The ATLAS Luminosity System
Per Grafstrom
CERN

On behalf of the ATLAS Luminosity &Forward Detector WG

To encourage and stimulate transfer of knowledge between the HERA and LHC communities and establish an ongoing interaction.

Luminosity Measurement – WHY ?

- Cross sections for "Standard " processes
  - t-tbar production
  - W/Z production
  - …….

Theoretically known to better than 10% ……will improve in the future

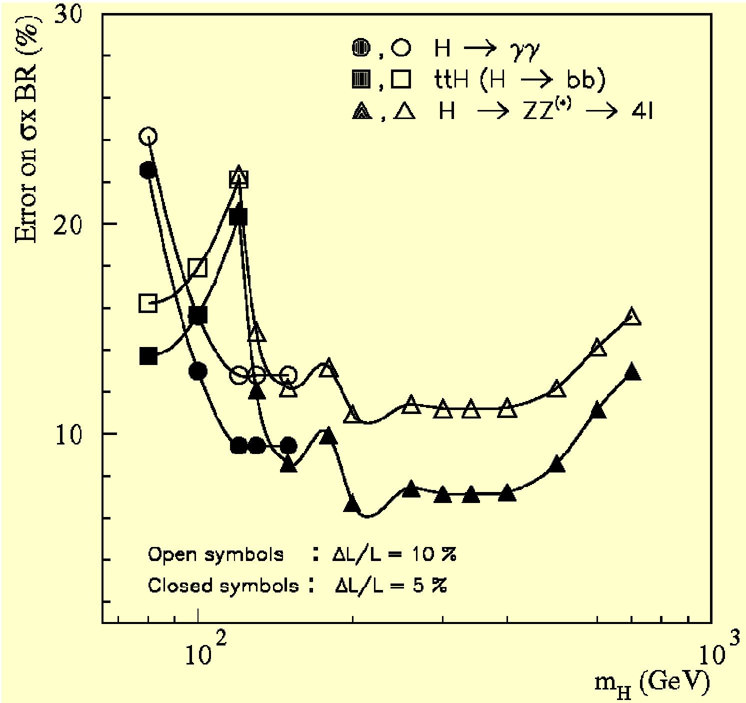
- New physics manifesting in deviation of σ x BR relative the Standard Model predictions

- Important precision measurements
  - Higgs production σ x BR
  - tanβ measurement for MSSM Higgs
  - …….

Luminosity Measurement – WHY ? (cont.)

Examples

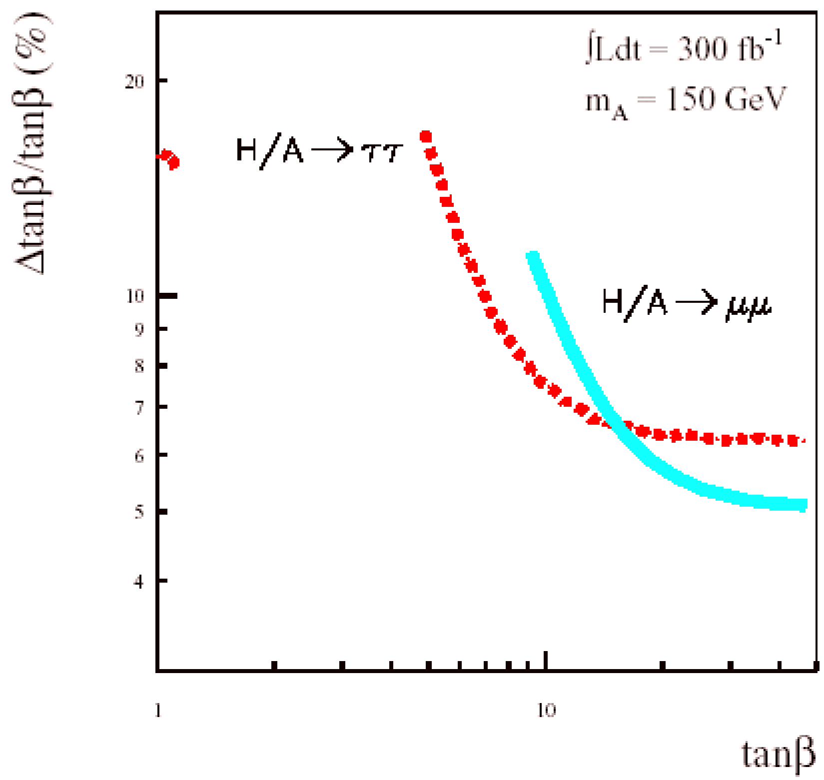
Higgs coupling



Relative precision on the measurement of $\sigma_H \times$BR for various channels, as function of m_H, at $\int Ldt = 300$ fb^{-1}. The dominant uncertainty is from Luminosity: 10% (open symbols), 5% (solid symbols).

(ATLAS-TDR-15, May 1999)

tanβ measurement



Systematic error dominated by luminosity (ATLAS Physics TDR)

Luminosity Measurement Options

- **Relative luminosity** a DEDICATED luminosity monitor is needed
  LUCID
- **Absolute luminosity**
  - Goal:
    - measure L with $\lesssim$ 2-3% accuracy
  - How:
    - LHC Machine parameters
    - Use ZDC in heavy ion runs to understand machine parameters
    - rates of well-calculable processes:
      e.g. QED, QCD
    - optical theorem: forward elastic rate + total inelastic rate: **Use Roman Pots**
      - needs ~full |η| coverage-ATLAS coverage limited
      - Use σ_{tot} measured by others (TOTEM)
      - Combine machine luminosity with optical theorem
    - luminosity from Coulomb Scattering **Use Roman Pots**

ATLAS pursuing all options

L from LHC Machine Parameters

- Luminosity depends exclusively on beam parameters:

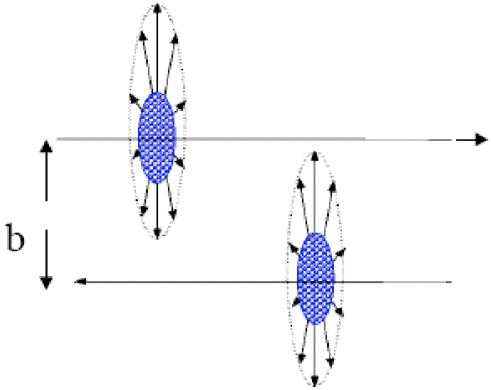
$$\mathcal{L} = \frac{f \sum_{i=1,..,2808} N_{1i} N_{2i}}{\text{Area of intersection } 1,2} \le \frac{f \sum_{i=1,..,2808} N_{1i} N_{2i}}{4\pi \sigma_x \sigma_y} = \frac{f\, k_b N^2}{4\pi\, \varepsilon_N\, \beta^* / \gamma}$$

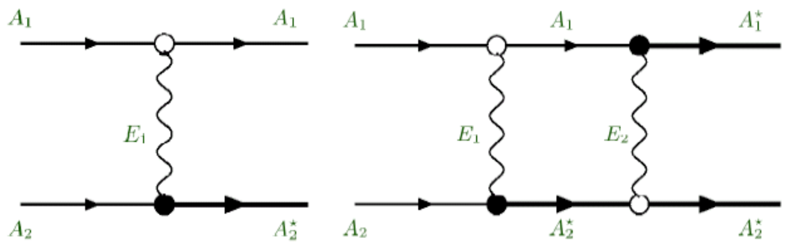
N_{ai} = #protons in bunch i of beam a; f = revolution frequency = $c/26659$ m, k_b = #bunches

$\beta^* = \beta$-function at IP; $\varepsilon_N = \sigma_x^* \sigma_y^* \gamma \big/ \beta^*$ normalized transverse emittance; $\gamma = E/m_p$ (~7460)

- Luminosity accuracy limited by:
  - extrapolation of σ_x, σ_y (or ε, β_x*, β_y*) from measurements of beam profiles elsewhere to IP; knowledge of optics, …
  - Precision in the measurement of the the bunch current
  - beam-beam effects at IP, effect of crossing angle at IP, …

Use ZDC in heavy ion runs to calibrate machine instrumentation (Sebastian White)





Weizsäcker-Williams (WW) method

Calculated cross sections for PbPb@LHC
A.J.Baltz, C.Chasman and SNW NIM A417(1998)p.1
(errors can be inferred from above RHIC discussion)

$\sigma_{1n,1n}$	0.537 barns
$\sigma_{1n,xn}$	1.897
$\sigma_{xn,xn}$	14.75
σ_{xn}	227.3

$$\mathcal{L} = B\frac{N_p N_{\overline{p}}}{4\pi\ \sigma_x \sigma_y} f$$

N_p = total current in a "bunch"
$\sigma_{x,y}$= transverse dimensions of the bunches

Above methodologies developed to check the instrumentation which measures these parameters.
This calibration is essentially independent of the beam species.

Luminosity from other Physics Signals

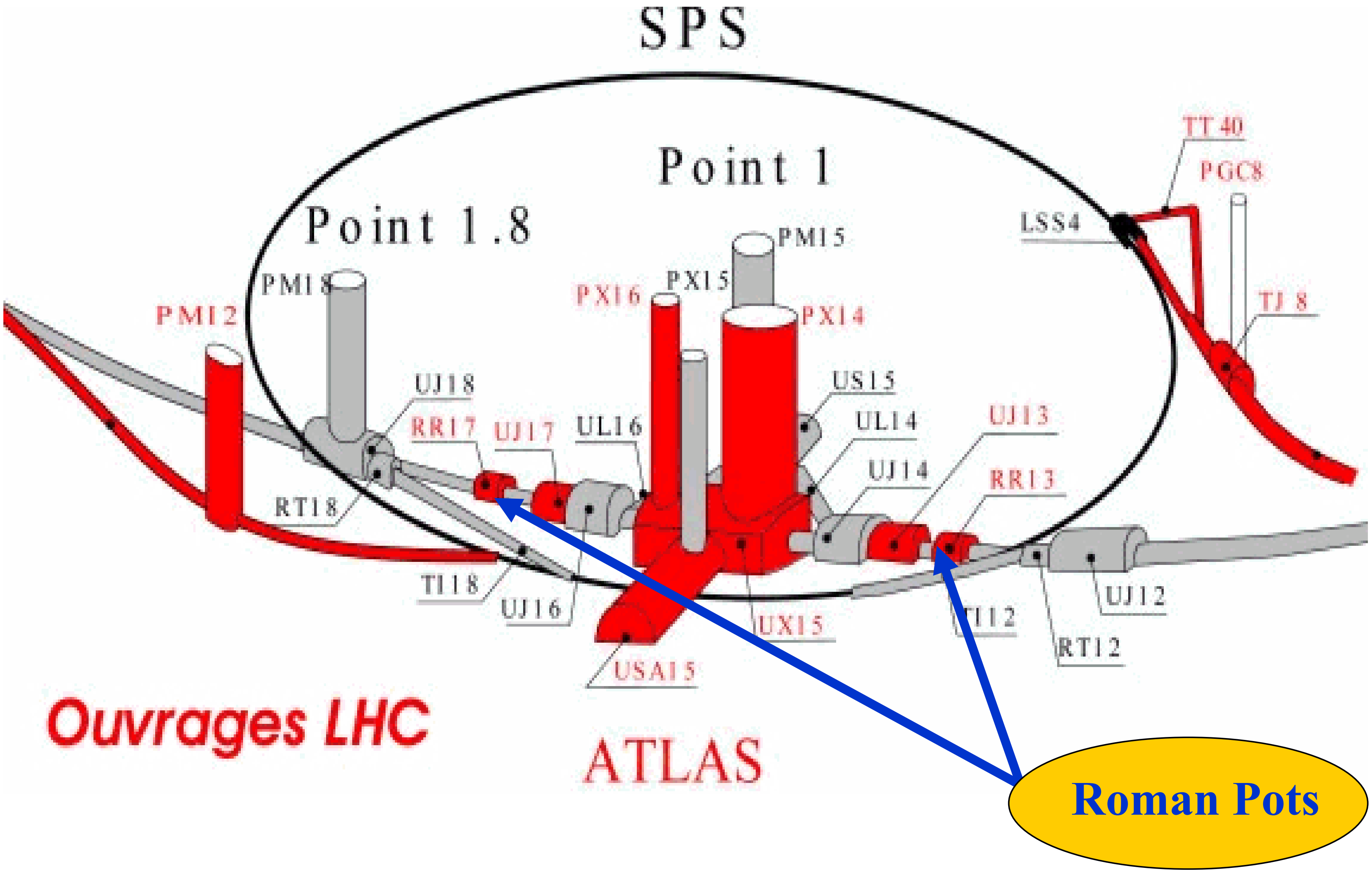
- **QED: pp $\rightarrow$ (p+γ*)+(p+γ*)$\rightarrow$p+($\mu^-\mu^+$)+p**
  - signal: ($\mu\mu$)-pair with $|\eta(\mu)|<2.5$, $p_T(\mu) \gtrsim$ 5-6 GeV, $p_T(\mu\mu) \simeq 0$
    - small rate ~1pb (~0.01 Hz at $L=10^{34}$)
    - clean: backgrounds from DY, b, c- decays can be handled by appropriate offline cuts
    - uncertainties: μ trigger acceptance & efficiency, …
      - (A.Shamov & V.Telnov, hep-ex/0207095)
- **QCD: W/Z $\rightarrow$ leptons**
  - high rate: $W\rightarrow\ell\nu$: ~60 Hz at $L=10^{34}$ (ε = 20%)
    - current "theory" systematics: PDF and parton cross sections $\approx$ 4%
    - gives relevant parton luminosity directly…
    - detection systematics:
      - trigger/acceptance/identification efficiency/ backgrounds
    - detailed study for ATLAS detector needed
- **Both processes will be used**

CERN/LHCC/2004-010
LHCC I-014
22 March 2004

ATLAS Forward Detectors for Luminosity Measurement and Monitoring

ATLAS Collaboration

Letter of Intent


SPS
Point 1
Point 1.8
TT 40
PGC8
LSS4
PM15
PX15
PX16
PX14
PM18
PM12
TJ 8
UJ18
US15
RR17
UJ17
UL16
UL14
UJ13
UJ14
RR13
RT18
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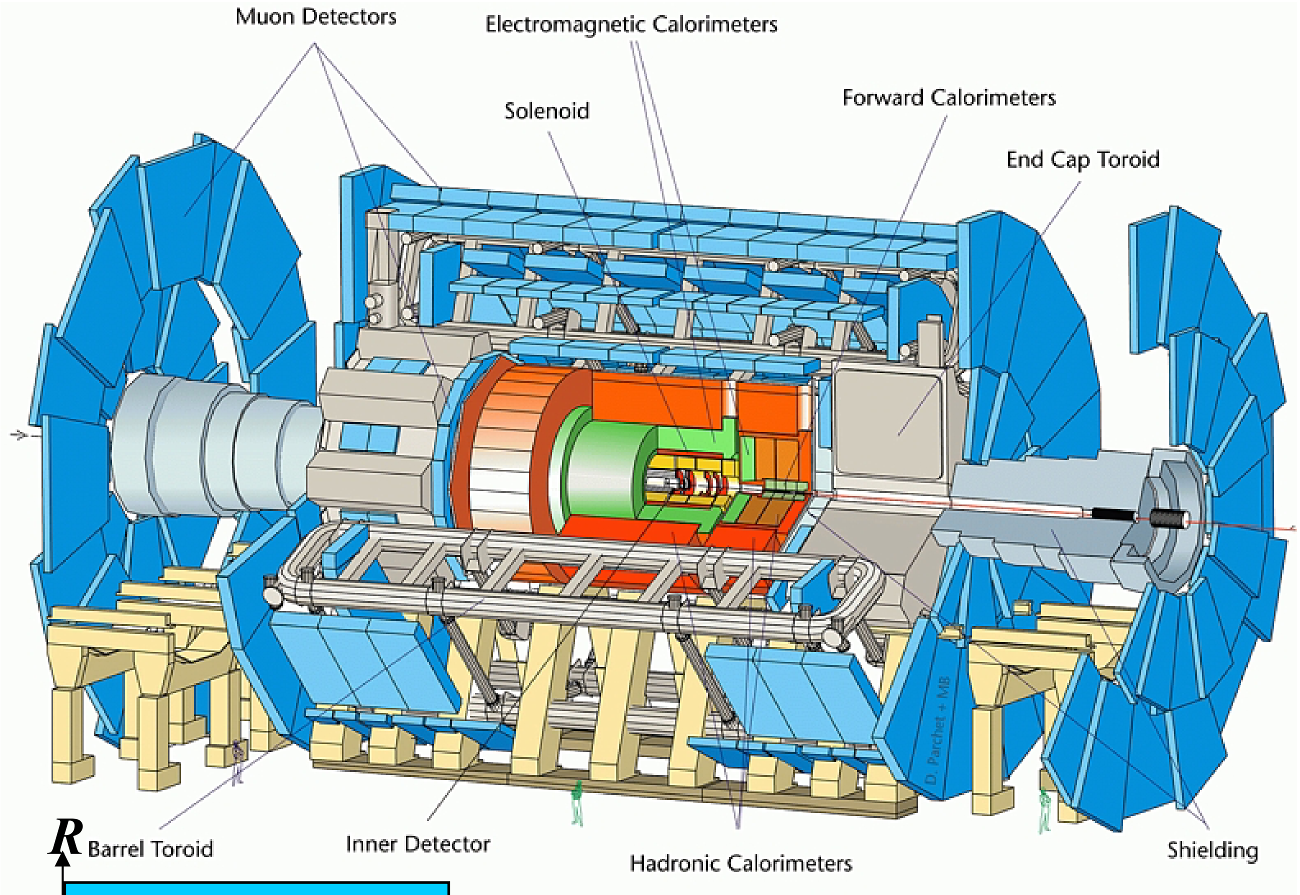
UX15
TI12
UJ12
RT12
USA15
Ouvrages LHC
ATLAS
Roman Pots

The ATLAS Detector



Calorimetry:

$$\frac{\sigma_E}{E}(e,\gamma) = \frac{10\%}{\sqrt{E/\mathrm{GeV}}} \oplus 0.3\%$$

$$\sigma_\theta = \frac{60\,\mathrm{mrad}}{\sqrt{E/\mathrm{GeV}}}$$

$$\sigma_t = \frac{4\,\mathrm{ns}}{E/\mathrm{GeV}}$$

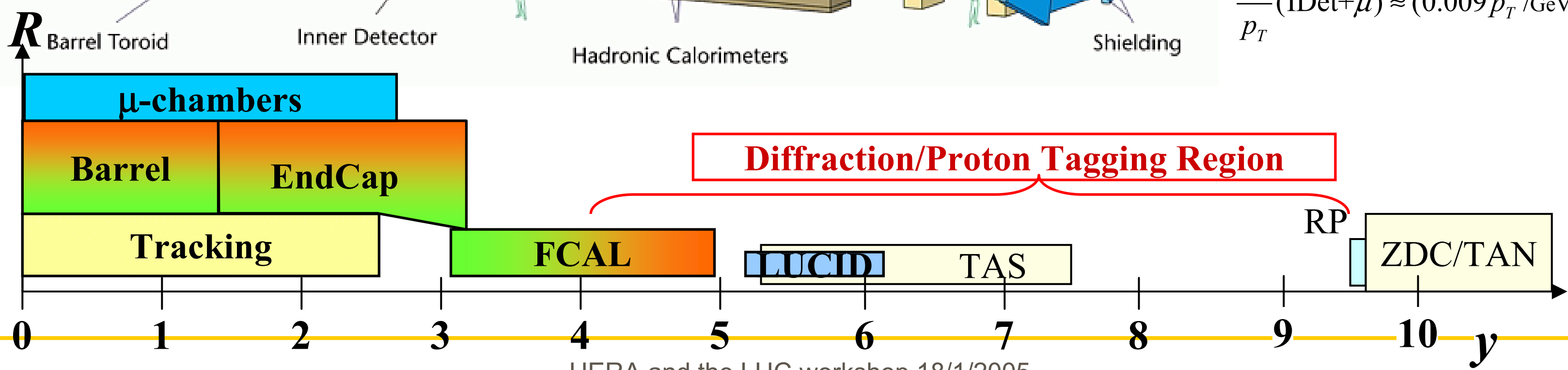
$$\frac{\sigma_E}{E}(\pi^\pm) = \frac{50\%}{\sqrt{E/\mathrm{GeV}}} \oplus 3\%$$

$$\frac{\sigma_E}{E}(\mathrm{jet}) = \frac{50\%}{\sqrt{E/\mathrm{GeV}}} \oplus 2\%$$

Tracking:

$$\frac{\sigma}{p_T}(\mathrm{Inner\ Det}) \approx (0.03\, p_T/\mathrm{GeV} + 1.2)\%$$

$$\frac{\sigma}{p_T}(\mathrm{IDet}+\mu) \approx (0.009\, p_T/\mathrm{GeV} + 1.4)\%$$



- Extension of ATLAS- A two stage process
  - **Short time scale**

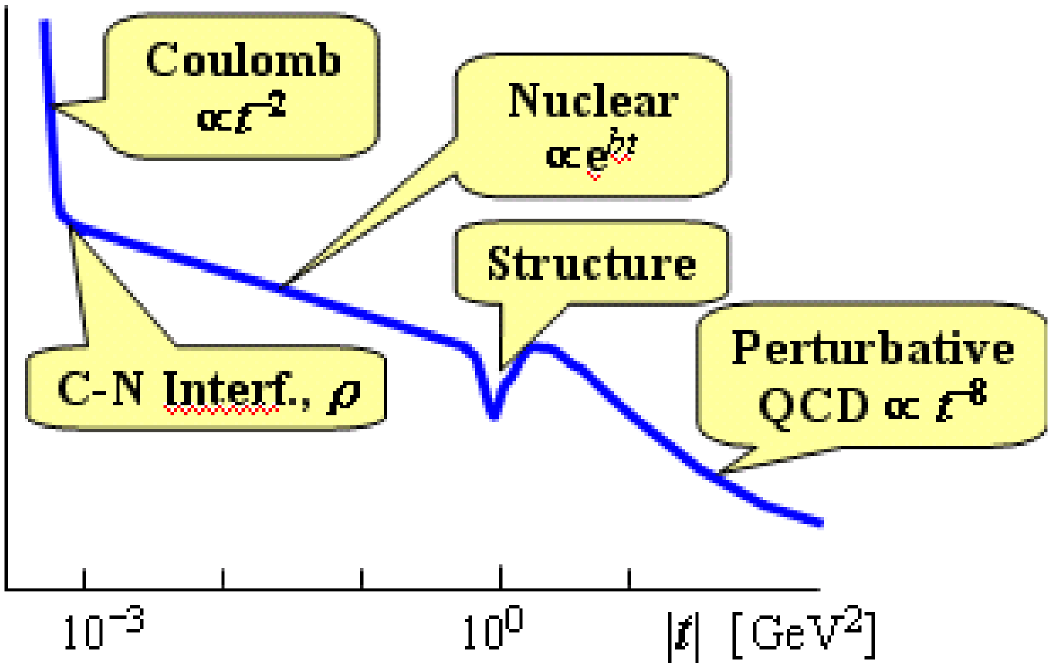
    Forward detector for Luminosity measurement

    Elastic scattering in the Coulomb region
  - **Longer time scale**

    Gain experience in working close to the beam

    $\Rightarrow$ propose a diffractive physics program using additional detectors

Elastic scattering in the Coulomb region

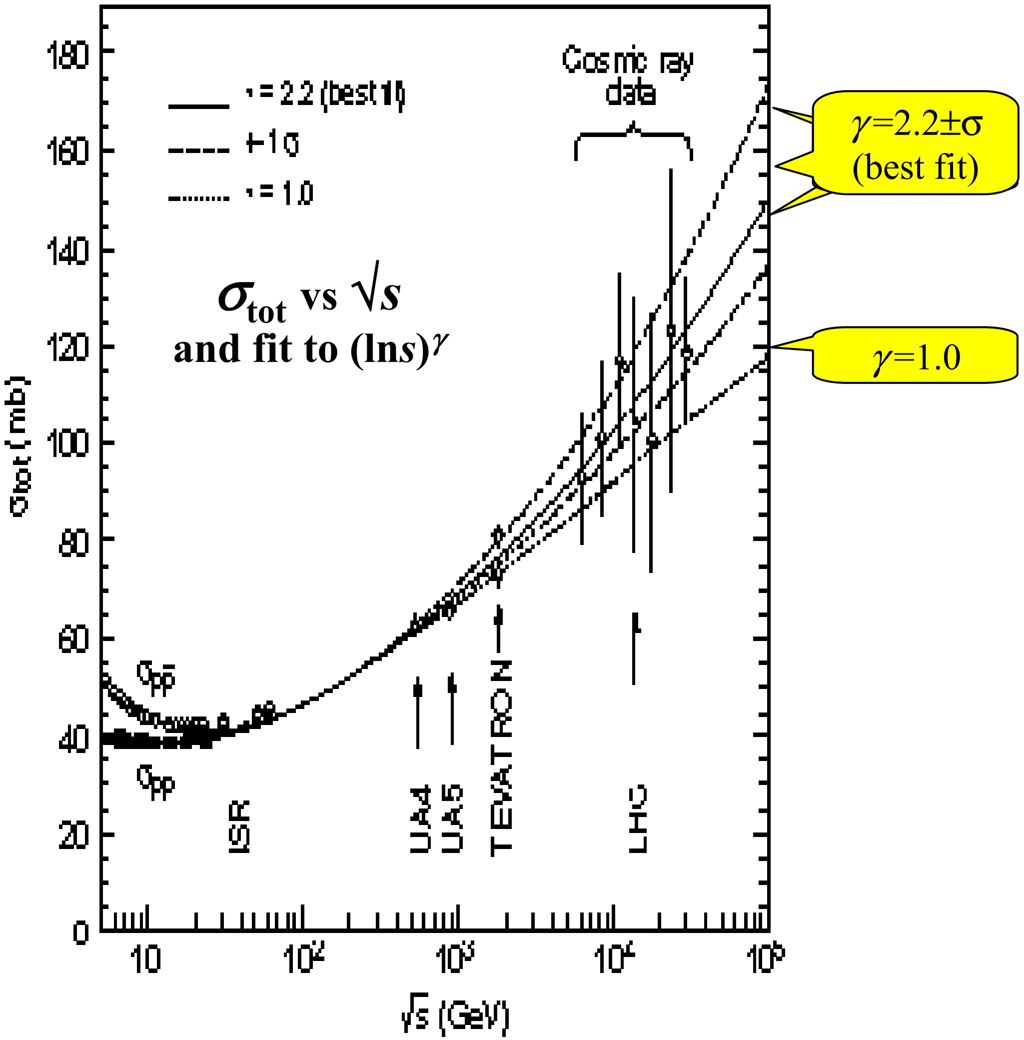


$$\left.\frac{dN}{dt}\right|_{t\approx 0} = L\pi\left|f_C + f_N\right|^2 \approx L\pi\left|-\frac{2a_{EM}}{|t|} + \frac{\sigma_{tot}}{4\pi}(i+\rho)\,e^{-b|t|/2}\right|^2$$

From the fit we will get

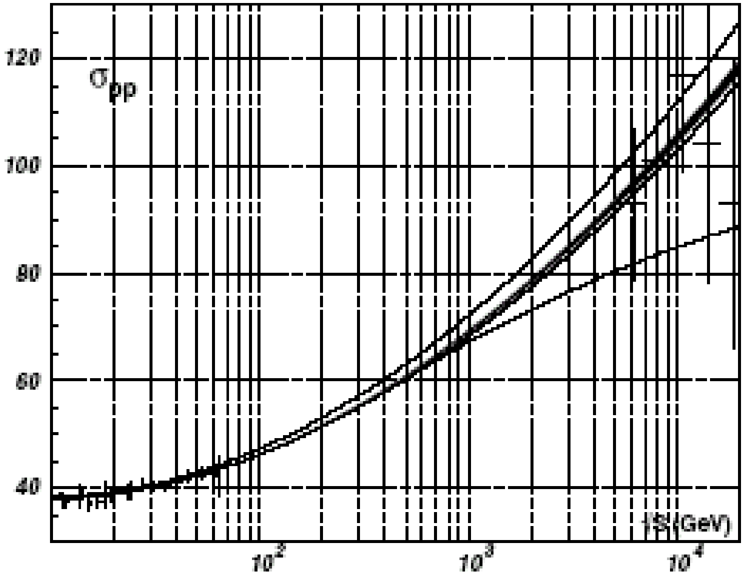
σ_{tot}, ρ, b and L

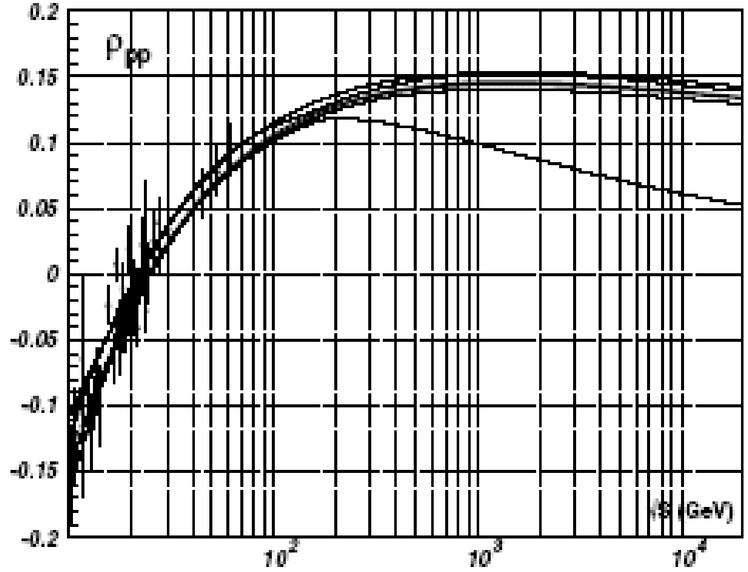
The total cross section



The ρ parameter

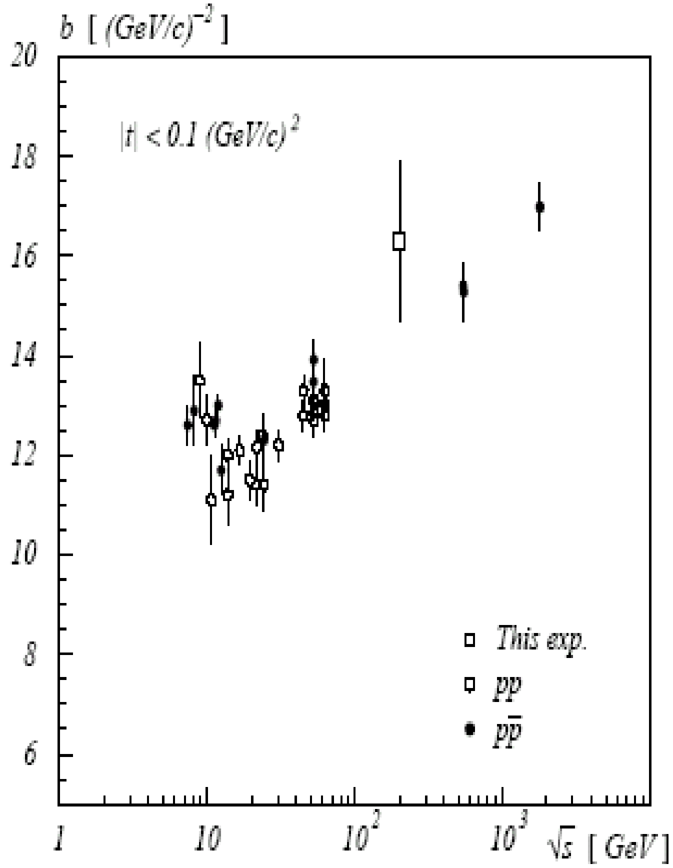
- ρ = Re F(0)/Im F(0) linked to the total cross section via dispersion relations
- ρ is sensitive to the total cross section beyond the energy at which ρ is measured ⇒ predictions of σ_{tot} beyond LHC energies is possible
- Inversely :Are dispersion relations still valid at LHC energies?





The b-parameter or the forward peak

- The b-parameter for |t |< .1 GeV^2
- "Old" language : shrinkage of the forward peak
  b(s) $\propto$ 2 α' log s ; α' the slope of the Pomeron trajectory ; $\alpha' \approx$ 0.25 GeV^2
- Not simple exponential - t-dependence of local slope
- Structure of small oscillations?



What else can we do?

Coulomb region extremely challenging. All aspects of design optimized for this.

- Medium (0.1-1.0 GeV**2) elastic scattering needs medium beta* optics, low Lumi, short runs)
- Large t (1-10 GeV**2) elastic scattering needs high Lumi, standard optics, and continuous runs.

  Studies needed

- Proton tagging to identify a diffractive interaction must be possible at some level . BUT t and ξ acceptance and t and ξ resolution need to be understood.

  Simulation and optics investigations needed to see if there is any physics reach for single and central diffraction using proton tagging.

  Signal and background rates have to be studied. Trigger set up?

  Many open questions

Requirements to reach the Coulomb region

- Required reach in t:

$$t_{\min} \leq -t(|f_C| = |f_N|) \approx \frac{8\pi a_{EM}}{\sigma_{TOT}} \approx 6\times10^{-4}\ GeV^2 \rightarrow \vartheta_{\min} \leq 3.5\mu rad$$

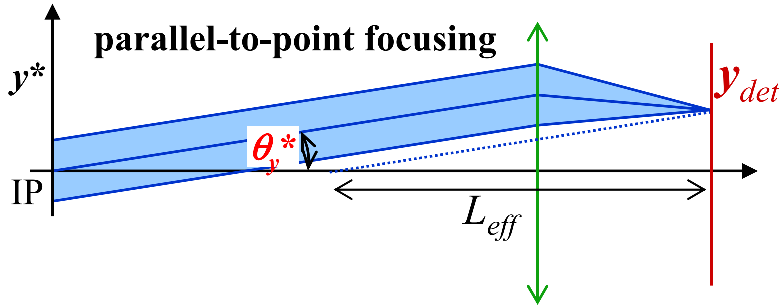
- Requires:
  - small intrinsic beam angular spread at IP
  - insensitive to transverse vertex smearing
  - large effective lever arm L_{eff}
  - detectors close to the beam, at large distance from IP

(first three items:) **Parallel–to–point focusing**

Experimental Technique

- Independence of vertex position:

$$y_{\det} = \sqrt{\beta\beta^*}\,\vartheta_y^* = L_{eff,y}\,\vartheta_y^*$$



- Limit on minimum $|t|_{min}$:

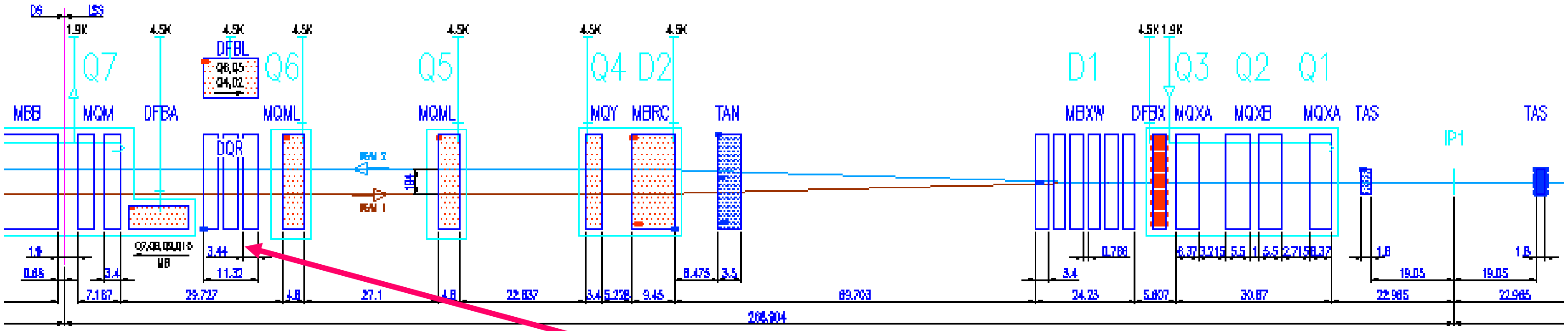
$$\left.\begin{aligned}\vartheta^*_{\min} &= \frac{d_{\min}}{L_{eff,y}}\\ t_{\min} &= \left(\vartheta^*_{\min}\,p_{beam}\right)^2\end{aligned}\right\} \xrightarrow{d_{\min}=n_\sigma\sigma_y=n_\sigma\sqrt{\beta\varepsilon_N/\gamma}} t_{\min} = p_{beam}^2\,n_\sigma^2\,\frac{\left(\varepsilon_N/\gamma\right)}{\beta^*}$$

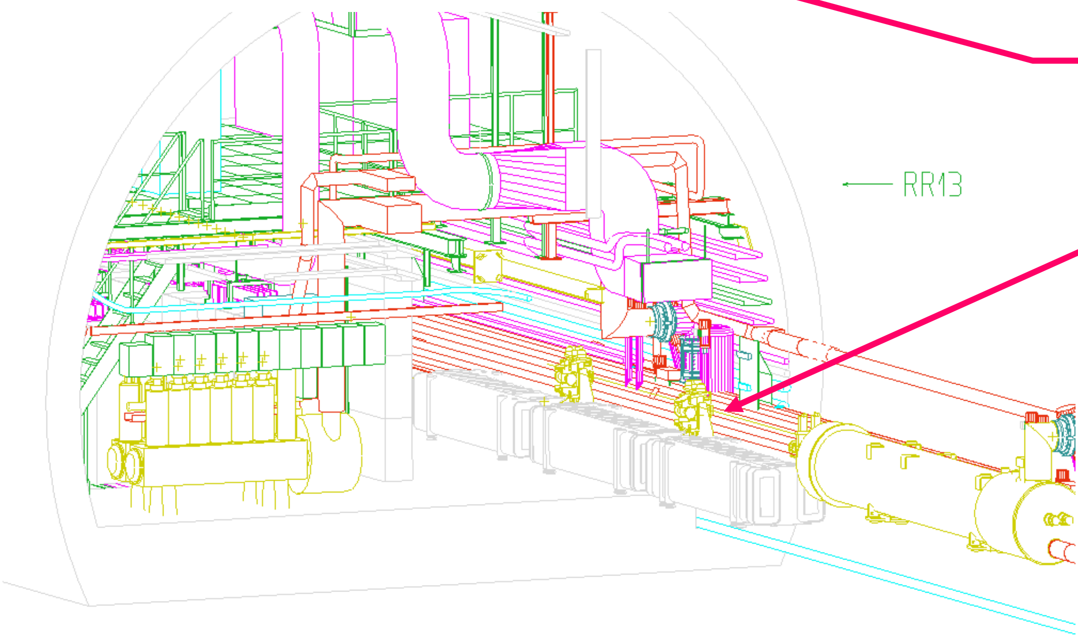
The main potential difficulties are all derived from the above

- ***$L_{eff,y}$* large** → detectors must be far away form the IP → potential interference with machine hardware
- **small t_{min}** ⇒
  - ***β**** **large** → special optics
  - **small emittance**
  - **small n_σ** → halo under control and the detector must be close to the beam

Roman Pot Locations

ATLAS





One **Roman Pot Station** per side on left and right from IP1

Each **RP station** consists of two **Roman Pot Units** separated by 3.4 m, centered at 240.0 m from IP1

Requirements for Roman Pot Detectors

- "Dead space" d_0 at detector's edge near the beam :
  $d_0 \lesssim 100\mu m$ (full/flat efficiency away from edge)

- Detector resolution: **$\sigma_d = 30\ \mu m$**

- Same **$\sigma_d = 10\ \mu m$** relative position accuracy between opposite detectors (e.g. partially overlapping detectors, …)

- Radiation hardness: **100 Gy/yr**

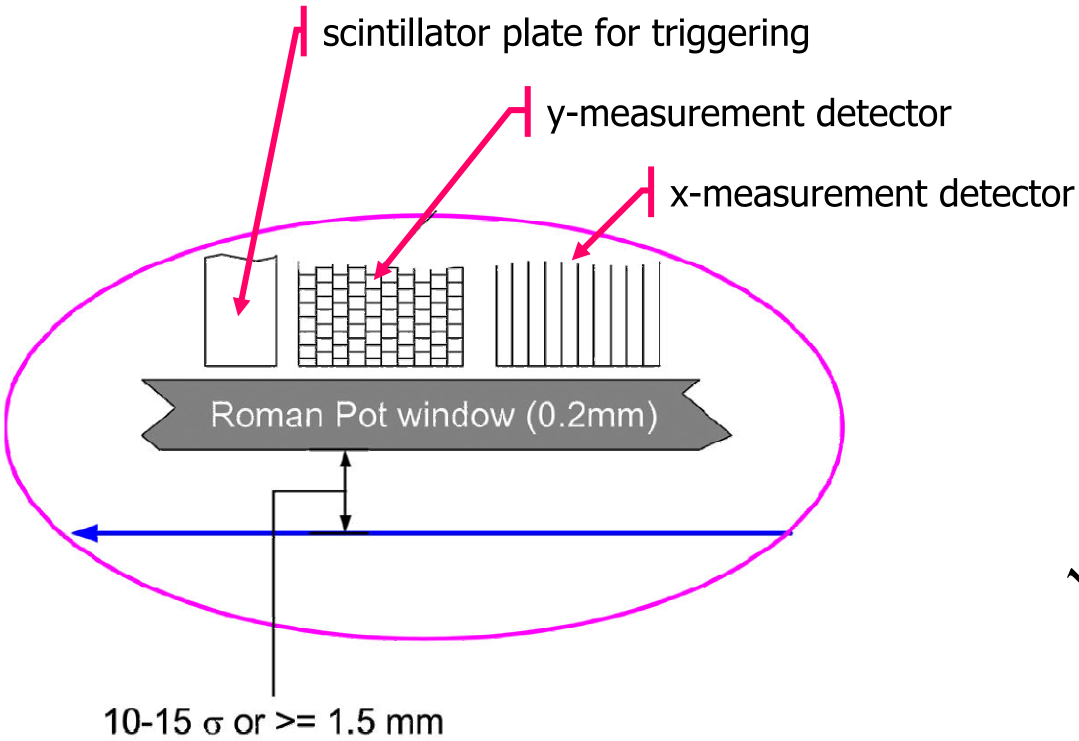
- Operate with the induced **EM pulse** from circulating bunches (shielding, …)

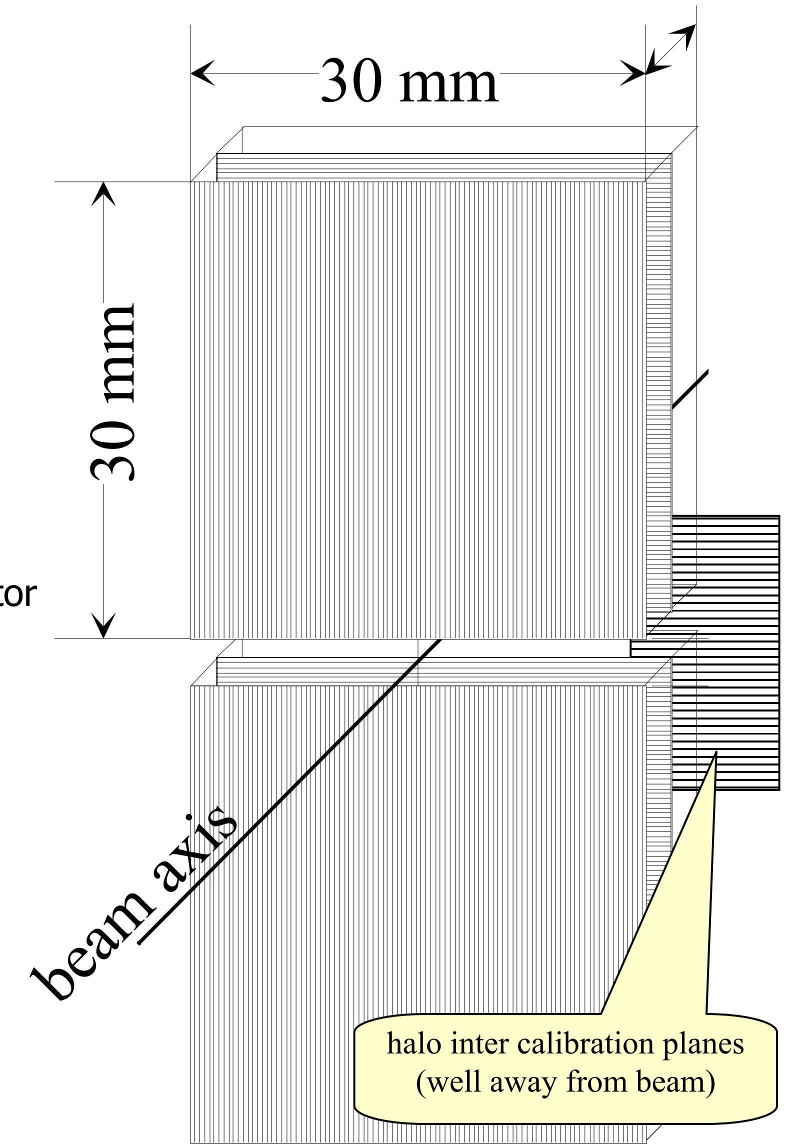
- Rate capability: **O**(MHz) (40 MHz); time resolution σ_t = **O**(1 ns)

- Readout and trigger compatible with the experiment DAQ
- Other:
  - simplicity, cost
  - extent of R&D needed, time scale, manpower, …
  - issues of LHC safety and controls

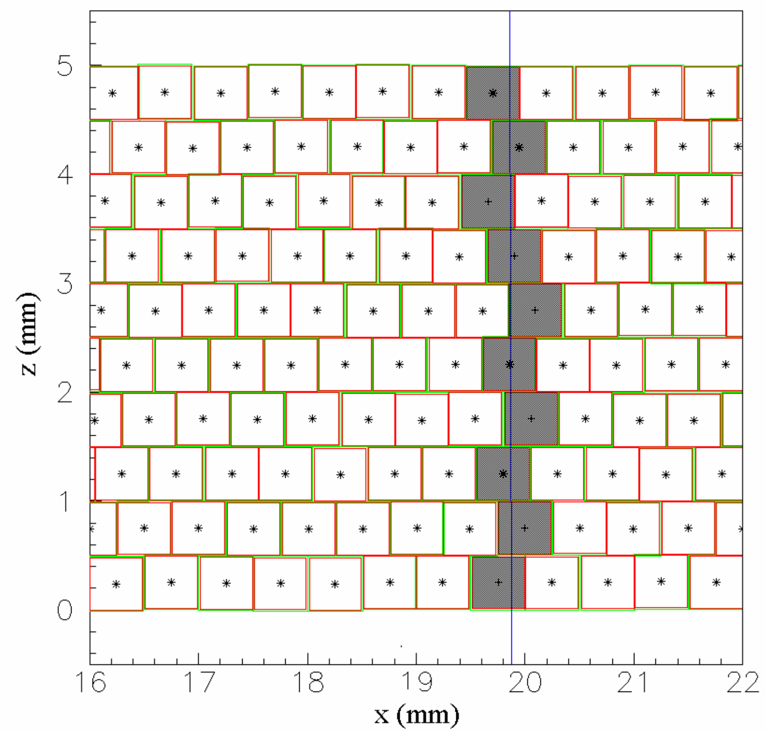
Roman Pot Detectors

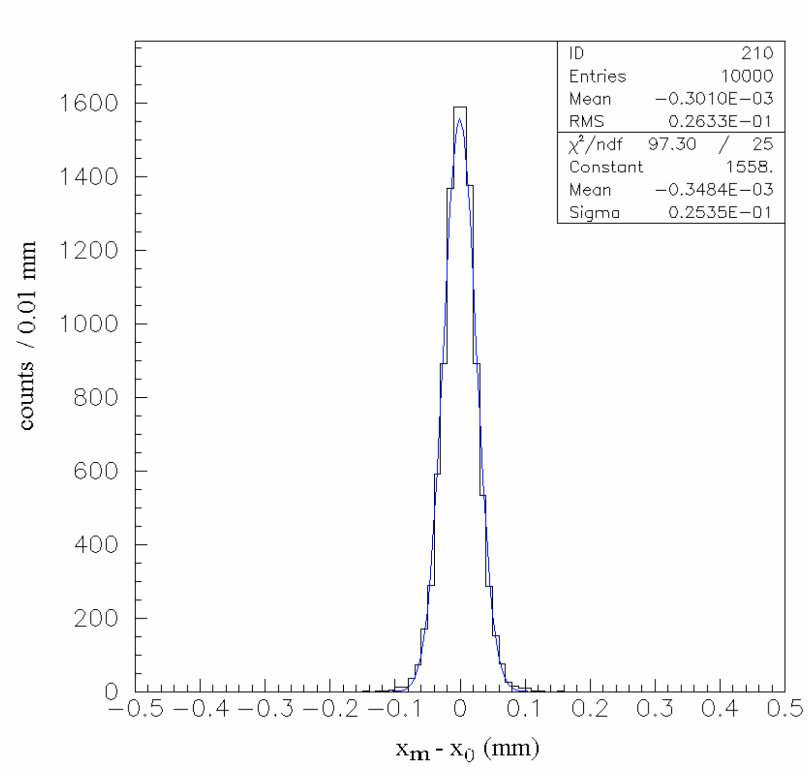
- Square scintillating fibers
  - Kuraray 0.5 mm × 0.5 mm fibers
  - 10 layers per coordinate
  - 50 μm offset between layers
- Main reason for choice
  - Small dead space
  - EM parasites not a problem





Scint. fiber detector





$$N_{pe} = \langle \frac{dE}{dx} \rangle \cdot d_{fiber} \cdot \frac{dN_{\gamma}}{dE} \cdot \varepsilon_A \cdot \varepsilon_T \cdot \varepsilon_C \cdot g_R \cdot \varepsilon_Q \cdot \varepsilon_d$$

expect N_{pe}/hit ~ 4.9

empirically: ~3 is more likely

Table 5-2 Summary of the performance figures of the baseline configuration.

detection efficiency per fiber	average number of hit fibers	$\sigma_{x,y}$ (μm) COG method	$\sigma_{x,y}$ (μm) overlap method
95%	9.1	19.9	17.2
85%	8.2	25.4	20.6

Detector Performance Simulations

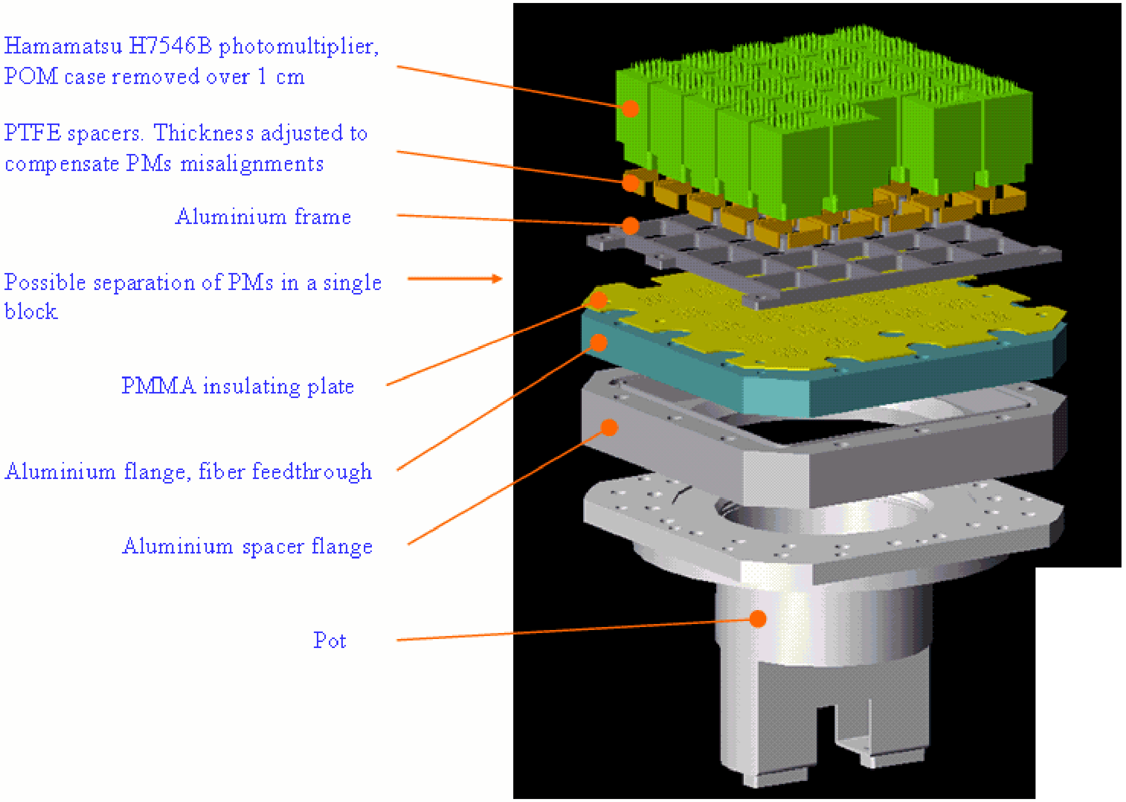
First simulation results

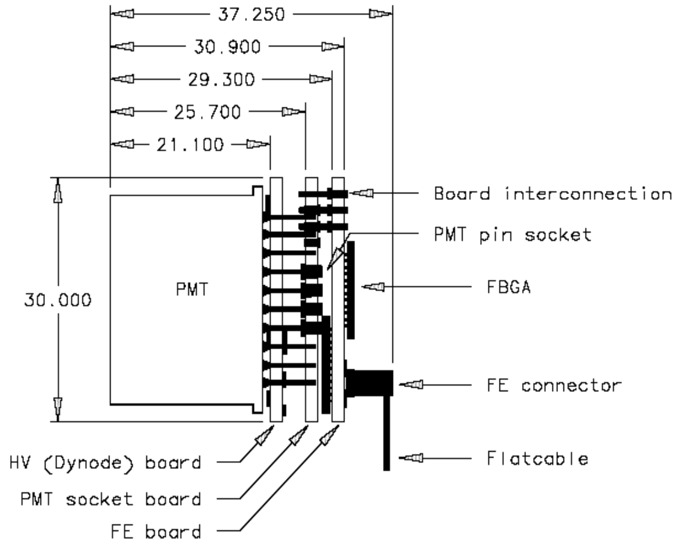
- strip positioning $\sigma_{\text{fiber}} \approx 20\ \mu\text{m}$
- light and photo-electron yield:

$$N_{pe} = \langle dE/dx \rangle\ d_{\text{fiber}}\ (dn_\gamma/dE)\ \varepsilon_A\ \varepsilon_T\ \varepsilon_C\ g_R\ \varepsilon_Q\ \varepsilon_d$$

		Baseline detector SCSF-38 (λ=428 nm) 0.5 mm square **MAPMT**	**Alternative configuration** SCSF-3HF (λ=530 nm) 0.5 mm square **GM-APD**
$\langle dE/dx \rangle$	specific energy loss of a MIP in scintillator	200 keV/mm	200 keV/mm
d_{fiber}	active thickness of fiber	0.48 mm	0.48 mm
dn_γ/dE	scintillation light yield	8.3 / keV	8.3 / keV
ε_A	geometrical acceptance	0.042	0.042
ε_T	attenuation in fiber	0.85	0.85
ε_C	coupling efficiency fiber/photodetector	0.80	0.80
g_R	Gain due to reflection from rear end	1.4	1.4
$\boldsymbol{\varepsilon_Q}$	**quantum efficiency photodetector**	**0.18**	**0.15 (0.3 in future ?)**
ε_d	detection efficiency (electronics/DAQ)	0.85	0.85
$\mathbf{N_{pe}}$	**Photoelectron yield**	**4.9**	**4 (8 in future ?)**

Fiber housing components





Fiber routing

Radius of curvature min 30mm

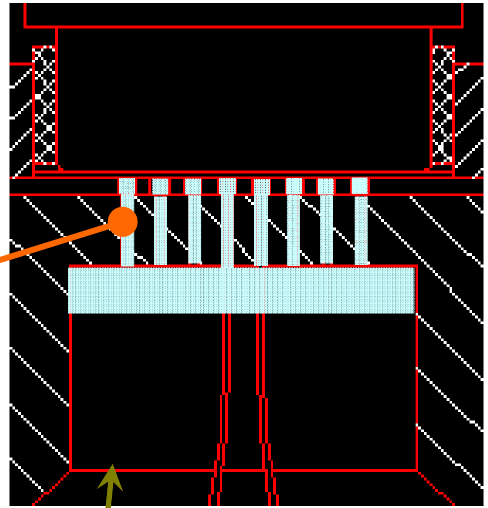
Average fiber length ~230mm

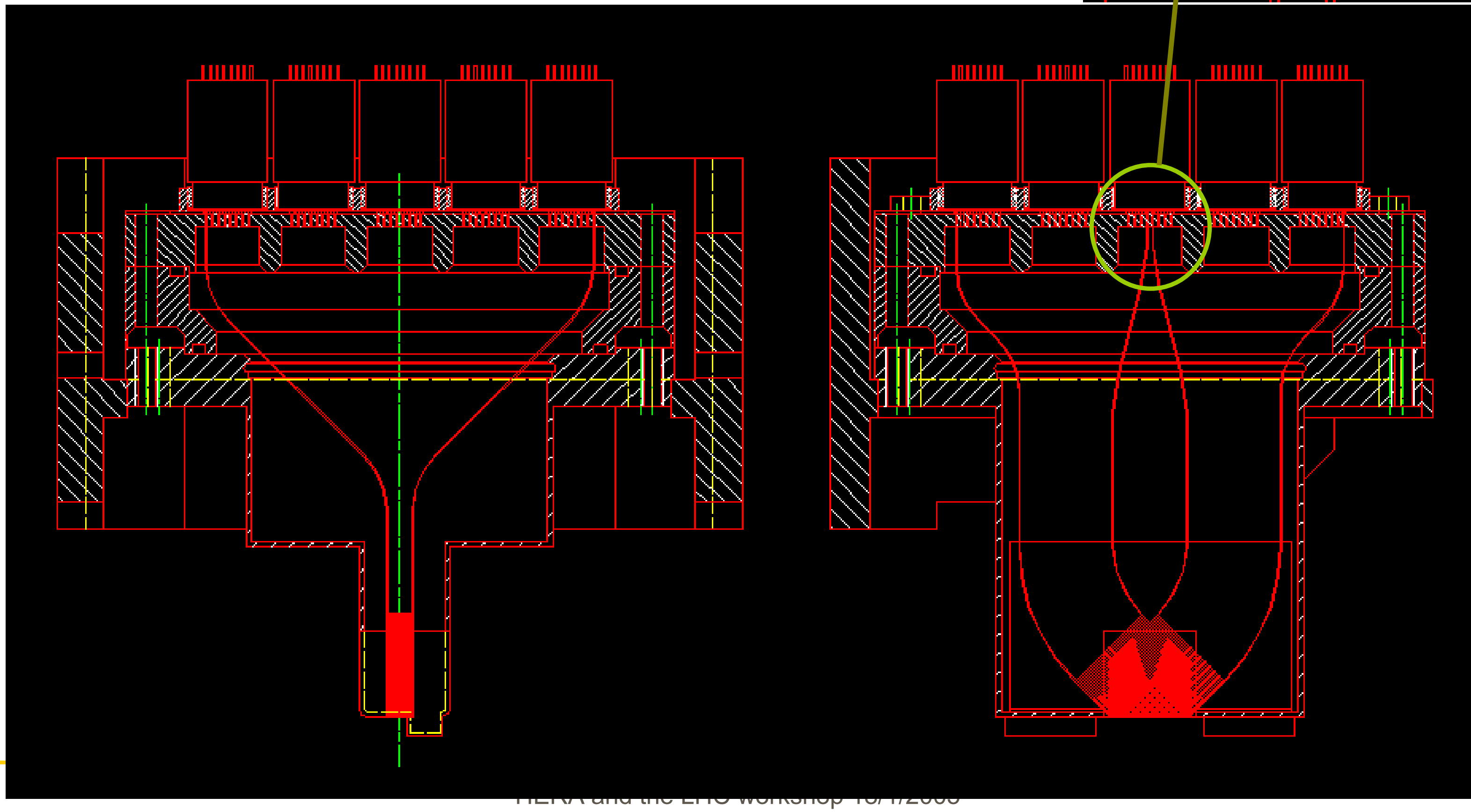
Nb of fibers in X config.: 71 x 10 x 2 = 1420

Total fiber length: ~330m

Square holes filled with glue

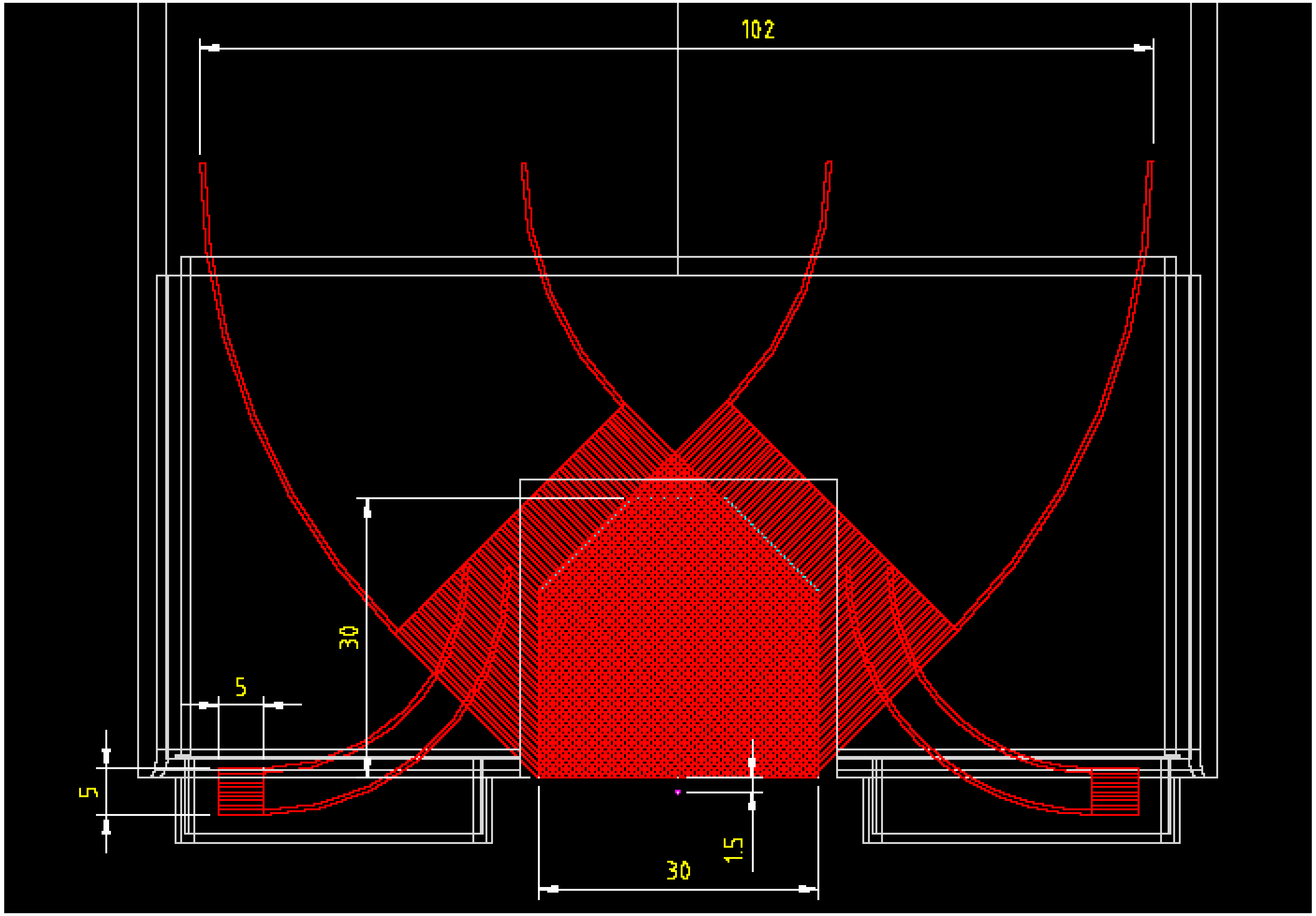
(to be tested in prototype)





ATLAS LUMI

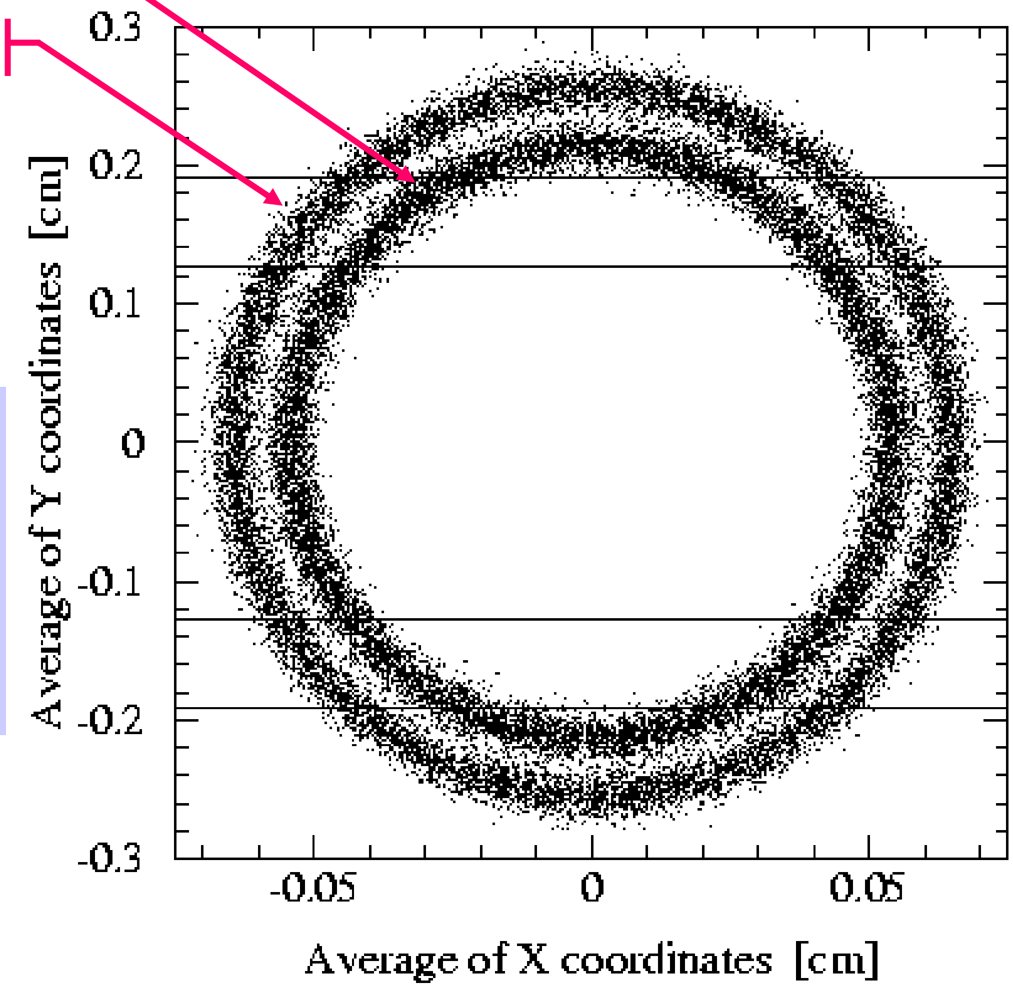
An alternative layout of the fiber detector



Simulated Elastic Scattering

Inner ring: $t = -0.0007\ \mathrm{GeV}^2$

Outer ring: $t = -0.0010\ \mathrm{GeV}^2$



- Reconstruct θ^*:

$$\theta^* = \sqrt{\overline{\theta}_x^{\,2} + \overline{\theta}_y^{\,2}} = \sqrt{\left(\frac{\overline{x}}{L_{eff,x}}\right)^2 + \left(\frac{\overline{y}}{L_{eff,y}}\right)^2}$$

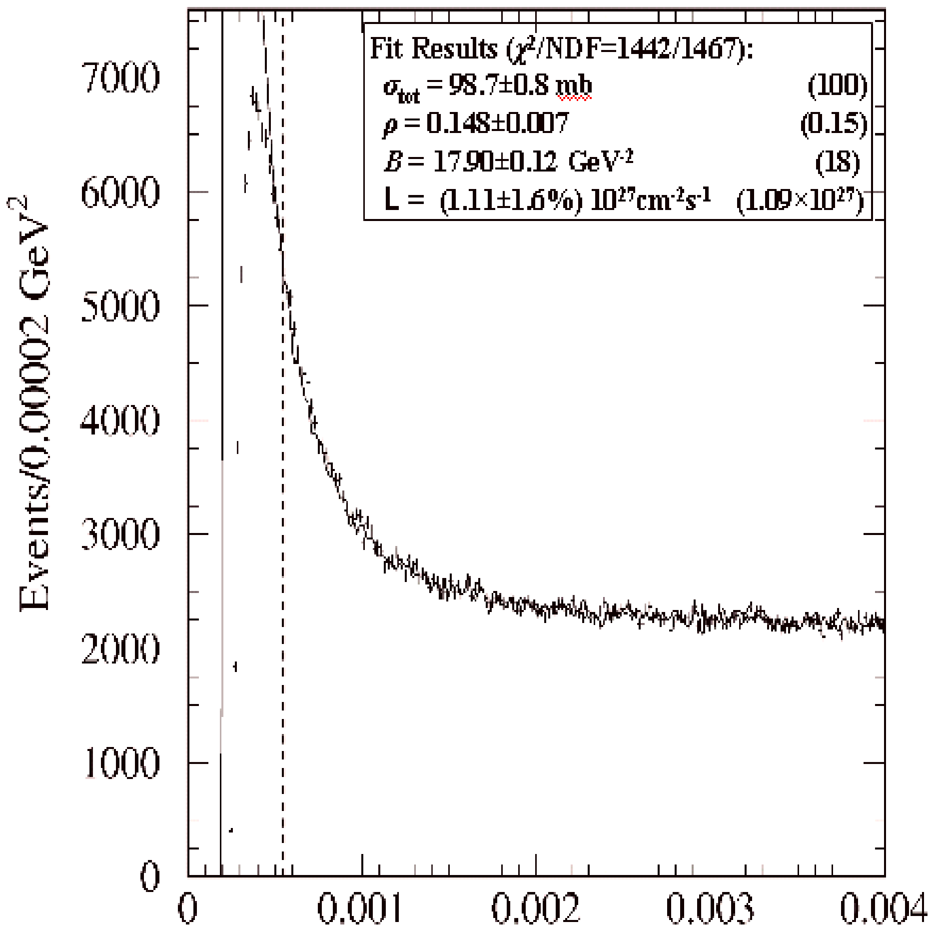
Simulated dN_{el}/dt and simple fit

Event generation:

- 5 M events generated corresponding to ~90 hr at L≈ 10^{27} cm^{-2} s^{-1}
- NO systematics on beam optics!
- Only 1 Roman Put unit/arm

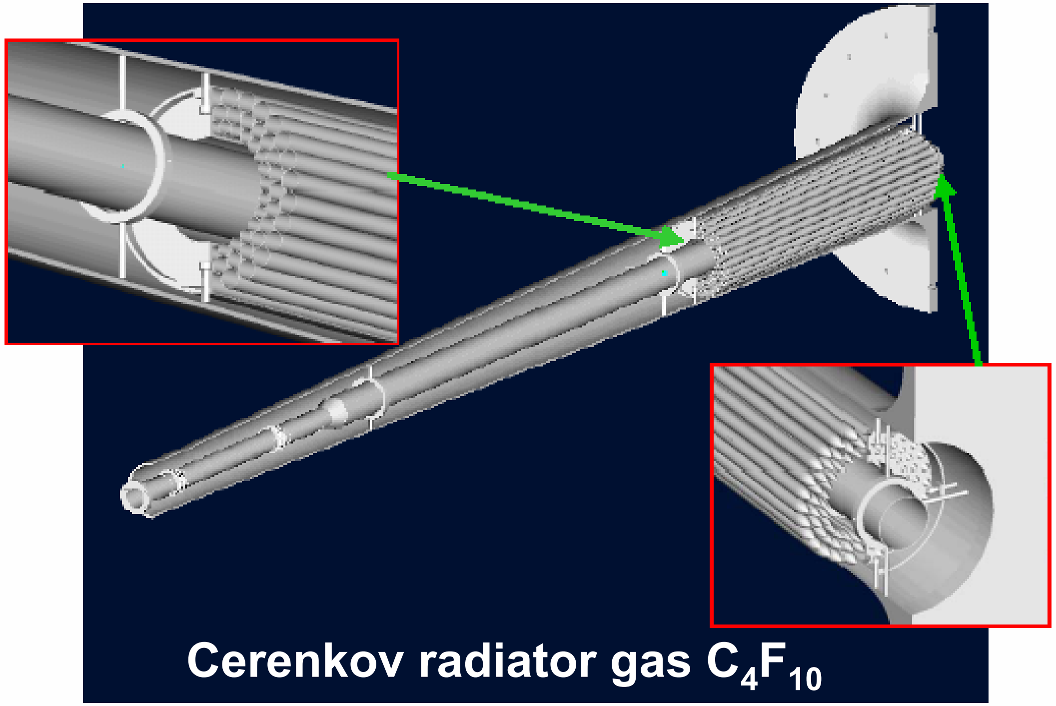
Simple fit

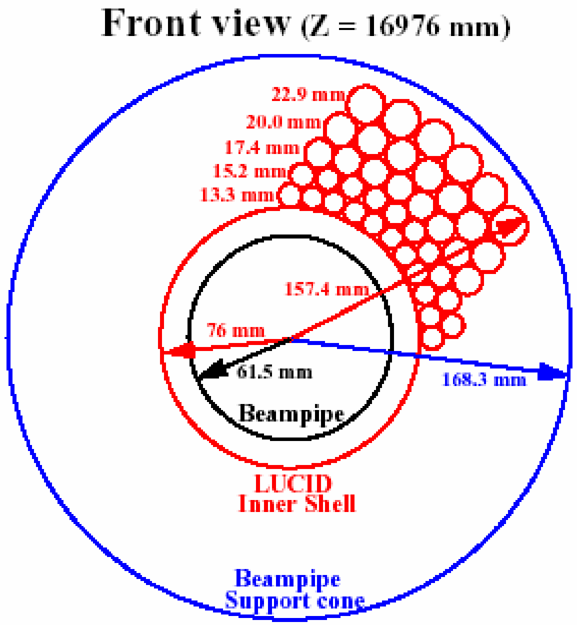
- range for fitting:
  - 0.00056 < |*t*| < 0.030 GeV^2
- ~4 M events "measured" for dN/dt

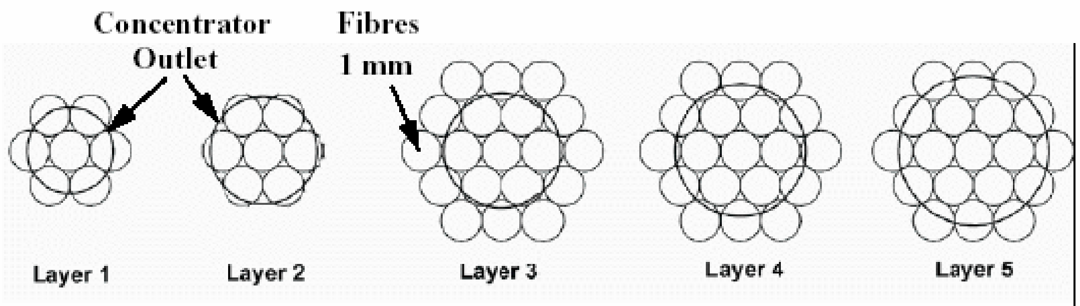


Relative Luminosity
The LUCID Luminosity Monitor
("LUminosity measurement using Cerenkov Integrating Detector")

A bundle of 200 (per end) projective Al Cerenkov tubes around the beam pipe







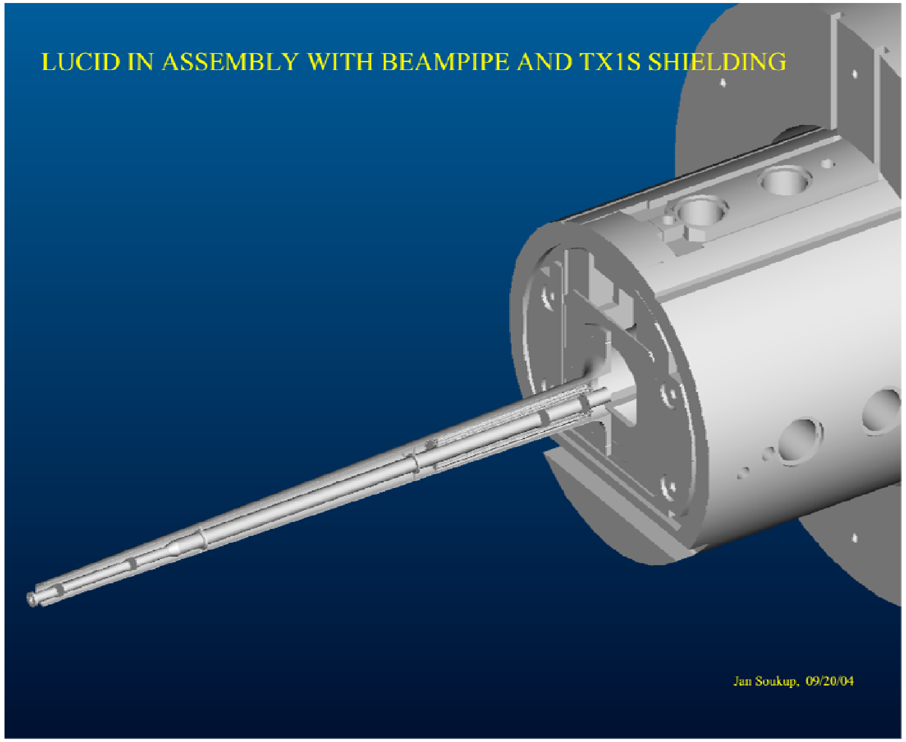
SERVICES

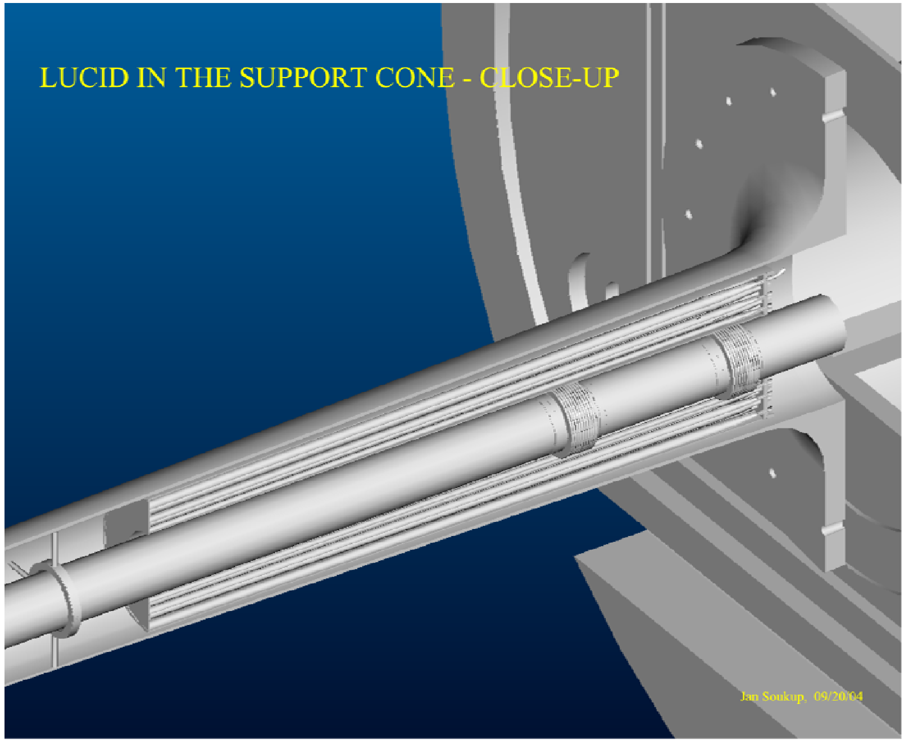
5 layers, 40 tubes, 7 fibres } 1400 fibres (minimum)

2 Gas pipes
2 LED cables
or 200 fibres

Light taken out to remote PMTs(ot APDs) via quartz fibres

Where is LUCID Deployed?





$$\eta_{MAX} = -\ln(\tan 0.132^{o}) = \mathbf{6.073}$$

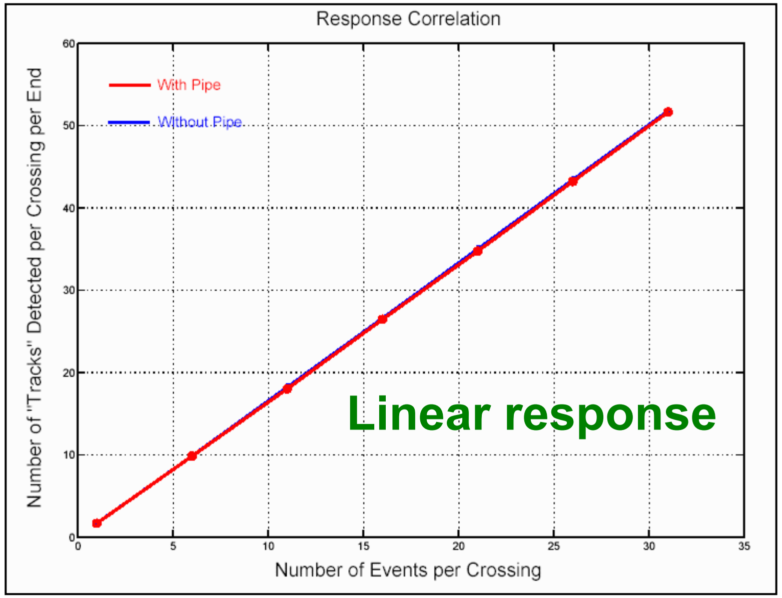
to

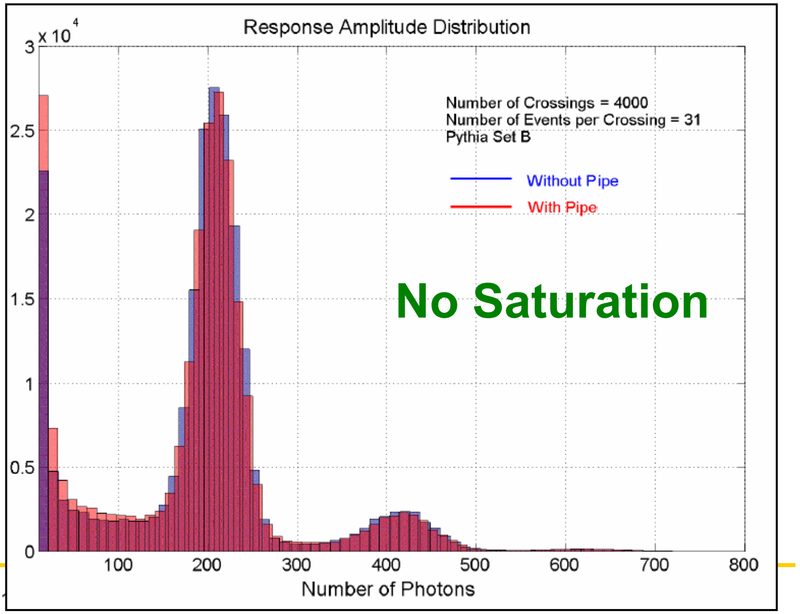
$$\eta_{MIN} = -\ln(\tan 0.266^{o}) = \mathbf{5.374}$$

Front face of each LUCID end is ~17m from the IP

LUCID Technique – tested at CDF

- Sensitive to right particles -- Much more light from primary particles than secondaries & soft particles:
  - **Much shorter paths for secondaries**
  - **Cerenkov thresholds**
- No Landau fluctuations for Cerenkov Light emission… a narrow single particle peak
- Excellent amplitude resolution - we can count multiple tracks/tube
  - **No saturation even at highest lumi**
- Linear relationship between lumi & tracks counted in CLC
- 200 tubes/end give position sensitivity
- Time resolution (~140ps @ CDF)
  - **We can "follow bunches".**
- Radiation hard (all aluminium) –it can fit in available space & has low mass (40kg per end)

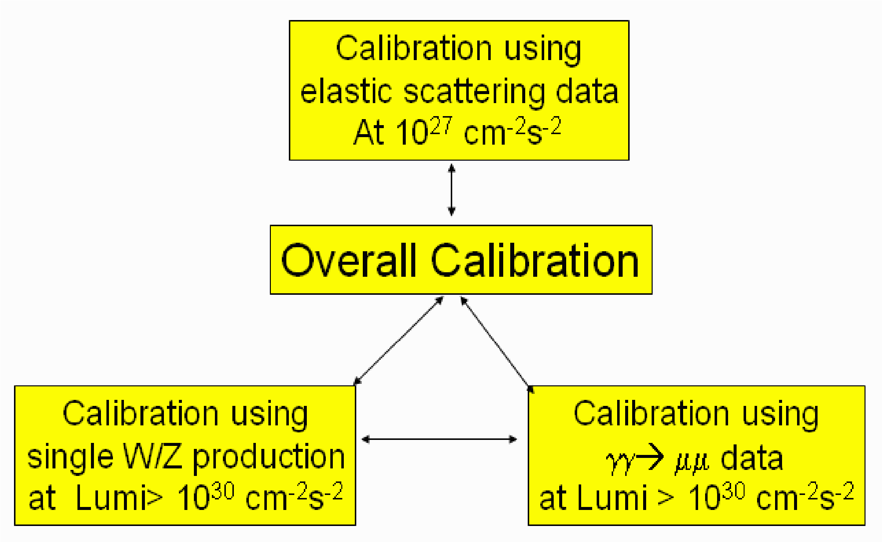




LUCID – Dynamic Range & Calibration

- LUCID can monitor luminosity over the full range expected at the LHC ($10^{27}\rightarrow 10^{34}$) ⇒ interactions / bunch ⇒ ~ 2 x10^{-4} ~20 (a factor of 10^5)
- Required dynamic range of the LUCID detector up to ~ 30 tracks (~1.7 x 20).
- The detector can also be run "independently" in order to asses: 1) beam background conditions, 2) beam quality & beam position
- The LUCID detector exploits the expected linear dependence between # reconstructed particles and # pp interactions (min. bias) to full lumi.

CALIBRATION



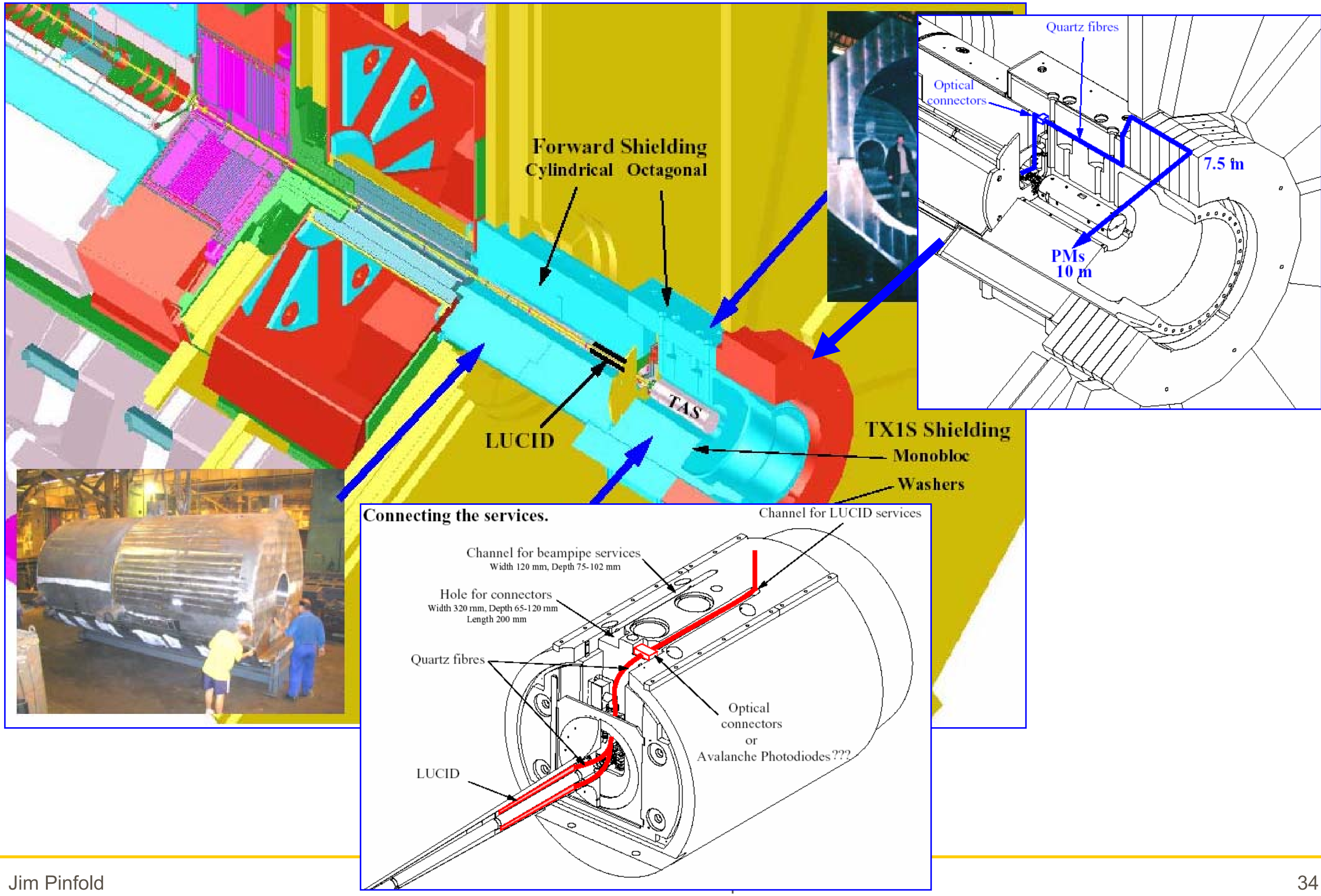
Calibration can be carried from elastic scattering data over the full dynamic range

•The cross calibration of LUCID will take place at 10^{27} cm^{-2} s^{-1}. A collision rate of 100Hz @ 100mb xsec → 170 Hz tracks per end of LUCID (cf: elastic rate in the RP of 30 Hz)

Simulation of LUCID

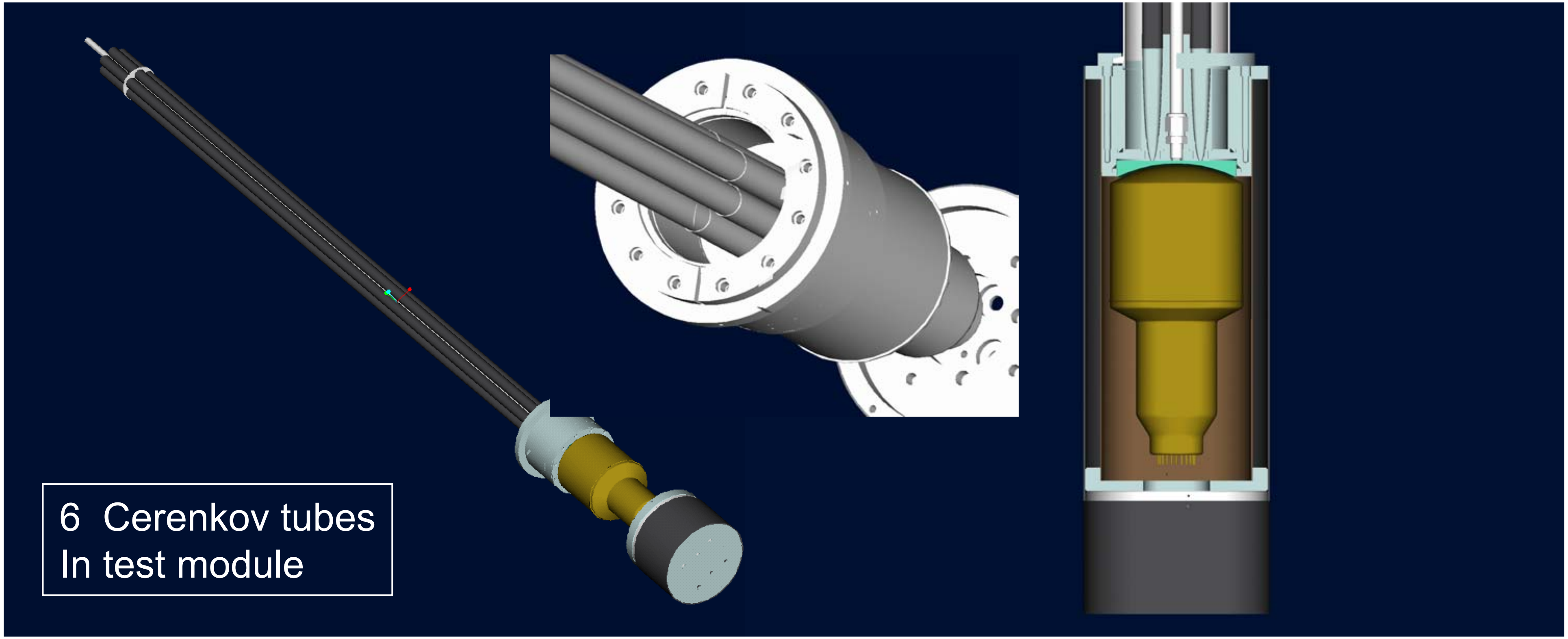
- A 20 GeV muon incident along the axis of a LUCID Cerenkov tube gives ~320 photons and ~230 photons are collected at the Winston cone exit.
- Only 60 photons enter the fibre acceptance and reach the end of a 10m quartz fibre, needed to transmit light from LUCID to remote photo-detectors.
- We would expect ~12 pe's/track with a PMT and ~ 30-40 pe's/track with an APD readout.
- A simple simulation of a beampipe has been included.
- Future full LUCID simulations development include:
  - A full description of LUCID, including gas-vessel and support structure and final fibre length estimates
  - Complete simulation of background conditions at the LUCID position
- A full simulation of the LUCID prototype is now underway

Reading out LUCID



LUCID Mock Up for the Study of Readout Routing, Space Allocation & Integration

The Cosmic Ray → Beam Test

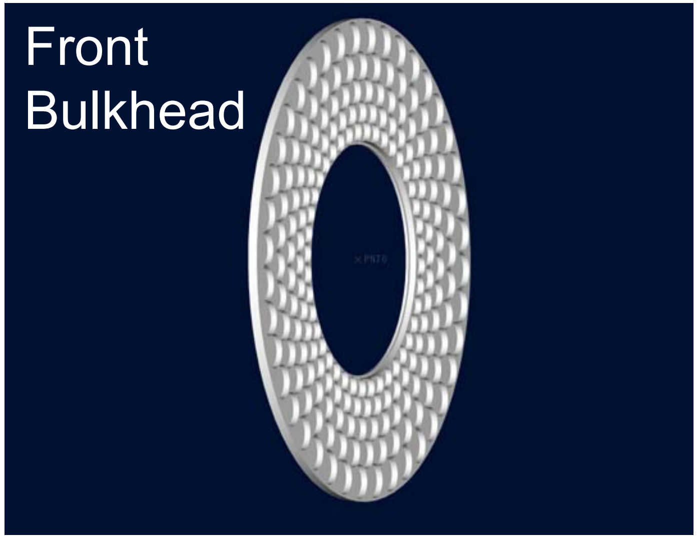


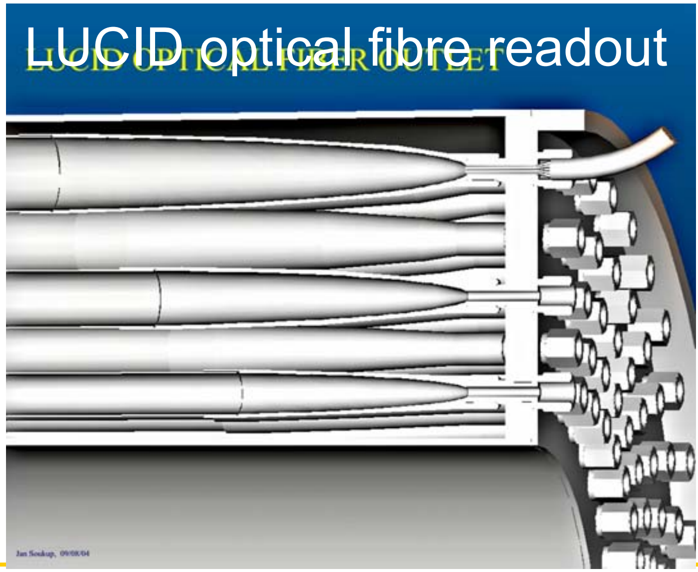
- Cosmic ray trigger rate is ~1/hour - consistent with our MC estimate. We are waiting for` statistics to build up.
- We really need access to testbeam (e,g with E_{μ} > 2.2 GeV)
- We are planning a beamtest at Fermilab in Spring 2005.

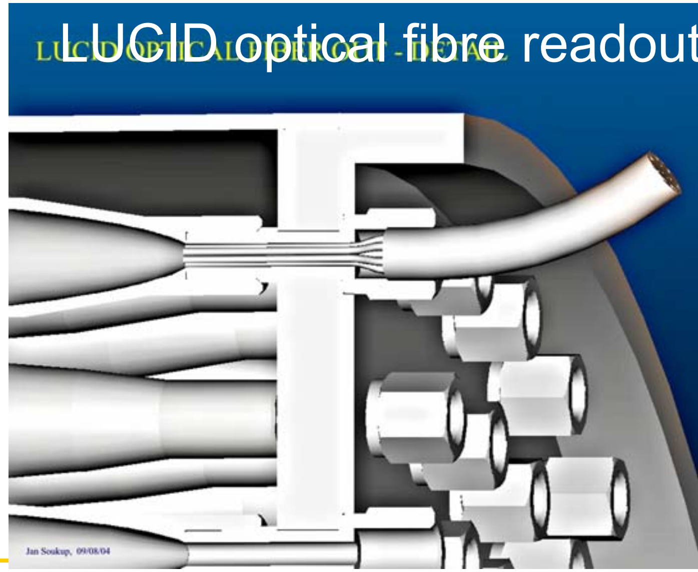
First Version of the LUCID – Mechanical Design Report

- This document was finished on the 18th of October 2004
- The design report details the:
  - Space allocation for LUCID
  - Pattern of Cerenkov light-collecting tubes
  - Design of Winston cones
  - LUCID gas volume
  - Front bulkhead
  - Rear bulkhead
  - Optical fibre feed-throughs
  - Optical bundle tips
  - Gas connections
  - Weight of various LUCID elements
  - Assembly procedure
  - Cost estimate
  - Remaining task list

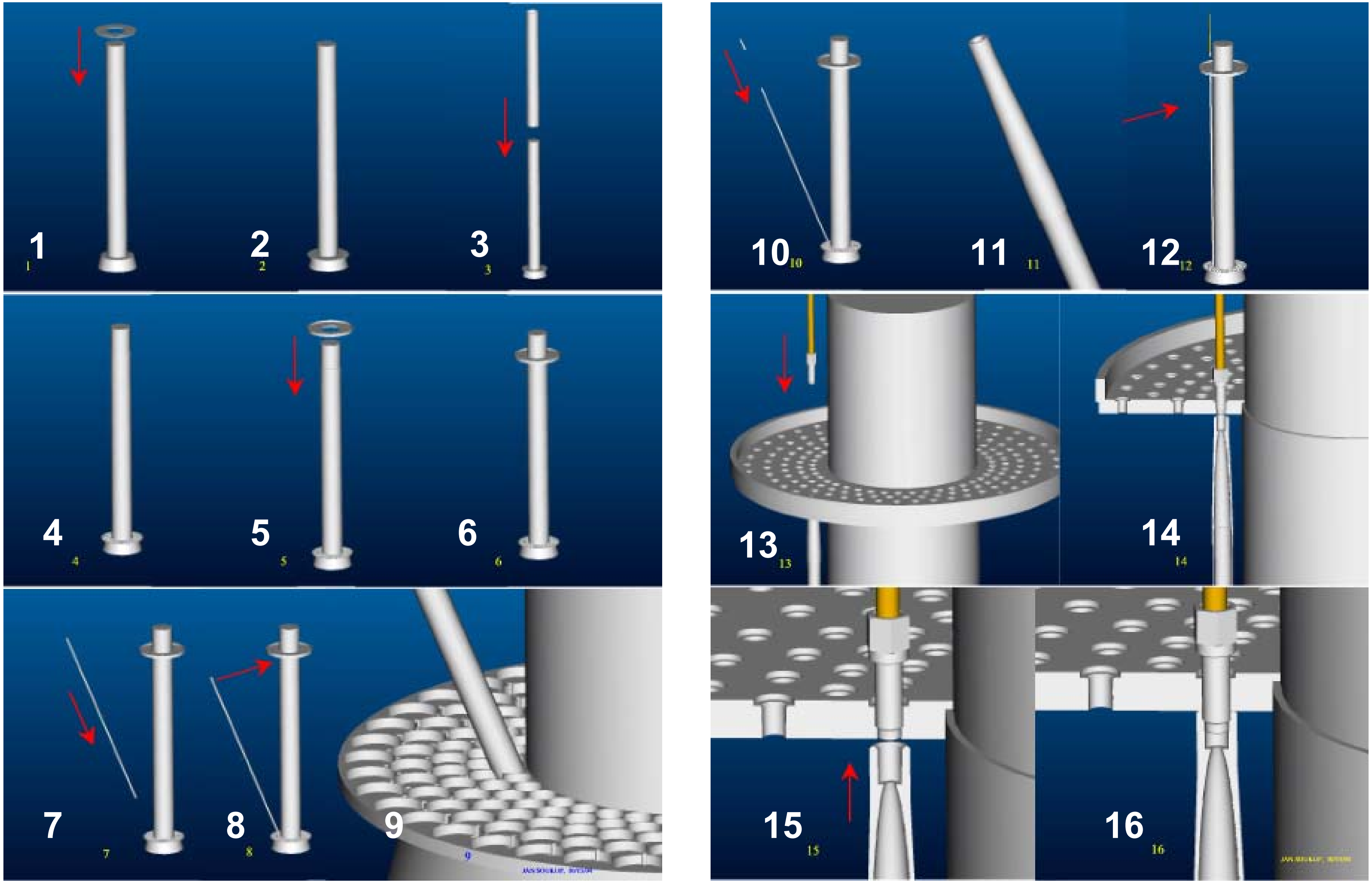
Sample Pictures from the Report



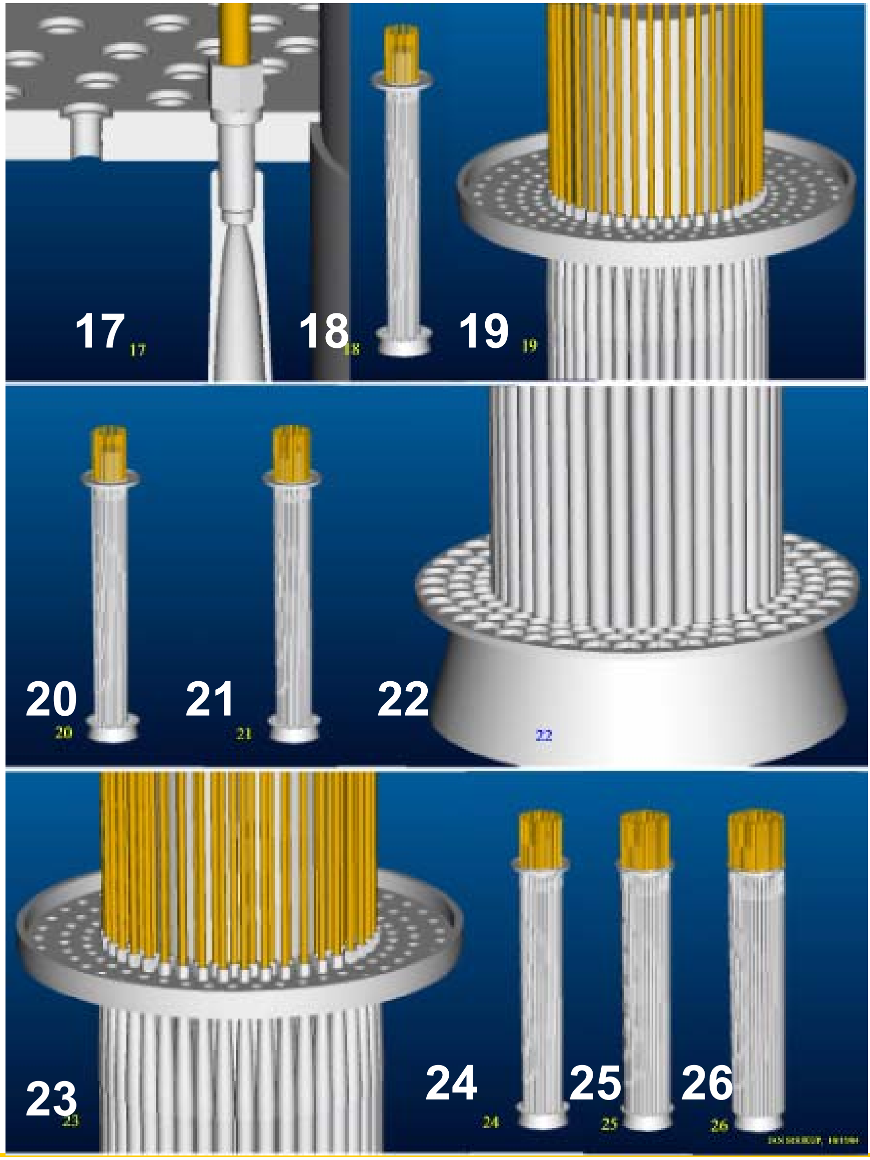


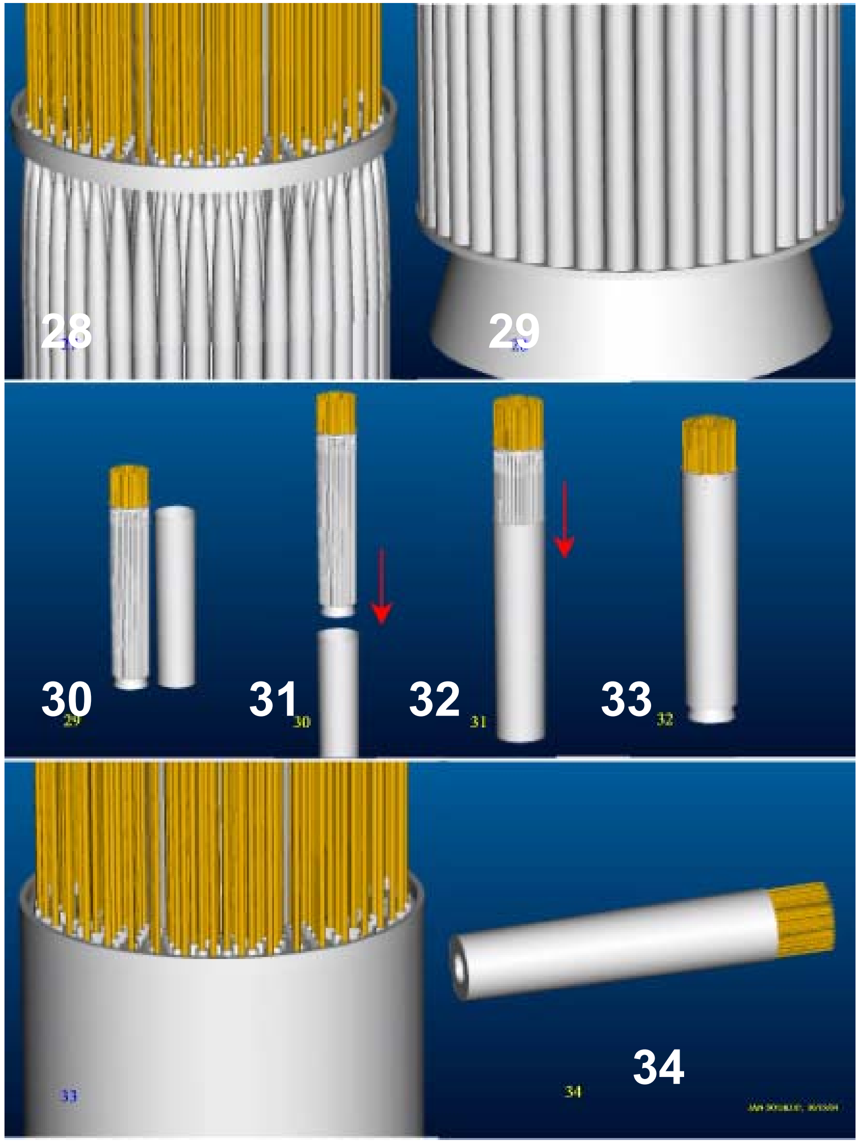


Detector Assembly (1)



Detector Assembly (2)





Initial Cost Estimate For LUCID Detector (NOT including readout)

- Total machining hours 2410
- Total machining cost @ $5/hr = $12,050 (CDN)
- Material cost $56,295 (CDN)
- LUCID assembly hours 1120
- Assembly cost @ $5/hr = $5,600 (CDN)
- Cost of tooling, jigs & tool sharpening = $5,000 (CDN)
- TOTAL Cost of the two LUCID assemblies = $ 79,000
- Obviously we expect this to increase, but it sets the scale at ~100,000 CHF.

Readout Issues To be Studied

- The radiation at the junction box is nominally a few Gry/year. Even if this a factor of 10 wrong we have the freedom to move away from quartz fibre in this region and connect at the junction box, to:
  - **UV transparent plastic fibre which is much cheaper**
  - **WLS + regular clear plastic fibre – even cheaper and would reduce the need for PMTs with UV transparent windows.**
- We still need to test various photodetector options that would depend on the readout method chosen (quartz fibre, UV transmitting plastic fibre, WLS + plastic fibre):
  - **APD's, Si-PMTs**
  - **PMTs with UV sensitivity**
  - **Multi-anode PMTs with or without UV sensitivity.**
- Readout electronics – which of course depends on point (2) above.

Milestones this Year & the Future

- Milestones in 2004 year
  - **March 2004 – the LOI.**
  - **May 2004 – LUCID report : "favourably received" by the LHCC**
  - **Engeering Change Report (ECR) for the LHC – *in progress***
- Beam test of 6-tube prototype in Spring/Summer 2005 at FERMILAB, testing:
  - **Direct PMT readout**
  - **Readout via quartz fibre**
- Institute ECR (during 2005)
- Use model to LUCID mounting and readout details (early 2005)
- Finish detailed simulation including the effect of background from quartz readout fibres (by spring 2005)
- Prototype readout and readout electronics
- Build LUCID!
- *CAVEAT- Money and help required*

Conclusion

- **ATLAS pursues a number of options for Absolute Luminosity Measurement**
  - Coulomb normalization
  - W/Z rates
  - production of muon pairs via double photon exchange
  - elastic slope extrapolated to $dN/dt|_{t=0}$ plus machine L
  - elastic slope extrapolated to $dN/dt|_{t=0}$ plus σ_{tot} from TOTEM
  - machine parameters alone
  - Cross calibration from ZDC in Ion runs
  - others…
- **The Coulomb Interference measurement is very challenging but seems within reach.**
- **Small angle elastic scattering will address "old fashion" physics in terms of σ_{tot} , ρ and b**
- **This experience of working close to the beam will prepare us for a Forward Physics Program with ATLAS in a possible future upgrade**

Back up slides

Summary on emittance and beam halo issues

"Looks feasible but no guarantees can be given"

However, if we don't reach the Coulomb region the effort is not in vain

we can still:

- Use σ_{tot} as measured by TOTEM/CMS and get the luminosity by measuring elastic scattering in a moderate t-range($-t=0.01$ GeV^2) and use the Optical theorem for the rest
- Use the luminosity measured by machine parameters and again via the Optical theorem get σ_{tot} and all other cross sections relative to σ_{tot} with a factor 2 better precision than from the machine parameters

Luminosity transfer 10^{27}-10^{34} cm^{-2} sec^{-1}

- Bunch to bunch resolution ⇒ we can consider luminosity / bunch

  ⇒ ~ 2 x10^{-4} interactions per bunch to 20 interactions/bunch

  ⇓

- Required dynamic range of the detector ~ 20
- Required background < < 2 x10^{-4} interactions per bunch
  - main background from beam-gas interactions
  - Dynamic vacuum difficult to estimate but at low luminosity we will be close to the static vacuum.
  - Assume static vacuum ⇒ beam gas ~ 10^{-7} interactions /bunch/m
  - We are in the process to perform MC calculation to see how much of this will affect LUCID

Alternative photodetectors

- Geiger Mode Avalanche Photodiodes

+ high gain, ~ 10^6
+ low bias voltage ~ 50 V
+ very fast signal characteristics
+ very simple electronics
+ small size

- low QE ~ 15% (geometrically limited)
- high dark count rate at R.T. ~ 10^6 Hz
- not yet really commercialized

GM-APD would become interesting if geometrical QE limitation can be overcome.
QE > 30% is claimed to be in reach.

This would mean N_{pe} ~ 6-8 for our baseline configuration.

Cost Estimates & Participants

	Item	Cost (KCHF)
LUCID	Cerenkov tubes	68.0
	Quartz fibers	62.0
	Readout	62.0
	Infrastructure	125.0
	R&D	62.0
	Total	***379.0***
Roman Pot system	RP units	220.0
	Q4 polarity inverters	60.0
	Scintillating fiber detectors	175.0
	Readout	650.0
	Integration	75.0
	R&D	100.0
	Total	***1280.0***

Participating institutes:

(as a subsystem, fully part of the ATLAS collaboration)

University of Alberta
CERN
Ecole Polytechnique
Institute of Physics Academy of Science, Czech Republic
University of Manchester
University of Montreal
University of Texas
University of Valencia
SUNY Stony Brook