Introduction
The hot intra-cluster medium (ICM) is rich in heavy elements (mostly from O to Ni), which are synthesized in Type Ia (SNIa) and core-collapse (SNcc) supernovae explosions. These metals accumulate over time into the deep gravitational potential well of galaxy clusters and groups since the major cosmic epoch of star formation (z ~ 2–3).

However, the SNIa explosion mechanisms (each predicting different yields) are not well constrained, while the SNcc yields depend on the initial mass function (IMF) and initial metallicity of their stellar progenitors.

Therefore, measuring the abundances in the ICM may provide valuable constraints on theoretical models for SNIa and SNcc.

Methods & Materials
Using the XMM-Newton EPIC and RGS instruments, we measure the abundances of 9 key elements (O, Ne, Mg, Si, S, Ar, Ca, Fe and Ni) in a sample of 44 nearby cool-core galaxy clusters/groups (the CHEERS catalog, ~4.5 Ms net exposure; de Plaa et al., to be submitted).

The RGS spectra are used to derive the O/Fe and Ne/Fe ratios. The EPIC spectra are used to derive average Cr/Fe and Mn/Fe abundances (Fig. 1). In particular, this is the first time that Mn is detected and robustly measured in the ICM.

Moreover, our large dataset allowed us to derive average X/Fe abundance pattern, representative of the nearby ICM as a whole. We address a careful attention to all the possible systematic, which we keep under control.

We then compare our average X/Fe abundance pattern with theoretical predictions of SNIa (Iwamoto et al. 1999) and SNcc (Nomoto et al. 2013) yields. We find that these classical yields models fail to reproduce our abundance ratios (Fig. 2), regardless of the assumptions made for the SNcc explosion mechanism (deflagration vs. delayed-detonation) and for the SNcc IMF and initial metallicity. In particular, the Ca/Fe and Ni/Fe ratios are clearly underestimated (see also de Plaa et al. 2007).

Current limitations & Future prospects
Because the systematic uncertainties largely dominate over the statistical uncertainties, stacking more observations will not help further to improve the accuracy of our results. Therefore, our sample constitutes the most accurate abundance estimates ever performed in the nearby cool-core ICM so far, and should be a legacy for any related future work.

A significant improvement to this study will be achieved by:
1) improving the predicted yields models for both SNIa and SNcc, as well as their uncertainties,
2) reducing the uncertainties in measuring the abundances, in particular thanks to the microcalorimeter technology onboard the next-generation X-ray missions (e.g. Athena, Fig. 4),
3) in parallel, keeping efforts on improving the atomic databases and plasma codes,
4) carry out new independent observations on SNIa and SNcc (including Ca-rich gap transients), in order to constrain their rates and their underlying physics.

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See talk by Jelle de Plaa! (Wednesday, 11:25)