Beta Beams
Safety issues and WBS

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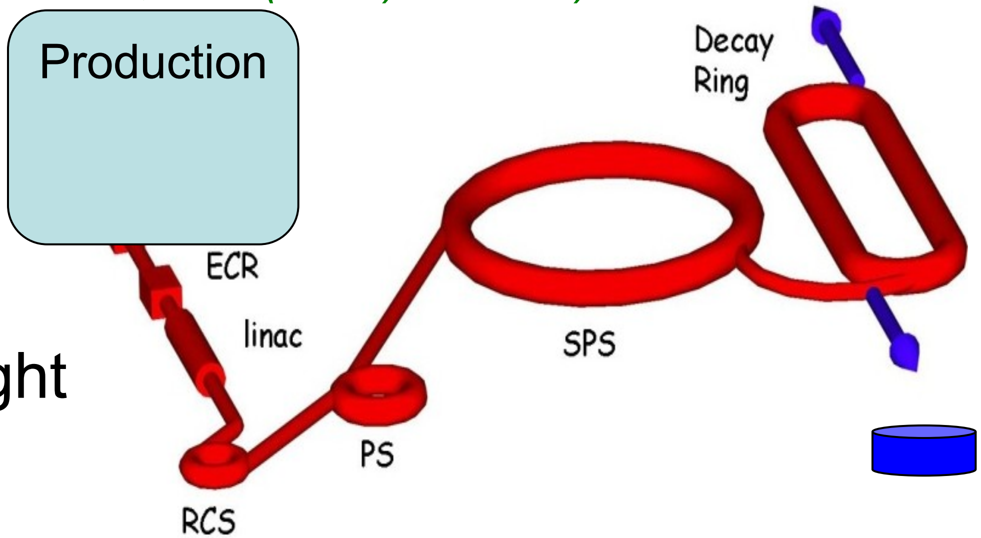
Outline

- Introduction: the Beta Beams
- Tentative WBS and Safety considerations
- For discussion…

Beta-Beams

- Aim: production of electron (anti-)neutrino beams from β-decay of radioactive ions circulating in a storage ring *(P. Zucchelli, Phys. Let. B, 532 (2002)166-172)*
  - **Produce** radio-isotopes
  - **Accelerate** them
  - **Store** in Decay Ring (DR)
  - **Let them β-decay** (a straight section points to detector)



  - **Pure ν_e/anti-ν_e** are emitted (need a pair of β^+/β^- emitters)
    - with a known energy spectrum ($E_\nu \sim 2\gamma Q$)
    - in forward direction (cone $\theta < 1/\gamma$)

Q = Reaction Energy ~ few MeV

Beta-Beams: the ions

- (^{6}***He***, ^{18}***Ne***) or (^{8}***Li***, ^{8}***B***) pairs, considered as anti-neutrino and neutrino emitters
  - **Lifetime at rest**: $\tau_{1/2}$~1s
  - **Low Z** (minimize mass/charge & reduce space-charge)
  - **Production rates & collection efficiency**
- Stored in a race-track Decay Ring at γ=100
- Q = Reaction Energy, $E_\nu \sim 2\gamma Q$
  - Different energy of produced neutrino
  - Different detector distance
  - Different physics (sensitivity to mass hierarchy)
  - (^{6}***He***, ^{18}***Ne***) “Low-Q” isotopes, Q ~3
  - (^{8}***Li***, ^{8}***B***) “High-Q” isotopes, Q ~13, but more difficult

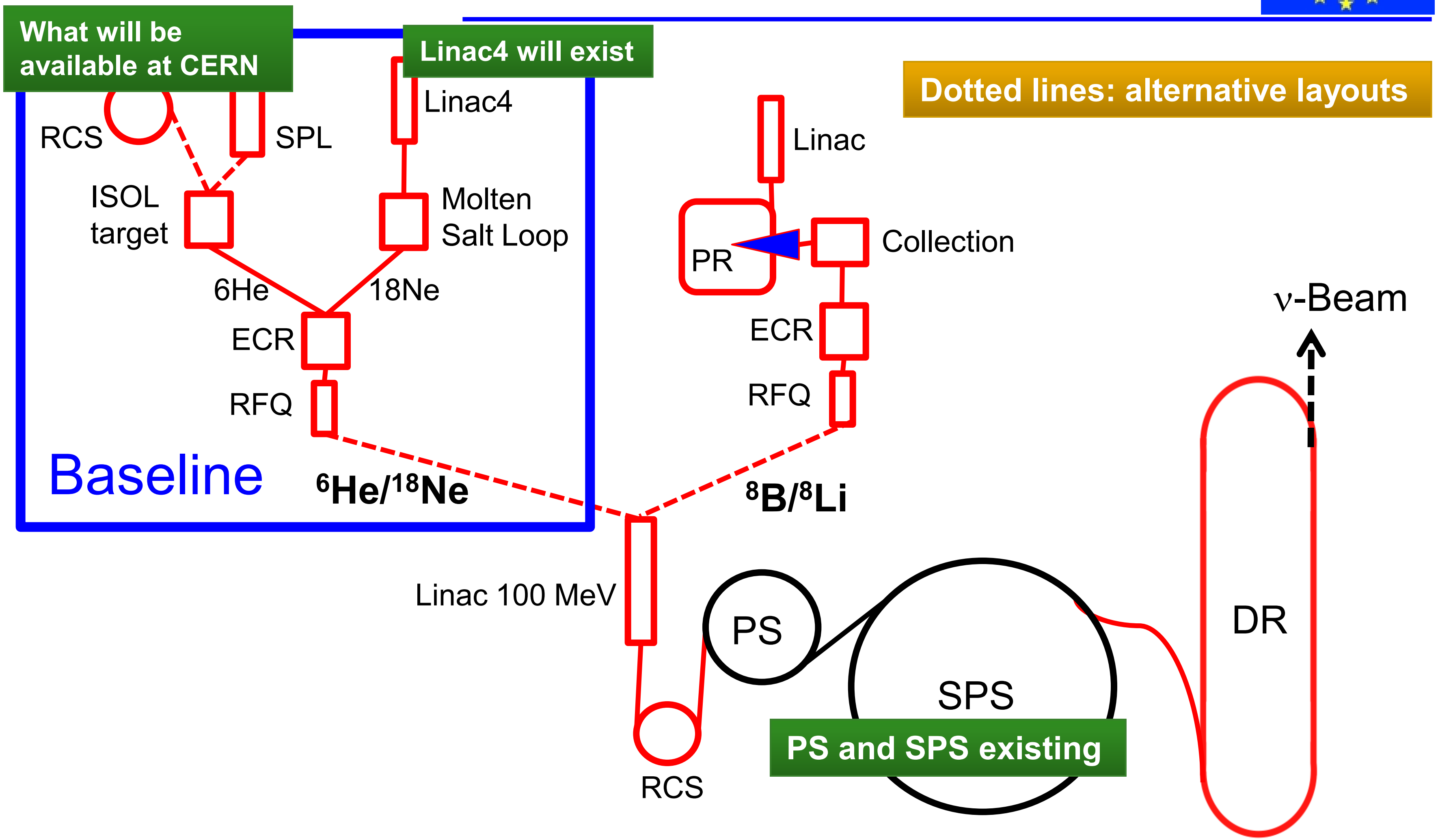
EUROnu guidelines

M.Dracos, EUROnu Annual Meeting, 21/1/2011, RAL

Organisation

- WBS for WP2, WP3, WP4 and WP5 to be prepared before the workshop, but before, the WPs have to well fix:
  - a baseline scenario
  - one main option (it will be painful to evaluate more options)
  - for open questions, the worst case will be considered
- WBS will be readjusted after the workshop according to the discussions/conclusions

Beta Beams: accelerator complex



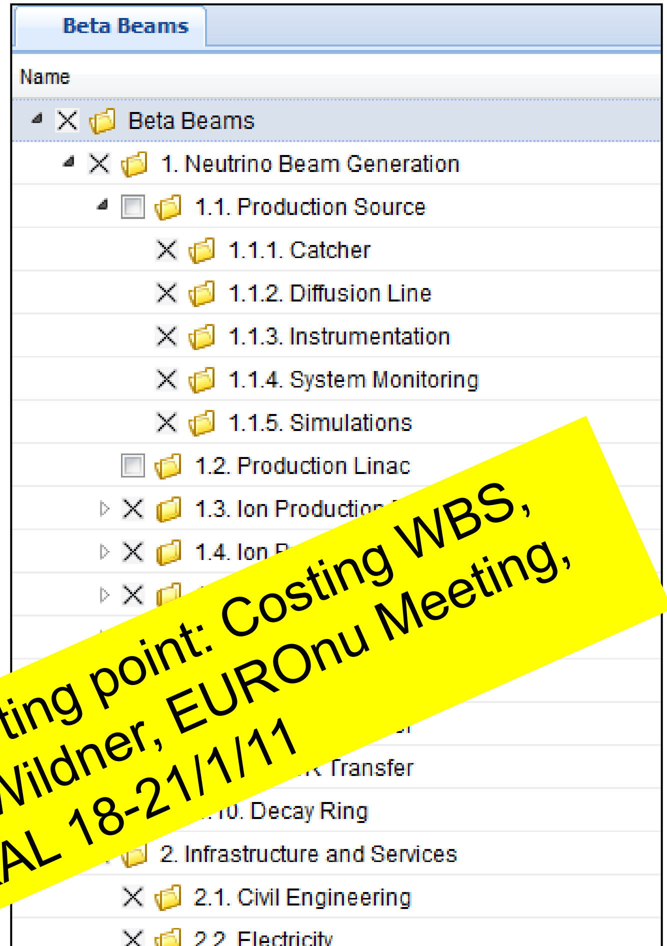
Bρ ~ 500 Tm, B = ~6 T, C = ~6900 m, L_{ss}= ~2500 m, γ = 100, all ions

Neu2012, EUCARD, Beta Beams, Elena Wildner

Beta Beam implementation

- Work Breakdown Structure (WBS)

CERN Safety Regulations



Starting point: Costing WBS, E.Wildner, EUROnu Meeting, RAL 18-21/1/11

Risk identification, analysis and mitigation

1st Level…easy!

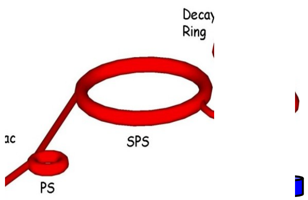
Production

- Production Source
- Production Linac
- Ion Production (ISOLDE-like)
- Ion Production Ring
- Collection + ECR Breeder

Accel + Storage

- Linac
- Transfer lines
- RCS
- PS & SPS
- Decay Ring

Acceleration & Storage

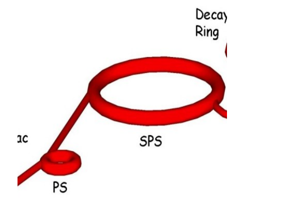


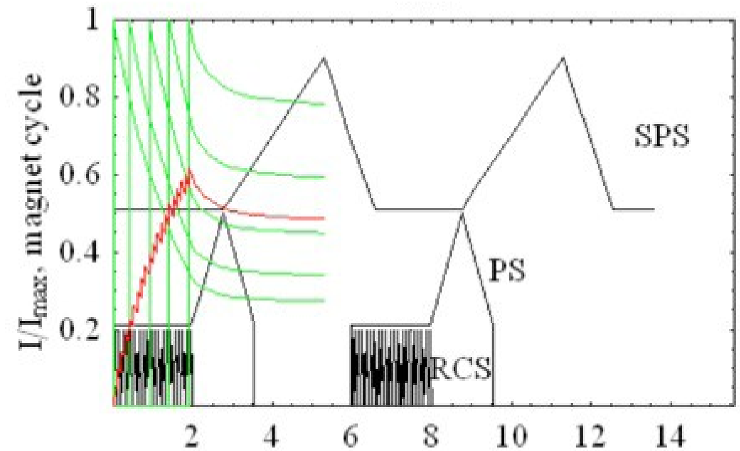
- Existing machines: PS & SPS
  - Integrate βBeams case in what existing
  - Work ongoing now for LHC Injectors

    Injectors and Experimental Facilities Committee 2011 Workshop, Monday Session:
    http://indico.cern.ch/conferenceOtherViews.py?view=standard&confId=123526
    - Following decision to run for another 25years
    - Radio protection, technical safety, consolidation, reliability
    - Access safety & control systems, shutdown activities,…
  - Safety:
    - No specific modifications
  - Radio Protection:
    - Some issues specific to BetaBeams

Acceleration & Storage

- Existing machines: PS & SPS
  - RP βBeams specific issues
  - Decay losses due to Long acceleration (constrain of existing hardware)
    - PS: 3.6s
    - SPS: 3.6s for ^{6}He and 6s for ^{18}Ne
    - 50% ^{6}He and 20% ^{18}Ne decay

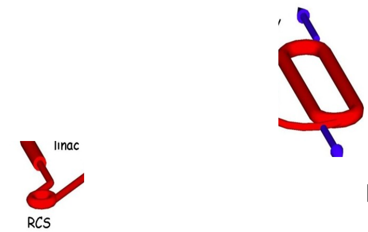




  - **Activation** → Done & documented (within FP6, Eurisol):
    - Identified area of controlled access or remote handling
  - **Localized losses** → Just started
    - Mitigation, shielding, collimators…
- Mainly for PS, SPS will follow

Acceleration & Storage

- New Machines: Decay Ring (cold), RCS, Lines
  - Safety: Learn from LHC experience
    1. Access system
    2. Fire detection system
    3. Evacuation alarm system
    4. Gas detection system
    5. Oxygen deficiency hazard detection (cold machine)
    6. Ventilation
    7. Electrical risks (Powering interlocked with Access)
    8. Cryogenic risks (cold machine)
    9. Civil engineering and construction
    10. Lifting/handling



tentative 2nd level,
valid for all machines

Acceleration & Storage

- New Machines:
  - Radio Protection: Learn from CERN experience
    1. Environment (dose to public):
        1. Stray radiation
        2. Releases of radioactivity (air & water) into the environment
    2. Workers:
        1. Shielding
        2. Air & water activation
    3. Induced radioactivity in accelerator components
        1. Activated fluids and contamination risk (closed circuits, etc.)
        2. Optimized design of components (material composition)
        3. Optimized design for maintenance and repair
        4. Optimized handling of devices, remote handling
        5. Ventilation and pressure cascades

tentative 2nd level,
valid for all machines

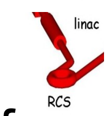
Acceleration & Storage

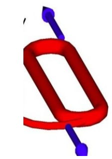
- New Machines:
  - Radio Protection: (continue)
    4. Radiation monitoring System (like RAMSES)
    5. Buffer Zones for Cool Down Repair Workshop (access control, filters, fire proof…)
    6. Operational Dosimetry system
    7. Closed systems (cooling water?)
    8. Maintenance & Remote handling
    9. Incident & accident releases
    10. Dismantling and waste (high costs!)

tentative 2nd level, valid for all machines

Acceleration & Storage

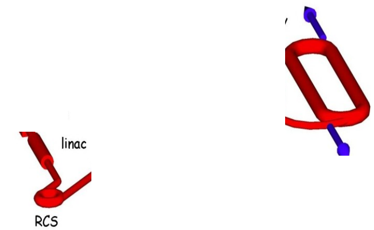
- New Machines, RP specific to βBeams
  - RCS:
    - Activation study → **done (FP6)**
    - Integration in the CERN site (where? On surface or underground ?)
  - Linac for radioisotopes:
    - Up to 100 MeV
    - To do, but should not be an issue

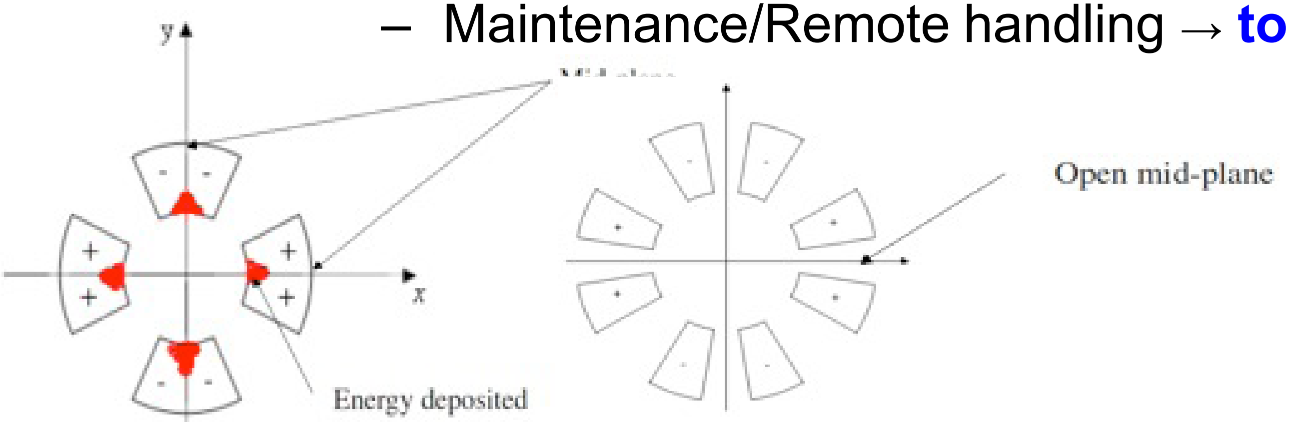


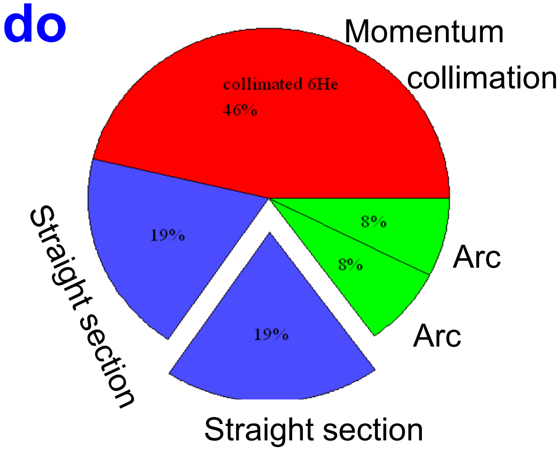


Acceleration & Storage

- New Machines, RP specific to βBeams
  - Decay Ring:
    - Momentum Collimators → **to do**
    - SC-magnets in radioactive environment → **done**
    - Losses in SC magnets, how to deal with?
      - » Absorbers → **but impedance, how to remove/maintenance?**
      - » Open mid-plane quadrupoles
      - » Beam dumps → **to be designed, standard**
    - Maintenance/Remote handling → **to do**

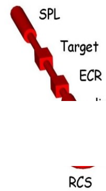


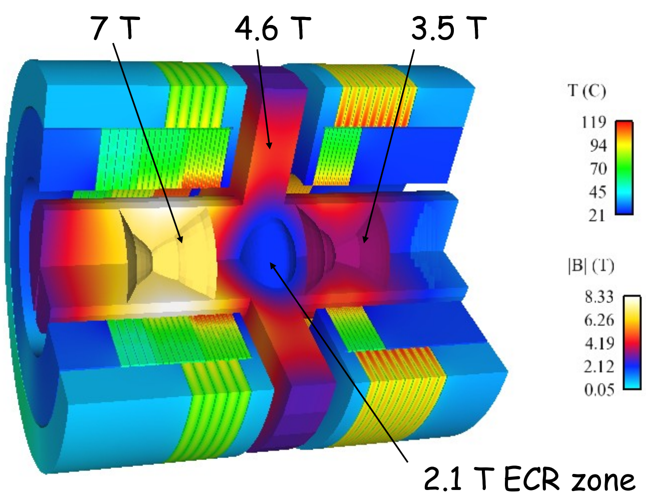




Production area

- Production area (Primary Linac, Target, ECR Breeder)
  - Radioactive environment
  - ECR Breeder:
    - e- resonance
    - 60 GHz ECR
    - 50us long pulses at 10Hz
    - High magnetic fields, high voltages
    - Microwave & X-rays monitored
    - Need controlled access

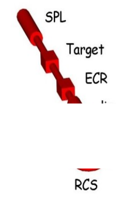


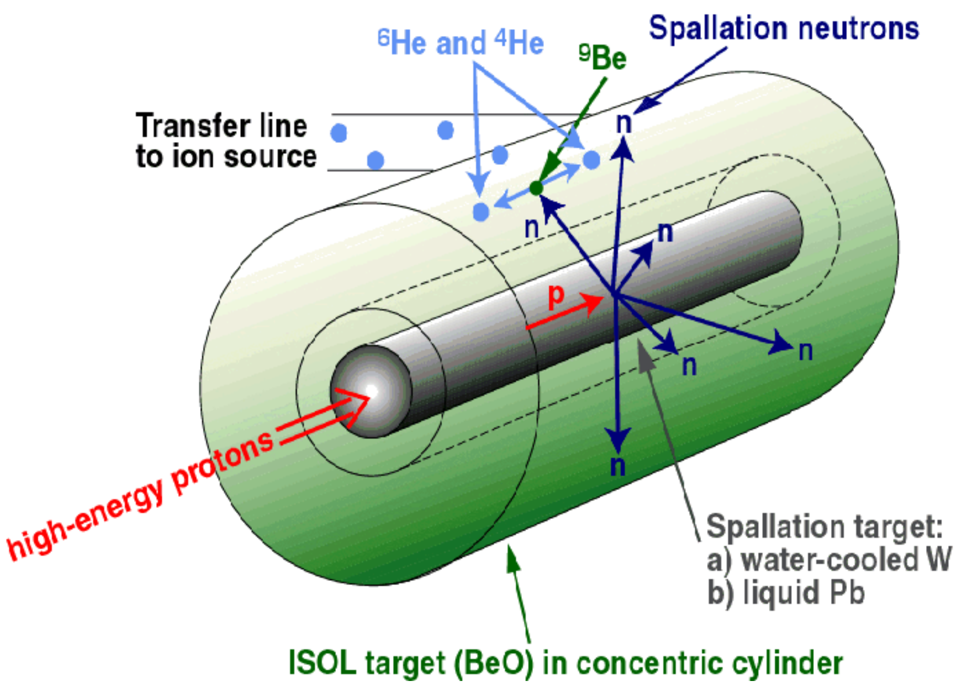


  - Production and collection devices
    - Depends on the choice of ions & baseline

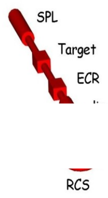
Production area

- Production area
  - Radioactive environment
  - ^{6}He production
    - RCS (or SPL)
      - → will be "existing CERN machine"
      - 2 GeV x 0.07mA = 135 kW
    - Spallation target:
      - W or Pb , BeO
    - Remote handling, ventilatio
    - Hot cell?
    - Is it comparable with ISOLD
    - …or SPIRAL2 ?

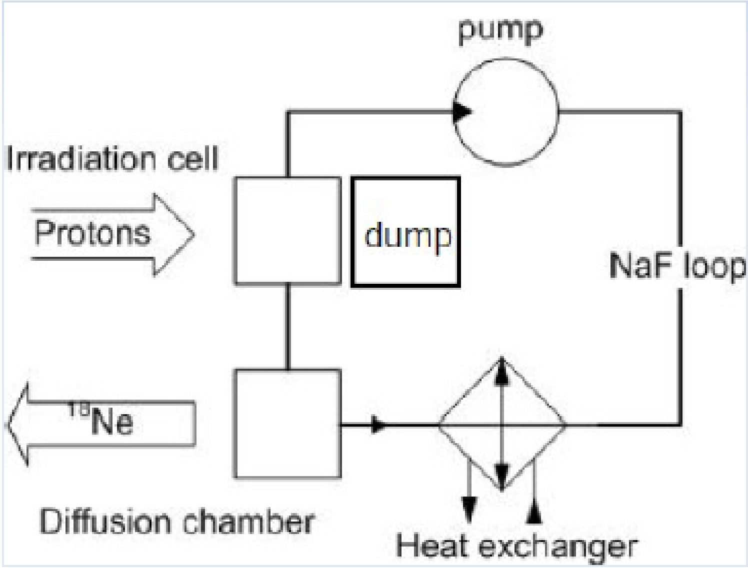




Production area



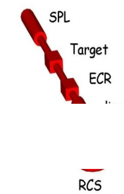
- Production area
  - Radioactive environment
  - ^{18}Ne production
    - LINAC4
      - → will be "existing CERN machine"
      - – 160 MeV x 6mA = 960 kW
    - NaF molten salt loop: **$^{19}F(p,2n)^{18}Ne$**
    - **Heat exchanger**



    - Newly developed concept
    - Experimental verification soon, then safety issues will be better understood

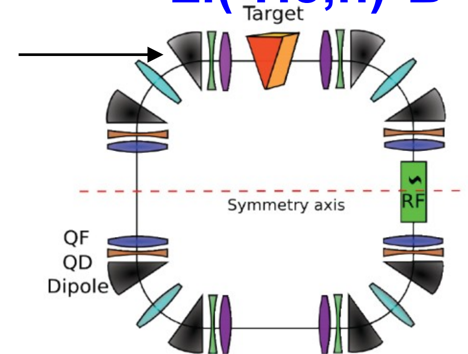
Production area

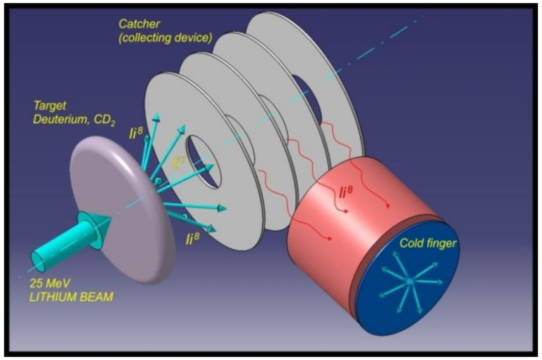
- Production area
  - Radioactive environment
  - ^8Li, ^8B production
    - Production Ring (*C.Rubbia et al, NIM A 568 (2006)*)
      - Multi-passage through an internal target
      - Ionization cooling of stored ring
    - Internal target technology
      - Gas-jet target: high pressure, etc…
      - Lithium loop: contact with water
  - ^8Li, ^8B Collection device:
    - Oven, high temperatures



$^7Li(d,p)^8Li$

$^6Li(^3He,n)^8B$





Summary & discussion

- BetaBeam implementation is site-specific (CERN)
- Need to identify in details risks due to:
  - Construction
  - Operation
  - Maintenance
  - Accidents
- Profit of what already exists at CERN:
  - Machines
  - Safety procedures
- But many (RP) issues specific to BetaBeams
- Isotopes Production: baseline identified but important option still open (different physics reach)

Summary & discussion

- WBS: to what detail?
- Which database, structure & connection to the costing WBS?
  - i.e. can we attach the entry 'safety' to the costing DB?
- Costing of the safety?
- Need common tooling & methodology for all the facilities
- Contacts at CERN aware /available for our needs?