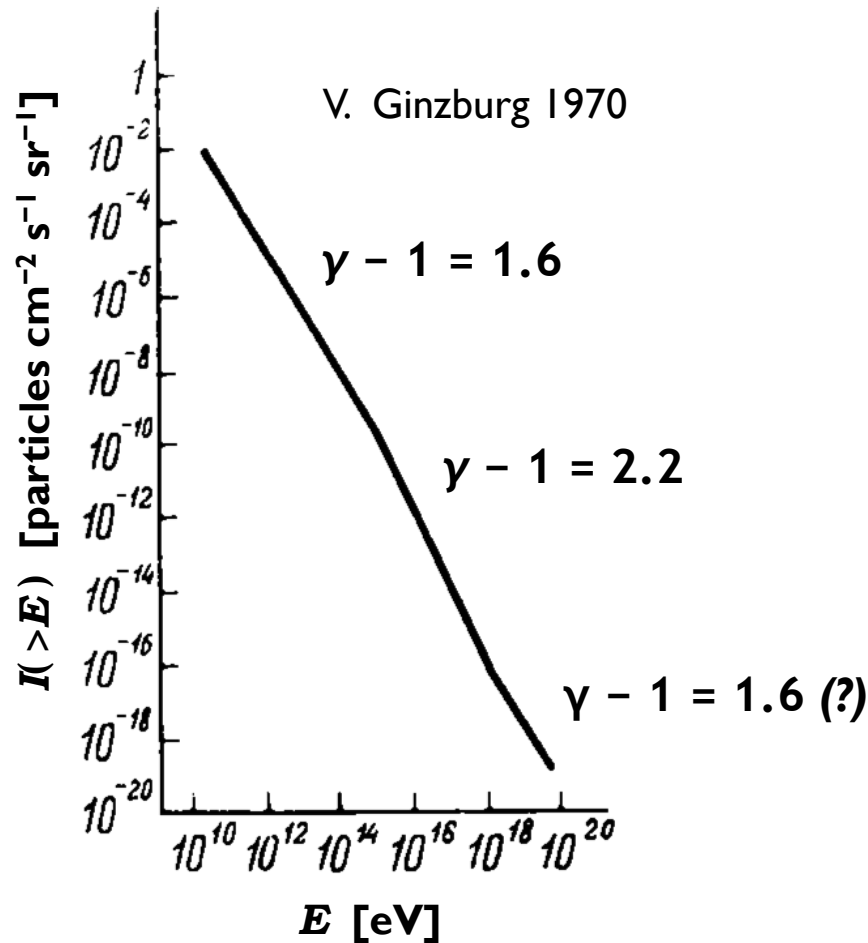
LPI, NRNU MEPhI

June 1, 2012

GAMMA-RAY ASTRONOMY AND COSMIC RAYS

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Spectrum known in 70s



Integral CR spectrum

Milky Way

LMC

View from
Andromeda Galaxy

SMC

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LMC

View from Earth

SMC

LMC

SN1987A

View from Earth

SMC

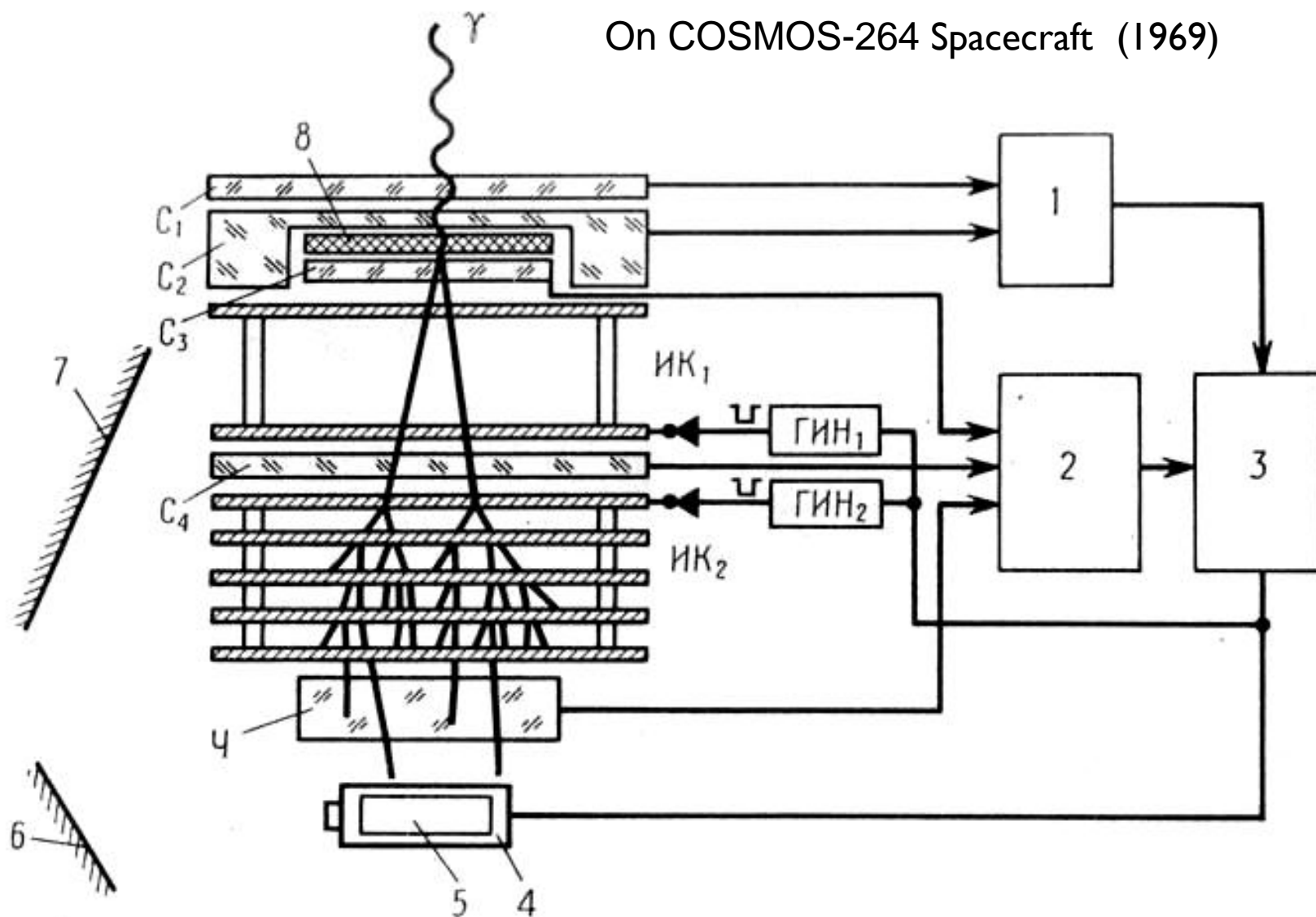
Fluxes from Magellanic Clouds

The galactic and extragalactic CR density are assumed to be both equal to $10^{-12} \text{ erg cm}^{-3}$ in the prediction

	Ginzburg's Prediction (June 1, 1972)	Experiment Fermi LAT (2010)
Gamma-ray flux from LMC	$2 \times 10^{-7} \text{ cm}^{-2} \text{ s}^{-1}$ Nature (Sept. 4, 1972)	$(2.6 \pm 0.2) \times 10^{-7} \text{ cm}^{-2} \text{ s}^{-1}$ arXiv: 1001.3298
Gamma-ray flux from SMC	$1 \times 10^{-7} \text{ cm}^{-2} \text{ s}^{-1}$ Nature (Sept. 4, 1972)	$(0.37 \pm 0.07) \times 10^{-7} \text{ cm}^{-2} \text{ s}^{-1}$ arXiv: 1008.2127
Their ratio	2	7.0 ± 1.4

ANNA-III Gamma-Ray Telescope

On COSMOS-264 Spacecraft (1969)

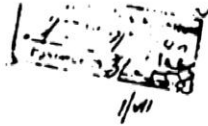


Session of the Presidium of the Academy of sciences of USSR on June 1, 1972:

- 1. Academician V.L. Ginzburg. Gamma-ray astronomy and cosmic rays.
- 2. Doctor A.M. Galper. The possibilities of creation of gamma-ray telescopes

The Minutes

Трёхколько:



2. Поручить Отделению общей физики и астрономии и Отделению ядерной физики до 1 июля с.г. изучить состояние и перспективы гамма-астрономии в СССР и представить в Президиум АН СССР предложения по ее дальнейшему развитию.

Президент
А. С. Шохин

(С академиком В. Л. Гинзбургом
текст согласован.
1/VI-72. С. К. Бурго)

Minutes

2. Presidium of Academy of Sciences charges the Section of General Physics and Astronomy and the Section of Nuclear Physics to discuss the status and vistas of gamma astronomy in USSR before July 1 and to submit proposals for its development to the Presidium of USSR Academy of Sciences.

President

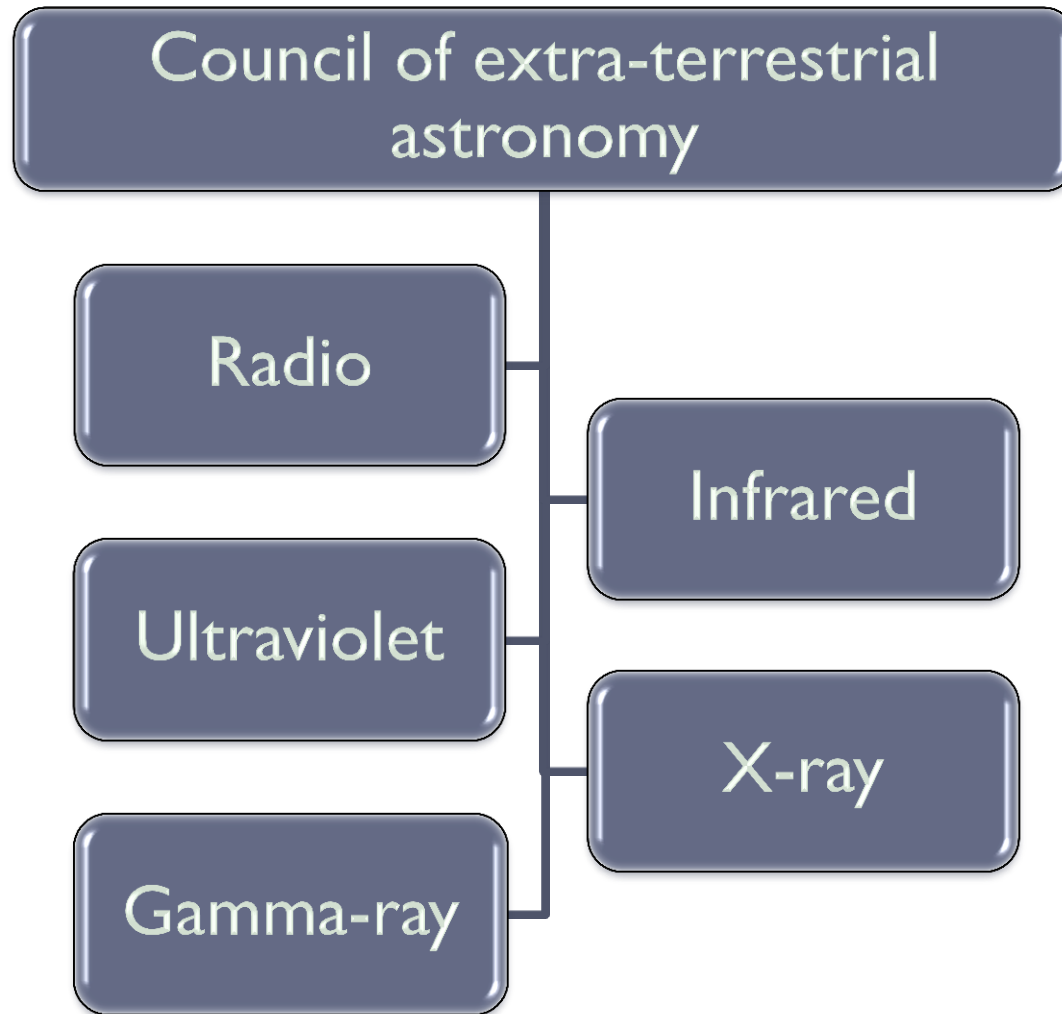
(Text is agreed with academician
V. L. Ginzburg)

1 /VI-72

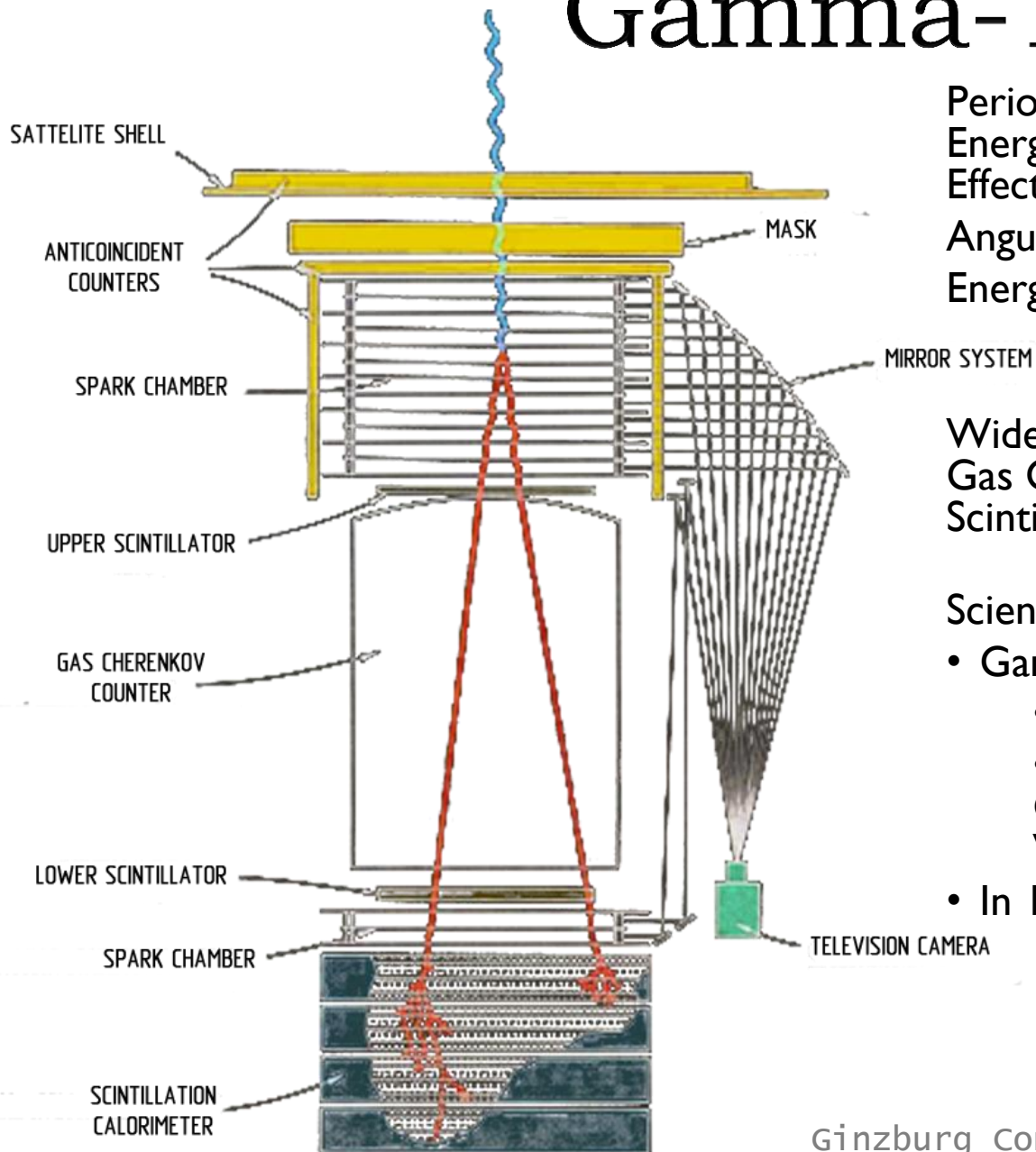
Decision

- In July 1972, V. Keldysh, the president of USSR Academy of Sciences, signed an order:
 - To create a Council of extra-terrestrial astronomy.
 - To assign every year a sum of 3.5 million rubles to the development of extra-terrestrial astronomy and 0.7 million rubles to the creation of the gamma-ray telescope.

Sections



Gamma-1



Period: 1990-1992
Energy range: 50 MeV–5 GeV
Effective area: 1400 cm²,
Angular resolution (300 MeV): 1.2°
Energy resolution (550 MeV): 34%

Wide-gap spark chamber,
Gas Cherenkov counter,
Scintillation lead calorimeter of 7.4 r.l.

Scientific results:

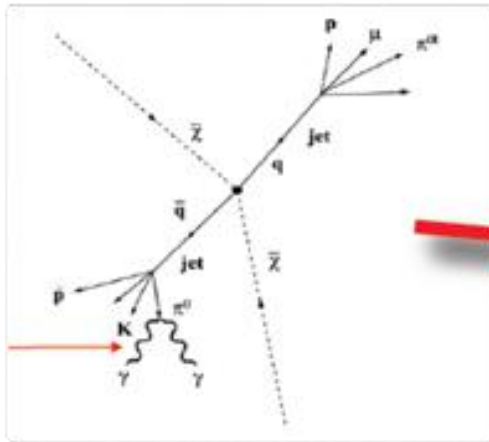
- Gamma rays registered from:
 - The Galactic Center,
 - Many galactic objects (Geminga, Crab, Hercules-X1, Cygnus-X3, Vela).
- In 1991, during the solar maximum, solar flares with high energy (several GeV) gamma rays were first registered.

GAMMA-RAY ASTRONOMY AND DARK MATTER

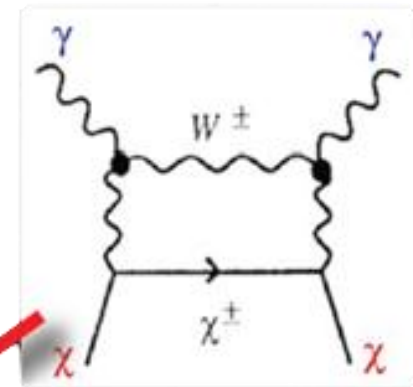
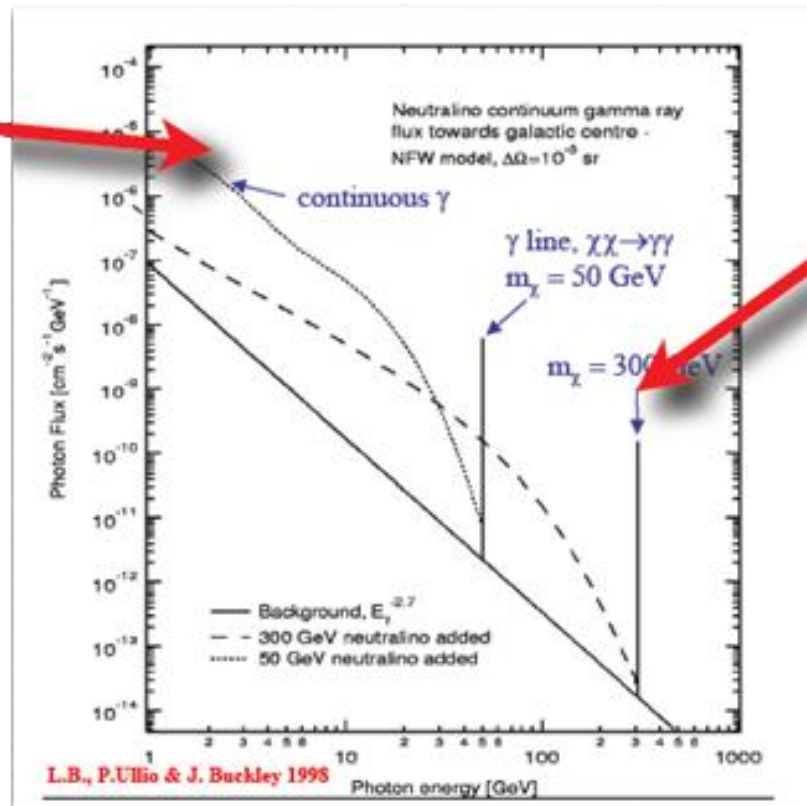
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γ -Rays Produced by Dark Matter

In regions of the highest dark matter density, dark matter particles and their antiparticles are expected to **annihilate into gamma-rays**, either directly into a **gamma-ray line** (with energy equal to the mass of the dark matter particle times the speed of light squared $E_\gamma = m_\chi c^2$) or a **broad spectrum of gamma-rays**.

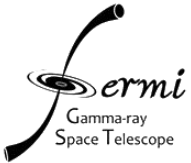
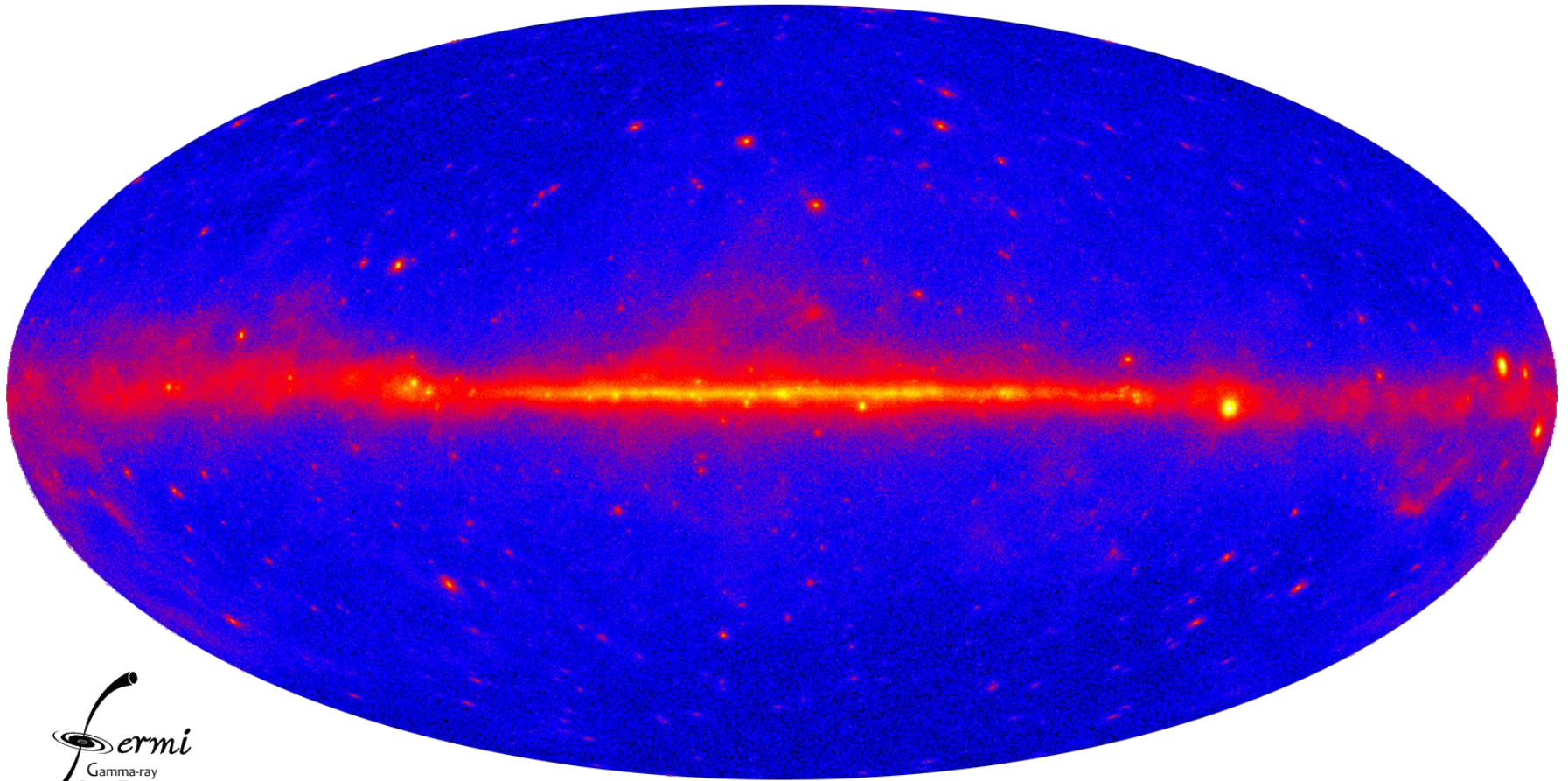


L. Bergström 2006



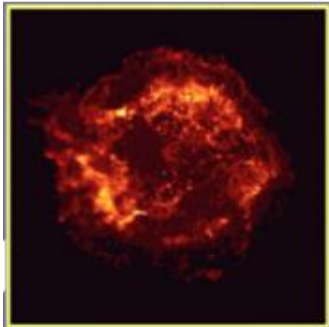
Jungman and Kamionkowski 1994

Fermi Gamma-Ray Sky Map



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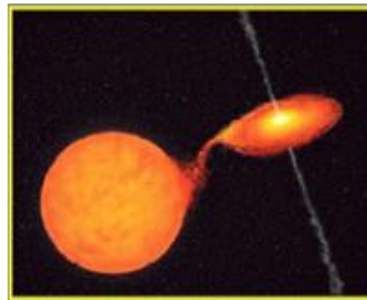
Gamma-Ray Sources



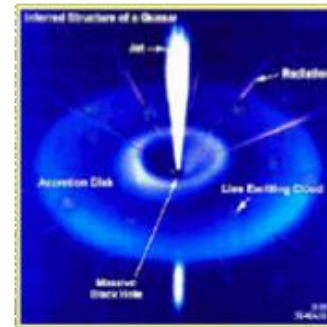
SNRs



**Pulsars
and PWNe**



**Micro quasars
X-ray binaries**



AGNs



GRBs

Some of the recent experimental claims for possible dark matter detection, and a comment on the present status.

(L. Bergström, arXiv: 1205.4882)

Experiment	Status of claim
DAMA/LIBRA annual modulation[66]	Unexplained at the moment; not confirmed by other experiments [68, 69, 72, 73]
CoGeNT excess events and annual modulation [71]	Tension with other data [68, 69, 72, 73]
CRESST excess events [75]	Tension with other data [68, 69, 72, 73]
EGRET excess of GeV photons [76, 77]	Due to instrument error (?) – not confirmed by Fermi-LAT [78]
INTEGRAL 511 keV γ -line from galactic centre region [79]	Does not seem to have spherical symmetry – shows an asymmetry which follows the disk (?) [80]

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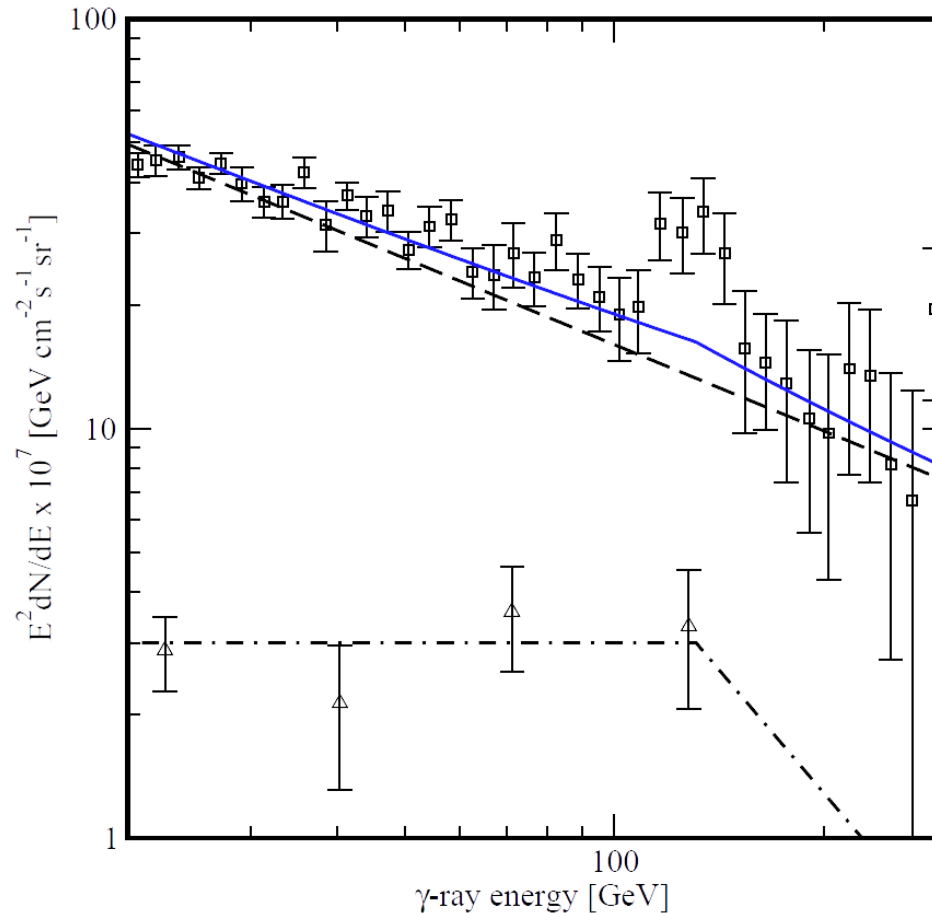
Some of the recent experimental claims for possible dark matter detection, and a comment on the present status.

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PAMELA: Anomalous ratio of cosmic ray positrons/electrons [81]	May be due to DM [82], or pulsars [83] – energy signature not unique for DM
Fermi-LAT positrons + electrons [31]	May be due to DM [82], or pulsars [83] – energy signature not unique for DM
Fermi-LAT GeV γ -ray excess towards galactic centre [84]	Unexplained at the moment – astrophysical explanations possible [85, 86], no statement from the Fermi-LAT collaboration
WMAP radio “haze” [87]	Has a correspondence in “Fermi bubbles” [88] – probably caused by outflow from the galactic centre
γ -ray structure [89] in public Fermi-LAT data [90] from galaxy clusters.	Very weak indication, could be cosmic-ray induced emission?

Gamma Ray Spectrum



C. Weniger, arXiv:
1204.2797,

L. Bergström,
arXiv: 1205.4882

The public Fermi-LAT [90] data extracted from [92] (squares; “Reg.4, SOURCE class”, in [92]) as well as the spectrum of the Fermi bubbles [88] (triangles). The dashed line is a featureless $E_\gamma^{-2.7}$ spectrum, and the dash-dotted line is a simple fit to the Fermi bubble data, where the actual location of the break and the slope above the break are unknown. The solid line is the summed spectrum (power-law plus bubbles), assuming that the break is coincidentally at the same energy as the line excess.

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γ line at 130 GeV [91, 92, 93] in Fermi-LAT public data [90]	$3.3\sigma - 4.6\sigma$ effect, unexplained at the moment. Not confirmed by the Fermi-LAT collaboration [94].

THE GAMMA-400 PROJECT

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The Title Page

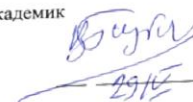
УТВЕРЖДАЮ
Директор
Учреждения Российской академии наук
Физического института
им. П.Н. Лебедева РАН
академик

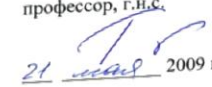
Месяц Г.А.
2009 г.



ПРОЕКТ ГАММА-400
ИССЛЕДОВАНИЕ КОСМИЧЕСКОГО ГАММА-ИЗЛУЧЕНИЯ
И ПОТОКОВ ЭЛЕКТРОНОВ И ПОЗИТРОНОВ В
ДИАПАЗОНЕ ЭНЕРГИЙ 1-3000 ГэВ

От ФИАН

Руководитель научного направления
академик

Гинзбург В.Л.
2009 г.

Научный руководитель проекта
ГАММА-400
профессор, г.н.с.

Гальпер А.М.
2009 г.

Москва, 2009 г.

APPROVED BY
The Lebedev Physical Institute
of the Russian Academy
of Sciences
academician
Mesyats G.A.

THE GAMMA-400 PROJECT
RESEARCH OF THE COSMIC GAMMA RADIATION
AND OF ELECTRON AND POSITRON FLUXES IN
ENERGY RANGE OF 1–3000 GeV

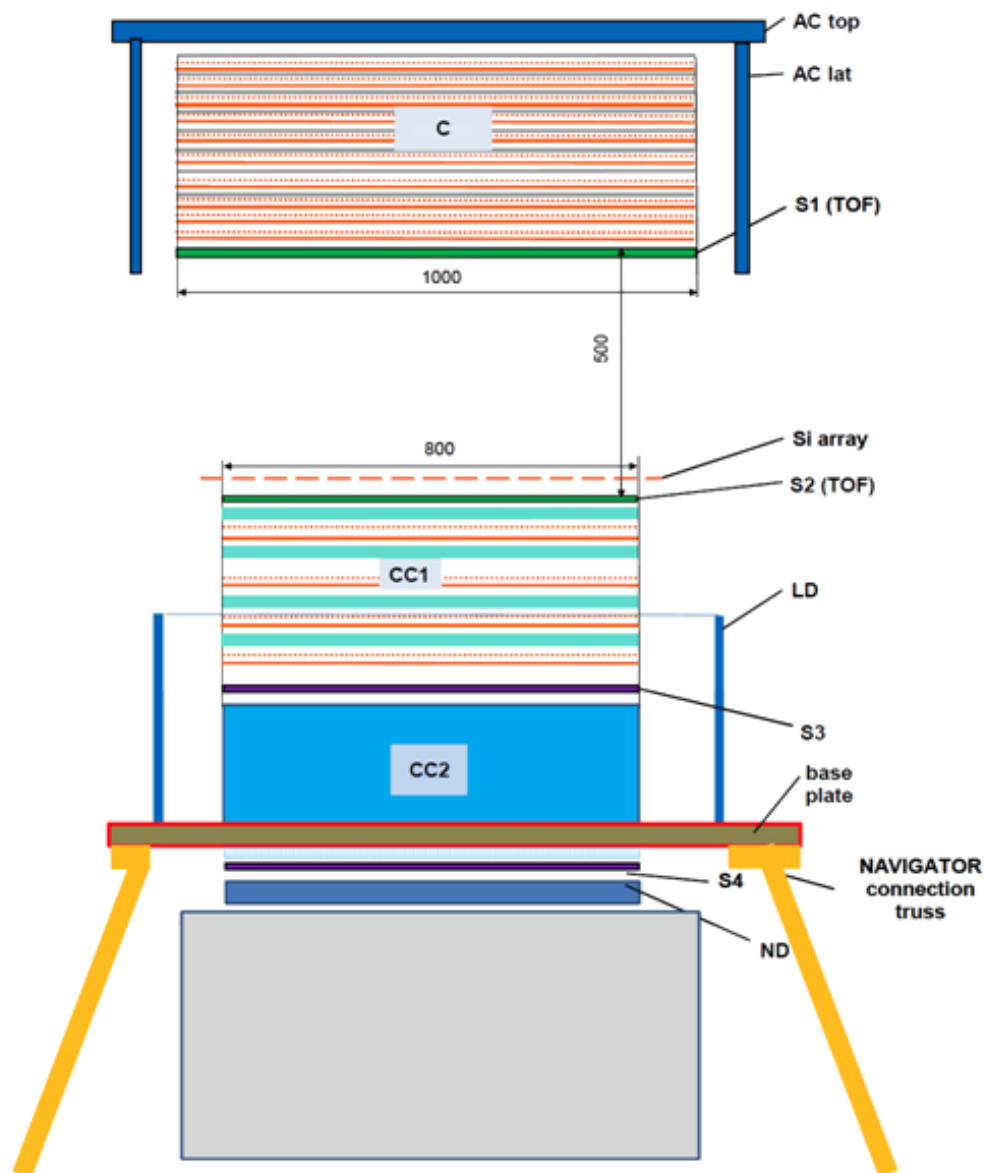
LPI

Scientific chief of problem
academician Ginzburg V.L.

GAMMA-400 project
principal investigator
professor I.r.f. Galper A. M.

Moscow, 2009

Gamma-400 physical Scheme



Main characteristics

Energy range 100 MeV – 3 TeV

Energy resolution

(at $E_\gamma > 100$ GeV): $\sim 1\%$

Angular resolution

(at $E_\gamma > 100$ GeV): $\sim 0.01^\circ$

Rejection factor: $\sim 5 \times 10^5$

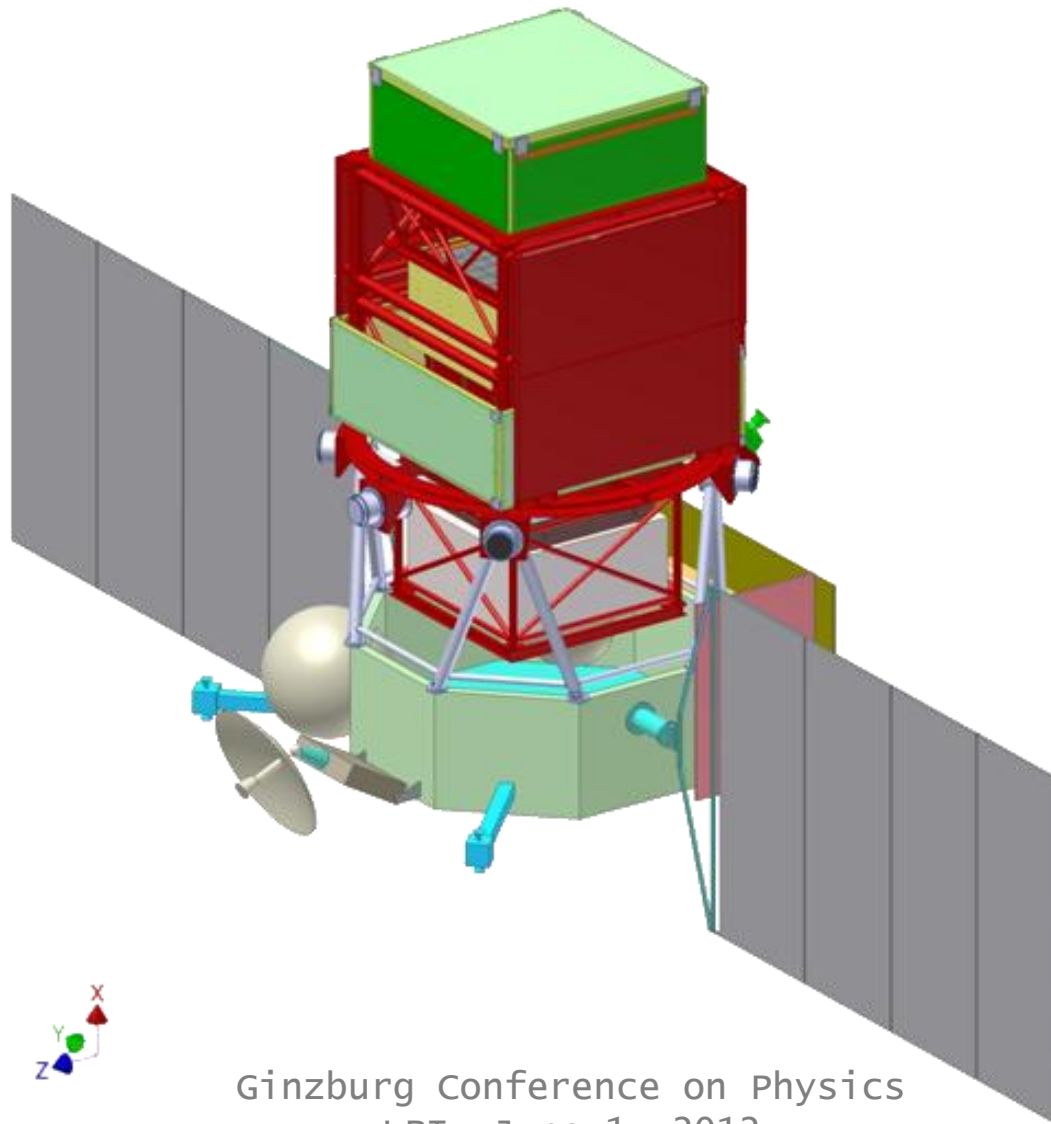
Power consumption: 2000 W

Total mass: 2600 kg

Comparison of main characteristics

	SPACE GAMMA-RAY TELESCOPES				GROUND BASED GAMMA-RAY TELESCOPES		
	EGRET	AGILE	Fermi	GAMMA 400	H.E.S.S.- II	MAGIC-II	VERITAS
	USA	ITALY	USA	RUSSIA	NAMIBIA	SPAIN, CANARY ISLANDS	USA, ARIZONA
Energy Range [GeV]	0.03–30	0.03–50	0.1– –300	0.1– –3000	100	50	100
Angular resolution ($E_\gamma > 100$ GeV) [degrees]	0.5 ($E_\gamma \sim 10$ GeV)	0.1 ($E_\gamma \sim 30$ GeV)	0,1	0.01	0.1	0.1	0.1
Energy resolution ($E_\gamma > 100$ GeV) [percent]	20 ($E_\gamma \sim 10$ GeV)	50 ($E_\gamma \sim 30$ GeV)	10	1	15	20	15

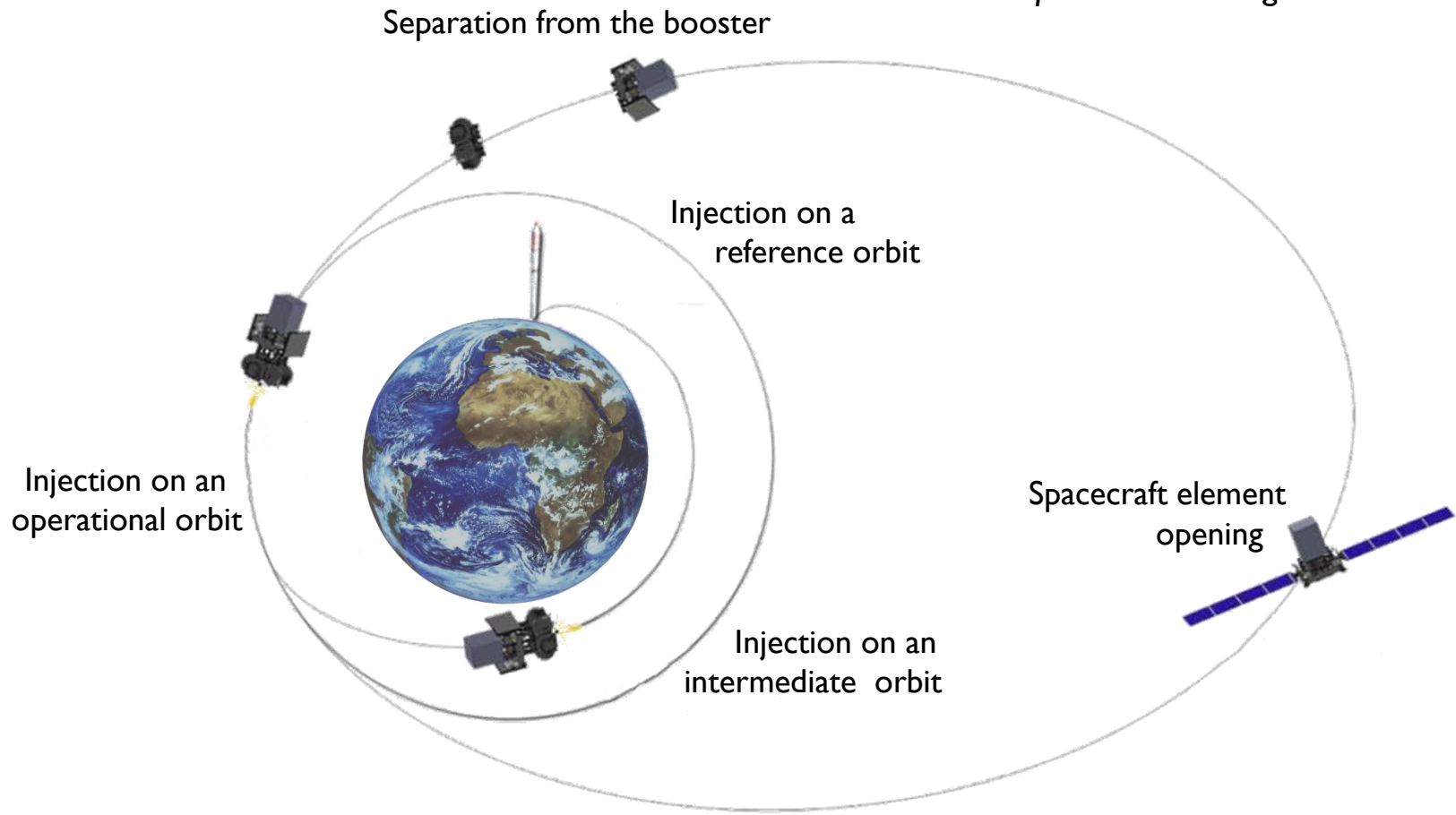
GAMMA-400 on the *Navigator* platform



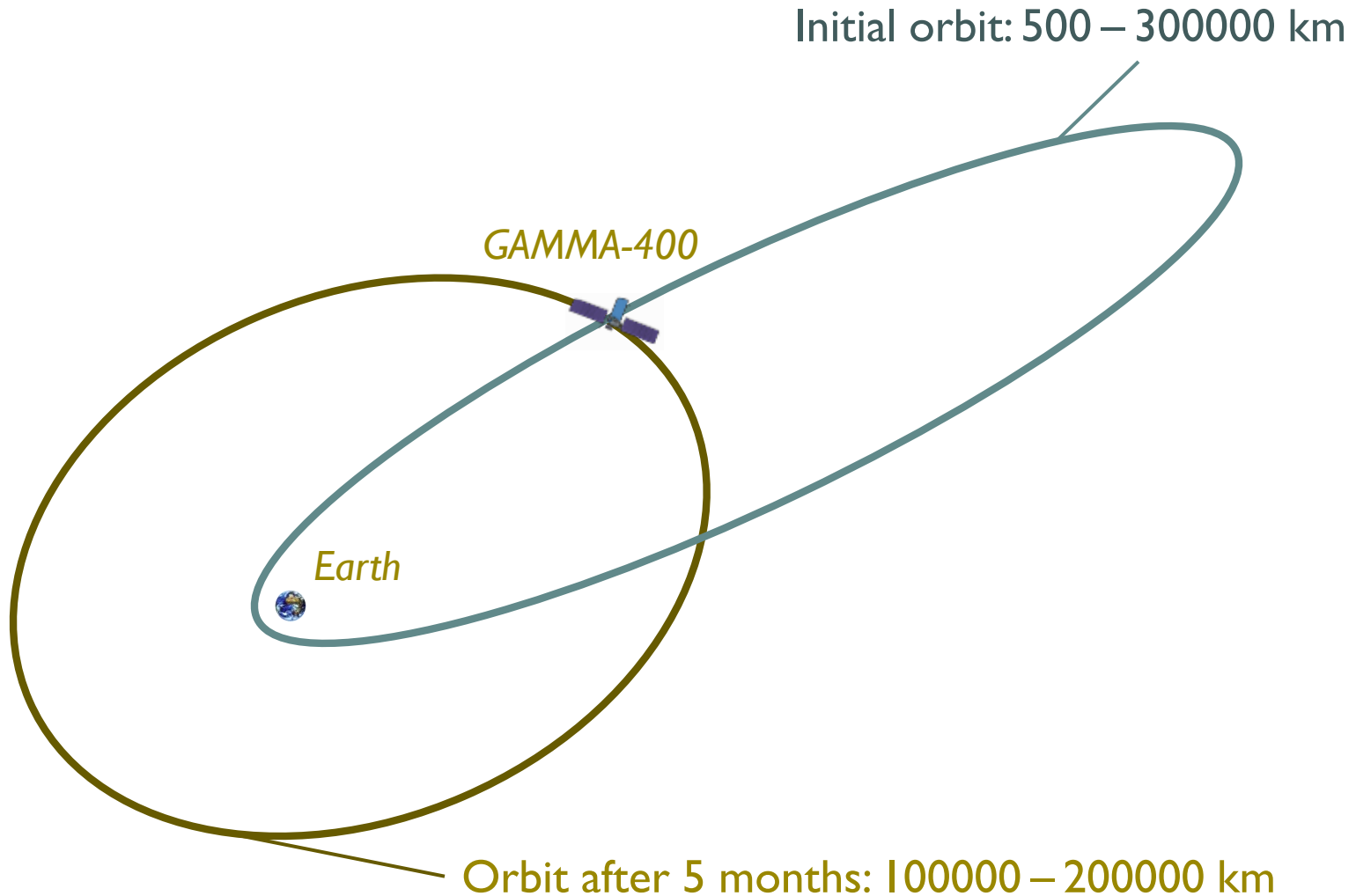
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GAMMA-400 Launching Scheme

Prospective launching date: 2018–2019



GAMMA-400 Orbit



Conclusion

- Cosmic rays were discovered one hundred years ago. 60 years later galactic or extragalactic origin of cosmic rays is still not known. Vitaly Ginsburg proposed solution to this problem. Today this problem has been solved—the bulk of CRs has a galactic origin.
- This year marks 80 years since the discovery of dark matter in the Universe. Today its nature is still not known. Vitaly Ginsburg proposed the way to solve this problem: the search for traces of self-annihilation of hypothetical dark matter. Today we are moving in this direction.