European
Laboratory
for Particle Physics

PAUL SCHERRER INSTITUT

PSI

ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

Particle Accelerator
Physics Laboratory

Accelerator R&D

Lenny Rivkin, PSI & EPFL

Some Accelerator R&D in Switzerland

CERN

- LHC and its upgrades
- e^+e^- linear collider, CLIC @ 3 TeV, ILC @ 500 GeV
- Neutrinos

PSI

- X-ray Free Electron Laser: PSI-XFEL
- High intensity proton beams for neutron sources (towards 1.8 MW average power beam, new targets)
- Medical applications (mainly proton therapy)

Important synergies!

LHC Upgrades

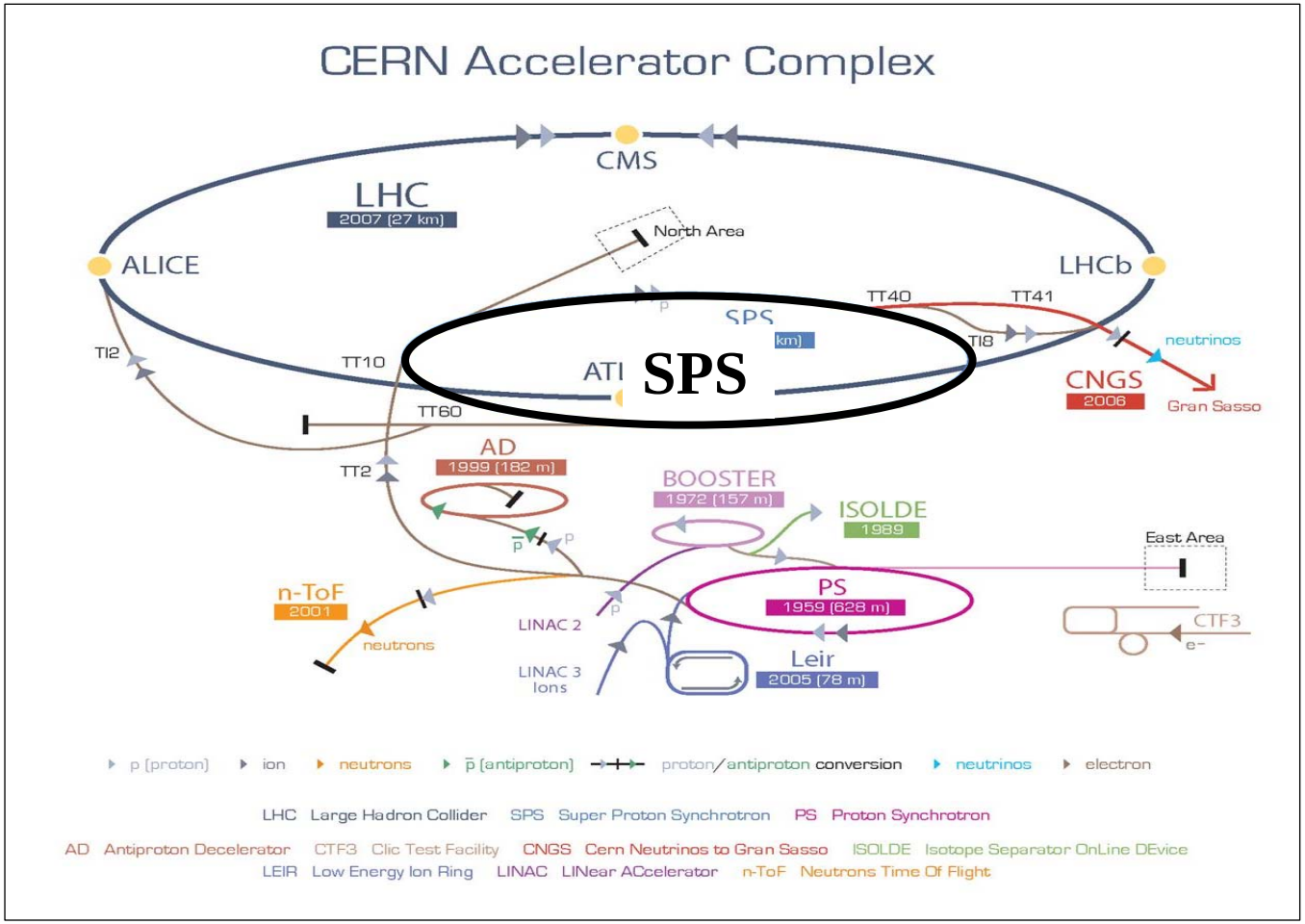
Currently 12 EPFL doctoral students

Some examples:

- Beam beam interaction simulations (T. Pieloni)
- Smaller beam size at the IP (R. de Maria)
- Dipole first ‚D0' (G. Sterbini)
- Injector chain upgrade, SPS intensity limit (B. Salvant)
- …

Example : CERN SPS bottleneck

B. Salvant

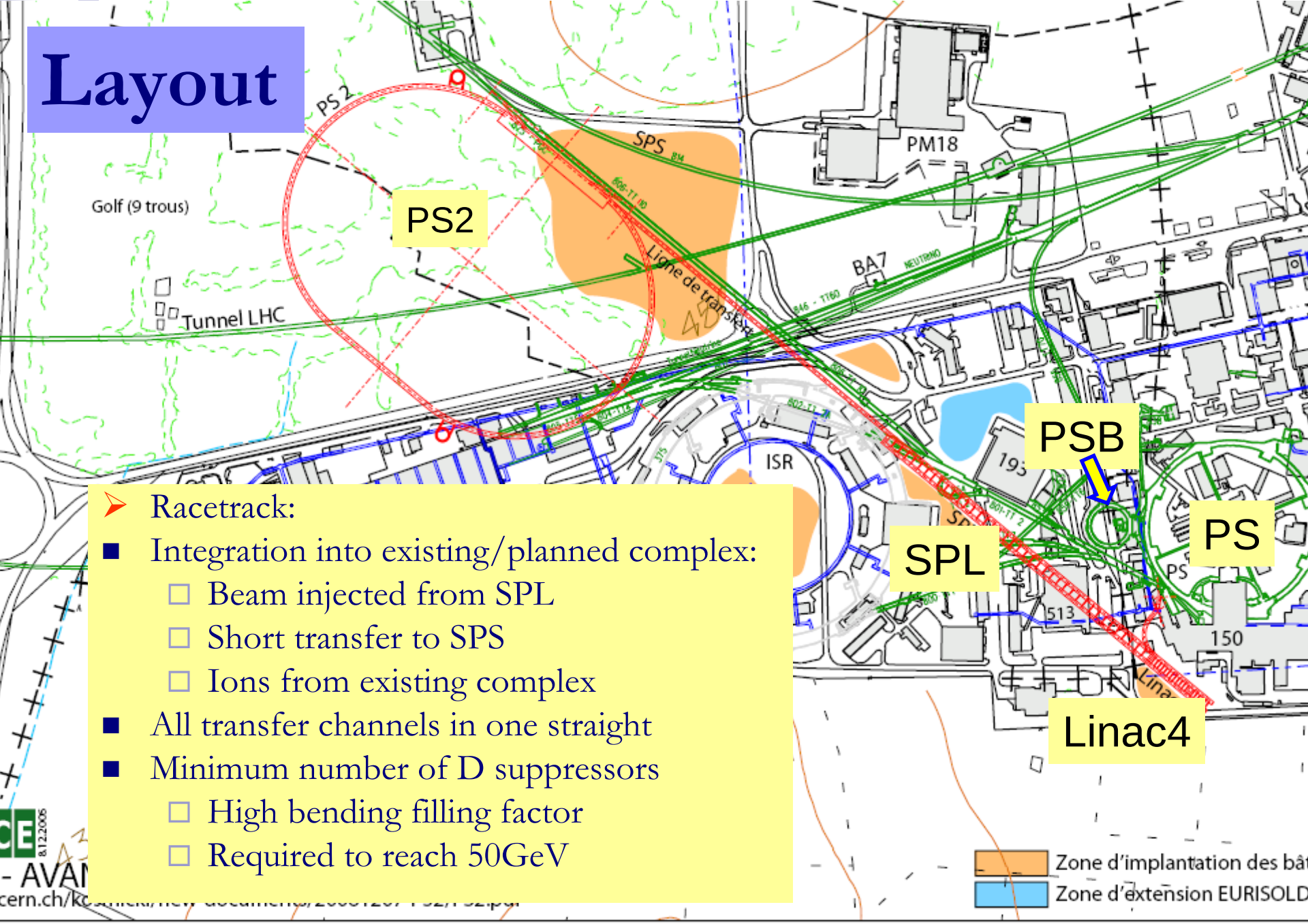


The SPS is now the last accelerator in the LHC injector chain.

Proton source → LINAC 2 → PS Booster → PS → SPS → LHC

26 GeV/c *450 GeV/c*

Layout

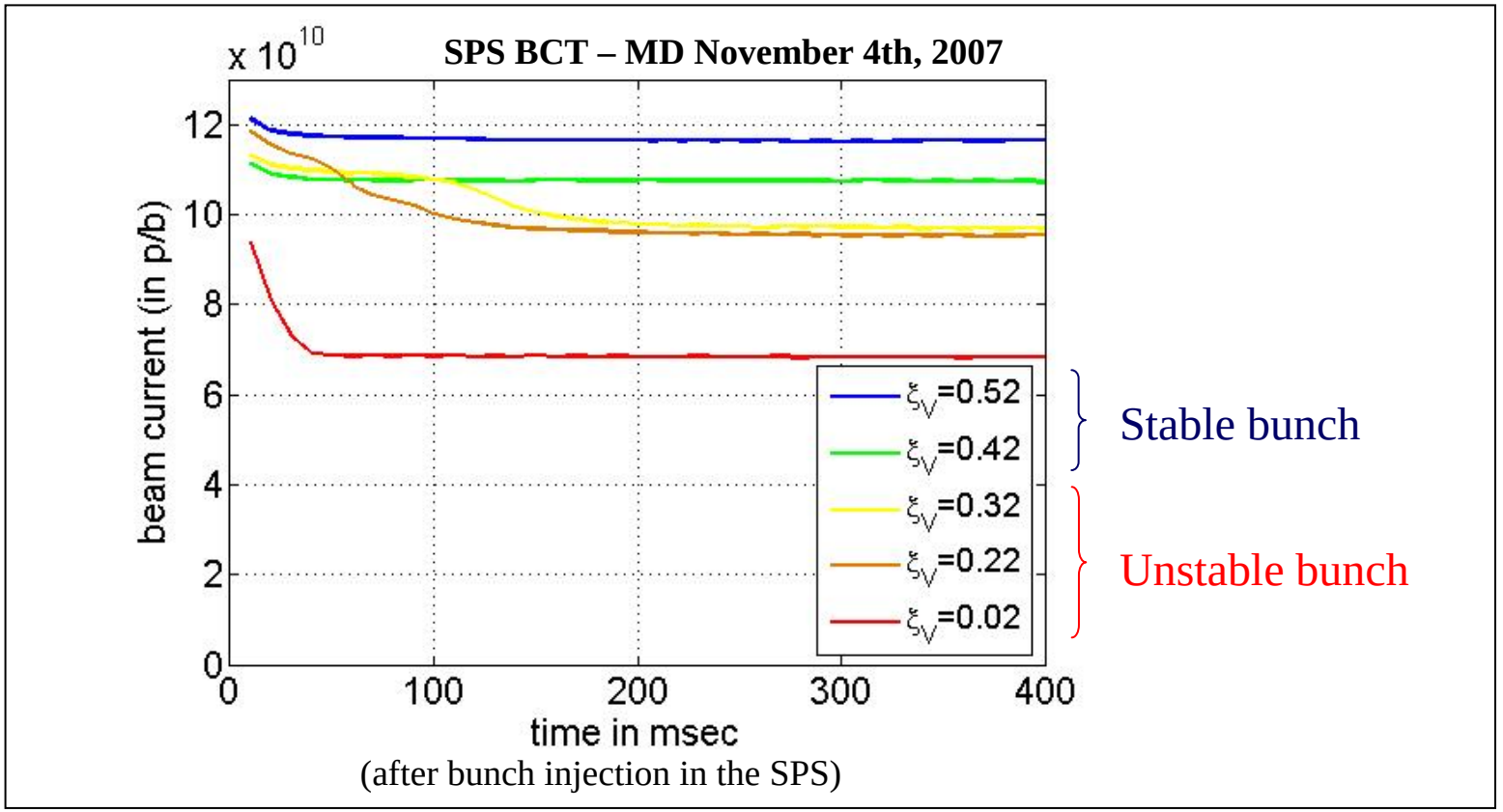


- Racetrack:
- Integration into existing/planned complex:
  - Beam injected from SPL
  - Short transfer to SPS
  - Ions from existing complex
- All transfer channels in one straight
- Minimum number of D suppressors
  - High bending filling factor
  - Required to reach 50GeV

SPS Fast Instability at injection

B. Salvant

To stabilize the low emittance high intensity single bunch of protons at injection in the SPS, the vertical chromaticity ξ_v has to be increased.



(after bunch injection in the SPS)

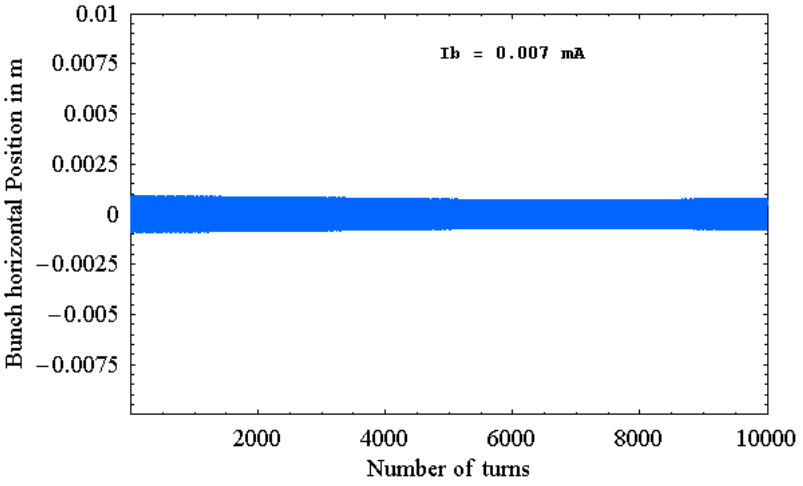
Upgrade of the LHC injector complex (4 10^{11} p/b) → Need to understand this instability

→ Also, observing TMCI would a way to measure SPS impedance characteristics

Results: HEADTAIL simulations

B. Salvant

HEADTAIL simulated coherent bunch transverse position at a BPM location

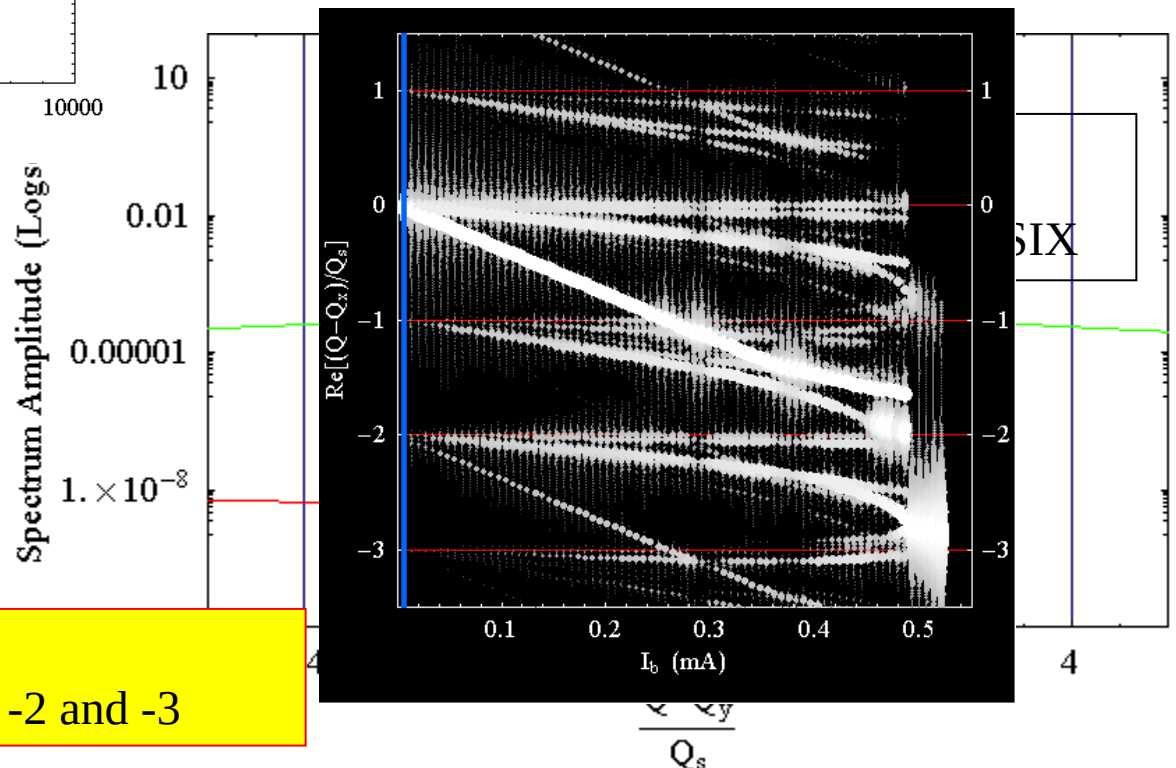


FFT
or
SUSSIX

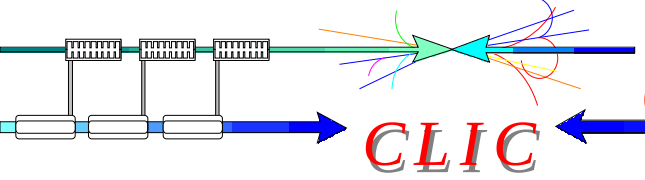
HEADTAIL simulation parameters:

- Broadband impedance
- Round beam pipe
- No space charge, no spread, no chromaticity
- Linear longitudinal restoring force

HEADTAIL Simulated mode spectrum



HEADTAIL predicts a TMCI:
coupling between transverse modes -2 and -3



CLIC Work program till 2010

- **Demonstrate feasibility of CLIC technology**
  - Major key issues addressed in CTF3
- **Design of a linear Collider based on CLIC technology**

  http://clic-study.web.cern.ch/CLIC-Study/Design.htm
- **Estimation of its cost in the CERN area**
- **CLIC Physics study and detector development:**

  http://clic-meeting.web.cern.ch/clic-meeting/CLIC_Phy_Study_Website/default.html
- **Conceptual Design Report including cost by 2010**

CLIC and ILC

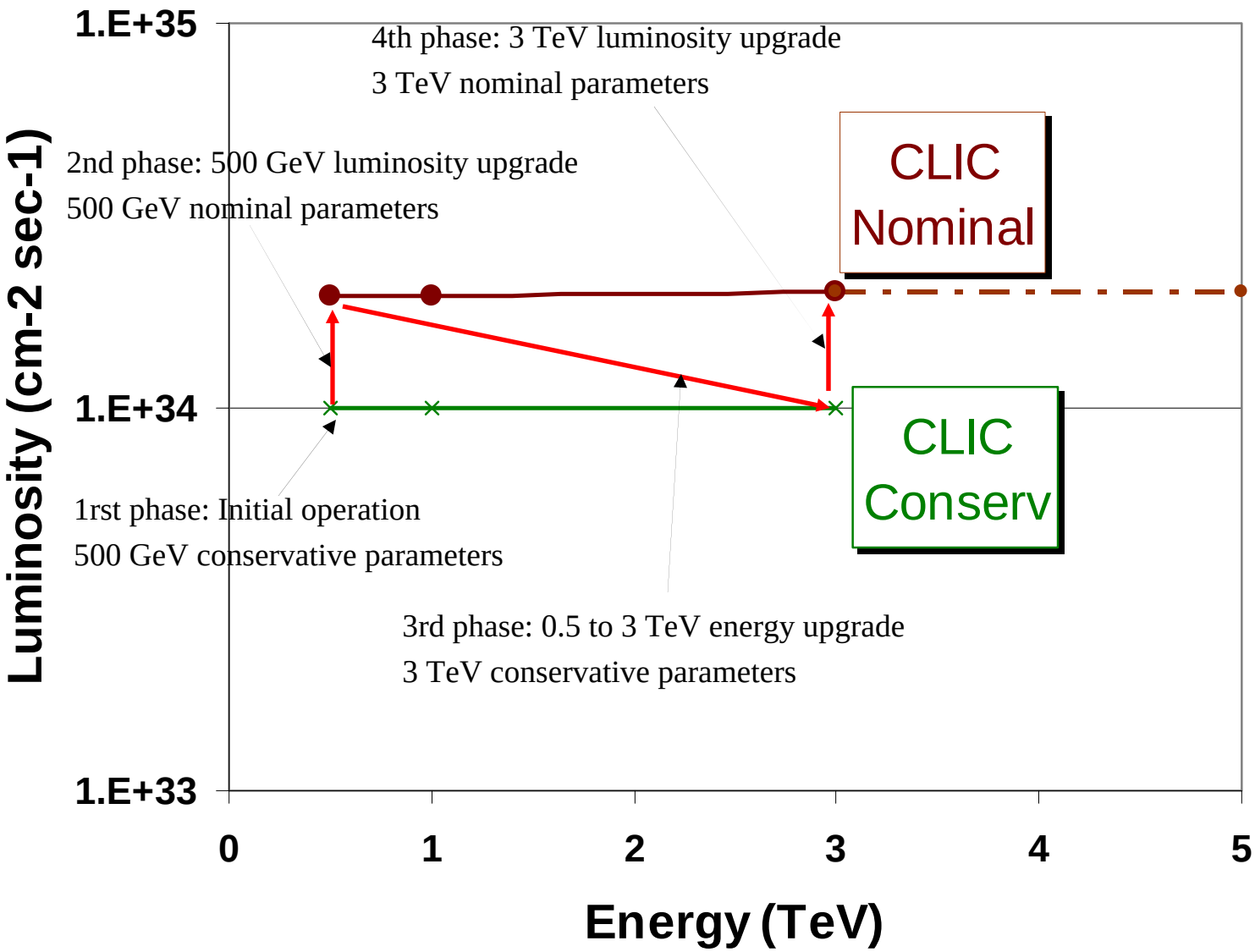
Design towards 3 TeV, detailed case of 500 GeV

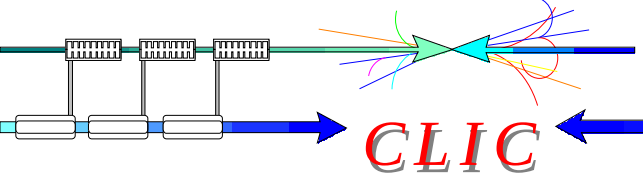
- E.g. AC power (MW): need to work on efficiency!

LHC	ILC	CLIC (500 GeV)	CLIC (3 TeV)
120	220	120	390

- 12 GHz RF accelerating structures
- Generation of extremely bright e^+e^- beams

CLIC upgrade scenario





New CLIC main parameters

Center-of-mass energy	CLIC 500 G		CLIC 3 TeV	
Beam parameters	Conservative	Nominal	Conservativ	Nominal
Accelerating structure	502		G	
Peak luminosity (1% of energy)	$1.0 \cdot 10^{34}$	$2.0 \cdot 10^{34}$	$1.1 \cdot 10^{34}$	$2 \cdot 10^{34}$
Repetition rate (Hz)	50			
Loaded accel. gradient MV/m	80		100	
Main linac RF frequency GHz	12			
Overall linac length km	4.4		20.8	
Bunch charge10^9	6.8			3.72
Bunch separation ns	0.5			
Beam pulse duration (ns)	177		156	
Beam power/beam MWatts	4.9		14	
Hor./vert. norm. emitt ($10^{-6}/10^{-9}$)	3 / 40	1 / 30	1 / 30	0.66 / 20
Hor/Vert FF focusing (mm)	8 / 0.1			4 / 0.1
Hor./vert. IP beam size (nm)	221 / 2.8	128 / 2.5	70 / 1.1	40 / 1
Total site length km	12.8		48.3	
Wall plug to beam transfer eff	7.8%		7.2%	
Total power consumption MW	125.6		389	

Nominal Structure Performance demonstrated

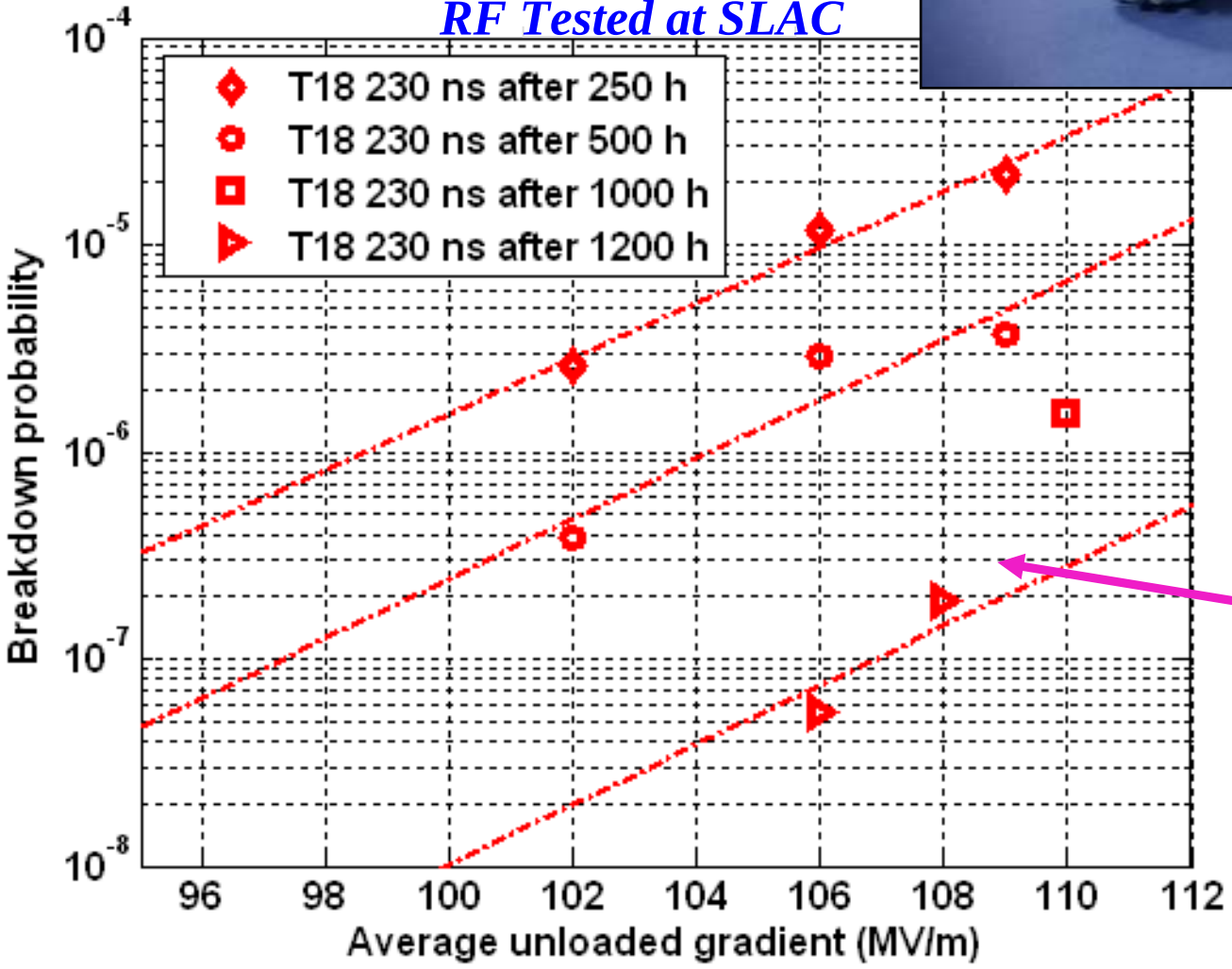
CLIC

A shining example of fruitful collaboration:

T18_VG2.4_disk: Designed at CERN,

(without damping) Built at KEK,

RF Tested at SLAC



Improvement by RF conditionning

CLIC target

CLIC @ 12 GHz: synergies with PSI-XFEL

CLIC 100 MeV/m accelerating structures development needs stand alone klystron source:

ordered 1 from SLAC

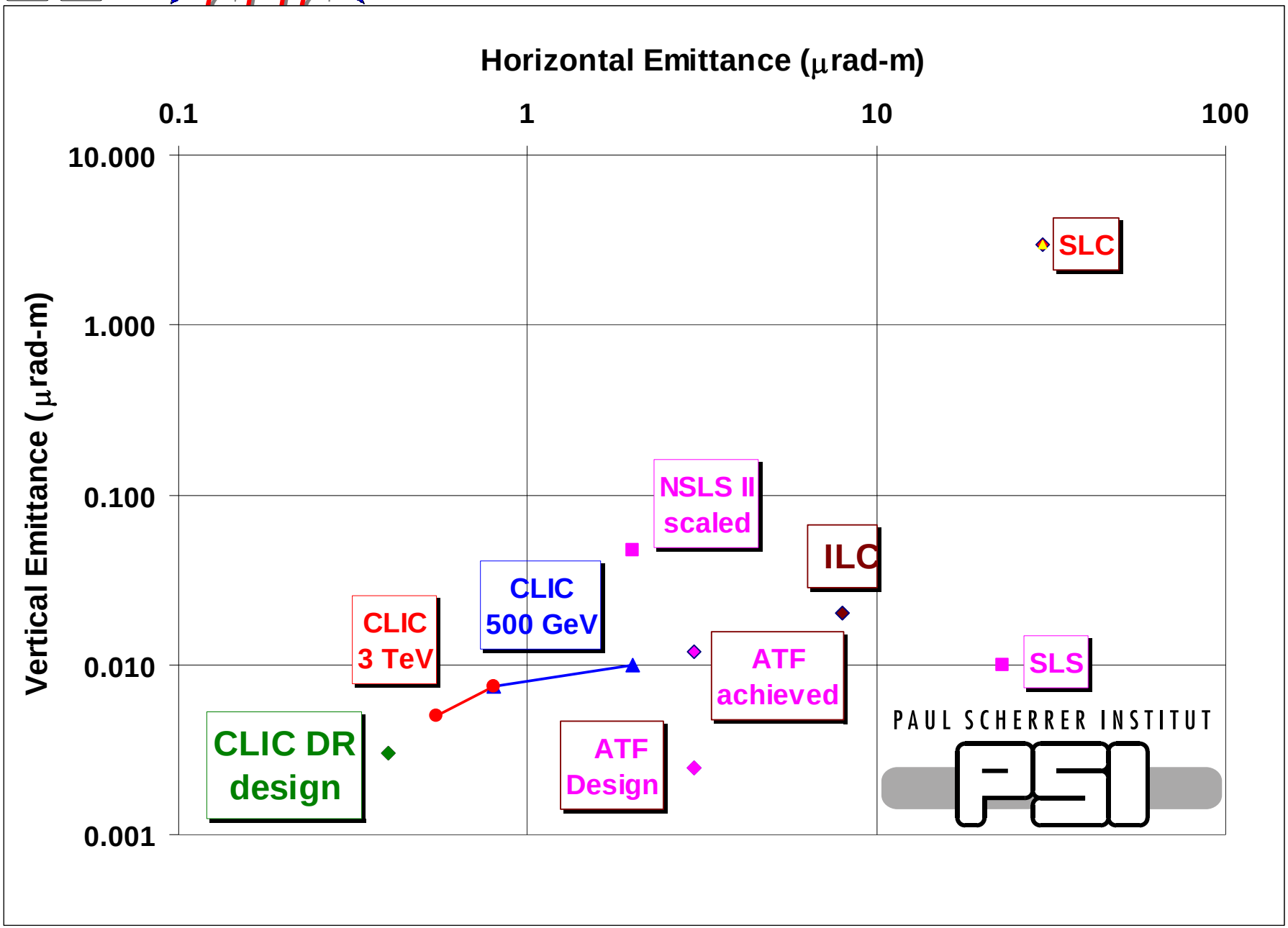
(Swiss host country contribution within the White Paper budget increase is used in part for this)

PSI – XFEL also needs such sources

ordered 2 from SLAC

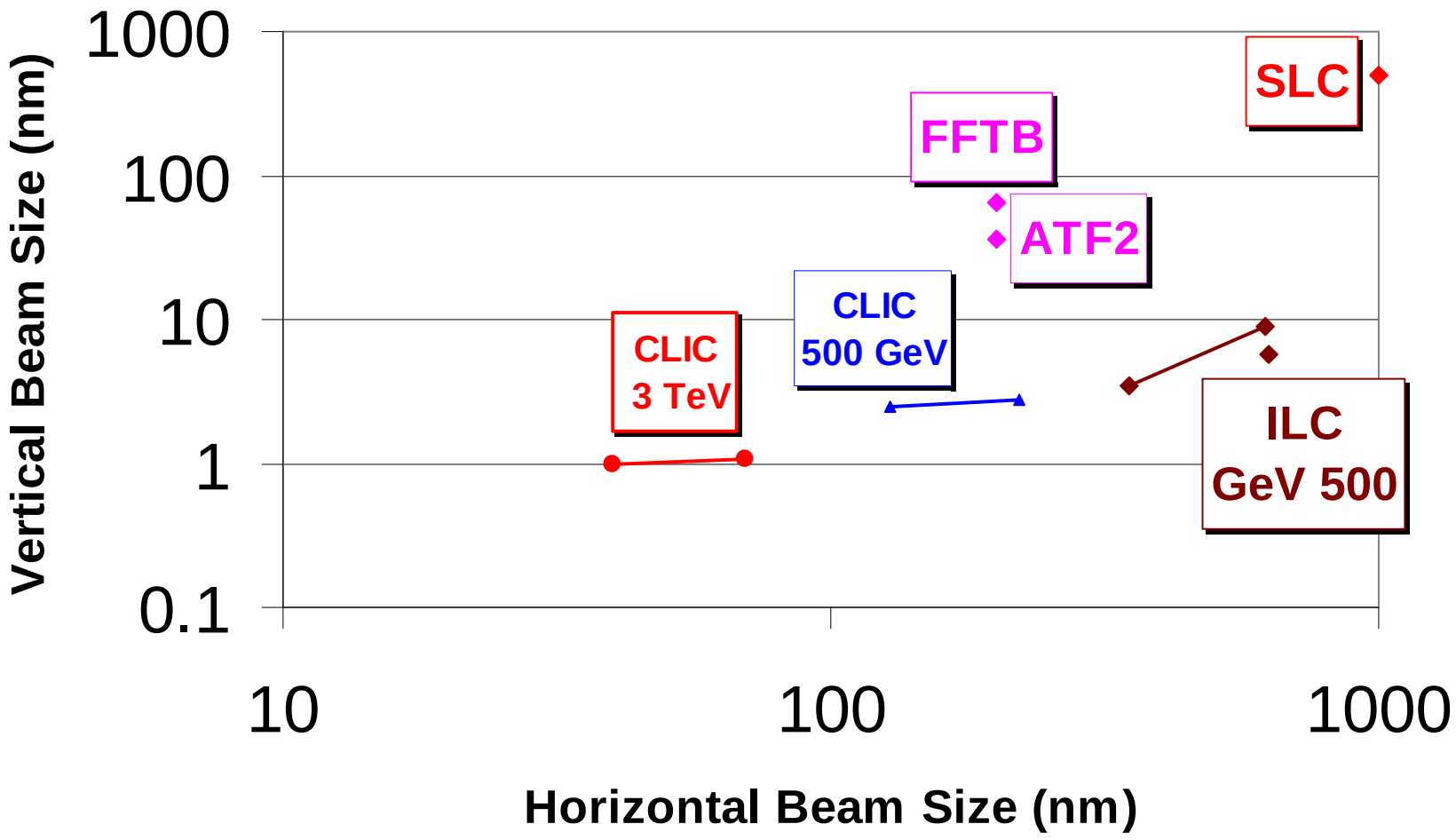
Testing is done at SLAC and KEK for now… two beam test stand at the CTF3 test facility at CERN

Beam emittances at Damping Rings



Beam sizes at Collisions

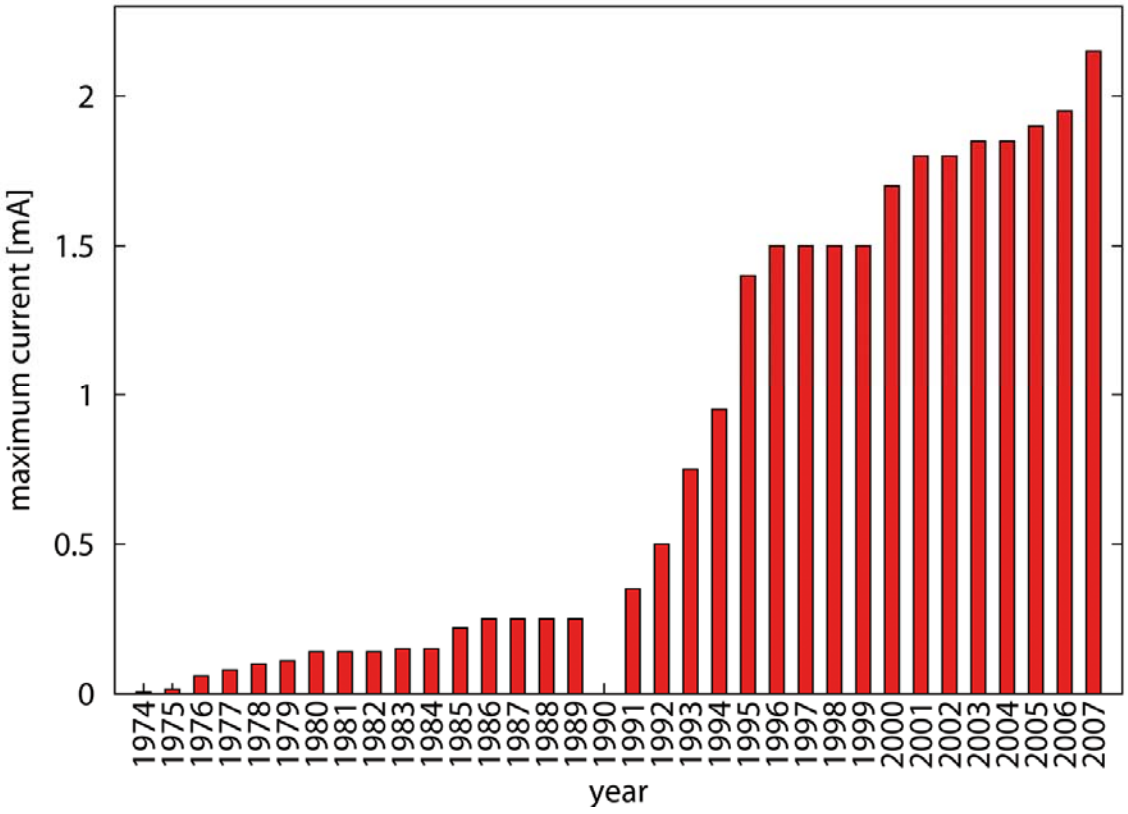
R.M.S. Beam Sizes at Collision in Linear Colliders



Handling of high power proton beams

LHC design: collimators @ 0.5 MW!

PSI now @ 1.3 MW



Rolf Wideröe‘s notebook