CsI(Tl) Semiconductor Detectors for Hard X-Ray Diagnostics at COMPASS Tokamak

Richard Paprok[1,2], Milos Vlainic[1,3], Jan Mlynar[1], Vladimir Weinzettl[1], Mykyta Varavin[1], Jozef Varju[1], Ondrej Ficker[1,4], Martin Imrisek[1,2] and the COMPASS Team

[1]*Institute of Plasma Physics AS CR, v.v.i., Prague, Czech Republic*
[2]*Faculty of Mathematics and Physics, Charles University in Prague, Prague, Czech Republic*
[3]*Department of Applied Physics, Ghent University, Ghent, Belgium*
[4]*Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague, Prague, Czech Republic*

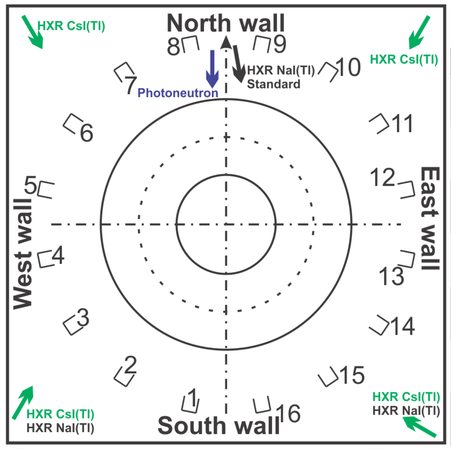
1. INTRODUCTION

Background: - runaway electrons (RE) can reach a few MeV
- RE hit the plasma facing components
- radiation in Hard-X Ray (HXR) region of the electromagnetic spectrum

Motivation: - toroidal asymmetry of the RE losses
- toroidal asymmetry of kinetic loads
- **ECONOMIC AND FAST DETECTORS**

Possibilities: - toroidal propagation of the Parail-Pogutse instability
- bremsstrahlung from the in-flight RE

Detectors [1,2]: - EURORAD (commercial) detectors
- "Solid State Scintillation Probe SC2525"
- 4 CsI(Tl) scintillators with Si photodiode
- diameter = 3.5 cm, length = 7 cm
- input +/- 12V
- integrated preamplifier
- scintillations in ~100 keV to 1 MeV range
- Aluminum encapsulation



Experimental setup of diagnostics used for RE loss detection during the 2nd COMPASS RE campaign.

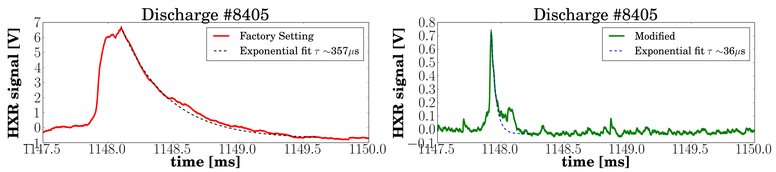
COMPASS tokamak parameters:

PARAMETER	VALUE
Major Radius	0.56 m
Minor Radius	0.23 m
Toroidal Magnetic Field	0.9-1.25 T
Plasma Current	< 400 kA
Discharge Length	< 0.4 s
Electron Density	10^{19} - 10^{20} m^{-3}
Plasma Facing Material	C-limiter & Inconel-625

2. TECHNICAL SOLUTIONS

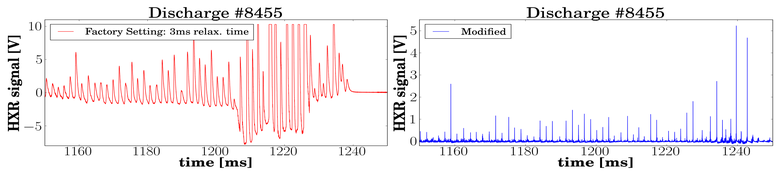
2.1 Modification of Temporal Characteristics

- Too long decay time
- The detector had to be opened
- Tested in the same position



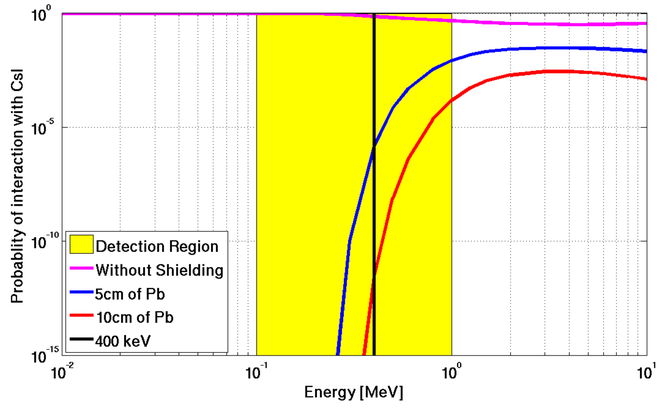
2.2 Relaxation Time Issue

- Artificial negative values
- Tested in the same places
- Higher peaks



2.3 Radiation Effect

- Manufacturer's threshold ~1 Gy:
  - 2nd campaign (unshielded): ~7.36 mGy [3]
  - RE discharge (unshielded): ~100 μGy
- Shielding with Pb-bricks needed:
  - 5 cm enough for non-RE experiments
  - 10 cm **NOT ENOUGH** for RE experiments

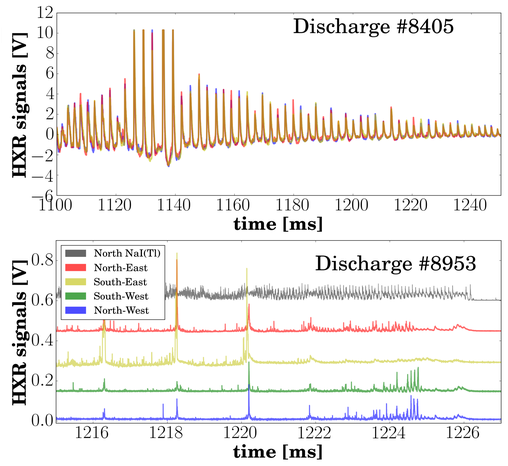


3. OBSERVATIONS OF TOROIDAL ASYMMETRIES ON COMPASS

The behavior or three detectors verified to be consistent before and after modification.

Details of discharge #8953:
- D-shaped L-mode plasma
- el. density ~4x10^{19} m^{-3}
- plasma current 150 kA
- disruption at 1229 ms

- HXR detectors toroidally distributed
- NBIs shielding North-East and North-West detectors
- South-East has the strongest signals
- South east only without signal before disruption



4. CsI(Tl)+Photodiode vs NaI(Tl)+PMT

ADVANTAGES	DISADVANTAGES
- Compactness	- Switches off in high gamma fluxes
- No need for high voltage (safer) and photomultiplier tube (cheaper)	- Space usage increases with the amount of the Pb-bricks
- Better quantum efficiency relative to the output signal	- Makes studies of the dedicated RE experiments in COMPASS difficult
- More stable control of the multiplication factor	- Temporal characteristics were too slow for the required application
- Weaker or none integration of consecutive detections	- Artificial negative signal still appears for strong peaks
- Better signal-to-noise ratio	- After modification: lower sensitivity

5. CONCLUSION

The purpose of the poster is to show potential of new HXR diagnostic for RE studies. The difficulties regarding the CsI(Tl) semiconductor detector presented are limiting factors for their performance on tokamaks.

OUTLOOK: Optimize the shielding!

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