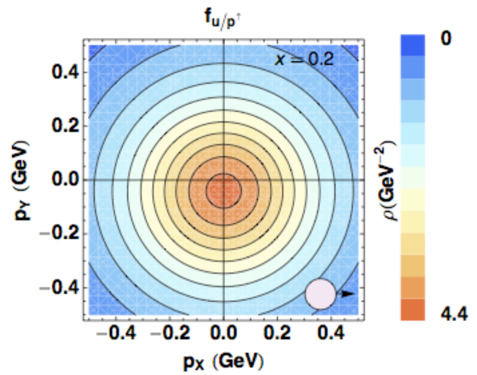
HD-ICE

JLab12, 12 Settembre 2012

Quantum phase-space distributions of quarks

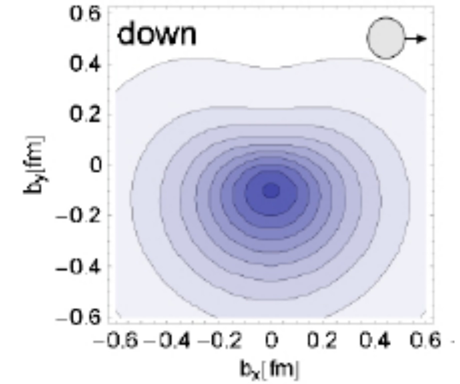
$W_p^q(x,k_T,r)$ "Mother" Wigner distributions

Probability to find a quark q in a nucleon P with a certain polarization in a position r & momentum k



d^3r

d^2k_T (FT)



TMD PDFs: $f_p^u(x,k_T)$,…

Semi-inclusive measurements
Momentum transfer to quark
Direct info about momentum distribution

GPDs: $H_p^u(x,\xi,t)$, …

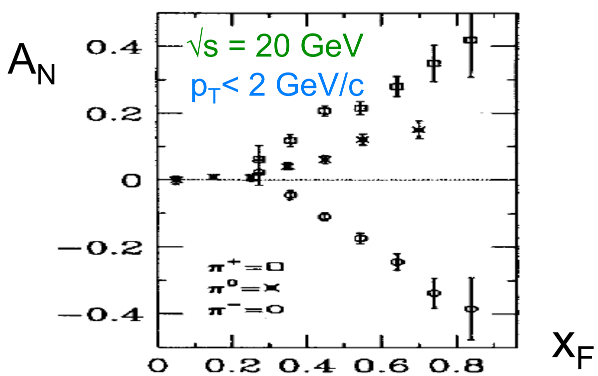
Exclusive Measurements
Momentum transfer to target
Direct info about spatial distribution

d^2k_T

$\xi=0, t=0$

PDFs $f_p^u(x)$,…

May explain SSA



C12-12-010*
Exclusive Physics: DVCS with Transverse Target
* Ferrara co-spokeperson

May solve proton spin puzzle

$$J_q = \frac{1}{2}\Delta\Sigma + L_q = \lim_{t\to 0}\int_{-1}^{1} dx\ x\ \left[H(x,\xi,t) + E(x,\xi,t)\right]$$

Leading Twist TMDs

Quark polarisation (columns) / **Nucleon** polarisation (rows)

	U	L	T
U	f_1 *Number Density*		$h_1^\perp$ *Boer Mulders*
L		g_1 *Helicity*	$h_{1L}^\perp$ *Worm-gear*
T	$f_{1T}^\perp$ *Sivers*	$g_{1T}^\perp$ *Worm-gear*	h_1 *Transversity* $h_{1T}^\perp$ *Pretzelosity*

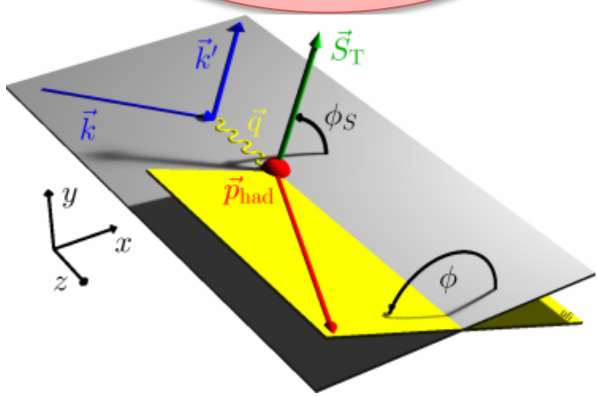
E12-09-007
Quark number and helicities

E12-06-112
E12-09-008*
Boer-Mulders for pions and kaons
* Ferrara co-spokeperson

E12-07-107
E12-09-009
Spin-effects for pions and kaons

C12-11-111*
C12-12-009*
Transverse target
Transversity & friends
* Ferrara co-spokeperson

CLAS12 has access to all of them through specific azimuthal modulations (ϕ, ϕ_S) of the cross-section thanks to the polarized beam and target



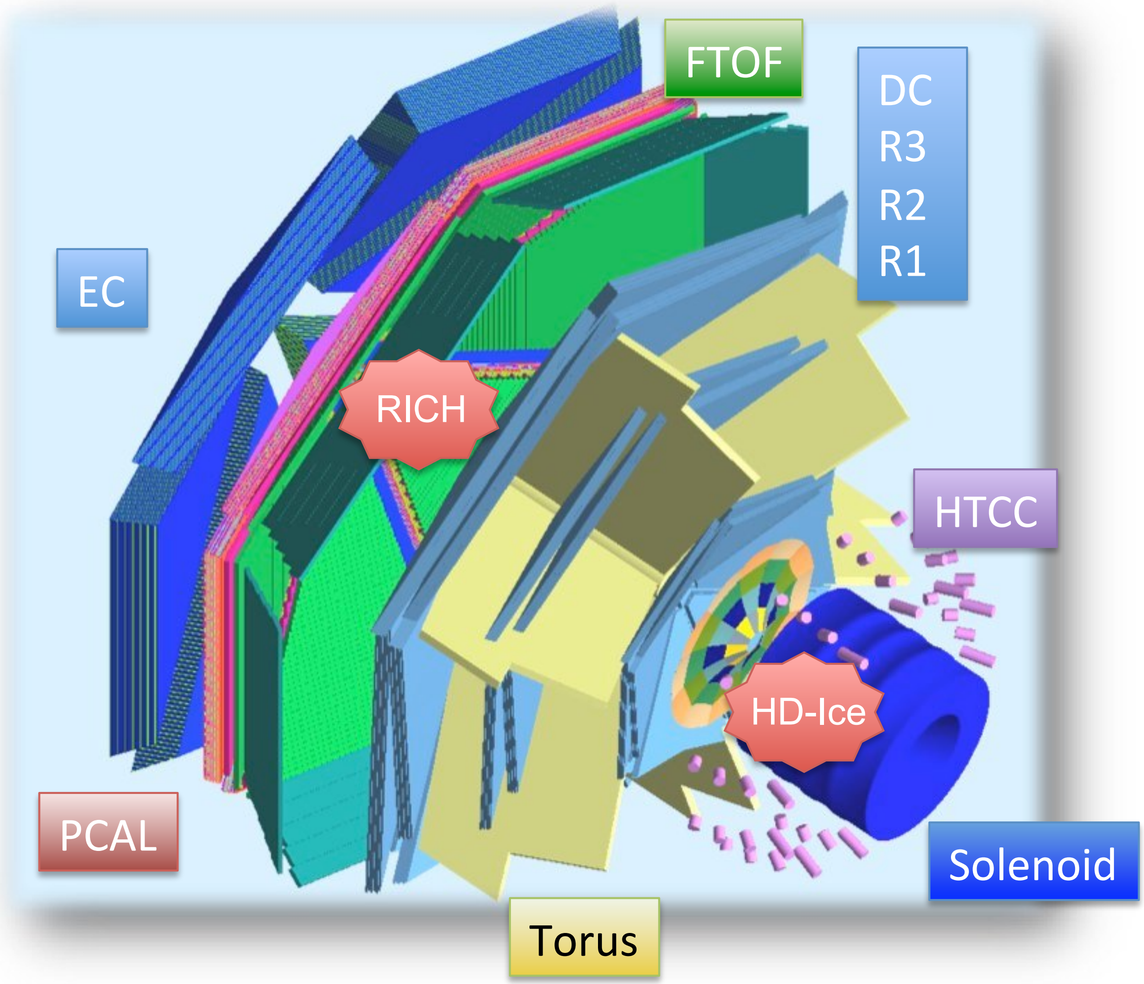
The CLAS12 Spectrometer

Luminosity up to 10^{35} cm^{-2} s^{-1}

Highly polarized electron beam

H and D polarized targets

Broad kinematic range coverage (current to target fragmentation)



Required upgrades for nucleon-3D investigation:

HD-Ice: Transverse Target
new concept
(commission with CLAS at 6 GeV
common to LOI 11-105)

RICH: Hadron ID
for flavor separation
(common to SIDIS approved exp.)

PAC30 report (2006): Measuring the kaon asymmetries is likely to be as important as pions …. The present capabilities of the present CLAS12 design are weak in this respect and should be strengthened.

Transversely Polarized HD-Ice Target

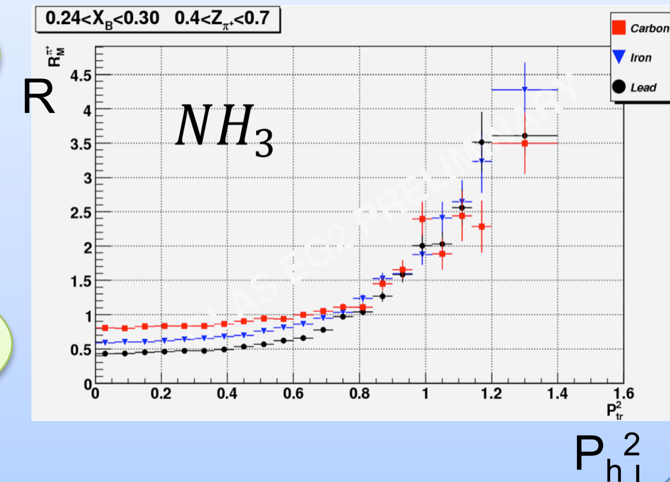
HD-Ice target vs standard nuclear targets (less luminosity for higher purity)

Advantages:

- **Minimize nuclear background**
  - smaller dilution, no attenuation at large p_T
- **Weak holding field (BdL ~ 0.1 Tm)**
  - wide acceptance, negligible beam deflection

Deuterium dilution is under control *E12-06-112*

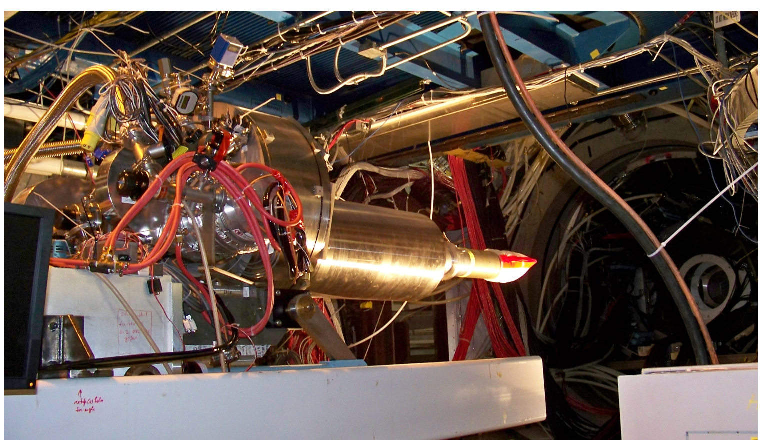
Suitable for di-hadron and recoil proton *PR12-12-009/010*



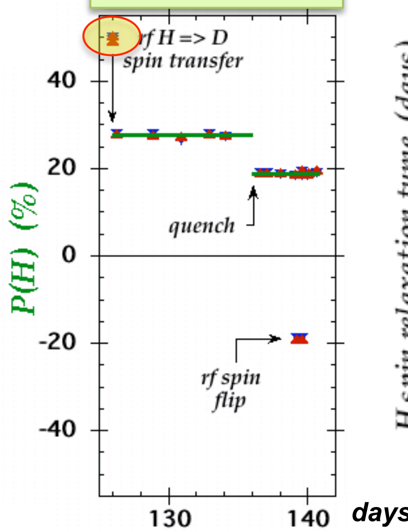
Disadvantages:

- **Very long polarizing times (months)**
- **Sensitivity to local heating by charged beams**

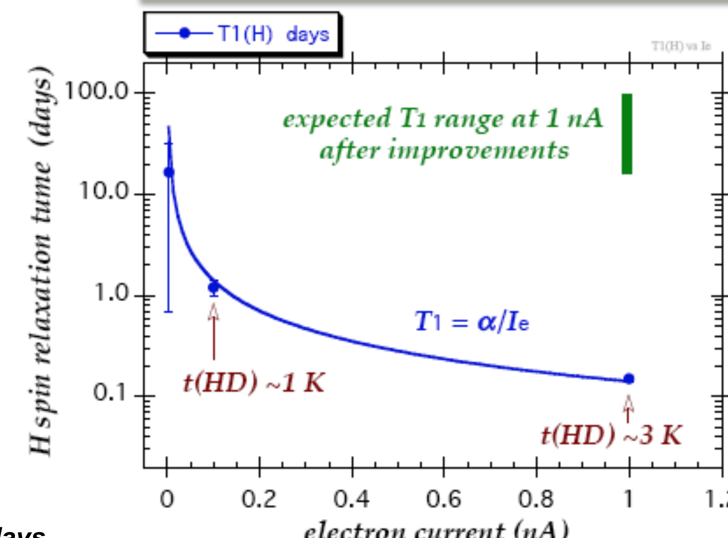
HD-ice ran from Nov/11 to May/12 at Jlab with 15mm Ø ×50 mm long HD cells



Photon beam
T1 ~ years



Commissioning with electrons (2014)

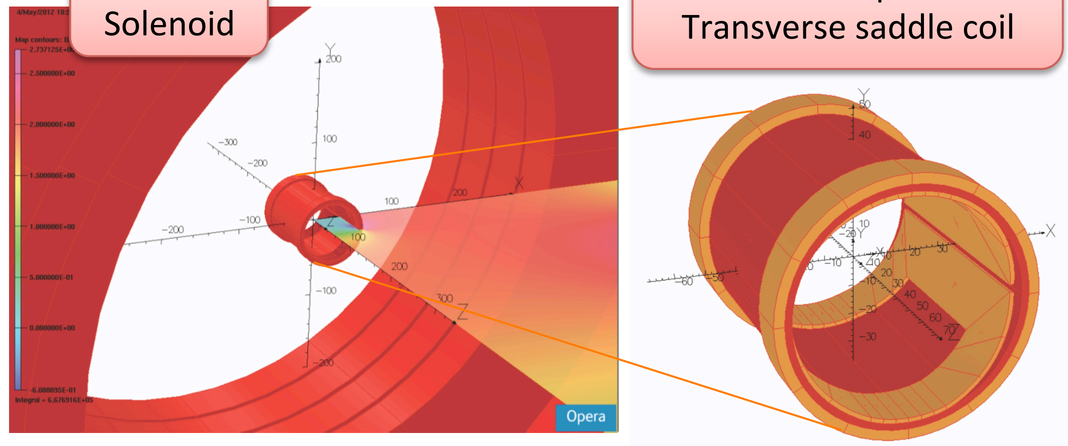


Magnet Configuration @ CLAS12

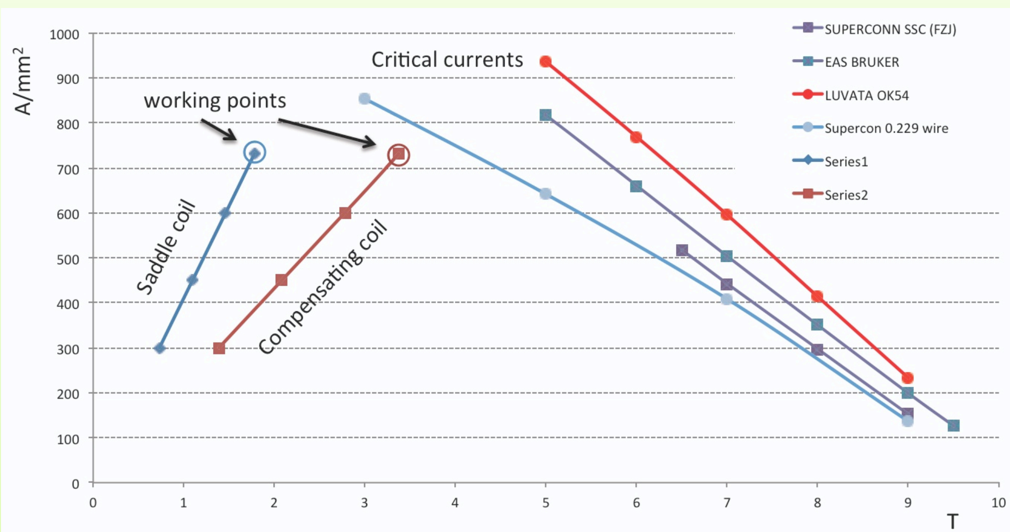
- 0.5T transverse, < 5mT long. field (@ 2T)
- Enhanced version of the existing NMR magnet system inside HD-ice cryostat
- No impact on CLAS12 central detector
- Free forward acceptance (> 35°)
- Recoiling proton detection

2T Main Solenoid

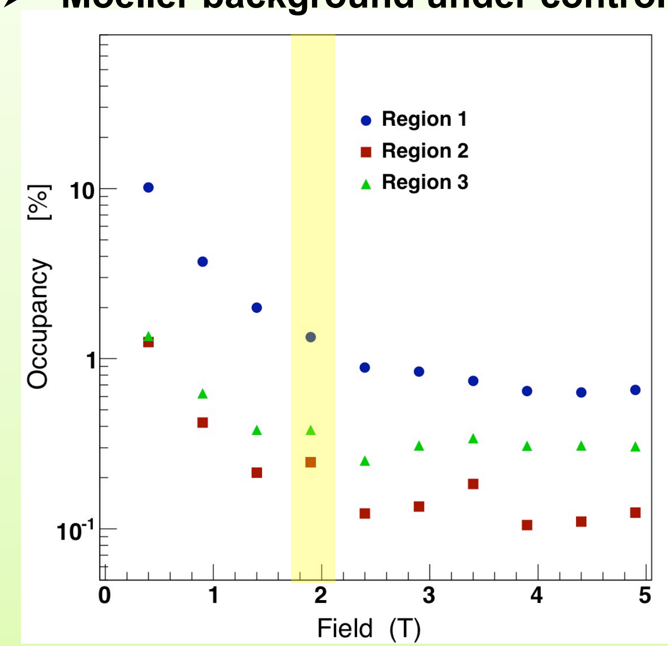
Solenoid compensation Transverse saddle coil



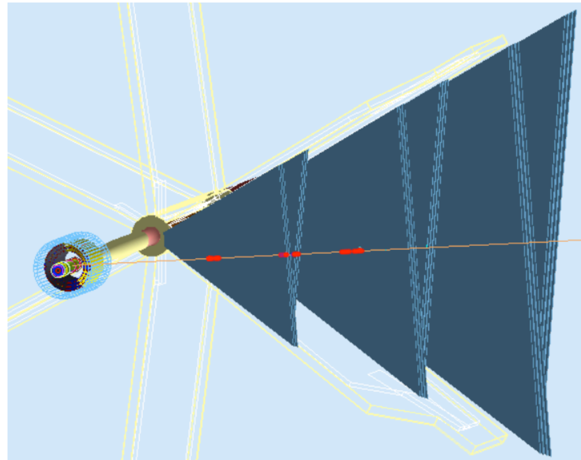
- Working point below critical current of existing SC wires
- Quench protection and static forces are not critical



- Moeller background under control

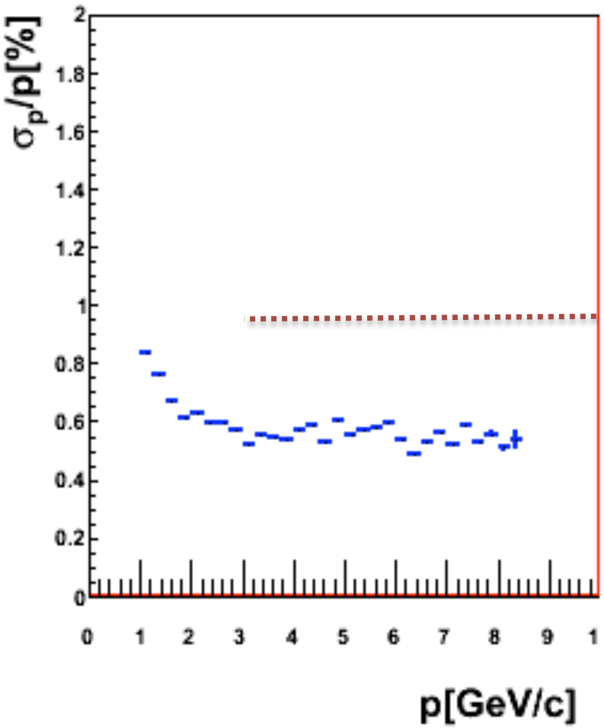


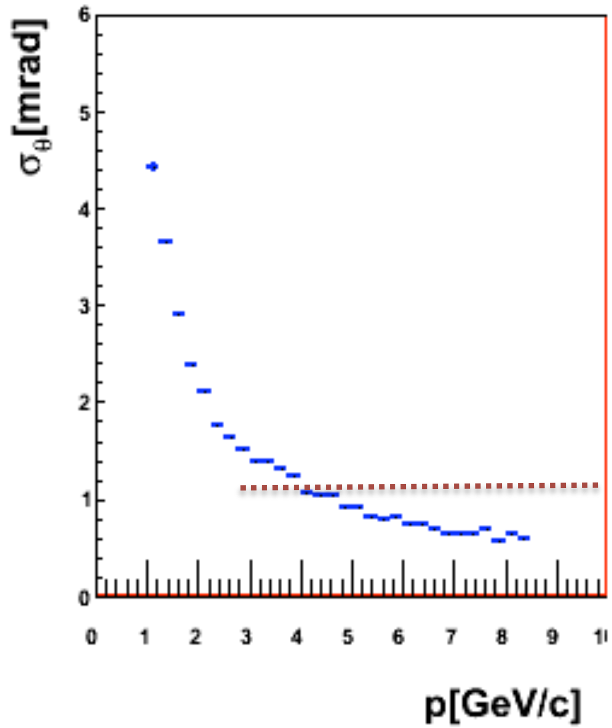
Tracking Performances

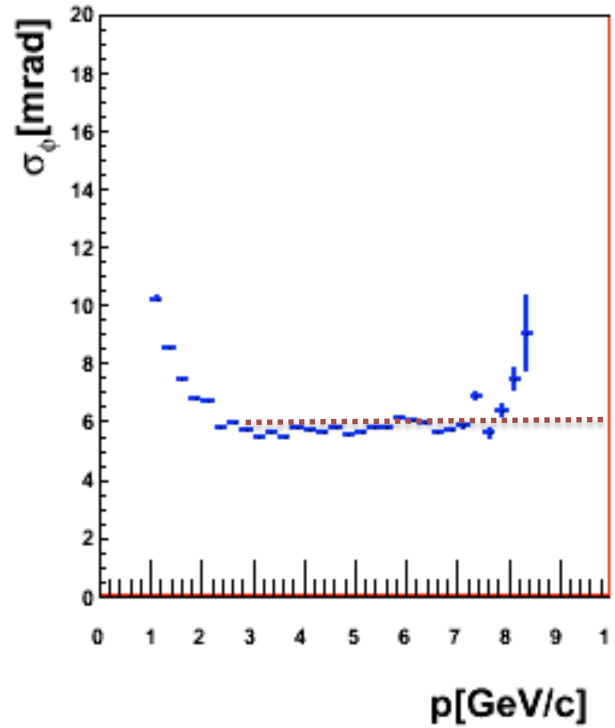


Study based on:
- Geant4 simulation
- Socrates tracking code

Resolutions fulfill TDR general specifications





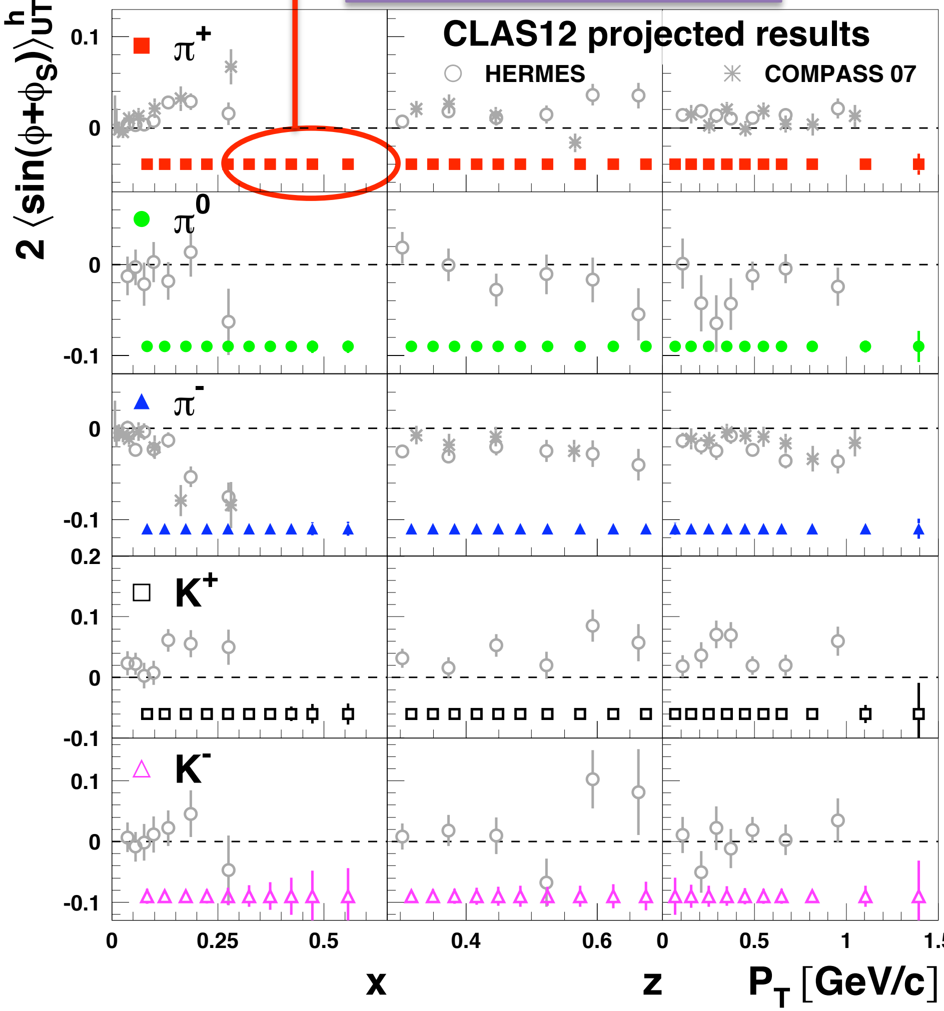


CLAS12 Projections

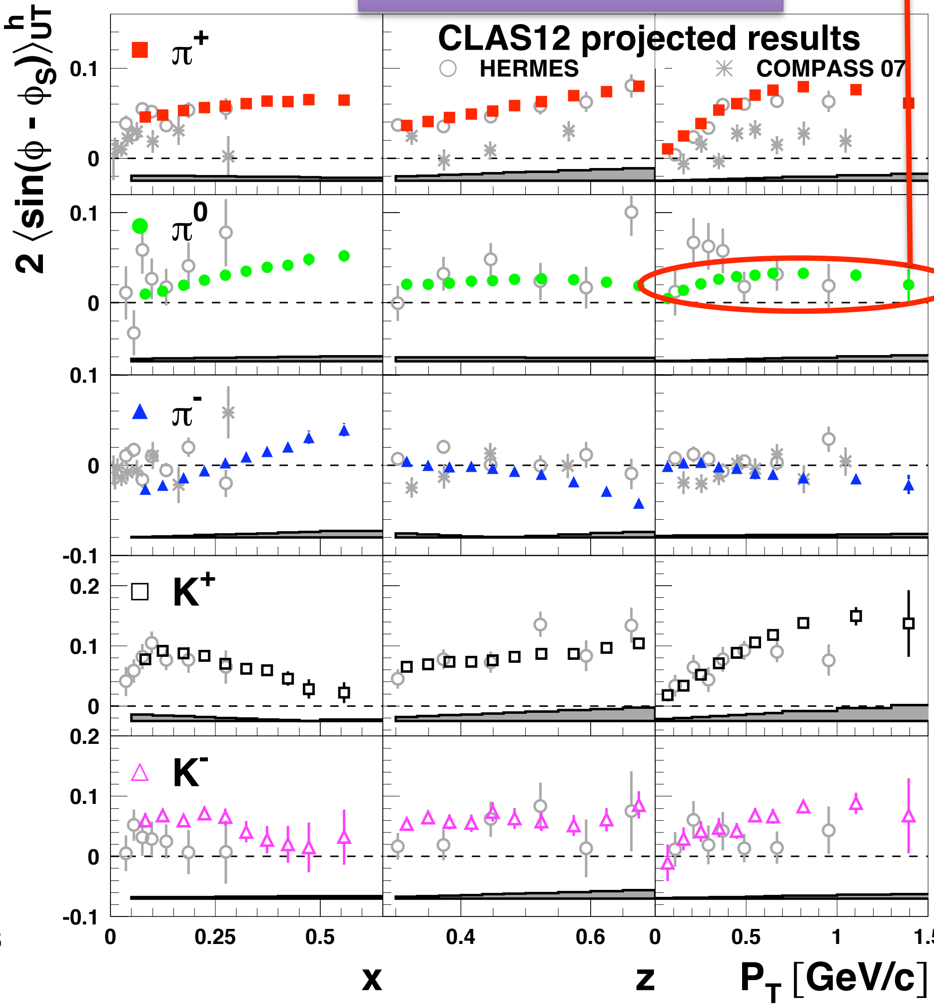
Large x important to constrain the tensor charge

High resolution and broad range in p_T to test perturb. non-perturb. transient and for Bessel function analysis

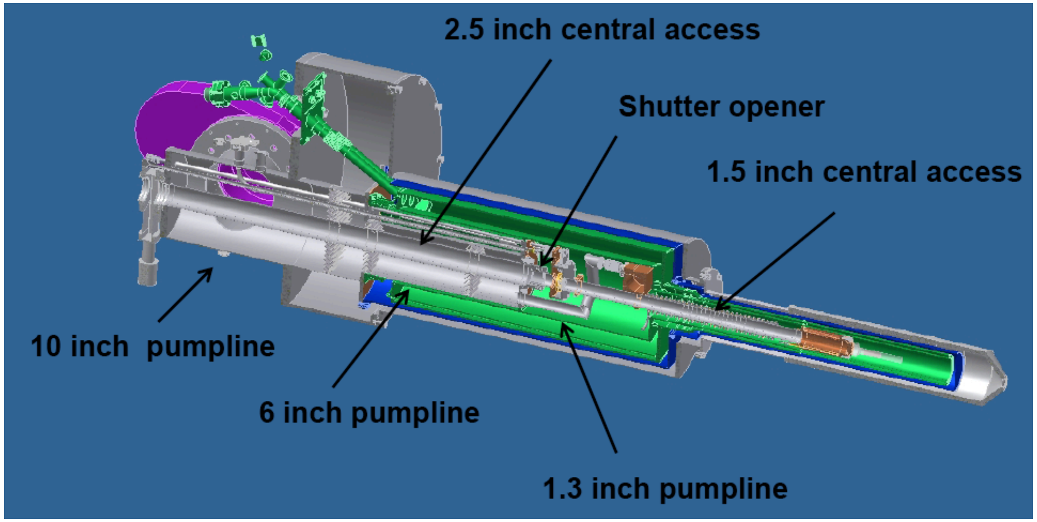
Collins asymmetry

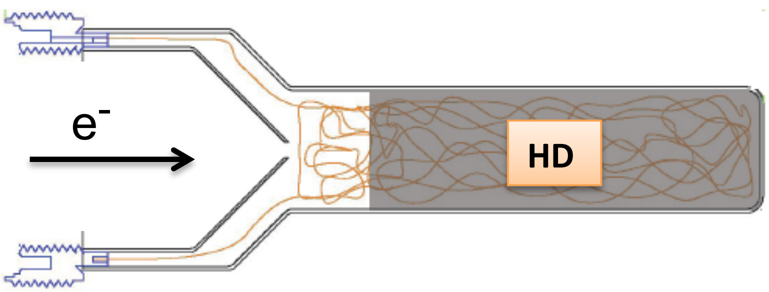


Sivers asymmetry

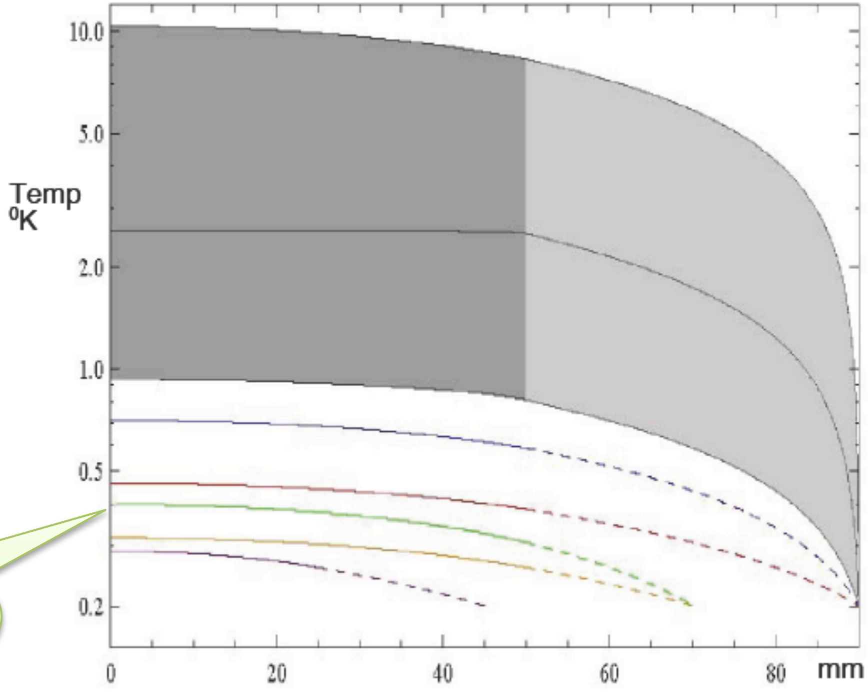


HD-ice Upgrade



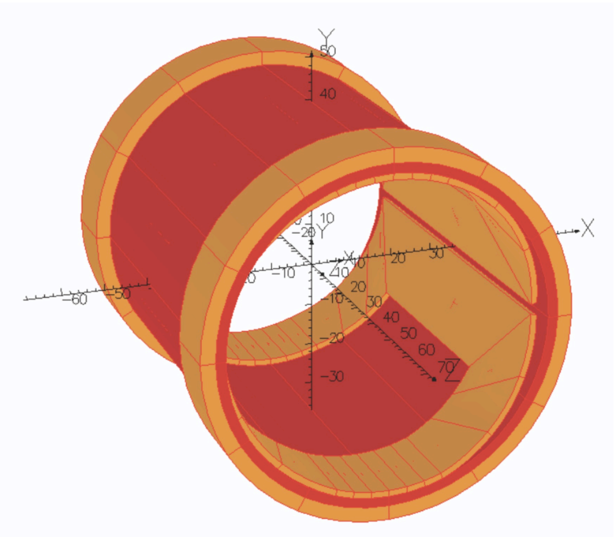


- Shorten the cryostat to reduce material budget in the CLAS12 forward acceptance
- Improve the HD-ice cooling:
  - Fast rastering
  - Wider cell radius, limited length
  - Shorten cooling wires



HD-ice Transverse Magent

parameter	Central detector solenoid (ideal)	Saddle coil	Compensat. solenoid	Compensat. Helmholtz
inner radius (mm)	471	35.8	37.4	38.4
outer radius (mm)	650	37.4	38.4	41.8
length (mm)	1225	100	100	15
current density (A/mm^2)		730	730	730

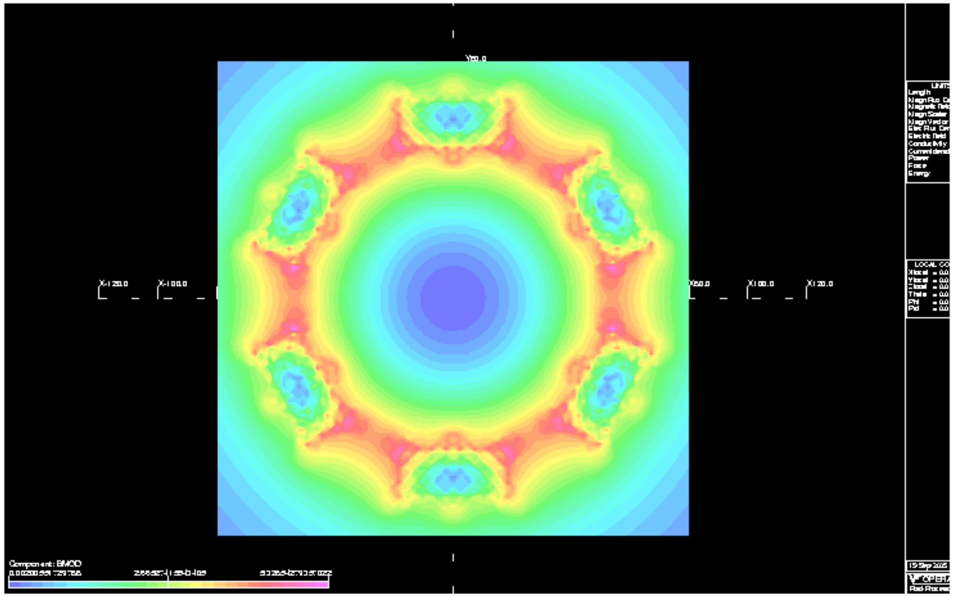


Towards the TDR:

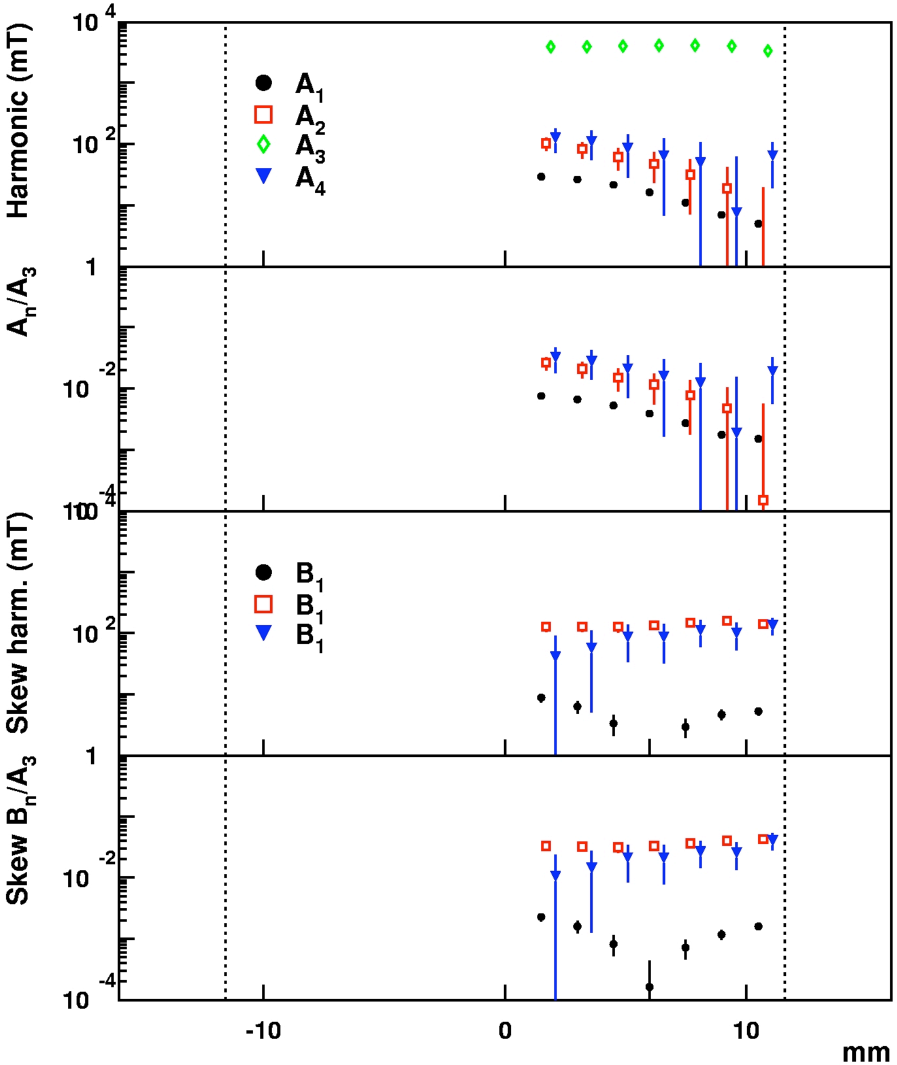
- **Saddle internal to the solenoid**
  - **Low field region supports higher current**
  - **Magnetic forces better compensated**
  - **Issue for solenoid wiring**
- **Minimize material budget**
- **Field homogeneity vs compactness**
- **Quench protection**

Magnets @ Ferrara

Multipole build in Ferrara for Atomic Beam Sources



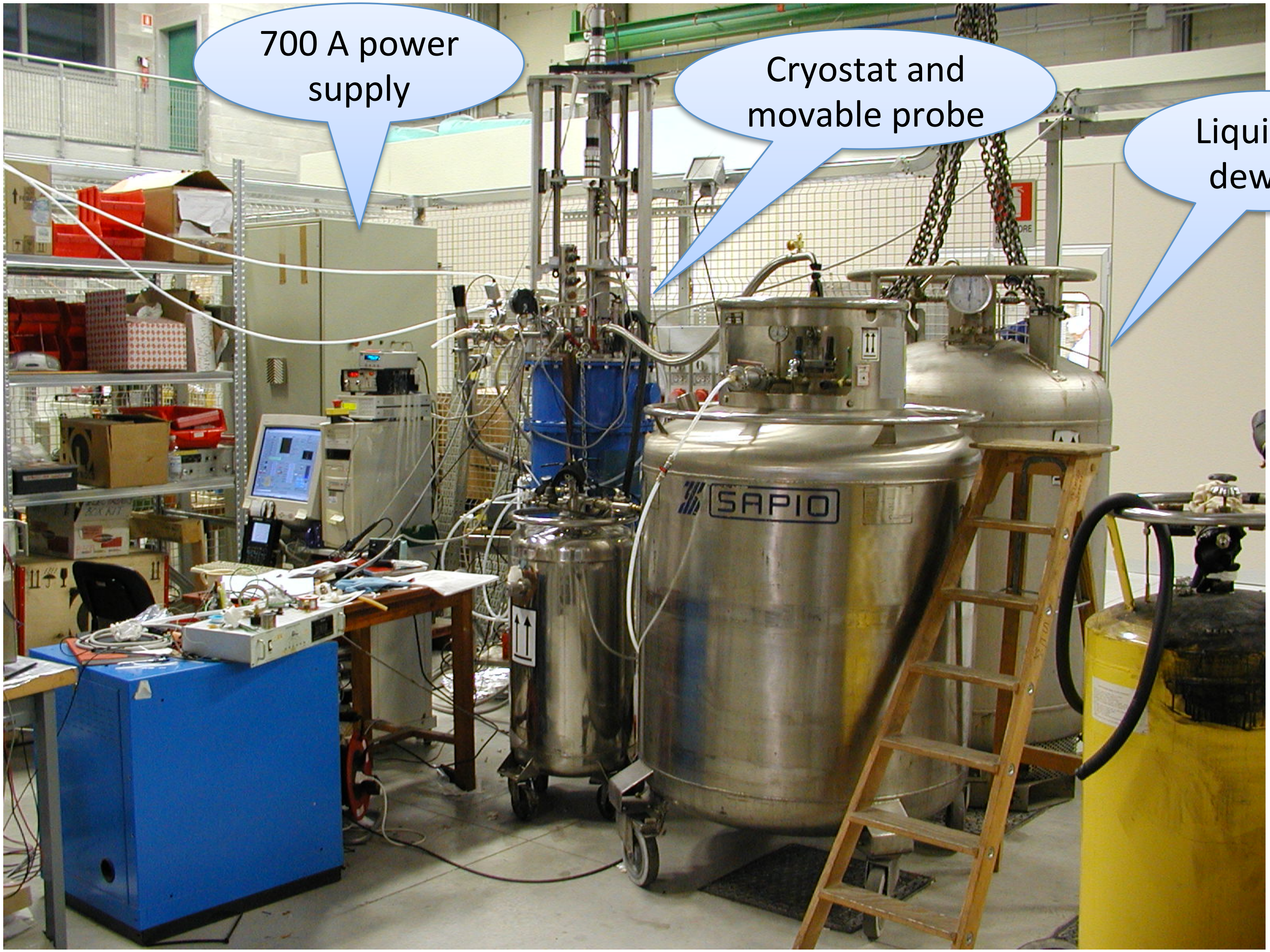
X-Y field map



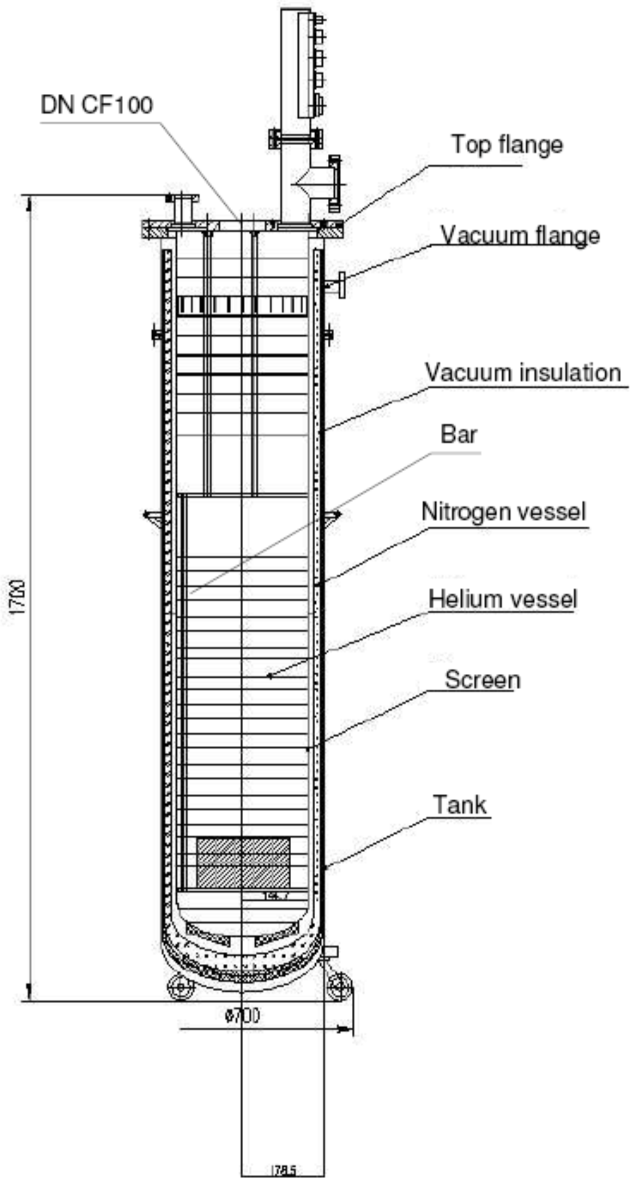
A_n (B_n) normal (skew) 2n-pole field comp.

Magnets build in Ferrara for CERN with a wiring machine

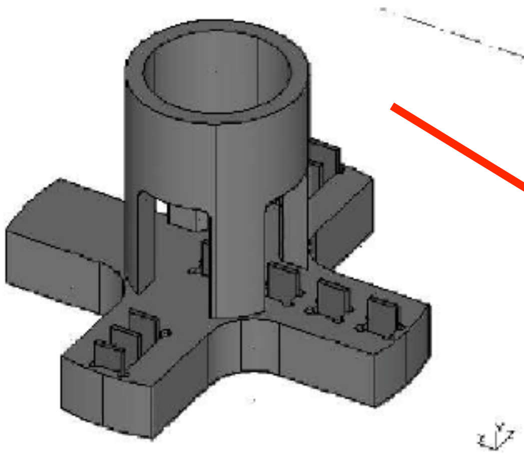
Test stand at 4 K

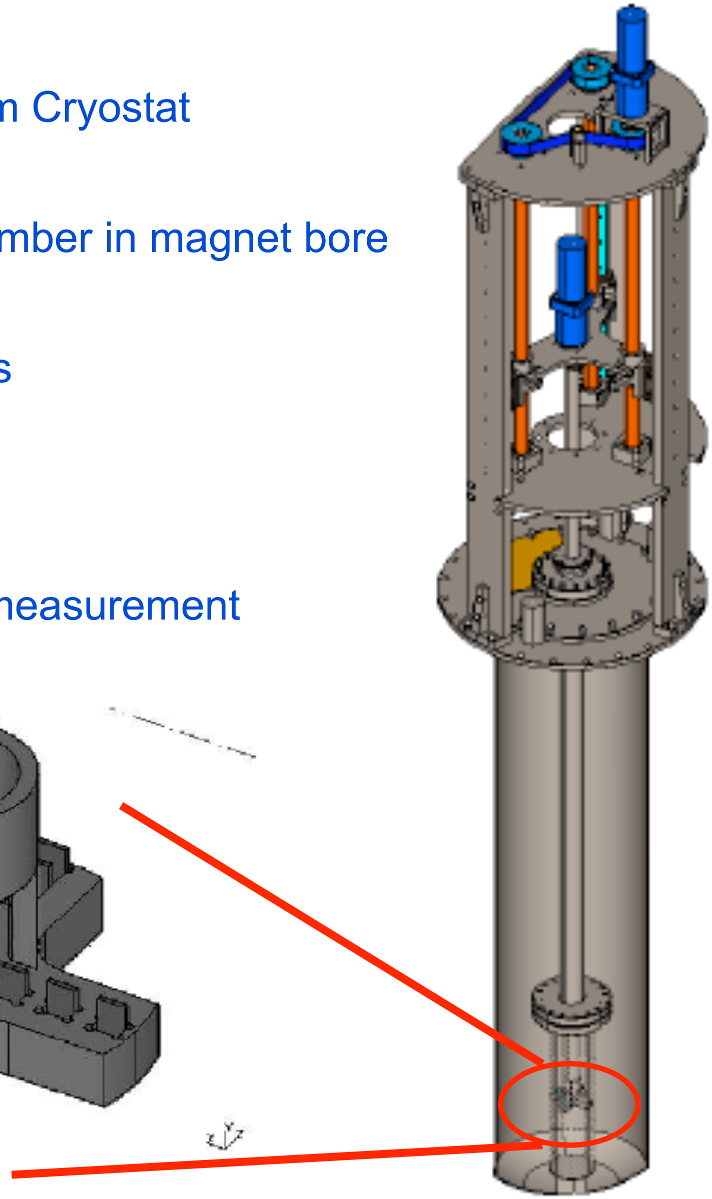


Test stand at 4 K



- Liquid Helium Cryostat
- Vacuum chamber in magnet bore
- 9 Hall probes
- Hollow shaft
- Automated measurement

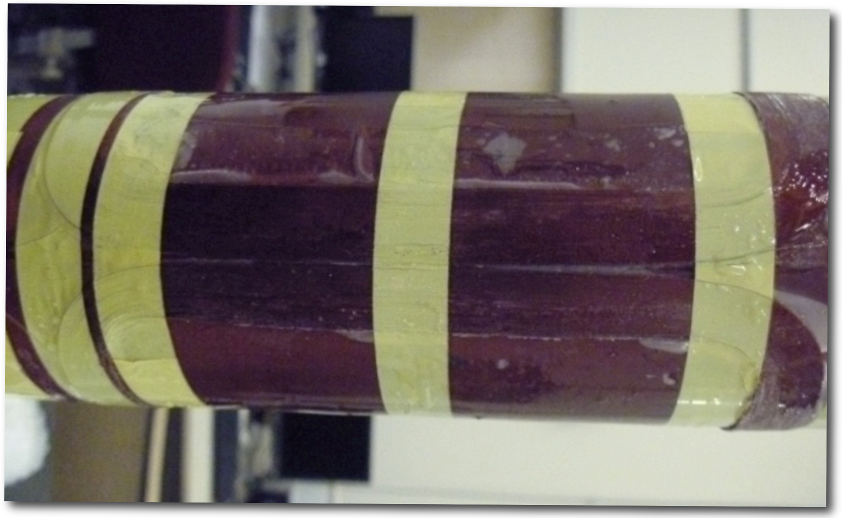


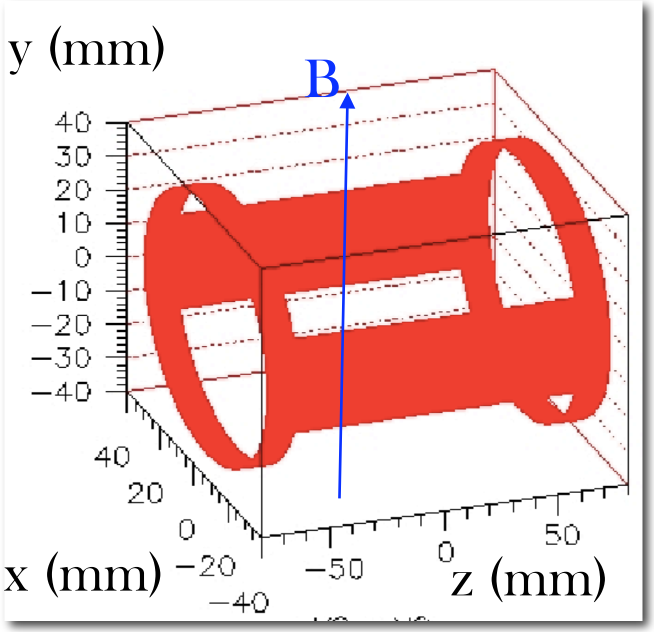


CLAS Saddle Coil

Provides:

- Some transverse holding field for polarized HD;
- Transverse field for parallel ⇔ anti-parallel rotation of the main solenoid field





Specifications:

- 750 Gauss field → superconducting magnet.
- 10^{-2} uniformity over target length (> 5cm)
- Minimum particle radiation losses → 1 layer same small superconducting wire used for the main solenoid
- Overlying the main solenoid

CLAS Saddle Coil

Design:

Final geometry : squares coils wrapped around the main solenoid

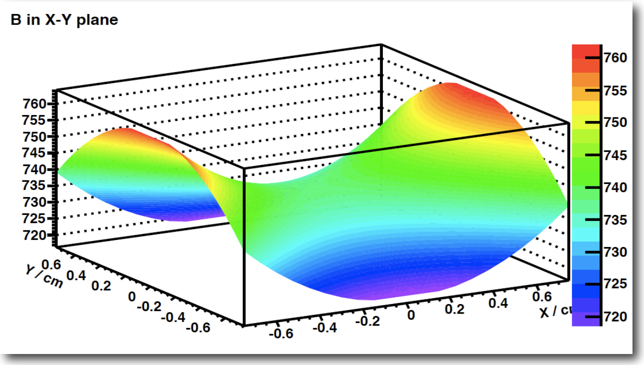
- ϕ = 2.897" = 7.358 cm
- L = 15 cm
- N = 54 in one layer
- I_{max} = 60 A $\rightarrow$ By_{max} = 750 Gauss
  (I_c> 65A at B=1 T)
- Uniformity over the target volume = 5 10^{-2}

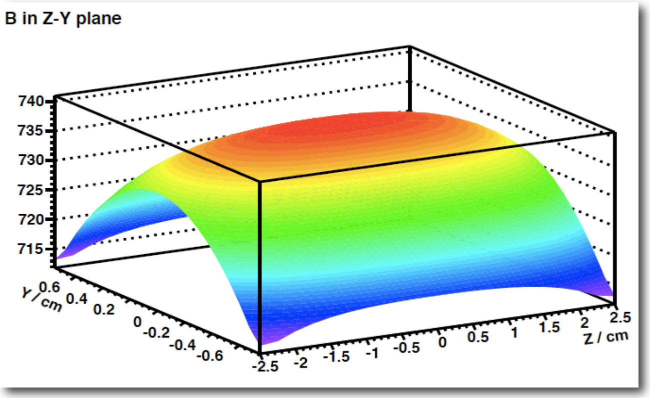
Construction:

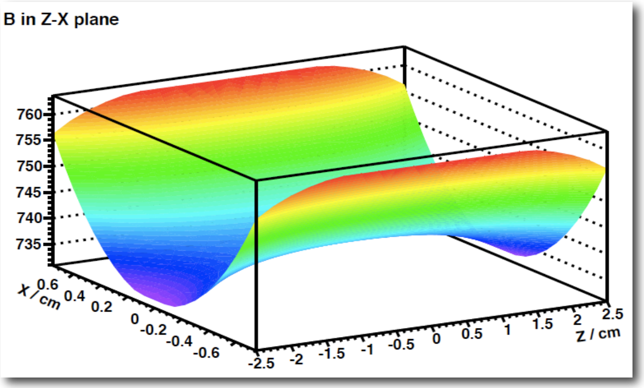
- Superconducting wire: SuperCon 54S43

54 Filaments	ϕ = 50 μm
Bare	ϕ=0.229 mm
Insulated	ϕ=0.250 mm

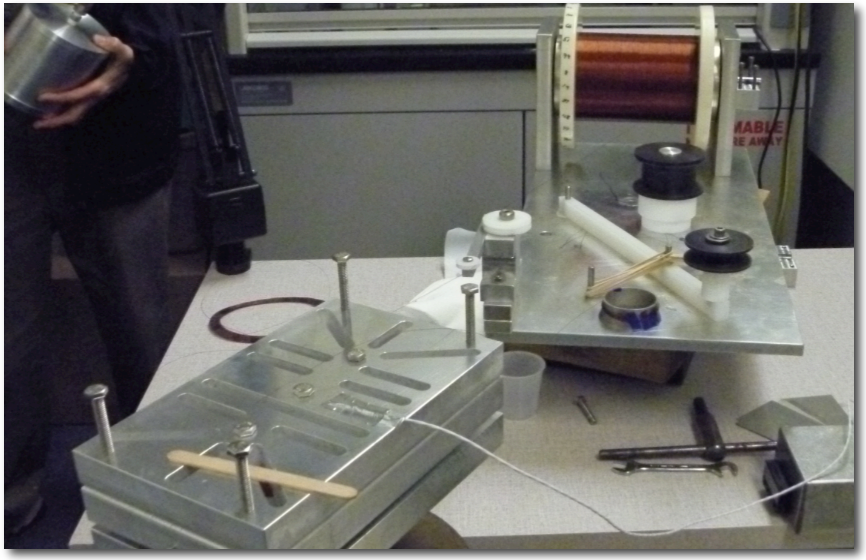
- Epoxy STYCAST 1265:
  soft gel, encapsulant, it cures in 4-6 days.





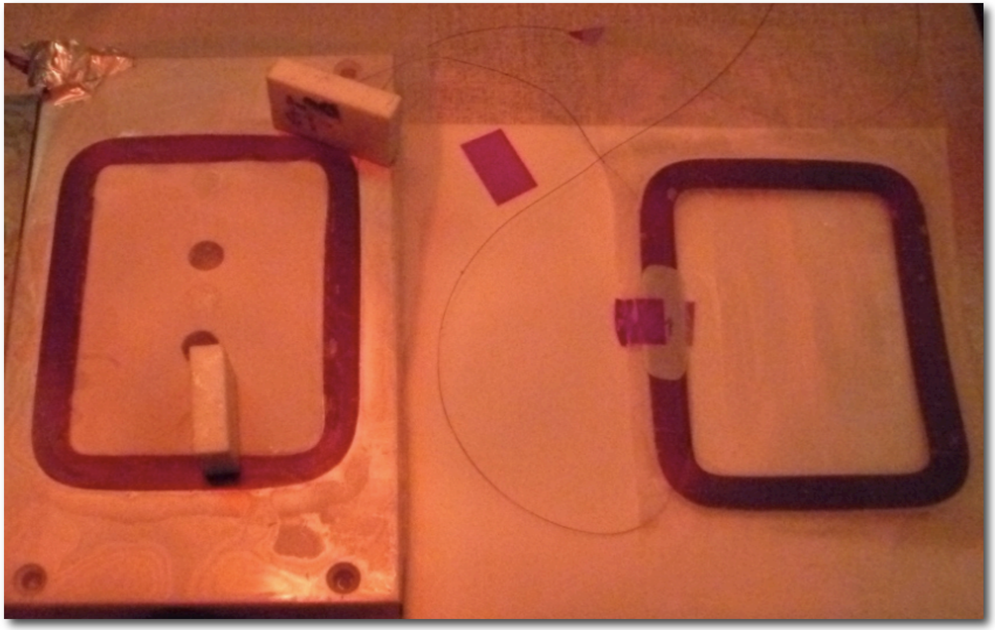


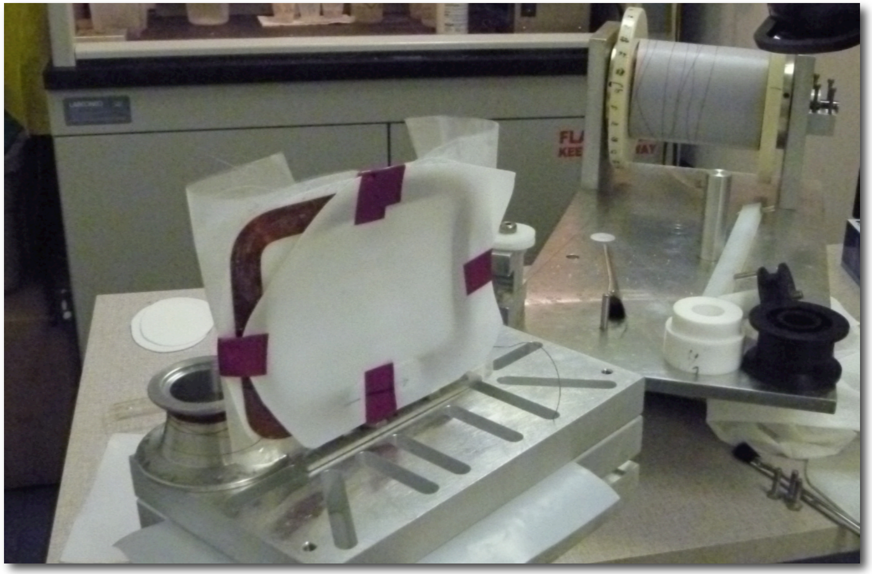
CLAS Saddle Coil



Construction

- Rotating support provided by the target group
    - Teflon shim constrains the coil shape
    - R&D: -teflon coated supports
        -mesh applied to keep the square shape





Attivita' HD-ice

Sezioni coinvolte: Ferrara & Roma 2

	2012	2013	2014	2015	2016	2017
Progetto	X	X				
Studi preliminari di fattibilita' su banco		X	X			
Bobinatrice			X	X		
Procurement Materiali			X	X	X	
Costruzione					X	
Commissioning						X
Budget	-	7	30	30	30	10