gt

DURRIDGE

Radon Capture & Analytics

ELSE

NUCLEAR

HED

CAEN

Tools for Discovery

ANTECH

SCIONIX

SOLUTIONS FOR RADIATION MONITORING IN PULSED FIELDS

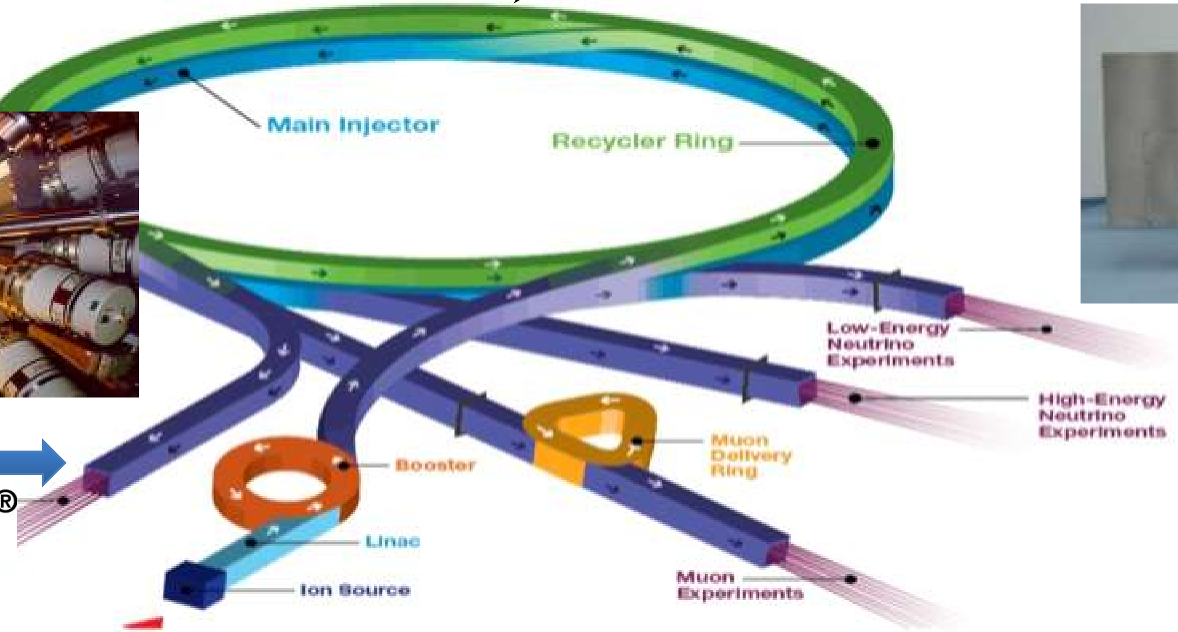
Bredikhin Ivan
Gammatech LLC

International Seminar on Interaction of Neutrons with Nuclei

better late than never...

ORTEC®

- Gamma Sphere and GASP detectors
- Clover detectors
- Double sided Ge Strip detectors
- Special point contact technology (Dark Matter)
- PopTop/Encapsulated
- Discrete element and Segmented Array detectors

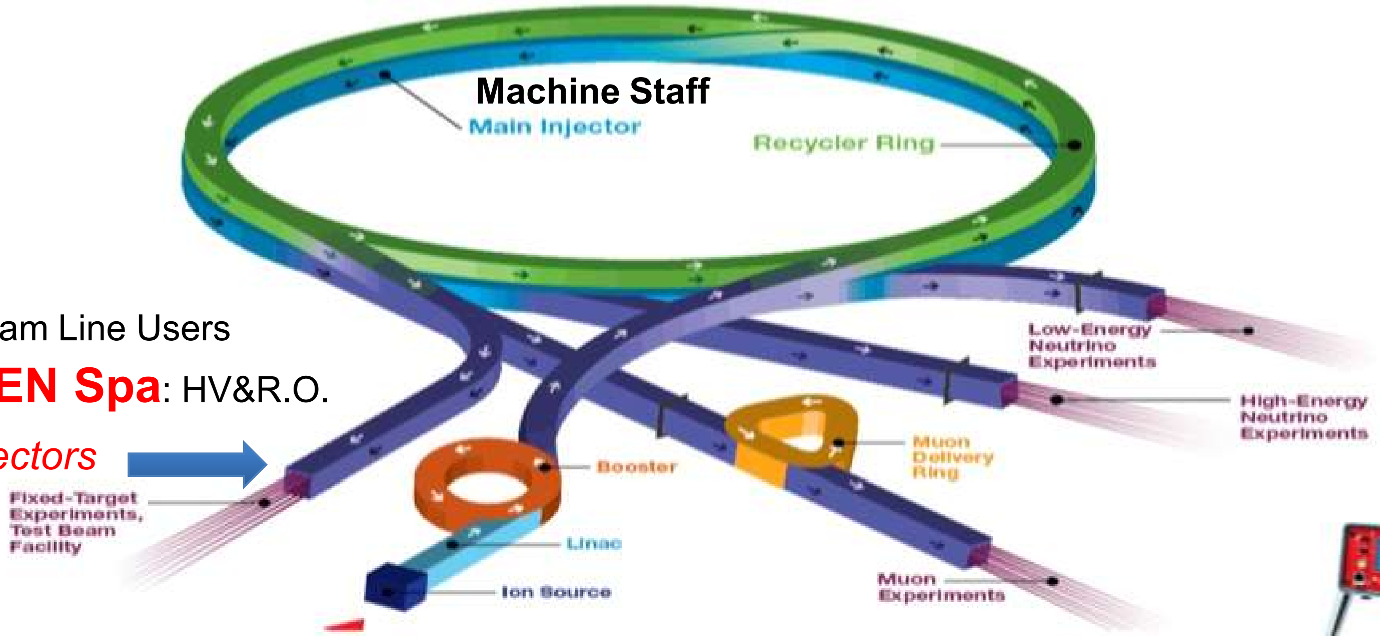


Detectors → ORTEC®

CAEN SpA (Costruzioni Apparecchiature Elettroniche Nucleari) was founded in 1979 as an important industrial spin-off of the INFN.

Core business&Primary Market: Electronic Instrumentation for particle accelerator physics experiments (world leader)

Machine Staff



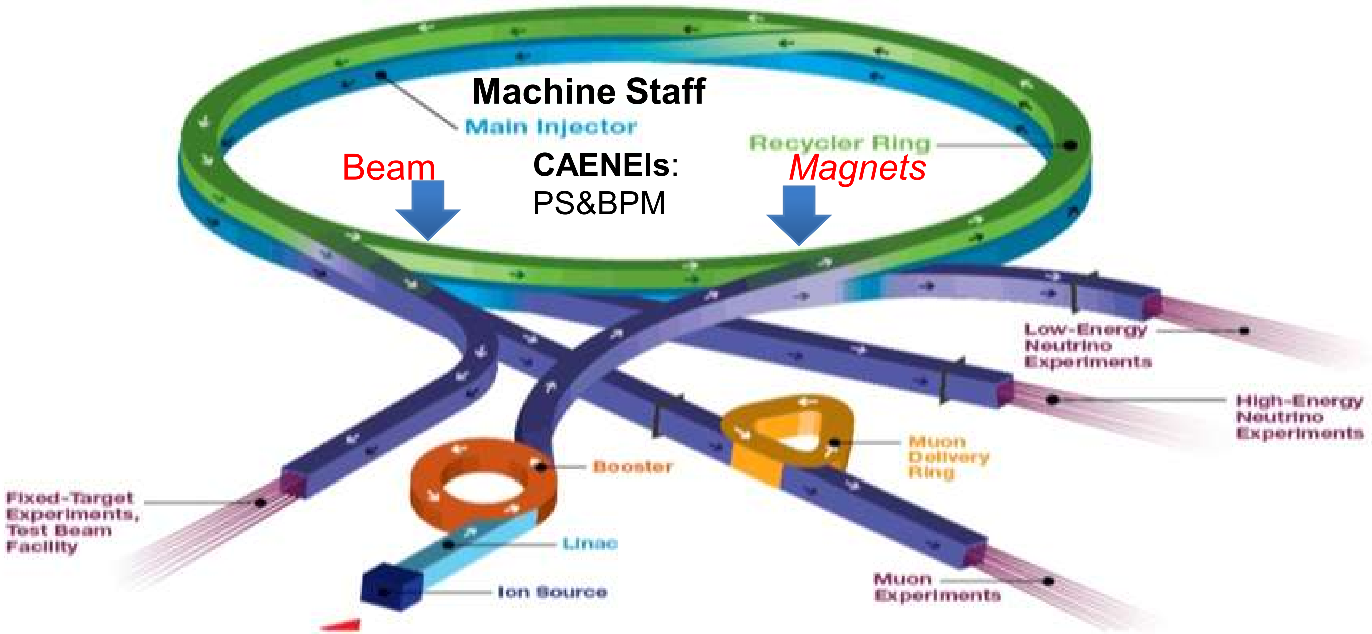
Beam Line Users

CAEN Spa: HV&R.O.

Detectors

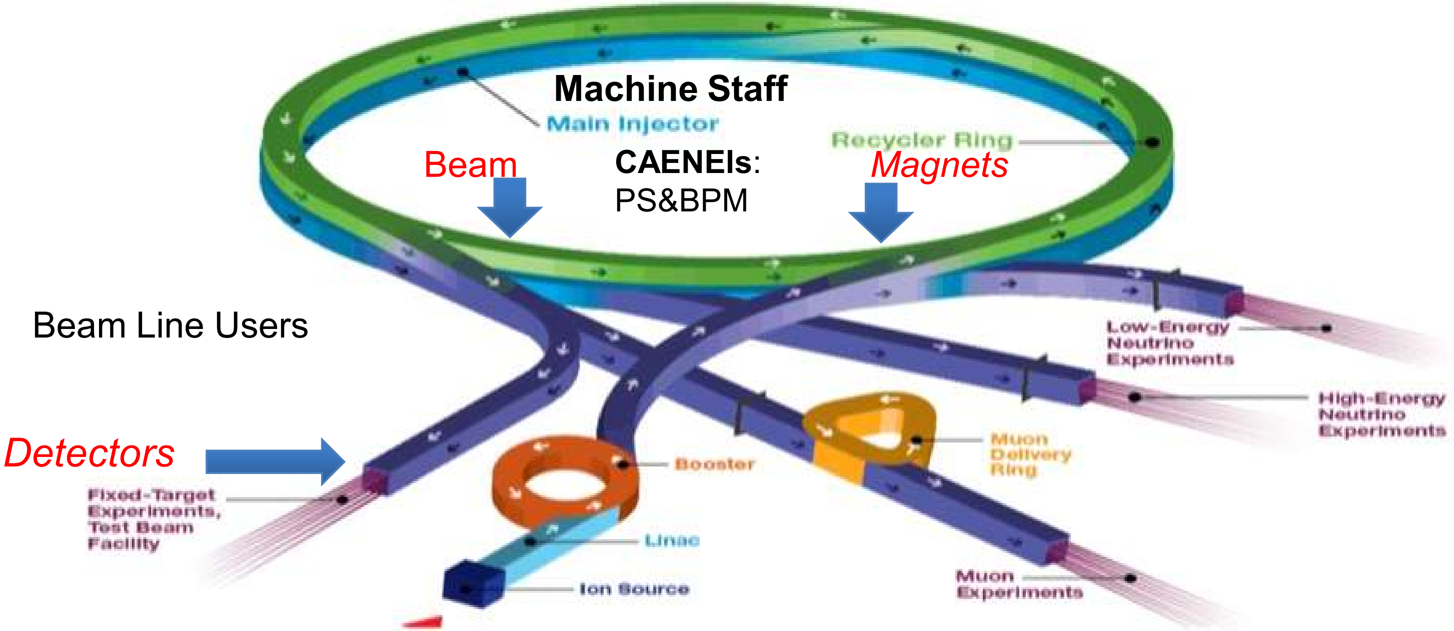
CAEN for the Synchrotrons Labs

Core business&Primary Market: Bipolar Power Supplies and Beam Profile Monitors for synchrotron accelerators



Radiation Monitors

- Environmental fixed monitors (gamma and neutrons)
- Mobile monitoring stations, including
  - ✓ Ultra-sensitive pressurised ionisation chamber
  - ✓ Innovative neutron rem counter
- Air monitoring system

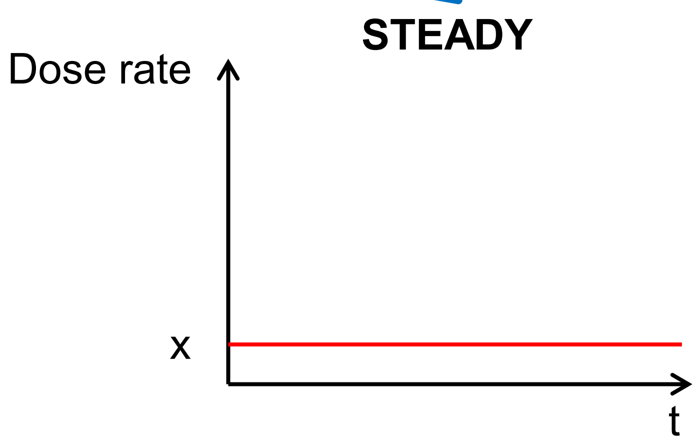


Detection of γ & η:

Could it be a problem at all?

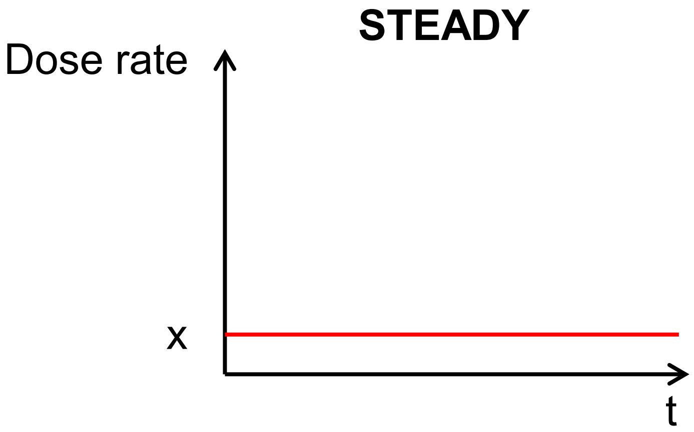
DETECTION

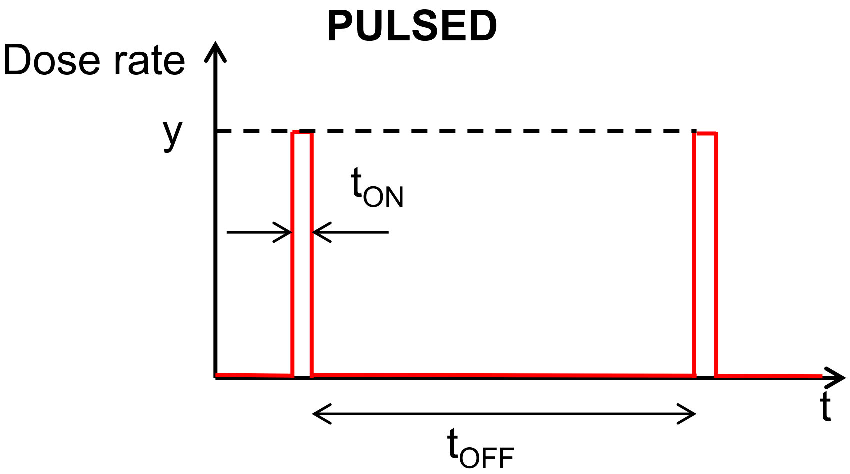
Radiation field



DETECTION
IN PULSED FIELDS

Radiation field



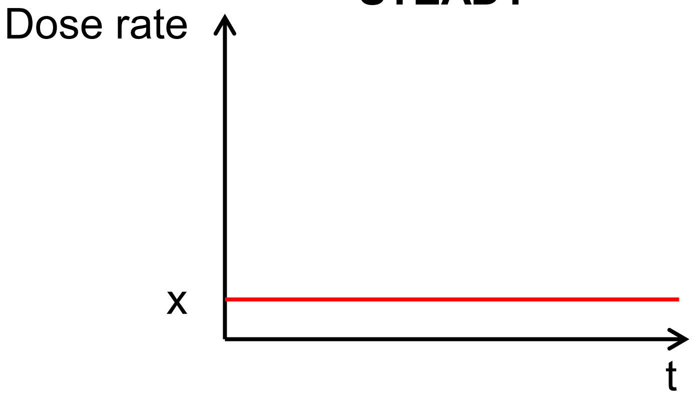


Same **averaged** dose rate but
different **instantaneous** dose rates

DETECTION
IN PULSED FIELDS

Radiation field

STEADY



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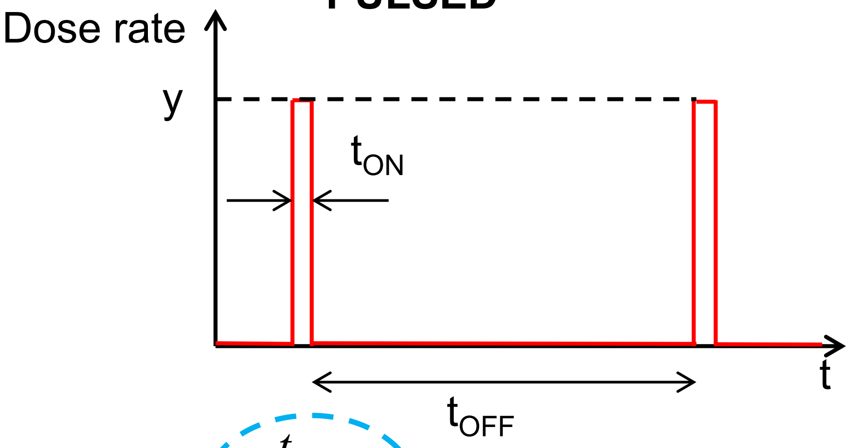
PULSED



$$x = y \cdot \frac{t_{ON}}{t_{ON} + t_{OFF}}$$

DUTY FACTOR

Small DUTY FACTORS (=> high instantaneous dose rates)
impose severe limitations on the survey meters to be employed

DEAD TIME

Fundamental property for a detector working in pulsed fields

Two response models

Typical values

GM: τ = 100 μs

Rem counter: τ = 1-10 μs

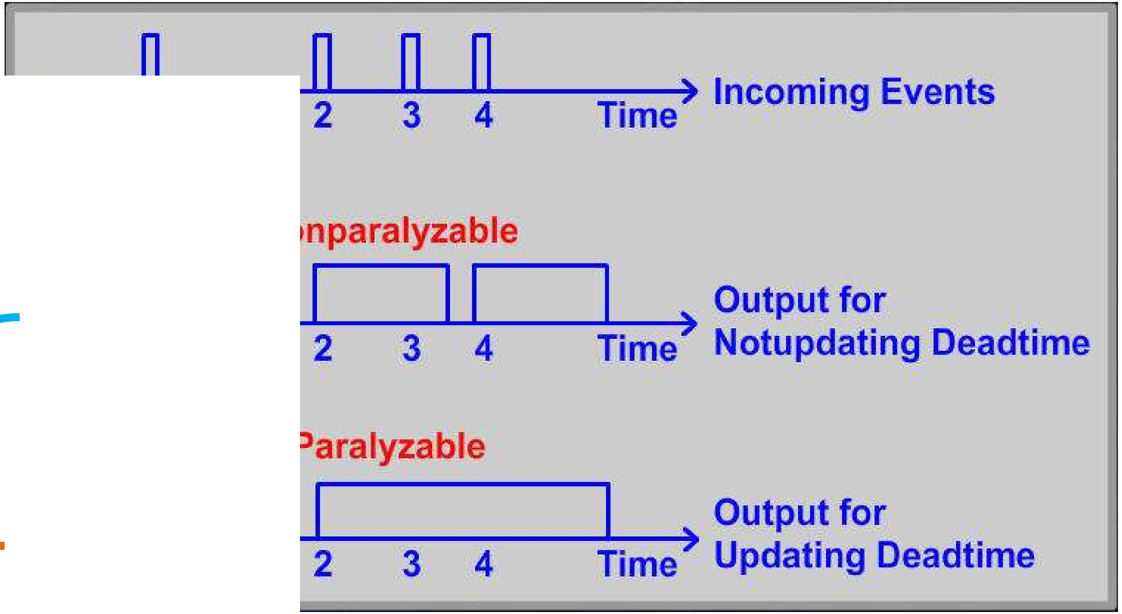
DEAD TIME

CORRECTION EQUATIONS

(n,m = true, measured interaction rate; τ = dead time):

$$n = \frac{m}{1 - m\tau}$$

$$n = m \cdot e^{-m\tau}$$



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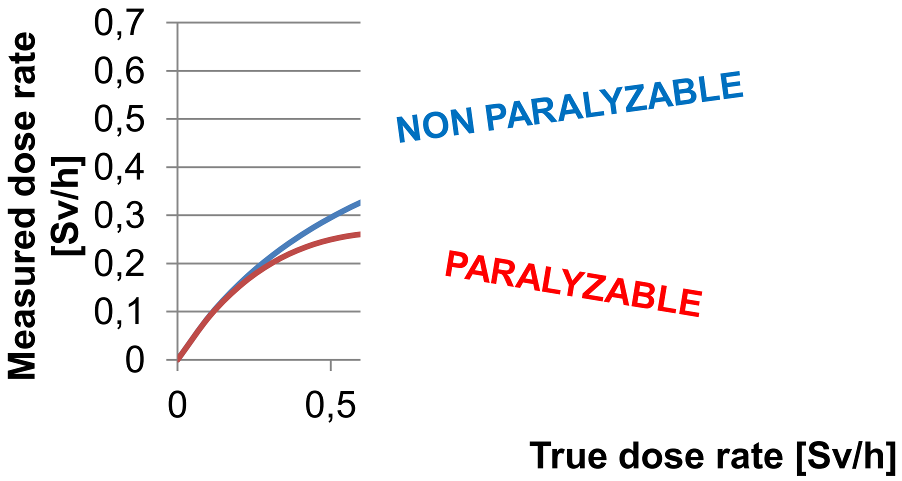
EXAMPLE



Rem counter with dead time = 5 µs, sensitivity = 1 nSv/count

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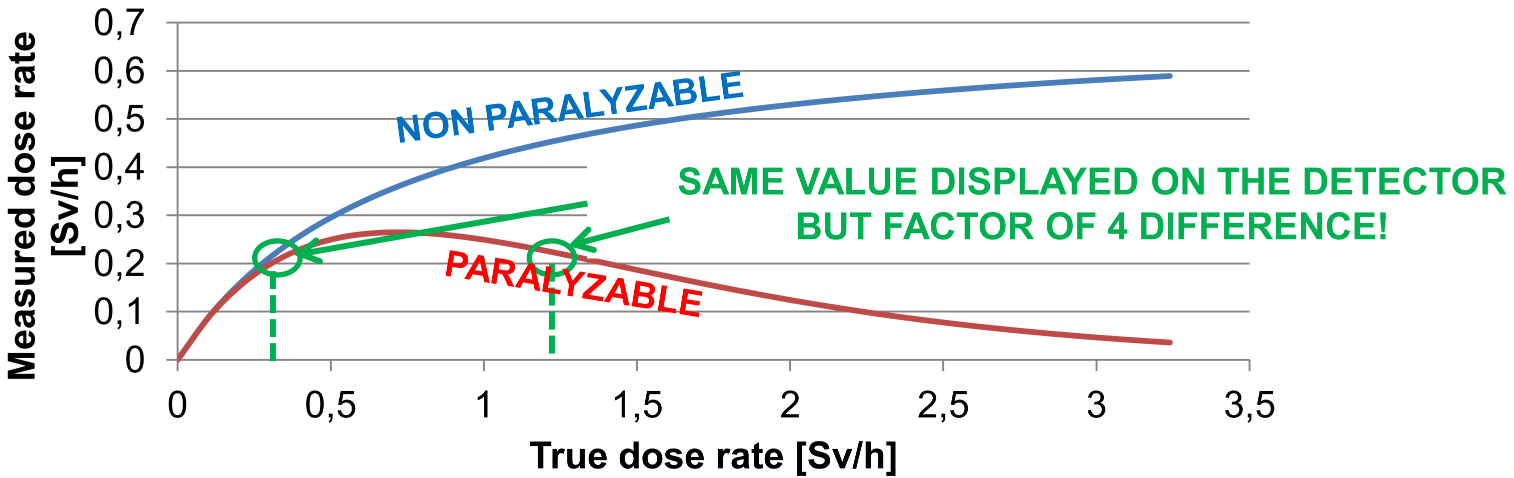


Rem counter with dead time = 5 μs, sensitivity = 1 nSv/count

Correction equations work, but…

- Valid only for relatively <u>low dead time losses</u>
- Valid under the assumption that the interactions are <u>uniformly distributed</u> **(=> This is not the case, by definition, for pulsed fields)**

BEAM LOSS CONSEQUENCES

Damage caused by a complete beam loss to an accelerator magnet (synchrotron)

CASE STUDY

PAUL SCHERRER INSTITUT

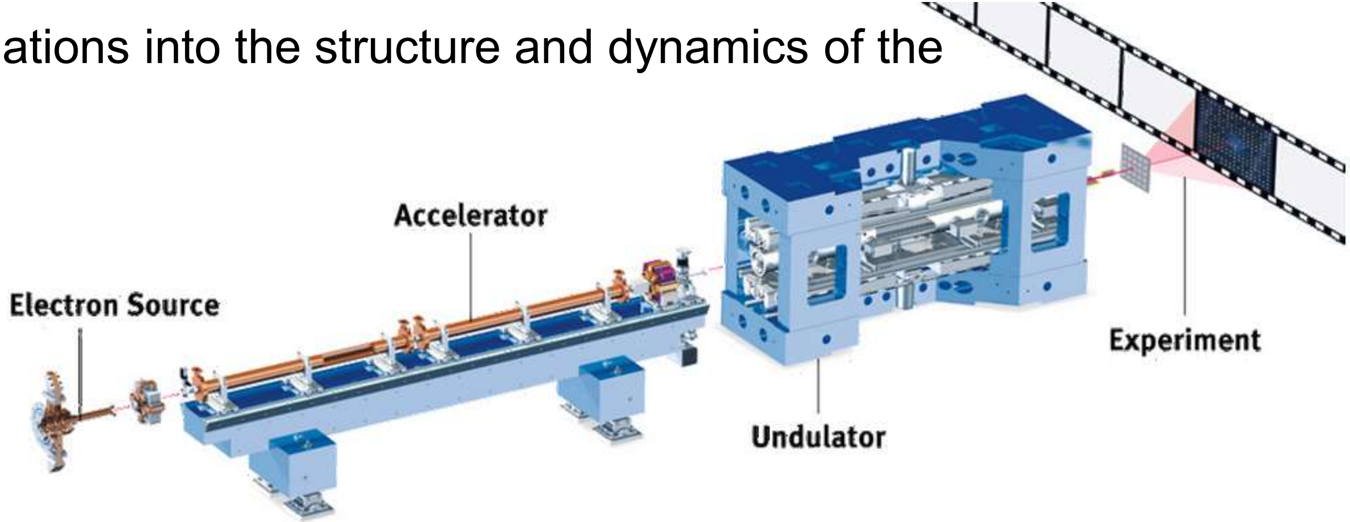
PSI

Paul Scherrer Institute, Villigen, Switzerland

CASE STUDY

PAUL SCHERRER INSTITUT PSI

- SwissFEL (**Free Electron Laser**) accelerator
- Deliver short (**1-60 fs**) and intense flashes of X-ray radiation of laser quality
- Enable new investigations into the structure and dynamics of the illuminated matter



THE PROBLEM

Fitness area, where radiation monitoring r
but…

Installation of active radiation detectors is

(only passive systems)

GROUND LEVEL
0 m

IDEAL DETECTOR SHOULD

1. Capability to withstand very high fluxes with little saturation
2. High sensitivity
3. Capability to measure correctly the intensity of a single burst
4. Capability to reject the photon contribution

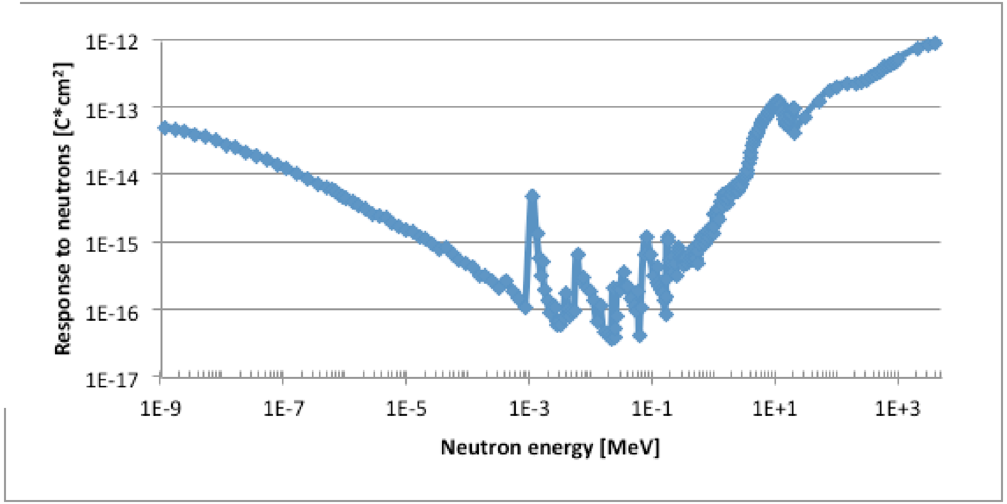
OPTIONS (STATE-OF-THE-ART DETECTORS)

- ACTIVATION DETECTORS (Ag or ^{12}C)
- DIAMOND DETECTORS (^{12}C)
- INSTRUMENTS WORKING IN CURRENT MODE (Ionisation chambers, **innovative rem counter (LUPIN)**)
- CORRECTION TECHNIQUES

GAMMA MONITORING

- Ion chamber
- 16 atm pressure (6 atm Ar + 10 atm N_2):
  higher pressure, higher sensitivity, but…
- Ulltra-sensitive electrometer (fA) range from 1 fA to 10 μA

NAUSICAA



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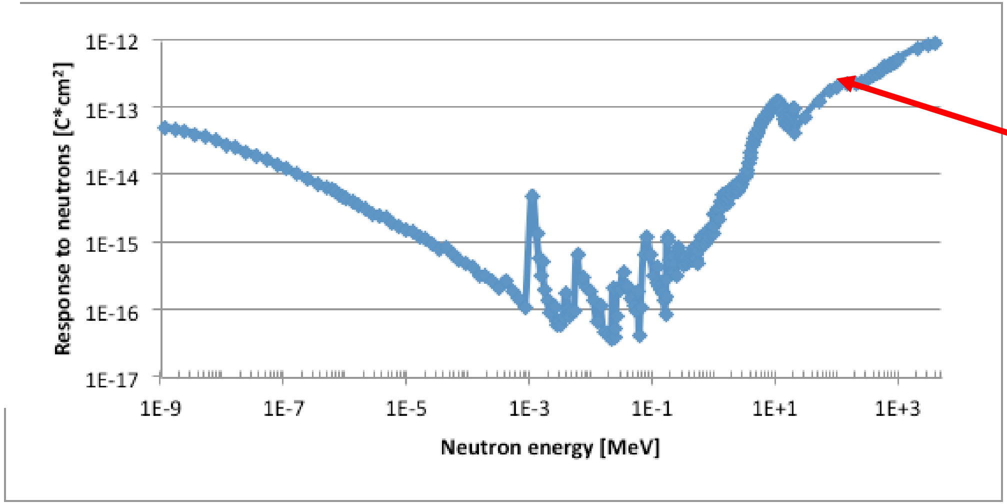


Argon is sensitive to neutron as well!

(n,p), (n,d), (n,α)

NEUTRON MONITORING REM COUNTER

ra short pulses (**1-60 fs**!)
gh energies (**5 GeV** primary beam)
ed of having a **dual-use**
P monitor + Beam Loss Monitor)
se rate from 10 nSv/h to 100 mSv/h
cellent gamma rejection **10^5 rejection factor**

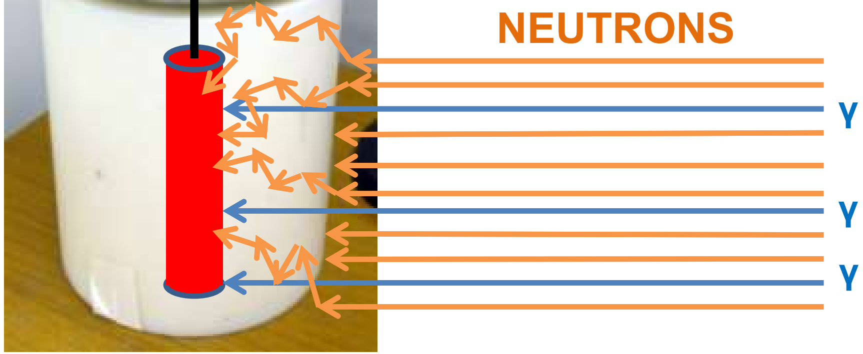
- Extended dynamic range (> 20 MeV)
- **Specifically conceived for pulsed fields**
- Excellent neutron/gamma discrimination
- **Fast alarm response (50 ms)**

DETECTION PROCESS

Detection of pulsed **neutron** fields shows an advantage, if compared to photons

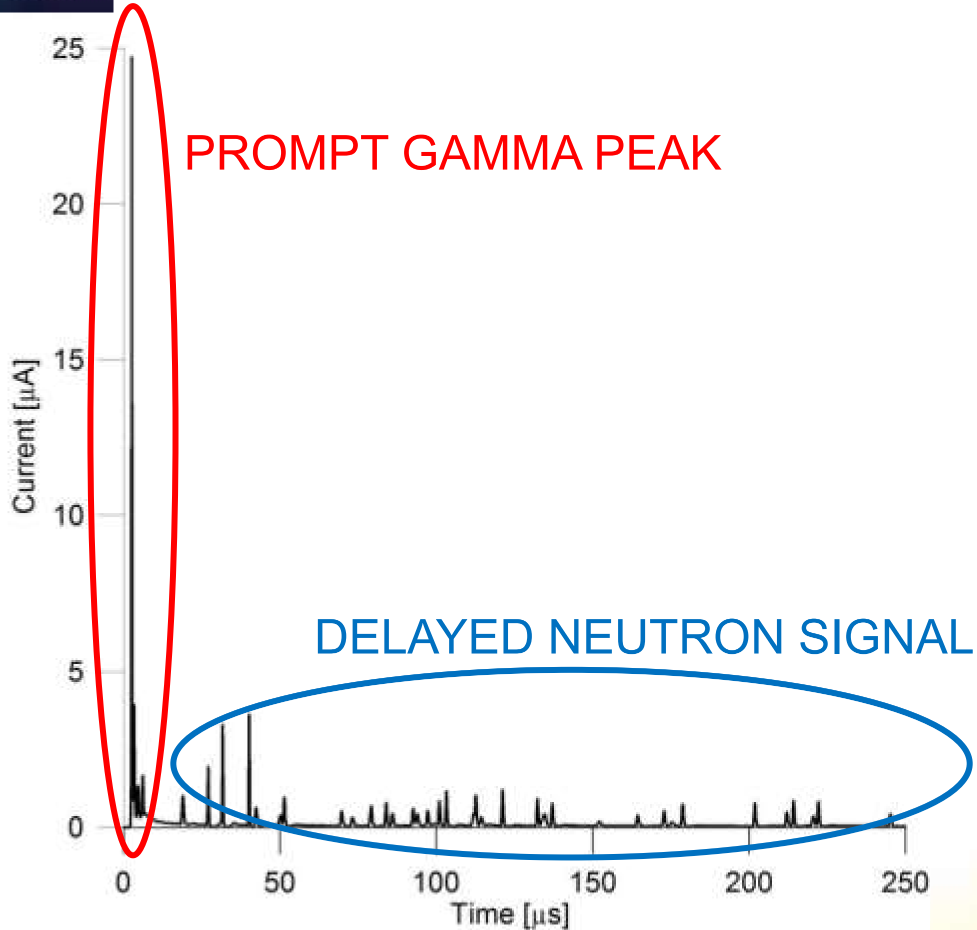
Neutron detection mechanism:

1) They reach the moderator surface
2) They are **thermalized** (scattering events)
3) Once thermalized they **diffuse**
4) They **reach the detector** (BF_3 or ^3He)

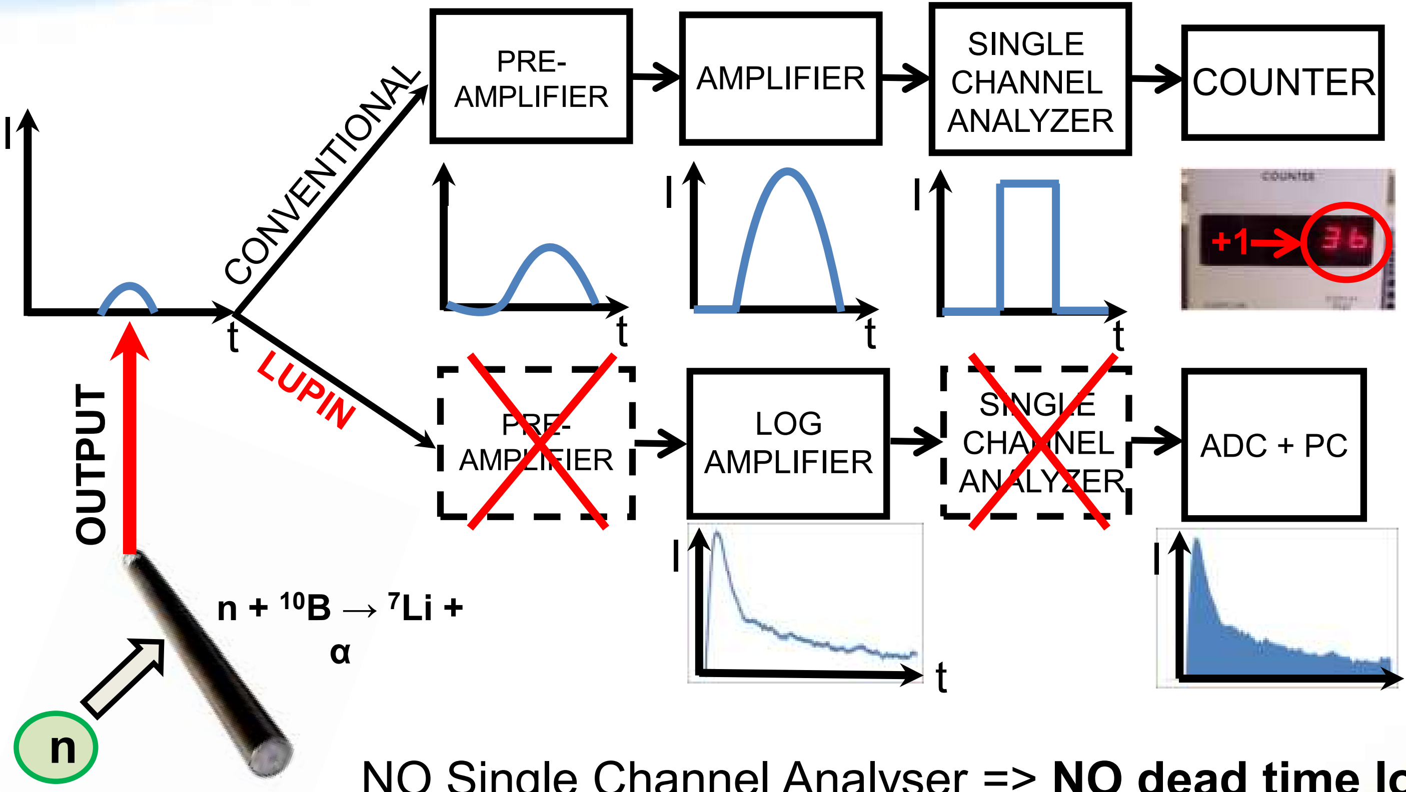


Photons do not need thermalization in order to be detected

OPERATION AT SWISSFEL



LUPIN WORKING PRINCIPLE (I)



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

Logarithmic amplifier => **Wide dynamic range**

Mobile stations

✓ ompletely customisable

able up to 30 m for remote measurements with both probes

onceived for 100% reliable use also in rough environments

- ✓ Open protocols
- ✓ Can handle multiple detectors
- ✓ Customisable reports

1. **BF3** or **He3** with energies up to **5GeV**

2. Dose rate range: 10 nSv/h to 100 mSv/h

3. Excellent gamma rejection
   10^5 rejection factor

4. Ultra short pulses (**1-60 fs**!)

Best instrument on the market capable of distinguishing the single neutron burst!

GAMMATECH

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