First results of the **RIPTIDE** fast neutron detector prototype.

Claudia Pisanti

on behalf of the **RIPTIDE** collaboration

cpisanti@bo.infn.it - INFN / University of Bologna - *iWoRID2026 – Ghent, 30/06/2026*

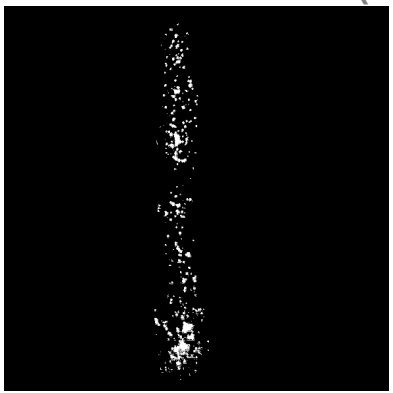
Radiation Imaging ...

Cosmic muon on **CsI(Tl)**

Radiation Imaging ...

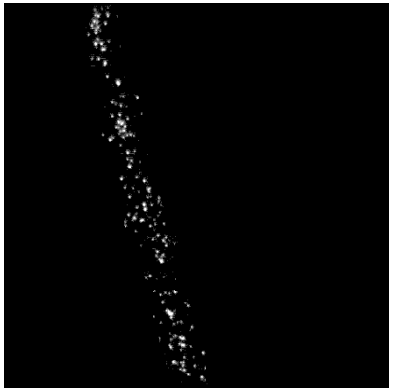
Cosmic muon on **CsI(Tl)**

450MeV electron on **CsI(Tl)**



Radiation Imaging ...

Cosmic muon on CsI(Tl)



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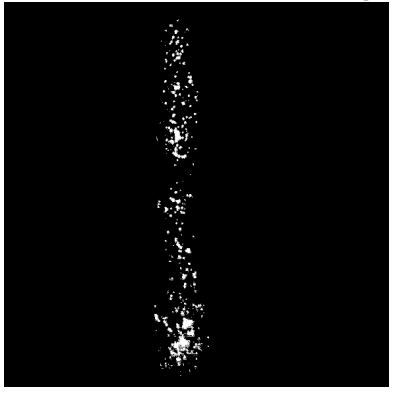
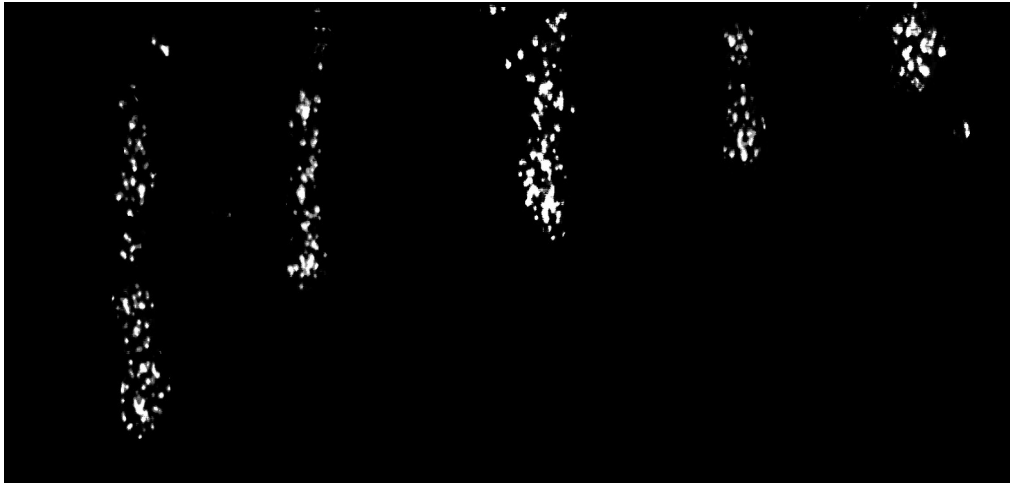


Protons in BC408

70 MeV **50** MeV **40** MeV **30** MeV **20** MeV



Radiation Imaging ...

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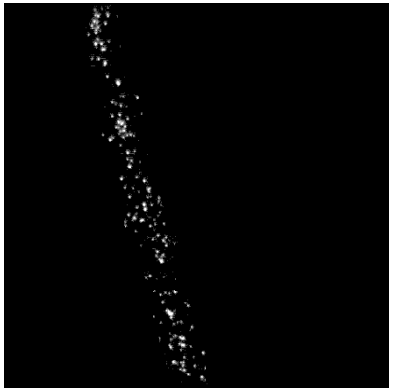

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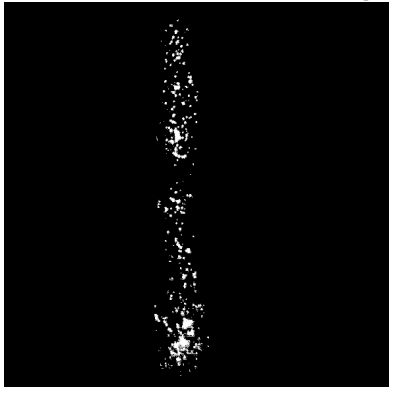

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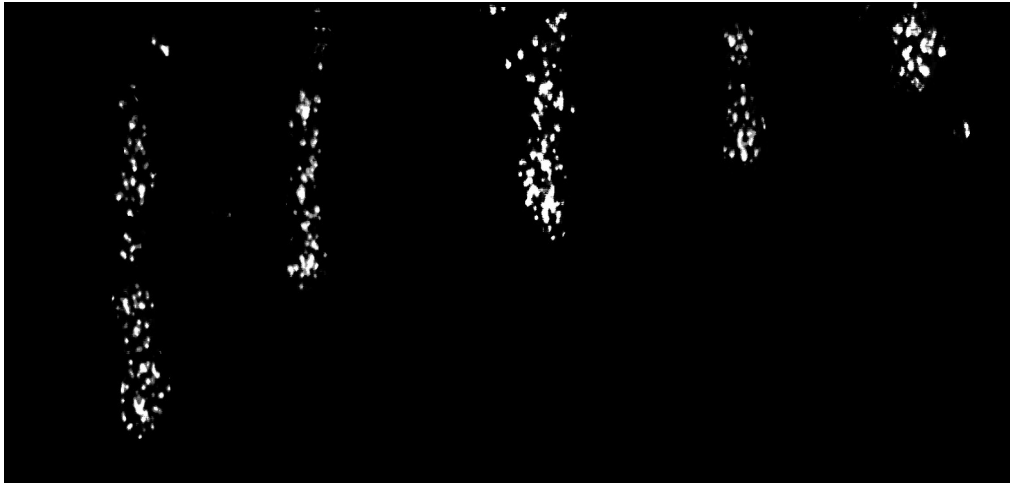
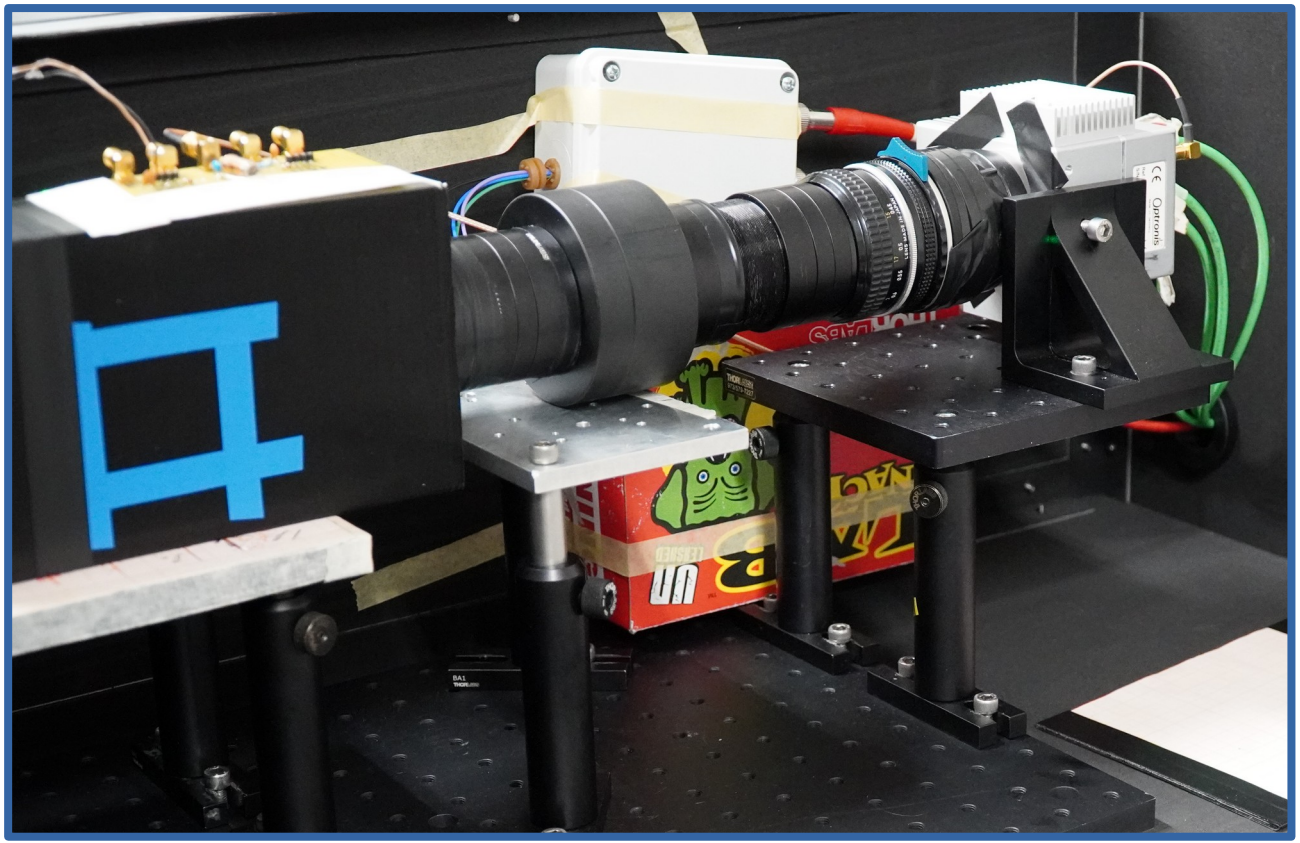


Neutron in **BC408**

?

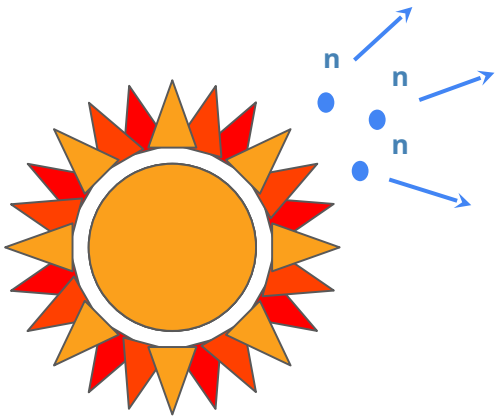
What is RIPTIDE (Recoil Proton Track Imaging DEtector)?

A **fast neutron detector** (5-50 MeV) aiming to provide **energy** and **direction** of incoming neutrons

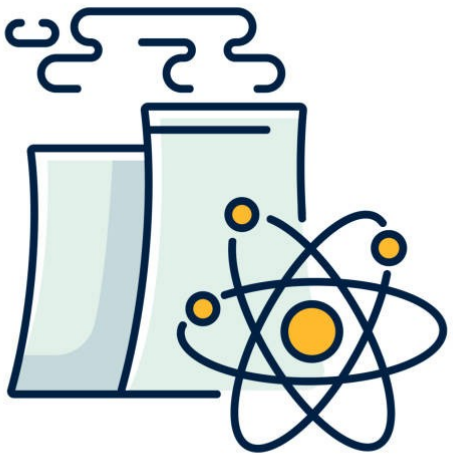


Why we need neutron direction**?**

Astrophysics:
e.g. study if solar neutrons

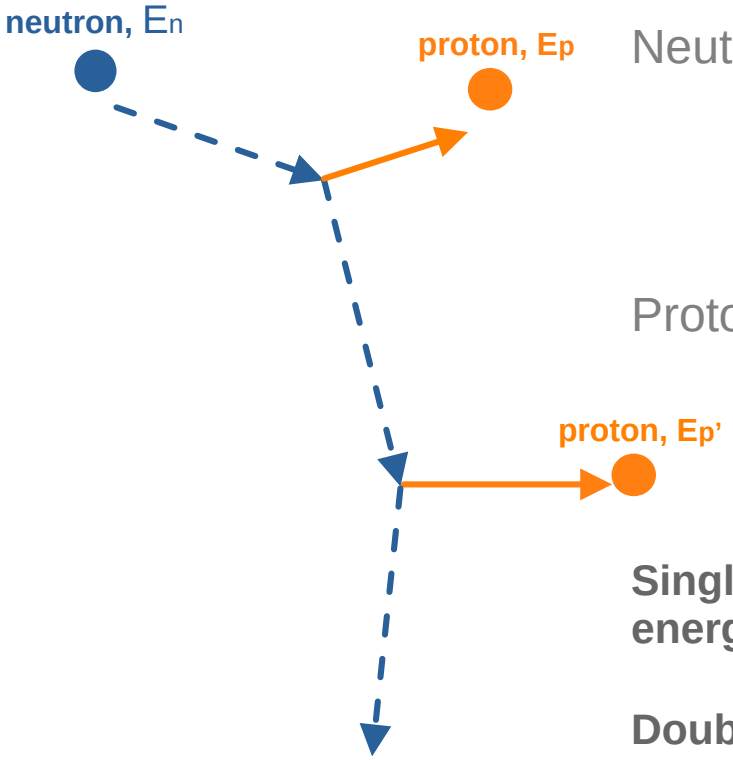


Environmental monitoring:
more accurate dosimeters



Nuclear physics research:
e.g. neutrons produced in nuclear fragmentation

How: Recoil Proton Track Imaging (RPTI) principle



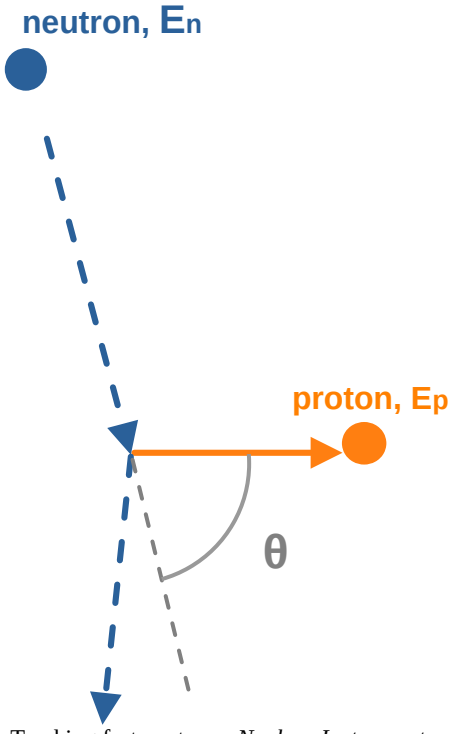
Neutron to proton elastic scattering:

$$E_n = E_p / \cos^2(\theta)$$

Proton Range: $R(E_p) = \alpha E_p^{p}$

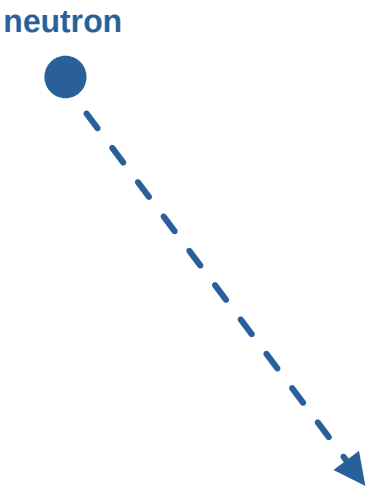
Single scattering provides neutron **energy** (when source position is known)

Double scattering provides neutron **energy and direction** (source position not known)



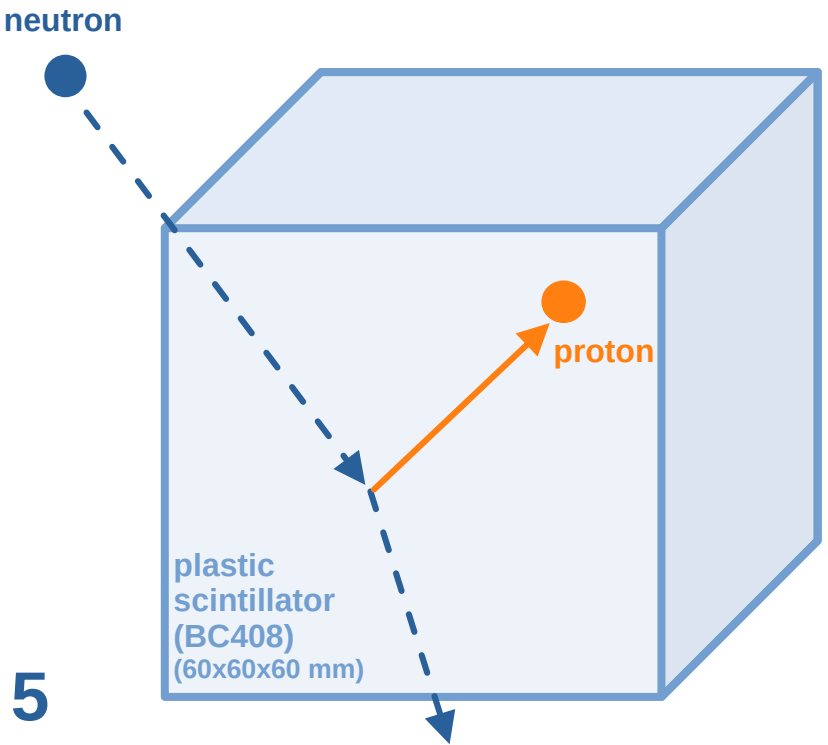
Wang, Morris. Tracking fast neutrons. *Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, 726:145–154, 2013.*

The **RIPTIDE** detector



The **RIPTIDE** detector

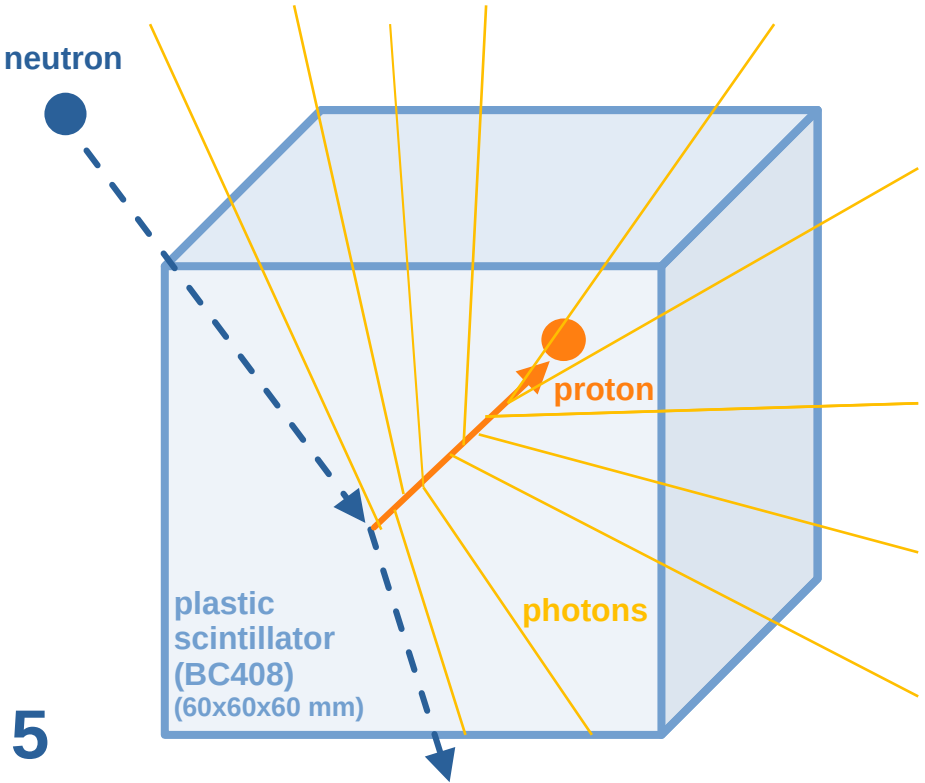
A proton-rich **plastic scintillator** is used to enhance n-p scattering



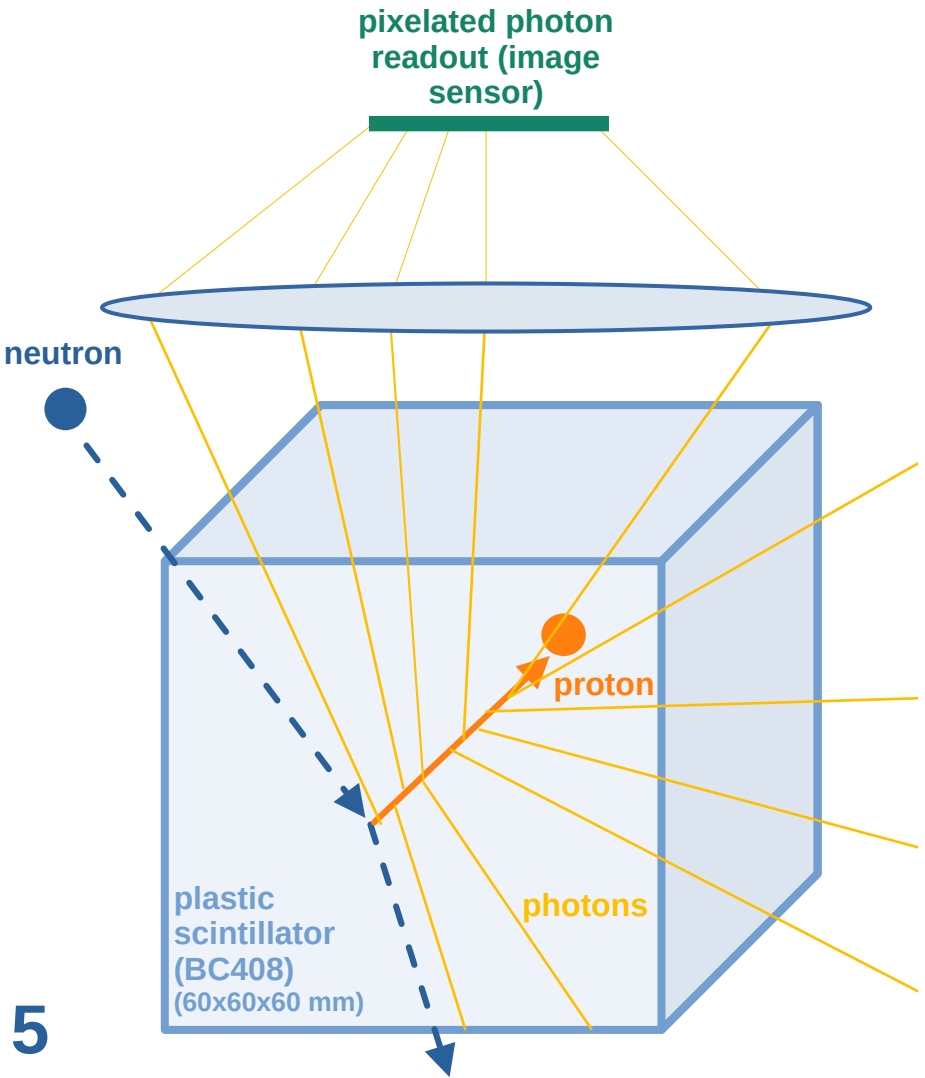
The **RIPTIDE** detector

A proton-rich **plastic scintillator** is used to enhance n-p scattering

Recoil protons in the scintillator emits light



The **RIPTIDE** detector



Optics

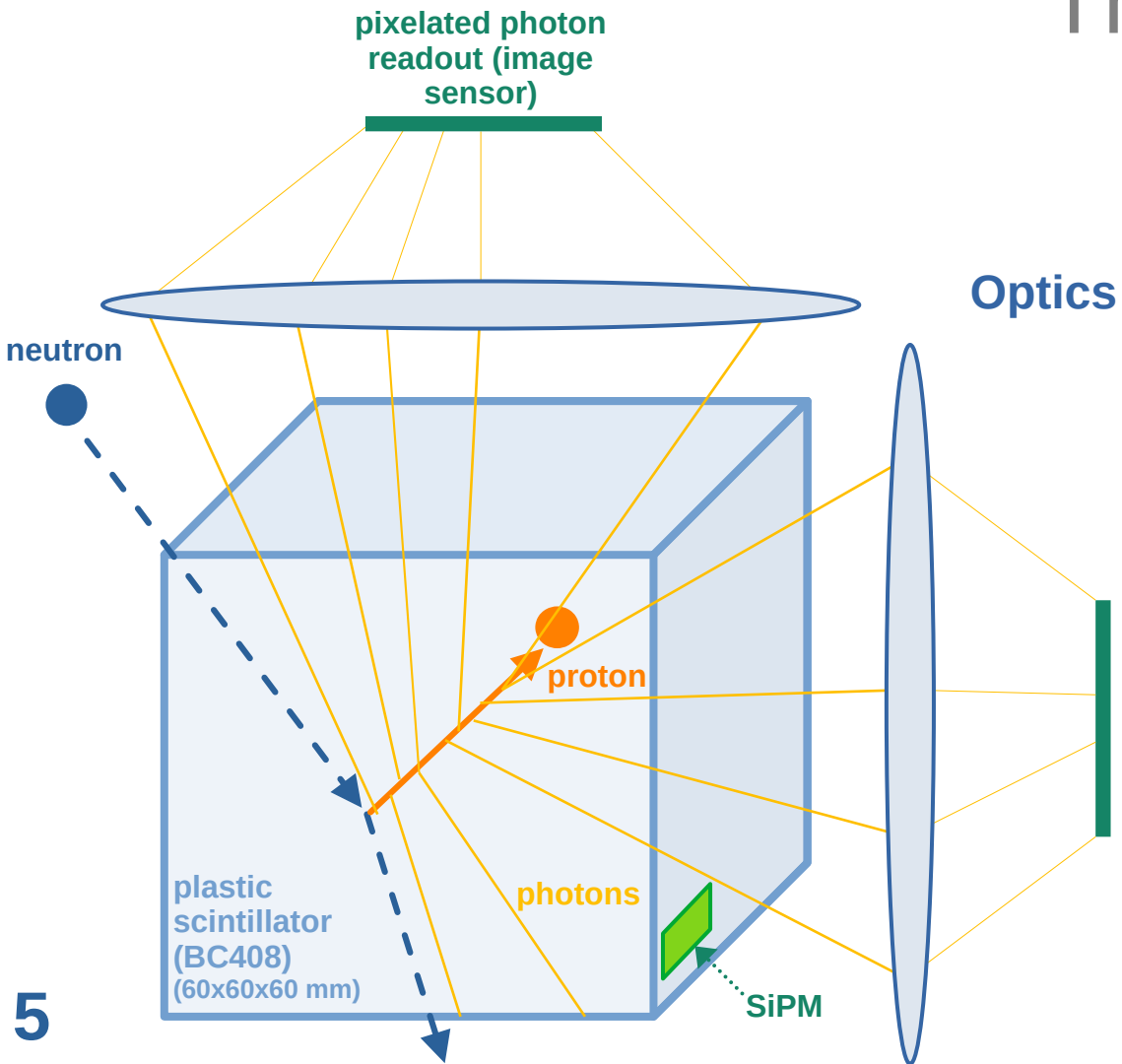
A proton-rich **plastic scintillator** is used to enhance n-p scattering

Recoil protons in the scintillator emits light

Which is focused via an **optical system**...

... to a **photon sensor**.

The **RIPTIDE** detector



A proton-rich **plastic scintillator** is used to enhance n-p scattering

Recoil protons in the scintillator emits light

Which is focused via an **optical system**...

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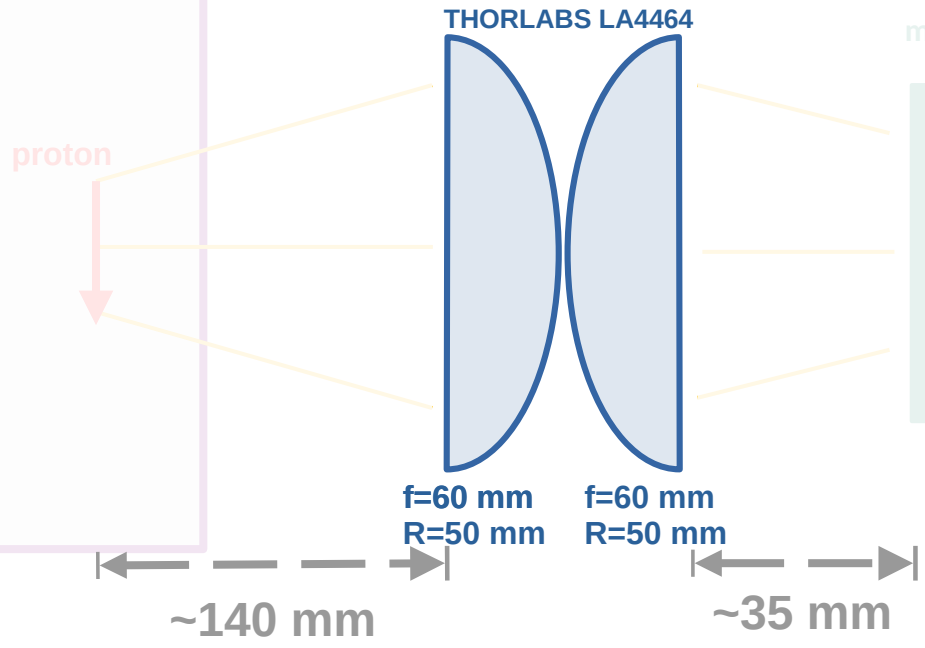
Two 2D-images allow 3D-reconstruction of the track

A **SiPM** is used to trigger the readout system

The **PHOTON** collection

OPTICS



THE OPTICS

Problem: need to maximize both photon collection and Depth of Field, minimizing the aberrations effects.

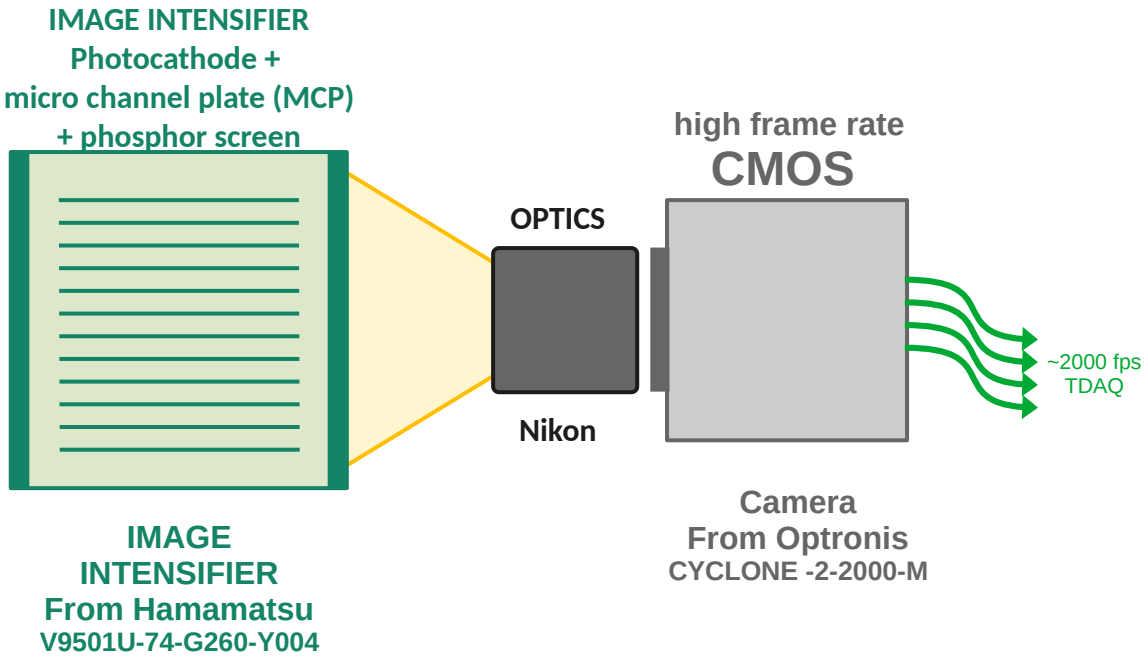
Solution: two large (2” diameter) plano-convex lenses with focal lengths 60mm and radius of 60 mm..

The **PHOTON** readout

THE PHOTON DETECTOR

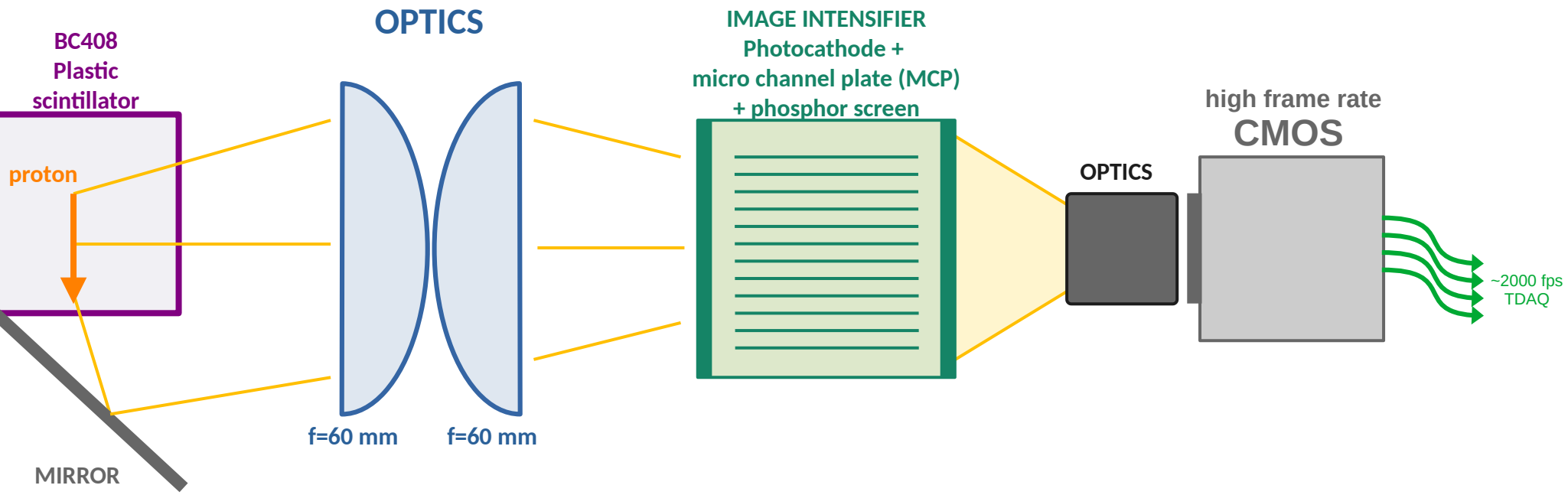
Problem: photon counting imaging o(100) photons + high frame rate needed.

Solution: image intensifier (MCP) coupled with high speed camera.

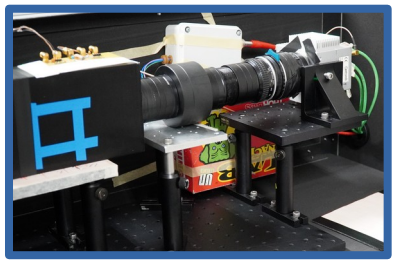


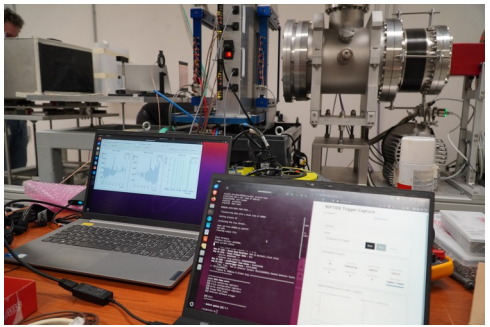
Pisanti, et al. "Sensor performance evaluation for candidate photon readout systems in the RIPTIDE detector." *Applied Radiation and Isotopes (2025): 112077.*

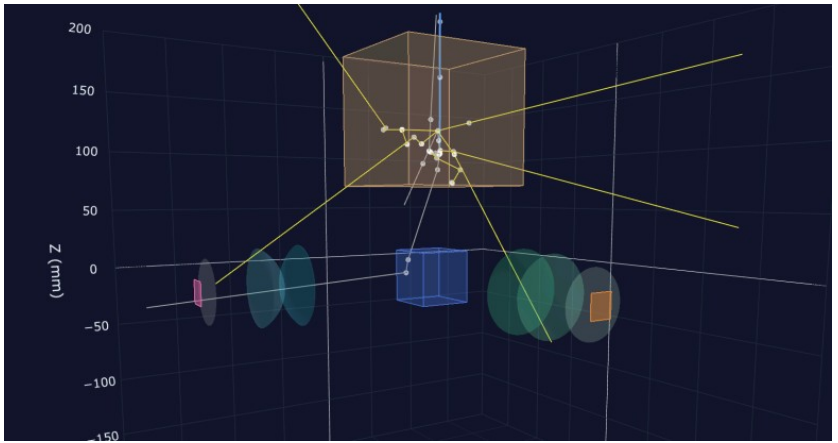
Scintillation light imaging – a **prototype**



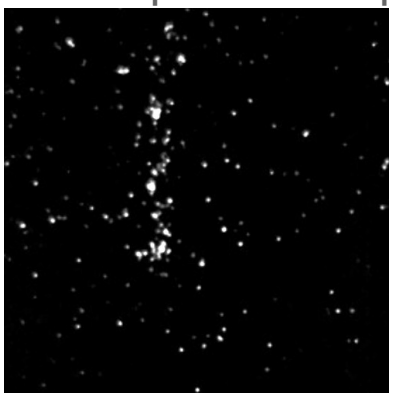
Experimental vs Monte Carlo



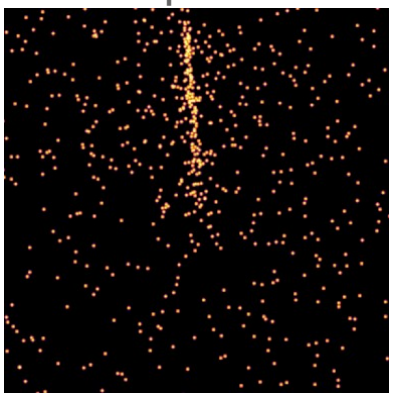




50 MeV proton - exp

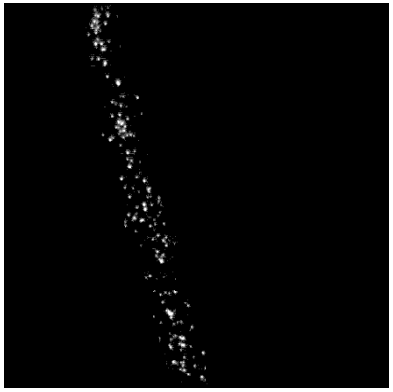


50 MeV proton - MC

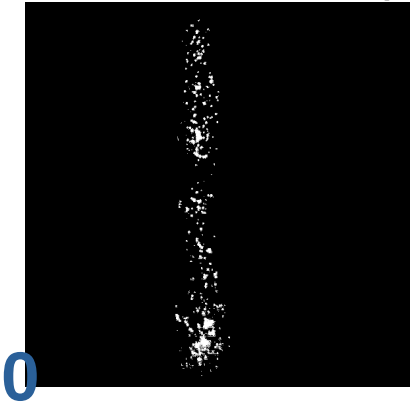


First **results** …

Cosmic muon on **CsI(Tl)**



450MeV electron on **CsI(Tl)**



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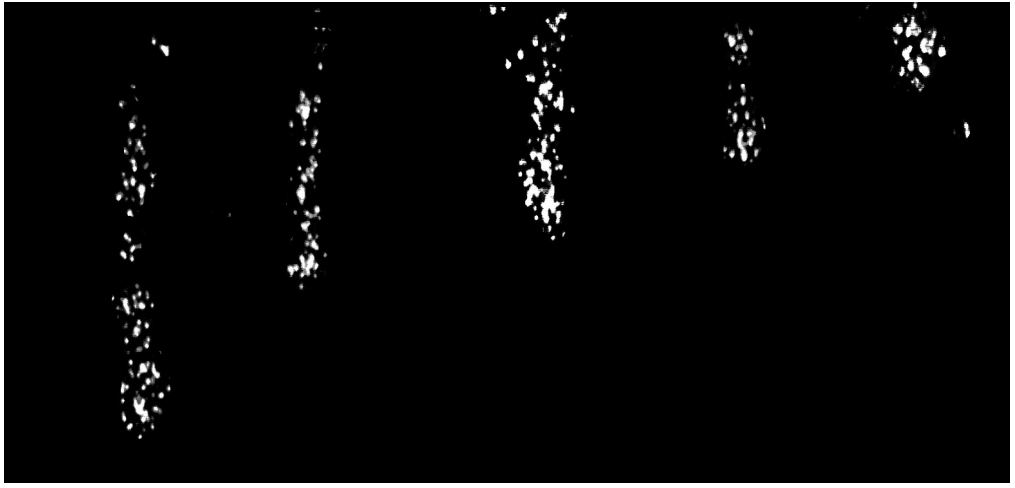
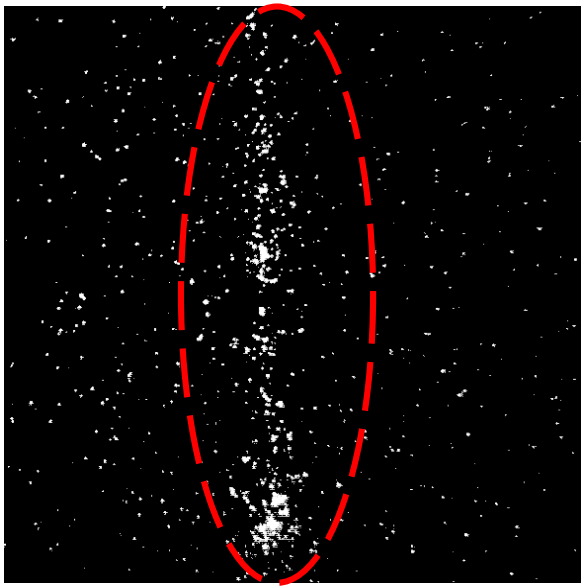


Neutron in **BC408**

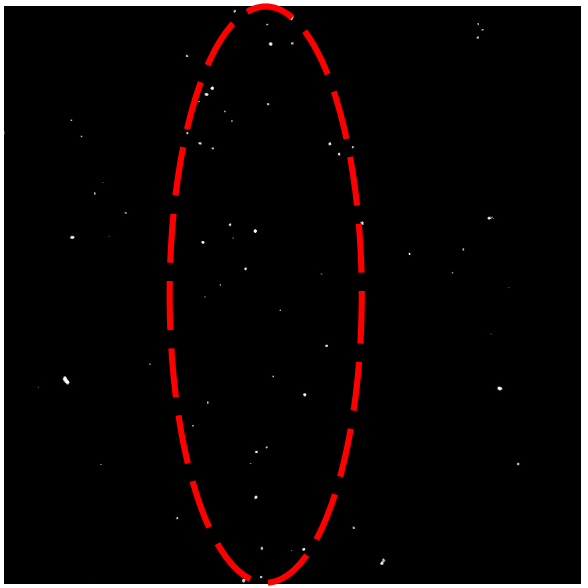
?

CsI(Tl) vs BC408

450 MeV electrons in
CsI(Tl)
Light yield ~50 000 photons/MeV
Density: ~4.5 g/cm³



450 MeV electrons in
BC408
Light yield ~10 000 photons/MeV
Density: ~1.0 g/cm³



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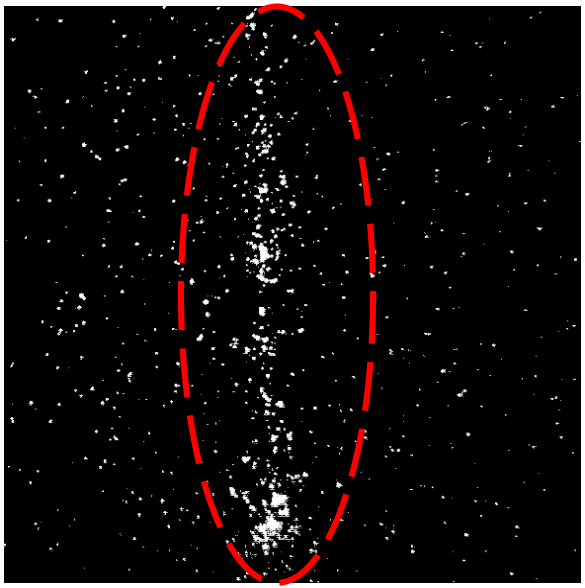

70MeV protons in **BC408**
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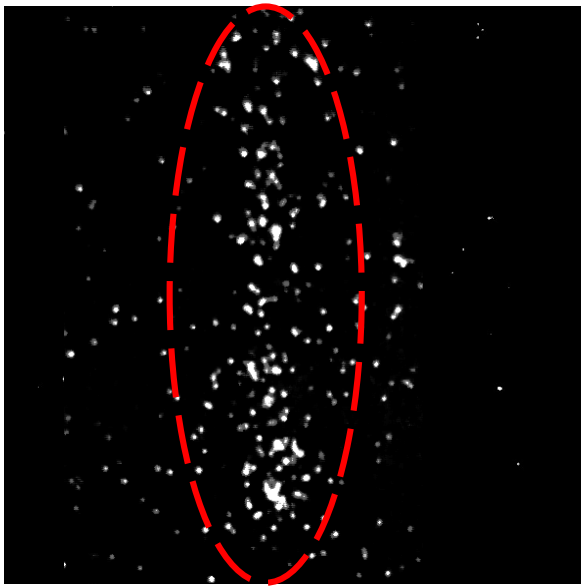
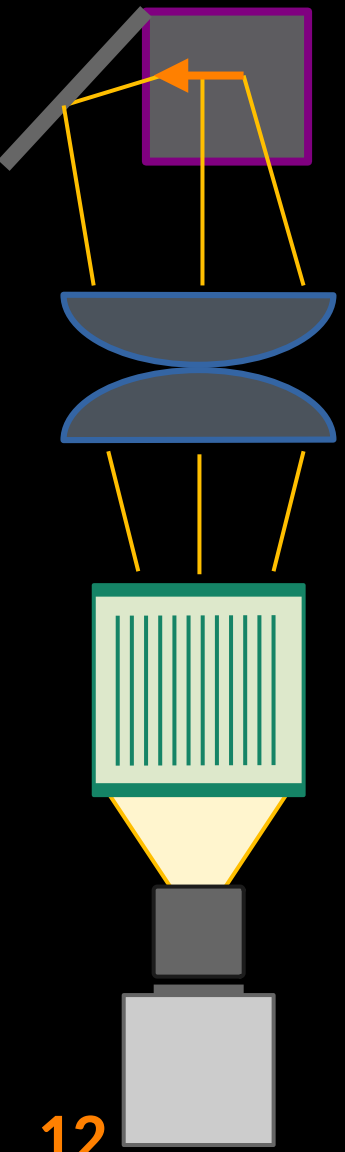
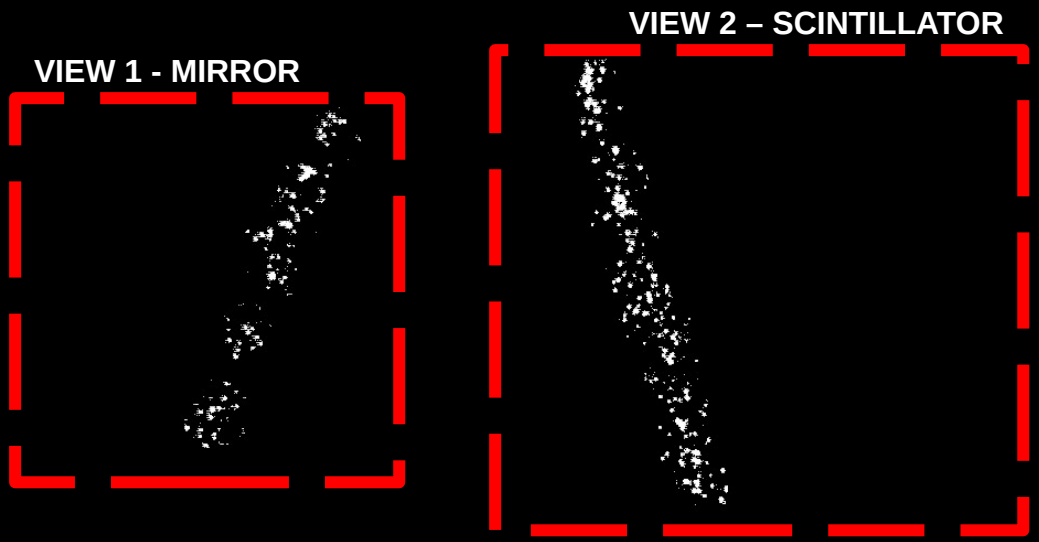
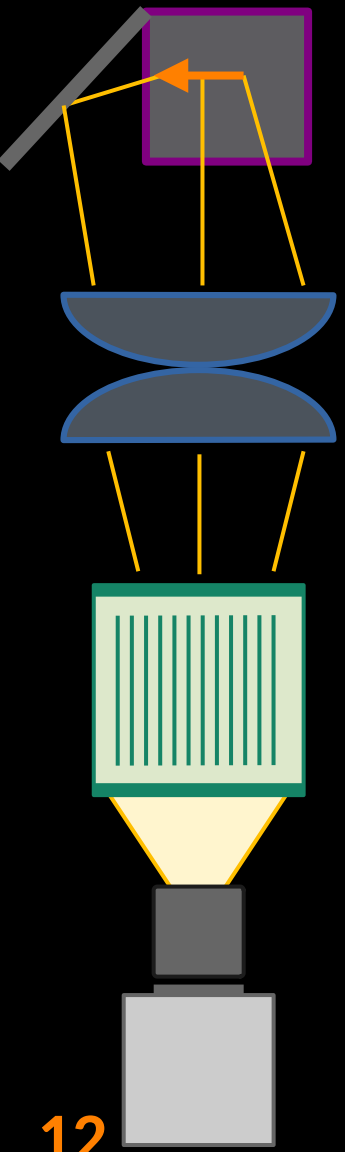


Cosmic **muons** in CsI(Tl)

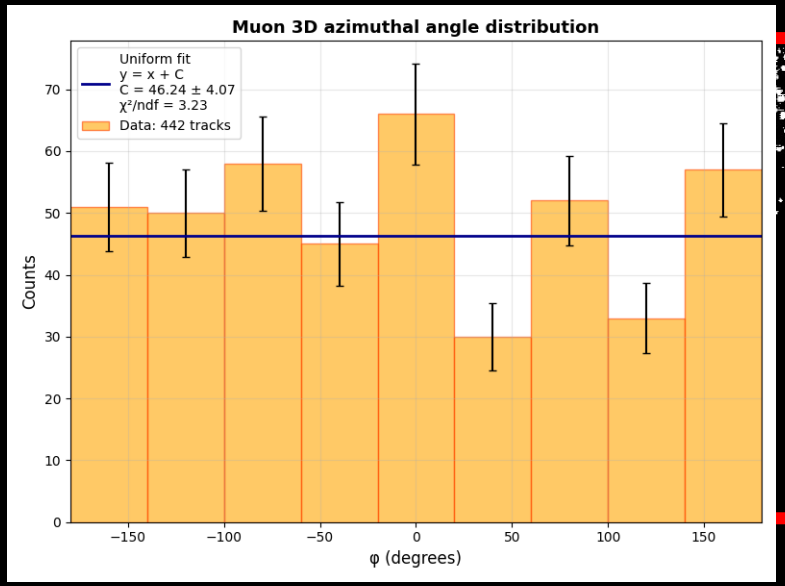






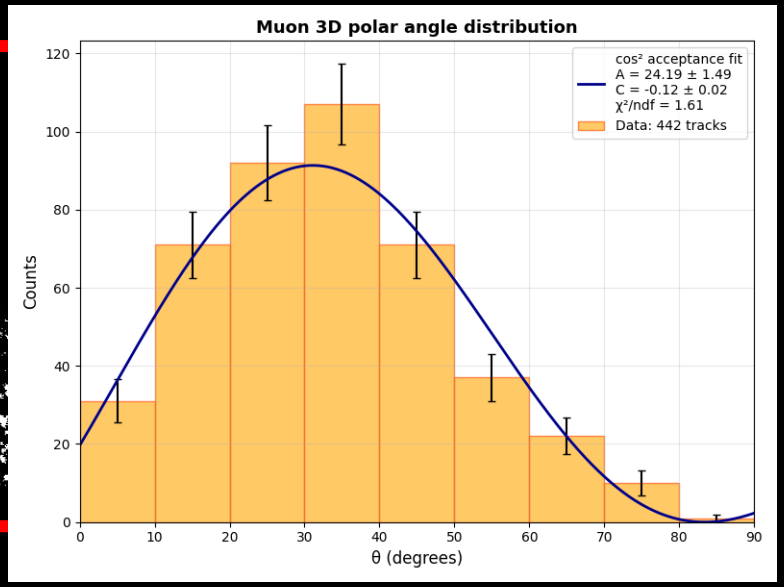
Cosmic **muons** in CsI(Tl)

Azimuthal angle (φ)



Should be uniform
in range [-180,180]

Zenith angle (θ)

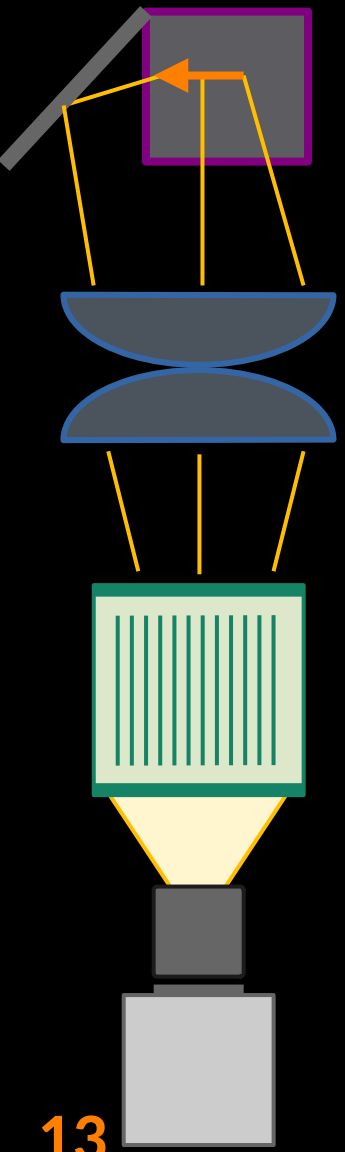


Should follow:

$$\frac{dN}{d\theta} = A\cos^2\theta\sin\theta\left(8\sin\theta + 2\pi\cos\theta\right)$$

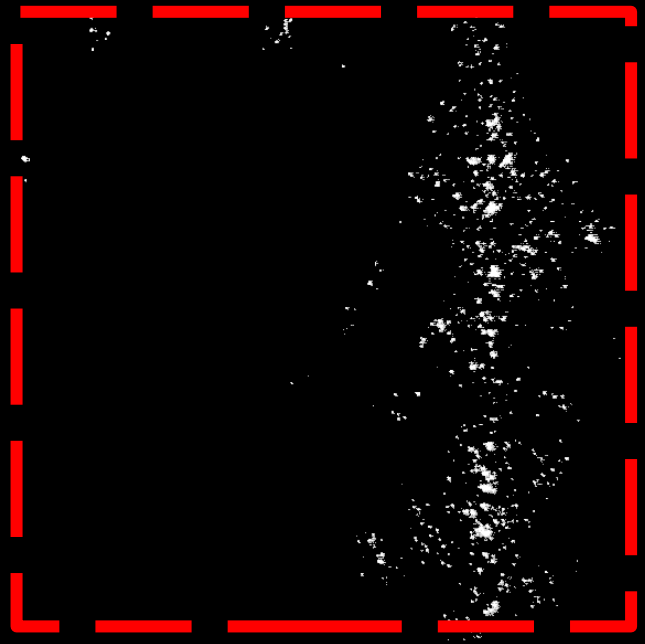
in range [0, 90]

450MeV **electrons** in CsI(Tl)

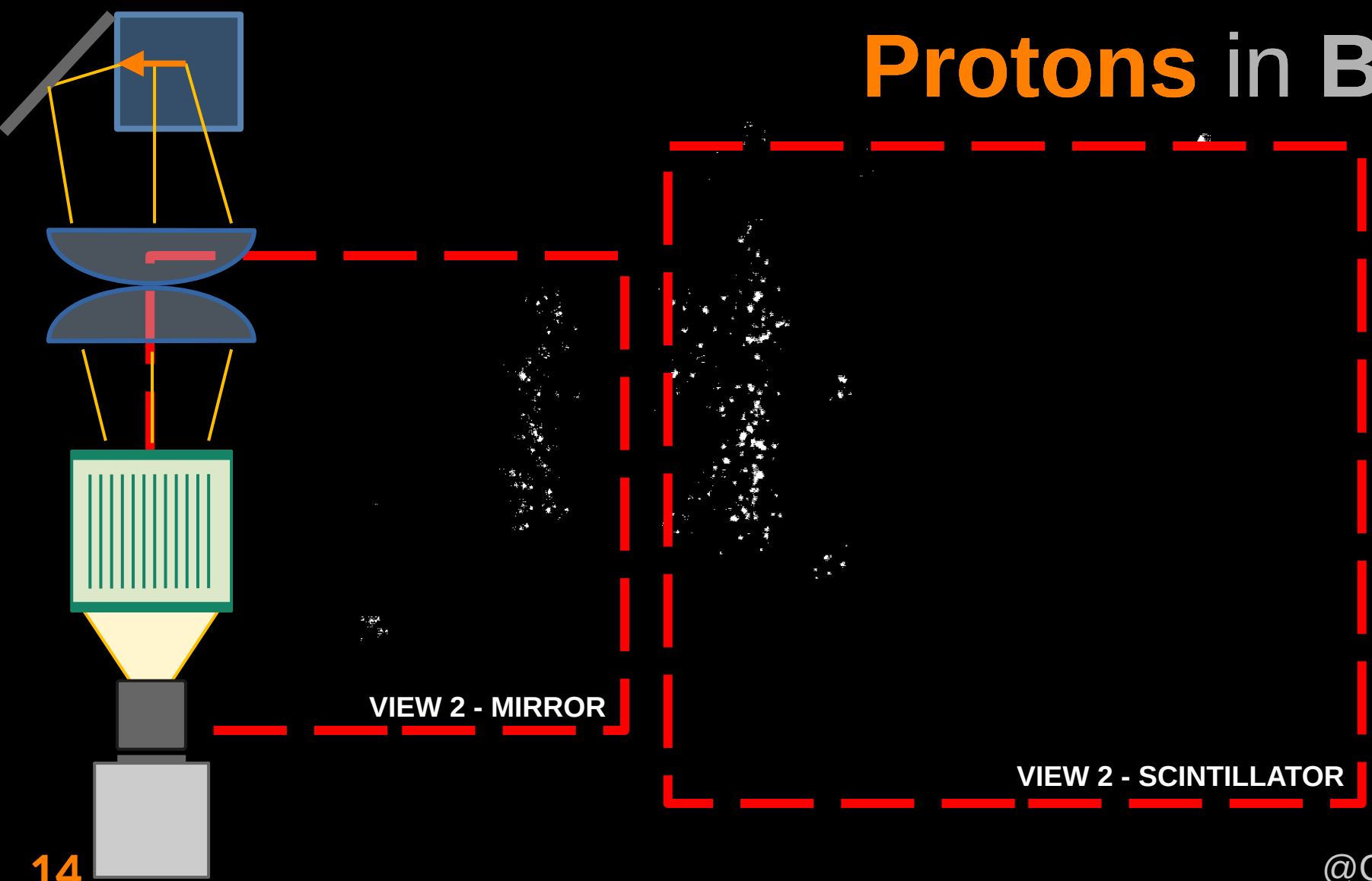


VIEW 1 - MIRROR

VIEW 2 - SCINTILLATOR



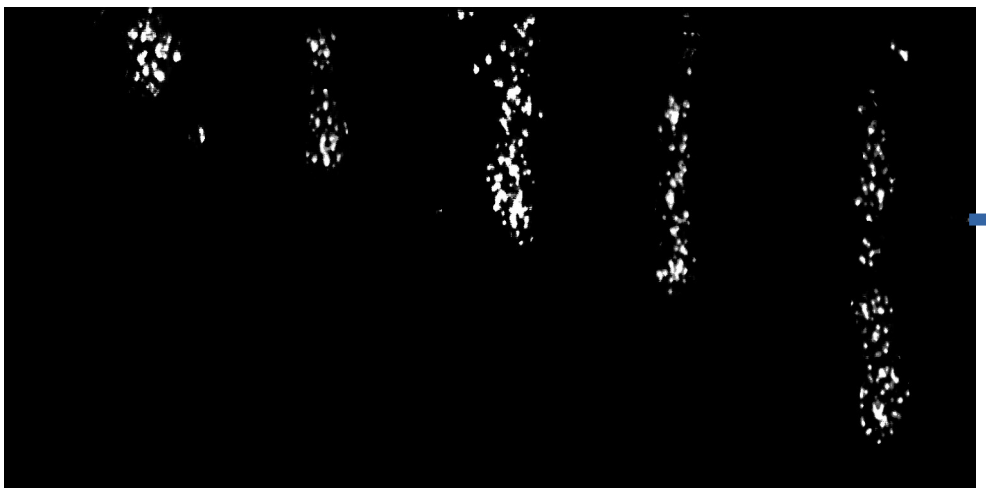
Protons in BC408

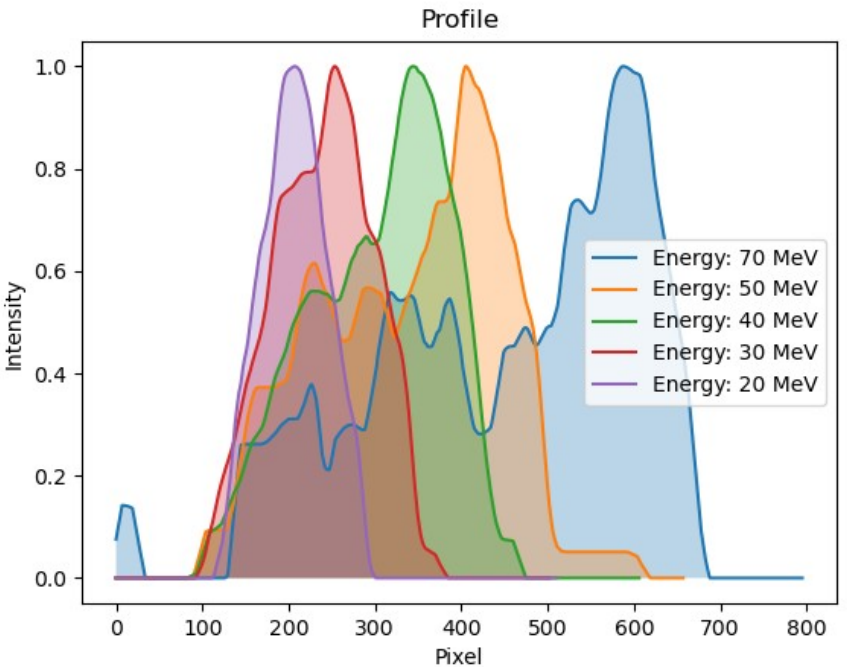


Protons analysis

Protons in **BC408**

20 MeV **30** MeV **40** MeV **50** MeV **70** MeV



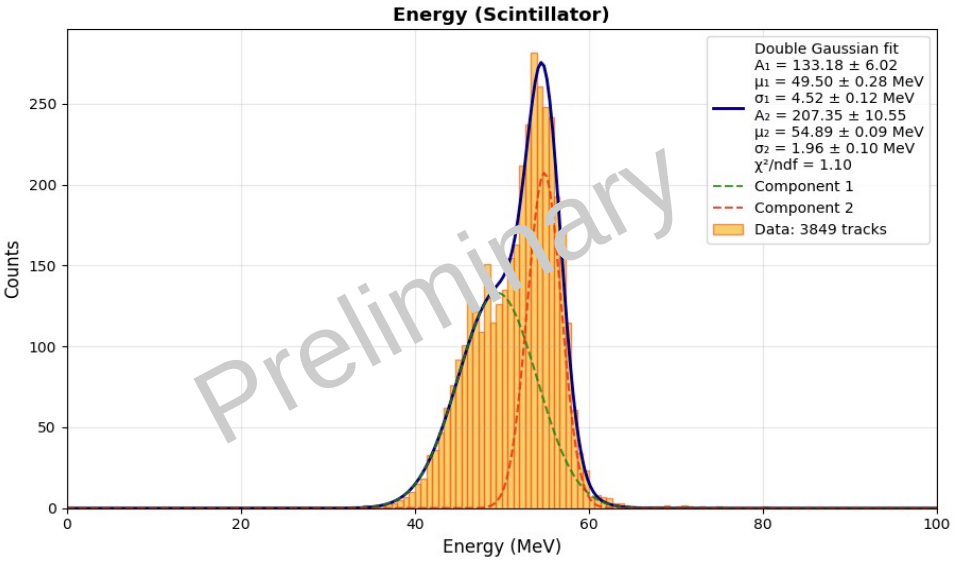


$E_n = E_p / \cos^2(\theta)$

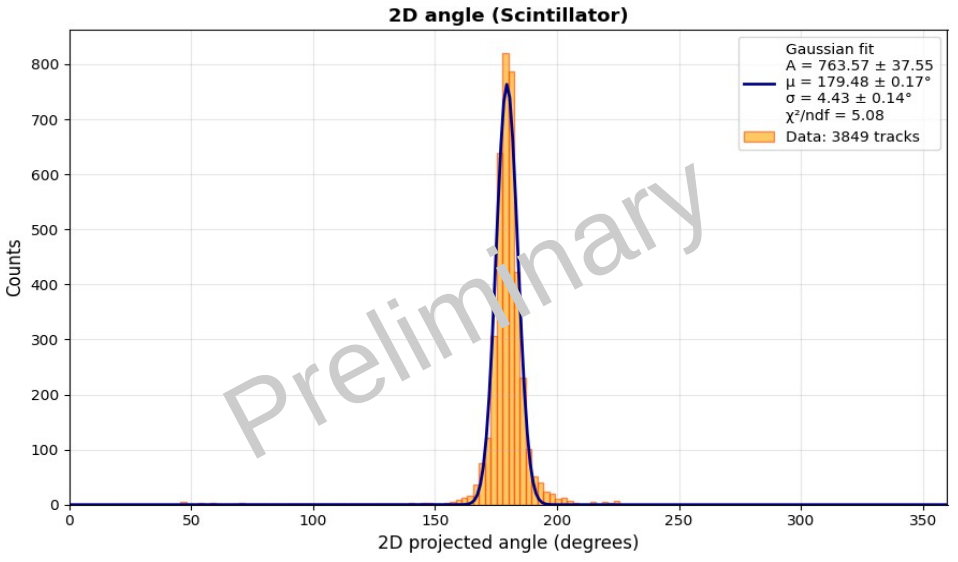
Results of track reconstruction algorithm

Protons at 50 MeV

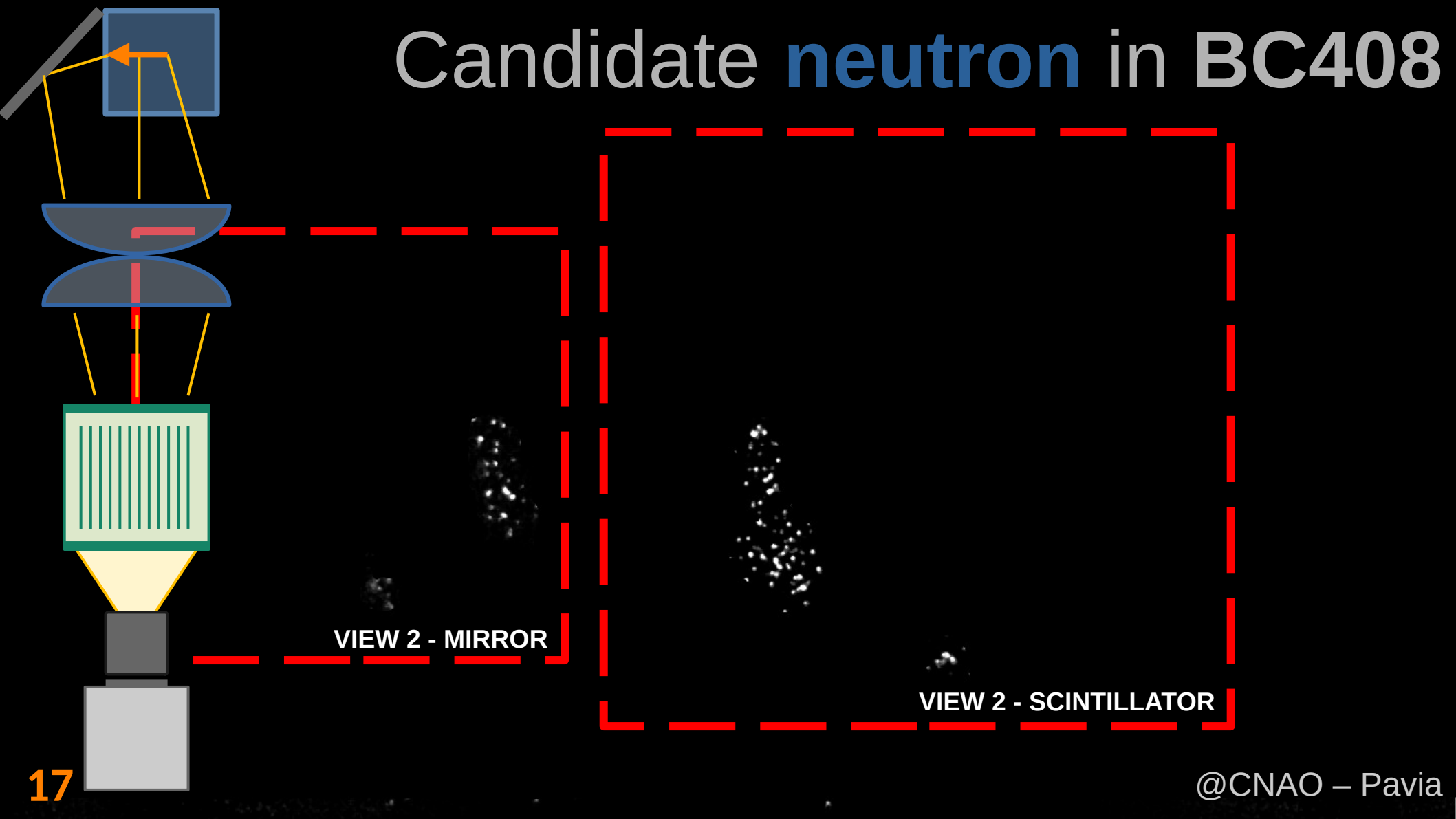
Energy (E_p)

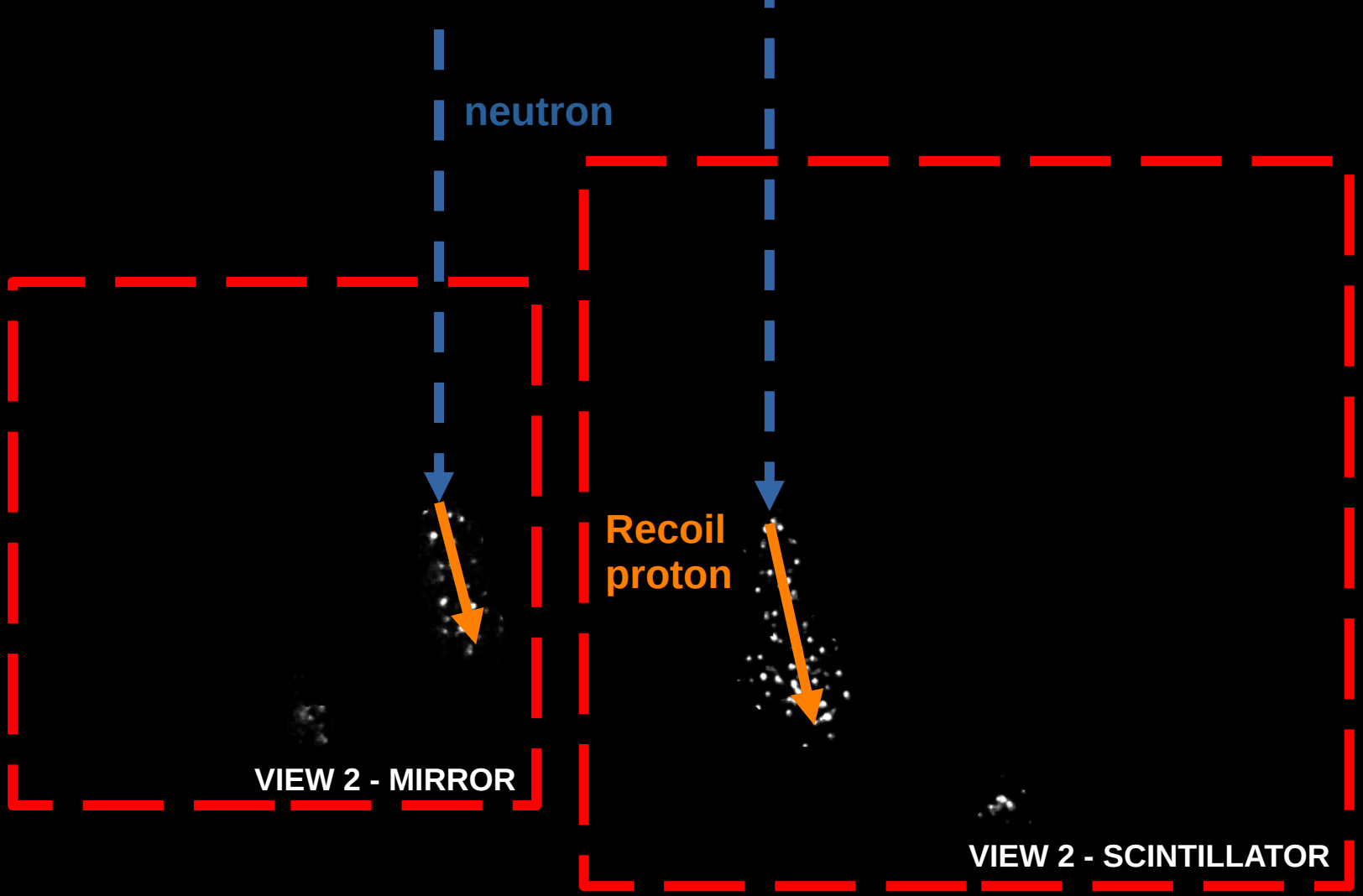


Angle (θ)

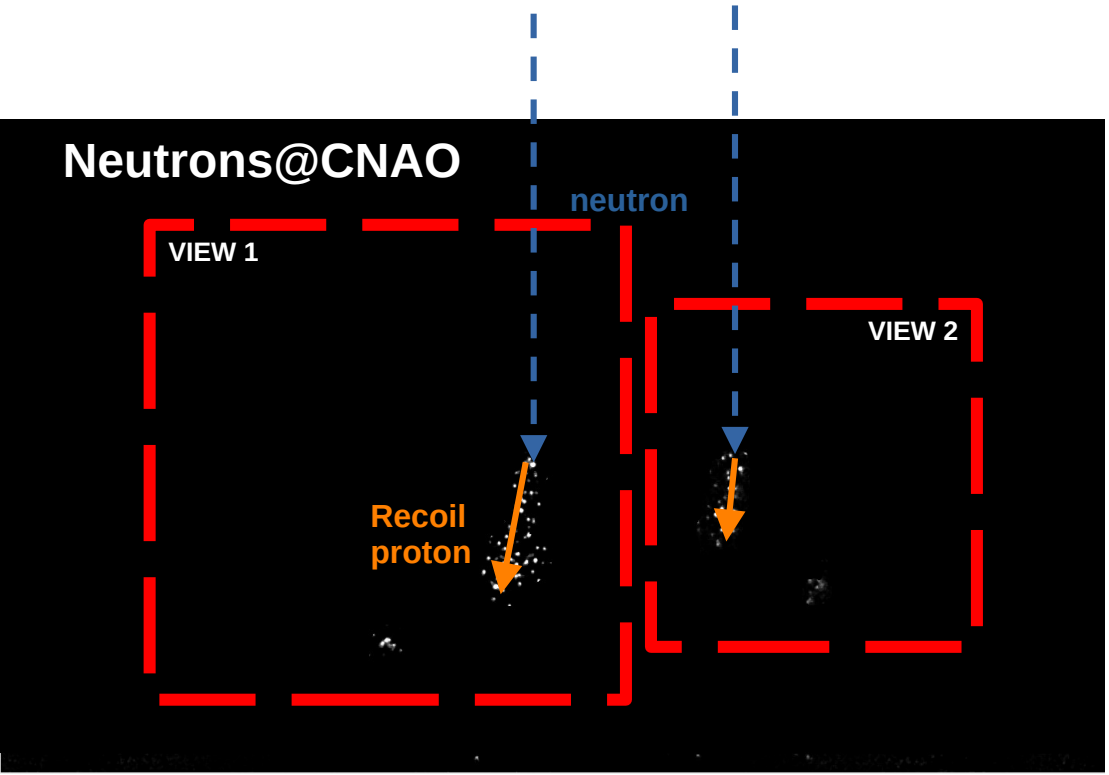


Candidate **neutron** in **BC408**




neutron
Recoil
proton
VIEW 2 - MIRROR
VIEW 2 - SCINTILLATOR

To conclude ...



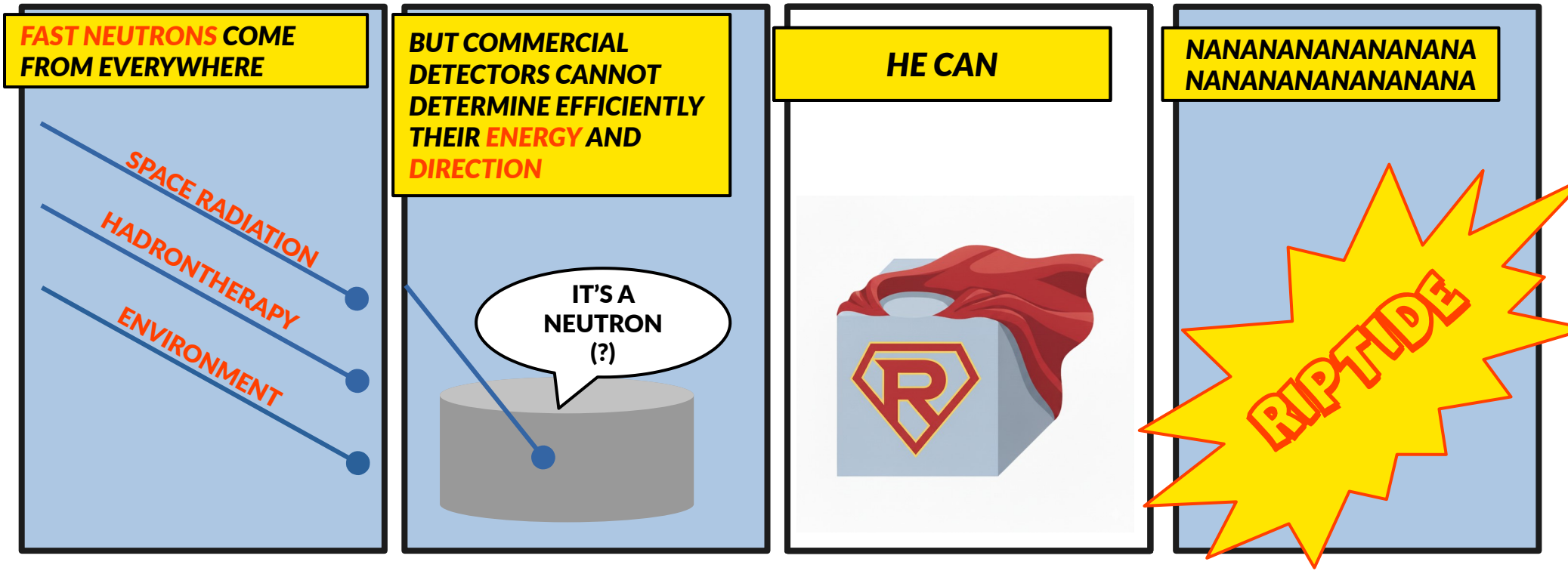
RIPTIDE is a fast neutron detector (5-50 MeV) aiming to provide **energy** and **direction** of incoming neutrons

We showed the feasibility to image tracks of **charged particles**.

Preliminary analysis show energy resolution < 10%

Proved the possibility to detect **fast neutrons**.

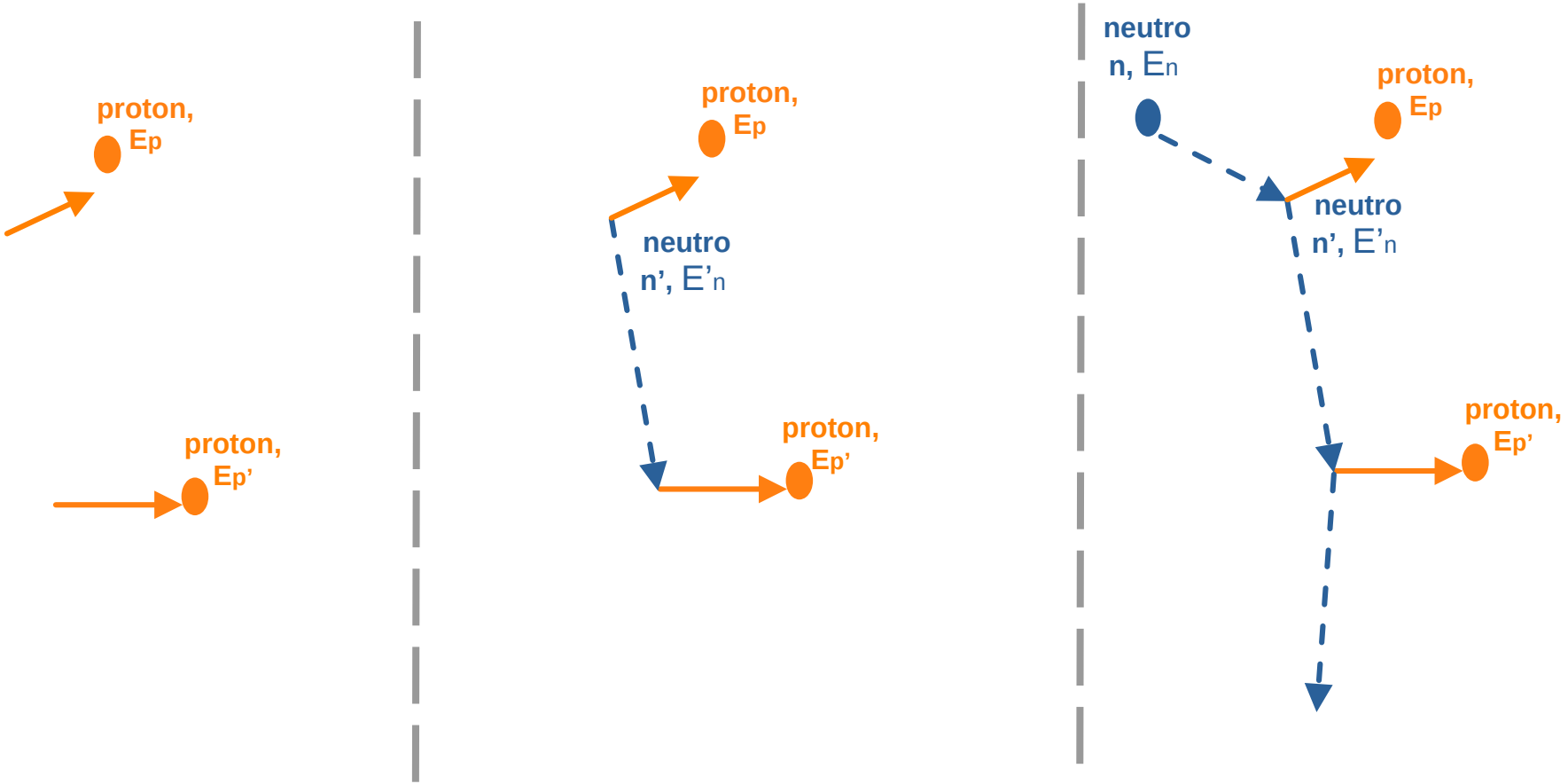
Questions?


FAST NEUTRONS COME FROM EVERYWHERE
SPACE RADIATION
HADRONTHERAPY
ENVIRONMENT
BUT COMMERCIAL DETECTORS CANNOT DETERMINE EFFICIENTLY THEIR ENERGY AND DIRECTION
IT'S A NEUTRON (?)
HE CAN
NANANANANANANANANA
NANANANANANANANANA
RIPTIDE

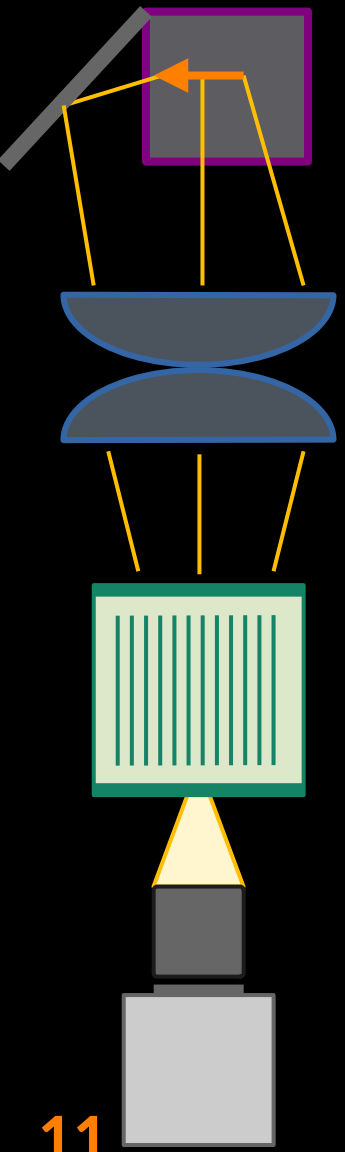
Back up slides

How: Recoil Proton Track Imaging (RPTI) principle

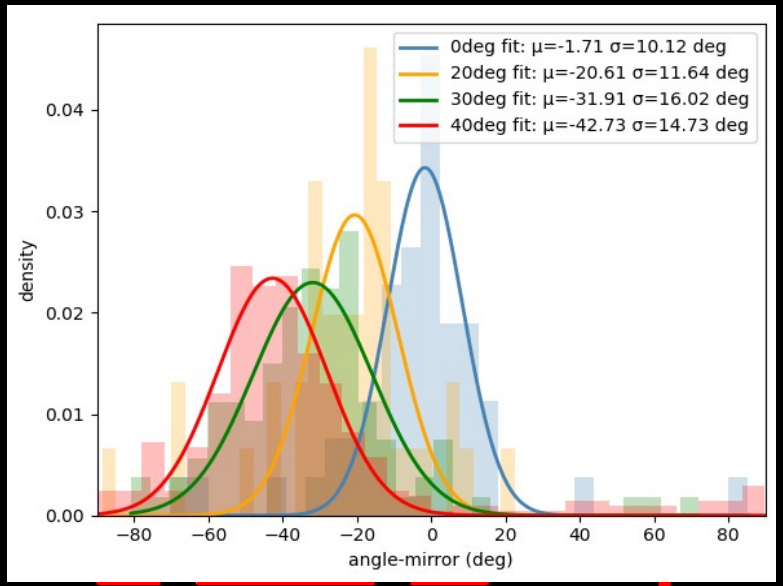
$E_n = E_p / \cos^2(\theta)$



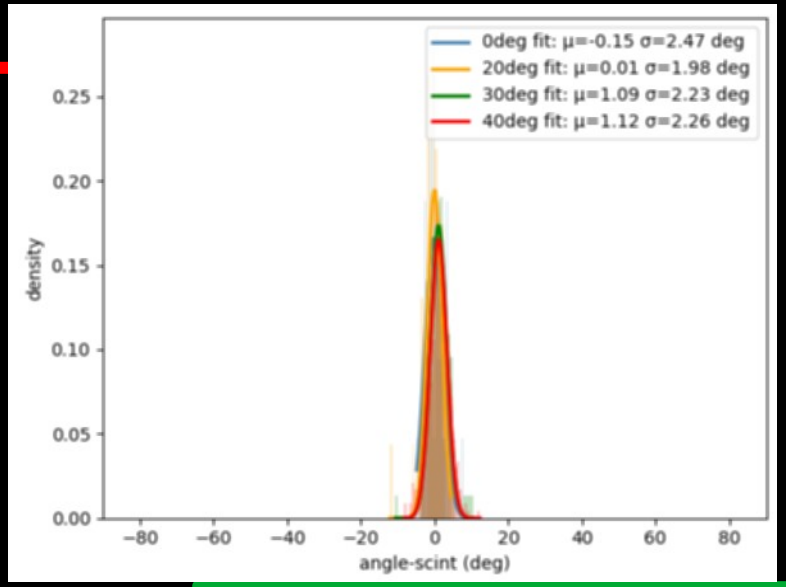
450MeV **electrons** in CsI(Tl)

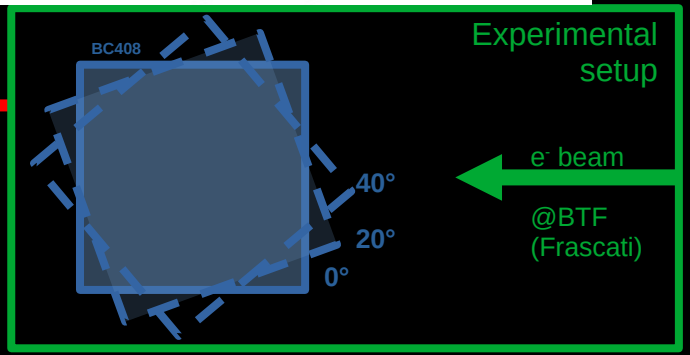


Angle reconstruction on mirror view



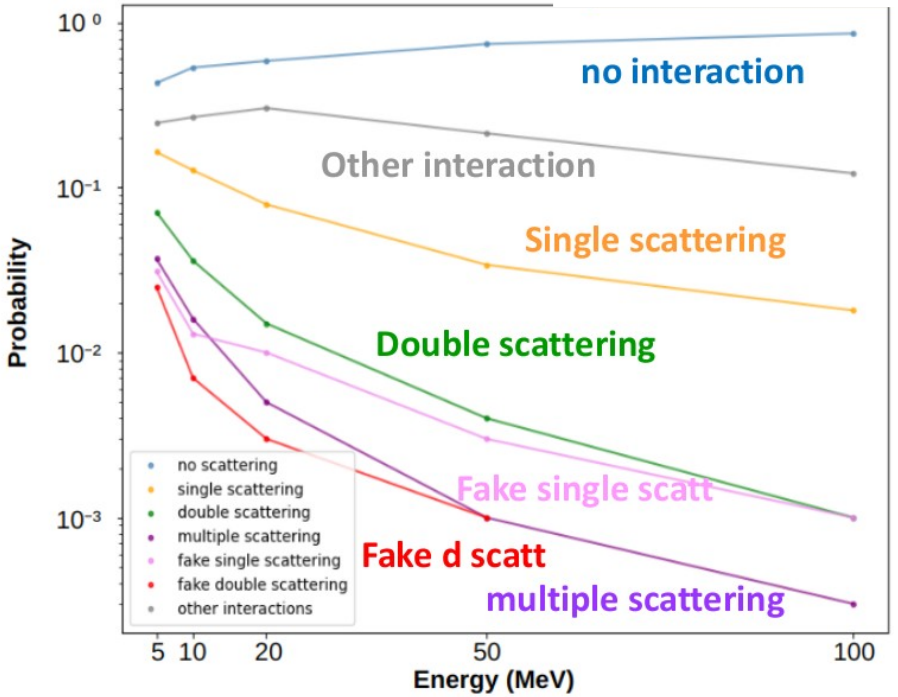
Angle reconstruction on scintillator view

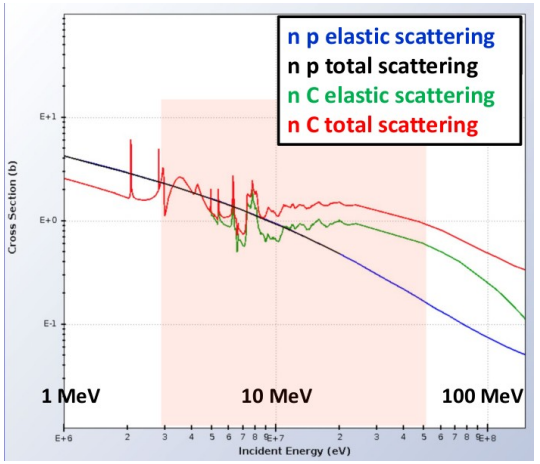




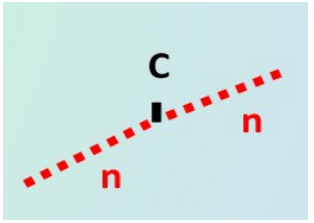
Neutron interaction in the scintillator: competing reactions

The plastic scintillator is made of carbon and proton nuclei

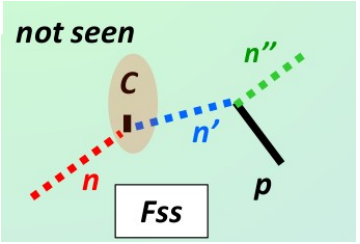
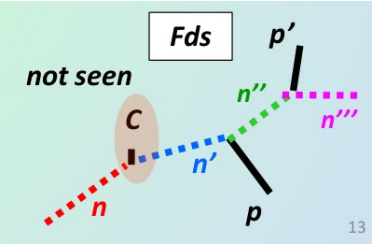




Carbon scattering



fake single scattering



fake double scattering