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

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1. INTRODUCTION

Background: The purpose of the poster is to show potential of new HXR diagnostic for RE studies. The difficulties regarding the Csl(Tl) semiconductor detector presented are limiting factors for their performance on tokamaks. OUTLOOK: Optimize the shielding!

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 #893:
- D-shaped L-mode plasma
- el. density ~4·10^{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 with signal before disruption

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

ADVANTAGES
- Better signal-to-noise ratio
- No need for high voltage (safer) and photomultiplier tube (cheaper)
- Better quantum efficiency relative to the photomultiplier tube (cheaper)
- More stable control of the multiplication factor
- Weak or none integration of consecutive detections
- Better signal-to-noise ratio

DISADVANTAGES
- Switches off in high gamma fluxes
- Space usage increases with the amount of the Pb-bricks
- Better studies of the dedicated RE experiments in COMPASS difficult
- Temporal characteristics were too slow for the required application
- Artificial negative signal still appears for strong peaks
- 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 Csl(Tl) semiconductor detector presented are limiting factors for their performance on tokamaks. OUTLOOK: Optimize the shielding!

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REFERENCES

EXPERIMENTAL SETUP OF DIAGNOSTICS USED FOR RE LOSS DETECTION DURING THE 2nd COMPASS RE CAMPAIGN.

COMPASS tokamak parameters:

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>VALUE</th>
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<tbody>
<tr>
<td>Major Radius</td>
<td>0.56 m</td>
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<tr>
<td>Minor Radius</td>
<td>0.23 m</td>
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<tr>
<td>Plasma Current</td>
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<td>Electron Density</td>
<td>10^{19} - 10^{20} m^{-3}</td>
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<td>Toroidal Magnetic Field</td>
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<td>Discharge Length</td>
<td>&lt; 0.4 s</td>
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<tr>
<td>Thickness of single Pb brick</td>
<td>~5 cm</td>
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</table>

EXPERIMENTAL SETUP OF DIAGNOSTICS USED FOR RE LOSS DETECTION DURING THE 2nd COMPASS RE CAMPAIGN.

- Aluminum encapsulation
- scintillations in ~100 keV to 1 MeV range
- integrated preamplifier
- input +/- 12V
- diameter = 3.5 cm, length = 7 cm
- “Solid State Scintillation Probe SC2525”
- EURORAD (commercial) detectors

- bremsstrahlung from the in-flight RE
- toroidal propagation of the Parail-Pogutse instability
- ECONOMIC AND FAST DETECTORS

- toroidal asymmetry of kinetic loads
- toroidal asymmetry of the RE losses

- radiation in Hard-X Ray (HXR) region of the electromagnetic spectrum

- RE hit the plasma facing components
- runaway electrons (RE) can reach a few MeV

- plasma current 150 kA
- el. density ~4·10^{19} m^{-3}
- D-shaped L-mode plasma