ATLAS-MUON Trigger hardware developments

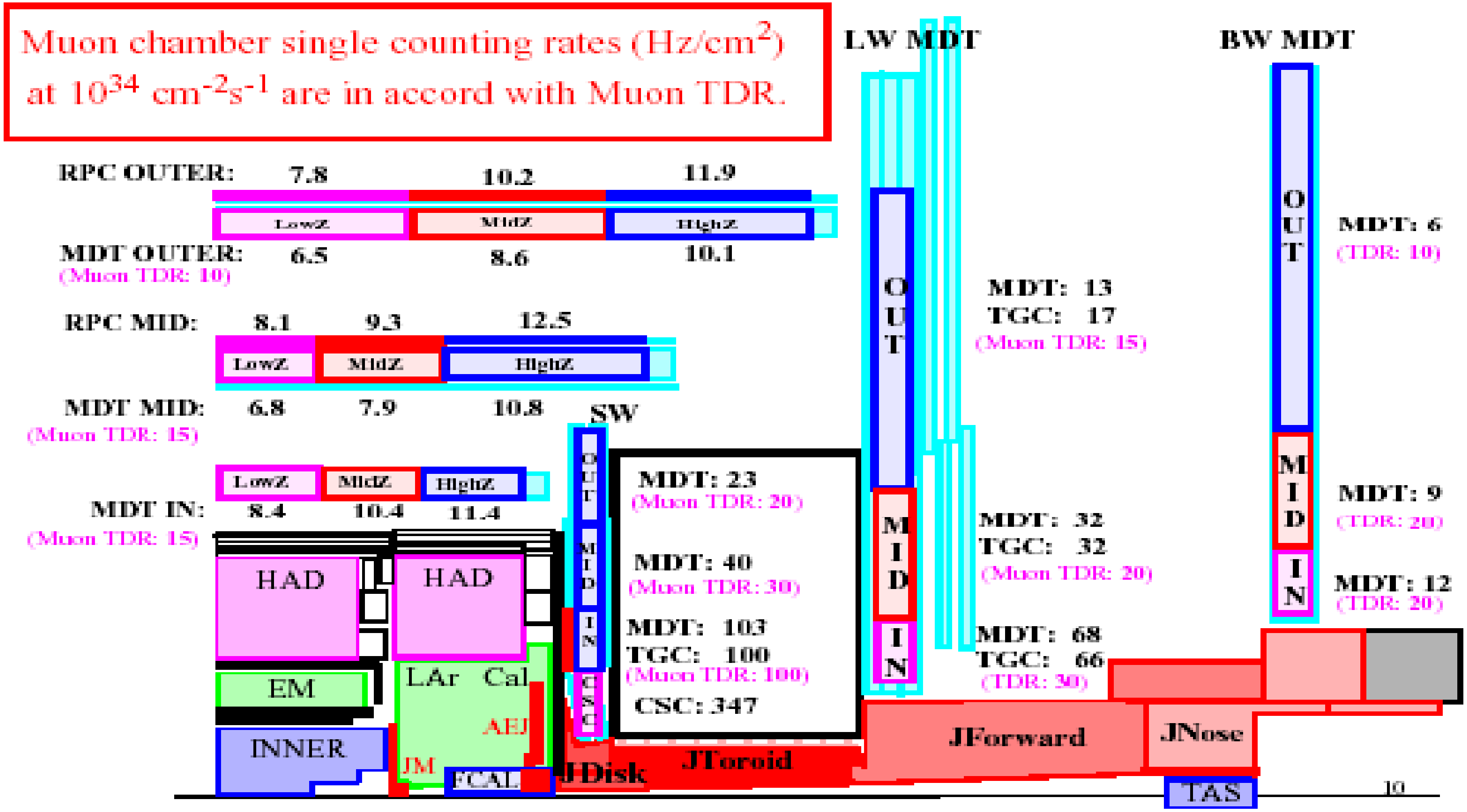
- Rates overview
- Barrel needs
- End cap needs
- Conclusions

Expected rates and upgrades at SLHC

- Many studies have been performed on trying to optimized the shielding in the forward region of ATLAS, to reduce the backgrounds at SLHC (including replacing forward Air-Toroid by Fe-Toroid).
- Main conclusion is that the most effective way is to replace Stainless Steel Beam Pipe in calorimeters by Be; giving a factor 2-3 in background reduction. All other options give marginal results.
- Options of removing MUON Spectrometer and replacing by other techniques for higher rates are too time consuming and expensive.
- Only realistic option is to upgrade forward trigger chambers and possibly replace some forward MDT-CSC by other technologies, including also smaller tubes.

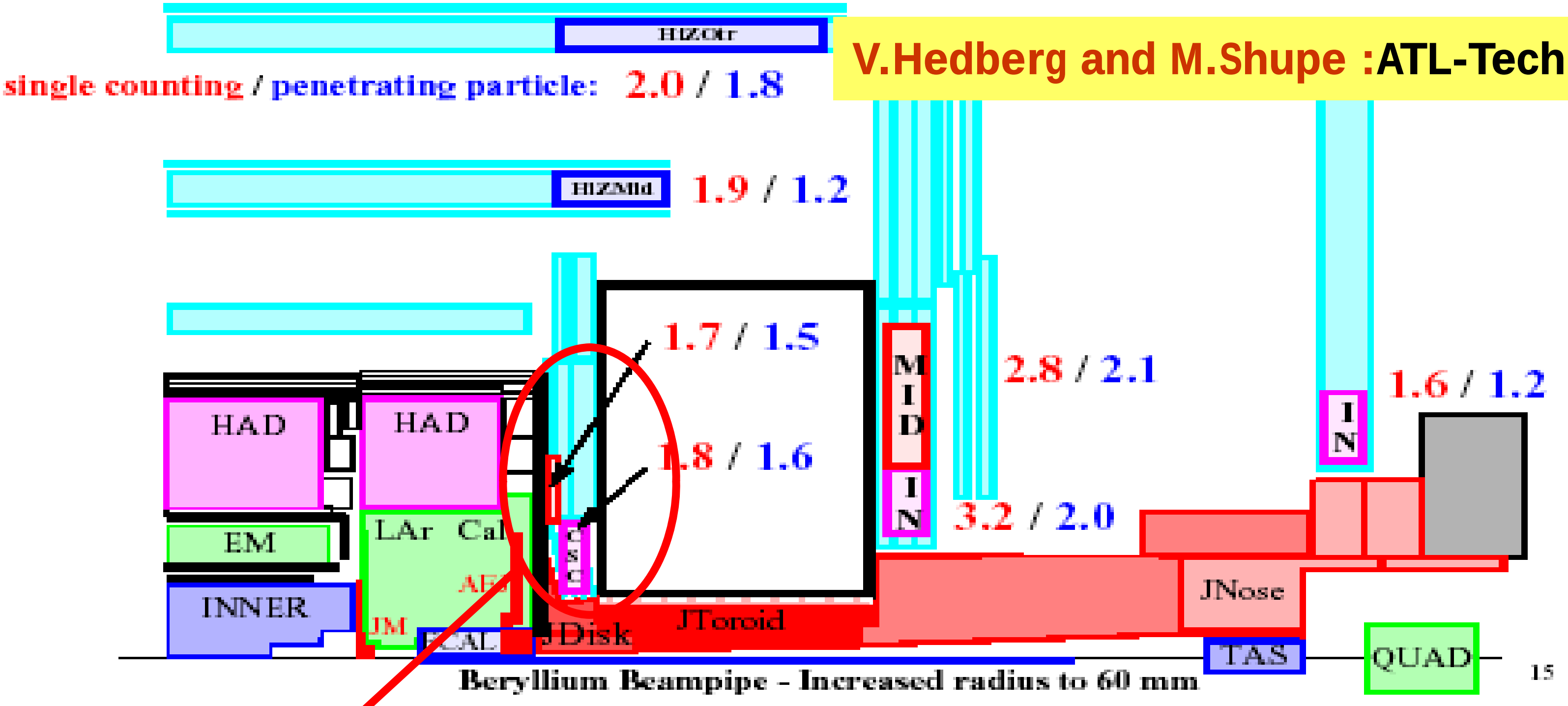
Muon background counting rate @L=10^{34}

Muon chamber single counting rates (Hz/cm^2) at 10^{34} cm^{-2}s^{-1} are in accord with Muon TDR.



Background rate: preliminary studies

Maximum increase of luminosity with unchanged single counting rate/penetrating particle rate
where
single counting rate = 0.0005n + 0.0117γ + (μ + p + π + 0.25e) / 2
penetrating particle rate = 0.00117γ + (μ + p + π + 0.25e) / 2

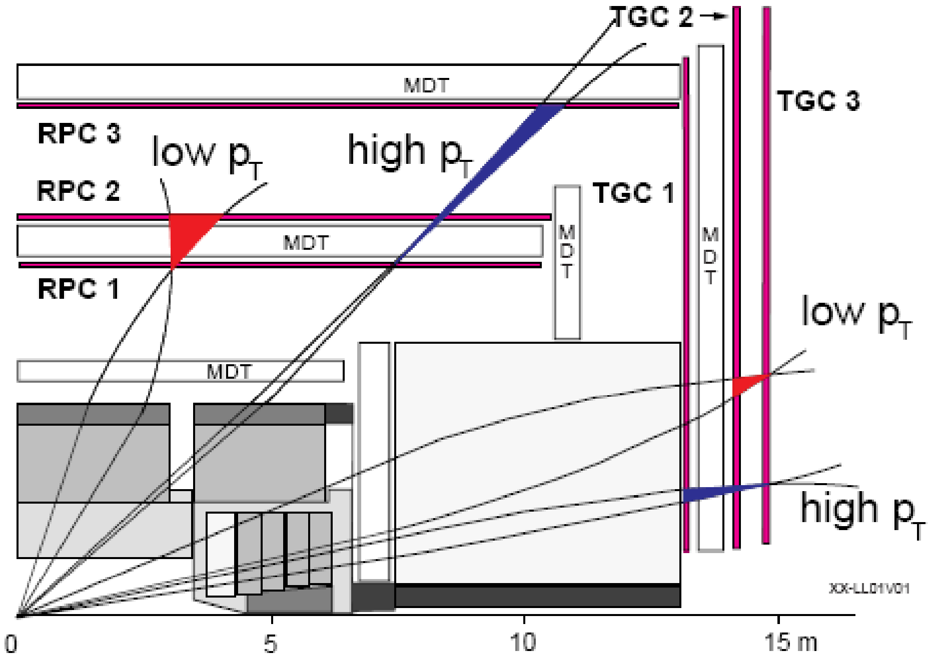


V.Hedberg and M.Shupe :ATL-Tech-2004-003

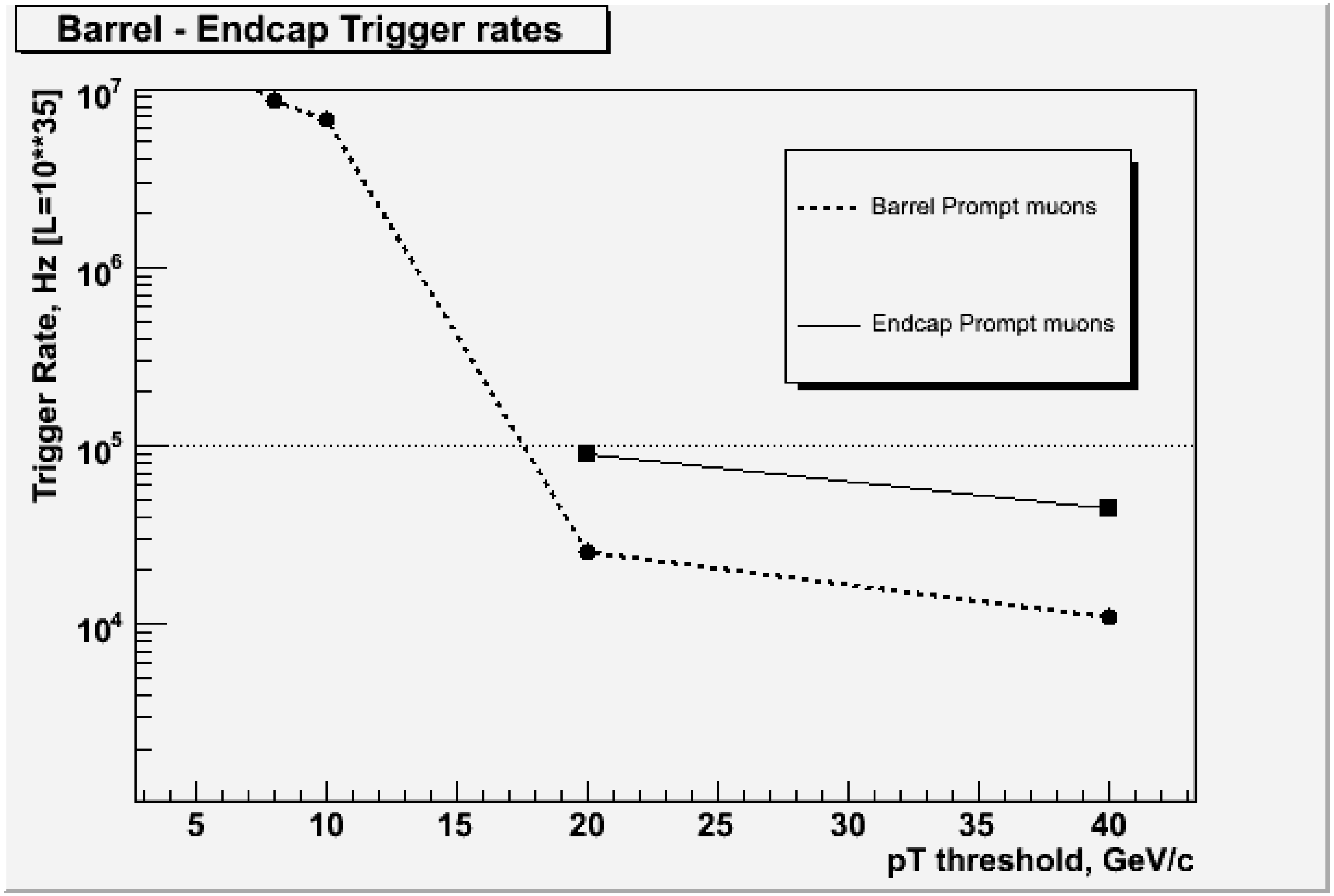
Already L=10E34 background rates are 100HZ/cm2.**

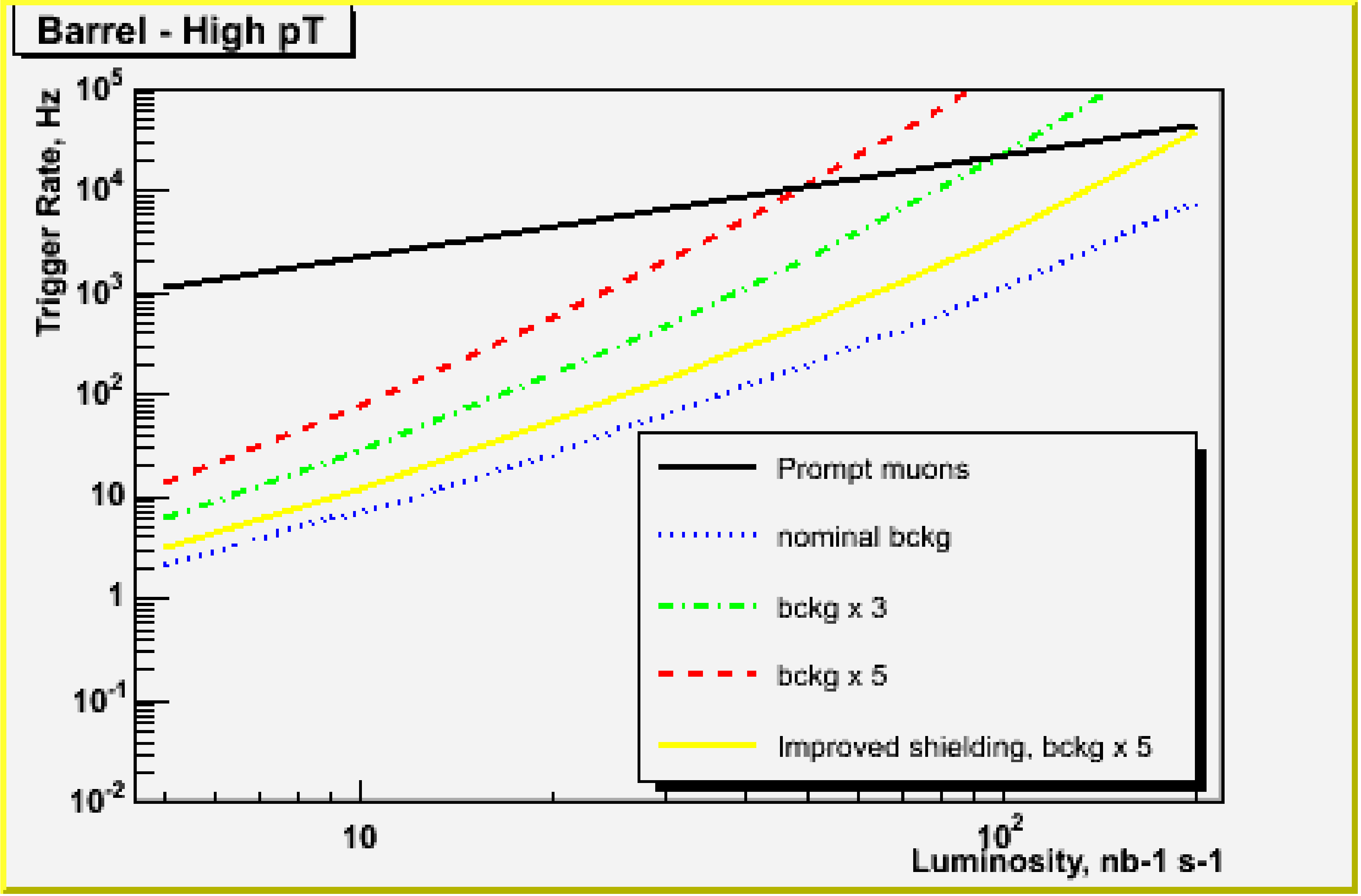
At factor 10 L, expects 600, without safety factor.

LV-1 MUON Trigger



- The MUON trigger philosophy is based on opening a cone (which defines a given p(t) threshold) around a point in a pivot plane (that contains non-overlapping geometry).
- The barrel includes a a 3-out-of-4 trigger logic for low p(t), combined with a 1-out-of-2 confirmation logic for high p(t)
- The end-cap requires a 3-out-of-4 logic combined with a 2-out-of-3 logic in the inner layer. The low p(t) is obtained by a non-linear combination in the inner layer, while linear for the high p(t)
- The end-cap has a more robust logic, due to the higher background conditions, combined with the fact that the stations are located in a non-magnetic region.


Barrel - Endcap Trigger rates
Trigger Rate, Hz [L=10**35]
10^7
10^6
10^5
10^4
5
10
15
20
25
30
35
40
pT threshold, GeV/c
Barrel Prompt muons
Endcap Prompt muons

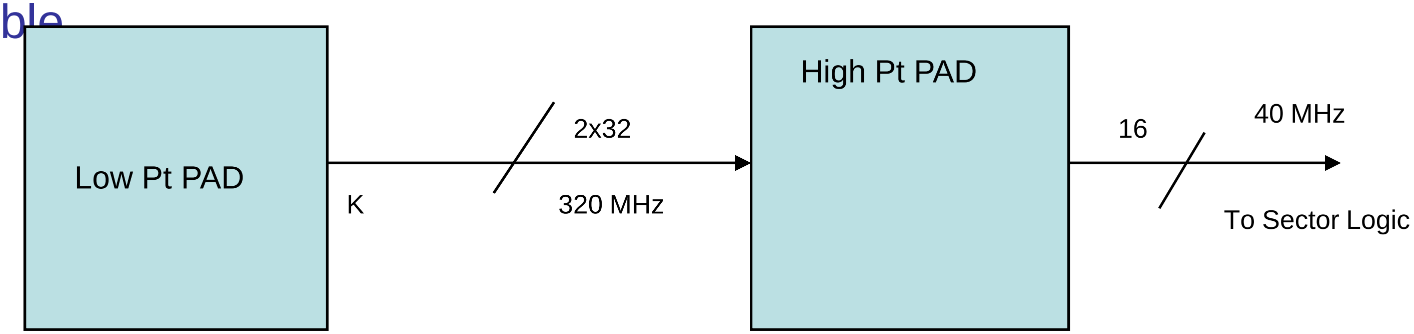


Trigger rates from proton rates are neglected

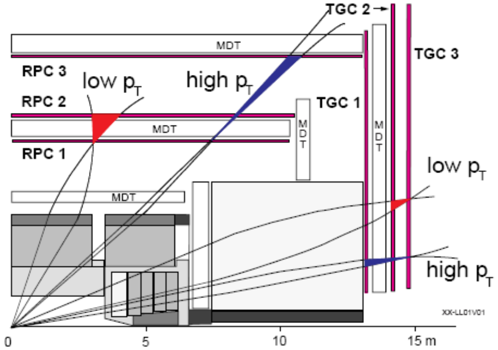
Main issue is the assumptions on the safety factor needed

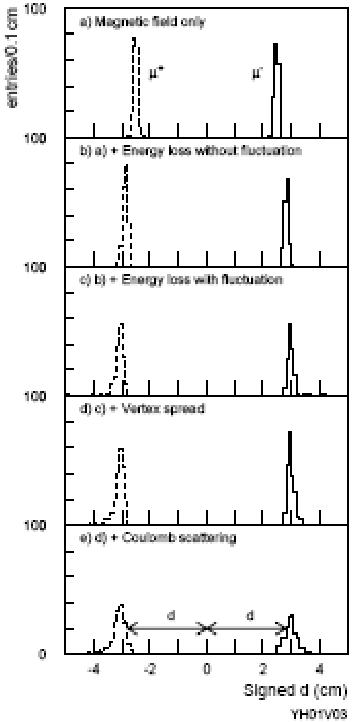
Electronics needs for the Barrel trigger

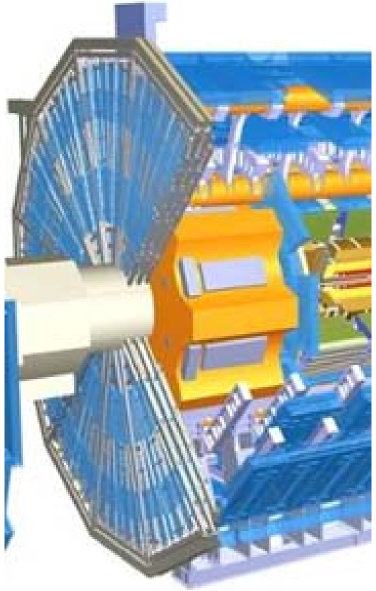
- The present CMA trigger chip works internally at 8 times the machine frequency F0x8 through a time interpolator
- The interpolator is locked to the BC frequency. If the BC period will be doubled (as in the case of 50 ns period) also the interpolator period will double and the chip will continue working properly
- The delay chips used in the PAD mother board have a delay adjustment shorter than 50 ns. This means that some rework of the PADs must be done
- In the case that aditional coincidences are needed, due to highaccidentals, provision has been made to include last calorimeter layer in the trigger.
- Present FPGA could suffer from a high level of Sigle event Upset and might need to be replaced. This can only be evaluated when LHC data becomes available

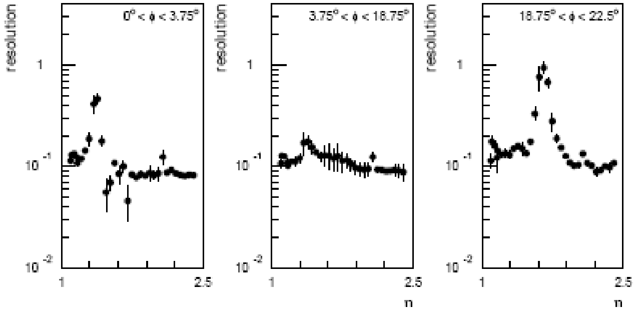


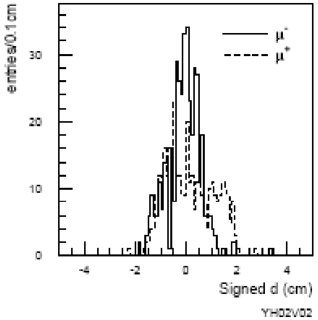
Problems with the integrated magnetic field

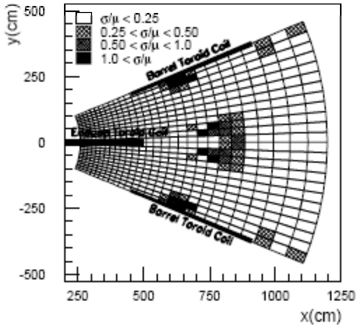






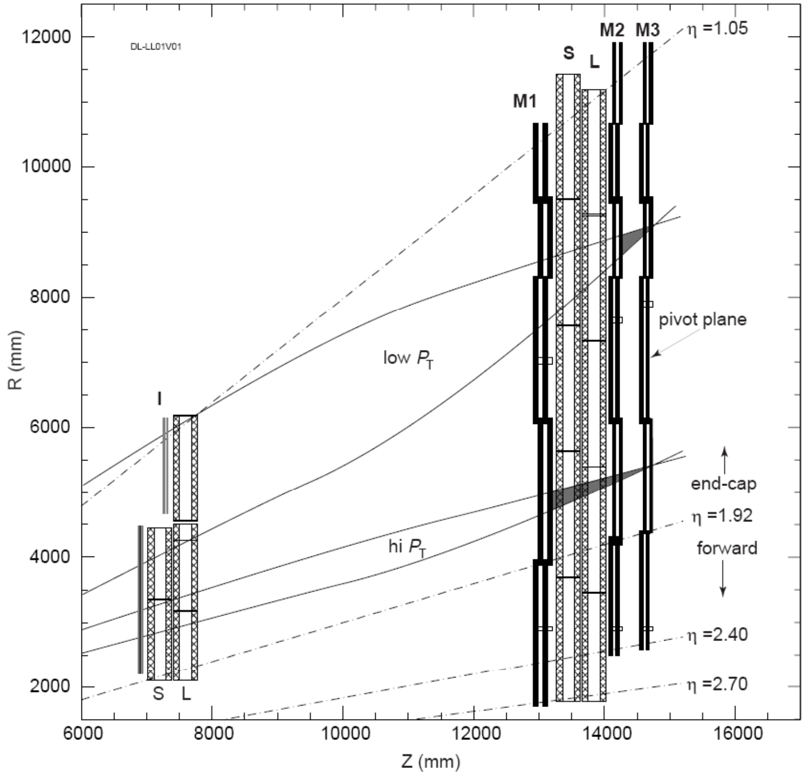


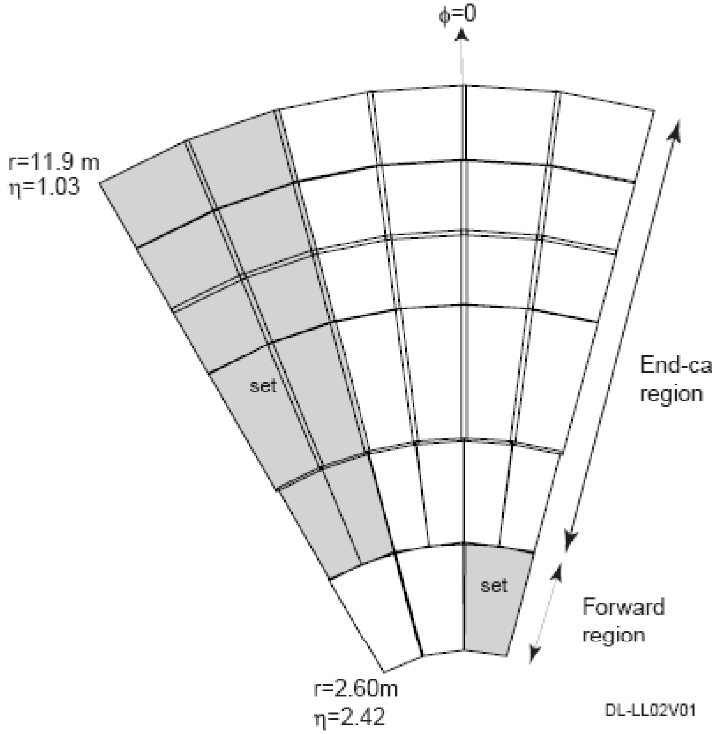




- The cone includes the both charges, they do not need to be symmetric and can be programmed.
- Due to the interference between the magnetic fields of the barrel and end-cap toroids, there are points were the integrated magnetic field is small. This can be solved either by masking these points or by taking the data and corrected at the LV-2, using the tracking chambers.
- For SLHC, one would have to implement new trigger chambers in the region where the field changes direction and include them in the corresponding trigger logic for the LV1.
- One would also have to include the innermost trigger chambers in the trigger logic (this would also be possible at the start of LHC, however the detail arrangement of these chambers might have to change for the SLHC).

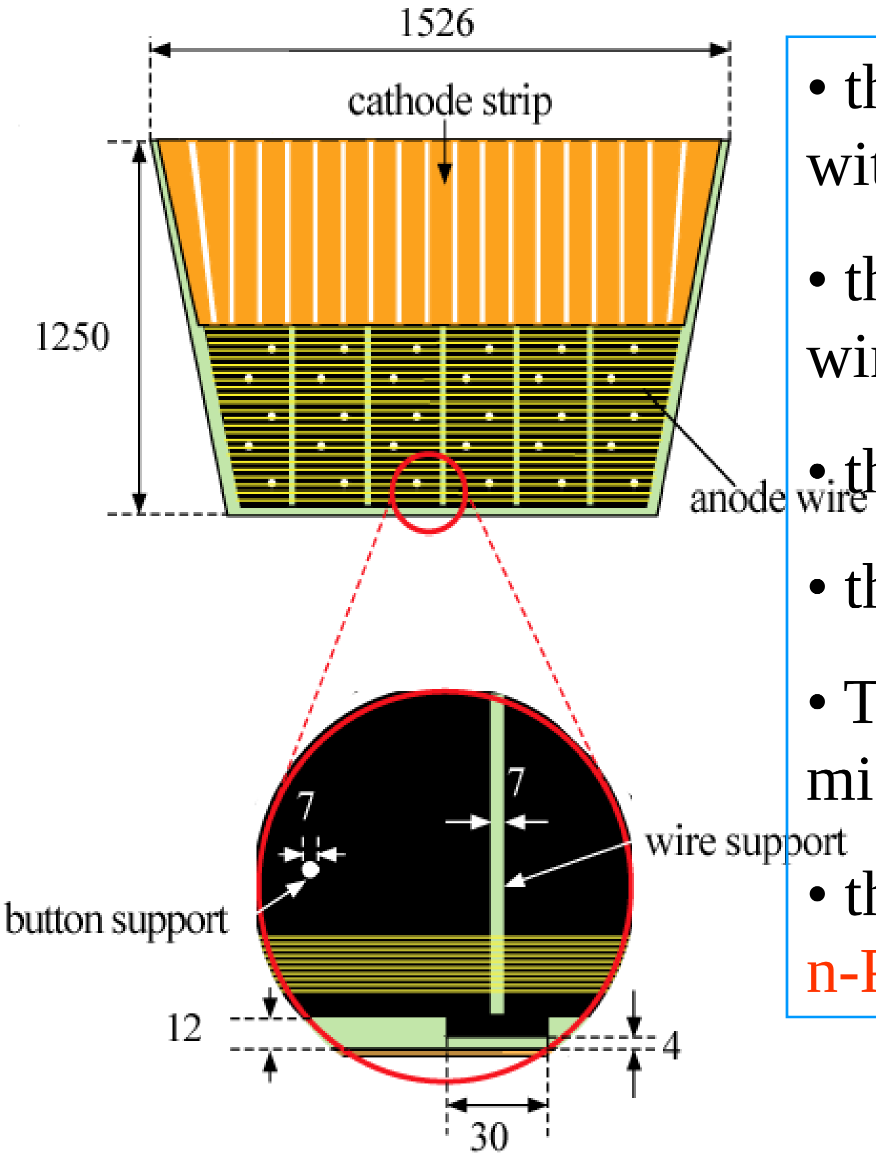
EI and forward region have independent services





- It could be relatively easy to exchange forward chambers, since their logic and services are independent.
- For the Forward component of the Big-Wheels (BW), the present technology, with some modifications would be able to cope with the increase in rates.
- The innermost layer (Small Wheels, SW) chambers will most likely have to be modified by either include a combination of trigger and tracking chambers (with additional n-shielding) or to keep separated functions with a new tracking device (smaller diameter tubes or micromegas) and TGC’s optimized for higher rates with an additional pad readout to solve ambiguities.
- For both regions SW and forward BW, new front-end electronics compatible with the higher radiation levels will have to be developed.

the basic property of TGC （ Thin Gap Chamber)



- the basic structure is like MWPC with graphite cathode
- the signal is read from both anode wires and cathode strips
- the gap between a / c is 1.4 mm
- the wire spacing is 1.8 mm
- The diameter of tungsten wire is 50 micron
- the gas is a mixture of CO2 and n-Pentane (55 : 45)

Structure and limitations

- TGC’s operate in a quasi saturated mode, however:
  - Saturation=high gain, shorter lifetime
  - Non-saturated=smaller gain, but longer lifetime (tested up to 1.4C/cm).
- Graphite cathode has advantages, but also disadvantages:
  - Uniform electric field, while any readout geometry can be used.
  - Sparks will not damage the detector.
  - Transparency will depend on graphite resistivity, and therefore size of clusters in strips (typically for ATLA 1M-Ohm/square for low rapidity, going to 0.5M-Ohm above rapidity of 1.7).
  - Resistivity limits your rate capability; you can have very high local rate capabilities 1 MHz/cm**2, but not on large areas.
  - With 1M-Ohm you can have a uniform 3KHz/cm**2 and double that for 0.5M-Ohm.

TGC has inherent high rate capabilities

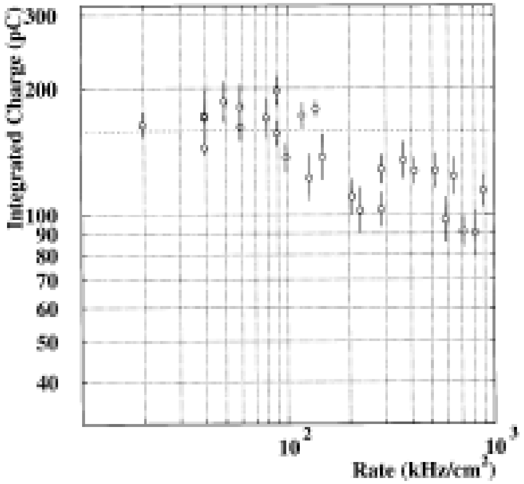


Fig. 4. The TGC gain as a function of the single hit rate for anode signals. The error bars show only statistical errors. The dashed line is the gain for the case of no background. The gain is constant up to 100 kHz/cm².

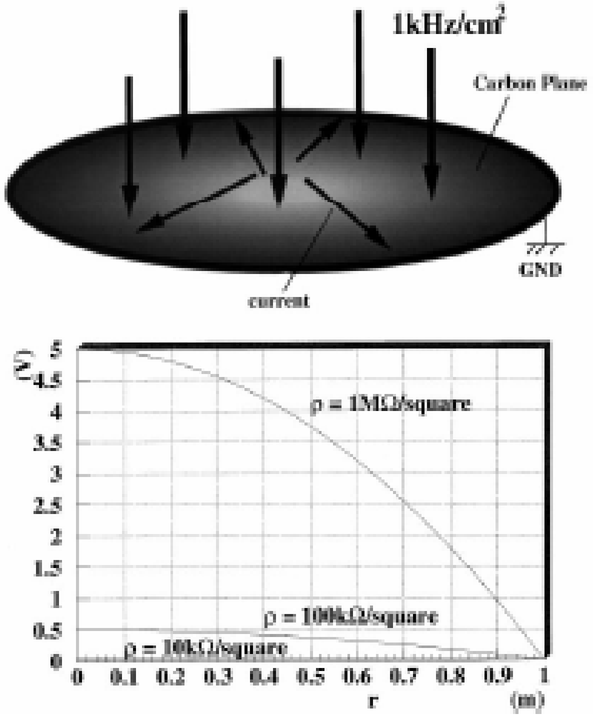
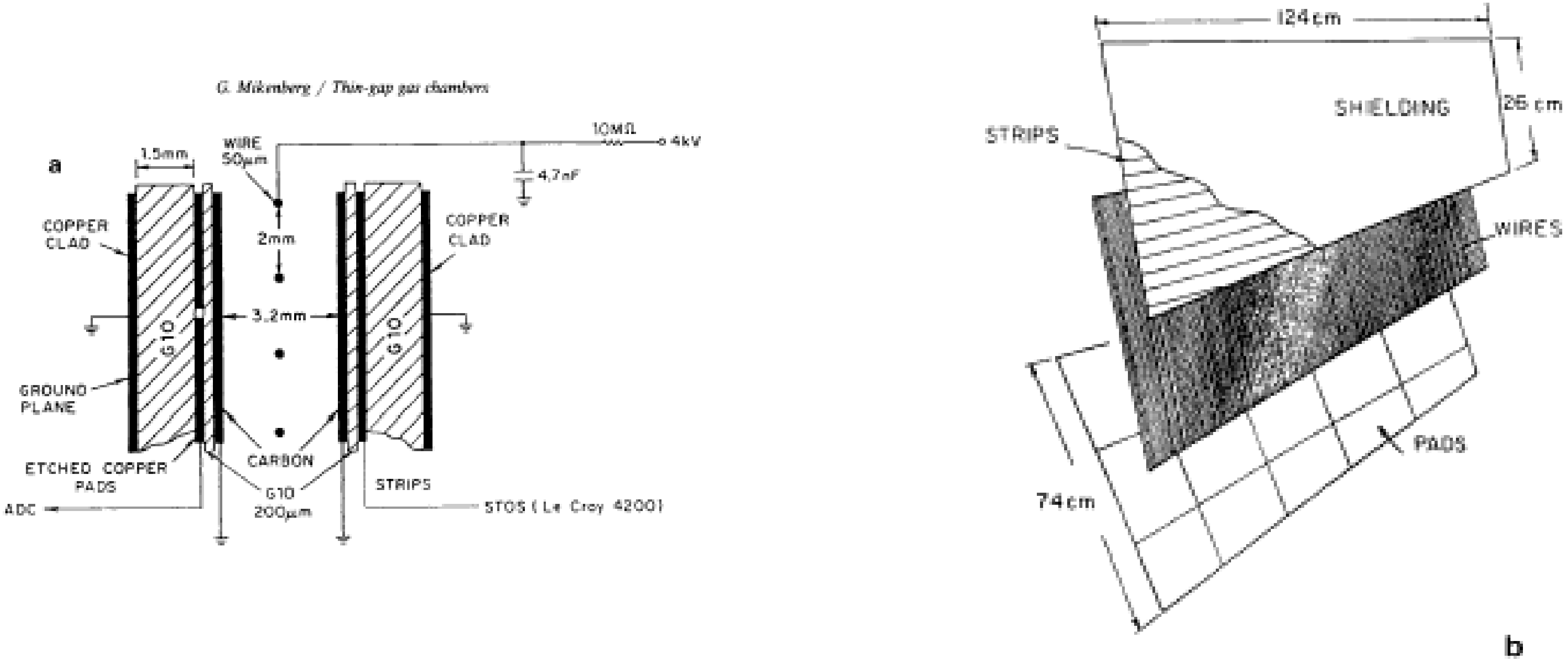


Fig. 5. The voltage on the cathode plane in the case of the existence of the background. The top figure is the conception of the calculation. The bottom figure shows the voltage on the cathode plane along the radius direction.

- Going to low resistivity cathodes (10K-Ohm/square, like in OPAL) would give a rate capability on large surface of up to 100KHz/cm**2.

Go back to OPAL



- In OPAL the cathode strips/pads were separated by 200microns from the graphite, allowing to operate with a graphite resistivity of 10K-Ohms/square.
- One could include 3 different coordinates with bunch ID (small drift time).
- In various prototypes with narrow strips, position resolutions of 80-100microns have been achieved, without any major optimization.

Conclusions

- The needed modifications to the trigger electronics will depend very strongly on the safety factors that one will be able to measure at the start of the LHC.
- Some changes might be needed for the trigger logic elements of the barrel, depending on the SEU behavior of some components.
- The End-Caps will need the development of more radiation tolerant front-end electronics in some limited regions (SW and Forward BW).
- Some additional chambers (and corresponding modifications of the High-Pt trigger logic) might be needed to cope with the small regions with non-uniform magnetic field.