THE LUPIN DETECTOR:

SUPPORTING LEAST INTRUSIVE BEAM MONITORING TECHNIQUE THROUGH NEUTRON DETECTION

Giacomo Paolo Manessi

Oxford, 18th September 2013, 15:00

2013 **I**nternational **B**eam **I**nstrumentation **C**onference

Beam Loss Detection session

AGENDA

- Aim of this presentation
- The **LUPIN** detector
- Application of LUPIN as a **Beam Loss Monitor**
- Measurements performed at **CNAO**
- Application of LUPIN as a **complementary detector**
- Summary

AIM OF THIS PRESENTATION

WIDE DYNAMIC RANGE

NO DEAD TIME LOSSES

INNOVATIVE WORKING PRINCIPLE

IDEAL TO WORK IN **PULSED NEUTRON FIELDS**

RADIATION PROTECTION

BEAM INSTRUMENTATION

???

LUPIN
Long interval, **U**ltra-wide dynamic, **PI**le-up free, **N**eutron rem counter

THE LUPIN DETECTOR

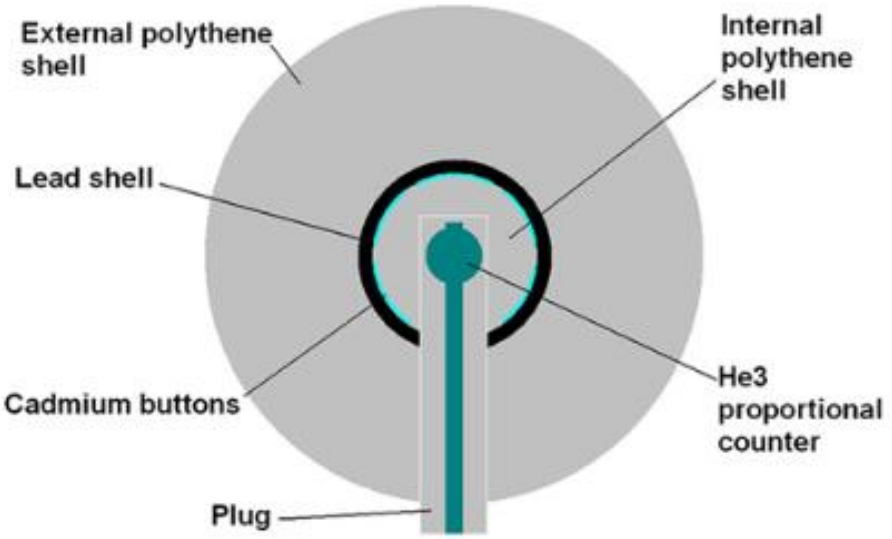
Proportional counter
^{3}He or BF_3

+

Moderator
(response function reproduces the curve of the **neutron fluence to H*(10)** conversion coefficients)

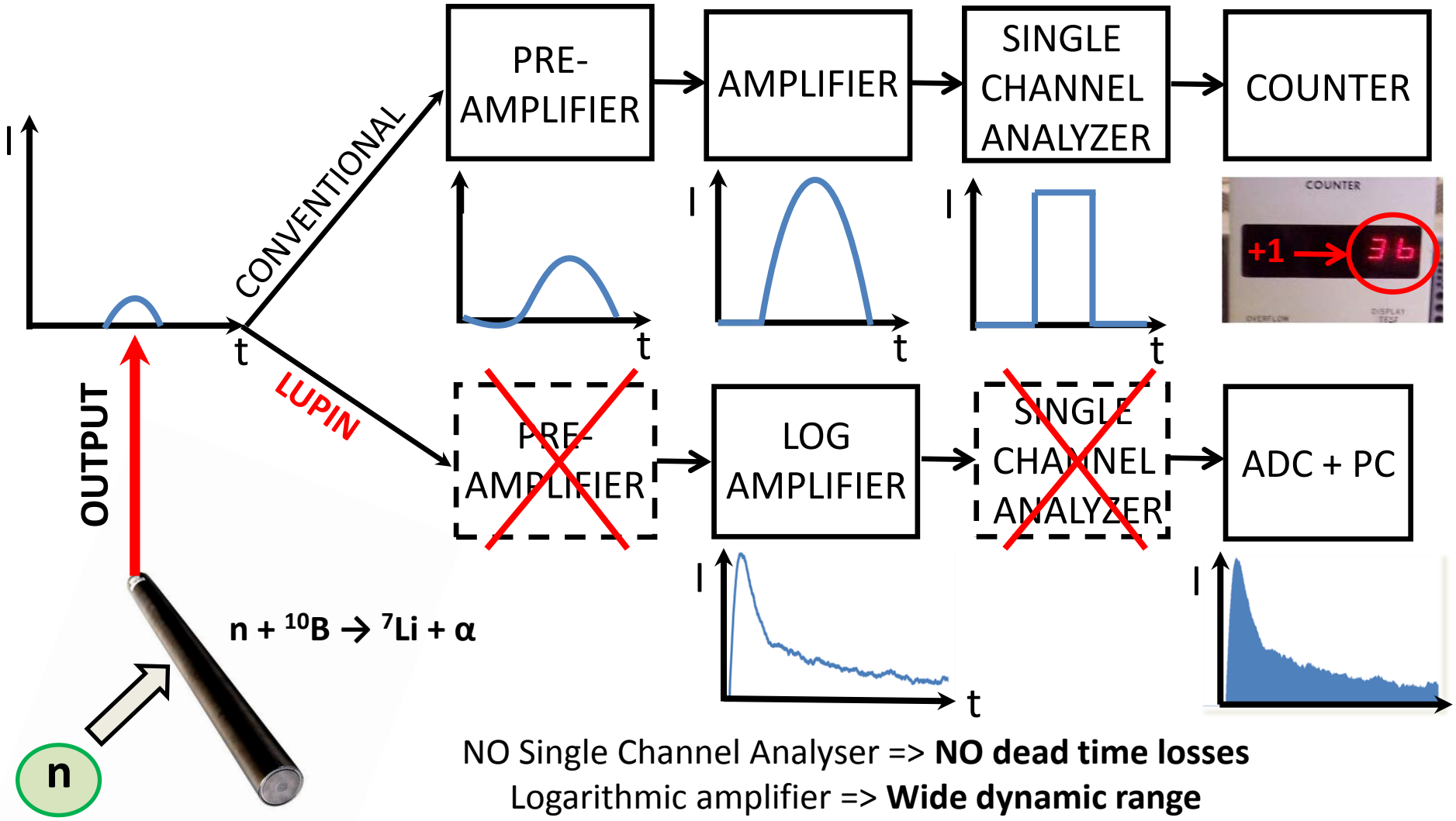
+

Innovative front end electronics



M. Caresana et al., NIM A 712 (2013) 15-26

WORKING PRINCIPLE



NO Single Channel Analyser => **NO dead time losses**

Logarithmic amplifier => **Wide dynamic range**

BLM: LUPIN VS ICs

BLM MUST-HAVE	IONISATION CHAMBER	LUPIN
TIME RESOLUTION	✓	✓ Dominated by therm/diffusion time
SPATIAL RESOLUTION	✗ Respond only to nearby losses	✓ Close & remote losses, **higher signal**
HIGH DYNAMIC RANGE	✗ Dark current & recomb effects	✓ Single interaction & high reaction rates
SENSITIVITY ONLY TO LOSS-INDUCED RADIATION	✓	✓ **γ/n discrimination**

Common features: Radiation hardness, no need of maintenance

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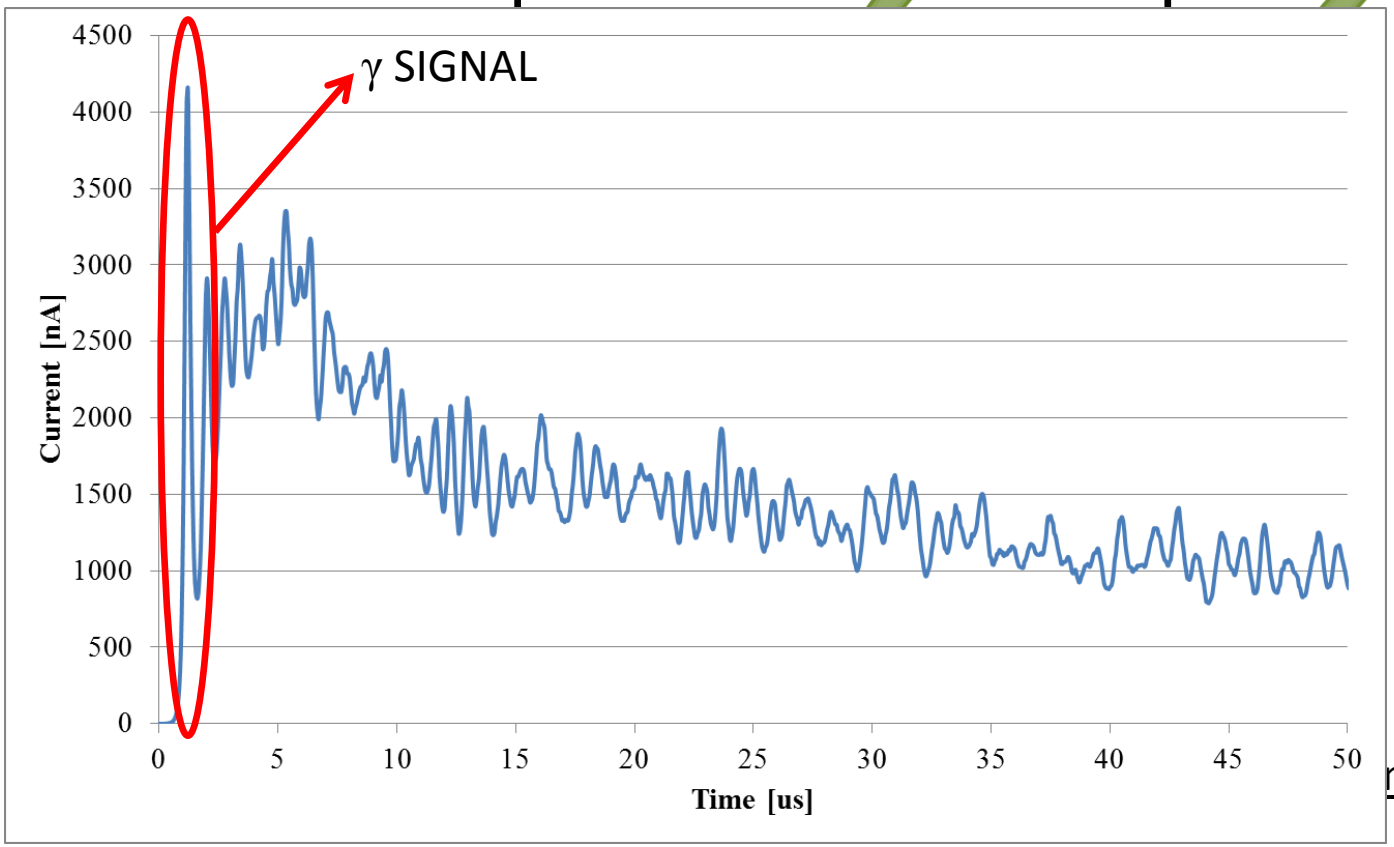
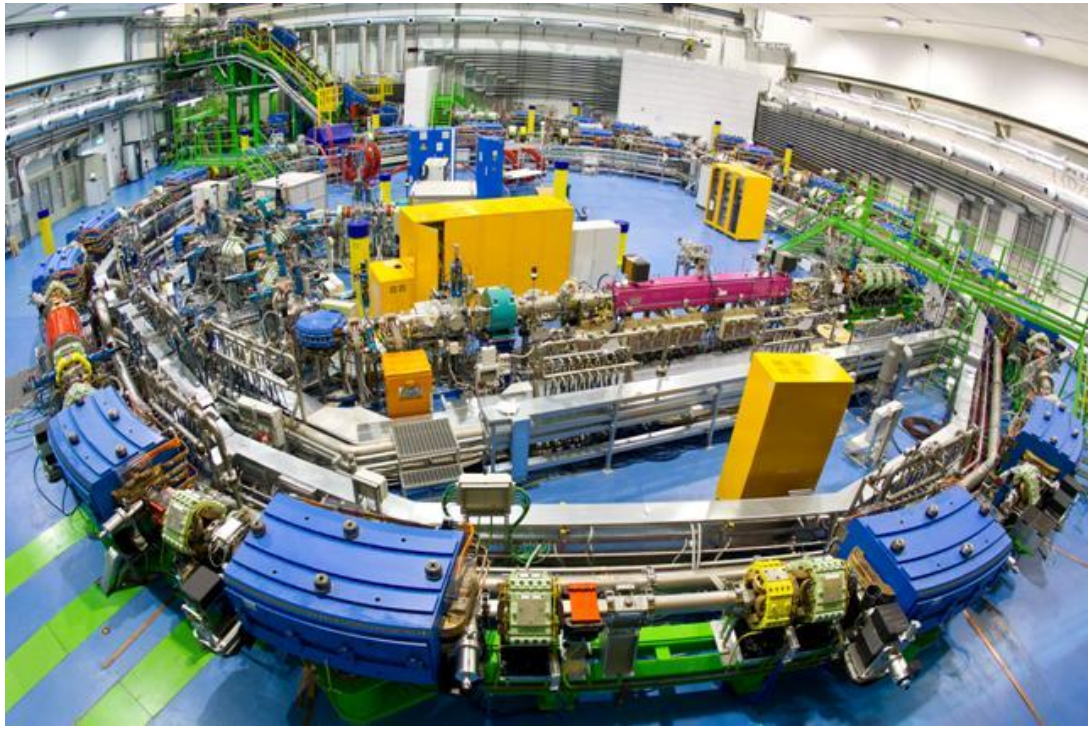


MEASUREMENTS @ CNAO (1)

LUPIN employed at **CNAO (National Centre for Oncological Hadrontheraphy)**, Pavia.
250 MeV protons, 400 MeV/u carbon ions. Beam injected at 7 MeV/u.

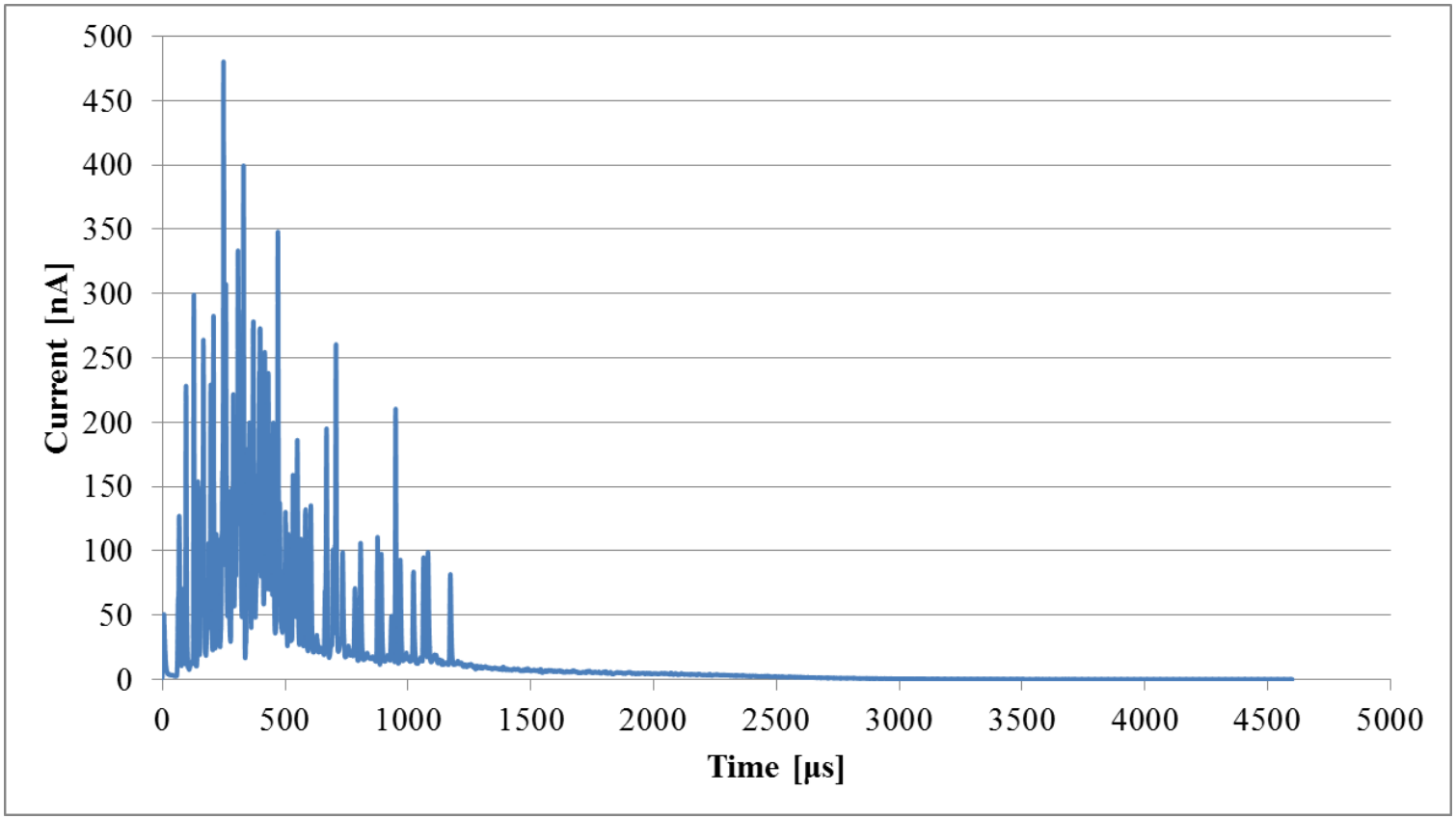


Two typical loss situations:

- **instantaneous & complete beam loss** => short & intense neutron flux (up to 10^5 n/cm^2 @ 1 m)
- continuous **loss of a fraction of the beam (1%)** during the beam spill all around the accelerator => spread & low intensity flux

MEASUREMENTS @ CNAO (2)

LUPIN at 1 m from a **Faraday cup** hit by **7 MeV protons** (accelerated by LINAC)



Reaction rate in the neutron burst ≃ **$4 \cdot 10^5$ s^{-1}**

Conventional neutron detector: dead time ≃ 5 µs => 65% underestimation

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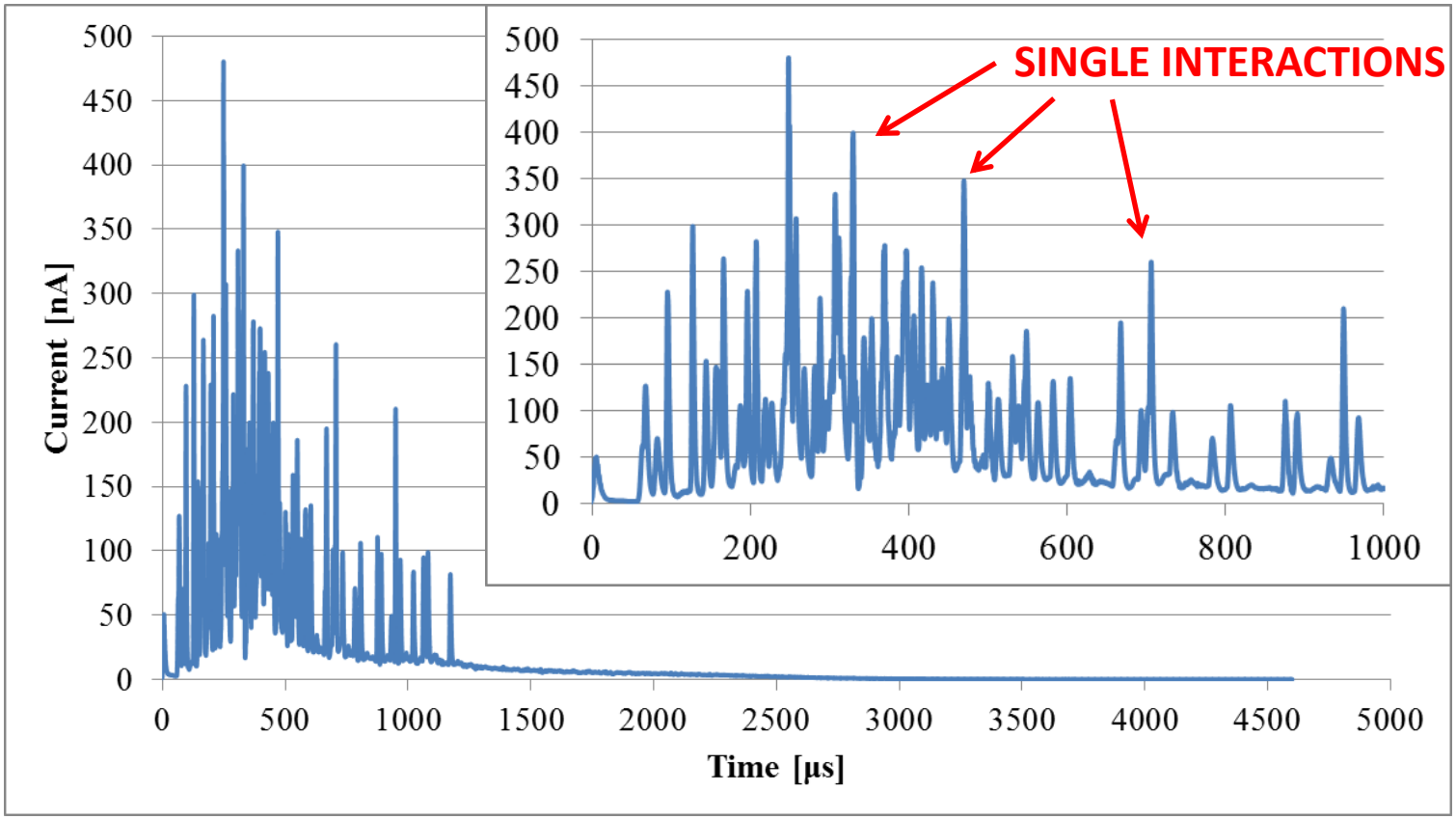

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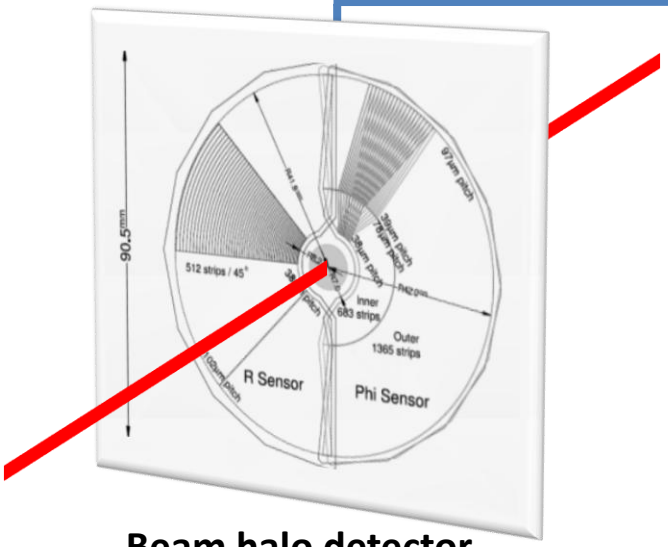
COMPLEMENTARY MONITOR

Challenge in hadrontherapy accelerators: non-intrusive **on-line** beam monitoring
(negligible effect on the beam, few % resolution)
Present monitors: interfere with the beam (beam disruption, low sensitivity)

'HALO' REGION RATE → BEAM CURRENT



Beam halo detector
(LHCb VErtex Locator)
T. Cybulski et al., **Poster MOPF29**

DOSE RATE
INFO ON THE LOSSES

LUPIN

BEAM PARAMETERS
(POSITION, INTENSITY, DOSE PROFILE)

- Online monitoring during treatment
- RP monitoring
- Machine protection
- Beam diagnostics

SUMMARY

- **LUPIN** is an innovative detector conceived for **pulsed neutron fields**, initially only for RP applications
- Unique properties: detection of **intense and short** neutron bursts with no saturation effects
- Suitable for other applications: **BLM** (advantages if compared to ICs), complementary detector for **non-intrusive beam monitoring**
- Other applications?

THANK YOU FOR YOUR ATTENTION

The LUPIN detector: supporting least intrusive beam monitoring technique through neutron detection

M. Caresana, M. Ferrarini, G.P. Manessi, M. Silari, C.P. Welsch

Oxford, 18th September 2013

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