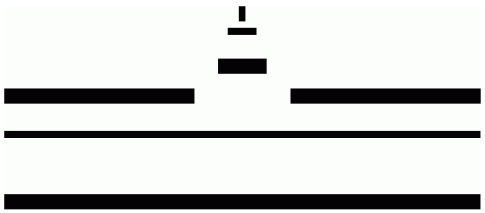
Gas Analysis and Purification for the Xenon Dark Matter Project

Hans Kettling



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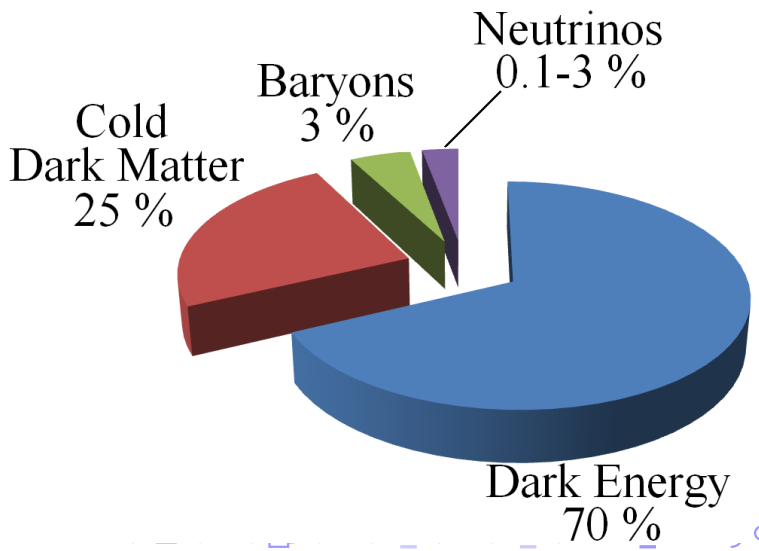
Contents

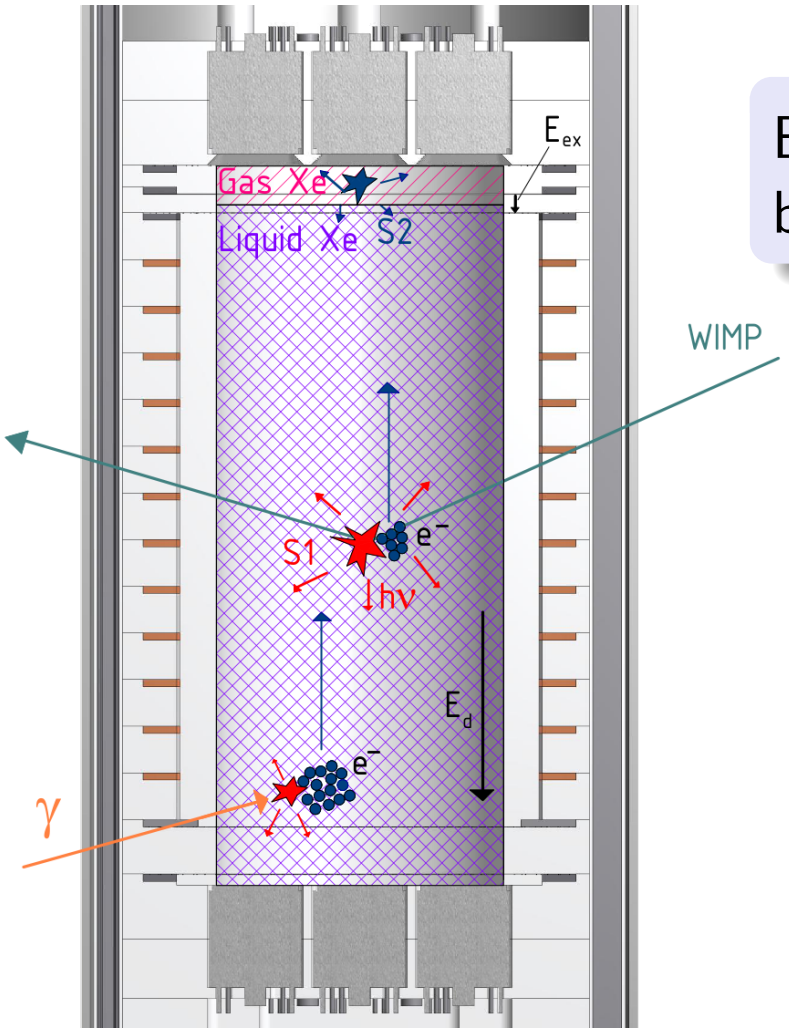
Xenon Dark Matter Project

Dark Matter is a thermal relic of the Big Bang

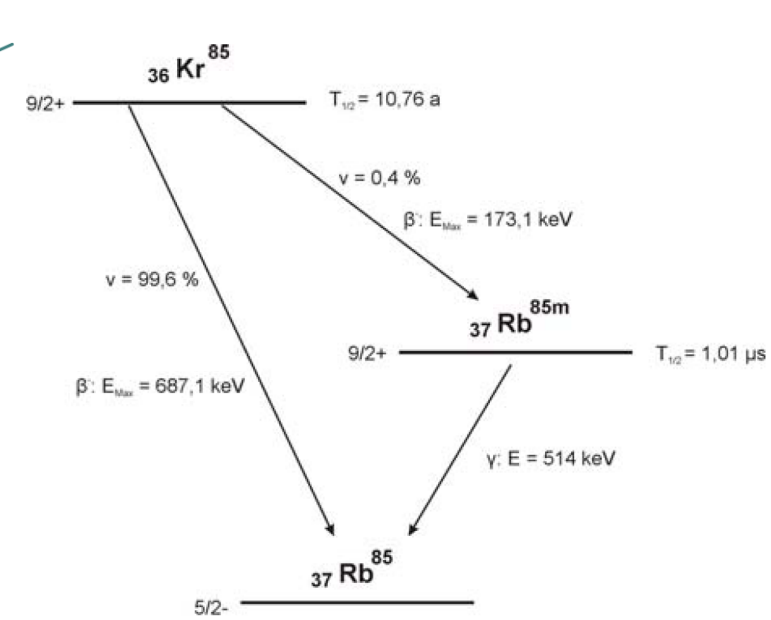
- Only weak interaction with ordinary matter
- Liquid noble gas detectors are extremly powerful for Dark Matter detection
- The XENON Experiment uses a 2-phase time projection chamber filled with liquid Xenon to look for Dark Matter in form of Weakly Interacting Massive Particles (WIMPs)



Münster´s TPC



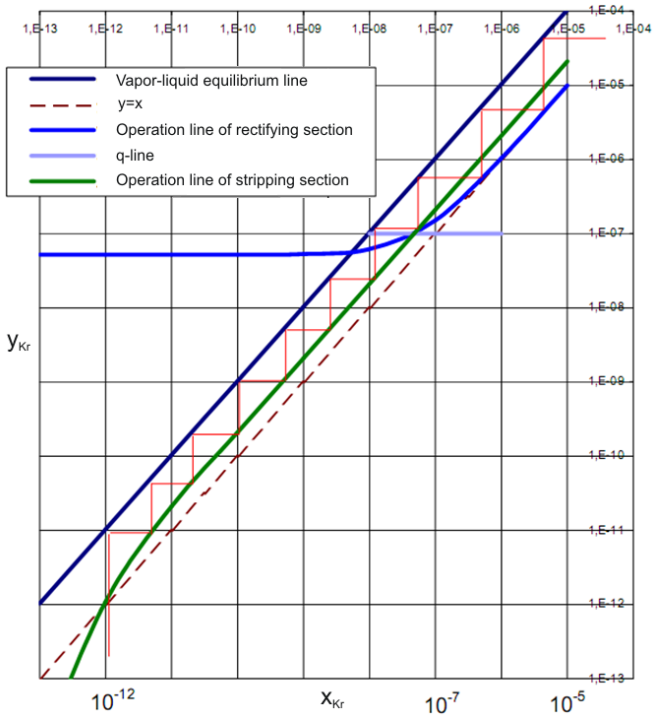
Beta decay of ^{85}Kr is a known background.



^{85}Kr Reduction

Cryogenic distillation:

- Aim: 0.5 ppt of Kr/Xe
- Reduction by 10^5
- $H = N_{th} \cdot HETP$[1]



[1]Height Equivalent for one Theoretical Plate

Gas Analysis via Mass Spectrometry

Detection:

Noble gases like Krypton and Xenon are hard to detect

→ Atom Trap

→ Mass Spectrometry

Idea:

Use a quadrupole mass filter to identify Krypton by its mass

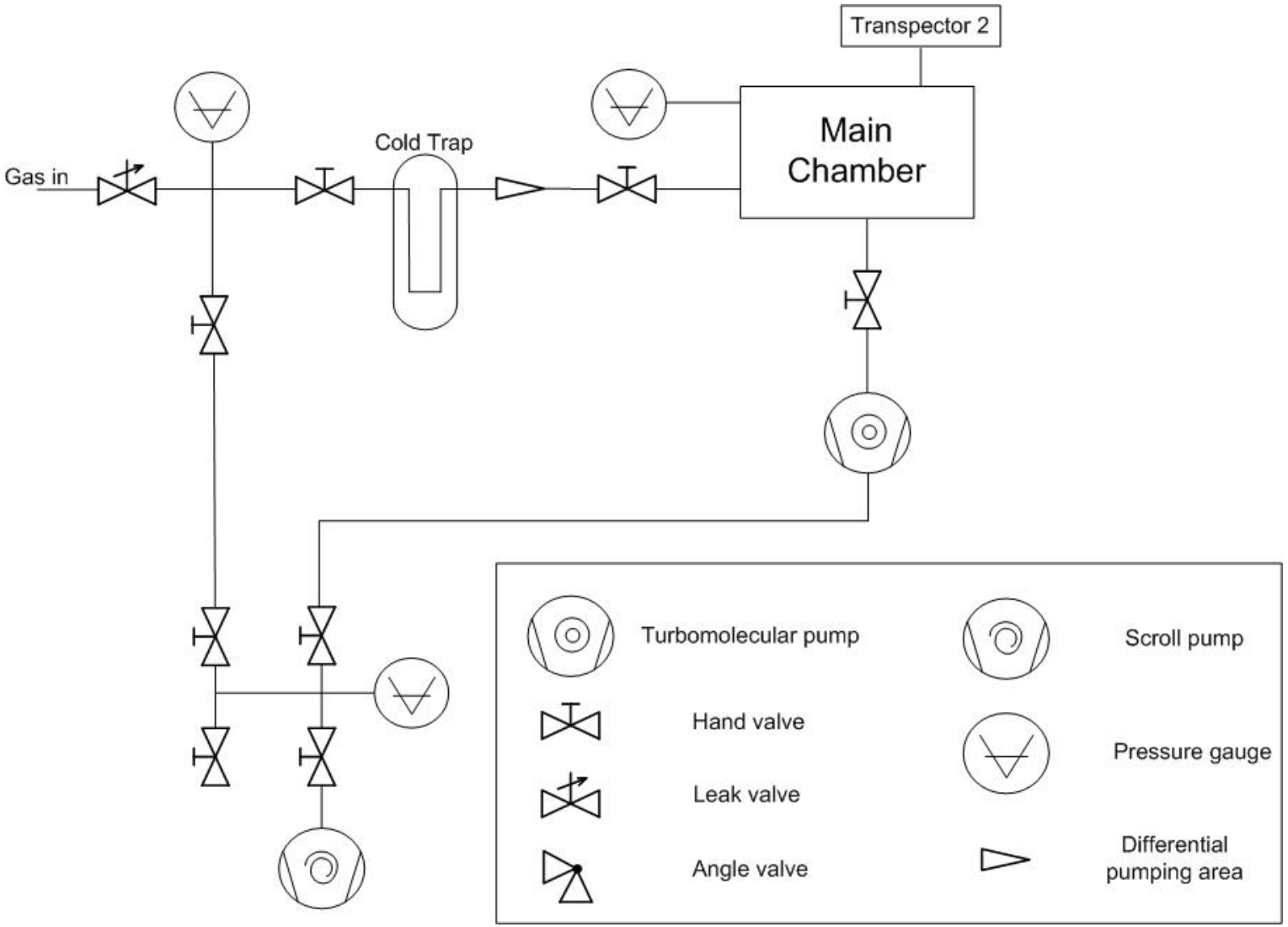
Problem:

Saturation of quadrupole mass filter

→ Gas chromatography

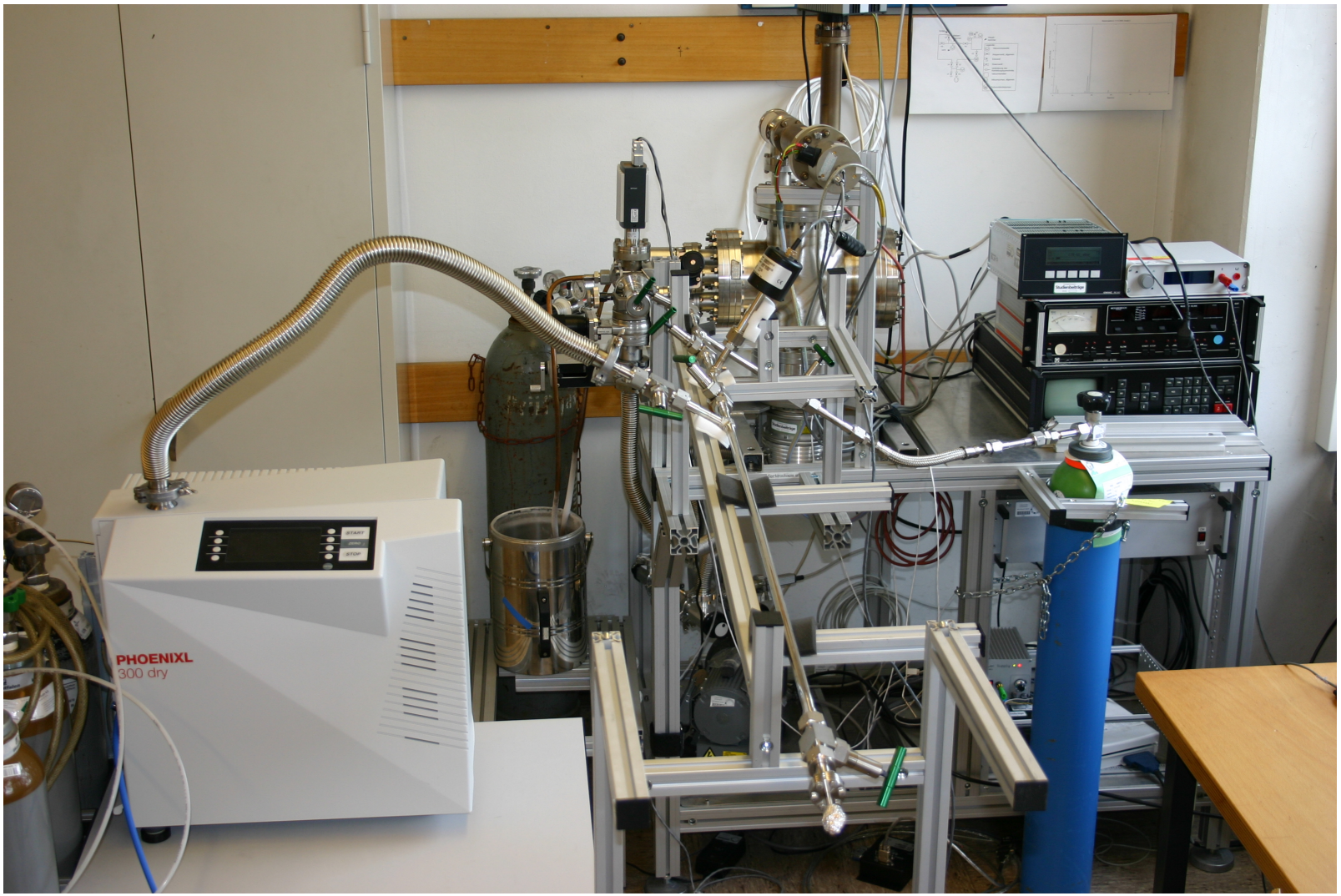
→ Cold traps

Experimental setup



Idea: A. Dobi et al., arXiv:1103.2714, arXiv:1106.1812, arXiv:1109.1046

Experimental setup

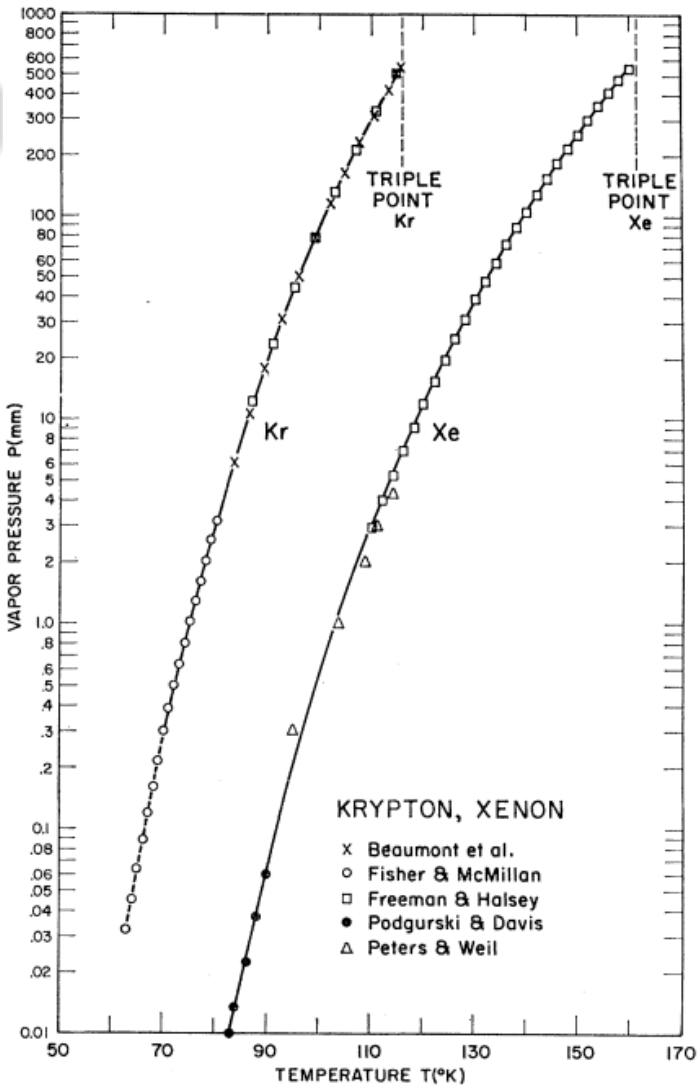


Thermodynamics – Vapour pressure

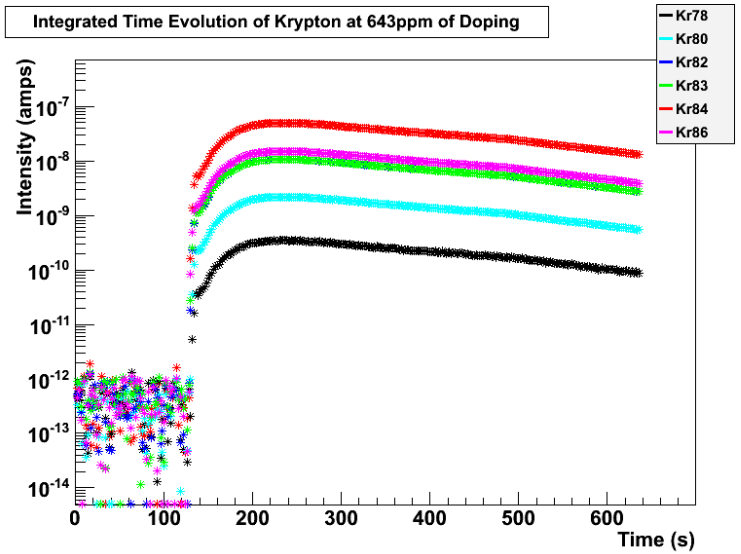
What happens inside the cold trap?

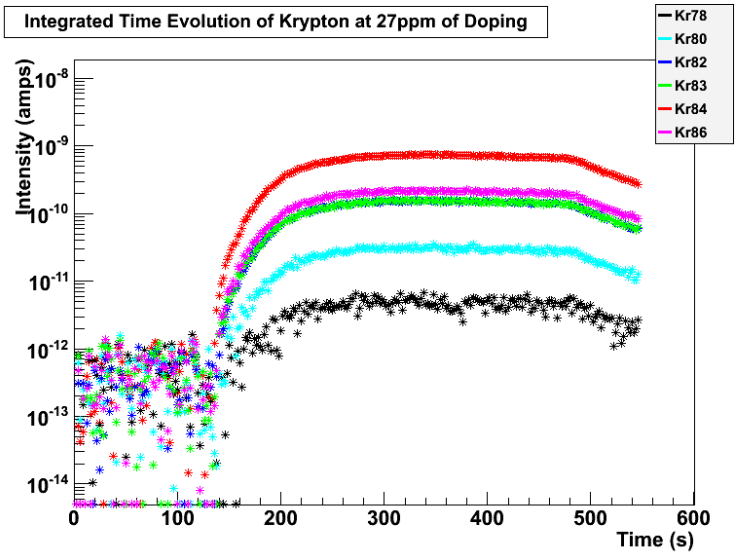
Gas	Sdp [K]	Smp [K]	$p_{vapor}^{T=LN_2}$ [mbar]
N_2	77.4	63.1	10^3
Kr	120.0	116.0	≈ 2
Xe	165.1	161.4	$2.4 \cdot 10^{-3}$
Ar	87.3	83.8	≈ 250
O_2	90.2	54.8	$10^2 - 10^3$
CH_4	111.7	90.1	≈ 10

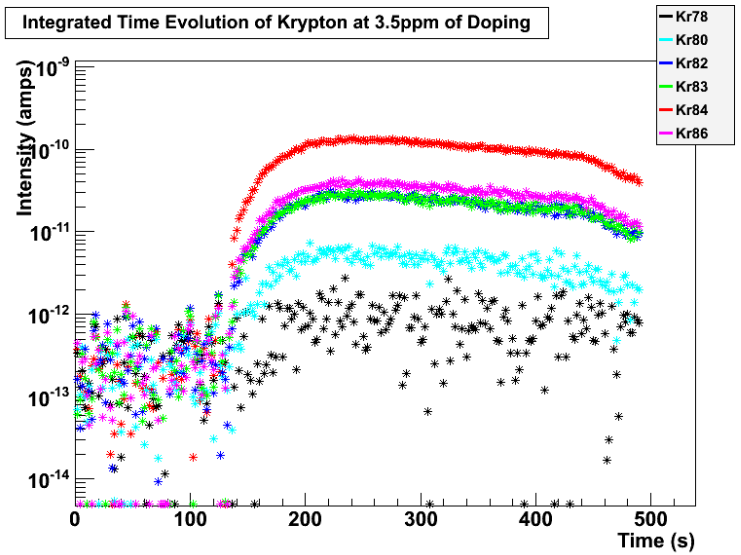
Table: Selection of melting and boiling points as well as vapor pressures at T=77.3 K [Jou04][Leo10][Pol64].

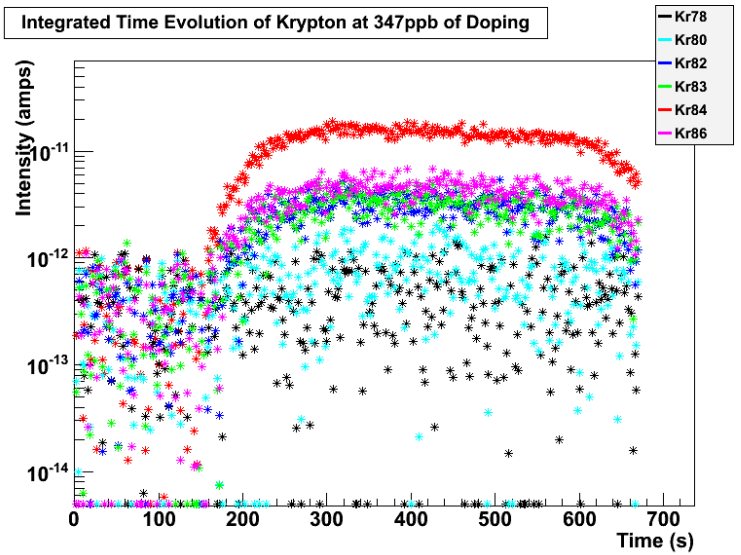


Preliminary Results

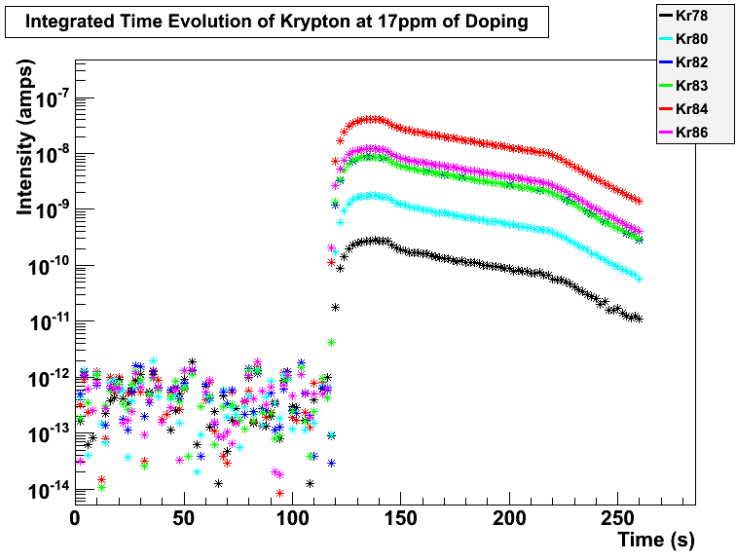


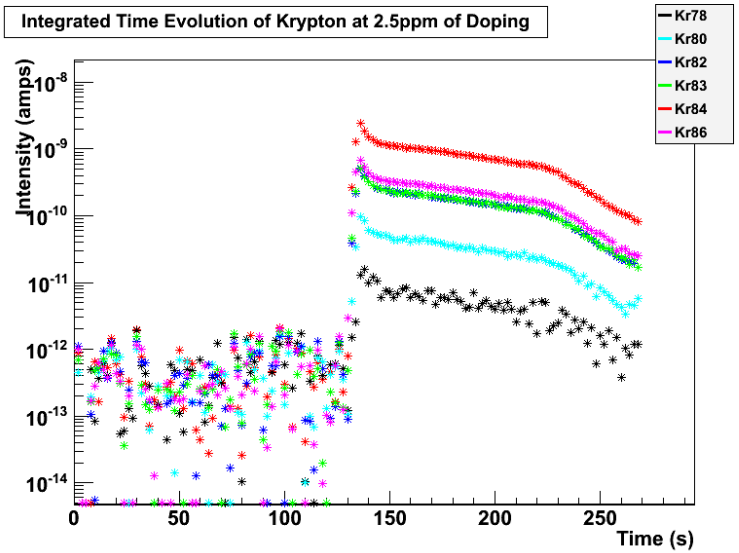


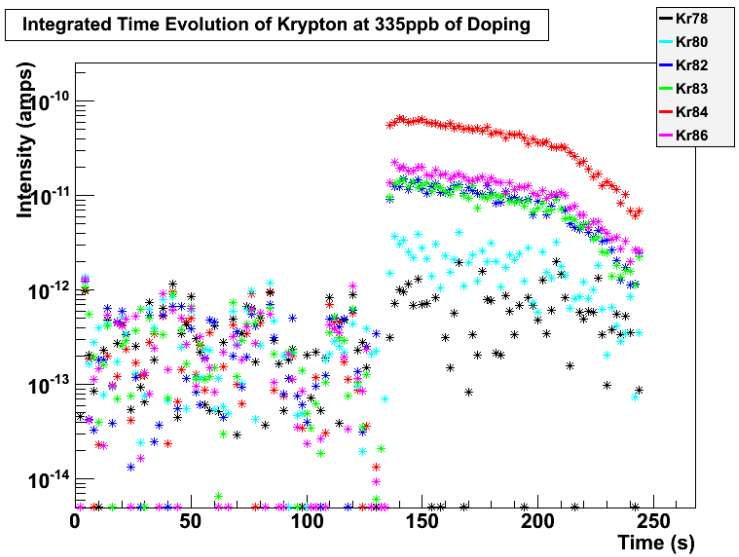


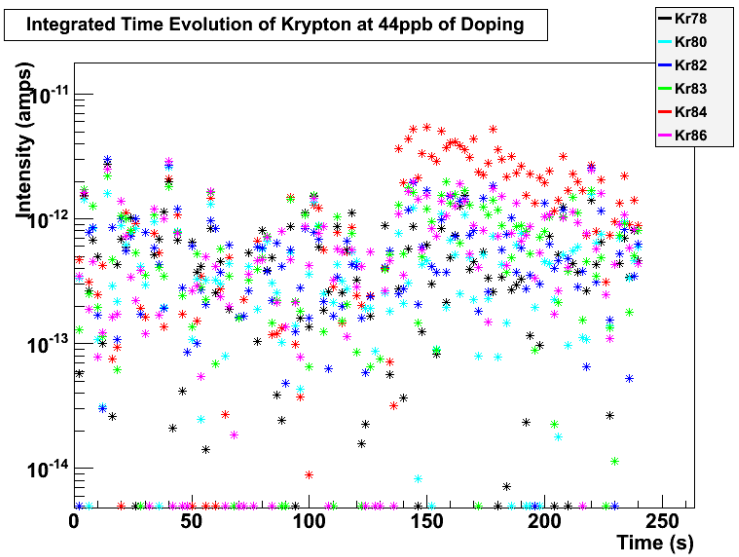


Preliminary Results — Higher Flow Rate









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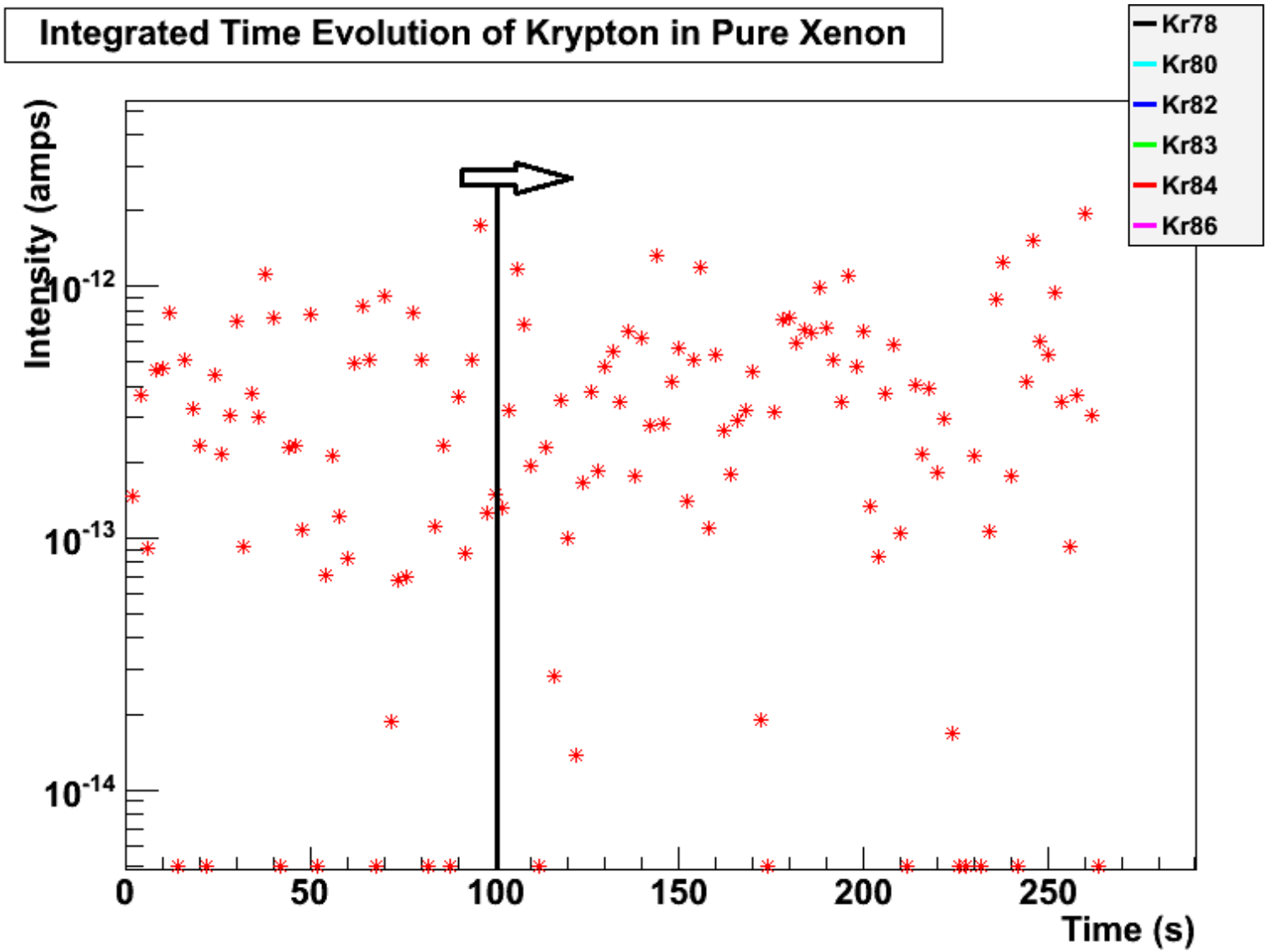

Conclusion

Conclusion:

- ppb level is achieved
- Only small samples needed
- Non-destructive method

Outlook:

- Minimize systematics
- Implement mass spectrometry into the gas system
- Developing a new kind of cold trap
- Recover the Xenon from the cold trap

The End

bmb+f - Förderschwerpunkt Astroteilchenphysik
Großgeräte der physikalischen Grundlagenforschung

Deutsche Forschungsgemeinschaft
DFG

Thank you very much for your attention.

The XENON Collaboration

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