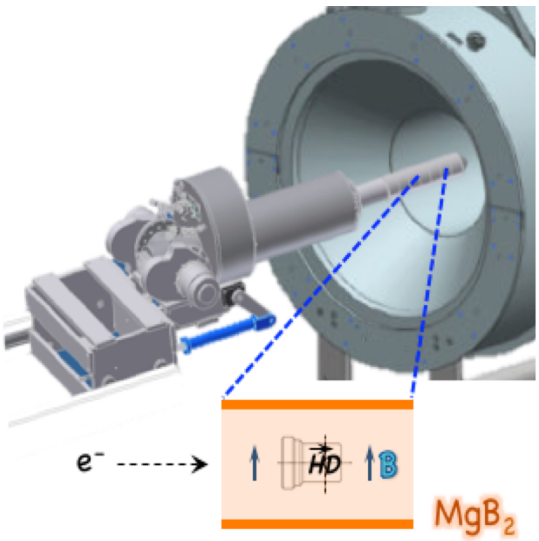
CLAS12 – Transversely Polarized HDice



A transversely polarized hydrogen target is under development for use with CLAS12. The target material, molecular HD in the solid phase, is polarized in the HDice Lab of Bldg. 58 by bringing the sample to thermal equilibrium at 15 tesla and 12 mK. Low level (~10^{-4}) impurities of metastable ortho-H_2 (and para-D_2) are used to catalyze the polarization and their decay to para-H_2 (ortho-D_2) leaves the HD in a true frozen-spin state. After this cycle the target is cold-transferred to the Hall and loaded into an open geometry In-Beam Cryostat (IBC), a dilution refrigerator operating at 50 mK. A short length (15–to–25 cm) holding field at 1.2 tesla is expected to be sufficient to maintain polarization with beam, and the small Field x Length product minimizes the *sheet of flame* in CLAS that arises with an electron beam in a transverse field. Operation of a transverse holding field inside the CLAS12 solenoid will be provided by a diamagnetic superconducting shell of MgB_2. This shell is energized outside CLAS12 by a warm dipole magnet exterior to the IBC, and then cooled below its critical point (39 K). The MgB_2 retains the *memory* of the transverse field and, once inside the detector, expels the longitudinal field of the CLAS12 solenoid. The proton polarization is expected to be greater than 60% and the lifetime goal is ≥1 nA-Week for a 2.5 cm long HD target.

Transversely Polarized Target – Technical Parameters

Parameter	Design Value
Polarizable target material; mass fraction	HD; 80%
Unpolarizable material; mass fraction	Al (as wire); 20%
Target dimensions	2.5 cm ∅ × 2.5 cm long
Polarization method	High-field, Low-temp equilibrium
In-beam holding field B × dL	1.2 tesla × 15 – 25 cm
H polarization	> 60%
H Luminosity	10^{33} cm^{-2} s^{-1} per 2 nA
In-beam lifetime	≥1 nA-week per target

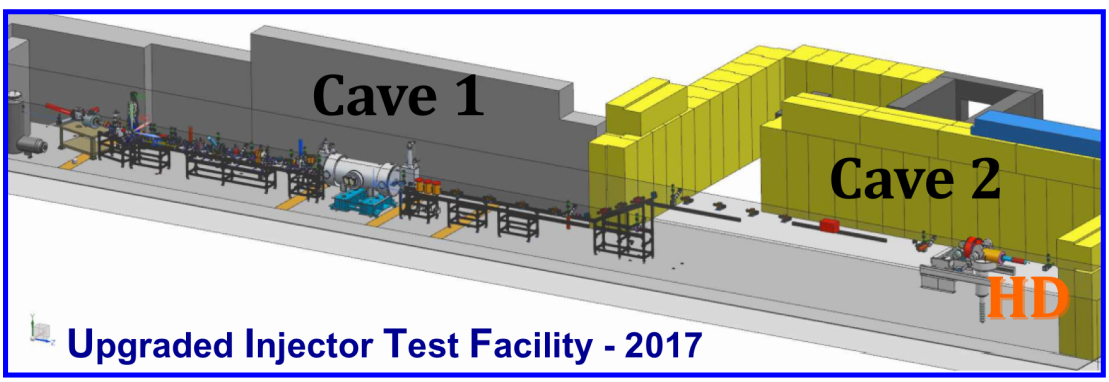
- **Construction Strategy and Project Leadership:**

I. Transversely polarized HDice is a collaborative effort between Jefferson Lab, INFN (Italy): U. Roma-II *tor Vergata* and U. Ferrara.

II. In-beam lifetime:

HD gas will be purified at the U. Roma-II *tor Vergata*. Condensation to a solid, polarization and target manipulations take place at JLab in the HDice Lab.

Tests with electrons in 2012 showed no evidence of permanent HD damage. The polarization life-time will be affected chiefly by (a) beam-on temperatures and holding fields, so that ionized/unpaired electrons are themselves polarized and (b) RF alignment of the HD spins with those of ionized electrons to eliminate hyperfine mixing. To optimize these parameters, the Laboratory is constructing a new 10 MeV **U**pgraded **I**njector **T**est **F**acility (UITF) in Bldg. 58, adjacent to the HDice Lab. (Electron energy deposition is chiefly through Møller scattering and nearly constant between 10 MeV and 10 GeV.) Although UITF construction has slowed due to budget constraints, first MeV beams are expected in Fall/2017. Tests will utilize the g14 cryostat with its 1 tesla solenoid field, and a new target cell design.



III. Transverse MgB_2 shell:

Development of the high-T_c MgB_2 shell is a collaboration between U. Ferrara and JLab, in cooperation with Edison-Milan. In recent tests at Ferrara, 1 tesla transverse fields have been repeatedly trapped in a 2/3 scale MgB_2 prototype for periods up to a month. Design of a full-scale shell is underway. After UITF studies, the IBC will be modified to incorporate a full scale MgB_2 shell.

- **Project status and significant dates:**
  - 1st MeV beams out of the new UITF ¼ Cryomodule: projected for Oct, 2017
  - 1st ~10 MeV UITF beams on polarized HD: estimated Mar, 2018

Last Updated: Mar. 24, 2017

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