

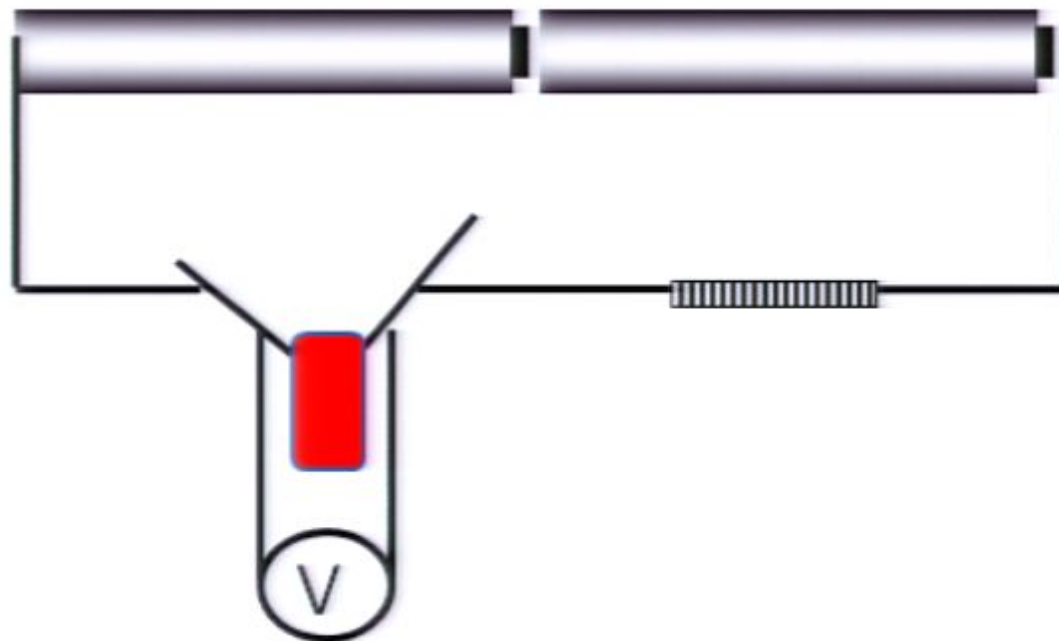
Title: Measuring Planck's Constant Lab

Date: Oct 23, 2010 01:00 PM

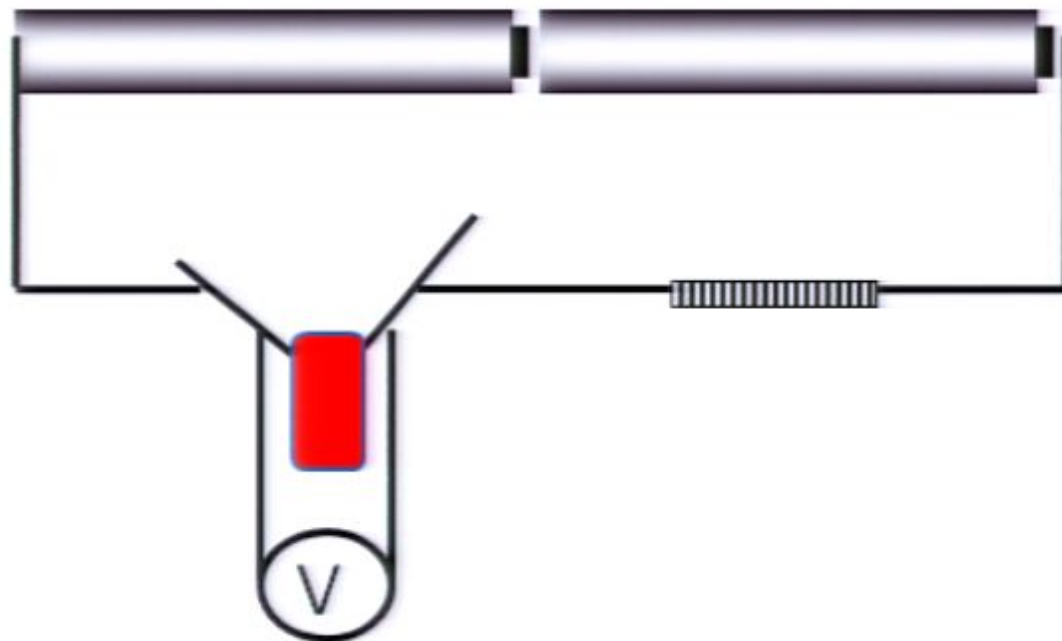
URL: <http://pirsa.org/10100102>

Abstract:

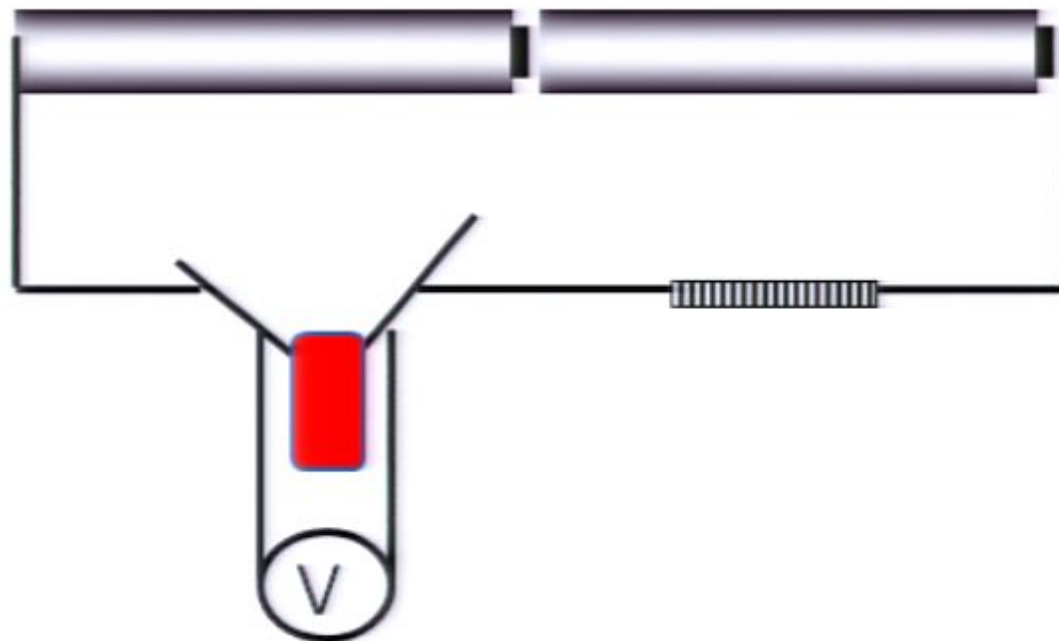
- Put an LED in series with 3 V and a resistor.
- Measure the potential drop across the LED.
- Graph V vs. h .



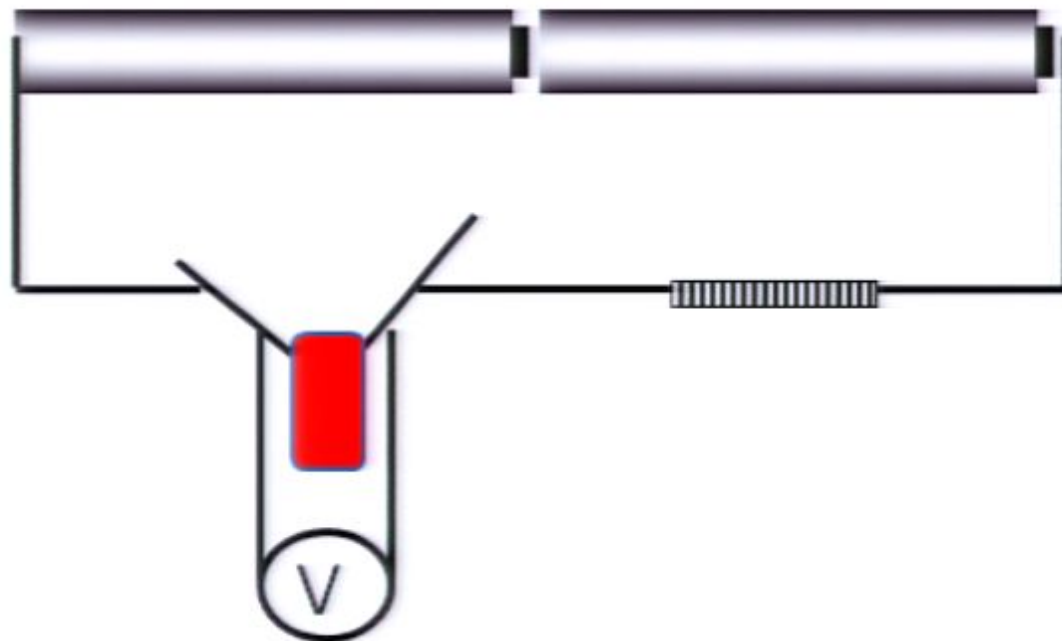
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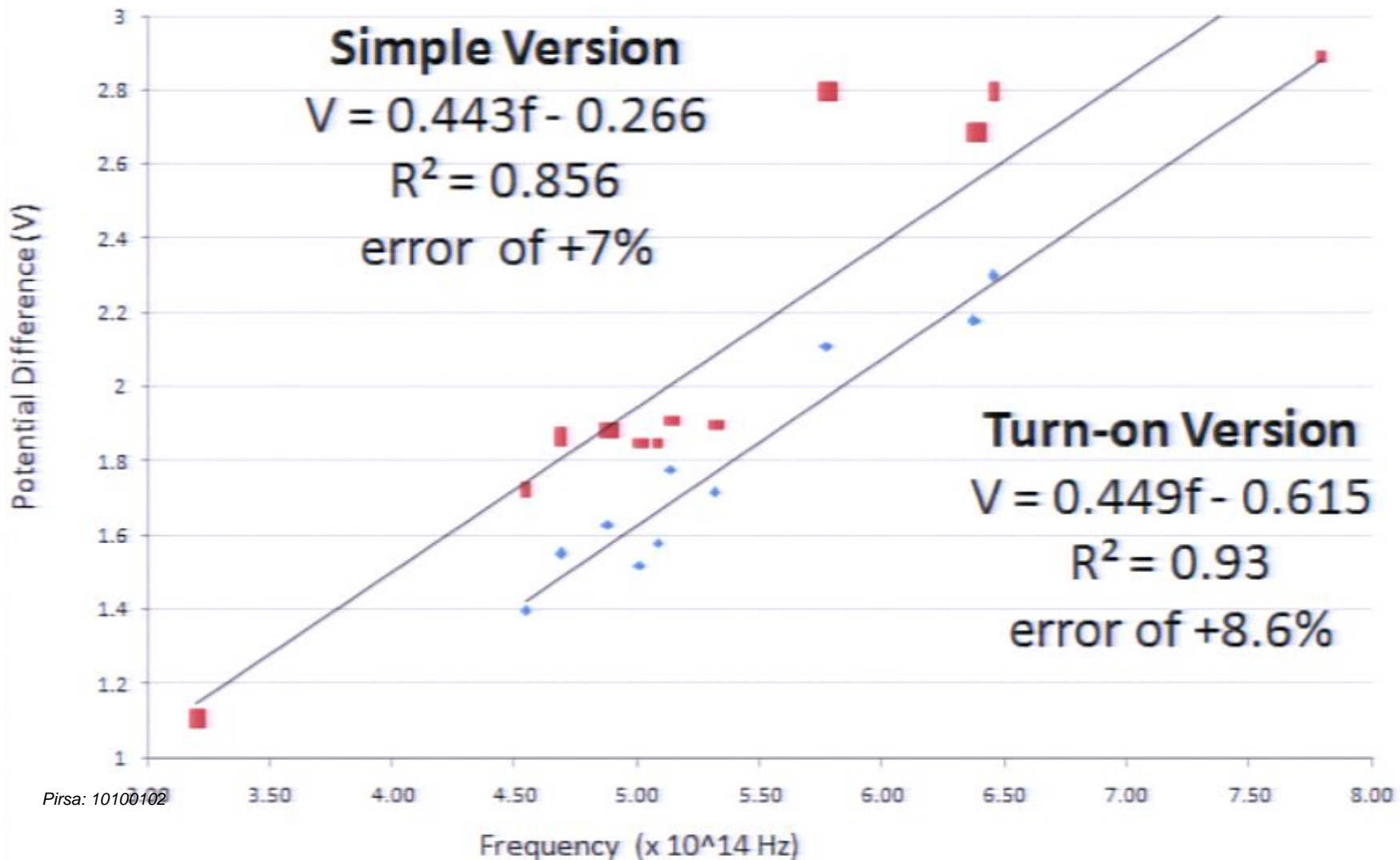


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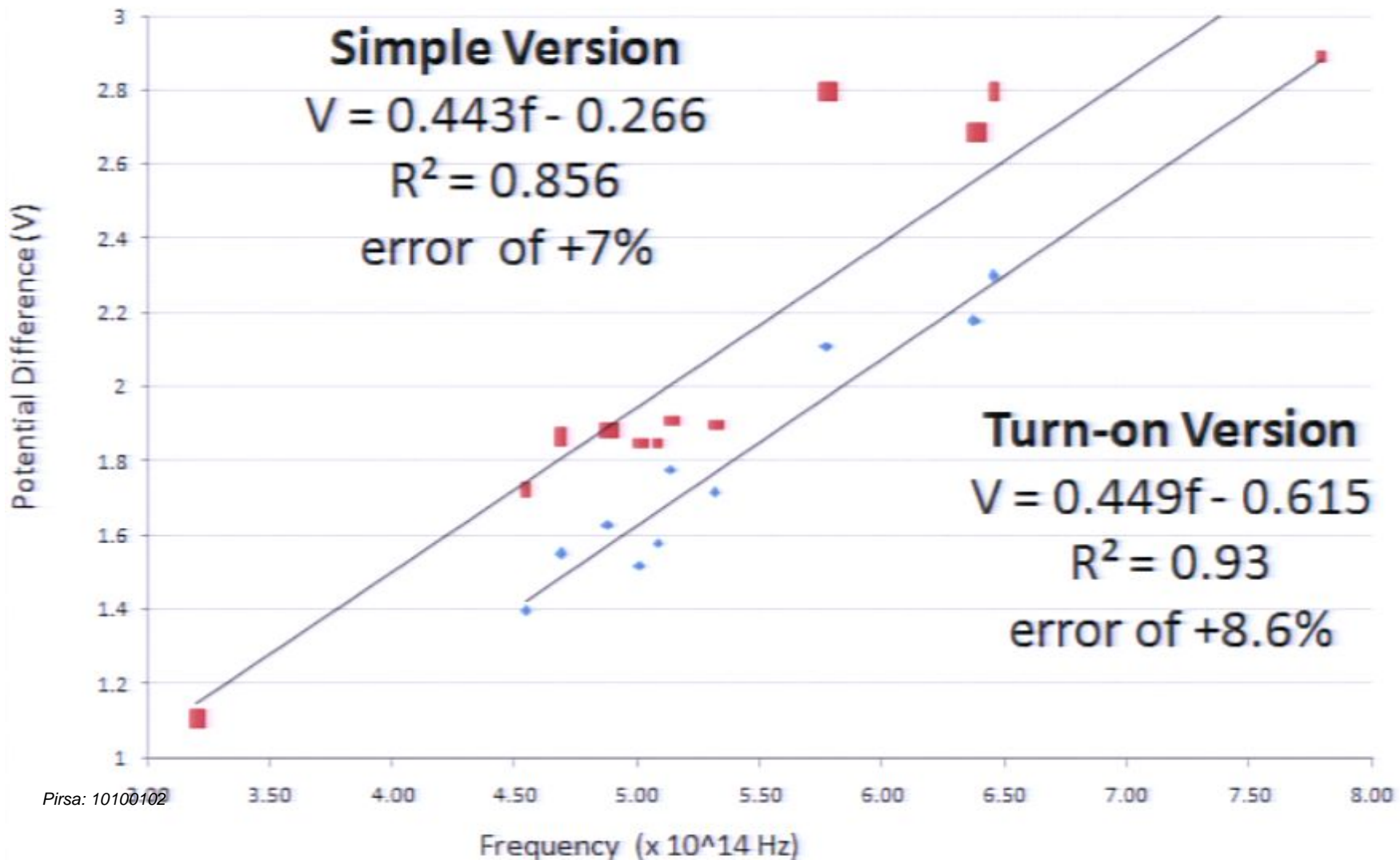
The Results

Measuring h (4.136) with LED's



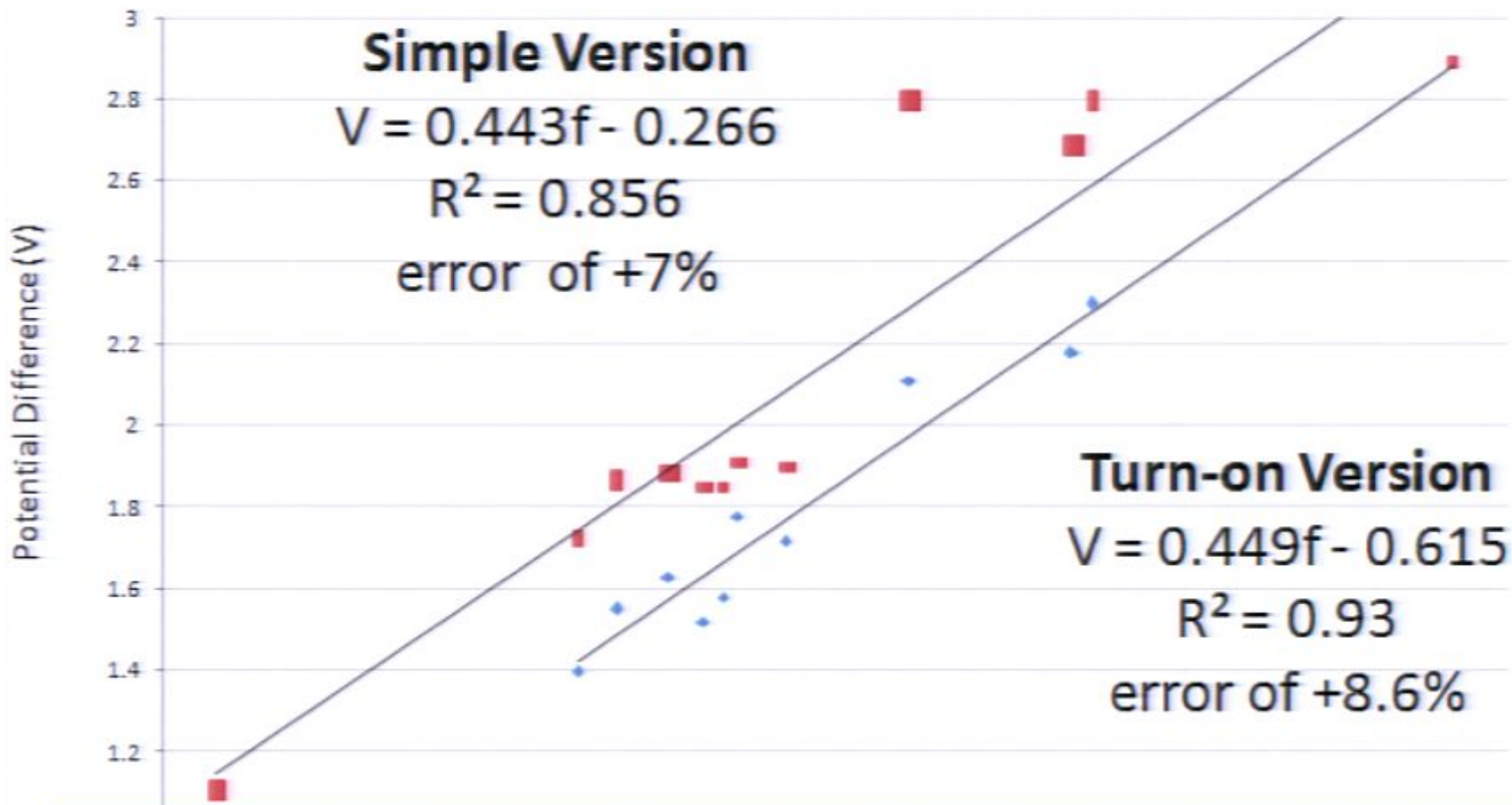
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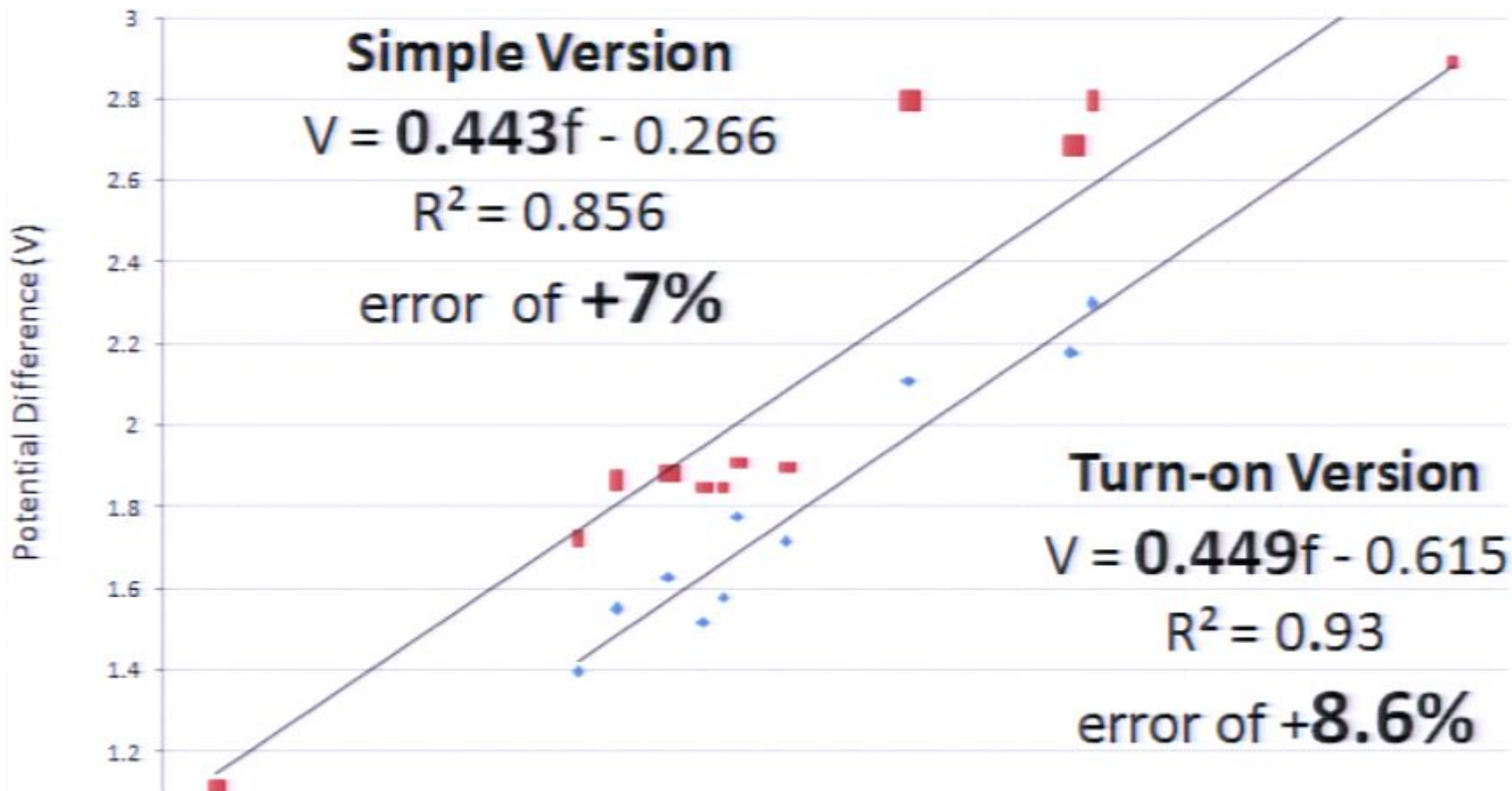
The Results

Measuring h (0.4136) with LED's



The Results

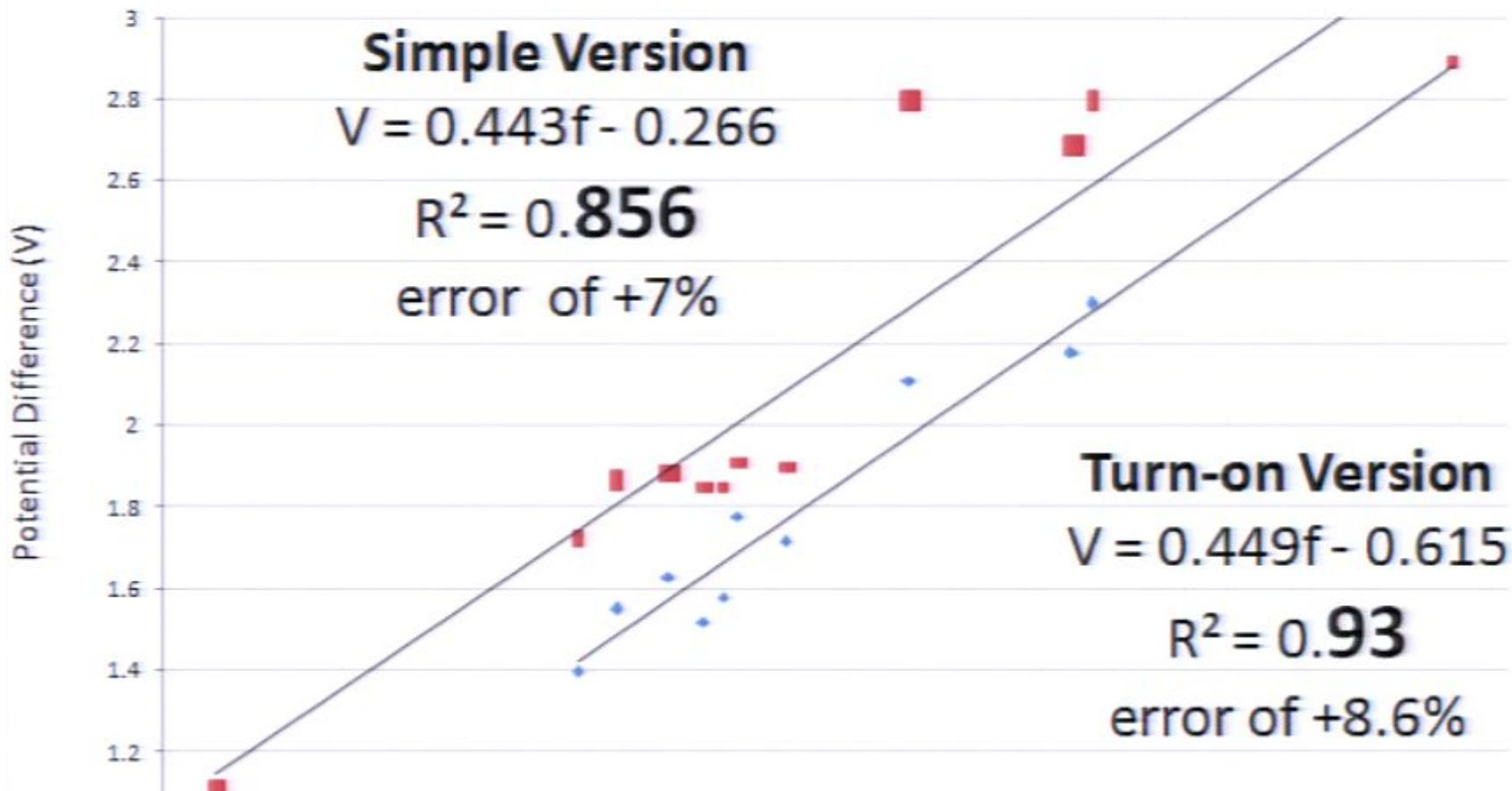
Measuring h (0.4136) with LED's



The values for h are similar.

The Results

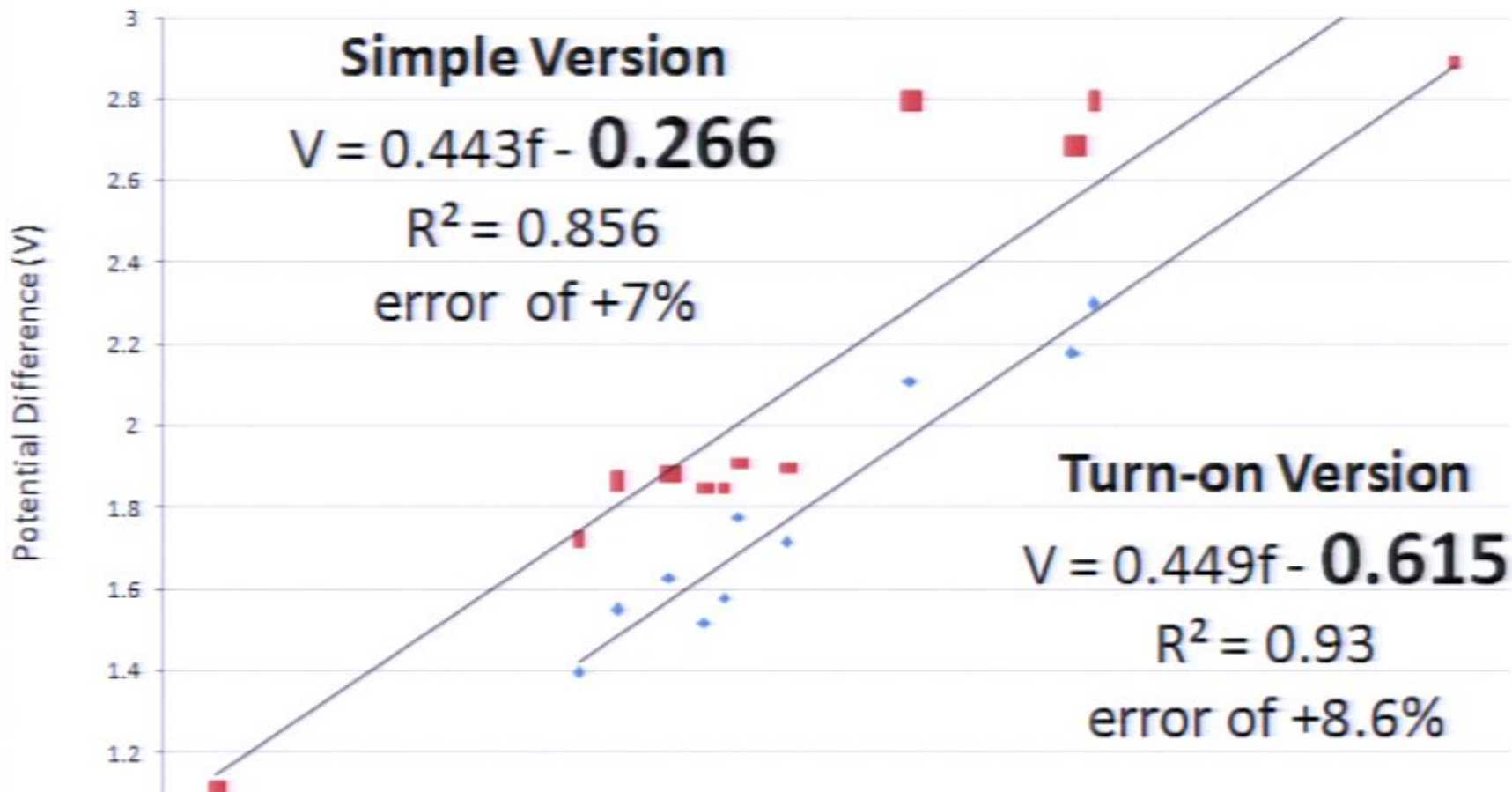
Measuring h (0.4136) with LED's



The simple data has more spread.

The Results

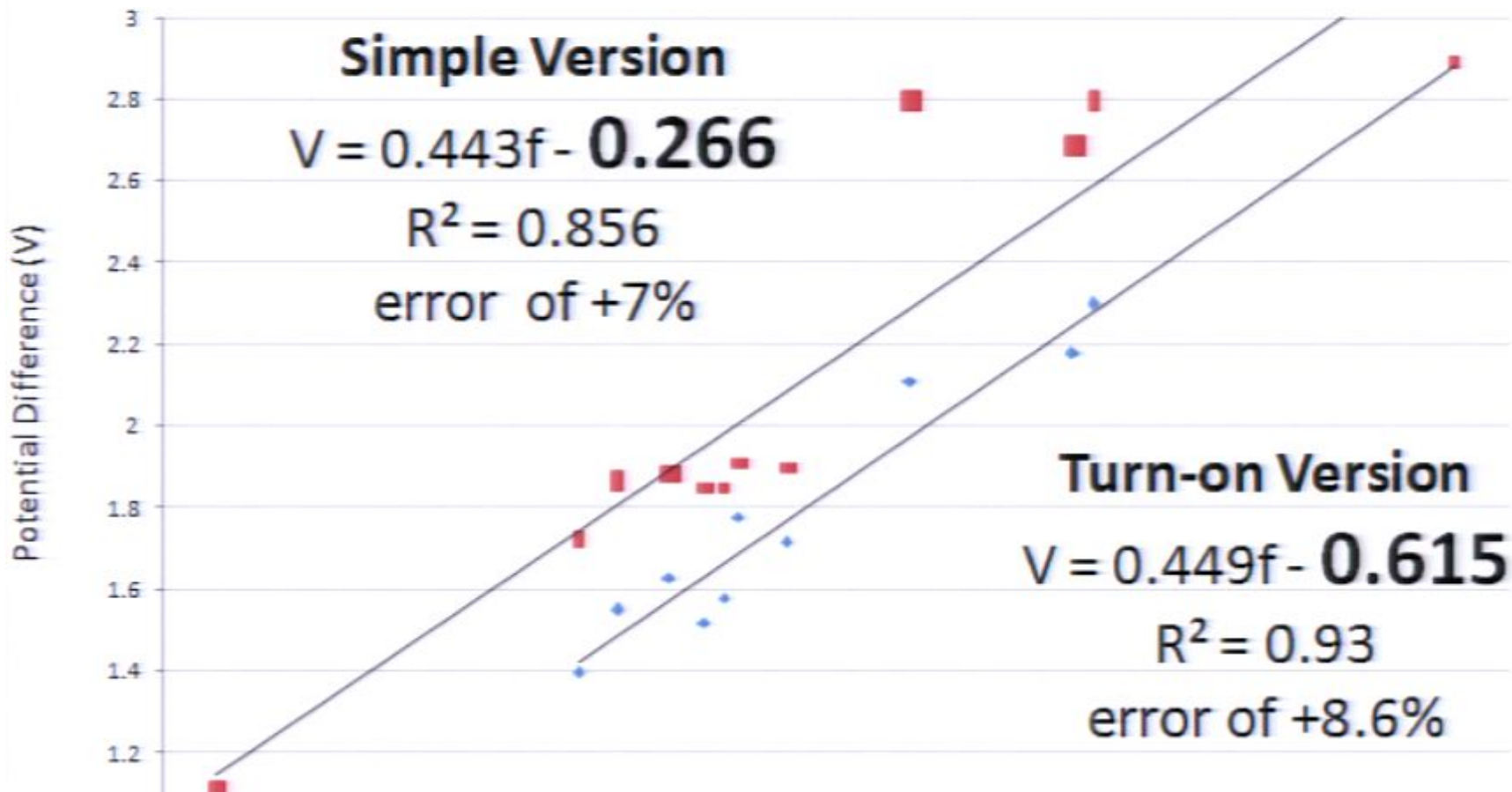
Measuring h (0.4136) with LED's



The simple voltages are higher.

The Results

Measuring h (0.4136) with LED's



The simple voltages are higher.

Why Does it Work?

- It will not work without a resistor. The potential drop of the LED will be close to 3 V for all LEDs.
- It will not work if the resistor is too big. The higher frequency LEDs won't have enough energy to turn on.
- It works if the resistor is somewhere from 10 to 1000 Ω .

Why Does it Work?

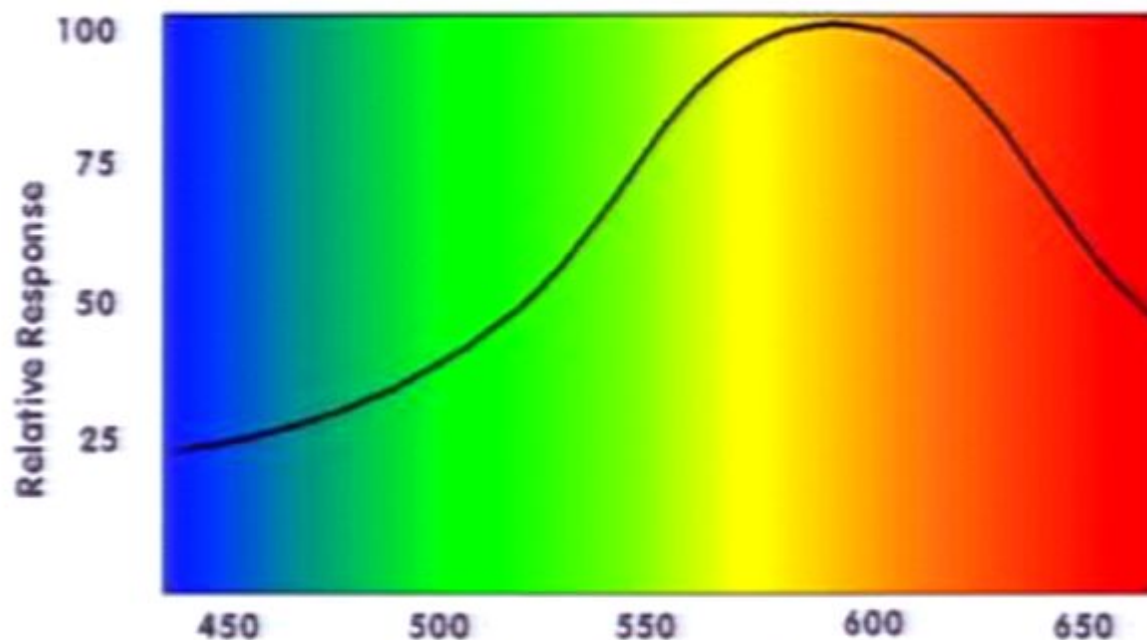
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Why Does it Work?

- The LEDs in this experiment have a larger potential drop than the LEDs in the PI lab.
- These LEDs are running at their peak voltage.



Why Does it Work?

- The LEDs will run at their peak voltage if an appropriate resistor is provided.
- The resistor uses up the excess energy.

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What are the advantages of this version of the lab?

What are the disadvantages?

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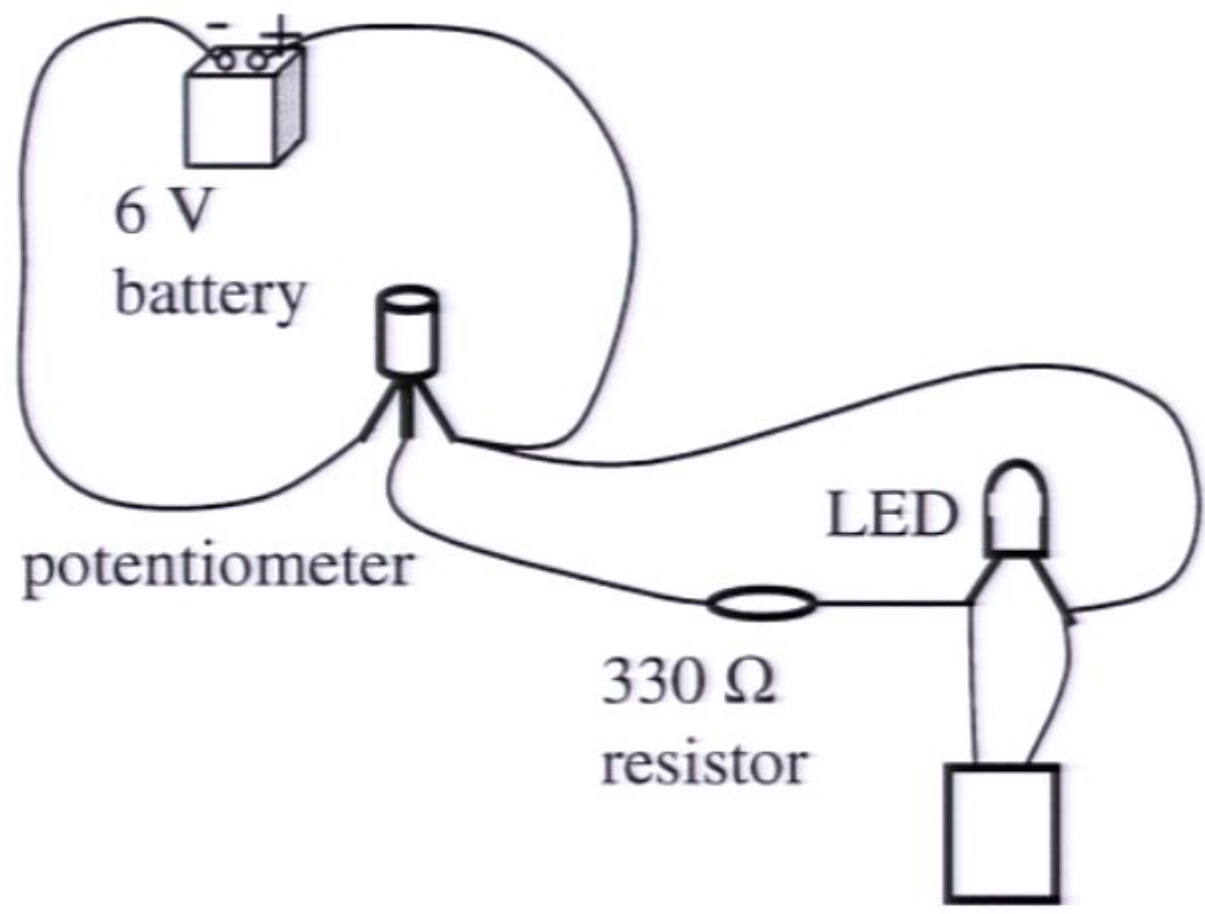
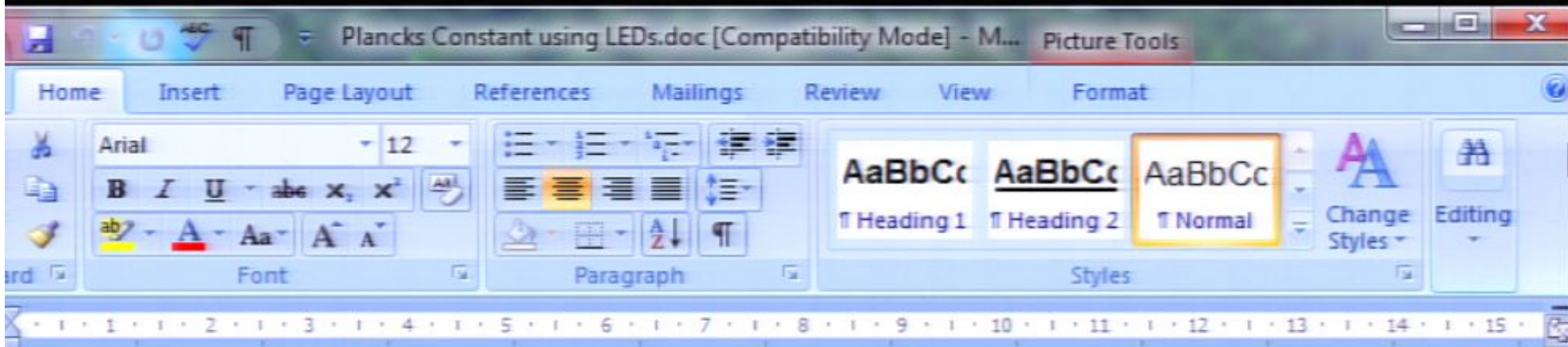
ther

Problem Ejecting USB Mass Storage Device

 Windows can't stop your 'Generic volume' device because it is in use. Close any programs or windows that might be using the device, and then try again later.

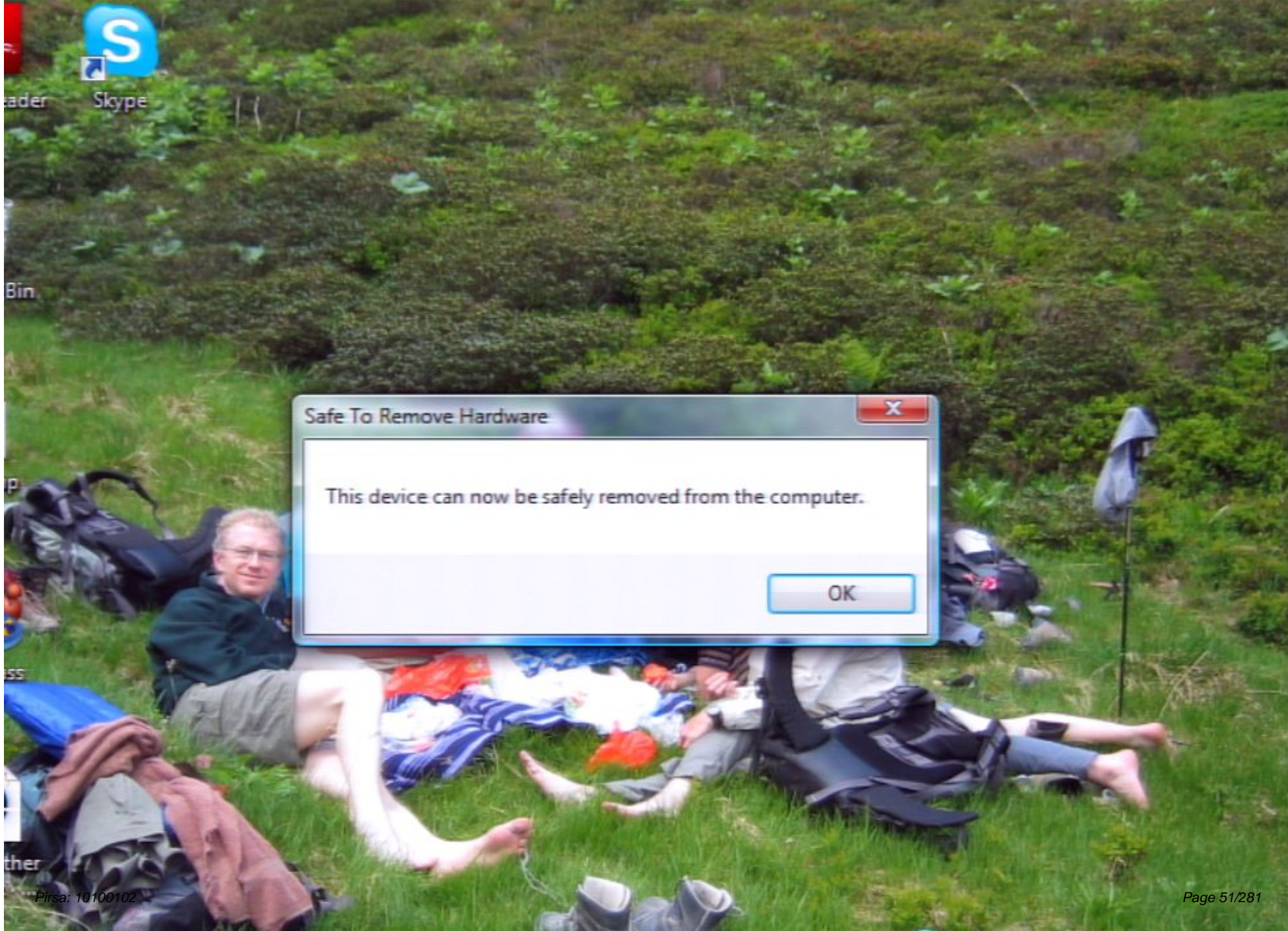
OK











Safe To Remove Hardware

This device can now be safely removed from the computer.

OK





The desktop background features a large, detailed image of the planet Saturn with its rings. Various application icons are scattered across the screen, including:

- DSC-S2100 Handbo...
- Add to sci 30
- PI Presentation
- PMB Help
- Norton Intern...
- Canon Soluti...
- Skype
- Quiz of the day
- DVD-Cloner VII
- Quiz of the Day friction
- DivX Plus Converter
- Phet Applets
- PI stuff 2010
- MP Navigator EX 2.0
- Principles of Physics
- Presentation1
- Completed AP Materials
- CanoScan LiDE 200...
- RealPlayer SP
- PMB Launcher
- Physics AP
- Projects

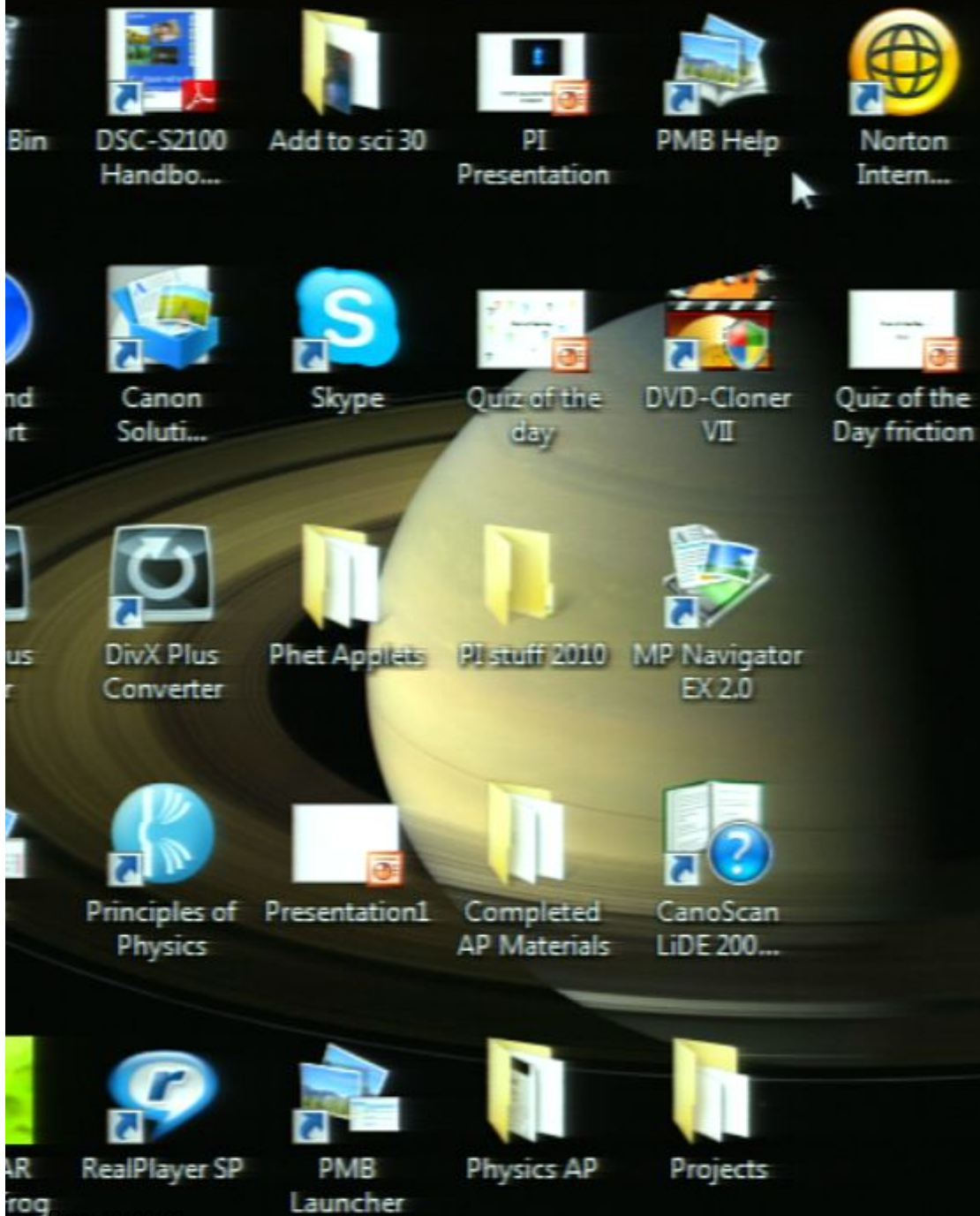
Teachers, students, F...
MSNBCN... Thu Oct 21

Giants walk off with ...
MSNBCN... Wed Oct 20

PFT: Magic wants to ...
MSNBCN... Wed Oct 20

Appeals court: Milita...
MSNBCN... Wed Oct 20

▲ 29-32 ▼



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▲ 29-32 ▼



Bin



DSC-S2100
Handbo...



Add to sci 30



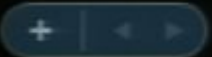
PI
Presentation



PMB Help



Norton
Intern...



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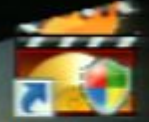
Canon
Soluti...



Skype



Quiz of the
day



DVD-Cloner
VII



Quiz of the
Day friction

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DivX Plus
Converter



Phet Applets



PI stuff 2010

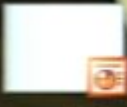


MP Navigator
EX 2.0

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Principles of
Physics



Presentation1



Completed
AP Materials



CanoScan
LiDE 200...

AR
rog



RealPlayer SP



PMB
Launcher



Physics AP



Projects



Bin

DSC-S2100
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Principles of
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Projects

Font Paragraph Drawing Editing

B *I* U ~~abc~~ **S** ΔV \leftrightarrow Aa A

Shapes Arrange Quick Styles



Ohm's Law and Planck's Constant

Click to add notes



Ohm's Law and Planck's Constant

PEOE: (Predict, Explain, Observe, Explain)



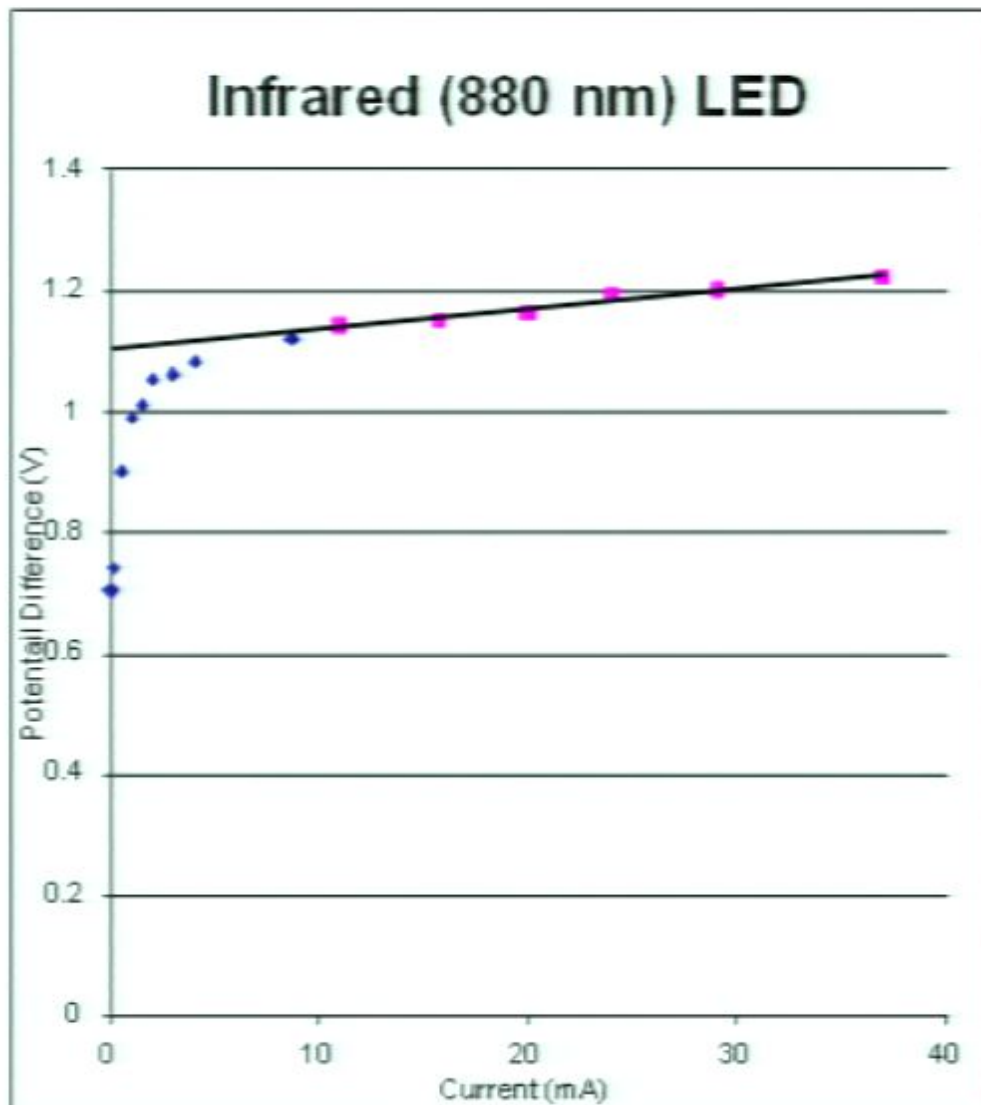
- An LED is attached to a variable power supply. The voltage will be slowly increased from zero. What will you see?

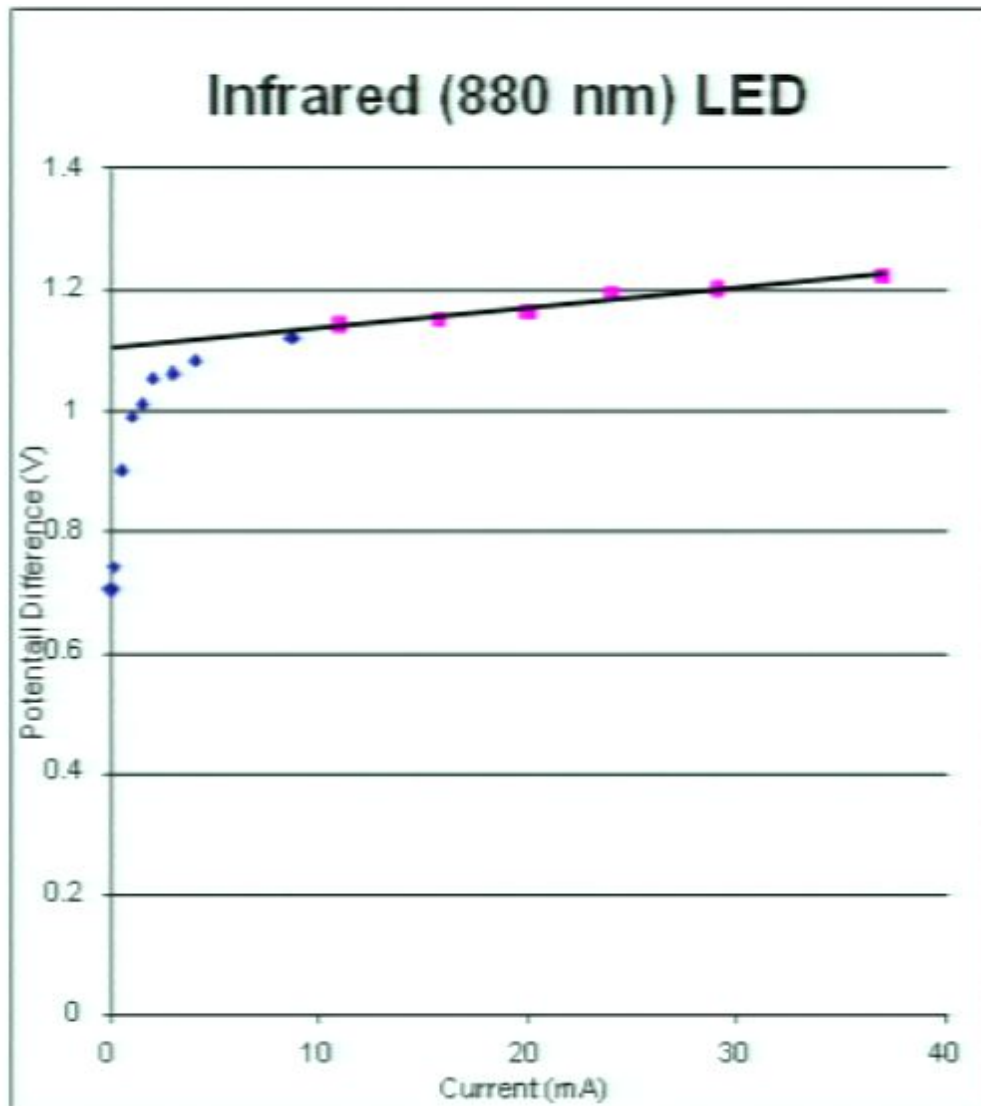
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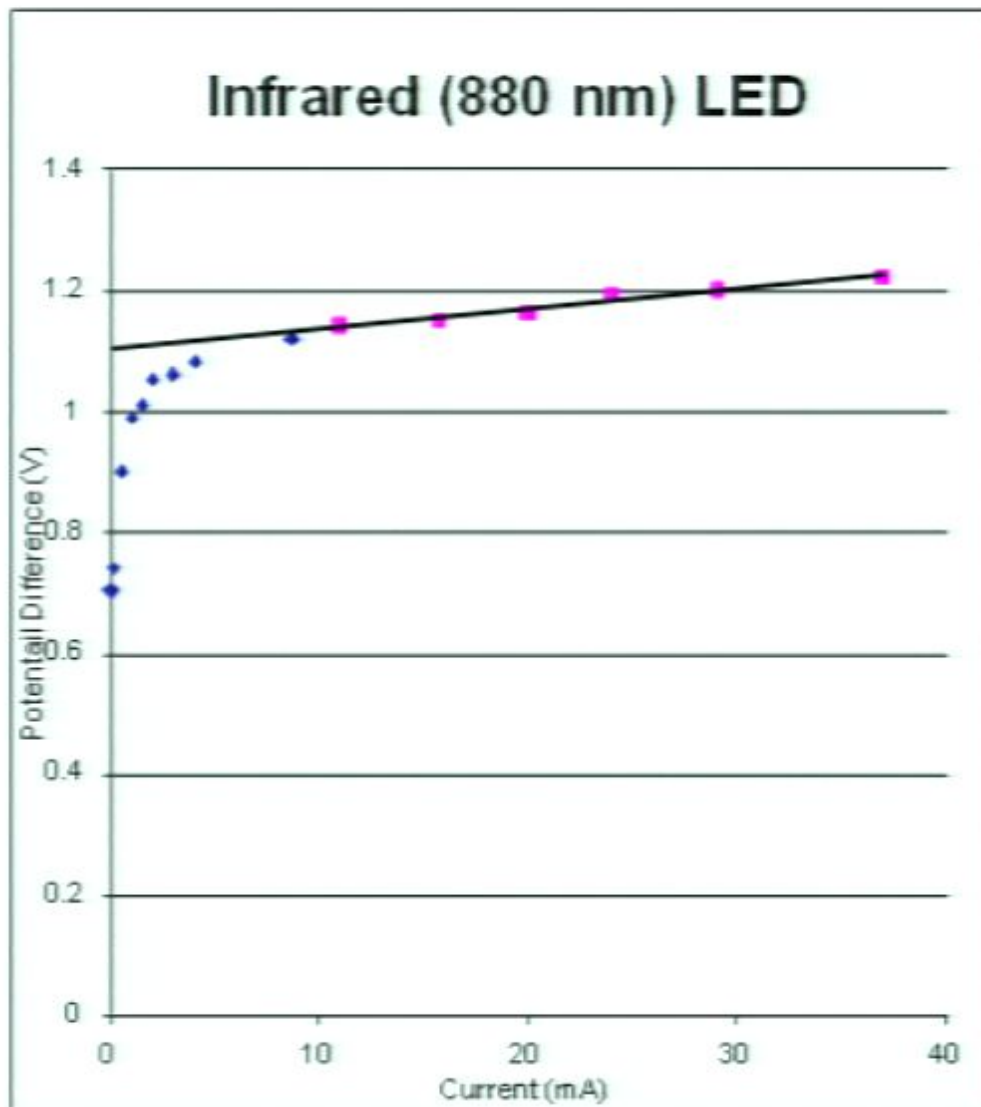
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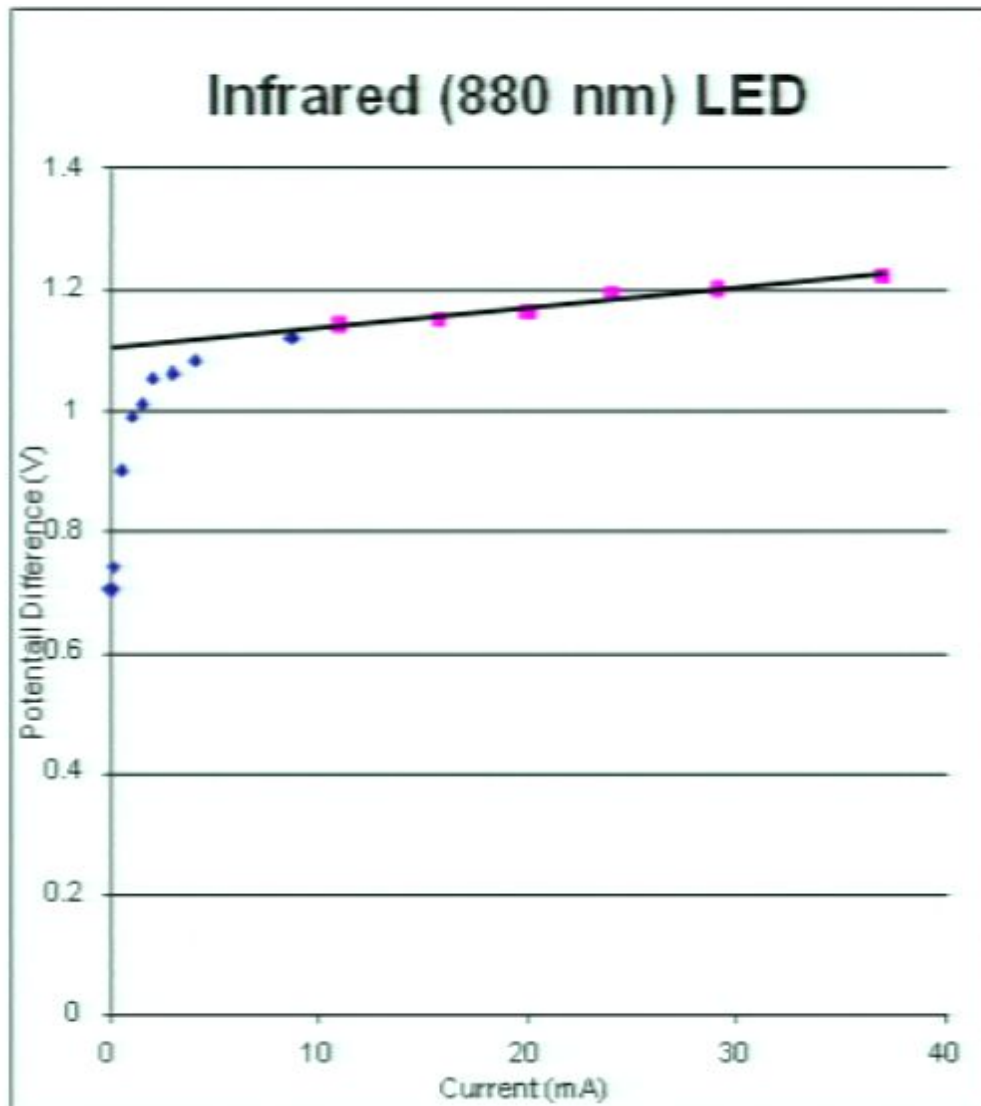
- What will a graph of V vs. I look like?





This is very different from Ohm's Law.





If the LED voltage is less than the threshold voltage, no current flows and no light is emitted

Ohm's Law

- Can use the LED lab as an application of Ohm's Law
- The resistor value can be determined by

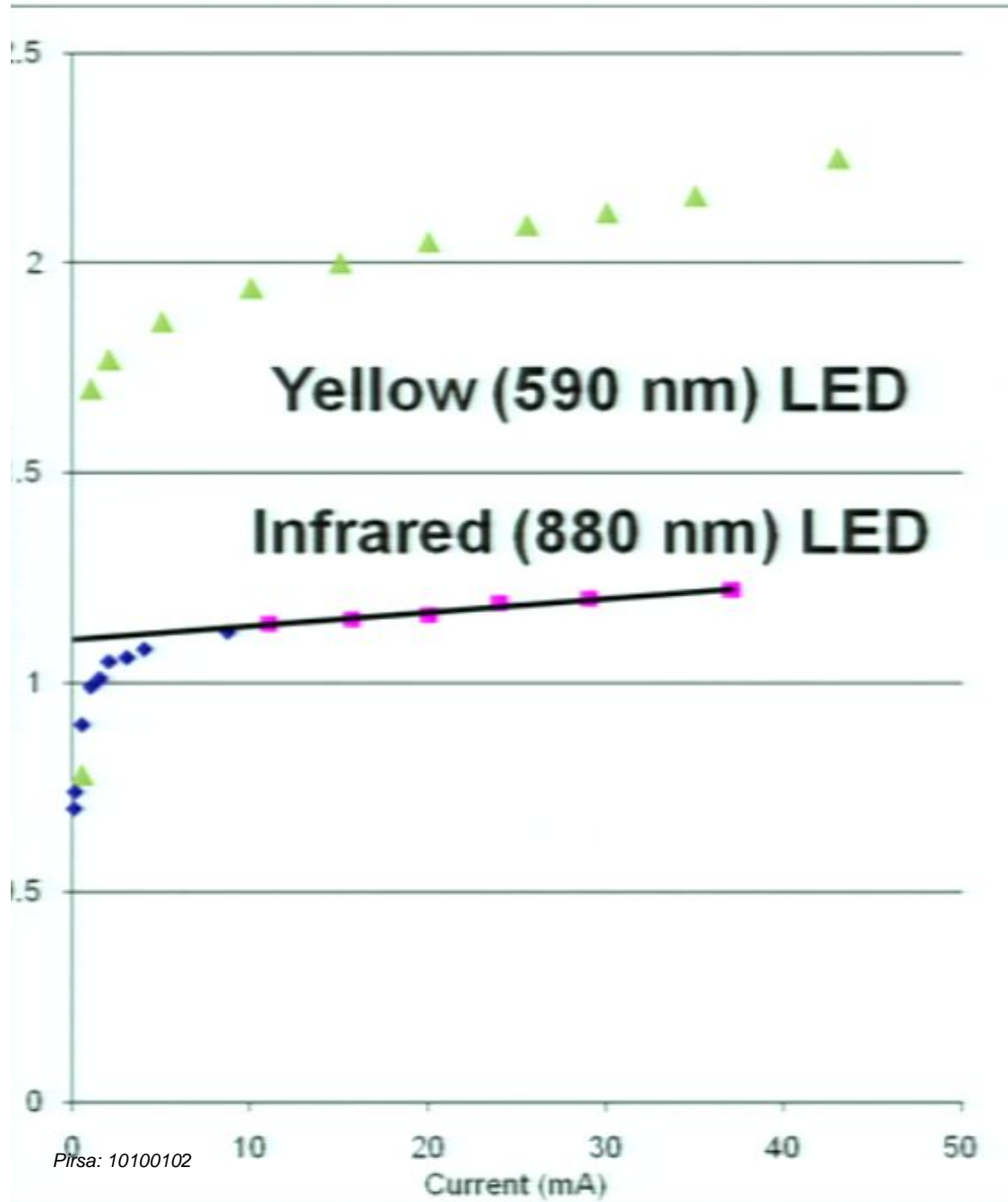
$$R = \frac{V_s - V_L}{I}$$

V_s = supply voltage

V_L = voltage needed to light LED

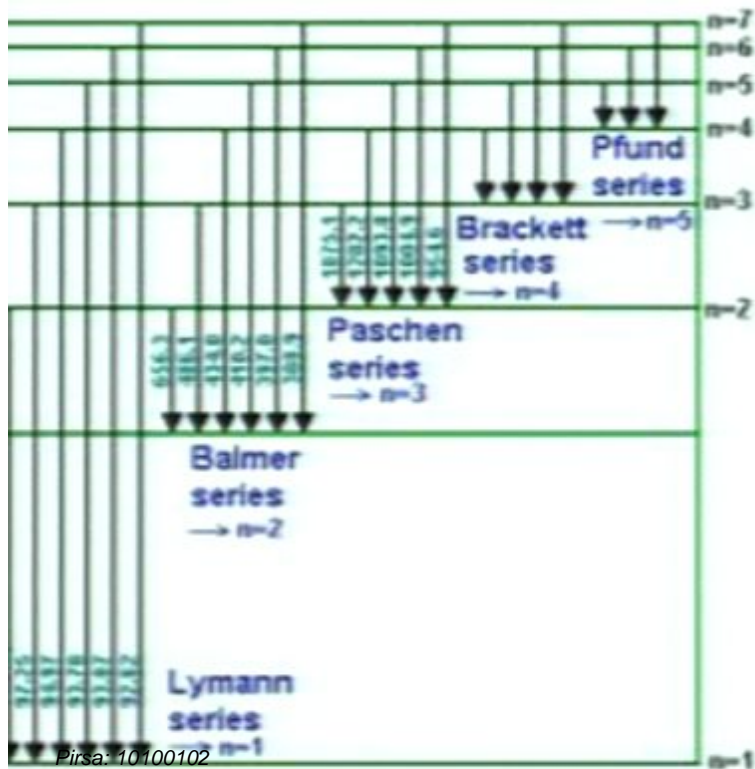
PEOE:

How will a graph of a yellow LED compare to an infrared LED?

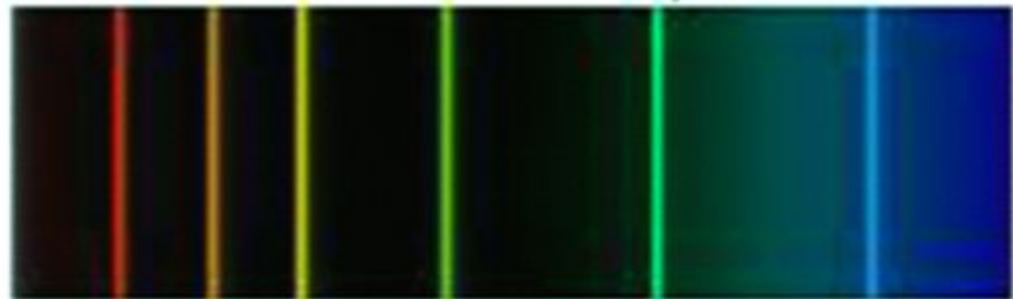


The yellow LED needs a higher voltage than the infrared LED.

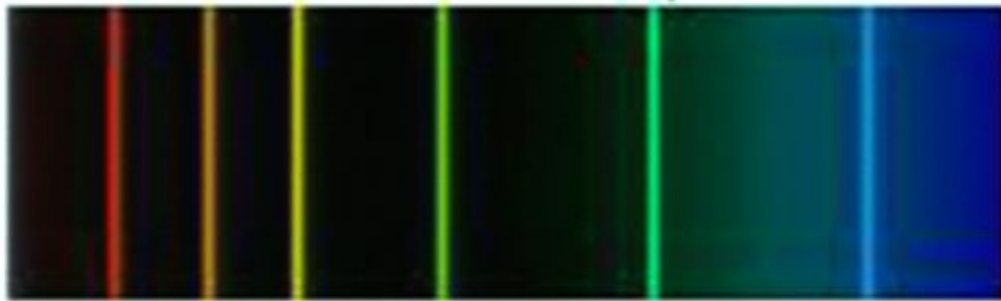
Each LED will only produce a certain colour and each colour requires a certain minimum energy. This is very similar to atomic spectra. Energy comes in chunks in quantum physics.



Emission Line Spectrum



Emission Line Spectrum



- Each line is emitted by a unique energy transition of electrons in an atom
- Similar physics happens in a LED

“Subversive” Physics

If your curriculum has no quantum physics in it:

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If your curriculum has no quantum physics in it:

- Where could you fit the LED lab in?

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“Subversive” Physics

If your curriculum has no quantum physics in it:

- Where could you fit the LED lab in?
- If your curriculum has quantum physics, but not until grade 12, where could you fit it in earlier?
- Would you do this? Why or why not?

Possibility?

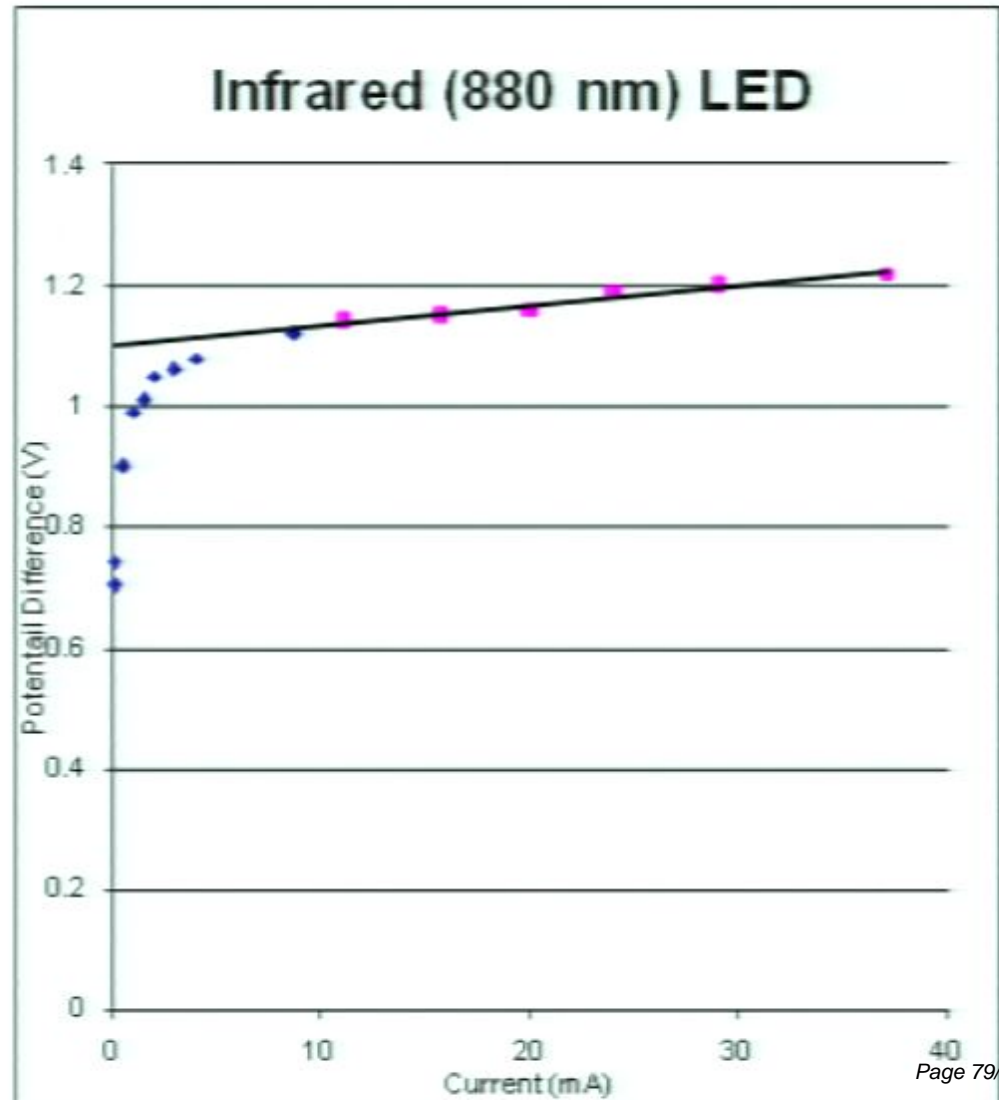
Possibility?

- Relate the wavelength to the differences in Bohr energy levels from chemistry class?

Possibility?

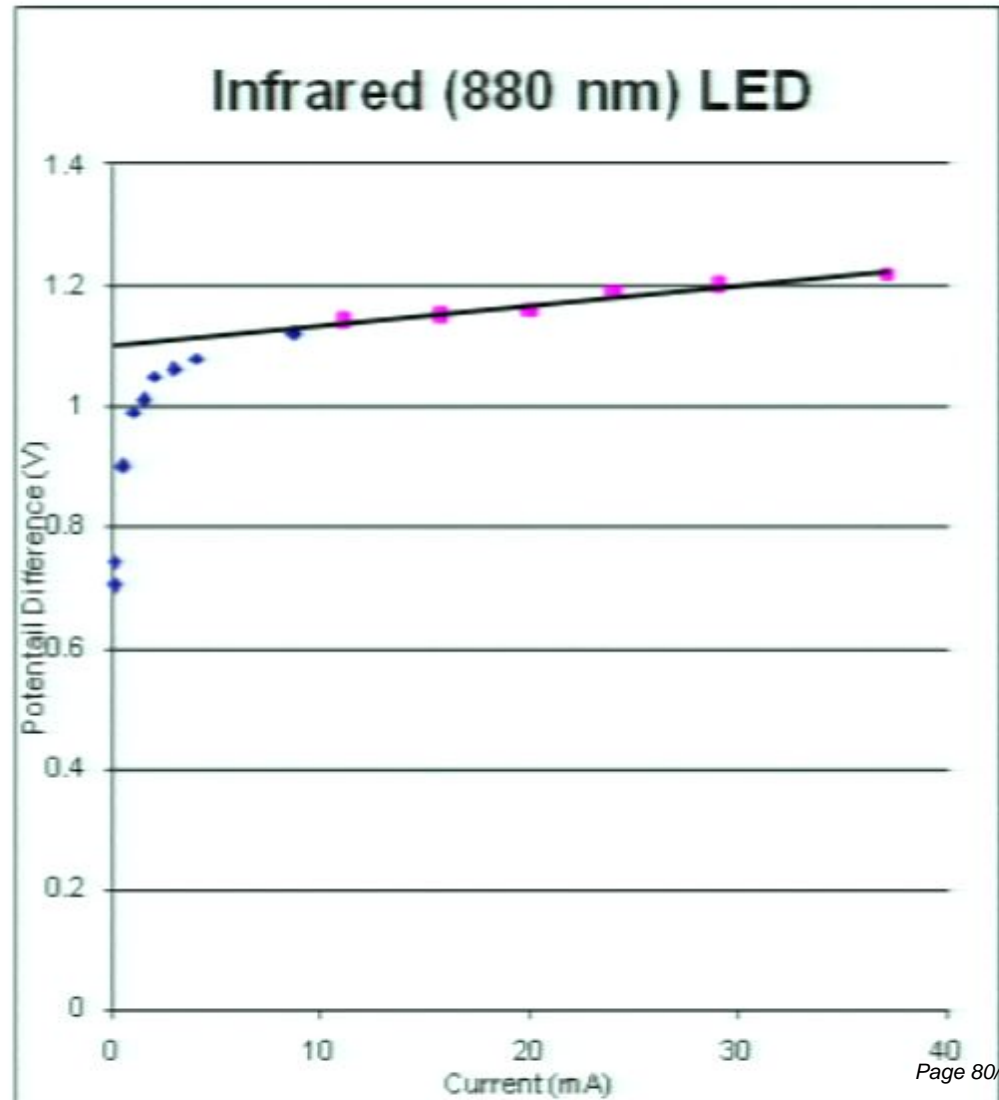
- Relate the wavelength to the differences in Bohr energy levels from chemistry class?
- The physics at the atomic scale is different than at macroscopic scales (give'em quantum anyway!)

Possibility?



Possibility?

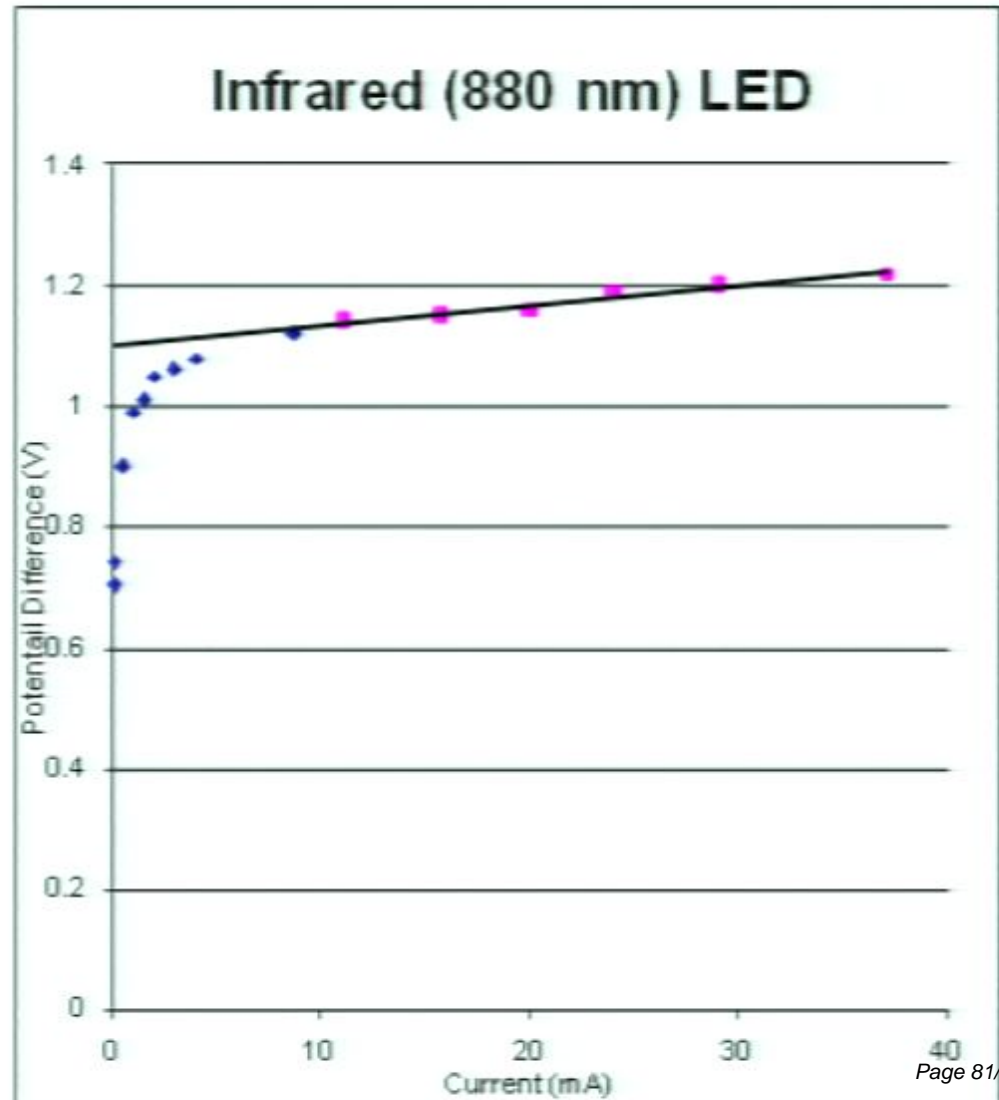
Circuits and energy conservation?



Possibility?

Circuits and energy conservation?

More current, more light (up to a point)

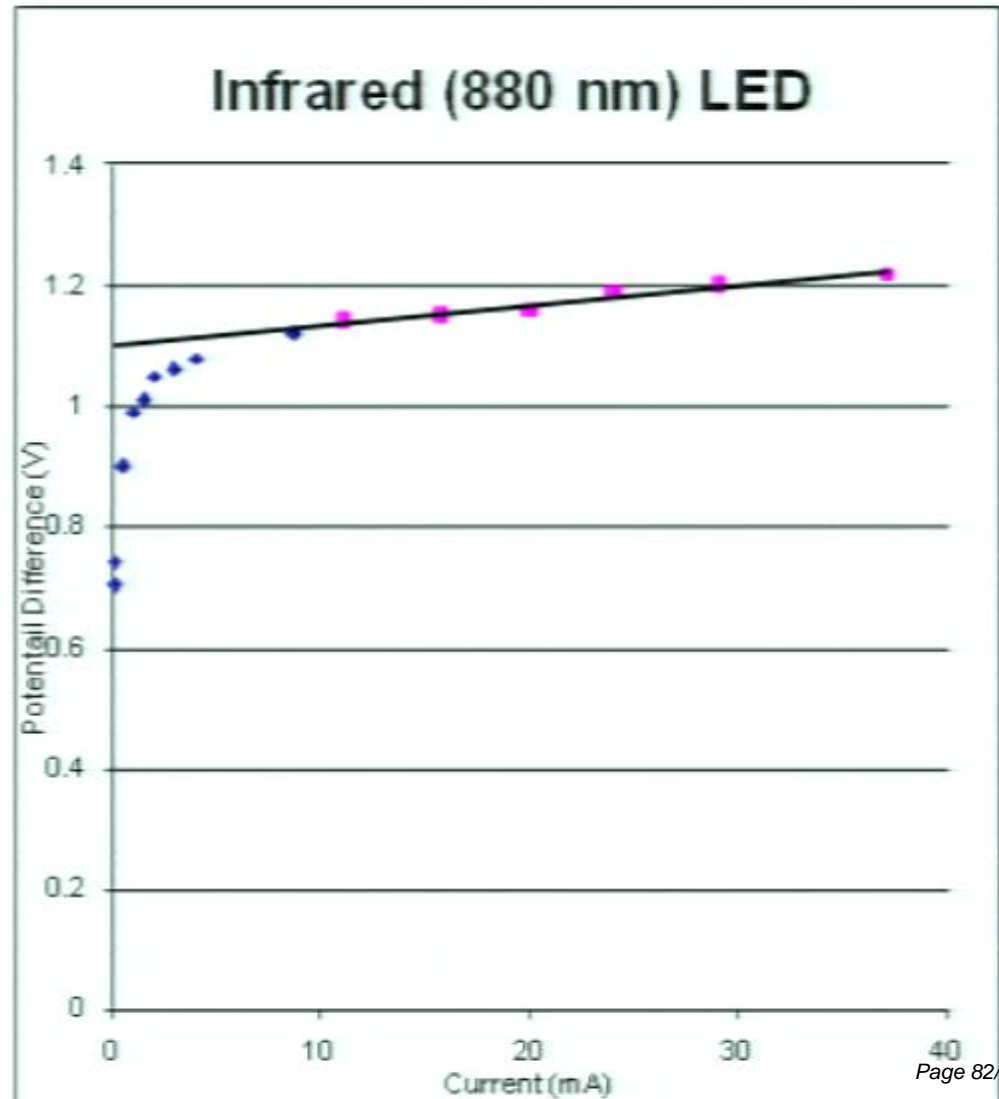


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$$E_{\text{supply}} = E_{\text{resistance}} + E_{\text{LED}}$$



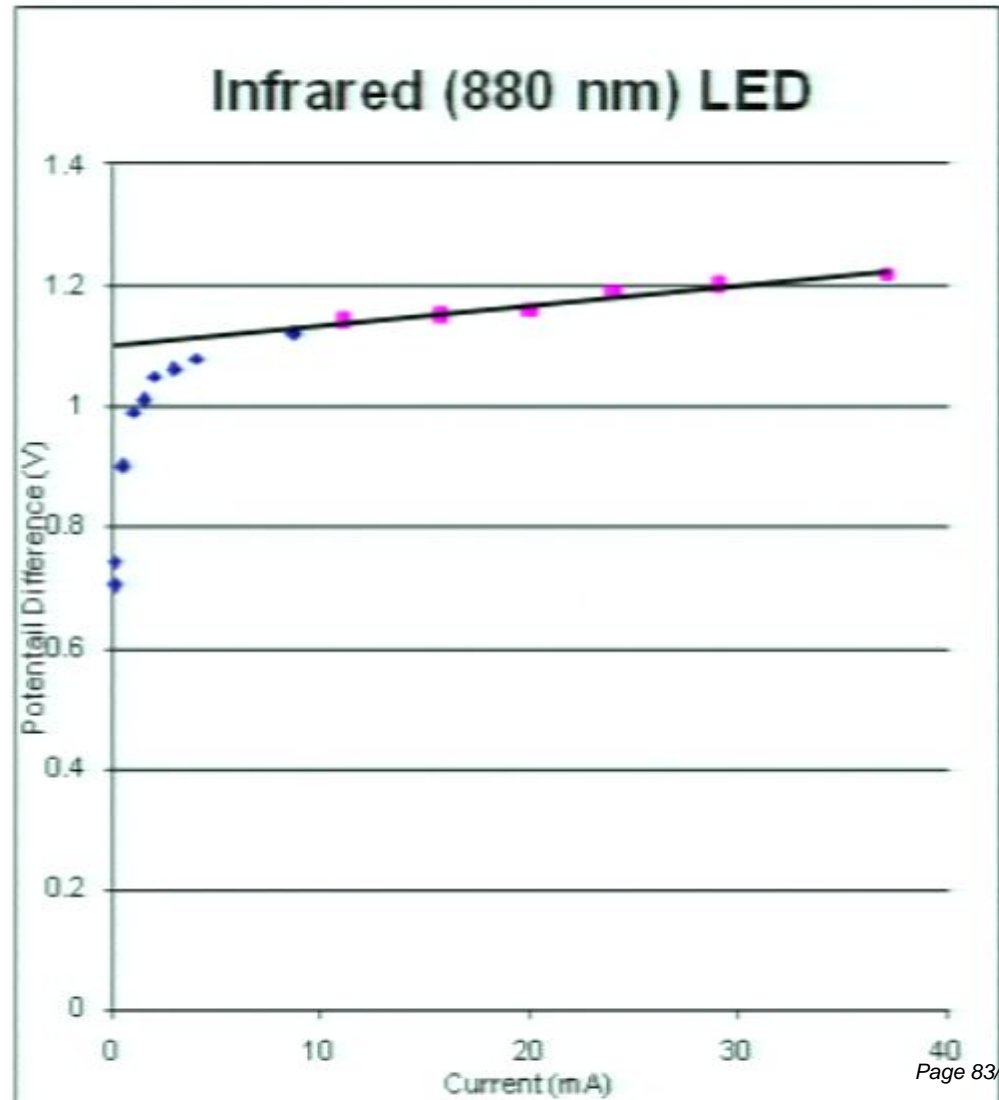
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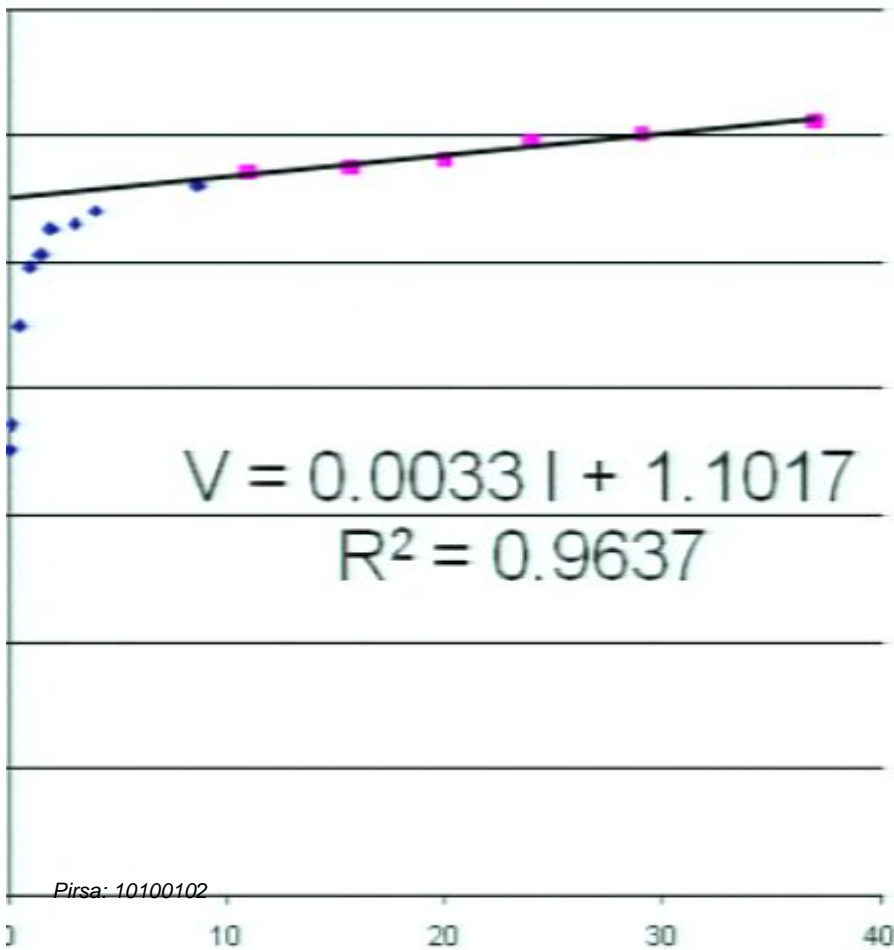
$$E_{\text{supply}} = E_{\text{resistance}} + E_{\text{LED}}$$

With Watt's Law & CBL spectrometer, can relate intensity to electrical energy



LED Lab v 3

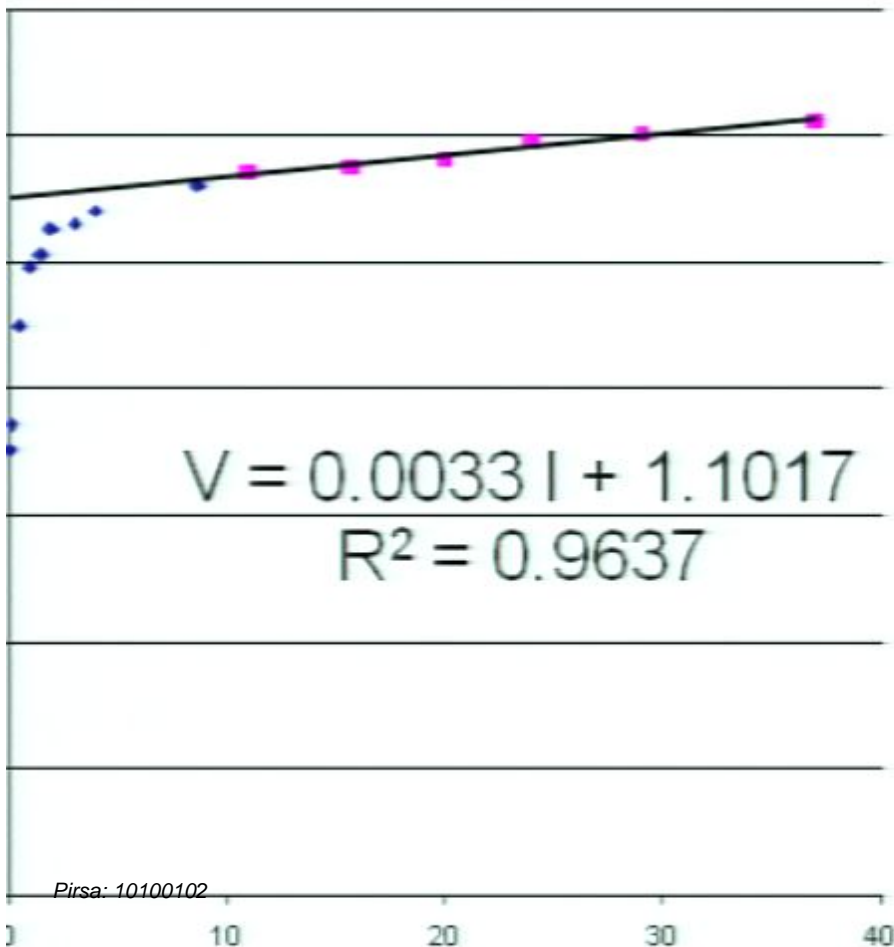
Infrared (880 nm) LED



- A third way to do the lab is to use the intercept of the linear portion as the voltage required to create the light.

LED Lab v 3

Infrared (880 nm) LED



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- The y-intercept implies that the minimum energy to make the LED emit is 1.1 eV

Using Planck's Law, how much energy IS needed to make the LED work?

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$$E = \frac{hc}{\lambda}$$

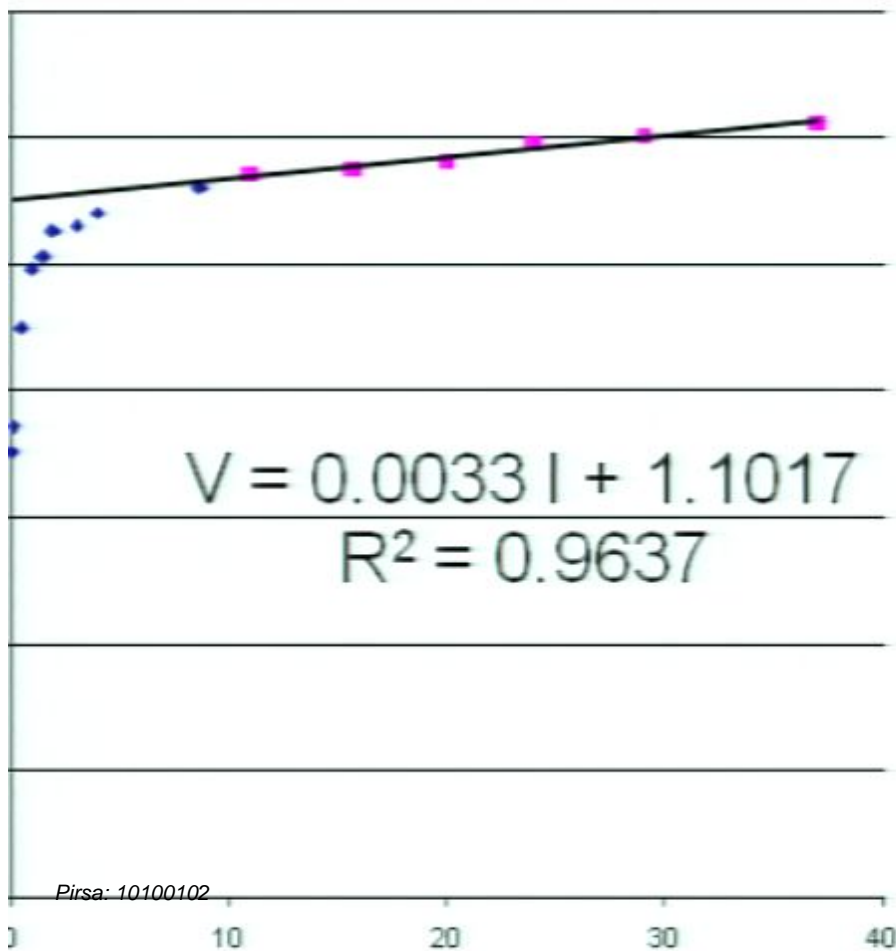
$$E = \frac{4.14 \times 10^{-15} \text{ eV} \cdot \text{s} \times 3.00 \times 10^8 \text{ m/s}}{880 \times 10^{-9} \text{ m}}$$

$$E = 1.41 \text{ eV}$$

What are the advantages of doing this version?

LED Lab v 3

Infrared (880 nm) LED



- A third way to do the lab is to use the intercept of the linear portion as the voltage required to create the light.
- The y-intercept implies that the minimum energy to make the LED emit is 1.1 eV

Using Planck's Law, how much energy IS needed to make the LED work?

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Why doesn't "it" work "better"?

- Experimental design

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- A range is emitted with the brightest λ reported in the specs

Why doesn't "it" work "better"?

(Answered)

- LEDs don't emit a single wavelength
- A range is emitted with the brightest λ reported in the specs
- Different materials will give different ranges

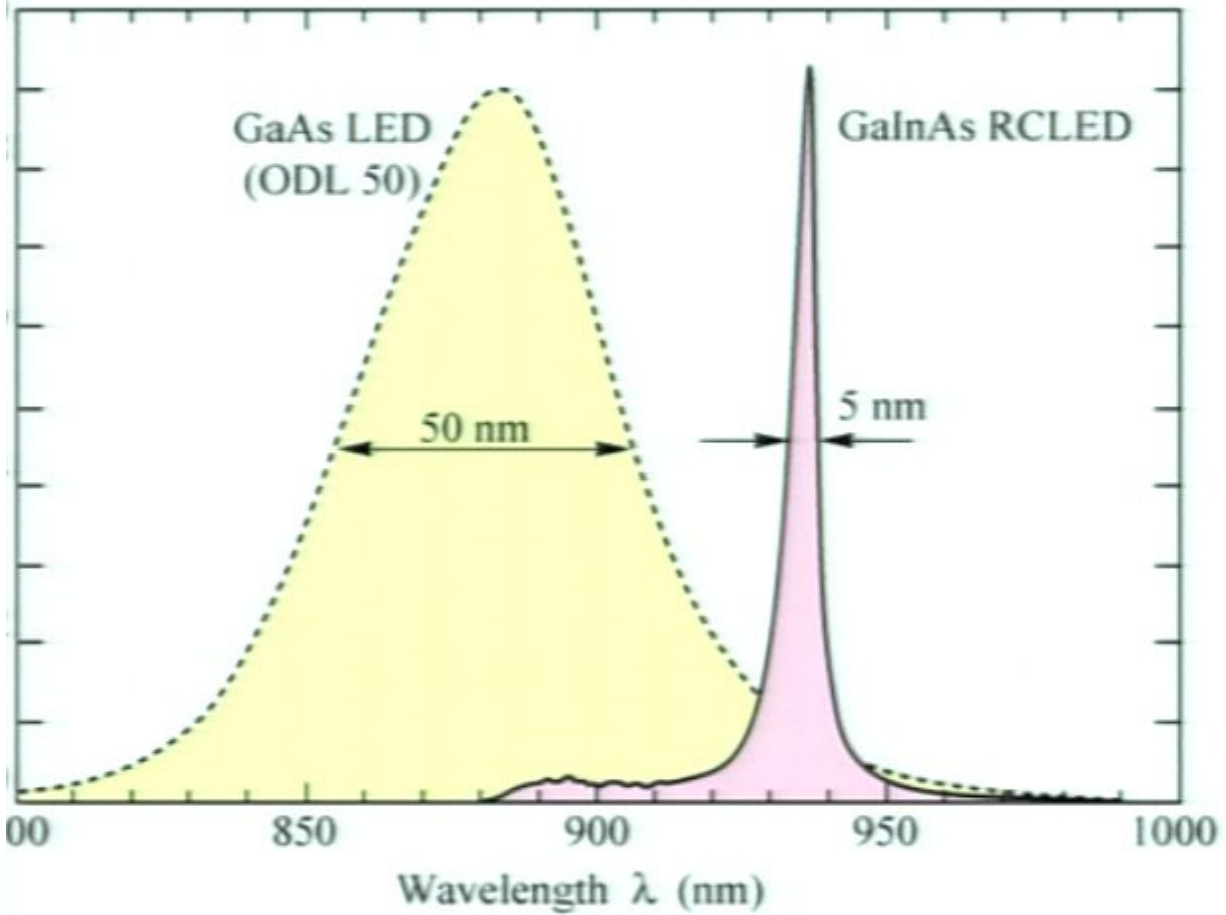
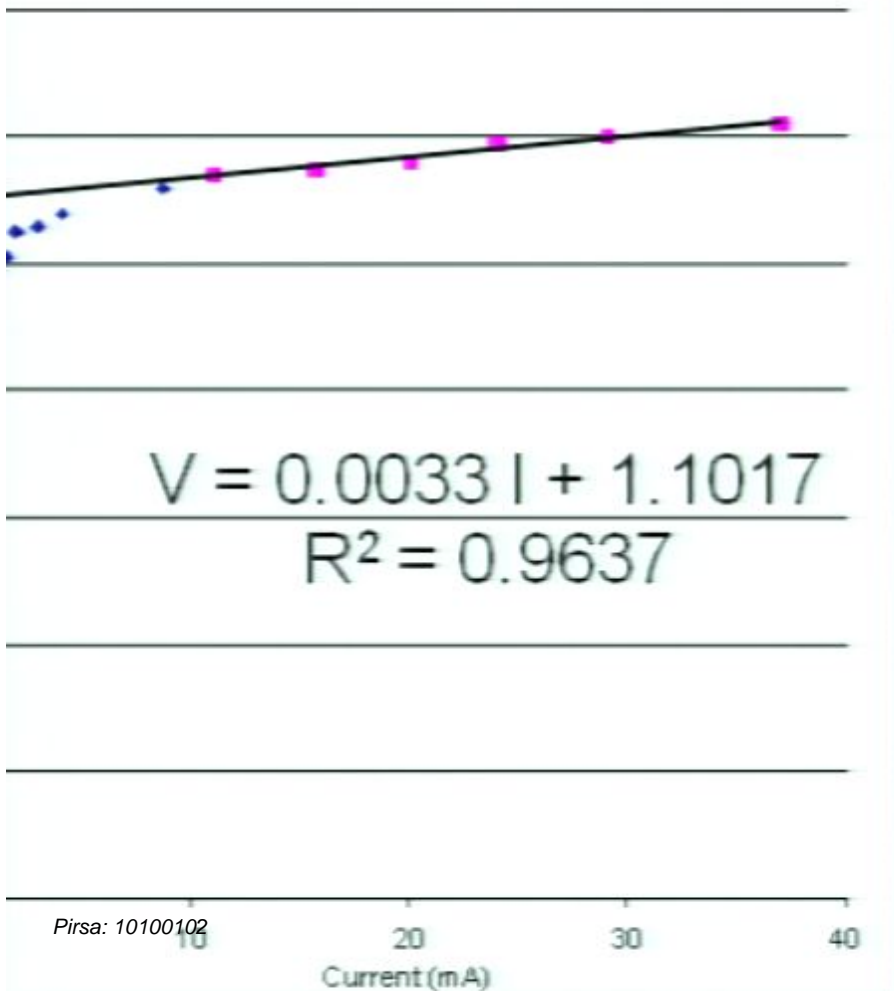


Fig. 15.6. Comparison of the emission spectra of a GaAs LED emitting at 870 nm (AT&T ODL 50 product) and a GaInAs RCLED emitting at 930 nm (after Hunt *et al.*, 1993).

E. F. Schubert
 Light-Emitting Diodes (Cambridge Univ. Press)
 www.LightEmittingDiodes.org

Evaluation of Lab v 3

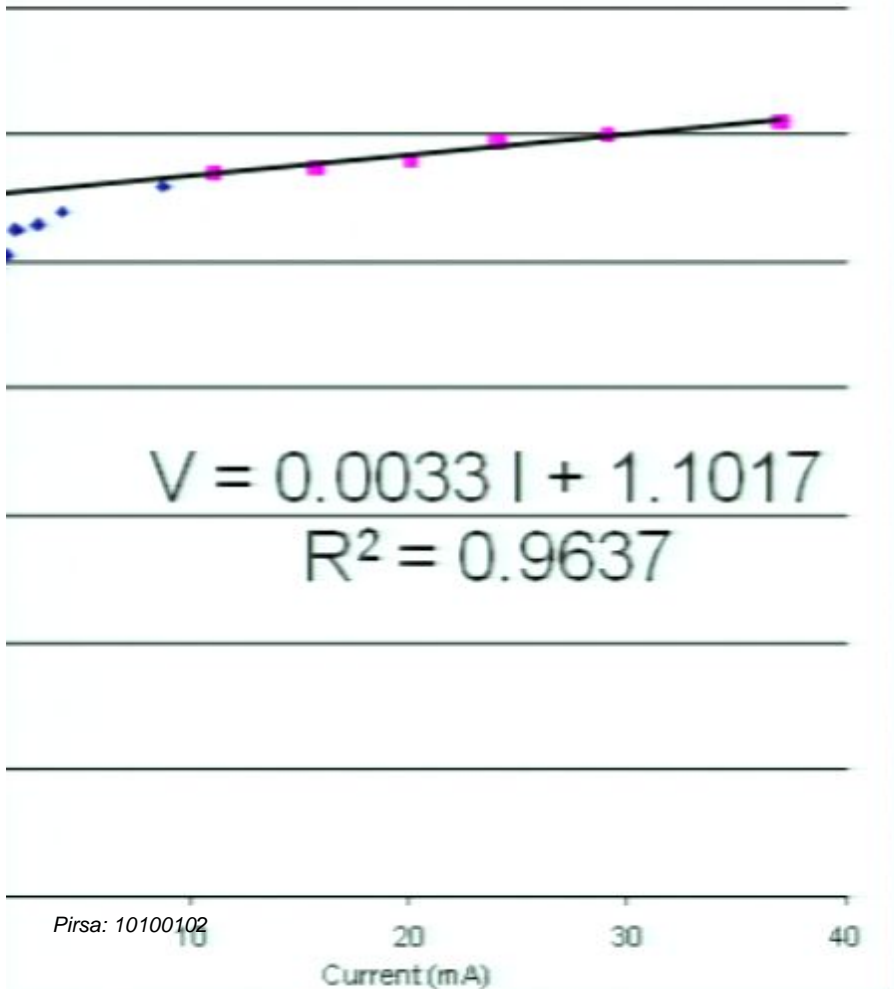
Infrared (880 nm) LED



- $E = hf$ predicts 1.41 eV
- Data say 1.1 eV

Evaluation of Lab v 3

Infrared (880 nm) LED



- $E = hf$ predicts 1.41 eV
- Data say 1.1 eV

End of slide show, click to exit.



Font Paragraph Drawing Editing

B I U Aa A

Shapes Arrange Quick Styles



Ohm's Law and Planck's Constant

Click to add notes

Bin

DSC-S2100 Handbo...

Add to sci 30

PI Presentation

PMB Help

Norton Intern...

Canon Soluti...

Skype

Quiz of the day

DVD-Cloner VII

Quiz of the Day friction

DivX Plus Converter

Phet Applets

PI stuff 2010

MP Navigator EX 2.0

Principles of Physics

Presentation1

Completed AP Materials

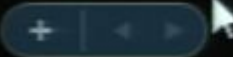
CanoScan LiDE 200...

RealPlayer SP

PMB Launcher

Physics AP

Projects



300-pound chimp run...
MSNBCN... Tue Oct 19

NBC/WSJ poll: GOP ...
MSNBCN... Tue Oct 19

Military recruiters te...
MSNBCN... Tue Oct 19

Van Damme reporte...
MSNBCN... Tue Oct 19

▲ 65-68 ▼

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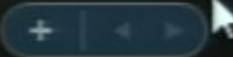
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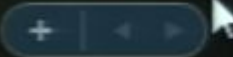
Military recruiters te...
MSNBCN... Tue Oct 19

Van Damme reporte...
MSNBCN... Tue Oct 19

▲ 65-68 ▼

The desktop features a space-themed background with a large image of Saturn. The icons are arranged in a grid:

- Row 1: Bin, DSC-S2100 Handbo..., Add to sci 30, **PI Presentation** (highlighted), PMB Help, Norton Intern...
- Row 2: nd rt, Canon Soluti..., Skype, Quiz of the day, DVD-Cloner VII, Quiz of the Day friction
- Row 3: us r, DivX Plus Converter, Phet Applets, PI stuff 2010, MP Navigator EX 2.0
- Row 4: Principles of Physics, Presentation1, Completed AP Materials, CanoScan LiDE 200...
- Row 5: AR prog, RealPlayer SP, PMB Launcher, Physics AP, Projects



French police fire tea...
MSNBCN... Tue Oct 19

Former UK PM Thatc...
MSNBCN... Tue Oct 19

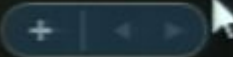
Study: Future drought...
MSNBCN... Tue Oct 19

Dow drops below 11,...
MSNBCN... Tue Oct 19

▲ 69-72 ▼

The desktop background features a large, detailed image of the planet Saturn with its rings. Scattered across the desktop are various icons and folders:

- Top Row:** DSC-S2100 Handbo..., Add to sci 30, **PI Presentation** (highlighted), PMB Help, Norton Intern...
- Second Row:** Canon Soluti..., Skype, Quiz of the day, DVD-Cloner VII, Quiz of the Day friction
- Third Row:** DivX Plus Converter, Phet Applets, PI stuff 2010, MP Navigator EX 2.0
- Fourth Row:** Principles of Physics, Presentation1, Completed AP Materials, CanoScan LiDE 200...
- Bottom Row:** RealPlayer SP, PMB Launcher, Physics AP, Projects



N.Y. Fed seeking mo...
MSNBCN... Tue Oct 19

Chile lawmaker: Min...
MSNBCN... Tue Oct 19

Healthy and pregnan...
MSNBCN... Tue Oct 19

Hormones may raise...
MSNBCN... Tue Oct 19

▲ 73-76 ▼

Bin

DSC-S2100 Handbo...

Add to sci 30

PI Presentation

PMB Help

Norton Intern...

Canon Soluti...

Skype

Quiz of the day

DVD-Cloner VII

Quiz of the Day friction

DivX Plus Converter

Phet Applets

PI stuff 2010

MP Navigator EX 2.0

Principles of Physics

Presentation1

Completed AP Materials

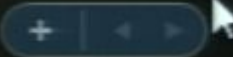
CanoScan LiDE 200...

RealPlayer SP

PMB Launcher

Physics AP

Projects



Cops: iPhone thief ID...
MSNBCN... Tue Oct 19

'Happy Days' dad To...
MSNBCN... Tue Oct 19

Democrats plead: Do...
MSNBCN... Tue Oct 19

U.S. soldier in custod...
MSNBCN... Tue Oct 19

▲ 77-80 ▼

Bin

DSC-S2100 Handbo...

Add to sci 30

PI Presentation

PMB Help

Norton Intern...

Canon Soluti...

Skype

Quiz of the day

DVD-Cloner VII

Quiz of the Day friction

DivX Plus Converter

Phet Applets

PI stuff 2010

MP Navigator EX 2.0

Principles of Physics

Presentation1

Completed AP Materials

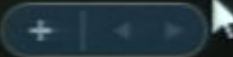
CanoScan LiDE 200...

RealPlayer SP

PMB Launcher

Physics AP

Projects



Man who decapitate...
MSNBCN... Tue Oct 19

JetBlue attendant in ...
MSNBCN... Tue Oct 19

Prince William to ma...
MSNBCN... Tue Oct 19

\$500 socks? High-en...
MSNBCN... Tue Oct 19

▲ 81-84 ▼

Bin

DSC-S2100 Handbo...

Add to sci 30

PI Presentation

PMB Help

Norton Intern...

Canon Soluti...

Skype

Quiz of the day

DVD-Cloner VII

Quiz of the Day friction

DivX Plus Converter

Phet Applets

PI stuff 2010

MP Navigator EX 2.0

Principles of Physics

Presentation1

Completed AP Materials

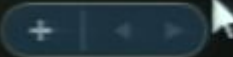
CanoScan LiDE 200...

RealPlayer SP

PMB Launcher

Physics AP

Projects



West get ready, here...
MSNBCN... Tue Oct 19

Chechen parliament, ...
MSNBCN... Tue Oct 19

Police hunt shooter a...
MSNBCN... Tue Oct 19

Low-cost carriers do...
MSNBCN... Tue Oct 19

▲ 85-88 ▼

Bin

DSC-S2100 Handbo...

Add to sci 30

PI Presentation

PMB Help

Norton Intern...

Canon Soluti...

Skype

Quiz of the day

DVD-Cloner VII

Quiz of the Day friction

DivX Plus Converter

Phet Applets

PI stuff 2010

MP Navigator EX 2.0

Principles of Physics

Presentation1

Completed AP Materials

CanoScan LiDE 200...

RealPlayer SP

PMB Launcher

Physics AP

Projects

+

Newsweek: The mos...
MSNBCN... Tue Oct 19

China raises key rate...
MSNBCN... Tue Oct 19

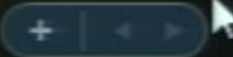
Judge leans against '...
MSNBCN... Mon Oct 18

Chaos as French prot...
MSNBCN... Mon Oct 18

▲ 89-92 ▼

The desktop background features a large, detailed image of the planet Saturn with its rings. Scattered across the desktop are several icons and folders:

- Row 1:** DSC-S2100 Handbo..., Add to sci 30, **PI Presentation** (highlighted), PMB Help, Norton Intern...
- Row 2:** Canon Soluti..., Skype, Quiz of the day, DVD-Cloner VII, Quiz of the Day friction
- Row 3:** DivX Plus Converter, Phet Applets, PI stuff 2010, MP Navigator EX 2.0
- Row 4:** Principles of Physics, Presentation1, Completed AP Materials, CanoScan LiDE 200...
- Row 5:** RealPlayer SP, PMB Launcher, Physics AP, Projects



Pace player tried to ...
MSNBC N... Mon Oct 18

Jury weighs fate of C...
MSNBC N... Mon Oct 18

2 female postal emp...
MSNBC N... Mon Oct 18

Goat that killed hike...
MSNBC N... Mon Oct 18

▲ 93-96 ▼

The desktop features a wallpaper of the planet Saturn. The icons are arranged in a grid:

- Row 1: Bin, DSC-S2100 Handbo..., Add to sci 30, **PI Presentation** (highlighted), PMB Help, Norton Intern...
- Row 2: Canon Soluti..., Skype, Quiz of the day, DVD-Cloner VII, Quiz of the Day friction
- Row 3: DivX Plus Converter, Phet Applets, PI stuff 2010, MP Navigator EX 2.0
- Row 4: Principles of Physics, Presentation1, Completed AP Materials, CanoScan LiDE 200...
- Row 5: RealPlayer SP, PMB Launcher, Physics AP, Projects

Navigation controls: +, ←, →

- Trial begins in death ...**
MSNBCN... Mon Oct 18
- Bank of America to r...**
MSNBCN... Mon Oct 18
- Crystal Cathedral file...**
MSNBCN... Mon Oct 18
- 4 men are convicted ...**
MSNBCN... Mon Oct 18

Page indicator: ▲ 97-100 ▼

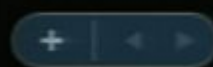
Bin DSC-S2100 Handbo... Add to sci 30 PI Presentation PMB Help Norton Intern...

nd rt Canon Soluti... Skype Quiz of the day DVD-Cloner VII Quiz of the Day friction

us r DivX Plus Converter Phet Applets PI stuff 2010 MP Navigator EX 2.0

Principles of Physics Presentation1 Completed AP Materials CanoScan LiDE 200...

AR: prog RealPlayer SP PMB Launcher Physics AP Projects



Trial begins in death ...
MSNBCN... Mon Oct 18

Bank of America to r...
MSNBCN... Mon Oct 18

Crystal Cathedral file...
MSNBCN... Mon Oct 18

4 men are convicted ...
MSNBCN... Mon Oct 18


▲ 97-100 ▼

AutoPlay








DVD RW Drive (E:) TRIUMF

Always do this for enhanced DVD movies:

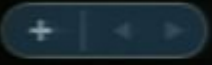
Run enhanced content

-  Run TRIUMFMenu.exe
Publisher not specified

DVD movie options

-  Play DVD movie
using Windows Media Player
-  Play DVD movie
using Windows Media Center
-  Copy Disc or Play Movie
using DVD Suite
-  Play DVD Video
using HP QuickPlay
-  Play DVD Video
using RealPlayer
-  Play DVD movie
using VideoLAN VLC media player
-  Burn DVD movie

[Set AutoPlay defaults in Control Panel](#)



Trial begins in death ...
MSNBCN... Mon Oct 18

Bank of America to r...
MSNBCN... Mon Oct 18

Crystal Cathedral file...
MSNBCN... Mon Oct 18

4 men are convicted ...
MSNBCN... Mon Oct 18

▲ 97-100 ▼

Bin DSC-S2100 Handbo... Add to sci 30

Canon Soluti... Skype

DivX Plus Converter Phet Applets

Principles of Physics Presentation

RealPlayer SP PMB Launcher Physics AP Projects



AutoPlay

DVD RW Drive (E:) TRIUMF

Always do this for enhanced DVD movies:

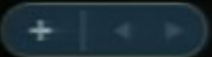
Run enhanced content

- Run TRIUMFMenu.exe
Publisher not specified

DVD movie options

- Play DVD movie
using Windows Media Player
- Play DVD movie
using Windows Media Center
- Copy Disc or Play Movie
using DVD Suite
- Play DVD Video
using HP QuickPlay
- Play DVD Video
using RealPlayer
- Play DVD movie
using VideoLAN VLC media player
- Backup DVD movies

[Set AutoPlay defaults in Control Panel](#)



Trial begins in death ...
MSNBCN... Mon Oct 18

Bank of America to r...
MSNBCN... Mon Oct 18

Crystal Cathedral file...
MSNBCN... Mon Oct 18








4 men are convicted ...
MSNBCN... Mon Oct 18

▲ 97-100 ▼


AutoPlay

DVD RW Drive (E:) TRIUMF

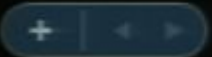
Always do this for enhanced DVD movies:

-  Play DVD movie using Windows Media Player
-  Play DVD movie using Windows Media Center
-  Copy Disc or Play Movie using DVD Suite
-  Play DVD Video using HP QuickPlay
-  Play DVD Video using RealPlayer
-  Play DVD movie using VideoLAN VLC media player
-  Backup DVD movie using DVD Cloner

General options

-  Open folder to view files using Windows Explorer

[Set AutoPlay defaults in Control Panel](#)



Trial begins in death ...
MSNBCN... Mon Oct 18

Bank of America to r...
MSNBCN... Mon Oct 18

Crystal Cathedral file...
MSNBCN... Mon Oct 18

4 men are convicted ...
MSNBCN... Mon Oct 18

▲ 97-100 ▼

Bin

DSC-S2100 Handbo...

Add to sci 30

Canon Soluti...

Skype

DivX Plus Converter

Phet Applets

Principles of Physics

Presentation

RealPlayer SP

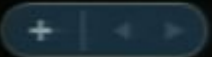
PMB Launcher

Physics AP

Projects

The desktop background features a large, detailed image of the planet Saturn with its rings. The desktop is populated with various icons and folders:

- Bin
- DSC-S2100 Handbo...
- Add to sci 30
- PI Presentation
- PMB Help
- Norton Intern...
- Canon Soluti...
- Skype
- Quiz of the day
- DVD-Cloner VII
- Quiz of the Day friction
- DivX Plus Converter
- Phet Applets
- PI stuff 2010
- MP Navigator EX 2.0
- Principles of Physics
- Presentation1
- Completed AP Materials
- CanoScan LiDE 200...
- RealPlayer SP
- PMB Launcher
- Physics AP
- Projects



Report: Mass graves ...
MSNBC N... Fri Oct 22

French Senate OKs r...
MSNBC N... Fri Oct 22

At least 142 dead in ...
MSNBC N... Fri Oct 22

Judge orders Lohan b...
MSNBC N... Fri Oct 22

▲ 1-4 ▼



Approaching the Speed of Light

Demonstrating Special Relativity
Using the TRIUMF Cyclotron

1ST VIDEO SEGMENT

2ND VIDEO SEGMENT

ADDITIONAL MATERIALS FOR
TEACHERS AND STUDENTS



Approaching the Speed of Light

Demonstrating Special Relativity
Using the TRIUMF Cyclotron

1ST VIDEO SEGMENT

2ND VIDEO SEGMENT

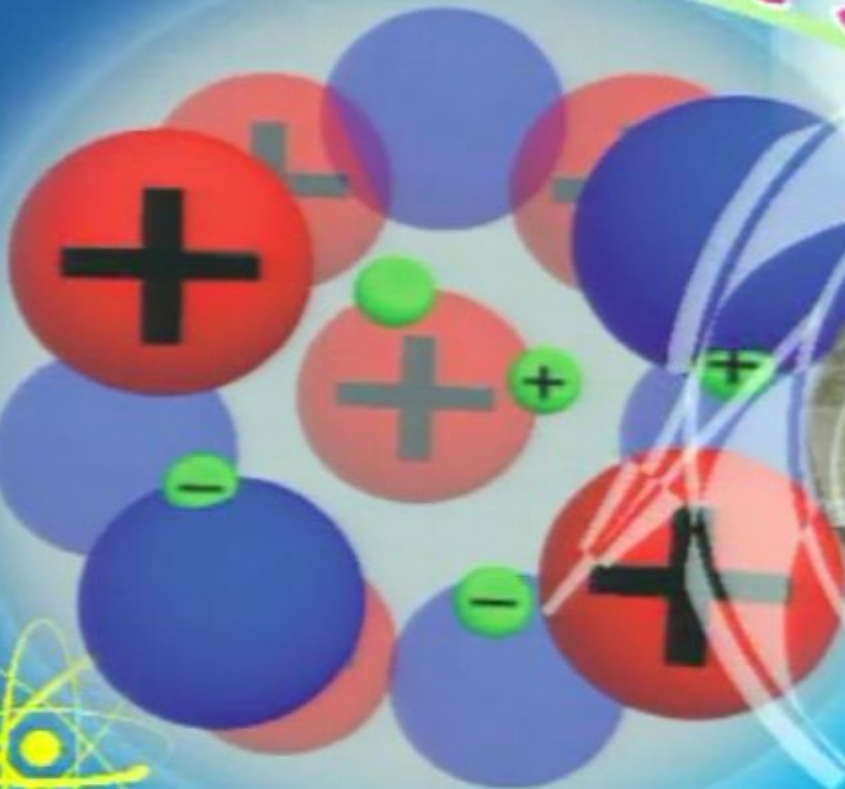
ADDITIONAL MATERIALS FOR
TEACHERS AND STUDENTS



Demonstrating Special
Relativity Using the
TRIUMF Cyclotron



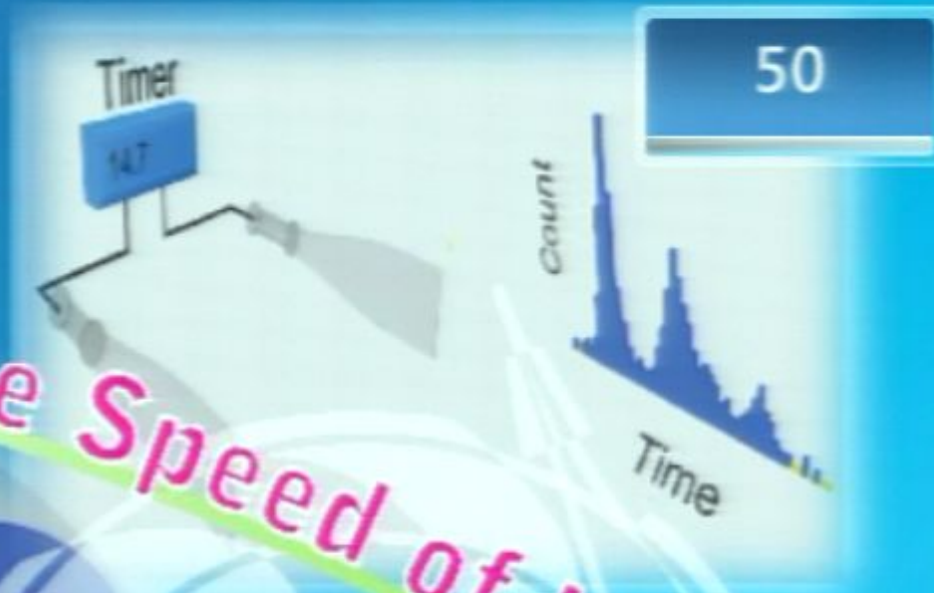
Approaching the Speed of Light

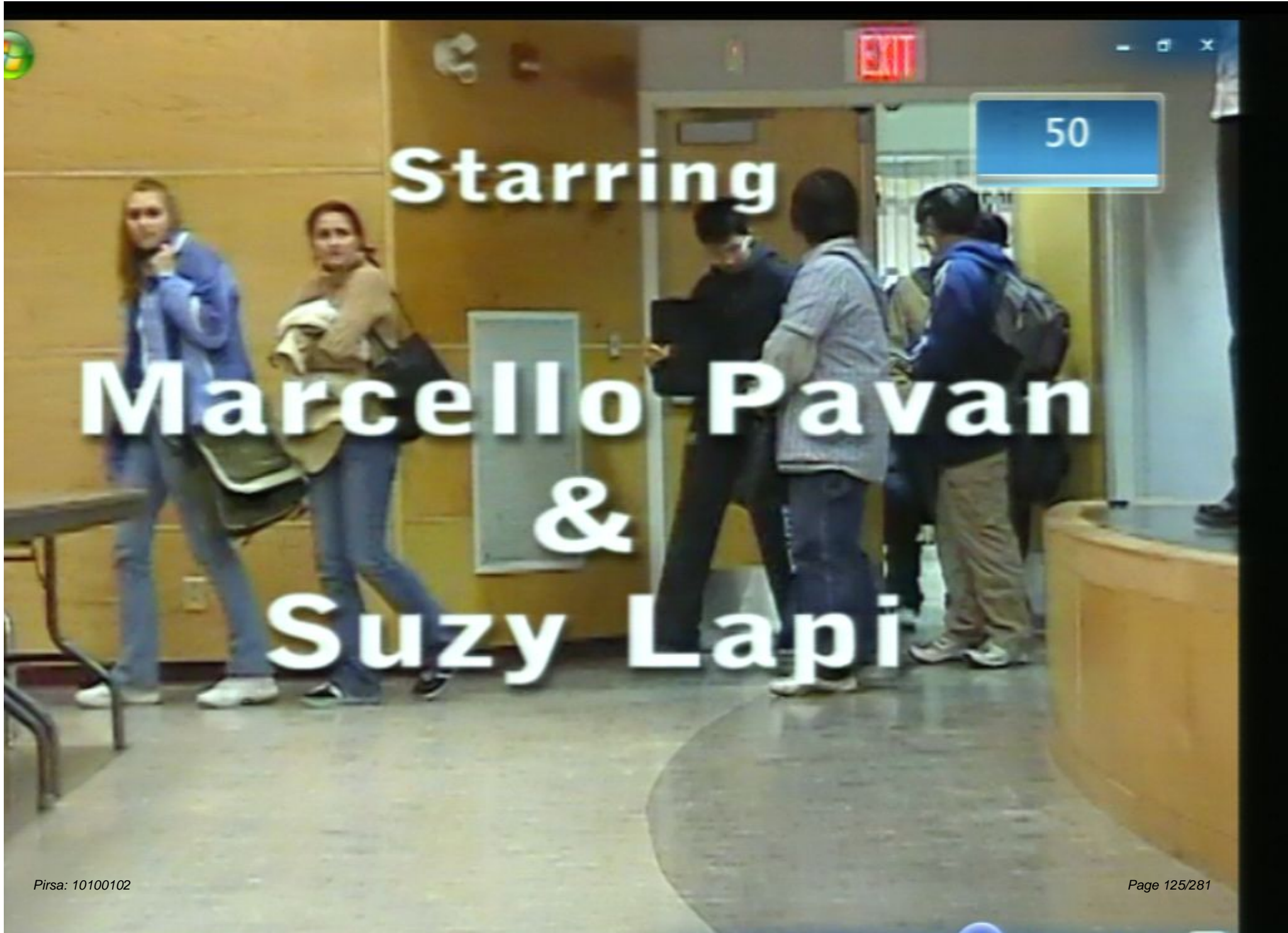


Demonstrating Special
Relativity Using the
TRIUMF Cyclotron



Approaching the Speed of Light





Starring

50

Marcello Pavan
&
Suzy Lapi



Starring

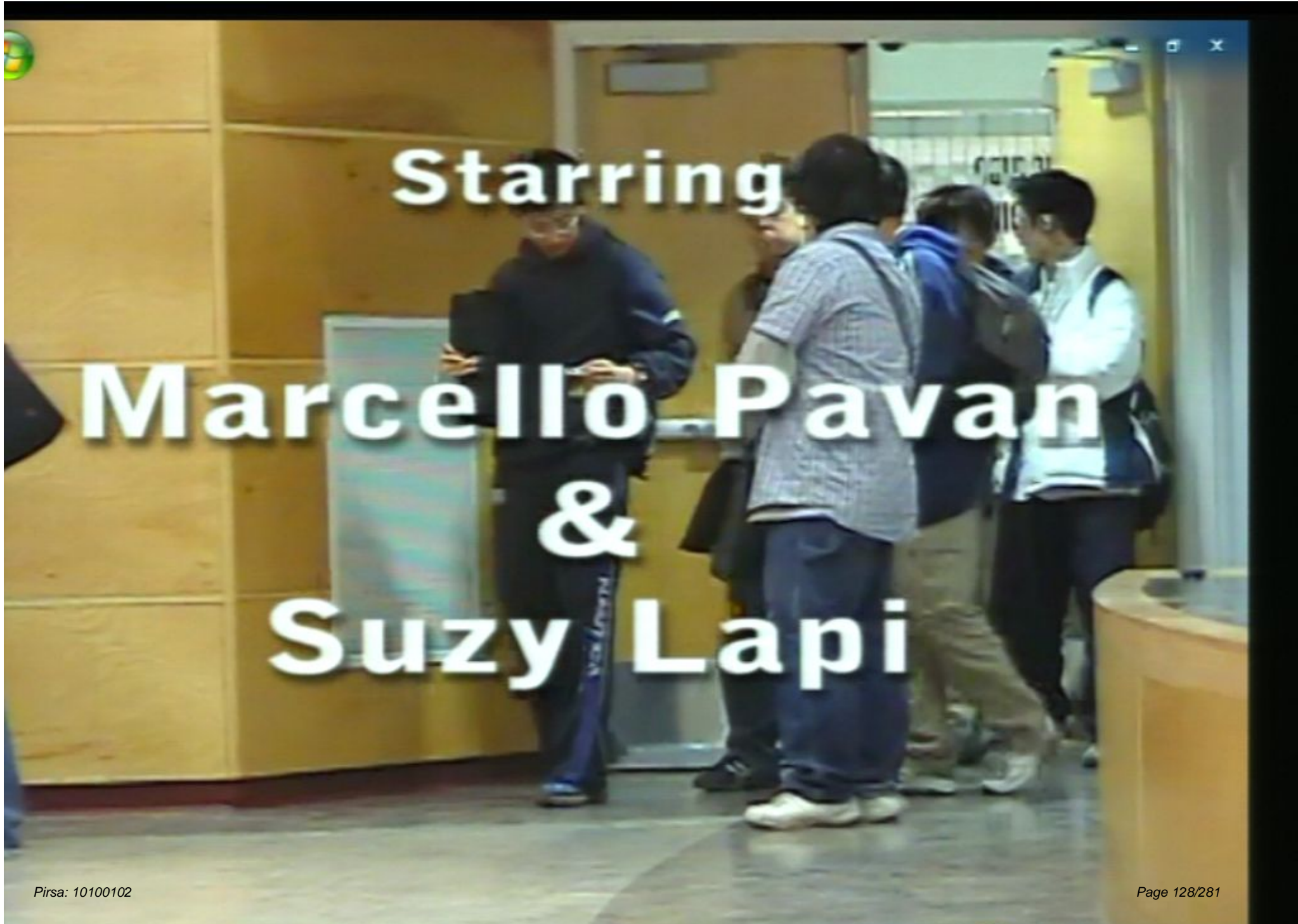
Marcello Pavan
&
Suzy Lapi

0:10 ||



Starring

**Marcello Pavan
&
Suzy Lapi**

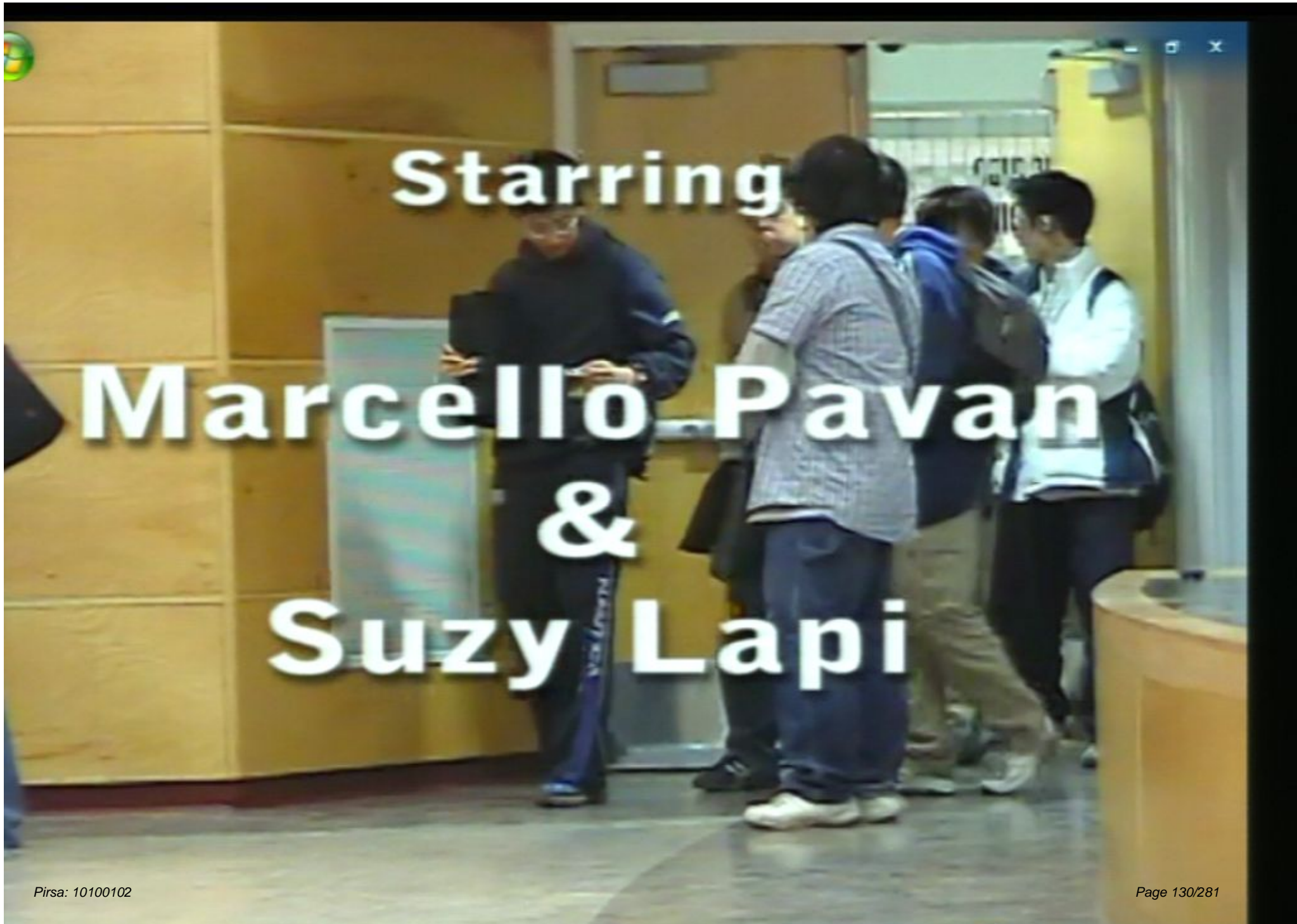


Starring

Marcello Pavan
&
Suzy Lapi

A photograph of a group of people in a hallway. The text 'Starring Marcello Pavan & Suzy Lapi' is overlaid in large white font. The background shows a hallway with wood-paneled walls and a door. A person in a dark blue jacket is in the foreground, looking at a device. Other people are standing in a line behind them.

Starring
Marcello Pavan
&
Suzy Lapi

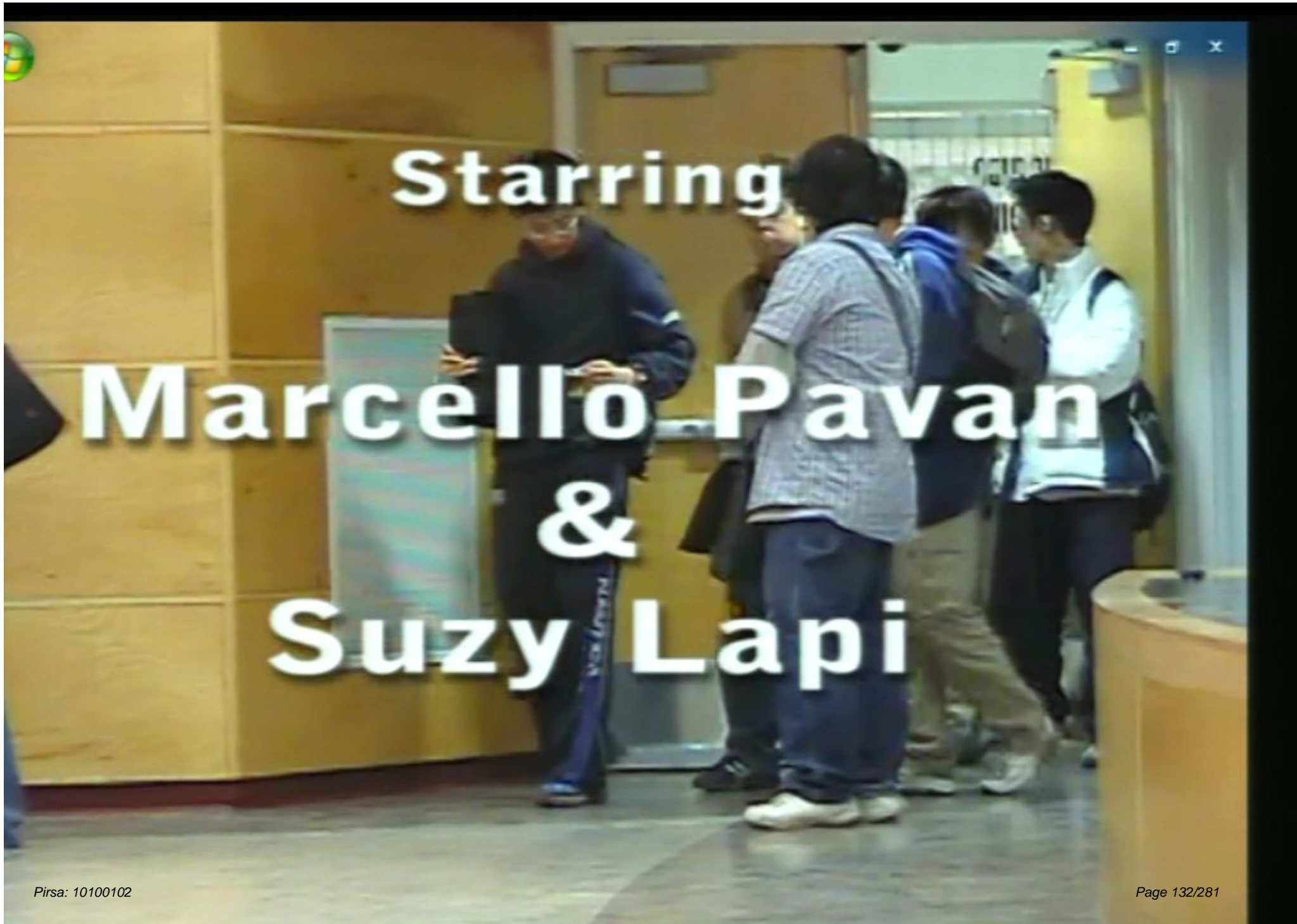


Starring

Marcello Pavan
&
Suzy Lapi

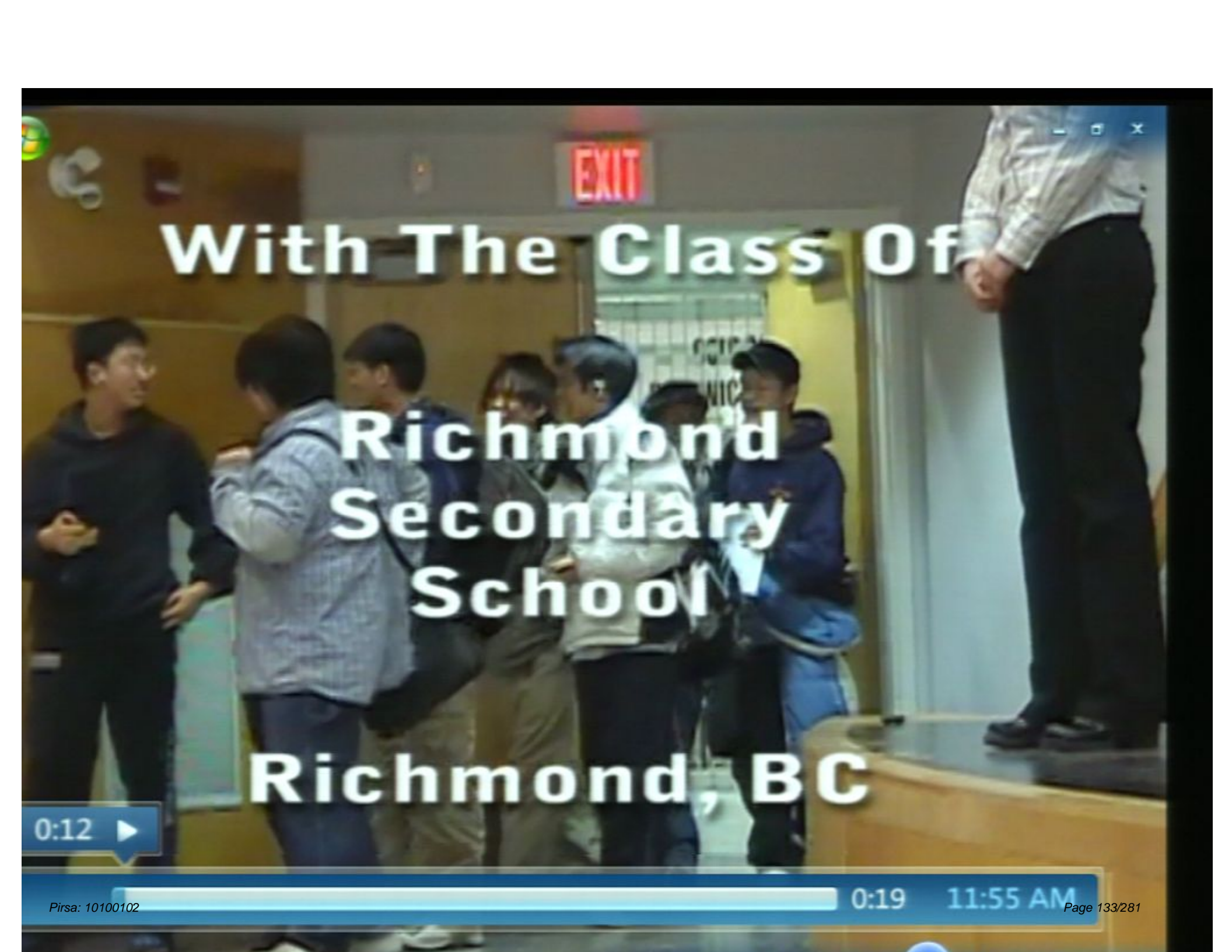
A photograph of a group of people in a hallway. The text 'Starring Marcello Pavan & Suzy Lapi' is overlaid in large white font. The background shows a hallway with wood-paneled walls and a door. A person in a dark blue jacket is in the foreground, looking at a device. Other people are standing in a line behind them.

Starring
Marcello Pavan
&
Suzy Lapi



Starring

Marcello Pavan
&
Suzy Lapi



With The Class Of

Richmond
Secondary
School

Richmond, BC

0:12 ▶

0:19

11:55 AM



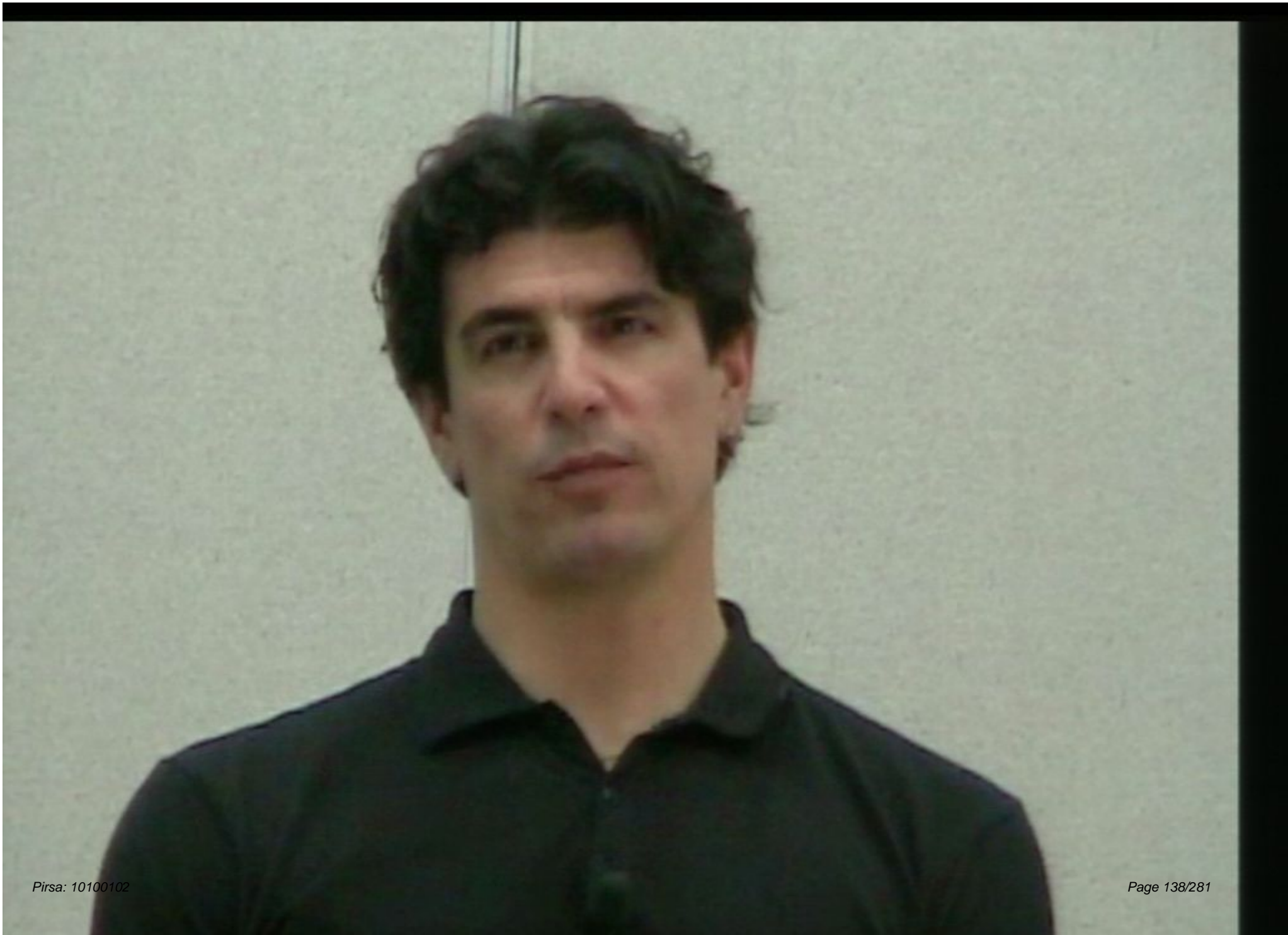
0:15 ▶

0:19 11:55 AM

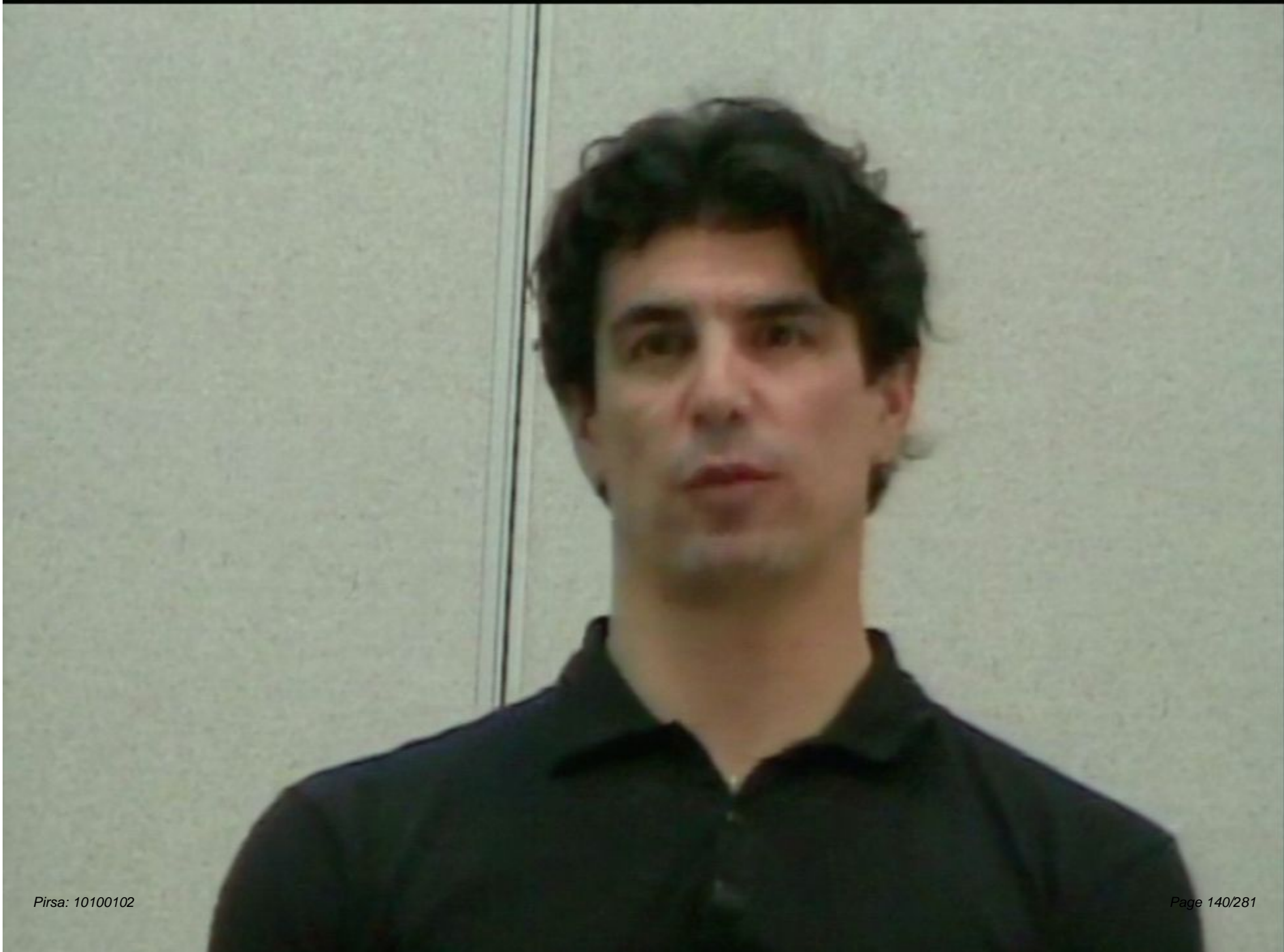


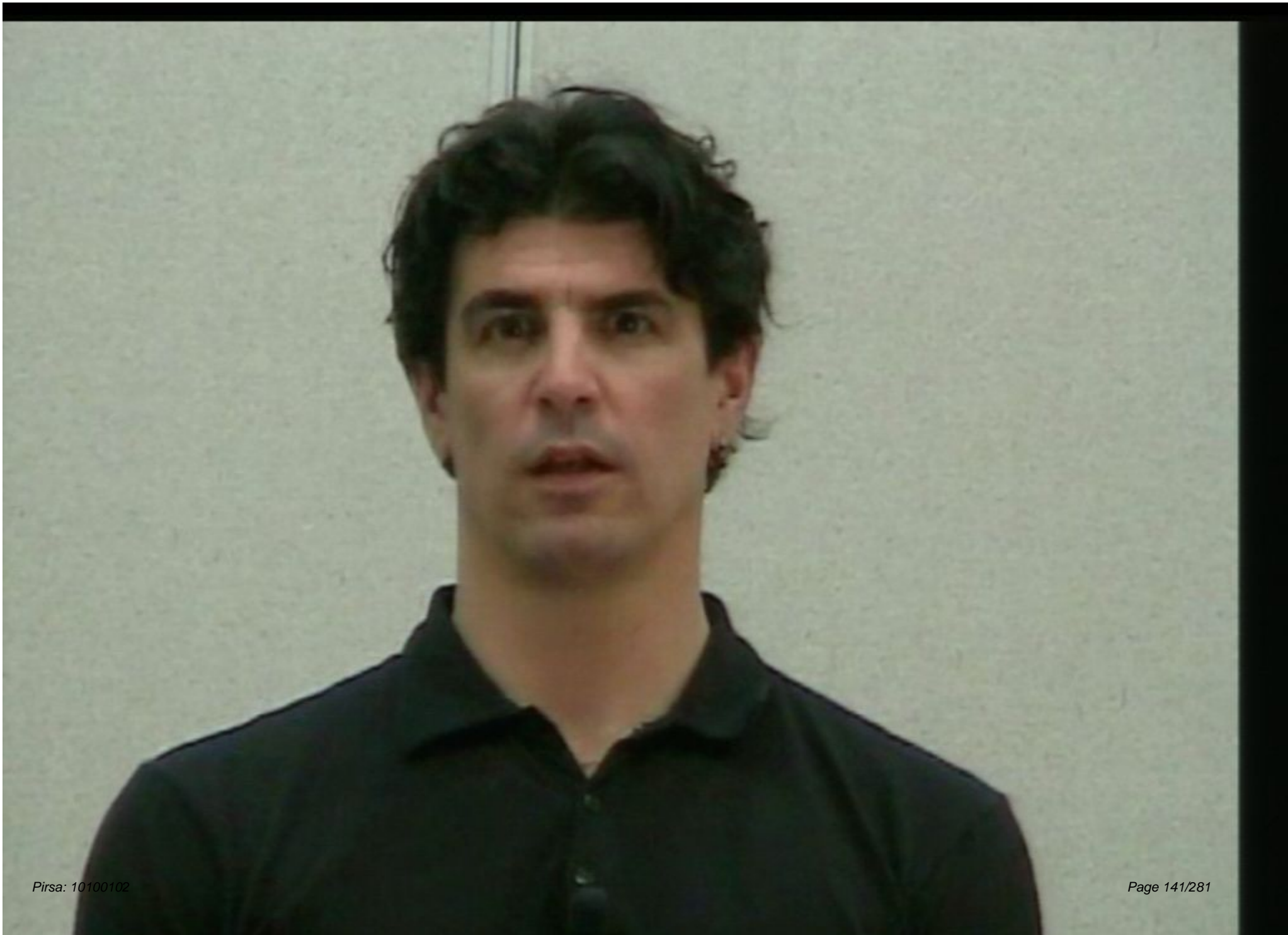


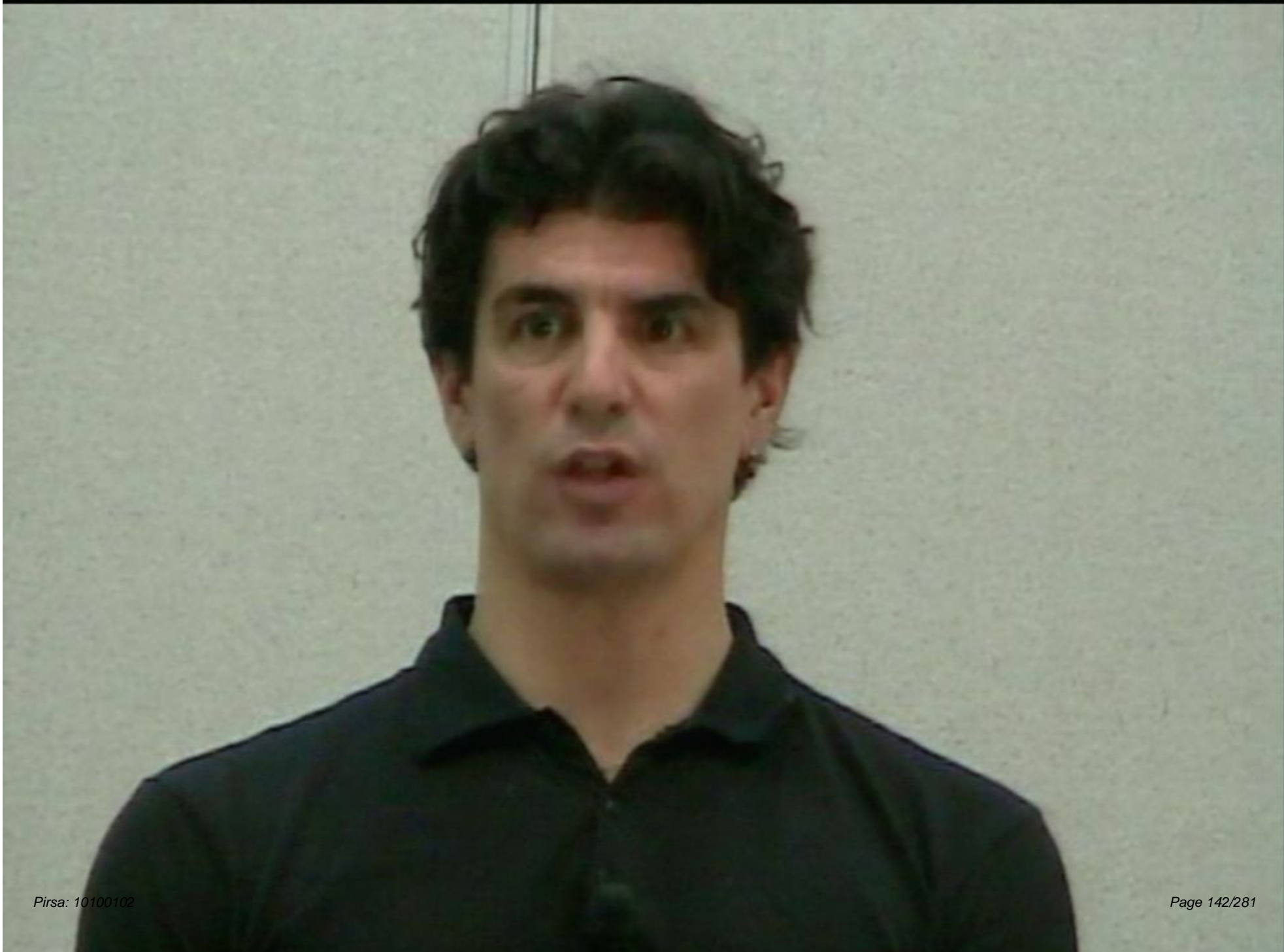


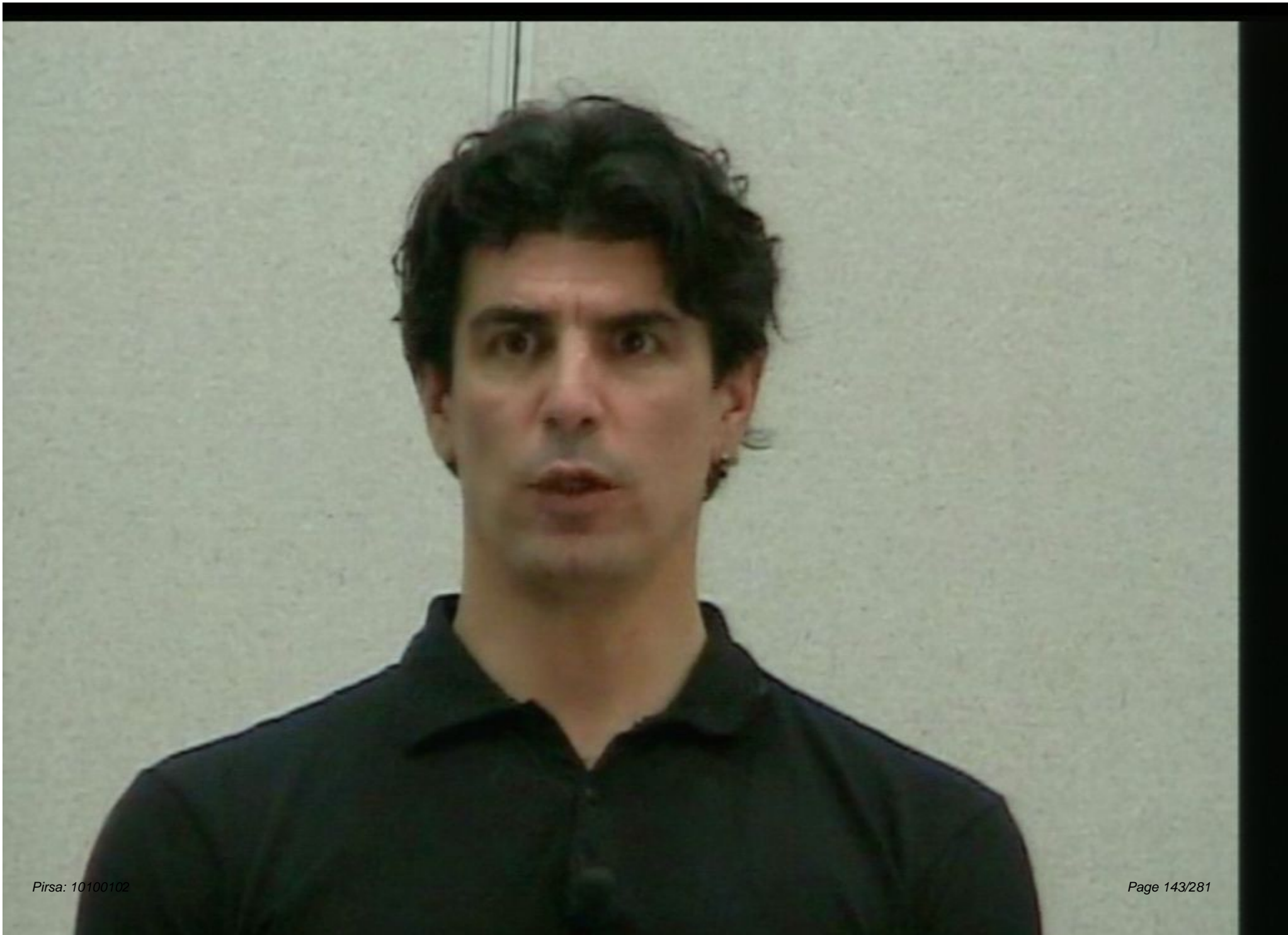


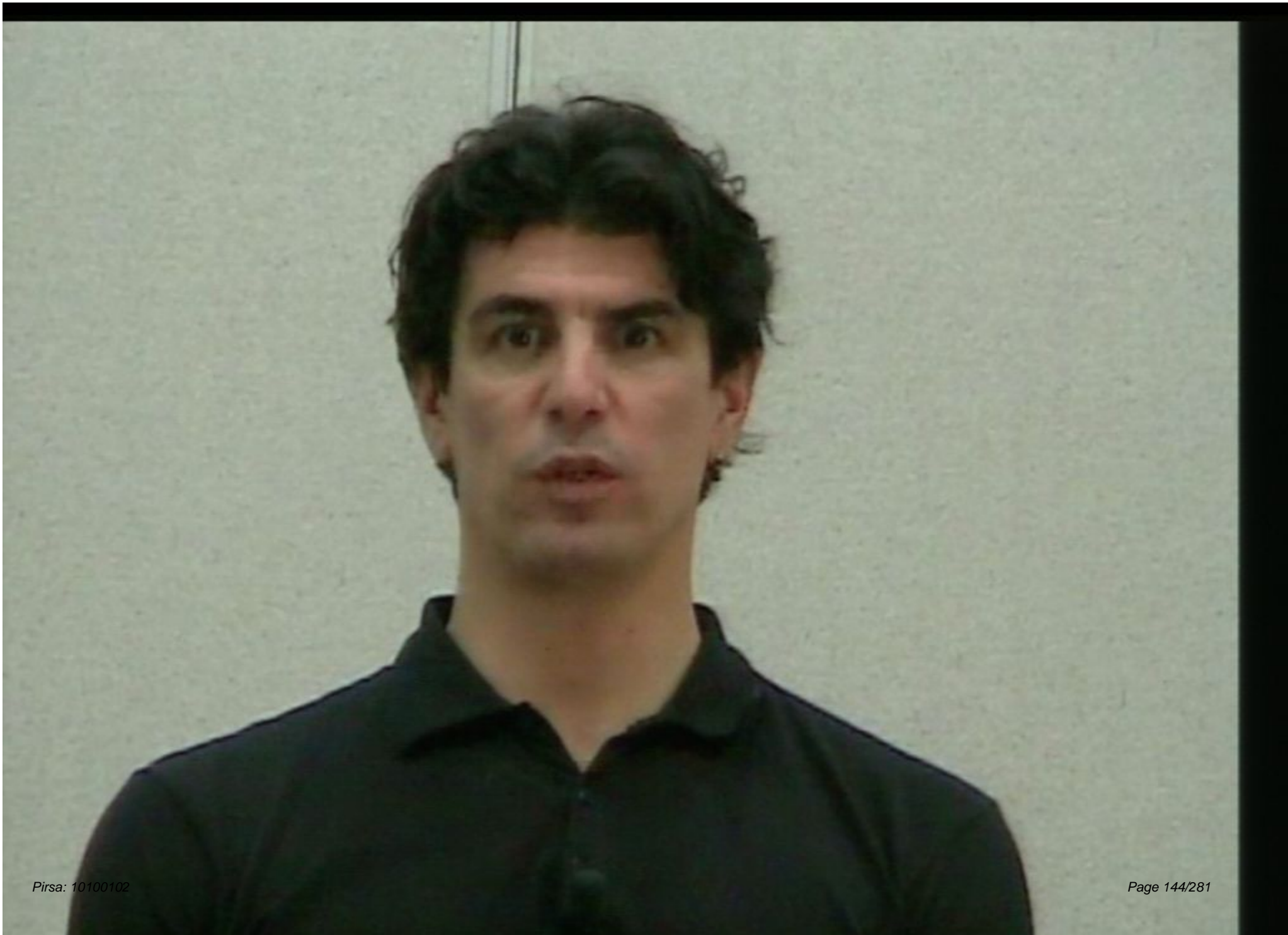


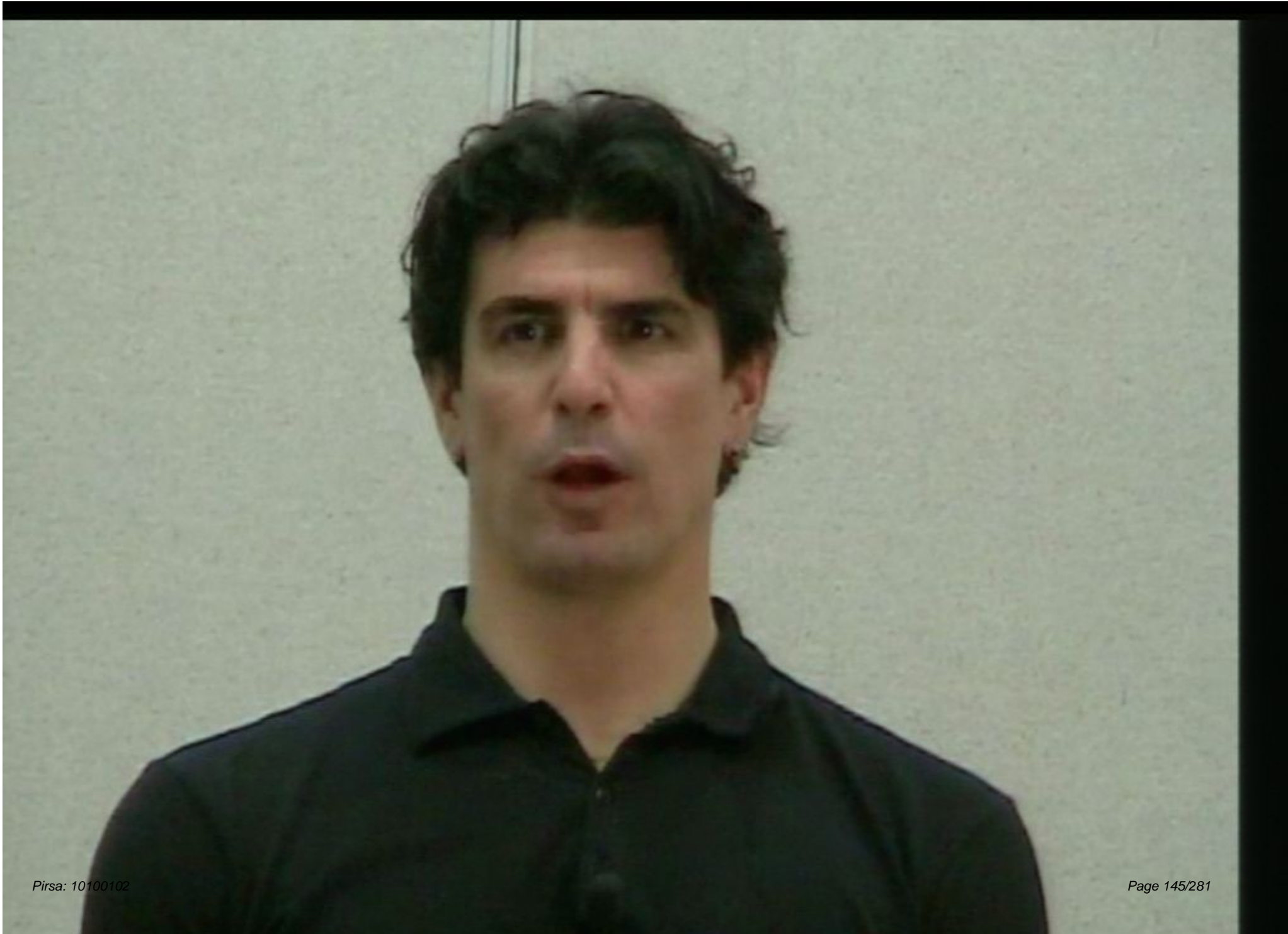


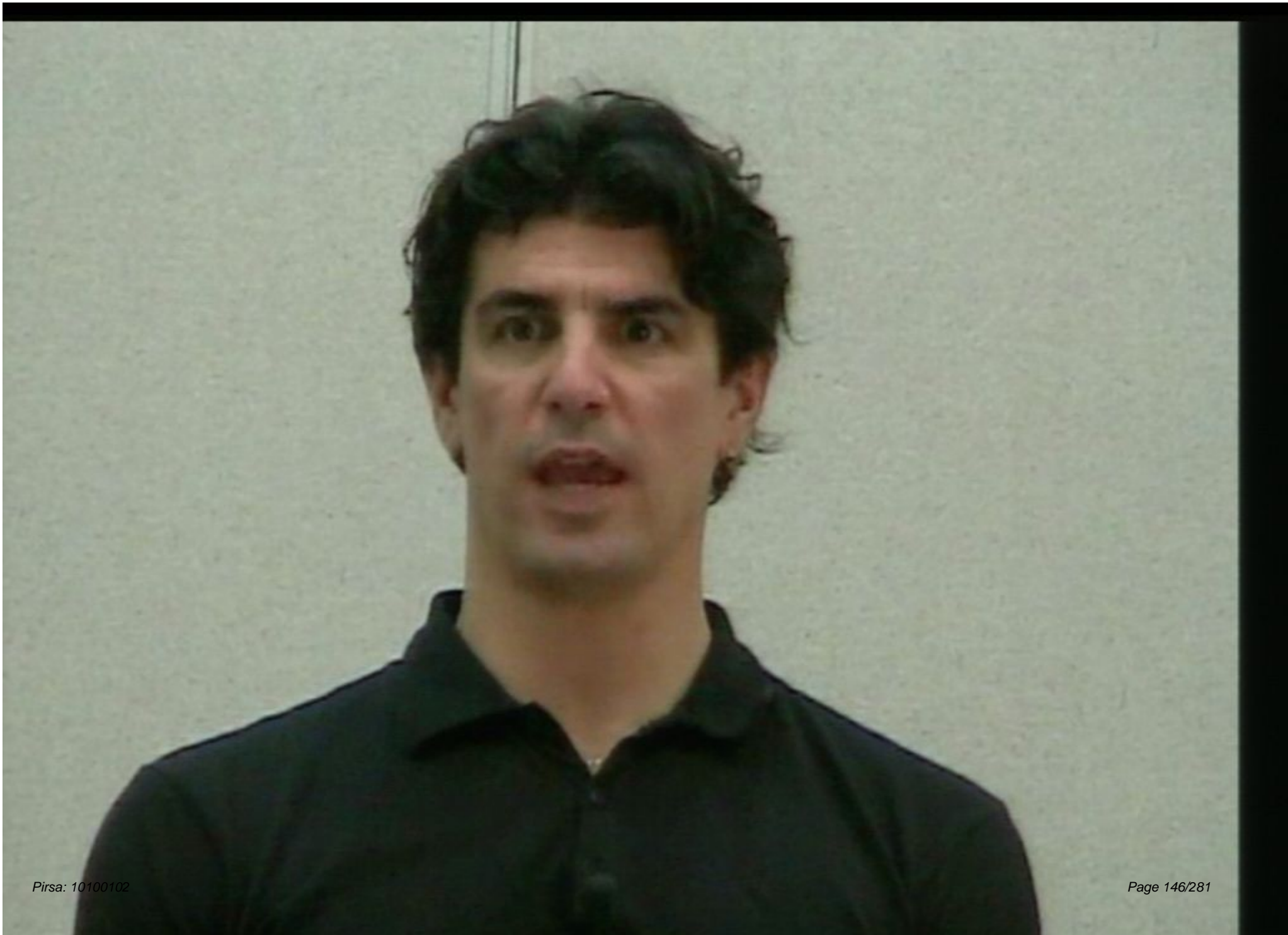




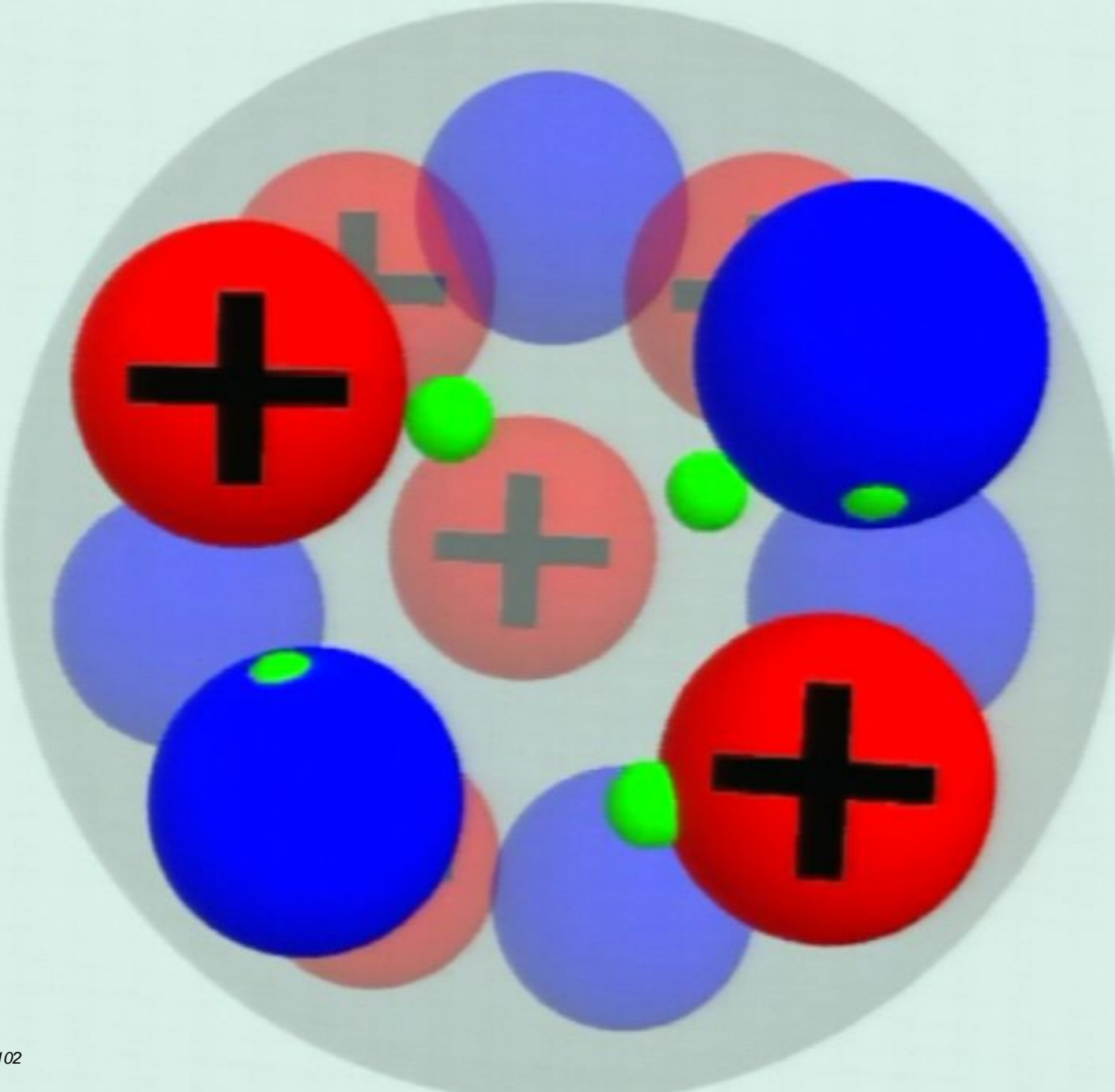


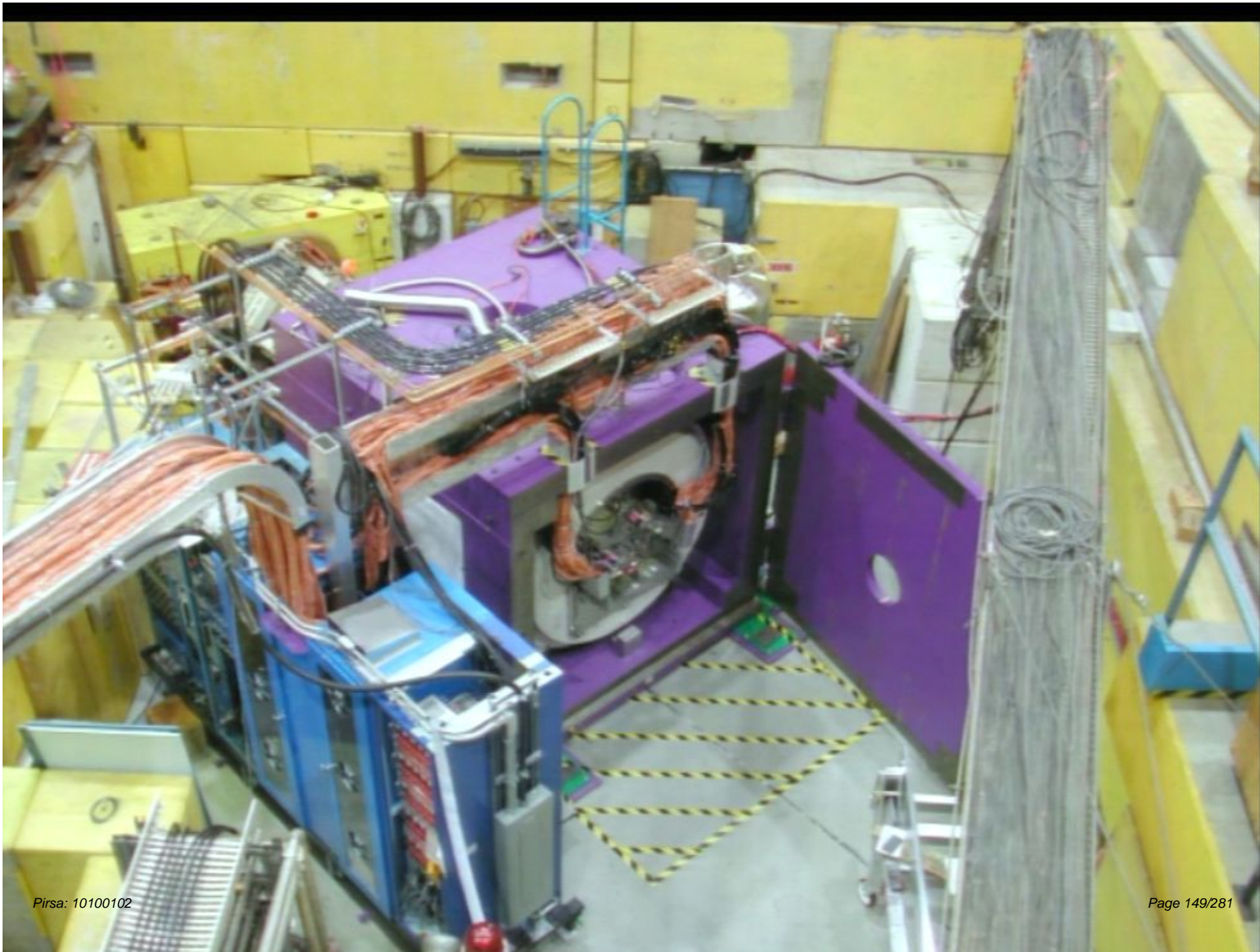


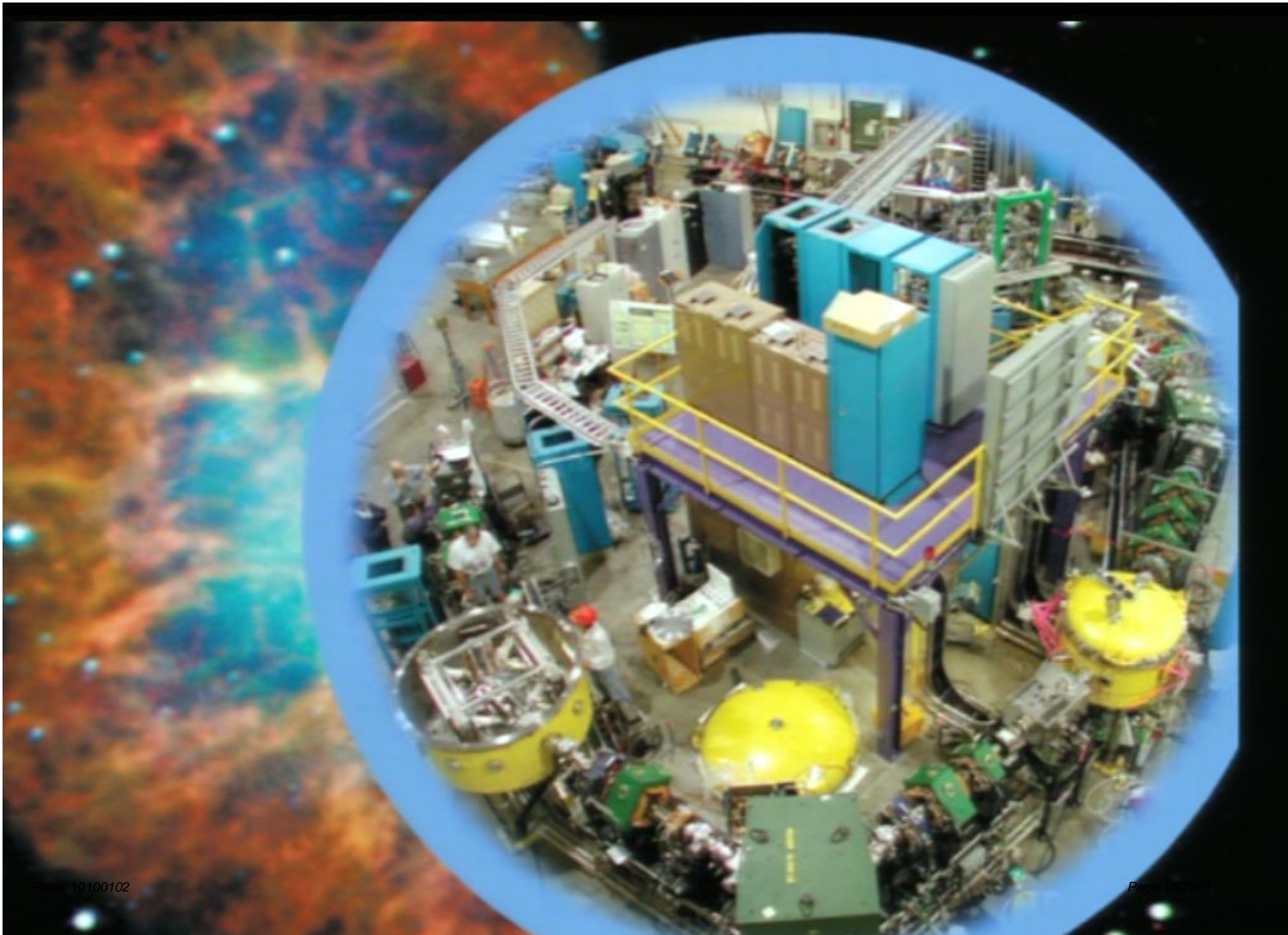




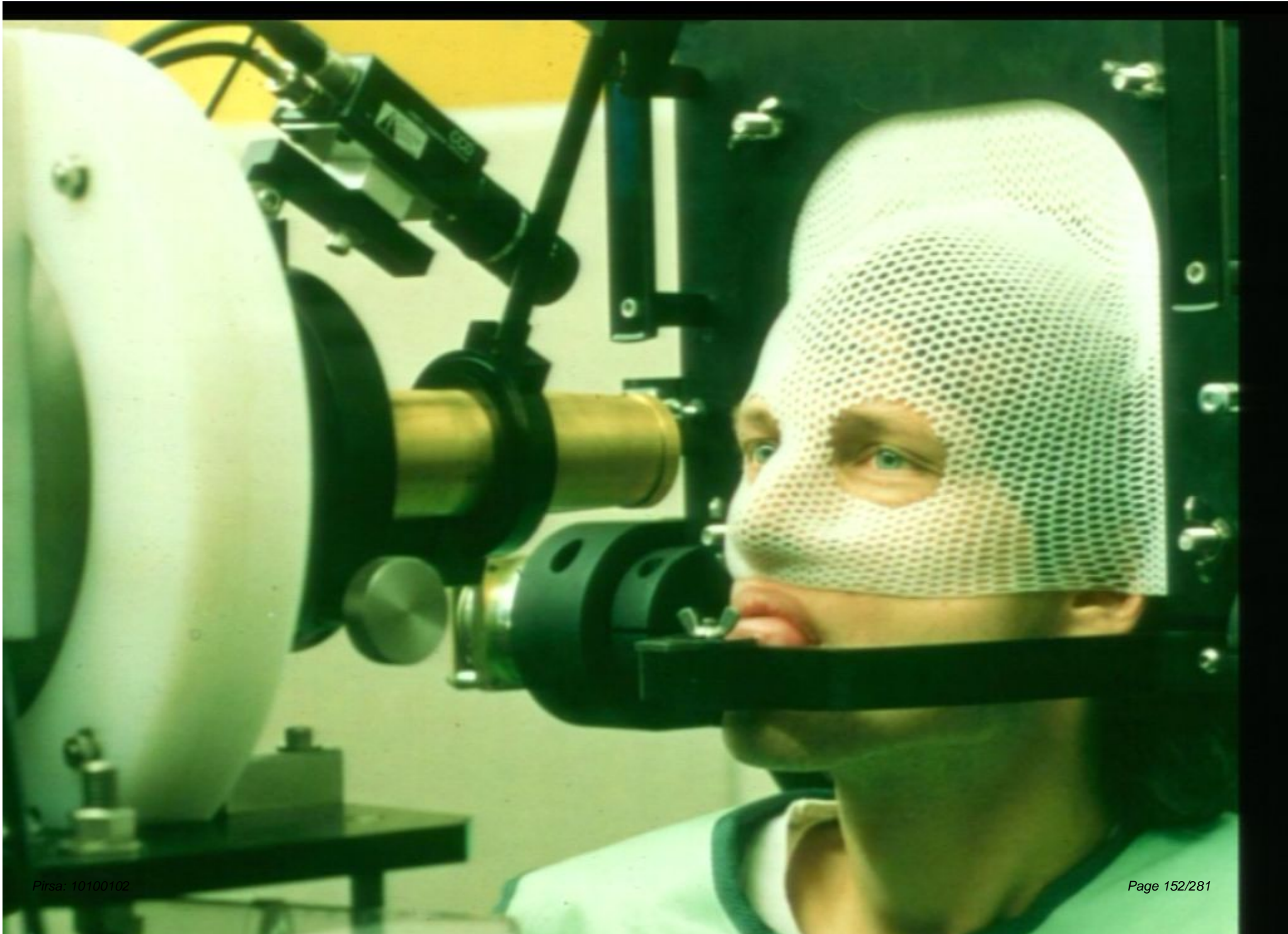


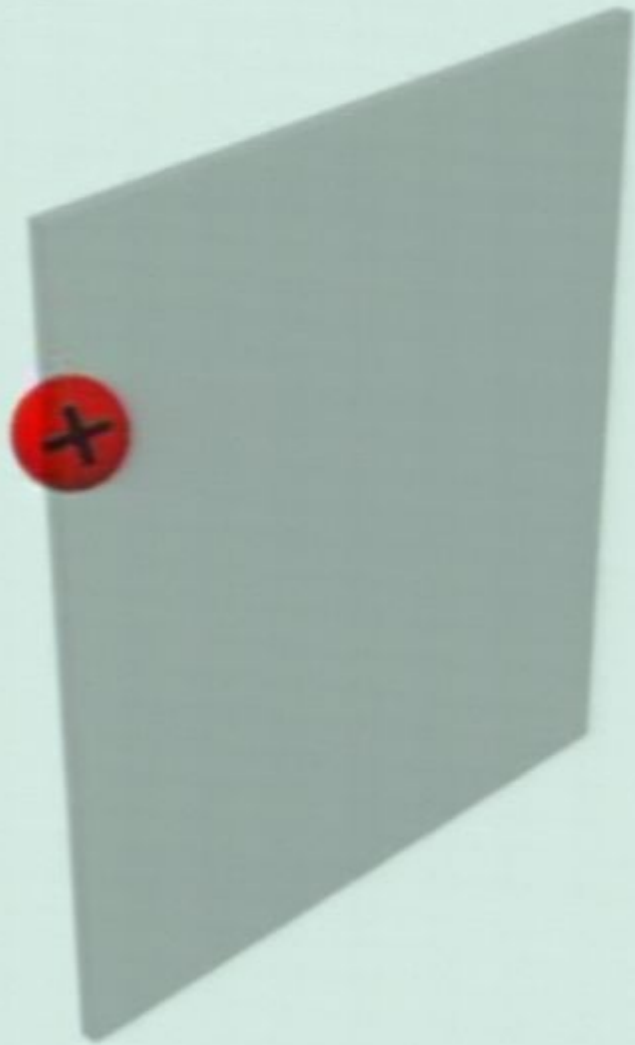


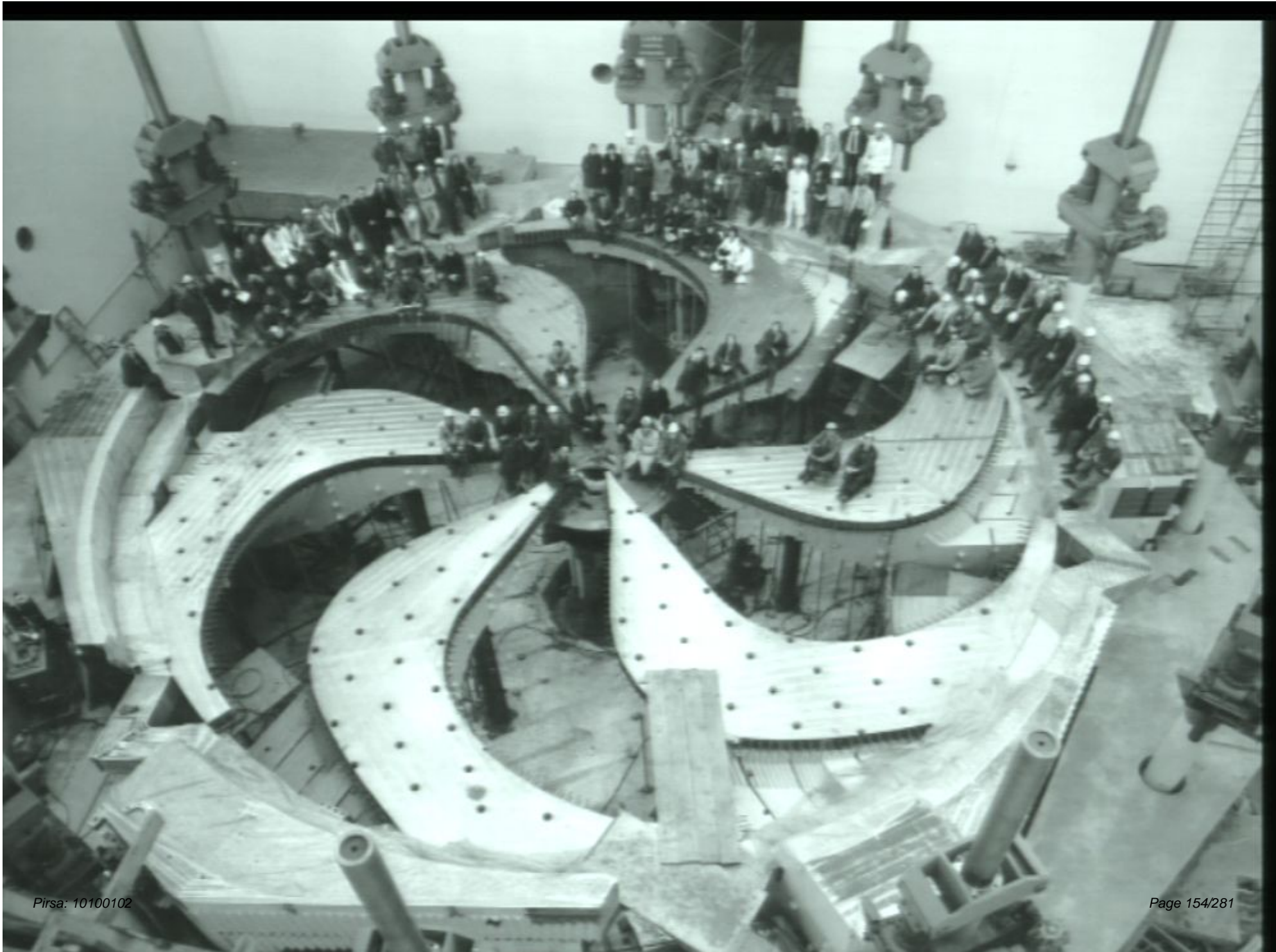














1:36 ||





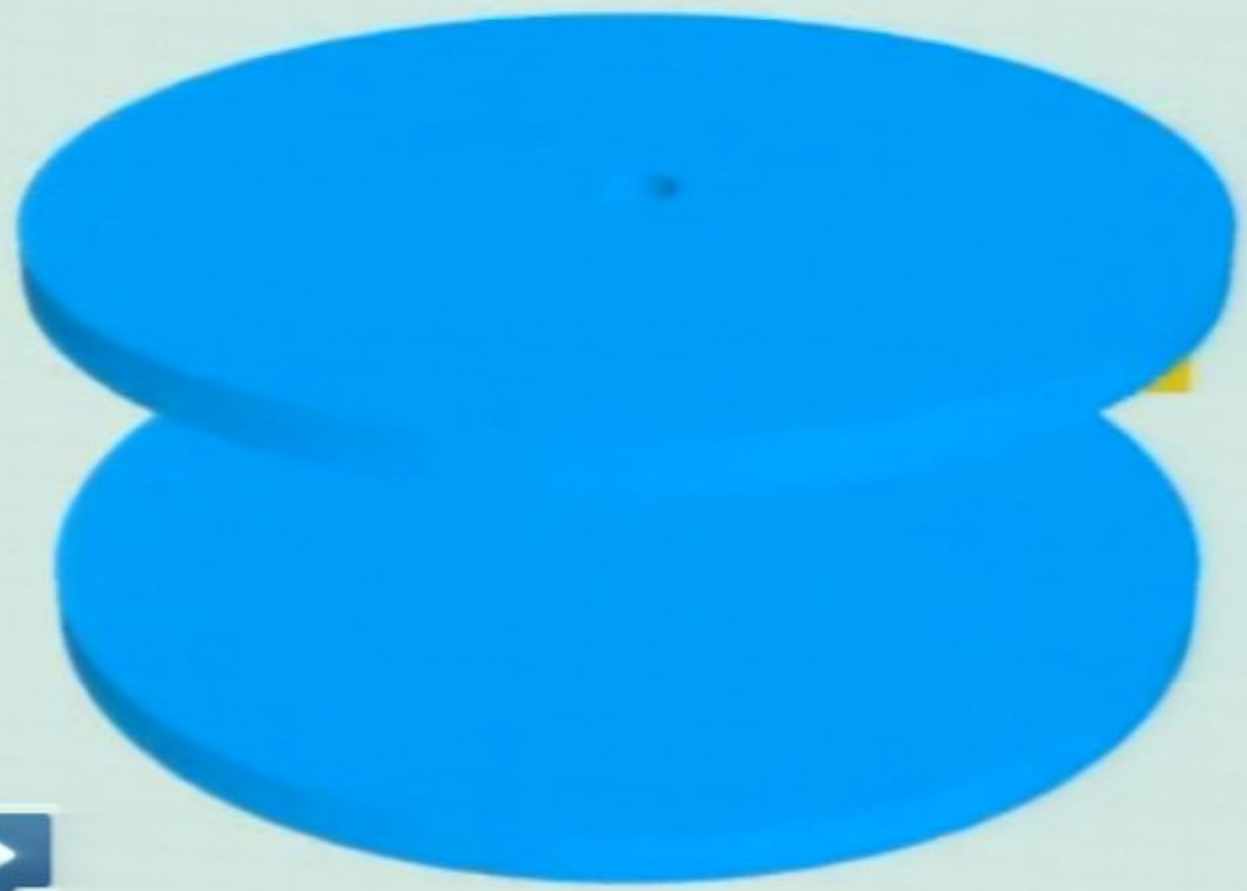




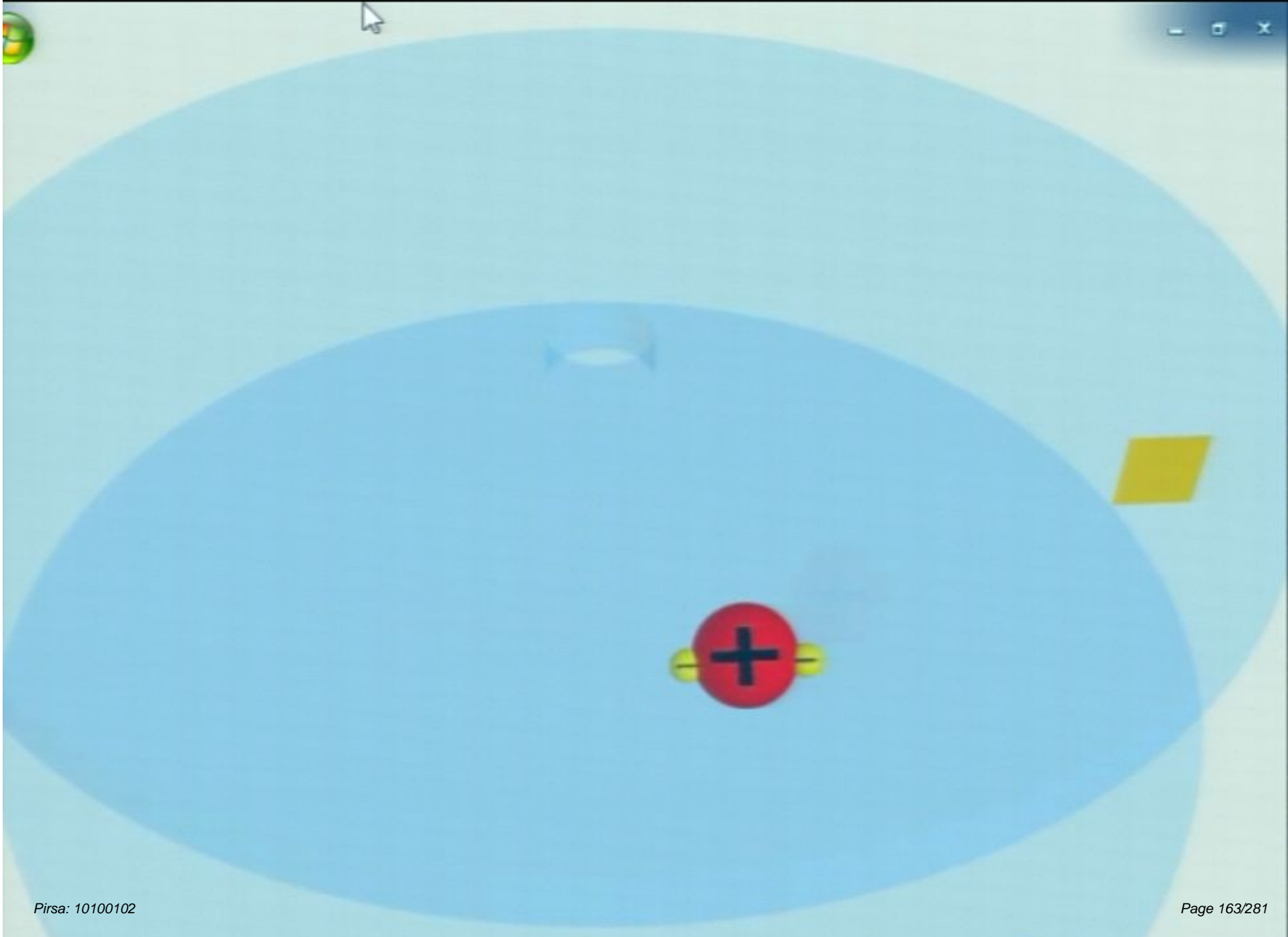


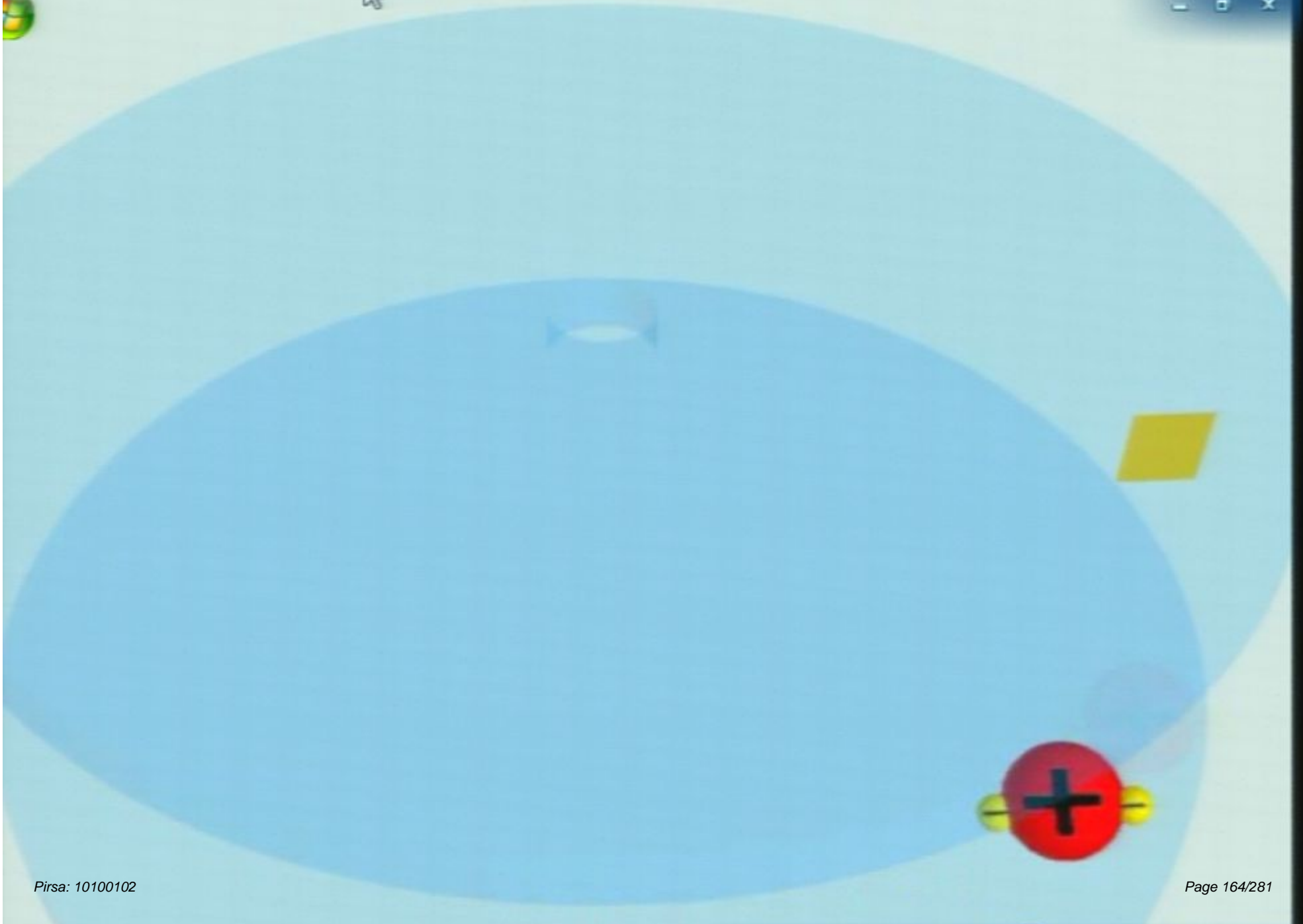


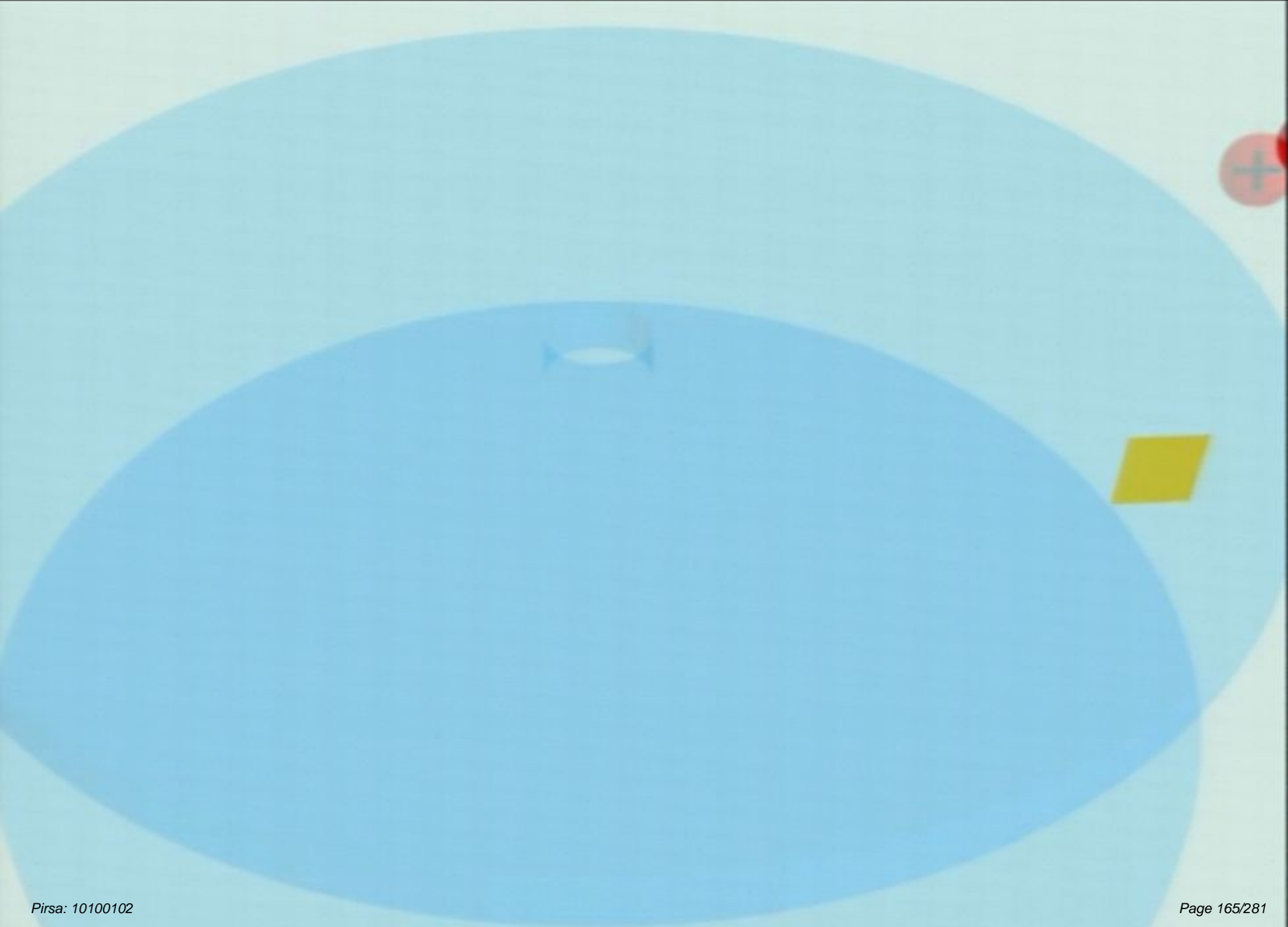
1:37 ▶



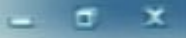
1:40 ▶

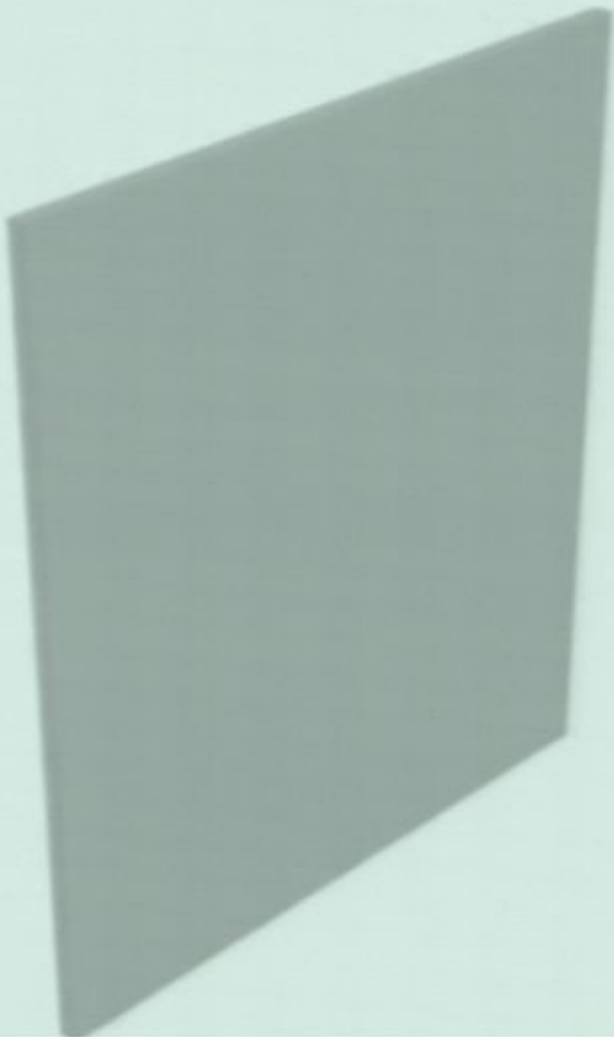










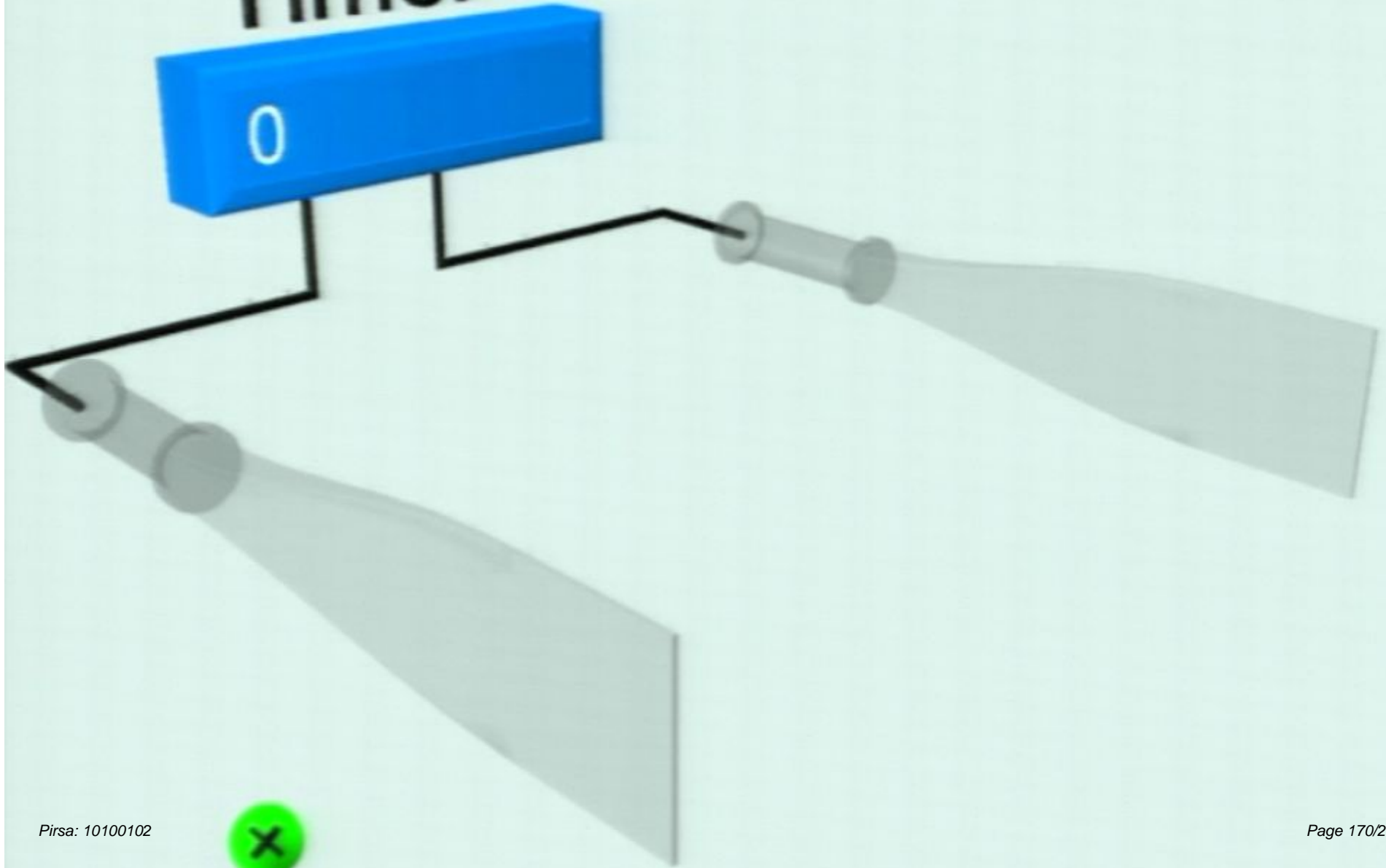


1:52 ||



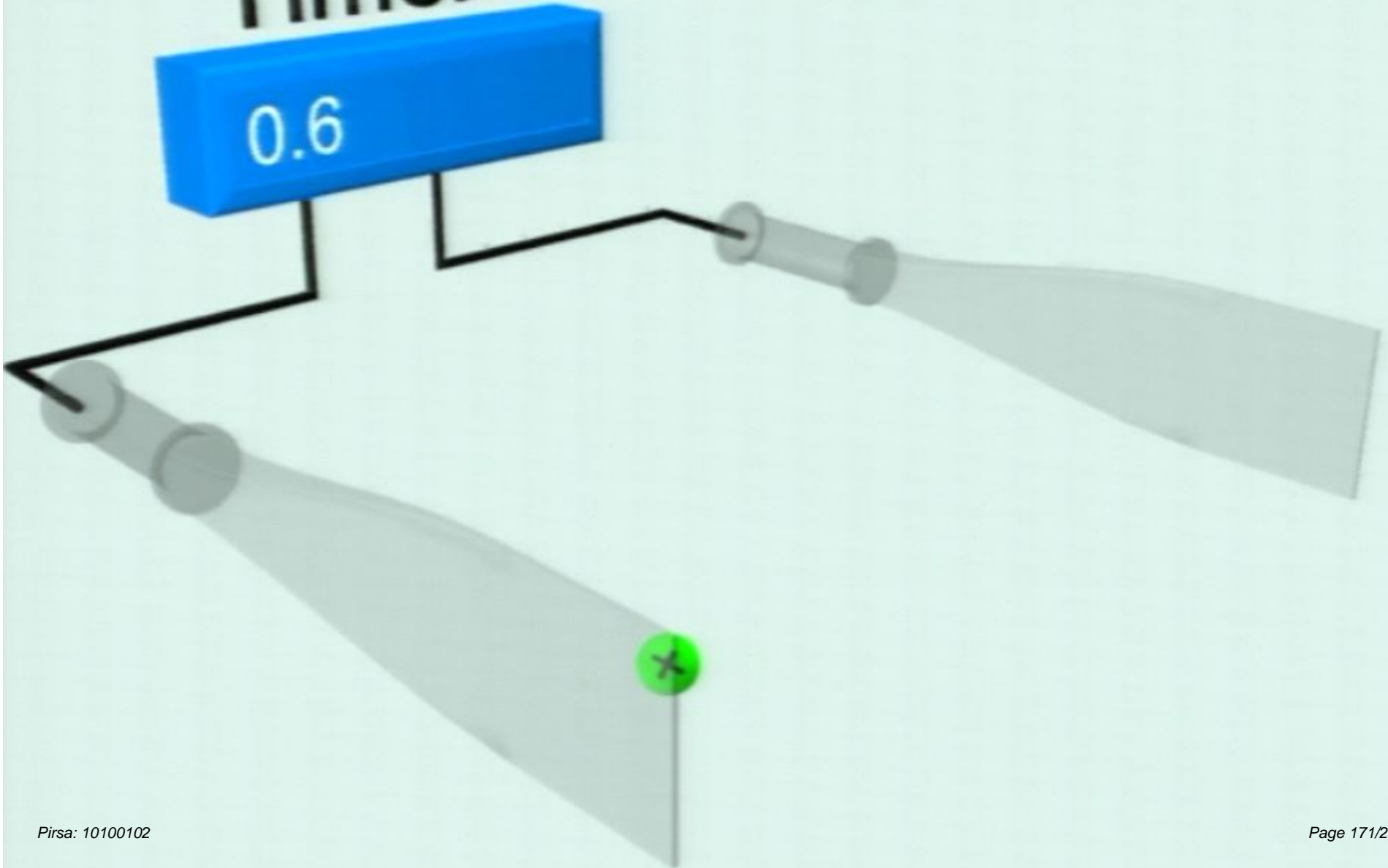
Timer

0



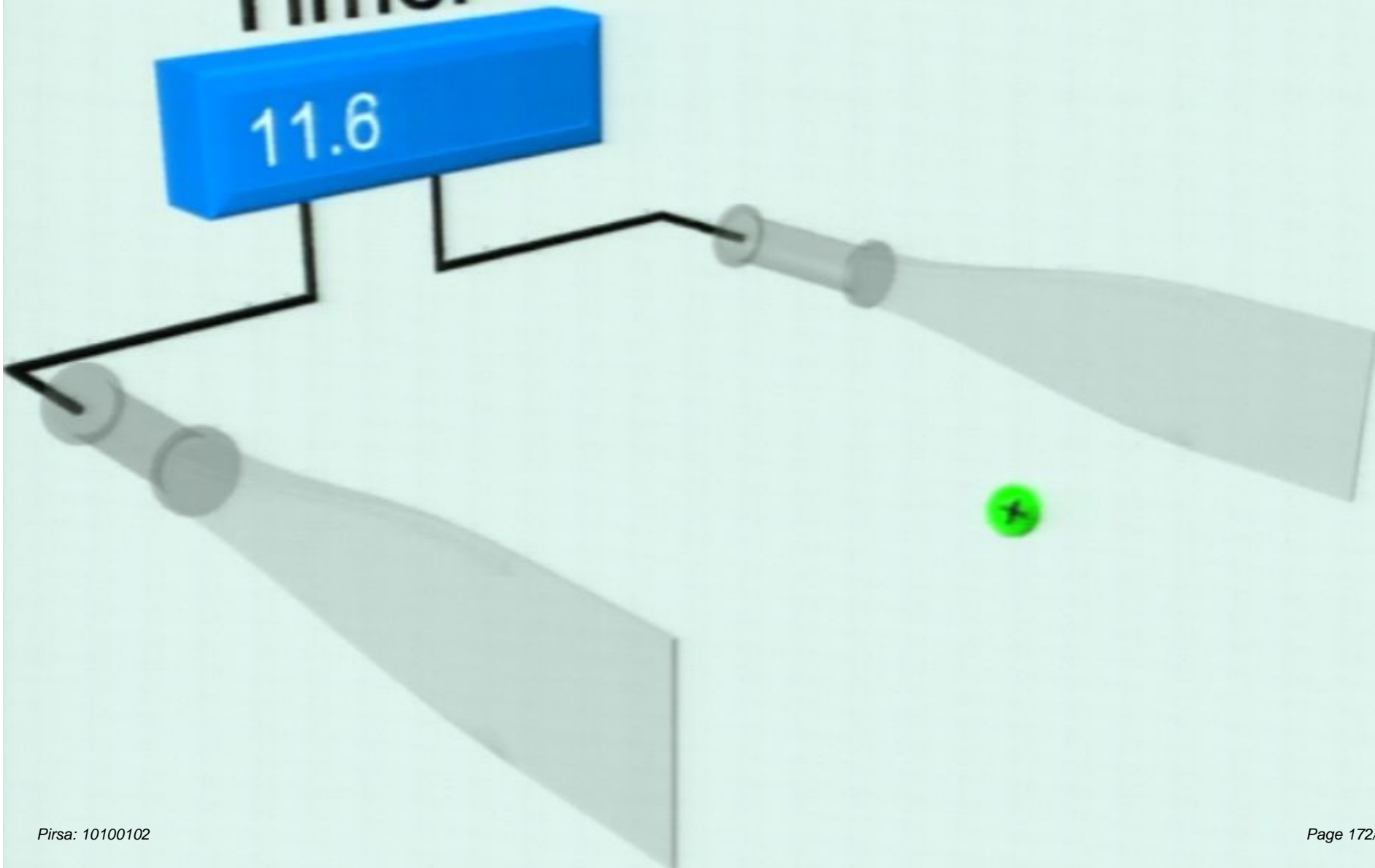
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0.6



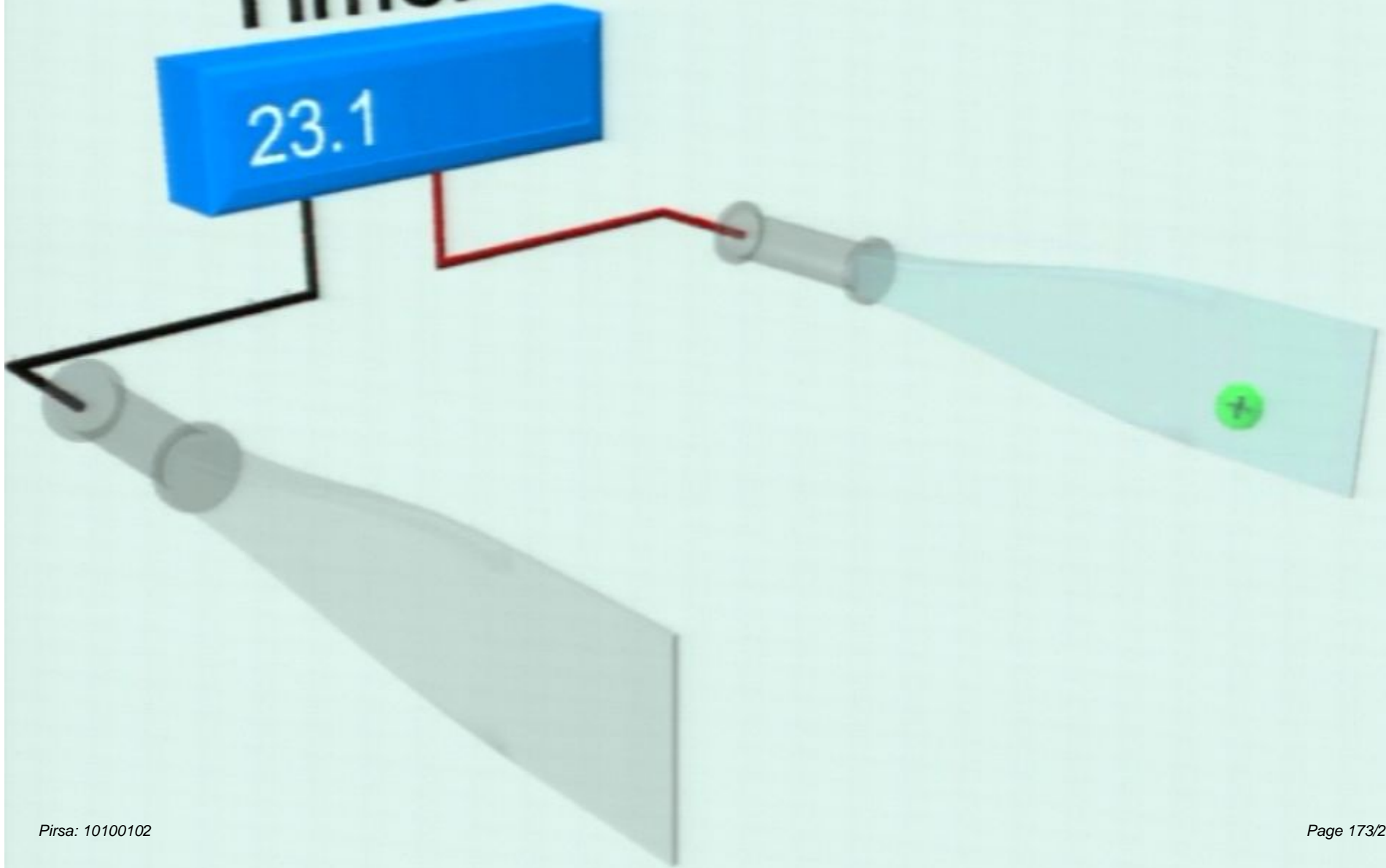
Timer

11.6



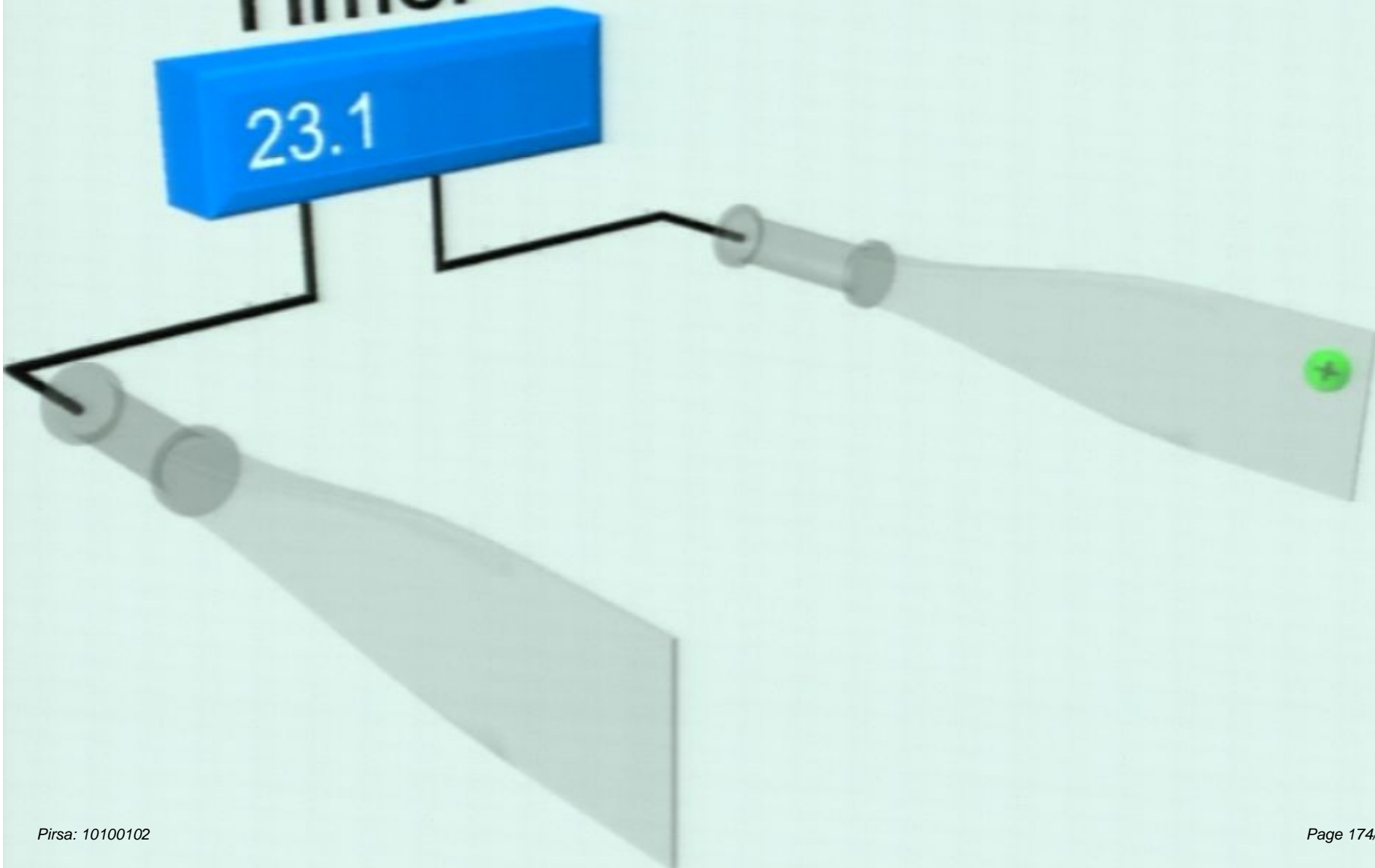
Timer

23.1



Timer

23.1



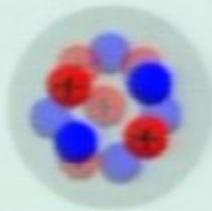
Classical

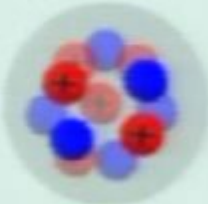
$$p = m v$$

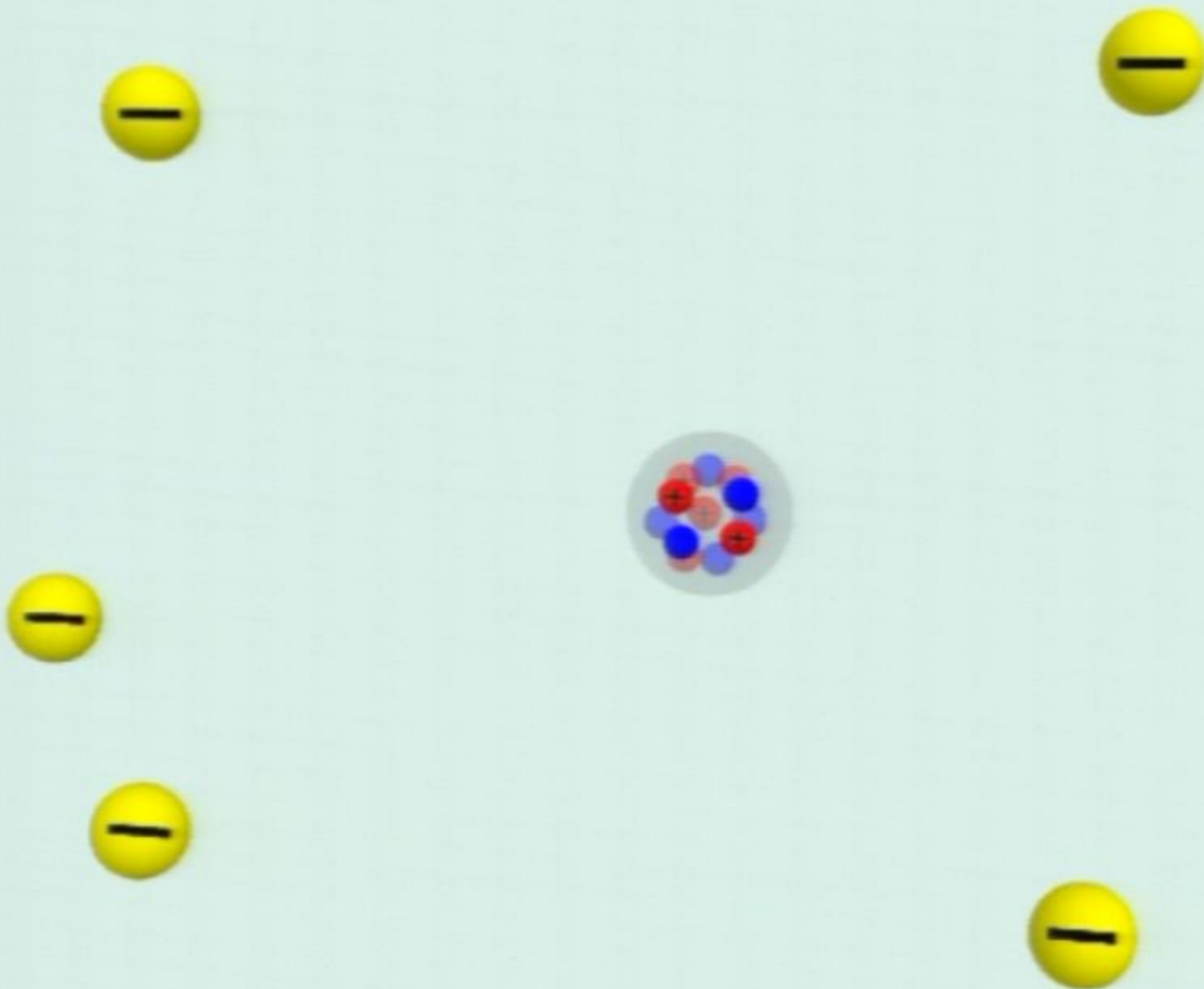


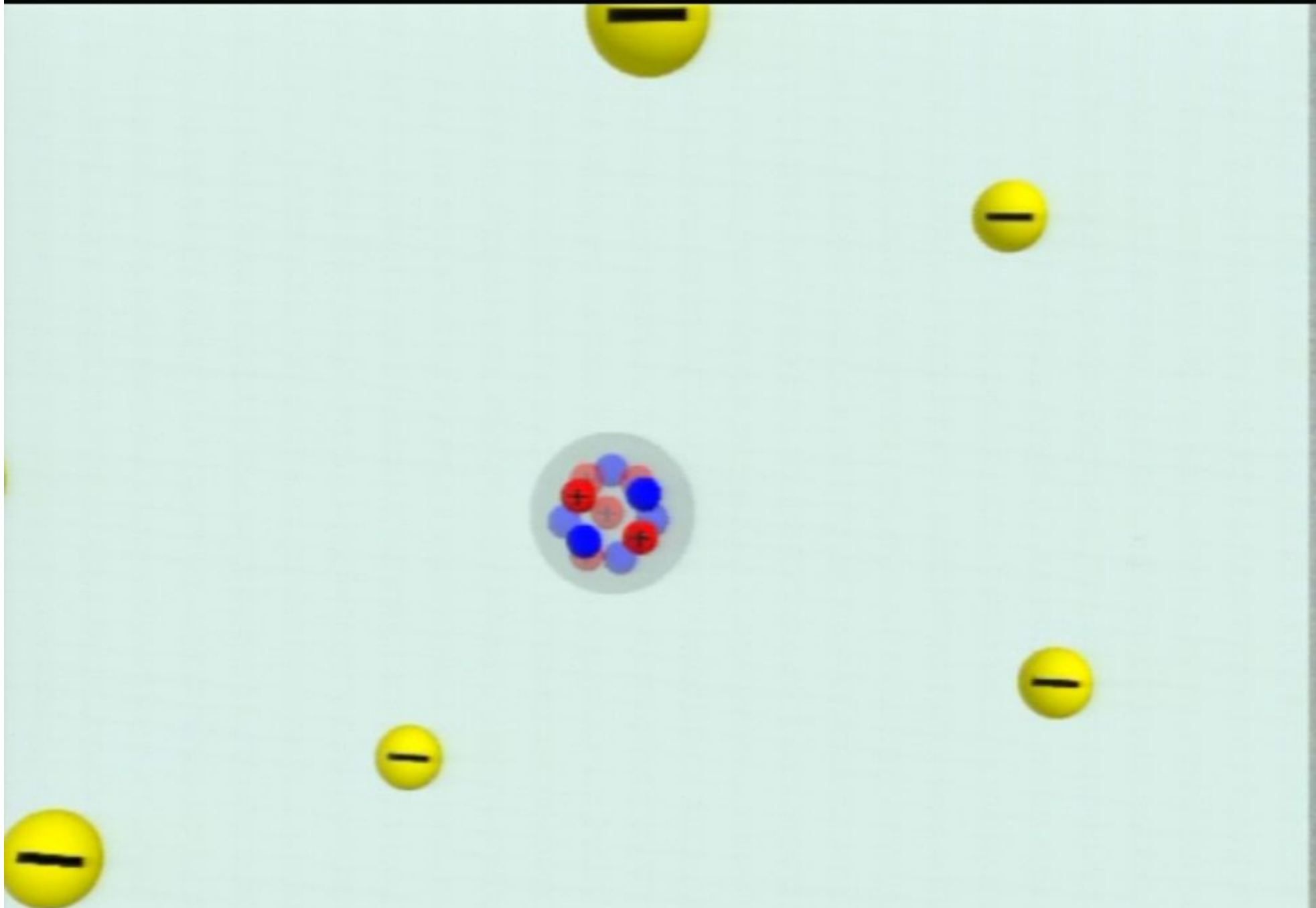
Classical

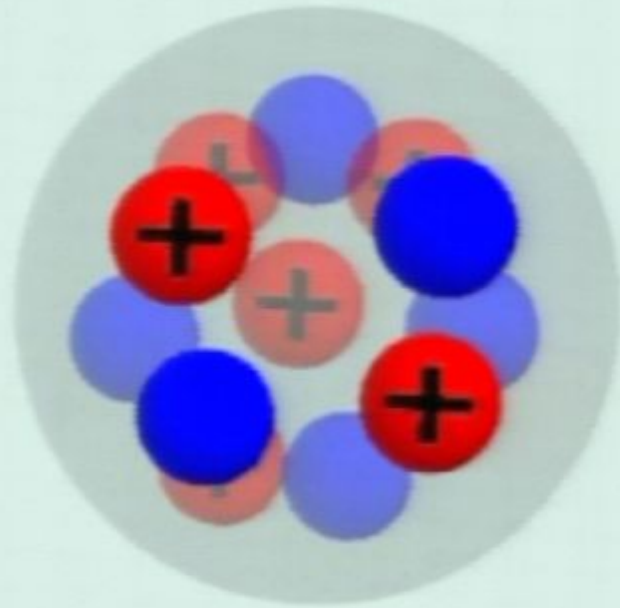
$$p = m v$$

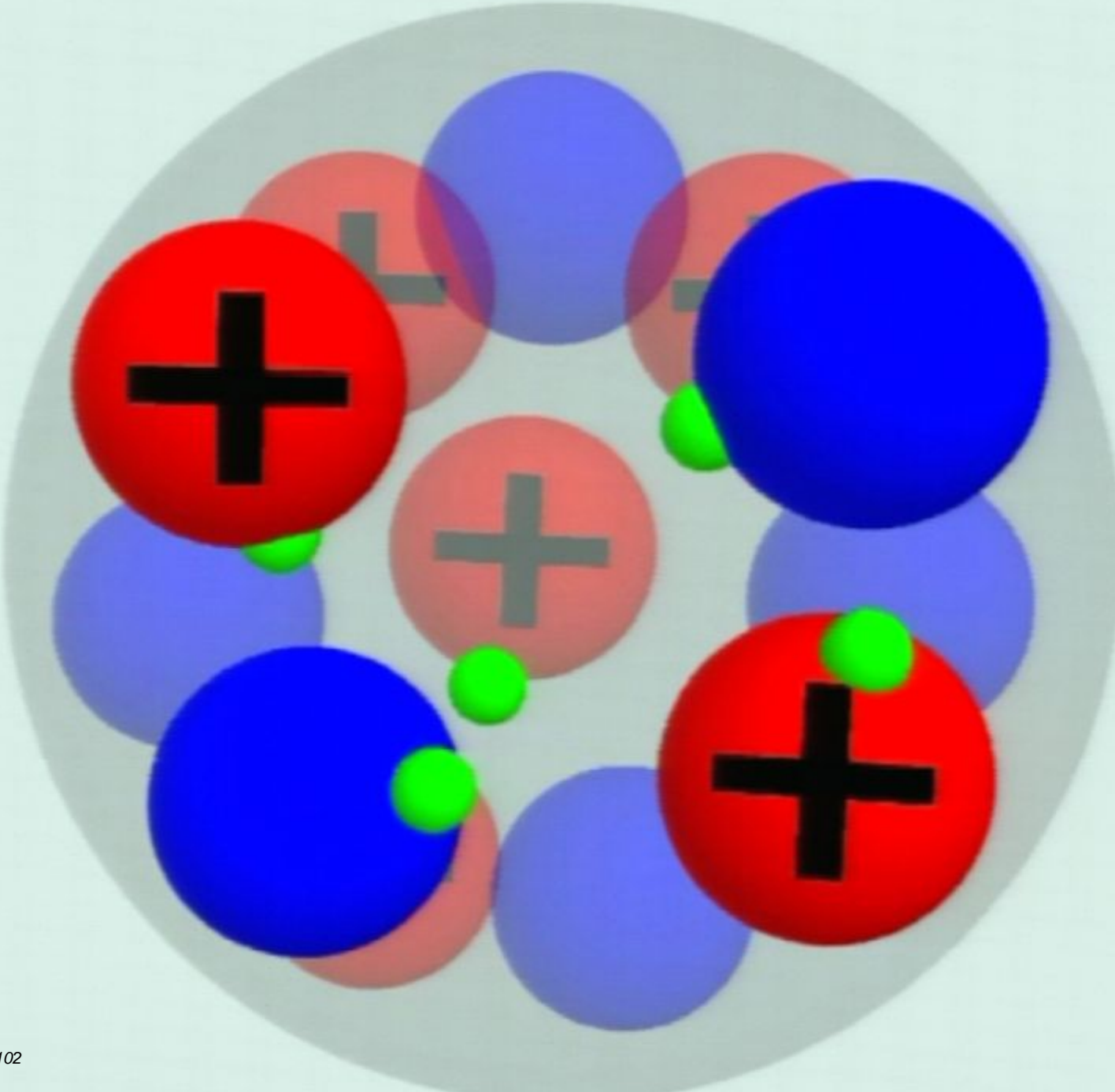


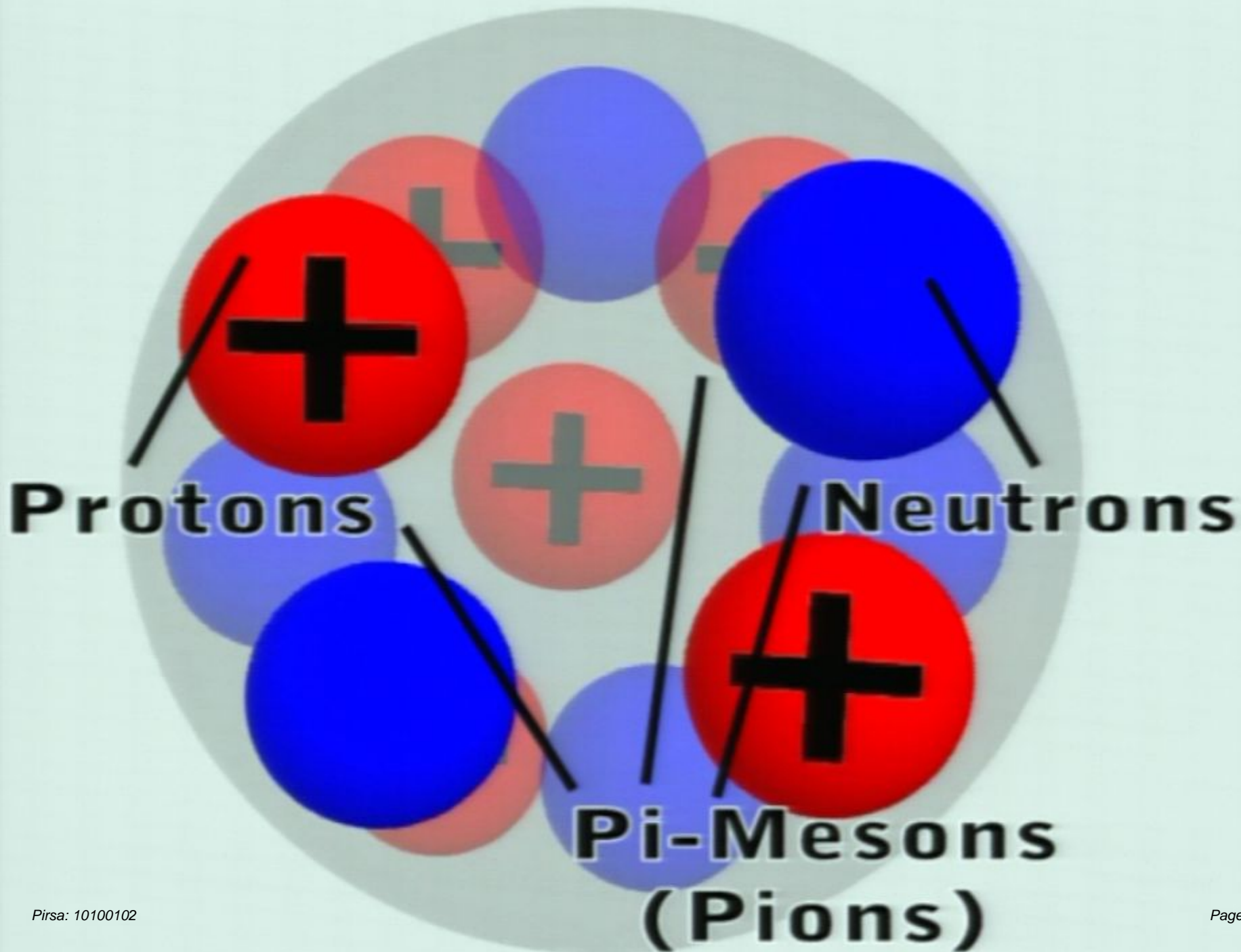


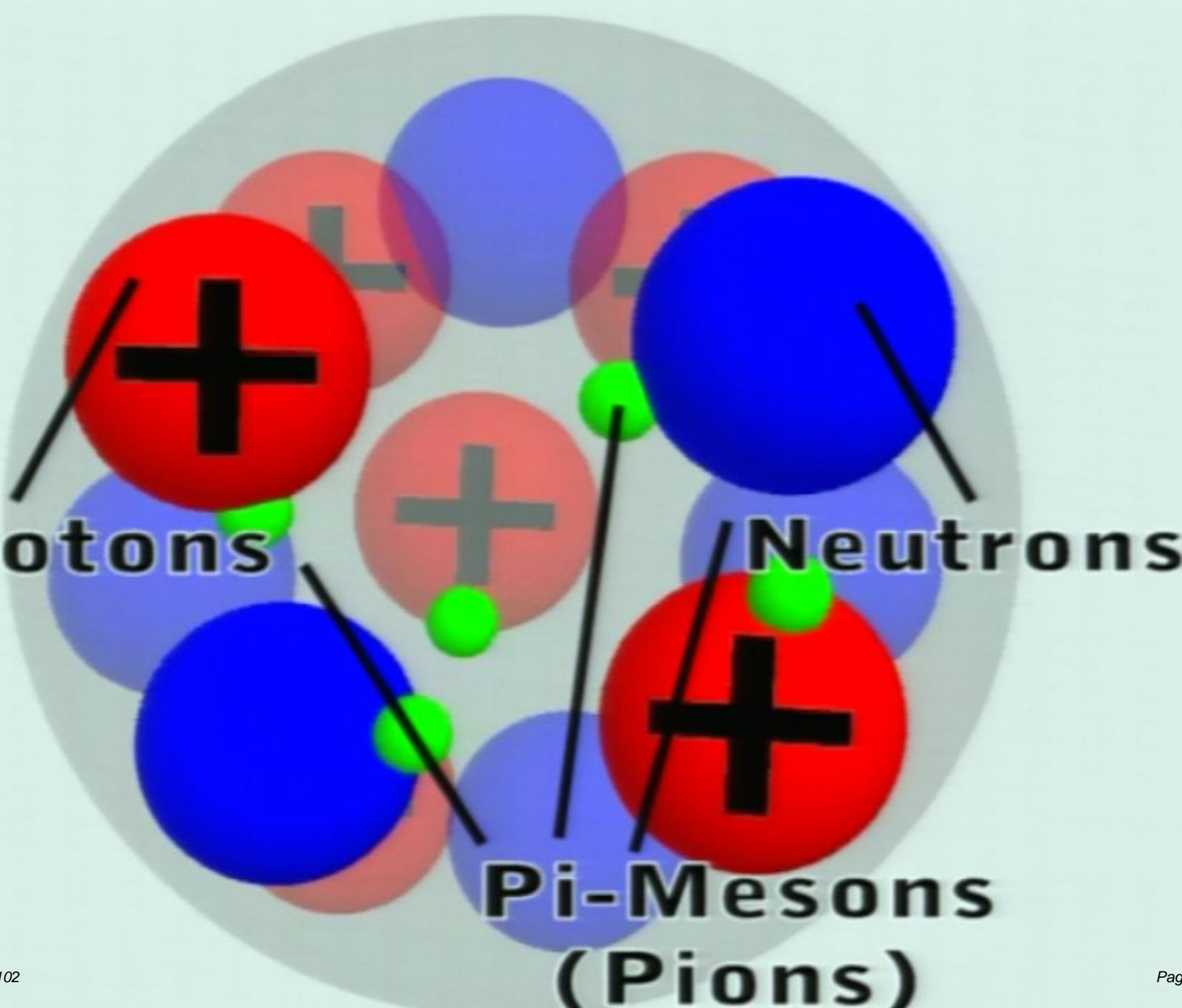








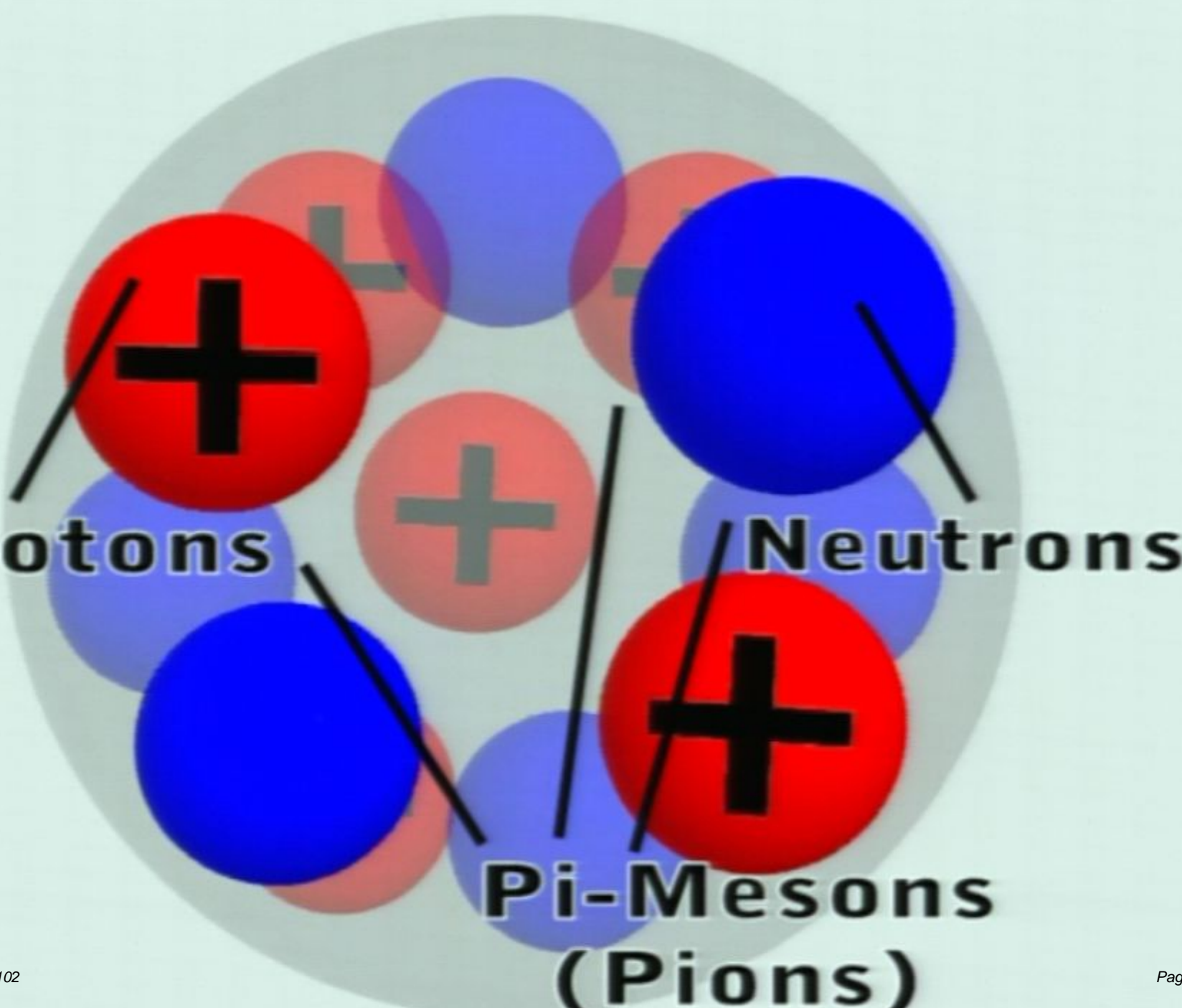




Protons

Neutrons

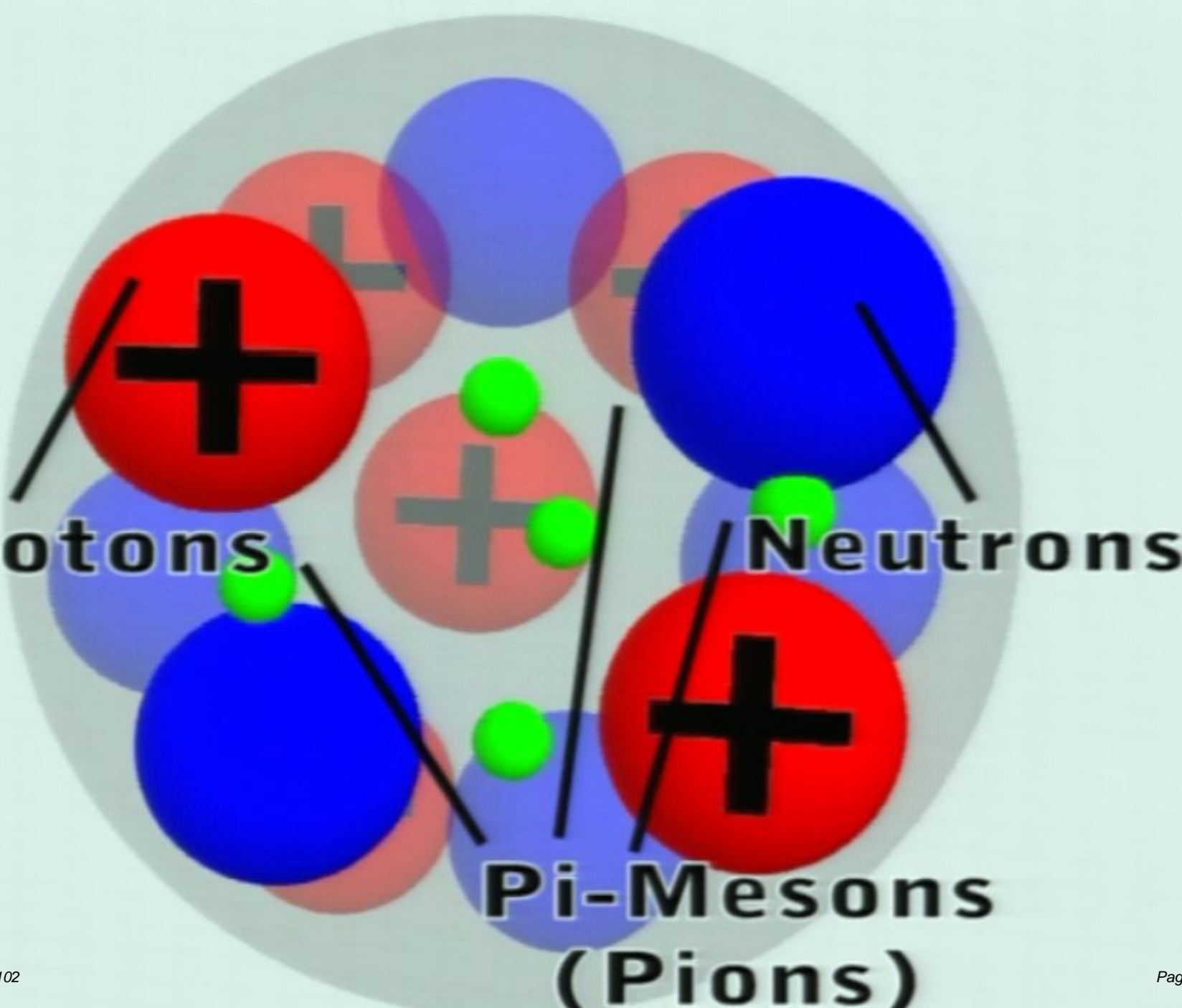
**Pi-Mesons
(Pions)**



Protons

Neutrons

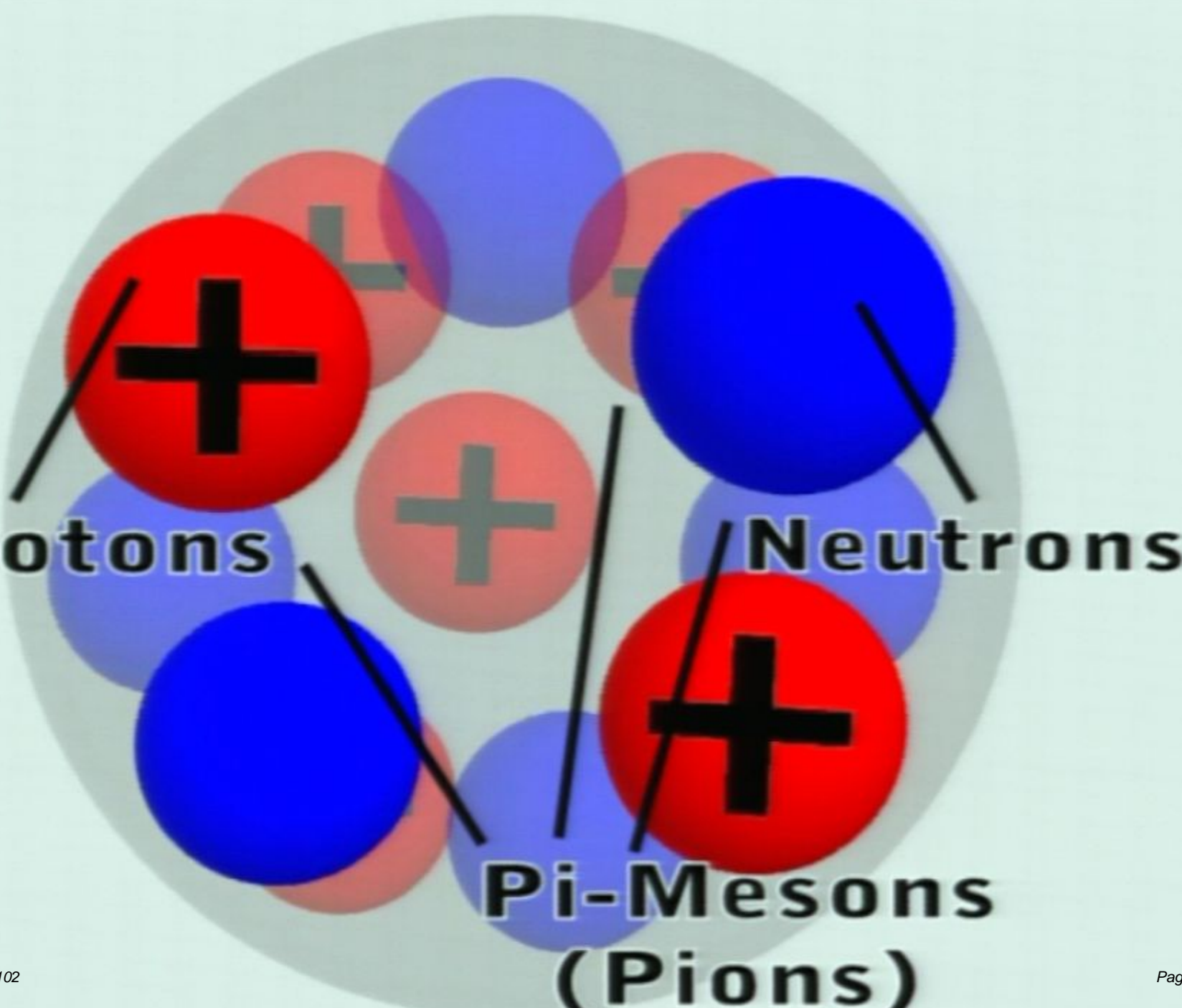
**Pi-Mesons
(Pions)**



Protons

Neutrons

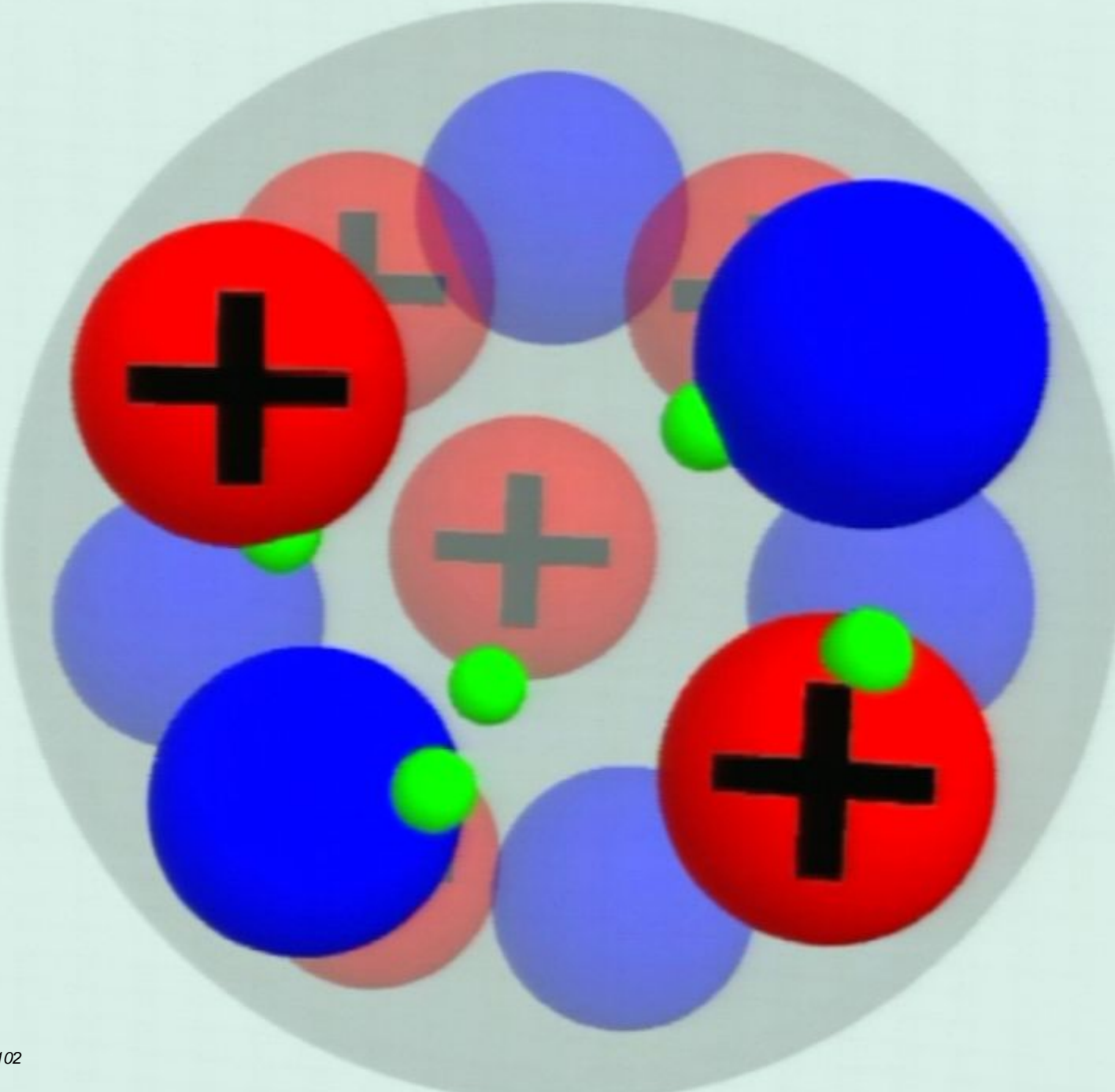
**Pi-Mesons
(Pions)**

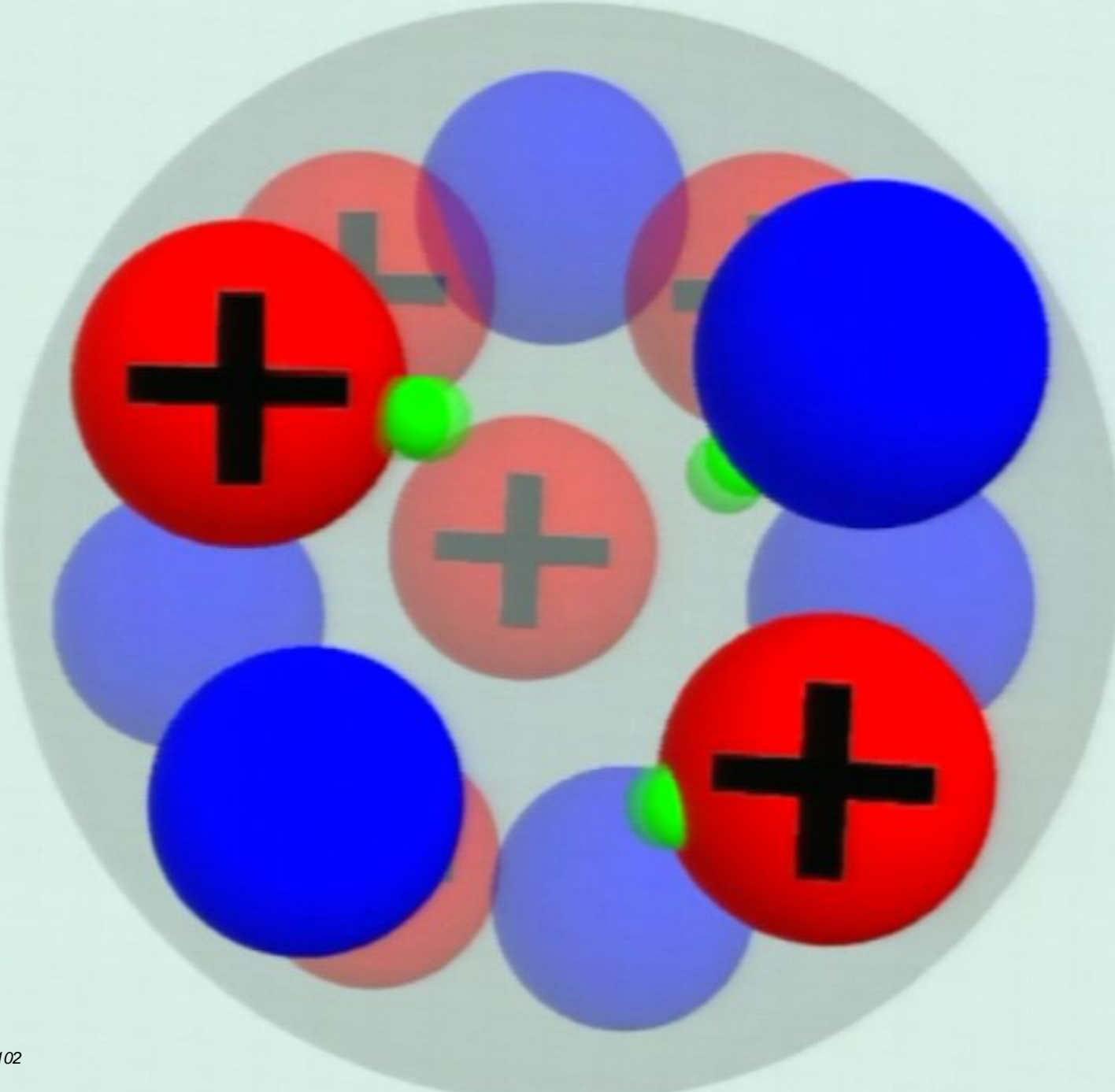


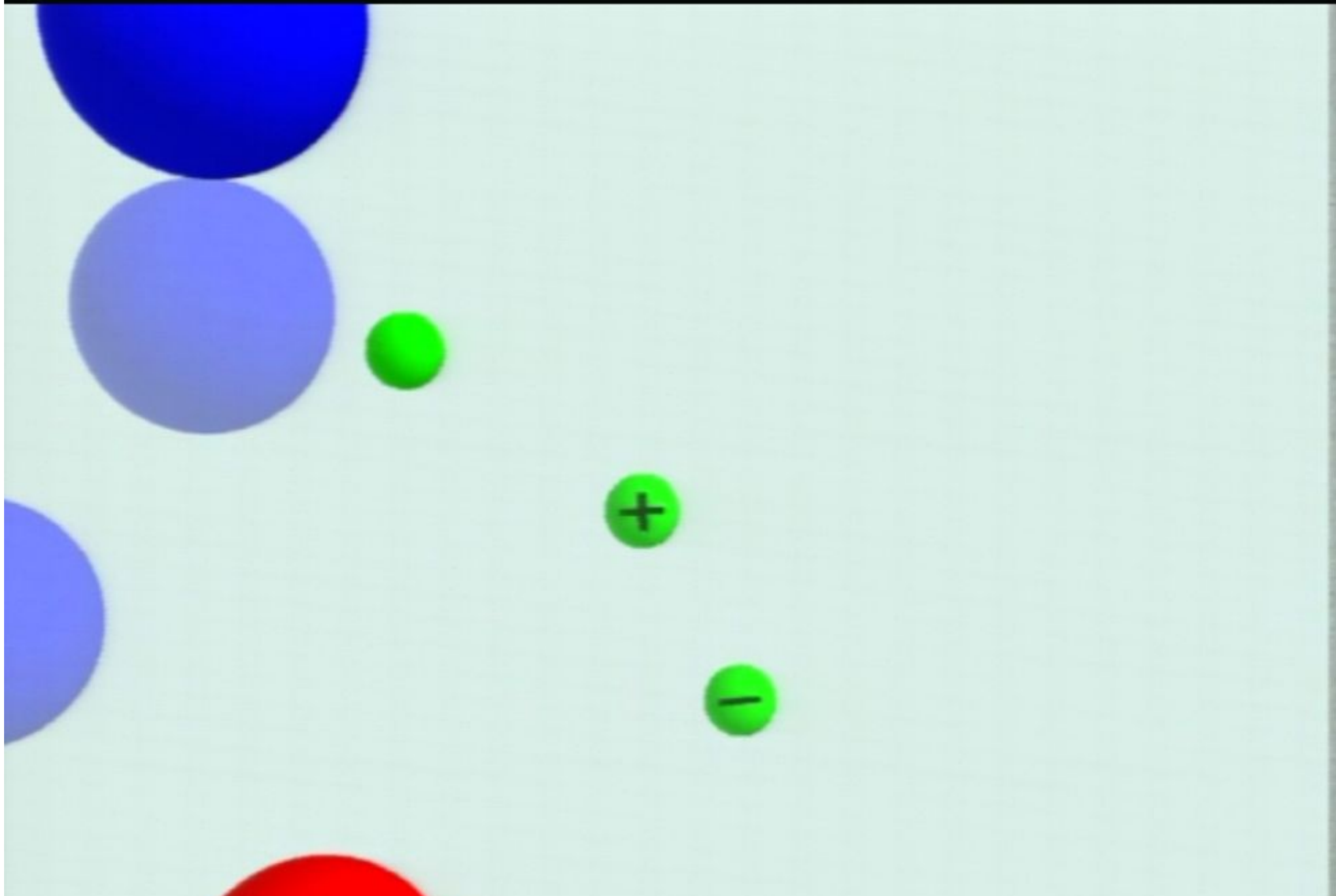
Protons

Neutrons

**Pi-Mesons
(Pions)**

















pions

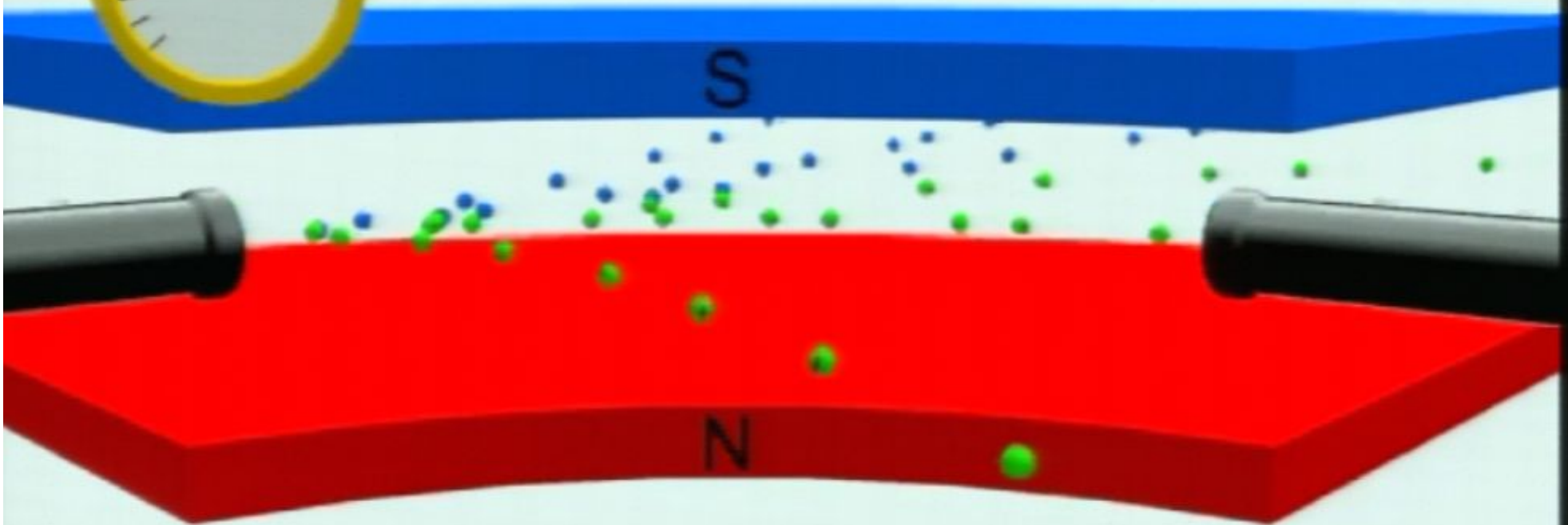


muons

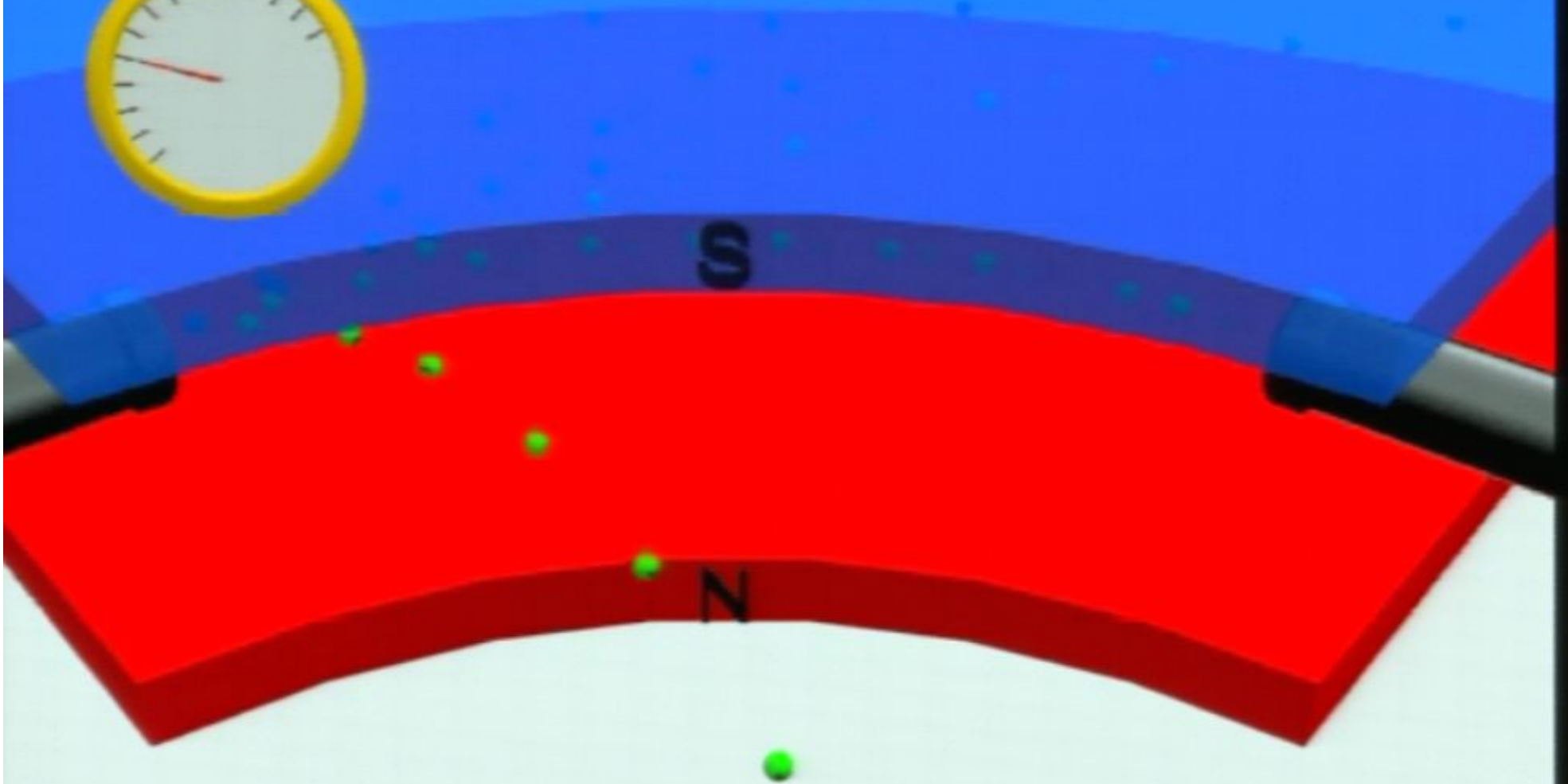


electrons

Field Strength



Field Strength



Field Strength



Field Strength



Field Strength



Field Strength



Field Strength



Field Strength



Field Strength



Field Strength



Field Strength



Field Strength



Field Strength



Field Strength



Field Strength



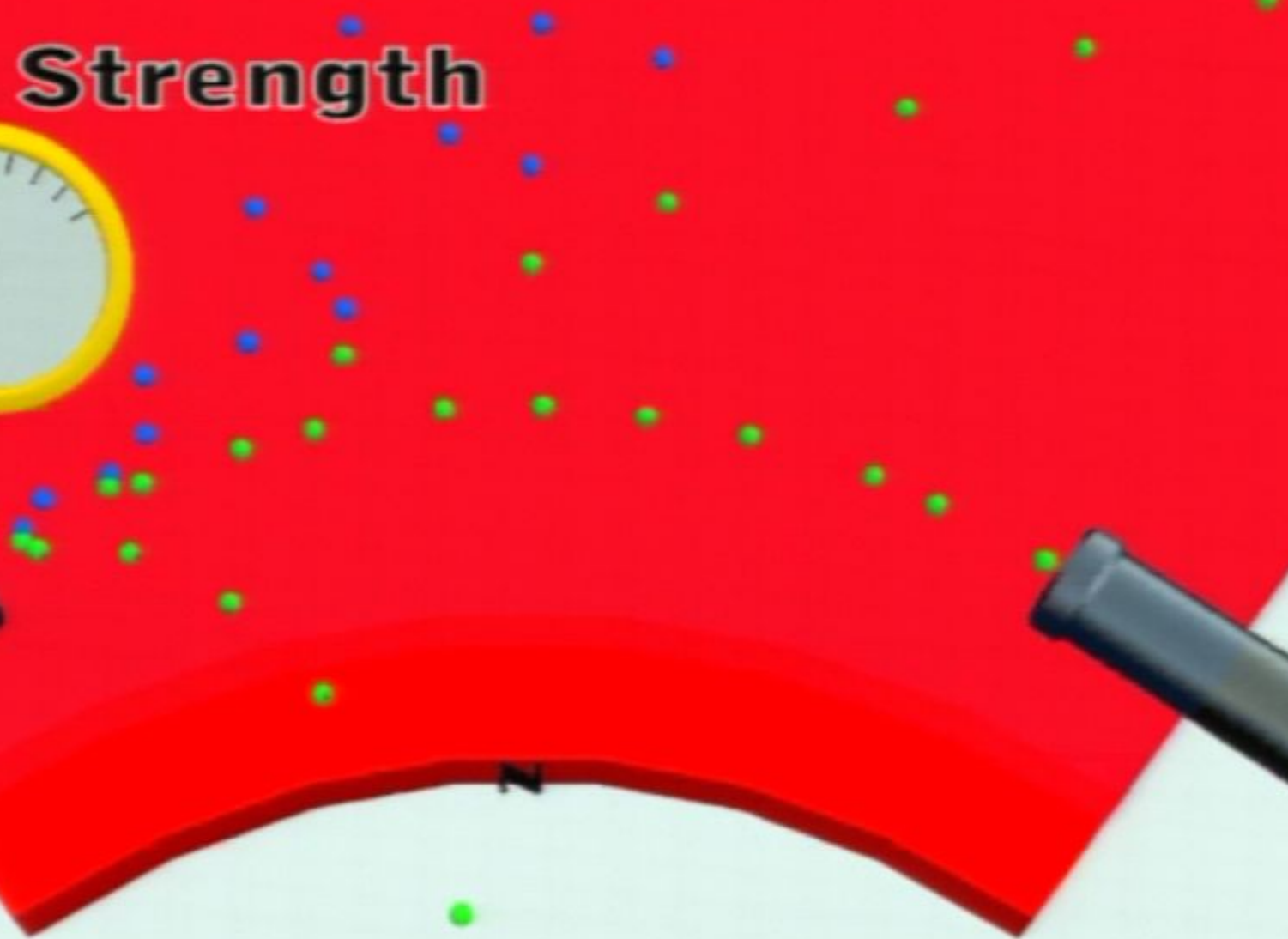
Field Strength



Field Strength



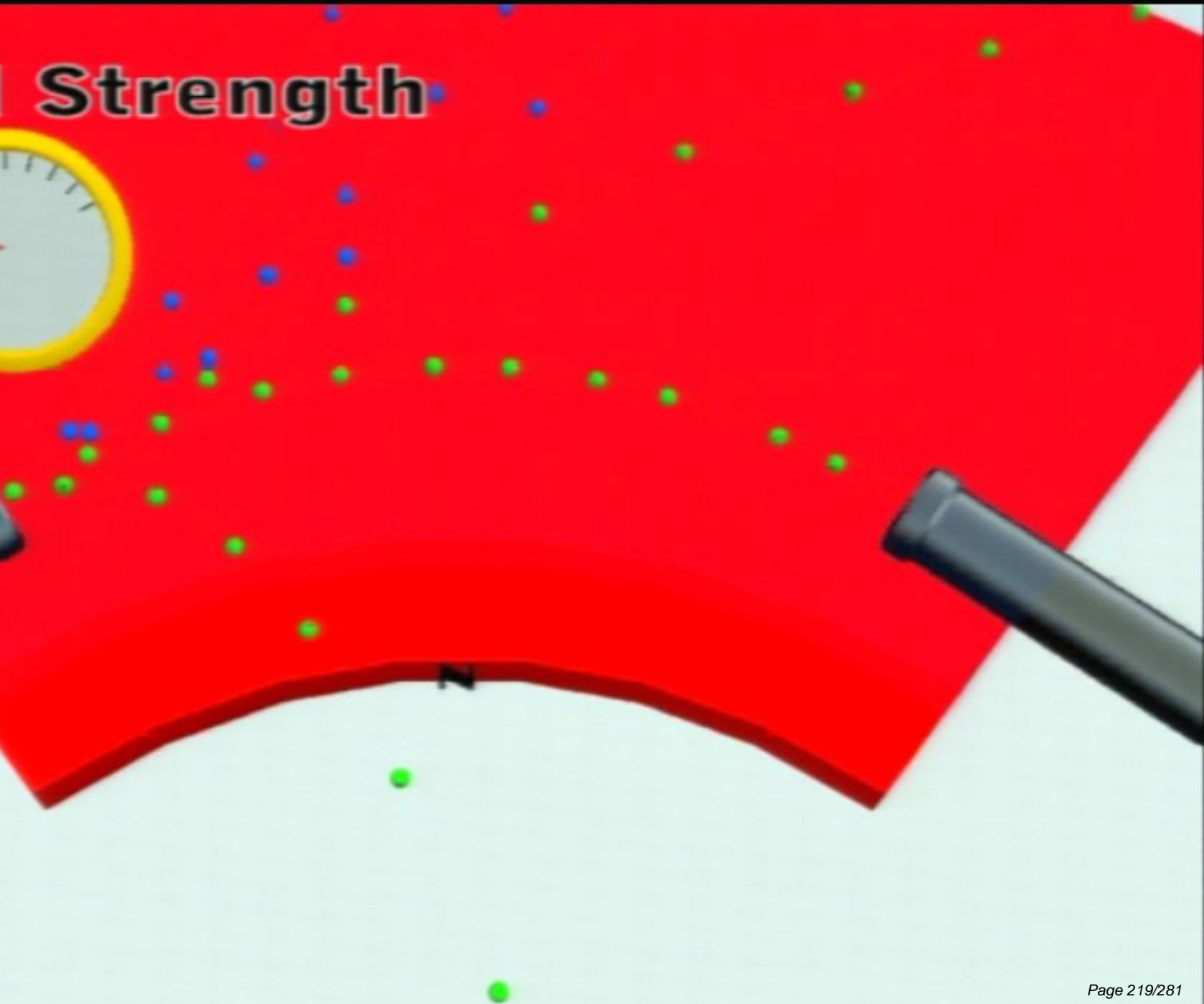
Field Strength



Field Strength



Field Strength



Field Strength



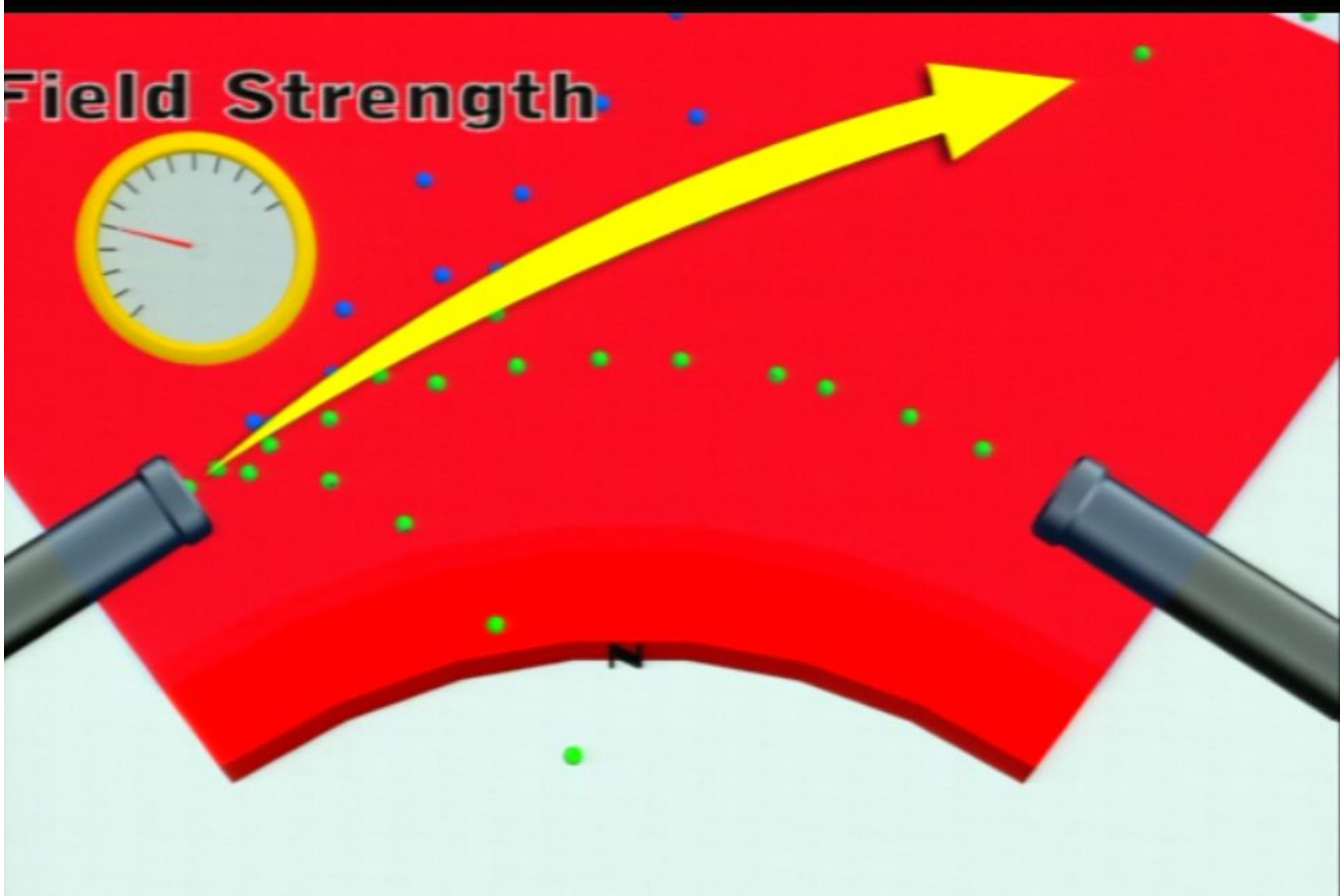
Field Strength



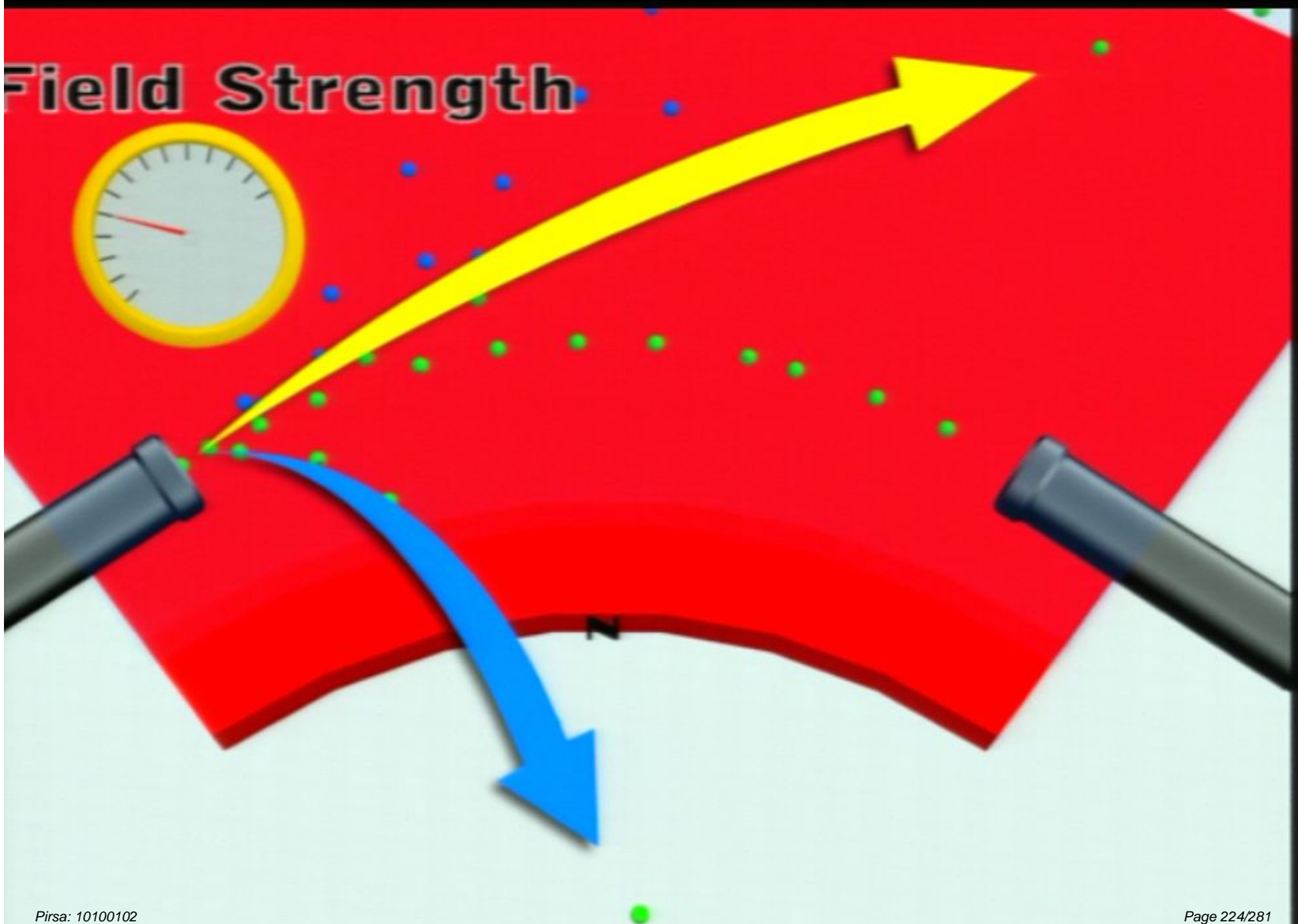
Field Strength



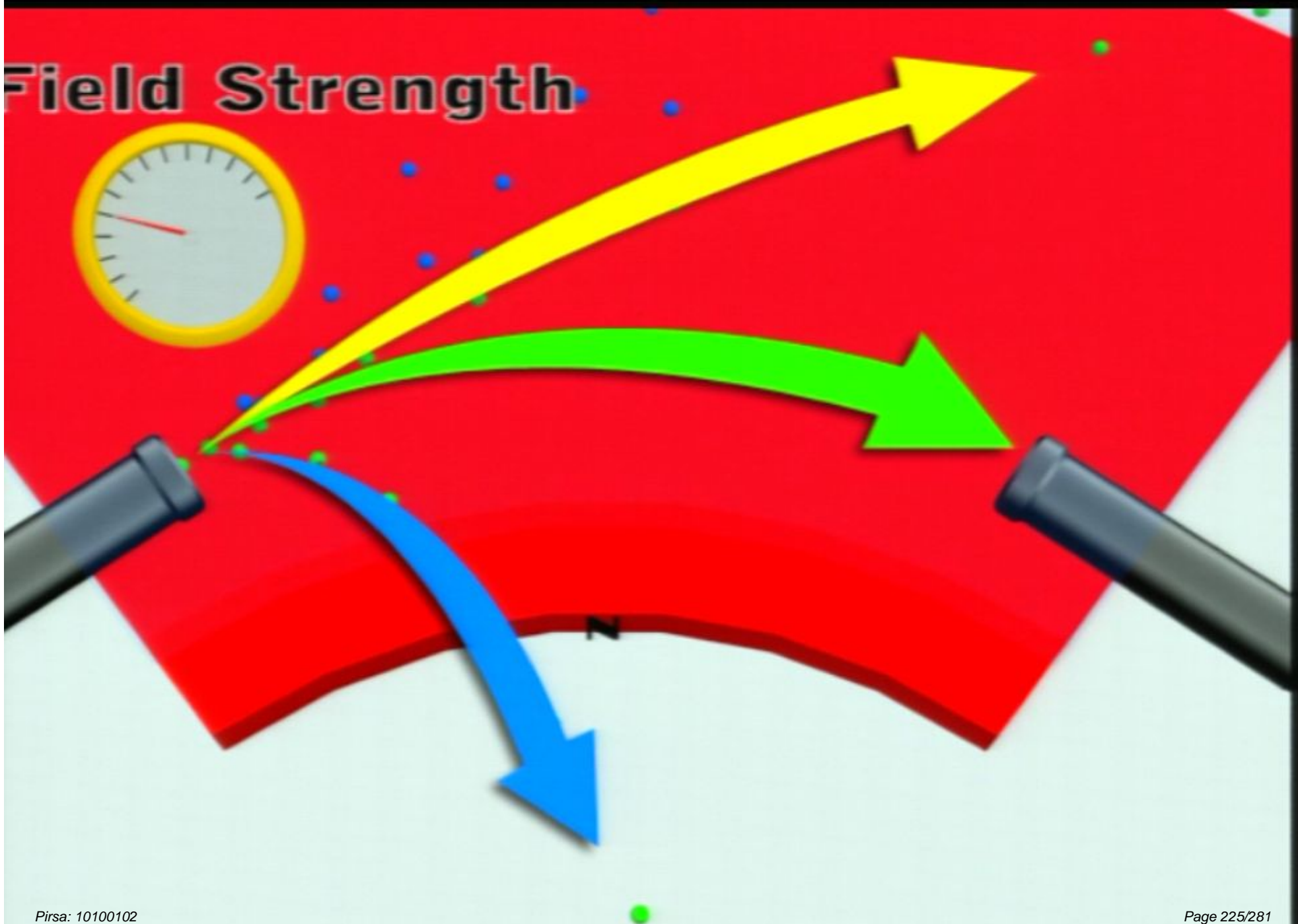
Field Strength



Field Strength



Field Strength



Field Strength



Field Strength



Field Strength



Field Strength



Field Strength



Field Strength



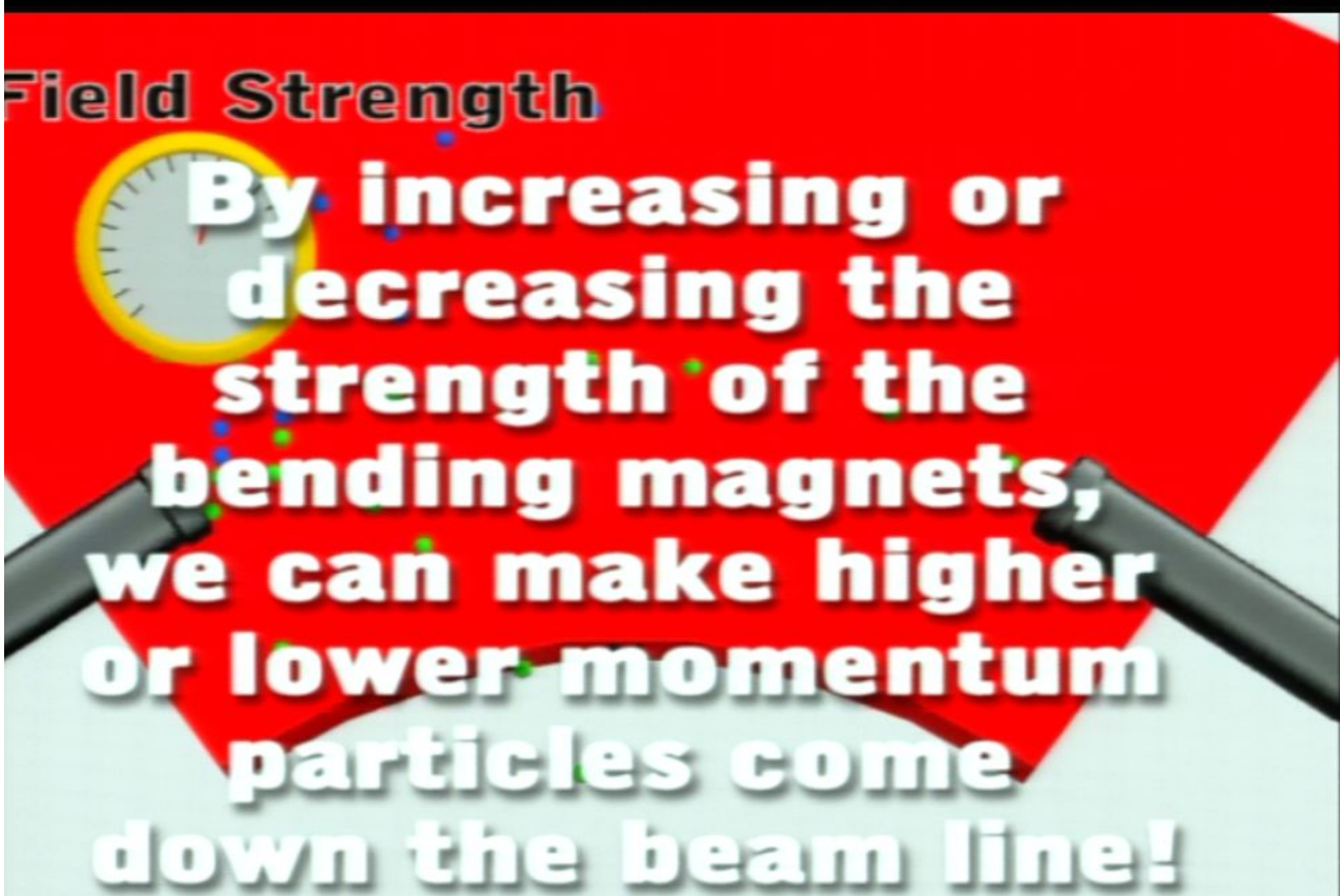
Field Strength



Field Strength




Field Strength




By increasing or decreasing the strength of the bending magnets, we can make higher or lower momentum particles come down the beam line!

Field Strength



By increasing or decreasing the strength of the bending magnets, we can make higher or lower momentum particles come down the beam line!



Field Strength



Field Strength

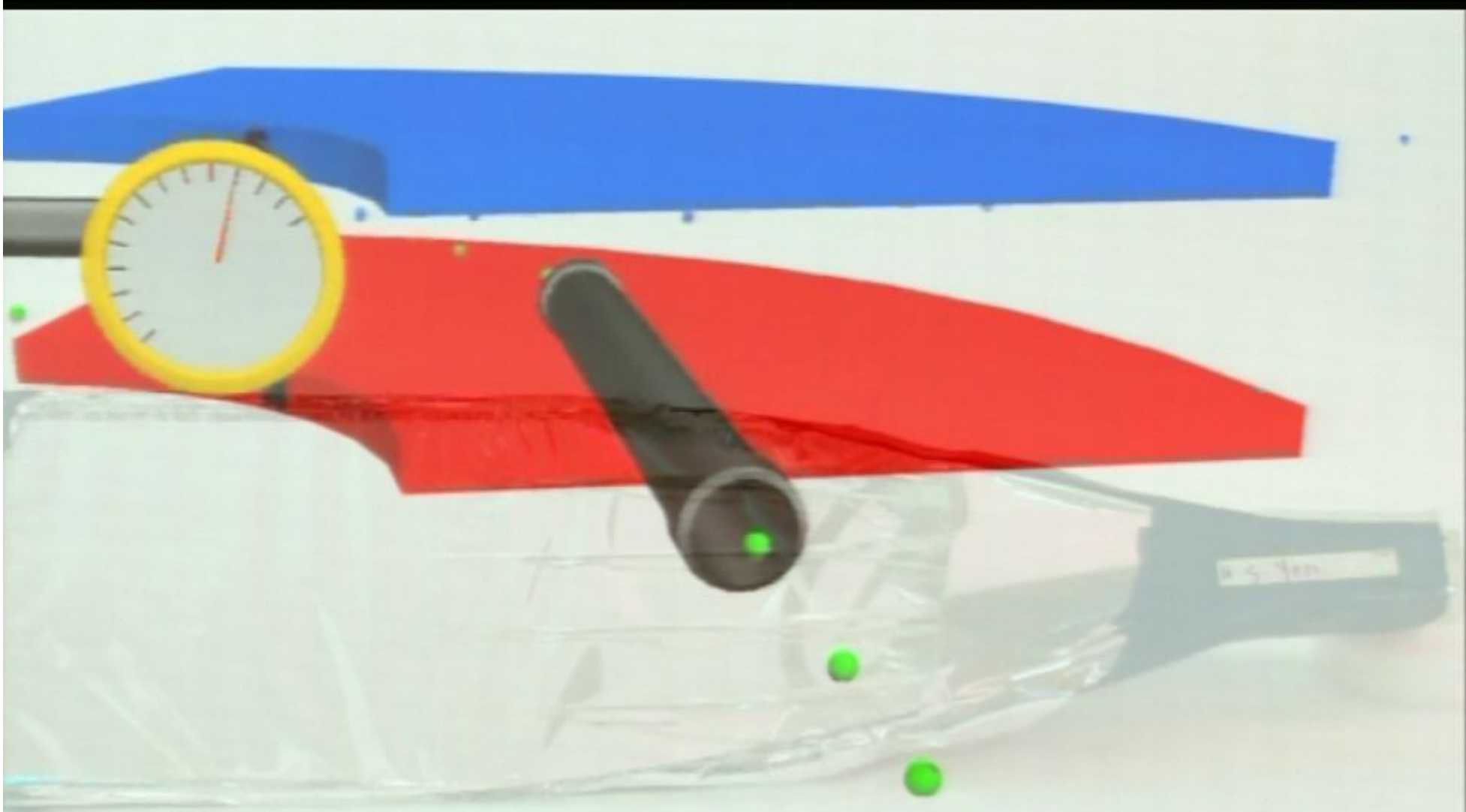


Field Strength



Field Strength

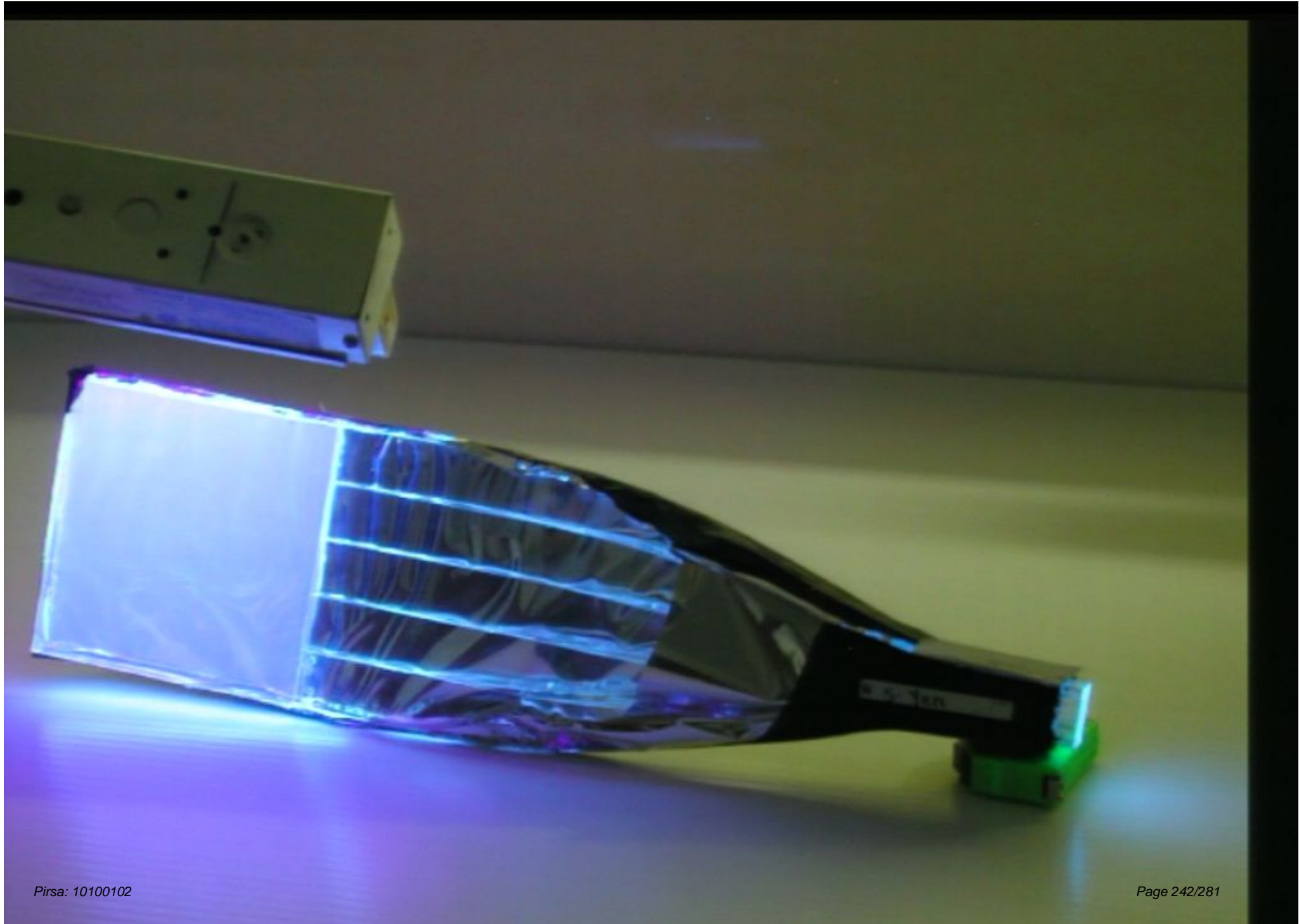




Plastic Scintillator



Plastic Scintillator







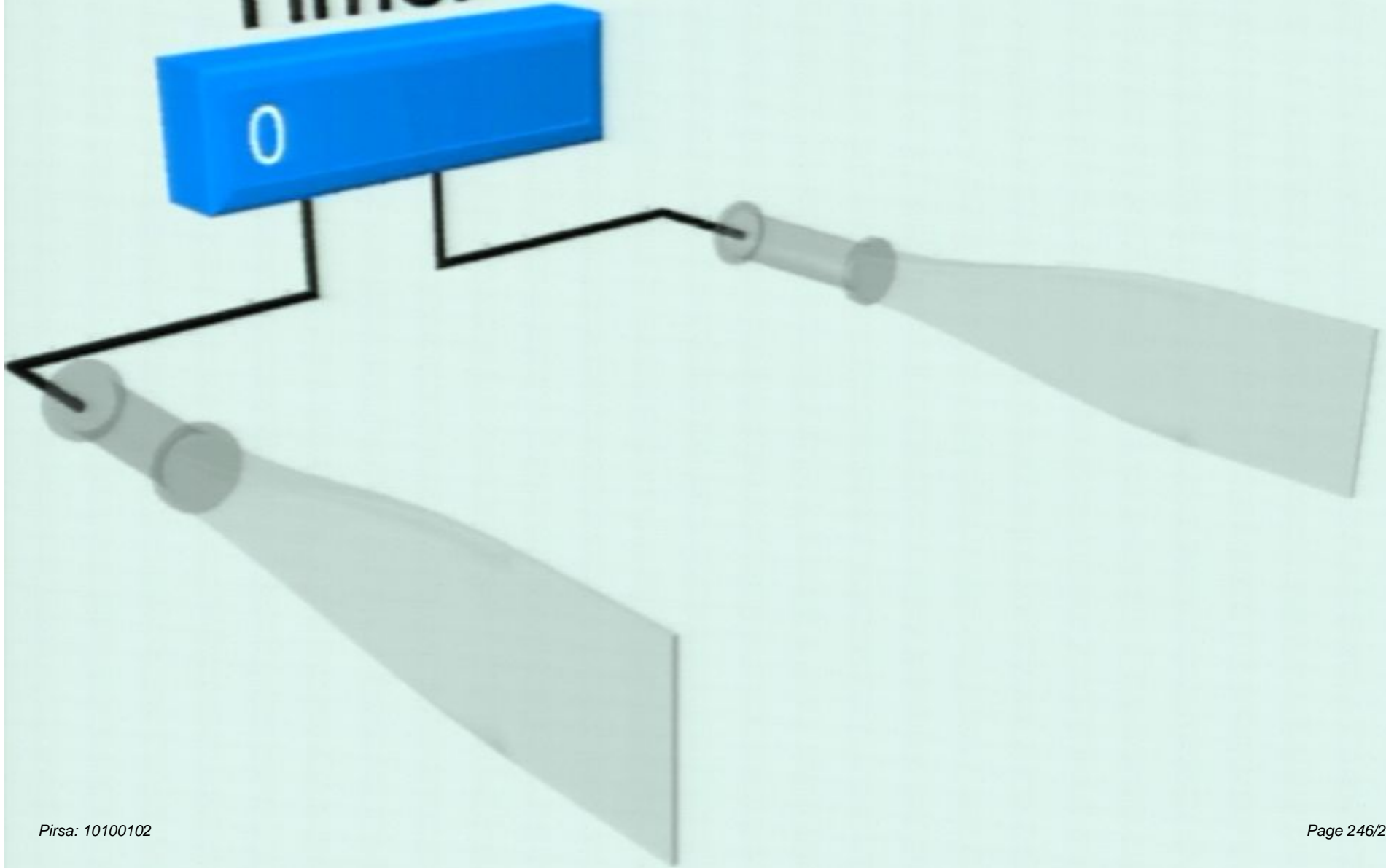
Scintillator

**Photomultiplier
Tube**



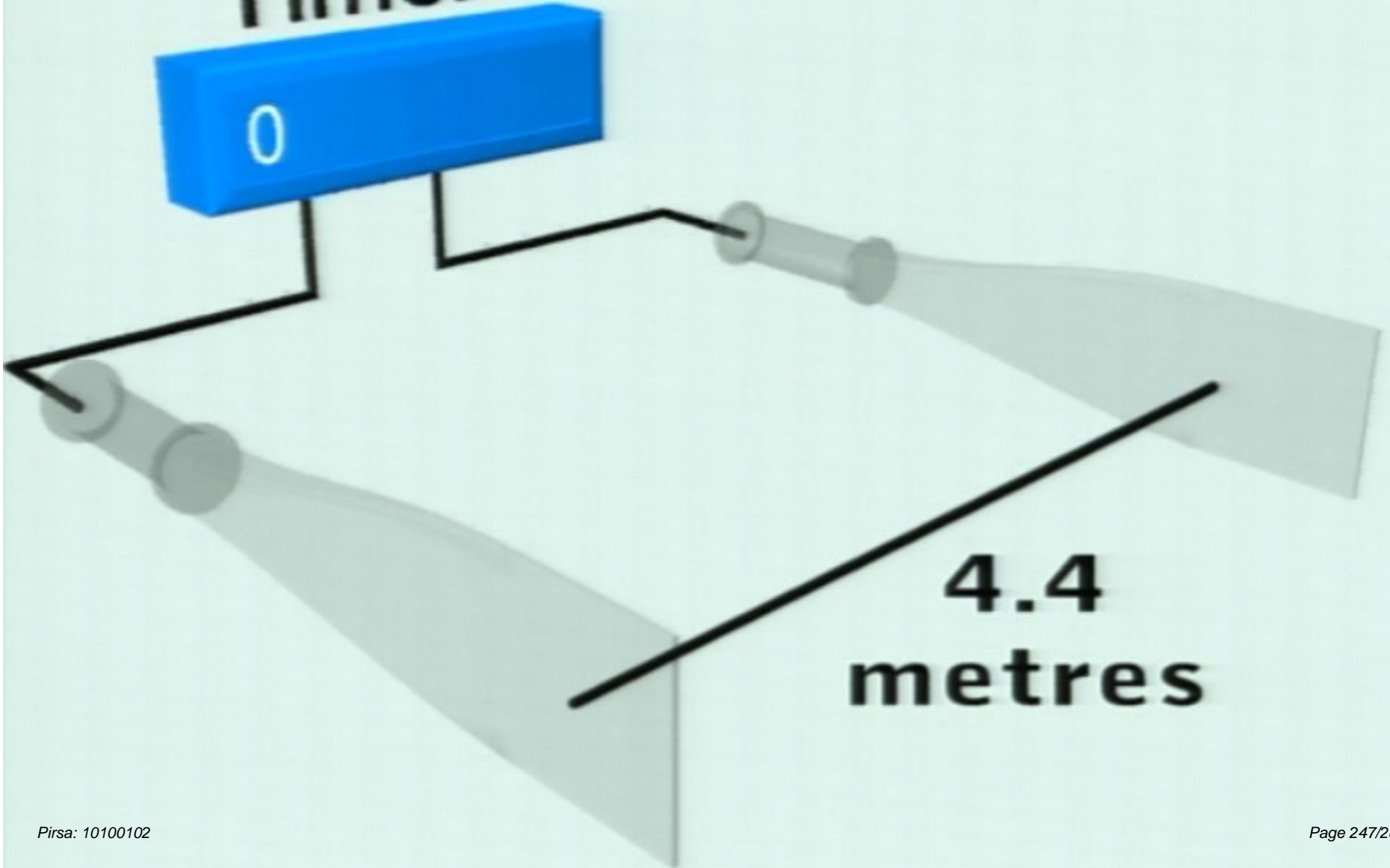
Timer

0



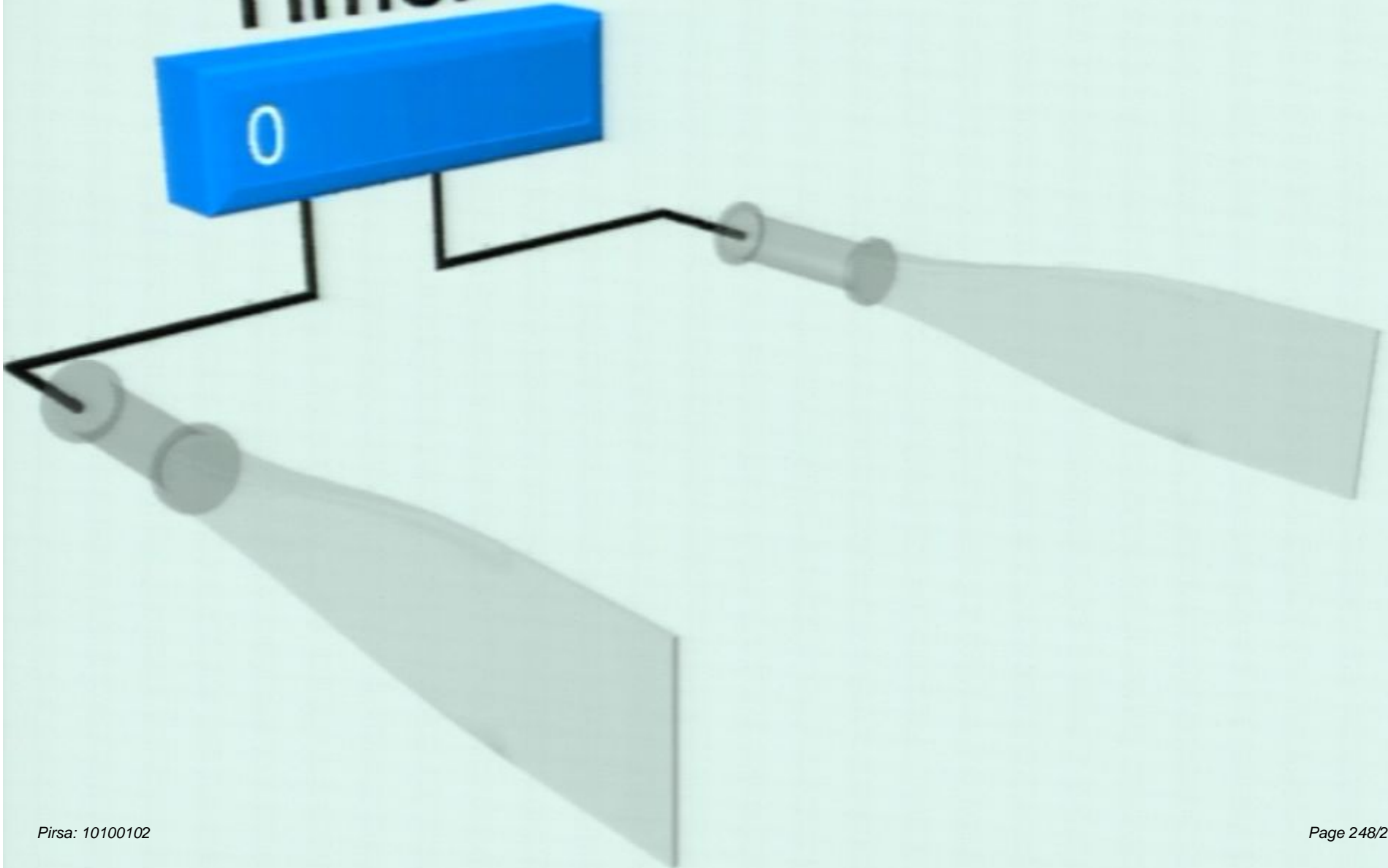
Timer

0



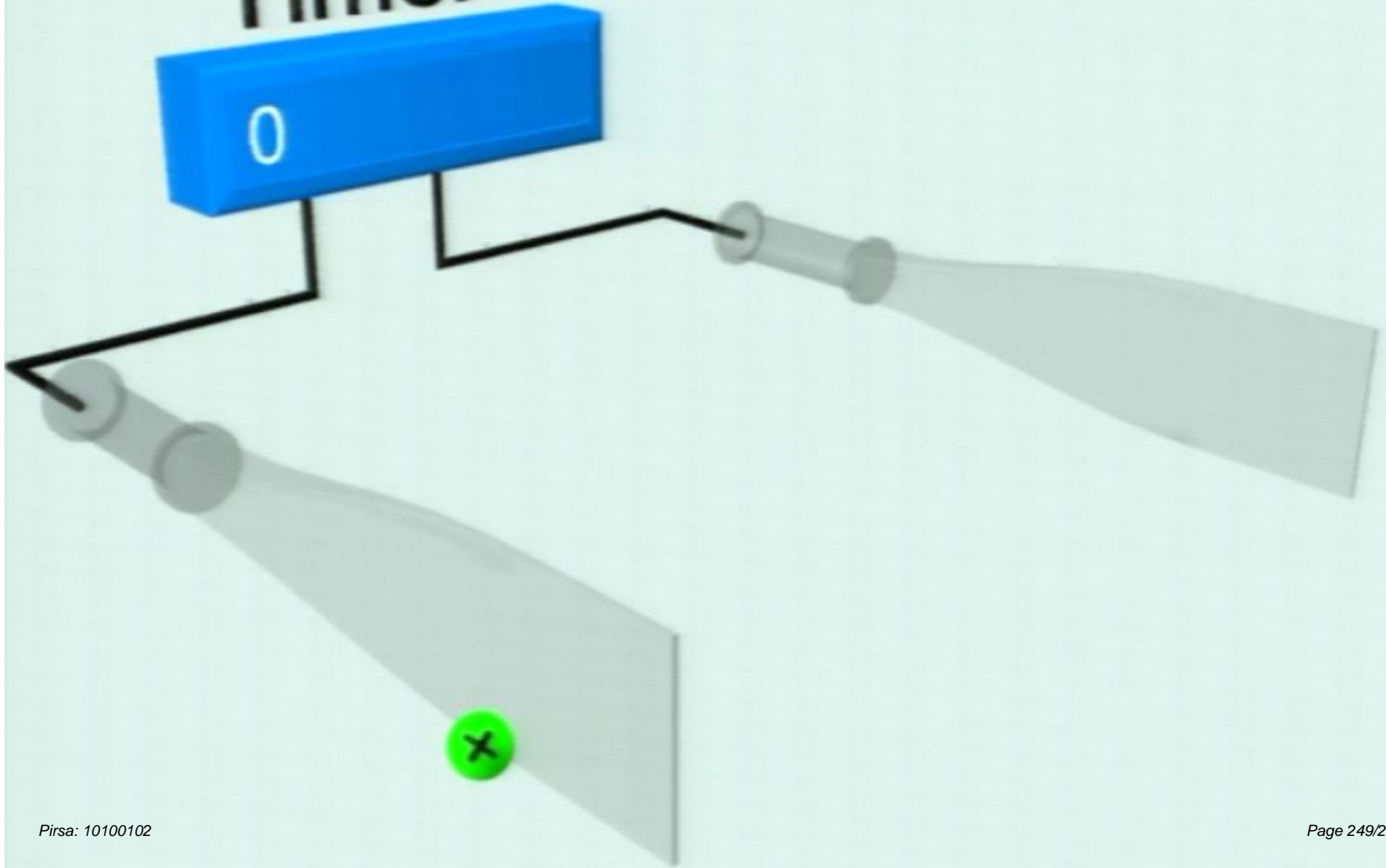
Timer

0



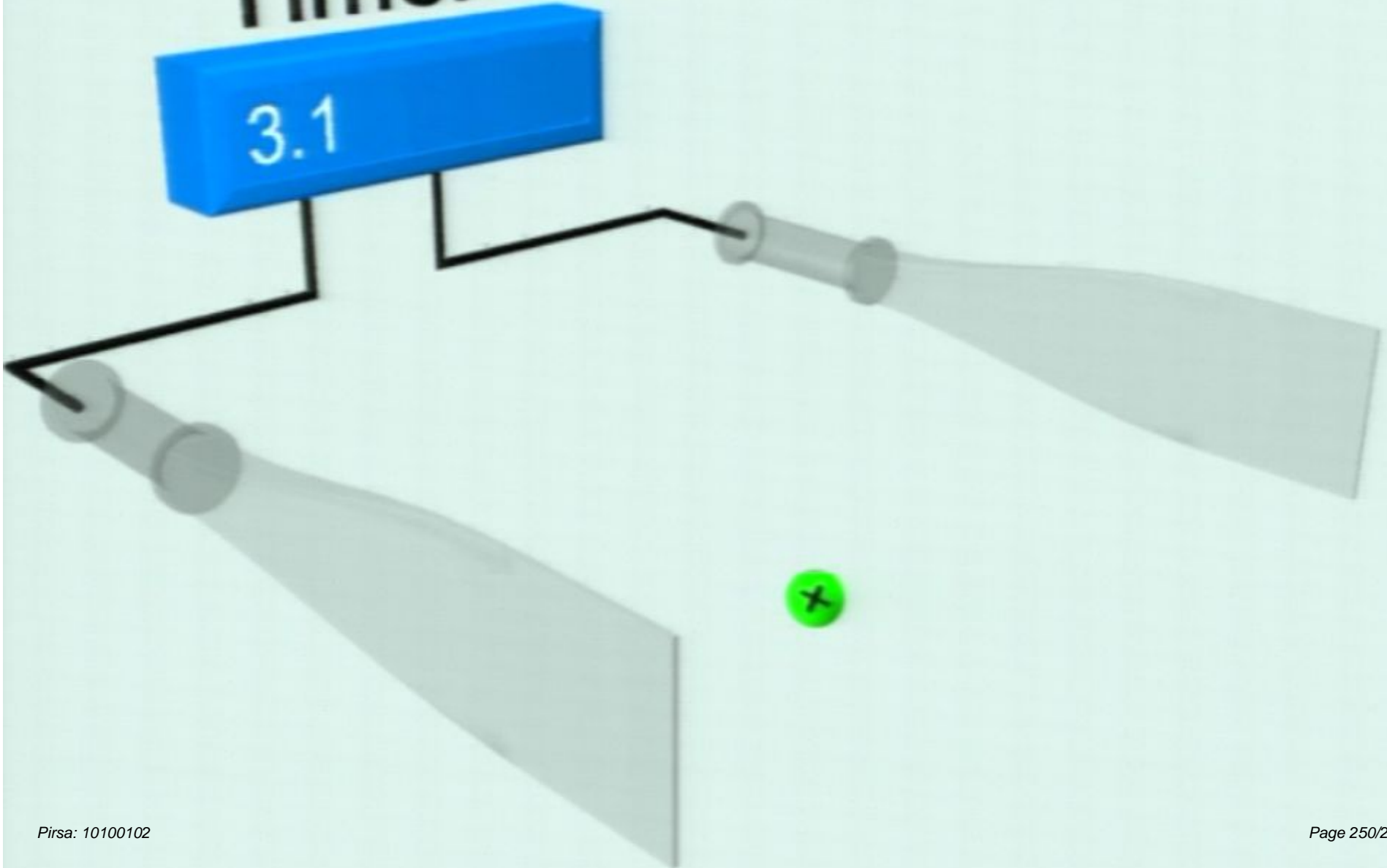
Timer

0



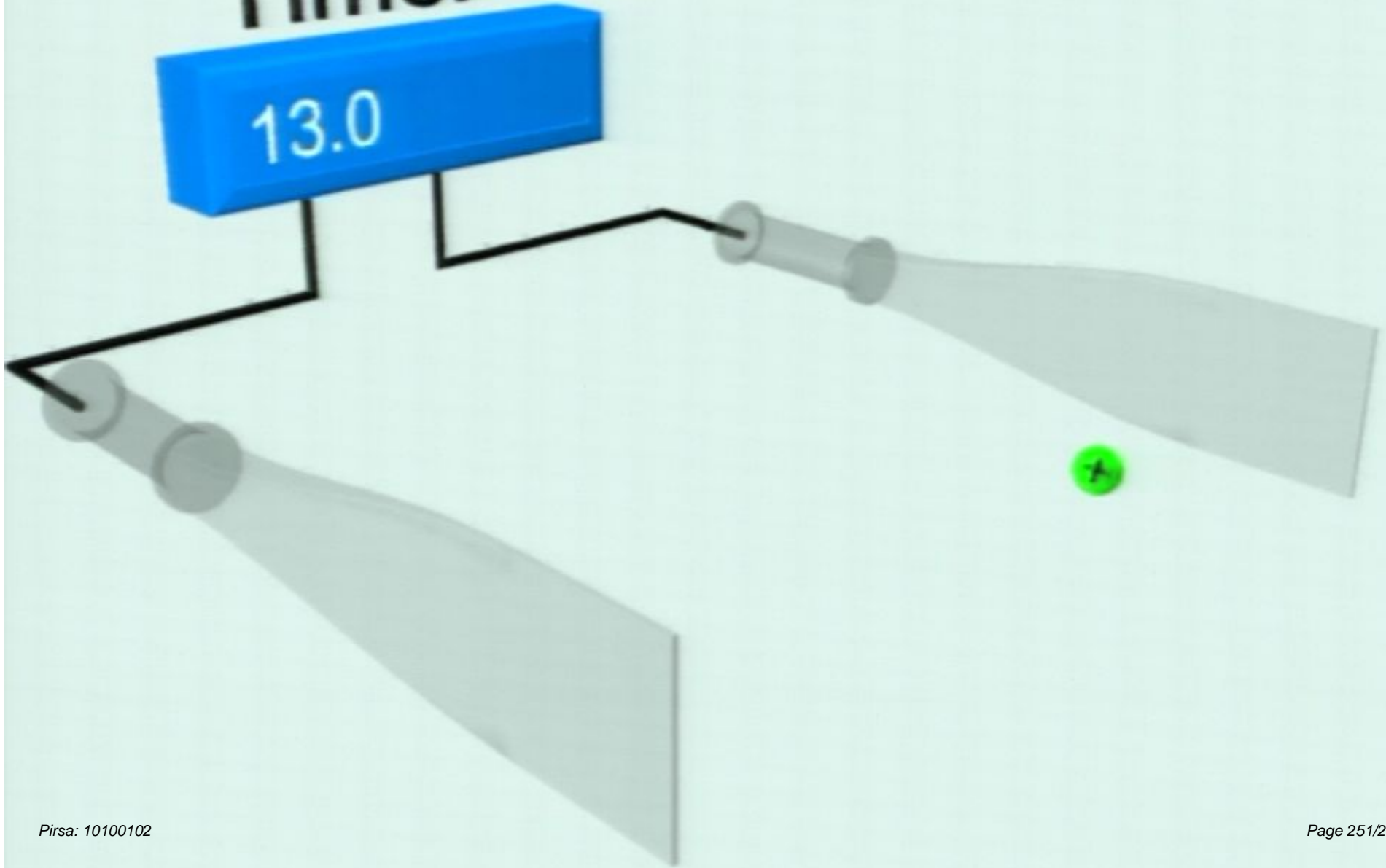
Timer

3.1



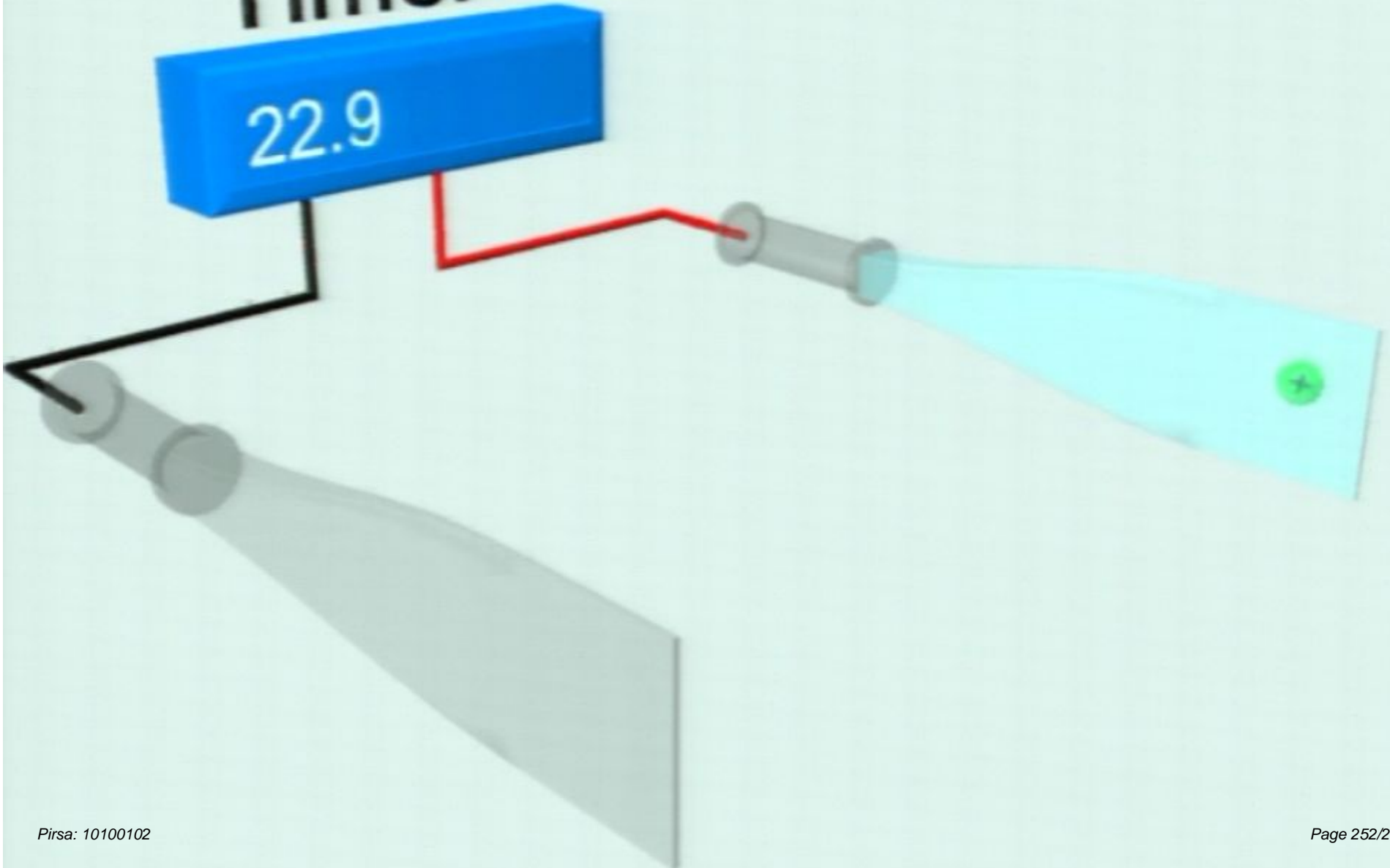
Timer

13.0



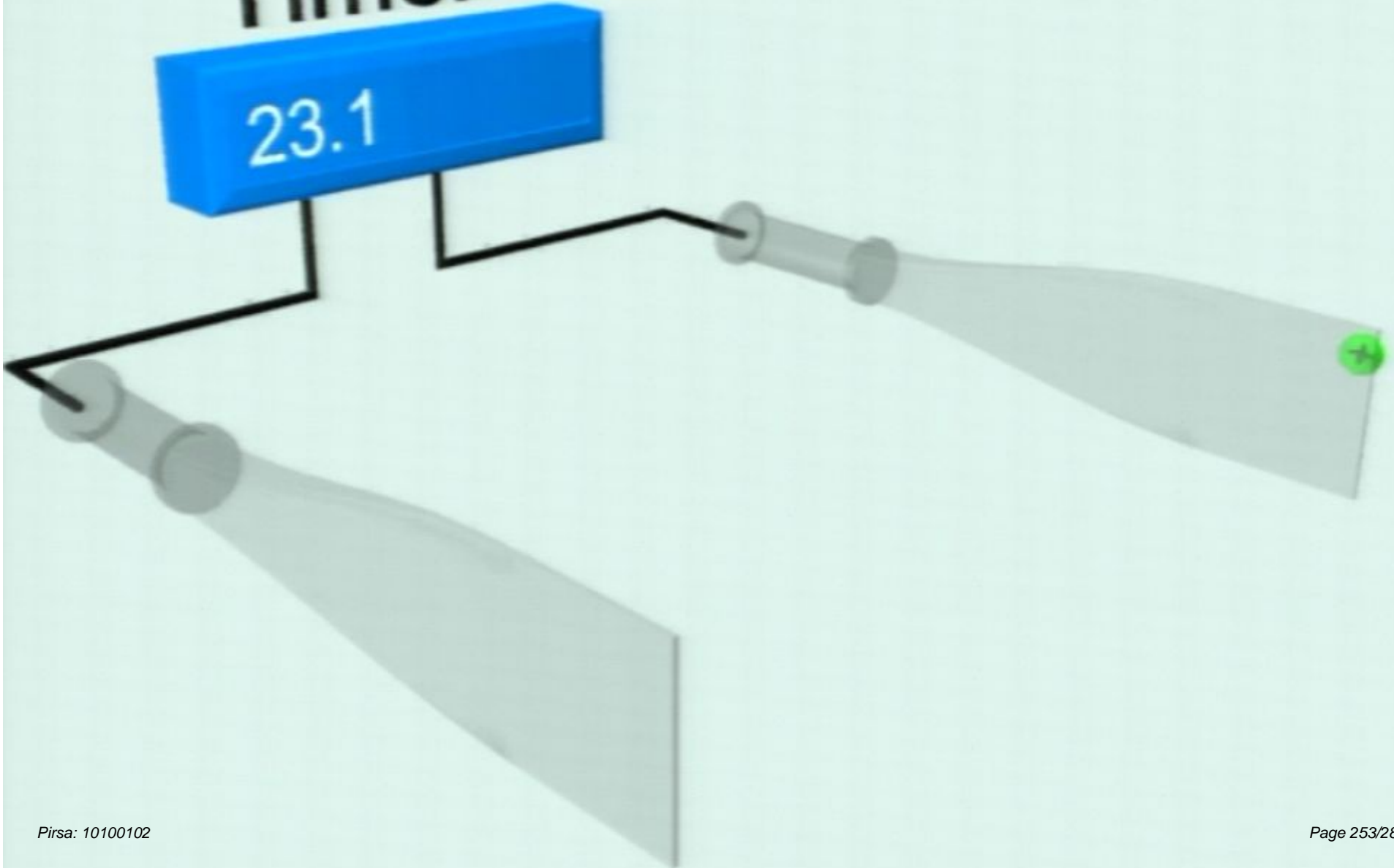
Timer

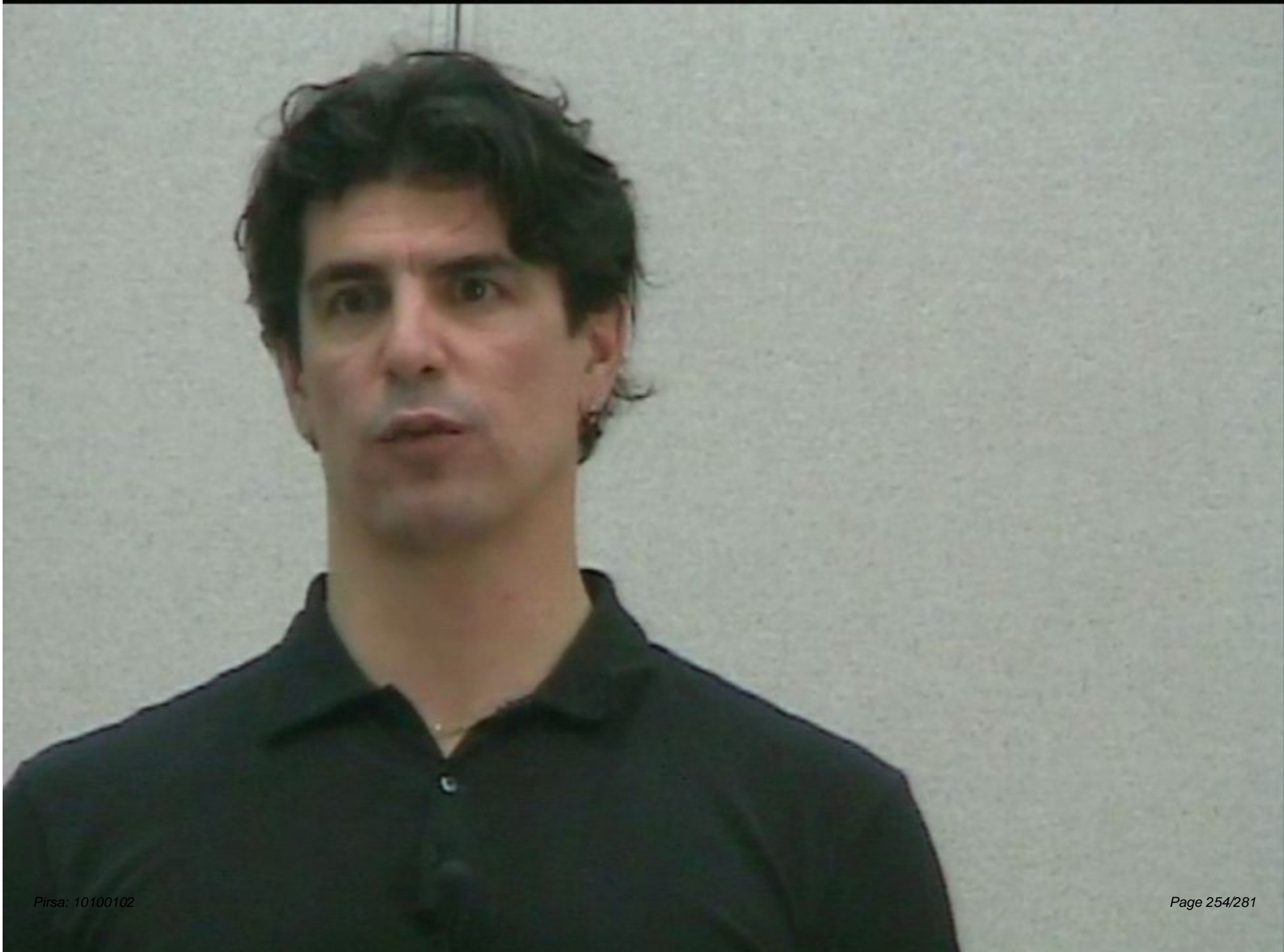
22.9

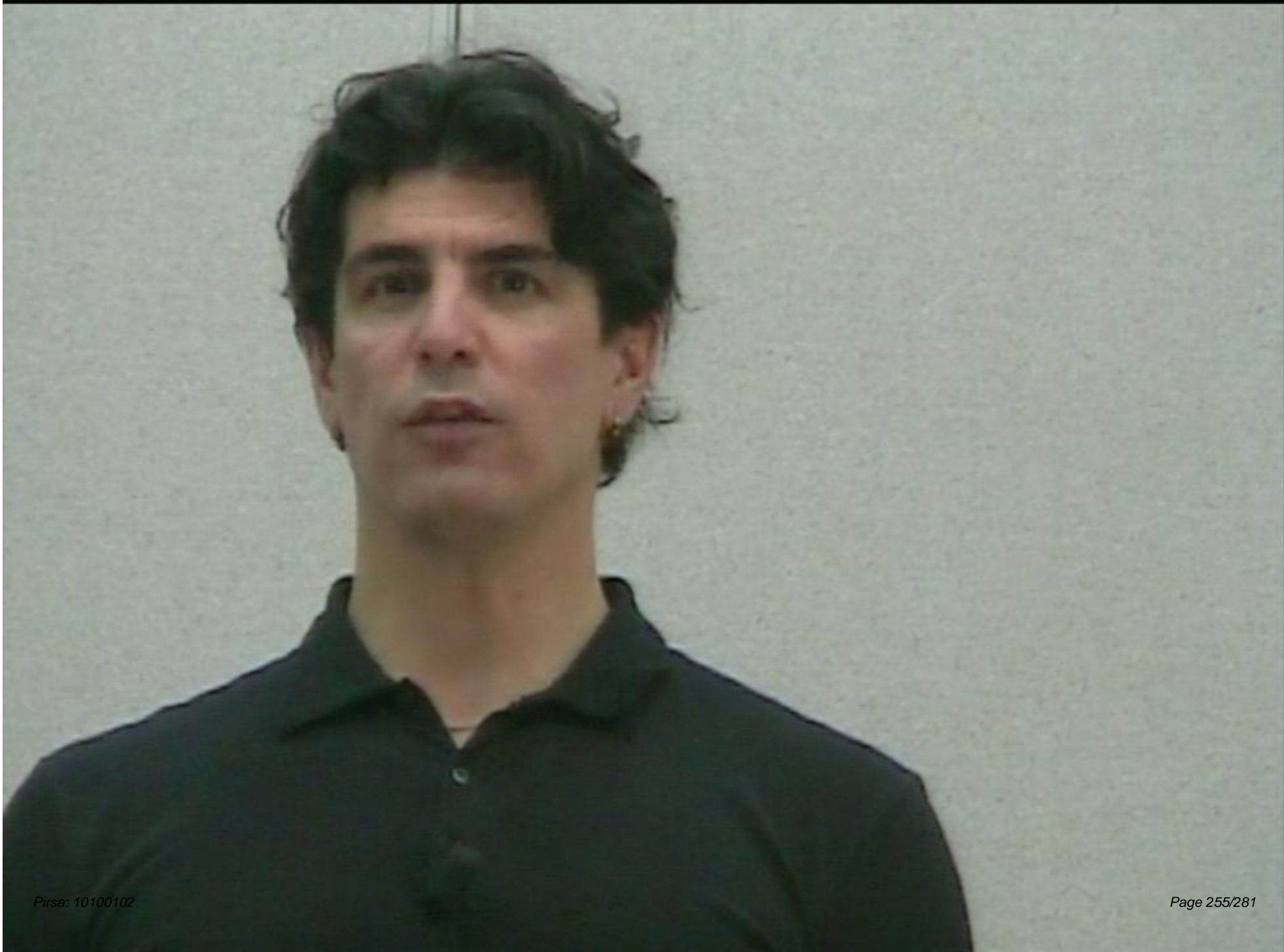


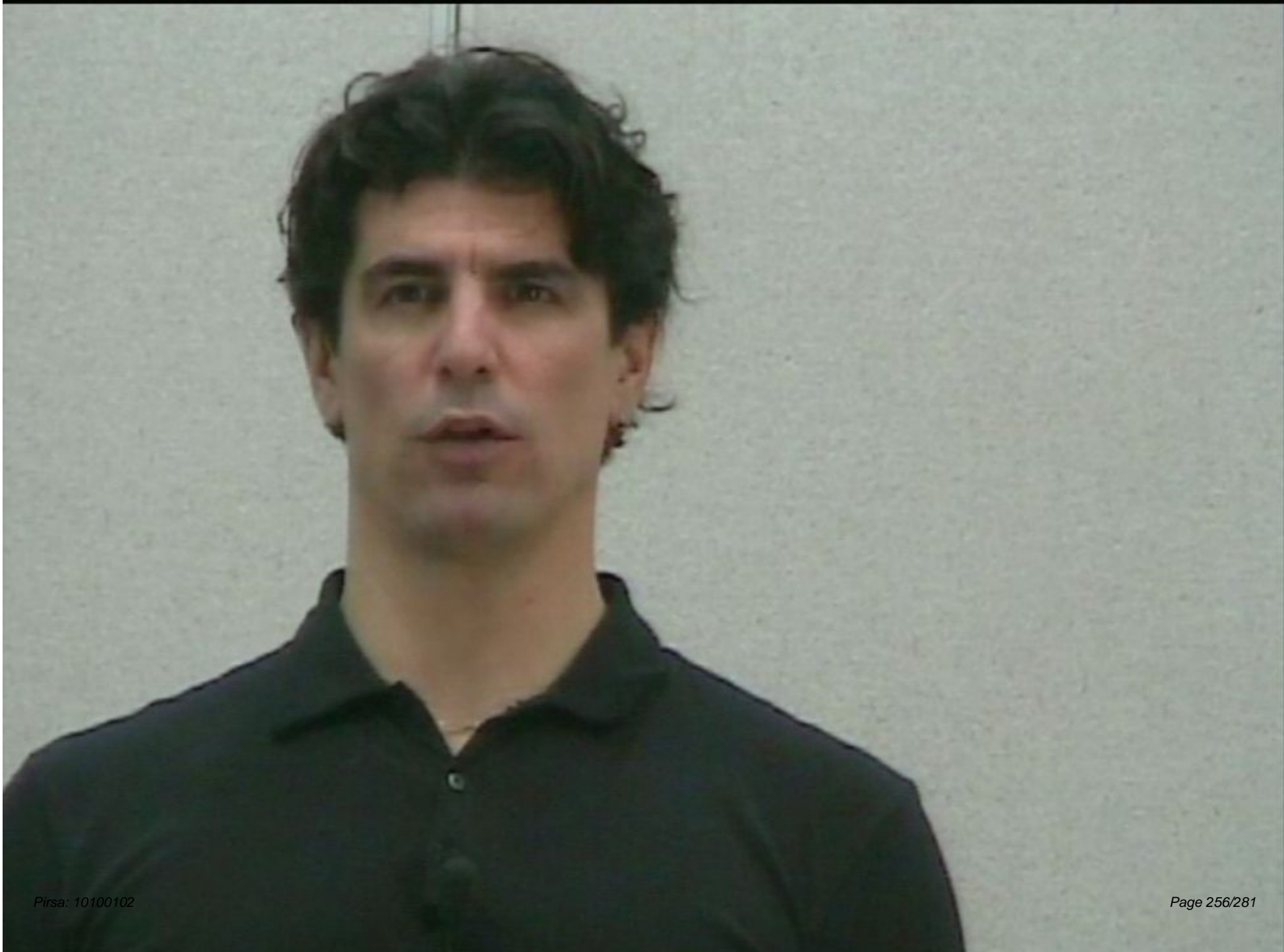
Timer

23.1











Classical

$$v = \frac{d}{t}$$







7:46 ||

0:19

12:03 PM





Bin

DSC-S2100 Handbo...

Add to sci 30

PI Presentation

PMB Help

Norton Intern...

Canon Soluti...

Skype

Quiz of the day

DVD-Cloner VII

Quiz of the Day friction

DivX Plus Converter

Phet Applets

PI stuff 2010

MP Navigator EX 2.0

Principles of Physics

Presentation1

Completed AP Materials

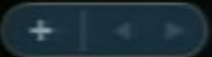
CanoScan LiDE 200...

RealPlayer SP

PMB Launcher

Physics AP

Projects



Horror rotting diseas...
MSNBC N... Fri Oct 22

Couple charged in \$1...
MSNBC N... Fri Oct 22

Public relations in Ch...
MSNBC N... Fri Oct 22

Mosques use open h...
MSNBC N... Fri Oct 22

▲ 13-16 ▼

Bin
DSC-S2100 Handbo...
Add to sci 30
PI Presentation
PMB Help
Norton Intern...

nd
Canon Soluti...
Skype
Quiz of the day
DVD-Cloner VII
Quiz of the Day friction

us
DivX Plus Converter
Phet Applets
PI stuff 2010
MP Navigator EX 2.0

Principles of Physics
Presentation1
Completed AP Materials
CanoScan LiDE 200...

AR
RealPlayer SP
PMB Launcher
Physics AP
Projects

+ | < | >

Typhoon unleashes d...
MSNBC N... Fri Oct 22

Man with high-tech ...
MSNBC N... Fri Oct 22

He survived plane cr...
MSNBC N... Fri Oct 22

U.S. to fund Pakistan...
MSNBC N... Fri Oct 22

▲ 17-20 ▼

Bin

DSC-S2100 Handbo...

Add to sci 30

PI Presentation

PMB Help

Norton Intern...

Canon Soluti...

Skype

Quiz of the day

DVD-Cloner VII

Quiz of the Day friction

DivX Plus Converter

Phet Applets

PI stuff 2010

MP Navigator EX 2.0

Principles of Physics

Presentation1

Completed AP Materials

CanoScan LiDE 200...

RealPlayer SP

PMB Launcher

Physics AP

Project

+

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→

Typhoon unleashes d...
MSNBCN... Fri Oct 22

Man with high-tech ...
MSNBCN... Fri Oct 22

He survived plane cr...
MSNBCN... Fri Oct 22

U.S. to fund Pakistan...
MSNBCN... Fri Oct 22

▲ 17-20 ▼

Information ✕

You just plugged a device into the audio jack.



Bin



DSC-S2100 Handbo...



Add to sci 30



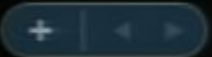
PI Presentation



PMB Help



Norton Intern...



'Dutch Sandwich' sa...

MSNBC N... Fri Oct 22

What really happene...

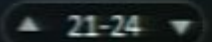
MSNBC N... Fri Oct 22

The best and worst s...

MSNBC N... Fri Oct 22

Halloween takes on ...

MSNBC N... Fri Oct 22



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rt



Canon Soluti...



Skype



Quiz of the day



DVD-Cloner VII



Quiz of the Day friction

us
r



DivX Plus Converter



Phet Applets



PI stuff 2010



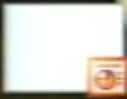
MP Navigator EX 2.0



...



Principles of Physics



Presentation1



Completed AP Materials



CanoScan LiDE 200...

AR
rog



RealPlayer SP



PMB Launcher



Physics AP



Project



Information

You just plugged a device into the audio jack.



The desktop features a background image of the planet Saturn. The icons are arranged in a grid:

- Row 1: Bin, DSC-S2100 Handbo..., Add to sci 30, PI Presentation, PMB Help, Norton Intern...
- Row 2: Canon Soluti..., Skype, Quiz of the day, DVD-Cloner VII, Quiz of the Day friction
- Row 3: DivX Plus Converter, Phet Applets, PI stuff 2010, MP Navigator EX 2.0
- Row 4: Principles of Physics, Presentation1, Completed AP Materials, CanoScan LiDE 200...
- Row 5: RealPlayer SP, PMB Launcher, Physics AP, Project

News feed sidebar with a scroll bar at the top and a page indicator at the bottom.

- Bride-to-be set to sa...
MSNBCN... Fri Oct 22
- Convicted killer stab...
MSNBCN... Fri Oct 22
- Hungary has toxic sl...
MSNBCN... Fri Oct 22
- Phillies edge Giants i...
MSNBCN... Thu Oct 21

25-28

Information notification box with a speaker icon and a close button (X).

Information
You just plugged a device into the audio jack.

The desktop background features a large, detailed image of the planet Saturn with its rings. The desktop is populated with several application icons and folders:

- Row 1: DSC-S2100 Handbo..., Add to sci 30, PI Presentation, PMB Help, Norton Intern...
- Row 2: Canon Soluti..., Skype, Quiz of the day, DVD-Cloner VII, Quiz of the Day friction
- Row 3: DivX Plus Converter, Phet Applets, PI stuff 2010, MP Navigator EX 2.0
- Row 4: Principles of Physics, Presentation1, Completed AP Materials, CanoScan LiDE 200...
- Row 5: RealPlayer SP, PMB Launcher, Physics AP, Project

A taskbar is visible at the bottom of the screen, showing the Start button and several open application windows. A mouse cursor is positioned over the 'MP Navigator EX 2.0' icon.


Teachers, students, F...
MSNBCN... Thu Oct 21

Giants walk off with ...
MSNBCN... Wed Oct 20

PFT: Magic wants to ...
MSNBCN... Wed Oct 20

Appeals court: Milita...
MSNBCN... Wed Oct 20

▲ 29-32 ▼

 **Information** ✕
You just plugged a device into the audio jack.

A Windows 7 desktop environment with a Saturn-themed background. The desktop contains several icons and folders:

- Bin
- DSC-S2100 Handbo...
- Add to sci 30
- PI Presentation
- PMB Help
- Norton Intern...
- Canon Soluti...
- Skype
- Quiz of the day
- DVD-Cloner VII
- Quiz of the Day friction
- DivX Plus Converter
- Phet Applets
- PI stuff 2010
- MP Navigator EX 2.0
- Principles of Physics
- Presentation1
- Completed AP Materials
- CanoScan LiDE 200...
- RealPlayer SP
- PMB Launcher
- Physics AP
- Project

Navigation: + | < | >

Penthouse magazine...
MSNBCN... Wed Oct 20

Stepmom of missing...
MSNBCN... Wed Oct 20

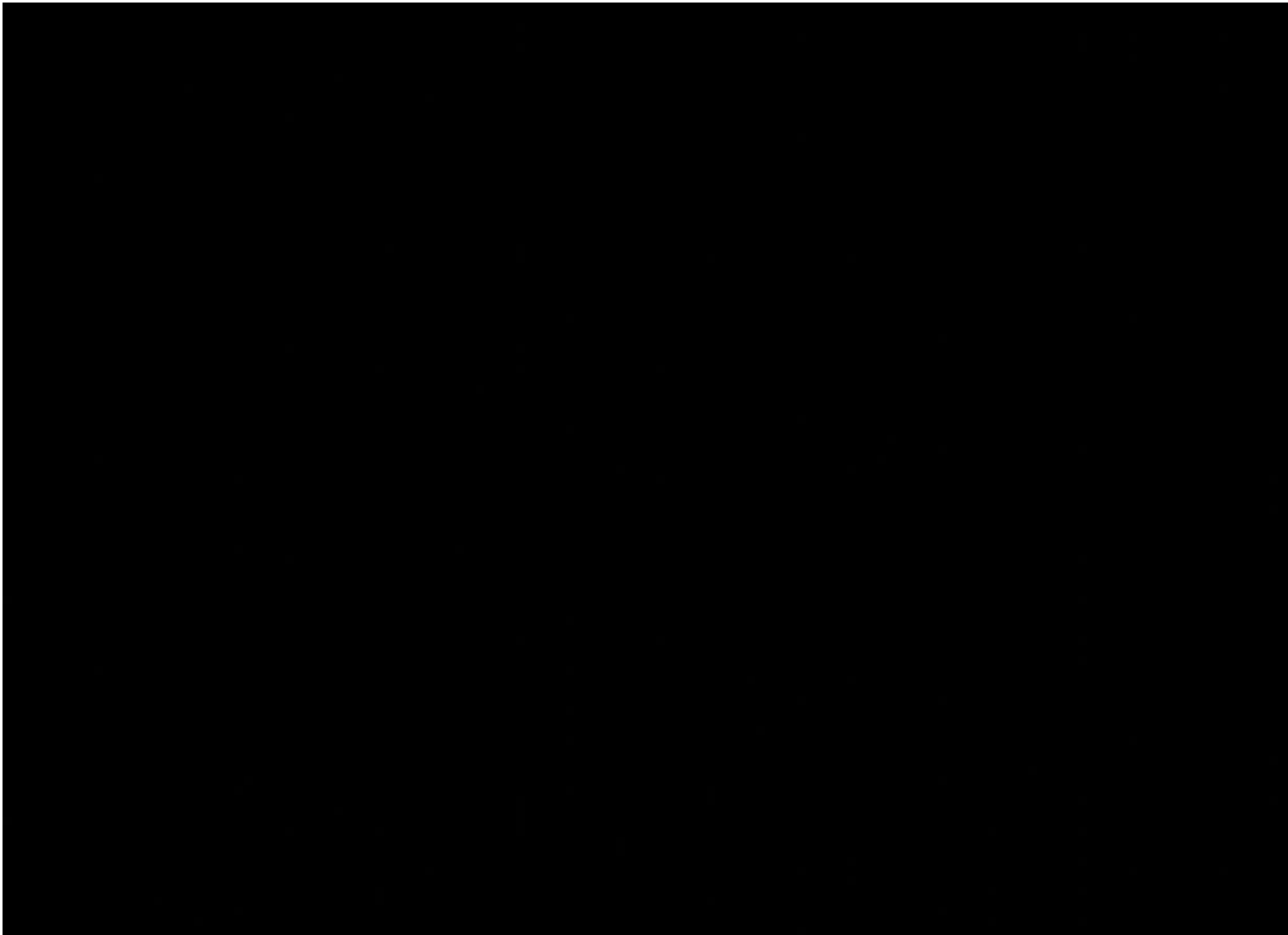
Yanks finally flex mu...
MSNBCN... Wed Oct 20

NBC: Al-Qaida figure...
MSNBCN... Wed Oct 20

Navigation: ▲ 33-36 ▼

Information [X]

You just plugged a device into the audio jack.



• Straighten?

• Slope Represents



The chalkboard features a diagram of a curved surface, possibly a cylinder or a similar shape, with a vertical dashed line and a horizontal solid line. The surface is shaded with horizontal lines. The text is written in white chalk.

- Straighten?

- Slope Represents

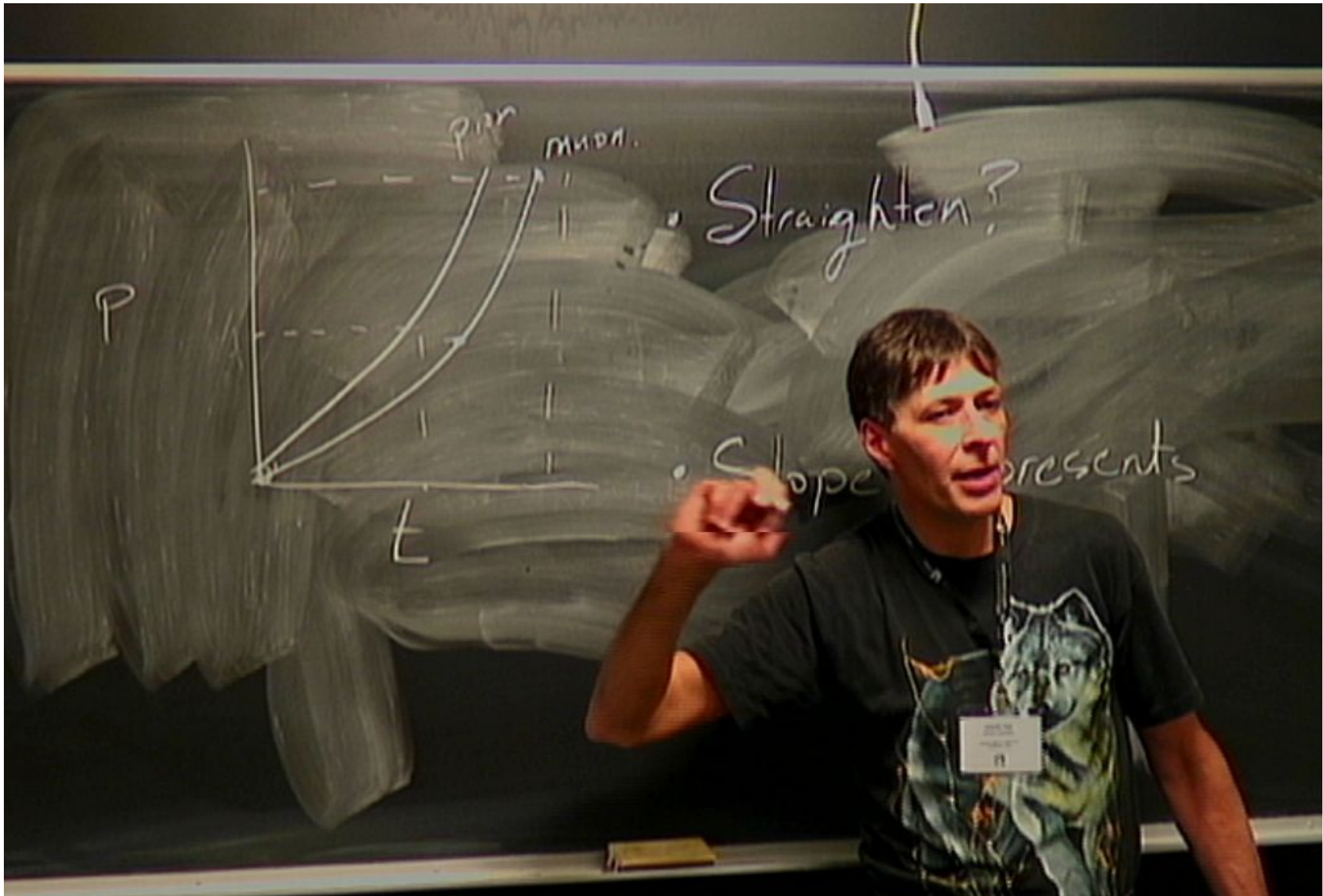
• Straighten?

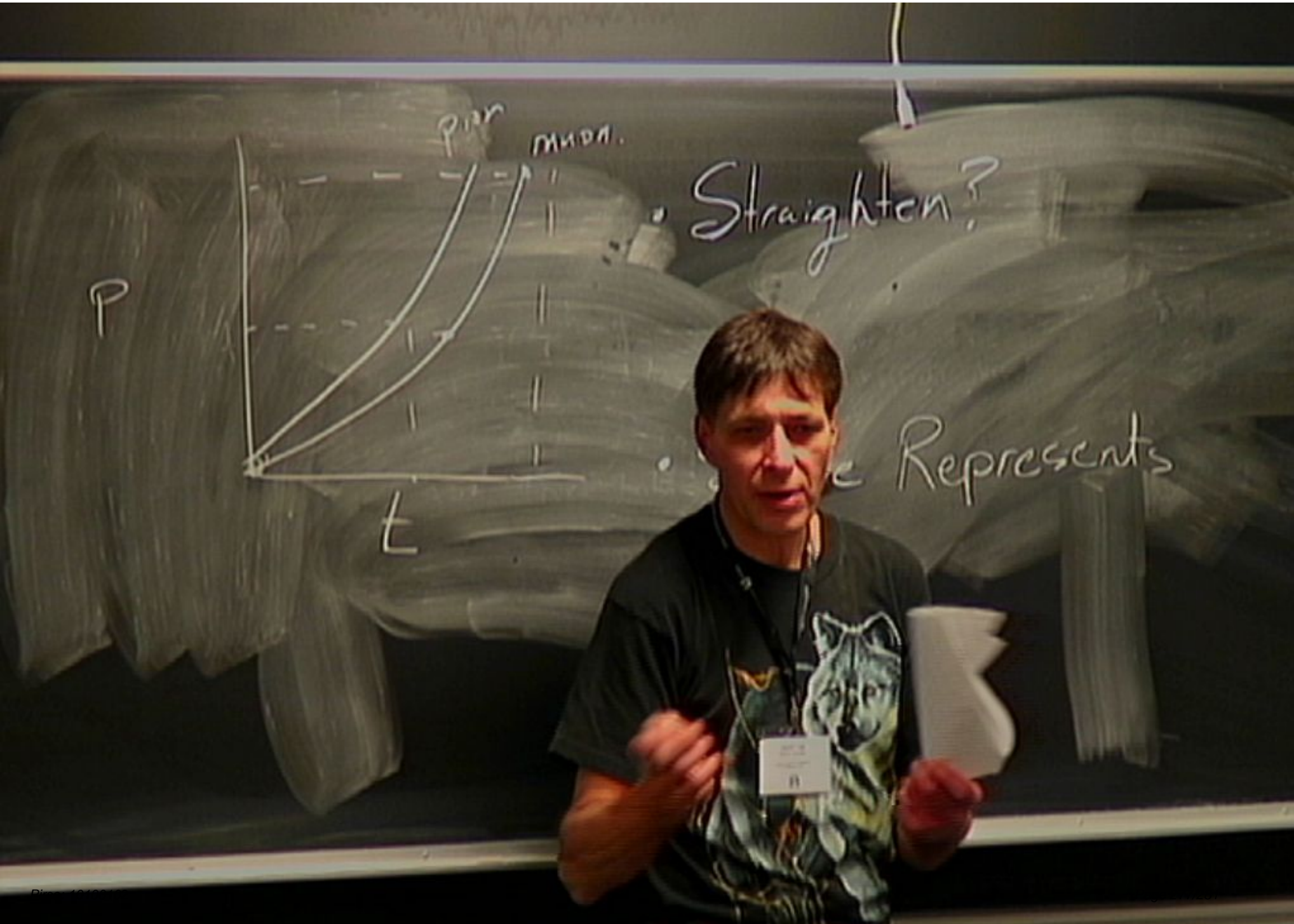
• Slope Represents



• Straighten?

• Slope Represents





Straighten?

e Represents



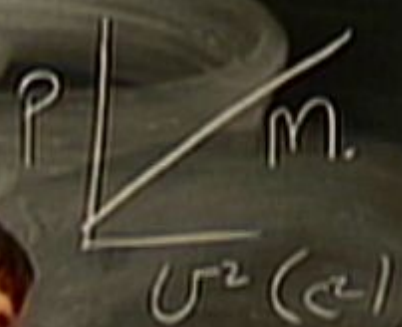
• Straighten?

• Slope Represents

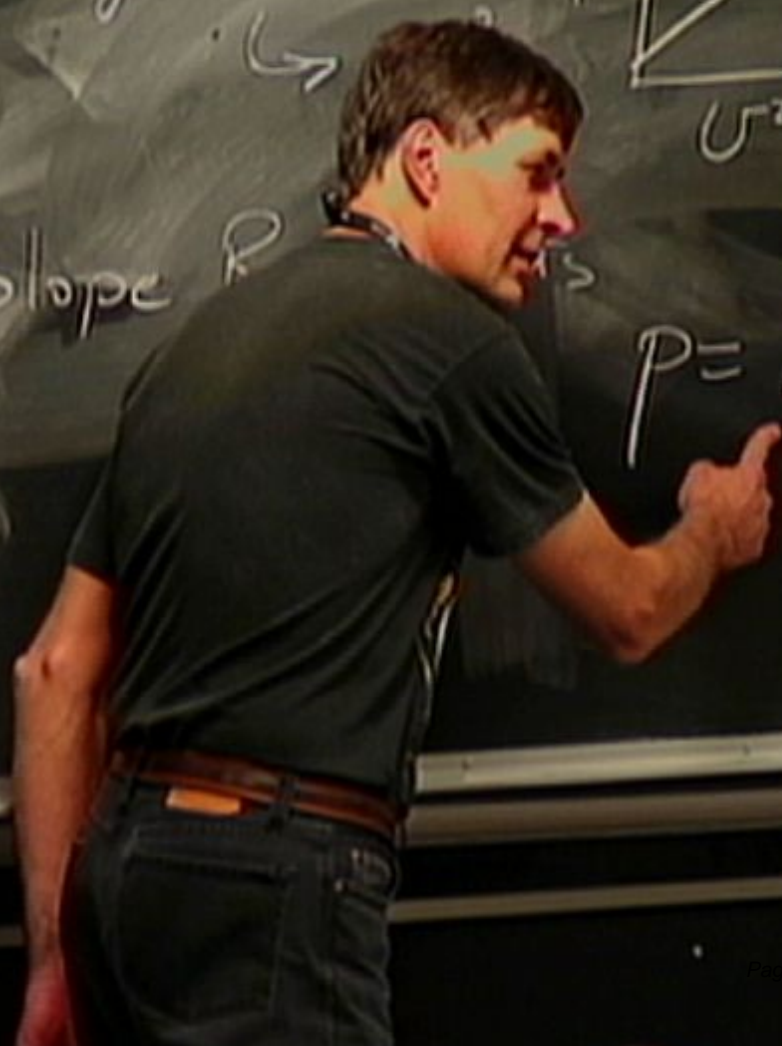


• Straighten?

• Slope P



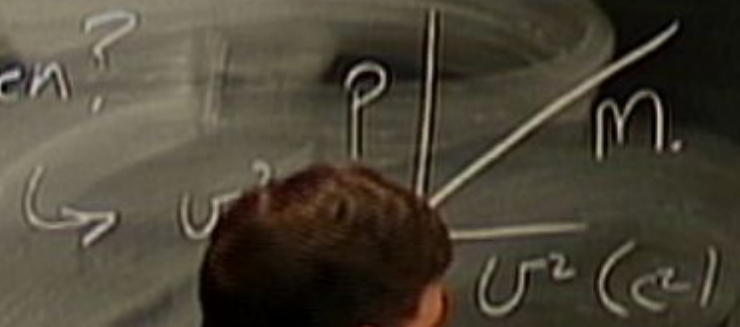
$$P = \gamma \mu v$$





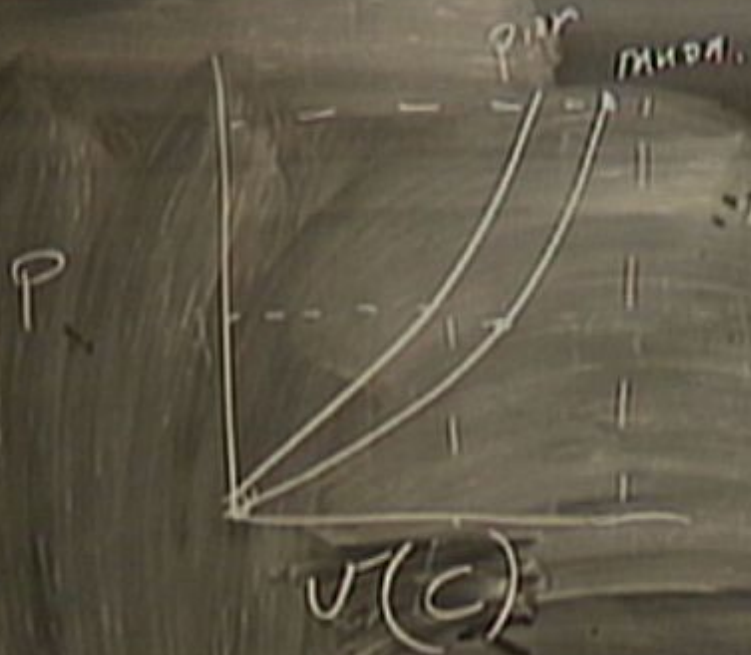
• Straighten?

• Slope Repre



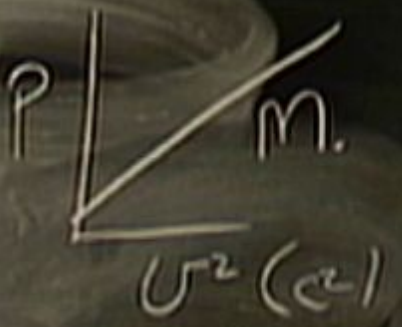
$$P = \gamma m v$$





• Straighten?

↳ v^2



• Slope Represents

$$P = \gamma m v$$