Safety Issues for HIE-ISOLDE and nTOF-Ph2

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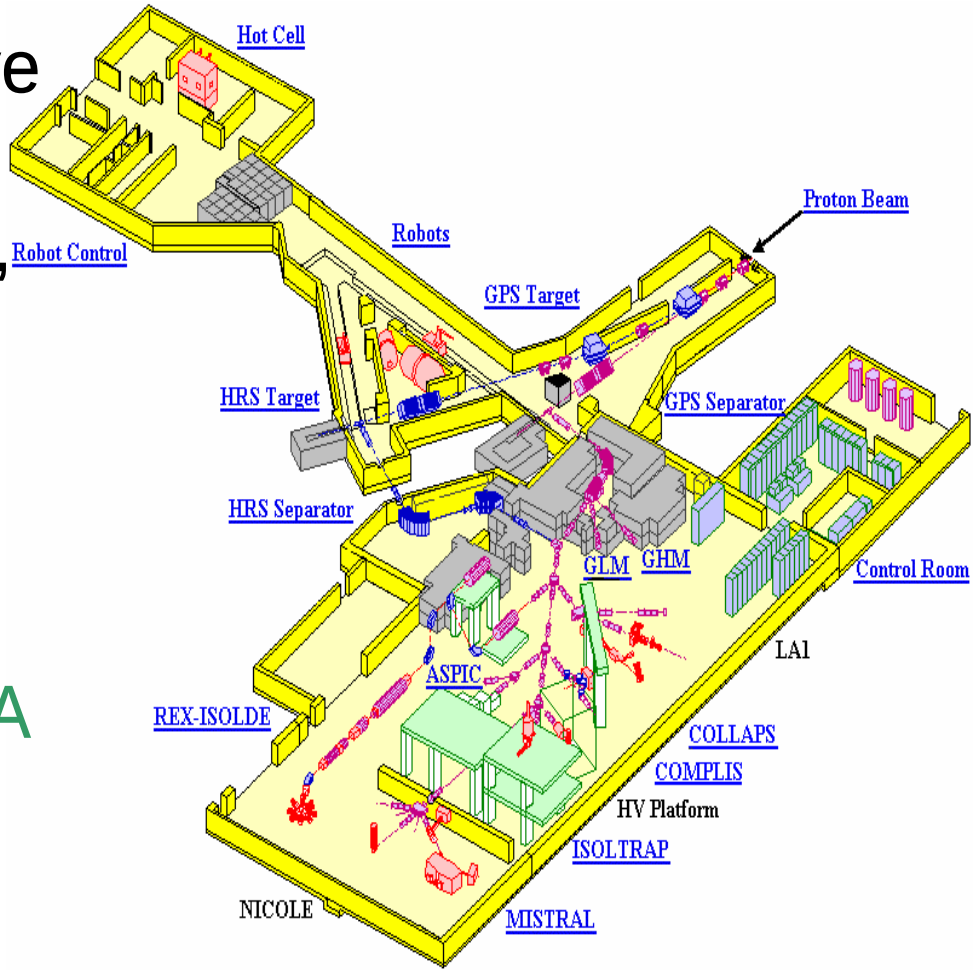
PSB ISOLDE: Parameters

- Protection features have been designed for
  E = 1 GeV , I = 1.6 µA,
  P = 1.6 kW.
  (A.H. Sullivan, 1990)
- Conservative design:
  facility operated at
  E = 1.4 GeV, I = 2.1 µA
  (P = 3 kW).



HIE ISOLDE: Parameters

- Increase of the average proton beam current:
  - higher input current from LINAC-4
  - shorter cycle of PS Booster
  - more pulses from PS Booster
- An overall gain of up to 5 is hoped for:
  E=1.4 GeV, I = 10 μA , P = 14 kW
- More exotic options (e.g. fission target driven by Linac-4) are not yet considered

PSB ISOLDE: Releases

- Activation of air in target area
- Extraction by ventilation
- Release into environment
- Exposure of public

- Present Situation:
  - Dose to “critical population group” from releases of Meyrin Site: 3.8 μSv/year (50% from ISOLDE).
    The Swiss Guideline value is 10 μSv/year and no NPP exceeds 5 μSv/year.
  - Triggering of radioactivity gates monitors at exits of CERN from activated air, when beam intenity increased (wind dependent)

HIE ISOLDE: Releases

- Air activation ~ number of protons on the target:
  - 1.9 μSv/year * 5 = 9.6 μSv/year
- More releases from PS and transfer to SPS due to (intense) CNGS beam:
  - 5 – 7 μSv/year
- Contribution from n-TOF sizeable, but presently unknown
- Guideline value exceeded, must apply optimisation
  - Option 1: recirculation of air in target area
  - Option 2: significantly higher ventilation stack

PSB ISOLDE: Maintenance

- Maintenace is “Hands-on”
- In the Faraday cages:

$$\dot{H}^{*}(10) \approx 5\ \mathrm{mSv/h}$$

- Collective dose :
  H_{coll} = 15–25 man-mSv/year
- Highest exposed individuals:
  between 4 and 6 mSv/year

HIE ISOLDE: Maintenance

- Simple scaling:
  Dose rate from activation ~ Number of protons
  - present “Hands-on” practice cannot continue.
- Option 1: improve reliability of target/front-end
- Option 2: rapid exchange of functional units
  (no intervention on recently irradiated components)
  Requires sufficient spare front-ends
  (repair might be deferred to years later, when dose rate acceptable for repair)

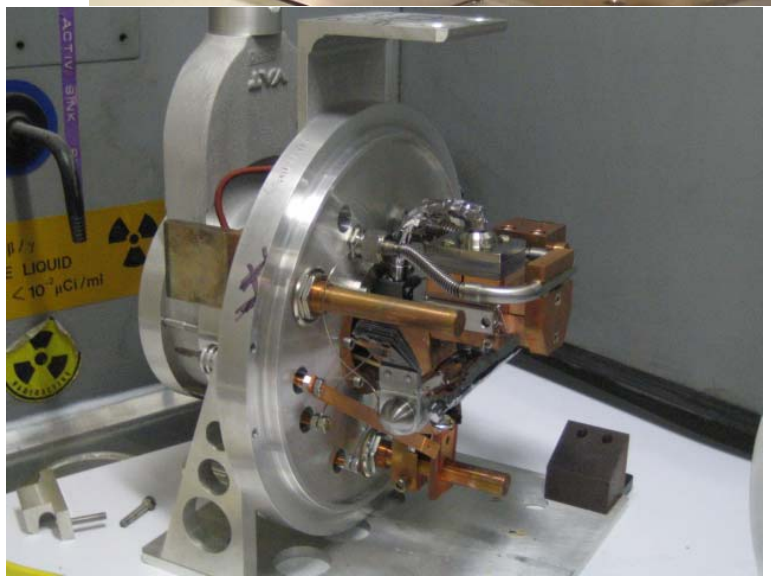
PSB ISOLDE: Contamination

- Internal structures of front end, separator, beam lines and vacuum system are heavily contaminated.
- Radiotoxic a-emitters from actinide targets
- Bat. 179 now classified as a worksector (type A):
- New, personnel-intensive, procedures

HIE ISOLDE: Contamination

- Remove potentially contaminating items from “normal” areas.
- Regroup vacuum equipment in HRS area
- Physically separate HRS area from experimental area
- Improve working conditions during interventions on vacuum system
- Retain radioactive gases from vacuum system in new tank (under-pressure)

PSB ISOLDE: Waste



- 30 targets used and declared waste per year, 50% actinide Contaminated and activated Waste
- 350 targets stored in temporary storage area under control of SC-RP.
- Potential radiation hazard:
  - dose rate
  - leakage of contamination
- Project for characterising, pre-conditioning and eliminating the waste has only just begun

HIE ISOLDE: Waste

- 5 times “more” target waste is going to be produced
  - either more targets or more active targets
- Use of fast-exchangeable components will increase activated waste volume
- Sufficient resources must be available for
  - waste characterisation,
  - pre-conditioning
  - and elimination
- Procedures for waste pre-conditioning and elimination shall take into account volume and activity of HIE-ISOLDE targets.

PSB ISOLDE: Exp. Areas/Contamination

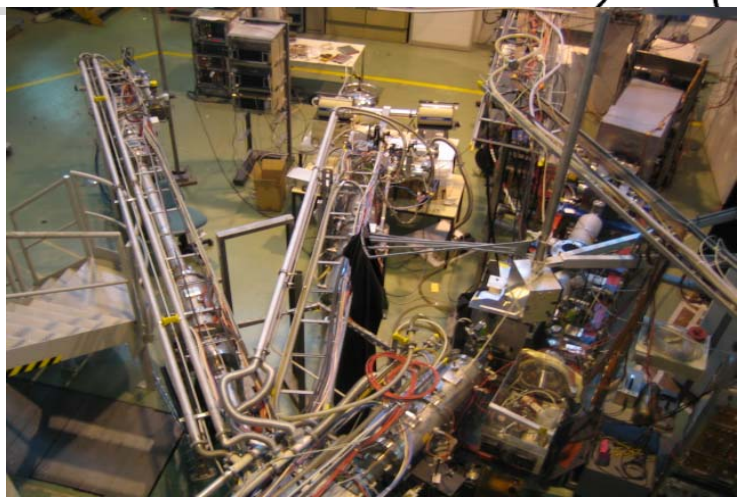
- Contamination control: ISOLDE Exp. Area is "Work sector of type C"
- Fire resistance criteria (roof, windows, gate) not fulfilled in Bat. 170 – little hope to upgrade
- Collections limited in activity (to allow manipulation) – severe for α-emitters
- Off-line workplaces (Bat. 26, Bat. 272): identical restrictions

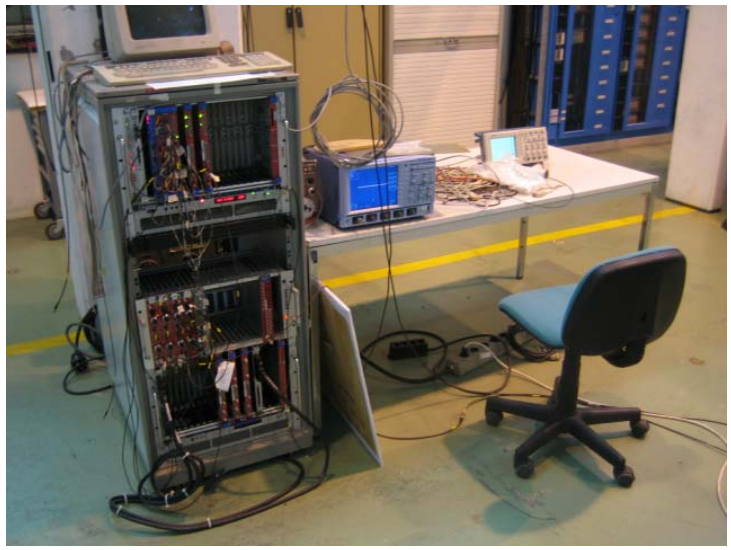
HIE ISOLDE: Exp. Areas/Contamination

- In spite of a 5 times higher availability of isotopes, activity of collections will remain limited to same amounts as at PSB ISOLDE.
- “Collection bunker” at one of collection lines (shielding and contamination control for “large” collections)
- Sealed transport vessels
- Have an off-line type A worksector for manipulations and measurements (see n-TOF-PH2)

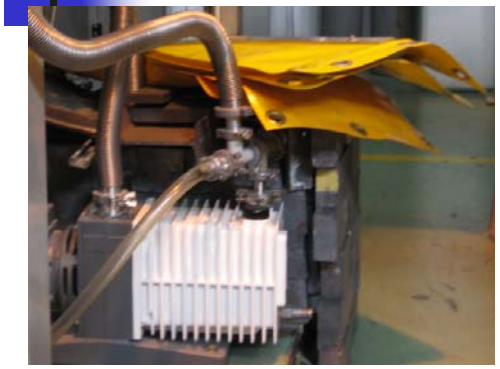
PSB ISOLDE Exp. Area / Irradiation

- CERN experimental areas “supervised areas”, relatively freely accessible. (Access to ISOLDE controlled due to contamination risk).
  - Effective dose limit for most experimenters:
    6 mSv/year (category B)
    1 mSv /2 months (“VCT”, short term visitor)
- Doserate guideline values:
  - on average 3 μSv/h
  - locally relaxed at passageways, corridors...
  - Potential additional doses from contamination

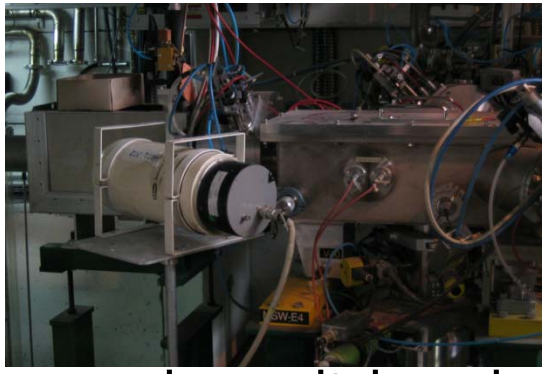




PSB ISOLDE Exp. Area / “Hot Spots”



vacuum pumps



merging switchyard

collection point/ ECR

vs. RILIS

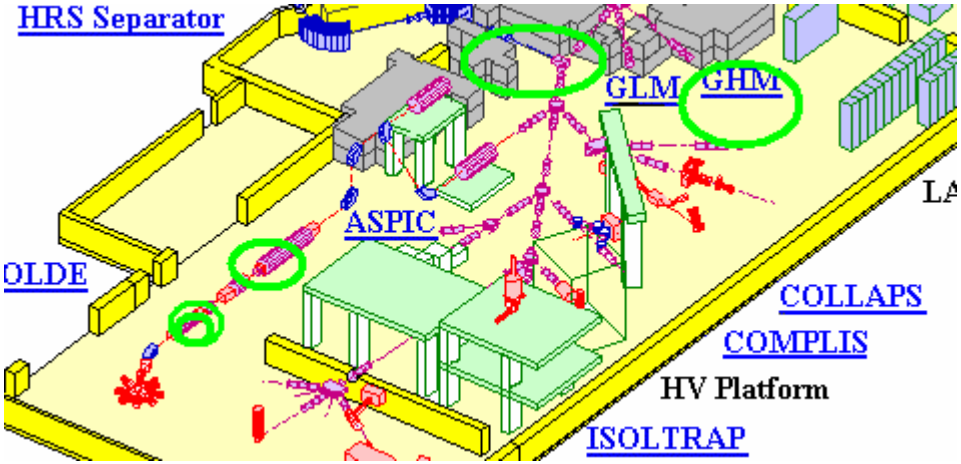
- Doserates
  - from collections,
  - at beam loss points
  - from the vacuum system

occasionally exceed guideline values.

- Consequently, the PSB proton beam is switched off.

HIE ISOLDE: Exp. Area / "Hot Spots"

- New regular "hot spots"
  - RF of LINAC
  - RF and beam loss ECRIS
  - RF and beam loss RFCooler
- Others arise temporarily:
  - tape station
  - neutraliser
  - collection points
  - in the beam preparation- and transport system
- Shielding is difficult (beamlines too close to each other)



Isotope	I or N	H*(10) (1m)
^{11}C, ^{15}O	10^{8} s^{-1}	16 µSv/h
^{18}Ne	10^{8} s^{-1}	50 µSv/h
^{22}Na	10^{18}	3 mSv/h

(Other values must be calculated case by case, no tabulated data available)

HIE ISOLDE: Exp. Area / Irradiation

- First measurements: direct radiation from the target area not limiting factor.
  Neutrons streaming from target into hall via HV-room
- Main radiation hazard from extracted beams
- Option: Experimental area "controlled area" (such as accelerator tunnels at CERN)
  - access and work practice continuously controlled by RP
  - stricter access requirements (personnel must be "occupationally exposed")
  - "Telecommand" experiments from Bat. 507, access only when proton beam is off.

PSB ISOLDE: Operation

- PSB ISOLDE is operated by personnel from experiments. An EIC is “on call” duty.
- Safety-critical events, usually in connection with extracted isotopes (“hot spots”, contamination during collections) are discovered late / too late
- These events can lead to operation interruptions and costly clean-up. Personnel might be exposed beyond guidelines or limits during these events.

HIE ISOLDE: Operation

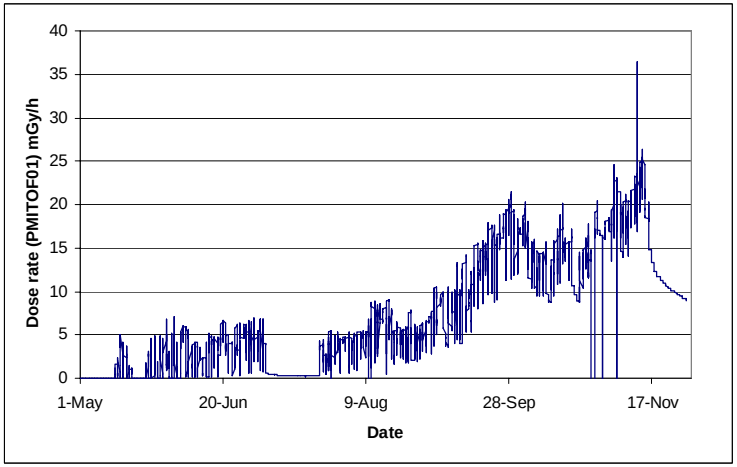
- The five-fold potential for safety critical incidents warrants continuous presence of an EIC during operations.
- EIC receives necessary training for first interventions in RP matters
- For certain experiments, RP staff has to be available on-site
  - Mon – Fri, 8^{00} – 18^{00}
  - RP staff on shift work ?

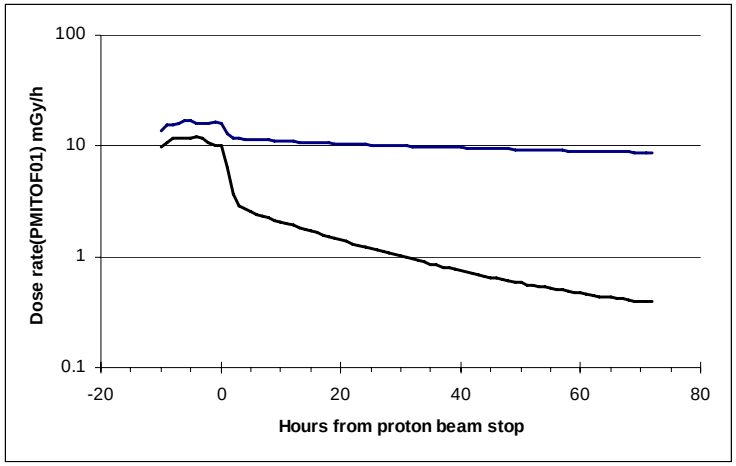
n-TOF-Ph2 Baseline

- Spallation target and proton beam similar to existing target, but cladded
- BL 1, 185 m, existing experimental area without contamination control
- BL 2 (vertical), 20 m, experimental area EAR-2

n-TOF-Ph2 target

- New cladded spallation target is required, to prevent heavy radioactive contamination of cooling water.
- The spallation target station must be equipped with monitored ventilation system.
- After estimating activation of air, it may be necessary to construct the ventilation with recirculation or other delay mechanism

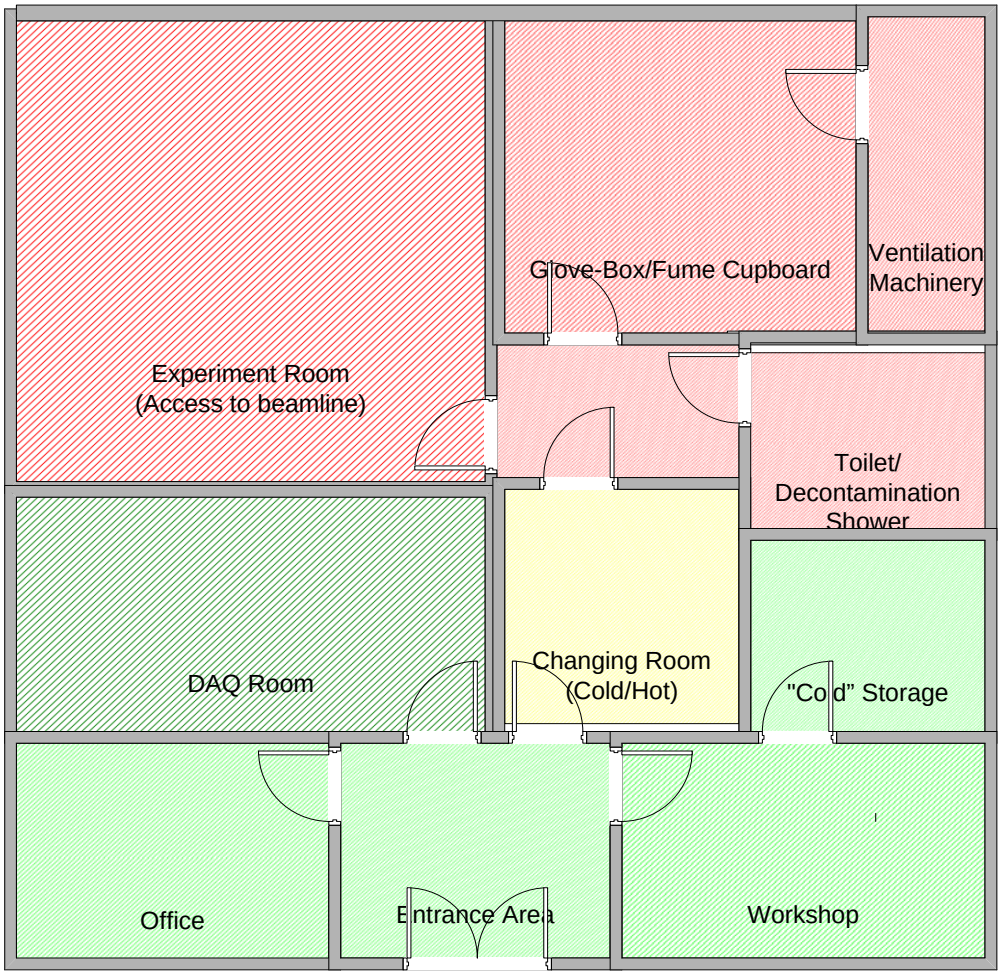




n-TOF-Ph2 Exp. Areas

- EAR 1 can receive experiments with inactive targets, and with radioactive samples which are considered “sealed” (ISO 2919) in order to prevent contamination
- EAR 2 should be built in form of a type A worksector.
- Activities remain limited by the fact, that CERN must guarantee the dose limit for the population (1 mSv) during accidents with a probability of more than 10^{-4}/year

n-TOF-Ph2: basic EAR 2



n-TOF-Ph2: Isotopes admitted

Isotope	Authorisation Limit L_A	Work sector type B (10 000 L_A)		Protection of public (1 mSv criterion)	
	Bq	Bq	mg	Bq	mg
Pb-210	5.00E+03	5.00E+07	0.0	2.22E+10	7.8
Bi-207	2.00E+06	2.00E+10	11.9	1.27E+11	75.6
Po-210	2.00E+03	2.00E+07	0.0	7.46E+09	0.0
Ra-226	2.00E+03	2.00E+07	0.5	6.99E+09	191.1
Pu-238	2.00E+02	2.00E+06	0.0	5.32E+08	0.8
Pu-239	2.00E+02	2.00E+06	0.9	4.90E+08	212.5
Pu-240	2.00E+02	2.00E+06	0.2	4.88E+08	57.8
Am-241	2.00E+02	2.00E+06	0.0	5.81E+08	4.6
Am-243	2.00E+02	2.00E+06	0.3	5.95E+08	80.7
Cm-244	3.00E+02	3.00E+06	0.0	9.01E+08	0.3
Cf-252	4.00E+02	4.00E+06	0.0	1.22E+09	0.1

SC-RP Ressources (1)

- At present (PSB-ISOLDE and n-TOF)
  - Section assignment: radiation protection at *all* “low-energy” accelerators and experiments
  - For ISOLDE and n-TOF:
    - 1.5 FTE RP engineers for monitoring
    - 0.2 FTE RP physicist for studies and authorisations
- HIE-ISOLDE / n-TOF-Ph2
  - Significant workload for studies and authorisations
    - physicist/ senior engineer required
  - More RP monitoring for all work in type A worksectors and in controlled radiation areas
    - technician/ tech. engineer required

SC-RP Ressources (2)

- LHC startup/commissionning/first years:
  - nearly all present RP physicist resources bound to LHC until at least 2011
    (LHC will reach nominal intensity)
  - numerous additional RP technicians/ engineers are required for LHC operation
- 1 aditional physicist & 1 technician/engineer requested for “low-energy” programme
  - shared with CTF-3, Linac-4, PS, PSB, East hall...
- The outcome of the requests depends on various factors (budget, personnel and priorities)

Summary

- HIE-ISOLDE
  - 5-fold increase in intensity and radiation levels in existing buildings, designed for nominal intensity
  - Technical investments for target system, ventilation, constructive changes in experimental areas. Experimental area remains a limiting factor !
  - Waste!
- n-TOF-Ph2 (EAR-2 and new target)
  - Essentially a new facility which can be built according to safety requirements
  - Few limitations if recommendations are realised
- Ressources
  - Significant additional resources are necessary for planning, operation and safety, in parallel to LHC startup and exploitation