A “PANDA Phase0” Project at MAMI?

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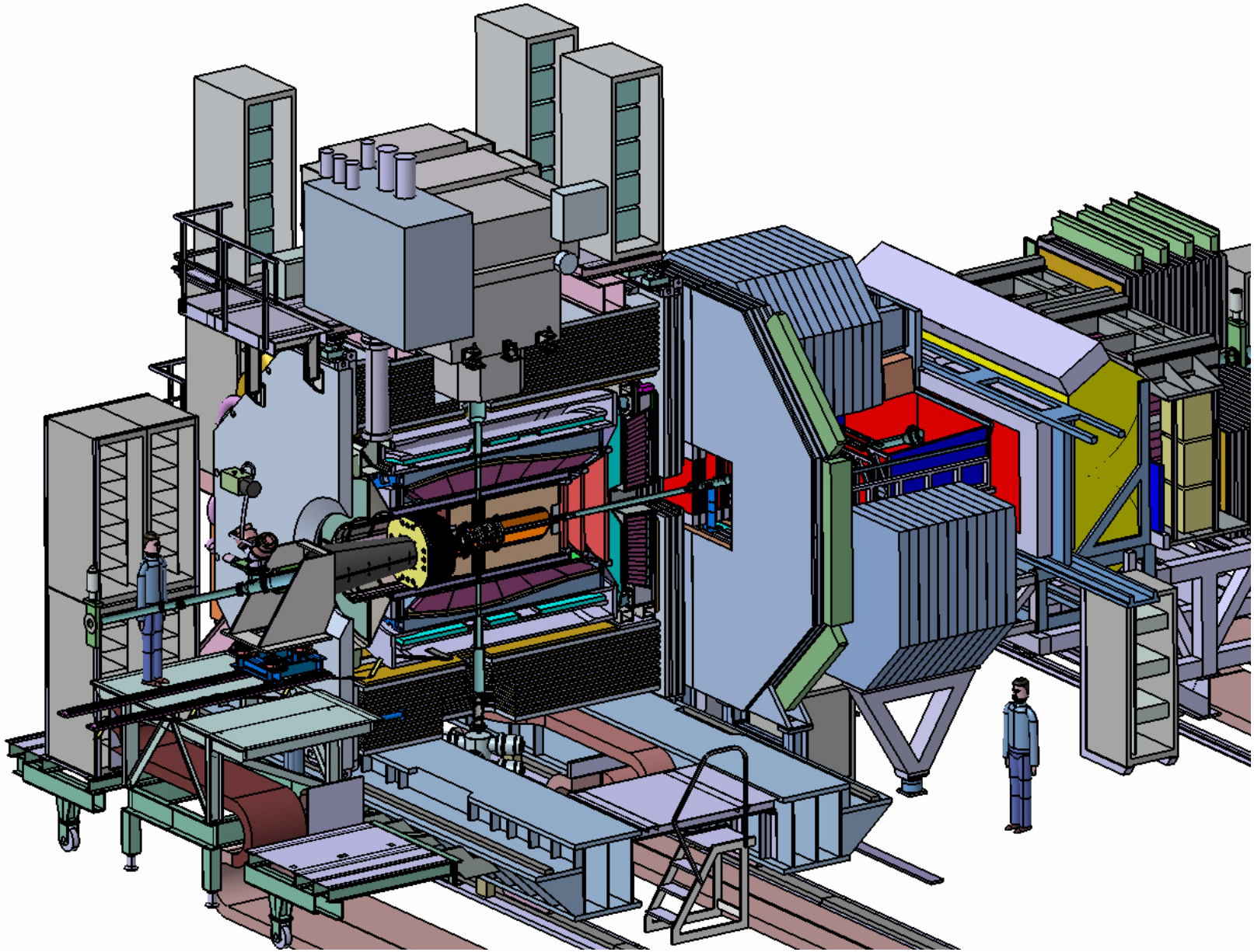
PANDA Meeting, December 2016 – EMP session

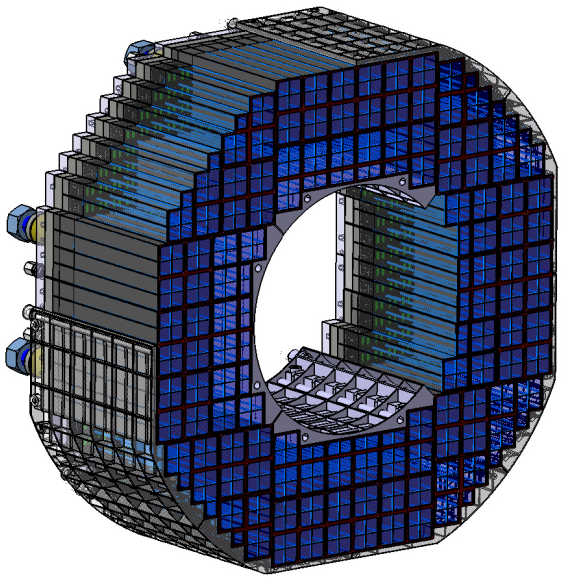
Outline

- What we (will) have at Mainz
  - Facility for electron scattering experiments
  - PANDA backward calorimeter (before PANDA!)
- What we could do
  - upgrade the existing capabilities
  - make fruitful use of new equipment
- What we need
  - something to measure...

The PANDA backward calorimeter

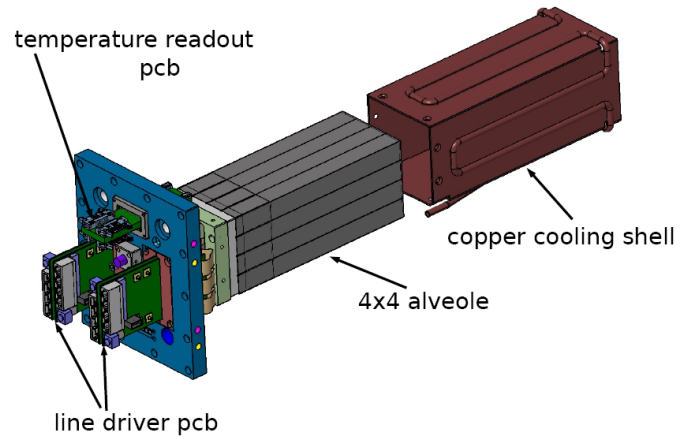


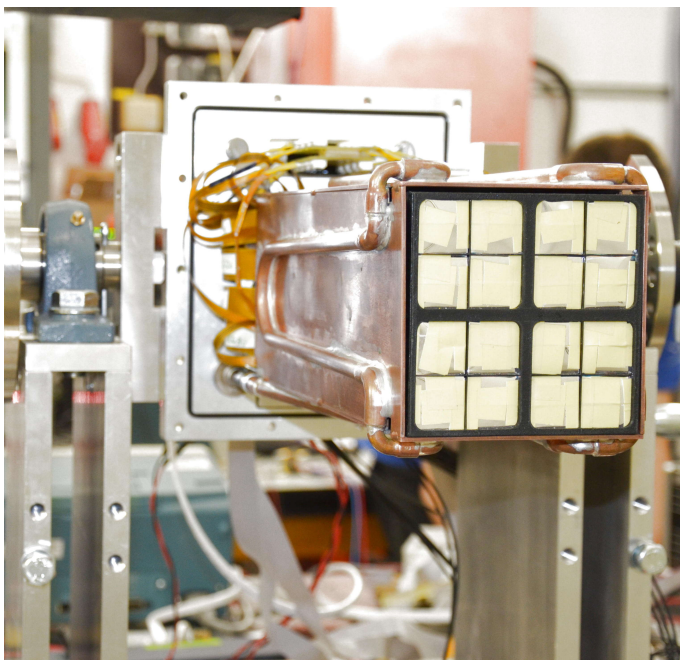
The backward calorimeter



- under development/construction at Mainz
- 524 PbWO crystals
- inner diameter 390 mm/outer diameter 745 mm
- best suited for electrons and gammas
- Energy range from 10 MeV to $\sim$10 GeV
- Energy resolution: 2.5% @ 1 GeV
- Event rate/channel up to $\sim$25 kHz (1% pile-up)

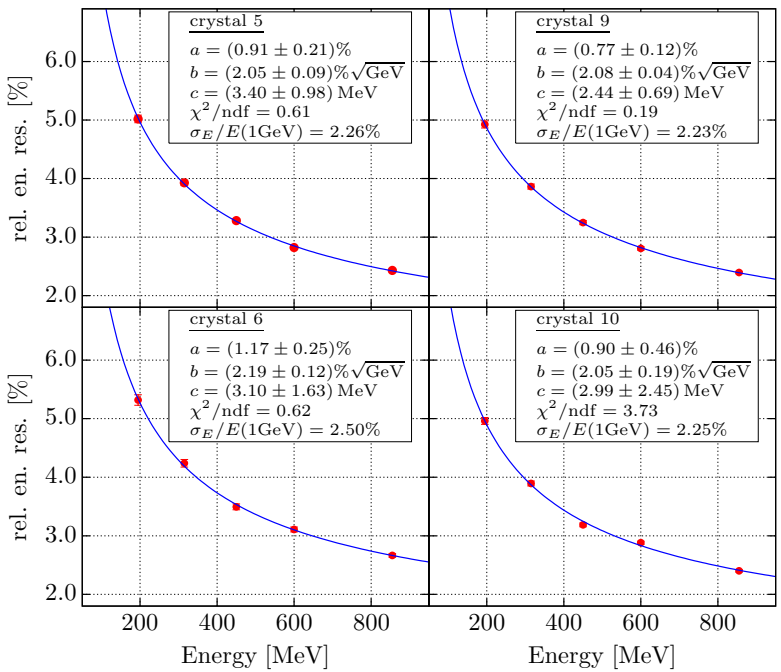
Prototype tests





Proto16

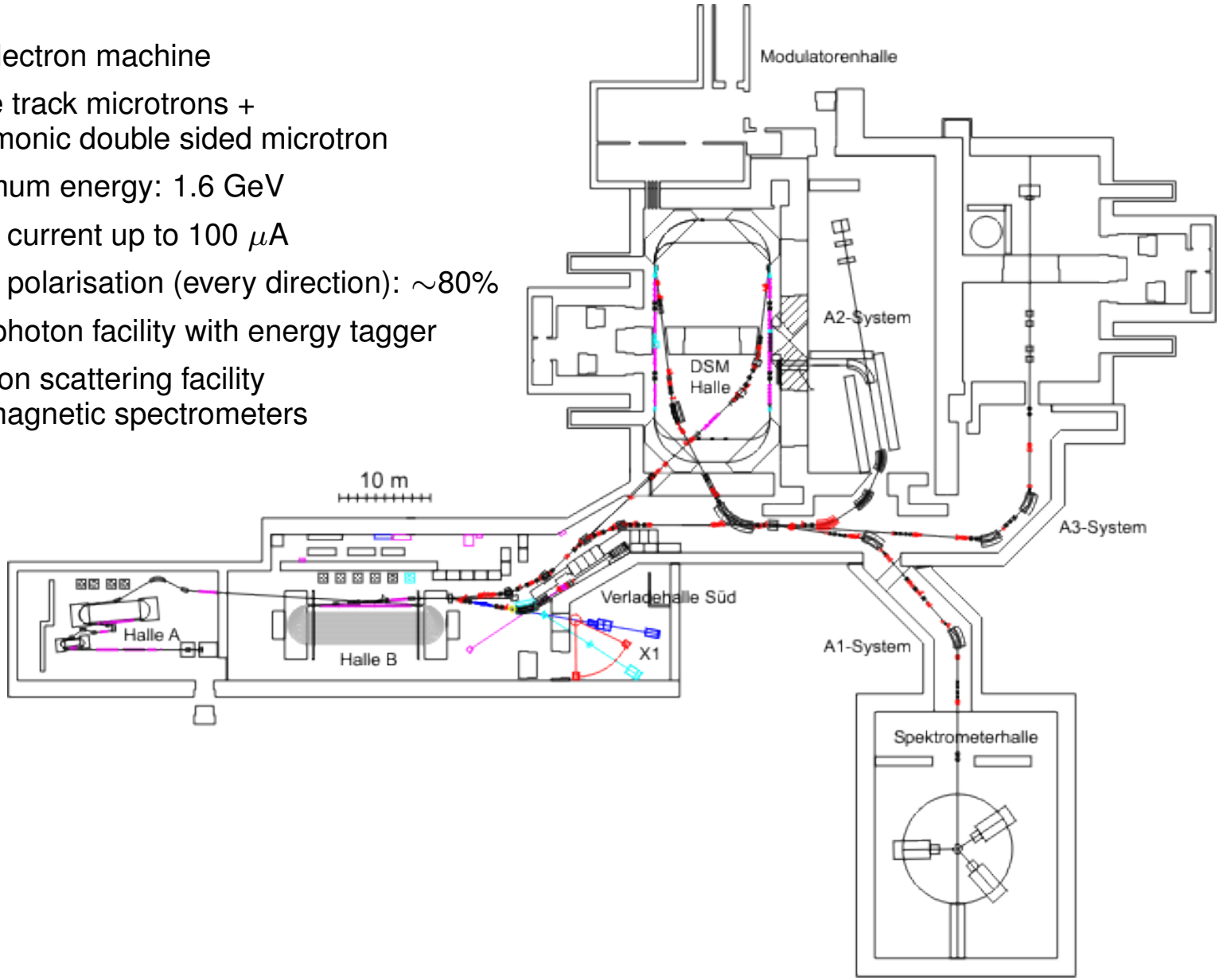
- 16 PbWO crystals (4×4 array)
- All features of the PANDA calorimeter
- Several beam tests done:
  TDR requirement matched



- **Can be used for testing experiment arrangements**

Mainz Microtron (MAMI)

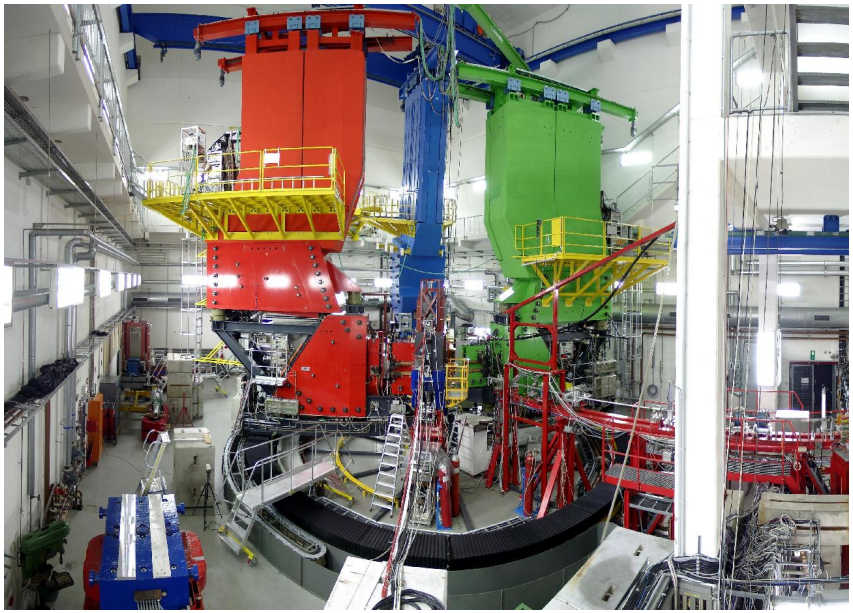
- CW electron machine
- 3 race track microtrons +
  1 harmonic double sided microtron
- Maximum energy: 1.6 GeV
- Beam current up to 100 μA
- Beam polarisation (every direction): $\sim$80%
- Real photon facility with energy tagger
- Electron scattering facility
  with magnetic spectrometers



Spectrometer facility at MAMI

- three magnetic spectrometers
- broad angular and momentum ranges
- high momentum resolution

Spectr.	A	B	C
max. mom. [MeV/c]	735	870	551
mom. acc.	20%	15%	25%
solid angle [msr]	28	5.6	28
min. angle	18°	7°	18°
maxi. angle	160°	62°	160°
out of plane	– –	0°-10°	– –
mom. res.	10^{-4}	10^{-4}	10^{-4}
ang. res. [mrad]	<3	<3	<3
pos. res. [mm]	3-5	1	3-5



courtesy: A1 Collaboration

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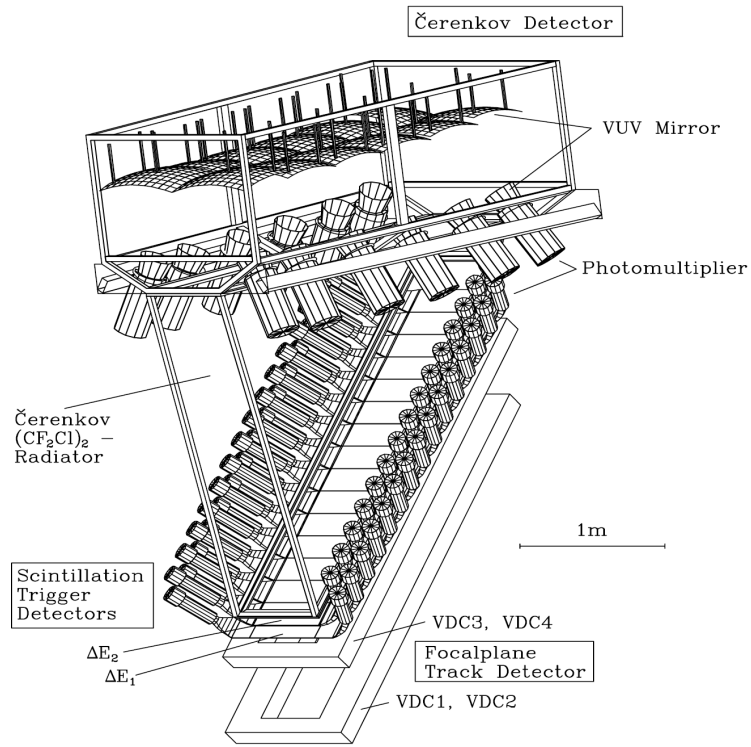

- triggering by scintillators (time res. $\leq$225 ps)
- focal plane tracking (vertical drift chambers)
- particle identification (dE/dx + Cherenkov)

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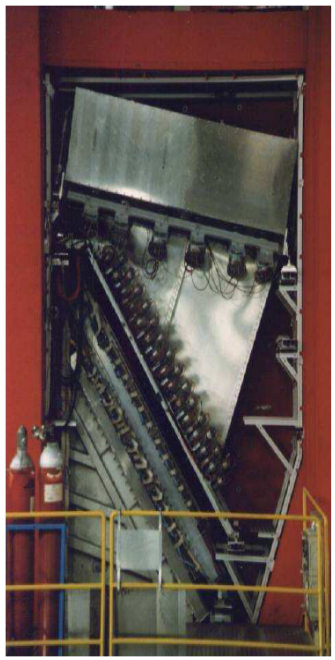

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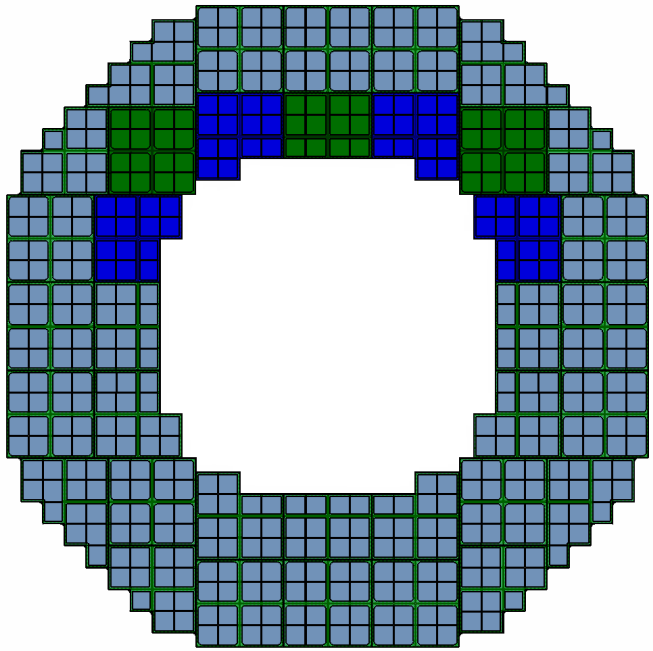
- triggering by scintillators (time res. $\leq$225 ps)
- focal plane tracking (vertical drift chambers)
- particle identification (dE/dx + Cherenkov)
- recoil proton polarimeter

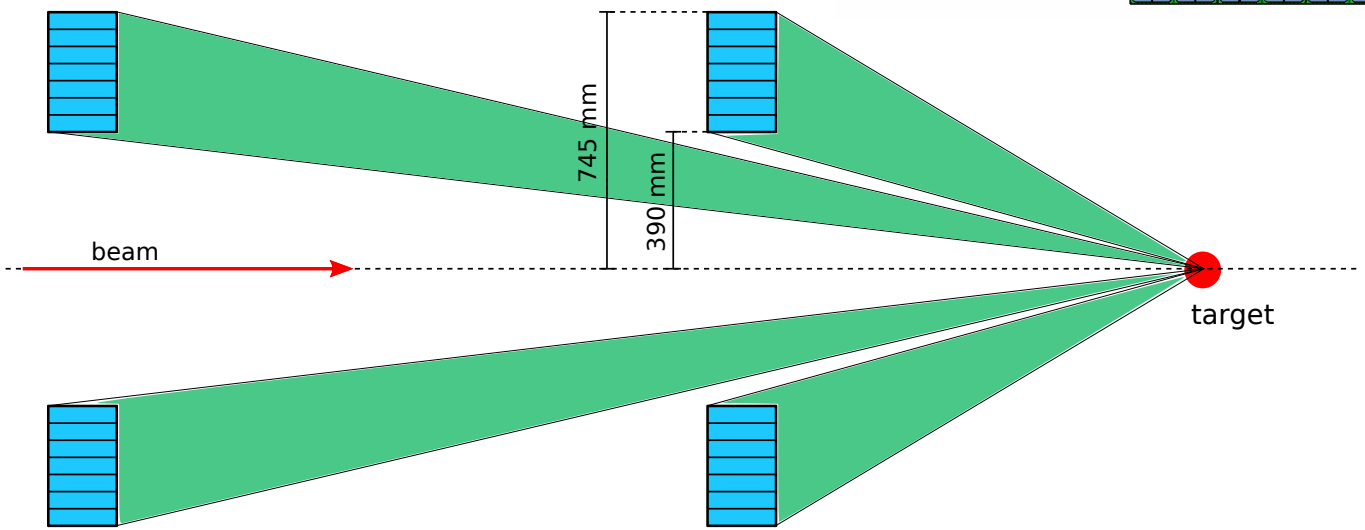
Calorimeter integration

Backward configuration

- same detector geometry as in PANDA
- calorimeter around beam pipe
- distance from target t.b.d.



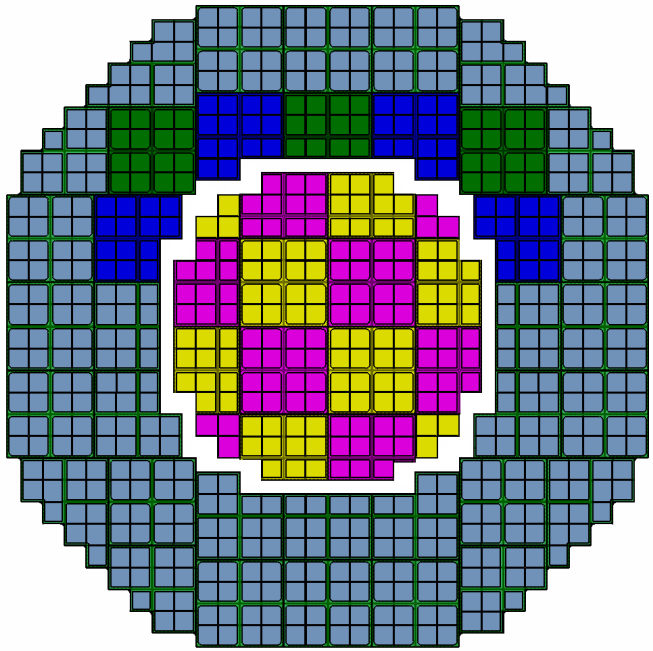
side view

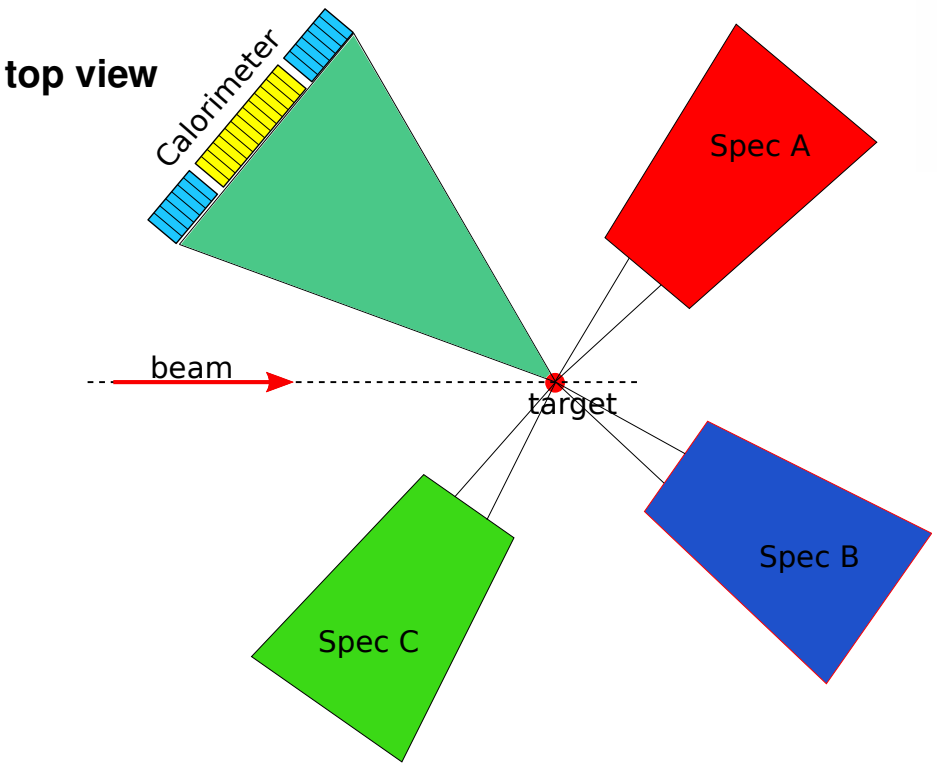


Calorimeter integration

Sideward configuration

- additional inner part
  $\Rightarrow$ 164 extra crystals (688 in total)
- central scattering angle t.b.d.
- distance from target t.b.d.
- possible large acceptance





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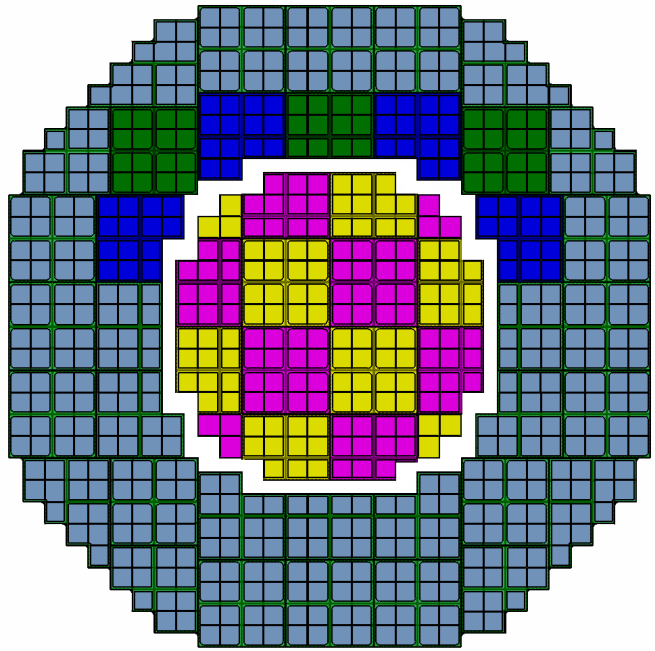
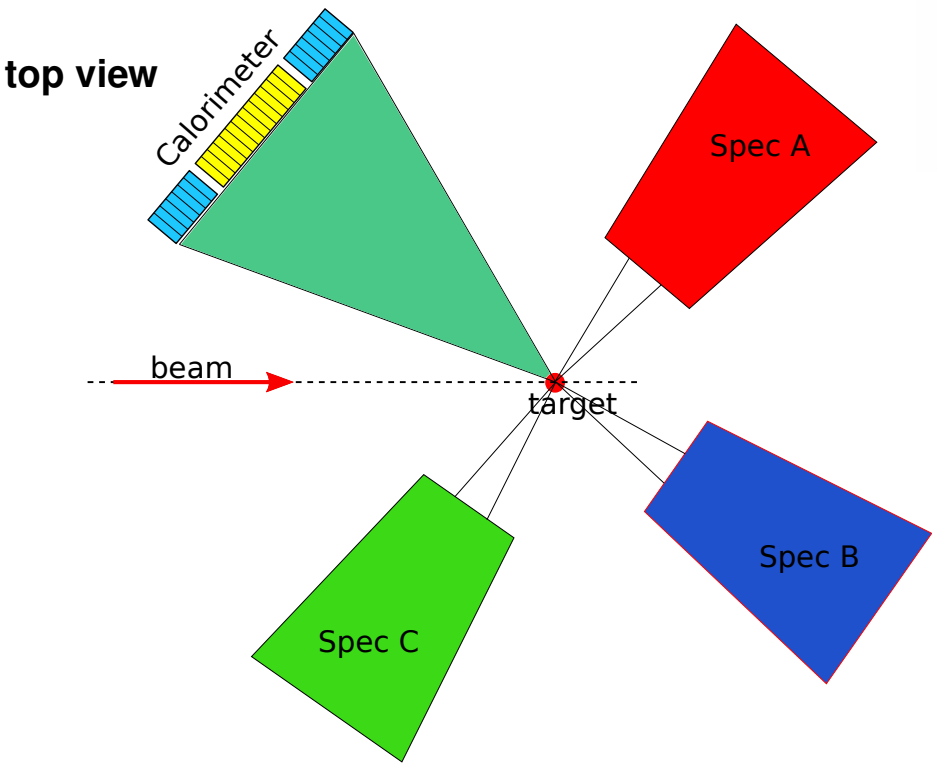


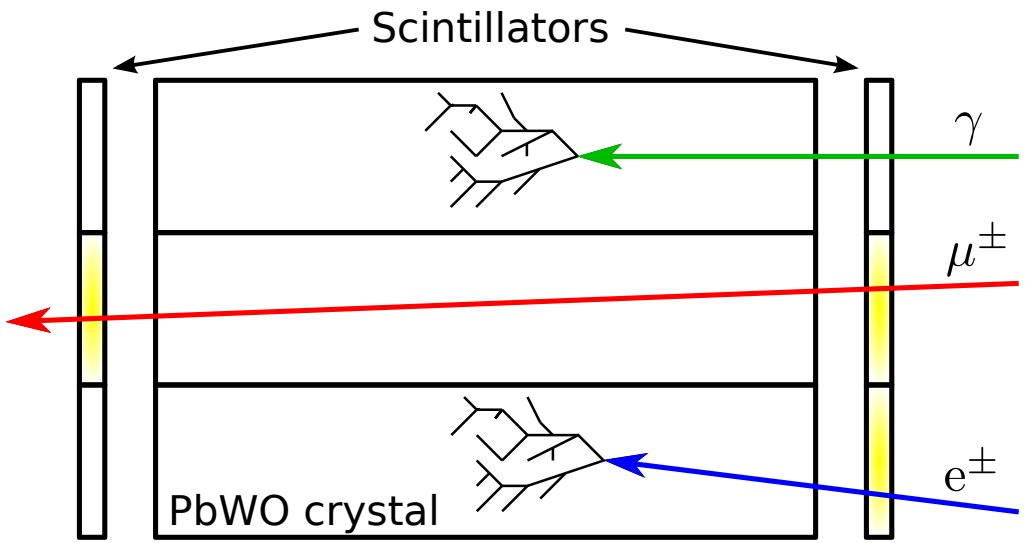


Open questions:

- possible kinematical ranges
- efficiency studies
- boundary effects
- ...

Need for detailed MC simulations!

Particle identification



- need to separate e from γ
- maybe also e from μ
- possible add-on: scintillating tiles or similar
- both in the front and in the back

- relative simple
- improve time resolution
- to be designed from scratch

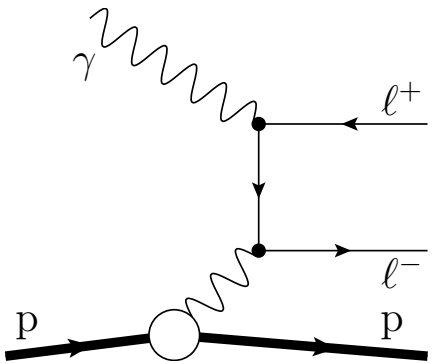
Possible physics cases

Lepton universality

- Triggered by proton radius puzzle (still up-to-date?)
- Interest in μ vs e coupling in scattering off proton (form factors)
- Proposal to measure lepton pairs **photo**production

  V. Pauk, M. Vanderhaeghen, Phys.Rev.Lett. 115 (2015) no.22, 221804

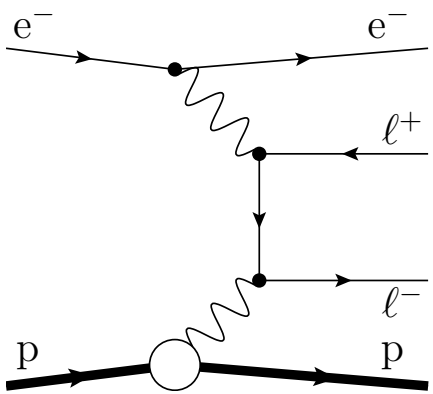
$$\gamma\,\mathrm{p} \to \mathrm{p}\,\ell^+\ell^- \;(\ell^+\ell^- = \mathrm{e}^+\mathrm{e}^- \text{ or } \mu^+\mu^-)$$

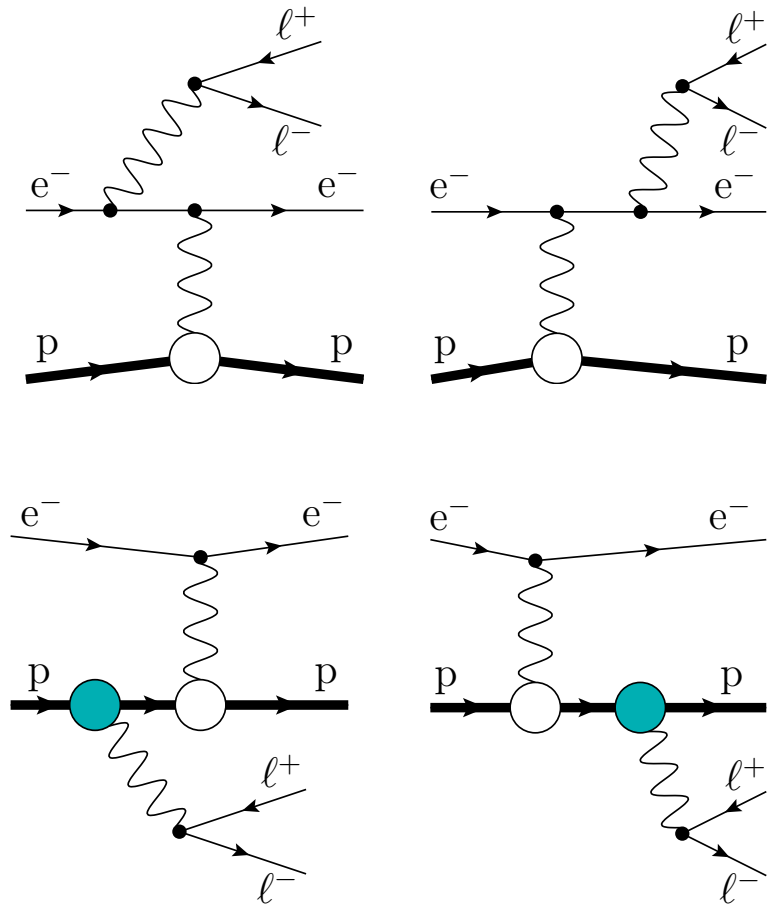


- Inclusive measurement: only recoil proton detected
  (most of leptons along the beamline)

Lepton universality

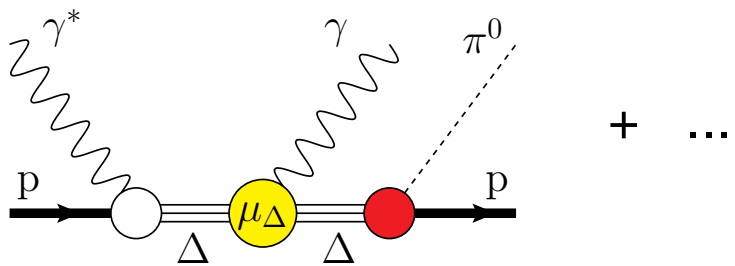
- Here proposed: **electro**production of lepton pairs: $\mathrm{e\,p} \to \mathrm{e\,p}\,\ell^+\ell^-$
- Define the momentum transfer by the mag. spectrometers
- Possibility to detect leptons: better constraint of kinematics
- Much larger acceptance than with only mag. spectrometers





Magnetic dipole moment of the $\Delta(1232)$

- Radiative single pion electroproduction: $\mathrm{e\,p} \to \mathrm{e\,p}\,\pi^0\,\gamma$



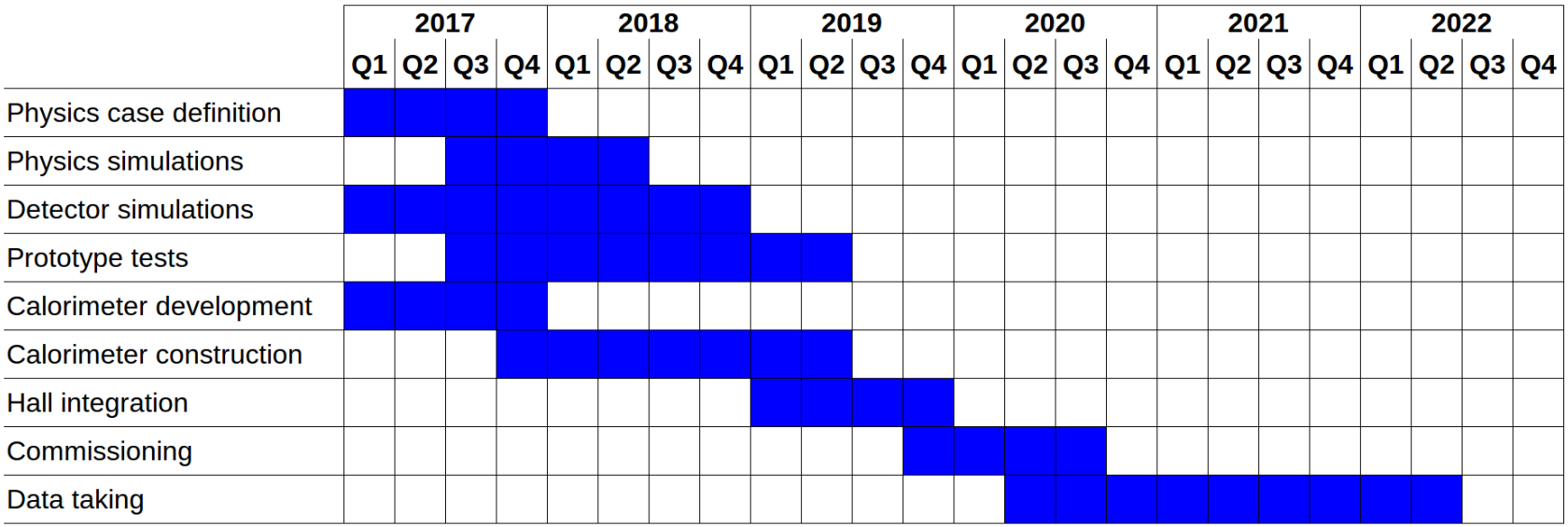
- Important for hadron structure
- Test of chiral dynamics/lattice QCD
- Possibility to detect the extra γ and/or π^0

Double-pion electroproduction

$$\mathrm{e\,p} \to \mathrm{e}\,N\,\pi\,\pi$$

- Several isospin channels: $\mathrm{e\,p} \to \mathrm{e\,p}\,\pi^+\,\pi^-$
  $\mathrm{e\,p} \to \mathrm{e\,n}\,\pi^+\,\pi^0$
  $\mathrm{e\,p} \to \mathrm{e\,p}\,\pi^0\,\pi^0$
- Charged-π channel measured at CLAS
- (Almost?) no data for π^0 channels
- Some resonances could be cleaner on the double-pion channel
- At low momenta: good test for chiral EFT
- Anomalous contributions?

Tentative timelines



Summary

- Possible versatile setup for a “PANDA phase0” project: embedding backward EMC into the spectrometer facility at MAMI
- Need to define a solid/ground physics programme
- Some extra development w.r.t. PANDA might be advisable (inner part, scintillating tiles...)
- Simulations should start soon
- Tough schedule but still feasible