POLARIS

POLarized **T**arget **A**dvancements
Refinements and **I**nnovation**S**

Town Meeting
Hadron Physics in Horizon Europe
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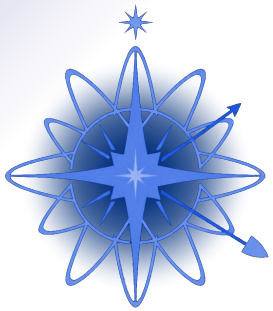
IMT Atlantique

Presenter:
Victoria Lagerquist

Victoria Lagerquist, Stefan Goertz (Uni Bonn), Gerhard Reicherz (RUB), Andreas Thomas (KPH Mainz), Giuseppe Ciullo (INFN Ferrara), Dan Watts (York)



Polarized Target Advancements Refinements and Innovations:

The **POLARIS** consortium aims to significantly progress fixed polarized target (PT) experiments by improving accuracy, performance, and versatility.

We hope to ***advance*** high-temperature superconductors for magnetic field generation, ***refine*** polarized solid-state target materials, and ***innovate*** novel hyperpolarization techniques.

These initiatives bring together five projects across six institutions as well as reach across fields into medical physics and clean energy development.

Institutions:

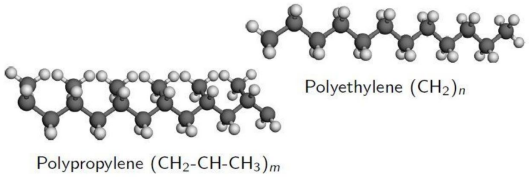
- ***University of Bonn*** *(Bonn)*
- ***Ruhr-Universität Bochum*** *(Bochum)*
- ***Johannes Gutenberg University*** *(Mainz)*
- ***University of Ferrara, INFN*** *(Ferrara)*
- ***University of York*** *(York)*

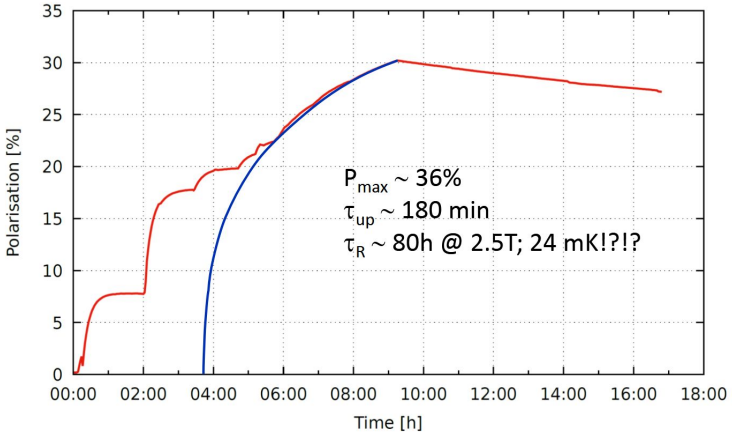
Transnational Access Infrastructures:

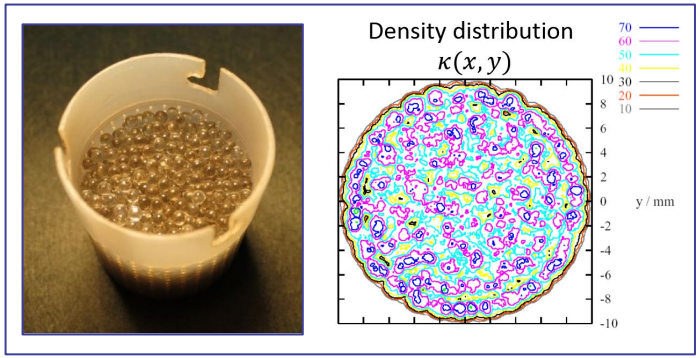
- ***ELSA***
- ***MAMI***
- ***CERN***
- ***JLab***

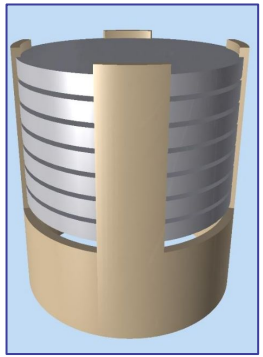
Polarized solid-state target materials: C_mH_n chains

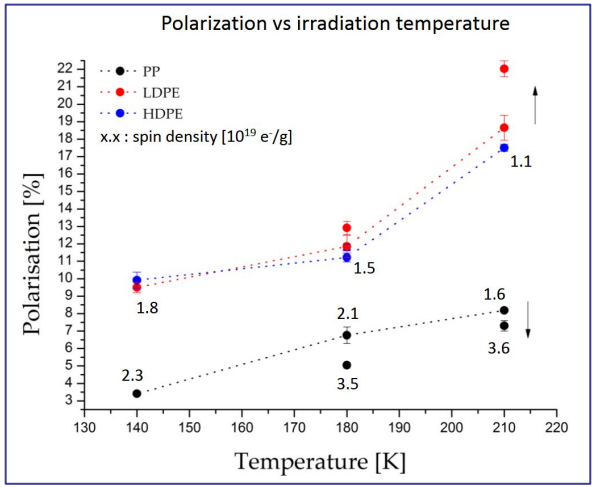
- Debated as targets for 30+ years
- Advantages
  - Filling Factor
  - Handling
  - Geometry
- New opportunity at Uni Bonn: Test under realistic experiment conditions
- Achieving high polarization would be a major advance towards an ideal target



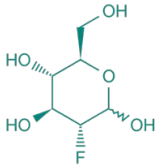




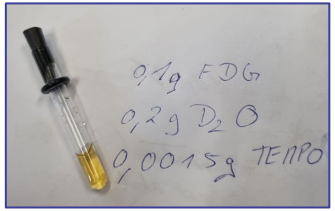


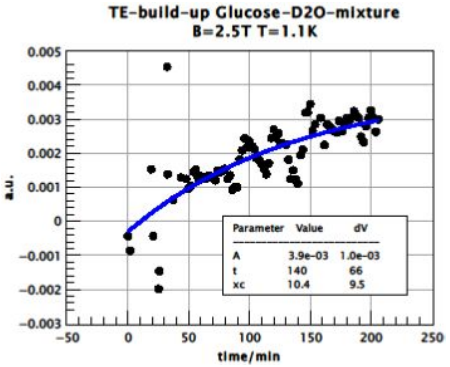


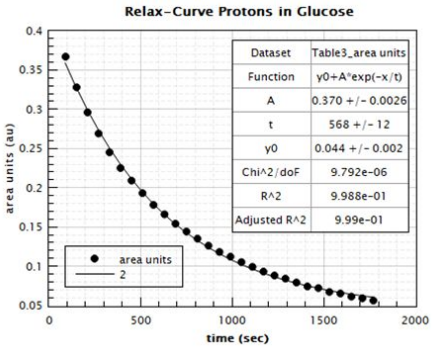
Polarized solid-state target materials: Fluorinated Hydrocarbons

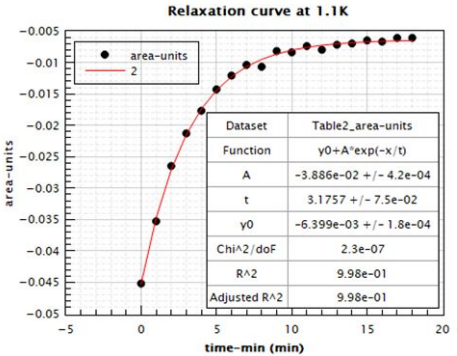


- High nuclear polarization is vital for advanced nuclear physics.
- Radiation Detected NMR (RD-NMR):
  - Boosts conventional NMR sensitivity by up to 10 orders of magnitude using asymmetric decay.
  - Enables ultra-precise measurement of unstable nuclei magnetic moments.
  - Holds potential for new medical imaging with biologically active nuclei (18F, 11C).
- Dynamic Nuclear Polarization (DNP): Growing interest in the NMR/MRI community for significantly enhancing sensitivity and resolution of conventional NMR.
- Proven expertise in RD-NMR and DNP, with support from CERN medical applications funding.



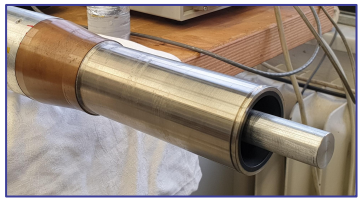


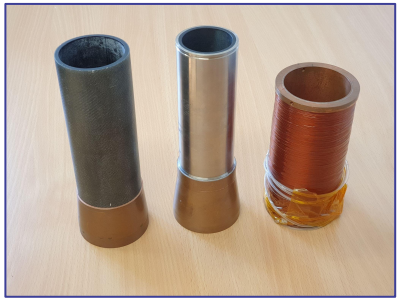




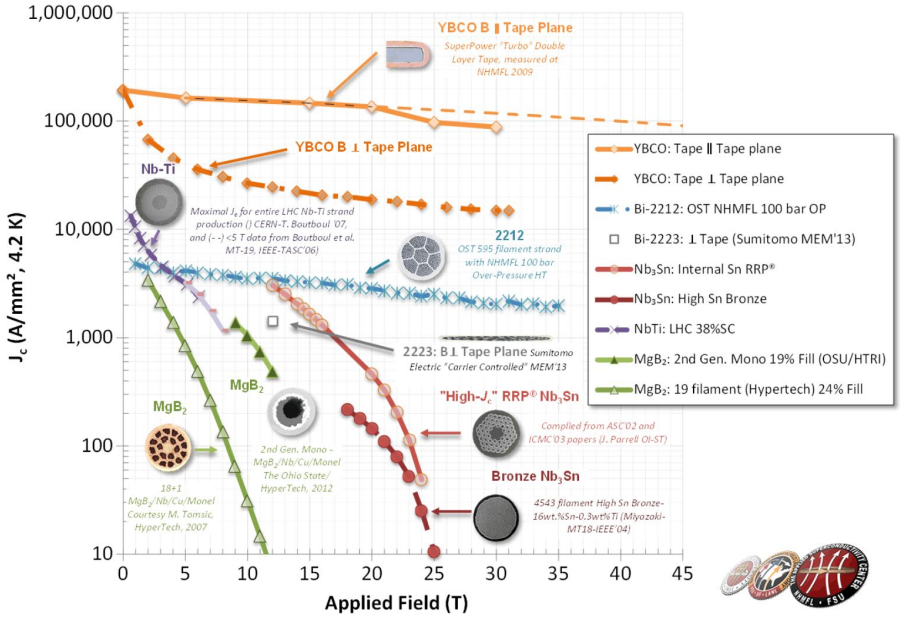
High-temperature superconductors: BISCO and YBCO

- Current targets use coils, increasing heat load and limiting field flexibility
- CryPTA explored HTS (BISCO, YBCO) to supplement coils via shielding
- We propose using HTS as primary "frozen spin" fields, removing traditional coils
- Testing will use Mainz materials and Bonn's cryo-magnetic infrastructure





Taken From:
Annual meeting of the STRONG 2020 Joint Research Activity "*Cryogenic Polarized Target Applications*" (WP28)

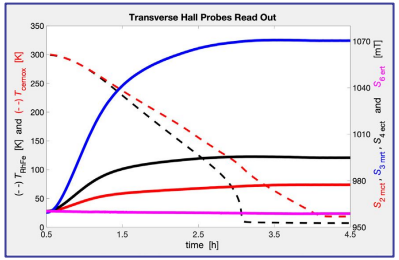


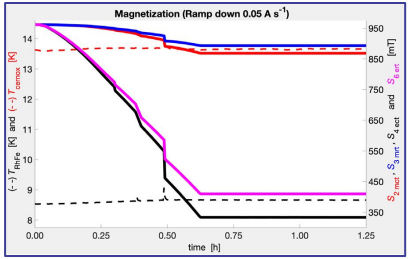
HIM Helmholtz-Institut Mainz

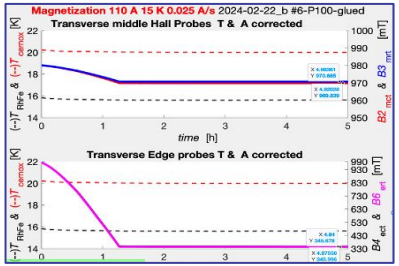
L. Capozza, A. Dbeyssi, **F. Maas**, B. Froelich, M. C. Mora Espi, O. Noll, Y. Wang, D. Lin – 22.09.2022, Mainz
Helmholtz-Institut Mainz, Institute of Nuclear Physics,
Johannes Gutenberg University, Prisma Cluster of Excellence

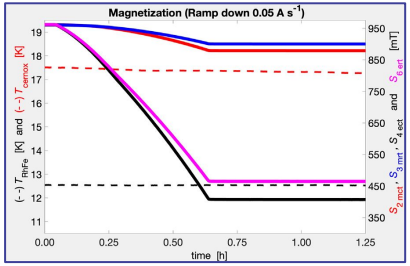
High-temperature superconductors: MgB_2

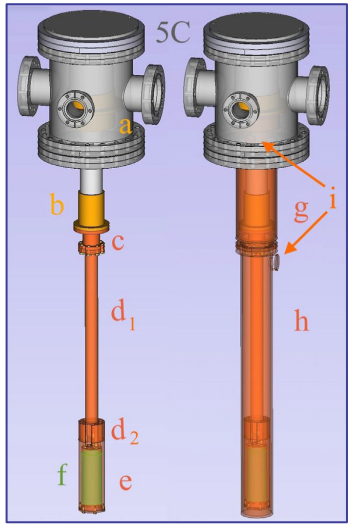
- Magnesium Diboride (MgB_2) is a promising superconductor: easily shaped, 39 K critical temperature, magnetic field holding and blocking proven
- System in Ferrara: 8 K temperatures, 1.2 T fields, 1-day turnaround, detailed mapping
- Key to developing polarized fusion fuel and exploring polarized nuclear targets.

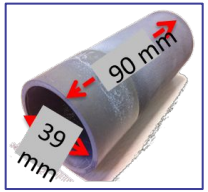


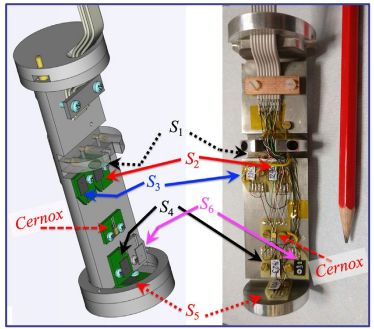


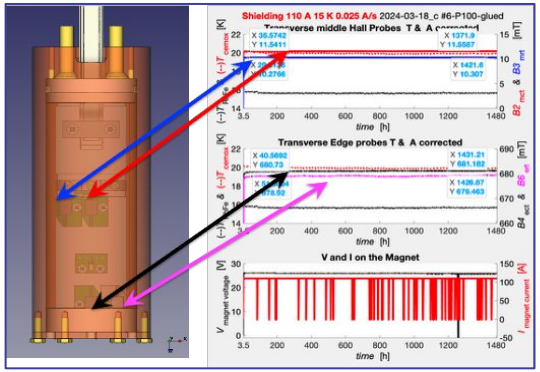


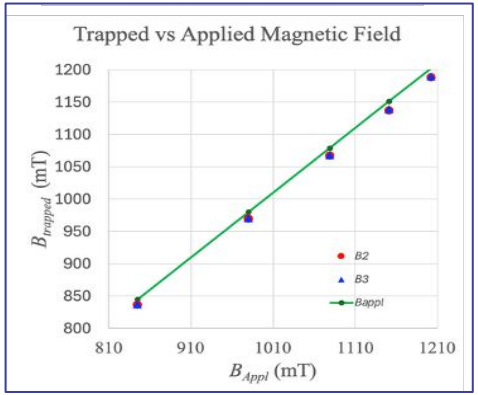






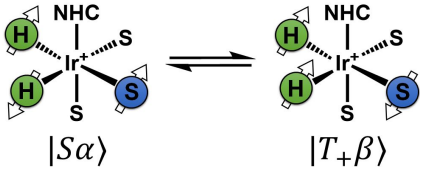




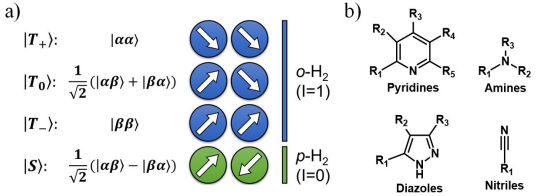


Chemical hyperpolarisation (ChHP)

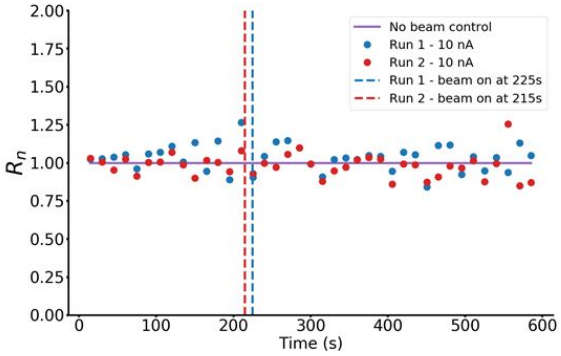
- Novel, room-temperature method to polarize nuclei in liquid targets using parahydrogen, cm³ volumes proven
- Continuous polarization and longer relaxation times show promise
- Deployment in EU infrastructures, foster collaboration with beam/target experts
- High-intensity electron beams (JLAB, MESA, MAMI) and ionizing environments where cryogenics are ineffective



Spin transfer mechanism with SABRE ChHP. Conversion of para-H2 to ortho-H2 and polarization of an unpolarized spin.

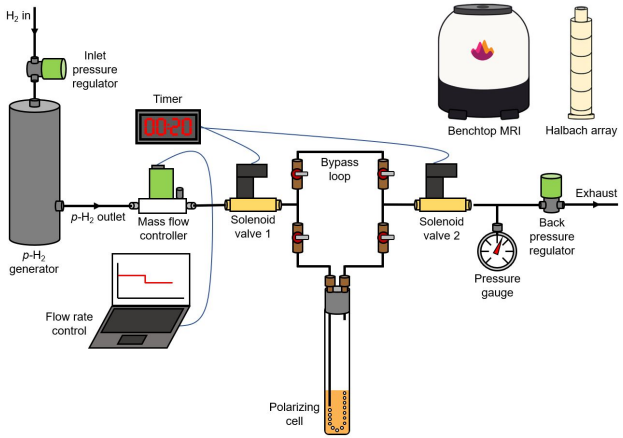


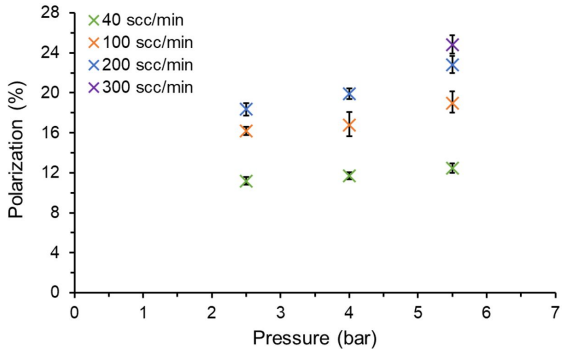
a) Spin states of H_2. b) Example classes of molecule polarizable by SABRE ChHP.



In-beam polarization decay results from MAMI, showing no increase to the relaxation rate.

Prototype SABRE ChHP target apparatus.





Performance of prototype polarized target with varying pressure and flow rate within the polarization cell.

€200k:

- €35k: Conference organization
  - Two workshops during funding period
- €165k (shared between 5 projects):
  - Travel between consortium institutions
  - Personnel (undergraduate and graduate students)
  - Consumable material investments

Annual meeting of the STRONG2020 Joint Research Activity **CryPTA** "Cryogenic Polarized Target Applications" (WP28) 2022

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THANK YOU

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