Geneva, February 10th, 2014

A Biomedical Research Facility at CERN based on the Low Energy Ion Ring

A. Garonna (CERN)

On behalf of

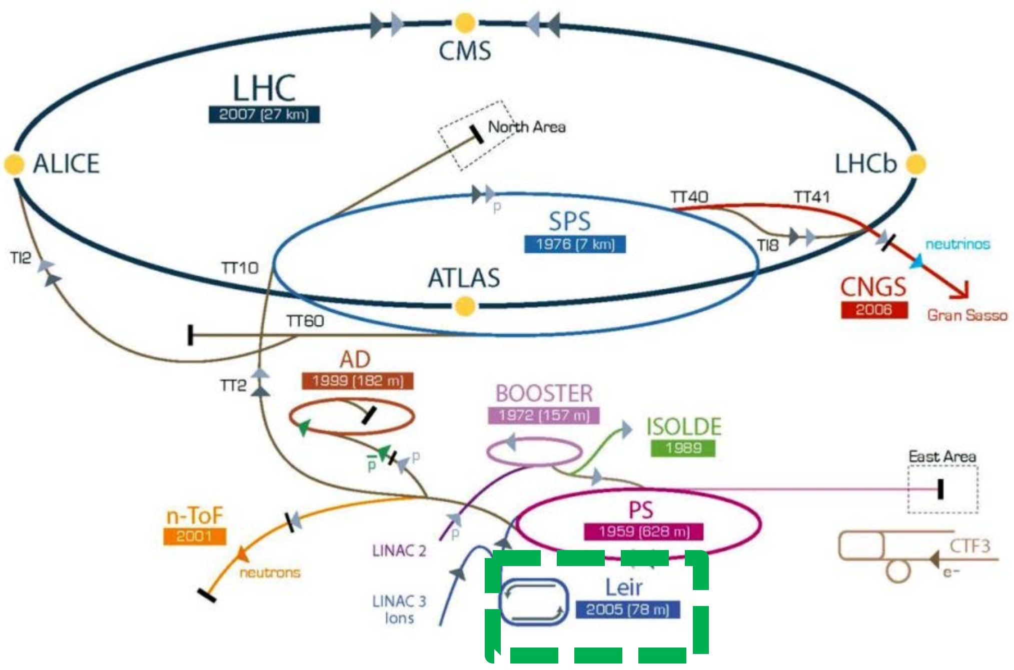
D. Abler (University of Oxford and CERN), C. Carli (CERN), P. Collier (CERN), M. Dosanjh (CERN), D. Kuechler (CERN), S. Myers (CERN), J. Stafford-Haworth (CERN)

Funding: CERN and Marie Curie Initial Training Network Fellowship of the European Community's 7th Framework Programme under contract number PITN-GA-2008-215840-**PARTNER**.

LEIR is a good candidate to provide needed beamtime

- Beamtime needed to develop full potential of hadrontherapy:
 radiobiology, fragmentation of ions, dosimetry, testing and developing of detectors for imaging, …

- Brainstorming meeting (>200 experts from >20 countries) in 2012 in support of dedicated research facility at CERN



- Energy range matches that of clinical centers (max 6.7 Tm, i.e. 440 MeV/u for C)

- Existing accelerator to be maintained for LHC, but not used all the time

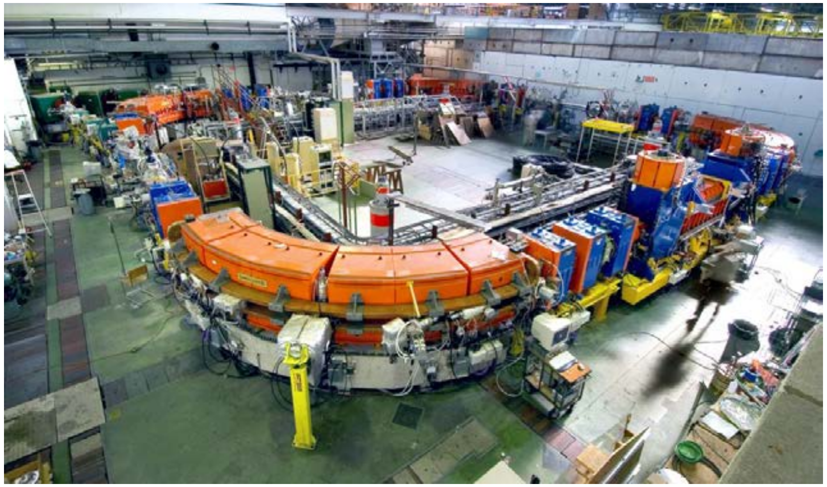
- Adjacent Hall (1500 m^2)

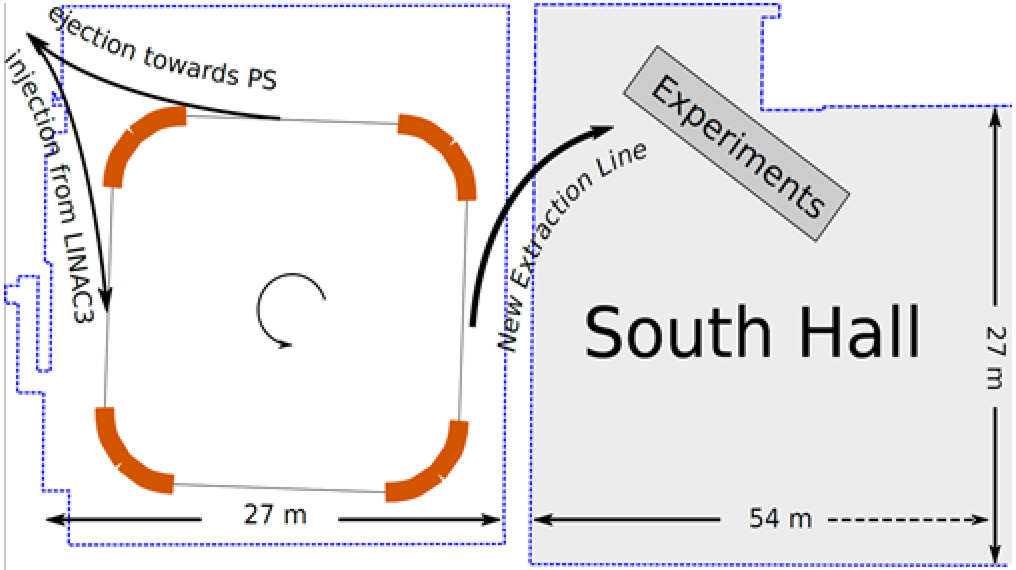
New hardware and modifications to existing hardware are needed

- LINAC3 front-end (source and injection) tailored for heavy ions

- Extraction system tailored for transfer of high-brightness short pulses (200 ns) for physics experiments

- South Hall presently used for storage -> new experimental area for wide range of biomedical experiments





Constraint : maintain the current operational performance for LHC and PS/SPS physics operation.

New dedicated source and RFQ are required

- Present heavy ion source (ECR) runs 6 months/year

- Time needed to swap between simple light ions and heavy ions is min 3 weeks

- Present RFQ not optimal for light ions (design: q/A=1/8, E= 2.5->250 keV/u)

New dedicated source and RFQ:

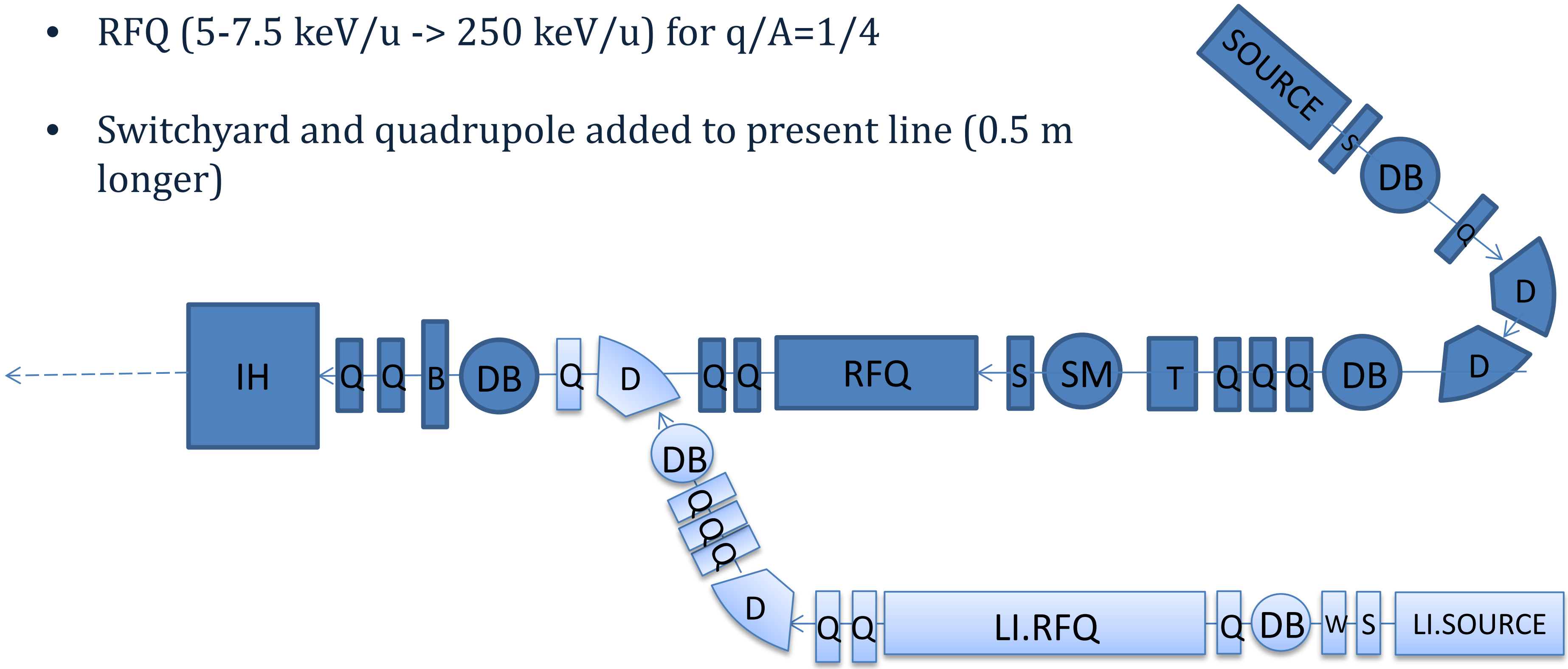
- **flexibility**,
- **faster switching** between species,
- operation during LHC run.

A new dedicated front-end is proposed

- ECR source (SuperNanogan, Pantechnik)
- H/H_2, He, C, N, O and Ne: previously extracted,
- B and Li: under development with Helmholtz-Berlin,

- RFQ (5-7.5 keV/u -> 250 keV/u) for q/A=1/4

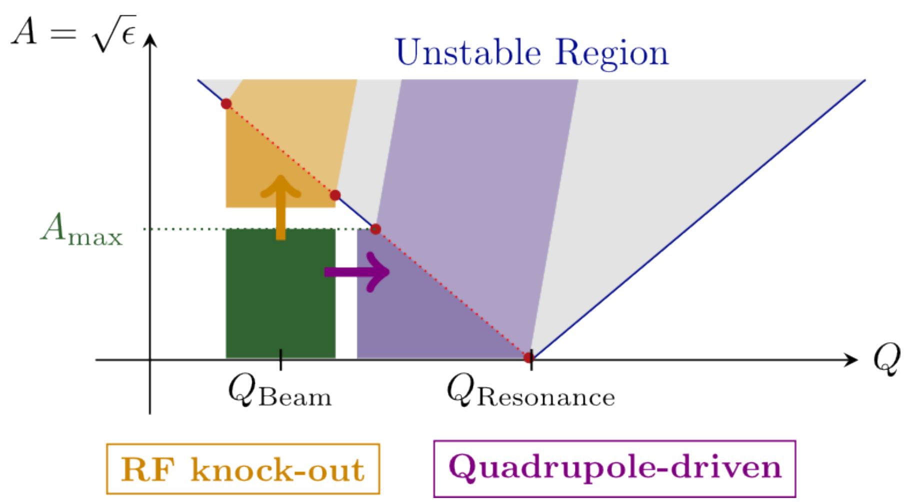
- Switchyard and quadrupole added to present line (0.5 m longer)



Legend: B - *Buncher*, D - *Dipole*, DB - *Diagnostic Box*, IH - *Interdigital H accelerating structure*, Q - *Quadrupole*, RFQ - *Radio Frequency Quadrupole*, S - *Solenoid*, SM - *Steering Magnets*, T - *Beam transformer*, W - *Wien Filter*

Feasibility proven by tracking with extremal beam parameters

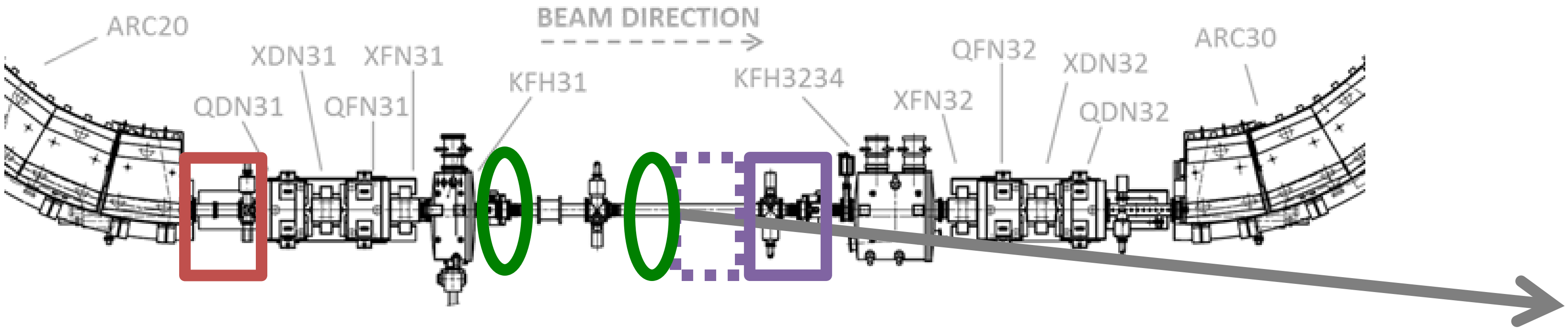
- Resonant slow extraction (1/3) allows to produce 1-10 s spills
- Two resonance driving mechanisms considered:
  - Quadrupole-driven
  - RF-KO



- Lowest extraction energy compatible with power converter stability from LEAR experience
- Highest extraction energy requires new power supplies (present limit is 4.8 Tm, i.e. 250 MeV/u C)

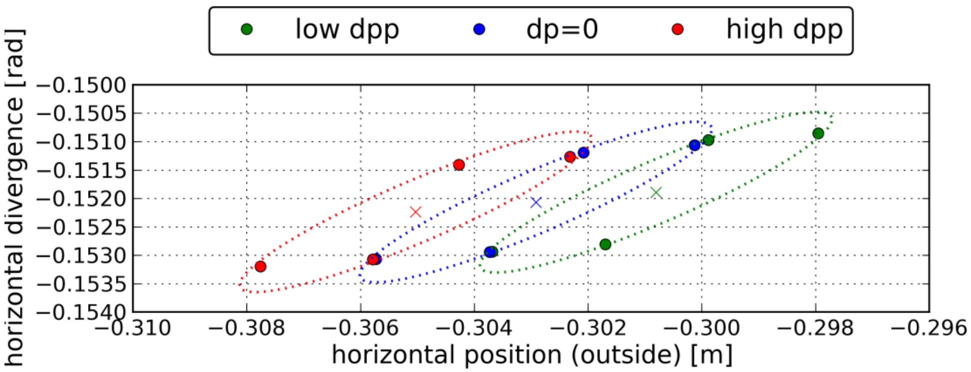
Reference Ion for Extraction Study	$^{12}C^{6+}$	
Energy	20 MeV/u	440 MeV/u
Emittance RMS	5 µm	1 µm
Momentum Spread RMS	$2 \cdot 10^{-4}$	$4 \cdot 10^{-5}$

Extraction is possible with minimal new hardware

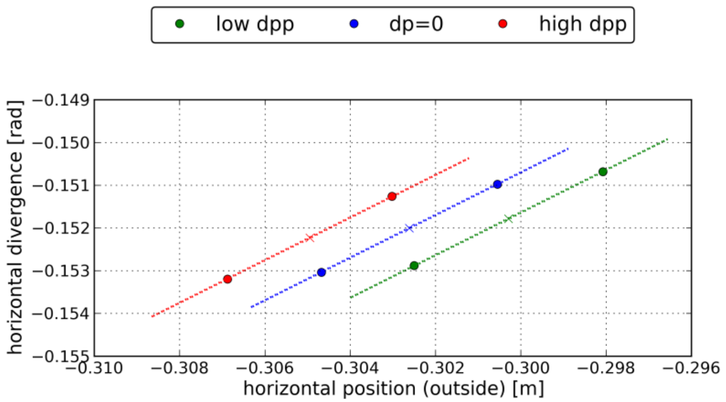


Devices	Electrostatic Septum	Orbit Correctors X 2	Magnetic Septum ('thin')	Magnetic Septum ('thick')
Septum Apparent Thickness	**0.1 mm**	**n.a.**	**9 mm**	**22 mm**
Max Field Strength	8 MV/m	0.2 T	0.5 T	0.7 T
Availability	LEAR Spare	new	LEAR spare	new

Previous results define initial beam parameters for extraction line



<u>QUADRUPOLE–DRIVEN</u>
EXTRACTION



<u>RF-KNOCKOUT</u>
EXTRACTION

+ Easy to implement
- Intensity Fluctuations
- Varying beam parameters during spill

+ Smooth spill with fast on/off
+ Constant beam parameters during spill
- New hardware to be installed

Easier to Implement

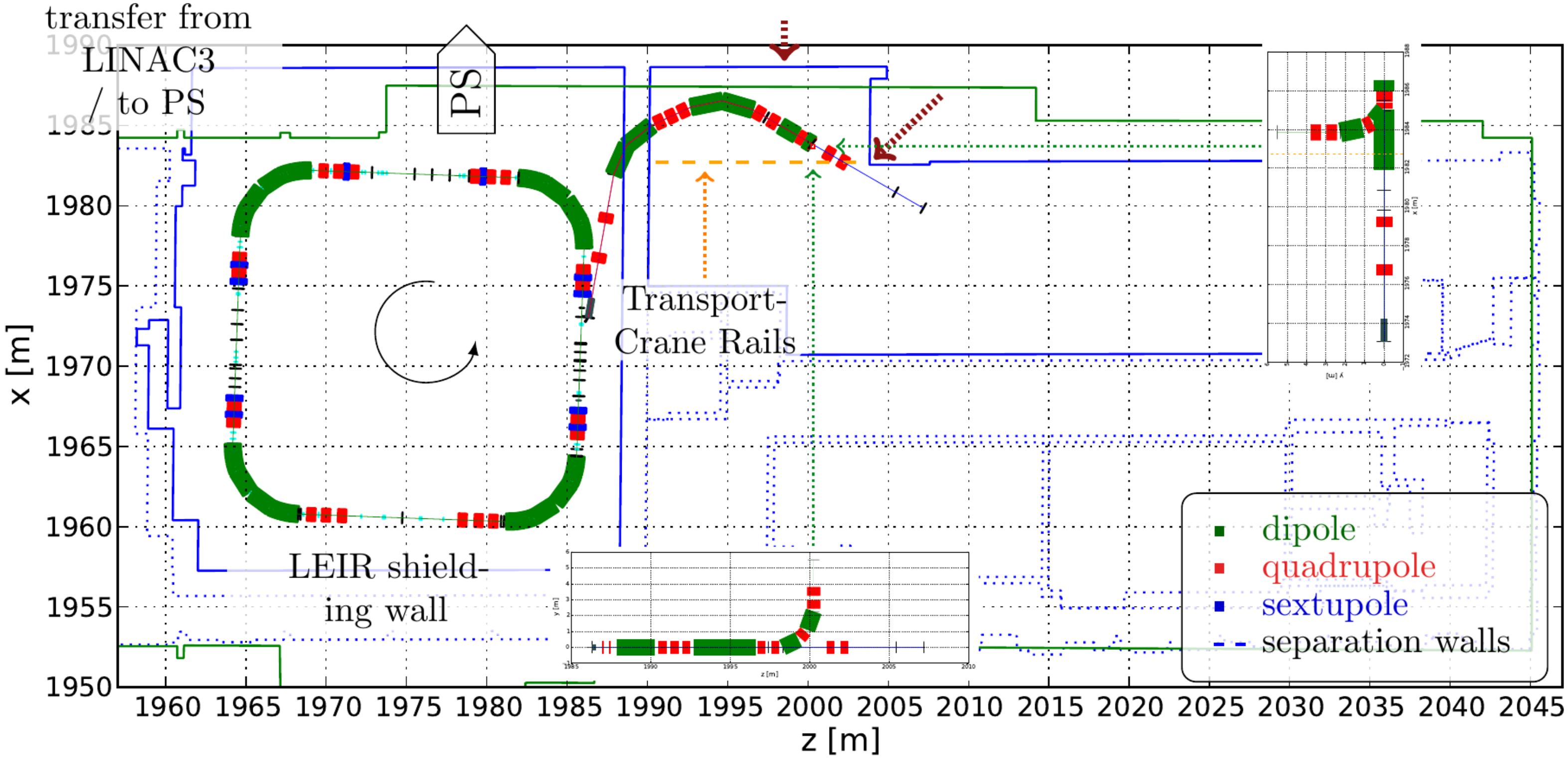
Better beam quality

Two experimental beamlines are foreseen

- Horizontal beamline up to maximum energy and Vertical beamline up to 2.6 Tm (75 MeV/u C)

- Pencil beam 5-10 mm FWHM and broad beam 5x5 cm^2 considered

- 4 bending magnets (max 1.6 T, ± 40 mm gap) and 12 quadrupoles (max 23 T/m, max 40 mm radius) in total



CONCLUSION

FRONT-END

- Light ions source chosen with methods for H, He, C, O, Ne ready to go.
- Experiments to develop Boron and Lithium beams.
- RFQ design in progress.

SLOW EXTRACTION

- Feasibility of both quadrupole-driven and RF-KO extraction proven
- Minimal impact on LEIR and possibility to reuse spare devices
- Radioprotection study to be done: rooftop/intensity limit

EXPERIMENTAL BEAMLINES

- First proposal for vertical and horizontal beamline completed
- Alternative solutions under investigation: downwards vertical beamline, octupole transverse spreading, scanning system for horizontal beamline
- Biolabs available for experimental groups (cell culture in situ, analysis, imaging,…)

<u>THANK YOU FOR YOUR ATTENTION</u>