Some ideas about the H1 $\mathcal{L}$ system for after the Y2K

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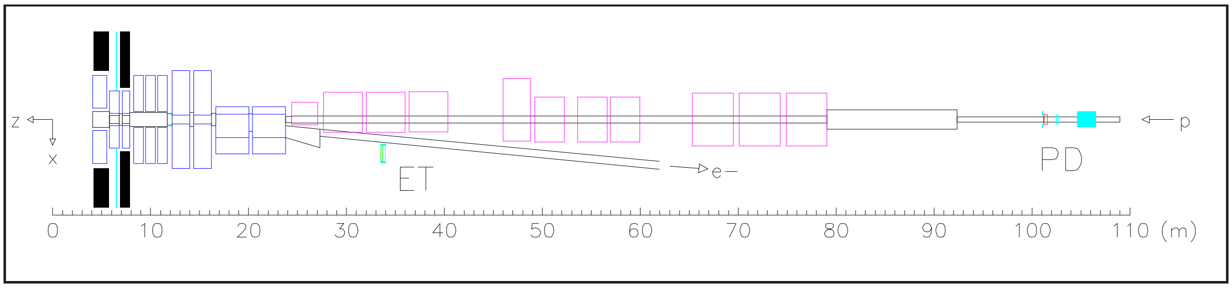
Paris VI, Orsay.

- The H1 $\mathcal{L}$ system & measurement
- Conditions in Y2K
- Proposition for a Detector...
- ...and its associated Electronics

The H1 $\mathcal{L}$ system & measurement

The H1 $\mathcal{L}$ system:

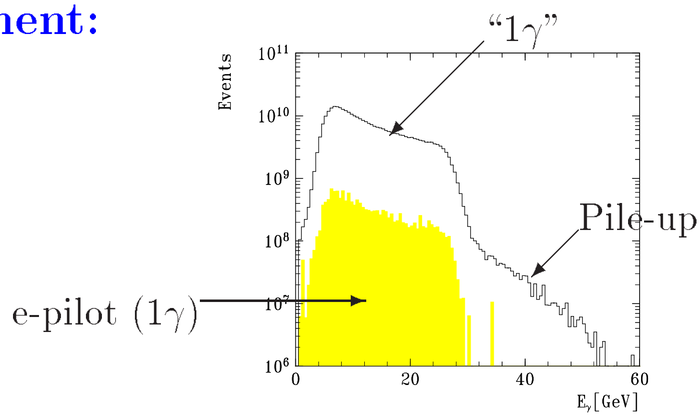


$\Rightarrow$ 1 PD (γ Detector), several ET (Electron taggers): 7,8, **33**, and 44 m.

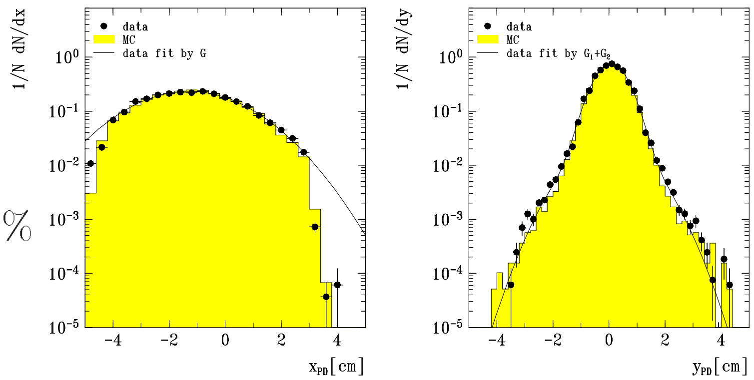
Principle of the $\mathcal{L}$ measurement:

elastic Bremsstrahlung

$$\mathbf{ep \rightarrow ep\gamma}$$



- Corrections:
  - in bunch pile-up
  - Satellite bunches
  - PD acceptance: $(95 \pm 0.6)\,\%$ due to magnet shadows



- Main Errors:
  - Energy Scale (0.8 %) $\Rightarrow$ $\boxed{\textbf{Absolute Energy Scale}}$
  - Acceptance ($\sim 0.5\,\%$) $\Rightarrow$ $\boxed{(\boldsymbol{x}, \boldsymbol{y})\ \textbf{impact determination}}$

Other use of the H1 $\mathcal{L}$ system:

- Radiative Corrections
- Photo-production (ET)
- ISR based analysis ($\mathcal{F}_L$)

Conditions in Y2K

- $\mathcal{L}\times 5$ (lastest values): peak luminosity

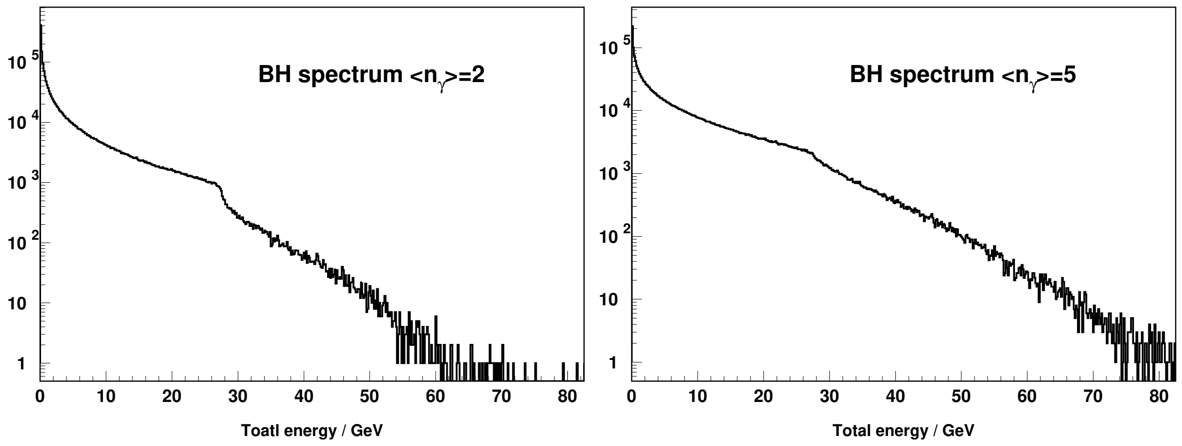
$$\mathcal{L} = 1.5 \cdot 10^{31}\,\mathrm{cm}^2\,\mathrm{s}^{-1} \rightarrow 7.4 \cdot 10^{31}\,\mathrm{cm}^2\,\mathrm{s}^{-1}$$

- γ **beam conditions**: $\sim$ same beam size in x, doubled in y

$$\Rightarrow \sigma_x = 1.9\,\mathrm{cm},\ \sigma_y = 1.3\,\mathrm{cm} \text{ at } 100\,\mathrm{m} \text{ from the IP.}$$

(size mainly due to beam divergence)

- **Rates $\times$5:** $\Rightarrow$ 1 γ with $E_\gamma > 5\,\mathrm{GeV}$ / 2 bunches
  $\Rightarrow \sim 5$ γ with $E_\gamma > 10\,\mathrm{MeV}$ per bunch



$\Rightarrow$ **No bunch to bunch pile-up allowed!**

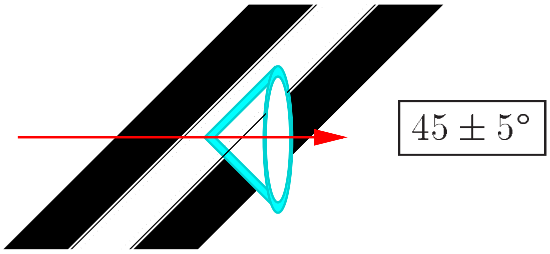
- **Hostile environment:** 2 sources of radiation
  - Synchrotron Radiation (SR): 3.3 kW or $2{\cdot}10^{17}$ γ per second, with a harder spectrum ($E_c = 145\,\mathrm{keV}$) $\Rightarrow \gtrsim 4\,\mathrm{X}_0$ of shielding
  - Bethe-Heitler photons: $\sim 60\,\mathrm{Mrad/y}$ in the central part of the calorimeter ($\sigma_x{\times}\sigma_y{\times}10\,\mathrm{X}_0$) (Max value)

- **Polarisation:**
  unknown polarisation effects $\Rightarrow$ per bunch $\mathcal{P}$ measurements.
  $\mathcal{L}$ and $\mathcal{P}$ have to match $\Rightarrow$ **per bunch "instantaneous" (online) $\mathcal{L}$**

Proposition for a Detector...

Active shielding:

- **Purpose:** Resolution improvement, no VETO on ISR events.
- **Set-Up:** $\Longrightarrow$Set-up
- **Idea:** use a quartz fibre SpaCal as active shielding
- **Principle:** Čerenkov effect

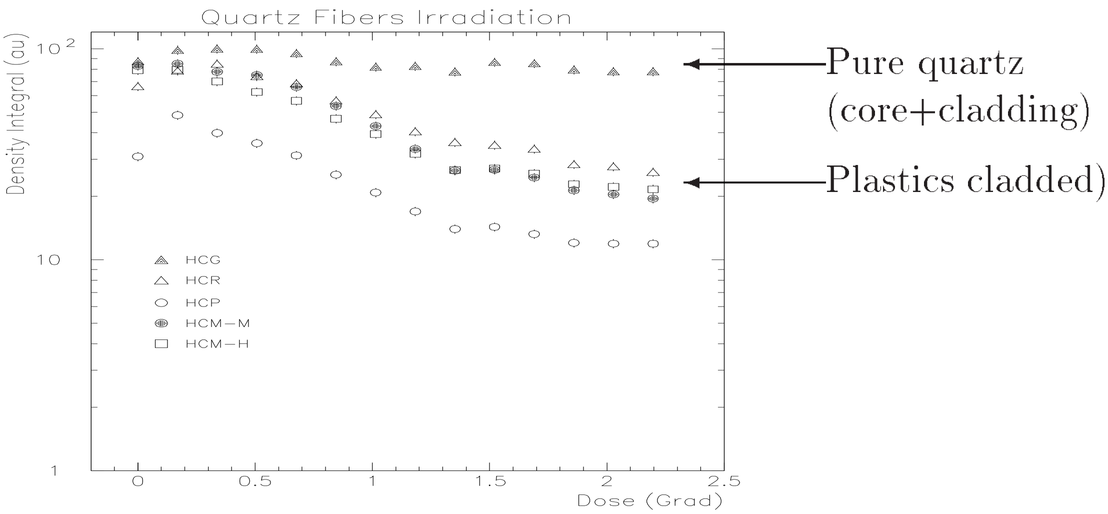


The light yield depends on the numerical aperture of the fibres.

Advantages:

$\Rightarrow$ Insensitive to γ with $E_\gamma < E_c \simeq 2m_e * \gamma_c \sim$ few MeV. (SR)

$\Rightarrow$ Č-fibres: quartz core fibres with plastic or quartz cladding.
Radiation hardness:

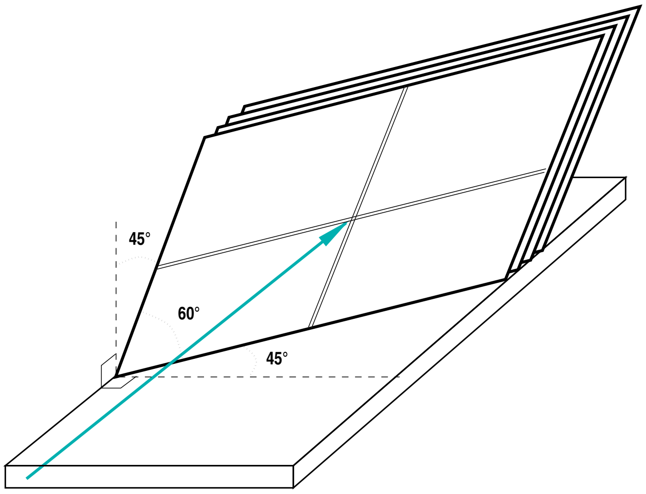


(2 MeV electrons $\simeq$ SR)

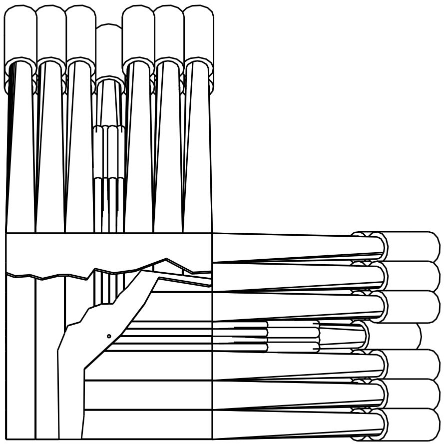
$\Rightarrow$ Number of Photons per mm of fibre: ~ 1

$\Rightarrow$ Sensitiveness only in one direction: no signal from p induced background...

- **Optimisation:**
  - first X_0 of dead absorber: best ratio λ/X_0 to be chosen (C vs. W)
    Additional parameter: heat evacuation from the SR: 3.3kW in $10{\times}2\,\mathrm{cm}^2$.
  - Main absorber: thermal conduction, ratio λ/X_0: W or Pb
  - Internal arrangement of the shielding: (x,y) resolution.



$12{\times}12\,\mathrm{cm}^2$
$2n$ channels



front view

Granularity determined by: precision on the acceptance, the overlap probability (for $\mathcal{L}$ and physics).

  - Optical Calibration (O.C.)
    Easy to implement (no extra radiation hard optical device needed)

$\Longrightarrow$perspective view.

Calorimeter:

Characteristics:

SpaCal

- Material: Lead or Tungsten (smaller R_M [1.2 cm for 2:1 SpaCal] for a better showers separation)
- Tower Size: $\sim 2\times2\,\mathrm{cm}^2\times24-26\,X_0$ for full containment.
- geometry:
  - option 1: standard horizontal tower $\Longrightarrow$ geometry
  - option 2: same geometry as the active shielding
  easiest way to feed the O.C. (favored option)

For the fibres, two options are considered:

- **Scintillating fibres**
  $\Rightarrow \sigma_E/E = 7\,\%/\sqrt{E} + 1\,\%$
  Best if scintillating fibres are resistant enough. (yearly replacement?)
- **Č-Fibres:**
  Continuation of the active shielding
  Achieved resolutions: $\sigma_E/E = 24\,\%/\sqrt{E}$ for an 1 : 4 Fibre:Pb ratio
  (improvement with higher sampling ratio $\rightarrow$ simulation needed).

  - Enough for $\mathcal{L}$ measurement
  - Narrower lateral shower profile $\Rightarrow$ better shower containment
    $\Rightarrow$ better shower separation

... and its associated Electronics

Requirements:

- An analog processing fitting the rate conditions

  $\Rightarrow$ return $< 1\,\%$ to the baseline within 1 BC.
  No bunch to bunch pile-up at first order.

  $\Rightarrow$ Task for electronics experts

- Minimum bias trigger (on bunch number)

  $\Rightarrow$ Shape of the measured energy spectrum depends only on the lowest energy response of the calorimeter. (No trigger threshold effect)

  $\Rightarrow$ No DAQ phase effect (like more triggering on first filled bunches)

- Optical calibration for **gain monitoring of the full chain** (PM+electronics)

  $\Rightarrow$ **essential!!!!**

- Very fast DAQ ($\sim$100 kHz)

  $\Rightarrow$ bunch to bunch independant luminosity measurement
  $1\,\%$ stat. error per bunch each $20\,$s

  $\Rightarrow$ complete **online** control of the beam

  $\Rightarrow$ connection with the polarisation

Almost the same requirements apply to the $\mathcal{P}$
$\Rightarrow$ same basic scheme for $\mathcal{L}$ & $\mathcal{P}$
(common work of Ecole, P6 and Orsay labs and electronics engineers)

$\Longrightarrow$Diagram

Characteristics:

- Light Readout: achieved by HPD and/or reduced gain PM.
- Fast Shaping: return to the baseline in 96 ns$\Rightarrow$ no pile-up
  CFD function $\Rightarrow$ timing adjustment of the electronics chain.
- Semi-flash ADC (32 ns) $>$ 12 bits interfaced with both the H1 CDAQ (through a pipeline) and the fast Local DAQ.
- Monitoring of timing stability by TDC
- independent interface with H1 CDAQ
- very fast local DAQ ($\sim$ 100 kHz) with bunch based histograming.

Optimisation:

- Shortening of path analogical signals through the cable
  - Displacement of the electronics on the West wall.
  OR
  - Digitisation in the tunnel
- Integration with the existing chain.

Calibration

- Done on BH spectrum from the e-pilot bunches (very small pile-up)
- movable table $\Rightarrow$ fast cell wise inter-calibration.
- Continuous
- O.C. $\Rightarrow$ not needed too often.

Conclusion

- Radiation hardness of the calorimeter is essential.
  $\Rightarrow$ limit on the choice of the technique.
  - Quartz fibre SpaCal is good candidate
  - Energy resolution is certainly not as good as with scintillating fibre *but* present energy resolution ($\sim 25\,\%\sqrt{E}$) does prevent the $\mathcal{L}$ measurement

    The other constraints (e.g. from ISR events, radiative corrections) are connected with ET, shower separation in PD and global $E - P_z$.
- Active Shielding is a good solution wrt the energy resolution.
  $\Rightarrow$ complete calibration procedures have to be investigated.
- Electronics: - No pile up effect from bunch to bunch
  - $>$ 12 bits dynamics
  - High rate DAQ $\Rightarrow$ per bunch $\mathcal{L}$.
- Optical Calibration essential for the control of the systematics (radiation damage/recovery, PM gain, etc.)
  It has to be taken into account in the design of the elements.