UPPSALA UNIVERSITET

European Spallation Source (ESS)

Roger Ruber

FREIA Laboratory

Dept. of Physics and Astronomy

Uppsala University

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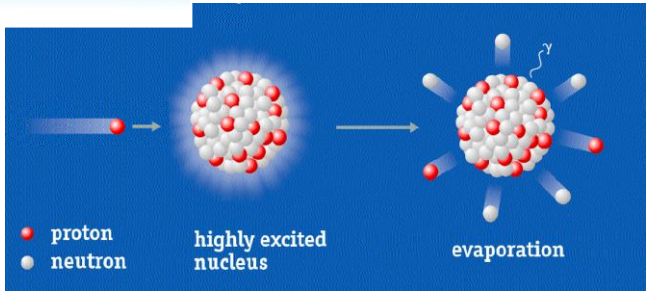
European Spallation Source (ESS)

ESS Philosophy and Parameters

- User facility demanding high availability of scheduled operation time (>95%)
  - Lund, Sweden, next to MAX-IV, to replace aging research reactors
    - 2019 first neutrons
    - 2019 – 2025 consolidation and operation
    - 2025 – 2040 operation

- **5 MW** pulsed **cold neutron source**, long pulse
  - 14 Hz rep. rate, 4% duty factor
  - short pulse requires ring, but user demand satisfied by existing facilities (ISIS, SNS, J-PARC)

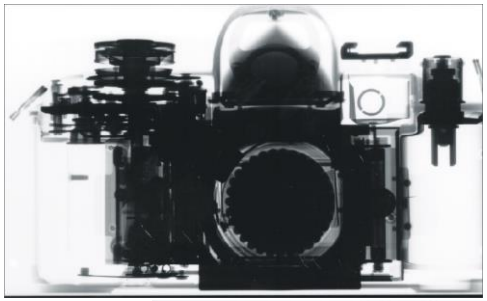
- Proton beam on rotating tungsten target
  - 2 GeV, 2.89 ms, 62.5 mA beam pulse
  - peak power 125 MW

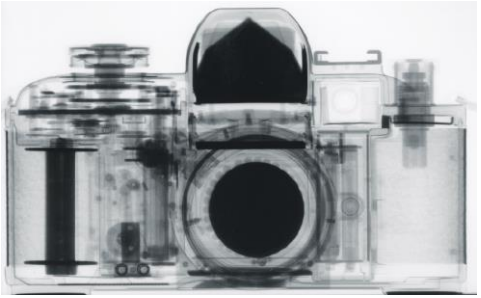


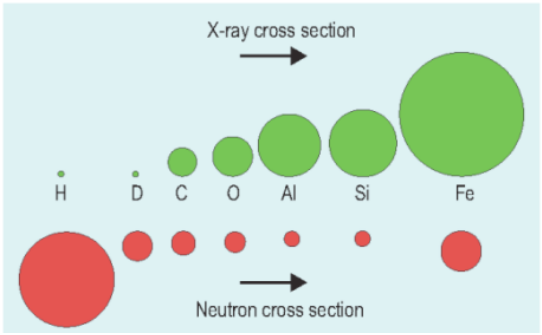
- High intensity allows studies of
  - complex materials, weak signals, time dependent phenomena

Why Neutron Imaging?

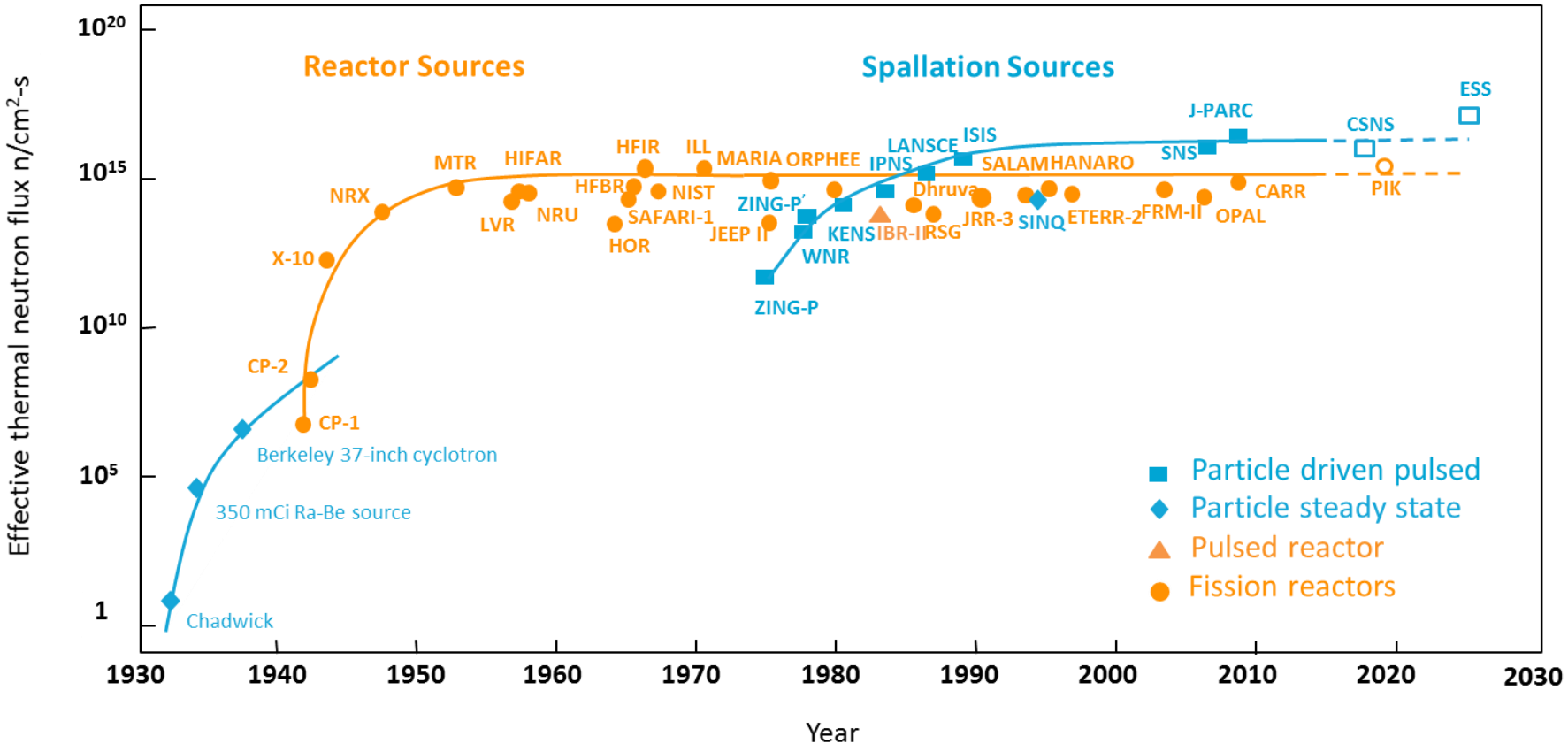
- charge neutral:
  - deeply penetrating except for some isotopes
- nuclear interaction:
  - cross section depending on isotope (not Z), sensitive to light elements.
- spin S = 1/2:
  - probing magnetism
- unstable $n \rightarrow p + e + \underline{\nu}_e$ with life time $\tau \sim 900s$, $I = I_0 \ e^{-t/\tau}$
- thermal energies result in non-relativistic velocities.
  - mass: n ~p; E = 293 K = 25 meV, v = 2196 m/s , λ = 1.8 Å







Overview of Neutron Facilities



(Updated from *Neutron Scattering*, K. Skold and D. L. Price, eds., Academic Press, 1986)

What is 5 MW?

At 5 MegaWatt,

- one beam pulse has the same energy as
  - a 16 lb (7.2kg) shot traveling at 1100 km/h (Mach 0.93)
  - a 1000 kg car traveling at 96 km/hour

- with 14 beam pulses per second
  - you boil 1000 kg of ice in 83 seconds
    - A ton of tea!!!

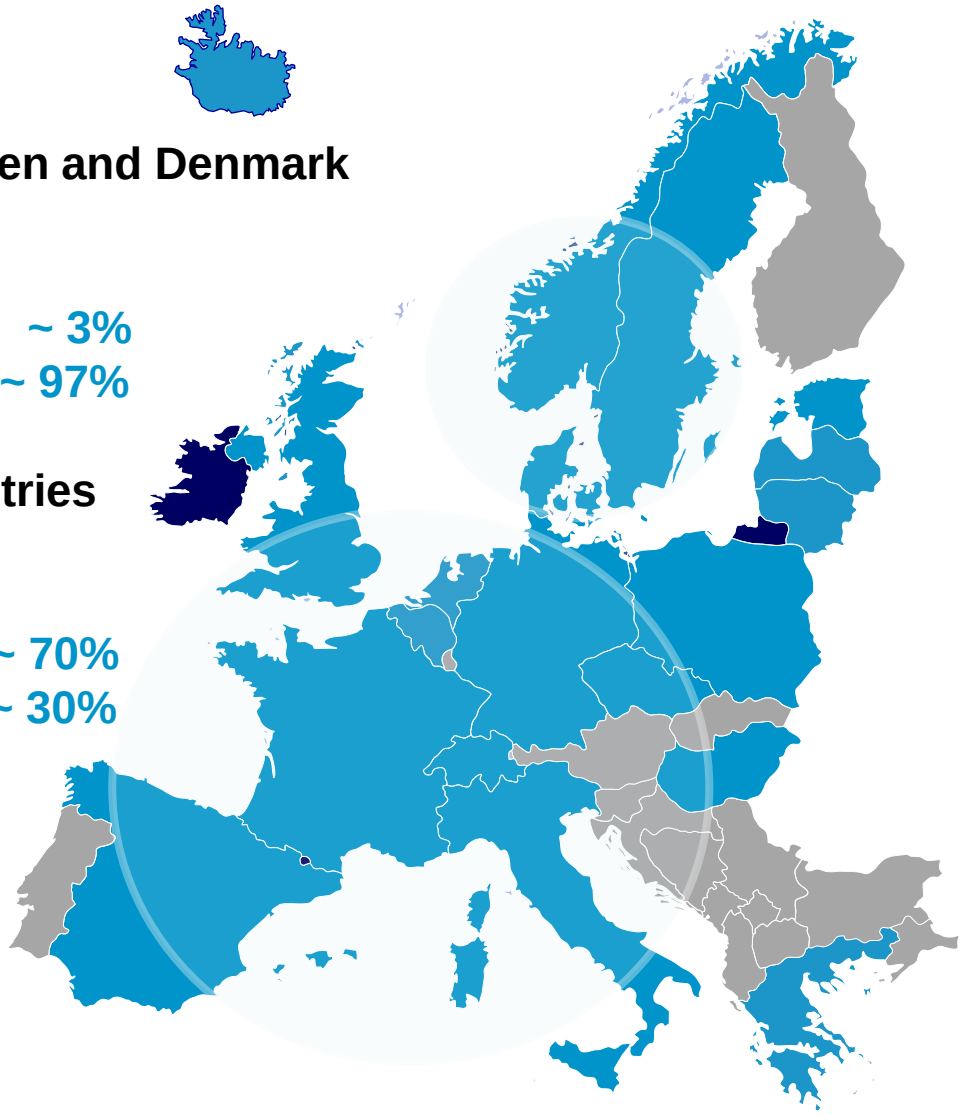
The Organization

Host Countries of Sweden and Denmark

- 47,5% Construction
- 15% Operations
- In-kind Deliverables ~ 3%
- Cash Investment ~ 97%

Non Host Member Countries

- 52,5% Construction
- 85% Operations
- In-kind Deliverables ~ 70%
- Cash Investment ~ 30%



How it Works

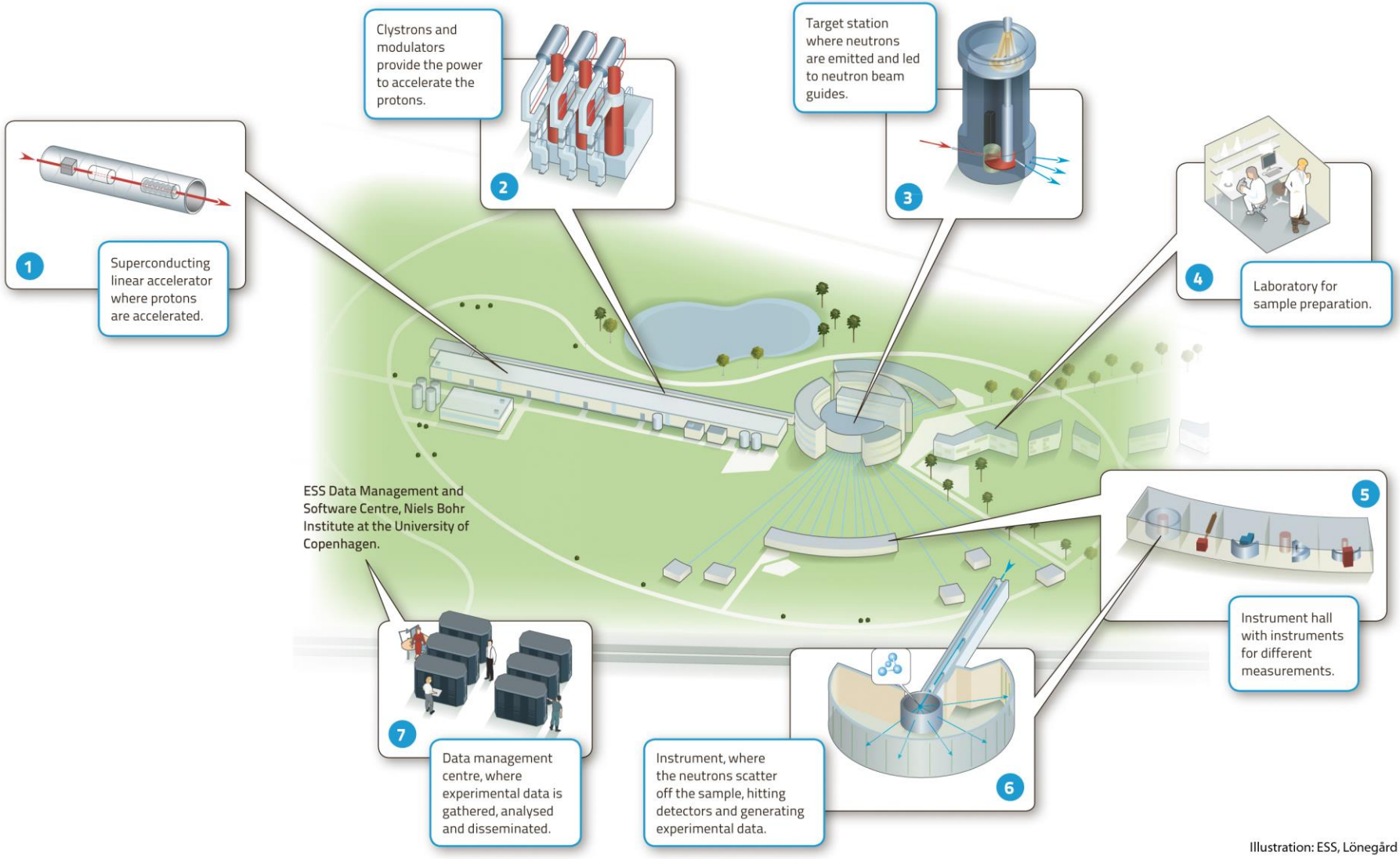
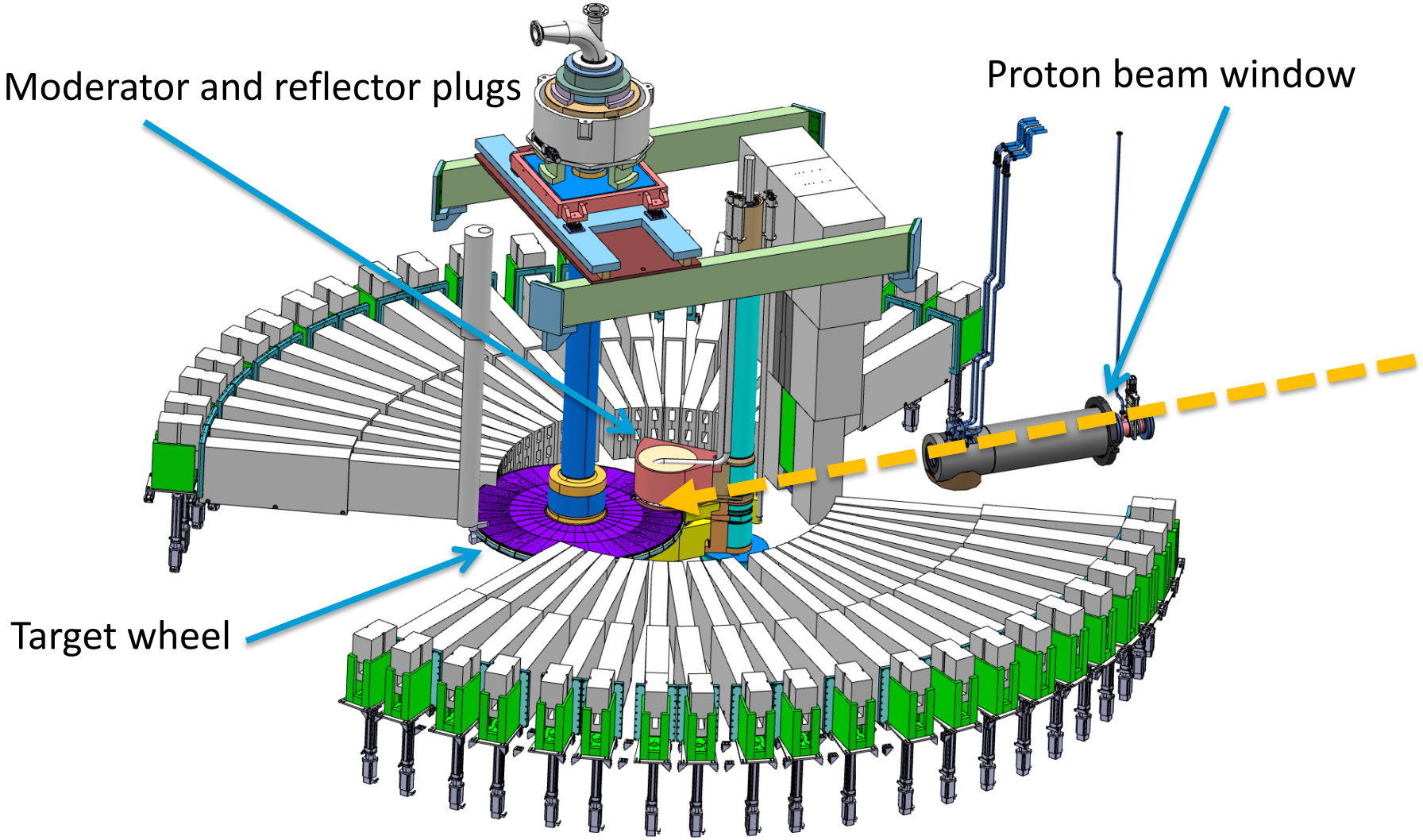
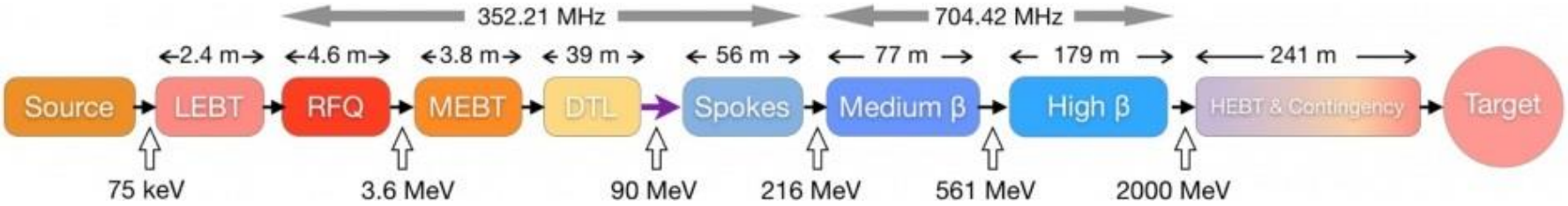


Illustration: ESS, Lönegård

The ESS Target



The ESS Accelerator



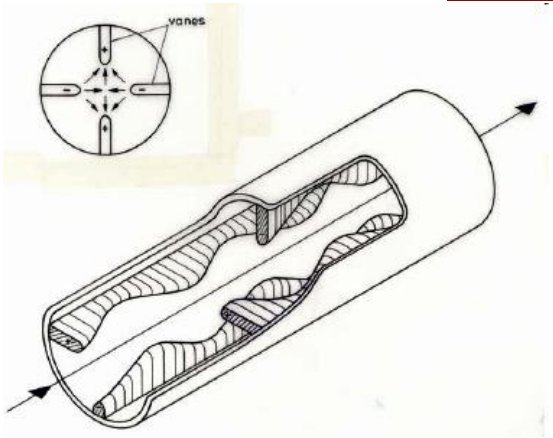
	Length [m]	No. Cavities	β	No. Magnets	No. Steerers	No. Sections	Power [kW]
LEBT	2.38			2 Solenoid	2 x 2	1	
RFQ	4.6	1				1	1600
MEBT	3.83	3		11 Quad	10 x 2	1	15
DTL	38.9	5		PM-Quads	15 x 2	5	2200
LEBT + Spoke	55.9	26	0.50	26 Quad	26	13	330
Medium Beta	76.7	36	0.67	18 Quad	18	9	870
High Beta	178.9	84	0.86	42 Quad	42	21	1100
HEBT	130.4		(0.86)	32 Quad	32	15	
DogLeg	66.2			12 Quad + 2D	14		
A2T	46.4			6 Quad + 8 Raster			
	604.21	**155**					

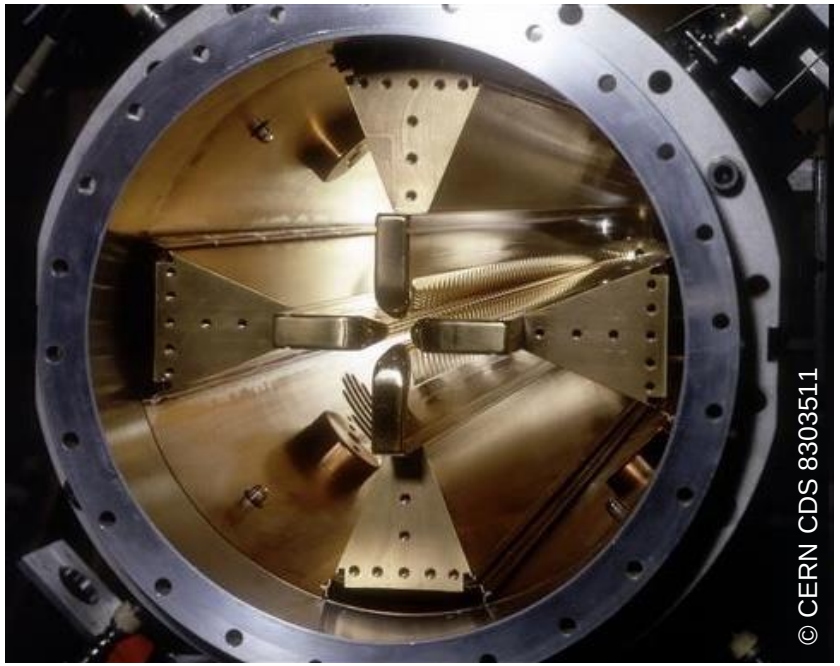
RF Quadrupole (RFQ)

- electric quadrupole mode
  high field quality

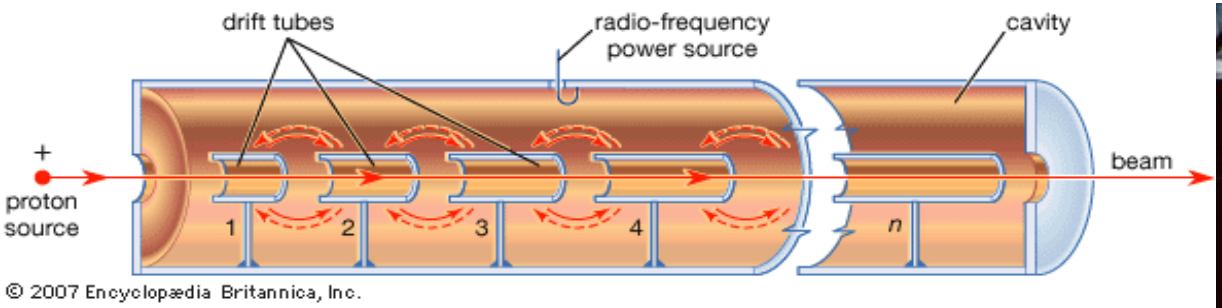
- RF electric field concentrated near the vane tips, hence
  strong transverse focusing

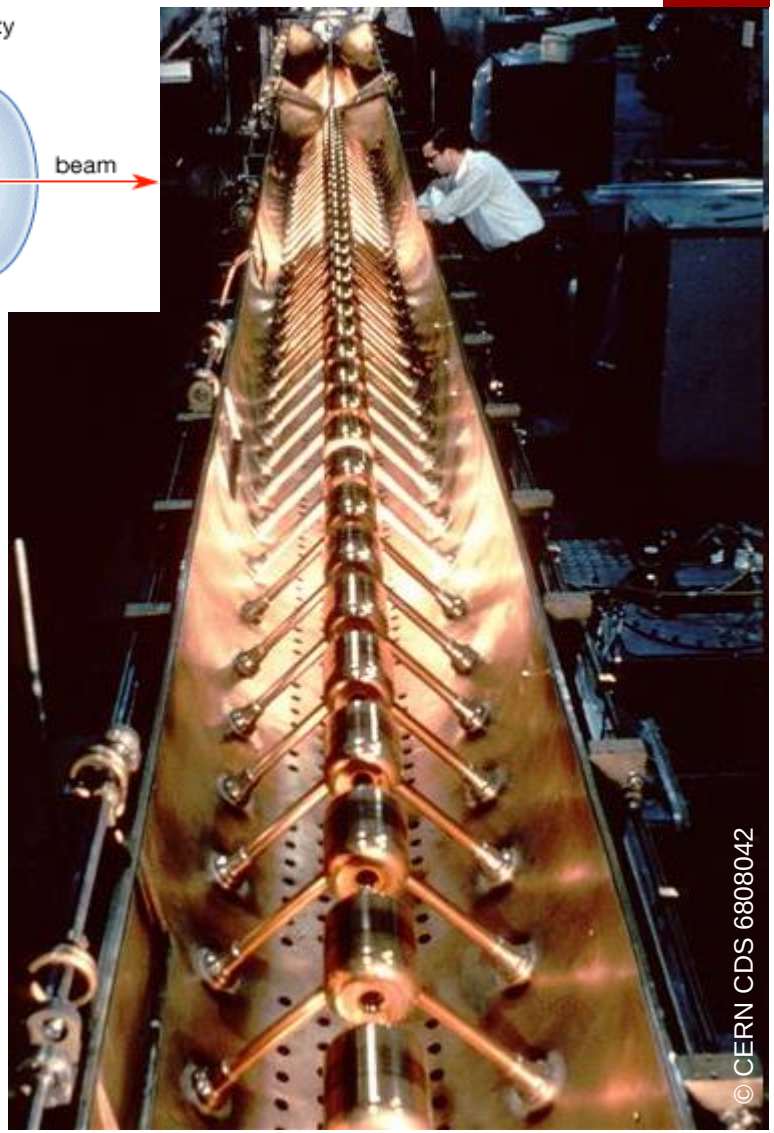
- acceleration through
  longitudinal modulation
  pattern, hence
  effective array of
  accelerating cells





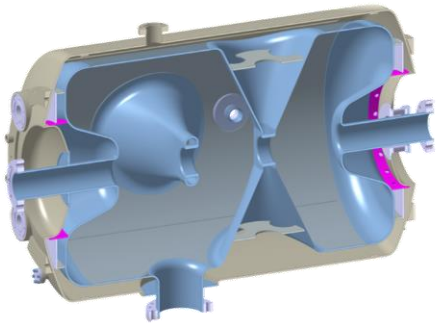
Drift Tube Linac (DTL)

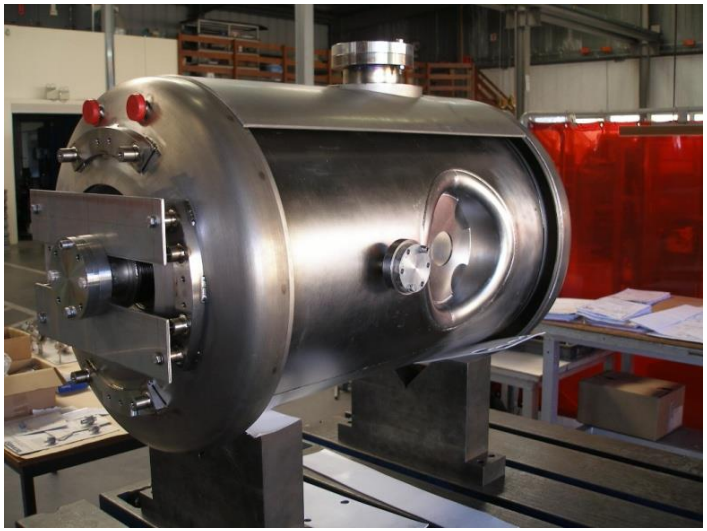


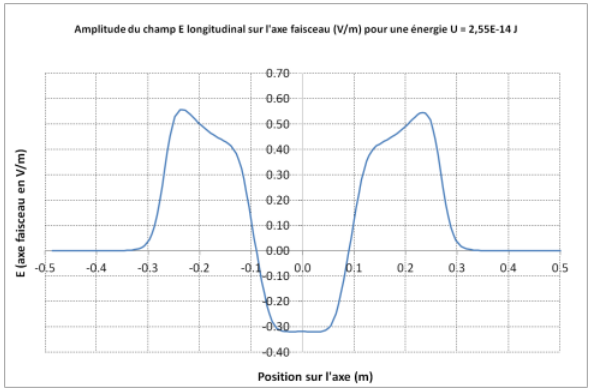


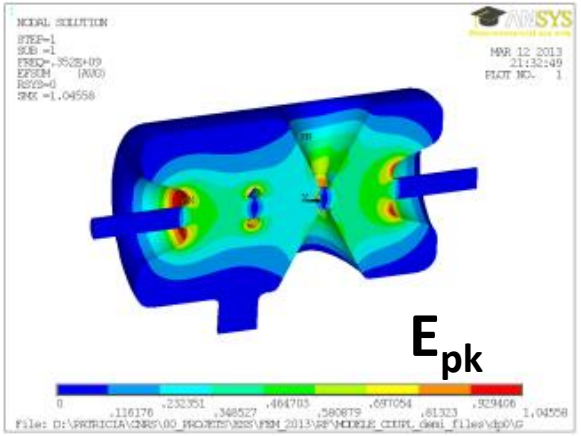
- drift tube shields particle while field direction is reversed
- drift tube length adapted to particle velocity
- permanent magnet included for focusing

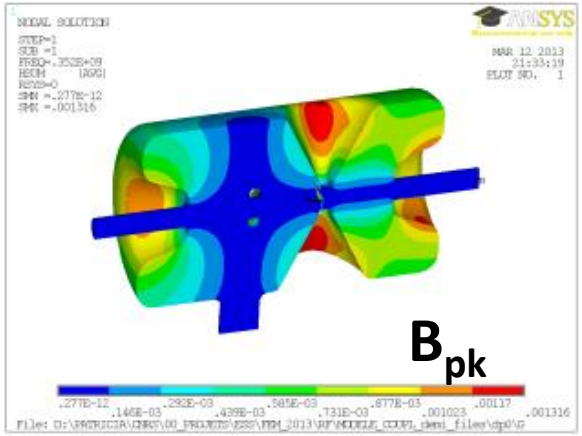
Superconducting Spoke Resonator

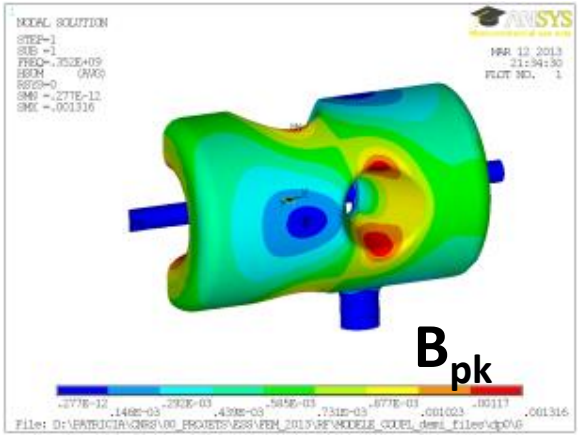




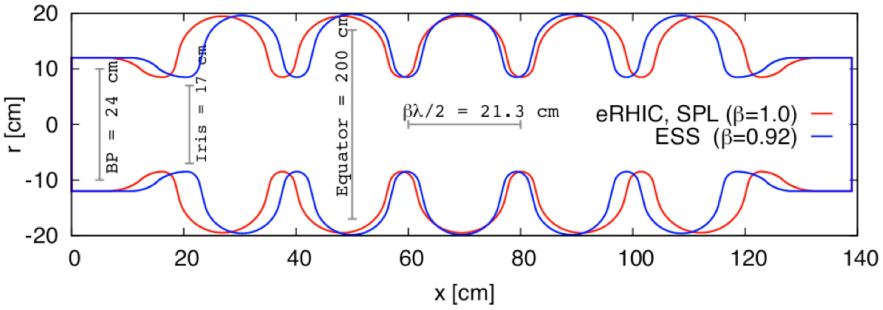


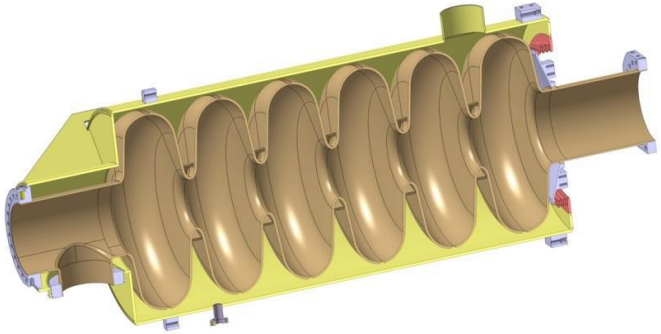


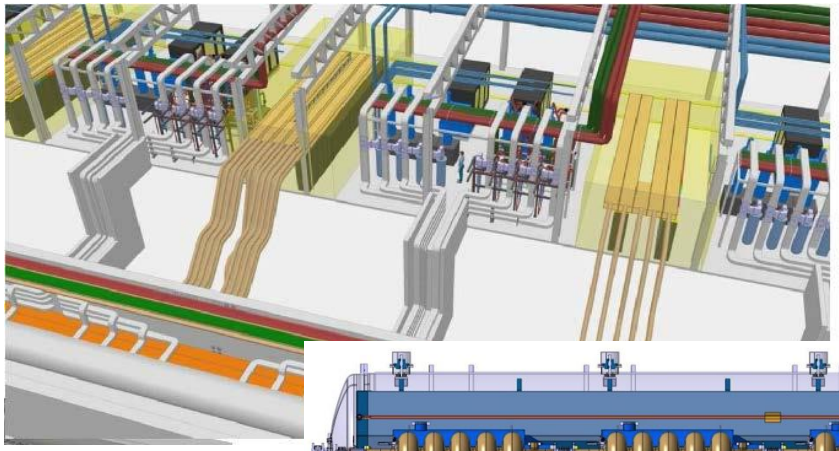


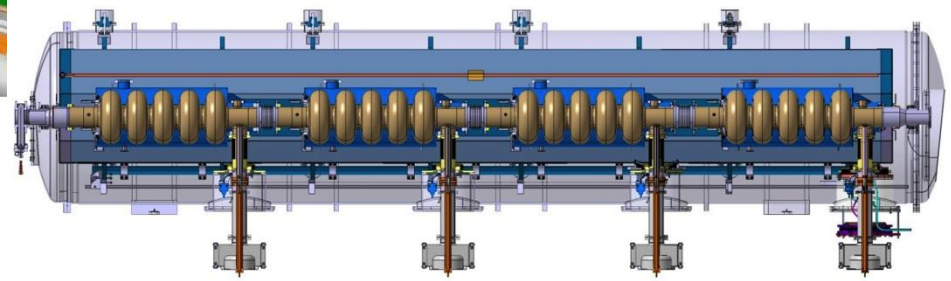


Superconducting Elliptical Cavity







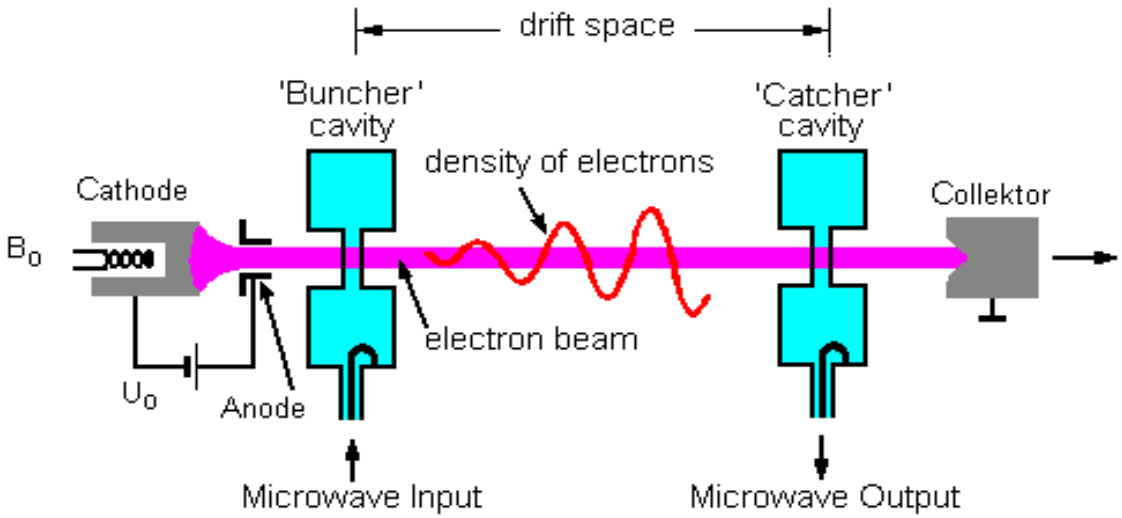


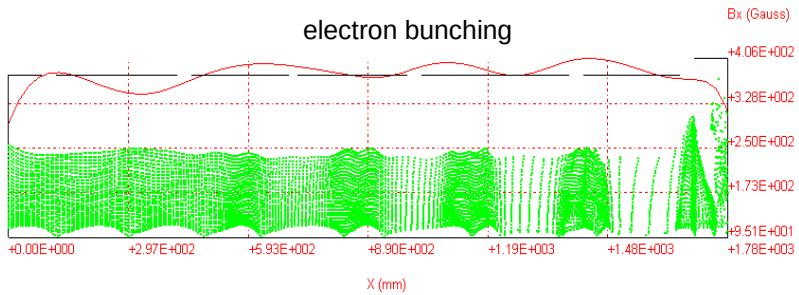
High Power RF Amplifiers

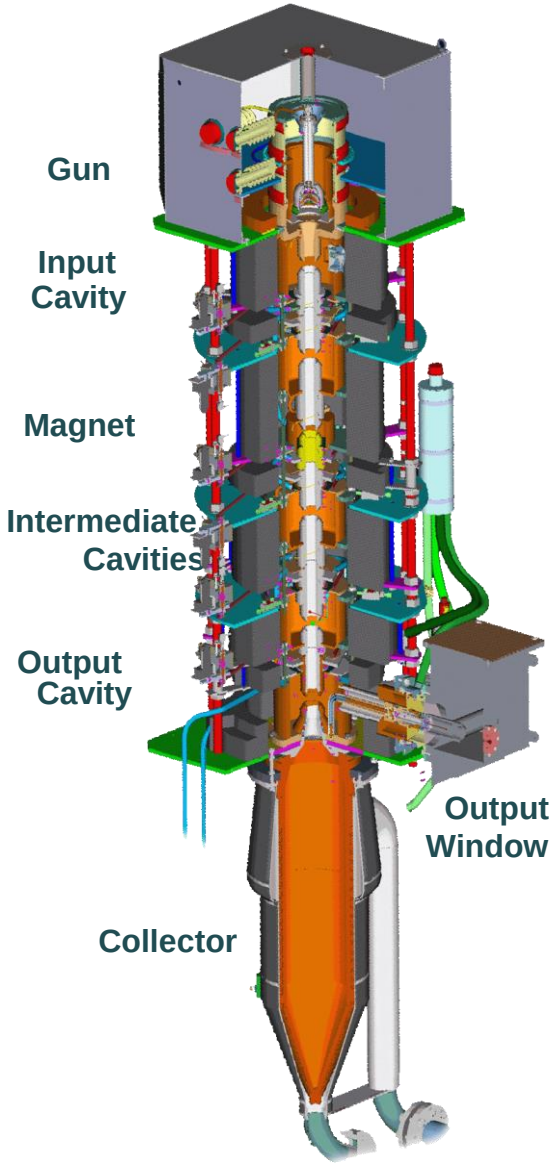
- base frequency is 352.21 MHz (LEP)
  - and 704.42 MHz for elliptical sections
- one (1) amplifier per accelerating cavity
  - multiple amplifiers can be driven by a single power supply
  - 15 to 25% required overhead for operation
    - depending on amplifier type
  - extra RF time for cavity filling
    - 0.2 to 0.6 ms depending on cavity

Klystron Microwave Amplifier

- vacuum tube amplifier by electron density bunching
- 200 MHz – 20 GHz
- <1.5 MW ave.; <150 MW peak



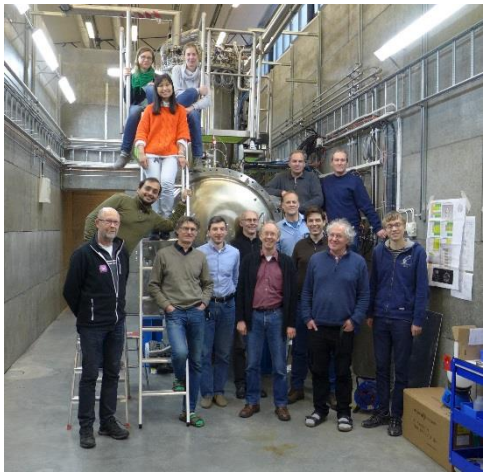




Test Facilities

What & Whom?

Facility for Research Instrumentation and Accelerator Development



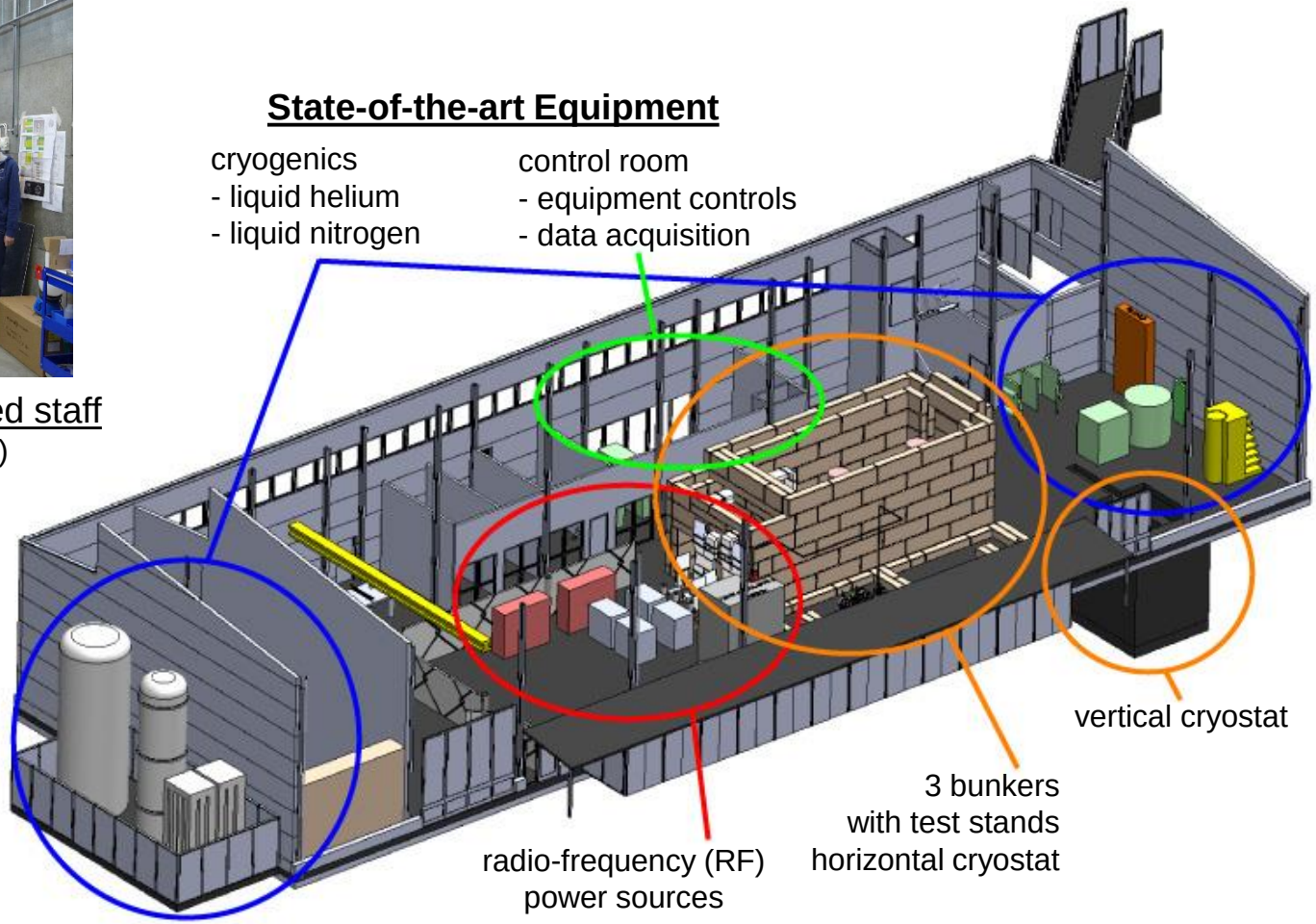
Competent and motivated staff
collaboration of physics (IFA)
and engineering (Teknikum).

Funded by KAWS, Government, Uppsala Univ.

State-of-the-art Equipment

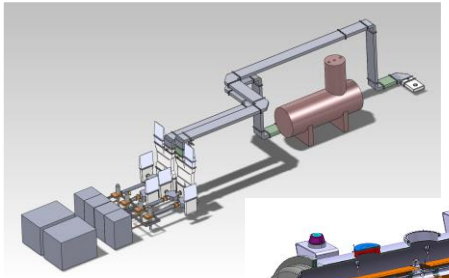
cryogenics
- liquid helium
- liquid nitrogen

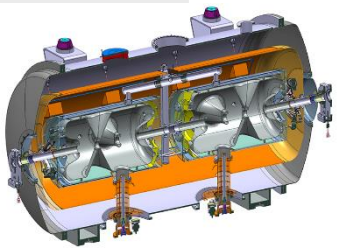
control room
- equipment controls
- data acquisition

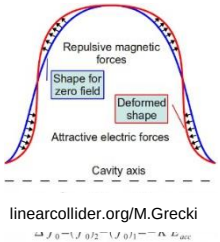


Overview of Activities

ESS Spoke Linac



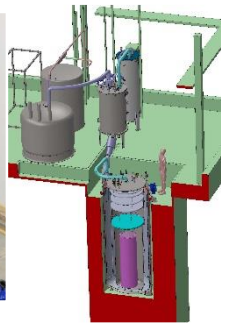




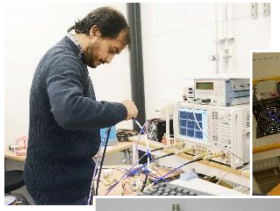
linearcollider.org/M.Grecki

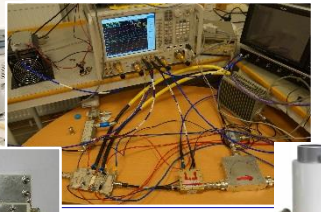
Cryogenics

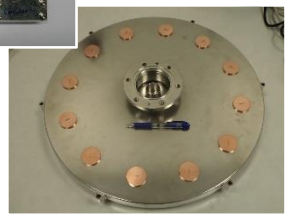
Cryo Test Stands



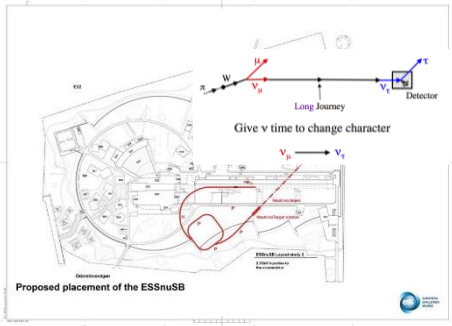
High Power RF Amplifiers Solid-state & Vacuum Tube



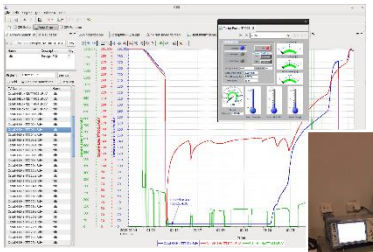




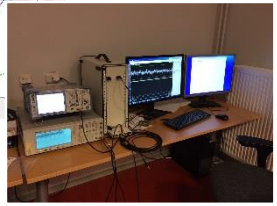
ESS neutrino Super-beam



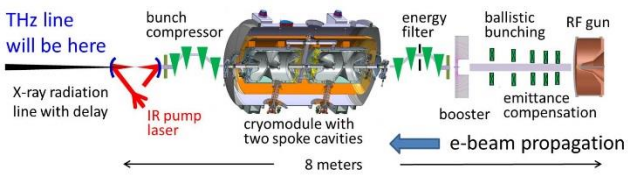
Controls & Data Acquisition



EPICS



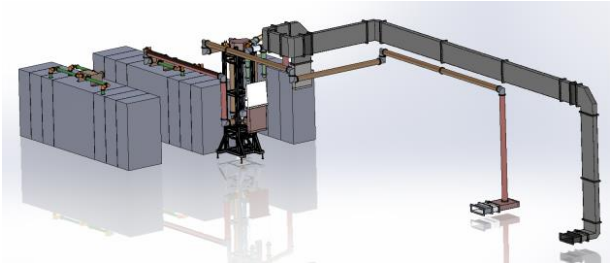
THz-FEL



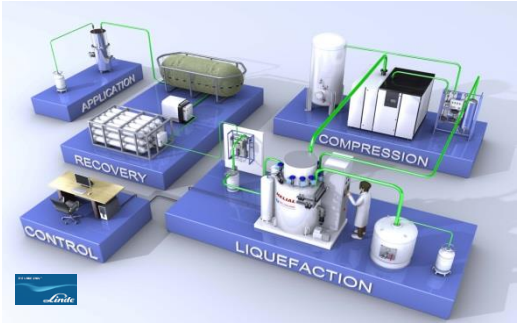
RF = Radio Frequency
SRF = Superconducting RF
FEL = Free Electron Laser

Horizontal SRF Test Stand

Three main subsystems:



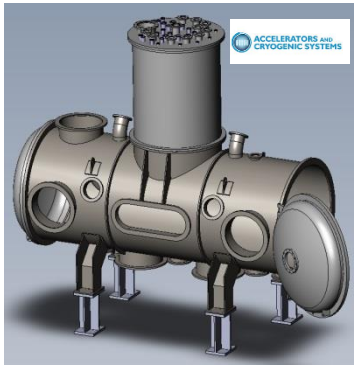
RF Power Source



Cryogenics

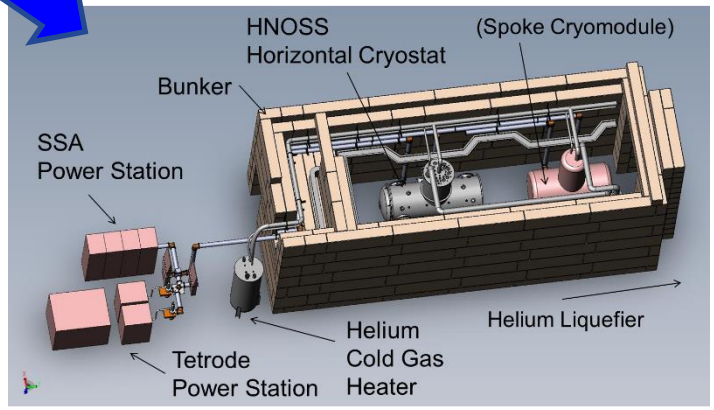
Courtesy of P. Duthil

SRF Cavity
(superconducting)

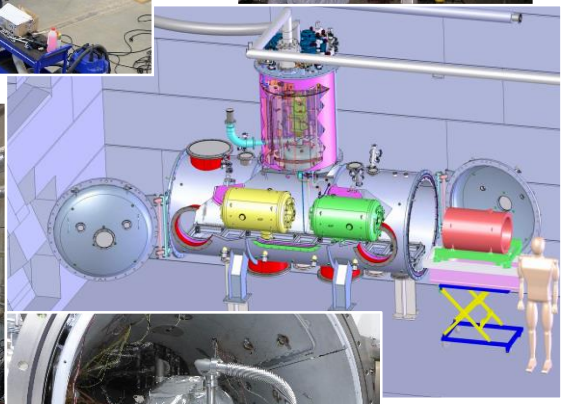


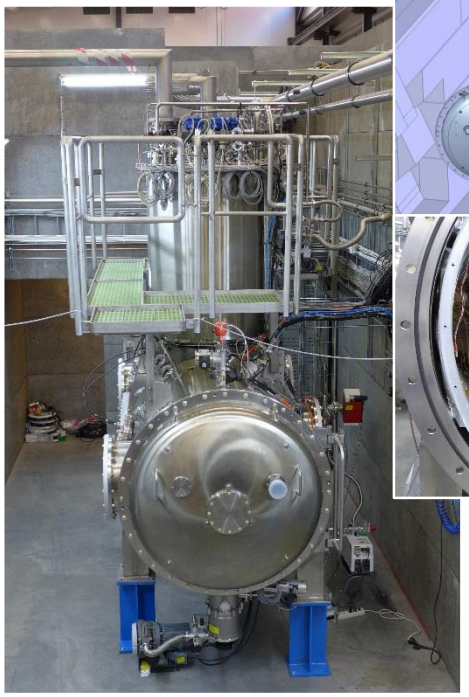
Horizontal Cryostat

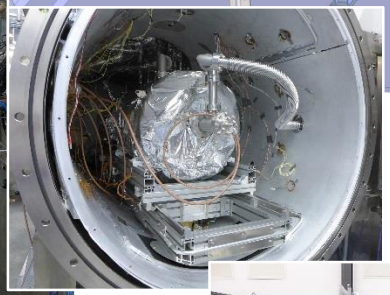
Implementation



HNOSS Cavity Test Stand

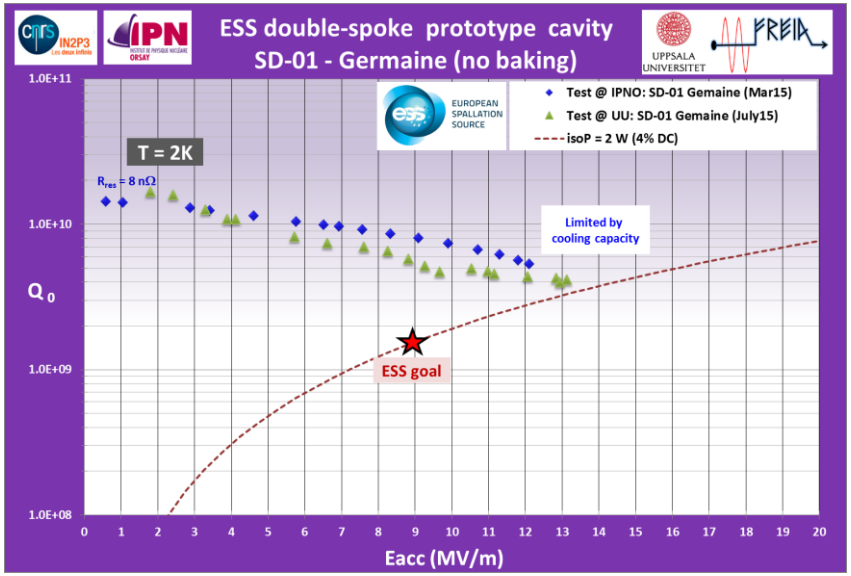






HNOSS: Horizontal Nugget for Operation of Superconducting Systems

- Horizontal cryostat
  - 3240 x ø1200mm inner volume
  - Valve box (on top of main vessel)
    - Distribute cryogens
    - 4K and 2K pots, JT-valve, heat exchanger
    - 5K supercritical helium
- SRF Spoke Prototype Cavity “Germaine”



High Power RF Amplifiers

352 MHz, 400 kW, 3.5 ms, 14-28 Hz

- Uppsala design
  - investigation and tube choice 2012
    - combine two water cooled TH595
  - design review December 2012
  - call for tender Spring 2013 & Fall 2014
- Itelco-Electrosys (Orvieto, IT)
  - installed and in operation
- DB Elettronica/DB Science (Padua, IT)
  - factory test next week

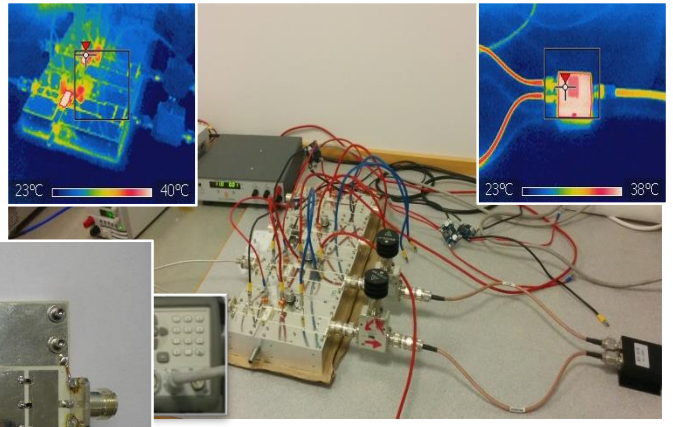
352 MHz, 50 kW, CW

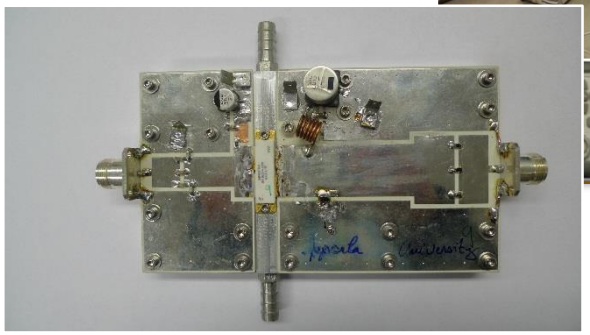
- CERN (loan since Feb.2015)
  - tube TH571b

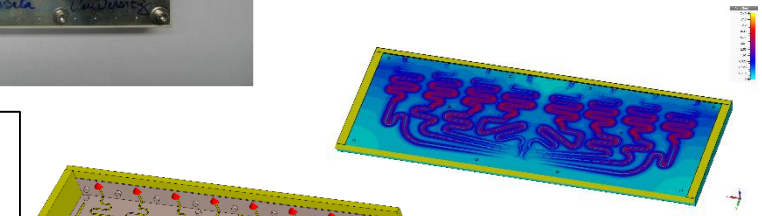
RF Development

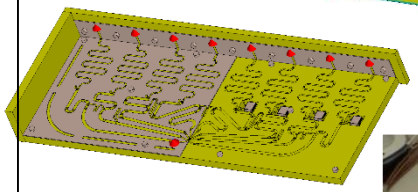
Solid State Amplifier

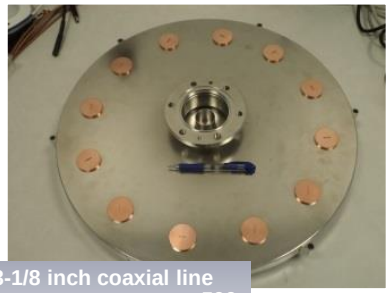
- transistor module optimization (efficiency)
- 100 kW compact combiner
- 10 kW planar gysel combiner

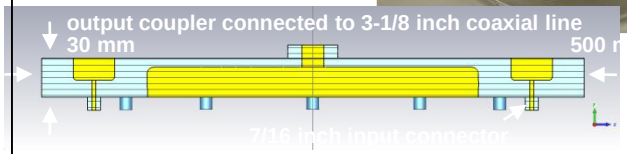


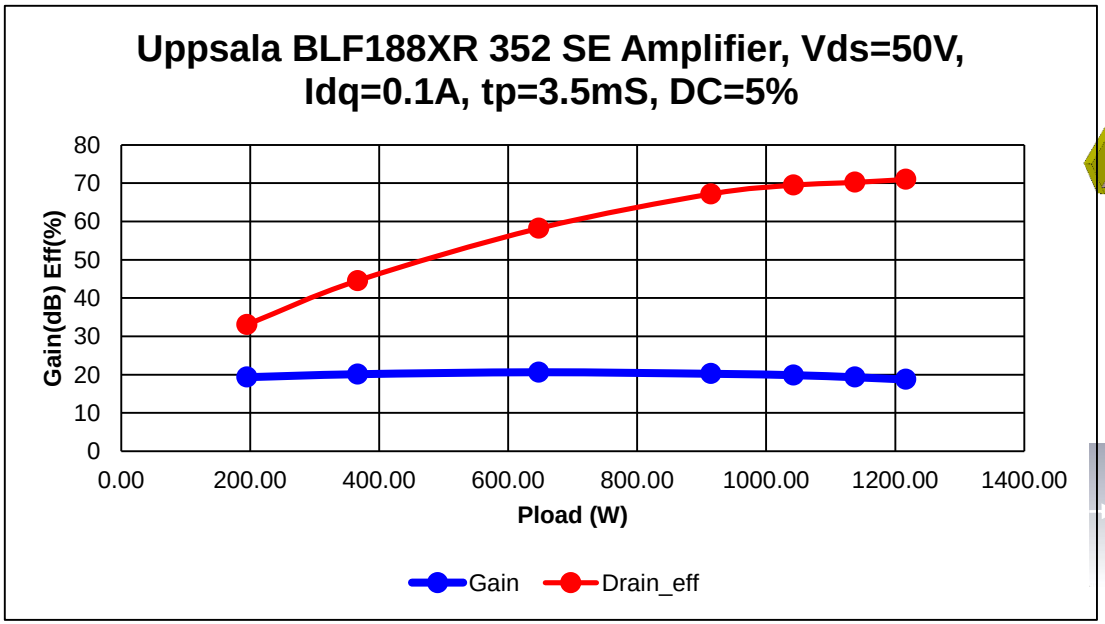








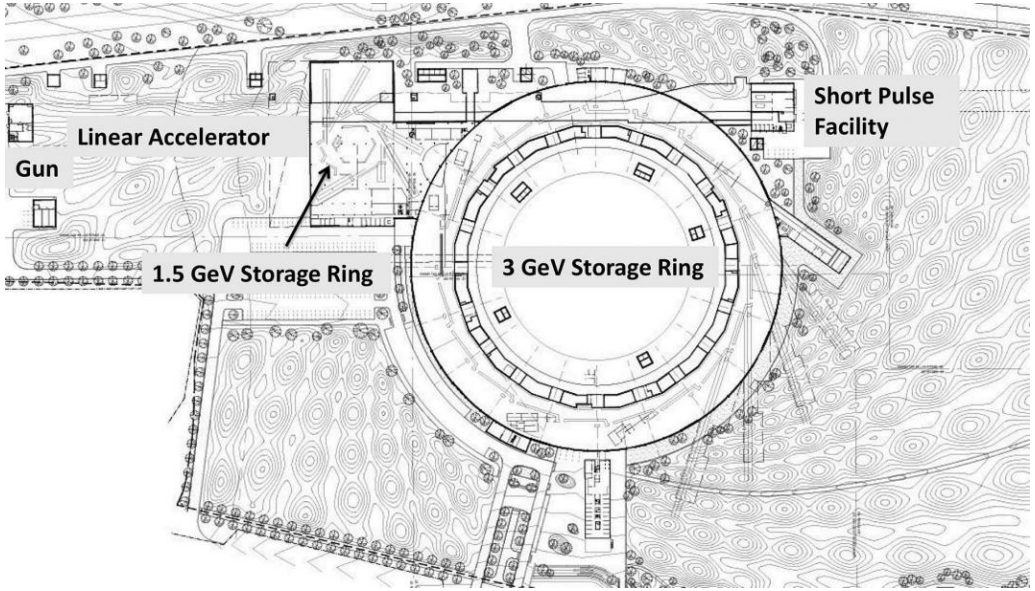




MAX IV Laboratory

MAX IV Accelerators

- **Linac**
  - continuous top-up
  - 3.7 GeV
  - ~300m length, 39 structures
  - bunch structure
    - 1 x 100 pC at 100 Hz
    - 10 x 3 x 100 pC at 10 Hz
- **3 GeV Storage Ring**
  - 528m circumference
  - 20 straight sections
  - 500 mA stored beam
- **1.5 GeV Storage Ring**
  - 96 m circumference
  - 12 straight sections
  - 500 mA stored beam



Summary and Info

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