The LHeC Design

Max Klein (U.Liverpool+CERN)

for the LHeC Study Group

DRAFT 1.0
Geneva, September 3, 2011
CERN report
ECFA report
NuPECC report
LHeC-Note-2011-003 GEN

A Large Hadron Electron Collider at CERN

Report on the Physics and Design Concepts for Machine and Detector

LHeC Study Group

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DRAFT VERSION
24.11. 6pm

TUPC017

Civil Engineering Studies for Major Projects after LHC

Project
Physics
Detector

Accelerator
Schedule → O.Brüning

Report to ECFA 25.11.2011 CERN

http://cern.ch/lhec

LHeC Study Group

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About 150 Experimentalists and Theorists from 50 Institutes

Tentative list

Thanks to all and to
CERN, ECFA, NuPECC

Project Milestones

2007: Invitation by SPC to ECFA and by (r)ECFA to work out a design concept

2008: First CERN-ECFA Workshop in Divonne (1.-3.9.08)

2009: 2nd CERN-ECFA-NuPECC Workshop at Divonne (1.-3.9.09)

2010: 3rd CERN-ECFA-NuPECC Workshop at Chavannes-de-Bogis (12.-13.11.10)
NuPECC puts LHeC to its Longe Range Plan for Nuclear Physics (12/10)

2011: Draft CDR (530 pages on Physics, Detector and Accelerator) (5.8.11)
being refereed and updated

2012: Publication of CDR – European Strategy
New workshop (tentatively in May 10-11, 2012)

Goal: TDR by 2014
Perspective: Operation by 2023 (synchronous to pp)

Organisation for CDR

Scientific Advisory Committee

Guido Altarelli (Roma)
Sergio Bertolucci (CERN)
Stan Brodsky (SLAC)
Allen Caldwell (MPI Muenchen) - Chair
Swapan Chattopadhyay (Cockcroft Institute)
John Dainton (Liverpool)
John Ellis (CERN)
Jos Engelen (NWO)
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Rolf Heuer (CERN)
Roland Horisberger (PSI)
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Anthony Thomas (JLab)
Steve Vigdor (Brookhaven)
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Steering Committee

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Wesley Smith (Wisconsin)
Bernd Surrow (MIT)
Katsuo Tokushuku (KEK)
Urs Wiedemann (CERN)
Frank Zimmermann (CERN)

Working Group Convenors

Accelerator Design

Oliver Bruening (CERN)
John Dainton (Liverpool)

Interaction Region

Bernhard Holzer(CERN)
Uwe Schneekloth (DESY)
Pierre van Mechelen (Antwerpen)

Detector Design

Peter Kostka (DESY)
Alessandro Polini (Bologna)
Rainer Wallny (Zurich)

New Physics at Large Scales

Georges Azuelos (Montreal)
Emmanuelle Perez (CERN)
Georg Weiglein (Hamburg)

Precision QCD and Electroweak

Olaf Behnke (DESY)
Paolo Gambino (Torino)
Thomas Gehrmann (Zurich)
Claire Gwenlan (Oxford)

Physics at High Parton Densities

Néstor Armesto (Santiago de Compostela)
Brian A. Cole (Columbia)
Paul R. Newman (Birmingham)
Anna M. Stasto (PennState)

CERN Referees

Ring Ring Design
Kurt Huebner (CERN)
Alexander N. Skrinsky (INP Novosibirsk)
Ferdinand Willeke (BNL)
Linac Ring Design
Reinhard Brinkmann (DESY)
Andy Wolski (Cockcroft)
Kaoru Yokoya (KEK)
Energy Recovery
Georg Hoffstaetter (Cornell)
Ilan Ben Zvi (BNL)
Magnets
Neil Marks (Cockcroft)
Martin Wilson (CERN)
Interaction Region
Daniel Pitzl (DESY)
Mike Sullivan (SLAC)
Detector Design
Philippe Bloch (CERN)
Roland Horisberger (PSI)
Installation and Infrastructure
Sylvain Weisz (CERN)
New Physics at Large Scales
Cristinel Diaconu (IN2P3 Marseille)
Gian Giudice (CERN)
Michelangelo Mangano (CERN)
Precision QCD and Electroweak
Guido Altarelli (Roma)
Vladimir Chekelian (MPI Munich)
Alan Martin (Durham)
Physics at High Parton Densities
Alfred Mueller (Columbia)
Raju Venugopalan (BNL)
Michele Arneodo (INFN Torino)

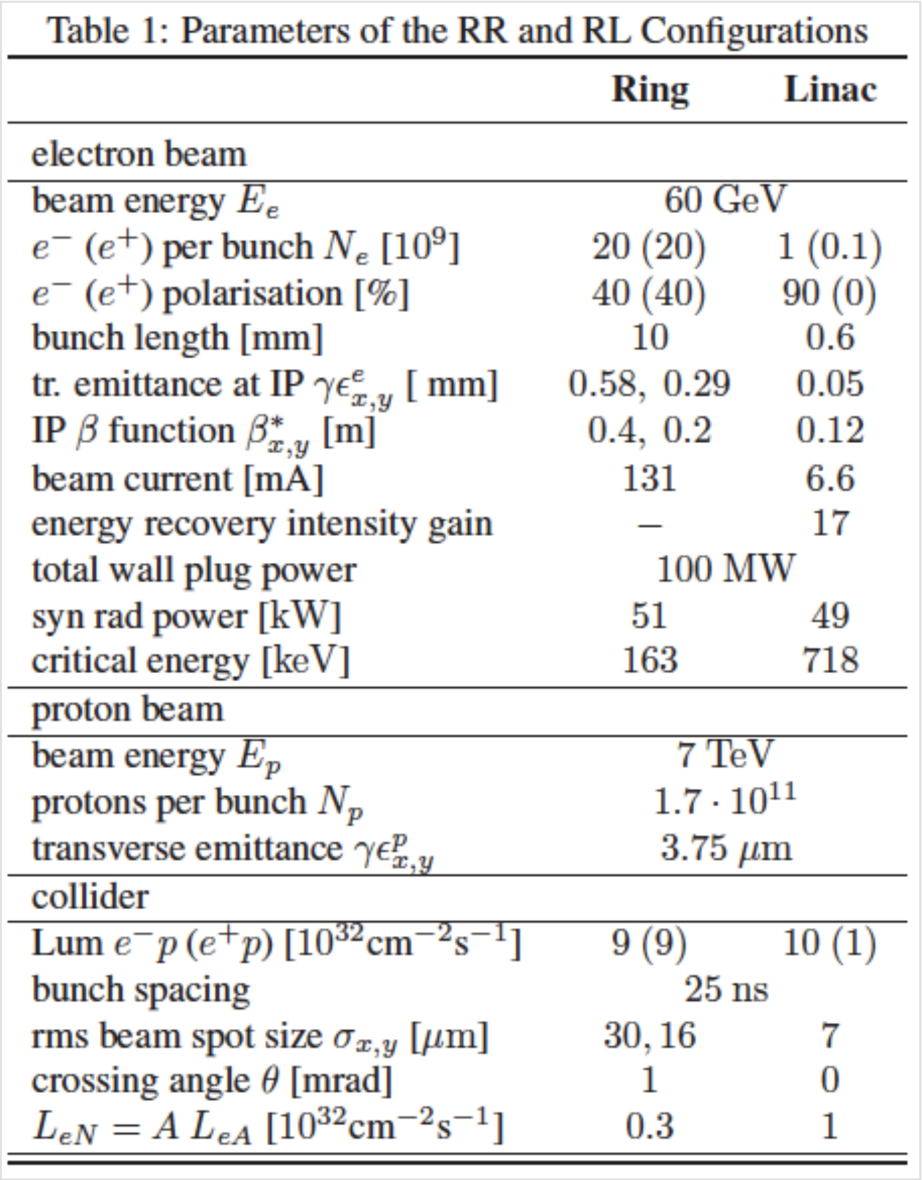


Table 1: Parameters of the RR and RL Configurations

	Ring	Linac
electron beam		
beam energy E_e	60 GeV	
e^- (e^+) per bunch N_e [10^9]	20 (20)	1 (0.1)
e^- (e^+) polarisation [%]	40 (40)	90 (0)
bunch length [mm]	10	0.6
tr. emittance at IP $\gamma\epsilon^e_{x,y}$ [mm]	0.58, 0.29	0.05
IP β function $\beta^*_{x,y}$ [m]	0.4, 0.2	0.12
beam current [mA]	131	6.6
energy recovery intensity gain	–	17
total wall plug power	100 MW	
syn rad power [kW]	51	49
critical energy [keV]	163	718
proton beam		
beam energy E_p	7 TeV	
protons per bunch N_p	$1.7 \cdot 10^{11}$	
transverse emittance $\gamma\epsilon^p_{x,y}$	3.75 μm	
collider		
Lum e^-p (e^+p) [10^{32}cm^{-2}s^{-1}]	9 (9)	10 (1)
bunch spacing	25 ns	
rms beam spot size $\sigma_{x,y}$ [μm]	30, 16	7
crossing angle θ [mrad]	1	0
$L_{eN} = A\, L_{eA}$ [10^{32}cm^{-2}s^{-1}]	0.3	1

Both the ring and the linac are feasible and both come very close to the desired performance. The pleasant challenge is to soon decide for one.

CERN-ECFA-NuPECC:
CDR Draft (530pages) being refereed
Publish early 2012

Steps towards TDR (tentative)
-Prototype IR magnet (3 beams)
-Prototype Dipole (1:1)
-Develop Cavity/Cryomodule
-Civil Engineering, …

Build international collaborations
for the accelerator and detector development. Strong links to ongoing accelerator and detector projects.

The LHC offers the unique perspective for a further TeV scale collider. The LINAC's are of about 2mile length, yet the Q^2 is 10^5 times larger than was achieved when SLAC discovered quarks. Particle physics needs pp, ll and ep.
Here is a realistic prospect to progress.

Summary slide IPAC11 M.Klein

Why an ep/A Experiment at TeV Energies?

1. For resolving the quark structure of the nucleon with p, d and ion beams

   QPM symmetries, quark distributions (complete set from data), GPDs, nuclear PDFs ..

2. For the development of perturbative QCD [37-28-15]

   N^kLO ($k \geq 2$) and h.o. eweak, HQs, jets, resummation, factorisation, diffraction

3. For mapping the gluon field

   Gluon for $\sim 10^{-5} < x < 1$, Pomeron, unintegrated gluon

4. For searches and the understanding of new physics

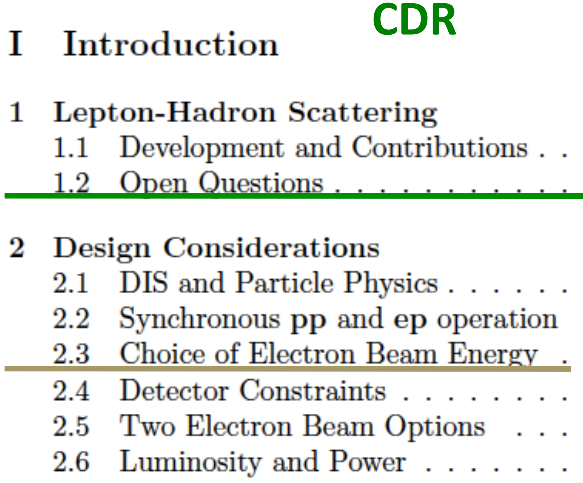
   GUT (α_s to 0.2%), LQs RPV, Higgs (bb, HWW), PDFs4LHC, instanton, odderon,..?

5. For investigating the physics of parton saturation

   Non-pQCD (chiral symm breaking, confinement), black disc limit, saturation border..

..For providing data which could be of use for future experiments [Proposal for SLAC ep 1968]

CDR



Why differ leptons from quarks? (Leptopartons)
Higgs? (production via gg (SM), bb(MSSM), quartic selfcoupling)
Mapping of the Gluon Field (next slide)
Non pQCD – 10 dim string theory (BFKL, odderon)
Ultimate precision of α_s and $\sin^2\Theta$ (0.1%, μ dependence)
Determination of ALL quark distributions
Confinement?? (Diffraction)
Generalised parton distributions (DVCS)
DGLAP → BFKL? (saturation of gluon density)
Structure of the neutron (no eD at HERA)
Partons in nuclei (4 orders of magnitude extended range)
New singly produced states (e^*)
Unfolding of Contact interaction effects (up to 50 TeV)

…

Default energy: E_e=60 GeV

So far LQ limits ~0.5 TeV

$Q^2 >> M_Z^2$

Gluon saturation at x ~10^{-5}
in the DIS region $Q^2 > M_p^2$

Synchrotron radiation ~ E_e^4

Cost and Luminosity:

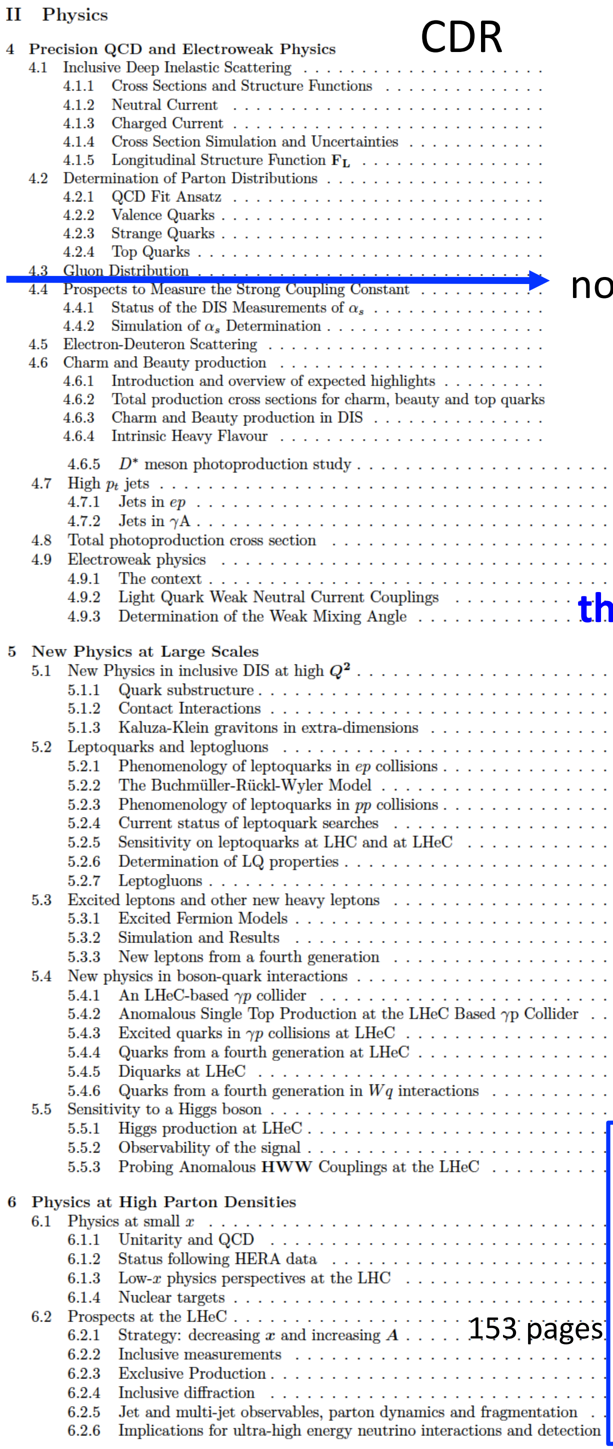
L = 100 L_{HERA}, Q^2 and 1/x = 20 HERA

[LHC in 2015 may affect that choice.]

The LHeC has an outstanding, unique programme, which is complementary to the LHC. It requires:

High energy, high luminosity, polarised $e^{\pm}$, p, D, A.
The LHC provides all of that if complemented
by an intense, high energy electron beam. This
determines the schedule, and the site is no question.

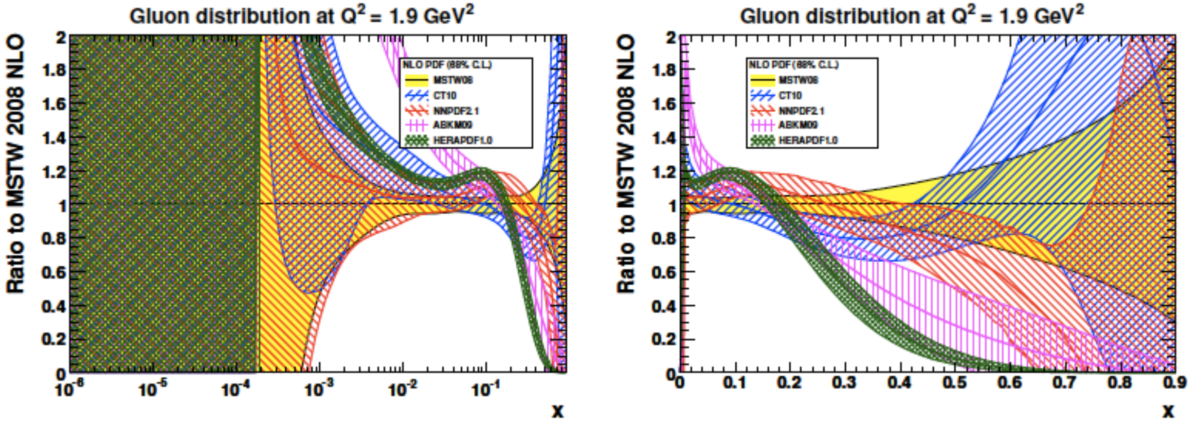
CDR



now

then

153 pages



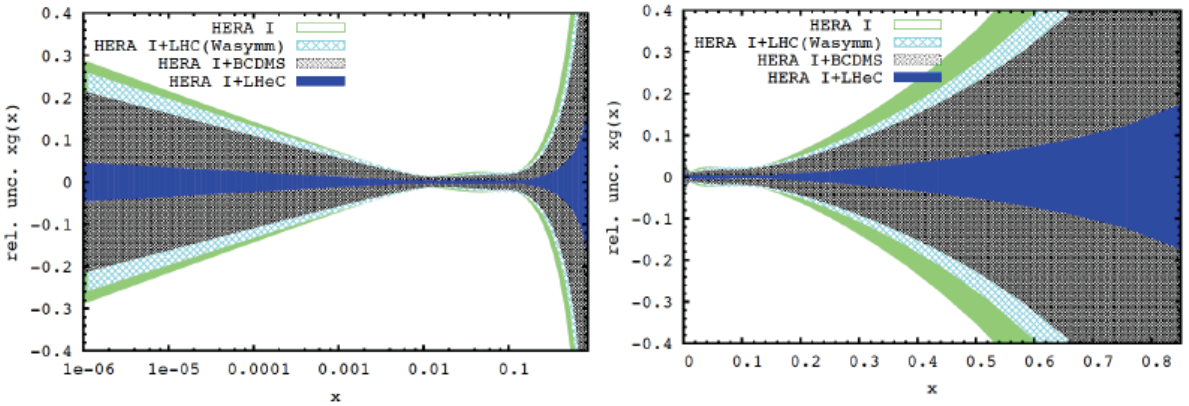
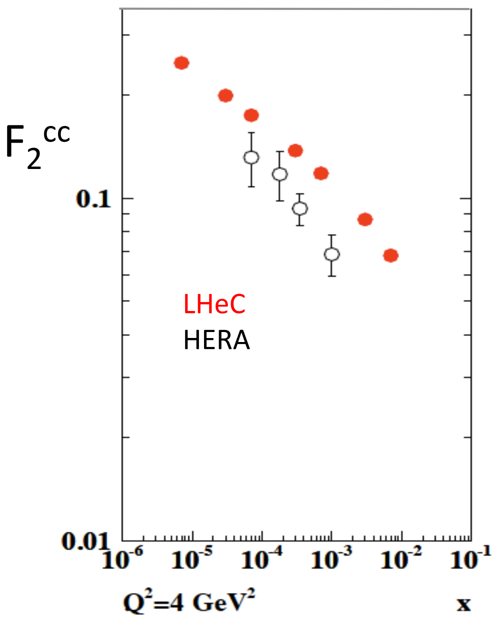
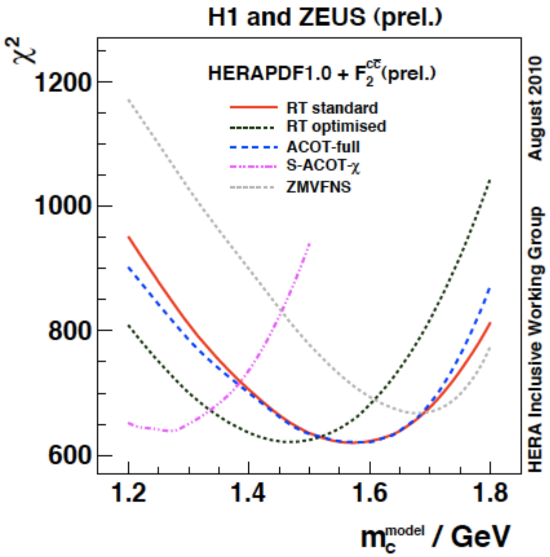


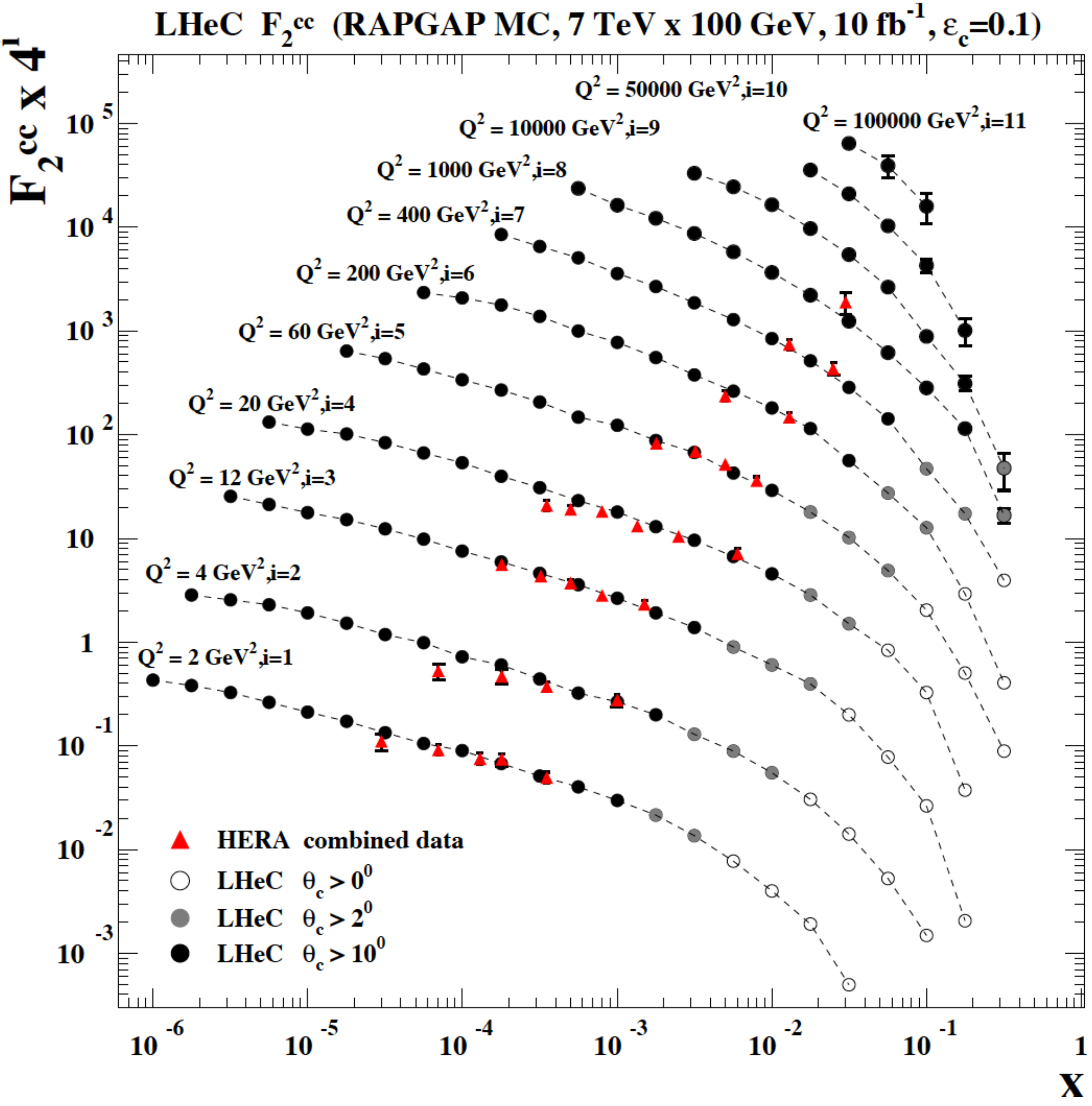
Figure 4.17: Relative uncertainty of the gluon distribution at $Q^2 = 1.9\,\mathrm{GeV}^2$, as resulting from an NLO QCD fit to HERA (I) alone (green, outer), HERA and BCDMS (crossed), HERA and LHC (light blue, crossed) and the LHeC added (blue, dark). Left: logarithmic x, right: linear x.

Precision measurement of gluon density to extreme x → α_s
Low x: saturation in ep? Crucial for QCD, LHC, UHE neutrinos!
High x: xg and valence quarks: resolving new high mass states!
Gluon in Pomeron, odderon, photon, nuclei.. Local spots in p?
Heavy quarks intrinsic or only gluonic?

Charm – α_s



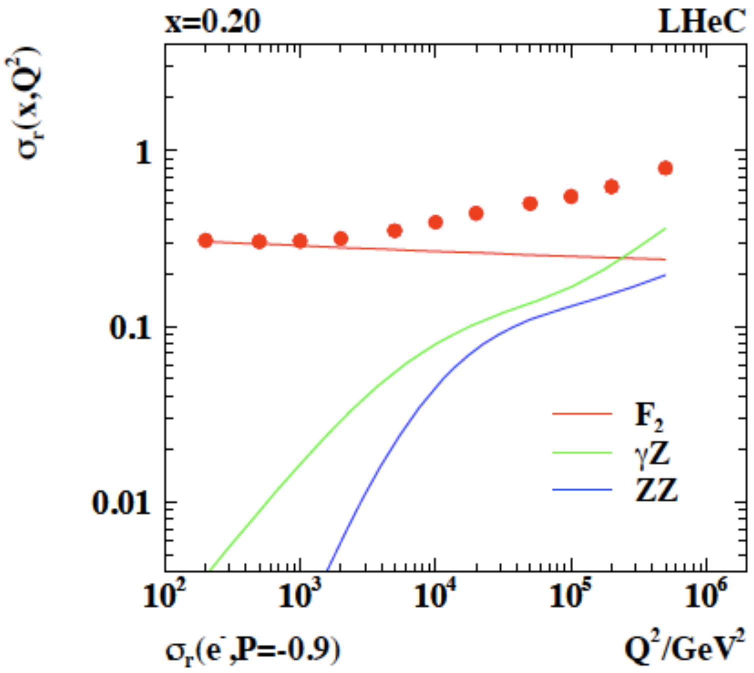


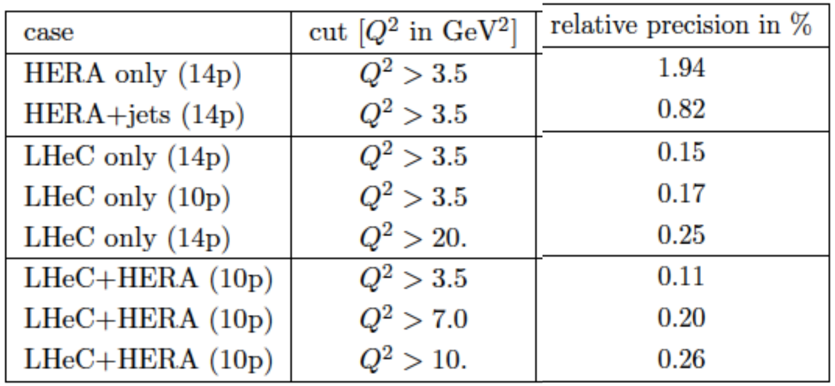


LHeC vs HERA: higher fraction of c, larger range, smaller beam spot, better Silicon detectors

CDR

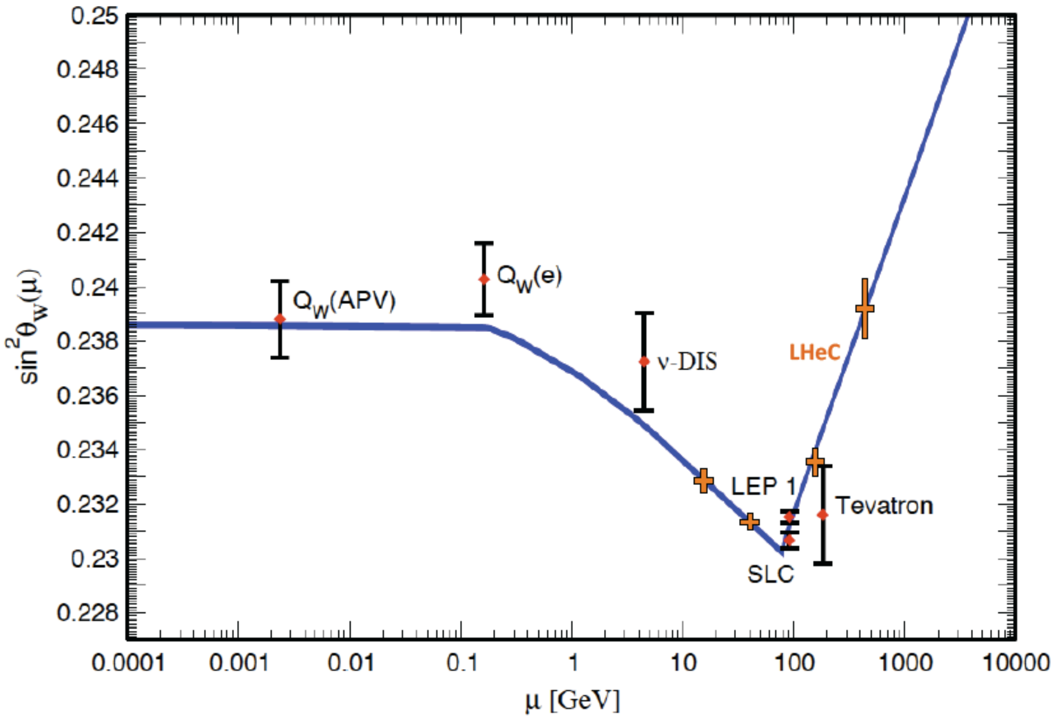
Electroweak+Strong Precision Physics





case	cut [Q^2 in GeV^2]	relative precision in %
HERA only (14p)	$Q^2 > 3.5$	1.94
HERA+jets (14p)	$Q^2 > 3.5$	0.82
LHeC only (14p)	$Q^2 > 3.5$	0.15
LHeC only (10p)	$Q^2 > 3.5$	0.17
LHeC only (14p)	$Q^2 > 20.$	0.25
LHeC+HERA (10p)	$Q^2 > 3.5$	0.11
LHeC+HERA (10p)	$Q^2 > 7.0$	0.20
LHeC+HERA (10p)	$Q^2 > 10.$	0.26

α_s to permille
GUT
BCDMS



Scale dependence of weak mixing angle from polarisation asymmetry and NC/CC ratio.

Light quark NC couplings

Joint QCD+eweak at high orders becomes crucial at LHC too

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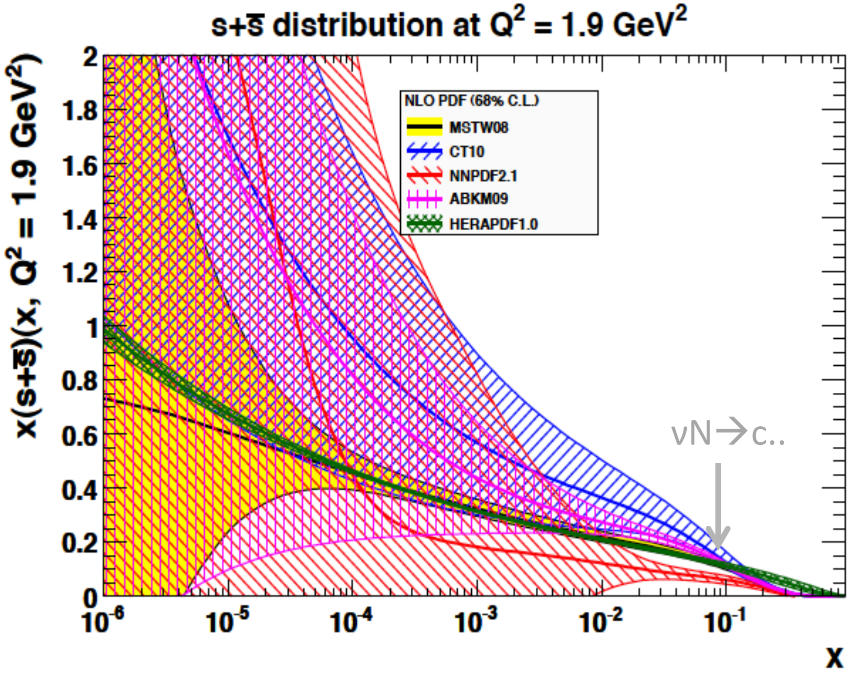
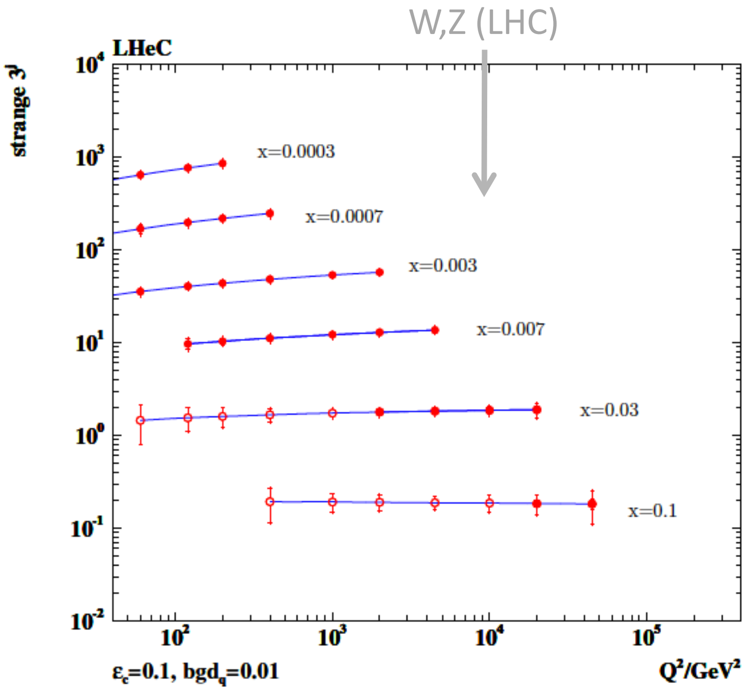
Quarks – strange and valence



νN→c..

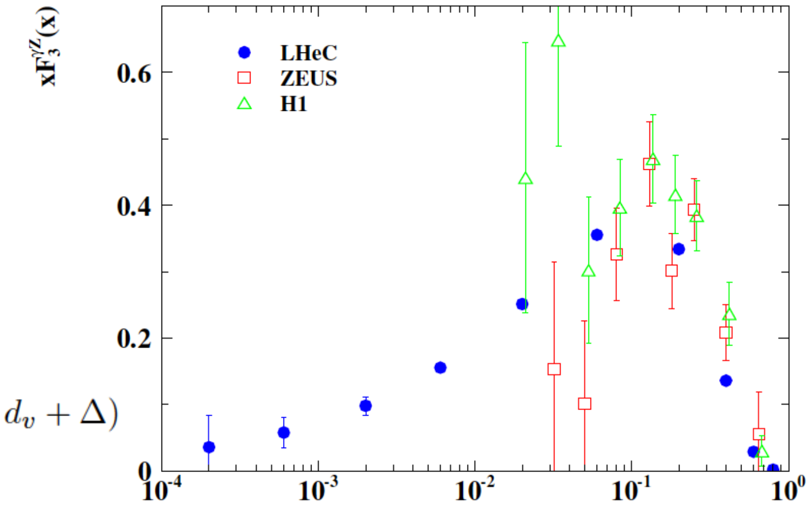
W,Z (LHC)



Strange quark density unknown
at low x and controversial at high x~0.1

Low x sea to be unfolded with LHeC
CC and ep and eD measurements
down to $x=10^{-4..6}$

$$xF_3^{\gamma Z} = \frac{x}{3}(2u_v + d_v + \Delta)$$



LHeC: much extended range and 100 * L (HERA)

Sea Quarks=Antiquarks? Need u_v,d_v

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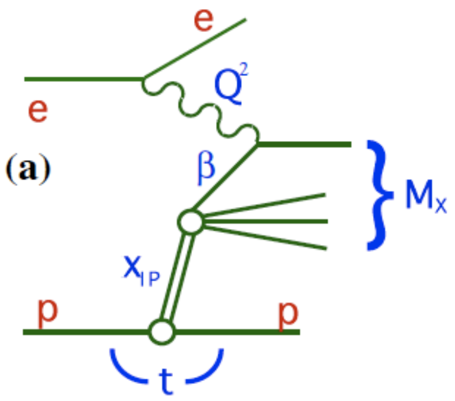
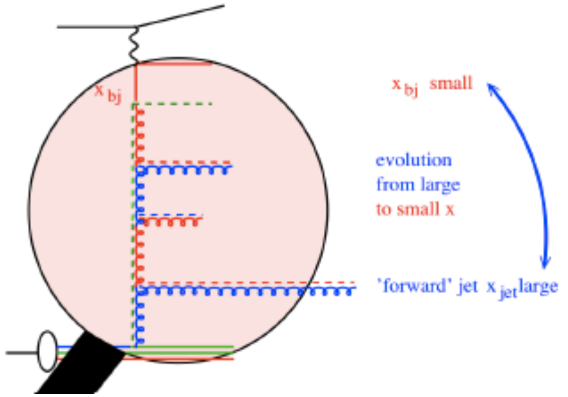
Quark-Gluon Dynamics - Diffraction and HFS (fwd jets)

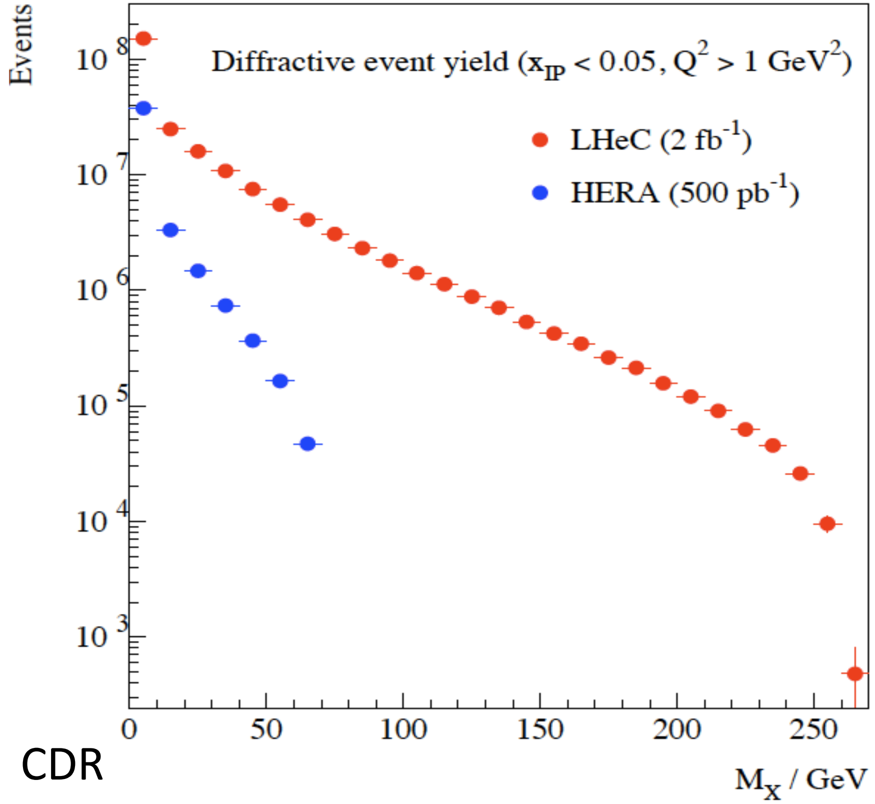


Factorisation broken
(LHC fwd – LHeC diff)



Understand multi-jet emission (unintegr. pdf's), tune MC's

Production of high mass 1^- states



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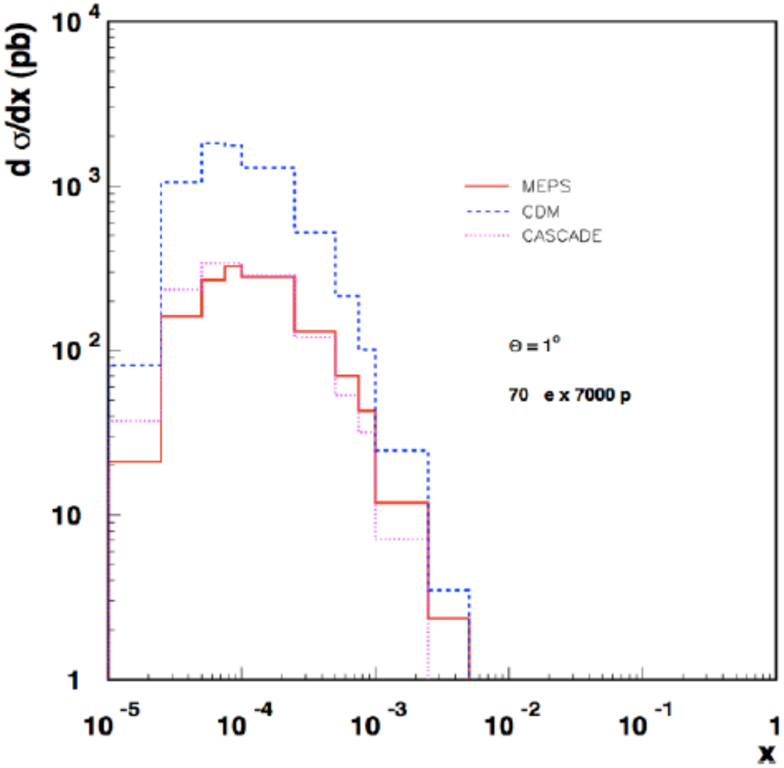
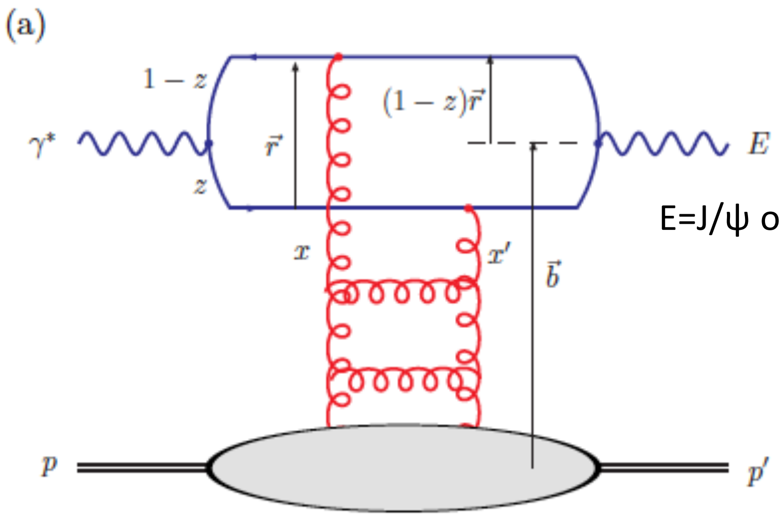


At HERA resolved γ effects mimic non-kt ordered emission

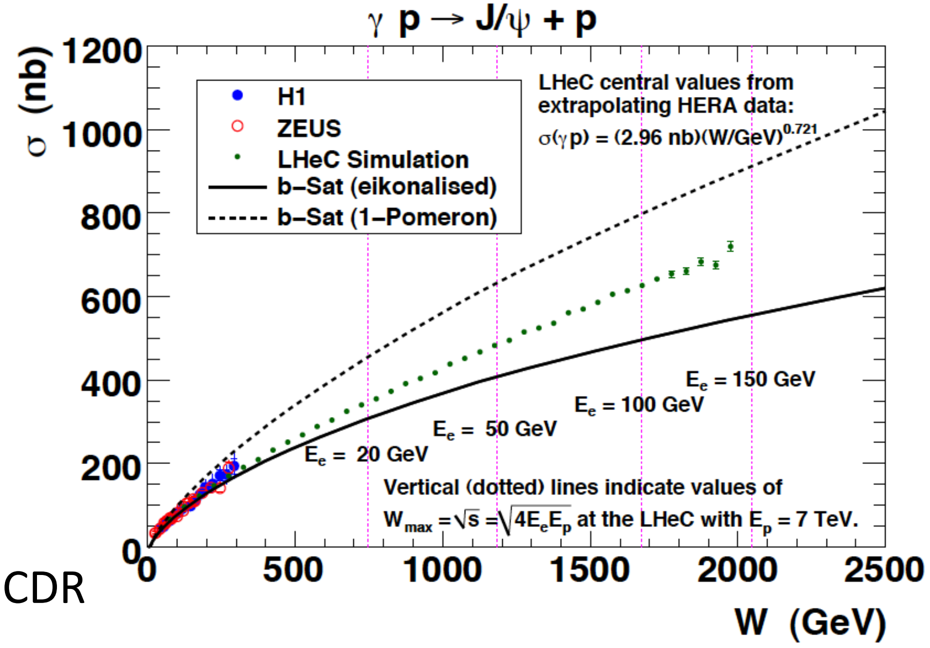
J/ψ in γ^*p/A



E=J/ψ or γ (DVCS)

$$\sigma_{T,L}^{\gamma^* p}(x,Q) = \mathrm{Im}\,\mathcal{A}_{T,L}^{\gamma^* p\to\gamma^* p}(x,Q,\Delta=0) = \sum_f \int \mathrm{d}^2\boldsymbol{r}\int_0^1 \frac{\mathrm{d}z}{4\pi}(\Psi^*\Psi)_{T,L}^f \int \mathrm{d}^2\boldsymbol{b}\,\frac{\mathrm{d}\sigma_{q\bar q}}{\mathrm{d}^2\boldsymbol{b}}$$

Optical theorem relates J/ψ to $F_T=F_2-F_L$



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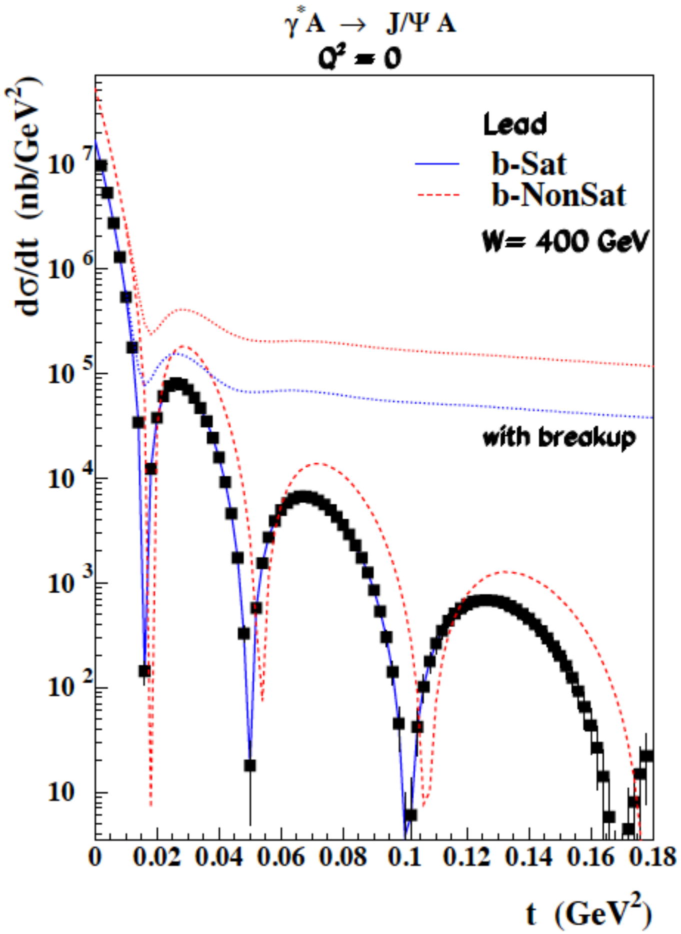
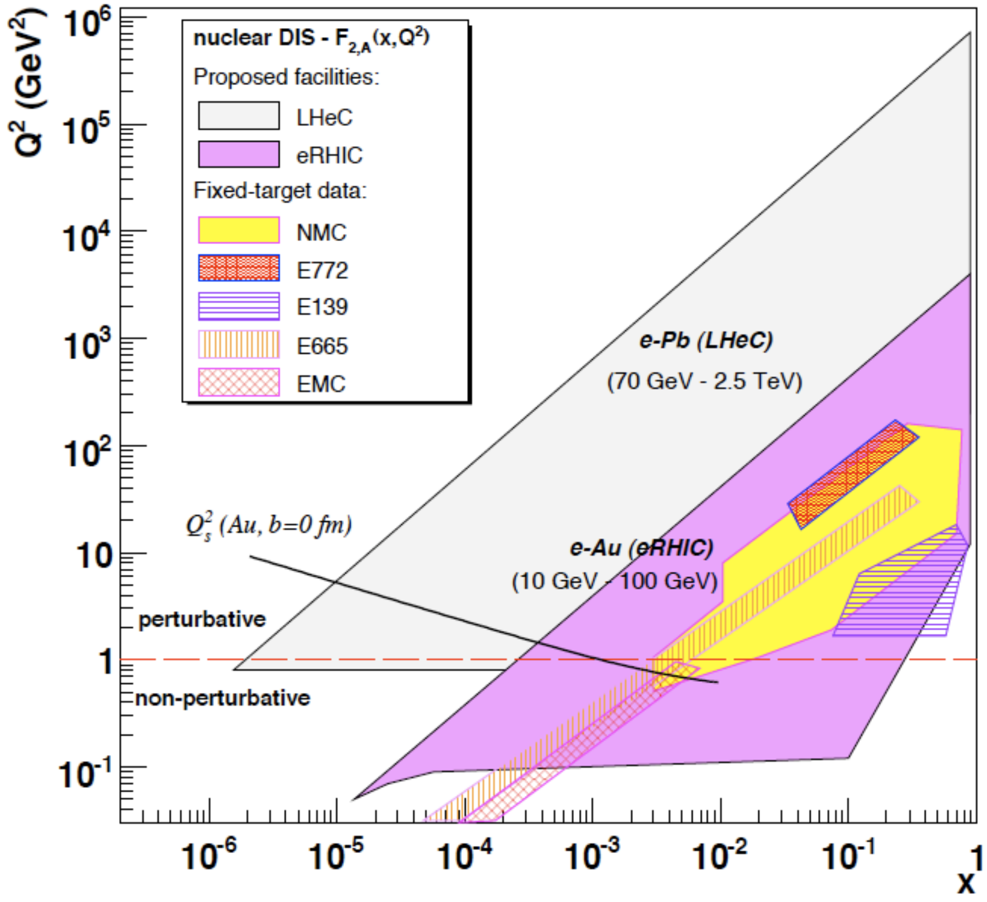
Test of saturation



Coherent production in γ*A

Probing of nuclear matter

Electron-Ion Scattering



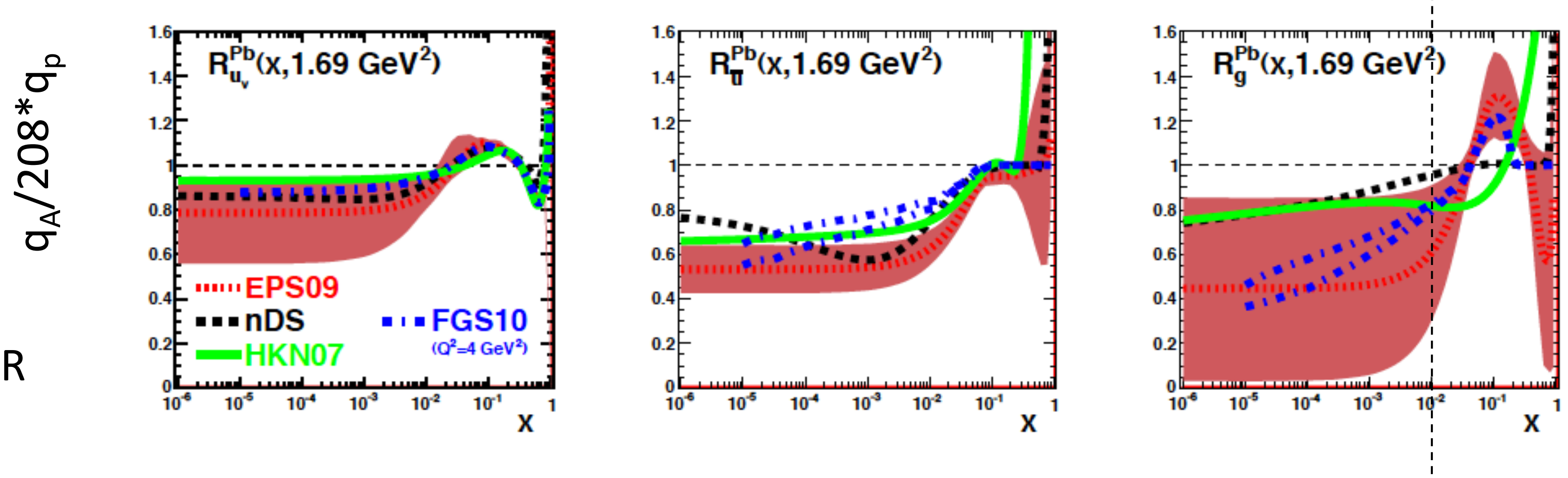
Dipole models predict **saturation** which resummation in pQCD moves to lower x..
requires highest energy, low x, $Q^2 > M_p^2$

Expect **qualitative changes of behaviour**

- Black body limit of F_2
- Saturation of cross sections amplified with $A^{1/3}$
- Rise of diffraction to 50%? ….

A huge terra incognita (p without HERA)
below x ~ 10^{-2}: DIS data end. NO flavour separation though indications are that shadowing is flavour dependent, for example..

Deuterons: tag spectator, shadowing-diffraction!
Neutron structure (light sea, UHE neutrinos, QPM)



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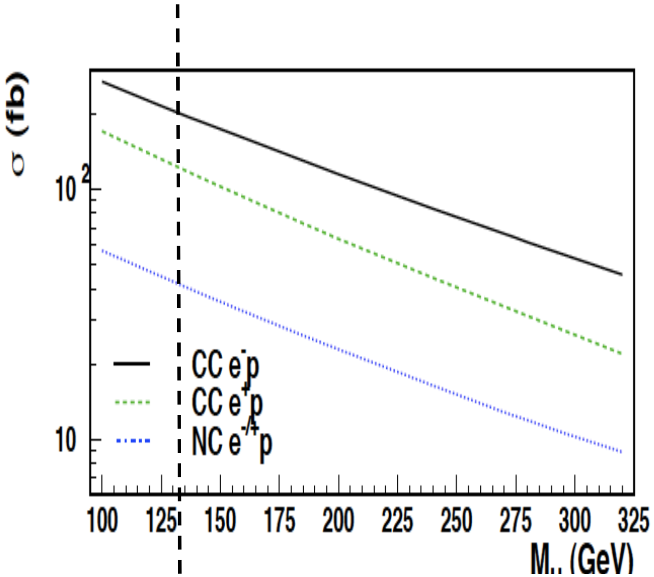
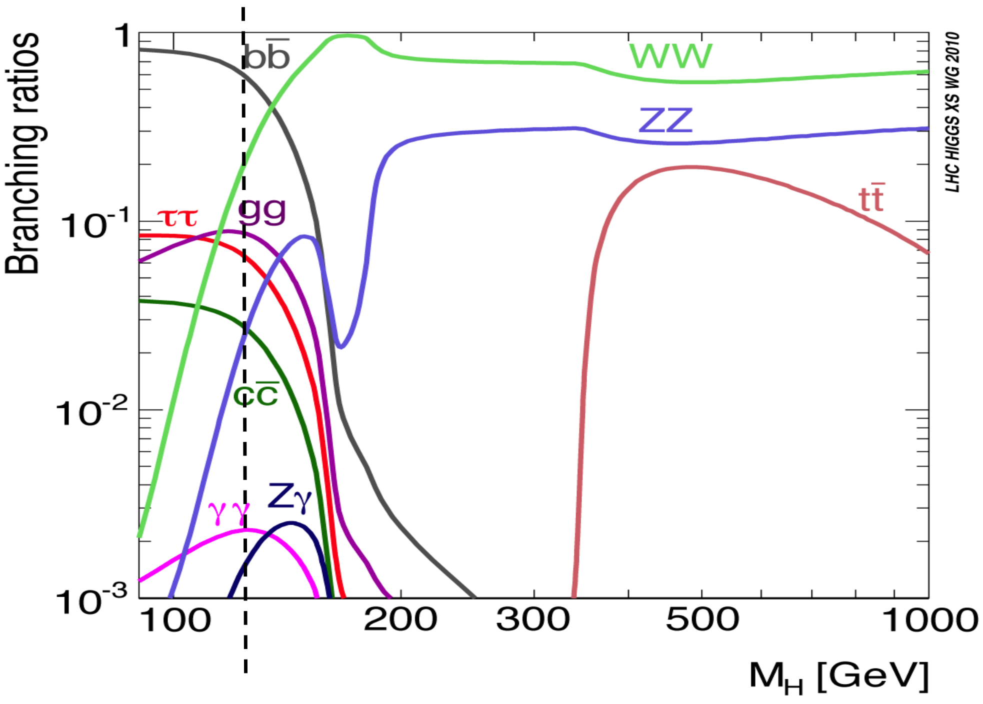
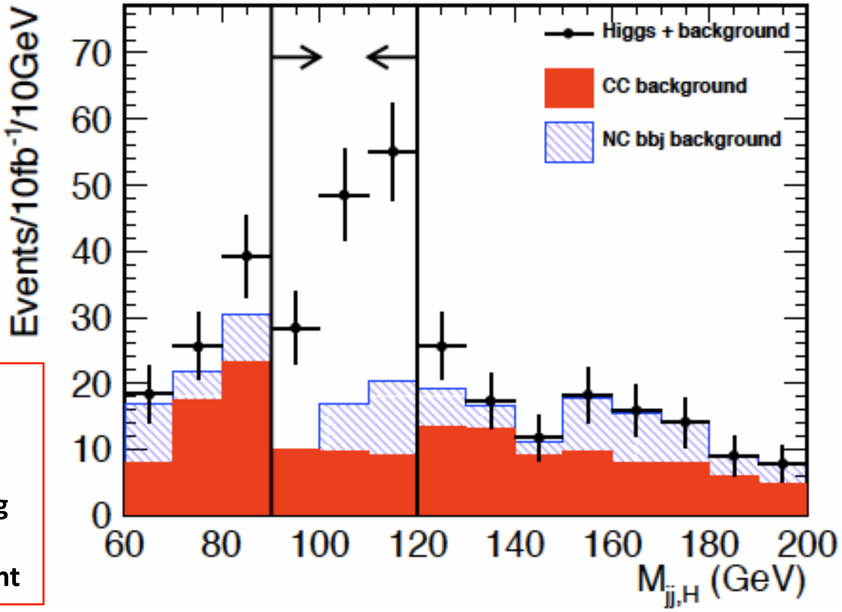
Higgs

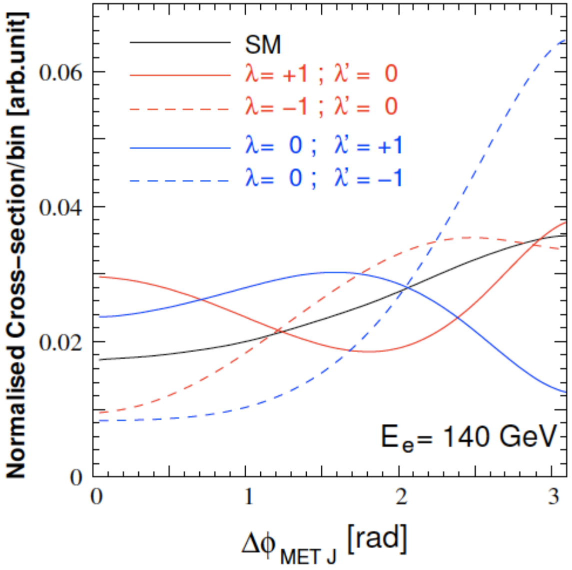




Process determines much of detector acceptance and calibration and b tag (also single top) and L/E_e requirement



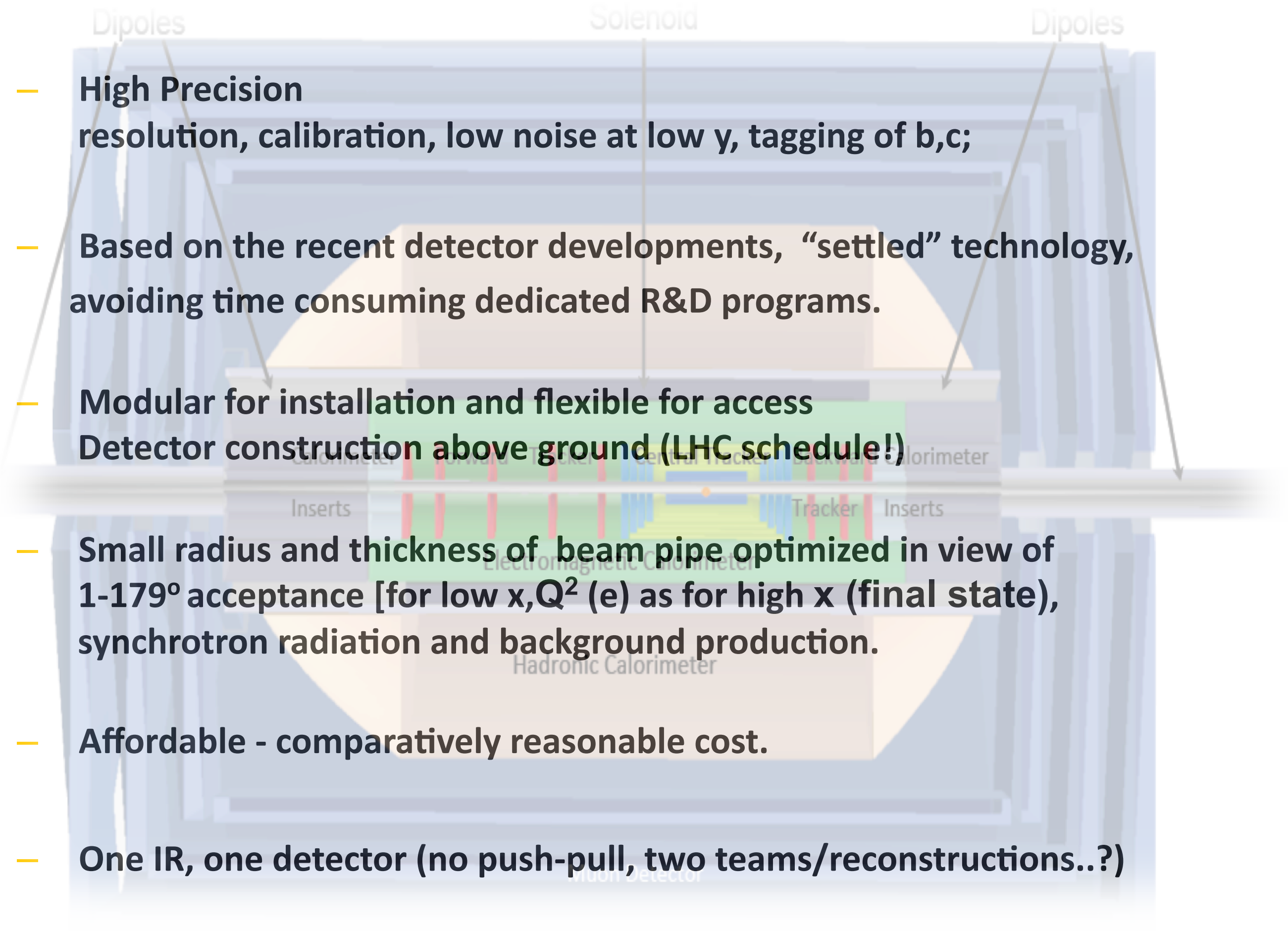
Higgs is light (or absent), CC: WW→H→bb
CP even: SM, CP odd: nonSM, mixture?



The LHeC Detector Concept

IV Detector

85 pages



- **High Precision**
  resolution, calibration, low noise at low y, tagging of b,c;
- **Based on the recent detector developments, "settled" technology, avoiding time consuming dedicated R&D programs.**
- **Modular for installation and flexible for access**
  Detector construction above ground (LHC schedule!)
- **Small radius and thickness of beam pipe optimized in view of 1-179° acceptance [for low x,Q^2 (e) as for high x (final state), synchrotron radiation and background production.**
- **Affordable - comparatively reasonable cost.**
- **One IR, one detector (no push-pull, two teams/reconstructions..?)**

Magnets

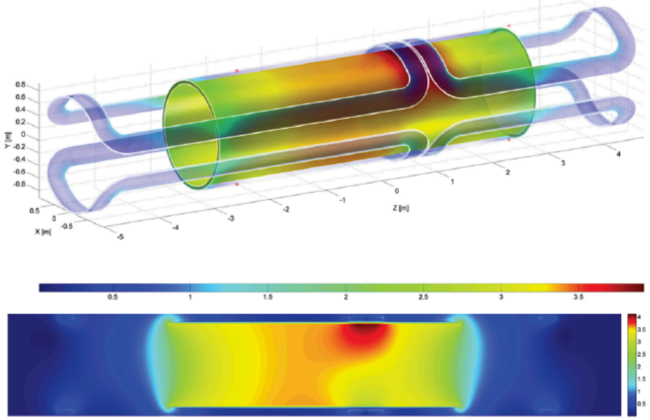
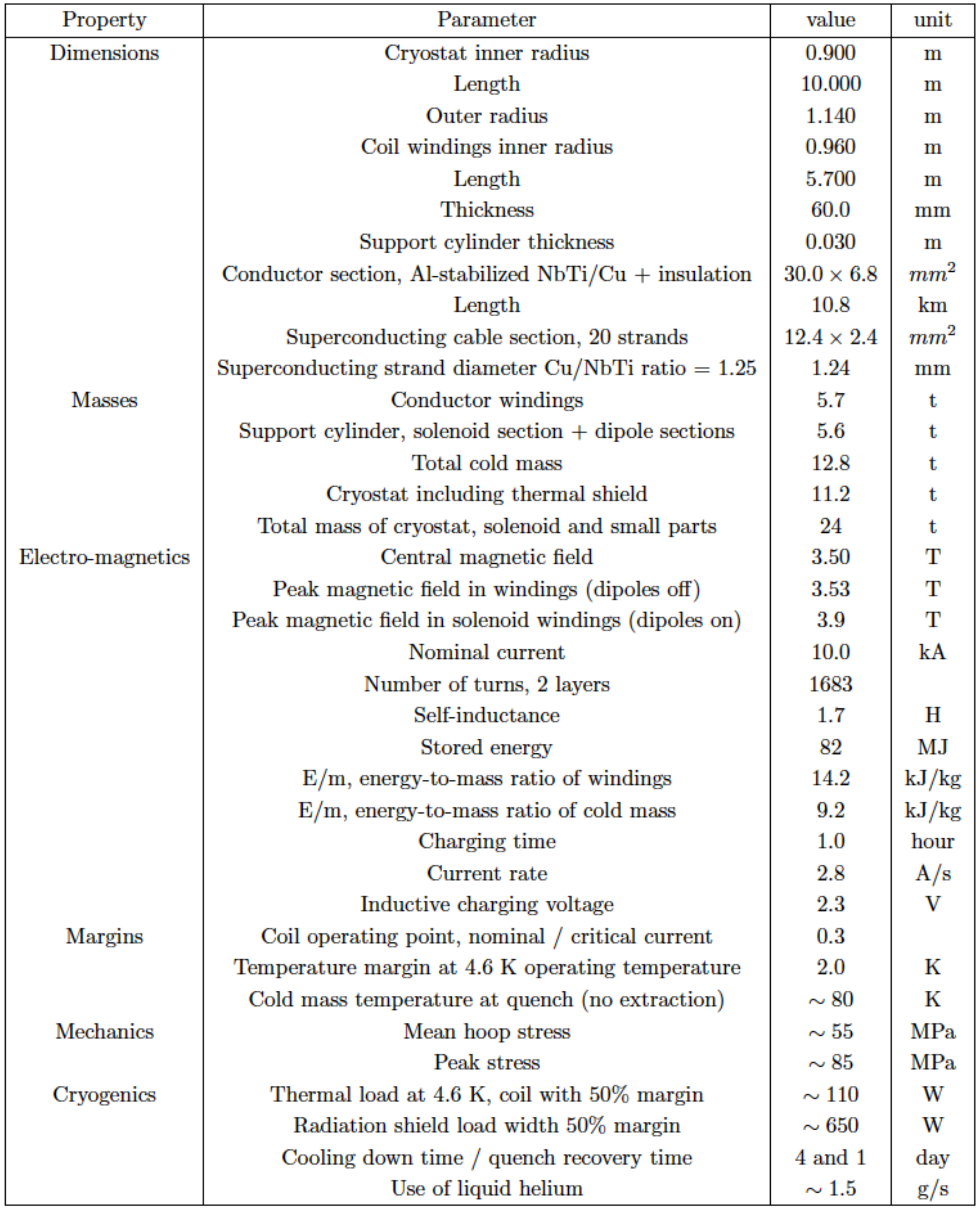


Figure 13.13: Magnetic field of the magnet system of solenoid and the two internal superconducting dipoles at nominal currents (effect of iron ignored). The position of the peak magnetic field of 3.9 T is local due to the adjacent current return heads on top of the solenoid where all magnetic fields add up.

Dipole (for head on LR) and solenoid in common cryostat, perhaps with electromagnetic LAr

3.5T field at ~1m radius to house a Silicon tracker

Based on ATLAS+CMS experience

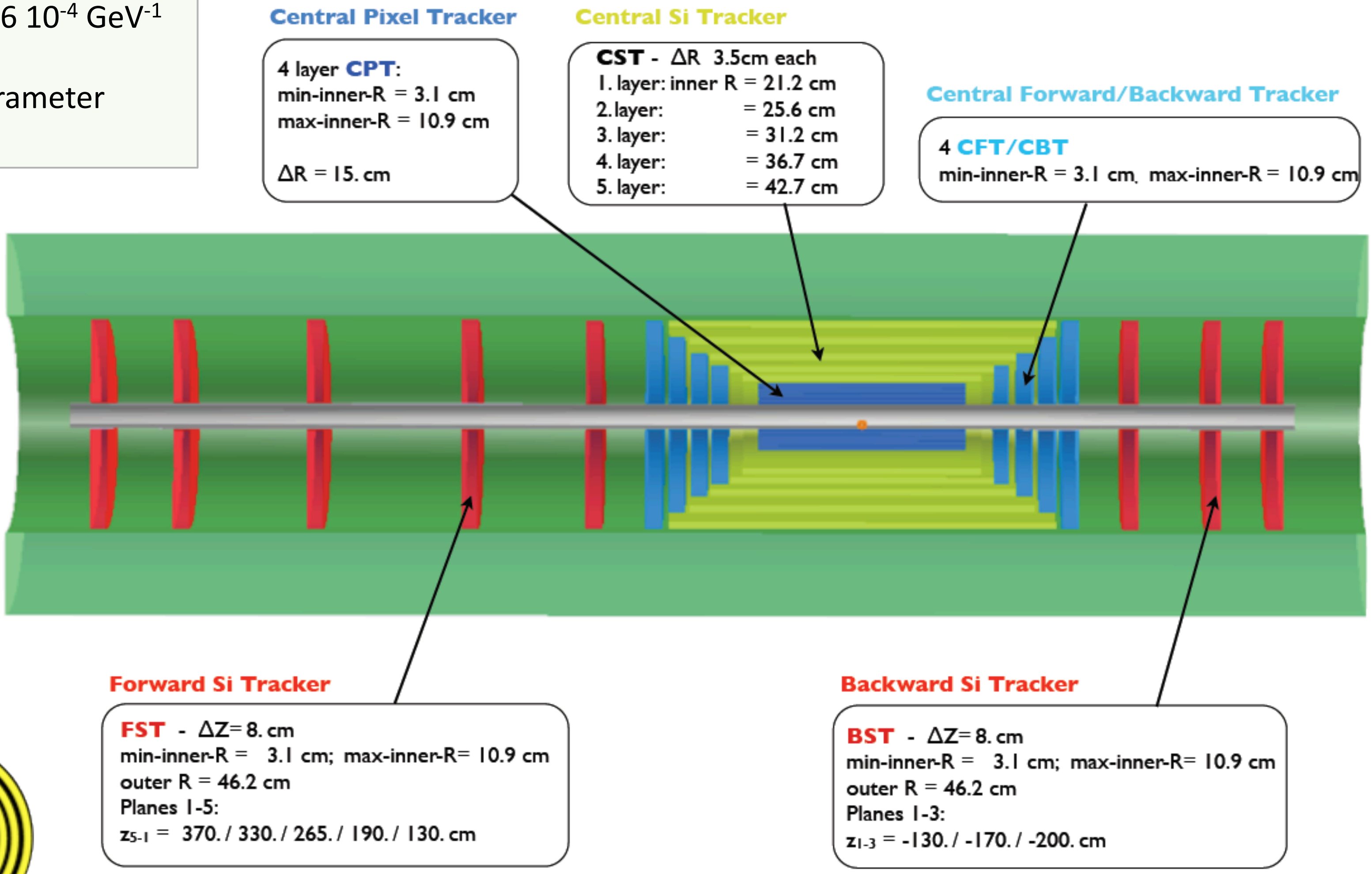


Property	Parameter	value	unit
Dimensions	Cryostat inner radius	0.900	m
	Length	10.000	m
	Outer radius	1.140	m
	Coil windings inner radius	0.960	m
	Length	5.700	m
	Thickness	60.0	mm
	Support cylinder thickness	0.030	m
	Conductor section, Al-stabilized NbTi/Cu + insulation	30.0×6.8	mm^2
	Length	10.8	km
	Superconducting cable section, 20 strands	12.4×2.4	mm^2
	Superconducting strand diameter Cu/NbTi ratio = 1.25	1.24	mm
Masses	Conductor windings	5.7	t
	Support cylinder, solenoid section + dipole sections	5.6	t
	Total cold mass	12.8	t
	Cryostat including thermal shield	11.2	t
	Total mass of cryostat, solenoid and small parts	24	t
Electro-magnetics	Central magnetic field	3.50	T
	Peak magnetic field in windings (dipoles off)	3.53	T
	Peak magnetic field in solenoid windings (dipoles on)	3.9	T
	Nominal current	10.0	kA
	Number of turns, 2 layers	1683	
	Self-inductance	1.7	H
	Stored energy	82	MJ
	E/m, energy-to-mass ratio of windings	14.2	kJ/kg
	E/m, energy-to-mass ratio of cold mass	9.2	kJ/kg
	Charging time	1.0	hour
	Current rate	2.8	A/s
	Inductive charging voltage	2.3	V
Margins	Coil operating point, nominal / critical current	0.3	
	Temperature margin at 4.6 K operating temperature	2.0	K
	Cold mass temperature at quench (no extraction)	~ 80	K
Mechanics	Mean hoop stress	~ 55	MPa
	Peak stress	~ 85	MPa
Cryogenics	Thermal load at 4.6 K, coil with 50% margin	~ 110	W
	Radiation shield load width 50% margin	~ 650	W
	Cooling down time / quench recovery time	4 and 1	day
	Use of liquid helium	~ 1.5	g/s

Table 13.1: Main parameters of the baseline LHeC Solenoid providing 3.5 T in a free bore of 1.8 m.

Silicon Tracker and EM Calorimeter

Transverse momentum
$\Delta p_t/p^2_t$ → 6 10^{-4} GeV^{-1}
transverse
impact parameter
→ 10µm



Central Pixel Tracker

4 layer **CPT**:
min-inner-R = 3.1 cm
max-inner-R = 10.9 cm

ΔR = 15. cm

Central Si Tracker

CST - ΔR 3.5cm each
1. layer: inner R = 21.2 cm
2. layer: = 25.6 cm
3. layer: = 31.2 cm
4. layer: = 36.7 cm
5. layer: = 42.7 cm

Central Forward/Backward Tracker

4 **CFT/CBT**
min-inner-R = 3.1 cm, max-inner-R = 10.9 cm

Forward Si Tracker

FST - ΔZ= 8. cm
min-inner-R = 3.1 cm; max-inner-R= 10.9 cm
outer R = 46.2 cm
Planes 1-5:
z_{5-1} = 370. / 330. / 265. / 190. / 130. cm

Backward Si Tracker

BST - ΔZ= 8. cm
min-inner-R = 3.1 cm; max-inner-R= 10.9 cm
outer R = 46.2 cm
Planes 1-3:
z_{1-3} = -130. / -170. / -200. cm

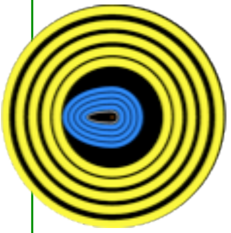
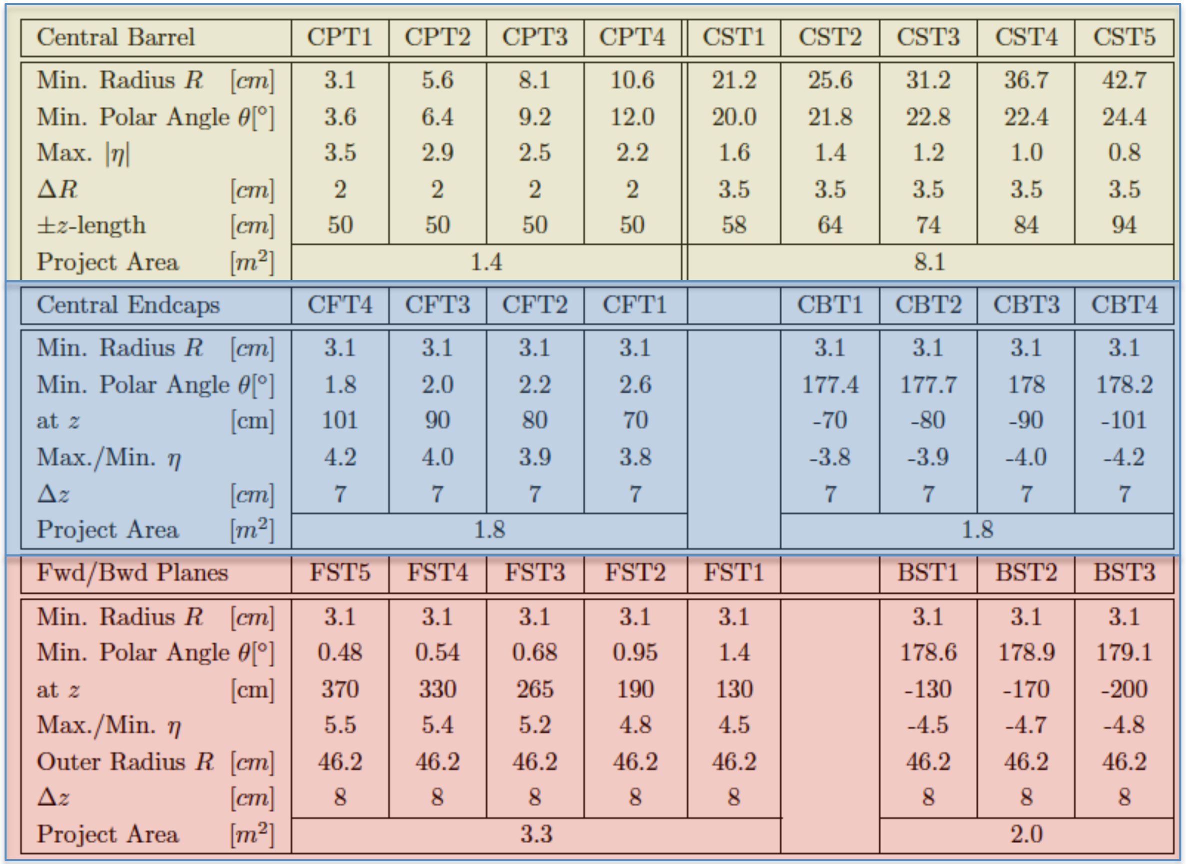


Figure 13.18: Tracker and barrel Electromagnetic-Calorimeter rz view of the baseline detector (Linac-Ring case).

LHeC Si Tracker



Central Barrel	CPT1	CPT2	CPT3	CPT4	CST1	CST2	CST3	CST4	CST5
Min. Radius R [cm]	3.1	5.6	8.1	10.6	21.2	25.6	31.2	36.7	42.7
Min. Polar Angle $\theta[^\circ]$	3.6	6.4	9.2	12.0	20.0	21.8	22.8	22.4	24.4
Max. $\|\eta\|$	3.5	2.9	2.5	2.2	1.6	1.4	1.2	1.0	0.8
ΔR [cm]	2	2	2	2	3.5	3.5	3.5	3.5	3.5
$\pm z$-length [cm]	50	50	50	50	58	64	74	84	94
Project Area [m^2]	1.4				8.1				
Central Endcaps	**CFT4**	**CFT3**	**CFT2**	**CFT1**		**CBT1**	**CBT2**	**CBT3**	**CBT4**
Min. Radius R [cm]	3.1	3.1	3.1	3.1		3.1	3.1	3.1	3.1
Min. Polar Angle $\theta[^\circ]$	1.8	2.0	2.2	2.6		177.4	177.7	178	178.2
at z [cm]	101	90	80	70		-70	-80	-90	-101
Max./Min. η	4.2	4.0	3.9	3.8		-3.8	-3.9	-4.0	-4.2
Δz [cm]	7	7	7	7		7	7	7	7
Project Area [m^2]	1.8					1.8			
Fwd/Bwd Planes	**FST5**	**FST4**	**FST3**	**FST2**	**FST1**		**BST1**	**BST2**	**BST3**
Min. Radius R [cm]	3.1	3.1	3.1	3.1	3.1		3.1	3.1	3.1
Min. Polar Angle $\theta[^\circ]$	0.48	0.54	0.68	0.95	1.4		178.6	178.9	179.1
at z [cm]	370	330	265	190	130		-130	-170	-200
Max./Min. η	5.5	5.4	5.2	4.8	4.5		-4.5	-4.7	-4.8
Outer Radius R [cm]	46.2	46.2	46.2	46.2	46.2		46.2	46.2	46.2
Δz [cm]	8	8	8	8	8		8	8	8
Project Area [m^2]	3.3						2.0		

Table 13.4: Summary of tracker dimensions. The 4 Si-Pixel-Layers CPT1-CPT4 (resolution of $\sigma_{\text{pix}} \approx 8\mu m$) are positioned as close to the beam pipe as possible. Si-strixel (CST1-CST5) (resolution of $\sigma_{\text{strixel}} \approx 12\mu m$) form the central barrel layers. An alternative is the 2_in_1 single sided Si-strip solution for these barrel cylinders ($\sigma_{\text{strip}} \approx 15\mu m$) [752]. The endcap Si-strip detectors CFT/CBT(1-4) complete the central tracker. The tracker inserts, 5 wheels of Si-Strip detectors in forward direction (FST) and 3 wheels in backward direction (BST), are based on single sided Si-strip detectors of 2_in_1-design ($\sigma_{\text{strip}} \approx 15\mu m$). They have to be removed in case of high luminosity running for the Ring-Ring option of the accelerator configuration (see Fig. 13.4).

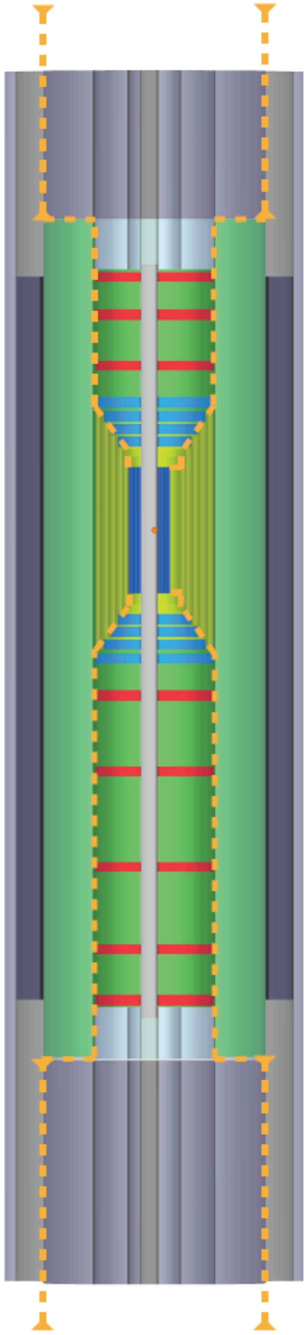


Figure 13.29: Path of services for all tracking detectors (shown in orange). The services are integrated into support structures whenever possible

Various types of pixel and strip detectors. NO pileup. Less radiation vs pp but be safe

Liquid Argon Electromagnetic Calorimeter

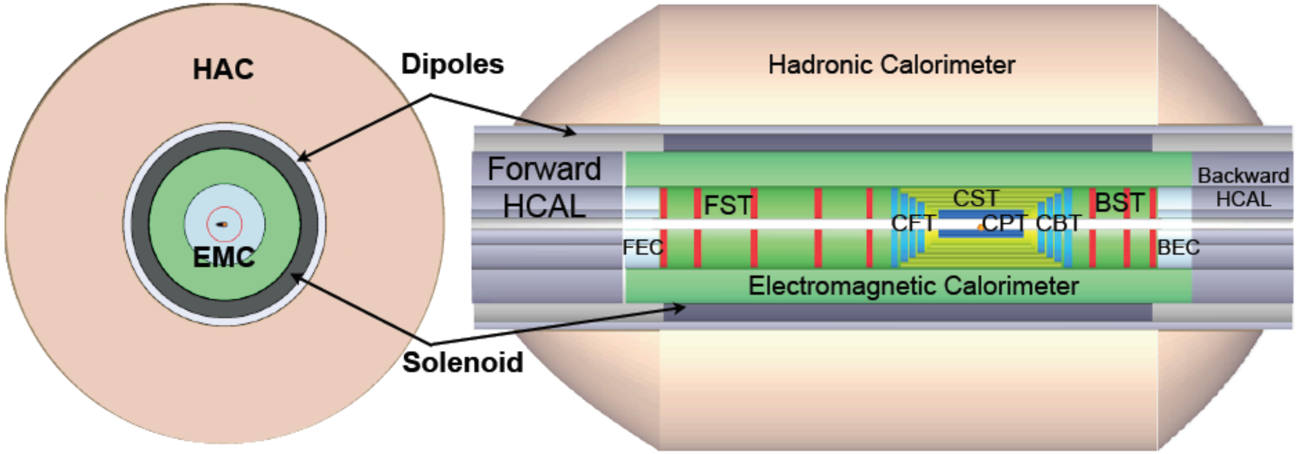


Figure 13.30: x-y and r-z view of the LHeC Barrel EM calorimeter (green).

Inside Coil
H1, ATLAS
experience.

Barrel: Pb, 20 X_0 , 11m^3

fwd/bwd inserts:

FEC: Si -W, 30 X_0 ,0.3m^3

BEC: Si -Pb, 25 X_0,0.3m^3

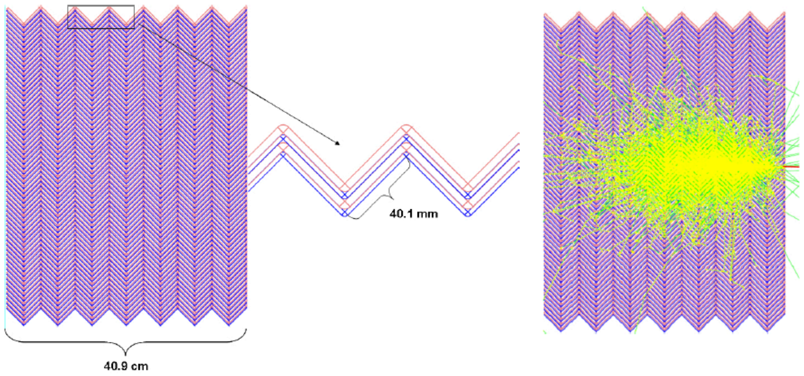


Figure 13.35: View of the parallel geometry accordion calorimeter (left) and simulation of a single electron shower with initial energy of 20 GeV (right).

GEANT4 Simulation

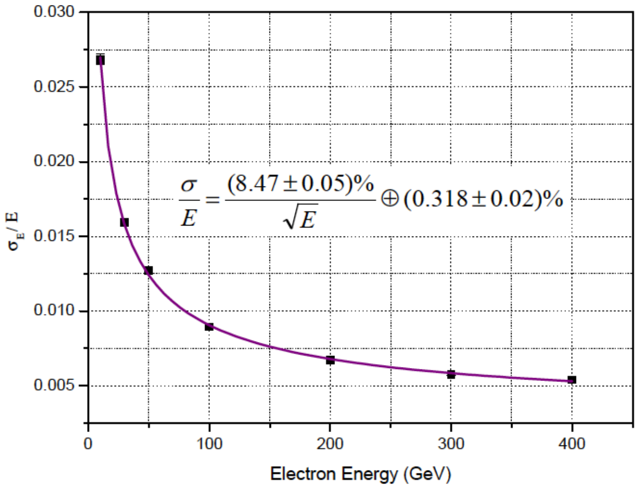
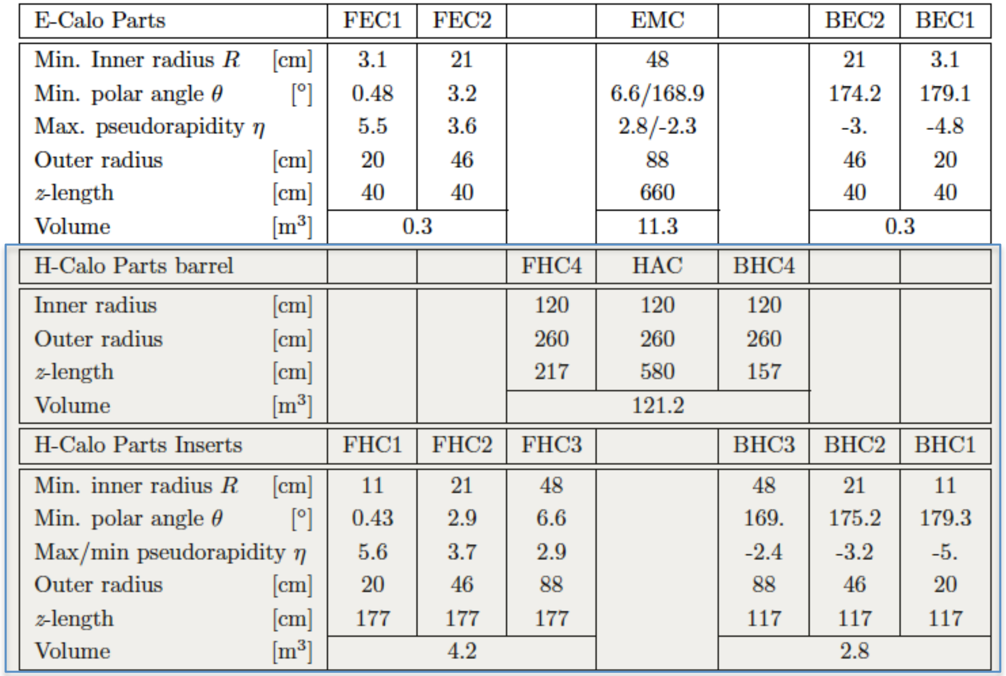


Figure 13.36: LAr accordion calorimeter energy resolution for electrons between 10 and 400 GeV.

Hadronic Tile Calorimeter

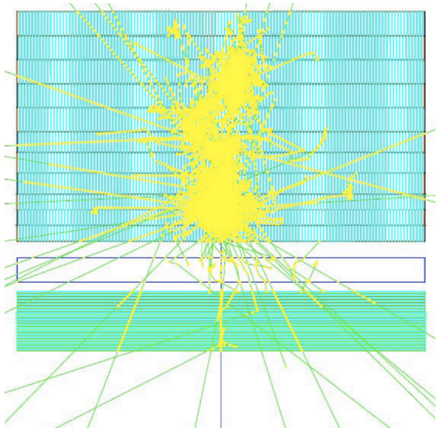
Outside Coil: flux return

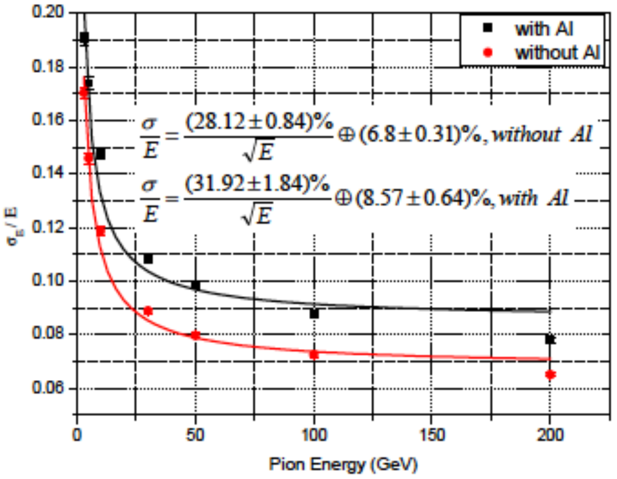
Modular. ATLAS experience.



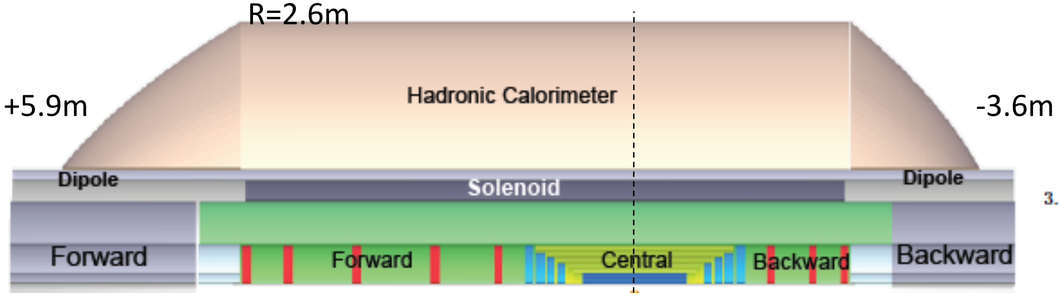
E-Calo Parts	FEC1	FEC2		EMC		BEC2	BEC1
Min. Inner radius R [cm]	3.1	21		48		21	3.1
Min. polar angle θ [°]	0.48	3.2		6.6/168.9		174.2	179.1
Max. pseudorapidity η	5.5	3.6		2.8/-2.3		-3.	-4.8
Outer radius [cm]	20	46		88		46	20
z-length [cm]	40	40		660		40	40
Volume [m^3]	0.3			11.3		0.3	
H-Calo Parts barrel			FHC4	HAC	BHC4		
Inner radius [cm]			120	120	120		
Outer radius [cm]			260	260	260		
z-length [cm]			217	580	157		
Volume [m^3]				121.2			
H-Calo Parts Inserts	FHC1	FHC2	FHC3		BHC3	BHC2	BHC1
Min. inner radius R [cm]	11	21	48		48	21	11
Min. polar angle θ [°]	0.43	2.9	6.6		169.	175.2	179.3
Max/min pseudorapidity η	5.6	3.7	2.9		-2.4	-3.2	-5.
Outer radius [cm]	20	46	88		88	46	20
z-length [cm]	177	177	177		117	117	117
Volume [m^3]		4.2				2.8	

Table 13.6: Summary of calorimeter dimensions.
The electromagnetic barrel calorimeter is currently represented by the barrel part EMC (LAr-Pb module); the setup reaches $X_0 \approx 25$ radiation length) and the movable inserts forward FEC1, FEC2 (Si-W modules ($X_0 \approx 30$) and the backward BEC1, BEC2 (Si-Pb modules; $X_0 \approx 25$).
The hadronic barrel parts are represented by FHC4, HAC, BHC4 (forward, central and backward - Scintillator-Fe Tile modules; $\lambda_I \approx 8$ interaction length) and the movable inserts FHC1, FHC2, FHC3 (Si-W modules; $\lambda_I \approx 10$), BHC1, BHC2, BHC3 (Si-Cu modules, $\lambda_I \approx 8$) see Fig. 13.9.



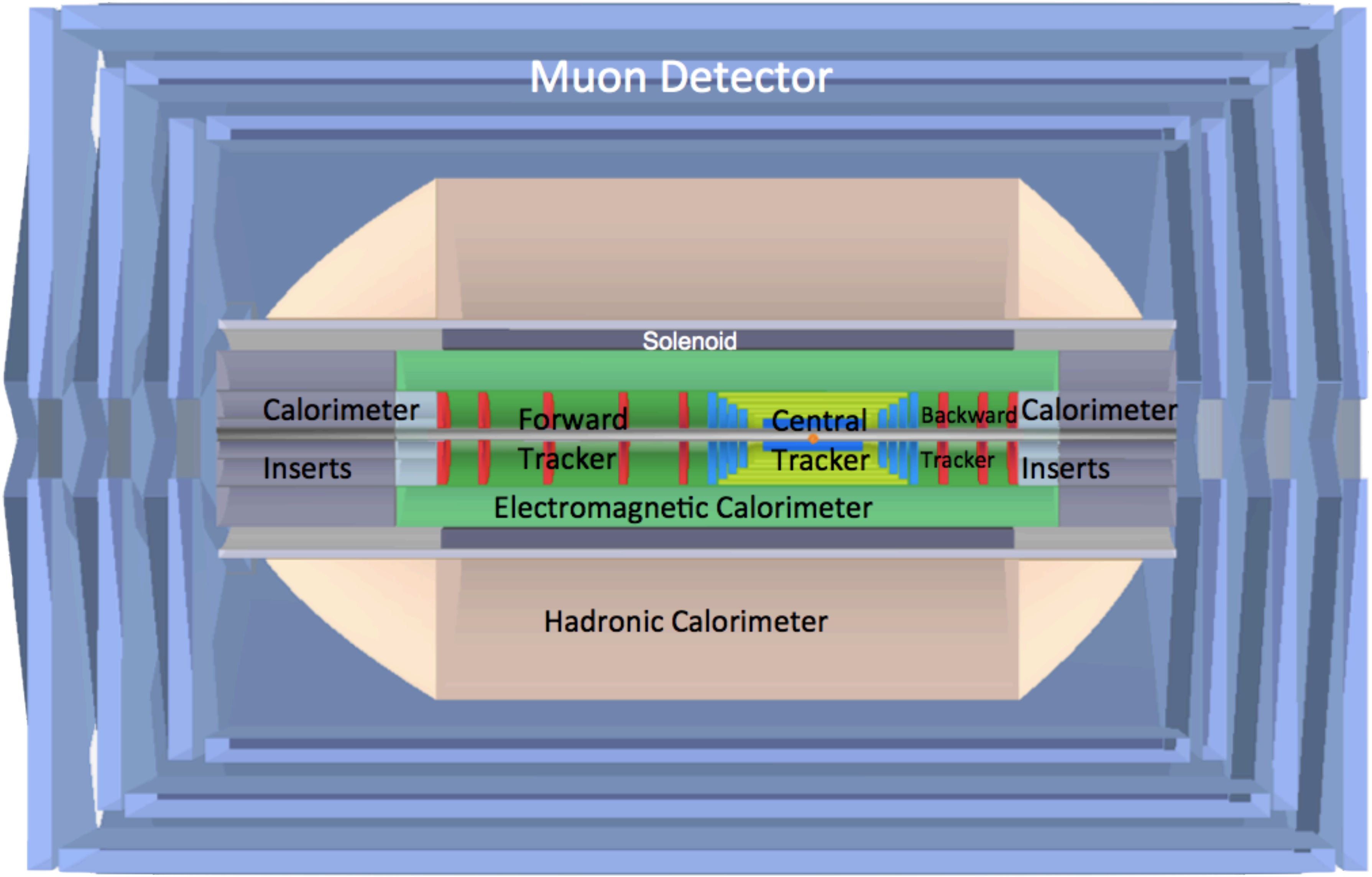


3.37: Accordion and Tile Calorimeter energy resolution for pions with and without 14cm Al block.



Combined GEANT4 Calorimeter Simulation

LHeC Detector Overview



Detector option 1 for LR and full acceptance coverage

Forward/backward asymmetry in energy deposited and thus in geometry and technology
Present dimensions: LxD =14x9m^2 [CMS 21 x 15m^2 , ATLAS 45 x 25 m^2]
Taggers at -62m (e),100m (γ,LR), -22.4m (γ,RR), +100m (n), +420m (p)

Summary [for physics and detector part or report]

The (draft) Report on Designs for the LHeC has been delivered and is under review by 24 referees appointed by CERN, publish spring.

The physics of a TeV scale ep collider is unique and complementary to the LHC at the same time. Its main virtues are: [eq/eeqq,H] new physics should that occur at the LHC, ultra-high precision QCD and e.weak measurements, a complete unfolding of the quark and anti-q structure of the proton, including top, new physics at lowest x related to UHE neutrinos and the understanding of the QGP initial state with unique measurements of the partonic structure of nuclei…

A detector concept has been worked out which indicates that the required acceptance and precision may be reached. Its technology is suggested to be chosen for a fast installation and in line with mainly the LHC detector choices, taken and for the ongoing upgrades.

Courage is now required to move towards building a further, unique LHC experiment at CERN. Half of it is built, and it may start in 2022.

Special thanks to ECFA for an encouraging and demanding Collaboration

backup

New Physics at the LHeC

Divonne 08

- **Lepto-Quark Production and Decay (s and t-channel effects)**
- **Squarks and Gluinos**
- **ZZ, WZ, WW elastic and inelastic collisions**
- **Technicolor**
- **Novel Higgs Production Mechanisms**
- **Composite electrons**
- **Lepton-Flavor Violation**
- **QCD at High Density in ep and eA collisions**
- **Odderon**

$$\text{Maximum } W < 1.4 \text{ TeV}$$
$$\text{for } E_e = 140 \text{ GeV}, E_p = 7 \text{ TeV}$$

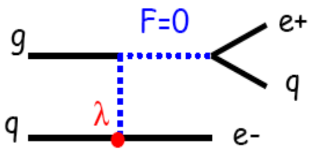
Broad physics goals (to be discussed at the Workshop)

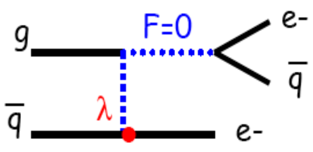
- Proton structure and QCD physics in the domain of x and Q^2 of LHC experiments
- Small-x physics in eP and eA collisions
- Probing the $e^{\pm}$-quark system at ~TeV energy
  eg leptoquarks, excited e*'s, mirror e, SUSY with no R-parity......
- Searching for new EW currents
  eg RH W's, effective eeqq contact interactions...

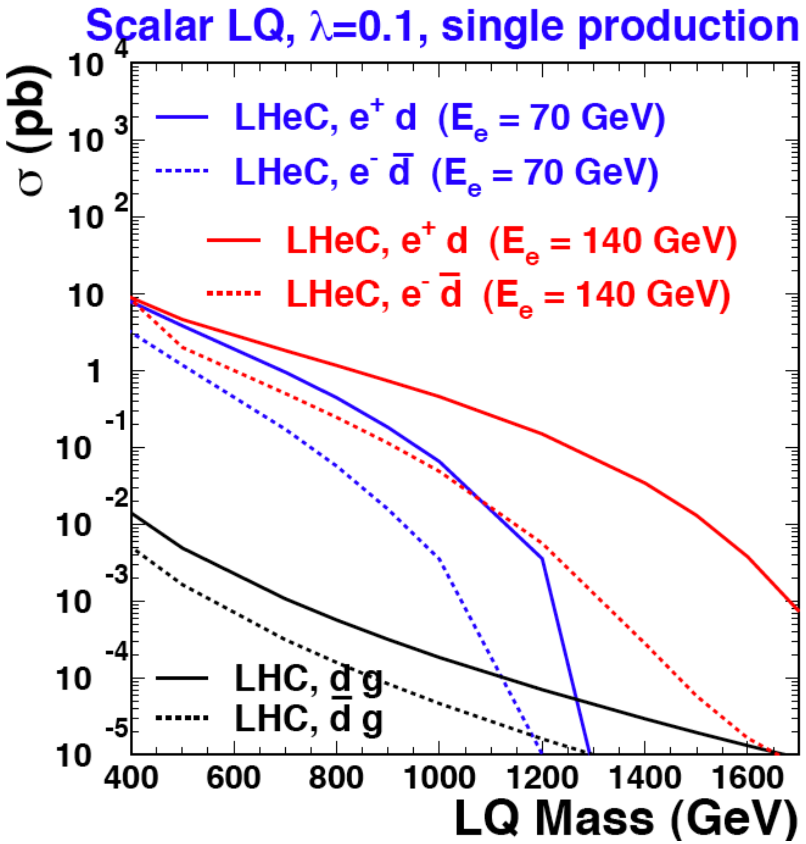
G. Altarelli

J.Bartels: Theory on low x

LQ Quantum Numbers







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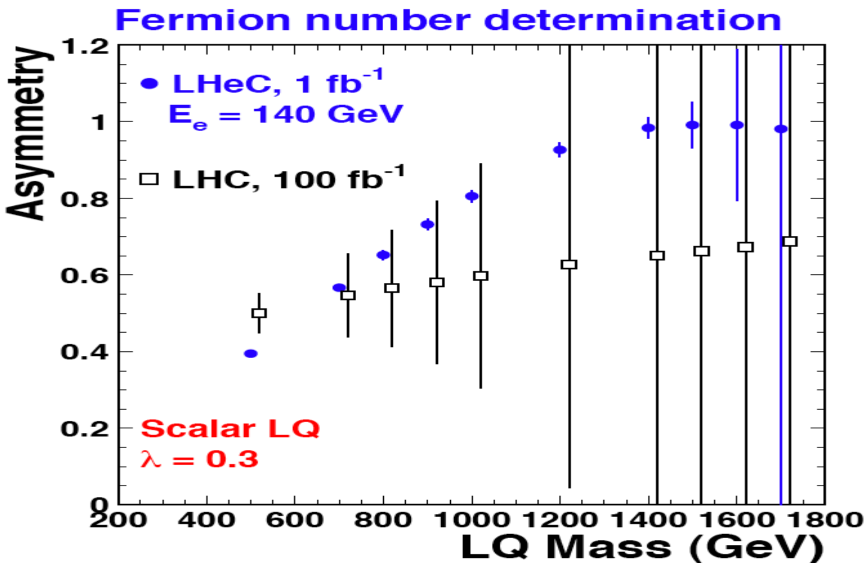

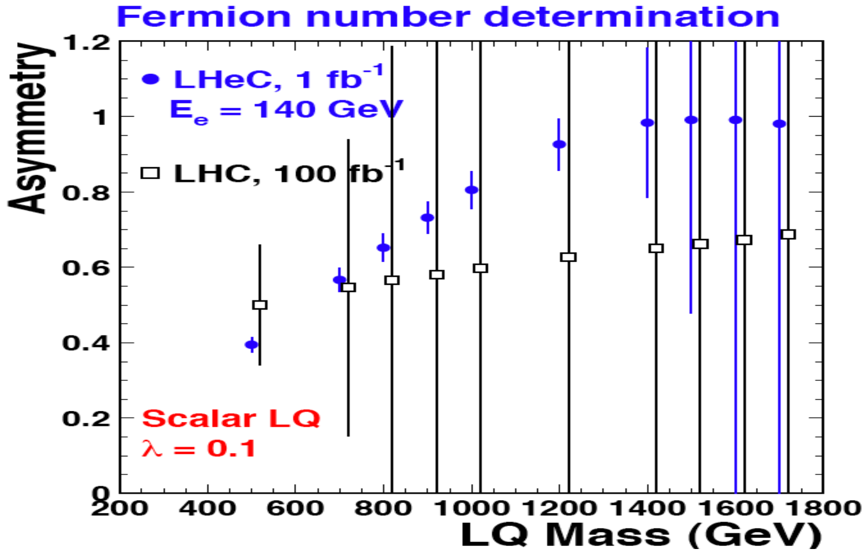

Charge asymmetry much cleaner in ep [in] than in pp [out].
Similar for simultaneous determination of coupling
and quark flavour. Polarisation for spectroscopy