PAUL SCHERRER INSTITUT

PSI

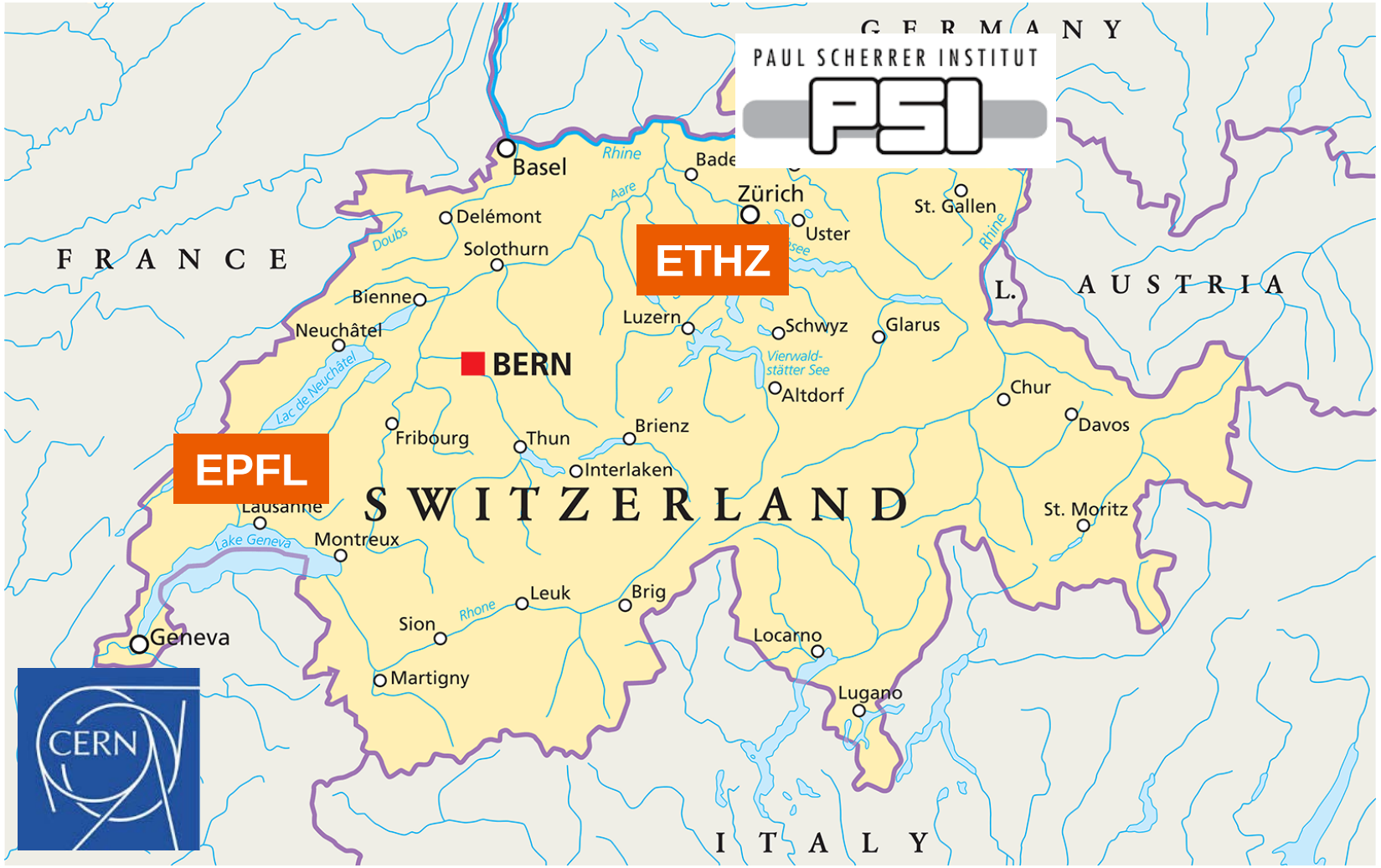
Accelerators in Switzerland

Lenny Rivkin

CERN Accelerator School
Beam Dynamics and Technologies for Future Colliders,
21 February – 6 March 2018, Zürich

EPFL
ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

Switzerland: host to two world leading accelerator centres



Intensity Frontier

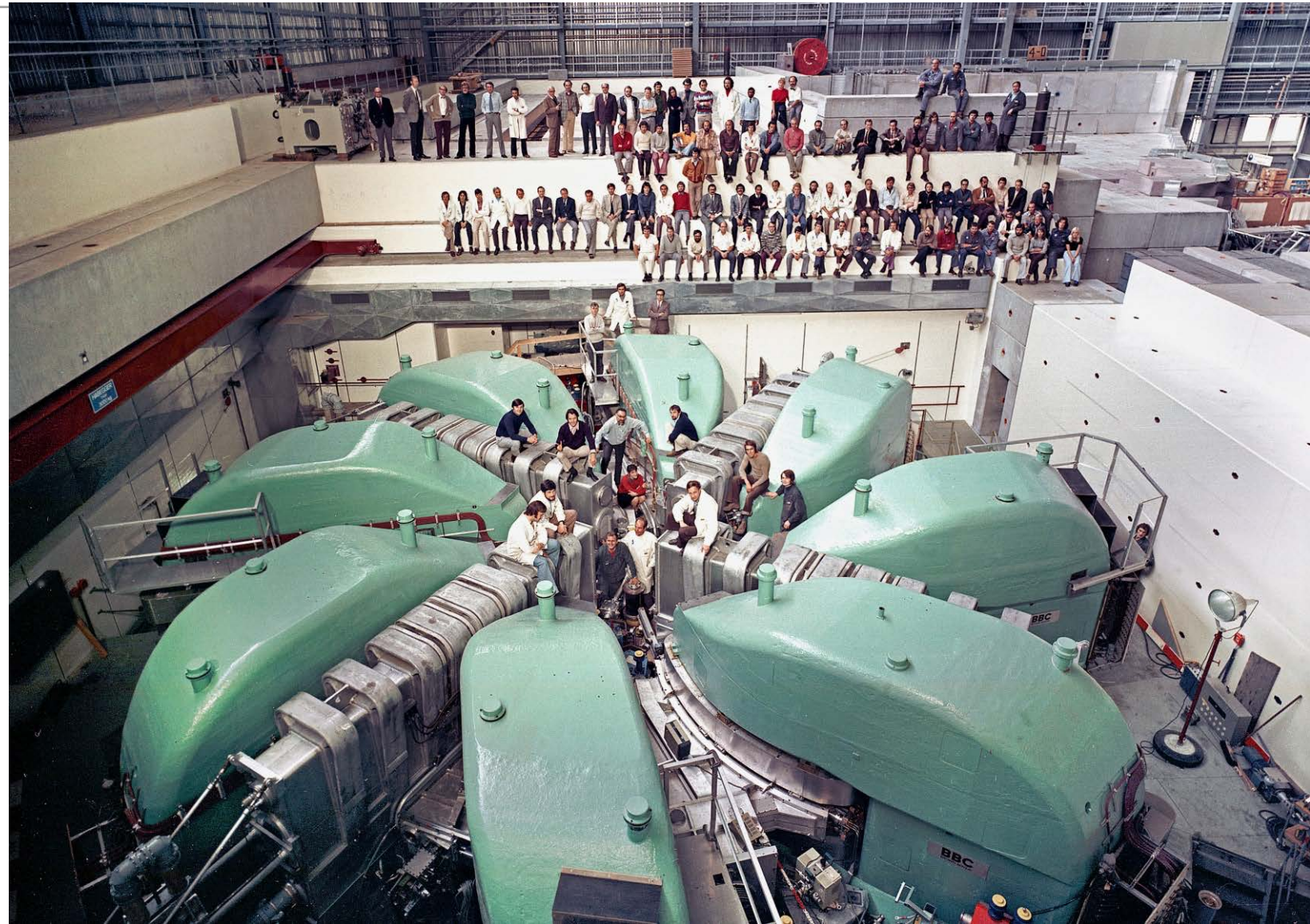
PSI Ring Cyclotron in 1973 planned for 100 μA

590 MeV proton cyclotron was planned for **100 μA**

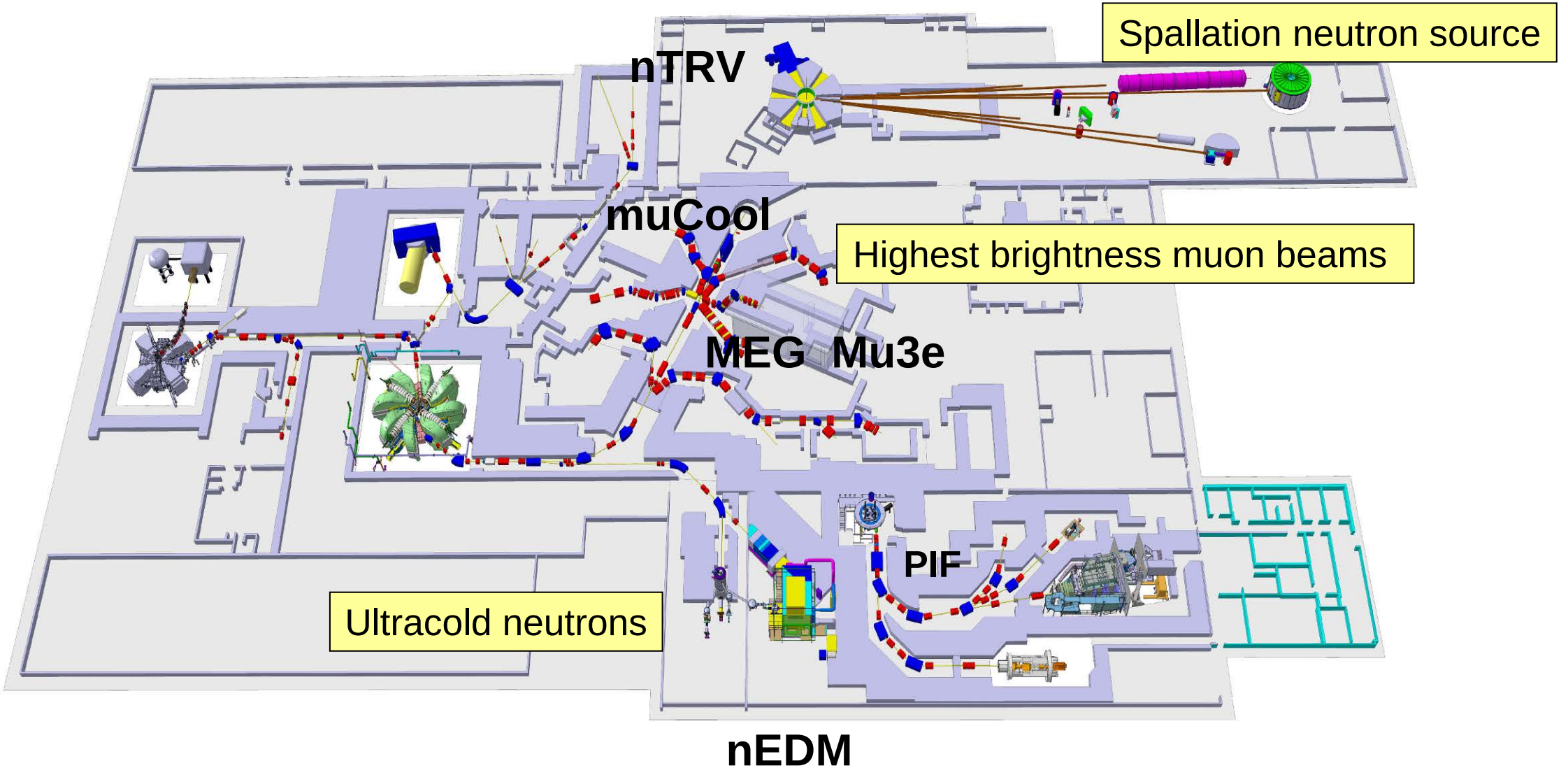
Today **2400 μA**

or

1.4 MW beam power



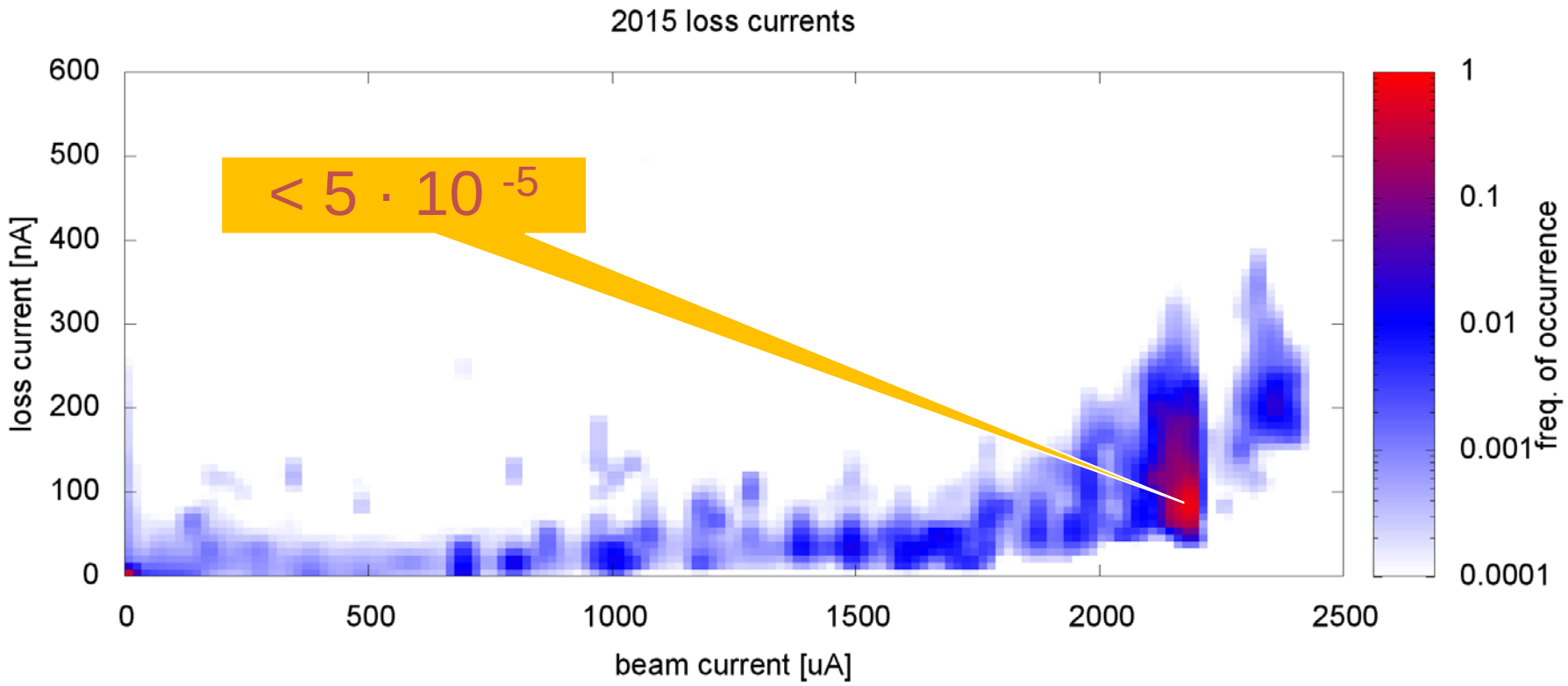
High intensity accelerators for research and industry



High intensity frontier: essential to have low beam losses

Frequency of operation at certain level of beam losses

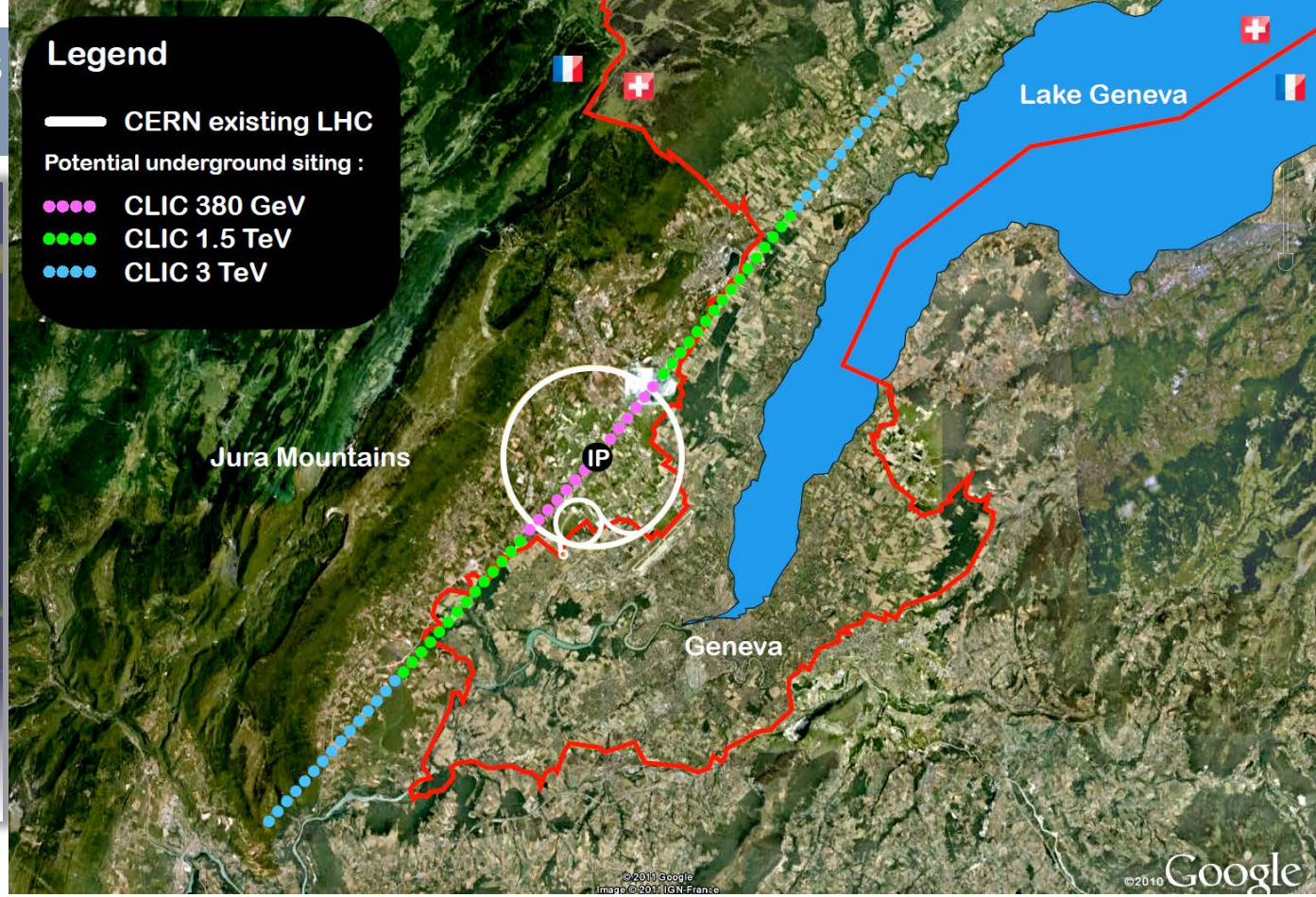
+ reliability increases to over 90 %



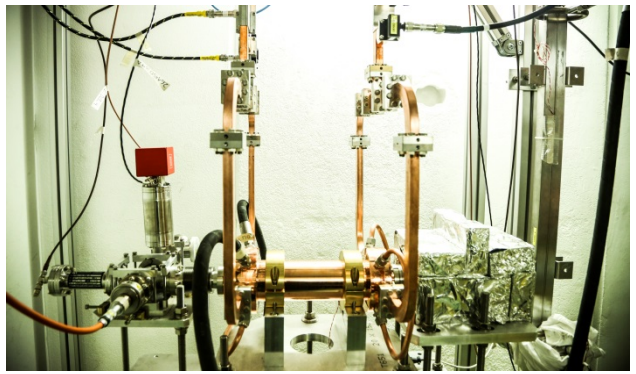
High energy particle physics

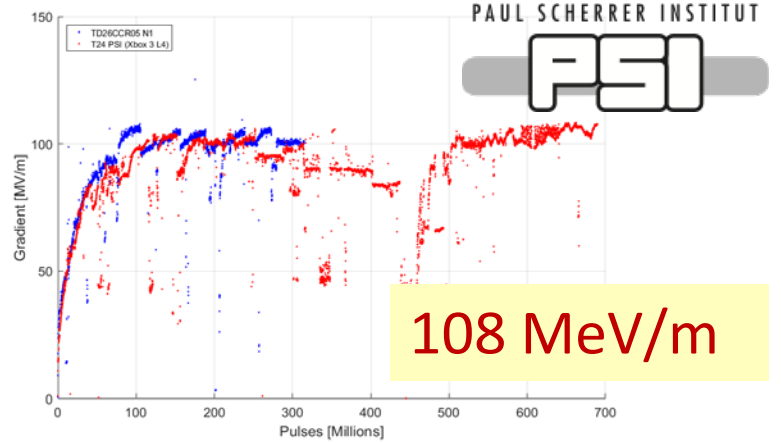
CLIC

Accelerator collaboration with ~50 institutes
Detector collaboration with ~29 institutes



Parameter	Unit	380 GeV	3 TeV
Centre-of-mass energy	TeV	0.38	3
Total luminosity	$10^{34}cm^{-2}s^{-1}$	1.5	5.9
Luminosity above 99% of √s	$10^{34}cm^{-2}s^{-1}$	0.9	2.0
Repetition frequency	Hz	50	50
Number of bunches per train		352	312
Bunch separation	ns	0.5	0.5
Acceleration gradient	MV/m	72	100
Site length	km	11	50





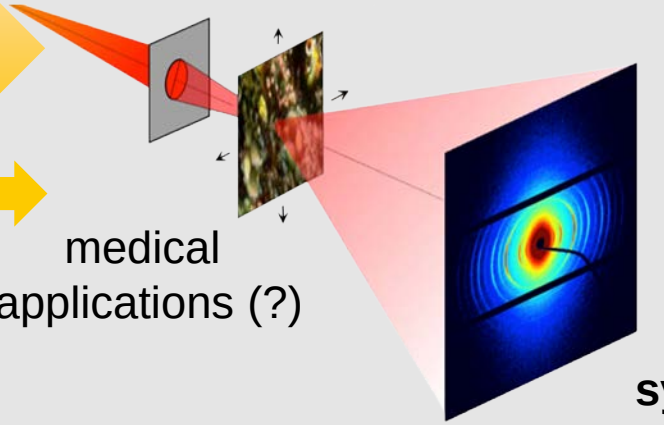
Spin-off product from basic research

15 years

pixel detector for particle physics

CMS detector at CERN, Geneva

spin-off



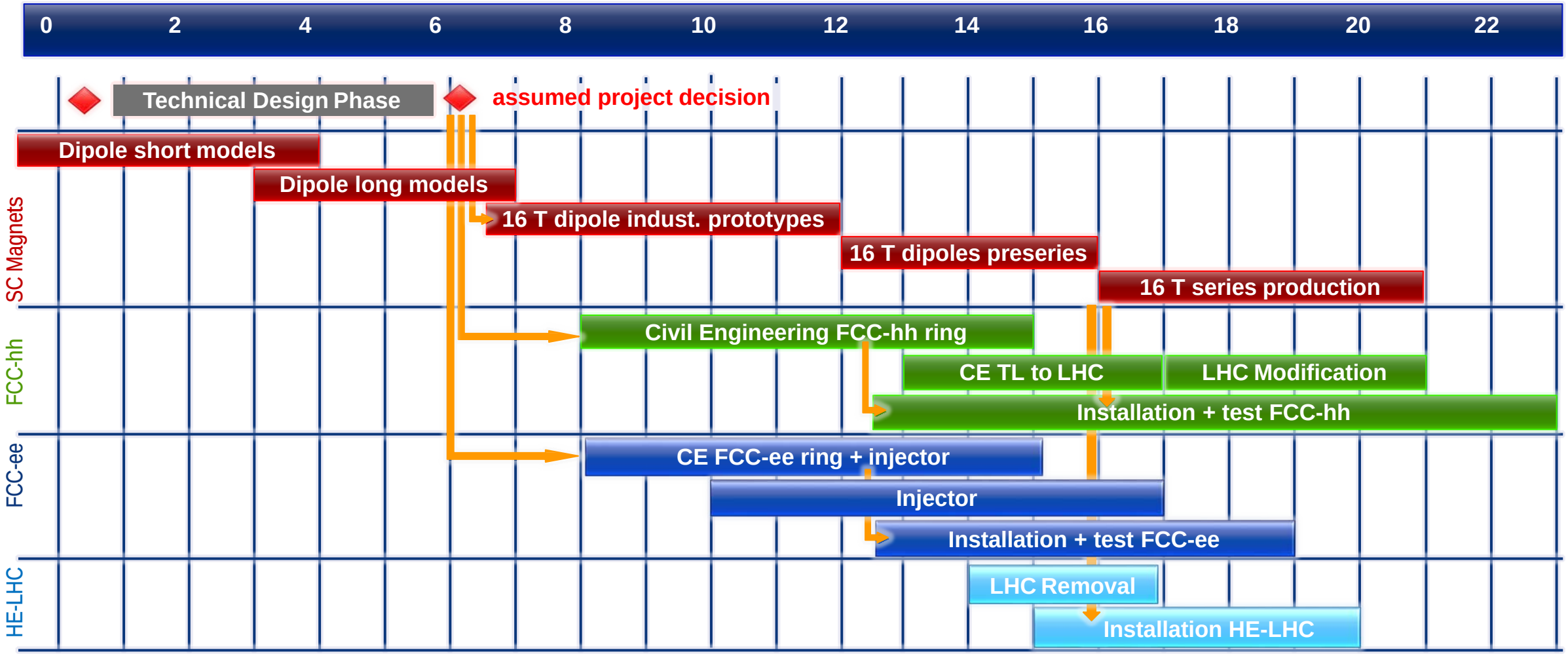
medical applications (?)

synchrotron sources worldwide

PILATUS 6M Pixel-Detector (Dectris Ltd., Switzerland)

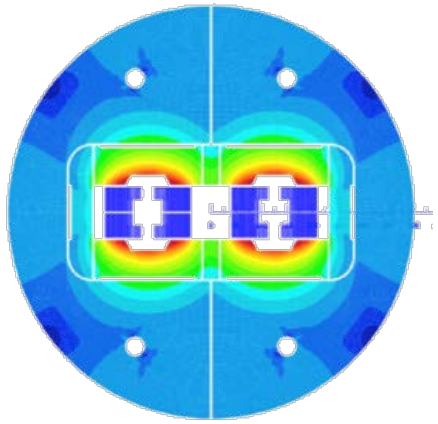
applications in materials research

Technical Schedule Considerations

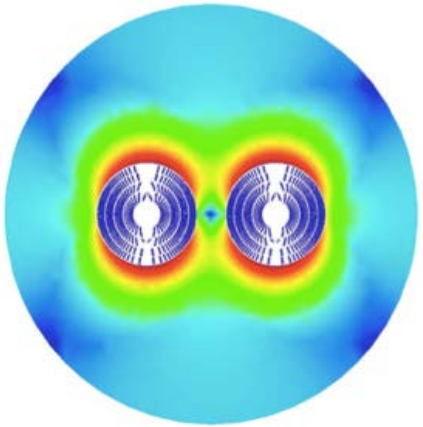


16 Tesla magnet R&D for FCC

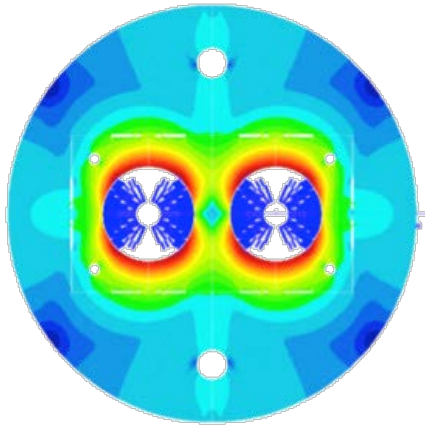
Block coil



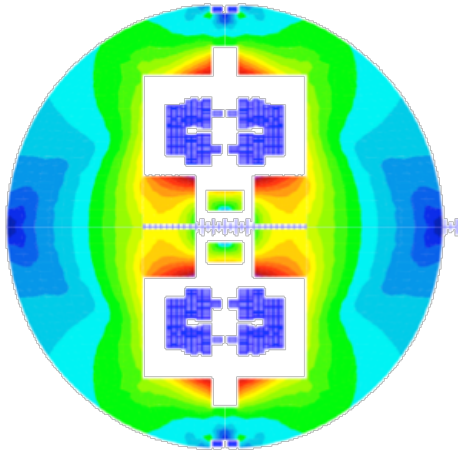
Canted Cosine Theta



Cos-theta



Common coils

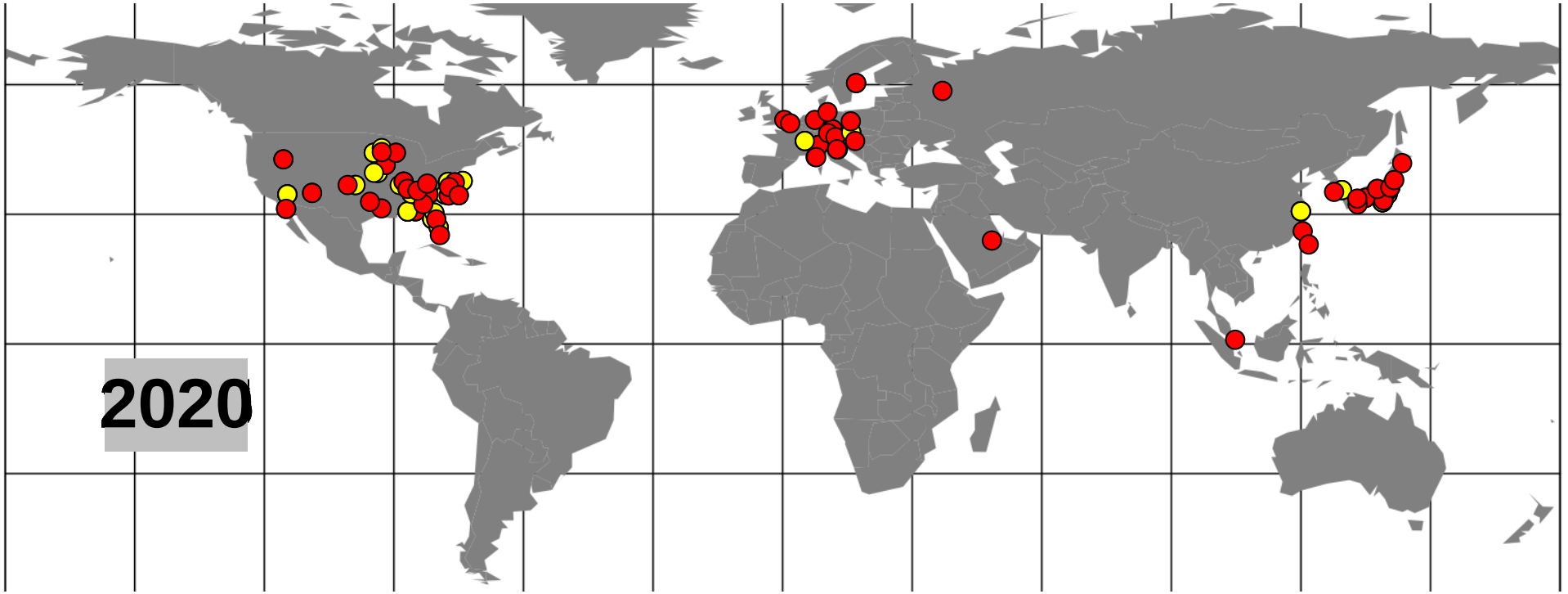


Accelerators for medicine

Spread of proton therapy technologies (Gantries)

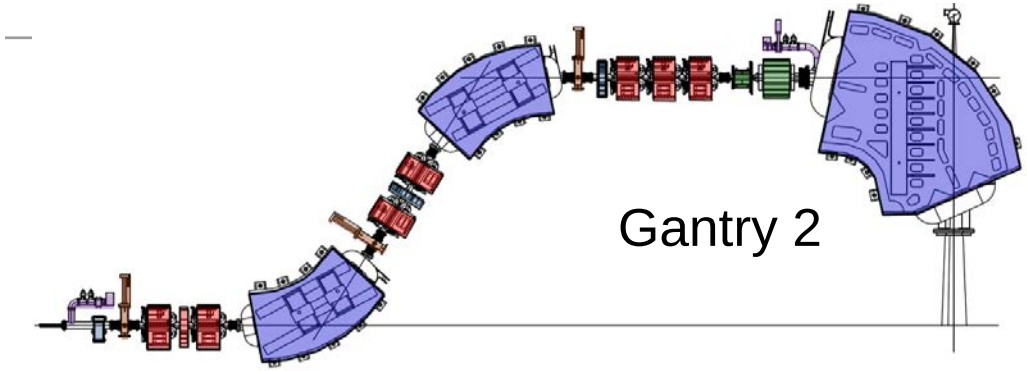
“Passive Scattering”
(developed at Harvard/Loma Linda/FermiLab

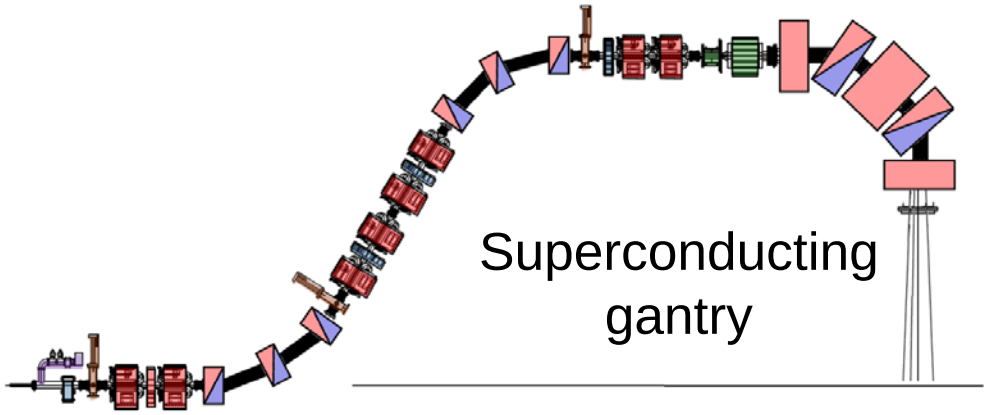
“Pencil Beam Scanning”
(developed at PSI)

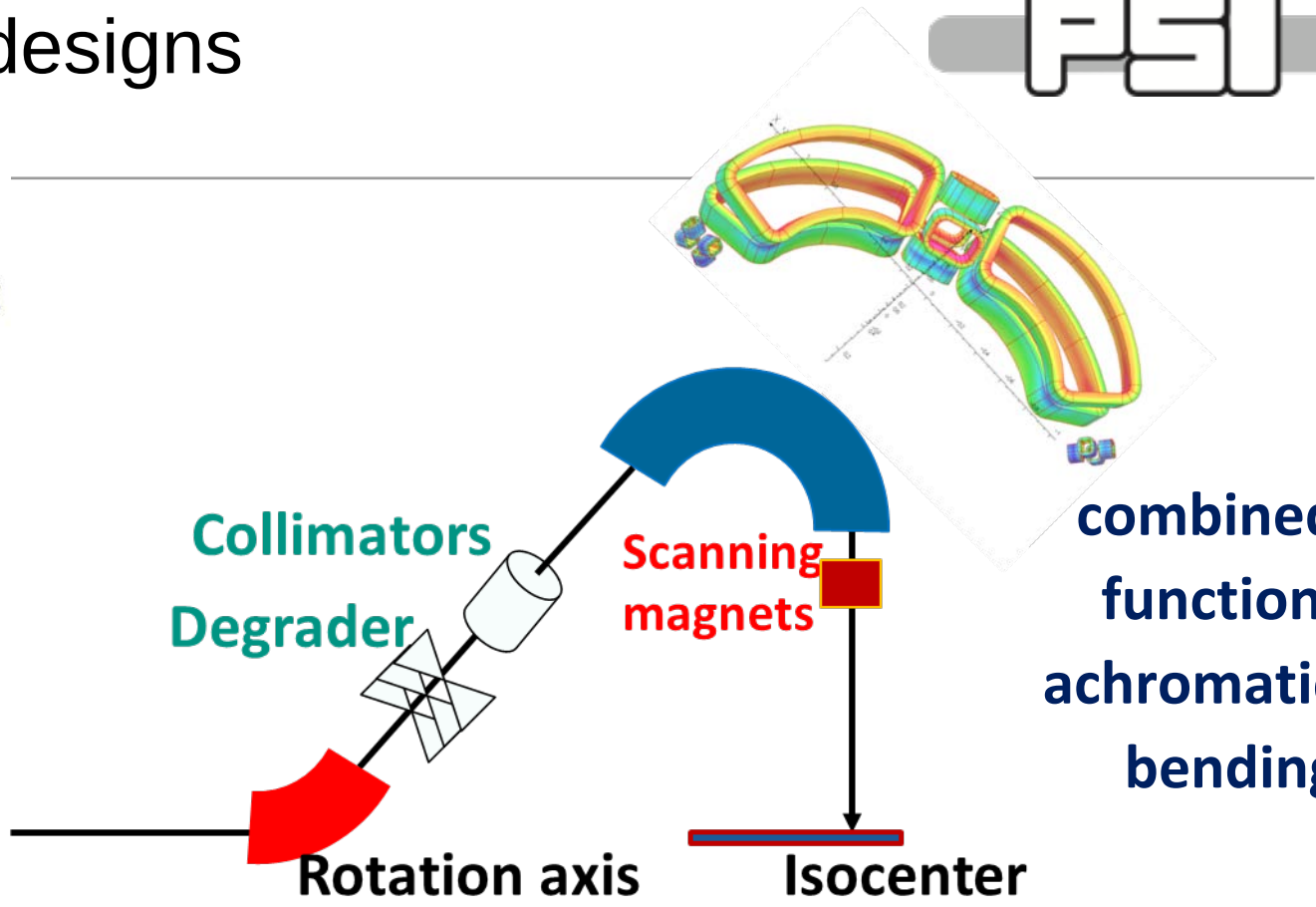


Gantries for hadron therapy

PSI Superconducting gantry designs







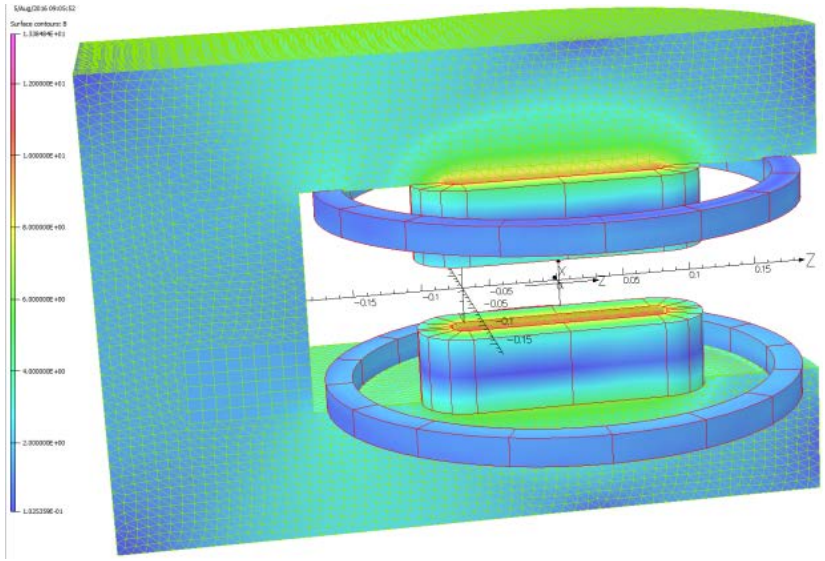
EXPECTED IMPROVEMENTS: NOT much smaller, but:

⇒ Weight: 200 tons → 50 tons

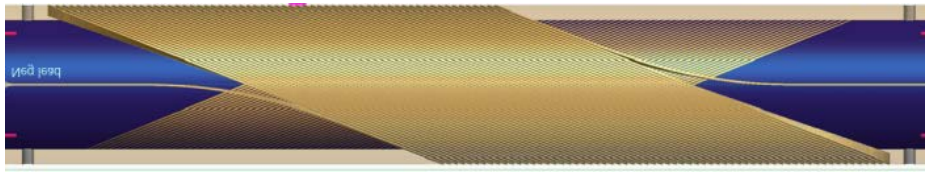
⇒ Field size: 12 x 20 cm^2 → 20 x 20 cm^2

⇒ Energy acceptance 1.5% → 20 %

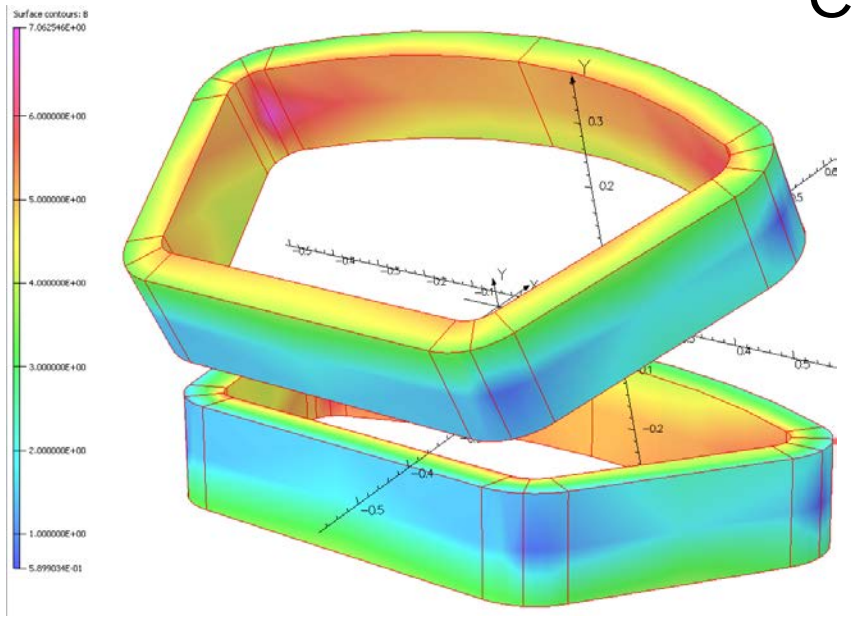
High field magnets for HEP, medicine and light sources



SLS 2 Superbend
(2015-2018)



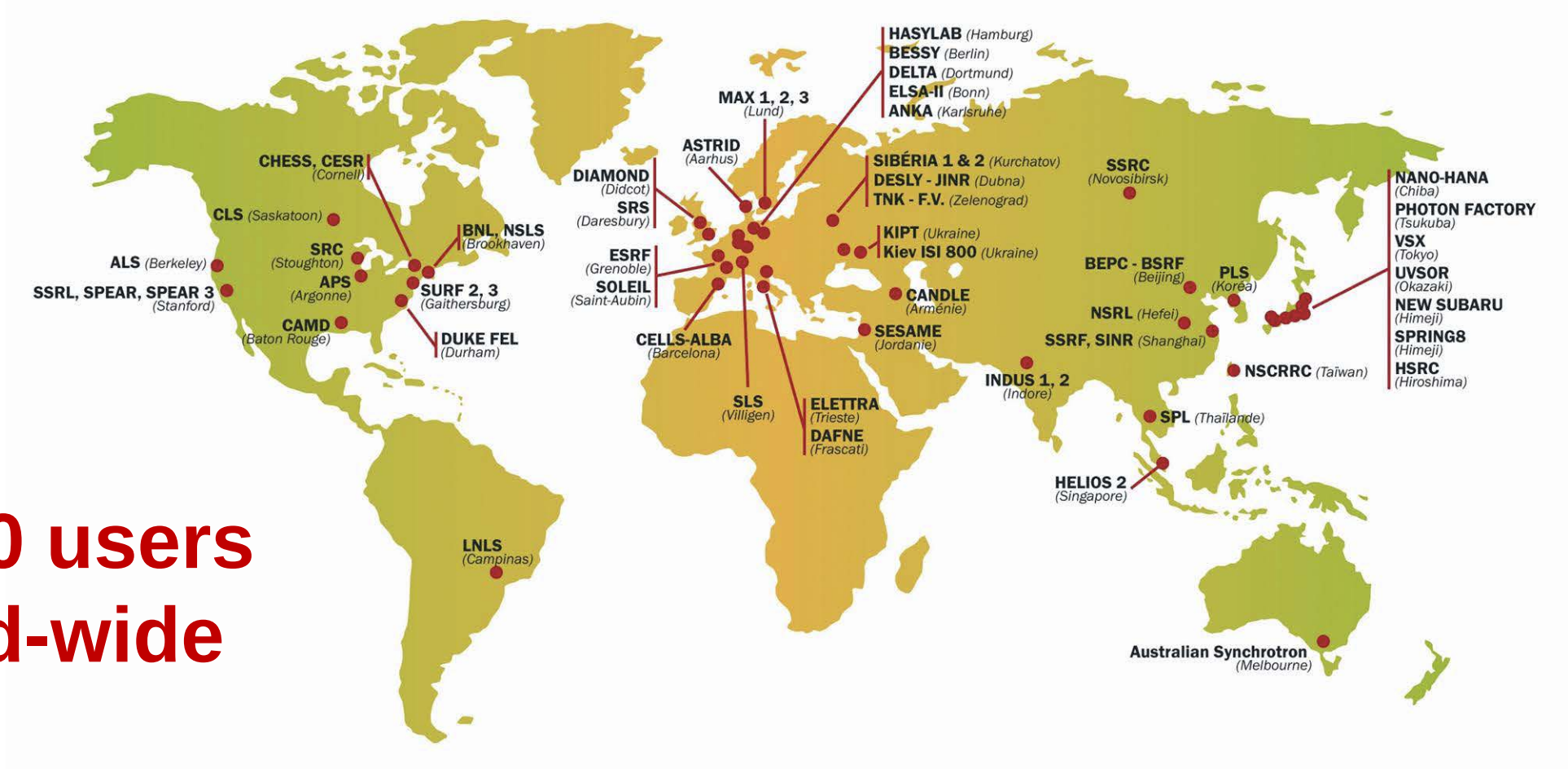
16 T Dipole magnet for the Future Circular Collider
(2016-2019)



Superconducting dipole for gantry
(2015-2019)

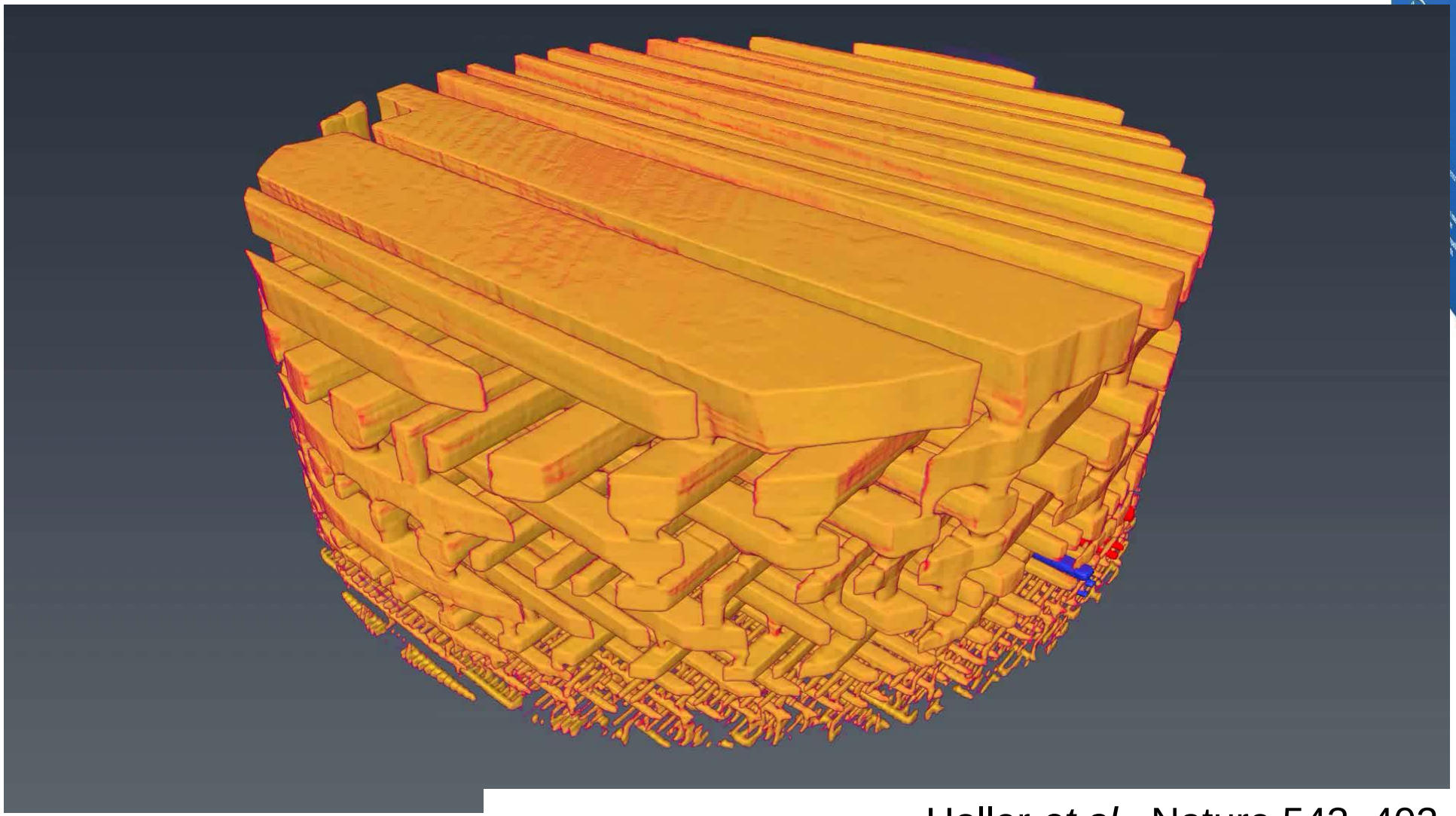
Synchrotron Light Sources

Synchrotron Light Sources: about 50 storage ring based

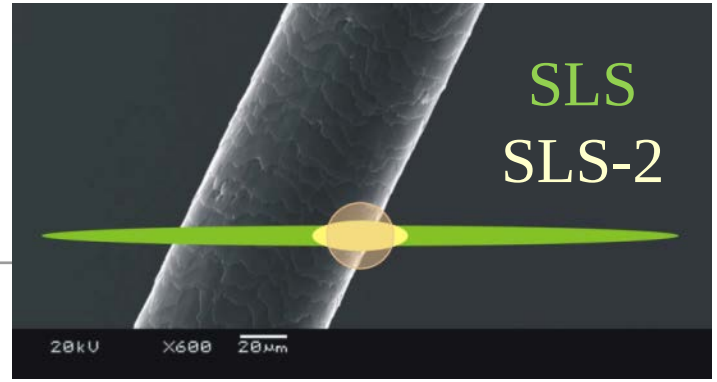


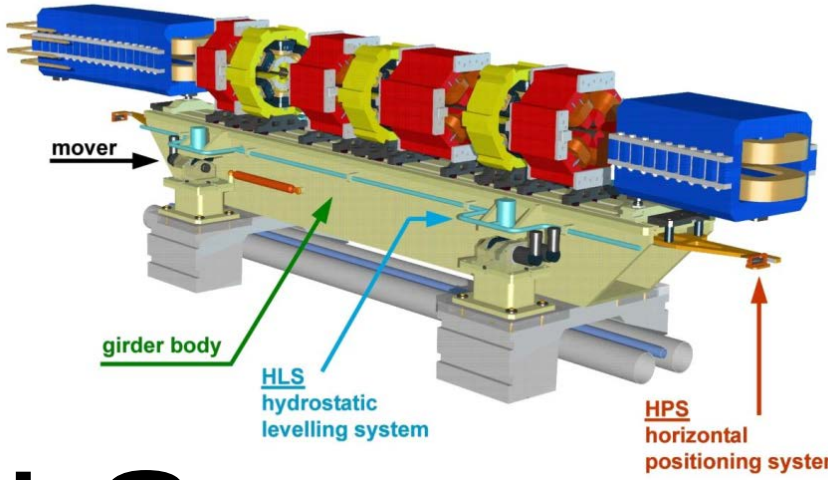
60‘000 users world-wide

Intel Core Pentium G3260 (3300) Dual Core

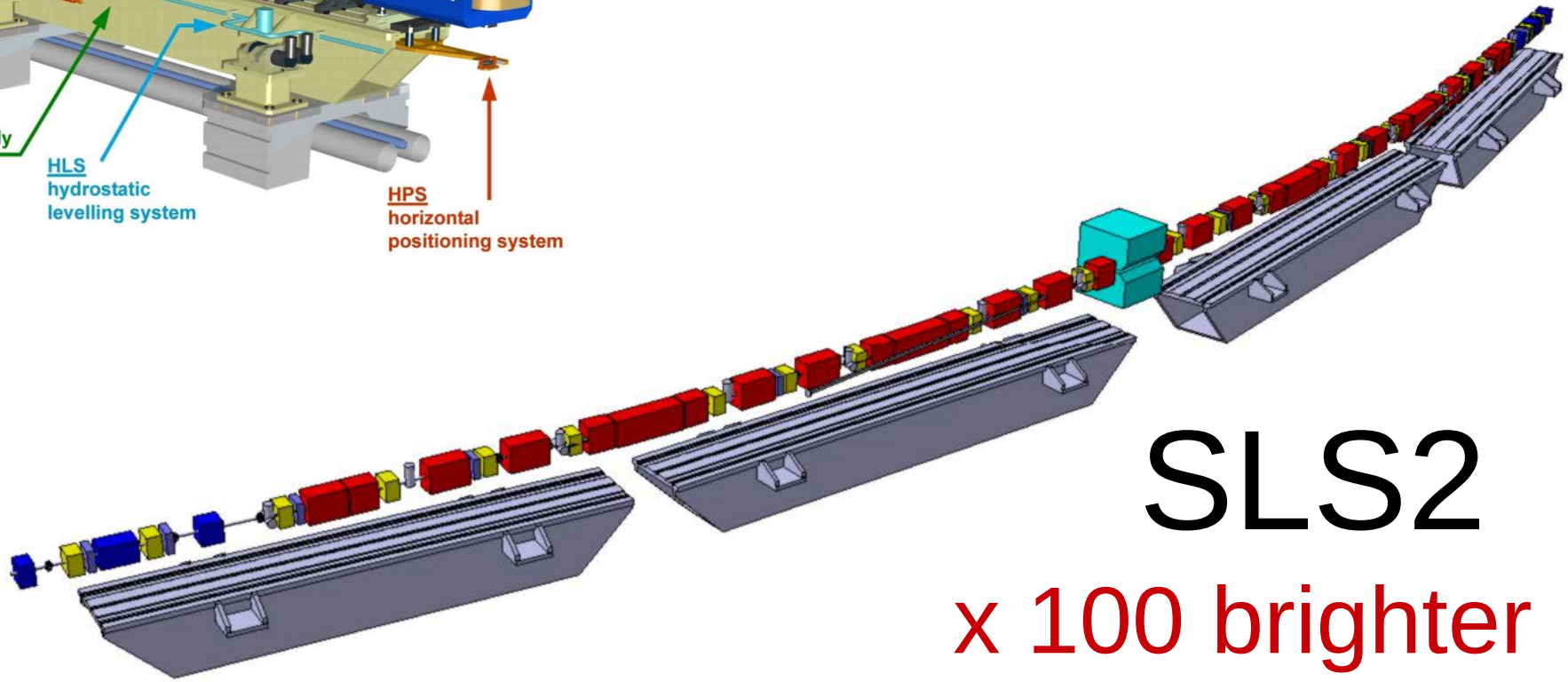


Holler *et al.*, Nature 543, 402–406 (16 March 2017)





SLS

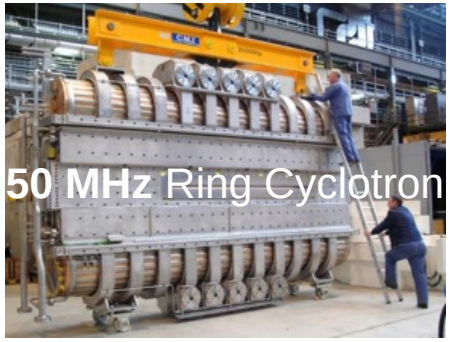


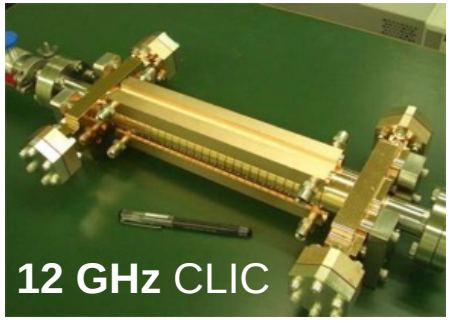
SLS2

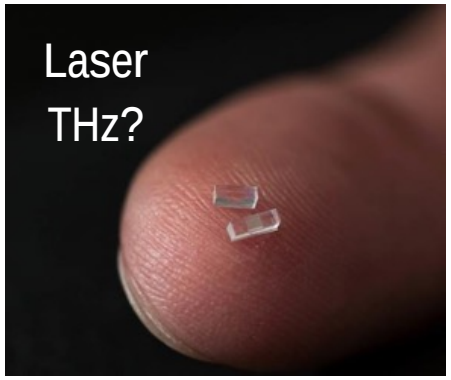
x 100 brighter

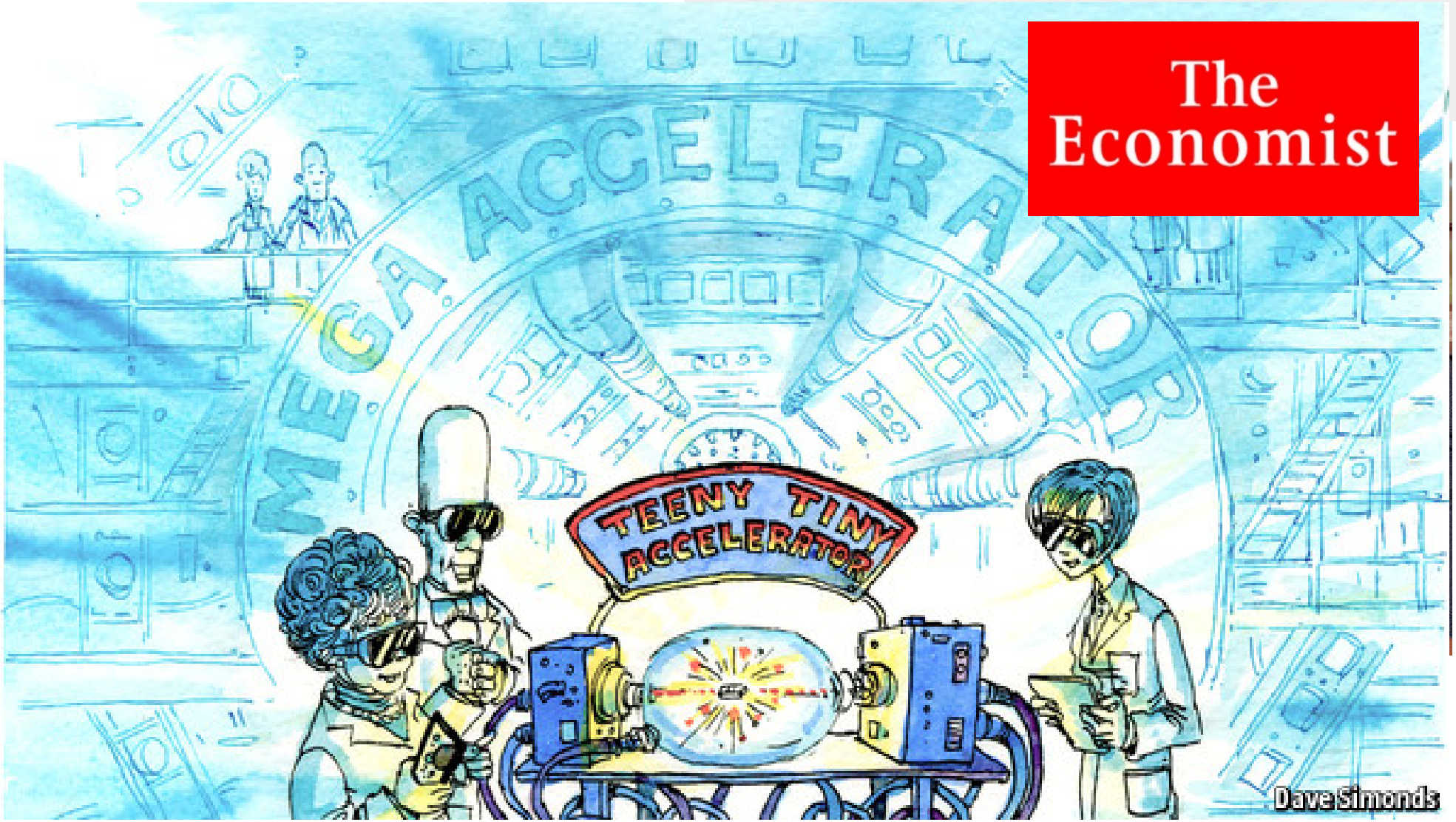
Compact accelerators:
sources of photons, neutrons, electrons etc.

RF Acceleration: scaling with frequency

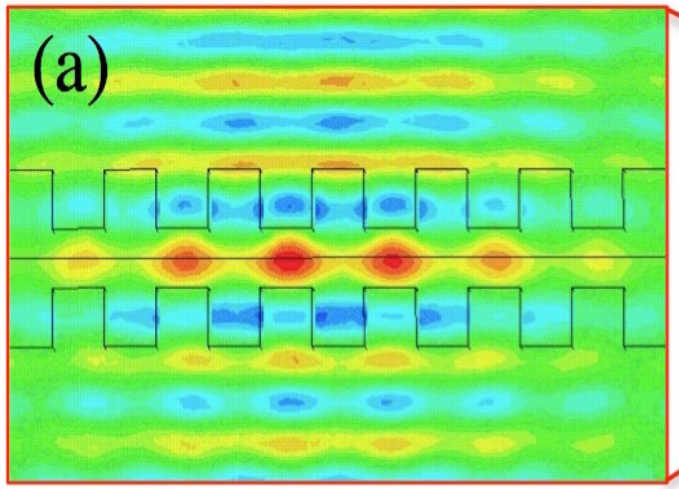


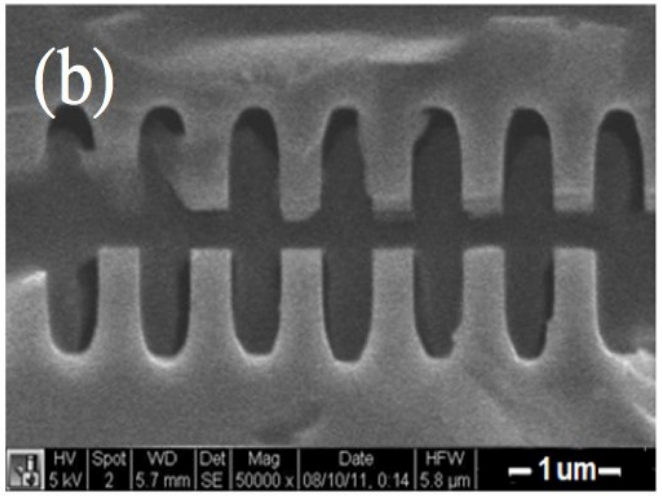


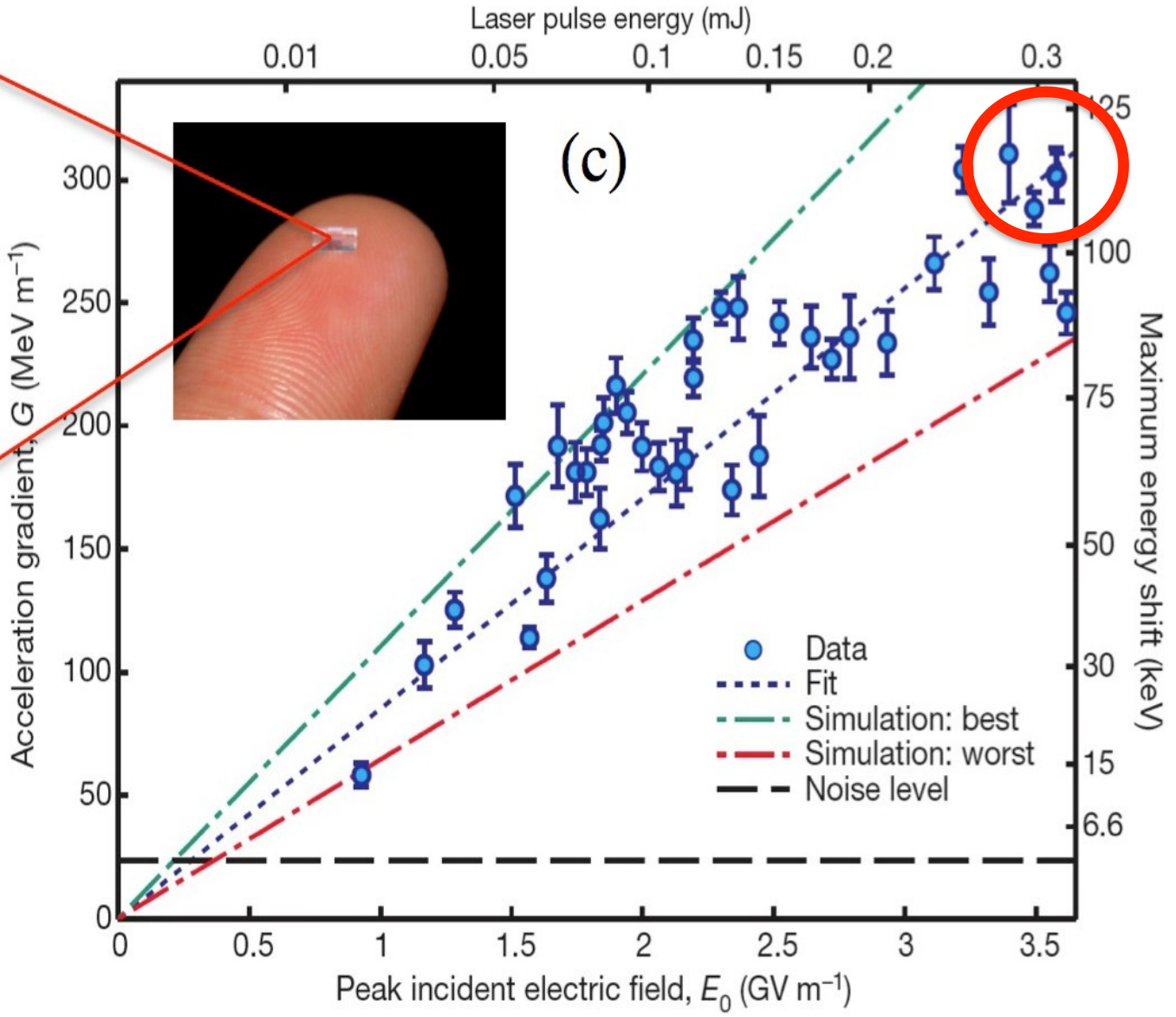




Peak gradient as a function of Laser Field







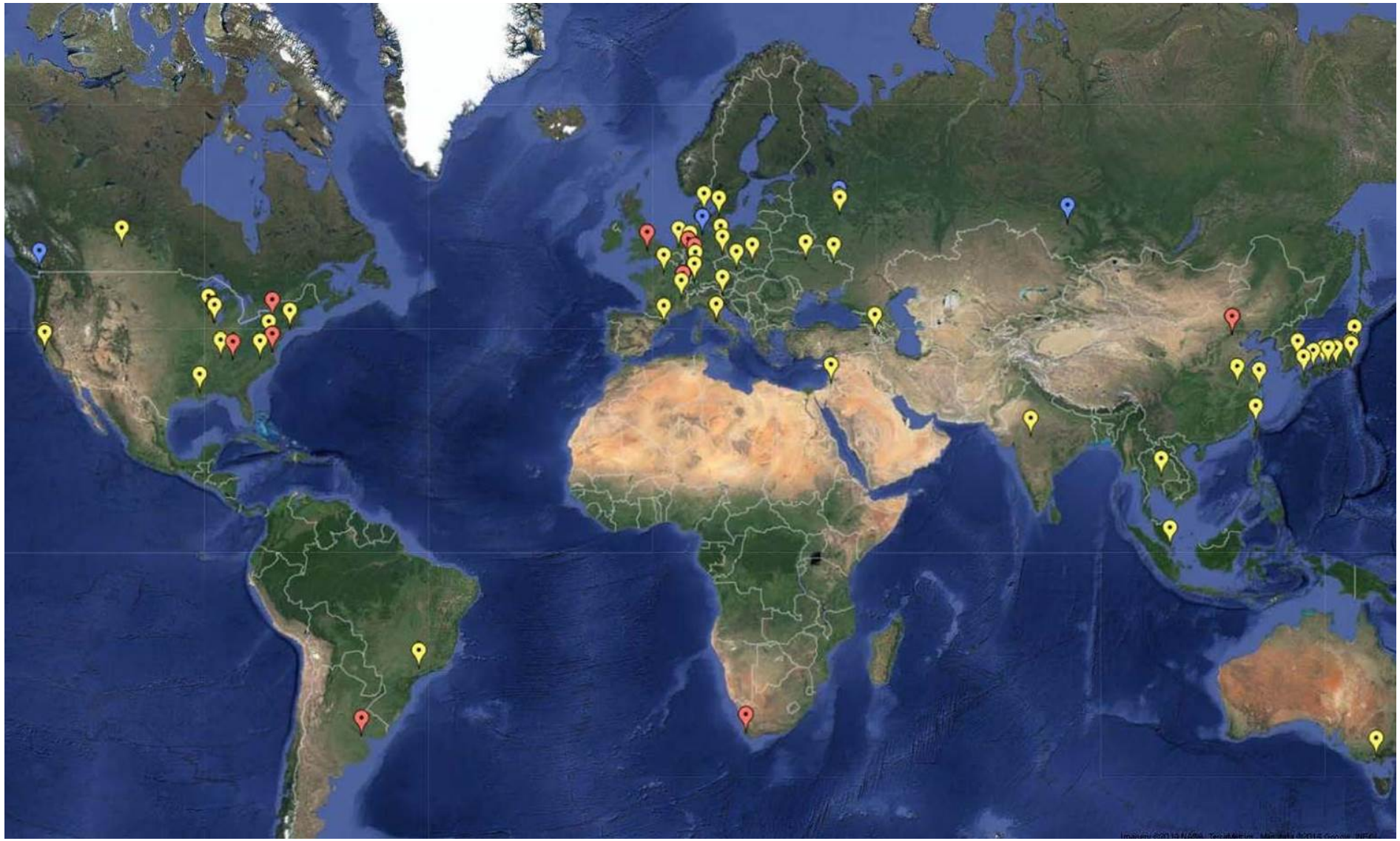
Peralta et al.,
Nature **503**, 91 (2013)

Accelerators for industry

World Accelerators: instruments for science and industry: growing market, Swiss effort to utilize this local advantage

~40’000 accelerators

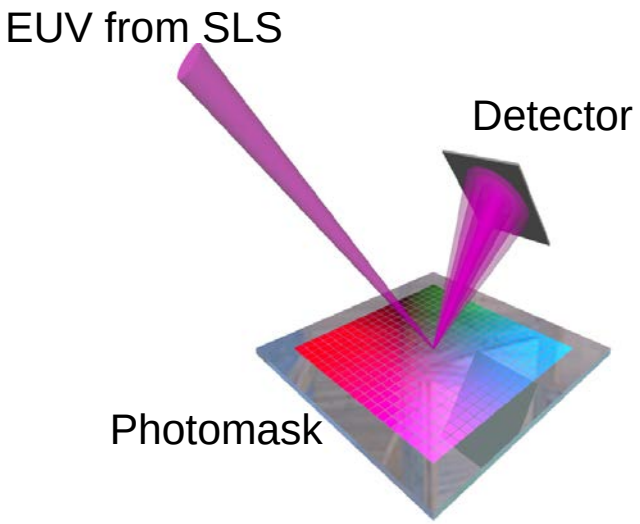
- 2 G$ market
- 500 G$ of goods produced with accelerators



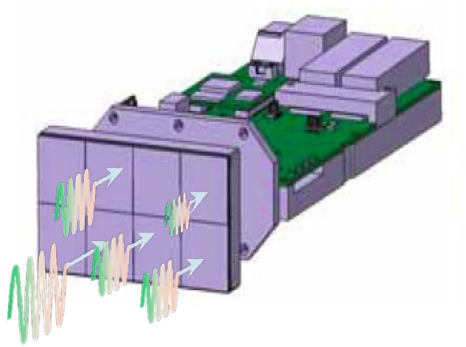
Lensless EUV mask inspection tool for semiconductor industry

Required is:

1. **Experience in EUV coherent scattering microscopy**



2. **Fast, sensitive detectors**



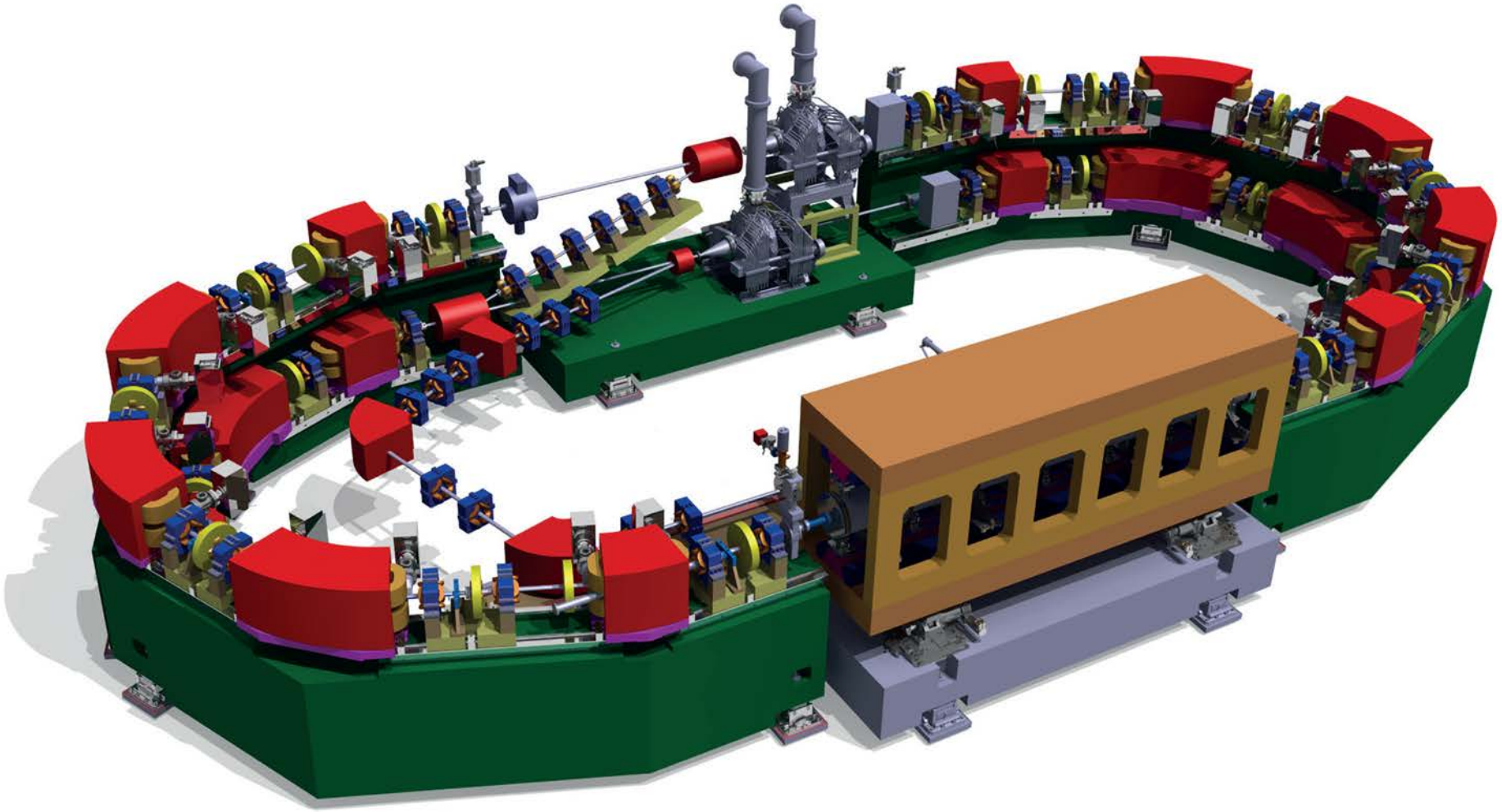
Jungfrau detector

All available at PSI!

3. **Know-how in accelerator physics & design**

Compact synchrotron

Diffraction limited rings technology: a much brighter compact source



COSAMI design
5 x 11 meter
Footprint

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