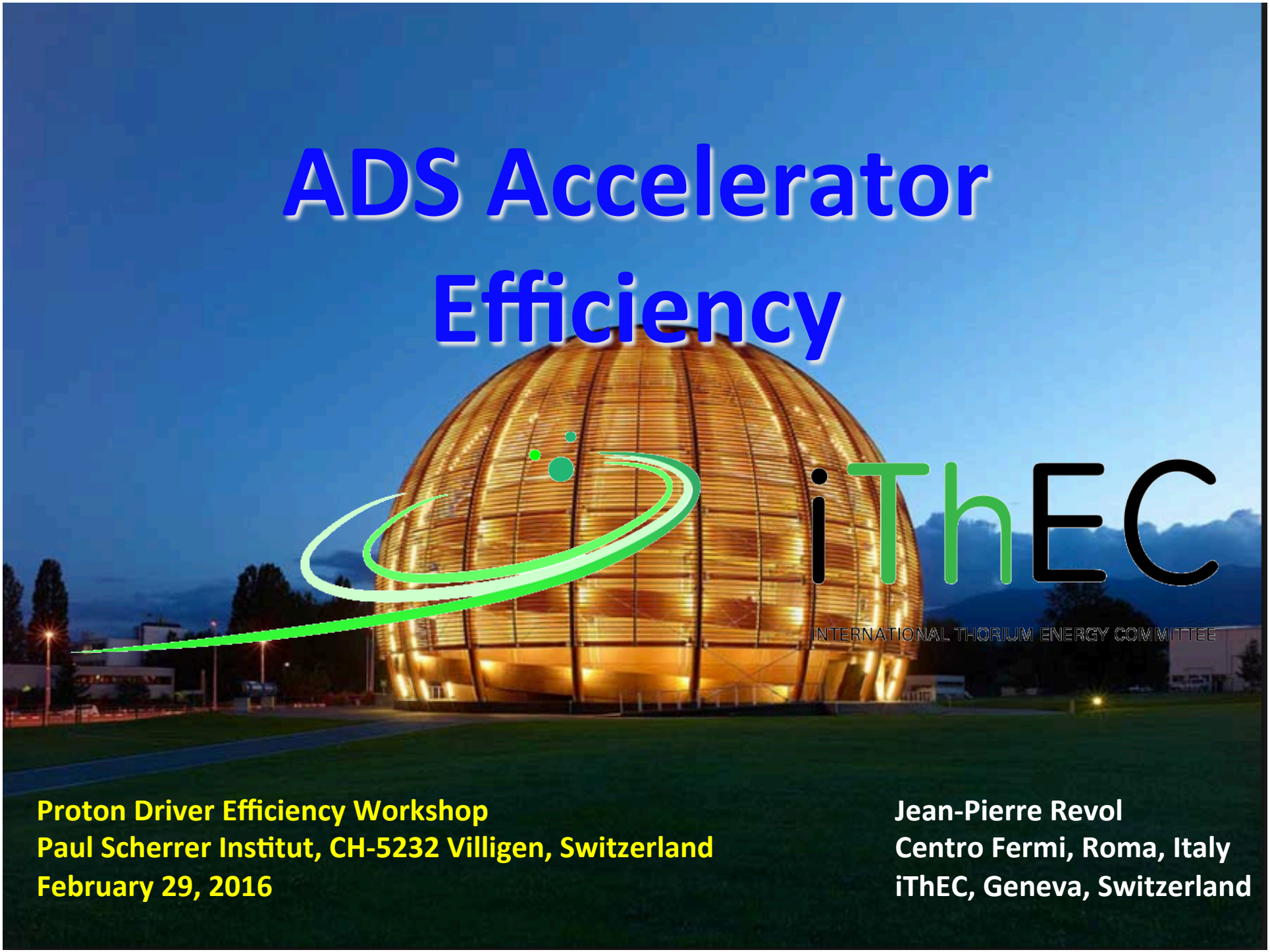
ADS Accelerator Efficiency



Proton Driver Efficiency Workshop
Paul Scherrer Institut, CH-5232 Villigen, Switzerland
February 29, 2016

Jean-Pierre Revol
Centro Fermi, Roma, Italy
iThEC, Geneva, Switzerland

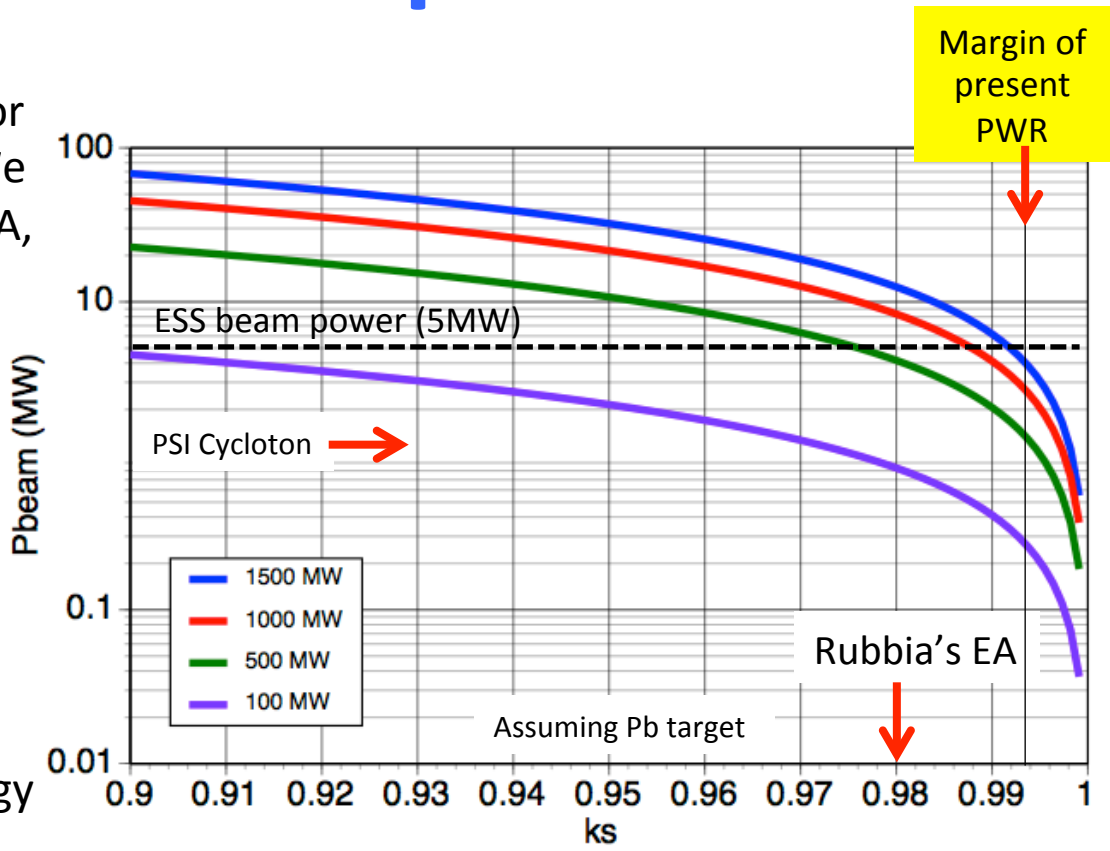
ADS Accelerator power

- Applications range from 50 MW_{th} for sea water desalination to 1000 MWe for electricity production. In the USA, SMR ≤ 300 MWe. Economics optimisation of ADS needed.

- The application defines the power output P_{ADS}:

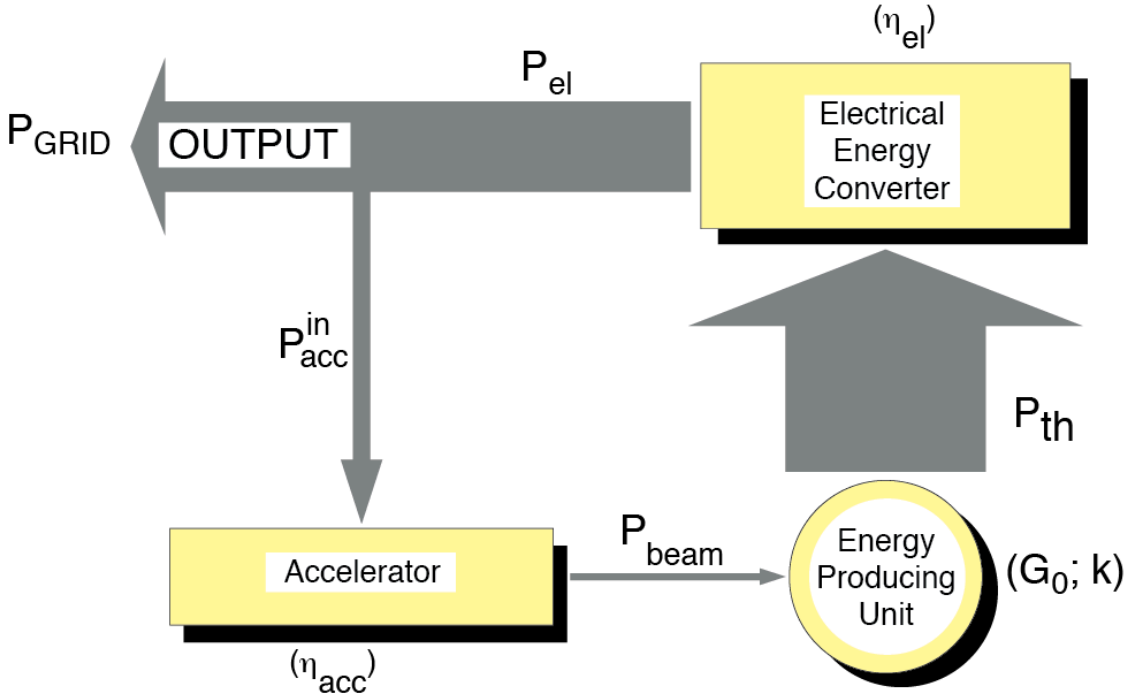
$$P_{ADS} = G \times P_{beam} = \frac{G_0 k_s}{1 - k_s} \times P_{beam}$$

- For a given power output, the energy gain *G* (choice of k_s and G_0) determines the accelerator power. **Trade-off between accelerator power and criticality margin**



$$P_{beam} = \frac{(1 - k_s)}{k_s G_0} P_{ADS}$$

ADS Accelerator Efficiency



Electric conversion efficiency

$$P_{el} = \eta_{el} \times P_{th}$$

Energy gain in core

$$P_{th} = P_{beam} \times \frac{G_0 k}{(1-k)}$$

Running the accelerator

$$P_{beam} = \eta_{acc} \times P_{acc}^{in}$$

$$P_{GRID} = P_{el} - P_{acc}^{in} = P_{beam}\left[\frac{\eta_{el} G_0 k}{1-k} - \frac{1}{\eta_{acc}}\right]$$

Electric power produced

Electric power to run the accelerator

ADS Accelerator Efficiency

$$P_{GRID} = P_{beam}\left[\frac{\eta_{el} G_0 k}{1-k} - \frac{1}{\eta_{acc}}\right]$$

For a typical ADS (Rubbia) the first term is of the order of 50

- The electric power to run the accelerator must be small compared to the power produced in the ADS core:

$$\frac{1}{\eta_{acc}} << 50 \Rightarrow \eta_{acc} >> 0.02$$

- Minimum is $\eta_{acc} = 0.2$, but $\eta_{acc} = 0.4$ should achievable and in that case the accelerator takes only 5% of the electric power produced by the ADS, which seems reasonable
- For very high power beams (≥ 10 MW), every MW saved matters, and it is useful to have the highest possible accelerator efficiency, if it does not compromise other properties (cost, reliability, etc.)