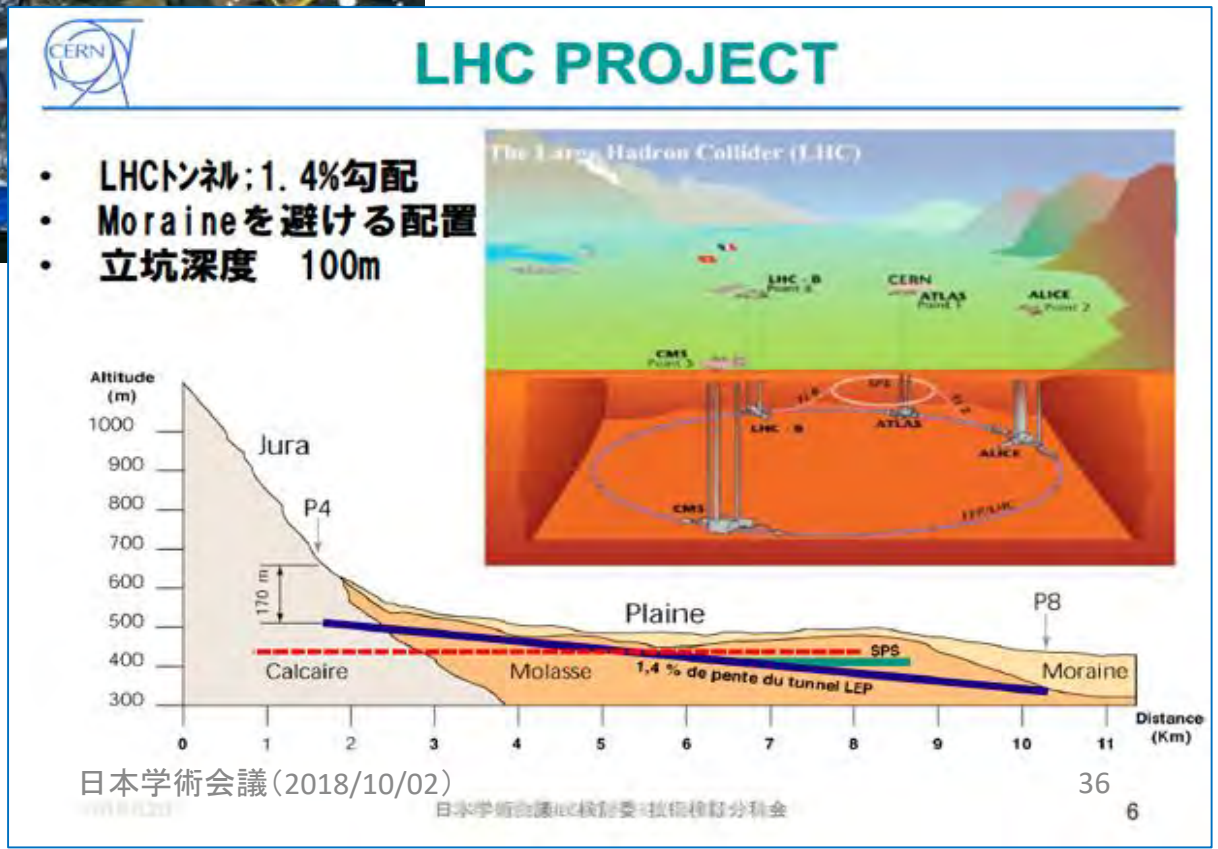
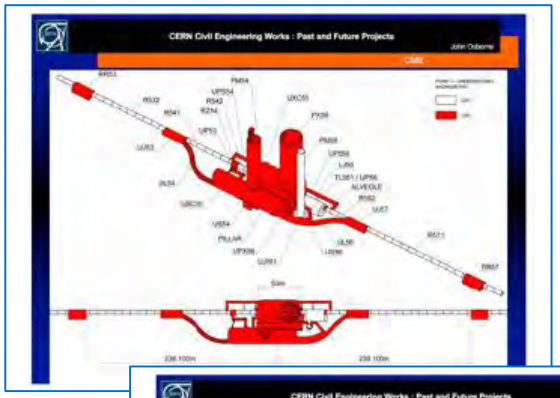
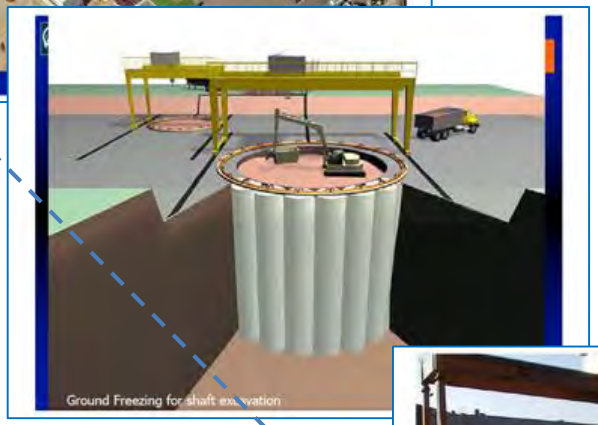

世界最大の加速器 LHC
CMS
LHCb
ATLAS
ALICE
CERN
陽子-陽子衝突型加速器 リングコライダー
LHC リング:周長27 km


LHC PROJECT
• LHCトンネル:1.4%勾配
• Moraineを避ける配置
• 立坑深度 100m
The Large Hadron Collider (LHC)
CERN
ATLAS
ALICE
CMS
Altitude (m)
1000
900
800
700
600
500
400
300
Jura
P4
170 m
Plaine
P8
SPS
Calcaire
Molasse
1,4 % de pente du tunnel LEP
Moraine
0
1
2
3
4
5
6
7
8
9
10
11
Distance (Km)

CMS Vertical Shaft Construction
By using LN2 Freezing Technology





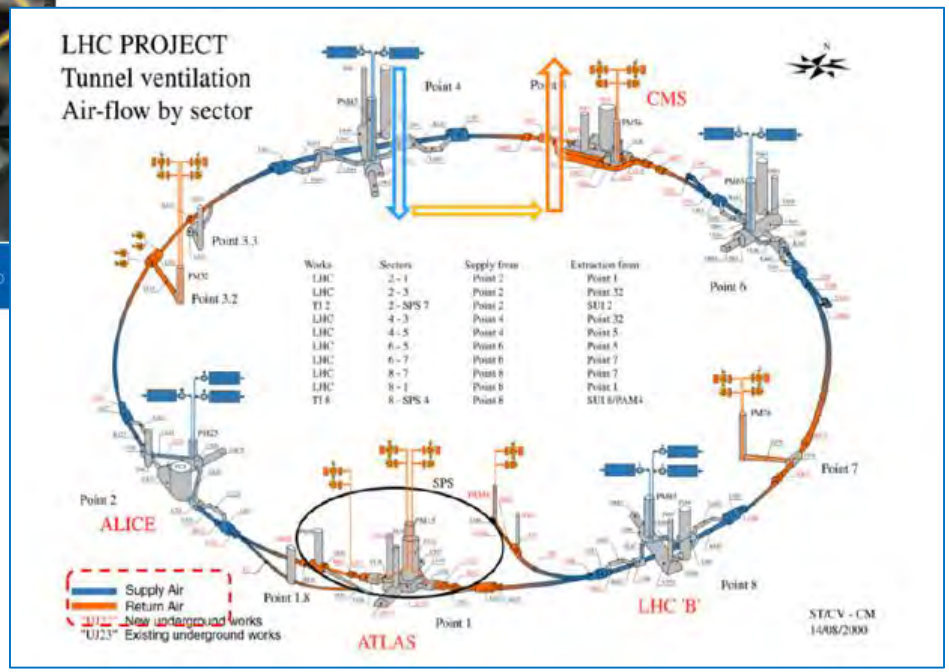
CERN HSE
LHC general safety measures
(Fire, Cryogenic Leaks)

CERN Health, Safety, and Environment (健康・安全・環境)

一般安全への取り組み

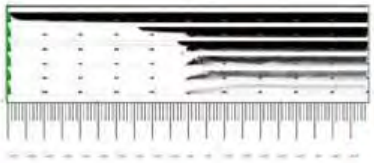
トンネル内の火災、冷媒の漏洩を焦点として、、

Fabio Corsanego



CFD studies of smoke propagation in LHC

- Scenarios from 10 KW to 1 MW
  - (10-50-100-500-1000 KW)



6 runs with smoke of fires of different power compared

CFD Findings

- After a distance up to a few hundred m smoke velocity approaches ventilation velocity
- 数100 mの範囲で、煙の速度は、ベンチレーションの速度に、
- Slope adds up to the velocity (but LHC slope is of about 1.5% so the effect is small)
- LHC のスロープは、1.5% なので、勾配による影響は少ない

Smoke management principles

- Air flow shall respect:
  - Minimum speed of ~0.5 m/s
  - Maximum speed of ~1.2m/s
  - 最低速度: 05 m/s
  - 最高速度: 1.2 m/s
- A person (1.5-1.8 m/s) shall always be enabled to walk faster than the smoke;
  - 人速度: 1.5 ~ 1.8 m/s
  - 煙より早い
- Smoke extraction can be initiated only after that evacuation is complete (to avoid smoke over-speed wrto people);
  - 煙の排出は、人の避難を終えた後、

Pressurized lift and stair areas

加圧されたエレベータ（通常とは異なる安全対策、非常時はエレベータで避難）

Emergency Self Contained Breathing Apparatus

非常時酸素呼吸器

- SCBA –Potassium Superoxyde (KO_2) covers residual risk (personal protection equipment).
- 残るリスクを抑制，人の安全を確保する酸素吸入器

Weight	1.3 kg (1.6 kg SSR 30/100B)
Carrying mode	in front of chest with neckstrap and waist belt (SSR 30/100) or in front of chest in lower part of container (SSR 30/100 B)
Principle of operation	regeneration of breathable air through KO_2
Flow principle	pendulum breathing (see schematic)
Duration	30 min at 35 l/min (Class R 30 S according EN 13794) 30 min at 30 l/min (escape) 100 min at 10 l/min (at rest)
Temperature class	T3

Strong and weak points of LHC ventilation scheme

The good:

- Minimized ground excavation
- Simple handling of the ventilation

The less good:

- People can stop only after 2.5 km
- Critical for fire fighters safety (long distance with no intermediate safe areas)
- Suitable only for small amount of combustibles
- Critically depending on management of ventilation velocity

LHC 空気循環スキーム

利点

- 最小限の地下掘削
- 単純な空気循環

良いとは言えない点

- 2.5 km 毎の避難ポイント
- 消防士安全、長距離間隔の安全x地点
- 少量可燃物に対してのみ適切
- 空気循環速度管理

Helium spill in tunnels: the risk

- **Low temperatures**
  - Cold burns Embrittlement
  - O_2 enrichment (cold surface→ liquid air)
- **Pressure build up:**
  - Inside equipment
  - In the tunnel & surface buildings
- **Oxygen deficiency hazard (ODH)**

- 低温冷媒
  - 凍傷
  - 低温機器表面での酸素液化・凝縮
- 圧力上昇
  - 機器内部
  - トンネル内、地上建物内
- 酸欠

Mitigation actions in LHC

- **Minimize access**
  - No access during cool down (300K-80K)
  - Magnets powering phase 1
    - Use remote controlled instrumentation when possible
    - Access only for powering experts
  - No access when magnets above powering phase 1
  - No access to adjacent sectors during power tests.
  - Forbidden zones when filled with LHe (dead ends etc).

- 最小限のアクセス
  - 冷却中はアクセス不可
  - 通電中はアクセス不可
  - デッドエンドなどへのアクセス禁止

Mitigation actions in LHC

- **Restrict the activities**
  - Mechanical impact assessment of heavy transport
  - No transport allowed which could potentially create a helium leak.
- **Vent lines to safe areas**
- **ODH alarms (collective and personal).**
  - Partial pressure sensors due to helium
  - Electronics separated due to radiation
- **Self rescue masks provide O_2 for 30 minutes**
- **Training (online + class room for self rescue mask)**

冷却されている間の活動の制限
- 重量物の移動
- 安全地域でのガス放出
- 酸欠警報
- 酸素ボンベ（30分対応）
- 訓練

Emergency Self Contained Breathing Apparatus donning sequence

- アクセス状態での空気速度の抑制
- 室温ヘリウムガスの移送を行わない
- 安全弁の段階的運用
- 空気速度モニターの導入