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Abstract:

SPECIAL RELATIVITY RESOURCE - Microsoft Word

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SPECIAL RELATIVITY RESOURCES

Dave Harding, daveh_4_4@hotmail.com, Kalamalka Secondary, Vernon B.C.
Fax 2505457394, School 2505451396

RESOURCES (paper):

READINGS: Chp. 15 – Relativity I ; Hewitt, Paul, (1992) Conceptual Physics
Chp. 16 – Relativity II ; Hewitt, Paul, (1992) Conceptual Physics
http://www.conceptualphysics.com/books.shtml

Various excerpts from other resources re Twin Trip Paradox, Michelson Morley exp. Etc.
Concept Development Exercises Hewitt, Paul, (1992) Conceptual Physics
Problem solving Drill exercises for Time dilation, Length contraction and momentum increase

RESOURCES (A.V., www):

VIDEO/DVD1 Special Relativity I : Hewitt, Paul, (1992) Conceptual Physics (45 min)
Al's Adventures in Special Relativity (http://www.onestick.com/relativity/)
VIDEO/DVD2 Special Relativity II : Hewitt, Paul, (1992) Conceptual Physics (45 min)
VIDEO3 The Michelson Morley Experiment (1990) Mechanical Universe Series (15 min) (this may be available on the web as streaming video now)
VIDEO4 Special Relativity (1990) Mechanical Universe Series (25 min)
**excellent capstone or one day treatment (this may be available on the web as streaming video now)
http://www.ed.gov/pubs/EPTW/eptw7/eptw7k.html
http://www.jsd.claremont.edu/Physics/demo/movies.htm

Unit Outline

Pre-class 1 reading-- Chp. 15 – Relativity I
Video 1 - Special Relativity I : Hewitt, Paul
Twin Trip conceptual Exercises; Post Chp 15 exercises #1-15

Debrief Class 1
Internet Lab Exercises: Al's Adventures in Relativity
Video 2 – Michelson Morley Experiment
Short summary essay on Michelson Morley Experiment

Pre-class 2 reading-- Chp. 16 – Relativity II

Name:_____ Period: _____ Date: _____

CONCEPT DEVELOPMENT – Special Relativity : The Twin Trip [Ship-based clock]
Reference: Hewitt, Paul. (1992). Conceptual physics.

The twin trip compares the times experienced by a traveling twin and a stay-at-home twin. The two hour trip experienced by the traveling twin is observed to take 2.5 hours from a frame of reference on earth, as evidenced by the sending and receiving of regularly-spaced flashes of light – an effective clock for showing Doppler effects. The 6 minute-interval flashes emitted by the spaceship are seen from the earth at 12-minute intervals when the spaceship is leaving the earth, and at 3-minute intervals when the space ship approaching the earth. After studying the resource materials for the twin trip, fill in the readings on the spaceship clock below for each light flash emitted, and on the earth-based clock for each flash received.

SHIP LEAVING EARTH **SHIP APPROACHING EARTH**

FLASH	TIME ON SHIP WHEN FLASH SENT	TIME ON EARTH WHEN FLASH SEEN	FLASH	TIME ON SHIP WHEN FLASH SENT	TIME ON EARTH WHEN FLASH SEEN
0	12:00	12:00	11	__:__	__:__
1	12:06	__:__	12	__:__	__:__
2	__:__	__:__	13	__:__	__:__
3	__:__	__:__	14	__:__	__:__
4	__:__	__:__	15	__:__	__:__

Einstein Plus Shared Resources – Week One 2006

David Harding	Special Relativity Resources
Julie Lemay	Canadian Center for Remote Sensing Student Activities using satellite imagery w answers *also available in french http://CCRS.nrcan.gc.ca/Ressource/tutor/planet/index_e.php
Bob Boyko	Relativity Assignment based on data from TRIUMF
Angelina Thornhill	Introduction to Modern Physics and Web Resources (on CD) Video: Einstein's Big Idea (PBS)
Rob Schultz	Voice Clips (Thomson, Rutherford, Bohr) Hydrogen Spectrum Experiment Emission Diagram
Henry Sikkema	Share-ware / Simulations On CD
Bill Riddick	Bill's Atlas Companion
Roberta / Damian	Thomas Moore "A Traveler's Guide to Space-Time" or "Six Great Ideas in Physics – Volume R"
John Cutts	Physics Teaching Ideas

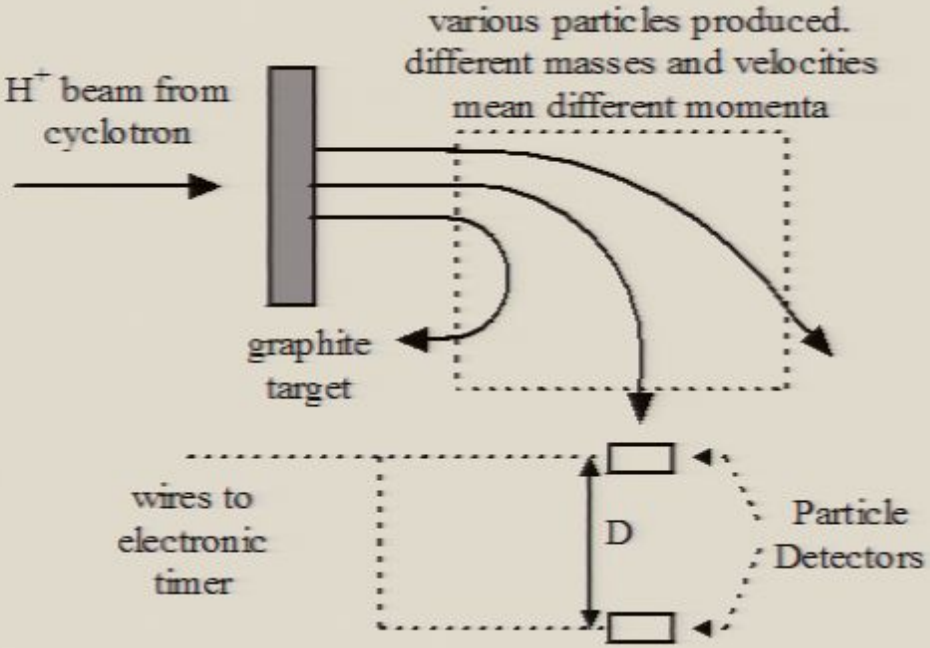
The TRIUMF Cyclotron
A Relativity Exploration

TRIUMF is a world class subatomic physics laboratory located on the campus of the University of British Columbia, a twenty-minute drive from downtown Vancouver. The heart of the facility is the world's biggest cyclotron.

The TRIUMF cyclotron looks like a giant pinwheel with each 'spiral' being a large electromagnet. Negative hydrogen ions are created by passing hydrogen gas through a spark which splits bond holding the two hydrogen atoms in the gas together. Some of the resulting atoms will be neutral, some positive (no electrons = H+) and some negative (two electrons = H-). The H- ions are given an initial acceleration (300 kV) and their path is bent 90° three times by parallel electric plates on their way to the cyclotron. These negative ions are then injected into the air free chamber between the poles of a 4 000 ton electromagnet 18 m in diameter. A current of 18 500 Amps has its polarity reversed 23 million times per second to create an alternating magnetic field of 5600 Gauss, roughly 11 200 times as powerful as the Earth's magnetic field. A charged particle entering this field at right angles is accelerated in an ever increasing spiral over 326 microseconds to a speed of 224 000 km/sec (roughly 3/4 of the speed of light). At the edge of the cyclotron, the ions strike a thin carbon film which strips most of them of their electrons

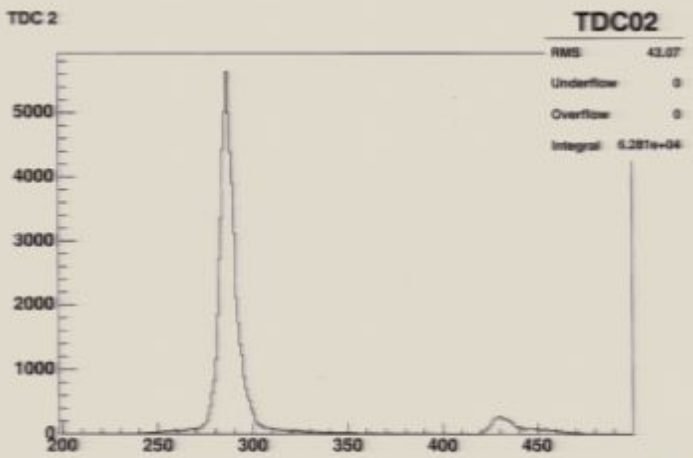
circle. The radius of the circle depend on the strength of the field (B), the mass of the particle (m), the speed of the particle (v) and the charge on the particle (q). The relationship between these values is: $qvB = \frac{mv^2}{r}$ which simplifies to $mv = qBr$.

In this activity a magnet is used to bend the stream of particles coming from the cyclotron into the path of two detectors. The time it takes for the various particles to travel the 4.40 m between the detectors is measured and these values are plotted on a frequency graph. By placing the detectors in only one position outside the magnetic field, we restrict the particles we look at to a single radius.

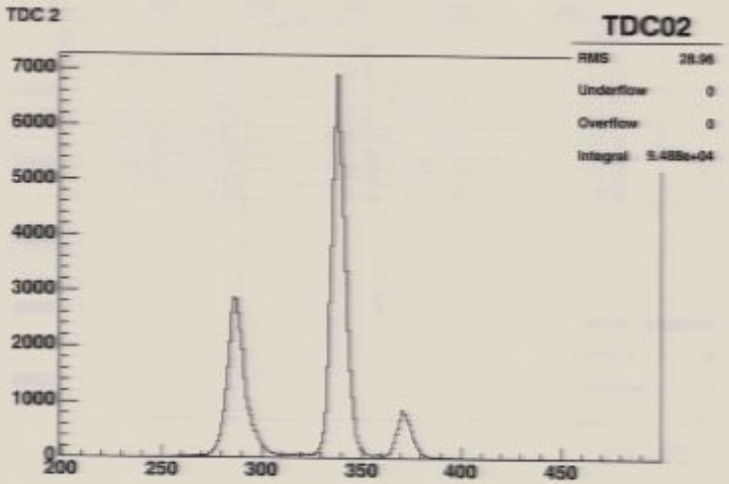


reach the other becomes significant. In addition one wire is 4 meters longer than the other which adds its own problems. Thus we need to use a correction factor of $t = (t' - 133) \times 10^{-10}$. The following are the actual frequency graphs for particles at various momenta. Remember that higher momenta mean that the particles are traveling faster.

Momentum = 70 MeV/c



Momentum = 120 MeV/c



Page 3

4. Calculate the mass of the particle. { p = mv }. How does this value compare to the rest mass of the muon (1.895×10^{-28} kg). Why are the values different?

5. Calculate the expected relativistic mass for the muon using the formula $m = \frac{m_o}{\sqrt{1 - \frac{v^2}{c^2}}}$

What is the percent difference between the accepted value (above) and your

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John Cutts	Physics Teaching Ideas
Magdy Nashed	Photoelectric Effect Lab Excercise
James Ball	Cartoons
Bob Shaw	Movie Project

Shop PBS - NOVA: NOVA: Einstein's Big Idea (DVD) - Microsoft Internet Explorer provided by Rogers Hi-Speed Internet

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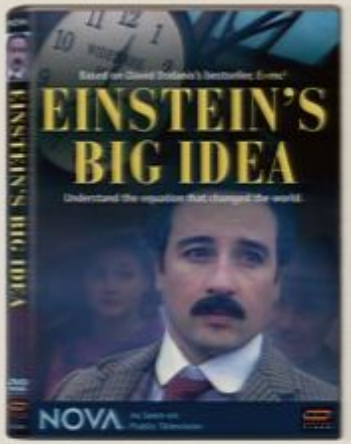

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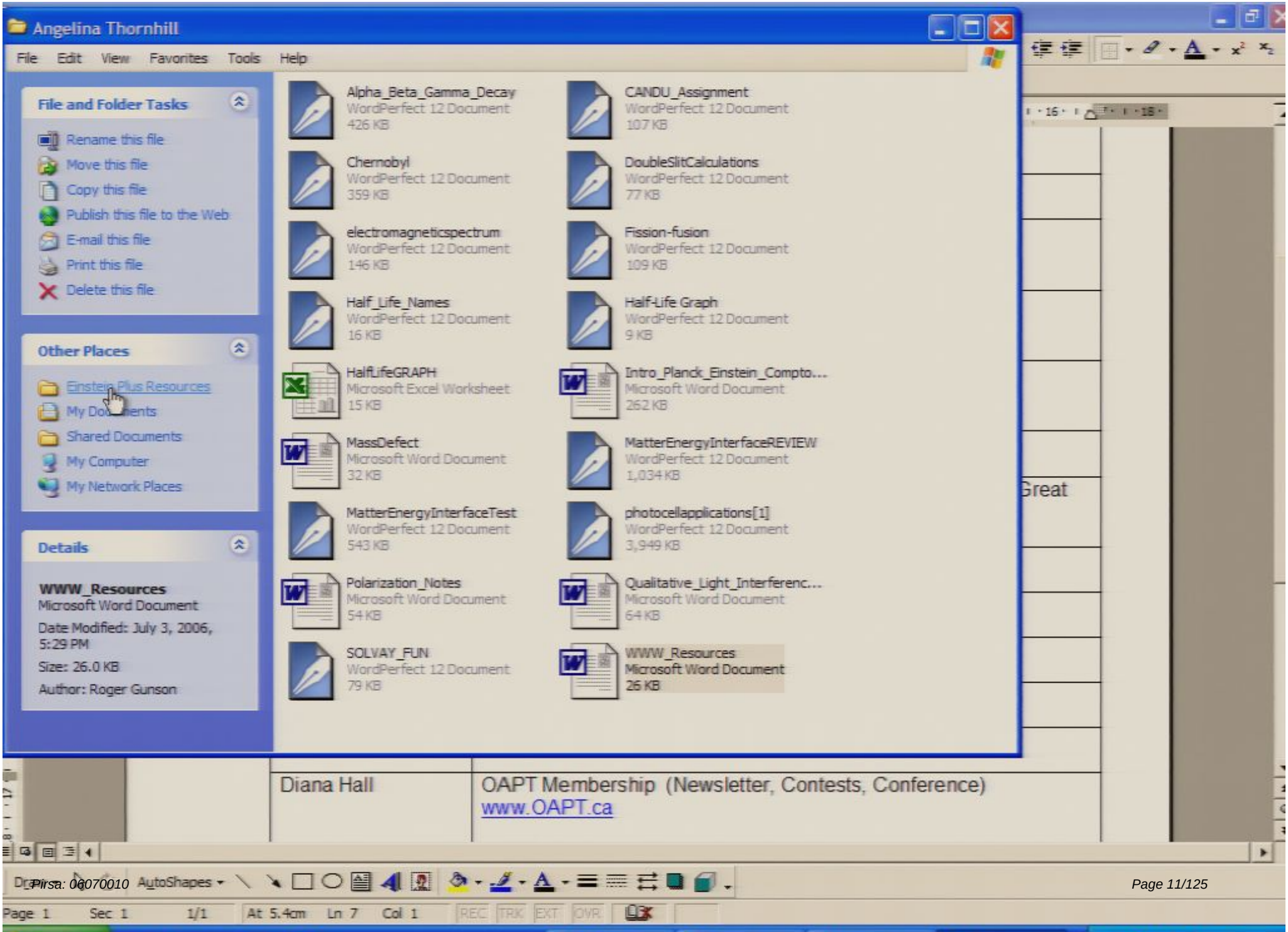
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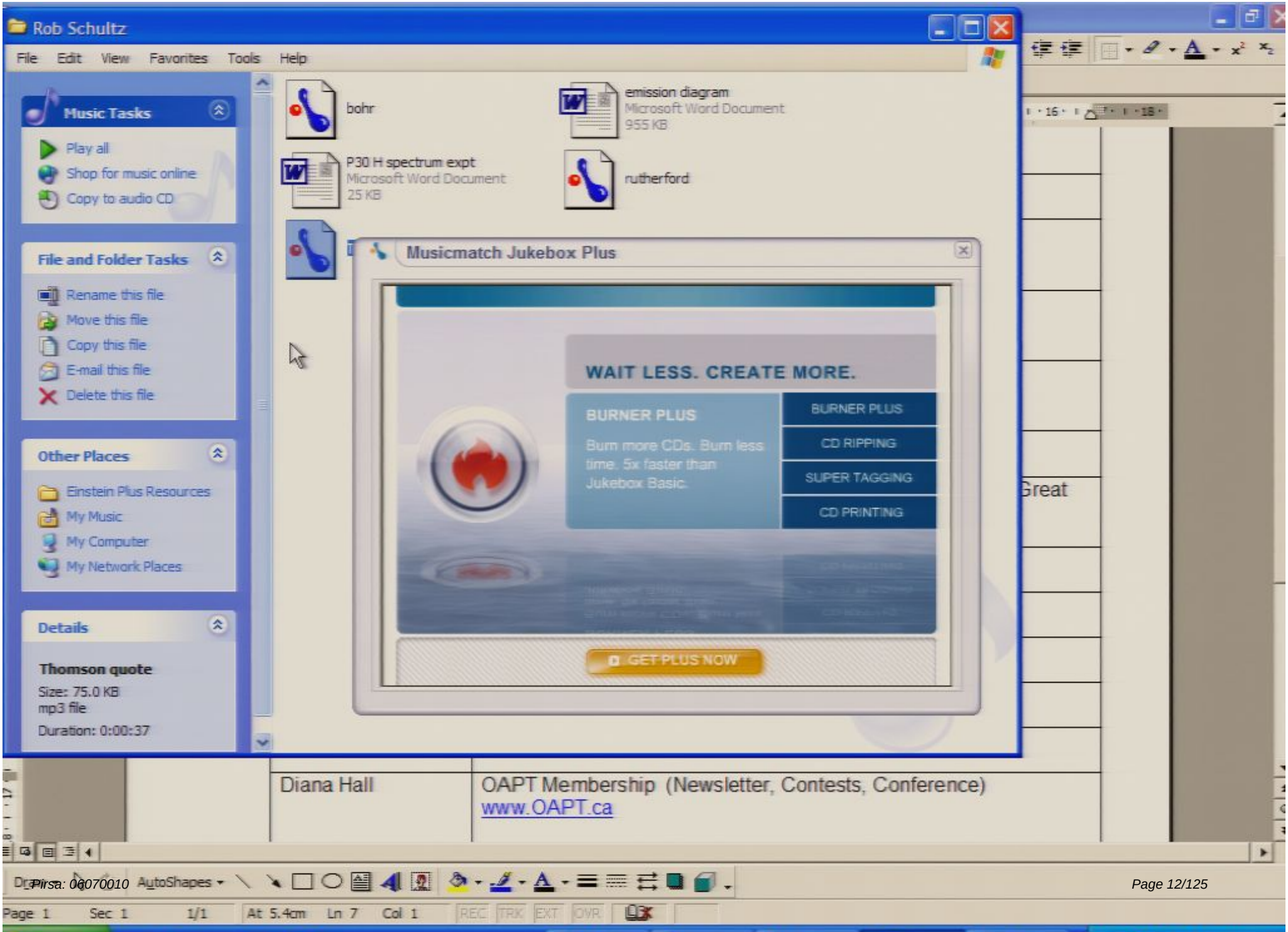
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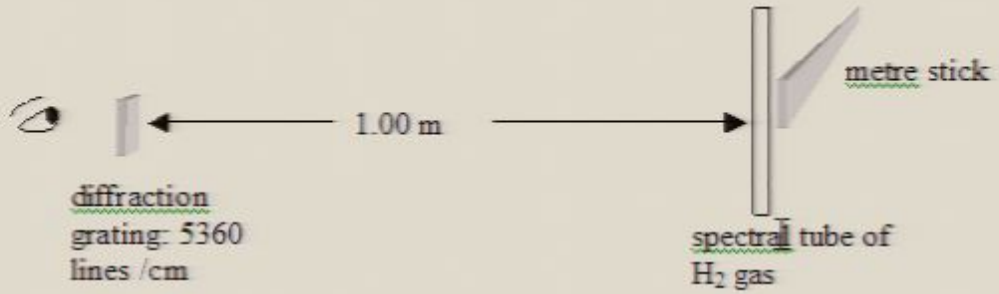
B The apparatus diagrammed below will allow you to measure the actual wavelength of the spectral lines using the formula $\lambda = \frac{d\,x}{n\,l}$. Observe each spectral line's position and calculate its wavelength. All of these lines are first-order spectra meaning that n in the formula is 1. Note that this n is not the principal quantum number n in the previous formula.



Set up notes – I clamp the tube power supply between 2 rings on a stand and use some weights on the stand base to counter balance it. The grating is clamped to another stand using a thermometer clamp. The meter stick is clamped to a 3rd stand so that the spectral lines appear just below it. This experiment can be done in a fully lighted room!

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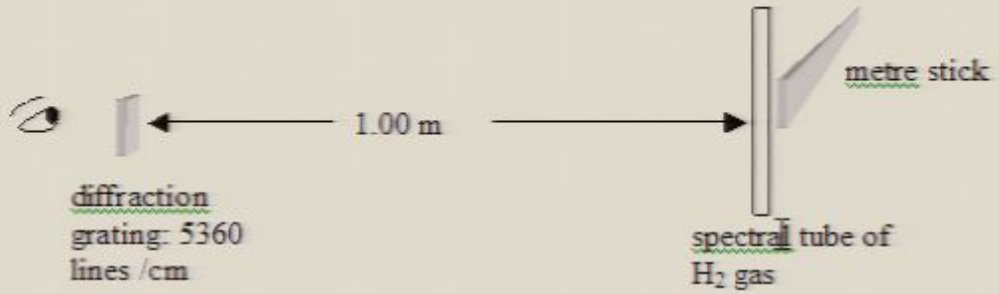

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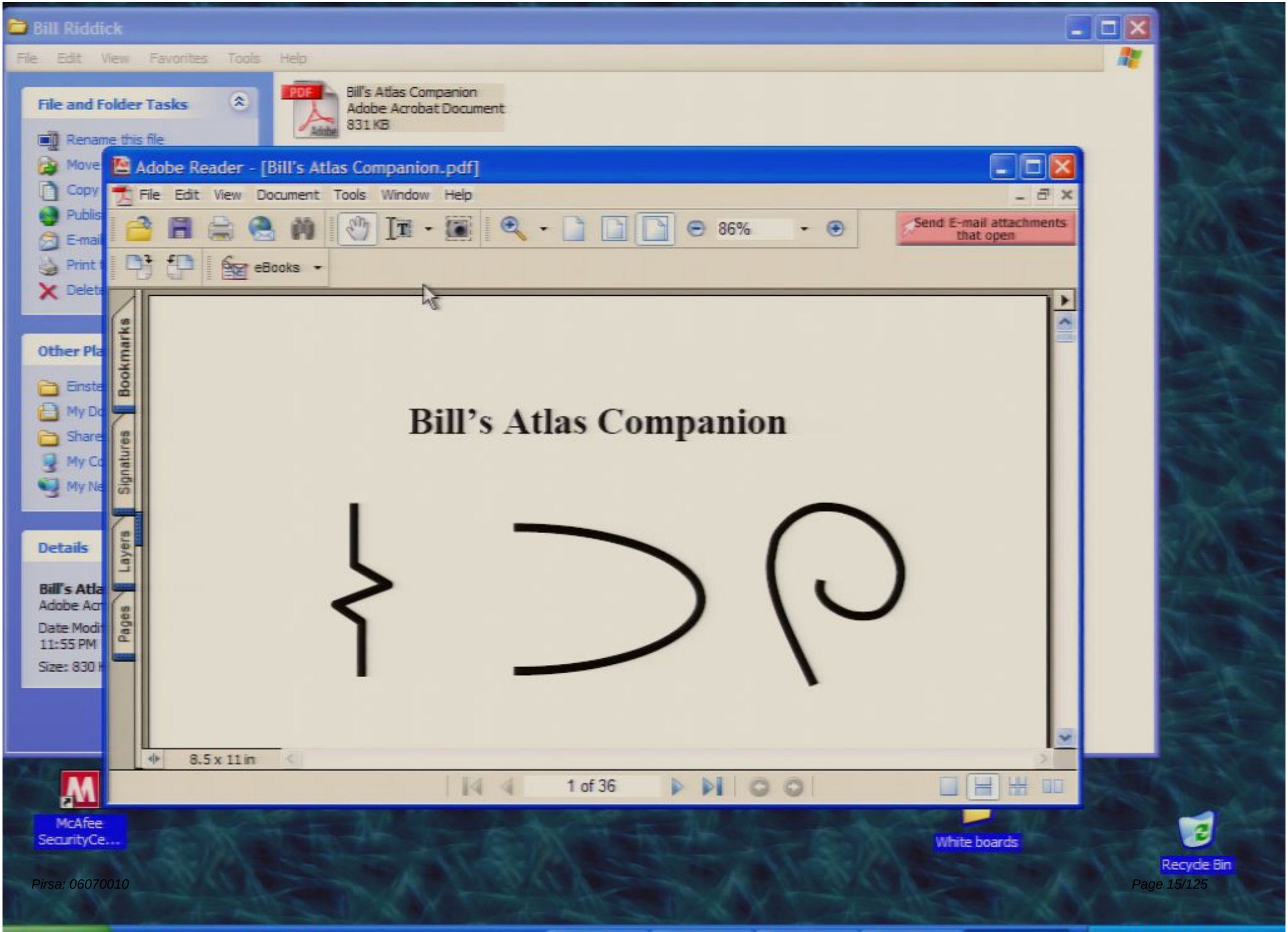
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pigs for much of the material that is contained herein.

To Mr. Hoogenraad and his Grade 10 History class at Nepean High School in Ottawa, for giving me the stimulus to turn draft notes into structured text, and for being the first class to receive this material in a structured way.

Bill Riddick

June 2004

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appears to be very little need to have to remember anything!

Imagine, however, that you are 23 years old and traveling through Europe on a train with your backpack. Someone of approximately the same age (and perhaps the opposite gender) is sitting across from you, also with a backpack. Clearly you have a common interest, and one of the first things you ask is, "Where are you from?" to which the answer "Slovenia" is given. Your response can take one of three forms. If you believe that technological marvels require you not to have to remember anything, then you might say to your traveling companion, "I've never heard of the place, but if you'll give me a minute while I consult my super-lightweight-always-on-wireless-connected-pocket-computer, I will be able to tell you anything about your country that you would like to know!"

If you choose this response, then you get what you deserve.

More likely is the second form of response, consisting of questions on your part ("Slovenia? Sounds interesting. Where exactly is that?") followed by a further discussion of your companion's, and perhaps your own, homeland. While your ignorance of Slovenia has not hampered your discussion, it certainly hasn't enhanced it. Many introductory conversations revolve around the exchange of information about people's homelands, and you may have missed a great opportunity to establish a meaningful connection with another human being.

Suppose that you are able to make the third form of response:

"Slovenia?" you say. "Are you from Ljubljana?"

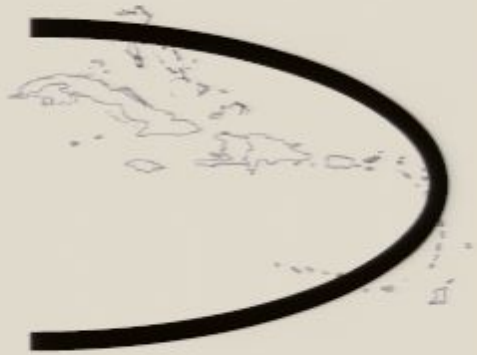
"Why yes I am! Have you been there?"

"No, actually, I haven't. But I'm very interested in your country and I've heard there is some great skiing there. Doesn't it share a mountainous region with Austria?"

MS/NMS = 191/79

NA 10/2

WI 13/15



SA 12/3

EU 35/10

ME 15/2

EA 15/0

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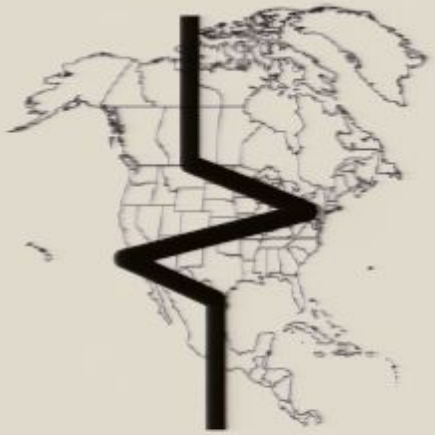

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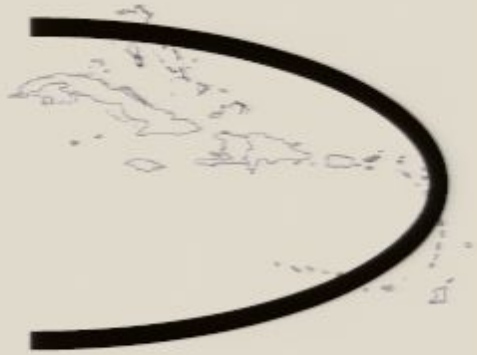

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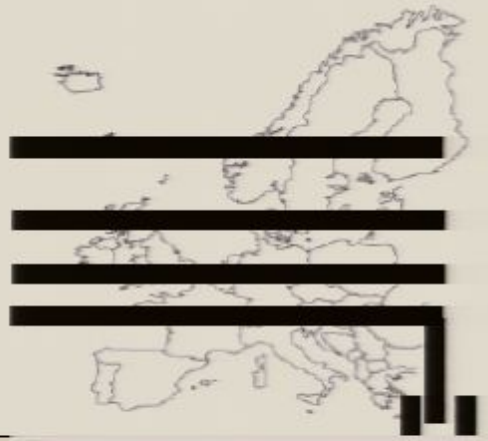

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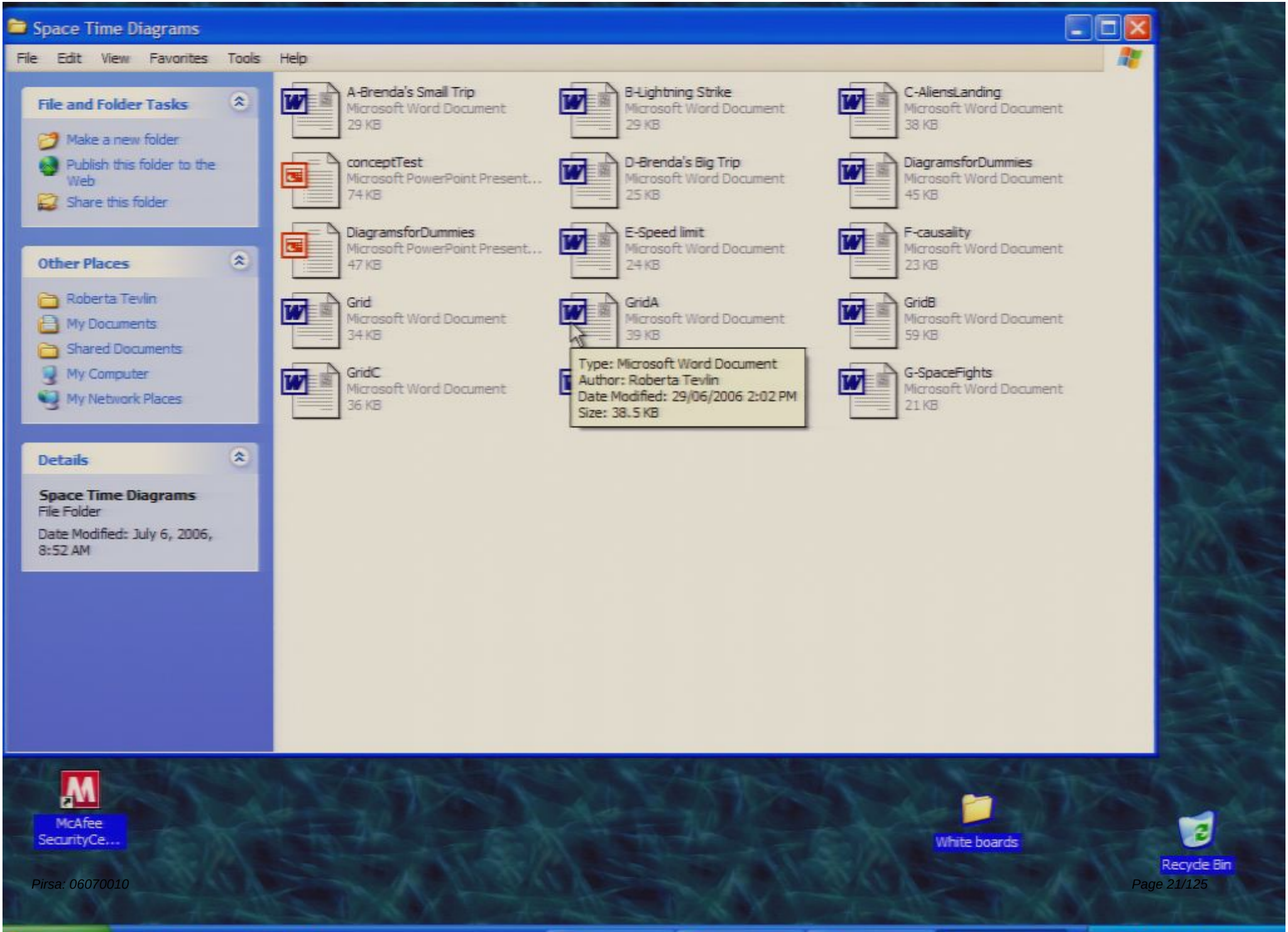
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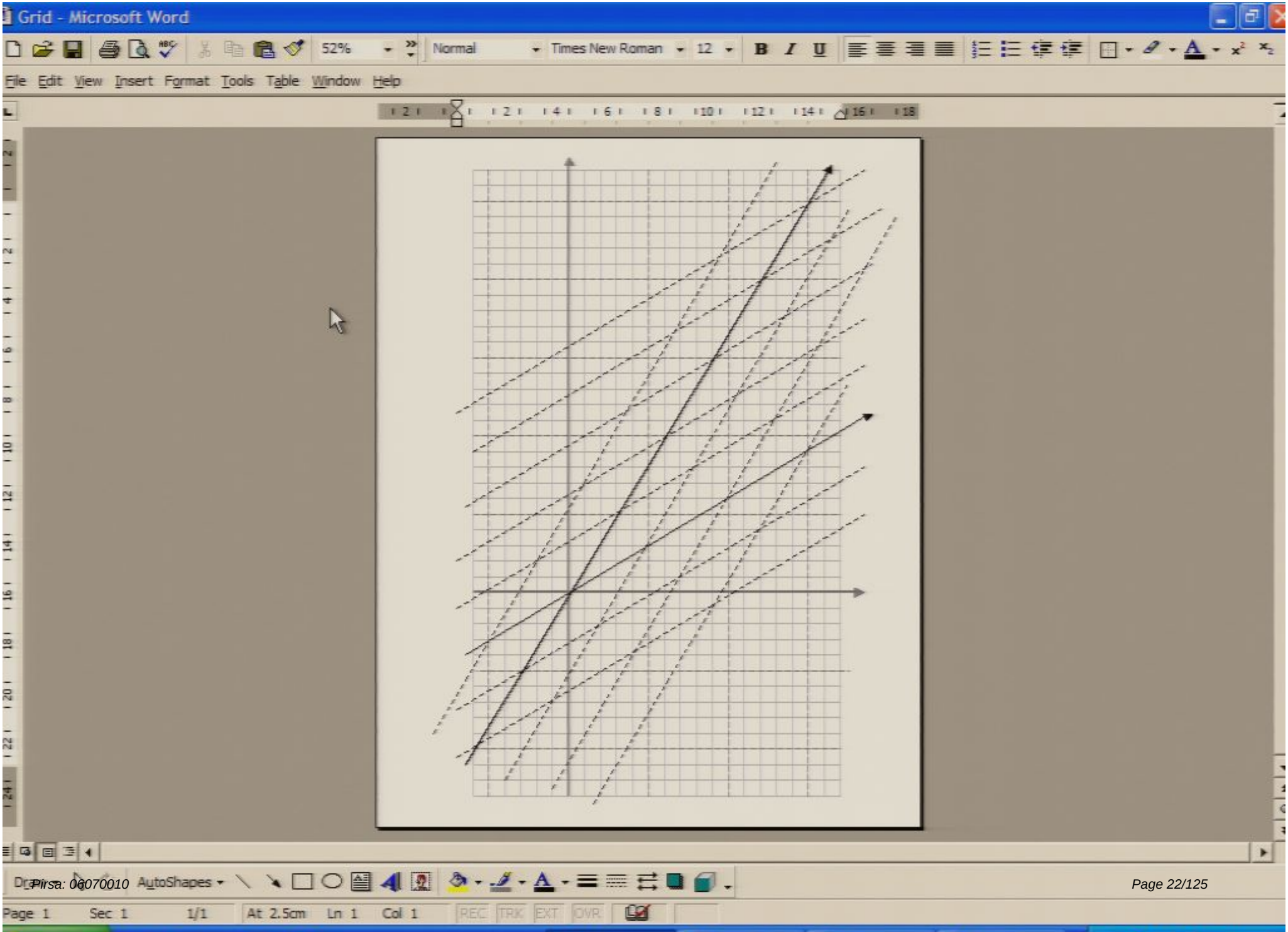
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A Portfolio of Teaching Ideas for High School Physics

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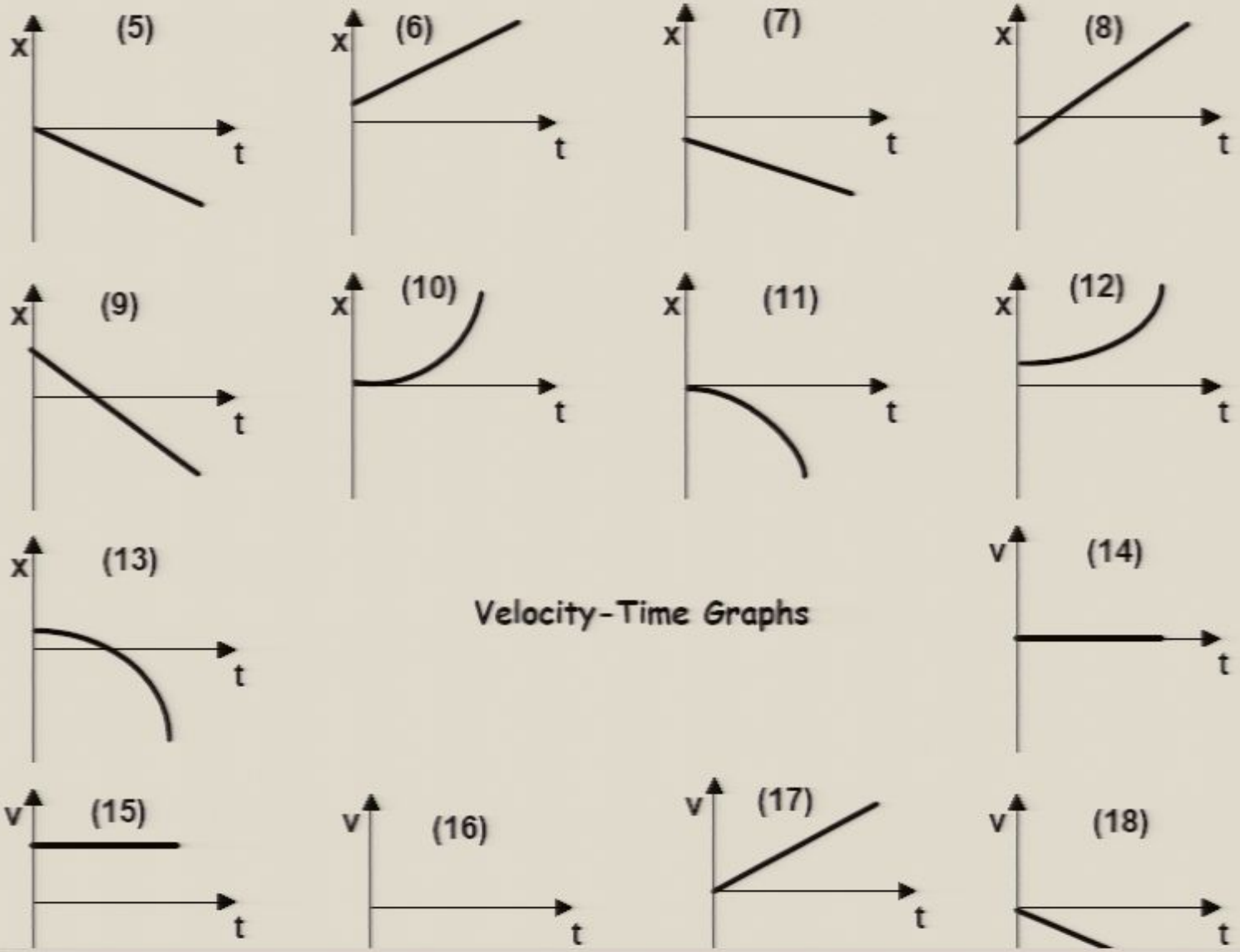

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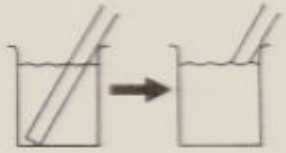
Disappearing Pyrex Test Tube



Outline:

This demonstration can be used as an aid to visually understand the importance of the ***index of refraction*** ("*n*"), and how it affects the way we see things. This demonstrations relates to the Ontario Curriculum Expectations (for SPH1IU) through:

Light and Geometric Optics

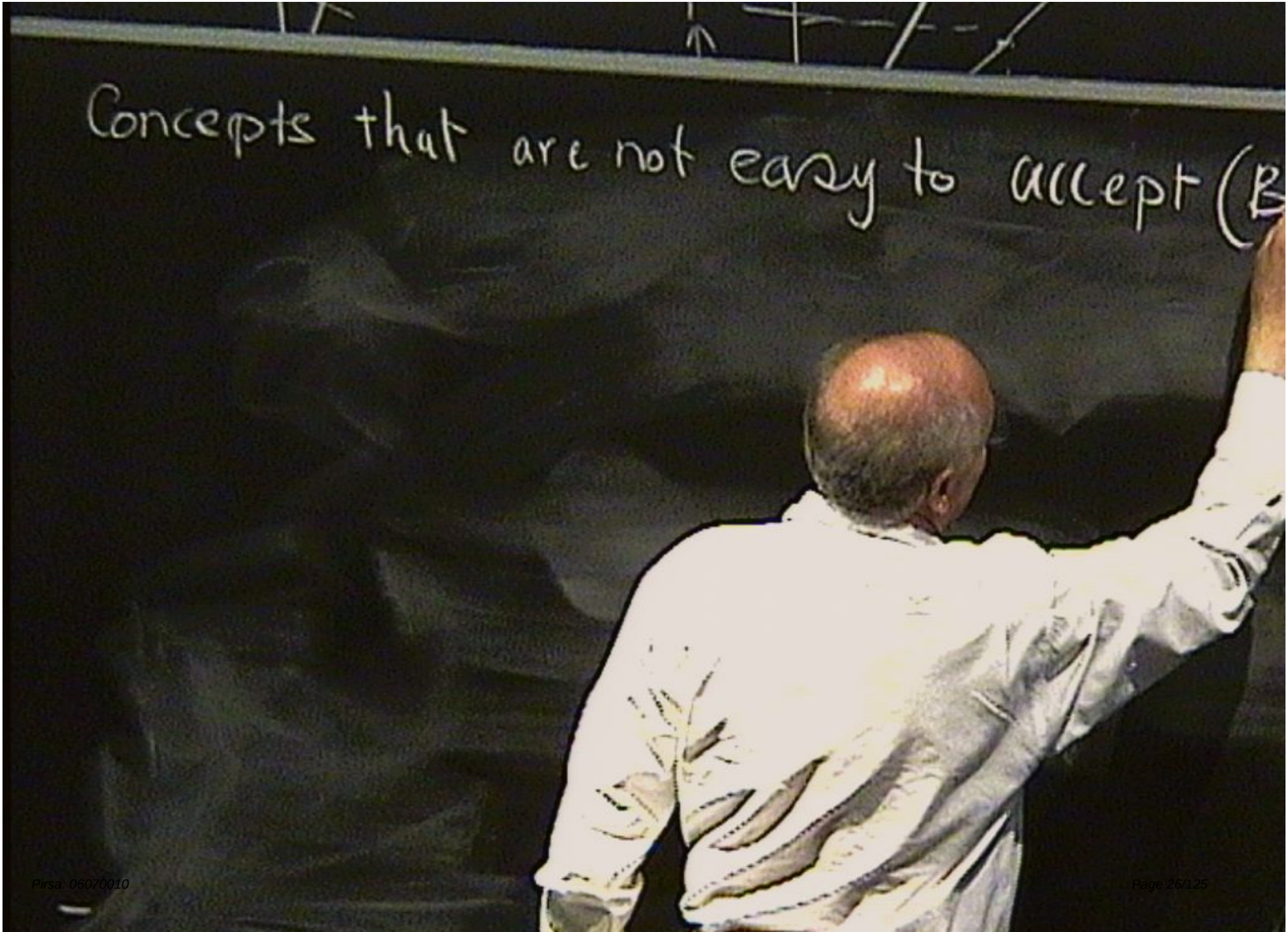
LGV.01 –Demonstrate an understanding of the properties of light and the principles underlying the transmission of light through a medium and from one medium to another

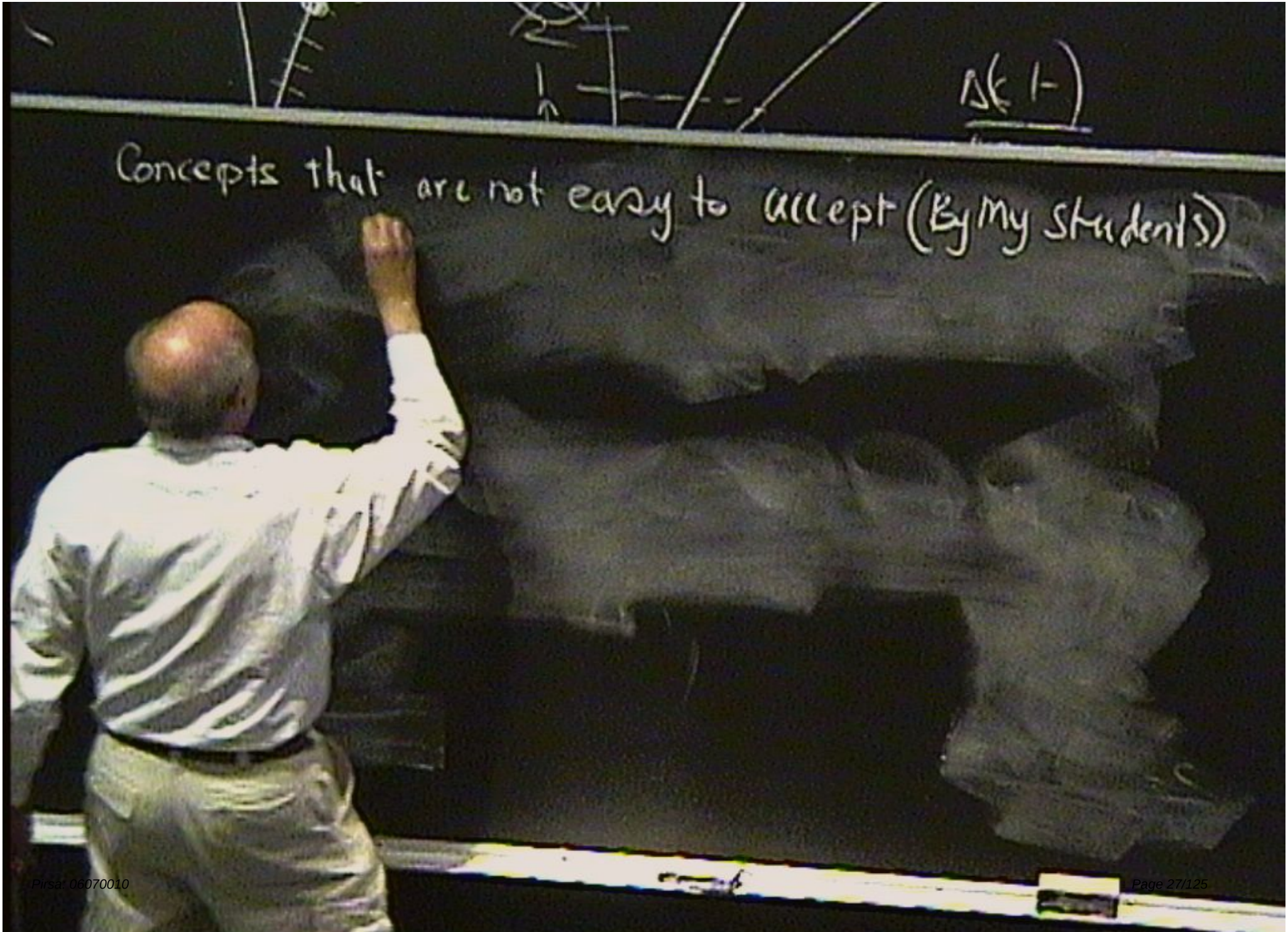
LG1.03 – Predict, in qualitative and quantitative terms, the refraction of light as it passes from one medium to another, using Snell's law

Materials:

Beaker (300 ~500mL preferable)	x 1
Pyrex test tube	x 2
Wesson Oil (or canola oil)	100~300mL
Extra beaker to hold the test tubes upright	(optional)

Demonstration:


Concepts that are not easy to accept (B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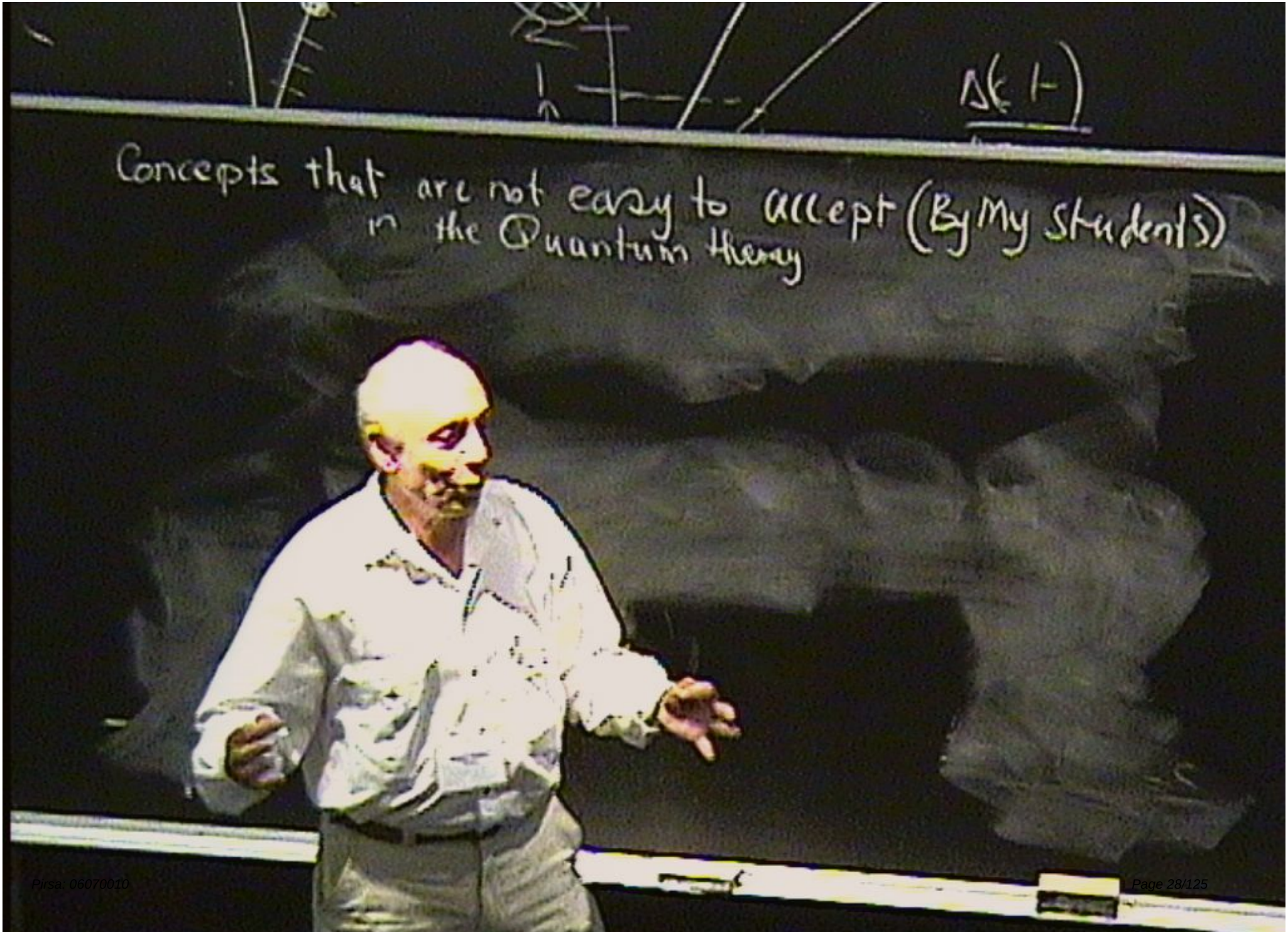
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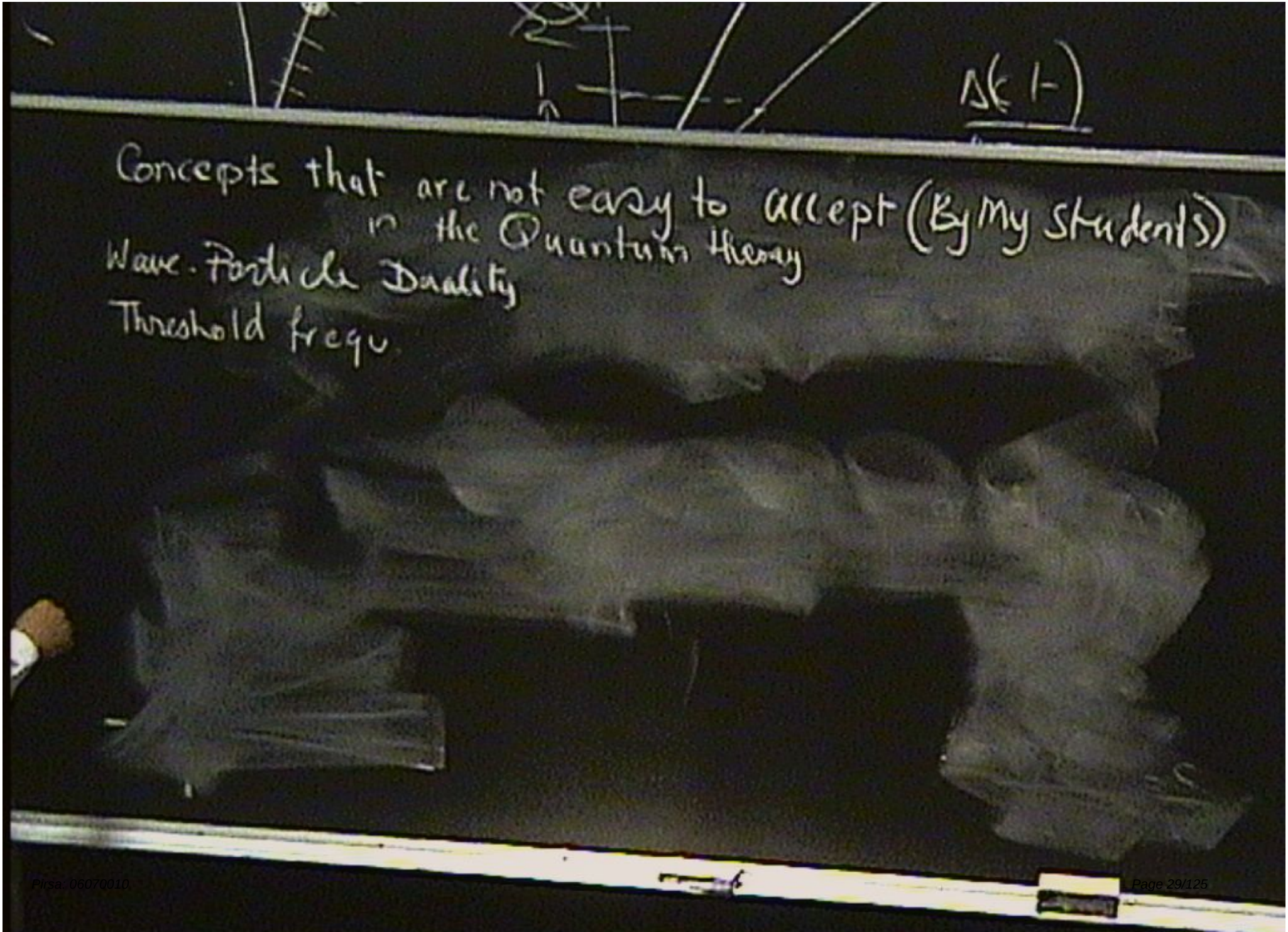
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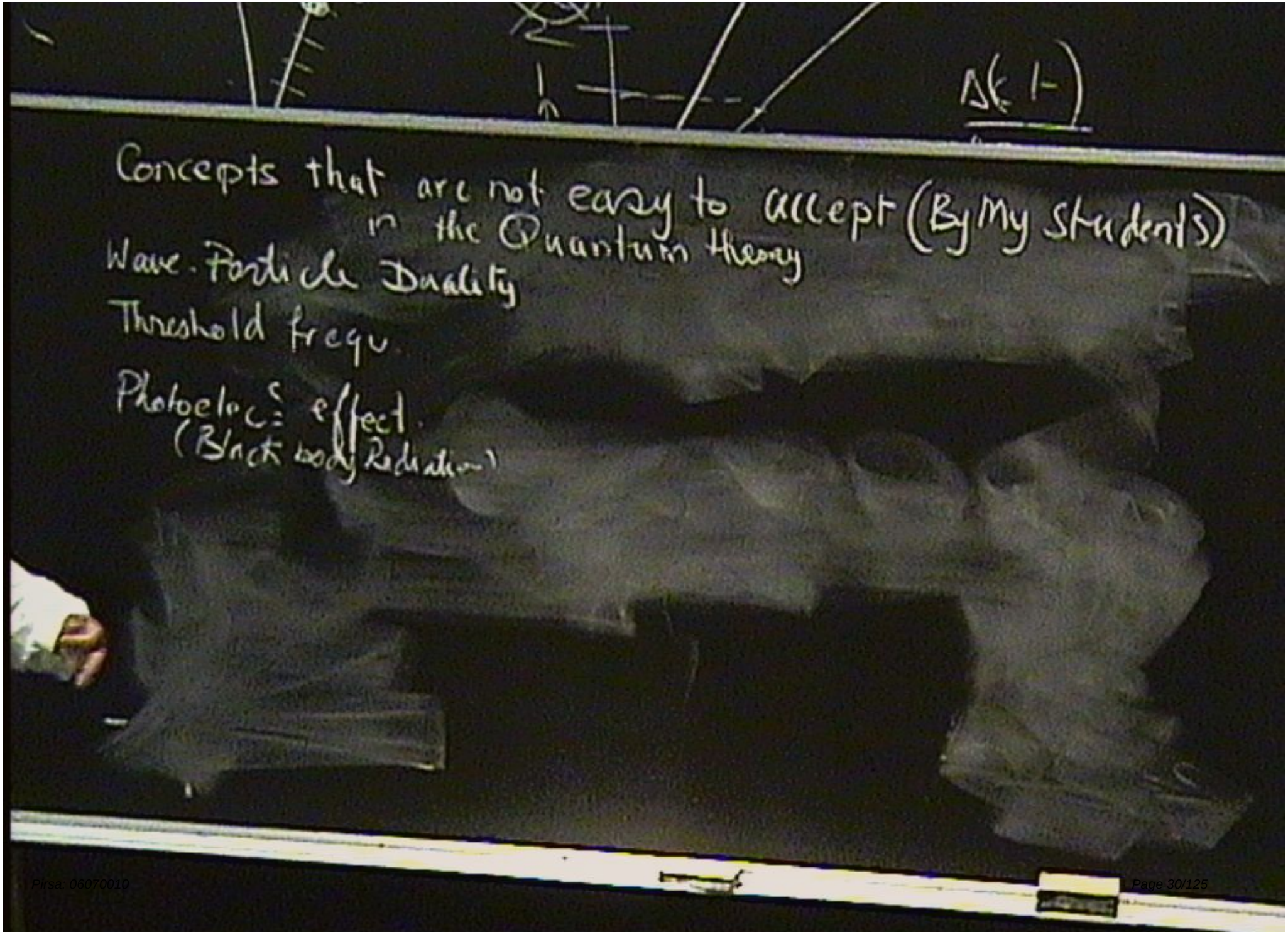
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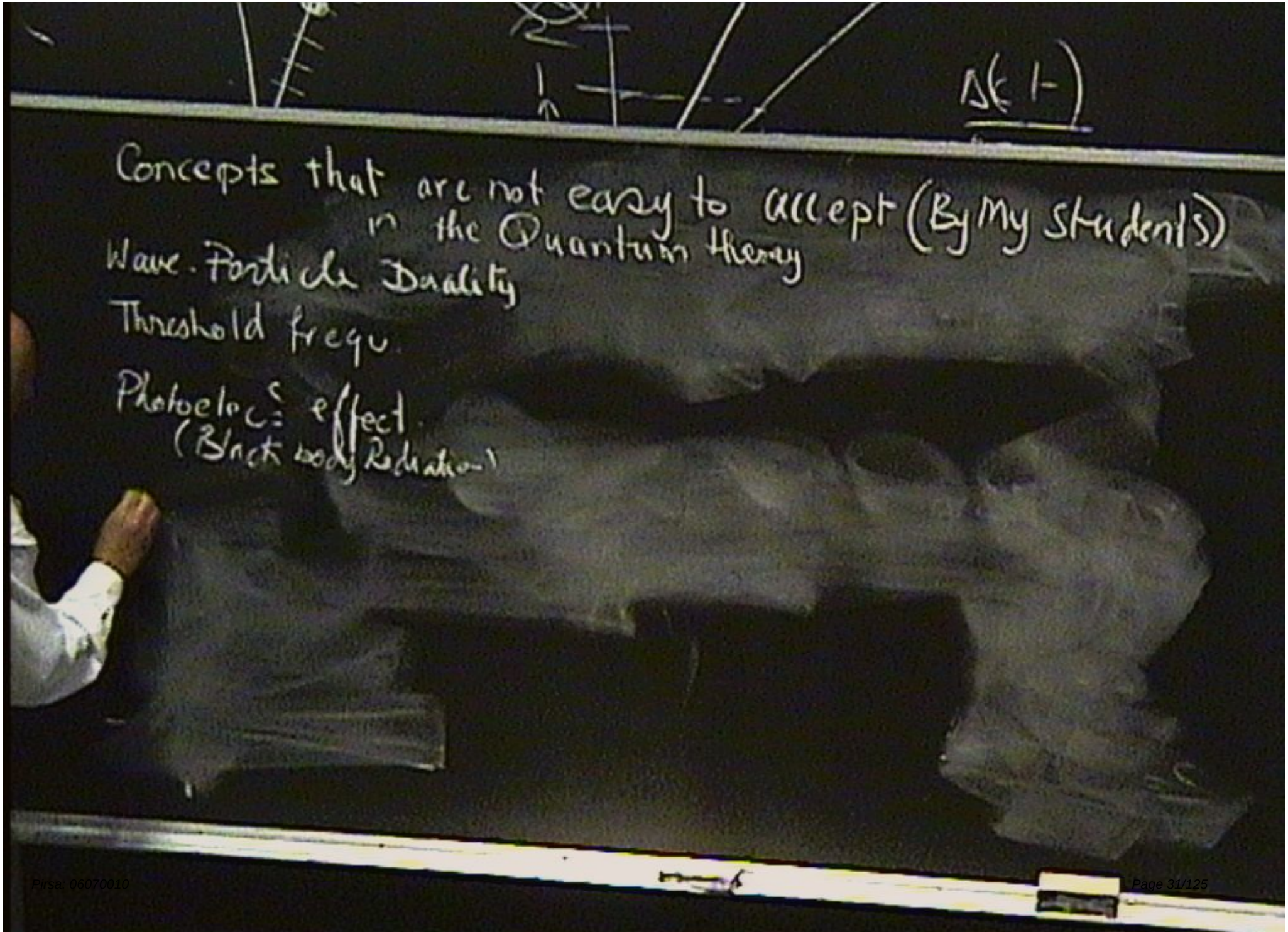
Concepts that are not easy to accept (By My Students)
in the Quantum Theory
Wave. Particle Duality
Threshold frequ.
Photoelectric effect.
(Black body Radiation)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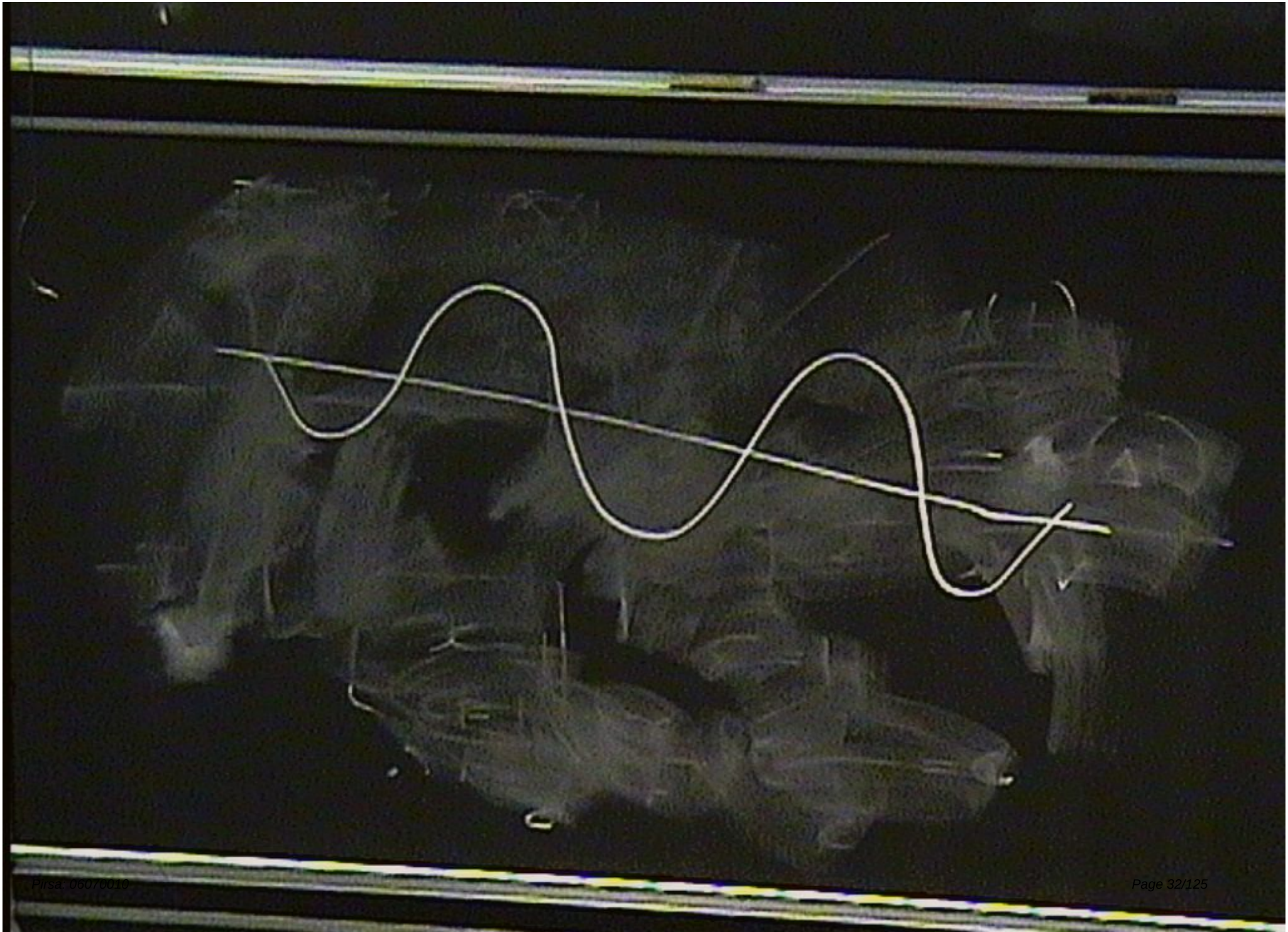
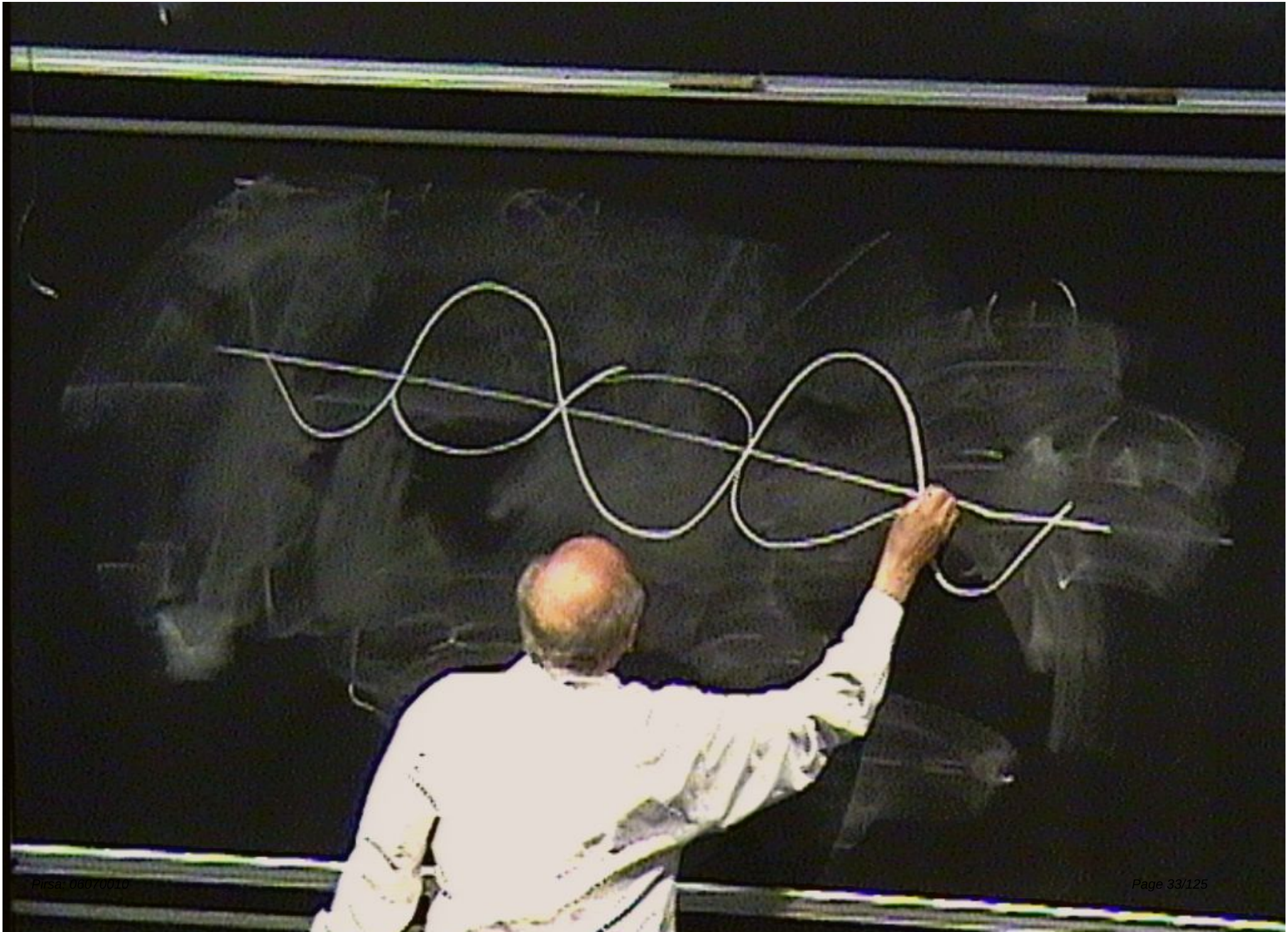
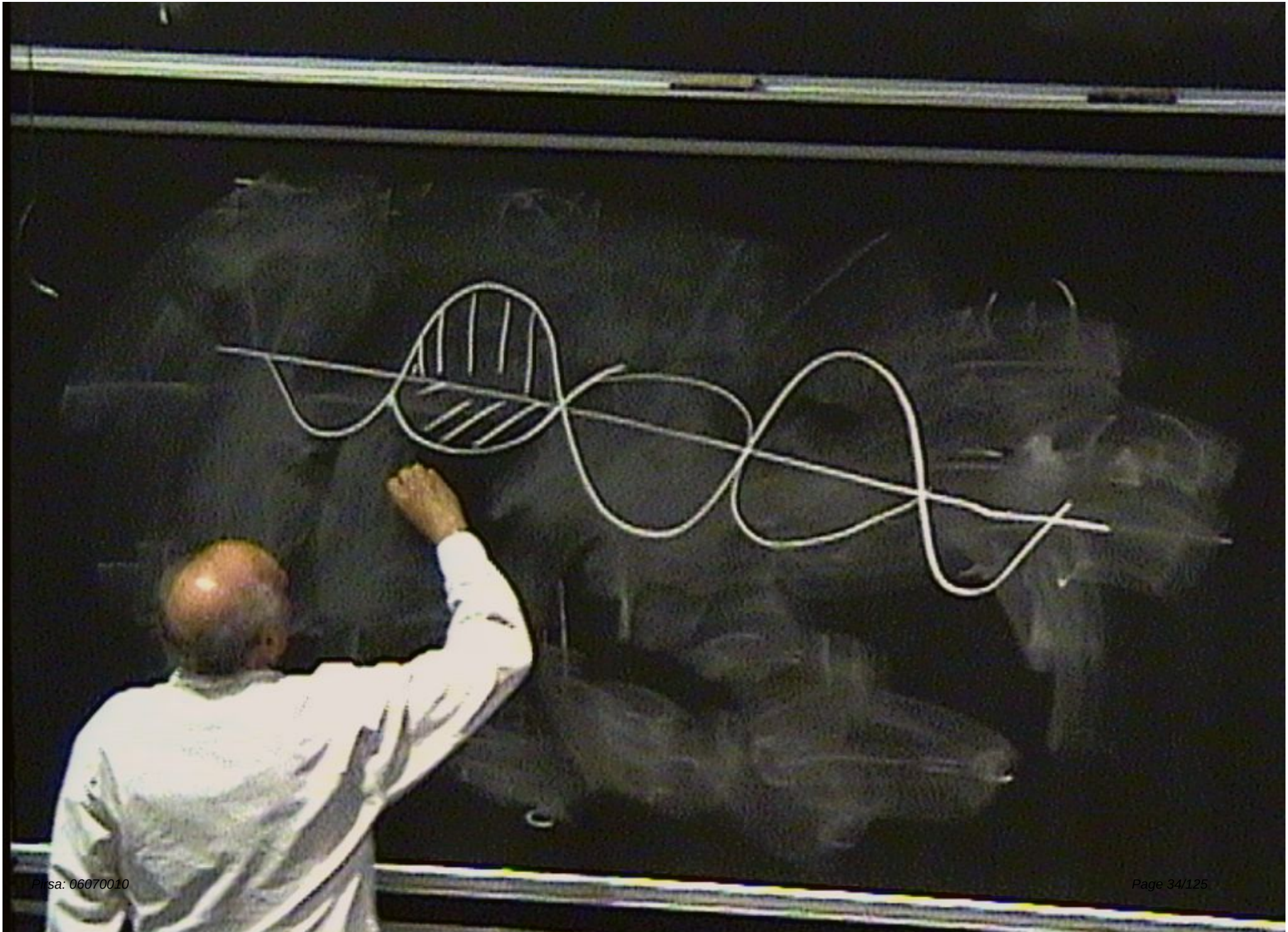
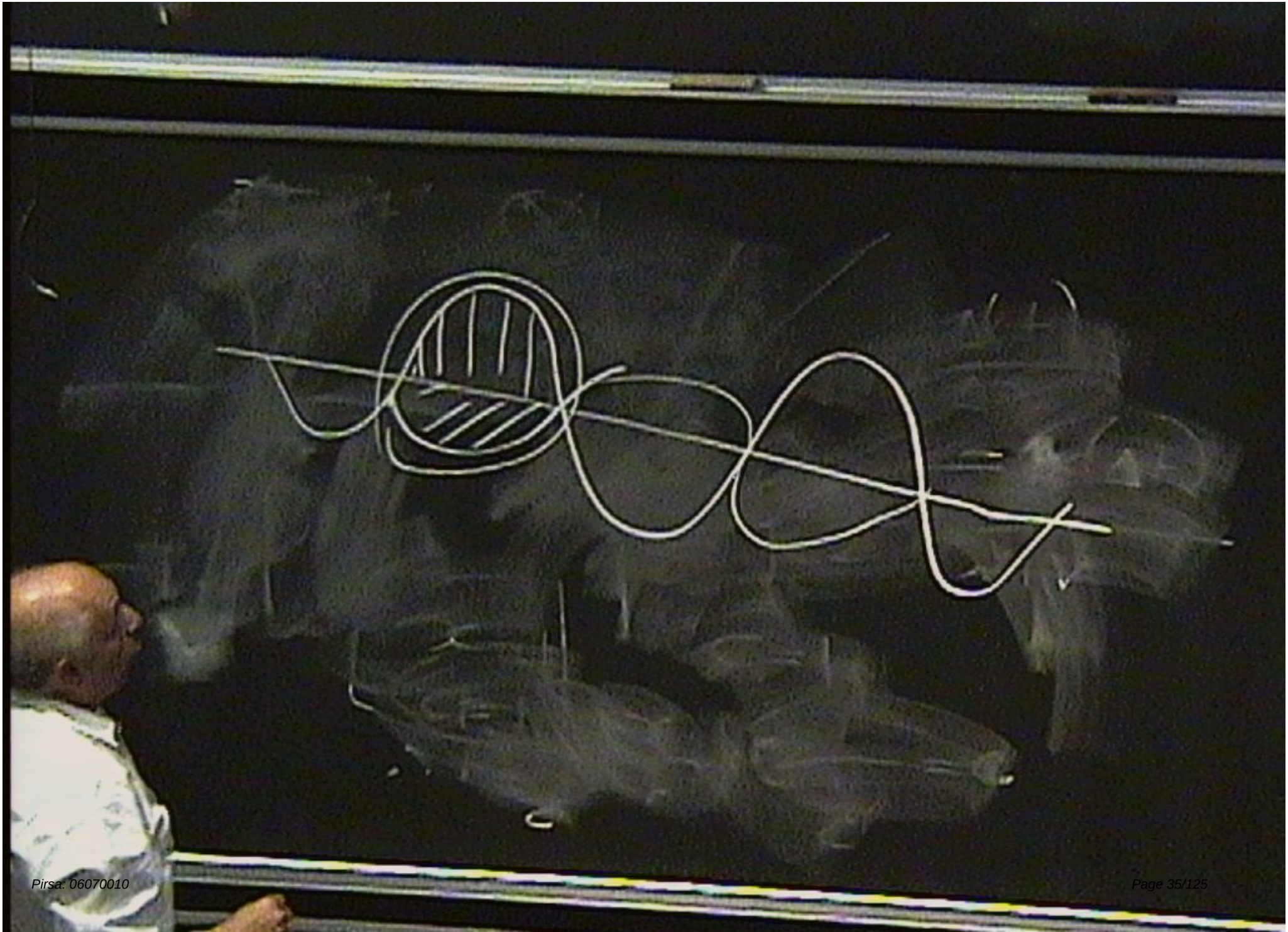
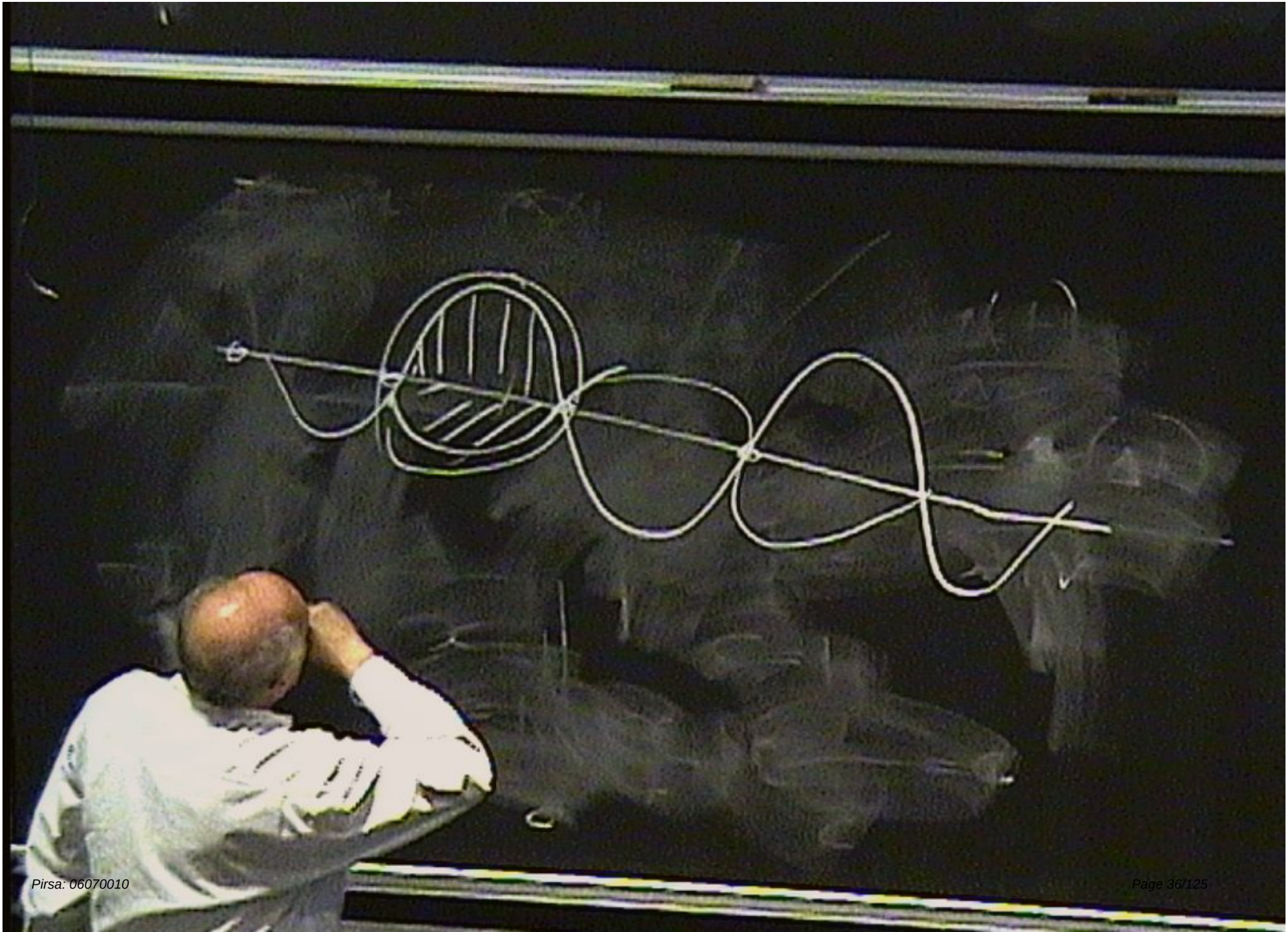
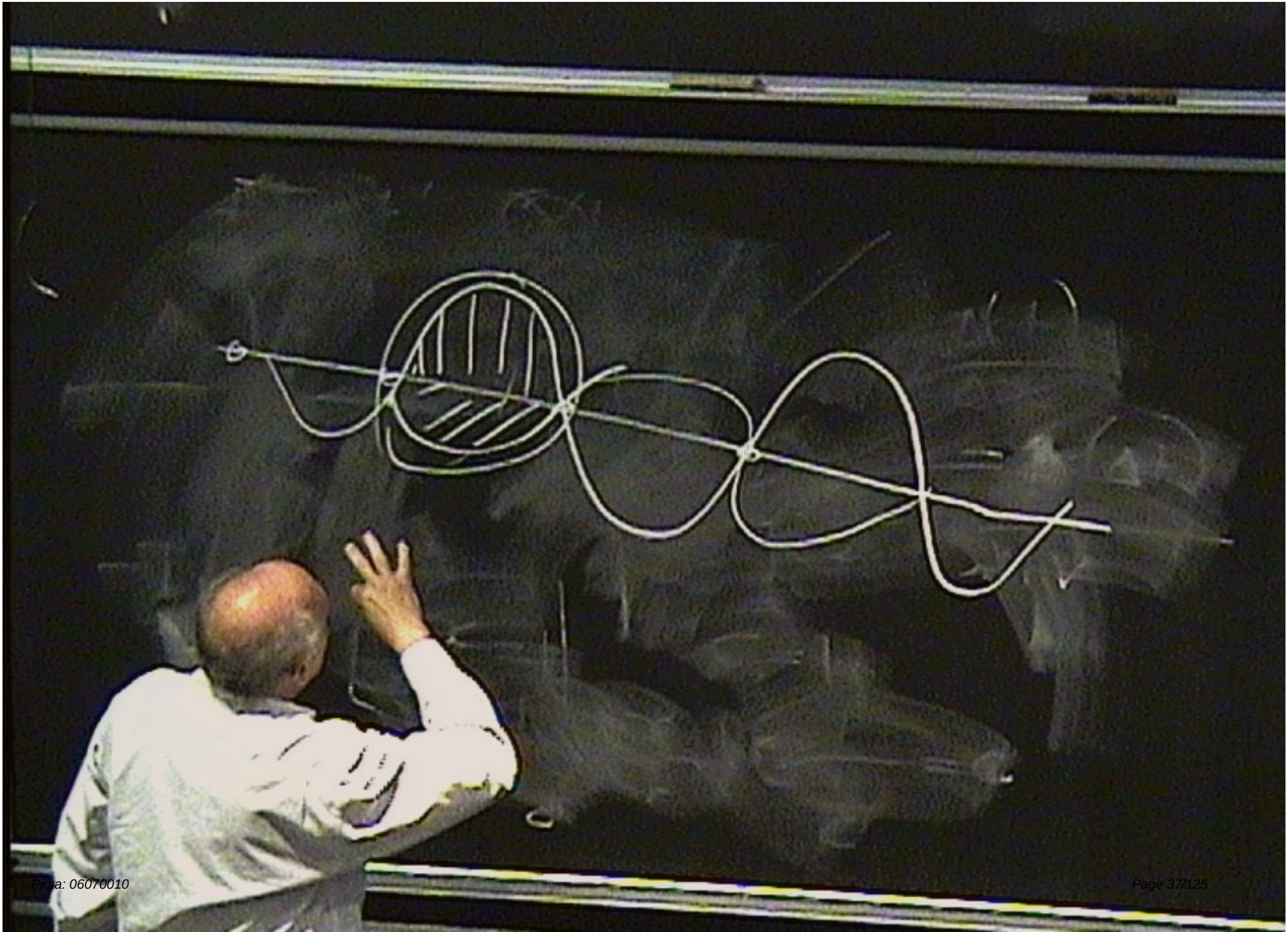


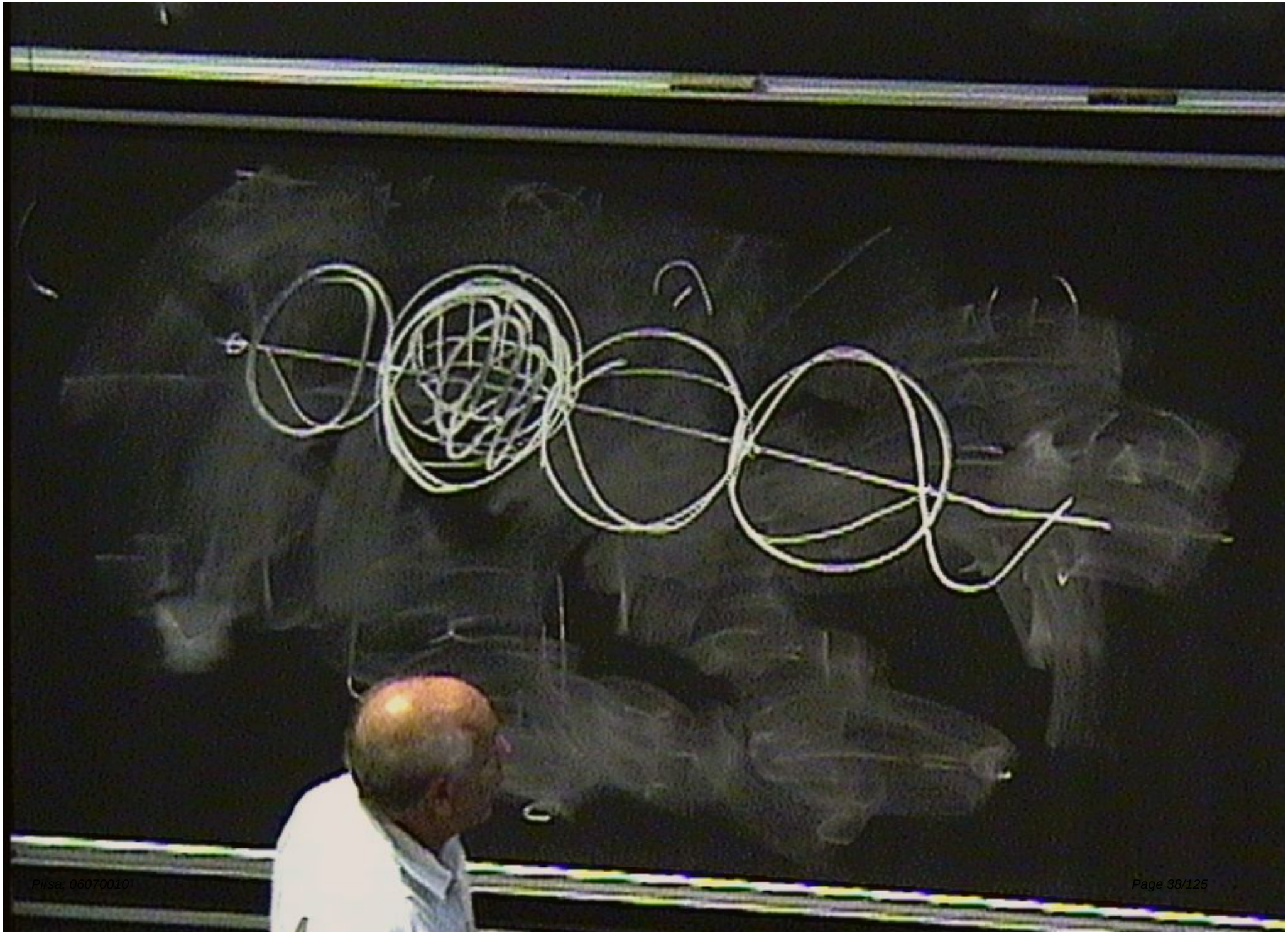








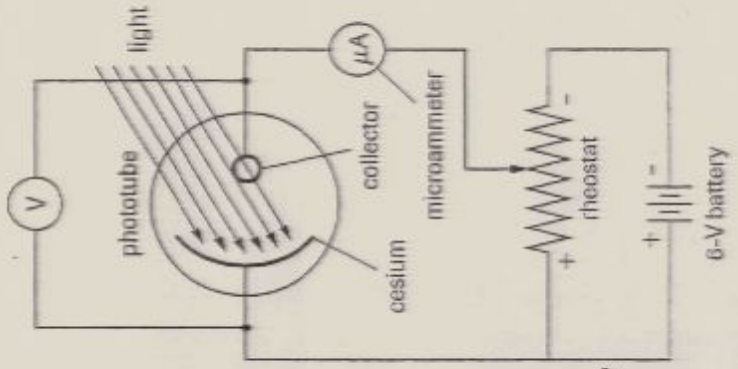




Lab Excercise
Analyzing the Photoelectric Effect

Introduction:

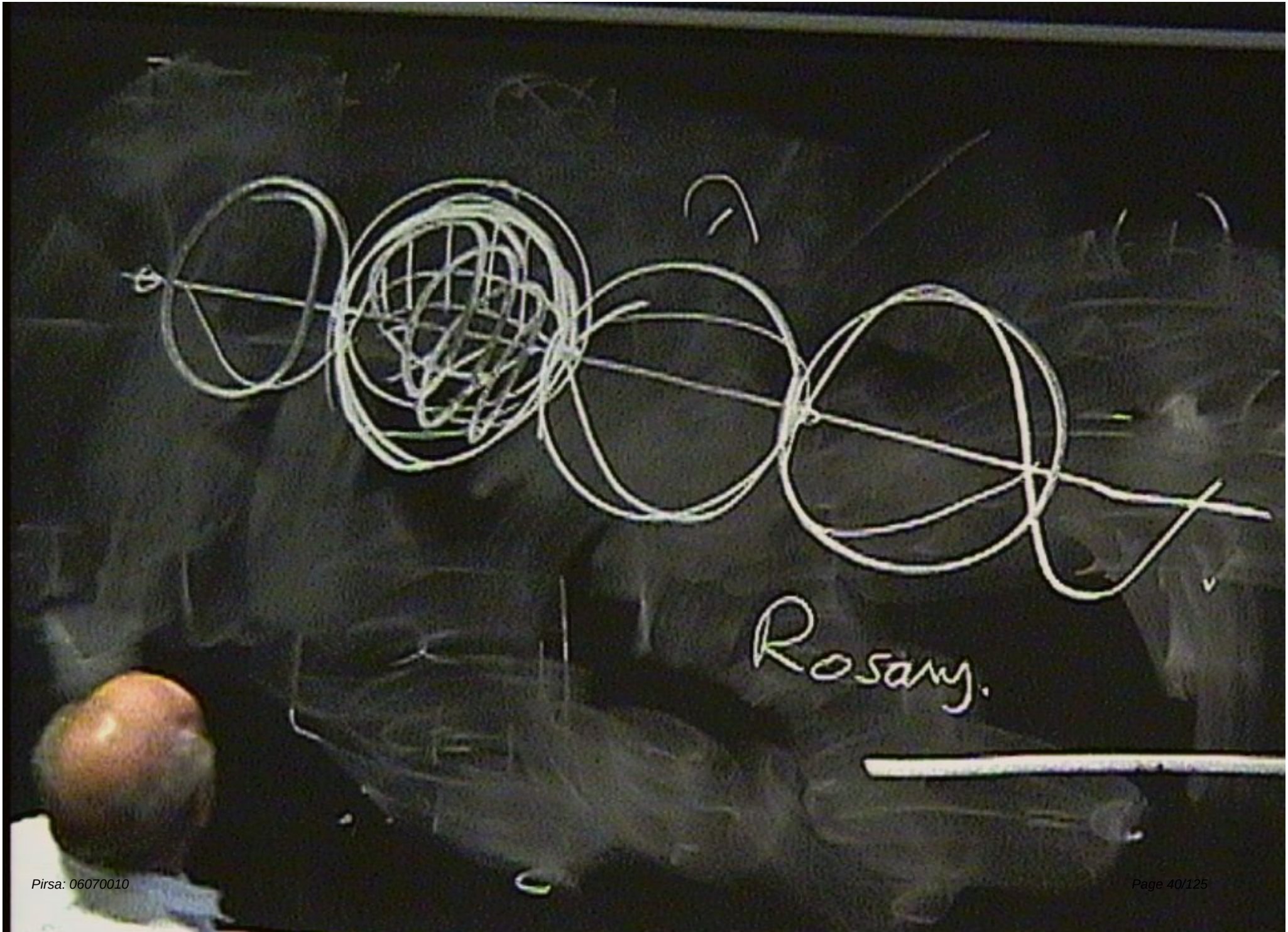
- Since most schools do not have access to a phototube, data from an actual experiment are provided for analysis.
- Working with these data will acquaint the students with most of the important concepts that are required to understand the photoelectric effect and its relationship to the photon theory of light.
- Photoelectric current will flow at any time that light of sufficiently high frequency shines on the photoelectric surface. The effect of the intensity of the shining (incident) light.
- In this lab exercise, the collector will be connected to variable negative potential to impede the current in the tube (retarding potential). The relationship between
- At a sufficiently negative **retarding collector potential V_o (cut off potential),** the photoelectric current will stop altogether. At this point, the reading of this retarding potential difference represents the **maximum possible kinetic energy** of the ejected photoelectrons. If the potential difference is expressed in volts, this kinetic energy of the electrons can be found in joules from the relationship, $E = q V_o$.
- **Planck's constant**. The **discrete energy** of photons. **Einstein's photoelectric equation**.
- The significance of **the intercepts** on the Energy vs Frequency graphs.

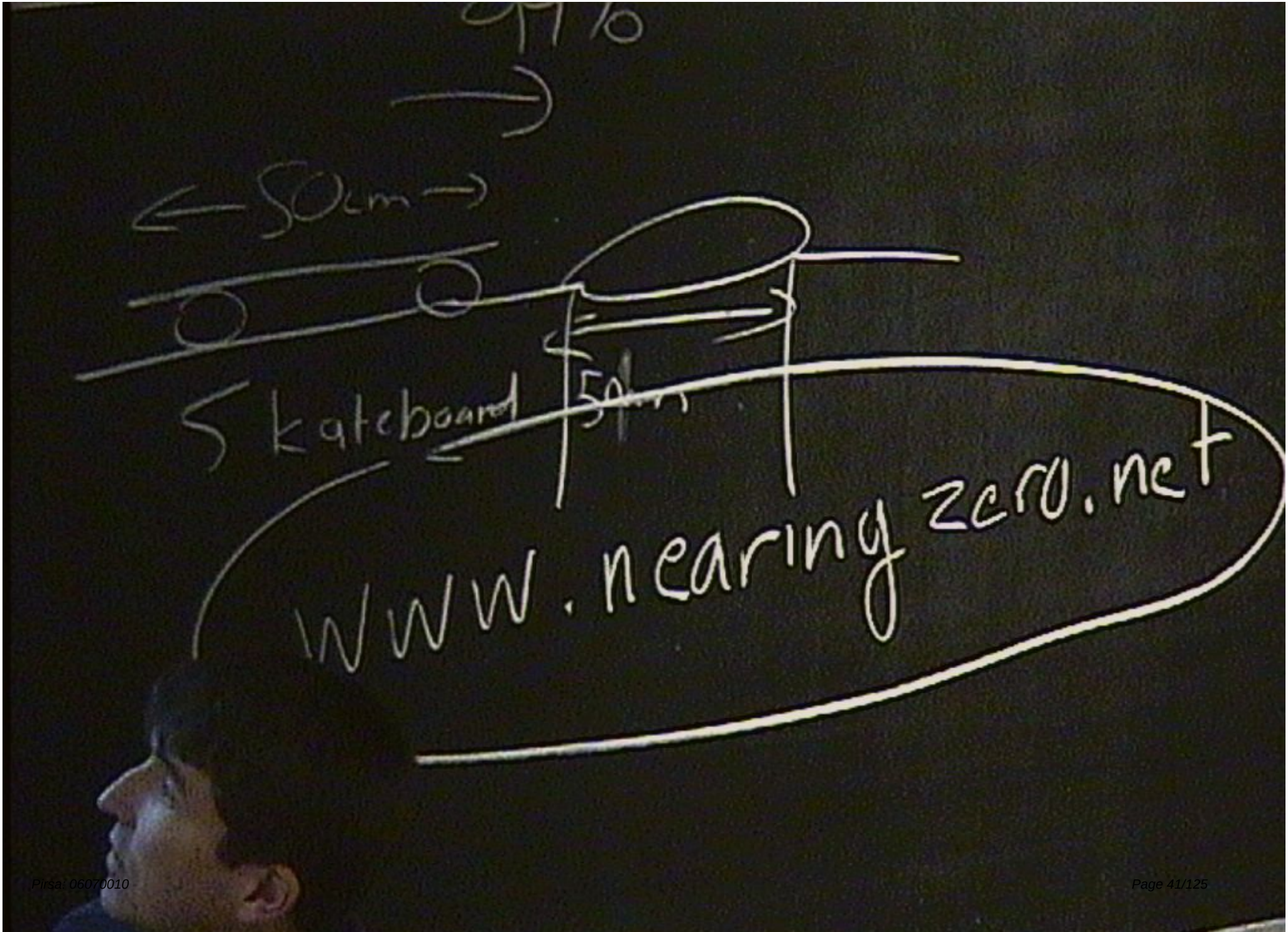


Collected data:

Refer to the observation chart on next page.

Analysis:


Rosary.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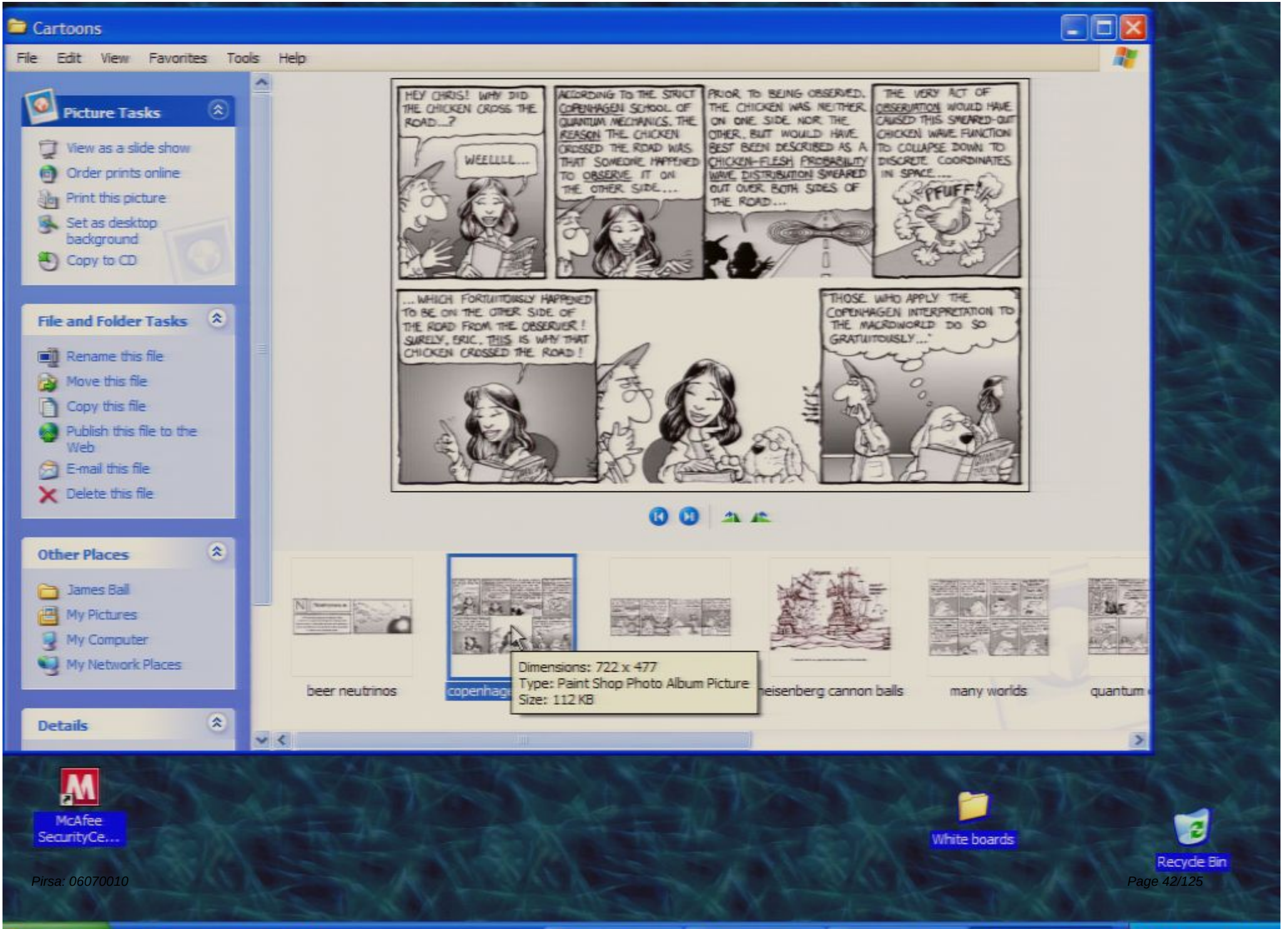
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Copy this file
Publish this file to the Web
E-mail this file
Delete this file
Other Places
James Ball
My Pictures
My Computer
My Network Places
Details
HEY CHRIS! WHY DID THE CHICKEN CROSS THE ROAD...?
WEEEEEE...
ACCORDING TO THE STRICT COPENHAGEN SCHOOL OF QUANTUM MECHANICS, THE REASON THE CHICKEN CROSSED THE ROAD WAS THAT SOMEONE HAPPENED TO OBSERVE IT ON THE OTHER SIDE...
PRIOR TO BEING OBSERVED, THE CHICKEN WAS NEITHER ON ONE SIDE NOR THE OTHER. BUT WOULD HAVE BEST BEEN DESCRIBED AS A CHICKEN-FLESH PROBABILITY WAVE DISTRIBUTION SMEARED OUT OVER BOTH SIDES OF THE ROAD...
THE VERY ACT OF OBSERVATION WOULD HAVE CAUSED THIS SMEARED-OUT CHICKEN WAVE FUNCTION TO COLLAPSE DOWN TO DISCRETE COORDINATES IN SPACE...
PFUFF!
...WHICH FORTUITOUSLY HAPPENED TO BE ON THE OTHER SIDE OF THE ROAD FROM THE OBSERVER! SURELY, ERIC, THIS IS WHY THAT CHICKEN CROSSED THE ROAD!
THOSE WHO APPLY THE COPENHAGEN INTERPRETATION TO THE MACROWORLD DO SO GRATUITOUSLY...
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Type: Paint Shop Photo Album Picture
Size: 112 KB
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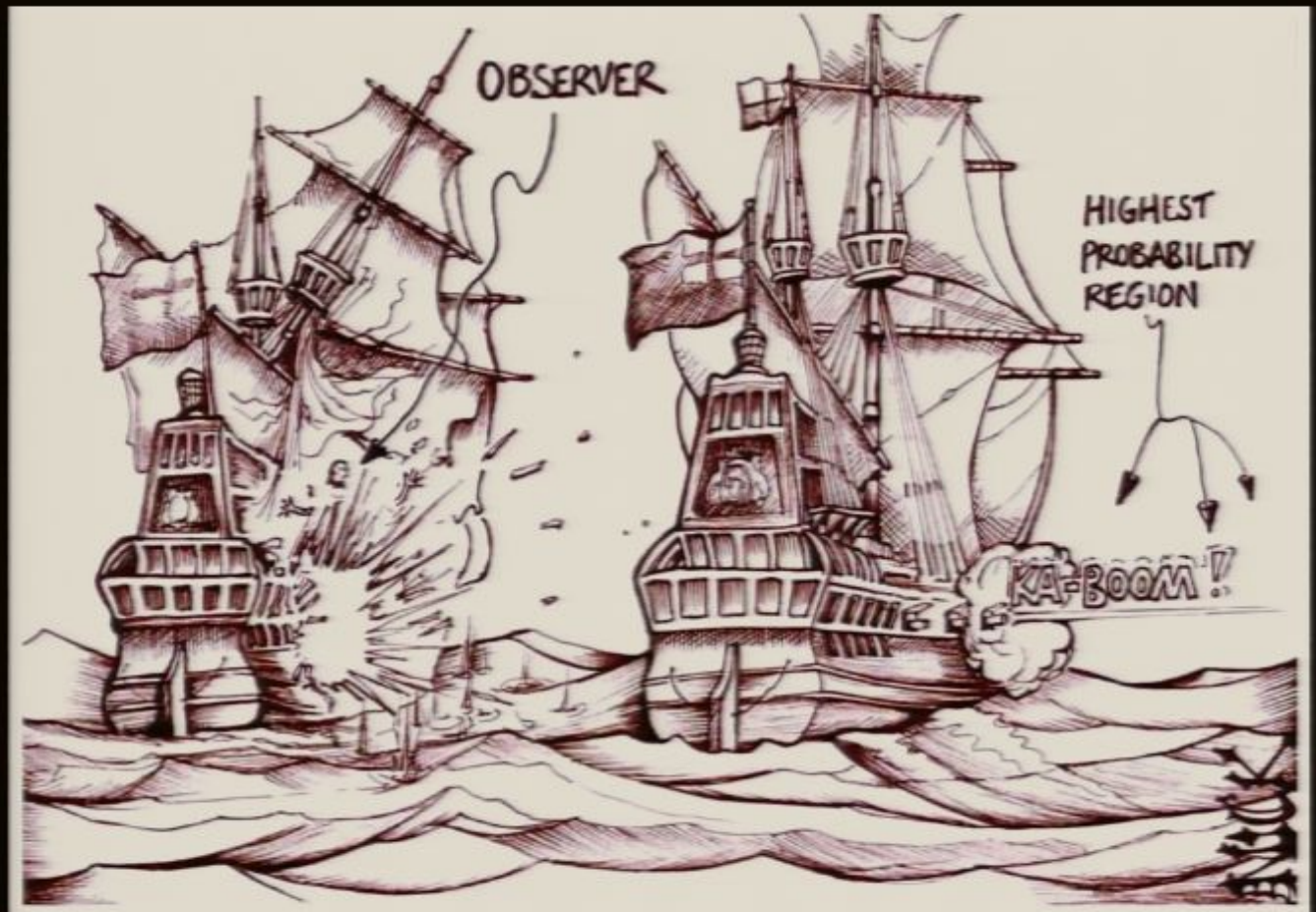
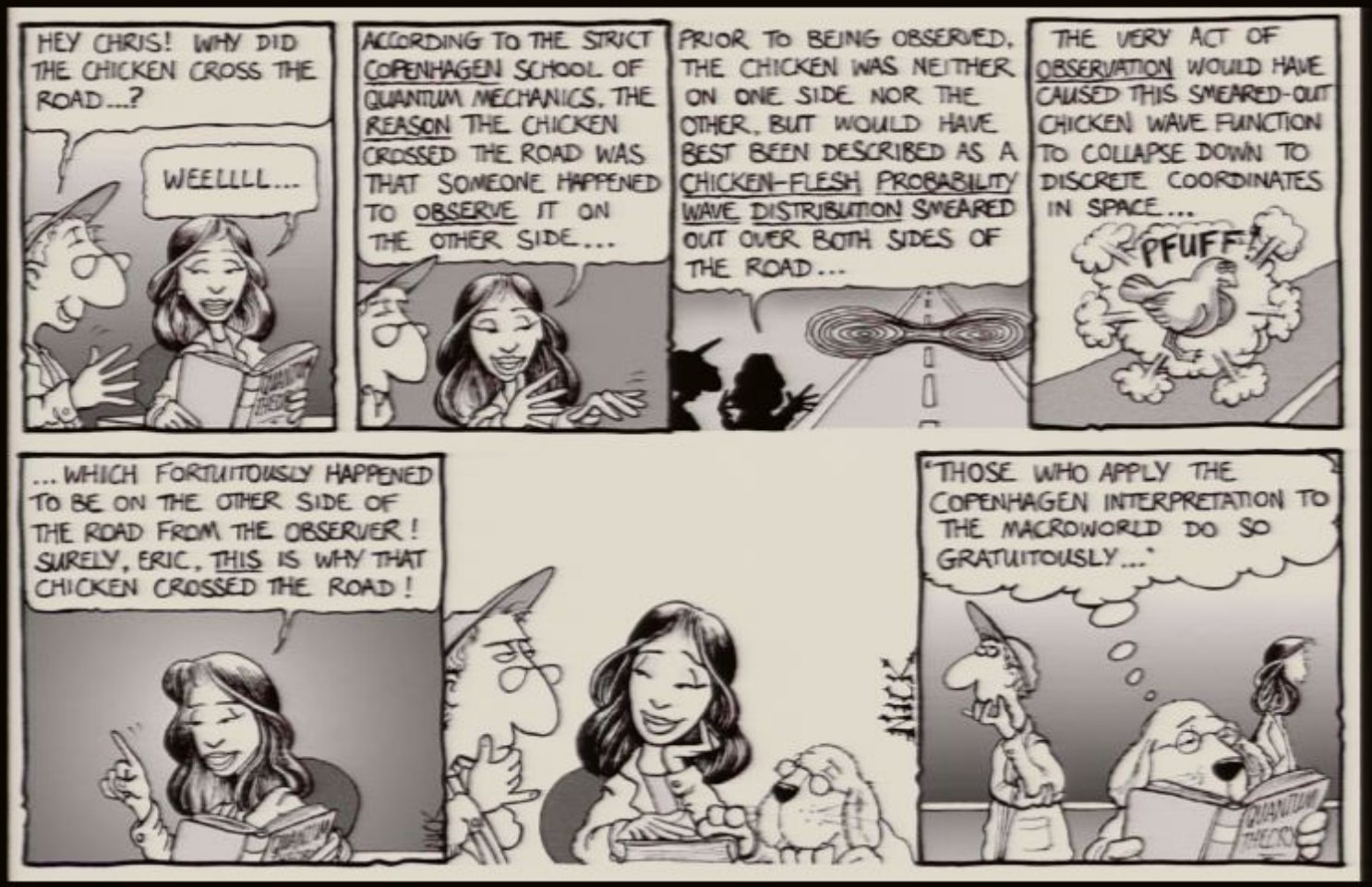
White boards
Recycle Bin



Cannon balls: a quantum mechanical treatment.


HEY CHRIS! WHY DID THE CHICKEN CROSS THE ROAD...?
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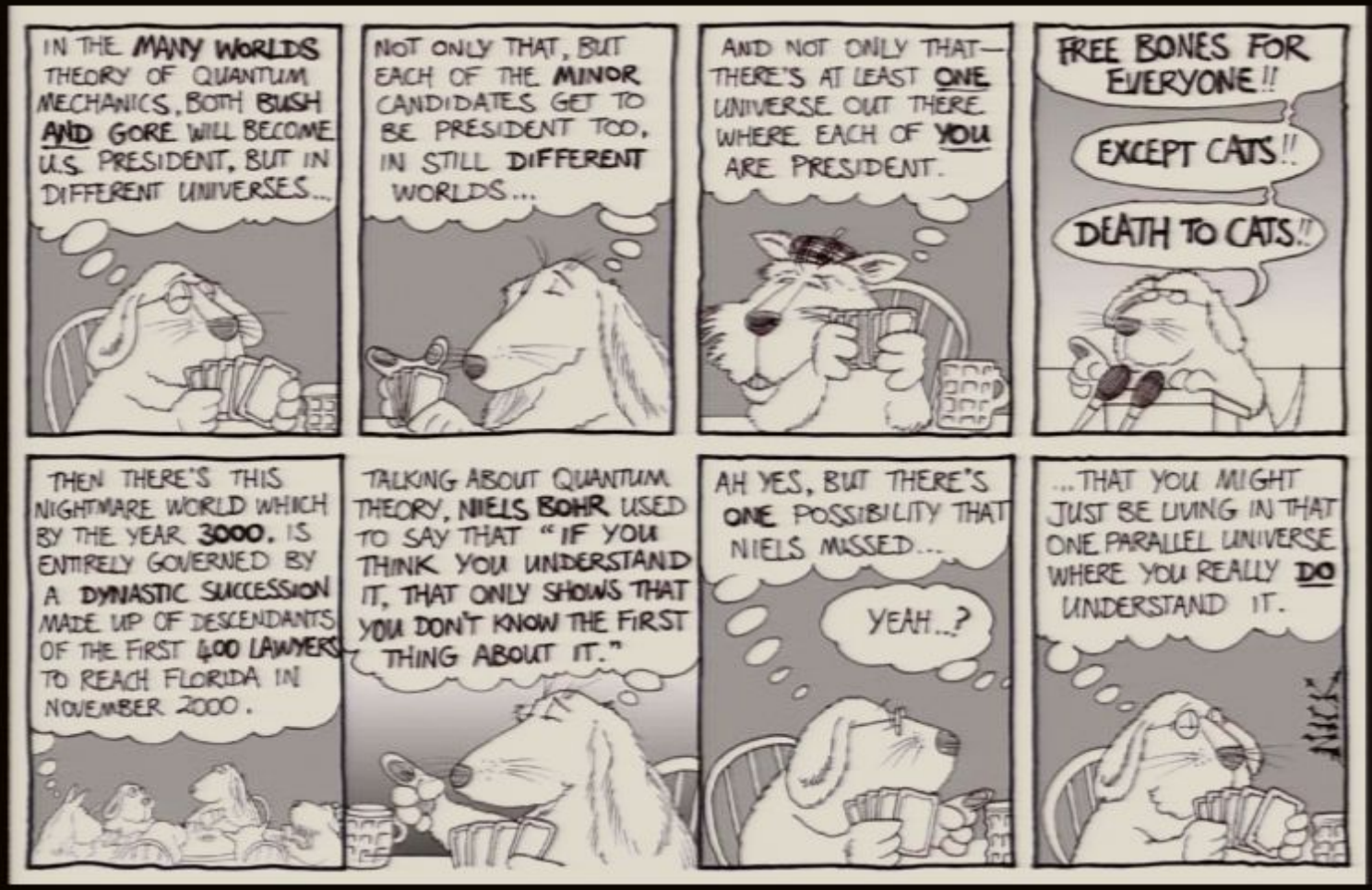
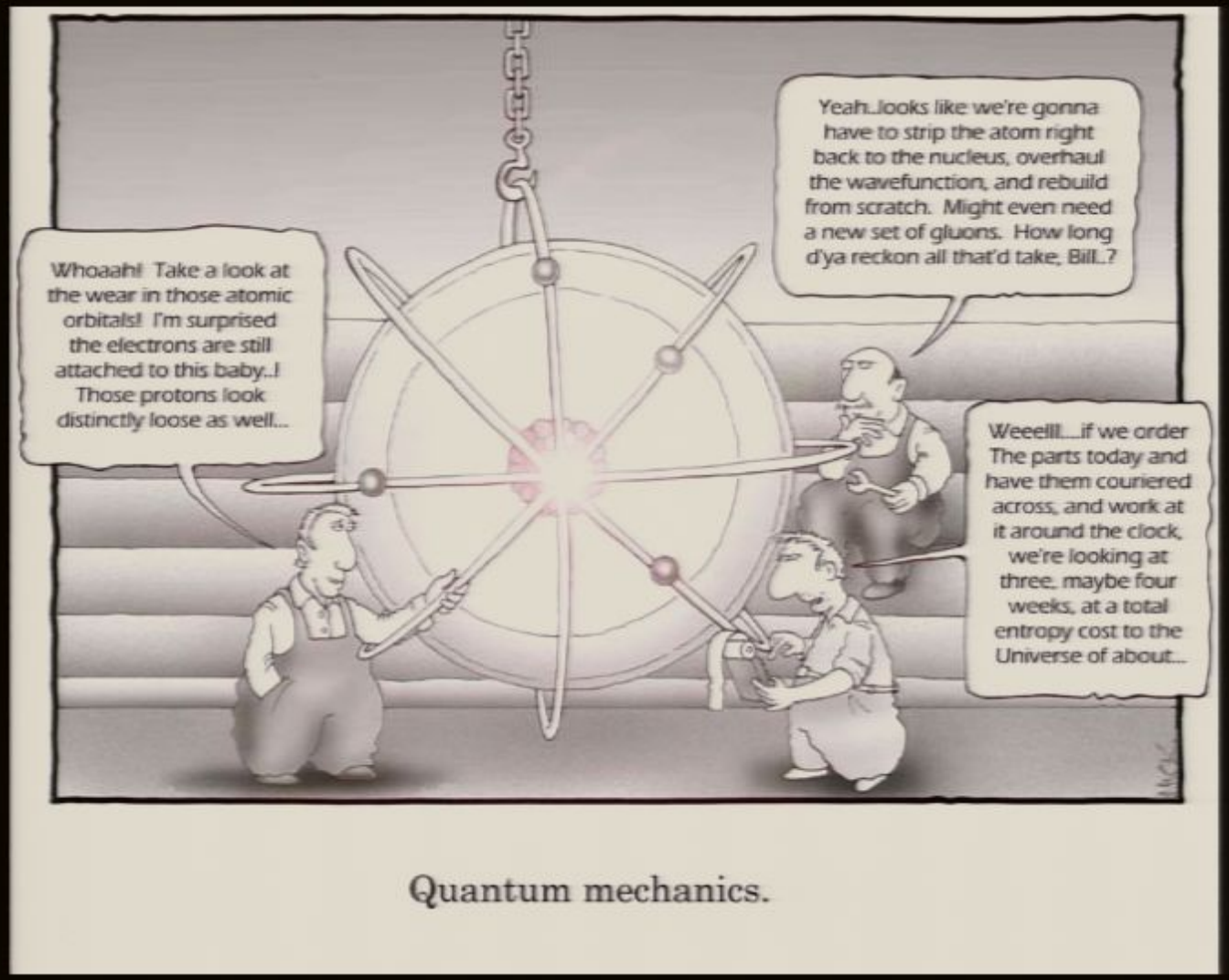
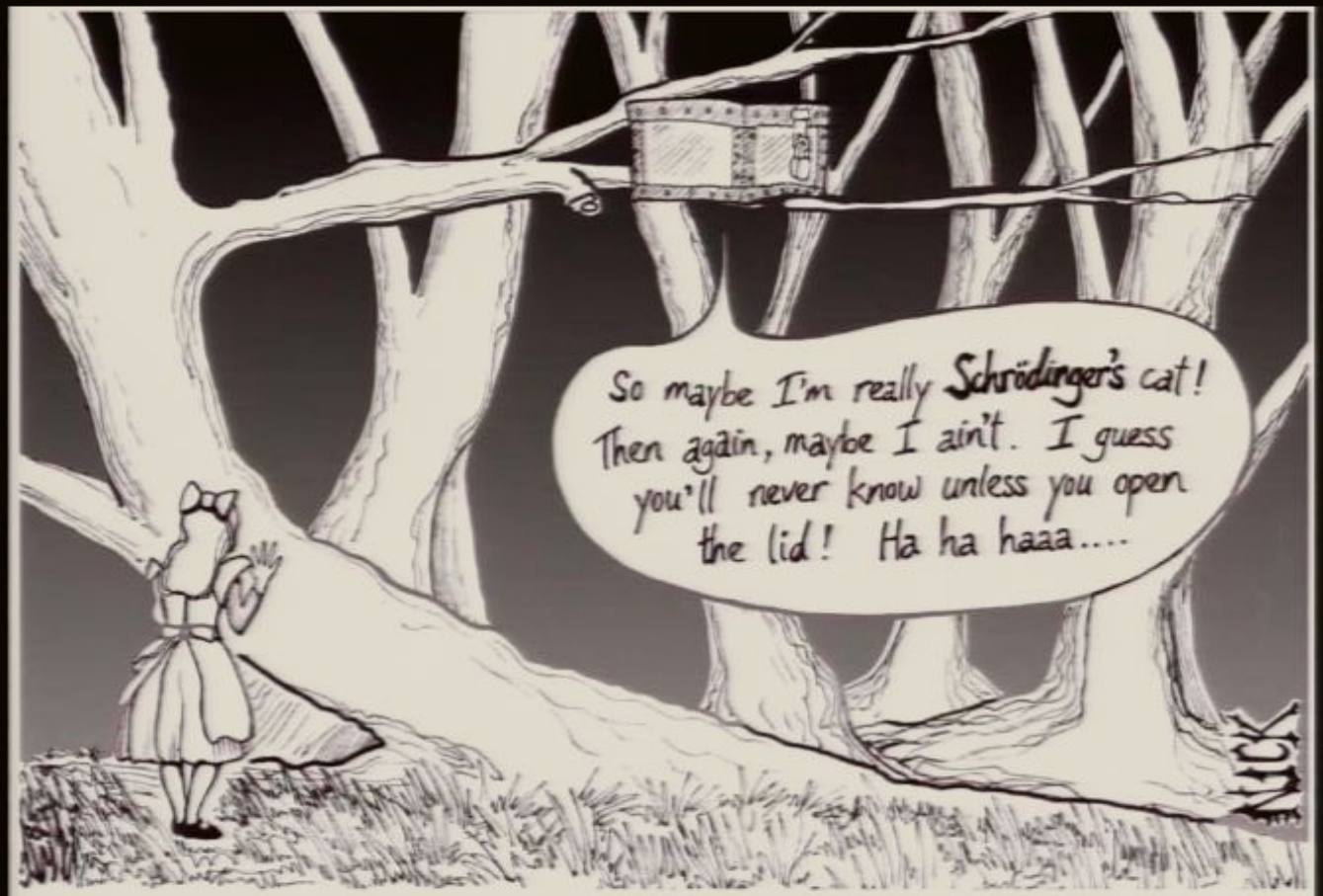
"THOSE WHO APPLY THE COPENHAGEN INTERPRETATION TO THE MACROWORLD DO SO GRATUITOUSLY..."
QUANTUM THEORY


IN THE MANY WORLDS THEORY OF QUANTUM MECHANICS, BOTH BUSH AND GORE WILL BECOME U.S. PRESIDENT, BUT IN DIFFERENT UNIVERSES...
NOT ONLY THAT, BUT EACH OF THE MINOR CANDIDATES GET TO BE PRESIDENT TOO, IN STILL DIFFERENT WORLDS...
AND NOT ONLY THAT— THERE'S AT LEAST ONE UNIVERSE OUT THERE WHERE EACH OF YOU ARE PRESIDENT.
FREE BONES FOR EVERYONE!!
EXCEPT CATS!!
DEATH TO CATS!!
THEN THERE'S THIS NIGHTMARE WORLD WHICH BY THE YEAR 3000. IS ENTIRELY GOVERNED BY A DYNASTIC SUCCESSION MADE UP OF DESCENDANTS OF THE FIRST 400 LAWYERS TO REACH FLORIDA IN NOVEMBER 2000.
TALKING ABOUT QUANTUM THEORY, NIELS BOHR USED TO SAY THAT "IF YOU THINK YOU UNDERSTAND IT, THAT ONLY SHOWS THAT YOU DON'T KNOW THE FIRST THING ABOUT IT."
AH YES, BUT THERE'S ONE POSSIBILITY THAT NIELS MISSED...
YEAH..?
...THAT YOU MIGHT JUST BE LIVING IN THAT ONE PARALLEL UNIVERSE WHERE YOU REALLY DO UNDERSTAND IT.
JOHN

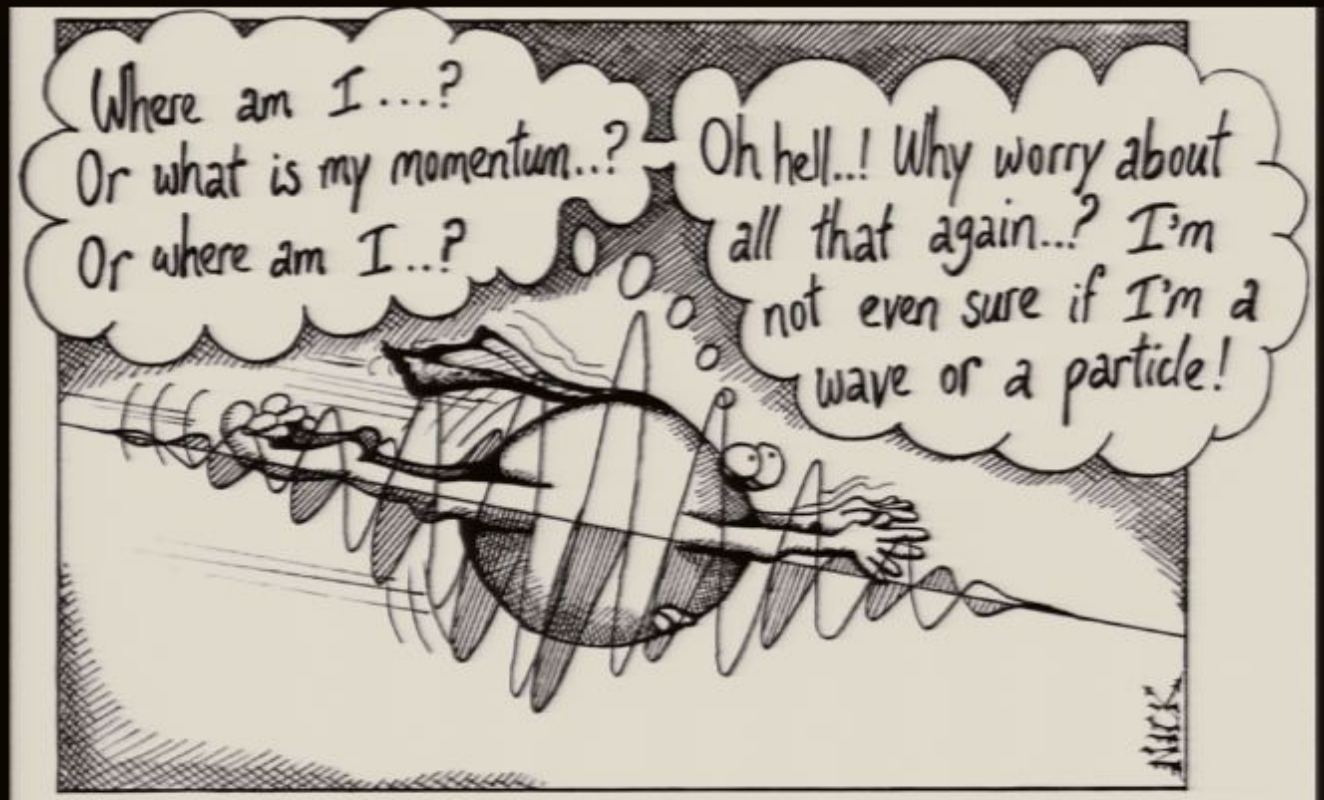


Quantum mechanics.



Alice's Adventures in Wonderland, Chapter VI:
The Cheshire Cat gets Weirder.

At a resolution of 10^{-24} metres, isolated clumps of Strange Matter pop briefly out of the quantum foam to debate the possible existence of Particle Physicists.

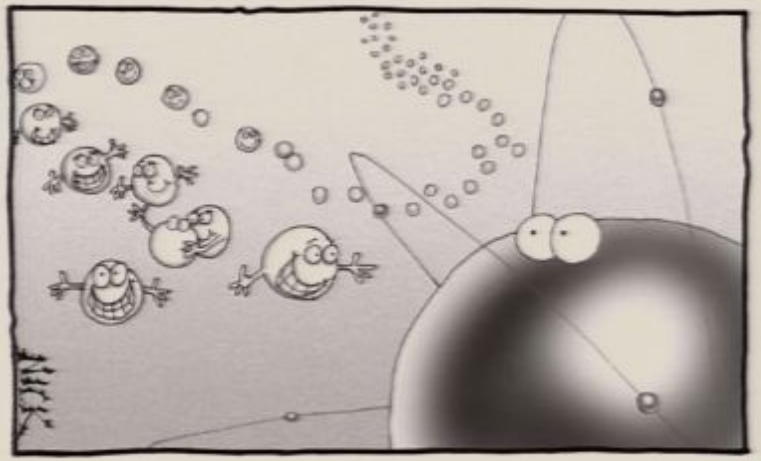


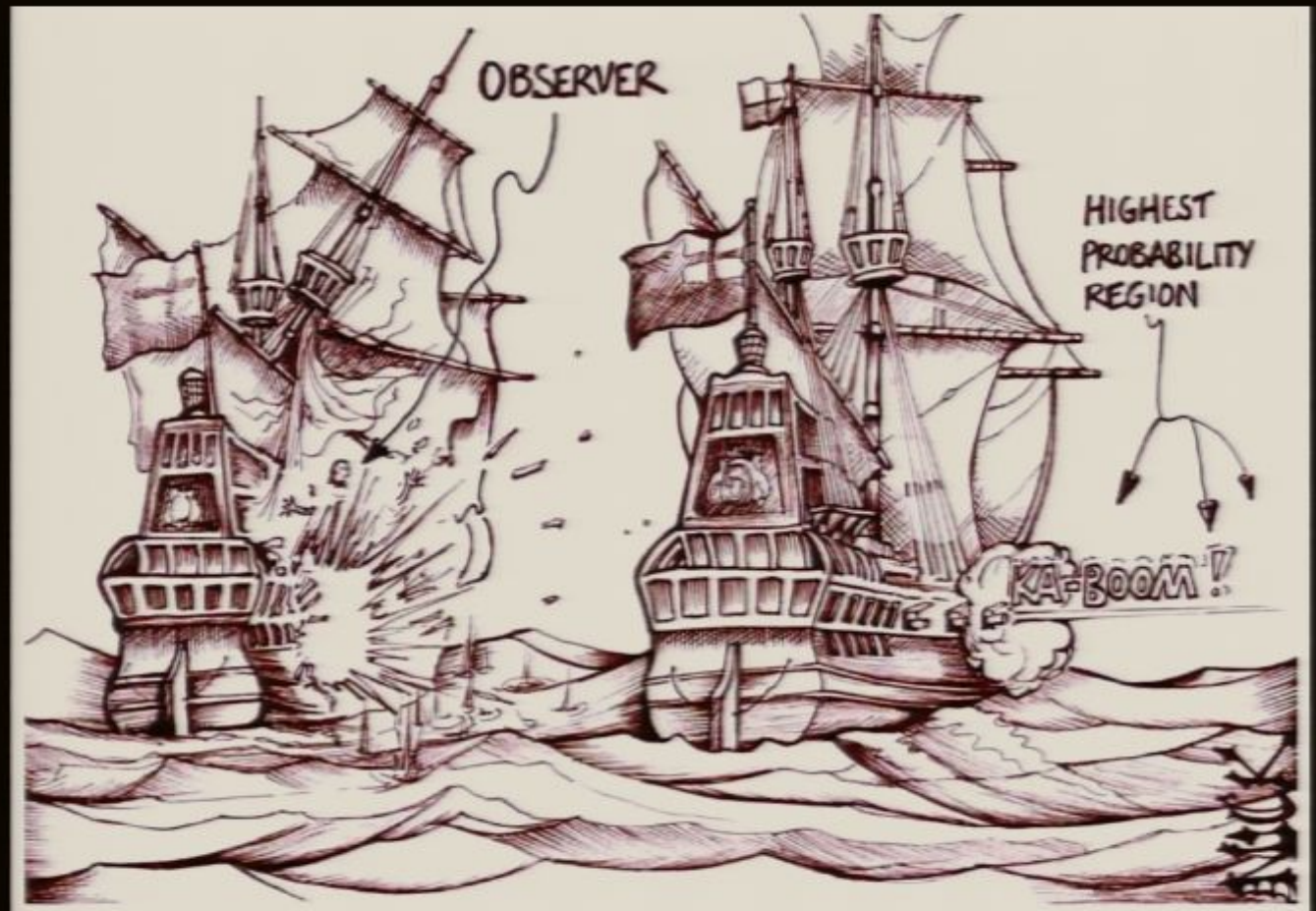
Photon self-identity problems.

N

Neutriyeses, n.

Affectionate particles produced when neutrinos are passed through an underground tank of beer. Unlike the neutrino, the neutriyes can be identified by its indiscriminate attraction to almost any available atom.





Cannon balls: a quantum mechanical treatment.

Movie Physics Project - Microsoft Word

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IB Physics

Movie Physics Project

Special effects are significant in film media such as action-adventure movies, television

Special effects are significant in film media such as action-adventure movies, television, and commercials. There are many things that we see in media that we have never witnessed in our daily lives. However, many people accept that the way that an event occurs in a movie is consistent with how it would occur in the real world.

Here are a few examples:

- When a bullet strikes a hard surface it creates a spark.
- Cars explode in most collisions or roll-overs.
- A car will always explode after falling off a cliff, (usually before striking the ground).
- A hand-held automatic weapon can fire continuously for up to a minute.
- A person can survive crashing through plate-glass window or extremely long fall so long as the motion ends with a shoulder roll.
- A person struck by a bullet will fly across a room. (Typically crashing through plate-glass windows.)
- A person encountering a long freefall can safely come to rest by grabbing onto a tree branch.
- Anything placed on the end of a handgun, (a towel, pillow, empty plastic pop bottle, etc.), will reduce the sound of the explosion to a gentle "pud".

Movie Physics Project - Microsoft Word

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The purpose of this project is to examine the validity of a movie scene from a physics standpoint. In groups of **two** you will select one scene from a movie, T.V. show or a commercial. Choose a scene that looks **plausible**. Do not choose a scene that involves people flying, floating in mid-air, or rising upward due to some psychic or supernatural power.

Your project will be assessed on the following criteria:

1. A written report that includes:
   - A **problem statement** that addresses the questionable physics of the scene.
   - A **prediction** of what should happen based on physics principles.
   - A **procedure** describing how you will investigate the difference between what was observed and what should have happened.
   - An **evidence** section summarizing the data collected.
   - An **analysis** of the data.
   - An **evaluation** of the correctness of the scene. Include estimations that you made and experimental uncertainties.

2. A 6-minute oral presentation that includes:
   - An overview of the scene.
   - A statement of your investigation question.
   - A brief description of how you investigated the question.
   - Your findings.

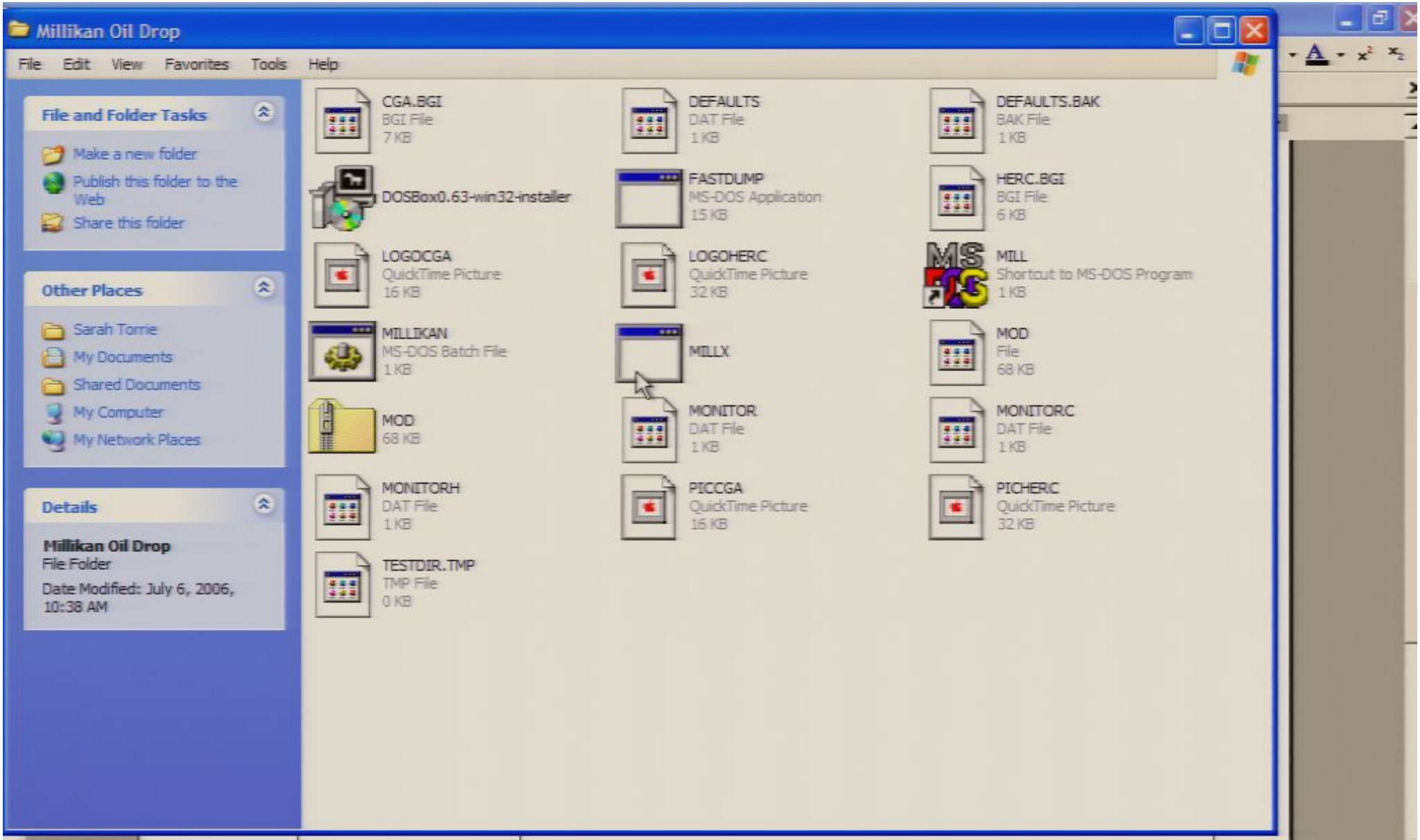

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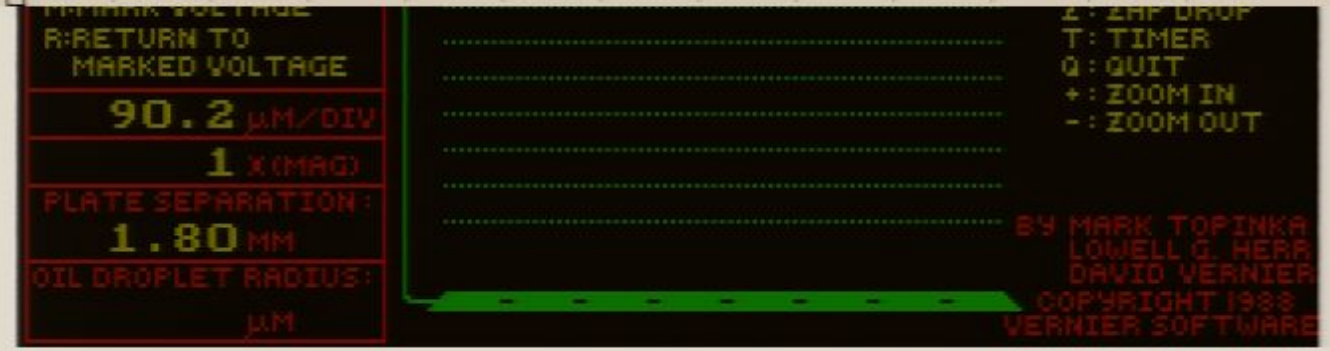
Table 1: Oil Drop Data Table

Drop #	Stopping Voltage (Volts)	# of Divisions travelled in 4 seconds		Drop #	Stopping Voltage (Volts)	# of Divisions travelled in 4 seconds
1	154	9		8	315	10
	180	9			252	10
	539	9			210	10
	216	9			252	10
	270	9			210	10
2	539	9.1		9	405	9.8
3	1091	9.1			202	9.8
4	261	8.8			152	9.8
	149	8.8			243	9.8
5	132	7.3		10	817	7.5
	267	7.3			204	7.5
6	728	11			163	7.5
7	884	7.9			136	7.5
	221	7.9			102	7.5



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Members of the OAPT prepare to go 2100 m underground to visit the Sudbury Neutrino Observatory at the 2005 conference.

Major Programs

- Grade 11 High School Exam written by 3500 students in May.
- Photography Contest for high school students.
- Conference in May for teachers.
- Quarterly Newsletter.

What's New

Conference 2006

Perimeter Institute

Innovative Teaching Strategies for Modern Physics

Authentic Inquiry

25 - 27 May 2006

- Workshops
- Outstanding speakers
- Tours
- Rejuvenation

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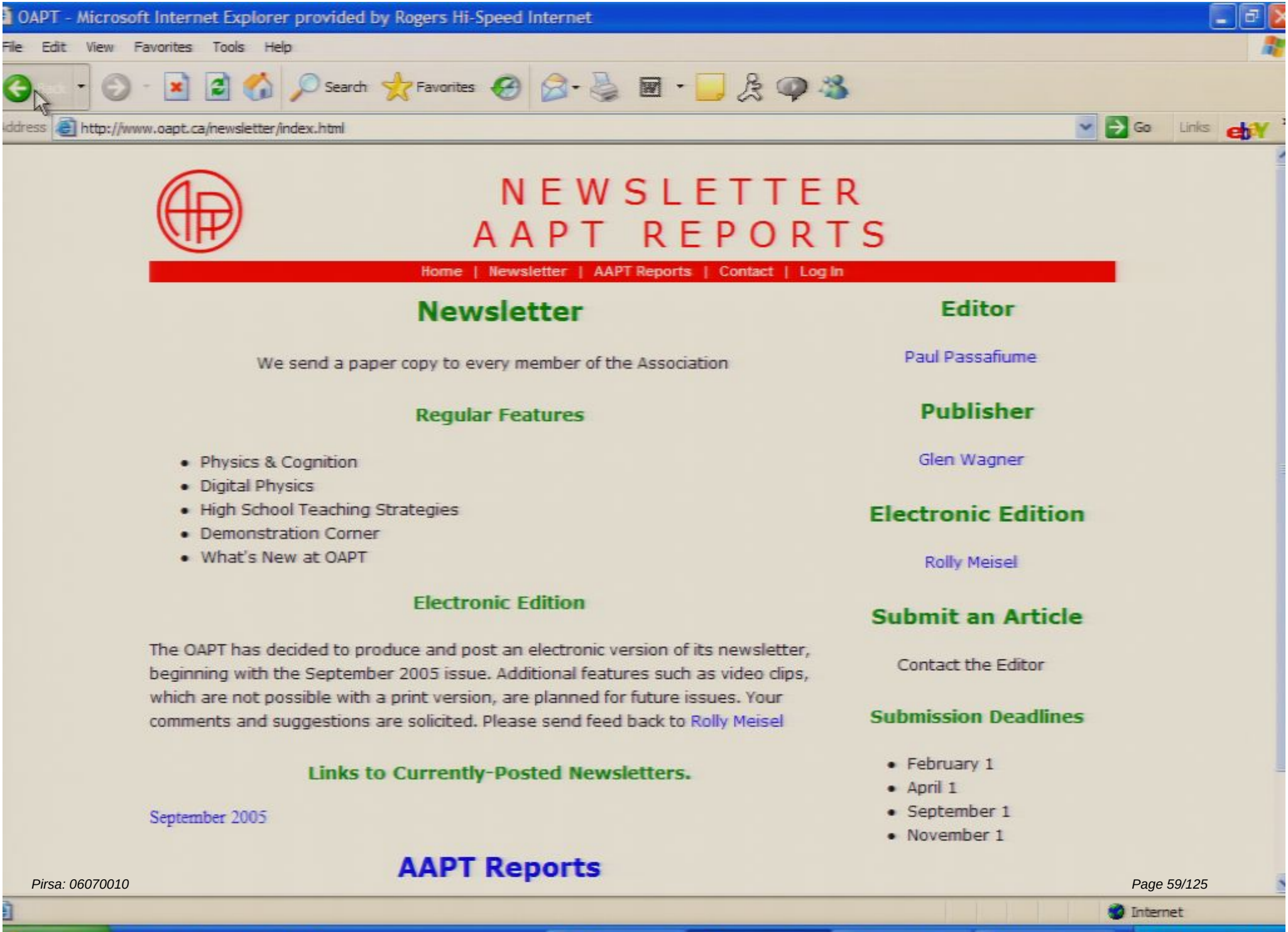
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Demonstration Corner
What's New at OAPT
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The OAPT has decided to produce and post an electronic version of its newsletter, beginning with the September 2005 issue. Additional features such as video clips, which are not possible with a print version, are planned for future issues. Your comments and suggestions are solicited. Please send feed back to Rolly Meisel
Links to Currently-Posted Newsletters.
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PHOTOGRAPHY CONTEST

Sponsored by A.J. Hirsch

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Who can Participate?

- Any student enrolled in a day school Grade 12 physics course in Ontario in the 2005 - 2006 school year.
- One category for those registered in SPH4U (university).

Internet

Teaching Modern Physics using Eric Mazur's Peer Instruction

Mazur's Peer Tutoring Method?

A) I have never heard of it.

B) I have heard of it but not used it.

C) I have used it a little bit.

D) I use it frequently.

Eric Mazur is a physics professor at Harvard who studied why his students hadn't learnt the material after he had explained it all so clearly.

Eric Mazur is a physics professor at Harvard who studied why his students hadn't learnt the material after he had explained it all so clearly.

Most students do not learn physics by listening.

Students learn physics by being actively involved.

Concept questions can be used to get the students actively involved even in huge lecture halls

Concept questions can be used to test what students know at the start or during the lesson.

His research showed that students did much better on concept problems

and

on standard calculation problems after he started using peer instruction with concept questions.

The Polarization of Photons

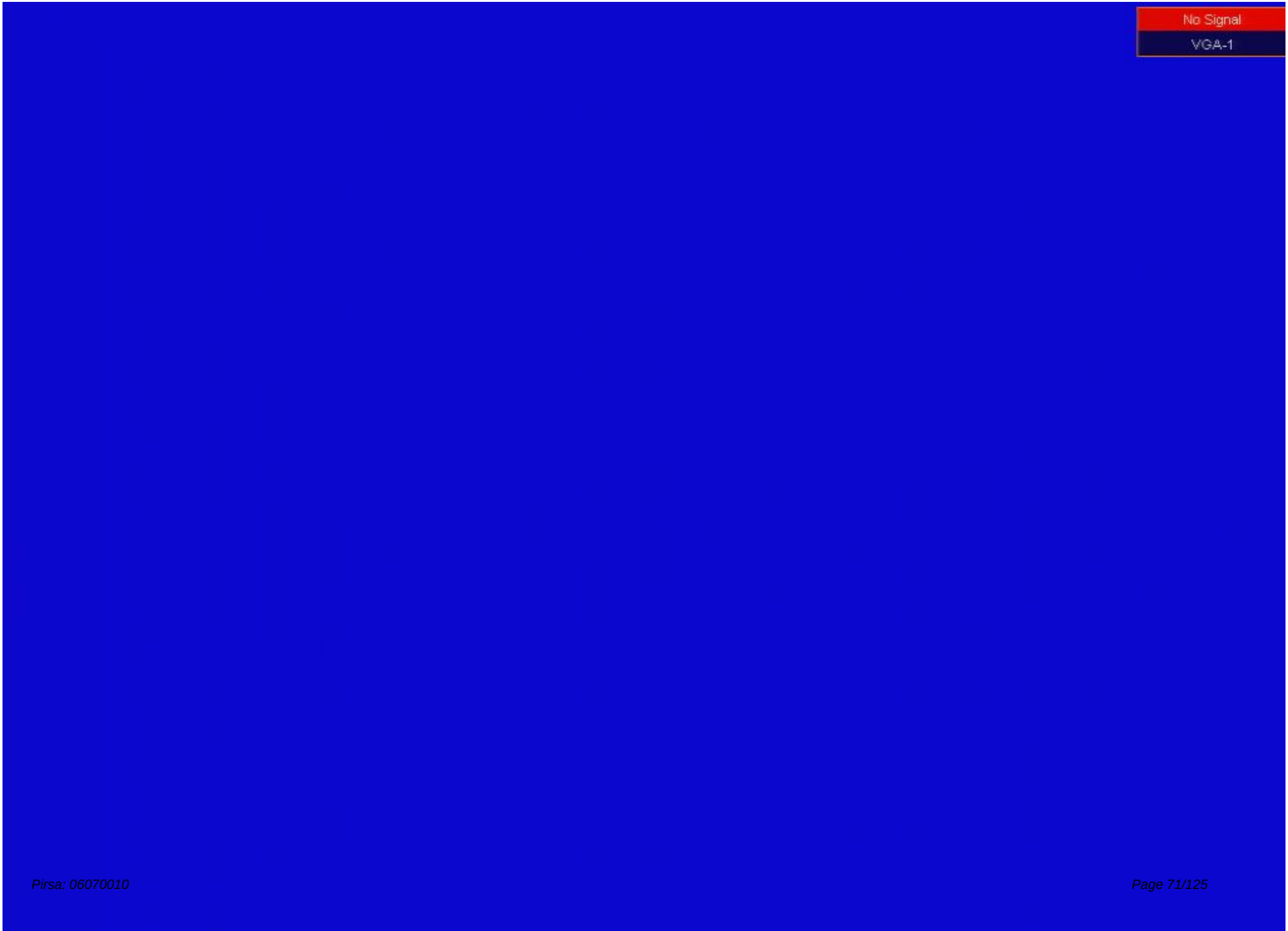
Unpolarized light is shone through a polarizing filter. Through the filter you will get

A) all the light

B) light with 1/2 the intensity

C) light with 1/2 the frequency

D) nothing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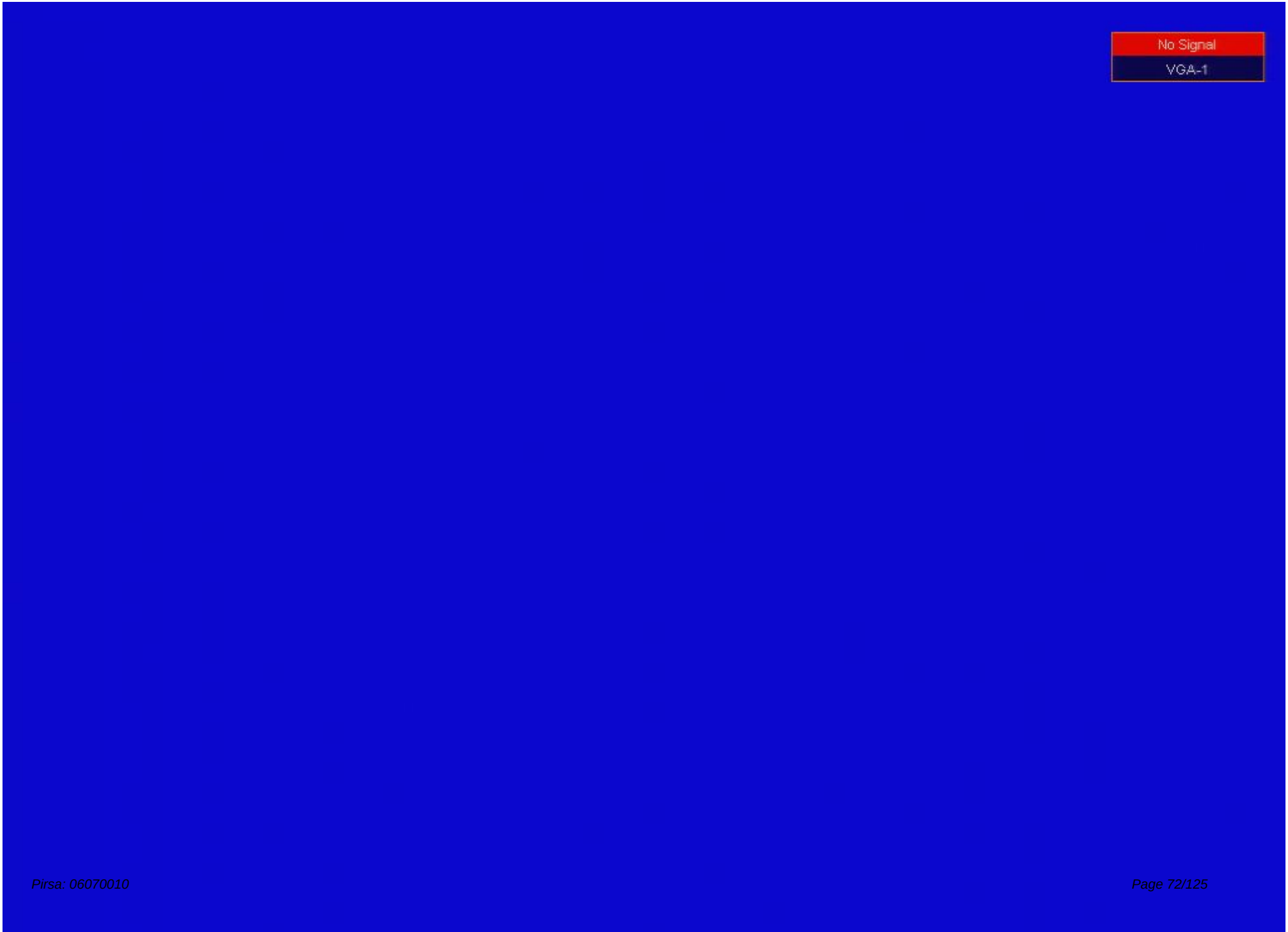
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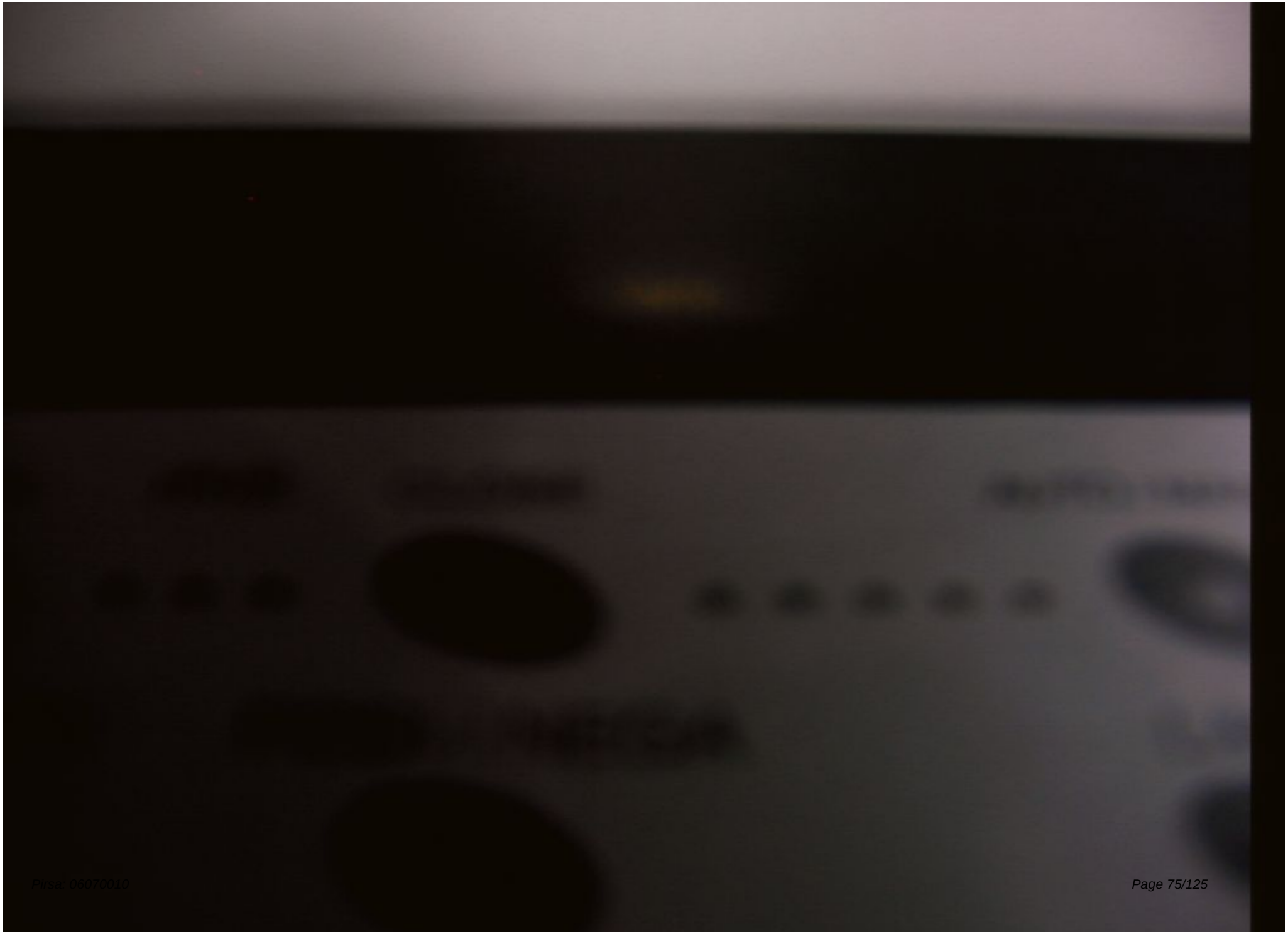


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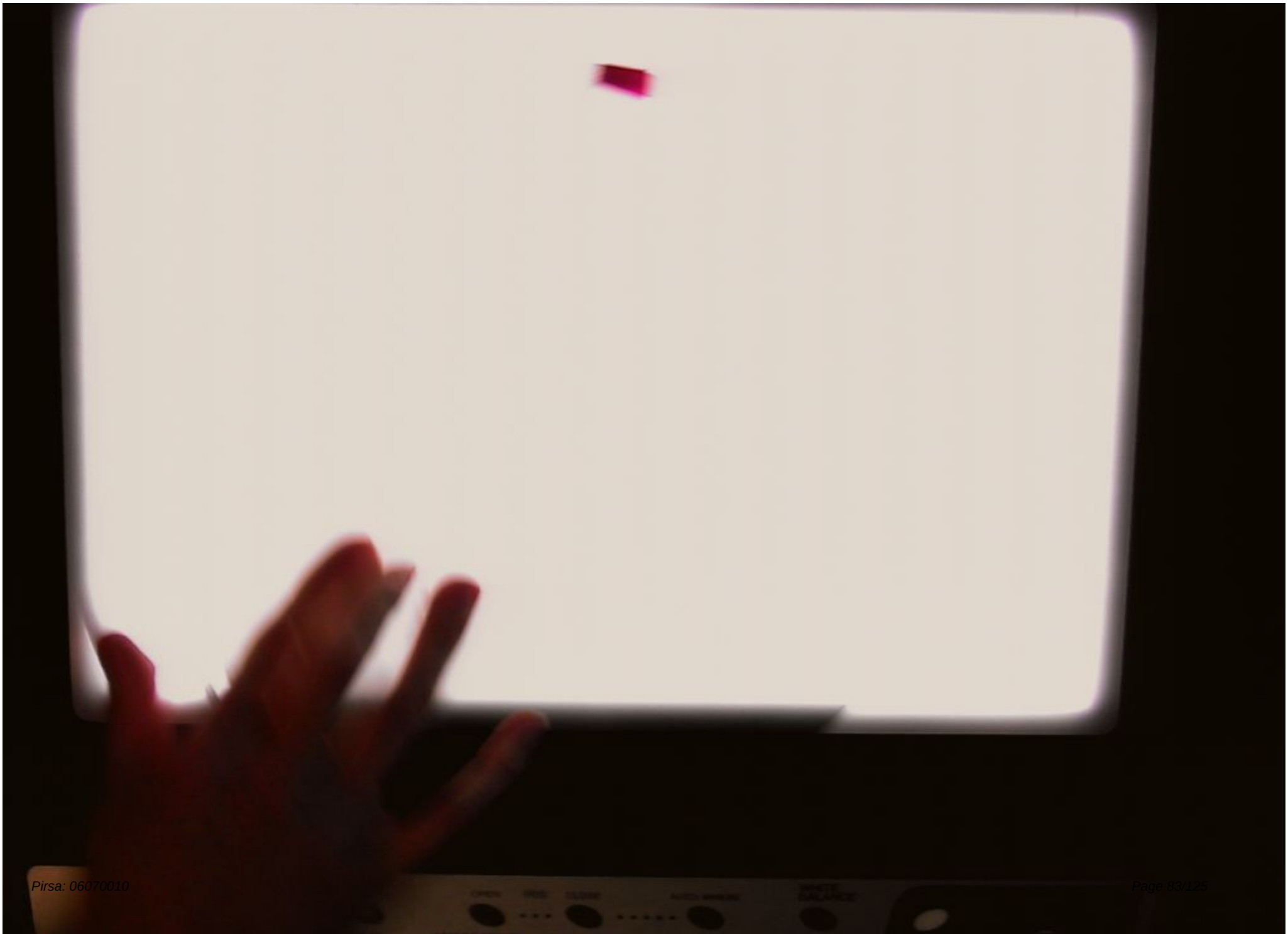

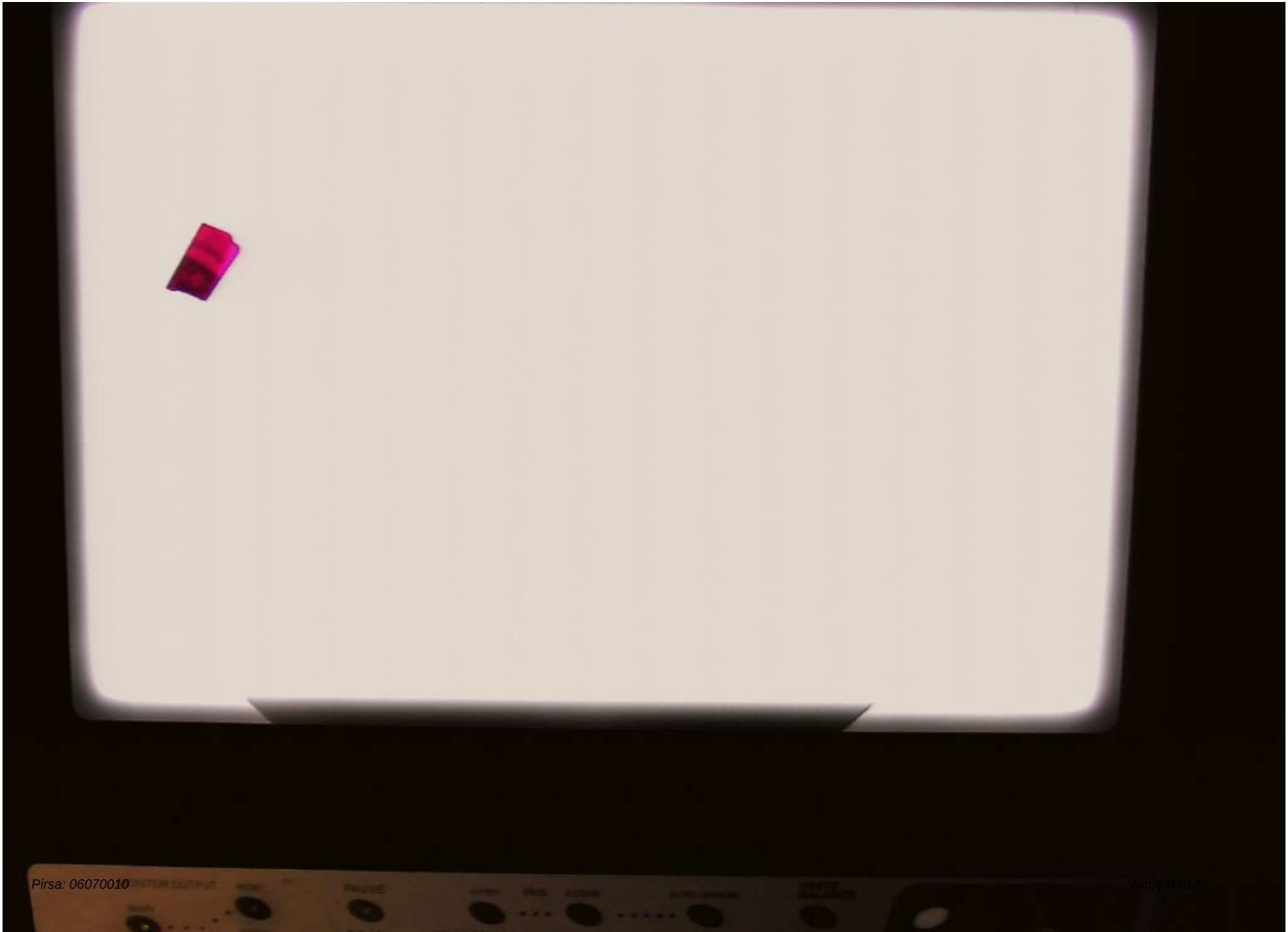

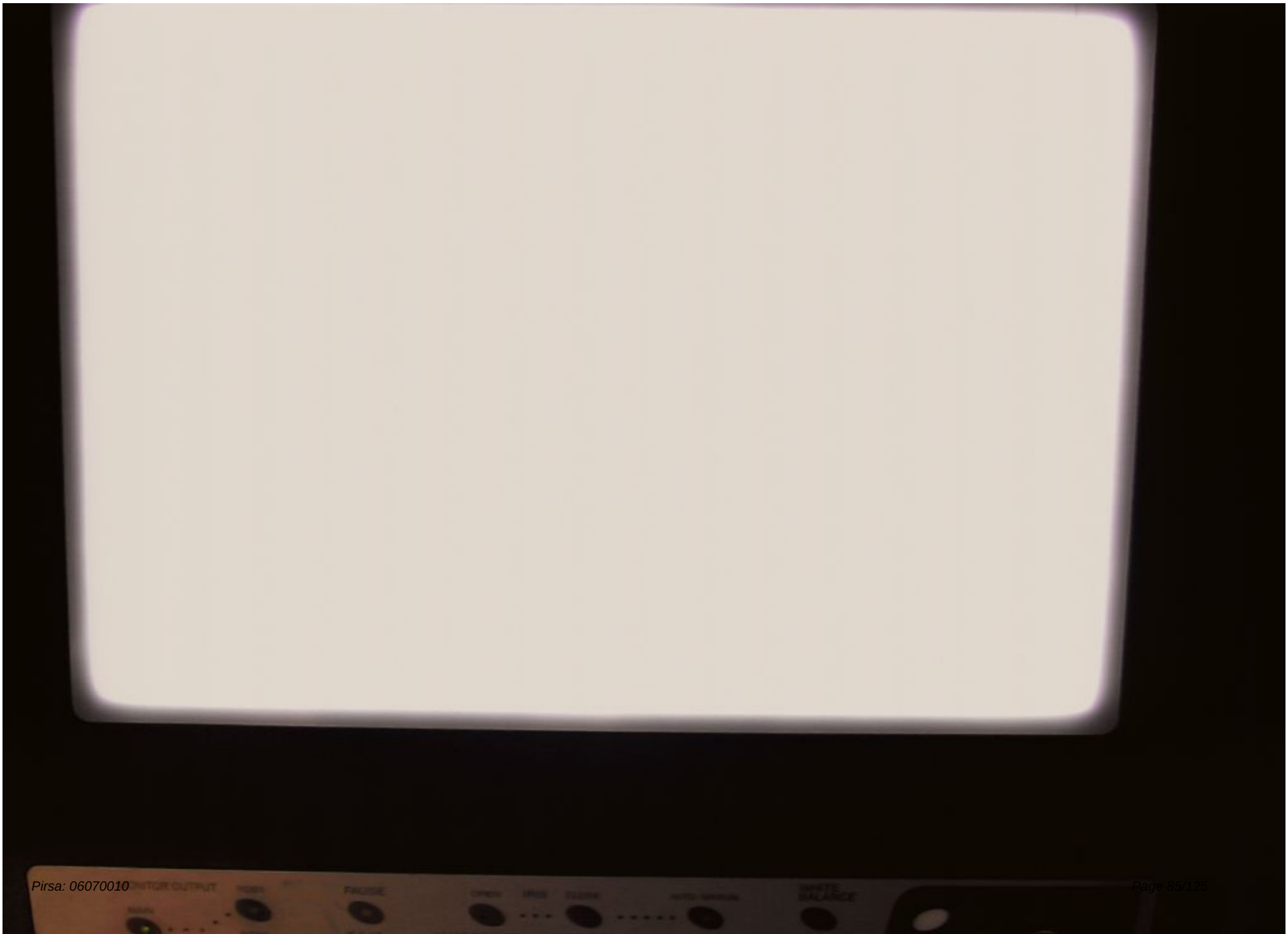
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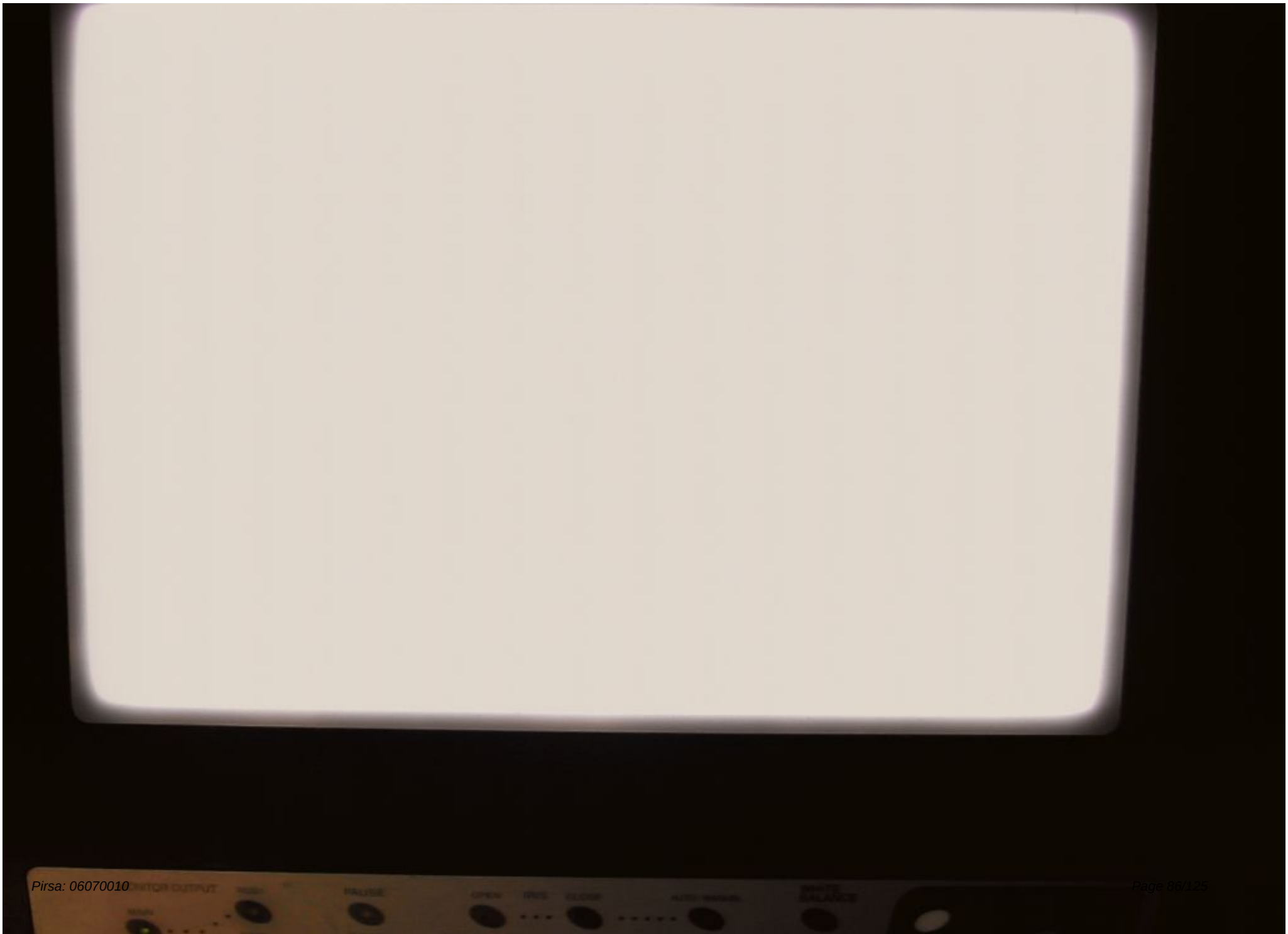
WHITE BALANCE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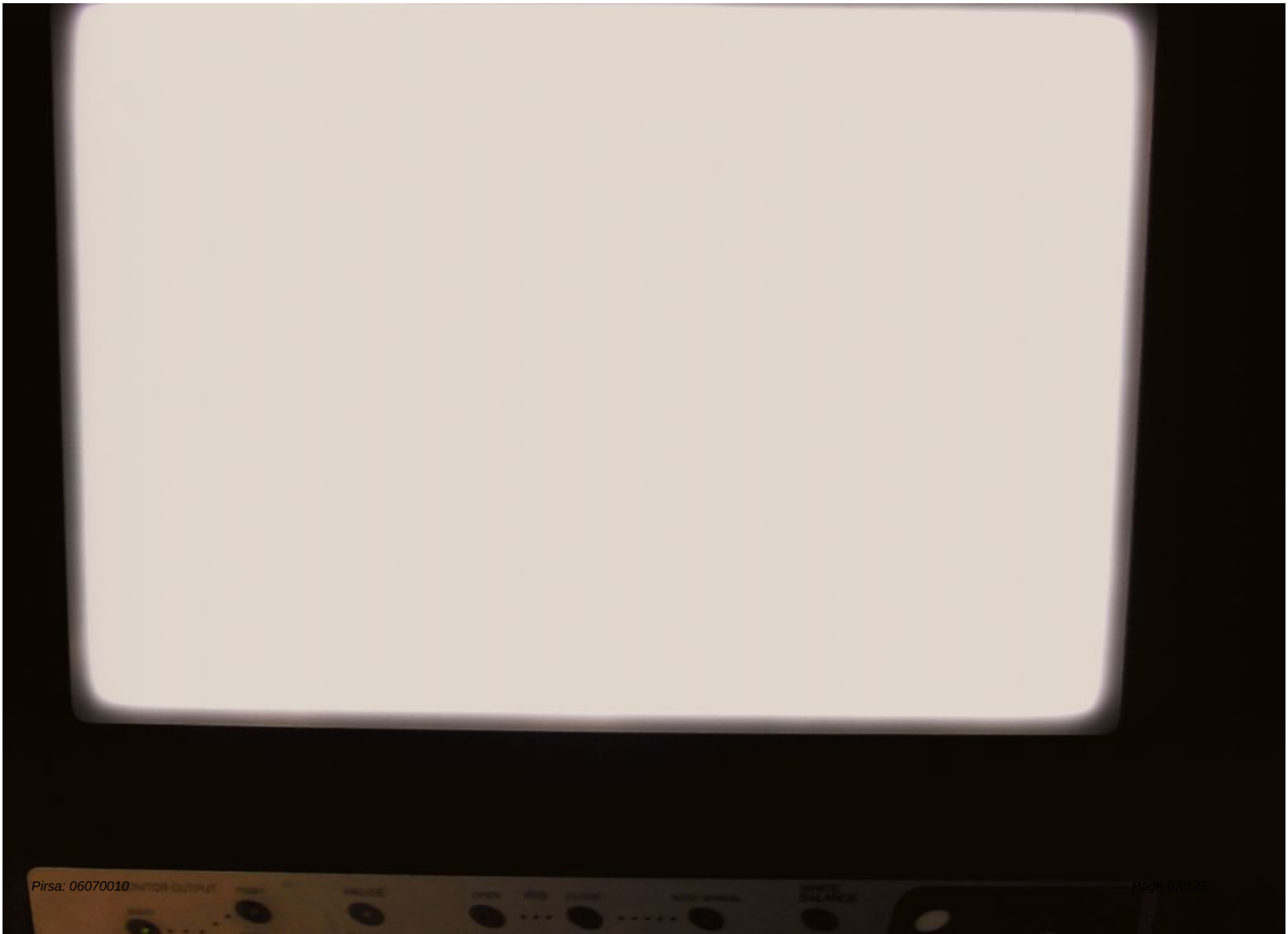
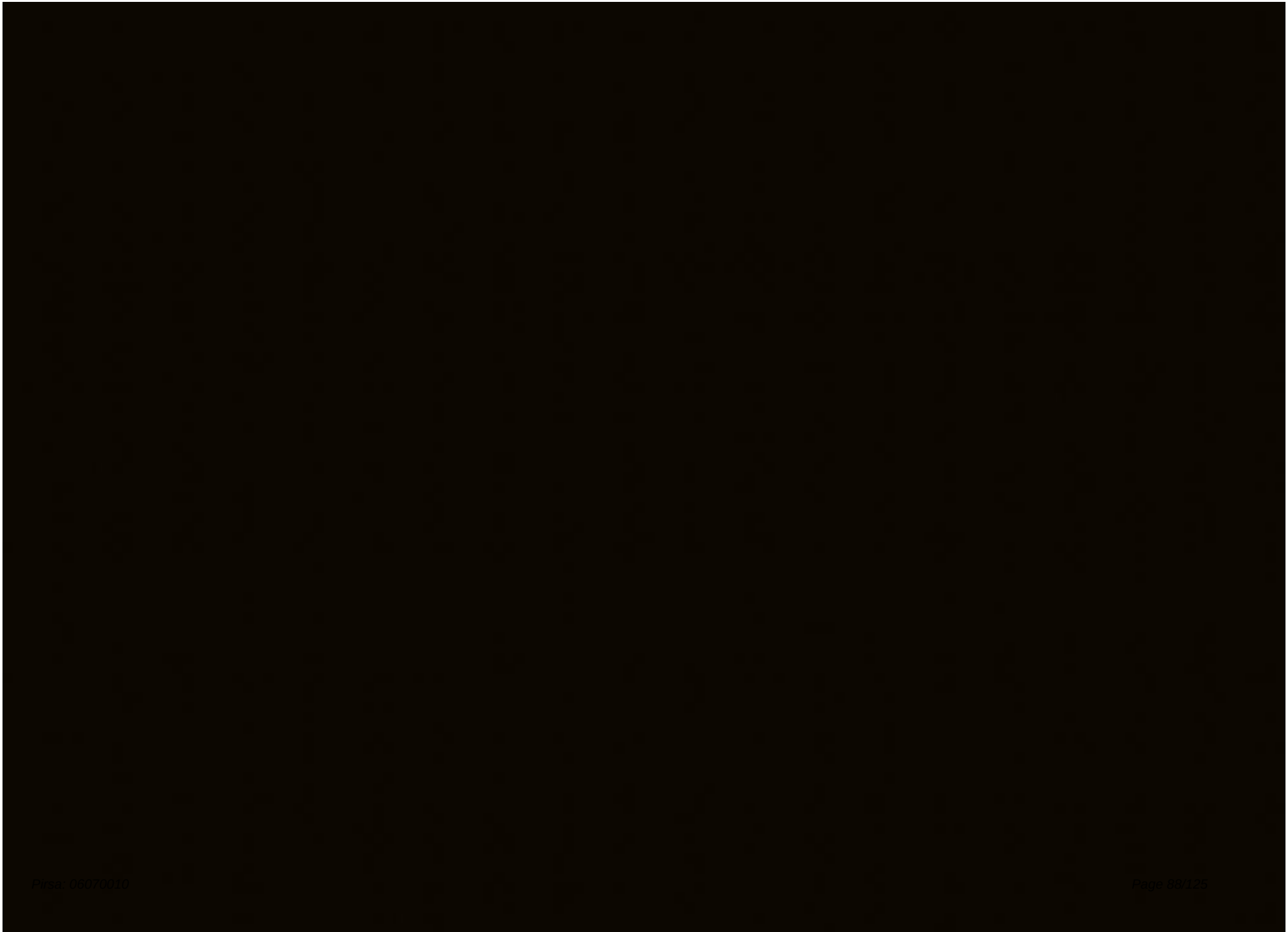
CLOSE





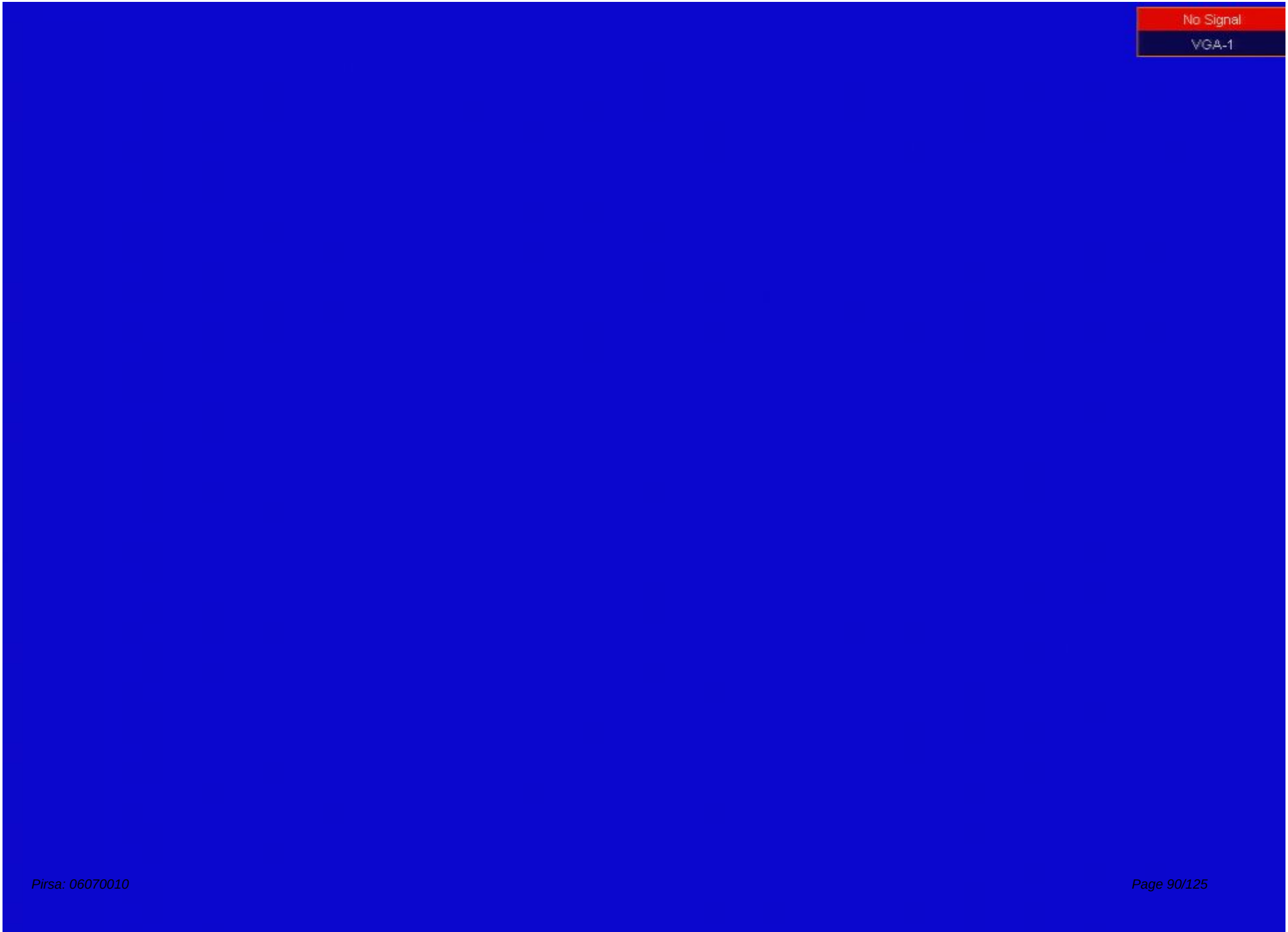
Unpolarized light is shone through a polarizing filter. Through the filter you will get

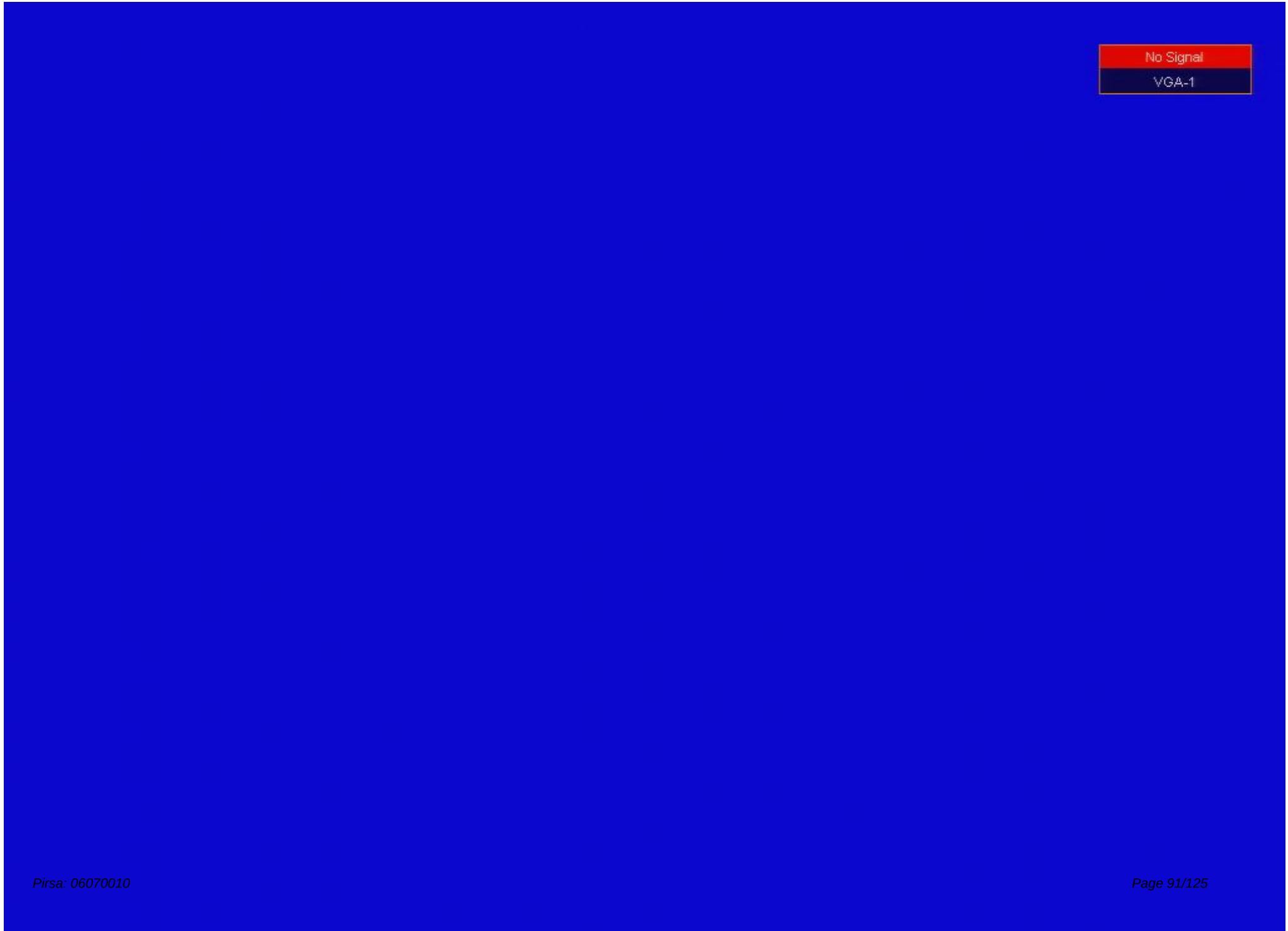
A) all the light

B) light with 1/2 the intensity

C) light with 1/2 the frequency

D) nothing


No Signal
VGA-1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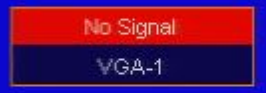
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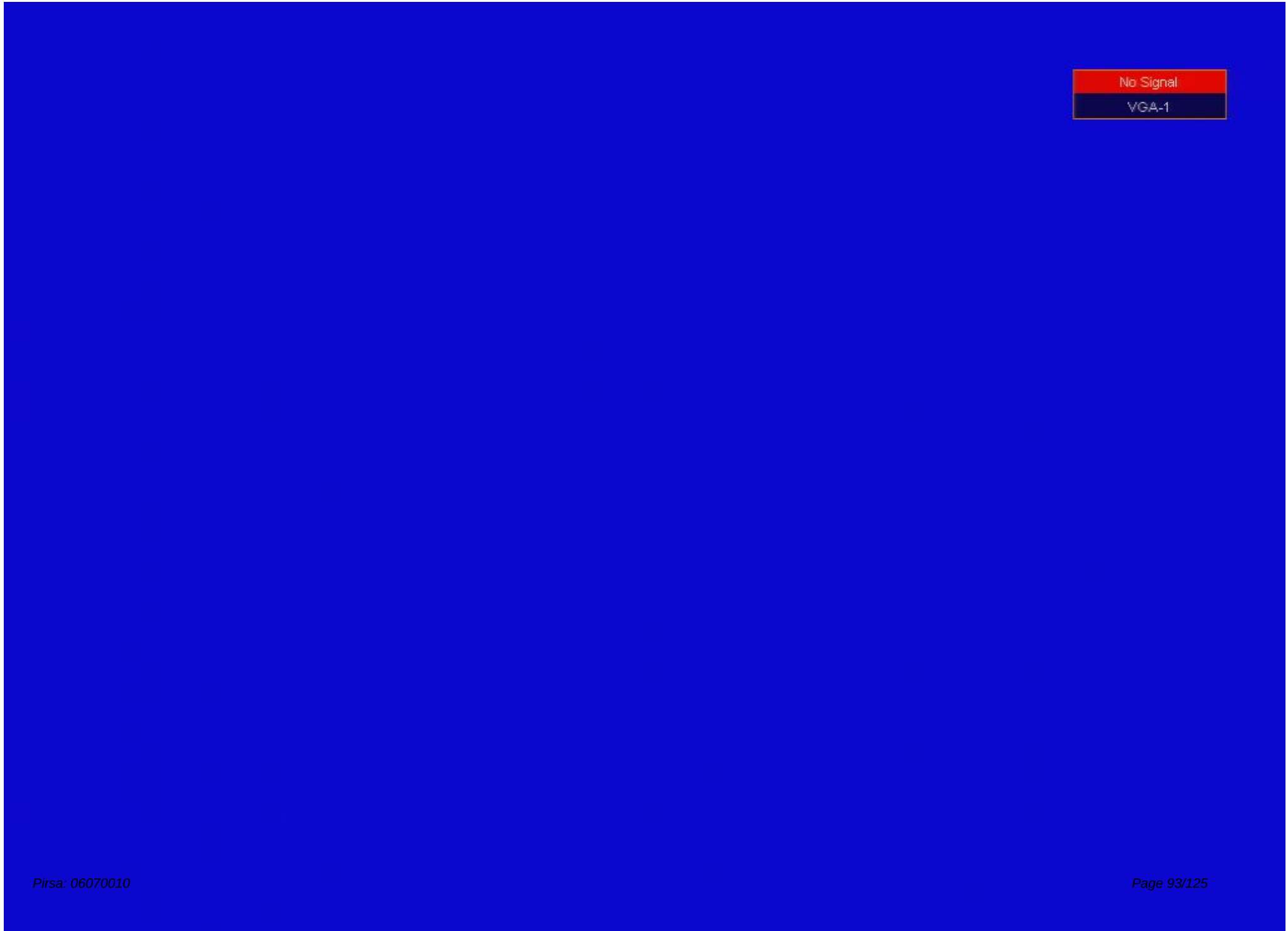
VGA-1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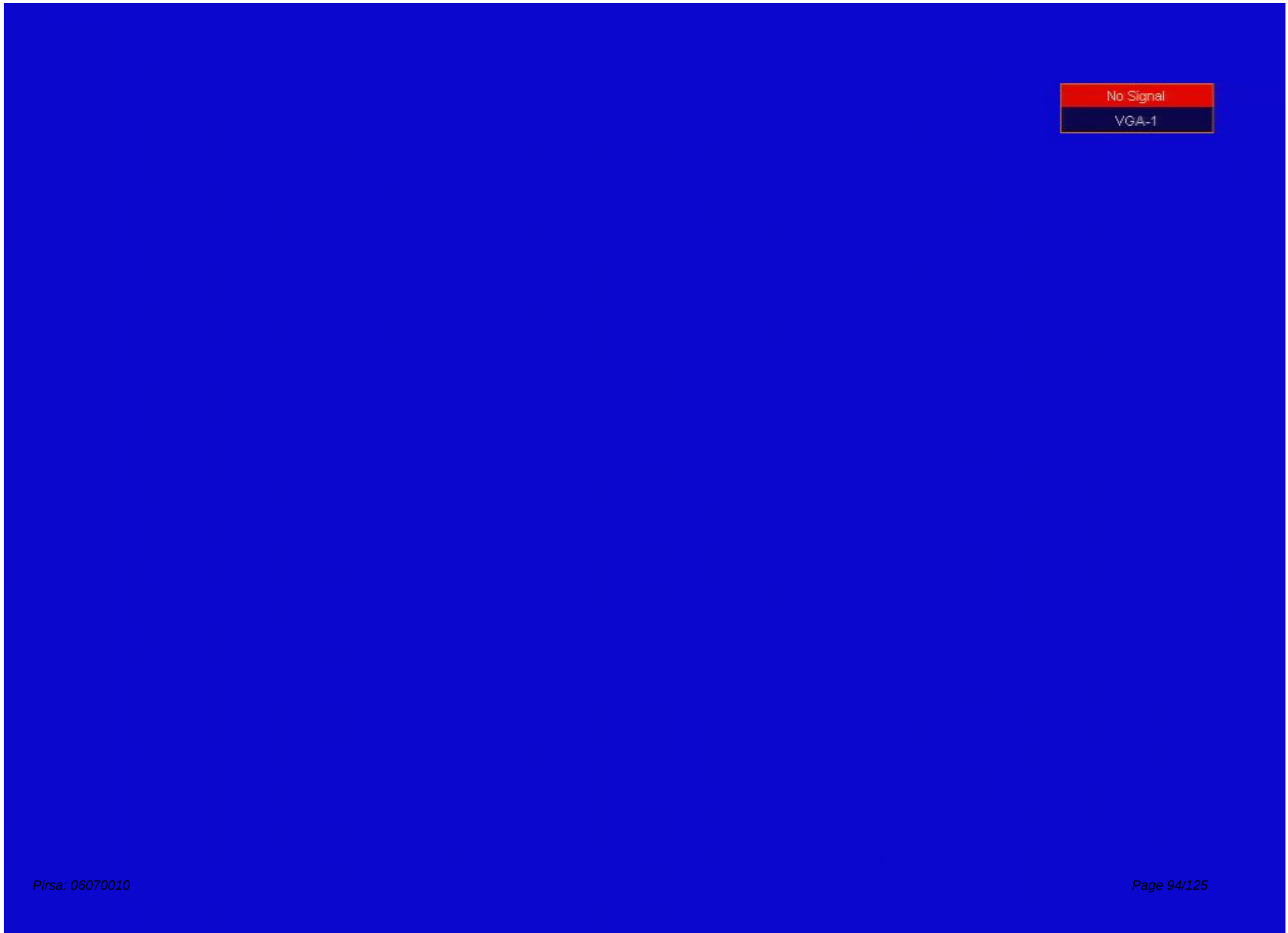
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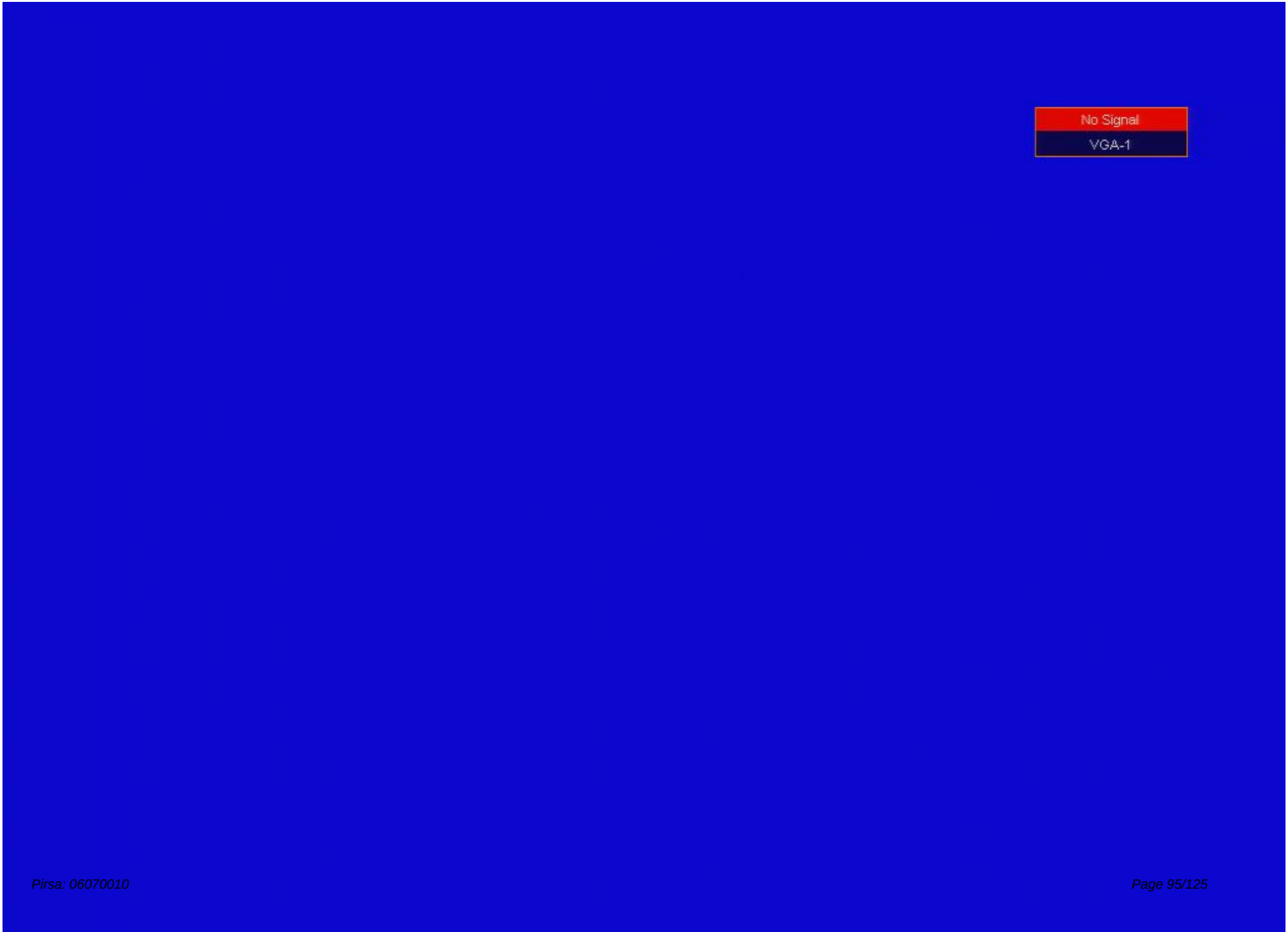
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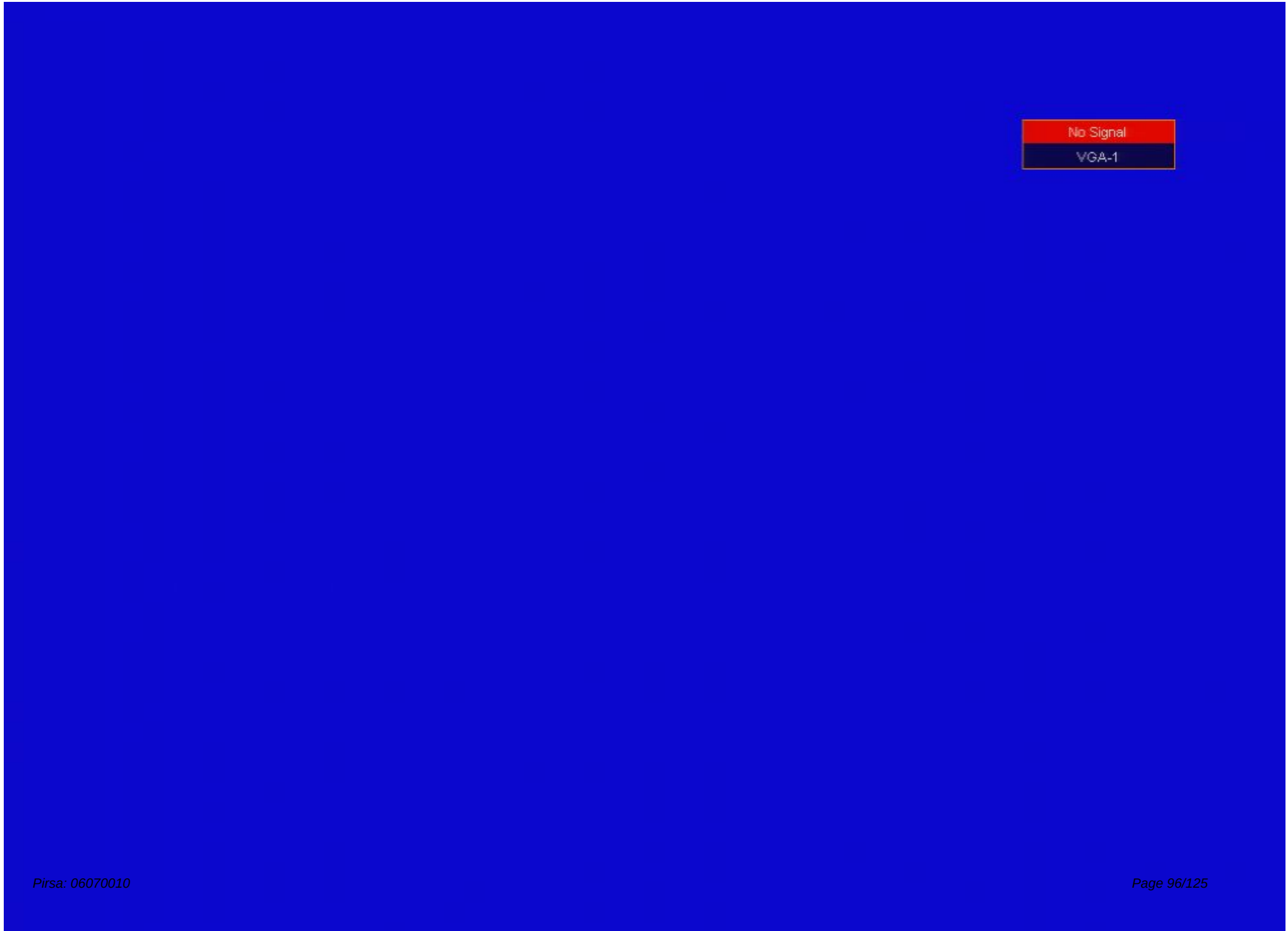
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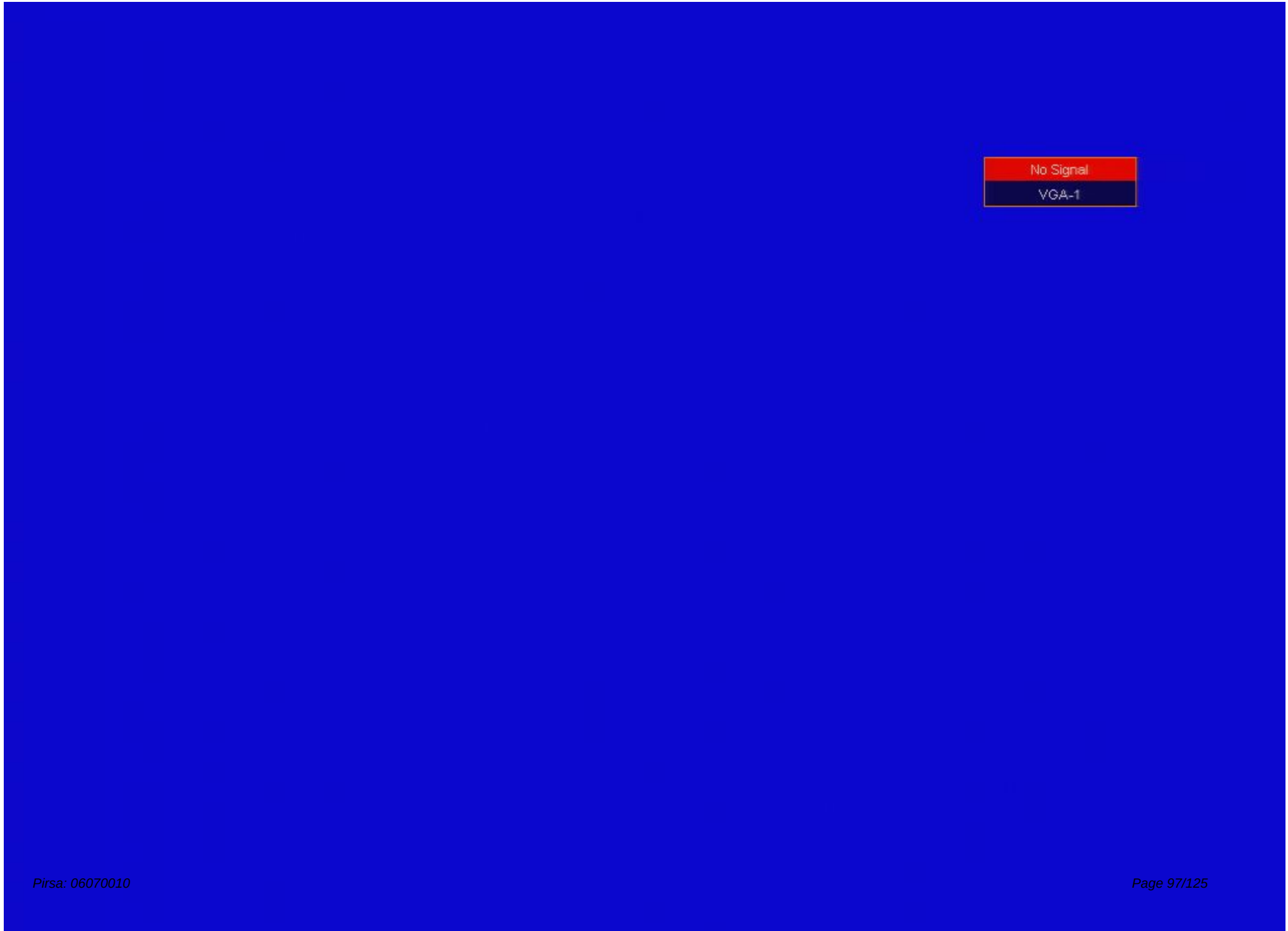
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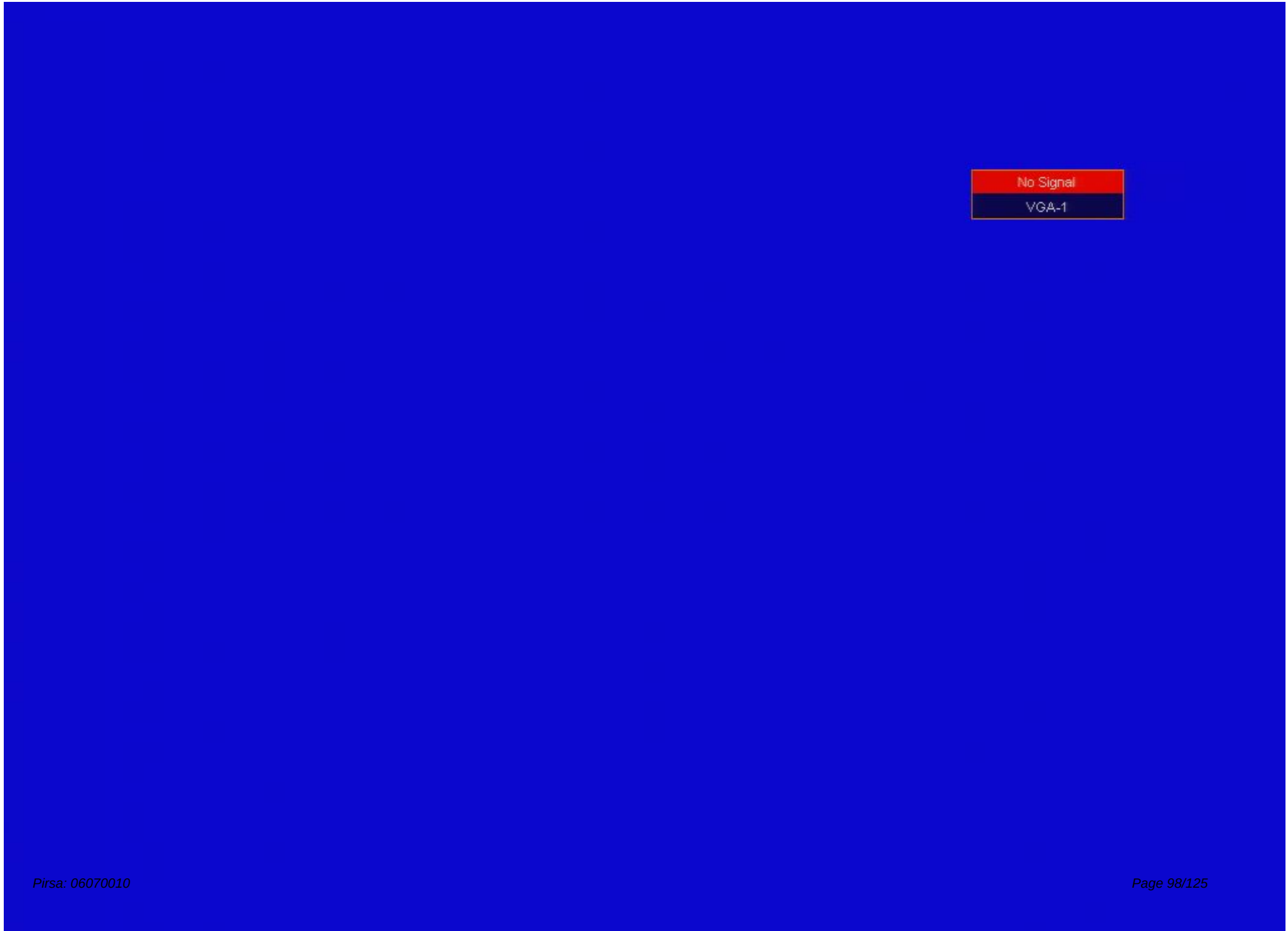
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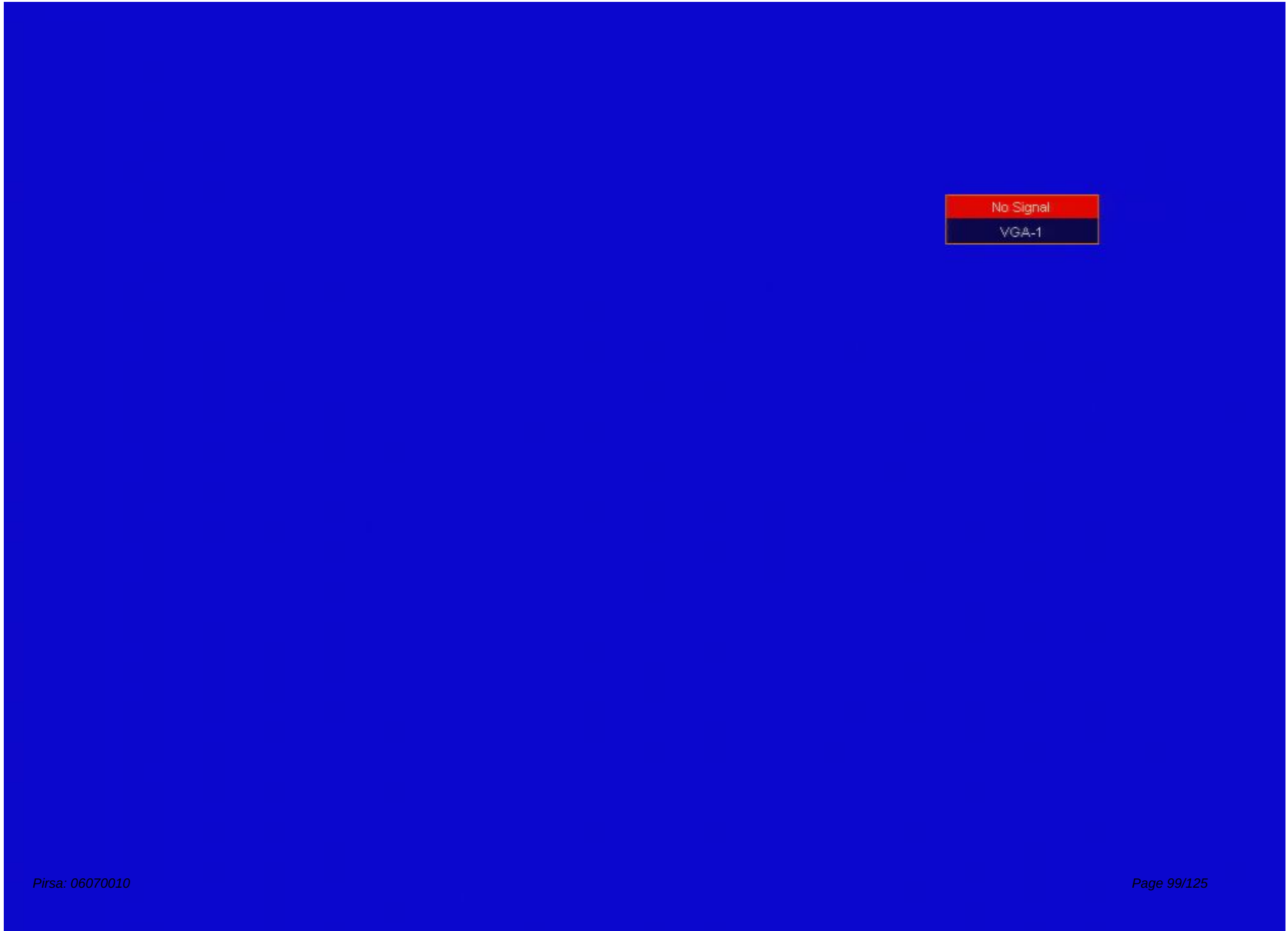
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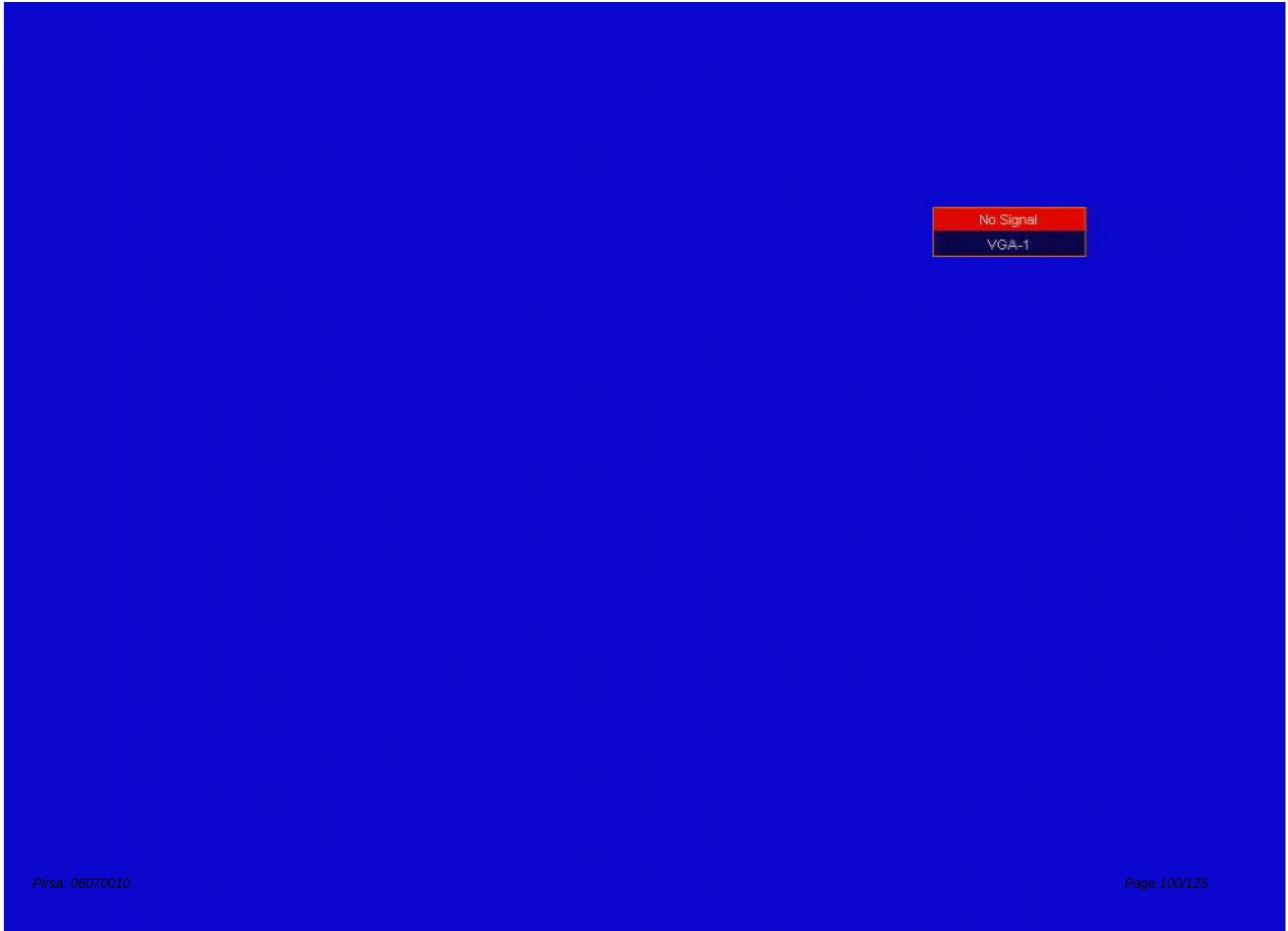
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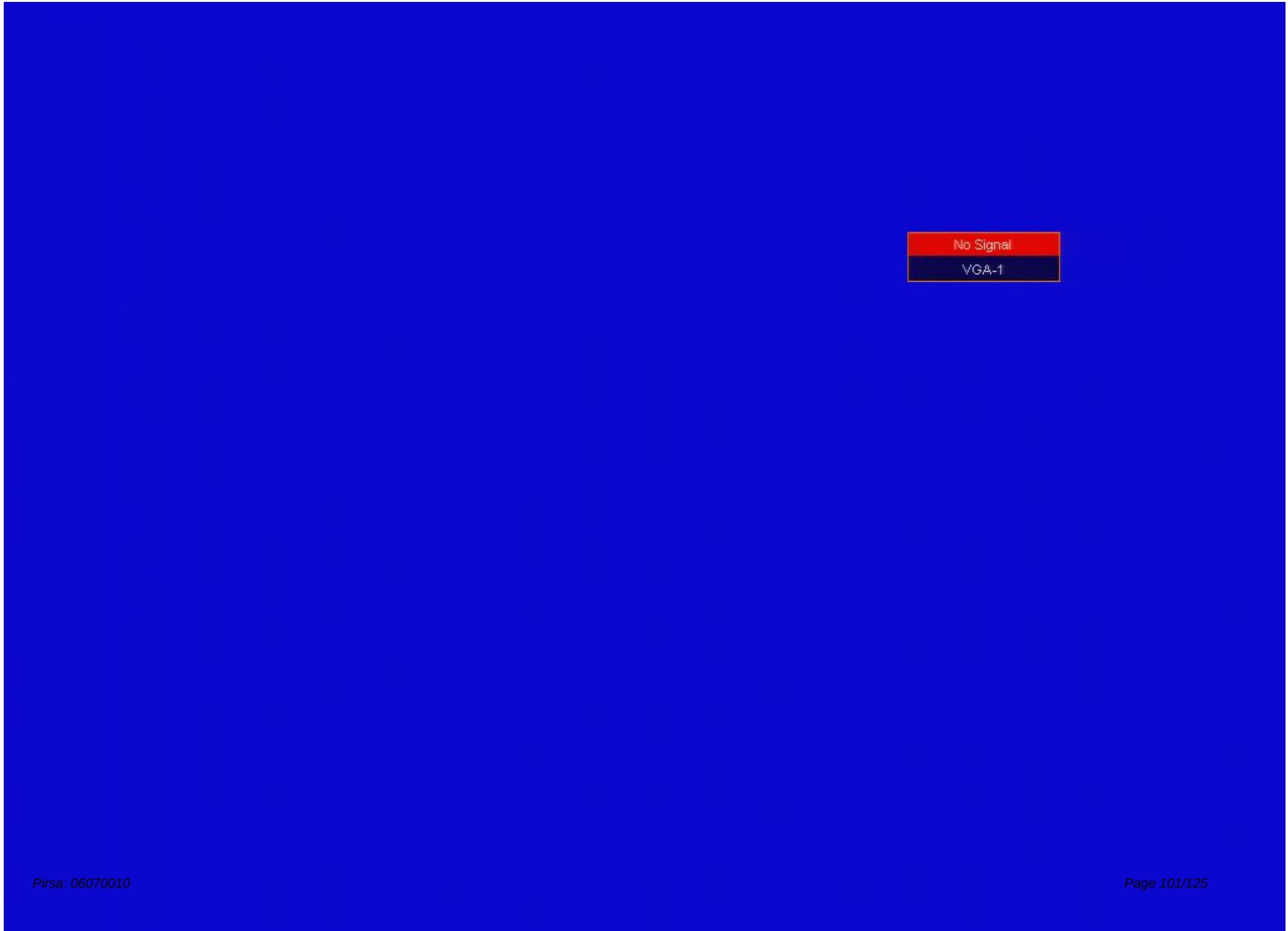
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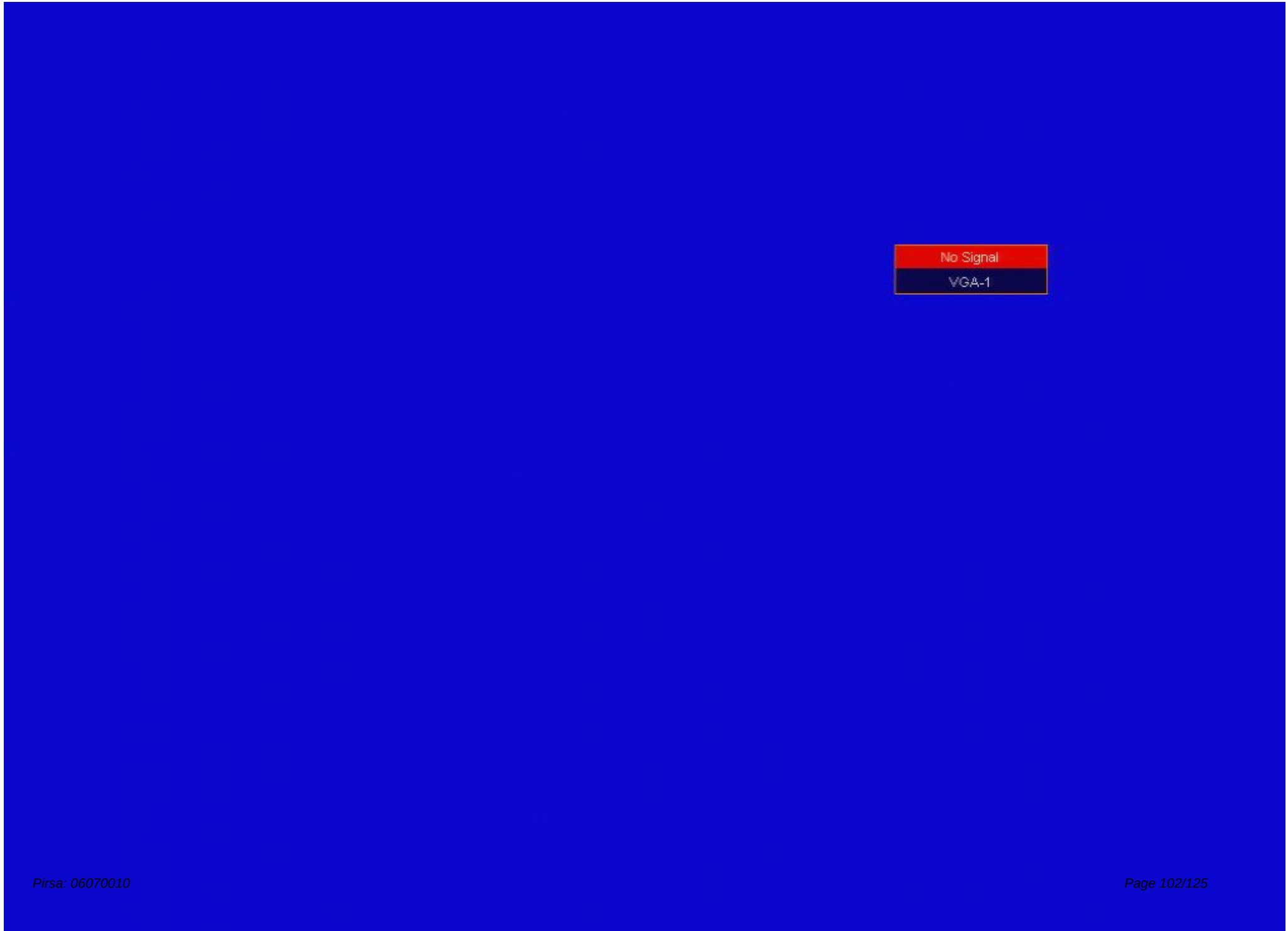
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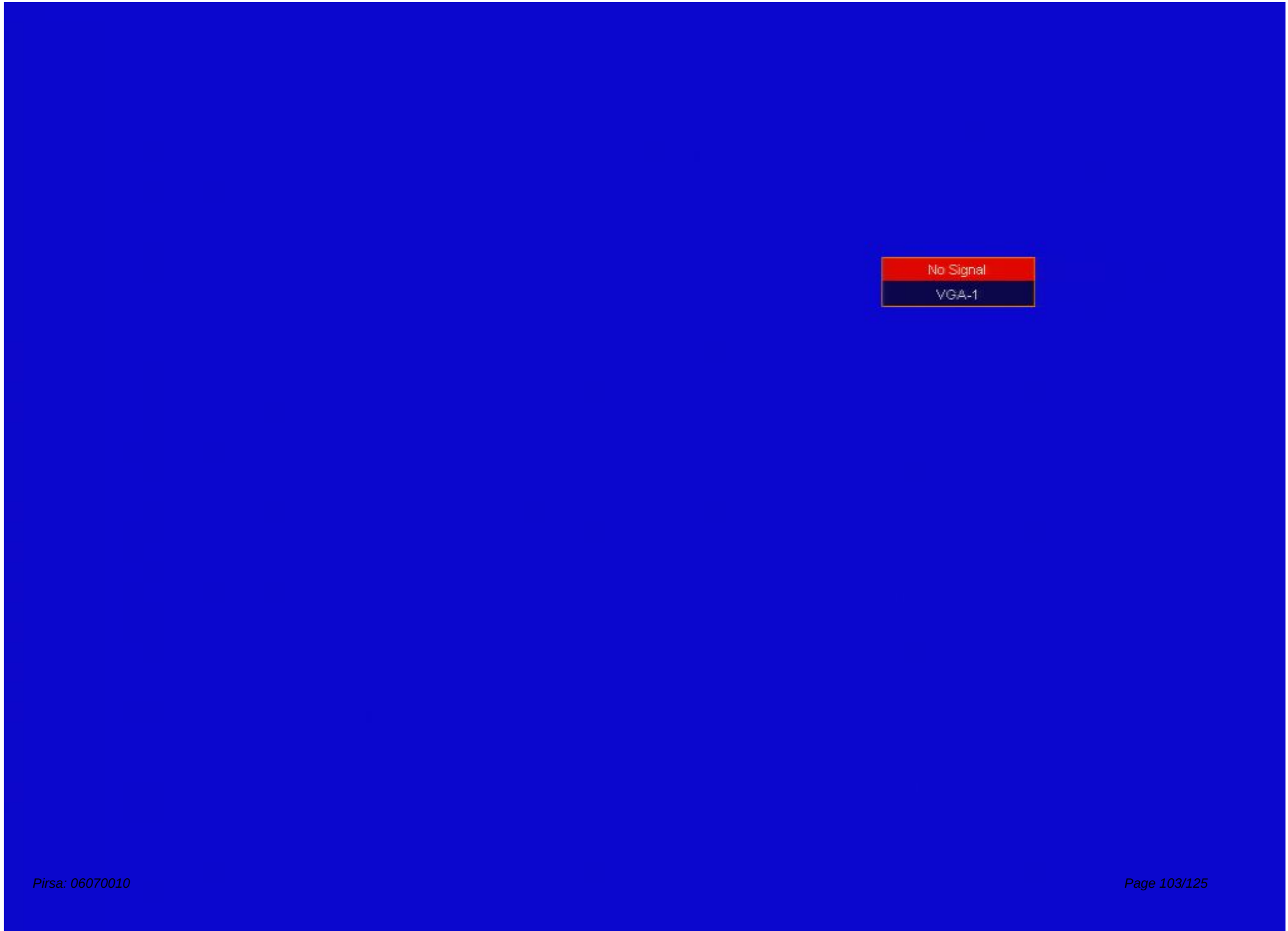
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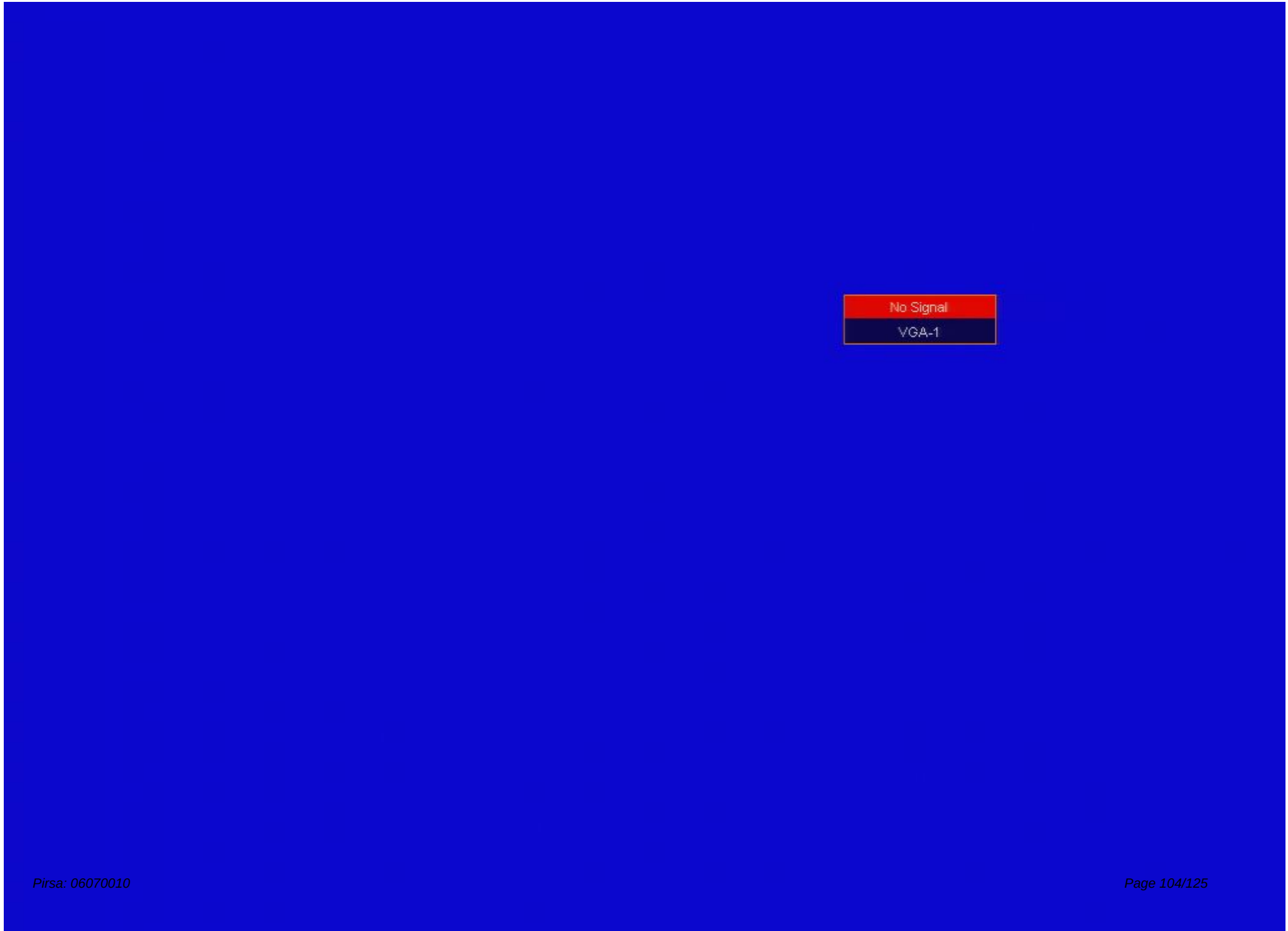
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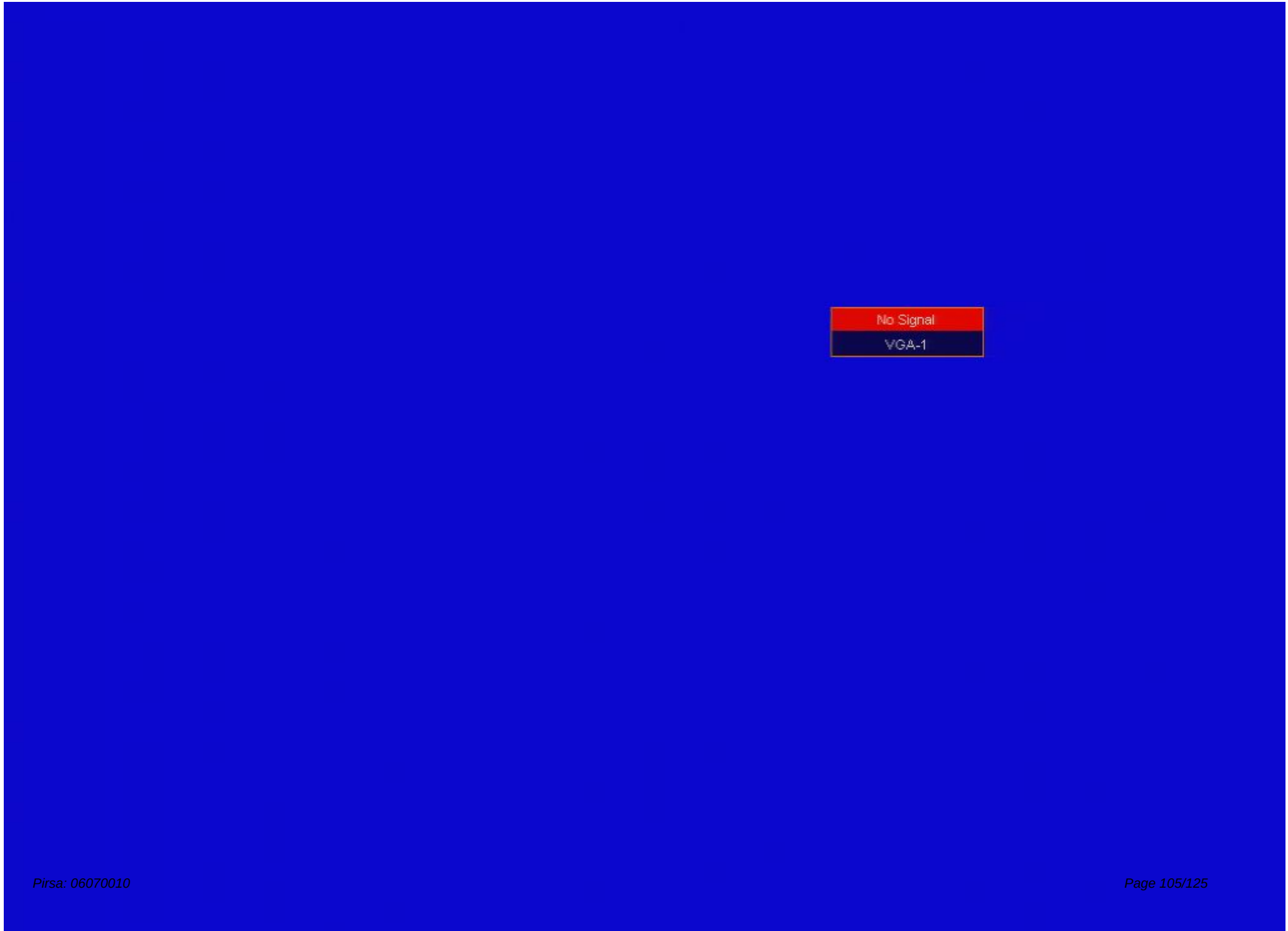
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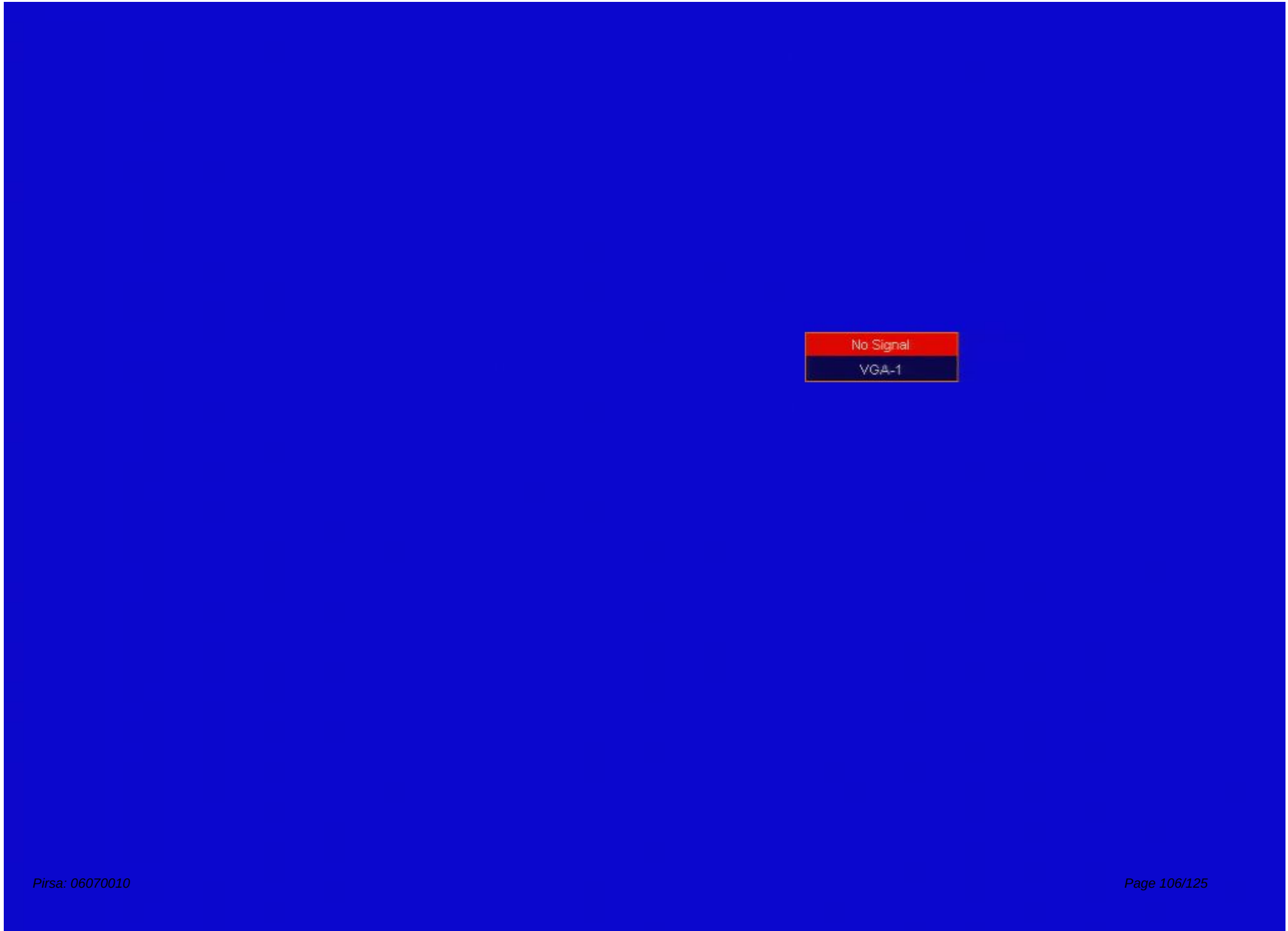
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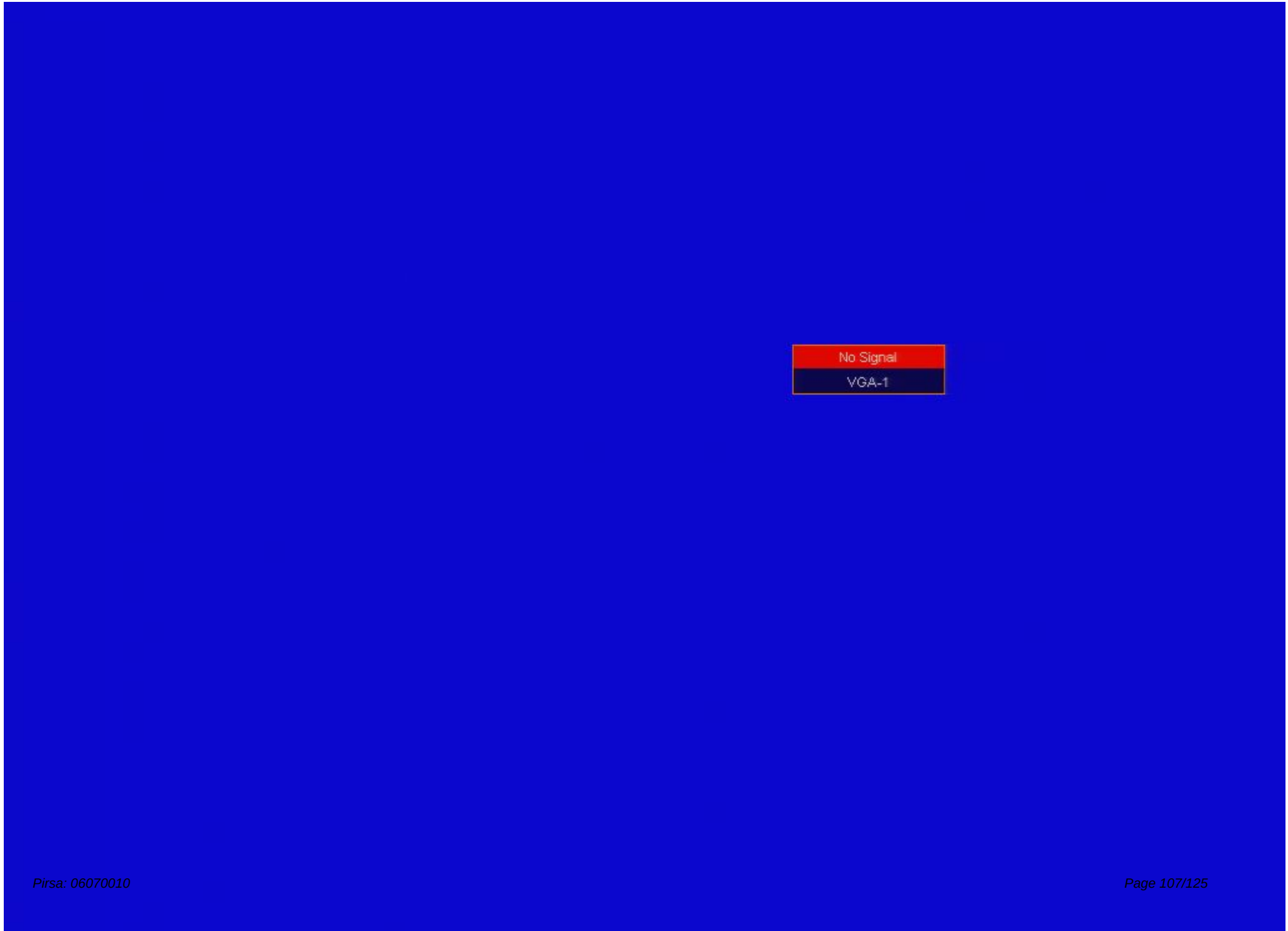
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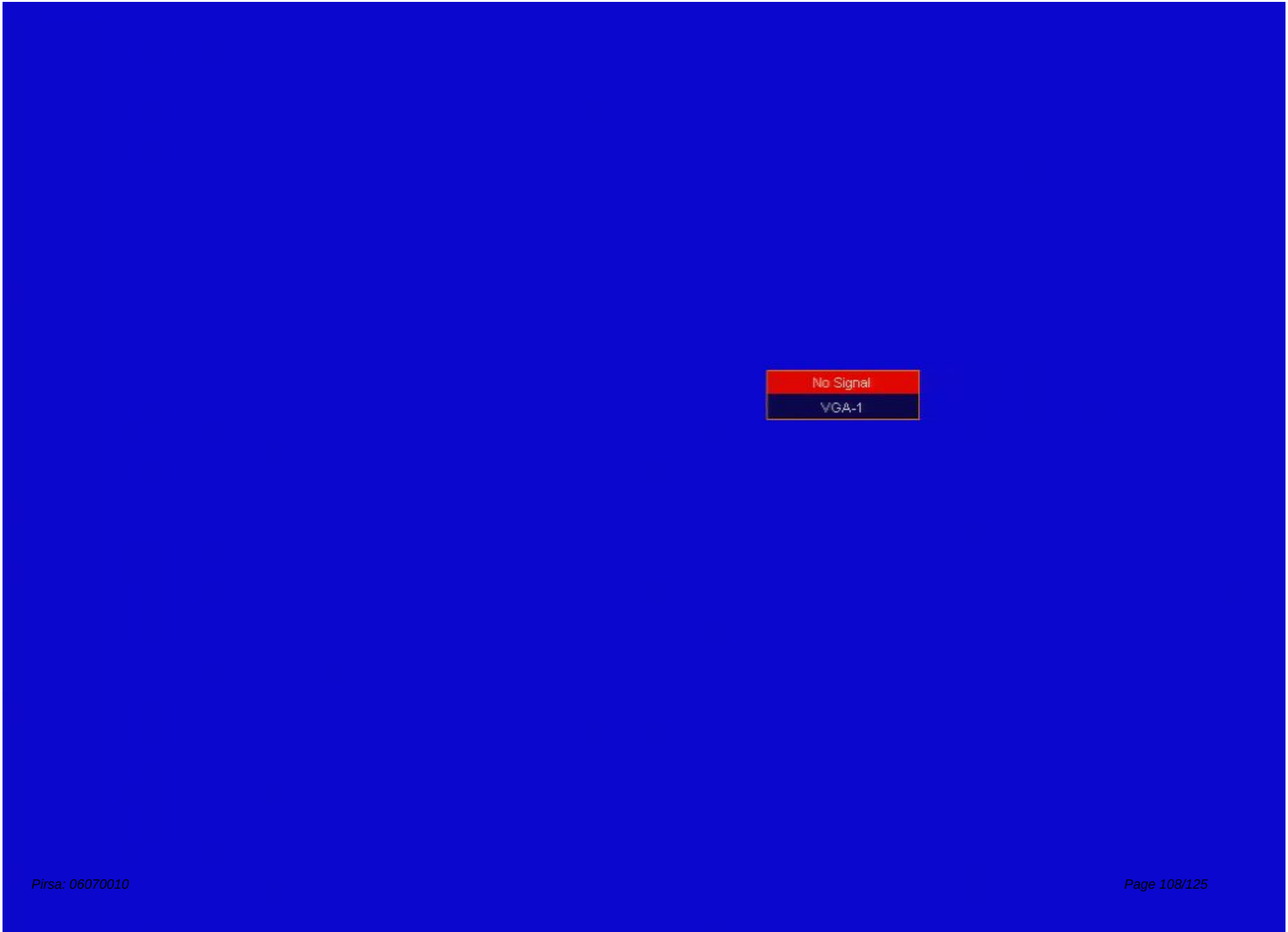
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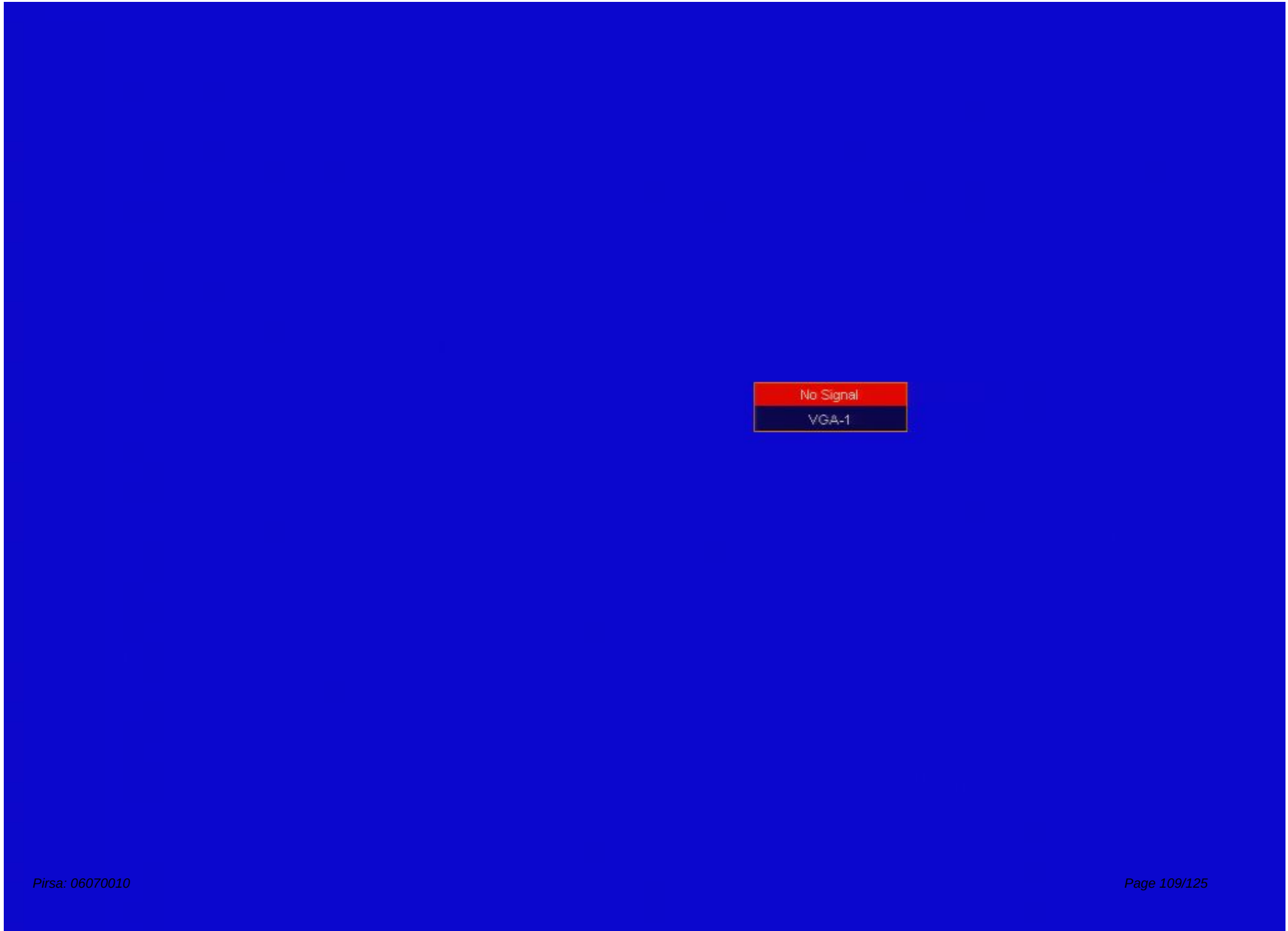
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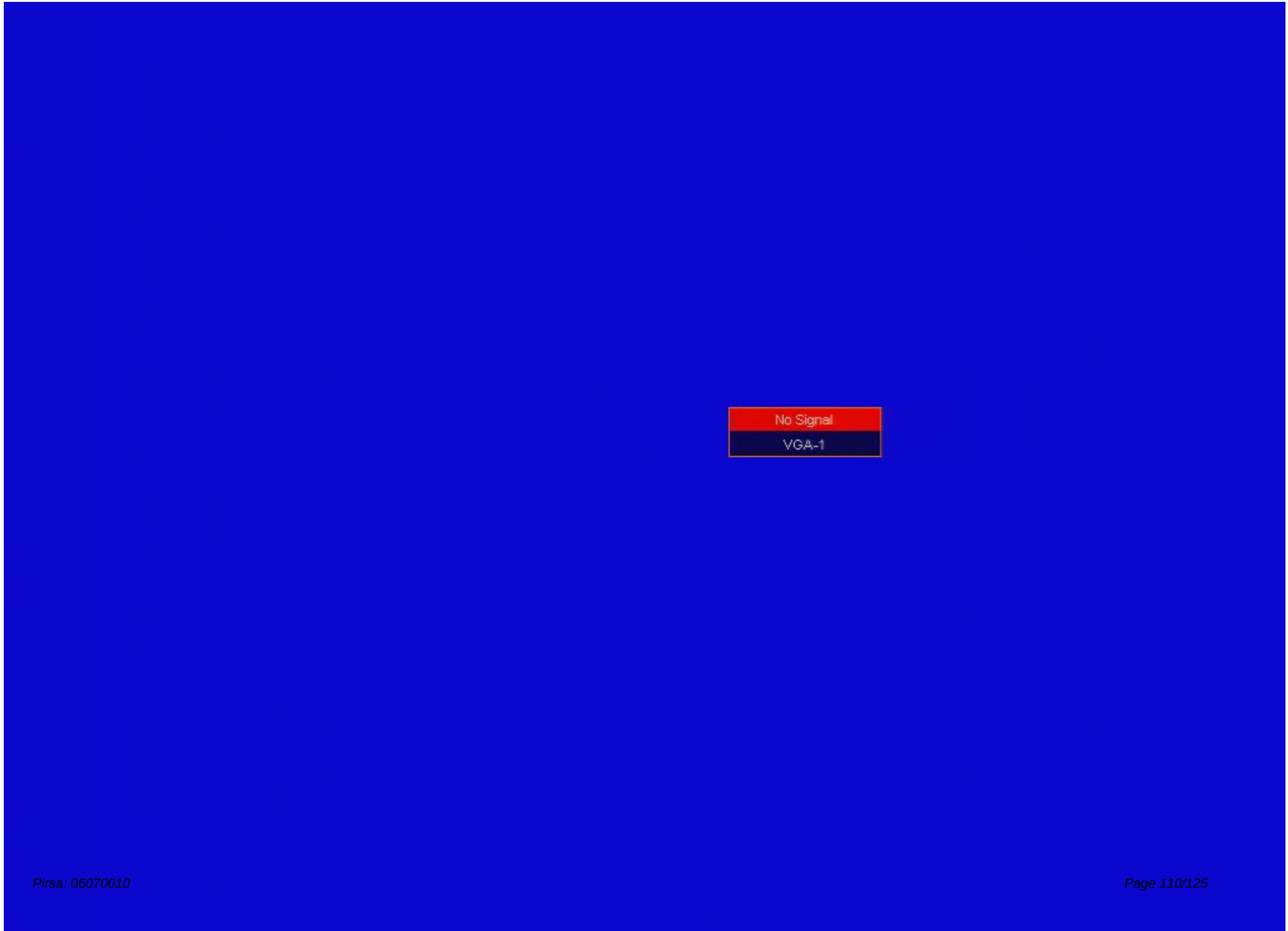
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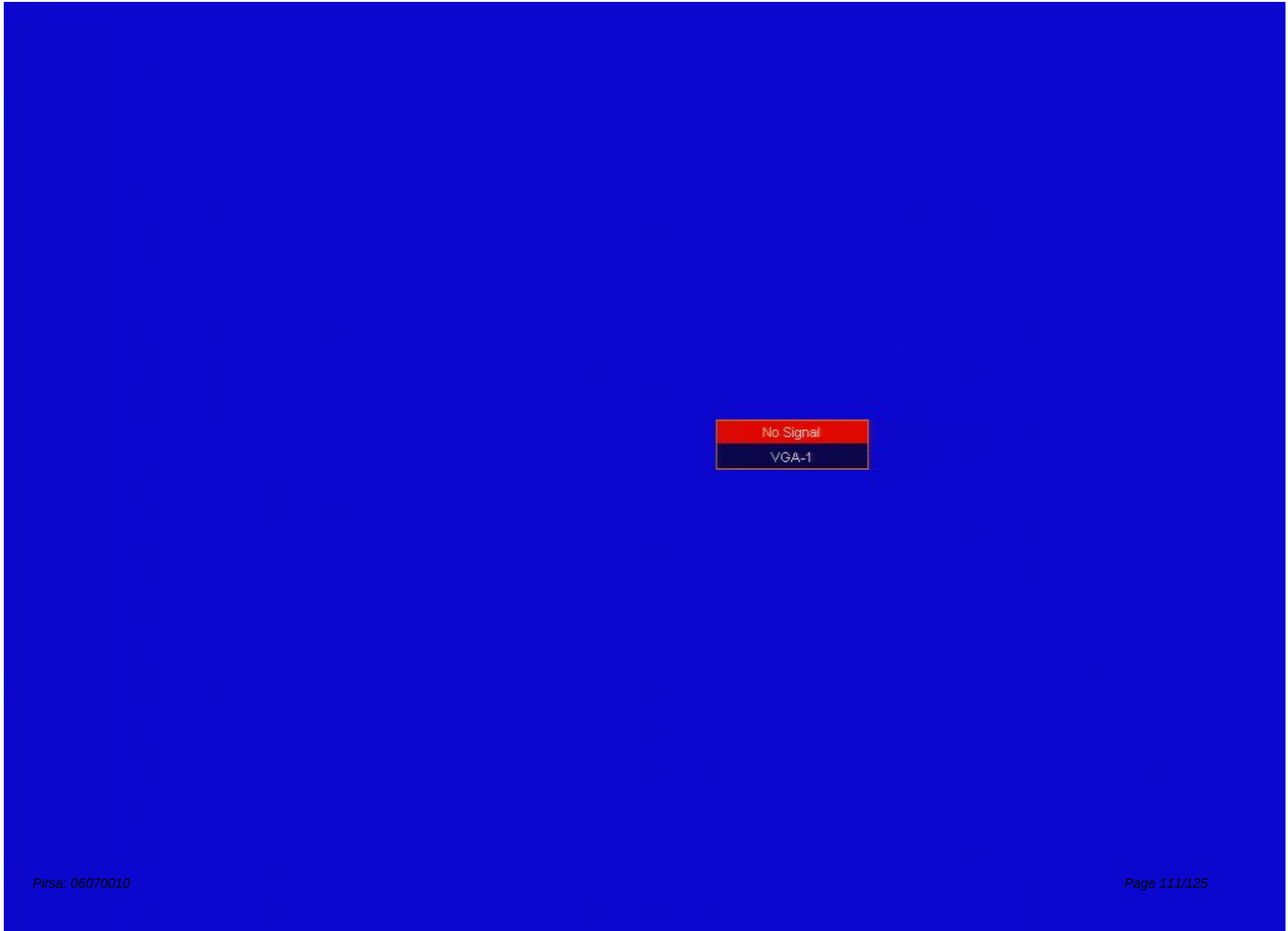
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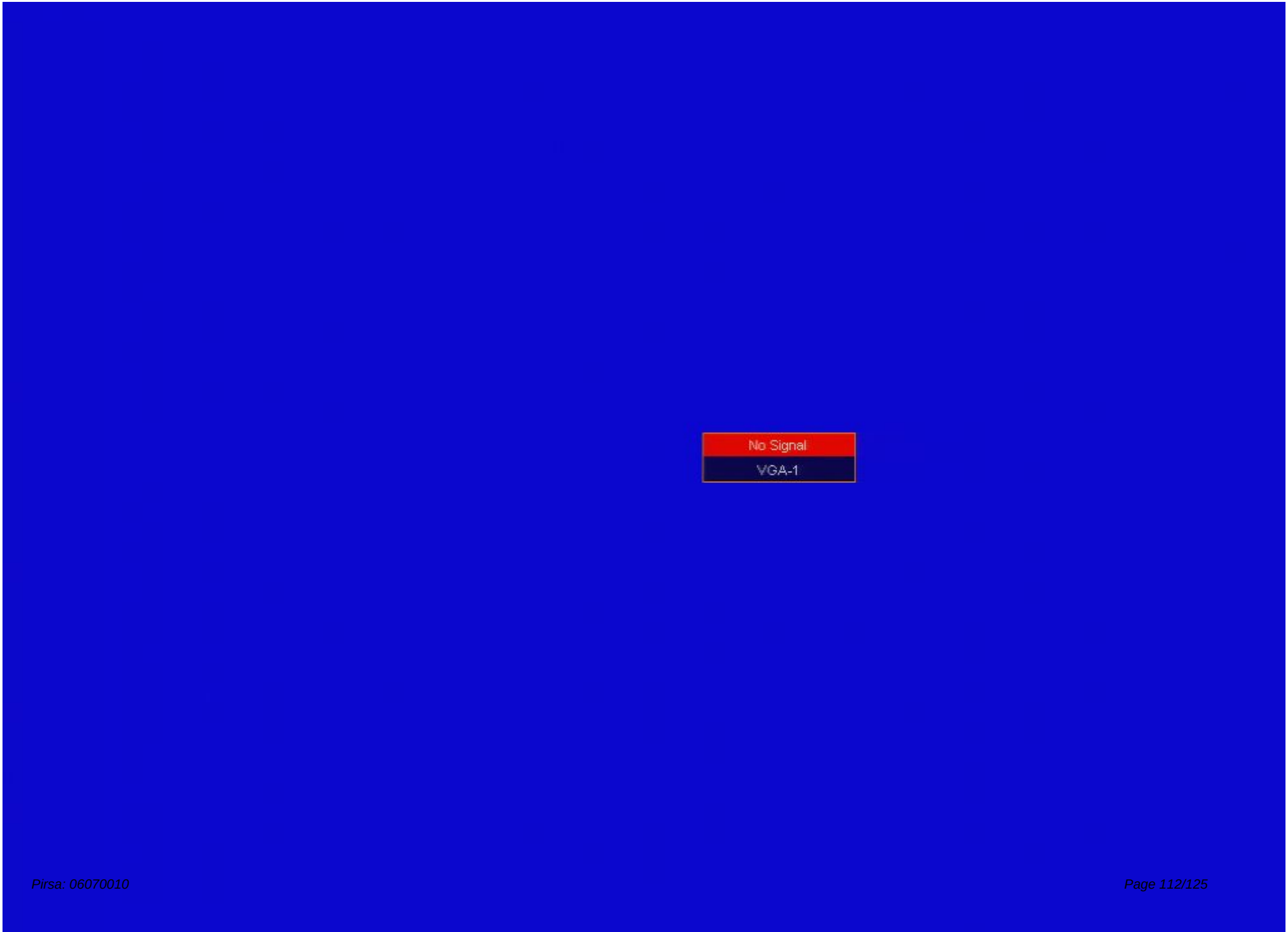
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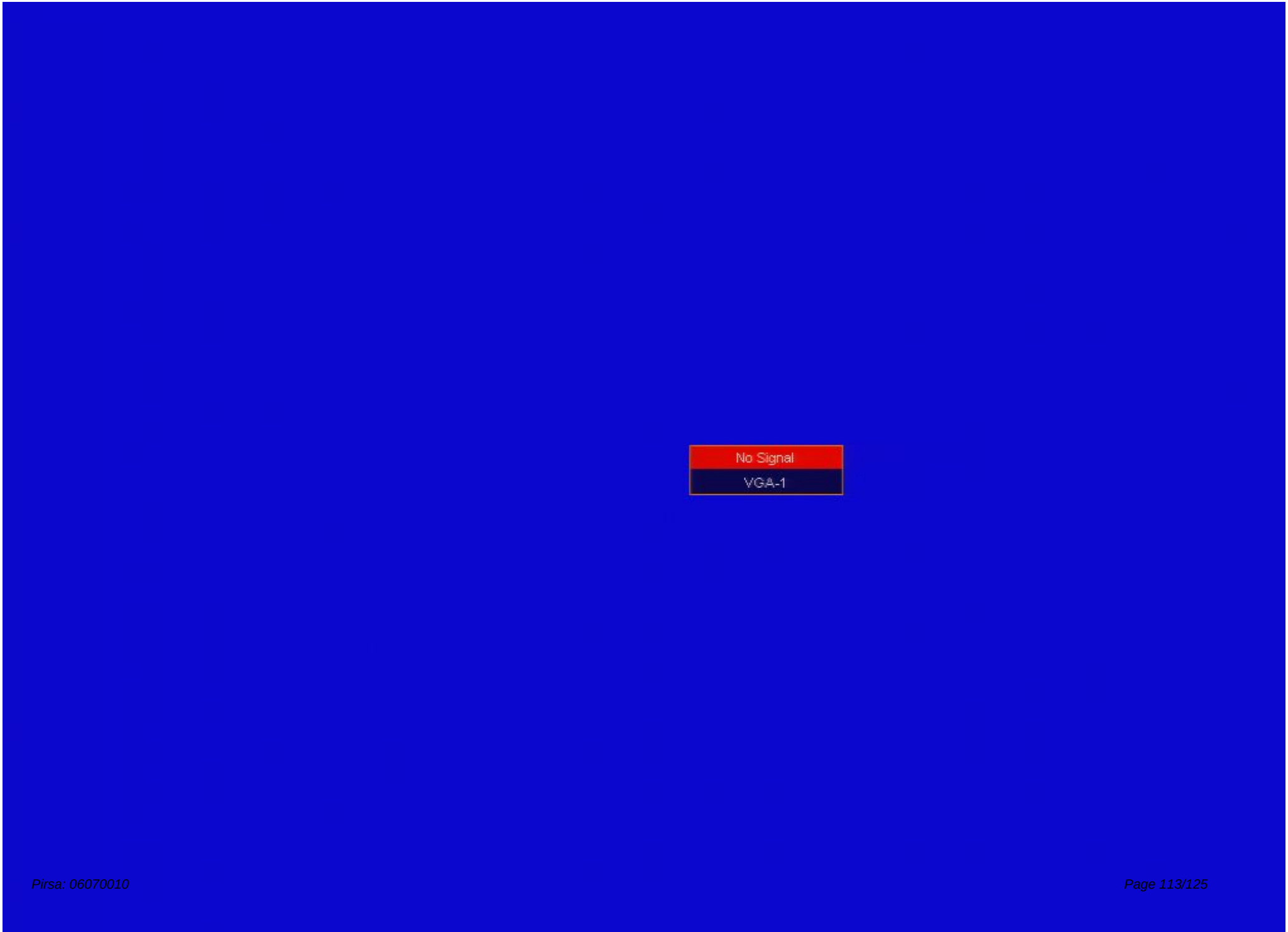
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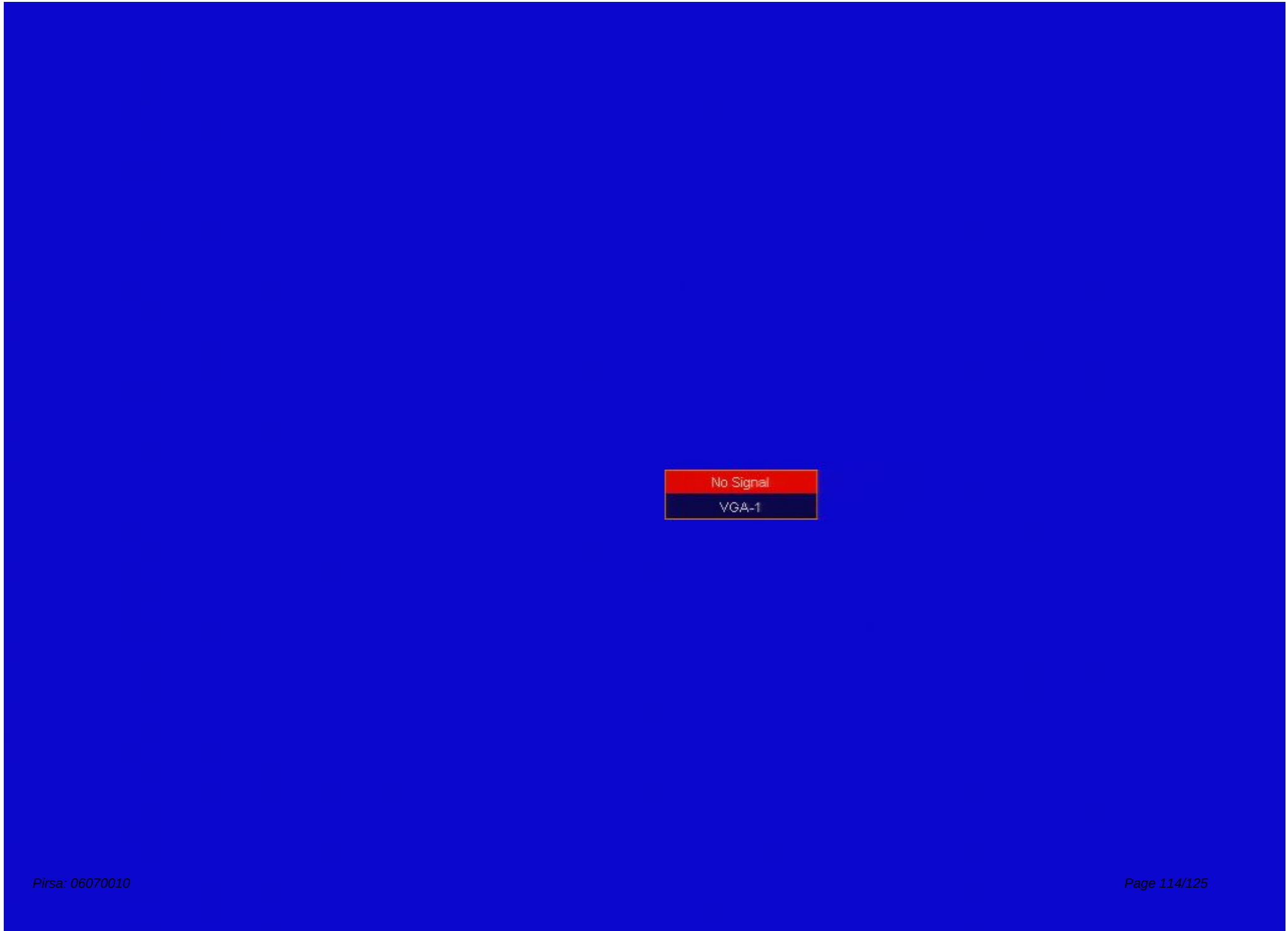
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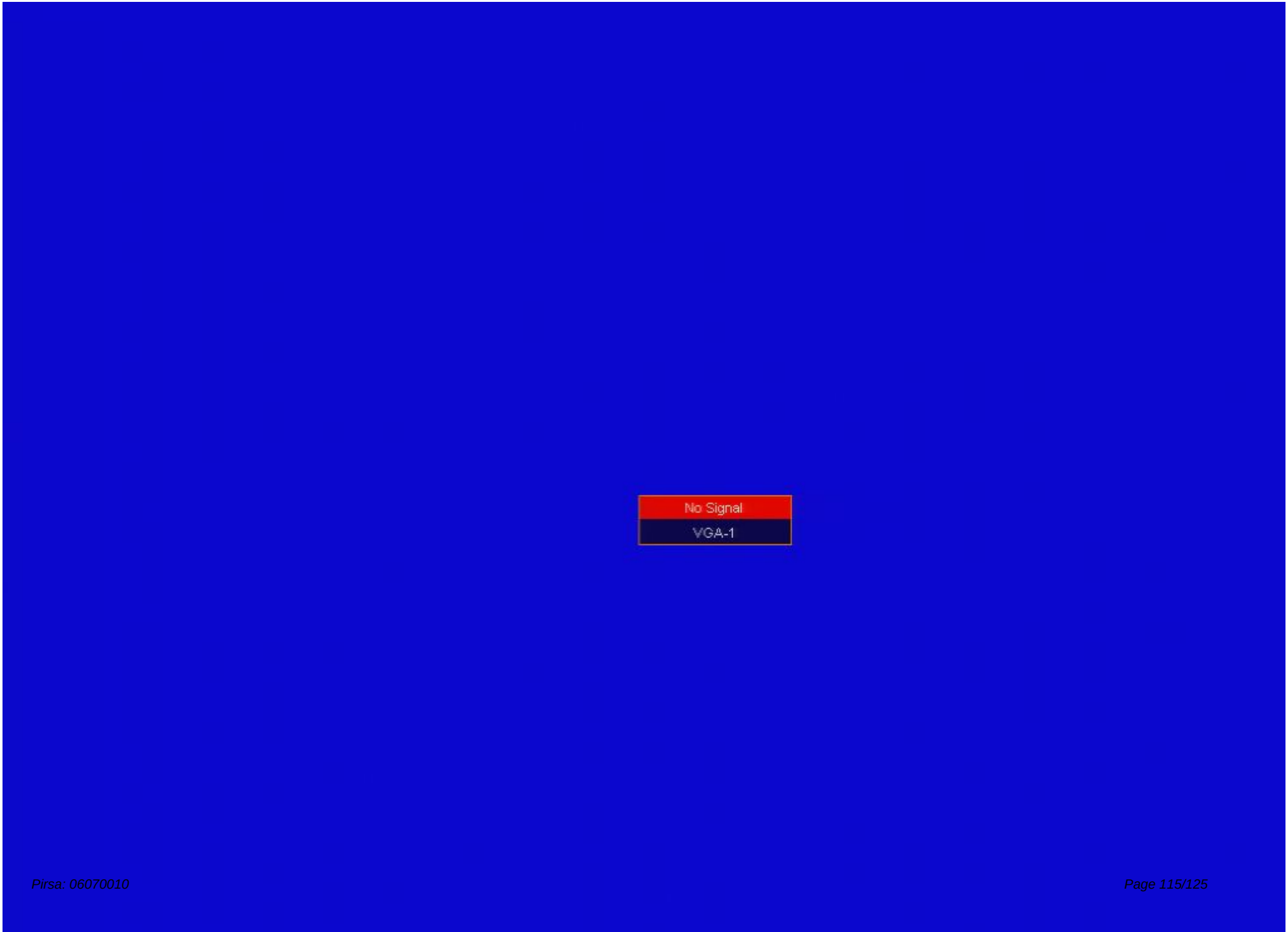
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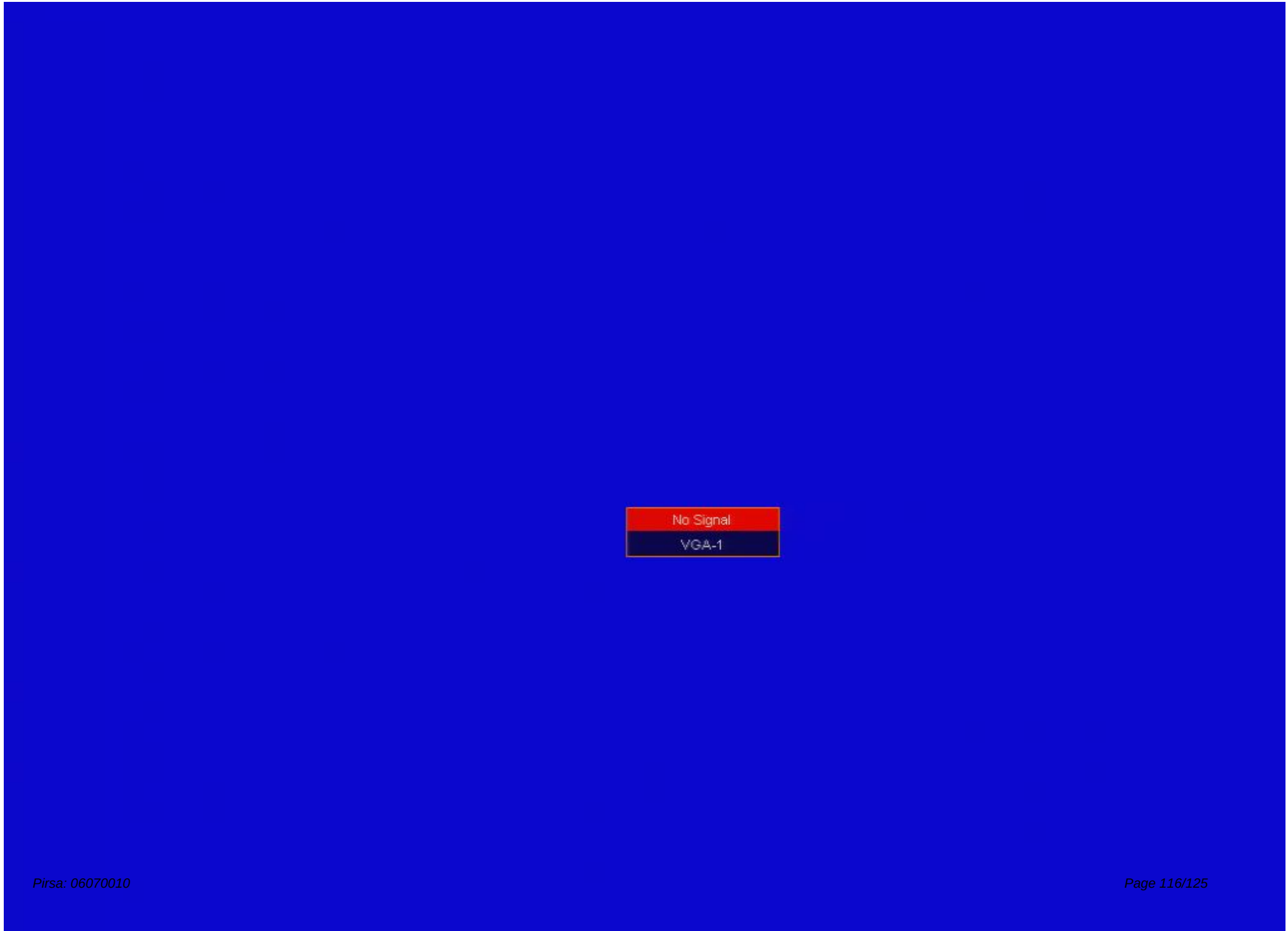
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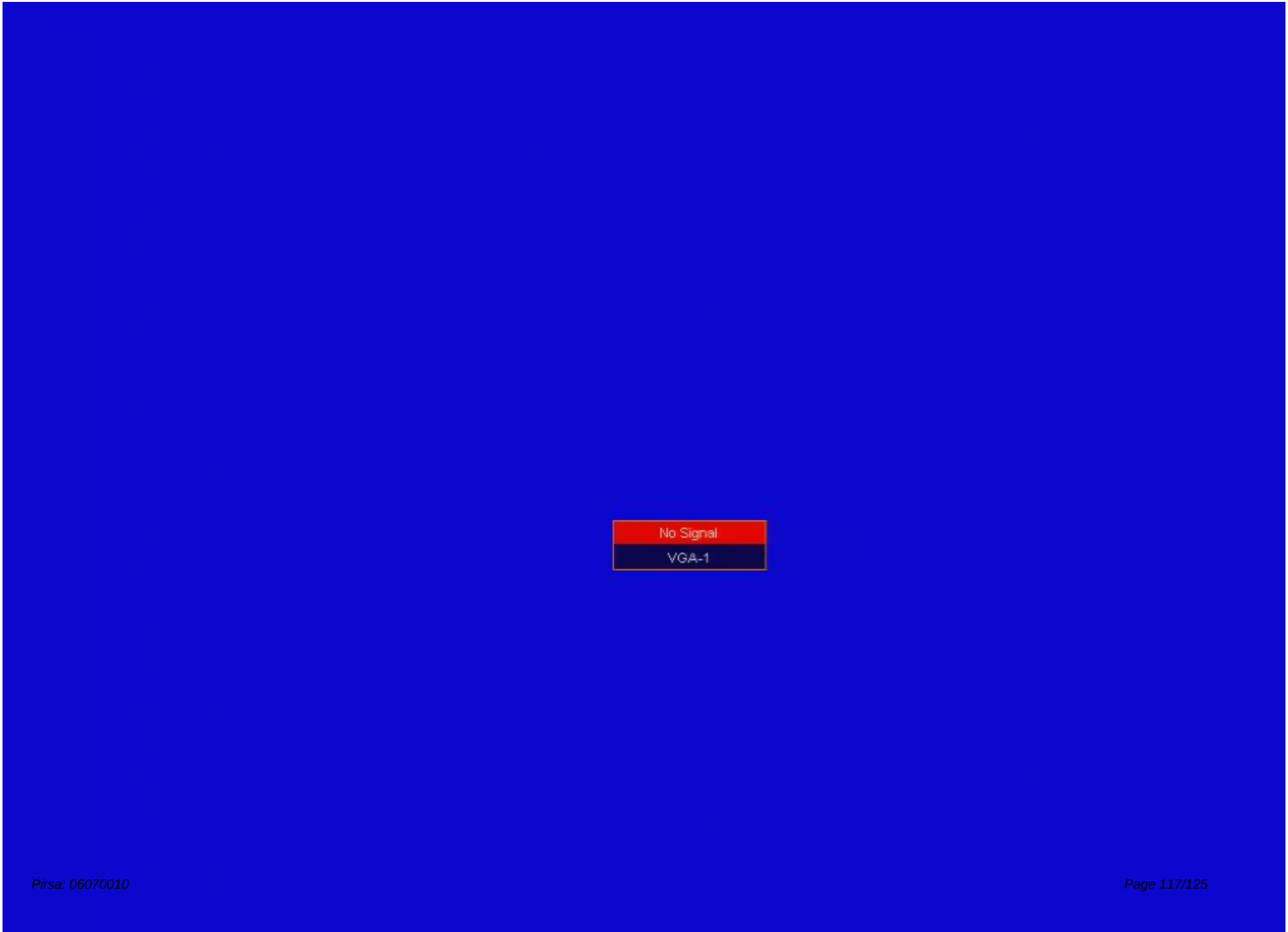
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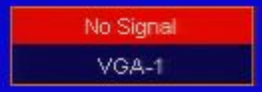
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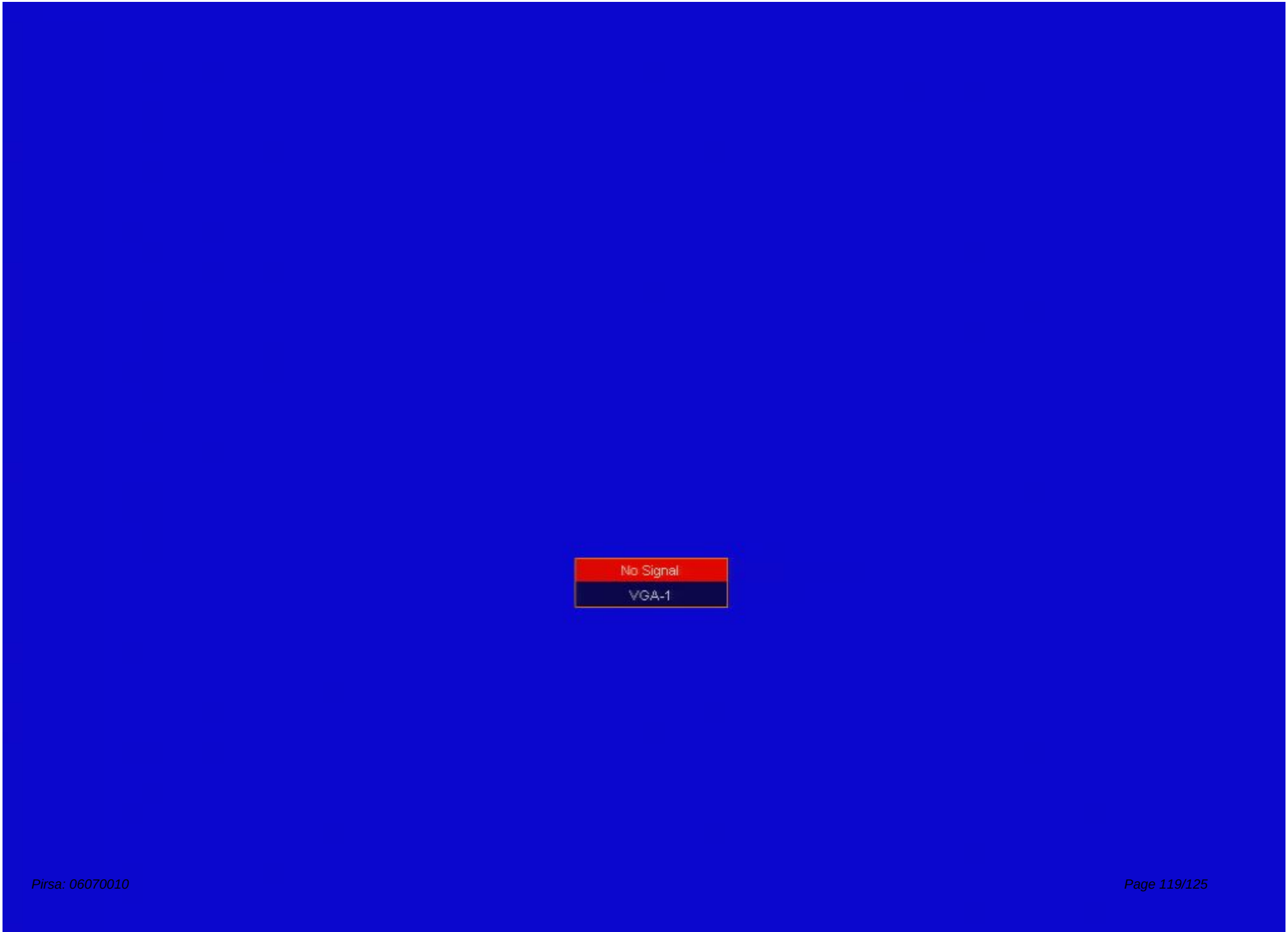
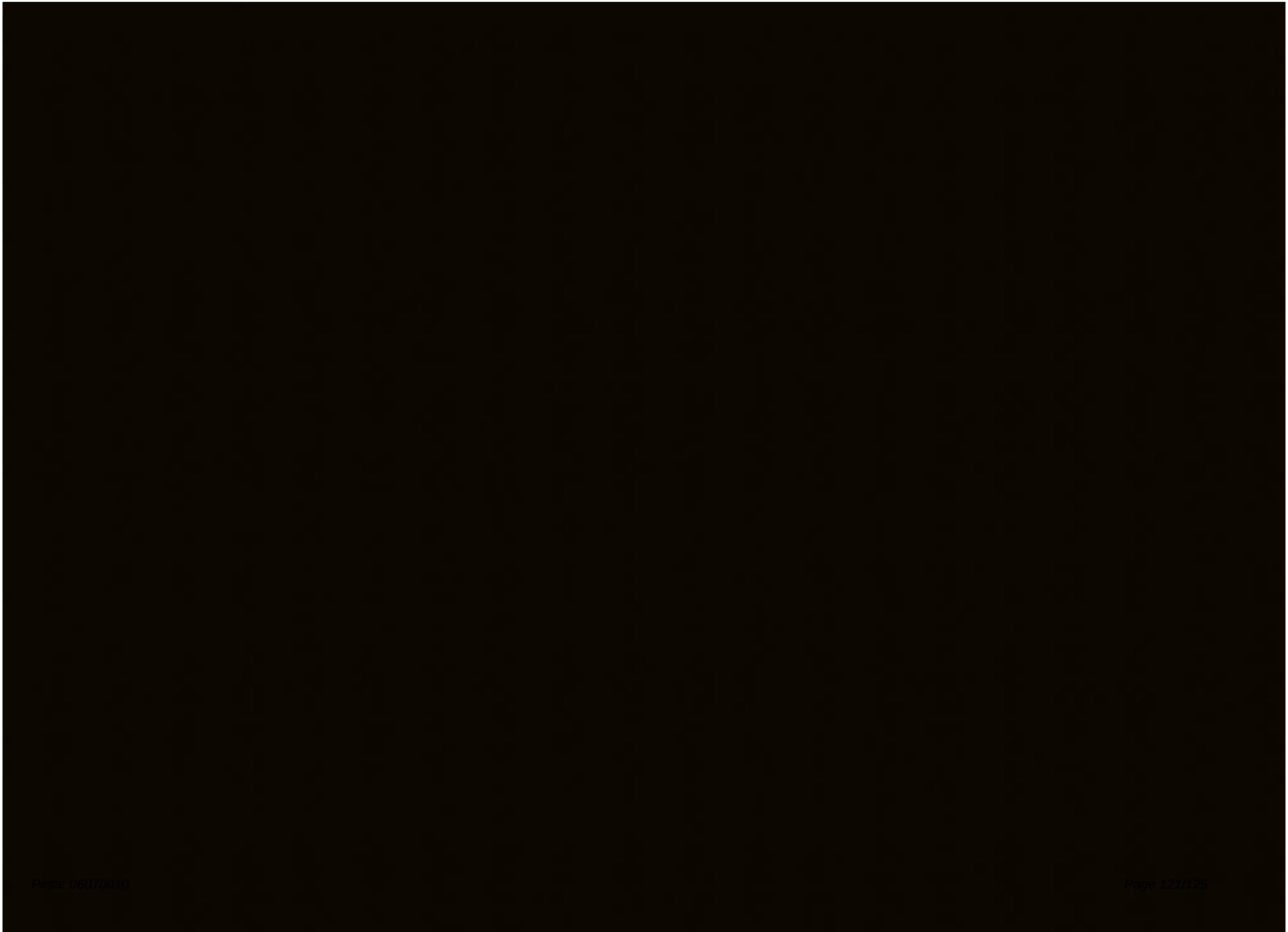

No Signal
VGA-1

a polarizing filter. Through the
filter you will get



Unpolarized light is shone through a polarizing filter. Through the filter you will get

A) all the light

B) light with 1/2 the intensity

C) light with 1/2 the frequency

D) nothing

Unpolarized light is shone through a polarizing filter and then another turned by 90°. Through both filters you will get

A) all the light
B) light with 1/2 the intensity
C) light with 1/4 the intensity
D) nothing

Unpolarized light is shone through a polarizing filter and then another turned by 45°. Through the filter you will get

A) light with 1/2 the intensity
B) light with 1/4 the intensity
C) nothing
D) I don't know

Unpolarized light is shone through a polarizing filter, then one turned by 45° and then one turned by 90° from the original. Through all three you will get

A) light with 1/2 the intensity
B) light with 1/4 the intensity
C) light with 1/8 the intensity
D) nothing