CT for secondary particle monitoring

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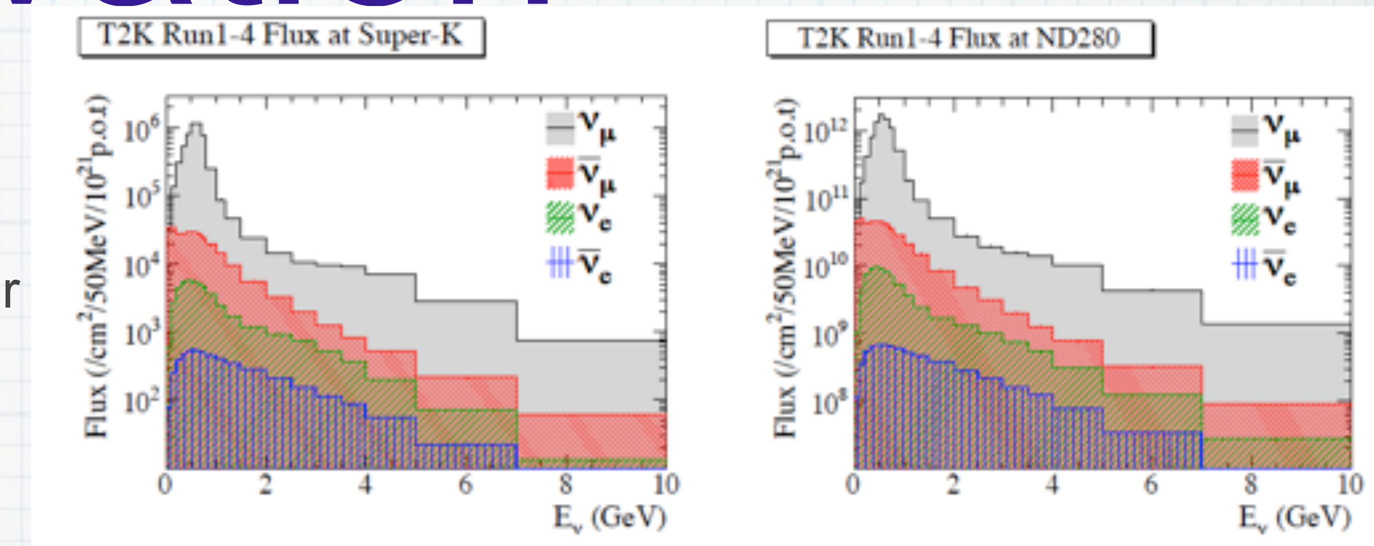
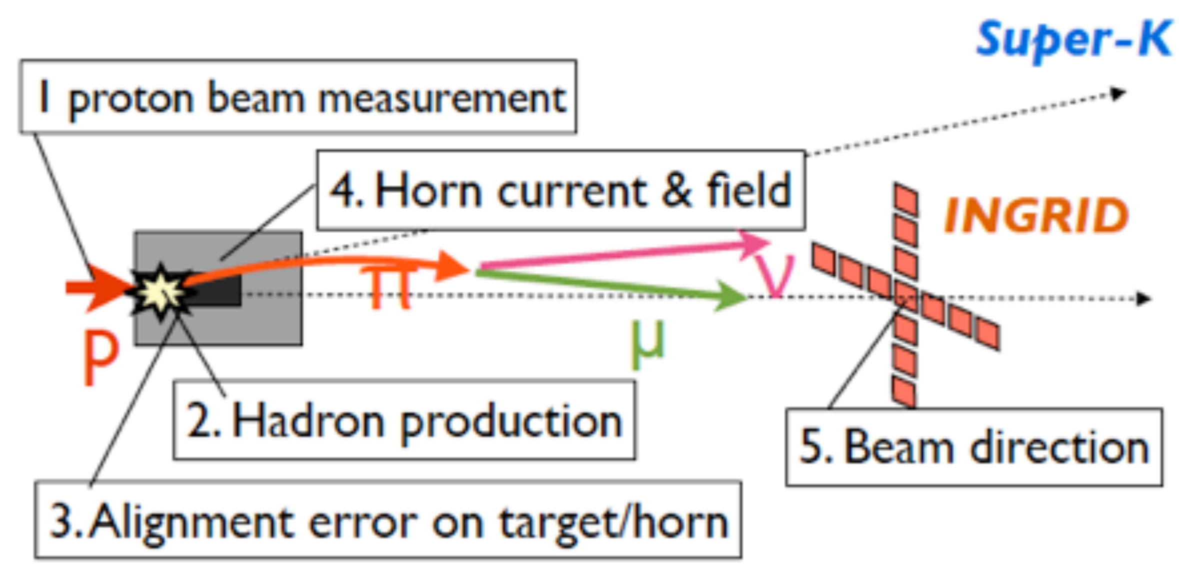
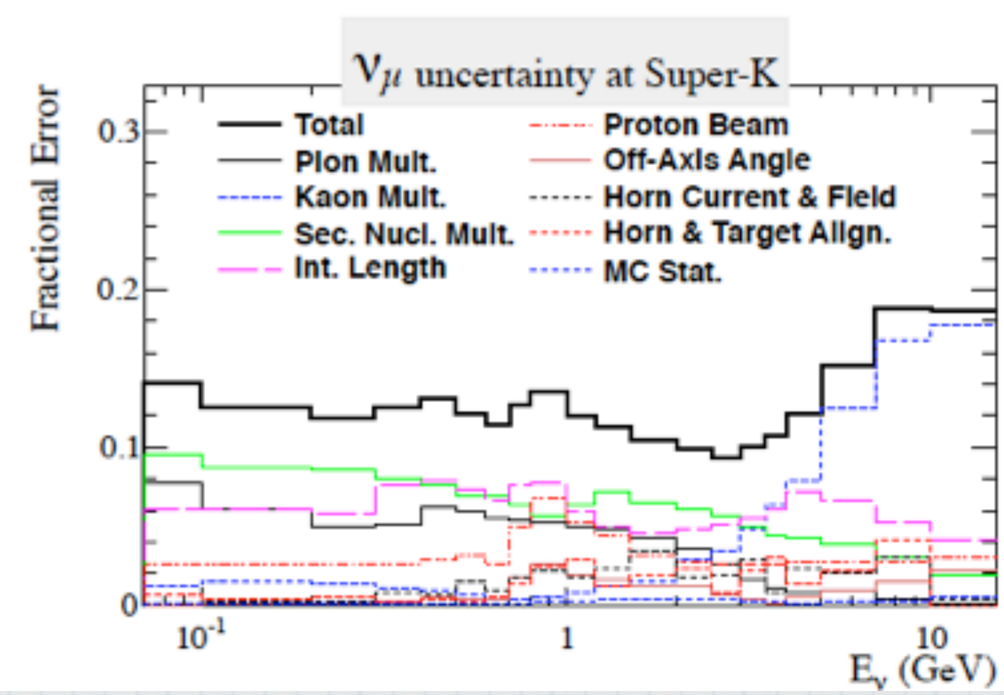
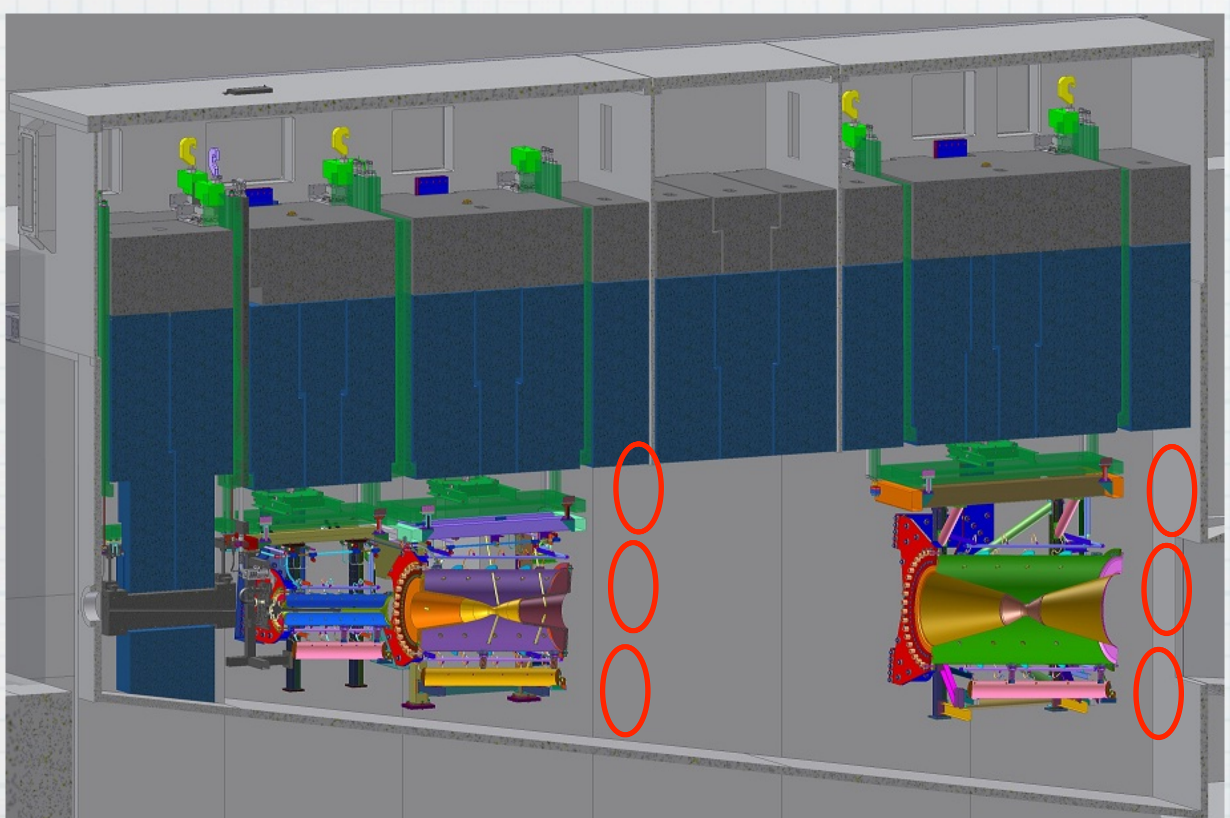
Motivation

* We want to increase the beam monitor for targeting.
    * To reduce the beam flux uncertainty.
    * To check the proton beam hitting the center of of target/horns.
        * Asymmetric heat load is severe for target.
* Independent measurement from MUMON/Near Detector..
    * MUMON: muon > 5 GeV
    * ND: Limited statistics in short period.
* New idea: Putting CT in Target station.



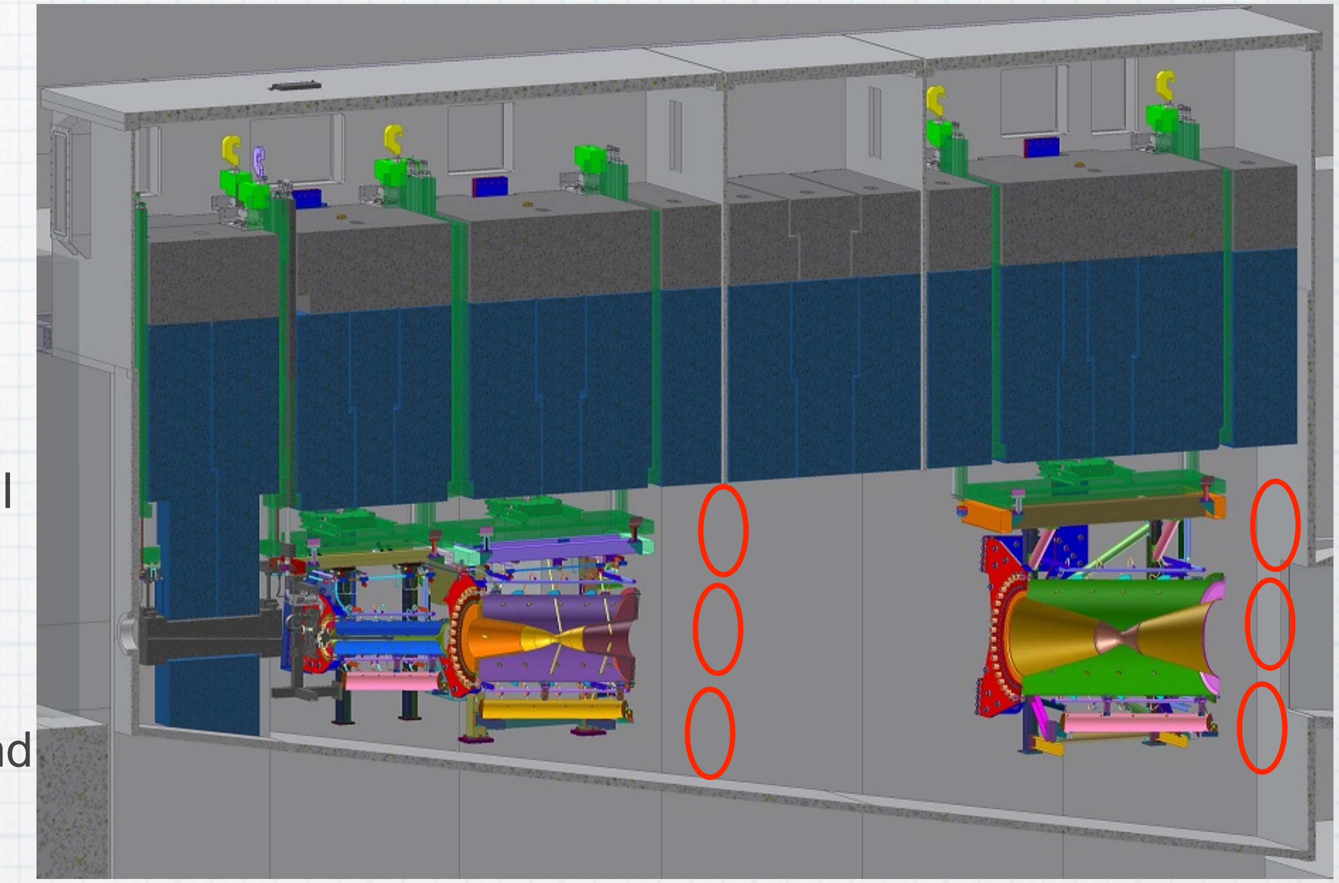


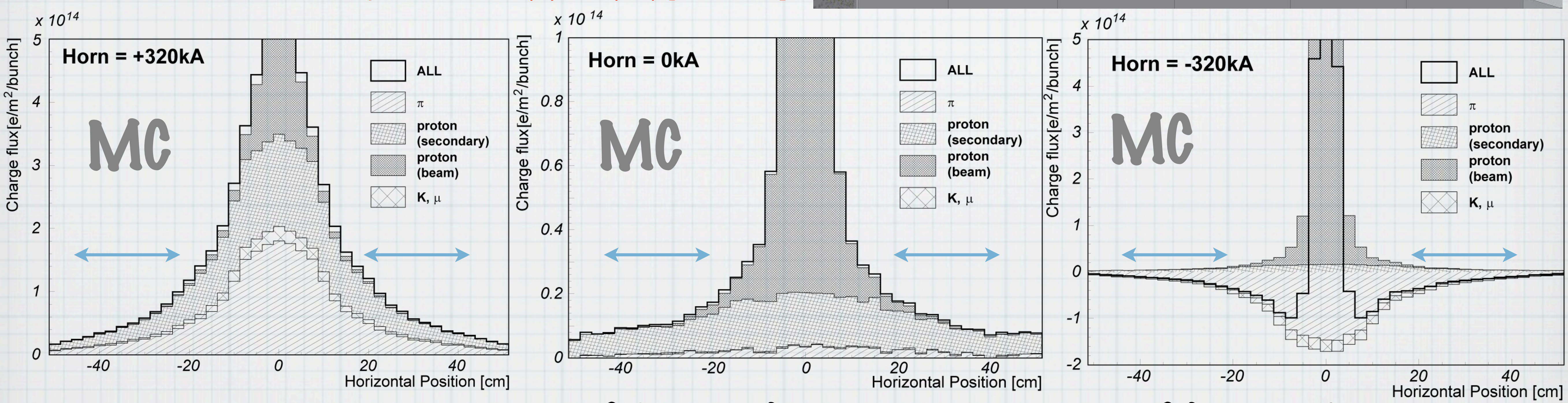




Conceptual design of CT for secondary beam-line.

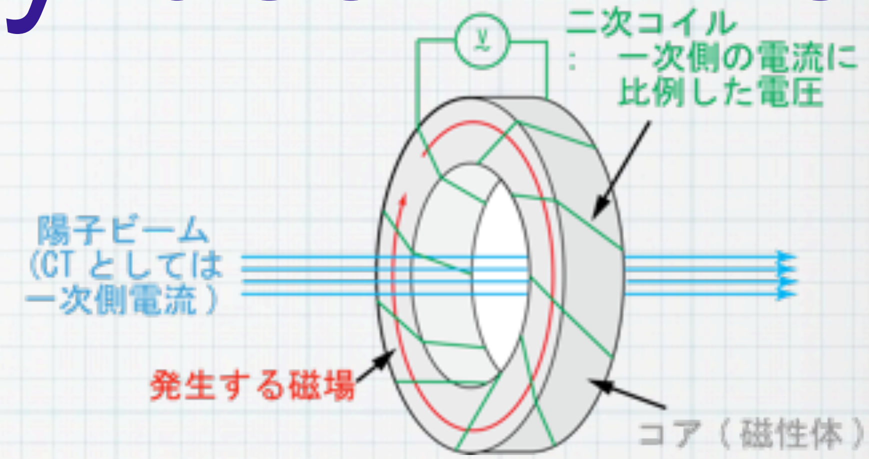
- Put array of CTs at the secondary line:
  Measure current profile difference between positive particle flux and negative flux:
- Interesting region: 20-40cm from beam axis:
  - horn +320kA: π+ and proton is dominant
  - horn +0kA (off): proton is dominant.
  - horn -320kA: π- is dominant.
- By combining the hadron production data (NA61), it will gives the constraint for ν beam flux.
- Expected current density: 0.1〜1[10^{14}e/m^2/bunch]
  - Assuming 750kW beam with 60ns bunch width and
  - If active area is φ200mm、O(1)〜O(10) [A/bunch]



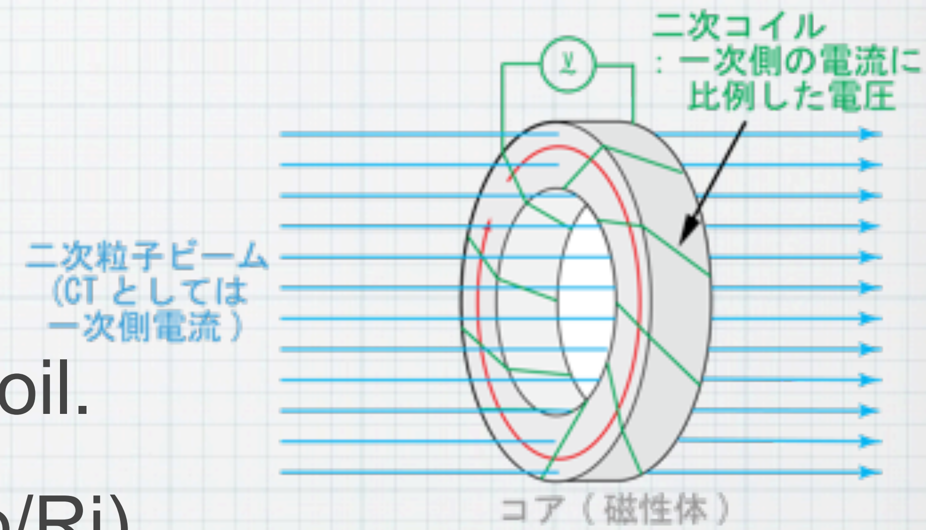


“Beam current” profile at the downstream of horn-3.

Note for CT in secondary beam-line

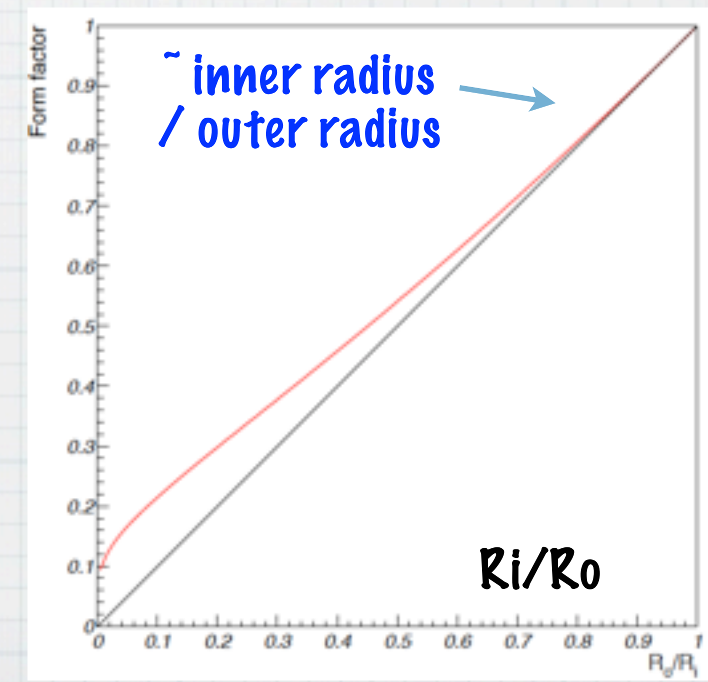


- Difference from usual CT (ex. primary proton intensity monitor)
  - CT size is smaller than “beam size”: Beam current density is non-zero at core/coil.



- Ratio of current trans formation(=G): Output current / input current:
  - Usual CT: $G_0 = 1/N$
    - N: Number of the turn of the secondary coil.
  - Secondary CT: $G = 1/N \times \{1-(R_i/R_o)^2\}/2\ln(Ro/Ri)$
    - Uniform current density is assumed.
    - Ri: Inner radius of the core.
    - Ro: Outer radius of the core.
- Form factor: G/G_0 is ~ Ri/Ro for Ri/Ro ~ 1.

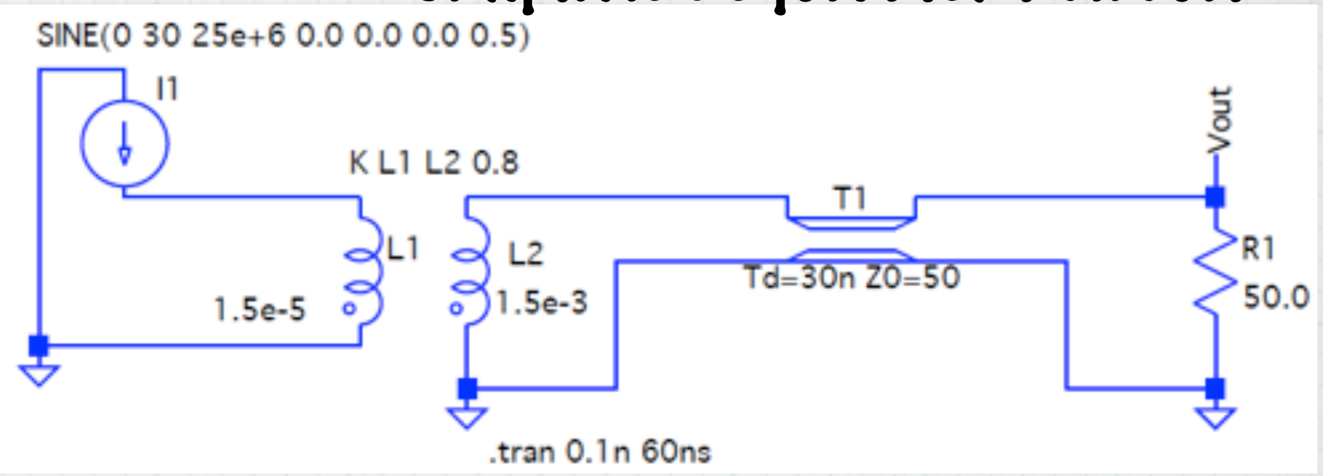
Form factor: G/G_0



Component of secondary beam-line CT

- Core material: FINEMET® (Hitachi Metals)
  - Same material as J-PARC primary proton beam monitor
- Catalogue products: FM-3KM F200160 (Ro=200mm, Ri=160mm) ... AL: ~15 [μH/turn^2] @ 100kHz
- "Expected beam current": 0.01 ～ 10A
  - Min: p-beam: 4×10^{12}[p/bunch], bunch width = 60ns, horn off.
  - Max: p-beam 4×10^{13}[p/bunch], bunch width = 60ns, horn=+320kA
- If N_turn = 20, 50Ω readout, output voltage is 100mV～100V.
  - Amplification/attenuation is necessary.

Simplified equivalent circuit



Requirements for CT assembly.

* High radiation environment:
  * Use non-organic material only.
    * Insulation of signal cable from out side is key of design.
  * Cooling may be necessary.
    * Energy deposit by secondary particles is non negligible.
* Contained by chamber.
  * We afraid the contamination of the area by the fragment when it is degraded/broken.
* Remote maintenance for exchange should be prepared.
  * The moving mechanism to evacuate from the beam-line may be necessary.

The prototype design

* The prototype to check the mechanical structure, the signal response and the cooling capability is under preparation.