Low Energy Ring:
Pipetron use in the LHC

- **Framework and Collaboration**
- **LHC limits**
- **Global description Low Energy Ring**
- **Subjects on study at the moment**
- **LER Workshop**

Framework and Collaboration

Aim of the study:

To find out what can be gained with, and whether there are show-stoppers for a pre-accelerator in the LHC tunnel

Collaboration:

- **FNAL**

  Henryk Piekarz , John Johnstone, Steven L. Hays, Yuenian Huang, Tanaji Sen, Vladimir Shiltsev

- **CERN**

  Lucio Rossi, Gijs de Rijk

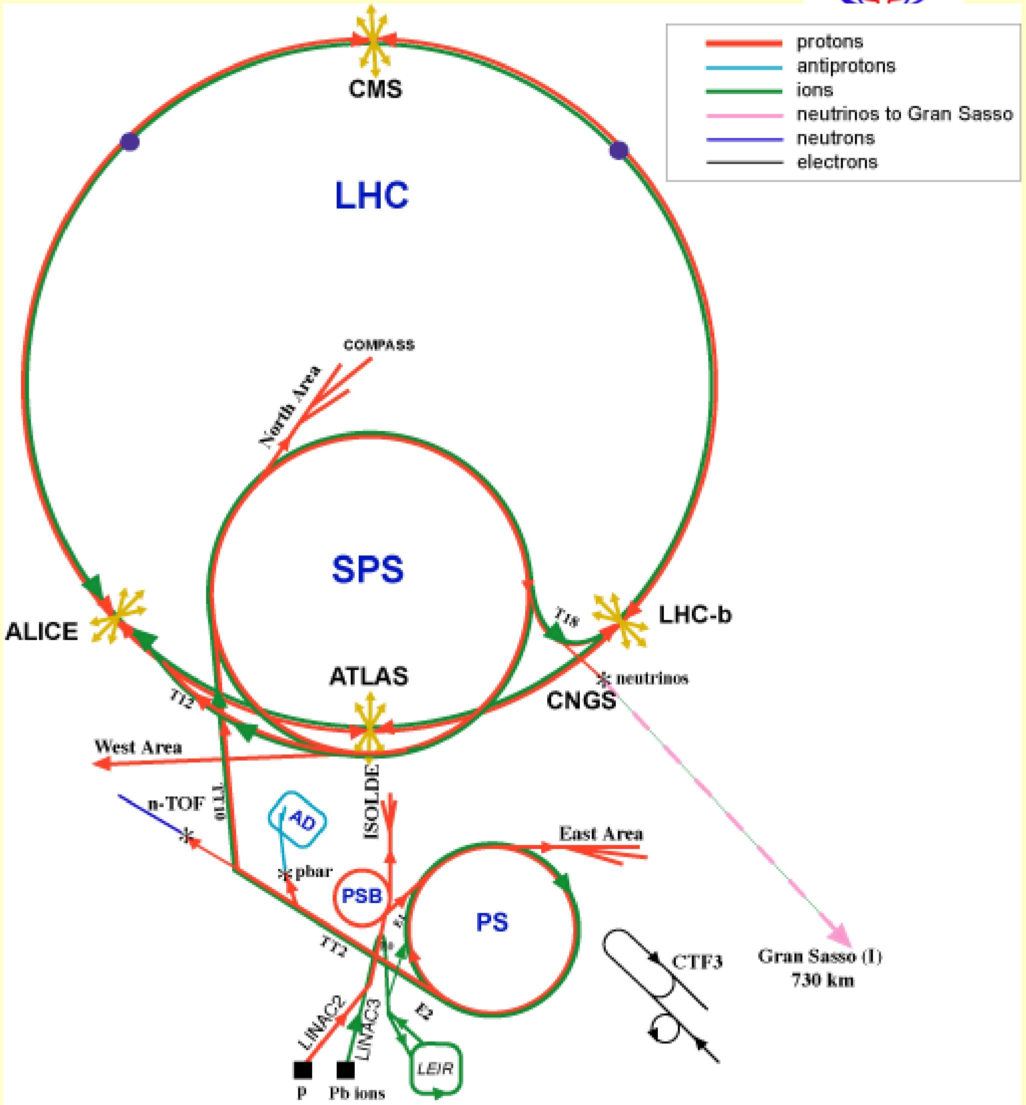
LHC Limits

- LHC will be limited in bunch intensity and emittance due to the multipole fields at the injection plateau and by the quality of the beam coming from the injectors
- The large ‘swing’ of the machine 0.45 TeV => 7 TeV

  0.53 T => 8.34 T is the cause of sizable persistent currents in the cables.
- Persistent currents in cables give rise to multipolar fields. These currents are not stable and this causes the ‘snapback’ of e.g. the b_3 during the beginning of the ramp
- These effects should be smaller at a higher injection energy (between 1 Tev-1.5 TeV instead of 0.45 TeV) and a shorter injection plateau (e.g. few ms instead of 20 min)

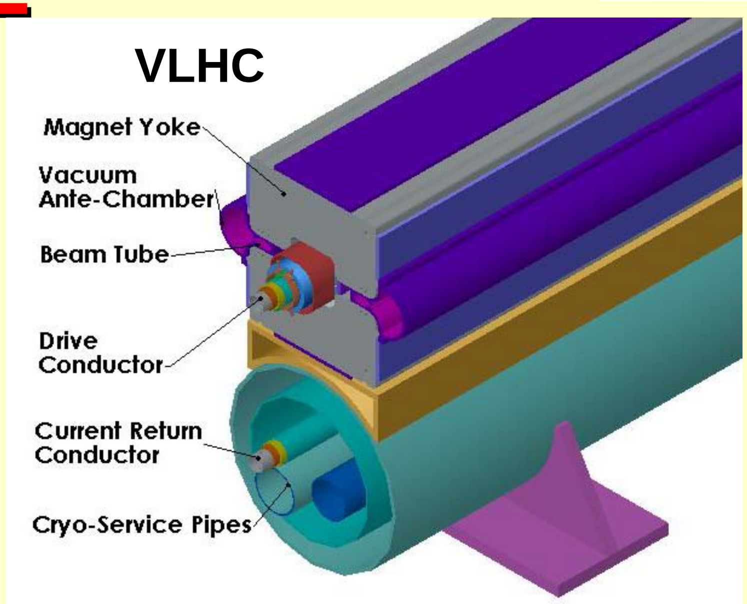
Pre-accelerator LER

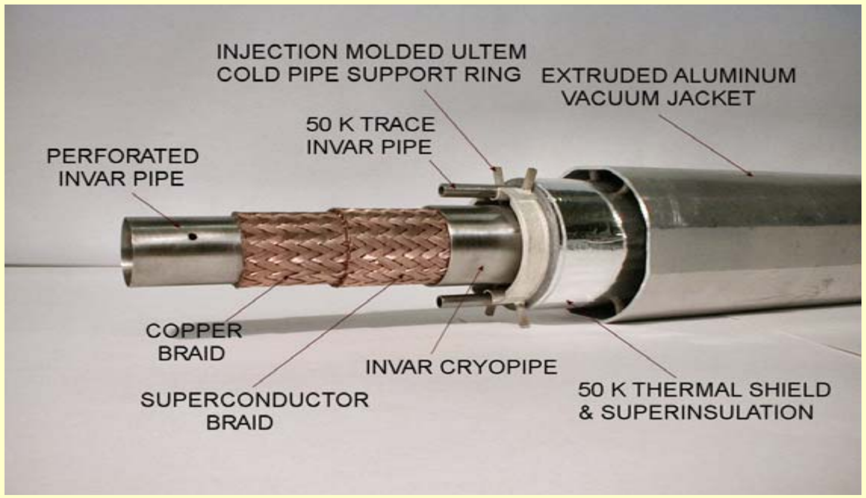
- Pre-accelerator of 0.45 TeV => 1 TeV-1.5 TeV in the LHC tunnel.
- Small transverse dimensions
- Cheap
- Using VLHC 'pipetron' magnets.
- Inject all bunches into the LER, accelerate and transfer to the LHC in one go

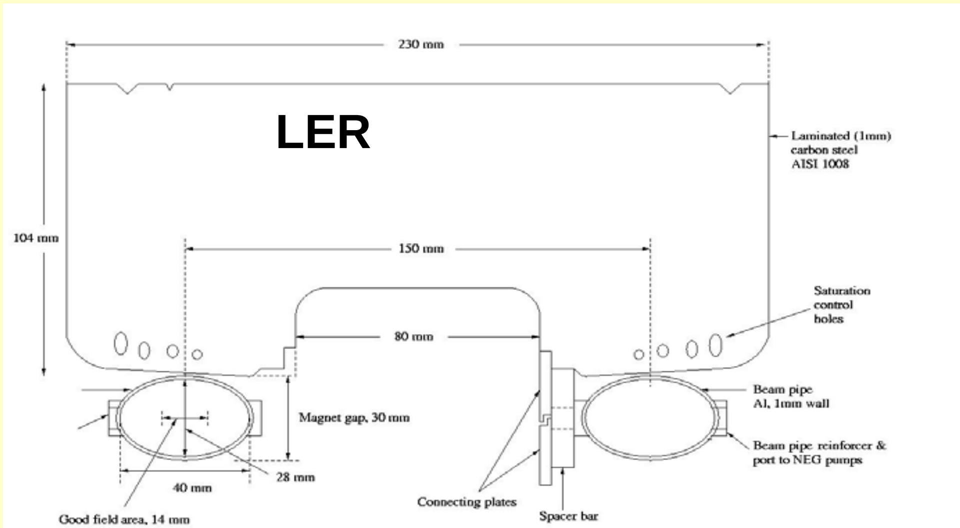


Pipetron - VLHC magnets FNAL

- **0.45 TeV injection at 0.48 T**
- **1.5 TeV top at 1.595 T (55KA)**
- **Gradient ~ 4%**
- **Enlarged magnet aperture v 30 mm x h 40 mm**

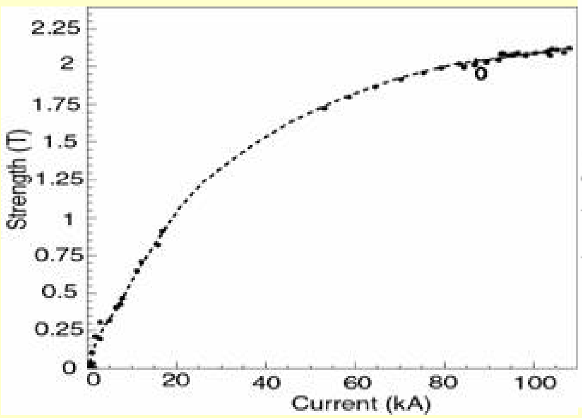


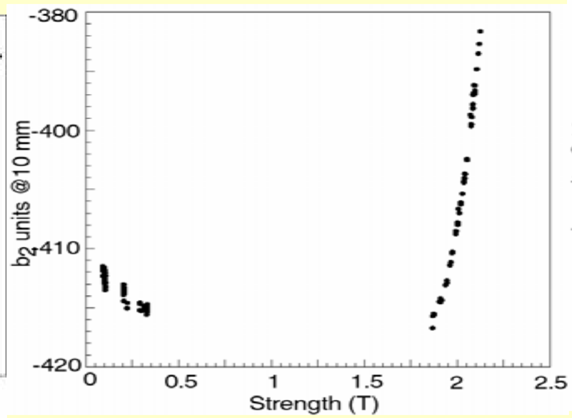


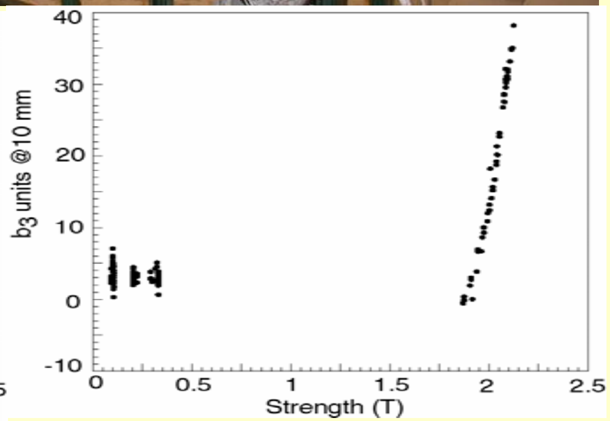


Pipetron - VLHC magnets FNAL

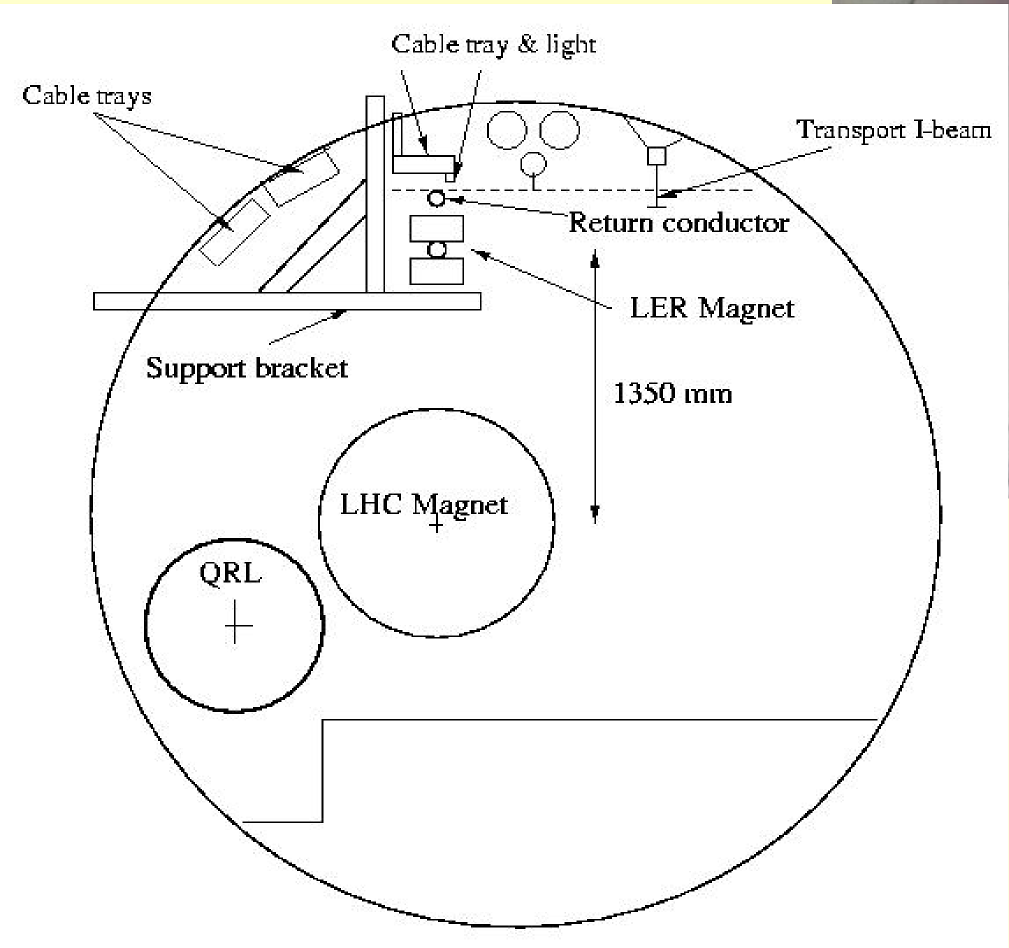
- 1 m prototype tested at FNAL
- Reported at MT19

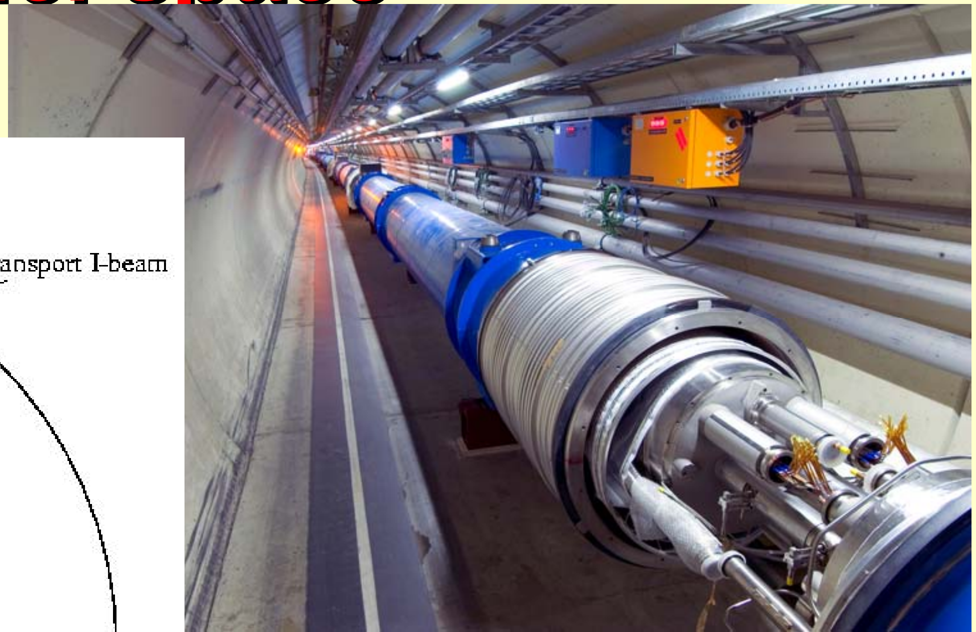






Feasibility study - tunnel space

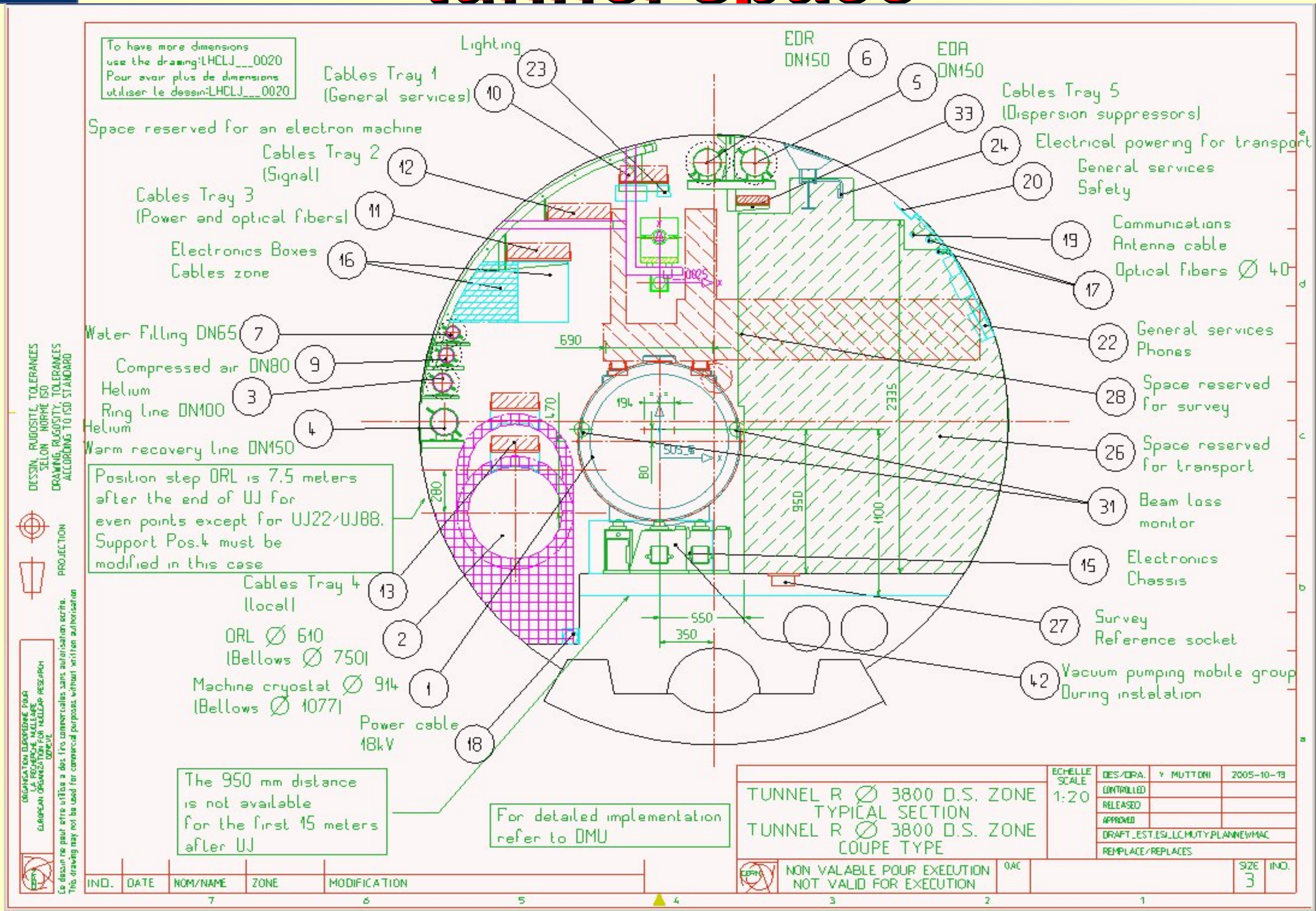




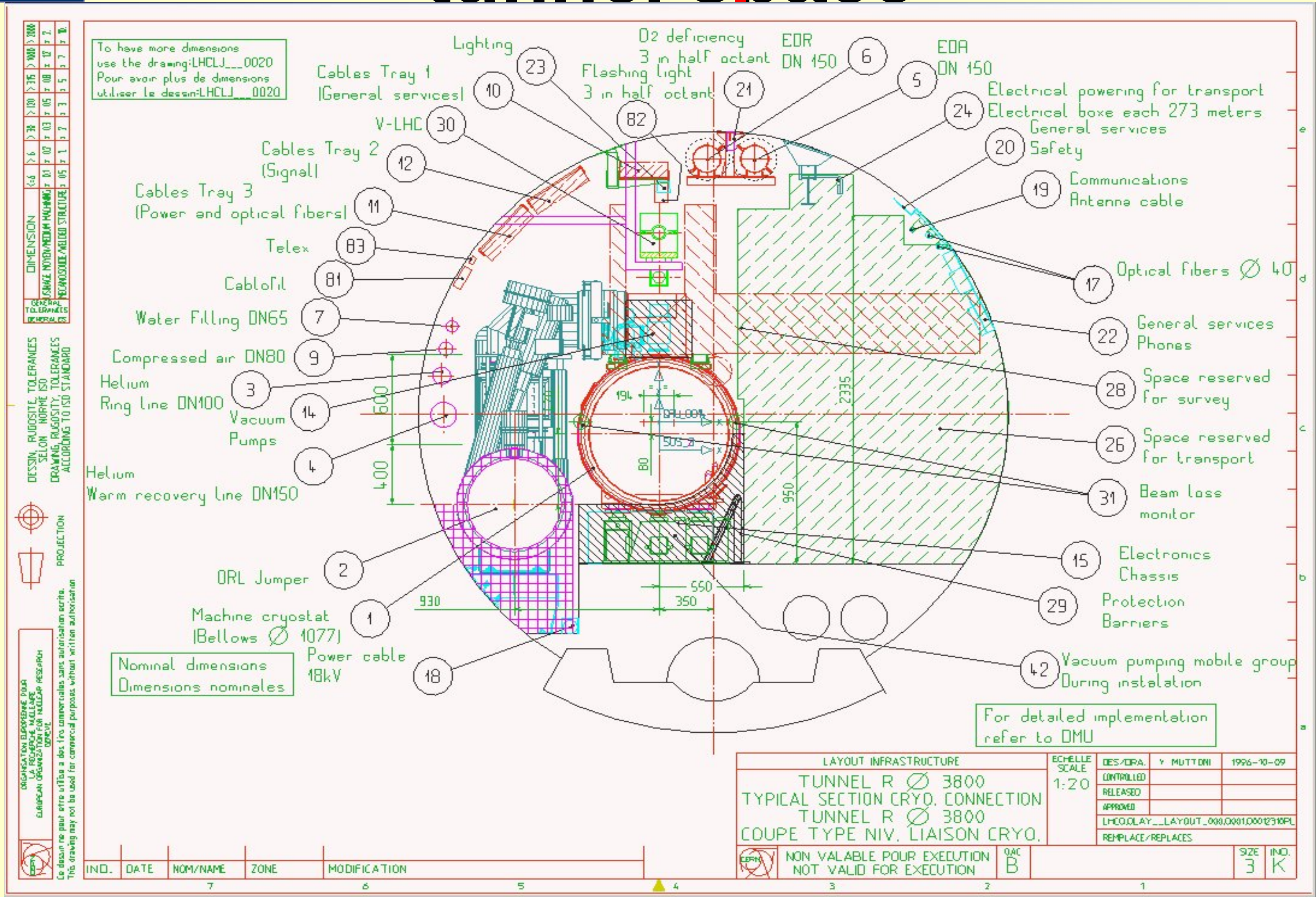
Fits above the LHC ring

(some cabling exceptions in straight sections)

Feasibility study - tunnel space



Feasibility study - tunnel space



The challenge: Experiment bypasses

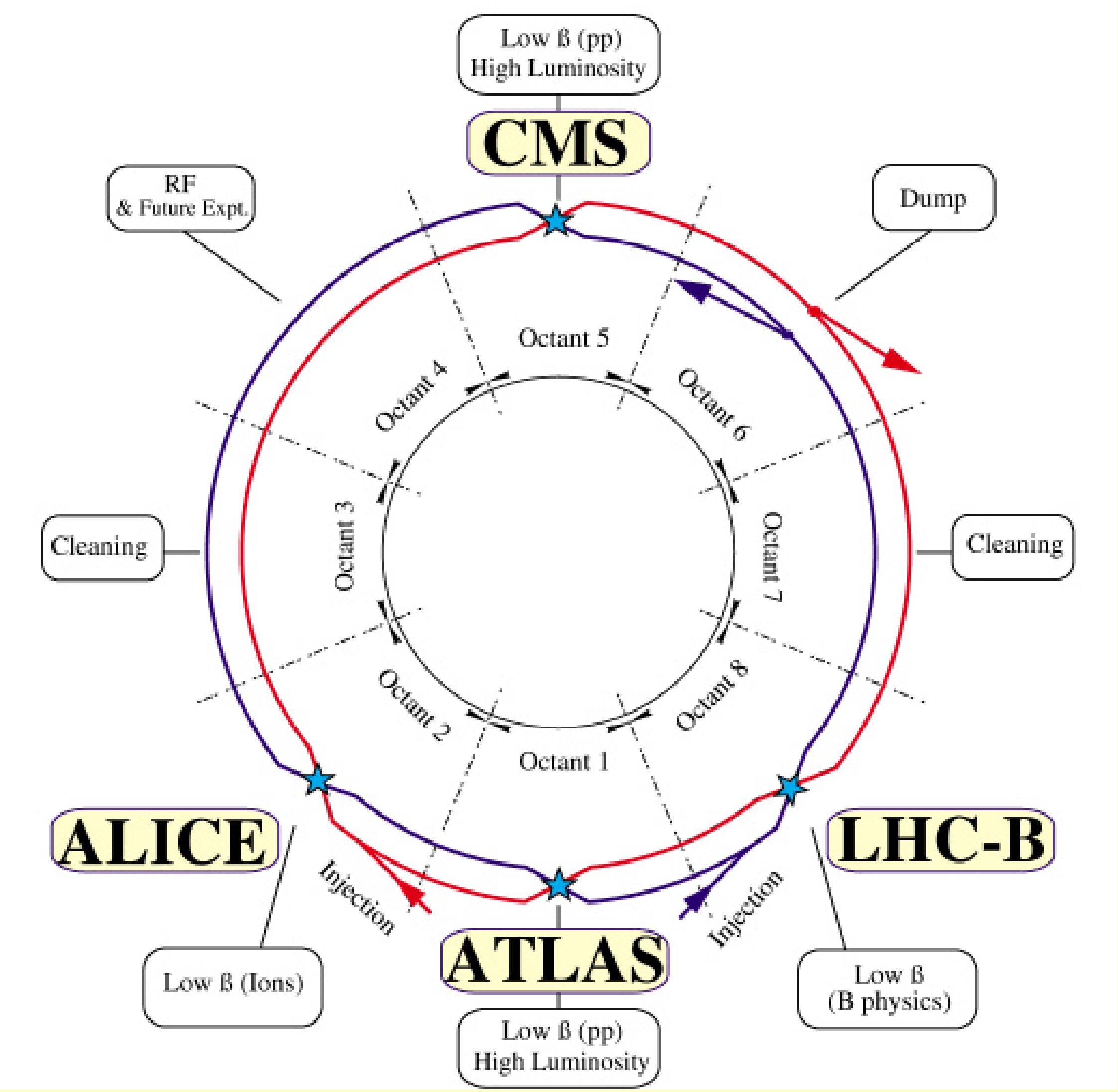
There are:

2 large (ATLAS & CMS)

2 less big (ALICE & LHCb)

experiments to bypass

For this study we assume that after an upgrade only ATLAS and CMS will remain



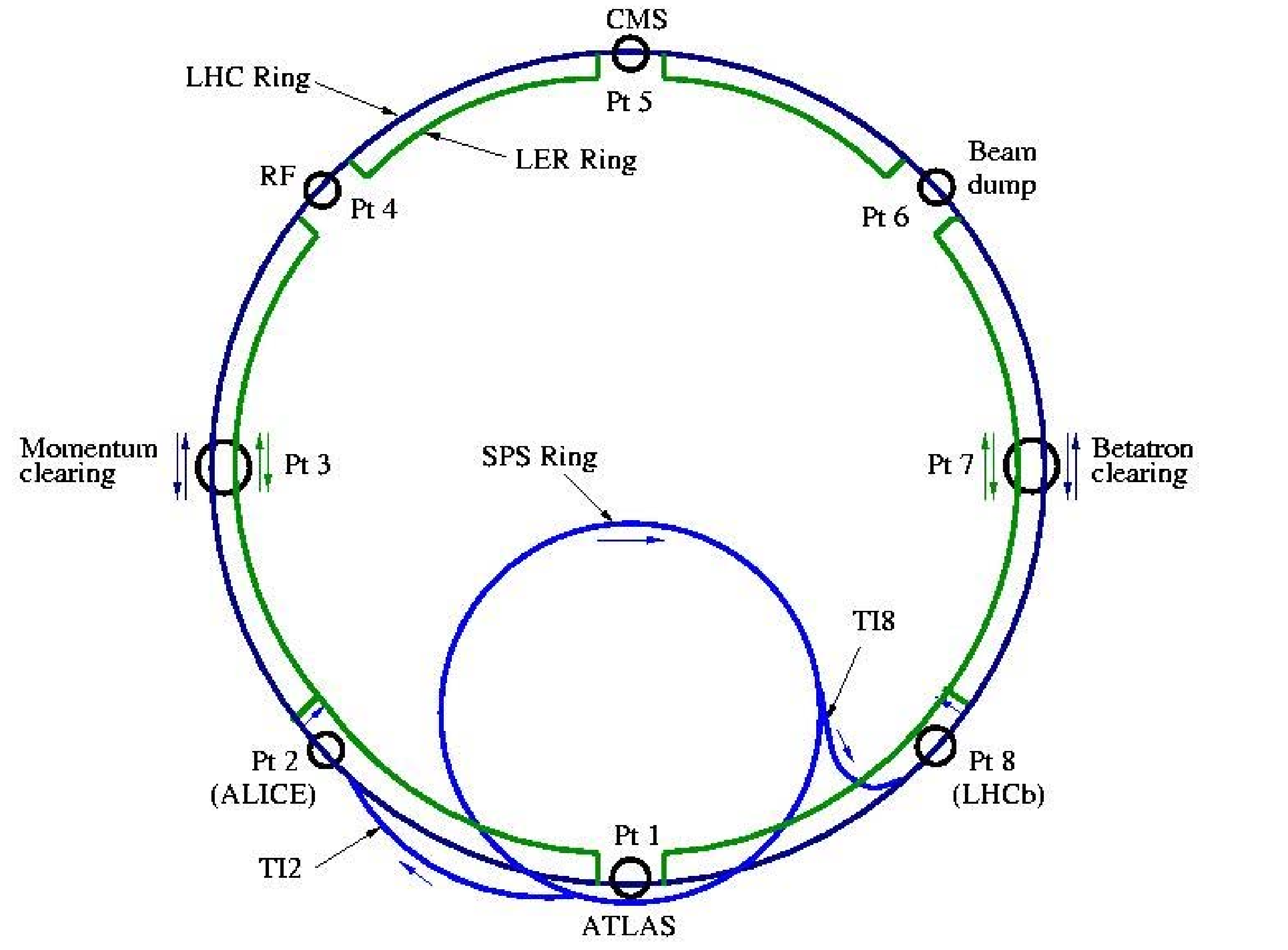
Experiment bypass options

1. **Bypass the experiments in a tunnel**
   - typically be ~300 long
   - Digging a bypass requires to empty the main tunnel at the junctions
   - An extra shaft is probably needed for each bypass
   - ==> at least a year shutdown

2. **Bypass the experiments through the detectors**
   - Drilling a hole through the detectors is probably a very bad idea

3. **Bypass the experiments through the LHC beampipe**
   - Bump beam down (and back up) into beam experimental beam pipe
   - Study concentrates on this option

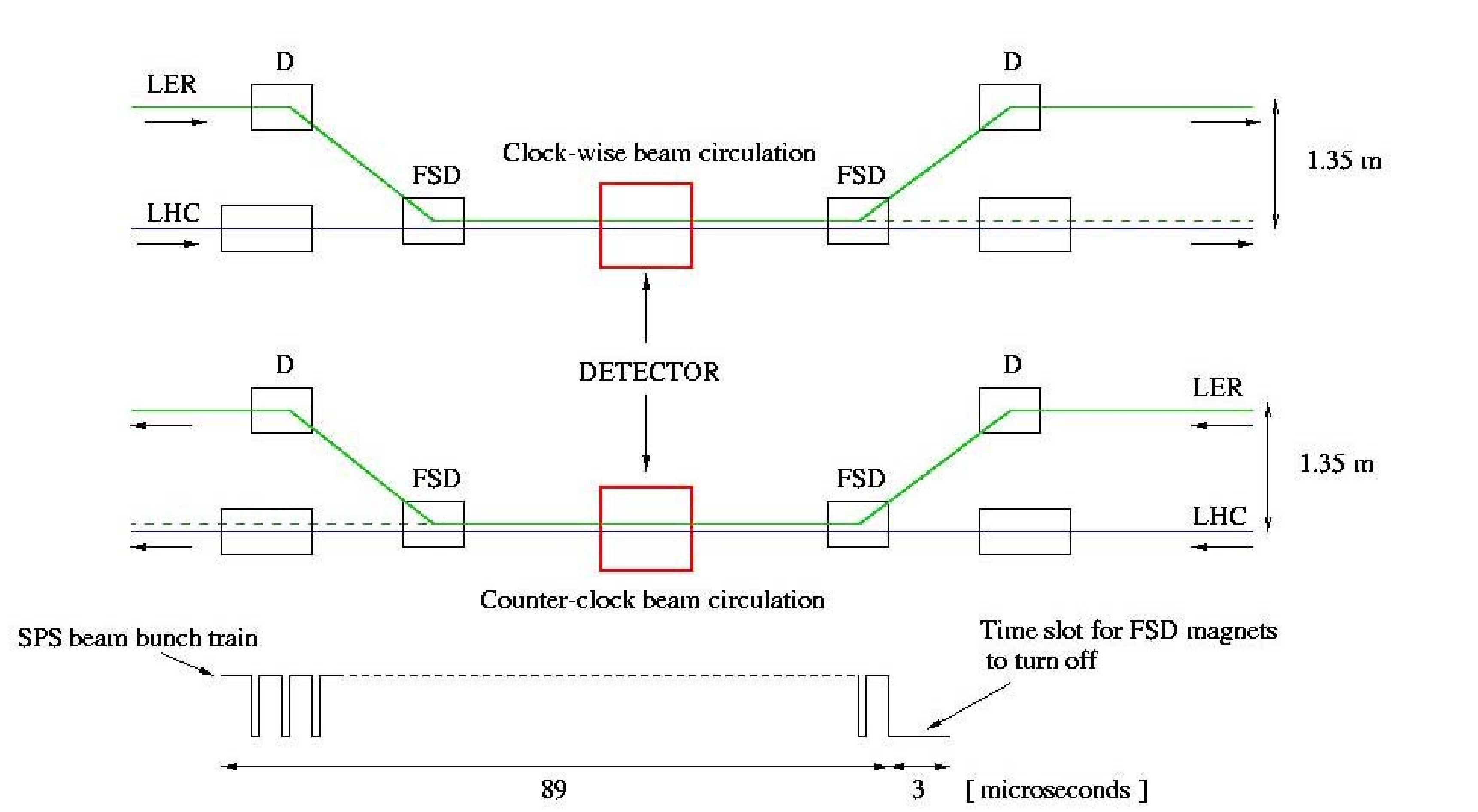
Injection / bypass scheme



Subjects being studied

- **Optics**
  - Combined function lattice
  - Beam size => required aperture
  - Matching
- **Impedance, instabilities, dynamic aperture**
- **Batch coalescing to increase bunch intensity (x 2)**
- **Beam transfer LER => LHC**
  - Transfer positions
  - Magnets
    - Fast switched Vertical bending magnets (~3 μs)
    - Vertical septum magnets
    - Vertical bends
- **Dumping system and detector protection**

Injection / bypass scheme (2)

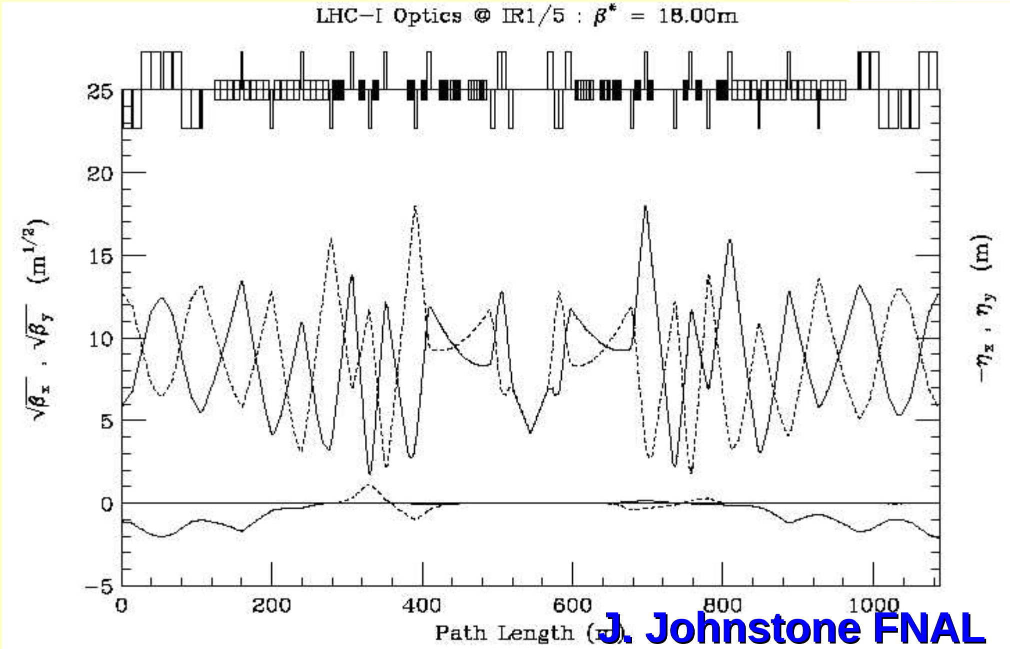


Optics (1)

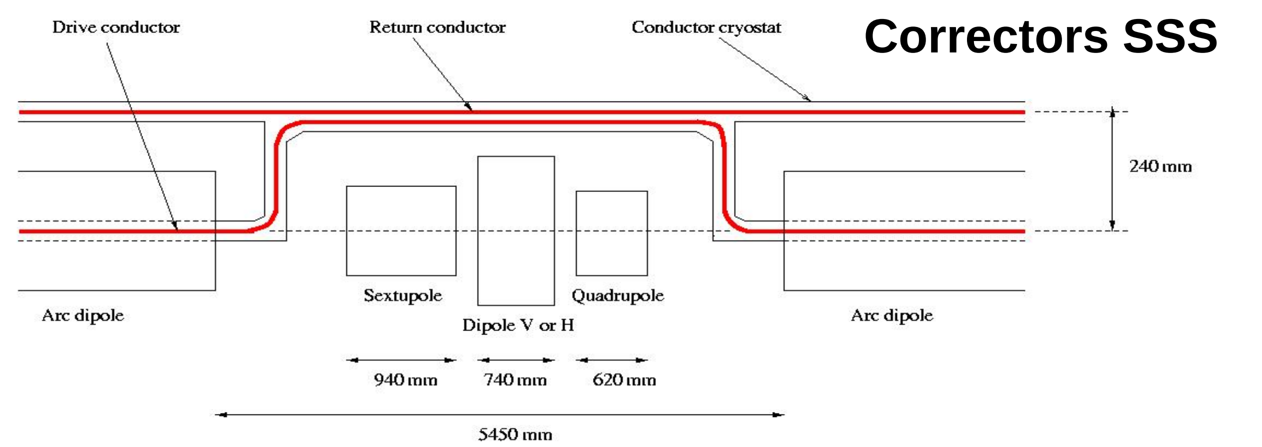
- **Arc cells match the LHC length**
- **4 Combined function magnets (12 m) per half cell Bmax 1.595 T, G = ± 4.969 T/m**
- **Dispersion suppressor with separated function magnets (8 m dipoles and 3 m quads).**
- **Straight sections have 4 m long quads**
- **Low beta insertion is common with the LHC**

J. Johnstone FNAL

Optics (2)



J. Johnstone FNAL



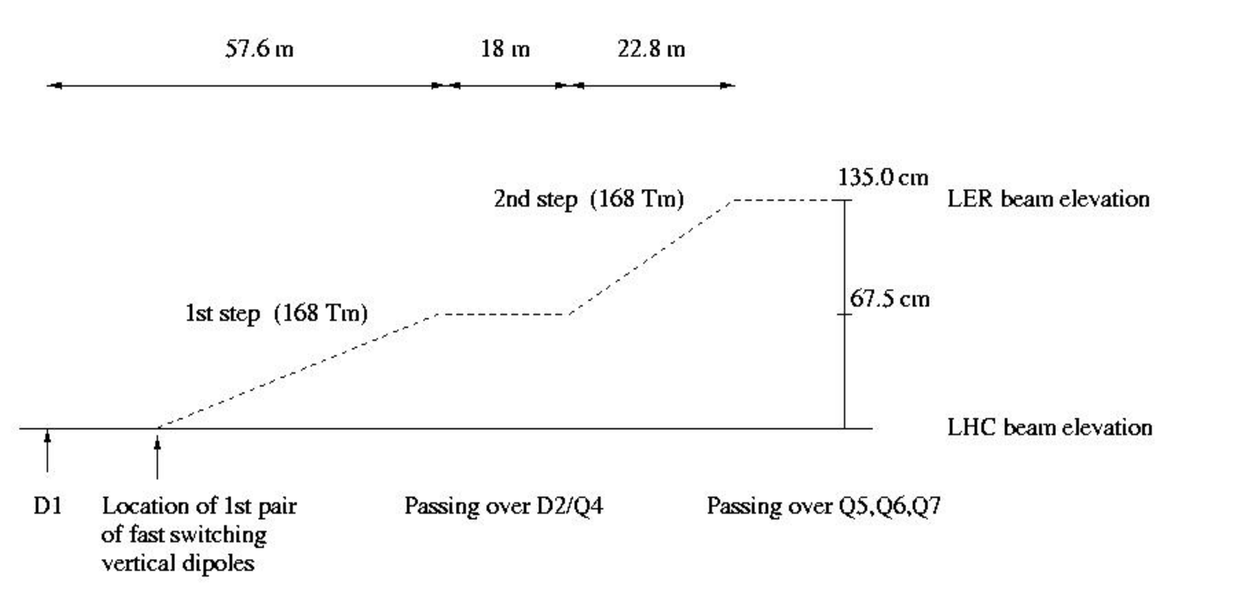
Correctors SSS

Transfer between LER and LHC (1)

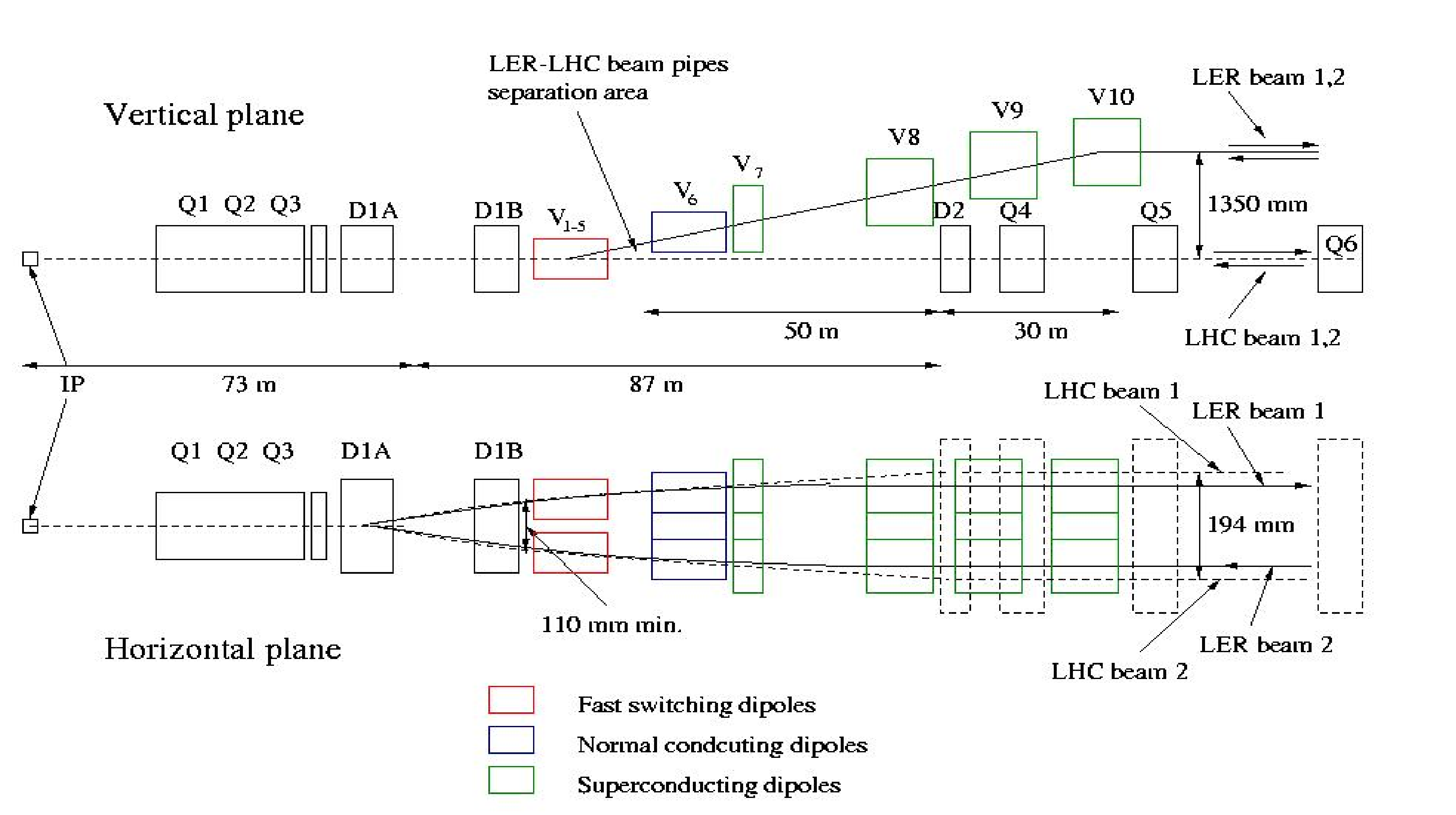
- **Horizontal separation 150 ==> 0 mm**
- **Vertical separation 1350 ==> 0 mm**

- One fast switched magnet

- horizonal bend 2 is made by tilting the vertical bends

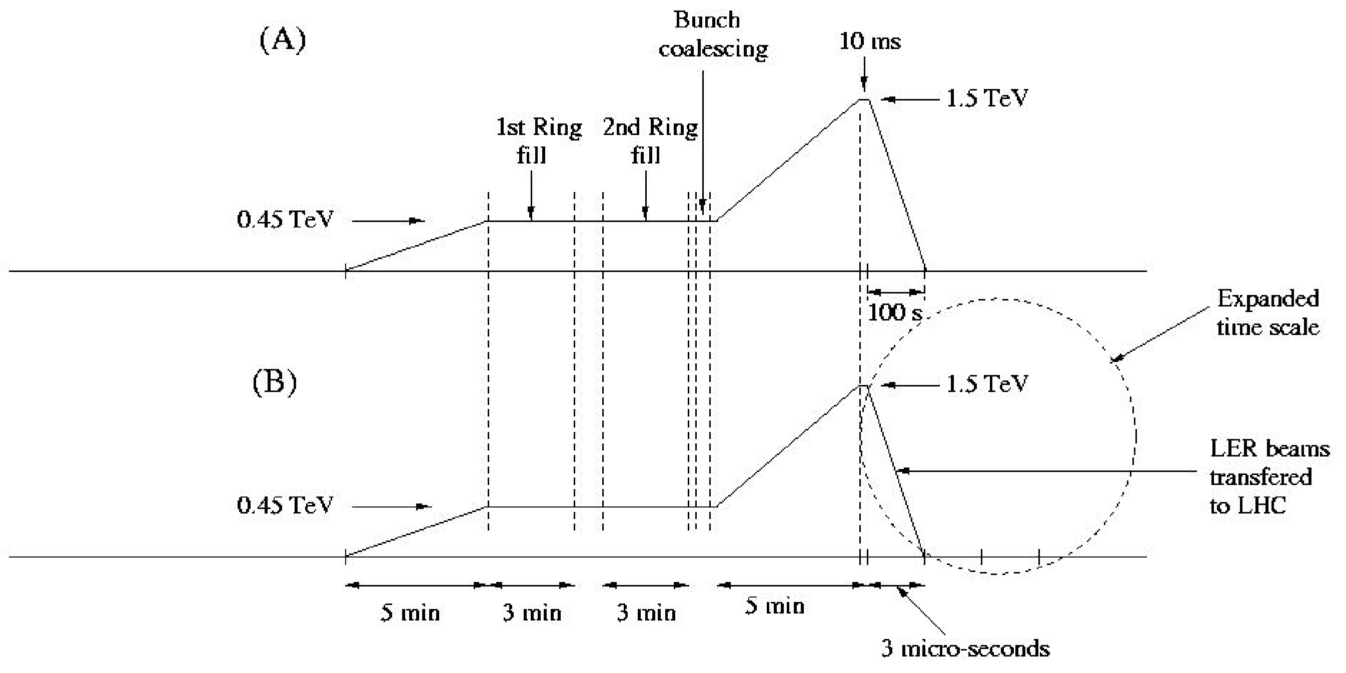


Transfer between LER and LHC (2)



Timing sequence

- **Ramp up time from 0.45 TeV to 1.5 GeV is 100 s.**
- **Fast pulsed magnets ramps down to 20% in 3 μs**

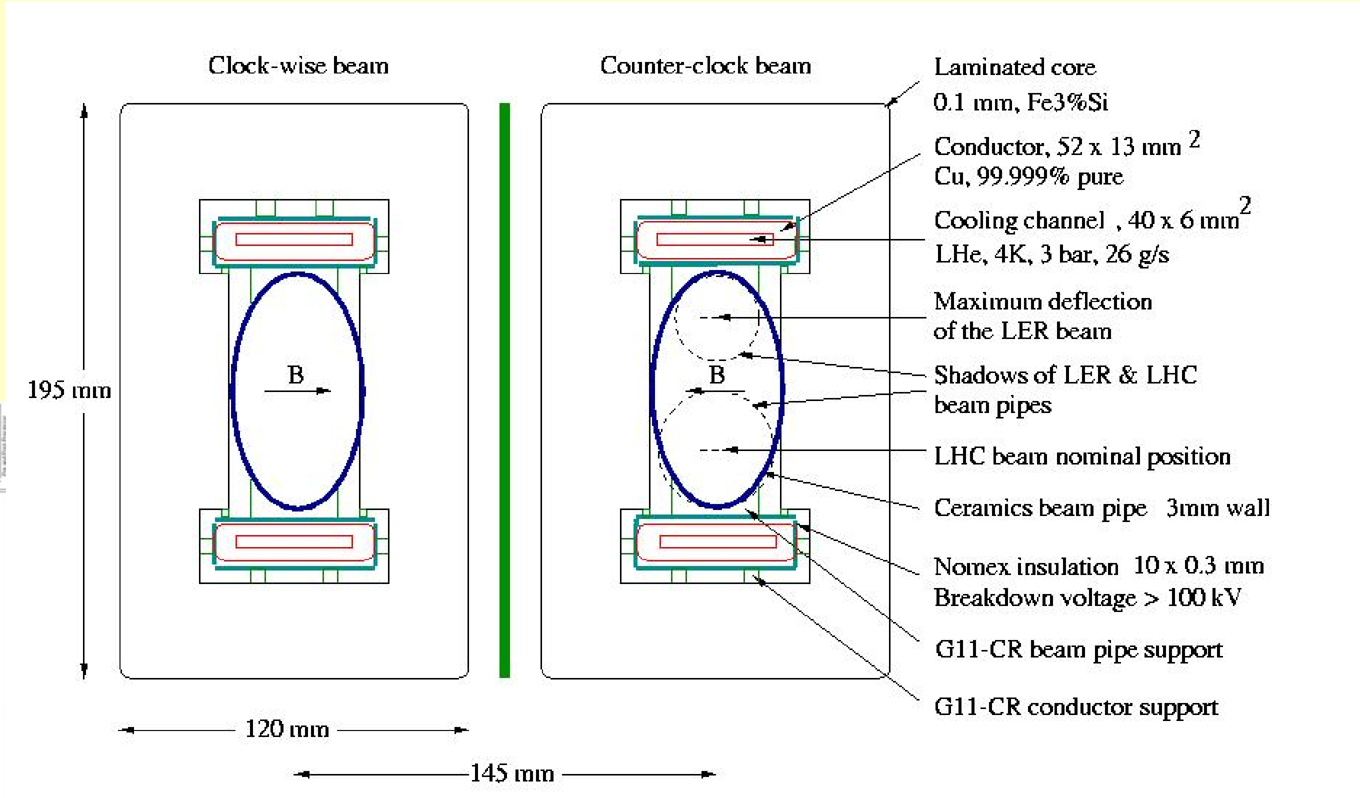


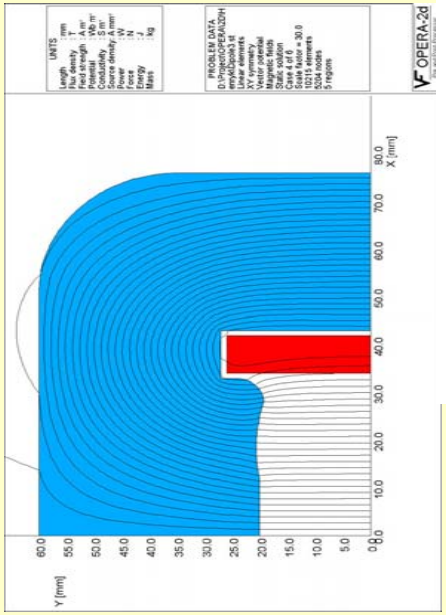
A - Ramping scheme for LER arc and transfer line continuing operation magnets

B - Ramping scheme for LER transfer line fast switching dipole magnets

Fast switched magnets

Option 1





Magnetic design by
Vadim Kashikhin
FNAL

Beam dump and protection

- Use separate kicker magnets to send beam to LHC dump.
- Misfiring fast magnets: send beam into collimators in front of the experiments

Possible schedule

	Time[y]	Total[y]
LER accelerator design, including transfer lines	1	1
Prototyping and testing transfer line magnets		
(and main arc dipole magnet, if needed)	2	2
Preparation of main arc magnet industrial production	1	2
Magnet production	3	5
Magnet installation in the tunnel	2	5
LER commissioning	1	6

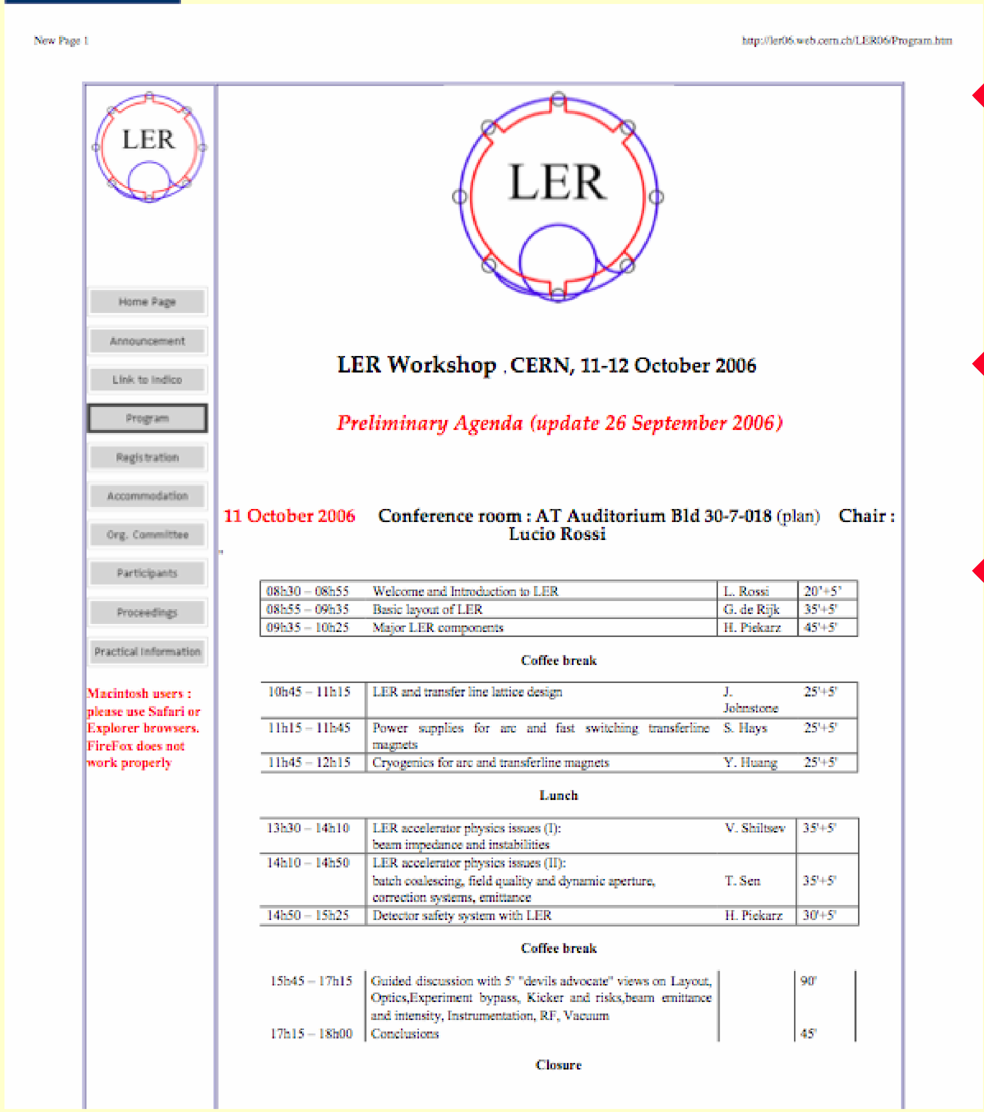
Items 1–3 and the items 4-5 can proceed simultaneously,

The overall lapsed time for the LER completion work will be determined, however, by the number of months per year allowed for the LER installation,

We assumed that 20 crews of 6 people should be able to install 40 magnets per week, or 1200 magnets in 30 weeks (~8 month).

In summary, the LHC operation with the LER as injector could be ready in 6 years from the time "zero".

LER Workshop



New Page 1 http://ler06.web.cern.ch/LER06/Program.htm

LER

Home Page
Announcement
Link to Indico
Program
Registration
Accommodation
Org. Committee
Participants
Proceedings
Practical Information

Macintosh users : please use Safari or Explorer browsers. FireFox does not work properly

LER

LER Workshop , CERN, 11-12 October 2006

Preliminary Agenda (update 26 September 2006)

11 October 2006 Conference room : AT Auditorium Bld 30-7-018 (plan) Chair : Lucio Rossi

08h30 – 08h55	Welcome and Introduction to LER	L. Rossi	20'+5'
08h55 – 09h35	Basic layout of LER	G. de Rijk	35'+5'
09h35 – 10h25	Major LER components	H. Piekarz	45'+5'

Coffee break

10h45 – 11h15	LER and transfer line lattice design	J. Johnstone	25'+5'
11h15 – 11h45	Power supplies for arc and fast switching transferline magnets	S. Hays	25'+5'
11h45 – 12h15	Cryogenics for arc and transferline magnets	Y. Huang	25'+5'

Lunch

13h30 – 14h10	LER accelerator physics issues (I): beam impedance and instabilities	V. Shiltsev	35'+5'
14h10 – 14h50	LER accelerator physics issues (II): batch coalescing, field quality and dynamic aperture, correction systems, emittance	T. Sen	35'+5'
14h50 – 15h25	Detector safety system with LER	H. Piekarz	30'+5'

Coffee break

15h45 – 17h15	Guided discussion with 5' "devils advocate" views on Layout, Optics,Experiment bypass, Kicker and risks,beam emittance and intensity, Instrumentation, RF, Vacuum		90'
17h15 – 18h00	Conclusions		45'

Closure

- **LER workshop Wednesday 11 Oct (AT auditorium bld 30-7-18)**
- **Full presentations of the studies done at FNAL**
- **Discussion session at 15h45**

WEB page:

http://ler06.web.cern.ch/LER06/

also on indico

Conclusions

- **The main difficulty is the transfer between the LER and LHC rings**
  - **Match both optics**
  - **Fast switched magnets**
  - **Detector protection**
- **LER has only one application : fill the LHC at 1 TeV -1.5 TeV**

  (no fixed target physics)
- **It is very challenging, but not impossible**
- **Up to now it is a <u>study</u> and not a proposal**