The LHeC Detector Summary

P. Kostka, A. Polini

LHeC Workshop Chavannes- de-Bogis

June 15th 2012

Detector Session Agenda

Thursday:

| Detector (14:00 ->18:00)		
14:00	Interaction Region (30')	Rogelio Tomas Garcia (CERN)
14:30	IR Beam Pipe and Vacuum (30')	Paul Cruikshank (CERN)
15:00	Muon Detection (30')	Ludovico Pontecorvo (Universita e INFN, Roma I (IT))
15:30	Detector Magnet Designs (30')	Herman Ten Kate (CERN)
16:00	Coffee (30')	
16:30	LHeC Tracker Design viewed from LHCb (30')	Themis Bowcock (CERN)
17:00	LHeC Tracker Design viewed from CMS (30')	Andrei Starodumov (Eidgenoessische Tech. Hochschule Zuerich (CH))
17:30	LHeC Tracker Design viewed from ATLAS (30')	Ilya Tsurin (University of Liverpool (GB))

Friday:

Detector (09:00 ->13:00)		
09:00	ECAL Design viewed from ATLAS and H1 (30')	Juraj Bracinik (University of Birmingham (GB))
09:30	Tile/hadronic Calorimeter Design viewed from ATLAS (30')	Claudio Santoni (Univ. Blaise Pascal Clermont-Fe. II (FR))
10:00	Developments in Hadron Calorimetry (30')	Jose Repond (Argonne National Laboratory)
10:30	Coffee (30')	
11:00	Forward and Backward Taggers (30')	Armen Bunyatian (DESY)
11:30	A Detector Installation Study (20')	Andrea Gaddi (CERN)
11:50	Resources Estimates (20')	Markus Nordberg (CERN)

Linac Ring - Favored Option

Linac-Ring:
- Reduced impact on LHC schedule/running
- Design: Energy Recovery Linac
- Head on collisions: Dipole field along the whole interaction region
- Detector cavern: LHC Interaction Point P2
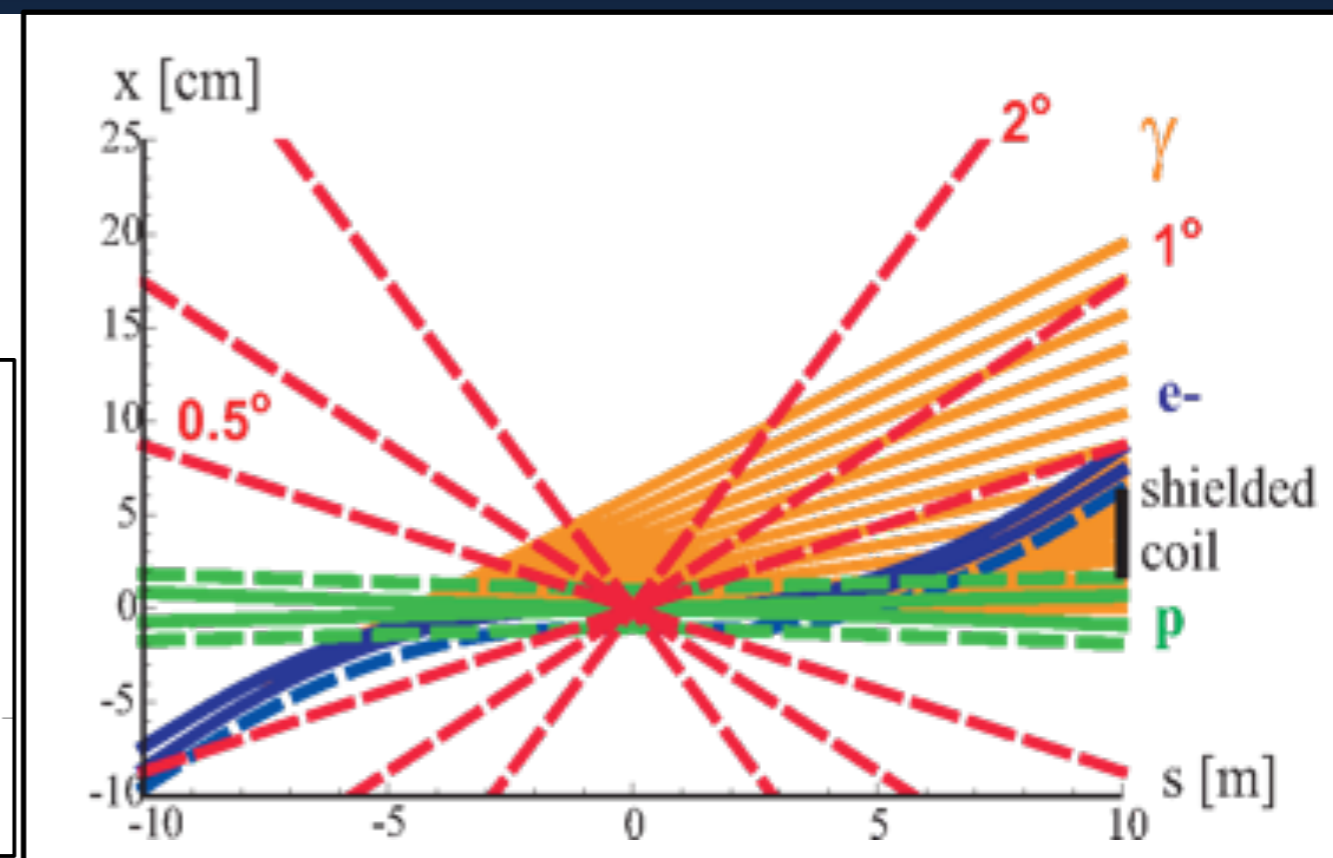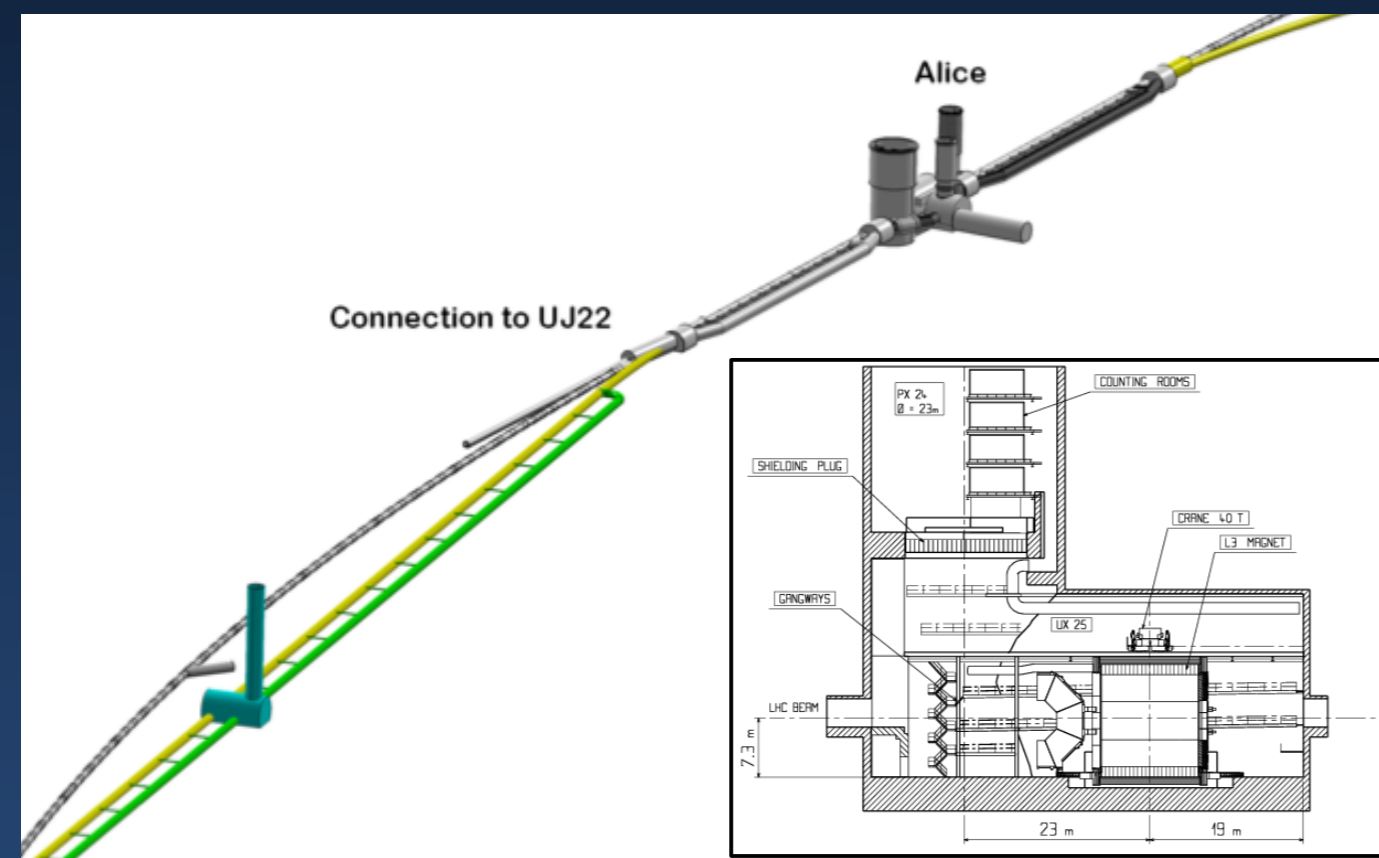
LHeC interaction region

R. Tomas

Many thanks for contributions to J. Abelleira,
N. Bernard, O. Bruning, Y.I. Levinsen, H. Garcia,
M. Klein, P. Kostka, S. Russenschuck, D. Schulte,
L. Thompson and F. Zimmermann

Status and DIS12 feedback

- Concept OK

- IR synchrotron radiation scary

- Detector solenoid to be considered

- B field in e⁻ Q1 aperture to be considered

- e⁻/e⁺ compatibility

- Chromaticity correction and FFS synchrotron radiation to be balanced (3 e⁻ optics designs)

Linac-Ring IR magnets

-High-gradient SC IR quadrupoles based on Nb3Sn for colliding proton beam with common low-field **exit hole for electron beam and non-colliding proton beam**
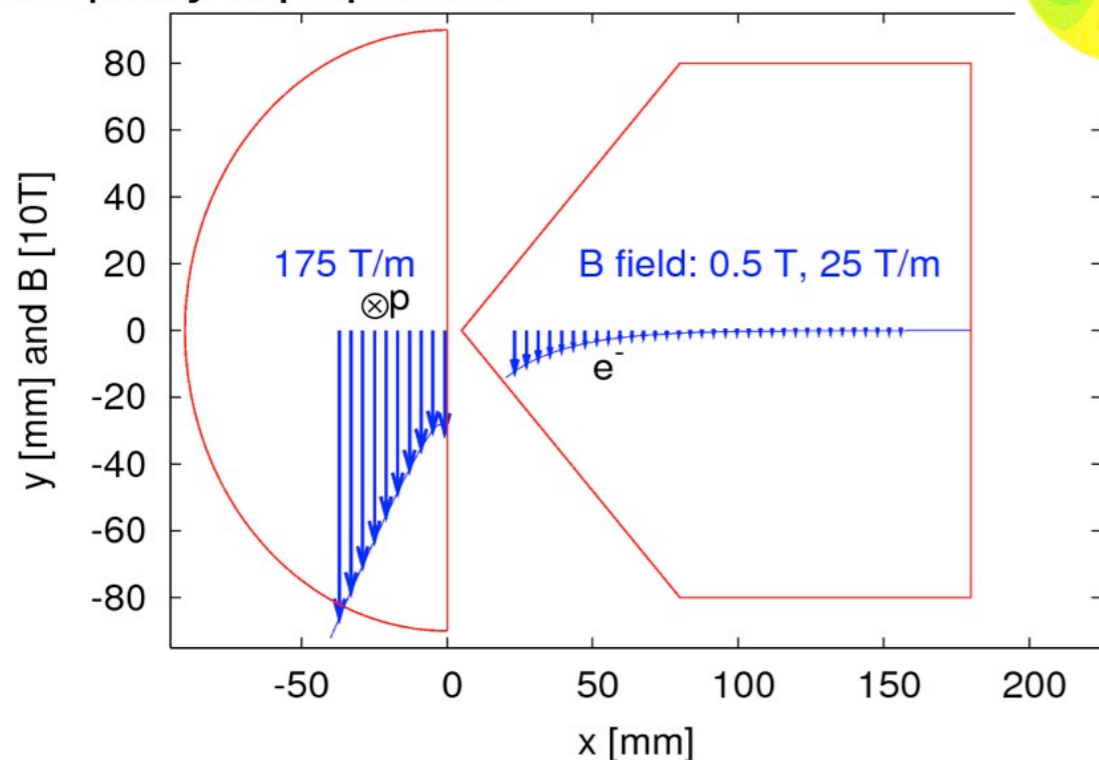

-**Detector integrated dipole**: 0.3 T over +/- 9 m
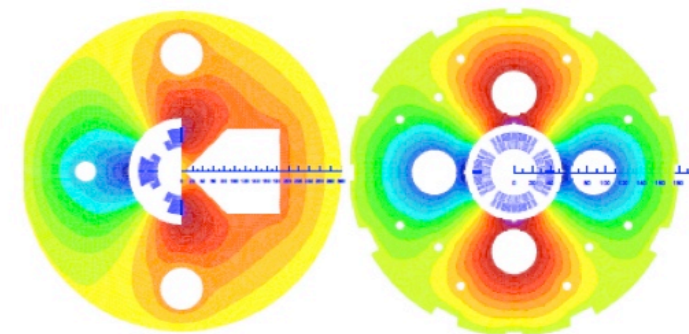
Nb3Sn (HFM46): 5700 A, 175 T/m, 4.7 T at 82% on LL (4 layers), 4.2 K	Nb3Sn (HFM46): 8600 A, 311 T/m, at 83% LL, 4.2 K
46 mm (half) ap., 63 mm beam sep.	23 mm ap.. 87 mm beam sep.
0.5 T, 25 T/m	0.09 T, 9 T/m

Fields in Q1

Poor quality in p aperture

175 T/m ⊗p

B field: 0.5 T, 25 T/m

e⁻

strong field and gradient in e⁻ aperture

Fields in Q1 with larger beam separation

175 T/m ⊗p

B field: 0.003 T, 1 T/m

e⁻
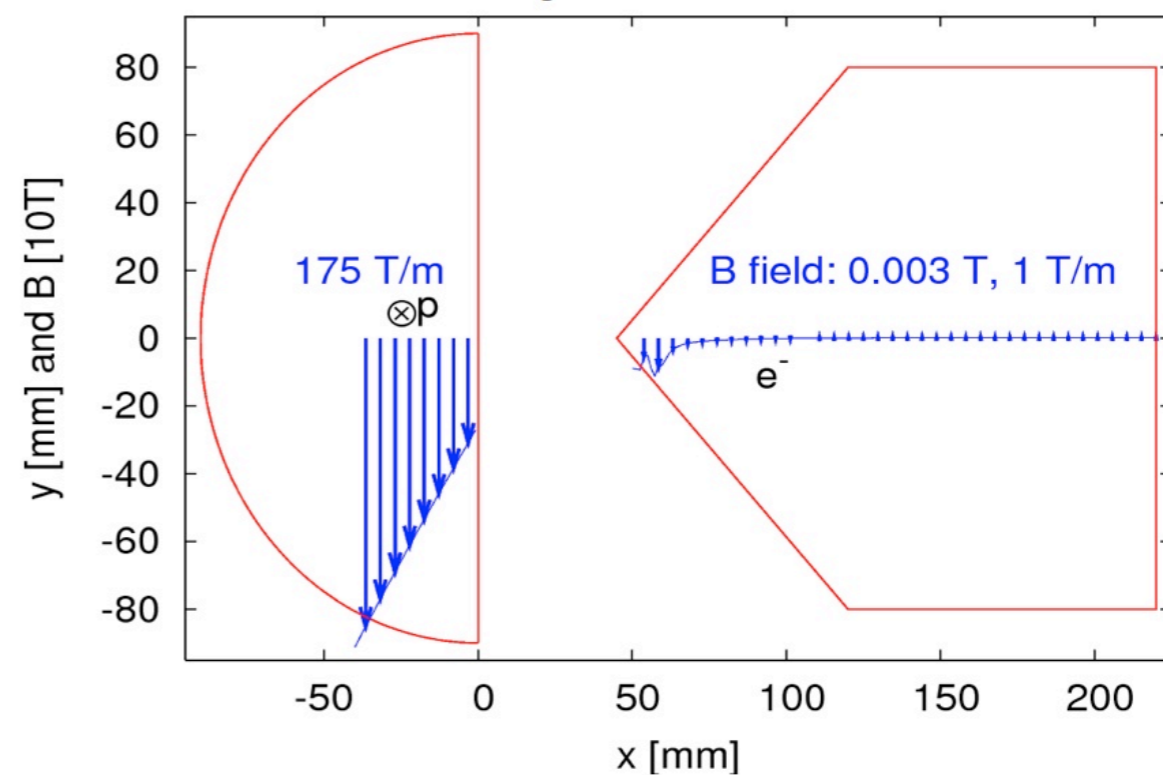
Larger separation helps a lot for field quality

Larger beam separation

- Best way is to increase also L*

- L*=20 m and B=0.15T:
  - Beam separation = 130 mm
  - Photon critical energy = 360 keV
  - IR synchrotron power = 25 kW (factor 2 lower!)
  - Half quadrupole might not be necessary anymore

  !

- This introduces larger chromaticity in LHC → larger beta* → lower luminosity

  !

- Unless the LHeC IP could be IP3 or IP7 to adopt ATS optics-like approach

e⁻/e⁺ compatibility

- All e⁻ IR and FFS dipoles and quadrupoles should be bipolar

- The solenoid polarity can stay unchanged, the orbit correction system should do

- The field in the Q1 e⁻ aperture should be negligible → another motivation for larger beam separation

Conclusions

- SR and back shining from absorber is the largest concern (lower bend/SR welcome), followed by SR power in the spin rotator *!*

- Solenoid effects are reasonably small *!*

- Q1 field quality might impose larger beam separation and longer L* (→reduce By/SR) *!*

- Optimization of L* and β* within the LHC

- e⁻ FFS optics: balance between chromaticity correction, SR and length

- Common effort needed for the global optimization *!*
  → study group

LHeC Experimental Beam Pipe

Paul Cruikshank,
Technology Department ,
Vacuum, Surfaces & Coatings Group

(based on LHeC presentations, CDR and inputs from R.Veness, J.Bosch & P.Kostka)
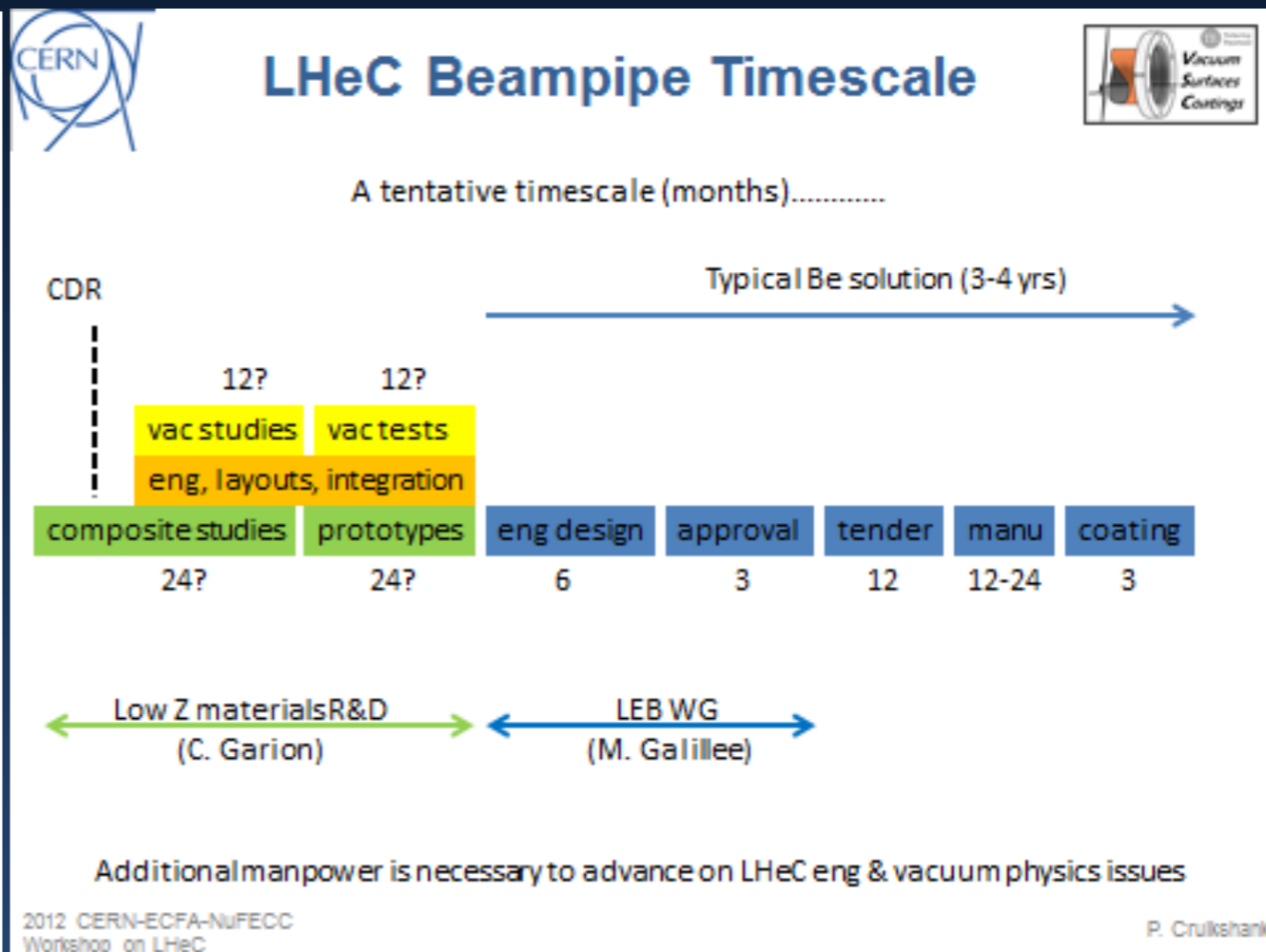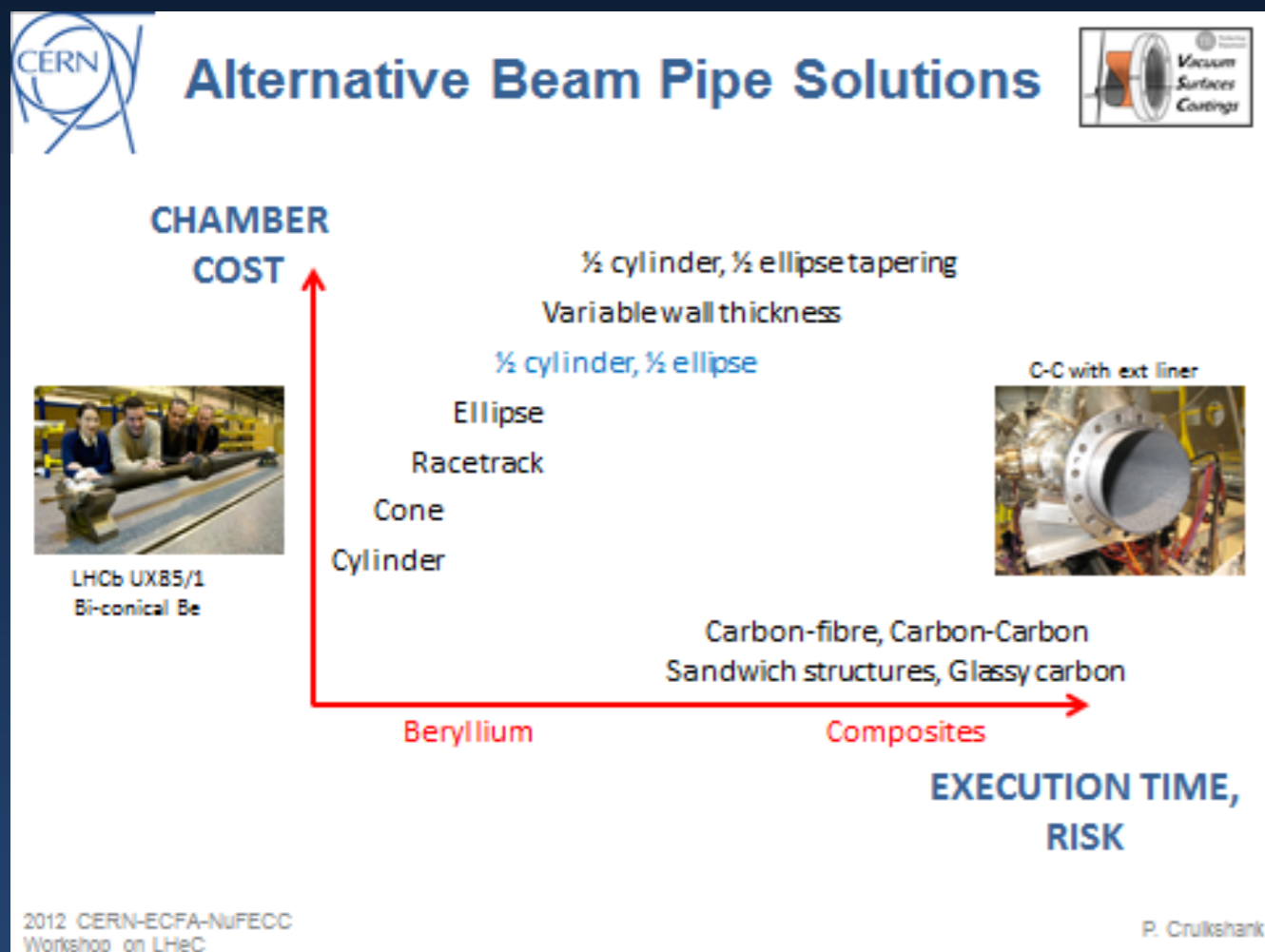
Beampipe Summary

- The combined requirements of LHC/LHeC machine and experiments place a serious limit on the choice of materials for beampipes
- The baseline for the central beampipe can be considered as a solid beryllium chamber, NEG coated and in-situ baked.
- Preliminary calculations have been made for simple 'solid', half-cylindrical half-elliptical geometries.
- In beryllium, thickness in the order of 1.3 to 1.5 mm (RR) and 2.5 to 3 mm (LR) appear feasible.
- Experience with LHCb conical chambers does not rule out complex shapes.
- Ongoing R&D for new materials and coatings may give other options, but will require several years.
- Vacuum physics & engineering studies must be made in parallel with detector (& machine) studies.
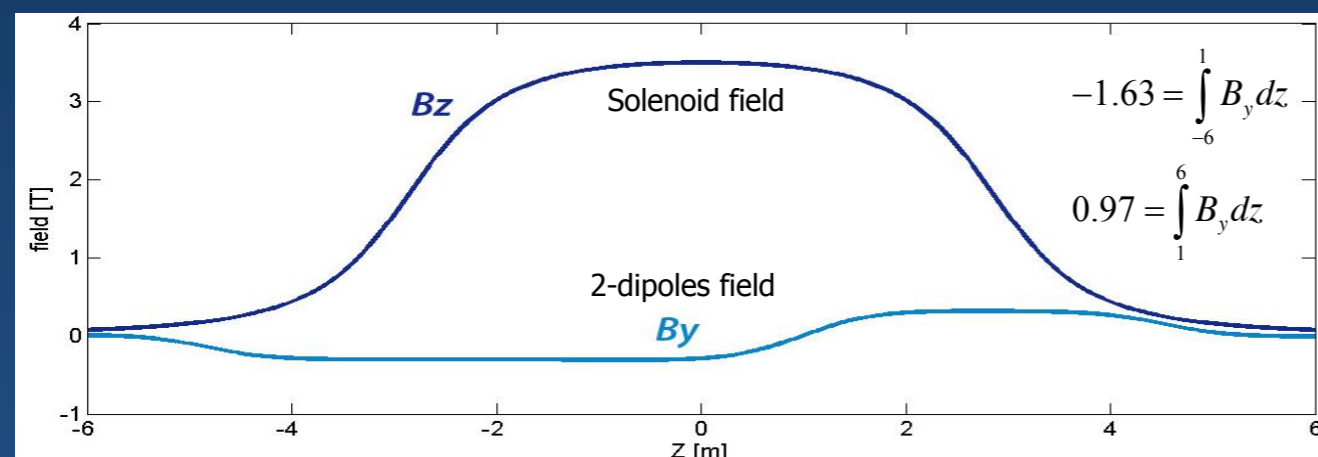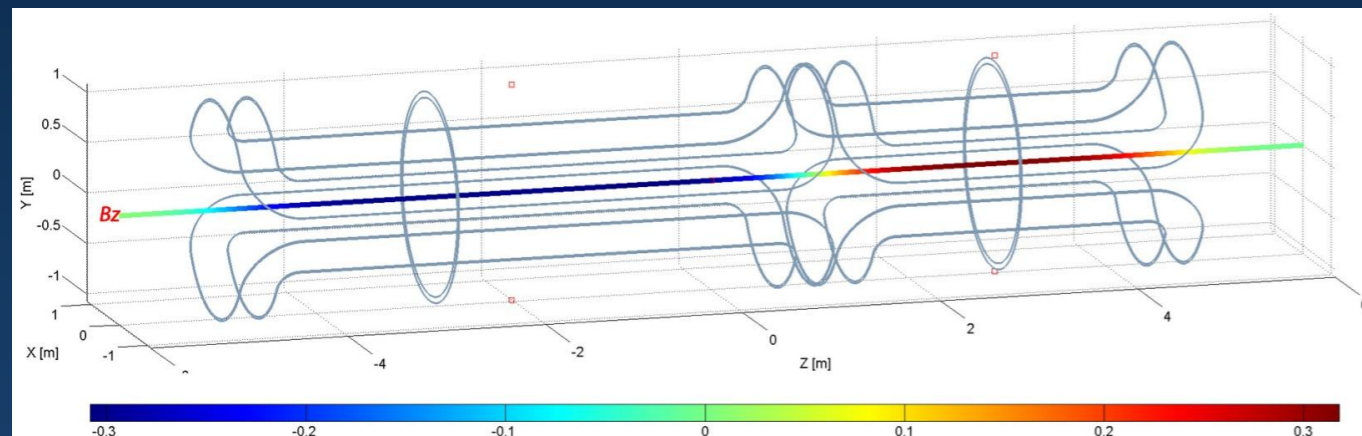- Additional vacuum resources (personnel & material) are required to continue with the these studies.

LHeC Detector Magnet system

a 3.5 T Superconducting Solenoid, eventually two end cap Toroids, e-beam bending Dipoles

Herman ten Kate
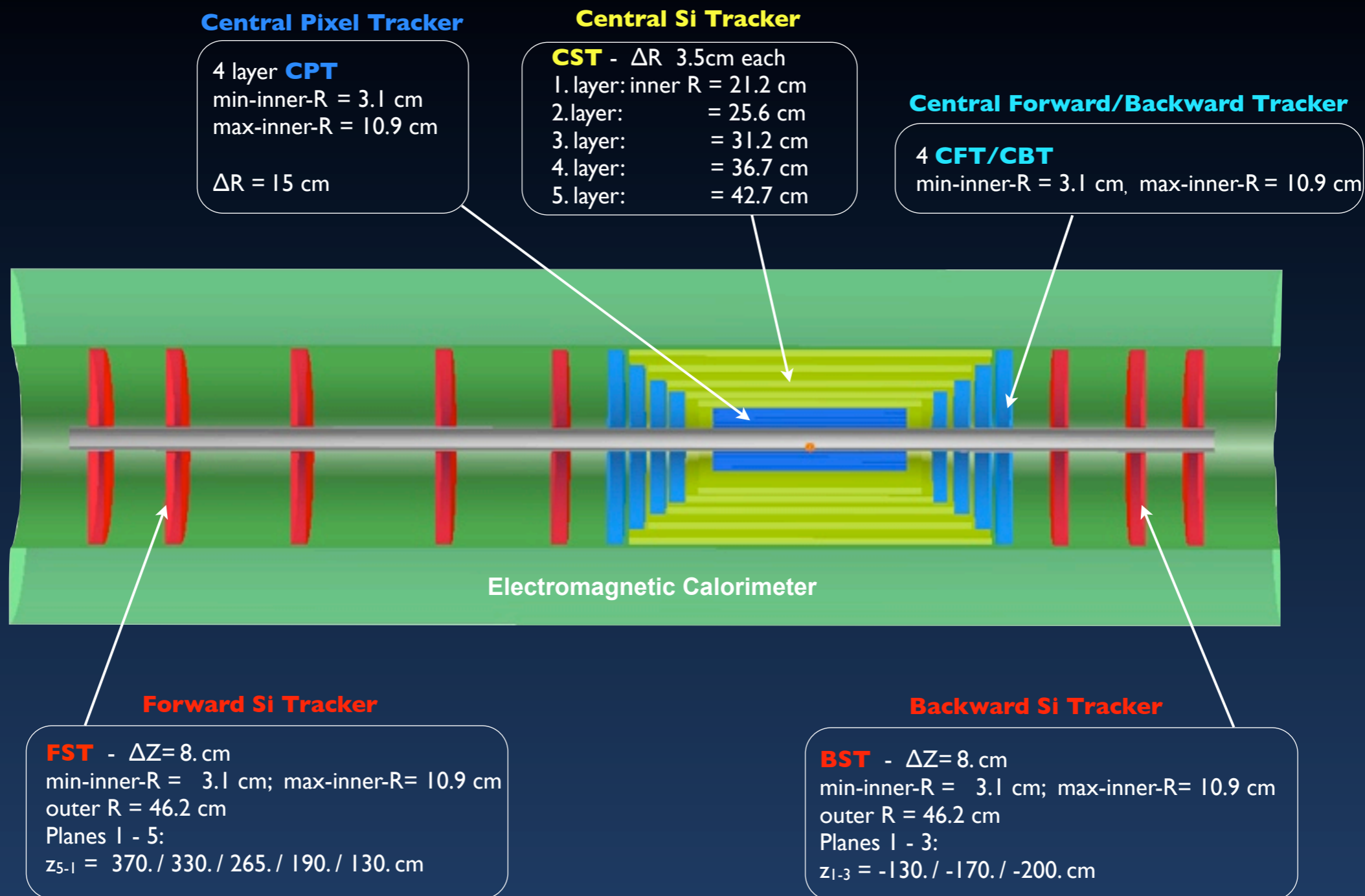
(on behalf of the LHeC detector magnets study group)

Magnetic field on beam axis

Conclusion

- A proposed extension of the LHC physics reach is to add an extra electron beam and allow e-p/A collisions (following HERA) but now at a much higher energy

- The conceptual design of the magnet system for an LHeC Experiment is completed aiming at lowest cost, low risk, relatively fast production allowing readiness by 2023-2025

- A 3.5 T Solenoid, 1.8 m bore, 10 m long, is combined with the necessary 0.3 T, 2x9 m long e-bending dipoles to guide the e-beam

- When a large 3.5 T Solenoid is preferred, a novel light and compact design is proposed using an actively shielded solenoid

- An elegant engineering solution is proposed which is feasible as it builds on the present technology of detector magnets for the LHC

- Next steps: magnet R&D approval; integration study with present structures in cavern; completing an engineering design to prepare the production when requested.

$$-1.63 = \int_{-6}^{1} B_y\,dz$$

$$0.97 = \int_{1}^{6} B_y\,dz$$

Tracking

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

Electromagnetic Calorimeter

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

- LHCb, CMS, ATLAS
  → Experience on construction, commissioning, performance

LHeC Tracking

A forward look – LHCb
Themis Bowcock

UNIVERSITY OF
LIVERPOOL

14/6/12

LHCb LHCP

VELO sensors

7 mm

Beam 1   Beam 2
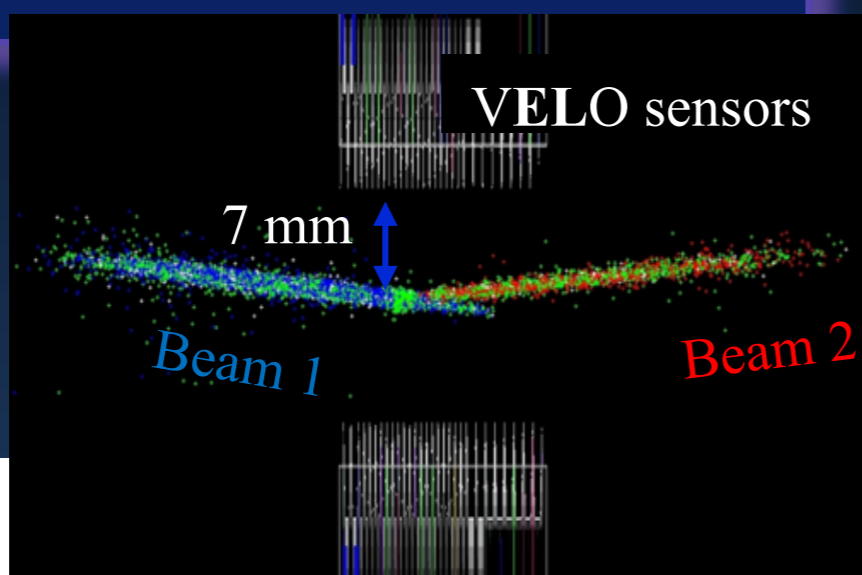
Summary

Beautiful (aka challenging) detector to build(!)

High level of performance specified

    e, jets

    Also with serious flavour tagging capability

Very tight schedule for completion even re-using GPD technology

    Will be large undertaking by the community

Do not underestimate the mechanical/electrical engineering required

    Small changes are never such

[PLB 693 69]

From CDR: Practical Issues

LHeC

Cost

    This IS a big expensive detector

    Huge undertaking (At least 4 separate systems) each one of which is complex.

Sensor Type

    CDR Suggested p+n technology

    MAPS/Planar Si

Radiation Tolerance

    MIP and Synchrotron. A CRITICAL ISSUE

    FLUKA, BG, (pp?)

Trigger & R/O Electronics

    Not addressed here. Re-use CMS/ATLAS?

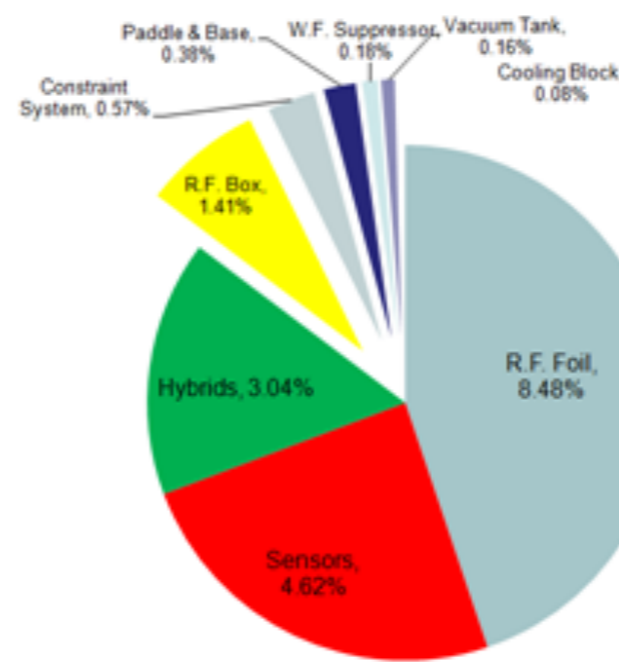   VELO used full Analog R/O 10bit ADCs

Power and Cooling

    A serious undertaking (compact space with 20kW+ just from electronics)
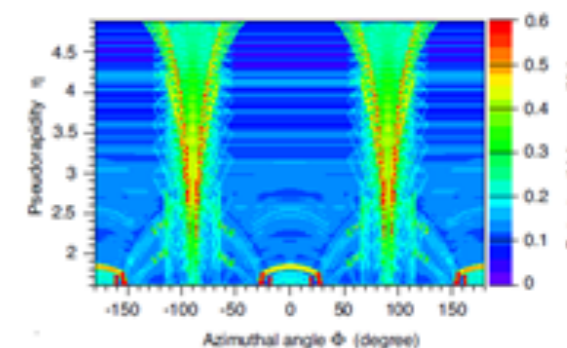
Mechanical Support & Beampipe

    Complex

VELO: Material Budget

LHeC

Average is 18.91% X_0
Particle exiting the

Material Budget (% X_0)

LIVERPOOL   Themis Bowcock   1   LHCb LHCP

Cooling requirements

Low voltage:

100mA/chip x 2.5V x 2000 / m2 → 0.5 kW/m2 (strips)

100mA/chip x 2.5V / 2.5 cm2 → 1 kW/m2 (pixels)

(estimates based on the current ROCs for the ATLAS upgrade)

High voltage (for sensor dose 1e14 neq):

10..100 μA/cm2 x 500 V → 0.5 kW/m2 (@ 0 deg. C)

Convection: 0.2 kW/m2 (@ 0 deg. C)

CPT (1.4 m2) → 2.5 kW
CST (8.1 m2) → 10 kW
CFT, CBT (1.8 m2) → 2.2 kW each
FST (3.3 m2) → 4 kW
BST (2.0 m2) → 2.5 kW

assuming all modules
are equipped with pixel
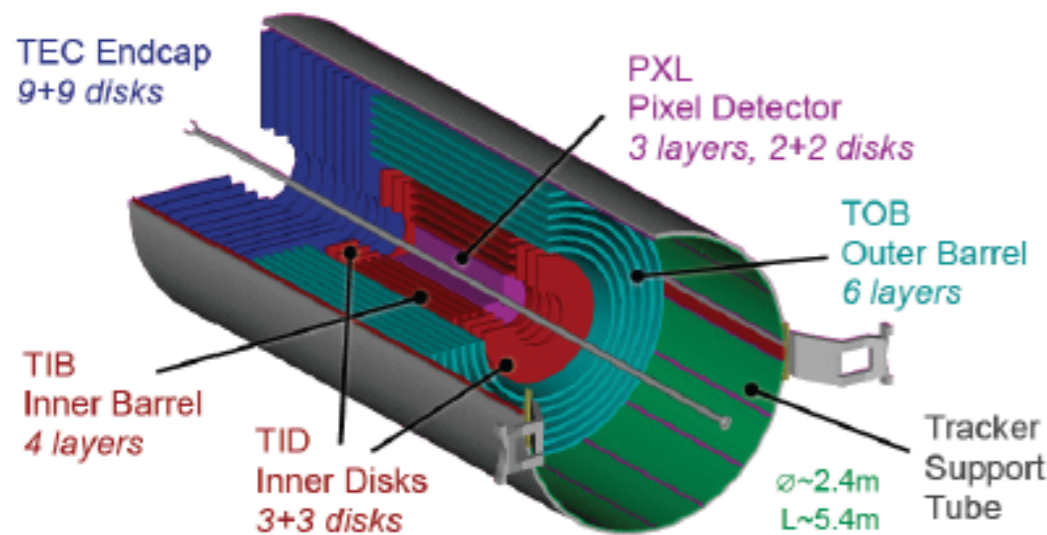and strixel sensors only

~ 25 kW in total

(+50% overhead for el. and thermal interfaces)

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LHeC Tracker Design viewed from CMS

A. Starodumov

IPP, ETH Zurich, Switzerland

2012 Workshop on the Large Hadron electron Collider
June 14-15, 2012, Chavannes-de-Bogis, Switzerland

TEC Endcap
9+9 disks

PXL
Pixel Detector
3 layers, 2+2 disks

TOB
Outer Barrel
6 layers

TIB
Inner Barrel
4 layers

TID
Inner Disks
3+3 disks

Tracker
Support
Tube

∅~2.4m
L~5.4m

Tracking Detector:

- Pixel volume: $L = 93(53)\,\text{cm}$, $R = 4.2 \div 15\,\text{cm}$
- Strip volume: $L = 540(225)\,\text{cm}$, $R = 21 \div 120\,\text{cm}$
- Pixel: 65.9M ch.($1.1\,\text{m}^2$), Strips: 9.7M ch.($210\,\text{m}^2$)

Present Pixel Detector

- Designed for radiation fluences of $6\times10^{14}\,n_{eq}/\text{cm}^2$
    - ROC with sensor irrad.tests show at least 3-4 more → rad. damage not main issue

- More passive material in support structures than needed
    - e.g. cooling designed for larger power DMILL readout chip pre-dating 250nm CMOS

- 3 Layer system designed for 20-25 PU events of nominal LHC operation
    - future LHC operation with 50 PU or even 100 PU events will require more robust track seeding by pixel system.
    - defects (thermal contacts & lost modules) in silicon strip TIB need more pixel hits

- Readout designed for nominal LHC conditions of $10^{34}\,\text{Hz/cm}^2$ and 25ns bunch spacing → operations beyond this and 50ns bc timing impose serious limits
    - ROC data losses at 2x $10^{34}\,\text{Hz/cm}^2$ and 25ns   ~16% data loss for BPIX layer-1
    - Optical links from pixel modules to FED & DAQ impose limits at 50nsec operations beyond $1.3\times10^{34}\,\text{Hz/cm}^2$ (same for 25ns at $2.6\times10^{34}\,\text{Hz/cm}^2$ and 100KHz L1)

- Tracking and vertexing, important to almost all physics analyses, will be compromised for operations significantly above $10^{34}\,\text{Hz/cm}^2$ and/or 50ns

# CO2 cooling for lighter detector

- **Use 2PACL method**

  (2PACL = 2-Phase Accumulator
  Controlled Loop)
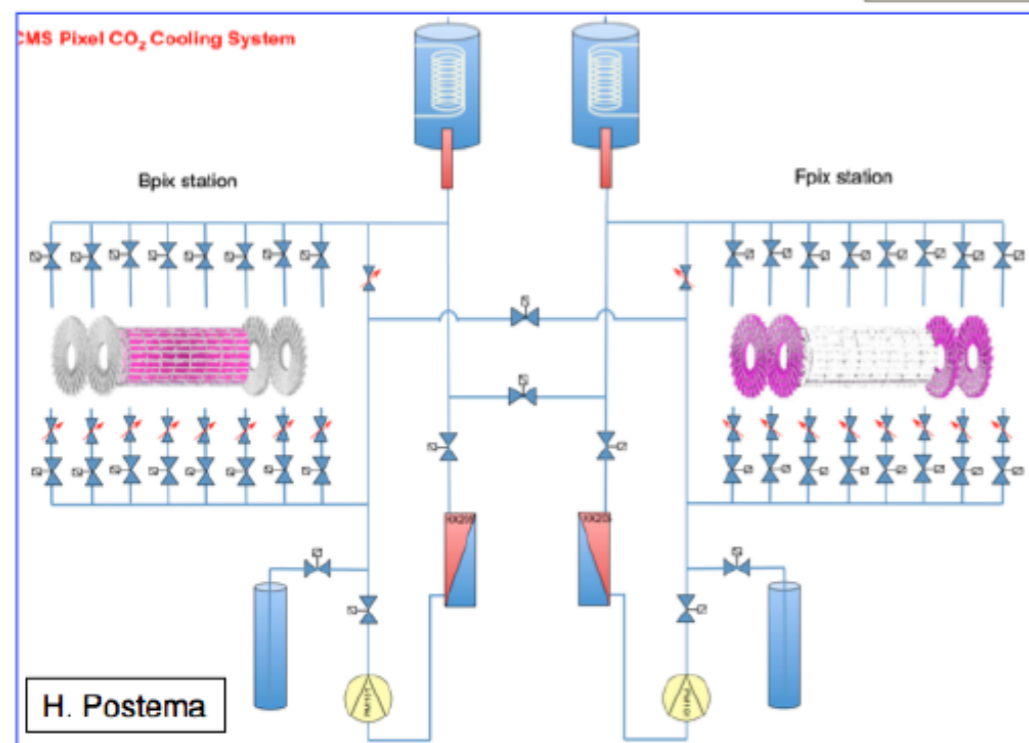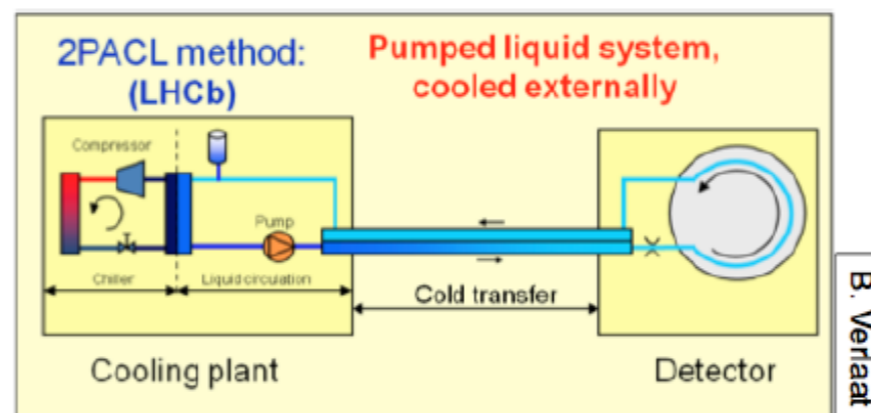
Construction and operation experience

- ► Avoid too many module designes

- ► Readout chip DACs should be optimized in a lab for different operational T (to be used later during detector operation)

- ► Foresee enough time for detector commissioning after installation (several months: 5-6)

- ► Foresee T and current measurements of the installed detector with highest possible granularity

- ► In case of presence detector volumes operated at different T, pay attention on sealing

- ► Foresee spare cabling (for future possible upgrades)

Calorimetry
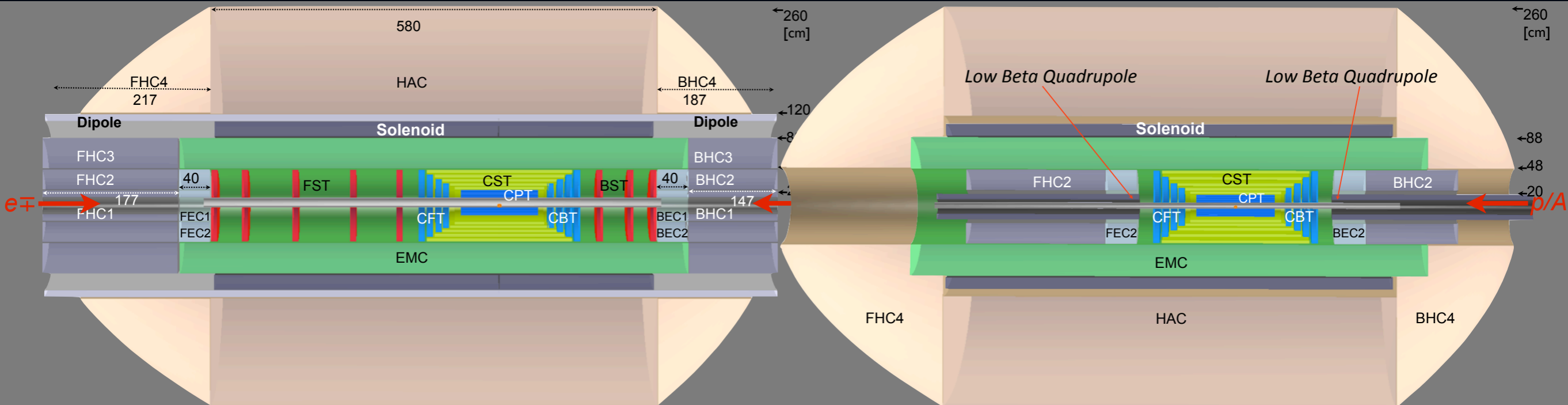
The baseline configuration (LR case).
Central barrel:
   silicon pixel detector (CPT)
   silicon tracking detectors (CST,CFT/CBT)
   electromagnetic calorimeter (EMC)
   surrounded by the magnets (Solenoid, Dipoles)
   hadronic calorimeter (HAC)
Backward silicon tracker (BST)
   energy measured in the BEC and BHC calorimeters
Forward silicon tracking (FST)
   and calorimetry (FEC, FHC) measuring TeV energy final states

Main detector for the RR
- luminosity maximised by low β quadrupole magnets

The forward/backward tracking removed &
the outer calorimeter inserts placed near to IP (|1.2| m)

**Detector design
- follow BP shape (CPT/CST shown)**

Linac-Ring - beam pipe
inner-R_{circ}=2.2cm
inner-$R_{elliptical}$=10.cm

*For numeric studies and plots see recent talks at
DIS10, DIS11, ICHEP10, EPS11, IPAC11, ...
EIC and LHeC Workshops, the CDR
at http://cern.ch/lhec*

LHeC

Looking back at H1 (and ATLAS) LAr calorimeter and trigger operations

Juraj Bracinik
(University of Birmingham, UK)

LHeC workshop, Chavannes-de-Bogis, 15 june 2012

- Introduction
- Operation of H1 LAr(T)
- Is ATLAS different ?
- (Possible) implications for LHeC

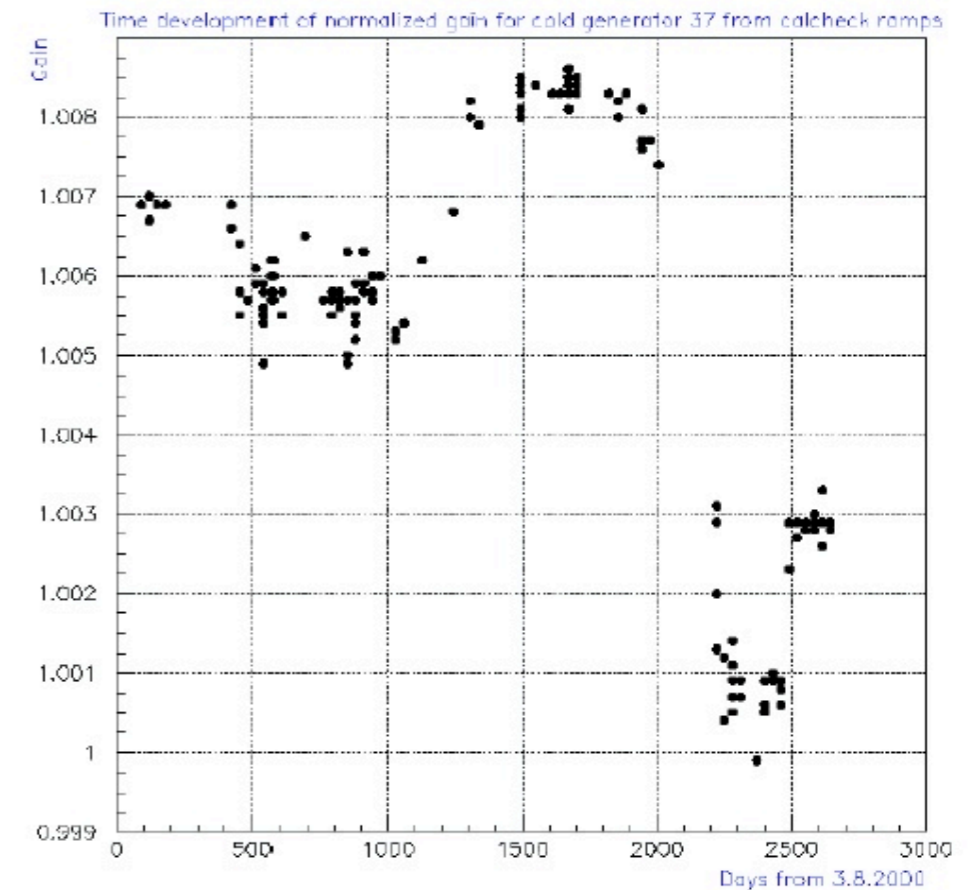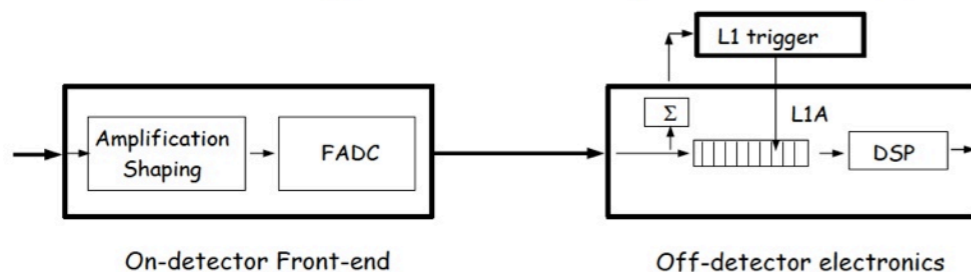Juraj Bracinik   LHeC workshop, 15 June 2012   1

Stability of gain as measured by a LAr cold generator (H1):

Time development of normalized gain for cold generator 37 from calcheck ramps

Days from 3.8.2000

FE for next generation of experiments I (?)

On-detector Front-end   Off-detector electronics

- Time-scale of LHeC – early 2020s
- Similar to ATLAS/CMS Phase 2 upgrade, can take inspiration from there...

FE architecture nr I:
- Very simple front end (radiation hard electronics)
- Ship all digital data off detector
- Digital pipeline off the detector, can have large latency
- Need huge bandwidth between front end and off detector

Juraj Bracinik   LHeC workshop, 15 June 2012   13

FE for next generation of experiments II (?)

On-detector Front-end   Off-detector electronics
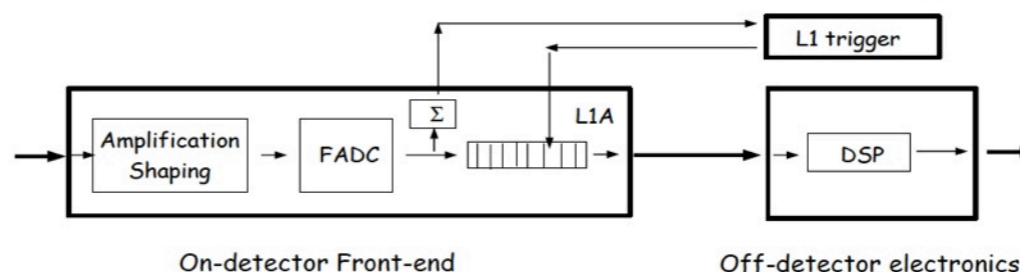
FE architecture nr II:
- ADCs and digital pipeline on detector
- Low granularity data to L1 trigger
- L1 sends its decision back to front-end
- Disadvantage is more complicated FE (shorter pipeline probably)
- Much smaller bandwidth between FE and off-detector electronics (especially if L1A rate is small)

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# Tile/hadronic Calorimeter design viewed from ATLAS

Claudio Santoni

LPC, CNRS/IN2P3 Clermont-Ferrand FRANCE
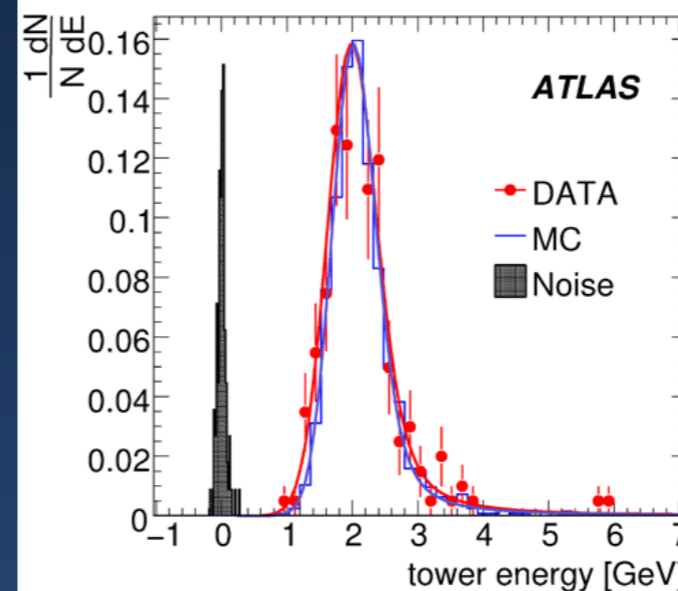
On behalf of the ATLAS Collaboration

Detector Response Stability

- 2010: up drift of Cs response (about 1%/year)
- 2011: Up/Down drift oscillation (<1%) during beam/no beam periods.
  - Consistent behaviour seen by all thee calibration systems
  - Drift dominated by PMT gain effects

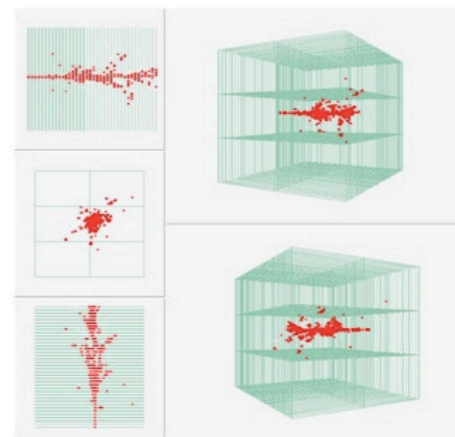Corrections applied to the PMT response
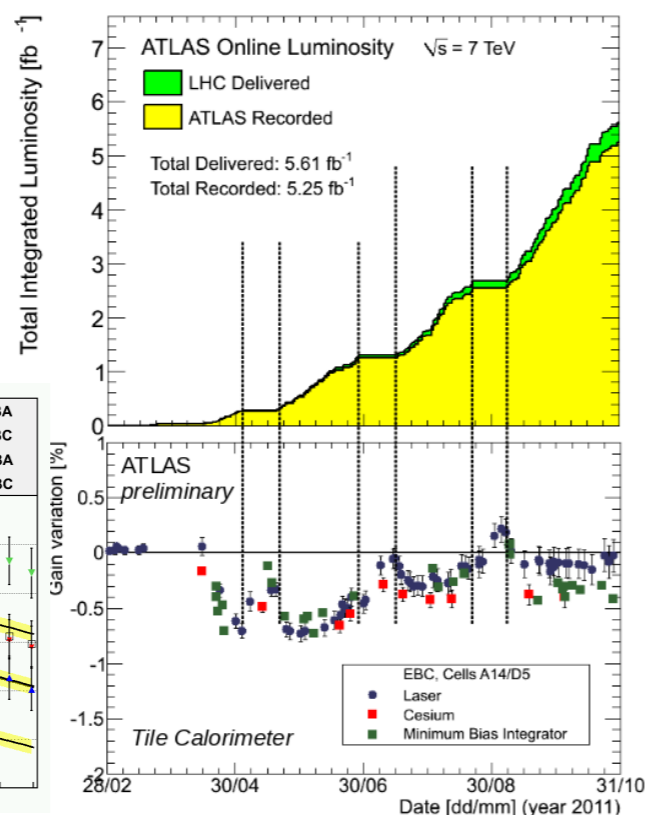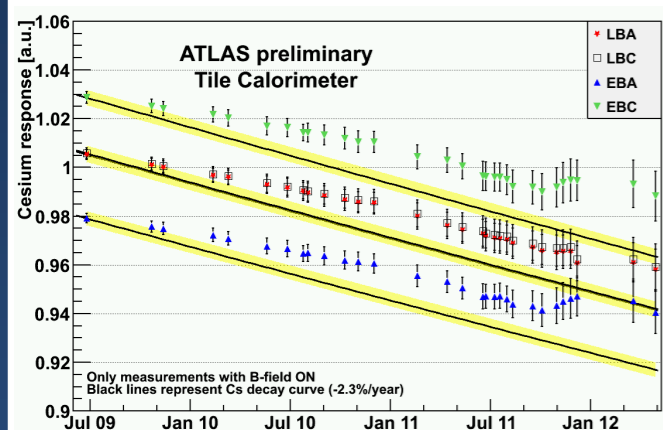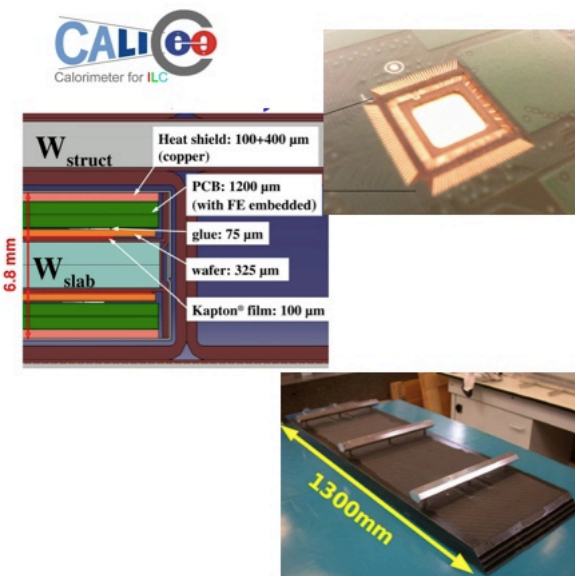

Performance with single muons

- Muon signal in TileCal is well separated from noise
- Cosmic muons can be used to cross-check cell energy inter-calibration and overall EM scale
- Data and MC dE/dx comparisons as a function of η and ϕ show good cell inter-calibration within one layer (within 2-4%)

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Development of Particle Flow Calorimetry

José Repond
Argonne National Laboratory

Silicon – Tungsten ECAL: Technical Prototypes

Heat shield: 100+400 μm (copper)
PCB: 1200 μm (with FE embedded)
glue: 75 μm
wafer: 325 μm
Kapton® film: 100 μm

1300mm

- Based on experience with physics prototype
- Reduced cell size (~0.25cm^2)
- Embedded front-end electronics
- Address 'all' technical issues
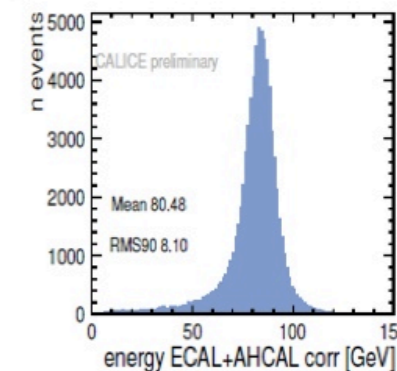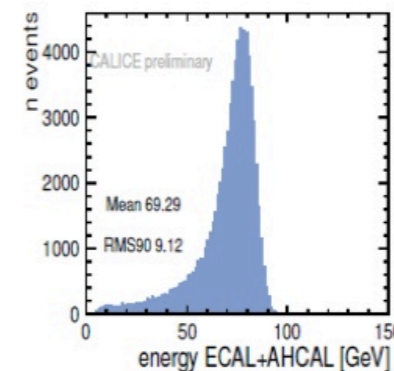- Total active medium thickness 3 – 4 mm
- Test beam module being assembled
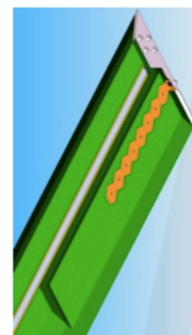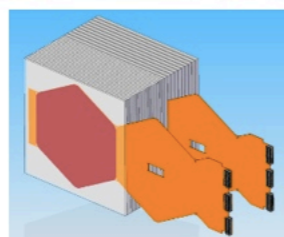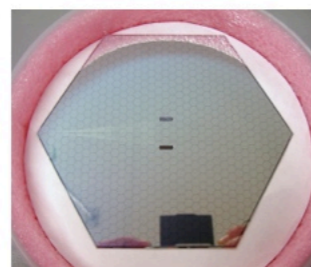
- Target at very compact readout and small cell (~0.13cm^2)
- Address many technical issues from the beginning
- Push technical limits in many aspects
- Uses KPiX chip with 1024 channels for front-end readout
- Total active medium thickness targets at ~1mm
- Test beam module expected soon

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The power of imaging calorimeters III: Leakage correction

ECAL   HCAL   TCMT
1λ   4.5λ   10 λ
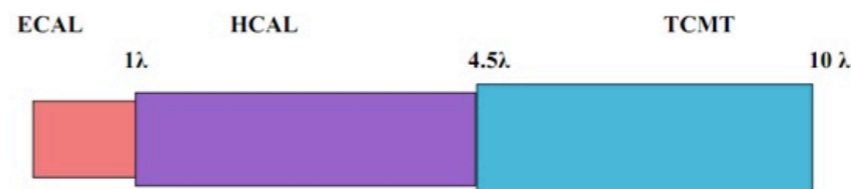
Select showers (80 GeV π) starting in first part of AHCAL
Apply **corrections** depending on

Interaction layer (shower start)
Fraction of energy in last 4 layers
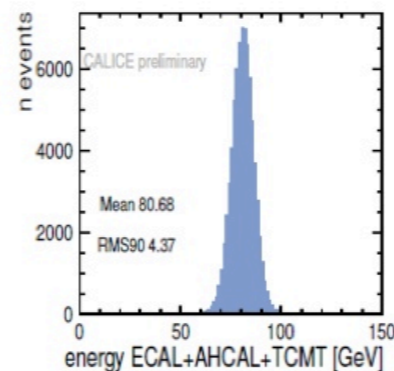
Correction
Restores mean value
Reduces RMS by ~ 24%
(but still worse than direct measurement)

CALICE preliminary
Mean 80.68
RMS90 4.37
energy ECAL+AHCAL+TCMT [GeV]

CALICE preliminary
Mean 69.29
RMS90 9.12
energy ECAL+AHCAL [GeV]

CALICE preliminary
Mean 80.48
RMS90 8.10
energy ECAL+AHCAL corr [GeV]

LHeC : Muon Systems

L. Pontecorvo

Air Core Toroids:
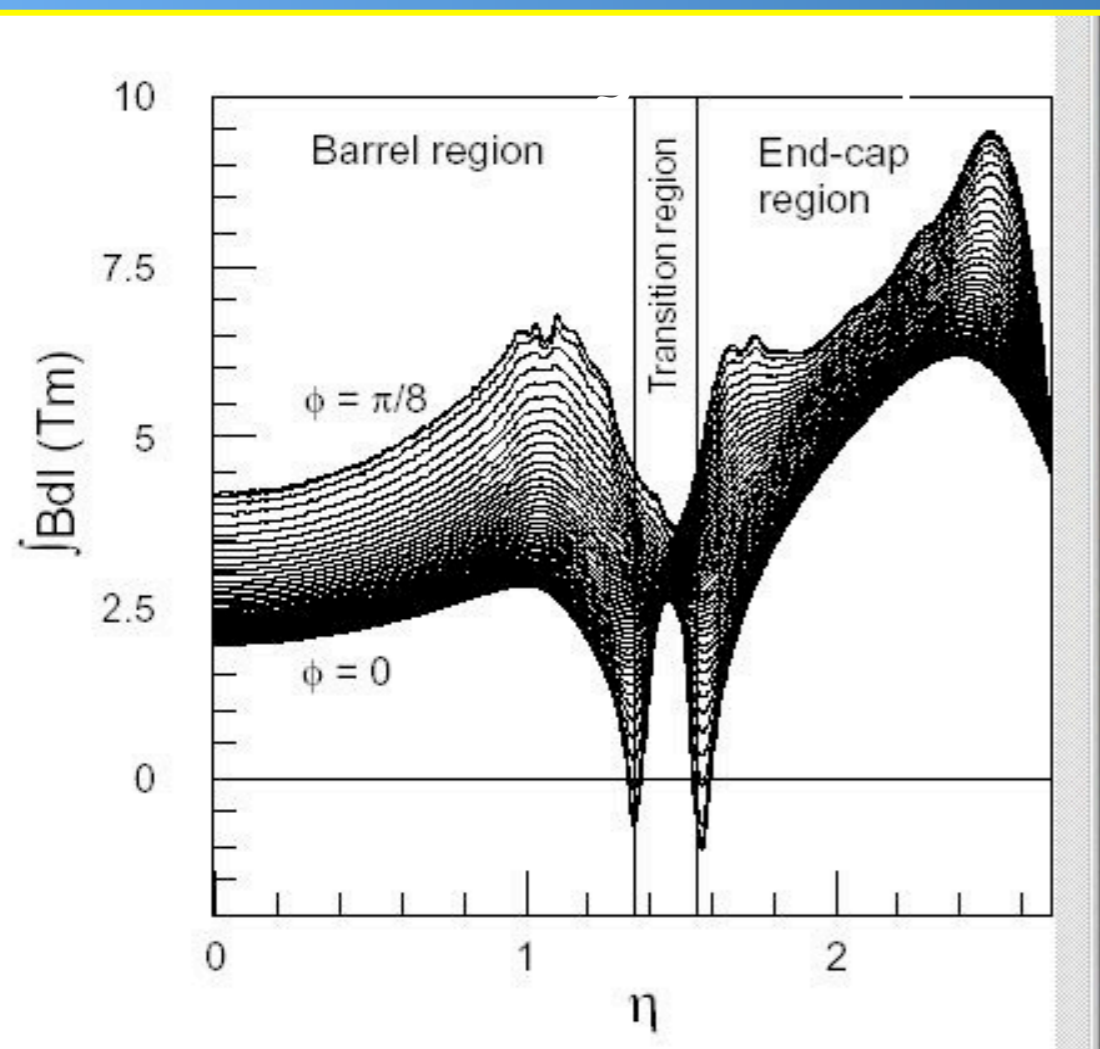
Central Solenoid with Iron return Flux:

- Barrel Region
  - DTs & RPCs
  - low, almost uniform B-field
  - low muon rate R(μ) ≲ 1Hz/cm²
  - negligible neutron induced background
- Endcap Region
  - CSCs & RPCs
  - strong, non-uniform B-field (up to ~ 3.5 T)
  - high muon rate R(μ) ≲ 1000 Hz/cm²
  - γ and neutron indu-ced background rate comparable to muon rate

B-field [Tesla]

superconducting coil

Courtesy of C.Hof using IguanaCMS
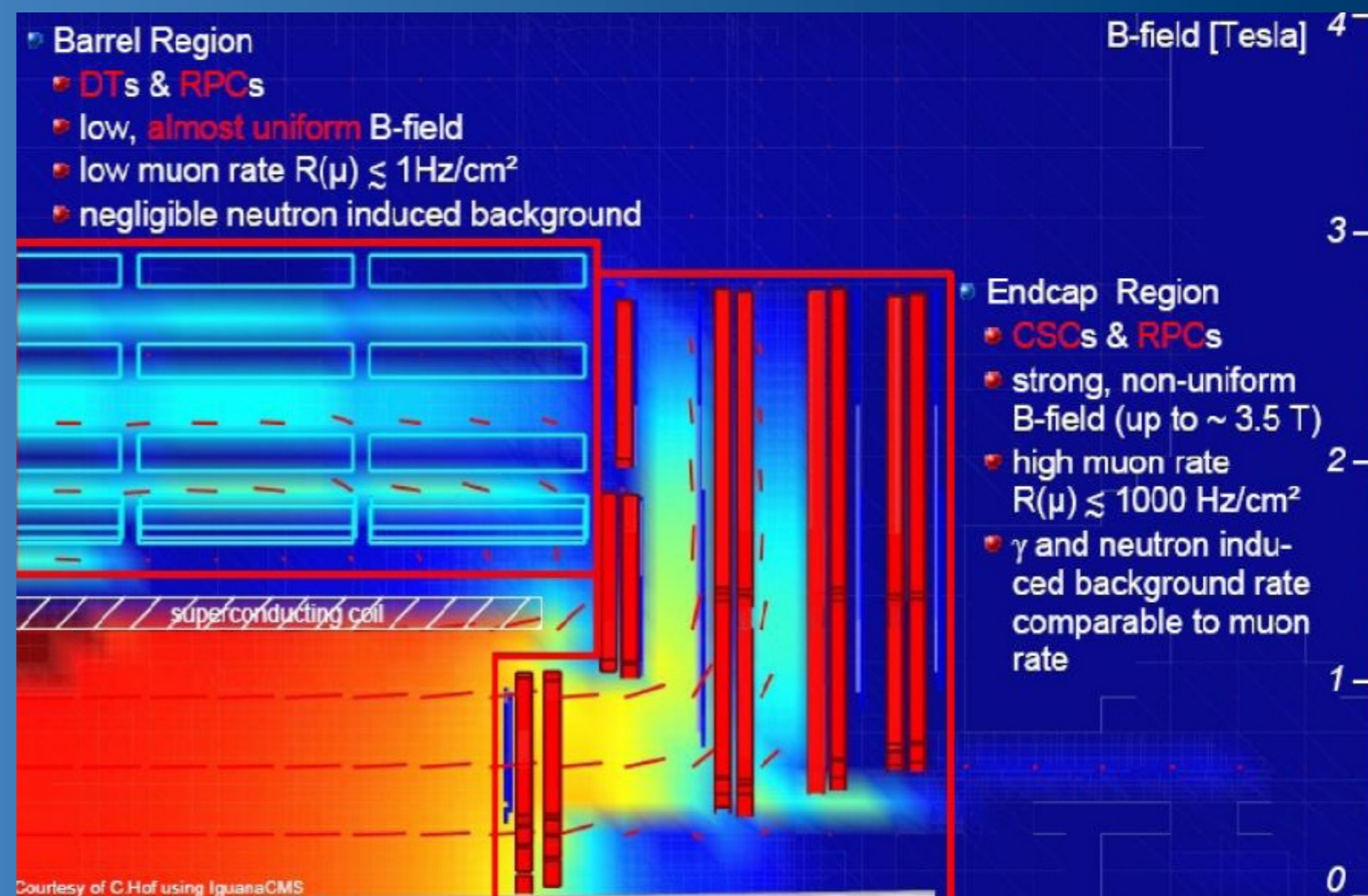
Installation and Commissioning

➢Installation of both ATLAS and CMS took years

➢Ex. The Construction of the ATLAS Muon Spectrometer started in 2005 (Barrel) and ended in 2008 (End Cap).

ATLAS Barrel Resolution with Cosmic rays

χ² / ndf	3.8118 / 10
Prob	0.9554
p0	0.3693 ± 0.0549
p1	0.0387 ± 0.0024
p2	0.0163 ± 0.0032

ATLAS preliminary 2009 cosmic data
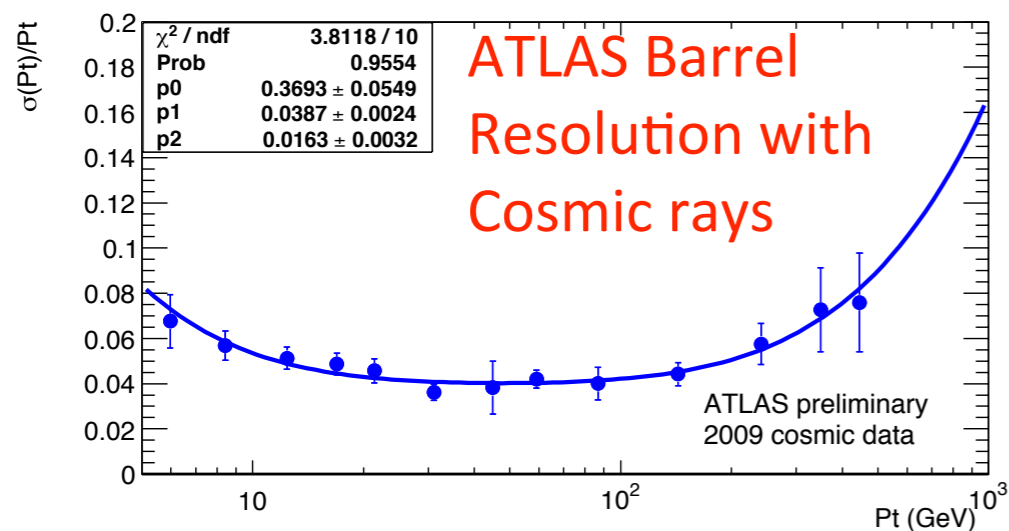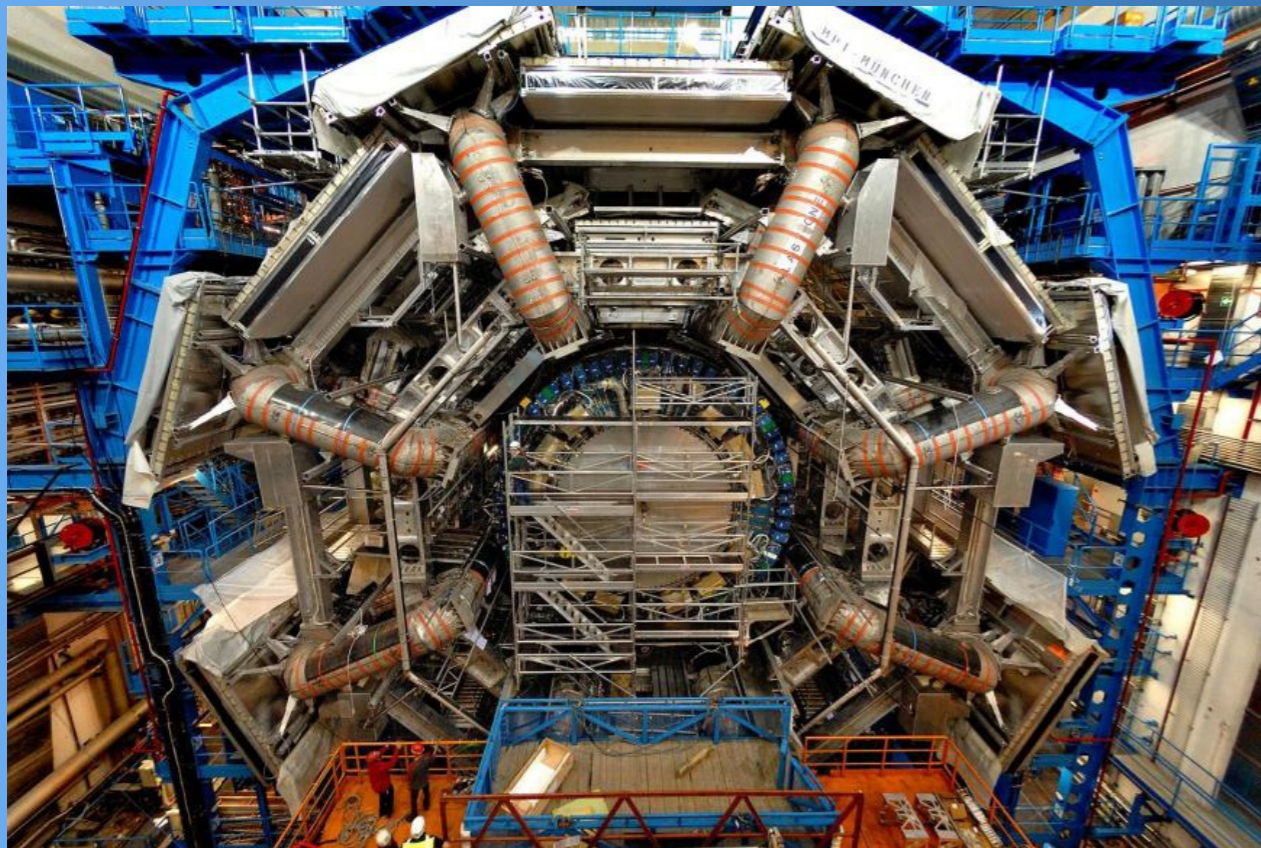
Very long years of commissioning with Cosmic rays were essential to be able to efficiently record and understand data from the very first collision.

This has to be considered in building the schedule for the construction and commissioning of the LHeC detector

Possible Muon Systems

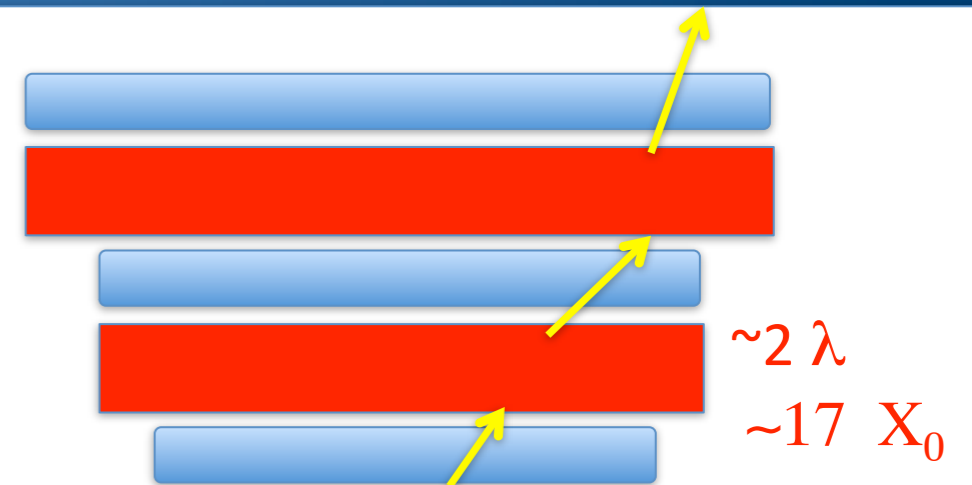➢ Barrel and and End Cap Region

➢ Option 1 cntd)

  ➢ Three stations of triggering and tracking detectors spaced by iron absorbers.

  ➢ Can possibly profit from an Existing Magnet As Absorber

~2 λ
~17 X_0

Iron 30-40 cm
  Density 7.87 g/cm^3
  Radiation length 1.76 cm
  Interaction Length 131.9 g/cm^2
  dE/dx 1.45 MeV/g/cm^2

3 Stations
3-4 layers of measuring planes per station
No momentum selection from trigger only geometrical coincidences.
Pointing to IP

Possible Magnetic configurations

- **Air Core Toroid**
  - Excellent stand alone momentum resolution
  - Need of excellent space resolution, segmentation and alignment on detector side
  - More Complex
  - Possible interference of the fringe field on Beam
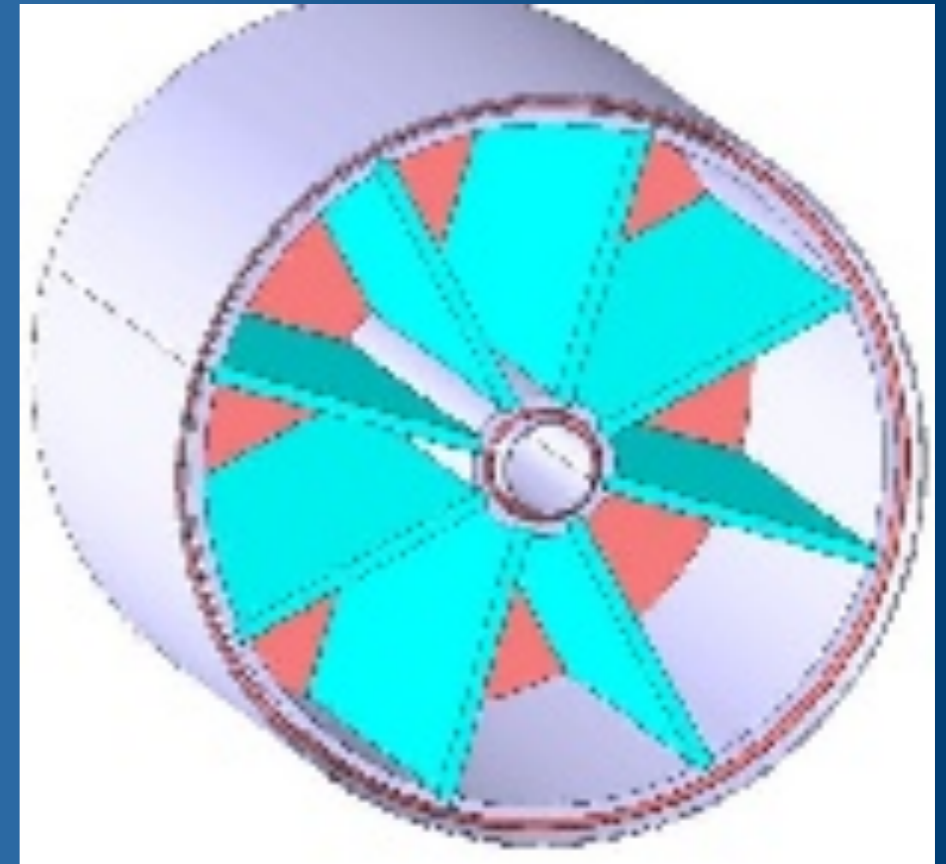
- **Iron Toroid**
  - Easy and Cheap
  - No Fringe Field on Beam
  - Limited Pt resolution due to Multiple Scattering: > 10%
  - Higher production of δ rays
  - Need of average spatial resolution and mild requirements on alignment.

Beam Pie
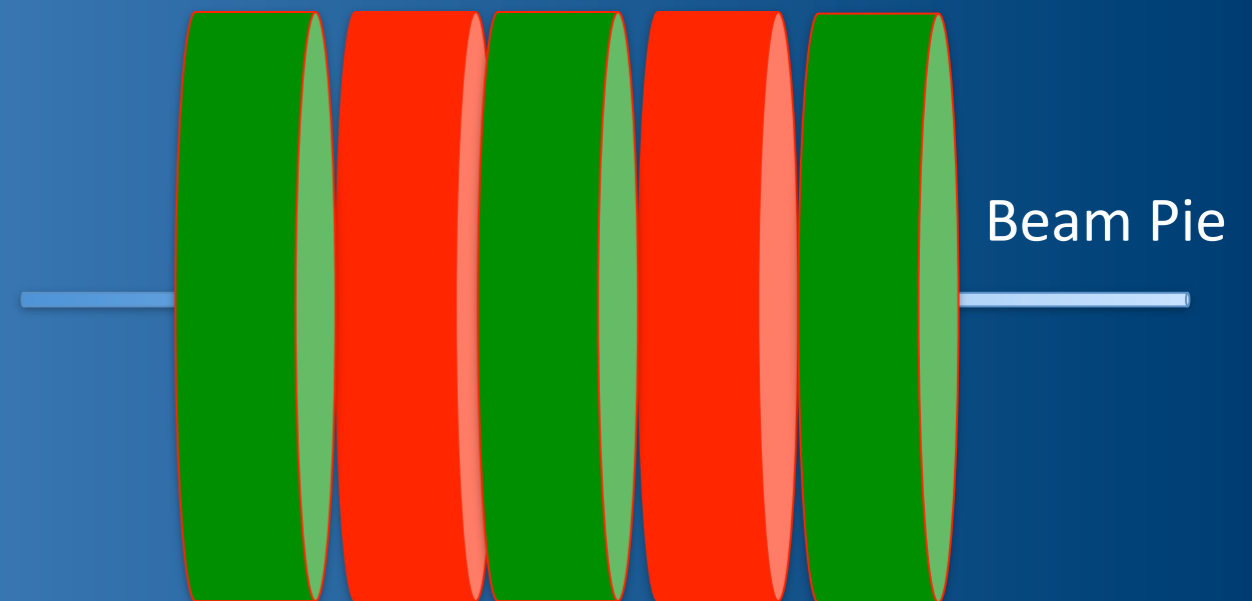
Tracking Chambers
Micromegas or Triple Gem

Iron toroids
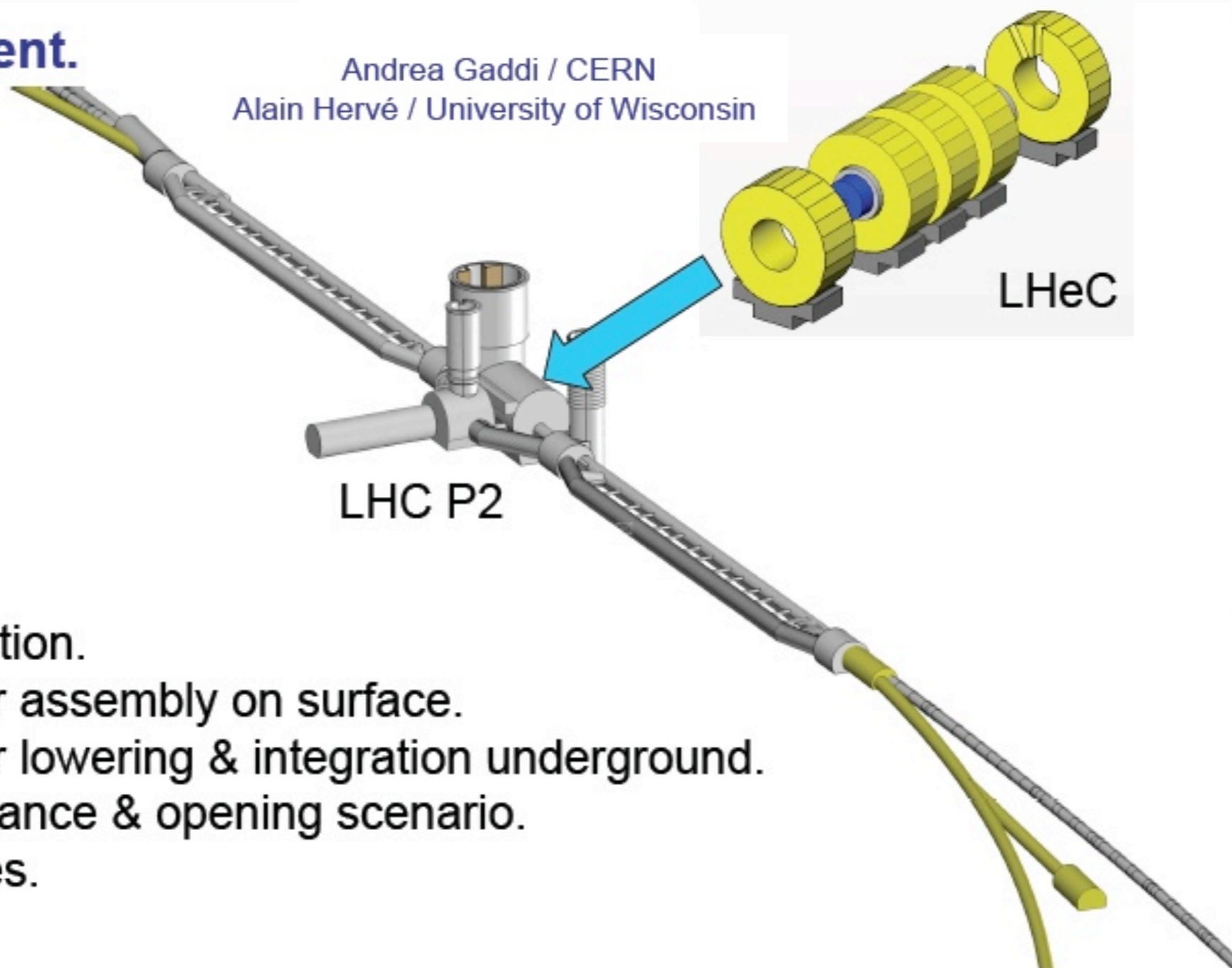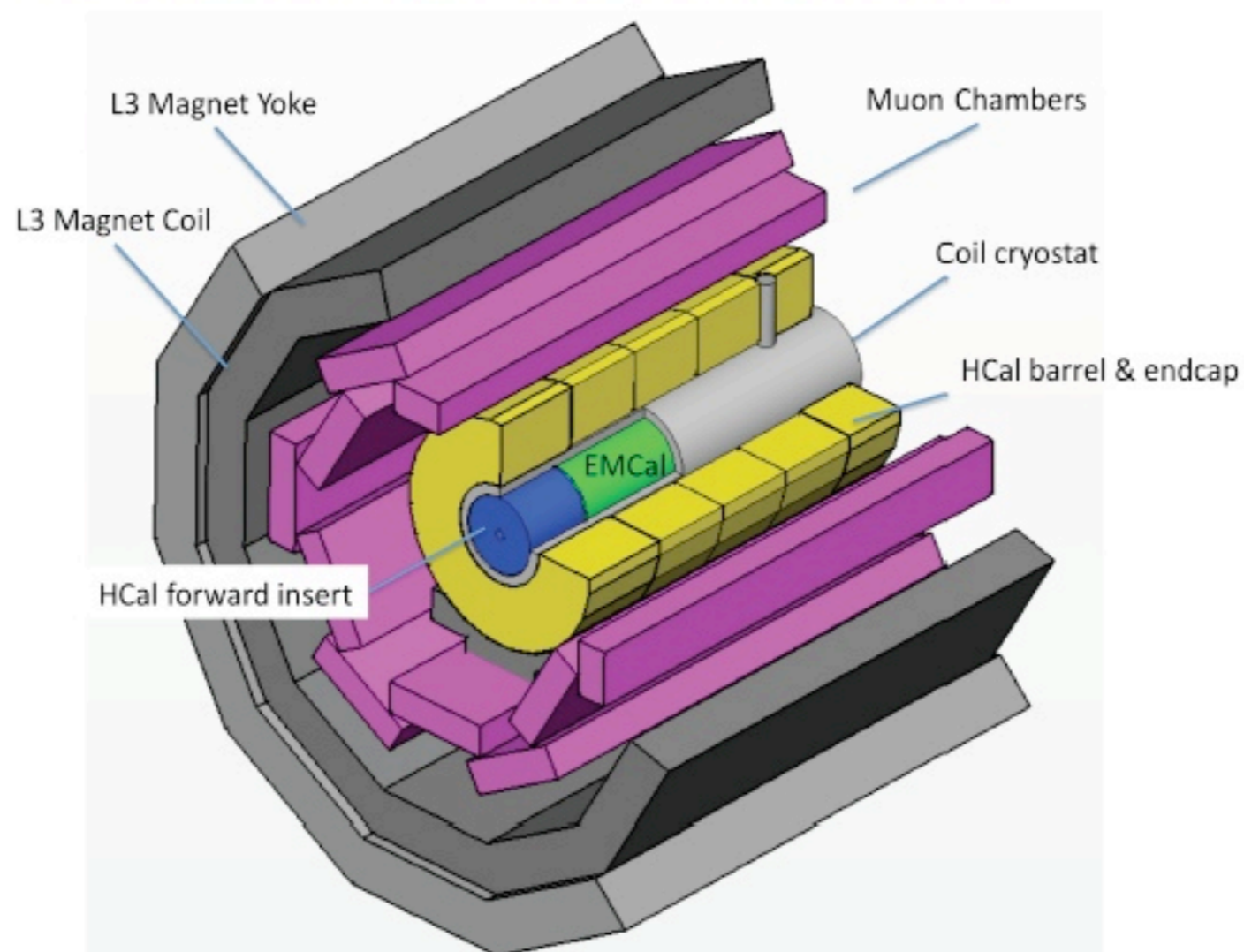
Timeline - Installation

- The assembly on surface of the main detector elements as approximately 16 months

- The Coil system commissioning on site three additional month, preparation for lowering one month and lowering one week per piece

- Underground completion of the integration of the main detector elements inside the L3 Magnet would require about two months, cabling and connection to services

- Some six months, in parallel with the installation of Muons Tracker and the EMCal

- The total estimated time, is thus 30 months.

- The field map would take one extra month.

- Some contingency is foreseen between the lowering (8 weeks) and integration inside the L3 Magnet of the same elements (2 months).

- Tight but doable

1st-order Cost Estimates of LHeC Detector

NuPEcc WS Chavannes, June 15, 2012

Max Klein/Univ. of Liverpool

Peter Kostka/DESY

Alessandro Polini/Univ. of Bologna

Markus Nordberg/CERN

LHeC CORE Costs

Detector materials, components, electronics, DAQ, computing etc..

CORE

Sub-system		R(inn) cm	R(out) cm	A (m2)	Length (m)	V (m3)	W (tn)	Power (kW)	Unit cost	Cost (M) (sensor)	Error (M)	Scaling-f	Total cost	Total error
Tracker														
	CST			16.2					0.25	4.1		3	12	6
	CPT			2.8					0.5	1.4		10	14	7
	CFT			3.6					0.25	0.9		3	3	1
	CBT			3.6					0.25	0.9		3	3	1
	FST			6.6					0.25	1.7		3	5	2
	BST			4.0					0.25	1.0		3	3	2
	Total			36.8						9.9	5.0		40	20
Calorimeter														
LAr	EMC				6.6	11	128		0.03	3.8	0.38	4	15.3	1.53
LAr	FEC1/2				0.8	0.3	6		0.03	0.2	0.02	4	0.7	0.07
LAr	BEC1/2				0.8	0.3	3		0.03	0.1	0.01	4	0.4	0.04
Tile	FHC1/2/3				5.3	4	32		0.002	0.1	0.03	3	0.2	0.10
Tile	FHC/4/HAC/BHC/4				9.5	121	921		0.002	1.8	0.9	3	5.5	2.76
Tile	BHC1/2/3				5.3	3	21		0.002	0.0	0.0	3	0.1	0.06
	Total				10.1	140	1111			6.1	1.4		22	5
Muons		450	1187	14					0.001	1.2	0.1	4	4.7	0.5
Sub-total 1													67	25
TDAQ									20%				13	1
Solenoid													11	3
Cryogenics								2	1.4				3	1
SC Quadrupole													1	0.5
Calorimeter cryostat														
Sub-total 2													95	31
Infrastructure									10%				9	5
Total													104	36

- LHeC 1st-order cost estimates based on ATLAS-CORE numbers, with an error bar reflecting current costs
  - 104 +/- 36 MCHF

- It is assumed ATLAS-numbers scale downwards

- Solenoid costs follow the "A. Herve/ A. Gaddi-equation"

  …which is also consistent with the experimental observation that magnet system ~ 25% of the total (CORE) cost

Measuring very forward (backward) at the LHeC

Armen Buniatyan

Detectors located outside of the main detector
(~ 10 ÷ 100m from the Interaction Point)

__Goals:__
- Instantaneous luminosity
- Tag photo-production ($Q^2 \sim 0$)
    - Luminosity Detectors, Electron Tagger
- Very forward nucleons
    - Zero Degree Calorimeter, Forward Proton Spectrometer

LH$_e$C

Luminosity measurement: QED Compton - uncertainty

HERA (H1) $\sigma_{vis} \approx$ 50 pb;   ‹L› = 1.5e+31cm^{-2}s^{-1} → 0.75e-3 Hz
LHeC   ~2000 pb;   ‹L› = 4.0e+32cm^{-2}s^{-1} → 0.80 Hz (1000 x HERA !)

Stat.error: H1   ~ 4.50% /month (0.8% for full HERA2 sample)
            LHeC   ~ 0.15% /month

This allows much harder cuts against background → smaller syst.error

	H1(2004-2007)	LHeC/month
syst.error		
experimental	1.4%	0.8% (improved E-scale and E-resolution)
background	1.2%	0.4% (harder cuts, esp. on acoplanarity)
theory	1.1%	0.6% (improved higher order corrections)
stat.error	0.8%	0.2% (bigger acceptance, Luminosity)
total error	2.3%	1.1%

Conclusions

Forward and backward 'tunnel' detectors – important parts of the future ep (ed,eA) experiment

Ideas for the luminosity detectors, electron tagger, ZDC and FPS detectors described in the LHeC CDR

Next steps: clarify the geometrical constraints; investigate the possible design options in details

Design of detectors – challenging task !
- Use the experiences from HERA, LHC, RHIC,…
- Explore novel particle detector methods.

Summary

- Reducing the machine options allows detector optimisation.

- The interaction region (beam optics, synchrotron radiation, vacuum/ beam pipe system, magnet system) needs careful optimisation and coordinated R&D.

- Appropriate tools for simulation and discussion among experts has to be set up / enforced.

- The experience of running experiments are guidance for directions to go for:
    - lightweight mechanics & incorporated services
    - tracker sensor technology, R/O electronics, powering …
    - calorimeter design
    - muon system set up
- ɣ, n, p, d tagger - interesting status report
  based on H1 experience the luminosity measurements is feasible with high accuracy

- Construction and time for installation not to be underestimated!

Thanks to all speakers of the sessions for the

beautiful presentations, interesting discussions,

and valuable informations in a nice atmosphere!

Future is bright !

The secret of getting ahead is getting started