Ideas for a cooling experiment

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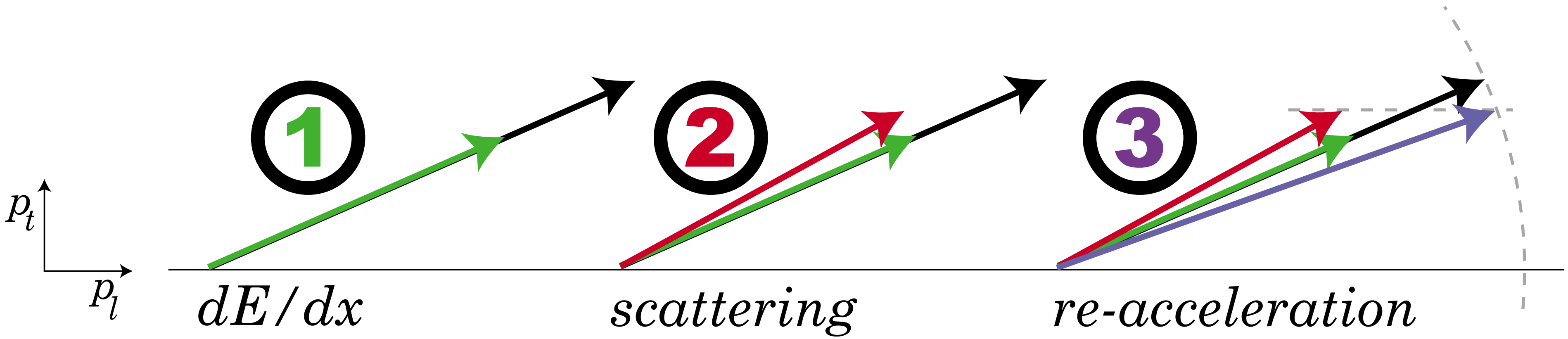
Cooling

- Phase space reduction

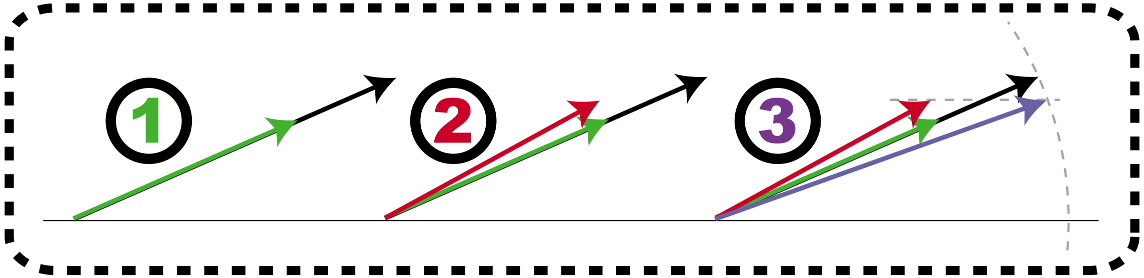
$$\frac{d\epsilon_n}{ds} = -\frac{1}{\beta^2}\frac{dE_\mu}{ds}\frac{\epsilon_n}{E_\mu} + \frac{1}{\beta^3}\frac{\beta_\perp (0.014)^2}{2E_\mu m_\mu L_R}$$

- In fact: not ε, but x' reduction
- Three steps, each step (well) known

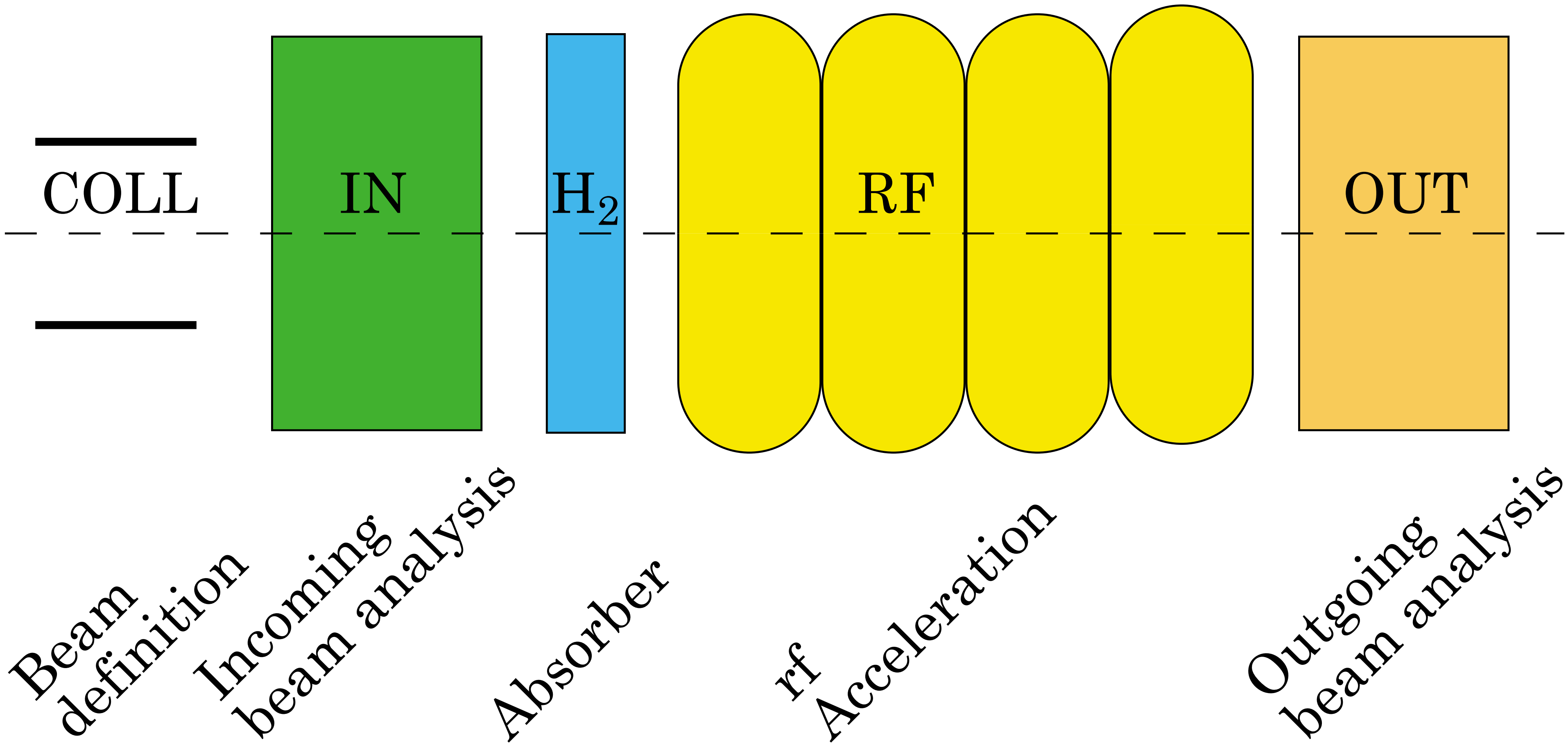


A cooling Experiment ...

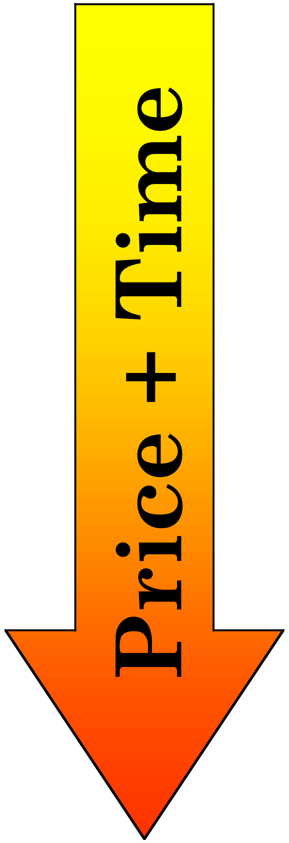
- *All* three steps *integrated* in one setup
- Possible cooling-killers taken into account
  - Misalignment
  - Scattering from rf windows, detectors
  - Straggling
  - rf defocusing
  - Measurement precision + statistics
- Measurement: $\varepsilon_{in} > \varepsilon_{out}$



Cooling experiment setup



What to check ...



- Prove principle
- Prove FNAL/other cooling scheme
- Measure cooling yield of FNAL/other scheme
- Second order effects
- Study collective effects

Fastcool

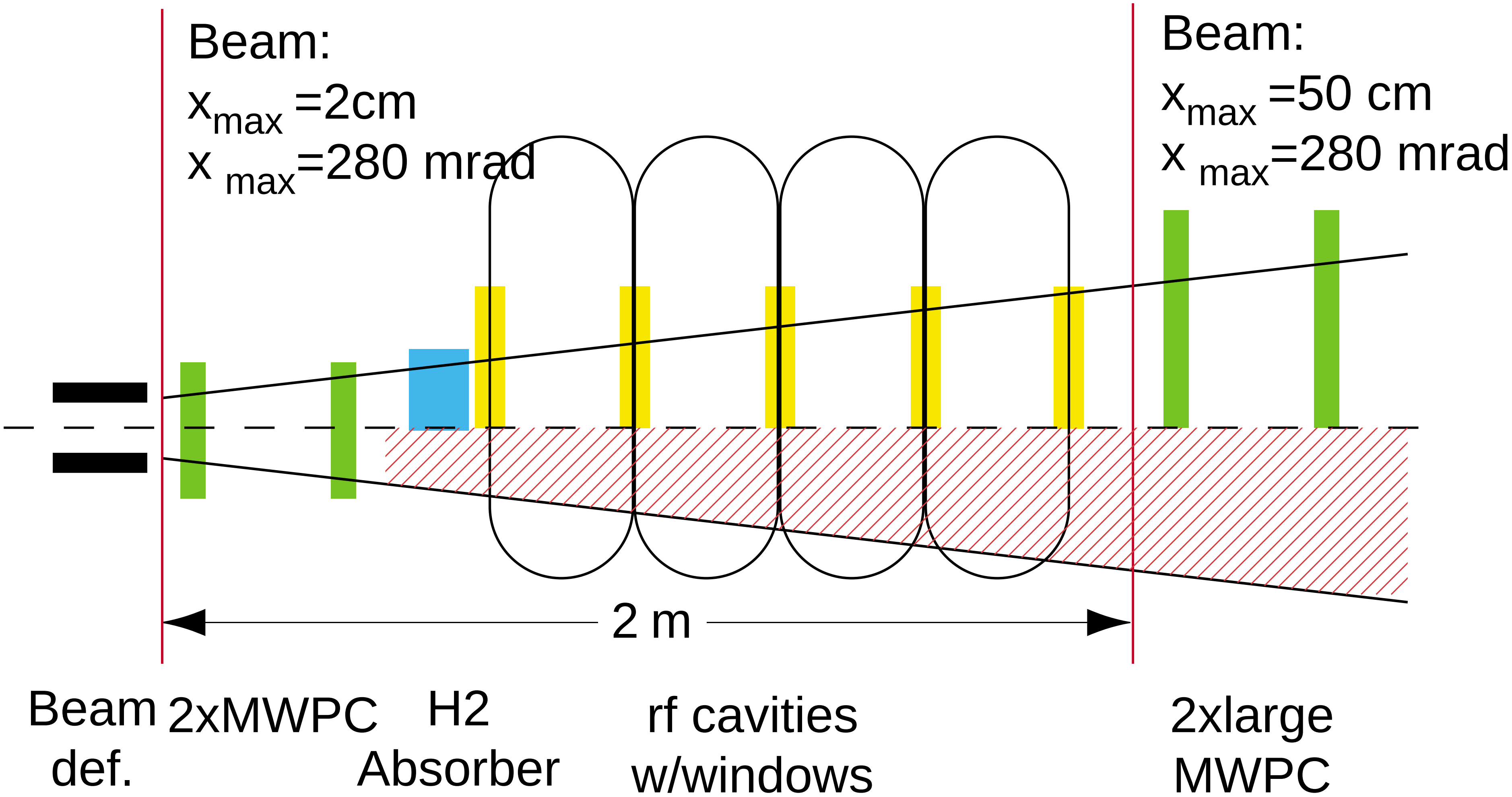
- If there is a need for a *fast*, cheap experiment that only proves, that ionization cooling is possible, then …
  - strip down cooling channels as much as possible
  - think of similar layouts that are easier to build
  - focus on detection precision
  - cool only 2%, just to show it works
  - use single particle method + reconstruct beams
  - get fast results

Challenges

- Cooling is a small effect
- Everything works against cooling
  - Misalignment
  - Scattering
  - Straggling
  - rf defocusing
  - Measurement precision + statistics
- Everything has to be *very* precise

Experiment Layout

Whole experiment
in vacccum.



Key parameters

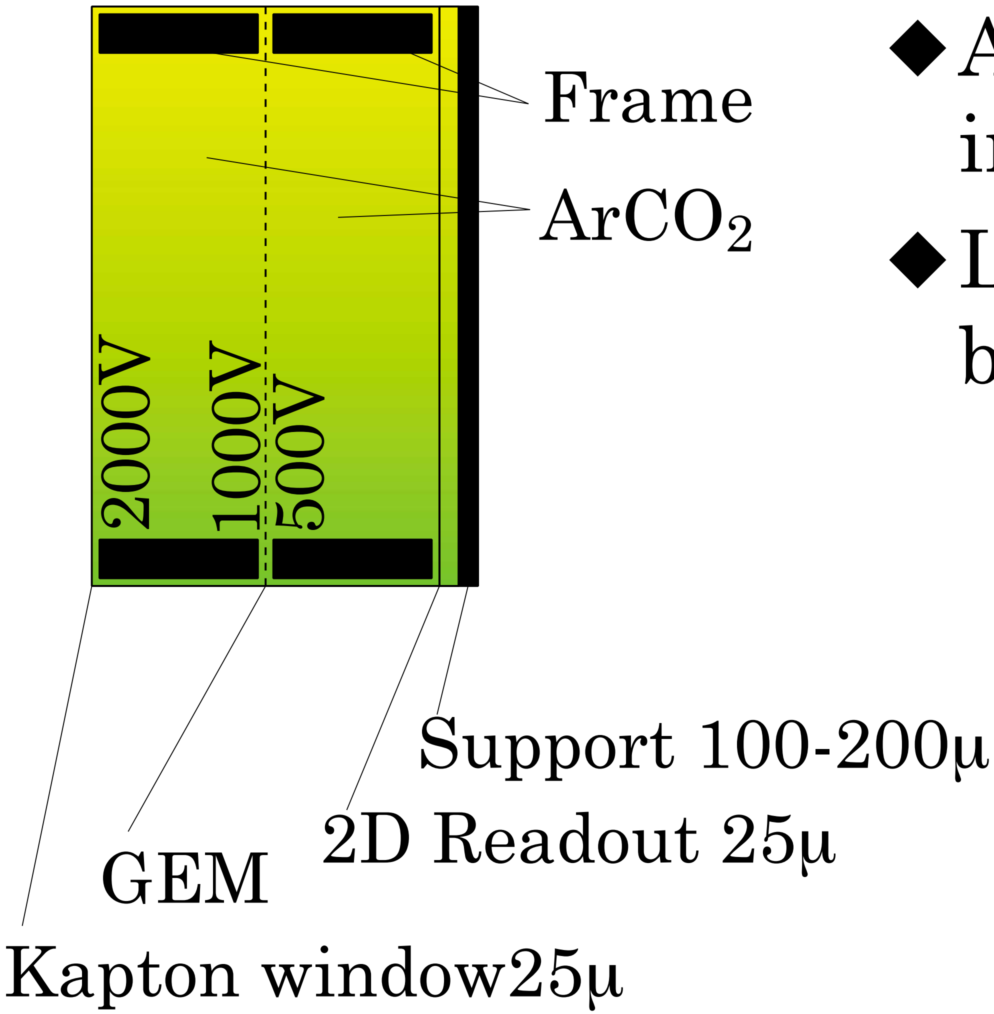
Muon momentum	150 MeV/c
Total rf voltage	6MV
Rf length	2m
Frequency	46MHz
Aperture	∅ 50cm
Absorber	30cm H_2
Budget for win+detect	1mm Al
Incoming rms x’	125mrad
Outgoing rms x’	122mrad
Detection precision	±2x0.2mrad

⇦ Matched to TRIUMF beam (all muons arrive within 18deg phase)

Beam diagnostics - in

- Use 2 MWPC or GEM detectors
- Resolution = 40 μm
- Length=1cm
- Distance=40cm
- Angular resolution ≈ 0.2 mrad
- Beam should see as little material as possible
- 2x2x2 windows of 25μm Kapton
- rf X-rays??

GEM detectors



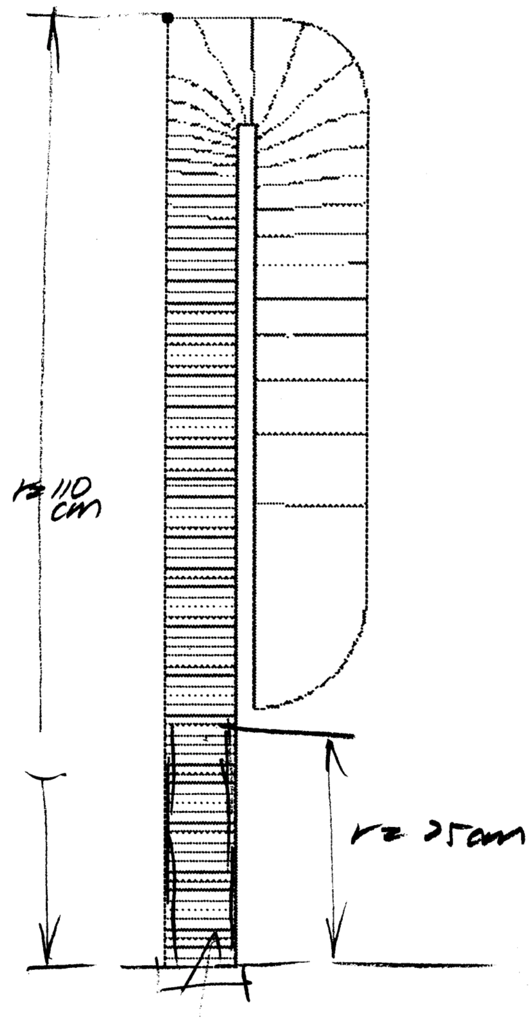
- Already existing in 30x30cm
- Low matter budget

Beam diagnostics - out

- Use MWPC/GEM and silicon detector
- MWPC as before
- Silicon detector with 10μm resolution, energy detection, kills beam.
- Questions
  - Is the energy resolution of the silicon good enough?
    If not, we need a more complicated setup of 3 detectors and a spectrometer magnet.

rf cavity

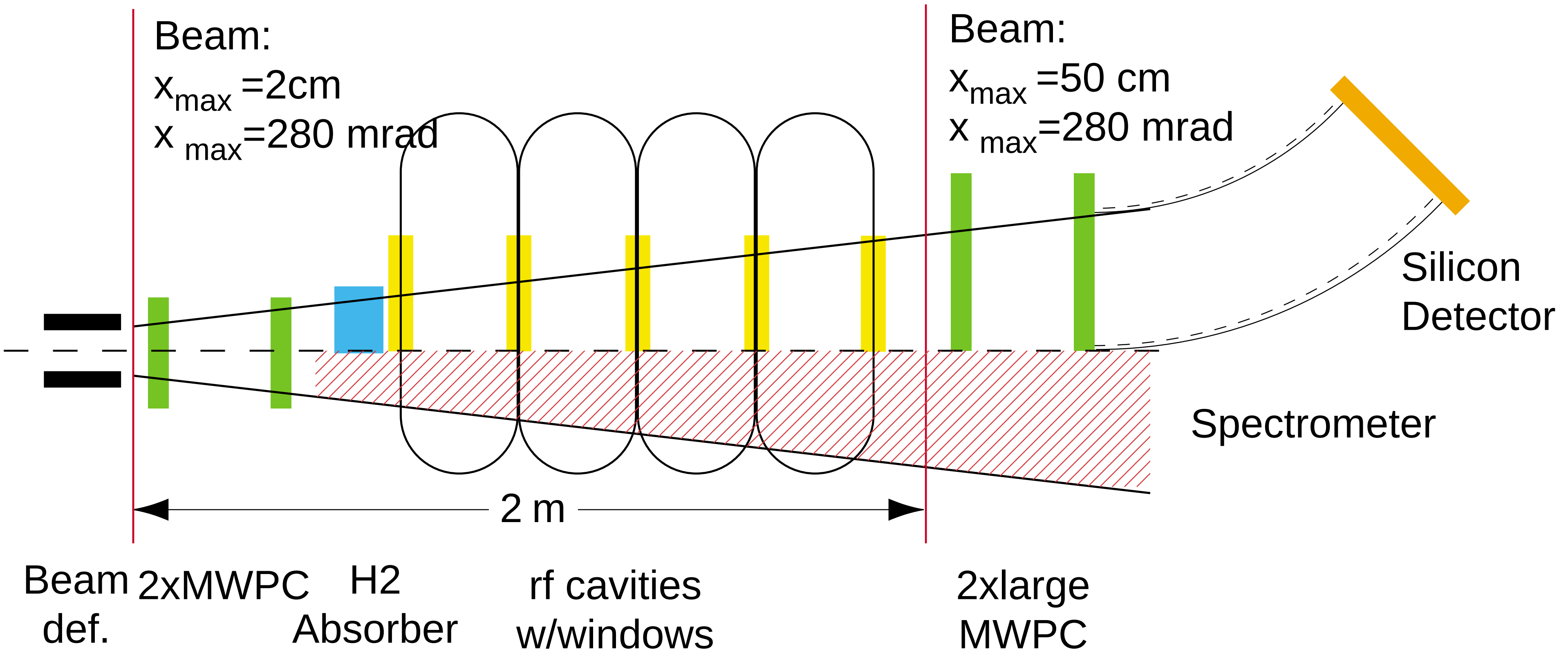
- Calculated with SFH, parameters as desired
- 1.4MV/m
- 50cm aperture, Al window
- 50cm length, 16cm gap
- 3.5 MW per cavity
- Field very uniform (±0.5%)
- Questions
  - Hope to absorb higher modes
  - Do Al windows (50µm) work?



Reconstruction

- Experiment yields a database of particle behaviors
- Incoming beam can be freely chosen
- Outgoing beam reconstructed from incoming beam data
- Analysis of most efficient beam shapes is possible

If we need energy



Summary

- Strengths
  - Fast
  - Cheap
  - Uses known technology
- Weaknesses
  - We don't learn a lot
  - Very different to NF cooling
  - May hold up research
- Opportunities
  - Prove cooling within 1-2 years
  - May help promoting NF to non-physicists
- Threats
  - If it does not work, „major blow for NF" (E. Keil)
  - rf cavity is biggest risk