What ALICE requires and provides for background optimization

Andreas Morsch

Workshop on Experimental Conditions and Beam Induced Detector Backgrounds

CERN 4/4/2008

ALICE Running Strategy

- Initial heavy ion program
  - Pb-Pb physics pilot run
  - 1-2 years Pb-Pb
  - 1 year pPb like collisions (pPb, dPb or αPb)
  - 1-2 years Ar-Ar
- Regular pp runs at $\sqrt{s}$ = 14 TeV
  - Absolutely needed as reference for Pb-Pb analysis
  - Luminosity (10^{29}- 3 x 10^{30}) cm^{-2} s^{-1}
  - Ideal 10^{29} cm^{-2} s^{-1} no event overlapping within the TPC drift time
  - 200 kHz rate limit translates to 3 x 10^{30} cm^{-2} s^{-1}

See for example LHC-B-ES-0007

Planned collisions vs background

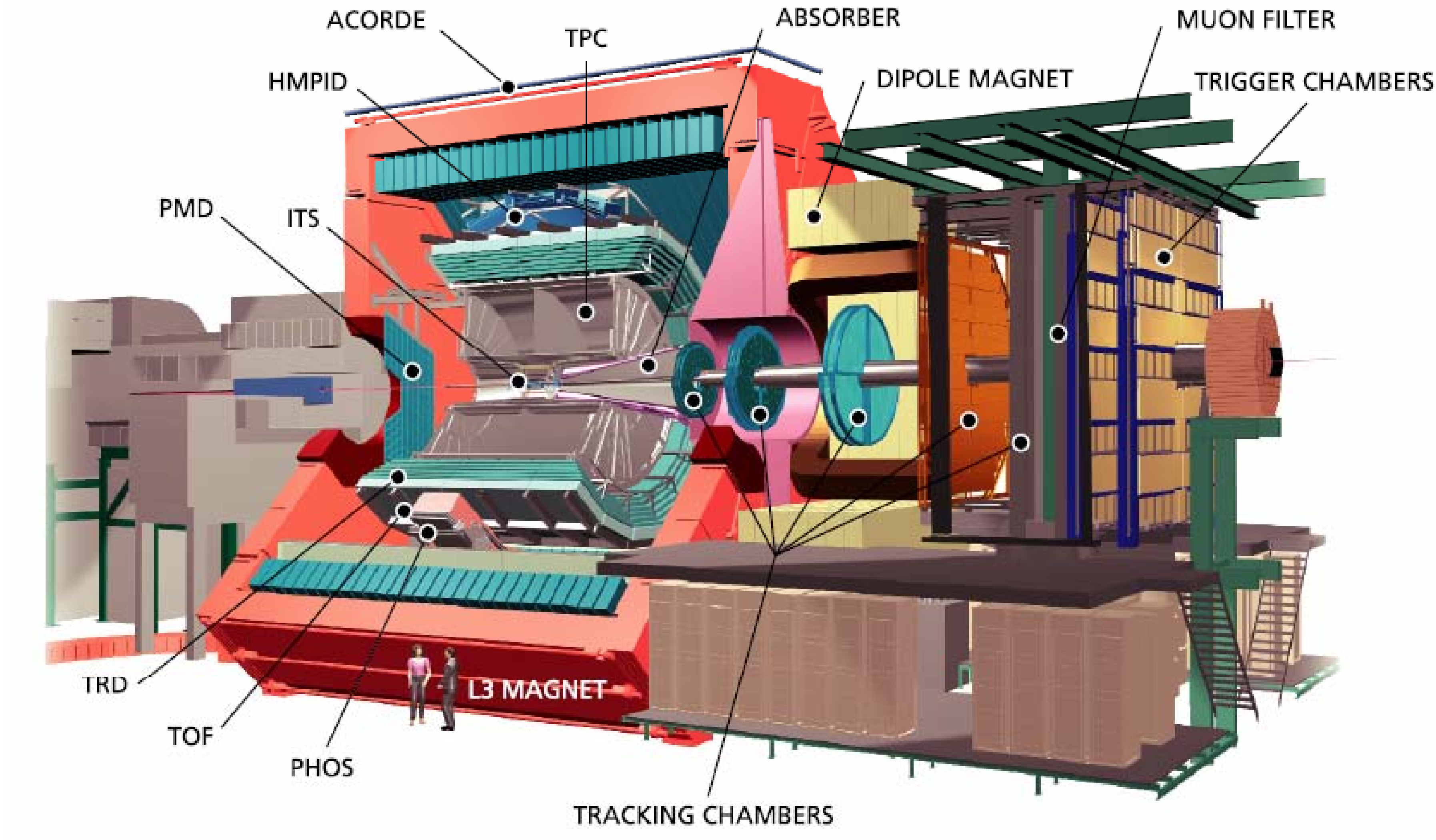
- ALICE has the most unfavorable Luminosity/Background ratio
  - At least factor of 1000 less than high luminosity experiments. But also
    - Typical trigger rejection factor $\mathcal{O}(1000)$
    - ALICE has been designed to perform tracking for 1000 times the pp multiplicity
    - So far main effects of background are integral effects
      - Integrated dose, neutron fluence
      - Aging
      - Event size
        - Mass media
        - Combinatorics = computing time

Background sources considered

- Secondaries from planned collisions
- Beam-gas within experimental region
- Beam halo from beam-gas scattering (V. Talanov)
- Need input for quartiary halo which might well be the dominant source.
  - What is the interaction rate in the inner triplet without collimation ?
  - For standard collimation scheme including all sources ?
- Need system optimisation including all machine background sources.
  - Optimize running conditions for the LHC physics program.
  - One should not try to minimize the simple sum of the backgrounds in the experiments, but take also into account background/luminosity ratio.

Size: 16 x 26 meters
Weight: 10,000 tons

Solenoid Magnet: 0.5 T
Dipole Magnet: 3 Tm



Running Scenario

Table 1: Operational scenario for a ten year running period ($< L >$ stands for mean luminosity, σ_t for inelastic cross section and $\sqrt{s_{NN}}$ for centre of mass energy.)

	pp	pPb	ArAr	ArAr	PbPb
$< L >$ [$cm^{-2}s^{-1}$]	$3.0 \cdot 10^{30}$	$1.0 \cdot 10^{29}$	$3.0 \cdot 10^{27}$	$1.0 \cdot 10^{29}$	$1 \cdot 10^{27}$
σ_t[mb]	70	1900	3000	3000	8000
Rate [s^{-1}]	$2.0 \cdot 10^{5}$	$2.0 \cdot 10^{5}$	$9.0 \cdot 10^{3}$	$3.0 \cdot 10^{5}$	$8.0 \cdot 10^{3}$
Runtime [s]	$1.0 \cdot 10^{8}$	$2.0 \cdot 10^{6}$	$1.0 \cdot 10^{6}$	$2.0 \cdot 10^{6}$	$5.0 \cdot 10^{6}$
Events	$2.0 \cdot 10^{13}$	$4.0 \cdot 10^{11}$	$9.0 \cdot 10^{9}$	$6.0 \cdot 10^{11}$	$4.0 \cdot 10^{10}$
$\sqrt{s_{NN}}$ [TeV/n]	14	8.8	6.3	6.3	5.6
N/event	100	300	2400	2400	14200
N/10 y	$2.1 \cdot 10^{15}$	$1.2 \cdot 10^{14}$	$2.2 \cdot 10^{13}$	$1.4 \cdot 10^{15}$	$5.7 \cdot 10^{14}$

pp dominates

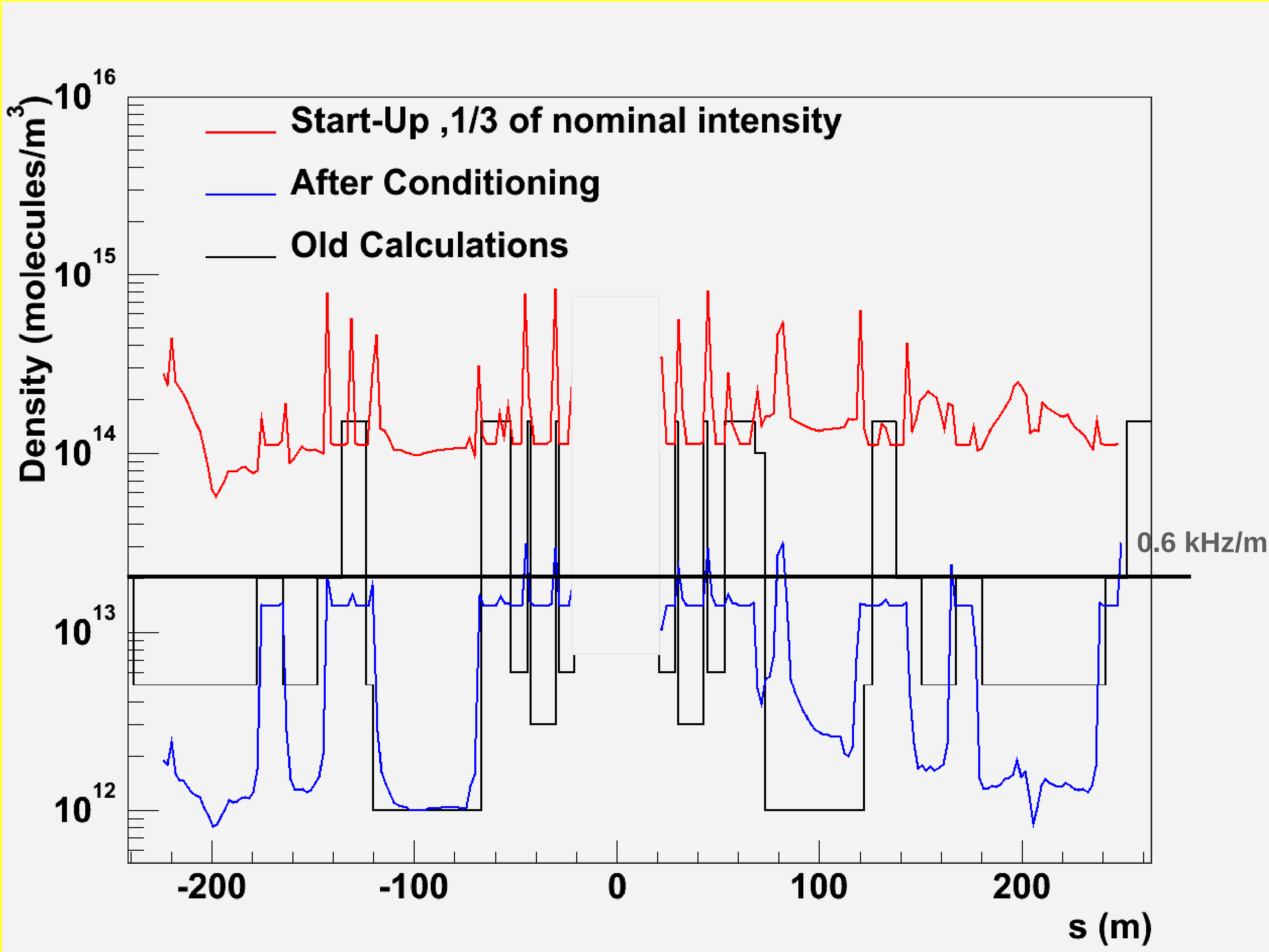
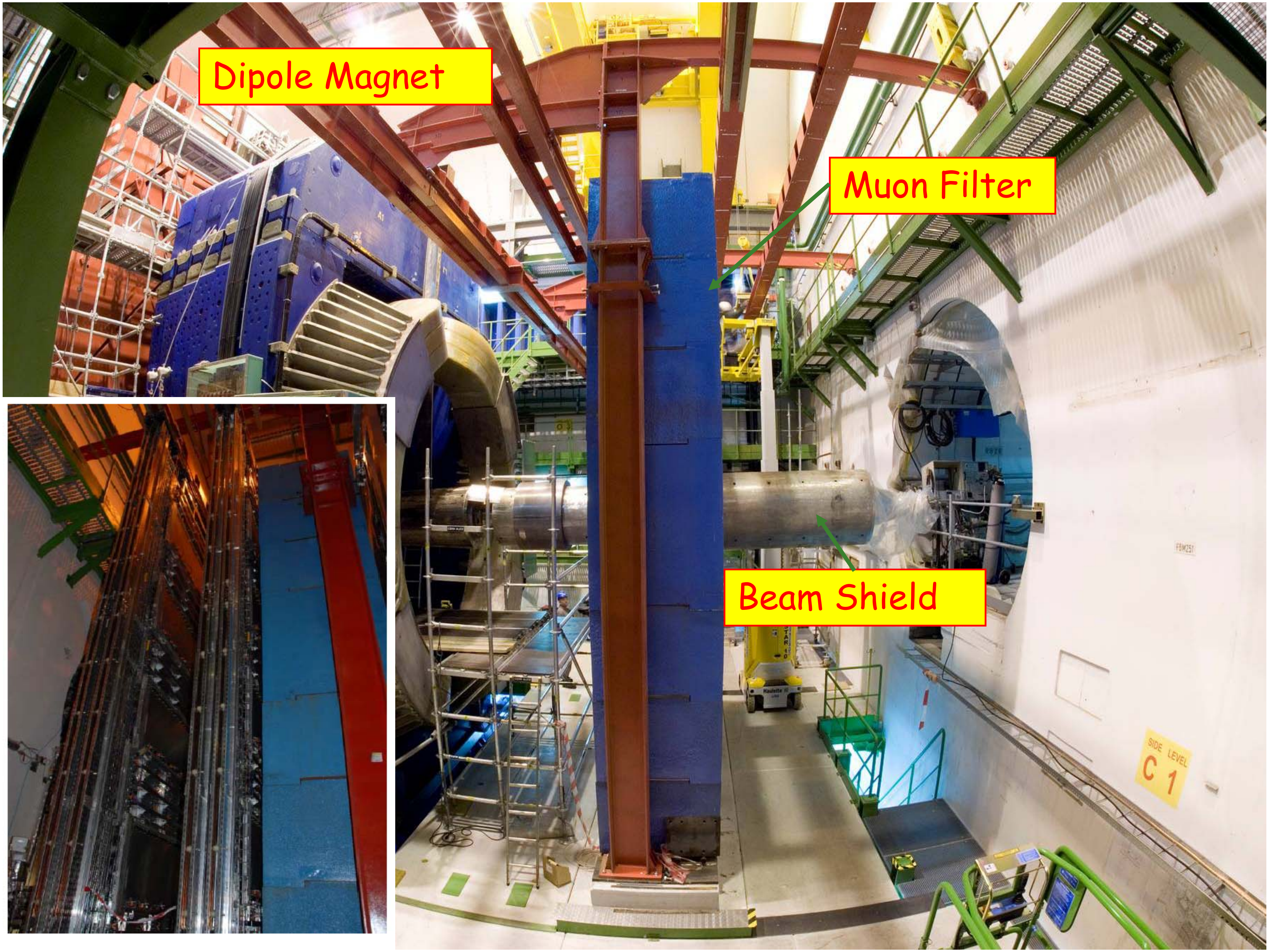

Start-Up ,1/3 of nominal intensity
After Conditioning
Old Calculations
0.6 kHz/m
Density (molecules/m^3)
10^{16}
10^{15}
10^{14}
10^{13}
10^{12}
-200
-100
0
100
200
s (m)

Table 4: Doses in mid-rapidity detectors.

Detector	Dose [Gy] IP Collisions	Dose [Gy] Beam-Gas	Dose [Gy] Halo	Dose [Gy] Total
SPD1	2000	250	500	2750
SPD2	510	48	120	680
SDD1	190	12	45	250
SDD2	100	2.4	13	120
SSD1	40	1.2	7	50
SSD2	26	0.6	2.5	30

Very conservative
10^{13} $H_2^{equiv.}/m^3$

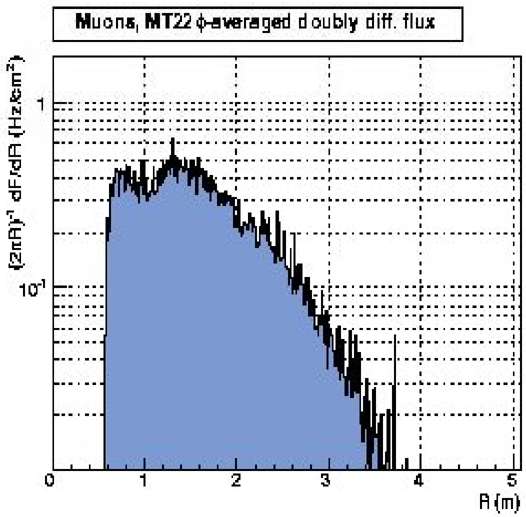
Only halo from beam gas
No quartiary halo

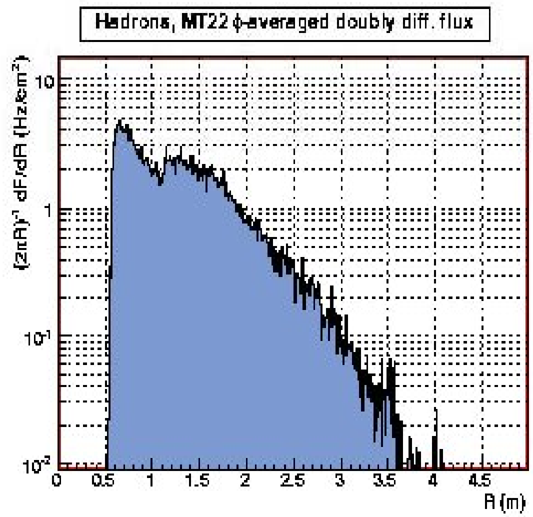

Dipole Magnet
Muon Filter
Beam Shield

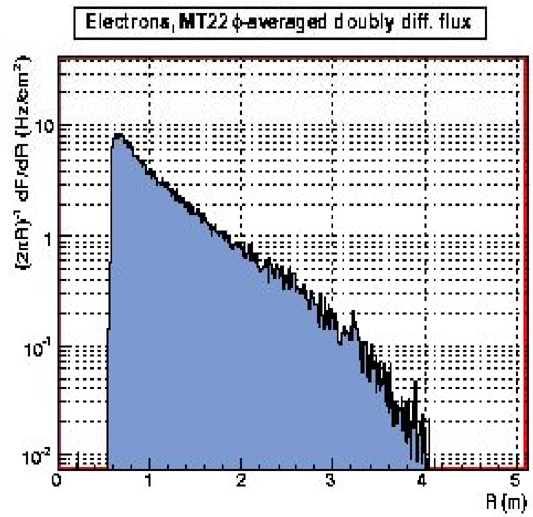
Fluxes on MT22

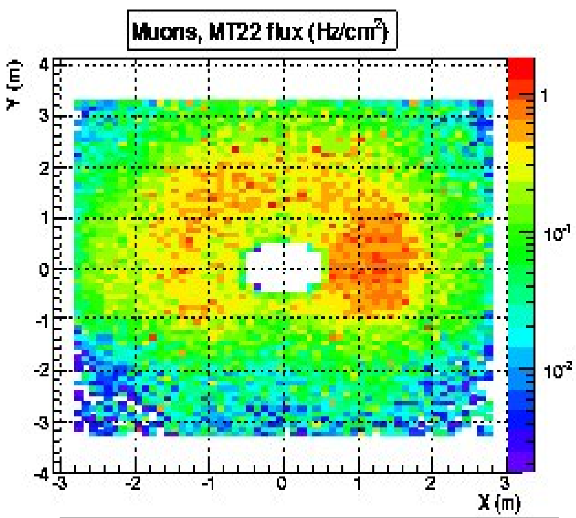
X-Y coordinates (Hz./cm²)

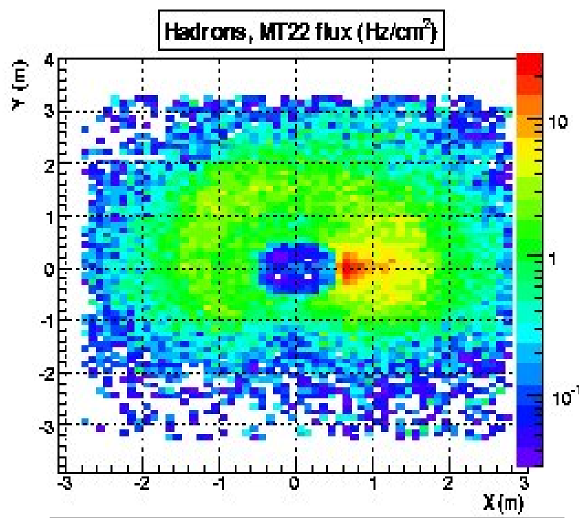
MUONS ***HADRONS*** ***ELECTRONS***

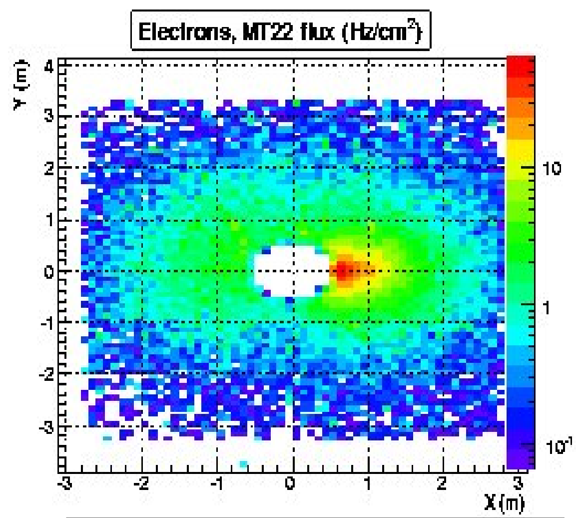










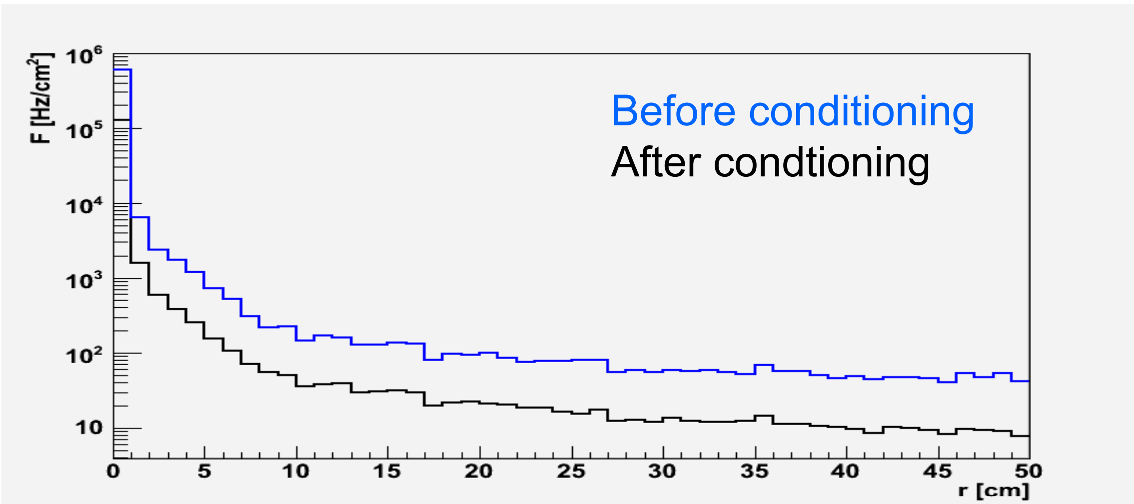


Hot spot max. ~ 1 Hz/cm²

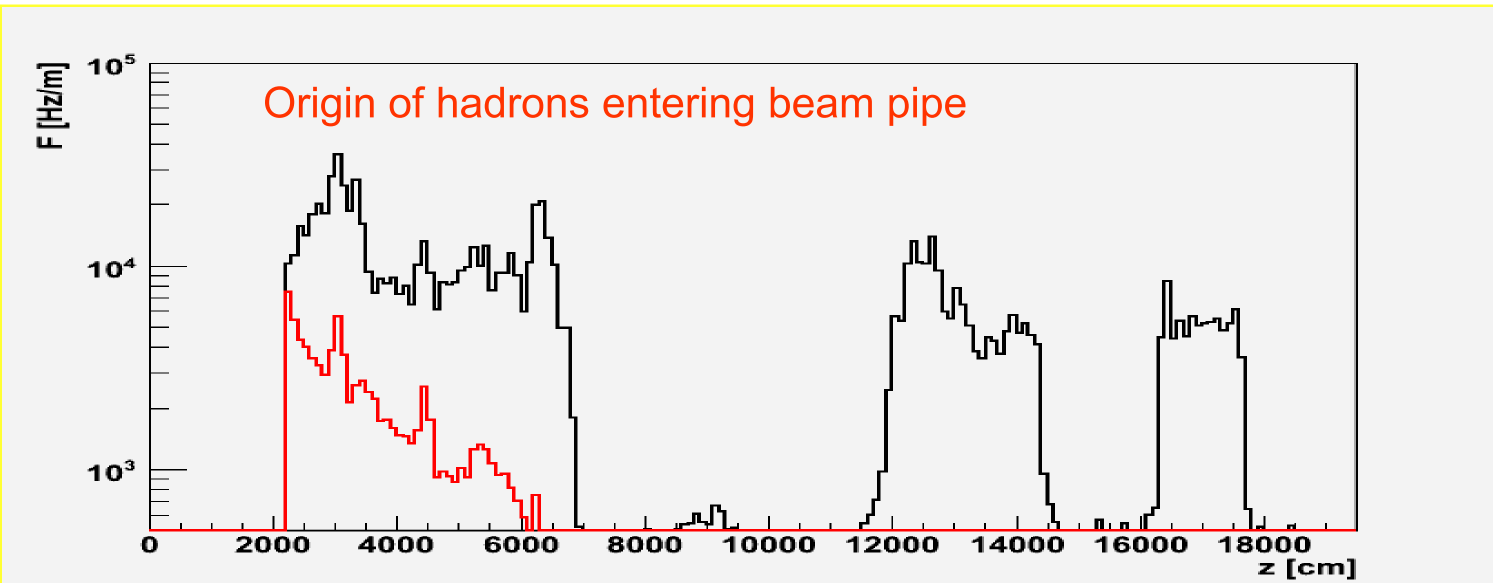
Hot spot max. ~ 20 Hz/cm²

Hot spot max. ~ 60 Hz/cm²

Beam halo

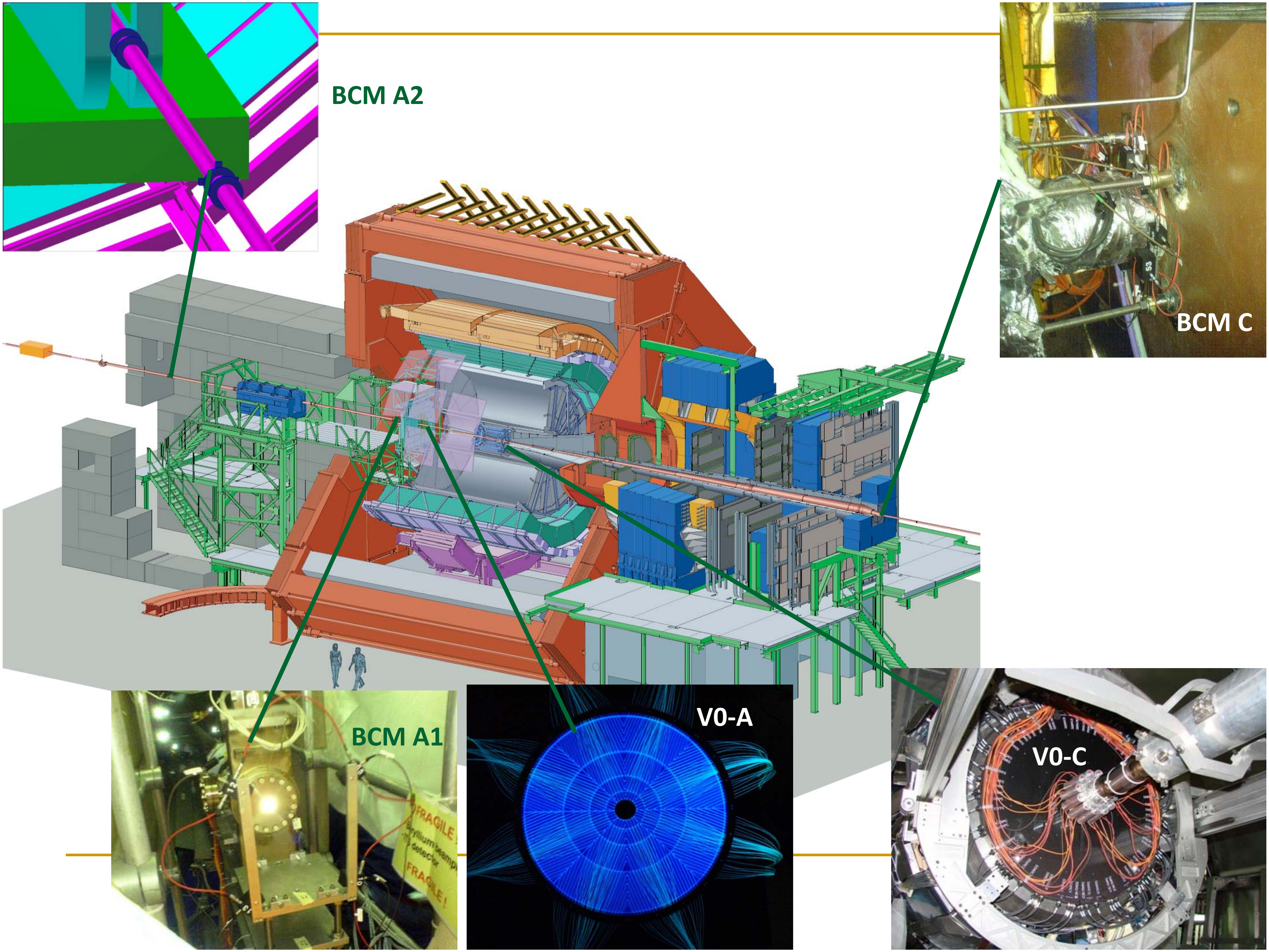


Flux of high-energy hadrons entering the beam pipe compatible with beam-gas interaction rate.



Background monitoring

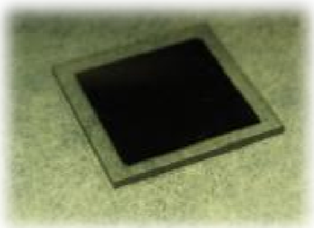
- During Injection: BCM + V0 at safe PM setting (OR of the two signals, due to different coverage of space surrounding beam pipe)
- With circulating (stable) beams: combination of BCM, V0, SPD, TPC, μ-arm.


BCM A2
BCM C
BCM A1
V0-A
V0-C

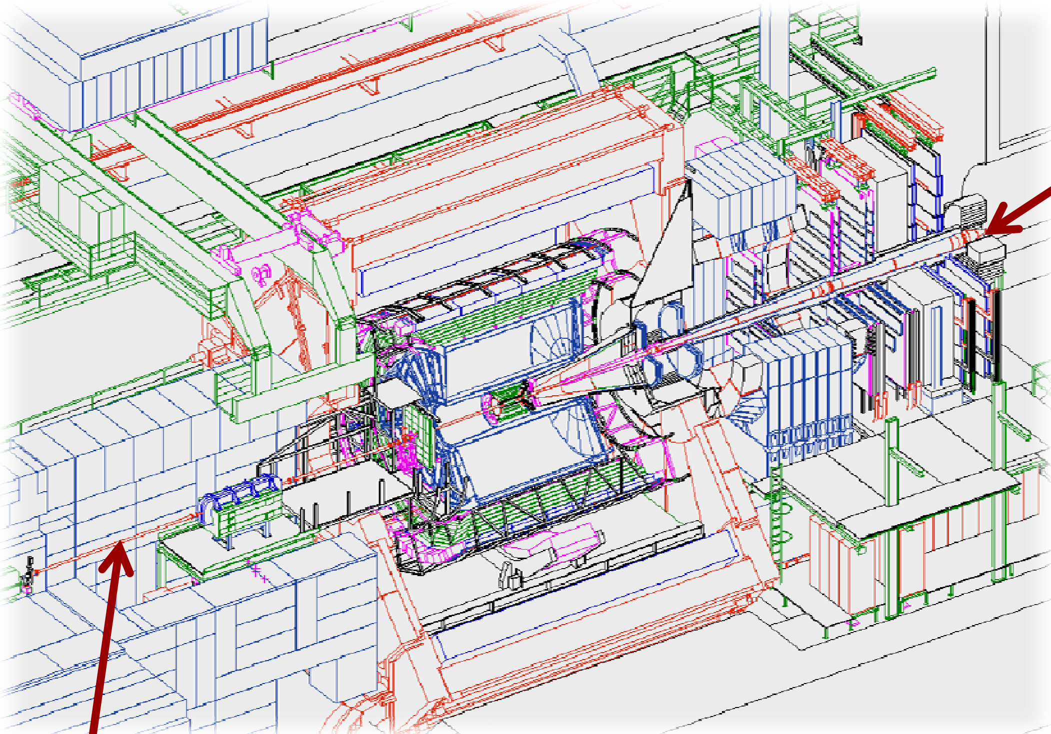
ALICE BCM

Concept

- Detection of adverse beam conditions within the ALICE experimental region
- Active protection of detectors (in particular the ITS) against multi-turn beam failures (time between occurrence of a critical situation and complete extraction of the beam 200 – 290 μs)
- Based on pCVD diamond sensors (1 cm^2 x 500 μm)
- Design copied from the **LHCb BCM**.

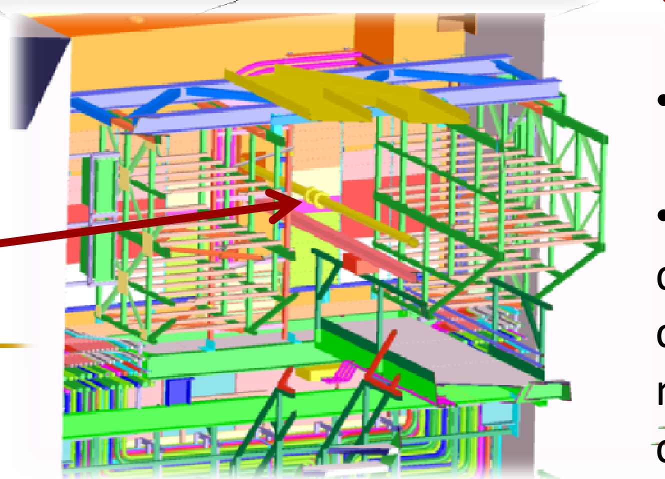


Locations



BCM C
behind last muon absorber
(z = -19.1 m)

BCM A
between Compensator Magnet and Low β shielding
(z=+15.6 m)



Why these locations?

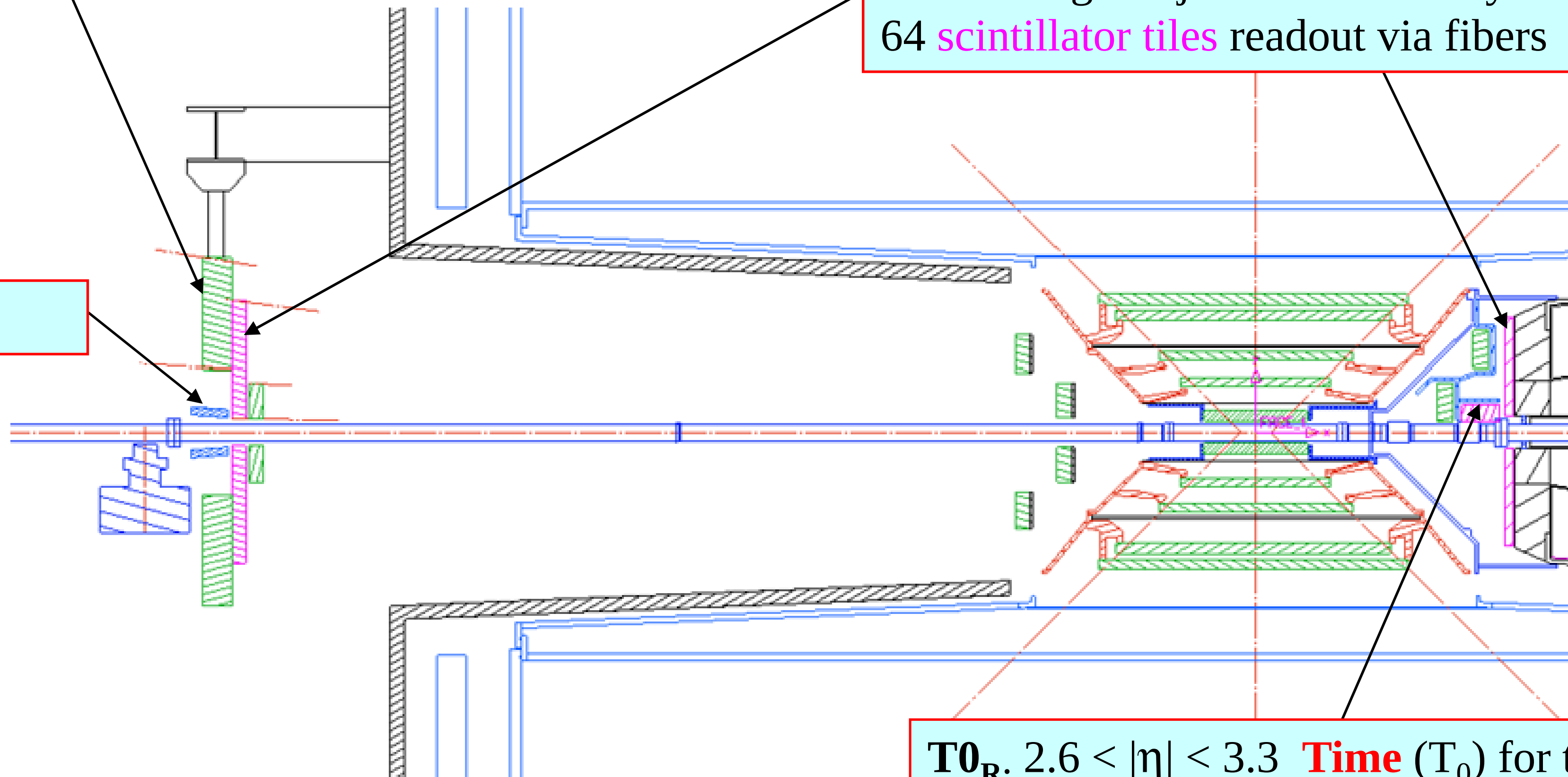
- no other space left on muon arm side
- expect signals due to pp collisions and due to background events (beam-gas collisions in the experimental region, machine induced background) to be of comparable intensity

Forward Detectors

PMD **Pre-shower** detector 2.3 < η < 3.5, $N_{charged}$ and $N_{photons}$ **(DCC's)**

V0 1.6 < |η| < 3.9 **Interaction** trigger (beam-gas rejection), centrality trigger and beam-gas rejection. Two arrays of 64 scintillator tiles readout via fibers

$T0_L$



$T0_{R:}$ 2.6 < |η| < 3.3 **Time** (T_0) for the TOF (~ 50 ps time res.) Two arrays of 12 quartz counters. Also backup to V0

Summary

- ALICE will participate in standard pp runs
and at reduced luminosity (3 10^{30} cm^{-2} s^{-1})
- Quartiary halo is a concern since it might represent the largest background source.
  - At full intensity ALICE will run at β^* = 10 m. The inner triplet does not represent a limiting aperture.
  - See no reason for tertiary collimation with stable beams.
- Special BCMs and ALICE forward detectors are used for background monitoring.