Diamonds for Beam Instrumentation

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Erich Griesmayer

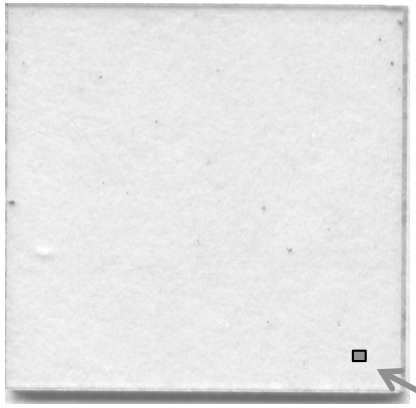
CIVIDEC Instrumentation, Austria

Overview

- Diamond Detectors
- Physics
- Application Examples
- Summary

Diamond Detector

Substrate



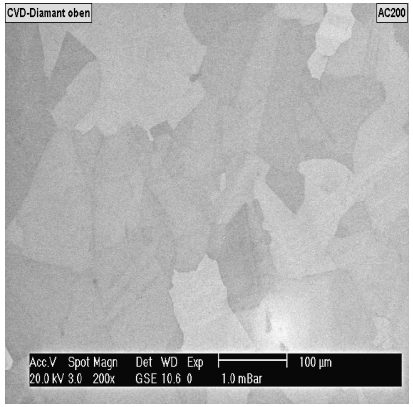
10 mm

Diamond Substrate:

pCVD = 10x10 mm^2 x 0.5 mm
sCVD = 5x5 mm^2 x 0.5 mm

Next transparency

pCVD Substrate



500 um

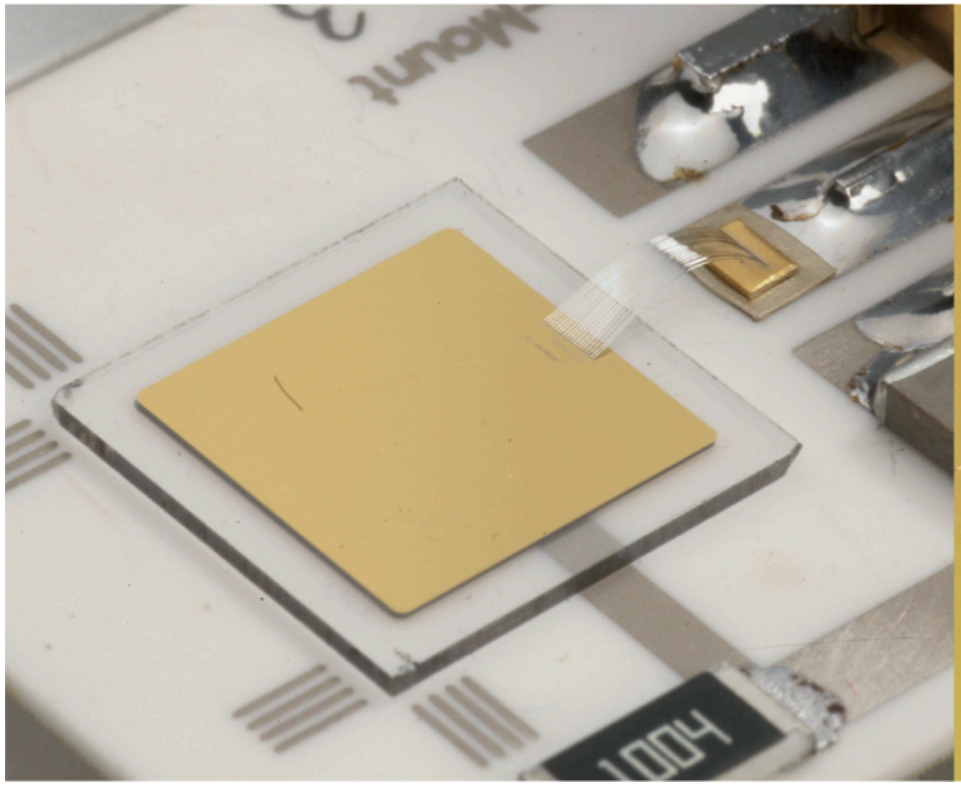
Crystal boundaries, 100 – 200 um

→ Trapping

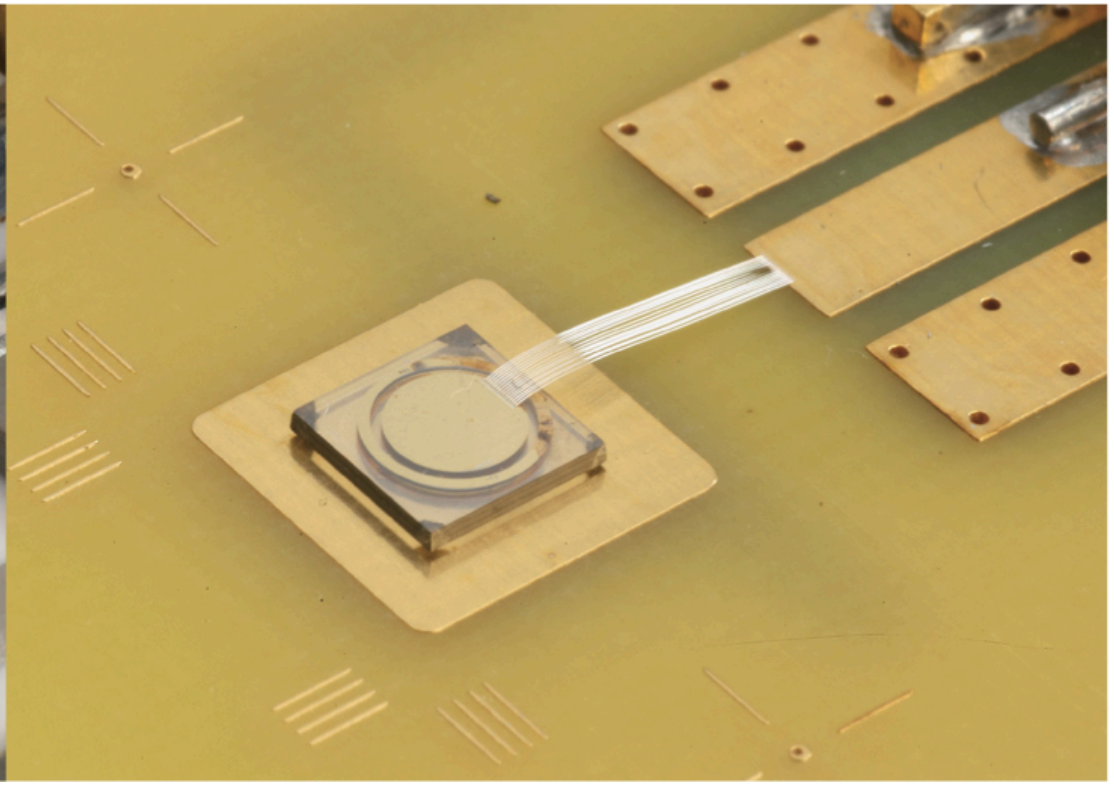
→ Reduction of ionization charges

Charge-collection distance typ. 200 um

Diamond Detectors

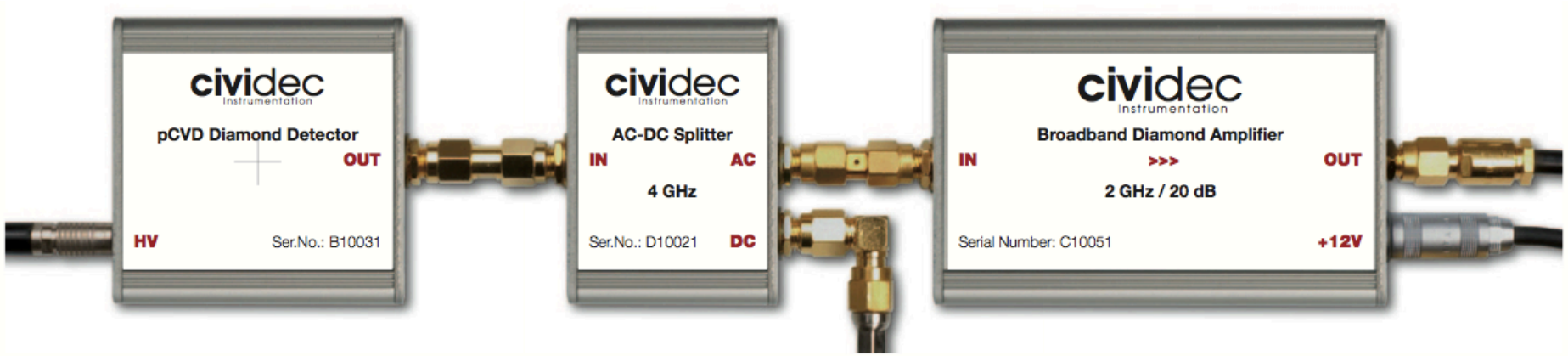


pCVD



sCVD

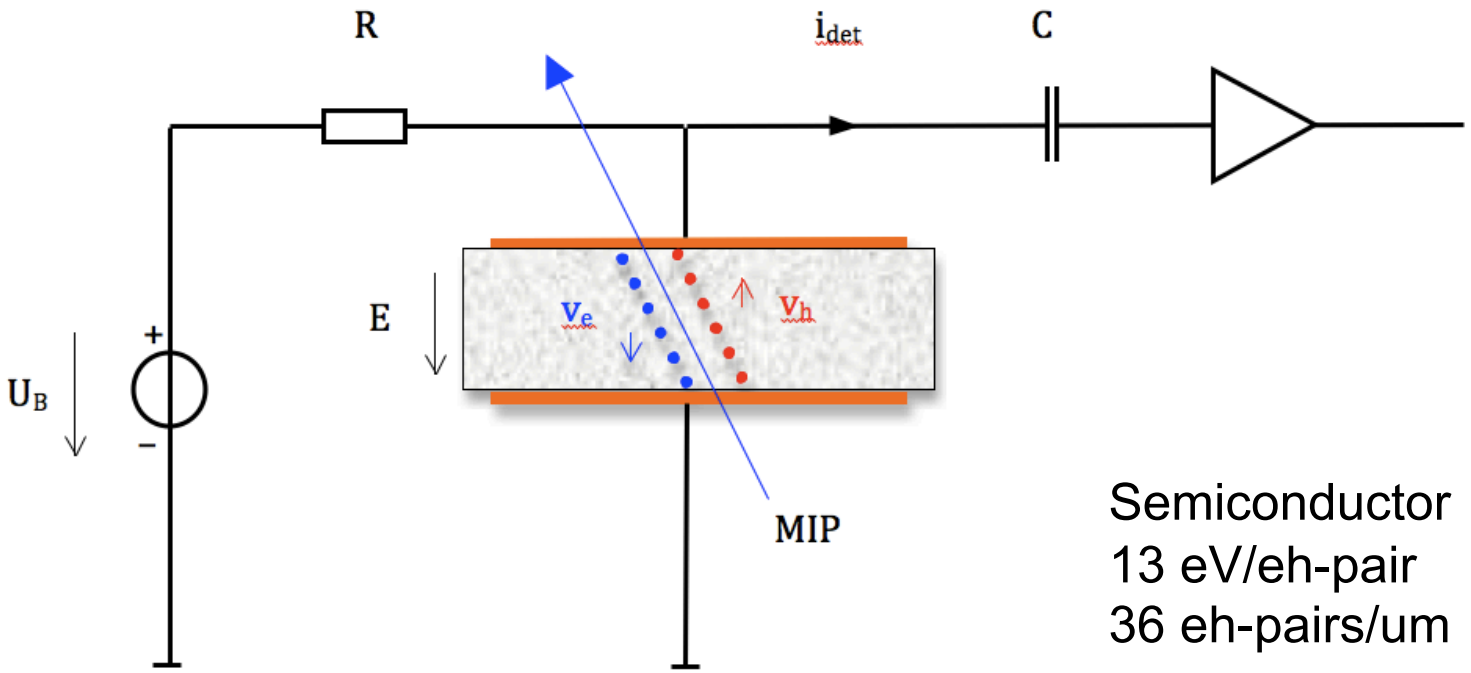
LHC Diamond Beam Monitor



Detector AC/DC Splitter 2 GHz Amplifier

Physics

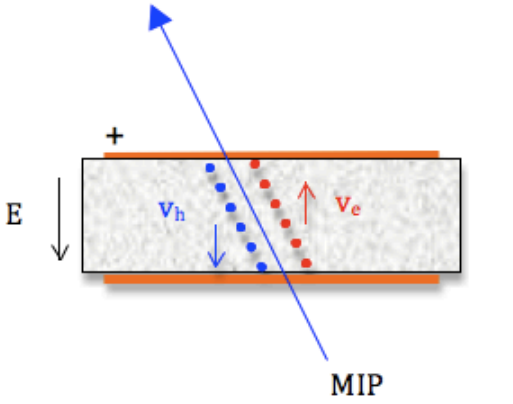
Principle of Ionization

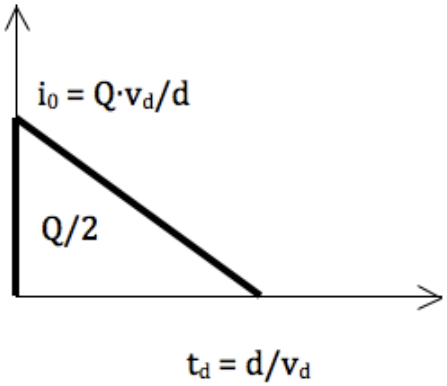


Semiconductor
13 eV/eh-pair
36 eh-pairs/um

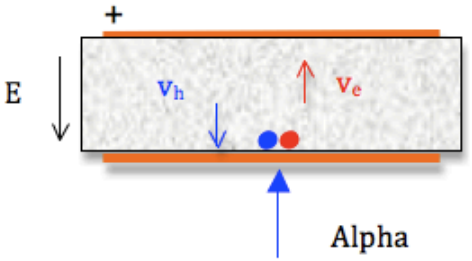
Modes of Operation

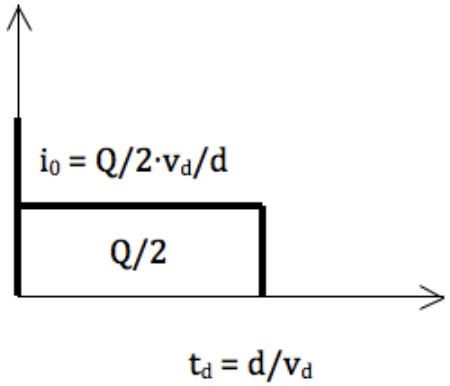
Counting Mode





Calorimetric Mode



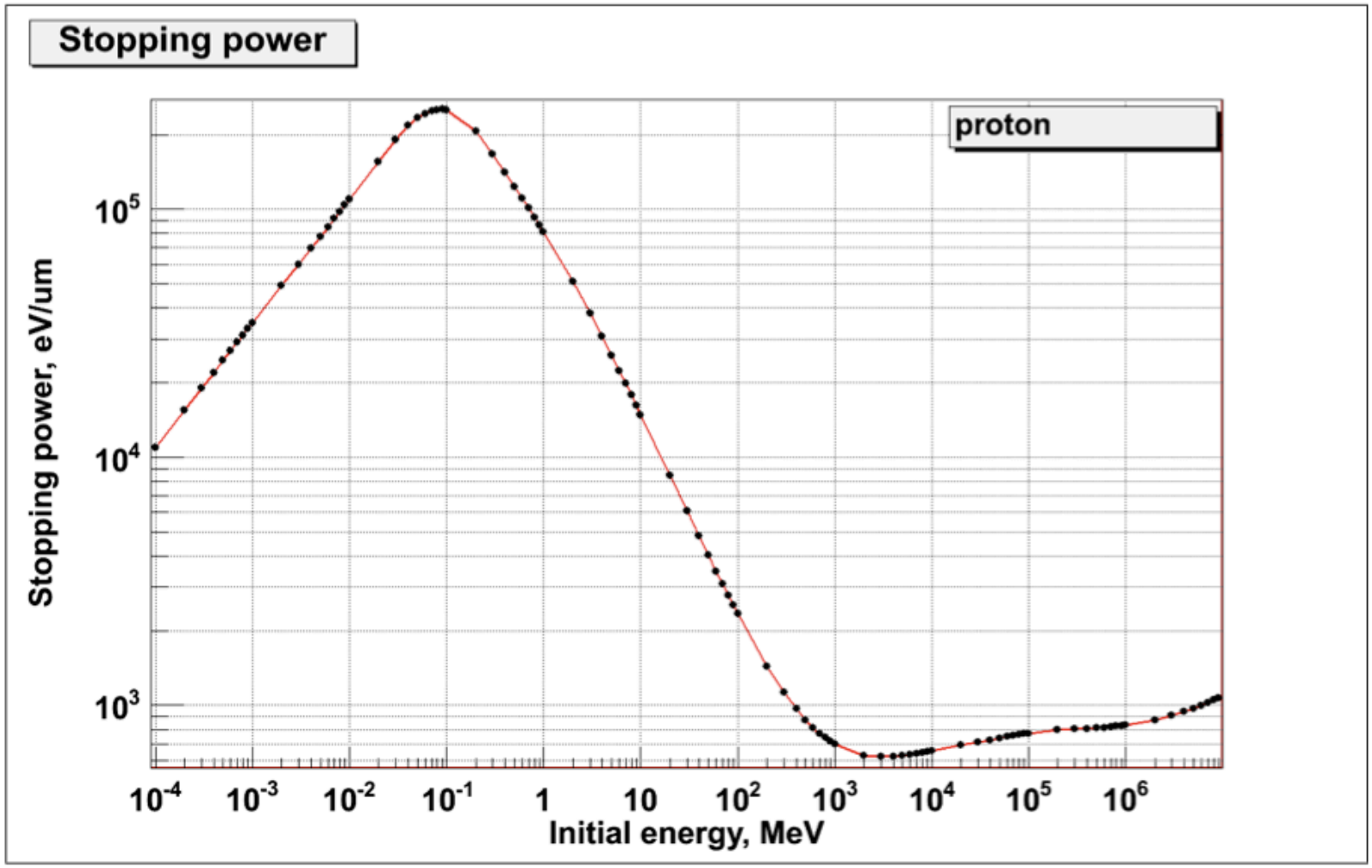


Proton Interaction

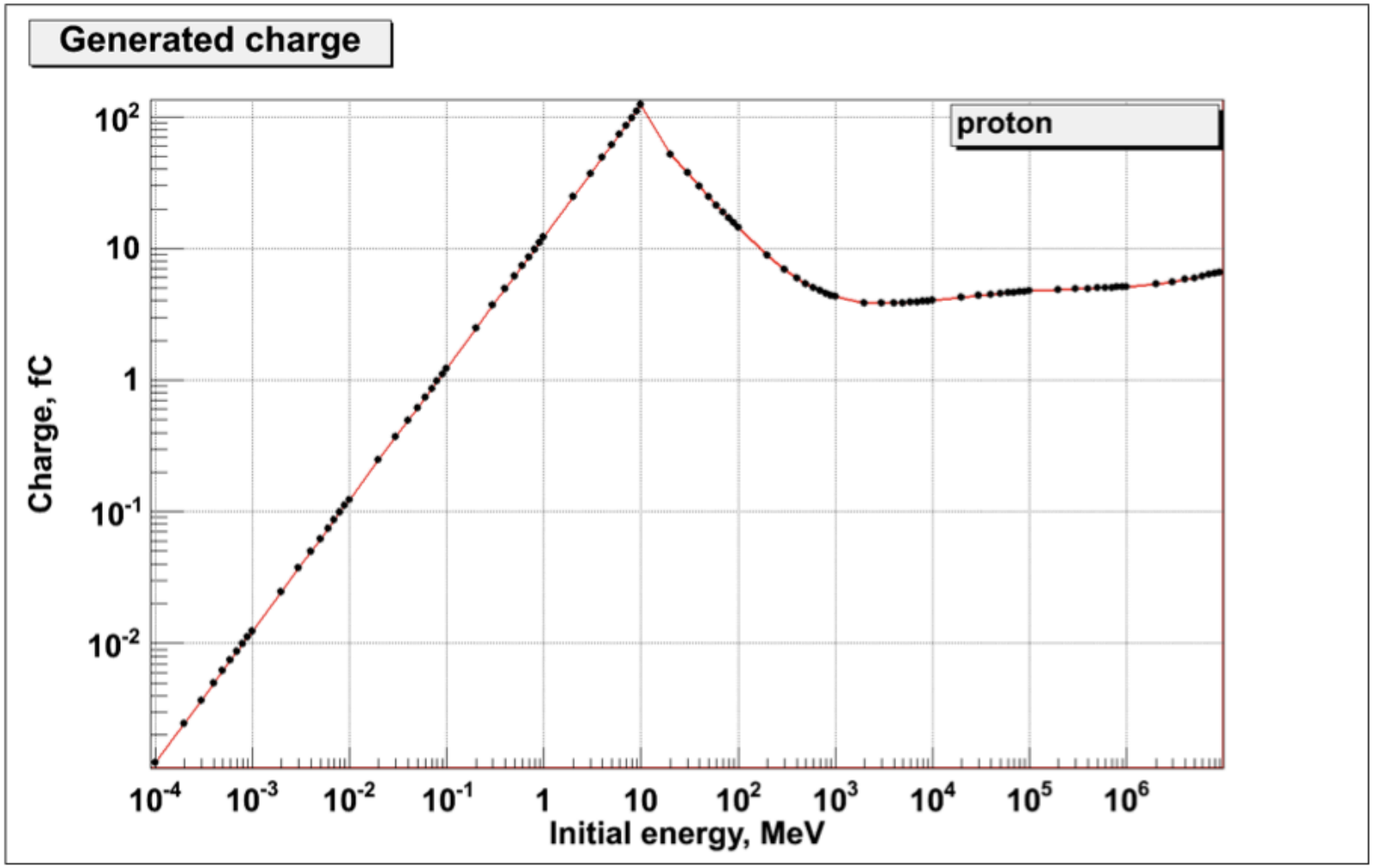
→ Direct measurement of the ionization charge

→ Single protons, efficiency = 100%

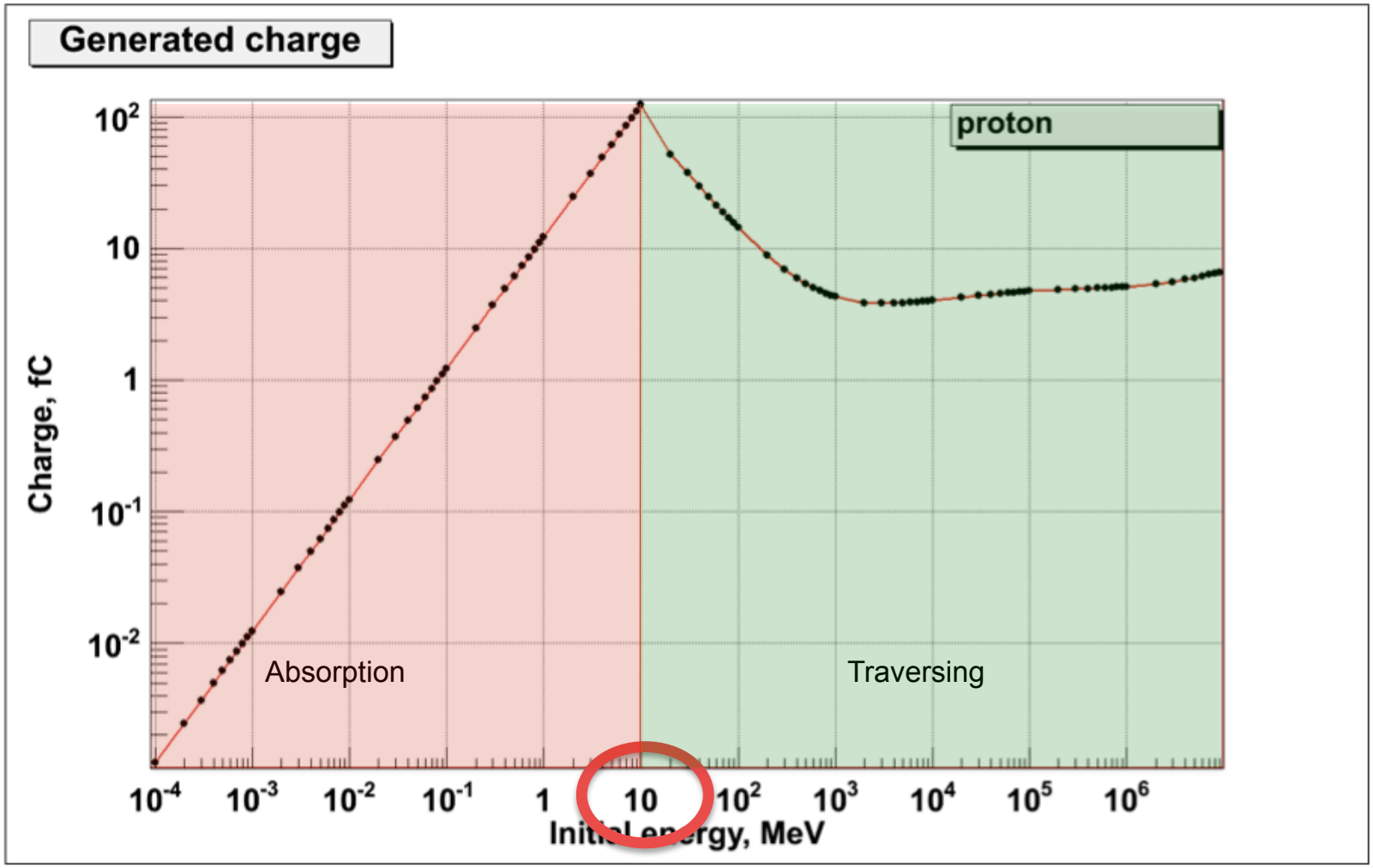
Proton Interaction



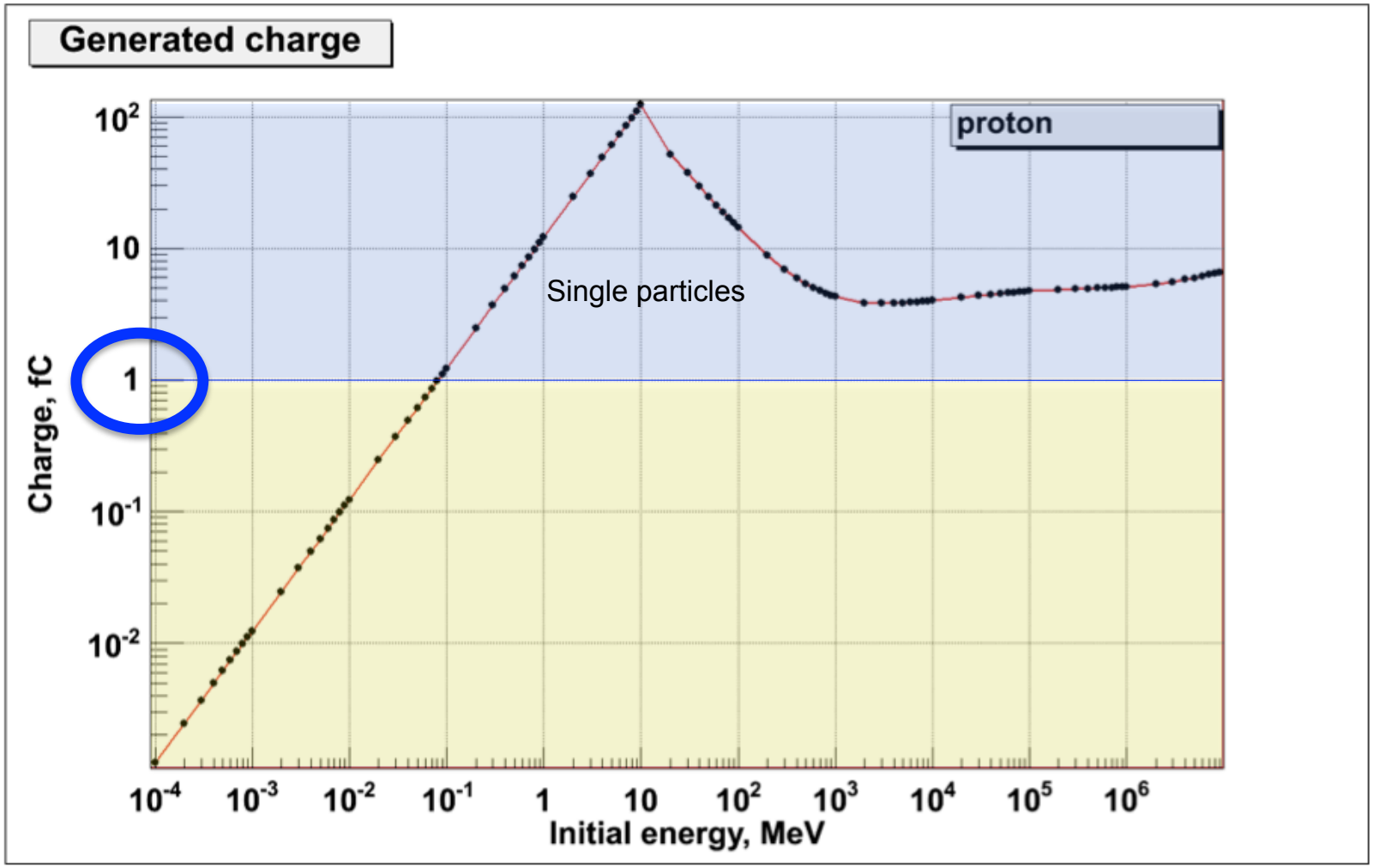
Proton Interaction



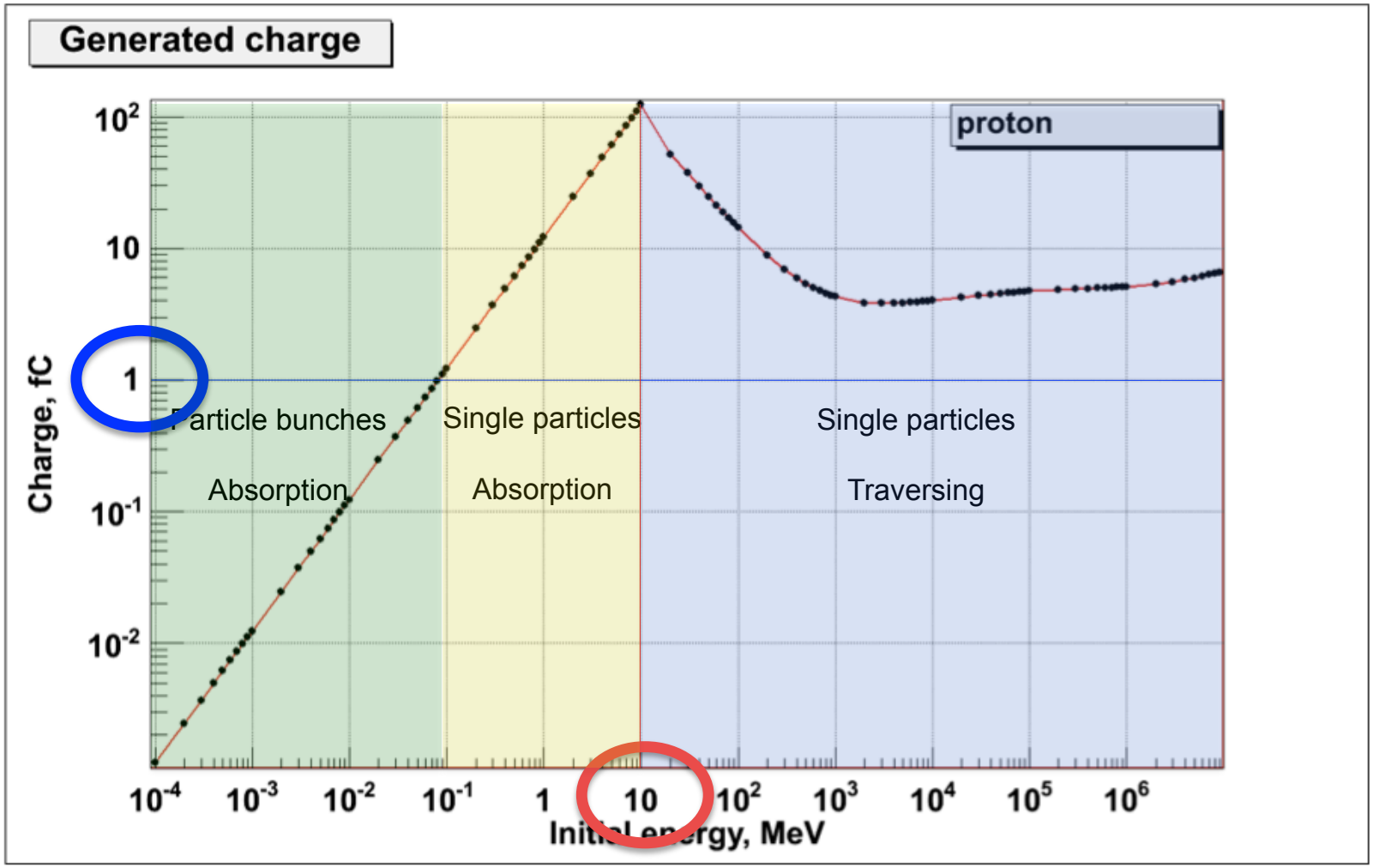
Proton Interaction



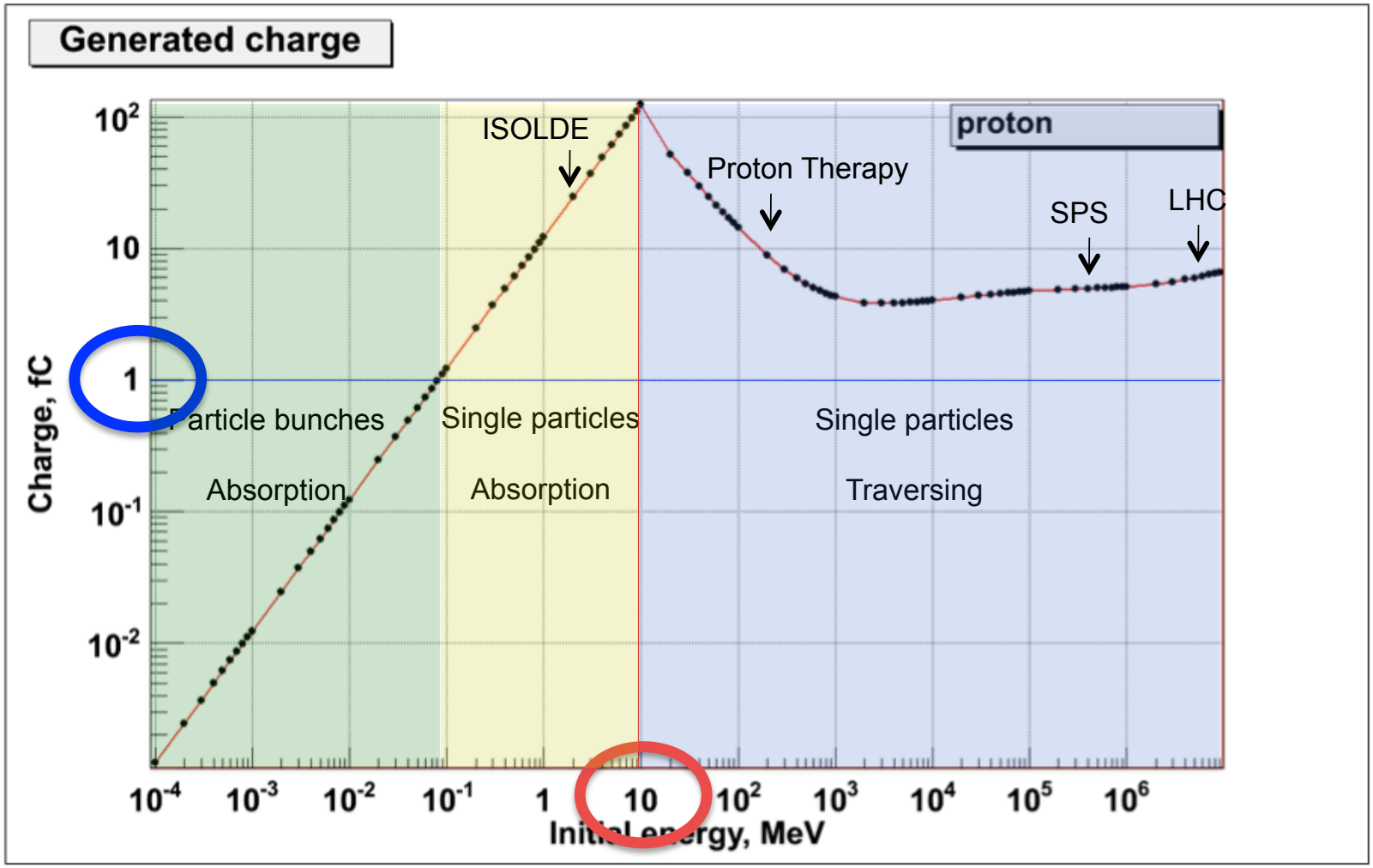
Proton Interaction



Proton Interaction



Proton Interaction



Applications

Beam Instrumentation Detectors

- Beam Loss Monitors (CERN LHC)
- Beam Position Monitors (XFEL)
- Beam Profile Monitors (Particle Therapy)
- Neutron Flux Monitors (ITER)

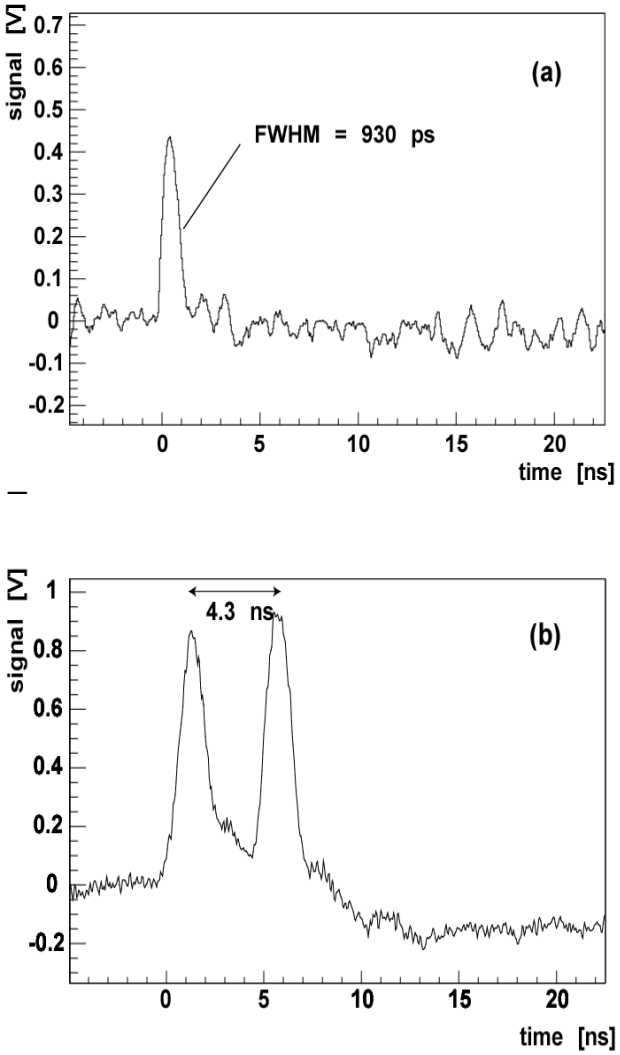
Application Example 1:

PROTON THERAPY

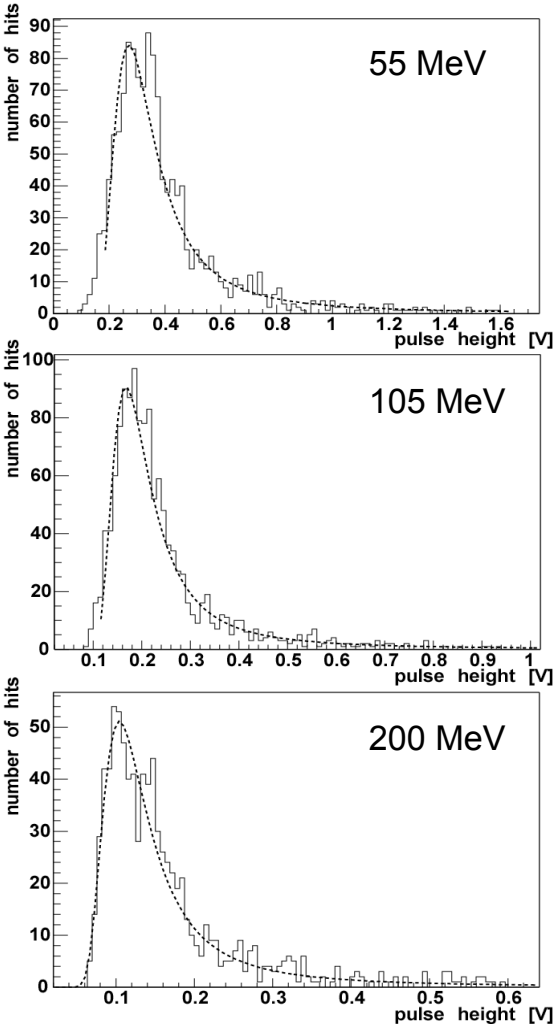
Indiana University

Medical Protons

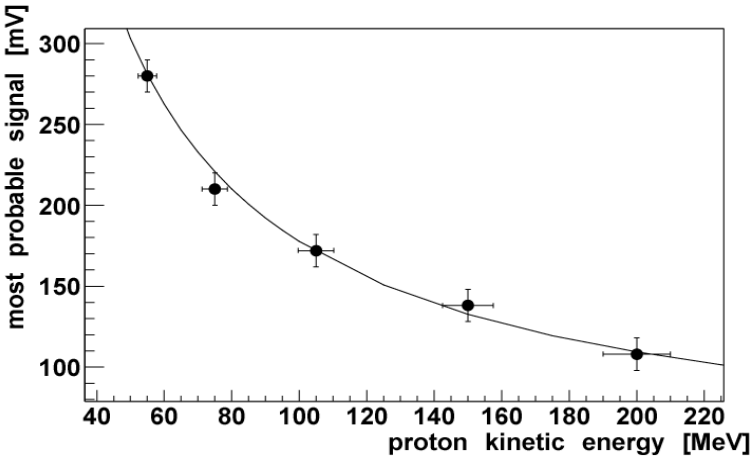
Pulse shapes



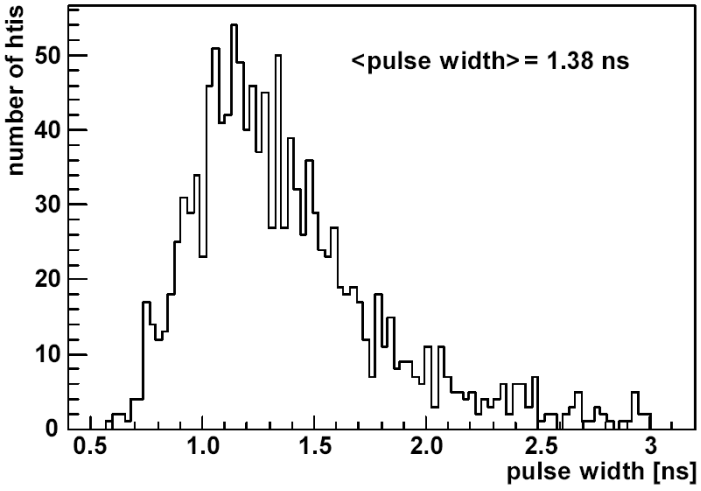
Landau



Bethe-Bloch



Pulse-Width Distribution



Application Example 2:

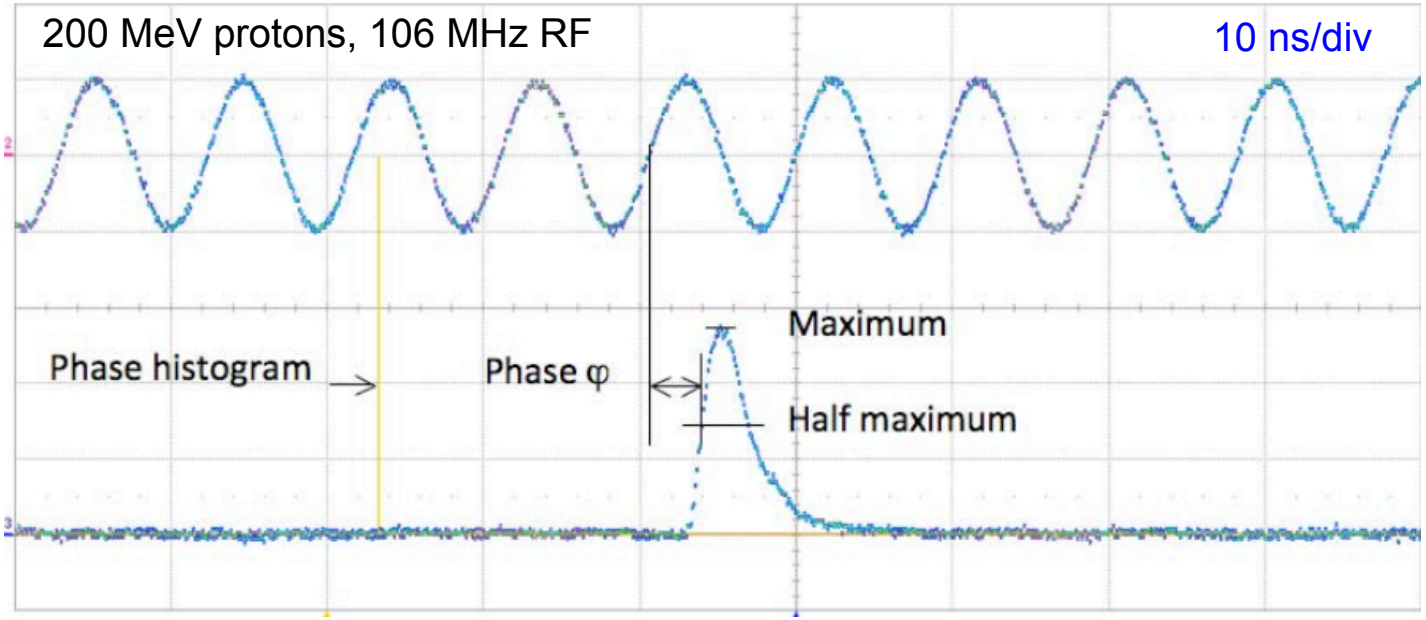
PROTON THERAPY

Proton Therapy

IBA Cyclotron in Orsay

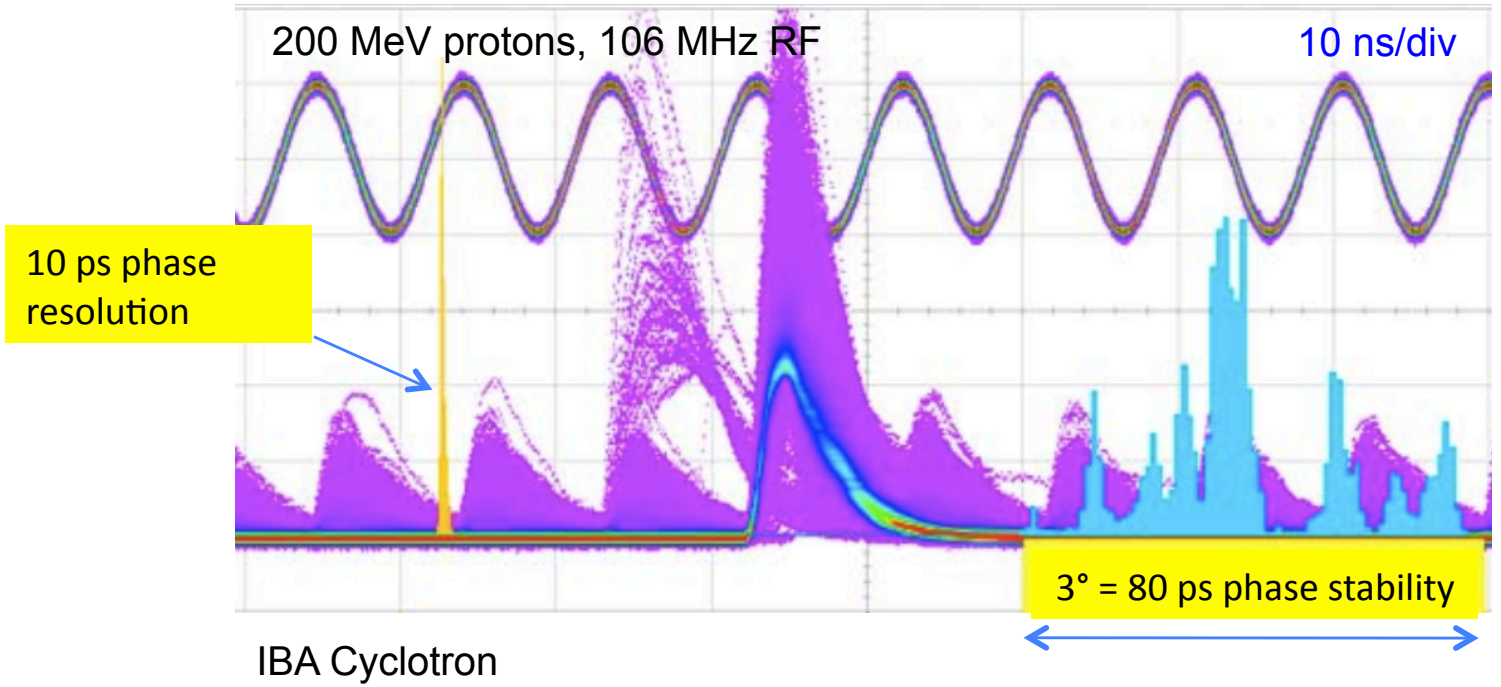
Proton Therapy

Phase measurement



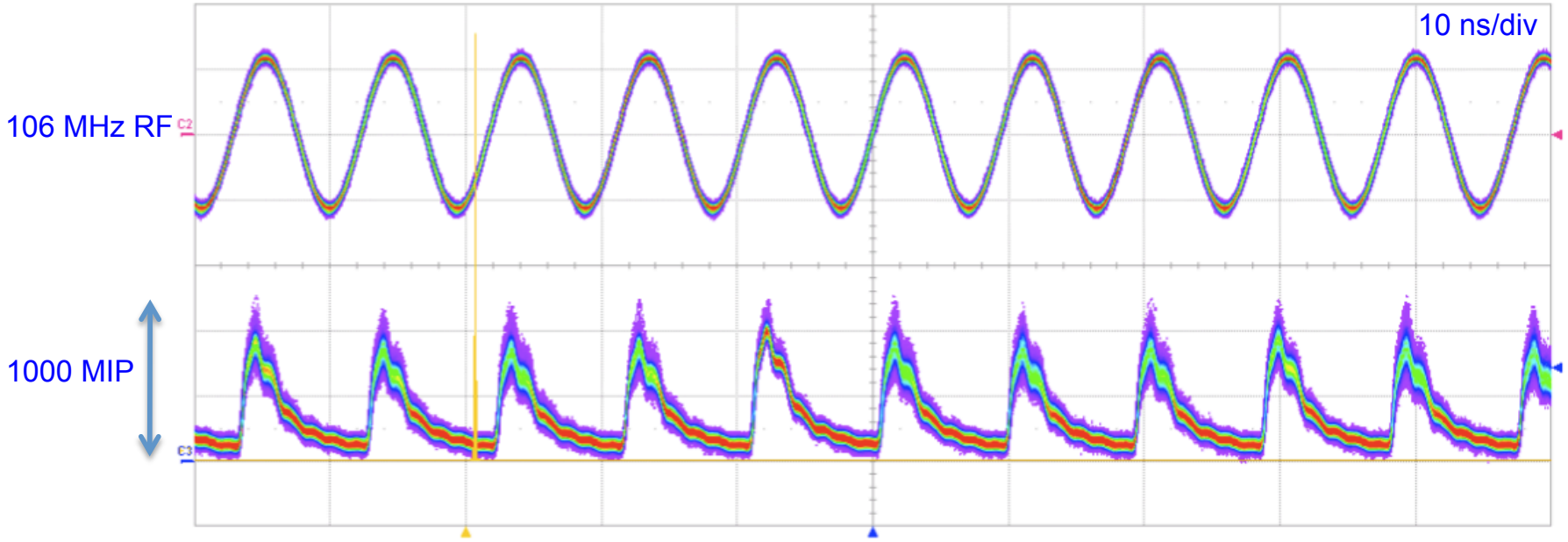
Proton Therapy

Phase measurement



Proton Therapy

Intensity measurement

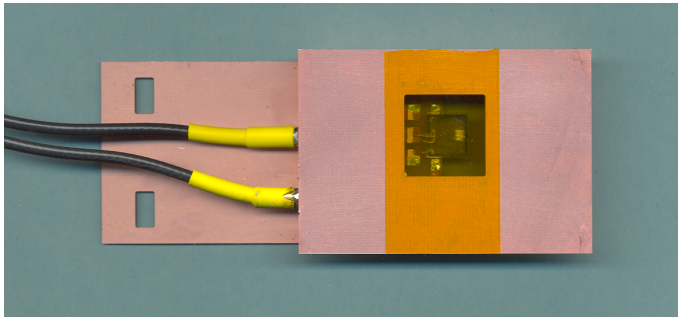


Application Example 3:

PHOTON THERAPY

Photon Therapy

AKH Vienna
X-rays: 10 MV
Dose-rate: 4 Gy/min
Courtesy: D. Georg

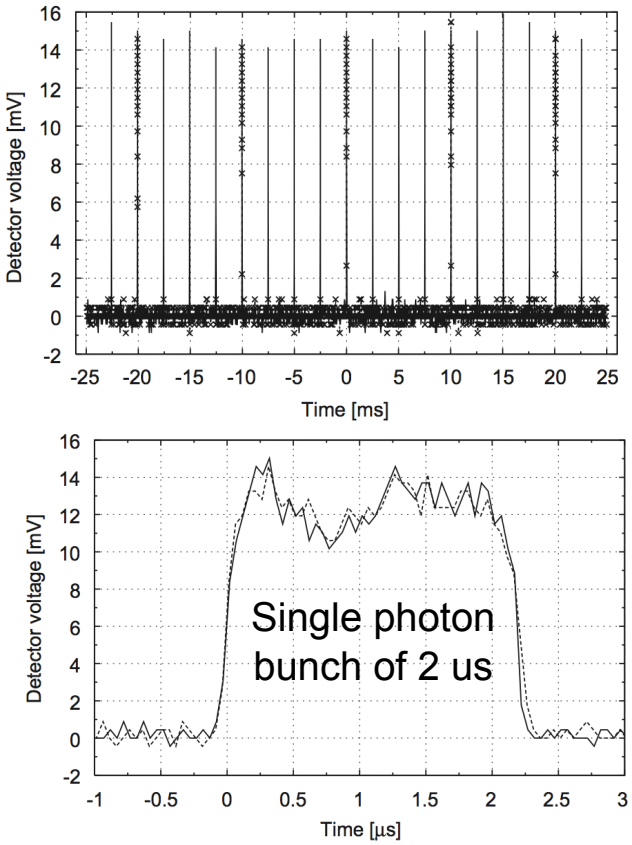


Diamond Detector

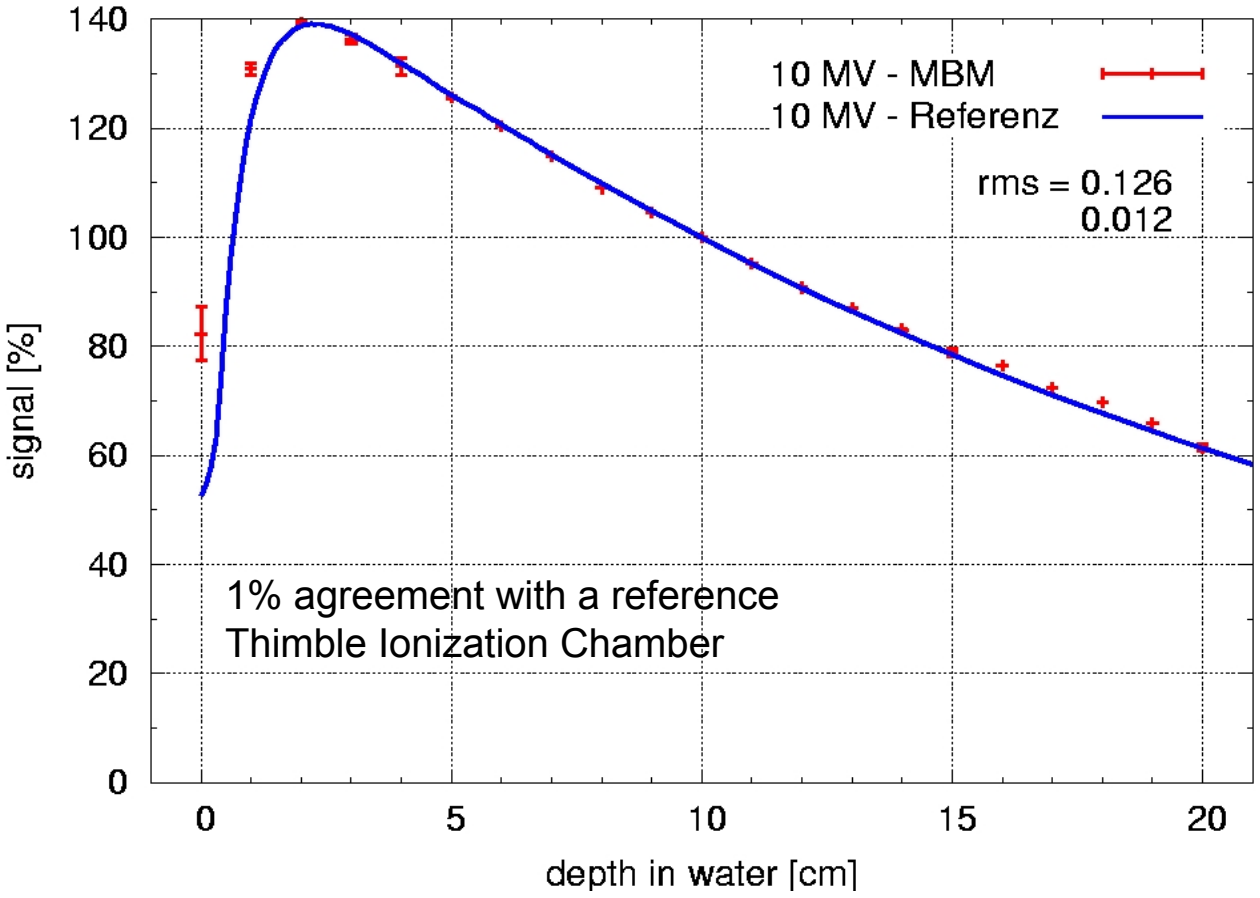
Water phantom

Photon Therapy

2.5 ms bunch rate



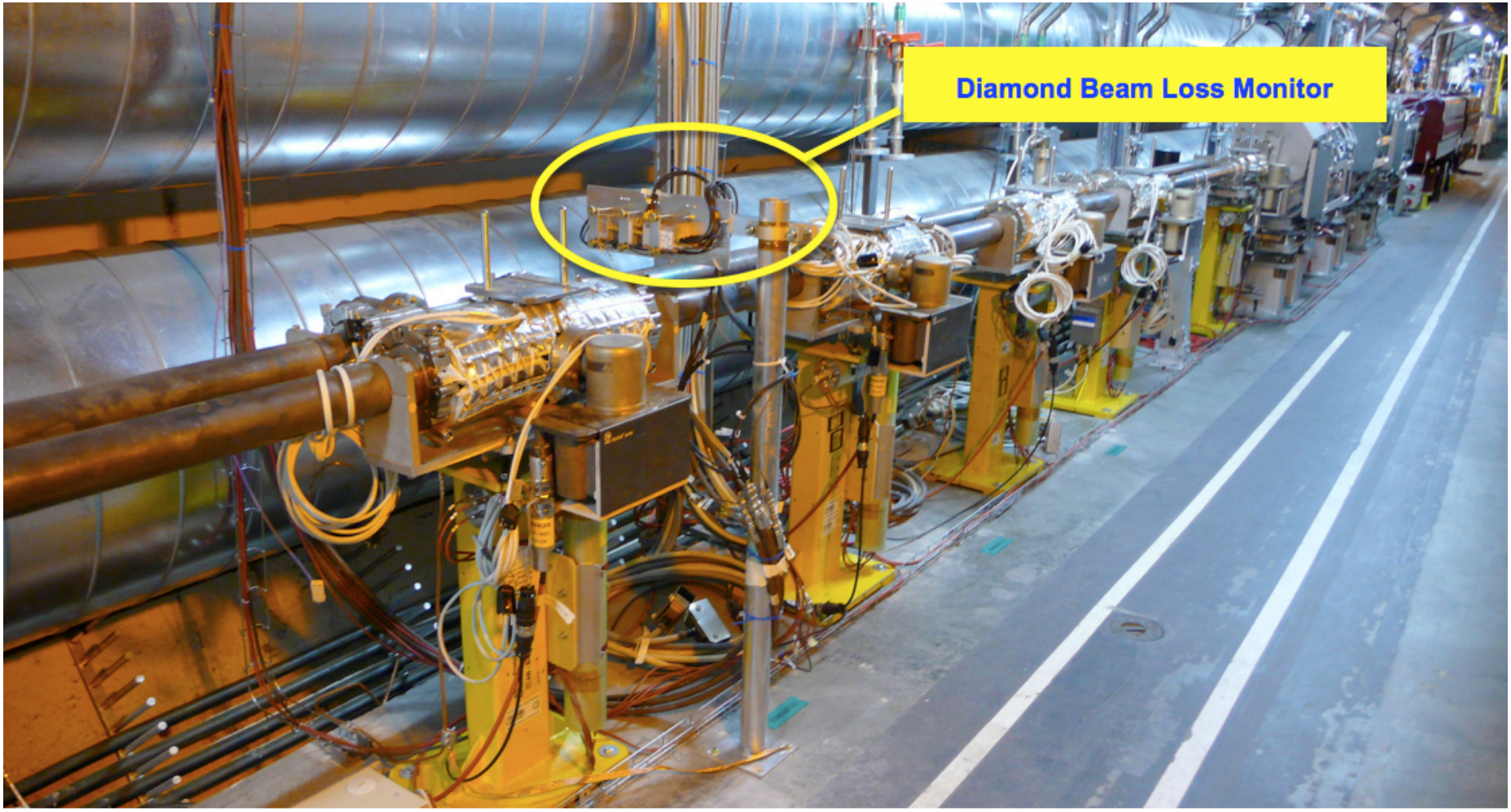
Depth-dose profile measurement



Application Example 4:

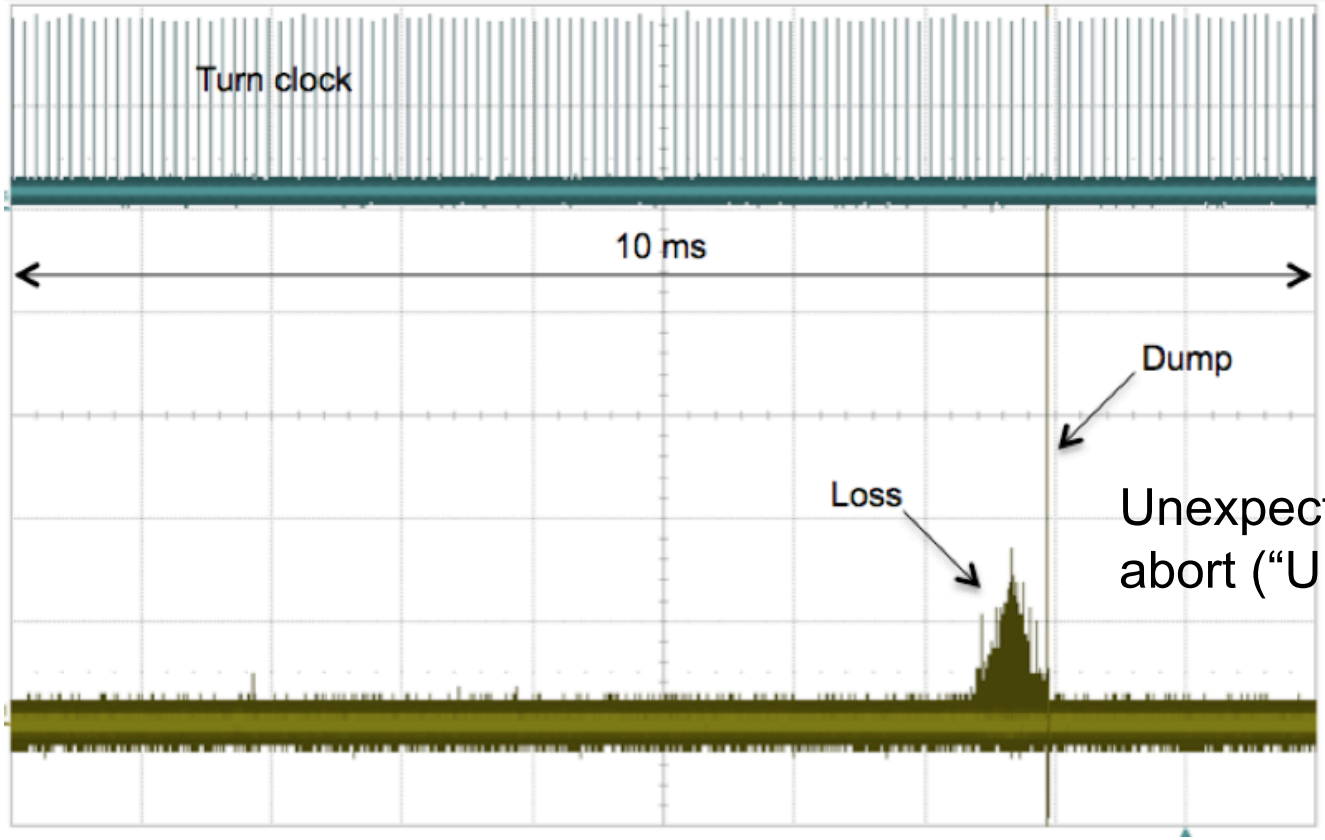
LHC – Beam Loss Monitoring

LHC - Beam Loss Monitors

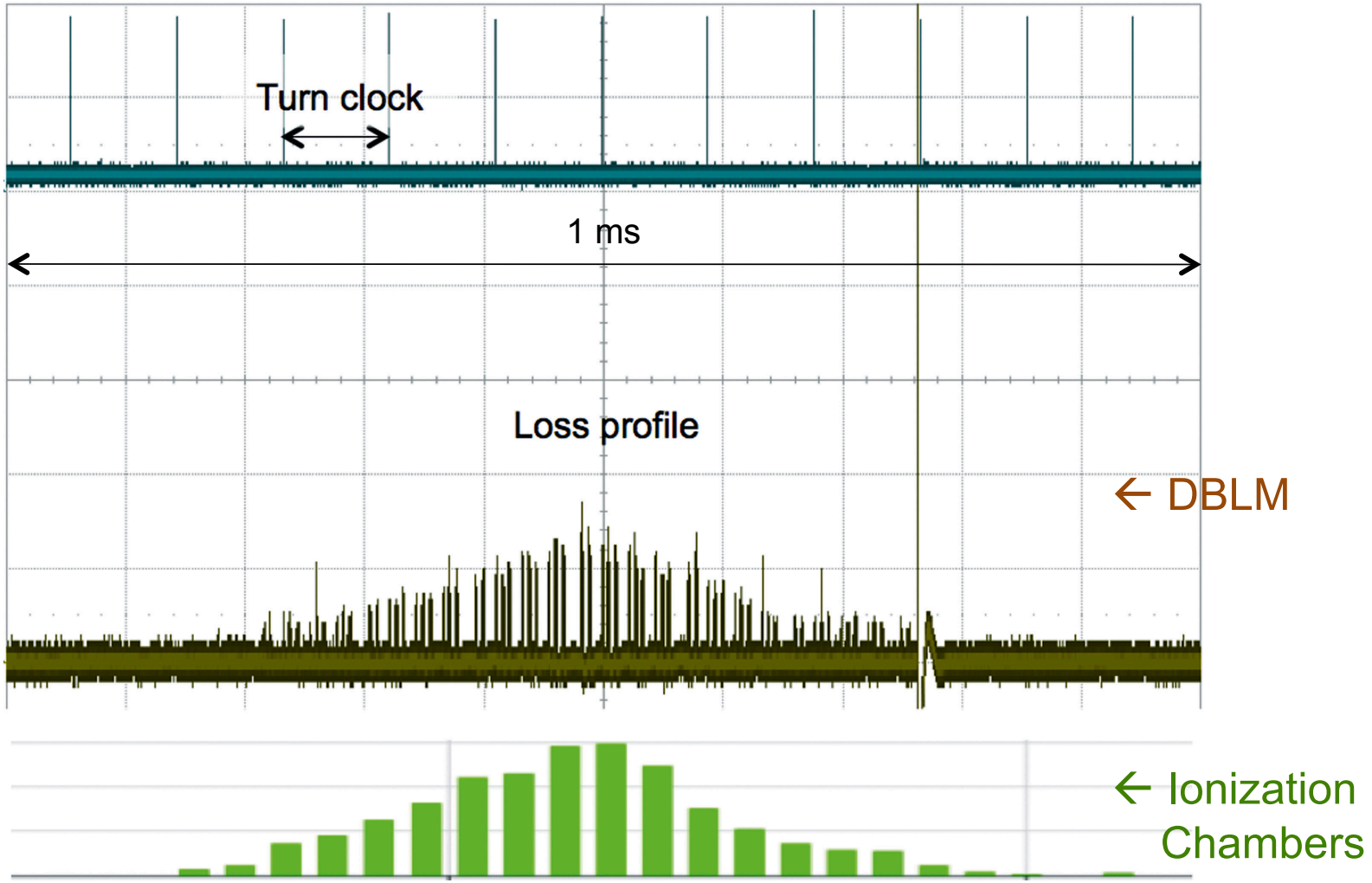


LHC – Collimation Area – IP7

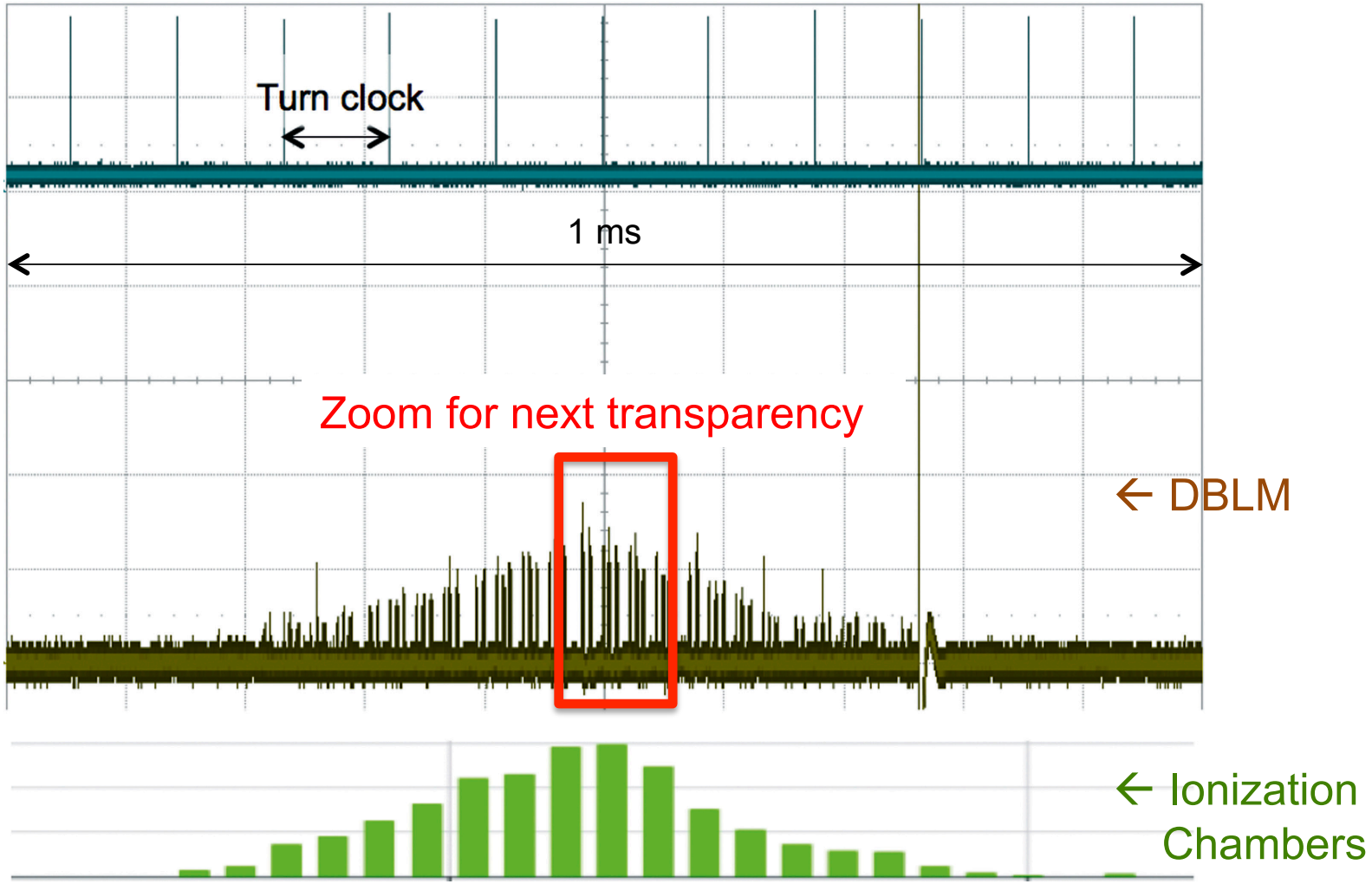
LHC - DBLM



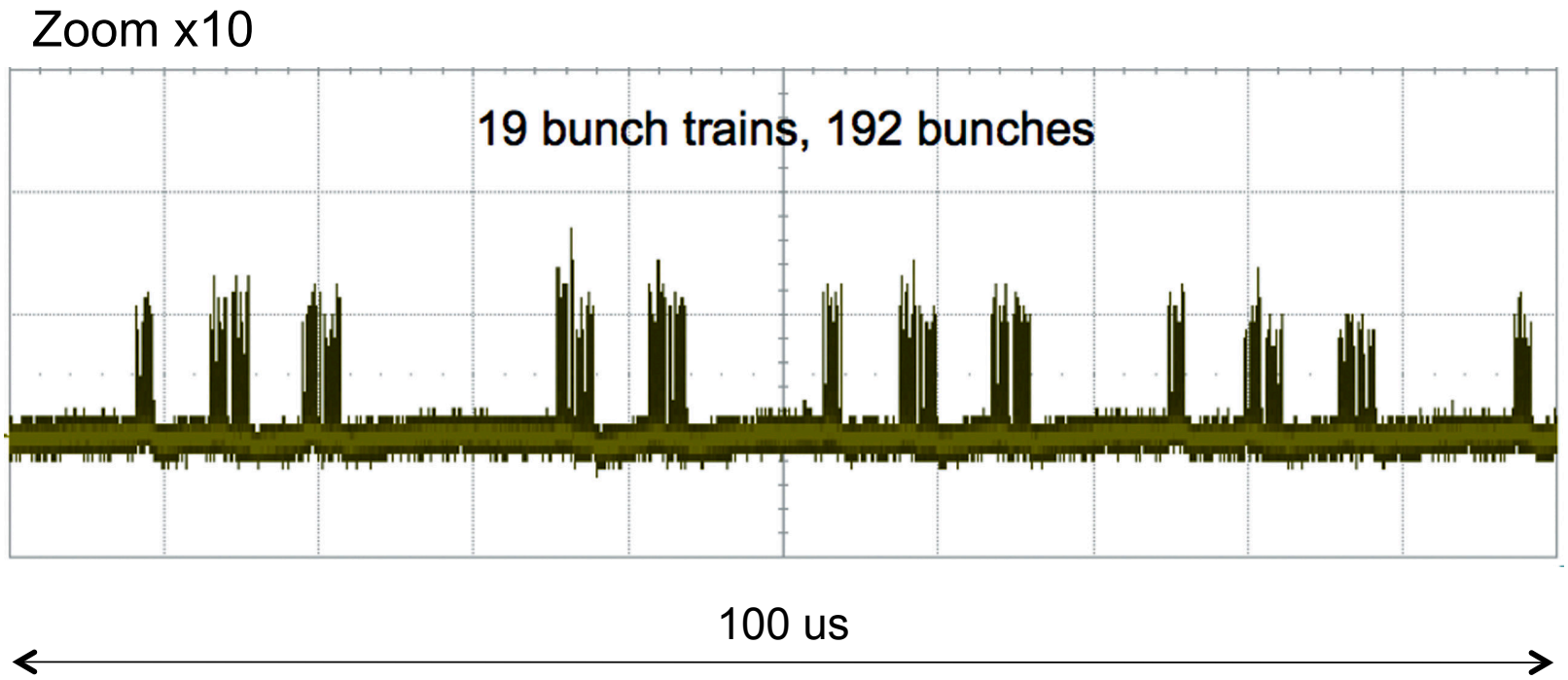
LHC - DBLM



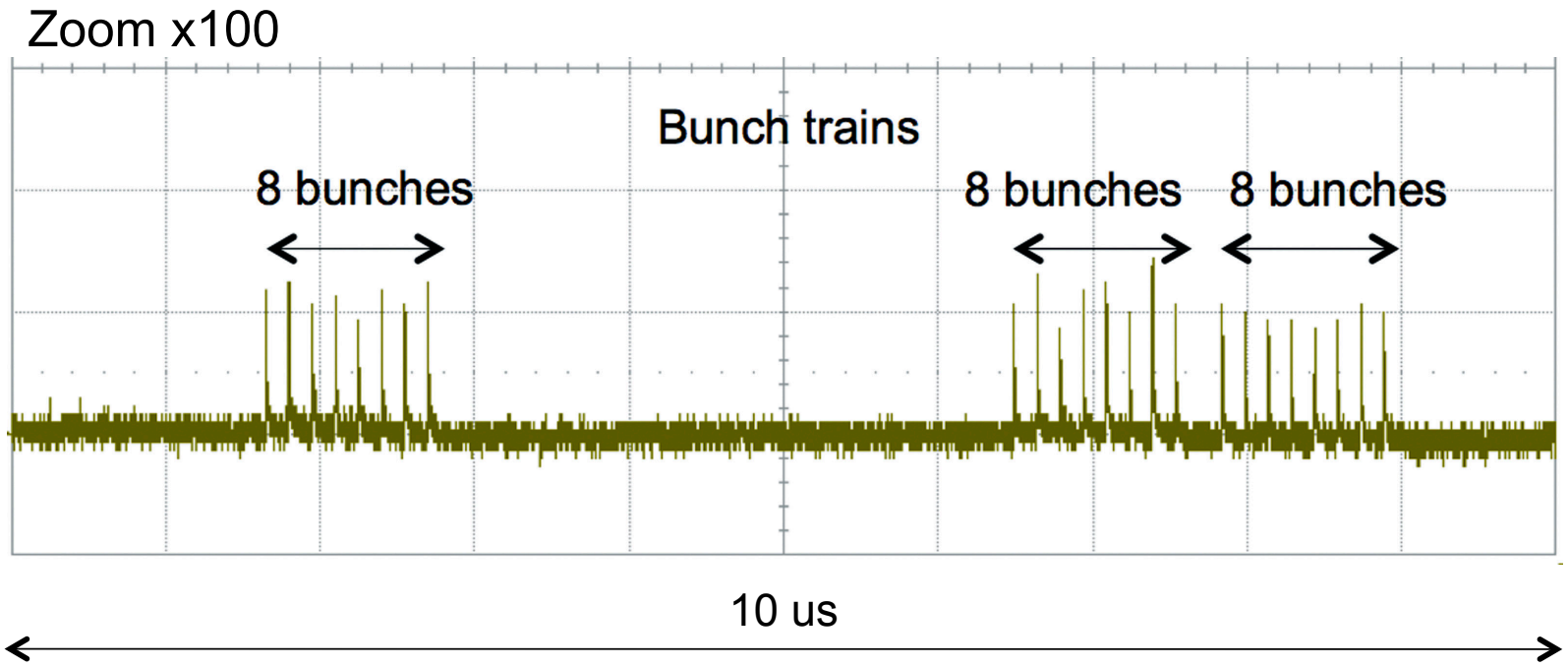
LHC - DBLM


Turn clock
1 ms
Zoom for next transparency
← DBLM
← Ionization Chambers

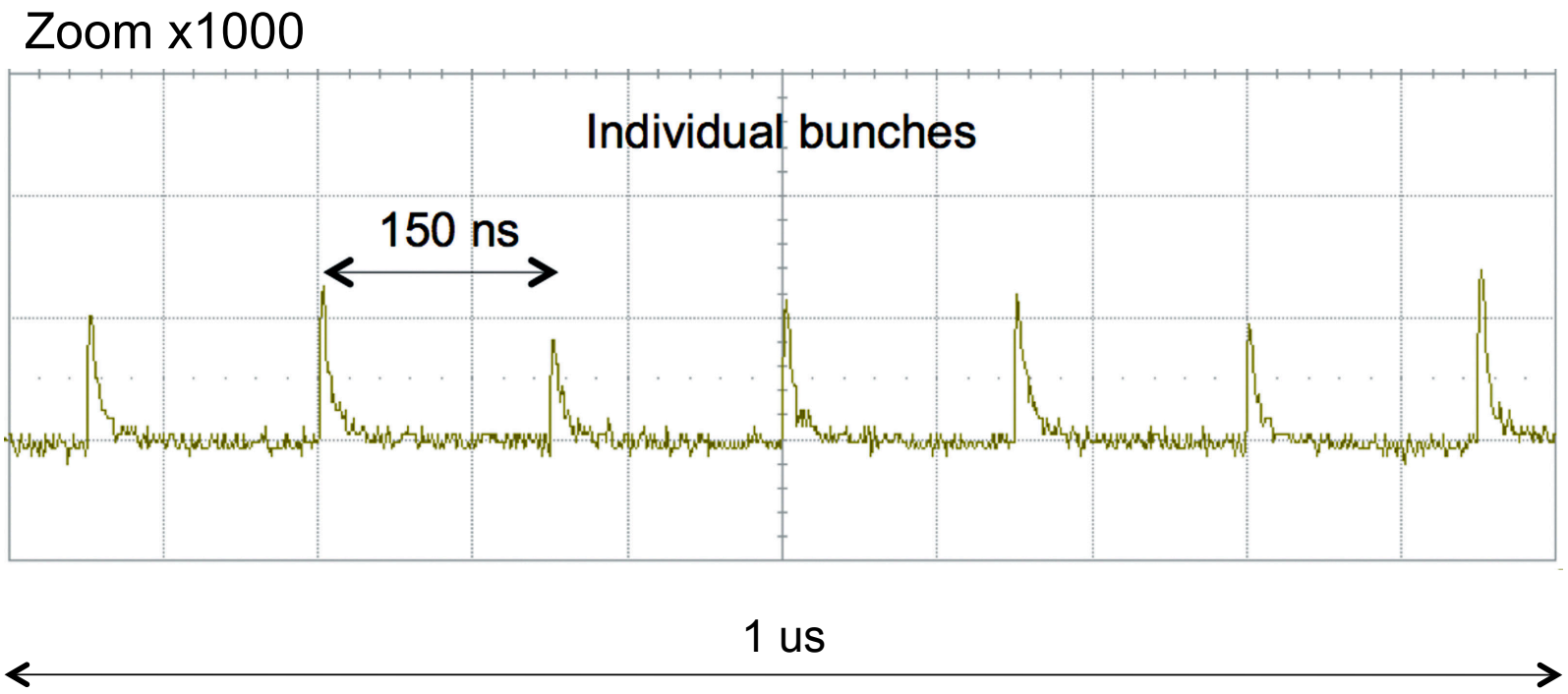
LHC - DBLM



LHC - DBLM

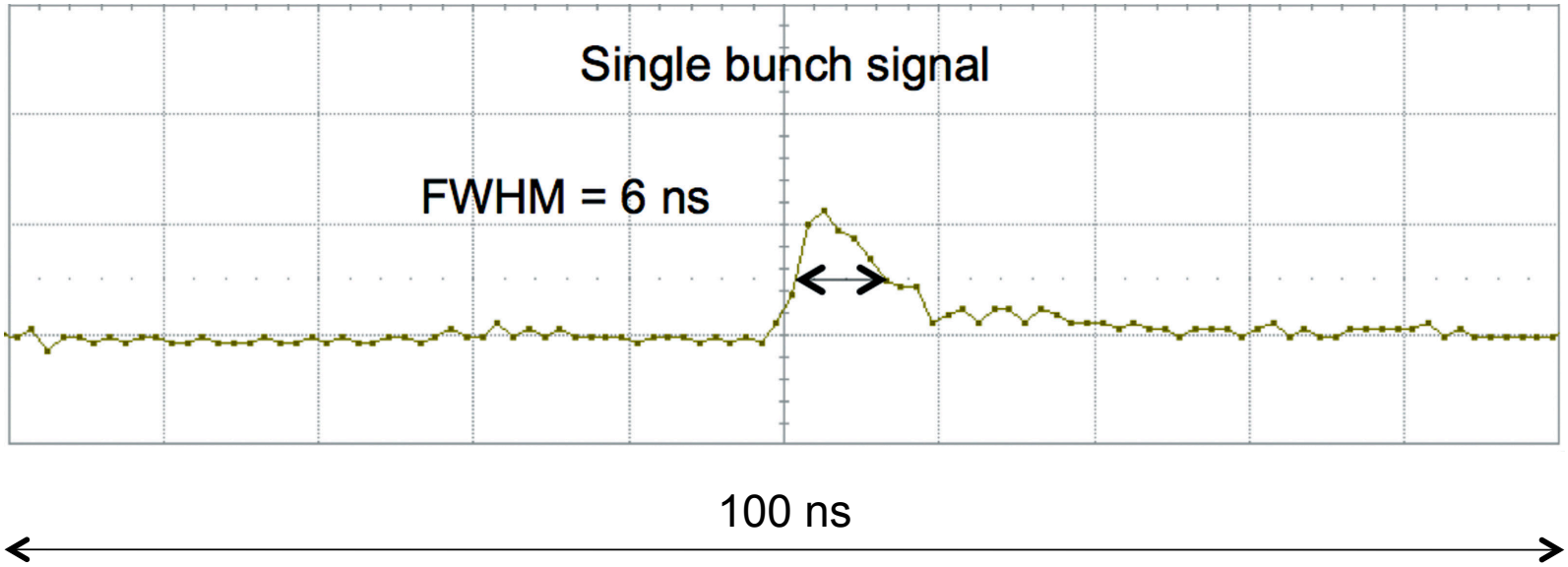


LHC - DBLM



LHC - DBLM

Zoom x10’000



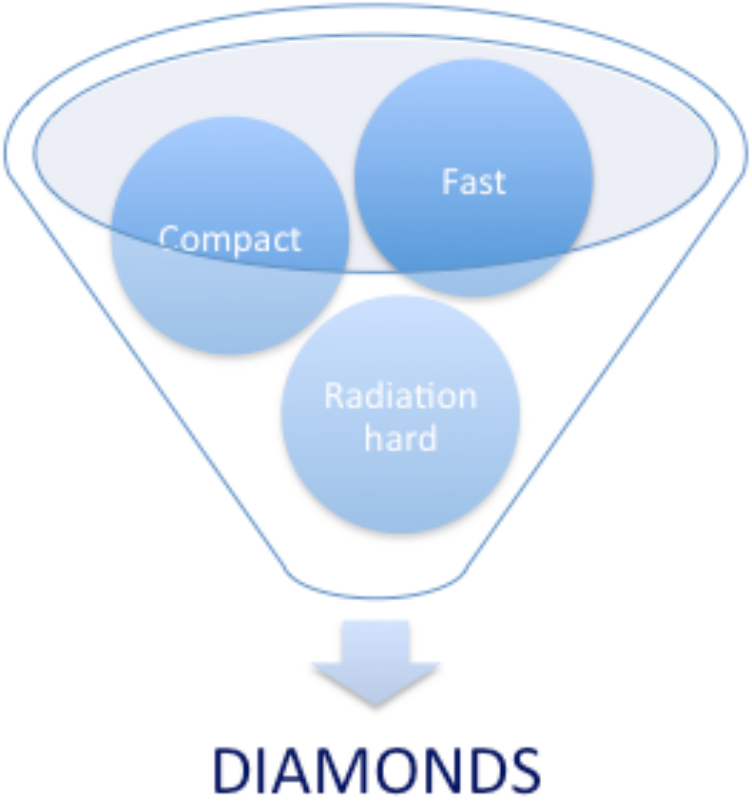
Application Example 5:

NEUTRINO SPEED-OF-LIGHT

Summary

- Radiation resistant → 10 MGy
- Fast → 10 ps / 1 ns
- Sensitive → MIP detection
- High dynamic range → 120 dB
- Protons + electrons & neutrons + photons

Conclusion



Thank you for your attention !