Machine-Induced Background in the Forward Experiments

TOTEM
ATLAS ALFA
LHCf
FP420

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CERN PH-TOT

with contributions from
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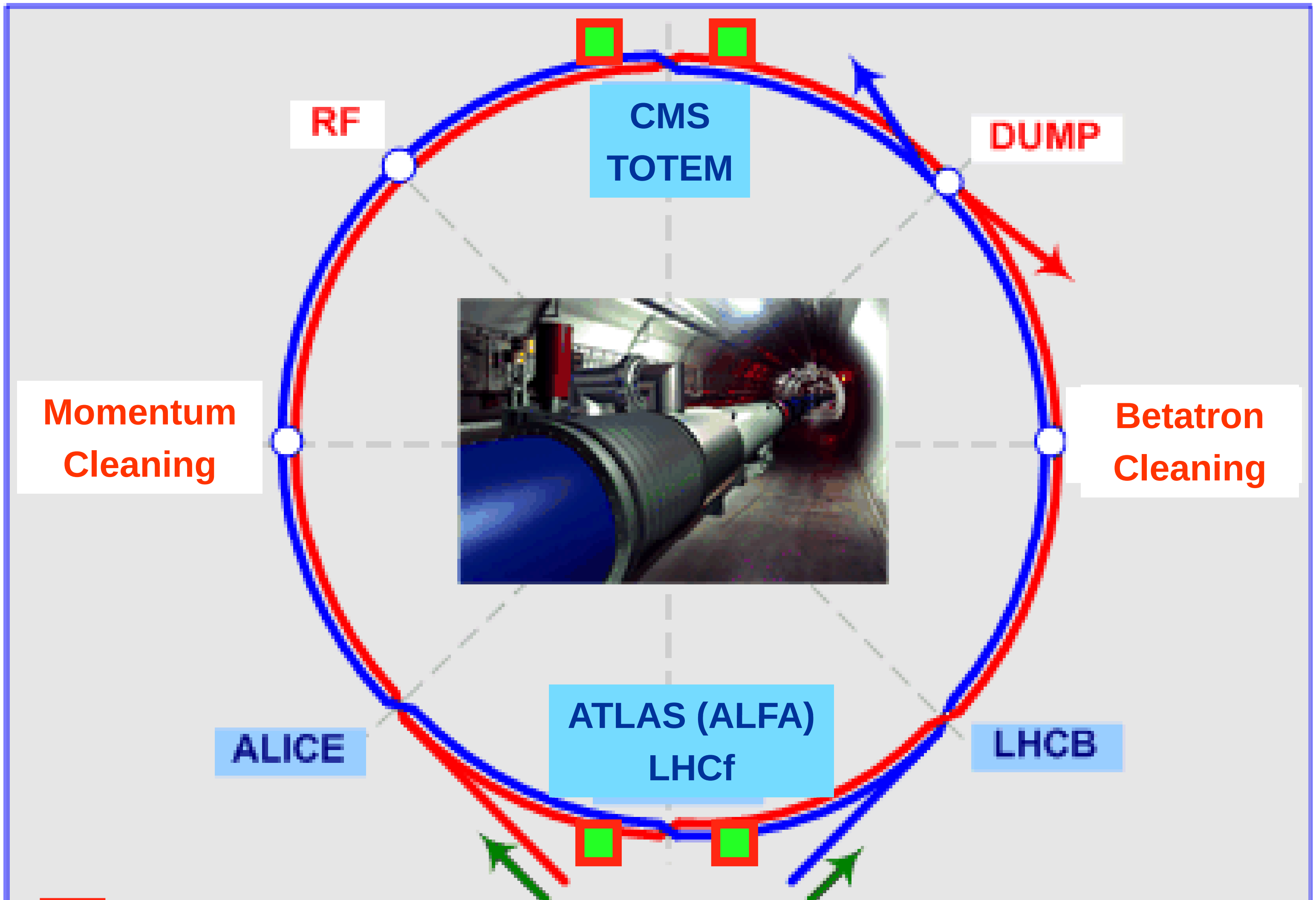
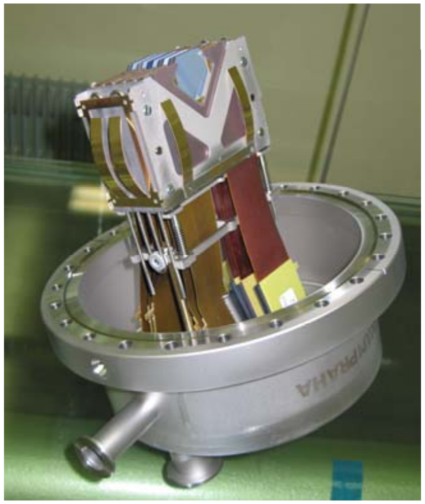
The Experiments

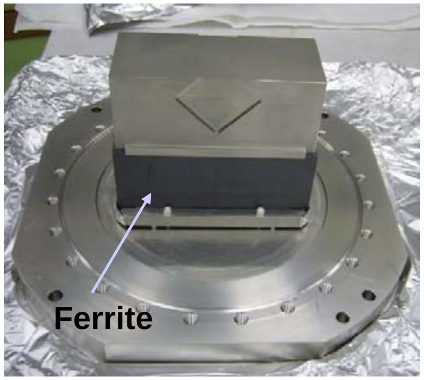


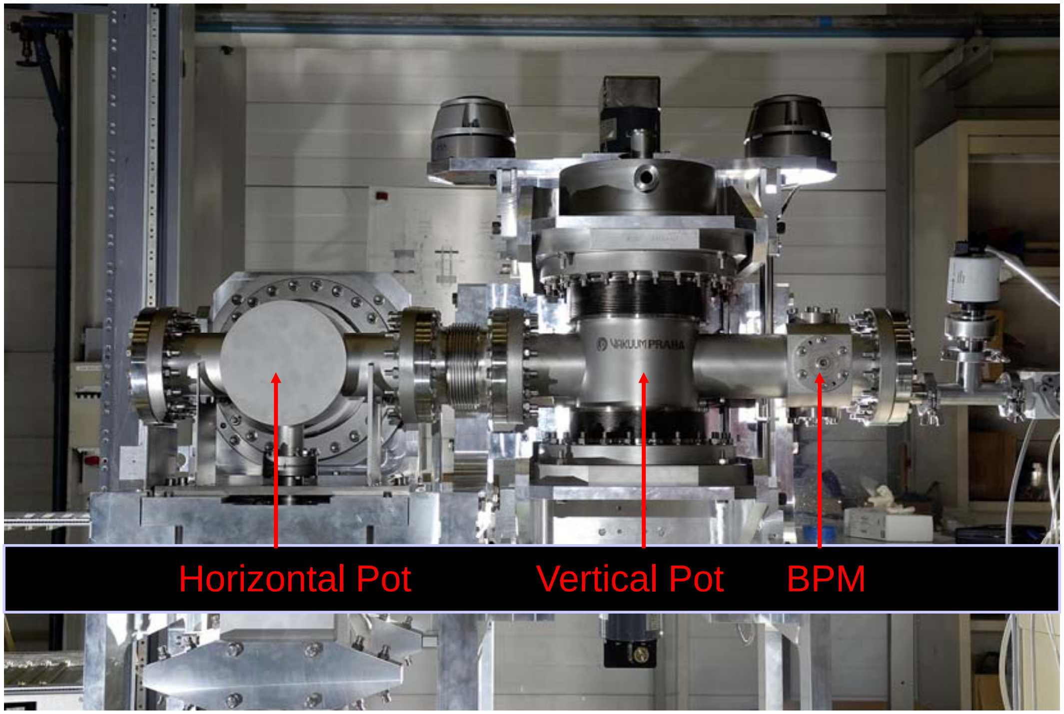
= **FP420** detectors at about 420 meters around ATLAS and CMS

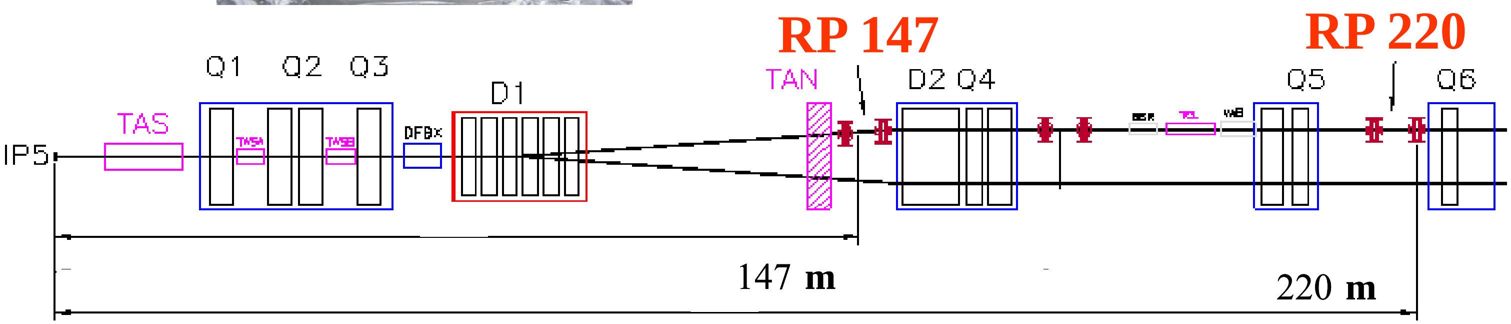
The Experiments: TOTEM

Hybrid with "edgeless" Si detector





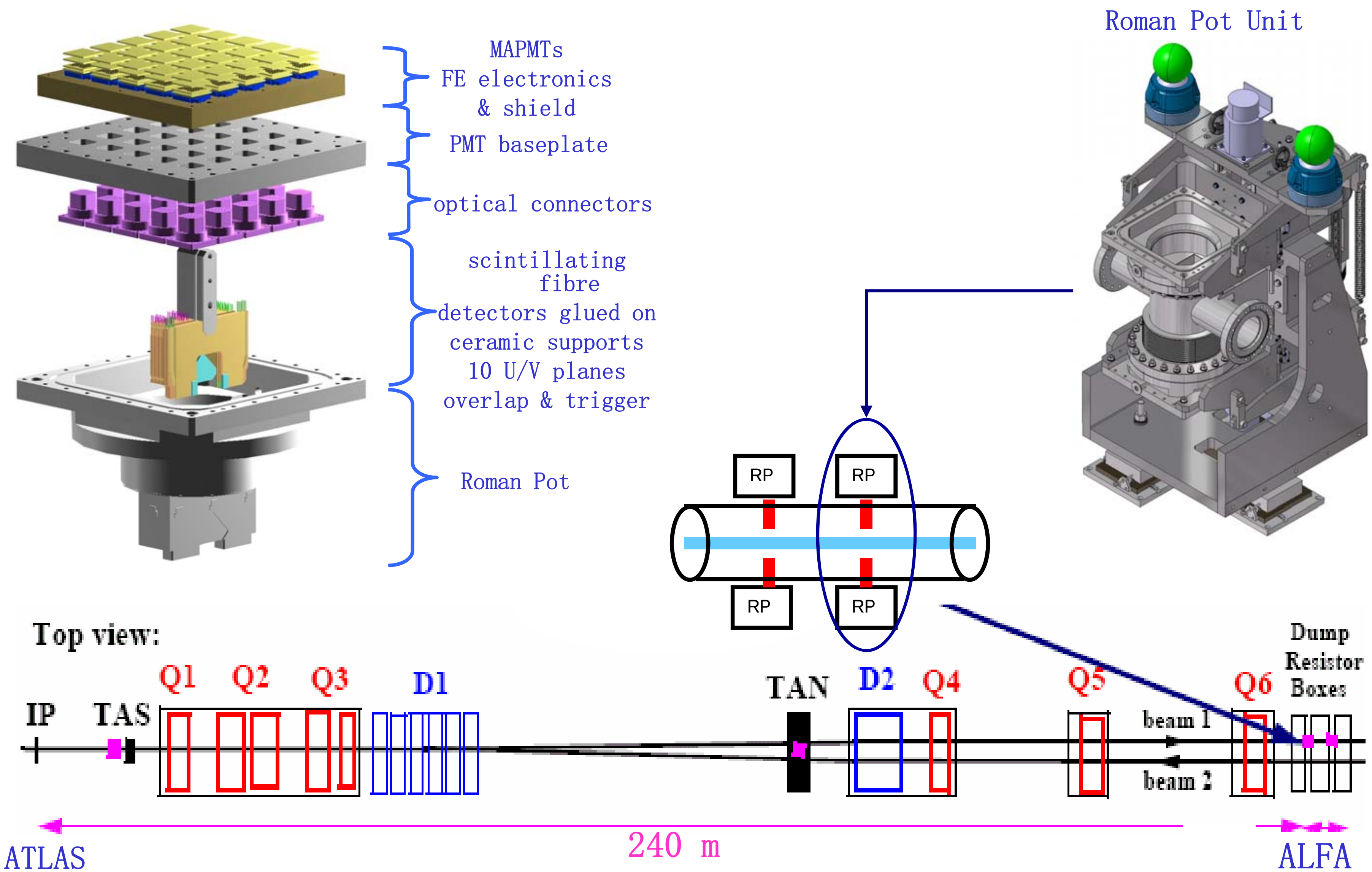




Same configuration on the other side of IP5

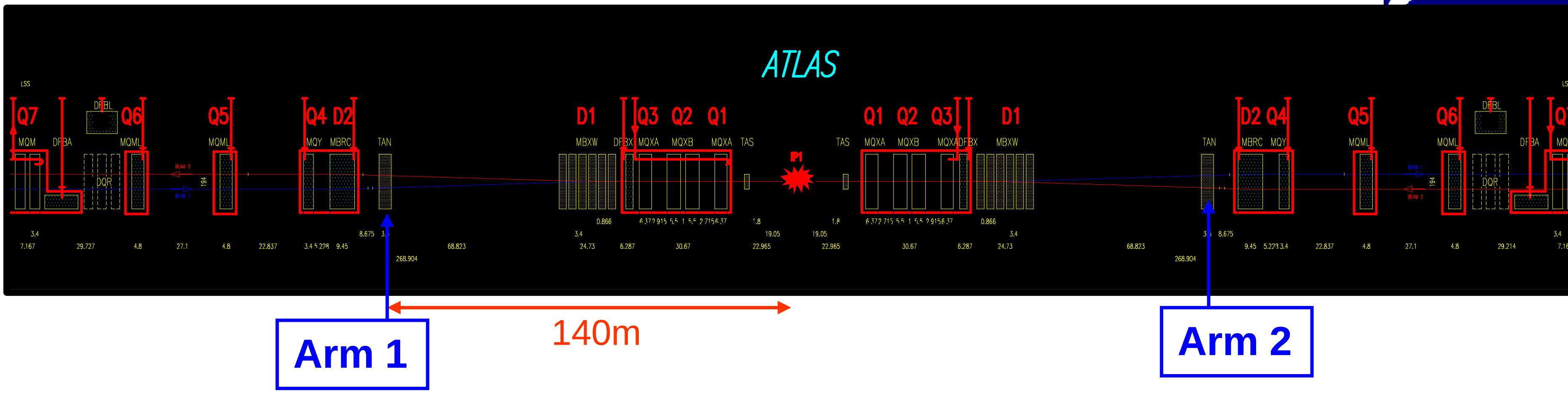
The Experiments: ALFA (IP1)

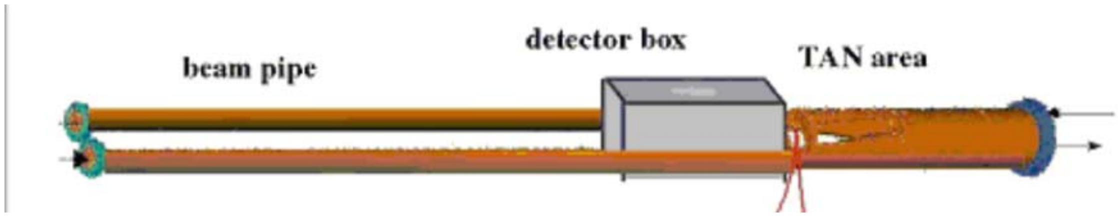
The ATLAS Experiment
ALFA - absolute luminosity for ATLAS

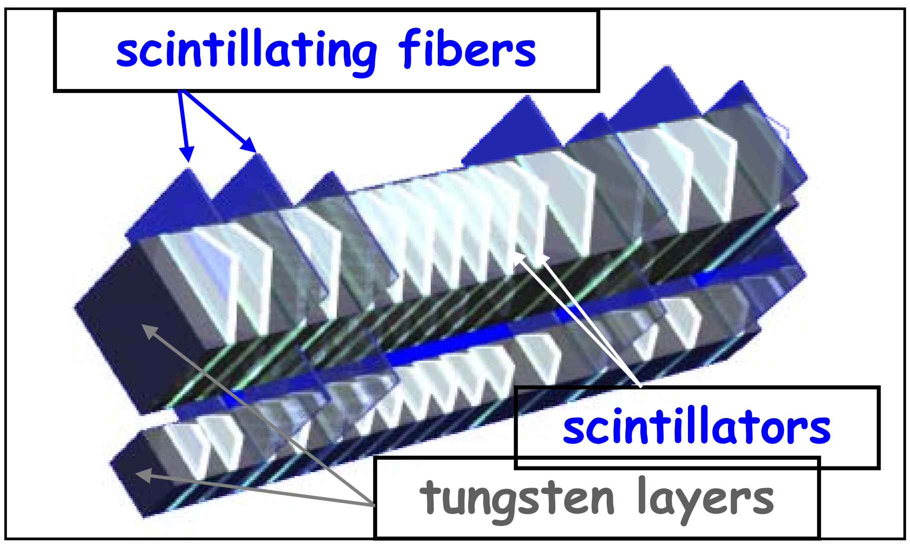


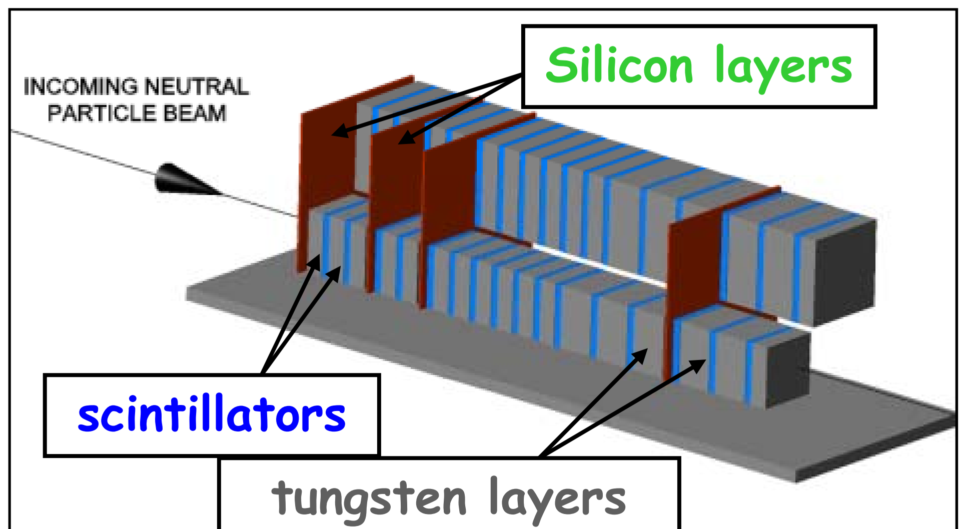
Same configuration on the other side of IP1

The Experiments: LHCf (IP1)









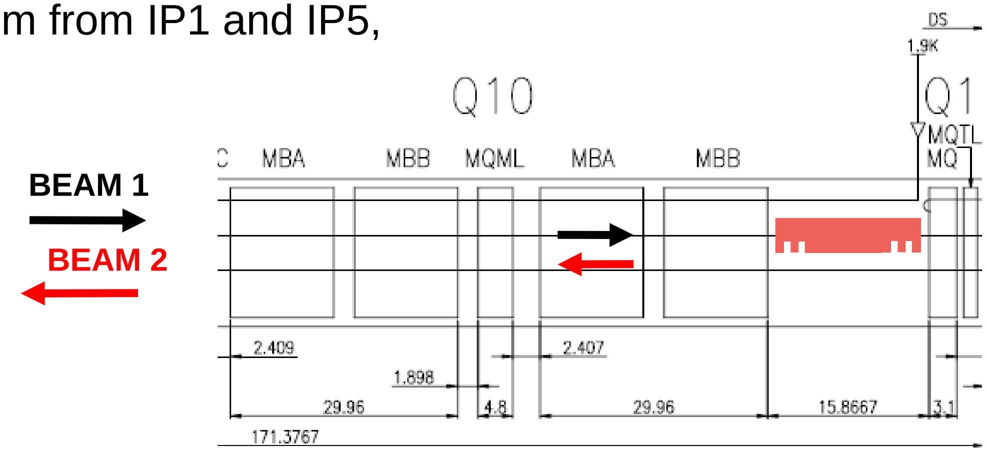
The Experiments: FP420 (IP1 and IP5)

FP420 R&D Project

Four proton spectrometers proposed: at ~420 m from IP1 and IP5, beam1 and beam2

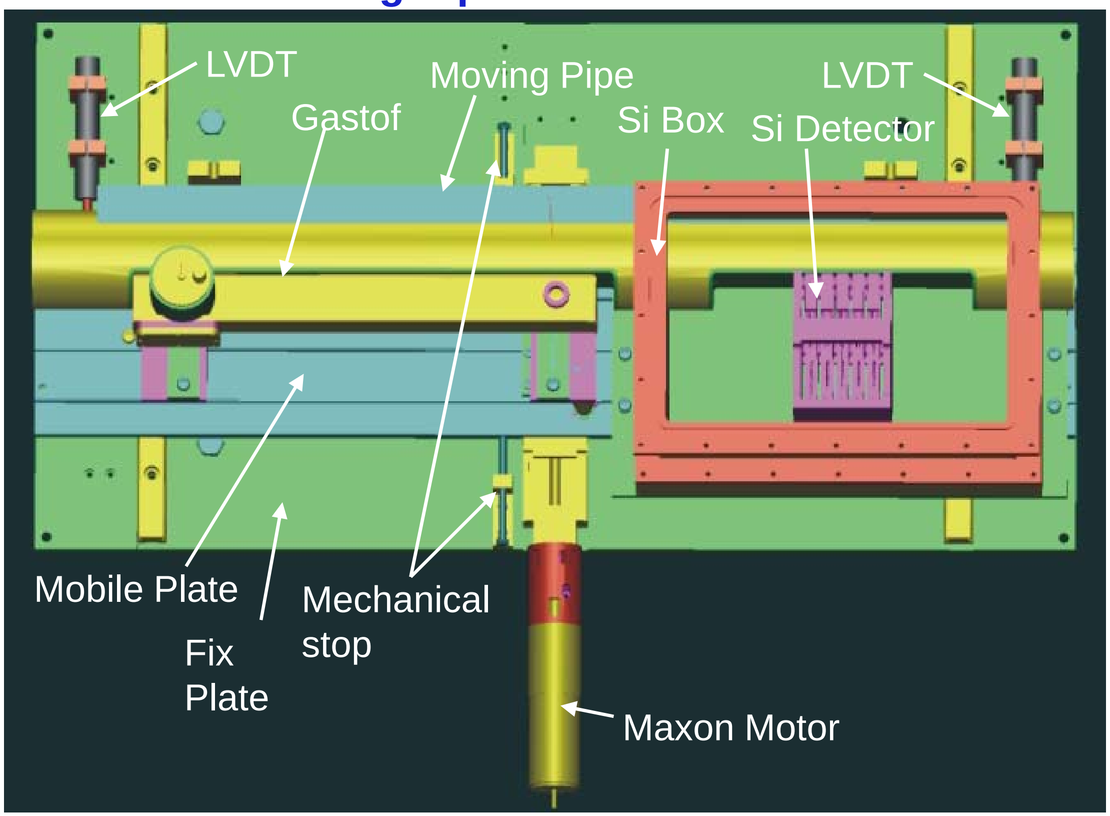
Two (or three) stations for each spectrometer

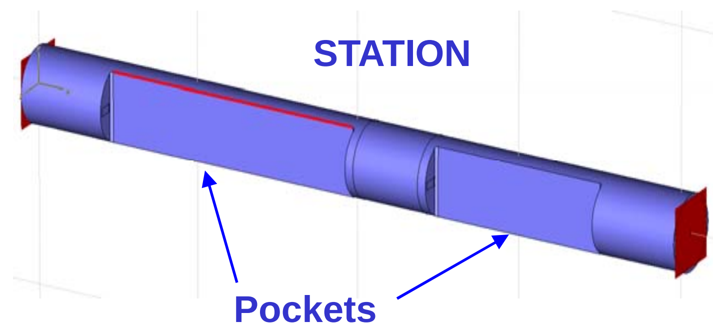
Two pockets for each station: tracking and timing detectors

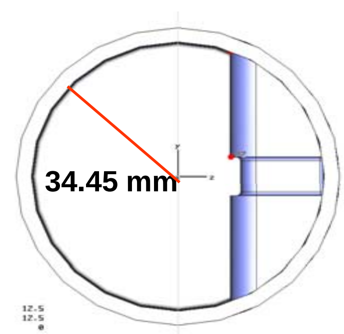


Mechanical design based on

movable "Hamburg Pipe":







Types of Background

Characteristics:

1. **Beam halo**
   from distant beam-gas interactions, betatron and momentum cleaning inefficiency:
   protons parallel to the beam; look like signal protons;
   reducible only by left-arm / right-arm coincidence
   scales with beam current; optics play a role.

2. **Local beam-gas interaction products:**
   reducible by cuts on: track angle, hit multiplicity
   scales with beam current (but also the rest-gas density changes).

3. **Beam-Beam background from interactions in the IP:**
   - diffractive proton component
     directly reaching detectors or showering on beam pipe
   - inelastic component
     randomised and softened by secondary interactions with machine:
     reducible by cuts on: track angle, hit multiplicity

   scales with luminosity.

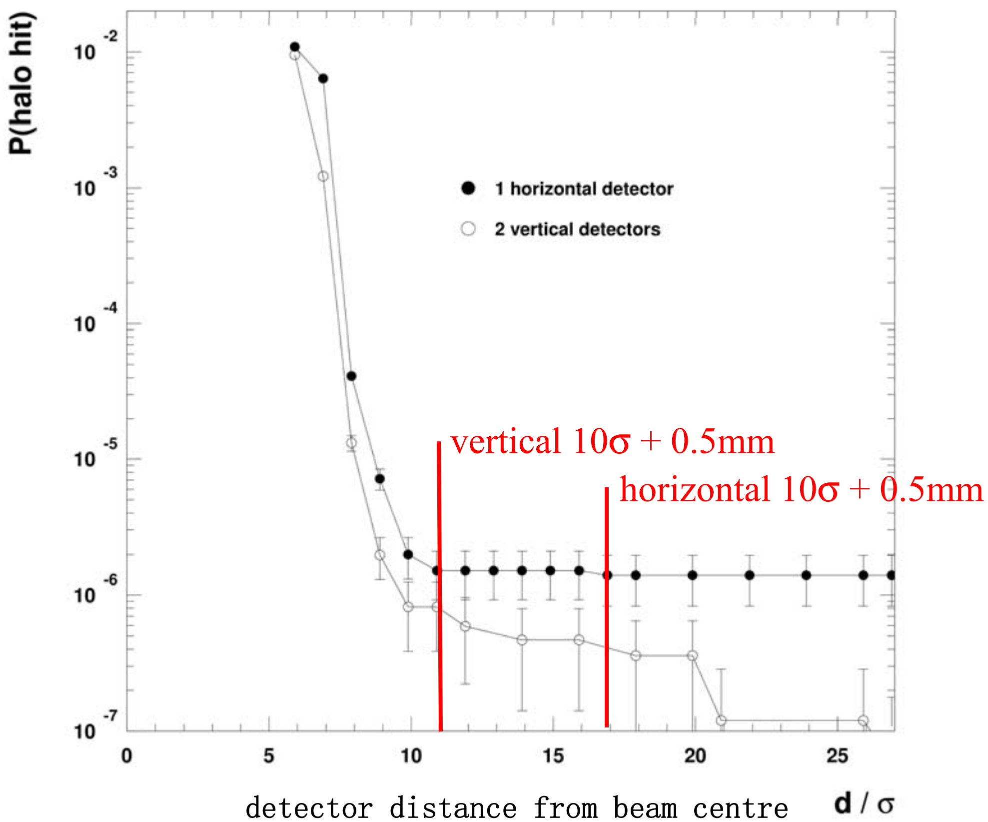
Running Conditions

	TOTEM	ALFA	LHCf	FP420
Luminosity $[cm^{-2}\ s^{-1}]$	$10^{28} \div 10^{33}$	10^{27}	$10^{29} \div 10^{30}$	$10^{33} \div 10^{34}$
k bunches	$43 \div 2808$	43	43	2808
N protons per bunch	$(1 \div 11.5) \times 10^{10}$	10^{10}	$(1 \div 4) \times 10^{10}$	$(4 \div 11.5) \times 10^{10}$
β^* [m]	$0.5 \div 1535$ (different physics)	2625	$2 \div 11$	0.5
min. det.-beam approach	$\sim 10 \div 15\ \sigma$	$\sim 10 \div 15\ \sigma$	N/A	$15\ \sigma$

Beam Halo: TOTEM

From collimation group: Betatron cleaning inefficiency seen at RP 220 for $\beta^* = 0.5$ m

Probability of hit in RP detector per lost proton:



Halo rate: $f_{halo} = f_{loss}\ P_{halo\ hit}$

Loss rate: $f_{loss} = k\ N / \tau$

beam lifetime $\tau = 34$ h

(includes τ_{vacuum} and τ_{IBS})

$k = 2808$ bunches

$N = 0.4 \times 10^{11}$ p / bunch

➔ $f_{loss} = 0.9$ GHz

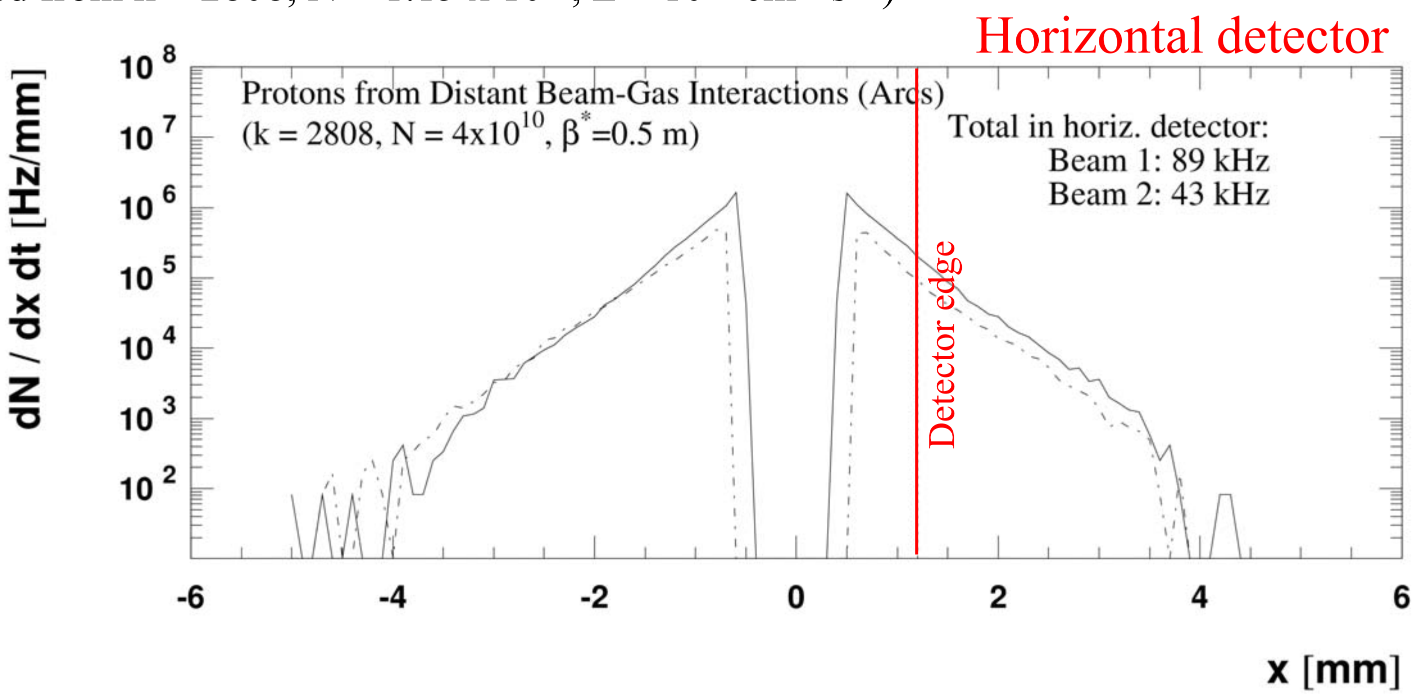
$f_{coinc} = f^2_{halo}\ \Delta t$

horizontal RP detector $P = 1.4 \times 10^{-6}$	$f_{halo} = 1.3$ kHz $= 4.2 \times 10^{-5}$ / b	$f_{coinc} = 0.04$ Hz $= 2 \times 10^{-9}$ / bx

Beam Halo: TOTEM

From Igor Bayshev (IHEP): Distant beam-gas collisions (arcs beyond opposite TAS)

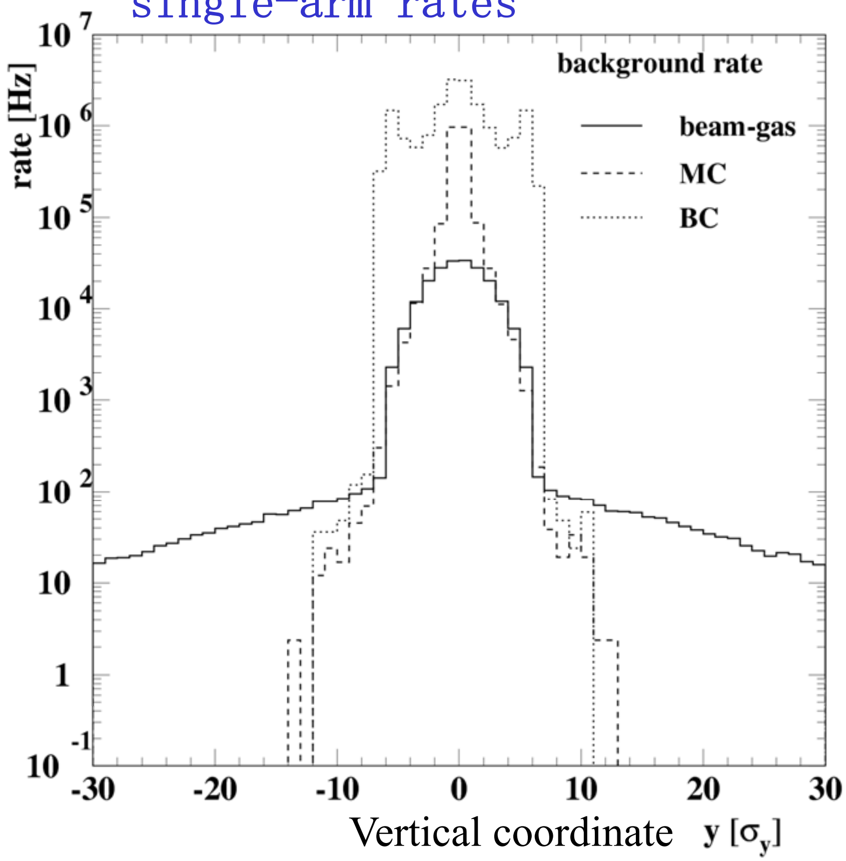
(scaled from k = 2808, N = 1.15 x 10^{11}, L = 10^{34} cm^{-2} s^{-1})



- No data available for the β^* =1540 m scenario yet → for now only estimate by scaling.
- Background reduction by two-arm coincidence
- For selecting elastic events: collinearity cut

Beam Halo: ALFA

Simulations provided by Igor Bayshev, IHEP



$$k_{bunch} = 43$$
$$N = 10^{10}$$
$$\Delta t_{bunch} = 2.021 \mu s$$
$$L = 10^{27} s^{-1} cm^{-2}$$

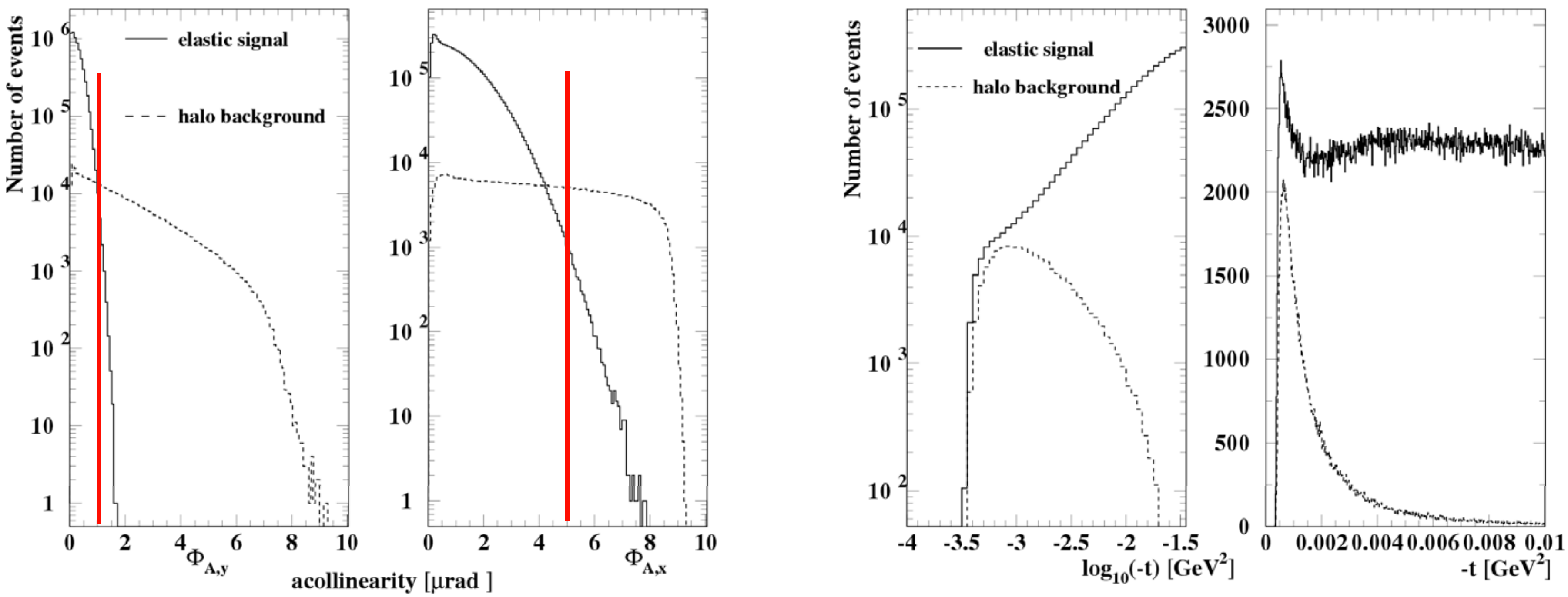
beam lifetime contribution from vacuum:

- **100 hrs for momentum and betatron cleaning (MC & BC)**
- **1000 hrs for distant beam-gas collisions (arcs)**

- **accidental coincidence rate inside detector acceptance of about 9 Hz (elastic: 27 Hz)**
- **potentially dangerous since all mimicking small t**

Beam Halo: ALFA

Beam halo rejection cuts



Exploit back-to-back signature of elastic events and vertex reconstruction

after vertex and acollinearity cuts still 140 k events survive!

(compared to 6.6 M elastic signal)

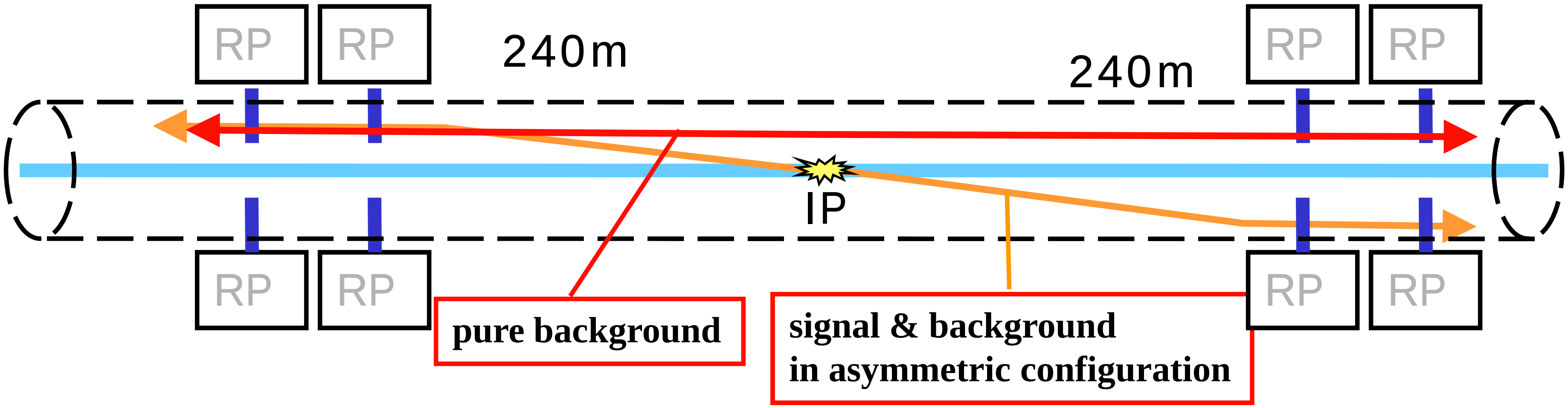
irreducible background at small t in the luminosity region!

→ must be subtracted

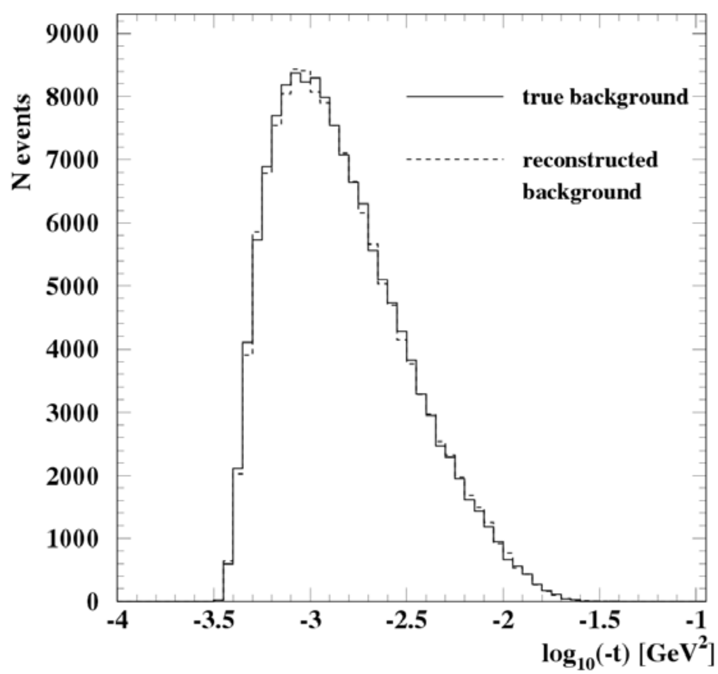
Beam Halo: ALFA

Statistical Subtraction

The ATLAS Experiment
ALFA - absolute luminosity for ATLAS



- signal and irreducible background appear in asymmetric configurations: +/- and -/+
- pure background is also present in symmetric configurations +/+ and -/-
- the irreducible background can be calculated by inverting randomly (left/right) the vertical sign of the hits
- halo asymmetries can be corrected for using data
- free of MC, good systematics
- error contribution to ΔL/L: 1.1-1.5 % (total error ΔL/L = 2.8-3.2 %)

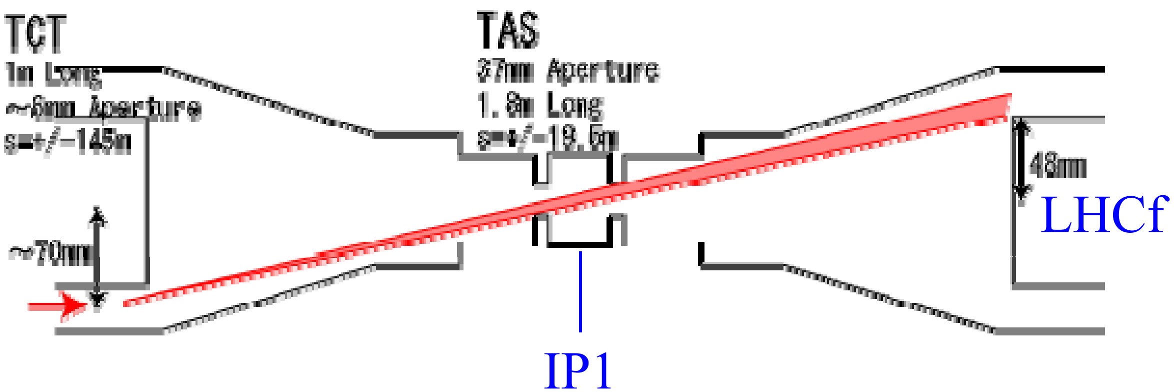


Beam-Halo: LHCf

Proton collisions with TCT during LHCf operation: 10 kHz

but background for the detectors probably negligible:

- TCT (Tungsten, 1 m long, 10 interaction lengths) is thick enough to stop the beam-halo particles and the secondaries.
- The secondary particles produced in beam-halo / TCT collisions will not reach the LHCf detectors:
  - Charged particles swept away by D1 magnet.
  - Neutral particles collimated at TAS (s = ±20 m, 37 mm aperture)



- never calculated in detail but halo colliding with beam pipe estimated << 20 % (very conservative number)
- If needed, reduction by coincidences between the two arms and by reconstructing the π° invariant mass

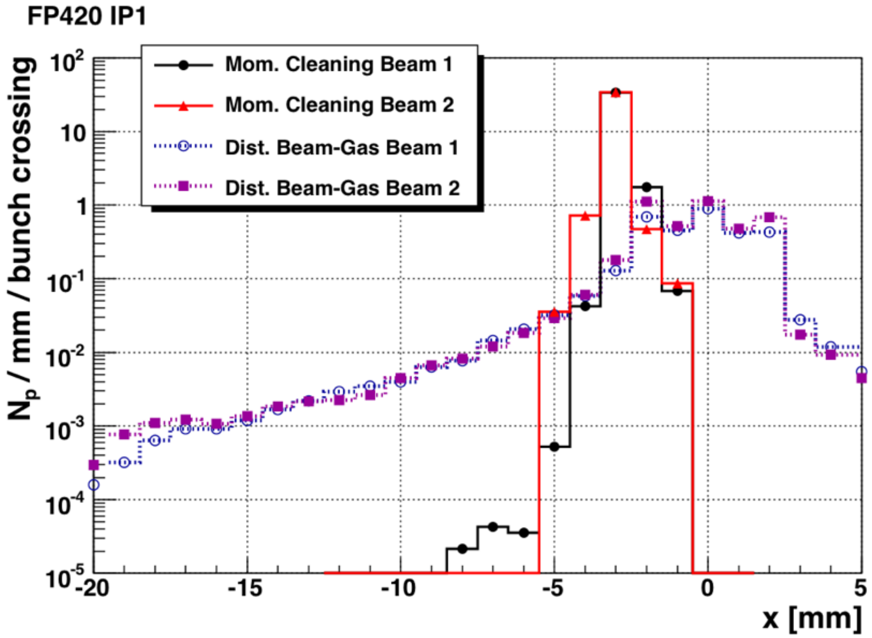
Beam Halo: FP420

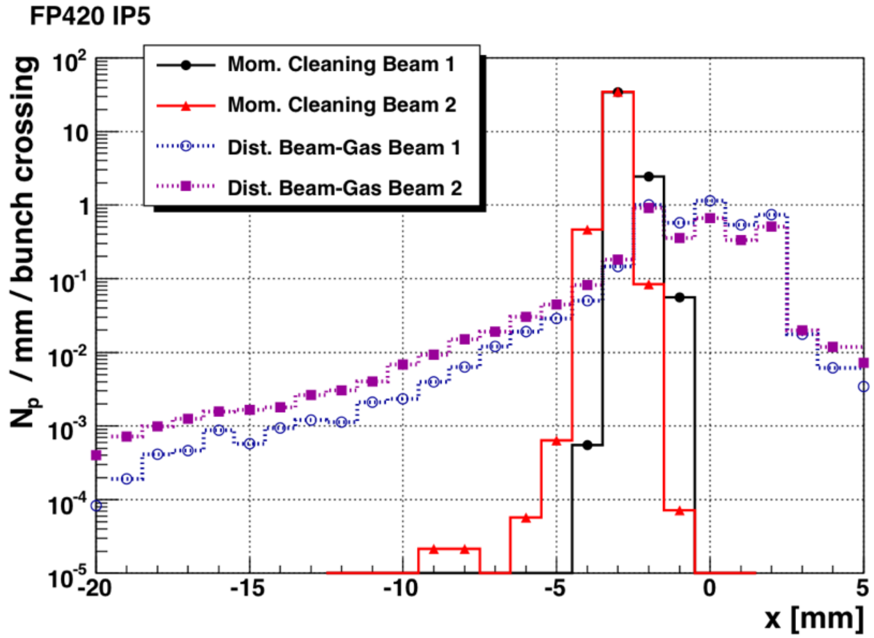
Halo from Distant Beam-Gas Scattering

FP420 R&D Project

10^6 beam-gas interactions simulated along all the LHC cold regions

Distributions recorded at FP420 here are normalised for a **beam-gas lifetime** of **500h** and compared to momentum cleaning beam halo normalised for an **off-momentum** beam **lifetime** of **150h**





Halo from local beam-gas scattering expected to be very small, but needs to be investigated.

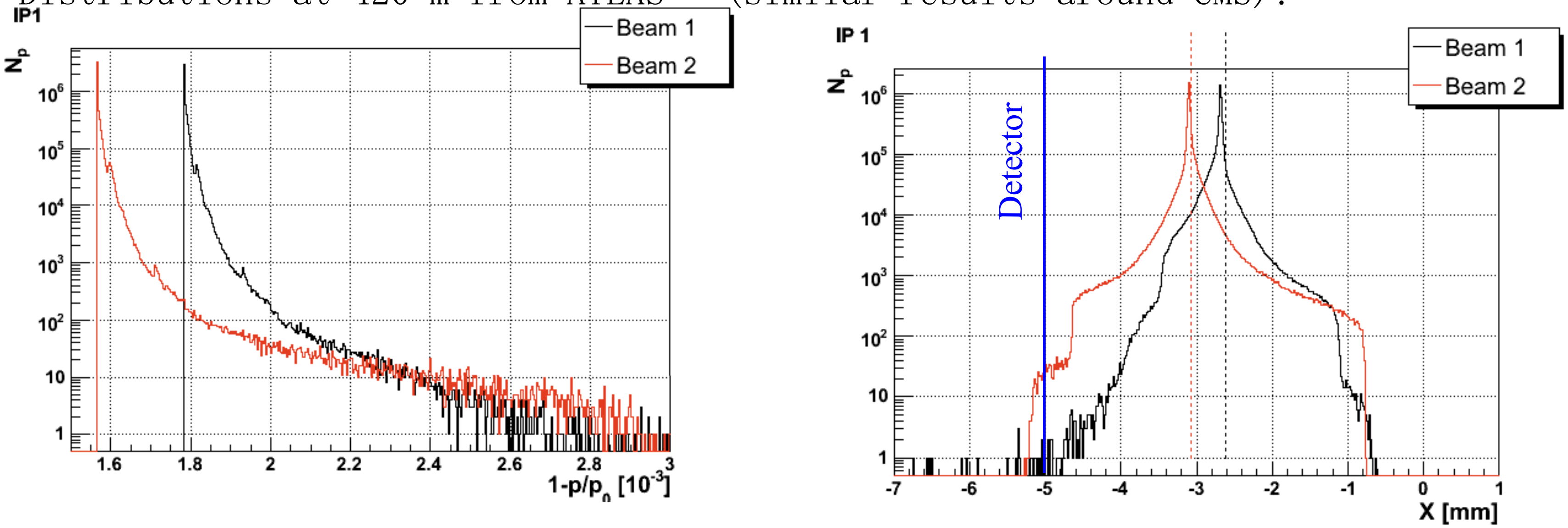
Beam Halo: FP420

Halo from Momentum Cleaning

FP420 R&D Project

Off momentum particles surviving beam cleaning

Simulation of 2 x 10^6 protons hitting momentum cleaning collimators.
Distributions at 420 m from ATLAS (similar results around CMS):



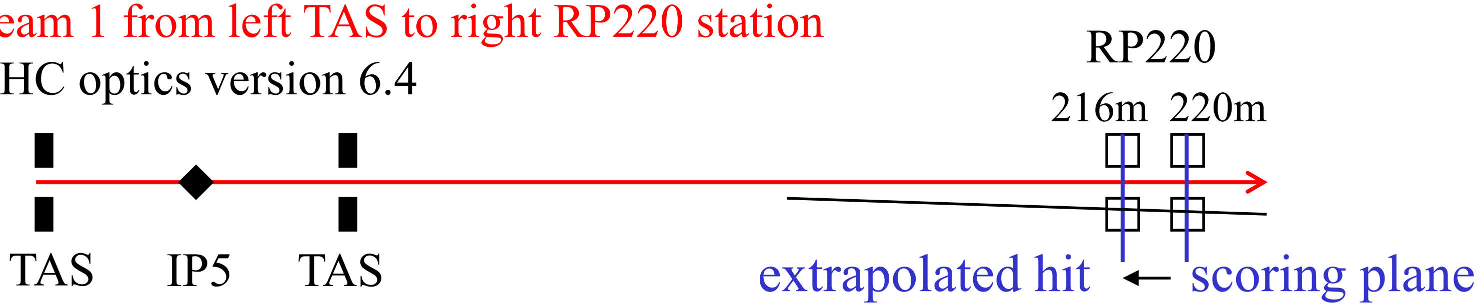
FP420 is sensitive to off-momentum protons because of big dispersion (by design of the experiment).

Halo from betatron cleaning not shown but very small.

Local Beam-Gas Background: TOTEM

Simulation by V. Talanov:

- Simulate flux of particles in the RP station at 220 m
  generated by beam-gas interactions and subsequent collisions with machine elements
  content: particle ID, x, y, θ_x, θ_y, E, stat. weight, **no time or correlation info**
- β^* = 1540 m, 156 bunches, 1.15 x 10^{11} p/b ($\Rightarrow$ L = 2.4 x 10^{29} s^{-1} cm^{-2})
- done:
  beam 1 from left TAS to right RP220 station
  LHC optics version 6.4



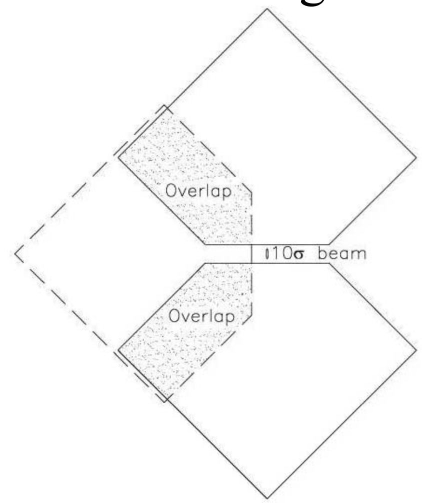
Particles included: p, n, π^+, π^-, e^+, e^-, γ with E_{kin} > 100 keV

- distant interactions (before left TAS) not included.

Local Beam-Gas: TOTEM

Analysis Strategy

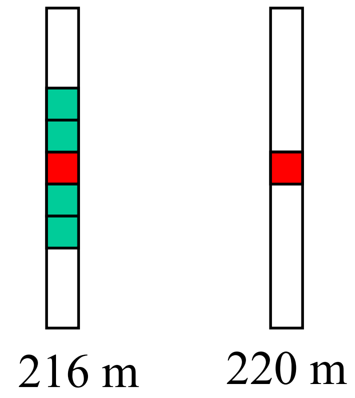
- Get hits at s = 220 m
- Extrapolate to s = 216 m using track angle information
- Calculate single-pot and 2-pot coincidence rates using detector geometry
- For γ and n GEANT4 simulation to assess interaction and detection probability



- Refine 2-pot angular cut with coincidence road:

Divide detector in groups of 32 strips à 66 μm (~ 2 mm)

Include 2 neighbours into coincidence condition (determined by angular spread of signal p)

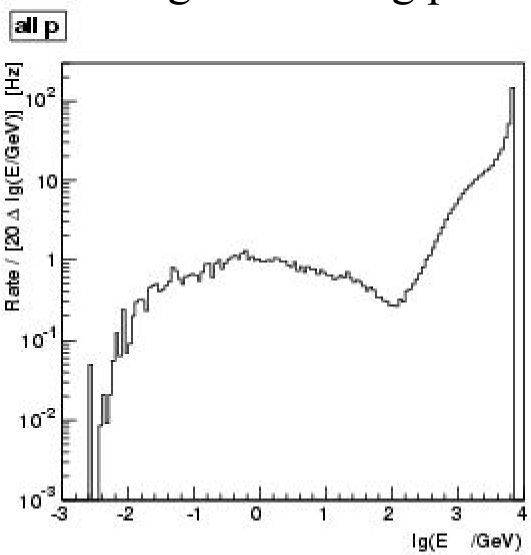


Local Beam-Gas: TOTEM

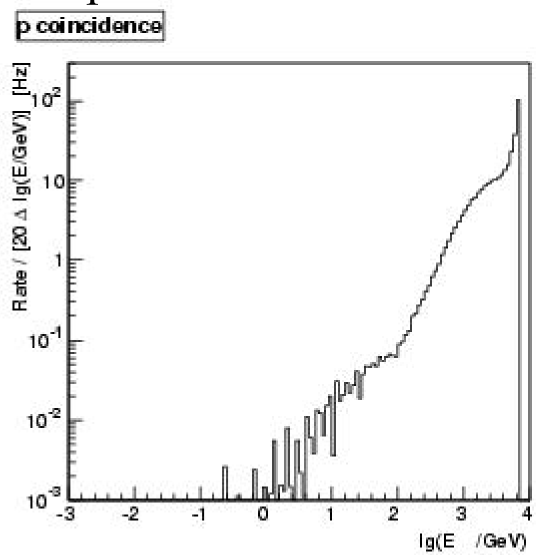
Reduction by Two-Unit Coincidence

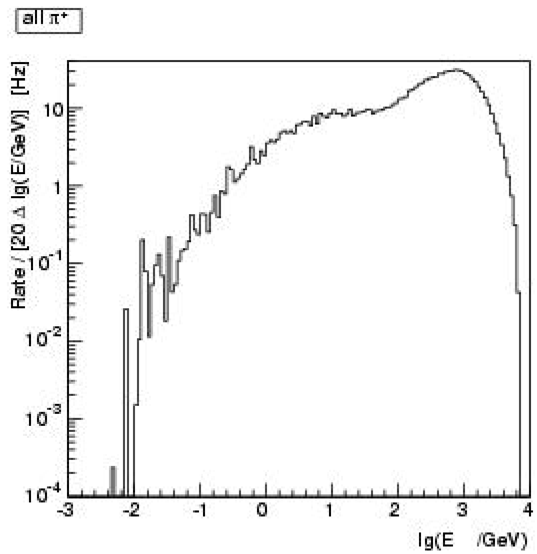
E_{kin}: Protons and Pions

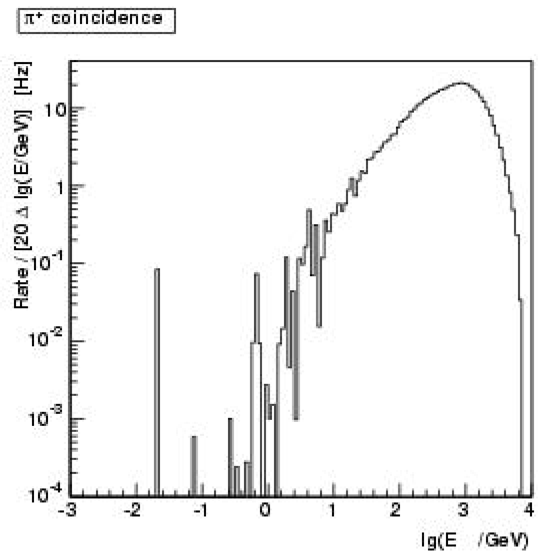
all traversing the scoring plane



simple coincidence 216 m x 220 m





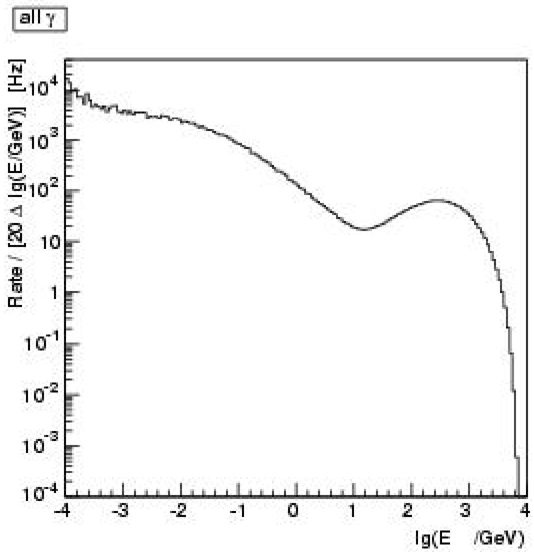


Local Beam-Gas: TOTEM

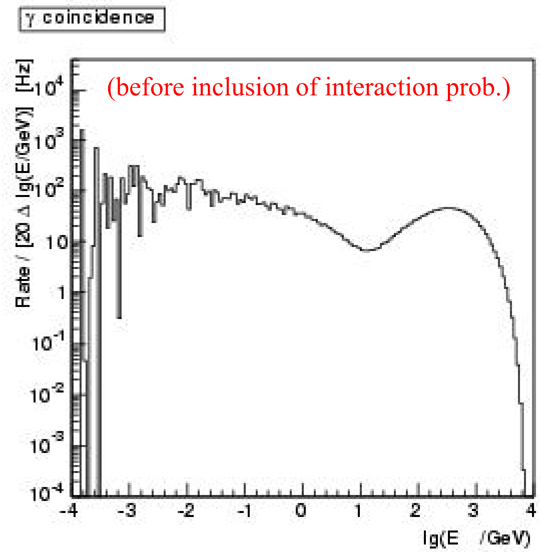
Reduction by Two-Unit Coincidence

E_{kin}: Photons

all traversing the scoring plane



simple coincidence 216 m x 220 m



E < 20 keV:
photons stopped by 200 μm Inconel window

20 keV < E < 100 keV:
photons create isolated hits;
fake tracks suppressed by majority coincidence in 5 planes per projection (u, v) within road width

E > 100 keV:
photons create Compton e^-; above 1 MeV: e^+e^- pairs → Tracks
Interaction probability taken into account for background trigger rate estimate.

Local Beam-Gas: TOTEM

Rate Evolution with Cuts

β^{*} = 1540 m, k = 156 bunches, N = 1.15 x 10^{11} p / bunch, 2 vert. + 1 hori. detectors:

	p	n	π^{+}	π^{-}	e^{+}	e^{-}	γ
220 m pot	344 Hz	174 Hz	616 Hz	406 Hz	4630 Hz	3361 Hz	94.72 kHz
simple coinc. 216 x 220	307 Hz	131 Hz	479 Hz	289 Hz	75 Hz	122 Hz	10.17 kHz
coinc. within roads	303 Hz	129 Hz	385 Hz	220 Hz	21 Hz	14 Hz	3.90 kHz
with det. efficiency	303 Hz	13 Hz (all showers)	385 Hz	220 Hz	21 Hz	14 Hz	< 330 Hz (95% CL)

Total Single Arm Rate:

0.9 – 1.3 kHz = (5 – 7) x 10^{-4} / b

No multiplicity cuts applied.

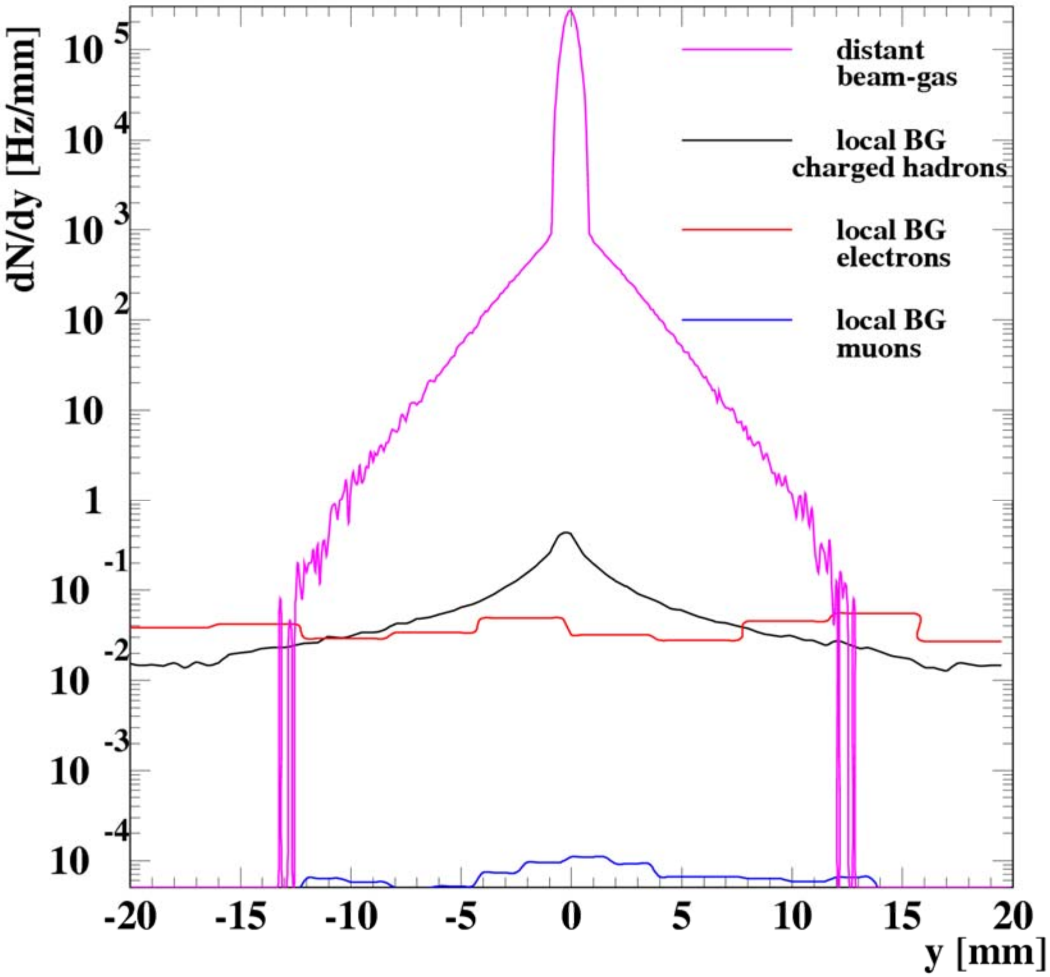
No simulation for β^{*} = 0.5 m scenario (k = 2808, N = 0.4 x 10^{11} p / bunch)

→ Results scaled with current, correcting also for higher gas density

Local Inelastic Beam-Gas Background: ALFA

The ATLAS Experiment
ALFA - absolute luminosity for ATLAS

Simulations provided by Igor Azhgirey, IHEP



The comparison of the rate of distant and local beam-gas background shows that the latter contribution can be neglected.

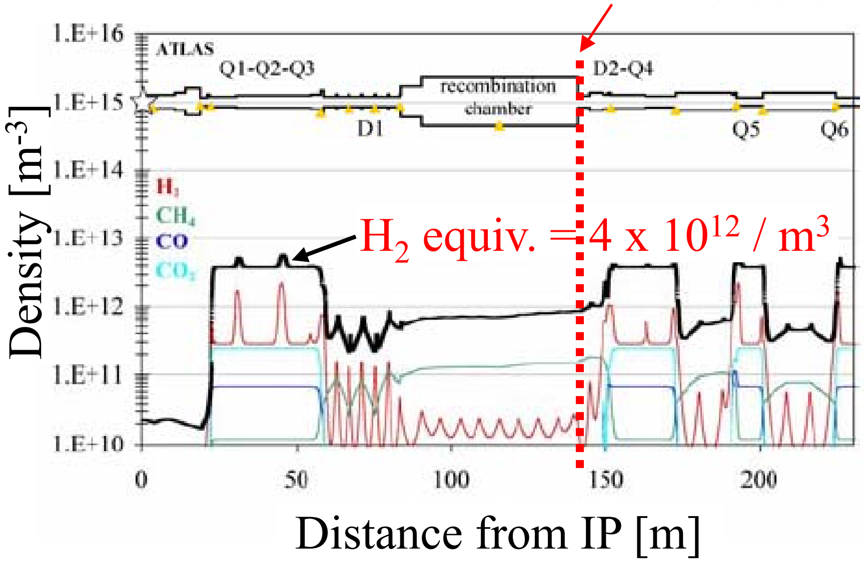
Beam-Gas Background: LHCf

MC simulation:

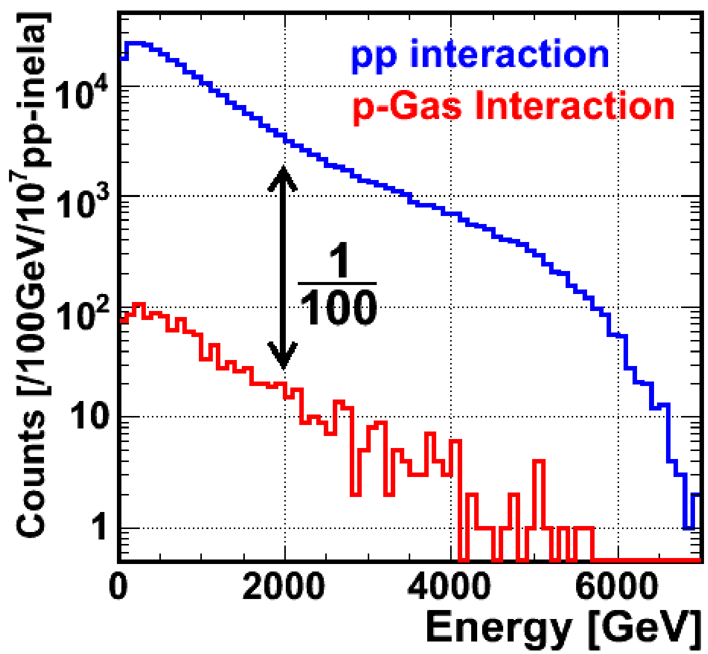
- geometry: includes the TAS and beam pipes from IP to +/-140 m.
- gas density: from LHC-project-Report 783
- Luminosity: 10^{29} cm^{-2} s^{-1}

Start-up with 43 bunches:

LHCf detector



γ Spectrum
(Arm 1)



Beam-Gas: LHCf

Background Reduction

- Double arm coincidence

  Expected gas density: <ρ> (H_2 equiv.) = 1.8 x 10^{12} m^{-3} (at start-up)

  → Beam-gas collision rate: 16 Hz, Signal rate from p-p: 6 kHz

  → single arm: S/B = 375, double arm: S/B = 10^7

  If gas density is higher: <ρ> (H_2 equiv.) = 10^{14} m^{-3}

  → single arm: S/B = 10, double arm: S/B = 10^4

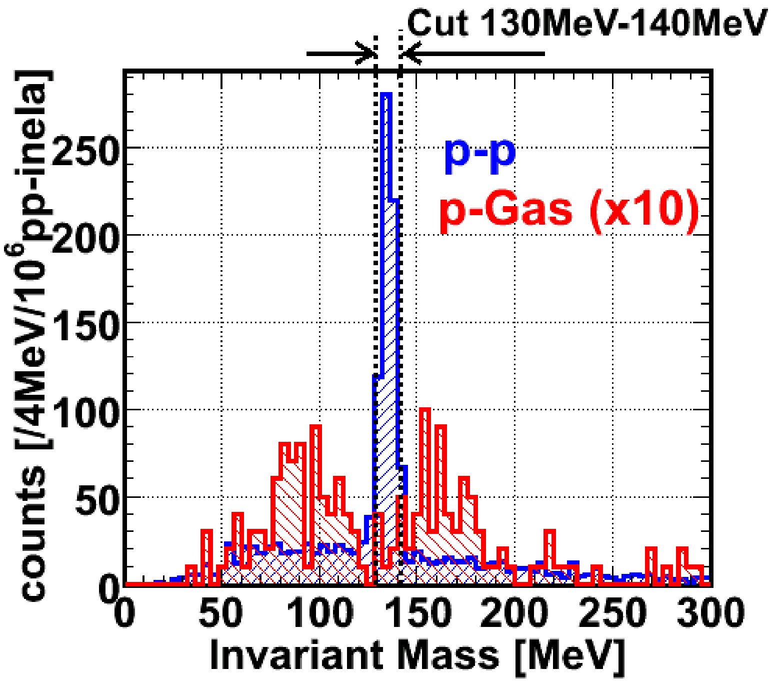
- π^0 Analysis

  Reconstruct π^0 from 2 photons

  In case of high residual gas density (H_2 equiv. = 10^{14} m^{-3}):

  S/B = 10 for single photons,

  S/B = 120 for π^0 .



Beam-Beam Background: TOTEM

Note: This is based on an old simulation from 2003 with limited information.
New data are available, but not yet analysed.

Source:

N. Mokhov et al.: FERMILAB-Conf-03/086 and LHC Project Report 633

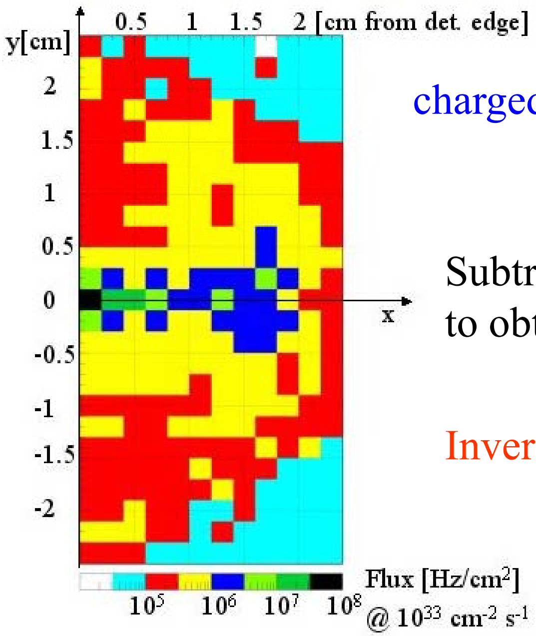
Simulation of background at **$L = 10^{33}$ cm^{-2} s^{-1}** from:

- pp in IP5 (minimum bias with DPMJET)
- beam-gas scattering: contributes 0.1% – 1%

Information available:

- fluxes of charged hadrons, neutrons, electrons, photons
  averaged over Si detectors at:
  145 m (vertical), 149 m (vertical), 220 m (vertical), 220 m (horizontal);
  but no angle or energy distributions at these positions;
- angular distributions at TAN to study efficiency of angular cuts

Beam-Beam Background: TOTEM



charged hadrons in horizontal detector at RP220

Subtract peak of diffractive protons (|y| < 2 mm) (signal for TOTEM) to obtain pure background.

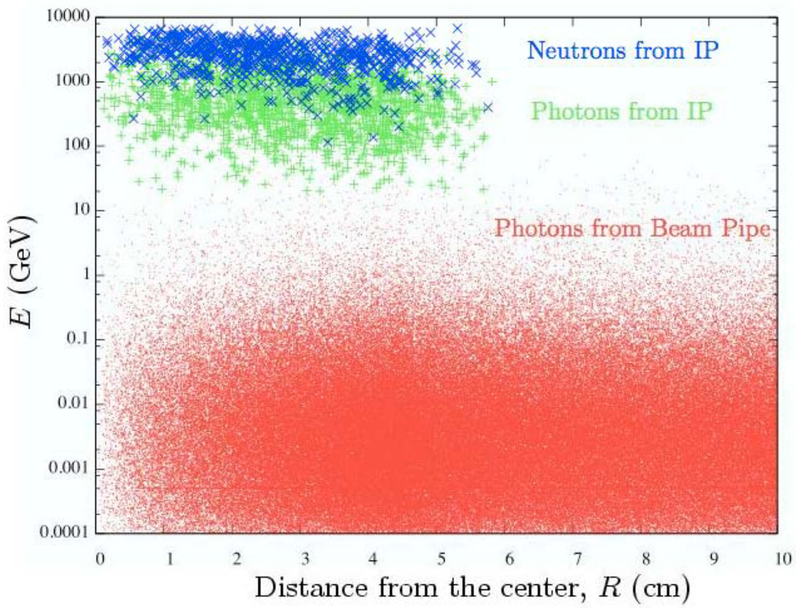
Inversely: accepting only diffractive region cuts background rate by factor 10^{-2}.

Beam-beam background rate [MHz] for 1 horizontal detector at L = 10^{33} cm^{-2} s^{-1} :

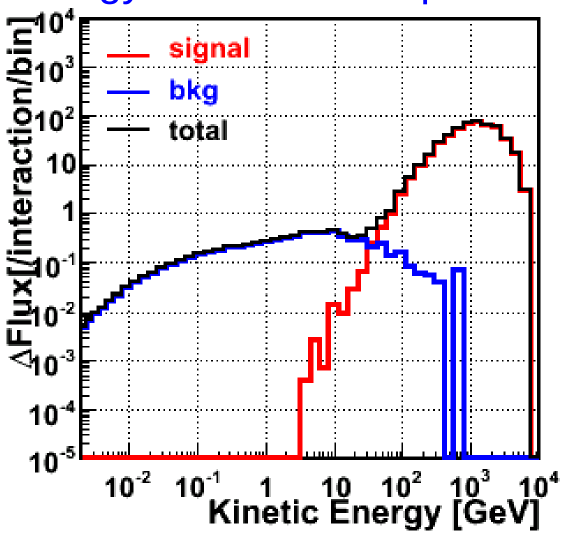
	ch. hadrons	n	e+-	γ	total
before cuts	3.7	1.5	19.1	155.8	180.1
after angular cuts and effic.	0.56 – 2.48	0.0009 – 0.004	0.038 – 0.09	0.005 – 0.45	0.6 – 3.0
Selecting diffract. region					0.006 – 0.03

Beam-Beam Background: LHCf

Background produced by particles from p-p collisions in IP1 interacting with beam pipe.



Energy distribution of photons



The S/N of this background is
> 10 for photons with E > 100 GeV and
> 140 for photons with E > 350 GeV.

→ Not a problem.

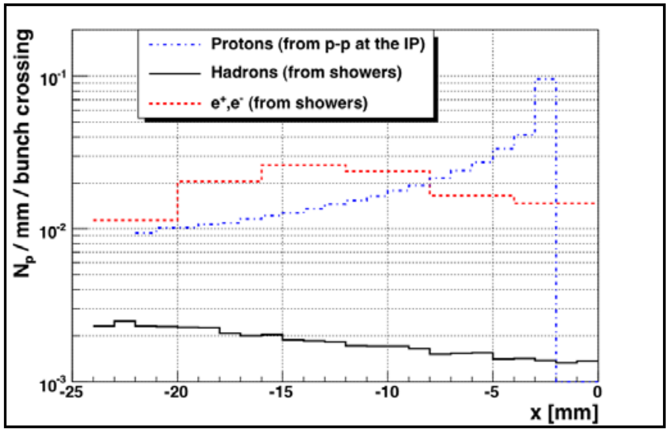
Beam-Beam Background: FP420

Secondary showers from diffractive proton losses

FP420 R&D Project

Protvino simulations (preliminary) for a total inelastic cross section of 80mb

- track diffractive protons losses on MB.B11 (last dipole upstream FP420)
- produce secondary particles and store their distribution at FP420 entrance

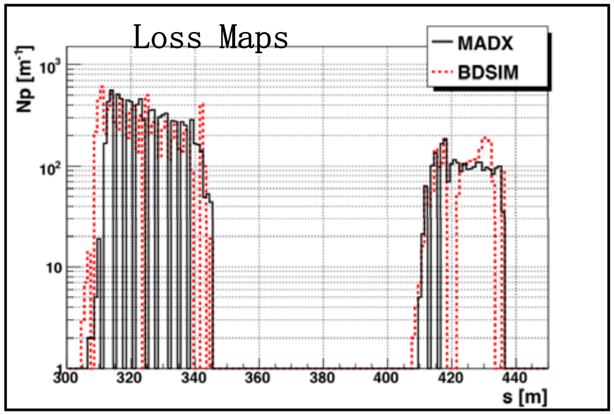


+

- 0.015 neutrons / bx with E >14.5MeV
- 24 photons / bx with E > 10 MeV

Manchester BDSIM simulations (preliminary) for a total cross section of 100mb

- track diffractive protons losses along the line from IP to MB.B11
- produce secondary particles and store their distribution at FP420 entrance



- 0.11 neutrons / bx
- photons and charged particles to be assessed

TOTEM Summary: Background Estimates

Rates for RP 220:

	$L = 10^{29}\ s^{-1}\ cm^{-2}$ (k = 156, N = 7.4 x 10^{10} p / b) $\beta^* = 1540$ m **2 vertical + 1 horizontal detector**	$L = 10^{33}\ s^{-1}\ cm^{-2}$ (k = 2808, N = 4 x 10^{10} p / b) $\beta^* = 0.5$ m **1 horizontal detector only**
Local Beam-Gas (single arm)	before cuts: 246 x 10^{-4} / b (b=bunch) (hadrons: 3.6 x 10^{-4} / b) after cuts: 3.0 x 10^{-4} / b 2nd background	before cuts: 248 x 10^{-4} / b after cuts: 1.9 x 10^{-4} / b 2nd leading background
Beam-Beam (single arm)	before cuts: 177 x 10^{-4} / b (?) after cuts: (0.4 ÷ 2) x 10^{-4} / b (?) 3rd background	before cuts: 6 / b (?) after cuts: (0.02 ÷ 0.1) / b (?) 1st leading background
Beam Halo (single arm)	Betatron cleaning: 1 x 10^{-4} / b distant beam-gas: 11 x 10^{-4} / b 1st background	Betatron cleaning: 0.4 x 10^{-4} / b distant beam-gas: 22 x 10^{-4} / b 3rd background
2-arm coincidence	(237 ÷ 289) x 10^{-8} / bx	(0.0004 ÷ 0.01) / bx
Signal (example)	17 x 10^{-4} / bx (elastic events)	0.003 / bx (DPE events)
S/B	(0.6 ÷ 0.7) x 10^{3} improvable with collinearity cut	7.5 ÷ 0.3 selecting diffract. det. regions: factor 10^4

See CMS+TOTEM common physics TDR (LHCC 2006-039/G-124) for details on S/B.

ALFA Summary: Background Estimates

The ATLAS Experiment
ALFA - absolute luminosity for ATLAS

	$L = 10^{27}\ s^{-1}\ cm^{-2}$ ($k = 43$, $N = 1 \times 10^{10}$ p / b) $\beta^* = 2625$ m **2 vertical detectors**
Local Beam-Gas	negligible
Beam-Beam	negligible
Beam Halo (mainly distant beam-gas)	2-arm coincidence: 9 Hz
Signal (elastic events)	27 Hz
S/B before cuts	3
S/B after vertex & collin. cuts, before statistical bg reconstruction	50
contribution to $\Delta L/L$	1.1 – 1.5 %

LHCf Summary: Background Estimates

	$L \sim 10^{29}$ s^{-1} cm^{-2} ($k = 43$, $N = 1 \times 10^{10}$ p / b) $\beta^* = 11$ m
Local Beam-Gas (single arm)	S/B = 375
Beam-Beam	S/B > 140 for $E_\gamma > 350$ GeV
Beam Halo (single arm)	S/B >> 5 (improvable by π^0 reconstr.)
Double-arm coincidence	S/B >> 2.5×10^3

FP420 Summary: Background Estimates

FP420 R&D Project

$L \sim 10^{34}\ s^{-1}\ cm^{-2}$
$(k = 2808,\ N = 11.5 \times 10^{10}\ p / b)$
$\beta^* = 0.5$ m

<table>
<tr><th></th><th>IP1</th><th>IP5</th></tr>
<tr><td>Halo from distant beam-gas (single arm)</td><td>0.1 / b</td><td>0.1 / b</td></tr>
<tr><td>Halo from momentum cleaning (single arm)</td><td>B1: 7×10^{-4} / b
B2: 4×10^{-2} / b</td><td>B1: $< 10^{-5}$ / b
B2: 8×10^{-4} / b</td></tr>
<tr><td>Halo from betratron cleaning (single arm)</td><td colspan="2">negligible</td></tr>
<tr><td>Beam-Beam: showers from diffractive protons (single arm) preliminary</td><td>diffract. p: ~ 0.4 / b
ch. had.: ~ 0.04 / b
n: ~ 0.1 / b
e: ~ 0.3 / b
γ: ~ 24</td><td></td></tr>
<tr><td>Local beam-gas (single arm)</td><td colspan="2">small, to be studied</td></tr>
</table>

Background Measurements, Data Exchange

Common to all forward experiments:

- single-beam runs
- non-colliding bunches in two-beam operation

would be useful to identify beam-gas + beam-halo backgrounds.

- To be provided to the machine:
  trigger rates
- Desired from the machine:
  1. BLM data
  2. collimator positions
  3. machine vacuum measurements
  4. BPM data
  5. Optics information, beam quality information (bunch sizes, emittances etc.)

Summary

- Backgrounds are managable.
  At $L < 10^{29}$ s^{-1} cm^{-2} halo from distant beam-gas scattering is dominant
  At $L > 10^{29}$ s^{-1} cm^{-2} p-p induced background takes over
- Not all studies are completed.
- Comparisons between forward experiments should be extended.
- Signal exchange schemes are not yet at a finalised level.

Appendix

TOTEM: Background Measurements, Data Exchange

- to be provided to the machine:

1. RP detector and coincidence rates (monitored at least at 1 Hz):
   e.g. (left top & right top) compared with (left top & right bottom)
   to subtract beam-gas and beam halo backgrounds
   But: detectors retracted and off during injection;
2. Radiation monitors (always on; can see injection anomalies; read out every 20 s)

Interpretation of the rates observed will need experience.

- needed from the machine:

1. BLM data
2. collimator positions
3. machine vacuum measurement
4. BPM data

Acceptable in terms of:

- luminosity variations in time: luminosity monitored by TOTEM,
  varies anyway within a fill (factor ~3) → not problematic
- satellite bunches: problematic particularly with zero crossing-angle
- bad vacuum conditions in IR: to be avoided

ALFA: Background Measurements, Data Exchange

- to be provided to the machine:

  RP trigger rates (single arm) are a good measure of beam halo
  But: detectors retracted and off during injection;

- needed from the machine:
  1. BLM data
  2. collimator positions
  3. machine vacuum measurement
  4. BPM data

Acceptable in terms of:

- luminosity variations in time: luminosity monitored by ALFA, variations within factor ~ 3 not problematic
- satellite bunches: problematic particularly with zero crossing-angle → < 1%
- bunch-to-bunch variations: < 20%
- bad vacuum conditions in IR: to be avoided

LHCf: Background Measurements, Data Exchange

- to be sent to the machine:
  - trigger rate, also asynchronised to the bunch crossings
  - energy distributions
  - position distributions
  - luminosity monitoring
- desired from the machine:
  - nearby BLM data
  - Radmon data from the TAN
  - vacuum information
- Gas density 100 x higher than foreseen could be accepted.

FP420: Data exchange and Answers to Questionnaire

FP420 R&D Project

- **Information that could be given to LHC**

  Installed detectors:
  - 3D silicon for tracking → information about off-momentum beam halo particles
  - Gastof and Quartic for timing

  instrumentation for alignment and calibration
  - special BPMs with high accuracy
    - fixed to LHC beam pipe
    - movable with FP420 pipe
  - Wire Position Sensors
  - BLMs

- **Information needed from LHC**
  - IR3 collimator positions (and efficiency?)
  - beam
    - orbit stability, optics errors, bunch-to-bunch variations
    - emittances (beam size, momentum spread ...)

During injection, ramp and squeeze: detectors in retracted position
→ no danger due to unexpected losses/background

Physics results should not be affected by beam condition variations (e.g. bunch to bunch variations etc..) once such variations are known.

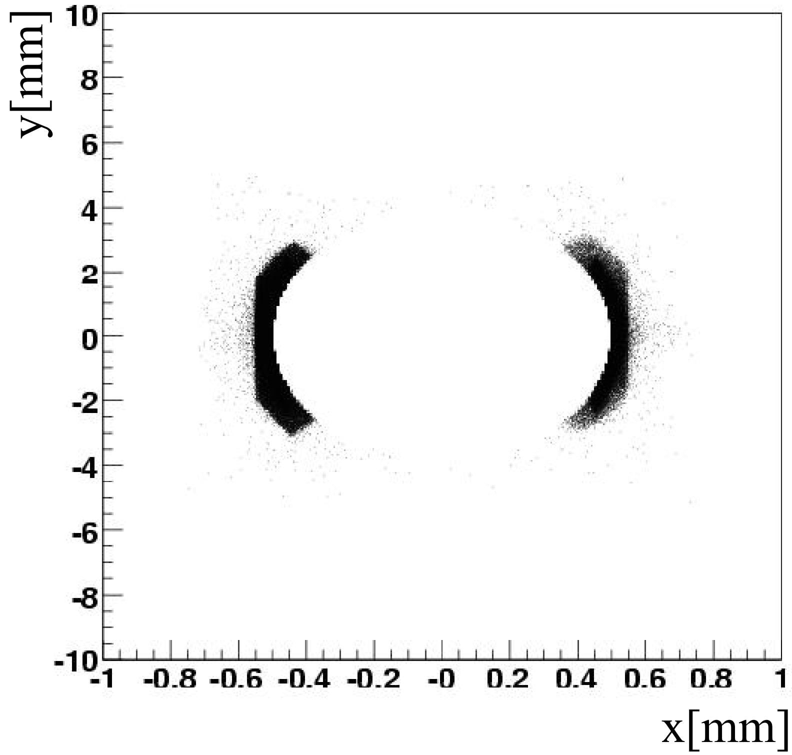
Reserve

Beam Halo Simulation from Collimation Group

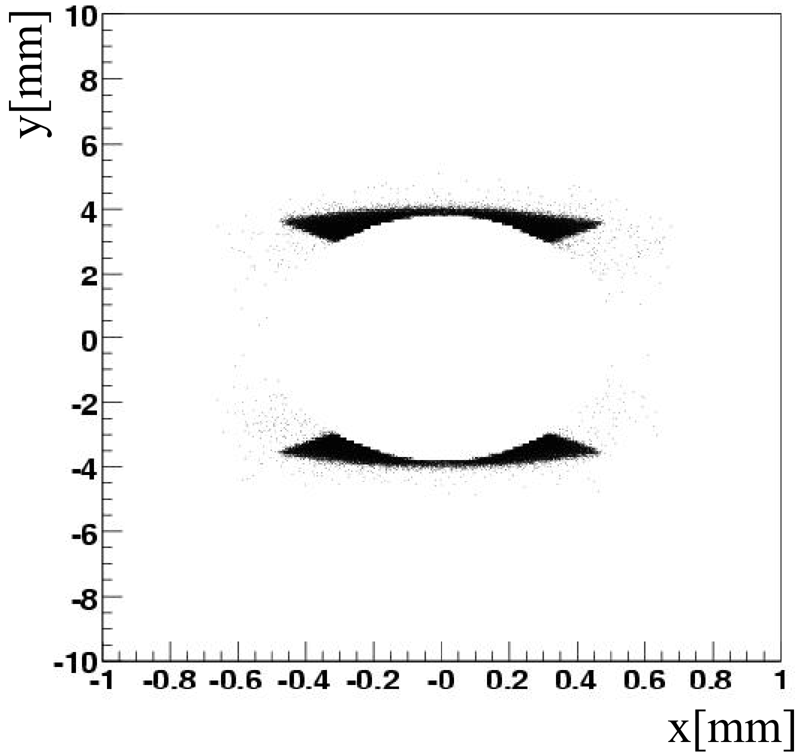
Beam halo distributions at specific locations in the ring for β* = 0.5 m.

Examples at 220 m:

For horizontal losses:



For vertical losses:



Beam Halo at $\beta^* = 0.5$ m

$k = 2808$ bunches

$N = 0.4 \times 10^{11}$ p / bunch

$\tau = 34$ h

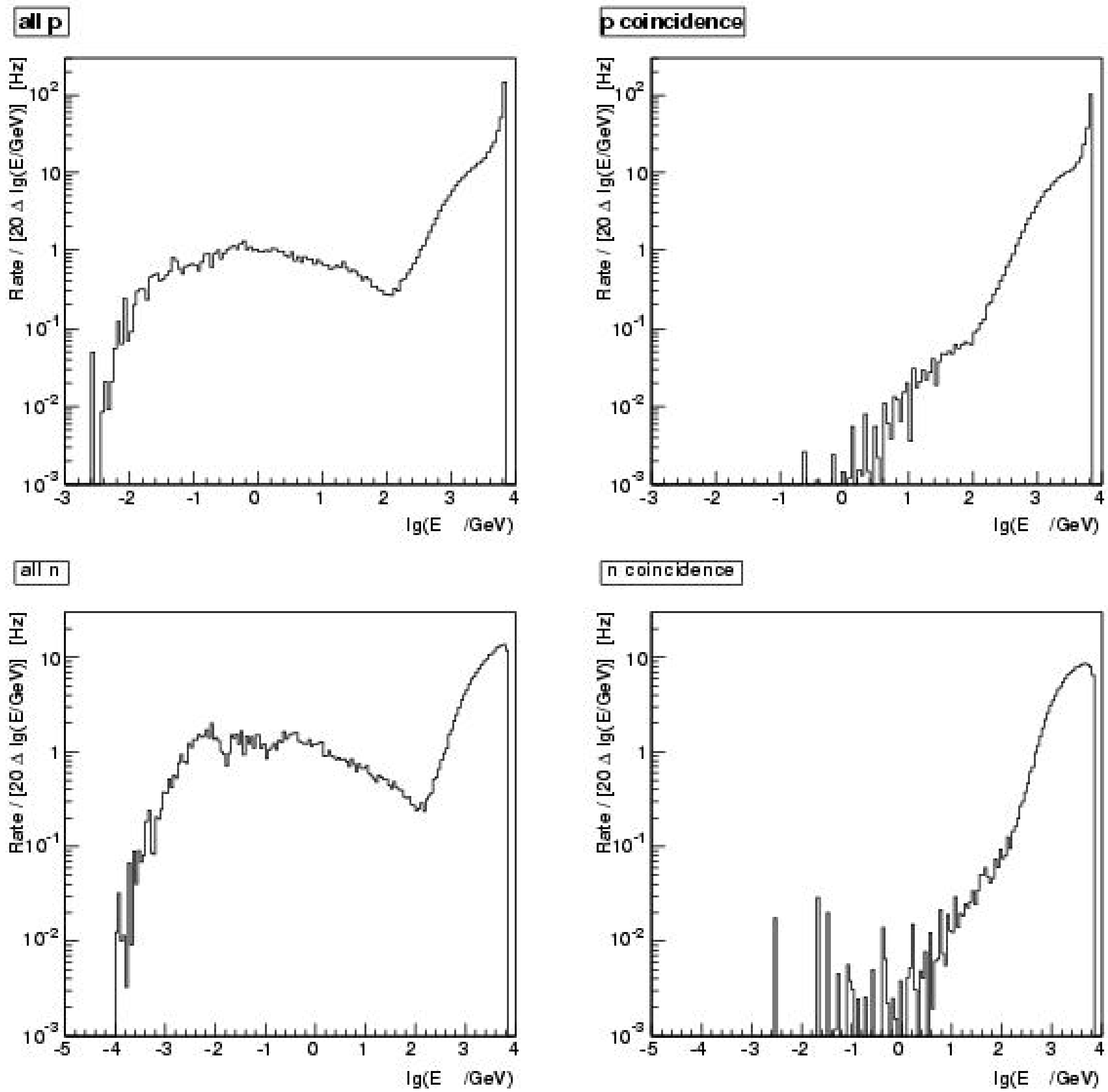
$f_{loss} = 0.9$ GHz (assume $f_{loss,hori} = f_{loss\ vert}$)

f_{halo} for correctly-shaped detectors at $10\ \sigma + 0.5$ mm:

	single arm	double arm
1 horizontal RP detector $P = 2 \times 10^{-6}$	$f_{halo} = 1.8$ kHz $= 4.5 \times 10^{-5}$ / b	$f_{coinc} = 0.08$ Hz $= 2 \times 10^{-9}$ / bx
2 vertical RP detectors $P = 1 \times 10^{-6}$	$f_{halo} = 0.9$ kHz $= 2.3 \times 10^{-5}$ / b	$f_{coinc} = 0.02$ Hz $= 0.5 \times 10^{-9}$ / bx
1 hori. + 2 vert. det. – overlap $P = 2.5 \times 10^{-6}$	$f_{halo} = 2.3$ kHz $= 5.6 \times 10^{-5}$ / b	$f_{coinc} = 0.12$ Hz $= 3.1 \times 10^{-9}$ / bx

E_{kin}: Protons and Neutrons

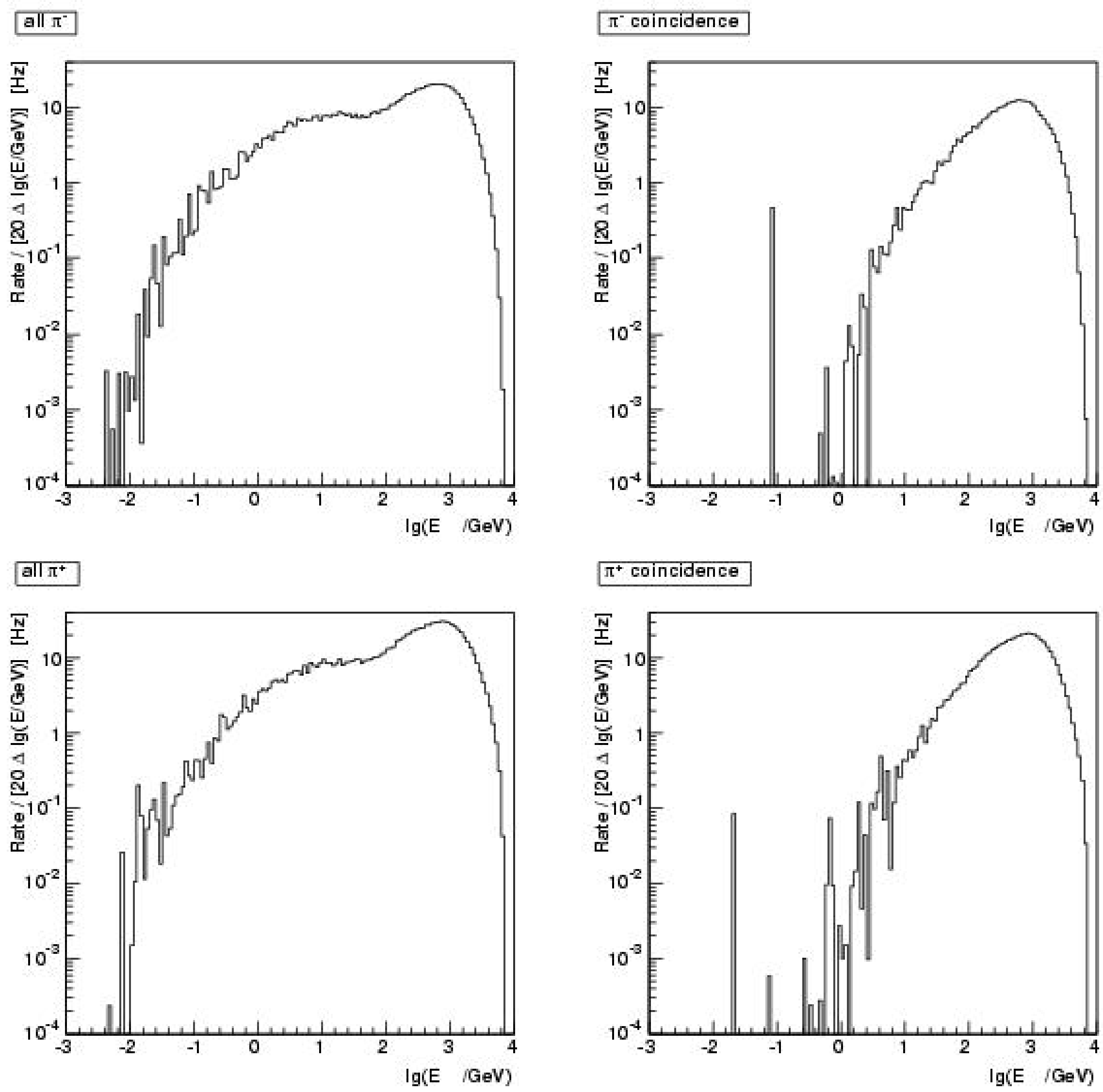
all traversing the scoring plane   simple coincidence 216 m x 220 m



estimated neutron – detector interaction probability: 0.5 %

E_{kin}: Pions

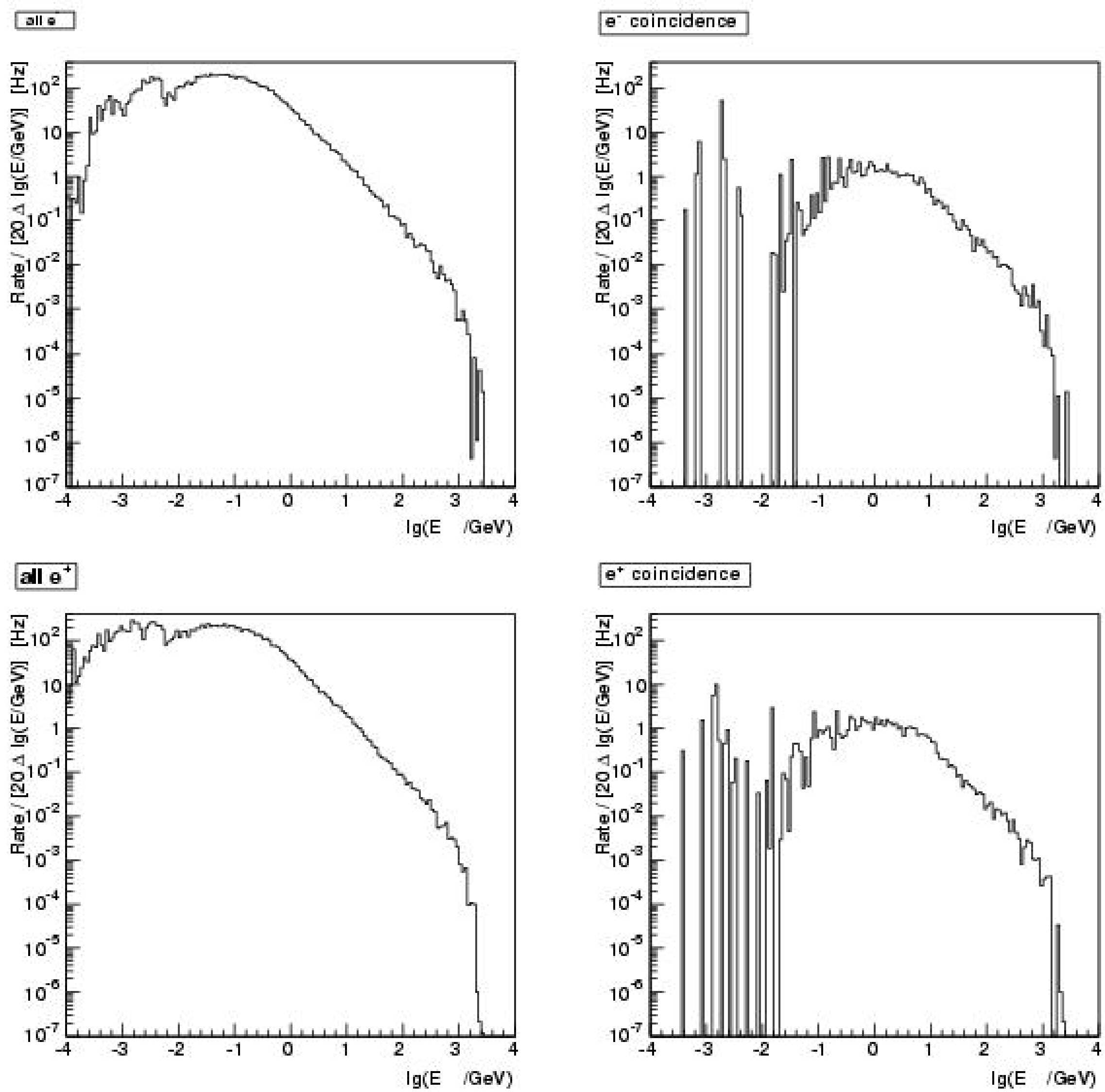
all traversing the scoring plane — simple coincidence 216 m x 220 m



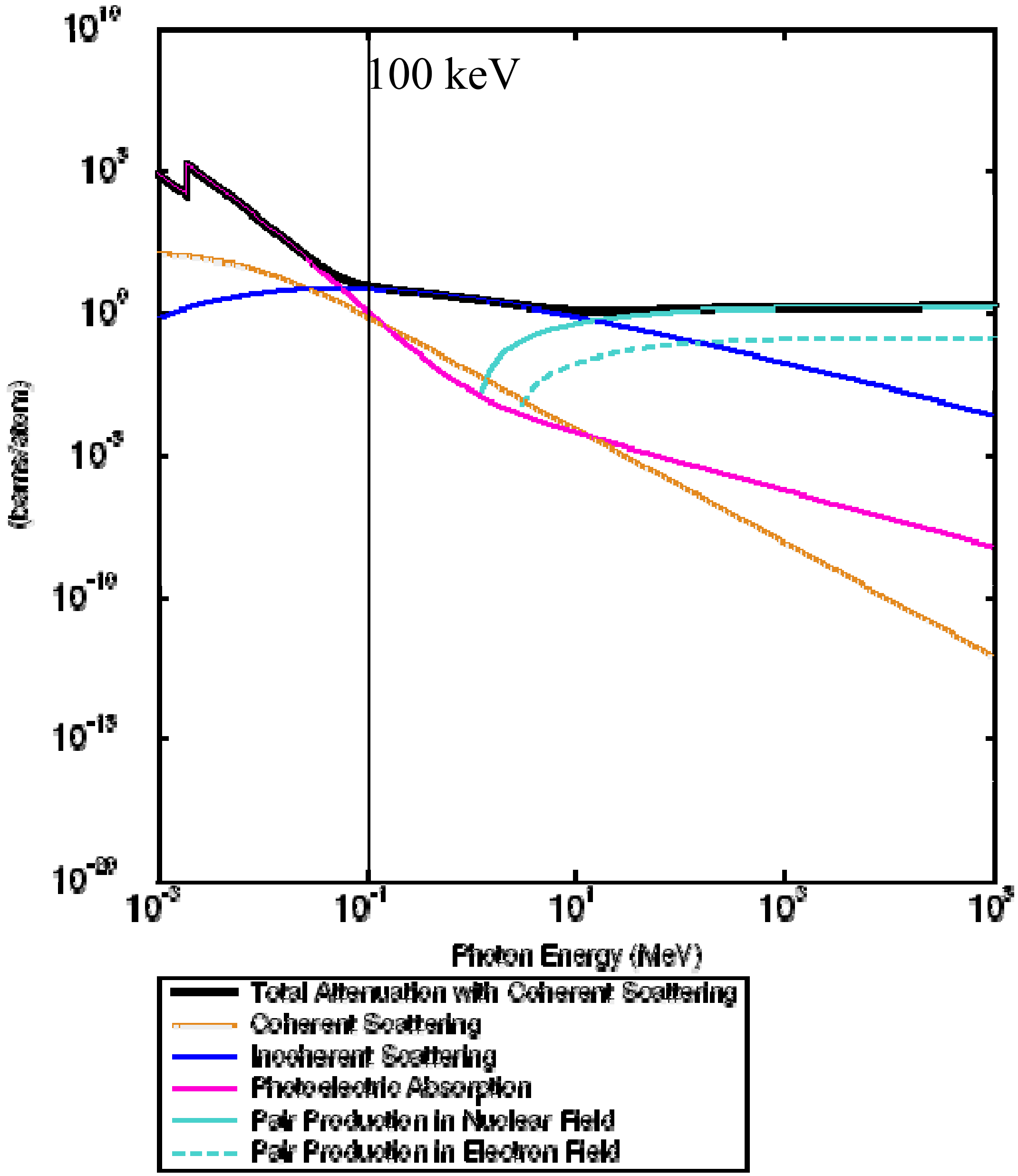
E_{kin}: Electrons and Positrons

all traversing the scoring plane

simple coincidence 216 m x 220 m



Photons in Silicon



E < 20 keV:
photons stopped by 200 μm Inconel window

20 keV < E < 100 keV:
photons create isolated hits;
fake tracks suppressed by majority coincidence in 5 planes per projection (u, v)
within road width:

$\binom{5}{5}$ or $\binom{5}{4}$ in u

$\binom{5}{5}$ or $\binom{5}{4}$ in v

E > 100 keV:
photons create Compton e^-;
above 1 MeV: e^+e^- pairs
→ Tracks

Beam-Gas Rate Evolution with Cuts

k = 156 bunches, N = 1.15 x 10^{11} p / bunch (1 horizontal detector only):

	p	n	π^+	π^-	e^+	e^-	γ
220 m pot	131 Hz	68 Hz	223 Hz	196 Hz	2054 Hz	1392 Hz	38.86 kHz
simple coinc. 216 x 220	114 Hz	49 Hz	143 Hz	135 Hz	26 Hz	21 Hz	3.2 kHz
coinc. within roads	113 Hz	48 Hz	115 Hz	103 Hz	7 Hz	2 Hz	1.2 kHz
with det. efficiency	113 Hz	5 Hz (all showers)	115 Hz	103 Hz	7 Hz	2 Hz	< 100 Hz (95% CL)

Total Single Arm Rate:

340 – 440 Hz for k = 156 bunches, N = 1.15 x 10^{11} p / bunch
(= 2 x 10^{-4} / b)

No multiplicity cuts applied.

Backgrounds in T1/T2

available:

- simple beam-gas simulation: Pythia p(7TeV)-p(rest)
  interaction position distribution flat from -20 m to +15 m
- beam-gas rate from rest-gas densities (A. Rossi):
  for 156 bunches à 1.15×10^{11} p/b:

Gas X	σ (p - X) [mb]	ρ [molec./m^3]
H_2	94	1.2×10^{11}
CH_4	568	1.2×10^{10}
CO	840	3.4×10^{8}
CO_2	1300	4.2×10^{8}

Interaction rate: $kNc/l_{LHC}\ \Sigma\, \sigma_i\, \rho_i = 0.4$ Hz/m per beam
from left TAS (aperture limit) to right T2: (20 m + 14 m) x 0.4 Hz/m = 13.6 Hz per beam

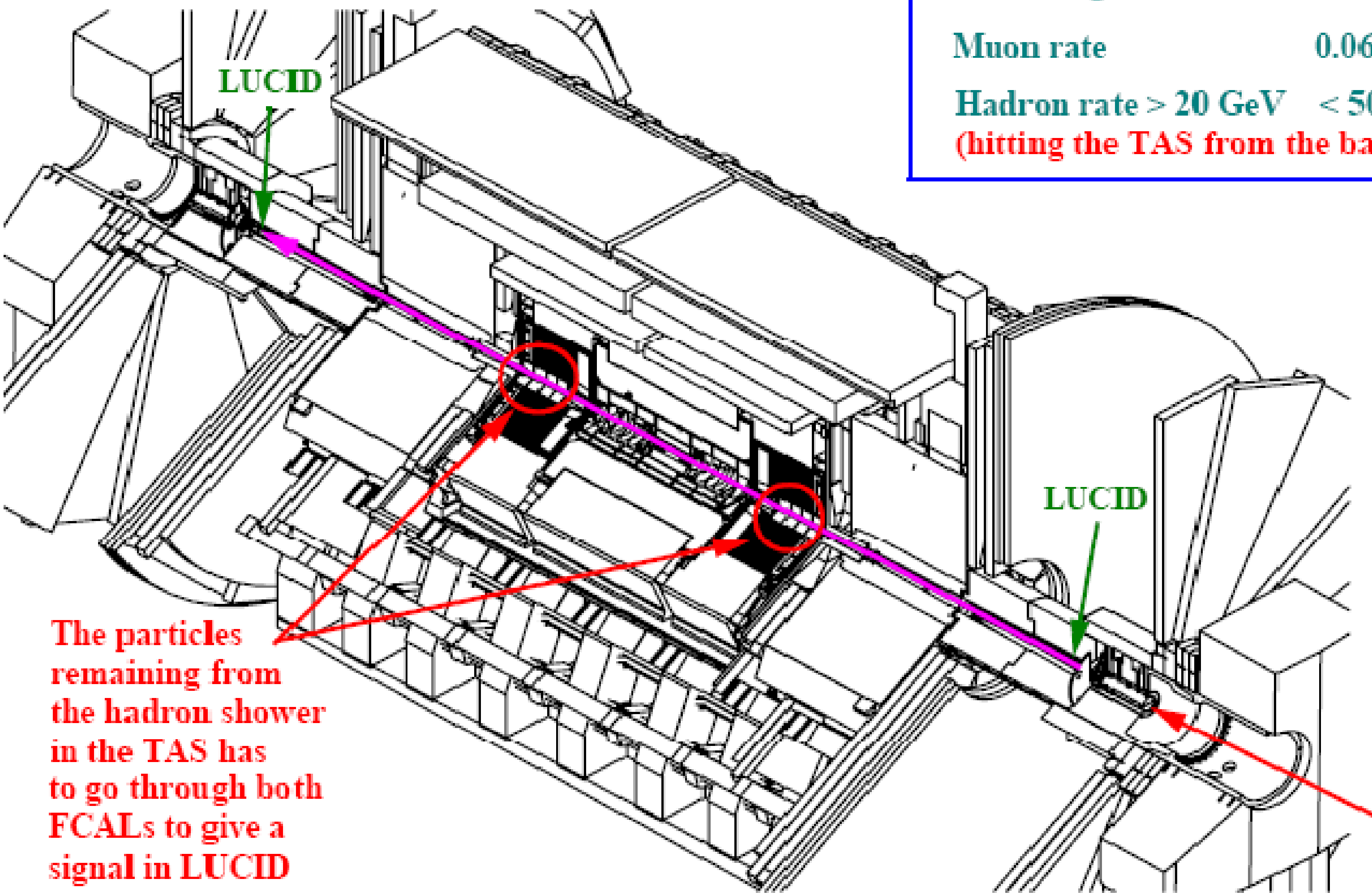
missing:

- impact of more distant interactions
- full simulation with full geometry (shieldings etc.),
  2 scoring planes: entrances of T1, T2;
  details: particle energies, angles, bunch crossing information
- muon halo in CMS

LUCID
Machine background

from Vincent Hedberg

Luminosity:	10^{27}	10^{34} $cm^{-2}s^{-1}$
LUCID signal rate:	16 Hz	32 MHz
Muon rate	0.06 Hz	40 Hz
Hadron rate > 20 GeV (hitting the TAS from the back)	< 50 Hz	< 31 kHz



From a calculation by V. Talanov that gives beam gas background entering the ATLAS cavern.

It is assumed that only hadrons with E > 20 GeV can penetrate the TAS

LUCID

open issue: beam-gas background for LUCID

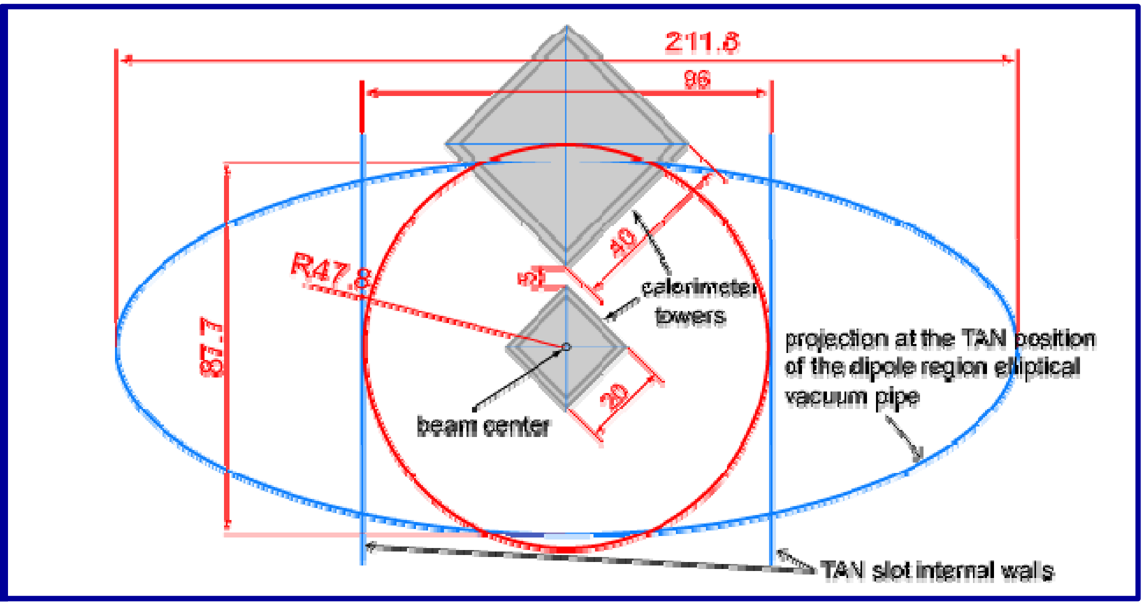
- **The beam-gas background entering LUCID from the *back* has been estimated to be at a small level**

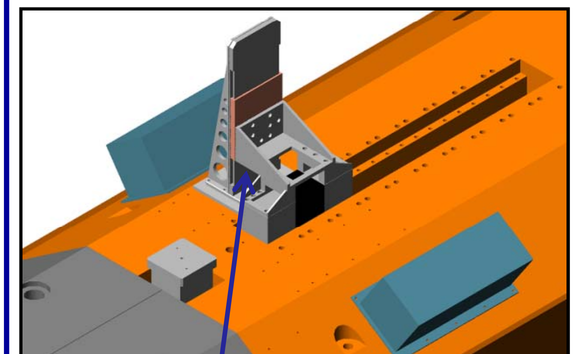
- **The beam gas entering LUCID from the *front* is presumably rather small (length ratio) but could be dangerous, since it is pointing to LUCID**

- **Can we get a background calculation for this contribution at a scoring plane of the LUCID front face (~17m)?**

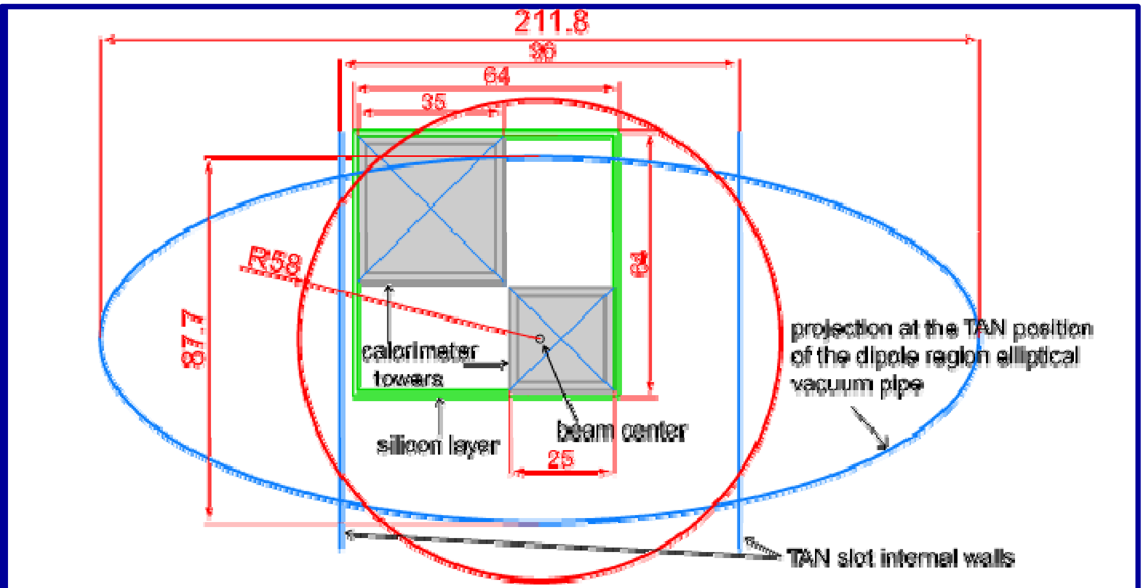
LHCf: Transverse projection in the TAN slot

ARM 1





ARM 2



The detectors can be remotely moved in the vertical direction (range 10 cm)