

Biomedical Research Facility @ LEIR OPENMED

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University of Coimbra

Al-Quds University



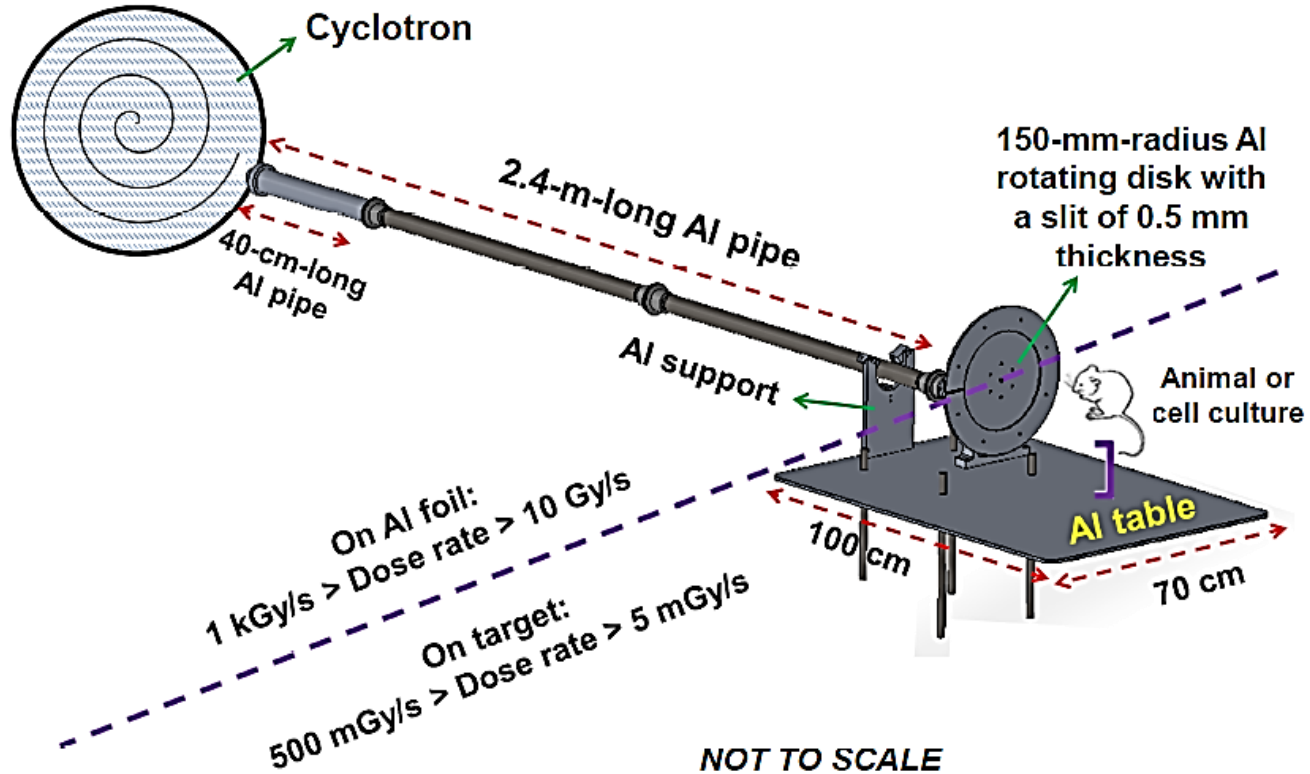
Birzeit University



Development of a PET Cyclotron Based Irradiation Setup for Proton Radiobiology

The ICNAS cyclotron:
Cyclone®18/9 -HC, from IBA

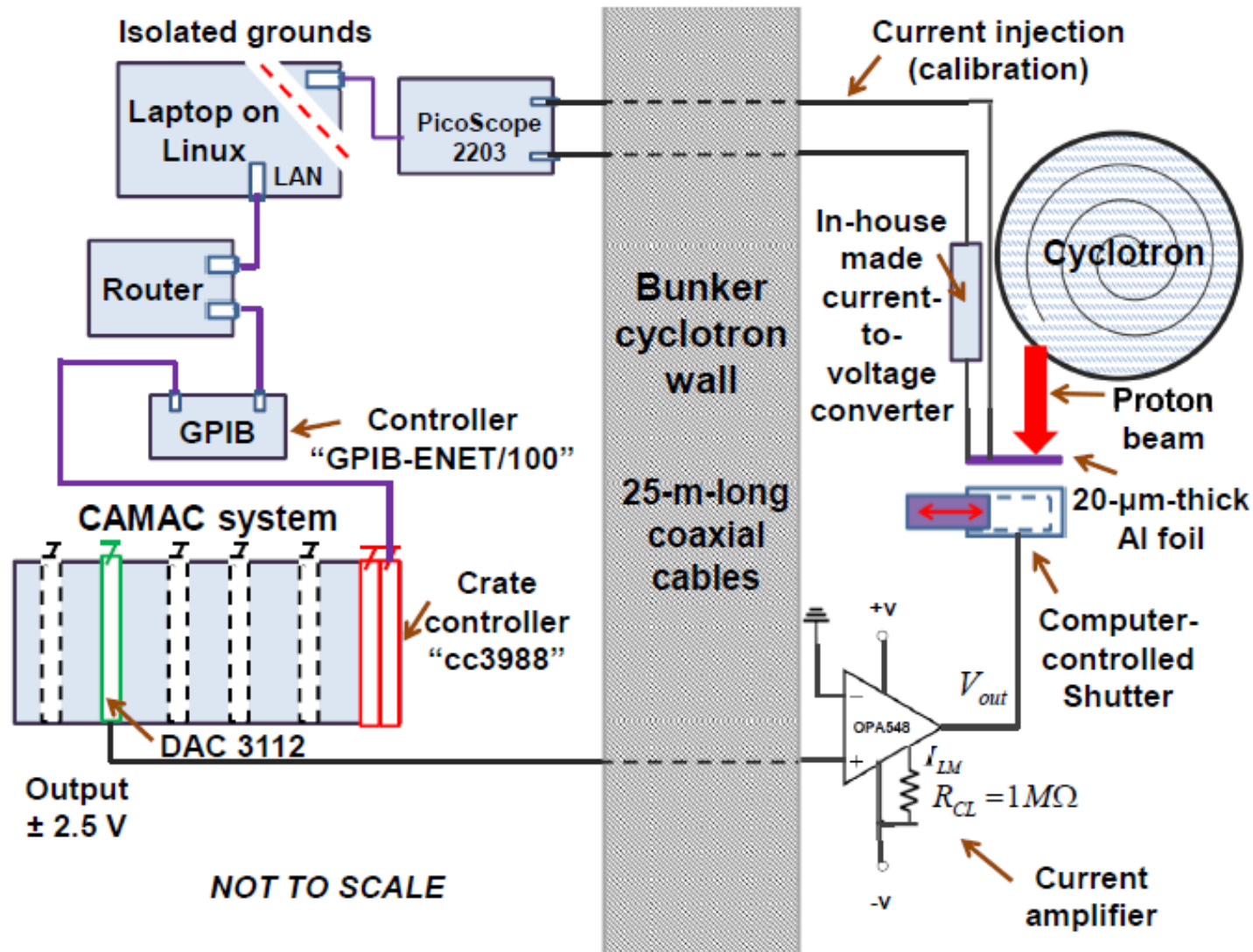
Beam lines



University of Coimbra

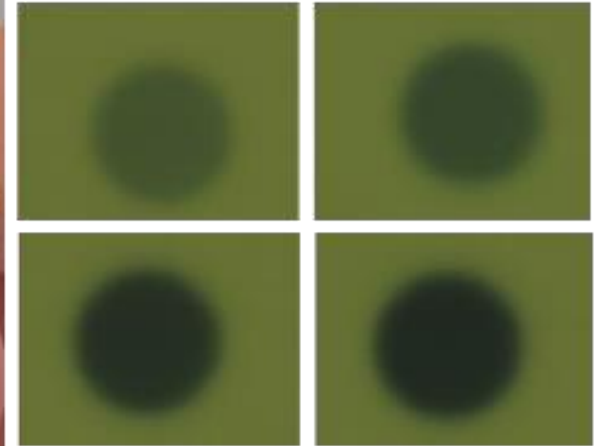
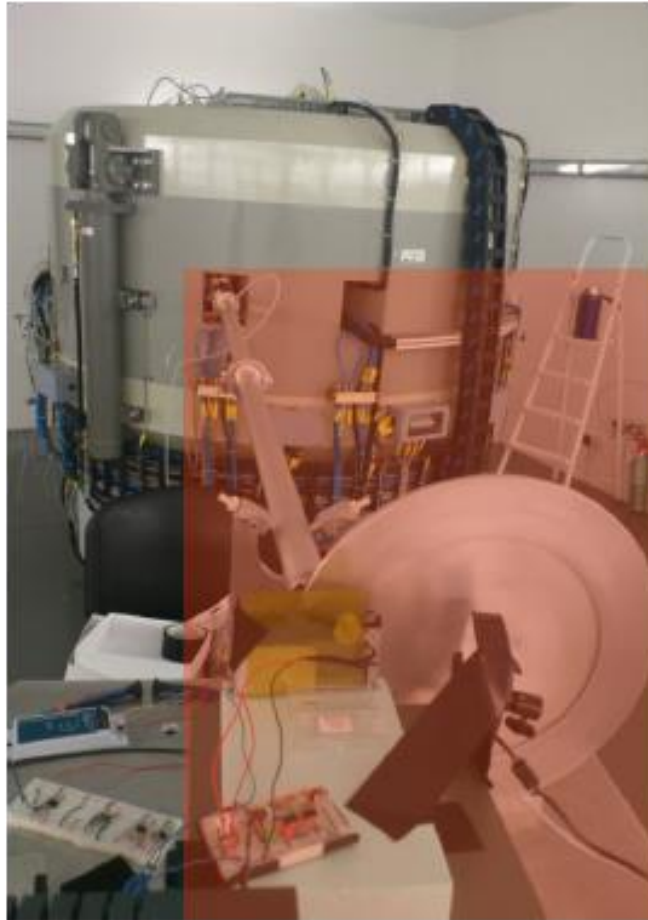
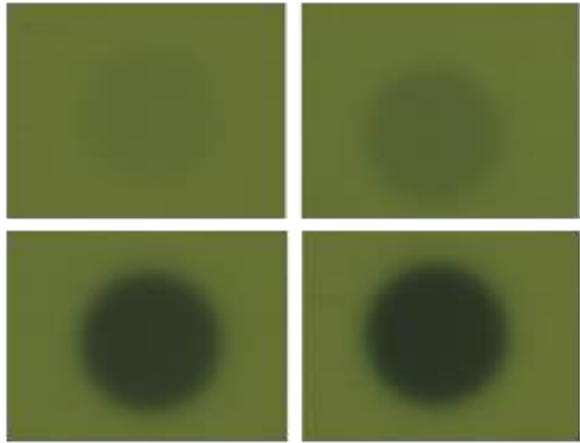
(Ghithan et al. 2015 JINST)

Development of a PET Cyclotron Based Irradiation Setup for Proton Radiobiology



(Ghithan et al. 2015 JINST)

Development of a PET Cyclotron Based Irradiation Setup for Proton Radiobiology



(Ghithan et al. 2015 JINST)

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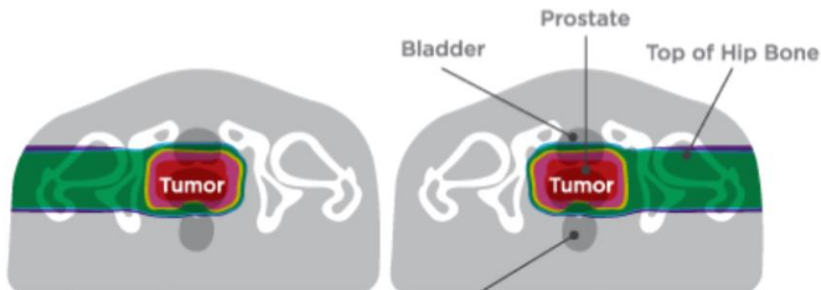
Conclusions

Motivation

Need for radiobiological research with ion beams:

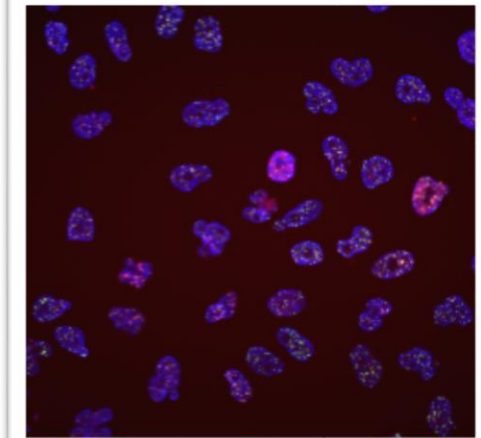
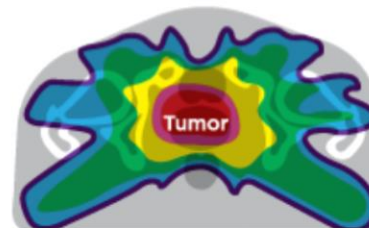
- ❑ Protons and Carbon ions in clinical use
- ❑ Incoherent sets of data with very **different experimental conditions**
- ❑ **Radiobiology**: cell survival for different ions/doses, bystander effects, ...
- ❑ **Detector Development**: in-beam prompt gamma/PET imaging, ...
- ❑ ...

PROTONS



Provision Center for Proton Therapy

CONVENTIONAL RADIATION



Netherlands Society for Radiobiology (NVRB)

Motivation

Lack of Beam-time

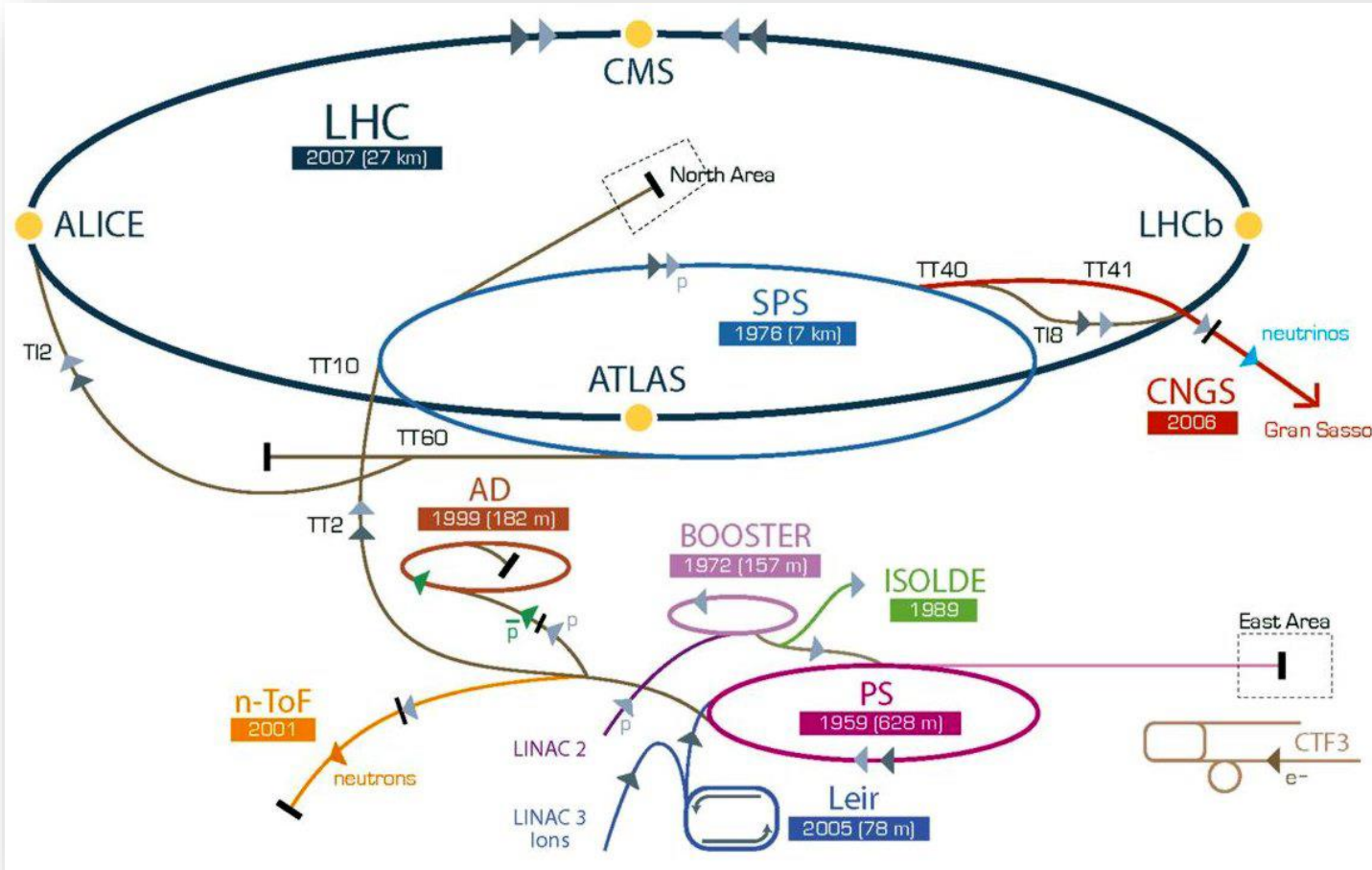
OPENMED would complement the research beam-time available at other laboratories

- ❑ **Nuclear physics laboratories (e.g. GANIL, GSI, INFN LNS, ITEP, JINR ...)**
 - Limited beam time availability

- ❑ **Ion Beam Therapy Centers (HIT, CNAO, MedAustron)**
 - Only limited range of ions
 - Priority given to clinical use

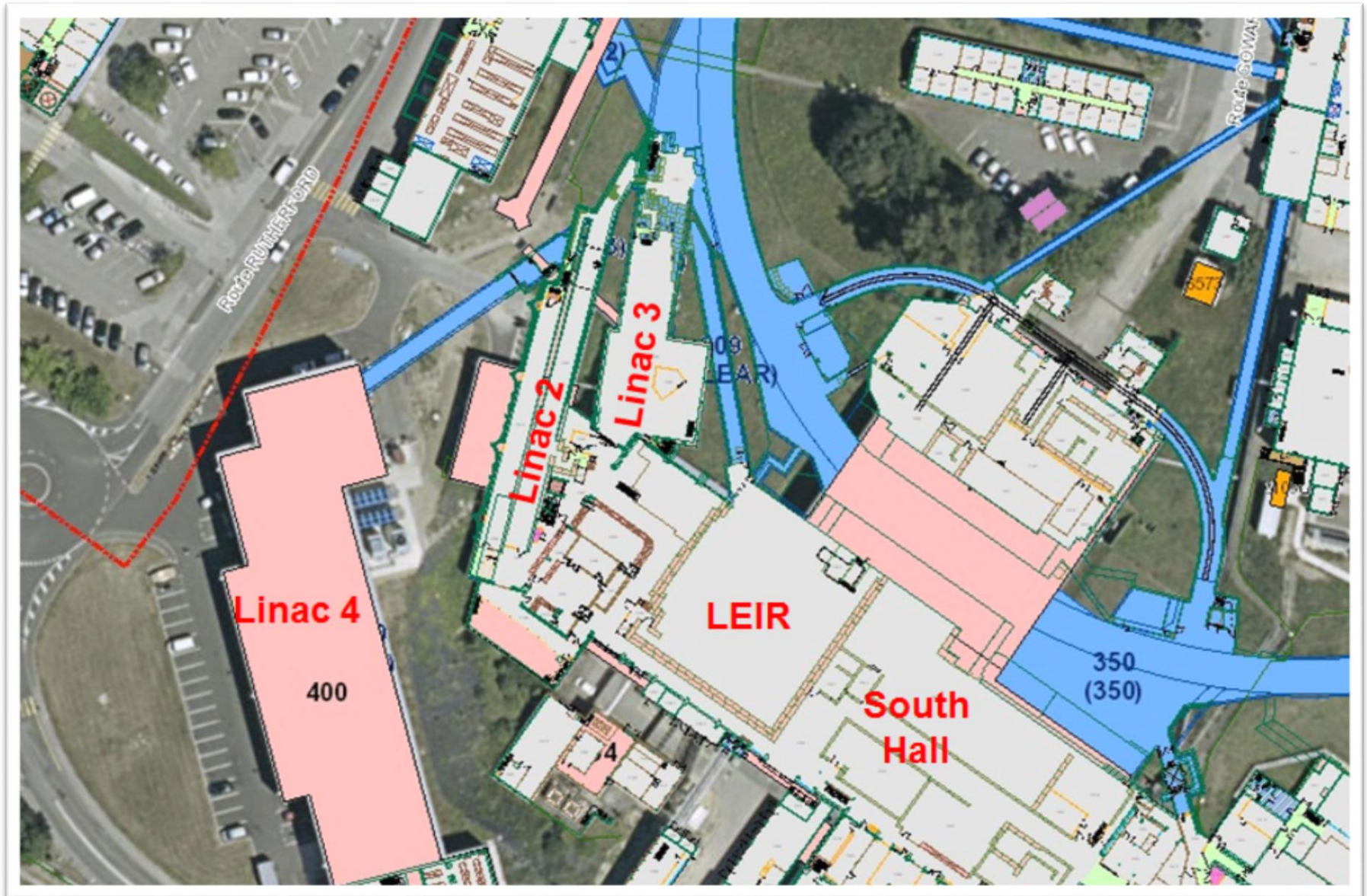


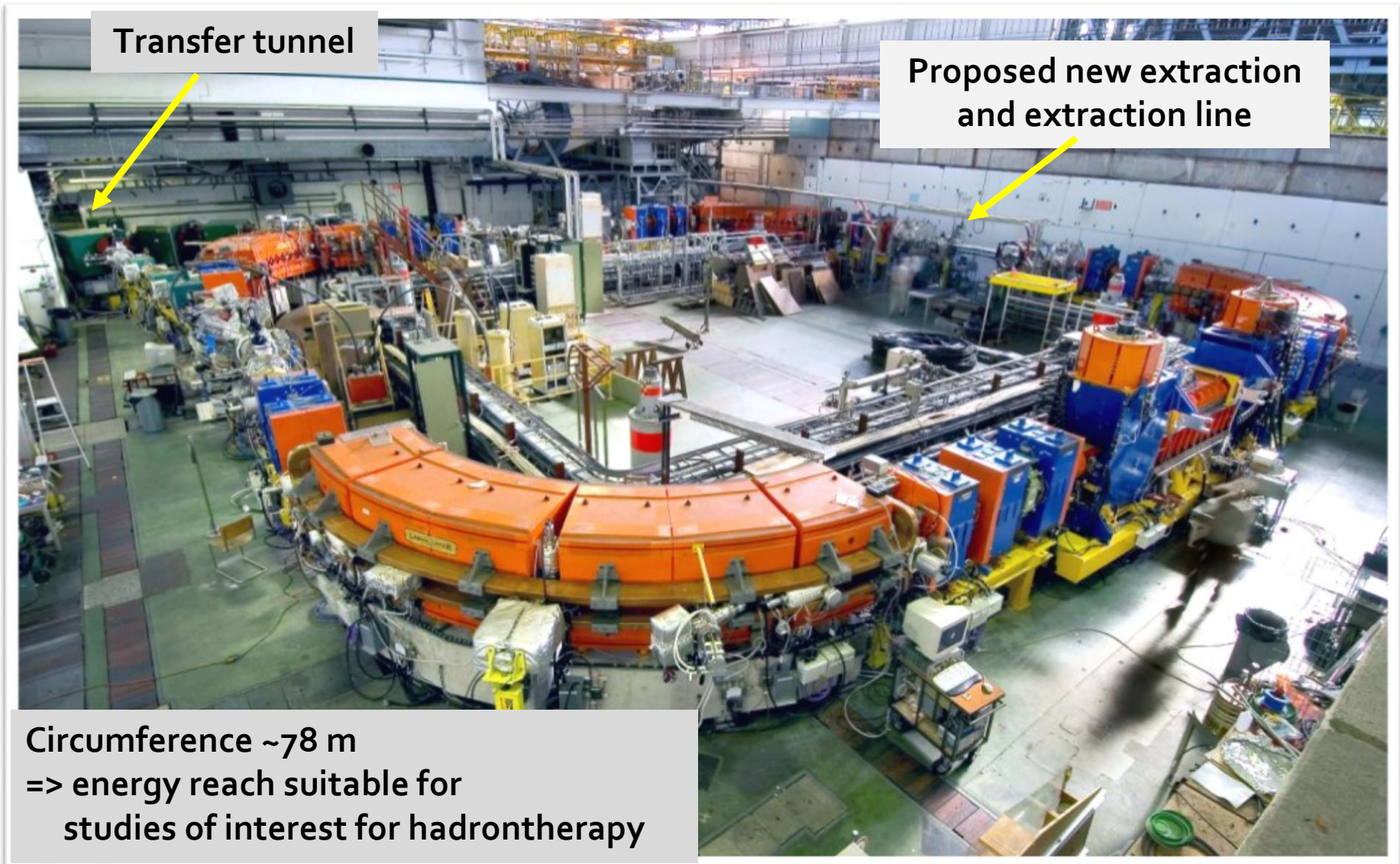
CERN accelerators



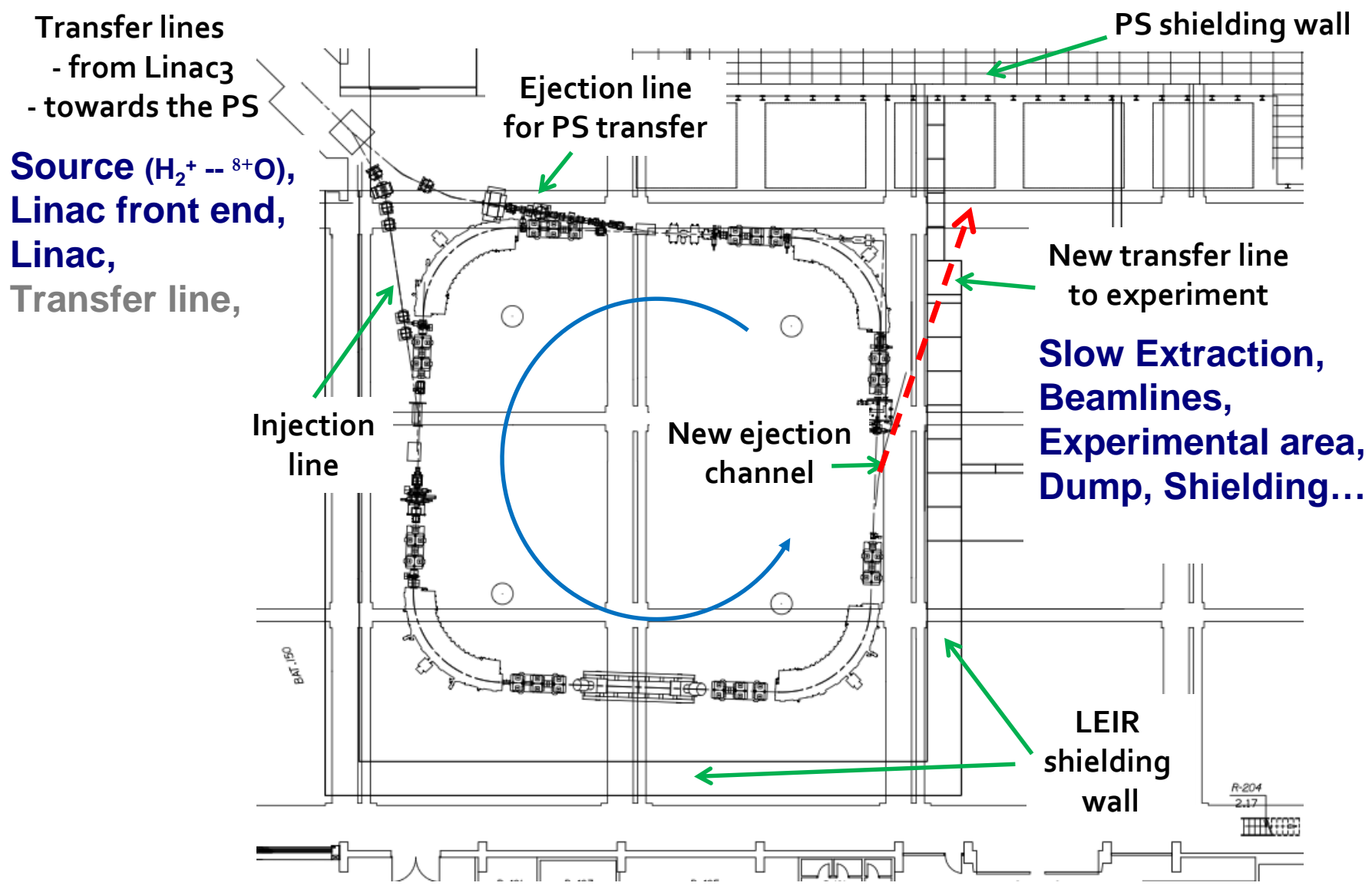
- LEIR (Low Energy Ion Ring) part of injection chain for LHC ion program
- Not used all the time
- Energy range ~ ion beam therapy energies
- Ancillary space for experiments and laboratories

LEIR and Linacs



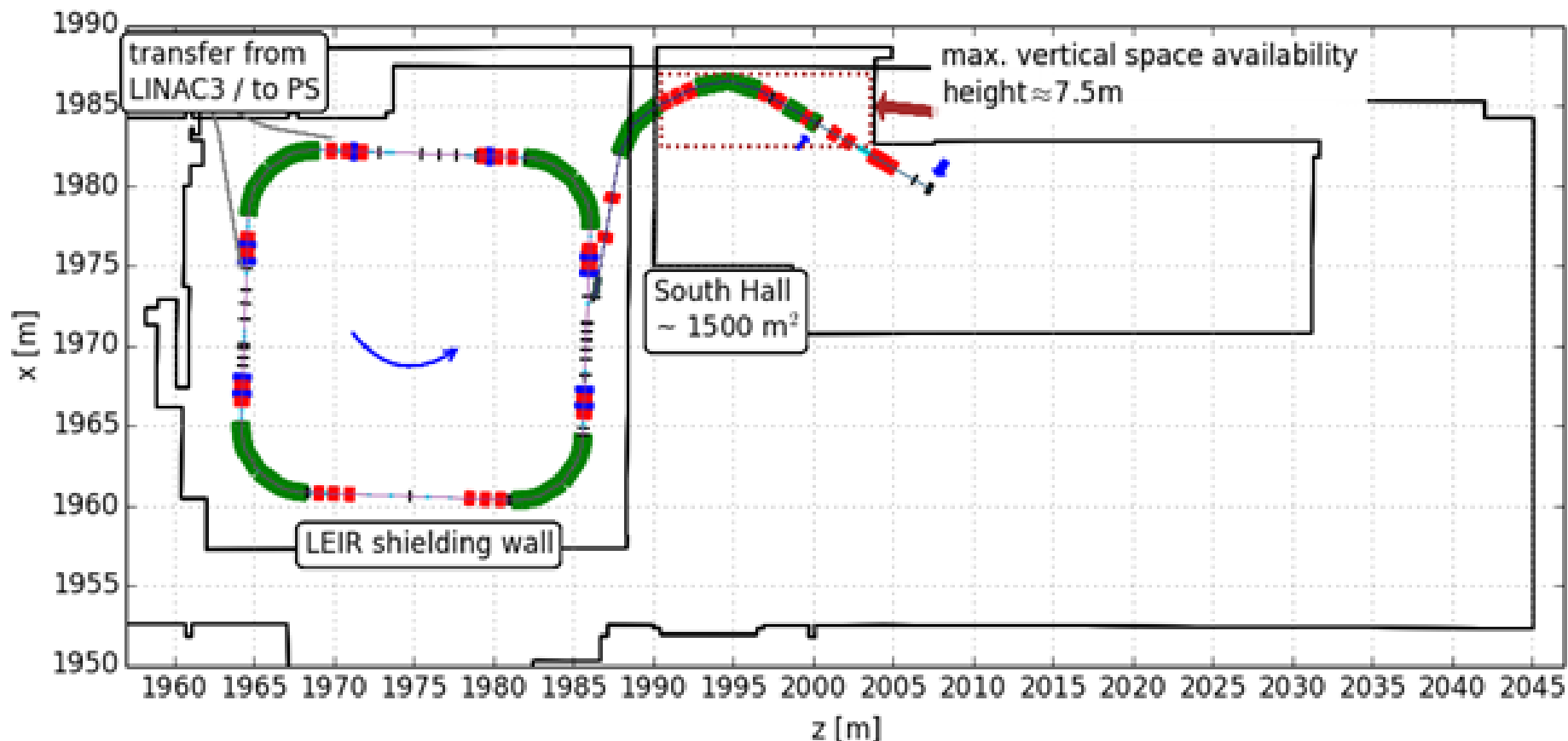


OPENMED modifications



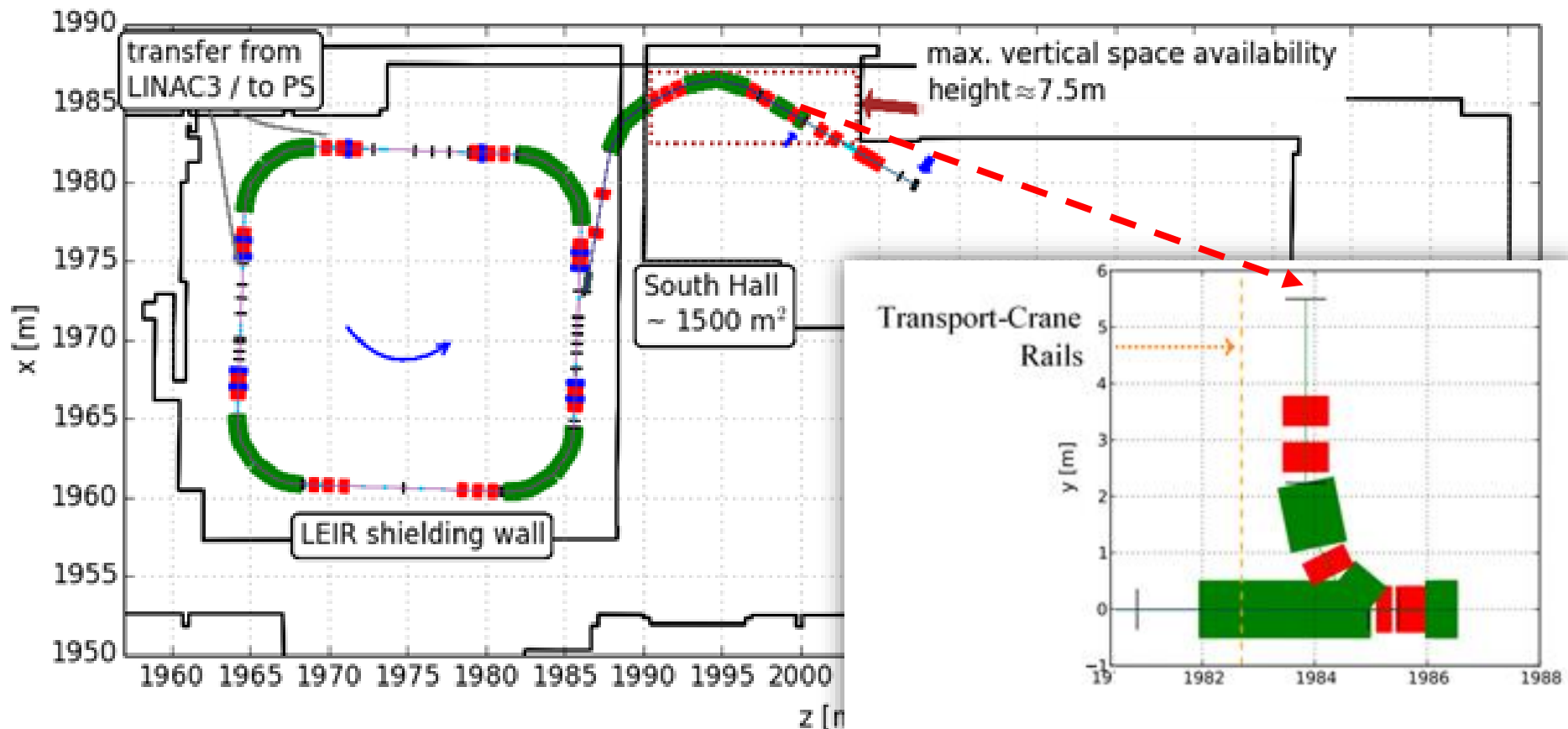
Transfer Beamlines

- Hor. @ 430 MeV/u
- Vert. @ 70 MeV/u
- Pencil Beam : 5-10 mm FWHM
- Broad Beam : $50 \times 50 \text{ mm}^2$
- Field uniformity > 90% across irradiation field

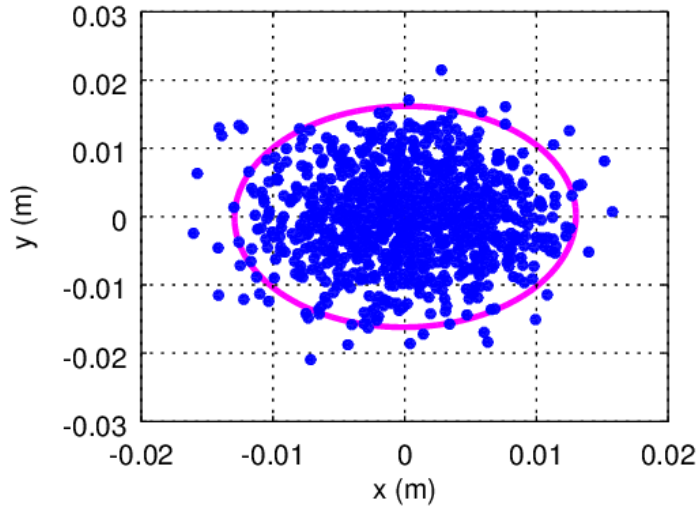


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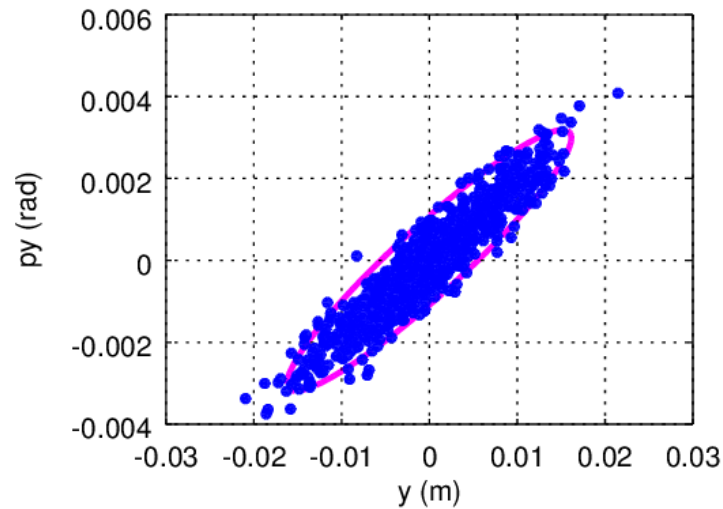
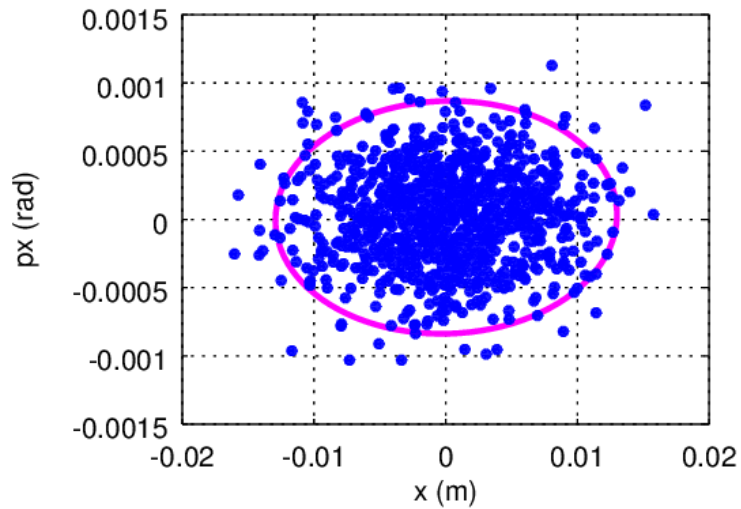


Start Parameters and Matching Constraints

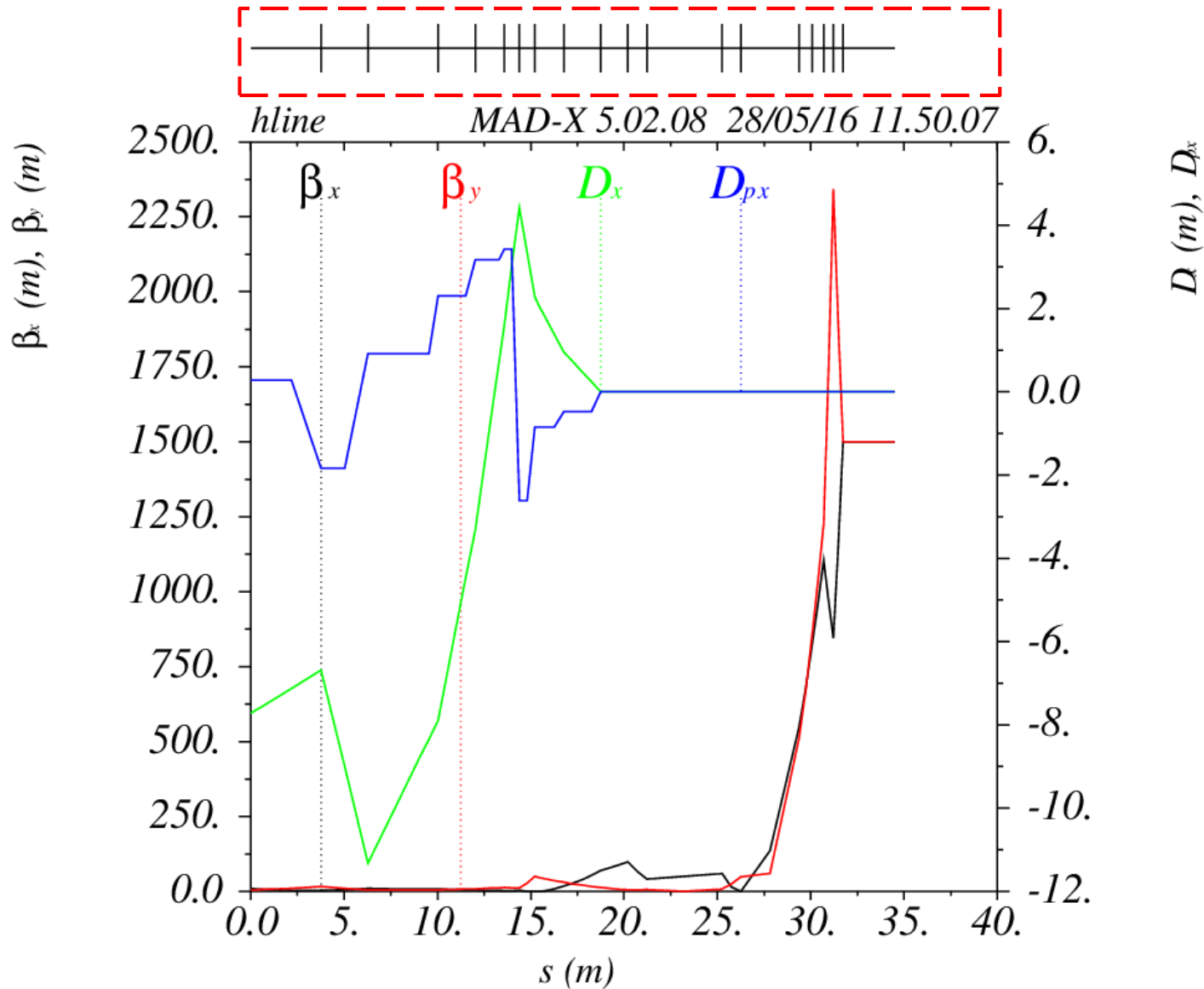


	ϵ_{rms} [π mm mrad]	β [m]	D [m]	D'	α
<i>Start parameters at first electrostatic extraction septum:</i>					
Vertical	0.6–4.2	15	0	0	-2.8
Horizontal	2	15	-4	-1	0
<i>Target parameters at end of beam lines:</i>					
Pencil beam	4.5	1	0	0	0
Broad beam	4.5	1500	0	0	–

(Abler et al. IPAC2014)

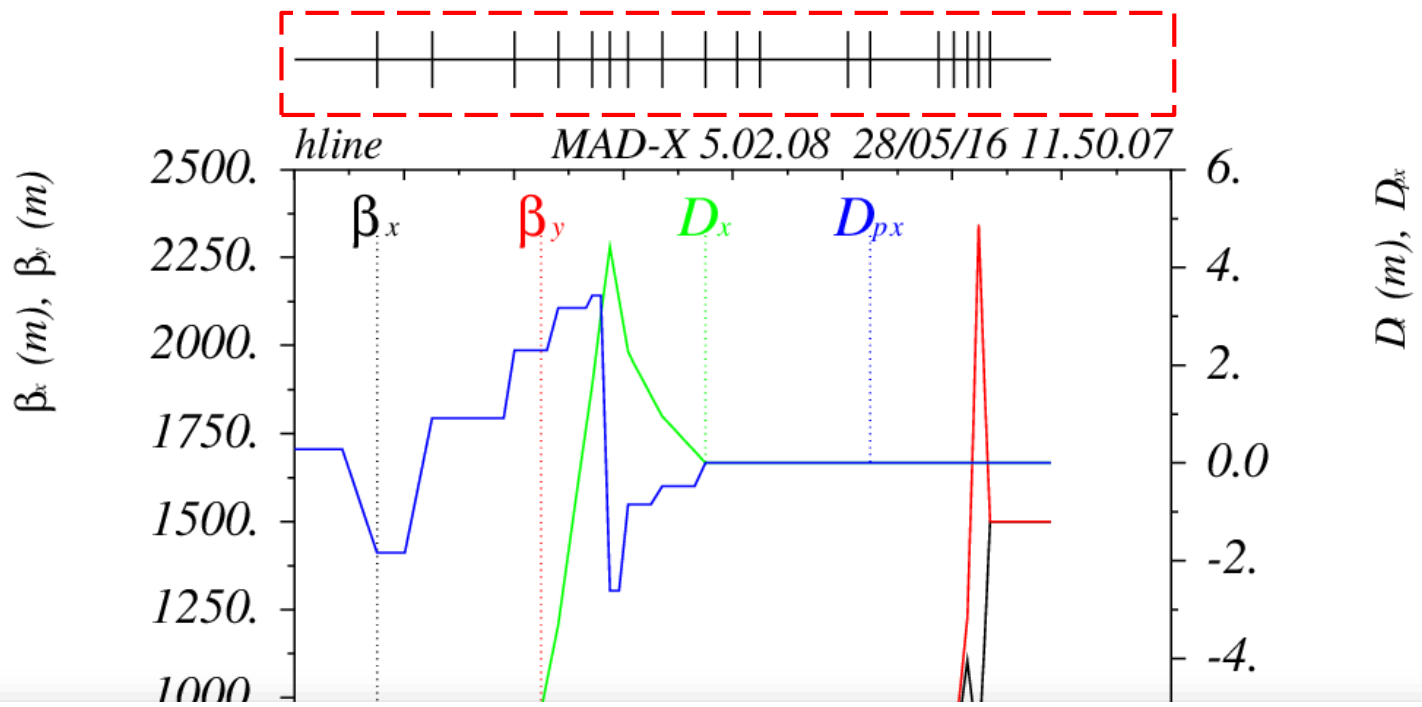


Horizontal Transferline – Broad Beam

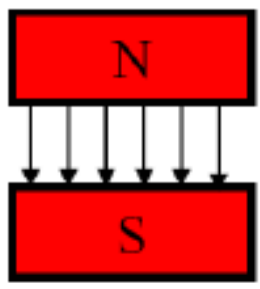


PRELIMINARY

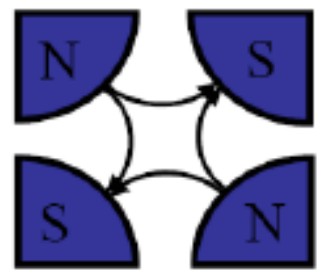
Horizontal Transferline – Broad Beam



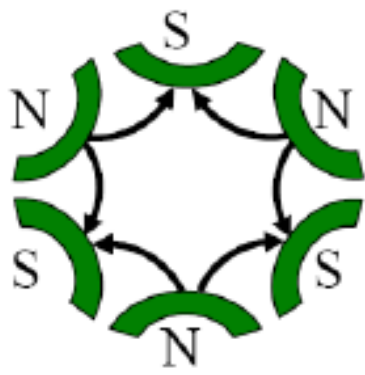
n=1: Dipole



n=2: Quadrupole



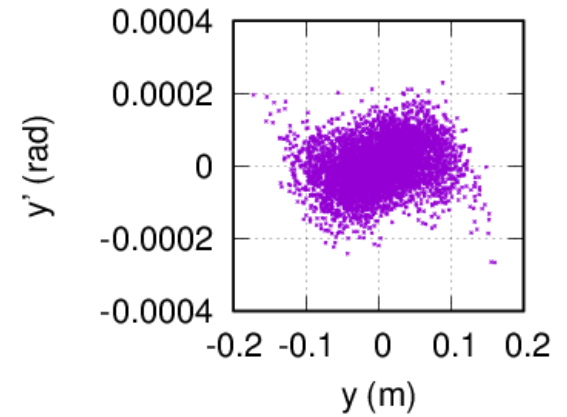
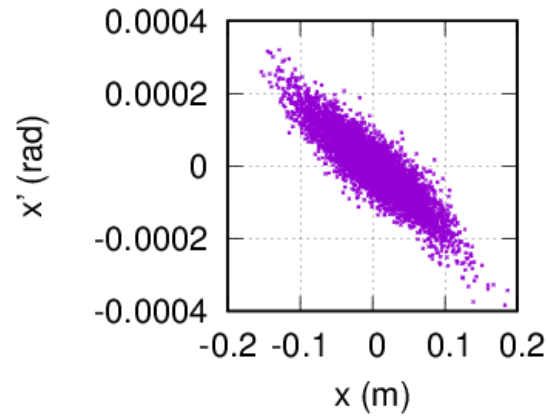
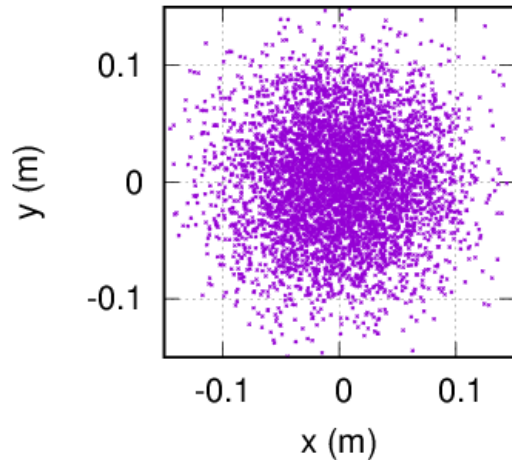
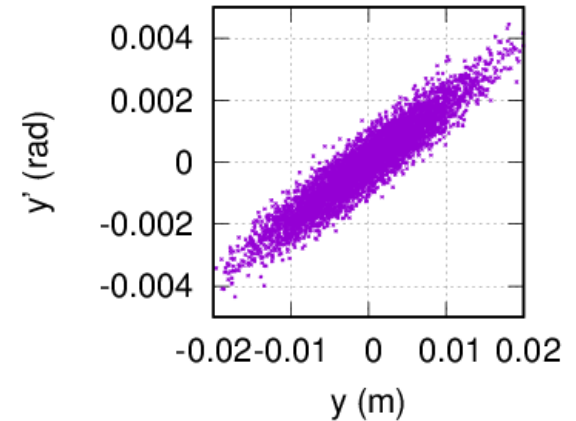
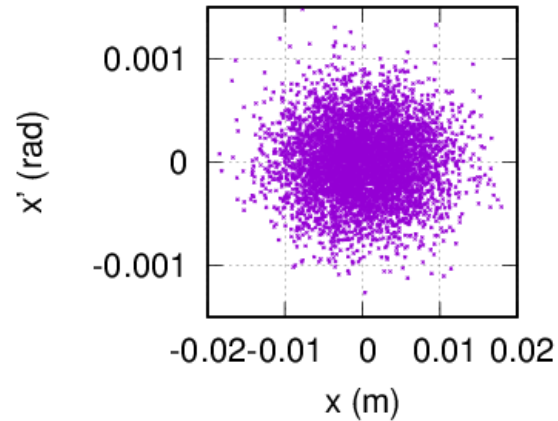
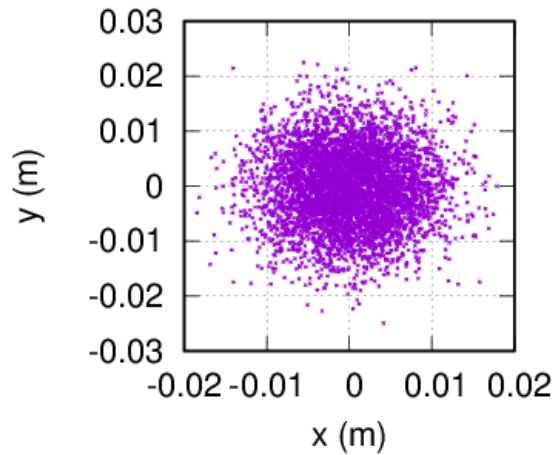
n=3: Sextupole



n=4: Octupole



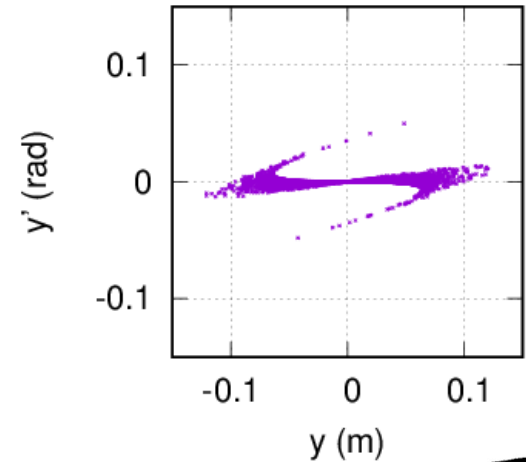
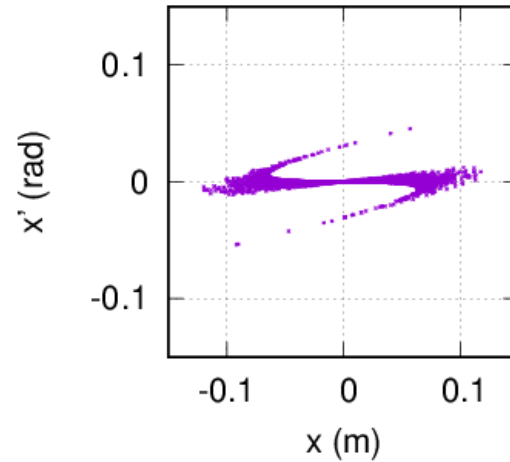
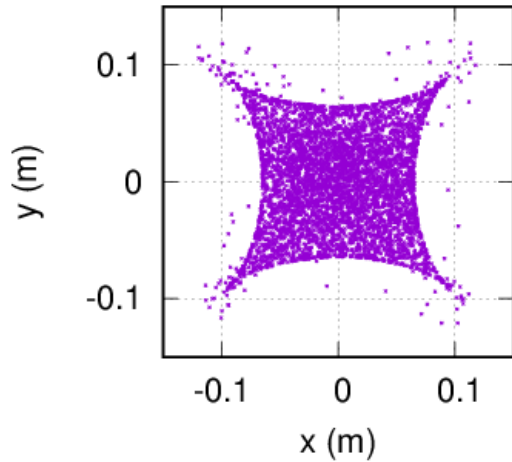
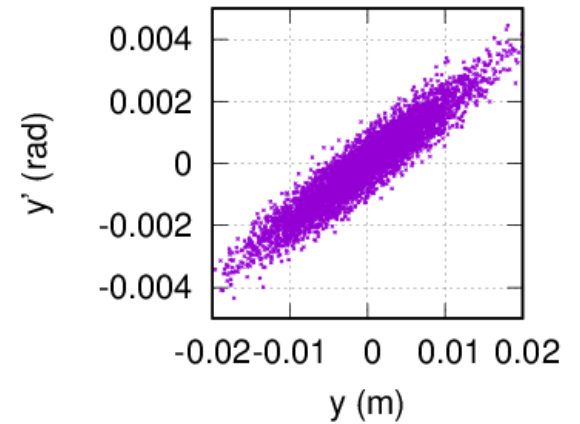
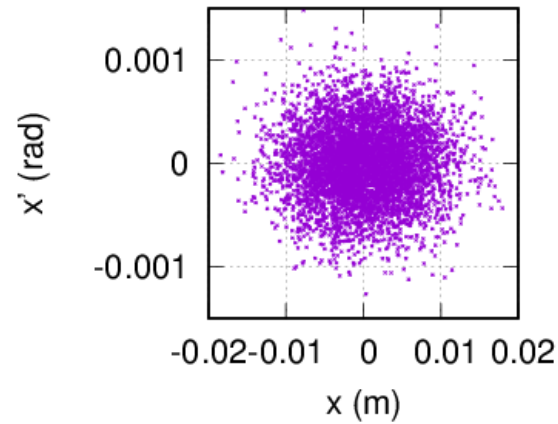
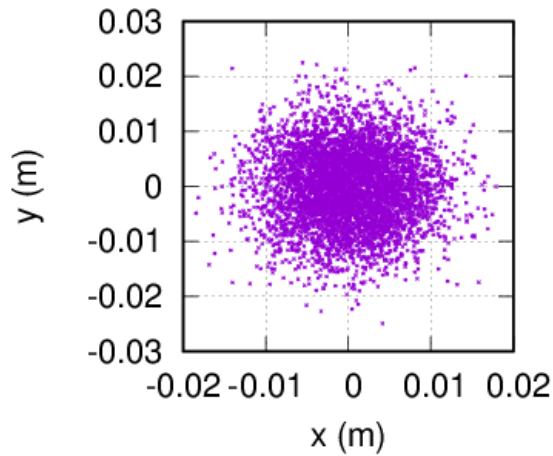
Horizontal Transferline – Broad Beam



Octupoles OFF

PRELIMINARY

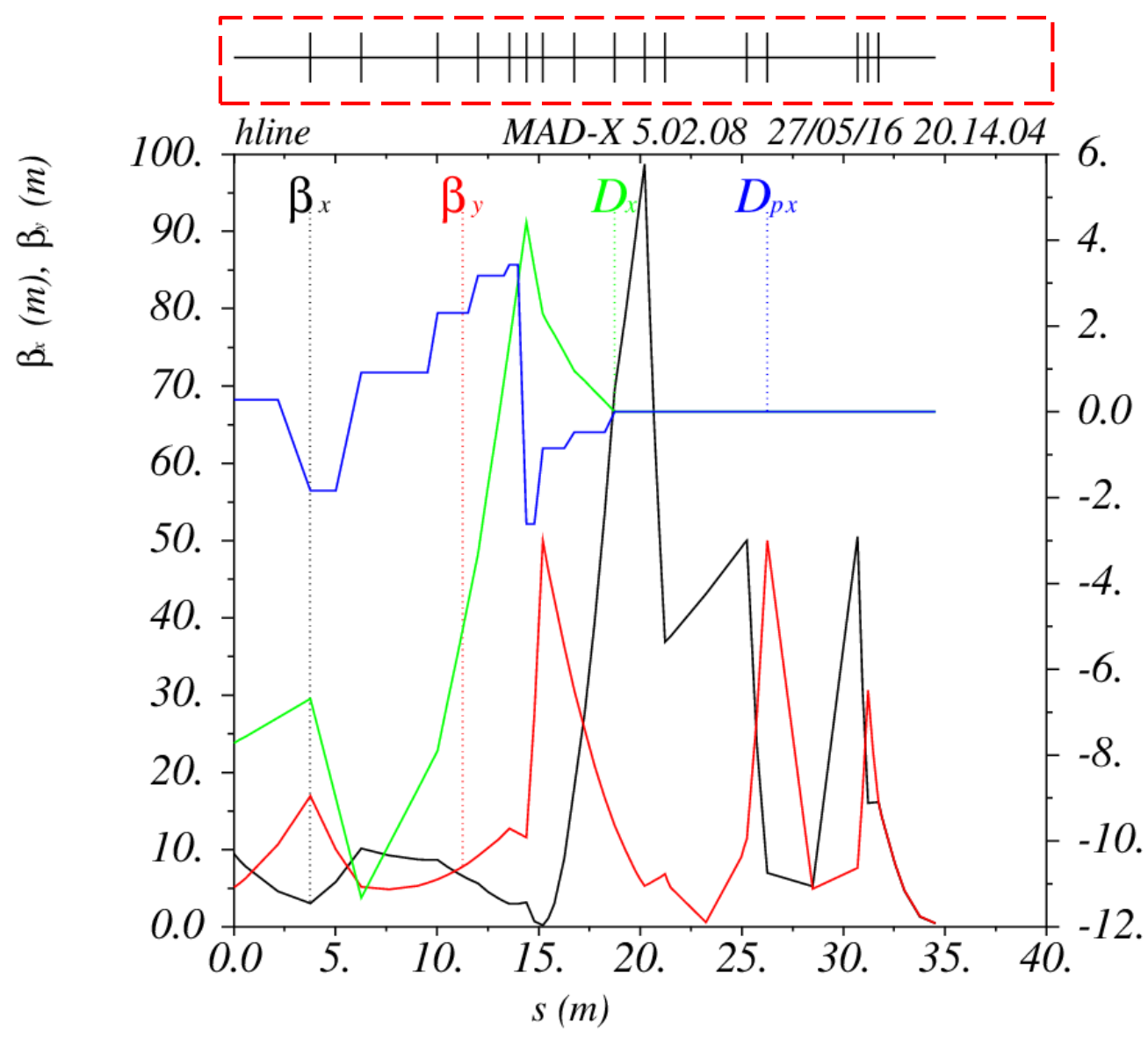
Horizontal Transferline – Broad Beam



Octupoles ON

PRELIMINARY

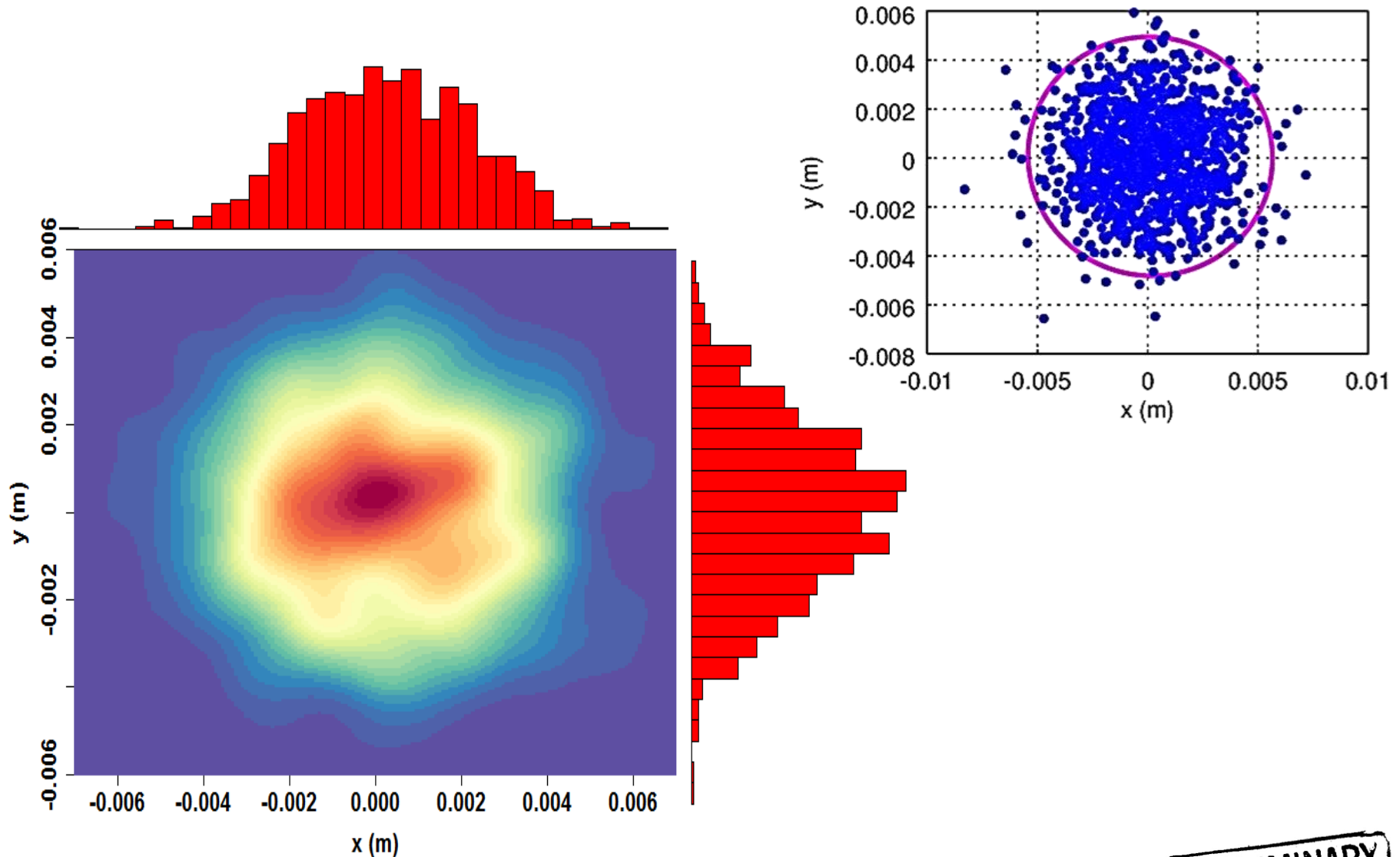
Horizontal Transferline – Pencil Beam



Scanning System:
Kicker Magnets

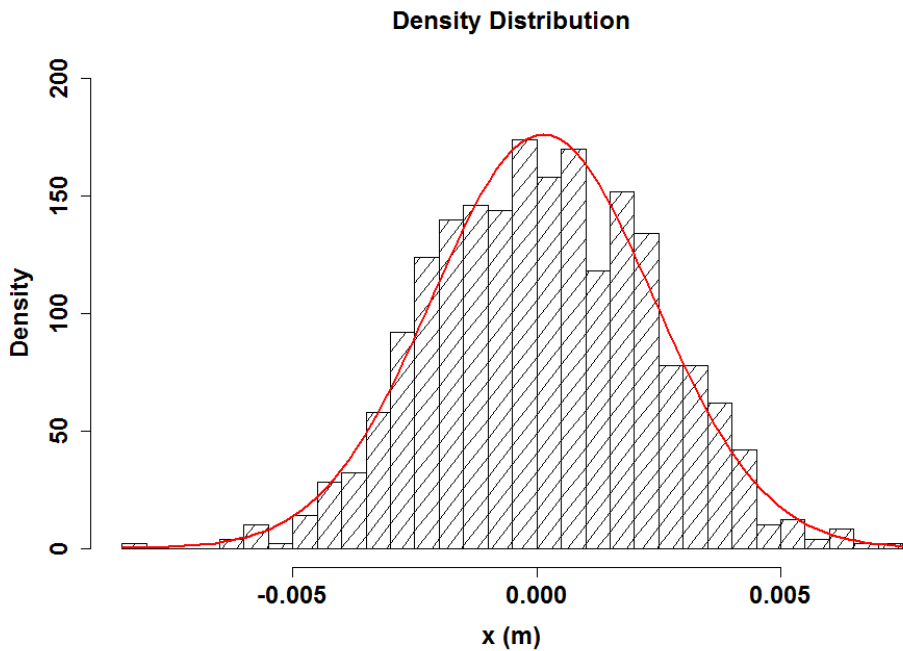
PRELIMINARY

Horizontal Transferline – Pencil Beam

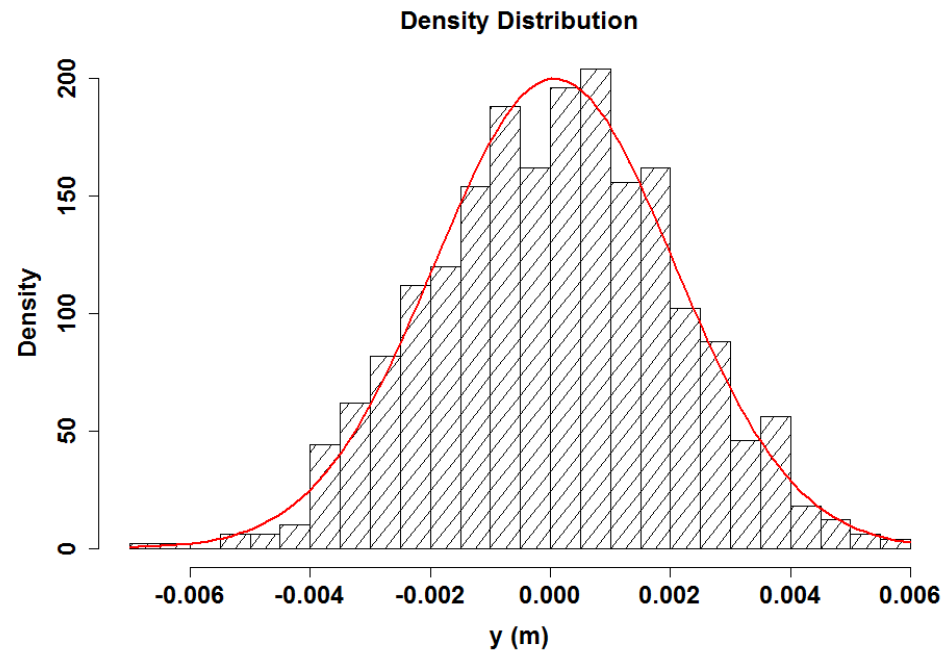


PRELIMINARY

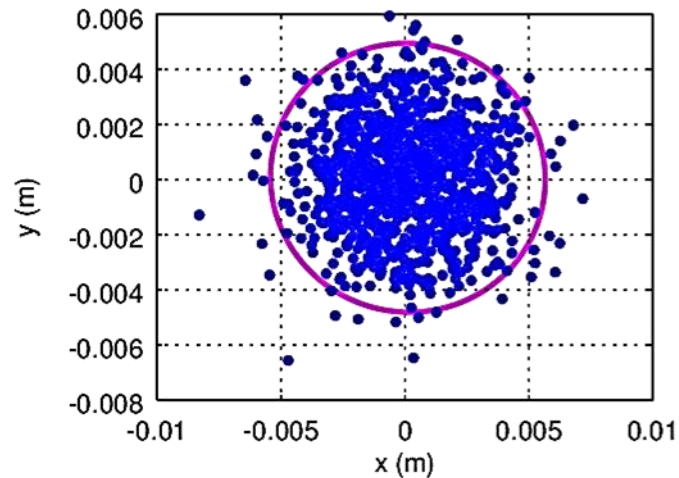
Horizontal Transferline – Pencil Beam



FWHM: 5 mm



FWHM: 4 mm



PRELIMINARY

Beam Instrumentation and Controls

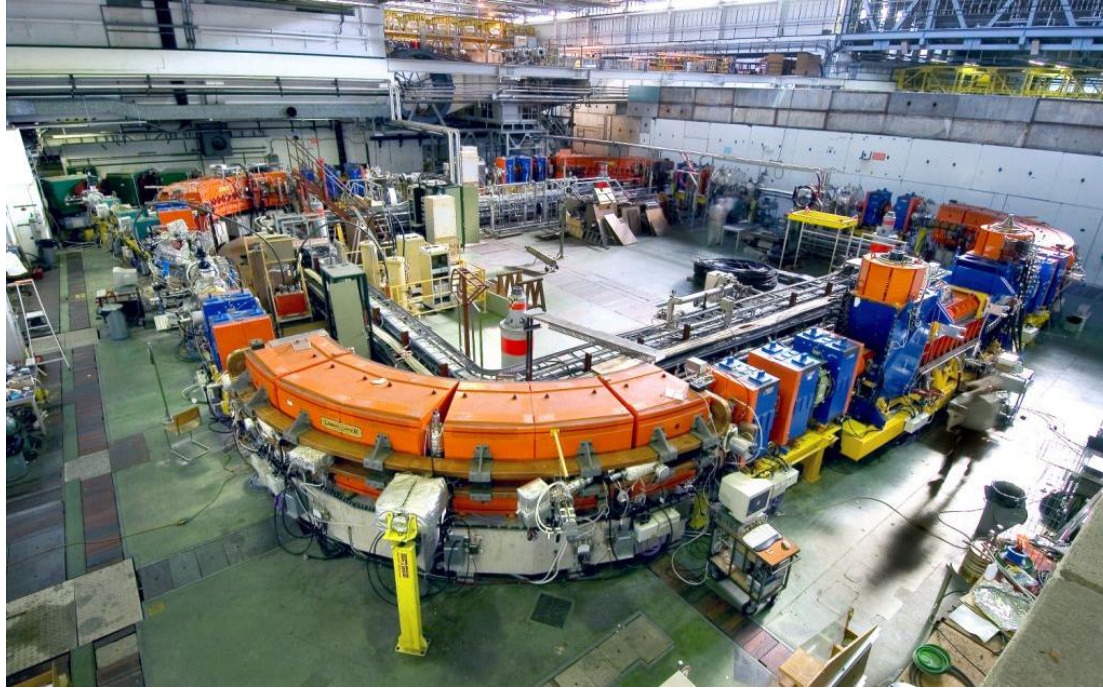
- ❑ Control of extracted beam
 - Position
 - Intensity: ions/s, or dose equivalent
- ❑ Target station and bio-labs to be defined and constructed
- ❑ Sample preparation and handling requirements
- ❑ ...



Summary and Outlook

- ❑ Demand exists for **radiobiological research** with ion beams
- ❑ **Proposal:** upgrade of the Low Energy Ion Ring LEIR (moderate effort)
- ❑ Ongoing work: Design of experimental beamlines
- ❑ OPENMED Study Meetings:
 - Discussions with hardware experts (magnets, vacuum, etc.)
 - Get clear picture of the conceptual design by the end of the year
 - Estimate resources needed: material and manpower, possible timescales
- ❑ **Aim to have a document “pre-CDR” by end of 2016 covering the entire facility from source to end stations.**

Acknowledgements



Supervision by:

Ghislain Roy

Manuela Cirilli

Further Thanks to:

Daniel Abler

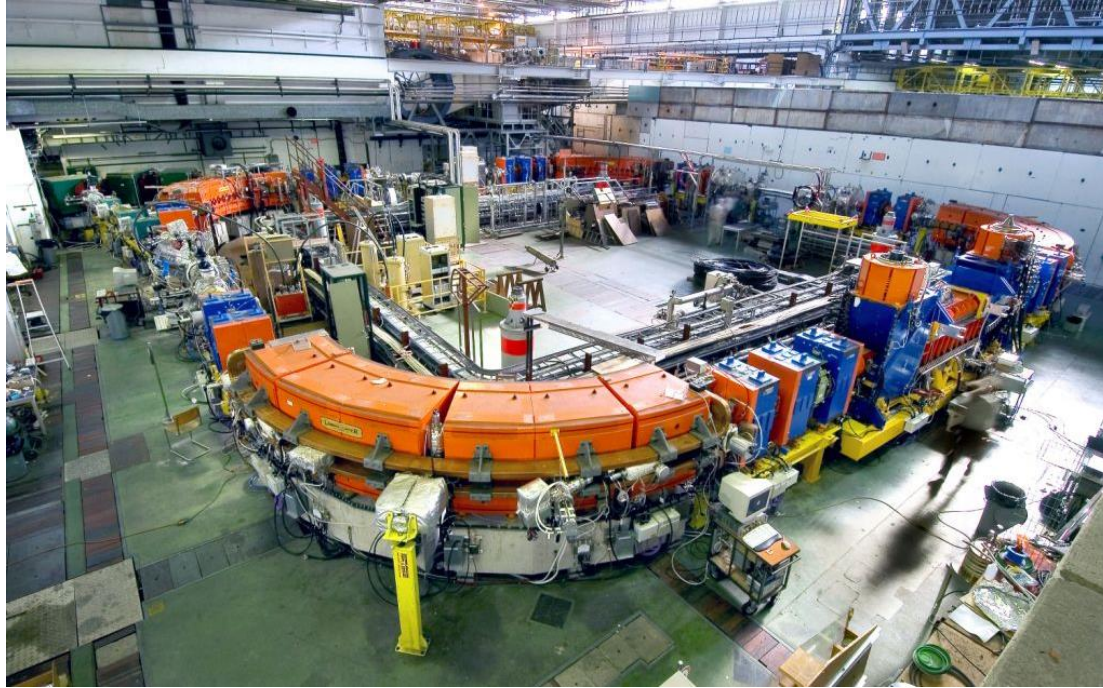
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THANK YOU!