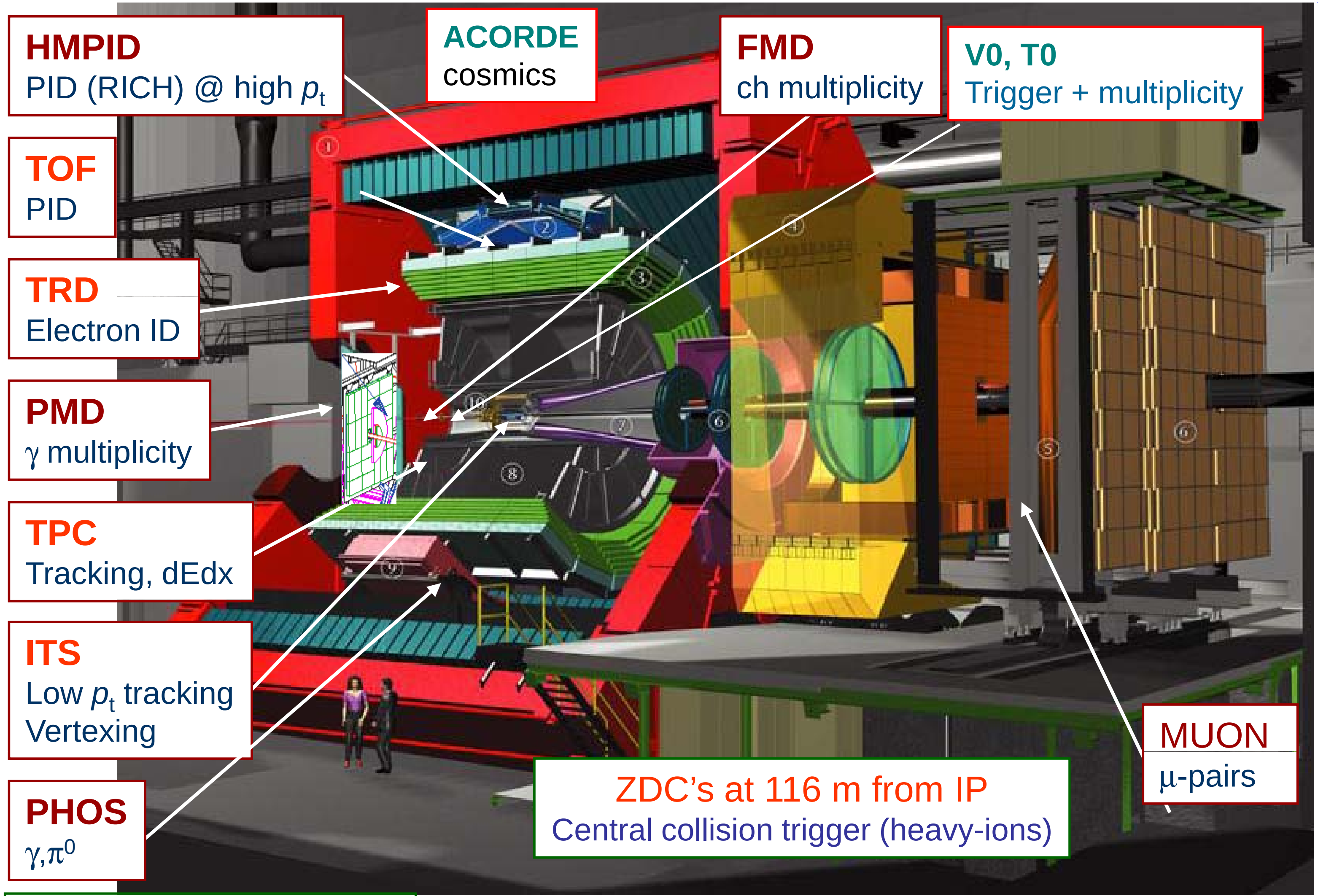
Protecting ALICE from beam failures

A. Di Mauro
for the ALICE collaboration

ALICE layout

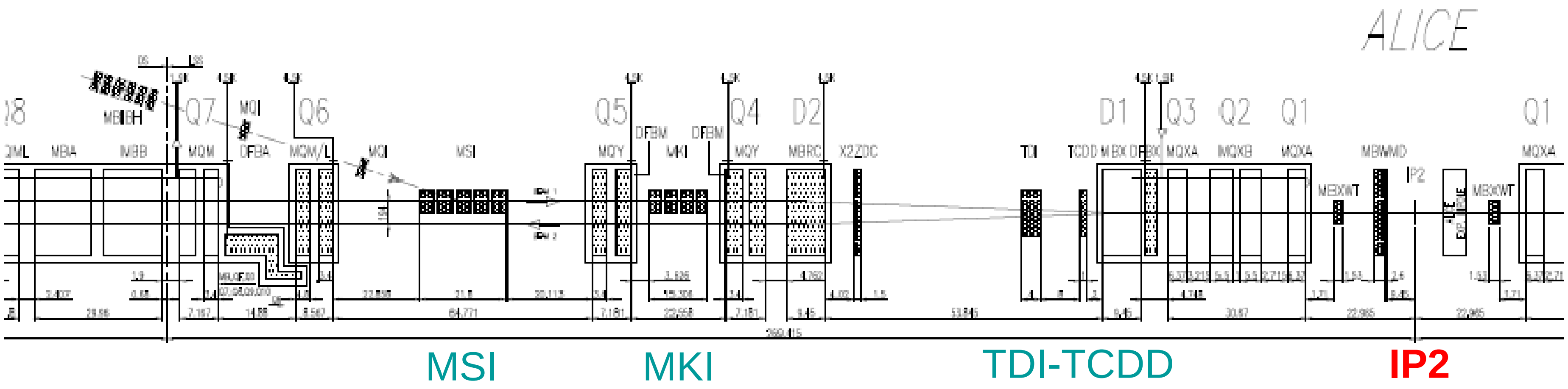


EM Calorimeter (future)

Simulation studies on radiation environment

From ALICE-INT-2002-28 and ALICE-INT-2001-03

- “normal” LHC operation: contributions from beam-beam, beam-gas and beam-halo
- Transfer line TI2 close to IP2-ALICE: failures due to injection kicker MKI

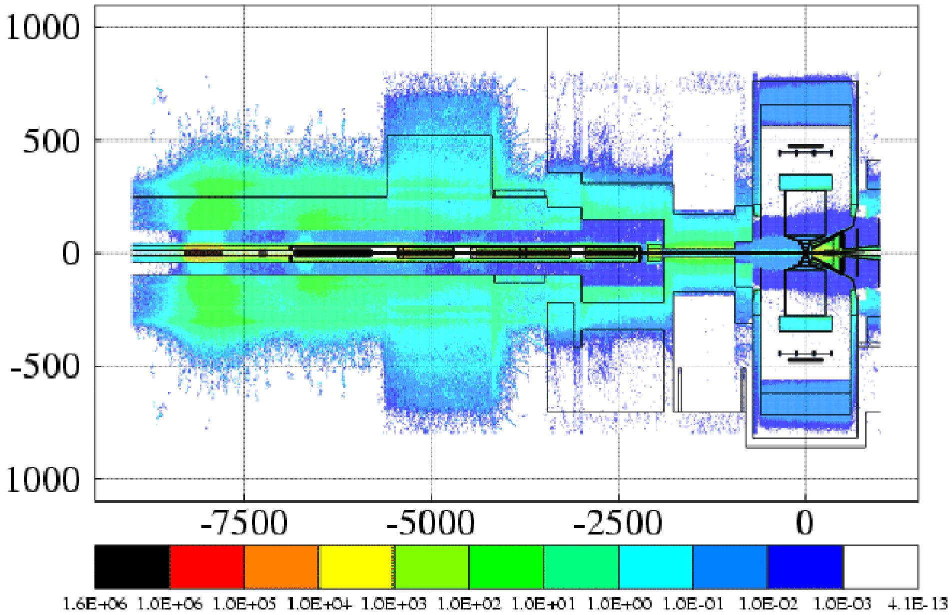


MKI failure modes

Case	Kick [%]	Impact on TDI [mm] from edge [mm]	Potential reasons	Expected rate
1	0	28.7	SPS extract. launched,LHC not ready Trigger logiccomplete fault	several/year 0.2/year
2	75	3.4	One MKI module full fault	0.2/year
3	0-100	various	Beam sweep: Prepulses timing wrong Trigger timing wrong	 several/year 0.2/year
4	75-125	0.- 3.4 worst: grazing impact, 86 %	One MKI module working partially (flashower in magnet, term.resistor or resistance in transmission line	0.05/year

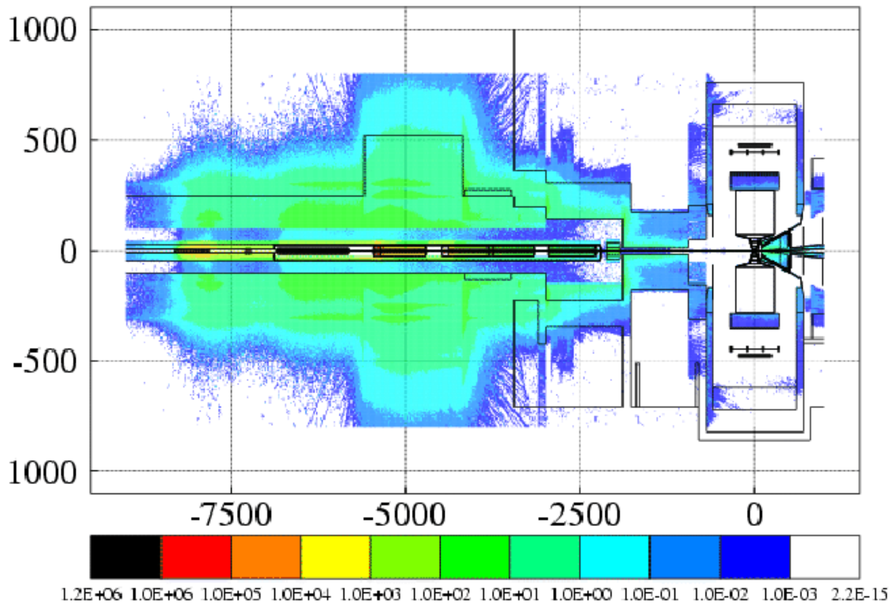
Energy deposition mapping for one accident

Case 4 (grazing)



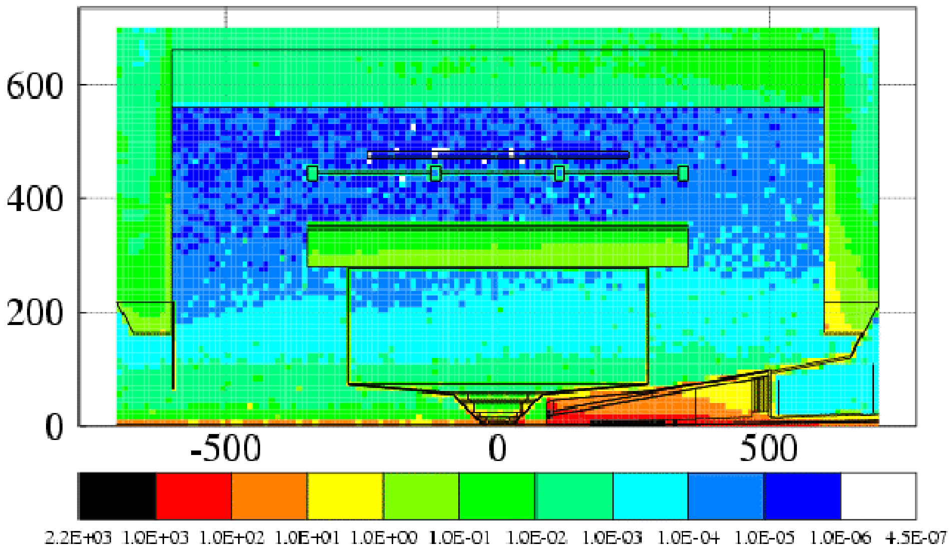
- **Region between TDI and ALICE**
- **Values in rad**

Case 3 (sweep)



Energy deposition mapping for one accident

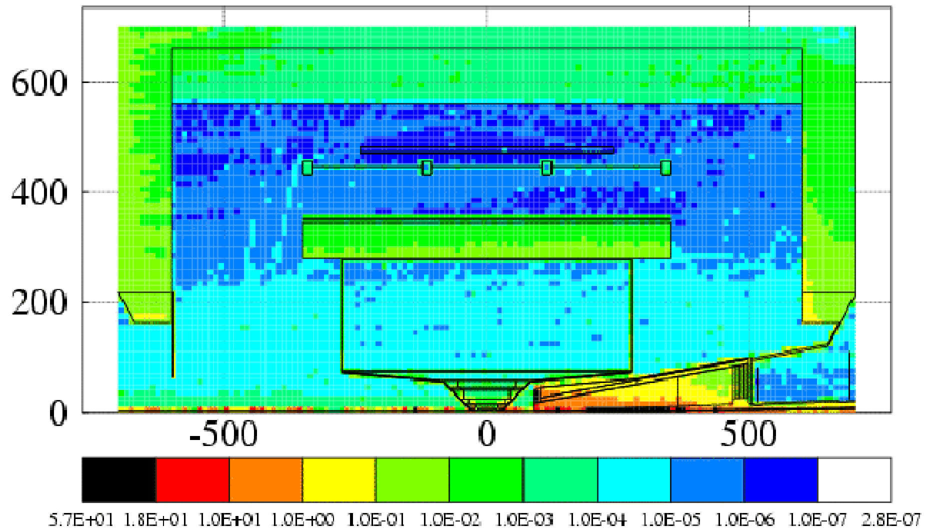
Case 4 (grazing)



- **Region inside ALICE**
- **Values in rad**

Largest dose in SPD1 and ITS electronics ~ 100 rad

Case 3 (sweep)



Summary of simulation studies

Expected doses for 10 years ALICE running

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
TPC(in)	13	0.25	2.9	16
TPC(out)	2	0.05	0.2	2.2
TRD	1.6	0.03	0.16	1.8
TOF	1.1	0.03	0.1	1.2
PHOS	0.5	0.01	0.04	0.5
HMPID	0.5	0.01	0.04	0.5

- Contribution from failure at injection negligible wrt normal detector operation (1% of total), however
  - Are such failure modes and rates still valid?
  - What about other failure scenarios ?

Detector damages

- SPD
  - MKI-grazing: 1 Gy (~ $5x10^9$ mips/cm^2 in a single burst) - That would not produce crystal defects, however it may induce very large currents (100 mA /pixel) , far above electronics specs → saturation and LV power supply trip, possible damages to electronics
  - According to performed irradiation tests 10^{12} mips/cm^2 could be at the limit…
- Gaseous detectors (PMD, TPC, TRD, TOF, HMPID, Muon-arm, CPV)

  Depending on the (primary and secondary) particle flux →

  discharges inside detector and HV power supply trip, possible accelerated ageing or breaking of sense wires (20 μm diameter)

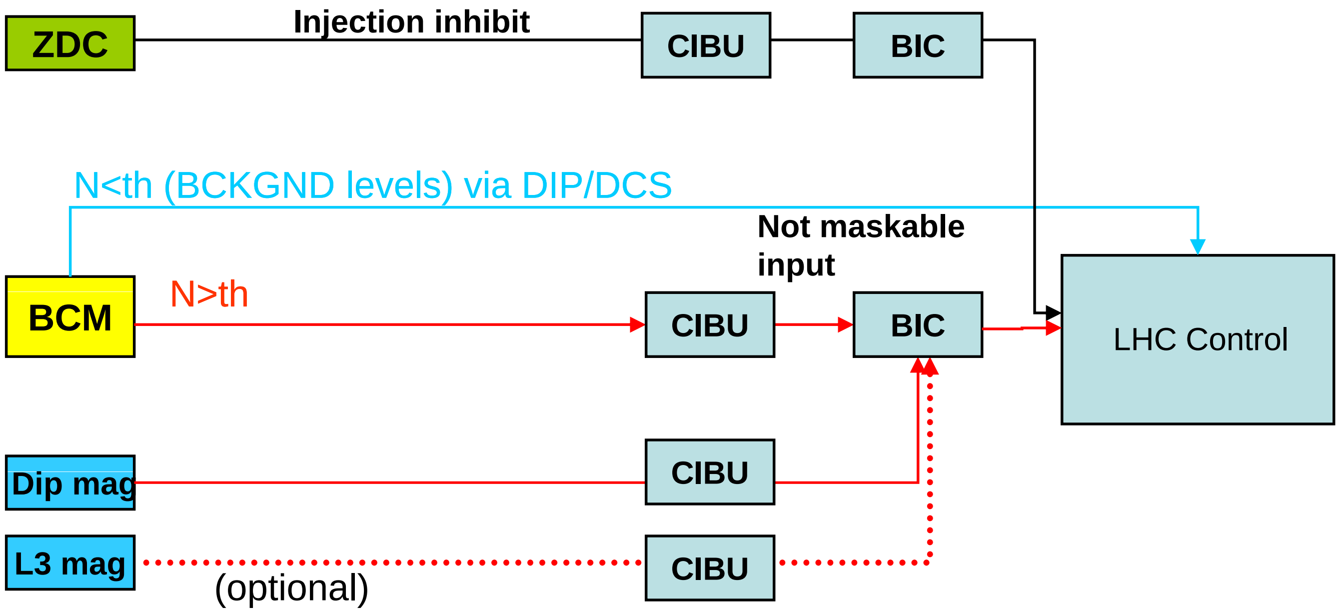
Thresholds to be verified in each detector

Protection against beam losses

- During injection:
  - only Beam Condition Monitors (+ZDC inhibit and Dipole magnet) will be active for hardware interlock, option: use V0/T0 if proven necessary and not affected by noise
  - all detectors could be in a configuration of no signal production (low V_{bias} in ITS, HV below gas multiplication in gaseous detectors, limited HV in PMT's), however ramping down/up could be very slow (30'-60') for some at the beginning
  - possibility to be checked: use some detectors at safe settings (LV / HV) to monitor beam losses inside experimental area

- During normal operation:
  - all detectors running
  - hardware interlock from BCM (+ZDC and Dipole Magnet)
  - software interlock from V0, T0, SPD, CTP, ….

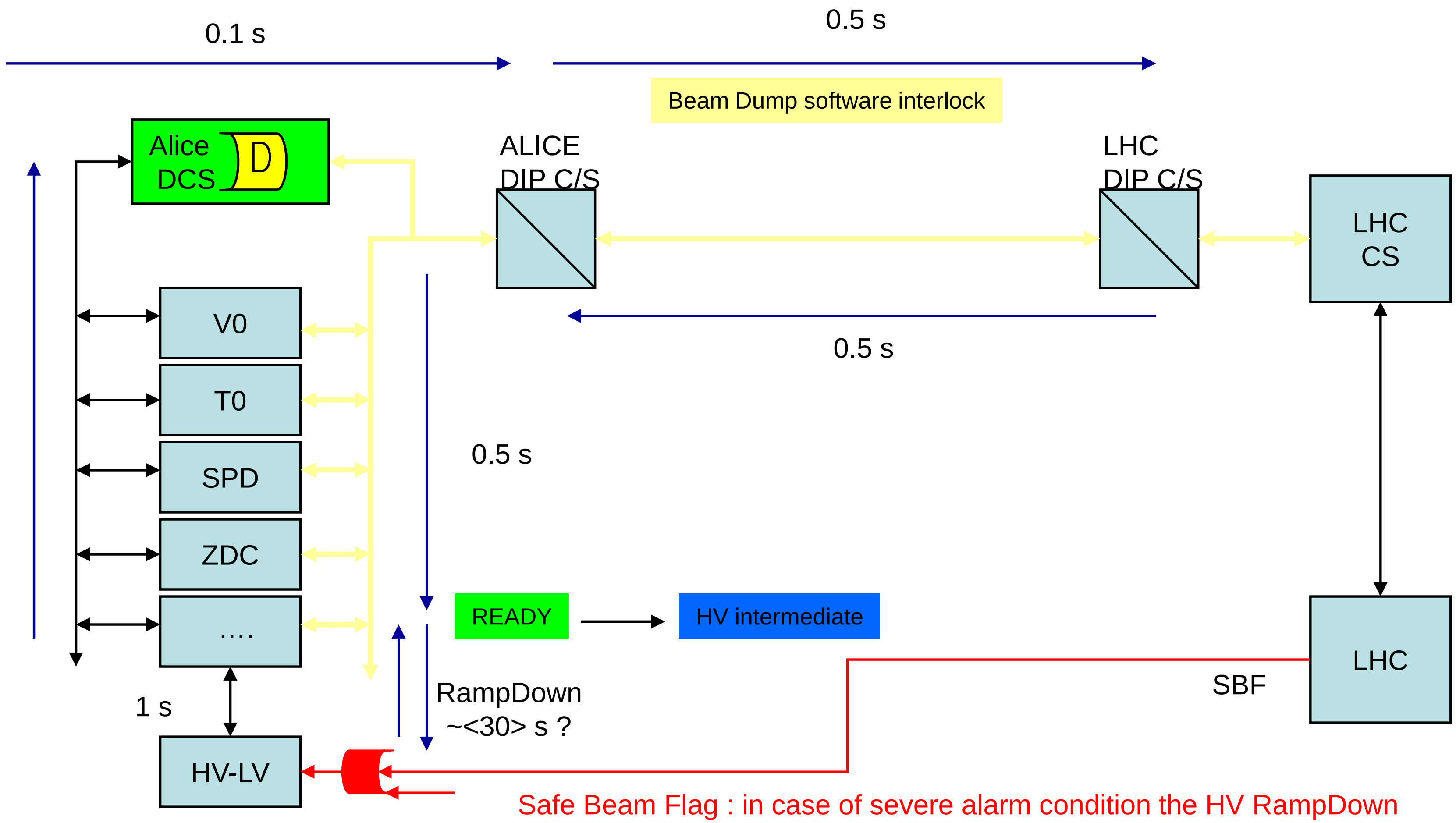
Hardware interlock scheme



- ZDC must be moved to its OUT position during beam injection
- ALICE dipole magnet has large effects on the beam and is part of beam optics; beam will have to be dumped in case of dipole magnet failure
- rack C28 (BCM readout board TELL1 and CIBU) and rack X07 in CR4 (power supplies) connected to UPS

Software interlocks

Implementation in DCS and timing info from G. De Cataldo



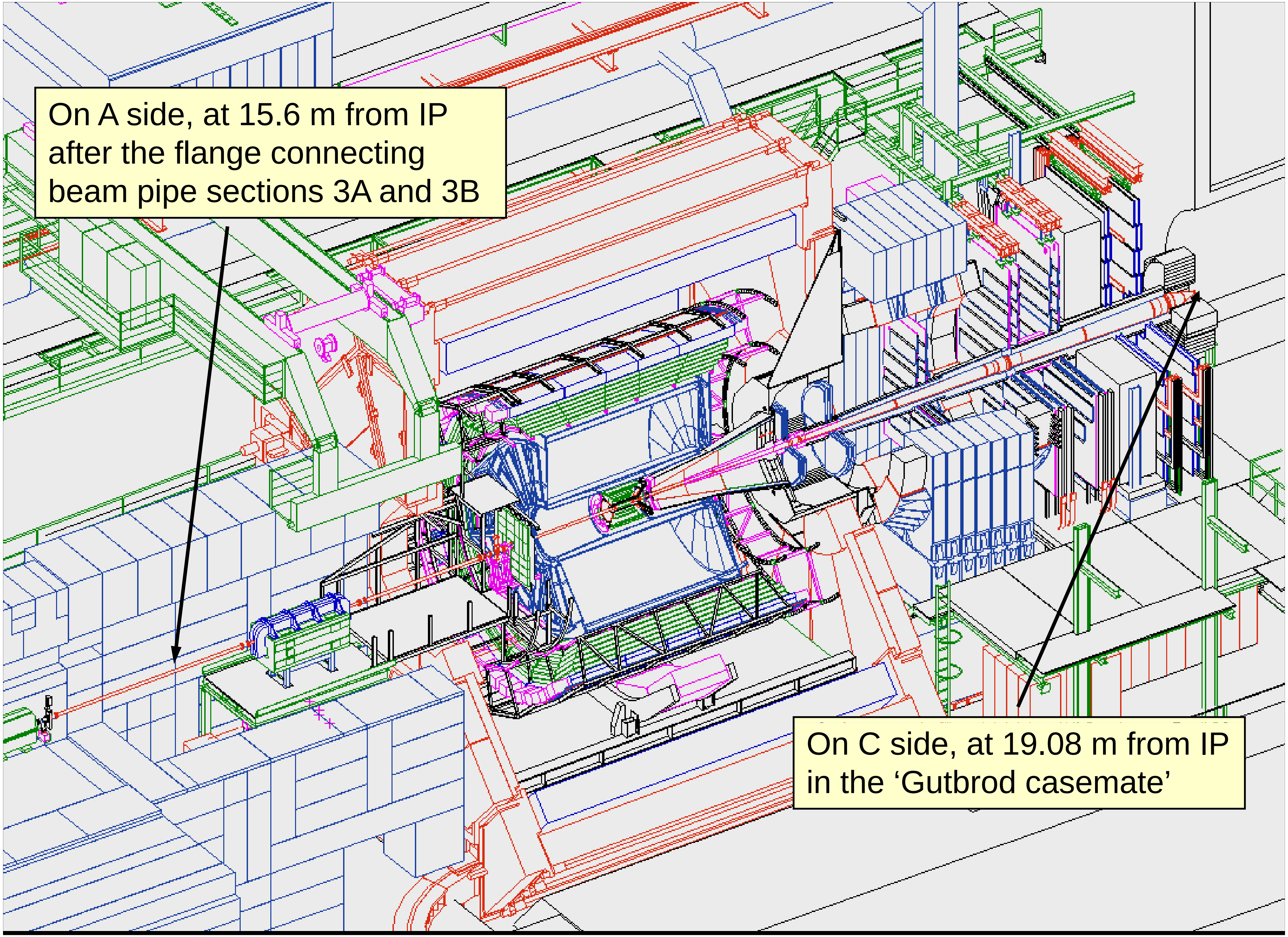
Safe Beam Flag : in case of severe alarm condition the HV RampDown could be triggered by LHC

Software interlocks

- All data exchange and software interlocks will use DIP
- Data to LHC (from D. Evans talk at LEADE)
  - Average rates – from Central Trigger Processor (CTP) counters
  - Average luminosity = factor x average rates
  - Rates/bunch – from CTP interaction records
  - Luminosity/bunch = factor x rates/bunch
  - Position and size of luminous region – fast (online) vertex reconstruction from pixel detectors
- S/W interlocks from ALICE to LHC: Injection-Inhibit, Ready-for-Adjust, Ready-for-Beam-Dump
- S/W interlocks from LHC to ALICE: Adjust-Request, Beam-Dump-Request

Beam Condition Monitors

- ALICE will use 1 cm^2 CVD Diamond sensors and signal processing system (TELL1 board) developed by LHCb
- Four doublets of sensors will be installed in the A side at 15.6 m from IP and four in the C side at 19.08 m from IP
- Expected response time for beam-dump signal is ~ 2 μs after 40 μs integration time
- Such detectors will be used to provide the BEAM_PERMIT signal to LHC, to dump the beam in case of danger and to monitor the machine background
- H/W procurement under way


On A side, at 15.6 m from IP after the flange connecting beam pipe sections 3A and 3B
On C side, at 19.08 m from IP in the 'Gutbrod casemate'

H/W interlock system commissioning

- BCM calibration from LHCb or in dedicated test-beam
- Measurement of normal signal levels for each location and tuning of thresholds: in-situ during Pilot Run, eventually with single beam and with colliding beams (valid also for V0, T0)
- Implementation in ALIROOT and study with simulation the response for normal/good beam and correlation of total current/signal asymmetry with V0, T0, SPD, …
- Long-term: use post-mortem data from all beam dumps to check system failures and refine thresholds

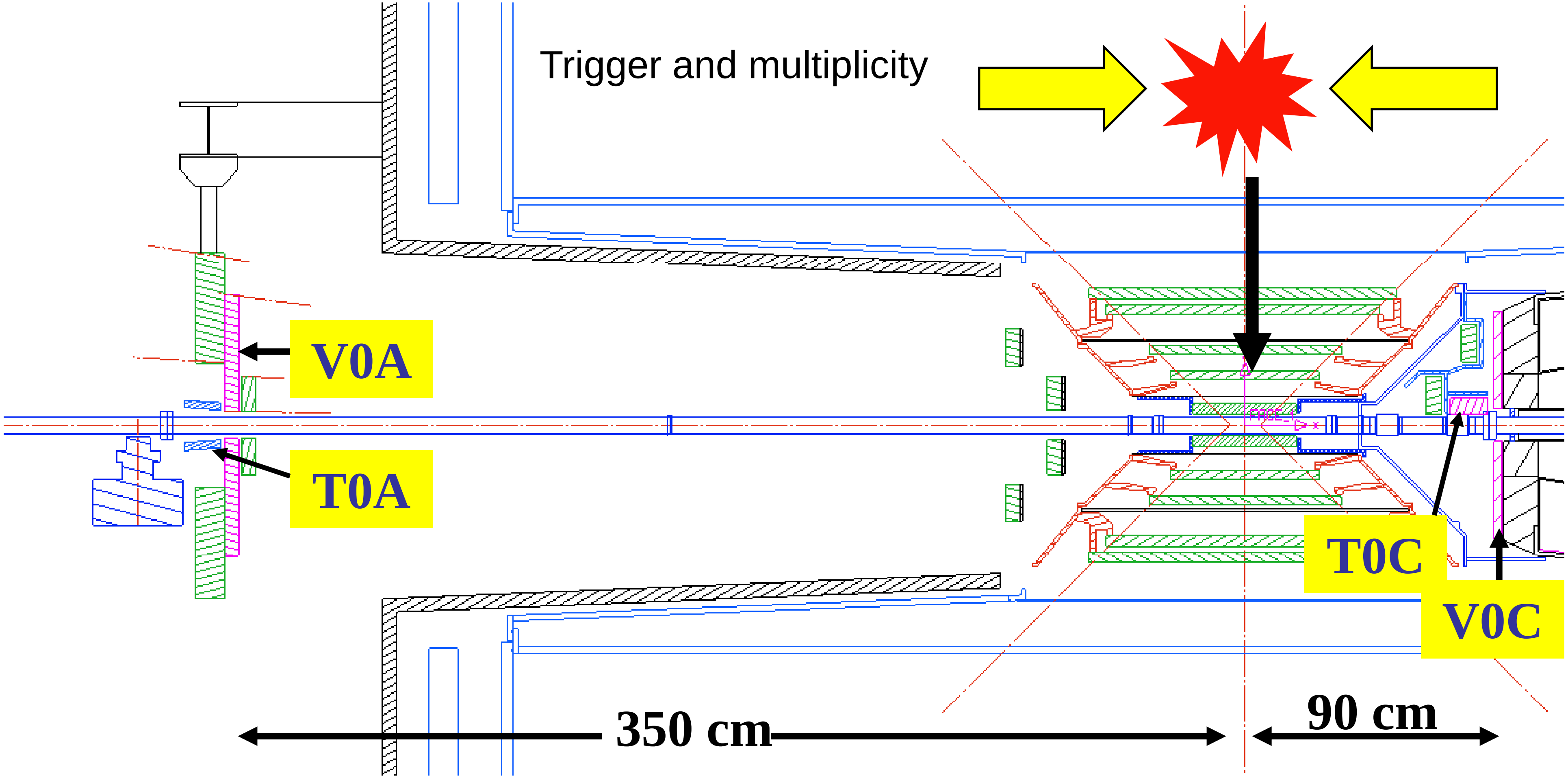
Conclusions

- ALICE has developed a clear concept about on beam protection. It will be implemented in the next 6 months.
- Answers:
  - New simulation for beam losses at IR2 could be needed due to differences in layout wrt other IRs
  - At the present 10^{12} does not seem a Safe Beam for ALICE, further checks are needed

Ackowledgements

- BCM H/W installation: W. Riegler, H. Schindler
- Luminosity/ background measurements : T. Nayak
- TTC, CTP: D. Evans
- Implementation in DCS: G. De Cataldo
- Dipole Magnet interlock: E. Sbrissa
- ZDC Injection Inhibit: D. Swoboda
- Simulation: A. Morsch, H. Schindler

V0 and T0 positions in ALICE



V0A @ -340 cm, T0A @ -350 cm
V0C @ 90 cm,   T0A @ 70 cm

Luminosity in ALICE

- Luminosity measurements using V0, T0, ZDC (only heavy –ions) and LHC Luminometer (close to ZDC)
- Target values:

  - $3x10^{30}$ cm^{-2} s^{-1} in pp (max, 200 kHz limit as TPC drift time is 90 μs)

  - $1x10^{27}$ cm^{-2} s^{-1} in PbPb
- Online luminosity estimated from measured rates
- **Feedback to LHC: needed for beam tuning, optimizing beam conditions and establishing proper running conditions**