New ALICE Beam Pipe: Injection Protection

C. Bracco on Behalf of ABT/BTP
Acknowledgment: M. Giovannozzi
Outlines

• Reminder
• Assumptions
• Aperture and beam envelope:
  – Nominal injection
  – Grazing event (MKI failure)
• Conclusions
• The protection elements must always be set to an aperture $a_{prot} < n_1$.

• For secondary collimators the condition $a_{sec} < a_{prot}$ must always be satisfied.

• The primary collimators must be the closest element to the beam and $a_{prim} < a_{sec}$ has to be valid. Primary collimators do not have to intercept the beam core ($3 \sigma$)!!
To protect the LHC aperture at injection (bottleneck in the arc) and respect the collimation hierarchy:

- LHC injection protection collimators (TDI, TCLIA and TCLIB) are at 6.8 σ
- TCDI (in the TL) are at 4.5 – 5 σ

• The protection elements must always be located inside the aperture.

• For secondary collimators the condition \( a_{\text{prim}} < a_{\text{sec}} \) has to be valid. Primary collimators are always at the beam core (3 σ)!!
Alice aperture: results - I

\[ n_1 (\sigma) \]

Distance from IP (m)

- Beam 1 - Nominal - Inj
- Beam 1 - After LS2 - Inj
- Beam 1 - After LS2 Rev 2 - Inj

\( \beta^* = 10 \text{ m} \)
\( \theta_{\text{ext}} = 170 \mu \text{rad} \)
\( \text{Sep} = 2 \text{ mm} \)

Ok!...check MKI grazing failure..

Minimum aperture = 13 \( \sigma \)
(bottleneck in the arc)

4 \( \sigma \) bottleneck in the experiment

Minimum aperture = 13 \( \sigma \)
(bottleneck in the arc)
MKI Failures

- **Injected batch**
- **Circulating LHC beam**
- **Miss-kicked Injected batch**
- **Grazing**
- **Kicked Circ. beam**
- **Over-kicked inj. batch**

**Injected beam:**

- **Nominal kick**
- **No kick**
- **¾ kick**
- **Grazing**

**Reminder**

90% MKI strength

10% MKI strength

Most critical
**Assumptions**

- Only MKI failures are considered: Only vertical plane
- Normalised emittance of 3.5 mm mrad also for postLS2 case
- Optics for protons (minimum n1): $\beta^* = 10$ m, crossing angle = 170 $\mu$rad, separation =2 mm
- Beam envelope: $6.8 \sigma_\beta$ (what can go through TCDIs and TDI)
- Aperture: Mech.aperture$^* - Mech.tol.* - Orbit** - Disp.offset
  * Data from ALICE and Massimo
  ** 3 mm *sqrt($\beta$/max($\beta$))
  ** Dy*3e-4
Aperture and Beam Envelope PreLS2

Nominal kick

TDI

TDI
Aperture and Beam Envelope PostLS2

Nominal kick

TDI

TDI
Grazing Event

- Nominal MKI kick
- TDI
- Nominal MKI kick
- TDI

grazing (10% MKI kick)
Conclusions

• The new proposed aperture fulfills the n1 requirements of collimation hierarchy: bottleneck kept in the arc and $> 7.5 \sigma$
• No direct beam impact on the new aperture is expected also in case of the most critical MKI failure (grazing event)
• Recommendation: calculate energy deposition induced by secondary showers in case of grazing event.