TREATMENT FACILITY OPTIMISATION

OMA 1st topical workshop

PSI, 13-3-18

Andrea De Franco

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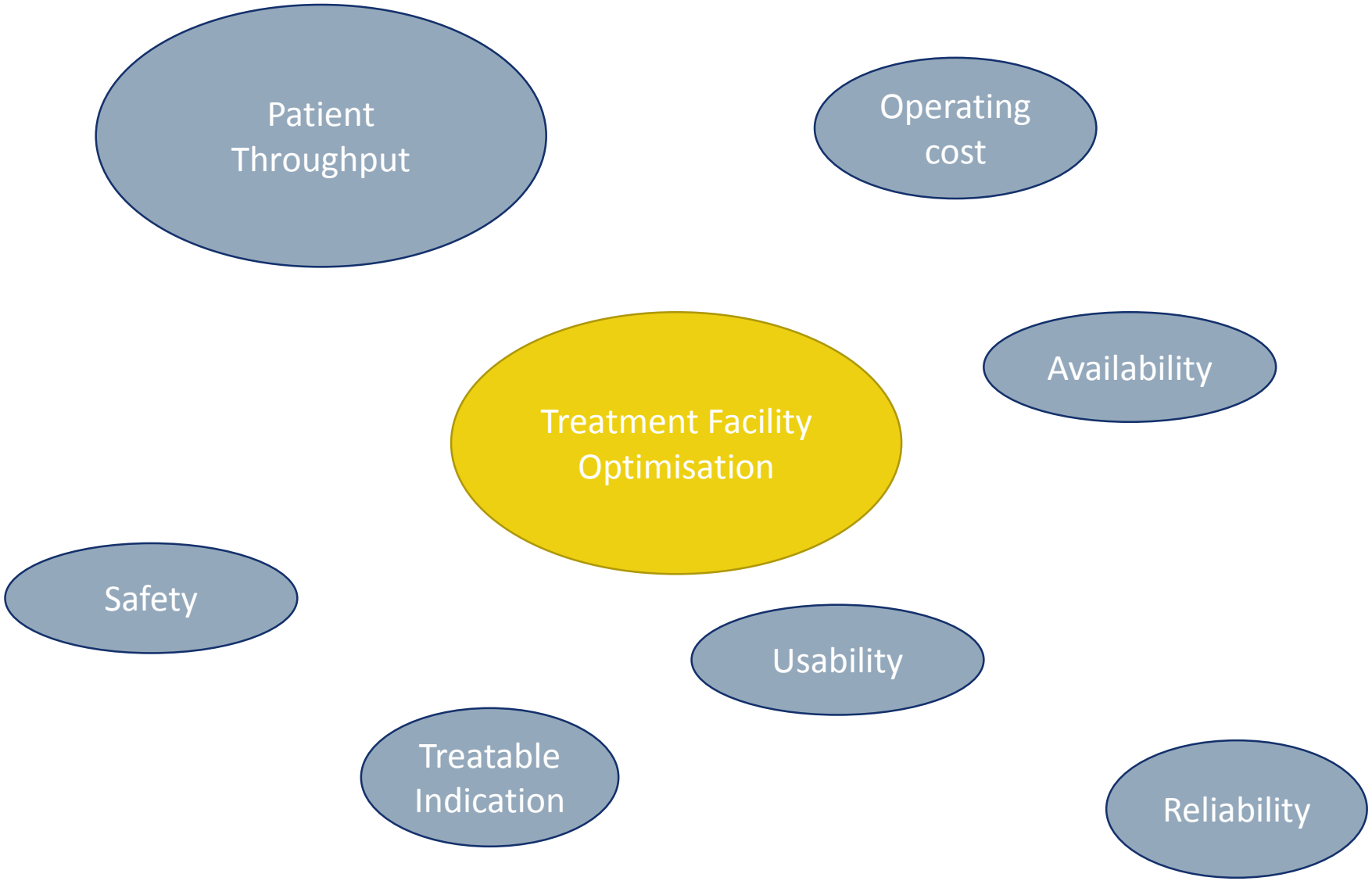
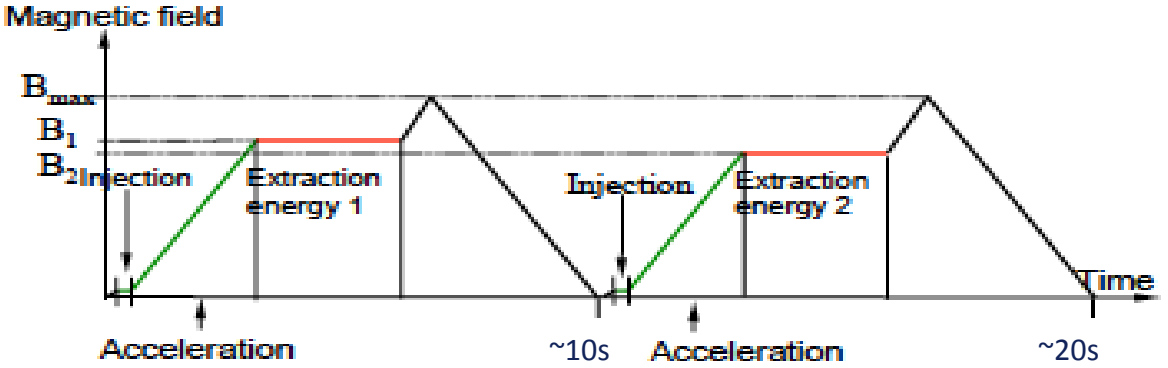

Patient Throughput
Operating cost
Treatment Facility Optimisation
Availability
Safety
Usability
Treatable Indication
Reliability

Synchrotron – pencil beam. MedAustron

Proton: 60 – 250 MeV (NCR: 800)
Carbon: 120 – 400MeV/u

Machine Operation

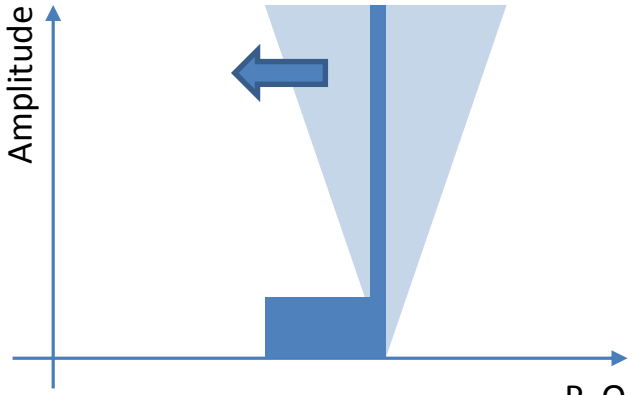


Proton: 60 – 250 MeV (NCR: 800)
Carbon: 120 – 400MeV/u

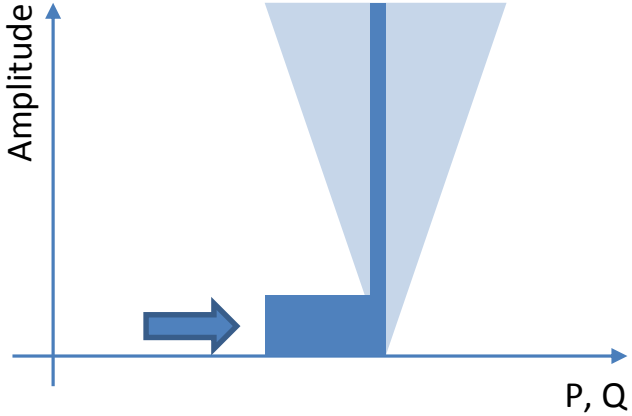
3rd Order Resonant Slow Extraction

Wrong way to use resonances:
Tacoma Narrows Bridge example

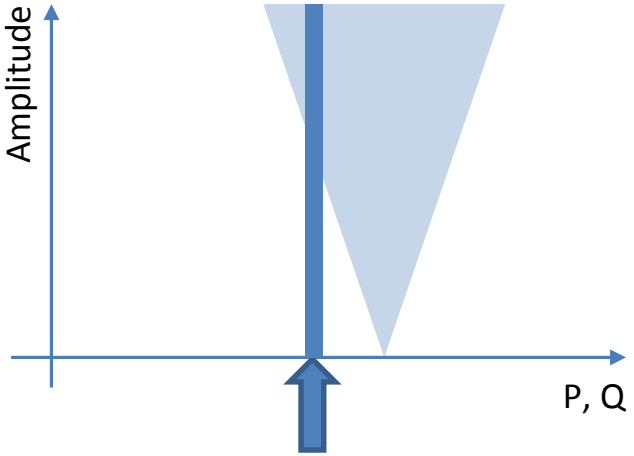
Change Condition of Resonance



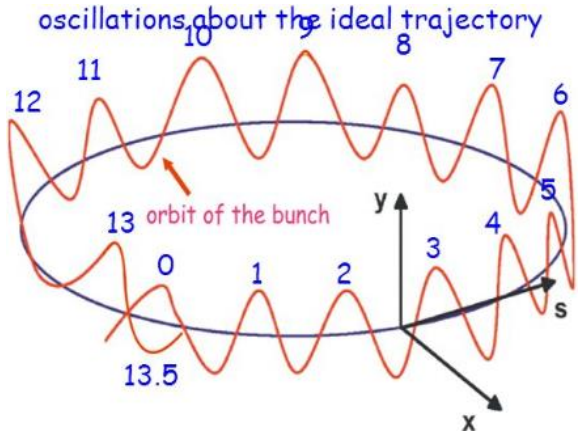
Increase Momentum



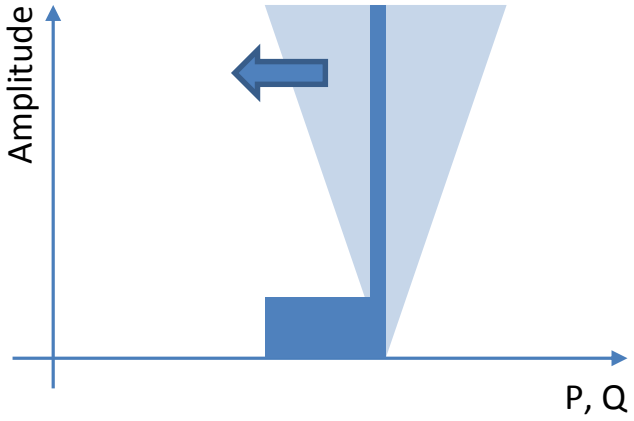
Increase Oscillation Amplitude



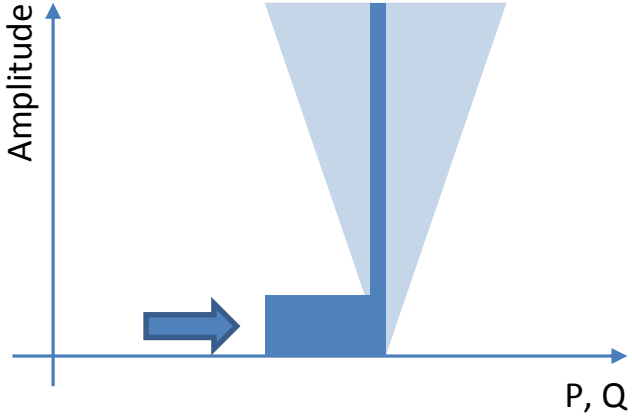
3rd Order Resonant Slow Extraction



Change Condition of Resonance



Increase Momentum



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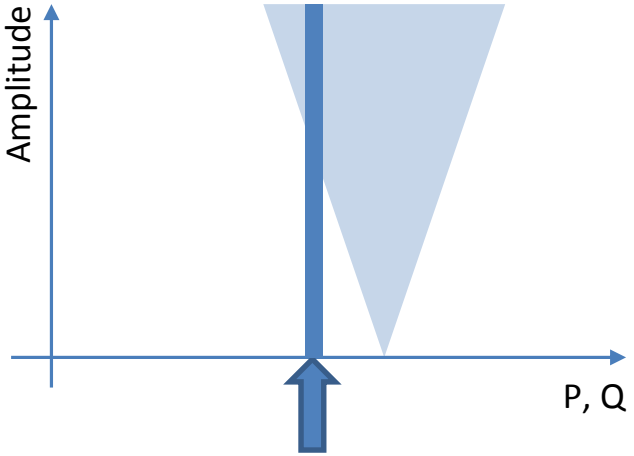

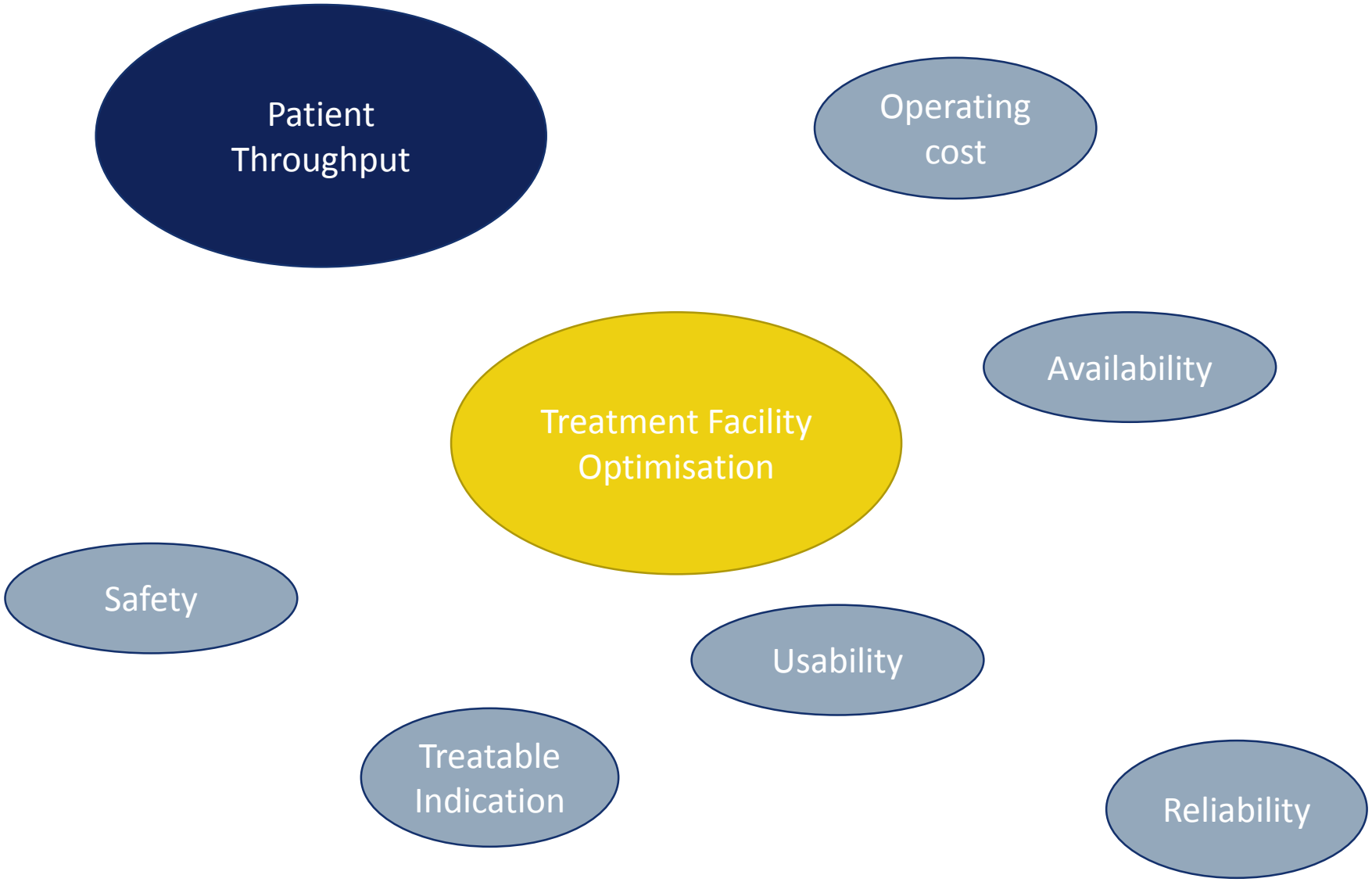
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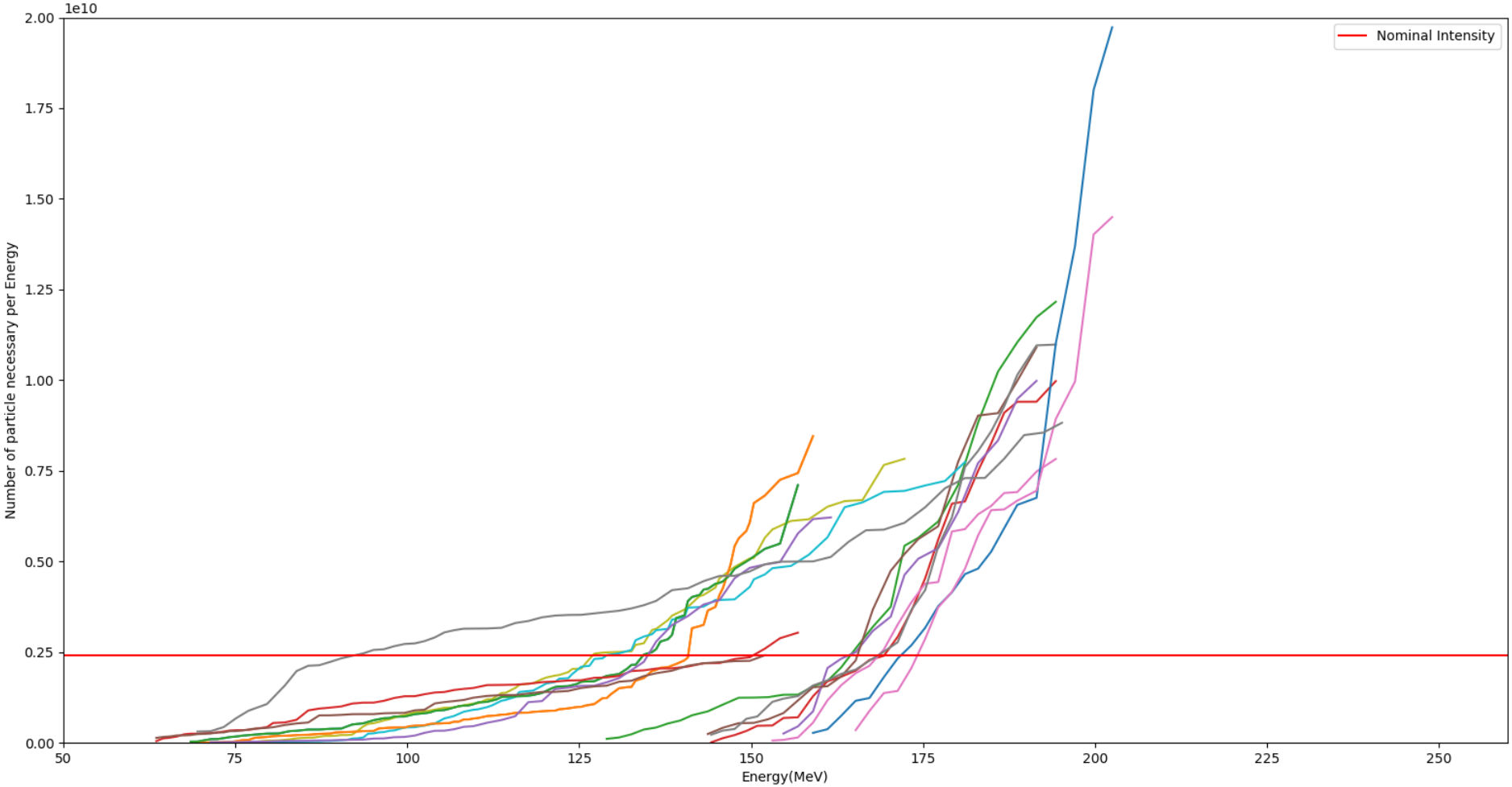
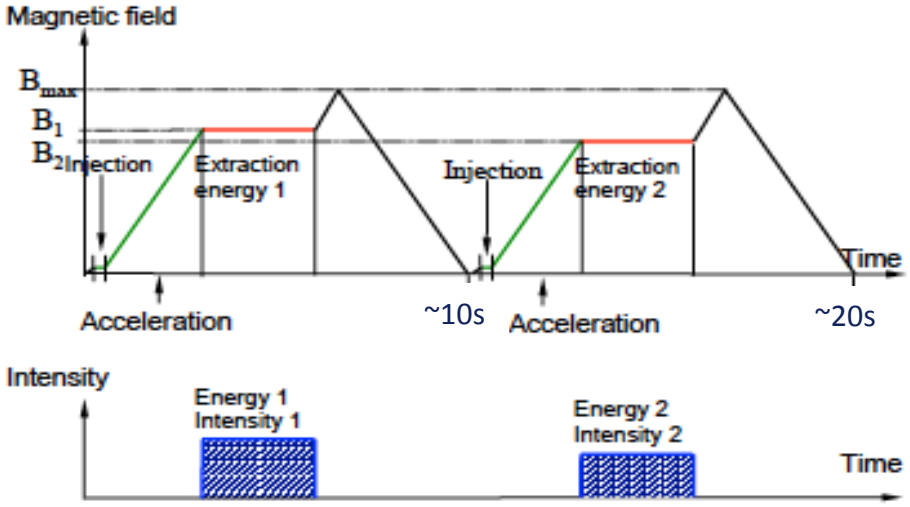
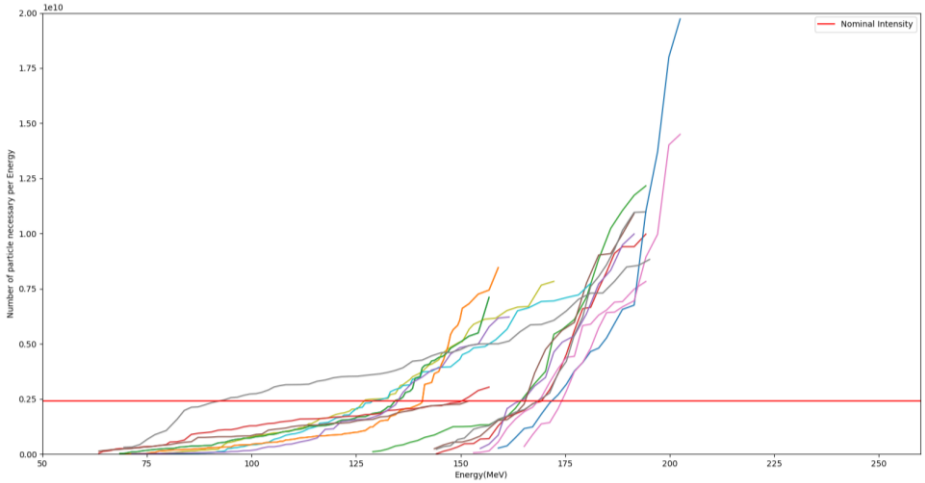
Particle Energy Distribution



Indications treated with proton (3 prostate, 1 head, 1 nasal, 1 paranasal, 1 paraspinal)

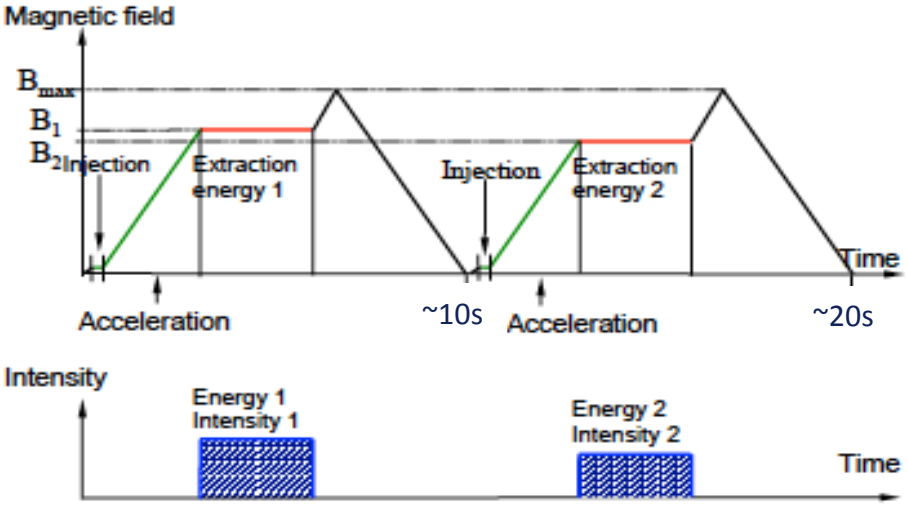
What can we do?

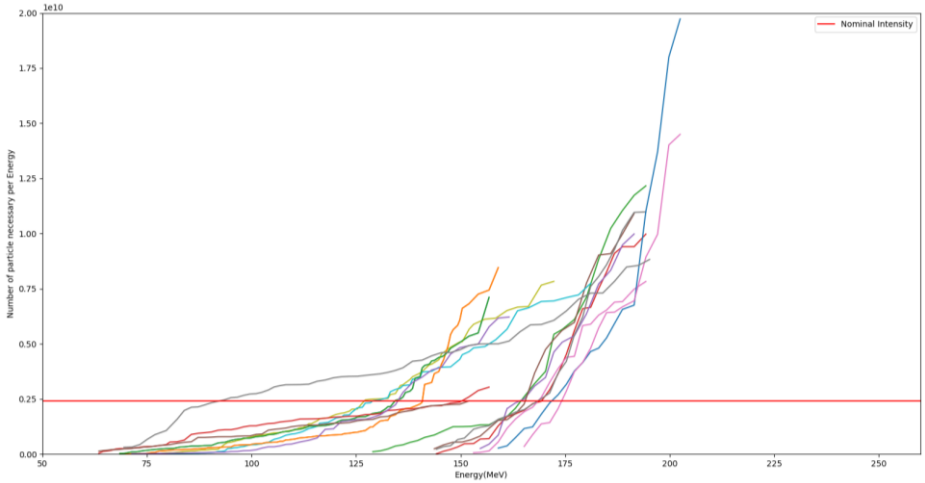




- Dynamic cycle shortening
- Remove B-field “chimney”
- Higher Intensity
- Multi energy cycles

What best to do?





Upgrade	Beam delivery time
Higher intensity (HI)	98%
Magnetic field regulation (MF)	84%
Cycle Abort (CA)	61%
Multi energy spills (ME)	23%
MF + HI	82%
CA + HI	51%
CA + MF	45%
ME + MF	20%
ME + HI	7%

De Franco et al., proceedings of IPAC17

Remove B-field "chimney"

i.e. active magnetic field regulation

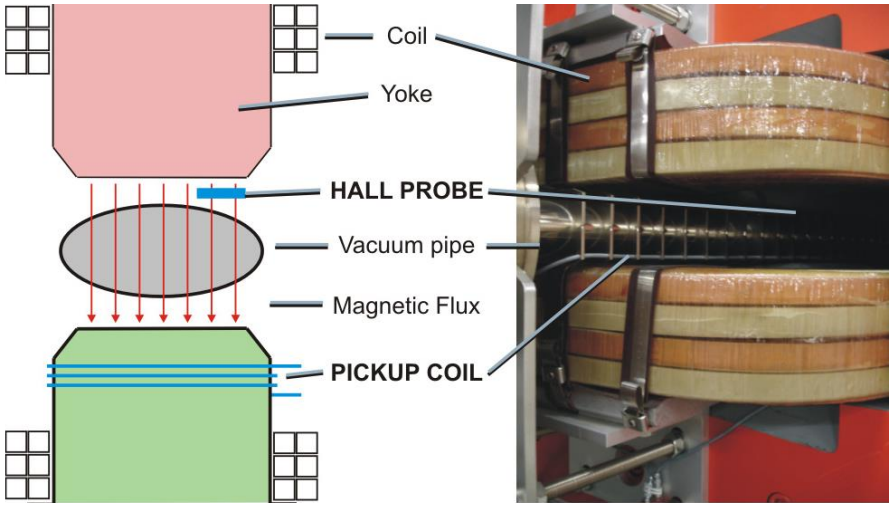


Fig: E. Feldmeier et al., proceedings of IPAC10

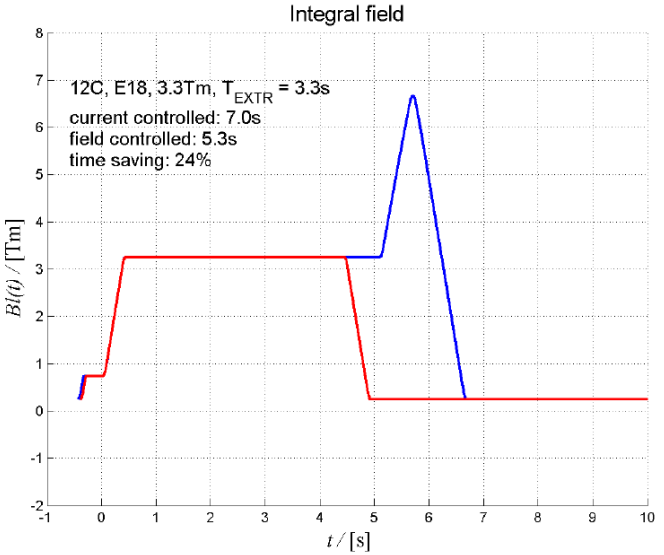


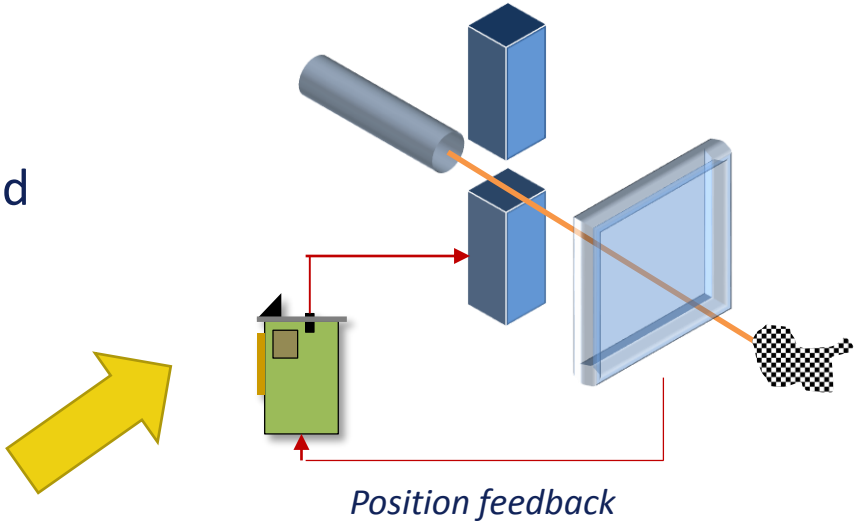
Fig: E. Feldmeier et al., proceedings of IPAC12

Challenges:

- Relative accuracy < 10^{-4}
- Fast changing field ≥ 1T/s
- Quadrupoles, Sextupoles

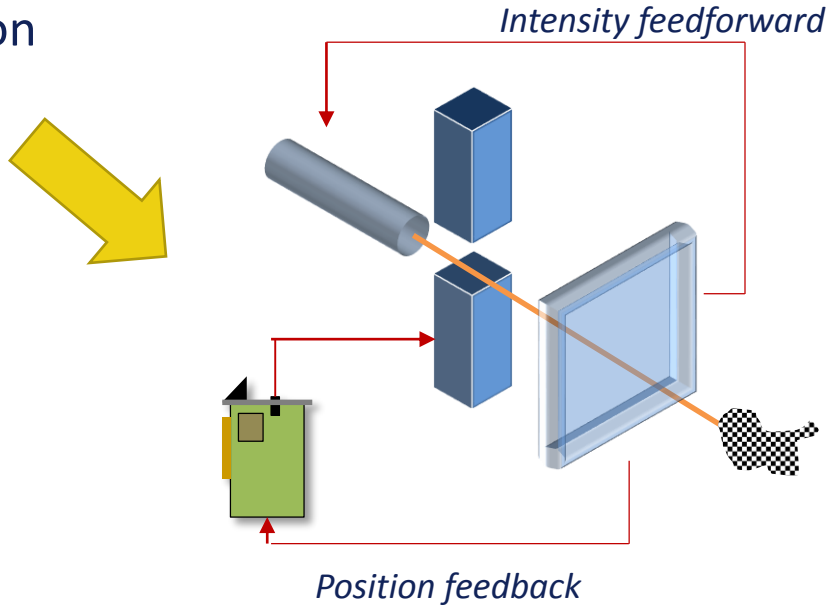
Higher Intensities

MedAustron operating intensity artificially limited to 20% of its capability

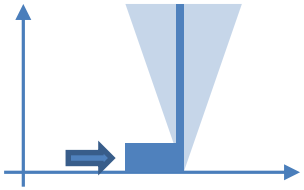


Challenge:

- Dynamic range in a slice
- Dose position verification
- Termination time



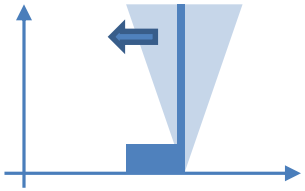
Intensity Modulation



Betatron core → too slow

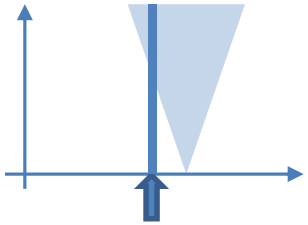
RF cavity :

- can be too fast (hazard)
- Synchrotron motion to be treated with care (spillage after termination, spill ripples, etc.)



Air core quadrupole:

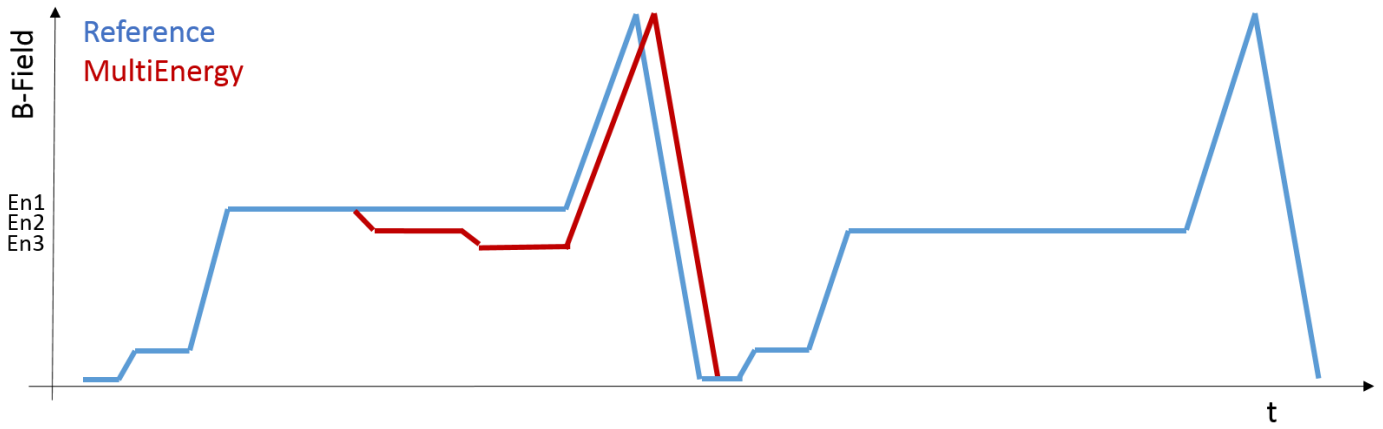
- Can be too fast (hazard)
- Change also Chromaticity (dp/p) & Vertical tune (be careful!)
- Intensity ripples prone (without feedback)



RF-KO:

- Can be too fast (hazard)
- Spillage after termination

Multi Energy Cycles



Challenges:

- Minimise beam losses
- Decrease energy → emittance growth (bigger beam)
- Going both direction → B-field regulation prerequisite

Reacceleration - Extraction

Unbunched beam:

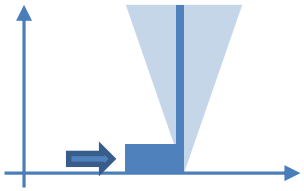
(a) re-capture (lossy)

(b) Empty bucket phase space displacement (dp/p growth)

Bunched beam:

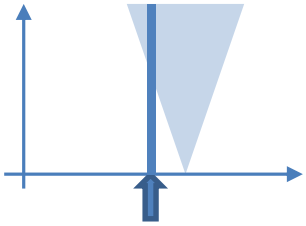
easy peasy

Betatron core, consider different extraction



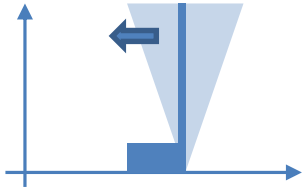
RF driven, watch out for sync motion

Why??

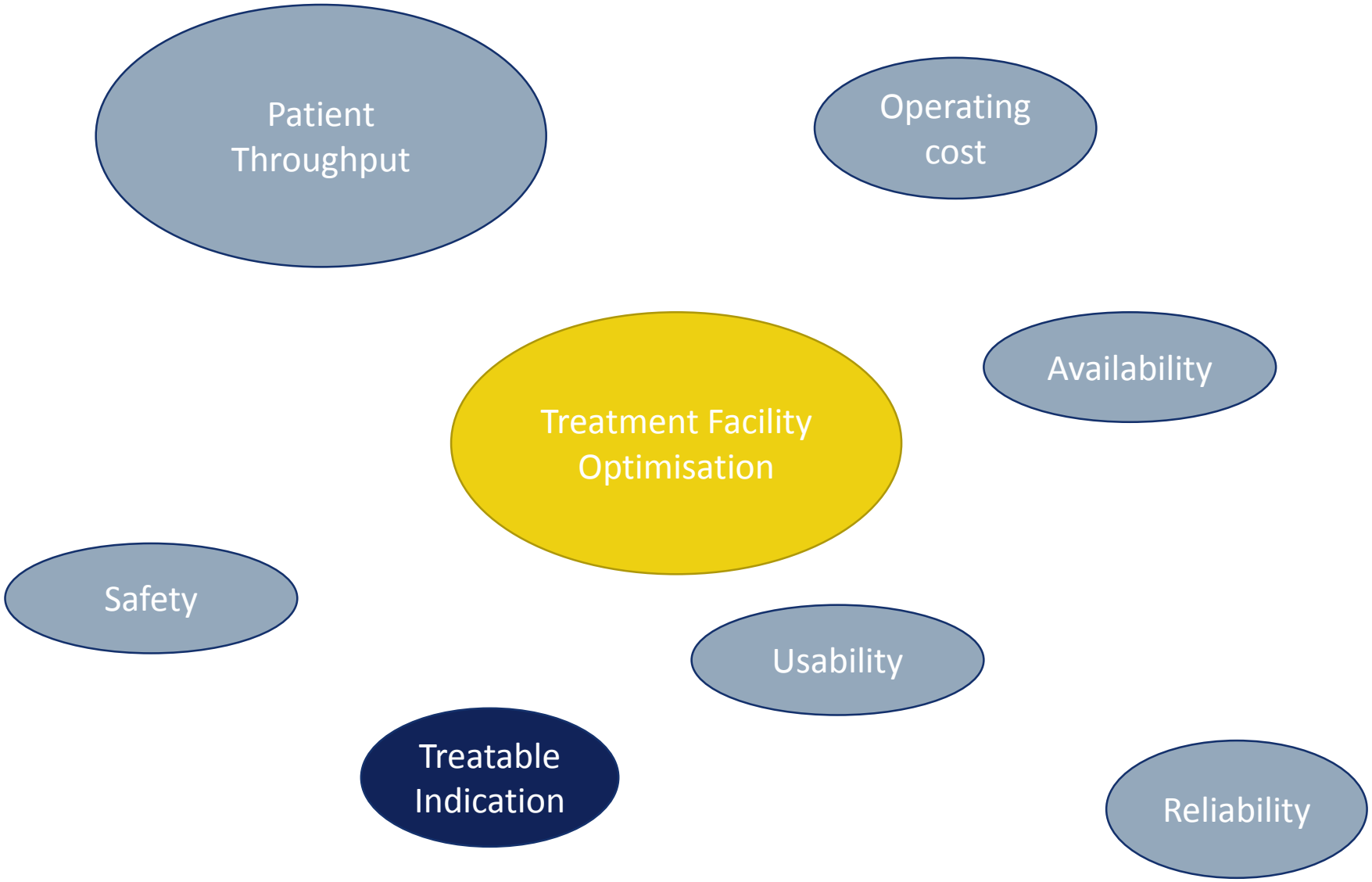


RF-KO, watch out for sync motion.

You like challenges…



Air core quadrupoles.
Everything is moving: watch out long & transv in both planes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Moving Targets

Additional challenges for Synchrotrons…

Gating:

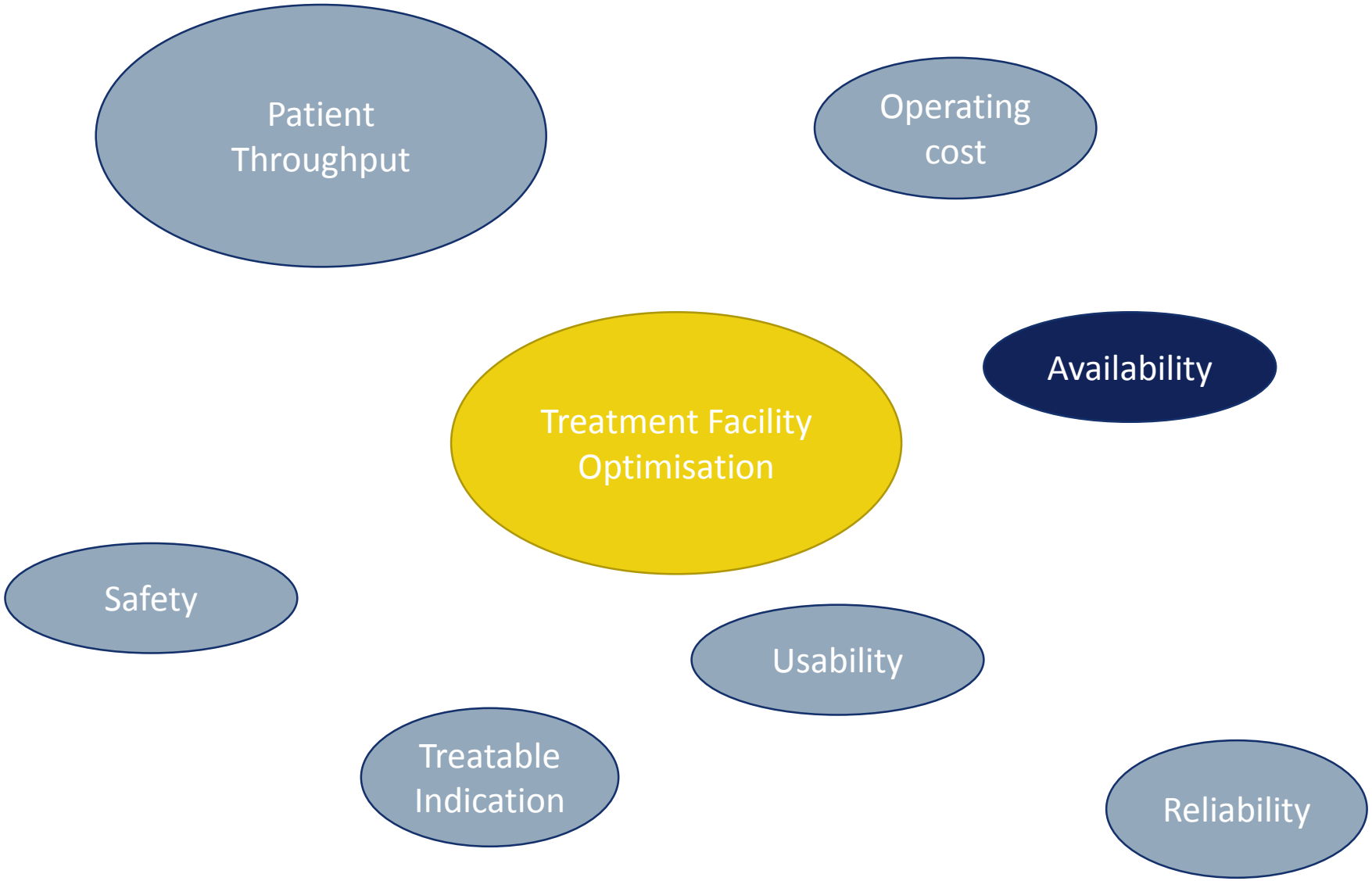
Stop/Start quickly beam without losses.

Not a big deal unless you have a Betatron core, which is slow.

Volumetric rescanning:

like Multi Energy cycles…but very fast

Going up/down in energy requires magnetic field regulation an ALL magnets(Quad, Sext, Correctors…)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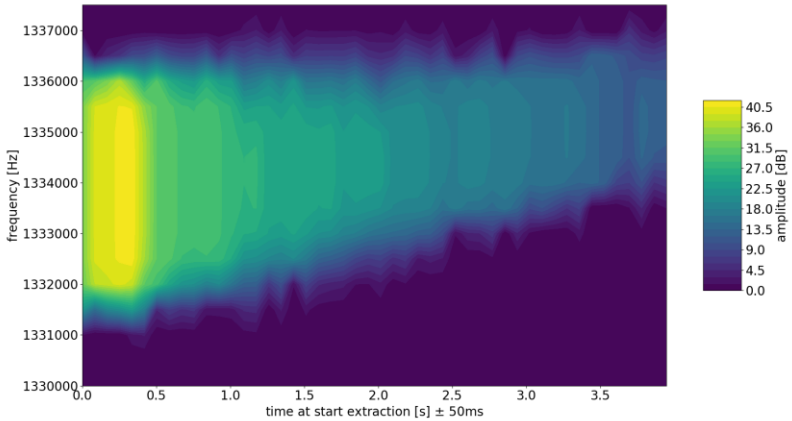
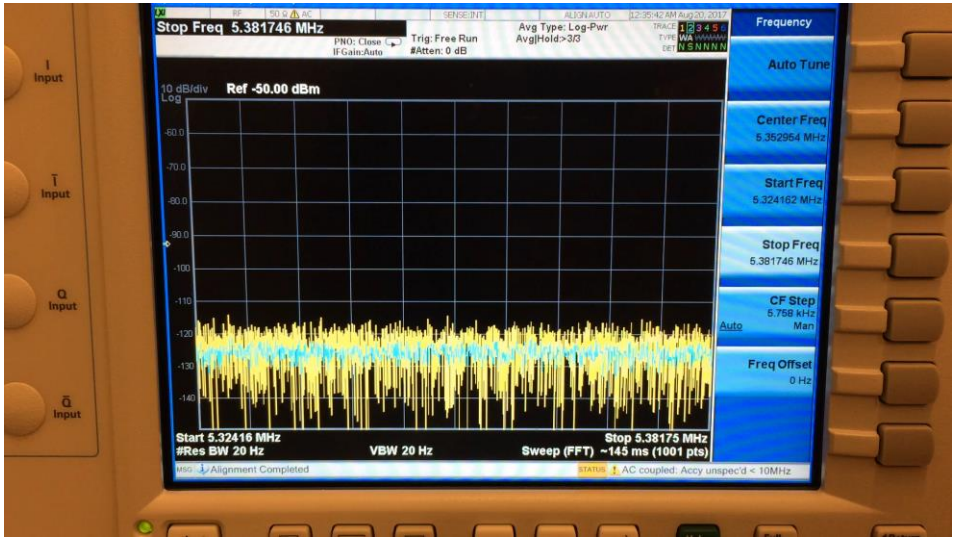
i.e. Beam diagnostic…

Especially non destructive: record all the time

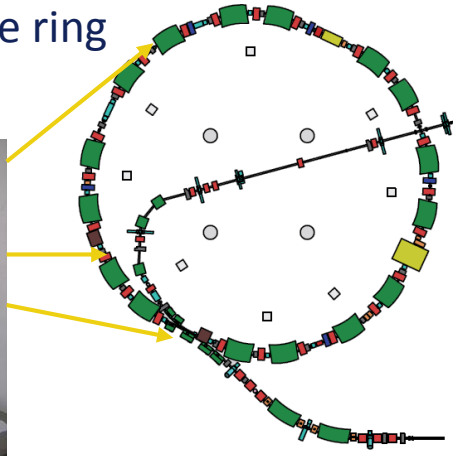
Momentum distribution: Schottky

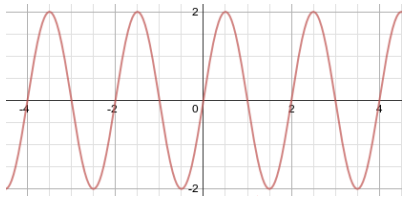




Position in the ring

Pick up





1year

THANK YOU

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