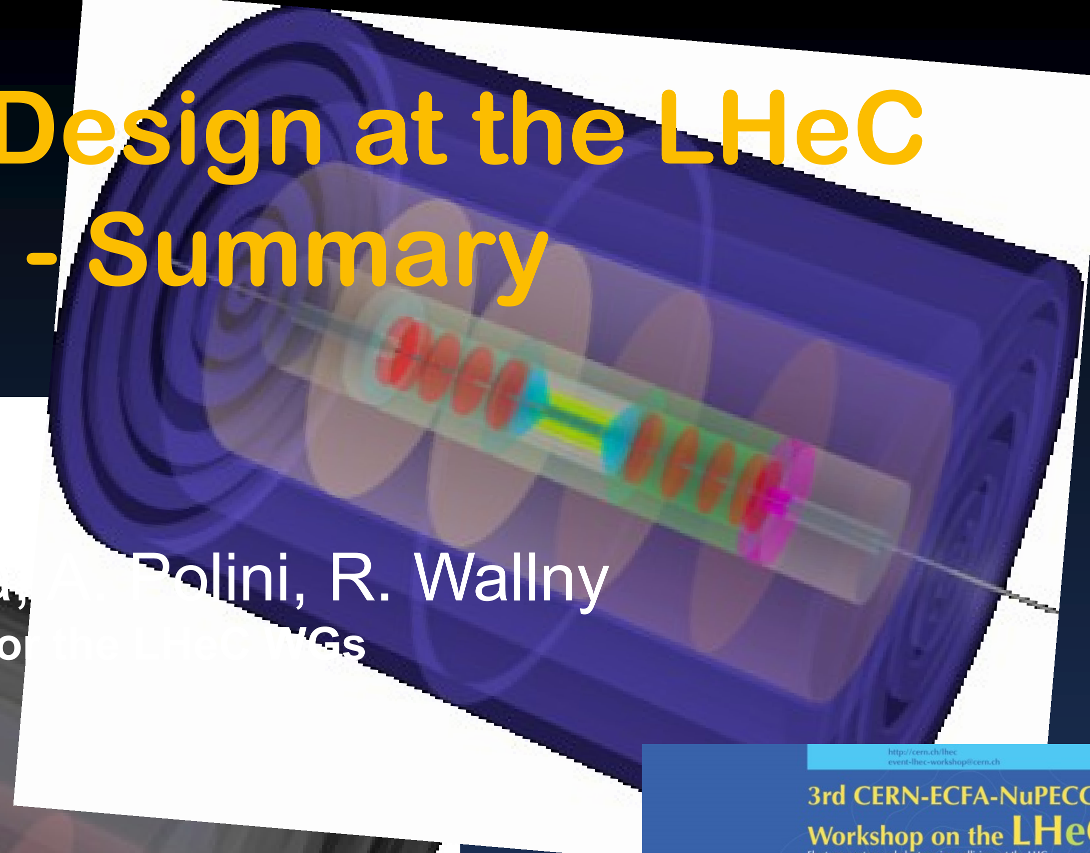
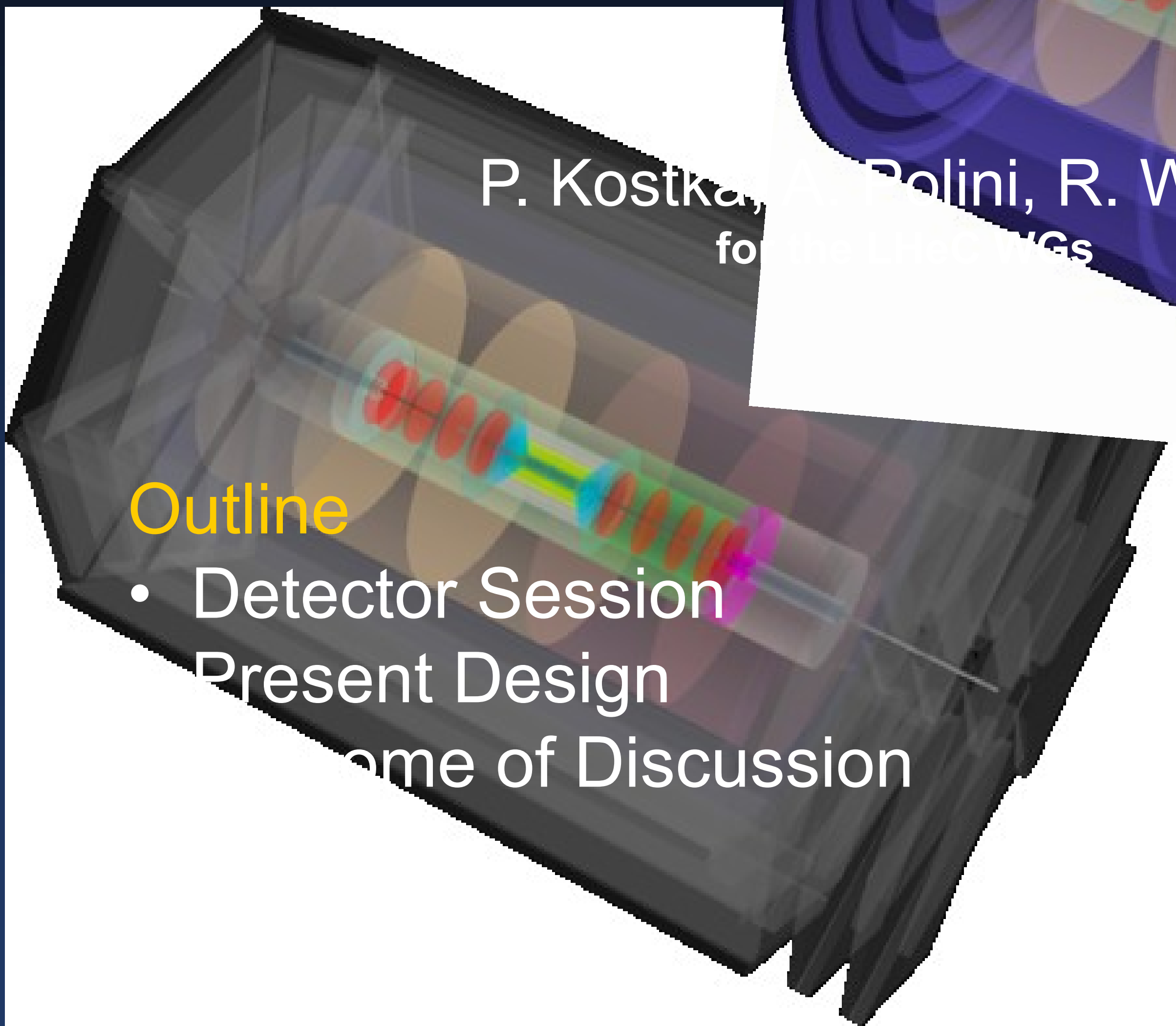
Detector Design at the LHeC WG - Summary





P. Kostka, A. Polini, R. Wallny
for the LHeC WGs

Outline

- Detector Session
- Present Design
- Outcome of Discussion

Detector Sessions

Detector Requirements — *KLEIN, Max*
Chavannes-de-Bogis, Switzerland

Detector Design Studies — *KOSTKA, Peter*
Chavannes-de-Bogis, Switzerland

Beam pipe — *VENESS, R.*
Chavannes-de-Bogis, Switzerland

Si pixel/strip Tracker — *ALLPORT, Ph.*
Chavannes-de-Bogis, Switzerland

Si-Gas pixel/strip Tracker
H. Van Der Graaf
Chavannes-de-Bogis, Switzerland

RR Interaction Region — *THOMPSON, Luke*

LR Interaction Region — *TOMAS, Rogelio*

IR quadrupole magnets
Chavannes-de-Bogis, Switzerland

IR SR — *BERNARD, Nathan*
Chavannes-de-Bogis, Switzerland

RR beam-beam effects — *PIELONI, Tatiana*

Vacuum
Chavannes-de-Bogis, Switzerland

BNL studies
Chavannes-de-Bogis, Switzerland

Solenoid, Dipole Design — *TEN KATE, H.*

Comparison with HERA/LHC/ILC Detectors
Chavannes-de-Bogis, Switzerland

Particle Flow Calorimetry and CALICE Detectors — *SIMON, Frank*

A Dual Readout Integrally Active Calorimetry (ADRIANO)

Calorimeter Discussion
Chavannes-de-Bogis, Switzerland

Luminosity Measurement and e/γ taggers — *LEVONIAN, S.*

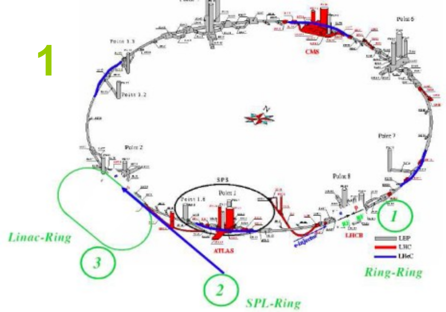
Neutron Tagging — *BUNYATYAN, A.*

- Latest updates on LHeC design, constrains, R&D Technologies
- Very interesting discussions
- Dialogue on Concerning the Two Chief World Systems ☺

Aim of present studies

- Prove together with Physics & Machine WG the feasibility and the physics potential
- Establish the Machine and the Interaction Region constrains (beam-pipe, synchr. rad, magnets)
- Provide a detector baseline within reach of currently available and established technologies
- Verify that such solution already fulfills the physics requirements
- Foresee more advanced options means R&D available by the time of detector construction

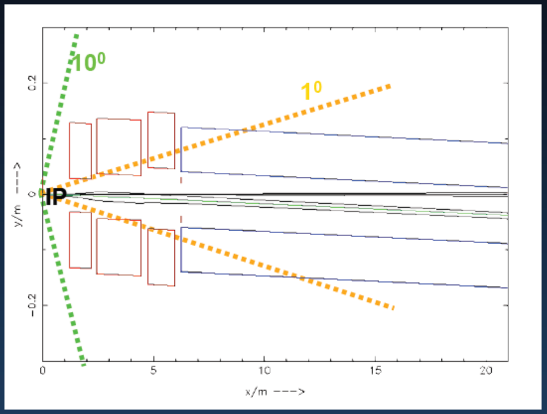
Ring-Ring Option

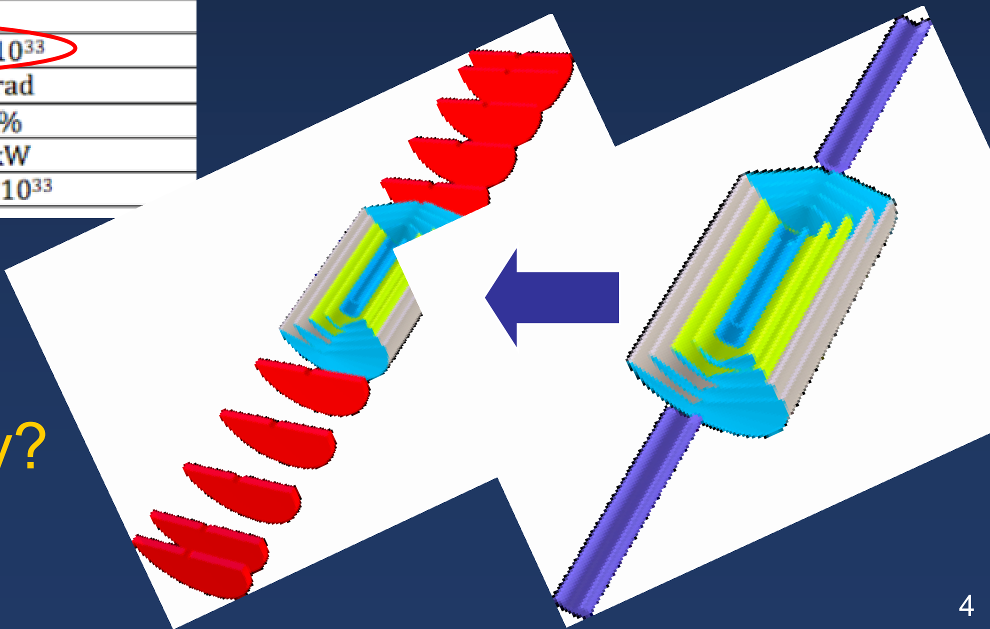


LHeC Ring-Ring Option
Main Parameters

B. Holzer

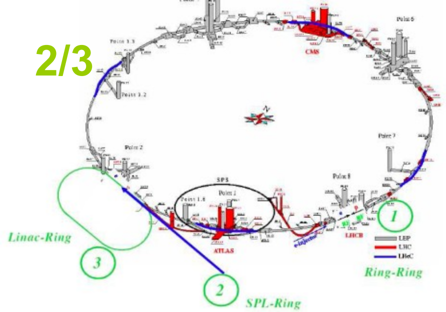
	Electrons	Protons		
Energy	60 GeV	7 TeV		
Current	100mA	860mA		
Part. per Bunch	$2*10^{10}$	$1.7*10^{11}$	B. Holzer	
ε_x	$5*10^{-9}$ m	$5*10^{-10}$ m		
ε_y	$2.5*10^{-9}$ m	$5*10^{-10}$ m		
P_γ	43.5 MW			
	1 degree		10 degree	
	Electrons	Protons	Electrons	Protons
β_x	40cm	4.05 m	18 cm	1.8 m
β_y	20cm	0.97 m	10 cm	0.5 m
σ_x	45µm		30µm	
σ_y	22µm		15.8µm	
L_0	$8.5*10^{32}$		$1.8*10^{33}$	
crossing angle	0.7mrad		1mrad	
loss factor	92 %		75%	
P_γ	44kW		28kW	
L_{eff}	$7.9*10^{32}$		$1.34*10^{33}$	





- Hi Lumi / Low Lumi ~ 1.8
- Moving towards 1 option only?

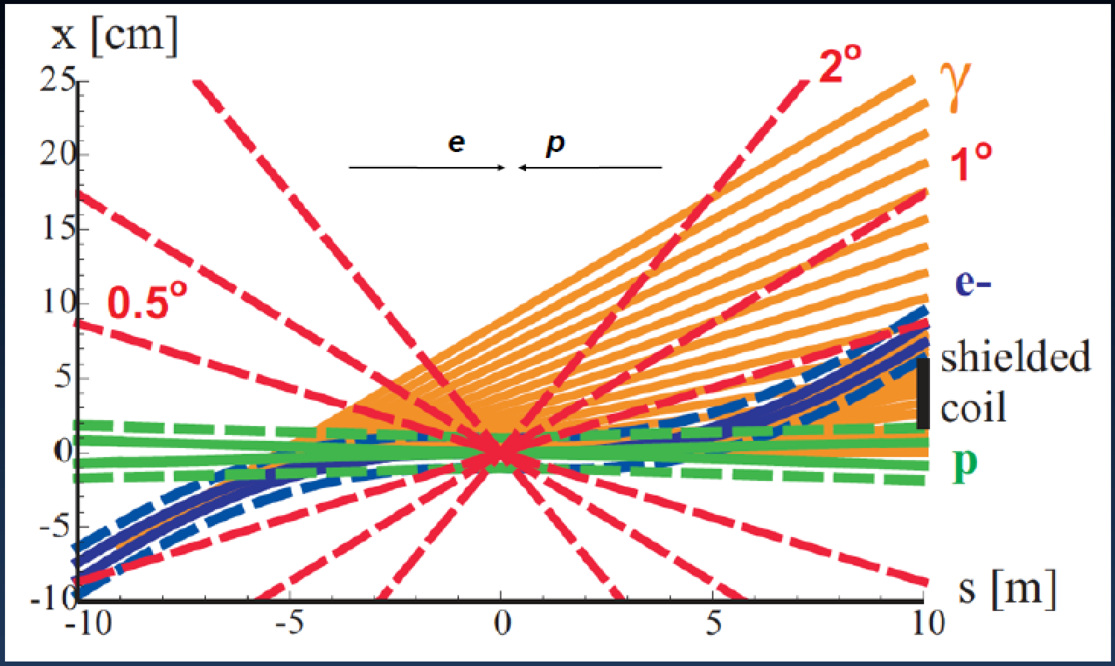
Linac-Ring Option



M. Sullivan

- **Elliptical Beam Pipe**:
  (March 2010 - prelim.)
- inner-$\varnothing_x$ = 12cm
- inner-$\varnothing_y$ = 5cm
- outer-$\varnothing_x$ = 12.4cm
- outer-$\varnothing_y$ = 5.4cm
- thickness: 0.2cm

INTERACTION-REGION DESIGN OPTIONS FOR A LINAC-RING LHEC by F.Zimmermann et.al. submitted IPAC'10



Beam envelopes of 10σ (electrons) [solid blue] or 11σ (protons) [solid green], the same envelopes with an additional constant margin of 10 mm [dashed], the synchrotron radiation fan [orange], and the approximate location of the magnet coil between incoming protons and outgoing electron beam [black].

9 m 0.4 T bending dipoles inside the main detector

Preliminary View on the LHeC Experimental Vacuum Chambers

Jonathan Bosch - University of Manchester
And
Ray Veness - TE/VSC

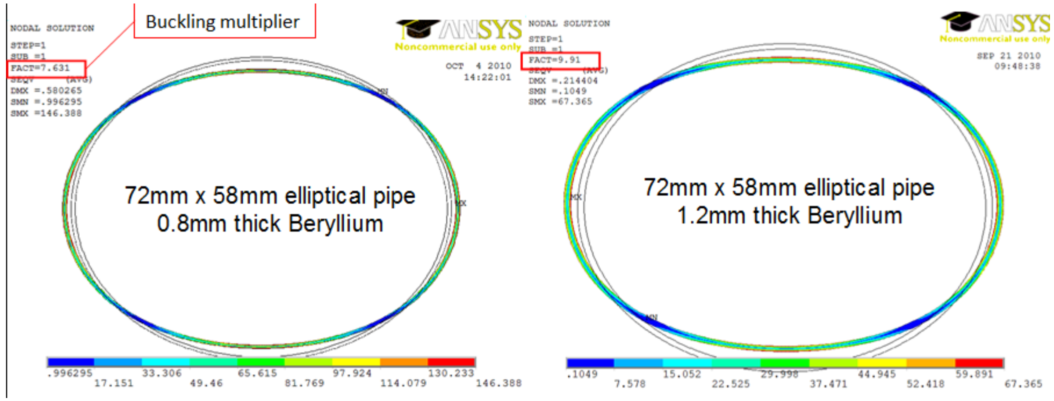
Requirements for the LHC experimental vacuum systems

Choice of beampipe materials and sections

Preliminary calculations of LHeC geometries

Conical beampipes

Summary



LHC requirements

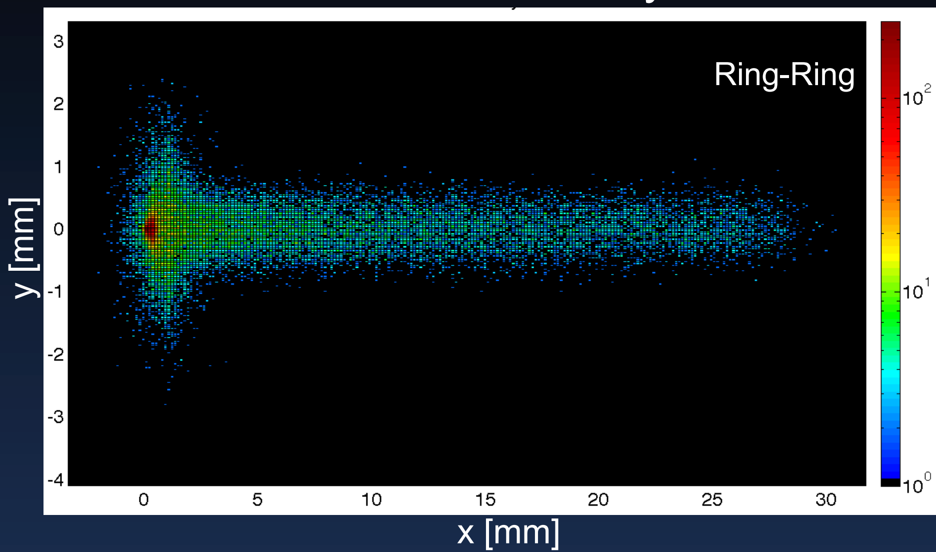
- The <u>combined requirements of LHC machine and experiments</u> (of which not all have been considered here) <u>place a serious limit</u> on the choice of materials and forms for beampipes.

Preliminary analysis

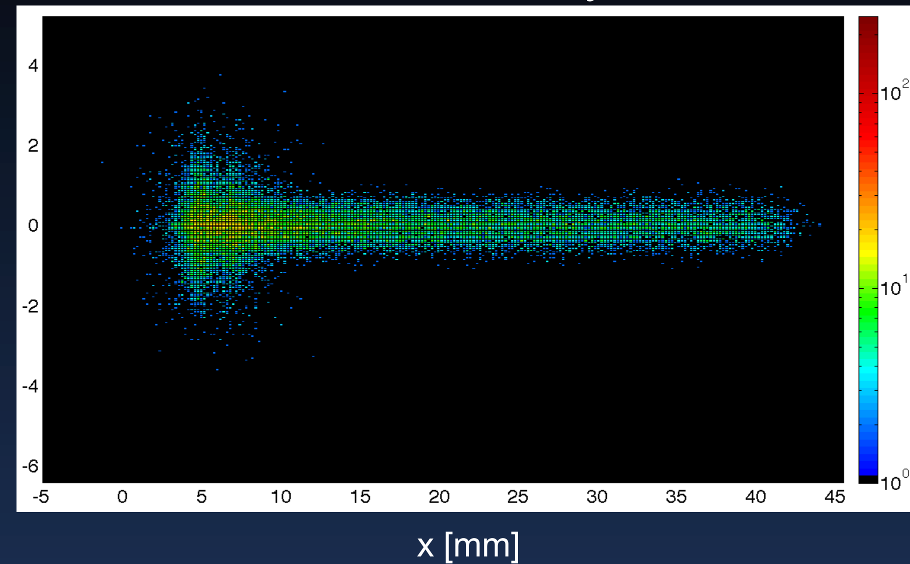
- <u>Preliminary calculations</u> have been made for simple 'solid', elliptical geometries made from aluminium, titanium and beryllium.
- <u>In beryllium, thickness in the order of 1 mm (for 72x58mm) and 2 mm (for 120x50mm) appear feasible</u>.
- Experience with conical chambers at LHCb does not rule out development of "Fwd/Central/Bwd" beampipe design.
- <u>Ongoing R&D for new materials and coatings may give other options</u>

SR Fan Extension - High Lumi

Photon Number Density at the IP

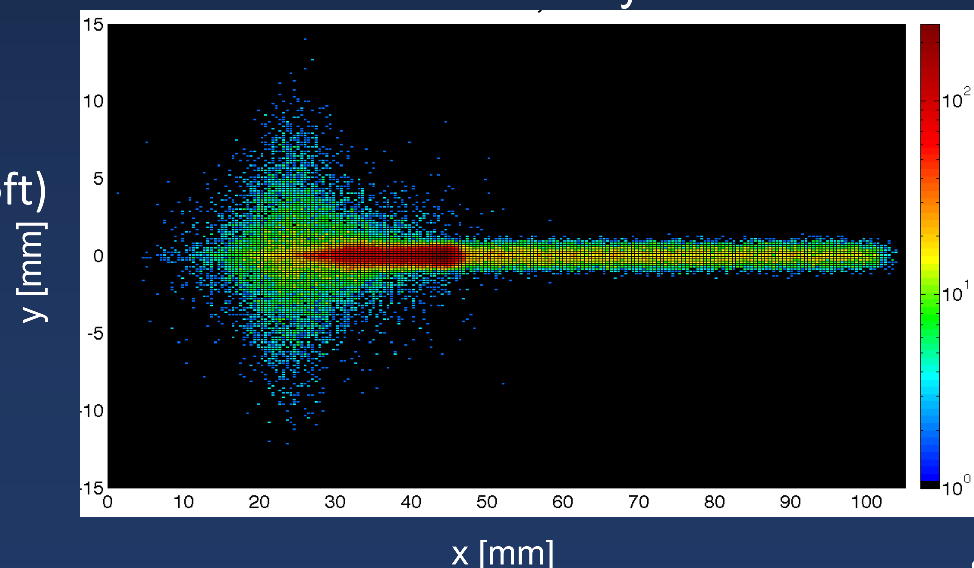


Photon Number Density at z = 4m



- Calculations being cross checked and complemented using (by):
  - GEANT4 (N.Bernard, UCLA/CERN)
  - IRSYN (R.Appleby, Manch./Cockroft)
  - MadX (B.Nagorny, DESY (left))
  - GEANT4-Fluka (E.Pilicer, E.Eroglu, Uladag University)

Photon Number Density at z = 9m



Requirements on the LHeC Detector

Max Klein

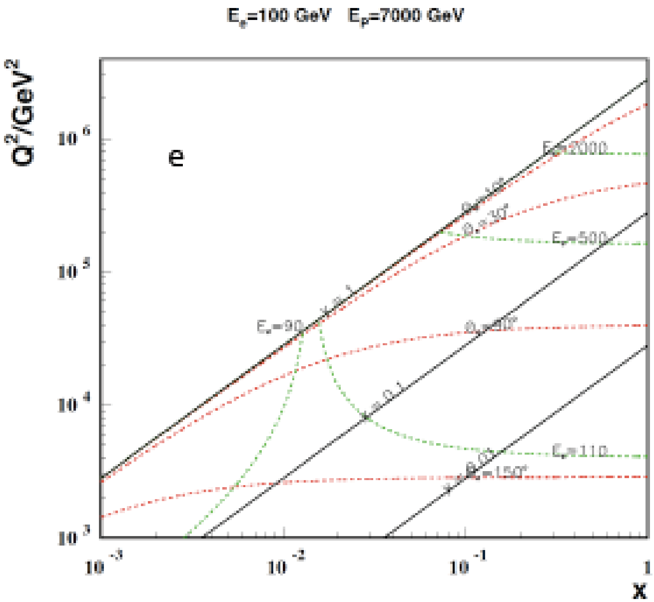
UNIVERSITY OF LIVERPOOL

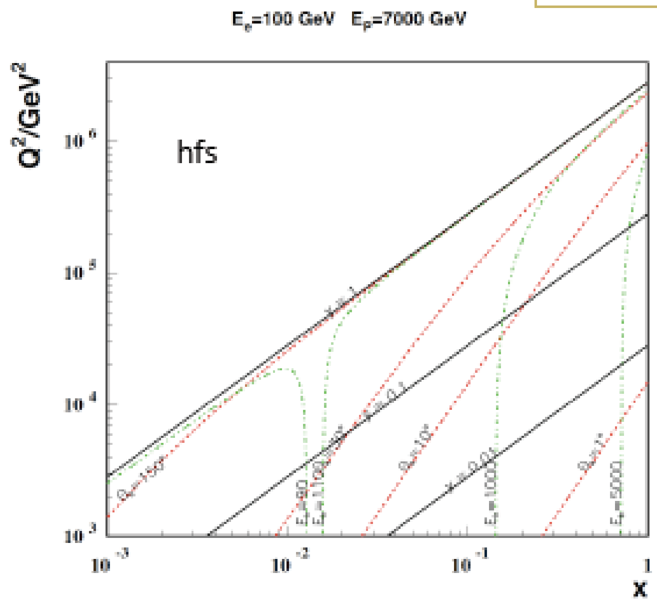
LHeC

Plan for Section Det.1

Physics
Acceptance+ E variation
Resolution
Calibration

Kinematics – high Q^2





The electron kinematics at high Q^2 is no big problem, apart from extreme backscattering at very high Q^2 of electrons of a few TeV energy.

→**Need forward elm. calorimeter of few TeV energy range down to 10° and below with reasonable calibration accuracy.**

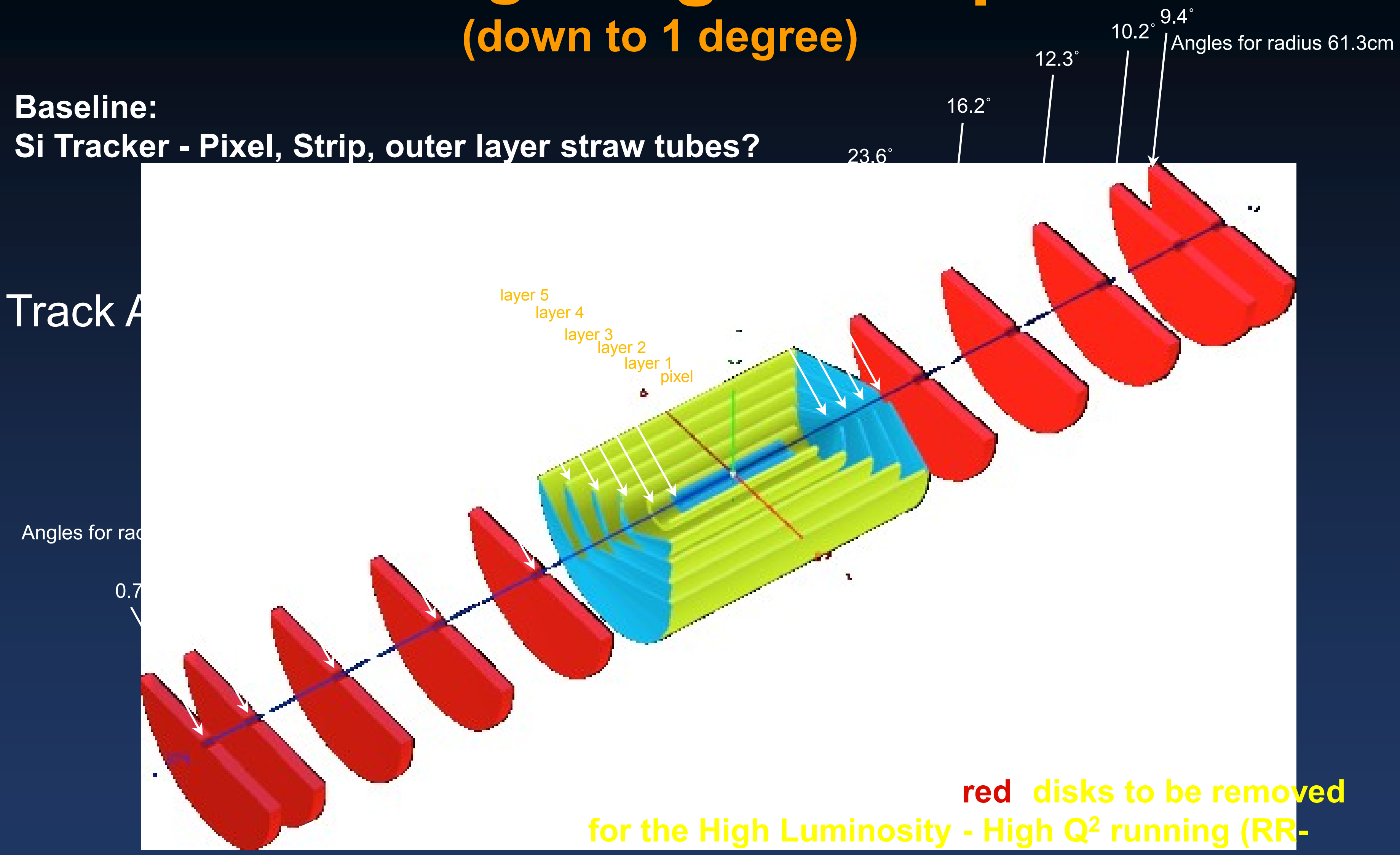
High x and high Q^2: few TeV HFS scattered forward:

→**Need forward had. calorimeter of few TeV energy range down to small angle, 1°. Mandatory for charged currents.**

Tracking

Full Tracking - High Acceptance
(down to 1 degree)

Baseline:
Si Tracker - Pixel, Strip, outer layer straw tubes?



red disks to be removed for the High Luminosity - High Q^2 running (RR-option)

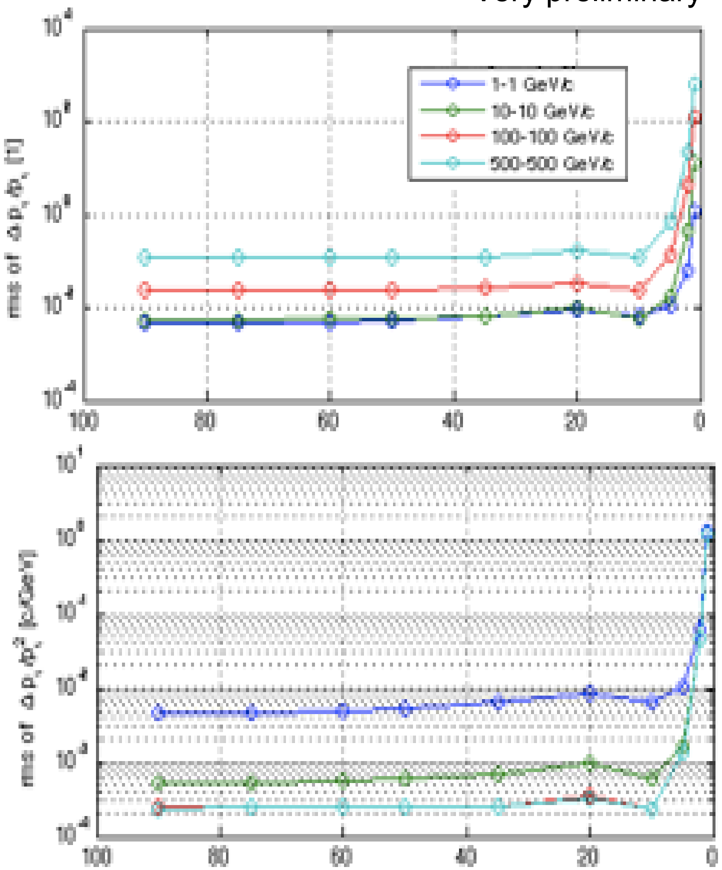
Alternative technologies: MAPS, DEPFET, GOSSIP* (talk of H.van de Graf)

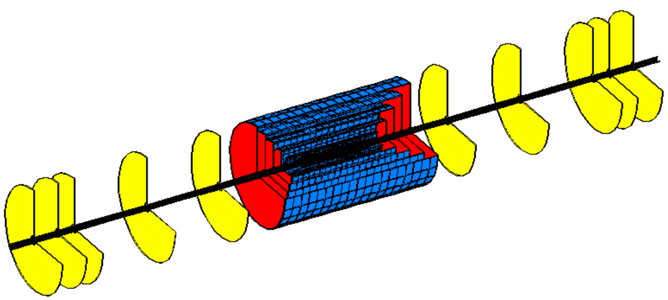
*Gas On Slimmed Silicon Pixels (or Strixels/Pads) - *NIKHEF*

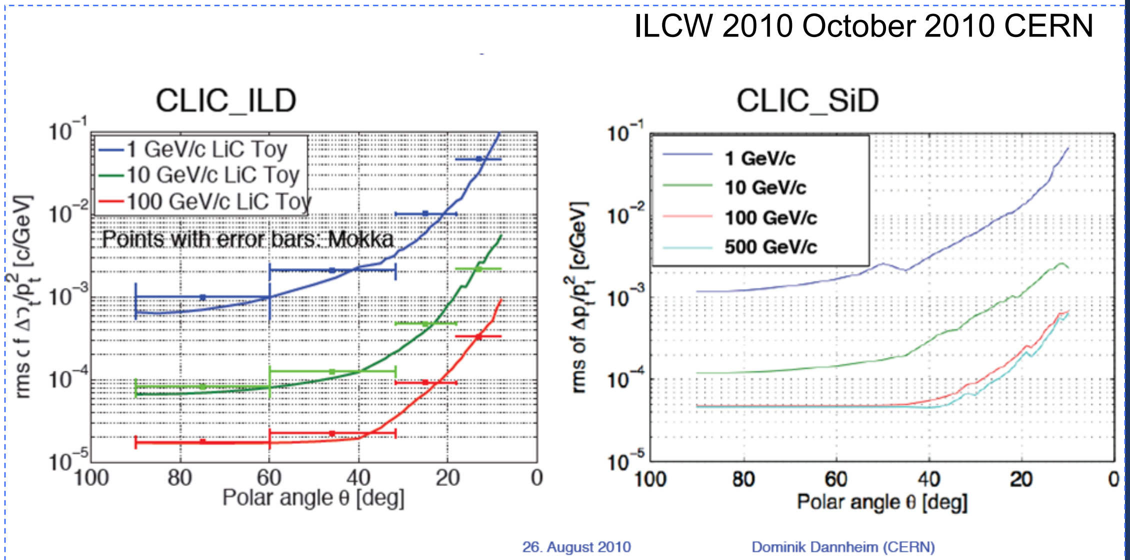
Tracking Simulation

- LicToy 2.0 Simulation (http://wwwhephy.oeaw.ac.at/p3w/ilc/lictoy/UserGuide_20.pdf)
- Simplified Geometry (barrel cylinders, fwd/bwd disks, no fwd/bwd cones)
- with basic assumption (layer resolutions, X/X_0)

Very preliminary



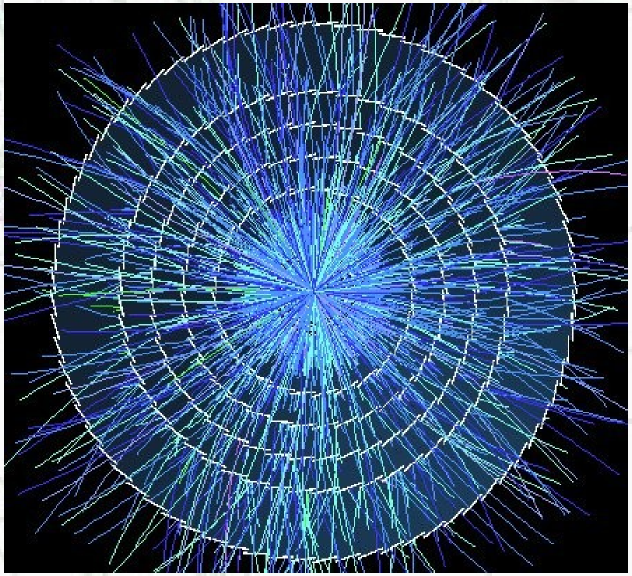




“Conventional” Silicon Pixel/Strip Tracker

Phil Allport
The University of Liverpool
12/11/10
3rd CERN-ECFA-NuPECC Workshop on LHeC

- Brief Overview of Tracking in CMS and ATLAS
- Silicon Detectors for sLHC (High Luminosity Upgrade LHC)
- LHC Vertex Detector Technologies
- Suggestions for LHeC
- Conclusions

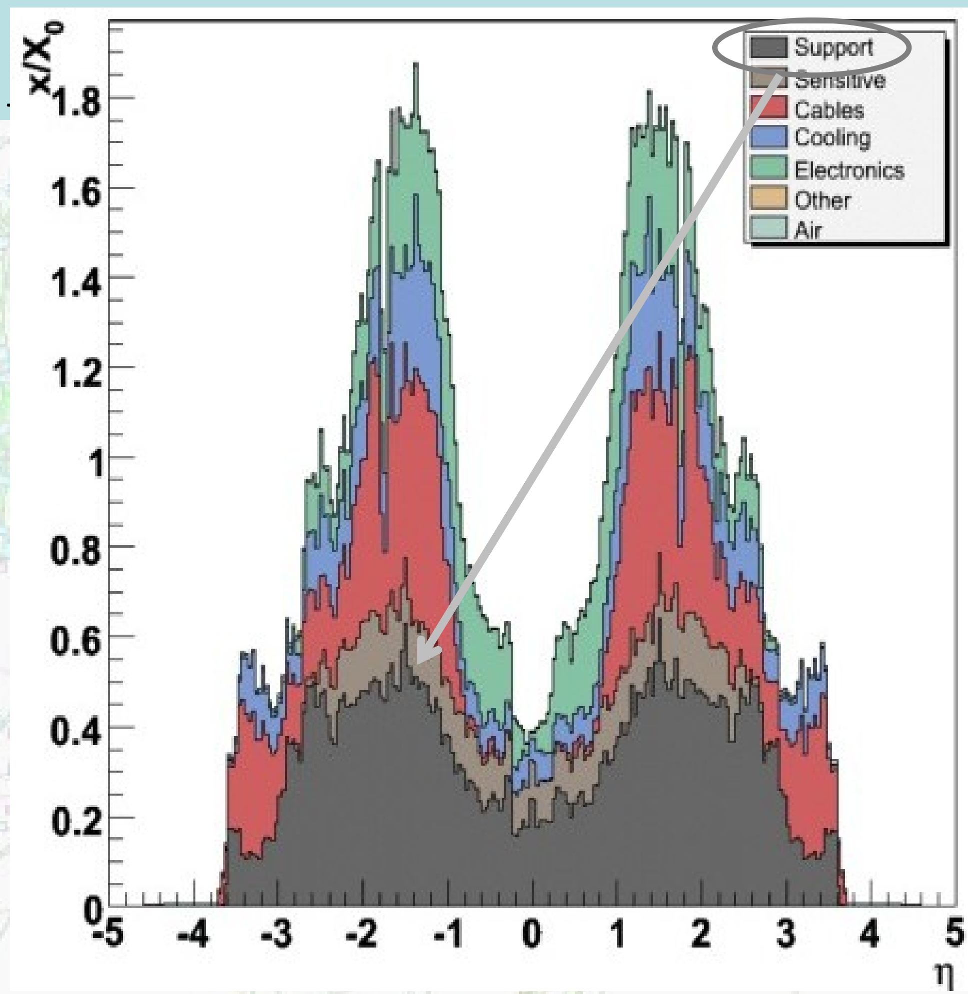


CMS Tracker Services

- **Be aware of material budget from services -cables, cooling, electronics …. dominant!**

- **LHeC - tracker limited to**
- **radial track length ~60cm**

- **Si - Pix/Strip ~8 points**
- **- high accuracy**



This is an old analysis but it still illustrates where one needs to focus

Costing Speculations [CHF/cm²]

R. Horisberger PSI (2006)

* = C4NP (IBM)

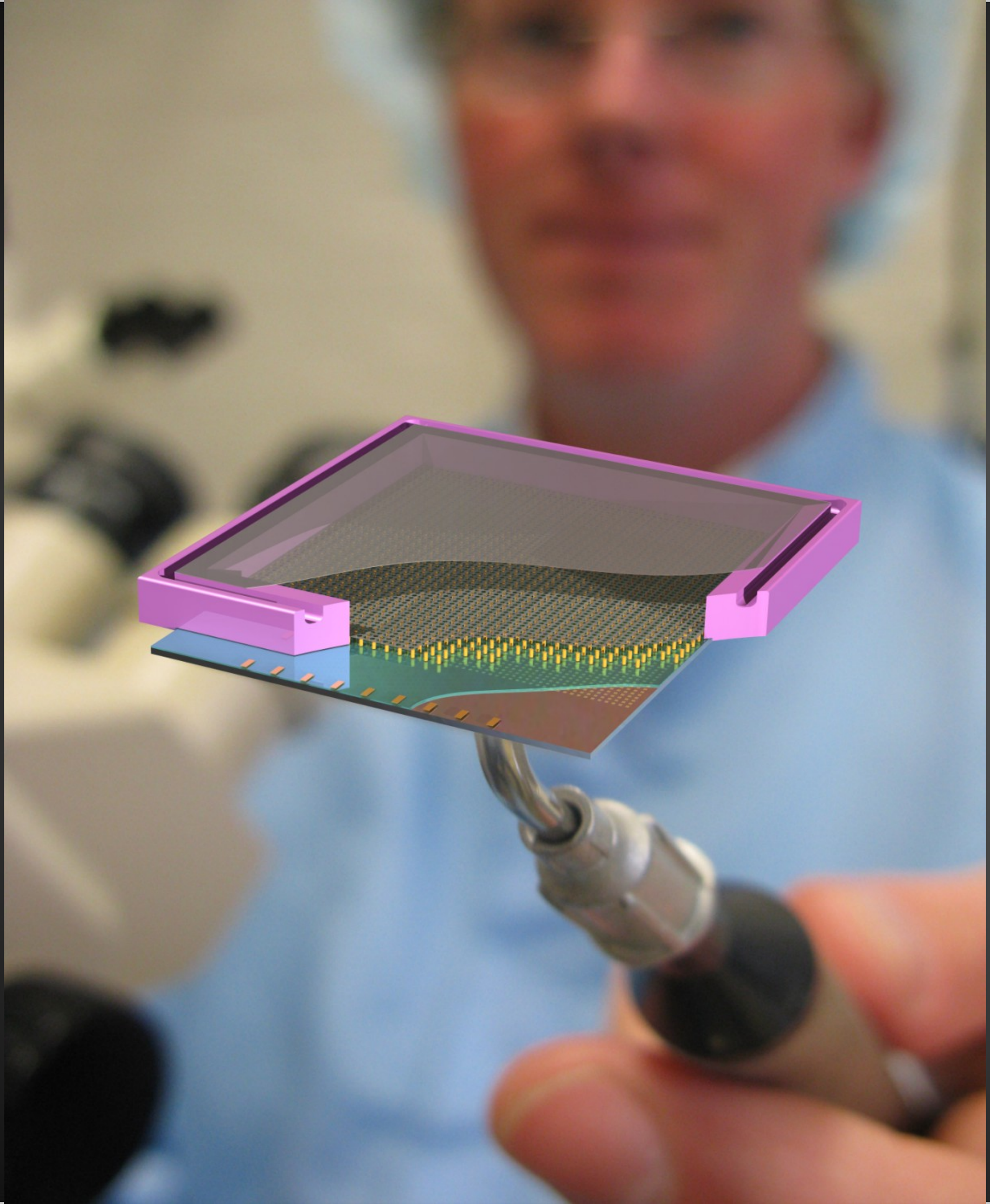
	Pixel (now)	Large pixels	Macropixels	MAPS	CMOS+Sensor
Pixel Area	0.015 mm²	0.15 mm²	1.5 mm²	- - -	- - -
Sensor/ROC	1 / 1	1 / 1	10 / 1	0 / 1	1 / 1
Tiling unit	10 cm²	40 cm²	100 cm²	4 cm²	4 cm²
Bumping	320	20*	2*	0	0
Sensors	80	10	10	0	10+10?(4)
ROC	25	50	2	50	200?(3)
HDI	30	30	3	30	30
Cables	8	8	0.8	8	8
Baseplate	5	5	0.5	5	5
Pitchadjust	0	0	15(2)	0	0
Optical Link (1)	32	6	0.6	6	32
pxFED	25	4	0.4	4	25
Total	**525**	**~130**	**~35**	**~105**	**~320?**

(1) ~ 320 CHF/channel
(2) ~ 0.02 CHF/cm fine pitch trace
(3) Yield speculations based on experience with DMILL SOI-wafers
(4) Extra cost for anodic wafer bonding or SOI wafer growth

(Current CMS microstrips ~40CHF/cm²)

Implications of LHeC Tracker Layout

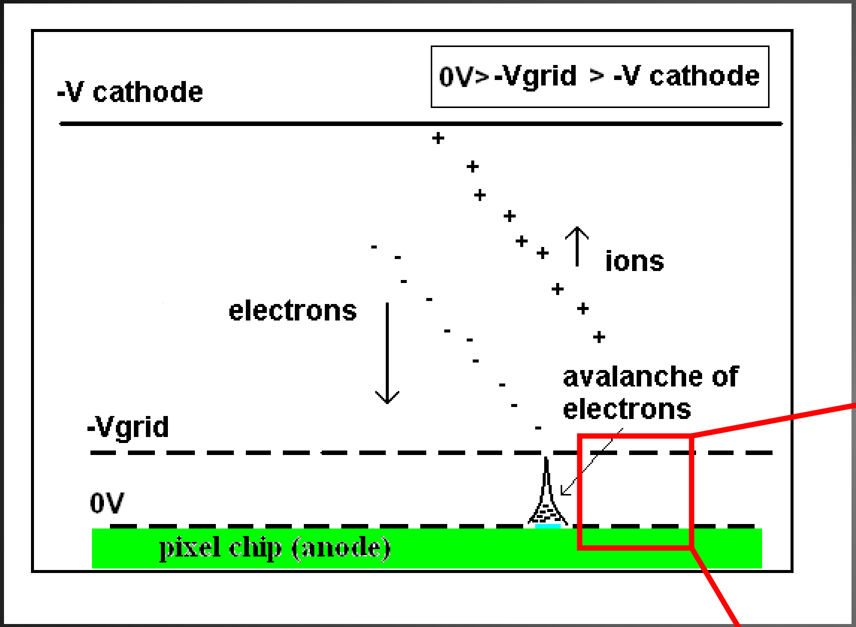
- Without knowing the average track densities per beam crossing it is hard to gauge at what radii the transition from pixel layers to strip layers should take place
- A similar comment applies to radiation levels, but it is hard to believe the expected levels for current ATLAS and CMS (never mind at sLHC) would be exceeded
- Since pixel layers are capable of having very low occupancy and being therefore much better for pattern recognition (never mind vertexing), a possible solution might be a highly performant (4-5 layer) central pixel detector, with the strip layers mostly for sagitta measurement (ie as a spectrometer)
- Issues of material tend to be more influenced by supports and services than very fancy sensor designs
- Silicon based tracking would seem to meet LHeC requirements but optimisation depends on required radiation tolerance and granularity



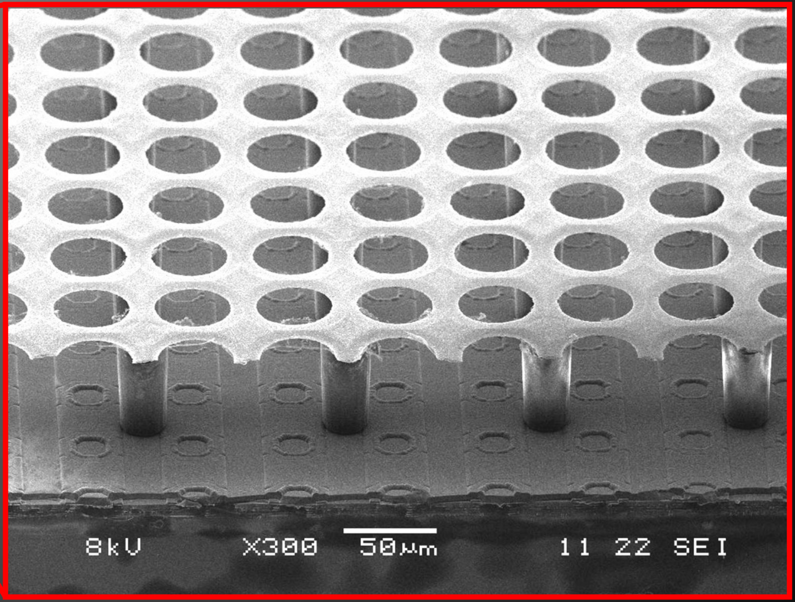
Gossip/GridPix
LHeC
Nov 12, 2010

HvdG
Nikhef

GridPix detectors

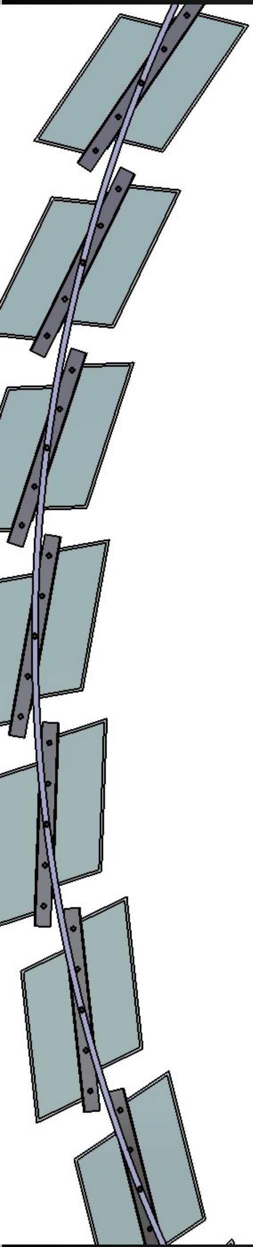


- Pixels of chip: x & y-coordinate
- Drift time gives z-coordinate
- Sensitive to single electrons

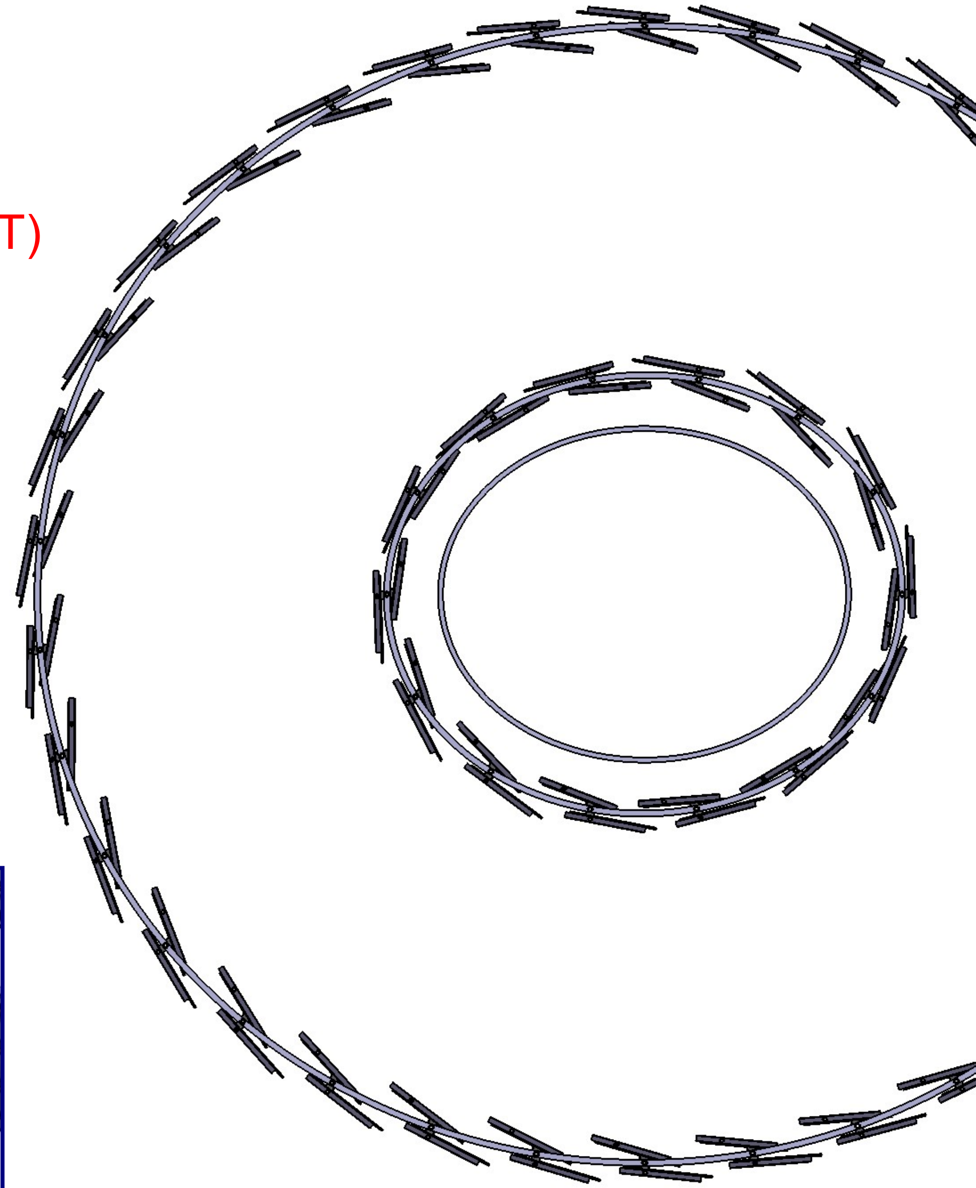


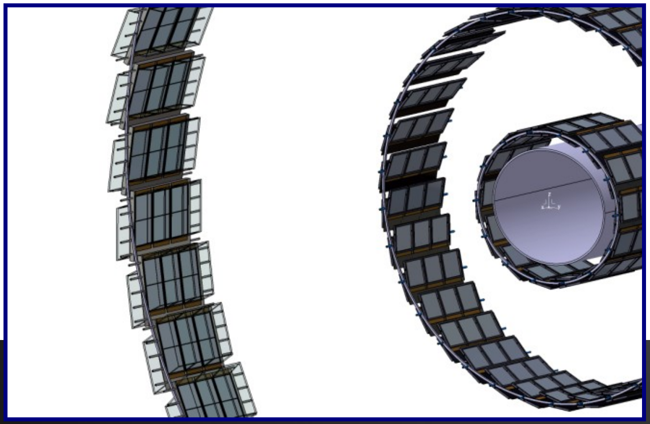
- Cathode
  - Drift volume (~0.1-few kV/cm)
- Grid
  - Gain region (~50-150 kV/cm)
- Pixel readout chip

Gossip/GridPix in LHeC



~ 4 layers pixel Gossips
1 (double) layer LVL1 (+ TRT)





See for many issues:

http://www.nikhef.nl/~d90/gossip/RD51ATLASGossip.pdf

- detector layer radiation length
- rate effects: space charge, occupancy
- ageing
- vertex layer performance:
    - track efficiency
    - position resolution
    - rate effects
- LVL1 performance
- TRT performance

Nikhef can deliver information & hardware
Nikhef can NOT participate in LHeC:
representative required

Calorimetry

Detector Acceptance

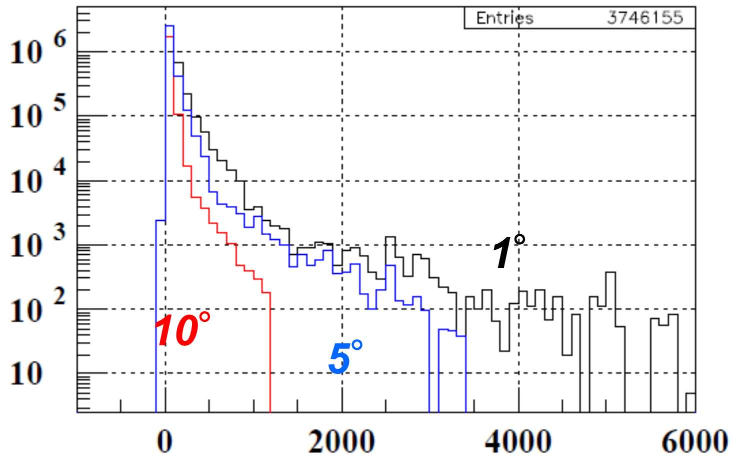
RAPGAP-3.2 (H.Jung et.al.- http://www.desy.de/~jung/rapgap.html)

HzTooL-4.2 (H.Jung et.al. - http://projects.hepforge.org/hztool/)

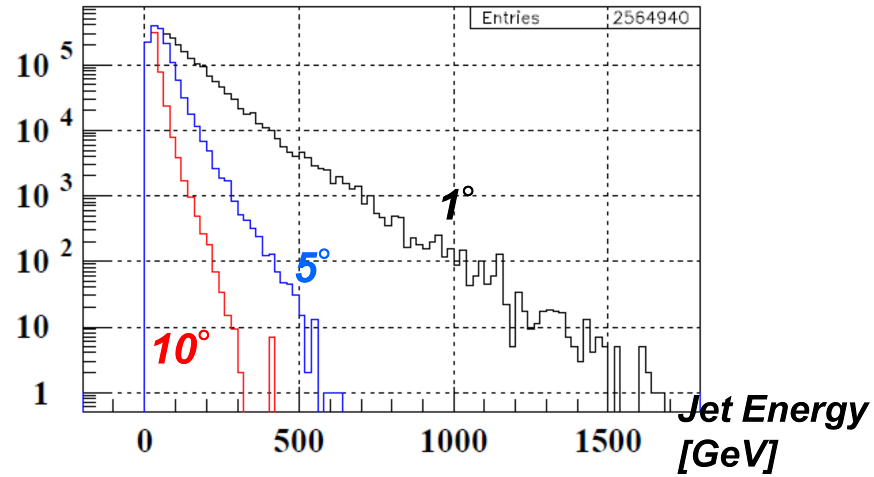
selection: q^2.gt.5.

→ Highest acceptance desirable

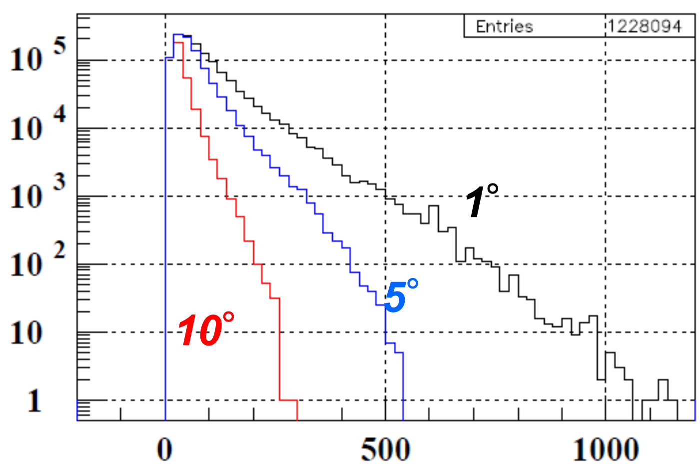
RAD: 60 GeV electron x 7 TeV proton



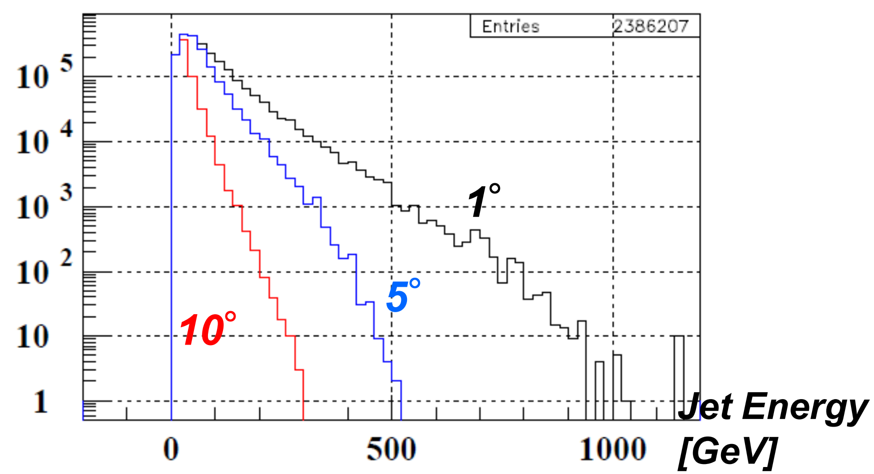
CHARM: 60 GeV electron x 7 TeV proton



DIFF : 60 GeV electron x 7 TeV proton



NRAD: 60 GeV electron x 7 TeV proton



Calorimeter Discussion

Requirements:

- Precision physics
- Similar energies and resolution required for ILC
- Jet Energies ~ O(1 TeV) especially in the p forward region
- High energy resolution, higher granularity
- Possibly compact design (detector size)

Technologies:

- **Liquid Argon (H1/ATLAS) concept applicable as baseline solution**
- PFA (particle Flow Algorithm) → see F. Simon

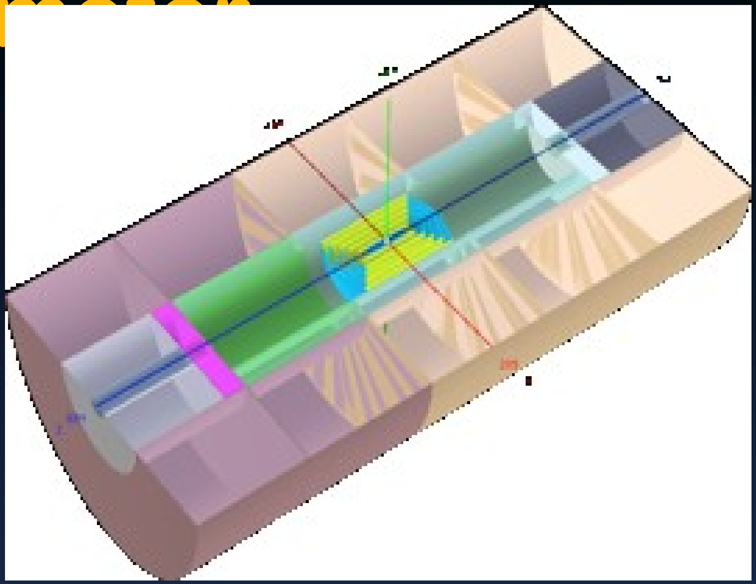
  CALICE High granularity calorimeters. Software compensation & PID combining with information coming from the tracking system
- New Concepts

  - Silicon, RPC, Micromegas etc.

  - Full Active/Dual Readout Calorimeters: → see C. Gatto

  Combine energy and Cherenkov measurements

LHeC Calorimeter



For the geometry given:

- Electromagnetic Calorimeter:
  ~30 x X_0 Pb/W & different det./R/O
- Hadronic Calorimeter:
  6 ~10+ x λ_I Fe/Cu & different det./R/O

- Presently the fwd/bwd calorimeter asymmetry more in functionality/detector response rather then in geometry

- A dense EmCAL with high granularity (small transverse size cells), high segmentation (many thin absorber layers), and with ratio λ_I/X_0 large, is optimal for E-Flow measurement → 3-D shower reconstruction
- Example Fe, W

Material	Nuclear interaction length λ [cm]	Density [g/cm^3]	Moliere radius [cm]	Radiation length X_0 [cm]	λ/X_0
Fe	16.98	7.87	1.66	1.77	9.59
W	10.31	19.3	0.92	0.35	29.46

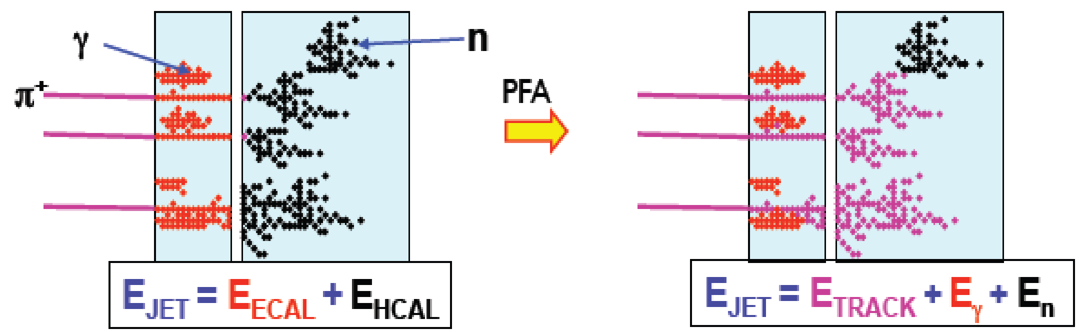
- brass (Cu) an option also (CMS), λ_I =15.1cm - denser than Fe (adding λ_I)

→ Liquid Argon Calorimeter (H1/ATLAS) being also considered as Baseline

Particle Flow Calorimetry and CALICE Detectors

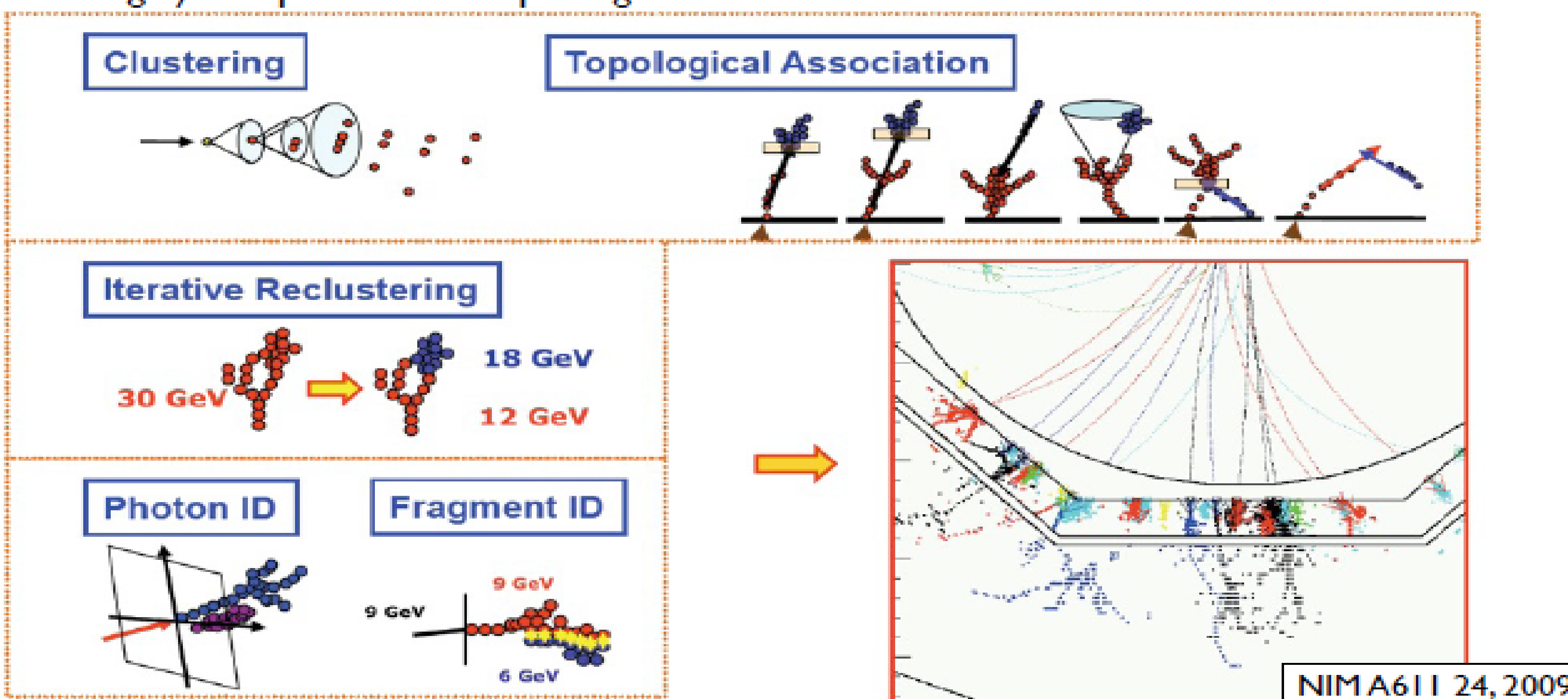
Frank Simon
MPI for Physics & Excellence Cluster 'Universe'
Munich, Germany

➪ 60% of the jet (charged hadrons) are measured with better precision in the tracker!



Particle Flow Algorithms: Technology

- The most performant PFA at present: PandoraPFA (Mark Thomson, Cambridge)
  - highly complex software package



ADRIANO:
***A D**ual **R**eadout **I**ntegrally **A**ctive **N**on-segmented **O**ption for Future Colliders*

Corrado Gatto
INFN

- On behalf of:

TWICE Collaboration

ADRIANO Calorimeter

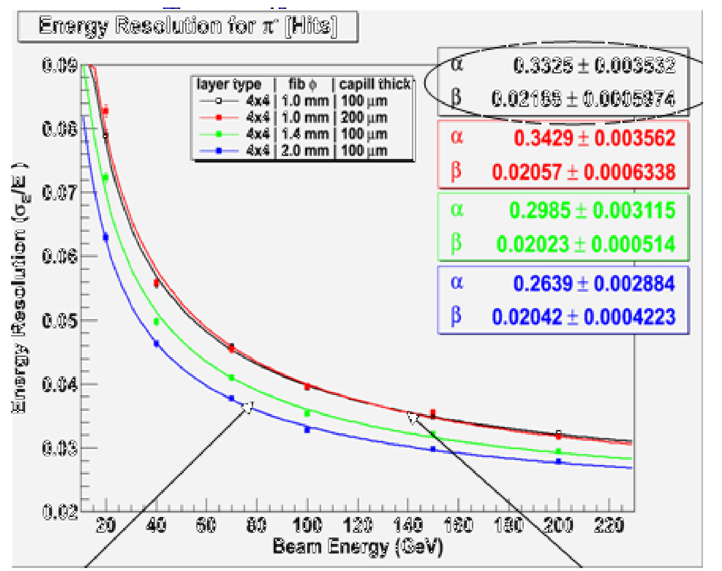
- Lead glass + scintillating fibers
- Fully projective layout
- ~1.4° aperture angle
- 4x4 cm² cells
- Length = 180 cm
- Azimuth to 2.8°
- < > ~ 8 ; X/Xo ~ 100
- Barrel: 16384 cells
- Endcap: 7450 cells/ea

Merging the advantages of sampling and total active techniques

***ADRIANO* technique: i.e. embedd scintillating fibers into heavy glass**

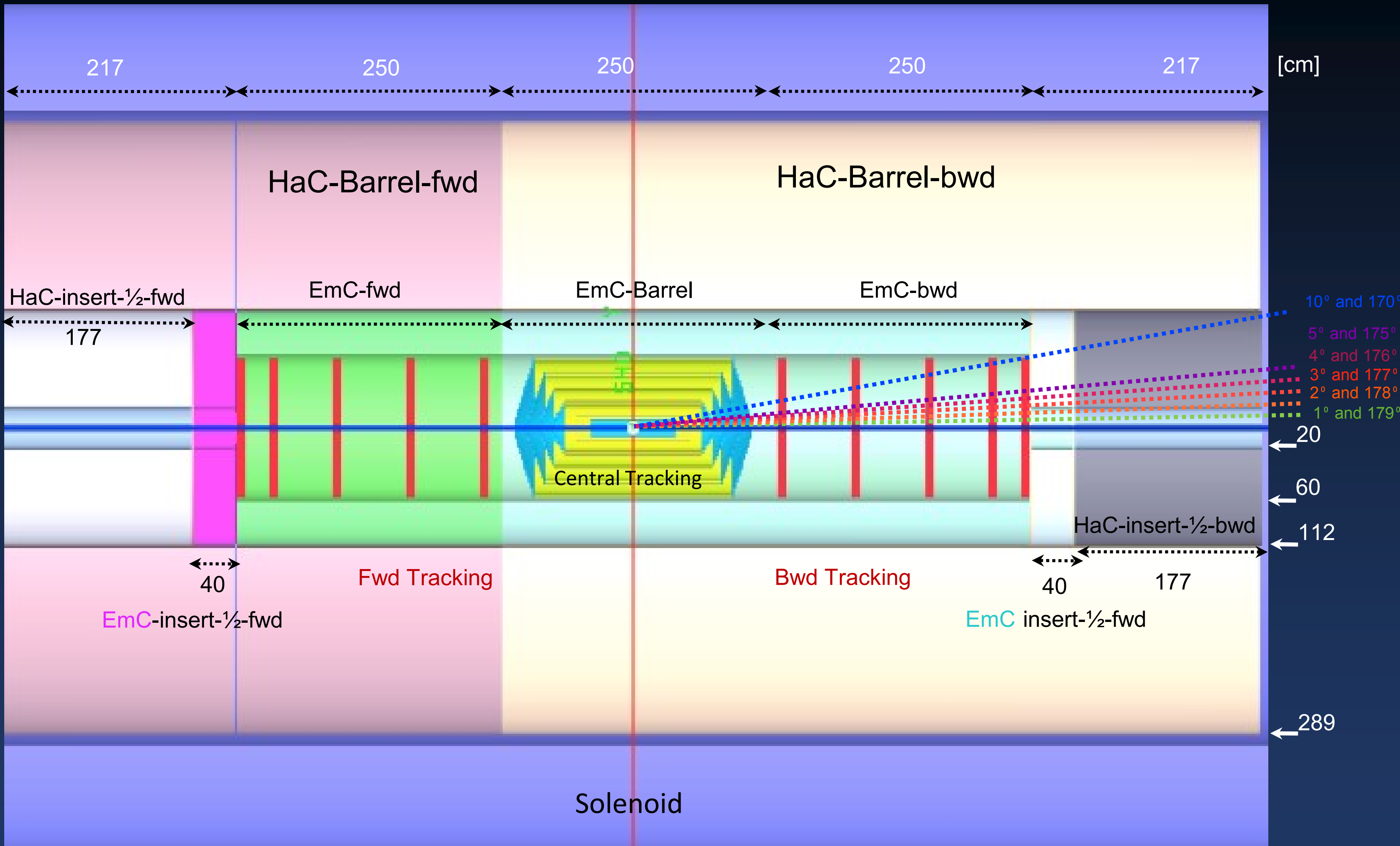
- Active Cerenkov component is Optical Heavy Glass
  - It functions as an **active absorber**
  - No scintillation light
  - Lots of Cerenkov photons thanks to n_f=1.85
- Scintillating component are scintillating fibers
  - **Optically separated** from Cerenkov absorber
  - Control the scintillation/Cerenkov signal with appropriate pitch between fibers
  - Faction of surface to instrument with photodetectros = 8%

ADRIANO in Dual-readout



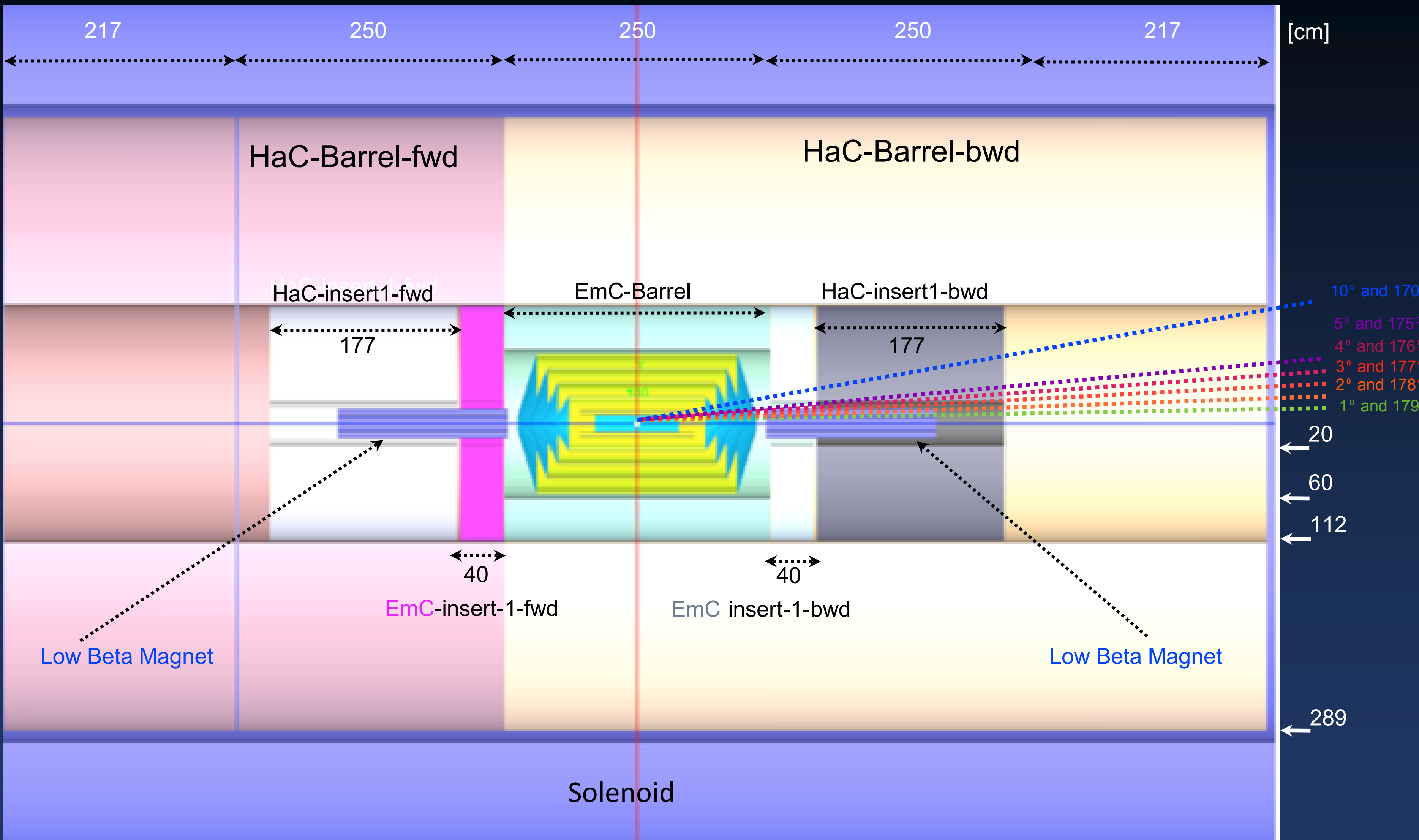
$\sigma_E/E \approx 26\%/\sqrt{E} \oplus 2.2\%$ $\sigma_E/E \approx 33\%/\sqrt{E} \oplus 2.2\%$

The Detector - High Acceptance



Fwd/Bwd asymmetry in energy deposited and thus in technology [W/Si vs Pb/Sc..]
Present dimensions: LxD =17x10m^2 [CMS 21 x 15m^2 , ATLAS 45 x 25 m^2]

The Detector - High Luminosity

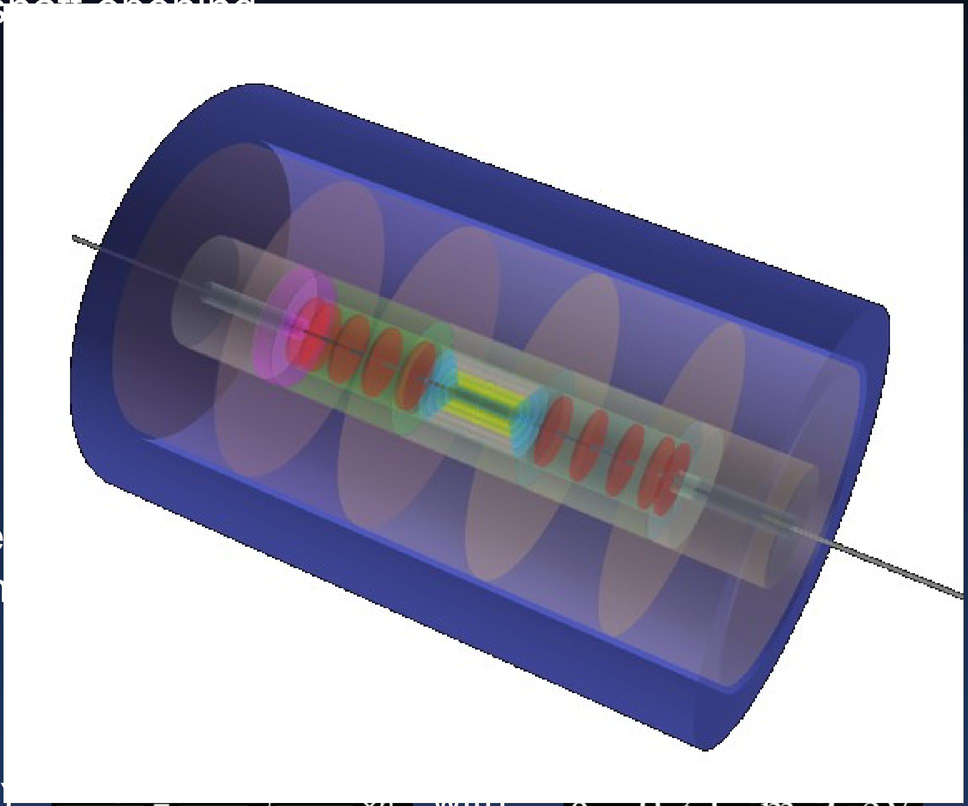


➔Aim of current evaluations: avoid detector split in two phases: time and effort

Solenoid

Modular structure:

- assembly CMS like on surface level or in the experimental area depending on time constraints and access s



Solenoid dimensions:

- 6m half length
- 300 cm inner radius
- B field = 3.5 T

Geometry constraints:

- Current beam pipe dimensions
- Requirement of 10° tracking cove
- Homogeneous B field in the trackin

Detector Track Resolution:

i.e. assuming / using (Glückstern relation): $\frac{\quad}{p_T} = \frac{\quad}{aBL^2}\sqrt{\frac{\quad}{N+4}} \times p_T$ with $a = 0.3\ T\ \ m\ \ GeV$

N track points on L; length of track perpendicular to field B, accuracy σ(x)

B = 3.5 T, N_{min}= 56 track points (2 x 5 (min. hits per layer) x 5 + 2 x 3 B-layer hits)

s-gas module ~10° inclined more track points for inclined tracks - extended track segments

➔ $\Delta p_T/p_T$ = 0.03% p_T

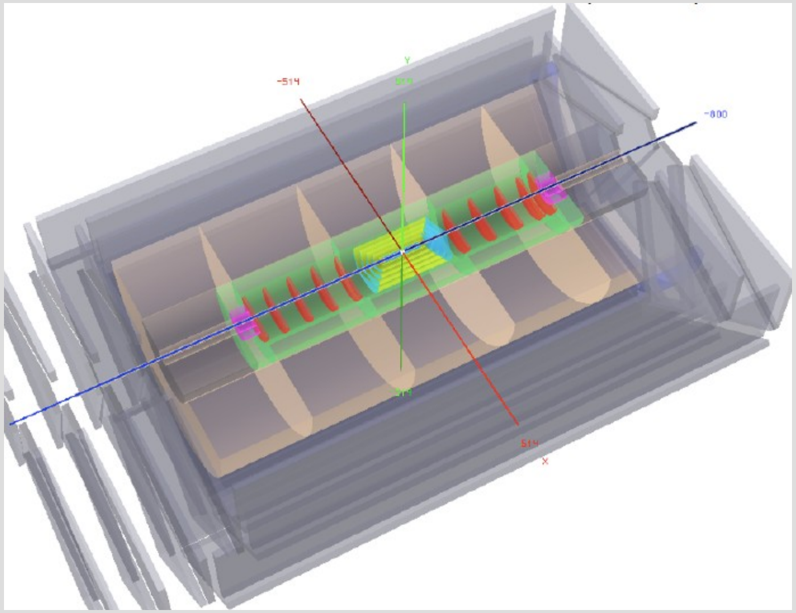
Superconducting Magnets for LHeC

Solenoids, e-bending Dipoles and a Toroid

Herman ten Kate and Alexey Dudarev
CERN Physics Department

Content

Solenoid and Dipole (LR) Options



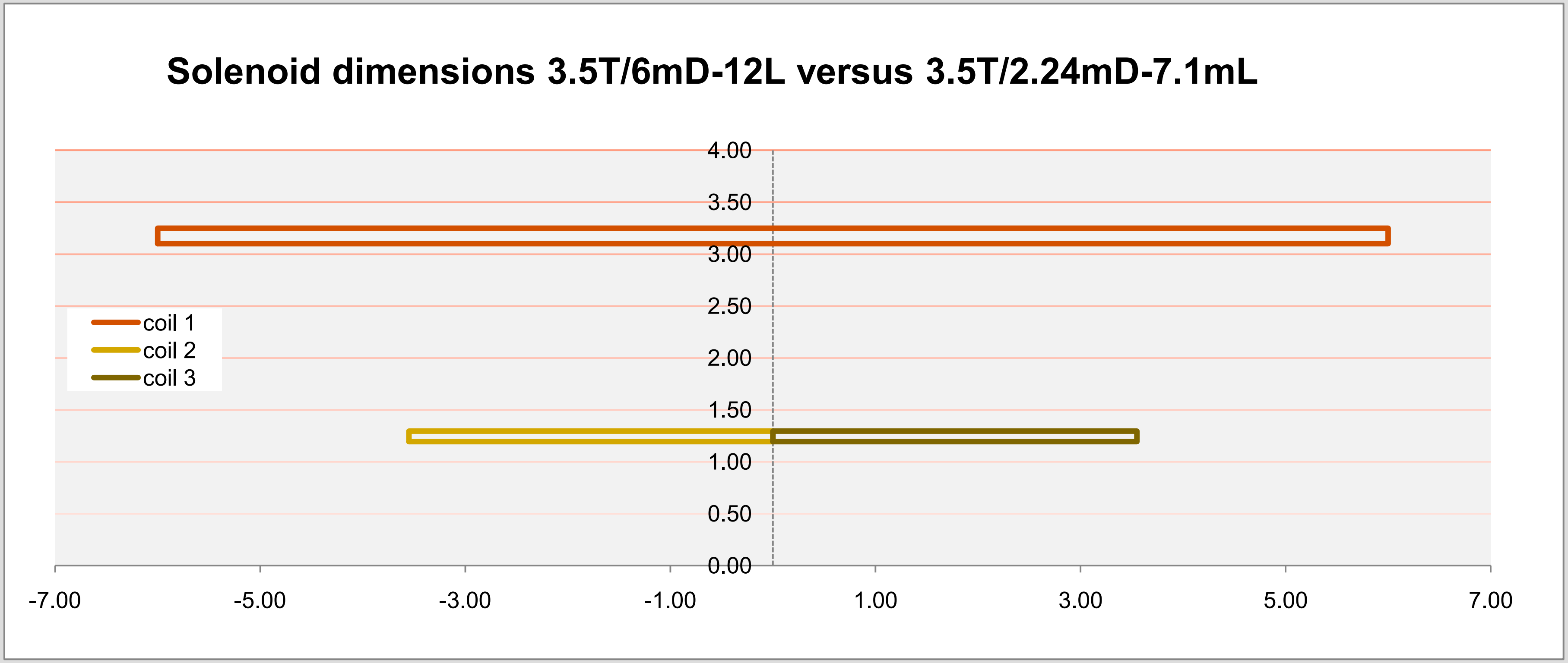
1. Large solenoid outside the H-cal
   3.5T, 6.0m bore,12m long
   with iron yoke (CMS like)
2. Large solenoid outside H-cal
   3.5T, 6.0m bore,12m long
   with shielding solenoid for flux return
3. Small solenoid in between E- and H-cal
   3.5T, 2.2m bore, 7.1m long
   with iron return yoke
4. Small solenoid in between E-cal and H-cal
   3.5T, 2.2m bore, 7.1m long with shielding solenoid

Combine solenoid options with twin dipole on 6 or 2.2m bore ?

- However, dipole on 6m bore is very inefficient and bulky, so needs to be positioned at low radius
- ✓ If space is reserved along 12m for the twin dipole at low radius, then combine with the solenoid

Big and Small Solenoids

- Dramatic difference in size, complexity & cost of these two options



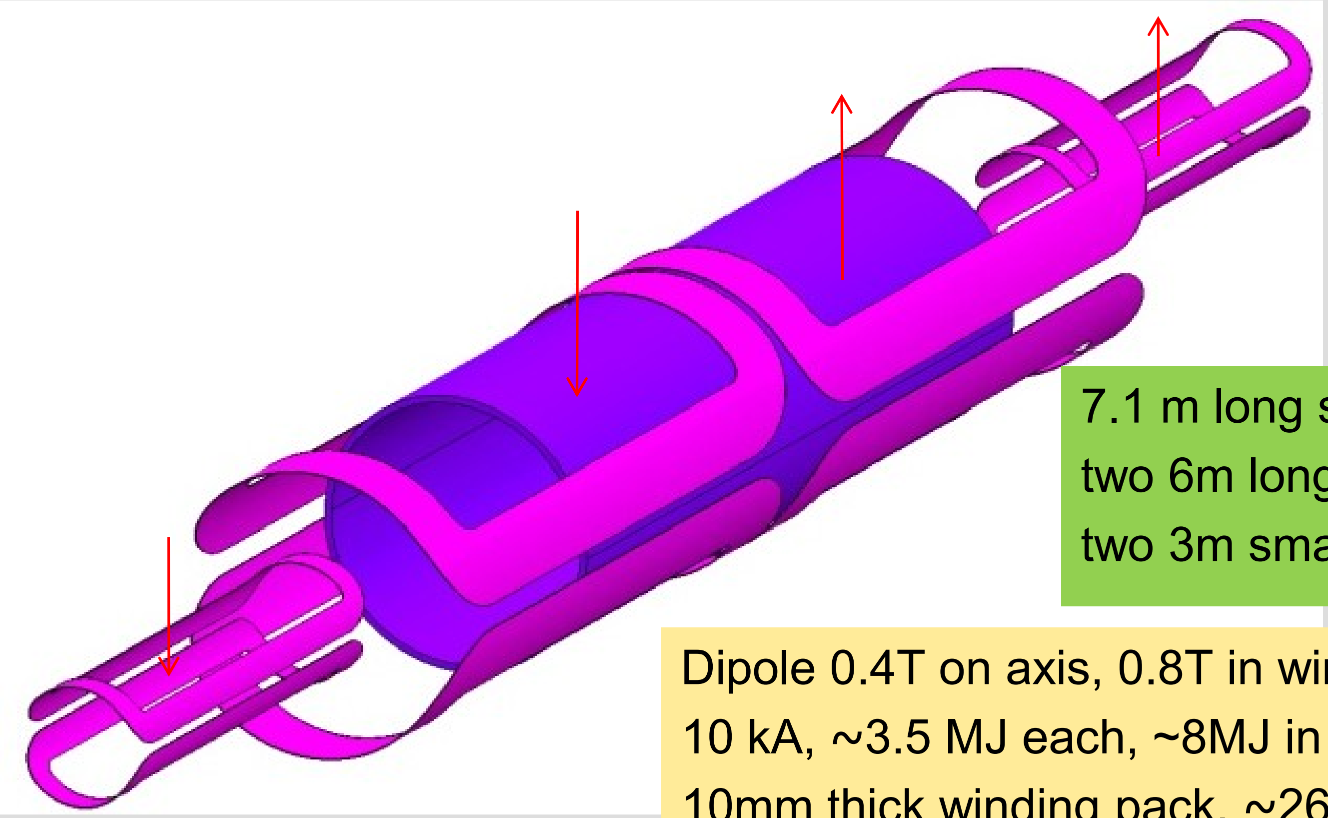
- Big solenoid requires 3m thick iron shielding weighing 10,000 tons
- Small solenoid at 3m radius shows ~0.15T to shield, iron of < 500 tons!
- ✓ If for physics acceptable, take the small solenoid !

3.5T – 2.24mD – 7.1mL Solenoid arrangement

Solenoid and Twin Dipole arrangement as required for LR option

Elegant solution: combine solenoid and the 9m long dipoles

- ✓ 6m long sections of dipoles within the detector bore in one cryostat, add the remaining 3m long side dipoles separately

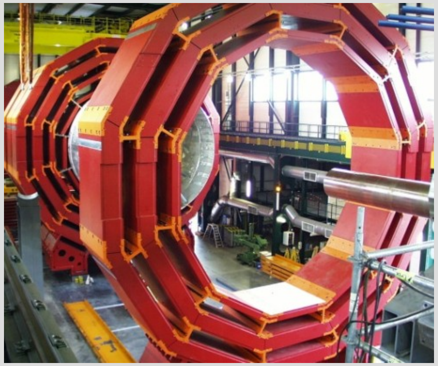


7.1 m long solenoid combined with
two 6m long dipoles and
two 3m smaller radius side dipoles

Dipole 0.4T on axis, 0.8T in windings
10 kA, ~3.5 MJ each, ~8MJ in total
10mm thick winding pack, ~260t force/6m

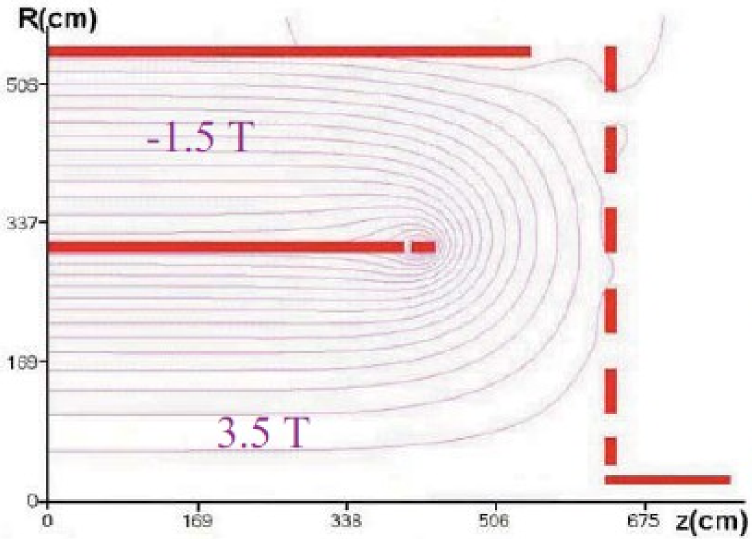
Iron or actively shielded solenoid

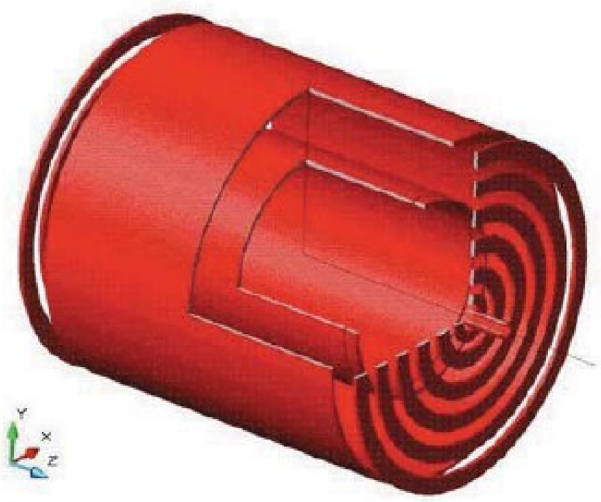
Flux return by active outer solenoid in stead of iron: much lighter, more elegant, muon tracking space for “free”, possibly cheaper as well



4th detector design for ILC
3.5T in 6mD - 9mL

- inner solenoid like CMS
- outer solenoid and end coils driven in opposite direction
- zero fringe field
- outer solenoid is “only” big
- iron-free (less massive by 15,000 t)



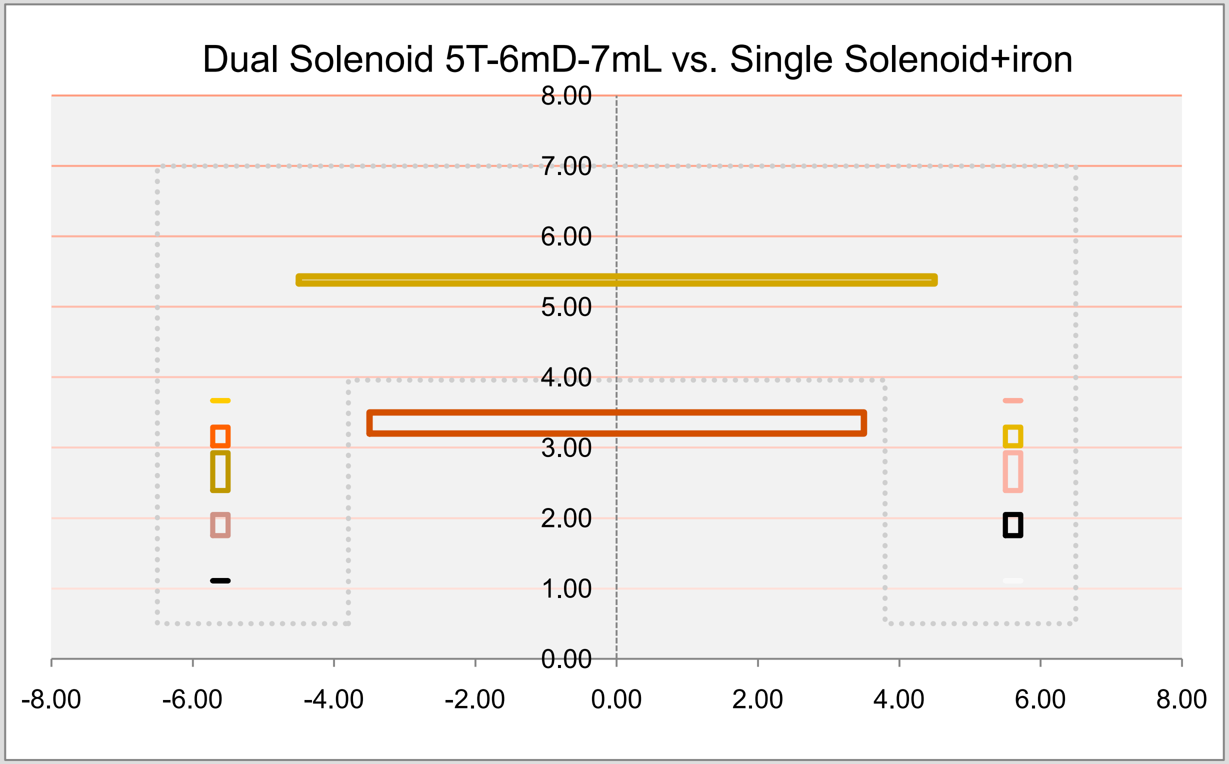


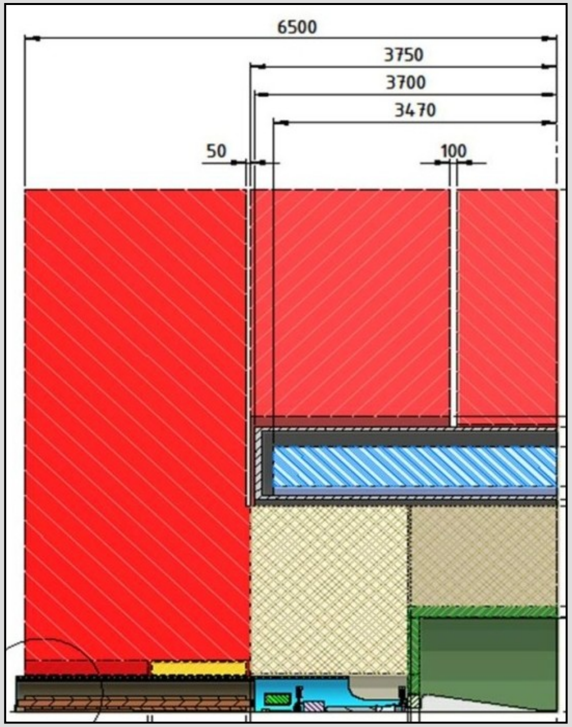
Example LCD-CLIC SiD 5T-6mD-7mL

Alternative Conceptual Design of a 5T CLIC detector magnet

50% smaller, 20 times lighter, easy to move, “modern in 2025-2035”

(but not X-ray closed, like ATLAS and most detectors are not hermetic)

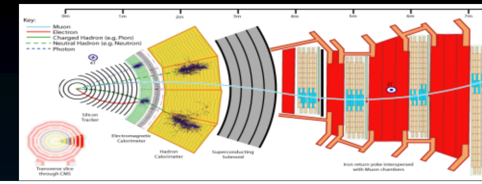




~400t Solenoids + ~200t Structures = ~600t only!
And a nice ~3T muon tracking volume for free

~ 14000t iron
~ 20 times heavier !
Heavy and expensive

Solenoid Options



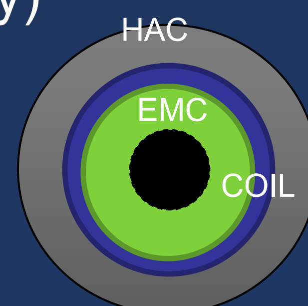
Large Coil

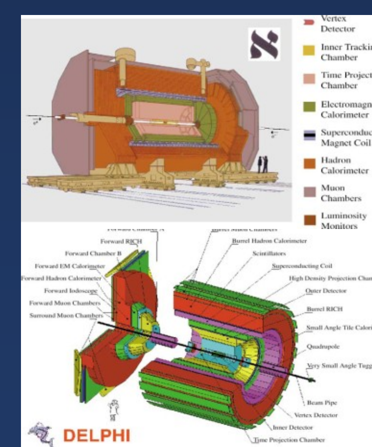
- Large Solenoid containing the Calorimeter
- 3.5 T Solenoid of similar to CMS/ILC
- Precise Muon measurement
- Large return flux either enclosed with Iron or Option of active B shielding with 2nd solenoid

General parameters	
Magnetic length	12.5 m
Free bore diameter	6.3 m
Central magnetic induction	4 T
Total Ampere-turns	41.7 MA-t
Nominal current	19.14 kA
Inductance	14.2 H
Stored energy	2.6 GJ
Cold mass	
Layout	Five modur coupled
Radial thickness of cold mass	312 mm
Radiation thickness of cold mass	3.9 X_0
Weight of cold mass	220 t
Maximum induction on conductor	4.6 T
Temperature margin wrt operating temperature	1.8 K
Stored energy/unit cold mass	11.6 kJ/kg
Iron yoke	
Outer diameter of the iron flats	14 m
Length of barrel	13 m
Thickness of the iron layers in barrel	300, 630 a
Mass of iron in barrel	6000 t
Thickness of iron disks in endcaps	250, 600 a
Mass of iron in each endcap	2000 t
Total mass of iron in return yoke	10 000 t

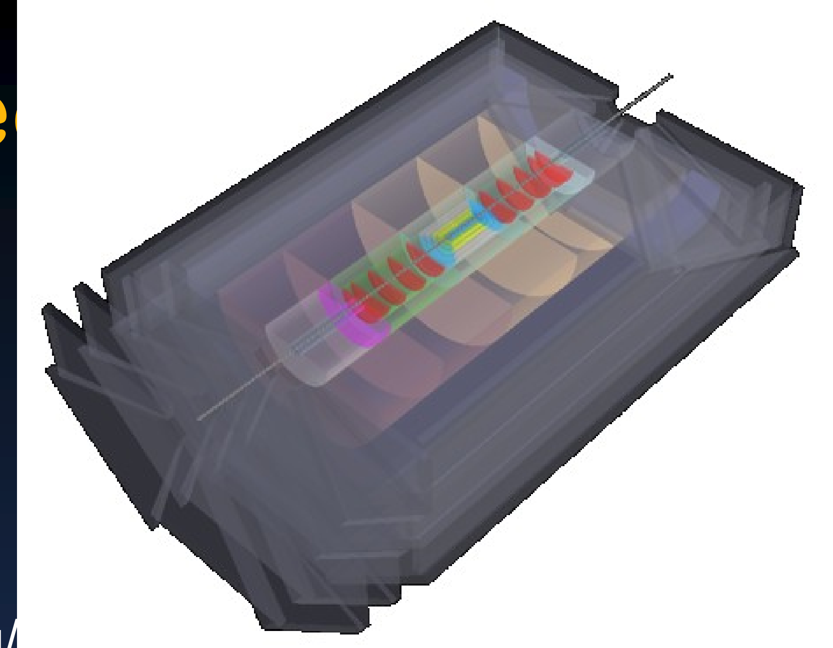
Small Coil

- Smaller Solenoid placed between EMC and HAC
- Cheaper option
- Convenient displacement of Solenoid and Dipoles in same cold vacuum vessel (Linac-Ring Only)
- Smaller return flux (less iron required)
- Muon p, p_t measurement compromised





Muon Dete



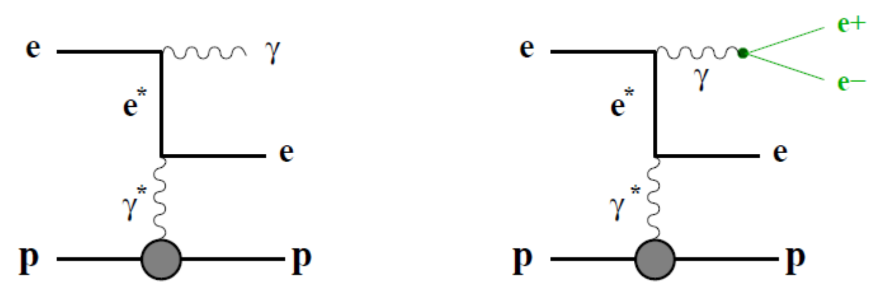
- Physics:
  - Heavy flavour
  - Vector Mesons
  - Diffraction etc.
- HERA Experience:
  - Beam background understanding/shielding essential (fwd)
  - Running in conjuction with tracking (forward) and CAL has shown to be very important both for trigger and RO
- LHeC Different Energy Range. Large acceptance could extend the LHeC physics potential
- Detector technologies
  - Detector technologies available (LHC) and very active R&D developments ongoing (sLHC)
- Magnet design essential for an independent momentum measurements

3rd CERN-ECFA-NuPECC Workshop on the LHeC

12-13 November 2010 *Chavannes-de-Bogis, Switzerland*

Luminosity Measurement and *e*-tagging at the LHeC

S. Levonian, DESY



- Brief preview
- Mission
- Challenges
- Possible options
- Conclusions

Dedicated (tunnel) detectors ($\theta_{\gamma,e} < 0.5$mrad)

B-H process: $\sigma(E > 8) = 102$mb
(poles in both e^* and γ^* propagators)

B-H with "internal conversion"
$\sigma \simeq 1/200\sigma_{BH}$

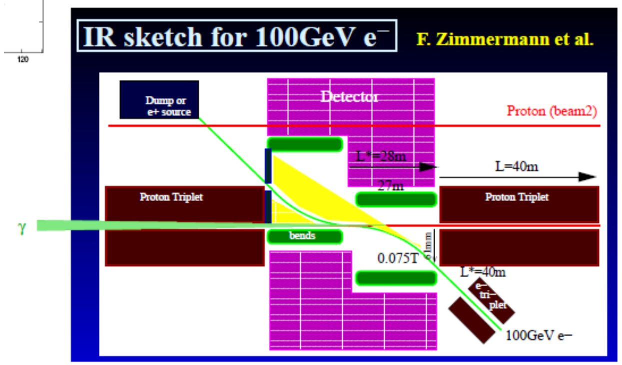
Main detector

QED Compton: $\sigma_{el}(\theta < 179^o) = 5$nb
(poles in γ^* propagator, but large e^* mass)

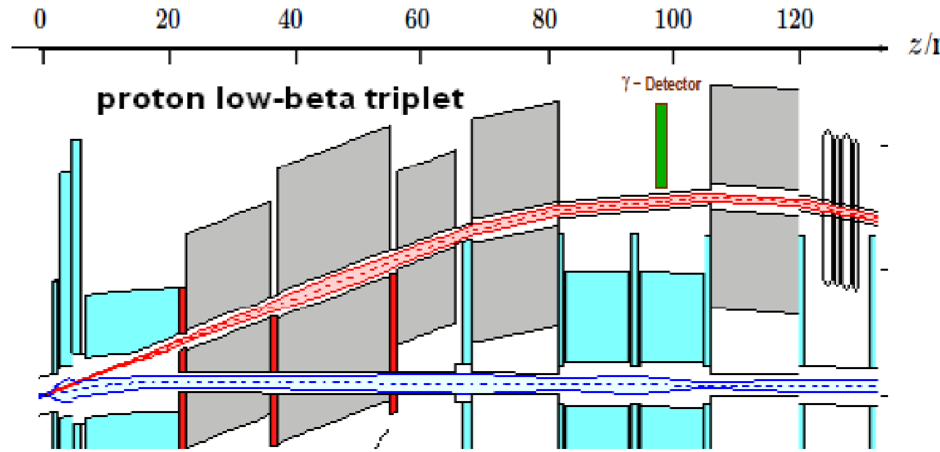
F2 (NC DIS): $\sigma(Q^2 > 10) = 300$nb
$\sigma(Q^2 > 100) = 25$nb

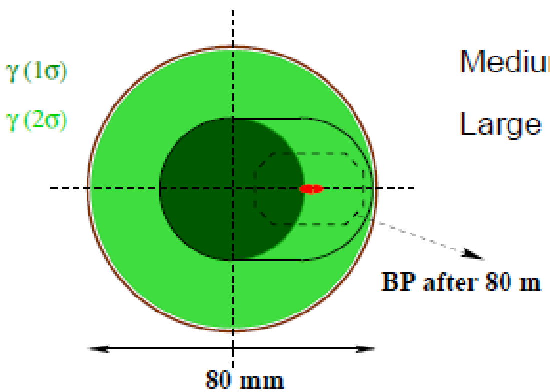
γTagger — LR option

- Head-on collisions.
  Similar to HERA, γ's travel along the p-beam
- Lumi monitor located after proton dipole at $z = 100$m
  ⇒ Challenge: large aperture required for proton magnets at $z = 60 - 80$m



LR scheme



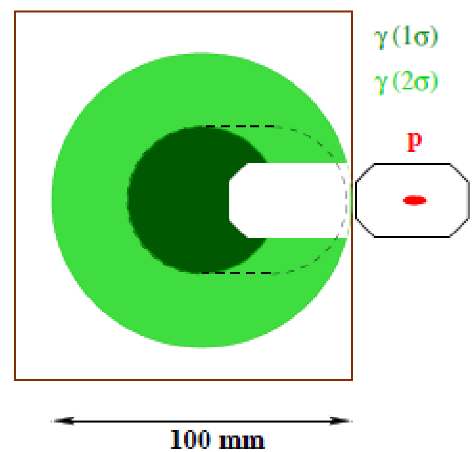


Beampipe at z=80m

Medium BP – $A_\gamma = 35 - 45\%$

Large BP – $A_\gamma = 70 - 80\%$

$\delta L = 2.5 - 6.0\%$

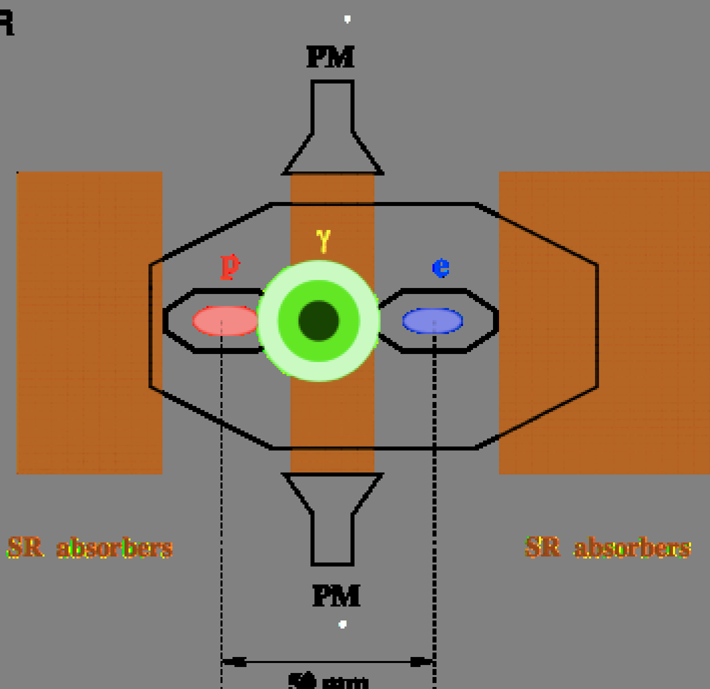


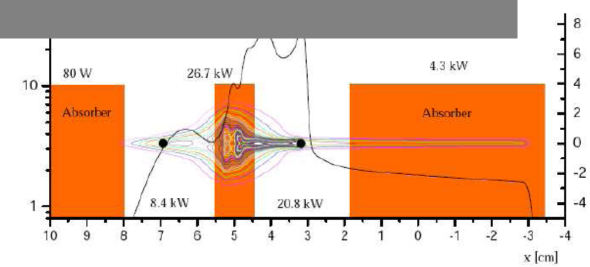
Photon Detector at z=100m

BH-photon detector integrated into SR absorber

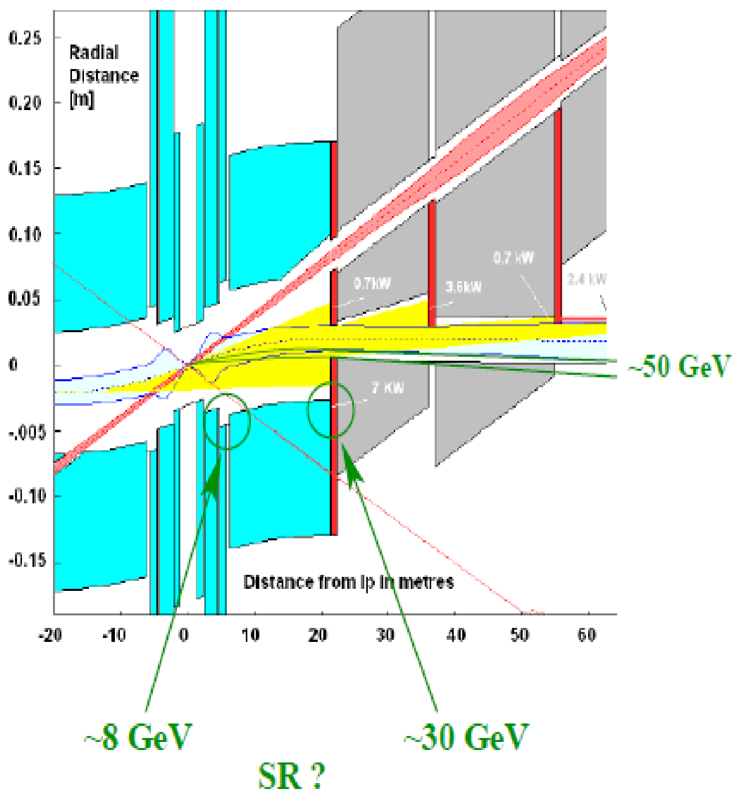
- Cooling system with 10 – 20 cm long water bath acting as Čerenkov radiator for BH γ's
- Radiation hard, (almost) insensitive to SR
  (but: high E_{crit} ⇒ effect of the tail?)
- For latest optics (1 mrad crossing angle)
  acceptance is up to 90%
- Exact BH counter design and R/O
  still to be worked out
- Accurate acceptance control
  requires precise beam tilt
  monitoring (10-15% of the x-angle)

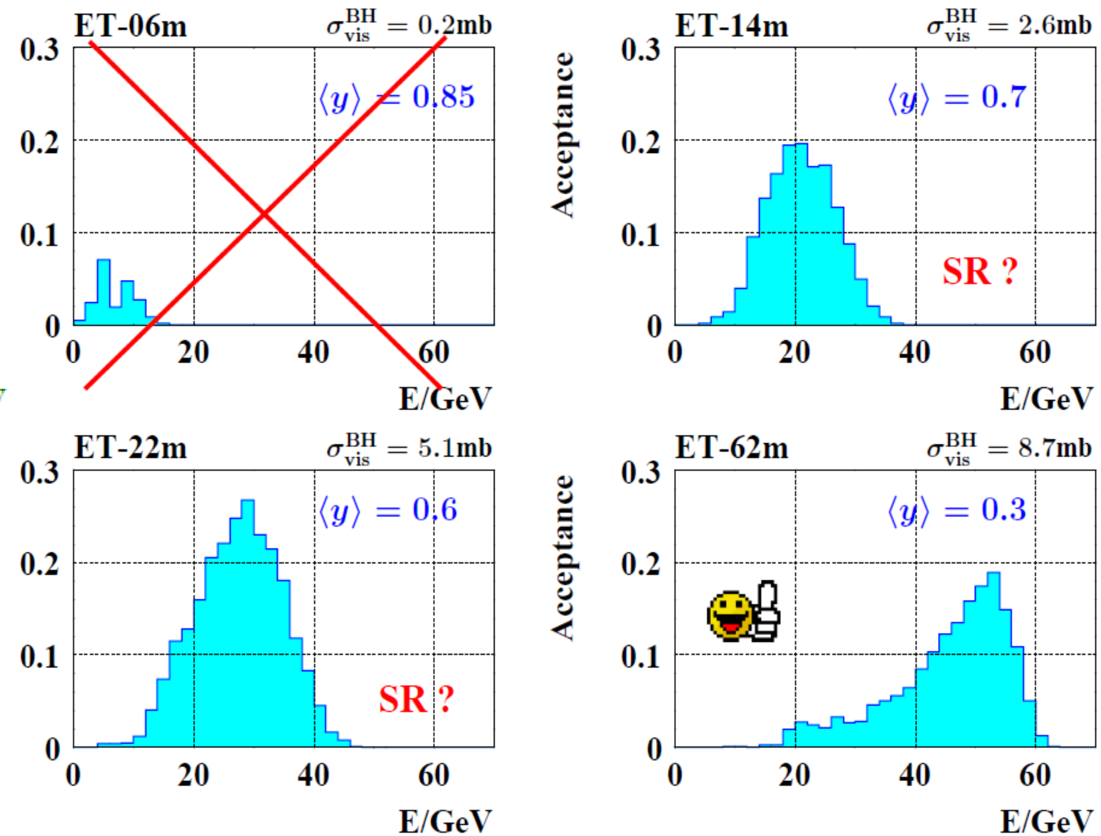
$\delta L = 3\%$ within reach





Options for Electron Taggers





Summary

- Luminosity measurement at the LHeC is a non-trivial task.
  HERA experience: surprises are possible $\Rightarrow$ prepare several scenarios

- Precise integrated $\mathcal{L}$ for physics is possible with main Detector (QEDC, F2)
  $\delta\mathcal{L} = 2\%$ is within reach

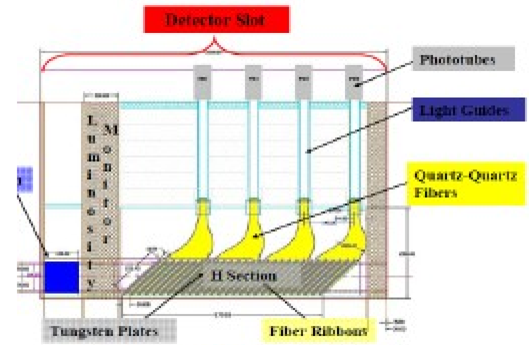
- Fast instantaneous L monitoring is challenging, but few options do exist
  - ▷ Photon Detector for LR option requires large p-beampipe at $z = 80$m
  - ▷ In case of RR option B-H photons can be detected using water Čerenkov counter integrated with SR absorber at 22m
  - ▷ Electron tagger at 62 m is very promising for both LR and RR schemes

- Good control of the e-beam optics at the IP is essential to monitor acceptances of the tunnel detectors at $3-5\%$ level

Tagging very forward neutral particles at the LHeC

(Zero Degree Calorimeter)

Armen Bunyatyan



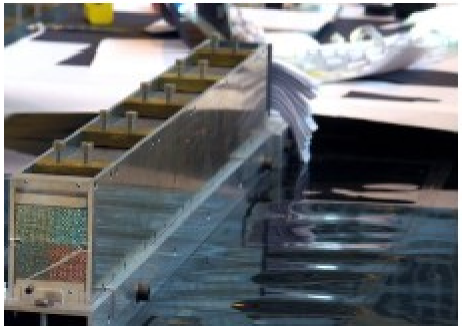
CMS

Zero Degree Calorimeter – important part of the future ep(ed,eA) detector.

For LHeC energies, we may have quite reasonable energy acceptance for forward neutrons with the calorimeter at ~100m and transverse acceptance of up to 3cm

Requirement to the calorimeter: measure energy and position of neutrons and photons with a reasonable resolution, identify γ (π^0),n; reconstruct >1 particles ; radiation hard

Alice

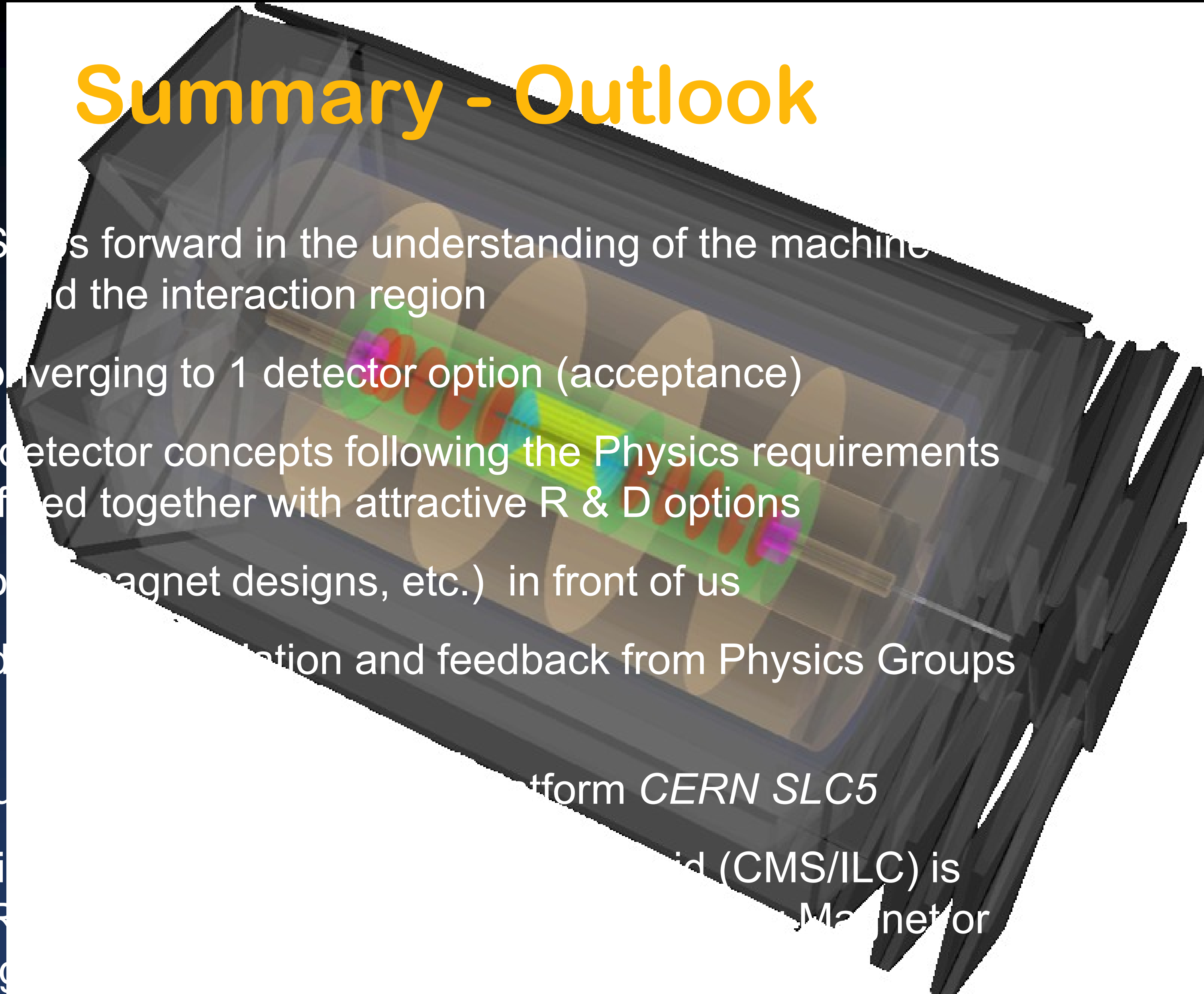


Detector design – challenging task !
Based on the experience from FNC/ZDC calorimeters at the LHC, HERA and RHIC, explore novel methods

Next steps: clarify the geometrical constraints;
Investigate the possible design options.

0.75 mrad aperture cut at HERA corresponds to 0.1 mrad at LHeC !
With ~ ±3cm we can get quite reasonable acceptance, >90% for x_L>0.3, $|t|$<3 GeV^2

Summary - Outlook



- Important S s forward in the understanding of the machin
  constraints d the interaction region
- Possibly co verging to 1 detector option (acceptance)
- A baseline etector concepts following the Physics requirements is being def ed together with attractive R & D options
- Key decisio agnet designs, etc.) in front of us
- Extensive d tion and feedback from Physics Groups needed
- New compu tform *CERN SLC5*
- Detector-wi d (CMS/ILC) is preferred. R net or L-R bendin
- Converge to CDR