First Outcome of the Task Force on Safety of Personnel in LHC underground areas following the sector 34 accident of 19-Sep-2008

R. Trant on behalf of the Taskforce

19 March 2009 – HWC Day

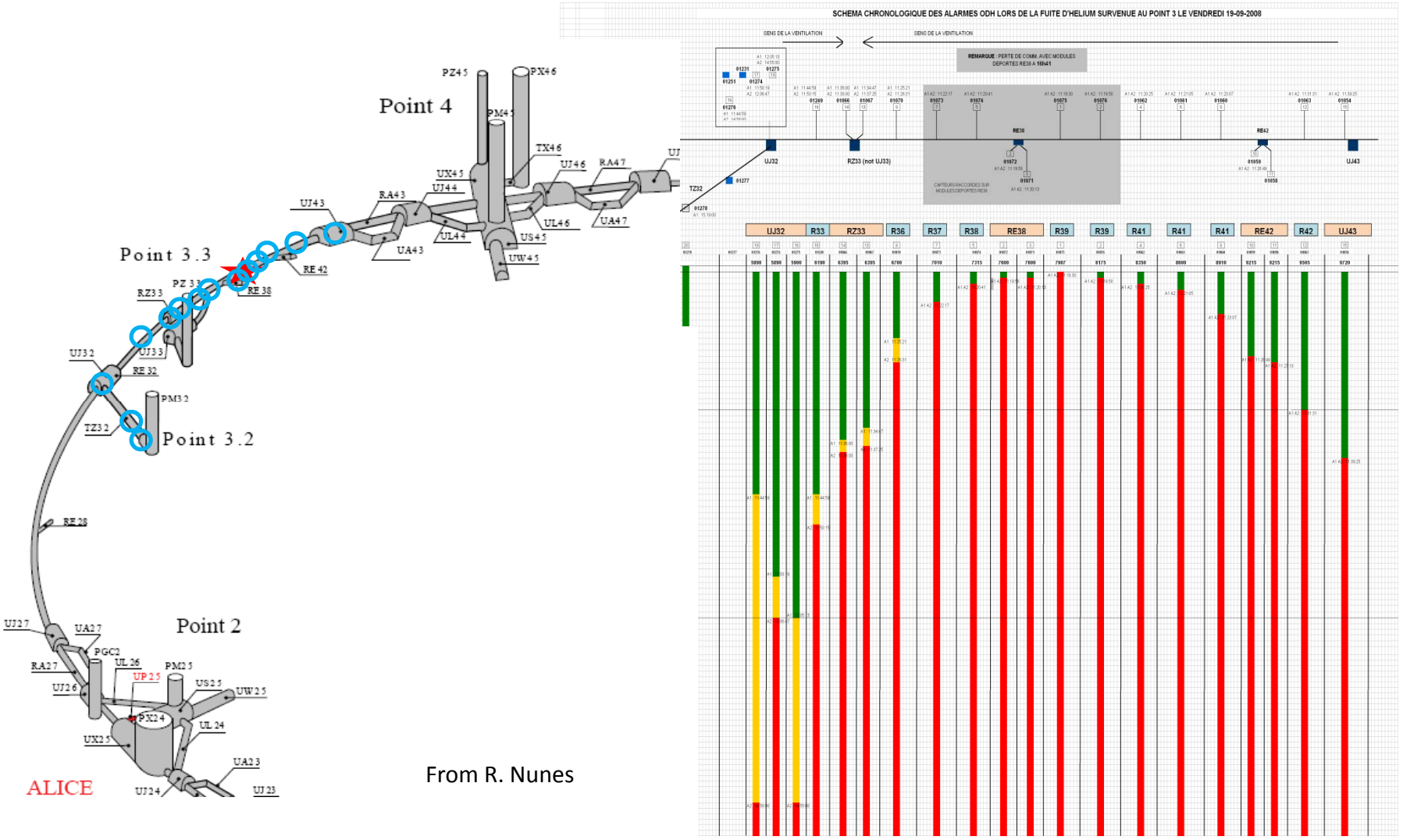
Mandate

- 1st Step: Establish the sequence of facts related to safety of personnel, based on e.g. AL3 data and FB emergency intervention records. *(Completed)*
- 2nd Step: Analyse the LHC underground environmental conditions with respect to Safety of personnel and explain their development, in relation with original risk analyses (incl. tests) performed. *(ongoing, 90% completed)*
- 3rd Step: Recommend preventive and corrective measures for the Safety of Personnel in the LHC underground *(started)*

Establish the sequence of facts

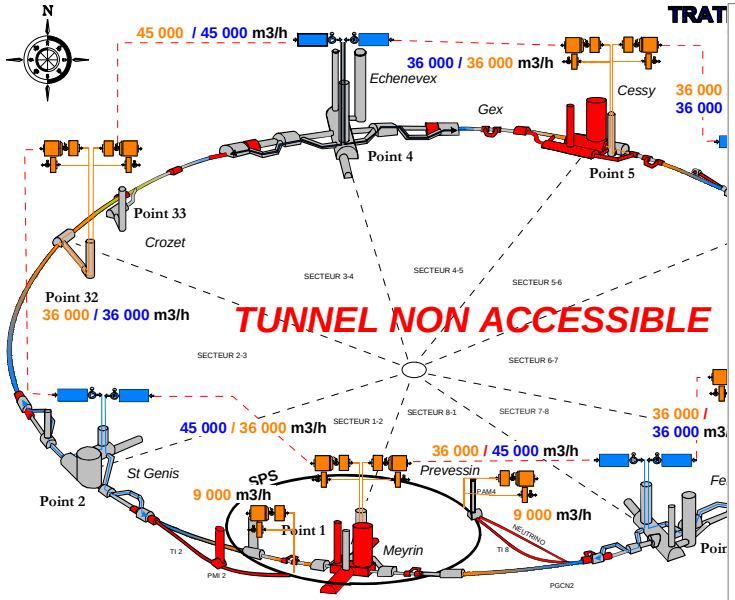
- Available data:
  - AL3 data (ODH, AFD);
  - FB intervention report;
  - He mass flow estimates;
  - Pt4: video surveillance A and B from access point
  - Manual actions on ventilation system & air measurements;
  - Sequence of facts from technical TF;
  - Geometry of tunnel [volume, length, …];
  - Position of equipment
    - *Safety valves;*
    - *ODH sensors & AFD sensors;*
    - *Ventilation doors & inlets/outlets;*
- Available simulations:
  - EN-CV CFD simulation: foreseen for 20th March 09
  - Wroclaw University of Technology, CFD simulation: provided on 13th March 09
  - Wroclaw University of Technology, ODH simulations from 1999
  - He spill and temperature simulations (M. Vadon et. al.) from 2002
- Available tests:
  - Wroclaw University of Technology, ODH propagation scaled tests from 1999
  - He spill test with QRL test cell in 2001

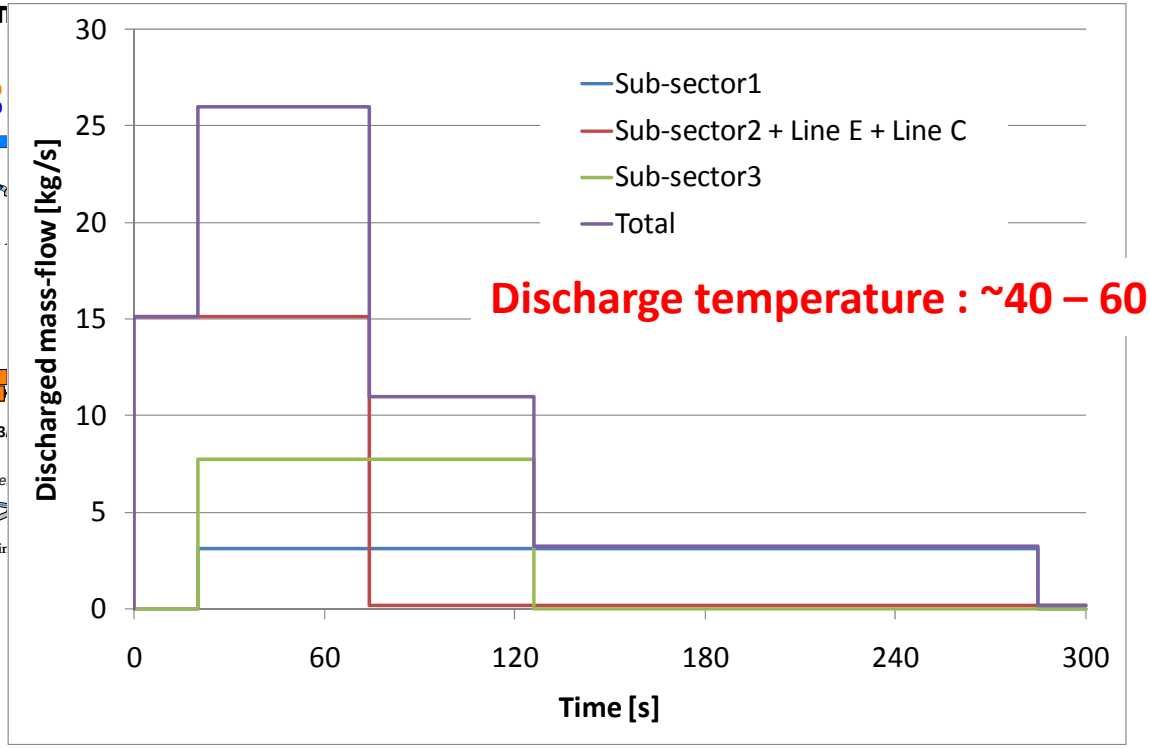
ODH data



From R. Nunes

Mass-flow discharge





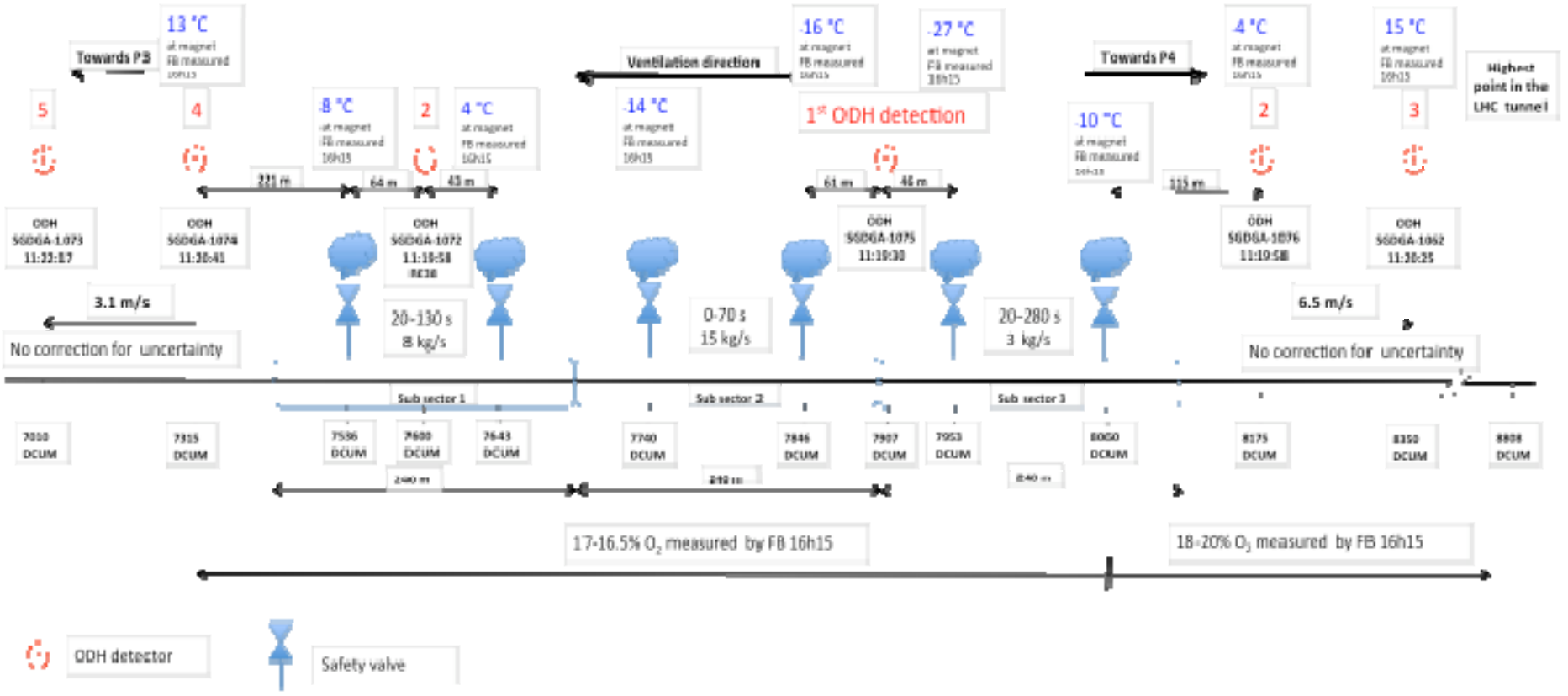
Discharge temperature : ~40 – 60 K

	14:30	14:55	15:13	16:10	16:45	17:55
% N2	49	39	44	41	41	43
% O2	12	9	10	10	10	11
% He	39	51	46	47	47	46

From L. Tavian & J. Inigo-Golfin

Measurements on air outlet Pt3, 19-Sep-08

D-area – ODH propagation & FB info compared



From G. Lindell

Analyse underground environmental conditions & explain their development

- 1st arcflash at 11:19 from cell A19R3
  - The accident results into He-release of ~2 tons in ~2 minutes;
  - ODH sensor close to D-area triggers immediately;
  - AFD in RE38 triggers due to He/H_2O vapour cloud in tunnel;
  - Massflow of 15 to 26 kg/s for about 40 sec increases static pressure in “closed” ventilation area of sector 34 ;
  - At ~135 mbar static overpressure the sector door in UL44 gives in thus creating a flushing of all sector 34;
  - This flushing creates dust allover which triggers AFD outside D-area in all S34 ~40 sec after the incident started;
  - Leads to He cloud propagation with ~5m/s close to D-area and ~1 m/s close to access points [remember: evacuation speed ~1.2 m/s].
- D-area (3x214m) became “death area”, for sure due to ODH (TF “opinion”) and most probably for temperature as well.

Preliminary Conclusions

- The environmental conditions and their development during S34 accident 19 September 2008 is sufficiently well understood to draw conclusions.
- The damage area of the S34 accident 19 September 2008 was about in the middle of the arc; this together with the ventilation door in UL44 being the weakest point limited the ODH risk to S34 and directly related access areas.
- The Safety TF understands that the conclusion of the technical TF and Chamonix 2009 are that the reoccurrence of an interconnect arc flash cannot be excluded, but the immediate He-release can be limited to 1100 kg [820 kg + E-line (290 kg)], [1500 kg in the midarc position] & [900kg in the DS area].
- The TF understands that such an arc flash/MCI can occur at any part of the cold machine, thus no distinction is made with respect to where inside a sector the MCI may occur.
- TF has so far not identified new “credible” failure modes resulting in a He release larger than 1 kg/s with the machine tunnel in access mode.
  - Input to be provided from TE-MSC on a break of insulation vacuum on a He-filled subsector with breaking of a fixed point (Jack or support post).

Recommendations (1/2)

- The approach to split the access during powering tests in two phases (low- & high current powering tests) is considered reasonable;
  - Threshold current value between phase I and phase II still has to be defined and agreed;
  - Technical means to control the different access phases still has to be defined and confirmed;
  - Possible access areas in powering phase II still have to be defined;
  - The TF expects an Engineering Spec. from the powering and access study team (see talk R.Schmidt, LMC 11-03-09);
  - Particularities of each sector have to be considered (*see also next slide).

Access in View of Particularities of each Sector

- General Rule for the underground
  - Access to sector tested, adjacent technical areas and neighbouring sector/cavern : forbidden;
    - *Point 1 - S12 - point 2 - **S23** - point 3 - S34 - Point 4*
    - *Point 2 - S23 - point 3 - **S34** - point 4 - S45 - Point 5*
    - *Point 3 - S34 - point 4 - **S45** - point 5 - S56 - Point 6*
    - *Point 4 - S45 - point 5 - **S56** - point 6 - S67 - Point 7*
    - *Point 5 - S56 - point 6 - **S67** - point 7 - S78 - Point 8*
    - *Point 6 - S67 - point 7 - **S78** - point 8 - S81 - Point 1*
    - *Point 7 - S78 - point 8 - **S81** - point 1 - S12 - Point 2*
    - *Point 8 - S81 - point 1 - **S12** - point 2 - S23 - Point 3*
  - Access to surface buildings still to be assessed case by case;
  - Same for UAs / ULs,…

Baseline scenario as applied in Oct-08

Recommendations (2/2)

- ODH risk has to be confined to ventilation sector concerned & controlled release at the surface
  - Limit via machine protection systems the maximum possible amount of immediate He-release to 1100 kg (or 1500 kg for mid-arc) [results of technical TF]
  - Seal machine tunnel towards experimental caverns; compatible to the max. pressure still to be defined [attention: e.g. concrete block shielding]
  - Install ventilation doors at the end of machine tunnel ventilation sector and allow for a controlled relief of the pressure from the ventilation area to the surface, both compatible to the max. pressure still to be defined.

Open Points

- Intermediate compensatory measures for sectors w/o technical TF recommendations being fully implemented before repowering.
- Intermediate compensatory measures for sectors w/o Safety-TF recommendations being fully implemented before repowering.
- Risk to personnel following mechanical impact from machine arc flash to experiment beam tube or inner detectors.
- May similar scenario happen to ATLAS/CMS SC magnets?