Progress in HXR diagnostics at GOLEM and COMPASS tokamaks

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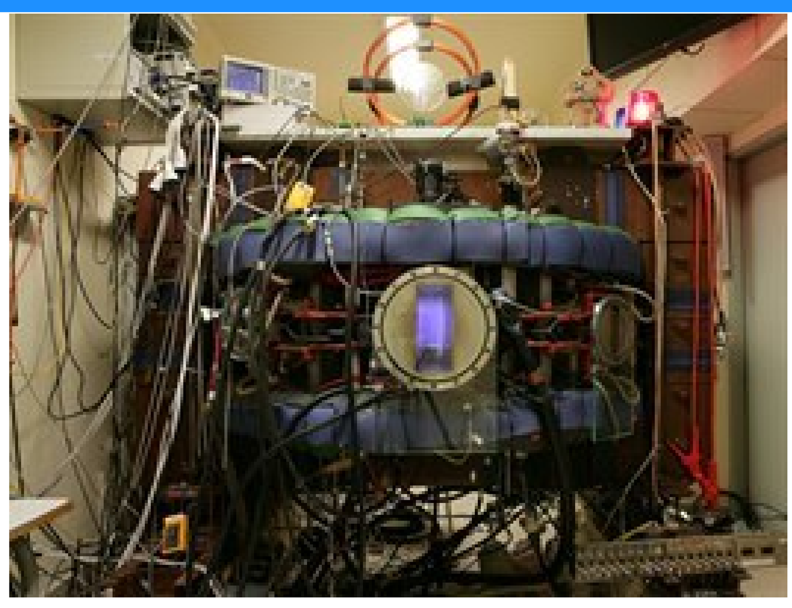
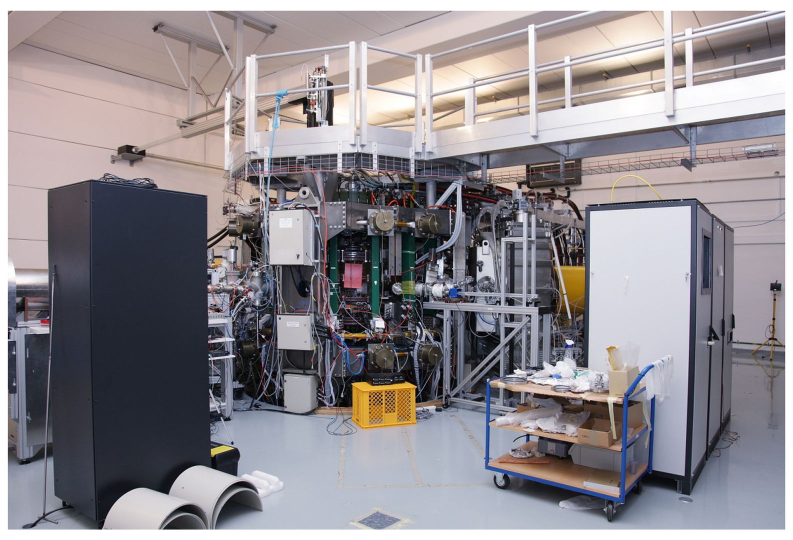
GOLEM and COMPASS tokamaks

- the GOLEM tokamak [1] is a small size device operated at FNSPE CTU
- → former tokamak CASTOR operated at IPP in Prague
- serves mainly for educational purposes and for diagnostics testing (probes and various HXR detectors)

R [m]	a [m]	I_p^{max} [kA]	B_T [T]
0.4	0.085	< 8	< 0.8





- the COMPASS tokamak [2] is a compact size tokamak operated at IPP Prague
- fields of research: H-mode physics, physics of plasma edge, plasma-wall interaction, physics of runaway electrons [3] and disruptions etc.

R [m]	a [m]	I_p^{max} [kA]	B_T [T]
0.56	0.23	400	0.9-1.6

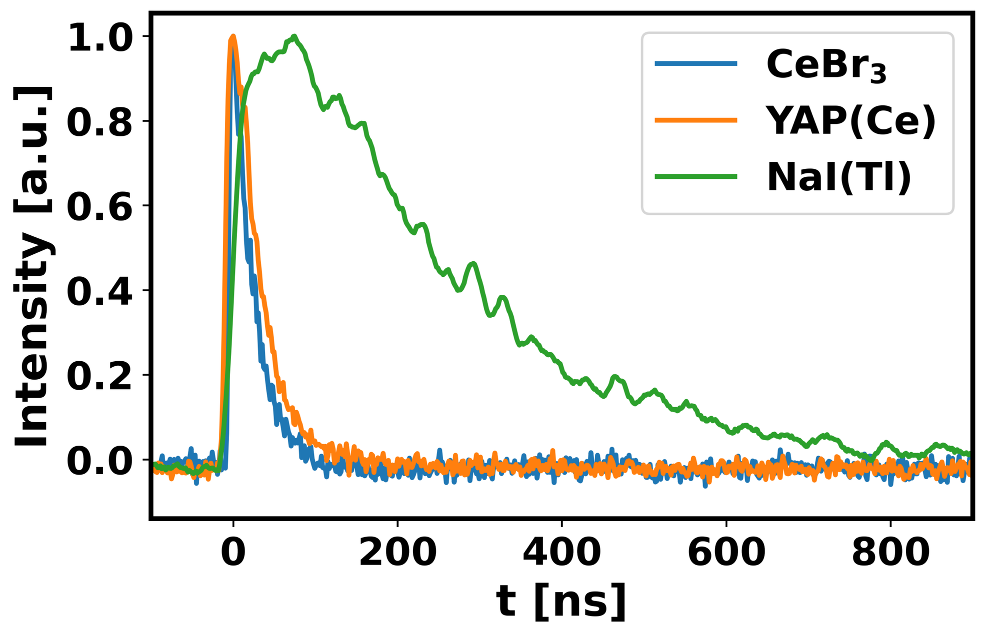
HXR detectors

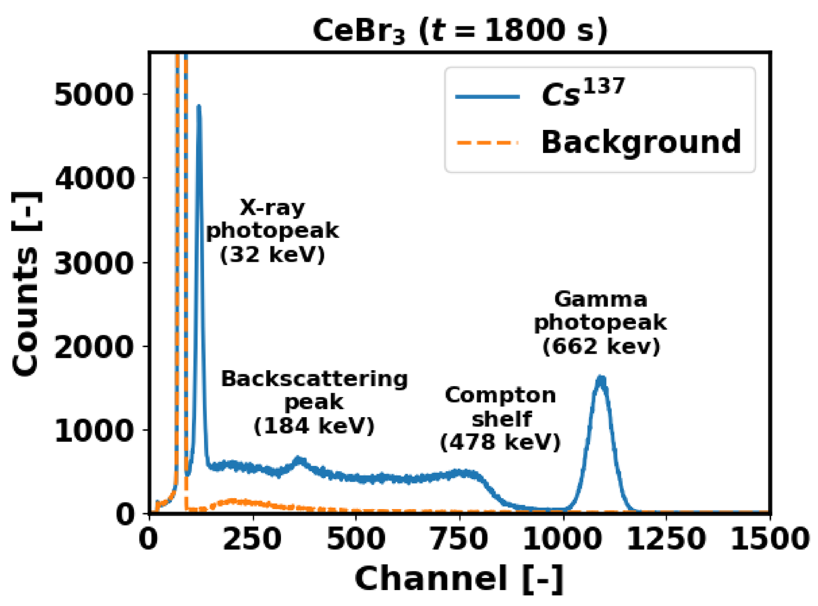
Scintillation material	Size	PMT type
NaI(Tl)	2"x2"	N/A*
YAP(Ce)	1"x1"	Hamamatsu R6094
NaI(Tl)	2"x2"	ET Enterprises 9266B
$CeBr_3$/YAP(Ce)	1"x1"	Hamamatsu R3998-02
$CeBr_3$/YAP(Ce)	1"x1"	Hamamatsu R1234A

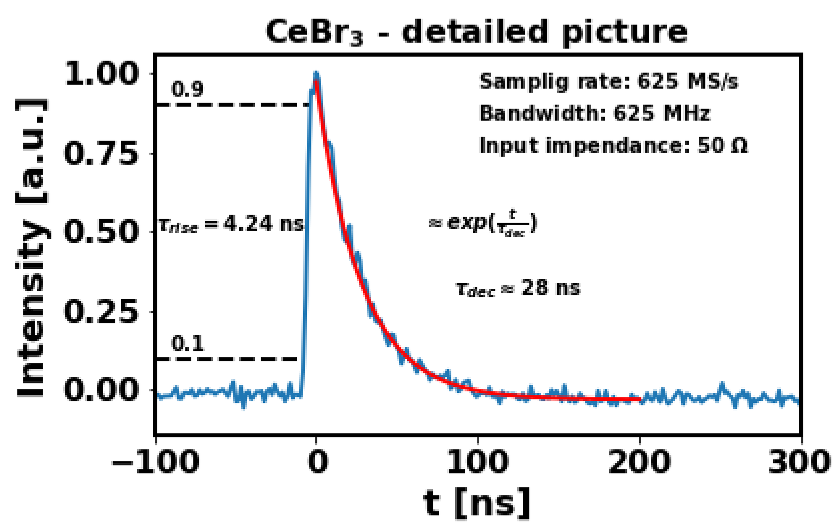
*Detector type: Envinet SNG.D40.0.2DN (PMT: 126512)

- up to 5 scintillation detectors of various size and type can be operated at same time
- → diagnostic capabilities enhanced by purchase of $CeBr_3$ scintillators (produced by Scionix)

- $CeBr_3$ has approximately ten times faster decay time than NaI(Tl) with better energy resolution
- → higher count rates possible (up to few of MHz)
- example of Cs^{137} spectrum recorded by $CeBr_3$ detector, where all features can be easily recognized
- → energy resolution: 5%@662 keV







Data acquisition system: Tektronix MSO58	
Sampling rate	2 GS/s*
Number of channels	8
Record length	500 Mpts
Bandwidth	1 GHz
Vertical resolution	12 bit**
Input impedance	50 Ω (1 MΩ)

* in experiment usually used $\leq$ 625MS/s
** up to 16 bit in High Resolution mode

- full waveform recorded and data processed offline after discharge
- → high requirement on size of storage and post-processing ($\approx$ 1 Gbyte per channel)

- during an experiment PMT voltage has to be adjusted to cover expected energy range and optimize to prevent non linearity response of PMT

Acknowledgement

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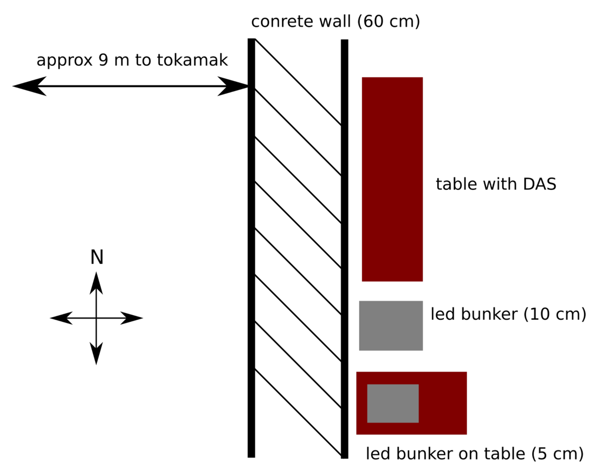
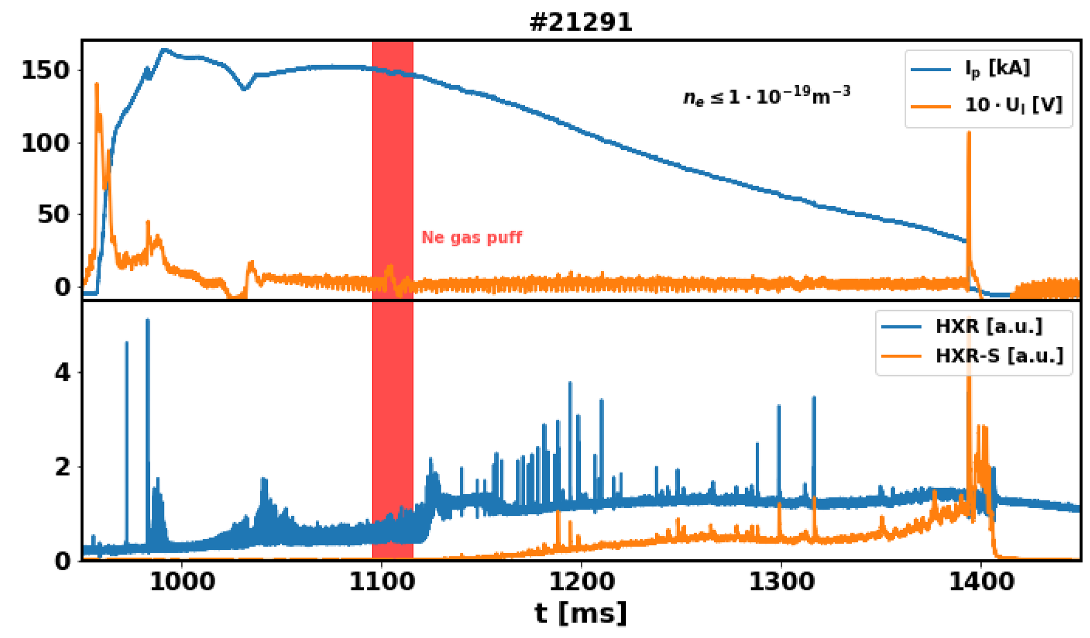
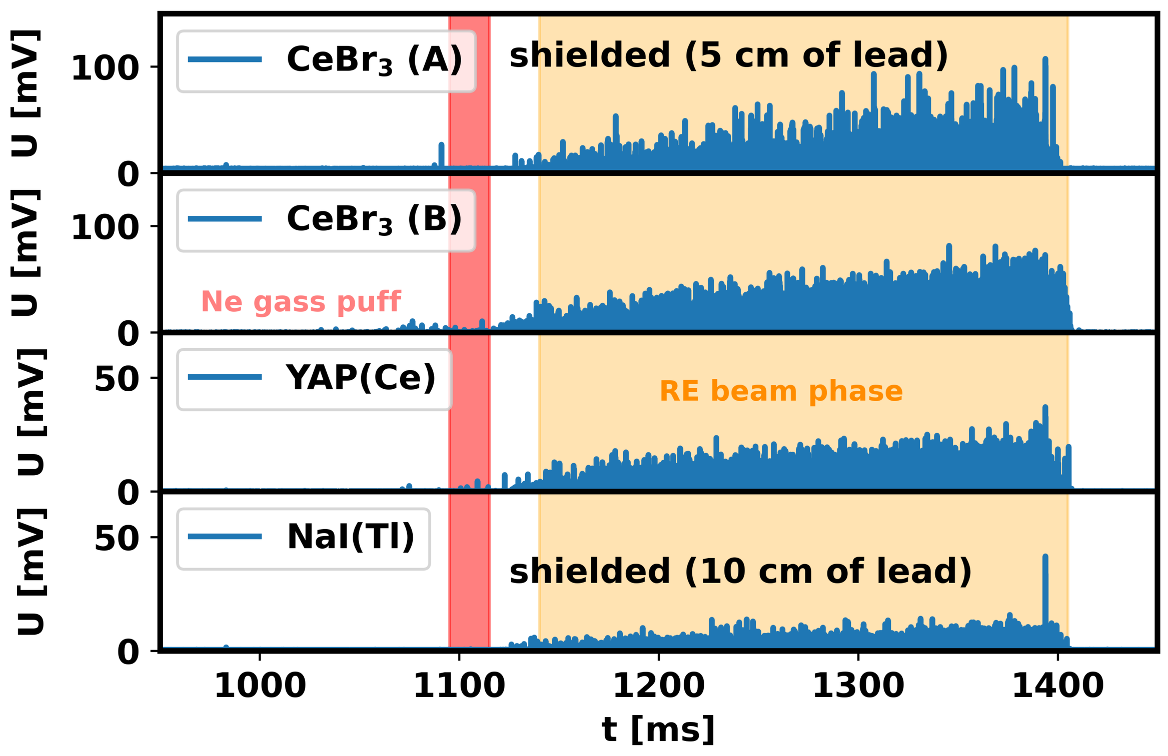
Experiments at COMPASS

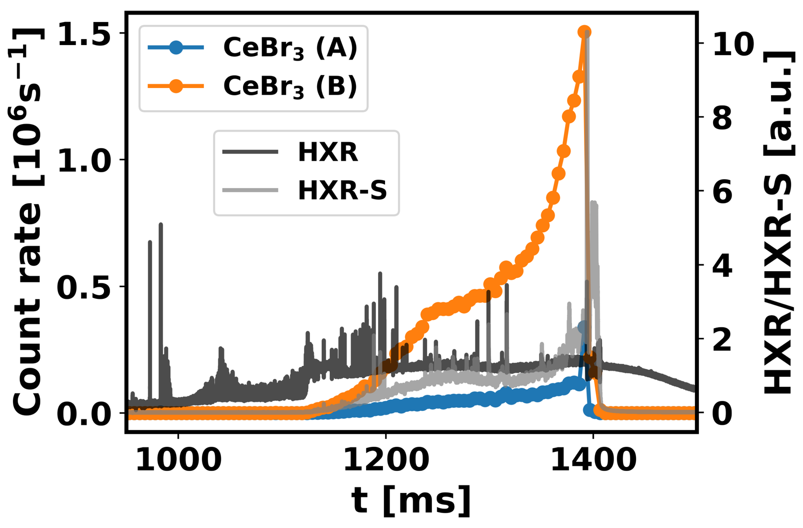


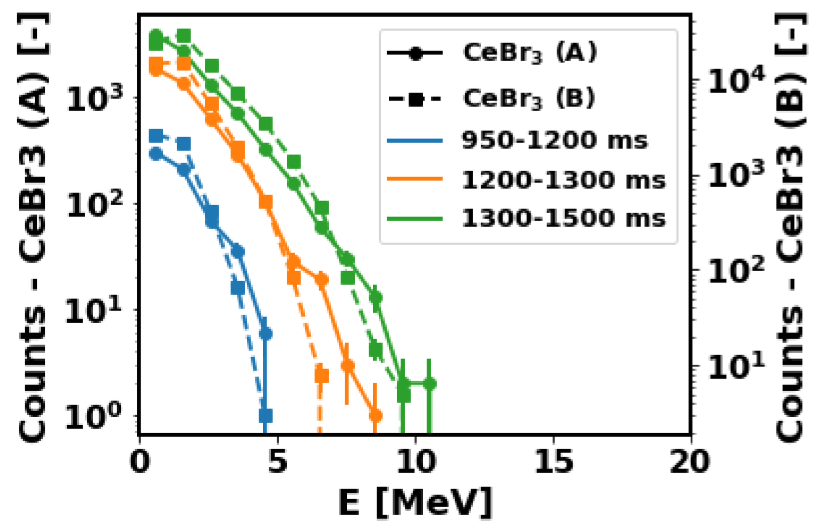


- scintillation detectors located outside tokamak hall, protected from high photon flux

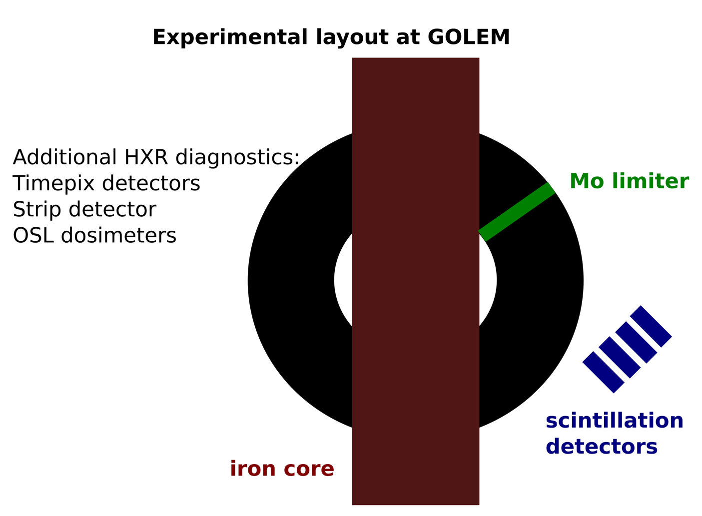


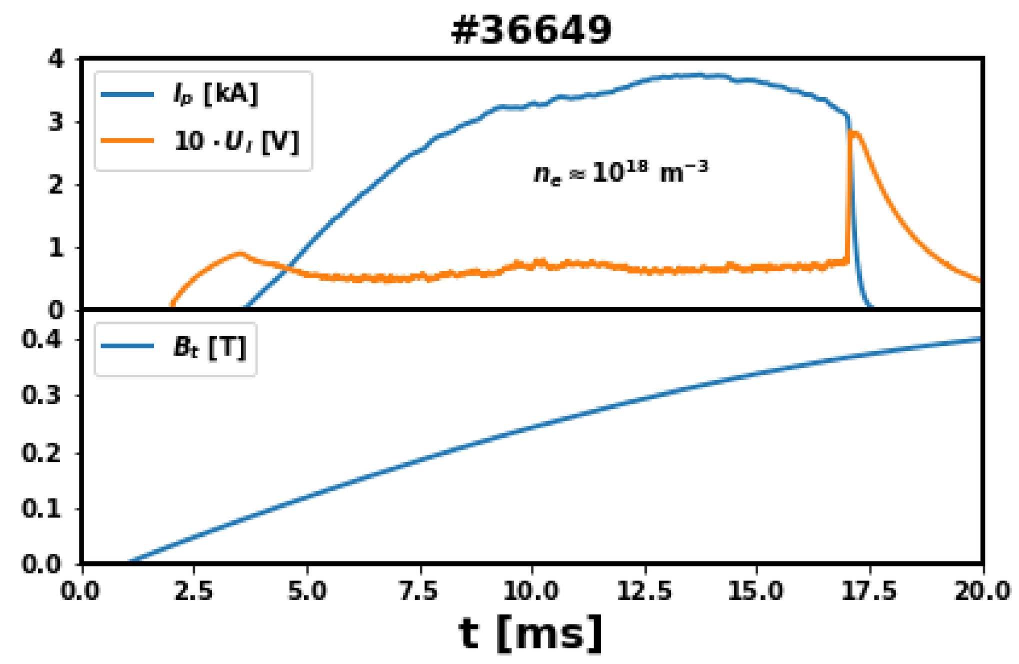
- HXR radiation detected mainly during RE beam phase
- estimated count rates in a range of few MHz
- → evolution similar to HXR-S detector
- spectra from $CeBr_3$ spectrometers in a good agreement
- → photons up 10 MeV registered

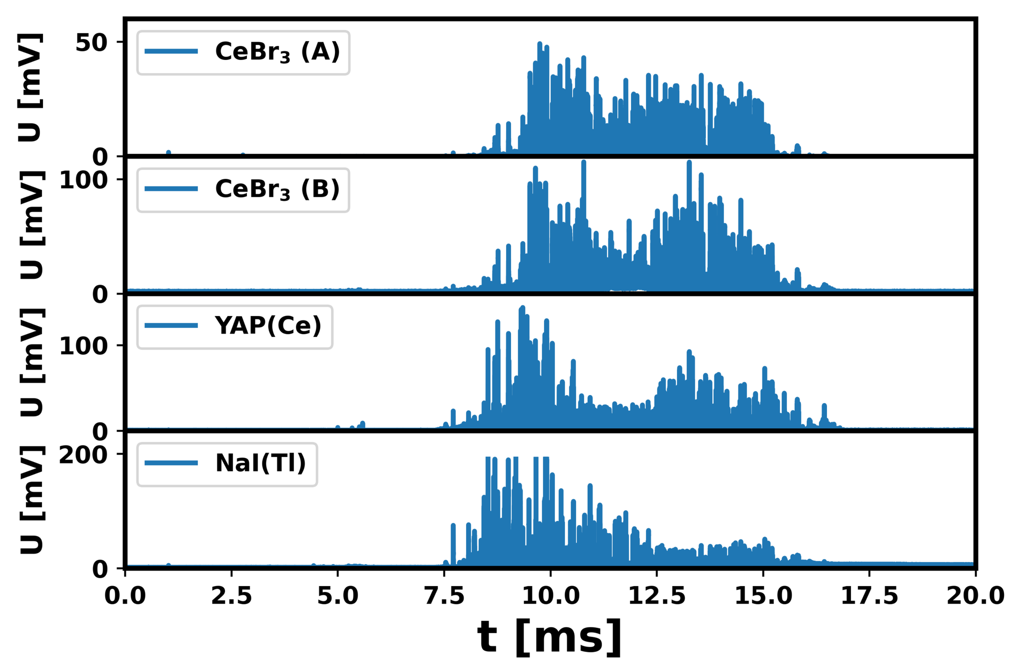




Experiments at GOLEM







- set of a detectors routinely used at GOLEM tokamak for monitoring HXR radiation
- favourable conditions for RE generation at GOLEM
- → high toroidal electric field $E \approx 4$ V/m
- → low plasma density $n_e \approx 10^{18}$ m^{-3}

Conclusion and outlook

- installed scintillation detectors during RE campaign at COMPASS tokamak greatly extends diagnostic capabilities of standard RE diagnostics
- → estimation of count rate ($\approx n_{RE}$) and maximal detected photon energy ($\approx E_{RE}$)
- experimental setup at GOLEM needs to be optimized to provide useful information about RE dynamics
- for further interpretation of data and optimization of experimental setup MC transport code (FLUKA) will be used

References

[1] Svoboda, V. et al. Jour. Fus. En. 2019 38.2 253-261
[2] Panek, R., et al. Plasma Phys. Control. Fusion 2016 58 014015.
[3] Mlynar, J., et al. Plasma Phys. Control. Fusion 2018 61.1 014010.