EUROnu, WP4, Beta Beams

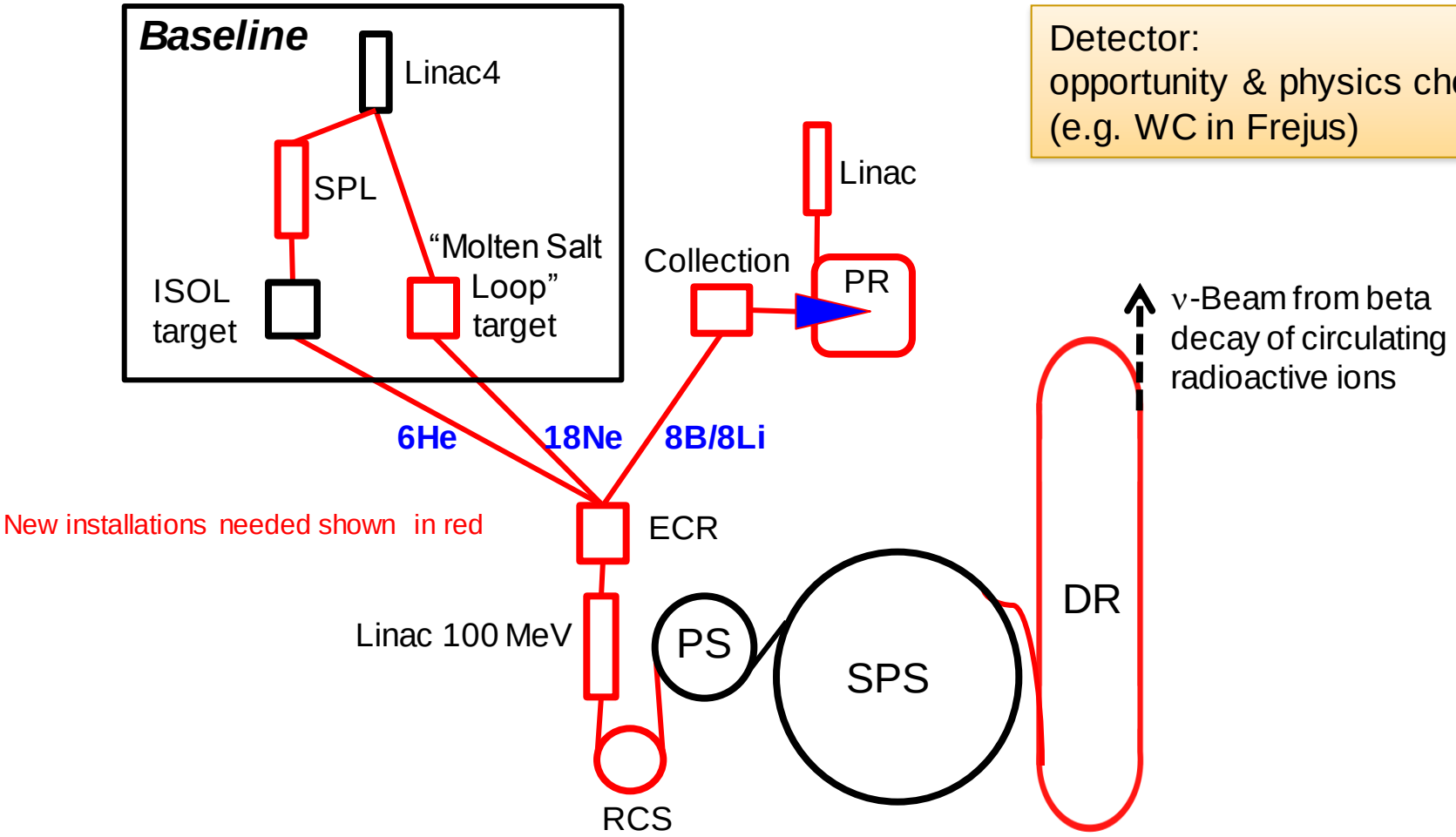
Elena Wildner

Presented by Christian Hansen

Outline

- T2K hints and benefits for beta beams
- Milestones and deliverables
- Progress
- Plan

Reminder: Baseline



Detector:
opportunity & physics choice
(e.g. WC in Frejus)

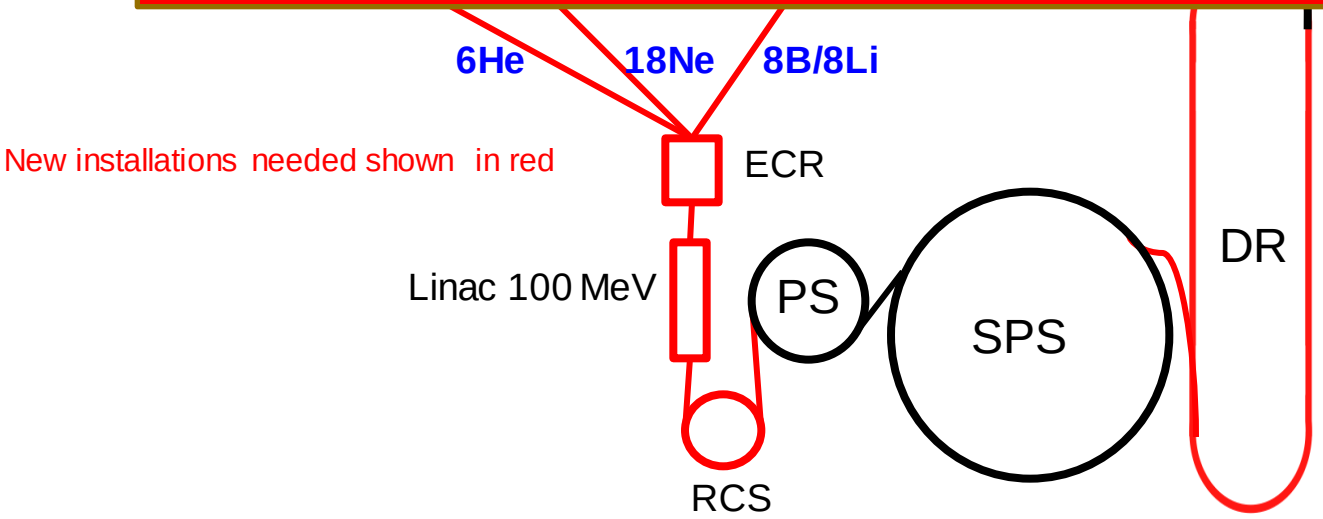
Decay Ring: Bρ ~ 500 Tm, B = ~6 T, C = ~6900 m, L_{ss}= ~2500 m, γ = 100, all ions

Reminder: Baseline

With T2K hints we may, if needed, take advantage of full energy span of SPS and longer baselines: these options and choices independent of our work! See E. Fernandez-Martinez et al.

physics choice
ejus)

from beta
f circulating
tive ions



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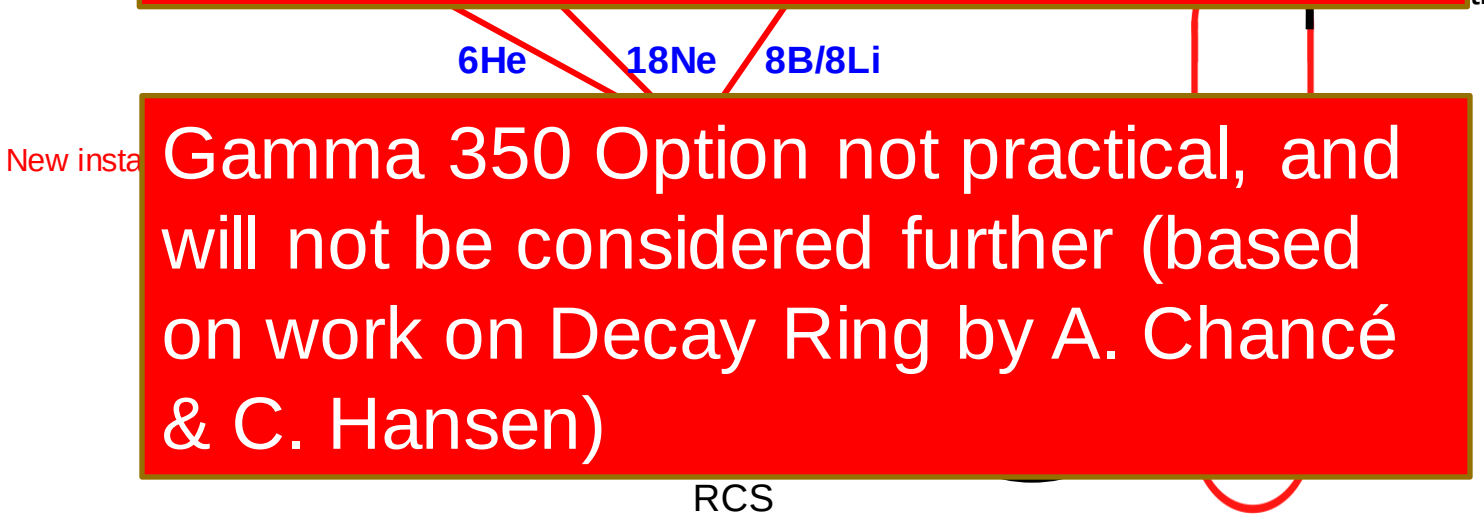

Gamma 350 Option not practical, and will not be considered further (based on work on Decay Ring by A. Chancé & C. Hansen)

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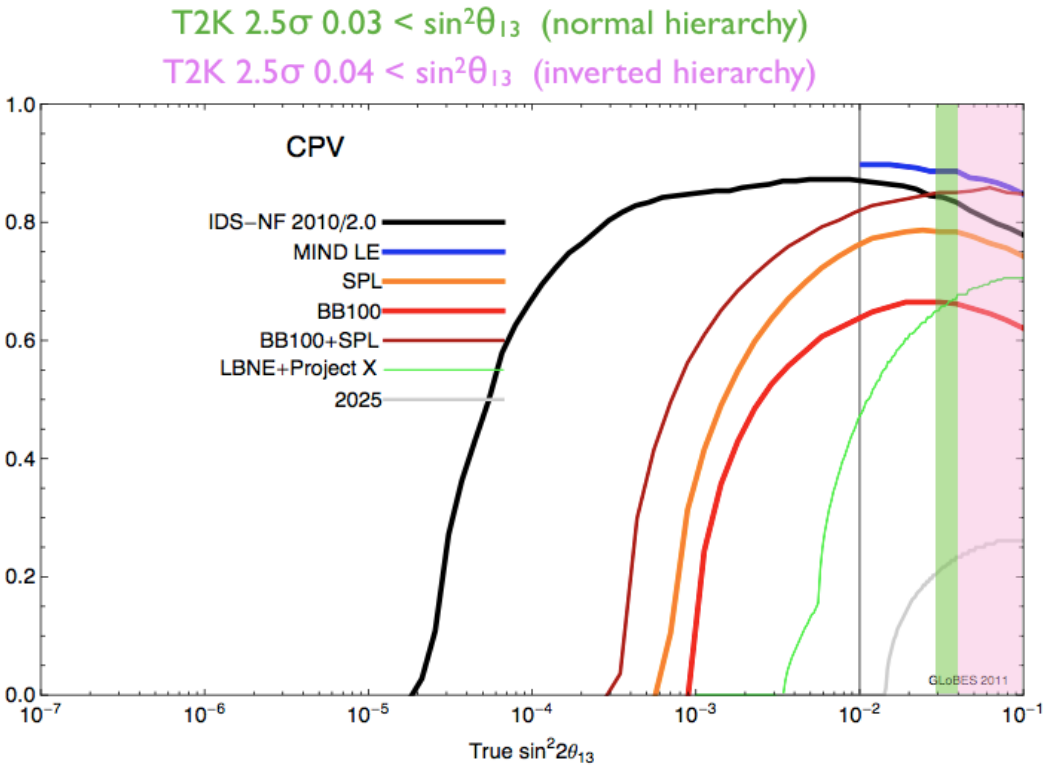
CPV



Larger matter effects and systematics at high theta13:
BB + SB give good reach and can be a staged option
In this plot beta beams are not yet optimized for large theta13!!!

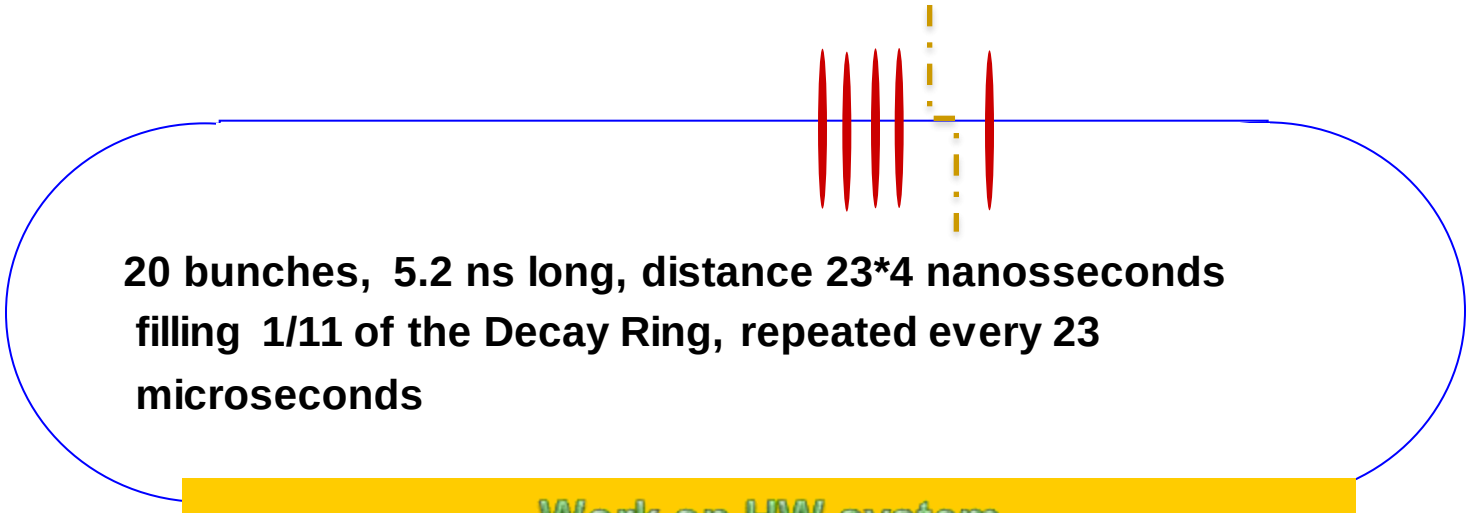
Large Theta13:
Optimization of beta beam flux needed
Systematics: needs to be calculated for BB (including detectors)

A. Longhin, P. Huber

We should include CN2PY in diagrams for comparison?

Duty factor in DR before T2K

10^{14} ions, ~0.5% duty (supression) factor for atmospheric background suppression in the detectors for the baseline !!!

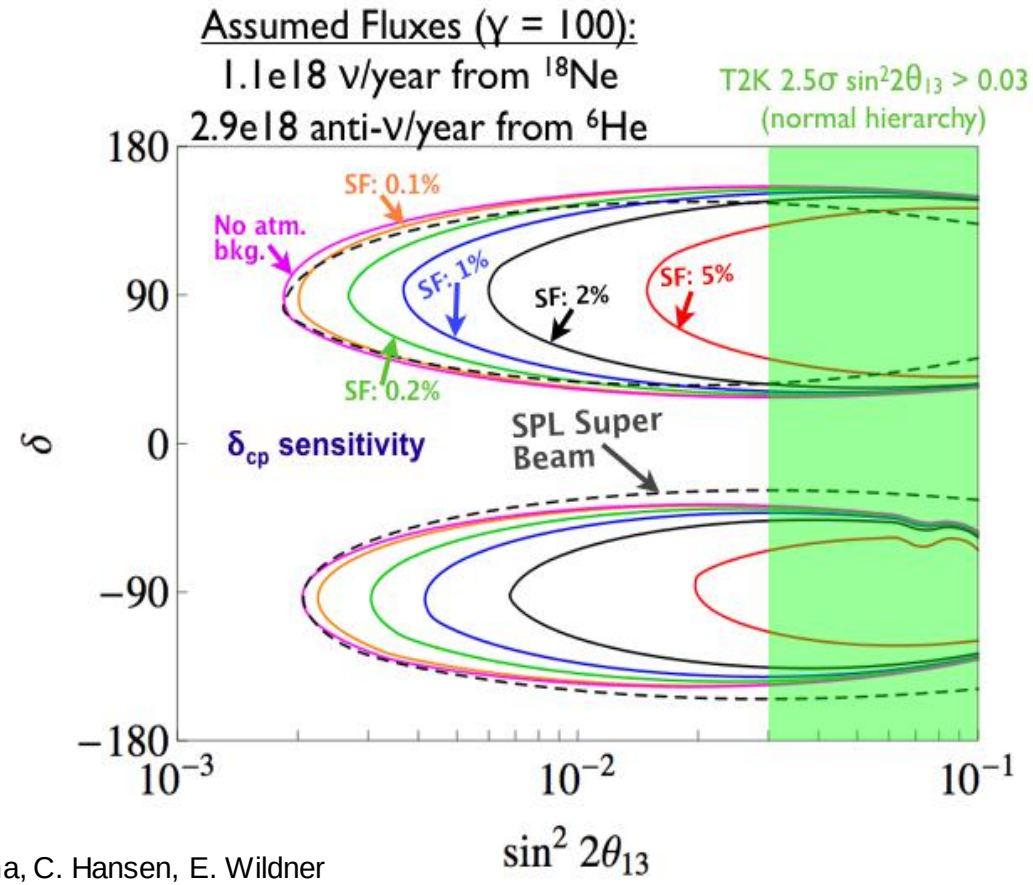


Background suppression for Beta Beams

- DF in DR to suppress atmospheric backgrounds :
  - serious constraint for βBeams!
- Larger $\sin^2 2\theta_{13}$ means
  - constraints are relaxed
  - larger bunches permitted
  - higher neutrino fluxes could be produced

CPV dependence on SF (Fréjus option)

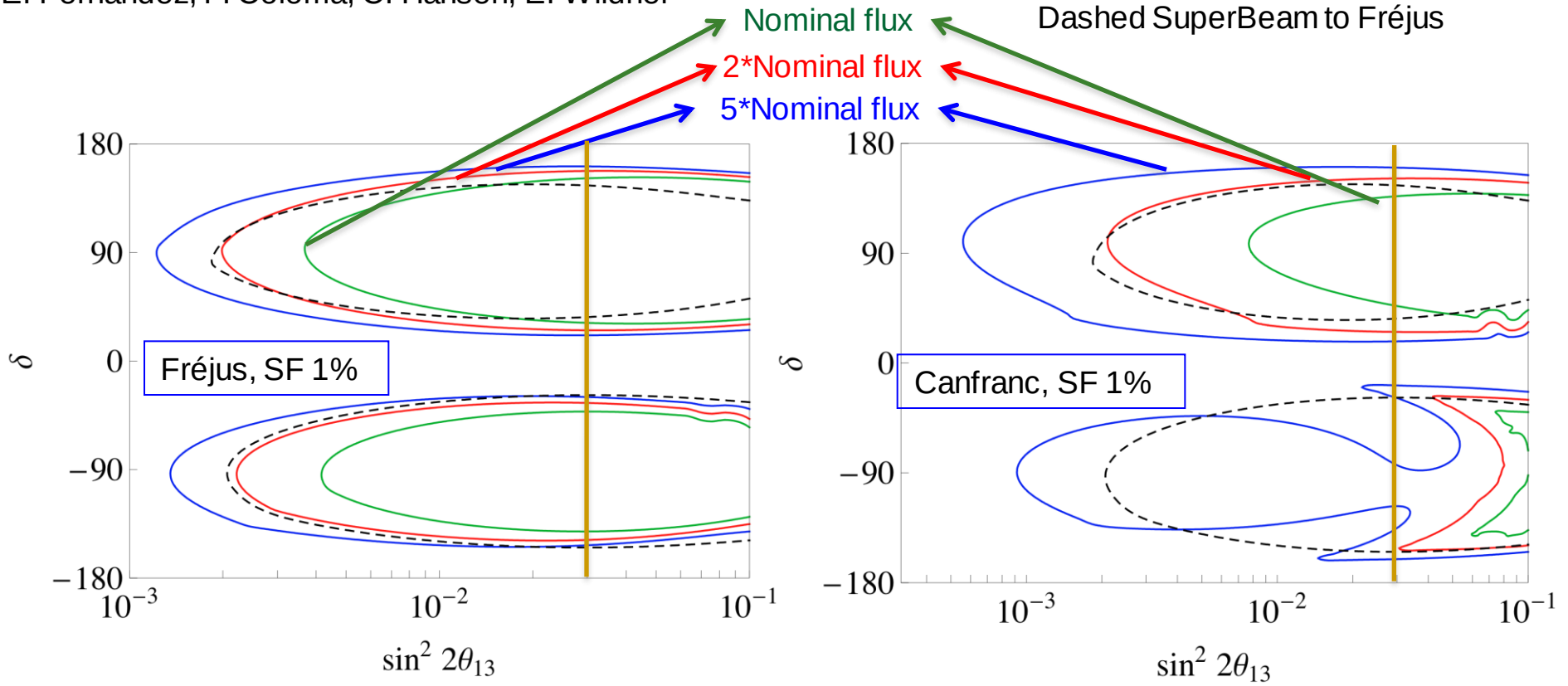
SF 2% seems sufficient for larger $\sin^2 2\theta_{13}$ (0.6% used up till now)
Permits higher fluxes and reach will increase (needs optimization)



E. Fernandez, P. Coloma, C. Hansen, E. Wildner

CPV and νFlux: Fréjus & Canfranc

E. Fernandez, P. Coloma, C. Hansen, E. Wildner



Fréjus: ^{18}Ne (1.1 10^{18} ν/year) & ^{6}He (1.1 10^{18} ν/year), γ=100
Canfranc: ^{18}Ne (4.4 10^{17} ν/year, γ=250) & ^{8}He (2.9 10^{18} ν/year, γ=100)
Other ion combinations may be efficient (A. Donini)

Negative delta, matter effects give degeneracies with the mass hierarchy.
Larger flux: no degeneracies, sensitivity for negative delta would increase, measurement of the mass hierarchy would be possible

Beta Beam Optimization, 2012

- Push Decay Ring intensities to the limit using 2% SF (T2K) !
- Optimize ECR performance by changing the acceleration cycle
- Optimize Accelerator Complex cycling and filling patterns (RF)
- All 4 ion species will benefit
- … this will be a real marathon…

Milestones & Deliverables

M 4.6 Full simulation of production ring

The change of production method from inverted to direct kinematics requires new lattice optimisation. The layout of the Liquid ^{7}Li target is not yet confirmed by ANL, presently working on the Liquid target approach. The remaining part of the simulations for the liquid target case and necessary lattice optimizations will follow.

M 4.5 Interim report on reaction channels, collimation and magnet protection

The interim report describes the the very successful experiments; analysis of results is ongoing and will be reported beginning 2012. The collimation and magnet protection systems have not yet been looked at in detail. A preliminary study of the collimation system can be seen in

M 4.4 New decay ring optics for 8Li and 8B

The Decay Ring optics has been refined for ^{18}Ne and ^{6}He to give more flux of neutrinos by compacting the lattice gaining almost 10% in neutrino flux. The new gamma transition optics giving a higher intensity limit for the TMCI instabilities [Ref].

D 13 Bunching performance evaluation

The ECR bunching performance will be tested at the end of the assembly and test phase of the complete ECR prototype during 2012 (not month 7 as stated in the proposal). The progress towards this objective is very good.

Costing: Layout

- Layout on track for Beta Beams (J.Osborne)
  - Decay Ring in place close to the SPS
  - Have to check:
    - Tunnel dimension (magnet size)
    - shaft sizes and numbers (RF, Cryo, Ventilation, Access…)
    - tunnel distances from the LHC for rad safety
    - transfer line optics etc. needs
  - Meeting with concerned experts
    - Hopefully end October
- After Decay Ring: RCS to be placed on site…
- Equipment costing: WBS updated (P.B. & E.W)

Layout BB: Very First Draft

Costing of equipment

- Need a list of experts
  - Superconducting magnets: priority (including infrastructure)
  - Collimation System in decay Ring
  - Decay Ring RF will be cost estimated at Cockroft

Safety

- We have a list of items to be studied
  - See presentations by Elena W and Elena B at costing & safety meetings held last year
- Estimated cost for DR safety: proportional to LHC
- The rest of the CERN complex safety systems
  - We suppose they exist
  - If guidelines for this are given we will adapt
- Some radiation studies on PS scheduled
- Will be documented by Elena*2 with explanations & proposals for the items (as of last safety meeting)

Machines, CERN

- Rf system for Decay Ring evaluated
- Direct kinematics for P-Ring being investigated
  - Collaboration intensified with ANL
- Measurement campaigns ongoing (PS)
  - Q-scans for protons, low intensity, are done
  - High intensity will come next
    - Permits projection of results for ions
- New ideas for instabilities
  - Integrate space charge in Head-Tail code
    - Will logically help!

Deliverables/Milestones

- Deliverable: Production Ring Simulations (M36)
  - Lattice optimizations for direct kinematics ongoing
- Milestone: Magnets and Collimation (M24)
  - Not ready
  - Lack of experts for magnet design
  - We be pending

ECR

- **First magnetic field measurements on the 60 GHz ECR ion** source prototype Current of 15000 A after some minor repairs.

- ECR plasma experiments at the ECR 28 GHz are technically feasible at this frequency using 2 LNCMI power supplies (among the 4 existing).

- The 60 GHz resonance zone should be closed at ~26000 A.

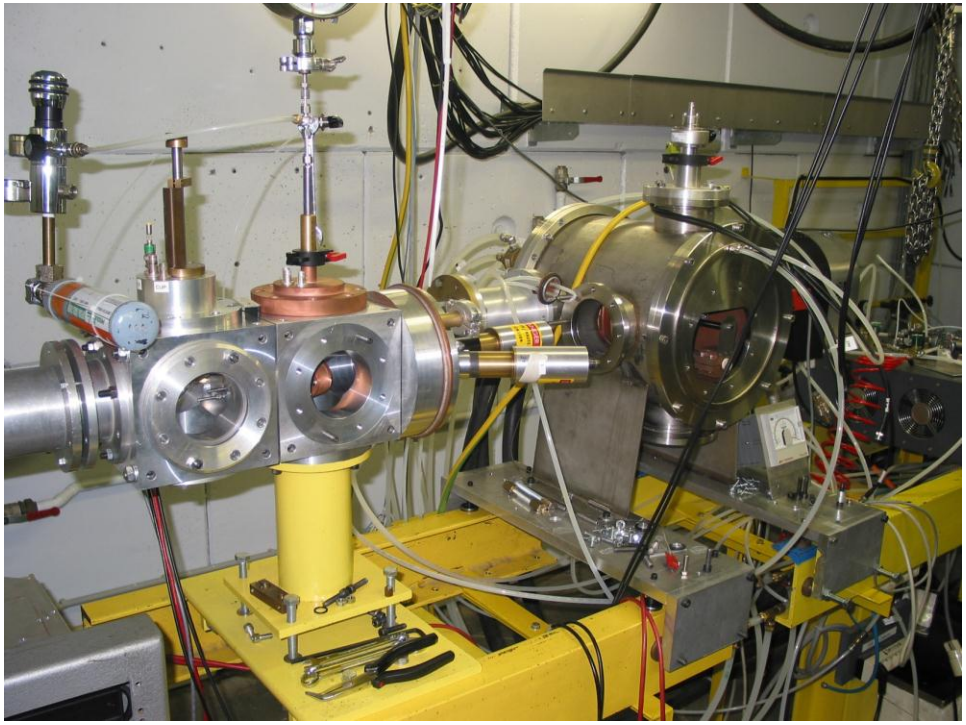
- These measurements fully validate the first magnetic structure, and allow foreseeing the first ion source, based on cusp topology with such a high magnetic field.

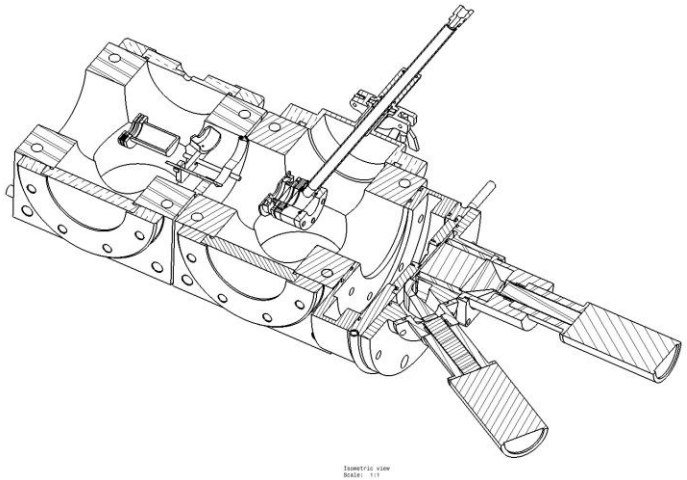
- Pulsed 60 GHz 10-300 kW gyrotron will come (Gycom, Russia) beginning 2012

Collection Device

- Test Schedule for 8B and 8Li
  - 23 September'11 - Li-714
  - October'11 - Li-7
  - 07 November'11 - Li-6 (technical test for B-8)
  - 05 December'11 - Li-6/7 (it will depend)
  - 23 December'11 - Li-6 (B-8)
- Milestones ok
  - Design
  - Drawings
  - Prototype
- Deliverable: Report on validation of 8Li (M30)
  - Delay another 6 months

Collection Device experiment (II)

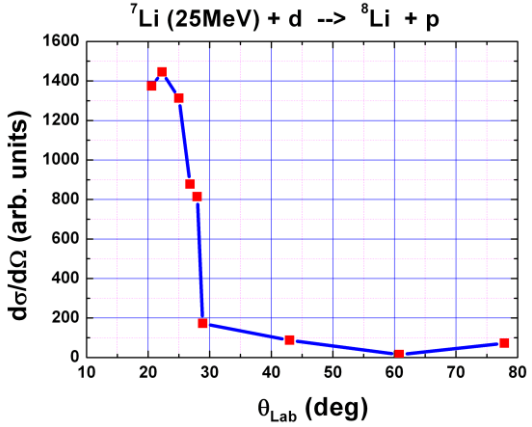




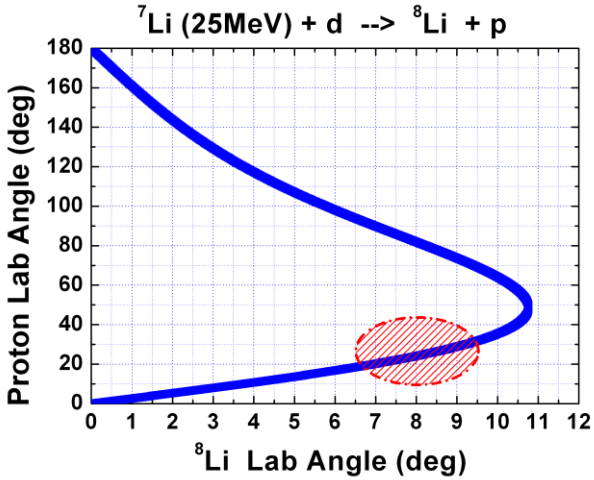
Results 2010-2011, Collection Device:

- the first results on the production and release of ^{8}Li have been obtained
- setup behavior as a function of temperatures to up to ~1400 ° C has been tested
- the problems related to the presence of the detectors in the vicinity of the collection device at 1400° C have been solved

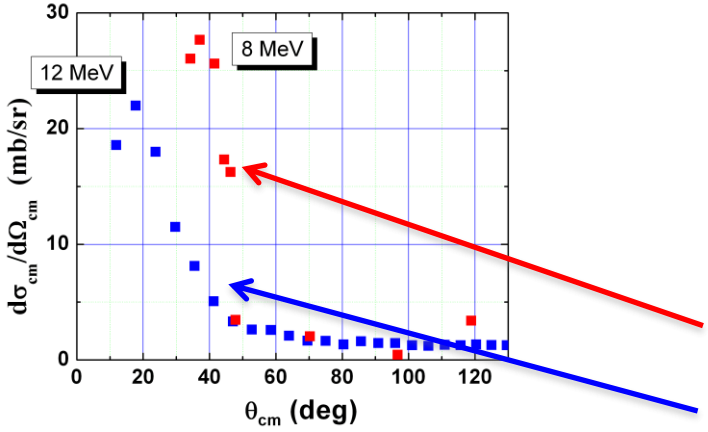
Cross sections 7Li(d,p)8Li



Lab frame angular distribution of the protons corresponding to ^{8}Li in the ground state.



Correlation of the laboratory angle of protons with respect to the laboratory angle of ^{8}Li. The hatched area highlights the region of maximum production of ^{8}Li.



Center of mass frame angular distribution of the protons corresponding to ^{8}Li in the ground state.

New results

From Literature

More analysis needed

8B production results

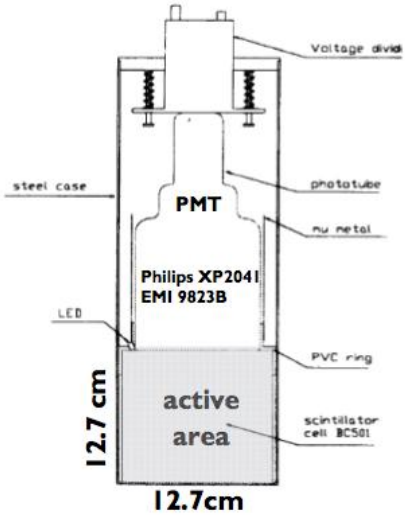
- THE ^{8}B EXPERIMENT WAS SUCCESSFULLY PERFORMED AT THE CN FACILITY, LNL FROM 10 TO 28 JUNE, 2011
- THE STATISTICS OBTAINED DURING THE MEASUREMENT IS ABOUT 30% MORE WITH RESPECT TO WHAT WAS PLANNED
- ALL NECESSARY BACKGROUND MEASUREMENTS FOR THE ACCURATE SUBTRACTION WERE PERFORMED
- THE DATA REDUCTION AND THE ANALYSIS OF THE EXPERIMENTAL RUNS ARE JUST STARTED AND WE EXPECT THE RESULTS IN AUTUMN 2011 - WINTER 2012

Vladimir Kravchouk

Cross sections 6Li(3He,n)8B

- Highly Ranked experiment
- Extensive measurement campaign
- Ample statistics
- Complete analysis 2012

7 MV CN accelerator (10-28 giugno 2011)
6 MeV $^{3}He+^{6}Li \rightarrow {}^{8}B + n$
Neutron angular distribution measurement



2 m Flight path
$\Delta\Omega \approx 3$ mSr
$\Delta\theta \approx \pm 2.5^{o}$

8 BC501 detectors covering angles from 15° to 140°