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## BGV Project Future

## BGV analysis paths

- Impact Parameter Correlation (IPC) method:
- Optimize event sleection
- Perform 'event-wide' track quality fit
- Vertex reconstruction to be developed

Both methods should be developed and used (competition is the source of improvement !)

## Beam spot $x-y$ position



Distance of closest approach (DOCA) vs track angle on the transverse plane ( $\phi$ )

Measured beam spot position
$x=0.3 \mathrm{~mm}$
$y=-0.8 \mathrm{~mm}$

DOCA correlation (pairs of tracks from the same event)


Nominal
$\sigma_{\text {beam }}=0.22 \mathrm{~mm}$ @ 7 TeV

Measured
$\sigma_{\text {beam }}=\sqrt{0.137}=0.37 \mathrm{~mm} \pm 0.13 \mathrm{~mm}$ (stat)

## Vertex reconstruction still not perfect

Run 1961 - Vertex Position



## Data taking quality

2016, data used for Andeas' presentation :

- 15\% of events with at least one track, 10\% with at least 16 clusters
- 80 KHz trigger rate @ 1.8e-8 mbar (Ne),
- 700 Hz R/O rate (No zero suppression)

New trigger scheme and BC selection will allow in 2017:

- $90 \%$ of events with at least one track, $80 \%$ with at least 16 clusters
- ? trigger rate,
- $\mathrm{R} / \mathrm{O} \simeq$ trigger rate (Zero suppression under implementation, summer 2017)


## Performance estimate for 2017

Optimistic estimation for full fledged 2017 data taking sessions:

- 5 times better event sample ( $10 \%$ to $50 \%$ ) => 3 smaller error in beam spot width estimation (10 minutes integration time)
- With implementation of ZS
- higher gas pressure if possible
- Full usage of 2000 B2 bunches (factor of 4 wrt 1961)
=> 8 smaller error in beam spot width estimation ( 5 minutes integration time)


## BGV Trigger Upgrade



- New trigger electronics
- CF Discriminators
- Delay and coincidence logic (~10ns coincidence window)
- Additional scintillators (L0 confirm)


## Trigger upgrade Status

- All hardware for $1 / 2$ of 'confirm' plane in ouir hands
- Commissioning : Summer 2017 (after a considerable data taking campaign with current conditions)
- If trigger rate is limited, extend 'confirm' plane to second $1 / 2$ (YETS2017-18)

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NB: A well tuned trigger system may on its own measure relative
    - Bunch populations
    - Ghost bunch charge
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## Gas injected ( $\mathrm{Ne}, \mathrm{Ar}, \ldots$ )

Improve BGV measurement precision by increasing number of particles per beam-gas interaction
$\sigma_{B G V} \propto 1 / \sqrt{N}$

Track multiplicity for (Ne, Ar) ~ (1, 1.5)

Ar can safely-simply be used instead of Ne

Possible modification at current BGV set-up during a TS (sept. 2017?)

## MicroMegas ps detector

For reconstructing the z profile of a beam bunch : need $\sim 6$ ops resolution


MM: small amplification gap (50-150 $\mu \mathrm{m}$ )

- fast signals (~ 1 ns)
- short recovery time (~50 ns)
- high rate capabilities (> MHz/cm²)
- high gain (up to $10^{5}$ or more)

Time resolution already achieved: <50ps

Anode can be in the form of wide ( $\sim \mathrm{cm}$ ) strips to match the BGV geometry

Could be placed possibly at the L0 confirm support frame
For more details see BE-BI seminar:
MicroMegas detector applications for beam diagnostics https://indico.cern.ch/event/540799/

## ps resolution detector

- Relatively wide strips (no need for precise space measurement) $\rightarrow$ limited number of F/E channels
- Sensor relatively cheap (single $30 \times 30 \mathrm{~cm}^{2}$ plane)
- R/O electronics still to be fully developed (and rad. hard. tested). Cost to be estimated
- Possible installation in LS2


## BGV and multiple scattering

- Multiple scattering is a limiting factor for the precision achievable with the BGV set-up
- Two sources of MS:
- Exit window for beam-gas induced tracks
- Radiation length thickness of ( $\left.1^{\text {st }}\right)$ detector plane


## DOCA error and Mult. Scatt.

## Analytical estimation



MC reconstructible tracks DOCA error
MC7TeVxOy0 - Error of DOCA as calculated


## BGV Material budget



Exit window ~ 3\% Xo
One detector plane ~ 3\% Xo

| Material | $\mathrm{E}(\mathrm{GPa})$ | $\mathrm{X}_{0}(\mathrm{~m})$ | $\mathrm{X}_{0} \mathrm{E}^{1 / 3}$ |
| :--- | :---: | :---: | :---: |
| Be | 290 | 0.353 | 2.34 |
| CFC | 200 | 0.271 | 1.58 |
| $\mathrm{Be}-\mathrm{Al}$ | 193 | 0.253 | 1.46 |
| Al | 70 | 0.089 | 0.37 |
| Ti | 110 | 0.036 | 0.17 |
| Fe | 210 | 0.0018 | 0.11 |

$\sigma_{M S} \propto \sqrt{X_{0}}$

Be instead of $\mathrm{Al} \rightarrow 1 / 2 \sigma_{M S}$ due to exit window
Table from R. Veness et al., Proceedings of IPAC2011

Detector material to be discussed at the detector upgrade part

## The Exit window



## New improved BGV detector

- What detector to be used instead of SciFi?
(optimal resolution, min. Xo)
-What is the best detector layout?
- Number of stations(currently 2 stations, may have to go to 3 if needed for alignment and performance issues)
- Relative distance
- Detector size
- What is the optimal BGV position for each beam in HL-LHC?


## New tracking detector

- $100 \mu \mathrm{~m}$ pitch
- 4 planes $30 \times 30 \mathrm{~cm}^{2}$ per multilayer $(x, y, u, v)=12.5$ Kchannels

Silicon Strip sensors

- 300-500 $\mu \mathrm{m}$ thick planes
- Ready-made sensors
- Available F/E chip
- 'Commercially developed' DAQ and control system
- Preliminary quote on the way

MicroMegas detector

- 50-100 $\mu \mathrm{m}$ thick planes
- Joint CERN-Saclay development
- Available F/E chip
- Data transmission using GBT chip
- R/O ~ 1 eur/channel (+ water cooling)
- Some R/D needed for final design

Both F/E chips will be certified for operation in BGV-like radiation environment in 2027

## MicroBulk MM



To be used in high rate environments, a resistive strip plane has to be added (BGV ~ 1KHz/cm²)

## BGV time-line

- 2017-18
- Precise beam width measurement
- On-line farm, CCC communication
- Upgrade tests (rad. hard., detectors ...)
- LS2
- ps detector demonstrator
- Optimization of current BGV (Geometry, gas volume, ...)
- LS3 BGV' in B1 and B2=
- Thin, $100 \mu \mathrm{~m}$ pitch, 2 or 3 detector stations, optimized position @HL-LHC
- Be exit window
- Gas volume optimization (and/or gas injection)
- Trigger and timing detectors as needed


## MC momentum of reconstructible tracks (MeV)

MC7TeVx0y0 - Momentum of the Rctbl Tracks


## Micromegas readout scheme



