Summary of mini-workshop on Cryogenic BLMs

Mariusz Sapinski and Christoph Kurfuerst

BI seminar November 4th 2011

Cryogenic Beam Loss Monitors workshop

Tuesday, October 18, 2011 from **08:45** to **18:00** (Europe/Zurich)
at **CERN (13-2-005)**

Tuesday, October 18, 2011

http://indico.cern.ch/event/CryoBLM2011

08:45 - 09:00	Welcome *15'* Speaker: Bernd Dehning (CERN) Material: **Slides**
09:00 - 09:30	BLMs on LHC triplet magnets *30'* Speaker: Alessio Mereghetti (University of Manchester (GB)) ms Material: **Slides**
09:30 - 09:45	Requirements for ESS *15'* ms Speaker: Dr. Lali Tchelidze (ESS) Material: **Slides**
09:45 - 10:15	Cryogenic particle detection with regard to BLM application *30'* ~~Speaker: Christoph Kurfuerst (Technische Universitaet Wien (TU))~~ next time Material: **Slides**
10:15 - 10:45	coffee
10:45 - 11:05	Diamond BLMs at CERN - readout electronics *20'* Speaker: Erich Griesmayer (Department of Physics-University of Wisconsin) CK Material: **Slides**
11:05 - 11:35	muLOSS for LIPAc *30'* ms Speaker: Dr. Jacques Marroncle (CEA Saclay) Material: **Slides**
11:35 - 12:00	discussion
12:00 - 14:00	lunch

Speaker: Dr. Jacques Marroncle (CEA Saclay)
Material: Slides

http://indico.cern.ch/event/CryoBLM2011

11:35 - 12:00	discussion	
12:00 - 14:00	lunch	
14:00 - 14:25	Diamond TCT measurements down to 60 K *25'* Speaker: Heinz Pernegger (CERN) Material: Slides	CK
14:25 - 14:30	Cryogenics for East Hall experiments *5'* Speaker: Thomas Eisel (Technische Universitaet Dresden) Material: Slides	CK
14:30 - 15:00	CryoBLM beam test - first results *30'* Speaker: Christoph Kurfuerst (Technische Universitaet Wien (TU)) Material: Slides	next time
15:00 - 15:30	Physics of Semiconductor Detectors *30'* Speaker: Vladimir Eremin (Ioffe Physical Technical Institute of Russian Academy of Scienc) Material: Slides	CK
15:30 - 16:00	coffee	
16:00 - 16:30	CID in harsh environment *30'* Speaker: Jasu Haerkoenen (Helsinki Institute of Physics (FI)) Material: Slides	CK
16:30 - 16:50	Liquid Helium Scintillation *20'* Speaker: Thijs Wijnands (CERN) Material: Slides	ms

FLUKA Simulations for Assessing Thresholds of BLMs Around the LHC Triplet Magnets

A. Mereghetti[1], on behalf of the FLUKA Team
M. Sapinski[2], on behalf of the BLM Team

[1] EN/STI/EET

[2] BE/BI/BL

October 18^{th}, 2011

Fluka Simulations

Aim

Relate the energy deposited in the superconducting coil of the *inner triplet* to the signal read by BLMs all around: **assessment of the signal thresholds**.

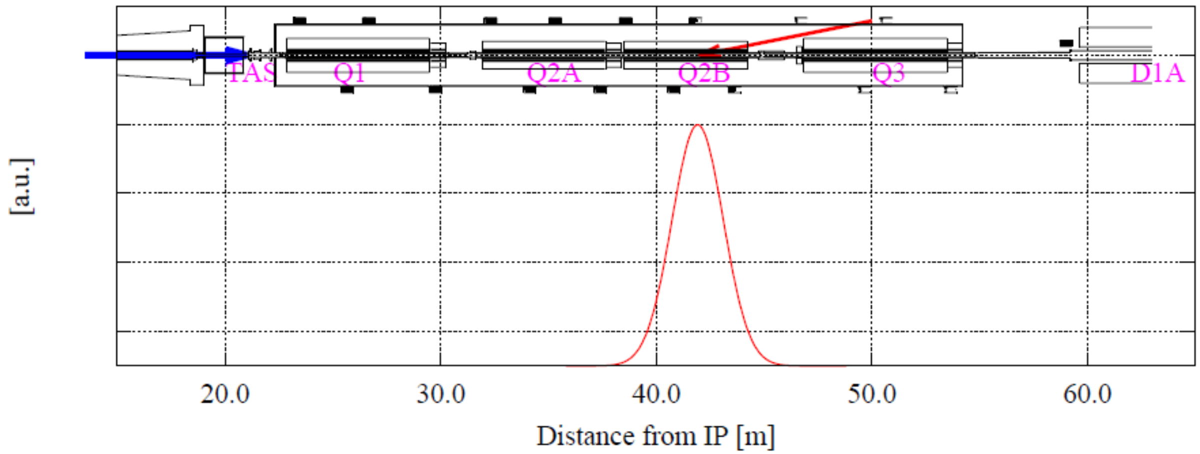
Fluka simulations of the *Inner Triplet* presently installed on the right side of Point 1 of LHC (ATLAS). Considered scenarios:

pp-collision debris

- $L_0 = \mathbf{10^{34}\ cm^{-2}\ s^{-1}}$ [1];
- **80 mb** as pp inelastic cross section at 14 GeV centre-of-mass energy;

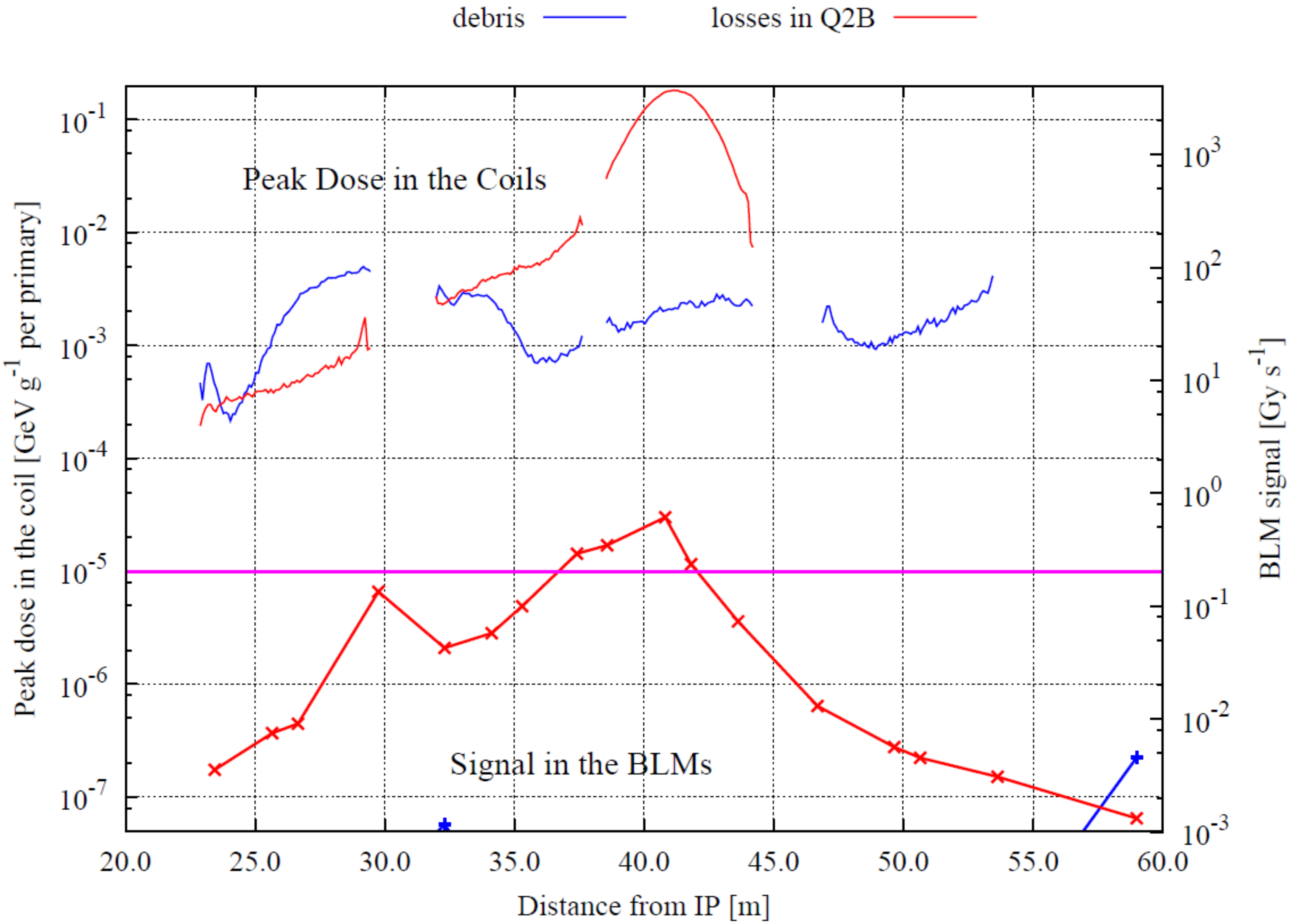
direct losses in Q2B (MQXB.2BR1)

7.0 TeV protons on Q2B magnet, due to wrong settings of collimators;



For other scenarios: EDMS doc in preparation.

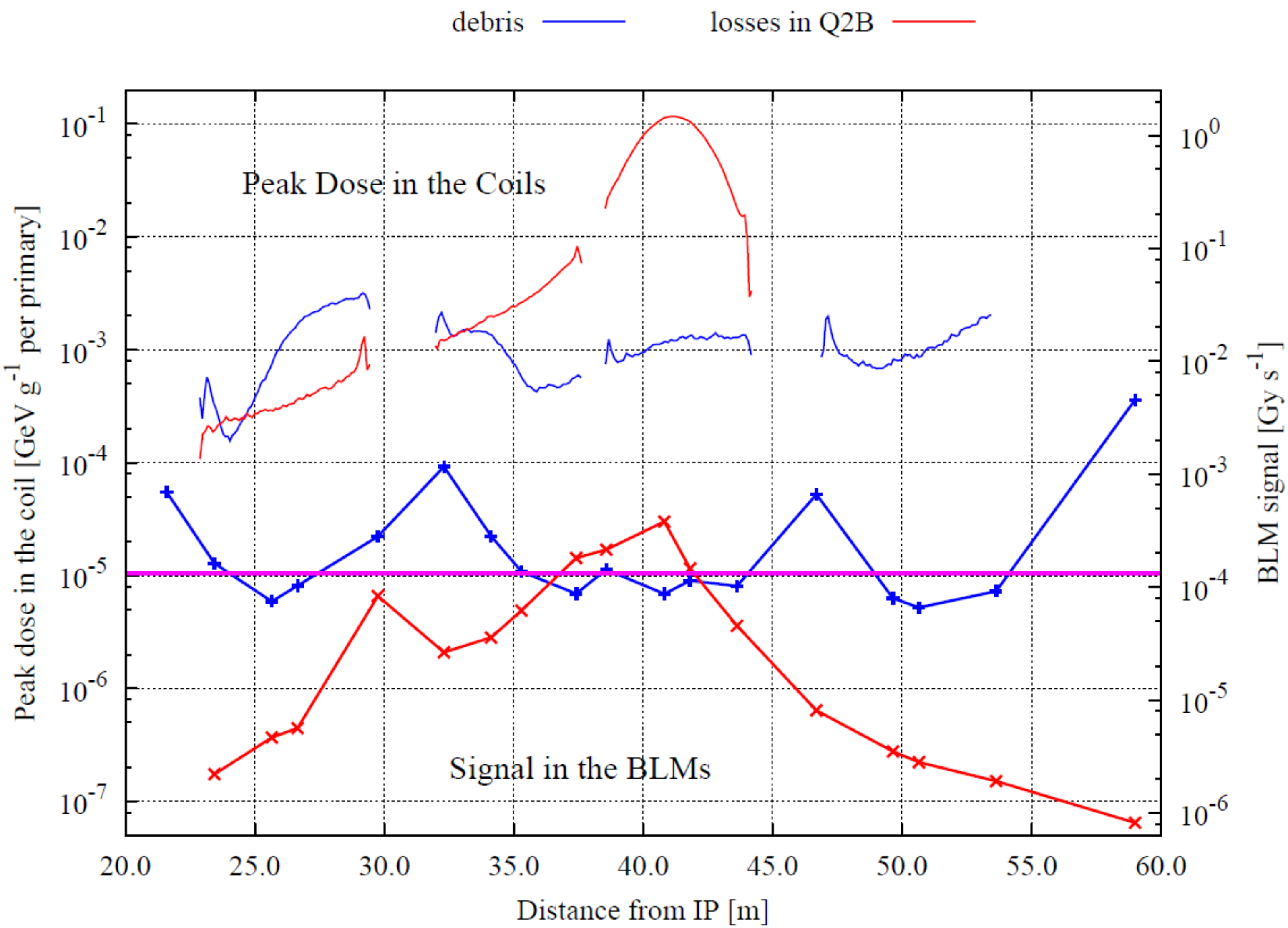
Fast Losses: Signals **Integrated over 40 μs**



After normalisation…

…the signal due to the debris is far below the one due to lost protons!

Steady-State Losses: **Final** Signals



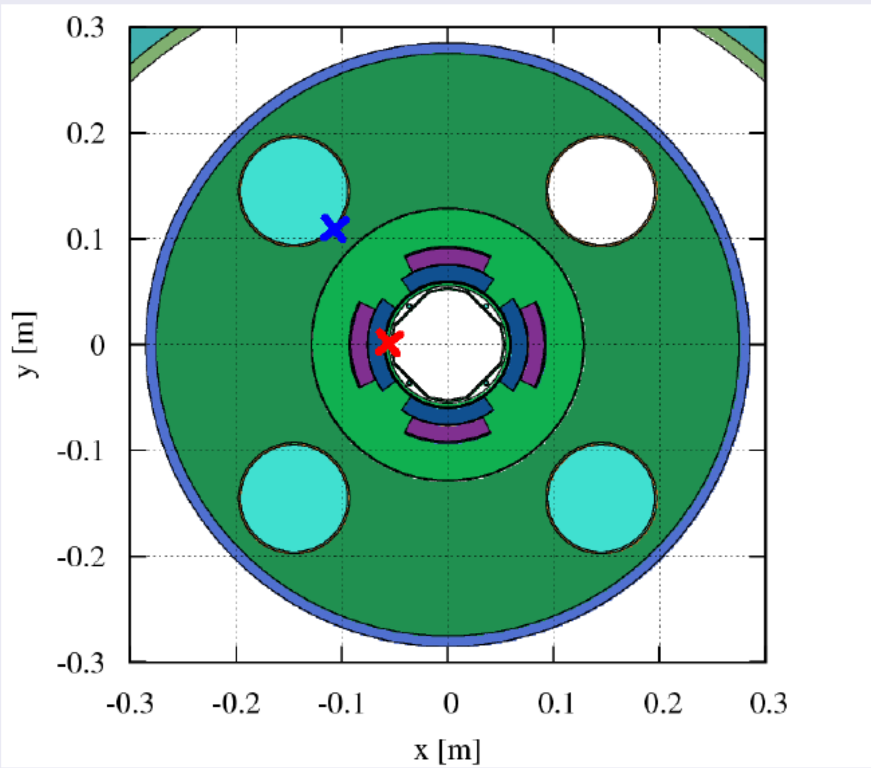
After normalisation…

…the signal due to the loss can't be distinguished from the one due to the debris!

New Positions of BLMs

The Closer to the Coils, the Better

- higher intensity of the signal;
- signal better follows the longitudinal pattern of the peak in the coil;



FLUKA geometry: LHC Phase I Upgrade

more prone to host the new BLMs, with no important change in the physics behind.

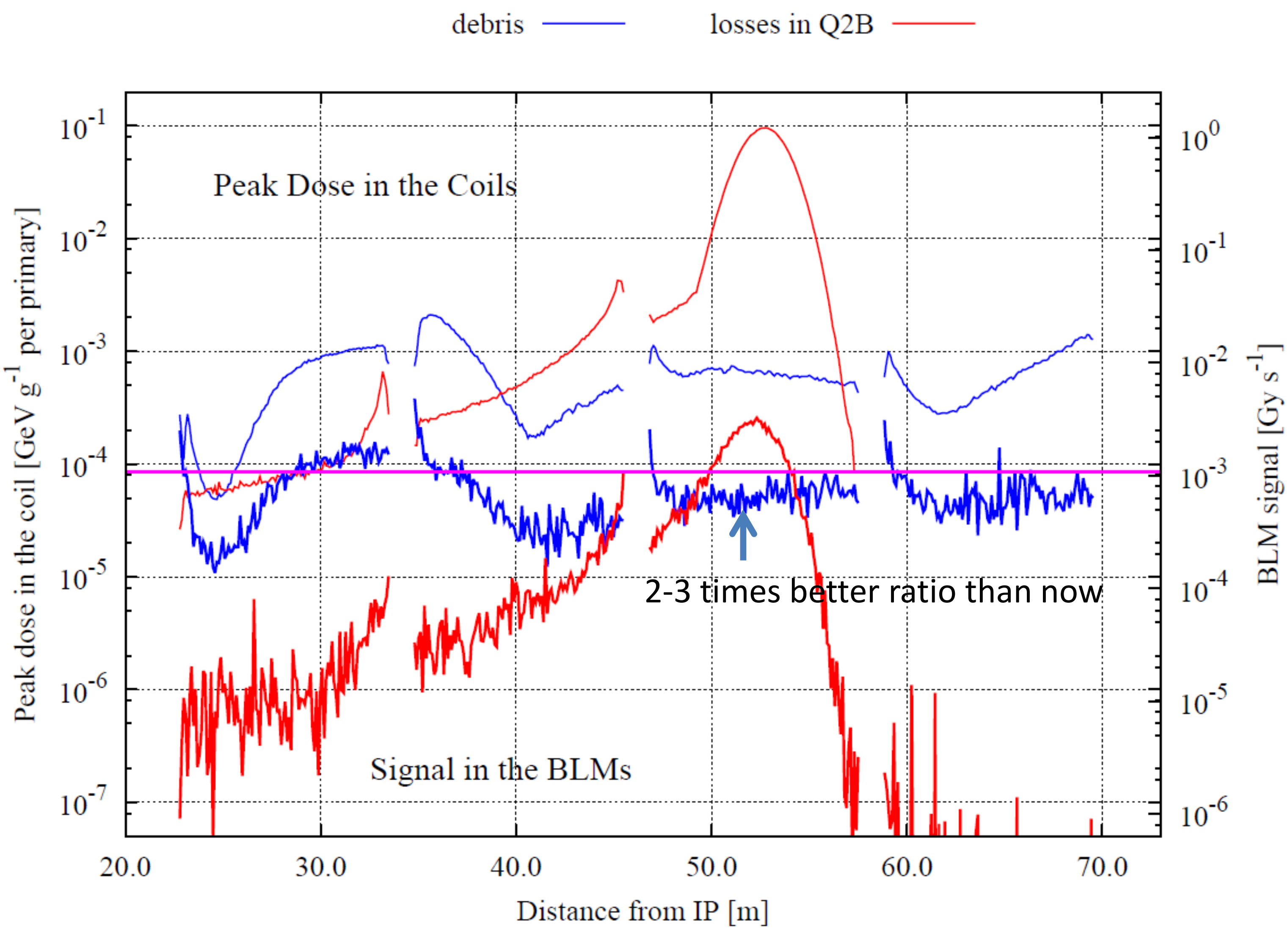
Four Holes

- one for the heat exchanger;
- the others for not breaking the quadrupole symmetry. Good location for the new BLMs.

FLUKA Estimation

No design or location of the new BLMs (at that moment): estimation of the signal via the dose inside the yoke (blue cross).

Steady-State Losses: **Final** Signals



After normalisation…

…the signal due to the loss can be distinguished from the one due to the debris.

Requirements of the ESS BLM

EUROPEAN SPALLATION SOURCE

by Lali Tchelidze

CERN, Geneva, 18 Oct. 2011

Cryogenic requirements

- A hybrid design of a cryostat is foreseen for ESS.
  - an operating loss detector might be needed at 70 K / 2 K!

- Physical size of the detector should not be very small – to cover a “large” part of the loss area.

μ-Loss for LIPAc

LIPAc: Linear IFMIF Prototype Accelerator

Cryogenic Beam Loss Monitors Workshop

CERN - 18th October 2011

Philippe **Abbon**, Jan **Egberts**, Anthony **Marchix**, Jacques **Marroncle** - *DSM/Irfu/Siiev - CEA Saclay*
Hassen **Hamrita**, Michal **Pomorski** - *DRT/List/DCSI - CEA Saclay*

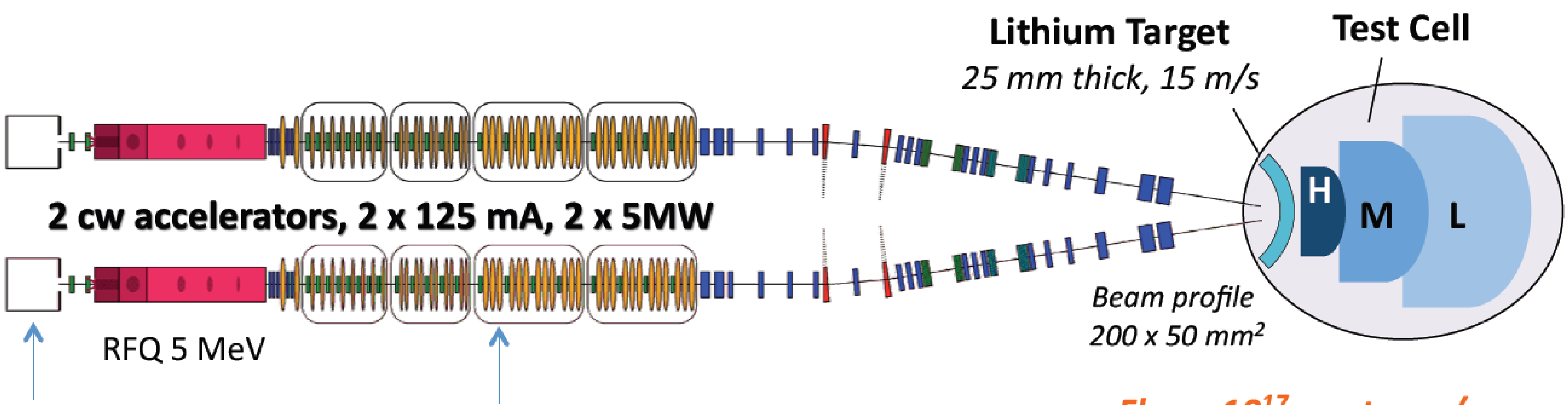
IFMIF

IFMIF* : to test materials submitted to very high neutron fluxes for future Fusion Reactors.

*International Fusion Materials Irradiation Facility

international agreement of the **BA** (JAEA+F4E) = **IFMIF** + IFERC + JT60-SA

High	> 20 dpa/y	0.5 l
Medium	> 1 dpa/y	6 l
Low	1 dpa/y	> 8 l



deuteron source
140 mA, 100 keV

Superconductive Linac 40 MeV
(Half Wave Resonators)

Flux ~ 10^{17} neutrons/s

Typical reactions

$^{7}Li(d,2n)^{7}Be$

$^{6}Li(d,n)^{7}Be$

$^{6}Li(n,T)^{4}He$

LIPAc

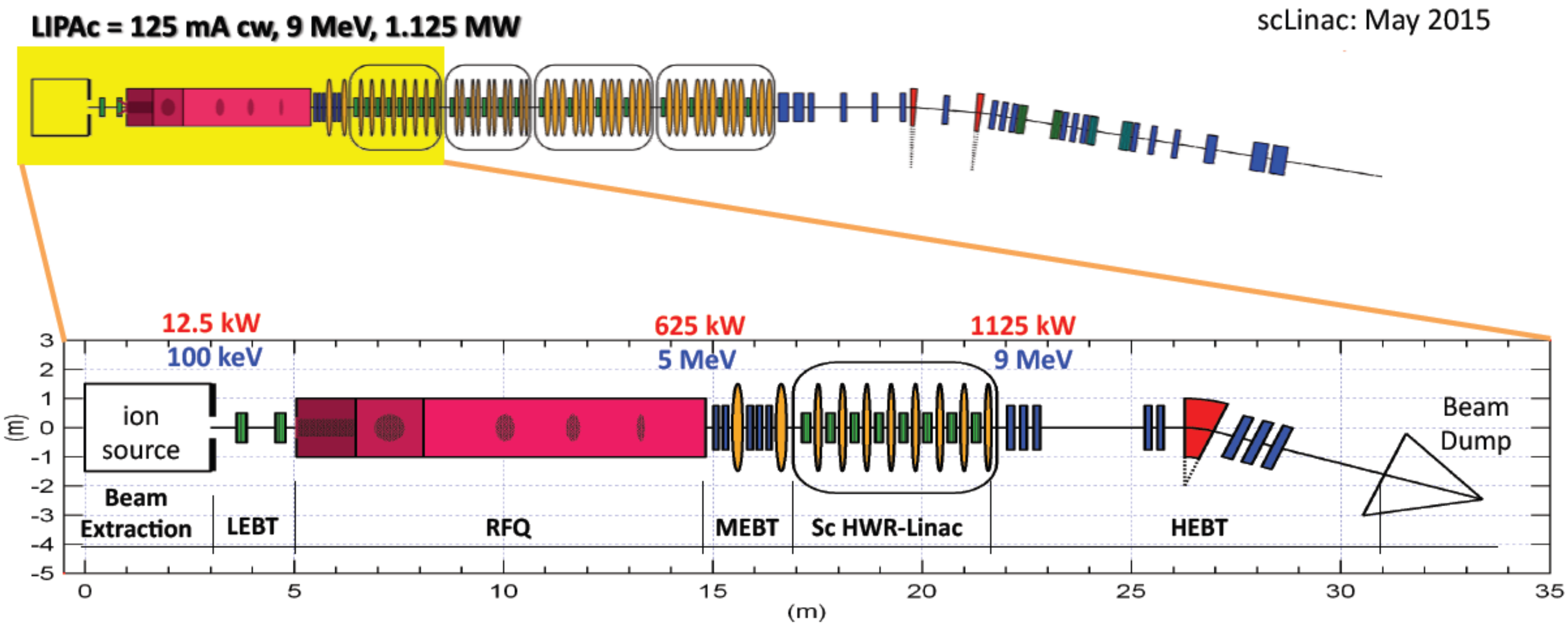
1.125 MW ≡ ability for the Beam Dump to evacuate the whole energy of the LHC beams every 11 minutes!

Validation phase: prototype accelerator → LIPAc*

*Linear IFMIF Prototype Accelerator

Commissioning at Rokkasho (Japan) beginning:

Injector: March 2013
RFQ: July 2014
scLinac: May 2015



energie atomique - energies alternatives

Beam Instrumentation Layout

deuteron beam:

E_{max} = 9 MeV

I = 125 mA

P_{max} = 1.125 MW

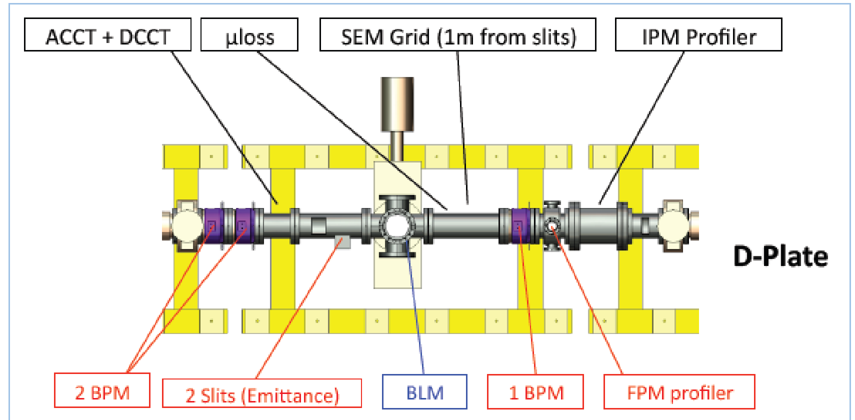
Duty Cycle: <10^{-4} to cw

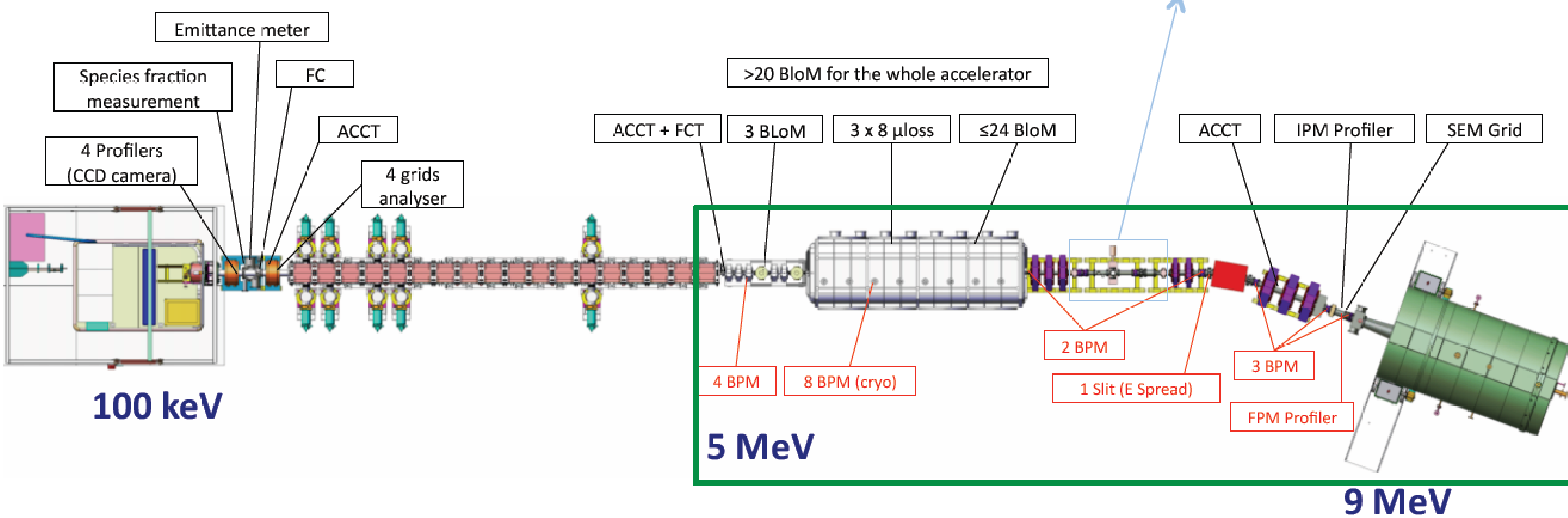
RF: 175 MHz (5.7 ns)

Glossary:

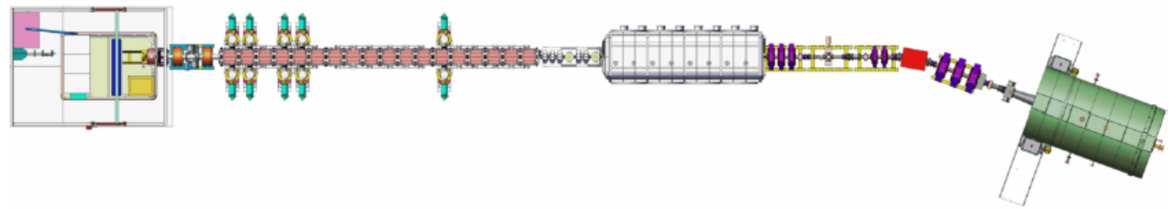
receipe for confusion

ACCT: AC Current Transformer
BLoM: Beam Loss Monitor
BLM: Bunch Length Monitor
BPM: Beam Position Monitor
DCCT: DC Current Transformer
FC: Faraday Cup
FCT: Fast Current Transformer
IPM: Ionization Profile Monitor
FPM: Fluorescence Profile Monitor





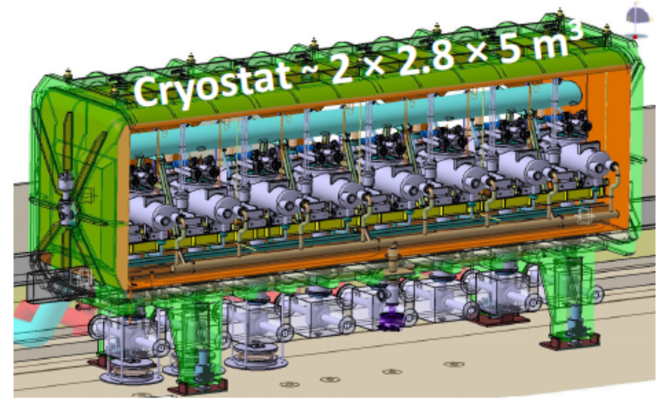
Superconductive Linac (scLinac)



scLinac:

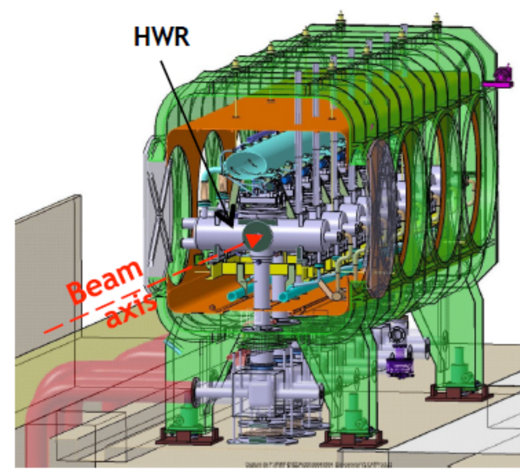
T = 4K
deuteron: 5 to 9 MeV (125 mA)
8 ensembles:
- 1 Half Wave Resonator (HWR)
- 1 solenoid
- 1 BPM

no more diagnostics
⇒ sensitive detectors to tune the beam ($<10^{-6}$ beam)
Note: HWR emits X-rays up to γ



Ideal μ-Loss:

sensitive only to neutrons → to avoid fake signals
expected time response ~ second (for good tuning sensitivity)
rough space resolution
radiation hard
ability to work at cryogenic temperature
Very good reliability (once closed, cryostat will not be re-open)



Compromise: diamond

"μ-Loss Detector for IFIMIF-EVEDA", J. Marroncle et al, DIPAC 2011

Diamond: counting rates

Feasibility study: Simulation *(A. Marchix, Saclay, Sept. 2010)*:

Loss: **1 W/m** with Thalis + neutron transports

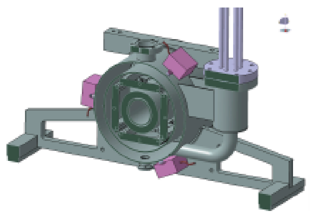
$D^+ + Fe \rightarrow$ neutron (or γ) + X

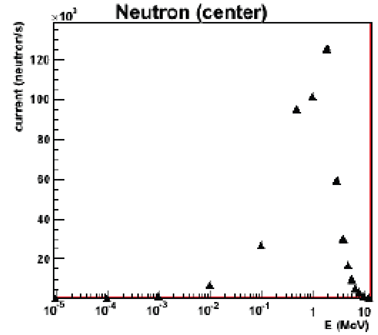
3 diamonds per Solenoid

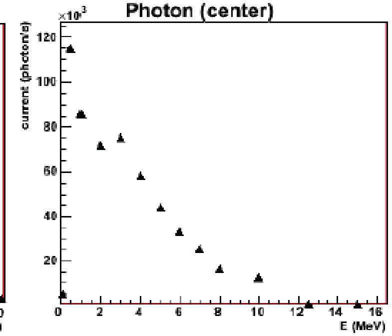
→ transverse localization + reliability

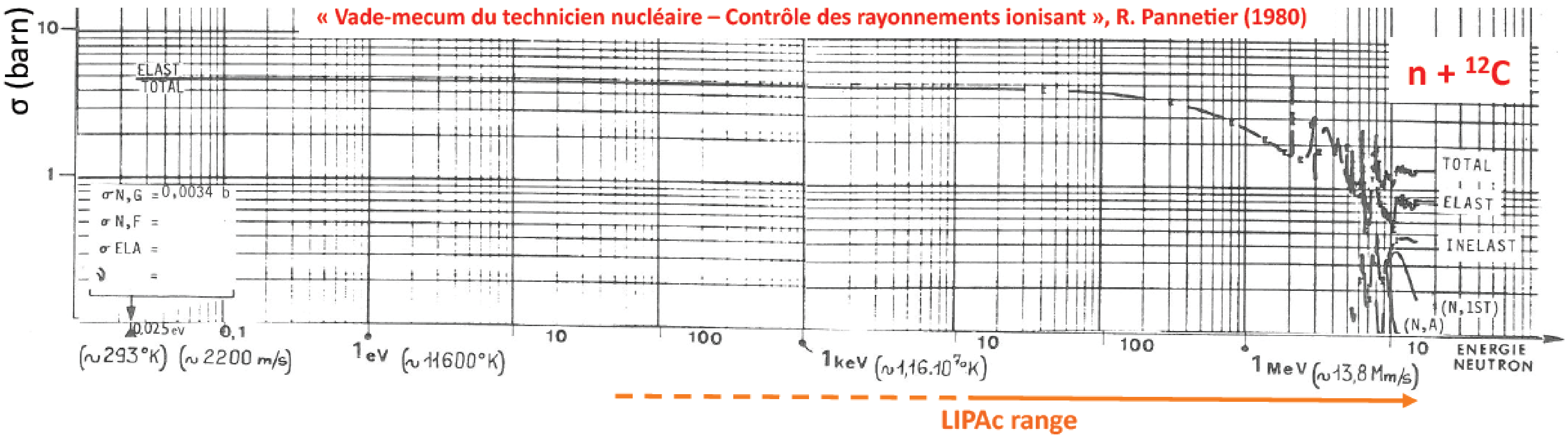
→ X-ray shielding

→ convertor foil to improve neutron sensitivity?









« Vade-mecum du technicien nucléaire – Contrôle des rayonnements ionisant », R. Pannetier (1980)

Counting rate estimation for 1 W/m beam losses:

Neutron (only elastic process)

all neutron spectrum → ~ 1200 Hz

E_{neut} > 1.5 MeV → ~ 400Hz

E_{neut} > 2.5 MeV → ~ 190 Hz

γ (all processes)

all γ spectrum → ~ 810 Hz

E_γ > 1.5 MeV → ~ 250Hz

E_γ > 2.5 MeV → ~ 180 Hz

Cryogenic test: LHe – 4.5 K

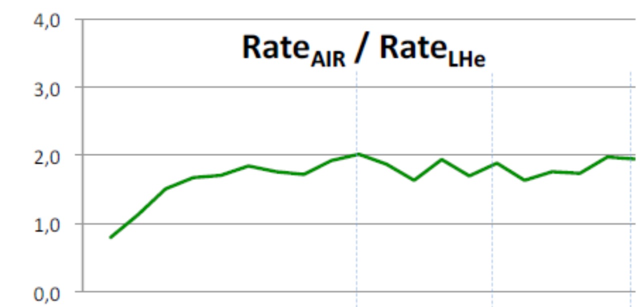
(May 2011)

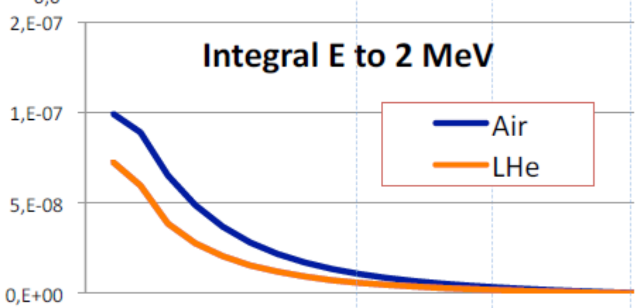
Simulation

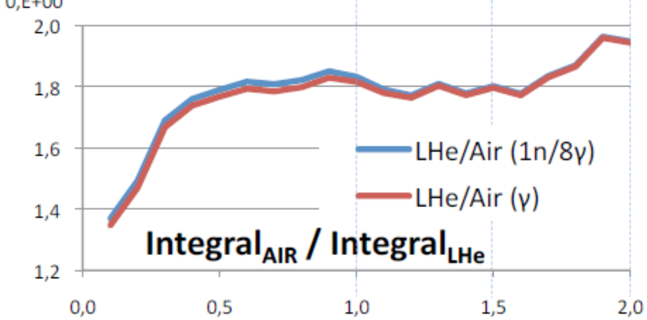
A. Marchix, Irfu, Oct 2011

Only γ (^{252}Cf)

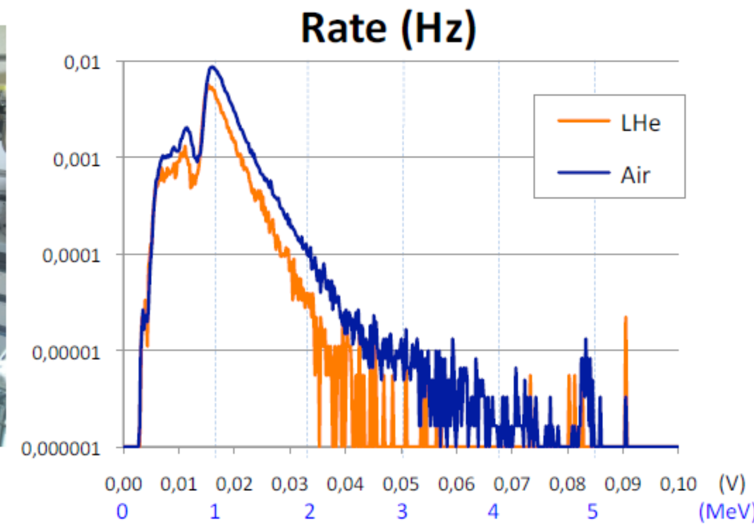
Dewar thickness taken into account

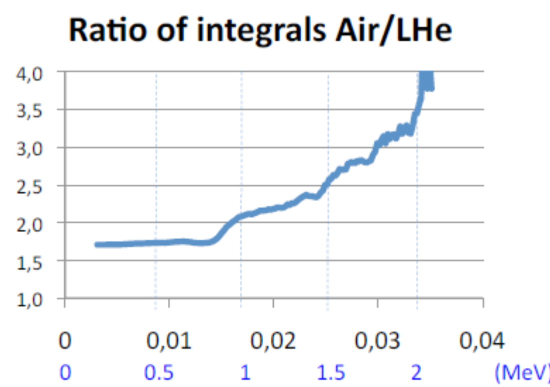


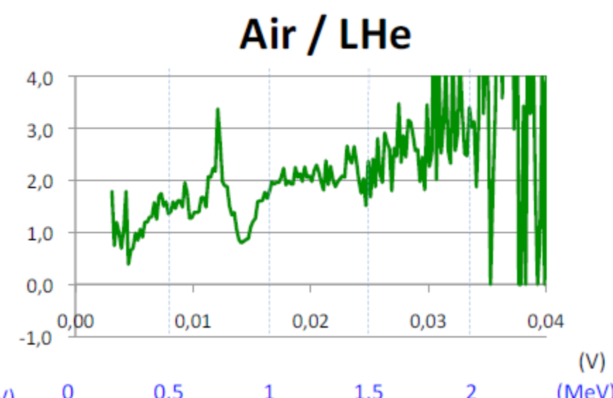




Experimental result





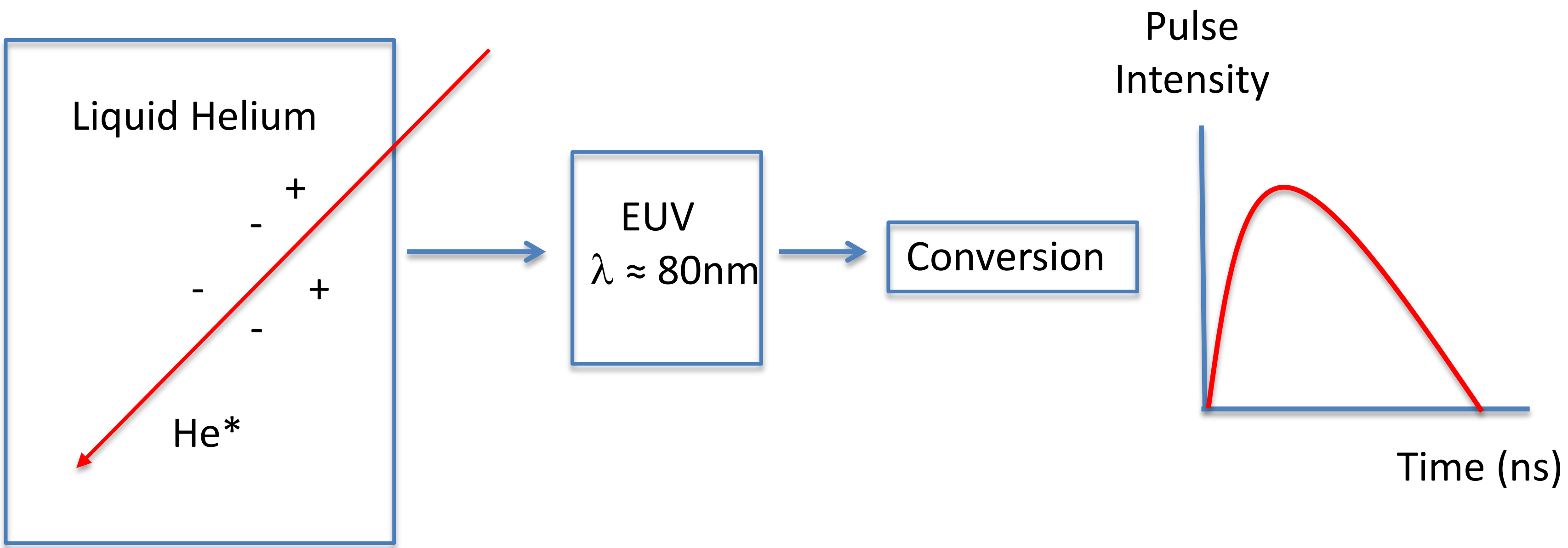


Liquid Helium Scintillation

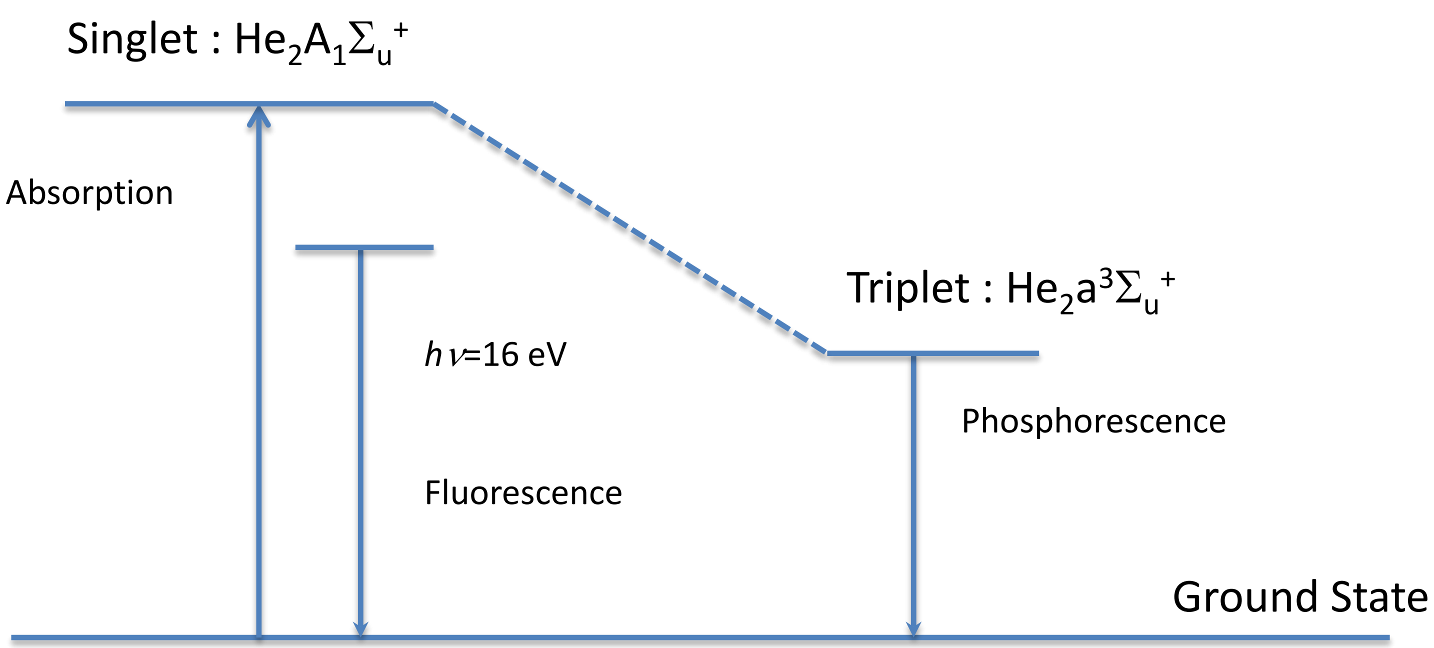
Candidate for detecting beam losses in the LHC ?

T. Wijnands EN/HDO

Basic principle



Scintillation mechanism



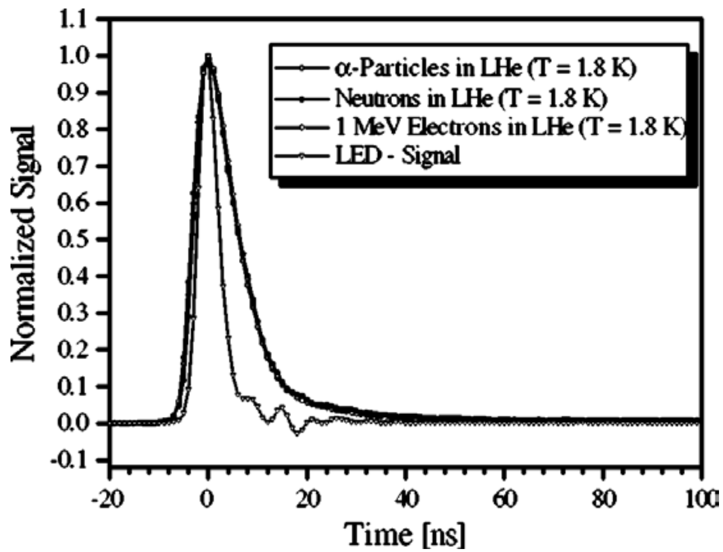
Radiative lifetime = 1 ns

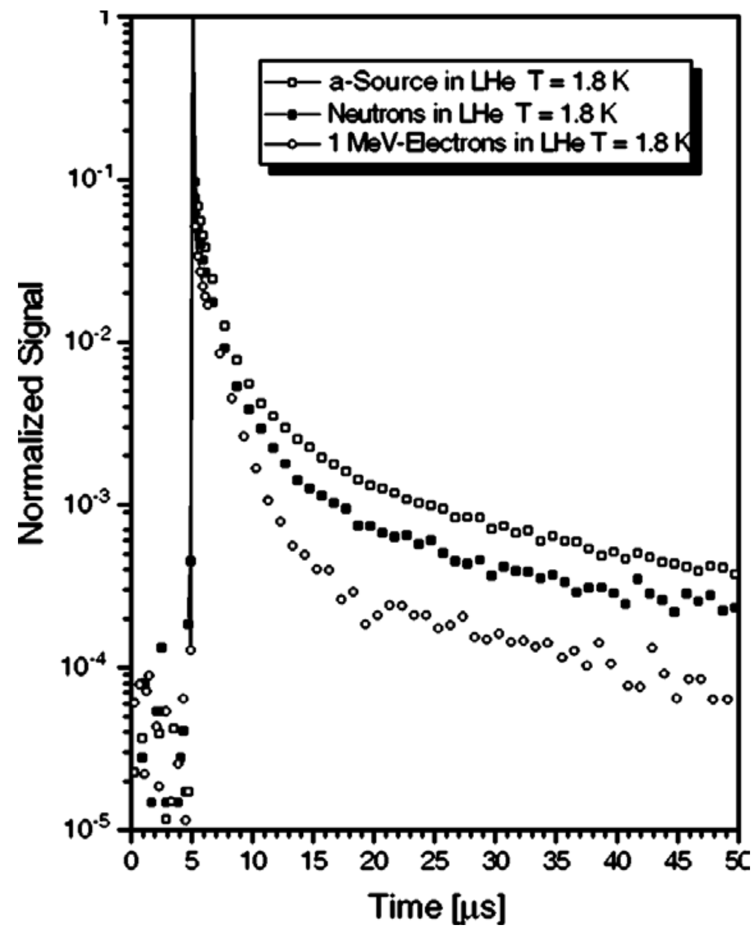
'Scintillation pulse'

Radiative lifetime = 10 s

'Afterglow effect'

Scintillation signals



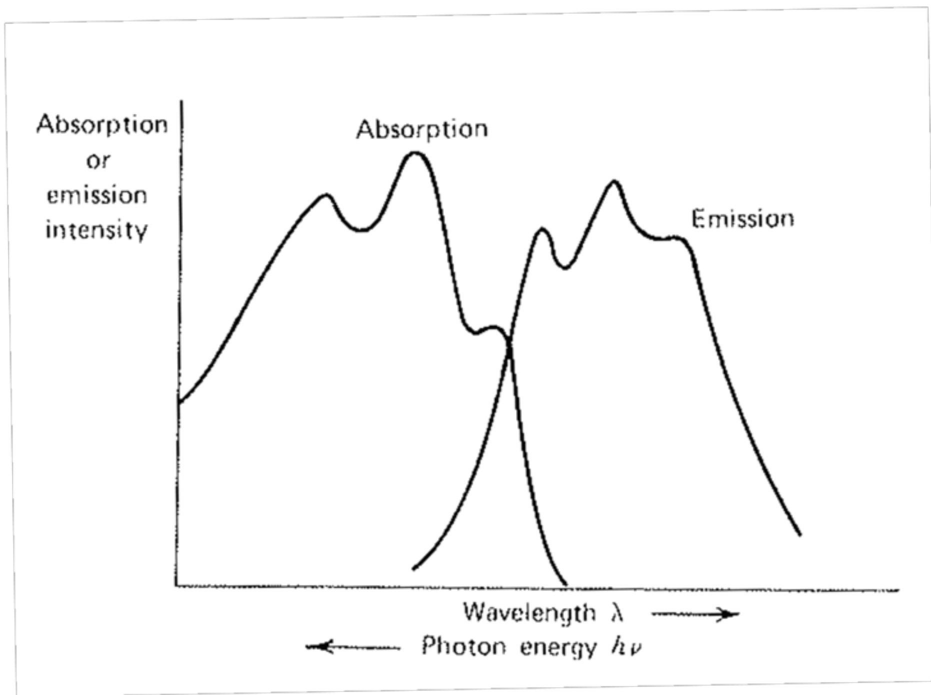


35% conversion efficiency
into scintillation light (β)

'McKinsey et al. Phys. Rev A 67 062716 (2003)'

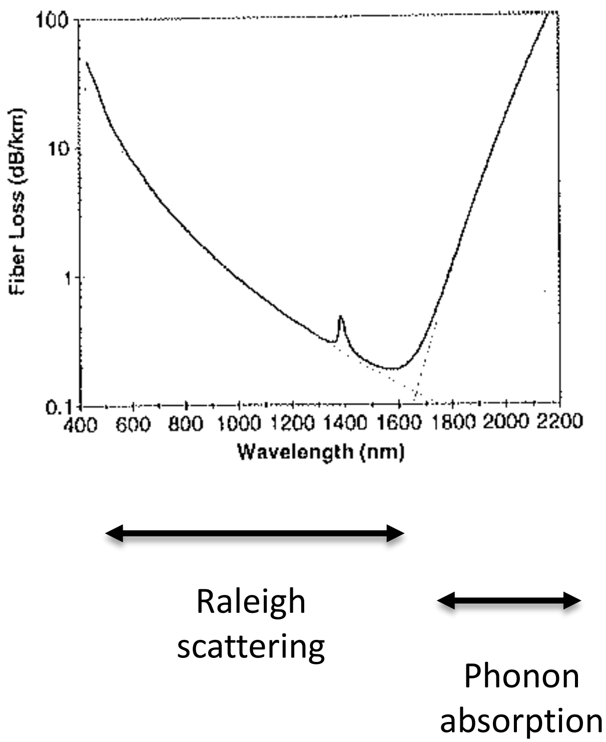
Scintillation light - I

- Fluorescence occurs at a <u>lower</u> energy level than that required for excitation
- There is thus little self absorption of the scintillation light



Scintillation light - II

- The peak of $He_2A_1\Sigma_u^+$ emits light at approximately 80-100 nm (EUV region)
- Light at this wavelength does not propagate through a SM silica optical fibre because of Raleigh scattering (spectral dependencies as $1/\lambda^4$)



Light detection techniques

- Direct detection technique

  Measure extreme UV light at 100 nm with special AXUV photodiodes which have :

  1. No surface dead region i.e. no recombination of photo generated carriers in the doped n-region or at the silicon-silicon dioxide interface
  2. An extremely thin (3 to 7 nm) silicon dioxide junction entrance window
  3. Silicon thickness can be optimized to maximize yield for Helium

- Indirect detection technique
  1. Wavelength shifting via coating of optical fibre to longer wavelength
     - Absorb the primary EUV light
     - Reradiate the energy at a lower wavelength
  2. Use classical detection (PMT) technique

Direct vs. Indirect detection

- Direct detection technique
  - Photodiodes are very resistant to TID
  - Neutron damage may deteriorate the devices rather rapidly (needs investigating)
  - EUV diodes are special R&D developments (http://www.ird-inc.com/)
- Indirect detection technique
  - Wavelength shifters typically induce a loss of 10-30%
  - Reduce the overall response time of the system
  - Wavelength shifting optical fibres are generally not radiation tolerant

Feasability

- Highly efficient conversion into detectable light ?
  - *Depending on detection technique of EUV light (direct/indirect)*
  - *Probably of the order of 10-15%*
- Linear relationship E_{dep} vs. light yield ?
  - *Not checked yet for exotic particles at high E in a HEP radiation field*
  - *Ok for X, neutrons and electron beams at 60 MeV*
- Transparency for $\lambda_{emitted}$? Ok !
- Short decay time without delay Ok !
- High optical quality & easy to manufacture ? Ok !
- Easy coupling to a light sensor ?
  - Needs further investigation, certainly not so easy

Open question : what is the purity of the He in the LHC ?